PRODUCT MANUAL

Dynamic C®

TCP/IP Volume 2

User's Manual

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Dynamic C User's Manual

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1. INTRODUCTION

The *Dynamic C TCP/IP User's Manual, Vol. 2* is intended for embedded system designers and support professionals who are using a Rabbit-based controller board. Most of the information contained here is meant for use with Ethernet- or WiFi-enabled boards, but using only serial communication is also an option. Knowledge of networks and TCP/IP (Transmission Control Protocol/Internet Protocol) is assumed. For an overview of these two topics a separate manual is provided, *An Introduction to TCP/IP.* A basic understanding of HTML (HyperText Markup Language) is also assumed. For information on this subject, there are numerous sources on the Web and in any major book store.

The Dynamic C implementation of TCP/IP comprises several libraries. The main library is `DCRTCP.LIB`. As of Dynamic C 7.05, this library is a light wrapper around `DNS.LIB`, `IP.LIB`, `NET.LIB`, `TCP.LIB` and `UDP.LIB`. These libraries implement DNS (Domain Name Server), IP, TCP, and UDP (User Datagram Protocol). This, along with the libraries `ARP.LIB, ICMP.LIB`, `IGMP.LIB` and `PPP.LIB` are the transport and network layers of the TCP/IP protocol stack.

The Dynamic C libraries:

- `BOOTP.LIB`
- `FTP_SERVER.LIB`
- `FTP_CLIENT.LIB`
- `HTTP.LIB`
- `HTTP_CLIENT.LIB`
- `POP3.LIB`
- `SMNP.LIB`
- `SMTP.LIB`
- `TFTP.LIB`
- `VSERIAL.LIB`

implement application-layer protocols. Except for BOOTP, which is described in the *Dynamic C TCP/IP User's Manual, Vol. 1*, these protocols are described here in the following chapters.

All user-callable functions are listed and described in their appropriate chapter. Example programs throughout both volumes of the manual illustrate the use of all the different protocols. The sample code also provides templates for creating servers and clients of various types.

To address embedded system design needs, additional functionality has been included in Dynamic C's implementation of TCP/IP. There are step-by-step instructions on how to create HTML forms, allowing remote access and manipulation of information. There is also a serial-based console that can be used with TCP/IP to open up legacy systems for additional control and monitoring. The console may also be used for configuration when a serial port is available. HTML forms and the console are discussed in Chapter 4 and Chapter 14, respectively.

Multiple interfaces are supported starting with Dynamic C version 7.30.

2. WEB-ENABLING YOUR APPLICATION

This chapter, and the next three, describe how to add web browser control to your application. Web-enabling is a logical and appealing choice for adding a user interface to your application, since the necessary hardware (an Ethernet or serial port) is available on all Rabbit core modules and SBCs. Most users of your application will be familiar with at least one web browser (Netscape, Mozilla, Internet Explorer, Opera), with its graphical user interface, so they will be ready to start controlling your application with minimal training.

This chapter provides an overview of the steps you will need to take to web-enable an application. Knowledge of browsers, and something of their capability, is assumed. With this knowledge, you can understand the concepts described in this chapter. The following chapters go into more detail about the specific libraries; but for simple programs, you may be able to use just the information in this chapter along with the sample code to write a working application.

Dynamic C provides libraries that implement most of the functions required to implement a web server, more formally known as an HTTP (HyperText Transfer Protocol) server. (The browser is formally called an HTTP client). You only need to write code specific to your application, such as dealing with I/Os and the Rabbit peripheral devices, and possibly some code to help the HTTP server generate the appropriate responses back to the user's web browser. In addition, there is a small amount of "boilerplate" that needs to be written to include and configure the HTTP server and any ancillary libraries such as the TCP/IP suite and filesystems.

2.1 Designing Your Application

Should you decide to web-enable your application, you probably already have some idea of the format and layout of the web pages that will be presented to the browser. Unless the application only returns information and does not allow any updates (such as a data logger), you will probably need to lay out some *forms*. Forms, in web parlance, allow the browser's user to fill in some information then submit it to the server. The server then performs the requested actions and sends a confirmation back to the browser. This is the most common means for implementing control of the server as opposed to merely querying it.

There are several other things to consider. Answers to the following list of questions will determine the pieces of software that need to be gathered into your application, and how they link together.

- Does access to some or all resources need to be limited to a select set of users?
- If so, how confident does your application need to be that the user's credentials are valid?
- Do you need to be able to upload large amounts of data (over, say, 250 bytes)?
- Do you want to update the web pages themselves, or maybe even the entire application firmware?
- Is the application small, medium, or large?

- Do you want to use this same (web) interface to configure all aspects of the application including, for example, the network settings? In other words, is the web interface going to be the *only* interface once the unit leaves the factory?

The first and second questions relate to *user authentication* and *access control*. The next two questions relate to the *HTTP upload* facility. The last two questions concern the overall design of your application; in particular, a large application may necessitate more storage than is usually available for a given Rabbit product, and may require a sophisticated filesystem to manage the large number of resources.

Since the terms small, medium and large are rather vague, we shall define them by example. A small application would be limited to less than 10 different web pages, and up to about 30 different "controls" (buttons to press, dials to twiddle, options to select etc.). A large application may have upwards of 100 pages, and more than 10KB of configurable data. A medium application sits, as you might expect, near the middle of these.

Note that we are not considering the size of the application other than the web interface part. For example, you may have a sophisticated G-code interpreter and motion control system, where the web interface is limited to simply enabling/disabling the actuators and showing an error log to maintenance personnel. For the purposes of our discussion, this would be a small application.

The next section describes a "smaller-than-small" application, that is, a toy, which we use to show the bare essentials of a web-enabled application.

2.2 The Smallest Web Server in the WWW

Before moving on to real applications, the following sample code shows how to create the simplest possible web server. It does nothing but show "Hello WWW" on the browser. There are two files needed for this. The first is the Dynamic C code to be loaded to the target board (which must support TCP/IP). The second is the web page content itself, written in a syntax known as HTML (HyperText Markup Language). The second file is effectively included in the program, using the #ximport directive.

```
// toy_http.c

#define TCPCONFIG 1
#use "dcrtcp.lib"
#use "http.lib"

#ximport "hellowww.html" hellowww_html

SSPEC_MIMETABLE_START
   SSPEC_MIME(".html", "text/html")
SSPEC_MIMETABLE_END

SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/hellowww.html", hellowww_html)
SSPEC_RESOURCETABLE_END

void main() {
   sock_init();
   http_init();

   for (;;) http_handler();
}
```

The second file, named `hellowww.html` is coded as follows:

```
<HTML>
<HEAD><TITLE>Hello, WWW</TITLE></HEAD>
<BODY><H1>Hello, WWW</H1></BODY></HTML>
```

That's all there is to it. However, there is actually a lot of activity going on beneath the covers. For a start, the #use "dcrtcp.lib" directive and the `TCPCONFIG` macro definition bring in the TCP/IP networking suite and configure it. Unless you have a private test network, you probably have to modify the default setting - how to do that is beyond the scope of this chapter; it is described in volume 1 of the manual. The #use "http.lib" statement is required in order to bring in the web server. The next lines down to the start of the `main()` function are setting up tables that are consulted by the HTTP server and other libraries in order to "do the right thing." Finally, the `main()` function calls the necessary runtime initialization of the network and the HTTP server. It then calls the HTTP server in an endless loop, which drives the entire system into motion.

The .html file is ASCII text, in HTML syntax, which is transferred back to the browser when it is requested. Apart from the server adding some header lines, the .html file is transferred verbatim. This markup is merely telling the browser to display "Hello, WWW" as a 1st level heading, i.e., big bold text. This is specified by the second line. The first line adds a title to the page, which most browsers display in the window bar.

To see this web page on screen, the user needs to tell their browser what to get. If doing it manually, they would need to enter something like "http://10.10.6.100/hellowww.html" in the browser's URL entry field. The browser strips off the http://10.10.6.100 part of it, and sends the rest to the specified host address (10.10.6.100) using a TCP connection to port 80 (interpreted from the http:// part). The server gets the /hellowww.html part, which it knows about since it has a page of that name, and returns the contents of that file as a response. The browser interprets the HTML it receives, and generates a nice visual rendition of the contents.

2.3 Web Server Architecture

Before describing a real application, it is useful to know how such an application is organized. The following diagram shows all of the relevant components of a web-enabled application. There may seem to be a large number of components, however keep in mind that not all components need to be used by your application.

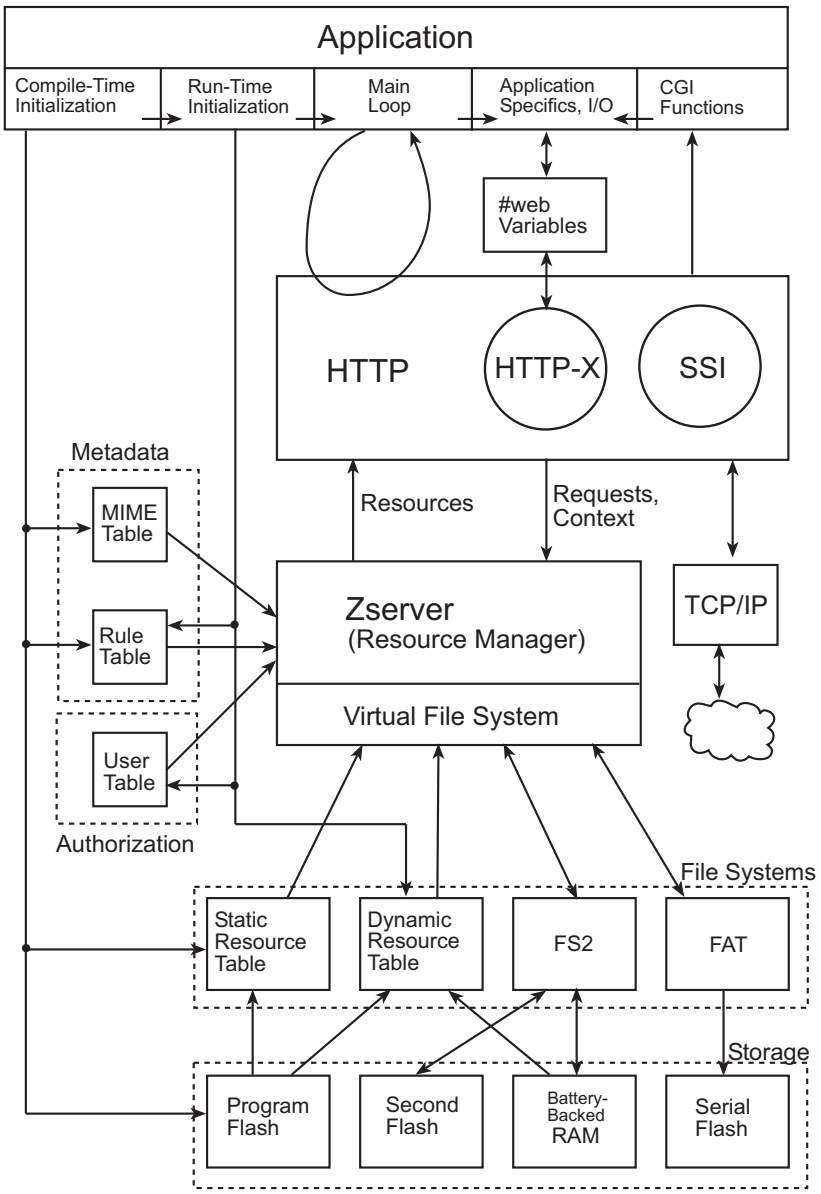


Figure 2.1 Components in a web-enabled application.

2.3.1 Application Block

At the top of this diagram is a block, called "Application," consisting of five sub-blocks. The Application block represents the code that you have to create. Everything below this is provided by the libraries, although you will need to specify some parts of the interface to these components. This will be described in detail in the following sections.

The application block is subdivided into 5 parts:

1. Compile-time initialization. This includes things like selection of the appropriate library modules; initialization of static (constant) data structures and tables; selecting default network configuration; and inclusion of static resources (external files) via the `#ximport` or `#zimport` directives. The arrows leading from the "Compile-Time Initialization" sub-block indicate the tables that may be set up at compile time; namely:
   - The MIME type mapping table. This mandatory table indicates to the browser how the content is to be presented to the user. This is necessary for the browser, and needs to be specified by the server, however the server does not need to be particularly aware of the details.
   - The rule table. This is only necessary if a filesystem is in use. It is used by the resource manager to apply access permissions to the resources contained in a filesystem. This is necessary because not all filesystems can associate file ownership and access rights with individual files.
   - The static resource table. This is the classic method of defining resources in Dynamic C. This table is optional, since all necessary resources may be loaded in a filesystem, or in the dynamic resource table. Most applications will contain at least a few static resources, as an initial default or fallback, or for data that will never change such as a logo image.
   - Program flash. This really represents the loading of resource files into program memory via the `#ximport` directive. There will almost always need to be a few `#ximport` files, but this can be limited to a few kilobytes total.
2. Runtime initialization. Your `main()` function needs to call some specific library functions, once only, when it starts:
   - `sock_init()`. This is always mandatory. It initializes the TCP/IP networking system.
   - `sspec_automount()`. This is optional. It initializes the available filesystems (FS2 and/or FAT) for use by the resource manager, Zserver.
   - `http_init()`. This is mandatory. It initializes the HTTP server.
   - Various functions for setting up a user ID table, the rule table and/or the dynamic resource table. These are optional, but would be used in the majority of applications. The user ID table can only be initialized at run time, unlike the other tables that may, at least partially, be initialized at compile-time.
3. Main loop. The final code in the `main()` function continuously calls `http_handler()` and possibly other functions. This is mandatory, since it allows the HTTP server to process requests from the network. Other functions may be specific to your application. For example, you may need to poll an I/O device in order to obtain best performance.
4. Application specifics and I/O. This is really *your* part of the application or, if you like, the "back end" to the HTTP server. There are a number of ways that your application can communicate with the HTTP server. (These are not all shown on the diagram since it would add needless complexity.) Your application can directly call functions in the HTTP server, in the resource manager (Zserver),

in TCP/IP, and just about anywhere else. One very clean and powerful interface is provided via #web variables, provided by RabbitWeb software which was introduced in Dynamic C 8.50.

5. CGI functions. CGI stands for "Common Gateway Interface," however this acronym has a more specific use in Dynamic C—it refers to a C function that is called by the HTTP server to generate some dynamic content for the browser. This is the only truly optional block. Many applications can be written without resorting to CGI functions; however, there are some cases where the power and flexibility of a CGI will be required. Prior to Dynamic C 8.50, writing a robust CGI was the most difficult part of the process. Starting with Dynamic C 8.50, there is a new style of CGI writing that simplifies the process and reduces the chances of error. The old-style CGI is still supported for backwards compatibility.

2.3.2 HTTP Block

Let us now progress to the HTTP server itself. In the diagram, this is the block with two circles inside. The server is responsible for fielding requests from the outside world. Each request is analyzed to determine the resource that is being requested, the user who is making the request, and whether the user is authorized to obtain that resource. If the resource is available, the user is known and has the proper permissions, then the resource is transmitted back to the browser.

Following the above steps in more detail, we have:

1. Analyze the request: obtain the resource name. Part of the information provided by the browser is a request header that contains a URL (Uniform Resource Locator). The URL is simply the name of the resource to retrieve. URLs typically look like a file name in a Unix-style filesystem, that is, component directory and file names separated by slash (/) characters.
2. Obtain the user ID. The browser has the option of sending the username and password of its user. If it does not do this, then the userid is "anonymous." If this is not good enough, then the browser can always try again when it is denied a protected resource. On receipt of user credentials (name and password), the HTTP server consults the resource manager (which in turn looks up the rule table) to see if the user's credentials are OK. If they are, then the resource manager also determines the group(s) of which this user is a member. Thereafter, all access and permission checking is based on the group, not the individual user.[1]
3. Return the resource. Having verified the group access rights (if necessary), the resource is transmitted back to the user. The resource may be an HTML or image file obtained from program memory or a filesystem, or it may be a script file that is processed "on the fly" to generate markup language. It may even represent a CGI function that will be called to generate all the necessary response. Note that a complete response requires a small amount of header information to be prefixed to the actual resource. The HTTP server usually takes care of this, however CGIs sometimes need to generate the header themselves.

Referring to the diagram in Figure 2.1, you can see that there are several arrows leading in and out of the HTTP server block. These represent lines of communication, and the arrow heads indicate the usual direction of data flow or, for function calls, "who calls whom."

1. This is a necessary optimization. There may be hundreds of individual users; however, the majority of these would be considered to be in a single "class," with that class giving equal access to all its members. Considering the class, i.e., group, as the entity that is requesting a resource reduces the amount of information that needs to be stored.

2.3.3 HTTP Block Subcomponents

The inner circles represent subcomponents of the server. The first of these, RabbitWeb, was introduced in Dynamic C 8.50. RabbitWeb is an extension to C language syntax to simplify presentation of C language objects (variables, structures) to a browser. RabbitWeb allows you to write web pages in a special scripting language. The script makes it easy to generate HTTP, which is the format expected by the browser. In addition, the script allows the contents of your C language objects to be turned into HTML fragments for presentation by the browser. See Chapter 5 for details about RabbitWeb.

The small block named "#web Variables," between the Application block and the RabbitWeb circle, indicates that the `#web` variables are the means of communication between your application and the server. Since `#web` variables are really just ordinary C variables, arrays or structures, they are extremely easy to manipulate by your application. Since they also have the property of being *registered* with the web server, the server has easy access too. (Registering an object with the web server is discussed in Chapter 5.)

The second circle in the HTTP server block represents the classic way of generating dynamic content. SSI (Server Side Includes) is also a scripting language. It is not nearly as easy to use SSI as it is to use RabbitWeb; however, an SSI can generate the same content as a RabbitWeb script. It is just that you will need to write CGI functions, and such functions can get large and complicated fairly quickly! In fact, SSI has the ability to invoke CGI functions whereas RabbitWeb does not. In addition, SSIs have the ability to include other resources directly in the primary returned resource much like how #include works in ANSI C.

The server also communicates with lower layers in the diagram. On the right hand side is the TCP/IP block. This is the pipeline to the outside world, i.e., the browser. Usually only the server needs to talk directly to TCP/IP (via a TCP socket). Prior to Dynamic C 8.50, it was often necessary for the application's CGI functions to call TCP/IP functions. This is no longer recommended. Instead, there are functions in the HTTP server that should be called to mediate all networking calls.

2.3.4 Zserver Block

Directly under the HTTP server block is the Zserver, or resource manager, block. This is the "central telephone exchange" of the entire application. It controls access to many of the other blocks in the diagram. In spite of its importance and central placing, you do not usually need to be aware of its inner workings. Zserver has applicability to other types of servers, such as FTP, because it provides a consistent interface to the various different types of resource. As indicated in the diagram, Zserver is architected as a resource manager and a virtual filesystem. The virtual filesystem is basically a notational convenience for accessing all resources using a uniform naming scheme. The external appearance of the virtual filesystem is modelled on the Unix approach. In Unix, all storage devices, and the filesystems contained therein, are accessed from a single starting point known as the root directory, written as a single slash (/) character. Under the root directory may be any number of files and directories. Some of these directories may actually refer to a completely different device and filesystem. The term for such directory entries is *mount-point*.

Note the distinction between this naming convention and the one used by (PC) DOS and similar operating systems. In DOS, you have to explicitly indicate the device by prefixing the file name. For example, C:\index.htm and A:\index.htm are different files, on different devices. On Unix you create two mount points in the root directory; /backup and /production for example. Then, the above mentioned files are known as /backup/index.htm and /production/index.htm. This may seem like a fine distinction, however it matches better with the naming convention used by HTTP, i.e., the URL. It also offers greater flexibility with regards to naming devices.

Zserver does not currently allow arbitrary mount-point names like Unix. Instead, there is an established convention for each filesystem. If FS2 is in use, then there is a mount-point called "/fs2." If the FAT file-system is in use, then one or more mount points called "/A," "/B," "/C" etc. are created.

Since Zserver is the resource manager, it takes responsibility for mapping the various filesystems and resource types into a single unified API. This API not only takes care of the detailed differences between the various filesystem APIs, but also allows some functions to be emulated that are not natively supported by the underlying filesystem.

In addition to the resource storage and filesystem, the resource manager needs to be able to associate other data with each resource. This other data is divided into two categories, which are listed in the blocks on the left of the diagram.

The two categories are "metadata" and "authorization." Metadata consists of two tables: the MIME table and the Rule table. The authorization data is currently just a single table of userids. The reason for the split into two categories is this: the metadata is logically associated with individual resources, whereas the authorization data is a mapping from external entities ("users") to the unit in which authorization is performed, namely user groups. The Rule table has some overlap, since it associates groups with individual resource permissions.

The lowest blocks in the diagram are divided into two groups, with a dashed outline. The upper group is labelled "filesystems," and the lower "storage." Both of these groups are indefinitely extensible, meaning that new classes of storage and their organization (filesystems) may be added in future releases of Dynamic C, or by you. The arrows between these groups are indicative of the most common patterns of communication; others may be defined.

2.4 Architecture of a Toy Application

Using the diagram of the previous section as a basis, we now focus on writing a simple web-enabled application. The following diagram is the same as the one above, except that the relevant parts have been visually emphasized. This diagram is essentially the toy application that was described at the start of this chapter. It shows the mandatory components for all web-enabled applications. Later, we introduce the other elements of the diagram to show how a fully featured application is built up.

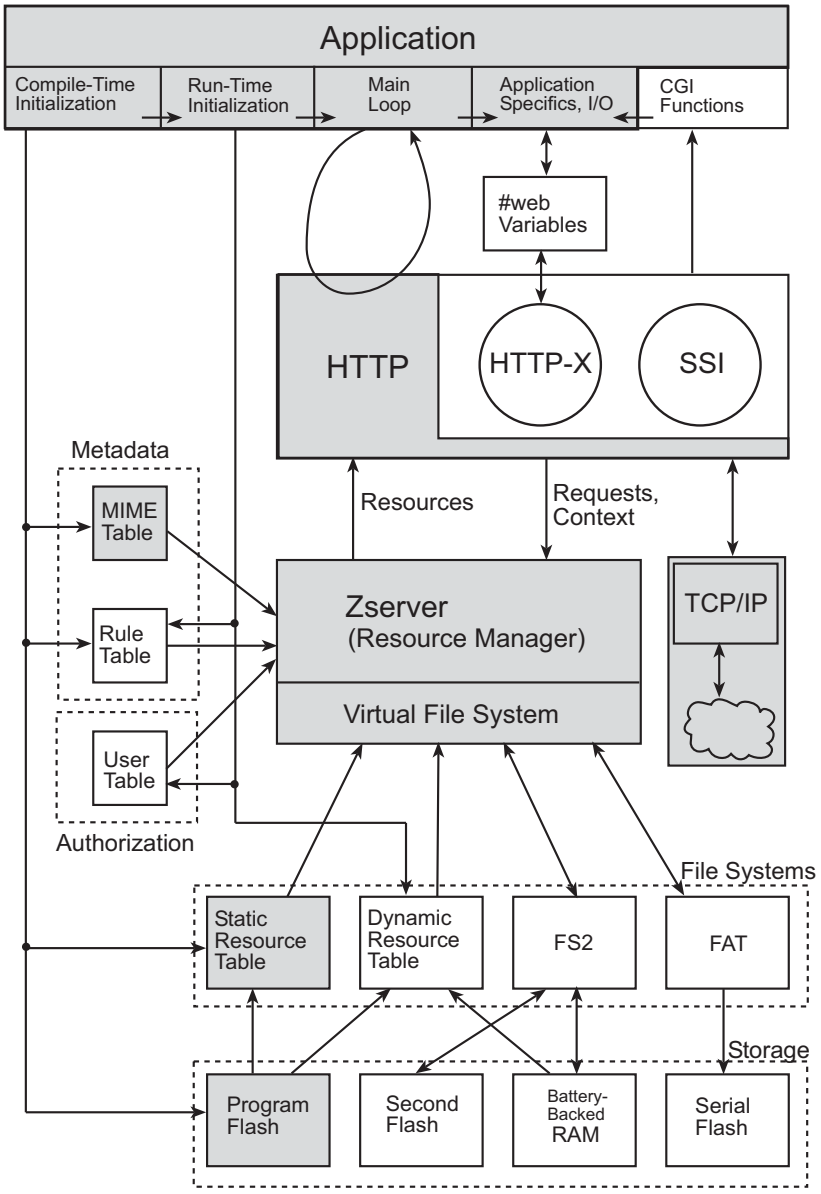


Figure 2.2 Minimum components for a web-enabled application

Let us work again from left to right in the Application block. To reiterate, the Application block represents the coding that you have to do. First, there is the compile-time initialization. Taking the super-simple example illustrated in Figure , Dynamic C code is given with the relevant part highlighted in **boldface**.

```
#define TCPCONFIG 1
#use "dcrtcp.lib"
#use "http.lib"

#ximport "hellowww.html" hellowww_html

SSPEC_MIMETABLE_START
   SSPEC_MIME(".html", "text/html")
SSPEC_MIMETABLE_END

SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/hellowww.html", hellowww_html)
SSPEC_RESOURCETABLE_END

void main() {
   sock_init();
   http_init();
   for (;;) http_handler();
}
```

The first boldface line is the `#ximport` directive. This tells the compiler to include the specified file in the program flash, and make it accessible via the `hellowww_html` constant. In the diagram, the arrow from compile-time initialization to program flash represents this inclusion. In most cases you would be including more than just one file.

The three lines starting with `SSPEC_MIMETABLE_START` are initialization statements for the MIME table. In this case, there is a single mapping from resources that end with ".html" to a MIME type of "text/html." All MIME types are registered with the relevant standards body, and must be entered correctly so that the browser does not get confused. "text/html" is the registered MIME type for HTML.

The next three lines, starting with `SSPEC_RESOURCETABLE_START`, set up the static resource table. Again, this contains a single entry that associates the resource name "/hellowww.html" with the file that was #ximported on the first line. Note that the resource name suffix (.html) matches the first parameter of the `SSPEC_MIME` entry.

Although not directly indicated on the diagram, the other compile-time initialization that is always required is the `#use` of the appropriate libraries. In this case, the first three lines create a default TCP/IP configuration (TCPCONFIG = 1) and bring in the networking and HTTP libraries. Note that `http.lib` automatically includes `zserver.lib`.

Back in the Application block of the diagram, we move right and consider the runtime initialization block. This is contained in the `main()` function. `sock_init()` comes first, to initialize the TCP/IP network library and bring up the necessary interface(s). `http_init()` resets the HTTP library to a known state.

The last statement embodies the Main Loop sub-block. This is always required. Typically, only `http_handler()` needs to be called; however, your application can insert calls to its own polling and event handling code. Since this is such a simple example, there is not even any application-specific code.

2.5 A Simple but Realistic Application

To turn the above toy example into something more realistic, we need to add some application specifics, and the ability to customize the resource returned to the browser depending on the relevant state of the application. The following diagram shows the necessary parts.

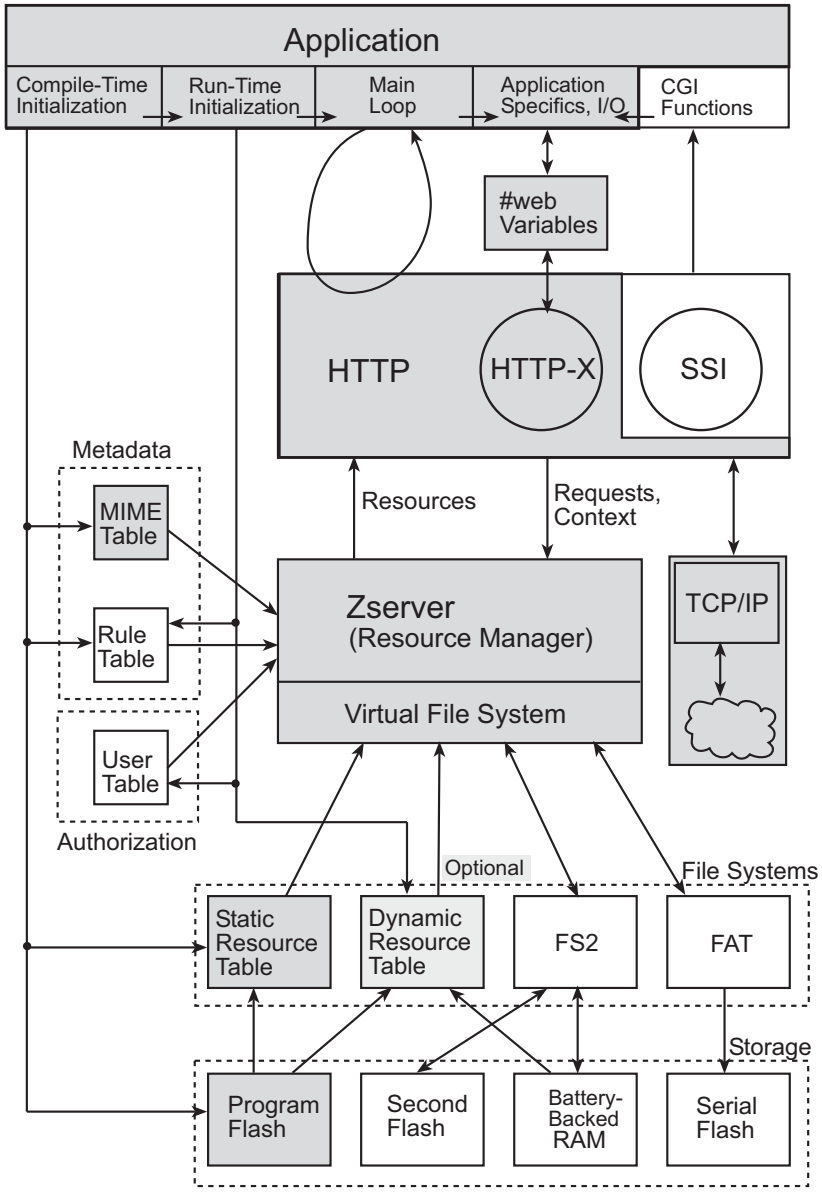


Figure 2.3 Minimum components for a web-enabled application with dynamic content.

The easiest way to introduce dynamic content is to use RabbitWeb and the associated scripting language. SSI can be used instead (described in Section 4.5.2.1). This example, illustrated in Figure , assumes that you have RabbitWeb. Chapter 5 describes RabbitWeb and the scripting language, ZHTML, in detail.

The following code is a simplification of Samples\tcpip\rabbitweb\web.c.

```
#define TCPCONFIG 1
#define USE_RABBITWEB 1

#use "dcrtcp.lib"
#use "http.lib"

#ximport "my_app.zhtml" my_app_zhtml

SSPEC_MIMETABLE_START
   SSPEC_MIME_FUNC(".html", "text/html", zhtml_handler),
SSPEC_MIMETABLE_END

SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.html", my_app_zhtml)
SSPEC_RESOURCETABLE_END

int io_state;
#web io_state

void my_io_polling(void);

void main()
{
   sock_init();
   http_init();

   for (;;) {
      my_io_polling();
      http_handler();
   }
}

void my_io_polling()
{
   io_state = read_that_io_device();
}
```

The differences between the above code and the toy example in the previous section are in **boldface**. All the differences relate to the use of RabbitWeb. The first addition is a #define of USE_RABBITWEB. This is necessary in order to include the necessary library code.

Next, there is a modification to the MIME table. The SSPEC_MIME_FUNC macro defines an entry that says that if the resource name ends with ".html" then the MIME type is text/html (as before), *and* there is a special scripting function that must be run by the HTTP server. This scripting function is called zhtml_handler; it is provided by the HTTP library. ZHTML is the unique embedded scripting language that converts script files into ordinary HTML so the browser can understand it.[1]

The int io_state and #web statements define and register a web variable. Such a variable is an ordinary global variable as far as your C program is concerned. In addition, the script is able to access it.

my_io_polling() is a function that is part of the Application Specifics sub-block. As the name suggests, it is called regularly to poll some external device so as to keep the #web variable up-to-date. The

implementation of the `my_io_polling()` function is shown updating the `#web` variable, but we don't specify the actual I/O reading function since that is too, well, application specific.

Now you may be wondering what this scripting language, ZHTML, looks like. The following code shows the contents of the `my_app.zhtml file`:

```
<HTML><HEAD><TITLE>Web Variables</TITLE></HEAD>
<BODY><H1>Web Variables</H1>
<P>The current value of io_state is
   <?z echo($io_state) ?>
</P>
</BODY></HTML>
```

This looks like plain HTML, and it is, with the only difference being the existence of special commands flanked by "`<?z`" and "`?>`." In this case, the command simply echos the current value of the web variable that was registered. The value (binary in the global variable) is converted to ASCII text by a default `printf()` conversion, in this case "%d" because the variable is an integer. When the browser gets the results returned by the HTTP server, it will see:

```
<HTML><HEAD><TITLE>Web Variables</TITLE></HEAD>
<BODY><H1>Web Variables</H1>
<P>The current value of io_state is
   50
</P>
</BODY></HTML>
```

Where the "50" represents the current variable value—of course, it may be any decimal value that an integer variable could take: -32768 through 32767.

This is still a trivial example, but it is infinitely more real-world than the toy example. We have introduced the concept of dynamic content, which is required for embedded type applications. One thing that has been glossed over is how (and even whether) the variable can be updated from the browser, rather than just within the application. Yes, all `#web` variables may be updated via the browser. This requires use of HTML forms, which is a subject covered in Chapter 4 and Chapter 5. We will not go over this again here; however, the possibility of remote updating introduces us to the topic of the next section, access control.

1. Most applications will want to use a different resource suffix to distinguish between "ordinary" HTML files and script files. The samples provided with dynamic C use .zhtml for script files, and .html for plain HTML. In this sample, we only have script files, so it is convenient to retain the .html suffix. The other reason for this relates to the way the HTTP server handles requests for a directory. If given a URL of "/", the HTTP server will append "index.html" to determine the actual resource. We take advantage of this default behavior so that this sample would work as expected.

2.6 Adding Access Controls

If your application allows updating of the controller state via remote access, and the network connection allows access from locations that are not always under control, then it is important to add some access controls or "security."

The most common way of doing this is to define a set of users, plus a method of authenticating those users, and attaching a set of "permissions" to each resource. The Dynamic C libraries allow you to do this fairly easily, via two tables. The relevant tables are:

The User Table

The user table contains a list of user IDs (short strings) and authentication information (currently a password string). Each user table entry also contains a group mask. The group mask indicates the user groups to which this user belongs. Up to 16 groups can be defined, and any given user can belong to one or more of these 16 groups. There are two additional masks in each user table entry. The first is a write access mask that indicates which server(s) allow the user to write (modify) its resources. The second mask indicates the server(s) that can recognize the user.

The Rule Table

The rule table is a list of information associated with each resource name, generally called "permissions." Each resource has the following information:

- The realm (string) that may be used by certain servers (including HTTP).
- The group mask of the user groups that are allowed read-only access.
- The group mask of the user groups that are allowed modify/write access.
- The server(s) that are allowed any access to this resource.
- The authentication method that is recommended.
- The MIME type of the resource.

Resources in the static and dynamic resource tables may be set up to have their own specific permissions, independent of the rule table itself. Resources in a filesystem may be very numerous hence a simple one-to-one table would waste a lot of storage. To solve this problem, the rule table uses a name *prefix* matching algorithm. Using this technique, entire directories of resources need only have one rule table entry provided that all resources therein use the same permissions.

The following diagram shows the application components when access control is added:

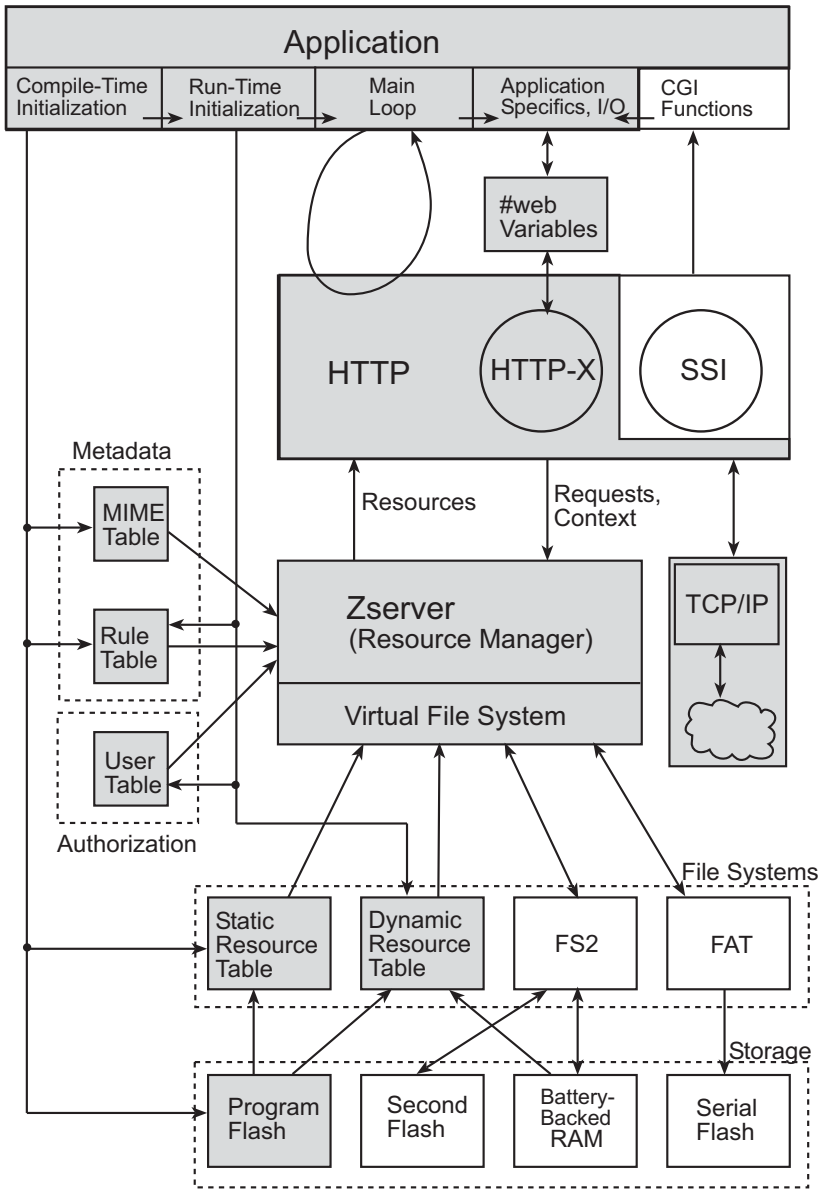


Figure 2.4 Minimal components of a web-enabled application with dynamic content and access control

The main difference between this and the previous diagram is that the Rule Table and User Table blocks have been activated.

The sample program is now expanded to add access control. As before, the changes are in **boldface**.

```
#define TCPCONFIG 1
#define USE_RABBITWEB 1

#define USE_HTTP_BASIC_AUTHENTICATION 1

#use "dcrtcp.lib"
#use "http.lib"

#web_groups monitor_group, admin_group

#ximport "my_app.zhtml" my_app_zhtml

SSPEC_MIMETABLE_START
   SSPEC_MIME_FUNC(".html", "text/html", zhtml_handler),
SSPEC_MIMETABLE_END

SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.html", my_app_zhtml)
SSPEC_RESOURCETABLE_END

int io_state;
#web io_state auth=basic groups=monitor_group(ro),admin_group

void my_io_polling(void);

void main(){

   sspec_addrule("/index.html", "Pet",
admin_group|monitor_group,
            0, SERVER_HTTP, SERVER_AUTH_BASIC, NULL);

   sauth_setusermask(sauth_adduser("admin", "dog", SERVER_ANY),
            admin_group, NULL);

            sauth_setusermask(sauth_adduser("monitor", "cat",
SERVER_ANY),
            monitor_group, NULL);

   sock_init();
   http_init();

   for (;;) {
      my_io_polling();
      http_handler();
   }
}
void my_io_polling()
{
   io_state = read_that_io_device();
}
```

The first change is the definition of USE_HTTP_BASIC_AUTHENTICATION. This sets up the HTTP server to be able to process this form of authentication. If not defined, then the server is unable to do this; there is little point in setting up any other access controls if the user cannot be verified!

Next, the user groups are defined. In this case, we are defining an "admin" and a "monitor" group. Presumably, the admin group has ability to alter the state of the controller, but the monitor group can only read its current state. The names admin_group and monitor_group are actually defined to be unsigned integer constants with just one bit set out of 16.

The #web registration of the io_state variable is augmented with some access controls. #web variables are not strictly resources—they are included as parts of other resources—however, they can be assigned some access controls of their own. In this example, access to the variable is being set to require "basic authentication," and the allowable user groups are both of the defined groups, with the proviso that the monitor group is to be allowed read-only access.

The last major change is in the main() function, where some runtime initialization needs to be performed. Since the user ID table cannot be statically initialized (i.e., at compile-time), this is a necessary step. The rule table *can* be statically initialized, but in this example we choose to do it at runtime.[1] First, the rule table entry:

```
sspec_addrule("/index.html", "Pet", admin_group|monitor_group, 0,
SERVER_HTTP, SERVER_AUTH_BASIC, NULL);
```

The first parameter specifies the name of the resource to which this rule applies; or rather, the first characters in the resource name. For clarity, the sample shows the full name. In practice, since there is only one resource, it would be acceptable to use just "/" instead of "/index.html."

The second parameter, "Pet," is an arbitrary string called the "realm." This is presented to the browser's user when prompted for the password, as shown in Figure 2.5.

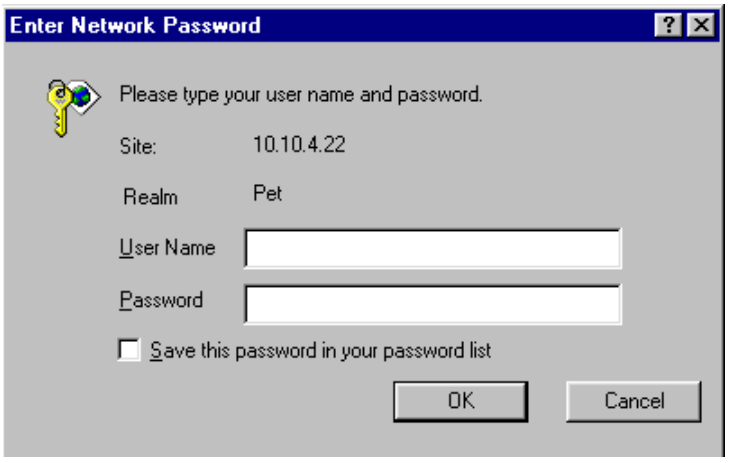


Figure 2.5

1. In this example we also choose to use a rule table. This is not strictly necessary since no filesystem is in use. The alternative is to use a different form of initializing the static resource table, namely by using the SSPEC_RESOURCE_P_XMEMFILE macro, which allows permission information to be stored in the static table instead of in the rule table. See Section 3.2.5.3 "Static Resource Table."

The third and fourth parameters indicate the group(s) that have read and write access to the resource. Both groups are allowed read access, and none write (0). Note that the resource in this case is the `index.html` page, *not* the variables which may or may not be displayed on it. Since this web page (actually a ZHTML script) is in program flash, it is obviously not modifiable.

The `SERVER_HTTP` parameter indicates that this resource is only visible from the HTTP server. This would be more relevant is there was another server, such as FTP, running concurrently.

`SERVER_AUTH_BASIC` indicates that the server should use "basic authentication" when the browser calls for this resource. Note that Zserver does not enforce the method of authentication; it only stores the recommended method in the rule table. Any enforcement of authentication requires the co-operation of the server, since each different type of server may have widely different means of implementing the same type of authentication. Rest assured that the HTTP server (and other servers provided with Dynamic C) always enforce the suggested authentication method.

The final NULL parameter allows some arbitrary data to be stored in the rule table entry. This data is available to the server. It is not currently used by any of the servers in Dynamic C, but it may be useful if you implement your own server.

Now, let's turn to the user ID initialization:

```
sauth_setusermask(sauth_adduser("admin", "dog", SERVER_ANY),
admin_group, NULL);
```

This is a nested function call. `sauth_adduser()` is called first, to add a user called "admin" with password "dog." This user is visible to all servers (`SERVER_ANY`).

The result of this function call is a userID handle, which is the first parameter to `sauth_setusermask()`. This function explicitly assigns a group mask to the user. You can omit this call; however, the default method of assigning group masks is designed to be backward compatible with old versions of the library, and may not be what you want when using new features. You should always use the `sauth_setusermask()` function for each user ID.

In this example, we have added access control to the code. We do not need to change the ZHTML script, although in reality you would probably want to. Using the script unchanged, when the user tries to retrieve `index.html`, the browser will prompt for a userid and password. If one of the valid users is entered, then the page will be displayed. Otherwise, the browser will print an error message saying that access was denied.

Unfortunately, as written above, the sample will not allow us to test the distinction between the two users regarding the ability to modify the #web variable. We have shown how to add access control, but not how to actually specify a web form that allows the user to update the variable. It turns out that adding a form is not difficult. A modified script file is shown below. There is quite a lot to HTML forms, so most of the details are documented elsewhere. There are many good HTML reference books available.

```
<HTML><HEAD><TITLE>Web Variables</TITLE></HEAD>
<BODY><H1>Web Variables</H1>
<P>The current value of io_state is
   <?z echo($io_state) ?>
</P>

<?z if (error($io_state)) { ?>
   <P>Sorry, you were not authorized to perform an update.</P>
<?z } ?>

<FORM ACTION="/index.html" METHOD="POST">

   <P>Enter a new value if you dare:</P>

   <INPUT TYPE="text" NAME="io_state" SIZE=5
      VALUE="<?z echo($io_state) ?>">
   <INPUT TYPE="submit" VALUE="Submit">
   <INPUT TYPE="reset" VALUE="Reset">
</FORM>
</BODY></HTML>
```

If you run the above sample with this script, then the user will be able to attempt an update to the #web variable, io_state. If the user was "monitor," that is, not able to make an update, then the "Sorry" message will be printed. Recall that the access to io_state was set up when the variable was registered with #web.

You may be asking how the application notices when the #web variable is updated by the browser, not just in the my_io_polling() function. This is a good question, since the HTTP server updates the variable just like a normal C variable. The solution to this requires that you specify an "update" callback function in the #web variable registration. This is described in detail in Chapter 5. For the purposes of this section, just remember that it is easy to do.

2.7 A Full-Featured Application

The previous examples have relied on `#ximport` to store files in the program flash. This is limiting in terms of storage capacity and does not allow for dynamic file updates. Adding the ability to store files in a filesystem that is located somewhere besides the program flash is of high value because it adds storage capacity and allows for dynamic updates.

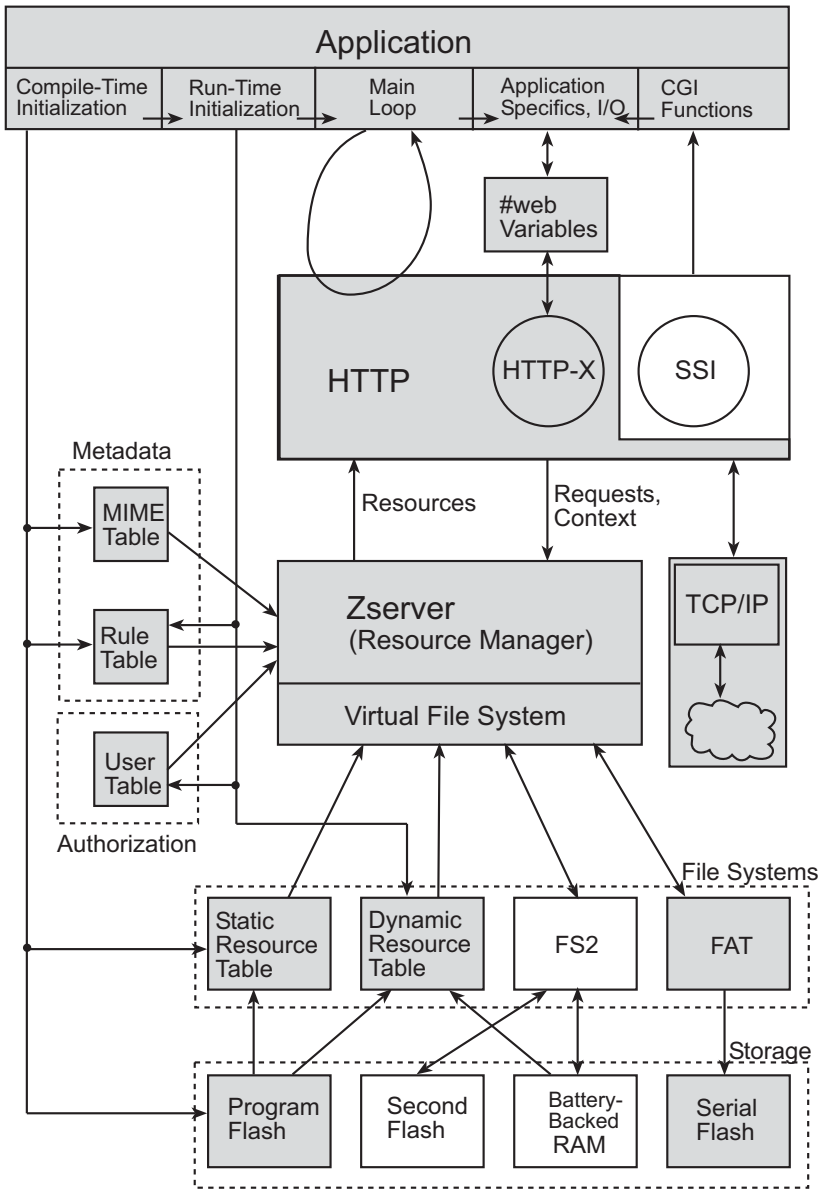


Figure 2.6 Components of a full-featured web-enabled application.

As mentioned previously, Zserver implements a virtual filesystem that can be used by an application for a clean, consistent interface to the various available methods of resource organization. An application can also bypass the resource manager and access a filesystem directly. (Note that there is no arrow in the diagram showing this line of communication.)

Looking at the bottom of the diagram in Figure you can see that there are some additional hardware requirements when using FAT or FS2. The FAT needs a serial flash; and FS2 needs a second flash or battery-backed RAM, as well as a Rabbit 2000 or 3000 processor.

The sample program is now expanded to use a FAT filesystem and has the ability to upload files to it. As before, the changes are in **boldface**.

```
#define FAT_USE_FORWARDSLASH
#define FAT_BLOCK
#define USE_HTTP_UPLOAD

#define TCPCONFIG 1
#define USE_RABBITWEB 1
#define USE_HTTP_BASIC_AUTHENTICATION 1

#use "sflash_fat.lib"
#use "fat.lib"

#use "dcrtcp.lib"
#use "http.lib"
#web_groups monitor_group, admin_group
#ximport "my_app.zhtml" my_app_zhtml

SSPEC_MIMETABLE_START
   SSPEC_MIME_FUNC(".html", "text/html", zhtml_handler),
   SSPEC_MIME(".cgi", "")
SSPEC_MIMETABLE_END

SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.html", my_app_zhtml),
   SSPEC_RESOURCE_CGI("upload.cgi", http_defaultCGI)
SSPEC_RESOURCETABLE_END

int io_state;
#web io_state auth=basic groups=monitor_group(ro),admin_group

void my_io_polling(void);

void main(){

   int rc;

   sspec_addrule("/index.html", "Pet",
admin_group|monitor_group,
            0, SERVER_HTTP, SERVER_AUTH_BASIC, NULL);

   sauth_setusermask(sauth_adduser("admin", "dog", SERVER_ANY),
            admin_group, NULL);

   sauth_setusermask(sauth_adduser("monitor", "cat",
SERVER_ANY),
            monitor_group, NULL);

   rc = sspec_automount(SSPEC_MOUNT_ANY, NULL, NULL, NULL);
```

```
   if (rc)
      printf("Failed to initialize, rc=%d\n
         Proceeding anyway...\n", rc);

   sock_init();
   http_init();

   for (;;) {
      my_io_polling();
      http_handler();
   }
}
```

The first change is the addition of FAT_USE_FORWARDSLASH and FAT_BLOCK. These are needed by Zserver to work with the FAT filesystem. The definition of USE_HTTP_UPLOAD is needed for Zserver to use the file upload feature. Next, the libraries for the FAT (fat.lib) and for the serial flash driver (sflash_fat.lib) are brought in with #use statements.

The MIME type mapping for CGIs is added to the MIME table with SSPEC_RESOURCE_CGI. An empty string is the registered type for CGIs. This makes sense since CGIs are not displayed by the browser.

Next, we want to give the server access to the CGI function by creating an entry for it in the static resource table with SSPEC_RESOURCE_CGI. The first parameter is a string that must match the string used in the FORM ACTION tag in the HTML code. The second parameter identifies the CGI function that will be called when the form is submitted. http_defaultCGI() is a CGI that is provided with the HTTP server. It uploads files to a FAT filesystem, shows a status page to the browser after the upload and allows the user to click back to the server's home page. For a detailed description of the file upload feature, see Section 4.6.

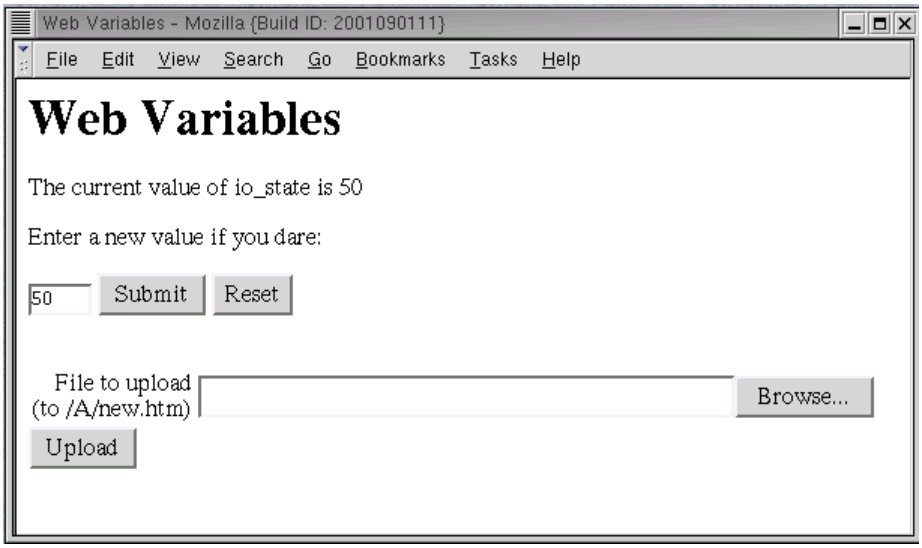
Finally, the FAT filesystem must be readied for use. The call to sspec_automount() takes care of everything, assuming that a FAT partition already exists on the serial flash. How to create the initial filesystem is discussed in the *Dynamic C User's Manual*.

The application now supports uploading files to the FAT, but we have yet to give the user any way to actually do it. That involves changing the HTML page.

```
<HTML><HEAD><TITLE>Web Variables</TITLE></HEAD>
<BODY><H1>Web Variables</H1>
<P>The current value of io_state is
   <?z echo($io_state) ?>
</P>
<?z if (error($io_state)) { ?>
   <P>Sorry, you were not authorized to perform an update.</P>
<?z } ?>

<FORM ACTION="/index.html" METHOD="POST">
   <P>Enter a new value if you dare:</P>
   <INPUT TYPE="text" NAME="io_state" SIZE=5
      VALUE="<?z echo($io_state) ?>">
   <INPUT TYPE="submit" VALUE="Submit">
   <INPUT TYPE="reset" VALUE="Reset">
```

```
</FORM><BR>
<FORM ACTION="upload.cgi" METHOD="POST" enctype="multipart/form-
data">
   <TABLE BORDER=0 CELLSPACING=2 CELLPADDING=1>
   <TR>
      <TD ALIGN=RIGHT>File to upload<BR>(to /A/new.htm)</TD>
      <TD><INPUT TYPE="FILE" NAME="/A/new.htm" SIZE=50></TD>
   </TR>
   </TABLE>
         <INPUT TYPE="SUBMIT" VALUE="Upload">
</FORM>
</BODY></HTML>
```

The text in **boldface** is the description of a new form, which, when displayed by the browser, allows a file to be uploaded to a FAT filesystem.



The FORM tag includes the METHOD attribute, which is the same as that of the first form. The ACTION attribute has changed to specify the CGI function that was added to the server's static resource table; this is the default CGI provided by the server. When the Upload button is clicked, `http_defaultCGI()` will be called by the server. A new attribute is included that specifies the MIME type used to submit the form to the server: enctype="multipart/form-data". This is the MIME type required when the returned document includes files.

Note that the two forms are being submitted and processed separately. Could they be processed as one form? Yes, but from a modular design perspective, it makes sense to keep the form submissions separate when the purpose of each form is entirely separate.

You may have noticed that no security was added to protect the filesystem—anyone can upload a file that passed the initial user and password protection that limits access to the web page. This is probably not the ideal situation. Typically there needs to be some limit placed on who is able to write to the filesystem.When considering security, there are three possible things to protect:

- The web page that contains the form. Give read access only to those users who could conceivably upload the files specified therein.
- The CGI itself. Protect the same as the web page.

- The uploaded resource. You should set up a rule allowing write access only to the intended user(s).

When defining user IDs that can use the upload, don't forget to give those users overall write access using e.g.,

```
sauth_setwriteaccess(uid, SERVER_HTTP);
```

Another way to design this application is to have a separate HTML file that contains the form for the file upload; then instead of having the form for the file upload on the current HTML page, you put a link to the new page and then apply a permission to allow the new page to be displayed, such as:

```
sspec_addrule("/newpage.html", "Pet", admin_group, admin_group,
SERVER_HTTP, SERVER_AUTH_BASIC, NULL);
```

That way the only people who see the Upload button are those authorized to use it. Design decisions such as these are guided by the needs of the application. The point here is that these design decisions are not limited by the underlying tools you are using to accomplish your goal.

2.8 Living Without RabbitWeb and FAT

Without the use of RabbitWeb we are back to SSI tags in the HTML page and writing a CGI to process them. With the new-style CGIs introduced in Dynamic C 8.50, this is easier than it used to be. If there is no serial flash, the FAT filesystem isn't available; but if there is a second flash or some battery-backed RAM, FS2 is. The following diagram shows the components that are used in this case. Note that even though both the second flash and the battery-backed RAM are highlighted, an application can use either or both.

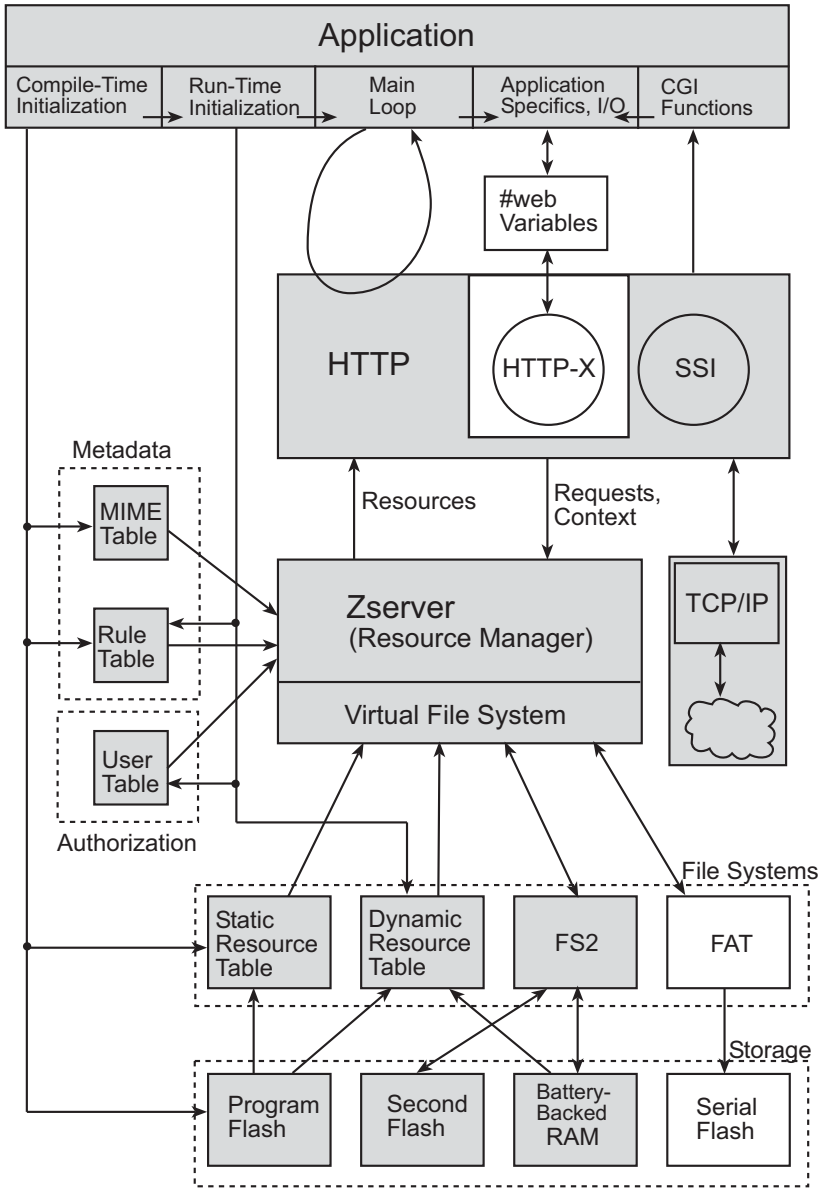


Figure 2.7 Components of a full-featured web-enabled application.

The sample program is now modified to use the FS2 filesystem. It still has the ability to upload files to the filesystem. As before, the changes are in **boldface**.

```
#define USE_HTTP_UPLOAD

#define TCPCONFIG 1
#define USE_HTTP_BASIC_AUTHENTICATION 1

#use "fs2.lib"

#define admin_group 0x0001
#define monitor_group 0x0002

#use "dcrtcp.lib"
#use "http.lib"

#ximport "my_app.shtml" my_app_shtml

SSPEC_MIMETABLE_START
   SSPEC_MIME_FUNC(".ssi", "text/html", shtml_handler),
   SSPEC_MIME(".cgi", "")
SSPEC_MIMETABLE_END

int io_state;

SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_ROOTVAR("io_state", &io_state, INT16, "%d"),
   SSPEC_RESOURCE_XMEMFILE("/index.html", my_app_shtml),
   SSPEC_RESOURCE_CGI("upload.cgi", http_defaultCGI),
   SSPEC_RESOURCE_CGI("update.cgi", VarUpdateCGI)
SSPEC_RESOURCETABLE_END

void my_io_polling(void);

void main(){
   int rc;

   io_state = 42;

   sspec_addrule("/index.html", "Pet",
admin_group|monitor_group,
            0, SERVER_HTTP, SERVER_AUTH_BASIC, NULL);

   sauth_setusermask(sauth_adduser("admin", "dog", SERVER_ANY),
            admin_group, NULL);

   sauth_setusermask(sauth_adduser("monitor", "cat",
SERVER_ANY),
            monitor_group, NULL);

   rc = sspec_automount(SSPEC_MOUNT_ANY, NULL, NULL, NULL);

   if (rc)
      printf("Failed to initialize, rc=%d\n
         Proceeding anyway...\n", rc);
```

```
    sock_init();
    http_init();

    for (;;) {
       my_io_polling();
       http_handler();
    }
}
```

The first change is the removal of the macros we added for FAT and also the removal of `#use` statements for the FAT library and the associated serial flash driver library. As with the sample in the last section, this code assumes that a valid filesystem partition exists on the target board; in this case, it's an FS2 partition. In the simplest case, which is one FS2 partition on the secondary flash, bringing in `fs2.lib` and then mounting the filesystem with a call to `sspec_automount()` is all that is required. (For more information on FS2, refer to the *Dynamic C User's Manual*.)

The next change is the `#define` of the user groups. Each user group has to be explicitly given a value when RabbitWeb is not available to do it. Note that they are word values, each with a unique bit position set.

Next, the first entry in the MIME table was changed. Recall that the entry "`/`" and requests without an extension are dealt with by the handler in the first entry of the MIME table. In this example, if a browser points to the Rabbit board's IP address, the page is processed by `shtml_handler()`, a handler that will understand the SSI tags that we are about to add to the HTML file. The #ximport statement did not, technically, need to change. The extension used for the file was changed from `.zhtml` to `.shtml`. These file extensions are only a convention. The important thing is that the HTML file is touched by the correct handler function. As a matter of fact, in this example, our HTML page is not recognized by the server as ending with either .zhtml or .shtml, but by `.html`. The name known to the server is determined by the name parameter of the file's resource table entry, "/index.html."

The next change is a new entry in the static resource table. This reflects the shift in how the variable `io_state` becomes known to the HTTP server. Previously, it was done using the `#web` statement of RabbitWeb.

A second new entry in the resource table is for a CGI function that will handle the processing when `io_state` is updated. When using RabbitWeb, this same form submission did not require a CGI. The enhanced HTTP server took care of all the details for us. Without RabbitWeb, we have to do the work ourselves. Fortunately, the new-style CGIs make this job easier. A detailed description of writing a new-style CGI is given in Section 4.6 "HTTP File Upload." As we saw in Section 2.7, there is a CGI in `http.lib` that processes file uploads to a filesystem. If you study and understand Section 4.6 and the code in `http_defaultCGI()`, you will be able to write a new-style CGI that will process the form that is submitted when `io_state` is changed.

Since we are not using RabbitWeb and have changed from using FAT to FS2, the HTML page must be changed. As before, all changes are in **boldface**.

```
<HTML><HEAD><TITLE>Web Variables</TITLE></HEAD>
<BODY><H1>Web Variables</H1>

<P>The current value of io_state is:
   <!--#echo var=”io_state” -->
</P>

<FORM ACTION="update.cgi" METHOD="POST" enctype="multipart/form-
data">

   <P>Enter a new value if you dare:</P>
   <INPUT TYPE="text" NAME="io_state" SIZE=5
      VALUE="<!--#echo var=”io_state” -->">
   <INPUT TYPE="submit" VALUE="Submit">
   <INPUT TYPE="reset" VALUE="Reset">
</FORM><BR>

<FORM ACTION="upload.cgi" METHOD="POST"
   enctype="multipart/form-data">

   <TABLE BORDER=0 CELLSPACING=2 CELLPADDING=1>
   <TR>
      <TD ALIGN=RIGHT>File to upload<BR>(to /A/new.htm)</TD>
      <TD><INPUT TYPE="FILE" NAME="/fs2/ext1/new.htm"
        SIZE=50></TD>
   </TR>
   </TABLE>
   <INPUT TYPE="SUBMIT" VALUE="Upload">
</FORM>
</BODY></HTML>
```

The first change is the substitution of the new server-parsed tags with SSI tags. The next change is the absence of any error checking. Without RabbitWeb, it is difficult to achieve this same functionality. The CGI responsible for the processing the variable update would need to do it. Which brings us to the next change in this HTML page, the need for a second CGI function.

The ACTION attribute in the FORM tag identifies the new CGI by name, `update.cgi`. The FORM tag also has a parameter for the encoding type. When no encoding type is specified, it defaults to URL-encoded. All new-style CGIs must set the encoding type in the FORM tag to “multipart/form-data” as shown above.

The other change on this page is the NAME attribute in the first INPUT tag of the second form. When uploading to an FS2 partition, the mount-point “/fs2” must be prepended to the filename. The /ext1 part is also prepended to the filename and refers to the second flash. The default CGI function can now store an uploaded file in a valid FS2 partition.

3. SERVER UTILITY LIBRARY

This chapter is intended to be a detailed description of the resource manager, Zserver, and how it interfaces to other libraries, such as servers (HTTP, FTP etc.) and filesystems (FS2, FAT). For an overview, please see Chapter 2., "Web-Enabling Your Application."

The resource manager, `Zserver.lib`, contains the structures, functions, and constants to allow HTTP (Hypertext Transfer Protocol) and FTP (File Transfer Protocol) servers to share data and user authentication information while running concurrently.

In general, you do not need to know some of the details of Zserver described in this chapter if you are using the server libraries provided with Dynamic C. Such sections are marked as "advanced," and you may skip them unless you are writing a server or filesystem. Some sections are marked "historical." They are included to describe how previous versions of the library worked. These may be skipped for new code.

The basic facility provided by Zserver is the ability to translate resource names (URLs in the case of HTTP) into references to filesystem and memory objects. The term resource refers to the objects (files, functions and variables) that are manipulated by the Zserver library on behalf of the server. A *file resource* refers specifically to a resource of type file, as opposed to the actual file that is manipulated by an underlying filesystem (which may not be a resource as such).

Support for HTML forms is also included in `Zserver.lib`. Starting with Dynamic C 8.50, an enhanced HTTP server (RabbitWeb) is available that has an easy-to-use interface for form generation and no limitations on the form layout. See Chapter 5 for more information on this enhanced HTTP server.

Zserver supports the concept of a virtual file system. This is modeled on the Unix directory structure.

3.1 Data Structures for Zserver.lib

There are several data structures in this library that servers with Zserver functionality must use, and may need to be manipulated or initialized by the application program:

- `MIMETypeMap`
- `ServerSpec`
- `ServerAuth`
- `ServerPermissions`
- `RuleEntry`

Use of the following structures is considered advanced:

- `ServerContext`
- `SSpecStat`
- `sspec_fatinfo`

The following structures are documented for historical reasons:

- FormVar
- SSpecFileHandle

3.1.1 MIMETypeMap Structure

This structure, organized into a table, associates a file extension with a MIME type (Multipurpose Internet Mail Extension) and a function that handles the MIME type. Users can override HTTP_MAXNAME (defaults to 20 characters) in their source file. If the function pointer given is NULL, then the default handler (which sends the content verbatim) is used.

```
typedef struct {
   char extension[10];
   char type[HTTP_MAXNAME];
   int (*fptr)(/* HttpState* */);
} MIMETypeMap;
```

For example, to create an HTTP server that can serve files with html or gif extensions, the following declaration is required in the application code:

```
SSPEC_MIMETABLE_START
   SSPEC_MIME(".html", "text/html"),
   SSPEC_MIME(".gif", "image/gif"),
SSPEC_MIMETABLE_END
```

Use of the above macros is the recommended method for maintaining forward compatibility. For more information, see Section 3.2.5.2 "Static MIME Type Table." All these macros are doing is generating the correct C syntax for a static constant initializer.

Note that servers that do not implement MIME, such as FTP, do not require a MIME table to be defined. Currently, this table is required only for HTTP.

3.1.2 ServerSpec Structure

This structure is used for both the static and dynamic resource tables. The only difference between these two tables is that one is a constant (initialized at compile-time) and the other is created at runtime in RAM, and thus modifiable.

Historical note: The `HttpSpec` data structure in `HTTP.lib` used prior to Dynamic C 8.50 is now synonymous with this structure, `ServerSpec`.

```
typedef struct {
   word type;
   char name[SSPEC_MAXNAME];
   long data;
   void *addr;
   word vartype;
   char *format;
   ServerPermissions perm;

   #ifdef FORM_ERROR_BUF
   ...
   #endif
} ServerSpec;
```

The structure fields are described below. The `#ifdef` expression adds some fields to the `ServerSpec` structure if the HTML form functionality provided by Zserver is included by the web server application. These fields are not described below. For more details, Section 4.5.4 "HTML Forms Using Zserver.lib."

Starting with Dynamic C 8.50, enhanced support is provided for HTML forms with the Dynamic C RabbitWeb software. RabbitWeb provides an easy to develop web interface for your embedded device and allows for complete flexibility in form layout. See Chapter 5 for more information on this enhanced HTTP server.

In older versions of Dynamic C, it was necessary to explicitly create the static resource table by doing something like this:

```
const HttpSpec http_flashspec[] = {
   ...
};
```

in your main application code (filling in the entries, of course). Starting with Dynamic C 8.50, there is new recommended syntax for creating these resources, using the `SSPEC_RESOURCETABLE*` series of macros. This new method is recommended for maintaining future compatibility. For more information, see Section 3.2.5.3 "Static Resource Table."

3.1.2.1 ServerSpec Fields

The fields in each resource table (static or dynamic) are usually manipulated via Zserver functions, or by using the SSPEC_RESOURCE* macros. The field descriptions below are for reference only.

type This field tells the server if the entry is a file, variable or function (SSPEC_FILE, SSPEC_VARIABLE, SSPEC_FUNCTION, etc.).

name This field contains the resource name, as a null-terminated string.

data Location of data (when *FILE is the type of data), or maximum number of variables in a form (when SSPEC_FORM is the type of data)

addr Address of function or variable (when SSPEC_FUNCTION, SSPEC_CGI or SSPEC_VARIABLE is the type of data). Address of form struct for SSPEC_FORM.

vartype Type of variable (when SSPEC_VARIABLE is the type of data), or length of data (when *FILE is the type of data and the length is needed e.g., a root file). For SSPEC_HARDLINK, contains the sspec index number of a http_flashspec or server_spec entry.

format sprintf() format for a variable, or form title for a form, or base address for SSPEC_ROOTFILE. For SSPEC_LINK, points to a string containing the linked-to resource name.

perm Permissions associated with this resource. If realm subfield is NULL, then the permissions table is consulted as for filesystem resources. Note: this field used to be char* for the realm string (only). Programs that used this feature need to be modified. This structure is detailed under ServerPermissions.

There are some other fields that are conditionally included if HTTP forms are in use. These are not generally relevant. See the library source for details.

3.1.3 ServerAuth Structure

This structure defines a global array that is a list of user name/password pairs.

```
ServerAuth server_auth[SAUTH_MAXUSERS];
```

Throughout this manual, this array is called the user table. The fields in the `ServerAuth` struct are manipulated using the `sauth_*()` functions. The description below is for reference only.

`username`	Name of user, or ""
`password`	Password, or ""
`mask`	Group mask
`writeaccess`	Which servers this user has write access to
`servermask`	Which servers this user is visible to
`data`	Arbitrary data (application-dependent)

3.1.4 ServerPermissions Structure

This data structure holds access permissions for a resource or a group of resources. An instance of `ServerPermissions` is contained in each `ServerSpec` structure, as well as within each rule table entry. The fields for the `ServerPermissions` struct are:

`realm`	Pointer to realm string of the resource. It is only used by HTTP servers, but can be used for other purposes.
`readgroups`	Read permission is granted if the current `ServerAuth.mask` value matches in at least one bit position.
`writegroups`	Write permissions is granted if the current `ServerAuth.mask` value matches in at least one bit position and `ServerAuth.writeaccess` is set.
`servermask`	A 16-bit mask with a bit set for each server that can access this resource. NB: for backwards compatibility, if this is set to zero then all servers are allowed.
`method`	Authentication method(s) allowed: combination of `SERVER_AUTH_*` bits. Note that `Zserver.lib` does not directly support anything other than basic authentication, that is `SERVER_AUTH_BASIC`; however, the required information is stored here so that servers can access it as needed in a consistent manner.
`mimetype`	MIME type for this resource, or NULL. If NULL, the MIME type will be derived from the file name using the `MIMETypeMap` table called `http_types`. If not found in that table, the first entry in that table will be used (for backward compatibility.)

Historical note: Prior to Dynamic C 8.50, `HttpRealm` was used in place of `ServerPermissions`. If you have used `HttpRealm` for password protection in existing code and are upgrading to Dynamic C 8.50 or later, you must rewrite any code that used this old structure. For an example of the new way to password protect an entity, see the sample program `samples\tcpip\http\authentication.c`.

3.1.5 RuleEntry Structure

This structure associates a resource name prefix with a `ServerPermissions` structure. The rule table is an array of these structures.

`prefix`	Prefix of resource name(s) which are associated with this rule table entry. If there are multiple entries which match a resource name, then the rule with the longest matching prefix is used.
`perm`	`ServerPermissions` to use for this entry.

3.1.6 ServerContext Structure

Starting with Dynamic C 8.50, context information must be maintained by each server that wants Zserver functionality. Therefore, servers must provide a `ServerContext` struct when required. The fields of `ServerContext` are:

`userid`	This field identifies the current user.
`server`	This field identifies the server, for example, `SERVER_HTTP`. This is one of the few cases where only a single server bit should be set.
`rootdir`	This field is a pointer to the root directory This is usually "`/`" if the whole namespace is to be accessible. Otherwise, it may be, for example, "`/A`" to restrict access to just the first DOS FAT partition. The first and last character must be "`/`"!
`cwd[]`	This field is an array containing the current working directory. This would normally contain the root directory as a prefix. The first and last character must be "`/`"!
`dfltname`	This field points to a file name to be used as a resource name suffix when the first parameter refers to a directory name.

The `ServerContext` structure helps support more powerful resource access control. It is needed by several of the new API functions that deal with resource retrieval and control, as well as functions that perform directory navigation.

There are two functions that return a `ServerContext` struct: `http_getcontext()` and `http_getContext()`. The latter is for use in CGI functions.

These functions can be used with other API functions that need the context structure. For example:

```
sspec_open("MyFile", http_getcontext(servno), O_READ, 0);
```

will open "MyFile" for reading for the server instance identified by `servno`.

3.1.7 SSpecStat Structure

This structure holds status information about a file resource. It is filled in by the function `sspec_stat()`.

The fields of `SSpecStat` are:

`flags` A 16-bit mask that passes information about the file resource. The `flags` field can be any number of the following:

- `SSPEC_ATTR_MDTM` - have modification date/time
- `SSPEC_ATTR_LENGTH` - have current length
- `SSPEC_ATTR_WRITE` - file is writable
- `SSPEC_ATTR_EXEC` - file is "executable"
- `SSPEC_ATTR_HIDDEN` - "Hidden" attribute bit
- `SSPEC_ATTR_SYSTEM` - "System" attribute bit
- `SSPEC_ATTR_ARCHIVE` - "Archive" attribute bit
- `SSPEC_ATTR_DIR` - directory name
- `SSPEC_ATTR_COMPRESSED` - stored in compressed format
- `SSPEC_ATTR_MAXLENGTH` - have maximum length
- `SSPEC_ATTR_SEEKABLE` - resource is randomly accessible
- `SSPEC_ATTR_EXTENSIBLE` - File may be expanded at end

`mdtm` Modification date/time (`SEC_TIMER` format), this field is only valid if `SSPEC_ATTR_MDTM` is set.

`length` The current file size; this field is only valid if `SSPEC_ATTR_LENGTH` is set.

`maxlength` The maximum allowable file size; this field is only valid if `SSPEC_ATTR_MAXLENGTH` is set.

`perm` Pointer to `ServerPermissions` struct. This structure is described above.

3.1.8 sspec_fatinfo Structure

This structure is only relevant if you are using the FAT filesystem. It allows the `sspec_automount()` function to return some FAT-related information to your application. The fields in this structure are:

`ctrl` Pointer to `dos_ctrl` (controller) structure.

`drive` Pointer to `mbr_drive` structure.

`part[4]` 4 pointers to `fat_part` (partition) structures. Only the mounted partitions are returned.

Note that when used with `sspec_automount()`, some of the above fields may be set to non-NULL in order to indicate to `sspec_automount()` that the application has already initialized some or all of the FAT.

3.1.9 FormVar Structure

An array of `FormVar` structures represent the variables in an HTML form. The developer will declare an array of these structures, with the size needed to hold all variables for a particular form. The `FormVar` structure contains:

- A `server_spec` index that references the variable to be modified. This is the location of the form variable in the server spec list.
- An integrity-checking function pointer that ensures that the variables are set to valid values.
- High and low values (for numerical types).
- Length (for the string type, and for the maximum length of the string representations of values).
- A Pointer to an array of values (for when the value must be one of a specific, and probably short, list).

The developer can specify whether the variable is set through a text entry field or a pull-down menu, and if the variable should be considered read-only.

This `FormVar` array is placed in a `ServerSpec` structure using the function `sspec_addform()`. `ServerSpec` entries that represent variables will be added to the `FormVar` array using `sspec_addfv()`. Properties for these `FormVar` entries (for example, the integrity-checking properties) can be set with various other functions. Hence, there is a level of indirection between the variables in the forms and the actual variables themselves. This allows the same variable to be included in multiple forms with different ranges for each form, and perhaps be read-only in one form and modifiable in another.

3.1.10 SSpecFileHandle Structure

This structure is used internally by Zserver, and is only of interest to developers of new filesystems which may be incorporated into Zserver.

3.2 Constants Used in Zserver.lib

The constants in this section are values assigned to the fields of the structures `ServerSpec` and `ServerAuth`. They are used in the functions described in Section 3.5, some as function parameters and some as return values.

3.2.1 ServerSpec Type Field

This field describes the resource in the server spec list. The possible values are:

- `SSPEC_XMEMFILE` - The data resides in xmem
- `SSPEC_ZMEMFILE` - The data resides in xmem and is compressed
- `SSPEC_ROOTFILE` - The data resides in root memory
- `SSPEC_FATFILE` - The data resides in a DOS FAT file.
- `SSPEC_FILE` - The data resides in a file - generic type returned by `sspec_gettype()`.
- `SSPEC_ROOTVAR` - The data is a variable in root memory (for HTTP)
- `SSPEC_XMEMVAR` - The data is a variable in xmem (for HTTP)
- `SSPEC_VARIABLE` The data is a variable (for HTTP) - generic type returned by `sspec_gettype()`.
- `SSPEC_FUNCTION` - The data is a function (for HTTP.)
- `SSPEC_FORM` - A set of modifiable variables.

- SSPEC_CGI - The data is a CGI function (for HTTP) - new style CGIs with better interface.
- SSPEC_LINK - Symbolic link ("alias") to another resource name.
- SSPEC_HARDLINK - Symbolic link ("alias") to another resource table entry.

3.2.2 ServerSpec Vartype Field

If the object is a variable, then this field will tell you what type of variable it is:

```
INT8, INT16, INT32, PTR16, FLOAT32
```

3.2.3 ServerPermissions Servermask Field

The type of server (HTTP and/or FTP) that has access to a particular resource is determined by the servermask field in the ServerPermissions structure.

- SERVER_HTTP - Web server
- SERVER_FTP - File transfer server
- SERVER_SMTP - Mail server
- SERVER_HTTPS - Secure web server
- SERVER_SNMP - SNMP agent
- SERVER_USER - Placeholder for first user-defined server
- SERVER_USER2 - Placeholder for second user-defined server (etc.) - grow down.
- SERVER_ANY - Any server. May be passed in most cases when any server will do.

3.2.4 Configuration Macros

There are several configuration macros that may be set up by the application to control the memory usage and behavior of Zserver. These should be defined before #use Zserver.lib, unless otherwise noted.

HTTP_NO_FLASHSPEC
SSPEC_NO_STATIC

When defined, these macros save space by not compiling in code that supports a static resource table. Presumably the application is using only the dynamic resource table, or filesystems are in use.

Historical note: the name of HTTP_NO_FLASHSPEC implies HTTP; however, it actually applies to Zserver as a whole, not any specific server. Dynamic C 8.50 introduces SSPEC_NO_STATIC, an alias for HTTP_NO_FLASHSPEC.

SAUTH_MAXNAME

Maximum length of the name and password strings in the ServerAuth structure. Default is 20. Strings must include a NULL character, so with its default value of 20, strings in this structure may be at most 19 characters long.

SAUTH_MAXUSERS

Define the maximum number of unique users. Defaults to 4. This determines the size of the userid table. Each table entry takes up 2*SAUTH_MAXNAME + 8 bytes of root storage.

SERVER_PASSWORD_ONLY

This is set to a bitmask of the server mask bits for each server that supports the concept of a password-only user, that is, no user name. Defaults to zero since currently no servers are implemented that use this facility.

SSPEC_DEFAULT_READGROUPS
SSPEC_DEFAULT_WRITEGROUPS
SSPEC_DEFAULT_SERVERMASK
SSPEC_DEFAULT_REALM
SSPEC_DEFAULT_METHOD

This group of macros establishes global default permissions for resources that do not have a rule associated. SSPEC_DEFAULT_READGROUPS is "0xFFFF" which means "all users." For writegroups, this is "0" meaning "no users." The servermask defaults to SERVER_ANY (all servers can access). realm defaults to "" that is, an empty string, or no realm.
SSPEC_DEFAULT_METHOD defaults to no authentication method required.

SSPEC_MAX_FATDRIVES

Determine the maximum number of independent FAT filesystem "drives." Defaults to 1. Each drive takes 8 bytes of root storage (plus whatever is required by the filesystem itself). Each drive can have up to 4 partitions. This macro is only relevant if you use the FAT library.

SSPEC_MAXNAME

Define the maximum name length of each dynamic or static resource. Defaults to 20. You can minimize memory usage by choosing short names for all resources, and reducing the value of this macro.

SSPEC_MAXRULES

Define the maximum number of dynamically added "rules." Defaults to 10, but you can explicitly define it to zero if all the rule table entries are static (see SSPEC_RULETABLE_* macros). Each rule takes up 13 bytes of root storage, plus whatever storage is required for the realm and prefix strings (which must be null-terminated, and in static storage, since pointers to these are stored in the rule table).

SSPEC_MAXSPEC

Define to the number of dynamic (RAM) resource table entries to allocate for the global array, server_spec. Each entry takes SSPEC_MAXNAME + 23 bytes of root memory (or SSPEC_MAXNAME + 33 if FORM_ERROR_BUF is defined).

Defaults to 10 entries (approximately 530 bytes). Do not set higher than 511.

SSPEC_MAX_OPEN

Determine the maximum number of simultaneously open resources. Defaults to 4. Choose this number carefully, since each entry can take up a fairly large amount of root storage, depending on the mix of filesystems in use. Unless you are anticipating a very busy server, 4 should be enough.

If you increase the default value of HTTP_MAXSERVERS from 4, you may experience 404 or 503 messages. The solution is to increase SSPEC_MAX_OPEN. Ideally, this value should be HTTP_MAXSERVERS + FTP_MAXSERVERS + any special use of zserver.lib that you create.

SSPEC_XMEMVARLEN

Defines the size of the stack-allocated buffer used by sspec_readvariable() when reading a variable in xmem. It defaults to 20.

3.2.5 Macros for Control Data Initialization

As of Dynamic C 8.50, the following macros are available for building the static tables used by the servers.

3.2.5.1 Static Rule Table

Resource rules are used to associate access information with resource names. The following macros define and initialize a static rule table. If using a static rule table, the dynamically added entries will be searched before the static ones.

SSPEC_FLASHRULES

Define this if your application is using static rules. You must define this if you want to use the macro SSPEC_RULETABLE_START. If you define SSPEC_FLASHRULES, and you do not need dynamic rules, you can define the macro SSPEC_MAXRULES to zero to recover the root memory that would be wasted otherwise.

SSPEC_RULETABLE_START
SSPEC_RULE(prefix, realm, rg, wg, sm)
SSPEC_MM_RULE(prefix, realm, rg, wg, sm, method, mimetype)
SSPEC_RULETABLE_END

This sequence of macros is used to define static rules. See the documentation with the sspec_addrule() function for more information. You must define SSPEC_FLASHRULES to use these macros.

3.2.5.2 Static MIME Type Table

This table maps file extensions and MIME types. You only need such a table if using a server that requires MIME types. Currently, only the HTTP server needs this.

```
SSPEC_MIMETABLE_START
SSPEC_MIME(extension, type)
SSPEC_MIME_FUNC(extension, type, function)
SSPEC_MIMETABLE_END
```

This sequence sets up the MIME type mapping table. Currently only a static MIME table is supported. Though you cannot dynamically add new MIME types to this table, it is possible to allocate new `MIMETypeMap` structures in RAM and assign them to specific resources using `sspec_addrule()` or `sspec_setpermissions()`. Such entries will not be accessed using the default resource name extension method.

3.2.5.3 Static Resource Table

The static resource table associates the names of web server resources (files, functions, and variables) to references to memory objects.

`HTTP_NO_FLASHSPEC`

Define if there is to be NO static resource table, that is, all resources are in the dynamic (RAM) table or in the filesystem(s). If you define this, then there is no point in using the `SSPEC_RESOURCE_*` series of macros below.

```
SSPEC_RESOURCETABLE_START
SSPEC_RESOURCE_ROOTFILE(name, addr, len)
SSPEC_RESOURCE_XMEMFILE(name, addr)
SSPEC_RESOURCE_ZMEMFILE(name, addr)
SSPEC_RESOURCE_FSFILE(name, fnum)
SSPEC_RESOURCE_ROOTVAR(name, addr, type, format)
SSPEC_RESOURCE_XMEMVAR(name, addr, type, format)
SSPEC_RESOURCE_FUNCTION(name, addr)
SSPEC_RESOURCE_CGI(name, addr)
SSPEC_RESOURCE_P_ROOTFILE(name, addr, len, realm, rg, wg, sm, meth)
SSPEC_RESOURCE_P_XMEMFILE(name, addr, realm, rg, wg, sm, meth)
SSPEC_RESOURCE_P_ZMEMFILE(name, addr, realm, rg, wg, sm, meth)
SSPEC_RESOURCE_P_FSFILE(name, fnum, realm, rg, wg, sm, meth)
SSPEC_RESOURCE_P_ROOTVAR(name, addr, type, format, realm, rg, wg, sm, meth)
SSPEC_RESOURCE_P_XMEMVAR(name, addr, type, format, realm, rg, wg, sm, meth)
SSPEC_RESOURCE_P_FUNCTION(name, addr, realm, rg, wg, sm, meth)
SSPEC_RESOURCE_P_CGI(name, addr, realm, rg, wg, sm, meth)
SSPEC_RESOURCETABLE_END
```

These macros are used to initialize the static resource table. Prior to Dynamic C 8.50 this had to be done by explicitly using C language initialization of a table declared as:

```
const HttpSpec http_spec[]
```

These macros perform the same function. It is recommended to use them instead of static initializers in order to maintain forward compatibility.

The macros with `_P_` in the name are the same as the others, except that they explicitly allow all the server permissions information (except for the MIME type mapping) to be initialized. See

`sspec_addrule()` for more information on the parameters.

The `name` parameter to all these macros is the resource name. This usually starts with a "`/`" for files, but not for variables. The string length should be less than or equal to `SSPEC_MAXNAME`.

The other parameters depend on the resource type being created:

`ROOTFILE`: `addr` = root memory address of first byte of file, `len` = length of file (0..32767).

`XMEMFILE`: `addr` = longword (physical address) of the length word of the file. The length word (4 bytes) is followed by the first byte of data.

`ZMEMFILE`: as for `XMEMFILE`, except the file is compressed and imported using `#zimport` instead of `#ximport`.

`FSFILE`: `fnum` = FS2 file number of file (1..255)

`ROOTVAR`: `addr` = root memory address of data, `type` = type of data, as documented with `sspec_addvariable()`, `format` = char * format, as used by `printf()`. For example, "%d" for a decimal number.

`XMEMVAR`: as for `ROOTVAR` except the address is a longword physical address.

`FUNCTION` or `CGI`: `addr` = address of C function.

Note that a maximum of 511 static resource table entries can be defined.

3.3 File Compression Support

Dynamic C 8.50 introduces file compression support. The sample program `/samples/tcpip/http/zimport.c` demonstrates how to use this functionality. This sample is oriented towards the HTTP server; however, under the covers, HTTP is relying on Zserver to perform the compressed file handling.

In the sample program, notice that the statement "`#use zimport.lib`" comes before the statement "`#use http.lib`" in the code. This is required to have file compression support in Zserver and the web server. The next thing to notice is the use of the compiler directive `#zimport` instead of `#ximport`. `#zimport` performs a standard `#ximport`, but compresses the file by invoking a compression utility before emitting the file to the target.

When adding a compressed file to the static resource table, use the macro `SSPEC_RESOURCE_ZMEMFILE` instead of `SSPEC_RESOURCE_XMEMFILE`. When you add a compressed file to the dynamic resource table using the `sspec_addxmemfile()` function, it will be recognized as a compressed file automatically. `sspec_addxmemfile()` is thus used for both compressed and uncompressed imported files.

Each instance of a server will use a buffer for decompression—this is necessary since multiple server instances can be decompressing files at the same time. Make sure that the buffer macro `INPUT_COMPRESSION_BUFFERS` is at least as large as the number of servers which may need concurrently to decompress a compressed resource. The buffer macro describes the number of 4KB xmem RAM buffers used for decompression. This definition is used by the `zimport.lib` library.

For details on compression ratios, memory usage and performance, please see Technical Note 234, "File Compression." For more information on using `#zimport` and the support libraries, please see the *Dynamic C User's Manual* and the *Dynamic C Function Reference Manual*.

All of these documents are available on our website: www.rabbit.com.

3.4 HTML Forms

This facility is oriented towards the HTTP server, however it is Zserver that actually handles the form data (as a special resource type in the dynamic resource table only).

Defining `FORM_ERROR_BUF` is required to use the HTML form functionality in `ZSERVER.LIB`. The value assigned to this macro is the number of bytes to reserve in root memory for the buffer used for form processing. This buffer must be large enough to hold the name and value for each variable, plus four bytes for each variable.

An array of type `FormVar` must be declared to hold information about the form variables. Be sure to allocate enough entries in the array to hold all of the variables that will go in the form. If more forms are needed, then more of these arrays can be allocated. Please see Section 4.5.4 on page 183 for an example program.

Starting with Dynamic C 8.50, a more flexible way of supporting form generation is available with RabbitWeb. See Chapter 5 for more information on this enhanced HTTP server.

3.5 API Functions

The resource manager API functions are described in this section. These functions give servers a consistent interface to files, variables and client information.

sauth_adduser
sauth_authenticate
sauth_getpassword
sauth_getserver
sauth_getuserid
sauth_getusermask
sauth_getusername
sauth_getwriteaccess
sauth_removeuser
sauth_setpassword
sauth_setserver
sauth_setusermask
sauth_setwriteaccess
sspec_access
sspec_addCGI
sspec_addform
sspec_addfsfile
sspec_addfunction
sspec_addfv
sspec_addrootfile
sspec_addrule
sspec_adduser
sspec_addvariable
sspec_addxmemfile
sspec_addxmemvar
sspec_aliasspec
sspec_automount
sspec_cd
sspec_checkaccess
sspec_checkpermissions
sspec_close
sspec_delete
sspec_dirlist
sspec_fatregister
sspec_fatregistered
sspec_findfv
sspec_findname
sspec_findfsname
sspec_findnextfile
sspec_getfileloc
sspec_getfiletype
sspec_getformtitle
sspec_getfunction
sspec_getfvdesc
sspec_getfventrytype
sspec_getfvlen
sspec_getfvname
sspec_getfvnum
sspec_getfvopt
sspec_getfvoptlistlen
sspec_getfvreadonly
sspec_getfvspec
sspec_getlength
sspec_getMIMEtype
sspec_getname
sspec_getpermissions
sspec_getpreformfunction
sspec_getrealm
sspec_getservermask
sspec_gettype
sspec_getuserid
sspec_getusername
sspec_getvaraddr
sspec_getvarkind
sspec_getvartype
sspec_getxvaraddr
sspec_mkdir
sspec_needsauthentication
sspec_open
sspec_pwd
sspec_read
sspec_readfile
sspec_readvariable
sspec_remove
sspec_removerule
sspec_removeuser
sspec_resizerootfile
sspec_restore
sspec_rmdir
sspec_save
sspec_seek
sspec_setformepilog
sspec_setformfunction
sspec_setformprolog
sspec_setformtitle
sspec_setfvcheck
sspec_setfvdesc
sspec_setfventrytype
sspec_setfvfloatrange
sspec_setfvlen
sspec_setfvname
sspec_setfvoptlist
sspec_setfvrange
sspec_setfvreadonly
sspec_setpermissions
sspec_setpreformfunction
sspec_setrealm
sspec_setsavedata
sspec_setuser
sspec_stat
sspec_tell
sspec_write

sauth_adduser

```
int sauth_adduser( char *username, char *password, word servermask );
```

DESCRIPTION

This function adds a user to the user table. It fills in the fields of the ServerAuth structure associated with this user. Three of the fields are specified by the parameters passed into the function. Two other fields, one for the user group mask and the other for the write access mask, are given default values.

The default for the user group mask is the assigned index number (0 to SAUTH_MAXNAME-1) as a bit number; that is, 1<<index. This effectively creates each user in a unique (single) group. Since this does not offer any real control over the assigned group mask, it is recommended to use sauth_setusermask() after this to assign the correct access masks.

The default for the write access mask is the user has no write access to any server. To assign this permission, call the function sauth_setwriteaccess() with the user table index returned by sauth_adduser().

PARAMETERS

username	Name of the user, a character string up to SAUTH_MAXNAME characters.
password	Password for the user, another character string up to SAUTH_MAXNAME characters.
servermask	Bitmask representing valid servers (e.g., SERVER_HTTP, SERVER_FTP).

RETURN VALUE

-1: Failure.
≥0: Success; index into user table (id passed to sauth_getusername()).

SEE ALSO

sauth_authenticate, sauth_getwriteaccess, sauth_setusermask, sauth_setwriteaccess, sauth_removeuser

sauth_authenticate

```
int sauth_authenticate( char *username, char *password, word server
   );
```

DESCRIPTION

Authenticate user and return the user index representing the authenticated user, that is, the user table index. This performs only a plaintext comparison of the userid and password. Servers probably will have their own, more sophisticated, checks.

If `username` is NULL, or empty string, then password-only matching is attempted for servers who allow this type of authentication (as defined by the `SERVER_PASSWORD_ONLY` macro).

PARAMETERS

username	Name of user.
password	Password for the user.
server	The server for which this function is authenticating (e.g., `SERVER_HTTP`, `SERVER_FTP`).

RETURN VALUE

`-1`: Failure or user not authorized.
≥`0`: Success, array index of the `ServerAuth` structure for authenticated user.

SEE ALSO

`sauth_adduser`

sauth_getpassword

```
sauth_getpassword( int userid );
```

DESCRIPTION

Get the password for a user.

PARAMETER

userid user index

RETURN VALUE

!=NULL: password string
NULL: Failure

SEE ALSO

sauth_setpassword

sauth_getserver

```
int sauth_getserver( int sauth );
```

DESCRIPTION

Returns whether or not a user is visible to particular server(s).

PARAMETER

sauth user index

RETURN VALUE

`0`: This user is visible to all servers
`>0`: Visible to select servers. One bit is set for each server that knows about this user.
`-1`: Failure; for example, `sauth` is an invalid index into the user table.

SEE ALSO

`sauth_setserver`

sauth_getuserid

```
int sauth_getuserid( char *username, word server );
```

DESCRIPTION

Gets the user index for a user.

PARAMETERS

username User's name. If this name is not found, then the list is re-scanned looking for an entry with an empty user name ("") and a password that matches username. The second pass is only done for servers that allow password-only matching. Such servers must be specified by defining a symbol SERVER_PASSWORD_ONLY to be a bitmask of such servers.

server Server(s) for which we are looking up. Use SERVER_ANY if not concerned with the server mask.

RETURN VALUE

≥0: Success, index of user in the user table.
-1: Failure.

sauth_getusermask

```
int sauth_getusermask(int userid, word *groupbits, void **authdata);
```

DESCRIPTION

Get the group access bit(s) and/or authorization data for a given user ID.

PARAMETERS

userid	User index
groupbits	Pointer to bitmask that will be set to group(s) of which this user is a member. If NULL, this information is not retrieved.
authdata	Pointer to `void*` that is set to arbitrary server data. If NULL, this information is not retrieved.

RETURN VALUE

0: OK
-1: Failed: `userid` not valid.

sauth_getusername

```
char *sauth_getusername( int userid );
```

DESCRIPTION

Returns the name of the user, a character string from the `ServerAuth` structure associated with `userid`.

PARAMETERS

`userid` The user's id, that is, the index into the user table.

RETURN VALUE

`NULL`: Failure.
`!NULL`: Success, pointer to the user's name string.

SEE ALSO

`sspec_getusername`

sauth_getwriteaccess

```
int sauth_getwriteaccess( int sauth );
```

DESCRIPTION

Checks whether or not a user has write access to any server's resources. This is an “in principle” test. Each resource is individually protected from write access: this is not checked. In other words, this function may return TRUE even when none of the resources are writable to this user.

PARAMETERS

sauth Index into the user table.

RETURN VALUE

0: User does not have write access.
1: User has write access.
-1: Failure.

SEE ALSO

sauth_setwriteaccess

sauth_removeuser

```
int sauth_removeuser( int userid );
```

DESCRIPTION

Remove the given user from the user list.

IMPORTANT: Any associations of the given user with web pages should be changed. Otherwise, no one will have access to the unchanged web pages. Authentication can be turned off for a page with `sspec_setrealm(sspec, "")`.

PARAMETERS

userid Index in user table.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sauth_adduser`

sauth_setpassword

```
int sauth_setpassword( int userid, char *password );
```

DESCRIPTION

Sets the password for a user.

PARAMETERS

userid Index of user in user table.

password User's new password.

RETURN VALUE

0: Success.
-1: Failure.

SEE ALSO

sauth_getpassword

sauth_setserver

```
int sauth_setserver( int sauth, int server );
```

DESCRIPTION

Sets whether a user is visible to the specified server(s).

PARAMETERS

sauth	User index
server	Server bitmask, with bit set to 1 to make this user "known" to the server. If this parameter is zero, then the user is visible to ALL servers, however it is recommended to pass the value SERVER_ANY in this case.

RETURN VALUE

0: Success
-1: Failure

SEE ALSO

sauth_getserver

sauth_setusermask

```
int sauth_setusermask( int userid, word userid, void * authdata );
```

DESCRIPTION

Set the group access bit(s) and authorization data for a given user ID.

PARAMETERS

userid	User index
userid	Bitmask of group(s) of which this user is a member. This should be non-zero, otherwise the user will not have access to any resources.
authdata	Arbitrary data that can be used by specific servers.

RETURN VALUE

`0`: OK
`-1`: Failed: `userid` not valid.

sauth_setwriteaccess

```
int sauth_setwriteaccess( int sauth, int writeaccess );
```

DESCRIPTION

Set whether or not a user has write access with the specified server(s).

PARAMETERS

sauth	Index of the user in the user table.
writeaccess	Server bitmask, with bit set to 1 for write access, 0 for no write access. This is a bitwise OR of the server macros, SERVER_HTTP, etc., that you want the user to have write access to.

RETURN VALUE

0: Success.
-1: Failure.

SEE ALSO

sauth_getwriteaccess

sspec_access

```
int sspec_access( char * name, ServerContext * context );
```

DESCRIPTION

Test access to a given resource by a specified user. The `userid` is set in `context->userid`, or -1 for testing access by the server in general.

> **NOTE:** `sspec_checkpermissions()` performs a similar function, except on a resource handle rather than a resource name.

PARAMETERS

`name`	Resource name, as a null-terminated string. This name is assumed to be relative to `context->cwd` if it does not begin with a "`/`" character. Otherwise, the name is assumed to be relative to `context->rootdir`.
`context`	Additional context information. The `ServerContext` structure is set up by the caller. See `sspec_open()` for documentation on this structure. For this function, `context->userid` should be set to the current user whose access is being tested, or may be set to -1 to test access by the server in general.

RETURN VALUE

≥0: Success. The return value is a bitmask of the following values:

- `O_READ` - user+server has read access
- `O_WRITE` - user+server has write access
- 0 (zero) - no access

The following return values are negatives of the values defined in `errno.lib`.

- `-ENOENT` - The resource was not found.
- `-EINVAL` - The resource name was malformed (e.g., too long), or `context` was NULL, or the resource was not a file type.

SEE ALSO

`sspec_read, sspec_write, sspec_seek, sspec_tell, sspec_close, sspec_checkpermissions`

sspec_addCGI

```
int sspec_addCGI( char* name, void (*fptr)(), word servermask );
```

DESCRIPTION

Add a CGI function to the RAM resource list. This function is currently only useful for the HTTP server, in which case the function is registered as a CGI processor. Make sure that SSPEC_MAXSPEC is large enough to hold this new entry.

PARAMETERS

name URL name of the new function, for example, myCGI.cgi

fptr Pointer to the function. The prototype for this function is:

```
int (*fptr)(HttpState * state);
```

There is a specific documented interface that must be used when specifying this type of CGI handler function. See the manual for details.

servermask Bitmask representing valid servers (currently only useful with SERVER_HTTP)

RETURN VALUE

≥0: Successfully added spec index
-1: Failed to add function.

SEE ALSO

sspec_addfsfile, sspec_addfunction, sspec_addrootfile, sspec_addvariable, sspec_addxmemvar, sspec_addxmemfile sspec_aliasspec, sspec_addform

sspec_addform

```
int sspec_addform( char *name, FormVar *form, int formsize,
   word servermask );
```

DESCRIPTION

Adds a form (set of modifiable variables) to the TCP/IP servers' object list. Make sure that SSPEC_MAXSPEC is large enough to hold this new entry. This function is currently only useful for the HTTP server.

PARAMETERS

name	Name of the new form.
form	Pointer to the form array. This is a user-defined array to hold information about form variables.
formsize	Size of the form array
servermask	Bitmask representing valid servers (currently only useful with SERVER_HTTP)

RETURN VALUE

≥0: Success; location of form in server spec list.
-1: Failed to add form.

SEE ALSO

sspec_addfsfile, sspec_addfunction, sspec_addrootfile, sspec_addvariable, sspec_addxmemvar, sspec_addxmemfile, sspec_aliasspec, sspec_addfv

sspec_addfsfile

```
int sspec_addfsfile( char *name, byte filenum, word servermask );
```

DESCRIPTION

Adds a file, located in the FS2 filesystem, to the RAM resource list. Make sure that SSPEC_MAXSPEC is large enough to hold this new entry. This function associates a name with the file.

This creates an alias entry for /fs2/file<n>.

Note that all FS2 files are automatically accessible. There is no need to call this function unless it is desired to assign a name to an FS2 file other than the default, which is file1, file2 etc.

For more information regarding the FS2 filesystem, please see the *Dynamic C User's Manual*.

PARAMETERS

name	Name of the new file.
filenum	Number of the file in the file system (1-255). This is the number passed in as the second parameter to fcreate() or the return value from fcreate_unused().
servermask	Bitmask representing servers for which this entry will be valid (e.g., SERVER_HTTP, SERVER_FTP).

RETURN VALUE

-1: Failure.
≥0: Success; location of file in TCP/IP servers' object list.

SEE ALSO

sspec_addrootfile, sspec_addfunction, sspec_addvariable, sspec_addxmemfile, sspec_addform, sspec_aliasspec

sspec_addfunction

```
int sspec_addfunction( char *name, void (*fptr)(), word servermask );
```

DESCRIPTION

Adds a function to the RAM resource list. Make sure that SSPEC_MAXSPEC is large enough to hold this new entry. This function is currently only useful for HTTP servers.

> **NOTE:** If using HTTP upload facility and/or the new CGI interface, use sspec_addCGI() instead.

PARAMETERS

name	Name of the function.
(*ftpr)()	Pointer to the function.
servermask	Bitmask representing servers for which this function will be valid (currently only useful with SERVER_HTTP).

RETURN VALUE

-1: Failure.
≥0: Success, location of the function in the TCP/IP servers' object list.

SEE ALSO

sspec_addform, sspec_addfsfile, sspec_addrootfile, sspec_addvariable, sspec_addxmemvar, sspec_addxmemfile, sspec_aliasspec

sspec_addfv

```
int sspec_addfv( int form, int var );
```

DESCRIPTION

Adds a variable to a form.

PARAMETERS

form	spec index of the form (previously returned by `sspec_addform()`).
var	spec index of the variable to add (which must have been previously created using `sspec_addvariable()`)

RETURN VALUE

`-1`: Failure.
≥`0`: Success; next available index into the `FormVar` array.

SEE ALSO

`sspec_addform`

sspec_addrootfile

```
int sspec_addrootfile( char *name, char *fileloc, int len, word
   servermask );
```

DESCRIPTION

Adds a file that is located in root memory to the dynamic resource table. Make sure that SSPEC_MAXSPEC is large enough to hold this new entry.

PARAMETERS

name	Name of the new file. This must be unique, but this function does not check. The name should not conflict with the virtual filesystem hierarchy. That is, it should not start with /fs2/, /A/, /B/ etc.
fileloc	Pointer to the beginning of the file.
len	Length of the file in bytes.
servermask	Bitmask representing servers for which this entry will be valid (e.g., SERVER_HTTP, SERVER_FTP).

RETURN VALUE

-1: Failure.
≥0: Success; file index into the resource list.

SEE ALSO

sspec_addfsfile, sspec_addxmemfile, sspec_addxmemvar, sspec_addvariable, sspec_addfunction, sspec_addform, sspec_aliasspec, sspec_resizerootfile

sspec_addrule

```
int sspec_addrule( char * pfx, char * realm, word readgroups, word
   writegroups, word servermask, word method, MIMETypeMap *
   mimetype);
```

DESCRIPTION

Add a rule to the dynamic resource rule table. Resource rules are used to associate access information with resource names matching the specified prefix string. The most specific, that is, the longest, matching string is used.

Normally, the rule table is consulted only for resource names that belong in a file system (FS2 or FAT). You can also cause the rule table to be consulted for flash- or RAM-table entries if you leave the `realm` field as NULL in the entry. If the `realm` field is not NULL, then the rule table is not consulted for that entry. If the `realm` field was NULL, and there was no applicable entry in the rule table, then the resource table permissions are used (with NULL realm).

Do not attempt to use a very large number of rule table entries, since the table must be searched exhaustively for each initial resource access. There should be no need for a large number of entries provided that the resource name hierarchy is organized in a reasonably efficient manner. For example, keep the resources for a particular user or realm in one directory, and just add an entry for that directory instead of an entry for each resource. This works because the full path name is always used for matching, and the directory will always be a prefix string of the files that reside in that directory.

As an alternative to this function, you can statically initialize a rule table using the following macros:

```
#define SSPEC_FLASHRULES            // Required.
#use "zserver.lib"                  // this library

SSPEC_RULETABLE_START
SSPEC_RULE("prefix", realm, rg, wg, sm)
SSPEC_RULE("prefix", realm, rg, wg, sm)
SSPEC_MM_RULE("prefix", realm, rg, wg, sm, meth, mime)
SSPEC_MM_RULE("prefix", realm, rg, wg, sm, meth, mime)
 ...
SSPEC_RULETABLE_END
```

The `SSPEC_MM_RULE` macro parameters are basically the same parameters as would be passed to this function. These macros define and initialize a constant rule table named `f_rule_table`. `SSPEC_RULE` just omits the (rarely used) `method` and `mimetype` fields.

When using a static rule table, the dynamically added entries are searched before the static ones.

sspec_addrule (cont.)

PARAMETER

pfx Prefix of resource name. This must include the initial "/" character, since all matching is done using absolute path names. If this prefix string exactly matches an existing entry in the table, that entry is replaced. Otherwise, a new entry is created (if possible). This string is not copied, only the pointer is stored. Thus, pfx must point to static storage, that is, a string constant or a global variable. Initial characters other than "/" are reserved for future use.

realm If not NULL, is an arbitrary null-terminated string that may be used by the server. For HTTP, this is used as the "realm" of the resource. This string is not copied, only the pointer is stored. Thus, the parameter must point to static storage.

readgroups A word with a bit set for each group that can access this resource for reading. A maximum of 16 different user groups can exist.

writegroups A word with a bit set for each group that can access this resource for writing. The user must also be given write permission to resources in the userid table entry for the appropriate server(s).

servermask The server(s) that are allowed to access this resource. Servers have pre-defined bits. This parameter should be a combination of

- SERVER_HTTP: web server
- SERVER_FTP: file transfer protocol server
- SERVER_SMTP: email
- SERVER_HTTPS: secure web server
- SERVER_SNMP: SNMP agent
- SERVER_USER: user-defined server
- SERVER_ANY: for all servers.

method Allowable authentication method(s) to be used when accessing this resource. If zero, then the resource has no particular authentication method requirements. This is a bitwise combination of:

- SERVER_AUTH_BASIC: plaintext userid/password
- SERVER_AUTH_DIGEST: challenge-response protocol
- SERVER_AUTH_PK: public key (such as SSL/TLS)

mimetype An appropriate MIME type to use. If NULL, then the default table (called http_types) will be consulted.

RETURN VALUE

≥0: OK
-1: Error. For example, out of space in rule table; increase SSPEC_MAXRULES.

SEE ALSO

sspec_removerule, sspec_getMIMEtype

sspec_adduser

```
int sspec_adduser( int sspec, int userid );
```

DESCRIPTION

Add to the read permission mask for the given resource. The groups that `userid` is a member of are ORed into the existing permission mask for the resource. The write permissions are not modified.

> **NOTE:** This is not used to create new userids. For that, see `sauth_adduser()`.

Adds a user to the list of users that have access to the given spec entry. Up to `SSPEC_USERSPERRESOURCE` users can be added. Any more than that will result in this function returning -1.

This function is deprecated as of Dynamic C 8.50. Use the more general `sspec_setpermissions()` function instead.

PARAMETERS

`sspec` Spec index.

`userid` User index.

RETURN VALUE

≥`0`: Success, index of userid added for given spec entry.
`-1`: Failure.

SEE ALSO

`sspec_setuser, sspec_getusername, sspec_getuserid, sspec_removeuser, sspec_setpermissions`

sspec_addvariable

```
int sspec_addvariable( char *name, void *variable, word type, char
   *format, word servermask );
```

DESCRIPTION

Adds a variable to the dynamic resource table (aka, the RAM resource list). Make sure that SSPEC_MAXSPEC is large enough to hold this new spec entry. This function is currently only useful for the HTTP server.

PARAMETERS

name Name of the new variable. This must be unique, but this function does not check. The name should not conflict with the virtual filesystem hierarchy. That is, it should not start with `/fs2/`, `/A/`, `/B/` etc. Variables appear in a directory listing of the root directory "`/`" however, they cannot be opened using `sspec_open()`.

variable Address of actual variable.

type Variable type, one of:

- INT8 - single character
- INT16 - 2-byte integer
- PTR16 - string in root memory
- INT32 - 4-byte (long) integer
- FLOAT32 - floating point variable

format Output format of the variable as a `printf()` conversion specifier, e.g., "%d."

servermask Bitmask representing servers for which this function will be valid (currently only useful with SERVER_HTTP).

RETURN VALUE

`-1`: Failure.
≥`0`: Success, the index of the variable in the resource list.

SEE ALSO

```
sspec_addfsfile, sspec_addrootfile, sspec_addxmemfile,
sspec_addxmemvar, sspec_addfunction sspec_addform, sspec_aliasspec
```

sspec_addxmemfile

```
int sspec_addxmemfile( char *name, long fileloc,
   word servermask );
```

DESCRIPTION

Adds a file, located in extended memory, to the RAM resource list. Make sure that SSPEC_MAXSPEC is large enough to hold this new entry.

PARAMETERS

name — Name of the new file. This must be unique, but this function does not check. The name should not conflict with the virtual filesystem hierarchy. That is, it should not start with /fs2/, /A/, /B/ etc.

fileloc — Location of the beginning of the file. The first 4 bytes of the file must represent the length of the file (#ximport does this automatically).

servermask — Bitmask representing servers for which this entry will be valid (e.g., SERVER_HTTP, SERVER_FTP).

RETURN VALUE

-1: Failure.
≥0: Success, the location of the file in the dynamic resource list.

SEE ALSO

sspec_addfsfile, sspec_addrootfile, sspec_addvariable, sspec_addxmemvar, sspec_addfunction, sspec_addform, sspec_aliasspec

sspec_addxmemvar

```
int sspec_addxmemvar( char *name, long variable, word type,
   char *format, word servermask );
```

DESCRIPTION

Add a variable located in extended memory to the RAM resource list. Make sure that SSPEC_MAXSPEC is large enough to hold this new entry. Currently, this function is useful only for the HTTP server.

PARAMETERS

name Name of the new variable. This must be unique, but this function does not check. The name should not conflict with the virtual filesystem hierarchy. That is, it should not start with /fs2/, /A/, /B/ etc. Variables appear in directory listing of the root directory "/" however, they cannot be opened using sspec_open().

variable Address of the variable in extended memory.

type Variable type, one of:

- INT8 - single character
- INT16 - 2-byte integer
- PTR16 - string in root memory
- INT32 - 4-byte (long) integer
- FLOAT32 - floating point variable

format Output format of the variable as a printf() conversion specifier e.g., "%d."

servermask Bitmask representing valid servers (currently only useful with SERVER_HTTP).

RETURN VALUE

-1: Failure.

≥0: Success, the index of the variable in the resource list.

SEE ALSO

sspec_addfsfile, sspec_addrootfile, sspec_addvariable, sspec_addfunction, sspec_addform, sspec_addxmemfile, sspec_aliasspec

sspec_aliasspec

```
int sspec_aliasspec( int sspec, char *name );
```

DESCRIPTION

Creates an alias to an existing `ServerSpec` structure. Make sure that `SSPEC_MAXSPEC` is large enough to hold this new entry.

This is NOT a deep copy. That is, any file, variable, or form that the alias (the new spec entry) references will be the same copy of the file, variable, or form that already exists in the old spec entry. This should be called only when the original entry has been completely set up.

NOTE: do not attempt to alias a sspec handle that was returned by `sspec_open()`, because the handle may be dynamically allocated. In such a case, the alias will not work once the original handle is closed. You can test whether such a "virtual" handle has been returned using the macro `SSPEC_IS_VIRT(sspec)`.

PARAMETERS

sspec	sspec index that this function will alias.
name	Alias name.

RETURN VALUE

`-1`: Failure.
≥`0`: Success; return location of alias, i.e., new index.

SEE ALSO

`sspec_addform, sspec_addfsfile, sspec_addfunction, sspec_addrootfile, sspec_addvariable, sspec_addxmemfile`

sspec_automount

```
int sspec_automount( word which, void ** fatstuff, void ** fs2stuff,
   void ** reserved );
```

DESCRIPTION

This function automatically initializes and *mounts* the specified filesystem(s) for use by Zserver. Mounting a filesystem creates an entry point to that filesystem for the server.

You must `#use` the appropriate filesystem library (for example, `FS2.LIB`) otherwise the filesystem will not be mountable.

If using the FAT library, you must include one or more "driver libraries" (such as `sflash_fat.lib`) before `#use fat.lib`. Only the default device from the first driver library will be initialized and used by this routine. If you need to use any other devices, you will need to initialize them individually and call the `sspec_fatregister()` function. `SSPEC_MAX_FATDRIVES` will also need to be increased from its default value of one.

For the FAT library, this routine calls `fat_Init()` and mounts the first available FAT partition on that drive (if any). If the first available partition is the first partition on the drive, then it will be mounted at mount point "`/A`". If it is the second partition, it will be mounted at "`/B`" etc. Up to four partitions are scanned. If none are found (or none are FAT12 or FAT16 partitions) then an error is returned.

For FS2, all logical extents will be initialized via the `fs_init()` function.

PARAMETERS

`which` The filesystem(s) to mount. This is a bitwise OR of the following constants:

- `SSPEC_MOUNT_FS` - FS or FS2 flash filesystem
- `SSPEC_MOUNT_FAT` - FAT filesystem (1st drive).

You can also pass `SSPEC_MOUNT_ANY` to mount all known filesystems.

fatstuff Either NULL (no info return) or must point to a struct of type `sspec_fatinfo`. This structure (defined in `zserver.lib`) consists of the following fields:

```
typedef struct {
   dos_ctrl * ctrl;
   mbr_drive * drive;
   fat_part * part[4];
} sspec_fatinfo;
```

When calling this function, you should NULL out all these pointers using `memset(..., 0, ...)`. You can then optionally set some of the pointers to valid non-NULL values in order to override the defaults supplied by this function. If you set the `ctrl` pointer, then it is assumed by this function that you have already called the controller initialization function. If the pointer is NULL on entry, then this function will call the default controller initialization via the `DOS_CONTROLLER_INIT` macro.

On return, pointers that were NULL on entry may be changed to point to valid default information. In particular, the `ctrl` and `drive` fields will point to defaults. One (and only one) of the NULL `part` pointers may be set to a default partition structure if a default partition could be located on the drive.

If `fat.lib` is not included, the above structure is still defined, but contains 6 `void` pointers. This is just to avoid compilation problems, since no information will be used or returned.

fs2stuff This parameter is currently reserved for returning FS2 information. For now, pass as NULL.

reserved Reserved for other filesystems. For now, pass as NULL.

RETURN VALUE

0: OK
Otherwise, if a filesystem fails to mount, the return code is the bitwise OR of the `SSPEC_MOUNT_*` constants of those filesystem(s) that failed to initialize.

SEE ALSO

`sspec_fatregister, sspec_fatregistered`

sspec_cd

```
int sspec_cd(char * path, ServerContext * context, int check);
```

DESCRIPTION

Change the current working directory in the ServerContext structure. This function may be used by servers that support the concept of a current directory, such as FTP (but not HTTP). Standard Unix-like path names are used, including support for "." and ".." directory components.

The resulting directory name is not allowed to be closer to the root directory than context->rootdir. If there is any specification error, then the current directory is not changed. The resulting absolute directory name cannot be longer than SSPEC_MAXNAME, including a leading and trailing "/" character.

PARAMETERS

path — New directory path string, as a null-terminated string. If this starts with "/" it is merely appended to the context->rootdir string. Otherwise, it is appended to the current directory (in context->cwd). Directory components are separated by "/" characters. A trailing slash is optional. A directory component "." means "no change to this level," and a component of ".." means "up one level" (towards the root).

context — Server context structure. Two fields in this are of interest: rootdir points to a virtual root directory for this server. For example, if the FTP server is only allowed to access files under the /A/ directory, then rootdir points to a string "/A/". If the user entered a directory name of "/ftpfiles/" the full directory would be "/A/ftpfiles/"

The other field that is updated by this function, is cwd. This is an array of characters of length SSPEC_MAXNAME. It contains the absolute path of the current directory, with leading and trailing slash, including the rootdir part (if any).

check — If TRUE, check the resulting directory name to see if it exists. Otherwise, no check is made.

RETURN VALUE

0: OK.

Any other negative values indicate an error:
-E2BIG: Resulting directory name too long
-EACCES: Attempt to change above root directory
-ENOENT: 3rd parameter was TRUE, and the directory did not exist.

SEE ALSO

sspec_pwd

sspec_checkaccess

```
int sspec_checkaccess( int sspec, int userid );
```

DESCRIPTION

This function checks whether or not the specified user has permission to access the specified resource in the resource table. Only read access is checked.

This function is deprecated as of Dynamic C 8.50. Use the function `sspec_checkpermissions()` instead.

PARAMETERS

sspec spec index

userid user index

RETURN VALUE

`0`: User does not have access.
`1`: User has access.
`-1`: Failure.

SEE ALSO

`sspec_needsauthentication, sspec_checkpermissions`

sspec_checkpermissions

```
int sspec_checkpermissions( int sspec, ServerContext * context );
```

DESCRIPTION

Returns the access permissions for the given server and user, for the given resource.

`sspec_access()` performs the same function, except that a resource name can be given (rather than an open resource handle).

PARAMETERS

`sspec` spec index

`context` Server context. The relevant fields are:

`context->server`: the current server (`SERVER_HTTP` etc.)
`context->userid`: current user, or -1 for testing the server in general.

When testing the server in general, both `O_READ` and `O_WRITE` will be returned.

RETURN VALUE

≥`0`: Bitwise combination of:

- `O_READ`: resource is readable
- `O_WRITE`: resource has write permission. This does NOT necessarily mean that the resource can actually be written, only that the permission bits allow it.

<`0`: Error. For example, no permissions can be located or the sspec handle is invalid.

SEE ALSO

`sspec_setpermissions, sspec_getpermissions, sspec_access`

sspec_close

```
int sspec_close( int sspec );
```

DESCRIPTION

Close a file resource. This function must be called by servers when they have completed operations on the file, otherwise there will be a resource leak and future open calls will fail.

PARAMETER

sspec	Open file handle. This must be a handle that was returned by `sspec_open()`.

RETURN VALUE

≥0: Success.

The following return values are negatives of the values defined in `errno.lib`.

- -EBADF: The specified handle was not open or invalid.
- Other negative values indicate an error in closing the file resource.

SEE ALSO:

`sspec_read, sspec_write, sspec_seek, sspec_tell, sspec_open`

sspec_delete

```
int sspec_delete( char * name, ServerContext * context );
```

DESCRIPTION

Delete a resource by name. See `sspec_open()` for a detailed description of parameters.

PARAMETERS

`name` Name of resource.

`context` Current server context.

RETURN VALUE

0: OK.

The following return value is a negative of the values defined in `errno.lib`. Any other negative values indicate an error.

- `-ENOENT`: The specified resource did not exist.

SEE ALSO

`sspec_mkdir, sspec_rmdir, sspec_open`

sspec_dirlist

```
int sspec_dirlist( int item, char *line, int linelen, ServerContext
   * context, word options );
```

DESCRIPTION

Return formatted directory listing line. To use this function, call it with `item` = 0 the first time, then keep calling it with `item` = <previous return value> until it returns negative. This allows you to iterate through all entries in a directory.

The `ServerContext` structure contains the current user ID, server, and the name of the directory to list.

Note: For a given directory, you should call this function with `item` = 0, followed by more calls until it returns -1. If you want to terminate the directory listing without iterating through every entry, pass the `SSPEC_LIST_END` option flag (see below). This allows Zserver to release any temporary resources acquired for the purpose of iterating through the directory. This is especially important for FAT filesystem listings. After this function returns negative, you must start the next directory listing from the top, that is, `item` = 0.

If you do not complete the listing, then your application may not be able to perform further listings owing to internal resource leakage. This is similar to the need to close file resources that are opened. See the second example below.

Pass the same `ServerContext` structure for the entire directory list sequence, since Zserver keeps track of state information in this structure.

EXAMPLE

To iterate through all resources under "/A/":

```
ServerContext ctx;
int item;
char buf[80];
word opts;
word n;

ctx.rootdir = "/";
ctx.server = SERVER_FTP;
ctx.userid = sauth_getuserid("foo", SERVER_FTP);
sspec_cd("/A", &ctx);

for (item = 0; item >= 0;) {
   item = sspec_dirlist(item, buf, sizeof(buf), &ctx,
      SSPEC_LIST_LONG);

   if (item >= 0)
      printf(buf);
} // finished now, can re-use ctx.
```

To iterate through the first 5 resources only:

```
opts = SSPEC_LIST_LONG;

for (item = 0, n = 0; item >= 0; ++n) {
   if (n >= 4)
      opts |= SSPEC_LIST_END;

   item = sspec_dirlist(item, buf, sizeof(buf), &ctx, opts);

   if (item >= 0)
      printf(buf);
}
```

PARAMETERS

item Directory entry to list. If zero, this always returns the first entry in the directory. Thereafter, pass the return value from the previous call to this function to get the next item(s). NOTE: the return value does not necessarily count up 1, 2, 3 etc. Apart from 0, the only values you should pass in this parameter are previous return values, otherwise the results will be undefined.

line Points to buffer that is filled with resulting string. The string will be terminated with `\r\n` (CRLF) then a NULL.

linelen Length of the above buffer. If it is not long enough, then the line will be truncated (however it will still have the terminating CRLF + null). The minimum reasonable value is about 15 for format 0, and 80 for format 1.

context Server context. This structure will have the following fields initialized:

`userid`: current user who is doing the listing, or -1 if no specific user.

`server`: mask bit of the server who is performing the listing.

`cwd[]`: set to the directory to list. The `sspec_cd()` function can be used to set this field correctly.

This struct must be the same instance for all calls in a single directory listing sequence.

sspec_dirlist (cont.)

options Listing options. This is a bit field that should have a combination of the following flags:

- SSPEC_LIST_LONG: Long format listing (else just names)
- SSPEC_LIST_END: Close the current directory listing.

For the long format, the template is:

<permissions> 1 <user> <group> <length> <date> <name>

Where

- permissions is a string of 10 characters in 3 sets of 3, plus one. Each set of 3 indicates read, write or execute permissions for the user, group, and "world" respectively. The 1st char is "d" if the entry is a directory, or "-" otherwise. Since Zserver does not really support file owners or groups, or execute permissions, the 3 sets will be either "rw-" or "r--" or sometimes "-w-". The user bits are set according to the current user's access. The group bits are set if any other user has access, and the "world" bits are set if any other server has access.
- "1" is a constant for Unix compatibility.
- user is the username who "owns" the file resource. Since Zserver does not have the concept of resource ownership, this is set to the user ID of the context->userid field. If context->userid is -1, this is set to anon.
- group is the resource "group name." Zserver does not support this Unix concept either, so this field is set to the realm of the file resource (if it has one) otherwise it is set to anon.
- length is set to the current length of the file resource, or 0 if not known.
- date is set to the modification date of the file resource in Mon dd yyyy format.
- name is the name of the file resource in this directory.

Example:

```
dr--r--r-- 1 foo admin 0 Jan 1 1980 ftpfiles
-rw-rw-rw- 1 foo admin 1250 Mar 6 2003 index.htm
```

RETURN VALUE

-EEOF: there were no (more) entries in this directory.
Any other negative value: parameter or I/O error.
Otherwise (non-negative): the return value should be passed back to this function as the item parameter value, to retrieve the next entry.

SEE ALSO

sspec_cd

sspec_fatregister

```
int sspec_fatregister( int partno, fat_part * pt );
```

DESCRIPTION

This function must be used to register all FAT partitions that will be accessible to `Zserver.lib`. Partitions are numbered consecutively from 0, and they correspond to mount points /A, /B, /C etc.

It is assumed that by the time this function is called the required drives and partitions have been mounted. For example, call `fat_EnumDrive()` followed by as many `fat_MountPartition()` calls as required. The `fat_part` pointer returned by `fat_MountPartition()` should be passed to this function. Up to `SSPEC_MAX_PARTITIONS` can be registered. This number can be changed indirectly by defining `SSPEC_MAX_FATDRIVES` before `#use zserver.lib`. This defaults to one drive, and the number of partitions is set to 4 times this number (hence the default allows up to four partitions).

> **NOTE:** It is NOT necessary to call this function if you called `sspec_automount (SSPEC_MOUNT_FAT,...)` since that function does all the necessary initializations for a single "drive."

PARAMETERS

partno	Partition number to register. This starts at 0, corresponding to the "/A" mount point; 1 for "/B" etc.
pt	Pointer to `fat_part` data structure returned by `fat_MountPartition` etc. To unregister a partition, pass NULL for this parameter. Note: attempted access to an unregistered partition generally results in an error code of `-ENXIO`.

RETURN VALUE

≥0: Success.
`-ENXIO`: `partno` outside the allowable range of 0 .. `SSPEC_MAX_PARTITIONS`-1.

SEE ALSO

`fat_EnumDrive, fat_EnumPartition, fat_MountPartition, sspec_automount, sspec_fatregistered`

sspec_fatregistered

```
fat_part * sspec_fatregistered( int partno );
```

DESCRIPTION

Test whether a FAT partition has been registered with Zserver.

PARAMETER

partno Partition number to test. This starts at 0, corresponding to the "/A" mount point; 1 for "/B"etc.

RETURN VALUE

NULL: Not registered.
Otherwise: Registered, and this is the fat_part pointer.

SEE ALSO

fat_EnumDrive, fat_EnumPartition, fat_MountPartition, sspec_automount, sspec_fatregister

sspec_findfv

```
int sspec_findfv( int form, char *varname );
```

DESCRIPTION

Finds the index of a form variable in a given form.

PARAMETERS

form	spec index of the form in which to search.
varname	Name of the variable to find.

RETURN VALUE

`-1`: Failure.
≥`0`: Success; the index of the form variable in the array of type `FormVar`.

SEE ALSO

`sspec_addfv`

sspec_findname

```
int sspec_findname( char *name, word server );
```

DESCRIPTION

Find the spec entry with a `name` field that matches the given name and is allowed with the specified server(s). Note that a leading slash in the given name and/or in the resource name is ignored for backwards compatibility.

PARAMETERS

`name`	Name to search for in the resource list.
`server`	The server making the request (e.g., `SERVER_HTTP`).

RETURN VALUE

`-1`: Failure.
≥`0`: Success, spec index. The special value `SSPEC_VIRTUAL` is returned if the name refers to part of the virtual filesystem hierarchy. In this case, the server mask is not consulted. `SSPEC_VIRTUAL` is *not* a valid handle for other functions.

SEE ALSO

`sspec_findnextfile`

sspec_findfsname

```
int sspec_findfsname( byte filenum, word server );
```

DESCRIPTION

Find the server spec entry for `filenum`. The entry must be of type `SSPEC_FSFILE` and be allowed with the specified server.

PARAMETERS

`filenum`	File to search for. This value is the number passed in as the second parameter to `fcreate()` or the return value from `fcreate_unused()`.
`server`	The server making the request (e.g., `SERVER_HTTP`).

RETURN VALUE

`-1`: Failure.
≥`0`: Success, index into resource list.

SEE ALSO

`sspec_findname`

sspec_findnextfile

```
int sspec_findnextfile( int start, word servermask );
```

DESCRIPTION

Find the first spec file entry at or following the `start` spec that is accessible by the given server. When the end of the RAM entries is reached, the flash entries are searched. Virtual filesystem entries are not considered. Only entries for which `sspec_gettype()` would return `SSPEC_FILE` are considered.

If you are using this function to iterate through the available resources, then the caller is responsible for incrementing the starting point. To do this, you can call the function `sspec_nexthandle()` which will return the next valid handle after the given one (or -1 if no more handles).

PARAMETERS

start	The array index at which to begin the search. -1 starts searching the RAM entries.
servermask	The server making the request (e.g., `SERVER_HTTP`).

RETURN VALUE

`-1`: Failure.
≥`0`: Success, index of requested `ServerSpec` structure.

SEE ALSO

`sspec_findname, sspec_gettype`

sspec_getfileloc

```
long sspec_getfileloc( int sspec );
```

DESCRIPTION

Gets the location in memory or in the file system of a file represented by a `ServerSpec` structure. The location of the file is returned as a long, even if the file location should be represented by a `char*` (for a root file) or a `FileNum` (for the filesystem). The return value should be cast to the appropriate type by the user.

`sspec_getfiletype()` can be used to find the file type.

PARAMETERS

`sspec` spec index of the file in the resource list

RETURN VALUE

≥`0`: Success, location of the file.
`-1`: Failure.

SEE ALSO

`sspec_getfiletype, sspec_getlength`

sspec_getfiletype

```
word sspec_getfiletype( int sspec );
```

DESCRIPTION

Get the type of a file represented by the given spec index.

PARAMETERS

sspec spec index of the file in the resource list, that is, the index into the array of ServerSpec structures.

RETURN VALUE

SSPEC_ROOTFILE: root memory data
SSPEC_XMEMFILE: xmem data
SSPEC_ZMEMFILE: compressed xmem data
SSPEC_FSFILE: FS2 file
SSPEC_ERROR: failure - not a file, or invalid handle

SEE ALSO

sspec_getfileloc, sspec_gettype

sspec_getformtitle

```
char *sspec_getformtitle( int form );
```

DESCRIPTION

Gets the title for an automatically generated form.

PARAMETERS

form server_spec index of the form.

RETURN VALUE

NULL: Failure.
!NULL: Success, title string.

SEE ALSO

sspec_setformtitle

sspec_getfunction

```
void *sspec_getfunction( int sspec );
```

DESCRIPTION

Returns a pointer to the function represented by the sspec index. The entry must have been created as a SSPEC_FUNCTION or as a SSPEC_CGI.

PARAMETERS

sspec spec index

RETURN VALUE

NULL: Failure.
!NULL: Success, pointer to requested function.

SEE ALSO

sspec_addfunction

sspec_getfvdesc

```
char *sspec_getfvdesc( int form, int var );
```

DESCRIPTION

Gets the description of a variable that is displayed in the HTML form table.

PARAMETERS

form	spec index of the form.
var	Index (into the FormVar array) of the variable.

RETURN VALUE

NULL: Failure.
!NULL: Success, description string.

SEE ALSO

sspec_setfvdesc

sspec_getfventrytype

```
int sspec_getfventrytype( int form, int var );
```

DESCRIPTION

Gets the type of form entry element that should be used for the given variable.

PARAMETERS

form	spec index of the form.
var	Index (into the FormVar array) of the variable.

RETURN VALUE

-1: Failure;
Type of form entry element on success:
HTML_FORM_TEXT is a text box.
HTML_FORM_PULLDOWN is a pull-down menu.

SEE ALSO

sspec_setfventrytype

sspec_getfvlen

```
int sspec_getfvlen( int form, int var );
```

DESCRIPTION

Gets the length of a form variable (the maximum length of the string representation of the variable).

PARAMETERS

form	spec index of the form.
var	Index (into the FormVar array) of the variable.

RETURN VALUE

-1: Failure.
≥0: Success, length of the variable.

SEE ALSO

sspec_setfvlen

sspec_getfvname

```
char *sspec_getfvname( int form, int var );
```

DESCRIPTION

Gets the name of a variable that is displayed in the HTML form table.

PARAMETERS

form	spec index of the form.
var	Index into the array of `FormVar` structures of the variable.

RETURN VALUE

`NULL`: Failure.
`!NULL`, name of the form variable.

SEE ALSO

`sspec_setfvname`

sspec_getfvnum

```
int sspec_getfvnum( int form );
```

DESCRIPTION

Gets the number of variables in a form.

PARAMETERS

form spec index of the form.

RETURN VALUE

-1: Failure.
≥0: Success, number of form variables.

sspec_getfvopt

```
char *sspec_getfvopt( int form, int var, int option );
```

DESCRIPTION

Gets the numbered option (starting from 0) of the form variable. This function is only valid if the form variable has the option list set.

PARAMETERS

form	spec index of the form.
var	Index into the array of FormVar structures of the variable.
option	Index of the form variable option.

RETURN VALUE

NULL: Failure.
!NULL: Success, form variable option.

SEE ALSO

sspec_setfvoptlist, sspec_getfvoptlistlen

sspec_getfvoptlistlen

```
int sspec_getfvoptlistlen( int form, int var );
```

DESCRIPTION

Gets the length of the options list of the form variable. This function is only valid if the form variable has the option list set.

PARAMETERS

form	spec index of the form.
var	Index (into the FormVar array) of the variable.

RETURN VALUE

-1: Failure.
>0: Success, length of the options list.

SEE ALSO

sspec_getfvopt, sspec_setfvoptlist

sspec_getfvreadonly

```
int sspec_getfvreadonly( int form, int var );
```

DESCRIPTION

Checks if a form variable is read-only.

PARAMETERS

form	spec index of the form.
var	Index (into the `FormVar` array) of the variable.

RETURN VALUE

`0`: Not read-only.
`1`: Read-only.
`-1`: Failure.

SEE ALSO

`sspec_setfvreadonly`

sspec_getfvspec

```
int sspec_getfvspec( int form, int var );
```

DESCRIPTION

Gets the `server_spec` index of a variable in a form.

PARAMETERS

form	`server_spec` index of the form.
var	Index into the array of `FormVar` structures of the variable.

RETURN VALUE

`-1`: Failure.
≥`0`: Success, index of the form variable in the resource list.

SEE ALSO

`sspec_addfv`

sspec_getlength

```
long sspec_getlength( int sspec );
```

DESCRIPTION

Gets the length of the file associated with the specified `ServerSpec` structure. Get the length of the file specified by the sspec index. Note that compressed files (`#zimport`) return -1 because their expanded length is not known until they are processed.

PARAMETERS

`sspec` spec index of file in resource list

RETURN VALUE

`-1`: Failure (compressed file, or other type whose effective length is not known).
≥`0`: Success, length of the file in bytes.

SEE ALSO

`sspec_readfile, sspec_getfileloc`

sspec_getMIMEtype

```
MIMETypeMap *sspec_getMIMEtype( char* name, ServerContext *context);
```

DESCRIPTION

Return the MIME type information for a specified resource name, in the given server context.

Note that the available MIME types are set up by defining a global variable (or constant) table using the definition (for example),

```
const MIMETypeMap http_types[] =
{
   { ".html", "text/html", NULL},
   { ".gif", "image/gif", NULL}
};
```

The name `http_types` is required for backward compatibility even though servers other than HTTP can make use of MIME types.

When searching for the appropriate type, the rule table is consulted first. Only if this results in a NULL MIME type pointer is the `http_types` table consulted.

See `sspec_open()` for a detailed description of the parameters.

PARAMETER

`name` Name of the resource.

`context` Current server context.

RETURN VALUE

Pointer to the appropriate table entry. `MIMETypeMap` is defined as:

```
typedef struct {
   char extension[10];         // File extension or suffix.
   char type[SSPEC_MAXNAME];   // MIME type e.g., "text/html"
   int (*fptr)();              // Server-specific processing, e.g., SSI.
} MIMETypeMap;
```

A valid pointer is always returned. If the appropriate table entry cannot be located by the resource's extension (or using a rule (see `sspec_addrule`)) then the first table entry is returned.

SEE ALSO

`sspec_addrule`

sspec_getname

```
char * sspec_getname( int sspec );
```

DESCRIPTION

Returns the name of the spec entry represented by the sspec index. This only works for RAM and flash table entries.

PARAMETERS

sspec spec index

RETURN VALUE

NULL: Failure.
!NULL: Success, pointer to name string.

sspec_getpermissions

```
int sspec_getpermissions( int sspec, char ** realm,  word *
   readgroups, word * writegroups, word * servermask, word * method,
   MIMETypeMap ** mimetype );
```

DESCRIPTION

Get the permission (access control) attributes of a resource.

Except for `sspec`, all parameters are pointers to variables that will be set to the appropriate return value. If the parameter is NULL, then that information is not retrieved.

> **NOTE:** The data at `**realm` and `**mimetype` should not be altered by the caller. The data is read-only.

PARAMETERS

sspec	spec index
realm	Pointer to pointer to realm string
readgroups	Pointer to mask of user groups who have read access
writegroups	Pointer to mask of user groups who have write access
servermask	Pointer to servers allowed to access this resource.
method	Pointer to required authentication method.
mimetype	Pointer to pointer to MIME table entry.

RETURN VALUE

`0`: Success.
`<0`: Failure. For example, an invalid sspec handle

SEE ALSO

`sspec_setpermissions, sspec_checkpermissions, sspec_access`

sspec_getpreformfunction

```
void *sspec_getpreformfunction( int form );
```

DESCRIPTION

Gets the user function that will be called just before HTML form generation. This function is useful mainly for custom form generation functions.

PARAMETERS

form spec index of the form

RETURN VALUE

NULL: No user function.
!NULL: Pointer to user function.

SEE ALSO

sspec_setpreformfunction, sspec_setformfunction

sspec_getrealm

```
char *sspec_getrealm( int sspec );
```

DESCRIPTION

Returns the realm of the spec entry represented by `sspec`.

PARAMETERS

`sspec` spec index

RETURN VALUE

`NULL`: Failure.
`!NULL`: Success, pointer to the realm string.

SEE ALSO

`sspec_setrealm`

sspec_getservermask

```
int sspec_getservermask( int sspec, word *servermask );
```

DESCRIPTION

Gets the server mask for the given spec entry. This is the bitmask passed in when the entry is created with the `sspec_add*()` functions.

This function only works for RAM and flash table entries.

PARAMETERS

sspec	spec index of the variable
servermask	Address in which the `servermask` will be returned

RETURN VALUE

`0`: Success
`-1`: Failure

sspec_gettype

```
word sspec_gettype( int sspec );
```

DESCRIPTION

Returns the type (SSPEC_FILE, SSPEC_VARIABLE, etc.) of the spec entry represented by sspec. This is a generic type, in that, SSPEC_FILE is returned for any type (SSPEC_ROOTFILE, SSPEC_FSFILE etc.) that has file properties and SSPEC_VARIABLE is returned for SSPEC_ROOTVAR or SSPEC_XMEMVAR. Other types are returned without translation.

PARAMETERS

sspec spec index

RETURN VALUE

SSPEC_ERROR: Failure.
!SSPEC_ERROR: Success, type as described above.

SEE ALSO

sspec_getfiletype, sspec_getvartype

sspec_getuserid

```
int sspec_getuserid( int sspec, int index );
```

DESCRIPTION

Returns a userid for the given `sspec` resource. Since a resource can have multiple userids associated with it, `index` indicates which userid should be returned. Note that `index` should follow the relation $0 \leq$ `index` < `SSPEC_USERSPERRESOURCE`.

If there is no userid for a given index, -1 will be returned. If -1 is returned for an index, then -1 will also be returned for all higher indices.

This function may be used to iterate through all users that have read access to a particular resource.

This only works for RAM and flash table entries.

Starting with Dynamic C 8.50, access control is done by user groups rather than individual users; therefore, `sspec_getuserid()` may not work as expected.

PARAMETERS

sspec	spec index
index	index of userid for this `sspec` resource to return: 0, 1, 2 ...

RETURN VALUE

`-1`: Error, or no such userid.
$\geq$ `0`: Success, userid is returned.

SEE ALSO

`sspec_getusername, sauth_getusername`

sspec_getusername

```
char *sspec_getusername( int sspec );
```

DESCRIPTION

Gets the `username` field of the first user in the user table that has read access to the resource indexed by sspec. If multiple users are associated with this resource, the first user's username will be returned. See `sspec_getuserid()` to get all userids for a resource, and `sauth_getusername()` to convert the userids to usernames.

Starting with Dynamic C 8.50, access control is done by groups rather than individual users, therefore, `sspec_getusername()` may not work as expected.

This only works for RAM and flash table entries.

PARAMETERS

sspec spec index

RETURN VALUE

`NULL`: Failure, or no user has read access to this resource.
`!=NULL`: Success, pointer to `username`.

SEE ALSO

`sauth_adduser, sspec_setuser, sauth_getuserid, sauth_getusername`

sspec_getvaraddr

```
void *sspec_getvaraddr( int sspec );
```

DESCRIPTION

Returns a pointer to the requested variable in the resource list.

PARAMETERS

sspec spec index

RETURN VALUE

NULL: Failure.
!NULL: Success, pointer to variable.

SEE ALSO

sspec_readvariable

sspec_getvarkind

```
word sspec_getvarkind( int sspec );
```

DESCRIPTION

Returns the kind of variable represented by `sspec`.

PARAMETERS

`sspec` spec index

RETURN VALUE

`0`: Failure.
On success, returns one of:

- INT8 - single character
- INT16 - 2-byte integer
- PTR16 - string in root memory
- INT32 - 4-byte (long) integer
- FLOAT32 - floating point variable

SEE ALSO

`sspec_getvaraddr, sspec_getvartype, sspec_gettype`

sspec_getvartype

```
word sspec_getvartype( int sspec );
```

DESCRIPTION

Gets the type of variable represented by the spec index.

PARAMETERS

sspec spec index.

RETURN VALUE

SSPEC_ERROR: Failure.
SSPEC_ROOTVAR or SSPEC_XMEMVAR: Success.

SEE ALSO

sspec_getvaraddr, sspec_getvarkind, sspec_gettype

sspec_getxvaraddr

```
long sspec_getxvaraddr( int sspec );
```

DESCRIPTION

Returns a pointer to the variable in xmem represented by the sspec index.

PARAMETER

sspec spec index

RETURN VALUE

≥ 0: Variable pointer.
-1: Failure.

SEE ALSO

sspec_readvariable

sspec_mkdir

```
int sspec_mkdir( char * name, ServerContext * context );
```

DESCRIPTION

Create a named directory in the FAT filesystem.

PARAMETERS

name	Name of new directory.
context	Current server context.

RETURN VALUE

`0`: OK.
`-EPERM`: Not a filesystem that supports creation of new directories.
`-EACCES`: Not authorized
Any other negative values indicate an error.

SEE ALSO

`sspec_delete, sspec_rmdir, sspec_open`

sspec_needsauthentication

```
int sspec_needsauthentication( int sspec );
```

DESCRIPTION

Checks if the item represented by the spec entry needs authentication for access. This is defined by having a non-NULL "realm" string for the resource.

This function is deprecated starting with Dynamic C 8.50 in favor of `sspec_checkpermissions()`. It is retained for cases where the permissions structure for a resource contains an authentication method of `SERVER_AUTH_DEFAULT`.

PARAMETERS

`sspec` spec index

RETURN VALUE

`0`: Does NOT need authentication.
`1`: Does need authentication.
`-1`: Failure, no permissions struct assigned or invalid sspec handle.

SEE ALSO

`sspec_getrealm, sspec_checkpermissions`

sspec_open

```
int sspec_open( char * name, ServerContext * context, word mode);
```

DESCRIPTION

Open a file resource by name. The name may refer to a flash- or RAM-spec entry, or may be the name of a file in a filesystem.

The resource namespace is specified as a directory hierarchy, similar to a Unix-like filesystem. The root directory, "/", is the base for all named resources.

If `fs2.lib` is included, then files stored in the FS2 filesystem are accessible under a mount point called "`/fs2`." FS2 files do not have native names. Instead, each file is numbered from 1 to 255. Zserver assigns names to FS2 files by appending the file number (in decimal) to the string "file." For example, FS2 file number 99 has a complete resource name of "/fs2/file99."

If `fat.lib` is included, then all DOS FAT files are mounted under a drive letter. The first partition of the first DOS FAT filesystem is called "/A" and the second partition (if any) is called "/B" etc. For example, if the FAT filesystem has a file called "/system/admin.htm" then the complete resource name will be "/A/system/admin.htm".

> **NOTE:** Forward slashes are required. Do not use backslashes as is customary with DOS filesystems.

If the resource name does not begin with "/fs2" or "/A" etc., then the resource is located in the static resource table ("flashspec" that is, the `http_flashspec` global table) or in the dynamic (RAM) table.

To access the file resource, the return value from this function must be passed to other functions, such as `sspec_read()`. A few functions do not work with resources opened with this function. These cases are documented with the function.

> **NOTE:** When the application has finished accessing the resource, it must be closed using `sspec_close()`. This must be done because there is a limited amount of storage for maintaining the necessary file handles.

PARAMETERS

`name` Resource name, as a NULL terminated string. This name is assumed to be relative to `context->cwd` if it does not begin with a "`/`" character. Otherwise, the name is assumed to be relative to `context->rootdir`. Note that the name string can contain "`.`" and "`..`" directory components. These will be interpreted as "same directory" and "one level up" as is customary. If "`..`" components are included, the resulting name cannot be above or outside the root directory specified in `context->rootdir`.

context Additional context information. The `ServerContext` structure is set up by the caller. It has the following fields:

```
typedef struct {
      int userid;         // User ID of the current user, or
                          // -1 if not applicable.
      word server;        // Server id (e.g. SERVER_HTTP)
      char * rootdir;     // Root directory. Usually "/"
                          // if the whole namespace is to
                          // be accessible. Otherwise, may
                          // be e.g,. "/A" to restrict access to
                          // just first DOS FAT partition.
                          // First and last char must be “/”.
      char cwd[];         // Current working directory.
                          // Normally includes rootdir as
                          // a prefix. First and last char
                          // must be “/”.
      char * dfltname;    // A file name to be used as a
                          // resource name suffix in the case
                          // that the first parameter refers
                          // to a directory name.
   } ServerContext;
```

mode Resource opening mode. Bitwise OR of the following macros:

- `O_READ`: open for reading
- `O_WRITE`: open for writing (implies reading as well)
- `O_CREAT`: with `O_WRITE`, if file does not exist then create it with zero length and allocation.
- `O_TRUNC`: with `O_WRITE`, if file already exists, truncate it to zero length.
- `O_APPEND`: with `O_WRITE`, if file already exists, position at end of file so as to append new data. You can later seek to the existing portion of the file.

sspec_open (cont.)

RETURN VALUE

≥0: Success. The returned value should be passed to other functions that require a general handle, such as sspec_read(), sspec_seek(), sspec_write(), sspec_tell(), and sspec_close().

The following return values are negatives of the values defined in errno.lib.

- -ENOENT: The resource was not found when it was expected to exist.
- -EACCES: The context->userid field was not -1, and the specified user is not allowed to access the resource using the specified mode.
- -EINVAL: The resource name was malformed (e.g., too long), or context was NULL, or the resource was not a file type, or O_CREAT, O_TRUNC or O_APPEND were specified without O_WRITE.
- -ENOMEM: Insufficient storage for handle or buffers. Increase definition of SSPEC_MAX_OPEN.
- -EPERM: Operation not permitted, for example., opening an xmem file for writing.

SEE ALSO

sspec_read, sspec_write, sspec_seek, sspec_tell, sspec_close

sspec_pwd

```
char * sspec_pwd( ServerContext * context, char * buf );
```

DESCRIPTION

Print the current working directory in the `ServerContext` structure to the specified buffer. The `context->cwd` field contains the CWD. This function removes the root directory component (`context->rootdir`) and copies the result. This makes `rootdir` invisible to the end user.

The leading slash is included, but the trailing slash is omitted from the result (unless the result is just "`/`").

For example, if
`context->rootdir` points to "`/A/`" and
`context->cwd[]` contains "`/A/ftpfiles/`"
"`/ftpfiles`" will be the result returned in `buf`.

PARAMETERS

`context` Server context structure. Two fields in this are of interest: `rootdir` points to a virtual root directory for this server, and `cwd` is a character array containing the CWD.

`buf` Points to buffer that is filled with resulting string. This buffer is assumed to be dimensioned at least `SSPEC_MAXNAME` chars long, and it will be null terminated on return.

RETURN VALUE

The `buf` parameter is returned.

SEE ALSO

`sspec_cd`

sspec_read

```
int sspec_read( int sspec, char * buf, int len );
```

DESCRIPTION

Read the next byte(s) from the given file resource.

PARAMETERS

sspec Open file handle. This must be a handle that was returned by `sspec_open()`.

buf Buffer into which data is copied.

len Length of the above buffer. If `len` is zero, then the return value will be the minimum number of characters that could be read at the current position, which is usually at least 1 except at EOF (0). Thus, this function can be used to test for end-of-file (EOF), that is, if

```
(sspec_read(sspec, NULL, 0) == 0)
```

is TRUE, then EOF has been reached in the file identified by `sspec`.

RETURN VALUE

`0`: No data is currently available. If the `len` parameter was zero, then a return value of zero definitely means end-of-file has been reached. If `len` > 0, there may be data available in the future, e.g., because the underlying filesystem is socket-based and this host has read all available data, but the socket is still open to receive more data.

`1..len`: the specified number of characters has been copied to the supplied buffer, and the current file position has been advanced by that many bytes. Possibly less than `len` bytes may be read, in which case the server should test for EOF.

`>len`: no data was copied, because the underlying filesystem is unable to return a partial record and maintain its current position. The return value is the minimum sized buffer that should be passed on the next call. Note: this sort of return is not currently implemented by any of the file systems, however servers should be coded to handle this case for future anticipated systems which have record-level access rather than byte-level.

The following return values are negatives of the values defined in `errno.lib`.

- `-EINVA`: `len` parameter was < 0.
- `-EBADF`: The specified handle was not open or invalid.
- Any other negative values indicate an error.

SEE ALSO

`sspec_close, sspec_write, sspec_seek, sspec_tell, sspec_open, sspec_readchr`

sspec_readchr

```
int sspec_readchr(int sspec, char far * buf, int len, char delim);
```

DESCRIPTION

Read the next byte(s) from the given resource, until specified delimiter is read and transferred to buffer. If EOF is encountered before reading a delimiter char, then the buffer may not be terminated with the delimiter char. Similarly if the delimiter was not found before the given buffer was full. The buffer is *not* null terminated.

PARAMETERS

sspec	Open file handle. This must be a handle returned by `sspec_open()`.
buf	Buffer into which data is copied.
len	Length of the above buffer.
delim	Delimiter character.

RETURN VALUE

`0`: No data is currently available.
`1..len`: The specified number of characters has been copied to the supplied buffer, and the current file position has been advanced by that many bytes. Less than “len” bytes may be read, in which case the server should test for EOF.
`>len`: No data was copied because the underlying filesystem is unable to return a partial record and maintain its current position. The return value is the minimum sized buffer which should be passed on the next call. Note: this sort of return is not currently implemented by any of the file systems, however servers should be coded to handle this case for future anticipated systems which have record-level access rather than byte-level.

The following return values are negatives of the values defined in "errno.lib":
`-EINVAL`: len parameter was < 0.
`-EBADF`: The specified handle was not open or invalid.
Any other negative values indicate an error.

SEE ALSO

`sspec_close, sspec_read, sspec_seek, sspec_tell, sspec_open`

sspec_readfile

```
int sspec_readfile( int sspec, char *buffer, long offset, int len );
```

DESCRIPTION

Read a file (represented by the `sspec` index) into `buffer`, starting at `offset`, and only copying `len` bytes. For xmem files, this function automatically skips the first 4 bytes. Hence, an offset of 0 marks the beginning of the file contents, not the file length.

This function is intended for file types that do not require explicit open or close calls, that is, root or xmem files. It can also be called for FS2 files, but this is not recommended since each call requires the file to be opened, seeked, read then closed. Instead, use `sspec_open()`, `sspec_read()` and `sspec_close()` calls which are the most efficient.

`sspec_readfile()` has the advantage of being "stateless," but the price to pay is great loss of efficiency (especially when sequential access is all that is required).

This function will NOT work for compressed xmem files or DOS FAT files.

PARAMETERS

sspec	spec index
buffer	The buffer to put the file contents into.
offset	The offset from the start of the file, in bytes, at which copying should begin.
len	The number of bytes to copy.

RETURN VALUE

`-1`: Failure.
≥`0`: Success, number of bytes copied.

SEE ALSO

`sspec_getlength, sspec_getfileloc`

sspec_readvariable

```
int sspec_readvariable( int sspec, char *buffer );
```

DESCRIPTION

Formats the variable associated with the specified `ServerSpec` structure, and puts a `NULL`-terminated string representation of it in `buffer`. The macro `SSPEC_XMEMVARLEN` (default is 20) defines the size of the stack-allocated buffer when reading a variable in xmem.

PARAMETERS

sspec	spec index
buffer	The buffer in which to put the variable.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_getvaraddr`

sspec_remove

```
int sspec_remove( int sspec );
```

DESCRIPTION

Removes a spec entry (by marking it unused). In the case of files, note that this function does not actually remove the file, only the reference to the file in the spec structure.

This only works for RAM table entries.

PARAMETERS

sspec spec index

RETURN VALUE

0: Success.
-1: Failure (i.e., the index is already unused).

sspec_removerule

```
int sspec_removerule( char * pfx );
```

DESCRIPTION

Remove a rule from the dynamic resource rule table.

PARAMETER

pfx	Prefix of resource name. This must be an exact match to one of the rules previously added using `sspec_addrule()`.

RETURN VALUE

≥`0`: OK
`-1`: Error. For example, the rule was not found, or maybe the rule was in the flash table (`f_rule_table`).

SEE ALSO

`sspec_addrule`

sspec_removeuser

```
int sspec_removeuser( int sspec, int userid );
```

DESCRIPTION

Removes the user group(s) that `userid` belongs to from the read and write access masks for the specified resource. This will deny access to other users who have the same group(s) as the current user.

This function is deprecated as of Dynamic C 8.50. Use the more general `sspec_setpermissions()` function instead.

PARAMETERS

sspec spec index

userid user index

RETURN VALUE

`0`: Success, user was removed.
`-1`: Failure, no such `userid` found.

SEE ALSO

`sspec_setuser, sspec_adduser, sspec_getusername, sspec_getuserid, sspec_setpermissions`

sspec_resizerootfile

```
int sspec_resizerootfile( int spec_index, int new_size );
```

DESCRIPTION

Change the byte size of a SSPEC item stored in root memory. Item must be a `ROOTFILE`, thus the item must have been created with `sspec_addrootfile()`.

PARAMETERS

`spec_index` spec index of the item

`new_size` New size to assign to item.

RETURN VALUE

≥`0`: Successfully adjust size of item.
`-1`: Failed to adjust size.

SEE ALSO

`sspec_addrootfile`

sspec_restore

```
int sspec_restore( void );
```

DESCRIPTION

Restores the TCP/IP servers' object list and the TCP/IP users list (and some user-specified data if set up with `sspec_setsavedata()`) from the file system. This does not restore the actual files and variables, but only the structures that reference them. If the files are stored in flash, then the references will still be valid. Files in volatile RAM and variables must be rebuilt through other means.

RETURN VALUE

`0`: Successfully restored the server_spec and server_auth tables.
`-1`: Failure.

SEE ALSO

`sspec_save, sspec_setsavedata`

sspec_rmdir

```
int sspec_rmdir( char * name, ServerContext * context );
```

DESCRIPTION

Delete a named directory in the FAT filesystem.

PARAMETERS

name	Name of directory to delete.
context	Current server context.

RETURN VALUE

`0`: OK.
`-EPERM`: Not a filesystem that supports deletion of directories.
`-EACCES`: Not authorized

Any other negative values indicate an error.

SEE ALSO

`sspec_delete, sspec_mkdir, sspec_open`

sspec_save

```
int sspec_save( void );
```

DESCRIPTION

Saves the servers' object list and server authorization list (along with some user-specified data if set up with `sspec_setsavedata()`) to the file system. This does not save the actual files and variables, but only the structures that reference them. If the files are stored in flash, then the references will still be valid. Files in volatile RAM and variables must be rebuilt through other means.

RETURN VALUE

`0`: Successfully save the server_spec and server_auth tables.
`-1`: Failure.

SEE ALSO

`sspec_restore, sspec_setsavedata`

sspec_seek

```
int sspec_seek( int sspec, long offset, int whence );
```

DESCRIPTION

Seek to specified offset in the file resource. The next `sspec_read()` or `sspec_write()` call will start at this position.

Note that offsets that are not in the file are *clamped* to the start or end of the file as appropriate.

Clamp is terminology meaning that a value past the end is set to the end, or a value before the beginning is set to the beginning. For example, if a file is actually 10 bytes, then seek to position 20 is actually a seek to position 10. Likewise, seek to -20 is set to position 0.

PARAMETERS

sspec	Open file handle. This must be a handle that was returned by `sspec_open()`.
offset	Byte offset.
whence	Reference point for seek. One of the following constants: • `SEEK_SET`: start of file, offset should be non-negative. • `SEEK_CUR`: current position in file, offset may be negative, zero, or positive. • `SEEK_END`: end of file, offset should be non-positive to stay within the file.

RETURN VALUE

0: OK.

The following return values are negatives of the values defined in `errno.lib`.

- `-EINVAL`: `whence` parameter was invalid.
- `-EBADF`: The specified handle was not open or invalid.
- `-EPERM`: Operation not permitted on this file resource. This is usually because the resource is not seekable (such as a compressed file).
- Any other negative values indicate an error.

SEE ALSO:

`sspec_close, sspec_write, sspec_read, sspec_tell, sspec_open`

sspec_setformepilog

```
int sspec_setformepilog( int form, int function );
```

DESCRIPTION

Sets the user-specified function that will be called when the form has been successfully submitted. This function can, for example, execute a `cgi_redirectto` to redirect to a specific page. It should accept `HttpState *state` as an argument, return 0 when it is not finished, and 1 when it is finished (i.e., behave like a normal CGI function).

PARAMETERS

form	spec index of the form
function	spec index of the function to call when the specified form has been successfully submitted. This is the return value of the function `sspec_addfunction()`.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_setformprolog`

sspec_setformfunction

```
int sspec_setformfunction( int form, void (*fptr)() );
```

DESCRIPTION

Sets the function that will generate the form.

PARAMETERS

form	spec index of the form.
fptr	Form generation function (NULL for the default function).

RETURN VALUE

0: Success.
-1: Failure.

sspec_setformprolog

```
int sspec_setformprolog( int form, int function );
```

DESCRIPTION

Allows a user-specified function to be called just before form variables are updated. This is useful for implementing locking on the form variables (which can then be unlocked in the epilog function), so that other code will not update the variables during form processing. The user-specified function should accept `HttpState *state` as an argument, return 0 when it is not finished, and 1 when it is finished (i.e., behave like a normal CGI function).

PARAMETERS

`form` spec index of the form

`function` spec index of the function. This is the return value of `sspec_addfunction()`.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_setformepilog`

sspec_setformtitle

```
int sspec_setformtitle( int form, char *title );
```

DESCRIPTION

Sets the title for an automatically generated form.

PARAMETERS

form	spec index of the form.
title	Pointer to the title of the HTML page.

RETURN VALUE

0: Success.
-1: Failure.

SEE ALSO

sspec_getformtitle

sspec_setfvcheck

```
int sspec_setfvcheck( int form, int var, int (*varcheck)() );
```

DESCRIPTION

Sets a function that can be used to check the integrity of a variable. The function should return 0 if there is no error, or !0 if there is an error.

PARAMETERS

form	spec index of the form.
var	Index (into the `FormVar` array) of the variable.
varcheck	Pointer to integrity-checking function.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_setfvfloatrange, sspec_setfvoptlist, sspec_setfvrange`

sspec_setfvdesc

```
int sspec_setfvdesc( int form, int var, char *desc );
```

DESCRIPTION

Sets the description of a variable that is displayed in the HTML form table.

PARAMETERS

form	`server_spec` index of the form.
var	Index (into the `FormVar` array) of the variable.
desc	Description of the variable. This text will display on the HTML page.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_getfvdesc`

sspec_setfventrytype

```
int sspec_setfventrytype( int form, int var, int entrytype );
```

DESCRIPTION

Sets the type of form entry element that should be used for the given variable.

PARAMETERS

form	spec index of the form.
var	Index (into the FormVar array) of the variable.
entrytype	HTML_FORM_TEXT for a text box, HTML_FORM_PULLDOWN for a pull-down menu. The default is HTML_FORM_TEXT.

RETURN VALUE

0: Success.
-1: Failure.

SEE ALSO

sspec_getfventrytype

sspec_setfvfloatrange

```
int sspec_setfvfloatrange( int form, int var, float low, float high);
```

DESCRIPTION

Sets the range of a float variable.

PARAMETERS

form	spec index of the form.
var	Index (into the `FormVar` array) of the variable.
low	Minimum value of the variable.
high	Maximum value of the variable.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_setfvrange, sspec_setfvoptlist`

sspec_setfvlen

```
int ( int form, int var, int len );
```

DESCRIPTION

Sets the length of a form variable (the maximum length of the string representation of the variable). Note that for string variables, `len` should include the NULL terminator.

PARAMETERS

form	spec index of the form.
var	Index (into the `FormVar` array) of the variable.
len	Length of the variable.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_getfvlen`

sspec_setfvname

```
int sspec_setfvname( int form, int var, char *name );
```

DESCRIPTION

Sets the name of a variable that is displayed in the HTML form.

PARAMETERS

form	spec index of the form
var	Index (into the FormVar array) of the variable.
name	Display name of the variable.

RETURN VALUE

0: Success.
-1: Failure.

SEE ALSO

sspec_getfvname

sspec_setfvoptlist

```
int sspec_setfvoptlist( int form, int var, char *list[], int listlen
   );
```

DESCRIPTION

Sets an enumerated list of possible values for a string variable.

PARAMETERS

form	spec index of the form.
var	Index (into the `FormVar` array) of the variable.
list[]	Array of string values that the variable can assume.
listlen	Length of the array.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_getfvopt, sspec_getfvoptlistlen, sspec_setfvfloatrange, sspec_setfvrange`

sspec_setfvrange

```
int sspec_setfvrange( int form, int var, long low, long high );
```

DESCRIPTION

Sets the range of an integer variable.

PARAMETERS

form	spec index of the form.
var	Index (into the `FormVar` array) of the variable.
low	Minimum value of the variable.
high	Maximum value of the variable.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_setfvfloatrange, sspec_setfvoptlist`

sspec_setfvreadonly

```
int sspec_setfvreadonly( int form, int var, int readonly );
```

DESCRIPTION

Sets the form variable to be read-only.

PARAMETERS

form	spec index of the form.
var	Index (into the `FormVar` array) of the variable.
readonly	`0` for read/write (this is the default); `1` for read-only.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_getfvreadonly`

sspec_setpermissions

```
int sspec_setpermissions( int sspec, char * realm, word readgroups,
   word writegroups, word servermask, word method, MIMETypeMap *
   mimetype);
```

DESCRIPTION

Set the permission (access control) attributes of a resource.

This only works for RAM table entries. For entries in a filesystem, use `sspec_addrule()`.

PARAMETERS

sspec	spec index
realm	Realm string, or NULL
readgroups	Mask of user groups who have read access
writegroups	Mask of user groups who have write access
servermask	Servers that can access this resource (or SERVER_ANY for all servers).
method	Required authentication method (0, SERVER_AUTH_BASIC etc.)
mimetype	MIME table entry, or NULL.

RETURN VALUE

0: Success.
<0: Failure. For example, not a RAM spec handle.

SEE ALSO

sspec_checkpermissions, sspec_getpermissions, sspec_access

sspec_setpreformfunction

```
int sspec_setpreformfunction( int form, void (*fptr)() );
```

DESCRIPTION

Sets a user function that will be called just before form generation. The user function is not called when the form is being generated because of errors in the form input. The user function must have the following prototype:

```
void userfunction(int form);
```

The function may not use the `form` parameter, but it is useful if the same user function is used for multiple forms.

PARAMETERS

form	spec index of the form.
fptr	Pointer to user function to be called just before form generation

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_getpreformfunction`

sspec_setrealm

```
int sspec_setrealm( int sspec, char *realm );
```

DESCRIPTION

Sets the realm field of a `ServerSpec` structure for HTTP authentication purposes. Setting this field enables authentication for the given spec entry. Authentication can be turned off again by passing "" as the `realm` parameter to this function.

Note: `realm` must NOT point to an auto variable, since only the pointer is stored. The string is NOT copied.

PARAMETERS

sspec	spec index - this must refer to the RAM resource table
realm	Name of the realm.

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sspec_getrealm`

sspec_setsavedata

```
int sspec_setsavedata( char *data, unsigned long len, void *fptr );
```

DESCRIPTION

Sets user-supplied data that will be saved in addition to the spec and user authentication tables when `sspec_save()` is called.

PARAMETERS

data	Pointer to location of user-supplied data.
len	Length of the user-supplied data in bytes.
fptr	Pointer to a function that will be called when the user-supplied data has been restored.

RETURN VALUE

`0`: Successfully set up the user-supplied data.
`-1`: Failure.

SEE ALSO

`sspec_save, sspec_restore`

sspec_setuser

```
int sspec_setuser( int sspec, int userid );
```

DESCRIPTION

Set the read permission mask of a spec entry (usually a file). The permissions for this resource are set to readable only by the group(s) which this user is a member of. Write access is set to "none."

This function is deprecated in Dynamic C 8.50. Use `sspec_setpermissions()` instead.

PARAMETERS

sspec	spec index - this must refer to a RAM resource
userid	user index

RETURN VALUE

`0`: Success.
`-1`: Failure.

SEE ALSO

`sauth_adduser, sspec_getusername, sspec_setpermissions`

sspec_stat

```
int sspec_stat( char * name, ServerContext * context, SSpecStat * s);
```

DESCRIPTION

Get information about a resource by name. The name may refer to a flash- or ram-spec entry, or may be the name of a file in a filesystem. See `sspec_open()` for a more detailed description of the name and context parameters.

PARAMETERS

`name` Resource name, as a null-terminated string. This name is assumed to be relative to `context->cwd` if it does not begin with a "`/`" character. Otherwise, the name is assumed to be relative to `context->rootdir`.

`context` Additional context information. The `ServerContext` structure is set up by the caller.

`s` Returned data. This is a pointer to the following structure, which will be filled in on return.

```
typedef struct{
      word flags;               // See below.
      long mdtm;                // Date/time-SEC_TIMER format
      long length;              // Current file size
      long maxlength;           // Max allowable file size
      ServerPermissions *perm; //  See below.
   } SSpecStat;
```

The `flags` field can be one of the following:

- `SSPEC_ATTR_MDTM` - Modification date/time
- `SSPEC_ATTR_LENGTH` - Current length
- `SSPEC_ATTR_WRITE` - File is writable
- `SSPEC_ATTR_EXEC` - File is executable
- `SSPEC_ATTR_HIDDEN` - "Hidden" attribute bit
- `SSPEC_ATTR_SYSTEM` - "System" attribute bit
- `SSPEC_ATTR_ARCHIVE` - "Archive" attribute bit
- `SSPEC_ATTR_DIR` - This is directory name
- `SSPEC_ATTR_COMPRESSED` - Compressed format
- `SPEC_ATTR_MAXLENGTH` - Have maximum length
- `SSPEC_ATTR_SEEKABLE` - Randomly accessible
- `SSPEC_ATTR_EXTENSIBLE` - File may be expanded at end

The ServerPermissions structure is defined as follows:

```
typedef struct {
      word readgroups;
      word writegroups;
      word servermask;
      char * realm;
      char method;
   } ServerPermissions;
```

Read (or write) permission is granted for readgroups (or writegroups) if current ServerAuth.mask (i.e., userid entry group mask) matches in at least one bit position.

Bit is set in servermask field for each server that can access the resource.

Realm string of the resource (only used by HTTP server, but can be used for other purposes).

Authentication method(s) allowed: combination of SERVER_AUTH_* bits.

RETURN VALUE

≥0: Success.

The following return values are negatives of the values defined in errno.lib.

- -ENOENT: The resource was not found.
- -EINVAL: The resource name was malformed (for example, too long), or context was NULL, or the resource was not a file type.

SEE ALSO

sspec_open, sspec_delete, sspec_close

sspec_tell

```
long sspec_tell( int sspec );
```

DESCRIPTION

Return the current read/write offset in the file resource. This will be a non-negative value unless there was an error.

PARAMETER

sspec	Open file handle. This must be a handle that was returned by `sspec_open()`.

RETURN VALUE:

≥0: Offset in the file resource.

The following return value is a negative of the value defined in `errno.lib`. Any other negative values indicate an error.
`-EBADF`: The specified handle was not open or invalid.

SEE ALSO:

`sspec_close, sspec_write, sspec_read, sspec_tell, sspec_open`

sspec_write

```
int sspec_write( int sspec, char * buf, int len );
```

DESCRIPTION

Write byte(s) to the given file resource. The data is written to the current position, then the current position is advanced by the number of bytes written.

PARAMETERS

sspec	Open file handle. This must be a handle that was returned by `sspec_open()`.
buf	Buffer from which data is copied.
len	Length of the above buffer.

RETURN VALUE

`0`: No data was written because `len` was zero or because a local buffer is full (e.g., when writing to an underlying filesystem that streams data to a peer).

`1..len`: The specified number of characters has been copied from the supplied buffer, and the current file position has been advanced by that many bytes. Possibly less than `len` bytes may be written, in which case the server should attempt to write the remaining data later.

The following return values are negatives of the values defined in `errno.lib`.

- `-EINVAL`: `len` parameter was < 0.
- `-EBADF`: The specified handle was not open or invalid.
- `-ENOSPC`: There is insufficient space in the underlying filesystem, or the file cannot be extended.
- `-EPERM`: The file resource does not support writing (e.g. xmem files, or a read-only filesystem).

Any other negative values indicate an error.

SEE ALSO

`sspec_close, sspec_read, sspec_seek, sspec_tell, sspec_open`

4. HTTP SERVER

This chapter is intended to be a detailed description of the HTTP server, and how it interfaces to other libraries, such as Zserver and TCP/IP. For an overview of how these libraries interface with one another and with your application, please see Chapter 2., "Web-Enabling Your Application."

An HTTP (Hypertext Transfer Protocol) server makes HTML (Hypertext Markup Language) pages and other resources available to clients (that is, web browsers). HTTP is implemented by `HTTP.LIB`, thus you need to write `#use "http.lib"` near the top of your program. HTTP depends on the Dynamic C networking suite, which is included in your program by writing `#use "dcrtcp.lib"`.

Setting up the network subsystem is a necessary pre-requisite for use of HTTP. This is described in the *Dynamic C TCP/IP User's Manual, Vol. 1*. However, it can be quite simple for test applications and samples to initialize the network subsystem. In the file `tcp_config.lib` are predefined configurations that may be accessed by a #define of the macro `TCPCONFIG`. For instructions on how to set up different configurations, please see the *Dynamic C TCP/IP User's Manual, Vol. 1* or look in the file `\LIB\TCPIP\TCP_CONFIG.LIB`.

HTTP makes use of the Zserver library to manage resources and access control. The previous chapter discusses Zserver. When reading this chapter on the HTTP server, it will help if you are familiar with Zserver, its interfaces and capabilities.

Much of this chapter contains material that could be considered advanced usage. There is also some material of a historical nature, with relevant sections marked as such.

4.1 HTTP Server Data Structures

The single data structure in HTTP.LIB of interest to developers of CGI functions is discussed in this section.

4.1.1 HttpState

Use of the HttpState structure is necessary for CGI functions (whether or not they were written prior to Dynamic C 8.50). Some of the fields are off-limits to developers. The field that are available for use are described in the next section.

Historical note: prior to Dynamic C 8.50, it was sometimes necessary for CGI functions to access directly the fields of this structure. New programs should not directly access the fields, since it reduces the chance of upward compatibility. There is a new suite of macros (see http_getAction() and related macros) that should be used instead. Where applicable, the equivalent macro is documented with the field. Some fields do not have an equivalent macro (such as the cookie field); for now, use read-only access to such fields.

A pointer to HttpState is the first (and only) parameter to all CGI functions. Most of the time, this pointer should be passed on to other HTTP library functions.

Note that the HttpState structure is only valid within a CGI function that has been called from the HTTP server. Outside of this (for example, in your main() function) none of the fields are guaranteed to be meaningful or consistent.

4.1.1.1 HttpState Fields

The fields discussed here are available for developers to use in their CGI functions.

s

This is the socket associated with the given HTTP server. A developer can use this in a CGI function to output dynamic data (although there are better, safer ways of doing this: see the section on "Writing a CGI Function"). Any of the TCP functions can be used; however, you should not use any functions that may wait for long periods, or may change the state or mode of the socket (since the HTTP server depends on it being a normal ASCII mode TCP socket).

It is recommended that you use the http_getSocket() macro instead of directly accessing this field.

substate
subsubstate

Intended for holding the current state of a state machine for a CGI function. That is, if a CGI function relinquishes control back to the HTTP server, then the values in these variables will be preserved for the next http_handler() call, in which the CGI function will be called again. These variables are initialized to 0 before the CGI function is called for the first time. Hence, the first state of a state machine using substate should be 0.

It is recommended that you use the macros http_getState() and http_setState() to manipulate the substate field instead of directly accessing it. subsubstate is not accessible via these macros, but there are better alternatives.

timeout

This value can be used by the CGI function to implement an internal time-out.

main_timeout This value holds the timeout that is used by the web server. The web server checks against this timeout on every call of `http_handler()`. When the web server changes states, it resets `main_timeout`. When it has stayed in one state for too long, it cancels the current processing for the server and goes back to the initial state. Hence, a CGI function may want to reset this timeout if it needs more processing time (but care should be taken to make sure that the server is not locked up forever). This can be achieved like this:

```
state->main_timeout=set_timeout(HTTP_TIMEOUT);
```

`HTTP_TIMEOUT` is the number of seconds until the web server will time out. It is 16 seconds by default.

buffer[] A buffer that the developer can use to put data to be transmitted over the socket. It is of size `HTTP_MAXBUFFER` (defaults to 256 bytes).

Note: It is not recommended to directly access "buffer" or "p" (below). Use the new-style CGI functions and the `http_write()`, `http_getData()` and `http_getDataLength()` functions instead. These create a much easier-to-use and safer method of reading/writing data to the client.

p Pointer into the buffer given above. See above note.

method This should be treated as read-only. It holds the method by which the web request was submitted. The value is either `HTTP_METHOD_GET` or `HTTP_METHOD_POST`, for the GET and POST request methods, respectively.

Use `http_getHTTPMethod()` for new code.

url[] This should be treated as read-only. It holds the URL by which the current web request was submitted. If there is GET-style form information, then that information will follow the first `NULL` byte in the url array. The form information will itself be `NULL`-terminated. If the information in the url array is truncated to `HTTP_MAXURL` bytes, the truncated information is also `NULL`-terminated.

Use `http_getURL()` for new code.

version This should be treated as read-only. This holds the version of the HTTP request that was made. It can be `HTTP_VER_09`, `HTTP_VER_10`, or `HTTP_VER_11` for 0.9, 1.0, or 1.1 requests, respectively.

Use `http_getHTTPVersion()` for new code.

content_type[] This should be treated as read-only. This buffer holds the value from the Content-Type header sent by the client.

Use `http_getContentType()` for new code.

content_length This should be treated as read-only. This variable holds the length of the content sent by the client. It matches the value of the Content-Length header sent by the client.

Use `http_getContentLength()` for new code.

has_form This should be treated as read-only. If the value is 1 there is a GET style form, after the \0 byte in `url[]`.

abort_notify Set to `!0` in user-defined `formprolog()` function to indicate that the `formepilog()` function needs to be called on an abort condition. If the epilog function is reached normally, this field must be set to zero. This prevents the formepilog function from being called one more time on a connection abort.

cancel This should be treated as read-only. It is intended for when the user-defined functions, which may be called before and after an HTML form is submitted, are used for locking resources.

If the formprolog function was called and then the connection is aborted before the formepilog function can be called, `cancel` is set to 1 and the formepilog function is called exactly once. If the epilog function was already called but returned zero (not finished yet), then it is called again if the connection is aborted, except if `cgi_redirectto()` has been called from the epilog function. In that case the epilog function is not called after an abort.

username[] Read-only buffer has username of the user making the request, if authentication took place.

Note: New code should use the `http_getContext()` macro, then use the results to look up the user details using the `sauth_*` functions. See the documentation for the ServerContext Structure in the previous chapter.

password[] Read-only buffer has password of the user making the request, if authentication took place. See the above note.

cookie[] Read-only buffer contains the value of the cookie "DCRABBIT" (see `http_setcookie()` for more information).

headerlen
headeroff These variables can be used together to cause the web server to flush data from the `buffer[]` array in the `HttpState` structure. `headerlen` should be set to the amount of data in `buffer[]`, and `headeroff` should be set to 0 (to indicate the offset into the array). The next time the CGI function is called the data in `buffer[]` will be flushed to the socket.

For new code, consider writing a new-style CGI function, which obviates the need to manipulate these fields.

cond[] Support for conditional SSI (error feedback etc.).

New code should use the macros `http_getCond()`and `http_setCond()`.

userdata[] This field is included if `HTTP_USERDATA_SIZE` is defined. It is an optional user data area. The area is cleared to zero when the structure is initialized, otherwise it is not touched. Its size must be greater than zero.

New code should use the `http_getUserData()` macro to obtain a pointer to user-defined storage in this structure.

4.2 Configuration Macros

The following macros are specified in HTTP.LIB. Unless otherwise noted, you can override the default values by defining the macro (same name, different value) before you #use "http.lib".

HTTP_HOMEDIR

Specify the "home directory" for the server. This is the root directory to which all URLs are appended. The default is "/", which means that all resources are accessible. If this is set to, say, "/htdocs", then an incoming URL of "foo/bar.html" gets turned into "/htdocs/foo/bar.html". You can use this to restrict the HTTP server's access to all but a specific "branch" of resources.

Note: the string value for this macro must start and end with a "/" character.

HTTP_DFLTFILE

Specify the default file name to append to the URL if the URL refers to a directory. This is only applicable if the URL is "/", or is in a filesystem (not the static or dynamic resource tables). The default setting is "index.html". The value must *not* start or end with a "/" character.

HTTP_SOCK_BUF_SIZE

This macro is not defined by default. If you define it, then it specifies the amount of extended memory to allocate (xalloc()) for each HTTP server instance. If you do not define it, then socket buffers are allocated from the usual pool. See tcp_extopen() for more details.

HTTP_DIGEST_NONCE_TIMEOUT

This macro is used when USE_HTTP_DIGEST_AUTHENTICATION is set to one. Nonces that are generated by the server are valid for this many seconds (900 by default). If set to 0, nonces are good forever. Setting this to a smaller value can possibly result in higher security, although internal use of the nonce-count facility offsets this. Setting it to a larger value reduces the negotiation between the browser and the server, since when a nonce times out, the browser must be told that it is using a stale nonce value and provided with a new one. Since Mozilla and Netscape ignore the stale parameter, the user must reenter the username and password when a nonce times out. Internet Explorer and Opera respect the stale parameter, so they automatically try the username and password with the new nonce without asking the user.

HTTP_MAXBUFFER

This is the size of the buffer accessible through the HttpSpec structure. It defaults to 256 bytes. The size of this buffer affects the speed of the HTTP server; the larger the buffer (up to a point), the faster the server will run. The buffer size is also important for use in CGI functions because it is a work space the programmer can use. HTTP_MAXBUFFER must be at least 180 bytes for CGI functionality.

HTTP_MAX_COND

Support for conditional SSI (error feedback etc.). It defaults to 4. This is the maximum number of state variables that may be accessed using the http_getCond() or http_setCond() macros.

HTTP_MAX_NONCES

This macro is used when USE_HTTP_DIGEST_AUTHENTICATION is set to one. Defined to 5 by default, it specifies the number of nonces the HTTP server will allow as valid at any one time. This value should be somewhat larger than the maximum number of clients expected to be accessing the server simultaneously. Otherwise performance could suffer as clients are forced to retry authorization in order to acquire a fresh nonce.

HTTP_MAXSERVERS

This is the maximum number of HTTP servers listening on port 80. The default is 2. You may increase this value to the maximum number of independent entities on your page. For example, for a Web page with four pictures, two of which are the same, set HTTP_MAXSERVERS to 4: one for the page, one for the duplicate images, and one for each of the other two images. By default, each server takes 2500 bytes of RAM. This RAM usage can be changed by the macro SOCK_BUF_SIZE (or tcp_MaxBufSize which is deprecated as of Dynamic C ver. 6.57). Another option is to use the tcp_reserveport() function and a smaller number of sockets.

HTTP_MAXURL

This macro defines the maximum incoming URL. This could be important if someone is allowing GET requests with a large number of parameters.

HTTP_PORT

This macro allows the user to override the default port of 80.

HTTP_IFACE

This macro allows the user to override the default listening network interface. The default is IF_ANY, meaning that the HTTP server(s) will listen for incoming network connections on all interfaces which are up. You can restrict the HTTP servers to a single interface by overriding this macro to the specific interface number (for example, IF_ETH0).

HTTP_TIMEOUT

Defines the number of seconds of no activity that can elapse before the HTTP server closes a connection. The default is 16 seconds.

HTTP_USERDATA_SIZE

This macro causes "char userdata[]" to be added to the HttpState structure. Define your structure before the statement #use HTTP.LIB.

```
struct UserStateData {char name[50]; int floor; int model;};
#define HTTP_USERDATA_SIZE (sizeof(struct UserStateData))
#use http.lib
```

In your own CGI function code, access it using:

```
mystate = (struct UserStateData *)http_getUserData(state);
```

USE_HTTP_DIGEST_AUTHENTICATION

Set to 1 to enable digest authentication, 0 to disable digest authentication. Set to 0 by default.

USE_HTTP_BASIC_AUTHENTICATION

Set to 1 to enable basic authentication, 0 to disable basic authentication. Set to 1 by default.

4.2.1 Sending Customized HTTP Headers to the Client

The callback macro, HTTP_CUSTOM_HEADERS, will be called whenever HTTP headers are being sent. It must be defined as a function with the following prototype:

```
void my_headers(HttpState *state, char *buffer, int bytes);
```

state Pointer to the state structure for the calling web server.

buffer The buffer in which the header(s) can be written.

bytes The number of bytes available in the buffer.

Typically, the macro would be defined by the user before the #use "http.lib" statement, like in the following:

```
#define HTTP_CUSTOM_HEADERS(state, buffer, bytes) \
   my_headers(state, buffer, bytes)
```

Then, for the above to work, my_headers() must be defined by the user, like so:

```
void my_headers(HttpState *state, char *buffer, int bytes)
{
   strcpy(buffer, Hello Rabbit!\r\n");
   printf("bytes: %d\n", bytes);
}
```

In the real world, the user may need to check the number of bytes available to be sure they don't overwrite the buffer. The buffer must end with "\r\n" and be NULL-terminated.

4.2.2 Saving Custom Headers from the Client

Customers may want to save some specific headers that a web client sends to the server as part of a request. One possibility for this is to check the browser version of the client and display a different page depending on that value. This is mostly useful for CGI functions.

The user can create a structure like the following to indicate to the web server that it should save the specified tags:

```
const HttpHeader http_headers[] = {
   "Host",
   "Content-Length",
   "User-Agent",
   END_HTTP_HEADERS
};
```

`END_HTTP_HEADERS` is simply a macro (NULL) that indicates the end of the structure. These headers will be saved in an internal buffer of a user-specified size:

```
#define HTTP_CUSTOM_HEADERS_SIZE 1024
```

By default, `HTTP_CUSTOM_HEADERS_SIZE` is undefined, which disables the custom header functionality (since, in most cases, it will not need to be used). This buffer will be located in xmem, and there will be one per HTTP server. A define will also be provided to limit the maximum size of a single header (to keep one very long header from monopolizing all of the buffer space):

```
#define HTTP_CUSTOM_HEADER_MAX_SIZE 128
```

By default, this is undefined and there is no limit.

The user will also need functions that look up the data:

```
int http_getheader(HttpState *state, char *header, char
  *dest, int destlen);

int http_xgetheader(HttpState *state, char *header, long
  *destptr);
```

The first function requires the user to provide a root buffer to place the header. The `HttpState` state structure must be passed so that the server knows which set of headers to access. The header parameter is, of course, the name of the header the user wants to retrieve. `dest` is a pointer to the destination buffer. `destlen` is the length of the destination buffer (provided by the user). The function returns -1 on error, and the number of bytes in the header on success.

The second function, `http_xgetheader()`, simply returns a long pointer into the internal header buffer for the given header. It returns -1 on error, and the number of bytes in the header on success.

Note that some headers are saved by the HTTP server by default into the HTTP state structure, such as "Content-Length." We will also begin saving the "Host" header, which is useful in performing CGI redirection. Hence, we can change the semantics of the `cgi_redirectto()` function:

```
int cgi_redirectto(HttpState *state, char *url);
```

such that the `url` parameter no longer needs to be an absolute URL.

4.3 Authentication Methods

HTTP/1.0 Basic Authentication is used by default. This scheme is not a secure method of user authentication across an insecure network (e.g., the Internet). HTTP/1.0 does not, however, prevent additional authentication schemes and encryption mechanisms from being employed to increase security.

Starting with Dynamic C version 8.01, HTTP Digest Authentication as specified in RFC 2617 is supported. Instead of sending the password in cleartext as is done using Basic Authentication, MD5 is used to perform a cryptographic hash.

In general, adding a query string to the end of a GET request is poorly supported by digest authentication. Users should be aware that older browsers (e.g., IE6 and earlier) do not consider the query string to be part of the URL that is included in the cryptographic hash, whereas newer browsers (e.g., IE7 and later) are just the opposite. This means that digest authentication can work with one or the other, but not both. Therefore, it is only "safe" to use digest authentication without a query string at the end of the URL.

To use HTTP Digest Authentication, define `USE_HTTP_DIGEST_AUTHENTICATION` as 1. When this `USE_*` macro is defined, the macros `HTTP_MAX_NONCES` and `HTTP_DIGEST_NONCE_TIMEOUT` are available; they affect negotiation time between server and client. For more details see Section 4.2 "Configuration Macros."

In either case (basic or digest), you will need to add the appropriate rules and/or permissions to the appropriate tables. See the previous chapter for details on protecting resources. The HTTP server applies the strongest applicable authentication mechanism depending on the information it retrieves from the resource manager. Typically, in addition to defining user IDs and groups, you also need to associate an authentication mechanism with the resource using e.g. the `SSPEC_MM_RULE` macro, or the `sspec_setpermissions()` function.

Starting with Dynamic C 8.50, Secure Socket Layer (SSL) as specified in RFC 2818, is supported. It is also known by its newer official name, TLS (Transport Layer Security). To use SSL, you must create a secure HTTP server, known as an HTTPS server. To do this you must define some macros and import the SSL certificate.

```
#define USE_HTTP_SSL
#define HTTP_SSL_SOCKETS 1

#ximport "cert\mycert.dcc" SSL_CERTIFICATE
```

For complete documentation on the Dynamic C implementation of SSL, see the Dynamic C Module document entitled, "Rabbit Embedded Security Pack." Another good source of information are the sample programs that demonstrate using SSL. They are located in the `/Samples/tcpip/ssl` folder that will be created when the Rabbit Embedded Security Pack is installed.

4.4 Setting the Time Zone

The HTTP specification requires the server to indicate its current clock time in the response to any request. The HTTP implementation performs this function by consulting the `rtc_timezone()` library function (in `RTCLOCK.LIB`). The server uses the returned time zone to adjust the local real-time clock (RTC) value so that it is always returned to the client in UTC (Co-ordinated Universal Time).

There are several macros which you can set to define

- `TIMEZONE`: The local timezone offset from UTC.
- `RTC_IS_UTC`: Whether the RTC is already running on UTC.

The local timezone offset may be defined using the `TIMEZONE` macro, or it may be obtained automatically from a DHCP server if you are using DHCP to configure the network interface. Failing that, it defaults to zero.

If the RTC is already set to UTC (not local time), then you must define the macro `RTC_IS_UTC`, in which case the local timezone offset will be ignored.

For many reasons, including the fact that daylight savings transitions are more manageable, it is better to set the RTC to UTC, however some users prefer the clock to run in local time.

See the documentation for `rtc_timezone()` for more details. To do this, use the function lookup feature in Dynamic C or refer to the *Dynamic C Function Reference Manual*.

4.5 Sample Programs

Sample programs demonstrating HTTP are in the `Samples\Tcpip\Http` directory. There is a configuration block at the beginning of each sample program. The macros in this block need to be changed to reflect your network settings.

Starting with Dynamic C 7.30, setting up the network addresses is both more complex and more simple. The complexity lies in the added support for multiple interfaces. Luckily for us, the simplicity is in the interface to this more intricate implementation. In the file `tcp_config.lib` are predefined configurations that may be accessed by a #define of the macro `TCPCONFIG`. For instructions on how to set the configuration, please see volume 1 of the manual or `LIB\TCPIP\TCP_CONFIG.LIB`.

4.5.1 Serving Static Web Pages

The sample program, `Static.c`, initializes `HTTP.LIB` and then sets up a basic static web page. It is assumed you are on the same subnet as the controller. The code for `Static.c` is explained in the following pages.

From Dynamic C, compile and run the program. You will see the LNK light on the board come on after a couple of seconds. Point your internet browser at the controller (e.g., http://10.10.6.100/). The ACT light will flash a couple of times and your browser will display the page.

Program Name: `\Samples\tcpip\http\Static.c`

```
#define TCPCONFIG 1

#define TIMEZONE -8

#memmap xmem
#use "dcrtcp.lib"
#use "http.lib"

#ximport "samples/tcpip/http/pages/static.html" index_html
#ximport "samples/tcpip/http/pages/rabbit1.gif" rabbit1_gif

SSPEC_MIMETABLE_START
   SSPEC_MIME(".html", "text/html"),
   SSPEC_MIME(".gif", "image/gif")
SSPEC_MIMETABLE_END

SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.html", index_html),
   SSPEC_RESOURCE_XMEMFILE("/rabbit1.gif", rabbit1_gif)
SSPEC_RESOURCETABLE_END

main()
{
   sock_init();      // Initializes the TCP/IP stack
   http_init();      // Initializes the web server


   tcp_reserveport(80);

   while (1) {
      http_handler();
   }
}
```

The program serves the `static.html` file and the `rabbit1.gif` file to any user contacting the controller. If you want to change the file that is served by the controller, find and modify this line in `Static.c`:

```
#ximport "samples/tcpip/http/pages/static.html" index_html
```

Replace `static.html` with the name of the file you want the controller to serve.

4.5.1.1 Adding Files to Display

Adding additional files to the controller to serve as web pages is slightly more complicated. First, add an `#ximport` line with the filename as the first parameter, and a symbol that references it in Dynamic C as the second parameter.

```
#ximport "samples/tcpip/http/pages/static.html" index_html
#ximport "samples/tcpip/http/pages/newfile.html" newfile_html
```

Next, find these lines in `Static.c`:

```
SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.html", index_html),
   SSPEC_RESOURCE_XMEMFILE("/rabbit1.gif", rabbit1_gif)
SSPEC_RESOURCETABLE_END
```

Insert the name of your new file, preceded by "`/`", into this structure, using the same format as the other lines.

```
SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.html", index_html),
   SSPEC_RESOURCE_XMEMFILE("/newfile.html", newfile_html),
   SSPEC_RESOURCE_XMEMFILE("/rabbit1.gif", rabbit1_gif)
SSPEC_RESOURCETABLE_END
```

Compile and run the program. Open up your browser to the new page (for example, "http://10.10.6.100/newfile.html"), and your new page will be displayed by the browser.

4.5.1.2 Adding Files with Different Extensions

If you are adding a file with an extension that is not html or gif, you need to use the appropriate macros to make an entry in the `MIMETypeMap` structure for the new extension. The first field is the extension and the second field describes the MIME type for that extension. You can find a list of MIME types at:

http://www.iana.org/assignments/media-types

In the media-types document located there, the text in the type column would precede the "`/`", and the subtype column would directly follow. Find the type subtype entry that matches your extension and add it to the `http_types` table.

```
SSPEC_MIMETABLE_START
   SSPEC_MIME(".html", "text/html"),
   SSPEC_MIME(".pdf", "application/pdf"),   //added this one
   SSPEC_MIME(".gif", "image/gif")
SSPEC_MIMETABLE_END
```

4.5.1.3 Handling of Files With No Extension

The entry "/" and files without an extension are dealt with by the handler specified in the first entry in the MIME table. If you use the SSPEC_MIME macro, the default handler is used. It passes the information verbatim. You can also use the macro SSPEC_MIME_FUNC to specify a non-default text processor; this is necessary for SSI and RabbitWeb scripts (described later).

4.5.2 Dynamic Web Pages Without HTML Forms

Serving a dynamic web page without the use of HTML forms is done by sample program ssi.c. This program displays four "lights" and four buttons to toggle them. Users can browse to the device and change the status of the lights.

The sample code follows, but it has been edited for brevity. Open ssi.c in Dynamic C to see the fully-commented source.

```
#define TCPCONFIG 1
#define HTTP_MAXSERVERS 1
#define MAX_TCP_SOCKET_BUFFERS 1

// This is the address that the browser uses to access your server
#define REDIRECTHOST _PRIMARY_STATIC_IP


// Used by the cgi of each ledxtoggle function to tell the browser which page to hit next.
#define REDIRECTTO "http://" REDIRECTHOST "/index.shtml"

#memmap xmem

#use "dcrtcp.lib"
#use "http.lib"

#ximport "samples/tcpip/http/pages/ssi.shtml" index_html
#ximport "samples/tcpip/http/pages/rabbit1.gif" rabbit1_gif
#ximport "samples/tcpip/http/pages/ledon.gif" ledon_gif
#ximport "samples/tcpip/http/pages/ledoff.gif" ledoff_gif
#ximport "samples/tcpip/http/pages/button.gif" button_gif
#ximport "samples/tcpip/http/pages/showsrc.shtml" showsrc_shtml
#ximport "samples/tcpip/http/ssi.c" ssi_c

SSPEC_MIMETABLE_START
   SSPEC_MIME_FUNC(".shtml", "text/html", shtml_handler),
   SSPEC_MIME(".html", "text/html"),
   SSPEC_MIME(".gif", "image/gif"),
   SSPEC_MIME(".cgi", "")
SSPEC_MIMETABLE_END
```

```
char led1[15];
char led2[15];
char led3[15];
char led4[15];

int led1toggle(HttpState* state){
   if (strcmp(led1,"ledon.gif")==0)
      strcpy(led1,"ledoff.gif");
   else
      strcpy(led1,"ledon.gif");
   cgi_redirectto(state,REDIRECTTO);
   return 0;
}
int led2toggle(HttpState* state){
   // Entirely analogous to led1toggle
}
int led3toggle(HttpState* state){
   // Entirely analogous to led1toggle
}
int led4toggle(HttpState* state){
   // Entirely analogous to led1toggle
}

SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/", index_html),
   SSPEC_RESOURCE_XMEMFILE("/index.shtml", index_html),
   SSPEC_RESOURCE_XMEMFILE("/showsrc.shtml", showsrc_shtml),
   SSPEC_RESOURCE_XMEMFILE("/rabbit1.gif", rabbit1_gif),
   SSPEC_RESOURCE_XMEMFILE("/ledon.gif", ledon_gif),
   SSPEC_RESOURCE_XMEMFILE("/ledoff.gif", ledoff_gif),
   SSPEC_RESOURCE_XMEMFILE("/button.gif", button_gif),
   SSPEC_RESOURCE_XMEMFILE("/ssi.c", ssi_c),

   SSPEC_RESOURCE_ROOTVAR("led1", led1, PTR16, "%s"),
   SSPEC_RESOURCE_ROOTVAR("led2", led2, PTR16, "%s"),
   SSPEC_RESOURCE_ROOTVAR("led3", led3, PTR16, "%s"),
   SSPEC_RESOURCE_ROOTVAR("led4", led4, PTR16, "%s"),

   SSPEC_RESOURCE_FUNCTION("/led1tog.cgi", led1toggle),
   SSPEC_RESOURCE_FUNCTION("/led2tog.cgi", led2toggle),
   SSPEC_RESOURCE_FUNCTION("/led3tog.cgi", led3toggle),
   SSPEC_RESOURCE_FUNCTION("/led4tog.cgi", led4toggle)
SSPEC_RESOURCETABLE_END
```

```
void main(){
   strcpy(led1,"ledon.gif");
   strcpy(led2,"ledon.gif");
   strcpy(led3,"ledoff.gif");
   strcpy(led4,"ledon.gif");

   sock_init();
   http_init();

   tcp_reserveport(80);
   while (1) http_handler();
}
```

When you compile and run `ssi.c`, you see the LNK light on the board come on. Point your browser at the controller (e.g., http://10.10.6.100/). The ACT light will flash a couple of times and your browser will display the page.

This program displays pictures of LEDs. Their state is toggled by pressing the image of a button. This program uses Server Side Includes (SSI) and the old style of CGI (`SSPEC_RESOURCE_FUNCTION`). Use of SSI is explained in greater detail below.

4.5.2.1 SSI Feature

SSI commands are an extension of the HTML comment command (<!--This is a comment -->). They allow dynamic changes to HTML files and are resolved at the server side, so the client never sees them. HTML files that need to be parsed because they contain SSI commands, are conventionally recognized by the HTTP server by the resource name extension .shtml.[1]

The supported SSI commands are:

- `#echo var`
- `#exec cmd`
- `#include file`

They are used by inserting the command into an HTML file:

```
<!--#include file="anyfile" -->
```

The server replaces the command, `#include file`, with the contents of `anyfile`.

`#exec cmd` executes a command i.e. and old-style CGI and replaces the SSI command with the output.

1. This is just a convention. If you add a MIMETypeMap entry SSPEC_MIME_FUNC(".shtml", "text/html", shtml_handler) then you are following this convention.

Dynamically Changing the Display of a Variable on a Web Page

The Ssi.shtml file, located in \Samples\Tcpip\Http\Pages, gives an example of dynamically changing a variable on a web page using #echo var.

```
<img SRC="<!--#echo var="led1" -->">
```

In an shtml file, the "<!--#echo var="led1" -->" is replaced by the value of the variable led1 from the static resource table.

```
SSPEC_RESOURCETABLE_START
   ...
   SSPEC_RESOURCE_ROOTVAR("led1", led1, PTR16, "%s"),
   SSPEC_RESOURCE_ROOTVAR("led2", led2, PTR16, "%s"),
   SSPEC_RESOURCE_ROOTVAR("led3", led3, PTR16, "%s"),
   SSPEC_RESOURCE_ROOTVAR("led4", led4, PTR16, "%s"),
   ...
SSPEC_RESOURCETABLE_END
```

shtml_handler (which is the built-in script processor for SSI) looks up led1 and replaces it with the text output from:

```
printf("%s",(char*)led1);
```

The led1 variable is either ledon.gif or ledoff.gif. When the browser loads the page, it replaces

```
<img SRC="<!--#echo var="led1"-->">
```

with

```
<img SRC="ledon.gif">
```

or

```
<img SRC="ledoff.gif">
```

This causes the browser to load the appropriate image file.

SSI string variables are only appropriate for relatively short strings. (In the above example, the SSI string variables are "ledon.gif" and "ledoff.gif.") The size that can be output is limited to the size HTTP_MAXBUFFER. If you need larger strings, you should either increase HTTP_MAXBUFFER (which will use more root RAM) or switch to using a CGI function.

4.5.2.2 CGI Feature

Ssi.c also demonstrates the Common Gateway Interface. CGI is a standard for interfacing external applications with HTTP servers. Each time a client requests an URL corresponding to a CGI program, the server will execute the CGI program in real-time.

For increased flexibility, a CGI function is responsible for outputting its own HTTP headers. Information about HTTP headers can be found at:

```
http://deesse.univ-lemans.fr:8003/Connected/RFC/1945/
```

and many other web sites and books. In the Ssi.shtml file, the following line creates the clickable button viewable from the browser.

```
<TD> <A HREF="/led1tog.cgi"> <img SRC="button.gif"> </A> </TD>
```

When the user clicks on the button, the browser will request the /led1tog.cgi entity. This causes the HTTP server to examine the contents of the http_flashspec structure looking for /led1tog.cgi. It finds it and notices that led1toggle() needs to be called.

The led1toggle function changes the value of the led1 variable, then redirects the browser back to the original page. When the original page is reloaded by the browser, the LED image will have changed states to reflect the user's action.

This sample demonstrates the so-called "old-style" CGI. New-style CGIs are easier to write (especially when they are doing something non-trivial). They are described in Section 4.6 "HTTP File Upload."

Connection Abort Condition

There are two fields in the HttpState structure that allow a CGI function to appropriately respond to a connection abort condition. The user may set the field abort_notify to a non-zero value in a CGI function to request that the CGI function be called one more time with the cancel field set to one if a connection abort occurs.

4.5.3 Web Pages With HTML Forms

With a web browser, HTML forms enable users to input values. With a CGI program, those values can be sent back to the server and processed. The FORM and INPUT tags are used to create forms in HTML.

The FORM tag specifies which elements constitute a single form and what CGI program to call when the form is submitted. The FORM tag has an option called ACTION. This option defines what CGI program is called when the form is submitted (when the "Submit" button is pressed). The FORM tag also has an option called METHOD that defines the method used to return the form information to the web server. In Section 4.5.3.1, the POST method is used, which will be described later. All of the HTML between the <FORM> and </FORM> tags define what is contained within a form.

Starting with Dynamic C 8.50, you can also use the enctype option inside the FORM tag. This specifies a return encoding type for the form's information. If you did not specify this option, then you can use old-style CGIs (as described in this section). If you specify enctype="multipart/form-data" then you should specify a new-style CGI instead. See Section 4.6 describing the HTTP upload feature for more details on writing a new-style CGI.

The INPUT tag defines a specific form element, the individual input fields in a form. For example, a text box in which the user may type in a value, or a pull-down menu from which the user may choose an item.

The TYPE parameter defines what type of input field is being used. In the following example, in the first two cases, it is the text input field, which is a single-line text entry box. The NAME parameter defines what the name of that particular input variable is, so that when the information is returned to the server, then the server can associate it with a particular variable. The VALUE parameter defines the current value of the parameter. The SIZE parameter defines how long the text entry box is (in characters).

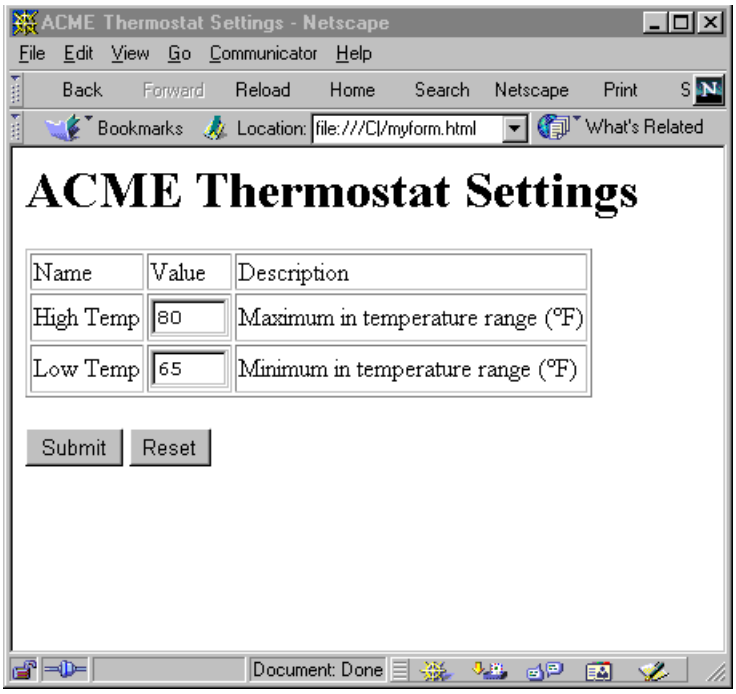
At the end of the HTML page in our example, the Submit and Reset buttons are defined with the INPUT tag. These use the special types "submit" and "reset," since these buttons have special purposes. When the submit button is pressed, the form is submitted by calling the CGI program "`myform`."

4.5.3.1 Sample HTML Page

An HTML page that includes a form may look like the following:

```
<HTML><HEAD><TITLE>ACME Thermostat Settings</TITLE></HEAD>
<BODY>
<H1>ACME Thermostat Settings</H1>
<FORM ACTION="myform.html" METHOD="POST">
   <TABLE BORDER>
      <TR>
         <TD>Name</TD> <TD>Value</TD> <TD>Description</TD></TR>
      <TR>
         <TD>High Temp</TD>
         <TD><INPUT TYPE="text" NAME="temphi" VALUE="80"
               SIZE="5">
         </TD>
         <TD>Maximum in temperature range (&deg;F)</TD></TR>
      <TR>
         <TD>Low Temp</TD>
         <TD><INPUT TYPE="text" NAME="templo" VALUE="65"
               SIZE="5">
         </TD>
         <TD>Minimum in temperature range (&deg;F)</TD></TR>
   </TABLE>
   <P>
      <INPUT TYPE="submit" VALUE="Submit">
      <INPUT TYPE="reset" Value="Reset">
</FORM></BODY>
</HTML>
```

The form might display as shown here:



When the form is displayed by a browser, the user can change values in the form. But how does this changed data get back to the HTTP server? By using the HTTP `POST` command. When the user presses the "Submit" button, the browser connects to the HTTP server and makes the following request:

```
POST myform HTTP/1.0
.
. (some header infor-
mation)
.
Content-Length: 19
```

where "`myform`" is the CGI program that was specified in the ACTION attribute of the FORM tag and `POST` is the METHOD attribute of the FORM tag. "Content-Length" defines how many bytes of information are being sent to the server (not including the request line and the headers).

Then, the browser sends a blank line followed by the form information in the following manner:

```
temphi=80&templo=65
```

That is, it sends back name and value pairs, separated by the '&' character. (There can be some further encoding done here to represent special characters, but we will ignore that in this explanation.) The server must read in the information, decode it, parse it, and then handle it in some fashion. It will examine the new values, and assign them to the appropriate C variables if they are valid.

4.5.3.2 POST-Style Form Submission

If an HTML file specifies a POST-style form submission (that is, `METHOD="POST"`), the form will still be waiting on the socket when the old-style CGI handler is called. Therefore, it is the job of the CGI handler to read this data off the socket and parse it in a meaningful way. The sample files `Post.c` and `Post2.c` in the `\Samples\Tcpip\Http` folder show how to do this.

The HTTP `POST` command can put any kind of data onto the network. There are many encoding schemes currently used, but we will only look at URL-encoded data in this document. Other encoding schemes can be handled in a similar manner.

4.5.3.3 URL-Encoded Data

URL-encoded data is of the form "name1=value1&name2=value2," and is similar to the CGI form submission type passed in normal URLs. This has to be parsed to `name=value` pairs. The rest of this section details an extensible way to do this.

This initializes two possible HTML form entries to be received, and a place to store the results.

```
#define MAX_FORMSIZE 64

typedef struct {
    char *name;
    char value[MAX_FORMSIZE];
} FORMType;

FORMType FORMSpec[2];

void init_forms(void) {
    FORMSpec[0].name = "user_name";
    FORMSpec[1].name = "user_email";
}
```

Reading & Storing URL-encoded Data

`parse_post()` is called from the CGI function (`submit()`) to read URL-encoded data off the network. It calls `http_scanpost()` to store the data in `FORMSpec[]`. These code snippets are from `Samples\tcpip\http\post.c`.

```
int parse_post(HttpState *state) {
   auto int retval;
   auto int i;

   retval = sock_aread(&state->s, state->p,\
      (state->content_length < HTTP_MAXBUFFER-1)?\
      (int)state->content_length:HTTP_MAXBUFFER-1);

   if (retval < 0)
      return 1;

   state->subsubstate += retval;

   if (state->subsubstate >= state->content_length) {
      state->buffer[(int)state->content_length] = '\0';
      for(i=0; i<(sizeof(FORMSpec)/sizeof(FORMType)); i++) {
         http_scanpost(FORMSpec[i].name, state->buffer,\
            FORMSpec[i].value, MAX_FORMSIZE);
      }
      return 1;
   }
   return 0;
}
```

4.5.3.4 Sample of a CGI Handler

This next function is the CGI handler that calls `parse_post()`. It is a state machine-based handler that generates the page. It calls `parse_post()` and references the structure that is now filled with the parsed data we wanted.

This function is from `Samples\tcpip\http\post.c`.

```
int submit(HttpState *state){
   auto int i;

   if(state->length) {                    // buffer to write out
      if(state->offset < state->length) {

         state->offset += sock_fastwrite(&state->s, state->buffer +
            (int)state->offset,(int)state->length -
            (int)state->offset);

      } else {
         state->offset = 0;
         state->length = 0;
      }

   } else {
      switch(state->substate) {

      case 0:
         strcpy(state->buffer, "HTTP/1.0 200 OK\r\n\r\n");
         state->length = strlen(state->buffer);
         state->offset = 0;
         state->substate++;
         break;

      case 1:

         strcpy(state->buffer,"<html><head><title>Results</title>
            </head><body>\r\n");

         state->length = strlen(state->buffer);
         state->substate++;
         break;

      case 2:                        // initialize the FORMSpec data
         FORMSpec[0].value[0] = '\0';
         FORMSpec[1].value[0] = '\0';
         state->p = state->buffer;
         state->substate++;
         break;
```

```
      case 3:                        // parse the POST information
         if(parse_post(state)) {

            sprintf(state->buffer, "<p>Username: %s<p>\r\n<p>Email:
                 %s<p>\r\n", FORMSpec[0].value, FORMSpec[1].value);

            state->length = strlen(state->buffer);
            state->substate++;
         }
         break;

      case 4:

         strcpy(state->buffer,"<p>Go <a href=\"/\">home</a></body>
        </html>\r\n");

         state->length = strlen(state->buffer);
         state->substate++;
         break;

      default:
         state->substate = 0;
         return 1;
      }
   }
   return 0;
}
```

4.5.4 HTML Forms Using Zserver.lib

In this section, we will step through a sample program, `Samples\tcpip\http\form1.c`, that uses HTML forms. Through this step-by-step explanation, the method of using the functions in `zserver.lib` will become clear. (As of Dynamic C 8.50, you have the option of using the RabbitWeb server, with its easier-to-use interface and completely flexible ZHTML page layout capabilities.

Defining `FORM_ERROR_BUF` is required in order to use the HTML form functionality in `Zserver.lib`. The value represents the number of bytes that will be reserved in root memory for the buffer that will be used for form processing. This buffer must be large enough to hold the name and value for each variable, plus four bytes for each variable. Since we are building a small form, 256 bytes is sufficient.

```
#define FORM_ERROR_BUF 256
```

Since we will not be using the static resource table, we can define the following macro, to remove some code for handling this table from Zserver.

```
#define HTTP_NO_FLASHSPEC
```

These lines are part of the standard TCP/IP and MIME table configuration.

```
#memmap xmem
#use "dcrtcp.lib"
#use "http.lib"

SSPEC_MIMETABLE_START
   SSPEC_MIME(".html", "text/html")
SSPEC_MIMETABLE_END
```

These are the declarations of the variables that will be included in the form.

```
int temphi;
int tempnow;
int templo;
float humidity;
char fail[21];
```

```
void main(void)
{
```

An array of type `FormVar` must be declared to hold information about the form variables. Be sure to allocate enough entries in the array to hold all of the variables that will go in the form. If more forms are needed, then more of these arrays can be allocated.

```
 FormVar myform[5];
```

These variables will hold the indices in the TCP/IP servers' object list for the form and the form variables.

```
    int var;
    int form;
```

This array holds the possible values for the fail variable. The fail variable will be used to make a pulldown menu in the HTML form.

```
    const char *const fail_options[] = {
     "Email",
     "Page",
     "Email and page",
     "Nothing"
   };
```

These lines initialize the form variables.

```
    temphi = 80;
    tempnow = 72;
    templo = 65;
    humidity = 0.3;
    strcpy(fail, "Page");
```

The next line adds a form to the dynamic resource table. The first parameter gives the name of the form. When a browser requests the page "`myform.html`" the HTML form is generated and presented to the browser. The second parameter gives the developer-declared array in which form information will be saved. The third parameter gives the number of entries in the `myform` array (this number should match the one given in the `myform` declaration above). The fourth parameter indicates that this form should only be accessible to the HTTP server, and not the FTP server. `SERVER_HTTP` should always be given for HTML forms. The return value is the index of the newly created form in the dynamic resource table.

```
    form = sspec_addform("myform.html", myform, 5, SERVER_HTTP);
```

This line sets the title of the form. The first parameter is the form index (the return value of `sspec_addform()`), and the second parameter is the form title. This title will be displayed as the title of the HTML page and as a large heading in the HTML page.

```
    sspec_setformtitle(form, "ACME Thermostat Settings");
```

The following line adds a variable to the resource table. It must be added to this table before being added to the form. The first parameter is the name to be given to the variable, the second is the address of the variable, the third is the type of variable (this can be `INT8`, `INT16`, `INT32`, `FLOAT32`, or `PTR16`), the fourth is a printf-style format specifier that indicates how the variable should be printed, and the fifth is the server for which this variable is accessible. The return value is the handle of the variable in the resource table.

```
    var = sspec_addvariable("temphi", &temphi, INT16, "%d",
     SERVER_HTTP);
```

The following line adds a variable to a form. The first parameter is the index of the form to add the variable to (the return value of `sspec_addform()`), and the second parameter is the index of the variable (the return value of `sspec_addvariable()`). The return value is the index of the variable within the developer-declared `FormVar` array, `myform`.

```
    var = sspec_addfv(form, var);
```

This function sets the name of a form variable that will be displayed in the first column of the form table. If this name is not set, it defaults to the name for the variable in the resource table (“temphi”, in this case). The first parameter is the form in which the variable is located, the second parameter is the variable index within the form, and the third parameter is the name for the form variable.

```
    sspec_setfvname(form, var, "High Temp");
```

This function sets the description of the form variable, which is displayed in the third column of the form table.

```
   sspec_setfvdesc(form, var, "Maximum in temperature range
                    (60 - 90 &deg;F)");
```

This function sets the length of the string representation of the form variable. In this case, the text box for the form variable in the HTML form will be 5 characters long. If the user enters a value longer than 5 characters, the extra characters will be ignored.

```
    sspec_setfvlen(form, var, 5);
```

This function sets the range of values for the given form variable. The variable must be within the range of 60 to 90, inclusive, or an error will be generated when the form is submitted.

```
    sspec_setfvrange(form, var, 60, 90);
```

This concludes setting up the first variable. The next five lines set up the second variable, which represents the current temperature.

```
    var = sspec_addvariable("tempnow", &tempnow, INT16, "%d",
     SERVER_HTTP);
    var = sspec_addfv(form, var);
    sspec_setfvname(form, var, "Current Temp");
    sspec_setfvdesc(form, var, "Current temperature in &deg;F");
    sspec_setfvlen(form, var, 5);
```

Since the value of the second variable should not be modifiable via the HTML form (by default variables are modifiable,) the following line is necessary and makes the given form variable read-only when the third parameter is 1. The variable will be displayed in the form table, but can not be modified within the form.

```
    sspec_setfvreadonly(form, var, 1);
```

These lines set up the low temperature variable. It is set up in much the same way as the high temperature variable.

```
    var = sspec_addvariable("templo", &templo, INT16, "%d",
         SERVER_HTTP);
    var = sspec_addfv(form, var);
    sspec_setfvname(form, var, "Low Temp");
    sspec_setfvdesc(form, var, "Minimum in temperature range
        (50 - 80 &deg;F)");
    sspec_setfvlen(form, var, 5);
    sspec_setfvrange(form, var, 50, 80);
```

This code begins setting up the string variable that specifies what to do in case of air conditioning failure. Note that the variable is of type `PTR16`, and that the address of the variable is not given to `sspec_addvariable()`, since the variable `fail` already represents an address.

```
    var = sspec_addvariable("failure", fail, PTR16, "%s",
     SERVER_HTTP);
    var = sspec_addfv(form, var);

    sspec_setfvname(form, var, "Failure Action");
    sspec_setfvdesc(form, var,
     "Action to take in case of air-conditioning failure");
    sspec_setfvlen(form, var, 20);
```

This line associates an option list with a form variable. The third parameter gives the developer-defined option array, and the fourth parameter gives the length of the array. The form variable can now only take on values listed in the option list.

```
    sspec_setfvoptlist(form, var, fail_options, 4);
```

This function sets the type of form element that is used to represent the variable. The default is `HTML_FORM_TEXT`, which is a standard text entry box. This line sets the type to `HTML_FORM_PULLDOWN`, which is a pull-down menu.

```
    sspec_setfventrytype(form, var, HTML_FORM_PULLDOWN);
```

Finally, this code sets up the last variable. Note that it is a float, so `FLOAT32` is given in the `sspec_addvariable()` call. The last function call is `sspec_setfvfloatrange()` instead of `sspec_setfvrange()`, since this is a floating point variable.

```
    var = sspec_addvariable("humidity", &humidity, FLOAT32,
     "%.2f", SERVER_HTTP);

    var = sspec_addfv(form, var);
    sspec_setfvname(form, var, "Humidity");
    sspec_setfvdesc(form, var, "Target humidity (between 0.0 and 1.0)");
    sspec_setfvlen(form, var, 8);
    sspec_setfvfloatrange(form, var, 0.0, 1.0);
```

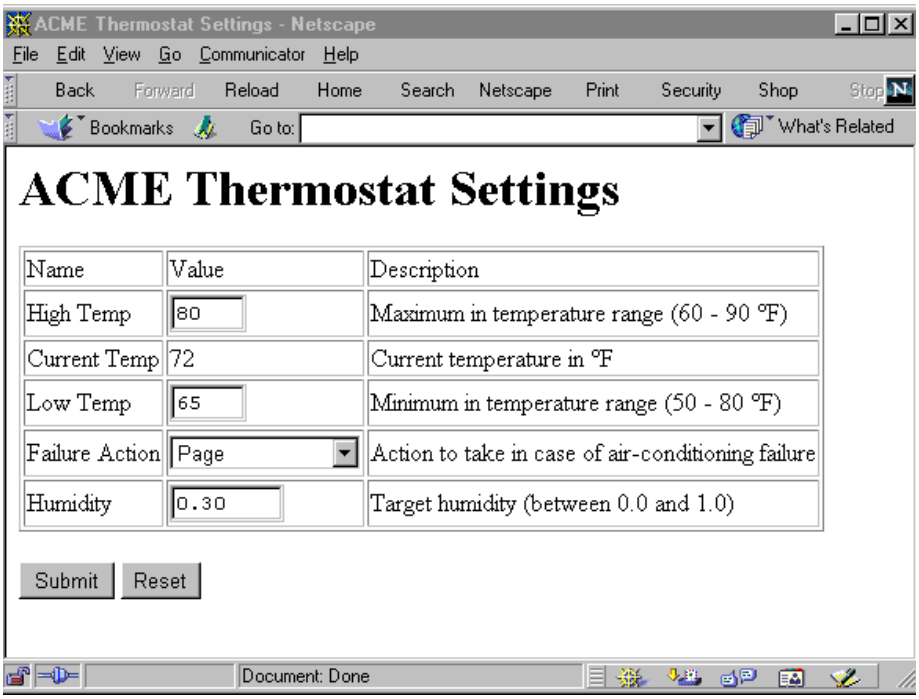
These calls create aliases in the dynamic resource table for the HTML form. That is, the same form can now be generated by requesting "`index.html`" or "`/`". Note that `sspec_aliasspec()` should be called after the form has already been set up. The aliasing is done by creating a new entry in the resource table and copying the original entry into the new entry. Note that aliasing can also be done for files and other types of server objects.

```
    sspec_aliasspec(form, "index.html");
    sspec_aliasspec(form, "/");
```

These lines complete the sample program. They initialize the TCP/IP stack and web server, and run the web server.

```
    sock_init();
    http_init();
    while (1) {
       http_handler();
    }
  }
```

This is the form that is generated:



4.6 HTTP File Upload

This section describes the HTTP file upload feature available starting with Dynamic C 8.50. The enhanced CGI capabilities of this version of Dynamic C allow files of unlimited size to be uploaded using a web interface. It has always been possible to upload files using FTP; however, it is usually more convenient to use a browser-based upload.

4.6.1 What is a CGI Function and Why is It Useful?

The HTTP library provided with Dynamic C allows the association of C functions with web page URLs. When the user, via their web browser, retrieves a specified resource, the C function may be called from the HTTP server. Such a function is called a Common Gateway Interface (CGI) function, and it is responsible for generating a response to the user's request.

The advantage of using a CGI is that it can generate web page content on-the-fly, and cause the browser to display or do anything that it is capable of. In addition, the CGI is able to read data that was sent by the browser.

Previous to this release of Dynamic C, the CGI was limited to handling relatively small amounts of data sent from the browser. This is satisfactory for processing simple forms, but does not allow large data sets to be uploaded. This release of Dynamic C supports upload of one or more files from the browser. The files can be of unlimited size. In conjunction with the latest Zserver (resource manager) enhancements introduced in Dynamic C 8.50, the uploaded files may be stored in the FS2 or FAT file systems, or even processed dynamically.

The new CGI file upload facility enables a range of convenient firmware features. Possibilities include:

- Remote firmware updates.
- Web page content updates (i.e. "publishing").
- Executable (interpreter) scripts.
- Remote hardware updates (if using an FPGA or other configurable logic device).
- Firmware configuration.

> **NOTE:** Throughout this document the FAT file system is the destination for the uploaded file. The FAT uses a variety of storage media, from the onboard serial flash, to NAND flash or SD cards.

4.6.2 How Do I Use the New CGI Facility?

There are a number of steps, some of which will be familiar to users of CGIs in previous releases. They are listed here and described in more detail in the following pages. The steps, if coding from scratch, are:

1. #use “dcrtcp.lib”, and specify network configuration options.
2. #use <filesystem(s) of choice>, and specify the file system configuration.
3. #define USE_HTTP_UPLOAD
4. #use “http.lib”
5. Create an initial web page with a form asking for the file(s) to be uploaded. The main requirement is that you specify `enctype="multipart/form-data"` inside the <FORM> tag(s).
6. Write a CGI function (if not using the default one provided).
7. Create an initial resource table containing at least an entry for each of the above two resources (the web page and the CGI).
8. Create a list of content type mappings, i.e., the MIME table.
9. Create rules which limit the upload facility to select user groups.
10. Create a set of user IDs
11. In the main program, call `http_handler()` in a loop.

Step 1: Specify Network Configuration

To make use of HTTP upload, you need to perform the usual inclusion and configuration of the networking library, `dcrtcp.lib`. At its simplest, it is two lines of code at the top of your main program:

```
#define TCPCONFIG 1
#use “dcrtcp.lib”
```

This specifies that the default TCP (networking) configuration is to be used. If you want to change the default networking configuration, first read the comments at the top of `tcp_config.lib`.

HTTP upload usually requires at least two additional libraries to be included: a file system library, and `http.lib` itself. A file system is required, otherwise the uploaded file has nowhere to go (although you can write a CGI which processes the file as it is uploaded, in which case you do not need to store it permanently, and thus you do not need to include a file system; the following discussion assumes that you are using a file system).

Steps 2, 3 and 4: Specify File system and Web Server

You need to include the file system library (or libraries) *before* including `http.lib`. This is because the HTTP library needs to know about the filesystem(s) it is going to support. In addition, you need to tell the HTTP library to use the upload facility. For example, if you want to use the FAT file system, then you would write the following:

```
#define TCPCONFIG 1
#use "dcrtcp.lib"
#use "fat.lib"                  // Step 2: the filesystem
#define USE_HTTP_UPLOAD         // Step 3: enable upload feature
#use "http.lib"                 // Step 4: HTTP server code
```

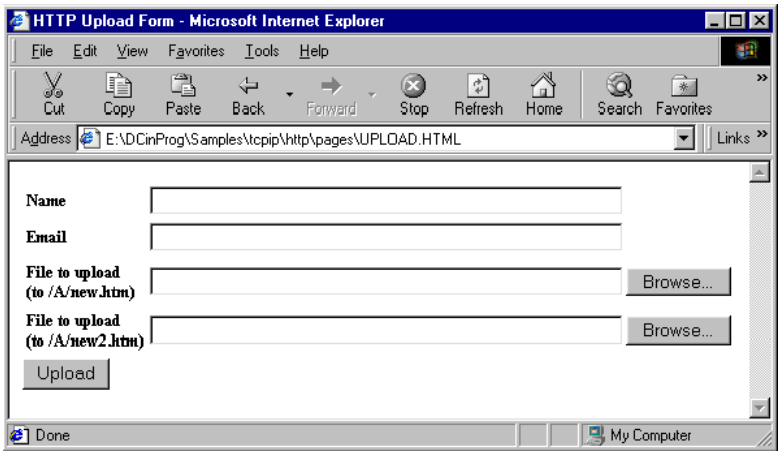
The order of the above statements is important. A possible exception is that the order of `dcrtcp.lib` and `fat.lib` may be interchanged, since these libraries are independent. However, it is recommended you use the given ordering since future releases of the FAT may be able to use networking services.

Step 5: Create a Web Page

When using HTTP upload, there needs to be a way to prompt the user (web browser) to enter a file name to upload. This is done by using an HTML form. The form specifies input fields that may be filled out by the user, and one or more "submit" buttons that the user presses to start the upload process.

If you have an existing web-based application to which you want to add a file upload facility, you probably already have a web page with a form on it; in this case, you can add an extra input field to an existing form on that page, or create a new form on the same page. You may already have a CGI function that processes the results of the form submission. This will need to be rewritten to process data that is not URL encoded.

If you are creating a new application, you need to construct an initial page to contain the necessary form elements. As a starting point you can use the sample page in `samples\tcpip\http\pages\upload.html`. Click on `upload.html` and the browser will display something like this:



The construction of this page is outlined below, but it has been simplified and reformatted slightly. A blow-by-blow description of each line is added in *italics*.

```
<html>
```

This introduces the page as an HTML document.

```
<head><title>HTTP Upload Form</title></head>
```

This ("HTTP Upload Form") gets displayed at the top of the browser window. You can change this to whatever is appropriate for describing the overall purpose of this page.

```
<body>
```

Introduce the main content of this page.

```
<FORM ACTION="upload.cgi" METHOD="POST" enctype="multipart/form-data">
```

Start a form definition. The parameters are
action="upload.cgi": this refers to the CGI function that will process the results of the form submission. This is a URL name, which is mapped to a C function on the server.
method=post: this is required, since a post-type request must be sent to the server.
enctype="multipart/form-data": this is also required, and is the part that is different from the old style of processing. The old style did not specify an encoding type, thus the default of "URL encoded" was used.

```
<TABLE BORDER=0 CELLSPACING=2 CELLPADDING=1>
```

For neatness of screen layout, we put everything in an HTML table. The following <TR>...</TR> sections delimit each row of the table, and the data for each cell is delimited by <TD>...</TD>.

```
<TR>
   <TD WIDTH=130 ALIGN=RIGHT><B>Name</B></TD>
   <TD WIDTH=500><INPUT TYPE="TEXT" NAME="user_name" SIZE=50></TD>
```

This is the first input field. It is not a file to upload, but it is information that the server may nevertheless be interested in. This shows that not every form field needs to be a file to upload. The order is important. Browsers will send back the form fields in the same order that they are defined in the HTML, however it is probably best not to rely on this if you can help it.

```
</TR>
<TR>
   <TD ALIGN=RIGHT><B>File to upload<BR>(to /A/new.htm)</B></TD>
   <TD><INPUT TYPE="FILE" NAME="/A/new.htm" SIZE=50></TD>
```

This is the file-to-upload input field. The browser displays this as a text input field, with an additional "browse" button so that the user can easily navigate his local filesystem to find the appropriate file. The critical distinction is that it contains a type=file parameter (as opposed to, for example, type=text in the previous field). The name="/A/new.htm" parameter specifies the name of the input field, not the name of the file on the user's system! As it happens, this looks like a file name, and indeed the server may use it as the name of a local file, but this is a convention only. The size=50 parameter specifies the number of characters that the browser will display for file name selection.

```
<TR>
</TABLE>
<INPUT TYPE="SUBMIT" VALUE="Upload">
```

It is necessary to supply a type=submit form element. The user presses this button to start to post (upload) process. Note that this is another input field, however if you leave out the name= parameter (as in this example) then the browser will not send the value of this button back with the form submission. If there is only one submit button, then there is no need to name it.

```
</FORM></body></html>
```

Close and complete the form, body, and entire page.

If you have an existing application, you can take out the relevant parts of the above, and insert them in your existing web page. The relevant parts are the enctype="multipart/form-data" parameter in the <FORM> element, and the <INPUT type=file> element.

If you have an existing application that processes the form data submission, you will need to rewrite the CGI function that handles the submitted data. This is because the `enctype` parameter changes the syntax that the browser uses to encode the data. In short, you will need to rewrite the CGI as a "new-style" CGI as described in Step 6: Writing a CGI Function.

Having created the HTML file with the upload form, it is necessary to import it into your main program, so that the HTTP server can present it to the user. This can be done using `#ximport`, or you can write it directly to the filesystem (although, initially at least, this presents a chicken-and-egg type problem since you might not have established an upload procedure in the first place!)

Step 6: Writing a CGI Function

The CGI function is responsible for processing the form submission data as it comes in from the client (browser). In addition, it generally needs to write some sort of response back to the client indicating whether or not the submission was acceptable.

If you start reading the following, and start feeling somewhat overwhelmed, please be aware that there is a default CGI function in the HTTP library that is very useful. The default CGI, called `http_defaultCGI()`, automatically saves uploaded files into the filesystem. If that is all you need to do, then you do not need to fully comprehend this section on first reading.

Note that all of this section is describing *new-style* CGIs. Old-style CGIs are covered in Section 4.5.3.

CGI Syntax

All CGI functions are C functions with the following prototype:

```
int my_CGI(HttpState * s);
```

The `HttpState` parameter is a pointer to the internal state variables of the HTTP server instance that is handling the current request. You can have one or more server instances. If there is more than one, the same CGI may be invoked at the same time for more than one client (if both happen to press the submit button at about the same time). Thus, it is important to write the CGI function so that it is re-entrant. This basically means that the function should not update global or static variables. The CGI should not attempt to modify directly any of the fields in the `HttpState` structure, otherwise the server may become inoperable.

API Functions

The HTTP library provides a set of API functions that can be called safely from the CGI. The list of safe functions is in the index under "Function Reference, CGI."

It is unwise to make direct calls to TCP/IP functions, especially functions that may not return for a long time such as `sock_read()`.

How to Transfer Form Submission Data

To understand how to write a CGI function, it is necessary to have some understanding of the protocol used to transfer the form submission data. Since the data can consist of one or more files and/or form fields, there needs to be a way of separating them within the one, sequential, stream of data that is sent by the client.

The way this is done is that the client specifies a unique string that separates each item of data. The following text is a dump of the actual data sent by a client (with some irrelevant details omitted, and with comments added in *italics*):

```
POST /upload.cgi HTTP/1.1
```

This indicates that it is POSTed form data, and the target handler is upload.cgi.

```
Content-length: 277
```

This gives the total *number of bytes of data following the initial header.*

```
Content-Type: multipart/form-data; boundary=3vAL1QsFOUg2GsY3p6n3YQ
```

The multipart/form-data type indicates that this is a multipart form data submission. The boundary parameter specifies a unique character sequence that separates each part. The boundary is deliberately chosen as a long, random, string of characters so that it is unlikely to be confused with the actual data content.

The above blank line is significant; it indicates the end of the initial header lines, and the start of data.

```
--3vAL1QsFOUg2GsY3p6n3YQ
```

This is the first boundary. Boundary strings are always prefixed by an additional -- sequence. The following lines are header lines for the individual part. The actual data follows the first empty line.

```
Content-Disposition: form-data; name="/A/new.htm"; filename="test.txt"
```

The Content-Disposition header indicates the presentation of the data. The only type which is relevant is "form-data". The name= parameter indicates the field name (which was originally part of the name= parameter of the <input> element). The filename= parameter is only set if this is an uploaded file. It gives the name of the file on the remote (client) side. This is not usually relevant to the server. The name of the file as it is stored on the server is not *specified (since the browser does not know it or have control over where the file is stored). We are using the convention that the field name indicates the local file name, but this is just a convention!*

```
Content-Type: text/plain
```

Content-Type indicates the type of information. The default is plain (i.e. ascii) text, however it could also be set to image/gif for a GIF file, text/html for HTML etc. The following blank line indicates the end of headers for this part.

```
test file contents, first line
```

This is the actual file or form field content.

```
--3vAL1QsFOUg2GsY3p6n3YQ
```

The boundary string terminates the data for the previous part. Headers for the next part immediately follow.

```
Content-Disposition: form-data; name="submit"
```

This is form field data, in this case the submit button itself.

```
upload
```

```
--3vAL1QsFOUg2GsY3p6n3YQ--
```

The boundary terminates the previous form field. Since this is the last boundary, it also has a trailing --.

When writing the CGI, you do not have to worry about parsing the headers and boundary separators. This is already done by the HTTP server. However, you do need to be aware of the stream-oriented nature of the incoming data. The HTTP server separates out the parts (and parses the headers). As it does this, it calls the defined CGI with the data for each section.

Action Codes Received by a CGI Function

The CGI is called in a number of different contexts. It determines the context by calling the `http_getAction()` function. The return value of `http_getAction()` indicates the reason that the CGI is being called by the HTTP server.

For a given upload, the CGI is called with a typical sequence of action codes. The first code is `CGI_START` (for the start of a new part), `CGI_DATA` (for each chunk of data in that part), then `CGI_END` (for the end of the part). Thus, the typical sequence for a single part is

```
CGI_START, CGI_DATA, CGI_DATA, .... CGI_DATA, CGI_END
```

Finally, at the end of all the parts, the action code is set to CGI_EOF.

Most CGIs should also handle a special action code called `CGI_ABORT`. This code only occurs if the upload is terminated early by a network problem (or by the user pressing the browser's cancel or stop button).

Let's examine a simple CGI that handles these five action codes. This is the minimum requirement; however, there are some additional codes that may be used by more advanced CGIs. The switch statement ignores action codes that are not listed. This is deliberate, since any other action codes may be safely ignored.

```
int my_CGI(HttpState * s)
{
   switch(http_getAction(s)) {
      case CGI_START:
         break;
      case CGI_DATA:
         break;
      case CGI_END:
         break;
      case CGI_EOF:
         break;
      case CGI_ABORT:
         break;
   }
   return 0;
}
```

The above code is a skeleton that does nothing! In other words, all incoming data is sent to the bit-bucket. It is ready to fill out with more useful actions. To avoid repeating the code, we just take each `case` condition, and fill in the details.

Action Code CGI_START

When the action code CGI_START is received, all of the part headers have been read, so the server knows everything relevant about the data that follows. The CGI can access this information using several of the HTTP API functions. The most important information is the field name on the form, from the <INPUT NAME= “fieldname”> element in the HTML form:

```
case CGI_START:
   if (http_getField(s)[0] == '/') {
      printf("Found a file to upload!\n");
      ...
   }
   break;
```

http_getField() looks at the first character of the field name to see if it is a slash character. We are using the convention that if the field starts with a slash, it is the name of a local file to be overwritten with the following data. Note that the field names are controlled by the server, via the NAME= parameters in the INPUT fields. We can choose any naming convention desired; in this case, using an initial slash seems to make sense for file destinations.

Now let’s fill in what happens when there is a file to save. In most cases, when writing or reading a file, it is necessary to “open” the file. When a file is open, it can be read and/or written. Finally, it is closed. All this implies that some sort of state needs to be maintained so that we can refer to the correct open file. It would be very easy if all the data was presented at once to the CGI, so that it could open, write, and close the file in one fell swoop. Unfortunately, that cannot happen since the data is not yet available on the CGI_START call. The CGI has no choice than to return to the HTTP server after doing whatever it can in the CGI_START state.

The solution to this problem is that the CGI opens the file on the CGI_START call, and stores the open file handle somewhere where it can be retrieved on the next (CGI_DATA or CGI_END) call. The recommended method for accomplishing this is to save the handle back with the server. You can use the http_setCond() and http_getCond() functions to do this.

The HTTP server maintains a set of so-called “cond” variables for each CGI instance. Your application decides how many cond variables there are by defining the HTTP_MAX_COND macro, which defaults to 4. Each cond variable is a 16-bit integer.

There is also a single integer variable accessed using http_getState() and http_setState().

Expanding on the above, let's add opening of the file:

```
#define COND_HANDLE 0                    // cond variable for storing the handle.
case CGI_START:
   if (http_getField(s)[0] == '/') {
      printf("Found a file to upload!\n");
      http_setCond(s, COND_HANDLE,
         sspec_open(http_getField(s), http_getContext(s),
            O_WRITE|O_CREAT|O_TRUNC, 0));
      if (http_getCond(s, COND_HANDLE) < 0)
         http_skipCGI();
   }
   else
      http_skipCGI(s);
   break;
```

The `sspec_open()` function opens the file (whose name is in the field name) with write access. The `http_getcontext()` function returns a server context structure which is required for the `sspec_open()` call. The context structure contains some details, such as the current user ID, but the details are usually not relevant to the CGI function itself. The file is created if it does not exist, and it is initially truncated if it already exists. The return value from `sspec_open()` is stored in the cond variable `COND_HANDLE`, which is a macro we defined to zero so we wouldn't have to remember hard-coded numbers. The return value is either negative (if there was an error), or not negative in which case it is a valid file handle. We check the cond variable just set, to make sure it has a valid value.

The `else` clause is added so that if the part is not a file to upload the rest of the data for this part is ignored. This is convenient, since we don't want to get called with `CGI_DATA` or `CGI_END` if this is not a file. If `http_skipCGI()` is called, then the next action code will be either `CGI_START` (if there is another part), or `CGI_EOF` (if there were none). Note that we are also calling `http_skipCGI()` in the case that the file could not be opened.

Action Code CGI_DATA

Let's now turn to saving the data. For this, we make use of the `CGI_DATA` action code:

```
int handle;
...
case CGI_DATA:
   handle = http_getCond(s, COND_HANDLE);
      sspec_write(handle, http_getData(s), http_getDataLength(s));
   break;
```

First, the open file handle is retrieved from the cond variable. This works because the HTTP server does not touch these variables between calls. The only time the server changes the cond variables is at the start of a completely new form submission, in which case they are usually set to zero. But don't depend on them being zero, since a form submission can sometimes contain syntax that sets them to non-default values. You can rely on `http_getState()` returning zero on the very first call; thereafter, it is not touched, but can be manipulated by the CGI calling the function `http_setState()`.

Having retrieved the open file handle (you didn't save it in a static variable, did you?) it is used in the `sspec_write()` call. `http_getData()` returns the available data, and `http_getDataLength()` returns its length (in bytes). The maximum length that `http_getDataLength()` will return is `HTTP_MAXBUFFER`, which is a macro controlled by the application (defaulting to 256). Often, the available data length will be less than this, even in the middle of a long file.

Note that the return code from `sspec_write()` is not checked. This is a shortcoming that we fix later, since the solution can be slightly complex. For now, we just hope that it works.

Action Code CGI_END

The next thing to consider is closing the file when the upload is complete. For this, we make use of the `CGI_END` action code:

```
case CGI_END:
   handle = http_getCond(s, COND_HANDLE);
   sspec_close(handle);
   break;
```

This is quite simple. We simply retrieve the handle, and close it.

Response to the Client: Redirection

Finally, we have to consider what to do at the end of all parts (`CGI_EOF`), or if the connection was cancelled (`CGI_ABORT`). You may recall that the CGI has two responsibilities: one is to process the incoming data, and the other is to write some results back to the client. We have already done the former, it is only left to do the latter.

Writing results to the client means we have to generate the proper HTTP response, including all the necessary headers and web page content. The CGI can do this itself, by putting strings in the buffer provided by the `http_getData()` call. Alternatively, the CGI can simply redirect back to another local (or even remote) web page and not bother writing anything itself.

If the CGI wants to generate the response itself, then this has the advantage of being slightly more efficient, but the disadvantage of requiring more code in the CGI. Usually, the application already has some sort of web page that can display the necessary results. This is often an "SSI" page (that is, dynamically generated using a specialized function) or may be just a static page (for example, `/index.html`).

Action Code CGI_EOF

Since referring to another web page is easiest, it is shown first:

```
case CGI_EOF:
   cgi_redirectto(s, "/index.html");
   break;
```

The `cgi_redirectto()` function tells the HTTP server to stop calling this CGI function, and tell the client to retrieve its next web page from the specified location (in this case, the `index.html` page on the current server). The onus is on the client (browser) to go and get that page. It will come straight back to this server, but the CGI does not have to worry about it. Easy!

In a similar vein, you can use the `http_switchCGI()` function. Again, the current CGI does not have to generate a response. The difference is that the HTTP server goes straight to the specified web page and presents it to the client on the same connection (rather than requiring the client to come back to the server with a new request).

`http_switchCGI()` can transfer control to any local web page, as if the client had directly requested that resource. If the resource happens to be another new-style CGI (like the one we are describing), then it gets control with the current action code, which will usually be `CGI_EOF`. Otherwise, the resource is processed as if it was directly retrieved by the client, by name. Note: the current CGI must not have written anything back to the client, otherwise the data wil not be intelligible to the client). Here is an example:

```
case CGI_EOF:
   http_switchCGI(s, "/index.html");
   break;
```

As you can see, it is very similar to the `cgi_redirectto()` case.

Action Code CGI_ABORT

The conventions for having the CGI generate its own response back to the client are covered in the next section, titled, Writing Responses to the Client from a CGI Function. First, we look at the proper handling of a `CGI_ABORT` action code. This code means that the connection has been lost and there is no point in handling any more incoming data or generating any response. Thus, processing of `CGI_ABORT` is necessarily limited to cleaning up any open files or other resources:

```
case CGI_ABORT:
   handle = http_getCond(s, COND_HANDLE);
   sspec_close(handle);
   break;
```

In this example, we simply close the handle, possibly leaving the file with partially written contents. It is important to do this, since if the handle is left open, then that handle is lost forever (or until the next reboot). The `CGI_ABORT` code can happen at any time, so the CGI must handle it if it ever uses "leakable" resources.

If you are alert, you noticed that `CGI_ABORT` may be called when there is no open handle. We must guard against the possibility of trying to close an "invalid" handle, since it may happen to belong to another active CGI. We can do this by ensuring the value in the cond variable is "-1" if the handle is not open.

Minimum Required Functionality of CGI

All the above code is pulled together, with the proper tests and comments on the additional code:

```
#define COND_HANDLE 0                    // cond variable for storing the handle.
int my_CGI(HttpState * s){
   int handle;

// Following block ensures that the first time (http_getState() is zero) we set the handle to -1.
   if (http_getState(s) == 0) {
      http_setState(s, 1);
      http_setCond(s, COND_HANDLE, -1);
   }
   switch(http_getAction(s)) {
      case CGI_START:
         if (http_getField(s)[0] == '//') {
            printf("Found a file to upload!\n");
            http_setCond(s, COND_HANDLE,
               sspec_open(http_getField(s), http_getContext(s),
               O_WRITE|O_CREAT|O_TRUNC, 0));
            if (http_getCond(s, COND_HANDLE) < 0)
               http_skipCGI();
         }
         else
            http_skipCGI(s);
         break;

      case CGI_DATA:
         handle = http_getCond(s, COND_HANDLE);
         sspec_write(handle, http_getData(s),
            http_getDataLength(s));
         break;

      case CGI_END:
         handle = http_getCond(s, COND_HANDLE);
         sspec_close(handle);

// The following statement ensures that the handle is set back to -1 when we know it is closed.
         http_setCond(s, COND_HANDLE, -1);
         break;

      case CGI_EOF:
         http_switchCGI(s, "/index.html");
         break;

      case CGI_ABORT:
         handle = http_getCond(s, COND_HANDLE);
```

```
// The following test is added so we don't try to close the handle if it is already closed.
            if (handle >= 0)
               sspec_close(handle);
            break;
      }
      return 0;
}
```

What Happens if the Write Fails?

There is still one point to cover. That is, the `sspec_write()` call is not guaranteed to swallow all of the data that it was told to write. In fact, `sspec_write()` may completely fail (for example, if the file system runs out of space).

First, let's handle the case where `sspec_write()` returns an error, that is, its return code is negative. In this case, we probably want to return an error indication to the client. This can be done using the `http_switchCGI()` or `cgi_redirectto()` functions. A special page will need to be created for this purpose. If this page is called "`/upld_err.html`", then the following code could be used:

```
case CGI_DATA:
   handle = http_getCond(s, COND_HANDLE);
   if (sspec_write(handle, http_getData(s),
      http_getDataLength(s)) < 0)
   {
      sspec_close(handle);
      http_switchCGI(s, "/upld_err.html");
   }
   break;
```

In the case of an error, the handle is closed, then the HTTP server presents the `upld_err.html` page to the client. The current CGI is abandoned, including any pending data that is still incoming. This is why the handle is explicitly closed (since `upld_err.html` probably doesn't know anything about it!). Naturally, `upld_err.html` is a web page that tells the user that something went wrong. In practice, this would usually be an SSI rather than a static web page, since you would probably want to give the user different feedback depending on the exact type of error.

The final consideration is what to do if `sspec_write()` can only write some (or perhaps none) of the data it was given. The normal course of action is to just retry later, with the data that was not written. You could just sit in a loop in the CGI function waiting for the data to be written. This may be satisfactory in some cases, but often this will unnecessarily reduce system performance (since nothing else will get a chance to run except interrupts). It is preferable to return to the HTTP server, which in turn can return to the application before coming back into the CGI.

CGI Return Codes

This is where the CGI return code becomes important. Up to now, the return code has always been zero, which means “continue as usual.” (However, some of the APIs such as `http_abortCGI()` override this.)

There are several other legitimate values for the return code:

- CGI_MORE: Call back again when free space in transmit buffer.
- CGI_DONE: CGI has finished writing data to the client.
- CGI_SEND: Send the data (null term string) in the main buffer.
- CGI_SEND_DONE: combination of the above two.

Action Code CGI_CONTINUE

In the case we are discussing, the `CGI_MORE` return code is used. This tells the server that the CGI function is busy trying to do something, but it could not complete the task. It wants to be called back again, but without any new incoming data.

Thus, if the CGI function returns `CGI_MORE`, the HTTP server will eventually come back with a special action code, which has not been mentioned yet, called `CGI_CONTINUE`. The CGI needs to respond to this code so that it can continue doing what it was trying before. This implies that the CGI will need to remember at least a bit of information (like how many bytes of the total it successfully wrote). For this, it can use the “state” and “cond” variables.

The following code shows the relevant sections for following this protocol:

```
int len, newlen;
#define COND_LEN 1
case CGI_DATA:
   handle = http_getCond(s, COND_HANDLE);
   len = sspec_write(handle, http_getData(s),
      http_getDataLength(s));

   if (len < 0) {                              //permanent error
      sspec_close(handle);
      http_switchCGI(s, “/upld_err.html”);
   }
   else if (len < http_getDataLength(s))       //no error, but not all written
   {
      http_setCond(s, COND_LEN, len);          //save place in file
      return CGI_MORE;                         //tell server we’re not done
   }
   break;
```

```
case CGI_CONTINUE:                          //CGI_MORE returned last time
   handle = http_getCond(s, COND_HANDLE); //get file handle
   len = http_getCond(s, COND_LEN);        //get place in file


   //  Try writing the part that wasn't written.
   newlen = sspec_write(handle, http_getData(s)+len,
      http_getDataLength(s)-len);
   if (newlen < 0) {                       //permanent error when retrying.
      sspec_close(handle);
      http_switchCGI(s, "/upld_err.html");
   }
   else {                                  //sum the total written count
      len += newlen;
      if (len < http_getDataLength(s)) {  //still haven't written all
         http_setCond(s, COND_LEN, len);   //save new place
         return CGI_MORE;                   //tell server we're not done
      }
   }
   break;
```

The important point is that when `CGI_CONTINUE` is the action code, the CGI retries the failed part of the previous operation, then tests whether it is complete. On completion, the usual "0" return code is returned, otherwise the CGI keeps returning `CGI_MORE` until the operation either completes or permanently fails. (The above code does not show the CGI returning zero. Look at the code in the default handler, `http_defaultCGI()`, to see this being done.)

You may notice the repetition of parts of this code, for example the calls to `http_switch_CGI()`. This is for clarity; you can condense some of this by factoring out the common parts.

The CGI remembers where it was up to by using another cond variable, `COND_LEN`. This is all that is required, since the contents of `http_getData()` and its length are guaranteed not to be changed on the next call, when the CGI returns `CGI_MORE`.

Writing Responses to the Client from a CGI Function

A CGI function is able to generate all or part of the response to the client. To do this, it has to follow the HTTP specification. That is, it must write the response headers, plus the HTML content. The HTTP headers must be the first thing written. At a minimum, the header lines look like the following:

```
HTTP/1.0 200 OK
Date: Sun, 20 Jan 1980 23:27:10 GMT
Content-Type: text/html
```

> **NOTE:** Each line must be terminated with a CRLF (that is, "`\r\n`"), and there must be a blank line after the last header. The date string can be constructed using the `http_date_str()` function.

You can create the headers in one hit using the following code:

```
char date[30];
sprintf(http_getData(s),
   "HTTP/1.0 200 OK\r\nDate: %s\r\nContent-Type: text/html\r\n\r\n",
   http_date_str(date));
```

Then send it to the client by returning CGI_SEND straight away. CGI_SEND tells the HTTP server that the CGI function has put a null-terminated string in the http_getData() buffer, and that the server should not call the CGI again until the string has been sent.

This is the most convenient way of sending relatively small amounts of data at a time. It relies on the fact that the CGI is allowed to write to the buffer returned by http_getData(). Since http_getData() is used to pass incoming data to the CGI, it is important to ensure that the *incoming data has been fully processed* before writing over that buffer. In addition, the buffer's length is HTTP_MAXBUFFER which limits the size of the string (including the null terminator).

The CGI can return CGI_SEND for any action code (except CGI_ABORT). When the action code is CGI_EOF, there is no more incoming data, so strings can be written back to the client indefinitely; the server keeps calling the CGI at CGI_EOF. When the CGI has finished generating all the content, it must return CGI_DONE.

When the server gets the CGI_DONE return code, it closes the client connection normally, and ceases calling the CGI.

If the CGI has one more thing to write before it is "done," it can return CGI_SEND_DONE which combines the CGI_SEND and CGI_DONE return codes. This can simplify the CGI if it does not have to do much when it first gets the CGI_EOF action code.

Using CGI_SEND return code has some limitations. In particular, only a limited size of string may be sent to the client on any one call. Also, a null character cannot be sent to the client because the null is interpreted as the end of the string. The null character problem is not usually important, since nulls are rarely (if ever) sent in an HTML document. The length limitation is more important, since some HTML constructs can be very verbose.

The http_write() function is designed to overcome these limitations. http_write() writes data from an arbitrary buffer (with a higher length limit on any one call), and returns either zero meaning that all data was successfully queued, or it may return CGI_MORE if it could not write the data. Either all or none of the data will be written, respectively. In the case that none was written, the CGI returns the CGI_MORE return code to the HTTP server. The CGI will then be called back with an action code of CGI_CONTINUE, where it should retry the failed http_write() call.

If `http_write()` returns zero, it can be called again immediately with more data, or the CGI can return zero to the HTTP server. Otherwise, the CGI function will generally need to remember what it was up to, and retry the `http_write()` on the next call. The following code illustrates use of `http_write()`:

```
static const char * a_very_long_html_fragment = "...."; //512 bytes
case CGI_END:
   return http_write(s, a_very_long_html_fragment,
      strlen(a_very_long_html_fragment));

case CGI_CONTINUE:
   if (was_writing_that_long_fragment)
      return http_write(s, a_very_long_html_fragment,
         strlen(a_very_long_html_fragment));
   break;
```

The details of determining which write was in progress have been glossed over. Basically, you would have to use a cond variable to keep track of which `http_write()` was in progress, if there is more than one possibility.

There is a limit to the amount of data that `http_write()` can possibly write on any given call. This limit is set by the HTTP server socket transmit buffer size. This buffer size is given by `TCP_BUF_SIZE`/2. The transmit buffer is usually at least 1024 bytes, which is considerably larger than the limitation when using the `CGI_SEND` return code (typically 255 bytes). If you try exceeding that limit, `http_write()` will never succeed.

Step 7: Creating the Resource Tables

Web browsers use URLs, which are specially formatted strings, to refer to resources (web pages) on the server. For example, a user may enter `http://rabbit_server/admin/upload.html` to retrieve the `/admin/upload.html` resource from the HTTP server on "rabbit_server."

When the server receives such a request, it needs to look up the name, open the resource that it refers to, and send the contents back to the client.

CGI functions are no different from other resources, as far as the client is concerned. The server, of course, does entirely different things. The server needs to have a lookup table defined, which translates URLs into the appropriate local type of resource. This is the function of the "resource table," which is also known as the "flashspec" or "ramspec" table in Dynamic C parlance.

The static resource table is a statically defined, constant, table. The dynamic resource table is generated at runtime. Both types can be used in the same program, with dynamic entries overriding static entries with the same URL.

With this release of Dynamic C, there is no need to put anything in either of these tables, provided that a filesystem (FAT or FS2) is used. However, it is convenient to have at least a few entries in the dynamic table, and it is mandatory to have entries in either or both the static and dynamic tables if CGI functions are used.

When using the HTTP upload facility, you will need at least one CGI function to be defined, and probably another entry for the initial form. The resource table may be defined as follows:

```
SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.html", index_html),
   SSPEC_RESOURCE_CGI("upload.cgi", my_CGI)
SSPEC_RESOURCETABLE_END
```

This defines a static resource table with two entries. The first is a static web page for the form (`index.html`) and the second points to the CGI that will be used to process the uploaded data. Important: use `SSPEC_RESOURCE_CGI`, not `SSPEC_RESOURCE_FUNCTION` - this defines the CGI as new-style. `SSPEC_RESOURCE_XMEMFILE` specifies a file that has been imported in the server's flash memory using the `#ximport` directive. For example,

```
#ximport "samples/tcpip/http/pages/upload.html"    index_html
```

`index_html` is a placeholder (a `long int`) for the start of the file. This is mentioned in the resource table entry so that the server knows where to get it.

The second entry above specifies a "new-style" CGI function, which has been the subject of the preceding sections. You must use the `SSPEC_RESOURCE_CGI` macro to specify this type of CGI. The URL (string) parameter is whatever is mentioned in the <form action=...> parameter of the initial web page. The other parameter is the function pointer to the CGI that will process the upload.

If you do not wish to write a CGI just for handling file uploads, you could specify `http_defaultCGI()` as the CGI function.

Step 8: Create List of Content Type Mappings

The HTTP server needs to recognize different file formats. This is done using file extensions and MIME types. The server shares this information with the browser in its header. In this way, the browser knows how to handle the file.

The following code creates a table that maps file extensions to the appropriate MIME type.

```
SSPEC_MIMETABLE_START
   SSPEC_MIME(".htm", "text/html"),
   SSPEC_MIME(".html", "text/html"),
   SSPEC_MIME(".gif", "image/gif"),
   SSPEC_MIME(".cgi", "")
SSPEC_MIMETABLE_END
```

This method of creating the MIME type mapping table is new with Dynamic C version 8.5.

Step 9: Rule Creation

There must be rules to limit the upload facility to select user groups. This access control adds security to the system by disallowing unauthorized tampering.

This is done be assigning a unique user (or user group) the privilege of uploading new files. All other users will be permitted only read access. To do this, there are several things that need to be coordinated. First, the user(s) need to be created and assigned the correct group bit (which defines the upload privilege). Then, the CGI and the file system need to be protected so that only the privileged group can use the CGI, and only the privileged group can write to a defined subset of the file system.

Let's take this step-by-step. In the main program, define a group bit to represent the privileged user(s):

```
#define ADMIN_GROUP   0x0002
```

Groups are assigned one bit out of 16. In this case, we select bit 1. (Bit 0, or 0x0001, will be used for all other users).

Next, augment the resource table so that the CGI is accessible only to users in `ADMIN_GROUP`:

```
SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.html", index_html),
   SSPEC_RESOURCE_P_CGI("upload.cgi", my_CGI,
                        "newPages", ADMIN_GROUP, 0x0000,
                        SERVER_HTTP, SERVER_AUTH_BASIC)
                        SSPEC_RESOURCETABLE_END
```

The `SSPEC_RESOURCE_P_CGI` is a macro that allows specification of access control parameters. After the usual URL string and function pointer, the next parameters are:

- "newPages" - this is the so-called "realm" of the CGI resource. This is not particularly significant, except that it notifies the client that this is a restricted resource, and that a userid/password will be required. The user sees this string when prompted for his or her credentials.
- `ADMIN_GROUP` - this was the group defined above. In this context, it applies to the read access rights. To read this resource (that is, to use the CGI), the user needs to be in this group.
- 0x0000 - this is also a group bit parameter, for write access. CGIs themselves do not have the concept of "writability" (that would imply the ability to change the CGI function!) so this is always zero for a CGI.
- `SERVER_HTTP` - this specifies the server that can use the CGI function. CGIs are currently only usable by the HTTP server, thus there is no other sensible choice for this parameter.
- `SERVER_AUTH_BASIC` - this specifies the required (minimum) authentication method. `BASIC` means that a simple plain-text userid and password will be required. A better choice is `SERVER_AUTH_DIGEST` since that does not reveal the password to anyone listening in on the conversation; however, older web browsers do not support this.

Next, the file system needs to be protected. Usually, you do not want the entire file system to be writable, even to the privileged group members. To establish this sort of protection, you need to set up a rule-based access control. This is done using the SSPEC_RULETABLE method, or equivalent runtime control:

```
#define SSPEC_FLASHRULES
...
#use “http.lib”
...
SSPEC_RULETABLE_START
   SSPEC_MM_RULE("/A/new", "newPages", 0xFFFF, ADMIN_GROUP,
     SERVER_HTTP, SERVER_AUTH_NONE, NULL)
SSPEC_RULETABLE_END
```

The SSPEC_FLASHRULES macro must be defined before you #use “http.lib”. The rule table has one entry in this example. The parameters to this entry are:

- “/A/new” - this is the string prefix of all file names to which this rule applies. In this example, everything in the first FAT partition (/A/) with a filename starting with “new” is protected according to the remaining parameters. This includes any file in the root directory whose name starts with “new,” or any file in any subdirectory of the root directory where the subdirectory name starts with “new.”
- “newPages” - this is the realm string assigned to these files. This is the same as the CGI realm, but need not be.
- 0xFFFF - this is the user groups who are allowed read access. In this case, everyone is allowed.
- ADMIN_GROUP - this is the writable group: only the one defined for the CGI is allowed.
- SERVER_HTTP - only the HTTP server can access.
- SERVER_AUTH_NONE - this is only relevant when the resource is being read directly by the client. When the file is written (via the CGI) the CGI has already authenticated the user in its own way, and doesn’t need to re-authenticate. In this example, no authentication is required for retrieval (read-only) of the file.
- NULL - this is an additional parameter that is not relevant to this discussion.

By default, every other file in the filesystem(s) that is not covered by this rule is denied write access. In general, a rule is only required when it is desired to permit write access (not deny it).

4.6.2.1 Step 10: Create Set of User IDs

The last step is to actually define the users. This must be done at runtime, using the sauth_*() functions. The following code illustrates:

```
int uid;

uid = sauth_adduser("admin", "upload", SERVER_HTTP);
sauth_setusermask(uid, ADMIN_GROUP, NULL);
sauth_setwriteaccess(uid, SERVER_HTTP);
```

This sets up a single user, with userid “admin” and password “upload.” The user is only “known” to the HTTP server. sauth_setusermask() is required when a userid is created (since the default may not be satisfactory). It makes sure the user is placed into the correct group(s), in this case, the ADMIN_GROUP that we defined above. Finally, each user must be *individually* granted write access using the sauth_setwriteaccess() function. If this is not done, the user will not be able to write the file in spite of passing other tests.

Step 11: Tying It All Together

After performing the above steps, the actual running of the HTTP server and CGI is almost trivial. The main C function should have a loop in it which calls `http_handler()`:

```
void main()
{
   int uid;

   sock_init();                  // Initialize the network

   // Mount the FAT filesystem.
   sspec_automount(SSPEC_MOUNT_ANY, NULL, NULL, NULL);

   // Create the authorized user, as described in the previous section.
   uid = sauth_adduser("admin", "upload", SERVER_HTTP);
   sauth_setusermask(uid, ADMIN_GROUP, NULL);
   sauth_setwriteaccess(uid, SERVER_HTTP);

   http_init();              // Initialize the HTTP server

   tcp_reserveport(80);      // Enable smooth handling of multiple HTTP requests
   for (;;) http_handler(); // The big loop! Drives everything.
}
```

All error handling has been pared out of the above code. For full details, please refer to the sample program `samples\tcpip\http\upld_fat.c`.

4.7 API Functions for HTTP Servers

Below is a list of links to the function descriptions for each of the API functions for the HTTP server.

cgi_continue
cgi_redirectto
cgi_sendstring
http_abortCGI
http_addfile
http_contentencode
http_date_str
http_defaultCGI
http_delfile
http_finderrbuf
http_finishCGI
http_getAction
http_getCond
http_getContentDisposition
http_getContentLength
http_getContentType
http_getcontext
http_getContext
http_getData
http_getDataLength
http_getField
http_getHTTPMethod
http_getHTTPMethod_str
http_getHTTPVersion
http_getHTTPVersion_str
http_getRemainingLength
http_get_sock
http_getSocket
http_getState
http_getTransferEncoding
http_getURL
http_getUserState
http_handler
http_idle
http_init
http_is_secure
http_nextfverr
http_parseform
http_safe
http_scanpost
http_set_anonymous
http_setauthenticati on
http_setCond
http_setcookie
http_set_path
http_setState
http_shutdown
http_skipCGI
http_sock_bytesready
http_sock_fastread
http_sock_fastwrite
http_sock_gets
http_sock_mode
http_sock_readable
http_sock_writable
http_sock_tbleft
http_sock_write
http_sock_xfastread
http_sock_xfastwrite
http_status
http_switchCGI
http_urldecode
http_write
shtml_addfunction
shtml_addvariable
shtml_delfunction
shtml_delvariable

cgi_continue

```
int cgi_continue( HttpState * state, char * localurl );
```

DESCRIPTION

Called from a CGI function after processing any data submitted. This function continues creating a response as if from a normal GET request to the specified local URL.

NOTE: the CGI function must NOT have sent any data to the socket.

PARAMETERS

state	A pointer to the HTTP server state structure.
localurl	The URL string, which must be a URL defined in the server spec table (otherwise the browser will see a "not found" message).

RETURN VALUE

The return value from this function should be used as the return value from the CGI handler function that calls it.

LIBRARY

HTTP.LIB

cgi_redirectto

```
void cgi_redirectto( HttpState *state, char *url );
```

DESCRIPTION

This utility function may be called in a CGI function to redirect the user to another page. It sends a user to the URL stored in `url`. You should immediately issue a "`return 0;`" after calling this function. The CGI is considered finished when you call this, and will be in an undefined state.

The HTTP samples work correctly with `cgi_redirectto()` because they use macro constants to define the URL parameter. If you manipulate the url string, please be aware of the following issues:

- The library function sets a pointer to the 2nd parameter - url. The calling routine is responsible for ensuring that the location represented by the pointer remains valid after the call. This is because the URL string will not be processed until after the CGI function is finished.
- If the application has `MAX_TCP_SOCKET_BUFFERS` and `HTTP_MAXSERVERS` set to more than one, it is possible that the CGI function will be called successively with different server states serving different client requests. In these circumstances it is necessary to ensure that the pointer to the url is valid for each of the server states.
- After the cgi function has called `cgi_redirecto()` and returns 0, the http_handler then causes the server response to be sent to the browser. The information is sent as follows:

  1. HTTP header response containing the redirection information response code 302.
  2. A human readable redirection html page telling the user that redirection has taken place, and to click "here" to go to the new URL. This is for browsers that do not recognize the redirection 302 command in the header.

This may cause a problem for browsers which **do** recognize the 302 redirection command. Some browsers immediately issue a GET request to the new location while still reading in the human readable page. If `MAX_TCP_SOCKET_BUFFERS` and `HTTP_MAXSERVERS` are set to one, the server will not receive the GET request because it is busy sending out the human-readable page. The symptom is that the browser appears to time-out. (This timing problem may be masked when a proxy server is used.) Set `MAX_TCP_SOCKET_BUFFERS` and `HTTP_MAXSERVERS` to a value more than one to prevent this problem.

cgi_redirectto

PARAMETERS

state	Current server struct, as received by the CGI function.
url	Fully qualified URL to redirect to.

RETURN VALUE

None - sets the state, so the CGI must immediately return with a value of `0`.

LIBRARY

HTTP.LIB

SEE ALSO

cgi_sendstring

cgi_sendstring

```
void cgi_sendstring( HttpState *state, char *str );
```

DESCRIPTION

Sends a string to the user. You should immediately issue a "`return 0;`" after calling this function. The CGI is considered finished when you call this, and will be in an undefined state. This function greatly simplifies a CGI handler because it allows you to generate your page in a buffer, and then let the library handle writing it to the network.

PARAMETERS

state	Current server struct, as received by the CGI function.
str	String to send.

RETURN VALUE

None - sets the state, so the CGI must immediately return with a value of `0`.

LIBRARY

HTTP.LIB

SEE ALSO

cgi_redirectto

http_abortCGI

```
int http_abortCGI( HttpState * state );
```

DESCRIPTION

Terminate this CGI request. The client will receive an error message indicating the connection was closed.

The CGI should not make any further HTTP calls after calling this function. It should clean up any resources that it opened, since no further calls are made to this CGI for this request.

PARAMETERS

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

0

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction, http_skipCGI, http_switchCGI, http_finishCGI, http_write

http_addfile

```
int http_addfile( char *name, long location );
```

DESCRIPTION

Adds a file to the dynamic resource table.

PARAMETERS

name	Name of the file (for example, `/index.html`).
location	Address of the file data. (Return value from `#ximport`)

RETURN VALUE

`0`: Success.
`1`: Failure.

LIBRARY

`HTTP.LIB`

SEE ALSO

`http_delfile`

http_contentencode

```
char *http_contentencode( char *dest, const char *src, int len );
```

DESCRIPTION

Converts a string to include HTTP transfer-coding *tokens* (such as @ (decimal) for at-sign) where appropriate. Encodes these characters: "<>@%#&"

Source string is NULL-byte terminated. Destination buffer is bounded by len. This function is reentrant.

PARAMETERS

dest	Buffer where encoded string is stored.
src	Buffer holding original string (not changed)
len	Size of destination buffer.

RETURN VALUE

dest: There was room for all conversions.
NULL: Not enough room.

LIBRARY

HTTP.LIB

SEE ALSO

http_urldecode

http_date_str

```
char *http_date_str( char *buf );
```

DESCRIPTION

Print the date (time zone adjusted) into the given buffer. This assumes there is room!

PARAMETERS

buf The buffer to write the date into. This requires at least 30 bytes in the destination buffer.

RETURN VALUE

A pointer to the string.

LIBRARY

HTTP.LIB

SEE ALSO

http_handler

http_defaultCGI

```
int http_defaultCGI( HttpState * state );
```

DESCRIPTION

This function should not be called directly by the application. It is intended to be used as a new-style CGI for handling file uploads. See "samples\tcpip\http\upld_fat.c" for an example of using this function.

This CGI function accepts POST requests from the client (browser) which may contain one or more files that are being uploaded. It looks at the field name of the form data in the request. If the field name starts with "/", it is assumed to be the name of a resource which is to be created (if it does not already exist) and overwritten with the uploaded file contents.

There are three steps required to use this CGI:

1. Define a CGI resource in the flash- or ram-spec table. If using flashspec, for example, there would be an entry like

   ```
   SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.html",index_html),
   SSPEC_RESOURCE_CGI("/upload.cgi", http_defaultCGI)
   SSPEC_RESOURCETABLE_END
   ```

   There may be other resources, but at least two are normally required. One resource is a web page (see below) that contains a form the user can fill in with the name of the file to upload. The other resource (CGI) is a reference to this function, giving it a URL name that identifies it to the browser.

2. Create a web page which contains a form like the following skeleton example:

   ```
   <FORM ACTION="/upload.cgi" METHOD="POST"
         enctype="multipart/form-data">
      <INPUT TYPE="FILE" NAME="/A/incoming/new.htm">
      <INPUT TYPE="SUBMIT" VALUE="Upload">
   </FORM>
   ```

   in the <FORM> element, the ACTION= parameter specifies the URL assigned to this CGI. In the <INPUT TYPE= "FILE"> element, the NAME= parameter specifies the resource name used to contain the uploaded file contents. In this example, the resource is called "/A/incoming/new.htm", which will work if you are using the FAT filesystem.

   If uploading to a subdirectory, "incoming" in the above example, the subdirectory must already exist. If not, the upload will fail.

3. To add user authentication and other facilities there are three possible things to protect:
    - The web page containing the form. Give read access only to those users who could conceivably upload the files specified therein.
    - The CGI itself (this function). Protect as for (a).
    - The uploaded resource. You should set up a rule allowing write access only to the intended user(s).

When defining user IDs which can use the upload, do not forget to give those users overall write access using, for example:

```
sauth_setwriteaccess(uid, SERVER_HTTP)
```

Be aware that "rogue clients" could easily change the resource name to something other than the one that was intended in the original form. This is why resource protection is important.

Having done these three things, the HTTP server is now set up to automatically place uploaded files in the filesystem.

Note that this CGI is limited to placing files into fixed resource locations (as specified by the field name of the INPUT element). If you need more sophisticated control, you may wish to write your own CGI function, using the code of this one as a starting point.

This CGI also presents a default status web page back to the client. This page indicates whether the upload was successful, the number of bytes uploaded, and a link to test out the new file (assuming it is something the browser will understand, such as an HTML document or GIF image). You can use this function as a starting point for generating your own content.

PARAMETERS

state	HTTP state pointer, provided by HTTP server to all CGIs.
newURL	The resource name to present to the client. This may be another CGI, or any other type of resource that could be presented to the client in response to an HTTP GET or POST request. The resource must exist in the flash- or ram-spec table, or in a filesystem.

RETURN VALUE

See documentation for "writing a data handler CGI"

LIBRARY

HTTP.LIB

SEE ALSO

```
http_getAction, http_skipCGI, http_switchCGI, http_finishCGI,
http_write
```

http_delfile

```
int http_delfile( char *name );
```

DESCRIPTION

Deletes a file from the RAM spec table.

PARAMETERS

name Name of the file, as passed to `http_addfile()`.

RETURN VALUE

`0`: Success;
`1`: Failure (not found).

LIBRARY

`HTTP.LIB`

SEE ALSO

`http_addfile`

http_finderrbuf

```
char *http_finderrbuf( char *name );
```

DESCRIPTION

Finds the occurrence of the given variable in the HTML form error buffer, and returns its location.

PARAMETERS

name Name of the variable.

RETURN VALUE

NULL: Failure.
!NULL: Success, location of the variable in the error buffer.

LIBRARY

HTTP.LIB

http_findname

```
int http_findname(char *name);
```

DESCRIPTION

Finds a spec entry, searching first in RAM, then in flash.

This function is deprecated as of Dynamic C 8.50. Use `sspec_findname()`.

PARAMETERS

name Name, in text, of the spec to find.

RETURN VALUE

The spec entry.

LIBRARY

HTTP.LIB

http_finishCGI

```
int http_finishCGI( HttpState * state );
```

DESCRIPTION

Indicate to the HTTP server that this CGI has finished processing data from this multi-part data stream. The server reads (and discards) data to the end of the entire stream (including epilog). The next call to the CGI function will have an action code of `CGI_EOF` (or possibly `CGI_ABORT` if there was a stream error).

PARAMETERS

`state` HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

0

LIBRARY

HTTP.LIB

SEE ALSO

`http_getAction, http_skipCGI, http_abortCGI, http_switchCGI, http_abortCGI, http_write`

http_genHeader

```
void http_genHeader( HttpState * state, char * buf, int buflen, int
   code, char * content_type, int more_hdrs, char * content);
```

DESCRIPTION

This function builds HTTP headers to send in response to a request.

PARAMETERS

state	HTTP state pointer, as provided in the first parameter to the CGI function.
buf	Buffer to store headers and copy of content.
buflen	Size of buffer.
code	HTTP Status code (e.g., 200 for OK).
content_type	Content type string or NULL for default of "text/html"
more_hdrs	0 = no more headers 1 = caller will add headers 2 = caller will add headers, but call custom headers function (if HTTP_CUSTOM_HEADERS is defined)
content	If "more_hdrs" is non-zero, this parameter can include additional headers, followed by two \r\n pairs and then content for the response. If "more_hdrs" is zero, this parameter is sent as page content only.

LIBRARY

HTTP.LIB

http_getAction

```
char http_getAction( HttpState * state );
```

DESCRIPTION

Return the current CGI action. This should be called only from a CGI function registered as a SSPEC_CGI resource in the zserver resource table.

> **NOTE:** This is implemented as a macro. You must define the macro USE_HTTP_UPLOAD if using this macro, otherwise you will get a compile-time error.

http_getAction() should be called at the top of the CGI function. Other http_get* functions/macros may or may not be valid depending on the action code. The following table shows which functions are applicable:

Table 4-1. Valid Functions per Action Code

CGI Action Code	Valid Functions/Macros
Any action code except CGI_ABORT	http_getContext, http_getURL, http_getState, http_setState, http_getCond, http_setCond, http_getUserState, http_getSocket, http_write, http_abortCGI, http_skipCGI, http_finishCGI, http_switchCGI, http_getHTTPVersion, http_getHTTPVersion_str, http_getHTTPMethod, http_getHTTPMethod_str, http_getRemainingLength
CGI_START	http_getField, http_getContentLength, http_getContentType, http_getContentDisposition, http_getTransferEncoding
CGI_DATA	http_getField, http_getContentLength, http_getContentType, http_getContentDisposition, http_getTransferEncoding, http_getData, http_getDataLength
CGI_END	http_getField, http_getContentLength, http_getContentType, http_getContentDisposition, http_getTransferEncoding
CGI_HEADER, CGI_PROLOG, CGI_EPILOG, CGI_EOF	http_getData, http_getDataLength
CGI_CONTINUE	Depends on previous action code at time of returning CGI_MORE, however http_getData will NOT be valid.

Table 4-1. Valid Functions per Action Code

CGI Action Code	Valid Functions/Macros
CGI_ABORT	Should only do resource cleanup. http_getContext, http_getURL, http_getState, http_getCond, http_getUserState, http_getHTTPVersion, http_getHTTPVersion_str, http_getHTTPMethod, http_getHTTPMethod_str

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Action code. One of the following values:

- CGI_START - start of a part in a multi-part transfer.
- CGI_DATA - binary data for this part
- CGI_END - end of a part
- CGI_HEADER - header line of a part
- CGI_PROLOG - binary data before the first part
- CGI_EPILOG - line of data after the last part
- CGI_EOF - normal end of all parts and epilog
- CGI_ABORT - abnormal termination. CGI should recover and/or close any open resources.
- CGI_CONTINUE - being called from the HTTP server after the CGI previously returned CGI_MORE.

LIBRARY

HTTP.LIB

SEE ALSO

(functions mentioned above), http_defaultCGI

http_getCond

```
int http_getCond( HttpState * state, int idx );
```

DESCRIPTION

Return the current HTTP condition state variable (aka., cond variable). There are HTTP_MAX_COND of these integer state variables, thus idx must be between 0 and HTTP_MAX_COND-1, inclusive.

Use of cond variables is entirely up to the application; however, they are initialized by the HTTP server under certain conditions. By default, they are set to zero at the start of each request from the client. If the client request includes URL GET-type parameters of the form http://host/resource.html?A=1&B=2&C=3 etc. then cond state 0 is set to the value for 'A', cond state 1 is set to the value for 'B' etc. The values must be integers, which are coerced into 16 bit signed integers.

NOTE: This is implemented as a macro.

PARAMETERS

state	HTTP state pointer, as provided in the first parameter to the CGI function.
idx	Index of cond variable: 0..HTTP_MAX_COND-1. Validity is not checked.

RETURN VALUE

Value of cond variable idx.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction, http_setCond

http_getContentDisposition

```
char http_getContentDisposition( HttpState * state );
```

DESCRIPTION

Return the current disposition of the data which is being provided by the client. This is one of the following enumerated values:

- MIME_DISP_NONE: unspecified disposition
- MIME_DISP_INLINE: the content is to be displayed "inline"
- MIME_DISP_ATTACHMENT: the content is only to be displayed if there is some action by the user
- MIME_DISP_FORMDATA: the content is form field data (or an uploaded file).

Of these, only NONE and FORMDATA are really relevant to HTTP. It is only valid to call this when the action code is CGI_START, CGI_DATA or CGI_END.

NOTE: This is implemented as a macro.

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Content disposition code, as documented above.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_getContentLength

```
long http_getContentLength( HttpState * state );
```

DESCRIPTION

Return the length of data in the current part of a multi-part data stream. The return value is interpreted differently, depending on the action code.

It is only valid to call this when the action code is CGI_START, CGI_DATA or CGI_END.

When CGI_START, this returns the value of the ContentLength header for this part (or -1 if there was no such header).

When CGI_DATA or CGI_END, it is the total number of bytes that have actually been read and presented to the CGI. This increases for each CGI_DATA call, until it represents the total content length when action is CGI_END.

NOTE: This is implemented as a macro.

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Length of part data.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_getContentType

```
char * http_getContentType( HttpState * state );
```

DESCRIPTION

Return the current content type of the data which is being provided by the client. This is a MIME type string e.g., “text/html” or “image/jpeg”.

The CGI might need to look at this to determine the appropriate way to process the data. Normal form fields will usually contain “text/plain”; however, uploaded files may contain any type of data.

It is only valid to call this when the action code is `CGI_START`, `CGI_DATA` or `CGI_END`.

NOTE: This is implemented as a macro.

PARAMETER

`state` HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Null terminated string containing the MIME type name.

LIBRARY

HTTP.LIB

SEE ALSO

`http_getAction`

http_getcontext

```
ServerContext * http_getcontext( int servno );
```

DESCRIPTION

Return the ServerContext struct for the specified HTTP server instance.

NOTE: This structure should not be modified by the application.

PARAMETER

servno Server instance number (0..HTTP_MAXSERVERS-1)

RETURN VALUE

NULL: invalid server instance.
Otherwise, pointer to this server's ServerContext.

LIBRARY

HTTP.LIB

http_getContext

```
ServerContext * http_getContext( HttpState * state );
```

DESCRIPTION

Return the current HTTP server context. The context pointer is required by many zserver resource handler functions.

NOTE: This is implemented as a macro.

PARAMETER

state	HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Pointer to the HTTP server's context structure. See zserver documentation.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_getData

```
char * http_getData( HttpState * state );
```

DESCRIPTION

Return a pointer to the data that is available. It is only valid to call this if the action code is one of CGI_DATA, CGI_PROLOG, CGI_EPILOG, CGI_HEADER or CGI_EOF.

When CGI_DATA, this is the next chunk of data received as the content of the current part of a multi-part transfer. The data arrives in arbitrary amounts. CRLF boundaries (if any) are not respected, and the data may contain NULLs and other binary values. THE CGI MUST CONSUME ALL DATA PROVIDED since the data will not be presented again on the next call.

When CGI_PROLOG, this is data that occurs before the first boundary (part) but after the main HTTP headers. This data (like that for CGI_DATA) is not line-oriented.

When CGI_EPILOG, CGI_HEADER or CGI_EOF, the data will be a complete line of input (with the terminating CRLF stripped off). The returned string will also be null-terminated. When CGI_EOF, the data (if any) is technically part of the epilog.

Prolog data is lines of input that were provided before the first "official" part of the multi-part data. Most HTTP clients will not provide any prolog data. Epilog data is lines of data after the last official part. Again, HTTP clients do not usually generate it. It is always safe to ignore prolog and epilog data, since it is usually provided only for non-MIME compliant servers.

Data provided when the action is CGI_HEADER is a line of header data provided at the start of each part of the multi-part data. It is safe for the CGI to ignore header lines, since the HTTP server also processes the ones that it needs. The CGI is given these header lines so that it can extract useful or customized information if desired.

The length of the data may be obtained using http_getDataLength().

The CGI is allowed to overwrite data at the returned area, provided that it writes no more than HTTP_MAXBUFFER bytes.

NOTE: This is implemented as a macro.

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Pointer to the first character of data.

SEE ALSO

http_getAction

http_getDataLength

```
word http_getDataLength( HttpState * state );
```

DESCRIPTION

Return the length of data that is available. It is only valid to call this if it is valid to call `http_getData()`. That is, if the action code is one of `CGI_DATA`, `CGI_PROLOG`, `CGI_EPILOG`, `CGI_HEADER` or `CGI_EOF`.

NOTE: This is implemented as a macro.

PARAMETER

state	HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Length of available data. This will range from 0 to `HTTP_MAXBUFFER`. 0 will only be returned for PROLOG and EPILOG when a blank line is read.

LIBRARY

HTTP.LIB

SEE ALSO

`http_getAction`

http_getField

```
char * http_getField( HttpState * state );
```

DESCRIPTION

Return the current form field name. This function should only be called when the action code is CGI_START, CGI_DATA or CGI_END.

NOTE: This is implemented as a macro.

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Null-terminated string containing the current field name. The field name is the name of a form element, specified using, for example,

```
<INPUT TYPE="TEXT" NAME="srv_file">
```

in the HTML, where srv_file is the field name.

If there was no "name=" parameter in the returned form data, this will be an empty string (zero length, not NULL).

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_getHTTPMethod

```
char http_getHTTPMethod( HttpState * state );
```

DESCRIPTION

Return the HTTP request method of the current request protocol. The CGI might need to look at this to generate the correct response headers.

NOTE: This is implemented as a macro.

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

One of the following codes:

- HTTP_METHOD_GET - "GET" i.e., normal retrieval, without making any permanent state update.
- HTTP_METHOD_POST - "POST" i.e., uploading some information to be stored, or making some permanent state change. This is the normal method for invoking CGIs.
- HTTP_METHOD_HEAD - "HEAD" i.e., the client only wants the headers, not the actual content e.g. it might be trying to determine the most recent modification date.

Other codes may be returned in the future.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_getHTTPMethod_str

```
char *http_getHTTPMethod_str( HttpState * state);
```

DESCRIPTION

Return the HTTP request method of the current request protocol. The CGI might need to look at this in order to generate the correct response headers.

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

One of the following strings:
"GET" - (HTTP_METHOD_GET) i.e., normal retrieval, without making any permanent state update.
"POST" - (HTTP_METHOD_POST) i.e., uploading some information to be stored, or making some permanent state change. This is the normal method for invoking CGIs.
"HEAD" - (HTTP_METHOD_HEAD) i.e. the client only wants the headers, not the actual content; e.g., it might be trying to determine the most recent modification date.
"unknown" - returned for unrecognized method

Other strings may be returned in the future.

SEE ALSO

http_getHTTPMethod, http_getAction

http_getHTTPVersion

```
char http_getHTTPVersion( HttpState * state );
```

DESCRIPTION

Return the HTTP version number of the current request protocol. The CGI might need to look at this in order to generate the correct response headers.

NOTE: This is implemented as a macro.

PARAMETER

state	HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

One of the following codes:
HTTP_VER_09 - version 0.9
HTTP_VER_10 - version 1.0
HTTP_VER_11 - version 1.1

Other codes may be returned in the future.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_getHTTPVersion_str

```
char * http_getHTTPVersion_str( HttpState * state);
```

DESCRIPTION

Return the HTTP version number of the current request protocol. The CGI might need to look at this in order to generate the correct response headers.

PARAMETERS

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

One of the following strings:
“0.9” - version 0.9
“1.0” - version 1.0
“1.1” - version 1.1
“unknown” - unknown version

Other strings may be returned in the future.

LIBRARY

HTTP.LIB

SEE ALSO

http_getHTTPVersion, http_getAction

http_getRemainingLength

```
long http_getRemainingLength( HttpState * state );
```

DESCRIPTION

Return the remaining length of the incoming data stream. This length includes all parts (not just the current part) and also includes the boundary separators and epilog data. Normally, this value will be zero when the action code is CGI_EOF. If the value is negative, then the client might not have indicated the total data length, or might not have set the right value.

NOTE: This is implemented as a macro.

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Length of remaining data, or negative if not known.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_get_sock

```
tcp_Socket * http_get_sock( HttpState *state );
```

DESCRIPTION

This function allows direct access to the TCP socket of an HTTP or HTTPS server. This will always return the TCP socket associated with the server, even if that server is HTTPS. This is intended for READ-ONLY operations. Since this function returns a pointer to the actual socket, changing fields directly affects the connection, which could lead to problems, especially with HTTPS servers.

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Pointer to the TCP socket structure of the HTTP or HTTPS server.

LIBRARY

HTTP.LIB

http_getSocket

```
tcp_Socket * http_getSocket( HttpState * state );
```

DESCRIPTION

Return the current HTTP server socket. The socket may be written/read; however, this is inadvisable since it may interfere with the server's use of it.

NOTE: This is implemented as a macro.

PARAMETER

state	HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Pointer to the HTTP server's TCP socket structure.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_getState

```
int http_getState( HttpState * state );
```

DESCRIPTION

Return the current primary HTTP CGI state variable.

Use of this state variable is entirely up to the application; however, it is initialized by the HTTP server to zero before calling the CGI for the first time.

NOTE: This is implemented as a macro.

PARAMETER

state	HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Value of primary state variable.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_getTransferEncoding

```
char http_getTransferEncoding( HttpState * state );
```

DESCRIPTION

Return the current encoding of the data which is being provided by the client. This is one of the following enumerated values:

- CTE_BINARY - The default
- CTE_7BIT - 7-bit safe ASCII
- CTE_8BIT - 8-bit ASCII
- CTE_QP - Quoted printable
- CTE_BASE64 - Base 64

Of these, the CGI is only likely to see CTE_BINARY, since HTTP is an 8-bit protocol, and most clients (browsers) will not bother to encode the data. Encoding is only an issue for internet mail, which sometimes has to cross interfaces that do not support full 8-bit binary transfers.

If the CGI detects a transfer encoding that requires non-null operation (that is, CTE_QP or CTE_BASE64) then it should either reject the transfer, or decode the data as it comes in.

It is only valid to call this when the action code is CGI_START, CGI_DATA or CGI_END.

NOTE: This is implemented as a macro.

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Transfer encoding code, as documented above.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_getURL

```
char * http_getURL( HttpState * state );
```

DESCRIPTION

Return the URL of the current HTTP client request. In a CGI, this will usually be something like `foo.cgi`.

NOTE: This is implemented as a macro.

PARAMETER

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Null-terminated string containing the URL. Note that GET-style form parameters will be stripped off: for example, the URL, `foo.cgi?A=99&D=-45`, will be returned as `foo.cgi`.

The GET parameters are available using `http_getCond()`.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_getUserState

```
void * http_getUserState( HttpState * state );
```

DESCRIPTION

Get the "user state" area of the HTTP server structure. This is an area of memory that can be used by the CGI to keep track of its internal state, from call to call.

The size of this area is `HTTP_USERDATA_SIZE`. If that macro is not defined, it defaults to zero, so use of the `http_getUserState` macro will result in a compile-time error.

NOTE: This is implemented as a macro.

Example:

```
typedef struct { ... } myCGIdata;
...
#define HTTP_USERDATA_SIZE sizeof(myCGIdata)
#use "http.lib"
...
int myCGI(HttpState * s) {
   myCGIdata * d;
   d = (myCGIdata *)http_getUserState(state);
   ...
}
```

PARAMETERS

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Returns the address of the first byte of the user area. This should be cast to the appropriate structure type.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_handler

```
void http_handler( void );
```

DESCRIPTION

This is the basic control function for the HTTP server, a tick function to run the HTTP daemon. It must be called periodically for the daemon to work. It parses the requests and passes control to the other handlers, either `html_handler`, `shtml_handler`, or to the developer-defined CGI handler based on the request's extension.

LIBRARY

HTTP.LIB

SEE ALSO

http_init

http_idle

```
int http_idle( void );
```

DESCRIPTION

Query to see if any HTTP servers are active.

RETURN VALUE

`0`: at least one HTTP server is active
`1`: all HTTP servers are idle

LIBRARY

HTTP.LIB

SEE ALSO

http_handler

http_init

```
int http_init( void );
```

DESCRIPTION

Initializes the HTTP daemon. This must be called after `sock_init()`, and before calling `http_handler()` in a loop.

This sets the root directory to "/" and sets the default file name to `index.html`. You can change these defaults by calling `http_set_path()` after this function.

You can override these defaults at compile-time by defining the macros

```
#define HTTP_HOMEDIR "/"
#define HTTP_DFLTFILE "index.html"
```

to be something other than these defaults. If you do this, then there is no need to invoke the `http_set_path()` function.

RETURN VALUE

`0`: Success.

LIBRARY

`HTTP.LIB`

SEE ALSO

`http_handler, http_shutdown, http_status, http_set_path`

http_is_secure

```
int http_is_secure( HttpState* state);
```

DESCRIPTION

Test if this HTTP server state represents a secure (SSL/TLS) connection.

PARAMETER

state	HTTP state structure.

RETURN VALUE

None.

LIBRARY

HTTP.LIB

http_nextfverr

```
void http_nextfverr( char *start, char **name, char **value,
   int *error, char ** next );
```

DESCRIPTION

Gets the information for the next variable in the HTML form error buffer. If any of the last four parameters in the function call are NULL, then those parameters will not have a value returned. This is useful if you are only interested in certain variable information.

PARAMETERS

start	Pointer to the variable in the buffer for which we want to get information.
name	Return location for the name of the variable.
value	Return location for the value of the variable.
error	Return location for whether or not the variable is in error (0 if it is not, 1 if it is).
next	Return location for a pointer to the variable after this one.

RETURN VALUE

None, although information is returned in the last four parameters.

LIBRARY

HTTP.LIB

http_parseform

```
int http_parseform( int form, HttpState *state );
```

DESCRIPTION

Parses the returned form information. It expects a POST submission. This function is useful for a developer who only wants the parsing functionality and wishes to generate forms herself. Note that the developer must still build the array of `FormVar`s and use the `server_spec` table. This function will not, however, automatically display the form when used by itself. If all variables satisfy all integrity checks, then the variables' values are updated. If any variables fail, then none of the values are updated, and error information is written into the error buffer If this function is used directly, the developer must process errors.

PARAMETERS

`form` `server_spec` index of the form (i.e., location in TCP/IP servers' object list).

`state` The HTTP server with which to parse the POSTed data.

RETURN VALUE

`0`: There is more processing to do.
`1`: Form processing has been completed.

LIBRARY

`HTTP.LIB`

http_safe

```
int http_safe( char *to, char *from, int tolen, int fromlen );
```

DESCRIPTION

Convert a http-unsafe string in `from` (length `fromlen`) into a properly escaped string. For example, the string "hello&goodbye<>" would be changed to "hello&goodbye<>".

Returns non-zero if result could not fit in `tolen`-1 bytes. A null is always added, thus `tolen` should account for this. Double quotes are escaped since the result may itself be quoted.

Newline characters are turned into HTML line break "
" markup. Control characters (codes less than 32) are turned into "&#xx;" where "xx" is the hexadecimal control char value. The source string can contain null character(s) which is why its length is passed in the parameter `fromlen`.

PARAMETERS

to	Destination buffer for escaped string
from	Source buffer for string to convert
tolen	Length of destination buffer (must be at least equal to `fromlen`, since string is never smaller than source string).
fromlen	Length of source buffer.

RETURN VALUE

`0`: Success.
non-zero if resulting string (plus its null terminator) could not fit in the provided buffer.

LIBRARY

`HTTP.LIB`

SEE ALSO

`http_handler`

http_scanpost

```
int http_scanpost( char *tag, char *buffer, char *dest, int maxlen );
```

DESCRIPTION

This function allows you to scan a buffer with a POST response for the key/value pairs. This function is reentrant.

PARAMETERS

tag	Buffer holding the tag name.
buffer	Buffer to read data from.
dest	Buffer to store value to.
maxlen	Size of destination buffer.

RETURN VALUE

0: Successful
!0: Not successful

LIBRARY

HTTP.LIB

http_set_anonymous

```
int http_set_anonymous( int uid );
```

DESCRIPTION

Set the "anonymous" user ID. This is the assumed user ID when no credentials are provided by the client (browser). A typical use of this function would be:

```
int anon;
anon = sauth_adduser("anonymous", "", SERVER_FTP|SERVER_HTTP);
sauth_setusermask(uid, WORLD_GROUP, NULL);
http_set_anonymous(uid);
ftp_set_anonymous(uid);        // if using FTP too
```

which defines an "anonymous" login for the HTTP and, optionally, the FTP servers. (Since FTP also requires an anon user, you can use the same user ID for both FTP and HTTP).

When a web browser initially requests a resource, it may not pass any user credentials (i.e., user name and password). The HTTP server will assume that the user is anonymous, and apply the access permissions tests on that basis. If access is denied, then the browser will prompt the user for a real user name and password, and the request will be re-tried.

You do not always need to define an anonymous user to HTTP. But it is required if you have some resource which is (say) protected for write access, but you want any user to be able to retrieve the resource without requiring a user name/password.

> **NOTE:** This function is non-reentrant. It sets a global variable which is accessed by all HTTP server instances. For this reason, you should call this function once only before starting to call `http_handler()`.

PARAMETER

uid — The userID to use as the anonymous user. This should have been defined using `sauth_adduser()`. Pass -1 to set no anonymous user. In this case, only resources which are completely free of any access controls will be accessible to users who do not provide credentials.

RETURN VALUE

Same as the uid parameter, except -1 if uid invalid.

LIBRARY

HTTP.LIB

SEE ALSO

sauth_adduser, ftp_set_anonymous, sauth_setusermask

http_setauthentication

```
int http_setauthentication( int auth );
```

DESCRIPTION

Sets the type of authentication to be used globally by the HTTP server. By default, this is set to the strongest available type of authentication available (in order of weakest to strongest: HTTP_NO_AUTH, HTTP_BASIC_AUTH, HTTP_DIGEST_AUTH. This function returns the type of authentication that was actually configured. If the type of authentication that you ask for was not compiled in at compile time, then the type of authentication will not be changed.

> **NOTE:** this function only sets the "default" authentication method for resources who have their authentication method set to SERVER_AUTH_DEFAULT (or none specified).

PARAMETERS

auth Type of authentication. Choices are:

- HTTP_NO_AUTH
- HTTP_BASIC_AUTH
- HTTP_DIGEST_AUTH

RETURN VALUE

Actual resulting type of authentication.

LIBRARY

HTTP.LIB

http_setCond

```
int http_setCond( HttpState * state, int idx, int val );
```

DESCRIPTION

Set the value of an HTTP condition state variable (aka., cond variable). There are HTTP_MAX_COND of these integer state variables, thus idx must be between 0 and HTTP_MAX_COND-1, inclusive.

NOTE: This is implemented as a macro.

PARAMETERS

state	HTTP state pointer, as provided in the first parameter to the CGI function.
idx	Index of cond variable: 0..HTTP_MAX_COND-1. Validity is not checked.
val	New value.

RETURN VALUE

Returns the new value of the cond variable, i.e., val.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction, http_getCond

http_setcookie

```
void http_setcookie( char *buf, char *value );
```

DESCRIPTION

This utility generates a cookie on the client. This will store the text in `value` into a cookie-generation header that will be written to `buf`. The header placed in `buf` is not automatically sent to the web client. It is the caller's responsibility to send the header in `buf`, along with any other HTTP headers, to the client.

When a page is requested from the client, and the cookie is already set, the text of the cookie will be stored in `state->cookie[]`. This is a `char*`, and if no cookie was available, then `state->cookie[0]` will equal `'\0'`.

PARAMETERS

buf	Buffer to store cookie-generation header, that is, the name of the cookie.
value	Text to store in cookie-generation header, that is, the value of the cookie.

LIBRARY

HTTP.LIB

http_set_path

```
int http_set_path( char * rootdir, char * dfltname );
```

DESCRIPTION

Set the default root directory and resource name for all HTTP server instances. In general, this function should be called once only, after `http_init()` but before `http_handler()`.

The root directory is the base directory and is used as a prefix for all resource requests from clients. For example, if the root directory is set to "/A/" then a client request for `http://<hostname>/foo.htm` will look up the resource called `/A/foo.htm` on this server.

The default resource name is used if the client's URL requests a directory. For example, if `dfltname` is set to "index.htm" (and rootdir is "/A/") then a client request for "http://<hostname>/admin" will look up the resource called "/A/admin". If that resource is actually a directory, then it will look up a resource called "/A/admin/index.htm". If it is not a directory, then the default name is not used.

PARAMETERS

rootdir — Root directory name to use. This must be a null-terminated string and MUST start and end with a forward slash (/) character. If this function is not called, the root directory name is set to "`/`" by `http_init()`.

dfltname — Default file name to use. This is appended to the directory part of the URL, if the URL actually refers to a directory. If this function is not called, the default file name is set to `index.html` by `http_init()`.

If this parameter is NULL, there will be no default name. A request for a directory will generally return a 404 error (not found) to the client. If it is not NULL, this parameter must be a null-terminated string. It must not start or end with a "`/`" character.

RETURN VALUE

`0`: OK
`-E2BIG`: rootdir was too long. It should be limited to less than about 12 characters, but you can increase the value of `SSPEC_MAXNAME` if necessary.
`-EINVAL`: rootdir was NULL, or did not start and end with a forward slash character.

LIBRARY

`HTTP.LIB`

SEE ALSO

`http_handler, http_init`

http_setState

```
int http_setState( HttpState * state, int val );
```

DESCRIPTION

Set the current primary HTTP CGI state variable.

Use of this state variable is entirely up to the application; however, it is initialized by the HTTP server to zero before calling the CGI for the first time.

NOTE: This is implemented as a macro.

PARAMETER

state	HTTP state pointer, as provided in the first parameter to the CGI function.
val	New value for the primary state variable.

RETURN VALUE

Returns the new value, that is, `val`.

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction

http_shutdown

```
int http_shutdown( int graceful );
```

DESCRIPTION

Shut down the http daemon. Use `http_init()` to restart.

PARAMETER

If non-zero, current connections are allowed to terminate normally. Otherwise, any open connections are reset.

RETURN VALUE

0

LIBRARY

HTTP.LIB

SEE ALSO

http_handler, http_init, http_status

http_skipCGI

```
int http_skipCGI( HttpState * state );
```

DESCRIPTION

Indicate to the HTTP server that the CGI has finished processing this part of a multi-part data stream. The server reads (and discards) data from the stream until the next part is found (or the epilog). When the next part is found, the server continues calling the CGI function as before.

PARAMETERS

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

0

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction, http_abortCGI, http_switchCGI, http_finishCGI, http_write

http_sock_bytesready

```
int http_sock_bytesready( HttpState *state );
```

DESCRIPTION

HTTP wrapper function for `sock_bytesready()`. This function may be used by CGI applications to determine if there is data waiting on the socket associated with a particular HTTP server.

PARAMETERS

`state` HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

`-1`: no bytes waiting to be read
`0`: in ASCII mode, a blank line is waiting to be read,
or, for UDP, an empty datagram is waiting to be read
`>0`: number of bytes waiting to be read

LIBRARY

`HTTP.LIB`

http_sock_fastread

```
int http_sock_fastread( HttpState *state, byte *dp, int len );
```

DESCRIPTION

HTTP wrapper function for `sock_fastread()`, that is for non-blocking reads (root). This function can be used to read data from a socket associated with a particular HTTP server. This function is intended for use in CGI applications.

PARAMETERS

state	HTTP state pointer, as provided in the first parameter to the CGI function.
dp	Pointer to return buffer
len	Maximum size of return buffer

RETURN VALUE

`>0`: the number of bytes read
`-1`: error

LIBRARY

`HTTP.LIB`

http_sock_fastwrite

```
int http_sock_fastwrite( HttpState *state, byte *dp, int len );
```

DESCRIPTION

HTTP wrapper function for `sock_fastwrite()`, that is, for non-blocking writes. This function can be used to write data from a root buffer to a socket associated with a particular HTTP server. This function is intended for use in CGI applications.

PARAMETERS

state	HTTP state pointer, as provided in the first parameter to the CGI function.
dp	Pointer to buffer containing data to be written.
len	Maximum number of bytes to write to the socket.

RETURN VALUE

`>0`: the number of bytes written
`-1`: error

LIBRARY

HTTP.LIB

http_sock_gets

```
int http_sock_gets( HttpState *state, byte* dp, int len );
```

DESCRIPTION

HTTP wrapper function for `sock_gets()`. This function can be used by CGI applications to retrieve a string waiting on an ASCII-mode socket associated with a particular HTTP server.

PARAMETERS

state	HTTP state pointer, as provided in the first parameter to the CGI function.
dp	Pointer to return buffer
len	Maximum size of return buffer

RETURN VALUE

`0`: if buffer is empty, or
if no "`\r`" or "`\n`" is read, but buffer had room *and*
the connection can get more data!
`>0`: is the length of the string
`-1`: error

LIBRARY

`HTTP.LIB`

SEE ALSO

`http_sock_mode`

http_sock_mode

```
void http_sock_mode( HttpState* state, http_sock_mode_t mode );
```

DESCRIPTION

HTTP socket wrapper function for socket mode. This function can be used by CGI applications to set the mode of a socket associated with a particular HTTP server.

PARAMETERS

state HTTP state pointer, as provided in the first parameter to the CGI function.

mode HTTP mode to use for the socket. Valid values for `mode` are:

- `HTTP_MODE_ASCII` - Sets the associated socket to ASCII mode.
- `HTTP_MODE_BINARY` - Sets the associated socket to BINARY.

RETURN VALUE

None

LIBRARY

`HTTP.LIB`

http_sock_readable

```
int http_sock_readable( HttpState * state );
```

DESCRIPTION

HTTP wrapper function for socket readable function. This function may be used by CGI applications to determine if a socket is readable or not. See sock_readable for more information.

PARAMETER

state HTTP state structure, as provided in the first parameter to the CGI function.

RETURN VALUE

If parameter is a TCP or SSL server:
0: socket is not readable. It was aborted by the application or the peer has closed the socket and all pending data has been read by the application. This can be used as a definitive "EOF" indication for a receive stream.
non-zero: the socket is readable. The amount of data that the socket would deliver is this value minus 1; which may turn out to be zero if the socket's buffer is temporarily empty, or the socket is not yet connected to a peer.

If parameter is a UDP server:
0: socket is not open.
non-zero: socket is open. This value minus 1 equals the size of the next datagram in the receive buffer, that would be returned by `udp_recvfrom()` etc. Note that ICMP error messages are also considered if the socket is set up to receive ICMP messages.

LIBRARY

HTTP.LIB

http_sock_writable

```
int http_sock_writable( HttpState * state );
```

DESCRIPTION

HTTP wrapper function for socket writable function. This function may be used by CGI applications to determine if a socket is writable or not. See sock_writable for more information.

PARAMETER

state HTTP state structure, as provided in the first parameter to the CGI function.

RETURN VALUE

If parameter is a TCP or SSL server:
0: socket is not writable. It was closed by the application or it may have been aborted by the peer.
Non-zero: the socket is writable. The amount of data that the socket would accept is this value minus 1; which may turn out to be zero if the socket's buffer is temporarily full. On a freshly-established socket, and at any other time when all data has been acknowledged by the peer, the return value (minus one) indicates the maximum socket transmit buffer size.

If parameter is a UDP server:
0: socket is not open.
Non-zero: socket is open. This value minus 1 equals the maximum size datagram payload that would be sent without fragmentation at the IP level. Note: the maximum payload depends on the interface which is selected. Since this is not known a-priori, the interface with the largest MTU is arbitrarily selected.

LIBRARY

HTTP.LIB

http_sock_tbleft

```
long http_sock_tbleft( HttpState *state );
```

DESCRIPTION

HTTP wrapper function for `sock_tbleft()`. This function may be used by CGI applications to determine how much space is left in the HTTP socket's transmit buffer.

PARAMETERS

state HTTP state pointer, as provided in the first parameter to the CGI function.

RETURN VALUE

Number of bytes of free space remaining in the transmit buffer.

LIBRARY

HTTP.LIB

http_sock_write

```
int http_sock_write( HttpState *state, byte *dp, int len );
```

DESCRIPTION

HTTP wrapper function for blocking writes. This function can be used to write data from a root buffer to a socket associated with a particular HTTP server. This function is intended for use in CGI applications.

PARAMETERS

state	HTTP state pointer, as provided in the first parameter to the CGI function.
dp	pointer to buffer containing data to be written
len	maximum number of bytes to write to the socket

RETURN VALUE

Number of bytes of written or -1 if there was an error

LIBRARY

HTTP.LIB

http_sock_xfastread

```
int http_sock_xfastread( HttpState *state, long dp, long len );
```

DESCRIPTION

HTTP wrapper function for `sock_fastxread()`, that is, for non-blocking reads (xmem). This function can be used to read data from a socket associated with a particular HTTP server. This function is intended for use in CGI applications.

PARAMETERS

state	HTTP state pointer, as provided in the first parameter to the CGI function.
dp	Pointer to return xmem buffer.
len	Maximum length of the return xmem buffer.

RETURN VALUE

Number of bytes of read or -1 if there was an error

LIBRARY

HTTP.LIB

http_sock_xfastwrite

```
int http_sock_xfastwrite( HttpState *state, long dp, long len);
```

DESCRIPTION

HTTP wrapper function for `sock_xfastwrite()` that is for non-blocking writes. It can be used to write the contents of an xmem buffer to a socket associated with a particular HTTP server.

PARAMETERS

state	HTTP state pointer, as provided in the first parameter to the CGI function.
dp	Buffer containing data to be written, as an xmem address obtained from, for example, `xalloc()`.
len	Maximum number of bytes to write to the socket.

RETURN VALUE

Number of bytes of written or -1 if there was an error

LIBRARY

HTTP.LIB

https_set_cert

```
void https_set_cert( SSL_Cert_t far * cert);
```

DESCRIPTION

Register a server certificate with all HTTPS server instances. Client hosts (such as web browsers) will verify this certificate, and may refuse to connect if there is no certificate, or the server certificate is not valid.

This must be called at least once, otherwise there may be no default certificate.

Alternatively, you can use the method that was deprecated in Dynamic C 10.54. Have the following line at the top of your main program:

```
#ximport "cert.dcc" SSL_CERTIFICATE
```

where cert.dcc is the name (and path) of the server certificate file to use, which must be in .dcc format. The use of `SSL_CERTIFICATE` is deprecated since `https_set_cert()` provides a more flexible interface.

PARAMETER

cert Pre-parsed certificate, as generated by `SSL_new_cert()`.

LIBRARY

`HTTP.LIB`

SEE ALSO

`SSL_new_cert`

http_status

```
int http_status( void );
```

DESCRIPTION

Determine whether the HTTP server is allowing connections.

RETURN VALUE

0: server is currently disabled
non-zero: server is enabled.

LIBRARY

HTTP.LIB

SEE ALSO

http_handler, http_init, http_shutdown

http_switchCGI

```
int http_switchCGI( HttpState * state, char * newURL );
```

DESCRIPTION

Tell the HTTP server to switch processing to a different CGI function or resource.

The CGI is responsible for generating the correct HTTP response header(s) using `http_write()` etc. If this function is used to pass control to a different CGI, then both CGIs must coordinate so that only one header is written. You can use the HTTP state variable (`http_setState()` and `http_getState()`) and/or `http_getUserState()` to achieve the necessary coordination.

If `newURL` refers to a file or SSI resource (not a CGI), then the CGI function must NOT have already written the HTTP response header(s); the headers will be generated when the new resource is opened.

If `newURL` refers to a new-style CGI (that is, a CGI resource added using `SSPEC_CGI`, not `SSPEC_FUNCTION`) then that CGI is presented with the remaining content of the current request data stream.

If `newURL` refers to an old-style CGI (that is, a CGI added using `SSPEC_FUNCTION` or `HTTPSPEC_FUNCTION`) then the HTTP server abandons parsing of the request data stream, since old-style CGIs are expected to read the HTTP socket themselves.

Rather than calling `http_switchCGI()`, it is often more convenient to call `cgi_redirectto()`, which tells the client to retrieve the next resource rather than the resource being provided in the current connection. Using redirect is less efficient, however.

PARAMETERS

state	HTTP state pointer, as provided in the first parameter to the CGI function.
newURL	The resource name to present to the client. This may be another CGI, or any other type of resource that could be presented to the client in response to an HTTP GET or POST request. The resource must exist in the flash- or ram-spec table, or in a filesystem.

RETURN VALUE

0

LIBRARY

HTTP.LIB

SEE ALSO

http_getAction, http_skipCGI, http_abortCGI, http_finishCGI, http_write

http_urldecode

```
char *http_urldecode( char *dest, const char *src, int len );
```

DESCRIPTION

Converts a string with URL-escaped "tokens" (such as %20 (hex) for space) into actual values. Changes "+" into a space. String can be NULL terminated; it is also bounded by a specified string length. This function is reentrant.

PARAMETERS

dest	Buffer where decoded string is stored.
src	Buffer holding original string (not changed).
len	Maximum size of string (NULL terminated strings can be shorter).

RETURN VALUE

dest: if all conversion was good.
NULL: if some conversion had trouble.

LIBRARY

HTTP.LIB

SEE ALSO

http_contentencode

http_write

```
int http_write( HttpState * state, char * data, word length );
```

DESCRIPTION

Write data back to the client. This function either sends all of the given data or none of it. If the data cannot be sent (for example, because the socket transmit buffer is already full) then a special return code indicates that the CGI should try again on the next call.

Often, the CGI itself will not need to write anything to the client—the `http_switchCGI()` function takes care of most needs. If this function is used, then the CGI is responsible for generating the correct HTTP response (including headers) and `http_switchCGI()` and similar functions should NOT be called.

Use of this function can often be avoided. Instead, the CGI can copy a string to the pointer provided by `http_getData()`, then return `CGI_SEND`. This will cause the server to send out the (null terminated) string in the buffer, and not call the CGI until the string is sent to the client. See the source to `http_defaultCGI()` for an example of this method.

PARAMETERS

state HTTP state pointer, as provided to the CGI function.

data Pointer to first char to transmit. It is OK to make this the same pointer that was returned by `http_getData()`, since that buffer can be used for output as well as input. In any case, the CGI must ensure that it has processed any incoming data before writing new data to that buffer.

length Length of data to transmit. There is a limit to the amount of data that `http_write()` can write on any given call. This limit is set by the HTTP server socket transmit buffer size. This buffer size is given by `TCP_BUF_SIZE/2`. The transmit buffer is usually at least 1024 bytes. If you try exceeding that limit, `http_write()` will never succeed.

RETURN VALUE

`0`: data written (or buffered) successfully.
`CGI_MORE`: data not written, try again on next call to the CGI. In general, the CGI should pass this code (`CGI_MORE`) back to the HTTP server. When the server calls the CGI next time, it will set the action code to `CGI_CONTINUE` which will be a cue to the CGI to try retransmitting the previous data. When `CGI_CONTINUE` is provided, the contents in the `http_getData()` buffer will not have been altered.

LIBRARY

`HTTP.LIB`

SEE ALSO

`http_getAction, http_skipCGI, http_switchCGI, http_finishCGI, http_abortCGI, http_defaultCGI`

shtml_addfunction

```
int shtml_addfunction( char *name, void (*fptr()) );
```

DESCRIPTION

Adds a CGI/SSI-exec function for making dynamic web pages to the RAM resource table.

PARAMETERS

name	Name of the function (e.g., "`/foo.cgi`").
fptr	Function pointer to the handler, that must take `HttpState*` as an argument. This function should return an `int` (`0` while still pending, `1` when finished).

RETURN VALUE

`0`: Success;
`1`: Failure (no room).

LIBRARY

`HTTP.LIB`

SEE ALSO

`shtml_delfunction`

shtml_addvariable

```
int shtml_addvariable( char *name, void *variable, word type, char
   *format );
```

DESCRIPTION

This function adds a variable so it can be recognized by `shtml_handler()`.

PARAMETERS

name	Name of the variable.
variable	Pointer to the variable.
type	Type of variable. The following types are supported: `INT8`, `INT16`, `INT32`, `PTR16`, `FLOAT32`.
format	Standard printf format string. (e.g., "%d").

RETURN VALUE

`0`: Success.
`1`: Failure (no room).

LIBRARY

`HTTP.LIB`

SEE ALSO

`shtml_delvariable`

shtml_delfunction

```
int shtml_delfunction( char * name );
```

DESCRIPTION

Deletes a function from the RAM resource table.

PARAMETERS

name Name of the function as given to `shtml_addfunction()`.

RETURN VALUE

`0`: Success;
`1`: Failure (not found).

LIBRARY

`HTTP.LIB`

SEE ALSO

`shtml_addfunction`

shtml_delvariable

```
int shtml_delvariable( char * name );
```

DESCRIPTION

Deletes a variable from the RAM resource table.

PARAMETERS

name Name of the variable, as given to `shtml_addvariable()`.

RETURN VALUE

`0`: Success;
`1`: Failure (not found).

LIBRARY

`HTTP.LIB`

SEE ALSO

`shtml_addvariable`

5. RABBITWEB

The Dynamic C RabbitWeb software allows developers to web-enable embedded applications. This chapter explains the ease with which a web interface to a Rabbit-based device can now be created. In most cases this enhanced HTTP server eliminates the need for complicated CGI programming while giving the developer complete freedom in web page design.

The enhanced HTTP server is called RabbitWeb and uses:

- A simple scripting language consisting of server-parsed tags added to the HTML page that contains the form.
- Dynamic C language enhancements, which includes new compiler directives that can be added to the application calling the HTTP server.

Section 5.1 presents a simple example to show the power and ease of developing a RabbitWeb server that presents a web interface to your device. This example gives step-by-step descriptions of the HTML page and the Dynamic C code. New features will be briefly explained, then linked to their comprehensive descriptions in Section 5.2 and Section 5.3. These sections are followed by a more complex example in Section 5.4, which in turn is followed by quick reference guides for both the Dynamic C language extensions and the new scripting language, which is called ZHTML (Section 5.5).

5.1 Getting Started: A Simple Example

In this example, we pretend that a humidity detector is connected to your Rabbit-based controller. Your controller runs a web server that displays a page showing the current reading from the humidity detector. From this monitoring page there is a link to another page that contains an HTML form that allows you to remotely change some configuration parameters. This example introduces web variables and user groups. It also illustrates some new security features and the use of error checking.

This example assumes you have already installed Dynamic C version 8.5 (or later) and hooked up a Rabbit-based core module that has an Ethernet jack. Hardware hook up instructions are in the user's manual for the device. The hardware user's manual describes network connections for your device, as well as setting IP addresses for running sample programs.

5.1.1 Dynamic C Application Code for Humidity Detector

This section describes the application for our example. The program is shown in its entirety for convenience. It is broken down into manageable pieces on the following pages.

File Name: /Samples/tcpip/rabbitweb/humidity.c

```
#define TCPCONFIG 1
#define USE_RABBITWEB 1
#memmap xmem
#use "dcrtcp.lib"
#use "http.lib"
#ximport "samples/tcpip/rabbitweb/pages/humidity_monitor.zhtml"
  monitor_zhtml
#ximport "samples/tcpip/rabbitweb/pages/humidity_admin.zhtml" admin_zhtml
SSPEC_MIMETABLE_START
   SSPEC_MIME_FUNC(".zhtml", "text/html", zhtml_handler),
   SSPEC_MIME(".html", "text/html")
SSPEC_MIMETABLE_END
SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.zhtml", monitor_zhtml),
   SSPEC_RESOURCE_XMEMFILE("/admin/index.zhtml", admin_zhtml)
SSPEC_RESOURCETABLE_END
#web_groups admin
int hum;
#web hum groups=all(ro)
int hum_alarm;
#web hum_alarm ((0 < $hum_alarm) && ($hum_alarm <= 100))\
      groups=all(ro),admin
int alarm_interval;
char alarm_email[50];
#web alarm_interval ((0 < $alarm_interval) && ($alarm_interval < 30000)) \
      groups=all(ro),admin
#web alarm_email groups=all(ro),admin
void main(void){
   int userid;
   hum = 50;
   hum_alarm = 75;
   alarm_interval = 60;
   strcpy(alarm_email, "somebody@nowhere.org");
   sock_init();               // initialize TCP/IP stack
   http_init();               // initialize web server

   http_set_path("/", "index.zhtml");
   tcp_reserveport(80);
   sspec_addrule ("/admin", "Admin", admin, admin,
                          SERVER_ANY, SERVER_AUTH_BASIC, NULL);
   userid = sauth_adduser("harpo", "swordfish", SERVER_ANY);
   sauth_setusermask(userid, admin, NULL);
   while(1) {
      http_handler();
   }
}
```

The source code walk-through consists of blocks of code followed by line-by-line descriptions. Particular attention is given to the RabbitWeb #web and #web_groups statements, which are new compiler directives.

```
#define TCPCONFIG 1
#define USE_RABBITWEB 1

#memmap xmem

#use “dcrtcp.lib”
#use “http.lib”
```

The macro TCPCONFIG is used to set network configuration parameters. Defining this macro to 1 sets 10.10.6.100, 255.255.255.0 and 10.10.6.1 for the board’s IP address, netmask and gateway/nameserver respectively. If you need to change any of these values, read the comments at the top of \lib\tcpip\tcp_config.lib for instructions.

The USE_RABBITWEB macro must be defined to 1 to use the HTTP server enhancements. The #define of USE_RABBITWEB is followed by a request to map functions not flagged as root into xmem. The two #use statements allow the application the use of the main TCP/IP libraries (all brought in by dcrtcp.lib) and the HTTP server library (which also brings in the resource manager library, zserver.lib).

```
#ximport “samples/tcpip/rabbitweb/pages/humidity_monitor.zhtml”
monitor_zhtml

#ximport “samples/tcpip/rabbitweb/pages/humidity_admin.zhtml” admin_zhtml

SSPEC_MIMETABLE_START
   SSPEC_MIME_FUNC(".zhtml", "text/html", zhtml_handler),
   SSPEC_MIME(".html", "text/html")
SSPEC_MIMETABLE_END

SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/index.zhtml", monitor_zhtml),
   SSPEC_RESOURCE_XMEMFILE("/admin/index.zhtml", admin_zhtml)
SSPEC_RESOURCETABLE_END
```

The HTML pages are copied to Rabbit memory using #ximport. The first one is a status page and the second one is a configuration interface.

Next the MIME type mapping table is set up. This allows zhtml_handler() to be called when a file with the extension .zhtml is processed. Then the static resource table is set up, which gives the server access to the files that were just copied in using #ximport. The first parameter is the name of the resource and the second parameter is its address.

```
#web_groups admin
```

The RabbitWeb server has a concept of user groups, which are created using the compiler directive, `#web_groups`. Users can be added to and removed from these groups at runtime by calling the API functions `sauth_adduser()` and `sauth_removeuser()`.

The purpose of the user groups is to protect directories and variables from unauthorized access. User groups are fully described in Section 5.2.3.

```
int hum;
#web hum groups=all(ro)
```

This declares a variable named `hum` of type integer using normal Dynamic C syntax. It will be used to store the current humidity reported by the humidity detector. The `#web` expression registers this C variable with the web server. The read-only attribute is assigned by the "groups=all(ro)" part which gives read-only access to this variable to all user groups.

More information on registering variables is given in Section 5.2.1.

```
int hum_alarm;
#web hum_alarm \
   ((0 < $hum_alarm) && ($hum_alarm <= 100)) groups=all(ro),admin
```

This code creates a variable called `hum_alarm` to indicate the level at which the device should send an alarm. Unlike the #web statement for `hum`, there is a *guard* added when `hum_alarm` is registered. A guard is an error-checking expression used to evaluate the validity of submissions for its variable. The guard given for `hum_alarm` ensures only the range of values from 1 to 100 inclusive are accepted for this variable. More information on the syntax of the error-checking expression is in Section 5.2.2. The way error information is used in the HTML form is described in Section 5.3.5.

The dollar sign symbol in `$hum_alarm` specifies the latest submitted value of the variable, not necessarily the latest committed value of the variable. The difference between, and the importance of, the latest submitted value and the latest committed value of a variable will make more sense when you have read Section 5.2.2. Also, $-variables in web guards must be simple variables: for example, int, long, float, char, or string (char array). They cannot be structures or arrays.

The "admin" group is given full access to the variable (access is read and write by default), while all other users are limited to read-only access. If no "group=" parameter is given, then anyone can read or write `hum_alarm`. The order of group names is important. If "admin" came before "all(ro)" then the admin group would not have write access.

```
int alarm_interval;
char alarm_email[50];

#web alarm_interval \
   ((0 < $alarm_interval) && ($alarm_interval < 30000))\
   groups=all(ro),admin
#web alarm_email groups=all(ro),admin
```

These lines declare and register an integer variable and a string. The variable `alarm_interval` gives the minimum amount of time in minutes between two alarms, thus preventing alarm flooding. The variable `alarm_email` gives the email address to which alarms should be sent.

This concludes the compile-time initialization part of the code.

```
void main(void)
{
   int userid;
   hum = 50;
   hum_alarm = 75;
   alarm_interval = 60;
   strcpy(alarm_email, "somebody@nowhere.org");

   sock_init();                  // initialize TCP/IP stack
   http_init();                  // initialize web server


   http_set_path("/", "index.zhtml");
   tcp_reserveport(80);

   sspec_addrule (“/admin”, “Admin”, admin, admin, SERVER_ANY,
      SERVER_AUTH_BASIC, NULL);
   userid = sauth_adduser(“harpo”, “swordfish”, SERVER_ANY);
   sauth_setusermask(userid, admin, NULL);

   while(1) {
      http_handler();            // call the http server
   }
}
```

In `main()`, after the local variable `userid` is declared, there is run-time initialization of the variables that will be visible on the HTML page. Then the stack and the web server are initialized with calls to `sock_init()` and `http_init()`, respectively.

The function `http_init()` sets the root directory to "`/`" and sets the default file name to `index.html`. The call to `http_set_path()` can be used to change these defaults. We only want to change the default filename, so in the function call we keep the default root directory by passing "`/`" as the first parameter and change the default filename by passing `index.zhtml` as the second parameter. The reason we want to do this is for when the browser specifies a directory (instead of a proper resource name) we want to default to using `index.zhtml` in that directory, if it exists. If we don't use the set path function, the default is `index.html` which won't work for this sample because the file `index.html` doesn't exist.

The call to `sspec_addrule()` configures the web server to give write and read access to the directory `/admin` to any members of the `admin` group and to require basic authentication for any access to this directory. The call to `sauth_adduser()` adds the user named `harpo` with a password of `swordfish` to the list of users kept by the server. The next function call, `sauth_setusermask()`, adds the user named `harpo` to the user group named `admin`. This sequence of calls allows you to restrict access to the file `humidity_admin.zhtml`. Only members of the user group `admin`,which in this case is the one user named `harpo`, can get the server to display a file resource that starts with `/admin`. Recall that the file `humidity_admin.zhtml` was copied to memory by the `#ximport` directive and given the label `admin_zhtml`. The file was then added to the static resource table and given the name `/admin/index.zhtml`. This is the name by which the server recognizes the file and the name by which access to it is restricted.

The web server is driven by the repeated call to `http_handler()`.

The second part of our example requires additions to the HTML page that is served by our web server. The use of the new scripting language will be explained as it is encountered in the sample pages. Regular HTML code will not be explained, as it is assumed the reader has a working knowledge of it. If that is not the case, refer to one of the numerous sources that exist (on the web, etc.) for information on HTML.

5.1.2 HTML Pages for Humidity Detector

This sample requires two HTML files: one to display the current humidity to all users, and another page that contains the form that allows some parameters to be changed.

5.1.2.1 The Monitor Page

The first HTML file is `humidity_monitor.zhtml`. The "`.zhtml`" suffix indicates that it contains special server-parsed HTML tags. That is, the server must inspect the contents of the HTML file for special tags, rather than just sending the file verbatim.

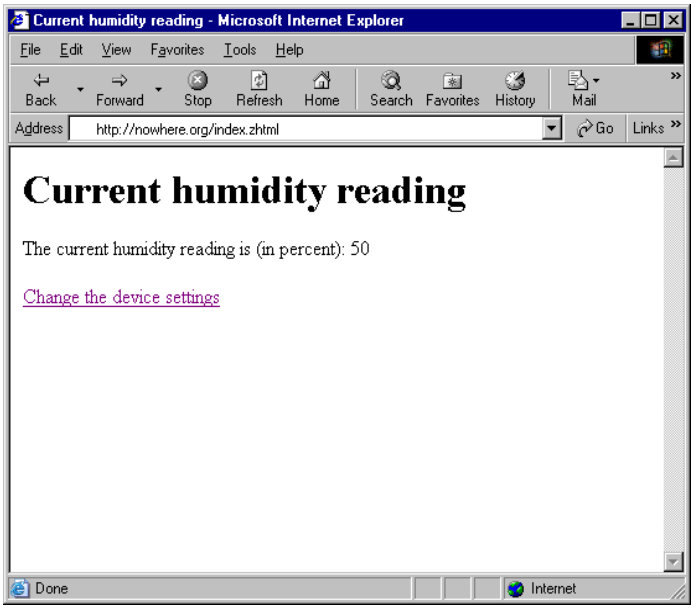
File name: `\Samples\tcpip\rabbitweb\pages\humidity_monitor.zhtml`

```
<HTML>
   <HEAD><TITLE>Current humidity reading</TITLE></HEAD>
   <BODY>

      <H1>Current humidity reading</H1>
         The current humidity reading is (in percent):
            <?z print($hum) ?>
      <P>
      <A HREF="/admin/index.zhtml">Change the device settings</A>
   </BODY>
</HTML>
```

The above code displays the current humidity reading. The new server-parsed tags begin with "<?z" and end with "?>". "print ($hum)" displays the given variable (that must have been registered with #web).

This code sets up a hyperlink that the user can click on to change the device settings. Note that since it is in the "`/admin`" directory, the user will need to enter a username and password ("harpo" and "swordfish") to access the file. The username and password requirement was determined by the call to `sspec_addrule()` in `humidity.c`. Also note that the reference to the second HTML file uses the name that was given to `humidity_admin.zhtml` when it was entered into the static resource table in `humidity.c`.

Figure 5.8 Web Page Served by RabbitWeb



This web page is very simple, as shown in Figure 5.8, but you are free to create more complex web pages (probably containing more variables to monitor). HTML editors such as Netscape's Composer, Hotdog Professional, and Macromedia Dreamweaver can be used to create these web pages.

5.1.2.2 The Configuration Page

The second HTML file is known to the server as: "`/admin/index.zhtml`". Using `error()` and some conditional code allows multiple display options with the same HTML file. Again, the file is shown in its entirety for convenience. It is broken down on the following pages.

File name: Samples/tcpip/rabbitweb/pages/humidity_admin.zhtml

```
<HTML>
<HEAD><TITLE>Configure the humidity device</TITLE></HEAD>
<BODY>
   <H1>Configure the humidity device</H1>
   <?z if (error()) { ?>
      ERROR! Your submission contained errors. Please correct
      the entries marked in red below.
   <?z } ?>
   <FORM ACTION=”/admin/index.zhtml” METHOD=”POST”>
      <P><?z if (error($hum_alarm)) { ?>
            <FONT COLOR="#ff0000">
         <?z } ?>
         Humidity alarm level (percent):
         <?z if (error($hum_alarm)) { ?>
            </FONT>
         <?z } ?>
         <INPUT TYPE=”text” NAME=”hum_alarm” SIZE=3
            VALUE=”<?z print($hum_alarm) ?>”>
      <P><?z if(error($alarm_email)) { ?>
            <FONT COLOR="#ff0000">
         <?z } ?>
         Send email alarm to:
         <? if (error($alarm_email)) { ?>
            </FONT>
         <?z } ?>
         <INPUT TYPE=”text” NAME=”alarm_email” SIZE=50
            VALUE=”<?z print($alarm_email) ?>”>
      <P><?z if (error($alarm_interval)) { ?>
            <FONT COLOR="#ff0000">
         <?z } ?>
         Minimum time between alarms (minutes):
         <?z if (error($alarm_interval)) { ?>
            </FONT>
         <?z } ?>
         <INPUT TYPE=”text” NAME=”alarm_interval” SIZE=5
            VALUE=”<?z print($alarm_interval) ?>”>
      <P><INPUT TYPE=”submit” VALUE=”Submit”>
   </FORM>
   <A HREF=”/index.zhtml”>Return to the humidity monitor page</A>
</BODY>
</HTML>
```

After the usual opening lines of an HTML page, is our first server-parsed tag.

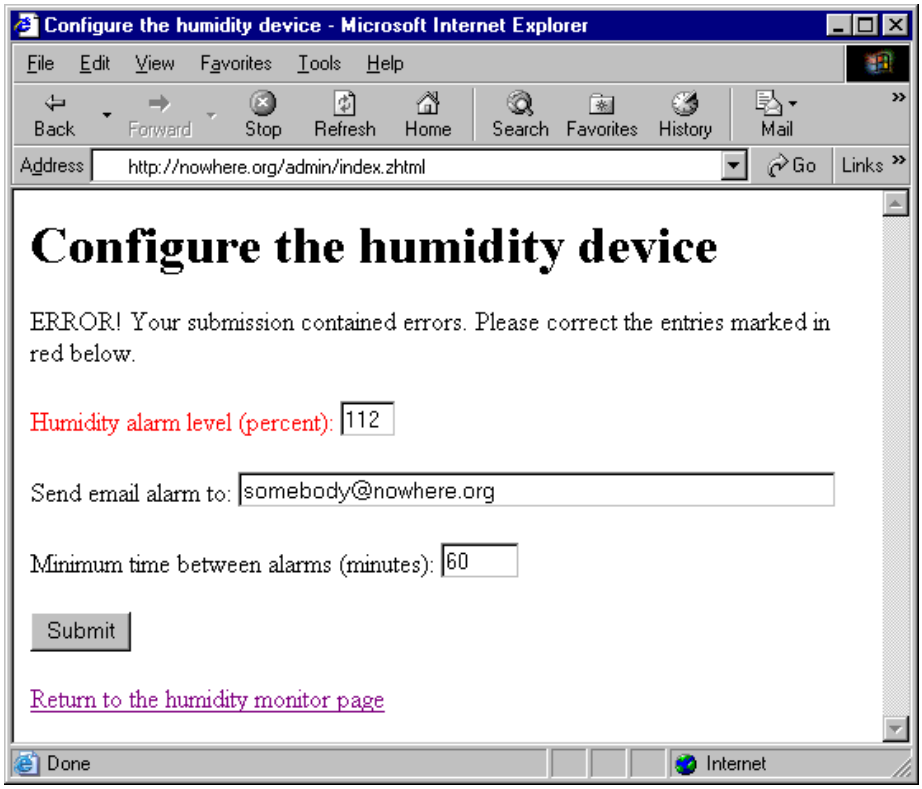
```
<?z if (error()) { ?>
   ERROR! Your submission contained errors. Please correct
   the entries marked in red below.
<?z } ?>
```

Without any parameters, `error()` returns TRUE if there were any errors in the last form submission. When the submit button for the form is clicked, the POST request goes back to the zhtml page specified by the line:

```
<FORM ACTION="/admin/index.zhtml" METHOD="POST">
```

Since this refers back to itself, if there were any errors in the last form submission, the page is redisplayed and along with it the error message inside the `if` statement.

Figure 5.9 Web Page with Error Message



There are five actions the user can take on this page. The Submit button was discussed above and the link to the monitor page is a common HREF link. The other three actions are the input fields of the form. These are text fields created by the INPUT tags.

```
<INPUT TYPE="text" NAME="hum_alarm" SIZE=3
   VALUE="<?z print($hum_alarm) ?>">
```

Notice how, with the use of `print()`, the value of the text fields are filled in by the server before the page is given to the browser.

Before the INPUT tag there is some code that displays text to describe the input field, along with some error checking:

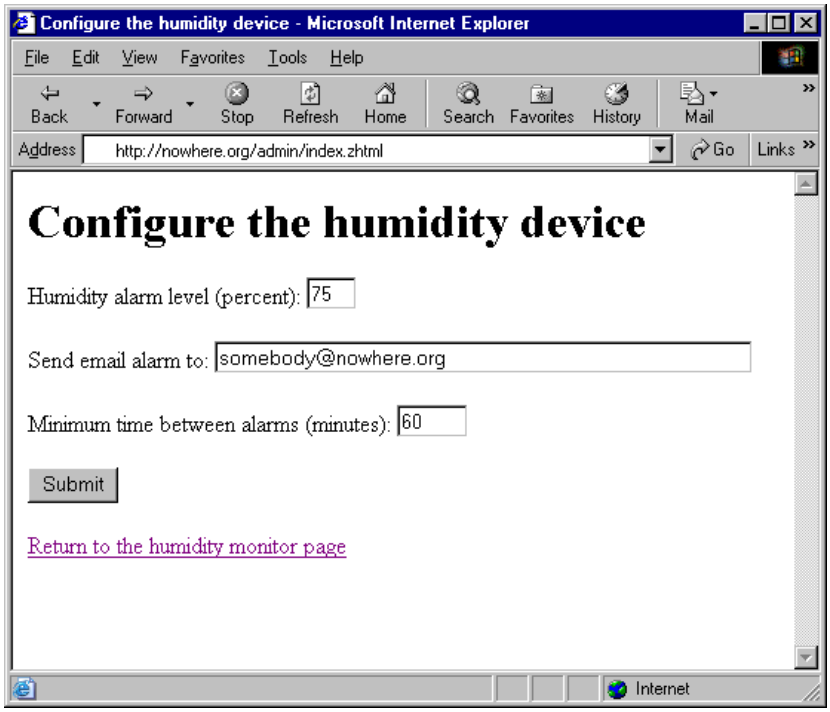
```
<?z if (error($hum_alarm)) { ?>
   <FONT COLOR="#ff0000">
   <?z } ?>
   Humidity alarm level (percent):
   <?z if (error($hum_alarm)) { ?>
      </FONT>
   <?z } ?>
```

Instead of calling `error()` with no parameters, the variable whose input field we are considering is passed to `error()`. Used with an if statement, this call to `error()` lets us change the font color to red if the value for that variable was invalid in the last form submission. Note that it is the text we have used to describe the web variable on the HTML page that is shown in red, not the value of the web variable itself. Also note that it is necessary to call `error()` twice, the second call is to close the FONT tag.

If in the last form submission the web variable had a valid value, the code above will still display the descriptive text but its font color will not be changed.

If there were no errors with any of the web variables in the last form submission, the page display reflects this status.

Figure 5.10 Web Page with No Error Message



5.2 Dynamic C Language Enhancements for RabbitWeb

This section describes the RabbitWeb language enhancements and how to make use of them to create a RabbitWeb server. These language enhancements are designed to interact with the ZHTML scripting language, (described in Section 5.3). They work together to provide an easy-to-program web-enabled interface to your device.

5.2.1 Registering Variables, Arrays and Structures

Registering variables, arrays or structures with the web server is easy. First, we'll look at the simple case of an integer variable.

```
int foo;
#web foo
```

The variable foo is declared as an integer in the first expression and then registered with the web server in the second. Variable registration can only be done at compile-time.

Arrays and structures are registered in the same way as variables.

```
int temps[20];
#web temps
```

Strings, which are character arrays, can also be registered:

```
char mystring[20];
#web mystring
```

Strings receive special handling by RabbitWeb. The bounds are always checked when updating a string through a RabbitWeb interface, which means that the character buffer will not overflow.

It is permissible to register an array element without registering the entire array. For example,

```
int temps[20];
#web temps[0]
```

will register `temps[0]` but not temps[1], temps[2], etc. The same holds true for structure members.

```
struct foo2 {
   int a;
   int b;
};
struct foo2 bar;
#web bar
```

The above #web statement is functionally the same as:

```
#web bar.a
#web bar.b
```

Registering structure members or array elements separately lets you assign separate error-checking expressions to them, a topic covered in Section 5.2.2.

It is also possible to have arrays of structures:

```
struct foo2 bar[3];
#web bar
```

Arrays of structures can contain structures that contain arrays:

```
struct foo {
   int a;
   int b[2];
};
struct foo bar[3];
#web bar
```

And so on, and so on...

5.2.1.1 Selection-type Variables

Defining variables that can take on one of a list of variables is done with the `select()` feature at compile time.

```
int color;
#web color select("blue", "red", "green")
```

The `select()` feature is useful when creating a drop-down menu or a set of radio buttons. It is similar to an enumerated type. In this case, the actual variable, `color`, is an `int` and holds one of the values 0, 1, or 2 corresponding to the strings "blue," "red" and "green," respectively. To specify starting numbers other than zero, do the following:

```
int color
#web color select("blue" = 5, "red", "green" = 10)
```

This causes "blue" to be 5, "red" to be 6, and "green" to be 10. Unlike an `enum`, a selection-type variable can be of type `long` as well as `int`.

5.2.2 Web Guards

Registering variables, arrays and structures with the server is not enough—when data is received from the user, it should be checked for errors before being committed to the actual C variables. The `#web` syntax allows an optional expression to be added that is evaluated when the user submits a new value for that variable.

```
int foo;
#web foo (($foo > 0) && ($foo < 16))
```

If the C expression evaluates to TRUE (i.e., !0), the new value is accepted. If it evaluates to FALSE (i.e., 0), the new value is rejected. The new values are not applied until all variables in a submission have been checked.

To reference the old, committed (and therefore guaranteed correct) value, reference the variable directly:

```
int foo;
#web foo ((0 < $foo) && ($foo < foo))
```

One variable can reference another variable in an error-checking expression:

```
int low;
int high;

#web low
#web high ($high > $low)
#web low ($low < $high)
```

Notice that the variable `low` is registered with the web server before it is used in the error-checking expression for the variable `high`. This ordering lets the guard for `high` know that `low` is a web variable.

Arrays also need to be considered when doing error checking. The "@" character represents a wild-card for the index value. It is replaced with the index being checked in the expression:

```
int temps[20];
#web temps[@] ((50 <= $temps[@]) && ($temps[@] <= 100))
```

For example, if `temps[0]` is being checked for errors, the error-checking expression becomes:

```
((50 <= $temps[0]) && ($temps[0] <= 100))
```

Alternatively, it is possible to give each array element its own error-checking expression:

```
int temps[3];
#web temps ((50 <= $temps[0]) && ($temps[0] <= 100) && \
            (60 <= $temps[1]) && ($temps[1] <= 90) && \
            (70 <= $temps[2]) && ($temps[2] <= 80))
```

Note that the above statement spans lines. The statement is continued on the next line by escaping the end of the line.

It is also possible to register and check array variables individually:

```
int temps[3];
#web temps[0] ((50 <= $temps[0]) && ($temps[0] <= 100))
#web temps[1] ((60 <= $temps[1]) && ($temps[1] <= 90))
#web temps[2] ((70 <= $temps[2]) && ($temps[2] <= 80))
```

Structures are also supported with error checking.

```
struct foo {
   int a;
   int b;
};
struct foo bar;
#web bar ((0 < $bar.a) && ($bar.a < 10) && \
          (-5 < $bar.b) && ($bar.b < 5))
```

Alternatively, each structure element can be specified separately (using the same structure definition as above) and given its own error-checking expression.

```
struct foo bar;
#web bar.a ((0 < $bar.a) && ($bar.a < 10))
#web bar.b ((-5 < $bar.b) && ($bar.b < 5))
```

In the two code sections shown above, two similar methods for registering a structure are presented. The difference between these two methods is that the first one registers the entire structure as a single web variable, and the second one registers each element as separate web variables. In the first case, a change to any element of the structure causes the guard expression to be evaluated. In other words, changing either `bar.a` or `bar.b` will cause the guard expression to be evaluated and so both variables will be checked. In the second case, `bar.a` and `bar.b` are registered as independent web variables and so changing one does not cause the guard expression of the other one to be evaluated.

Structure elements can be specified separately in arrays of structures, as well:

```
struct foo bar[3];
#web bar[@].a (0 < $bar[@].a)
#web bar[@].b ($bar[@].a > 10)
```

The same holds true for arrays of structures, in which the structures themselves contain arrays.

```
struct foo {
   int a;
   int b[2];
};
struct foo bar[3];
#web bar[@].a (0 < $bar[@].a)
```

Of special note are variables with more than one array index. Which index is "@" referring to? Consider the following example:

```
#web bar[@].b[@] ((0 < $bar[@[0]].b[@[1]]) && ($bar[@[0]].b[@[1]] < 10))
```

In this case, the "@" in the guard is not enough. Instead, a different syntax is used, "@[#]", where # is the #th index being referenced. If the user uses a simple "@" for a wildcarded index, it is implicitly replaced with "@[0]" (since, in general, @ is a shorthand notation for @[0]).

If the error-checking expression is not flexible enough, a user-defined function can be specified instead:

```
struct (
   int a;
   int b;
}foo;

#web foo (check_foo($foo.a, $foo.b))
```

Remember that a $-variable must be a simple variable or a string (char array). It would be illegal to call the above function, `check_foo()`, with "`$foo`" since `foo` is a structure.

Consider the order of evaluation of each of the variable error checks to be undefined, that is, do not depend on the order. Also, only changed variables are checked for errors. This must be taken into account when writing guards. For example, in the following code:

```
#web low
#web high ($high > $low)
```

let us say the value of `high` is 60 and the value of `low` is 40. If these variables are presented in an HTML form and a value of 65 for `low` is submitted while the value for `high` is kept the same, it would be accepted because `low` has no guard. Since the value of `high` did not change, its guard was not activated. Hence, the guards for interdependent variables must be symmetric.

5.2.2.1 Reporting Errors

When a variable fails its error-check, the reason for the failure can be displayed in an HTML page by using the `WEB_ERROR()` function:

```
#web foo ((0 < $foo)?1:WEB_ERROR("too low"))
#web foo (($foo < 16)?1:WEB_ERROR("too high"))
```

Note that the checks for the variable `foo` have been split into two parts; both checks are done during the error-checking phase. If the check (such as "(0 < $foo)") succeeds, then the expression evaluates to 1. If the check fails, then the special `WEB_ERROR()` function is triggered, which will associate the given error string with the variable and will return 0.

`RWEB_WEB_ERROR_MAXBUFFER`, which is 512 by default, defines the size of the buffer for the error strings. The buffer must be large enough to hold all error strings for a single form submission. To change it, `#define` this macro before the `#use "http.lib"` statement in the application code.

Go to Section 5.3.5 to see how the error string passed to `WEB_ERROR()` is displayed in an HTML page.

5.2.3 Security Features

Various HTTP authentication methods (basic, digest, and SSL) are supported to protect web pages and variables. Each method requires a username and password for access to the resource. (More information on the HTTP authentication methods is found in Section 4.3.) In addition to the security offered by authentication, the concept of permissions allow specific protection for selected resources. Permissions are granted based on user groups rather than on individual user ids. User groups are defined at compile-time; however, users can be added to or removed from a user group at run-time.

The groups are defined at compile-time in this manner:

```
#web_groups admin,users
```

This statement creates the two groups, "admin" and "users." The symbols "admin" and "users" are added to the global C namespace. These represent unsigned 16-bit numbers. Each group has one of the 16 bits set to 1, so that the groups can be ORed together when multiple groups need to be referenced. Note that this limits the number of groups to 16.

The web server does not directly know that “admin” is for administrative users and “users” is for everyone else. This distinction is made by how the programmer assigns protection to server resources. For example,

```
#web foo ($foo > 0) groups=users(ro),admin
```

limits access to the variable `foo`. This variable is read-only for those in the “users” group. “(rw)” can be specified to mean read-write for the “admin” group, but this is the default so it is not necessary. The group “all” is a valid group, which will give access to a variable to all users regardless of group affiliation. By default, all groups have access to all variables. The “groups=” is used to limit access. Consider the line:

```
#web foo ($foo > 0) groups=users(ro)
```

This line causes the `admin` group to have no access to the variable `foo`. In other words, if there is a “groups=” clause then any group that is not mentioned explicitly in it will have no access to the variable to which it applies.

Also the order of the groups is important if the “all” group is mentioned. For example, the line:

```
#web foo ($foo > 0) groups=all(ro),admin
```

gives read/write access to the admin group. But the line

```
#web foo ($foo > 0) groups=admin,all(ro)
```

limits the admin group to read-only access.

To add a user to a group, you must first add the user to the list kept by the server by calling `sauth_adduser()`. The value returned by `sauth_adduser()`identifies a unique user. This value is passed to `sauth_setusermask()` to set the groups that the user will be in. For example:

```
id = sauth_adduser(“me”, “please”, HTTP_SERVER);
sauth_setusermask(id, admin|users, NULL);
```

The user `me` is now in both the “admin” group and the “users” group. The groups determine what server resources the user can access. The user information only determines what username and password must be provided for the user to gain access to that group’s resources.

The web server has no concept of which variables are located on which forms. By allowing certain variables to be available to certain user groups, it doesn’t matter which variables are located on which forms—any user can update variables through any POST-capable resource as long as a group the user is a member of has access to that variable.

It may also be important to update certain variables only through certain authentication methods. For instance, if the data must be secret, you can require that it only be updated via SSL. You can also make certain variables be read-only for certain user groups.

Valid user groups and authentication methods can be specified as follows:

```
#web foo(foo > 0) auth=basic,digest,ssl groups=admin,users(ro)
```

By default, all authentication methods and user groups are allowed to update the variable. That is, to limit access to the variable, you must include the applicable auth= or groups= parameters when registering the variable.

“none” is a valid authentication method.

If `foo` is a structure or array, the protection modes are inherited by all members of the structure or array unless specifically overridden with another `#web` statement.

If a received variable fails a security check, then the client browser will be given a "Forbidden access" page.

5.2.4 Handling Variable Changes

Receiving, checking, and applying the variable changes works well when the program does not immediately need to know the new values. For instance, if we are updating a value that represents the amount of idle time needed on a serial port before sending the queued data over the Ethernet, the program does not need to know the new interval value immediately—it can just use the new value the next time it needs to do the calculation. But sometimes the program must perform some action when values have been updated. For example, if a baud rate is changed on a serial port, then that serial port likely needs to be closed and reopened. To handle this, and similar situations, a callback function can be associated with an arbitrary group of variables:

```
#web_update foo, bar, baz user_callback
```

If any variable within a group is changed, then the callback function for that group is called. The user program, through the callback function, can then take the proper action based on the new value. The above statement means that if any of the variables `foo`, `bar`, or `baz` are updated, then the function `user_callback()` will be called to notify the application. If variables in more than one group are updated at once, each group's callback function will be called in turn (with no guarantees on order of calls). If a variable is in multiple groups and that is the only variable updated, then all update callback functions are called, although the order in which they are called is unspecified.

There is an important restriction on the use of `#web_update` for arrays and structures: for an array element or structure member registered explicitly (that is, with its own `#web` statement), the callback function associated with the array or structure as a whole will not be called when the variable is updated. For example, consider:

```
struct foo2 {
   int a;
   int b;
};
struct foo2 bar;

#web bar
#web bar.a      //#web_update variables must be explicitly #web registered

#web_update bar user_callback
#web_update bar.a differentuser_callback
```

If `bar.b` is updated, `user_callback()` is called, but if `bar.a` is updated, the function `differentuser_callback()` is called and not `user_callback()`.

5.2.4.1 Interleaving Problems

Consider the following scenario: Users A and B are operating a web interface on Device C. User A gets a form page from Device C and then leaves the computer for a while. User B then gets the same form page from Device C, updates the data, and then the new values are committed on Device C. Then, User A comes back to his computer, makes changes to the form that was left on his screen from earlier, and submits those values. Keep in mind that User A never saw the update done by User B. What should Device C do? Should it allow A's update? Or should it tell User A that an interim update has been made, and that he should thus review his changes in light of that fact?

Ideally, the developer should be in control of how this scenario is handled since different applications have different needs. One way to avoid trashing a valid update is given here:

```
int foo;
#web foo ($foo == foo + 1)
#web_update foo increment_value

void increment_value(void) {
   foo++;
}
```

Some client-side JavaScript is needed in the ZHTML file where the `foo` value is included:

```
<SCRIPT>
   document.write('<INPUT TYPE="hidden" NAME="foo"
     VALUE="' + (<?z echo($foo) ?> + 1) + '">')
</SCRIPT>
```

This causes the variable `foo` to be updated whenever a successful update is made. Here's how it works:

- The developer gives `foo` an initial value
- Included in a form is a hidden field that represents the value of `foo` (see the HTML in the SCRIPT tags above)
- In the JavaScript above, the "`<?z echo($foo) ?>`" is first replaced by the HTTP server with the current value of `foo`.
- In the browser, the JavaScript is executed, which takes the value of `foo` and adds one to it. This is the value of the hidden input field.
- When the form data is submitted, the automatic error-checking will recognize that the value of `foo` has been updated along with the other data. If all data passes the error-checking, then the value of `foo` is incremented by the user's `increment_value()` function.
- If, when the form data is submitted, the current value of `foo` plus one does not match the submitted value of foo, then we know that an interim update has occurred. The value of `foo` is marked as an error by the server, which can be handled by the developer's ZHTML page. Note that none of the updated form values will be committed, since an error was triggered.

5.3 ZHTML Scripting Language

This section describes the ZHTML scripting language: a set of features that can be included in HTML pages. These features interact with some new features in Dynamic C (described in Section 5.2) to create an enhanced HTTP server.

5.3.1 SSI Tags, Statements and Variables

The new server-parsed tag is similar to SSI tags prior to Dynamic C version 8.5, in that they are included in HTML pages and are processed by the server before sending the page to the browser.

The new tags all have the following syntax:

```
<?z statement ?>
```

That is, a valid `statement` is preceded by `<?z` and followed by `?>`. This follows the naming scheme for PHP and XML tags ("<?php" and "<?xml", respectively) and so follows standard conventions.

To surround a block of HTML, do the following:

```
<?z statement { ?>
<H1>HTML code here!</H1>
<?z } ?>
```

The <?z ... ?> tags delimit statements. This means that you cannot put two statements in a single set of tags. For example,

```
<?z if (error($foo)) {
   echo($foo)
} ?>
```

is not valid. The `if`, `echo`, and "`}`" statements must be separated by the <?z ... ?> tags like the following:

```
<?z if (error($foo)) { ?>
   <?z echo($foo) ?>
<?z } ?>
```

Note that "`}`" is considered a statement in ZHTML (the "close block" statement), and must always be in its own <?z ... ?> tags.

The simplest use of the new SSI tag simply prints the given variable:

```
<?z print($foo) ?>
```

The value of the given variable is displayed using a reasonable default `printf()` specifier. For example, if `foo` is an `int`, `print()` uses the conversion specifier %d. `foo` must be registered with the web server. How to register a variable with the web server is described in Section 5.2.1.

A variable must begin with a "$" character to access its last submitted value. This value may or may not have been committed. The last committed value is accessible using "@," as in:

```
<?z print(@foo) ?>
```

Why is there a distinction between the last submitted value and the last committed one? In other words, does it matter in the HTML code whether the submission value is valid? It can. See Section 5.3.5 for more information.

To specify a printf-style conversion specifier, the `printf()` function can be used, but with the limitation that it will only accept one variable as an argument:

```
<?z printf("%ld", $long_foo) ?>
```

Note that the `print` function does not generate the code for the form widget itself—this is done with the INPUT tag, an HTML tag that generates a specific form element. Here is an example of using the `print` command to display a value in a form widget:

```
<INPUT TYPE="text" NAME="foo" SIZE=10
   VALUE= "<?z print($foo) ?>">
```

For the value to be updateable, the NAME field must be the name of the variable. Otherwise, when the form is submitted, the web server will not know where to apply the new value. This is not true of arrays. When referencing arrays the name must differ somewhat from the C name because the '[' and ']' symbols are not valid in the NAME parameter of the INPUT tag due to limitations in HTTP.

The `varname()` function must be used to make the variable name safe for transmission.

```
NAME="<?z varname($foo[3]) ?>"
```

That is, `varname()` automatically encodes the variable name correctly.

5.3.2 Flow Control

In addition to simply displaying variables in your HTML documents, the new ZHTML tag allows some simple looping and decision making.

5.3.2.1 Looping

A `for` loop, when combined with arrays, makes it easy to display lists of variables. The format of the `for` loop is as follows:

```
<?z for ($A = start; $A < end; $A += step) { ?>
   <H1>HTML code here!</H1>
<?z } ?>
```

where:

- **A**: A single-letter variable name from A-Z. These loop-control variables take on an `unsigned int` value.
- **start**: The initial value of the for loop. The value of the variable will start at this value and count to the `end` value.
- **end**: The upper value of the `for` loop. The operator may be any one of the following: `<`, `>`, `==`, `<=`, `>=`, `!=`.
- **step**: The number by which the variable will change for each iteration through the loop. The operator may be any one of the following: `++`, `--`, `+=step`, `-=step`. Note that `$A++` will increment the variable by 1.

Note that although this `for` loop looks like the regular Dynamic C `for` loop, its use is restricted to what is documented here.

To display a list of numbers in HTML using a `for` loop, you can do something like this:

```
<TABLE><TR>
<?z for ($A = 0; $A < 5; $A++) { ?>
   <TD><?z print($foo[$A]) ?>
<?z } ?>
</TR></TABLE>
```

This code will display the variables `foo[0]`, `foo[1]`, `foo[2]`, `foo[3]`, and `foo[4]` in an HTML table.

It is also possible to get the number of elements in a one-dimensional array by doing the following:

```
<?z for ($A = 0; $A < count($foo, 0); $A++) { ?>
```

The second parameter to `count()` indicates that we want the upper bound of the nth array index of `foo`. (From this you can infer that the first parameter must be an array!) For example, if `$foo` is a three-dimensional array, then count `($foo, 0)` yields the array bound for the first dimension, count `($foo, 1)` yields the array bound for the second dimension and count `($foo, 2)` yields the array bound for the third dimension.

5.3.2.2 Conditional Code

In addition to looping, you can have conditional code with `if` statements. The `if` statement is specified as follows:

```
<?z if ($A == 0) { ?>
   HTML code
<?z } ?>
```

where:

- **A**: The variable to check in the conditional. This can be anything that evaluates to a number, whether it be a normal integral #web-registered variable, a loop variable, a numeric literal, or a `count()` expression.
- ==: The relational operator in the `if` statement. This can be “==”, “!=”, “<“, “>”, “<=”, or “>=”.
- **0**: The number to which the variable should be compared. This can be anything that evaluates to a number, whether it be a normal integral #web-registered variable, a loop variable, a numeric literal, or a `count()` expression.

For example:

```
<?z if ($foo == 0) { ?>
   HTML code
<?z } ?>
```

or

```
<?z if ($foo == @foo) { ?>
   HTML code
<?z } ?>
```

are both legal.

The table from the previous example was modified to allow one of the values to be displayed in an input widget, whereas all the other values are simply displayed.

```
<TABLE><TR>
   <?z for ($A = 0; $A < count($foo, 0); $A++) { ?>
      <TD>
      <?z if ($A == 3) { ?>
         <INPUT TYPE=”text” NAME=”<?z varname($foo[$A]) ?>”
            VALUE=”<?z print($foo[$A]) ?>”>
      <?z } ?>
      <?z if ($A != 3) { ?>
         <?z print($foo[$A]) ?>
      <?z } ?>
   <?z } ?>
</TR></TABLE>
```

The `if` statements can be nested. Even `for` loops can be nested within other `for` loops. The nesting level has an upper limit defined by the macro `ZHTML_MAX_BLOCKS`, which has a default value of 4.

5.3.3 Selection Variables

Put together, `if` statements and `for` loops are useful for selection-type variables. To iterate through all possible values of a selection-type variable and output the appropriate “<OPTION>” or “<OPTION SELECTED>” tags, something like the following can be done:

```
<?z for ($A = 0; $A < count($select_var); $A++) { ?>
   <OPTION
      <?z if (selected($select_var, $A)) { ?>
         SELECTED
      <?z } ?>
   >
<?z print_opt($select_var, $A) ?>
```

This syntax allows for maximum flexibility. In this case, the `count()` function returns the number of options in a selection variable. The `selected()` function takes a selection variable and an index as parameters. It returns TRUE if that option matches the current value, and FALSE if it doesn’t.

The `print_opt()` function outputs the $A-th possible value.

The following is a convenience function that automatically generates the option list for a given selection variable:

```
<?z print_select($select_var) ?>
```

5.3.4 Checkboxes and RadioButtons

This section describes how to add checkboxes and radiobuttons to your web page.

Checkboxes are a bit tricky because if a checkbox is not selected, then no information on that variable is sent to the server. Only if it is selected will the variable value ("on" by default, or whatever you have in the VALUE="this_is_the_value" attribute) be passed in. In particular this means that if a variable was checked, but then you uncheck it, the server will not be able to tell the difference between that variable being unchecked and that variable value simply not being sent. The server would need a notion of the full list of variables that should be in a specific form, information which RabbitWeb does not have.

However, there is a workaround. If a variable is included in a form multiple times, its value will be submitted multiple times. RabbitWeb will take the last value given as the true value, and ignore all previous ones. So, to force a default unchecked value, you can include a hidden variable before you do the checkbox INPUT field. Since you can do ZHTML comparisons with numbers, if you give the variable the value 0 or 1, it can be used in the checkbox INPUT tag.

```
<INPUT TYPE="hidden" NAME="<?z varname($checkbox[0]) ?>"
   VALUE="0">

<INPUT TYPE="checkbox" NAME="<?z varname($checkbox[0]) ?>
   VALUE="1"
   <?z if ($checkbox[0] == 1) { ?>
      CHECKED
   <?z } ?>
>
```

So, if the value of `$checkbox[0]` is 1, then the `CHECKED` attribute will be included and the checkbox will be checked. Otherwise, it will be blank. If it is checked when the form is displayed, but you clear the value, this still works, since the hidden field with a value of 0 will always be sent.

Since a list of radiobuttons is more likely to be subject to different formatting depending on user taste than something like a pulldown menu, there is no automatic way of generating the list. The best way to generate a list of radiobuttons is to use a for loop and the count function.

The following page displays both a checkbox and a list of radiobuttons.

```
<HTML>
<HEAD>
<TITLE>Radio button and checkbox</TITLE>
</HEAD>
<BODY>
<form action="./index.zhtml" method="post" >
   <INPUT TYPE="hidden" name="checkboxBoolean"  VALUE="0" >
   <INPUT TYPE="checkbox"
      <?z if($checkboxBoolean==1) { ?>
         CHECKED
      <?z } ?>
      NAME="checkboxBoolean" VALUE="1" >
   <br><br>
```

```
   <?z for ($A = 0; $A < count($radiobutton); $A++){ ?>
      <INPUT TYPE="radio" NAME="radiobutton"
         VALUE="<?z print_opt($radiobutton, $A) ?>"
         OPTION
         <?z if (selected($radiobutton, $A) ) { ?>
            CHECKED
         <?z } ?> >
   <?z } ?>
   <br><br>

   <INPUT TYPE="Submit"   VALUE="Submit" >
</form>
</BODY>
</HTML>
```

To take advantage of the above zhtml script, the server code would need something like the following:

```
int checkboxBoolean, radiobutton;
#web checkboxBoolean
#web radiobutton select("0" = 0, "1", "2", "3", "4", "5", "6", "7")

checkboxBoolean = 0;
radiobutton = 0;
```

5.3.5 Error Handling

One of the biggest benefits to the new server-parsed HTML tags is the ability to perform actions based on whether a user-submitted variable was in error. A natural way of creating an HTML user interface is to create the form on an HTML page. When the user enters (or changes) values and submits the result, the server should check the input for errors. If there are errors, then the same form can be redisplayed. This form can mark the values that are in error and allow the user to update them. With the use of conditionals, it is possible to create both the original form and the form that shows the errors in the same page.

The destination page of a submitted form can be any page. When the web server receives a POST request with new variable data, it checks the data using the error-checking expression in the `#web` statement that registered the variable. If there is an error, then the destination web page is displayed in error mode. The following text describes how error mode affects the display of the destination web page.

By default, the `print` statement displays the new value of the variable when in error mode. To override the default behavior and show the old, committed value (note that the erroneous value has not been committed), do the following:

```
<?z print(@foo) ?>
```

The “@” symbol specifies the old value of the variable.

To execute some code only when a certain variable has an error, do the following:

```
<?z if (error($foo)) { ?>
   This value is in error!
<?z } ?>
```

It is also possible to say: `!error($foo)`.

If a value submitted for a variable has an error, then `error(var)` used in a `print` statement evaluates to an error string if one was defined using the method described in Section 5.2.2.1. Here is an example:

```
<?z if (error($foo)) { ?>
   This value is <?z print(error($foo)) ?>!
<?z } ?>
```

Although the ZHTML parser can output error messages into the HTTP stream, these messages may not be visible on a web page depending on how the browser is displaying pages. The surest way to find out exactly the result of a ZHTML page is to check the source of the page in the browser. For Internet Explorer, the user can choose the "View/Source" menu item. Other browsers have equivalent functionality.

To display some information if the page is being displayed in error mode, use `error()` with no parameter. If any variable in the form has an error, `error()` will return TRUE. Here is an example of its use:

```
<?z if (error()) { ?>
   Errors are in the submission! Please correct them below.
<?z } ?>
```

5.3.6 Security: Permissions and Authentication

To check if a user has authorization for a specific variable, call the `auth()` function:

```
<?z if (auth($foo, “rw”)) { ?>
   You have read-write access to the variable foo.
<?z } ?>
```

“ro” is also a valid second parameter.

To check if the current page is being displayed as the result of a POST request instead of a GET request, call the `updating()` function.

```
<?z if (updating()) { ?>
   <?z if (!error()) { ?>
      <META HTTP-EQUIV=”Refresh” CONTENT=”0;
          URL=http://yoururl.com/”>
   <?z } ?>
<?z } ?>
```

Both `auth()` and `updating()` may be preceded by “1” (the not operator).

5.4 TCP to Serial Port Configuration Example

This section is a step-by-step description of the sample program `ethernet_to_serial.c`. It is located in `Samples\tcpip\rabbitweb`.

This sample program can be used to configure a simple Ethernet-to-serial converter. For simplicity, it only supports listening on TCP sockets, meaning that Ethernet-to-serial devices can only be started by another device initiating the network connection to the Rabbit.

Each serial port is associated with a specific TCP port. The Rabbit listens on each of these TCP ports for a connection. It then passes whatever data comes in to the associated serial port, and vice versa.

5.4.1 Dynamic C Application Code

The program starts with a configuration section:

```
#define TCPCONFIG 1
```

This `#define` statement sets the predefined TCP/IP configuration for this sample. If the default network configuration of 10.10.6.100, 255.255.255.0 and 10.10.6.1 for the board's IP address, netmask and gateway/nameserver respectively are not acceptable, change them before continuing. See `LIB\TCPIP\TCP_CONFIG.LIB` for instructions on how to change the configuration.

```
const char ports_config[] = { 'E', 'F' };

#define E2S_BUFFER_SIZE 1024
#define HTTP_MAXSERVERS 1

#define MAX_TCP_SOCKET_BUFFERS (HTTP_MAXSERVERS +
  sizeof(ports_config))

#define SERINBUFSIZE 127
#define SEROUTBUFSIZE 127
```

Each element in array `ports_config` corresponds to a serial port. In the following code, the size of this array will be used in `for` loops to identify, initialize and monitor the serial ports. A buffer is defined that will hold the data that is being passed from the Ethernet port to the serial port. The number of server instances is set to one and the number of socket buffers is set to the number of server instances plus the number of serial ports. The last two defines will be used later to allocate space for the receive and transmit buffers used by the serial port drivers.

This is the end of the configuration section.

```
#memmap xmem

#define USE_RABBITWEB 1

#use "dcrtcp.lib"
#use "http.lib"

#ximport "samples/tcpip/rabbitweb/pages/config.zhtml"
      config_zhtml

SSPEC_MIMETABLE_START
   SSPEC_MIME_FUNC(".zhtml", "text/html", zhtml_handler),
   SSPEC_MIME(".html", "text/html"),
   SSPEC_MIME(".gif", "image/gif")
SSPEC_MIMETABLE_END

SSPEC_RESOURCETABLE_START
   SSPEC_RESOURCE_XMEMFILE("/", config_zhtml),
   SSPEC_RESOURCE_XMEMFILE("/index.zhtml", config_zhtml)
SSPEC_RESOURCETABLE_END
```

This block of code asks the compiler to map functions not declared as root to extended memory. Setting the macro USE_RABBITWEB to one enables the use of the scripting language and the HTTP enhancements. (Other macros that affect these features are described in the reference section.) Next the TCP/IP libraries are brought in, as well as the HTTP library. The HTML page that contains the configuration interface to the serial ports is copied into memory with the #ximport directive.

HTTP servers require MIME type mapping information. This information is kept in the MIME table, which is set up by the SSPEC_MIME_* macros.

The SSPEC_RESOURCE* macros set up the static resource table for this server. The resource table is a list of all resources that the server can access. In this case, the server has knowledge of two resources named "/" and "/index.zhtml". When either of these is requested, the config.zhtml file is served. The file extension (zhtml) identifies the file as containing server-parsed tags.

```
void restart_socket(int i);
void update_tcp(void);
void restart_serial(int i);
void update_serial(void);
void serial_open(int i);
void e2s_init(void);
void e2s_tick(void);
```

These are the function declarations. They will be defined later in the program.

```
struct SerialPort {
   word tcp_port;
   struct {
      char port;
      long baud;
      int databits;
      int parity;
      int stopbits;
   } ser;
};

struct SerialPort serial_ports[sizeof(ports_config)];
struct SerialPort serial_ports_copy[sizeof(ports_config)];
```

The `SerialPort` structure has fields for the configuration information for each serial port and TCP port pair. The `serial_ports` array (and its copy) stores configuration information about the serial ports. `serial_ports_copy[]` is used to determine which port information changed when the update function is called.

```
#web serial_ports[@].tcp_port ($serial_ports[@].tcp_port > 0)
#web serial_ports[@].ser.port
```

The first `#web` statement is registration for the TCP port. Note that the only rule in the guard is that the new value must be greater than zero. The next `#web` statement registers the character representing the serial port, in this case, “E” or “F.”

```
#web serial_ports[@].ser.baud(($serial_ports[@].ser.baud >= 300)? \
                              1:WEB_ERROR("too low"))

#web serial_ports[@].ser.baud(($serial_ports[@].ser.baud <= 115200)? \
                              1:WEB_ERROR("too high"))
```

These two `#web` statements correspond to the baud rate. The guards are split into two so that the `WEB_ERROR()` feature can be used. The string passed to `WEB_ERROR()` can later be used in the ZHTML scripting to indicate why the guard statement failed.

```
#web serial_ports[@].ser.databits select("7" = 7, "8" = 8)
#web serial_ports[@].ser.parity select("None" = 0, "Even", "Odd")
#web serial_ports[@].ser.stopbits select("1" = 1, "2" = 2)
```

These are selection variables. They limit the available options for serial port configuration parameters.

```
#web_update serial_ports[@].tcp_port update_tcp
#web_update serial_ports[@].ser.baud,serial_ports[@].ser.databits,\
        serial_ports[@].ser.stopbits update_serial
```

The #web_update feature will initiate a function call when the corresponding variables are updated. Note that update_tcp() will be called when the TCP port changes, and update_serial() will be called when any of the other serial port configuration parameters are updated.

```
#define AINBUFSIZE SERINBUFSIZE
#define AOUTBUFSIZE SEROUTBUFSIZE
#define BINBUFSIZE SERINBUFSIZE
#define BOUTBUFSIZE SEROUTBUFSIZE
#define CINBUFSIZE SERINBUFSIZE
#define COUTBUFSIZE SEROUTBUFSIZE
#define DINBUFSIZE SERINBUFSIZE
#define DOUTBUFSIZE SEROUTBUFSIZE
#define EINBUFSIZE SERINBUFSIZE
#define EOUTBUFSIZE SEROUTBUFSIZE
#define FINBUFSIZE SERINBUFSIZE
#define FOUTBUFSIZE SEROUTBUFSIZE
```

These set the receive and transmit buffer sizes for the serial ports. In this example only serial ports “E” and “F” are being used, but here, as well as in the function e2s_init(), code is included for all possible serial ports. In this way it is relatively easy to change the serial ports being used simply by changing the character array, ports_config[].

```
enum {
   E2S_INIT,
   E2S_LISTEN,
   E2S_PROCESS
};
```

These are symbols representing different states in the Ethernet-to-serial state machine.

```
struct {
   int state;                    // Current state of the state machine
   tcp_Socket sock;              // Socket associated with this serial port


   // The following members are function pointers for accessing this serial port
   int (*open)();
   int (*close)();
   int (*read)();
   int (*write)();
   int (*setdatabits)();
   int (*setparity)();

} e2s_state[sizeof(ports_config)];
```

The `e2s_state` array of structures holds critical information for each socket/serial port pair, namely the socket structures that are used when calling TCP/IP functions and the various serial port functions that access the serial ports or set serial port parameters.

The first member of the structure (`state`) is the value of the variable that determines which state of the Ethernet-to-serial state machine will execute the next time `e2s_tick()` is called.

```
char e2s_buffer[E2S_BUFFER_SIZE];
```

This is a temporary buffer for copying data between the serial port buffers and the socket buffers.

Now we will look at the functions that were declared earlier in the program.

```
void restart_socket(int i)
{
   printf("Restarting socket %d\n", i);

   // Abort the socket
   sock_abort(&(e2s_state[i].sock));

   // Set up the state machine to reopen the socket
   e2s_state[i].state = E2S_INIT;
}
```

The function `restart_socket()` displays a screen message and then aborts the socket. The state variable for the Ethernet-to-serial state machine is set to the initialization state, which will cause the socket to be opened for listening the next time the state machine tick function is called.

```
void update_tcp(void){
   auto int i;

   // Check which TCP port(s) changed
   for (i = 0; i < sizeof(ports_config); i++) {
      if (serial_ports[i].tcp_port != serial_ports_copy[i].tcp_port)
      {
         // This port has changed, restart the socket on the new port
         restart_socket(i);

         // Save the new port, so we can check which one changed on the next update
         serial_ports_copy[i].tcp_port = serial_ports[i].tcp_port;
      }
   }
}
```

The function `update_tcp()` is called when a TCP port is updated via the HTML interface. It determines which TCP port(s) changed, and then restarts them with the new parameters.

```
void restart_serial(int i){
   printf("Restarting serial port %d\n", i);
   e2s_state[i].close();       // Close the serial port
   serial_open(i);             // Open the serial port
}
```

The function `restart_serial()` closes and then reopens the serial port specified by its parameter.

```
void update_serial(void){
   auto int i;

   // Check which serial port(s) changed
   for (i = 0; i < sizeof(ports_config); i++)
   {
      if (memcmp(&(serial_ports[i].ser),
               &(serial_ports_copy[i].ser),
               sizeof(serial_ports[i].ser)))
      {
         // This serial port has changed, so re-open the serial port with the new parms
         restart_serial(i);

         // Save the new parameters, so we can check which one changed on the next update
         memcpy(&(serial_ports_copy[i].ser),
               &(serial_ports[i].ser),
               sizeof(serial_ports[i].ser));
      }
   }
}
```

The function `update_serial()` is called when a serial port is updated via the HTML interface. It determines which serial port(s) changed, and then restarts them with the new parameters.

```
void serial_open(int i)
{
   // Open the serial port
   e2s_state[i].open(serial_ports[i].ser.baud);

   // Set the data bits
   if (serial_ports[i].ser.databits == 7) {
      e2s_state[i].setdatabits(PARAM_7BIT);
   }
   else {
      e2s_state[i].setdatabits(PARAM_8BIT);
   }
   // Set the stop bits
   if (serial_ports[i].ser.stopbits == 1) {
      if (serial_ports[i].ser.parity == 0) {         // No parity
         e2s_state[i].setparity(PARAM_NOPARITY);
      }
      else if (serial_ports[i].ser.parity == 1) {    // Even parity
         e2s_state[i].setparity(PARAM_EPARITY);
      }
      else {                                         // Odd parity (== 2)
         e2s_state[i].setparity(PARAM_OPARITY);
      }
   }
   else {                                           // 2 stop bits
      e2s_state[i].setparity(PARAM_2STOP);
   }
}
```

The function, `serial_open()`, is called from the function that initializes the Ethernet-to-serial state machine, `e2s_init()`. It does all of the work necessary to open a serial port, including setting the number of data bits, stop bits, and parity.

The first statement opens the serial port using the baud rate value that was initialized in `main()`. In the rest of the code, the values for the other serial port parameters, which are also initialized in `main()`, are used to determine the correct bitmask to send to the serial port functions `serXdatabits()` and `serXparity()`. (The bitmasks, `PARAM_*`, are defined in the serial port library, `RS232.lib`.)

```
void e2s_init(void)
{
   auto int i;
   for (i = 0; i < sizeof(ports_config); i++) {
      e2s_state[i].state = E2S_INIT;      // Initialize the state

      // Initialize the serial function pointers
      switch (ports_config[i]) {
         case 'A':
            e2s_state[i].open = serAopen;
            e2s_state[i].close = serAclose;
            e2s_state[i].read = serAread;
            e2s_state[i].write = serAwrite;
            e2s_state[i].setdatabits = serAdatabits;
            e2s_state[i].setparity = serAparity;
            break;
         . . .

         default:
            // Error--not a valid serial port
            exit(-1);
      }
      // Open each serial port
      serial_open(i);
   }
}
```

The above function initializes the Ethernet-to-serial state machine: first by setting the variable that is used to travel around the state machine (`e2s_state[i].state`), then by setting the function pointers used to access the serial ports. For example, `serAopen()` is a function defined in `RS232.lib` that opens serial port A.

The `switch` statement has cases for serial ports B, C and D that are not shown here. They are functionally the same as the above code for serial port A. If the chip on the target board is a Rabbit 3000, there are cases for serial ports E and F as well. The default case is an error condition that will cause a run-time error if encountered.

The last statement in the `for` loop is a call to `serial_open()`. This function, which was described earlier, makes calls to the appropriate serial port functions using the function pointers that were just initialized.

```
void e2s_tick(void)
{
   auto int i;
   auto int len;
   auto tcp_Socket *sock;

   for (i = 0; i < sizeof(ports_config); i++) {
      sock = &(e2s_state[i].sock);
      switch (e2s_state[i].state) {
         case E2S_INIT:
            tcp_listen(sock, serial_ports[i].tcp_port, 0, 0, NULL, 0);
            e2s_state[i].state = E2S_LISTEN;
            break;

         case E2S_LISTEN:
            if (!sock_waiting(sock)) {
               // The socket is no longer waiting
               if (sock_established(sock)) {
                  // The socket is established
                  e2s_state[i].state = E2S_PROCESS;
               }
               else if (!sock_alive(sock)) {
                  //The socket was established but then aborted by the peer
                  e2s_state[i].state = E2S_INIT;
               }
               else {
                 //socket was opened, but is now closing. Go to PROCESS state to read any data.
                  e2s_state[i].state = E2S_PROCESS;
               }
            }
            break;
```

The function, `e2s_tick()`, drives the Ethernet-to-serial state machine. Each time this tick function is called, it loops through all of the serial ports, first grabbing the socket structure that associates a particular serial port with a TCP port, then determining which state is active for that TCP port. There are three states in the Ethernet-to-serial state machine, identified by:

- `E2S_INIT`
- `E2S_LISTEN`
- `E2S_PROCESS`

The first state, `E2S_INIT`, opens the socket with a call to `tcp_listen()` and then sets the state variable to be in the listen state. The next time the tick function is called the `E2S_LISTEN` state will execute. The state machine will stay in this listen state until a connection to the socket is attempted, a condition determined by a call to `sock_waiting()`.

As noted in the code comments above, once a connection is attempted there are several stages it can be in, which one will determine the next state of the Ethernet-to-serial state machine.

```
         case E2S_PROCESS:
            // Check if the socket is dead
            if (!sock_alive(sock)) {
               e2s_state[i].state = E2S_INIT;
            }
            // Read from TCP socket and write to serial port
            len = sock_fastread(sock, e2s_buffer, E2S_BUFFER_SIZE);
            if (len < 0) {                          //Error
               sock_abort(sock);
               e2s_state[i].state = E2S_INIT;
            }
            if (len > 0) {
               // Write the read data to the serial port--Note that for simplicity,
               // this code will drop bytes if more data has been read from the TCP
               // socket than can be written to the serial port.
               e2s_state[i].write(e2s_buffer, len);
            }
            else { /* No data read, do nothing */ }

            // Read from the serial port and write to the TCP socket
            len = e2s_state[i].read(e2s_buffer, E2S_BUFFER_SIZE,
          (unsigned long)0);

            if (len > 0) {
               len = sock_fastwrite(sock, e2s_buffer, len);
               if (len < 0) {                       //Error
                  sock_abort(sock);
                  e2s_state[i].state = E2S_INIT;
               }
            }
         break;
      }
   }
}
```

The E2S_PROCESS state checks to make sure the user did not abort the connection since the last time the tick function was called. If there was no abort, an attempt is made to read data from the socket buffer. If an error is returned from `sock_fastwrite()`, the connection is aborted and we go back to the init state the next time the tick function is called. If data was read, it is written to the serial port. If no data was read, then nothing happens.

Next an attempt is made to read data from the serial port. If data was read, it is then written out to the TCP socket. If the data read from the serial port was not written successfully to the TCP socket, the connection is aborted and we go back to the init state the next time the tick function is called.

If no data was read from the serial port, the process state will execute again the next time the tick function is called.

```
void main(void)
{
   auto int i;

   // Initialize the serial_ports data structure
   for (i = 0; i < sizeof(ports_config); i++) {
      serial_ports[i].tcp_port = 1234 + i;
      serial_ports[i].ser.port = ports_config[i];
      serial_ports[i].ser.baud = 9600;
      serial_ports[i].ser.databits = 8;
      serial_ports[i].ser.parity = 0;
      serial_ports[i].ser.stopbits = 1;
   }

   // Make a copy of the configuration options to be compared against when
   // the update functions are called
   memcpy(serial_ports_copy, serial_ports, sizeof(serial_ports));

   // Initialize the TCP/IP stack, HTTP server, and Ethernet-to-serial state machine.
   sock_init();
   http_init();
   e2s_init();

   // This is a performance improvement for the HTTP server (port 80),
   // especially when few HTTP server instances are used.
   tcp_reserveport(80);

   while (1) {
      // Drive the HTTP server
      http_handler();

      // Drive the Ethernet-to-serial state machine
      e2s_tick();
   }
}
```

In the `main()` function, the configuration parameters for the serial ports are given initial values which are then copied for later comparison. After initialization of the stack, the web server and finally the state machine, the while loop allows us to wait for a connection.

5.4.2 HTML Page for TCP to Serial Port Example

The file `config.zhtml` that was copied into memory at the beginning of this program contains the HTML form that is presented when someone contacts the IP address of the Rabbit that is running the above application code. `config.zhtml` uses the ZHTML scripting language that interacts with the code above to create the web interface to a Rabbit-based controller board.

File name: `Samples/tcpip/rabbitweb/pages/config.zhtml`

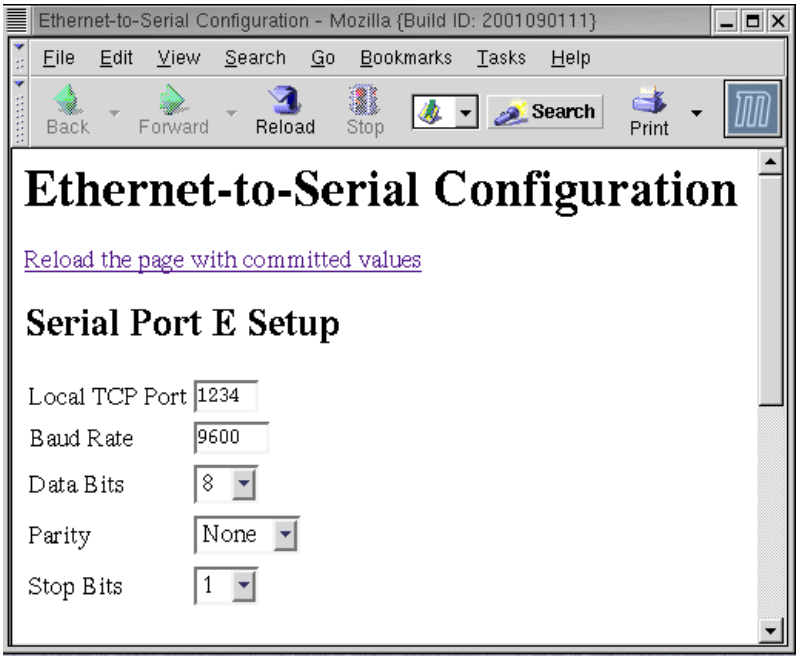
```
<HTML><HEAD>
<TITLE>Ethernet-to-Serial Configuration</TITLE></HEAD>
<BODY>

<H1>Ethernet-to-Serial Configuration</H1>

<A HREF="/index.zhtml">Reload the page with committed values</A>

<P>
<?z if (error()) { ?>
   There is an error in your data! The errors are both listed below
   and marked in <FONT COLOR="#ff0000">red</FONT>.
   <UL>
      <?z for ($A = 0; $A < count($serial_ports, 0); $A++)
      { ?>
         <?z if (error($serial_ports[$A].tcp_port))
         { ?>
            <LI>Serial Port <?z echo($serial_ports[$A].ser.port) ?>
            TCP port is in error (must be greater than 0)
            (committed value is
            <?z echo(@serial_ports[$A].tcp_port)?>)
         <?z } ?>

         <?z if (error($serial_ports[$A].ser.baud))
         { ?>
            <LI>Serial Port <?z echo($serial_ports[$A].ser.port) ?>
            baud rate is in error
            (<?z echo(error($serial_ports[$A].ser.baud)) ?>)
            (must be between 300 and 115200 baud)
            (committed value is
            <?z echo(@serial_ports[$A].ser.baud) ?>)
         <?z } ?>
      <?z } ?>
   </UL>
   <?z } ?>
```

After the usual opening lines of an HTML page, the first server-parsed tag we encounter is used with the call to `error()` to display a form submission error message, the same way we did in the humidity detector example in Section 5.1.2.2. Next is an example of a `for` loop used to print additional, more focused, error messages regarding the local TCP port number and the baud rate for each serial port. Again, `error()` is used with an `if` statement to verify the submission of particular web variables and display whatever error messages are chosen.

```
<FORM ACTION="/index.zhtml" METHOD="POST">
   <?z for ($A = 0; $A < count($serial_ports, 0); $A++) { ?>
      <H2>Serial Port <?z echo($serial_ports[$A].ser.port) ?> Setup
      </H2>
         <TABLE>
```

The form is defined next. Another `for` loop allows us to have the same form entries for each serial port in turn.When displayed without errors, the page looks like this:

Figure 5.11 Web Page Served by RabbitWeb



There are two tables, one for serial port E and, if you could scroll down in Figure 5.11, you would see that it is followed by a table for serial port F. Each table consists of five rows and two columns. Of the five rows, two have text entries and three have drop-down menus, one for each of the three selection variables defined in the Dynamic C application code shown above. We will not show the rest of the HTML code here because it is too repetitive and we have seen similar code in the humidity detector example. There are two lines, however, that are worth further discussion.

```
<INPUT TYPE="text"
   NAME="<?z varname($serial_ports[$A].tcp_port) ?>"
   SIZE=5 VALUE="<?z echo($serial_ports[$A].tcp_port) ?>">
```

The two text fields in the above form are created with INPUT tags like the one shown here. Recall that the NAME attribute does not allow the use of "[" or "]." The call to `varname()` solves that problem for us.

```
<SELECT NAME="<?z varname($serial_ports[$A].ser.parity) ?>">
   <?z print_select($serial_ports[$A].ser.parity) ?>
</SELECT>
```

The SELECT tag is used to create a drop-down menu in HTML, which is a convenient way to display a RabbitWeb selection-type variable.

5.5 RabbitWeb Reference

This section is the repository of some specialized details, such as the grammars that describe the scripting language and the Dynamic C enhancements. It is also intended as a way to quickly find descriptions of particular components of the RabbitWeb software.

5.5.1 Language Enhancements Grammar

Terminals are in bold, "[ ]" indicate optional parts, and "|" indicates an OR in the statement.

```
web-extension -> #web-statement |
                 #web_groups-statement |
                 #web_update-statement
```

```
#web-statement -> #web variable expression [authorization]
```

End-of-line escaping must be used for the #web statement to span lines.

```
variable -> case-insensitive-C-variable
expression -> modified-C-expression |
              select ( select-list )
select-list -> "string" [ = numeric-literal ] [, select-list]
```

variable is a C variable in the global scope. Due to details of how variables are transferred over HTTP, the variable name must be treated as case-insensitive. We can catch variables that conflict because of case-insensitivity at run-time.

modified-C-expression is a regular C expression, with an optional "$" symbol preceding C variables which is used to reference the newest value of the variable.

```
authorization -> [authorization] [auth-method] [valid-groups]
```

```
auth-method -> auth = auth-type-list
```

```
auth-type-list -> ssl | basic | digest [, auth-type-list]
```

```
valid-groups -> groups = valid-groups-list
```

```
valid-groups-list -> group [( group-rights )] [, valid-groups-list]
```

```
group-rights -> ro | rw
```

```
#web_groups-statement -> #web_groups groups-list
```

```
groups-list -> group-name [, groups-list]
```

group-name follows the same rules of a C variable name (it will, in fact, be in the namespace as a C variable).

```
#web_update-statement -> #web_update variable-list function-spec
variable-list -> variable [, variable-list]
```

`function-spec` is the name of a previously declared C function.

5.5.2 Configuration Macros

There are several macros that can be used when setting up a RabbitWeb server.

`USE_RABBITWEB`

Define to 1 to enable the HTTP extensions, including the ZHTML scripting language. Defaults to 0.

`RWEB_POST_MAXBUFFER`

This defines the size of a buffer that is created in xmem. This buffer stores POST requests that contain variable updates. Hence, this macro limits the size of POST requests that can be processed. Defaults to 2048.

`RWEB_POST_MAXVARS`

This macro defines the maximum number of variables that can be processed in a single POST request. That is, it limits the number of variables that can be updated in a single request. Each variable requires 20 bytes of root memory for bookkeeping information, so the total memory usage is 20 * `RWEB_POST_MAXVARS`. Defaults to 64.

`RWEB_ZHTML_MAXBLOCKS`

This macro determines the number of `if` and `for` blocks that can be nested in ZHTML. Each additional block allowed adds 11 bytes for each HTTP server instance (defined by `HTTP_MAXSERVERS`). Defaults to 4.

`RWEB_ZHTML_MAXVARLEN`

This defines the size of a root buffer (in bytes) that is used to store variable names and values, and hence limits the maximum length of a variable name or value. Only strings can be larger than four bytes, so realistically this macro only affects strings.

Please note that the macro `HTTP_MAXBUFFER` limits the size of the root buffer that is used to hold the output of ZHTML commands. Strings the size of `RWEB_ZHTML_MAXVARLEN` are outputs of ZHTML commands and will need to fit in the buffer of size `HTTP_MAXBUFFER` if they are to be sent over the network. This effectively limits the value of `RWEB_ZHTML_MAXVARLEN` to be no more than the value of `HTTP_MAXBUFFER`. Both macros default to 256. If `RWEB_ZHTML_MAXVARLEN` is increased, `HTTP_MAXBUFFER` should be increased by the same amount.

`RWEB_WEB_ERROR_MAXBUFFER`

This macro defines the size of a buffer in xmem that is used to hold `WEB_ERROR()` error messages. This buffer limits the total size of the error messages associated with a single form update. Defaults to 512.

5.5.3 Compiler Directives

The RabbitWeb compiler directives are summarized here.

#web

Registers a variable, array or a structure with the server. For more information, see Section 5.2.1.

The #web statement has several optional parts that can be used when a variable (or array or structure) is registered. The optional parts are:

- An error-checking expression to limit the acceptable values that are submitted. For more information see Section 5.2.2. A macro called WEB_ERROR can be included in the error-checking expression to associate a string with an error. For more information, see Section 5.2.2.1.
- The “auth=” parameter is a comma separated list of acceptable authentication methods. The possible choices are basic, digest and ssl. For more information, see Section 5.2.3.
- The “groups= “ parameter is a comma separated list of user groups that are allowed access to the web variable (or array or structure). For more information, see Section 5.2.3.

One or more of the optional parts can be used in a #web statement.

#web_groups

This directive defines a web group. For more information, see Section 5.2.3.

#web_update

This directive identifies a user-defined function to call in response to a variable update. For more information, see Section 5.2.4.

5.5.4 ZHTML Grammar

Terminals are in bold, "[ ]" indicate optional parts, and "|" indicates an OR in the statement.

```
zhtml-tag -> <?z statement ?>
statement -> print-function | printf-function |
               varname-function | print_opt-function |
               print_select-function | if-statement | for-loop

print-function -> print( variable )

variable -> $ registered-variable | loop-variable
```

`registered-variable` is an array, structure or variable that is registered with the web server.

```
loop-variable -> $ A-Z
```

`loop-variable` is a one-letter variable (A-Z) defined in the `for` loop, and can be used as the index for an array.

```
printf-function -> printf ( printf-specifier , variable )
```

The `printf-specifier` is like a C printf specifier, except that it is limited to a single variable.

```
varname-function -> varname( variable )
print_opt-function -> print_opt( variable , number ) |
                      print_opt( variable , loop-variable )
print_select-function -> print_select( variable )

count-expression -> count( variable, number ) | count( variable )
```

Note that in the first option `variable` is an array; in the second option it is a selection-type variable.

```
numeric-expression -> loop-variable | integral-variable |
                        count-expression | numeric-literal
```

`integral-variable` refers to a registered #`web` variable of integral (`int` or `long`, `signed` or `unsigned`) type.

```
if-statement -> if ( if-expression ) { html-code }

if-expression ->numeric-expression operator numeric-expression |
                [ ! ] error( variable ) |
                [ ! ] auth( variable , " group-rights " ) |
                [ ! ] updating( )

operator -> == | != | > | < | >= | <=

group-rights -> ro | rw

for-loop -> for ( loop-variable = numeric-expression ;
                  loop-variable operator numeric-expression ;
                  loop-variable for-inc ) { html-code }
for-inc -> ++ | -- | += numeric-expression | -= numeric-expression
```

`ro` stands for read-only

`rw` stands for write-only

5.5.5 RabbitWeb Functions

This section lists all of the functions that can be called within ZHTML tags.

auth()

This function is used to check if a user has authorization for accessing a specific variable.

```
<?z if (auth($foo, “rw”)) { ?>
   You have read-write access to the variable foo.
<?z } ?>
```

This function can be preceded by “!” (the not operator).

count()

This function is for arrays and selection-type variables.

If the first parameter is an array, the second parameter specifies an array dimension. For a one-dimensional array, the second parameter must be zero. For a two-dimensional array, the second parameter must be zero or one. And so on. If the first parameter is an array, the return value of the function is the upper bound for the specified array dimension.

If the first parameter is a selection variable, there is no second parameter. The `count()` function returns the number of options for a selection variable. The return value of `count()` can be used in a `for` loop to cycle through all elements of an array.

```
<?z for ($A = 0; $A < count($foo, 0); $A++) { ?>
```

echo(), print()

These are display functions to make web variables visible on an HTML page. `They` display the variable passed to them using a default conversion specifier. The function `echo()` is an alias for `print()`.

```
<?z print($foo) ?>
```

error()

The `error()` function can be called both with and without a parameter. If it is called without a parameter it will return TRUE if there were any errors in the form submission and FALSE otherwise. To call `error()` with a parameter, you must pass it the name of a web variable. The function will return TRUE if that variable did not pass its error check, and FALSE otherwise.

It can be used to print out the `WEB_ERROR()` message:

```
print(error($foo))
```

printf()

This is a display function to make web variables visible on an HTML page. With `printf()` you can display a variable of type `int` or `long`:

```
<?z printf(“%ld”, $long_foo) ?>
```

print_opt()

This is a display function to make selection-type web variables visible on an HTML page. It takes two parameters. The first parameter is a selection-type variable and the second parameter is the index into the list of possible values for the selection-type variable.

```
<?z print_opt($select_var, $A) ?>
```

print_select()

This is a display function to make selection-type web variables visible on an HTML page. `It` automatically generates the option list for a given selection variable:

```
<?z print_select($select_var) ?>
```

selected()

The `selected()` function takes two parameters. The first parameter is a selection variable and the second parameter is an integer index into the array of options for the specified selection variable. The function returns TRUE if the option indicated by the index parameter matches the currently selected option, and FALSE if it doesn't.

For example, to iterate through all possible values of a selection-type variable and output the appropriate "<OPTION>" or "<OPTION SELECTED>" tags, something like the following can be done:

```
<?z for ($A = 0; $A < count($select_var, 0); $A++) { ?>
   <OPTION
   <?z if (selected($select_var, $A)) { ?>
      SELECTED
   <?z } ?>
   >

<?z print_opt($select_var, $A) ?>
```

The page `Samples/tcpip/rabbitweb/pages/selection.zhtml` uses the `selected()` function.

updating()

This function can be used with an `if` statement to test whether the current page is being displayed as the result of a POST request instead of a GET request. This is useful to redirect to another page on a successful form submission. Use this function as follows:

```
<?z if (updating()) { ?>
   <?z if (!error()) { ?>
      <META HTTP-EQUIV="Refresh" CONTENT="0;
          URL=http://yoururl.com/">
   <?z } ?>
<?z } ?>
```

This function can be preceded by "!" (the not operator).

varname()

This is a convenience function that gets around the limitation of no square brackets in the NAME attribute of the INPUT tag in HTML.

```
<INPUT TYPE="text" NAME="<?z varname($foo[3]) ?>
   "VALUE=" <?z echo($foo[3]) ?>">
```

6. HTTP CLIENT

The HTTP client library, `http_client.lib`, is used for connecting to web servers. A common HTTP client implementation that most of us have used is found in a web brower, e.g., Internet Explorer or Mozilla Firefox. The client that can be implemented by this library is far less ambitious in terms of bells and whistles, but is useful for the basics of making valid requests of an HTTP server and understanding the subsequent responses.

The initial version of `http_client.lib` requires Dynamic C 10.54 or later.

The following programs demonstrate using the library:

```
Samples/tcpip/http/http client.c
Samples/tcpip/http/dyndns.c
```

6.1 Configuration Macros

The following macros may be defined in a `#define` statement before the inclusion of `http_client.lib` in an application program.

HTTPC_VERBOSE

If defined, library will print status messages to Stdio window.

HTTPC_DEBUG

If defined, functions will be debuggable (e.g., you can set breakpoints and single-step into them).

HTTPC_HEADER_TIMEOUT

Timeout, in milliseconds, to wait for headers to complete when calling `httpc_skip_headers()`. Defaults to 5000 (5 seconds).

HTTPC_PROXY_AUTH_STRLEN

Length of authentication information (printable string in “username:password” format) for proxy server. Does not include null-terminator at end of string.

6.2 API Functions

This section contains a quick API overview, followed by detailed function descriptions. The functions are located in `/Lib/../tcpip/http_client.lib`, relative to the Dynamic C installation folder.

6.2.1 Initialization Functions

The initialization function `httpc_init_if()` must be called before any other HTTP client function. This function lets you specify an interface. `httpc_init()` is a macro for `httpc_init_if()`, using `IF_ANY` as the interface designator.

6.2.2 Connect and Request Functions

As is usual with client-side software, the HTTP client initiates the connection and makes a request of the server. Common requests are GET, POST and HEAD. The Dynamic C HTTP client has seven functions to choose from that accomplish the connect/request tasks.

There are two functions that allow you to connect and request separately. They are: `httpc_open()` and `httpc_request()`. You must use `httpc_request()` to make a HEAD request. You may also make GET and POST requests with this function as it allows you to specify the request method. The other five functions couple the connect and request tasks and are method specific. They differ in the form that the resource and its server are identified.

The connect/request functions are:

- `httpc_get` - connect and GET
- `httpc_get_url` - connect and GET
- `httpc_post` - connect and POST
- `httpc_post_ext` - connect and POST
- `httpc_post_url` - connect and POST

6.2.3 Read Server Response Functions

A valid HTTP server response has a fixed structure. The HTTP client may read any of the header lines and/or the optional message body using the following functions:

- `httpc_read_header` - read the next header from the response
- `httpc_read_body` - read bytes from the body of the response

6.2.4 Miscellaneous Functions

- `httpc_close` - release resources for the specified socket
- `httpc_headermatch` - find string in header
- `httpc_skip_headers` - skip over the headers entirely (blocking call)
- `httpc_use_proxy` - configure client to use a proxy server for all new connections

6.2.5 Function Descriptions

httpc_close	httpc_init_if	httpc_read_body
httpc_get	httpc_open	httpc_read_header
httpc_get_url	httpc_post	httpc_request
httpc_headermatch	httpc_post_ext	httpc_skip_headers
httpc_init	httpc_post_url	httpc_use_proxy

httpc_close

```
void httpc_close( httpc_Socket far *s);
```

DESCRIPTION

Closes an open socket to the web server.

PARAMETER

s Pointer to socket structure to use for connection.

httpc_get

```
int httpc_get( httpc_Socket far *s, const char *host, word port,
   const char far *file, const char far *auth);
```

DESCRIPTION

Connect to “host” and GET “file” using “auth” credentials.

PARAMETERS

s	Pointer to socket structure to use for connection.
host	Hostname (or dotted IP) to connect to.
port	Port to connect to (typically 80).
file	Filename to request (should start with “/”)
auth	Optional username and password (separated with “:”) to authenticate with. Use NULL for no credentials.

RETURN VALUE

`0`: Success
`-NETERR_DNSERROR`: Can't resolve hostname
`-EIO`: Unable to send request over socket
`-E2BIG`: Buffer full trying to create HTTP request

httpc_get_url

```
int httpc_get_url( httpc_Socket far *s, const char far *url );
```

DESCRIPTION

Connect to the HTTP server referenced in “url” and GET the resource referenced in “url”. This function is like `httpc_get`, but with a URL instead of separate host, authentication, port and file parameters.

PARAMETERS

s	Pointer to socket structure to use for connection.
url	URL, in the following format (items in [] are optional): [http://][user[:pass]@]hostname[:port]/filename

RETURN VALUE

`0`: Success
`-EINVAL`: Error parsing URL
`-E2BIG`: URL is too big to parse. Increase `URL_MAX_BUFFER_SIZE` to handle larger URLs.
`-NETERR_DNSERROR`: Can't resolve hostname.

EXAMPLE

```
// Connect to google.com and request their homepage
httpc_get_url( &hsock, "http://www.google.com/");
```

httpc_headermatch

```
char far *httpc_headermatch( char far *header, char far *match );
```

DESCRIPTION

See if a header matches a particular field name.

PARAMETERS

header	Pointer to a line from the headers.
match	Header to match.

RETURN VALUE

NULL: header does not match
non-NULL: far pointer to value of header

EXAMPLE

```
// returns a pointer to "text/html"
httpc_headermatch( "Content-Type: text/html", "Content-Type");
```

httpc_init

```
int httpc_init( httpc_Socket far *s, tcp_Socket *t);
```

DESCRIPTION

This function initializes the `httpc_Socket` structure and binds it to `tcp_Socket` "t".

NOTE: `httpc_init()` is a macro for `httpc_init_if`, using `IF_ANY`.

PARAMETERS

s	Pointer to an `httpc_Socket` structure.
t	Pointer to the `tcp_Socket` that the HTTP client will use for its connections.

RETURN VALUE

`0`: OK
`-EINVAL`: NULL passed for one of the first two parameters.

EXAMPLE

```
httpc_init( &hsock, &tsock);
```

httpc_init_if

```
int httpc_init_if( httpc_Socket far *s, tcp_Socket *t, int iface);
```

DESCRIPTION

This function initializes the `httpc_Socket` structure, binds it to `tcp_Socket` "t" and forces it to use interface "iface".

PARAMETERS

s	Pointer to an `httpc_Socket` structure.
t	Pointer to the `tcp_Socket` that the HTTP client will use for its connections. Caller should memset this structure to 0 before first use.
iface	Interface to use for connection (if on a multi-interface device).

RETURN VALUE

`0`: OK
`-EINVAL`: NULL passed for one of first two parameters, or invalid interface passed for "iface".

EXAMPLE

```
httpc_init_if( &hsock, &tsock, IF_PPP0);
```

httpc_open

```
int httpc_open( httpc_Socket far *s, const char *host, word port);
```

DESCRIPTION

Attempts to open a connection to a web server.

> **NOTE:** If a proxy server has been configured by calling `httpc_use_proxy`, the host and port parameters are ignored and the proxy server settings are used for establishing the connection.

PARAMETERS

s	Pointer to `httpc_Socket` structure to use for connection.
host	Hostname (or dotted IP) to connect to.
port	Port to connect to, or 0 for default port (80).

RETURN VALUE

`0`: Success
`-NETERR_DNSERROR`: Cannot resolve hostname
`-NETERR_NOHOST_ARP`: Local host or gateway unreachable

EXAMPLE

```
httpc_open( &hsock, "192.168.1.1", 80);
```

httpc_post

```
int httpc_post( httpc_Socket far *s, const char *host, word port,
   const char *file, const char *auth, const char far *postdata);
```

DESCRIPTION

Connect to “host” and POST “postdata” to “file” using “auth” credentials.

PARAMETERS

s	Pointer to socket structure to use for connection.
host	Hostname (or dotted IP) to connect to.
port	Port to connect to (typically 80).
file	Filename to request (should start with “/”)
auth	Optional username and password (separated with “:”) to authenticate with (or NULL for no authentication).
postdata	Data to post (already URL-encoded and null terminated)

RETURN VALUE

`0`: Success
`-NETERR_DNSERROR`: Can't resolve hostname

SEE ALSO

httpc_post_url, httpc_post_ext

httpc_post_ext

```
int httpc_post_ext( httpc_Socket far *s, const char *host, word port,
   const char *file, const char *auth, const char far *postdata, word
   postlen, const char *contenttype );
```

DESCRIPTION

Connect to “host” on “port” and POST “postlen” bytes from “postdata” to “file” using “auth” credentials.

PARAMETERS

s	Pointer to socket structure to use for connection.
host	Hostname (or dotted IP) to connect to.
port	Port to connect to (typically 80).
file	Filename to request (should start with “/”).
auth	Optional username and password (separated with “:”) to authenticate with (or NULL for no authentication).
postdata	Data to post (already URL-encoded).
postlen	Length of data to post (typically strlen(postdata)).
contenttype	String to send as “Content-Type”. Use NULL for default of “application/x-www-form-urlencoded”.

RETURN VALUE

0: Success
`-EIO`: couldn't write to socket
`-NETERR_DNSERROR`: Can't resolve hostname
`-E2BIG`: Buffer full trying to create HTTP request

SEE ALSO

httpc_post_url, httpc_post

httpc_post_url

```
int httpc_post_url( httpc_Socket far *s, const char far *url, const
   char far *postdata, word plen, const char *contenttype);
```

DESCRIPTION

Connect to resource at “url” and POST “plen” bytes of “postdata”.

PARAMETERS

s	Pointer to socket structure to use for connection.
url	URL, in the following format (items in [] are optional): [http://][user[:pass]@]hostname[:port]/filename
postdata	Data to post, already url-encoded.
plen	Length of data to post (typically strlen(postdata))
contenttype	String to send as "Content-Type". Use NULL for default of “application/x-www-form-urlencoded”

RETURN VALUE

`0`: Success
`-EINVAL`: Error parsing URL
`-E2BIG`: URL is too big to parse. Increase `URL_MAX_BUFFER_SIZE` to handle larger URLs.
`-NETERR_DNSERROR`: Can't resolve hostname.

SEE ALSO

httpc_post, httpc_post_ext, url_encodestr

httpc_read_body

```
int httpc_read_body( httpc_Socket far *s, char *buffer, int buflen);
```

DESCRIPTION

Read some of the body returned by the HTTP server.

PARAMETERS

s	Pointer to socket structure to use for connection.
buffer	Buffer to store the data in.
buflen	Length of buffer for storing data.

RETURN VALUE

>0: length of data read
0: waiting on data from socket
-ENOTCONN: connection closed, can't read from socket
-NETERR_REMOTE_RESET: connection closed before end of headers
-EIO: error in chunked encoding

EXAMPLE

```
// read bytes from the body of the response, retval = # of bytes written
do {
   retval = httpc_read_body( &hsock, buffer, sizeof(buffer) - 1);
} while (hsock.status == HTTPC_STATE_BODY);
```

httpc_read_header

```
int httpc_read_header( httpc_Socket far * s, char * buffer,
   int buflen );
```

DESCRIPTION

Read the next header from the socket.

PARAMETERS

s	Pointer to socket structure to use for connection.
buffer	Buffer to store the header in, recommend at least 128 bytes. Header will be up to (buflen-1) bytes, followed by a null terminator. Pass NULL if the calling function does not need a copy of the header.
buflen	Length of buffer for storing header. Ignored if parameter 2 is NULL.

RETURN VALUE

`>0`: length of header read (excluding null-terminator byte)
`0`: no more headers or incomplete header read from socket
`-NETERR_REMOTE_RESET`: connection closed before end of headers
`-EEOF`: socket is not readable

EXAMPLE

```
do {
   retval = httpc_read_header(&hsock, buffer, sizeof(buffer)-1);
} while (hsock.status == HTTPC_STATE_HEADER);
```

httpc_request

```
int httpc_request( char *buffer, int bufsize, const char far *method,
   const char far *host, word port, const char far *file, const char
   far *auth);
```

DESCRIPTION

Generate HTTP headers to request a file from an HTTP server.

PARAMETERS

buffer	Pointer to socket structure to use for connection.
bufsize	Length of buffer for storing header.
method	Method (typically "GET", "POST" or maybe "HEAD")
host	Hostname (or dotted IP) to connect to.
port	Port to connect to or 0 for default (80). Only used with proxy servers, ignored otherwise.
file	Filename to request (must start with "/")
auth	Optional username and password (separated with ':') to authenticate with. Use NULL for no credentials.

RETURN VALUE

Number of bytes written to buffer. Caller can add additional headers, but must append \r\n (CRLF) before sending.
`-E2BIG`: request would overflow buffer

SEE ALSO

`httpc_get`, `httpc_get_url`, `httpc_post_url`, `httpc_post`, `httpc_post_ext`

httpc_skip_headers

```
int httpc_skip_headers( httpc_Socket far *s);
```

DESCRIPTION

Skip through the headers to get to the body of the HTTP response. Blocks up to HTTPC_HEADER_TIMEOUT milliseconds (defaults to 5000 if not defined).

> **NOTE:** Note, the macro HTTPC_HEADER_TIMEOUT controls the timeout, in milliseconds, that httpc_skip_headers() will block while waiting for the headers to complete. If not set, HTTPC_HEADER_TIMEOUT defaults to 5000 (5 seconds).

PARAMETER

s	Pointer to socket structure to use for connection.

RETURN VALUE

Total bytes in headers, or <0 for error
-NETERR_INACTIVE_TIMEOUT: timed out due to inactivity
-NETERR_REMOTE_RESET: connection closed before end of headers

httpc_use_proxy

```
void httpc_use_proxy( unsigned long ip, word port, const char far
   *auth);
```

DESCRIPTION

Configure the HTTP client library to use a proxy server for all new connections. Pass 0UL for the IP address to switch back to the default behavior of making direct connections.

PARAMETERS

ip	IP address of the proxy server.
port	Port number to connect to.
auth	Basic authentication credentials (in username:password format) to use when connecting. Use NULL or an empty string if the proxy server does not require authentication.

RETURN VALUE

None

EXAMPLE

```
httpc_use_proxy(inet_addr("192.168.1.1"),80,"username:password");
```

7. FTP CLIENT

The library FTP_CLIENT.LIB implements the File Transfer Protocol (FTP) for the client side of the connection.

This library supports a single FTP session at any one time since the session state is maintained in a single global structure in root memory.

You can upload and download files to either a static buffer in root data memory (for simple applications) or, starting with Dynamic C version 7.20, you can have the data passed to, or generated by, a data handler callback function that you specify. The data handler function can implement large file transfers in extended memory buffers, or it can be used to generate or process data on-the-fly with minimal buffering.

Starting with Dynamic C 7.20, you can specify "passive" mode transfers. This is most important for clients which are inside a firewall. Passive mode is specified by passing the FTP_MODE_PASSIVE option to ftp_client_setup(). When passive mode is specified, the client will actively open the data transfer port to the server, rather than the other way around. This avoids the need for the server to penetrate the firewall with an active connection from the outside, which is most often blocked by the firewall. For this reason, it is recommended that your FTP client application uses passive mode by default, unless overridden by an end-user.

7.1 Configuration Macros

The following macros may be defined in a #define statement before the inclusion of FTP_CLIENT.LIB in an application program. Note that strings must contain the NULL byte, so if a maximum string length is 16, the maximum number of characters is 15.

FTP_MAX_DIRLEN

The default is 64, which is the maximum string length of a directory name.

FTP_MAX_FNLEN

The default is 16, which is the maximum string length of a file name.

FTP_MAX_NAMELEN

The default is 16 which is the maximum string length of usernames and passwords.

FTP_MAXLINE

The default is 256, which is both the maximum command line length and data chunk size that can be passed between the FTP data transfer socket and the data handler (if any defined).

FTP_TIMEOUT

The default is 16, which is the number of seconds that pass before a time out occurs.

7.2 API Functions

ftp_client_setup

```
int ftp_client_setup( long host, int port, char *username, char
   *password, int mode,  char *filename, char *dir, char *buffer, int
   length );
```

DESCRIPTION

Sets up a FTP transfer. It is called first, then `ftp_client_tick()` is called until it returns non-zero. Failure can occur if the host address is zero, if `length` is negative, or if the internal control socket to the FTP server cannot be opened (e.g., because of lack of socket buffers).

PARAMETERS

host	Host IP address of FTP server.
port	Port of FTP server, 0 for default.
username	Username of account on FTP server.
password	Password of account on FTP server.
mode	Mode of transfer: `FTP_MODE_UPLOAD` or `FTP_MODE_DOWNLOAD`. You may also OR in the value `FTP_MODE_PASSIVE` to use passive mode transfer (important if you are behind a firewall).
filename	Filename to get/put.
dir	Directory file is in, `NULL` for default directory.
buffer	Buffer to get/put the file from/to. Must be `NULL` if a data handler function will be used. See `ftp_data_handler()` for more details.
length	On upload, length of file; on download size of buffer. This parameter limits the transfer size to a maximum of 32767 bytes. For larger transfers, it will be necessary to use a data handler function.

RETURN VALUE

`0`: Success.
`1`: Failure.

LIBRARY

`FTP_CLIENT.LIB`

SEE ALSO

`ftp_client_setup_url`, `ftp_client_tick`, `ftp_data_handler`

ftp_client_setup_url

```
int ftp_client_setup_url( const char far * url, int mode,
   char * buffer, int length);
```

DESCRIPTION

Sets up a FTP transfer. It is called first, then `ftp_client_tick()` is called until it returns non-zero.

PARAMETERS

`url` URL to download.

`mode` Mode of transfer:

- `FTP_MODE_UPLOAD` -
- `FTP_MODE_DOWNLOAD` -

You may also OR in the value `FTP_MODE_PASSIVE` to use passive mode transfer (important if you are behind a firewall).

Use `FTP_MODE_GETLIST` if you just want to retrieve the file information given by “LIST filename.” If `FTP_MODE_GETLIST` is used with a NULL filename the, the results of "LIST" are given. These results may just be a list of file names, or they may contain more information with each file this is server-dependent.

`buffer` Buffer to get/put the file to/from. Must be NULL if a data handler function will be used. See `ftp_data_handler()` for more details.

`length` On upload, length of file; on download size of buffer. This parameter limits the transfer size to a maximum of 32767 bytes. For larger transfers, it will be necessary to use a data handler function.

RETURN VALUE

0: Success
`-NETERR_DNSERROR`: Couldn't resolve hostname from URL.
`-NETERR_HOST_REFUSED`: Couldn't connect to FTP server.
`-EINVAL`: Error parsing URL
`-E2BIG`: URL is too big to parse. Increase `URL_MAX_BUFFER_SIZE` to handle larger URLs.

LIBRARY

`FTP_CLIENT.LIB`

SEE ALSO

`ftp_client_setup`, `ftp_client_tick`, `ftp_data_handler`

ftp_client_tick

```
int ftp_client_tick( void );
```

DESCRIPTION

Tick function to run the FTP daemon. Must be called periodically. The return codes are not very specific. You can call `ftp_last_code()` to get the integer value of the last FTP message received from the server. See RFC959 for details. For example, code 530 means that the client was not logged in to the server.

RETURN VALUE

`FTPC_AGAIN`: still pending, call again.
`FTPC_OK`: success (file transfer complete).
`FTPC_ERROR`: failure (call `ftp_last_code()` for more details).
`FTPC_NOHOST`: failure (Couldn't connect to remote host).
`FTPC_NOBUF`: failure (no buffer or data handler).
`FTPC_TIMEOUT)`: warning (Timed out on close: data may or may not be OK).
`FTPC_DHERROR`: error (Data handler error in `FTPDH_END` operation).
`FTPC_CANCELLED`: FTP control socket was aborted (reset) by the server.

LIBRARY

`FTP_CLIENT.LIB`

SEE ALSO

`ftp_client_setup`, `ftp_client_filesize`, `ftp_client_xfer`, `ftp_last_code`

ftp_client_filesize

```
int ftp_client_filesize( void );
```

DESCRIPTION

Returns the byte count of data transferred. This function is deprecated in favor of `ftp_client_xfer()`, which returns a long value.

If the number of bytes transferred was over 32767, then this function returns 32767 which may be misleading.

RETURN VALUE

Size, in bytes.

LIBRARY

FTP_CLIENT.LIB

SEE ALSO

ftp_client_setup, ftp_data_handler, ftp_client_xfer

ftp_client_xfer

```
longword ftp_client_xfer( void );
```

DESCRIPTION

Returns the byte count of data transferred. Transfers of over 2^{32} bytes (about 4GB) are not reported correctly.

RETURN VALUE

Size, in bytes.

LIBRARY

FTP_CLIENT.LIB

SEE ALSO

ftp_client_setup, ftp_data_handler, ftp_client_filesize

ftp_data_handler

```
void ftp_data_handler( int (*dhnd)(), void *dhnd_data, word opts );
```

DESCRIPTION

Sets a data handler for further FTP data transfer(s). This handler is only used if the "buffer" parameter to `ftp_client_setup()` is passed as `NULL`.

The handler is a function which must be coded according to the following prototype:

```
int my_handler(char *data, int len, longword offset, int
flags, void *dhnd_data);
```

This function is called with `data` pointing to a data buffer, and `len` containing the length of that buffer. `offset` is the byte number relative to the first byte of the entire FTP stream. This is useful for data handler functions that do not wish to keep track of the current state of the data source. `dhnd_data` is the pointer that was passed to `ftp_data_handler()`.

`flags` contains an indicator of the current operation:

- `FTPDH_IN`: data is to be stored on this host (obtained from an FTP download).
- `FTPDH_OUT`: data is to be filled with the next data to upload to the FTP server.
- `FTPDH_END`: data and len are irrelevant: this marks the end of data, and gives the function an opportunity to e.g., close the file. Called after either in or out processing.
- `FTPDH_ABORT`: end of data; error encountered during FTP operation. Similar to END except the transfer did not complete. Can use this to e.g., delete a partially written file.

The return value from this function depends on the in/out flag. For `FTPDH_IN`, the function should return `len` if the data was processed successfully and download should continue; -1 if an error has occurred and the transfer should be aborted. For `FTPDH_OUT`, the function should return the actual number of bytes placed in the data buffer, or -1 to abort. If zero is returned, then the upload is terminated normally. For `FTPDH_END`, the return code should be zero for success or -1 for error. If an error is flagged, then this is used as the return code for `ftp_client_tick()`. For `FTPDH_ABORT`, the return code is ignored.

ftp_data_handler (cont'd)

PARAMETERS

dhnd	Pointer to data handler function, or NULL to remove the current data handler.
dhnd_data	A pointer which is passed to the data handler function. This may be used to point to any further data required by the data handler such as an open file descriptor.
opts	Options word (currently reserved, set to zero).

LIBRARY

FTP_CLIENT.LIB

SEE ALSO

ftp_client_setup

ftp_last_code

```
int ftp_last_code( void );
```

DESCRIPTION

Returns the most recent message code sent by the FTP server. RFC959 describes the codes in detail. This function is most useful for error diagnosis in the case that an FTP transfer failed.

RETURN VALUE

Error code; a number between 0 and 999. Codes less than 100 indicate that an internal error occurred e.g., the server was never contacted.

LIBRARY

FTP_CLIENT.LIB

SEE ALSO

ftp_client_setup, ftp_client_tick

7.3 Sample FTP Transfer

Program Name: Samples\tcpip\ftp\ftp_client.c

```
//#define MY_IP_ADDRESS "10.10.6.105"
//#define MY_NETMASK "255.255.255.0"

#define TCPCONFIG 1

#memmap xmem
#use "dcrtcp.lib"
#use "ftp_client.lib"

#define REMOTE_HOST "10.10.6.19"
#define REMOTE_PORT 0

main() {
  char buf[2048];
  int ret, i, j;

  printf("Calling sock_init()...\n");
  sock_init();

/*  Set up the ftp transfer. This is to the host defined above, with a normal
 *  anonymous/e-mail password login info. A get of the file bar is requested, which
 *  will be stored in buf.*/

   printf("Calling ftp_client_setup()...\n");

   if(ftp_client_setup(resolve(REMOTE_HOST), REMOTE_PORT,
      "anonymous", "anon@anon.com", FTP_MODE_DOWNLOAD,"bar",
       NULL, buf,sizeof(buf)))

   {
      printf("FTP setup failed.\n");
      exit(0);
   }
   printf("Looping on ftp_client_tick()...\n");
   while( 0 == (ret = ftp_client_tick()) )
      continue;

   if( 1 == ret ) {
      printf("FTP completed successfully.\n");

    // ftp_client_filesize() returns transfer size, since we asked for download.
      buf[ftp_client_filesize()] = '\0';

      printf("Data => '%s'\n", buf);
   }
  else {
      printf("FTP failed: status == %d\n",ret);
   }
}
```

8. FTP SERVER

This chapter documents the FTP server. The following information is included:

- configuration macros
- the default file handlers
- how to assign replacement file handlers
- what to do when there is a firewall
- API functions
- commands accepted by the server
- reply codes generated by the server
- sample code demonstrating a working FTP server

The library FTP_SERVER.LIB implements the File Transfer Protocol for the server side of a connection. FTP uses two TCP connections to transfer a file. The FTP server does a passive open on well-known port 21 and then listens for a client. This is the command connection. The server receives commands through this port and sends reply codes. The second TCP connection is for the actual data transfer.

Anonymous FTP is supported. Most FTP servers on the Internet use the identifier "anonymous." So since FTP clients expect it, this is the identifier that is recommended. But any string (with a maximum length of SAUTH_MAXNAME) may be used.

Dynamic C 8 includes some enhancements that basically let the FTP server act as a full FTP server, where you can create, read and delete files at will. To use these enhancements, the configuration macro FTP_USE_FS2_HANDLERS must be defined to enable FS2 support in the default file handler functions. The structure that holds the association of filenames and FS2 file locations is the server spec list—the global array defined in zserver.lib. It is stored in the User block and the API functions ftp_save_filenames() and ftp_load_filenames() are used for support of this.

> **NOTE:** For a demonstration of the enhanced FTP server, see the sample program, /SAMPLES/TCPIP/FTP/FTP_SERVER_FULL.C.

8.1 Configuration Macros

The configuration macros control various conditions of the server's operation. Read through them to understand the default conditions. Any changes to these macros may be made in the server application with #define statements before inclusion of FTPSERVER.LIB.

FTP_CMDPORT

This macro defaults to 21 which is the well-known FTP server port number. You can override this to cause the server to listen on a non-standard port number.

FTP_CREATE_MASK

This macro specifies the mask that is passed into the servermask parameter in sspec_addfsfile() calls when a new file is created. In particular, this defines which servers will be allowed to access this file. By default, it is defined to SERVER_FTP | SERVER_WRITABLE.

FTP_DTPTIMEOUT

The default is 16, the same as FTP_TIMEOUT. This applies to the data transfer port instead of the command port. The data transfer port is involved with get/store commands, as well as directory listings.

FTP_EXTENSIONS

The macro is not defined by default. Define it to allow the server to recognize the DELE, SIZE and MDTM commands. If this macro is defined, then the FTP handler structure (FTPhandlers) is augmented with pointers to mdtm and delete handlers.

FTP_INTERFACE

This macro defaults to IF_DEFAULT, i.e., the (single) default interface. Define to IF_ANY if FTP sessions can be accepted on any active interface, or a specific interface number (e.g., IF_ETH0) to allow sessions on that interface only. Note that you are currently limited to a single interface, or all interfaces. This macro is only relevant starting with Dynamic C version 7.30.

FTP_MAXLINE

The default is 256: the number of bytes of the working buffer in each server. This is also the maximum size of each network read/write. The default value of 256 is the minimum value that allows the server to function properly.

FTP_MAXSERVERS

The default is 1: the number of simultaneous connections the FTP server can support. Each server requires a significant amount of RAM (4096 bytes by default, though this can change through SOCK_BUF_SIZE or tcp_MaxBufSize (deprecated)).

FTP_NODEFAULTHANDLERS

This macro is undefined. Define it to eliminate the code for the default file handlers. You must then provide your own file handlers. This macro is no longer needed starting with Dynamic C version 7.20.

FTP_TIMEOUT

The default is 16: the number of seconds to wait for FTP commands from the remote host before terminating the connection. In a high-latency network this value may need to be increased to avoid premature closures.

FTP_USE_FS2_HANDLERS

Define this to enable the full use of FS2 in the default FTP handler functions. Defining this macro will automatically define `FTP_WRITABLE_FILES` to 1, as well.

FTP_USERBLOCK_OFFSET

This macro should be defined to a number that specifies the offset into the User block at which the list of filenames will be saved. This list correlates the filenames with the locations of the files in the filesystem (FS2). This macro defaults to 0. If the user is putting other information in the User block, this offset may need to be adjusted to prevent clobbering the other data.

FTP_WRITABLE_FILES

The defaults is 0. Define to 1 to provide support in `ftp_dflt_open()` for authenticating a user for write access before a file is opened. This also provides support in the file listing function, `ftp_dflt_list()`, to show the write permission for writable files.

> **NOTE:** The user will need to override both the write and close default file handlers to provide full support for writing a file.

SSPEC_NO_STATIC

This macro must be defined in any FTP server application compiled with Dynamic C 8.50 or later.

8.2 File Handlers

Default file handlers are provided. The defaults access the server spec list, which is set up using `sspec_addxmemfile()`, `sauth_adduser()` etc. The default file handlers are used when `NULL` is passed to the initialization function `ftp_init()`.

8.2.1 Replacing the Default Handlers

The `FTPhandlers` structure contains function pointers to the file handlers. This structure may be passed to `ftp_init()` to selectively replace the default file handlers. You may provide a `NULL` pointer for handlers that you do not wish to override. If you have defined `FTP_EXTENSIONS` then there are an additional two function pointers that should be initialized.

```
typedef struct {
   int (*open)();
   int (*read)();
   int (*write)();
   int (*close)();
   long (*getfilesize)();
   int (*dirlist)();
   int (*cd)();
   int (*pwd)();
#ifdef FTP_EXTENSIONS
   long (*mdtm)();
   int (*delete)();
#endif
} FTPhandlers;
```

Starting with Dynamic C 7.30, all FTP server instances share the same set of data handlers. Before this release, there was a separate copy of the handler pointers for each instance of the server. This change does not affect your existing application except to slightly reduce memory usage. This change does add flexibility because it gives any file handler the ability to call any other file handler. In particular, `ftp_dflt_list()` may now call `ftp_dflt_getfilesize()` to get the file's size

8.2.2 File Handlers Specification

Function descriptions for the default handlers are detailed in this section. Additional information is provided in these descriptions when the default handler does not cover the entire function specification.

The default file handlers are in `FTPSERVER.LIB`.

ftp_dflt_open

```
int ftp_dflt_open( char *name, int options, int uid, int cwd );
```

DESCRIPTION

Opens a file. If a file is successfully opened, the returned value is passed to subsequent handler routines to identify the particular file or resource, as the 'fd' parameter. If necessary, you can use this number to index an array of any other state information needed to communicate with the other handlers. The number returned should be unique with respect to all other open resource instances, so that your handler does not get confused if multiple FTP data transfers are active simultaneously.

Note that the specified file to open may be an absolute or relative path: if the handler supports the concept of directories, then it should handle the path name appropriately and not just assume that the file is in the current directory. If the filename is relative, then the `cwd` parameter indicates the current directory.

PARAMETERS

`name` The file to open.

`options` File access options:

`O_RDONLY` (marks file as read-only).
`O_WRONLY` (not currently supported by the default handler).
`O_RDWR` (not used since it's not supported by the FTP protocol).

`uid` The userid of the currently logged-in user.

`cwd` Current directory (not currently supported by the default handler).

RETURN VALUE

≥`0`: File descriptor of the opened file.
`FTP_ERR_NOTFOUND`: File not found.
`FTP_ERR_NOTAUTH`: Unauthorized user.
`FTP_ERR_BADMODE`: Requested option (2nd parameter) is not supported.
`FTP_ERR_UNAVAIL`: Resource temporarily unavailable.

In the first case, the returned value is passed to subsequent handler routines to identify the particular file or resource, as the 'fd' parameter. If necessary, you can use this number to index an array of any other state information needed to communicate with the other handlers. The number returned should be unique with respect to all other open resource instances, so that your handler does not get confused if multiple FTP data transfers are active simultaneously. Note that the given file name may be an absolute or relative path: if the handler supports the concept of directories, then it should handle the path name as appropriate and not just assume that the file is in the current directory. If the filename is "relative," then the `cwd` parameter indicates the current directory.

ftp_dflt_getfilesize

```
long ftp_dflt_getfilesize( int fd );
```

DESCRIPTION

Return the length of the specified file. This is called immediately after open for a read file. If the file is of a known constant length, the correct length should be returned. If the resource length is not known (perhaps it is generated on-the-fly) then return -1. For write operations, the maximum permissible length should be returned, or -1 if not known.

PARAMETERS

fd	The file descriptor returned when the file was opened.

RETURN VALUE

≥0: The size of the file in bytes.
-1: The length of the file is not known.

ftp_dflt_read

```
int ftp_dflt_read( int fd, char *buf, long offset, int len );
```

DESCRIPTION

Read file identified by `fd`. The file contents at the specified offset should be stored into `buf`, up to a maximum length of `len`. The return value should be the actual number of bytes transferred, which may be less than `len`. If the return value is zero, this indicates normal end-of-file. If the return value is negative, then the transfer is aborted. Each successive call to this handler will have an increasing offset. If the getfilesize handler returns a non-negative length, then the read handler will only be called for data up to that length — there is no need for such read handlers to check for EOF since the server will assume that only the specified amount of data is available.

The return value can also be greater than `len`. This is interpreted as "I have not put anything in `buf`. Call me back when you (the server) can accept at least `len` bytes of data." This is useful for read handlers that find it inconvenient to retrieve data from arbitrary offsets, for example a log reader that can only access whole log records. If the returned value is greater than the server can ever offer, then the server aborts the data transfer. The handler should never ask for more than `FTP_MAXLINE` bytes.

PARAMETERS

fd	The file descriptor returned when the file was opened.
buf	Pointer to the buffer to place the file contents.
offset	Offset in the file at which copying should begin.
len	The number of bytes to read.

RETURN VALUE

`0`: EOF.
`>0`: The number of bytes read into `buf`.
`-1`: Error, transfer aborted.

ftp_dflt_write

```
int ftp_dflt_write( int fd, char *buf, long offset, int len );
```

DESCRIPTION

The default write handler does nothing but return zero.

The specification states that the handler may write the file identified by `fd`. `buf` contains data of length `len`, which is to be written to the file at the given offset within the file. The return value must be equal to `len`, or a negative number if an error occurs (such as out of space).

The FTP server does not handle partial writes: the given data must be completely written or not at all. If the return code is less than `len`, an error is assumed to have occurred. Note that it is up to the handler to ensure that another FTP server is not accessing a file which is opened for write. The open call for the other server should return `FTP_ERR_UNAVAIL` if the current server is writing to a file.

PARAMETERS

fd	The file descriptor returned when the file was opened.
buf	Pointer to the data to be written.
offset	Offset in the file at which to start.
len	The number of bytes to write.

RETURN VALUE

$\geq$`0`: The number of bytes written. If this is less than `len`, an error occurred.
`-1`: Error.

ftp_dflt_close

```
int ftp_dflt_close( int fd );
```

DESCRIPTION

The default close handler does nothing but return zero.

The handler may close the specified file and free up any temporary resources associated with the transfer.

PARAMETERS

fd The file descriptor returned when the file was opened.

RETURN VALUE

0

ftp_dflt_list

```
int ftp_dflt_list( int item, char *line, int listing, int uid, int
   cwd );
```

DESCRIPTION

Returns the next file for the FTP server to list. The file name is formatted as a string.

PARAMETERS

item	Index number starting at zero for the first function call. Subsequent calls should be one plus the return value from the previous call.
line	Pointer to location to put the formatted string.
listing	Boolean variable to control string form: 0: print file name, permissions, date, etc. 1: print file name only.
uid	The currently logged-in user.
cwd	The current working directory.

RETURN VALUE

≥0: File descriptor for last file listed.
-1: Error.

ftp_dflt_cd

```
int ftp_dflt_cd( int cwd, char *dir, int uid );
```

DESCRIPTION

Change to new "directory." This is called when the client issues a CWD command. The FTP server itself has no concept of what a directory is —this is meaningful only to the handler.

PARAMETERS

cwd	Integer representing the current directory.
dir	String that indicates the new directory that will become the current directory. The interpretation of this string is entirely up to the handler. The `dir` string will be passed as ".." to move up one level.
uid	The currently logged-in user.

RETURN VALUE

`0`: No such directory exists.
`-1`: Root directory.
`>0`: Anything that is meaningful to the handler.

ftp_dflt_pwd

```
int ftp_dflt_pwd( int cwd, char *buf );
```

DESCRIPTION

Print the current directory, passed as `cwd`, as a string. The result is placed in `buf`, whose length may be assumed to be at least (`FTP_MAXLINE`-6). The return value is ignored.

PARAMETERS

cwd	The current directory.
buf	Pointer to buffer to put the string.

RETURN VALUE

The return value is ignored.

ftp_dflt_mdtm

```
unsigned long ftp_dflt_mdtm( int fd );
```

DESCRIPTION

This handler function is called when the server receives the FTP command MDTM. The return value of this handler function is the number of seconds that have passed since January 1, 1980. A return value of zero will cause the reply code 213 followed by a space and then the value 19800101000000 (yyyymmddhhmmss) to be sent by the server.

The FTP server assumes that this return value is in UTC (Coordinated Universal Time). If SEC_TIMER is running in local time, the handler should make the necessary time zone adjustment so that the return value is expressed in UTC.

The handler is only recognized if FTP_EXTENSIONS is defined.

PARAMETERS

fd File descriptor for the currently opened file.

RETURN VALUE

The number of seconds that have passed since January 1, 1980. The default handler always returns zero. The number of seconds will be converted to a date and time value of the form yyyymmddhhmmss.

ftp_dflt_delete

```
int ftp_dflt_delete( char *name, int uid, int cwd );
```

DESCRIPTION

The default handler does not support the delete command. It simply returns the error code for an unauthorized user.

The delete handler is only recognized by the server if FTP_EXTENSIONS is defined. It is called when the DELE command is received. The given file name (possibly relative to cwd) should be deleted.

PARAMETERS

name	Pointer to the name of a file.
uid	The currently logged-in user.
cwd	The current directory.

RETURN VALUE

0: File was successfully deleted .
FTP_ERR_NOTFOUND: File not found.
FTP_ERR_NOTAUTH: Unauthorized user.
FTP_ERR_BADMODE: Requested option (2nd parameter) is not supported.
FTP_ERR_UNAVAIL: Resource temporarily unavailable.

8.3 API Functions

The API functions described here, initialize and run the FTP server.

---

ftp_dflt_is_auth

```
int ftp_dflt_is_auth( int spec, int options, int uid );
```

DESCRIPTION

Determine amount of access to a file. If the FTP anonymous user has been set, then also checks that. "options" is how to access the file. Currently, this value is ignored. If the anonymous user ID has been set, then files it owns are globally accessible.

Returns whether the user can access it ("owner permission") or if access is because there is an anonymous user ("world permission").

NOTE: This routine only determines accessibility of a name, not whether the user can read and/or write the contents.

PARAMETERS

spec	Handle to SSPEC file (item).
options	How to access O_RDONLY, O_WRONLY or O_RDWR. Currently this value is ignored.
uid	The userID to access as.

RETURN VALUE

0: No access.
1: uid only access.
2: anonymous access (user "anonymous" has been set).

SEE ALSO

sspec_checkaccess

ftp_init

```
void ftp_init( FTPhandlers *handlers );
```

DESCRIPTION

Initializes the FTP server. You can optionally specify a set of handlers for controlling what the server presents to the client. This is done with function pointers in the FTPhandlers structure. All FTP server instances share the same list of handlers.

The FTPhandlers structure is defined as:

```
typedef struct {
   int (*open)(char *name, int options, int uid, int cwd);
   int (*read)(int fd, char *buf, long offset, int len);
   int (*write)(int fd, char *buf, long offset, int len);
   int (*close)(int fd);
   long (*getfilesize)(int fd);
  int (*dirlist)(int item, char *line, int listing, int uid, int
       cwd);
   int (*cd)(int cwd, char *dir, int uid);
   int (*pwd)(int cwd, char *buf);
   [long (*mdtm)(int fd);]
   [int  (*delete)(char *name, int uid, int cwd);]
} FTPhandlers;
```

If you always provide all your own handlers, then you can define FTP_NODEFAULTHANDLER to eliminate the code for the default handlers. The handlers must be written to the specification described in Section 8.2.2. To use a default handler, leave the field NULL. If you pass a NULL handlers pointer, then the all default handlers will be used.

The defaults access the server spec list which is set up using the zserver functions sspec_addxmemfile(), sauth_adduser() etc.

PARAMETERS

handlers NULL means use default internal file handlers. Otherwise, you must supply a struct of pointers to the various file handlers (open, read, write, close, get-filesize, list). To not override a particular handler, leave it NULL in the structure.

LIBRARY

FTP_SERVER.LIB

SEE ALSO

ftp_tick

ftp_load_filenames

```
int ftp_load_filenames( void );
```

DESCRIPTION

This function is used in conjunction with the FTP_USE_FS2_HANDLERS macro. It loads the data structure (i.e., the server spec list) that keeps track of the association of filenames to file locations in the file system. The information is loaded from the User block, from the offset given in FTP_USERBLOCK_OFFSET.

The function removes any entries from the server spec list that are not FS2 files.

RETURN VALUE

0: Success
-1: Failure (possibly due to the filenames having not yet been saved)

SEE ALSO

ftp_save_filenames

ftp_save_filenames

```
int ftp_save_filenames( void );
```

DESCRIPTION

This function is used in conjunction with the FTP_USE_FS2_HANDLERS macro. This function saves the data structure (i.e., the server spec list) that keeps track of the association of filenames to file locations in the file system. The information is saved to the User block, at the offset given in FTP_USERBLOCK_OFFSET.

RETURN VALUE

0: Success.
-1: Failure, the information could not be saved (due to a write error).

SEE ALSO

ftp_load_filenames

ftp_set_anonymous

```
int ftp_set_anonymous( int uid );
```

DESCRIPTION

Set the "anonymous" user ID. Resources belonging to this userID may be accessed by any user. A typical use of this function would be

```
ftp_set_anonymous (sauth_adduser("anonymous", "", SERVER_FTP));
```

which defines an "anonymous" login for the FTP server. This only applies to the FTP server. The username "anonymous" is recommended, since most FTP clients use this for hosts that have no account for the user.

PARAMETER

uid	The user ID to use as the anonymous user. This should have been defined using `sauth_adduser()`. Pass `-1` to set no anonymous user.

RETURN VALUE

Same as the `uid` parameter, except -1 if `uid` is invalid.

LIBRARY

FTP_SERVER.LIB

SEE ALSO

sauth_adduser

ftp_shutdown

```
void ftp_shutdown( int bGraceful );
```

DESCRIPTION

Close and cancel all FTP connections. If the server is connected to a client, forces the QUIT state. If the application has called `tcp_reserveport()`, then it must call `tcp_clearreserve()`. For a graceful shutdown, the application must call `tcp_tick()` a few more times.

After the FTP sockets close, the application must call `ftp_init()` to again start the server running.

PARAMETER

`bGraceful` (boolean) zero to immediately abort all open connections, or non-zero to simulate the QUIT command.

RETURN VALUE

None

LIBRARY

`FTP_SERVER.LIB`

SEE ALSO

`ftp_init`

ftp_tick

```
void ftp_tick( void );
```

DESCRIPTION

Once `ftp_init()` has been called, `ftp_tick()` must be called periodically to run the server. This function is non-blocking.

LIBRARY

FTP_SERVER.LIB

SEE ALSO

ftp_init

8.4 Sample FTP Server

This code demonstrates a simple FTP server, using the ftp library. The user "anonymous" may download the file "rabbitA.gif," but not "rabbitF.gif." The user "foo" (with password "bar") may download "rabbitF.gif," but also "rabbitA.gif," since files owned by the anonymous user are world-readable.

File Name: `Samples\tcpip\ftp_server.c`

```
#define TCPCONFIG 101
#define SSPEC_NO_STATIC                 //Required for DC 8.50 or later

#memmap xmem
#use "dcrtcp.lib"
#use "ftp_server.lib"

#ximport "samples/tcpip/http/pages/rabbit1.gif" rabbit1_gif

main(){
   int file, user;

   /* Set up the first file and user */
   file = sspec_addxmemfile("rabbitA.gif", rabbit1_gif,
       SERVER_FTP);

   user = sauth_adduser("anonymous", "", SERVER_FTP);
   ftp_set_anonymous(user);
   sspec_setuser(file, user);

   sspec_setuser(sspec_addxmemfile("test1", rabbit1_gif,
      SERVER_FTP), user);

   sspec_setuser(sspec_addxmemfile("test2", rabbit1_gif,
      SERVER_FTP), user);

   /* Set up the second file and user */

   file = sspec_addxmemfile("rabbitF.gif", rabbit1_gif,
      SERVER_FTP);

   user = sauth_adduser("foo", "bar", SERVER_FTP);
   sspec_setuser(file, user);

   sspec_setuser(sspec_addxmemfile("test3", rabbit1_gif,
      SERVER_FTP), user);

   sspec_setuser(sspec_addxmemfile("test4", rabbit1_gif,
      SERVER_FTP), user);

   sock_init();
   ftp_init(NULL);                    // use default handlers
   tcp_reserveport(FTP_CMDPORT);    // Port 21

   while(1) {
      ftp_tick();
   }
}
```

Each user may execute the "dir" or "ls" command to see a listing of the available files. The listing shows only the files that the logged-in user can access.

Notice the definition for TCP_CONFIG. When the value for this macro exceeds 100, a special configuration file is pulled in that will not be overridden by future updates of Dynamic C. In the file CUSTOM_CONFIG.LIB, you may specify any network configuration that suits your purposes. Please see /LIB/TCPIP/TCP_CONFIG.LIB for examples of setting up a library of configuration options.

8.5 Getting Through a Firewall

If a client is behind a firewall, it is incumbent upon the client to request that the server do a passive open on its data port instead of the normal active open. This is so that the client can then do an active open using the passively opened data port of the server, thus getting through the firewall.

Typically the server would not be behind a firewall.

8.6 FTP Server Commands

The following commands are recognized by the FTP server. The reply codes sent in response to these commands are detailed in Section 8.7 on page 377. They are noted here to associate them with the commands that may cause them to be sent.

Command	Description	Possible Reply Codes
ABOR	The current data transfer completes before the abort command is read by the server.	226
CDUP	A special case of CWD (Change Working Directory); the parent of the working directory is changed to be the working directory.	250, 431
CWD	Changes working directory.	250, 431
DELE	Delete the specified file.	250, 450, 550
LIST	Displays list of files requested by its argument in ls -l format. This gives extra information about the file.	150, 226, 425
MDTM	Shows the last modification time of the specified file.	213, 250, 450, 550
MODE	Confirms the mode of data transmission. Only stream mode is supported.	200, 504
NLST	Displays list of files requested by its argument, with names only. This allows an application to further process the files.	150, 226, 425
NOOP	Specifies no action except that the server send an OK reply. It does not affect any parameters or previously entered commands.	200
PASS	Password for the user name (sent in clear text). It is accepted only after USER returns code 331	230, 530

Command	Description	Possible Reply Codes
PASV	Requests a passive open on a port that is not the default data port. The server responds with the host and port address on which it is listening.	227, 452
PORT	Changes the data port from the default port to the port specified in the command's argument. The argument is the concatenation of a 32-bit internet host address and a 16-bit TCP port address.	200
PWD	Prints the working directory name.	257
QUIT	Closes the control connection. If a data transfer is in progress, the connection will not be closed until it has completed.	221
RETR	Transfers a copy of the file specified in the pathname argument from the server to the client.	150, 226, 425, 550
SIZE	Returns the size of the specified file.	213, 250, 450, 550
STOR	Stores a file from the client onto the server. The file will be overwritten if it already exists at the specified pathname, or it will be created if it does not exist.	150, 226, 250 425, 450, 452, 550
STRU	Confirms the supported structure of a file. Only file-structure is supported: a continuous stream of data bytes.	200, 504
SYST	Sends the string "RABBIT2000."	215
TYPE	Confirms the transfer type. The types IMAGE (binary), ASCII and Local with 8-bit bytes are all supported and are treated the same.	200, 504
USER	User name to use for authentication.	331, 530

8.7 Reply Codes to FTP Commands

The FTP server replies to all of the commands that it receives. The reply consists of a 3-digit number followed by a space and then a text string explaining the reply. All reply codes sent from the FTP server are listed here.

Reply Code	Reply Text
150	File status okay; about to open data connection.
200	Command okay.
202	Command not implemented, superfluous at this site.
211	System status, or system help reply.
213	File status
214	Help message. On how to use the server or the meaning of a particular non-standard command. This reply is useful only to the human user.
215	System type.
220	Service ready for new user.
221	Service closing connection.
226	Closing data connection. Requested file action successful (for example, file transfer or file abort).
227	Entering Passive Mode (h1,h2,h3,h4,p1,p2).
230	User logged in, proceed
250	Requested file action okay, completed.
257	"PATHNAME" created.
331	User name okay, need password.
425	Can't open data connection.
450	Requested file action not taken. File unavailable (e.g., file busy).
452	Requested action not taken. Insufficient storage space in system.
502	Command not implemented.
504	Command not implemented for that parameter.
530	Not logged in.
550	Requested action not taken. File unavailable (e.g., file not found, no access).

The text used for the reply codes, may be slightly different than what is shown here. It will be context specific.

9. TFTP CLIENT

TFTP.LIB implements the Trivial File Transfer Protocol (TFTP). This standard protocol (internet RFC783) is a lightweight protocol typically used to transfer bootstrap or configuration files from a server to a client host, such as a diskless workstation. TFTP allows data to be sent in either direction between client and server, using UDP as the underlying transport.

This library fully implements TFTP, but as a client only.

Compared with more capable protocols such as FTP, TFTP:

- has no security or authentication
- is not as fast because of the step-by-step protocol
- uses fewer machine resources.

Because of the lack of authentication, most TFTP servers restrict the set of accessible files to a small number of configuration files in a single directory. For uploading files, servers are usually configured to accept only certain file names that are writable by any user. If these restrictions are acceptable, TFTP has the advantage of requiring very little 'footprint' in the client host.

9.1 BOOTP/DHCP

In conjunction with DHCP/BOOTP and appropriate server configuration, TFTP is often used to download a kernel image to a diskless host. The target TCP/IP board does not currently support loading the BIOS in this way, since the BIOS and application program are written to non-volatile flash memory. However, the downloaded file does not have to be a binary executable - it can be any reasonably small file, such as an application configuration file. TFTP and DHCP/BOOTP can thus be used to administer the configuration of multiple targets from a central server.

Using TFTP with BOOTP/DHCP requires minimal additional effort for the programmer. Just #define the symbol DHCP_USE_TFTP to an integer representing the maximum allowable boot file size (1-65535). See the description of the variables _bootpsize, _bootpdata and _bootperror in volume 1 of the TCP/IP User's Manual for further details.

9.2 Data Structure for TFTP

This data structure is used to send and receive. The `tftp_state` structure, which is required for many of the API functions in `TFTP.LIB`, may be allocated either in root data memory or in extended memory. This structure is approximately 155 bytes long.

```
typedef struct tftp_state {
   byte state;            // Current state. LSB indicates read (0)
                          // or write(1). Other bits determine
                          // state within this (see below).
   long buf_addr;         // Physical address of buffer
   word buf_len;          // Length of buffer
   word buf_used;         // Amount Tx or Rx from/to buffer
   word next_blk;         // Next expected block #, or next to Tx
   word my_tid;           // UDP port number used by this host
   udp_Socket *sock;      // UDP socket to use
   longword rem_ip;       // IP address of remote host
   longword timeout;      // ms timer value for next timeout
   char retry;            // retransmit retry counter
   char flags;            // miscellaneous flags (see below).


// Following fields not used after initial request has been acknowledged.
   char mode;             // Translation mode (see below).
   char file[129];        // File name on remote host (TFTP server)
                          // - NULL terminated. This field will be
                          // overwritten with a NULL-term error message
                          // from the server if an error occurs.
};
```

The following macros are valid for tftp_state->mode.

```
#define TFTP_MODE_NETASCII 0  // ASCII text
#define TFTP_MODE_OCTET 1     // 8-bit binary
#define TFTP_MODE_MAIL 2      // Mail (remote file name is email address,
                              // e.g., user@host.blob.org)
```

9.3 API Functions

Any of the following functions will require approximately 600-800 bytes of free stack. The data buffer for the file to put or to get is always allocated in xram (see `xalloc()`).

TFTP Session

A session can be either a single download (get) or upload (put). The functions ending with 'x' are versions that use a data structure allocated in extended memory, for applications that are constrained in their use of root data memory.

tftp_init

```
int tftp_init( struct tftp_state *ts );
```

DESCRIPTION

This function prepares for a TFTP session and is called to complete initialization of the TFTP state structure. Before calling this function, some fields in the structure `tftp_state` must be set up as follows:

```
ts->state    = <0 for read, 1 for write>
ts->buf_addr = <physical address of xmem buffer>
ts->buf_len  = <length of physical buffer, 0-65535>
ts->my_tid    = <UDP port number. Set 0 for default>
ts->sock      = <address of UDP socket (udp_Socket *),or NULL to use
                 DHCP/BOOTP socket>
ts->rem_ip    = <IP address of TFTP server host, or zero to use default
                 BOOTP host>
ts->mode     = <one of the following constants:
                  TFTP_MODE_NETASCII (ASCII text)
                  TFTP_MODE_OCTET (8-bit binary)
                  TFTP_MODE_MAIL (Mail)>
strcpy(ts->file, <remote filename or mail address>)
```

Note that mail mode can only be used to write mail to the TFTP server, and the file name is the e-mail address of the recipient. The e-mail message must be ASCII-encoded and formatted with RFC822 headers. Sending e-mail via TFTP is deprecated. Use SMTP instead since TFTP servers may not implement mail.

PARAMETERS

ts Pointer to `tftp_state`.

RETURN VALUE

`0`: OK.
`-4`: Error, default socket in use.

LIBRARY

`TFTP.LIB`

tftp_initx

```
int tftp_initx( long ts_addr );
```

DESCRIPTION

This function is called to complete initialization of the TFTP state structure, where the structure is possibly stored somewhere other than in the root data space. This is a wrapper function for `tftp_init()`. See that function description for details.

PARAMETERS

ts_addr Physical address of TFTP state (struct `tftp_state`)

RETURN VALUE

`0`: OK
`-1`: Error, default socket in use

LIBRARY

`TFTP.LIB`

tftp_tick

```
int tftp_tick( struct tftp_state *ts );
```

DESCRIPTION

This function is called periodically in order to take the next step in a TFTP process. Appropriate use of this function allows single or multiple transfers to occur without blocking. For multiple concurrent transfers, there must be a unique `tftp_state` structure, and a unique UDP socket, for each transfer in progress. This function calls `sock_tick()`.

PARAMETERS

ts	Pointer to TFTP state. This must have been set up using `tftp_init()`, and must be passed to each call of `tftp_tick()` without alteration.

RETURN VALUE

`1`: OK, transfer not yet complete.
`0`: OK, transfer complete
`-1`: Error from remote side, transfer terminated. In this case, the ts_addr->file field will be overwritten with a `NULL`-terminated error message from the server.
`-2`: Error, could not contact remote host or lost contact.
`-3`: Timed out, transfer terminated.
`-4`: (not used)
`-5`: Transfer complete, but truncated -- buffer too small to receive the complete file.

LIBRARY

`TFTP.LIB`

tftp_tickx

```
int tftp_tickx( long ts_addr );
```

DESCRIPTION

This function is a wrapper for calling `tftp_tick()`, where the structure is possibly stored somewhere other than in the root data space. See that function description for details.

PARAMETERS

`ts_addr` Physical address of TFTP state (struct `tftp_state`).

RETURN VALUE

`1`: OK, transfer not yet complete.
`0`: OK, transfer complete
`-1`: Error from remote side, transfer terminated. In this case, the ts_addr->file field will be overwritten with a `NULL`-terminated error message from the server.
`-2`: Error, could not contact remote host or lost contact.
`-3`: Timed out, transfer terminated.
`-4`: (not used)
`-5`: Transfer complete, but truncated -- buffer too small to receive the complete file.

LIBRARY

`TFTP.LIB`

tftp_exec

```
int tftp_exec( char put, long buf_addr, word *len, int mode, char
   *host, char *hostfile, udp_Socket *sock );
```

DESCRIPTION

Prepare and execute a complete TFTP session, blocking until complete.This function is a wrapper for `tftp_init()` and `tftp_tick()`. It does not return until the complete file is transferred or an error occurs. Note that approximately 750 bytes of free stack will be required by this function.

PARAMETERS

put	`0`: get file from remote host; `1`: put file to host.
buf_addr	Physical address of data buffer.
len	Length of data buffer. This is both an input and a return parameter. It should be initialized to the buffer length. On return, it will be set to the actual length received (for a get), or unchanged (for a put).
mode	Data representation: 0=NETASCII, 1=OCTET (binary), 2=MAIL.
host	Remote host name, or `NULL` to use default BOOTP host.
hostfile	Name of file on remote host, or e-mail address for mail.
sock	UDP socket to use, or `NULL` to re-use BOOTP socket if available.

RETURN VALUE

`0`: OK, transfer complete.
`-1`: Error from remote side, transfer terminated. In this case, `ts_addr->file` will be overwritten with a `NULL`-terminated error message from the server.
`-2`: Error, could not contact remote host or lost contact.
`-3`: Timed out, transfer terminated
`-4`: sock parameter was `NULL`
`-7`: host was NULL

LIBRARY

`TFTP.LIB`

10. SMTP MAIL CLIENT

SMTP (Simple Mail Transfer Protocol) is one of the most common ways of sending e-mail. SMTP is a simple text conversation across a TCP/IP connection. The SMTP server usually resides on TCP port 25 waiting for clients to connect. (Define SMTP_PORT to override the default port number.)

Sending mail with the Dynamic C SMTP client library is a simple process, demonstrated in the sample program shown in Section 10.3. Dynamic C 9 introduced SMTP authentication, described below in Section 10.2.

10.1 Sample Conversation

The following is a typical listing of mail from the controller (me@somewhere.com) to someone@somewhereelse.com. The mail server that the controller is talking to is mail.somehost.com. The lines that begin with a numeric value are coming from the mail server. The other lines were sent by the controller. More information on the exact specification of SMTP and the meanings of the commands and responses can be found in RFC821 at www.ietf.org.

```
220 mail.somehost.com ESMTP Service (WorldMail 1.3.122)
ready
HELO 10.10.6.100

250 mail.somewhere.com
MAIL FROM: <me@somewhere.com>

250 MAIL FROM:<me@somewhere.com> OK
RCPT TO: <someone@somewhereelse.com>

250 RCPT TO:<someone@somewhereelse.com> OK
DATA

354 Start mail input; end with <CRLF>.<CRLF>
From: <me@somewhere.com>
To: <someone@somewhereelse.com>
Subject: test mail

test mail
.

250 Mail accepted
QUIT

221 mail.somehost.com QUIT
```

You can see a listing of the conversation between your controller and the mail server by defining the SMTP_DEBUG macro at the top of your program. Note that there must be a blank line after the line "Subject: test mail."

10.2 SMTP Authentication

In most situations, Internet access is provided by an Internet Service Provider (ISP). Usually the ISP runs an email server that will accept emails without authentication from customers that are within their network. Users outside of their network are not allowed to send email through their servers because the mail server would quickly become a gateway for spam. With more people on the go with laptops, SMTP authentication allows them to send email through a trusted server without being directly on the network.

An informative tutorial on SMTP authentication is available at:
www.fehcom.de/qmail/smtpauth.html

Default behavior prior to Dynamic C 9.21 was for the login to fail if authentication failed. With Dynamic C 9.21 the SMTP library will fall back on unauthenticated login if authentication fails. To restore the old behavior when using Dynamic C 9.21, define the macro SMTP_AUTH_FAIL_IF_NO_AUTH.

Three methods of authentication are recognized by the implementation of an SMTP client.

AUTH PLAIN

The client sends "AUTH PLAIN <token>" where <token> is the Base64-encoded string "username\0username\0password" that will look something like:

```
AUTH PLAIN dGVzdAB0ZXN0AHRlc3RwYXNz
```

The server responds with a message indicating whether authentication was successful.

AUTH LOGIN

Client sends "AUTH LOGIN" command; server responds with "334 VXNlcm5hbWU6" (Base64-encoded "Username:"); client responds with its Base64-encoded username; server responds with "334 UGFzc3dvcmQ6"; client responds with its Base64-encoded password. At this point, the server should respond with a message indicating whether authentication was successful. This method is only slightly more complex than AUTH PLAIN.

AUTH CRAM-MD5

Client sends "AUTH CRAM-MD5"; server responds with "334 <challenge>" where <challenge> is a unique Base64-encoded challenge string (for example, "<4994.1088035610@rabbit.com>").

The client generates a digest using the following MD5 hashing algorithm (where password is null-padded to a length of 64 bytes, ipad is 0x36 repeated 64 times and opad is 0x5C repeated 64 times):

```
digest = MD5((password XOR opad), MD5((password XOR ipad),
challenge))
```

The client responds with the string "<username> <response>" Base64-encoded; <username> is in plaintext, and <response> is the 16-byte digest in hex form.This method is the most secure, since someone sniffing the connection would be unable to determine the cleartext password used to authenticate.

10.3 Sample Sending of an E-mail

This program, `smtp.c`, sends an e-mail. To have the client query the server for authentication, define the macro `USE_SMTP_AUTH` and call `smtp_setauth()` before calling `smtp_sendmail()` (or `smtp_sendmailxmem()`). If the mail server does not support authentication, either do not define `USE_SMTP_AUTH` or pass empty strings ("") as the parameters to `smtp_setauth()`.

Program Name: Samples\tcpip\smtp\smtp.c

```
#define TCPCONFIG 1              // pick network configuration

#define FROM "myaddress@mydomain.com"
#define TO "myaddress@mydomain.com"
#define SUBJECT "You've got mail!"
#define BODY "Visit the Rabbit web site.\r\n"

/* SMTP_SERVER identifies the mail server. This can be name or IP address. */
#define SMTP_SERVER "mymailserver.mydomain.com"

#define USE_SMTP_AUTH

#memmap xmem
#use dcrtcp.lib
#use smtp.lib

main() {
   sock_init();

   while (ifpending(IF_DEFAULT) == IF_COMING_UP) {
      tcp_tick(NULL);
   }

#ifdef USE_SMTP_AUTH
   smtp_setauth ("myusername", "mypassword");
#endif

   smtp_sendmail(TO, FROM, SUBJECT, BODY);

   while(smtp_mailtick()==SMTP_PENDING)
      continue;

   if(smtp_status()==SMTP_SUCCESS)
      printf("Message sent\n");

   else
      printf("Error sending message\n");
}
```

10.4 Configuration Macros

The SMTP client is configured by using compiler macros.

SMTP_AUTH_FAIL_IF_NO_AUTH

Defaults to undefined. This macro was introduced in Dynamic C 9.21. If it is defined, the login will fail if authentication fails. Otherwise, the library will fall back on an unauthenticated login if authentication fails. Prior to Dynamic C 9.21, the login failed if authentication failed, so the macro is restoring that behavior.

SMTP_DEBUG

This macro tells the SMTP code to log events to the STDIO window in Dynamic C. This provides a convenient way of troubleshooting an e-mail problem.

SMTP_DOMAIN

This macro defines the text to be sent with the HELO client command. Many mail servers ignore the information supplied with the HELO, but some e-mail servers require the fully qualified name in this field (i.e., somemachine.somedomain.com). If you have problems with e-mail being rejected by the server, turn on SMTP_DEBUG. If it is giving an error message after the HELO line, talk to the administer of the machine for the appropriate value to place in SMTP_DOMAIN. If you do not define this macro, it will default to MY_IP_ADDRESS.

```
#define SMTP_DOMAIN "somemachine.somedomain.com"
```

SMTP_MAX_DATALEN

Defaults to 256. Maximum buffer size for server responses and short client requests.

SMTP_MAX_PASSWORDLEN

Defaults to 16. Maximum length of the password used in authentication.

SMTP_MAX_USERNAMELEN

Defaults to 64. Maximum length of the user name used in authentication.

SMTP_MAX_SERVERLEN

Defaults to MAX_STRING, which defaults to 50. Maximum length of mail server name.

SMTP_SERVER

This macro defines the mail server that will relay the controller's mail. This server must be configured to relay mail for your controller. You can either place a fully qualified domain name or an IP address in this field.

```
#define SMTP_SERVER "mail.mydomain.com"
#define SMTP_SERVER "10.10.6.19"
```

SMTP_TIMEOUT

This macro tells the SMTP code how long in seconds to try to send the e-mail before timing out. It defaults to 20 seconds.

```
#define SMTP_TIMEOUT 10
```

USE_SMTP_AUTH

Define this macro to enable SMTP authentication.

10.5 API Functions

The user-callable functions described in this section are found in the Dynamic C library `Lib\...\tcpip\smtp.lib`.

---

smtp_data_handler

```
void smtp_data_handler( int (*dhnd)(), void * dhnd_data, word opts );
```

DESCRIPTION

Sets a data handler for generating mail message content. This function should be called after calling `smtp_sendmail()` etc. It overrides any message parameter set by the `smtp_sendmail()` call, since the message is generated dynamically by the callback function.

Note: you can use the same data handler as used for the FTP library (see the `ftp_data_handler()` description). The flags values are numerically equivalent to those of the same meaning for `ftp_data_handler()`. The SMTP data handler is only used to generate data, not receive it.

The handler is a function that must be coded according to the following prototype:

```
int my_handler(char *data, int len, longword offset,
               int flags, void *dhnd_data);
```

The data handler function must be called with the following parameters:

data Pointer to a data buffer

len The length of the above data buffer. This parameter is set to `SMTP_MAX_DATALEN` (256) by default. You can override that macro to allow larger "chunks."

offset The byte number relative to the first byte of the entire message stream. This is useful for data handler functions that do not wish to keep track of the current state of the data source.

flags Contains an indicator of the current operation: `SMTPDH_OUT`: data is to be filled with the next data to send to the mail server. The maximum allowable chunk of data is specified by 'len'. The data must not contain the sequence <CRLF>.<CRLF> since that will confuse the process. `SMTPDH_ABORT`: end of data; error encountered during SMTP operation. The mail was probably not delivered.

dhnd_data The pointer that was passed to `ftp_data_handler()`.

PARAMETERS

dhnd	Pointer to data handler function, or NULL to remove the current data handler.
dhnd_data	A pointer that is passed to the data handler function. This may be used to point to any further data required by the data handler such as an open file descriptor.
opts	Options word (currently reserved, set to zero).

RETURN VALUE

The return value from this function should be the actual number of bytes placed in the data buffer, or -1 to abort. If 0 is returned, then this is considered to be the end of data. You can write up to and including "len" bytes into the buffer, but at least one byte must be written otherwise it is assumed that no more data is following.

For SMTPDH_ABORT, the return code is ignored.

SEE ALSO

smtp_sendmail, smtp_sendmailxmem, smtp_mailtick

EXAMPLE

The program Samples/tcpip/smtp/smtp_dh.c makes use of this function.

smtp_mailtick

```
int smtp_mailtick( void );
```

DESCRIPTION

Repetitively call this function until e-mail is completely sent.

RETURN VALUE

SMTP_SUCCESS - e-mail sent.
SMTP_PENDING - e-mail not sent yet call smtp_mailtick again.
SMTP_TIME - e-mail not sent within SMTP_TIMEOUT seconds.
SMTP_UNEXPECTED - received an invalid response from SMTP server.
SMTP_DNSERROR - cannot resolve server name
SMTP_ABORTED - transaction aborted (by data handler)

If using SMTP AUTH, the following values are also possible:

SMTP_AUTH_UNAVAILABLE - unable to attempt authentication|
SMTP_AUTH_FAILED - attempts to authenticate failed

LIBRARY

SMTP.LIB

SEE ALSO

smtp_sendmail, smtp_status

smtp_sendmail

```
void smtp_sendmail( char *to, char *from, char *subject, char
   *message );
```

DESCRIPTION

Start an e-mail being sent. This function is intended to be used for short messages that are entirely constructed prior to being sent.

If you have previously installed a data handler via `smtp_data_handler()`, then you must call `smtp_data_handler()` with a NULL data handler, otherwise this message will not get sent.

> **NOTE:** The strings pointed to by the parameters must not be changed until the entire process is completed. Also, if the first character of any line of the message is a period (.), then this character will be deleted as part of normal mail processing. Thus, to actually send a line starting with '.', you must start the line with '..' i.e. double up an initial period.

PARAMETERS

to	String containing the e-mail address of the destination. Maximum of 192 characters. Currently, only one recipient is supported.
from	String containing the e-mail address of the source. Maximum of 192 characters for a return address. If no return should be sent by receiver, then pass an empty string ("").
subject	String containing the subject of the message. This may be NULL in which case no subject line will be sent. This string may also contain embedded \r\n sequences so that additional mail header lines may be inserted. The length of this string is unlimited.
message	String containing the message. (This string must *not* contain the byte sequence "\r\n.\r\n" (CRLF.CRLF), as this is used to mark the end of the e-mail, and will be appended to the e-mail automatically.) This message must be null terminated, and is only allowed to contain 7-bit characters. You can pass NULL if a data handler is to be used to generate the message.

RETURN VALUE

None.

SEE ALSO

`smtp_mailtick, smtp_status, smtp_sendmailxmem`

smtp_sendmailxmem

```
void smtp_sendmailxmem( char *to, char *from, char *subject, long
   message, long messagelen );
```

DESCRIPTION

Start an e-mail being sent. This is intended for moderately long, fixed messages that are stored in extended memory (e.g., via #ximport'ed file).

See `smtp_sendmail()` for more details.

PARAMETERS

to	String containing the e-mail address of the destination.
from	String containing the e-mail address of the source.
subject	String containing the subject of the message.
message	Physical address in xmem containing the message. (The message must NOT contain the byte sequence "\r\n.\r\n" (CRLF.CRLF), as this is used to mark the end of the e-mail, and will be appended to the e-mail automatically.)
messagelen	Length of the message in xmem.

RETURN VALUE

None

LIBRARY

SMTP.LIB

SEE ALSO

smtp_mailtick, smtp_status, smtp_sendmail

smtp_setauth

```
int smtp_setauth( char * username, char * password );
```

DESCRIPTION

Sets the username and password to use for SMTP AUTH (Authentication). You must #define USE_SMTP_AUTH in your program if you want to use SMTP AUTH on your outbound connections. To disable SMTP authentication, set both username and password to "" (empty strings).

PARAMETERS

username This is copied into the SMTP state structure. Note that some SMTP servers require a full email address while others just want a username.

password This is copied into the SMTP state structure.

RETURN VALUE

SMTP_OK: server name was set successfully
SMTP_USERNAMETOOLONG: the username was too long
SMTP_PASSWORDTOOLONG: the username was too long

SEE ALSO

smtp_sendmail, smtp_mailtick

smtp_setserver

```
int smtp_setserver( char* server );
```

DESCRIPTION

Sets the SMTP server. This value overrides SMTP_SERVER and the results of any previous call to smtp_setserver_ip().

PARAMETER

server Server name string. This is copied into the SMTP state structure. This name is not resolved to an IP address until you start calling smtp_mailtick().

RETURN VALUE

SMTP_OK: Server name was set successfully
SMTP_NAMETOOLONG: The server name was too long

SEE ALSO

smtp_sendmail, smtp_setserver_ip, smtp_mailtick

smtp_setserver_ip

```
int smtp_setserver_ip( longword server );
```

DESCRIPTION

Sets the SMTP server. This value overrides the value set by `smtp_setserver()`, and is used when the IP address of the mail server is known.

PARAMETER

`server` Server IP address.

RETURN VALUE

`SMTP_OK`: server IP was set successfully

SEE ALSO

`smtp_sendmail, smtp_setserver, smtp_mailtick`

smtp_status

```
int smtp_status( void );
```

DESCRIPTION

Return the status of the last e-mail processed.

RETURN VALUE

`SMTP_SUCCESS` - e-mail sent.
`SMTP_PENDING` - e-mail not sent yet call smtp_mailtick again.
`SMTP_TIME` - e-mail not sent within `SMTP_TIMEOUT` seconds.
`SMTP_UNEXPECTED` - received an invalid response from SMTP server.

LIBRARY

`SMTP.LIB`

11. POP3 CLIENT

Post Office Protocol version 3 (POP3) is probably the most common way of retrieving e-mail from a remote server. Most e-mail programs, such as Eudora, MS-Outlook, and Netscape's e-mail client, use POP3. The protocol is a fairly simple text-based chat across a TCP socket, normally using TCP port 110.

There are two ways of using `POP3.LIB`. The first method provides a raw dump of the incoming e-mail. This includes all of the header information that is sent with the e-mail, which, while sometimes useful, may be more information than is needed. The second method provides a parsed version of the e-mail, with the sender, recipient, subject line, and body text separated out.

In both methods, each line of e-mail has CRLF stripped from it and '\0' appended to it.

11.1 Configuration

The POP3 client can be configured through the following macros:

`POP_BUFFER_SIZE`

This will set the buffer size for `POP_PARSE_EXTRA` in bytes. These are the buffers that hold the sender, recipient and subject of the e-mail. `POP_BUFFER_SIZE` defaults to 64 bytes.

`POP_DEBUG`

This will turn on debug information. It will show the actual conversation between the device and the remote mail server, as well as other useful information.

`POP_NODELETE`

This will stop the POP3 library from removing messages from the remote server as they are read. By default, the messages are deleted to save storage space on the remote mail server.

`POP_PARSE_EXTRA`

This will enable the second mode, creating a parsed version of the e-mail as mentioned above. The POP3 library parses the incoming mail more fully to provide the Sender, Recipient, Subject, and Body fields as separate items to the call-back function.

11.2 Steps to Receive E-mail.

1. `pop3_init()` is called to provide the POP3 library with a call-back function. This call-back will be used to provide you the incoming data. This function is usually called once.
2. `pop3_getmail()` is called to start the e-mail being received, and to provide the library with e-mail account information.
3. `pop3_tick()` is called as long as it returns `POP_PENDING`, to actually run the library. The library will call the function you provided `pop3_init()` several times to give you the e-mail.

11.3 Call-Back Function

There are two types of call-back functions, which are described here.

11.3.1 Normal call-back

When not using `POP_PARSE_EXTRA`, you need to provide a function with the following prototype:

```
int storemail(int number, char *buf, int size);
```

The parameter `number` is the number of the e-mail being transferred, usually 1 for the first, 2 for the second, but not necessarily. The numbers are only guaranteed to be unique between all e-mails transferred.

The `buf` parameter is the text buffer containing one line of the incoming e-mail. This must be copied out immediately, as the buffer will be different when the next line comes in, and your call-back is called again. `size` is the number of bytes in `buf`.

The sample program `Samples\tcpip\pop3\ pop.c` provides an example of this style of call-back.

11.3.2 POP_PARSE_EXTRA call-back

If `POP_PARSE_EXTRA` is defined, you need to provide a call-back function with the following prototype:

```
int storemail(int number, char *to, char *from, char *subject, char
*body, int size);
```

`number`, `body`, and `size` are the same as before.

`to` has the e-mail address of who this e-mail was sent to.

`from` has the e-mail address of who sent this e-mail.

`subject` has the subject line of the e-mail.

These new fields should be used only the first time your call-back is called with a new `number` field. In subsequent calls, these fields are not guaranteed to have accurate information.

See `parse_extra.c` in Section 11.5 for an example of this type of call-back.

11.4 API Functions

pop3_init

```
int pop3_init( int (*storemail)() );
```

DESCRIPTION

This function must be called before any other POP3 function is called. It will set the call-back function where the incoming e-mail will be passed to. This probably should only be called once.

PARAMETERS

storemail A function pointer to the call-back function.

RETURN VALUE

0: Success.
1: Failure.

LIBRARY

POP3.LIB

pop3_getmail

```
int pop3_getmail( char *username, char *password, long server );
```

DESCRIPTION

This function will initiate receiving e-mail (a POP3 request to a remote e-mail server).

IMPORTANT NOTE - the buffers for `username` and `password` must NOT change until `pop3_tick()` returns something besides `POP_PENDING`. These values are not saved internally, and depend on the buffers not changing.

PARAMETERS

username The `username` of the account to access.

password The `password` of the account to access.

server The IP address of the server to connect to, as returned from `resolve()`.

RETURN VALUE

`0`: Success.
`1`: Failure.

LIBRARY

`POP3.LIB`

pop3_tick

```
int pop3_tick( void );
```

DESCRIPTION

A standard tick function, to run the daemon. Continue to call it as long as it returns `POP_PENDING`.

RETURN VALUE

`POP_PENDING`: Transfer is not done; call `pop3_tick` again.
`POP_SUCCESS`: All e-mails were received successfully.
`POP_ERROR`: Unknown error occurred.
`POP_TIME`: Session timed-out. Try again, or use `POP_TIMEOUT` to increase the time-out length.

LIBRARY

`POP3.LIB`

11.5 Sample Receiving of E-mail

This program connects to a POP3 server and downloads e-mail from it.

Program Name: Samples\tcpip\pop3\parse_extra.c

```
#define TCPCONFIG 1
#define POP_HOST "mail.domain.com" // Name of your POP3 server
#define POP_USER "myname"          // Username for POP3 account
#define POP_PASS "secret"          // Password for POP3 account
#define POP_PARSE_EXTRA
#memmap xmem
#use "dcrtcp.lib"
#use "pop3.lib"
int n;
int storemsg(int num, char *to, char *from, char *subject,
char *body, int len){
   #GLOBAL_INIT{n = -1;}
   if(n != num) {
      n = num;
      printf("RECEIVING MESSAGE <%d>\n", n);
      printf("\tFrom: %s\n", from);
      printf("\tTo: %s\n", to);
      printf("\tSubject: %s\n", subject);
   }
   printf("MSG_DATA> '%s'\n", body);
   return 0;
}
main(){
   static long address;
   static int ret;
   sock_init();
   pop3_init(storemsg);                          //set up call-back
   printf("Resolving name...\n");
   address = resolve(POP_HOST);
   printf("Calling pop3_getmail()...\n");
   pop3_getmail(POP_USER, POP_PASS, address);  // Request to
server
   printf("Entering pop3_tick()...\n");
   while((ret = pop3_tick()) == POP_PENDING)
      continue;
   if(ret == POP_SUCCESS)
      printf("POP was successful!\n");
   if(ret == POP_TIME)
      printf("POP timed out!\n");
   if(ret == POP_ERROR)
      printf("POP returned a general error!\n");
   printf("All done!\n");
}
```

11.5.1 Sample Conversation

The following is an example POP3 session from the specification in RFC1939. For more information see:

www.rfc-editor.org/rfc/std/std53.txt

In the following example, lines starting with "S:" are from the server, and lines starting with "C:" are from the client.

```
S: <wait for connection on TCP port 110>
C: <open connection>
S: +OK POP3 server ready <1896.697170952@dbc.mtview.ca.us>
C: APOP mrose c4c9334bac560ecc979e58001b3e22fb
S: +OK mrose's maildrop has 2 messages (320 octets)
C: STAT
S: +OK 2 320
C: LIST
S: +OK 2 messages (320 octets)
S: 1 120
S: 2 200
S: .
C: RETR 1
S: +OK 120 octets
S: <the POP3 server sends message 1>
S: .
C: DELE 1
S: +OK message 1 deleted
C: RETR 2
S: +OK 200 octets
S: <the POP3 server sends message 2>
S: .
C: DELE 2
S: +OK message 2 deleted
C: QUIT
S: +OK dewey POP3 server signing off (maildrop empty)
C: <close connection>
S: <wait for next connection>
```

For debugging purposes, you can observe this conversation by defining `POP_DEBUG` at the top of your program.

12. SNMP

Simple Network Management Protocol (SNMP) is a popular network management tool. Traditionally, SNMP was designed and used to gather statistics for network management and capacity planning. For example, the number of packets sent and received on each network interface could be obtained. But because of its simplicity, SNMP use has expanded into areas of interest to embedded systems. It is now used for many vendor-specific management functions, e.g., showing a thermostat temperature, machine tool RPM or whether the front door was left open.

After reading this document and studying and running the provided demo program, you will be able to:

- define a MIB
- code and run an SNMP agent

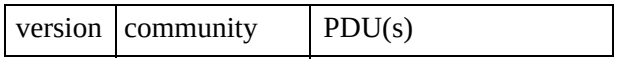
The SNMP library, **SNMP.LIB**, implements version 1 of the SNMP protocol. But before we get into the implementation details, let's discuss SNMP from a conceptual level.

12.1 SNMP Overview

The SNMP model is client/server based. The SNMP agent is the server part, passively listening for communication from an SNMP manager—the client side of things. The SNMP manager, which runs on a Network Management Station (NMS), may make one of three possible requests: Get, GetNext or Set.

These requests are made via SNMP messages. SNMP allows managers and agents to exchange SNMP messages for the purpose of sharing information about managed objects. The messages are embedded in UDP datagrams for transmission. Their format is shown in Figure 12.12

Figure 12.12 SNMPv1 Message Format



version: version of SNMP being used, 1, 2 or 3.

community: used for trivial authentication.

PDU: stands for Protocol Data Unit, another name for a packet. These are generated and parsed internally. A PDU contains the type of message (get, getnext, set, response or trap) and a list of affected objects, called the variable binding. The variable binding is a list of name and value pairs either to get or to set.

12.1.1 Managed Objects

A managed object can be a device or a device characteristic: e.g., the value of a temperature gauge, the setting of a switch or any other logical or physical component of an embedded system. Instances of managed objects are kept in a Management Information Base (MIB). Each managed object has a unique name, which is known as its object identifier, or OID.

The rules for naming and defining managed objects are specified by Structured Management Information (SMI). This formal definition is compiled by the SNMP manager, allowing the manager to understand the structure of the MIB on the managed device. In Section 12.2 we will look at a demo program that will clearly illustrate the correspondence between the SMI defined MIB used by the SNMP manager and the MIB used by the SNMP agent.

12.1.2 SNMP Agent

An agent listens on UDP port 161 (**SNMP_PORT**) of its device for SNMP messages from a manager. Programmatically, the SNMP agent is fairly simple. Any complexity lies in the organization of the managed objects that the agent accesses.

The agent sends messages back to the manager in response to the get, get-next and set requests that it receives. For a get-next request, the agent returns the next OID in lexicographic order from the OID specified in the variable binding of the PDU. Both get and set requests are atomic. They may request acting on multiple managed objects, but the agent will only process the request if all of the managed objects are accessible.

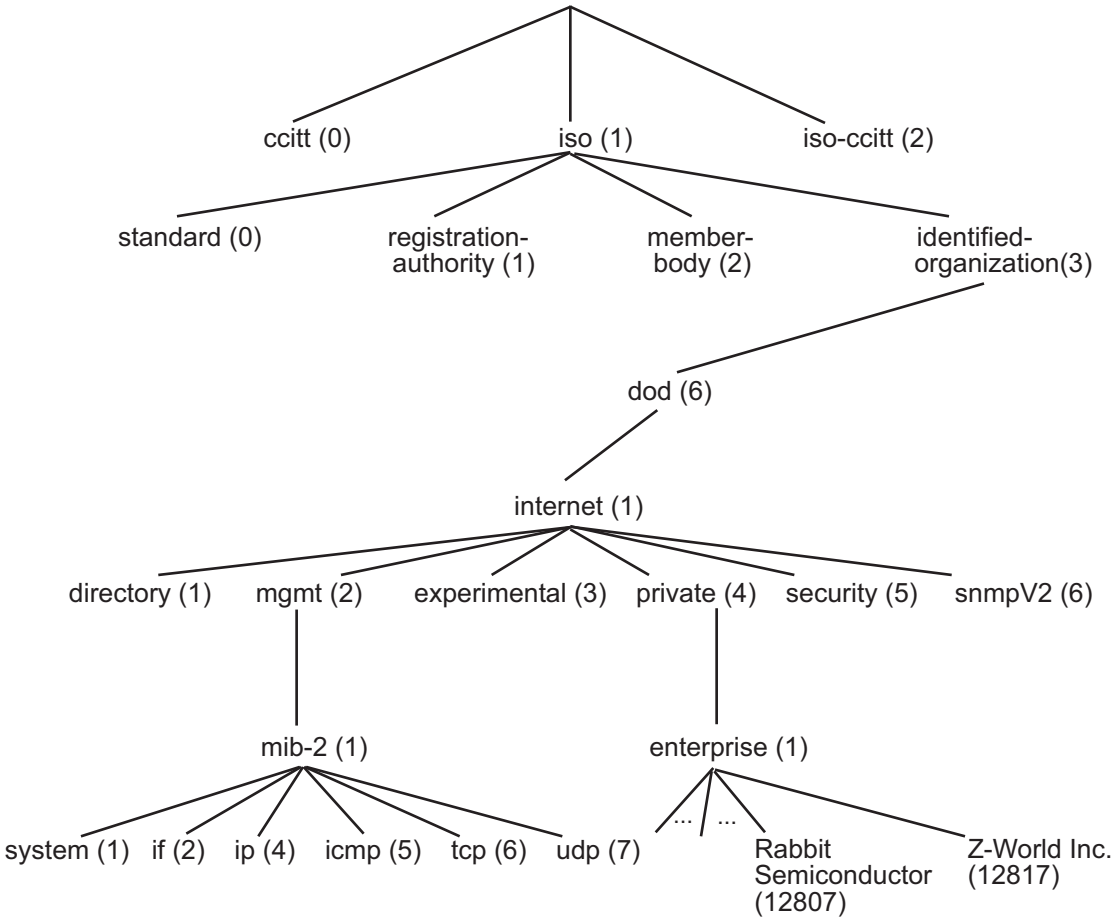
Agents may also send unsolicited messages to a manager. These unsolicited messages are called traps. They may be used to signal the manager that something has gone wrong, (perhaps a variable has gone out of range or a light bulb has burned out) or they may be used for informational purposes.

12.1.3 MIBs

A MIB is a structured arrangement of managed objects — a database that maps OIDs to actual variable instances. The MIB may be used as a stand-alone hierarchical database without SNMP if desired.

Instances of managed objects are always leaf nodes. And only leaf nodes may be accessed using SNMP.

Figure 12.13 MIB Tree Diagram from Root Node Down to MIB-II and Enterprise Subtrees



12.1.3.1 MIB-II Subtree

MIB-II has nine groups, six of which are usually of interest: *system*, *if*, *ip*, *icmp*, *udp* and *tcp*. Access to lots of useful information has been standardized by MIB-II. For example, in the system group are managed objects named sysContact, sysName and sysLocation. If set, they give the name and phone number of the person responsible for the device, the device name and its physical location.

The interfaces group (*if*) holds information about each interface on a device. The rest of the group names should be familiar. For those interested in the descriptions of managed objects in MIB-II, read chapter 3 in a "A Practical Guide to SNMPv3 and Network Management" by David Zeltserman.

Note that Dynamic C does not currently implement any of the MIB-II objects, since it does not support network router functionality.

12.1.3.2 Enterprise Subtree

The enterprise subtree is of special interest because it is where you can stake out a personal piece of the brave, new MIB world. In Figure 12.13, notice that both Rabbit Semiconductor and Z-World have nodes on the enterprise subtree. Enterprise numbers are assigned by the Internet Assigned Numbers Authority (IANA).

Our assigned enterprise numbers are:

- 12807 - Rabbit Semiconductor
- 12817 - Z-World Inc.

In Section 12.2.5.1 we will examine the Rabbit Semiconductor subtree.

To obtain an assigned enterprise number go to: `www.iana.org/cgi-bin/enterprise.pl`

12.1.4 SMI

Structure of Management Information (SMI) gives the rules for naming and defining the managed objects that are stored in a MIB. The actual storage of instances of managed objects is done programmatically by the SNMP agent, with the values being stored on the managed device. The definitions of managed objects required by SMI are compiled by SNMP managers. This is a standard that the manager uses in order to know what managed objects the agent can access and where they are logically located.

Object Name (OID)

SMI specifies a hierarchical naming scheme. The OID of an object is a series of non-negative integers traversing the tree to the node of the object.

Object Definition

SMI specifies the allowable data types, information organization and the encoding rules used (BER).

Object Data Types

Managed objects must be reducible to the data types defined for SNMP. The following table shows the mappings from the SMI defined types to the internal types used by the **MIB.LIB** implementation to store an object in the MIB tree.

SMI Defined Data Type	Internal Data Type
INTEGER	**SNMP_SHORT**
	SNMP_LONG
OCTECT STRING	**SNMP_OCT**
	SNMP_FOCT
	SNMP_STR
OBJECT IDENTIFIER	**SNMP_OID**
NULL	**SNMP_NULL**
IpAddress	**SNMP_LONG**
Counter	**SNMP_LONG**
Gauge	**SNMP_LONG**
TimeTicks	**SNMP_LONG**

The internal data types are specified in the following table:

Internal Type	Representation
SNMP_SHORT	2-byte integer in Rabbit order (little endian)
SNMP_LONG	4-byte integer in Rabbit order
SNMP_STR	Null terminated string, with specified maximum length. The null terminator is not counted in computing the string length. The null is only appended if the string is less than its maximum length.
SNMP_OCT	2-byte unsigned length field, followed by data. The length field contains the actual data length, not including the 2 bytes for the length field itself.
SNMP_FOCT	Fixed length binary data. The length is always equal to the maximum length specified.
SNMP_OID	Object identifier as defined by the **snmp_oid** structure.

The easiest way to understand this information is to look at the provided demo program as an example.

12.2 Demo Program

The sample program **SNMP1.C** implements an SNMP agent that will run on any Ethernet-enabled Rabbit-based target. The code fragments in this section are from **SNMP1.C**. To see the program in its entirety, open up the source code file located at **Samples\tcpip\snmp**.

```
#memmap xmem

// This is necessary for all SNMP applications.
// It causes inclusion of SNMP.LIB and MIB.LIB
#define USE_SNMP   1

//  This must be defined to support trap sending
#define SNMP_TRAPS

//  Standard DCRTCP network definitions. Change to suit your site requirements.
#define TCPCONFIG 1

//  Set the IP address of the SNMP manager that will receive trap messages.
#define MANAGER_IP "10.10.6.178"

//  For this demo only, send trap every 5 seconds.
#define SEND_TRAPS

//  Rabbit Semiconductor (do not change)
#define SNMP_ENTERPRISE 12807

#use "dcrtcp.lib"
```

The network definitions (**TCPCONFIG**) pertain to the target on which **SNMP1.C** is running. **MANAGER_IP** identifies the SNMP manager to which SNMP traps are sent.

The configuration macro **SNMP_TRAP_PORT** will default to UDP port 162 if it is not defined in the initialization code of the application.

12.2.1 Creating Managed Objects

The variable definitions in the following code fragment are the managed objects that the agent will store in a MIB.

```
// Managed variables. Read/write.
int rw_int;
long rw_long;
char rw_fixed[20];
char rw_str[20];
char rw_oct[22];
snmp_oid rw_oid;
longword trapdest_ip;
longword rw_tt;

// Managed variables. Read-only.
int r_int;
long r_long;
char r_fixed[20];
char r_str[20];
char r_oct[22];
snmp_oid r_oid;
```

The data structure **snmp_oid** is an internal data structure defined in **MIB.LIB**. It is used to hold the OID of a managed object. Another ubiquitous data structure, **snmp_parms**, is also defined in **MIB.LIB**. It is used to pass parameters to most of the API functions described in Section 12.4.

12.2.2 Callback Functions

Callback functions provide a way to customize data handling. The callback is invoked by the SNMP agent for each get or set request. If there is no callback for a particular object, then access to that object is always granted (according to the read/write masks).

The callback function should be defined as follows:

```
int my_callback (snmp_parms *p, int wr, int commit, void *v,
   word *len, word maxlen)
```

PARAMETERS

p — **snmp_parms** contains most of the information about the access. It is set up with the full OID of the object, plus its current value.

wr — This parameter is non-zero if this is a write access, otherwise it is a read access.

commit — This parameter implements a 2-stage query/commit process. It is necessary because any single SNMP request must be performed fully or not at all, i.e., the agent will only process the request if access to all of the managed objects in the variable binding is granted.

Read Request:

commit is always zero for read requests. The callback is only invoked once, not twice as it is for write requests.

Write Request:

When **commit** is equal to zero, the agent is checking the availability of the managed object. The callback should return zero to continue or non-zero to deny access. If at least one callback function denies access, no change will be made to any object in the transaction, and none of the callbacks will be called with **commit** equal to true.

When **commit** is not equal to zero, the callback function should skip checking the availability of the managed object (that was done the first time around) and just perform the desired side-effects associated with the write access. The callback's return value will be ignored.

v — Void pointer to a temporary location that may be altered by the callback. If the managed object is an integer, **v** points to a longword. If it is an OID, then **v** points to a structure of type **snmp_oid**. Otherwise, it points to the first character of a temporary buffer containing the string.

len — Points to the length of the string that is pointed to by **v**. Note that this is used by the SNMP agent to determine the string length.

maxlen — The maximum allowable length of the buffer pointed to by **v**.

RETURN VALUE

The non-zero return value may be chosen from **SNMP_ERR_*** definitions, in which case the value is used as the error type for the response. Otherwise, **SNMP_ERR_genErr** is used.

Read callbacks are used for SNMP get/get-next requests, as well as immediately after SNMP set requests, where the updated value of the variable is read back for generating the response. The return code for read callbacks is currently ignored, but should be set to zero for OK or non-zero for invalid (if applicable), to allow upward compatibility.

12.2.2.1 Callback Function Example

A callback function may be used for special actions that must be taken when a variable is written by the SNMP agent, such as creating entire table rows. Another use is to transform between internal and external representations. For example, the callback function shown below demonstrates how to scale a variable from internal units into the units expected by the SNMP manager. In this case, the variable appears as 1/10th of its internal value. Note that the transformation needs to work both ways if the variable is writable by the SNMP manager.

```
int scale(snmp_parms *p, int wr, int commit, long *v,
word *len, word maxlen){

   printf("Callback: wr=%d commit=%d v(in)=%ld ", wr, com-
mit, *v);

   if (wr) {
      // On write by agent, we ensure that the variable is within bounds.
      if (*v > 200000000)
         return SNMP_ERR_badValue;

      if (*v < -200000000)
         return SNMP_ERR_badValue;

      // OK, scale it up to internal representation.
      *v *= 10;
   }
   else
      // Read by the agent. Convert internal to external
      *v /= 10;

   printf("v(out)=%ld\n", *v);
   return 0;
}
```

The callback function has the opportunity to manipulate the value (including its length) as well as say whether the write operation is allowed or not.

12.2.3 Creating Communities

Before the MIB is created, variables are defined and some initialization takes place.

```
int main()
{
   auto snmp_parms _p;
   auto snmp_parms *p;
   auto word tt;
   auto word trapindices[2];
   auto word monindex;

   // Set the community passwords
   snmp_set_dflt_communities("public", "private", "trap");

   // Set p to be a pointer to _p, for calling convenience.
   p = &_p;

   // Set parameter structure to default initial state (required).
   snmp_init_parms(p);
```

There are three communities defined in this SNMP agent. The public and private communities are defined by default and the trap community is defined with the inclusion of **#define SNMP_TRAPS** at the beginning of the program. The configuration macro **SNMP_MAX_COMMUNITIES** limits the number of distinct community names. It will be set to 3 in this SNMP agent. It must be at least 1.

To add another community, call the API function **snmp_add_community()**. The return value of this function is used to set the password for the new community, by passing it as a parameter to **snmp_set_community()**. Each new community requires **SNMP_MAX_COMMUNITIES** to be increased by 1.

12.2.4 Creating the MIB

The MIB is created by the following code:

```
// define the root of this MIB tree
p = snmp_append_parse_stem(p, "3.1.1");
// make the following managed objects both readable and writable
p = snmp_set_access(p, SNMP_PUBLIC_MASK|SNMP_PRIVATE_MASK, SNMP_PRIVATE_MASK);
p = snmp_add_int(p, "1.1.0", &rw_int);
monindex = snmp_last_index(p);          // Save index 4 later monitor call

p = snmp_set_callback(p, scale);        // Setup for callback function
p = snmp_add_long(p, "1.2.0", &rw_long);  // Associate callback with var
p = snmp_set_callback(p, NULL);         // Don't associate with other vars

  p = snmp_add_foct(p, "1.3.0", rw_fixed, 20);
  p = snmp_add_str(p, "1.4.0", rw_str, 20);
  p = snmp_add_oct(p, "1.5.0", rw_oct, 22);
  p = snmp_add_objectID(p, "1.6.0", &rw_oid);
  p = snmp_add_ipaddr(p, "1.7.0", &trapdest_ip);
  p = snmp_add_timeticks(p, "1.8.0", &rw_tt);
  // make the following managed objects read only
  p = snmp_set_access(p, SNMP_PUBLIC_MASK|SNMP_PRIVATE_MASK, 0);
  p = snmp_add_int(p, "2.1.0", &r_int);
  trapindices[0] = snmp_last_index(p);   // save index for trap message

  p = snmp_add_long(p, "2.2.0", &r_long);
  p = snmp_add_foct(p, "2.3.0", r_fixed, 20);
  p = snmp_add_str(p, "2.4.0", r_str, 20);
  p = snmp_add_oct(p, "2.5.0", r_oct, 22);
  trapindices[1] = snmp_last_index(p);   // save index for trap message
  p = snmp_add_objectID(p, "2.6.0", &r_oid);
```

All of the API functions that were used to create the MIB are described in Section 12.4. A pointer to the parameter structure, **`snmp_parms`**, was passed to all functions, and also set to the return value. This is the recommended way of doing the MIB tree setup, since if any step fails it will return **`NULL`**. Passing the **`NULL`** on to subsequent functions is harmless, and avoids the need to do error checking after each call. Only at the end of sequence should "p" be tested for NULL.

Notice that the "root" of the MIB tree is set to

`SNMP_ENTERPRISE.oemExperiments.demos.rabbitsemiDemoSNMP1`

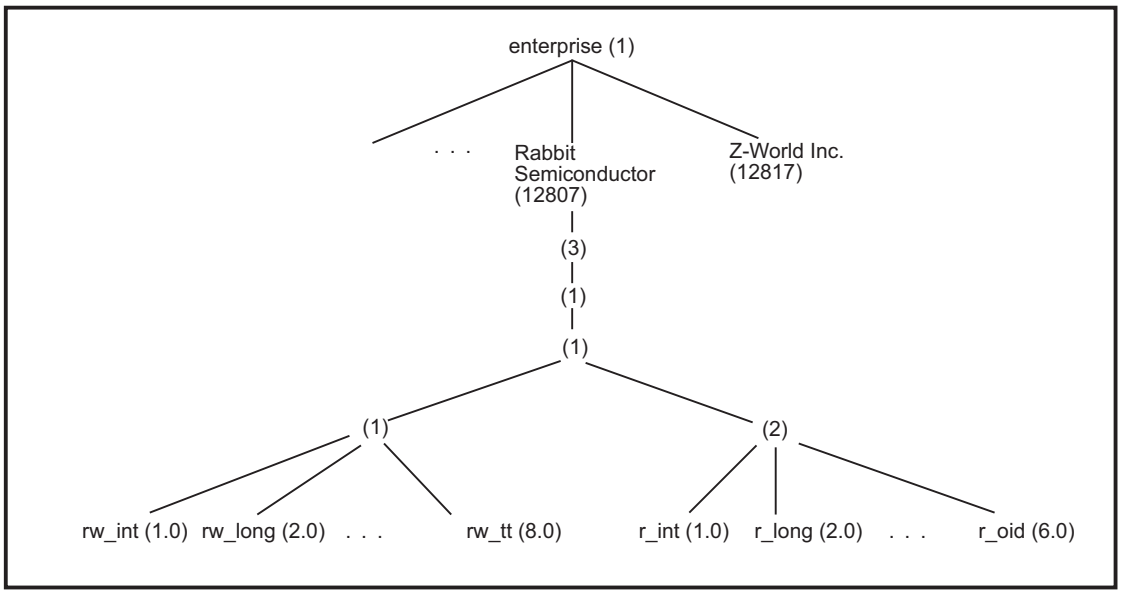
using the call:

```
p = snmp_append_parse_stem(p, "3.1.1");
```

The entire MIB tree can be rooted at a different point simply by changing this one call. But wait, you may well ask, where did the **oemExperiments.demos.** etc., come from? Before I answer that, let's look at a tree diagram of the MIB that was created in the previous code fragment.

The initial OID stem is set to "43.6.1.4.1.**SNMP_ENTERPRISE**" by the call to **snmp_init_parms()**. The first two levels in the tree, "iso.org" (1.3) are condensed to "43" to save transmitting an extra byte. The first 1 in "1.3.6.1.4.1" is multiplied by 40 then added to the second number "3," resulting in 1*40+3=43 or 0x2b.

This initial OID corresponds to the Rabbit Semiconductor node (rabbitsemi) on the enterprise subtree. Leaf nodes are created using the **snmp_add_*** macros. After the leaf node for **rw_tt** is created, access is set to read-only for the remainder of the managed objects. Addition of each object requires the additional levels below the "root" OID specified in the call to **snmp_append_parse_stem()**. By convention, objects with a single instance, i.e., not tabular, always have a zero at their lowest level.



But we still don't know where the **oemExperiments.demos.rabbitsemiDemoSNMP1** part comes in, unless you cheated and already looked in the text files that were named in the instructions at the beginning of **SNMP1.C**. These files:

- **RABBITSEMI-SMI.txt** - top level Rabbit Semiconductor
- **RABBITSEMI-PRODUCTS-MIB.txt** - listing of products (boards)
- **RABBITSEMI-DEMO-SNMP1.txt** - describes this demo.

contain the SMI definitions that are used by the SNMP manager.

12.2.5 Defining Managed Objects with SMI

The SNMP manager must compile the relevant **.txt** files that define a MIB that is compatible with the structure of the MIB defined by the SNMP agent.

12.2.5.1 Defining the Rabbit Subtree

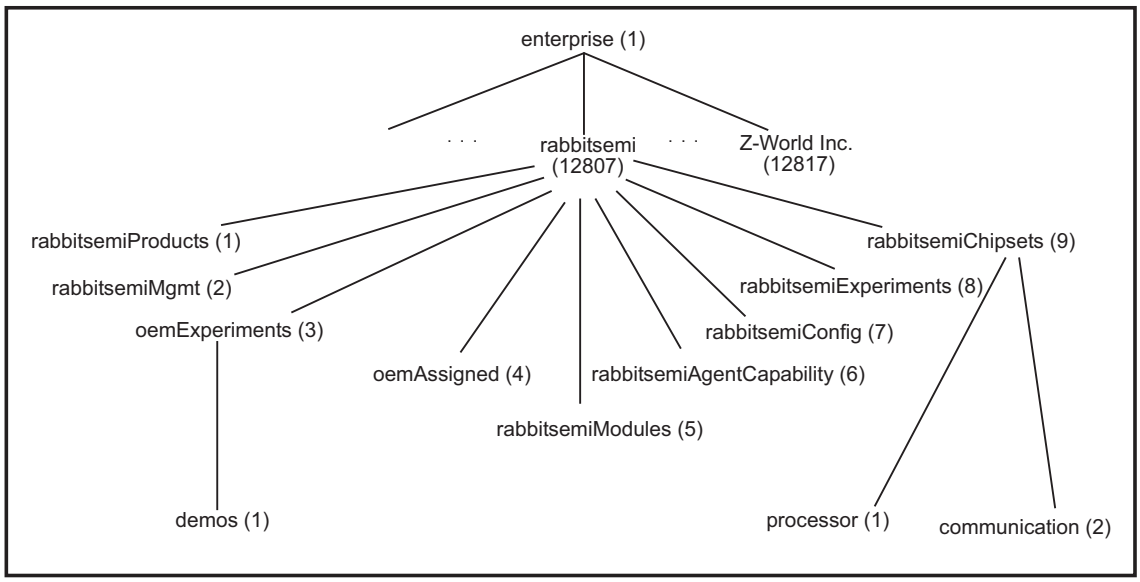
The text file **RABBITSEMI-SMI.txt** defines the top level of the Rabbit Semiconductor subtree.

```
RABBITSEMI-SMI DEFINITIONS ::= BEGIN

IMPORTS
   MODULE-IDENTITY,
   OBJECT-IDENTITY,
   enterprises
      FROM SNMPv2-SMI;

rabbitsemi MODULE-IDENTITY
   -- 2 dashes are the comment marker

   -- the information that should be here may be seen in RABBITSEMI-SMI.txt

   ::= { enterprises 12807 }  -- assigned by IANA
```

The **MODULE-IDENTITY** macro names rabbitsemi as node 12807 under enterprises.

```
rabbitsemiProducts OBJECT-IDENTITY

   STATUS current
   DESCRIPTION
      "rabbitsemiProducts is the root OBJECT IDENTIFIER from
      which sysObjectID values are assigned. Actual values
      are defined in RABBITSEMI-PRODUCTS-MIB."

   ::= { rabbitsemi 1 }
```

The **OBJECT-IDENTITY** macro names rabbitsemiProducts as node "1" under the rabbitsemi node. Studying the rest of the definitions in this file, you should be able to create the following tree diagram:



12.2.5.2 Defining the Demo MIB

The file **RABBITSEMI-DEMO-SNMP1.txt** defines another level in the MIB and then defines the leaf nodes that will hold the values of the managed objects for this demo. The leaf nodes correspond to the variable definitions in the code shown in Section 12.2.1.

```
RABBITSEMI-DEMO-SNMP1 DEFINITIONS ::= BEGIN

IMPORTS
   MODULE-IDENTITY,
   OBJECT-TYPE,
   NOTIFICATION-TYPE,
   IpAddress,
   TimeTicks
      FROM SNMPv2-SMI

   DisplayString
      FROM SNMPv2-TC

   demos
      FROM RABBITSEMI-SMI;


rabbitsemiDemoSNMP1 MODULE-IDENTITY

   -- Look in RABBITSEMI-DEMO-SNMP1.txt for the details that belong here.

   ::= { demos 1 }

demoRWObjects OBJECT IDENTIFIER ::= { rabbitsemiDemoSNMP1 1
}

demoROObjects OBJECT IDENTIFIER ::= { rabbitsemiDemoSNMP1 2
}
```

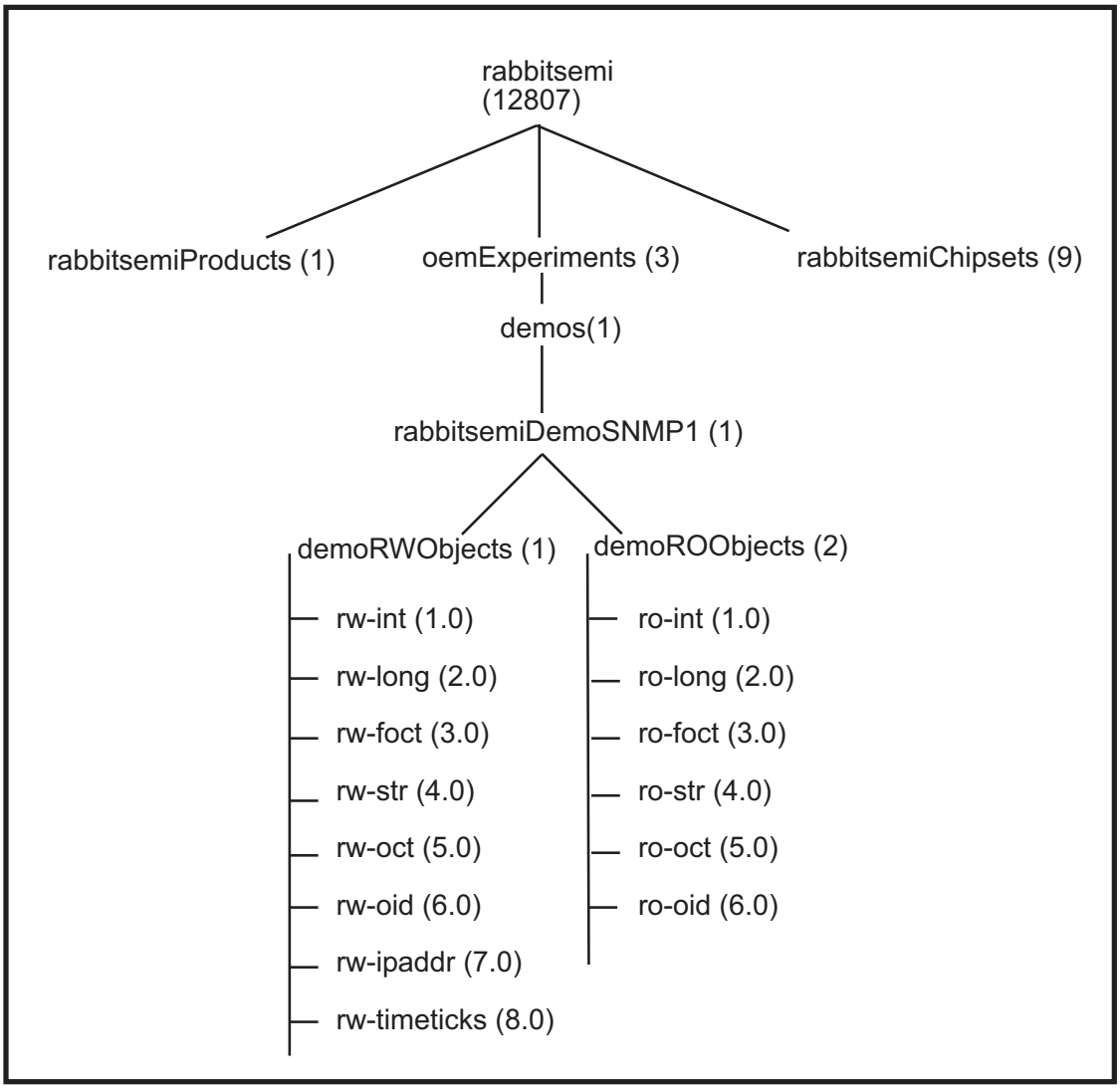
At this point, the correspondence between 12807. 3.1.1 and **SNMP_ENTERPRISE.oemExperiments.demos.rabbitsemiDemoSNMP1** becomes apparent.

The remainder of **RABBITSEMI-DEMO-SNMP1.txt** contains definitions for the rest of the MIB that will be used in the demo. Here are the first two leaf nodes:

```
    rw-int OBJECT-TYPE
       SYNTAX     INTEGER (-32768..32767)
       MAX-ACCESS read-write
       STATUS     current
       DESCRIPTION
          "A read/write short integer value."
       ::= { demoRWObjects 1 0 }


    rw-long OBJECT-TYPE
       SYNTAX     INTEGER (-200000000..200000000)
       MAX-ACCESS read-write
       STATUS     current
       DESCRIPTION
          "A read/write long integer value."
       ::= { demoRWObjects 2 0 }
```

The OBJECT-TYPE macro defines leaf nodes on the MIB tree. The SYNTAX line defines the data type of the managed object stored at the leaf node and gives the allowable range of values.

The tree diagram for this demo looks like this:



12.2.6 Running the SNMP Agent

Now that we've seen how the SNMP manager uses an SMI defined MIB to recognize the MIB controlled by the SNMP agent, let's look at the rest of the sample program **SNMP1.C** (our SNMP agent for this demo).

After the MIB is defined, the managed objects are initialized, the MIB tree is checked to make sure it was constructed without error and the network is started.

```
// Initialize the variables.
  rw_int = 1001;
  rw_long = 1000002;
  memcpy(rw_fixed, "rw_fixed abcdefghijk", 20);
  strcpy(rw_str, "rw_str");
  memcpy(rw_oct, "\x06\x00rw_oct", 8);
  memcpy(&rw_oid, &_p, sizeof(snmp_oid));
  trapdest_ip = aton(MANAGER_IP);
  rw_tt = snmp_timeticks();        // Set base epoch
  r_int = 2001;
  r_long = 2000002;
  memcpy(r_fixed, "r_fixed abcdefghijkl", 20);
  strcpy(r_str, "r_str");
  memcpy(r_oct, "\x05\x00r_oct", 7);
  memcpy(&r_oid, &_p, sizeof(snmp_oid));
  // Finally, we check that the MIB tree was constructed without error.
  // If there was any error, p will be set to NULL.
  if (!p) {
    printf("There was an error constructing the MIB.\n");
    exit(1);
  }
  // Monitor the rw_int variable (whose MIB tree index was saved in monindex).
  // trapindices was set up with the indices for r_int and r_oct.
    snmp_monitor(monindex, 0, 3000, 1, 16, 6, &trapdest_ip,
         SNMP_TRAPDEST, 30, 2, trapindices);
  // See what we've got.
  snmp_print_tree();
    printf("MIB tree: used %ld out of %ld bytes\n", snmp_used(),
         (long)SNMP_MIB_SIZE);
  // Now start up the network
  sock_init();
```

The SNMP handler is called the same way all the other TCP/IP handlers are called—by **tcp_tick()**.

```
      tt = _SET_SHORT_TIMEOUT(5000);

      for (;;) {
         if (_CHK_SHORT_TIMEOUT(tt)) {

   #ifdef SEND_TRAPS
            snmp_trap(trapdest_ip, SNMP_TRAPDEST, 20, 2,trapin-
   dices);
   #endif

            tt = _SET_SHORT_TIMEOUT(5000);
         }
         tcp_tick(NULL);
      }
   }
```

The macros **_SET_SHORT_TIMEOUT** and **_CHK_SHORT_TIMEOUT** are defined in **net.lib**. They are based on **MS_TIMER** and offer a consistent way of setting time outs of 1ms thru 32 seconds using only 16-bit arithmetic. This SNMP agent will send a trap message every 5 seconds.

12.3 Configuration Macros

These macros may be defined in the initialization code of the SNMP agent before the inclusion of **dcrtcp.lib**.

SNMP_DFLT_READMASK

The mask used to grant read access. The default is 0x03, which gives read access to both the private and public communities.

SNMP_DFLT_WRITEMASK

The mask used to grant write access. The default is 0x02, which gives write access to only the private community.

SNMP_INTERFACE

Specify the network interface to listen for SNMP messages. May be set to a fixed interface, or **IF_ANY** to listen on all interfaces. The default is **IF_DEFAULT**.

SNMP_TOS

Specifies the IP TOS for SNMP. The default is **IPTOS_RELIABLE**.

SNMP_MIN_TRAP_INTVL

Minimum interval between transmission of trap messages, specified in milliseconds. Helps prevent inadvertent network overload. Must not be more than 30,000 milliseconds. The default is 1000 ms.

SNMP_MAX_MONITOR

Maximum number of monitored variables. Each monitored variable requires (**SNMP_MAX_MON_DATA***2) + 33 bytes of root data.

SNMP_MAX_MON_DATA

Maximum number of additional variables sent with a monitor trap. The default is 2.

SNMP_MAX_DATA

Largest size of SNMP datagram supported (input or output). This must be at least 484 bytes to conform with RFC1157. Currently, this should not be larger than the default value since outgoing fragmentation is not supported. The default value is (**MIN_MTU**-28).

SNMP_MAX_NAME

Maximum size of an encoded object identifier (OID). The default is 32.

SNMP_MAX_STRING

The largest octet string that may be retrieved or set via SNMP. Making this larger only affects the amount of stack space used by the SNMP handler functions. It does not limit internal storage of string values in the MIB tree. The largest practical size would be a few bytes less than **SNMP_MAX_DATA**. The minimum allowable size is (2***SNMP_MAX_NAME**). The default is 128.

SNMP_MAX_BINDINGS

The maximum number of variables supported in any one message. This has a bearing on stack space usage. Each additional binding will require 4 more bytes of stack. The default is 32.

SNMP_MAX_COMMUNITY_NAME

The maximum string length of community names (i.e., passwords). The default is 16.

SNMP_MAX_COMMUNITIES

The number of communities recognized by the SNMP agent. The default is 2, or 3 if traps are supported.

SNMP_MIB_SIZE

Defines the maximum size of the MIB tree structure resident in xmem. The default size is 4096 bytes. The default allows for about 100 objects.

SNMP_PORT

The UDP port that the agent will listen on. The default is 161.

SNMP_TRAP_PORT

The UDP port that the agent will send traps to on the SNMP manager. The default is 162.

SNMP_TRAPS

Must be defined in the application to support trap sending.

USE_MIB

Defining this macro is only necessary if MIB functionality is being used without SNMP.

12.4 API Functions

This section describes all of the API functions available in **SNMP.LIB** and **MIB.LIB**.

snmp_add
snmp_add_community
snmp_append_binary_oid
snmp_append_binary_stem
snmp_append_oid
snmp_append_parse_oid
snmp_append_parse_stem
snmp_append_stem
snmp_community_mask
snmp_community_name
snmp_copy_oid
snmp_delete
snmp_format_oid
snmp_get
snmp_get_indexed
snmp_get_next
snmp_init_parms
snmp_last_index
snmp_last_int
snmp_last_len
snmp_last_long
snmp_last_maxlen
snmp_last_mem
snmp_last_objectID
snmp_last_snmp_type
snmp_last_type
snmp_last_xmem
snmp_monitor
snmp_print_tree
snmp_set_access
snmp_set_callback
snmp_set_community
snmp_set_dflt_communities
snmp_set_foct
snmp_set_int
snmp_set_long
snmp_set_objectID
snmp_set_oct
snmp_set_oid
snmp_set_parse_oid
snmp_set_parse_stem
snmp_set_stem
snmp_set_str
snmp_start
snmp_stop
snmp_time_since
snmp_timeticks
snmp_trap
snmp_unmonitor
snmp_up_oid
snmp_up_stem
snmp_used
snmp_xadd

snmp_add

```
snmp_parms *snmp_add( snmp_parms *p, char *n, word type, void *v,
   word maxlen );
```

DESCRIPTION

Add an object into the MIB tree. The parameter structure ***p** must be set up using **snmp_init_parms()** and other functions such as **snmp_set_stem()** to indicate the object ID of the object to be added.

This function is used to add objects which reside in root data storage. The object must persist at the specified location (**v**) at least until the object is deleted using **snmp_delete()**.

Typically, the object may already exist in some preexisting application (e.g., as a field in some structure). The object may be used exactly as an ordinary variable or field, except that its value may change whenever **tcp_tick()** is called and there happens to have been an SNMP SET request on that object. (If SNMP is not being used, the object will not be modified by any of the **MIB.LIB** functions.)

snmp_add() and **snmp_xadd()** are the most general functions. Cleaner code can result from using the equivalent macro invocations. There are 10 macro invocations of snmp_add and snmp_xadd. The macros ensure that the correct type and length parameters are passed.

The macros for **snmp_add()** are:

```
snmp_add_int(p,n,i)
snmp_add_uint(p,n,i)
snmp_add_long(p,n,i)
snmp_add_ipaddr(p,n,i)
snmp_add_timeticks(p,n,i)
snmp_add_ulong(p,n,i)
snmp_add_str(p,n,s,m)
snmp_add_oct(p,n,s,m)
snmp_add_foct(p,n,s,m)
snmp_add_objectID(p,n,s)
```

where parameters **p** and **n** are as for this function; **i** is an integer or long integer address; **s** is a **char ***; and **m** is a maximum length.

PARAMETERS

p Pointer to parameter structure to set. If **NULL**, does nothing but return **NULL**.

n Optional extra OID level to temporarily append to the OID in ***p**. If -1, this is not done. Otherwise, the level is appended; the value added; then the extra level removed. It is not possible to specify OID levels greater than 2^{31} - 1.

type Type of value to add. This is a composite of the internal type (indicating the memory layout) and the type visible to SNMP agents. The possible composite types are selected from the following list:

```
SNMP_INTEGER_AS_SHORT     (SNMP_P_INTEGER<<4 | SNMP_SHORT)
SNMP_INTEGER_AS_LONG      (SNMP_P_INTEGER<<4 | SNMP_LONG)
SNMP_INTEGER              SNMP_INTEGER_AS_LONG
SNMP_OCTETSTR_VARIABLE    (SNMP_P_OCTETSTR<<4 | SNMP_OCT)
SNMP_OCTETSTR_NULLTERM    (SNMP_P_OCTETSTR<<4 | SNMP_STR)
SNMP_ASCIISTR             SNMP_OCTETSTR_NULLTERM
SNMP_OCTETSTR_FIXED       (SNMP_P_OCTETSTR<<4 | SNMP_FOCT)
SNMP_OBJECT_ID            (SNMP_P_OID<<4 | SNMP_OID)
SNMP_IPADDR_AS_OCT        (SNMP_P_IPADDR<<4 | SNMP_FOCT)
SNMP_IPADDR_AS_LONG       (SNMP_P_IPADDR<<4 | SNMP_LONG)
SNMP_COUNTER_AS_SHORT     (SNMP_P_COUNTER<<4 | SNMP_SHORT)
SNMP_COUNTER_AS_LONG      (SNMP_P_COUNTER<<4 | SNMP_LONG)
SNMP_COUNTER              SNMP_COUNTER_AS_LONG
SNMP_GAUGE_AS_SHORT       (SNMP_P_GAUGE<<4 | SNMP_SHORT)
SNMP_GAUGE_AS_LONG        (SNMP_P_GAUGE<<4 | SNMP_LONG)
SNMP_GAUGE                SNMP_GAUGE_AS_LONG
SNMP_TIMETICKS            (SNMP_P_TIMETICKS<<4 | SNMP_LONG)
```

v	Pointer to the actual object in root data storage. This storage becomes managed by SNMP/MIB, which is why it must be static. To alter the value of the object, it is permissible (in fact recommended) to simply update the object directly. Note that it is this pointer value that is stored in the MIB tree, not a copy of the object. Note that variable-length octet strings are stored in a special format: the 1st two bytes of the location are used to store the current length. The specified maximum length, maxlen, includes the length of this 2-byte prefix. The actual length of the object can thus be no more than the maxlen - 2.
maxlen	Maximum permissible length of the object. This is applicable to variable length objects, since SNMP needs to know the allowable size bounds for the object to avoid overwriting past the end of the allocated space for the object.

RETURN VALUE

Returns **p** unless **p** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_set_parse_stem, snmp_append_stem, snmp_append_parse_stem, snmp_set_access, snmp_set_callback, snmp_up_stem, snmp_xadd, snmp_delete, snmp_get, snmp_last_index

snmp_add_community

```
int snmp_add_community( char *cname, byte mask );
```

DESCRIPTION

Add a new community with a given access mask to the table of community names. The size of the table is specified using **SNMP_MAX_COMMUNITIES**. The first 3 communities are automatically defined thus do not need to be added using this function.

PARAMETERS

cname Community name as a null-terminated string with a maximum length of **SNMP_MAX_COMMUNITY_NAME**.

mask This specifies the access groups (one or more of 8 groups) to which this community belongs. Three groups are predefined:

SNMP_PUBLIC_MASK - public group with read-only access

SNMP_PRIVATE_MASK - private group with read/write access

SNMP_TRAPDEST_MASK - trap group with no access

RETURN VALUE

-1: No room in table.

≥**0**: Number of entries in community table, after current addition. This is the community index, which is required for other API functions.

LIBRARY

SNMP.LIB

SEE ALSO

snmp_set_dflt_communities, snmp_set_community, snmp_community_name, snmp_community_mask

snmp_append_binary_oid

```
snmp_oid *snmp_append_binary_oid( snmp_oid *oid, word len,
   char *bname );
```

DESCRIPTION

Append the object ID encoded as a string of bytes to the OID currently set in ***oid**. This function may be used when all levels in the OID string are numbers between 0 and 255 inclusive. Each OID level is simply the binary value of each byte pointed to by **bname**. The number of levels (i.e., bytes) is specified by **len**. For example, to append "255.6.0.1" make the following call:

```
snmp_append_binary_oid(oid, 4, "\xFF\x06\x00\x01");
```

This function is identical to **snmp_append_binary_stem()**, except that it uses an **snmp_oid** structure.

PARAMETERS

oid	Pointer to **snmp_oid** structure to set. If NULL, does nothing but return NULL.
len	Number of bytes in bname.
bname	Pointer to first byte of OID.

RETURN VALUE

Returns **oid** unless the OID string is too long to fit in the **snmp_oid** structure in which case NULL is returned. If **oid** is NULL on entry, then nothing is done except to return NULL.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_append_oid, snmp_append_binary_stem, snmp_set_stem

snmp_append_binary_stem

```
snmp_parms * snmp_append_binary_stem( snmp_parms *p, word len, char
   *bname );
```

DESCRIPTION

Append the object ID encoded as a string of bytes to the OID currently set in ***p**. This function may be used when all levels in the OID string are numbers between 0 and 255 inclusive. Each OID level is simply the binary value of each byte pointed to by **bname**. The number of levels (i.e., bytes) is specified by **len**. For example, to append "255.6.0.1" make the following call:

```
snmp_append_binary_stem(p, 4, "\xFF\x06\x00\x01");
```

This function is identical to **snmp_append_binary_oid()**, except that it uses an **snmp_parms** structure.

PARAMETERS

p	Pointer to parameter structure to set. If **NULL**, does nothing but return **NULL**.
len	Number of bytes in **bname**.
bname	Pointer to first byte of OID.

RETURN VALUE

Returns **p** unless the OID string is too long to fit in the parameter structure in which case **NULL** is returned. If **p** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_append_oid, snmp_append_parse_stem, snmp_set_stem

snmp_append_oid

```
snmp_oid * snmp_append_oid( snmp_oid *oid, word len, char *eos );
```

DESCRIPTION

This function is identical to **snmp_append_stem**, except that it uses an **snmp_oid** structure. See documentation for **snmp_set_stem()** for an explanation of OID encoding.

PARAMETERS

oid	Pointer to **snmp_oid** structure to set. If **NULL**, does nothing but return **NULL**.
len	Length of eos.
eos	Encoded OID string.

RETURN VALUE

Returns **oid** unless the OID string is too long to fit in the **snmp_oid** structure in which case **NULL** is returned. If **oid** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_oid, snmp_append_parse_oid, snmp_append_stem

snmp_append_parse_oid

```
snmp_oid * snmp_append_parse_oid( snmp_oid *oid, char *name );
```

DESCRIPTION

Appends the specified OID string, expressed in dotted decimal format, to the OID currently set in the OID structure. This function is identical to **snmp_append_parse_stem()**, except that it uses an **snmp_oid** structure.

PARAMETERS

oid	Pointer to **snmp_oid** structure to set. If **NULL**, does nothing but return **NULL**.
name	OID string in dotted decimal notation e.g., "7.5.99"

RETURN VALUE

Returns **oid** unless the OID string is too long to fit in the **snmp_oid** structure in which case **NULL** is returned. If **oid** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_append_oid, snmp_append_parse_stem, snmp_set_stem

snmp_append_parse_stem

```
snmp_parms * snmp_append_parse_stem( snmp_parms *p, char *name );
```

DESCRIPTION

Appends the specified OID string, expressed in dotted decimal format, to the OID currently set in the parameter structure. This function is identical to **snmp_append_parse_oid()**, except that it uses an **snmp_parms** structure.

PARAMETERS

p	Pointer to parameter structure to set. If **NULL**, does nothing but return **NULL**.
name	OID string in dotted decimal notation e.g., "7.5.99"

RETURN VALUE

Returns **p** unless the OID string is too long to fit in the parameter structure in which case **NULL** is returned. If **p** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_set_parse_stem

snmp_append_stem

```
snmp_parms * snmp_append_stem( snmp_parms *p, word len, char *eos );
```

DESCRIPTION

Appends the encoded object identifier string to the OID already set in ***p**. See **snmp_set_stem()** for a description of OID encoding. This function is identical except that it appends rather than replaces the OID.

PARAMETERS

p	Pointer to parameter structure to append to. If **NULL**, does nothing but return **NULL**.
len	Length of **eos**.
eos	Encoded OID string.

RETURN VALUE

Returns **p** unless the OID string is too long to fit in the parameter structure in which case **NULL** is returned. If **p** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_parse_stem, snmp_append_oid

snmp_community_mask

```
int snmp_community_mask( word c_index );
```

DESCRIPTION

Return the community access mask of the specified community.

PARAMETERS

c_index Community table index. This is the value returned by `snmp_add_community()`, or may be **SNMP_PUBLIC**, **SNMP_PRIVATE** or **SNMP_TRAPDEST** for the predefined default communities.

RETURN VALUE

-1: The index was outside the table bounds.
0..255: The requested bit mask.

LIBRARY

SNMP.LIB

SEE ALSO

snmp_add_community, snmp_set_dflt_communities, snmp_set_community, snmp_community_name

snmp_community_name

```
char * snmp_community_name( word c_index, int *length );
```

DESCRIPTION

Return the name and, optionally, the length of the specified community.

PARAMETERS

c_index	The community table index is the value returned by **snmp_add_community()**, or may be **SNMP_PUBLIC**, **SNMP_PRIVATE** or **SNMP_TRAPDEST** for the predefined default communities.
length	If not **NULL**, then the addressed location will be set with the community name string length.

RETURN VALUE

NULL: the index was outside the table bounds.
Otherwise, a pointer to the community name is returned. The data at this location should not be modified.

LIBRARY

SNMP.LIB

SEE ALSO

snmp_add_community, snmp_set_dflt_communities, snmp_set_community, snmp_community_mask

snmp_copy_oid

```
snmp_oid * snmp_copy_oid( snmp_parms *p, snmp_oid *n );
```

DESCRIPTION

Copy the current object ID "stem" from ***p** into ***n**.

PARAMETERS

p	Parameter structure that was previously initialized by calls to **snmp_init_parms()**, **snmp_set_stem()** etc.
n	Object ID structure to be filled in with current stem from ***p**. Must not be **NULL**.

RETURN VALUE

If **p** was **NULL** returns **NULL**, otherwise returns **n**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_stem

snmp_delete

```
snmp_parms * snmp_delete( snmp_parms *p );
```

DESCRIPTION

Delete a node, or a subtree, of the MIB tree. The object ID to delete is specified in ***p**. All objects whose OID has a complete initial match with the specified OID will be deleted.

Note that the indices which may have been retrieved for a deleted object will no longer be valid.

PARAMETERS

p	Pointer to parameter structure whose stem is set up with the OID to delete. If **NULL**, does nothing but return **NULL**.

RETURN VALUE

Returns **p** unless it is **NULL** on entry, then nothing is done except to return **NULL**. If no objects were deleted, then the function also returns **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_set_parse_stem, snmp_append_stem, snmp_append_parse_stem, snmp_up_stem, snmp_add, snmp_xadd, snmp_last_index

snmp_format_oid

```
char * snmp_format_oid( snmp_oid *oid );
```

DESCRIPTION

Debugging only: format OID in dotted decimal and return static buffer.

PARAMETERS

oid oid to format.

RETURN VALUE

Address of string in static storage.

LIBRARY

MIB.LIB

snmp_get

```
snmp_parms * snmp_get( snmp_parms *p );
```

DESCRIPTION

Retrieves the object whose OID is set in ***p**. The retrieved object information is stored back in ***p**, and can be examined using the **snmp_last_*()** series of functions.

PARAMETERS

p	Parameter structure that was previously initialized by calls to **snmp_init_parms()**, **snmp_set_stem()** etc.

RETURN VALUE

NULL if **p** was **NULL**, or if there is no object with the given OID. Otherwise, returns **p**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_stem, snmp_get_indexed, snmp_get_next, snmp_last_int, snmp_last_long, snmp_last_mem, snmp_last_xmem, snmp_last_type, snmp_last_len

snmp_get_indexed

```
snmp_parms * snmp_get_indexed( snmp_parms *p, word i );
```

DESCRIPTION

Retrieves the object whose MIB tree index is given by **i**. The object information is stored in ***p**, and can be examined using the **snmp_last_*()** series of functions. The object ID of the retrieved object may be obtained by calling **snmp_copy_oid()**. The object ID is automatically set in ***p**, so **snmp_get_next()** can be called repeatedly to retrieve higher objects in ascending sequence of object ID.

See documentation for **snmp_last_index()** for information on MIB tree indices.

PARAMETERS

p	Parameter structure that was previously initialized by calls to **snmp_init_parms()**, **snmp_set_stem()** etc.
i	Index of object, e.g., from **snmp_last_index()**.

RETURN VALUE

NULL if **p** was **NULL**, or if there is no next object. Otherwise, returns **p**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_stem, snmp_copy_oid, snmp_get, snmp_get_next, snmp_last_index, snmp_last_int, snmp_last_long, snmp_last_mem, snmp_last_xmem, snmp_last_type, snmp_last_len

snmp_get_next

```
snmp_parms * snmp_get_next( snmp_parms *p );
```

DESCRIPTION

Retrieves the next object in lexicographically ascending sequence. The object information is stored in ***p**, and can be examined using the **snmp_last_*()** series of functions. The object ID of the retrieved object may be obtained by calling **snmp_copy_oid()**. The object ID is automatically set in ***p**, so this function can be called repeatedly to retrieve all objects in ascending sequence of object ID.

PARAMETERS

p	Parameter structure that was previously initialized by calls to **snmp_init_parms()**, **snmp_set_stem()** etc.

RETURN VALUE

NULL if **p** was **NULL**, or if there is no next object. Otherwise, returns **p**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_stem, snmp_copy_oid, snmp_get, snmp_get_indexed, snmp_last_int, snmp_last_long, snmp_last_mem, snmp_last_xmem, snmp_last_type, snmp_last_len

snmp_init_parms

```
snmp_parms * snmp_init_parms( snmp_parms *p );
```

DESCRIPTION

Initialize the parameter structure **p**. This is used to set ***p** to a known state prior to calling other functions in the MIB group. If **p** is not NULL, it is set to all binary zeros. The initial OID stem is then set to "43.6.1.4.1" or, if **SNMP_ENTERPRISE** is defined, it is set to "43.6.1.4.1.**SNMP_ENTERPRISE**". Note that the leading "43" is the standard compression of "1.3." The current read and write masks are set to **SNMP_DEFAULT_READMASK** and **SNMP_DEFAULT_WRITEMASK** respectively. The current index is set to NULL.

PARAMETERS

p	Pointer to parameter structure to initialize. If NULL, does nothing but return NULL.

RETURN VALUE

Always returns **p**.

LIBRARY

MIB.LIB

snmp_last_index

```
word snmp_last_index( snmp_parms *p );
```

DESCRIPTION

Return the MIB tree index for the last object added or retrieved. Indices are the most efficient way to access objects in the MIB tree, however the efficiency comes at a price: it is possible for indices to become invalid if the **snmp_delete()** function is ever used.

Once an object is created using **snmp_add_*()**, its index is guaranteed to remain valid until the same object is deleted using **snmp_delete()**. After such time, the index may refer to an unused tree entry (and thus be garbage) or another object may be created which will re-use the same index.

It is safe to store indices of objects which are never deleted. Otherwise, the programmer must exercise caution.

An index value of **SNMP_NULL** (which is not the same as zero!) indicates a null index, e.g., "not found" or "unknown."

PARAMETERS

p	Parameter structure that was previously set by a call to **snmp_add_*()** or **snmp_get()** or **snmp_get_next()**.

RETURN VALUE

SNMP_NULL if **p** was **NULL**, otherwise returns the index. The returned index may be garbage if no object was added or retrieved by previous calls.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_get, snmp_get_next, snmp_get_indexed, snmp_add, snmp_xadd, snmp_delete

snmp_last_int

```
int snmp_last_int( snmp_parms *p );
```

DESCRIPTION

Return the short integer value of the last object retrieved from the MIB tree. The object must be of a short integer type, and may be in either xmem or root storage. If the object is in fact a long integer, then the return value will reflect only the low 16 bits of the value. If the object is of any other type the returned value will be garbage.

PARAMETERS

p	Parameter structure that was used previously in a call to a retrieval function such as **snmp_get_indexed()**, **snmp_get()** or **snmp_get_next()**.

RETURN VALUE

Returns the object value. Result will be garbage if the object is not a short integer type, or if **p** was **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_get, snmp_get_next, snmp_get_indexed, snmp_last_long, snmp_last_mem, snmp_last_xmem, snmp_last_type, snmp_last_len

snmp_last_len

```
word snmp_last_len( snmp_parms *p );
```

DESCRIPTION

Return the current length of the last object retrieved from the MIB tree. The object may be of any type, and may be in either xmem or root storage. The current length may be less than or equal to the result from **snmp_last_maxlen()**.

PARAMETERS

p	Parameter structure that was used previously in a call to a retrieval function such as **snmp_get_indexed()**, **snmp_get()** or **snmp_get_next()**.

RETURN VALUE

Returns the object length. Result will be garbage if **p** was **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_get, snmp_get_next, snmp_get_indexed, snmp_last_int, snmp_last_long, snmp_last_mem, snmp_last_xmem, snmp_last_type, snmp_last_maxlen

snmp_last_long

```
long snmp_last_long( snmp_parms *p );
```

DESCRIPTION

Return the long integer value of the last object retrieved from the MIB tree. The object must be of a long integer type, and may be in either xmem or root storage. If the object is of any other type (including short integer) the returned value will be garbage.

PARAMETERS

p	Parameter structure that was used previously in a call to a retrieval function such as **snmp_get_indexed()**, **snmp_get()** or **snmp_get_next()**.

RETURN VALUE

Returns the object value. Result will be garbage if the object is not a long integer type, or if **p** was **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_get, snmp_get_next, snmp_get_indexed, snmp_last_int, snmp_last_mem, snmp_last_xmem, snmp_last_type, snmp_last_len

snmp_last_maxlen

```
word snmp_last_maxlen( snmp_parms *p );
```

DESCRIPTION

Return the maximum length of the last object retrieved from the MIB tree. The object may be of any type, and may be in either xmem or root storage. The current length (from **snmp_last_len()**) may be less than or equal to the result from this function.

PARAMETERS

p	Parameter structure that was used previously in a call to a retrieval function such as **snmp_get_indexed()**, **snmp_get()** or **snmp_get_next()**.

RETURN VALUE

Returns the maximum permissible object length. Result will be garbage if **p** was **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_get, snmp_get_next, snmp_get_indexed, snmp_last_int, snmp_last_long, snmp_last_mem, snmp_last_xmem, snmp_last_type, snmp_last_len

snmp_last_mem

```
char * snmp_last_mem( snmp_parms *p );
```

DESCRIPTION

Return the logical address of the last object retrieved from the MIB tree. The object may be of any type, however, it must NOT have been defined as an xmem object.

PARAMETERS

p	Parameter structure that was used previously in a call to a retrieval function such as **snmp_get_indexed()**, **snmp_get()** or **snmp_get_next()**.

RETURN VALUE

If **p** was **NULL**, or the object is in xmem storage, returns **NULL**. Otherwise, the logical (near) address of the object is returned.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_get, snmp_get_next, snmp_get_indexed, snmp_last_int, snmp_last_long, snmp_last_xmem, snmp_last_type, snmp_last_len

snmp_last_objectID

```
snmp_parms * snmp_last_objectID( snmp_parms *p, snmp_oid * oid );
```

DESCRIPTION

Copy the last OID object which was retrieved from the MIB tree into ***oid**.

PARAMETERS

p	Parameter structure that was used previously in a call to a retrieval function such as **snmp_get_indexed()**, **snmp_get()** or **snmp_get_next()**.
oid	Pointer to an **snmp_oid** structure, to which the result is copied.

RETURN VALUE

NULL: if **p** was **NULL** or the last object retrieved was not an object-ID object.
p: otherwise.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_get, snmp_get_next, snmp_get_indexed, snmp_last_int, snmp_last_long, snmp_last_mem, snmp_last_xmem

snmp_last_snmp_type

```
word snmp_last_snmp_type( snmp_parms *p );
```

DESCRIPTION

Return the SNMP type of the last object retrieved from the MIB tree. Each object has two "types." The SNMP type indicates the type of object to external entities using SNMP to examine objects on this agent. The internal type (see **snmp_last_type()**) indicates the memory layout for the object in the MIB tree. The same memory layout may be used for different SNMP types, and vice versa.

PARAMETERS

p Parameter structure that was used previously in a call to a retrieval function such as **snmp_get_indexed()**, **snmp_get()** or **snmp_get_next()**.

RETURN VALUE

SNMP type of the object. The currently supported types are:

- SNMP_P_INTEGER
- SNMP_P_OCTETSTR
- SNMP_P_OID
- SNMP_P_IPADDR0
- SNMP_P_COUNTER
- SNMP_P_GAUGE
- SNMP_P_TIMETICKS

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_get, snmp_get_next, snmp_get_indexed, snmp_last_int, snmp_last_long, snmp_last_mem, snmp_last_xmem, snmp_last_type, snmp_last_len

snmp_last_type

```
snmp_type snmp_last_type( snmp_parms *p );
```

DESCRIPTION

Returns the internal type of the last object retrieved from the MIB tree. Each object has two "types." The SNMP type (see **snmp_last_snmp_type()**) indicates the type of object to external entities using SNMP to examine objects on this agent. The internal type indicates the memory layout for the object in the MIB tree. The same memory layout may be used for different SNMP types, and vice versa.

PARAMETERS

p	Parameter structure that was used previously in a call to a retrieval function such as **snmp_get_indexed()**, **snmp_get()** or **snmp_get_next()**.

RETURN VALUE

Internal type of the object. The currently supported types are

- **SNMP_SHORT** - 16-bit integer
- **SNMP_LONG** - 32-bit integer
- **SNMP_STR** - null-terminated string
- **SNMP_OCT** - variable length binary (octet) string
- **SNMP_FOCT** - fixed length binary string
- **SNMP_OID** - Object ID

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_get, snmp_get_next, snmp_get_indexed, snmp_last_int, snmp_last_long, snmp_last_mem, snmp_last_xmem, snmp_last_snmp_type, snmp_last_len

snmp_last_xmem

```
long snmp_last_xmem( snmp_parms *p );
```

DESCRIPTION

Return the physical address of the last object retrieved from the MIB tree. The object may have been defined to reside in either xmem or root data space, and may be of any type.

PARAMETERS

p	Parameter structure that was used previously in a call to a retrieval function such as **snmp_get_indexed()**, **snmp_get()** or **snmp_get_next()**.

RETURN VALUE

If **p** was **NULL**, returns 0. Otherwise, returns the physical (20-bit linear) address of the object.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_get, snmp_get_next, snmp_get_indexed, snmp_last_int, snmp_last_long, snmp_last_mem, snmp_last_type, snmp_last_len

snmp_monitor

```
int snmp_monitor( word index, long minval, long maxval, word
  minintvl, word maxintvl, word nmesg, longword *ipaddr, word
  c_index, int trap_num, word noids, word *indices );
```

DESCRIPTION

Sets up automatic monitoring of a specified managed object. This monitors the object (which must be integer type), so that if the object goes outside the specified lower and upper bound, trap messages will be sent.

This function overcomes some of the limitations of the normal **snmp_trap()** mechanism, in that it performs automatic retransmissions to practically ensure that the network management agent notices the condition.

The managed object must exist in the MIB tree, and must not be deleted while it is being monitored. Any given object can only be monitored once. If the object is already being monitored, a call to this function with the same object (index) will change the monitor settings for that object.

You must **#define SNMP_TRAPS** to use this function.

The maximum number of different objects which may be monitored is specified by **SNMP_MAX_MONITOR**.

When an object is monitored, it is periodically examined (at intervals of **SNMP_MIN_TRAP_INTVL** milliseconds). If, at the time of examination, the object is outside the specified bounds then trap message are initiated. After the first message is sent, another message will be sent **minintvl** seconds later. Subsequent messages are sent at doubling time intervals up to a maximum of **maxintvl**. A maximum of **nmesg** messages will be sent for any "event." The time intervals and message counters are reset as soon as the object goes back inside the specified range.

PARAMETERS

index	MIB tree index of the object to monitor. This value may be obtained when the object is created, by calling **snmp_last_index()**.
minval	Minimum allowed value of object.
maxval	Maximum allowed value of object. If the object is stored with an SNMP type of **SNMP_P_INTEGER**, then the comparisons are done using signed arithmetic. All other SNMP types are assumed to be unsigned, so unsigned arithmetic is performed.
minintvl	Minimum interval, in seconds, between successive trap messages if the object goes outside the specified bounds.
maxintvl	Maximum interval, in seconds, between messages.
nmesg	Maximum number of messages to send while an object is outside bounds. The message count is reset when the variable goes back inside bounds.
ipaddr	Address of the IP address of the network management agent to which trap messages should be directed. A pointer is used for this parameter to allow sharing the same destination address between multiple monitor calls. The pointer must point to static storage.
c_index	Community table index. This is the value returned by **snmp_add_community()**, or may be **SNMP_TRAPDEST** for the predefined default trap destination community.
trap_num	Trap number to use. This must be ≥0. Negative numbers are reserved for SNMP predefined trap types. Otherwise, generic traps are sent.
noids	Number of MIB tree indices in the following list (may be zero). This must be less than or equal **SNMP_MAX_BINDINGS**.
indices	Array of MIB tree indices. Each element in this array is the MIB tree index of an object to send with the trap message. Tree indices may be obtained using **snmp_last_index()** and other MIB functions.

RETURN VALUE

-1: Insufficient room in monitor table.

-2: Inappropriate object specified for monitoring (i.e., it is not an integer type). This will only be returned if **SNMP_DEBUG** is defined, otherwise the check is not performed.

0..**SNMP_MAX_MONITOR**-1: The monitor table index used for this object

LIBRARY

SNMP.LIB

SEE ALSO

snmp_unmonitor, snmp_trap

snmp_print_tree

```
void snmp_print_tree( void );
```

DESCRIPTION

Debugging function only. Prints entire MIB tree. Leaf nodes are printed with their OID number and value. Non-leaf nodes are printed with their OID fragment suffixed with '.'. For simplicity, this function recurses.

LIBRARY

MIB.LIB

snmp_set_access

```
snmp_parms *snmp_set_access( snmp_parms *p, byte rm, byte wm );
```

DESCRIPTION

Set the read and write masks for access control of the next object to be added. Read/write masks are only applicable if SNMP is used. The functions in this library for accessing objects do not apply the access masks. This remains in effect for all further additions until changed by a new call to **snmp_set_access()**.

The **rm** and **wm** are bit 8-bit bitmasks. A bit "n" is set if the communities whose access mask have the "n"th bit set are allowed to access the object in that mode (read or write). By default, bit 0 is set for the PUBLIC community's access mask and bit 1 is set for the PRIVATE community. Typically, objects are created with **rm** = 3 and **wm** = 2, giving both public and private read access, but only private has write access.

PARAMETERS

p	Pointer to parameter structure to set. If **NULL**, does nothing but return **NULL**.
rm	Read access mask.
wm	Write access mask.

RETURN VALUE

Returns **p** unless **p** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms

snmp_set_callback

```
snmp_parms * snmp_set_callback( snmp_parms *p, snmp_callback cb );
```

DESCRIPTION

Set the callback function for the next object to be added. This remains in effect for all further additions until cancelled by passing **NULL** for the callback function.

Use of the callback function is described in the printed documentation. It is only applicable if SNMP is being used. The functions in **MIB.LIB** do not invoke the callback.

PARAMETERS

p	Pointer to parameter structure to set. If **NULL**, does nothing but return **NULL**.
cb	Pointer to callback function, or **NULL** to cancel.

RETURN VALUE

Returns **p** unless **p** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms

snmp_set_community

```
int snmp_set_community( word c_index, char *cname, byte mask );
```

DESCRIPTION

Changes the name (password string) and access mask for the community indexed by **c_index**.

PARAMETERS

c_index — Community table index. This is the value returned by **snmp_add_community()**, or may be **SNMP_PUBLIC**, **SNMP_PRIVATE** or **SNMP_TRAPDEST** for the predefined default communities.

cname — Community name as a null-terminated string with maximum length of **SNMP_MAX_COMMUNITY_NAME**.

mask — Access mask. This specifies the access groups (one or more of 8 groups) to which this community belongs. Three groups are predefined:

- **SNMP_PUBLIC_MASK** - public group with read-only access
- **SNMP_PRIVATE_MASK** - private group with read/write access
- **SNMP_TRAPDEST_MASK** - trap group with no access.

RETURN VALUE

-1: the supplied index was outside the table bounds.
Otherwise, returns the **c_index** parameter.

LIBRARY

SNMP.LIB

SEE ALSO

snmp_add_community, snmp_set_dflt_communities, snmp_community_name, snmp_community_mask

snmp_set_dflt_communities

```
int snmp_set_dflt_communities( char *public, char *private, char
   *trapdest );
```

DESCRIPTION

Sets the name (i.e., password string) of the first 3 default communities. These communities are assigned the following access masks:

- public: **SNMP_PUBLIC_MASK** - read-only access
- private: **SNMP_PRIVATE_MASK** - read/write access
- trapdest: **SNMP_TRAPDEST_MASK** - no local access, used when sending traps to the network management agent.

This function should be called once, when the application is initialized.

All parameters are null-terminated strings, with a maximum length of **SNMP_MAX_COMMUNITY_NAME**.

PARAMETERS

public	Public access password.
private	Private access password.
trapdest	Trap password sent with trap messages.

RETURN VALUE

0

LIBRARY

SNMP.LIB

SEE ALSO

snmp_add_community, snmp_set_community, snmp_community_name, snmp_community_mask

snmp_set_foct

```
snmp_parms * snmp_set_foct( snmp_parms *p, char *s );
```

DESCRIPTION

Set the value of a fixed-length object. The OID of the object must be set in ***p**. If the object is not in fact a fixed-length binary object, then **NULL** will be returned and there will be no alteration of the value. **s** is always assumed to point to an area of storage of the required length.

See **snmp_set_int()** for other general considerations.

PARAMETERS

p	Parameter structure that was previously initialized by calls to **snmp_init_parms()**, **snmp_set_stem()** etc.
s	New value for the object.

RETURN VALUE

NULL if **p** was **NULL**, or if there is no object with the given OID, or if the object was not stored with "foct" internal type. Otherwise, returns **p**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_stem, snmp_get_indexed, snmp_get, snmp_add, snmp_xadd, snmp_set_int, snmp_set_long, snmp_set_oct, snmp_set_str, snmp_set_objectID

snmp_set_int

```
snmp_parms * snmp_set_int( snmp_parms *p, int i );
```

DESCRIPTION

Set the value of a short integer object. The OID of the object must be set in ***p**. If the object is not in fact a short integer, then **NULL** will be returned and there will be no alteration of the value. The object may reside in either root or xmem data space.

This function only needs to be called when the address of the object itself is not known. Typically, this would be in functions which perform general processing of MIB objects. If the address of the object is known, it is far more efficient to update the object directly.

PARAMETERS

p	Parameter structure that was previously initialized by calls to **snmp_init_parms()**, **snmp_set_stem()** etc.
i	New value for the object.

RETURN VALUE

NULL if **p** was **NULL**, or if there is no object with the given OID, or if the object was not stored with short integer internal type. Otherwise, returns **p**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_stem, snmp_get_indexed, snmp_get, snmp_add, snmp_xadd, snmp_set_long, snmp_set_str, snmp_set_oct, snmp_set_foct, snmp_set_objectID

snmp_set_long

```
snmp_parms * snmp_set_long( snmp_parms *p, long L );
```

DESCRIPTION

Set the value of a long integer object. The OID of the object must be set in ***p**. If the object is not in fact a long integer, then **NULL** will be returned and there will be no alteration of the value.

See **snmp_set_int()** for other general considerations.

PARAMETERS

p	Parameter structure that was previously initialized by calls to **snmp_init_parms()**, **snmp_set_stem()** etc.
L	New value for the object.

RETURN VALUE

NULL if **p** was **NULL**, or if there is no object with the given OID, or if the object was not stored with long integer internal type. Otherwise, returns **p**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_stem, snmp_get_indexed, snmp_get, snmp_add, snmp_xadd, snmp_set_int, snmp_set_str, snmp_set_oct, snmp_set_foct, snmp_set_objectID

snmp_set_objectID

```
snmp_parms *snmp_set_objectID( snmp_parms *p, snmp_oid *oid );
```

DESCRIPTION

Set the value of an object-ID object. The OID of the object must be set in ***p**. If the object is not in fact an OID, then **NULL** will be returned and there will be no alteration of the value.

See **snmp_set_int()** for other general considerations.

PARAMETERS

p	Parameter structure that was previously initialized by calls to **snmp_init_parms()**, **snmp_set_stem()** etc.
oid	New value for the object.

RETURN VALUE

NULL if **p** was **NULL**, or if there is no object with the given OID, or if the object was not stored with object-ID internal type. Otherwise, returns **p**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_stem, snmp_get_indexed, snmp_get, snmp_add, snmp_xadd, snmp_set_int, snmp_set_str, snmp_set_oct, snmp_set_foct, snmp_set_long

snmp_set_oct

```
snmp_parms * snmp_set_oct( snmp_parms *p, word len, char *s );
```

DESCRIPTION

Set the value of a variable-length object. The OID of the object must be set in ***p**. If the object is not in fact an octet string, then **NULL** will be returned and there will be no alteration of the value. If **len** is too long for the specified maximum storage length for this object, the data is truncated to fit.

See **snmp_set_int()** for other general considerations.

PARAMETERS

p	Parameter structure that was previously initialized by calls to **snmp_init_parms()**, **snmp_set_stem()** etc.
len	New length for the object.
s	New value for the object. This points to the actual object data, not the 2-byte length prefix.

RETURN VALUE

NULL if **p** was **NULL**, or if there is no object with the given OID, or if the object was not stored with variable length octet string type. Otherwise, returns **p**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_stem, snmp_get_indexed, snmp_get, snmp_add, snmp_xadd, snmp_set_int, snmp_set_long, snmp_set_str, snmp_set_foct, snmp_set_objectID

snmp_set_oid

```
snmp_oid * snmp_set_oid( snmp_oid *oid, word len, char *eos );
```

DESCRIPTION

This function is identical to **snmp_set_stem()**, except that it uses an **snmp_oid** structure. See documentation for **snmp_set_stem()**.

PARAMETERS

oid	Pointer to **snmp_oid** structure to set. If **NULL**, does nothing but return **NULL**.
len	Length of **eos**.
eos	Encoded OID string.

RETURN VALUE

Returns **oid** unless the OID string is too long to fit in the **snmp_oid** structure in which case **NULL** is returned. If **oid** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_append_oid, snmp_set_parse_oid, snmp_set_stem

snmp_set_parse_oid

```
snmp_oid * snmp_set_parse_oid( snmp_oid *oid, char *name );
```

DESCRIPTION

This function is identical to **snmp_set_parse_stem()**, except that it uses an **snmp_oid** structure. See documentation for **snmp_set_parse_stem()**.

PARAMETERS

oid	Pointer to **snmp_oid** structure to set. If it is **NULL**, does nothing but return **NULL**.
name	OID string in dotted decimal notation e.g., "43.6.1"

RETURN VALUE

Returns **oid** unless the OID string is too long to fit in the **snmp_oid** structure in which case **NULL** is returned. If **oid** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_append_oid, snmp_set_parse_stem, snmp_set_stem

snmp_set_parse_stem

```
snmp_parms * snmp_set_parse_stem( snmp_parms *p, char *name );
```

DESCRIPTION

If **p** is not **NULL**, set the OID stem in ***p** to the OID expressed in dotted decimal notation in name. This function is easier to use than **snmp_set_stem()**, but has the disadvantage of being less efficient. Apart from the method of expressing the OID, the semantics are identical to **snmp_set_stem()**.

PARAMETERS

p	Pointer to parameter structure to set. If **NULL**, does nothing but return **NULL**.
name	OID string in dotted decimal notation e.g., "43.6.1"

RETURN VALUE

Returns **p** unless the OID string is too long to fit in the parameter structure in which case NULL is returned. If **p** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_set_parse_oid

snmp_set_stem

```
snmp_parms *snmp_set_stem( snmp_parms *p, word len, char *eos);
```

DESCRIPTION

If **p** is not **NULL**, the OID stem is set to the encoded OID string specified by **eos** (with length **len**). **eos** must be a fully qualified OID, encoded using the internal representation (RLER).

RLER encoding is performed as follows: each OID level is an unsigned number between 0 and 2^{32}-1 inclusive. Reading from left to right, each level is encoded and written left to right. If the level is less than 254, it is written as a single byte with that value. Otherwise, if it is less than 65536, it is written as 0xFE yy zz 0xFE where yy is the MSB of the 16-bit value and zz is the LSB. Otherwise the number is ≥ 65536 and it is written as 6 bytes: 0xFF ww xx yy zz 0xFF where ww is the MSB of the 32-bit number and zz is the LSB. The total length of the constructed string is passed in len.

Note that there are other functions which provide easier ways of setting the object ID in the parameter structure.

This function, and related functions, serve the purpose of setting the "current object identifier" in the parameter structure. This is necessary for other functions, such as **snmp_add_int()**, which need to know the applicable object identifier.

PARAMETERS

p	Pointer to parameter structure to set. If **NULL**, does nothing but return **NULL**.
len	Length of **eos**.
eos	Encoded OID string.

RETURN VALUE

Returns **p** unless the OID string is too long to fit in the parameter structure in which case **NULL** is returned. If **p** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_append_stem, snmp_set_parse_stem, snmp_set_oid

snmp_set_str

```
snmp_parms * snmp_set_str( snmp_parms *p, char *s );
```

DESCRIPTION

Set the value of an ascii string object. The OID of the object must be set in ***p**. If the object is not in fact a string, then **NULL** will be returned and there will be no alteration of the value. If the string is too long for the specified maximum storage length for this object, then the string is truncated to fit. This may result in the object having no null terminator.

See **snmp_set_int()** for other general considerations.

PARAMETERS

p	Parameter structure that was previously initialized by calls to **snmp_init_parms()**, **snmp_set_stem()** etc.
s	New value for the object.

RETURN VALUE

NULL if **p** was **NULL**, or if there is no object with the given OID, or if the object was not stored with string internal type. Otherwise, returns **p**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_append_stem, snmp_get_indexed, snmp_get, snmp_add, snmp_xadd, snmp_set_int, snmp_set_long, snmp_set_oct, snmp_set_foct, snmp_set_objectID

snmp_start

```
int snmp_start( void );
```

DESCRIPTION

Restart the SNMP subsystem after calling `snmp_stop()`.

RETURN VALUE

0

LIBRARY

SNMP.LIB

SEE ALSO

snmp_stop

snmp_stop

```
int snmp_stop( void );
```

DESCRIPTION

Temporarily suspends network access to the SNMP subsystem. Incoming SNMP messages are received but ignored while in the stopped state. If the stopped state is maintained for less than about 1 second, then external agents will retransmit the request. Otherwise, they may give up.

This function is used when there is a substantial amount of MIB tree processing to be performed locally, and it is also desired to prevent asynchronous access to the MIB tree (e.g., to prevent race conditions).

RETURN VALUE

0

LIBRARY

SNMP.LIB

SEE ALSO

snmp_start

snmp_time_since

```
longword snmp_time_since( longword epoch );
```

DESCRIPTION

Return the number of SNMP “timeticks” elapsed since a specified “epoch.”

PARAMETERS

epoch	The reference epoch. This should be a value obtained by a previous call to **snmp_timeticks()**.

RETURN VALUE

Number of 1/100 second intervals since `epoch`. This value counts from 0 to 2^{31}-1, then wraps around to zero.

LIBRARY

`SNMP.LIB`

SEE ALSO

`snmp_timeticks`

snmp_timeticks

```
longword snmp_timeticks( void );
```

DESCRIPTION

Return the current SNMP "timeticks" count.

RETURN VALUE

Number of 1/100 second intervals since the application started. This value counts from 0 to 2^{31}-1, then wraps around to zero.

LIBRARY

`SNMP.LIB`

SEE ALSO

`snmp_time_since`

snmp_trap

```
int snmp_trap( longword ipaddr, word c_index, int trap_num,
   word noids, word *indices );
```

DESCRIPTION

Send an SNMPv1 trap message. Traps are unsolicited messages sent to a network management agent, for example to inform the agent about an unusual condition. Traps are not delivered reliably, i.e., the message may be lost in the network. There is no acknowledgement of trap receipt by the agent.

You must **#define SNMP_TRAPS** to use this function.

PARAMETERS

ipaddr	IP address of network management agent.
c_index	Community table index. This is the value returned by **snmp_add_community()**, or may be **SNMP_TRAPDEST** for the predefined default trap destination community.
trap_num	Trap number to use. This must be ≥ 0. Negative numbers are reserved for SNMP predefined trap types. Otherwise, generic traps are sent.
noids	Number of MIB tree indices in the following list (may be zero). This must be less than or equal **SNMP_MAX_BINDINGS**.
indices	Array of MIB tree indices. Each element in this array is the MIB tree index of an object to send with the trap message. Tree indices may be obtained using **snmp_last_index()** and other MIB functions.

RETURN VALUE

-1: error, trap not sent because there was an error constructing the message (probably because too many or too long variables were specified), or because the message could not be sent using UDP. Otherwise, length of constructed message returned.

LIBRARY

SNMP.LIB

SEE ALSO

snmp_monitor

snmp_unmonitor

```
int snmp_unmonitor( word index );
```

DESCRIPTION

Stop monitoring the object that was previously monitored by **snmp_monitor()**. This function must be used if the object being monitored is to be deleted from the MIB tree.

You must **#define SNMP_TRAPS** to use this function.

PARAMETERS

index MIB tree index of the object to unmonitor.

RETURN VALUE

-1: the object is not currently being monitored.

Otherwise returns the monitor table index.

LIBRARY

SNMP.LIB

SEE ALSO

snmp_monitor, snmp_trap

snmp_up_oid

```
snmp_oid * snmp_up_oid( snmp_oid *oid, word levels );
```

DESCRIPTION

This function is identical to snmp_up_stem, except that it uses an **snmp_oid** structure. See documentation for **snmp_up_stem()**.

PARAMETERS

oid	Pointer to **snmp_oid** structure to set. If **NULL**, does nothing but return **NULL**.
levels	Number of levels to truncate on right of current OID. If this is greater than the current number of levels, the OID is set to empty.

RETURN VALUE

Returns oid unless **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_up_stem

snmp_up_stem

```
snmp_parms * snmp_up_stem( snmp_parms *p, word levels );
```

DESCRIPTION

Truncate the last n levels in the OID currently set in `*p`. This move "up" towards the first level in the OID.

PARAMETERS

p	Pointer to parameter structure to set. If **NULL**, does nothing but return **NULL**.
levels	Number of levels to truncate on right of current OID. If this is greater than the current number of levels, the OID is set to empty.

RETURN VALUE

Returns **p** unless **p** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem

snmp_used

```
long snmp_used( void );
```

DESCRIPTION

Obtain information about the amount of memory used by the MIB tree. The value returned may be used as the setting for **SNMP_MIB_SIZE** if the application does not dynamically add objects during normal execution.

RETURN VALUE

Number of bytes of xmem currently used by the MIB tree.

LIBRARY

MIB.LIB

snmp_xadd

```
snmp_parms * snmp_xadd( snmp_parms *p, char *n, word type, long xs,
   word maxlen );
```

DESCRIPTION

This function is identical to **snmp_add()**, except that the object resides in xmem storage. Instead of a **void *** address, an xmem (20-bit linear) address is stored.

In common with **snmp_add()**, there is also a set of macros, the use of which may result in cleaner code. The macro names are identical to those for **snmp_add**, except that the names all start with "snmp_xadd."

PARAMETERS

p	Pointer to parameter structure to set. If **NULL**, does nothing but return **NULL**.
n	Optional extra OID level to temporarily append to the OID in ***p**. If -1, this is not done. Otherwise, the level is appended; the value added; then the extra level removed. It is not possible to specify OID levels greater than 2^{31}-1.
type	Type of value to add. See description in snmp_add().
xs	xmem address of the actual object in xmem data storage. The same considerations apply to this address as they do for the near pointers used by **snmp_add()**.
maxlen	Maximum permissible length of the object.

RETURN VALUE

Returns **p** unless **p** is **NULL** on entry, then nothing is done except to return **NULL**.

LIBRARY

MIB.LIB

SEE ALSO

snmp_init_parms, snmp_set_stem, snmp_set_parse_stem, snmp_append_stem, snmp_append_parse_stem, snmp_set_access, snmp_set_callback, snmp_up_stem, snmp_add, snmp_delete, snmp_get, snmp_last_index

13. TELNET

The library Vserial.lib implements the telecommunications network interface known as telnet. The implementation is a telnet-to-serial and serial-to-telnet gateway. This chapter is divided into two parts. The first part describes the library from Dynamic C version 7.05 and later. The second part describes the library prior to 7.05.

13.1 Telnet (Dynamic C 7.05 and Later)

This implementation is more general than the previous one. Any of the four serial ports can be used and other I/O streams can be added. Multiple connections are supported by the use of unique gateway identifiers.

13.1.1 Setup

To use a serial port, the circular buffers must be initialized. For instance, if serial port A is used by an application, then the following macros must be defined in the program:

```
#define AINBUFSIZE   31
#define AOUTBUFSIZE  31
```

It might be necessary to have bigger buffers for some applications.

13.1.1.1 Low-Level Serial Routines

A table to hold the low-level I/O routines must be defined as type VSerialSpec.

```
typedef struct {
   int id;                 // unique ID to match with calls to listen/open
   int (*open)();          // serial port routines, or
   int (*close)();         // serial port compatible routines.
   int (*tick)();
   int (*rdUsed)();
   int (*wrFree)();
   int (*read)();
   int (*write)();
} VSerialSpec;
```

For each serial port A, B, C and D, there is a pre-defined macro in VSERIAL.LIB:

```
#define VSERIAL_PORTA(id) { (id), serAopen, serAclose, NULL,
   serArdUsed, serAwrFree, serAread, serAwrite }
```

The parameter passed to VSERIAL_PORTA is the unique gateway identifier mentioned earlier. This value is chosen by the developer when entries are made to the array of type VSerialSpec (also known as the spec table).

Dynamic C 9.21 includes support for serial ports E and F on all Rabbit 3000 based boards.

13.1.1.2 Configuration Macros

VSERDIAL_DEBUG

Turns on debug messages.

VSERIAL_NUM_GATEWAYS

The number of telnet sessions must be defined and must match the number of entries in the spec table.

13.1.2 API Functions (Dynamic C 7.05 and Later)

The following functions compose the latest telnet API. A sample program demonstrating their use is available at Samples\tcpip\telnet\vserial.c.

vserial_close

```
int vserial_close( int id );
```

DESCRIPTION

Closes the specified gateway. This will not only terminate any network activity, but will also close the serial port.

PARAMETERS

id	ID of the gateway to change, as specified in the spec table.

RETURN VALUE

0: Success.
1: Failure.

LIBRARY

VSERIAL.LIB

vserial_init

```
int vserial_init ( void );
```

DESCRIPTION

Initializes the daemon and parses the spec table.

RETURN VALUE

0: Success;
1: Failure.

LIBRARY

VSERIAL.LIB

vserial_keepalive

```
int vserial_keepalive ( int id, long timeout );
```

DESCRIPTION

This function sets the keepalive timer to generate TCP keepalives after **timeout** periods of inactivity. This helps detect if the connection has gone bad.

Keepalives should be used at the application level, but if that is not possible, then timeout should be set so as to not overload the network. The standard timeout is two hours, and should be set sooner than that only for a Very Good Reason.

PARAMETERS

id	Unique gateway identifier.
timeout	Number of seconds of inactivity allowed before a TCP keepalive is sent. A value of 0 shuts off keepalives.

RETURN VALUE

0: Success.
1: Failure.

LIBRARY

VSERIAL.LIB

vserial_listen

```
int vserial_listen( int id, long baud, int port, long remote_host,
   int flags );
```

DESCRIPTION

Listens on the specified port for a telnet connection. The gateway process is started when a connection request is received. On disconnect, re-listen happens automatically.

PARAMETERS

id	ID of the gateway to change, as specified in the spec table.
baud	The parameter to send to the `open()` serial port command; it's usually the baud rate.
port	The local TCP port to listen on.
remote_host	The remote host from whom to accept connections, or 0 to accept a connection from anybody.
flags	Option flags for this gateway. Currently the only valid bit flags are `VSERIAL_COOKED` to strip out telnet control codes, or 0 to leave it a raw data link.

RETURN VALUE

`0`: Success.
`1`: Failure.

LIBRARY

`VSERIAL.LIB`

vserial_open

```
int vserial_open( int id, long baud, int port, long remote_host, int
   flags, long retry );
```

DESCRIPTION

Opens a connection to a remote host and maintains it, starting the gateway process.

PARAMETERS

id	ID of the gateway to change, as specified in the spec table.
baud	The parameter to send to the `open()` serial port command; it's usually the baud rate.
port	The TCP port on the remote host to connect to.
remote_host	The remote host to connect to.
flags	Option flags for this gateway. Currently the only valid bit flags are `VSERIAL_COOKED` to strip out telnet control codes, or 0 to leave it a raw data link.
retry	The retry time-out, in seconds. When a connection fails, or if the connection was refused, we will wait this number of seconds before retrying.

RETURN VALUE

`0`: Success.
`1`: Failure.

LIBRARY

VSERIAL.LIB

vserial_tick

```
int vserial_tick( void );
```

DESCRIPTION

Runs the telnet daemon - must be called periodically.

RETURN VALUE

`0`: Success;
`1`: Failure.

But call it periodically no matter the return value! An error message can be seen when 1 is returned if you define `VSERIAL_DEBUG` at the top of your program.

LIBRARY

`VSERIAL.LIB`

13.2 Telnet (pre-Dynamic C 7.05)

The API available for telnet changed with Dynamic C version 7.05. This is the old API

13.2.1 Configuration Macros

SERIAL_PORT_SPEED

The baud rate of the serial port. Defaults to 115,200 bps.

TELNET_COOKED

`#define` this to have telnet control codes stripped out of the data stream.

This is useful if you are actually telneting to the device from another box. It should not be defined if you are using two devices as a transparent bridge over the Ethernet.

13.2.2 API Functions

---

telnet_init

```
int telnet_init( int which, longword addy, int port );
```

DESCRIPTION

Initializes the connection. This function must not be called by an application program starting with Dynamic C 7.05.

PARAMETERS

which	Is one of the following: TELNET_LISTEN—Listens on a port for incoming connections. TELNET_RECONNECT—Connects to a remote host, and reconnects if the connection dies. TELNET_CONNECT—Connects to a remote host, and terminates if the connection dies.
addy	IP address of the remote host, or 0 if we are listening.
port	Port to bind to if we are listening, or the port of the remote host to connect to.

RETURN VALUE

0: Success.
1: Failure.

LIBRARY

VSERIAL.LIB

telnet_tick

```
int telnet_tick( void );
```

DESCRIPTION

Must be called periodically to run the daemon.

RETURN VALUE

`0`: Success (call it again);
`1`: Failure; `TELNET_CONNECT` died, or a fatal error occurred.

LIBRARY

`VSERIAL.LIB`

telnet_close

```
void telnet_close( void );
```

DESCRIPTION

Terminates any connections currently open, and shuts down the daemon.

LIBRARY

`VSERIAL.LIB`

13.2.3 An Example Telnet Server

The following code implements a telnet server. It listens on well-known port 23 for a connection request. Data is passed transparently via serial port C.

```
#define MY_IP_ADDRESS "10.10.6.105"
#define MY_NETMASK "255.255.255.0"
#define MY_GATEWAY "10.10.6.19"
#define MY_NAMESERVER "10.10.6.19"

#define SERIAL_PORT_SPEED 115200              // Set serial port speed.

#undef TELNET_COOKED                          // This is a raw data port.

#memmap xmem
#use "dcrtcp.lib"
#use "vserial.lib"

#define SERVER_PORT 0                         // Defaults to port 23.

main() {
   sock_init();                               // Initialize stack.

   telnet_init(TELNET_LISTEN,0,SERVER_PORT);  // Initialize server

   while(!telnet_tick())                   // Run server; this is non-block-
ing
        continue;

   telnet_close();                         // Error, close telnet connection
}
```

13.2.4 An Example Telnet Client

This sample code implements a client that can connect to the above telnet server.

```
#define MY_IP_ADDRESS "10.10.6.106"
#define MY_NETMASK "255.255.255.0"
#define MY_GATEWAY "10.10.6.19"
#define MY_NAMESERVER "10.10.6.19"

#define SERIAL_PORT_SPEED 115200  // Must match server.

#undef TELNET_COOKED
#memmap xmem
#use "dcrtcp.lib"
#use "vserial.lib"

#define SERVER_PORT 0          // Defaults to port 23; must match server.

#define REM_HOST "10.10.6.19" // Remote IP to connect to.

main() {
   sock_init();               // Initialize the stack

   // Tell the server to connect and reconnect if the connection is lost
   telnet_init(TELNET_RECONNECT,resolve(REM_HOST),SERVER_PORT);

   while(!telnet_tick())      // Run client; this is non-blocking
      continue;

   telnet_close();            // Error, close telnet connection
}
```

14. General Purpose Console

The library, `zconsole.lib,` implements a serial-based console that we call Zconsole. It can be used to:

- Configure a board.
- Upload and download web pages.
- Change web page variables without re-uploading the page.
- Send e-mail.
- Calls subsystem initialization for ARP, TCP, UDP and DNS (if applicable).

14.1 Zconsole Features

Recognizing that embedded control systems are wide-ranging in their requirements, `zconsole.lib` was designed with flexibility and extensibility in mind. Designers can choose the available functionality they want and leave the rest alone. Zconsole includes:

- Login name and password protection.
- Default and custom Zconsole commands.
- Default and custom error messages.
- Help text for Zconsole commands, including custom commands
- Multiple I/O streams that can be used simultaneously.
- A fail-safe backup system for configuration data.

14.1.1 File System Requirement

Prior to Dynamic C 7.30, an application program using Zconsole must include the lines:

```
#use "filesystem.lib"          // If using the improved file system available with
                               // DC 7.05, substitute “fs2.lib” for “filesystem.lib”
#use "zconsole.lib"
```

Starting with Dynamic C 7.30, using the file system is no longer necessary.

14.1.2 TCP/IP and Zconsole

Dynamic C TCP/IP functionality may be used by a Zconsole application program by including the statement

```
#use "dcrtcp.lib"
```

in the program. Other TCP/IP protocols may be added with #use statements of the appropriate libraries.

14.2 Login Name and Password

There is a sample program, `Samples\tcpip\LOGINCONSOLE.C`, that demonstrates the use of the login name/password functionality for Zconsole. Zconsole command functions: `con_loginname()`, `con_loginpassword()` and `con_logout()` are described in Section 14.4.1.1 starting on page 491. The structure that saves the name and password information can be backed up using the backup macro `CONSOLE_BACKUP_LOGIN`. Please see Section 14.7 starting on page 512 for details on the backup system.

14.3 Zconsole Commands and Messages

Zconsole is a command-driven application. A command is issued either at the keyboard using a terminal emulator or a command is generated and sent from an attached machine. Zconsole carries out the command, and either the message "OK" \r\n is returned, or an error is returned in the form of:

ERROR XXXX This is an error message.\r\n

Note that the carriage return and new line characters (\r\n) are always returned by Zconsole whether the command completed successfully or not.

14.3.1 Zconsole Command Data Structure

The command system is set up at compile time with an array of `ConsoleCommand` structures. There is one array entry for each command recognized by Zconsole.

```
typedef struct {
   char *command;
   int (*cmdfunc)();
   long helptext;
} ConsoleCommand
```

`command`

This field is a string like the following: "SET MAIL FROM." That is, each word of the command is separated by a space. The case of the command does not matter. Entering this string is how the command is invoked.

`cmdfunc`

This field is a function pointer to the function that implements the command. The functions that come with Zconsole are listed in Section 14.4.1.1 on page 491.

helptext

This field points to a text file. The text file contains help information for the associated command. When HELP COMMAND is entered, this text file (the help information for COMMAND) will be printed to Zconsole. The help text comes from #ximported text files.

14.3.1.1 Help Text for General Cases

There are two cases in Zconsole.lib where help text is needed, but is not associated with a particular command. It is still necessary to allocate a ConsoleCommand structure to access the help text. The first case is the help overview given when HELP is entered by itself. The command field should be "" and the cmdfunc field should be NULL.

```
{ "", NULL, help_txt },
```

The second case is HELP SET. This is an overview of the family of SET commands, i.e., commands that set configuration values. For HELP SET, the command field should be "SET" and the cmdfunc field should be NULL.

```
{ "SET", NULL, help_set_txt },
```

This second case illustrates the general case of displaying help for a family of commands. The family name can not be the name of a command.

14.4 Zconsole Command Array

An array of ConsoleCommand structures must be defined in an application program as a constant global variable named console_commands[]. All commands available at the console, those provided in Zconsole.lib and custom commands, must have an entry in this array.

14.4.1 Zconsole Commands

The following is an example of a list of commands that may be defined in a Zconsole application. When the command name, i.e., the string in the `command` field, is received by the console, the function pointed to in the `cmdfunc` field is executed. When the console receives the command, **`HELP`** <command name>, the text file located at physical address `helptext` will be displayed.

```
const ConsoleCommand console_commands[] =
{
   { "HELLO WORLD", hello_world, 0 },
   { "ECHO", con_echo, help_echo_txt },
   { "HELP", con_help, help_help_txt },
   { "", NULL, help_txt },
   { "SET", NULL, help_set_txt },
   { "SET PARAM", con_set_param, 0 },
   { "SET IP", con_set_ip, help_set_txt },
   { "SET NETMASK", con_set_netmask, help_set_txt },
   { "SET GATEWAY", con_set_gateway, help_set_txt },
   { "SET NAMESERVER", con_set_nameserver, help_set_txt },
   { "SET MAIL", NULL, help_set_mail_txt },
   { "SET MAIL SERVER", con_set_mail_server, help_set_mail_server_ txt },
   { "SET MAIL FROM", con_set_mail_from, help_set_mail_from_txt },
   { "SHOW", con_show, help_show_txt },
   { "PUT", con_put, help_put_txt },
   { "GET", con_get, help_get_txt },
   { "DELETE", con_delete, help_delete_txt },
   { "LIST", NULL, help_list_txt },
   { "LIST FILES", con_list_files, help_list_txt },
   { "LIST VARIABLES", con_list_variables, help_list_txt },
   { "CREATEV", con_createv, help_createv_txt },
   { "PUTV", con_putv, help_putv_txt },
   { "GETV", con_getv, help_getv_txt },
   { "MAIL", con_mail, help_mail_txt },
   { "RESET FILES", con_reset_files, 0 }
   { "RESET VARIABLES”, con_reset_variables, help_reset_variables }
};
```

14.4.1.1 Default Command Functions

The following functions are provided in `Zconsole.lib`. Each one takes a pointer to a `ConsoleState` structure as its only parameter, following the prototype for custom functions described in Section 14.4.1.2 on page 496. Each of these functions return `0` when it has more processing to do (and thus will be called again), `1` for successful completion of its task, and `-1` to report an error.

Parameters needed by the commands using these functions are passed on the command line.

con_add_nameserver()

This function adds a name server to the list of name servers (unlike `con_set_nameserver()` that clears the list of name servers and adds one name server). A command that use this function takes one parameter: the IP address of the name server in dotted quad notation.

con_createv()

This function creates a variable that can be used with SSI commands in SHTML files. Certain SSI commands can be replaced by the value of this variable, so that a web page can be dynamically altered without re-uploading the entire page. Note, however, that the value of the variable is not preserved across power cycles, although the variable entry is still preserved. That is, the value of the variable may change after a power cycle. It can be changed again, though, with a `putv` command. It works in the following fashion (if the command is called “CREATEV”):

```
usage: "createv <varname> <vartype> <format> <value> [strlen]"
```

A web variable that can be referenced within web files is created.

`<varname>` is the name of the variable

`<vartype>` is the type of the variable (`INT8`, `INT16`, `INT32`, `FLOAT32`, or `STRING`)

`<format>` is the printf-style format specifier for outputting the variable (such as "%d")

`<value>` is the value to assign the variable.

`[strlen]` is only used if the variable is of type `STRING`. It is used to give the maximum length of the string.

con_delete()

This function deletes a file from the file system. A command that uses this function takes one parameter: the name of the file to delete.

con_echo()

This function turns on or off the echoing of characters on a particular I/O stream. That is, it does not affect echoing globally, but only for the I/O stream on which it is issued. A command that uses this function takes one parameter: ON | OFF.

con_get()

This function displays a file from the file system. It works in the following fashion (if the command is called “GET”):

- ASCII mode: usage: "get <filename>"

  The file is then sent, followed by the usual OK message.

- BINARY mode: usage: "get <filename> <size in bytes>"

  The message "LENGTH <len>" will be sent, indicating length of the file to be sent, and then the file will be sent, but not more than <size in bytes> bytes.

con_getv()

This function displays the value of the given variable. The variable is displayed using the printf-style format specifier given in the `createv` command. A command that uses this function takes one parameter: the name of the variable.

con_help()

This function implements the help system for Zconsole. A command that uses this function takes one parameter: the name of another command. Zconsole outputs the associated help text for the requested command. The help text is the text file referenced in the third field of the `ConsoleCommand` structure.

con_list_files()

This function lists the files in the file system and their file sizes. A command that uses this function takes no parameters.

con_list_variables()

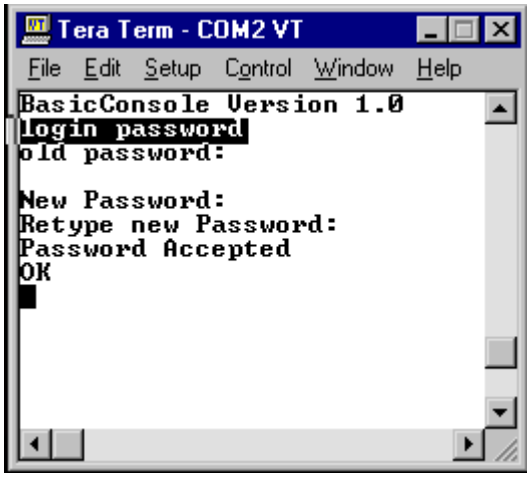
This function displays the names and types of all variables. A command that uses this function takes no parameters.

con_loginname()

This function stores an identifier that will be remembered across power cycles (with battery-backed RAM). The existence of the identifier will be used to prompt the user of a new console session. Before console access to the controller is allowed, a valid identifier must be entered in response to the prompt. A command that uses this function takes one parameter: an identifier that will be used as the login name.

con_loginpassword()

This function stores an identifier that will be remembered across power cycles (with battery-backed RAM). The existence of the identifier will be used to prompt the user for a password after a login name has been entered. Before console access to the controller is allowed, a valid identifier must be entered in response to the prompt. A command that uses this function takes no parameters on the command line, but requires a series of user inputs in response to prompts. In the following screen shot, the command is named "login password," and is typed in by the user. All other screen text shown here was printed by Zconsole.



If no identifier is stored for the password, a <CR> must be sent in response to the prompt for the old password.

> **NOTE:** A login name must be stored by a command using `con_loginname()` for a login password to be applicable, i.e., if a password has been stored but no login name, new console sessions will not prompt for the password or a login name. If a login name is applicable, but there is no password, new console sessions will prompt for the login name and grant access after a valid name is entered without prompting for a password.

con_logout()

This function exits the current console session and begins a new session by entering the initialization state of Zconsole. A command that uses this function takes no parameters.

con_mail()

This function sends e-mail to the server specified by `con_mail_server()`, with the return address specified by `set_mail_from()`. A command that uses this function takes one parameter: the destination e-mail address. If the command is named mail, the usage is:

```
"mail destination@where.com"
```

The first line of the message will be used as the subject, and the other lines are the body. The body is terminated with a ^D or ^Z (0x04 or 0x1A).

con_put()

This function creates a new file in the file system for use with the HTTP server. It works in the following fashion (if the command is called “PUT”):

- ASCII mode: usage: "put <filename>"
  The file is then sent, terminating with a ^D or ^Z (0x04 or 0x1A).
- BINARY mode: usage: "put <filename> <size in bytes>"
  The file is then sent, and must be exactly the specified number of bytes in length.

Note that ASCII mode is only useful for text files, since the console will ignore non-displayable characters. In binary mode, the put command will time out after `CON_TIMEOUT` seconds of inactivity (60 by default).

con_putv()

This function updates the value of a variable. A command that uses this function takes two parameters: the name of the variable, and the new value for the variable.

con_reset_files()

This function removes all web files.

con_reset_variables()

This function removes all web variables.

con_set_dhcp()

This function turns DHCP configuration for an interface "on" or "off." Currently this command only works with the default interface. After DHCP has been turned on, ZConsole will undertake reacquiring the lease should it be dropped. (For example, a lease might be dropped if the DHCP server is unavailable for an extended period of time.)

con_set_gateway()

This function changes the gateway of the board. A command that uses this function takes one parameter: the new gateway in dotted quad notation, e.g., 192.168.1.1.

con_set_icmp_config()

This function configures an interface to use directed ICMP echo request (ping) packets for configuration. A command that uses this function takes two parameters. The first is "on" or "off" to turn this feature on or off. The second parameter is optional, and specifies the intended interface (ETH0 or ETH1). Only non-PPPoE Ethernet may be used for ping configuration.

con_set_icmp_config_reset()

Normally, when an interface has been configured via a directed ping packet, further configuration via a directed ping packet is disabled (until the next power cycle). This function allows the interface to be configured via a ping packet again. A command that uses this function takes an optional interface argument (ETH0 or ETH1).

con_set_ip()

This function changes the IP address of the board. A command that uses this function takes one parameter: the new IP address in dotted quad notation, e.g., 192.168.1.112.

con_set_param()

This function sets the parameter for the current I/O device. Depending on the I/O device, this value could be a baud rate, a port number or a channel number. A command that uses this function takes one parameter: the value for the I/O device parameter.

con_set_mail_from()

This function sets the return address for all e-mail messages. This address will be added to the outgoing e-mail and should be valid in case the e-mail needs to be returned. A command that uses this function takes one parameter: the return address.

con_set_mail_server()

This functions identifies the SMTP server to use. A command that uses this function takes one parameter: the IP address of the SMTP server.

con_set_nameserver()

This function changes the name server for the board. A command that uses this function takes one parameter: the IP address of the new name server in dotted quad notation, e.g., 192.168.1.1.

con_set_netmask()

This function changes the netmask of the board. A command that uses this function takes one parameter: the new netmask in dotted quad notation, e.g., 255.255.255.0.

con_set_tcpip_debug()

This function is intended to aid in development and debugging. A command that uses this function takes one parameter: the numerical level of debugging messages. The higher the number, the more verbose the TCP/IP debugging messages will be.

con_show()

This function displays the current configuration of the board (IP address, netmask, and gateway). If the developer's application has configuration options she would like to show other than the IP address, netmask, and gateway, she will probably want to implement her own version of the show command. The new show command can be modelled after `con_show()` in `ZConsole.lib`. A command that uses this function takes no parameters.

con_show_multi()

Like the `con_show()` function, this function shows the current console configuration. This command will, however, show more network configuration than is available via `con_show()`.

Interface-specific configuration information is separated out. A command that uses this function takes an optional parameter (ETH0, ETH1, PPP0, PPP1, PPP2, etc.) to display the interface specific configuration for the specified interface. If the optional parameter is missing, the current console configuration for all valid interfaces is displayed.

14.4.1.2 Custom Zconsole Commands

Developers are not limited to the default commands. A custom command is easy to add to Zconsole; simply create an entry for it in `console_commands[]`. The three fields of this entry were described in Section 14.3.1. The first field is the name of the command. The second field is the function that implements the command. This function must follow this prototype:

```
int function_name ( ConsoleState *state );
```

The parameter passed to the function is a structure of type `ConsoleState`. Some of the fields in this structure must be manipulated by your custom command function, other fields are used by `Zconsole.lib` and must not be changed by the your program.

```
typedef struct {
   int console_number;
   ConsoleIO *conio;
   int state;
   int laststate;

   char command[CON_CMD_SIZE];
   char *cmdptr;
   char buffer[CON_BUF_SIZE];    // Use for reading in data.
   char *bufferend;              // Use for reading in data.

   ConsoleCommand *cmdspec;
   int sawcr;
   int sawesc;
   int echo;                     // Check if echo is enabled, or change it.
   int substate;
   unsigned int error;
   int numparams;                // Number of parameters on command line.
   int commandparams;            // Number of commands issued on cmd line
   char cmddata[CON_CMD_DATA_SIZE];

#ifndef CON_NO_FS_SUPPORT        // File processing not needed with DC 7.30
   FileNumber filenum;           // Use for file processing.
   File file;                    // Use for file processing.
#endif

   int spec;                     // Use for working with Zserver entities
   long timeout;                 // Use for extending the time out.
} ConsoleState;

#endif
```

To accomplish its tasks, the function should use `state->substate` for its state machine (which is initialized to zero before dispatching the command handler), and `state->command` to read out the command buffer (to get other parameters to the command, for instance). In case of error, the function should set `state->error` to the appropriate value.

The buffer at `state->cmddata` is available for the command to preserve data across invocations of the command's state machine. The size of the buffer is adjustable via the `CON_CMD_DATA_SIZE` macro (set to 16 bytes by default). Generally this buffer area will be cast into a data structure appropriate for the given command state machine.

Both `state->numparams` and `state->commandparams` are read-only. The latter was introduced in Dynamic C 7.30. It indicates the number of arguments in the command line that are NOT part of the command name itself. For instance, for the command

```
SET IP 10.10.6.112 ETHO
```

`state->commandparams` would be 2, but `state->numparams` would be 4. This distinction is made to allow the commands in Zconsole to be insensitive to the number of words that make up the name of the command itself, but still maintain backwards compatibility with custom commands that use `state->numparams`.

The function that implements the custom command should return 0 when it has more processing to do (and thus will be called again), 1 for successful completion of its task, and -1 to report an error.

The third and final field of the `console_commands[]` entry is the physical address of the help text file for the custom command in question. This file must be `#ximport`ed, along with all of the default command function help files that are being used.

> **IMPORTANT:** The fields discussed in the previous paragraph and the fields that have comments in the structure definition are the only ones that an application program should change. The other fields must not be changed.

14.4.2 Zconsole Error Messages

`ZCONSOLE.LIB` provides a list of default error messages for the default Zconsole commands. An application program must define an array for these error messages, as well as for any custom error messages that are desired. To include only the default error messages, the following array is sufficient:

```
const ConsoleError console_errors[] = {
   CON_STANDARD_ERRORS                // includes all default error messages
}
```

14.4.2.1 Default Error Messages

These are the error codes for the default error messages and the text that will be displayed by the console if the error occurs.

```
#define CON_ERR_TIMEOUT           1
#define CON_ERR_BADCOMMAND        2
#define CON_ERR_BADPARAMETER      3
#define CON_ERR_NAMETOOLONG       4
#define CON_ERR_DUPLICATE         5
#define CON_ERR_BADFILESIZE       6
#define CON_ERR_SAVINGFILE        7
#define CON_ERR_READINGFILE       8
#define CON_ERR_FILENOTFOUND      9
#define CON_ERR_MSGTOOLONG       10
#define CON_ERR_SMTPERROR        11
#define CON_ERR_BADPASSPHRASE    12
#define CON_ERR_CANCELRESET      13
#define CON_ERR_BADVARTYPE       14
#define CON_ERR_BADVARVALUE      15
#define CON_ERR_NOVARSPACE       16
#define CON_ERR_VARNOTFOUND      17
#define CON_ERR_STRINGTOOLONG    18
#define CON_ERR_NOTAFILE         19
#define CON_ERR_NOTAVAR          20
#define CON_ERR_COMMANDTOOLONG   21
#define CON_ERR_BADIPADDRESS     22
#define CON_ERR_INVALIDPASSWORD  23
#define CON_ERR_BADIFACE         24
#define CON_ERR_BADNETWORKPARAM  25
```

```
#define CON_STANDARD_ERRORS \
{CON_ERR_TIMEOUT,         "Timed out." },\
{CON_ERR_BADCOMMAND,      "Unknown command." },\
{CON_ERR_BADPARAMETER,    "Bad or missing parameter." },\
{CON_ERR_NAMETOOLONG,     "Filename too long." },\
{CON_ERR_DUPLICATE,       "Duplicate object found." },\
{CON_ERR_BADFILESIZE,     "Bad file size." },\
{CON_ERR_SAVINGFILE,      "Error saving file." },\
{CON_ERR_READINGFILE,     "Error reading file." },\
{CON_ERR_FILENOTFOUND,    "File not found." },\
{CON_ERR_MSGTOOLONG,      "Mail message too long." },\
{CON_ERR_SMTPERROR,       "SMTP server error." },\
{CON_ERR_BADPASSPHRASE,   "Passphrases do not match!" },\
{CON_ERR_CANCELRESET,     "Reset cancelled." },\
{CON_ERR_BADVARTYPE,      "Bad variable type." },\
{CON_ERR_BADVARVALUE,     "Bad variable value." },\
{CON_ERR_NOVARSPACE,      "Out of variable space." },\
{CON_ERR_VARNOTFOUND,     "Variable not found." },\
{CON_ERR_STRINGTOOLONG,   "String too long." },\
{CON_ERR_NOTAFILE,        "Not a file." },\
{CON_ERR_NOTAVAR,         "Not a variable." },\
{CON_ERR_COMMANDTOOLONG, "Command too long." },\
{CON_ERR_BADIPADDRESS,    "Bad IP address." },
{CON_ERR_INVALIDPASSWORD, "Invalid Password.", },\
{CON_ERR_BADIFACE,         "Bad interface name." },\
{CON_ERR_BADNETWORKPARAM, "Error setting network parameter."}
```

14.4.2.2 Custom Error Messages

Developers can create their own error messages by following the format of the default error messages. The error code numbers should be greater than 1,000 to save room for expansion of built-in error messages.

```
#define NEW_ERROR 1001

const ConsoleError console_errors[] = {
   CON_STANDARD_ERRORS,      // includes all default error messages
   { NEW_ERROR, "Any error message I want." }
}
```

The default error messages should be included in `console_errors[]` along with any custom error messages that are used since the commands that come with `Zconsole.lib` each expect their own particular error message.

14.5 Zconsole I/O Interface

Multiple I/O methods are supported, as well as the ability to add custom I/O methods. An array of `ConsoleIO` structures must be defined in the application program and named `console_io[]`. This structure holds handlers for common I/O functions for the I/O method.

```
typedef struct {
   long param;         // Baud for serial, port for telnet, etc.
   int (*open) ();
   void (*close)();
   int (*tick) ();
   int (*puts) ();
   int (*rdUsed) ();
   int (*wrUsed) ();
   int (*wrFree) ();
   int (*read) ();
   int (*write) ();
} ConsoleIO;
```

14.5.1 How to Include an I/O Method

Each supported I/O method is determined at compile time, i.e., each supported I/O method must have an entry in `console_io[]`.

14.5.2 Predefined I/O Methods

Several predefined I/O methods are in `Zconsole.lib`. They will be included by entering their respective macros in `console_io[]`.

```
const ConsoleIO console_io[] = {
   CONSOLE_IO_SERA(baud rate),
   CONSOLE_IO_SERB(baud rate),
   CONSOLE_IO_SERC(baud rate),
   CONSOLE_IO_SERD(baud rate),
   CONSOLE_IO_SP(channel number),
   CONSOLE_IO_TELNET(port number),
}
```

The macros expand to the appropriate set of pre-defined handler functions, e.g.,

```
#define CONSOLE_IO_SERA(param) { param, serAopen, serAclose, NULL,
  conio_serAputs, serArdUsed, serAwrUsed, serAwrFree, serAread,
  serAwrite}
```

14.5.2.1 Serial Ports

There are predefined I/O methods for all four of the serial ports on a Rabbit board. The baud rate is set by passing it to the macro. See above.

14.5.2.2 Telnet

Zconsole runs a telnet server. The port number is passed to the macro `CONSOLE_IO_TELNET`. The user telnets to the controller that is running the console.

14.5.2.3 Slave Port

The Rabbit slave port is an 8-bit bidirectional data port. Zconsole runs on the slave processor. Two drivers are needed.

Slave Port Driver

The slave port driver is implemented by `SLAVE_PORT.LIB`. For an application to use the slave port:

- The driver must be installed by including the library in the program.
- A call to `SPinit(mode)` must be made to initialize the driver.
    - A function to process Zconsole commands sent to the slave port must be provided.

The slave port has 256 channels, separate port addresses that are independent of one another. A handler function for each channel that is used must be provided. For details on how to do this, please see the *Dynamic C User's Manual*.

A stream-based handler, `SPShandler()`, to process Zconsole commands for the slave is provided in `SP_STREAM.LIB`. The handler is set up automatically by the console when the slave port I/O method is included. The macro, `CONSOLE_IO_SP`, expands to the I/O functions defined in `SP_STREAM.LIB`.

Master Connected to Rabbit Slave Port

The master controller board can be another Rabbit processor or something else.

The master also needs a driver for its end of the slave port connection. An example of the software needed on the master is given in `MASTER_SERIAL.LIB`. The software on the master controller is, of course, specific to the task at hand. In the example driver provided, most of the work is done by the slave, making minimal changes necessary to the code on the master.

14.5.2.4 Custom I/O Methods

To define a custom I/O method, you must add a structure of type `ConsoleIO` to `console_io[]`. This structure holds the common handler functions for the I/O method. The tick function may have a `NULL` pointer, but the rest of the function pointers must be valid pointers to functions.

14.5.3 Multiple I/O Streams

Each I/O method has its own state machine in Zconsole. That means that each I/O method is independent of the others and they can all be used simultaneously. This imposes the important restriction that all command handlers be able to run simultaneously on different I/O streams or support proper locking for functions that cannot be performed simultaneously.

14.6 Zconsole Execution

Normally, Zconsole will communicate over a serial link. The physical connection will differ slightly from board to board. Basically, you will need a 3 wire (GND, RXD, TXD) serial cable. Several initialization steps must be taken at the beginning of an application program to execute the console.

14.6.1 File System Initialization

Prior to Dynamic C 7.30, Zconsole depended on the flash file system included with Dynamic C. There are actually two file systems: FS1 was the first Dynamic C file system. The second one, FS2 (introduced with Dynamic C 7.05), is an improved file system.

Besides defining the macro that directs the file system to EEPROM memory and including the appropriate library, i.e.,

```
#define FS_FLASH
#use "filesystem.lib"      // If using the improved file system available with
                           // Dynamic C 7.05, substitute “fs2.lib” for “filesystem.lib”
```

the application program must initialize the file system with a call to `fs_init()`. Starting with Dynamic C 7.30 none of this is necessary because Zconsole saves configuration information to the User block. See the designer’s handbook for your Rabbit processor (e.g., the *Rabbit 4000 Designer’s Handbook*) for more information about the User block.

14.6.2 Serial Buffers

If the pre-defined serial I/O methods are used, the circular buffers used for I/O data can be resized from their default values of 31 bytes by using macros. For example, if `CONSOLE_IO_SERIALC` is included in `console_io[]`, then lines similar to the following can be in the application program:

```
#define CINBUFSIZE 1023
#define COUTBUFSIZE 255
```

In general, these buffers can be smaller for slower baud rates, but must be larger for faster baud rates.

14.6.3 Using TCP/IP

To use the TCP/IP functionality of Zconsole you must have the following line in your application program:

```
#use “dcrtcp.lib”
```

If you are serving web pages you must also include `http.lib`, and if you are sending e-mail you must include `smtp.lib`.

14.6.4 Required Zconsole Functions

To run the console, the following two functions are required.

console_init

```
int console_init( void );
```

DESCRIPTION

This function will initialize Zconsole data structures. It must be called before `console_tick()` is called for the first time. This function also loads the configuration information from the file system.

RETURN VALUE

`0`: Success;
`1`: No configuration information found.
`<0:` Indicates an error loading the configuration data;
`-1` indicates an error reading the 1st set of information,
`-2` the 2nd set, and so on.

LIBRARY

`zconsole.lib`

console_tick

```
void console_tick( void );
```

DESCRIPTION

This function needs to be called periodically in an application program to allow Zconsole time for processing.

LIBRARY

`zconsole.lib`

14.6.5 Useful Zconsole Function

Most of the following functions are only useful for creating custom commands.

con_backup

```
int con_backup( void );
```

DESCRIPTION

This function backs up the current configuration.

RETURN VALUE

`0`: Success
`1`: Failure

LIBRARY

`zconsole.lib`

SEE ALSO

con_backup_reserve, con_load_backup

con_backup_bytes

```
long con_backup_bytes( void );
```

DESCRIPTION

Returns the number of bytes necessary for each backup configuration file. Note that enough space for two of these files needs to be reserved. This function is most useful when `ZCONSOLE.LIB` is being used with `FS2.LIB`.

RETURN VALUE

Number of bytes needed for a backup configuration file.

LIBRARY

`zconsole.lib`

SEE ALSO

con_backup_reserve

con_backup_reserve

```
void con_backup_reserve( void );
```

DESCRIPTION

Reserves space for the configuration information in the file system. For more information on the file system see the *Dynamic C User's Manual*.

LIBRARY

zconsole.lib

SEE ALSO

con_backup, con_load_backup, con_backup_bytes

con_chk_timeout

```
int con_chk_timeout( unsigned long timeout );
```

DESCRIPTION

Checks whether the given timeout value has passed.

RETURN VALUE

0: Timeout has not passed
!0: Timeout has passed

LIBRARY

zconsole.lib

SEE ALSO

con_set_timeout

con_load_backup

```
int con_load_backup( void );
```

DESCRIPTION

Loads the configuration from the file system.

RETURN VALUE

`0`: Success
`1`: No configuration information found
`<0`: Failure
- `-1`: error reading 1st set of information
- `-2:` error reading 2nd set of information, and so on

LIBRARY

`zconsole.lib`

SEE ALSO

`con_backup, con_backup_reserve`

con_reset_io

```
void con_reset_io( void );
```

DESCRIPTION

Resets all I/O methods by calling `close()` and `open()` on each of them.

LIBRARY

`zconsole.lib`

con_set_backup_lx

```
void con_set_backup_lx( FSLXnum backuplx );
```

DESCRIPTION

Sets the logical extent (LX) that will be used to store the backup configuration data. For more information on the file system see the *Dynamic C User's Manual*. This is only useful in conjunction with FS2.LIB. This should be called once before `console_init()`. Care should be taken that enough space is available in this logical extent for the configuration files. See `con_backup_bytes()` for more information.

PARAMETER

backuplx LX number to use for backup

LIBRARY

zconsole.lib

SEE ALSO

con_set_files_lx, con_backup_bytes

con_set_files_lx

```
void con_set_files_lx( FSLXnum fileslx );
```

DESCRIPTION

Sets the logical extent (LX) that will be used to store files. For more information on the file system see the *Dynamic C User's Manual*. This is only useful in conjunction with FS2.LIB. This should be called once before `console_init()`.

PARAMETER

fileslx LX number to use for files.

LIBRARY

zconsole.lib

SEE ALSO

con_set_backup_lx

con_set_user_idle

```
void con_set_user_idle( void (*funcptr)() );
```

DESCRIPTION

Sets a user-defined function that will be called when the console (for a particular I/O channel) is idle. The user-defined function should take an argument of type `ConsoleState*` .

LIBRARY

`zconsole.lib`

SEE ALSO

`con_set_user_timeout`

con_set_timeout

```
unsigned long con_set_timeout( unsigned int seconds );
```

DESCRIPTION

Returns the value that `MS_TIMER` should have when the number of seconds given have elapsed.

LIBRARY

`zconsole.lib`

SEE ALSO

`con_chk_timeout`

con_set_user_timeout

```
void con_set_user_timeout( void (*funcptr)() );
```

DESCRIPTION

Sets a user-defined function that will be called when a timeout event has occurred. The user-defined function should take an argument of type `ConsoleState*`.

LIBRARY

`zconsole.lib`

SEE ALSO

`con_set_user_idle`

console_disable

```
void console_disable( int which );
```

DESCRIPTION

Disable processing for the designated console in the `console_io[]` array. This function, along with `console_enable()`, allows the sharing of the Zconsole port with some other processing.

PARAMETER

`which` The console to disable.

LIBRARY

`zconsole.lib`

SEE ALSO

`console_init, console_enable`

console_enable

```
void console_enable( int which );
```

DESCRIPTION

Enable processing for the designated console in the `console_io[]` array. This function, along with `console_disable()`, allows the sharing of the Zconsole port with some other processing.

PARAMETER

which The console to enable.

LIBRARY

`zconsole.lib`

SEE ALSO

`console_init, console_disable`

14.6.6 Zconsole Execution Choices

Zconsole can be used interactively with a terminal emulator or by sending commands from a program running on a device connected to the controller that is running the console.

14.6.6.1 Terminal Emulator

To manually enter Zconsole commands from a keyboard and view results in the Stdio window you must:

1. Run Dynamic C 7.05 or later.
2. Open a terminal emulator. Windows HyperTerminal comes with Windows. It does not work with binary files, only ASCII. Tera Term can handle both ASCII and binary. It is available for free download at

```
http://hp.vector.co.jp/authors/VA002416/teraterm.html
```

3. Configure the terminal emulator as follows:

COM port: (1 or 2) to which 3-wire serial cable is connected
Baud Rate: 57,600 bps
Data Bits: 8
Parity: None
Stop Bits: 1
Flow Control: None

The terminal emulator should now accept Zconsole commands.

To avoid losing an <LF> at the beginning of a file when using the `con_put` command function, select Setup->Terminal from the Tera Term menu and set the Transmit option to CR+LF. This option might be located elsewhere if you are using a different terminal emulator.

14.7 Backup System

Zconsole can save configuration parameters to the file system or, starting with Dynamic C 7.30, to the User block. The configuration is then available across power cycles. The backup process is done by `con_backup()`. Unlike the other Zconsole command functions, `con_backup()` does not take a parameter and it returns `0` if the backup was successful and `1` if it was not. This function is called by several of the Zconsole command functions that change configuration parameters, or that add or delete files or variables from the file system. Caution is advised when calling `con_backup()` since it writes to flash memory.

14.7.1 Data Structure for Backup System

The developer must define an array called `console_backup[]` of `ConsoleBackup` structures.

```
typedef struct {
   void *data;
   int len;
   void (*postload)();
   void (*presave)();
} ConsoleBackup;
```

data

This is a pointer to the data to be backed up.

len

This is how many bytes of data need to be backed up.

postload

This is a function pointer to a function that is called after configuration data is loaded, in case the developer needs to do something with the newly loaded configuration data.

presave

This is a function pointer that is called just before the configuration data is saved so that the developer can fill in the data structure to be saved. The functions referenced by `postload()` and `presave()` should have the following prototype:

```
void my_preload(void *dataptr);
```

The `dataptr` parameter is the address of the configuration data (the same as the data pointer in the `ConsoleBackup` structure).

14.7.2 Array Definition for Backup System

```
const ConsoleBackup console_backup[] = {
   CONSOLE_BASIC_BACKUP,       // echo state, baud rate/port number
   CONSOLE_TCPIP_BACKUP,
   CONSOLE_TCP_MULTI_BACKUP,
   CONSOLE_HTTP_BACKUP,
   CONSOLE_SMTP_BACKUP,
   CONSOLE_BACKUP_LOGIN,
   { my_data, my_data_len, my_preload, my_presave }
}
```

CONSOLE_BASIC_BACKUP

Causes backup of the echo state (on or off), baud rate and port number information.

CONSOLE_TCPIP_BACKUP

Causes backup of the IP addresses of the controller board and the IP address of its netmask, gateway and name server.

Note that only one of the CONSOLE_TCP_* structures should be used.

CONSOLE_TCP_MULTI_BACKUP

Using this structure causes ifconfig() to save and restore network configuration. In addition to the information saved by CONSOLE_TCP_BACKUP, multiple name servers, DHCP configuration, ICMP (Ping) configuration, and multiple interface configuration are all saved by CONSOLE_TCP_MULTI_BACKUP.

Some built-in console functions are for use with CONSOLE_TCP_MULTI_BACKUP. In general, except for backwards compatibility issues, CONSOLE_TCP_MULTI_BACKUP should be used instead of CONSOLE_TCP_BACKUP.

Note that only one of the CONSOLE_TCP_* structures should be used.

CONSOLE_HTTP_BACKUP

Causes backup of the files and variables visible to the HTTP server.

CONSOLE_SMTP_BACKUP

Causes backup of the mail configuration.

CONSOLE_BACKUP_LOGIN

Causes backup of the ConsoleLogin structure which stores the login name and password strings.

14.8 Zconsole Macros

Many macros are available to change the behavior of Zconsole. They are all listed here. Starting with Dynamic C 7.30 additional macros are available to support saving configuration information to the User block, DHCP, ping configuration, and multiple interfaces.

CON_BACKUP_FILE1

The file number used for the first backup file. For FS1, this number must be in the range 128-143, so that `fs_reserve_blocks()` can be used to guarantee free space for the backup files. Defaults to 128 for FS1. Defaults to 254 for FS2.

CON_BACKUP_FILE2

Same as above, except this is for the second backup file. Two files are used so that configuration information is preserved even if the power cycles while configuration data is being saved. For FS1, this number must be in the range 128-143. Defaults to 129 for FS1. Defaults to 255 for FS2.

CON_BACKUP_USER_BLOCK

Defaults to not defined. If this is defined, then configuration information for the console will be saved to the User block instead of to the flash file system. Note that the configuration is only safe in the case of power failures with a version 3 or higher System ID block.

CON_BUF_SIZE

Changes the size of the data buffer that is allocated for each I/O method. If the baud rate or transfer speed is too great for the console to keep up, then increasing this value may help avoid dropped characters. It is allocated in root data space. It defaults to 1024 bytes.

CON_CMD_SIZE

Changes the size of the command buffer that is allocated for each I/O method. This limits the length of a command line. It is allocated in root data space. Defaults to 128 bytes.

CON_CMD_DATA_SIZE

Default is 16. Adjusts the size of the user data area within the state structure so that user commands may preserve arbitrary information across calls. The user data area is allocated in root data space.

CON_DHCP_ACQUIRE_RETRY_TIMEOUT

Defaults to 120 seconds. If DHCP is enabled, then Zconsole will maintain the DHCP lease. This macro specifies the number of seconds after which a DHCP lease has been dropped that the board will attempt to reacquire the lease. Note that in the normal course of operation, a lease will never be dropped. Generally, that will only happen if the DHCP server is inoperable for an extended period of time (subject to the lengths of the leases that the DHCP server issues).

CON_HELP_VERSION

This macro should be defined if the developer wants a version message to be displayed when the HELP command is issued with no parameters. If this macro is defined, then the macro `CON_VERSION_MESSAGE` must also be defined.

CON_INIT_MESSAGE

Defines the message that is displayed on all Zconsole I/O methods upon startup. Defaults to "Console Ready\r\n".

CON_MAIL_BUF_SIZE

Maximum length of a mail message. Defaults to 1024.

CON_MAIL_FROM_SIZE

Maximum length of mail from address to `NULL` terminator. Default to 51.

CON_MAIL_SERV_SIZE

Maximum length of mail server name and `NULL` terminator. Defaults to 51.

CON_MAX_NAME

Default is 10: maximum number of characters for a login name. This value must be equal to or less than **CON_CMD_DATA_SIZE**.

CON_MAX_PASSWORD

Default is 10: maximum number of characters for a login password.

CON_NO_FS_SUPPORT

This macro is defined by default only if no filesystem libraries have been used. Even if a filesystem library has been used, this can still be explicitly defined by the user. When this is defined, then the console will not save configuration information to the filesystem, and no filesystem function calls will be included.

CON_SP_RDBUF_SIZE

Size of the slave port read buffer. Defaults to 255.

CON_SP_WRBUF_SIZE

Size of the slave port write buffer. Defaults to 255.

CON_TIMEOUT

Adjusts the number of seconds that the console will wait before cancelling the current command. The timeout can be adjusted in user code in the following manner:

```
state->timeout = con_set_timeout(CON_TIMEOUT);
```

This is useful for custom user commands so that they can indicate when something "meaningful" has happened on the console (such as some data being successfully transferred).

CON_VAR_BUF_SIZE

Adjusts the size of the variable buffer, in which values of variables can be stored for use with the HTTP server. It is allocated in xmem space. Defaults to 1024 bytes.

CON_VERSION_MESSAGE

This defines the version message to display when the HELP command is issued with no parameters. It is not defined by default, so has no default value.

14.9 Sample Program

The sample program `Samples\zconsole\tcpipconsole.c` demonstrates many of the features of `zconsole.lib`. Among the features this application supports is network configuration, uploading web pages, changing variables for use with web pages, sending mail, and access to the console through a telnet client. Please note that all libraries needed by `zconsole.lib` must be included with `#use` statements before the `#use` statement for the Zconsole library.

The following code is taken from `tcpipconsole.c`.

```
/*
 * Size of the buffers for serial port C. If you want to use another serial port, you should
 * change the buffer macros below appropriately (and change the console_io[] array below).
 */
#define CINBUFSIZE  1023
#define COUTBUFSIZE  255
/*
 *  Maximum number of connections to the web server. This indicates the number of sockets
 *  that the web server will use.
 */
#define HTTP_MAXSERVERS 2
/*
 * Maximum number of sockets this program can use. The web server is taking two sockets:
 * the mail client uses one socket, and the telnet interface uses the other socket.
 */
#define MAX_SOCKETS 4
/*
 *  All web server content is dynamic, so we do not need http_flashspec[].
 */
#define HTTP_NO_FLASHSPEC
/*
 *  The file system that the console uses should be located in flash.
 */
#define FS_FLASH
/*
 * The function prototype for a custom command must be declared before the
 * console_command[] array.
 */
int hello_world ( ConsoleState *state);
```

The following code is for Zconsole configuration.

```
/*
 * The number of console I/O streams that this program supports. Since we are supporting
 * serial port C and telnet, there are two I/O streams.
 */
#define NUM_CONSOLES 2
/*
 *  If this macro is defined, then the version message will be shown with the help command,
 *  when the help command has no parameters.
 */
#define CON_HELP_VERSION
/*
 *  Defines the version message that will be displayed in the help command if
 *  CON_HELP_VERSION is defined.
 */
#define CON_VERSION_MESSAGE "TCP/IP Console Version 1.0\r\n"
/*
 *  Defines the message that is displayed on all I/O channels when the console starts.
 */
#define CON_INIT_MESSAGE CON_VERSION_MESSAGE
/*
 *  The ximport directives include the help texts for the console commands. Having the help text
 *  in xmem helps save root code space.
 */
#ximport "samples\zconsole\tcpipconsole_help\help.txt" help_txt
   ...
/*  The rest of the #ximport statements may be seen in tcpipconsole.c.  */
```

The following code sets up all the data structures needed by the console.

```
/* The console will be available to the I/O streams given in the following array. The I/O streams
 * are defined through macros as documented in Section 14.5.2. The parameter for the first macro
 * represents the initial baud rate for serial port C. The second macro is passed the port number
 * for telnet.  If you change the number of I/O streams, update NUM_CONSOLES above.*/
const ConsoleIO console_io[] = {
   CONSOLE_IO_SERC(57600),
   CONSOLE_IO_TELNET(23)
};
/* This array defines the commands that are available in the console. The first parameter for the
 * ConsoleCommand structure is the command specification, i.e., how the console
 * recognizes a command.  The second parameter is the function to call when the command
 * is recognized. The third parameter is the location of the #ximport'ed help file for the command.
 * Note that the second parameter can be NULL, which is useful if help information is needed
 * for something that is not a command (like for the "SET" command below--the help file for
 * "SET" contains a list of all of the set commands). Also note the entry for the command "",
 * which is used to set up the help text that is displayed when the help command is used by
 * itself (that is, with no parameters).*/
const ConsoleCommand console_commands[] = {
   { "HELLO WORLD", hello_world, 0 },
   { "ECHO", con_echo, help_echo_txt },
   { "HELP", con_help, help_help_txt },
   { "", NULL, help_txt },
   { "SET", NULL, help_set_txt },
   { "SET PARAM", con_set_param, help_set_param_txt },
    ...
};
/* This array sets up the error messages that can be generated. CON_STANDARD_ERRORS is
 * a macro that expands to the standard errors used by the built-in commands in zconsole.lib.
 * Users can define their own errors here, as well.*/
const ConsoleError console_errors[] = {
   CON_STANDARD_ERRORS
};
/* This array defines the information (such as configuration) that will be saved to the file system.
 * Note that if, for example, the HTTP or SMTP related commands are included in the
 * console_commands array above, then the backup information must be included in
 * this array. The entries below are macros that expand to the appropriate entry for each set of
 * functionality.  Users can also add their own information to be backed up here by adding
 * more ConsoleBackup structures.*/
const ConsoleBackup console_backup[] = {
   CONSOLE_BASIC_BACKUP,
   CONSOLE_TCP_BACKUP,
   CONSOLE_HTTP_BACKUP,
   CONSOLE_SMTP_BACKUP
};
```

The following code defines the MIME types that the web server will handle.

```
const HttpType http_types[] = {
   { ".shtml", "text/html", shtml_handler},    // ssi
   { ".html", "text/html", NULL},              // html
   { ".gif", "image/gif", NULL},
   { ".jpg", "image/jpeg", NULL},
   { ".jpeg", "image/jpeg", NULL},
   { ".txt", "text/plain", NULL}
};
```

The function for the custom command is defined here and the main program finishes up the program. To see the complete sample, look in `Samples\zconsole\tcpipconsole.c`.

```
/* This is a custom command. Custom commands always take a ConsoleState* as an
 * argument (a pointer to the state structure for the given I/O stream), and return an int.
 * The return value should be 0 when the command wishes to be called again on the next
 * console_tick(), 1 when the command has successfully finished processing, or -1
 * when the command has finished due to an error.*/
int hello_world(ConsoleState *state){
   state->conio->puts("Hello, World!\r\n");
   return 1;
}
void main(void){
   /* Initialize TCP/IP, clients, servers, and I/O prior to using any console functions.*/
   sock_init();
   tcp_reserveport(80);    // Start a listen queue and disable the 2MSL wait .
   http_init();
   if (fs_init(0, 64))
      printf("Filesystem not present!\n");
   if (console_init() != 0) {
      printf("Console did not initialize!\n");
      fs_format(0, 64, 1);
      /* After the file system has been initialized or formatted, space must be
       * reserved in the file system for the backup information. */
      con_backup_reserve();
      con_backup();  // Save the backup information to the console.
   }
   while (1) {
      console_tick();
      http_handler();
   }
}
```

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