George Ornbo

Sams **Teach Yourself**

Go

Next Generation Systems Programming with **Golang**

in **24 Hours**

Pearson

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Next Generation Systems Programming with **Golang**

SAMS 800 East 96th Street, Indianapolis, Indiana 46240 USA

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Next Generation Systems Programming with Golang

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About the Author

George Ornbo is a software engineer, blogger, and author with 14 years of experience delivering software to startups and enterprise clients. He has experience with a broad range of programming languages, UNIX, and the underlying protocols of the web. He is currently working at a Blockchain startup in London.

Dedication

For Bea and Fin. I won a Golden Ticket with you two!

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HOUR 18

Creating HTTP Servers

What You'll Learn in This Hour:

- Announcing the presence of your web server
- Examining requests and responses
- Working with handler functions
- Handling 404s
- Setting a header
- Responding with different content types
- Responding to different types of requests
- Receiving data from GET and Post requests

Go offers strong support for creating web servers that can serve web pages, web services, and files. During this hour, you will learn how to create web servers that can respond to different routes, different types of requests, and different content types. By taking advantage of Go's approach to concurrency, writing web servers in Go is a great option.

Announcing Your Presence with the "Hello World" Web Server

The `net/http` standard library package provides multiple methods for creating HTTP servers, and comes with a basic router. It is traditional to create a Hello World program to announce a basic presence to the world. The most basic HTTP server in Go is shown in Listing 18.1.

LISTING 18.1 Basic HTTP Server in Go

```go
package main

import (
    "net/http"
)

func helloWorld(w http.ResponseWriter, r *http.Request) {
    w.Write([]byte("Hello World\n"))
}

func main() {
    http.HandleFunc("/", helloWorld)
    http.ListenAndServe(":8000", nil)
}
```

Although the program is just 14 lines, plenty is going on.

- The `net/http` package is imported.
- Within the `main` function, a route `/` is created using the `HandleFunc` method. This takes a pattern describing a path, followed by a function that defines how to respond to a request to that path.
- The `helloWorld` function takes a `http.ResponseWriter` and a pointer to the request. This means that within the function, the request can be examined or manipulated before returning a response to the client. In this case, the `Write` method is used to write the response. This writes the HTTP response including status, headers, and the body. The usage of `[]byte` initializes a byte slice and converts the string value into bytes. This means it can be used by the `Write` method, which expects a slice of bytes.
- The `ListenAndServe` method is used to start a server to respond to a client that listens on localhost and port 8000.

Although this is a short example, if you can begin to understand how a web server operates in Go, you will be well on your way to creating more complex programs.

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Running a “Hello World” Web Server

In this example, you run a Hello World web server:

1. Open the file hour18/example01.go in a text editor and try to understand what the example is doing. If you need to, refer to the previous bullet points and step through the code.
2. From the terminal, run the program with `go run example01.go`.
3. Open a web browser at `http://localhost:8000`.
4. You should see “Hello World” in your web browser.
5. Congratulations! You just ran your first web server in Go.

Examining Requests and Responses

As this hour progresses, we will examine requests and responses that are being sent and received. The tool we use for this is `curl`.

`Curl` is a command-line tool for making `HTTP` requests, and is generally available on all platforms. On macOS, `curl` is pre-installed. On Linux, `curl` is often installed and is available through package managers. For Windows, `curl` is not pre-installed. For Windows users, installing GIT for Windows was recommended in an earlier chapter. If you have not done this, visit https://git-scm.com/download/win, open the download file, and install it. Once installed, you will have a new Start menu item: Git Bash. Open it.

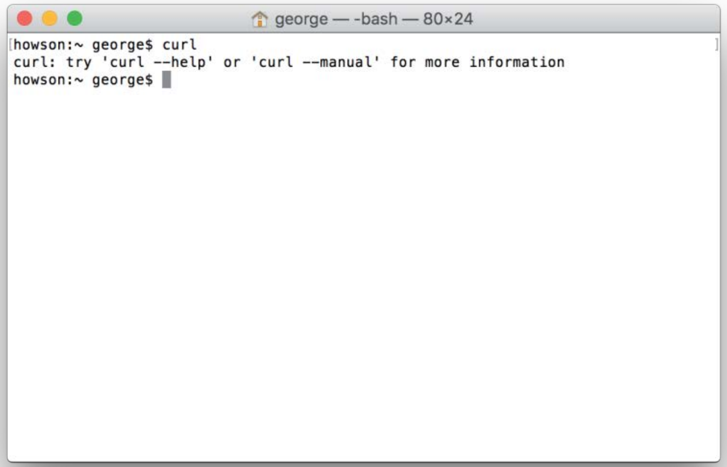
To verify everything is installed correctly, follow these steps:

1a. On macOS or Linux, open a terminal.

1b. On Windows, open “Git Bash” from the Start menu.

2. Type `curl` and hit Return.

3. If `curl` is installed successfully, you will see the output shown in Figure 18.1.



```
howson:~ george$ curl
curl: try 'curl --help' or 'curl --manual' for more information
howson:~ george$ 
```

FIGURE 18.1
Verifying `curl` is correctly installed.

Making a Request with `curl`

With `curl` installed, you can use it for developing and debugging web servers. Rather than using a browser, you can use `curl` to send a variety of requests to a web server and to examine the response. To make a request to the Hello World web server, open a terminal and run the server.

```
go run example01.go
```

On macOS or Linux, open another terminal tab or window. On Windows, switch to Git Bash. Run the following command. The `-is` options mean that headers are printed and that some unwanted output is ignored.

```
curl -is http://localhost:8000
```

If the command was successful, you will see a response from the web server that includes the headers and the response body.

```
HTTP/1.1 200 OK
Date: Wed, 16 Nov 2016 16:45:51 GMT
Content-Length: 12
Content-Type: text/plain; charset=utf-8

Hello World
```

The output may be explained as follows:

- The response uses the HTTP 1.1 protocol, and a 200 response was received.
- The `Date` header details when the response was sent.
- The `Content-Length` header details the length of the response. In this case, it is 12 bytes.
- The `Content-Type` header details the type of content and the encoding used. In this case, the response is `text/plain` encoded using `utf-8`.
- Finally, the response body is outputted. In this case, it is `Hello World`.

Routing in More Detail

The `HandleFunc` registers functions to respond to URL address mappings. In simplistic terms, `HandleFunc` sets up a routing table that allows the HTTP server to respond correctly.

```
http.HandleFunc("/", helloWorld)
http.HandleFunc("/users/", usersHandler)
http.HandleFunc("/projects/", projectsHandler)
```

In this example, whenever a request is made to `/`, the `helloWorld` function will be called. Whenever a request is made to `/users/`, the `usersHandler` function will be called, and so on.

Note the following points about the behavior of the router:

- The default router directs any request that it does not have a handler for to `/`.
- The route must match exactly; for example, a request to `/users` will go to `/`, as it is missing a trailing slash.
- The router has no concern over the type of request. It simply passes a request that matches a route to the handler.

Working with Handler Functions

While the Go router maps routes to functions, it is the handler functions that define how a request is handled and the response that is returned to the client. Many programming languages and web frameworks follow the pattern of passing a request and response through functions before returning the response. Go is similar in this respect. Handler functions are responsible for these common tasks:

- Reading or writing headers
- Examining the type of a request
- Fetching data from a database
- Parsing request data
- Authentication

Handler functions have access to the `Request` and the `Response`, so a common pattern is to complete everything needed for the request before writing the response back to the client. Once the response is written, no further processing on the response can take place. In the following example, the response is sent using the `Write` method. On the next line, a header is set on the response to be written. As the response has already been written, this will have no effect, but the code will compile. The key point: Write the response last.

```
func helloWorld(w http.ResponseWriter, r *http.Request) {
     w.Write([]byte("Hello World\n"))
     // This has no effect, as the response is already written
     w.Header().Set("X-My-Header", "I am setting a header!")
}
```

Handling 404s

The behavior of the default Handler is to pass any request that does not have a handler function defined to /. Returning to the first example, if a request is made to a non-existent page, the handler function for / is called, and a 200 along with the "Hello World" response is returned.

```
curl -is http://localhost:8000/asdfa
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2016 09:07:51 GMT
Content-Length: 12
Content-Type: text/plain; charset=utf-8
```

As the route does not exist, a 404 Page Not Found should be returned. On the default route, a check can be added to return a 404 if the path is not / (see Listing 18.2).

LISTING 18.2 Adding a 404 Response

```
package main

import (
   "net/http"
)

func helloWorld(w http.ResponseWriter, r *http.Request) {
   if r.URL.Path != "/" {
            http.NotFound(w, r)
            return
   }
   w.Write([]byte("Hello World\n"))
}

func main() {
    http.HandleFunc("/", helloWorld)
    http.ListenAndServe(":8000", nil)
}
```

The modifications to the initial Hello World web server may be explained as follows:

- In the `helloWorld` handler function, the path is checked to see if it is `/`.
- If it is not, the `NotFound` method from the `http` package is called, passing the response and request. This writes a 404 response to the client.
- If the path does match `/`, then the `if` statement is ignored and the `Hello World` response is sent.

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Adding a 404 Response

In this example, you will understand how to add a 404 response.

1. Open the file hour18/example02.go in a text editor and try to understand what the example is doing. If you need to, refer to the previous bullet points and step through the code.
2. From the terminal, run the program with `go run example02.go`.
3. Using `curl`, make a request to a non-existent page. For example:

   ```
   curl -is http://localhost:8000/asdfa
   ```

4. You should see that the response is now a 404:

   ```
   HTTP/1.1 404 Not Found
   Content-Type: text/plain; charset=utf-8
   X-Content-Type-Options: nosniff
   Date: Thu, 17 Nov 2016 09:15:23 GMT
   Content-Length: 19

   404 page not found
   ```

Setting a Header

A common requirement when creating HTTP servers is to be able to set headers on a response. Go offers great support for creating, reading, updating, and deleting headers. In the following example, suppose that the server will send some JSON. By setting the `Content-Type` header, the server can inform the client that JSON data is being sent. Through the `ResponseWriter`, a handler function can add a header as follows:

```
w.Header().Set("Content-Type", "application/json; charset=utf-8")
```

Provided this is before the response is written to the client, the header will be added to the response. In Listing 18.3, the header is added before the JSON content is sent. Note that for simplicity the JSON is set as a string, but normally data would be read from somewhere and then encoded to JSON.

LISTING 18.3 Adding a Header to a Response

```go
package main

import (
	"net/http"
)

func helloWorld(w http.ResponseWriter, r *http.Request) {
	if r.URL.Path != "/" {
		http.NotFound(w, r)
		return
	}
	w.Header().Set("Content-Type", "application/json; charset=utf-8")
	w.Write([]byte(`{"hello": "world"}`))
}

func main() {
	http.HandleFunc("/", helloWorld)
	http.ListenAndServe(":8000", nil)
}
```

TRY IT YOURSELF

Including an HTTP Header in a Response

In this example, you will understand how to add a HTTP header.

1. Open the file hour18/example03.go in a text editor and try to understand what the example is doing.
2. From the terminal, run the program with `go run example03.go`.
3. Using `curl`, make a request to the web server:

   ```
   curl -is http://localhost:8000/
   ```

4. You should see that the response contains a header setting the content type to: `application/json`.

   ```
   HTTP/1.1 200 OK
   Content-Type: application/json; charset=utf-8
   Date: Thu, 17 Nov 2016 09:28:44 GMT
   Content-Length: 18

   {"hello": "world"}
   ```

5. Congratulations! You just served JSON using Go.

Responding with Different Content Types

HTTP servers typically respond to clients with multiple content types. Some content types in common usage include `text/plain`, `text/html`, `application/json`, and `application/xml`. If a server supports multiple content types, a client may request a content type using an `Accept` header. This means the same URL can serve a browser with HTML or an API client with JSON. With a small modification, the example that you have been working through can now respond with multiple content types by examining the `Accept` header sent by the client, as shown in Listing 18.4.

LISTING 18.4 Responding with Different Content Types

```go
package main

import (
    "net/http"
)

func helloWorld(w http.ResponseWriter, r *http.Request) {
   if r.URL.Path != "/" {
            http.NotFound(w, r)
            return
    }
    switch r.Header.Get("Accept") {
    case "application/json":
            w.Header().Set("Content-Type", "application/json; charset=utf-8")
            w.Write([]byte(`{"message": "Hello World"}`))
   case "application/xml":
            w.Header().Set("Content-Type", "application/xml; charset=utf-8")
            w.Write([]byte(`<?xml version="1.0" encoding="utf-8"?><Message>Hello World</Message>`)
   default:
            w.Header().Set("Content-Type", "text/plain; charset=utf-8")
            w.Write([]byte("Hello World\n"))
    }

}

func main() {
    http.HandleFunc("/", helloWorld)
    http.ListenAndServe(":8000", nil)
}
```

The amendments to the example may be explained as follows:

- In the `helloWorld` function, a switch statement is added that examines the `Accept` header from the client.
- Depending on the contents of the `Accept` header, a `switch` statement is used to set the response accordingly.
- If no header is found, the server defaults to sending a plain text response.

▼ TRY IT YOURSELF

Serving Different Content Types

In this example, you will understand how to serve different content types and how to request them using a client.

1. Open the file hour18/example04.go in a text editor and try to understand what the example is doing. If you need to, refer to the previous bullet points and step through the code.
2. From the terminal, run the program with `go run example04.go`.
3. Using `curl`, make a request to the web server that requests the content type `application/json` . Note that the `-H` option is used to set a header:

```
curl -si -H 'Accept: application/json' http://localhost:8000
```

4. You should see that the response is of content type `application/json`:

```
HTTP/1.1 200 OK
Content-Type: application/json; charset=utf-8
Date: Thu, 17 Nov 2016 09:28:44 GMT
Content-Length: 18

{"hello": "world"}
```

5. Using `curl`, make a second request to the web server that requests the content type `application/xml`:

```
curl -si -H 'Accept: application/xml' http://localhost:8000
```

6. You should see that the response is of content type `application/xml`:

```
HTTP/1.1 200 OK
Content-Type: application/xml; charset=utf-8
Date: Thu, 17 Nov 2016 09:45:24 GMT
Content-Length: 68

<?xml version="1.0" encoding="utf-8"?><Message>Hello World</Message>
```

Responding to Different Types of Requests

As well as being able to respond to requests for different content types, HTTP servers typically need to be able to respond to different types of requests. The types of requests that a client may make are defined in the HTTP specification and include `GET`, `POST`, `PUT`, and `DELETE`. To create a HTTP server in Go that responds to different types of requests, a similar technique to serve multiple content types may be used, as shown in Listing 18.5. In the handler function for a route, the request type can be checked and then a switch can determine how to handle the request.

LISTING 18.5 Responding to Different Types of Requests

```go
package main

import (
    "net/http"
)

func helloWorld(w http.ResponseWriter, r *http.Request) {
    if r.URL.Path != "/" {
            http.NotFound(w, r)
            return
    }
    switch r.Method {
    case "GET":
            w.Write([]byte("Received a GET request\n"))
    case "POST":
            w.Write([]byte("Received a POST request\n"))
    default:
            w.WriteHeader(http.StatusNotImplemented)
            w.Write([]byte(http.StatusText(http.StatusNotImplemented)) + "\n")
    }

}

func main() {
    http.HandleFunc("/", helloWorld)
    http.ListenAndServe(":8000", nil)
}
```

The amendments to the server can be explained as follows:

- Instead of using content type to switch the response, the server uses the request method.
- The `switch` statement sends a response depending on the type of request.

- In this example, a plain text response is sent to indicate the type of request.
- If the method is not a GET or a POST, it falls through to the default. This sends a 501 Not Implemented HTTP response. The 501 code means the server does not understand or does not support the HTTP method sent by the client.

Running the server shows that both GET and POST requests may now be made. To change the request type using curl, the -X option is used.

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Understanding Different Types of Requests

In this example, you will understand how to respond to different types of requests, such as GET and POST.

1. Open the file hour18/example05.go in a text editor and try to understand what the example is doing. If you need to, refer to the explanation that follows Listing 18.5.
2. From the terminal, run the program with `go run example05.go`.
3. Using curl, make a request to the web server using a GET request. Note that the -X option is used to set the type of request:

```
curl -si -X GET http://localhost:8000
```

4. You should see the server responding that it has received a GET request:

```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2016 10:02:49 GMT
Content-Length: 23
Content-Type: text/plain; charset=utf-8

Received a GET request
```

5. Using curl, make a second request to the web server, this time making a POST request:

```
curl -si -X POST http://localhost:8000
```

6. You should see the server responding that it has received a POST request:

```
HTTP/1.1 200 OK
Date: Thu, 17 Nov 2016 10:03:27 GMT
Content-Length: 24
Content-Type: text/plain; charset=utf-8

Received a POST request
```

Receiving Data from GET and POST Requests

An HTTP client can send data to an HTTP server along with an HTTP request. Typical examples of this include:

- Submitting a form
- Setting options on data to be returned
- Managing data through an API interface

Getting data from a client request is simple in Go, but depending on the type of request it is accessed in different ways. For a GET, request data is usually set through a query string. An example of sending data through a GET request is making a search on Google. Here, the URL includes a search term as a query string:

```
https://www.google.com/?q=golang
```

A web server may then read in the query string data, using it to do something like fetch some data from a database before returning it to the client. In Go, the query string parameters for a request are available as a map of strings, and these can be iterated over using a range clause.

```
func queryParams(w http.ResponseWriter, r *http.Request) {
    for k, v := range r.URL.Query() {
        fmt.Printf("%s: %s\n", k, v)
    }
}
```

For a POST request, data is usually sent as the body of a request. This data may be read and used as follows:

```
func queryParams(w http.ResponseWriter, r *http.Request) {
    reqBody, err := ioutil.ReadAll(r.Body)
    if err != nil {
        log.Fatal(err)
    }

    fmt.Printf("%s", reqBody)
}
```

WARNING

Do Not Trust User Input

An aside on security for a moment: Data received on a server should be considered untrusted. An attacker may send a request that attempts to steal information, gain access to a server, or delete a database. All data coming into a server should be considered unsafe and should be filtered before use. For the purposes of these examples, data is used unfiltered, but when writing code for production use, ensure that the incoming data is sanitized before use.

A full code example can now be created to demonstrate handling data from different requests, which appears in Listing 18.6. This server builds on the previous example to show the data that is sent to the server. Running this example shows that data can be received for different types of requests. Of course, the server will probably want to do something more interesting with the data other than return it to the client.

LISTING 18.6 Handling Data from Different Requests

```
package main

import (
    "fmt"
    "io/ioutil"
    "log"
    "net/http"
)

func helloWorld(w http.ResponseWriter, r *http.Request) {
    if r.URL.Path != "/" {
            http.NotFound(w, r)
            return
    }
    switch r.Method {
    case "GET":
            for k, v := range r.URL.Query() {
                   fmt.Printf("%s: %s\n", k, v)
            }
            w.Write([]byte("Received a GET request\n"))
   case "POST":
            reqBody, err := ioutil.ReadAll(r.Body)
            if err != nil {
                     log.Fatal(err)
            }

            fmt.Printf("%s\n", reqBody)
            w.Write([]byte("Received a POST request\n"))
   default:
            w.WriteHeader(http.StatusNotImplemented)
            w.Write([]byte(http.StatusText(http.StatusNotImplemented)))
   }

}

func main() {
    http.HandleFunc("/", helloWorld)
    http.ListenAndServe(":8000", nil)
}
```

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Receiving Data from GET and POST Requests

In this example, you will understand how to receive data from `GET` and `POST` requests.

1. Open the file hour18/example06.go in a text editor and try to understand what the example is doing.
2. From the terminal, run the program with `go run example06.go`.
3. Using `curl`, make a request to the web server using a GET request that includes some query parameters:

   ```
   curl -si "http://localhost:8000/?foo=1&bar=2"
   ```

4. In the terminal that is running the server, you should see the data has been received:

   ```
   foo: [1]
   bar: [2]
   ```

5. Using `curl`, make a second request to the web server, this time making a POST request:

   ```
   curl -si -X POST -d "some data to send" http://localhost:8000/
   ```

6. In the terminal that is running the server, you should see the data has been received:

   ```
   some data to send
   ```

Summary

This hour introduced you to creating HTTP servers with Go. You were introduced to how routing works with the HTTP package and understood how handler functions may be used to handle requests. You learned how to set a header on an HTTP response and then progressed to being able to respond to different types of requests. Finally, you learned how to receive data from HTTP client requests.

Q&A

Q. Is it possible to set variables in the routing pattern? I want to set something like `/products/:id`, where `:id` is a variable.

A. The `http` package by default uses `ServeMux` to handle routing, and neither variables nor regular expressions are supported. Some popular community-created routers offer variables and other features like request and content types. Generally, they integrate with the `http` package.

Q. I used framework libraries in other languages to create servers. Is anything similar available in Go?

A. Yes. There are framework libraries available in Go. For many cases, however, the `http` package provides everything needed.

Q. How do I create a HTTPS server?

A. The `http` package supports creating a server served over HTTPS (TLS) through the `ListenAndServeTLS` method. This works in the same way as `ListenAndServe`, but expects certificate and key files to be passed to it.

Workshop

The workshop contains quiz questions and exercises to help you solidify your understanding of the material covered. Try to answer all questions before looking at the "Answers" section that follows.

Quiz

1. What is the difference between an `HTTP GET` and a `POST` request?
2. In a handler function, what does `w.Write` do in terms of processing the response where `w` is a `ResponseWriter`?
3. Should you trust data submitted to an `HTTP` server?

Answers

1. A `GET` request requests data from a specified resource. A `POST` request submits data to a specified resource. A GET request may set data through query string parameters. A `POST` request sends data to the server as the message body.
2. Calling `Write` on a `ResponseWriter` causes the response to be sent to the client. This includes headers and the body content. Once sent, it is not possible to modify the response.
3. No. You should never trust data submitted by a client to a server. Data should be sanitized before use.

Exercises

1. Modify example04.go to be able to respond to a request for `HTML` with a simple `HTML` document. The `HTML` content type is `"text/html; charset=utf-8"`.
2. Modify example05.go to allow the server to support `DELETE` requests.
3. Read the documentation for the http package and try to understand some of the modifications you can make to a request and a response when writing a server.