5 Wielding Web Protocols

This chapter covers the following ~~recipes~~

- Creating an HTTP server
- Receiving POST data
- Handling file uploads
- Making an HTTP POST request
- Communicating with WebSockets
- Creating an SMTP server

Introduction

One of the great qualities of Node is the simplicity it provides around low-level system operations.

Unlike template-centric languages such as PHP or ASP we have fine grain controlled over the behavior we want without sacrificing easy content control.

With Node we can create the server, customize it, and deliver content all at the code level.

Starting with a focus on core API's and low-level implementation then working our way up to more complex protocols with third party libraries, this chapter demonstrates how to create various clients and servers in the "Application Layer" of the TCP/IP stack.

> ### From Protocols to Frameworks
>
> This chapter focuses on Node's direct relationship with Network protocols. It's intended to develop understanding of fundamental concepts. For creating more extensive and enterprise focused HTTP infrastructure check out **Chapter 7. Working with Web Frameworks**.

Creating an HTTP server

HTTP is the most prolific protocol in the Application Layer of the Internet Protocol

Suite. Node comes bundled with the core `http` module which providers both client and server capabilities.

In this recipe we're going to create an HTTP server from scratch.

Getting Ready

To keep things interesting, our server is actually going to be a RESTful HTTP server, so let's create a folder called `rest-server`, containing a file named `index.js`.

How to do it

We only need one module, the `http` module.

Let's require it:

```
const http = require('http')
```

Now we'll define a host and port which our HTTP server will attach to:

```
const host = process.env.HOST || '0.0.0.0'
const port = process.env.PORT || 8080
```

Next, let's create the actual HTTP server:

```
const server = http.createServer((req, res) => {
  if (req.method !== 'GET') return error(res, 405)
  if (req.url === '/users') return users(res)
  if (req.url === '/') return index(res)
  error(res, 404)
})
```

In the request handling function we passed to the `http.createServer` method, we reference three other functions, `error`, `users` and `index`.

First let's write our route handling functions:

```
function users (res) {
  res.end('{"data": [{"id": 1, "first_name": "Bob", "second_name": "Smi
}
```

```
function index (res) {
  res.end('{"name": "my-rest-server", "version": 0}')
}
```

Next we'll write our `error` function:

```
function error (res, code) {
  res.statusCode = code
  res.end(`{"error": "${http.STATUS_CODES[code]}"}`)
}
```

Finally we'll tell our server to listen on the previously defined `port` and `host`.

```
server.listen(port, host)
```

We can now try out our server.

We start our server like so:

```
$ node index.js
```

Then in another terminal, we can use `curl` to check the routes:

```
$ curl http://localhost:8080/users
{"data": [{"id": 1, "first_name": "Bob", "second_name": "Smith"}]}
```

```
$ curl http://localhost:8080/
{"name": "my-rest-server", "version": 0}
```

How it works

Node's core `http` module sits on top of the core `net` module (just as the HTTP protocol is layer over the TCP protocol).

When we call `http.createServer` it returns an object (which we call `server`) that has a `listen` method. The `listen` method, binds our server to a given port and host.

Our `port` and `host` assignments at the top of the file check `process.env.PORT` and `process.env.HOST`, before defaulting to port 8080 and host '0.0.0.0'. This is good practice since it allows us (or a deployment orchestrator) to inject the desired settings into our server at execution time.

The `http.createServer` method takes a function, this is known as the request handler. Every time a client makes a request of our server, this request handler function is called, and passed a Request (`req`) object and a Response (`res`) object.

Our request handler sets up logic paths based on the `req.url` and `req.method` properties. The first thing we do is check `req.method`, which holds the HTTP verb. In our case we're only supporting `GET` request, so anything other than `GET` receives a 405 response (Method not Allowed). From a puritanical perspective we should only be giving a 405 to any unsupported yet recognized HTTP method, and 400 (Bad Request) to nonsensical methods. However, for our purposes we simply don't care.

The `url` property of the Request object tends to be a misnomer, since it generally relates more to the relative path (the route) than the full URL. This is because in an HTTP request, a client will usually only specify the relative path (the full URL is known because the client has connected to the domain already at this point). Whether the requested route is `/` or `/users` we delegate to a specific route handling function, passing it the `res` object and then in each route handling function we call `res.end` with the desired content.

Finally if no conditional checks match, we never explicitly `return` from the request handler function, and reach the final `error` function call, which sends a 404 (Not Found) HTTP status code. The `error` function uses the `http.STATUS_CODES` constants to map HTTP codes to their equivalent descriptions.

There's more

How can we bind to a any free port? what about serving dynamic content by handling more complex URL patterns?

Bind to a random free port

To assign the server to a random free port, we simply set the port number to 0.

Let's copy the `rest-server` folder and call the new folder `rest-server-random-port`.

Now in the `rest-server-random-port/index.js` file let's change our `port` reference near the top of the file to the following:

```
const port = process.env.PORT || 0
```

Next we'll change our `server.listen` statement at the bottom of the file like so:

```
server.listen(port, host, () => console.log(JSON.stringify(server.addre
```

We've added a third callback argument to `server.listen`. The server binding process is asychronous, so we won't know which port we're bound to immediately. The callback is triggered once the server has bound to a port, then we can use the `server.address` method to get the port, host and IP family (IPv4 or IPv6). We `JSON.stringify` the object returned from `server.address`, this way a deployment orchestrator could easily take the data and parse it, passing it to some kind of discovery server.

Dynamic Content

There's not much point in a static HTTP server written in Node. Node's strength lies in it's ability to rapidly serve dynamic content.

Let's add a small filtering feature to our server.

We'll begin by copying the main `rest-server` folder created in the main recipe to a new folder called `rest-server-dynamic-content`.

Let's modify the top of `rest-server-dynamic-content/index.js` to look like so:

```
const http = require('http')
const qs = require('querystring')
const url = require('url')
```

Next let's add a mocked out user list resource:

```
const userList = [
  {'id': 1, 'first_name': 'Bob', 'second_name': 'Smith', type: 'red'},
  {'id': 2, 'first_name': 'David', 'second_name': 'Clements', type: 'bl
]
```

Next we'll rearrange the `http.createServer` request handler function to the following:

```
const server = http.createServer((req, res) => {
  if (req.method !== 'GET') return error(res, 405)
  if (req.url === '/') return index(res)
  const {pathname, query} = url.parse(req.url)
  if (pathname === '/users') return users(query, res)

  error(res, 404)
})
```

We've moved the `/` route logic above the `/users` route logic, because the conditional check against `req.url` is very cheap, we want to prioritize low cost routes and rather than penalize them with prior routes that require additional parsing.

We then use `url.parse` to break up `req.url` into an object. We're particularly interested in the `pathname` and `query` portions of the URL. Once we have a pathname we can do a direct comparison (no regular expressions required), and pass the `query` to the `users` route handling function. Notice we've modified the `users` function signature to additionally accept a `query` argument.

Let's now modify our `users` route handling function:

```
function users (query, res) {
  const {type} = qs.parse(query)
  const list = !type ? userList : userList.filter((user) => user.type =
  res.end(`{"data": ${JSON.stringify(list)}}`)
}
```

By default the `query` portion of a URL string that has been parsed with `url.parse` is a string. So to find the `type` argument in the quesystring we use `qs.parse` to convert it to an object, then use ES2015 deconstruction assign the `type` property to a `type` reference. Imagine we have a route `/users?type=blue`, our `query` parameter will be `?type=blue`, and the result of passing that to `qs.parse` will be an object: `{type: 'blue'}`. This means our `type` reference will be the string: `'blue'`. If there is no query string, or there's a query string with no type argument then the `type` value will be `undefined` (which is coerced to a falsey value in the ternary condition). If we have a `type` we filter our `userList`, or other set `list` to the entire `userList`. Finally we call `JSON.stringify` on our `list` array, as we pass the entire JSON payload to `res.end`.

We can try this out like so:

```
$ node index.js
```

```
$ curl http://localhost:8080/users?type=blue
{"data": [{"id":2,"first_name":"David","second_name":"Clements","type":
```

For bonus points, we can refine our code a little more.

The `url.parse` module can run the querystring `parse` function for us.

Let's copy `rest-server-dynamic-content/index.js` to `rest-server-dynamic-content/terser-index.js` to begin refining.

First we'll remove the `querystring` module, our require statements at the top of the file should look like so:

```
const http = require('http')
const url = require('url')
```

Next in our `http.createServer` request handler function we alter the line where `url.parse` occurs to the following:

```
  const {pathname, query} = url.parse(req.url, true)
```

We've added a second argument to `url.parse`, with a value of `true`.

Finally we no longer need to manually parse the querystring in our `users` route handling function, so we'll update `users` to:

```
function users ({type}, res) {
  const list = !type ? userList : userList.filter((user) => user.type =
  res.end(`{"data": ${JSON.stringify(list)}}`)
}
```

This server will behave in exactly the same way.

See also

- *Creating an Express web app* in **Chapter 7 Working with Web Frameworks**
- *Creating a Koa web app* in **Chapter 7 Working with Web Frameworks**
- *Creating a Hapi web app* in **Chapter 7 Working with Web Frameworks**
- *Receiving POST data* in this chapter

Receiving POST data

If we want to be able to receive POST data, we have to instruct our server on how to accept and handle a POST request.

In a language where I/O blocking is the primary runtime behavior, accessing POST body data would be as straight forward as accessing a property.

For instance, in PHP we could access our POST values with `$_POST['fieldname']`, the execution thread would block until an array value was filled.

Contrariwise, Node provides low level interaction with the asynchronous flow of HTTP data allowing us to interface with the incoming message body as a stream, leaving it entirely up to the developer to turn that stream into usable data.

> ### Streams ![../info.png]
>
> For more information on streams see **Chapter 4 Using Streams**

Getting ready

Let's create a `server.js` file ready for our code, plus a folder called `public` with an HTML file inside called `form.html`.

The `form.html` file should contain the following:

```
<form method="POST">
  <input type="text" name="userinput1"><br>
  <input type="text" name="userinput2"><br>
  <input type="submit">
</form>
```

How to do it

We'll provision our server for both `GET` and `POST` requests.

Let's start with `GET` by requiring the core `http` module and loading `form.html` into memory, which we'll then serve via `http.createServer`:

```
const http = require('http')
const fs = require('fs')
const path = require('path')
const form = fs.readFileSync(path.join(__dirname, 'public', 'form.html'

http.createServer((req, res) => {
  if (req.method === 'GET') {
    get(res)
    return
  }
  reject(405, 'Method Not Allowed', res)
}).listen(8080)

function get (res) {
  res.writeHead(200, {'Content-Type': 'text/html'})
  res.end(form)
}

function reject (code, msg, res) {
  res.statusCode = code
  res.end(msg)
}
```

We are synchronously loading `form.html` at initialization time instead of accessing the disk on each request. When creating servers in Node, initialization is the only time when it's a good idea to perform synchronous I/O.

If we navigate to `http://localhost:8080` we'll be presented with a form.

But if we fill out the form and submit, we'll encounter a "Method Not Allowed" response. This is because the `method` attribute on our HTML form is set to `POST`. If the method is anything other than `GET`, our request handler (the function passed to `http.createServer`) will fall through to calling the `reject` function which sets the relevant status code and sends the supplied message via the `res` object.

Our next step is to implement `POST` request handling.

First we'll add the `querystring` module to our list of required dependencies at the top of the file. The top section of our `server.js` file should become:

```
const http = require('http')
const fs = require('fs')
const path = require('path')
const form = fs.readFileSync(path.join(__dirname, 'public', 'form.html'
const qs = require('querystring')
```

For safety we'll want to define a maximum request size, which we'll use to guard against payload size based DoS attacks:

```
const maxData = 2 * 1024 * 1024 // 2mb
```

Now we'll add a check for POST methods in the request handler, so our `http.createServer` calls looks like so:

```
http.createServer((req, res) => {
  if (req.method === 'GET') {
    get(res)
    return
  }
  if (req.method === 'POST') {
    post(req, res)
    return
  }
  reject(405, 'Method Not Allowed', res)
}).listen(8080)
```

Next, let's implement the `post` function that's called within the request handler:

```
function post (req, res) {
  if (req.headers['content-type'] !== 'application/x-www-form-urlencode
    reject(415, 'Unsupported Media Type', res)
    return
  }
  const size = parseInt(req.headers['content-length'], 10)
  if (isNaN(size)) {
    reject(400, 'Bad Request', res)
    return
  }
  if (size > maxData) {
    reject(413, 'Too Large', res)
    return
  }
```

```
  const buffer = Buffer.allocUnsafe(size)
  var pos = 0

  req
    .on('data', (chunk) => {
      const offset = pos + chunk.length
      if (offset > size) {
        reject(413, 'Too Large', res)
        return
      }
      chunk.copy(buffer, pos)
      pos = offset
    })
    .on('end', () => {
      if (pos !== size) {
        reject(400, 'Bad Request', res)
        return
      }
      const data = qs.parse(buffer.toString())
      console.log('User Posted: ', data)
      res.end('You Posted: ' + JSON.stringify(data))
    })
}
```

Notice how we check the `Content-Type` and `Content-Size` headers sent by the browser. In particular `Content-Size` is validated at several check-points, this is important for preventing various types of attack from DoS attacks to leaking deallocated memory.

Once the form is completed and submitted, the browser and terminal should present the data provided via the form.

How it works

The `http` module sits on top of the `net` module (Node's TCP library) which in turn interacts with an internal C library called libuv. The libuv C library handles network socket input/output, passing data between the C layer and the JavaScript layer.

When we call `http.createServer` an object is returned which represents the HTTP server. We immediately call the `listen` method on the server object which instructs the `http` module to listen for incoming data on the supplied port (`8080`).

Every time data is received at the network socket layer, if the data is successfully translated into an HTTP request the `http` module creates an object representing the request (`req`) and response (`res`) then calls our supplied request handler passing it the request and response objects.

Our request handler checks the `method` property of the request object to determine whether the request is `GET` or `POST`, and calls the corresponding function accordingly, falling back to calling our `reject` helper function if the request is neither `GET` nor `POST`.

The `get` function uses `writeHead` to indicate a success code (`200`) and set the `Content-Type` header to inform the browser of the mime-type of our form content (`text/html`). The `res` object is a `WriteStream`, which have `write` and `end` methods. Our `get` function finishes by calling `res.end` passing it the cached `form` content, this simultaneously writes to the response stream and ends the stream, thus closing the HTTP connection.

The `reject` function sets the `statusCode` and similarly calls `res.end` with the supplied message.

Our `post` function implements the core objective of our server. The `post` function checks the `Content-Type` and `Content-Size` HTTP headers to determine that we can support the supplied values (we'll talk more about size validation shortly) and uses it to preallocate a buffer. The HTTP request object (`req`) is a Node stream, which inherits from the `EventEmitter` object. Readable streams constantly emit `data` events until an `end` event is emitted. In the `data` event listener we use the `Buffer` `copy` method to duplicate the bytes in each incoming `chunk` into our preallocated `buffer` and update the `pos` to `chunk.length` so the next `data` event starts from where we left off in the previous event.

When all the data is received from the client the `end` event will be triggered. Our `end` event listener converts the buffer to a string, passing it into `qs.parse`. This converts the POST data (which is in the format `userinput1=firstVal&userinput2=secondVal`) into an object. This object is logged our to the console, and serialized with `JSON.stringify` as it's passed to `res.end` and thus mirrored back to the user.

We cannot trust the client to reliably represent the size of the content, as this could be manipulated by an attacker so we take several measures to validate the `Content-Size` HTTP header. HTTP headers will always be in string format, so we use `parseInt` to convert from string to number. If the `Content-Size` header sent wasn't a number `size` would be `NaN` - in that case we send a `400 Bad Request` response.

> ### Web Frameworks
>
> Node's core API provides a powerful set of primitives to build functionality as we see fit. Of course, this also means there's a lot of angles to think about. In Chapter 6 we'll be talking about Web Frameworks where the low-level considerations have been taken care of, allowing us to focus primarily on business logic.

If `size` is a number we pass it to `Buffer.allocUnsafe` which creates a buffer of the given size. The choice by Node core developers to put "unsafe" in name is deliberately alarming.

`Buffer.allocUnsafe` will create a buffer from deallocated (i.e. unlinked) memory. That means any kind of data might appear in a buffer created with `allocUnsafe`, potentially including highly sensitive data like cryptographic private keys. This is fine as long as there isn't some way of leaking previously deallocated memory to the client. By using it we accept the burden of ensuring that a malicious request can't leak the data. This is why in the `end` event listener we check that `pos` is equal to `size`. If it isn't then the request is ending prematurely, and the old memory in our `buffer` hasn't been fully overwritten by the payload. Without the `size` check in the `end` event listener internal memory could leak to the client.

We could use `Buffer.alloc` instead, which zero-fills the memory (overwrites the memory with `00` bytes) before handing the buffer back but `Buffer.allocUnsafe` is faster.

The other check against `size` is in the `data` event listener, where we make sure the payload size doesn't exceed the provided `Content-Size`. This scenario could be a malicious attempt to overload the memory of our server, resulting in a Denial Of Service attack.

There's More

POST data can also be sent as JSON, let's take a look at how to receive POST requests with an `application/json` mime type.

Accepting JSON

REST architectures (among others) typically handle the `application/json` content type in preference to the `application/x-www-form-urlencoded` type. Generally this is due to the versatility of JSON as a multi-language interchange data format.

Let's convert our form and server to working with JSON instead of URL-encoded data.

We're going to use a third party module called `fast-json-parse` for safely and efficiently parsing the JSON.

To do this we'll have to initialize our folder with a `package.json` file and then install `fast-json-parse`.

Let's run the following on the command line

```
$ npm init -y
$ npm install --save fast-json-parse
```

In the `server.js` file we need to add the following to our required dependencies at the top of the file:

```
const parse = require('fast-json-parse')
```

The first line of our `post` function should be changed to checking `Content-Type` for `application/json`, like so:

```
function post (req, res) {
  if (req.headers['content-type'] !== 'application/json') {
    reject(415, 'Unsupported Media Type', res)
    return
  }
  /* ... snip .. */
}
```

The final step in converting our `server.js` file is to adjust the `end` event listener like so:

```
/* ... snip .. */
    .on('end', () => {
      if (pos !== size) {
        reject(400, 'Bad Request', res)
        return
      }
```

```
        const data = buffer.toString()
        const parsed = parse(data)
        if (parsed.err) {
          reject(400, 'Bad Request', res)
          return
        }
        console.log('User Posted: ', parsed.value)
        res.end('{"data": ' + data + "}")
      })
  /* ... snip .. */
```

Unfortunately HTML forms do not natively support POSTing in the JSON format, so we'll need to add a touch of JavaScript to `public/form.html`.

Let's add the following `script` tag to `form.html`, underneath the `<form>` element:

```
<script>
  document.forms[0].addEventListener('submit', function (evt) {
    evt.preventDefault()
    var form = this
    var data = Object.keys(form).reduce(function (o, i) {
      if (form[i].name) o[form[i].name] = form[i].value
      return o
    }, {})
    form.innerHTML = ''
    var xhr = new XMLHttpRequest()
    xhr.open('POST', '/')
    xhr.setRequestHeader('Content-Type', 'application/json')
    xhr.send(JSON.stringify(data))
    xhr.addEventListener('load', function () {
      var res
      try { res = JSON.parse(this.response) } catch (e) {
        res = {error: 'Mangled Response'}
      }
      form.innerHTML = res.error
        ? res.error
        : 'You Posted: ' + JSON.stringify(res.data)
    })
  })
</script>
```

Our form and server should now largely behave in the same manner as the main recipe.

Except our frontend is a tiny Single Page App and JSON (the backbone of modern web architecture) is being used for communication between server and client.

See also

- *Handling file uploads* in this chapter
- *Implementing Authentication* in **Chapter 7 Working with Web Frameworks**
- *Creating an HTTP server* in this chapter
- *Processing big data* in **Chapter 4 Using Streams**

Handling file uploads

We cannot process an uploaded file in the same way we process other POST data. When a file input is submitted in a form, the browser embeds the file(s) into a multipart message.

Multipart was originally developed as an email format allowing multiple pieces of mixed content to be combined into one payload. If we attempted to receive the upload as a stream and write it to a file, we would have a file filled with multipart data instead of the file or files themselves.

We need a multipart parser, the writing of which is more than a recipe can cover. So we'll be using `multipart-read-stream` module which sits on top of the well-established `busboy` module to convert each piece of the multipart data into an independent stream, which we'll then pipe to disk.

Getting Ready

Let's create a new folder called `uploading-a-file` and create a `server.js` file and an `uploads` directory inside that:

```
$ mkdir uploading-a-file
$ cd uploading-a-file
$ touch server.js
$ mkdir uploads
```

We'll also want to initialize a `package.json` file and install `multipart-read-stream` and `pump`.

On the command line, inside the `uploading-a-file` directory we run the following commands:

```
$ npm init -y
```

```
$ npm install --save multipart-read-stream pump
```

> ### Streams
>
> For more about streams (and why `pump` is essential) see the previous chapter, **Chapter 4 Using Streams**

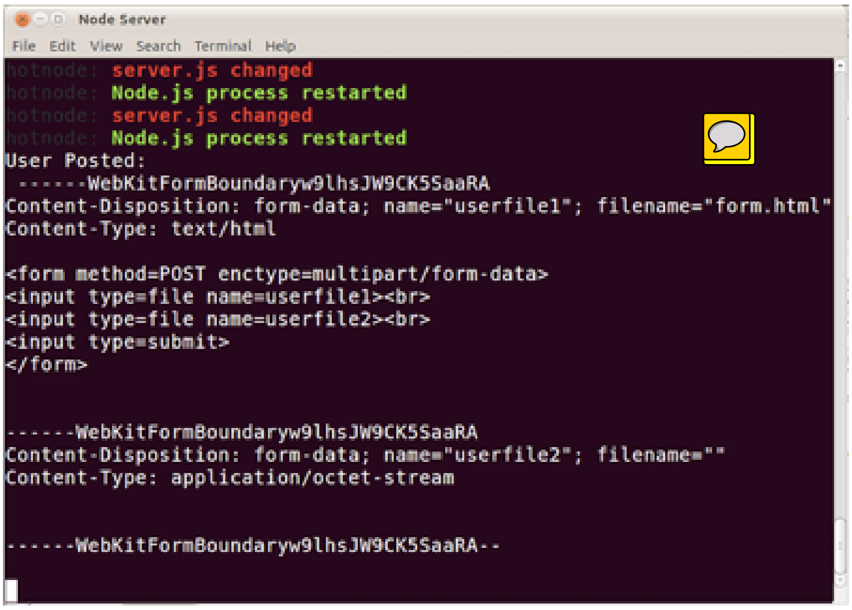
Finally we'll make some changes to our `form.html` file from the last recipe:

```html
<form method="POST" enctype="multipart/form-data">
  <input type="file" name="userfile1"><br>
  <input type="file" name="userfile2"><br>
  <input type="submit">
</form>
```

We've included an `enctype` attribute of `multipart/form-data` to signify to the browser that the form will contain upload data and we've replaced the text inputs with file inputs.

To gain some understanding of how multipart requests differ from normal `POST` requests, let's use our newly modified `form.html` file with the server from the previous recipe to see how a server without multipart capabilities handles a multipart upload.

If we upload the `form.html` file itself we should see something like the following:



Result of uploading multipart form data server from previous recipe

Our original POST server simply logs the raw HTTP message body to the console, which in this case is multipart data.

We had two file inputs on the form. Though we only uploaded one file, the second input is still included in the multipart request. Each file is separated by a predefined boundary that is set in a secondary attribute of the `Content-Type` HTTP headers.

How to do it

Let's set up our initial modules and load the form HTML as in our former recipe:

```
const http = require('http')
const fs = require('fs')
const path = require('path')
const mrs = require('multipart-read-stream')
const pump = require('pump')
const form = fs.readFileSync(path.join(__dirname, 'public', 'form.html'
```

Next we'll set up the HTTP server, along with a `GET` handler function and a `reject` function for dealing with unsupported methods.

```
http.createServer((req, res) => {
  if (req.method === 'GET') {
    get(res)
    return
  }
  if (req.method === 'POST') {
    post(req, res)
    return
  }
  reject(405, 'Method Not Allowed', res)
}).listen(8080)

function get (res) {
  res.writeHead(200, {'Content-Type': 'text/html'})
  res.end(form)
}

function reject (code, msg, res) {
  res.statusCode = code
  res.end(msg)
}
```

Finally we'll write the `post` function:

```
function post (req, res) {
  if (!/multipart\/form-data/.test(req.headers['content-type'])) {
    reject(415, 'Unsupported Media Type', res)
    return
  }
  console.log('parsing multipart data')
  const parser = mrs(req.headers, part)
  var total = 0
  pump(req, parser)

  function part (field, file, name) {
    if (!name) {
      file.resume()
      return
    }
    total += 1
    const filename = `${field}-${Date.now()}-${name}`
    const dest = fs.createWriteStream(path.join(__dirname, 'uploads', f
    pump(file, dest, (err) => {
      total -= 1
      res.write(err
        ? `Error saving ${name}!\n`
        : `${name} successfully saved!\n`
      )
      if (total === 0) res.end('All files processed!')
    })
  }
}
```

Now we have an upload server.

If we run

```
$ node server.js
```

Then open a browser at http://localhost:8080 we can upload some files, and check if our `upload` folder to see if they were added.

How it works

Setting the `enctype` attribute of the HTML `<form>` element to `multipart/form-data` causes the browser to set the `Content-Type` in the request header to `multipart/form-data` and to embed data in any files supplied via the `<input type="file">` elements into a multipart wrapper.

Our `post` function checks for the appropriate `multipart/form-data` content type in the `req.headers` object, rejecting the request with a 415 HTTP code (Unsupported Media Type) if the content type isn't `multipart/form-data`.

We create our `parser` by instantiating the `multipart-request-stream` module (`mrs`), passing it `req.headers`, and `part` (a function we declare shortly after).

We set up a `total` variable, which we use to track files from their point of discovery to when they've been completely written to disk.

The `pump` module is used to pipe data from the `req` object to the `parser`, this will cause our `part` function to be called each time the `parser` stream encounters a multipart boundary that contains file data.

In the `part` function we check to see that the `name` has a non-falsey value. This is because the browser will include all file fields even if they're not populated in the multipart data. If a file section has no name, then we can simply skip it. The `file` argument passed to `part` is a stream, in the event of an empty file section, we call the `resume` method (a stream method) to make the stream run to completion, allowing us to process the next file section in the multipart data.

Once we've verified the section has file data, we add one to `total`.

Then we create a filename based on the HTML elements field name, the current epoch time stamp and the original file name.

We create a write stream called `dest` that writes the incoming file into the `uploads` folder. We use `pump` again to pipe data from the `file` stream (as passed to the `part` function by the `multipart-read-stream` parser) to the `dest` stream.

This effectively writes a particular section of the multipart data to the `uploads` folder with the appropriate file. Using streams to do this means no matter how big the file is, memory and CPU usage will remain flat.

In the final parameter to the second call to `pump`, we provide a fat arrow callback. This will be called either in the event of an error or once all data has been written from the `file` stream into the `dest` stream. When the callback supplied to `pump` is called, we minus one from the `total` and write a message based on error state to the response stream.

When the `total` reaches 0 we know we've processed all the files in the multipart data and can end the response with a completion message.

There's more

Multipart data doesn't just contain files, and file uploading from the browser isn't limited to multipart POST requests. Let's explore.

Processing all field types in multipart data

Multipart data can contain both files and field values.

Let's copy the `uploading-a-file` folder to a folder called `processing-all-types`.

Let's modify our `public/form.html` file by changing one of the file inputs to a text input:

```
<form method="POST" enctype="multipart/form-data">
  <input type="text" name="userinput1"><br>
  <input type="file" name="userfile2"><br>
  <input type="submit">
</form>
```

The `multipart-read-stream` module is a thin wrapper around the `busboy` module, it listens to `busboy` for a `file` event and calls the user supplied function (which we called `part` in the main recipe).

Fortunately, `multipart-read-stream` returns the `busboy` instance, which also emits a `field` event. We can listen to this to process any non-file elements contained in the multipart data.

In `server.js`, let's add a `field` event listener directly under the assignment of our `parser` variable, making the top of our `post` function look like the following:

```
function post (req, res) {
  if (!/multipart\/form-data/.test(req.headers['content-type'])) {
    reject(415, 'Unsupported Media Type', res)
    return
  }
  console.log('parsing multipart data')
  const parser = mrs(req, res, part, () => {
    console.log('finished parsing')
  })
```

```
  parser.on('field', (field, value) => {
    console.log(`${field}: ${value}`)
    res.write(`processed "${field}" input.\n`)
  })
  var total = 0
  pump(req, parser)
  /* ... snip ... */
}
```

Uploading files via PUT

Browsers are also capable of uploading files via an HTTP PUT request.

While we can only send one file per request, we don't need to do any parsing on the server side since we can simply stream the request contents directly to a file. This means less server-side processing overhead.

It would be magnificent if we could achieve this by changing our form's method attribute from POST to PUT, but alas, no, there is no specification for this.

However thanks to XMLHttpRequest Level 2 (xhr2), we can now transfer binary data via JavaScript in modern browsers (see http://caniuse.com/xhr2 (IE9 and Opera mini are lacking support)).

We can grab a file pointer using a `change` event listener on the input file element, and then we open a PUT request and send the file upon form submission.

Let's copy the `uploading-a-file` folder to a folder called `uploading-a-file-with-put`.

We won't be needing `multipart-read-stream`, but we will need the `through2` module, so let's alter our dependencies accordingly:

```
$ npm i --save through2
$ npm uninst --save multipart-read-stream
```

Next we'll modify our `public/form.html` file like so:

```
<form id="upload">
  <input type="file" name="userfile1"><br>
  <input type="submit">
</form>
<pre id="status"></pre>
```

We've added an `id` attribute to the form and the `method` and `enctype` attributes have been removed. We're also using just one file element because we can only send one file per request.

We've also added a `<pre>` tag which we'll be using to display status updates from the server.

In the same `public/form.html` file let's add an inline script at the end of the file:

```
<script>
(function () {
  var fieldName = 'userfile1'
  var field = document.querySelector('[name=' + fieldName + ']')
  var uploadForm = document.getElementById('upload')
  var status = document.getElementById('status')
  var file
  field.addEventListener('change', function () {
    file = this.files[0]
  })
  uploadForm.addEventListener('submit', function (e) {
    e.preventDefault()
    if (!file) return
    var xhr = new XMLHttpRequest()
    xhr.file = file
    xhr.open('put', window.location, true)
    xhr.setRequestHeader("x-field", fieldName)
    xhr.setRequestHeader("x-filename", file.fileName || file.name)
    xhr.onload = updateStatus
    xhr.send(file)
    file = ''
    uploadForm.reset()
  })
  function updateStatus() {
    status.innerHTML += this.status === 200
      ? this.response
      : this.status + ': ' + this.response
  }
}())
</script>
```

Our script attaches a `change` listener to the file input element.

When the user selects a file, we the context (`this`) of the handler function for the `change` listener to take the first file in the files array (`this.files`).

Once a user submits the form our `submit` listener prevents default behavior (stops the browser from automatically submitting), checks whether a file is selected (doing nothing if no file has been selected), initializes an xhr object and opens a PUT request to our server. Then we set two custom headers, `x-field` and `x-filename`, we'll use these in our `server.js` file to determine the name of the input field and the original file name on the clients file system.

We set the `onload` method to our `updateStatus` function which will append responses from the server to our `<pre>` tag.

Finally we use the `send` method to initiate the PUT request and clean up by clearing the `file` variable and resetting our form.

Let's modify the top of our `server.js` file as follows:

```
const http = require('http')
const fs = require('fs')
const path = require('path')
const pump = require('pump')
const through = require('through2')
const form = fs.readFileSync('public/form.html')
const maxFileSize = 51200
```

We've removed the `multipart-read-stream` dependency, added `through2` and created a `maxFileSize` constant.

Let's modify `http.createServer` response handler like so:

```
http.createServer((req, res) => {
  if (req.method === 'GET') {
    get(res)
    return
  }
  if (req.method === 'PUT') {
    put(req, res)
    return
  }
  reject(405, 'Method Not Allowed', res)
}).listen(8080)
```

We've simply changed the check for the `POST` method to a check for `PUT` method and call a `put` function instead of a `post` function.

Finally we need to remove the old `post` function, and replace it with the following `put` function:

```
function put (req, res) {
  const size = parseInt(req.headers['content-length'], 10)
  if (isNaN(size)) {
    reject(400, 'Bad Request', res)
    return
  }
  if (size > maxFileSize) {
    reject(413, 'Too Large', res)
    return
  }

  const name = req.headers['x-filename']
  const field = req.headers['x-field']
  const filename = `${field}-${Date.now()}-${name}`
  const dest = fs.createWriteStream(path.join(__dirname, 'uploads', fil
  const counter = through(function (chunk, enc, cb) {
    this.bytes += chunk.length
    if (this.bytes > maxFileSize) {
      cb(Error('size'))
      return
    }
    cb(null, chunk)
  })
  counter.bytes = 0
  counter.on('error', (err) => {
    if (err.message === 'size') reject(413, 'Too Large', res)
  })
  pump(req, counter, dest, (err) => {
    if (err) return reject(500, `Error saving ${name}!\n`, res)
    res.end(`${name} successfully saved!\n`)
  })
}
```

After some `Content-Length` checks we grab the original filename and field as supplied through the HTTP headers and construct a filename in similar fashion to our output filenames in the main recipe. Also similar to the main recipe, we create a `dest` stream.

For safety we also use the `through2` module to create a byte counting stream. This could be important, since a malicious client could lie about `Content-Length` and send a much larger payload. We keep a running total of bytes passing through our stream, if they exceed the maximum we send an error down the stream.

As outlined in *Chapter 3 Using Streams* the `pump` module will propagate errors to all streams in the pipeline. We need to catch an error on the `counter` stream before `pump` does that, since it will close the `req` stream which will implicitly end the response. So we listen directly for an `error` event on the `counter` stream and send a `413: Too Large` response within the error event handler.

Then we set up a pipeline from `req` to `counter` to our output `dest`, when the pipeline ends we send a success message, or failure if some other error has occurred.

See also

- *Receiving POST data* in this chapter
- *Implementing authentication* in **Chapter 7 Working with Web Frameworks**
- *Creating an HTTP server* in this chapter
- *Piping streams in production* in **Chapter 4 Using Streams**

Making an HTTP POST request

Making a GET request with Node is trivial, in fact HTTP GET requests have been covered in **Chapter 4 Using Streams** in the context of stream processing.

HTTP GET requests are so simple we can fit a request that prints to stdout into a single shell command (the `-e` flag passed to the `node` binary instructs node to evaluate the string that follows):

```
$ node -e "require('http').get('http://example.com', (res) => res.pipe(
```

In this recipe we'll look into constructing POST requests.

Getting Ready

Let's create a folder called `post-request`, then create an `index.js` inside the folder and open it in our favorite text editor.

How to do it

We only need one dependency, the core `http` module. Let's require it:

```
const http = require('http')
```

Now let's define a payload we wish to POST to an endpoint:

```
const payload = `{
  "name": "Cian Ó Maidín",
  "company": "nearForm"
}`
```

Now we'll define the configuration object for the request we're about to make:

```
const opts = {
  method: 'POST',
  hostname: 'reqres.in',
  port: 80,
  path: '/api/users',
  headers: {
    'Content-Type': 'application/json',
    'Content-Length': Buffer.byteLength(payload)
  }
}
```

Notice how we use `Buffer.byteLength` to determine the `Content-Length` header.

> ### reqres.in
>
> We're using reqres.in, a dummy REST API provided as a public service. The endpoint we're posting to simply mirrors the payload back in the response.

Next we'll make the request, supplying a callback handler which will be called once the request has completed:

```
const req = http.request(opts, (res) => {
  console.log('\n  Status: ' + res.statusCode)
  process.stdout.write('  Body: ')
  res.pipe(process.stdout)
  res.on('end', () => console.log('\n'))
})
```

Let's not forget to handle errors:

```
req.on('error', (err) => console.error('Error: ', err))
```

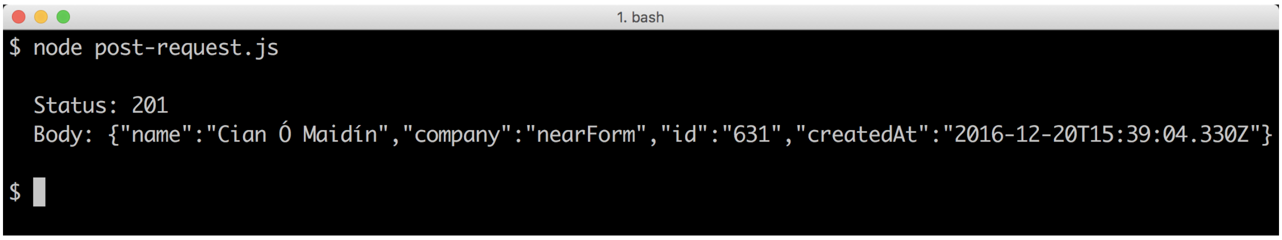
Finally the most important part, sending the payload.

```
req.end(payload)
```

Now if we execute our script:

```
$ node index.js
```

Providing the website reqres.in is functioning correctly, we should see something like the following:



reqres.in will simply mirror the posted payload

How it works

The `http` module provides both server and client capabilities.

We use the `http.request` method to create a request stream, which takes an options object (`opts`) describing the request and a callback.

> ### HTTPS Requests
>
> If the endpoint is encrypted (e.g. a standard HTTPS endpoint) We simply swap out the `http` module for the `https` module, the rest of the code remains the same.

In the `headers` of the `opts` object we set `Content-Type` and `Content-Length` headers. While the request will still be successful without providing `Content-Length` it is good practice and allows the server to make informed assumptions about the payload. However, setting `Content-Length` to a number lower than the payload size will result in an error. This is why it's important to use `Buffer.byteLength` because this gives the exact size of the string in bytes, which can differ from the string length when unicode beyond the ascii range are in the string (since unicode characters can be from 1 to 4 bytes, but are treated as a single character where `String.prototype.length` is concerned).

The `http.request` method opens a socket that's connected to the endpoint described in opts and returns a stream (which we assign to `req`).

When we write to this stream (using `req.end`) data is posted to the endpoint and the underlying socket is closed (because we ended the stream),

Since `req` is a stream it also has an `error` event, which we listen to. This would be fired in the event of network or socket errors, whereas a server error response would be reflected in the response status code.

The fat arrow callback passed to the `http.request` method is passed a response object, which we call `res`. We output the status using `res.statusCode`. Then we write the "Body:" label to the `process.stdout` stream (`console.log` would add a newline, we don't want that in this case), followed by piping the `res` object to `process.stdout`. Finally we listen to the `end` event on the `res` object to add two final newlines to the output (`console.log` adds an additional newline).

There's more

How would we parse an entire data set at once? Can we stream a payload to a POST endpoint? How would we go about making a multipart POST upload in Node?

Buffering a GET Request

Sometimes it may be necessary to receive response data in it's entirety before it can be parsed.

Let's create a folder called `buffering-a-request` with a fresh `index.js` file.

In the `index.js` file we write the following code:

```
const http = require('http')
const assert = require('assert')
const url = 'http://www.davidmarkclements.com/ncb3/some.json'

http.get(url, (res) => {
  const size = parseInt(res.headers['content-length'], 10)
  const buffer = Buffer.allocUnsafe(size)
  var index = 0
  res.on('data', (chunk) => {
    chunk.copy(buffer, index)
    index += chunk.length
  })
```

```
  res.on('end', () => {
    assert.equal(size, buffer.length)
    console.log('GUID:', JSON.parse(buffer).guid)
  })
})
```

When we run our script:

```
$ node index.js
```

We should see a log message containing the `guid` property found in the JSON data set.

We use `Buffer.allocUnsafe` to preallocate a buffer, "unsafe" is in the name because it uses garbage memory instead of zero-filling it - this is more performant but the risk of leaking internal data should be understood (for instance if the content length was greater than the actual amount of data received). In our case everything happens locally, so it's not a problem.

Then we listen to the `data` event of the response object (`res`), each `chunk` that comes through the `data` event is a `Buffer` instance, we use the `copy` method to copy the contents of the buffer into our pre-allocated `buffer` , keeping a running total of bytes copied in the `index` variable, which is passed to the `copy` method as the offset argument.

When the response ends, (in the `end` event handler), we check that the servers provided `Content-Length` header matches the amount of data received by checking `size` with `buffer.length` . Finally we parse the whole payload with `JSON.parse` and grab the `guid` property from the subsequent object returned from `JSON.parse` .

> ## Parsing remote data
>
> In a production setting, we should never call `JSON.parse` without wrapping a `try/catch` block around it. This is because any invalid JSON will cause `JSON.parse` to throw, which will cause the process to crash. The `fast-json-parse` supplies, safe, high performance and clean JSON parsing.

Streaming payloads

Since the instance returned from `http.request` is a writable stream, we can take an input stream and pipe it to the POST request as data.

In this case we want to notify the server that we'll be incrementally writing the request body to the server in chunks.

Let's copy the main recipe folder to a new folder, call it `streaming-payloads`.

Now we'll tweak the `index.js` file slightly.

Let's make the top of the file look accordingly:

```
const http = require('http')
const opts = {
  method: 'POST',
  hostname: 'reqres.in',
  port: 80,
  path: '/api/users',
  headers: {
    'Content-Type': 'application/json',
    'Transfer-Encoding': 'chunked'
  }
}
```

The `payload` assignment has been completely removed and we've replaced the `Content-Length` header with a `Transfer-Encoding` headed, set to `chunked`.

At the bottom of the file, we can replace the line `req.end(payload)` with:

```
http.get('http://reqres.in/api/users', (res) => {
  res.pipe(req)
})
```

We've initialized a stream of JSON from reqres.in (`res`) and piped it directly to request object (`req`).

When we run our script, we should see something like the following.

```
1. bash
$ node index.js

  Status: 201
  Body: {"page":1,"per_page":3,"total":12,"total_pages":4,"data":[{"id":1,"first_name":"george","last_name":"bluth","avatar":"https://s3.amazonaws.com/uifaces/faces/twitter/calebogden/128.jpg"},{"id":2,"first_name":"lucille","last_name":"bluth","avatar":"https://s3.amazonaws.com/uifaces/faces/twitter/josephstein/128.jpg"},{"id":3,"first_name":"oscar","last_name":"bluth","avatar":"https://s3.amazonaws.com/uifaces/faces/twitter/olegpogodaev/128.jpg"}],"id":"518","createdAt":"2016-12-20T18:48:38.175Z"}
```

Multipart POST uploads

For fun and profit, let's build our own multipart request which we can post to the multipart upload server we created in the Receiving POST data recipe (if we haven't completed that recipe now might be a good time to read up).

Let's create a new folder called `multipart-post-uploads`, with an `index.js`. We'll also initialize a `package.json` file and install `steed` (a low-overhead asynchronous control flow library).

```
$ mkdir multipart-post-uploads
$ touch index.js
$ npm init -y
$ npm install --save steed
```

Now in the `index.js` file let's begin by setting up our dependencies:

```
const http = require('http')
const fs = require('fs')
const path = require('path')
const steed = require('steed')()
```

Now for some configuration:

```
const files = process.argv.slice(2)
const boundary = Date.now()
const opts = {
  method: 'POST',
  hostname: 'localhost',
  port: 8080,
  path: '/',
  headers: {
    'Content-Type': 'multipart/form-data; boundary="' + boundary + '"',
    'Transfer-Encoding': 'chunked'
  }
}
```

We're using `process.argv` (command line arguments), to determine which files to send in the multipart data. Our `Content-Type` header tells the server the multipart boundary that will designate each section in the data, and signify the end of the multipart data.

Next we'll set up the request:

```
const req = http.request(opts, (res) => {
  console.log('\n  Status: ' + res.statusCode)
  process.stdout.write('  Body: ')
  res.pipe(process.stdout)
  res.on('end', () => console.log('\n'))
})

req.on('error', (err) => console.error('Error: ', err))
```

Finally we'll write the multipart data to the `req` stream, based on the files provided via the command line:

```
const parts = files.map((file, i) => (cb) => {
  const stream = fs.createReadStream(file)
  stream.once('open', () => {
    req.write(
      `\r\n--${boundary}\r\n` +
      'Content-Disposition: ' +
      `form-data; name="userfile${i}";` +
      `filename="${path.basename(file)}"\r\n` +
      'Content-Type: application/octet-stream\r\n' +
      'Content-Transfer-Encoding: binary\r\n' +
      '\r\n'
    )
  })
  stream.pipe(req, {end: false})
  stream.on('end', cb)
})

steed.series(parts, () => req.end(`\r\n--${boundary}--\r\n`))
```

The `parts` assignment is essentially a list of operations which we subsequently run in series using `steed.series`. To create this we map over each of the file paths, and return a function that takes a callback (`cb`).

Within that function, we create a read stream from the supplied file path. Read streams have an `open` event, which is triggered the moment the file is opened. We listen for this event and write the multipart header for the file. The header contains the field name (just called name in the header) - we set this simply to `userfile` plus the index of the file as it appeared in the command line arguments. A more sophisticated approach would involce mime-type detection and we'd be setting `Content-Type` in the multipart header appropriately. Since all data can be binary, we simplify by sending everything with the `Content-Type` of `application/octet-stream` and `Content-Transfer-Type` of binary.

Then we pipe from `stream` to `req`, passing an additional options argument to `pipe`, with an `end` property set to `false`. This will prevent `req` from being closed when `stream` finishes. Since we may have additional files, the `req` stream needs to stay open.

When `stream` ends we call `cb`. At this point, our flow control library `steed`, will process the next operation. When every function in the `parts` array has been processed by `steed.series` we end the request stream (`req`) with the multipart end boundary.

We can test this out by sending the source `index.js` twice to our multipart server from the Receiving POST data recipe.

First let's start the upload server.

In the `uploading-a-file` folder, which was created in the Receiving POST data recipe, we run:

```
$ node server.js
```

Then in a new terminal, in our `multipart-post-uploads` folder we run

```
$ node index.js package.json index.js
```

This will send the `package.json` file and the source `index.js` file to our server.

We can check the `uploads` folder in the `uploading-a-file` directory, to determine whether the `index.js` and `package.json` file were correctly uploaded.

See also

- *Receiving POST data* in this chapter
- *Using the pipe method* in **Chapter 4 Using Streams**
- *Processing big data* in **Chapter 4 Using Streams**

Communicating with WebSockets

HTTP was not made for the kind of real-time web applications that many developers are creating today. As a result, all sorts of workarounds have been discovered to mimic the idea of bidirectional, uninterrupted communication between servers and clients.

WebSockets don't mimic this behavior; they provide it.

In this recipe we will use the third-party `ws` module to create a pure WebSocket server that will receive and respond to WebSocket requests from the browser.

Getting Ready

Let's create a new folder called `websocket-app` with a `server.js` file, plus a folder called `public` containing a `index.html` file.

```
$ mkdir websocket-app
$ cd websocket-app
$ touch server.js
$ mkdir public
$ touch public/index.html
```

We also need to initialize our app as a Node package, and install the `ws` module.

```
$ npm init -y
$ npm install --save ws
```

How to do it

In `server.js` let's begin by requiring our dependencies:

```
const http = require('http')
const fs = require('fs')
const ws = require('ws')
```

Next we want to load `public/index.html` into memory (we'll write `index.html` shortly), create an HTTP server, and then enhance it with a WebSocket server:

```
const app = fs.readFileSync('public/index.html')
const server = http.createServer((req, res) => {
  res.setHeader('Content-Type', 'text/html')
  res.end(app)
})
const wss = new ws.Server({server})
```

Now that we have our WebSocket server instance (`wss`), we can listen to its `connection` event:

```
wss.on('connection', (socket) => {
  socket.on('message', (msg) => {
    console.log(`Received: ${msg}`)
    console.log(`From IP: ${socket.upgradeReq.connection.remoteAddress}
    if (msg === 'Hello') socket.send('Websockets!')
  })
})
```

Finally let's tell our HTTP server to listen on port 8080:

```
server.listen(8080)
```

Now for our frontend code.

Let's place the following in `public/index.html`

```
<input id="msg"><button id="send">Send</button>
<div id="output"></div>
```

Now in the same `public/index.html`, we'll place our client side JavaScript.

At the bottom of `public/index.html` let's add the following:

```
<script>
(function () {
  var ws = new WebSocket('ws://localhost:8080')
  var output = document.getElementById('output')
  var send = document.getElementById('send')

  function log (event, msg) {
    return '<div>' + event + ': ' + msg + '</div>';
  }

  send.addEventListener('click', function () {
    var msg = document.getElementById('msg').value
    ws.send(msg)
    output.innerHTML += log('Sent', msg)
  })

  ws.onmessage = function (e) {
```

```
    output.innerHTML += log('Received', e.data)
  }

  ws.onclose = function (e) {
    output.innerHTML += log('Disconnected', e.code + '-' + e.type)
  }

  ws.onerror = function (e) {
    output.innerHTML += log('Error', e.data);
  }
}())
</script>
```

Let's try it out by starting our server:

```
$ node server.js
```

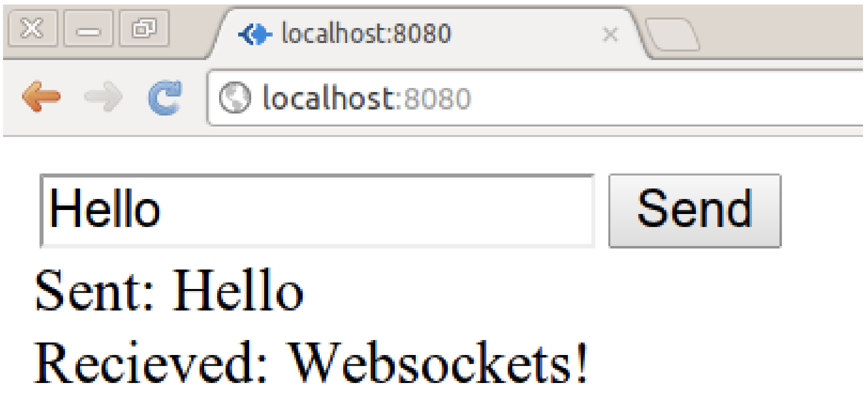
Then going to http://localhost:8080 in our browser, typing "Hello" in the textbox and clicking on the "Send" button.

The terminal should then output something like:

```
Received: Hello
From IP: ::1
```

On other systems (where IPv4 is the default) the IP might be 127.0.0.1 instead.

Our browser should display something like the following:



How it works

WebSocket servers start out as HTTP servers, then the browser connects to the HTTP server and asks to upgrade; at this point, the WebSocket logic takes over.

We supply an HTTP server instance to the WebSocket server at initialization time by passing it in the options object (we use ES6 shorthand to set a property of `server` with the value being the `server` instance).

When we navigate the browser to http://localhost:8080, an HTTP request is made and we send our in-memory `public/index.html` file as the response.

As soon as the HTML is loaded in the browser, the inline script is executed and the WebSocket upgrade request is made to our server.

When the server receives this WebSocket upgrade request, our WebSocket server instance (`wss`) emits a `connection` event that supplies `socket` as the first parameter of the connection event handler function.

The `socket` parameter is an instance of `EventEmitter` ; we use its `message` event to respond to incoming messages on the established WebSocket connection.

In the `message` event handler function we log the received data and the client IP address to the terminal and check whether the incoming message is "Hello". If it is, we use the `socket.send` method to respond to the client with "WebSockets!".

There's more

WebSockets have so much potential for efficient low latency real-time web apps. Let's take a look at a WebSocket client outside of the browser and then further see how browser APIs can be wrapped in one of Node's fundamental paradigms: streams.

Creating a Node.js WebSocket client

The `ws` module also allows us to create a WebSocket client outside of the browser environment.

Let's see if we recreate equivalent (and enhanced) functionality to our browser app in the terminal. Essentially we're going to create a generic interactive WebSocket testing command-line tool!

We'll start by creating a new folder called `websocket-client` with an `index.js` file. We'll also need to create a `package.json` and install the `ws` module

```
$ mkdir websocket-client
$ cd websocket-client
$ npm init -y
$ npm install --save ws
```

Now let's open `index.js` in our favorite editor, and begin by requiring and initializing the `ws` module and the core `readline` module:

```
const WebSocket = require('ws')
const readline = require('readline')
const ws = new WebSocket(process.argv[2] || 'ws://localhost:8080')
const rl = readline.createInterface({
  input: process.stdin,
  output: process.stdout,
  prompt: '-> '
})
```

Notice that we allow a command line argument to determine the WebSocket address, although we default to the address of the server in the main recipe.

Next let's set up some convenience references to ANSI terminal escape codes (we'll be using these to set colors in the terminal):

```
const gray = '\u001b[90m'
const red = '\u001b[31m'
const reset = '\u001b[39m'
```

Next we'll listen for an `open` event on our WebSocket client instance (`ws`), and output an appropriate status message when it fires:

```
ws.on('open', () => {
  rl.output.write(`${gray}-- Connected --${reset}\n\n`)
  rl.prompt()
})
```

Notably, we use `rl.output` instead of `process.stdout` , this makes our implementation agnostic to the I/O streams, which theoretically allows for extensible and plug-able code.

The readline module allows us to take line by line input, so let's listen for the `line` event and send user input as a WebSocket message:

```
rl.on('line', (msg) => {
  ws.send(msg, () => {
    rl.output.write(`${gray}<= ${msg}${reset}\n\n`)
    rl.prompt()
  })
})
```

If the message is successfully sent (using `ws.send`), the supplied callback (second argument passed to `ws.send`) is called. Here we output a status message confirming the user input was sent, and set up the prompt for further input.

WebSocket communication is of course bidirectional, so let's listen for any messages coming from the server:

```
ws.on('message', function (msg) {
  readline.clearLine(rl.output)
  readline.moveCursor(rl.output, -3 - rl.line.length, -1)
  rl.output.write(`${gray}=> ${msg}${reset}\n\n`)
  rl.prompt(true)
})
```

Finally we'll finish by listening the `close` and `error` events, and outputting relevant status' to the terminal:

```
ws.on('close', () => {
  readline.cursorTo(rl.output, 0)
  rl.output.write(`${gray}-- Disconnected --${reset}\n\n`)
  process.exit()
})
ws.on('error', (err) => {
  readline.cursorTo(rl.output, 0)
  rl.output.write(`${red}-- Error --${reset}\n`)
  rl.output.write(`${red}${err.stack}${reset}\n`)
})
```

Lets start out server from the main recipe by running (from the `websocket-app` folder):

```
$ node server.js
```

Then in a separate terminal, from the `websocket-client` folder, we can execute

```
$ node index.js
```

We should see an interaction illustrated in the following figure:

```
2. tmux
~/websocket-client $ node index.js         |~/websocket-app $ node server.js
-- Connected --                            |Received: Hello
                                           |From IP: ::ffff:127.0.0.1
-> Hello                                   |^C
<= Hello                                   |~/websocket-app $
=> Websockets!                             |
                                           |
-- Disconnected --                         |
                                           |
~/websocket-client $                       |
```

If we try to run our Node.js websocket client without the server started we'll see the error handler in effect:

```
2. bash
$ node index.js
-- Error --
Error: connect ECONNREFUSED 127.0.0.1:8080
    at Object.exports._errnoException (util.js:1022:11)
    at exports._exceptionWithHostPort (util.js:1045:20)
    at TCPConnectWrap.afterConnect [as oncomplete] (net.js:1087:14)
-- Disconnected --
```

Since we also allow command line input, we can easily connect to other WebSocket servers. For instance we could connect to ws://echo.websocket.org like so:

```
$ node index.js ws://echo.websocket.org
```

We can see the results of doing so, and typing "Echo :)" in the following figure:

```
2. bash
$ node index.js ws://echo.websocket.org
-- Connected --

-> echo :)
<= echo :)
=> echo :)

-> ^C
$
```

The WebSocket protocol is not purely request-response oriented, so a message may come from the server without direct client interaction. We cater to this possibility in several ways.

Every non-terminal status (everything other than close or error status') is followed by two newlines. This gives us space to seamlessly inject a received message. When a message comes from the server we use `readLine.clearline` to wipe the current user prompt. Then we use `readline.moveCursor` to jump to the above line, and set the X position to the first column. We write the message out to `rl.output` (the terminal), and then call `rl.prompt` with `true` (this preserves current prompt content and cursor position).

See also

- *Creating an HTTP server* in this chapter
- *Interfacing with standard I/O* in **Chapter 3 Coordinating I/O**
- *Processing big data* in **Chapter 4 Using Streams**

Creating an SMTP server

In this recipe, we'll create our own internal SMTP server (just like the first SMTP servers) using the `smtp-protocol` module,

For information on converting an internal SMTP server to an externally exposed MX record server, see the *There's more...* section at the end of this recipe.

Getting Ready

Let's create a folder called `smtp-server`, with an `index.js` file.

Then on the command-line from within the `smtp-server` directory, we can initialize our folder and install the `smtp-protocol` module:

```
$ npm init -y
$ npm install --save smtp-protocol
```

How to do it

Let's start by requiring relevant dependencies:

```
const fs = require('fs')
```

```
const path = require('path')
const smtp = require('smtp-protocol')
```

We're only going to accept emails to certain host domains, and only for certain users. We also need somewhere to store emails we have accepted.

So let's create two whitelist sets, one for hosts and the other users, along with a target path for mail boxes:

```
const hosts = new Set(['localhost', 'example.com'])
const users = new Set(['you', 'another'])
const mailDir = path.join(__dirname, 'mail')
```

Before we create the server, we have some set up to perform. We need to make sure that the mail directory and user mail boxes exist on the file system, if they don't we need to create them.

Let's write the following code to do that:

```
function ensureDir (dir, cb) {
  try { fs.mkdirSync(dir) } catch (e) {
    if (e.code !== 'EEXIST') throw e
  }
}

ensureDir(mailDir)
for (let user of users) ensureDir(path.join(mailDir, user))
```

Next we'll create out SMTP server:

```
const server = smtp.createServer((req) => {
  req.on('to', filter)
  req.on('message', (stream, ack) => save(req, stream, ack))
  req.on('error', (err) => console.error(err))
})

server.listen(2525)
```

This gives us an outline of what we'll do for each incoming SMTP request.

We still need to implement the `filter` and `save` functions shortly.

Our `filter` function will deconstruct the intended recipient email address and checks the `hosts` and `users` whitelist, calling `accept` or `reject` accordingly:

```
function filter (to, {accept, reject}) {
  const [user, host] = to.split('@')
  if (hosts.has(host) && users.has(user)) {
    accept()
    return
  }
  reject(550, 'mailbox not available')
}
```

Finally our `save` function will take the incoming message and save it to any relevant mailboxes:

```
function save (req, stream, {accept}) {
  const {from, to} = req
  accept()
  to.forEach((rcpt) => {
    const [user] = rcpt.split('@')
    const dest = path.join(mailDir, user, `${from}-${Date.now()}`)
    const mail = fs.createWriteStream(dest)
    mail.write(`From: ${from} \n`)
    mail.write(`To: ${rcpt} \n\n`)
    stream.pipe(mail, {end: false})
  })
}
```

Now if we run our `index.js` file our server should start (and create the relevant directory structures):

```
$ node index.js
```

We can manually test our mail server by opening a new terminal and running:

```
$ node -e "process.stdin.pipe(require('net').connect(2525)).pipe(proces
```

This will allow us to interact with our SMTP server in real time, which means we can manually create an email message at the protocol level.

If we follow the below script we should be able to construct a message to our SMTP server:

```
helo
mail from: me@me.com
rcpt to: you@example.com
data
hello there!
.
quit
```

After each line we should receive a response from our server, the whole interaction should look similar to the following figure.

How it works

SMTP is based upon a series of plain text communications between an SMTP client and server over a TCP connection. The `smtp-protocol` module carries out these communications for us.

When we call the `createServer` method, we pass an event handler that is passed a request object (`req`). This object is an event emitter (inherits from the core `events` module `EventEmitter` constructor). We listen for `to` , `message` , and `error` events.

The `to` event supplies two arguments to the handler callback (our `filter` function). The first argument is the full recipient address, the second (named `ack`) allows us to accept or reject the incoming message.

Our `filter` function uses parameter object deconstruction to pull out the `accept` and `reject` functions from the `ack` object and then uses assignment array deconstruction to define the `user` and `host` references. When we call `split` on the `to` string, splitting by the "at" (`@`) sign, we should have an array with two elements, using deconstruction, `user` points to index 0 of the resulting array while `host` points at index 1.

Our `hosts` and `users` whitelist are native `Set` objects, we use the `has` method to determine whether each side of the email address matches our criteria. If it does we call `accept`, if it doesn't we `reject` the recipient. At a protocol level a message prefixed with a `250` code (successful action) will be sent when we call `accept`. By default `reject` will respond with a code of `500` (command unrecognized), but we specify `550` (mailbox unavailable) which is more appropriate to the case.

The SMTP protocol allow for multiple recipients, until a message "data" message is sent. Each accepted recipient is added to an array stored on `req.to` (`smtp-protocol` builds this array internally). When a client sends a "data" message, the `message` event handler is fired.

The `message` event handler is passed two arguments, `stream` and `ack`. As with the `to` event handler, `ack` allows us to `accept` or `reject`. The `stream` object is a stream of the message body.

We call our `save` function in the `message` event handler, with the `req`, `stream` and `ack` objects.

The `save` function (like the `filter` function) deconstructs the `ack` object at the parameter level (we only need the `accept` function in this case). The `to` and `from` properties are pulled from the `req` object, also via deconstruction. Since we aren't performing any validating steps here, we can just immediately call the `accept` function.

The `to` reference is always an array (since there may be multiple recipients), we look through it with `forEach` and create a write stream (`mail`) pointing to the users mailbox, to a file name constructed from the `from` email address and a timestamp (`dest`). We write a simple header to the file, with "From" and "To" fields, and then pipe from our incoming message body stream (`stream`) to our file write stream (`mail`). When we call the `pipe` method we supply a second options argument, with `end` set to `false`. This is important when piping from a source stream to multiple destinations. Without passing this option, the first destination stream to finish would call `end` on the message body stream. Any other reading from the stream to other destination streams would cease, so data would be lost.

There's more

Let's make an SMTP client to go with our SMTP server!

Making an SMTP client

The `smtp-protocol` module can be used for creating clients too, so let's make a client and use it alongside our SMTP server from the main recipe.

Let's copy the `smtp-server` folder, naming the duplicate `smtp-client`.

We don't need to install any new dependencies, so let's simply clear the contents of `index.js` and open it in our favorite editor.

Let's start with by requiring dependencies:

```
const os = require('os')
const readline = require('readline')
const smtp = require('smtp-protocol')
```

We're going to use the core `readline` module as a user interface, creating an interactive shell for sending mail. Let's create a `readline` interface instance:

```
const rl = readline.createInterface({
  input: process.stdin,
  output: process.stdout,
  prompt: ''
})
```

Now a config object to hold mail settings:

```
const cfg = {
  host: 'localhost',
  port: 2525,
  email: 'me@me.com',
  hostname: os.hostname()
}
```

One more piece of housekeeping before we move on to the main task of connecting to our SMTP server. We're going to listen for the Ctrl + C key combination to cancel a writing an email, and quit the shell, and Ctrl + D to tell the interface we're done writing and ready to send.

The way to do this with the `readline` module is somewhat unintuitive. We listen for a `close` event to capture Ctrl + D and listen for `SIGINT` event to Ctrl + C (if we don't listen for `SIGINT` Ctrl + C would also trigger the `close` event).

So let's listen for `SIGINT` and respond accordingly:

```
rl.on('SIGINT', () => {
  console.log('... cancelled ...')
  process.exit()
})
```

Now let's write the SMTP connection section:

```
smtp.connect(cfg.host, cfg.port, (mail) => {
  mail.helo(cfg.hostname)
  mail.from(cfg.email)
  rl.question('To: ', (to) => {
    to.split(/;|,/gm).forEach((rcpt) => mail.to(rcpt))
    rl.write('===== Message (^D to send) =====\n')
    mail.data(exitOnFail)
    const body = []
    rl.on('line', (line) => body.push(`${line}\r\n`))
    rl.on('close', () => send(mail, body))
  })
})
```

We have yet to write the `exitOnFail` and `send` functions.

Let's start with `send`:

```
function send (mail, body) {
  console.log('... sending ...')
  const message = mail.message()
  body.forEach(message.write, message)
  message.end()
  mail.quit()
}
```

And finally `exitOnFail`:

```
function exitOnFail (err, code, lines, info) {
  if (code === 550) {
    err = Error(`No Mailbox for Recipient "${info.rcpt}"`)
  }
```

```
    if (!err && code !== 354 && code !== 250 && code !== 220 && code !==
      err = Error(`Protocol Error: ${code} ${lines.join('')}`)
    }
    if (!err) return
    console.error(err.message)
    process.exit(1)
  }
```

Now if we have two terminals open, both with the current working directory set as the parent folder of both the `smtp-server` and `smtp-client` folders we can start our SMTP server like so

```
$ node smtp-server
```

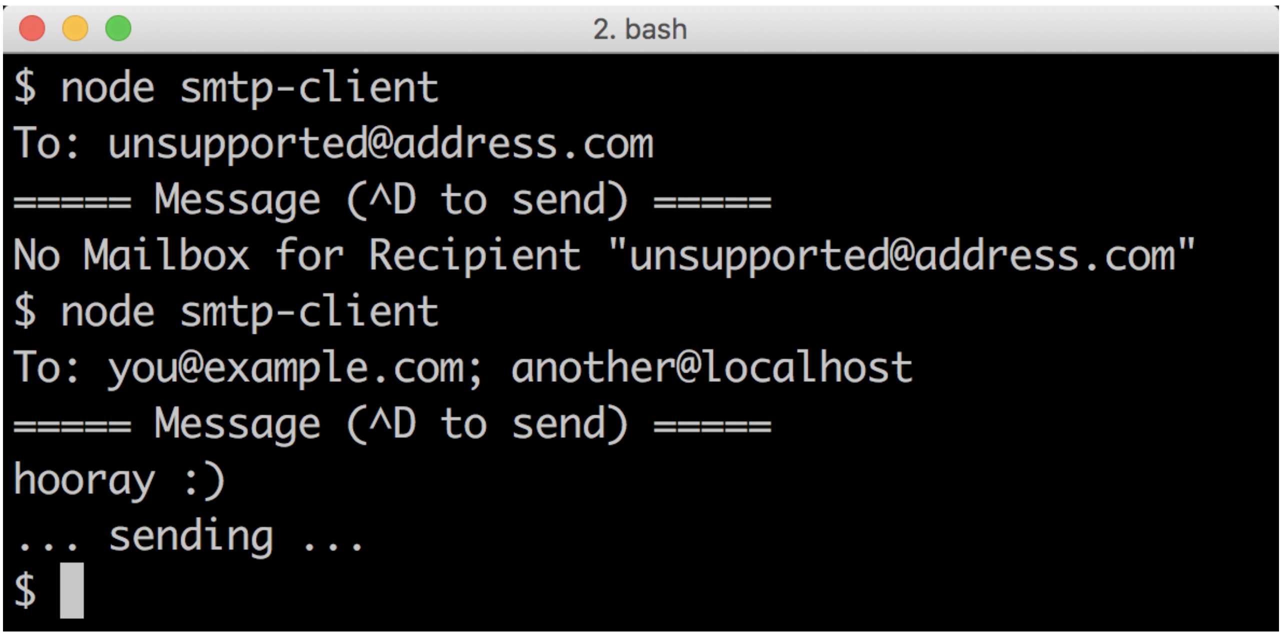
Then in the other terminal window, we can start our client thusly:

```
$ node smtp-client
```

If we supply a supported recipient address (such as "you@example.com") we should be able to successfully send mail to our SMTP server. We can also send to multiple addresses, delimiting either by comma (`,`) or semicolon (`;`).

If we try an unsupported address, we should see a message telling us that the server does not have an associated mailbox for the address specified.

The following figure shows interactions with the SMTP client:



Interacting with the SMTP client

The `smtp.connect` method is analogous to the `net` `connect` method, it creates a client connection to our server.

Instead of supplying a `socket` instance (an object representing a TCP connection), it gives us a `mail` instance (an object representing an SMTP connection).

We interact with the protocol in a fairly direct way, calling the respective `mail.helo` and `mail.from` methods to send relevant protocol data across the wire.

Then we use our `readline` interface instance (`rl`) to prompt the user for recipients (reading a line of user input).

We split the result using a regular expression, allowing for both comma (`,`) and semicolon (`;`) delimited recipient lists.

We call `mail.to` for every recipient which will again send addresses to the SMTP server. The callback passed to `mail.to` in turn calls `exitOnFail` with an object containing the recipient (for detailed errors later on).

Then we instruct the user to write a message, and press Ctrl + D when finished. We use the `line` event on the `rl` instance to compose an array of lines (the `body`), then the `close` event (triggered on Ctrl + D) to pass the `mail` and `body` object to our `send` function.

The `mail.message` method returns a writable message stream for the body of the email (much like the `message` event on our server supplies a readable message stream).

We loop through the lines of our `body`, calling `message.write` for each line, then end the `message` stream and call `mail.quit` to end our SMTP session.

See also

- *Using the pipe method* in **Chapter 4 Using Streams**
- *Interfacing with standard I/O* in **Chapter 3 Coordinating I/O**
- *Processing big data* in **Chapter 4 Using Streams**