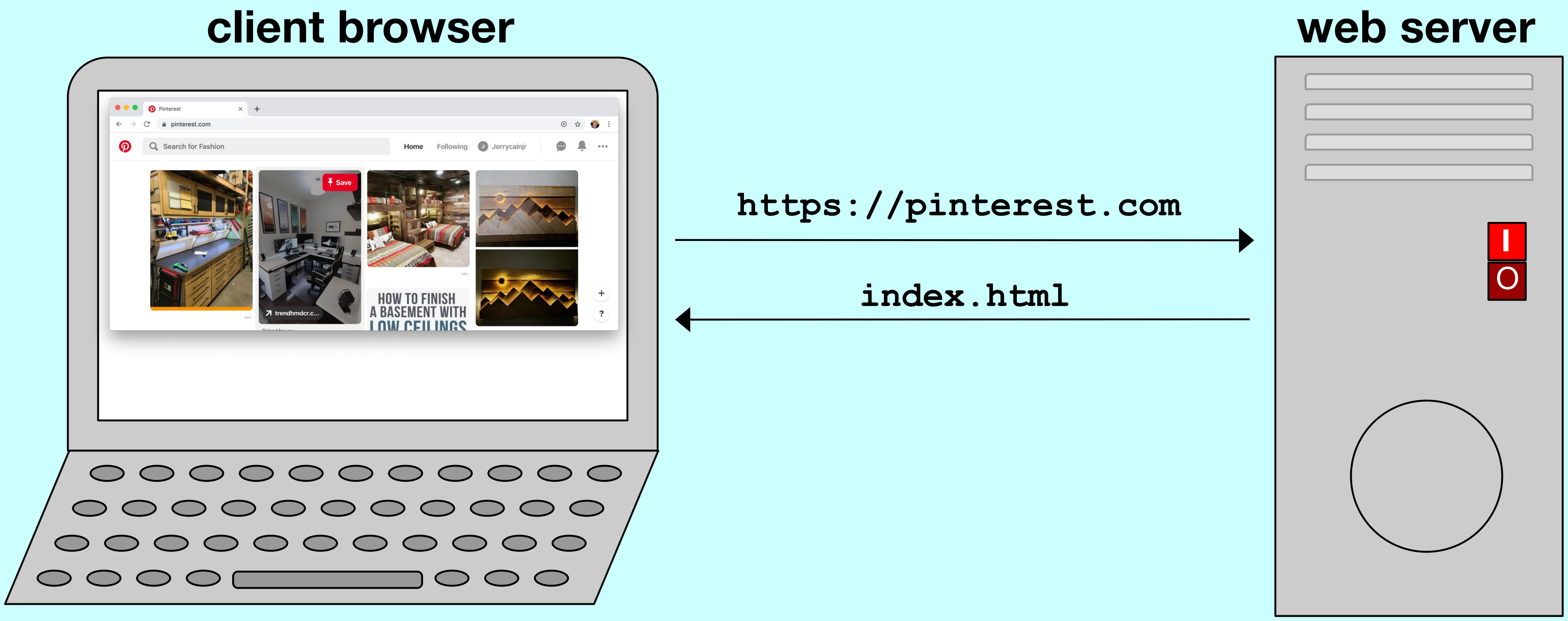
Introduction to HTTP

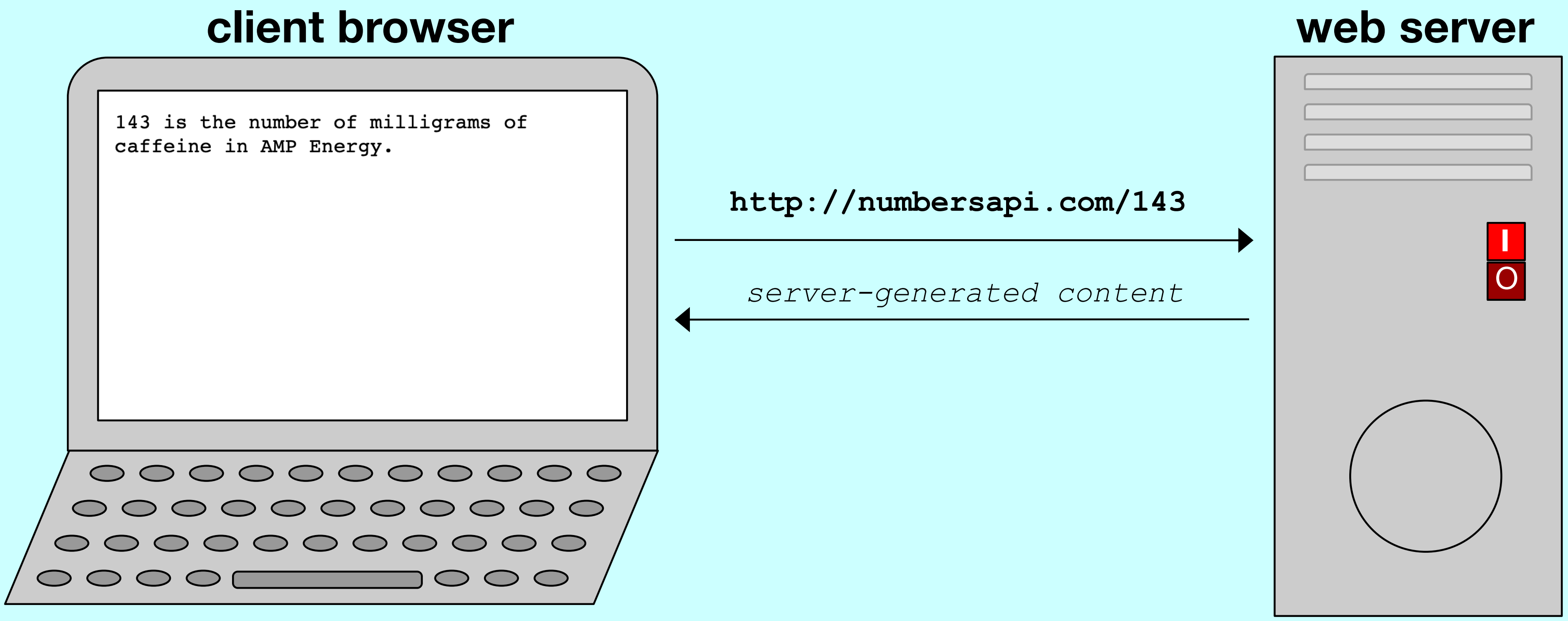
Jerry Cain
CS 106AX
November 27, 2023

The Client-Server Model, Take I



1. The user launches a web browser.
2. The user requests a web page.
3. The browser sends a request for the page.
4. The server sends back the requested HTML.
5. The browser interprets the HTML and renders it in the browser.

The Client-Server Model, Take II


client browser
web server
143 is the number of milligrams of caffeine in AMP Energy.
http://numbersapi.com/143
server-generated content
I
O

1. The user launches a web browser.
2. The user requests a document via some URL.
3. The browser sends a request for the document at that location.
4. The server synthesizes the requested document and replies with it.
5. The browser receives the document and renders it.

Establishing the Connection

- Whenever a web browser needs some resource, it opens a network connection to the server where that resource lives.
- Opening a connection to a server like **`www.stanford.edu`** or **`maps.google.com`** is akin to making a phone call, where the IP address of the host serves functions as the phone number.
- A ***port number***—almost always the number 80 for web servers—is used to identify the server process that's listening for incoming web requests. Other services (e.g. email) are managed by applications listening to different port numbers.
- Typically, web servers typically listen to port 80, secure web servers listen to port 443, email servers listen to port 993, etc.
- Most port numbers between 1 and 1024 have been assigned to well known services. Those that haven't are reserved for services that haven't been invented yet.

The Hypertext Transfer Protocol

- Once the connection has been established—that is, the client has initiated the connection and the server has accepted it—the two endpoints are free to exchange data, provided the exchange respects the ***Hypertext Transfer Protocol***, or ***HTTP***.
- In a standard exchange, the client sends over an HTTP-compliant request. The server ingests the request, processes it, and sends back an HTTP-compliant response.
  - In some cases, the response is little more than the contents of a static file, like **`index.html`** or **`JSGraphics.js`**.
  - Other times, the server programmatically synthesizes a response and sends that back as if the response payload were locally stored (e.g., your Google search result).

HTTP **`GET`** Request Structure

- When we enter **`http://numbersapi.com/156?json=true`**, the browsers opens a connection to **`numbersapi.com`**, port 80, and sends a request that looks like this:

```
GET /156?json=true HTTP/1.1
Host: numbersapi.com
Cache-Control: max-age=0
Accept-Encoding: gzip, deflate
Accept-Language: en-US,en;q=0.9,fr;q=0.8
other similarly structured request headers
<blank line>
```

- The first line is the request line contains three tokens: the ***method***, the ***request path***, and the ***protocol version***.
- The remaining lines are ***response headers***—think of them as key/value pairs of a dictionary—that further inform the server how to respond.
- All **`GET`** requests are terminated by a single blank line.

HTTP **`POST`** Request Structure

- Whenever the browser needs to upload new data to the server, the method will be **`POST`** instead of **`GET`**, as with:

```
POST /scripts/addListItem.py HTTP/1.1
Host: localhost:8000
Content-Length: 41
Content-Type: application/json
other similarly structured request headers
<blank line>
"Get dry cleaning before 7:00pm closing."
```

- The **`Content-Length`** request header must be present, so the server knows exactly how many bytes follow the blank line.
- The material after that blank line is referred to as the ***request payload***, and it can only be present for **`POST`** requests.
- The most common actions that result in **`POST`** requests are ones like secure logins, payment submissions, photo and video uploads, and so forth.

HTTP Response Structure

- HTTP responses have their own structure. Here are the two responses to each of the two requests presented earlier:

```
HTTP/1.1 200 OK
Content-Length: 157
Content-Type: application/json
other similarly structured response headers
<blank line>
{
 "text": "156 is the number of hourly…
 "number": 156,
 "found": true,
 "type": "trivia"
}
```

```
HTTP/1.1 200 Script output follows
Server: SimpleHTTP/0.6 Python/3.8.0
Date: Sun, 28 Nov 2023 04:39:35 GMT
Content-Length: 69
Content-Type: application/json
other similarly structured response headers
<blank line>
{
   "id": 55,
   "item": "Get dry cleaning before…
}
```

- The first line is the status line that lists the protocol, the status code (200 means success, and you've likely seen others like 403 and 404), and a status message consistent with the code.

- Everything following is structured much as HTTP requests are, except there's almost always a payload (and hence a **`Content-Length`** response header is always included).

Implementing HTTP Servers

- Python provides a generic HTTP server implementation that allows us to serve static resources (images, JavaScript files, etc.) and run Python scripts to dynamically generate responses.

```
def runServer(port):
    CGIHTTPRequestHandler.cgi_directories = ['/scripts']
    server = HTTPServer(("", port), CGIHTTPRequestHandler)
    server.serve_forever()

DEFAULT_PORT = 8000 # must be larger than 1024, choose 8000
runServer(DEFAULT_PORT)
```

- The **`HTTPServer`** and **`CGIHTTPRequestHandler`** classes are built-ins, and the above program can be run as is. Doing so creates a server that listens for incoming requests on port 8000.
- Any request path beginning with **`/scripts/`** invokes a specific Python program that knows to programmatically synthesize a response and send it back to the client.

Example: Prime Factorization Service

Let’s implement a server endpoint called **`factor.py`** that assumes assumes a single query string parameter (often called a **`GET`** parameter) called numbers and responds with an HTTP response payload that looks like this:

```
{
    success: true,
    number: 96294000,
    factors: [2, 2, 2, 2, 3, 5, 5, 5, 11, 1459]
}
```

`http://localhost:8000/scripts/factor.py?number=96294000`

The implementation can assume the existence of a function called **`extractRequestParameter(key)`** that returns the string value associated with the provided **`key`** in the query string. Assume the response is formatted as JSON so the client can easily parse the response.

Example: Prime Factorization Service

File: **factor.py**

```
def computeFactorization(n):
    factors = []
    factor = 2
    while n > 1:
        while n % factor == 0:
            factors.append(factor)
            n /= factor
        factor += 1
    return factors

number = extractRequestParameter("number")
response = {}
response["success"] = \
    number is not None and number.isdigit() and int(number) > 0
if response["success"]:
    response["number"] = int(number)
    response["factors"] = computeFactorization(int(number))

responsePayload = json.dumps(response)
print("Content-Length: " + str(len(responsePayload)))
print("Content-Type: application/json")
print()
print(responsePayload)
```

Example: Prime Factorization Service

- The script assumes the full HTTP request has already been ingested. In fact, that's what the **`HTTPServer`** class does.
- The only thing we need from the request is the value attached to **`number`** in the query string. We rely on a function we wrote for you—**`extractRequestParameter`**—to do that.
- Provided the **`number`** parameter is well-formed—that is, it's truly a number and it's positive so it can be factored—we tap a standard Python function that computes the prime factorization, places all factors in a list, and returns it.
- Once the **`response`** dictionary has been assembled, we invoke **`json.dumps`** to generate its JSON serialization. The script publishes two response headers (**`Content-Length`** is mandatory, the other is optional if the client knows to expect JSON), followed by a blank line, followed by the payload.

The End