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Hypertext Transfer Protocol

COMP3227 Web Architecture & Hypertext Technologies

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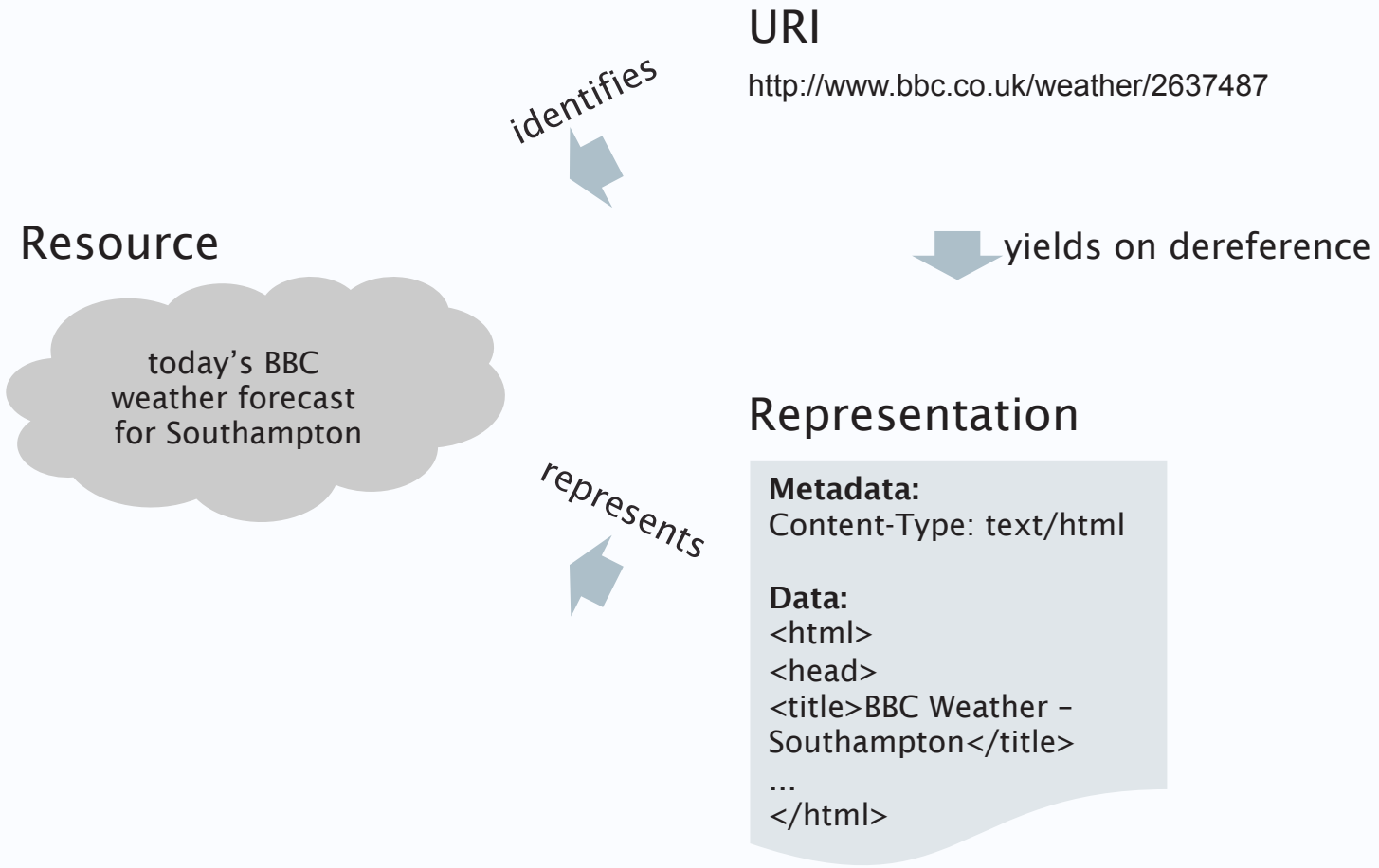
Interaction



HTTP in a Nutshell

Application protocol for distributed hypermedia

Client and server exchange representations by sending request/response messages

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The evolution of HTTP

- First documented in 1991 (HTTP/0.9)
- HTTP/1.0 introduced in 1996 (RFC1945)
- HTTP/1.1 introduced in 1997 (RFC2068)
- HTTP/1.1 updated in 1999 (RFC2616)
- HTTP/1.1 last updated in 2014 (RFC7230-7235)
- HTTP/2 introduced in 2015 (RFC7450)
- HTTP/3 introduced in 2022 (RFC9114)

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Anatomy of an HTTP URI

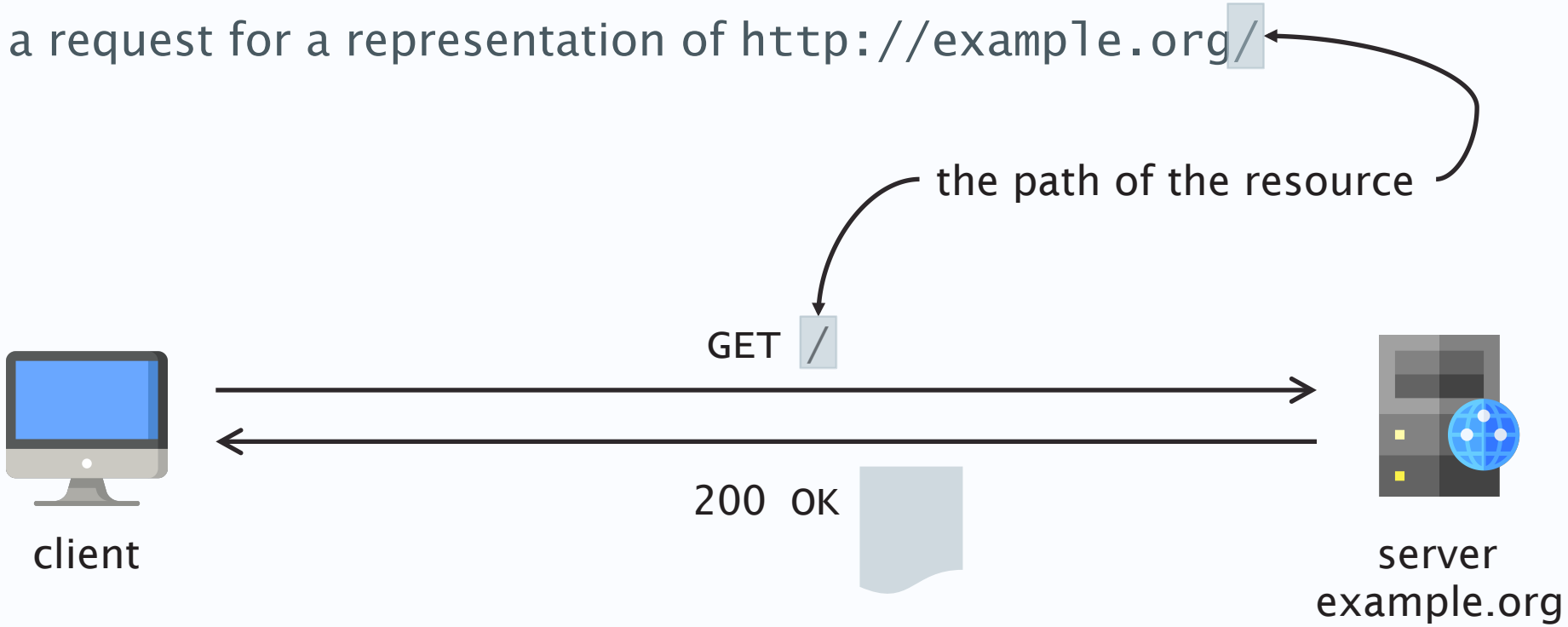
`http://<host><:port></path>?<query>#<fragment>`

Examples:

- `http://example.com/`
- `http://example.com:80/`
- `http://example.com/users/nmg`
- `http://example.com/?search=foo`
- `http://example.com/users/nmg#contact`

Typical HTTP message exchange

Consider a request for a representation of `http://example.org/`

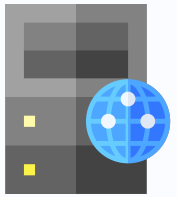


Minimal HTTP/1.1 Exchange

```
GET / HTTP/1.1
Host: example.org
```

```
HTTP/1.1 200 OK
Content-Type: text/html

<html>
  <head>
    <title>Example, Inc. Homepage</title>
  </head>
  <body><h1>Welcome to Example!</h1>...</body>
</html>
```



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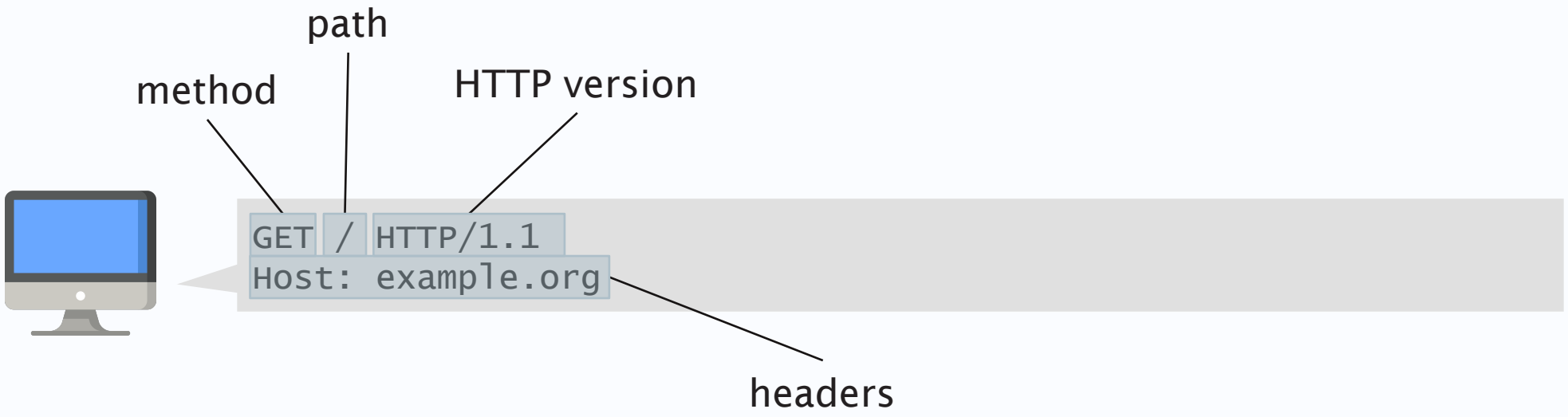
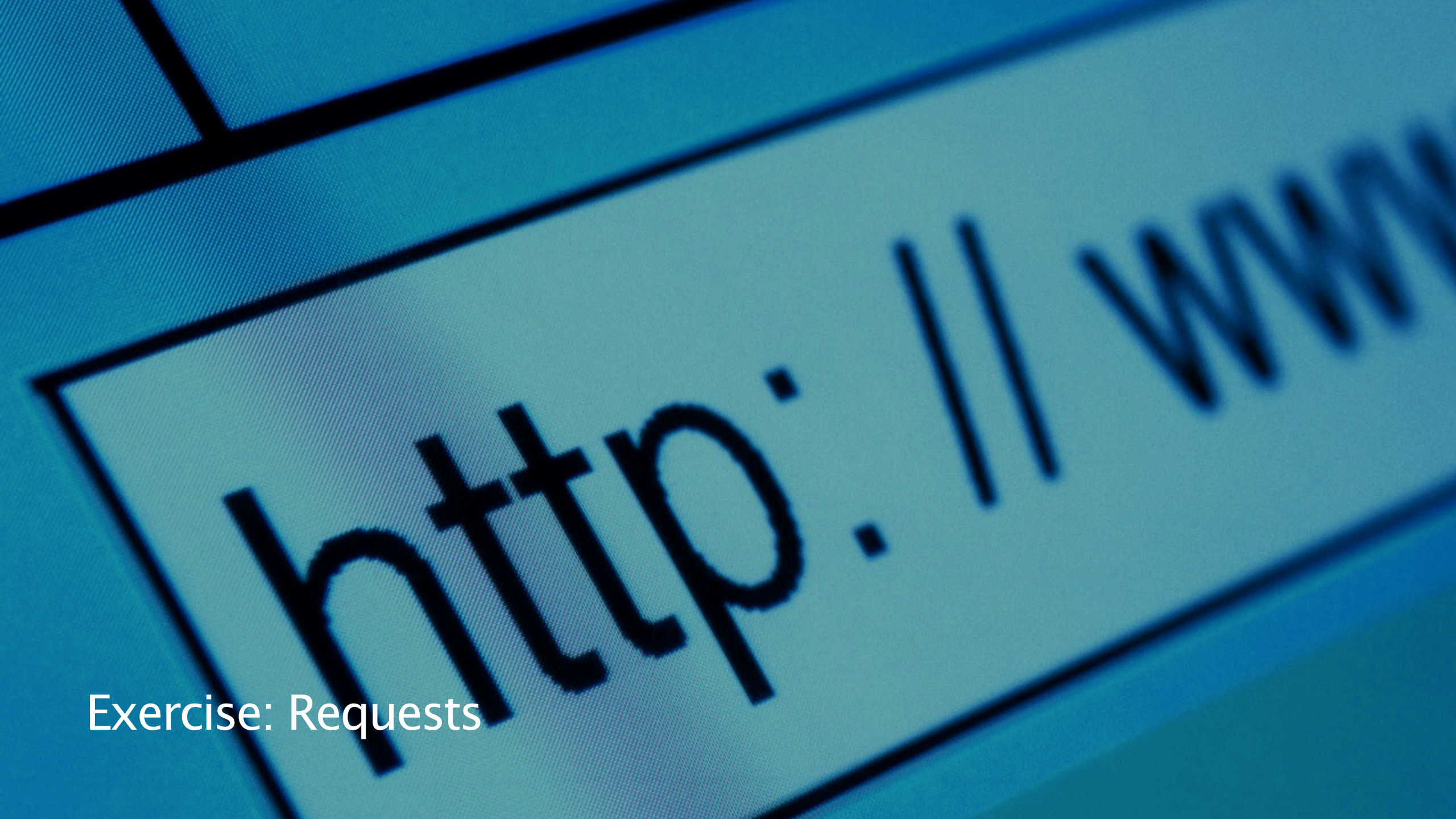
HTTP Requests





Exercise: Requests

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Using `curl`

`curl` is a command-line tool for retrieving URIs - we'll use it to study HTTP interactions

May already be installed on your machine – if not, download from `https://curl.haxx.se/`

```
curl -v [uri]
```

- verbose mode – writes HTTP interactions to stderr
- Redirect `stderr` to `stdout` and use `less` to page through output
- e.g. `curl -v https://www.google.com/ 2>&1 | less`
- Lines prefixed with ">" were sent by the client (i.e. curl)
- Lines prefixed with "<" were sent by the remote server

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Exercise: Requests

Use curl to study the following request:

```
curl -v http://www.google.com/
```

Use curl to study the following request:

```
curl -v https://www.google.com/
```

(we'll cover TLS in a future lecture)

Using nc (netcat)

nc (netcat) is a command-line tool for sending data from stdin to a port on a host

```
nc [hostname] [port]
```

Try: `nc -c httpbin.org 80` and type the following minimal GET request:

```
GET /headers HTTP/1.1
Host: httpbin.org
```

(you'll need to type an extra return after the `Host:` header)

Using openssl

`openssl` is a command-line toolkit that implements TLS (used by https)

```
openssl s_client -host [hostname] -port [port]
```

Try: `openssl s_client -crlf -host www.w3.org -port 443`
and then type the following minimal GET request very quickly (<5s):

```
GET / HTTP/1.1
Host: www.w3.org
```

(as before, you'll need to type an extra return after the `Host:` header)

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HTTP Methods

`GET`	request a representation of a resource
`HEAD`	request the body-less (i.e. headers only) response from a `GET` request
`POST`	request that a representation be accepted as a new subordinate of the specified resource (effectively, create a new resource)
`PUT`	upload a representation of the specified resource
`DELETE`	delete the specified resource
`OPTIONS`	request information about the methods supported by a resource

(also TRACE, CONNECT, PATCH, but these are far less common)

Fielding, R.T. and Reschke, J. (2014) *Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content.* RFC7231. pp.24-32.
Available at: https://tools.ietf.org/html/rfc7231

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Safe HTTP methods

A method is *safe* if it does not change the state of the resource

Read-only operations clients don't request any server changes

Web Crawlers use safe methods

Method	Safe?
GET	Y
HEAD	Y
POST	N
PUT	N
DELETE	N
PATCH	N
OPTIONS	Y

Idempotency

"An operation is said to be idempotent if it doesn't change the result even when applied multiple times. The multiple operations will have the same effect leaving us with the same result that we obtained when it was initially applied the first time."

- Derived from mathematics
  - 1x1x1x1x1
  - 5x5x5x5x5

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Safe and idempotent

A method is *idempotent* if a request can be made once or more than once while leaving the resource in the same final state

- All safe methods are idempotent (because the state doesn't change)
- Not all idempotent methods are safe

Method	Safe?	Idempotent?
GET	Y	Y
HEAD	Y	Y
POST	N	N
PUT	N	Y
DELETE	N	Y
PATCH	N	Y
OPTIONS	Y	Y

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Outlier Idempotency Cases

DELETE

- Soft delete is idempotent
- Hard delete is not idempotent

PATCH

- Patching just a part of a record is idempotent
- Patching a json object is not idempotent

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Safe and Idempotent

- HTTP Standards
- Users expect a certain behaviour

Exercise: Methods

Exercise: Methods

`curl -X [method] [uri]`

- Generates a HTTP request using the specified method

Use curl to study the following requests using different HTTP methods:

```
curl -v -X GET https://www.debian.org/
curl -v -X HEAD https://www.debian.org/
curl -v -X DELETE https://www.debian.org/
```

Common HTTP request headers

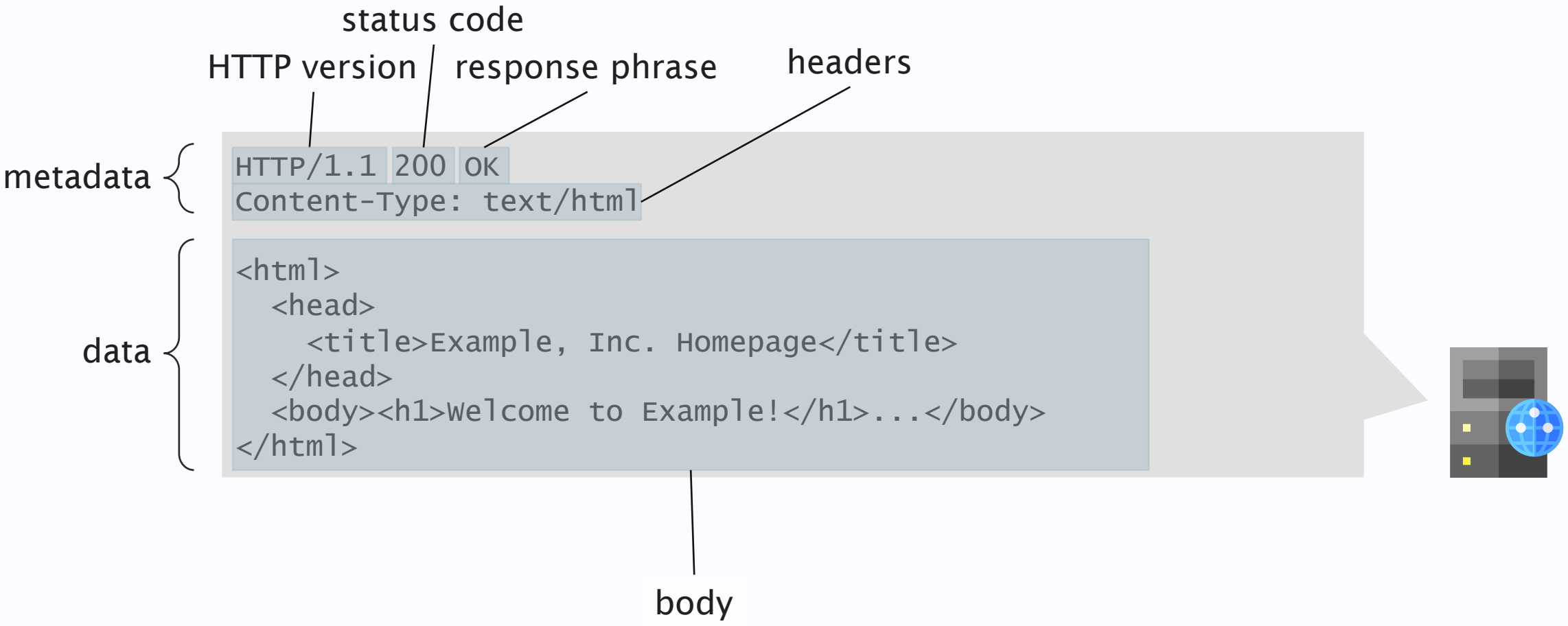
- `Accept:` specify desired media type of response
- `Accept-Language:` specify desired language of response
- `Date:` date/time at which the message was originated
- `Host:` host and port number of requested resource
- `Referer:` URI of previously visited resource
- `User-Agent:` identifier string for Web browser or user agent

Of these headers, only `Host:` is mandatory

(we'll study `Accept:` and `Accept-Language:` in more detail next lecture)

Fielding, R.T. and Reschke, J. (2014) *Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content.* RFC7231. pp.33-46. Available at: https://tools.ietf.org/html/rfc7231

HTTP Responses



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HTTP Status Codes

1xx	informational message
2xx	success
3xx	redirection
4xx	client error
5xx	server error

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200 OK

The request has succeeded.

For a GET request, the response body contains a representation of the specified resource

For a POST request, the response body contains a description of the result of the action

The Content-Location: header indicates a more specific identifier for the representation in the response body (see lecture on content negotiation)

The Content-Location: header indicates that the response body is available (for future access with GET) at the given URI

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201 Created

The request has been fulfilled and resulted in a new resource being created.

Typically results from a POST or PUT request

The Location: header indicates the resource created by the request

The Content-Location: header (if different from Location:) indicates that the body of the response is a representation reporting on the requested action's status and that the same report is available (for future access with GET) at the given URI

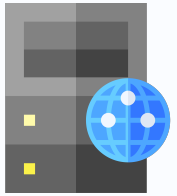
204 No Content

The request has been fulfilled, but there is no additional content to send in the response.

Used as the response to an `OPTIONS` request, with an appropriate `Allow:` header

```
OPTIONS / HTTP/1.1
Host: example.org
```

```
HTTP/1.1 204 No Content
Allow: GET, HEAD
```



300 Multiple Choices

Multiple representations of the requested resource exist, and the client is provided with negotiation so that it may select a preferred representation

(we'll cover this in the lecture on content negotiation)

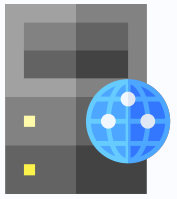
301 Moved Permanently

The requested resource has been assigned a new permanent URI and any future references to this resource **should** use one of the returned URIs.

New permanent URI given using the `Location:` header

```
GET / HTTP/1.1
Host: example.org
```

```
HTTP/1.1 301 Moved Permanently
Location: http://www.example.org/
```



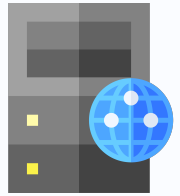
302 Found

The requested resource resides temporarily under a different URI. Since the redirection might be altered on occasion, the client **should** continue to use the Request-URI for future requests.

Temporary URI given using the `Location:` header

```
GET / HTTP/1.1
Host: example.org
```

```
HTTP/1.1 302 Found
Location: http://www.example.org/
```



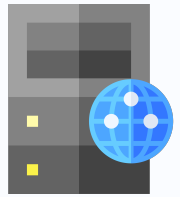
303 See Other

The server is redirecting the user agent to a different resource, using `Location`:

- Difference in typical usage, depending on the original HTTP method
- Commonly used as a response to a `POST` request that that was sent as a form submission

```
POST /form HTTP/1.1
Host: example.org
Content-Type: multipart/form-data
...
```

```
HTTP/1.1 303 See Other
Location: http://example.org/result
```



```
GET /result HTTP/1.1
Host: example.org
```

303 See Other

When used in response to a GET request, indicates that the server does not have a representation of the requested resource, but that it is able to indicate a different resource which is descriptive of the target resource

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304 Not Modified

A conditional GET or HEAD request has been received and would have resulted in a 200 OK response if it were not for the fact that the condition evaluated to false.

(we'll look at this in the lecture on conditional requests)

307 Temporary Redirect

The requested resource resides temporarily under a different URI. The user agent **must not** change the request method if it performs an automatic redirection to that URI

Temporary URI given using the `Location:` header

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308 Permanent Redirect

The requested resource has been assigned a new permanent URI and any future references to this resource ought to use that URI. The user agent **must not** change the request method if it performs an automatic redirection to that URI.

Permanent URI given using the `Location:` header

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Notes on redirects

What's the difference between `301 Moved Permanently` and `308 Permanent Redirect`?

What's the difference between `302 Found` and `307 Temporary Redirect`?

As originally specified, 301/302 didn't permit the user agent to change method for the subsequent request (that's what 303 is for)

Browser manufacturers ignored this; as implemented, 301/302 can change methods from `POST` to `GET`

307/308 introduced for when you want to prevent a user agent from changing methods

(this is why standards work is so fraught)

401 Unauthorized

The request requires user authentication.

The response MUST include a `WWW-Authenticate:` header field containing a challenge applicable to the requested resource (username/password, for example)

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403 Forbidden

The server understood the request, but is refusing to fulfill it. Authorisation will not help and the request SHOULD NOT be repeated.

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404 Not Found

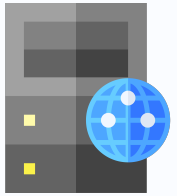
The server has not found anything matching the Request-URI. No indication is given of whether the condition is temporary or permanent.

405 Method Not Allowed

The method specified in the Request-Line is not allowed for the resource identified by the Request-URI. The response **must** include an `Allow:` header containing a list of valid methods for the requested resource.

```
DELETE / HTTP/1.1
Host: example.org
```

```
HTTP/1.1 405 Method Not Allowed
Allow: GET, HEAD
```



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412 Precondition Failed

One or more conditions given in the request header fields evaluated to false when tested on the server.

(as with 304 Not Modified, we'll look at this in the lecture on conditional requests)

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Common HTTP response headers

- `Allow:` lists methods supported by request URI (see `OPTIONS` method)
- `Content-Language:` language of representation
- `Content-Type:` media type of representation
- `Content-Length:` length in bytes of representation
- `Content-Location:` response body is a representation of the specified resource
- `Date:` date/time at which the message was originated
- `Expires:` date/time after which response is considered stale
- `Cache-Control:` used with `Expires:` for caching
- `ETag:` entity tag – identifier for version of resource
- `Last-Modified:` date/time at which representation was last changed
- `Link:` contains links for the resource

Fielding, R.T. and Reschke, J. (2014) *Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content.* RFC7231. pp.64-73. Available at: https://tools.ietf.org/html/rfc7231

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Further Reading

Fielding, R.T. and Reschke, J. (2014) *Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content.* RFC7231.

https://tools.ietf.org/html/rfc7231

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Next:
Content Negotiation, Conditional Requests and Cookies