[Docs] [txt|pdf] [draft-ietf-http...] [Tracker] [Diff1] [Diff2] [Errata]

Obsoleted by: 7230, 7231, 7232, 7233, 7234, 7235 DRAFT STANDARD
Updated by: 2817, 5785, 6266, 6585 Errata Exist
Network Working Group R. Fielding
Request for Comments: 2616 UC Irvine
Obsoletes: 2068 J. Gettys
Category: Standards Track Compaq/W3C
J. Mogul
Compaq
H. Frystyk
W3C/MIT
L. Masinter
Xerox
P. Leach
Microsoft
T. Berners-Lee
W3C/MIT
June 1999

Hypertext Transfer Protocol -- HTTP/1.1

HTTP and the Web

Mike Freedman

https://www.cs.princeton.edu/courses/archive/spr20/cos461/

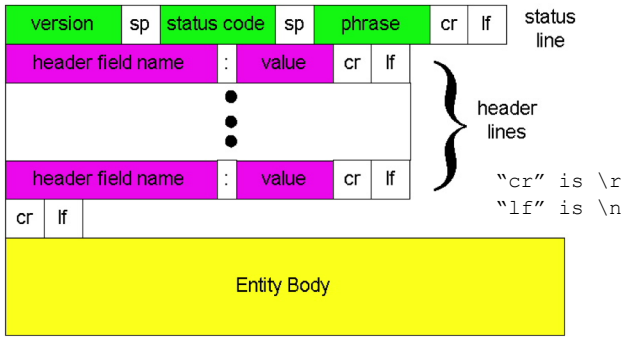
Two Forms of Header Formats

- Fixed: Every field (type, length) defined
  - Fast parsing (good for hardware implementations)
  - Not human readable
  - Fairly static (IPv6 ~20 years to deploy)
  - E.g., Ethernet, IP, TCP headers
- Variable length headers
  - Slower parsing (hard to implement in hardware)
  - Human readable
  - Extensible
  - E.g., HTTP (Web), SMTP (Email), XML

HTTP Basics (Overview)

- HTTP over bidirectional byte stream (e.g. TCP)
- Interaction
  - Client looks up host (DNS)
  - Client sends request to server
  - Server responds with data or error
  - Requests/responses are encoded in text
- Stateless
  - HTTP maintains no info about past client requests
  - HTTP "Cookies" allow server to identify client and associate requests into a client session

HTTP Response



HTTP Request

- Request line
  - Method
    - GET – return URI
    - HEAD – return headers only of GET response
    - POST – send data to the server (forms, etc.)
  - URL (relative)
    - E.g., /index.html
  - HTTP version

HTTP Request (cont.)

- Request headers
  - Variable length, human-readable
  - Uses:
    - Authorization – authentication info
    - Acceptable document types/encodings
    - From – user email
    - If-Modified-Since
    - Referrer – what caused this page to be requested
    - User-Agent – client software
- Blank-line
- Body

HTTP Request Example

GET /index.html HTTP/1.1
Host: www.example.com
Accept-Language: en-us
Accept-Encoding: gzip, deflate
User-Agent: Mozilla/4.0 (compatible; MSIE 5.5; Windows NT 5.0)
Connection: Keep-Alive

HTTP Response

- Status-line
  - HTTP version (now "1.1")
  - 3 digit response code
    - 1XX – informational
    - 2XX – success
      - 200 OK
    - 3XX – redirection
      - 301 Moved Permanently
      - 303 Moved Temporarily
      - 304 Not Modified
    - 4XX – client error
      - 404 Not Found
    - 5XX – server error
      - 505 HTTP Version Not Supported
  - Reason phrase

HTTP Response (cont.)

- Headers
  - Variable length, human-readable
  - Uses:
    - Location – for redirection
    - Server – server software
    - WWW-Authenticate – request for authentication
    - Allow – list of methods supported (get, head, etc)
    - Content-Encoding – E.g x-gzip
    - Content-Length
    - Content-Type
    - Expires (caching)
    - Last-Modified (caching)
- Blank-line
- Body

HTTP Response Example

HTTP/1.1 200 OK
Date: Tue, 27 Mar 2001 03:49:38 GMT
Server: Apache/1.3.14 (Unix) (Red-Hat/Linux) mod_ssl/2.7.1 OpenSSL/0.9.5a DAV/1.0.2 PHP/4.0.1pl2 mod_perl/1.24
Last-Modified: Mon, 29 Jan 2001 17:54:18 GMT
Accept-Ranges: bytes
Content-Length: 4333
Keep-Alive: timeout=15, max=100
Connection: Keep-Alive
Content-Type: text/html
…..

How to Mark End of Message?

- Close connection
  - Only server can do this
  - One request per TCP connection. Hurts performance.
- Content-Length
  - Must know size of transfer in advance
- No body content. Double CRLF marks end
  - E.g., 304 never have body content
- Transfer-Encoding: chunked (HTTP/1.1)
  - After headers, each chunk is content length in hex, CRLF, then body. Final chunk is length 0.

Example: Chunked Encoding

```
HTTP/1.1 200 OK <CRLF>
Transfer-Encoding: chunked <CRLF>
<CRLF>
25 <CRLF>
This is the data in the first chunk <CRLF>
1A <CRLF>
and this is the second one <CRLF>
0 <CRLF>
```

- Especially useful for dynamically-generated content, as length is not a priori known
  - Server would otherwise need to cache data until done generating, and then go back and fill-in length header before transmitting

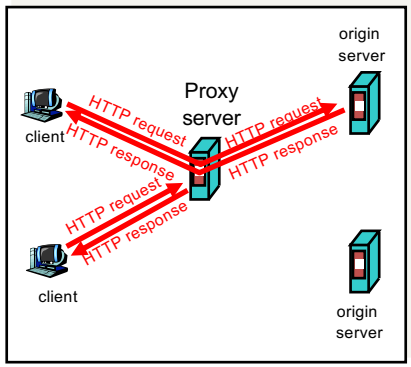
Proxies

Proxies

- End host that acts a broker between client and server
  - Speaks to server on client's behalf
- Why?
  - Privacy
  - Content filtering
  - Caching!!!

Proxies (Cont.)

- Accept requests from multiple clients
- Takes request and reissues it to server
- Takes response and forwards to client



HTTP Caching

- Why cache?
  - Lot of objects don't change (images, js, css)
  - Reduce # of client connections
  - Reduce server load
  - Reduce overall network traffic; save $$$

Caching is Hard

- Significant fraction (>50%?) of distinct HTTP objects may be uncacheable
  - Dynamic data: Stock prices, scores, web cams
  - CGI scripts: results based on passed parameters
  - Cookies: results may be based on passed data
  - SSL: encrypted data is not cacheable
  - Advertising / analytics: owner wants to measure # hits
    - Random strings in content to ensure unique counting
- Yet significant fraction of HTTP bytes are cacheable
  - Images, video, CSS pages, etc.
- Want to limit staleness of cached objects

How long should the client cache for?

- Clients (and proxies) cache documents
  - When should origin be checked for changes?
  - Every time? Every session? Date?
- HTTP includes caching information in headers
  - HTTP 0.9/1.0 used: "Expires: <date>"; "Pragma: no-cache"
  - HTTP/1.1 has "Cache-Control"
    - "No-Cache", "Max-age: <seconds>"
    - "ETag: <opaque value>

Why the changes between 1.0 and 1.1?

- Timestamps
  - Server hints when an object "Expires" (Expires: xxx)
  - Server provides last modified date, client can check if that's still valid
- Problems
  - Client and server might not have synchronized clocks
  - Server replicas might not have synchronized clocks
  - Max-age solves this: relative seconds, not abs time

What if cache expires?

- Store past expiry time (if room in cache)
- Upon request, first revalidate with server

```
GET / HTTP/1.1
Accept-Language: en-us
If-Modified-Since: Mon, 29 Jan 2001 17:54:18 GMT
Host: www.example.com
Connection: Keep-Alive
```

```
HTTP/1.1 304 Not Modified
Date: Tue, 27 Mar 2001 03:50:51 GMT
Connection: Keep-Alive
```

Another problem!

- What if server replicas don't have aligned modification times?

HTTP/1.1 200
Date: Tue, 27 Mar 2001 03:50:51 GMT
ETag: 686897696a7c876b7e

GET / HTTP/1.1
Accept-Language: en-us
If-None-Match: "686897696a7c876b7e"
Host: www.example.com
Connection: Keep-Alive

HTTP xfer = single object
Web pages = many objects

nytimes.com

How to handle many requests?

- Maximize goodput by reusing connections
  - Avoid connection (TCP) setup
  - Avoid TCP slow-start
- Client-server will maintain existing TCP connection for up to K idle seconds

GET / HTTP/1.1
Host: www.example.com
Connection: Keep-Alive

HTTP/1.1 200 OK
Date: Tue, 27 Mar 2001 03:50:51 GMT
Connection: Keep-Alive

Three approaches to multiple requests

Parallel Connections	Persistent Connections	Pipelined Connections
Conn 1:	Conn 1:	Conn 1:
• Request 1	• Request 1	• Request 1
• Response 1	• Response 1	• Request 2
	• Request 2	• Request 3
Conn 2:	• Response 2	• Response 1
• Request 2	• Request 3	• Response 2
• Response 2	• Response 3	• Response 3

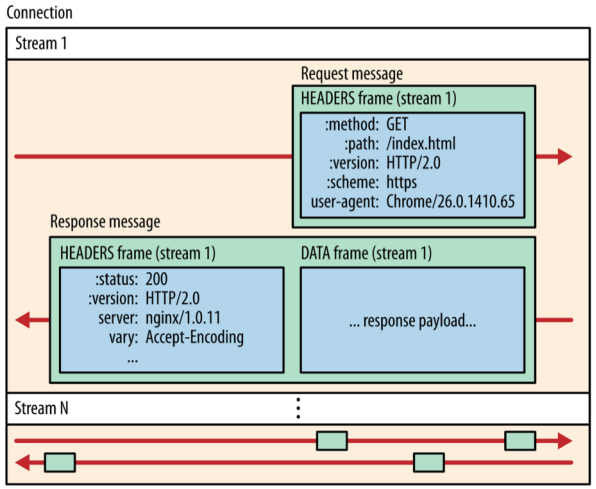
What are challenges with pipelining?

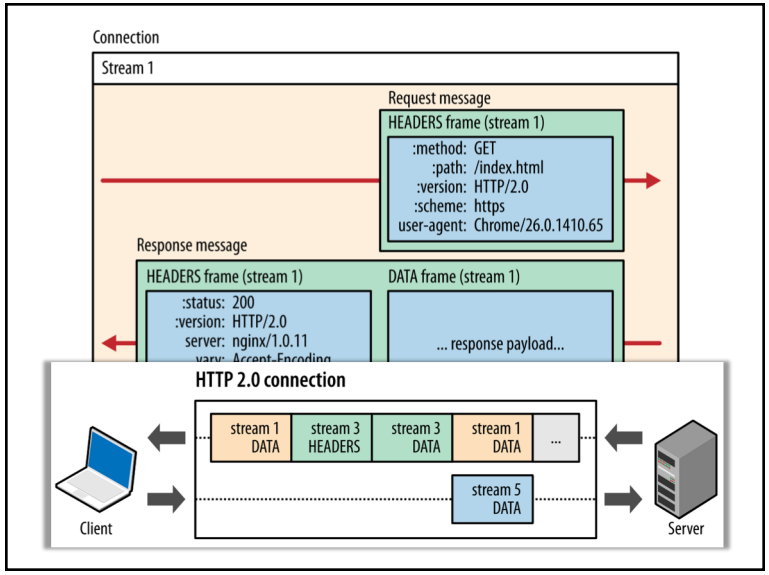
- Head-of-line blocking
  - Small xfers can "block" behind large xfer
- No reordering
  - HTTP response does not "identify" which request it's in response to; obvious in simple request/response
- Can behave *worse* than parallel + persistent
  - Can send expensive query 1 on conn 1, while sending many cheap queries on conn 2

Google's SPDY -> HTTP/2

- Server "push" for content
  - One client request, multiple responses
  - After all, server knows that after parsing HTML, client will immediately request embedded URLs
- Better pipelining and xfer
  - Multiplexing multiple xfers w/o HOL blocking
  - Request prioritization
  - Header compression

https://developers.google.com/web/fundamentals/performance/http2




Connection
Stream 1
Request message
HEADERS frame (stream 1)
:method: GET
:path: /index.html
:version: HTTP/2.0
:scheme: https
user-agent: Chrome/26.0.1410.65
Response message
HEADERS frame (stream 1)
:status: 200
:version: HTTP/2.0
server: nginx/1.0.11
DATA frame (stream 1)
... response payload...
HTTP 2.0 connection
stream 1 DATA
stream 3 HEADERS
stream 3 DATA
stream 1 DATA
...
stream 5 DATA
Client
Server