Http/2

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What is this?

The World Wide Web in 1996

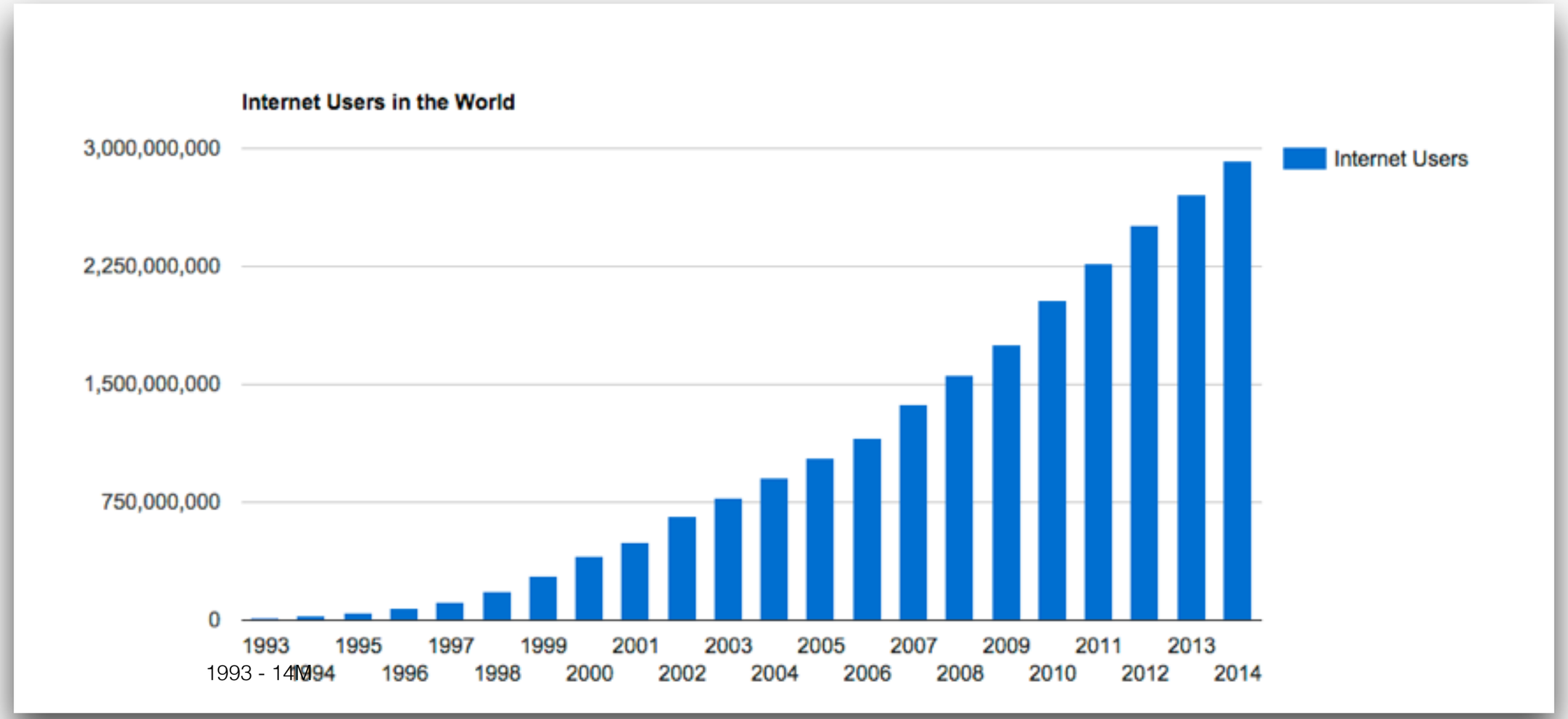
Yahoo! Deutschland CLICK HERE TO VISIT THE STARS YAHOO! LOS ANGELES Weekly Picks

Search Options

Yellow Pages - People Search - City Maps -- News Headlines - Stock Quotes - Sports Scores

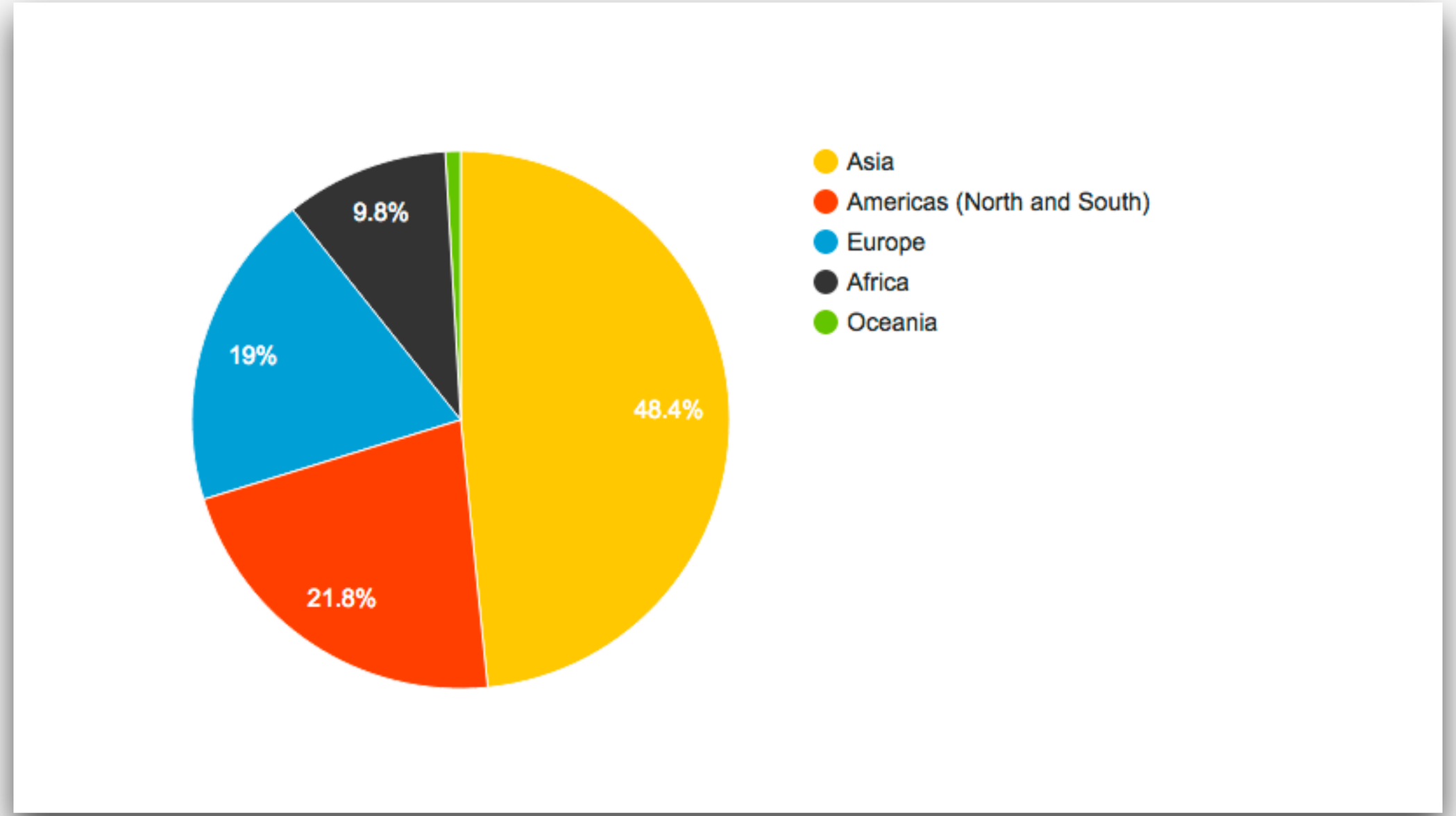
- **Arts** - - *Humanities*, *Photography*, *Architecture*, *...*
- **Business and Economy [Xtra!]** - - *Directory*, *Investments*, *Classifieds*, *...*
- **Computers and Internet [Xtra!]** - - *Internet*, *WWW*, *Software*, *Multimedia*, *...*
- **Education** - - *Universities*, *K-12*, *Courses*, *...*
- **Entertainment [Xtra!]** - - *TV*, *Movies*, *Music*, *Magazines*, *...*
- **Government** - - *Politics [Xtra!]*, *Agencies*, *Law*, *Military*, *...*
- **Health [Xtra!]** - - *Medicine*, *Drugs*, *Diseases*, *Fitness*, *...*
- **News [Xtra!]** - - *World [Xtra!]*, *Daily*, *Current Events*, *...*
- **Recreation and Sports [Xtra!]** - - *Sports*, *Games*, *Travel*, *Autos*, *Outdoors*, *...*
- **Reference** - - *Libraries*, *Dictionaries*, *Phone Numbers*, *...*
- **Regional** - - *Countries*, *Regions*, *U.S. States*, *...*
- **Science** - - *CS*, *Biology*, *Astronomy*, *Engineering*, *...*
- **Social Science** - - *Anthropology*, *Sociology*, *Economics*, *...*
- **Society and Culture** - - *People*, *Environment*, *Religion*, *...*

Internet Users



Source http://www.internetlivestats.com/internet-users/

Users by Country



Source http://www.internetlivestats.com/internet-users/

Better User Experiences and Visuals

The World Wide Web Today

YAHOO! Buscar en la Web Iniciar sesión Correo

- Correo
- Noticias
- Deportes
- Finanzas
- Celebrity
- Vida y Estilo
- Cine
- Horóscopo
- Videos

Más ›

eBay
Amazon
Meetic

Publicidad

El corredor del Laberinto: Las pruebas En cines 18/09/2015

Establecer YAHOO! como página de inicio

Al utilizar Yahoo, aceptas que nosotros y nuestros socios podamos definir cookies para distintos fines, tales como personalizar el contenido y la publicidad.

10 trucos para acelerar tu metabolismo

No tienes que pasarte el día en el gimnasio, basta con entrenamientos en intervalos de alta intensidad para quemar calorías, y sin dieta **Maneras rápidas de perder peso »** 1-5 de 45

'Narcogram' en Internet | ¿Qué fue de su vida? | Malas noticias para Mayweather Jr. | Trucos para estar en forma | Hay algo raro en esta foto

Titulares Noticias Deportes Finanzas Celebrity

Liga - De Gea-United 2019: Algunas sorprendentes preguntas sin respuesta

El portero David de Gea ha renovado su contrato con el Manchester United y pone punto y final a uno de los grandes culebrones de los últimos tiempos.

Eurosport

Los 10 lugares donde mejor se come de Espa a

Desde Sevilla a San Sebasti n haciendo parada en C ceres, Madrid o Segovia, nos vamos a comer el pa s, bocado a bocado

Skyscanner Patrocinado

Lo más buscado

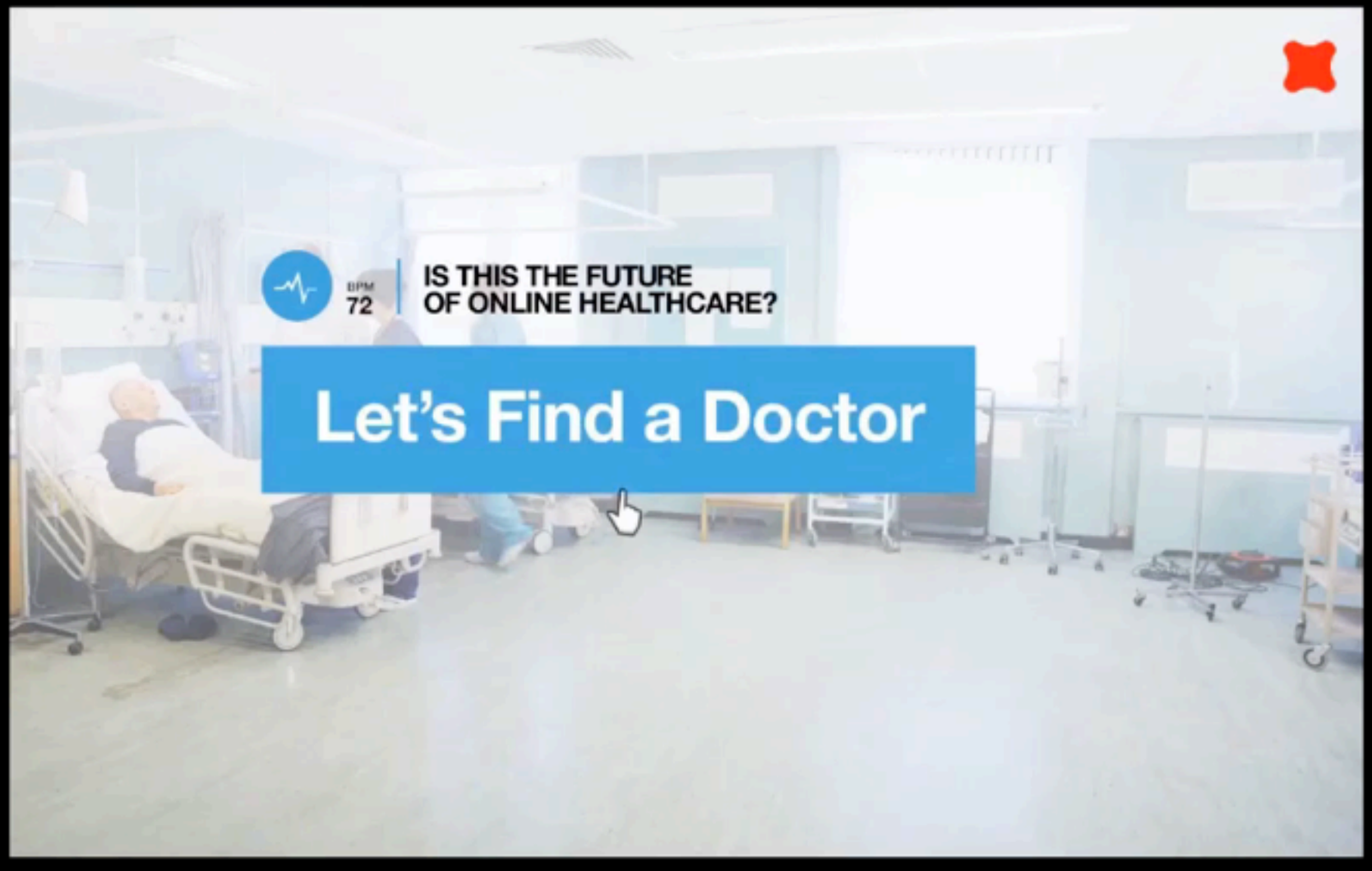
1 Liga BBVA
2 US Open
3 Casas rurales
4 Eurobasket 2015
5 Horóscopo
6 Oferta hoteles
7 Lionel Messi
8 Vestidos mujer
9 Floyd Mayweather
10 Previsión tiempo

29660, Marbella (Ubicación actual)

27 °F | °C
Buen tiempo

Hoy	Lu.	Ma.
29° 19°	29° 19°	28° 18°

Ver más »

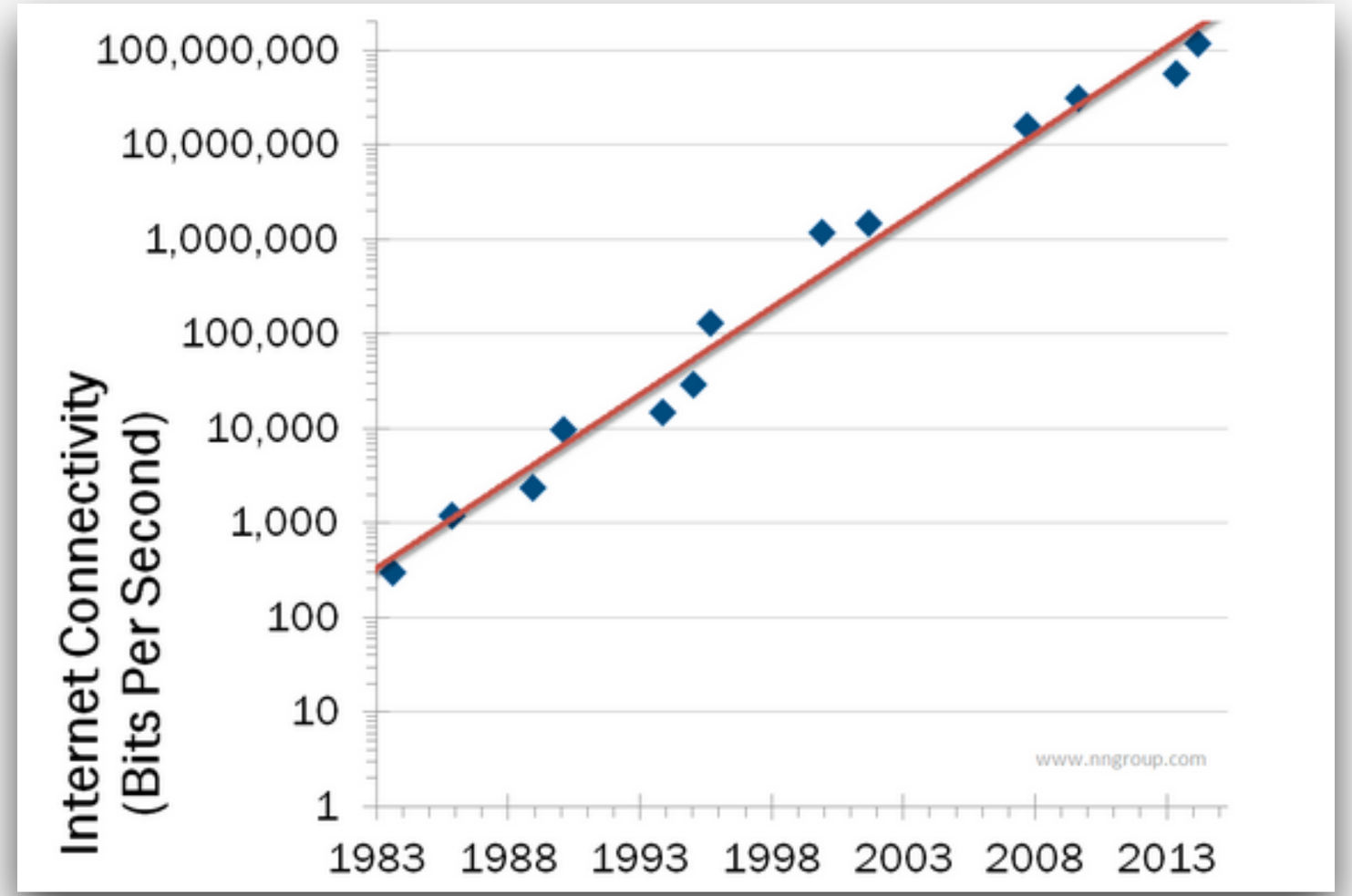

BPM
72
IS THIS THE FUTURE
OF ONLINE HEALTHCARE?
Let's Find a Doctor

by Fantasy

It’s all good. Everything runs smooth

Everyone has more bandwidth

Nielsen's Law of Bandwidth



1984 - 300 bps

50% Growth per Year

Source http://www.nngroup.com/articles/law-of-bandwidth/

Bandwidth by Country

Position	Country	Speed (Mbps)
1	South Korea	25.3
2	Hong Kong	16.3
3	Japan	15
4	Switzerland	14.5
…	…	…
12	United States	11.5
13	Belgium	11.4
…	…	…
24	Germany	8.7
…	…	…
28	Spain	7.8
…	…	…
30	Australia	6.9
31	France	6.9
…	…	…
55	Bolivia	1.1

Source Akamai 2014 Rankings - Wikipedia

Mobile Networks

Region	Average Speed (Mbps)
Europe	20.4
North America	9.6
Asia Pacific	8.8
South America	7.0
Africa	4.8

Source Akamai State of the Internet Q1 2015

So why we dumping HTTP 1.1?

The problem is no longer bandwidth

It’s the Latency, Stupid

Source https://rescomp.stanford.edu/~cheshire/rants/Latency.html, Stuart Cheshire May 1996

- Bandwidth

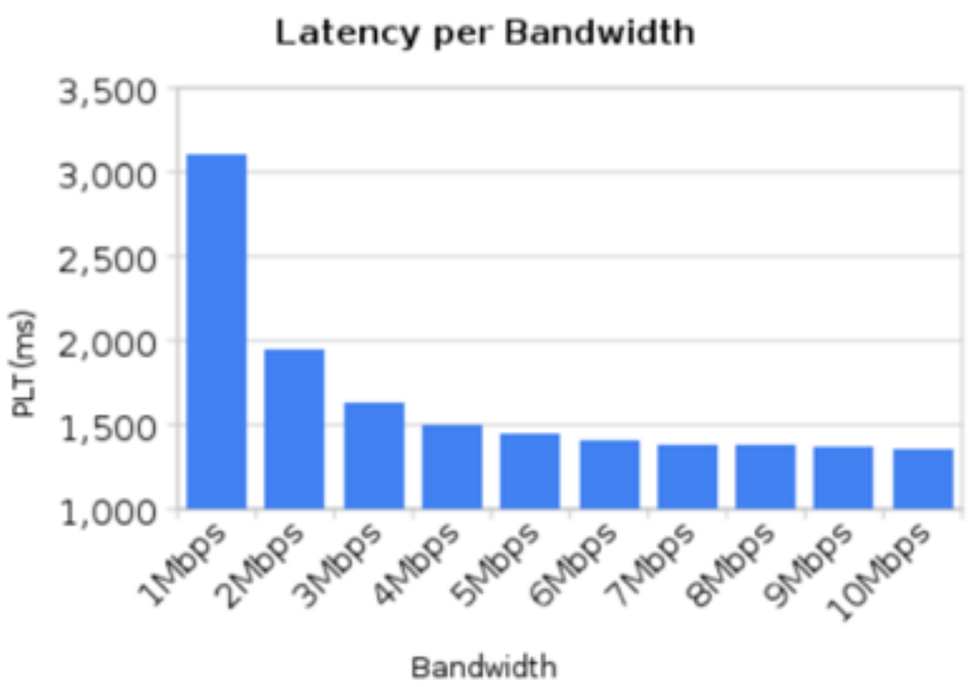
  In computing, bandwidth is the bit-rate of available or consumed information capacity expressed typically in metric multiples of bits per second. Variously, bandwidth may be characterized as network bandwidth, data bandwidth, or digital bandwidth.

- Latency

  Latency is a time interval between the stimulation and response, or, from a more general point of view, as a time delay between the cause and the effect of some physical change in the system being observed.

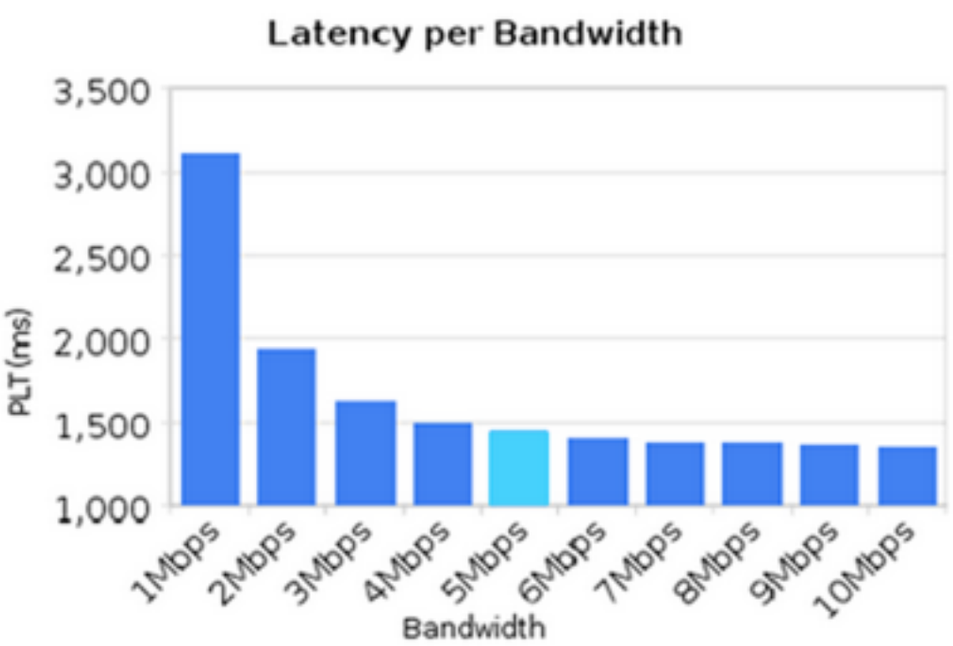
Latency

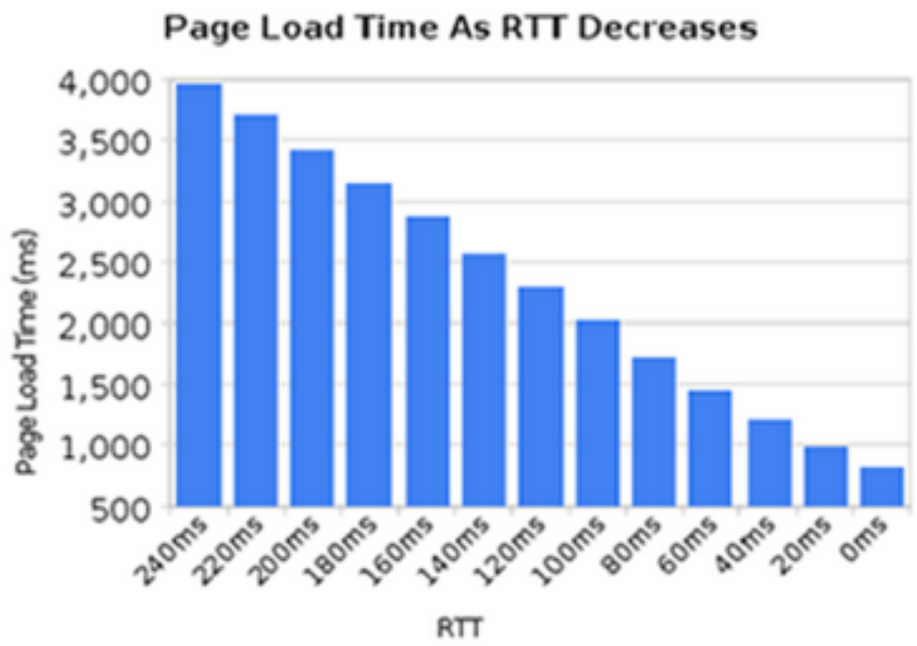
Bandwidth	Page Load Time via HTTP
1Mbps	3106
2Mbps	1950
3Mbps	1632
4Mpbs	1496
5Mbps	1443
6Mbps	1406
7Mbps	1388
8Mbps	1379
9Mbps	1368
10Mbps	1360



Source Mike Belshe Study 2010

Latency





Source https://www.igvita.com/2012/07/19/latency-the-new-web-performance-bottleneck/

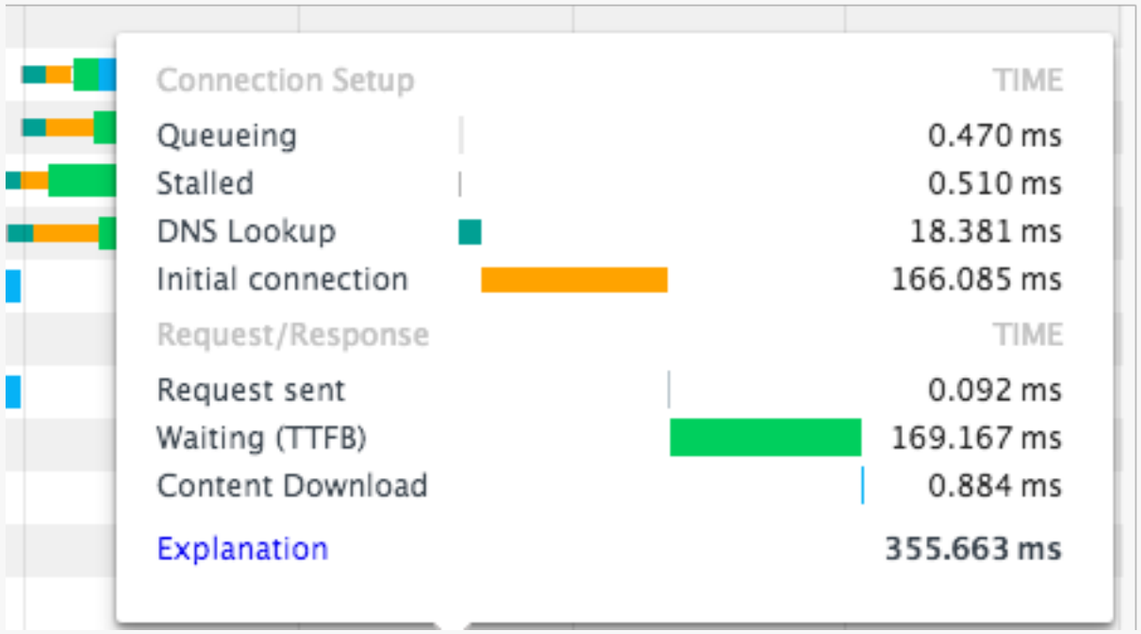
And latency is per connection

Typical Web Page

Name	Method	Status	Type	Initiator	Size	Time ▲
comunes.css	GET	200	stylesheet	(index):37	(from cache)	42 ms
pxlctl2.gif?r=2&m=1&s=25c10673e…	GET	302	gif	http://pxlctl.elpais.com/pxlc…	508 B	58 ms
advert.gif?648618153	GET	200	gif	(index):164	392 B	59 ms
caja_tlife.css	GET	200	stylesheet	(index):1619	793 B	70 ms
pxlctl2.gif?m=1&r=2&w=2123515	GET	302	gif	http://elpais.com/pxlctl.gif?…	347 B	80 ms
?script=0&random=4019638651&ip…	GET	200	gif	http://www.google.com/ads…	343 B	94 ms
gpt.js	GET	304	script	pbs.slots.js:1	363 B	95 ms
rta.js?netId=4045&cookieName=crt…	GET	200	script	pbs.slots.js:1	457 B	118 ms
pxlctl.gif?m=1&r=2&w=2123515	GET	302	text/html	(index):164	241 B	121 ms
elpais.com	GET	200	document	http://www.elpais.es/	61.9 KB	123 ms
?script=0&random=4019638651	GET	302	text/html	http://googleads.g.doublecli…	380 B	138 ms
rep.gif?ver=1&typ=pgv&rnd=iemvn…	GET	200	gif	(index):165	494 B	147 ms
bid?src=3226&u=http%3A%2F%2Felp…	GET	200	script	amzn_ads.js:1	217 B	191 ms
s64909375414717?AQB=1&pccr=tr…	GET	302	text/plain	http://prisacom.112.2o7.net…	811 B	213 ms
?value=0&guid=ON&script=0	GET	302	gif	(index):164	651 B	226 ms
?idsite=255&url=http%3A%2F%2Felp…	GET	200	xhr	vrs.20150907.js:6	337 B	355 ms
?transport=jsonp&idsite=255&url=h…	GET	200	xhr	vrs.20150907.js:6	1.1 KB	369 ms
s64909375414717?AQB=1&ndh=1&…	GET	302	text/plain	(index):165	1.8 KB	432 ms
ads?gdfp_req=1&correlator=231131…	GET	200	script	pubads_impl_72.js:189	29.4 KB	528 ms

380B

Loading


Connection Setup
TIME
Queueing
0.470 ms
Stalled
0.510 ms
DNS Lookup
18.381 ms
Initial connection
166.085 ms
Request/Response
TIME
Request sent
0.092 ms
Waiting (TTFB)
169.167 ms
Content Download
0.884 ms
Explanation
355.663 ms

Waterfall

Tester: VM7-IE11-8-192.168.101.188

Export HTTP Archive (.har)

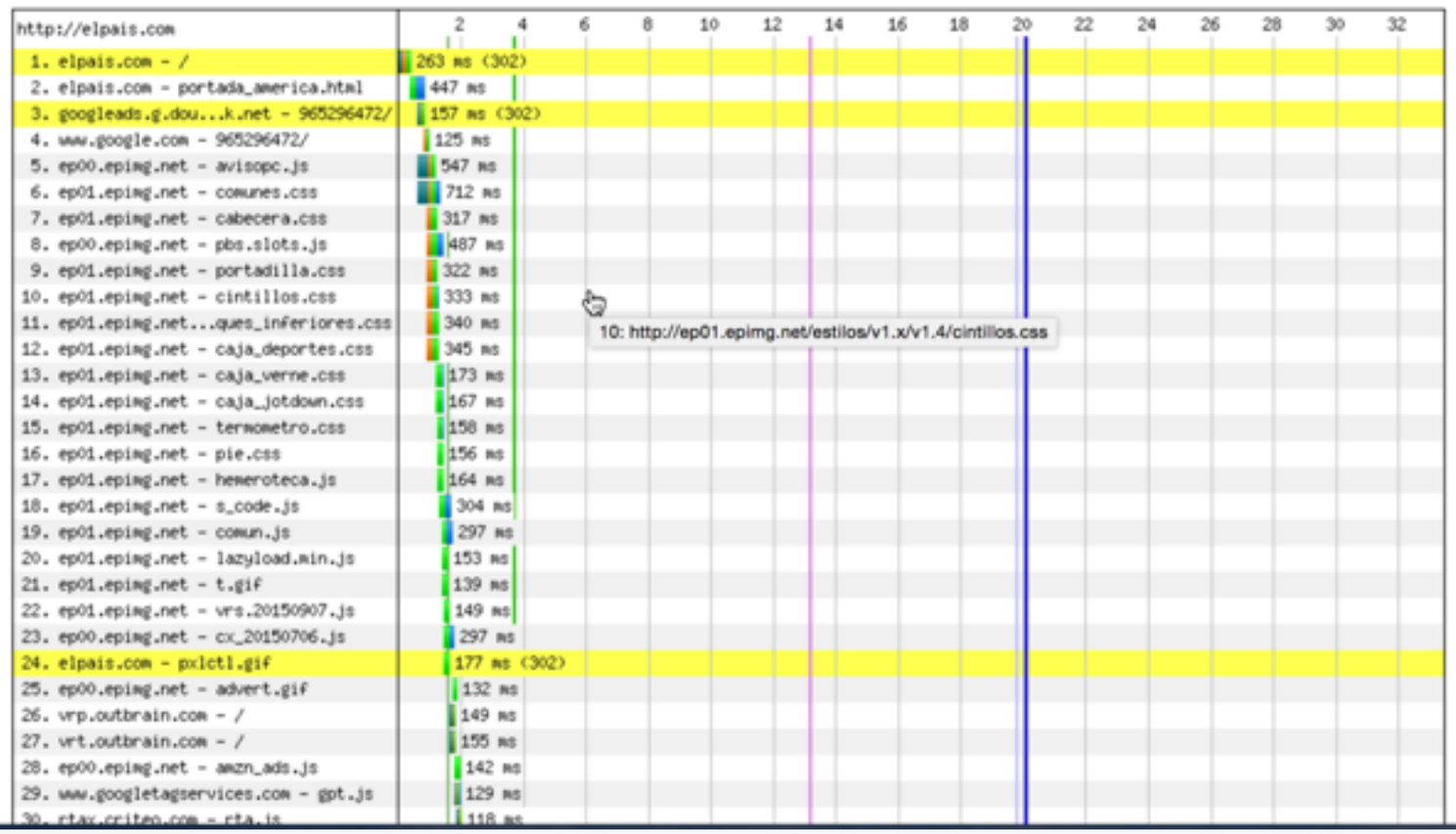
Load Time	First Byte	Start Render	Visually Complete	Speed Index	DOM Elements	Result (error code)	Document Complete			Fully Loaded		
							Time	Requests	Bytes In	Time	Requests	Bytes In
20.077s	0.498s	3.669s	16.500s	11235	3578	99999	20.077s	267	2,605 KB	33.400s	339	2,920 KB

RUM First Paint	domContentLoaded	loadEvent
1.568s	13.154s - 13.176s (0.022s)	19.735s - 19.744s (0.009s)

Waterfall View

DNS Lookup | Initial Connection | SSL Negotiation | Time to First Byte | Content Download | 3xx response | 4xx+ response

Start Render | msFirstPaint | DOM Content Loaded | On Load | Document Complete



http://www.webpagetest.org/result/150917_HE_CE5/1/details/

The 7 OSI Layers

Application — HTTP

Presentation

Session

Transport — TCP, UDP

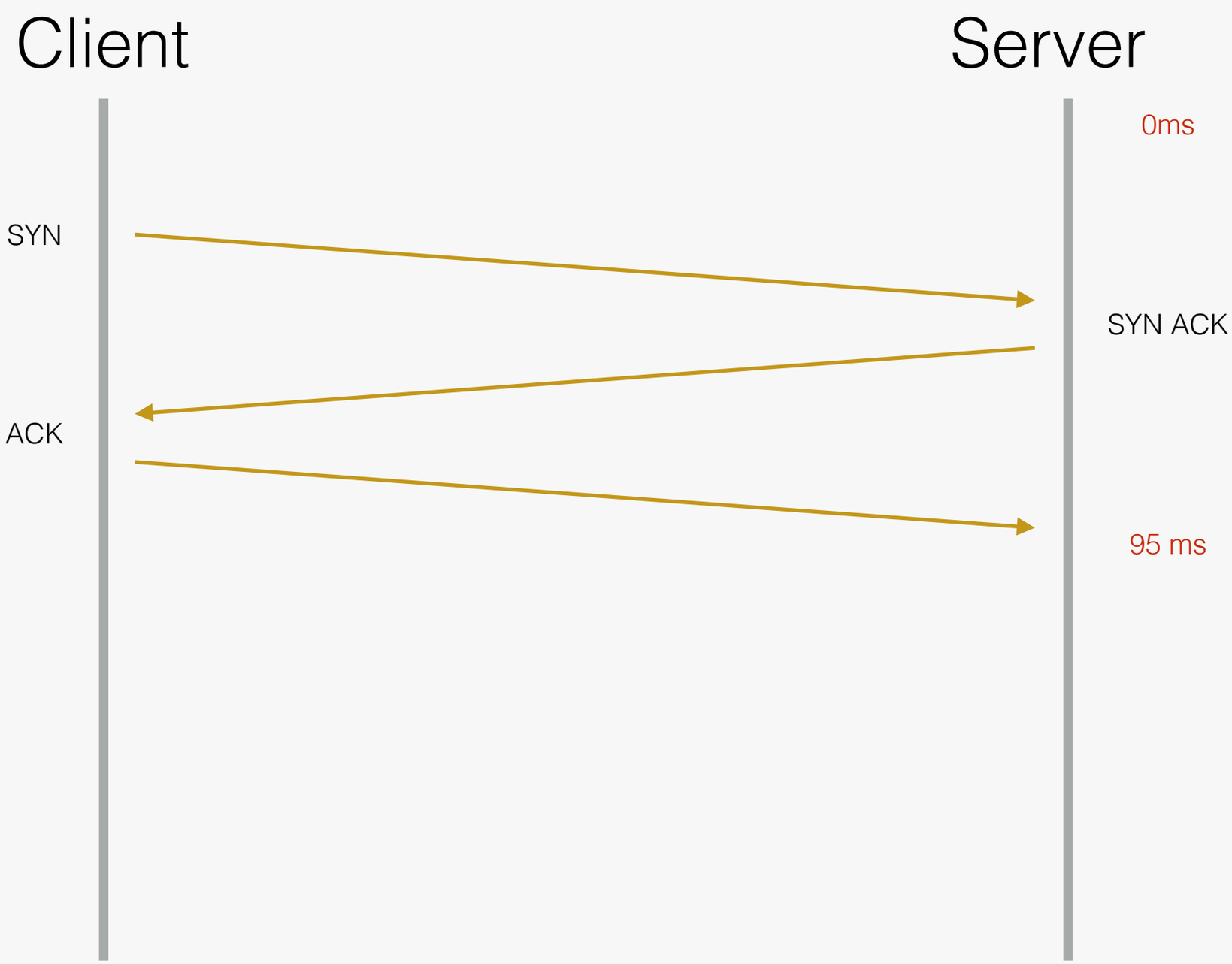
Network

Data Link

Physical

All runs on TCP

TCP's 3-Way Handshake



How TCP works

- Flow Control
- Slow Start
- Head of Line Blocking

HTTP 0.9 - 1991

```
GET /index.htm
```

```
<HTML>
  <HEAD>
    ...
  </HEAD>
  <BODY>
     ...
  </BODY>
</HTML>
```

HTTP 1.0 - 1996

```
GET /index.htm HTTP/1.0
User-Agent: Netscape
Accept: text/html


HTTP/1.0 200 OK
Content-Type: text/html

<HTML>
 <HEAD>
   …
  </HEAD>
  <BODY>
     …
  </BODY>
</HTML>
```

HTTP 1.1 - 1999

```
GET /index.htm HTTP/1.0
User-Agent: Netscape
Accept: text/html
Connection: close*

HTTP/1.0 200 OK
Content-Type: text/html

<HTML>
 <HEAD>
   …
  </HEAD>
  <BODY>
     …
  </BODY>
</HTML>
```

**Connection default: keep-alive*

New Optimization Possibilities

Keep Alive

- Using a single connection to send multiple successive requests
- Pipelining Requests
  - Send several requests together
  - Head of line blocking issues
  - Mostly abandoned by browsers

Multiple Connections

- Use multiple TCP Connections to perform parallel requests
- Limited to 6 connections
    - Domain Sharding
    - More DNS lookups
- Still creates overhead on client/server with many open connections

Other techniques to minimize requests

- Inlining resources
  - No Cache usage
  - Encoding overhead
- Concatenating and Spriting resources
  - Cache Issues
  - Delay in processing

The culprit is HTTP on TCP

- Http 1.1 chatty
- TCP is not made for chatty protocols
- TCP has slow start and head of line blocking

Http/2

It’s about performance!

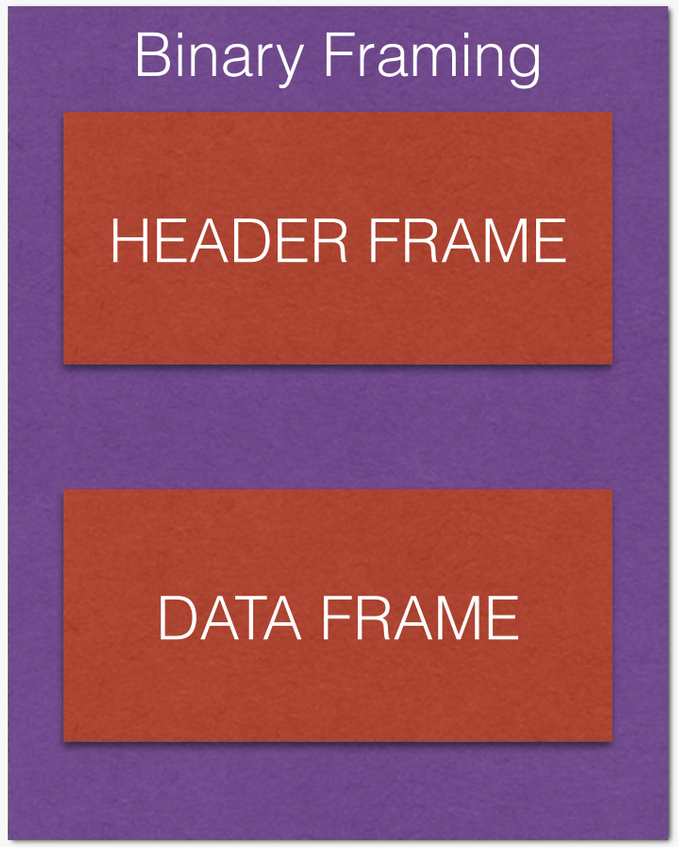
In a few words

- Binary Communication
- Compression and optimization techniques
- No change in HTTP semantics
- Not compatible with HTTP 1.x but can be used on top of it

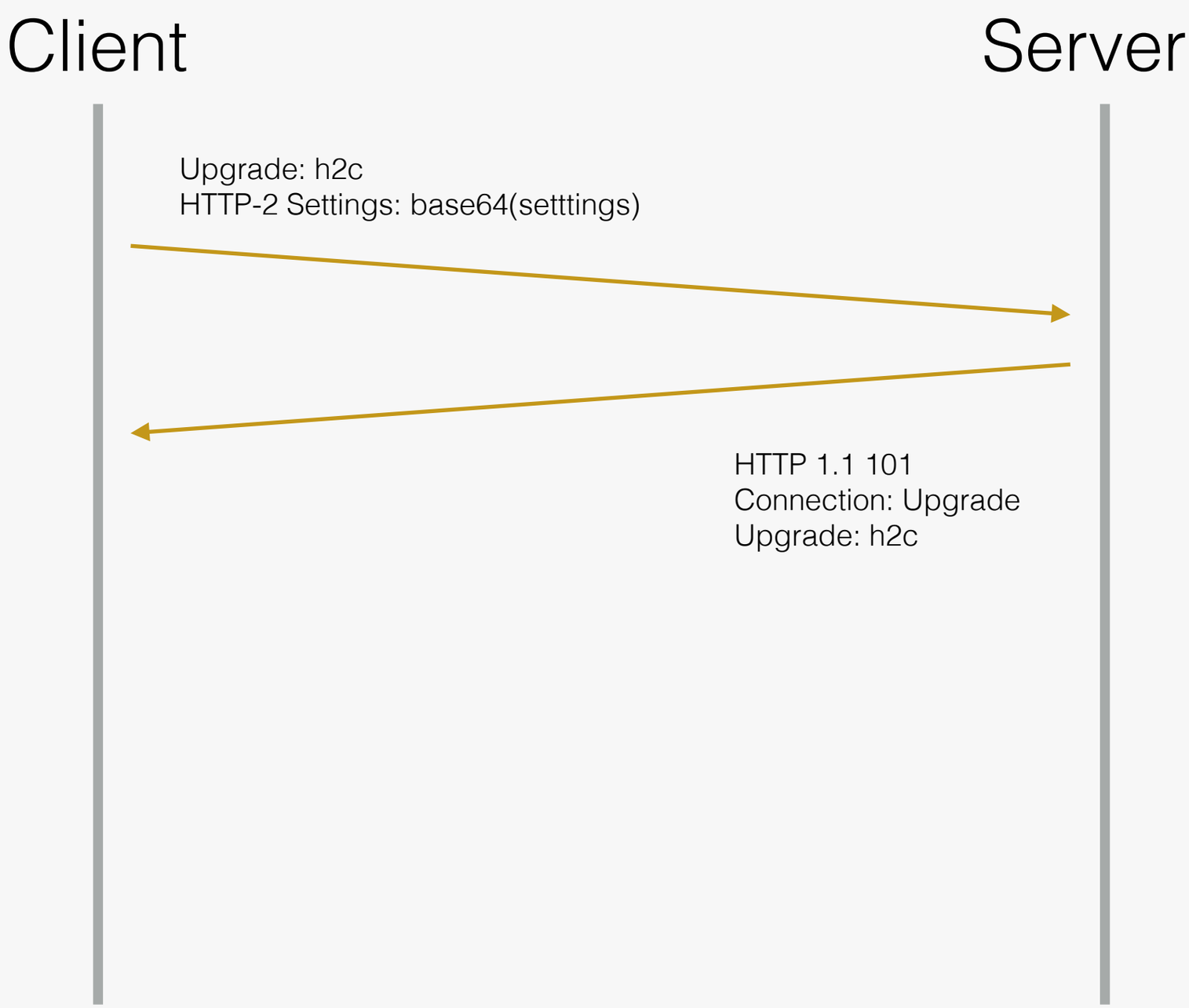
Is it SPDY?

Http/2

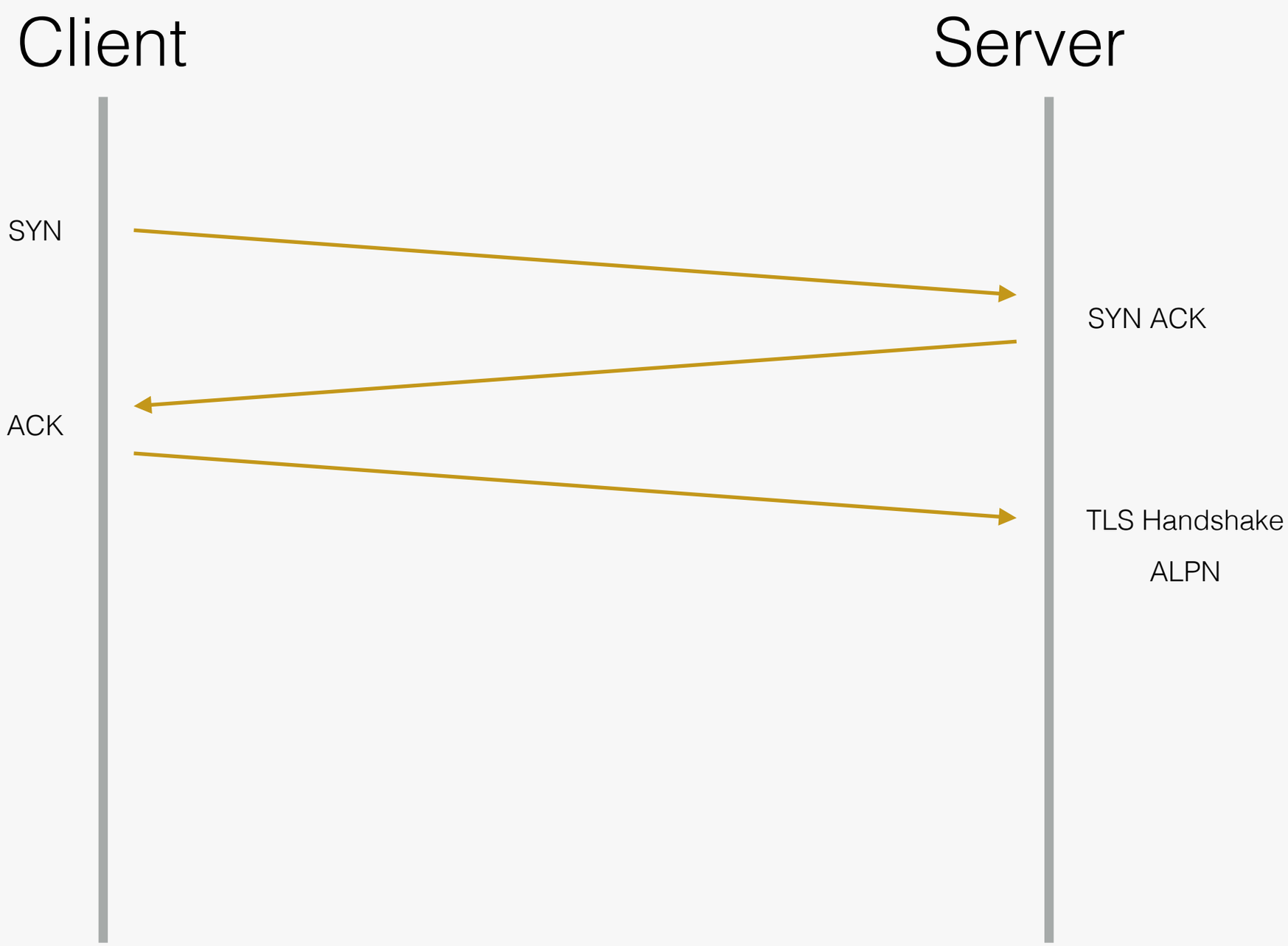
```
GET /index.htm HTTP/1.0
User-Agent: Netscape
Accept: text/html

<html>…</html>
```



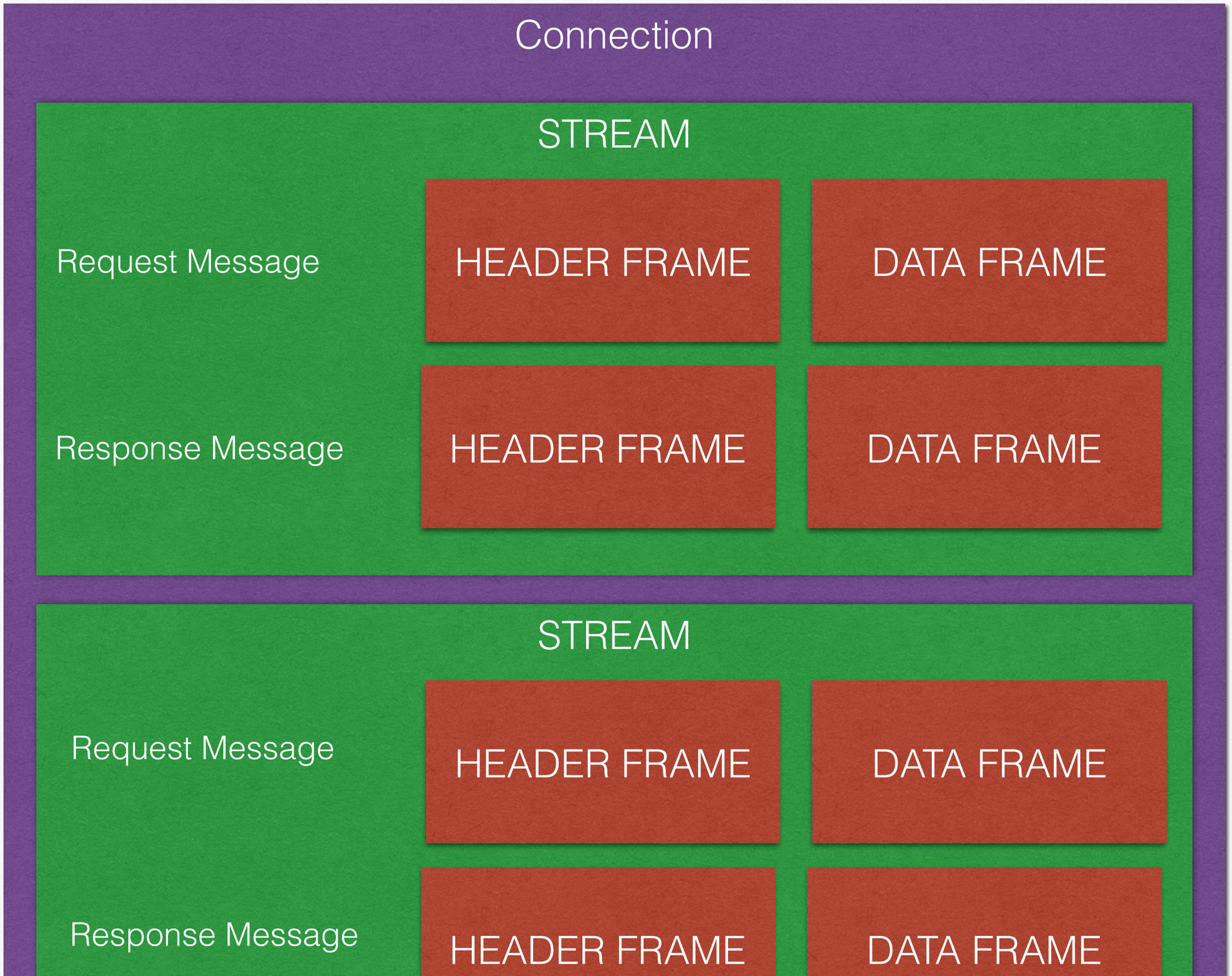
Http/2 Upgrade (h2c)



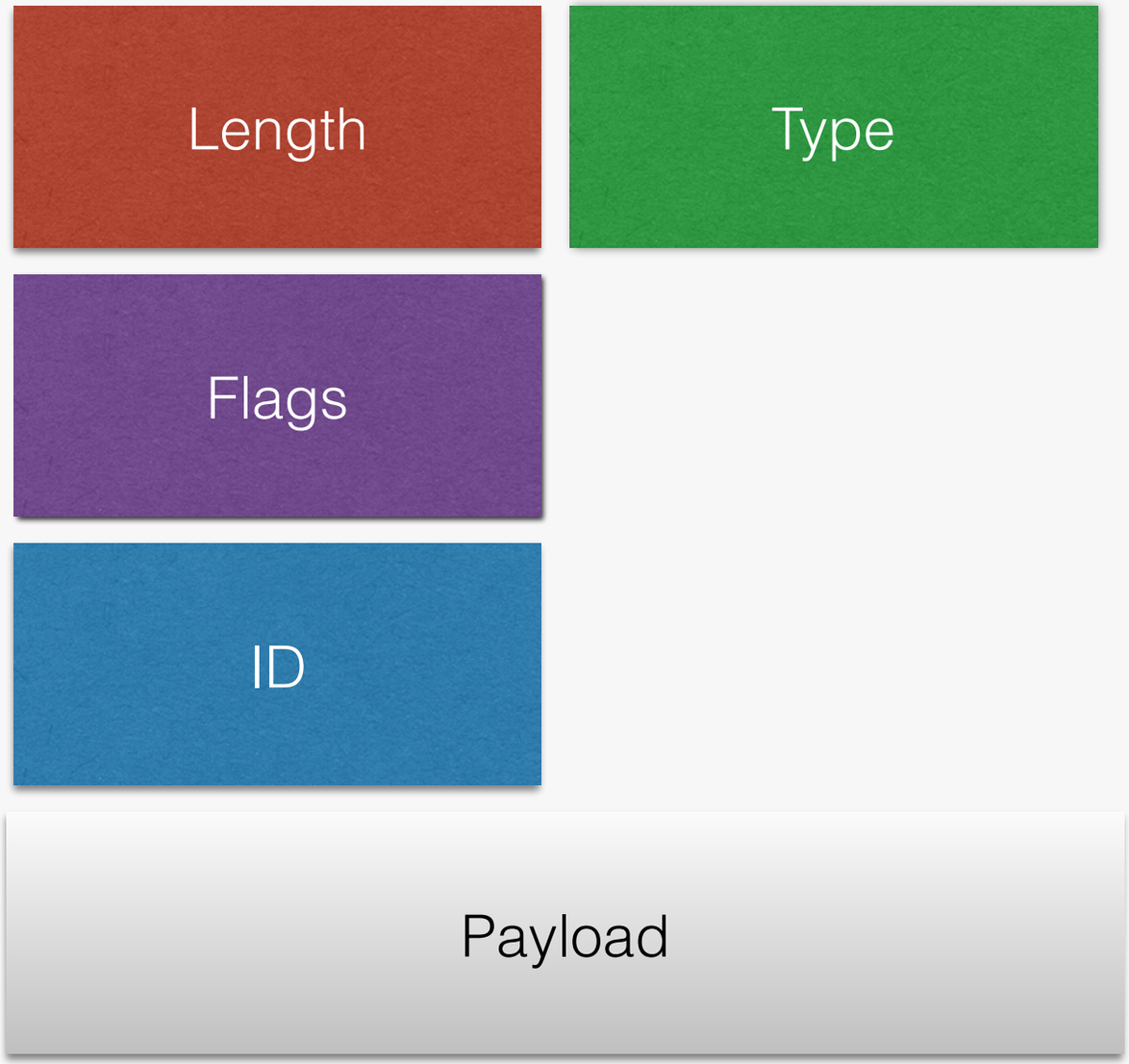
Http/2 TLS + ALPN (h2)



Http/2


Connection
STREAM
Request Message
HEADER FRAME
DATA FRAME
Response Message
HEADER FRAME
DATA FRAME
STREAM
Request Message
HEADER FRAME
DATA FRAME
Response Message
HEADER FRAME
DATA FRAME

A Frame

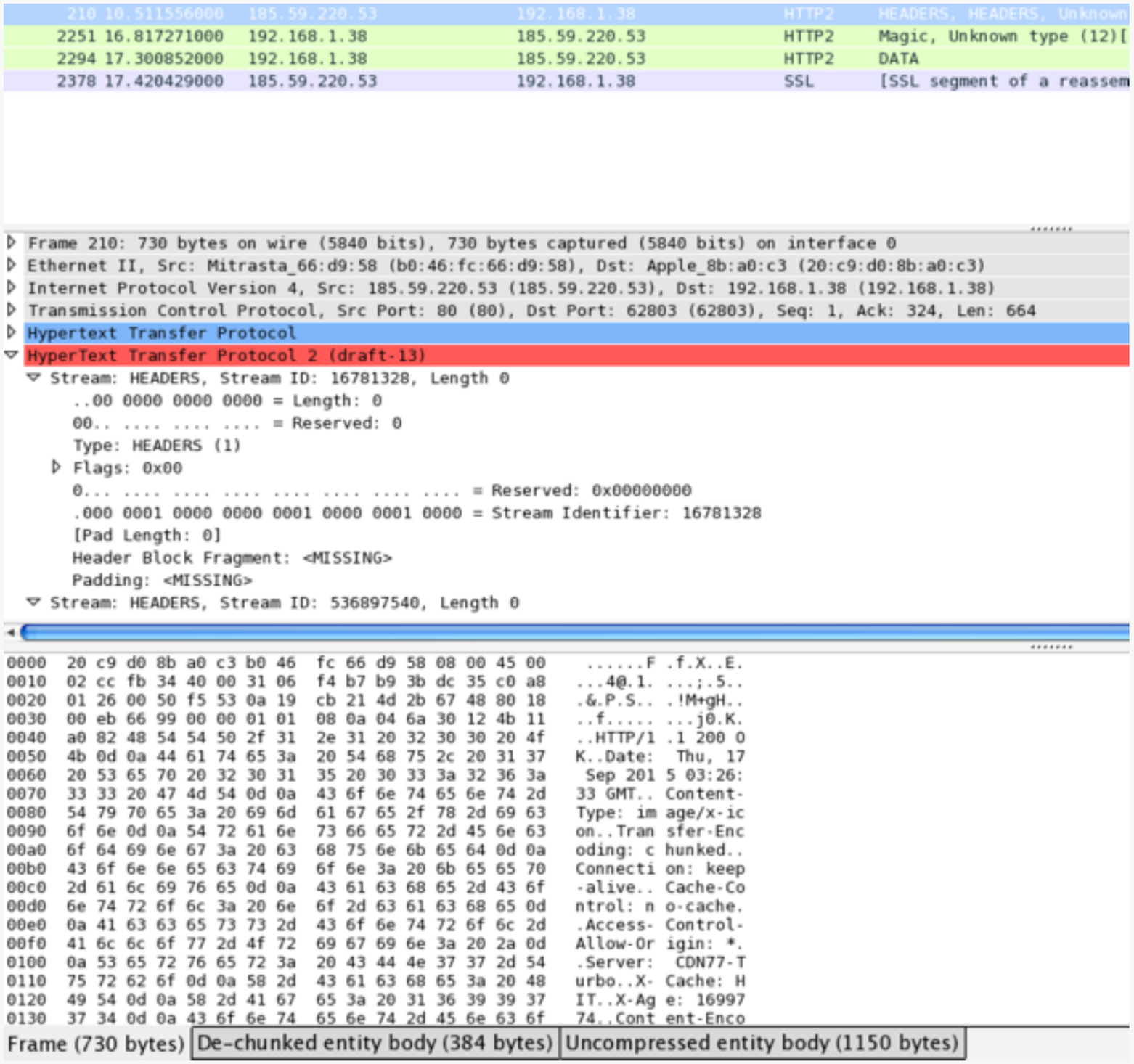


Response Message

Frame Types

- DATA
- HEADER
- WINDOW_UPDATE
- SETTINGS
- PRIORITY
- RST_STREAM
- PUSH_PROMISE
- PING
- GOAWAY
- CONTINUATION

In Action


210 10.511556000 185.59.220.53 192.168.1.38 HTTP2 HEADERS, HEADERS, Unknown
2251 16.817271000 192.168.1.38 185.59.220.53 HTTP2 Magic, Unknown type (12)[
2294 17.300852000 192.168.1.38 185.59.220.53 HTTP2 DATA
2378 17.420429000 185.59.220.53 192.168.1.38 SSL [SSL segment of a reassem
Frame 210: 730 bytes on wire (5840 bits), 730 bytes captured (5840 bits) on interface 0
Ethernet II, Src: Mitrasta_66:d9:58 (b0:46:fc:66:d9:58), Dst: Apple_8b:a0:c3 (20:c9:d0:8b:a0:c3)
Internet Protocol Version 4, Src: 185.59.220.53 (185.59.220.53), Dst: 192.168.1.38 (192.168.1.38)
Transmission Control Protocol, Src Port: 80 (80), Dst Port: 62803 (62803), Seq: 1, Ack: 324, Len: 664
Hypertext Transfer Protocol
HyperText Transfer Protocol 2 (draft-13)
Stream: HEADERS, Stream ID: 16781328, Length 0
..00 0000 0000 0000 = Length: 0
00.. .... = Reserved: 0
Type: HEADERS (1)
Flags: 0x00
0... .... = Reserved: 0x00000000
.000 0001 0000 0000 0001 0000 0001 0000 = Stream Identifier: 16781328
[Pad Length: 0]
Header Block Fragment: <MISSING>
Padding: <MISSING>
Stream: HEADERS, Stream ID: 536897540, Length 0
0000 20 c9 d0 8b a0 c3 b0 46 fc 66 d9 58 08 00 45 00 .....F .f.X..E.
0010 02 cc fb 34 40 00 31 06 f4 b7 b9 3b dc 35 c0 a8 ...4@.1. ...;.5..
0020 01 26 00 50 f5 53 0a 19 cb 21 4d 2b 67 48 80 18 .&.P.S.. .!M+gH..
0030 00 eb 66 99 00 00 01 01 08 0a 04 6a 30 12 4b 11 ..f..... ...j0.K.
0040 a0 82 48 54 54 50 2f 31 2e 31 20 32 30 30 20 4f ..HTTP/1 .1 200 O
0050 4b 0d 0a 44 61 74 65 3a 20 54 68 75 2c 20 31 37 K..Date: Thu, 17
0060 20 53 65 70 20 32 30 31 35 20 30 33 3a 32 36 3a Sep 201 5 03:26:
0070 33 33 20 47 4d 54 0d 0a 43 6f 6e 74 65 6e 74 2d 33 GMT.. Content-
0080 54 79 70 65 3a 20 69 6d 61 67 65 2f 78 2d 69 63 Type: im age/x-ic
0090 6f 6e 0d 0a 54 72 61 6e 73 66 65 72 2d 45 6e 63 on..Tran sfer-Enc
00a0 6f 64 69 6e 67 3a 20 63 68 75 6e 6b 65 64 0d 0a oding: c hunked..
00b0 43 6f 6e 6e 65 63 74 69 6f 6e 3a 20 6b 65 65 70 Connecti on: keep
00c0 2d 61 6c 69 76 65 0d 0a 43 61 63 68 65 2d 43 6f -alive.. Cache-Co
00d0 6e 74 72 6f 6c 3a 20 6e 6f 2d 63 61 63 68 65 0d ntrol: n o-cache.
00e0 0a 41 63 63 65 73 73 2d 43 6f 6e 74 72 6f 6c 2d .Access- Control-
00f0 41 6c 6c 6f 77 2d 4f 72 69 67 69 6e 3a 20 2a 0d Allow-Or igin: *.
0100 0a 53 65 72 76 65 72 3a 20 43 44 4e 37 37 2d 54 .Server: CDN77-T
0110 75 72 62 6f 0d 0a 58 2d 43 61 63 68 65 3a 20 48 urbo..X- Cache: H
0120 49 54 0d 0a 58 2d 41 67 65 3a 20 31 36 39 39 37 IT..X-Ag e: 16997
0130 37 34 0d 0a 43 6f 6e 74 65 6e 74 2d 45 6e 63 6f 74..Cont ent-Enco
Frame (730 bytes)
De-chunked entity body (384 bytes)
Uncompressed entity body (1150 bytes)

In Action

```
  210 10.511556000  185.59.220.53   192.168.1.38    HTTP2     HEADERS, HEADERS
 2251 16.817271000  192.168.1.38    185.59.220.53   HTTP2     Magic, Unknown t
 2294 17.300852000  192.168.1.38    185.59.220.53   HTTP2     DATA
 2378 17.420429000  185.59.220.53   192.168.1.38    SSL       [SSL segment of
```

```
▷ Frame 2294: 154 bytes on wire (1232 bits), 154 bytes captured (1232 bits) on interface 0
▷ Ethernet II, Src: Apple_8b:a0:c3 (20:c9:d0:8b:a0:c3), Dst: Mitrasta_66:d9:58 (b0:46:fc:66:d9:58)
▷ Internet Protocol Version 4, Src: 192.168.1.38 (192.168.1.38), Dst: 185.59.220.53 (185.59.220.53)
▷ Transmission Control Protocol, Src Port: 62812 (62812), Dst Port: 443 (443), Seq: 2168, Ack: 22047, L
▽ Secure Sockets Layer
  ▷ TLSv1.2 Record Layer: Application Data Protocol: spdy
    SSL segment data (59 bytes)
    SSL segment data (34 bytes)
▷ [19 Reassembled SSL segments (1288 bytes): #2251(88), #2252(216), #2258(9), #2279(124), #2280(59), #2
▽ HyperText Transfer Protocol 2 (draft-13)
  ▽ Stream: DATA, Stream ID: 4, Length 1280
      ..00 0101 0000 0000 = Length: 1280
      00.. .... .... .... = Reserved: 0
      Type: DATA (0)
    ▷ Flags: 0x40
      0... .... .... .... .... .... .... .... = Reserved: 0x00000000
      .000 0000 0000 0000 0000 0000 0000 0100 = Stream Identifier: 4
```

```
0000  b0 46 fc 66 d9 58 20 c9  d0 8b a0 c3 08 00 45 00   .F.f.X . ......E.
0010  00 8c 2c dc 40 00 40 06  b6 50 c0 a8 01 26 b9 3b   ..,.@.@. .P...&.;
0020  dc 35 f5 5c 01 bb 71 b6  2b 40 db 20 82 00 80 18   .5.\..q. +@. ....
0030  10 00 e2 4f 00 00 01 01  08 0a 4b 11 ba a2 04 6a   ...O.... ..K....j
0040  36 59 17 03 03 00 53 00  00 00 00 00 00 00 13 bf   6Y....S. ........
0050  68 ea aa 1f 41 8b 63 84  2f d0 dd 98 56 5b 55 22   h...A.c. /...V[U"
0060  b0 44 db a0 d5 12 53 5a  a4 7b c1 ff 73 09 c3 d2   .D....SZ .{..s...
0070  73 b6 35 92 ad 0a 1b 03  21 71 4a f7 50 79 5b 1b   s.5..... !qJ.Py[.
0080  1d 6d fb 50 50 06 59 ce  4b aa 67 fd b6 d5 ec ee   .m.PP.Y. K.g.....
0090  61 29 f7 c0 75 31 97 a4  ae a6                     a)..u1.. ..
```

Proper Multiplexing

- Allows interleaving of different requests and responses
    - Bidirectional
    - Each frame has a unique identifier
- Eliminates head-of-line blocking
- Single connection for parallel processing

Header Compression

- Uses HPACK
- Huffman code for encoding headers
- An index table is maintained between client and server
- CRIME prevented use of zlib

Priorities

- Define priorities of different streams

- Each stream has a weight and dependencies

Flow Control

- Multiplexing requires ability of flow control

- WINDOW_UPDATE

Server Push

- Replaces inlining of resources
- PUSH_PROMISE from server (even numbered streams)
- Allows for caching
- Allows for cancelation by client

Security

- Not forced

- TLS implemented by all supported browsers

Current Status

- May 2015 RFC 7540

- May 2015 RFC 7541 (HPACK)

Browser Support

Can I use http2 ? Settings

1 result found

HTTP/2 protocol - OTHER

Networking protocol for low-latency transport of content over the web. Originally started out from the SPDY protocol, now standardized as HTTP version 2.

Spain	65.4%	+ 6.04% =	71.43%
Global	53.15%	+ 6.17% =	59.32%

Current aligned | Usage relative | Show all

IE	Edge *	Firefox	Chrome	Safari	Opera	iOS Safari *	Opera Mini *	Android Browser *	Chrome for Android
8								4.1	
9		38	43					4.3	
10		39	44			7.1		4.4.4	
11 [1]	12	40	45	8	31	8.4	8	44	44
	13	41	46	9	32	9			
		42	47		33				
		43	48						

Implementations

- Servers: H2O, Warp, Netty, Lucid, Jetty…
- Clients: Jetty, Netty, Curl, OkHttp…
- Tomcat planned for 9

Demo Sites

- https://http2.akamai.com/

- http://www.http2demo.io/

Tooling

- Curl
- Chrome Tools
- Wireshark
- WebPageTest

How does it affect our applications?

Mostly transparent

A process of un-optimization

Rollback…

- Multiple TCP Connections
- Domain Sharding
- Concatenation and Spriting
- Inlining

What about API's?

- For our HTTP API's, no more concerns about chatty API's
- Library usage will expose some of the lower level aspects

Not all roses…

- Adding transport level complexity to application level
- TLS requirements
- How will Push really work?
- What about Priorities?

More information

- Starting point: https://github.com/http2

- High Performance Browser Networking by Ilya Grigorik

Thank you

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