# What now? What about performance? Goals depend on who you're talking about

| | User | Network operators | Content provider |
|---|---|---|---|
| wish | fast downloads<br>high availability | no overload | happy users<br>cost-effective infrastructure |
| solution | Improve HTTP to compensate for TCP weakspots | Caching and Replication | |

# What now? What about performance? Goals depend on who you’re talking about

User

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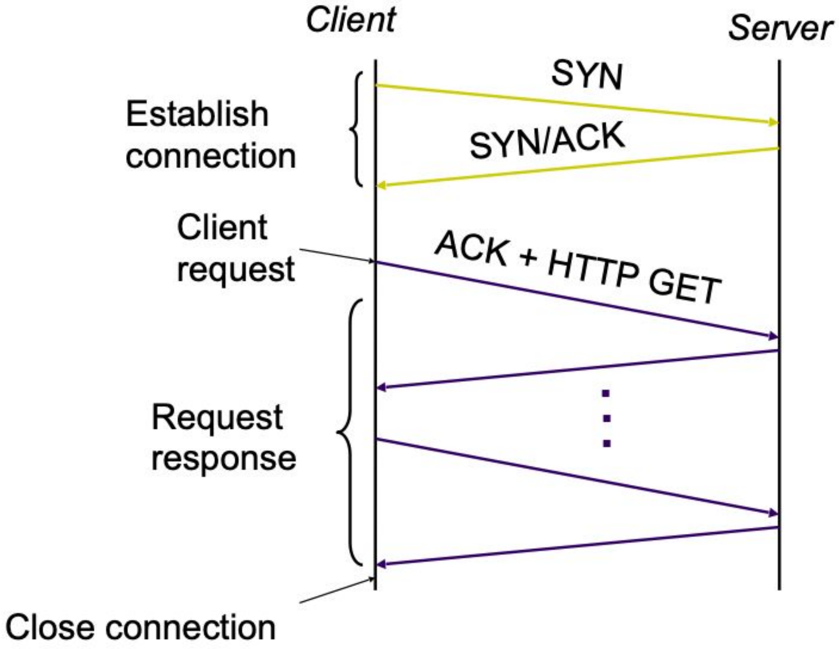
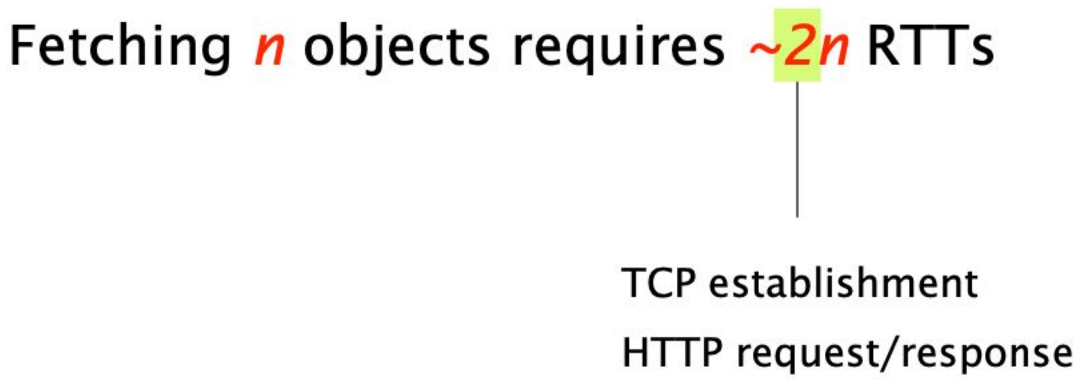
# Recall that a client to open a connection before exchanging any data



# Nearly all websites have multiple objects, naive HTTP opens one TCP connection for each...



Fetching $n$ objects requires ~$2n$ RTTs

TCP establishment

HTTP request/response

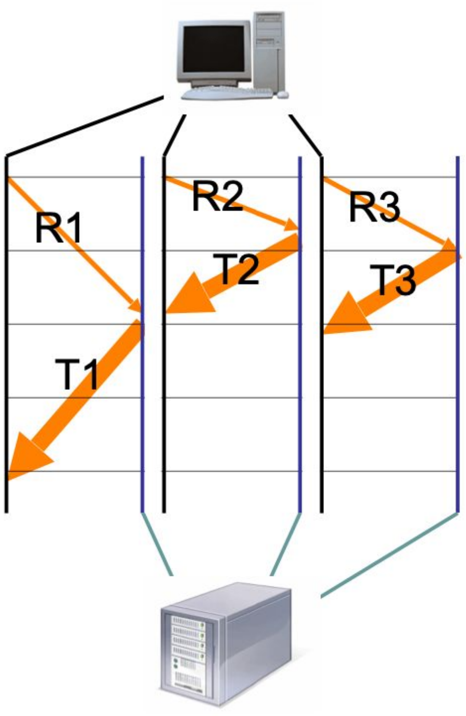
# One solution to that problem is to use multiple TCP connections in parallel

User Happy!

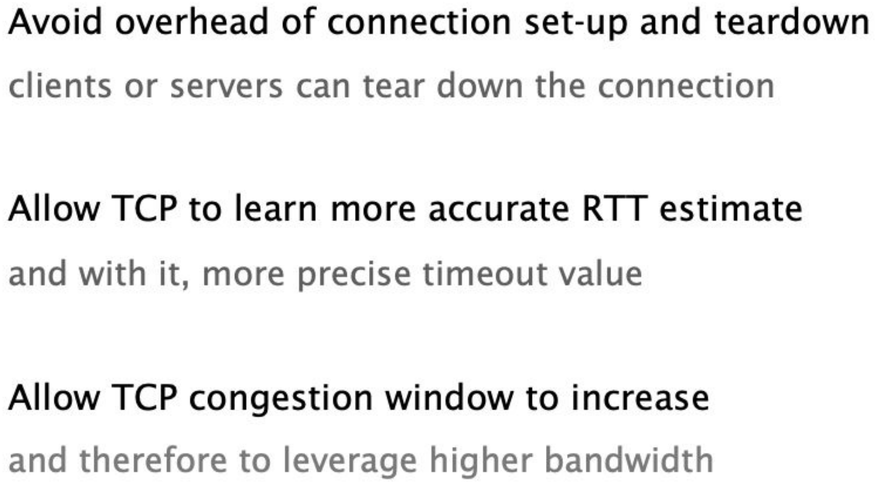
Content provider Happy!

Network operator Not Happy!

Why?



# Another solution is to use persistent connections across multiple requests (the default in HTTP/1.1)



**Avoid overhead of connection set-up and teardown**

clients or servers can tear down the connection

**Allow TCP to learn more accurate RTT estimate**

and with it, more precise timeout value

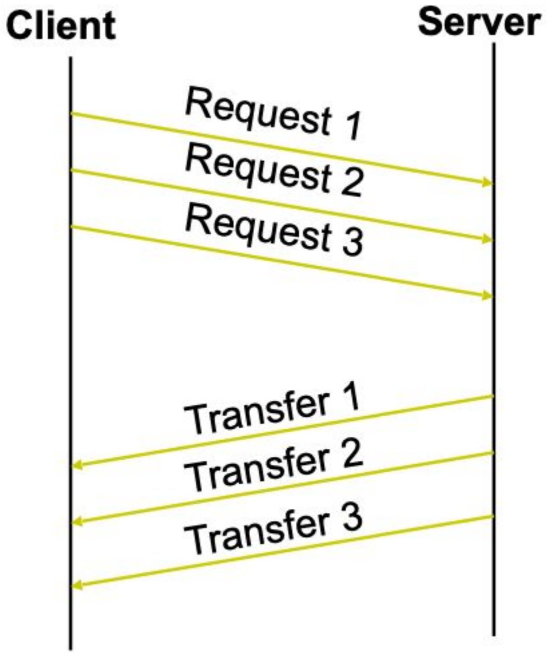
**Allow TCP congestion window to increase**

and therefore to leverage higher bandwidth

# Yet another solution is to pipeline requests & replies asynchronously, on one connection

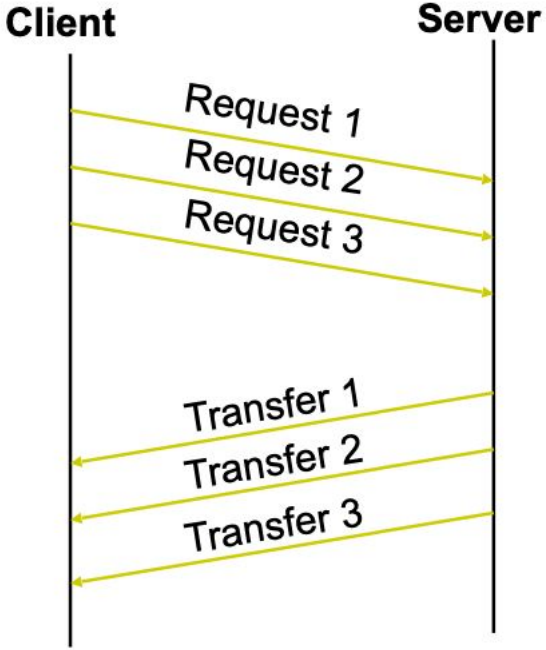
- batch requests and responses to reduce the number of packets

- multiple requests can be packed into one TCP segment



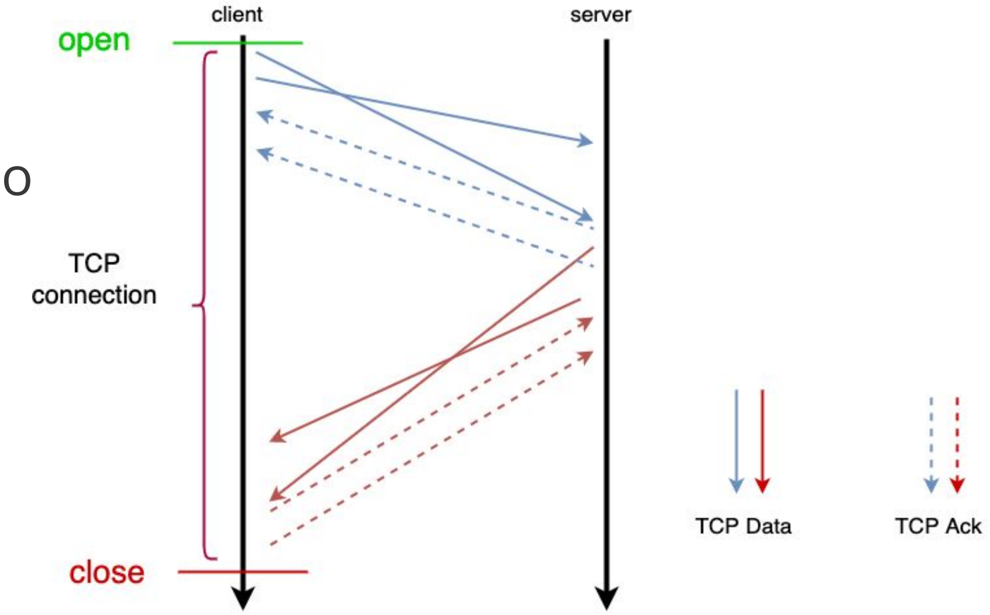
# Yet another solution is to pipeline requests & replies asynchronously, on one connection

- Pipelined connections aren't actually used
- But they seemed like a huge win
- What happened?!
    - .. primarily two reasons
- Reason 1: Bugs
    - One manifestation: images on page are swapped!
    - Often blamed on proxy servers
    - My guess: bad adaptation of multithreaded non-pipelined version
- Reason 2: Head-of-line blocking

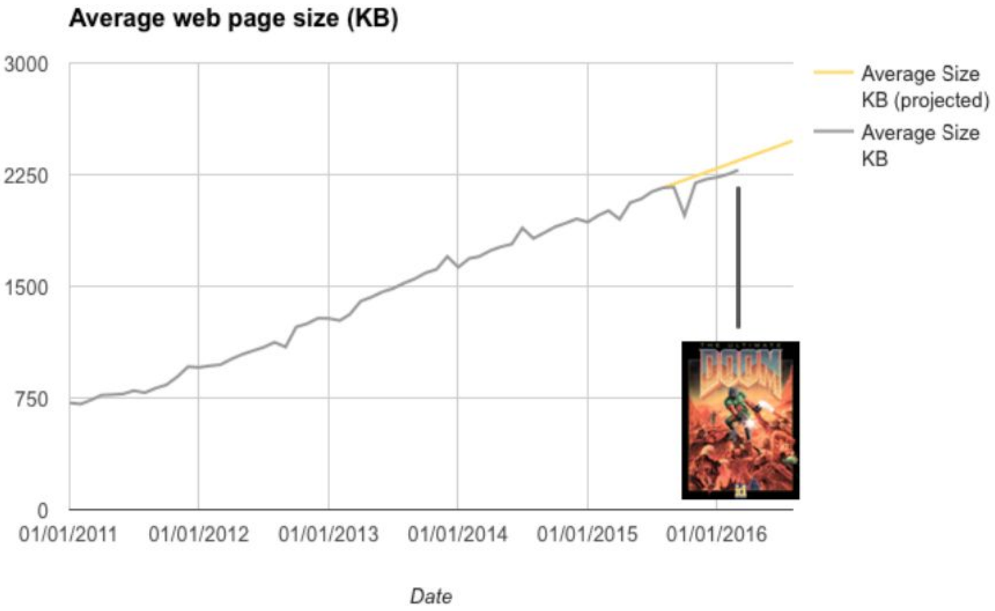


# HTTP2 Solves HTTP1.1 HOL Blocking Using Stream Multiplexing

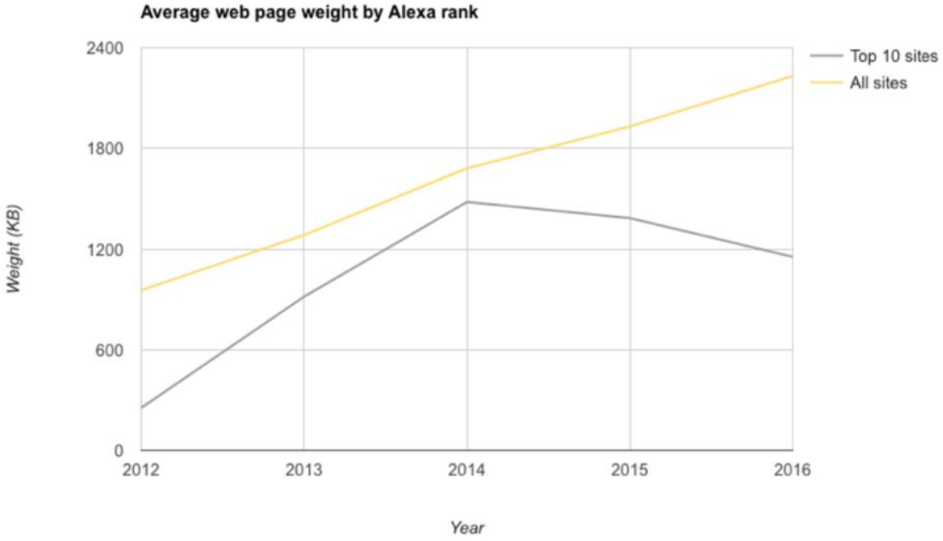
- Each stream is independent
- HTTP2 also moves from text to binary
- Server push was added



# The average webpage size nowadays is as large as the original DOOM...



# Top web sites have decreased in size though because they care about performance



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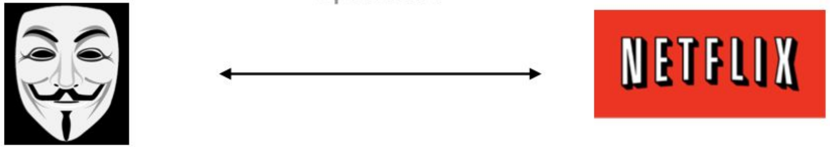

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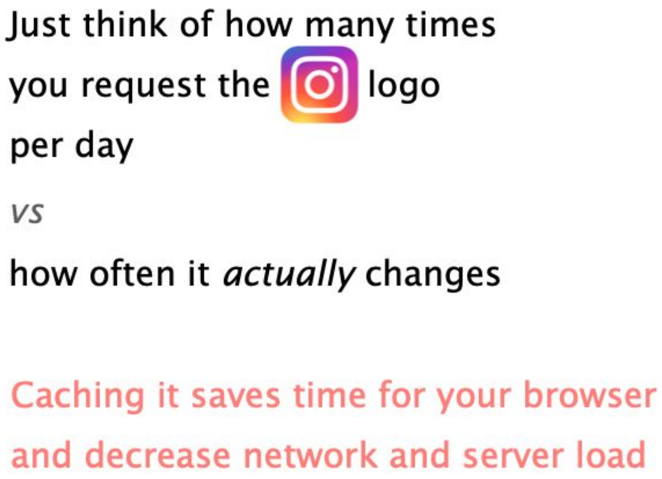
| solution |  | Caching and Replication |  |

# Caching leverages the fact that highly popular content largely overlaps



Just think of how many times
you request the logo
per day

*vs*

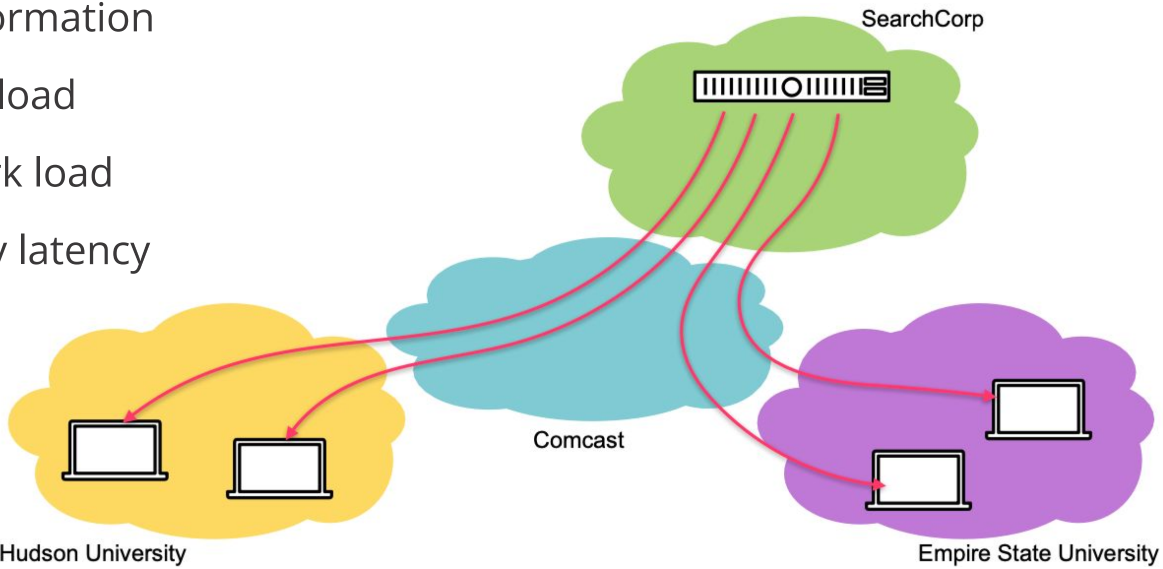
how often it *actually* changes

Caching it saves time for your browser
and decrease network and server load

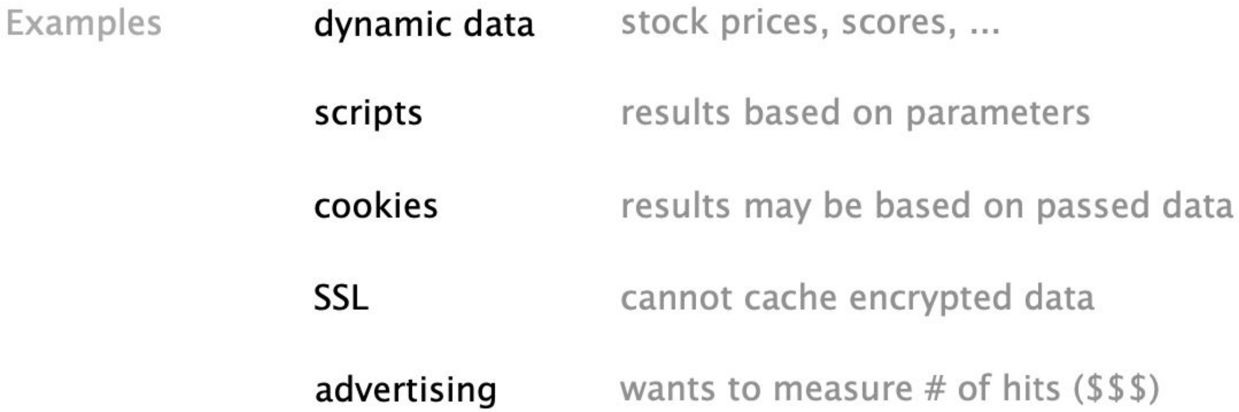
# HTTP Caching

**No caching**

- Many clients transfer same information
- Generates unnecessary server load
- Generates unnecessary network load
- Clients experience unnecessary latency



# Yet, a significant portion of the HTTP objects are “uncachable"



| | | |
|---|---|---|
| Examples | dynamic data | stock prices, scores, ... |
| | scripts | results based on parameters |
| | cookies | results may be based on passed data |
| | SSL | cannot cache encrypted data |
| | advertising | wants to measure # of hits ($$$) |

# To limit staleness of cached objects, HTTP enables a client to validate cached objects

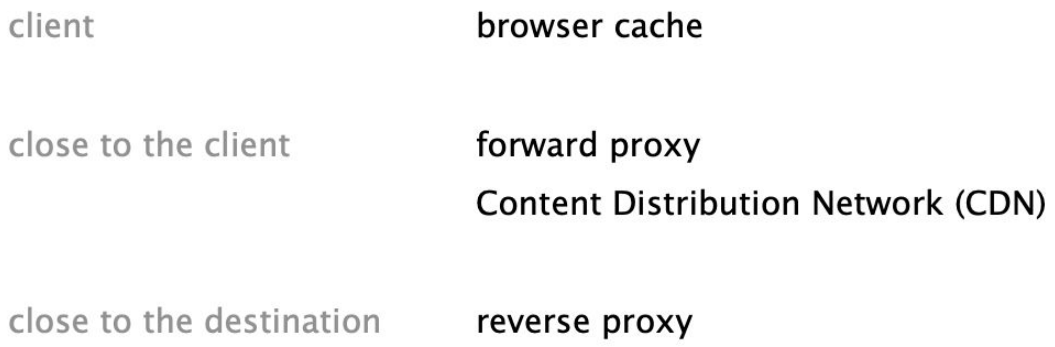
Server hints when an object expires (kind of TTL) as well as the last modified date of an object

Client conditionally requests a resource using the “if-modified-since” header in the HTTP request

Server compares this against “last modified” time of the resource and returns:

- **Not Modified** if the resource has not changed
- **OK** with the latest version

# Caching can be (and is) performed at different locations

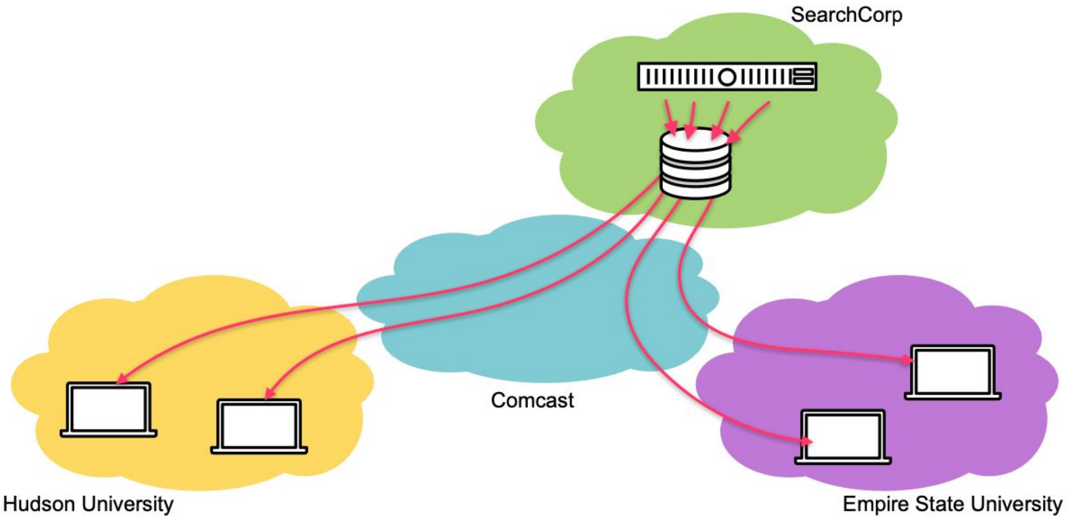


| | |
|---|---|
| client | browser cache |
| close to the client | forward proxy<br>Content Distribution Network (CDN) |
| close to the destination | reverse proxy |

# HTTP Caching

**Reverse proxies**

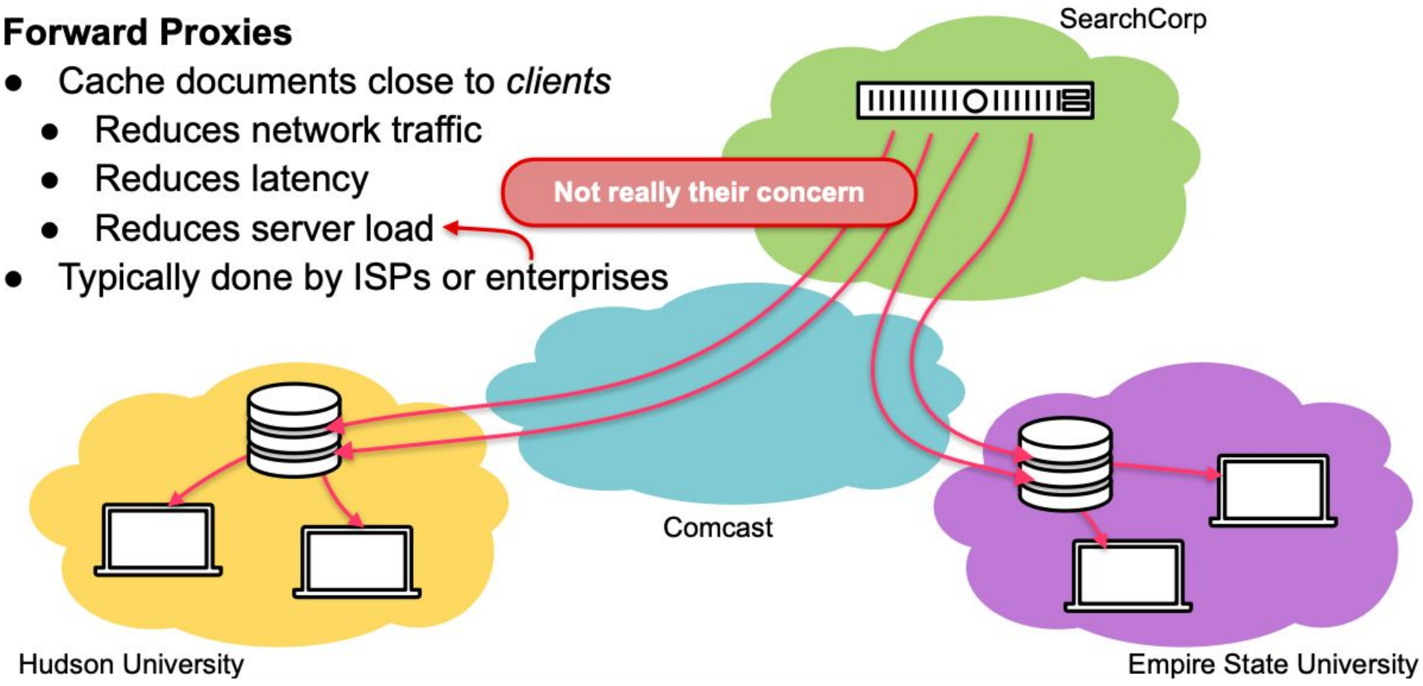
- Cache documents close to servers
    - Reduces server load
- Typically done by content provider



# HTTP Caching

**Forward Proxies**

- Cache documents close to *clients*
  - Reduces network traffic
  - Reduces latency
  - Reduces server load
- Typically done by ISPs or enterprises



Not really their concern