# Web 2.0

#### Lecture 6: HTTP/2

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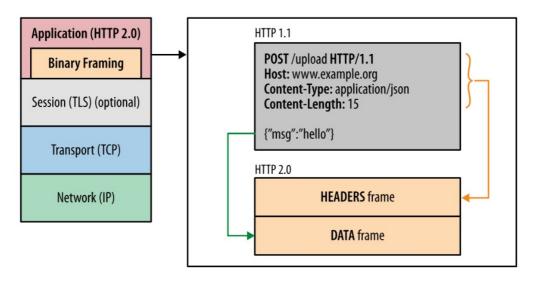
#### Overview

- Developed from SPDY (2009) experimental protocol by Google
  - May 2015: RFC 7540 (HTTP/2) and RFC 7541 (HPACK)
  - HTTP/2 standards extend (not replace) the previous HTTP standards
- HTTP/1.x limitations
  - HTTP/1.x clients need to use multiple connections to achieve concurrency
  - unnecessary network traffic request and response headers not compressed
  - no effective resource prioritization
- Primary goals
  - *Reduction of latency*
  - enabling full request and response multiplexing
  - minimize protocol overhead via efficient compression of HTTP header fields
  - support for request prioritization and server push
- HTTP/2 does not modify application semantics of HTTP
  - HTTP metods, URIs, header fields are the same
  - HTTP/2 modifies how data is formatted and transported in communication
- Literature and source
  - I. Grigorik: High Performance Browser Networking, O'Reilly Media, Inc. 2013. ISRN 9781449344757 №

# **Binary Framing Layer**

### • Binary framing layer

- defines how HTTP messages are encapsulated and transferred
- communication is split into messages and frames in binary format



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## HTTP/2 Communication

## • Data exchange between the client and server

- break down of the communication into frames
- frames are mapped to messages that belong to a particular stream
- communication is multiplexed within a single TCP connection.

#### Stream

- bi-directional flow of bytes in a connection
- may carry one or more messages
- may have a priority

# Message

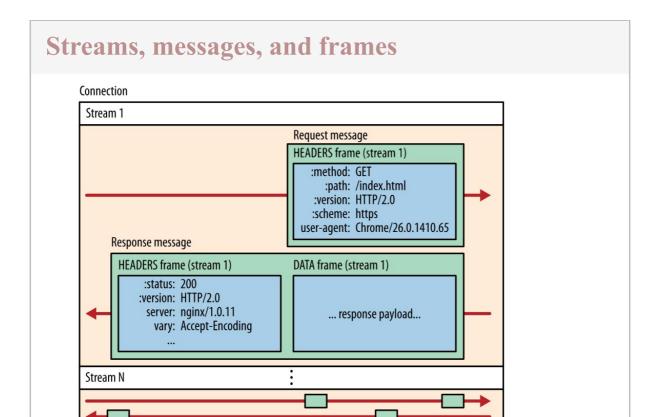
- a sequence of frames
- it maps to logical request or response message

#### • Frame

- the smallest unit of communication
- each has a frame header which identifies a stream to which it belongs.

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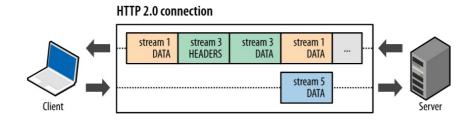


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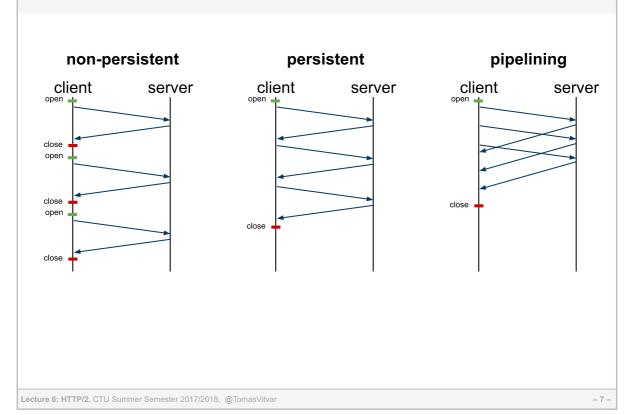
# Request and response multiplexing

- Parallel requests
  - HTTP/1.x can use HTTP pipelining; they open multiple connections
    - $\rightarrow$  browser typically opens up six connections
  - HTTP/2 allows full request and response multiplexing
    - → *Allows for parallel in-flight streams*



- Performance benefits
  - Interleave requests/responses in parallel without blocking any one.
  - Deliver lower page load times by eliminating unnecessary latency
  - Improve utilization of available network capacity

# HTTP/1.x Optimization



## One connection

- Multiplexing allows for:
  - all connections are persisted
  - only one connection required per origin
- Advantages
  - significant reduction of the overall protocol overhead
  - use of fewer connections reduces the memory and processing footprint along the full connection path (client, intermediaries, origin servers)
  - reduces operational costs and improves network capacity
  - Improves performance of HTTPS deployments
    - → fewer expensive TLS handshakes
    - $\rightarrow$  better session reuse
    - → overall reduction in required client and server resources

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#### Flow control

- Prevent sender from receiving data it doest not want
  - Receiver is busy or under heavy load
  - Receiver can allocate fixed amount of resources for particular stream
- Examples
  - Client request a video stream; a user pauses the stream
    - → the client wants to pause the stream delivery to avoid buffering
  - A proxy server has a fast downstream and slow upstream
    - → the proxy server can control how quickly the downstream delivers data to match the speed of upstream
    - → better control of resource usage
  - Similar problems as in TCP control
- Flow control
  - Sender and receiver both advertise stream flow control window in bytes
    - = the size of the available buffer space to hold the incoming data
  - exhanged by special SETTINGS and WINDOW\_UPDATE frames
  - Flow control is hop-by-hop, not end-to-end
    - → an intermediary can set its own flow control

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# Server push

- Ability to send multiple responses for a single request
  - A response to the request is sent back
  - Additional resources can be pushed without client requesting them
  - Hypertext "server knows what the client will need"

# Stream 1 | stream 2 | stream 2 | promise | stream 1 | frame 1 | stream 2 | promise | stream 2 | stream 1 | frame 1 | stream 2 | stream 3 | stream 4 | stream 2 | stream 4 | stream 2 | stream 4 | stream 4 | stream 5 | stream 6 | stre

- Similar to resource inlining
  - A resource is pushed to the client in HTML/CSS resource
- Performance benefits
  - Cached by the client, reused across pages, multiplexed, declined by the client

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# **Push promise**

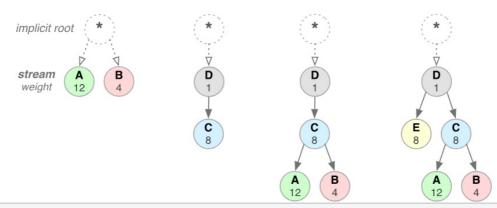
- PUSH\_PROMISE frames
  - A singual that the server intents to push resources to the client
  - The client needs to know which resources the server intends to push to avoid creating duplicate requests for these resources.
- After the client receives PUSH\_PROMISE
  - it may decline the stream (via RST\_STREAM frame)
    - $\rightarrow$  For example, when the resource is already in the cache
    - $\rightarrow$  As for inline resources, this is not possible, the client always receives them
  - it can limit the number of concurrently pushed streams
  - it can adjust the initial flow control window to control how much data is pushed when the stream is first opened
  - it can disable server push entirely
- pushed resources must obey the same-origin policy

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## **Stream Prioritization**

- Purpose
  - Messages split into frames which are delivered in multiplexed streams
  - The order in which frames are delivered is important for a good performance
  - Client can define stream prioritization
    - → optimizations in the browser, change prioritization based on user interaction
- Streams' weights and dependency
  - Each stream can be assigned an integer weight between 1 and 256.
  - Each stream may be given an explicit dependency on another stream.



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# **Stream Prioritization (cont.)**

#### Dependency

- referencing the unique identifier of another stream as its parent
- if the identifier is omitted the stream is dependent on the "root stream"
- The parent stream should be allocated resources ahead of its dependencies.
  - $\rightarrow$  "Please process and deliver response D before response C"

#### Weights

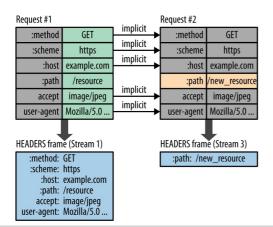
- Sibling streams have resources allocated as per their weights
- Example
  - $\rightarrow$  Sum all the weights: 4 + 12 = 16
  - $\rightarrow$  Divide each stream weight by the total weight: A = 12/16, B = 4/16
  - → Stream A receives 3/4 and stream B receives 1/4 of available resources;

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# **Header compression**

- Purpose
  - Each HTTP request/response contains a set of headers (metadata)
  - HTTP/1.x metadata sent as plain text, adds 500-800 bytes per transfer
- HTTP/2 provides
  - Request and response metadata are compressed sing HPACK format
    - → header fields encoded via a static Huffman code reduces size
    - → client and server maintain an indexed list of previously seen header fields



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