Web 2.0 Lecture 6: HTTP/2

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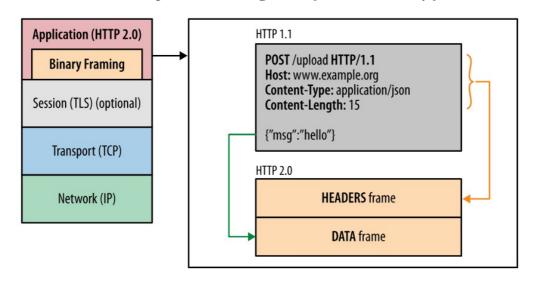
Overview

- 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

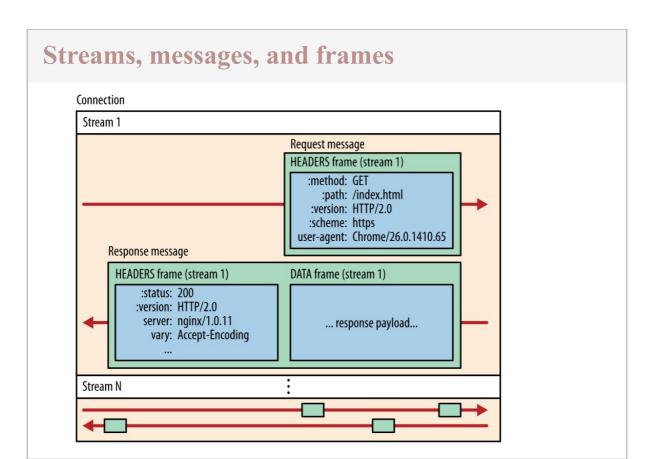
- a sequence of frames
- it maps to logical request or response message

Frame

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

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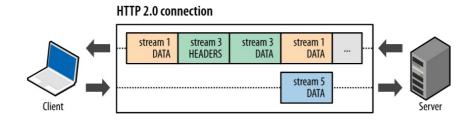


Request and response multiplexing

• Parallel requests

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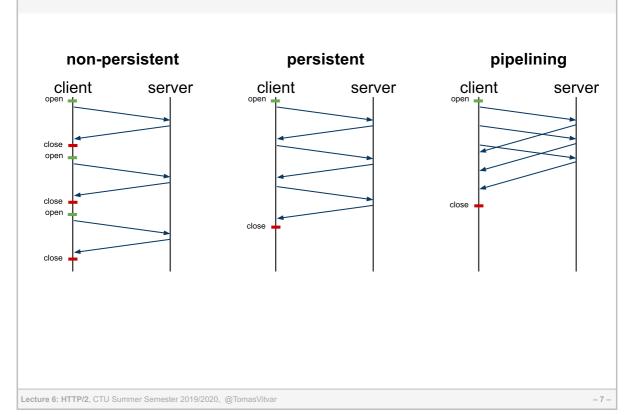
- HTTP/1.x can use HTTP pipelining; they open multiple connections
 - \rightarrow browser typically opens up six connections
- HTTP/2 allows full request and response multiplexing
 - \rightarrow Allows for parallel in-flight streams



- 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

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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 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

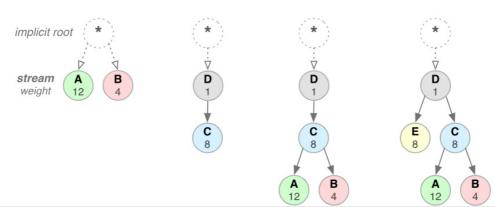
- PUSH_PROMISE frames
 - A singual that the server intents to push resources to the client
 - The client needs to know which resources the server intends to push to avoid creating duplicate requests for these resources.
- After the client receives PUSH_PROMISE
 - it may decline the stream (via RST_STREAM frame)
 - → 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

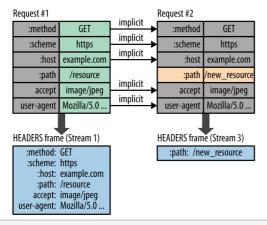
- Sibling streams have resources allocated as per their weights
- Example
 - \rightarrow Sum all the weights: 4 + 12 = 16
 - \rightarrow Divide each stream weight by the total weight: A = 12/16, B = 4/16
 - \rightarrow Stream A receives 3/4 and stream B receives 1/4 of available resources;

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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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