Performance Evaluation of WebSocket Protocol for Implementation of Full-Duplex Web Streams

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Università degli Studi di Salerno

1st Scalability Research Forum

Outline

Background

- *Historically*, creating web applications that need bidirectional communication between a client and a server has required an abuse of HTTP to poll the server for updates while sending upstream notifications as distinct HTTP calls.

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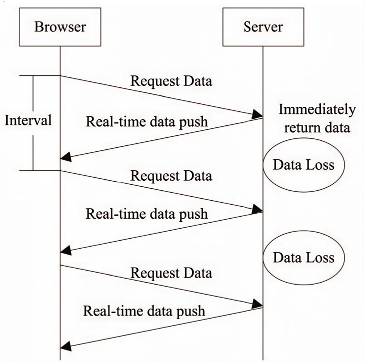
Check whether the server is changed in a while, thereby performing incremental updates.



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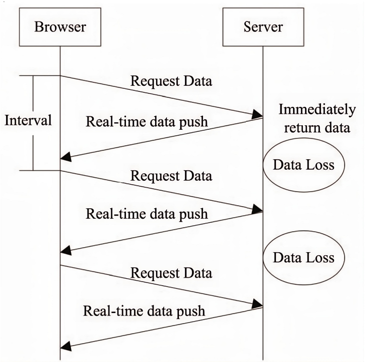

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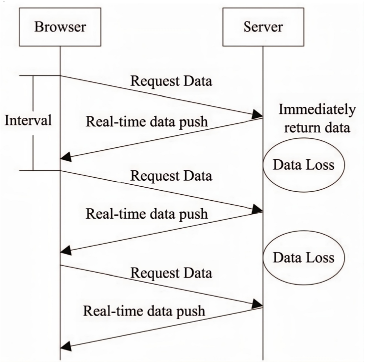

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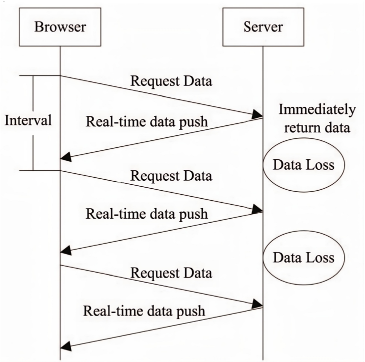
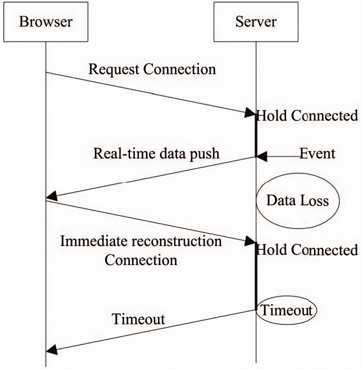


- How often to query?
- Continuously short interval requests will be washed away the server.
- Long interval will require more time to reach the client, no real-time data.

HTTP long polling

When a client sends a data request, the server will block the request until there is data transfer or timeout before returning.



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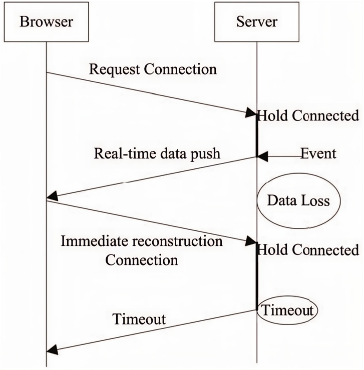

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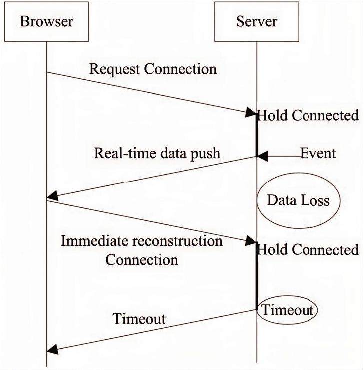

- Solve the short polling frequency to access the server.
- No bidirectional communication, server push data.

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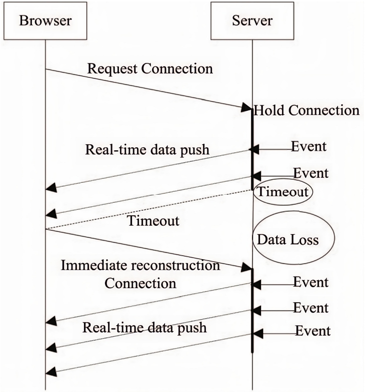

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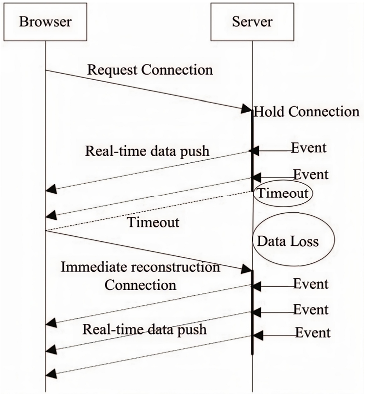

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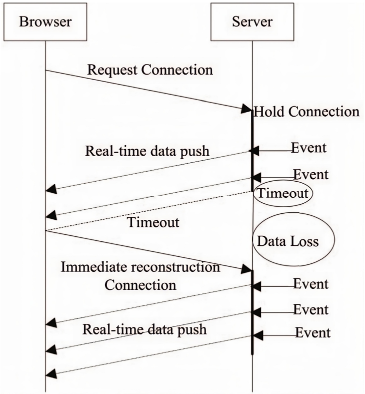

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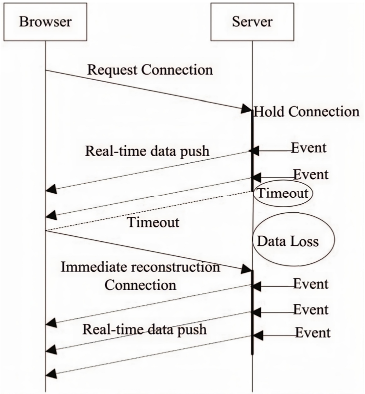

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- No bidirectional communication.

Outline

RFC 6455
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- The WebSocket Protocol enables two-way communication between a client running untrusted code in a controlled environment to a remote host that has opted-in to communications from that code.

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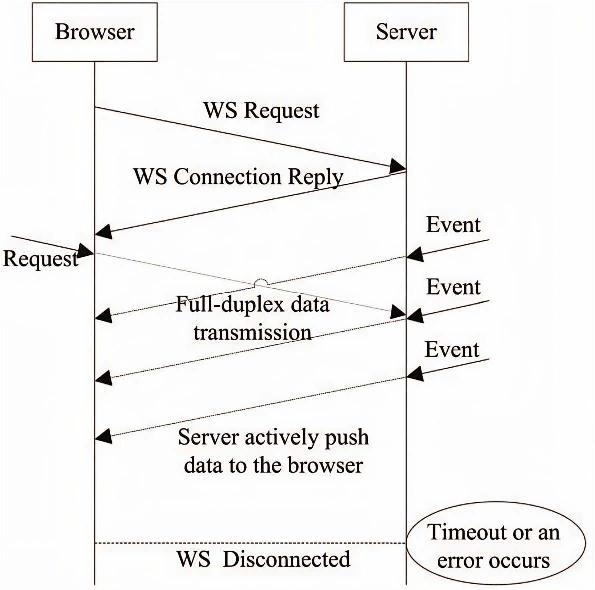
WebSocket


Browser
Server
WS Request
WS Connection Reply
Event
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Full-duplex data
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Server actively push
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- To establish a session, client sends a WebSocket Upgrade Request to the server, upon which server responds with a WebSocket Upgrade Response.
- From this point forward, the client and server can send data back and forth in asynchronous full-duplex mode.

WebSocket Upgrade Request

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- Server tells which protocol it supports.

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- The added overhead to the payload data is minimal because it does not send all the HTTP headers for each frame.
- Each frame adds at least 2 bytes of overhead to the payload data. Depending on the length of the payload data and the direction of the communication, the length of the overhead may increase up to 14 bytes.

WebSocket Frame Structure

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-------+-+-------------+-------------------------------+
|F|R|R|R| opcode|M| Payload len |    Extended payload length    |
|I|S|S|S|  (4)  |A|     (7)     |             (16/64)           |
|N|V|V|V|       |S|             |   (if payload len==126/127)   |
| |1|2|3|       |K|             |                               |
+-+-+-+-+-------+-+-------------+ - - - - - - - - - - - - - - - +
|     Extended payload length continued, if payload len == 127  |
+ - - - - - - - - - - - - - - - +-------------------------------+
|                               |Masking-key, if MASK set to 1  |
+-------------------------------+-------------------------------+
| Masking-key (continued)       |          Payload Data         |
+-------------------------------- - - - - - - - - - - - - - - - +
:                     Payload Data continued ...                :
+ - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - +
|                     Payload Data continued ...                |
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WebSocket API

The API is defined by its states of readiness, responses to a networking or messaging event.

Callback	Description
`onopen`	invoked when `WebSocket session` `is established`, signalizes that the protocol is ready to transfer payload data
`onerror`	invoked whenever an `error occurs`
`onclose`	invoked when one of the peers has `terminated the session`
`onmessage`	invoked when an `incoming message` from another peer has arrived

Outline

Background
- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol
- Definition
- Handshake
- Frame
- API

Performance vs TCP Socket
- Performance Evaluation
- WebSocket TCP
- Network traffic

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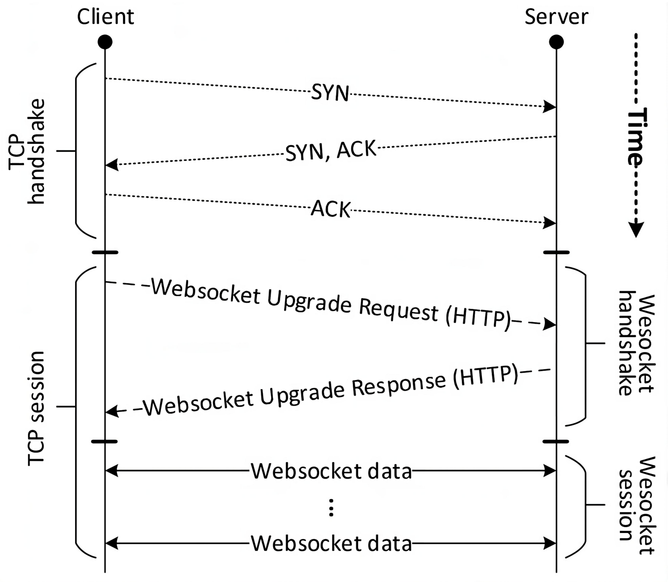
- Data transfer time is *evaluated experimentally* in a laboratory test bed.

WebSocket TCP sequence diagram



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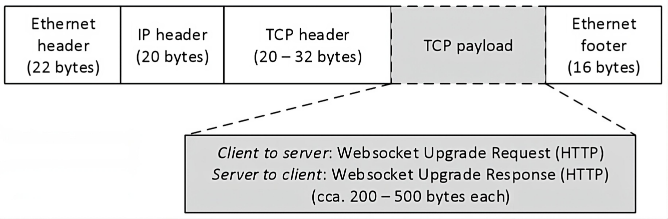
  - Handshake
  - Frame header for each frame

Handshake overhead



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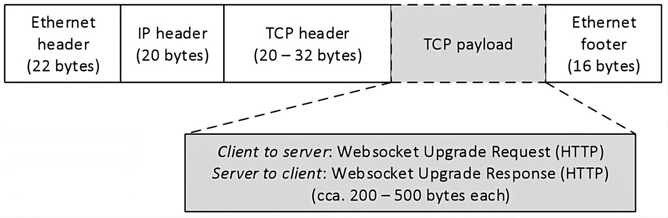

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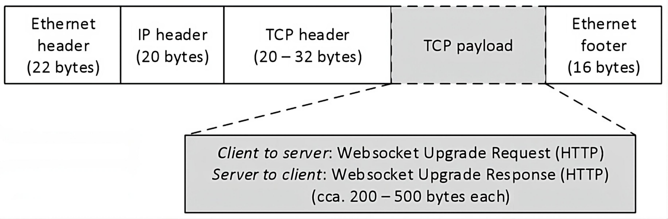

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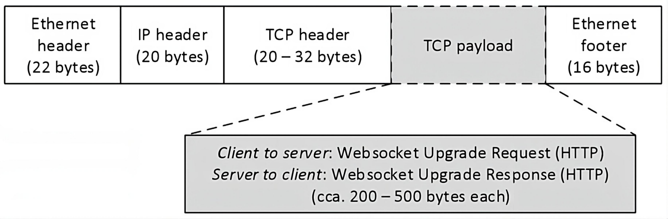

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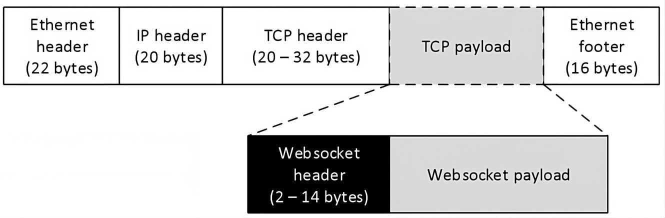
- It is performed only once per session.
- Its significance decreases with the increasing number of frames sent over the same session. Thus, the evaluation is focused on long-running sessions.

Frame overhead



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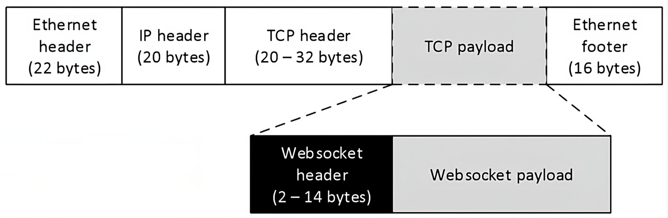

- The overhead counts 2 to 14 bytes for each frame.

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$$\begin{aligned} P &= \text{payload} \\ data &= \text{data to send} \\ H &= \text{length of frame's header} \end{aligned}$$

- We can now define the network traffic overhead O_p a WebSocket has over a TCP Socket:

$$O_p = \frac{P_{WS} - P_{TCP}}{P_{TCP}} \cdot 100\% \tag{3}$$

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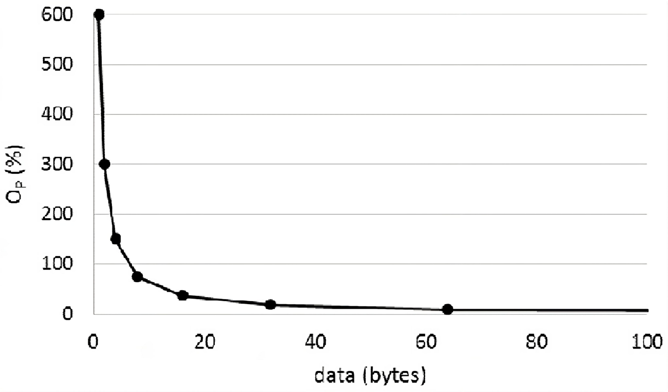

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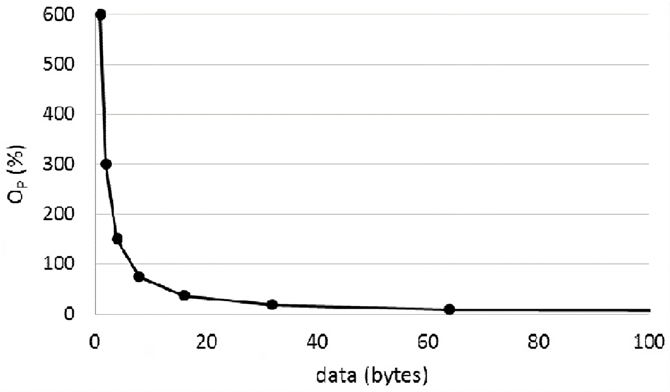

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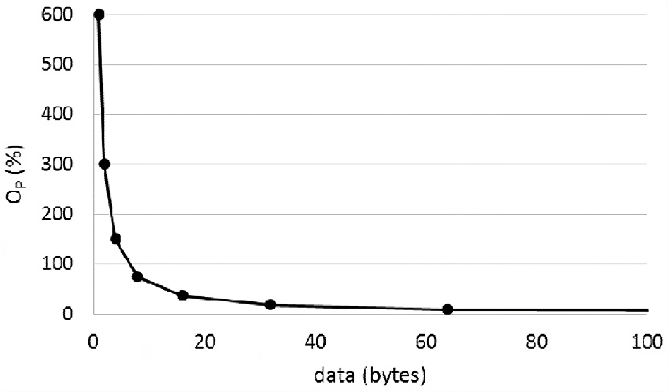

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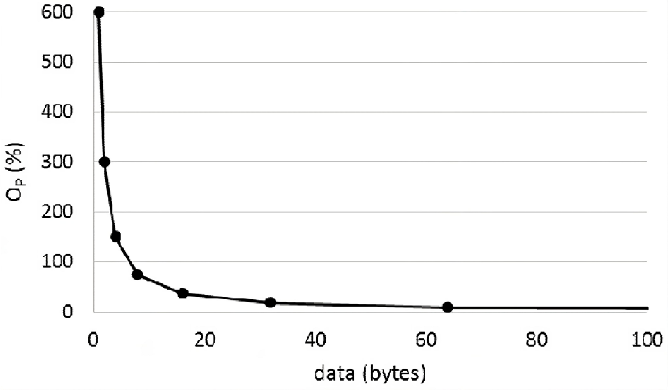

- Significant difference in performance only for tiny data.
- For biggest messages, the WebSocket frame size converges very fast towards the TCP Socket size.
- Except for the *initial* WebSocket Handshake, the amount of network traffic generated is comparable to that generated by to the TCP Socket.

References

- Alexey Melnikov and Ian Fette, *The WebSocket Protocol*, RFC 6455, December 2011.
- D. Skvorc, M. Horvat, and S. Srbljic, *Performance evaluation of websocket protocol for implementation of full-duplex web streams*, 2014 37th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), 2014, pp. 1003–1008.
- Lijing Zhang and Xiaoxiao Shen, *Research and development of real-time monitoring system based on websocket technology*, Proceedings 2013 International Conference on Mechatronic Sciences, Electric Engineering and Computer (MEC), 2013, pp. 1955–1958.