WebSocket

Oleg Bilovus

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HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request Upgrade Response

Frame API

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

Oleg Bilovus

Università degli Studi di Salerno

1st Scalability Research Forum

Outline

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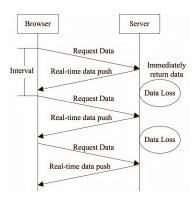
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Check whether the server is changed in a while, thereby performing incremental updates.



protocol Definition

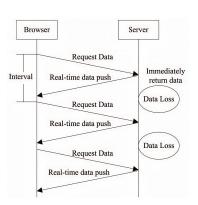
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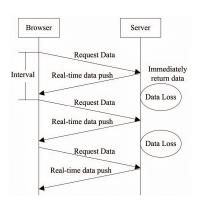
Check whether the server is changed in a while, thereby performing incremental updates.



How often to query?

HTTP polling

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



- ► How often to query?
- Continuously short interval requests will be washed away the server.

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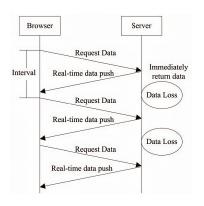
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HTTP polling

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



- 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

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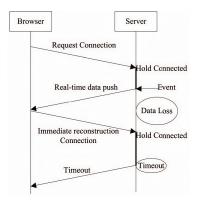
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HTTP long polling

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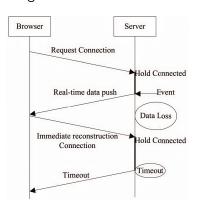
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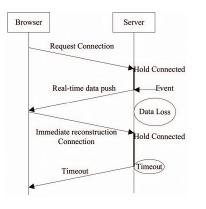
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When a client sends a data request, the server will block the request until there is data transfer or timeout before returning.



Solve the short polling frequency to access the server.

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



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

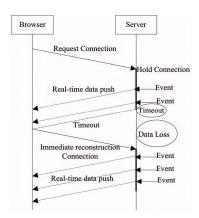
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Streaming

Iframe embed a hidden frame in an HTML page, then set it as a long connection request, thus the server can send data to the clients constantly.



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Frame API

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Browser Server Request Connection Hold Connection Event Real-time data push Event Timeout Timeout Data Loss Immediate reconstruction Event Connection Event Real-time data push Event

It can send multiple events from a single request.

to the clients constantly.

HTTP long polling Streaming

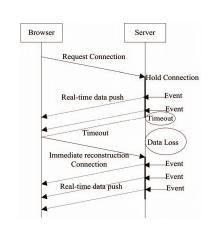
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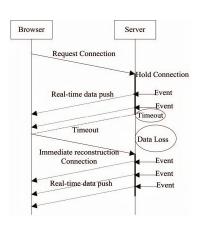
But. it increases the burden on the server. causing the server performance degradation, or even collapse.



Iframe embed a hidden frame in an HTML page, then set it as a long connection request, thus the server can send data

Streaming

Iframe embed a hidden frame in an HTML page, then set it as a long connection request, thus the server can send data to the clients constantly.



It can send multiple events from a single request.

- ▶ But, it increases the burden on the server, causing the server performance degradation, or even collapse.
- No bidirectional communication.

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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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- 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.
- ► The protocol consists of an opening handshake followed by basic message framing, layered over TCP.

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- ► The goal of this technology is to provide a mechanism for browser-based applications that need two-way communication with servers.

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Background HTTP polling

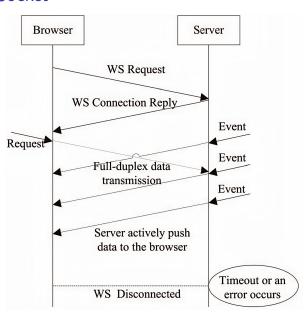
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► For WebSocket-based communication, a WebSocket session should be established first.

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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.

session should be established first.

For WebSocket-based communication, a WebSocket

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Upgrade Request Upgrade Response

- ► For WebSocket-based communication, a WebSocket session should be established first.
- ➤ 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

B

GET /chat HTTP/1.1

Host: server.example.com

Upgrade: WebSocket

Connection: Upgrade

Sec-WebSocket-Key:

dGhlIHNhbXBsZSBub25jZQ==

Origin: http://example.com

Sec-WebSocket-Protocol:

chat, superchat

Sec-WebSocket-Version: 13

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► HTTP GET request.

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► HTTP GET request.

► URI to identify endpoint.

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- HTTP GET request.
- URI to identify endpoint.
- ► Headers indicating the will to switch from regular HTTP to WebSocket.

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- ► HTTP GET request.
- URI to identify endpoint.
- Headers indicating the will to switch from regular HTTP to
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- A key the server has to use to prove that it can use WebSockets.

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- ► HTTP GET request.
- URI to identify endpoint.
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 WebSocket
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- ► WebSocket protocols.

Streaming

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- HTTP GET request.
- URI to identify endpoint.
- Headers indicating the will to switch from regular HTTP to WebSocket.
- A key the server has to use to prove that it can use WebSockets.
- WebSocket protocols.
- WebSocket version.

WebSocket Upgrade Response

HTTP/1.1 101 Switching protocols

Upgrade: WebSocket Connection: Upgrade

Sec-WebSocket-Accept:

dGhlIHNhbXBsZSBub25jZQ==

Origin: http://example.com

Sec-WebSocket-Protocol: chat

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HTTP/1.1 101 Switching protocols

Upgrade: WebSocket

Connection: Upgrade

Sec-WebSocket-Accept:

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Origin: http://example.com

Sec-WebSocket-Protocol: chat

Server confirms it supports WebSocket. WebSocket

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protocols Upgrade: WebSocket Connection: Upgrade Sec-WebSocket-Accept: dGhlIHNhbXBsZSBub25jZQ==

HTTP/1.1 101 Switching

Origin: http://example.com

Sec-WebSocket-Protocol: chat. Server confirms it supports WebSocket.

Server proves that it can use WebSocket. Client checks it.

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 Server confirms it supports WebSocket.

- Server proves that it can use WebSocket.
 Client checks it.
- Server tells which protocol it supports.

HTTP/1.1 101 Switching protocols

Upgrade: WebSocket

Connection: Upgrade
Sec-WebSocket-Accept:

dGhlIHNhbXBsZSBub25jZQ==

Origin: http://example.com

Sec-WebSocket-Protocol: chat

WebSocket Frame

After the handshake is successful, client and server can communicate in full-duplex by using frames. WebSocket

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- After the handshake is successful, client and server can communicate in full-duplex by using frames.
- ► The added overhead to the payload data is minimal because it does not send all the HTTP headers for each frame.

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- After the handshake is successful, client and server can communicate in full-duplex by using frames.
- ► 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
                                     Extended payload length
         opcode|M| Payload len
          (4)
                                               (16/64)
IISISIS
                IAI
                        (7)
N|V|V|V|
                IS
                                     (if payload len==126/127)
                IKI
     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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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

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.

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