

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

Oleg Bilovus

Università degli Studi di Salerno

1st Scalability Research Forum

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

Outline

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Data Transfer Time

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

Background

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Background

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

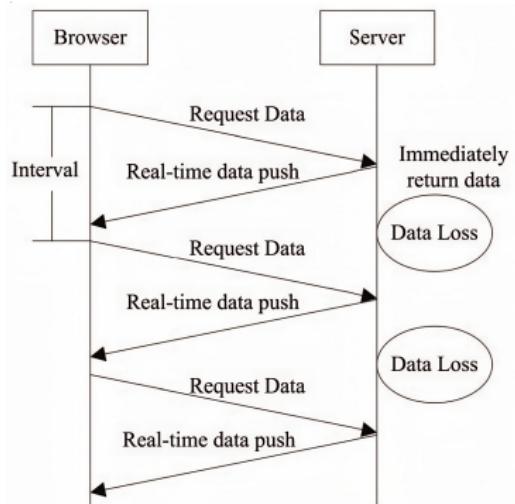
Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

HTTP polling

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



Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

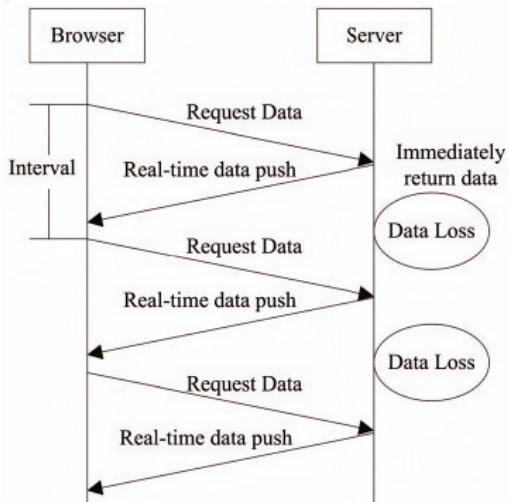
Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

HTTP polling

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▶ How often to query?



Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

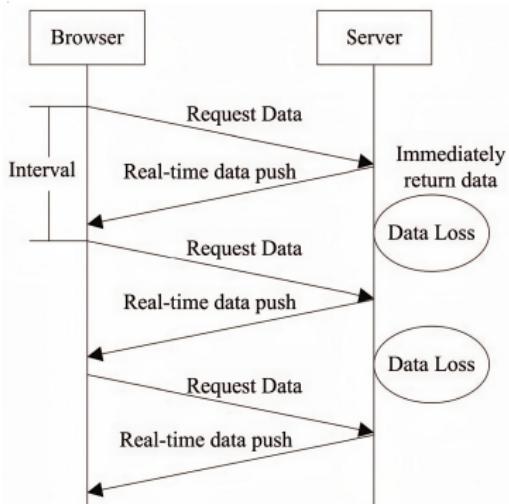
Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

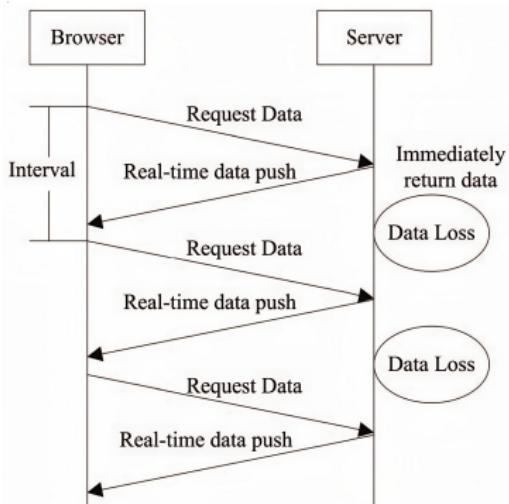
Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

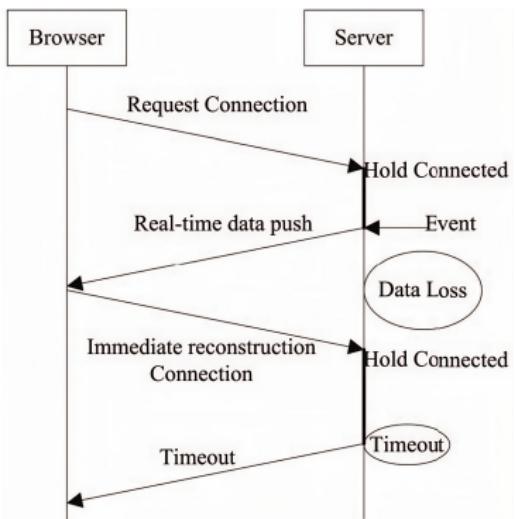
Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
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.



Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

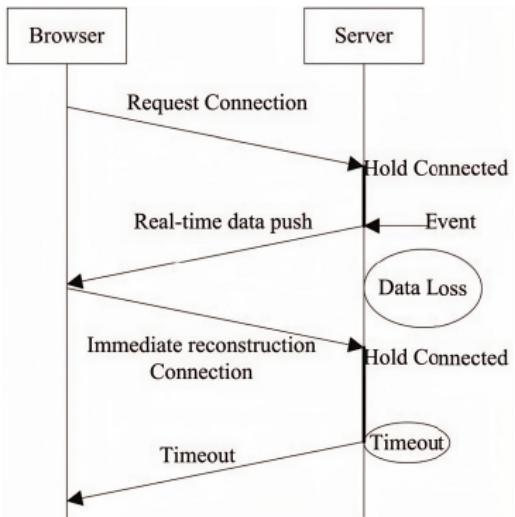
Data Transfer Time

Connection

Data

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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.

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

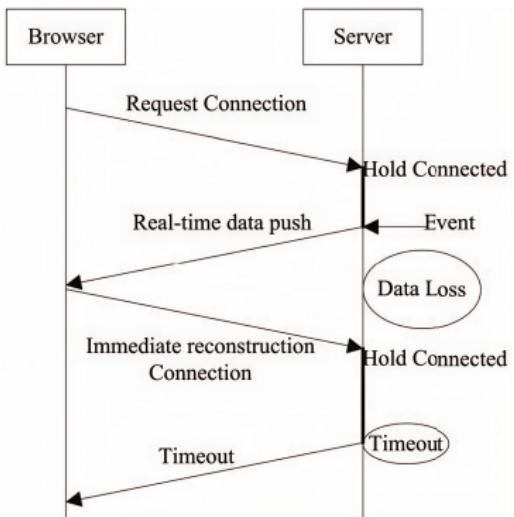
Data Transfer Time

Connection

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.



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

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

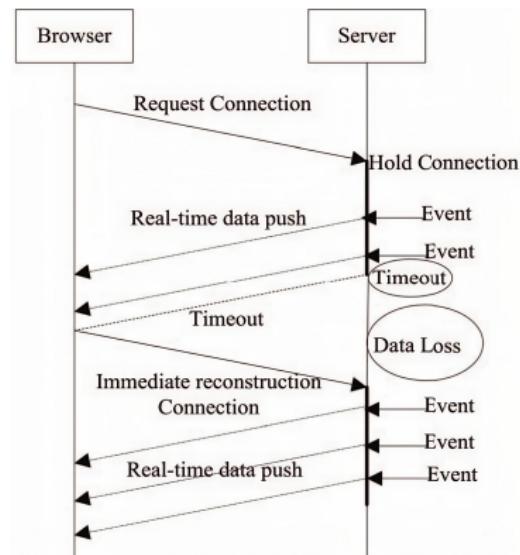
Frame overhead

Results

Data Transfer Time

Connection

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.

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

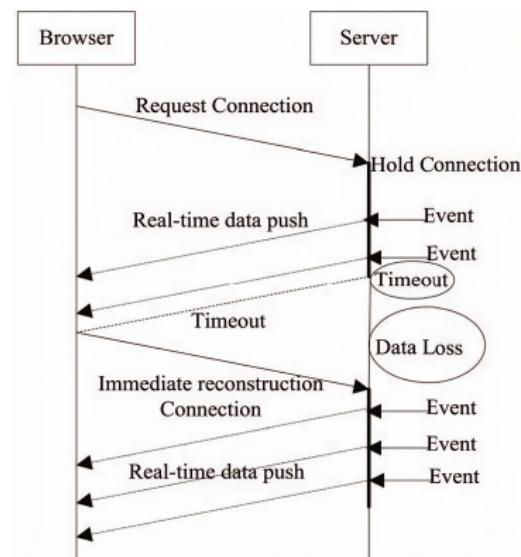
Frame overhead

Results

Data Transfer Time

Connection

Data



- ▶ It can send multiple events from a single request.

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

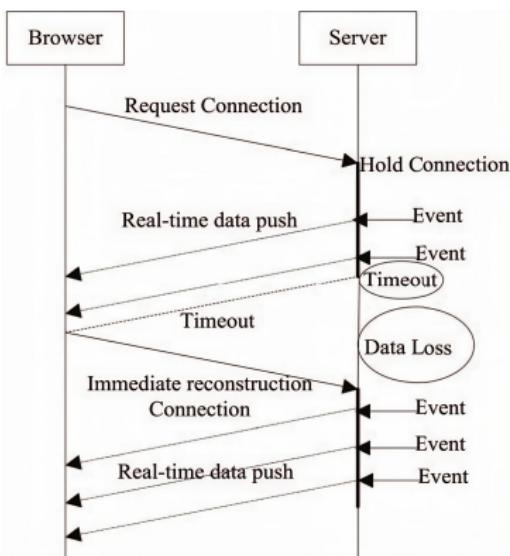
Data Transfer Time

Connection

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.

Background

HTTP polling

HTTP long polling

Streaming**WebSocket protocol**

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

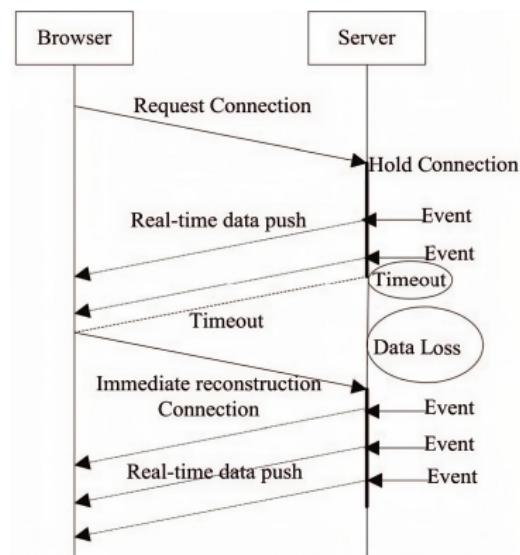
Frame overhead

Results

Data Transfer Time

Connection

Data



- ▶ 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.

Outline

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Data Transfer Time

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

RFC 6455

Keywords

- ▶ 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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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

RFC 6455

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Oleg Bilovus

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

RFC 6455

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Oleg Bilovus

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Background

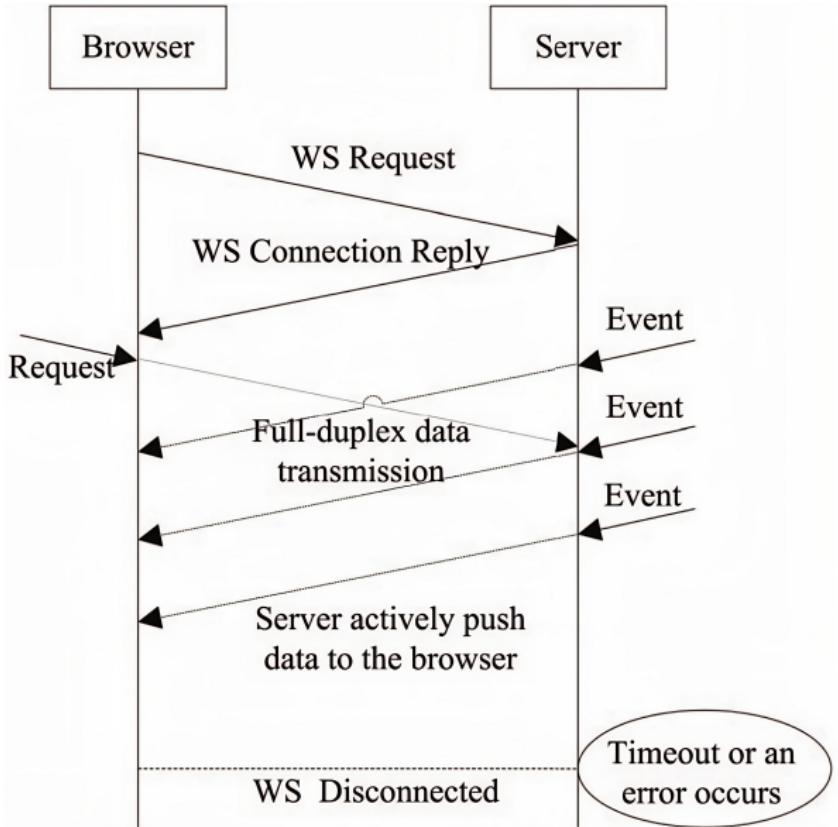
HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data



Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

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

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

- ▶ 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**.

Handshake

- ▶ 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**.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request**
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

```
GET /chat HTTP/1.1
Host: server.example.com
Upgrade: WebSocket
Connection: Upgrade
Sec-WebSocket-Key:
dGh1IHNhbXBsZSBub25jZQ==
Origin: http://example.com
Sec-WebSocket-Protocol:
chat, superchat
Sec-WebSocket-Version: 13
```

WebSocket Upgrade Request

► HTTP GET request.

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Host: server.example.com

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Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

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- ▶ HTTP GET request.
- ▶ URI to identify endpoint.

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

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

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Oleg Bilovus

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- ▶ 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.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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- ▶ **WebSocket protocols.**

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

WebSocket Upgrade Request

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chat, superchat
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- ▶ WebSocket protocols.
- ▶ **WebSocket version.**

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

WebSocket Upgrade Response

HTTP/1.1 101 Switching
protocols

Upgrade: WebSocket

Connection: Upgrade

Sec-WebSocket-Accept:

dGh1IHNhbXBsZSBub25jZQ==

Origin: http://example.com

Sec-WebSocket-Protocol: chat

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence
diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

WebSocket Upgrade Response

HTTP/1.1 101 Switching

protocols

Upgrade: WebSocket

Connection: Upgrade

Sec-WebSocket-Accept:

dGh1IHNhbXBsZSBub25jZQ==

Origin: http://example.com

Sec-WebSocket-Protocol: chat

► Server confirms it supports WebSocket.

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

WebSocket Upgrade Response

HTTP/1.1 101 Switching
protocols

Upgrade: WebSocket

Connection: Upgrade

Sec-WebSocket-Accept:

dGh1IHNhbXBsZSBub25jZQ==

Origin: http://example.com

Sec-WebSocket-Protocol: chat

- ▶ Server confirms it supports WebSocket.
- ▶ Server proves that it can use WebSocket.
Client checks it.

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

WebSocket Upgrade Response

HTTP/1.1 101 Switching
protocols

Upgrade: WebSocket

Connection: Upgrade

Sec-WebSocket-Accept:

dGh1IHNhbXBsZSBub25jZQ==

Origin: http://example.com

Sec-WebSocket-Protocol: chat

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

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

WebSocket Frame

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

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response

Frame

- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

WebSocket Frame

- ▶ 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.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

WebSocket Frame

- ▶ 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.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

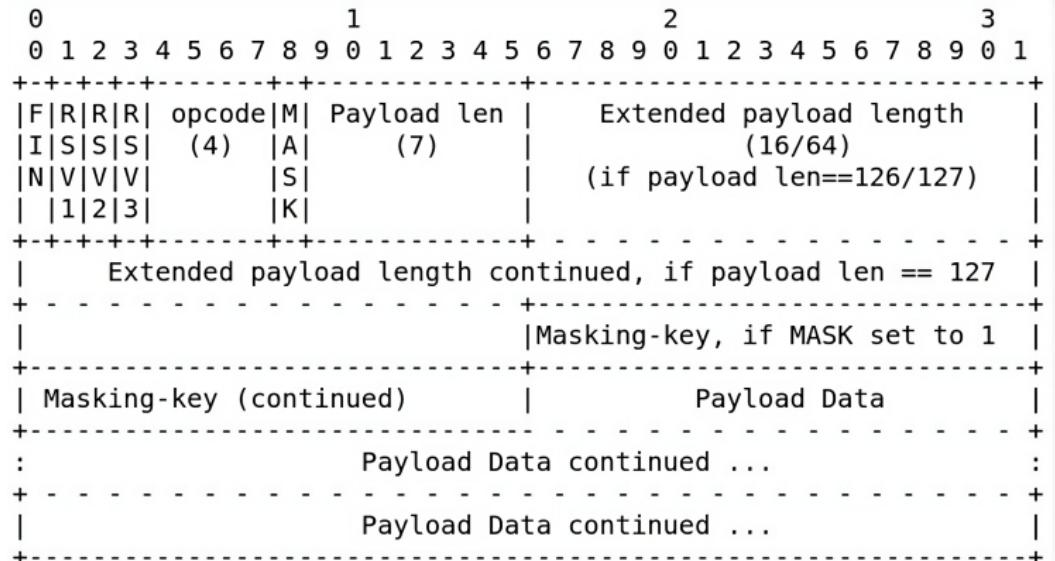
Results

Data Transfer Time

Connection

Data

WebSocket Frame Structure



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

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Outline

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Data Transfer Time

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

Performance Evaluation

WebSocket

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

- ▶ Performance evaluation of the WebSocket and the TCP Socket protocol consists of:

Performance Evaluation

WebSocket

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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Performance Evaluation

WebSocket

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

- ▶ Performance evaluation of the WebSocket and the TCP Socket protocol consists of:
 - ▶ Network traffic
 - ▶ Data transfer time

Performance Evaluation

WebSocket

Oleg Bilovus

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

- ▶ Performance evaluation of the WebSocket and the TCP Socket protocol consists of:
 - ▶ Network traffic
 - ▶ Data transfer time
- ▶ Network traffic is *evaluated analytically* using the protocol specifications.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Performance Evaluation

- ▶ Performance evaluation of the WebSocket and the TCP Socket protocol consists of:
 - ▶ Network traffic
 - ▶ Data transfer time
- ▶ Network traffic is *evaluated analytically* using the protocol specifications.
- ▶ Data transfer time is *evaluated experimentally* in a laboratory test bed.

WebSocket sequence diagram

WebSocket

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Background

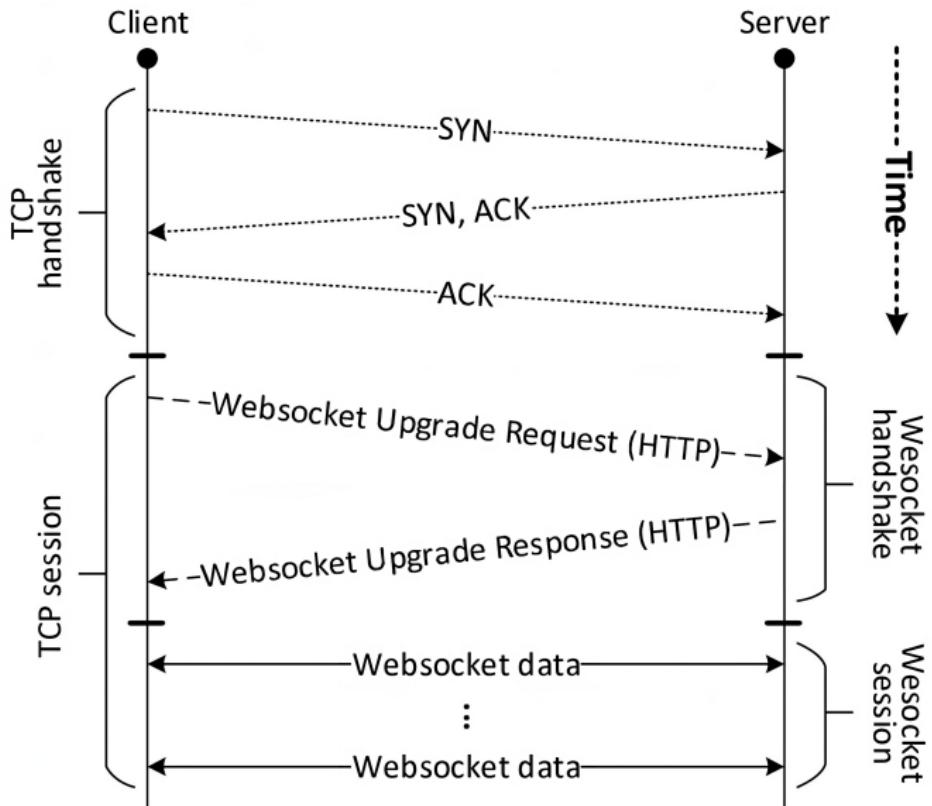
- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data



Analytical Evaluation of Network Traffic

WebSocket

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Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

Results

Data Transfer Time

Connection

Data

- ▶ Both protocols will have the lower level protocols fields overhead such as *Ethernet, IP and TCP header.*

Analytical Evaluation of Network Traffic

WebSocket

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram

Network traffic

Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

- ▶ Both protocols will have the lower level protocols fields overhead such as *Ethernet, IP and TCP header*.
- ▶ For this reason, the analysis consider only the overhead the WebSocket incurs:

Analytical Evaluation of Network Traffic

WebSocket

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram

Network traffic

Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

- ▶ Both protocols will have the lower level protocols fields overhead such as *Ethernet, IP and TCP header*.
- ▶ For this reason, the analysis consider only the overhead the WebSocket incurs:
 - ▶ Handshake

Analytical Evaluation of Network Traffic

WebSocket

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram

Network traffic

Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

- ▶ Both protocols will have the lower level protocols fields overhead such as *Ethernet, IP and TCP header*.
- ▶ For this reason, the analysis consider only the overhead the WebSocket incurs:
 - ▶ Handshake
 - ▶ Frame header for each frame

Background

HTTP polling
HTTP long polling
Streaming

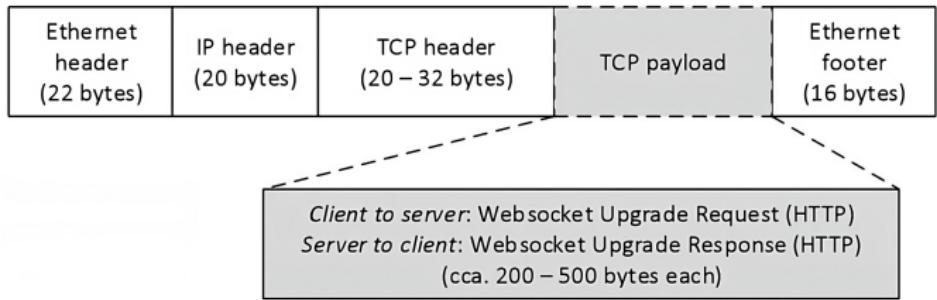
WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Handshake overhead



Background

HTTP polling
HTTP long polling
Streaming

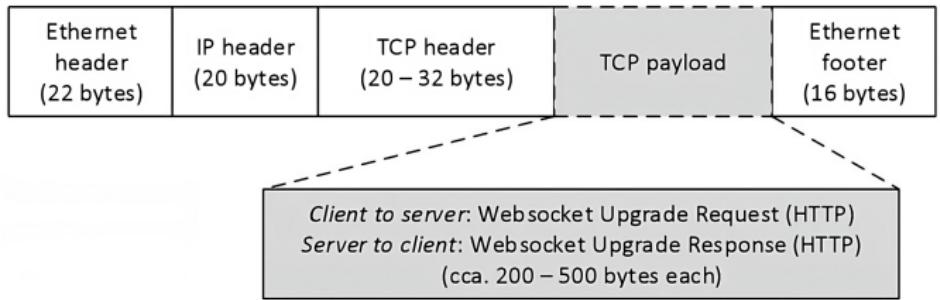
WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Handshake overhead



- ▶ The overhead is **fixed in length** and typically counts few hundreds of bytes.

Background

HTTP polling
HTTP long polling
Streaming

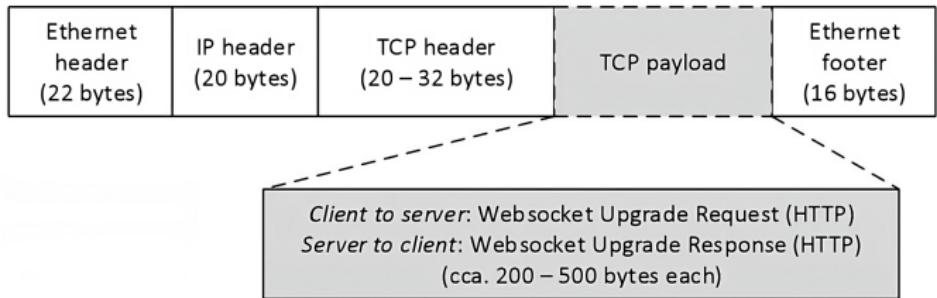
WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Handshake overhead



- ▶ The overhead is **fixed in length** and typically counts few hundreds of bytes.
- ▶ It is **performed only once** per session.

Background

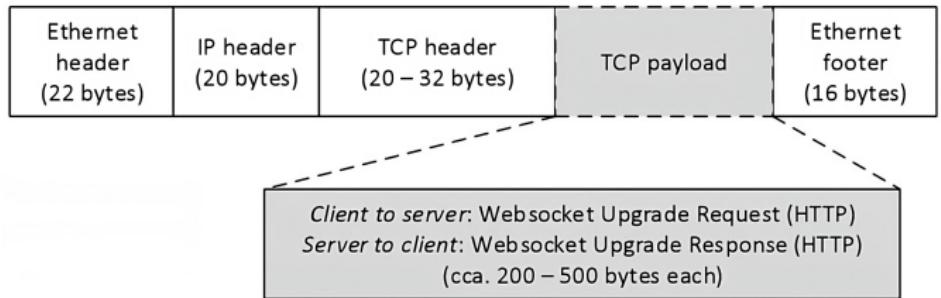
HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data



- ▶ The overhead is **fixed in length** and typically counts few hundreds of bytes.
- ▶ 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.

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

Frame overhead

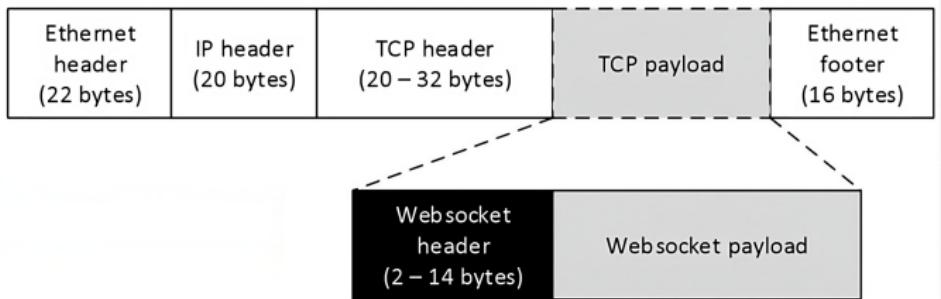
Results

Data Transfer Time

Connection

Data

Frame overhead



Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

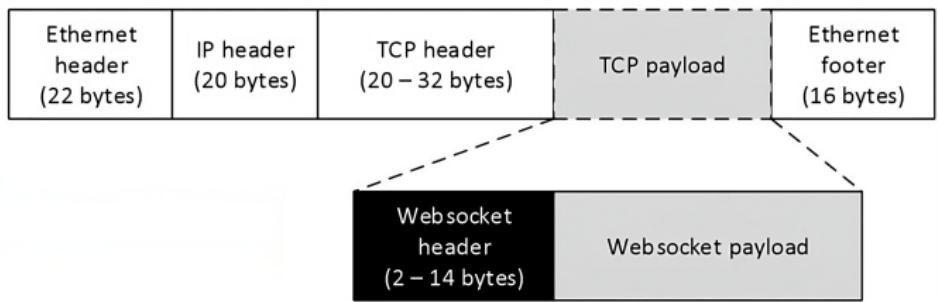
Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram

Network traffic
Handshake overhead

Frame overhead

Results
Data Transfer Time
Connection
Data



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

Results

- ▶ When the data are transferred with TCP Socket, they are **directly embedded as TCP Payload**.

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead

Results

- Data Transfer Time
- Connection
- Data

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Results

- ▶ When the data are transferred with TCP Socket, they are **directly embedded as TCP Payload**.
- ▶ With WebSocket, the TCP Payload consists of both data and Frame header.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead

Results

Data Transfer Time
Connection
Data

Results

- ▶ When the data are transferred with TCP Socket, they are **directly embedded as TCP Payload**.
- ▶ With WebSocket, the TCP Payload consists of both data and Frame header.
- ▶ This relation can be written as:

$$P_{TCP} = \text{data} \quad (1)$$

$$P_{WS} = \text{data} + H \quad (2)$$

where:

P = payload

data = data to send

H = length of frame's header

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead

Results
Data Transfer Time
Connection
Data

Results

- ▶ When the data are transferred with TCP Socket, they are **directly embedded as TCP Payload**.
- ▶ With WebSocket, the TCP Payload consists of both data and Frame header.
- ▶ This relation can be written as:

$$P_{TCP} = \text{data} \quad (1)$$

$$P_{WS} = \text{data} + H \quad (2)$$

where:

P = payload

data = data to send

H = length of frame's header

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

$$O_P = \frac{P_{WS} - P_{TCP}}{P_{TCP}} \cdot 100\% \quad (3)$$

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

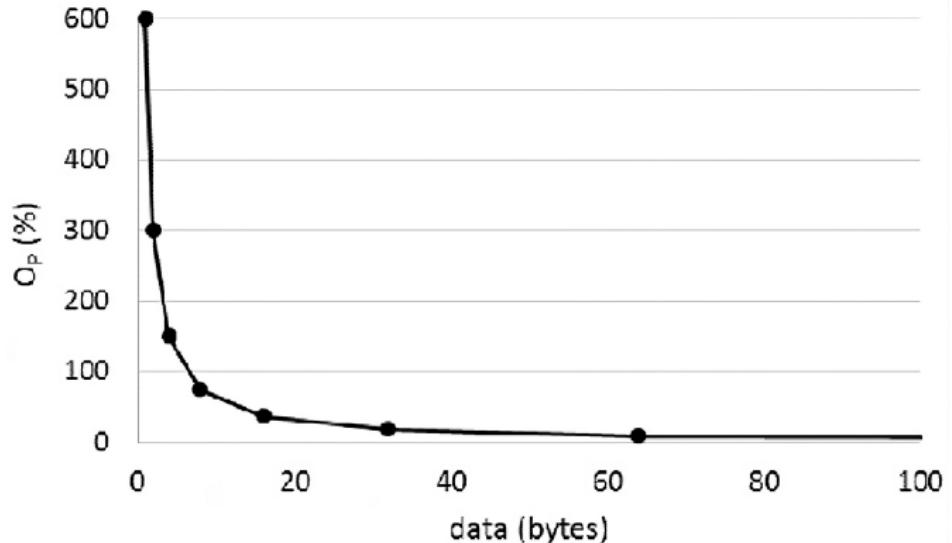
- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead

Results

- Data Transfer Time
- Connection
- Data



Background

- HTTP polling
- HTTP long polling
- Streaming

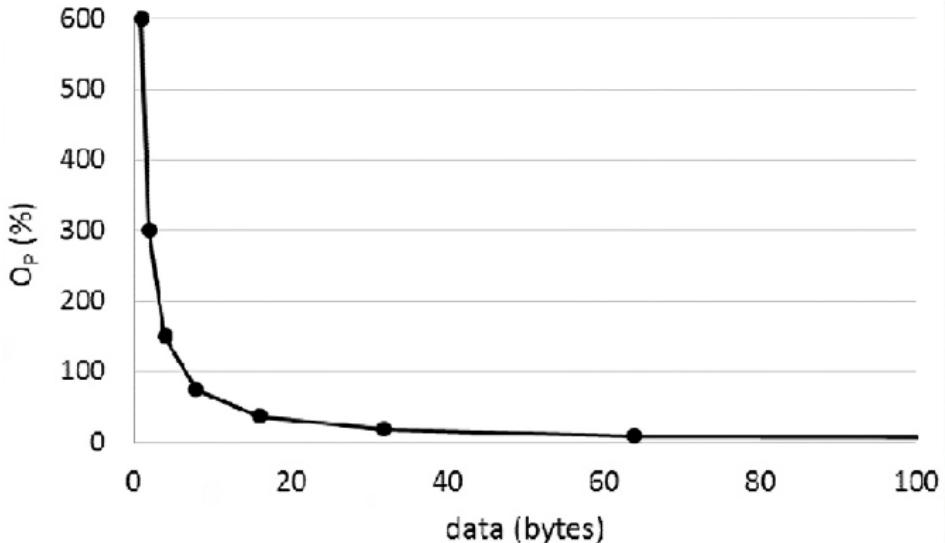
WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead

Results



- ▶ Significant difference in performance only for tiny data.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

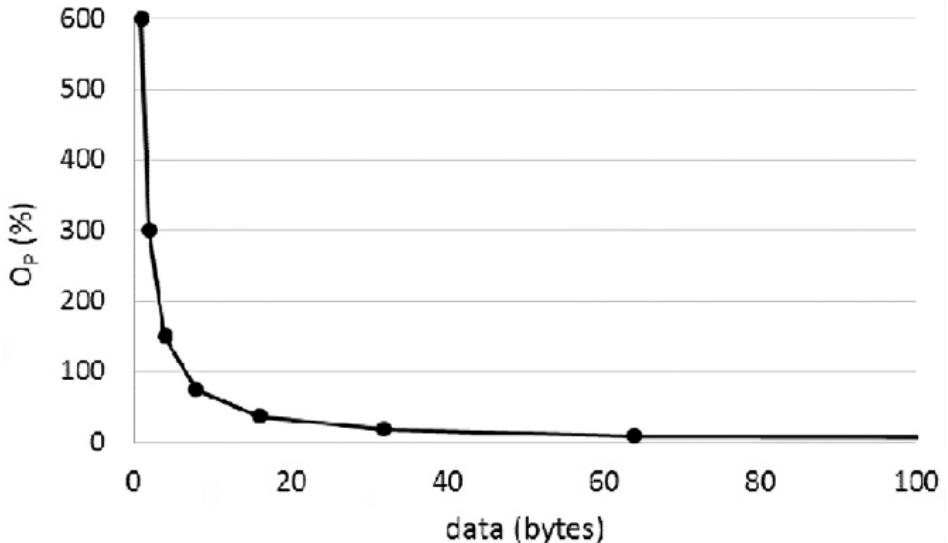
Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead

Results

Data Transfer Time
Connection
Data

Results



- ▶ Significant difference in performance only for tiny data.
- ▶ For biggest messages, the WebSocket frame size converges very fast towards the TCP Socket size.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

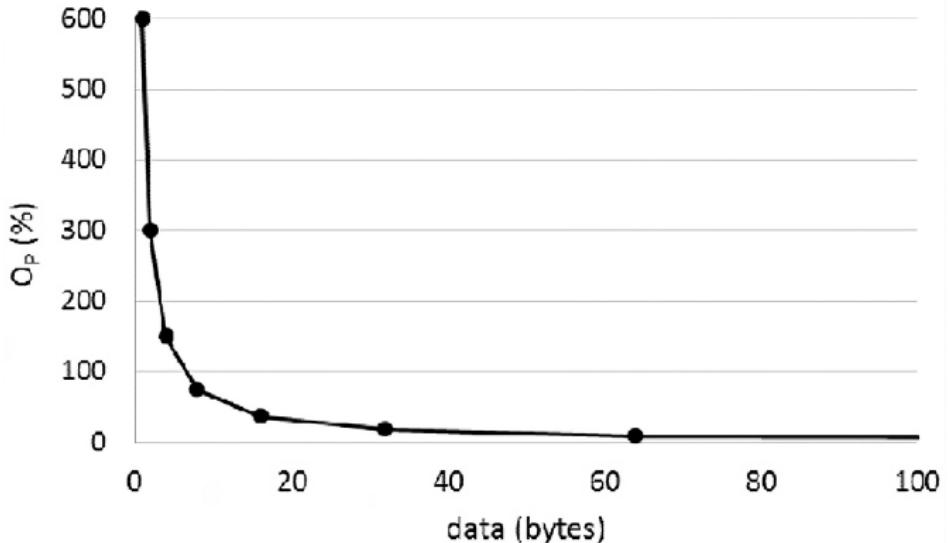
Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead

Results

Data Transfer Time
Connection
Data



- ▶ 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 the TCP Socket.

Experimental Evaluation of Data Transfer Time

WebSocket

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results

Data Transfer Time

Connection
Data

- ▶ Two host machines.

Experimental Evaluation of Data Transfer Time

WebSocket

Oleg Bilovus

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results

Data Transfer Time

Connection
Data

- ▶ Two host machines.
- ▶ One playing the role of the server.

Experimental Evaluation of Data Transfer Time

WebSocket

Oleg Bilovus

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results

Data Transfer Time

Connection
Data

- ▶ Two host machines.
- ▶ One playing the role of the server.
- ▶ While the other being a client.

Environment configuration

	Client	Server
Hardware	CPU: AMD Turion II P520 RAM: 6 GB	CPU: AMD Athlon X2 5000 RAM: 5 GB
OS	Windows 8 64-bit	Windows 8 64-bit
Network	1000BASE-T (Gigabit Ethernet, host machines directly connected using UTP Cat5 Ethernet cable)	
TCP implementation	<code>java.net.Socket</code> (Java JDK 1.7)	<code>java.net.Socket</code> (Java JDK 1.7)
WebSocket implementation	<code>websocket.client</code> (Jetty 9.1.0)	<code>websocket.servlet</code> (Jetty 9.1.0)

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results

Data Transfer Time

Connection
Data

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

TCP Connection and WebSocket session time

In the first experiment, it is measured the time required for client and server to establish a TCP connection and WebSocket session.

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

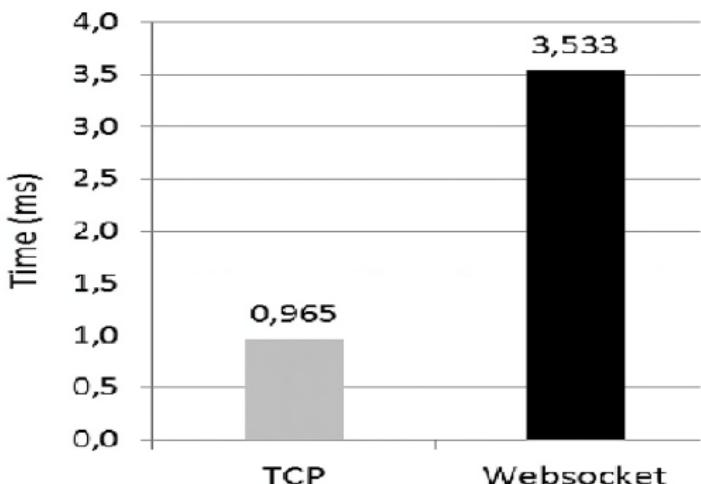
- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time

Connection

- Data

TCP Connection and WebSocket session time

In the first experiment, it is measured the time required for client and server to establish a TCP connection and WebSocket session.



- WebSocket session lasts **3.7 times longer** than establishing a TCP connection.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

TCP Connection and WebSocket session time

- ▶ The reason for such slow performance of the WebSocket is the fact that the protocol is not a *transport protocol*.

TCP Connection and WebSocket session time

- ▶ The reason for such slow performance of the WebSocket is the fact that the protocol is not a *transport protocol*.
- ▶ WebSocket sits on top of TCP and uses HTTP for the handshake.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

TCP Connection and WebSocket session time

WebSocket

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Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

- ▶ The reason for such slow performance of the WebSocket is the fact that the protocol is not a *transport protocol*.
- ▶ WebSocket sits on top of TCP and uses HTTP for the handshake.
- ▶ Which means it first has to establish a TCP connection, allocate the resource for HTTP and then can establish a WebSocket handshake.

WebSocket sequence diagram

WebSocket

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Background

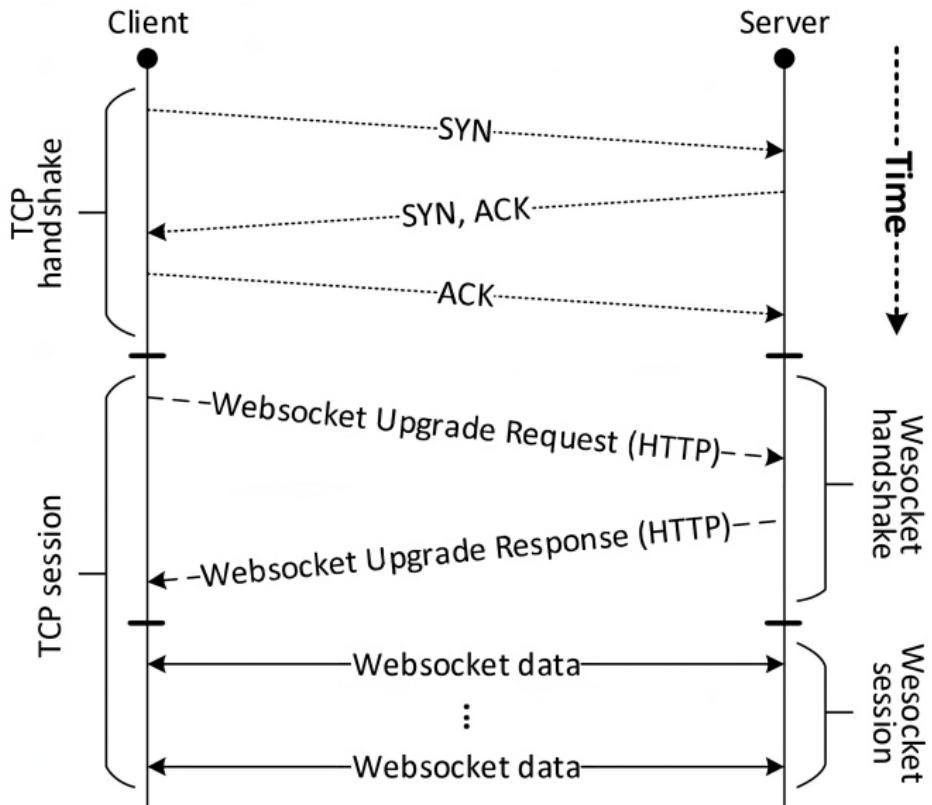
- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data



Data transfer time after connection

- ▶ In the second experiment, it is measured the data transfer time after the TCP connection and WebSocket session have been established.

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

Data transfer time after connection

- ▶ In the second experiment, it is measured the data transfer time after the TCP connection and WebSocket session have been established.
- ▶ The Client generates a given amount of data and sends them to the server.

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

Data transfer time after connection

- ▶ In the second experiment, it is measured the data transfer time after the TCP connection and WebSocket session have been established.
- ▶ The Client generates a given amount of data and sends them to the server.
- ▶ The Server echoes the same data back to the client.

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Data transfer time after connection

- ▶ In the second experiment, it is measured the data transfer time after the TCP connection and WebSocket session have been established.
- ▶ The Client generates a given amount of data and sends them to the server.
- ▶ The Server echoes the same data back to the client.
- ▶ It is possible to define the **relative time overhead** O_T a WebSocket incurs over TCP as:

$$O_T = \frac{T_{WS} - T_{TCP}}{T_{TCP}} \cdot 100\% \quad (4)$$

where:

T = time to transfer data

Background

HTTP polling

HTTP long polling

Streaming

WebSocket protocol

Definition

Handshake

Upgrade Request

Upgrade Response

Frame

API

Performance vs TCP Socket

Performance Evaluation

WebSocket sequence diagram

Network traffic

Handshake overhead

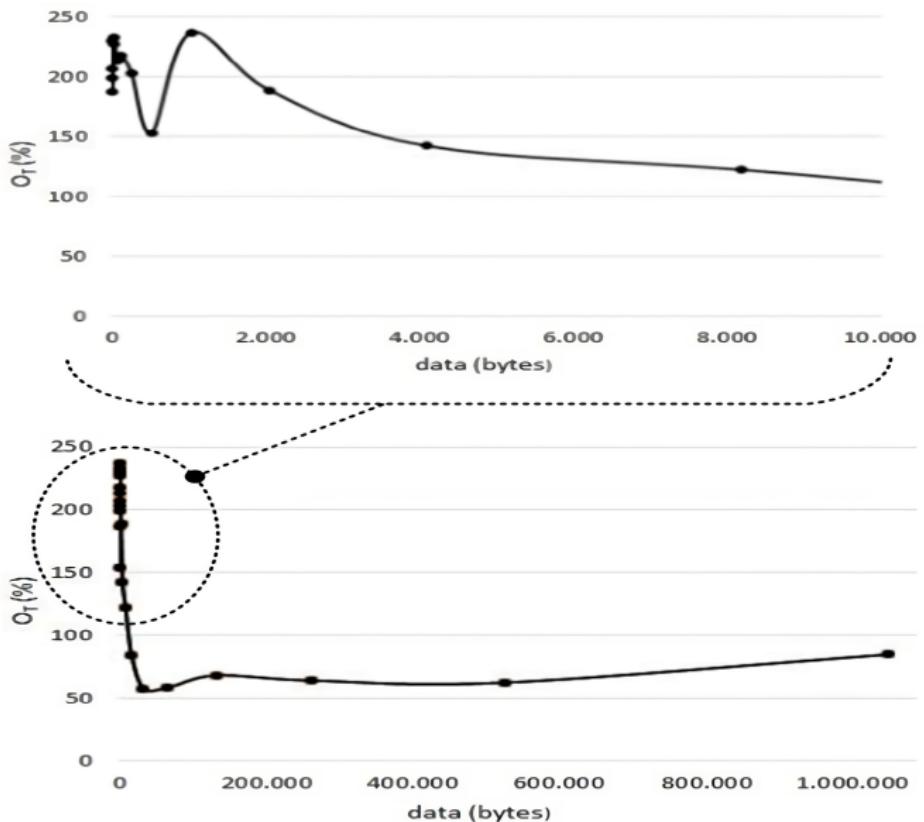
Frame overhead

Results

Data Transfer Time

Connection

Data



Data transfer time after connection

- ▶ The WebSocket performs slower than the TCP.

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

Data transfer time after connection

- ▶ The WebSocket performs slower than the TCP.
- ▶ The performance drop is more significant for small messages.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Data transfer time after connection

- ▶ The WebSocket performs slower than the TCP.
- ▶ The performance drop is more significant for small messages.
- ▶ The overhead of WebSocket *fluctuates* between 150% and 250% for small messages.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Data transfer time after connection

- ▶ The WebSocket performs slower than the TCP.
- ▶ The performance drop is more significant for small messages.
- ▶ The overhead of WebSocket *fluctuates* between 150% and 250% for small messages.
- ▶ For biggest messages, the overhead is more *stable* at 60-70%.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Why WebSocket performs slower?

- ▶ WebSocket sits on top of TCP.

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection
- Data

Why WebSocket performs slower?

- ▶ WebSocket sits on top of TCP.
- ▶ WebSocket uses event-driven callback-based API to deliver data, which requires additional application data handling.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

Why WebSocket performs slower?

- ▶ WebSocket sits on top of TCP.
- ▶ WebSocket uses event-driven callback-based API to deliver data, which requires additional application data handling.
- ▶ In 2014, the WebSocket protocol emerged just a few years before with little production systems deployed. While TCP has been used in production for decades and has highly optimized libraries.

Background

HTTP polling
HTTP long polling
Streaming

WebSocket protocol

Definition
Handshake
Upgrade Request
Upgrade Response
Frame
API

Performance vs TCP Socket

Performance Evaluation
WebSocket sequence diagram
Network traffic
Handshake overhead
Frame overhead
Results
Data Transfer Time
Connection
Data

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.

Background

- HTTP polling
- HTTP long polling
- Streaming

WebSocket protocol

- Definition
- Handshake
- Upgrade Request
- Upgrade Response
- Frame
- API

Performance vs TCP Socket

- Performance Evaluation
- WebSocket sequence diagram
- Network traffic
- Handshake overhead
- Frame overhead
- Results
- Data Transfer Time
- Connection

Data