Getting Started with WebSocket and Server-Sent Events in Java

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- Fitness freak

Agenda

- Primer on WebSocket
- JSR 356: Java API for WebSocket 1.0
- Primer on Server-Sent Events
- Comparing WebSocket and Server-Sent Events

Interactive Web Sites

- HTTP is half-duplex

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- HTTP is verbose

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- HTTP is verbose
- Hacks for Server Push
  - Polling
  - Long Polling
  - Comet/Ajax
  - Complex, Inefficient, Wasteful

WebSocket to the rescue

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  - Data Transfer
- W3C defined JavaScript API
  - Candidate Recommendation

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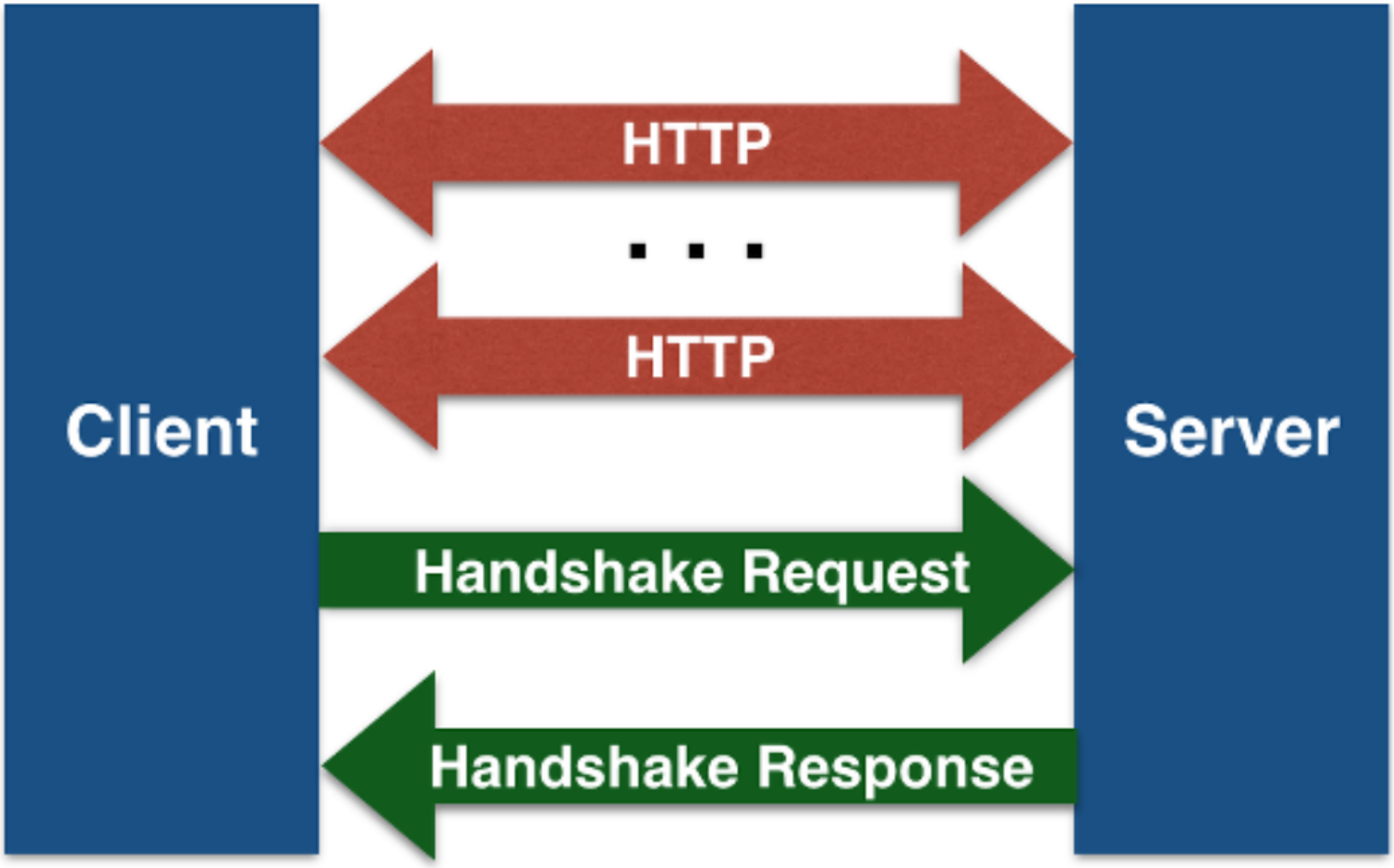
- Send message independent of each other (Full Duplex)
- End the connection

Establish a connection



Handshake Request

```
GET /chat HTTP/1.1
Host: server.example.com
Upgrade: websocket ❶
Connection: Upgrade ❷
Sec-WebSocket-Key: dGhlIHNhbXBsZSBub25jZQ==
Origin: http://example.com
Sec-WebSocket-Protocol: chat, superchat
Sec-WebSocket-Version: 13
```

❶ HTTP upgrade header

❷ Upgrade to WebSocket

Handshake Response

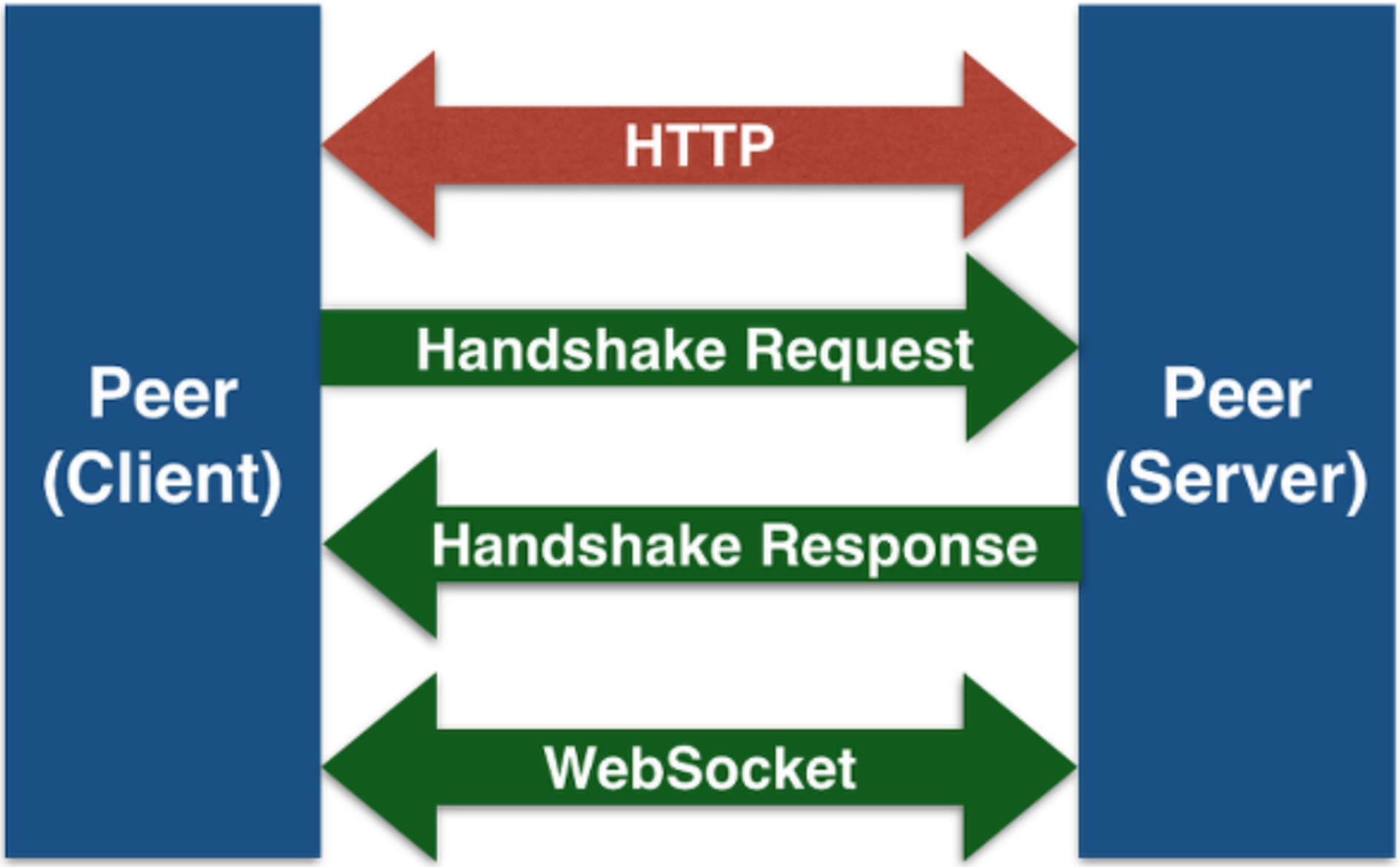
```
HTTP/1.1 101 Switching Protocols
Upgrade: websocket ❶
Connection: Upgrade ❷
Sec-WebSocket-Accept: s3pPLMBiTxaQ9kYGzzhZRbK+xOo= ❸
Sec-WebSocket-Protocol: chat
```

❶ Server echoes the header

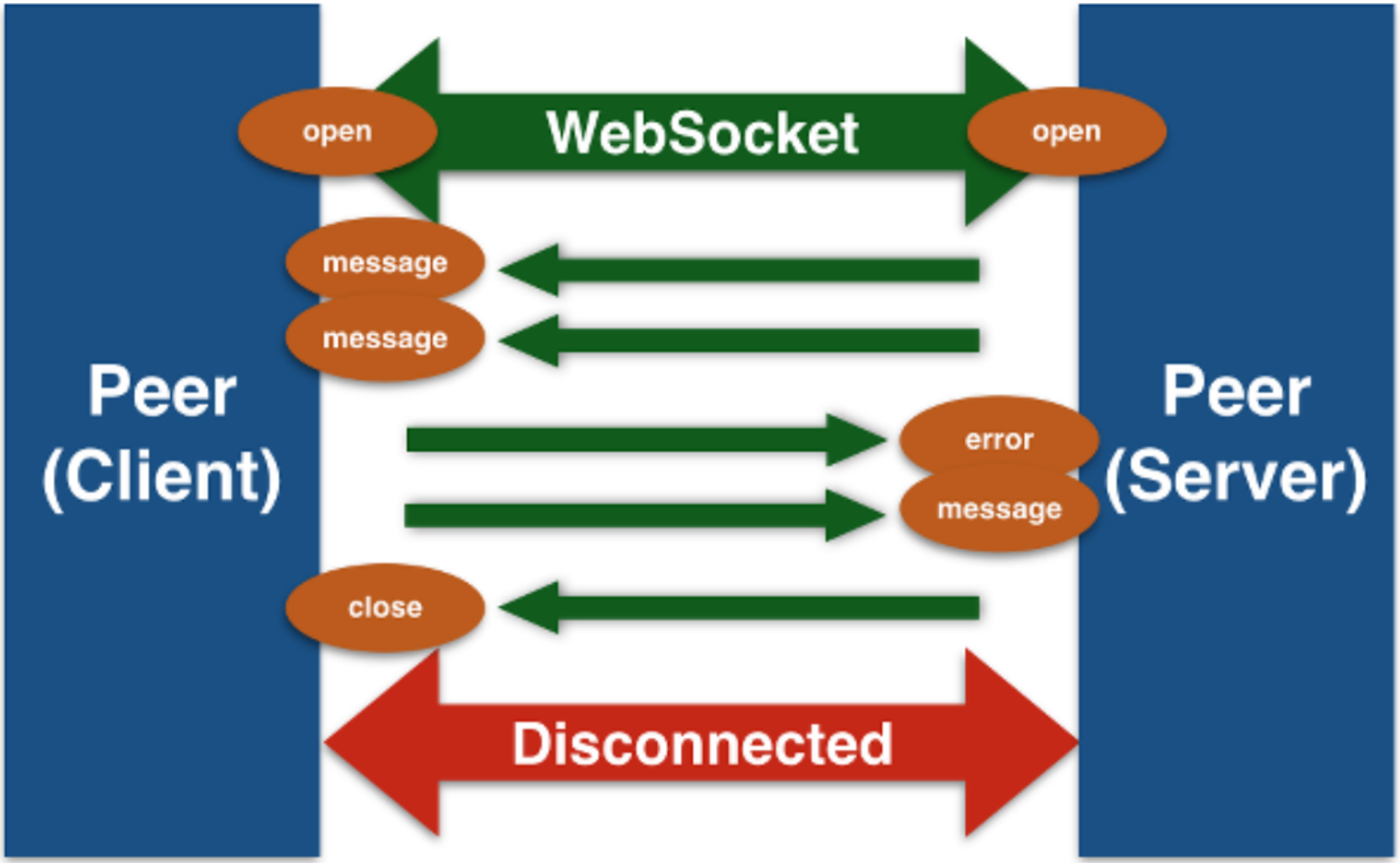
❷ Server echoes the header, completes the handshake

❸ Indicates server's acceptance of connection

Connection established



WebSocket Lifecycle



WebSocket API

```
[Constructor(DOMString url, optional (DOMString or DOMString[]) protocols)]
interface WebSocket : EventTarget {
  readonly attribute DOMString url;

  // ready state
  const unsigned short CONNECTING = 0;
  const unsigned short OPEN = 1;
  const unsigned short CLOSING = 2;
  const unsigned short CLOSED = 3;
  readonly attribute unsigned short readyState;
  readonly attribute unsigned long bufferedAmount;

  // networking
           attribute EventHandler onopen;
           attribute EventHandler onerror;
           attribute EventHandler onclose;
  readonly attribute DOMString extensions;
  readonly attribute DOMString protocol;
  void close([Clamp] optional unsigned short code, optional DOMString reason);

  // messaging
           attribute EventHandler onmessage;
           attribute DOMString binaryType;
  void send(DOMString data);
  void send(Blob data);
  void send(ArrayBuffer data);
  void send(ArrayBufferView data);
};
```

- http://www.w3.org/TR/websockets/

WebSocket JavaScript support in browsers

Can I use Web Sockets?

View in interactive mode

Compatibility table for support of Web Sockets in desktop and mobile browsers.

= Supported = Not supported = Partially supported = Support unknown

Web Sockets - Candidate Recommendation

Bidirectional communication technology for web apps

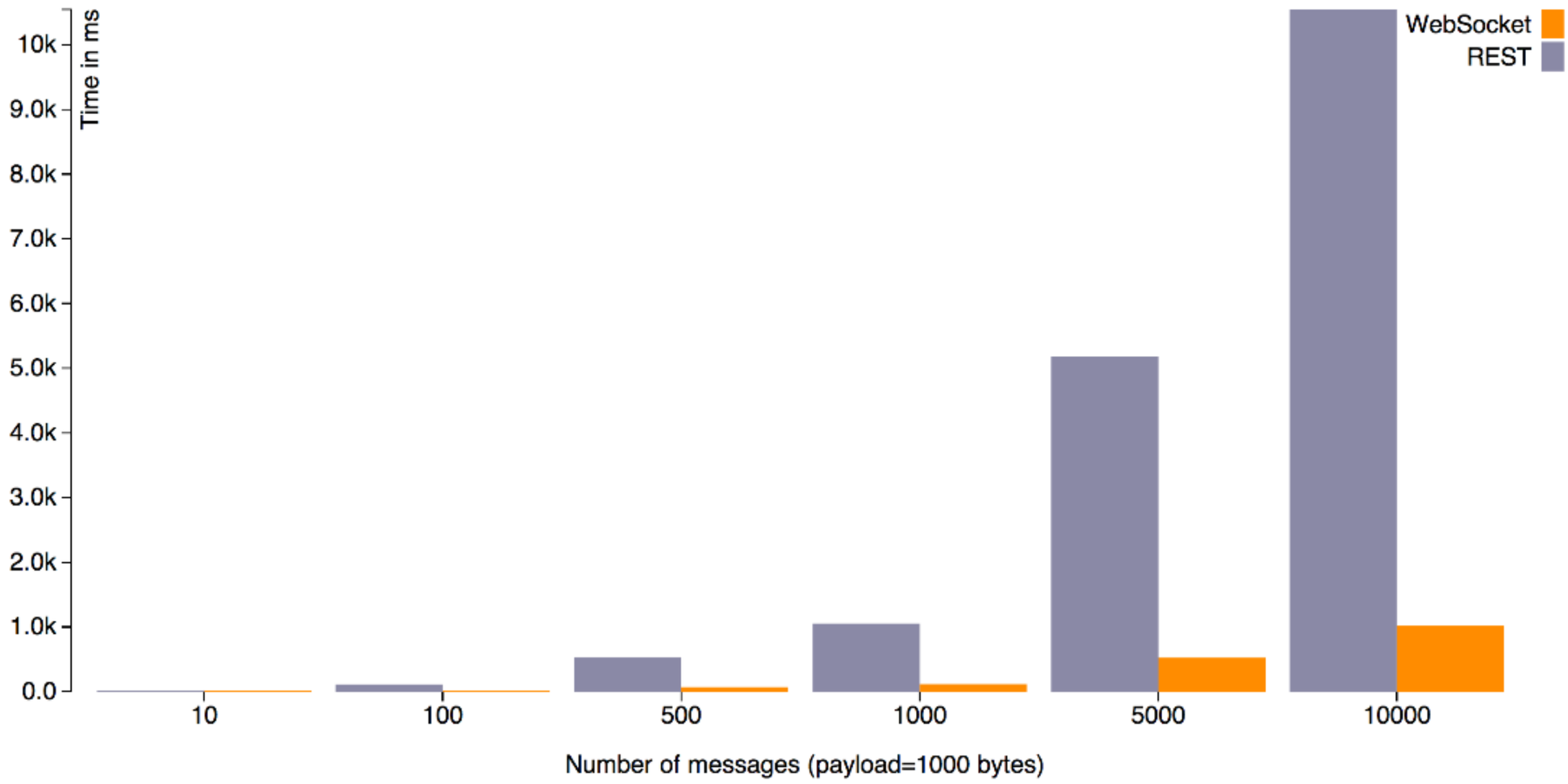
Global user stats*:	
Support:	70.61%
Partial support:	2.13%
Total:	72.74%

Resources: WebPlatform Docs Wikipedia Details on newer protocol WebSockets information has.js test

	IE	Firefox	Chrome	Safari	Opera	iOS Safari	Opera Mini	Android Browser	Blackberry Browser	Opera Mobile	Chrome for Android	Firefox for Android	IE Mobile
28 versions back			4.0										
27 versions back		2.0	5.0										
26 versions back		3.0	6.0										
10 versions back		17.0	22.0		11.0								
9 versions back		18.0	23.0		11.1								
8 versions back		19.0	24.0		11.5								
7 versions back		20.0	25.0	3.1	11.6			2.1					
6 versions back	5.5	21.0	26.0	3.2	12.0			2.2		10.0			
5 versions back	6.0	22.0	27.0	4.0	12.1	3.2		2.3		11.0			
4 versions back	7.0	23.0	28.0	5.0	15.0	4.0-4.1		3.0		11.1			
3 versions back	8.0	24.0	29.0	5.1	16.0	4.2-4.3		4.0		11.5			
2 versions back	9.0	25.0	30.0	6.0	17.0	5.0-5.1		4.1		12.0			
Previous version	10.0	26.0	31.0	6.1	18.0	6.0-6.1		4.2-4.3	7.0	12.1			
Current	11.0	27.0	32.0	7.0	19.0	7.0	5.0-7.0	4.4	10.0	16.0	32.0	26.0	10.0
Near future		28.0	33.0		20.0								
Farther future		29.0	34.0		21.0								
3 versions ahead		30.0	35.0										

- http://caniuse.com/websockets

REST vs WebSocket



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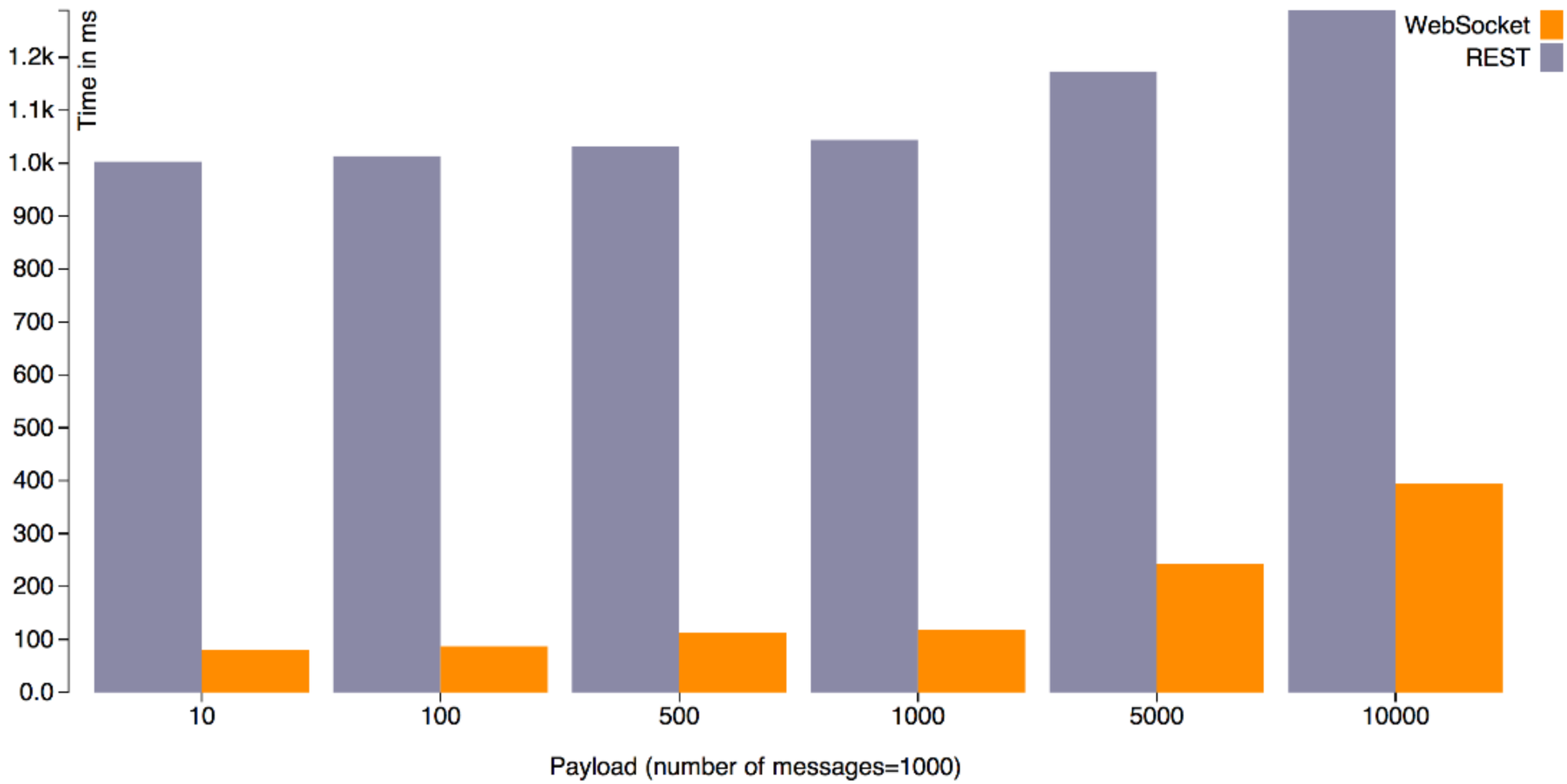

REST vs WebSocket

Constant number of messages, increasing payload			
Payload (in bytes)	REST (in ms)	WebSocket (in ms)	x times
10	1003	81	12.38
100	1013	87	11.64
500	1032	113	9.13
1000	1044	119	8.77
5000	1173	243	4.83
10000	1289	394	3.27

Constant payload, increasing number of messages			
Messages	REST (in ms)	WebSocket (in ms)	x times
10	17	13	1.31
100	112	20	5.60
500	529	68	7.78
1000	1050	115	9.13
5000	5183	522	9.93
10000	10547	1019	10.35

JSR 356 Specification

- **Standard Java API for creating WebSocket Applications**
- **Transparent Expert Group**
  - http://jcp.org/en/jsr/detail?id=356
  - http://java.net/projects/websocket-spec
- **Included in Java EE 7**

JSR 356 Implementations

GlassFish 4 (RI), WildFly 8, Atmosphere, Tomcat 7.0.x/8.0.x, Jetty 9.1.x, Caucho Resin

Java API for WebSocket Features

- API for WebSocket Server and Client Endpoint
  - Annotated: `@ServerEndpoint`, `@ClientEndpoint`
  - Programmatic: `Endpoint`
    - WebSocket opening handshake negotiation

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  - Programmatic: `Endpoint`
    - WebSocket opening handshake negotiation
- Lifecycle callback methods
- Integration with Java EE technologies

WebSocket Annotated Endpoint

```
import javax.websocket.*;

@ServerEndpoint("/hello") ❶
public class HelloBean {
  @OnMessage ❷
  public String sayHello(String name) {
    return "Hello " + name;
}
```

❶ `@ServerEndpoint` marks the POJO as WebSocket endpoint

❷ `@OnMessage` marks the method called when WebSocket message is received

WebSocket annotations

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- **Class-level annotations**
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  - `@OnError` Intercepts WebSocket error events
- **Parameter-level annotation**
  - `@PathParam` Matches path segment of a URI-template

@ServerEndpoint attributes

- `value` Relative URI or URI template e.g. '/hello' or '/chat/{subscriber-level}'
- `decoders` list of message decoder classnames
- `encoders` list of message encoder classnames
- `subprotocols` list of the names of the supported subprotocols

Custom Payloads

```
@ServerEndpoint(
  value="/hello",
  decoders={MyMessageDecoder.class}, ❶
  encoders={MyMessageEncoder.class} ❷
)
public class MyEndpoint {
  . . .
}
```

❶ Message decoder class

❷ Message encoder class

Custom payloads: Text decoder

```
public class MyMessageDecoder implements Decoder.Text<MyMessage> { ❶
  public MyMessage decode(String s) { ❷
    JsonObject jsonObject = Json.createReader("...").readObject();
    return new MyMessage(jsonObject);
  }

  public boolean willDecode(String string) { ❸
    . . .
    return true;
  }
  . . .
}
```

❶ Text decoder

❷ `decode` decodes a `String` to `MyMessage`

❸ Returns `true` if payload can be processed

Custom payloads: Text encoder

```
public class MyMessageEncoder implements Encoder.Text<MyMessage> { ❶
  public String encode(MyMessage myMessage) { ❷
    return myMessage.jsonObject.toString();
  }
  . . .
}
```

❶ Text encoder

❷ `encode` encodes a `MyMessage` to `String`

Custom payloads: Binary encoder

```
public class MyMessageDecoder implements Decoder.Binary<MyMessage> { ❶
  public MyMessage decode(byte[] bytes) { ❷
    . . .
    return myMessage;
  }

  public boolean willDecode(byte[] bytes) { ❸
    . . .
    return true;
  }
  . . .
}
```

❶ Binary decoder

❷ `decode` decodes a `byte[]` to `MyMessage`

❸ Returns `true` if payload can be processed

@OnMessage method signature

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- Exactly one of the following
  - Text: String, Java primitive or equivalent class, String and boolean, Reader, any type for which there is a decoder
  - Binary: byte[], ByteBuffer, byte[] and boolean, ByteBuffer and boolean, InptuStream, any type for which there is a decoder
  - Pong messages: PongMessage

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- An optional `Session` parameter

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  - Pong messages: PongMessage
- An optional `Session` parameter
- 0..n String parameters annotated with `@PathParam`
- Return type: String, byte[], ByteBuffer, Java

Sample Messages

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- `void m(String s);`

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- `Book m(int i, Session s, @PathParam("isbn")String is`

Chat server

```
@ServerEndpoint("/chat")
public class ChatBean {
  static Set<Session> peers = Collections.synchronizedSet("...");

  @OnOpen ❶
  public void onOpen(Session peer) {
    peers.add(peer);
  }

  @OnClose ❷
  public void onClose(Session peer) {
    peers.remove(peer);
  }
  . . .
```

❶ Called when connection is opened

❷ Called when connection is closed

Chat server (contd)

```
  . . .
  @OnMessage
  public void message(String message) {
    for (Session peer : peers) { ❶
      peer.getBasicRemote().sendObject(message);
    }
  }
}
```

❶ Iterate over all the connected clients

Chat server (simplified)

```
@ServerEndpoint("/chat")
public class ChatBean {
  @OnMessage
  public void message(String message, Session endpoint) {
    for (Session peer : endpoint.getOpenSessions()) {
      peer.getBasicRemote().sendObject(message);
    }
  }
}
```

URI-template matching

```
@ServerEndpoint("/orders/{order-id}") ❶
public class MyEndpoint {
  @OnMessage public void processOrder(@PathParam(“order-id”)String orderId) { ❷
    . . .
  }
}
```

❶ Template specified as {order-id}

❷ Value specified using @PathParam

Client endpoint

```
@ClientEndpoint
public class HelloClient {
  @OnMessage public void message(String message, Session session) {
    ❶
  }
}

WebSocketContainer c = ContainerProvider.getWebSocketContainer();
c.connectToServer(HelloClient.class, "hello"); ❷
```

❶ Process message from server

❷ Connect to server

Programmatic endpoint

```
public class MyEndpoint extends Endpoint { ❶
  @Override
  public void onOpen(Session session) {
    session.addMessageHandler(new MessageHandler.Text() { ❷
      public void onMessage(String name) { ❸
        try {
          session.getBasicRemote().sendText("Hello " + name); ❹
        } catch (IOException ex) { }
      }
    });
  }
}
```

❶ Extend an abstract class `Endpoint`

❷ Add handler for each message

❸ Handle the text message

❹ Send the message to client

Programmatic endpoint packaging

```
ServerEndpointConfiguration config =
  ServerEndpointConfigurationBuilder.create(MyEndpoint.class, "/foo")
    .build();
```

Server and client configuration

Server and client configuration

- Server
  - URI matching algorithm
  - Subprotocol and extension negotiation
  - Message encoders and decoders
  - Origin check
  - Handshake response

Server and client configuration

- Server
  - URI matching algorithm
  - Subprotocol and extension negotiation
  - Message encoders and decoders
  - Origin check
  - Handshake response
- Client
  - Requested subprotocols and extensions
  - Message encoders and decoders
  - Request URI

Relationship with Dependency Injection

- Full Dependency Injection support required in endpoints
  - Field, method, constructor injection
- Interceptors permitted too

Relationship with Servlet 3.1

- Allows a portable way to upgrade HTTP request
- New API
  - `HttpServletRequest.upgrade(ProtocolHandler handler)`

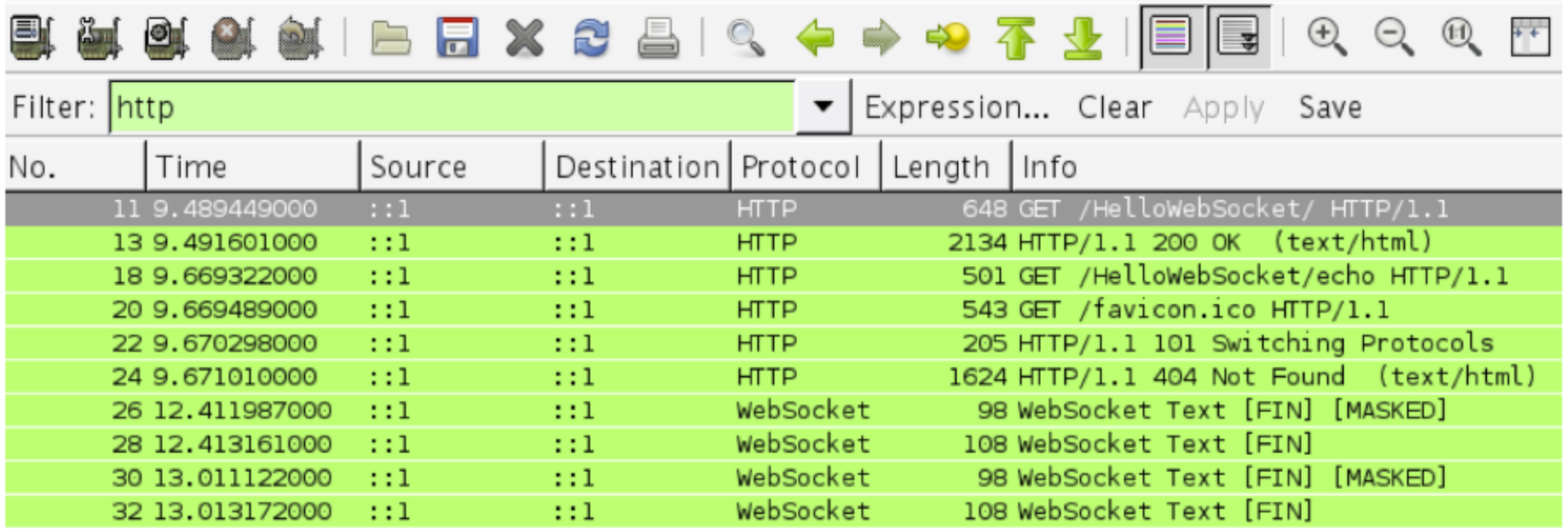
Security

- Authenticates using Servlet security mechanism during opening handshake
  - Endpoint mapped by ws:// is protected using security model defined using the corresponding http:// URI
- Authorization defined using

```
<security-constraint>
```

- Transport Confidentiality using wss://
  - Access allowed over encrypted connection only

Debugging WebSocket messages (Wireshark)



No.	Time	Source	Destination	Protocol	Length	Info
11	9.489449000	::1	::1	HTTP	648	GET /HelloWebSocket/ HTTP/1.1
13	9.491601000	::1	::1	HTTP	2134	HTTP/1.1 200 OK (text/html)
18	9.669322000	::1	::1	HTTP	501	GET /HelloWebSocket/echo HTTP/1.1
20	9.669489000	::1	::1	HTTP	543	GET /favicon.ico HTTP/1.1
22	9.670298000	::1	::1	HTTP	205	HTTP/1.1 101 Switching Protocols
24	9.671010000	::1	::1	HTTP	1624	HTTP/1.1 404 Not Found (text/html)
26	12.411987000	::1	::1	WebSocket	98	WebSocket Text [FIN] [MASKED]
28	12.413161000	::1	::1	WebSocket	108	WebSocket Text [FIN]
30	13.011122000	::1	::1	WebSocket	98	WebSocket Text [FIN] [MASKED]
32	13.013172000	::1	::1	WebSocket	108	WebSocket Text [FIN]

Server-Sent Events

- Part of HTML5 Specification

Server-Sent Events

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- Server-push notifications

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- **Cross-browser JavaScript API:** `EventSource`

Server-Sent Events

- Part of HTML5 Specification
- Server-push notifications
- Cross-browser JavaScript API: `EventSource`
- **Message callbacks**

Server-Sent Events

- Part of HTML5 Specification
- Server-push notifications
- Cross-browser JavaScript API: `EventSource`
- Message callbacks
- **MIME type:** `text/eventstream`

Server-Sent Events API

```
[Constructor(DOMString url, optional EventSourceInit eventSourceInitDict)]
interface EventSource : EventTarget {
  readonly attribute DOMString url;
  readonly attribute boolean withCredentials;

  // ready state
  const unsigned short CONNECTING = 0;
  const unsigned short OPEN = 1;
  const unsigned short CLOSED = 2;
  readonly attribute unsigned short readyState;

  // networking
            attribute EventHandler onopen;
            attribute EventHandler onmessage;
            attribute EventHandler onerror;
  void close();
};

dictionary EventSourceInit {
  boolean withCredentials = false;
};
```

- http://www.w3.org/TR/eventsource/

WebSocket and Server-Sent Events Comparison

WebSocket	Server-Sent Event
Custom protocol	Simple HTTP
Full-duplex, Bi-directional	Server-push only, client-server out of band
Native support in most browsers	Can be poly-filled to back port
Not straight forward	Simple protocol

WebSocket and Server-Sent Events Comparison

WebSocket	Server-Sent Event
Pre-defined message handlers	Arbitrary events
Application-specific	Built-in support for reconnection and event id
May require server/proxy configuration	No server/proxy changes required

References

- Java EE 7 collateral - https://github.com/javaee-samples (Samples, Hands-on Lab, Slides)
- WildFly 8 - http://wildfly.org, http://github.com/wildfly, @WildFlyAS
- Slides generated with Asciidoctor and DZSlides backend
- Original slide template - Dan Allen & Sarah White

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