

Java API for WebSocket

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- Fitness freak

Agenda

- Primer on WebSocket
- **JSR 356: Java API for WebSocket 1.0**

Interactive Web Sites

Interactive Web Sites

- **HTTP is half-duplex**

Interactive Web Sites

- **HTTP is half-duplex**
- **HTTP is verbose**

Interactive Web Sites

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

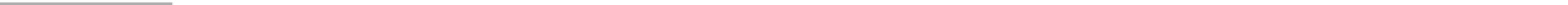
WebSocket to the rescue

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- **TCP based, bi-directional, full-duplex messaging**

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- Originally proposed as part of HTML5



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- IETF-defined Protocol: RFC 6455
 - Handshake
 - Data Transfer

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- TCP based, bi-directional, full-duplex messaging
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 - Handshake
 - Data Transfer
- W3C defined JavaScript API
 - Candidate Recommendation

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- Send data frames in both direction (**Bi-directional**)
 - No headers, cookies, authentication
 - No security overhead
 - “ping”/“pong” frames for keep-alive

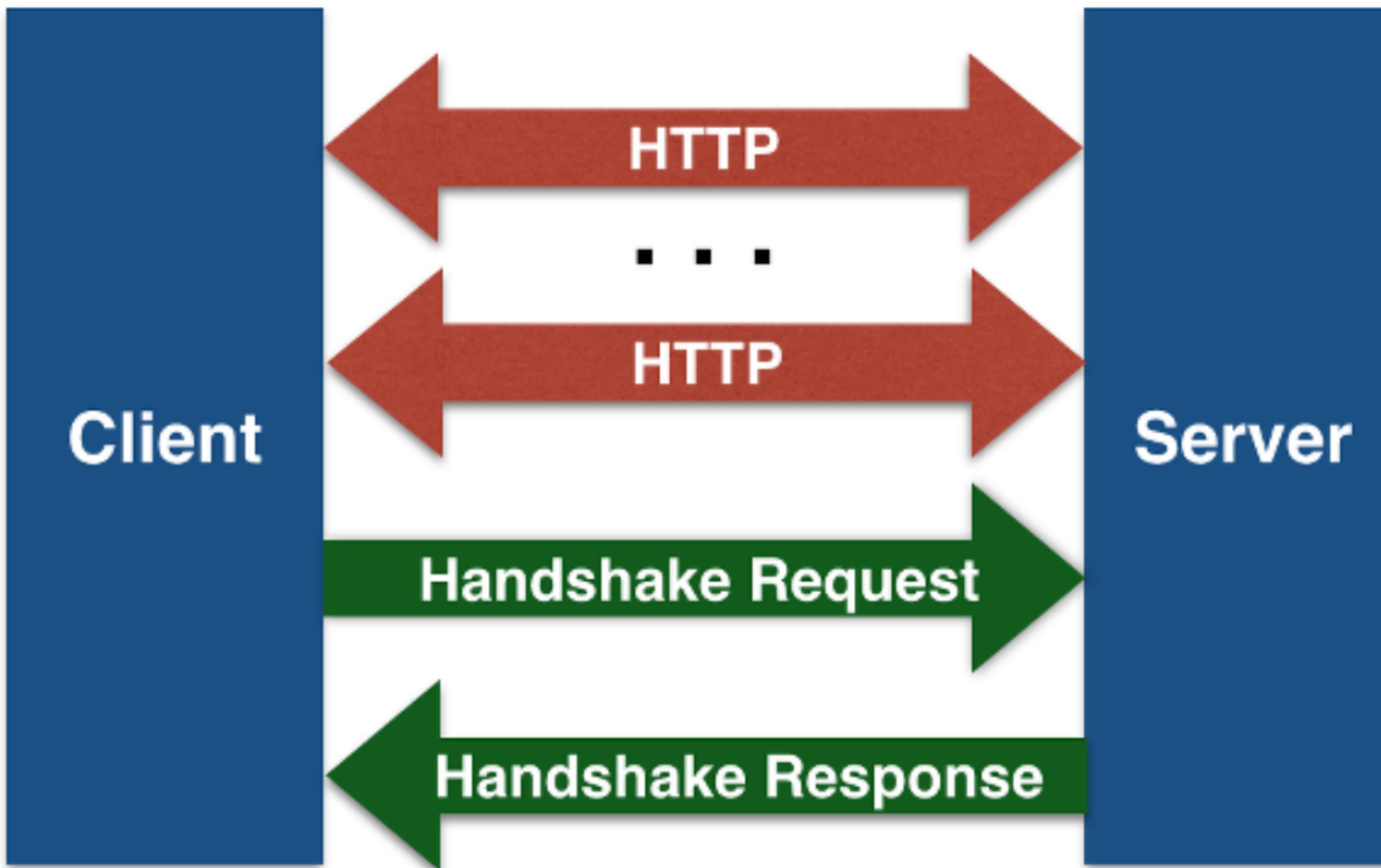
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 - Send message independent of each other (**Full Duplex**)
 - End the connection
-

Establish a connection



Handshake Request

```
GET /chat HTTP/1.1
Host: server.example.com
Upgrade: websocket ①
Connection: Upgrade ②
Sec-WebSocket-Key: dGh1IHNhbXBsZSSub25jZQ==
Origin: http://example.com
Sec-WebSocket-Protocol: chat, superchat
Sec-WebSocket-Version: 13
```

① HTTP upgrade header

② Upgrade to WebSocket

Handshake Response

HTTP/1.1 101 Switching Protocols

Upgrade: websocket ①

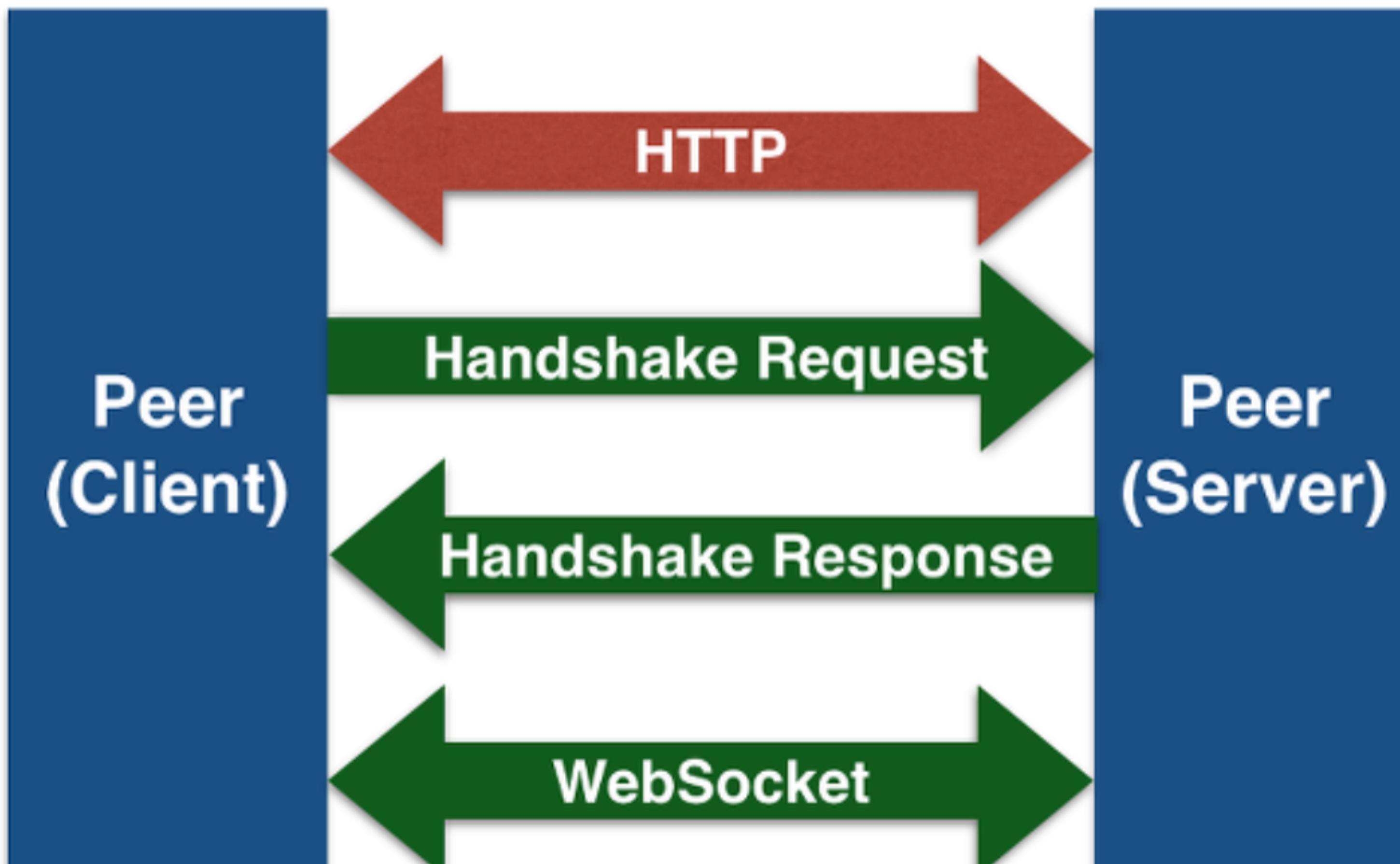
Connection: Upgrade ②

Sec-WebSocket-Accept: s3pPLMBiTxaQ9kYGzhZBk+xOo= ③

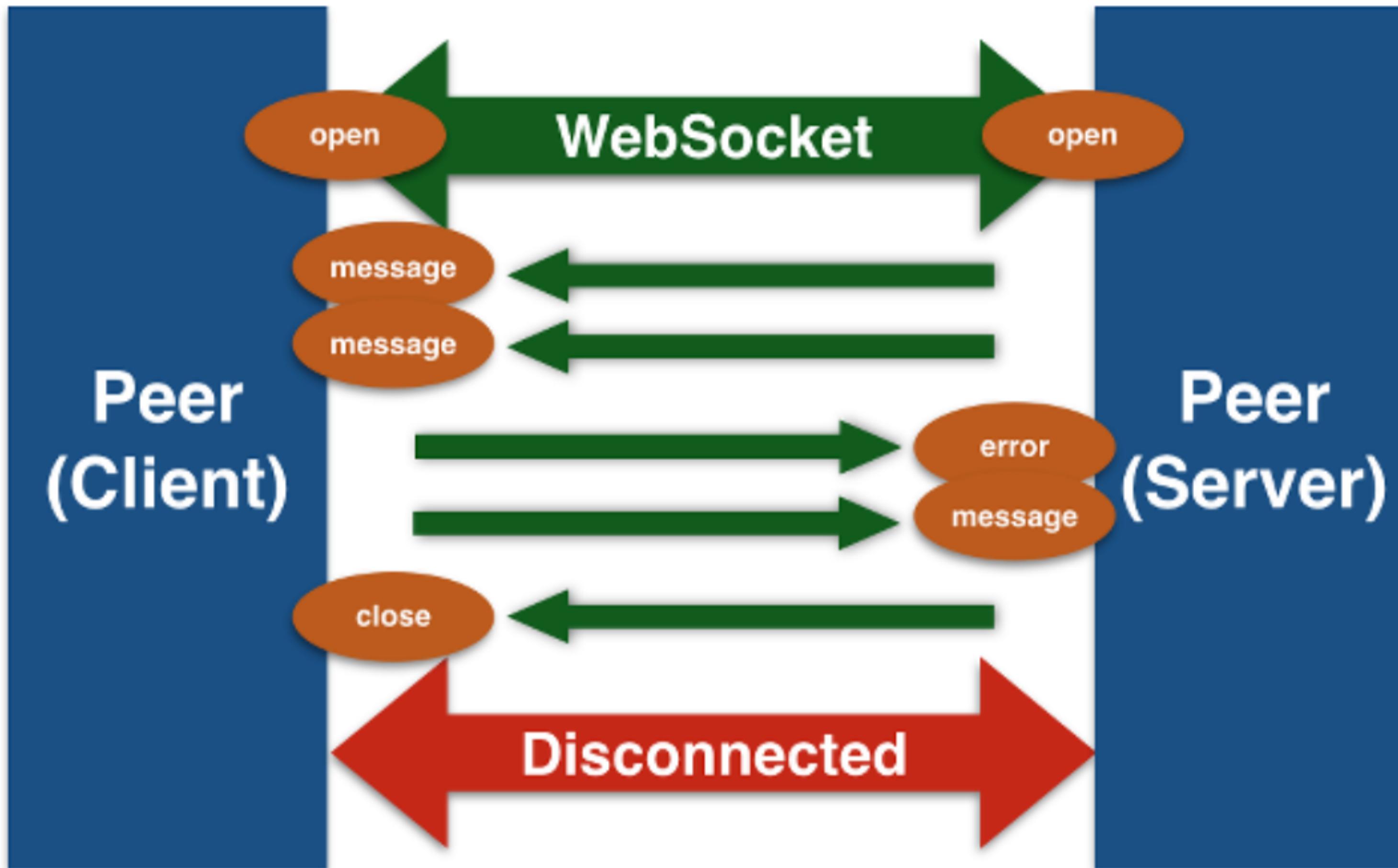
Sec-WebSocket-Protocol: chat

- ① Server echoes the header
- ② Server echoes the header, completes the handshake
- ③ 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?

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

[View in interactive mode](#)

= Supported = Not supported = Partially supported = Support unknown

Web Sockets - Candidate Recommendation

Bidirectional communication technology for web apps

Global user stats *:

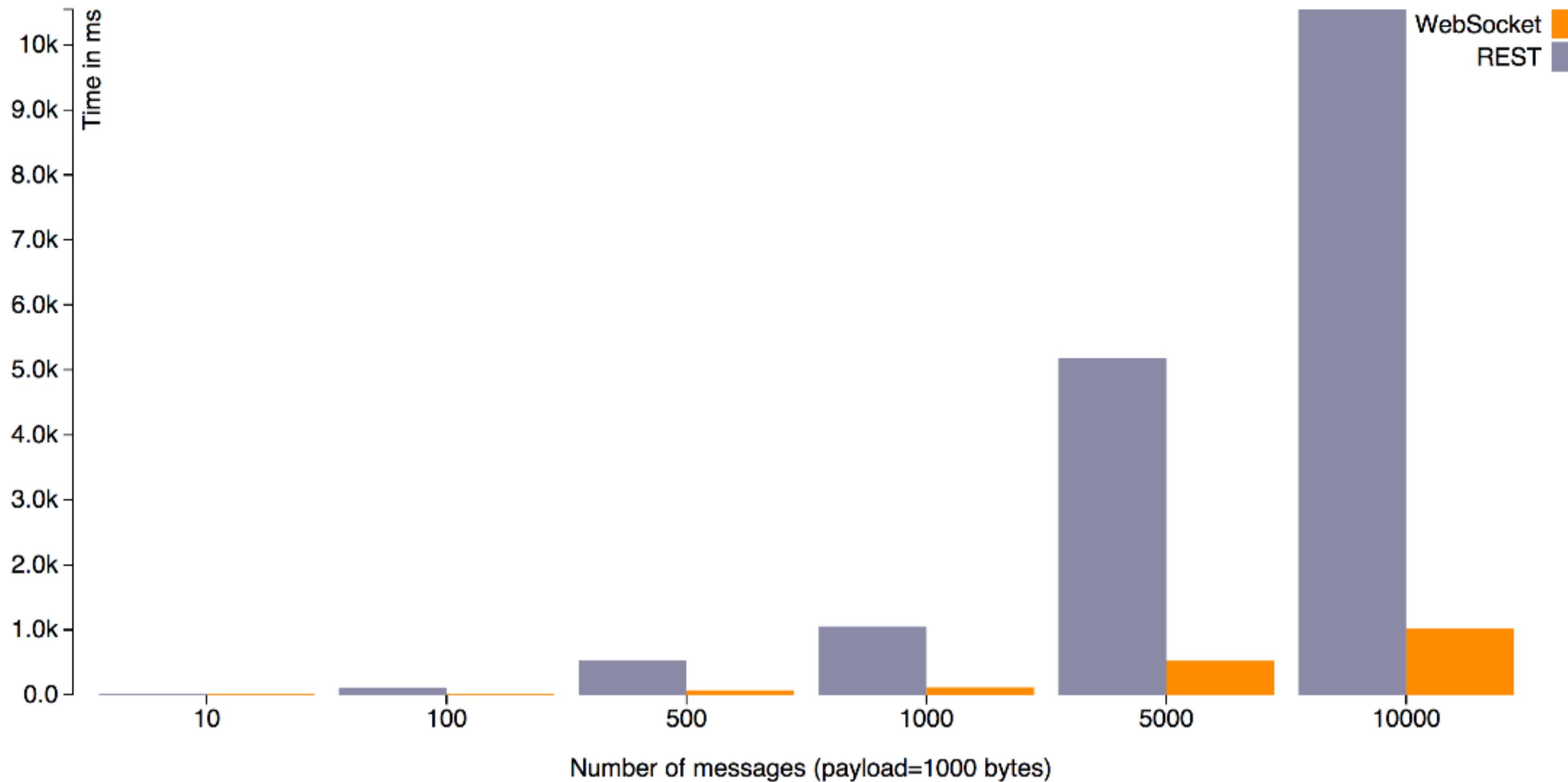
Support	70.61%
Partial support:	2.13%
Total:	72.74%

Resources: [WebPlatform Docs](#) [Wikipedia](#) [Details on newer protocol](#) [WebSockets Information](#) [has.js test](#)

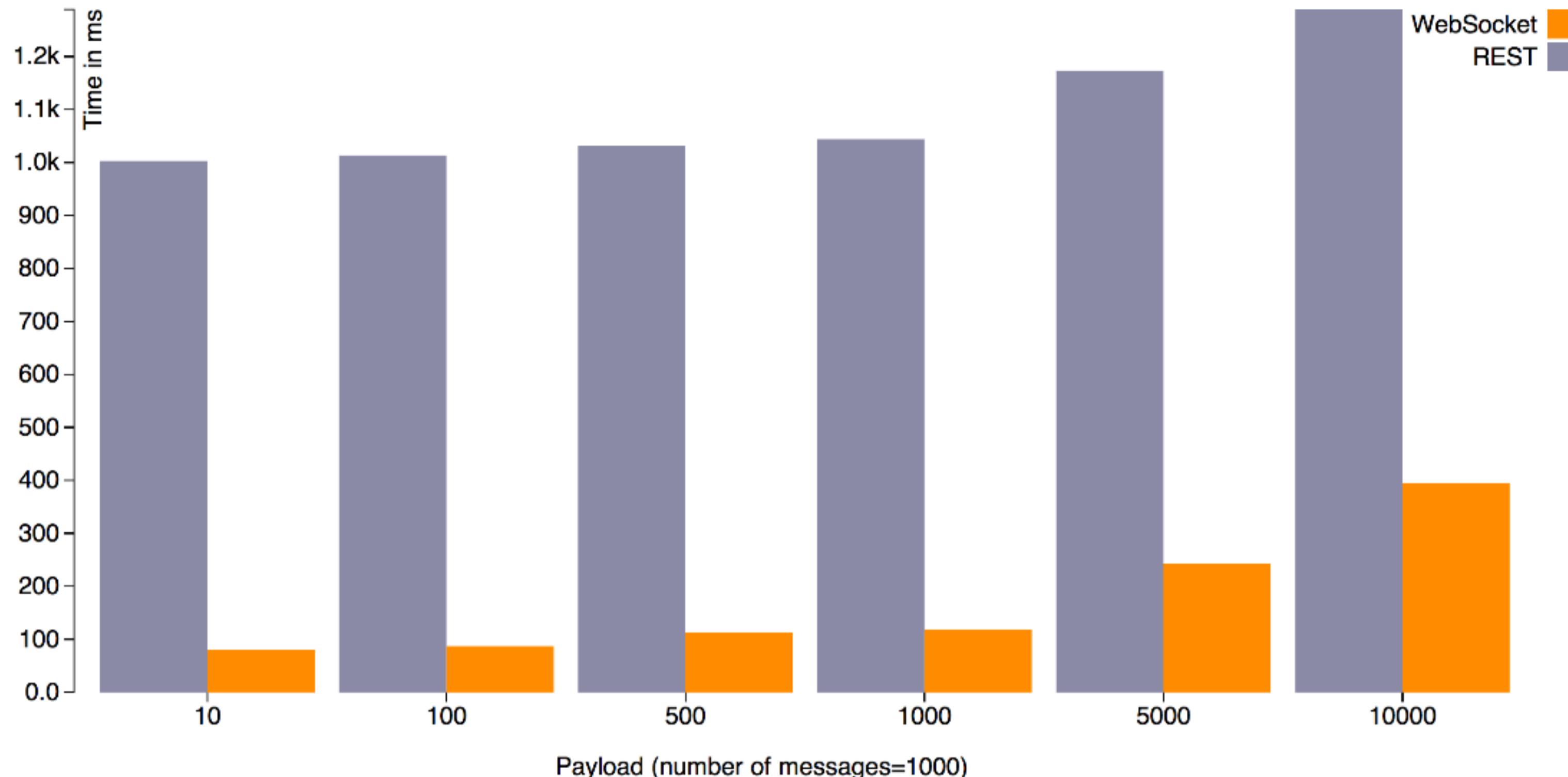
	IE	Firefox	Chrome	Safari	Opera	iOS Safari	Opera Mini	Android Browser	Blackberry Browser	Opera Mobile	Chrome for Android	Firefox for Android	IE Mobile
28 versions back			4.0										
27 versions back		2.0	5.0										
26 versions back		3.0	6.0										
10 versions back		17.0	22.0		11.0								
9 versions 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



REST vs WebSocket



- **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, Cauchon Resin**

Java API for WebSocket Features

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

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- **Lifecycle callback methods**

Java API for WebSocket Features

- API for WebSocket Server and Client Endpoint
 - Annotated: `@ServerEndpoint`, `@ClientEndpoint`
 - Programmatic: `Endpoint`
 - WebSocket opening handshake negotiation
- Lifecycle callback methods
- Integration with Java EE technologies

WebSocket Annotated Endpoint

```
import javax.websocket.*;  
  
@ServerEndpoint("/hello") ①  
public class HelloBean {  
    @OnMessage ②  
    public String sayHello(String name) {  
        return "Hello " + name;  
    }  
}
```

① `@ServerEndpoint` marks the POJO as WebSocket endpoint

② `@OnMessage` marks the method called when WebSocket message is received

WebSocket annotations

- ### Class-level annotations

- **@ServerEndpoint** Turns a POJO in a server endpoint
- **@ClientEndpoint** Turns a POJO in a client endpoint

WebSocket annotations

- **Class-level annotations**

- `@ServerEndpoint` Turns a POJO in a server endpoint
- `@ClientEndpoint` Turns a POJO in a client endpoint

- **Method-level annotations**

- `@OnMessage` Intercepts WebSocket message events
- `@OnOpen` Intercepts WebSocket open events
- `@OnClose` Intercepts WebSocket close events
- `@OnError` Intercepts WebSocket error events

WebSocket annotations

- **Class-level annotations**

- `@ServerEndpoint` Turns a POJO in a server endpoint
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- **Parameter-level annotation**

- `@PathParam` Matches path segment of a URL-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}, ①  
    encoders={MyMessageEncoder.class} ②  
)  
public class MyEndpoint {  
    . . .  
}
```

① Message decoder class

② Message encoder class

Custom payloads: Text decoder

```
public class MyMessageDecoder implements Decoder.Text<MyMessage> { ①
    public MyMessage decode(String s) { ②
        JsonObject jsonObject = Json.createReader("...").readObject();
        return new MyMessage(jsonObject);
    }

    public boolean willDecode(String string) { ③
        . . .
        return true;
    }
    . . .
}
```

① Text decoder

② `decode` decodes a `String` to `MyMessage`

③ Returns `true` if payload can be processed

Custom payloads: Text encoder

```
public class MyMessageEncoder implements Encoder.Text<MyMessage> { ①
    public String encode(MyMessage myMessage) { ②
        return myMessage.jsonObject.toString();
    }
    ...
}
```

① Text encoder

② `encode` encodes a `MyMessage` to `String`

Custom payloads: Binary encoder

```
public class MyMessageDecoder implements Decoder.Binary<MyMessage> { ①
    public MyMessage decode(byte[] bytes) { ②
        . . .
        return myMessage;
    }

    public boolean willDecode(byte[] bytes) { ③
        . . .
        return true;
    }
    . . .
}
```

① Binary decoder

② `decode` decodes a `byte[]` to `MyMessage`

③ 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, InputStream, any type for which there is a decoder
 - **Pong messages:** PongMessage

@OnMessage method signature

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 - Pong messages: PongMessage
- An optional Session parameter

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 - Binary: byte[], ByteBuffer, byte[] and boolean, ByteBuffer and boolean, InputStream, any type for which there is a decoder
 - 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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- `void m(String s);`
- `void m(Float f, @PathParam("id")int id);`

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- `void m(byte[] b); or void m(ByteBuffer b);`

Sample Messages

- `void m(String s);`
- `void m(Float f, @PathParam("id")int id);`
- `Product m(Reader reader, Session s);`
- `void m(byte[] b); or void m(ByteBuffer b);`
- `Book m(int i, Session s, @PathParam("isbn")String is`

Chat server

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

    @OnOpen ①
    public void onOpen(Session peer) {
        peers.add(peer);
    }

    @OnClose ②
    public void onClose(Session peer) {
        peers.remove(peer);
    }

    . . .
}
```

- ① Called when connection is opened
- ② Called when connection is closed

Chat server (contd)

```
    . . .
@OnMessage
public void message(String message) {
    for (Session peer : peers) { ①
        peer.getBasicRemote().sendObject(message);
    }
}
```

- ① 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}") ①
public class MyEndpoint {
    @OnMessage public void processOrder(@PathParam("order-id")String orderId) { ②
        . . .
    }
}
```

- ① Template specified as {order-id}
- ② Value specified using @PathParam

Client endpoint

```
@ClientEndpoint  
public class HelloClient {  
    @OnMessage public void message(String message, Session session) {  
        ①  
    }  
}
```

```
WebSocketContainer c = ContainerProvider.getWebSocketContainer();  
c.connectToServer(HelloClient.class, "hello"); ②
```

- ① process message from server
- ② connect to server

Programmatic endpoint

```
public class MyEndpoint extends Endpoint { ①
    @Override
    public void onOpen(Session session) {
        session.addMessageHandler(new MessageHandler.Text() { ②
            public void onMessage(String name) { ③
                try {
                    session.getBasicRemote().sendText("Hello " + name); ④
                } catch (IOException ex) { }
            }
        });
    }
}
```

- ① Extend an abstract class [Endpoint](#)
- ② Add handler for each message
- ③ Handle the text message
- ④ 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**
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- **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)`



- **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)

The screenshot shows the Wireshark interface with a network traffic capture. The filter bar at the top is set to "http". The main window displays 11 captured frames, with frames 26 through 32 highlighted in green. The columns in the table are: No., Time, Source, Destination, Protocol, Length, and Info.

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]

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

Arun Gupta



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