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HTTP 2 Comes to Java

What Servlet 4.0 Means to You

Ed Burns and Shing Wai Chan
Java EE Specification Team
Oracle

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Our Plan for Your Time Investment

1. Why HTTP 2?
2. HTTP 2 Big Features
3. How Servlet Might Expose These Features
4. Java SE 9 Support for HTTP 2
5. Summary and Current Status

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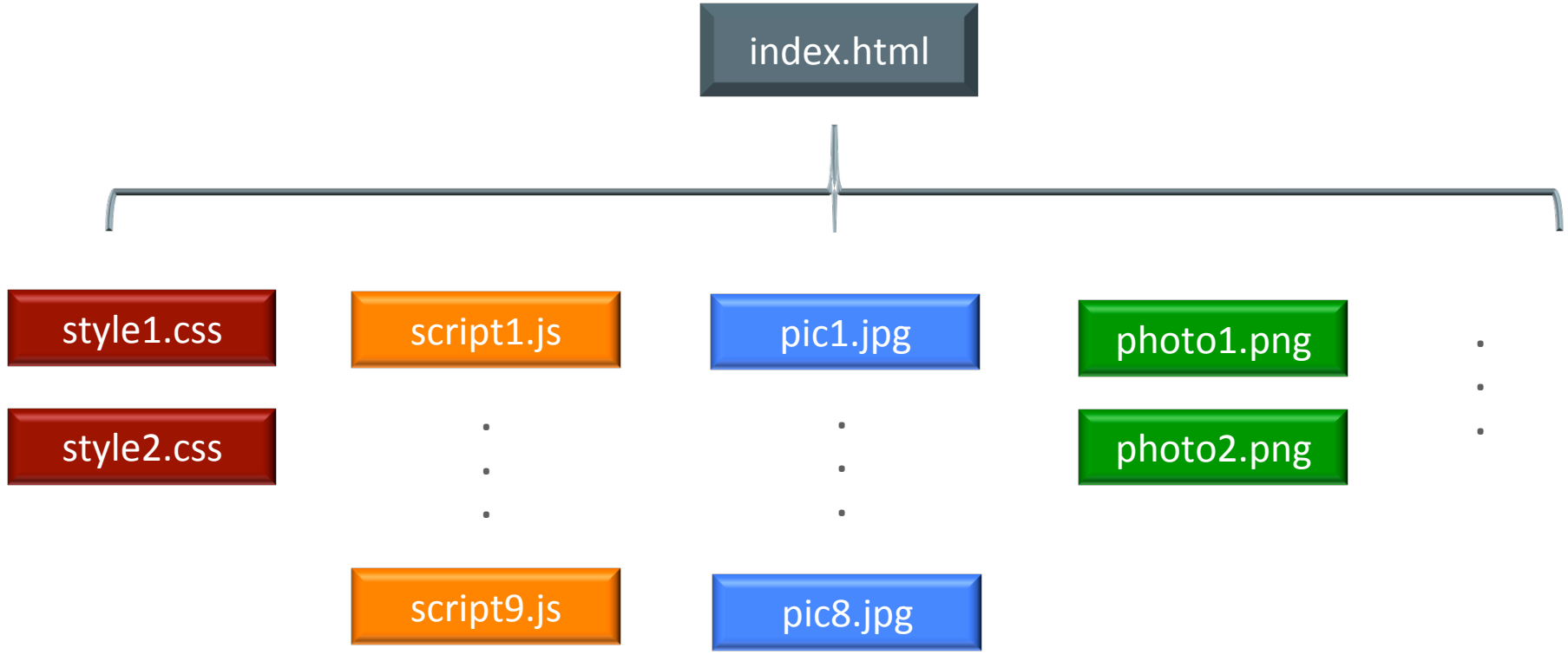
Why HTTP 2?

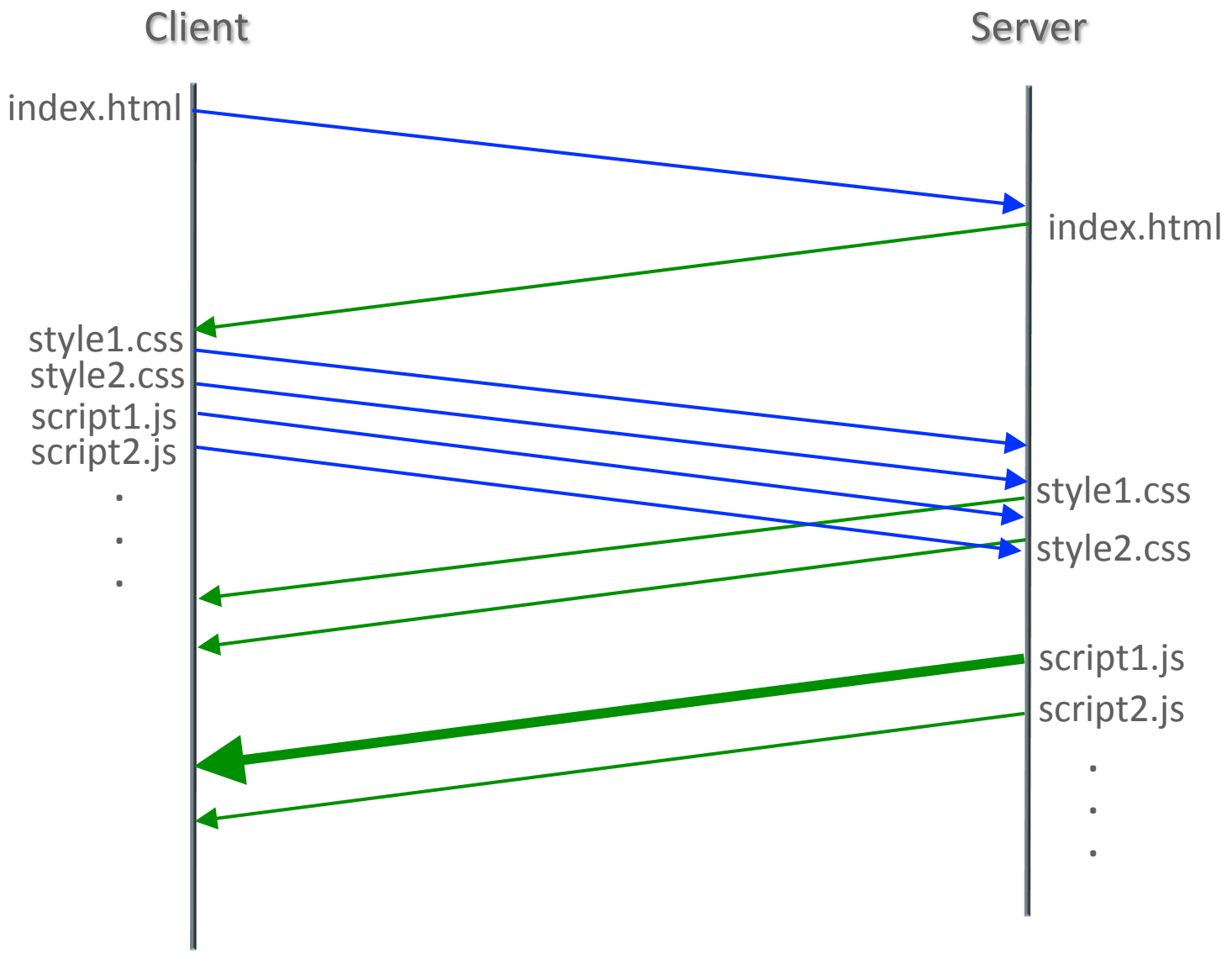
A Real Life Example



Why HTTP 2?

Problems in HTTP 1.1

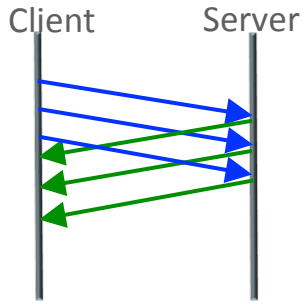
- HTTP Pipelining
- Head-of-Line blocking

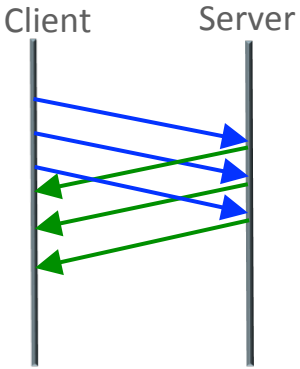


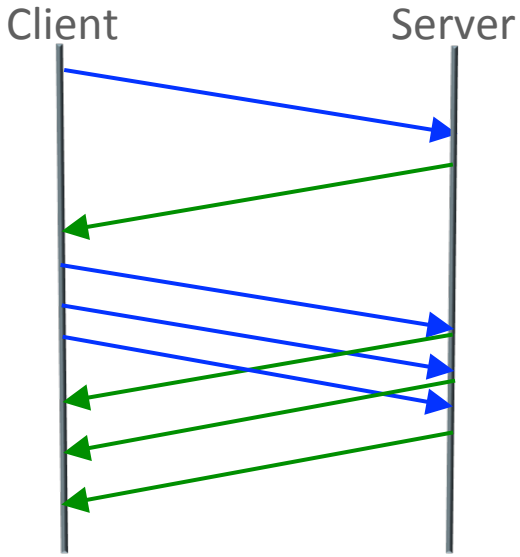
Why HTTP 2?

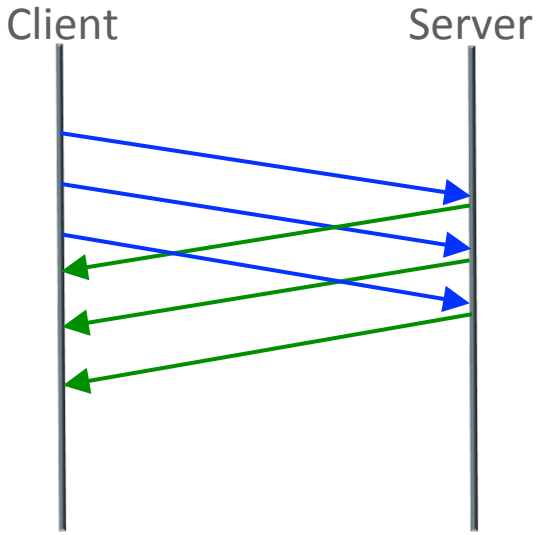
Problems in HTTP 1.1

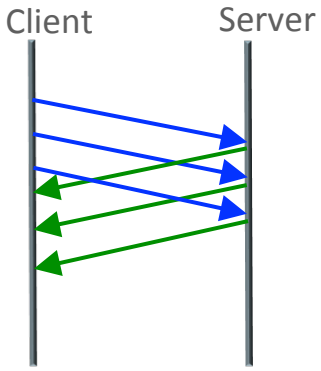
- Inefficient use of TCP sockets

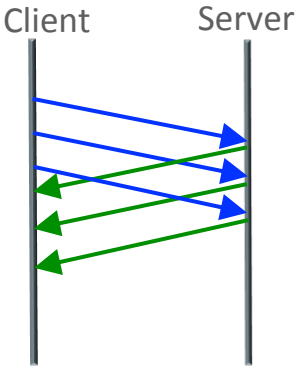












Why HTTP 2?

What is an optimization?

- Much of what we do in web-apps is a hack to work around shortcomings in HTTP 1.1
  - File concatenation and image sprites
  - Domain sharding
  - Inlined assets

File Concatenation and Image Sprites

TCP Efficiency Improves with Larger Files

File Concatenation and Image Sprites

TCP Efficiency Improves with Larger Files

- Modern web page now consists of more than 90 resources fetched from 15 distinct hosts
- Solution:
  - Just work around it by shoving more than one logical file into one physical file.
  - Seminal article: A List Apart **http://alistapart.com/article/sprites**
  - Useful tool: SpritePad **http://spritepad.wearekiss.com/**

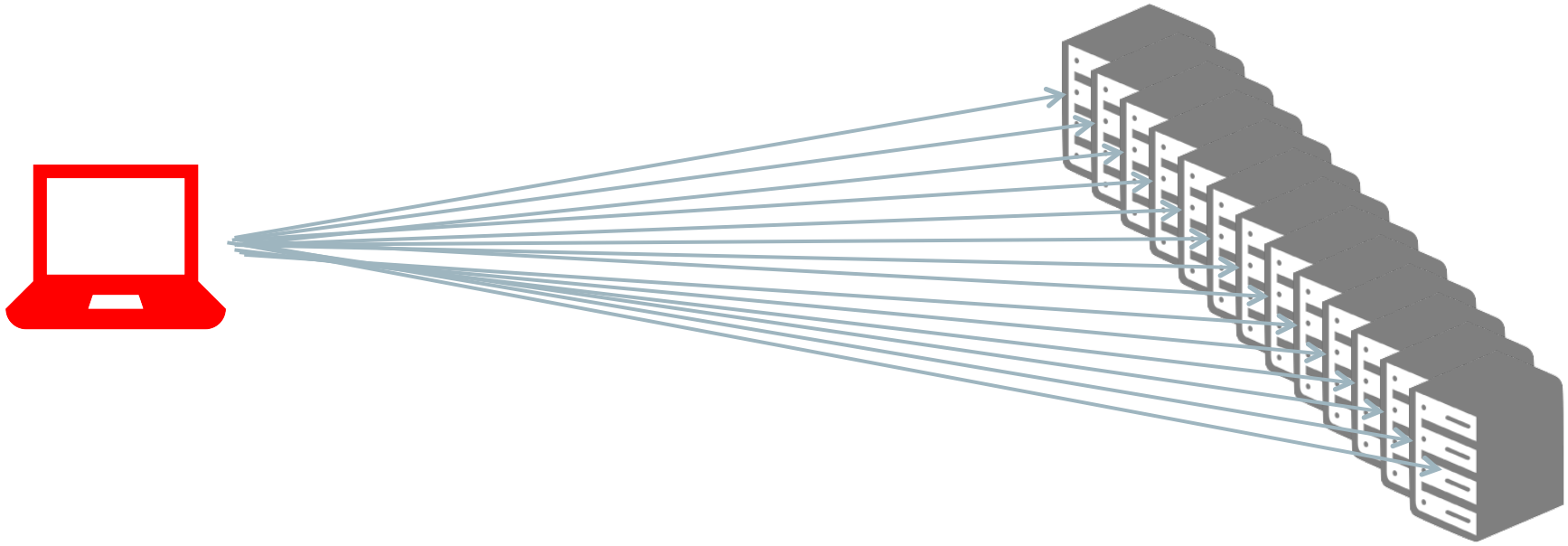
File Concatenation and Image Sprites

TCP Efficiency Improves with Larger Files

```
.ic-AerospaceAndDefense-wht-on-gray, .ic-AerospaceAndDefense-wht-on-red, .ic-Airline-wht-on-gray, .ic-Airline-wht-on-red{
        background: url(sprites.png) no-repeat;
}
.ic-AerospaceAndDefense-wht-on-gray{
        background-position: 0 0;
        width: 80px;
        height: 80px;
}
.ic-AerospaceAndDefense-wht-on-red{
        background-position: -81px 0;
        width: 80px;
        height: 80px;
}
.ic-Airline-wht-on-gray{
        background-position: 0 -80px ;
        width: 80px;
        height: 80px;
}
.ic-Airline-wht-on-red{
        background-position: -81px -79px ;
        width: 80px;
        height: 80px;
}
```

Domain Sharding

Split page resources across several hosts to work around browser limits



Inlined Assets

Base64 Encoding Will Never Die

- data URLs
-

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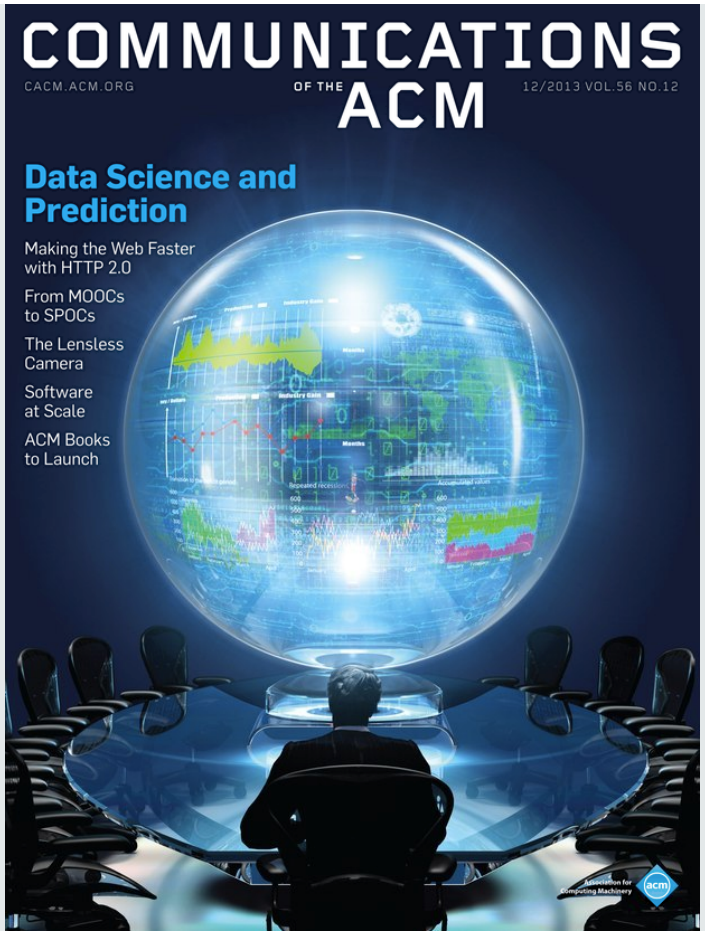
HTTP/2 Big Ticket Feature Review



- Request/Response multiplexing
- Binary Framing
- Stream Prioritization
- Server Push
- Header Compression
- Upgrade from HTTP 1.1
  - ALPN (or NPN)
  - 101 Switching Protocols

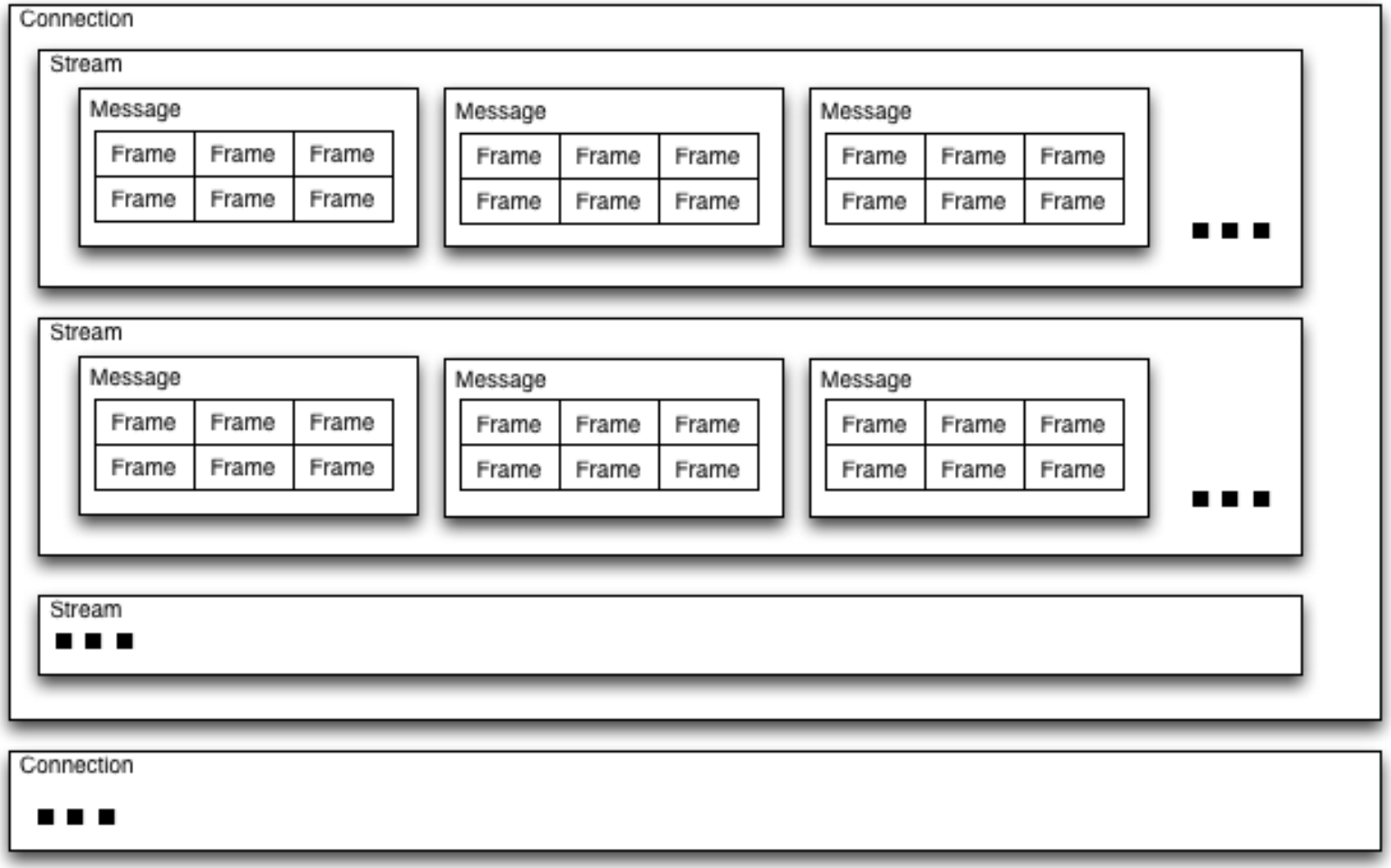
HTTP/2 Request Response Multiplexing

Lets you do more things with a single TCP connection

- Fully bi-directional
- Enabled by defining some terms
  - *Connection*
    A TCP socket
  - *Stream*
    A “channel” within a connection
  - *Message*
    A logical message, such as a request or a response
  - *Frame*
    The smallest unit of communication in HTTP/2.

HTTP/2 Request Response Multiplexing

Connections, Streams, Messages, Frames



HTTP/2 Request Response Multiplexing

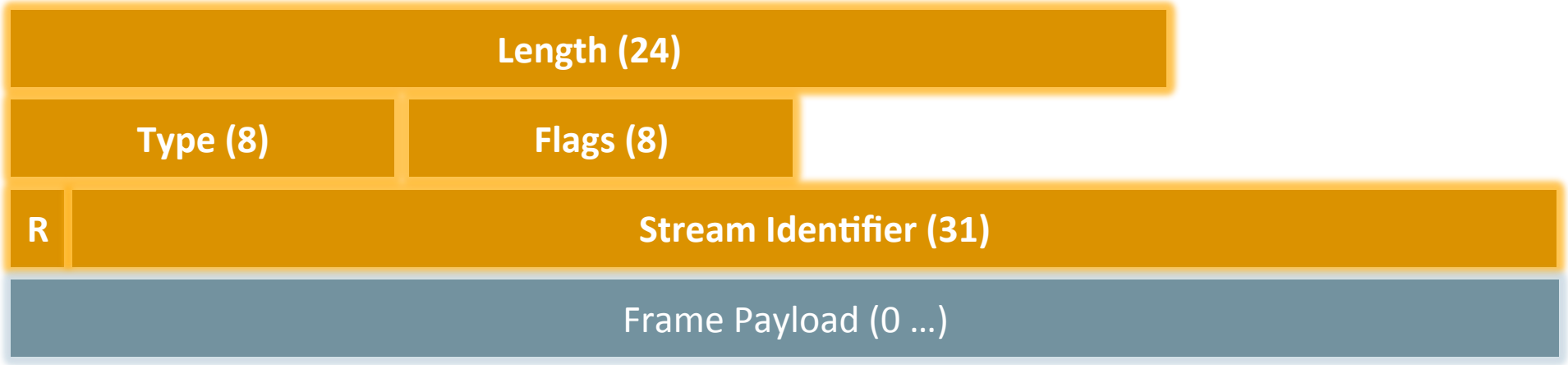
Connections, Streams, Messages, Frames

- Once you break the communication down into frames, you can interweave the logical streams over a single TCP connection.
- Yet another idea from the 1960s is new again.

HTTP/2 Binary Framing

Enabled by dumping newline delimited ASCII

- Solves Head-Of-Line (HOL) blocking problem



- Type field can be DATA, HEADERS, PRIORITY, RST_STREAM, SETTINGS, PUSH_PROMISE, PING, GOAWAY, WINDOW_UPDATE, CONTINUATION

HTTP/2 Binary Framing

Example 1

```
GET /index.html HTTP/1.1
Host: example.com
Accept: text/html
```

```
HEADERS
   + END_STREAM
   + END_HEADERS
      :method: GET
      :scheme: http
      :path: /index.html
      :authority: example.org
      accept: text/html
```

HTTP/2 Binary Framing

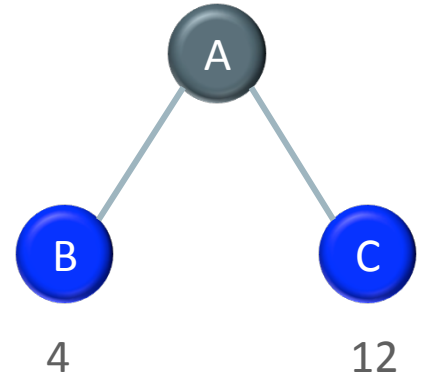
Example 2

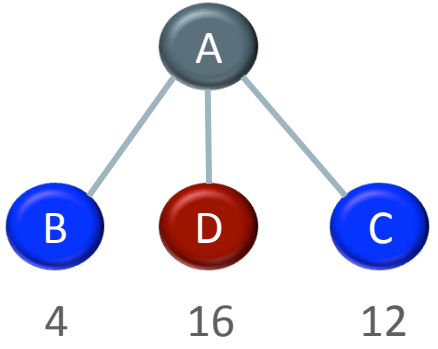
```
HTTP/1.1 200 OK
Content-Length: 11
Content-Type: text/html

Hello World
```

```
HEADERS
   - END_STREAM
   + END_HEADERS
      :status: 200
      content-length: 11
      content-type: text/html

DATA
   + END_STREAM
Hello World
```

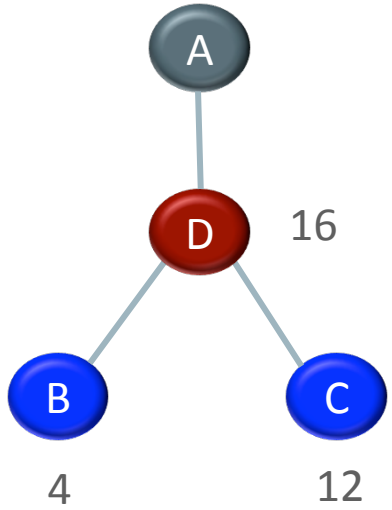
HTTP/2 Stream Prioritization

- Stream Dependency in HEADERS Frame
- PRIORITY frame type
- An additional 40 bytes
  - Stream id (31)
  - Weight (8): [1, 256]
  - Exclusive bit (1)
- Only an advice





exclusive = 0



exclusive = 1

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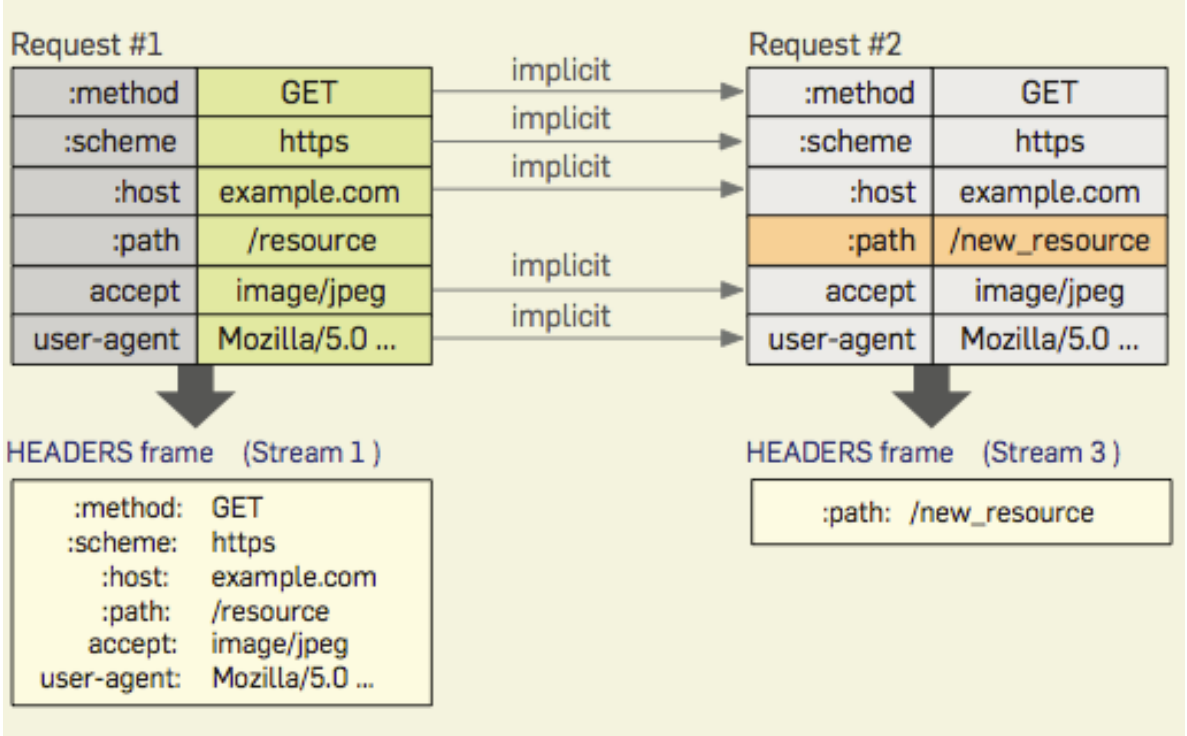
HTTP/2 Server Push

- Eliminates the need for resource inlining.
- Lets the server populate the browser's cache in advance of the browser asking for the resource to put in the cache.
- No corresponding JavaScript API, but can be combined with SSE
  - Server pushes stuff into the browser's cache.
  - Server uses SSE to tell the browser to go fetch it (but we know it's already in the browser's cache).

HTTP/2 Header Compression

Known as HPACK

- Observation: most of the headers are the same in a given stream
  - Host: Accept: user-agent: etc.
- Why send them every time?
- Have the server and the client keep tables of headers, then just send references and updates to the tables.



HTTP/2 Upgrade from HTTP 1.1

Secure or not-secure?

- Not secure
  - We have to use port 80
  - Use existing 101 Switching Protocols from HTTP 1.1
- Secure
  - Next Protocol Negotiation (NPN)
  - Application Layer Protocol Negotiation

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Servlet 4.0 Big Ticket New Features

Challenges in Exposing HTTP/2 Features in Servlet API

- Existing API is designed for One Request == One Response.
- HTTP/2 destroys this assumption.
- It will be challenging to do justice to the new reality of One Request == One or More Responses.
- We must not simply bolt the “One or More Responses” concept onto some convenient part of the existing API.

Servlet 4.0 Big Ticket New Features

HTTP/2 Features Potentially Exposed in Servlet API

- Request/Response multiplexing
- Binary Framing
- Stream Prioritization
- Server Push
- Header Compression
- Upgrade from HTTP 1.1
  - ALPN or (NPN)
  - 101 Switching Protocols

Servlet 4.0 Big Ticket New Features

HTTP/2 Features Potentially Exposed in Servlet API

- Add method `HttpServletRequest` and `HttpServletResponse`
  - `int getStreamId()`

Servlet 4.0 Big Ticket New Features

Stream Prioritization

- Add a new class `Priority`
  - `boolean exclusive`
  - `int streamId`
  - `int weight`
- Add method to `HttpServletRequest`
  - `Priority getPriority()`
- Add methods to `HttpServletResponse`
  - `Priority getPriority()`
  - `void setPriority(Priority p)`

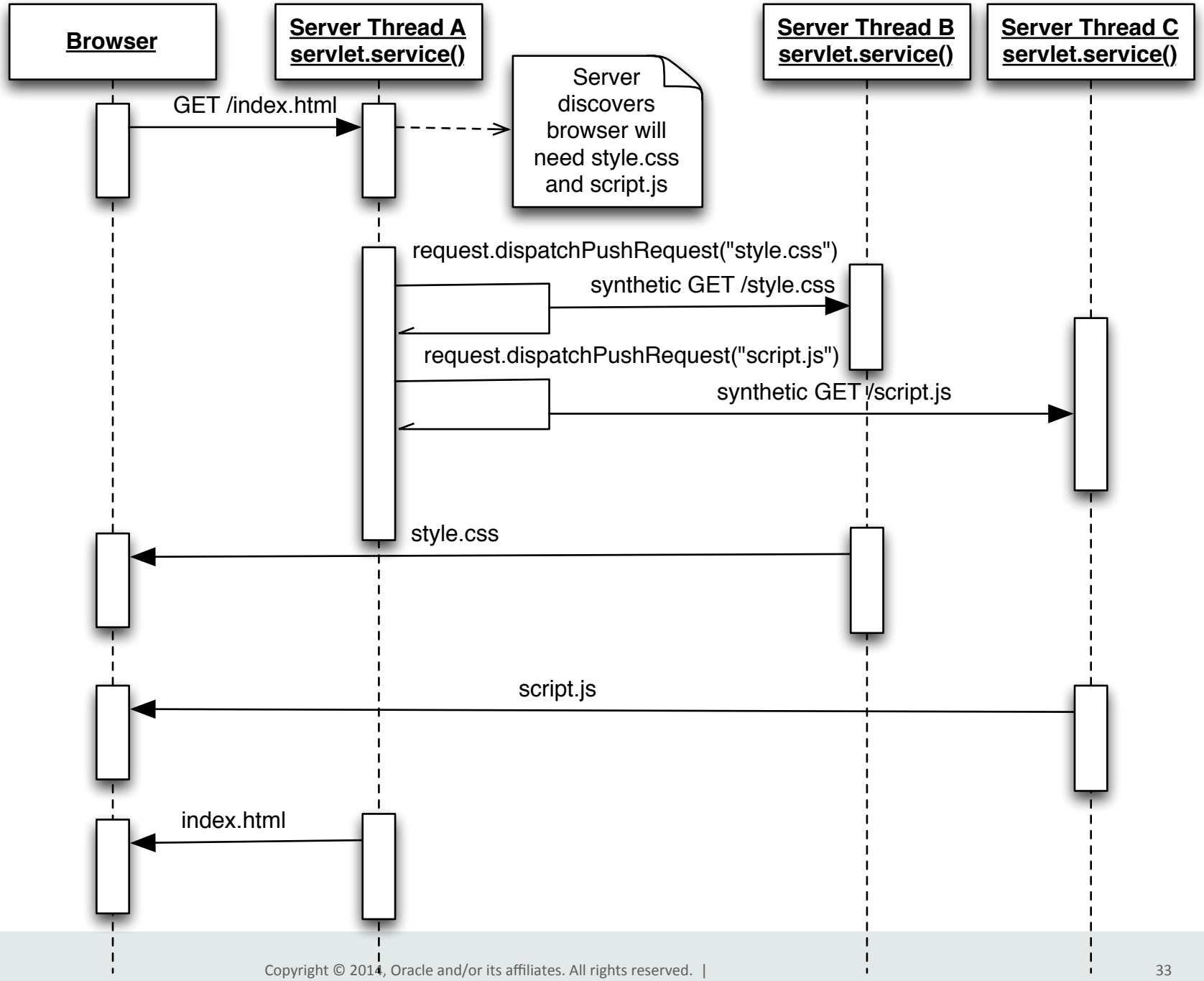
Servlet 4.0 Big Ticket New Features

Server Push

- Push resource to client for a given url and headers
- May add callback for completion or error of a push
- Not at all a replacement for WebSocket
- Really useful for frameworks that build on Servlet, such as JSF

Servlet 4.0 Big Ticket New Features

Server Push



Server Push

Example of Potential Use from JSF

```
public class FacesServlet implements Servlet {
public void service(ServletRequest req,
                    ServletResponse resp) throws IOException, ServletException {
    //..
    HttpServletRequest request = (HttpServletRequest) req;
    try {
        ResourceHandler handler =
            context.getApplication().getResourceHandler();
        if (handler.isResourceRequest(context) || request.isPushRequest()) {
            handler.handleResourceRequest(context);
        } else {
            lifecycle.attachWindow(context);
            lifecycle.execute(context);
            lifecycle.render(context);
        }
    }
}
```

Server Push

Example of Potential Use from JSF

```
public class ExternalContextImpl extends ExternalContext {
    //…
    public String encodeResourceURL(String url) {
        if (null == url) {
            String message = MessageUtils.getExceptionMessageString
                (MessageUtils.NULL_PARAMETERS_ERROR_MESSAGE_ID, "url");
            throw new NullPointerException(message);
        }
        Map attrs = getResourceAttrs();
        ((HttpServletRequest) request).dispatchPushRequest(url, attrs);
        return ((HttpServletResponse) response).encodeURL(url);
    }
    //…

}
```

Reactive Programming

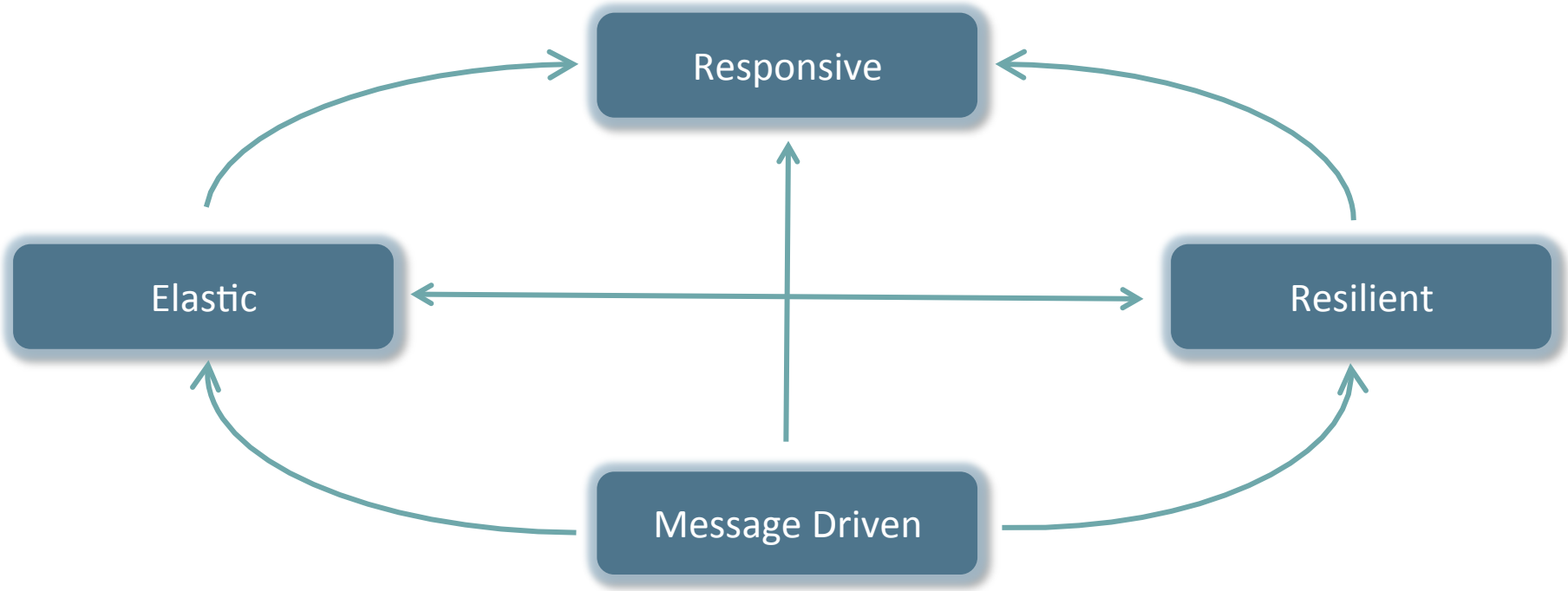


image credit: reactivemanifesto.org

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Servlet 4.0 and Reactive Programming

- Non-blocking IO in Servlet 3.1
  - `ServletInputStream`
    - `#setReadListener, #isReady`
  - `ServletOutputStream`
    - `#setWriteListener, #isReady`
  - `ReadListener`
    - `#onDataAvailable, #onAllDataRead, #onError`
  - `WriteListener`
    - `#onWritePossible, #onError`

Servlet 4.0 and Reactive Programming

- Asynchronous in Servlet 3.0
  - `ServletRequest#startAsync`
  - `AsyncContext`
    - `#addListener, #dispatch, #complete`
  - `AsyncListener`
    - `#onComplete, #onError, #onStartAsync, #onTimeout`
- Event-driven
  - Server-Sent Events

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Java SE 9 Support for HTTP/2

- JEP 110 http://openjdk.java.net/jeps/110
- Easy to use API
- Covers only the most common use cases
- Supports both HTTP 1.1 and 2

Java SE 9 Support for HTTP/2

Small footprint

- Two classes (working titles)
  - HttpRequestGroup
    - configuration for multiple requests
  - HttpRequest
    - one request/response interaction

Java SE 9 Support for HTTP/2

Small footprint

- Blocking mode: one thread per request/response
  - send request
  - get response
- Non-blocking mode: handle multiple request/response interactions in single thread using non-blocking API
  - analogous to NIO selectors

Java SE 9 Support for HTTP/2

Callback handlers

- Responses handled through lambda style callback handlers
  - invoked on the calling thread
  - Must allocate threads to responses manually
- Request/Response bodies handled as InputStream/OutputStream

Java SE 9 Support for HTTP/2

```
HttpRequestGroup group = HttpRequestGroup.create();
HttpRequest req = group.createRequest()
   .setRequestMethod("POST")
   .setRequestURI(new URI("http://www.foo.com/a/b")
   .setRequestBody("Param1=1,Param2=2")
   .onResponseHeader("X-Foo", (request, name, value) -> {
       System.out.printf(" received an X-Foo header");
     })
   .sendRequest()
   .waitForCompletion();
```

Java SE 9 Support for HTTP/2

```
HttpRequestGroup group = HttpRequestGroup.create();
HttpRequest req = group.createRequest() …
  .onResponseBody((HttpRequest request, InputStream in) -> {
    if (request.getResponseCode() == 200) {
      Path out = Paths.get("/tmp/out");
      try { Files.copy(in, out); } finally { in.close(); }
    }
   })
  .sendRequest()
  .waitForCompletion();
```

Java SE 9 Support for HTTP/2

HTTP/2 features

- Negotiation of HTTP/2 from 1.1
  - ALPN or plaintext
- Server Push
  - Support for PUSH_PROMISE frames
- HPACK parameters

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Summary and Current Status

- Servlet 4.0 brings HTTP 2 to Java EE
  - 100% compliant implementation of HTTP 2
  - Expose key features to the API
    - Server Push
    - Stream Prioritization
    - Request/Response multiplexing

Summary and Current Status

- JSR-369 just formed on 22 September
- Tentative Delivery Schedule
  - Q3 2014: expert group formed
  - Q1 2015: early draft
  - Q3 2015: public review
  - Q4 2015: proposed final draft
  - Q3 2016: final release

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