Chapter 3: Web Paradigms and Interactivity

Literature:

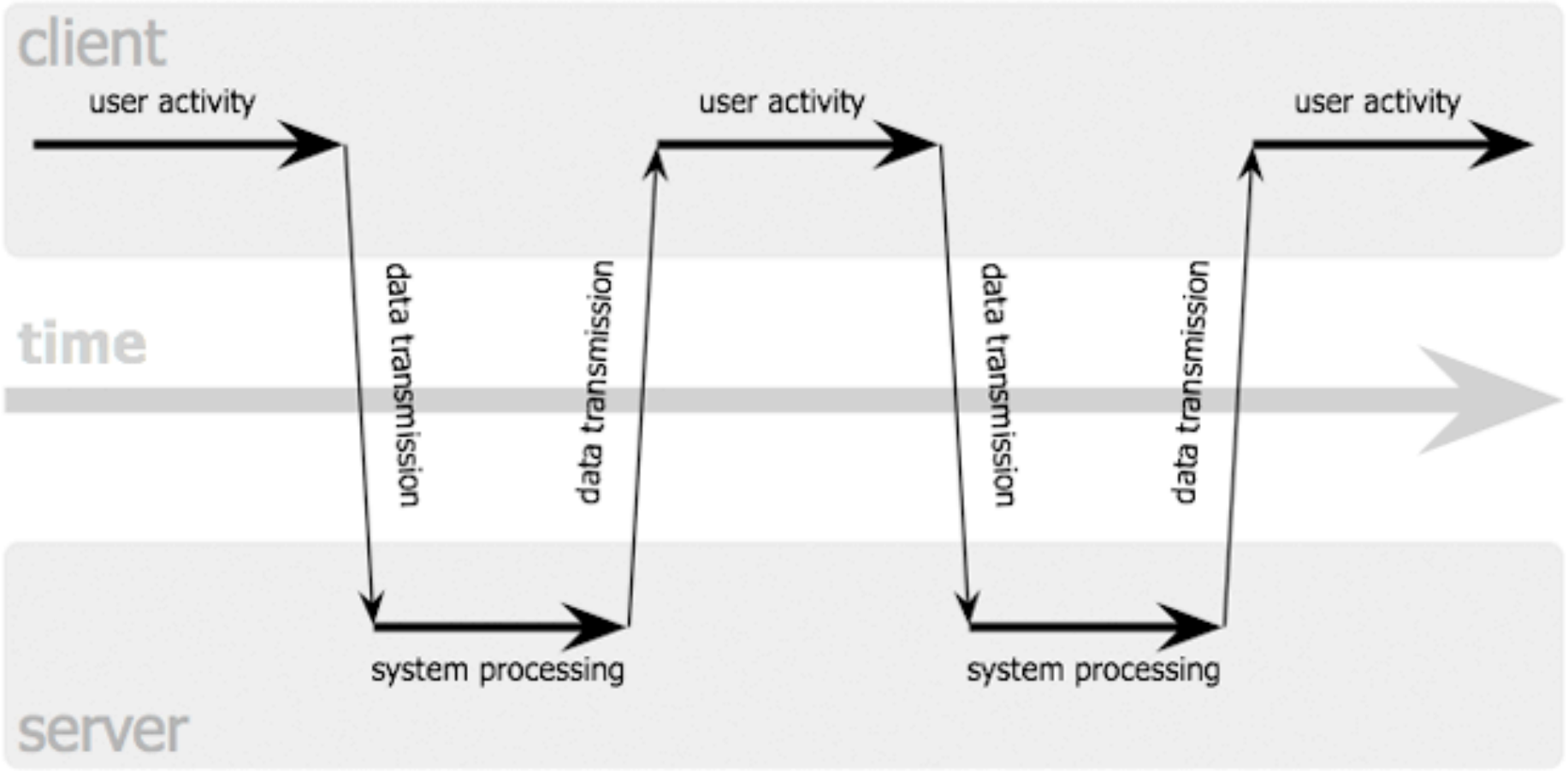
Christian Wenz: Ajax - schnell und kompakt. entwickler.press 2007

B. Brinzarea-Iamandi et al.: AJAX and PHP - Building Modern Web Applications, 2nd ed., Packt Publishing 2009

Asynchronous JavaScript + XML (AJAX)

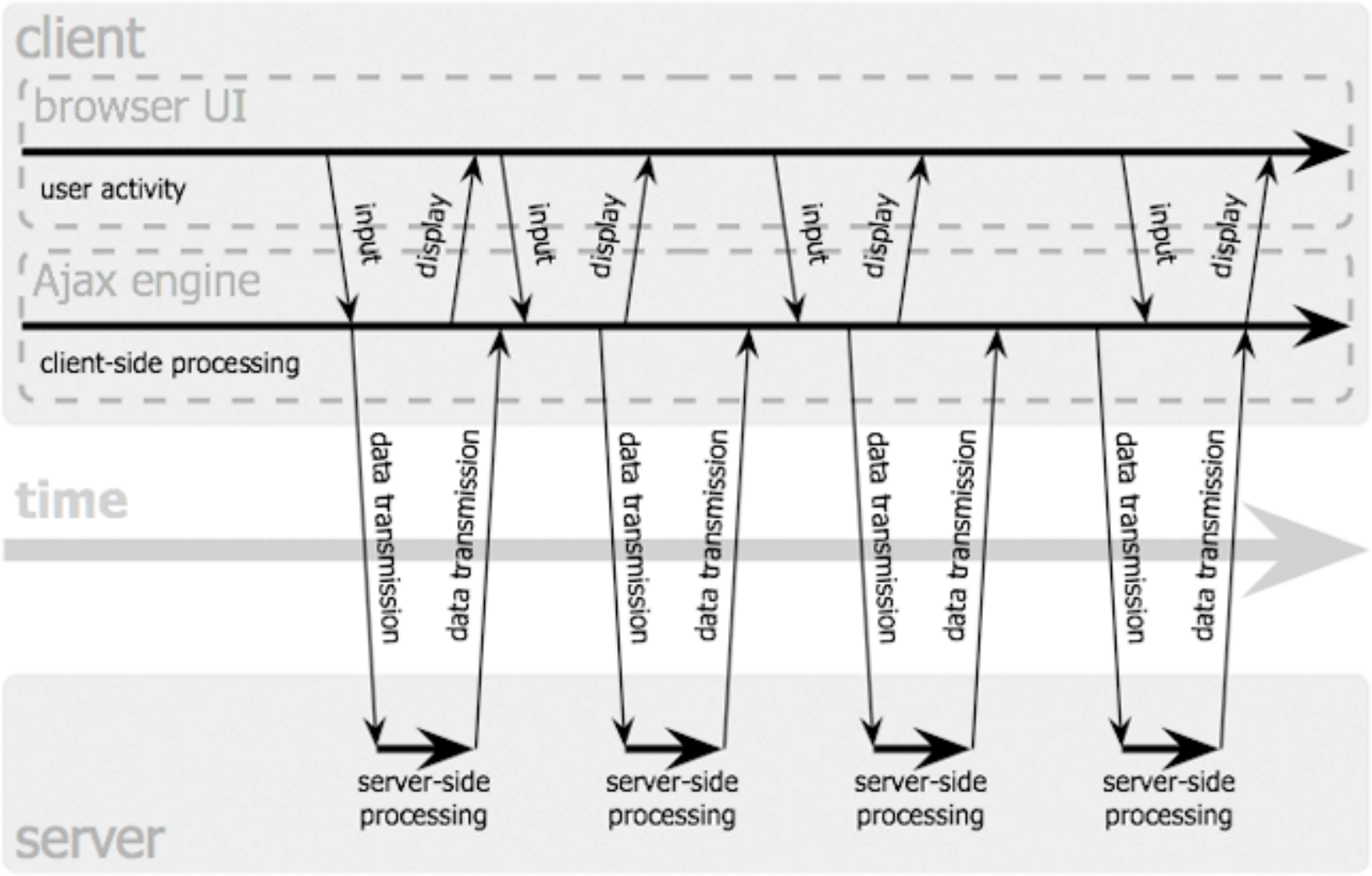
- James Garrett 2005: “Ajax: A New Approach to Web Applications”
  http://web.archive.org/web/20080702075113/
  http://www.adaptivepath.com/ideas/essays/archives/000385.php
  - Names an idea which was in use already at the time (e.g. Google Suggest)
  - Basic idea: Decouple server communication and changes in presentation
- Advantages:
  - User can interact fluidly with the application
  - Information from server is fetched in background
    – display can always stay up-to-date
- AJAX is ***not a technology***, it is a combination of known technologies
  - XHTML, CSS, DOM, XML, XSLT, JavaScript, XMLHttpRequest
- There are AJAX-like applications which use neither JavaScript nor XML
  - E.g. using Flash and querying servers in the background
  - Many applications nowadays use a different encoding than XML (e.g. JSON)

Classical Synchronous Web Application Model



Jesse James Garrett / adaptivepath.com

Asynchronous Web Application Model



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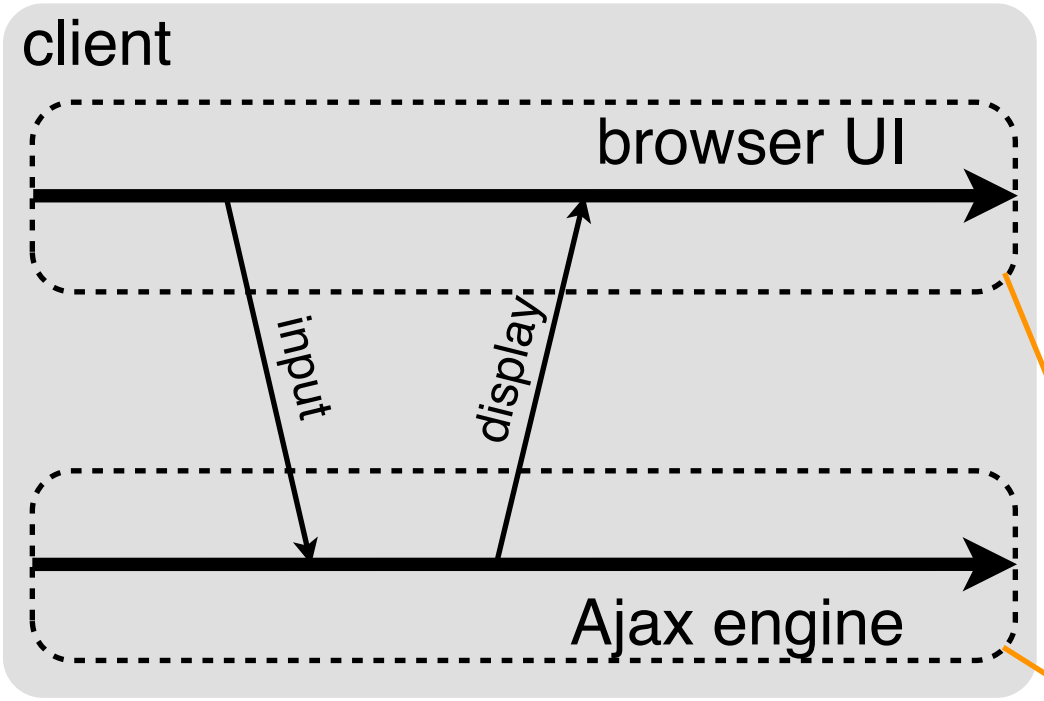
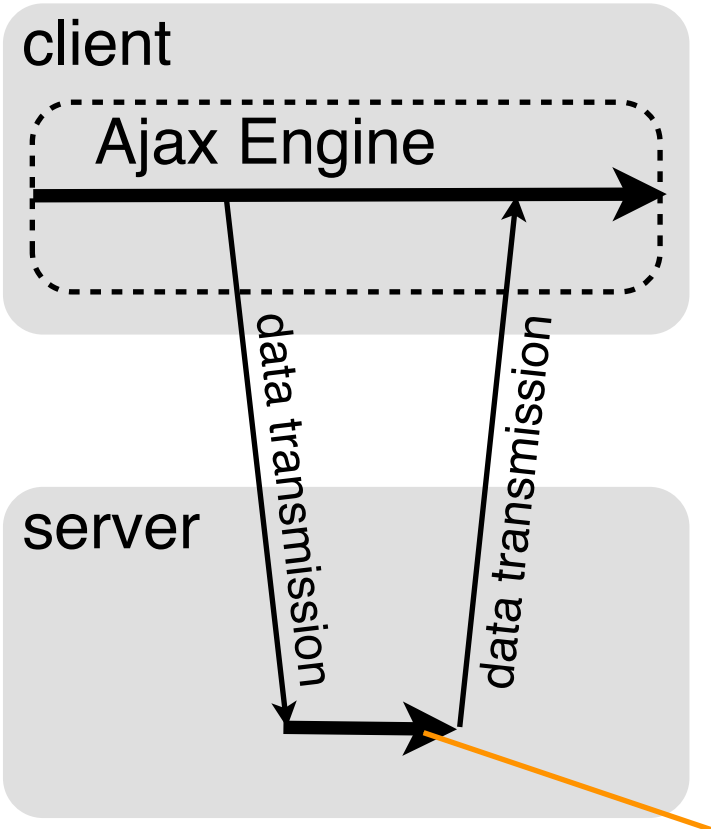
AJAX and Client-Side Scripting



- UI JavaScript
  - Access to loaded/displayed HTML via DOM
  - Flexible input elements (HTML5)
  - Graphics (HTML5 canvas)
- Engine JavaScript
  - Event handling
- jQuery is a good fit for AJAX

Written in JavaScript

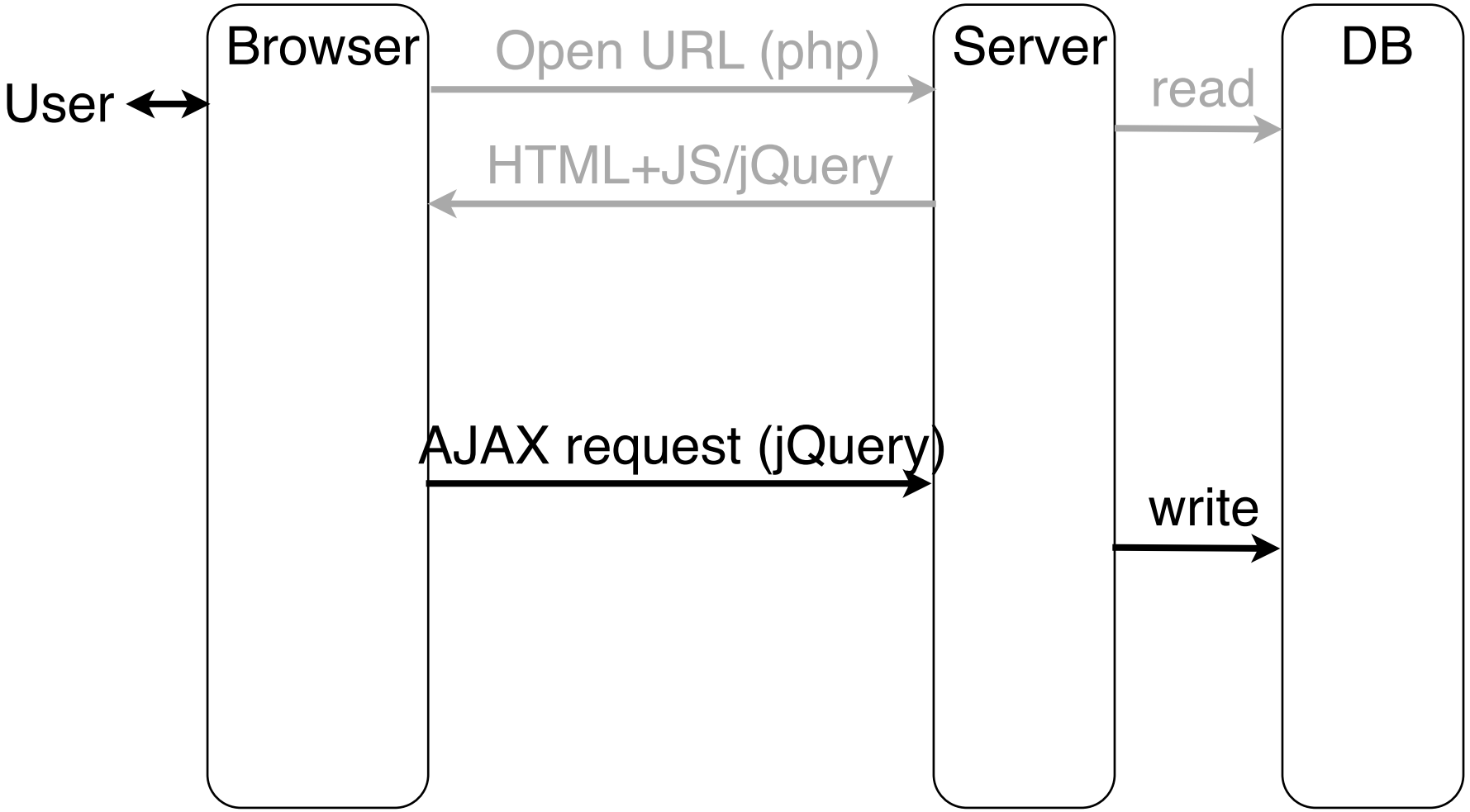
AJAX and Server-Side Scripting



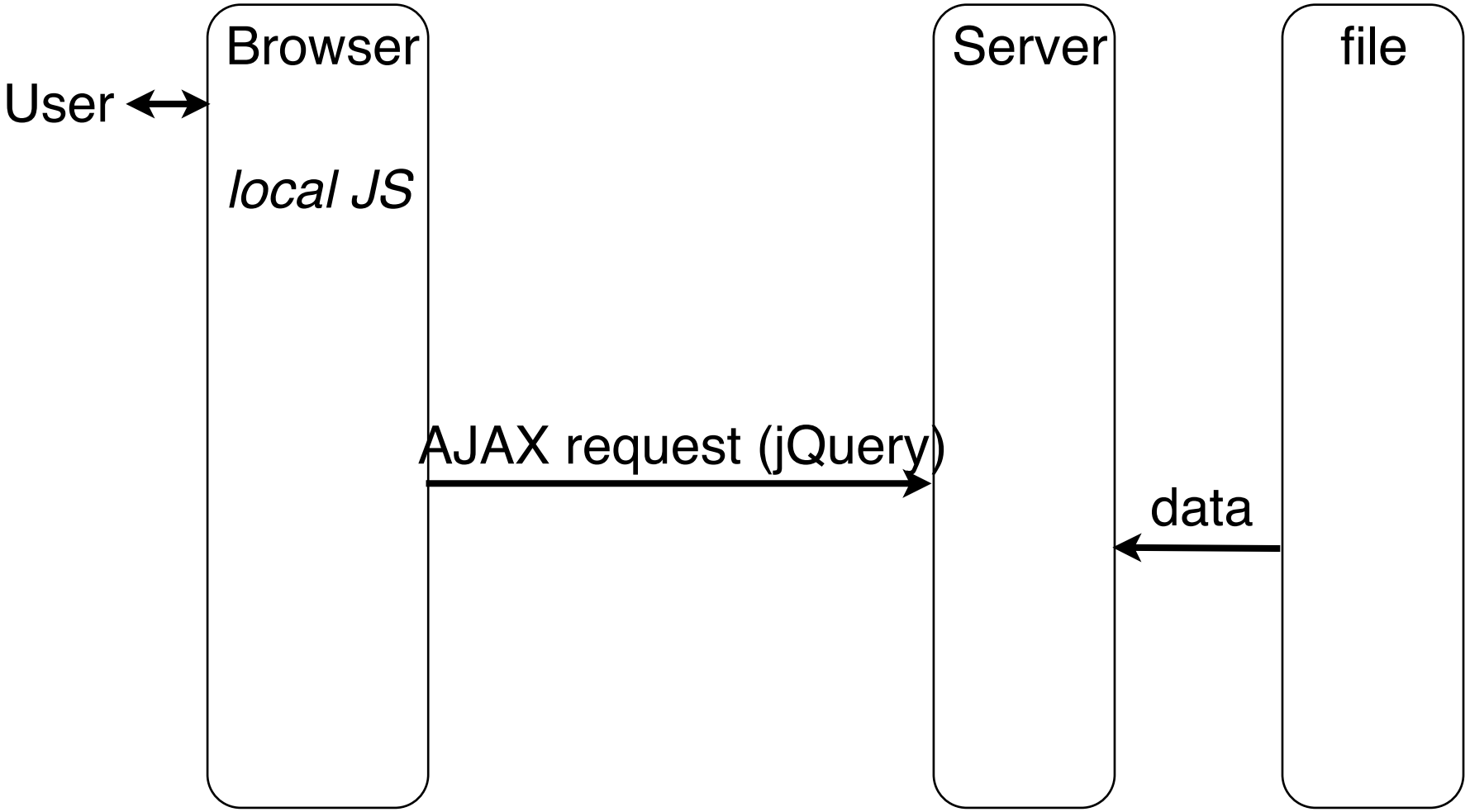
- Typical examples for asynchronous server interaction:
  - Assistance in form filling
    (search suggestions, post or bank code decoding)
  - Real-time data
    (news ticker, stock prices)
  - Event notification
    (incoming mail, update of presence status)
  - Live chat

Any language for
server-side processing
(e.g. PHP, also JavaScript)

Example 1 (Last Lecture), Using jQuery



Example 2 (Very Simple Request), Using jQuery



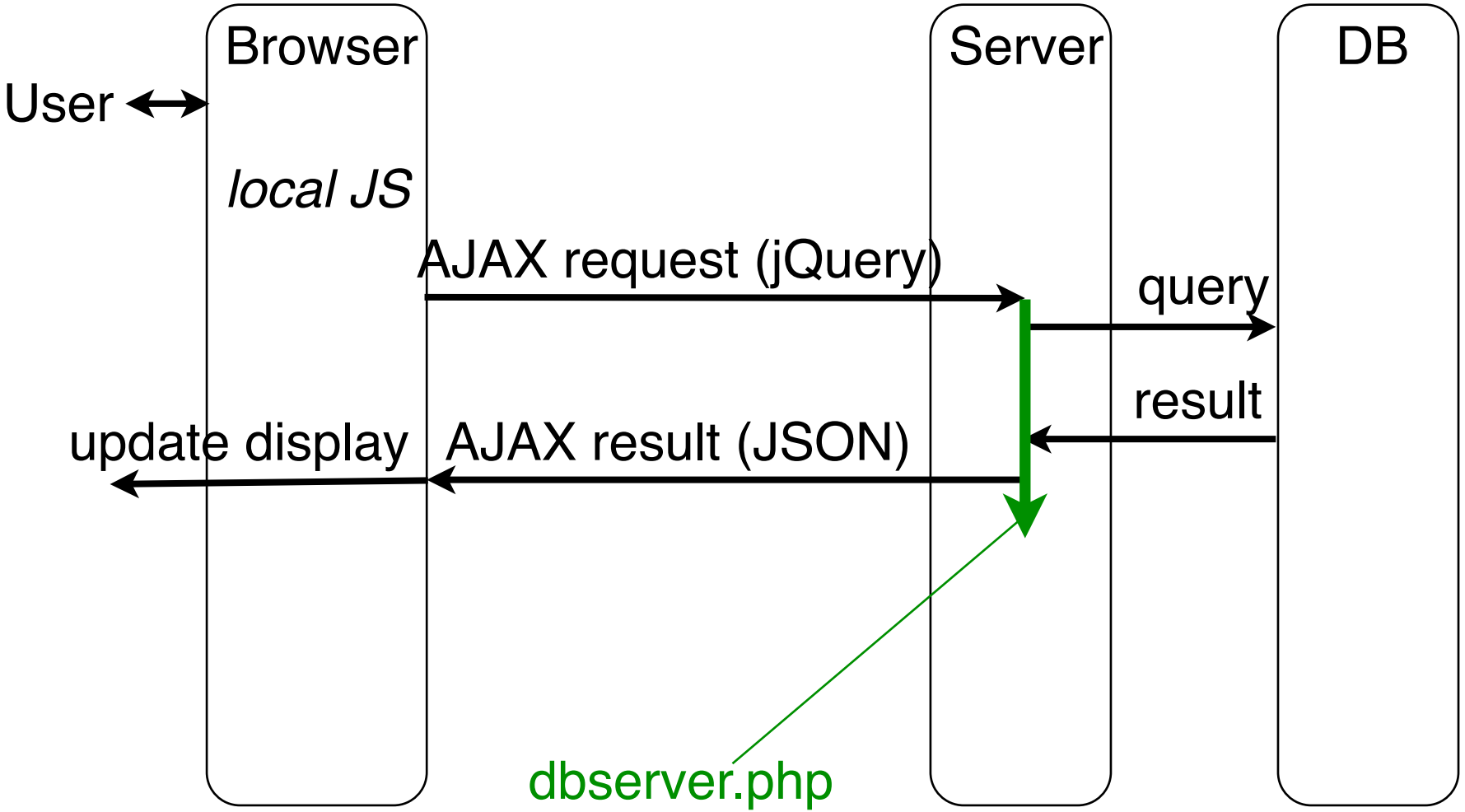
Example 2 (Very Simple Request), Using jQuery

```
<p>The following text is replaced with data retrieved from
server (data.txt):</p>
<hr/>
<p id='text'>Text to be inserted here</p>
<hr/>
<script type='text/javascript'> …
      $(document).ready( function() {
            $.ajax({
                  type: 'GET',
                  url: 'http://localhost/~hussmann/data.txt',
                  success: function(data, status) {
                        alert("Status: "+status);
                        $('#text').html(data);
                  }
            });
      });
</script>
```

Callback Function

ajaxreq_simple_txt.html

Example 3 (Answered Request), Using jQuery



Example 3 (Answered Request), DB Server

```
<?php

$link = mysql_connect('localhost','root','demopw')
 or die ('Could not connect: '.mysql_error());
mysql_select_db('music') or die ('Could not select db.');

$title = $_REQUEST['title'];
$query = "SELECT * FROM mysongs WHERE title='$title'";
$result = mysql_query($query) or die (...);
$row = mysql_fetch_array($result, MYSQL_ASSOC);
echo json_encode($row);

mysql_free_result($result);
mysql_close($link);fclose($file);

?>
```

dbserver.php

Example 3 (Answered Request), Request

```
<input id='inp_title' type='text' size='20'></input><br/>
<input id='btn' type='button' value='Search'></input>
<table id='results' class='result_displ'>
   <thead>...</thead>
   <tbody></tbody>
</table>

<script type='text/javascript'> ...
   $('#btn').click( function() {
      $.ajax({
        type: 'GET',
        url: 'http://localhost/~hussmann/dbserver.php',
        data: {title: $('#inp_title').val()},
        dataType: 'json',
        success: function(data) {
           $('#results tbody').append(
               '<tr><td>'+data.code+'</td>'+ ...</tr>'
           );
      });
    });
```

ajaxreq_result_jsn.html

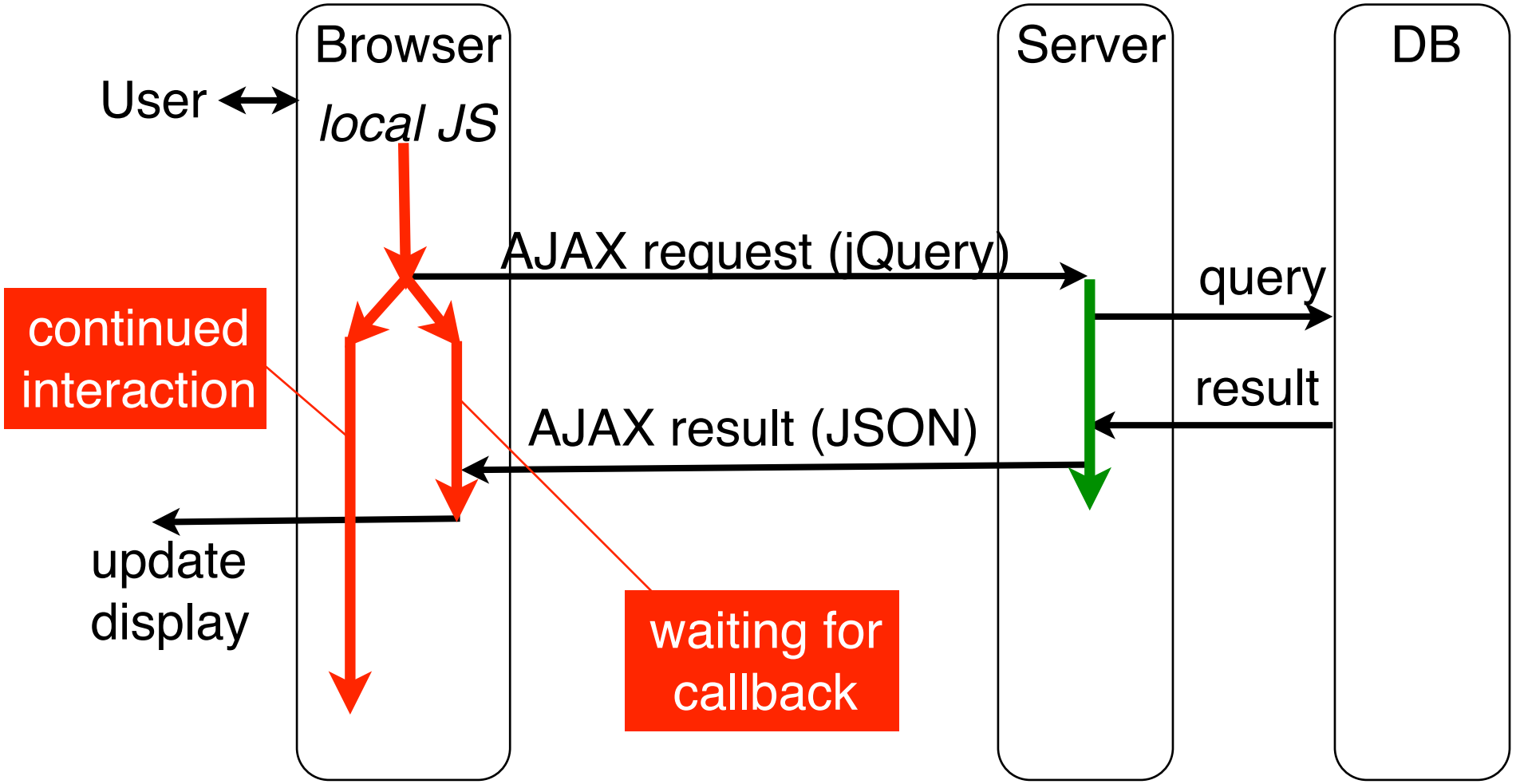
Building a List of Search Results

Search for a title name: Lady in Black

Search

Code	Title	Artist	Album	Runtime	
1	One	U2	The Complete U2	272	Remove
4	Lady in Black	Uriah Heep	Lady in Black	281	Remove

Example 3 (Answered Request), Asynchronous!



Demonstrating Asynchronicity of Handling

- Make the database server respond slowly:

  `sleep(10);` before sending the answer

- Make the currently displayed results interactive:
  - Add “remove” button in each row
  - Add event handler for removing the row (in parallel to waiting for server!)

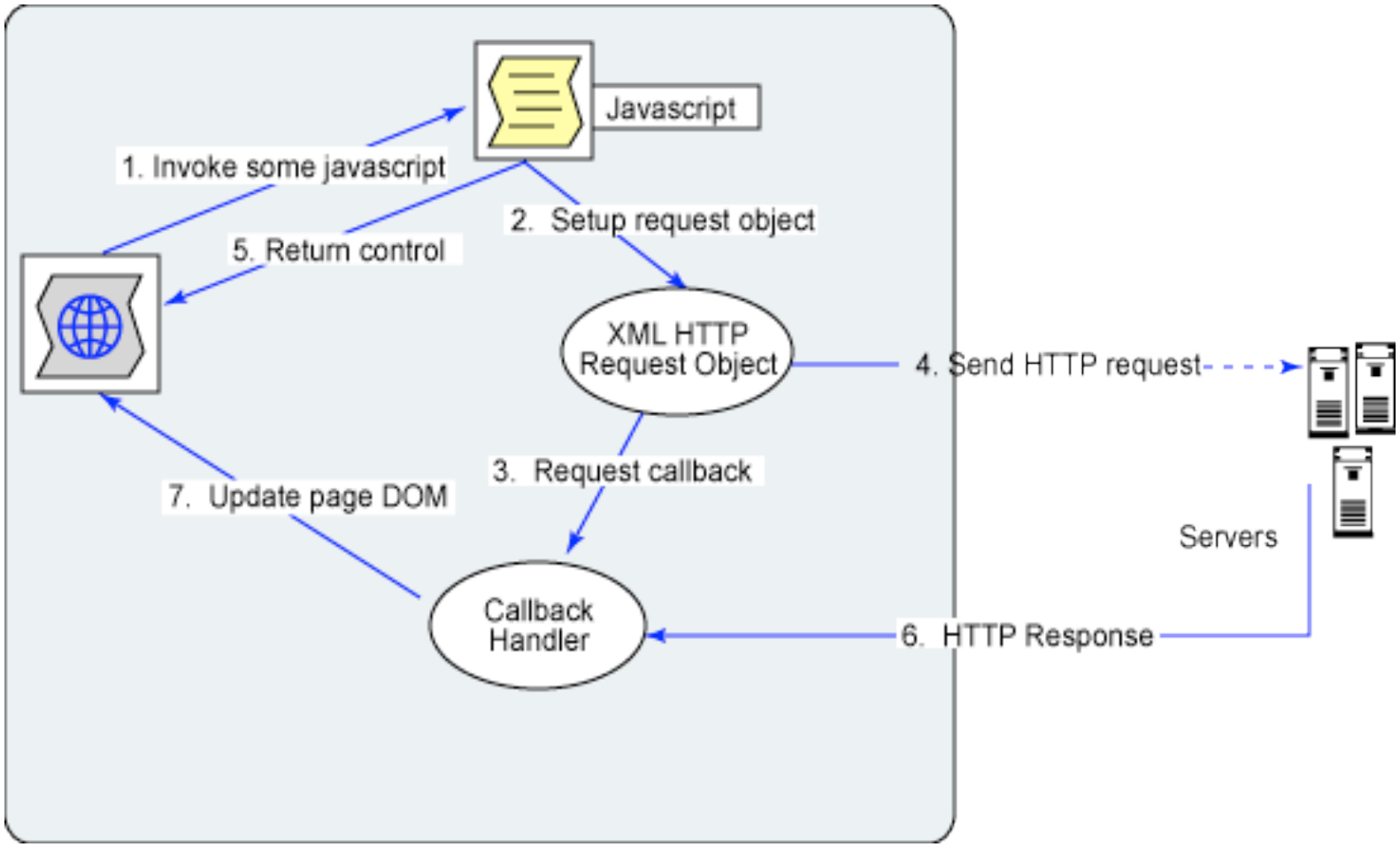
```
$('#results tbody').append(
  '<tr><td>'+data.code+'</td>'+ … +
  '<td><input type="button" value="Remove"></input></td></tr>'
).last().find('input').click( function() {
    $(this).parents('tr').remove();
  });
```

ajaxreq_result_jsn.html

AJAX Functionality (Without Using jQuery)

- Main functionalities required:
  - Construction of a request to be sent to the server
  - Sending a request to the server
  - Waiting (asynchronously) until server responds
  - Calling functions to analyze server response
- All these functionalities are realized in one single object (in the sense of object-orientation):
  - XMLHttpRequest

Basic Control Flow



http://www.ibm.com/developerworks, Dojo framework

XMLHttpRequest (XHR)

- Outlook Web Access for Internet Explorer 5 (end 90s):
  - XMLHttpRequest object invented at Microsoft
  - Realized as ActiveX object
- Mozilla 1.4 (Netscape 7.1) and derivates (including Firefox):
  - Native XMLHttpRequest object for JavaScript
  - Independent of Active X
- Other manufacturers:
  - Followed step by step: Konqueror, Apple Safari, Opera, iCab
- Since Internet Explorer 7 ActiveX no longer required
  - Just JavaScript
- Under W3C standardization (Level 2 Working Draft January 2012)
- Long term situation for creating XMLHttpRequest object will be:

```
var XMLHTTP = new XMLHttpRequest();
```

- Currently we have to fight with browser incompatibilities!
  - Frameworks like *Prototype* or *jQuery* can help

Platform Independent Creation of XMLHttpRequest

```
var XMLHTTP = null;
if (window.XMLHttpRequest) {
    XMLHTTP = new XMLHttpRequest();
} else if (window.ActiveXObject) {
    try {
        XMLHTTP = new ActiveXObject("Msxml2.XMLHTTP");
    } catch (ex) {
        try {
            XMLHTTP = new ActiveXObject("Microsoft.XMLHTTP");
        } catch (ex) {}
    }
}
```

IE >= 7.0 or standard

For older IE versions than 6.0

Construction of an HTTP Request

- `open()` method of XMLHttpRequest object
  - Note: No interaction with the server yet, despite the name!
- Required parameters:
  - HTTP method: GET, POST or HEAD
  - URL to send the request to
- Optional parameters:
  - Boolean indication whether to use asynchronous or synchronous treatment (default asynchronous = true)
  - Username and password for authentication

- Examples:

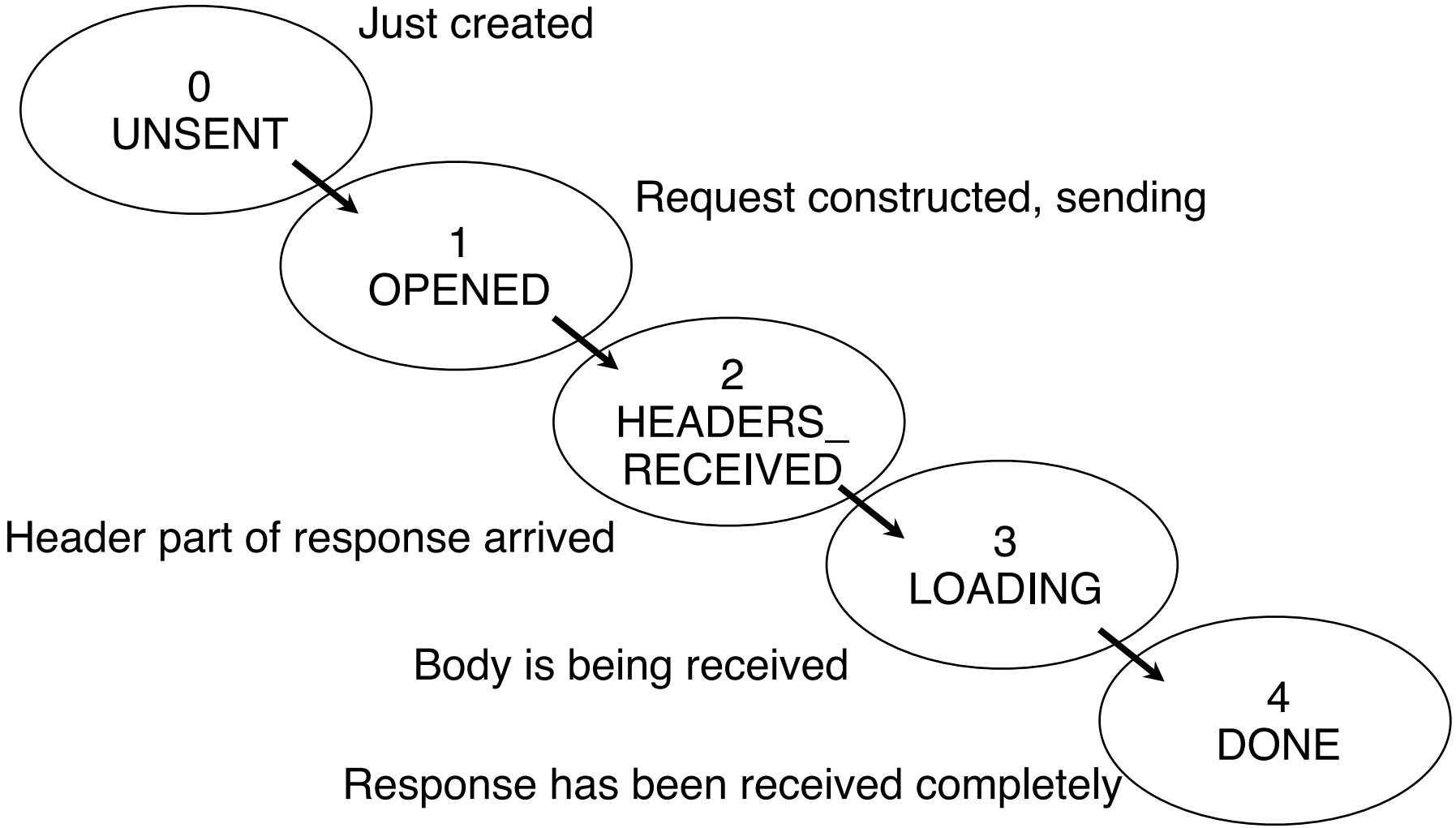
```
XMLHTTP.open("GET", "fibonacci.php?fib=12")
XMLHTTP.open("POST", "/start.html", false, un, pwd);
```

Sending a Request

- Before sending: **`XMLHTTP.setRequestHeader()`**
  - Setting headers for the request
  - Recommended: **`Content-Type`** (MIME type)

- **`XMLHTTP.send()`**
  - Sends request to server
- Parameter:
  - In the simplest case (in particular for GET method): **`null`**
  - For more complex cases:
    "Request entity body" is given as parameter
    - » Mainly for POST method

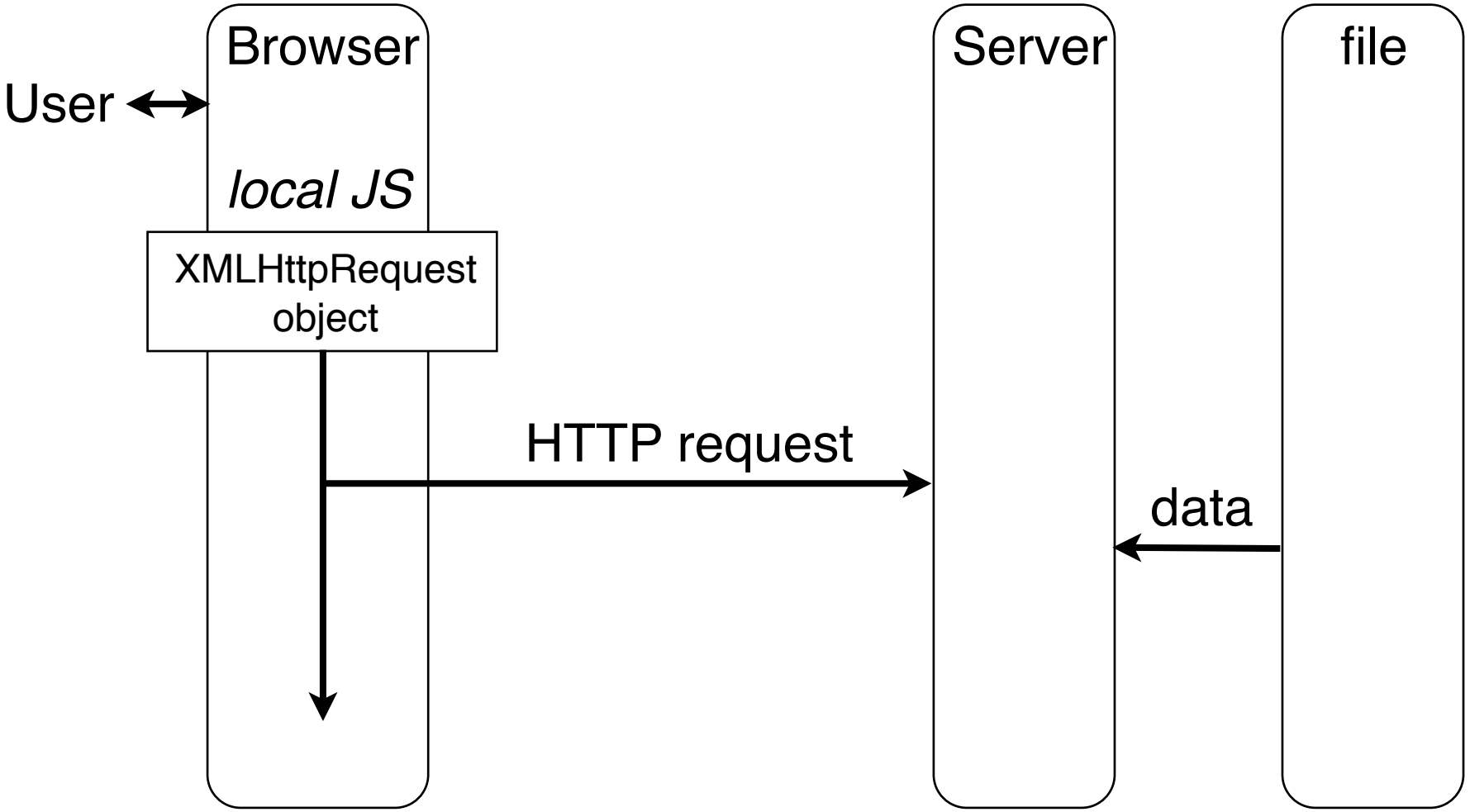
States of an XMLHttpRequest Object



Asynchronous Reaction by Event Handler

- In order to react to the received response:
  - Function has to be called when state 4 is reached
- Registering an event handler:
  - Callback function, called when event takes place
- Registering an Ajax event handler:
  - Callback method registered with **`XMLHttpRequest`** object
  - Event **`readystatechange`**, called at *any* state change
    - **`XMLHTTP.addEventListener ("readystatechange", function);`**
- Testing for the current state by attributes of **`XMLHttpRequest`** object:
  - **`readystate`** gives current state (as number)
  - **`status`** gives return code, **`statusText`** gives associated text
- Returned response: **`responseText`** and **`responseXml`** attributes

Example 2 (Very Simple Request), Without jQuery



Example 2 (Very Simple Request)

```
<body>
  <p>The following text is replaced with data retrieved from
  server (data.txt):</p>
  <hr/>
  <p id='text'>Text to be inserted here</p>
  <hr/>
…
  <script type = "text/javascript">
    var XMLHTTP = new XMLHttpRequest();
    document.addEventListener("DOMContentLoaded",function() {
      XMLHTTP.open("GET",
         "http://localhost/~hussmann/data.txt", true);
      XMLHTTP.addEventListener("readystatechange",function() {
        if (XMLHTTP.readyState == 4) {
          alert("Status: "+XMLHTTP.statusText);
          var d = document.getElementById("text");
          d.innerHTML = XMLHTTP.responseText;
        }
      }, false);
      XMLHTTP.send(null);
    }, false);
  </script>
</body>
```

ajax/simplerequest.html

Example XML Data

```
<?xml version="1.0" encoding="UTF-8"?>
<ResultSet totalResultsAvailable="24900000"
   totalResultsReturned="10">
  <Result>
    <Title>AJAX - Wikipedia</Title>
    <Summary>Background about the web development technique for
   creating interactive web applications.</Summary>
    <Url>http://en.wikipedia.org/wiki/AJAX</Url>
  </Result>
  <Result>
    <Title>Ajax: A New Approach to Web Applications</Title>
    <Summary>Essay by Jesse James Garrett from Adaptive Path.</
   Summary>
    <Url>http://www.adaptivepath.com/p...s/000385.php</Url>
  </Result>
  <Result>
    <Title>AFC Ajax</Title>
    <Summary>Official site. Club information, match reports, news,
   and much more.</Summary>
    <Url>http://www.ajax.nl/</Url>
  </Result>
</ResultSet>
```

From C.Wenz

AJAX Program Creating a HTML Table from XML

- HTML text template (coded in HTML on the result page):

```
<body>
  <p>
    <span id="number">0</span> of
    <span id="total">0</span> hits:
  </p>

  <table id="hits">
    <thead>
     <tr><th>Title</th><th>Description</th><th>URL</th></tr>
    </thead>
  </table>
</body>
```

Script has to fill the missing data from XML response.
Basic structure of script as above.

Adapted from C.Wenz

AJAX Callback Function for XML Using DOM (1)

```
function() { //event handler for readystatechange

  if (XMLHTTP.readyState == 4) {
    var xml = XMLHTTP.responseXML;

    var number = document.getElementById("number");
    var total = document.getElementById("total");
    number.innerHTML = xml.documentElement.getAttribute
      ("totalResultsReturned");
    total.innerHTML = xml.documentElement.getAttribute
      ("totalResultsAvailable");

    var hits = document.getElementById("hits");
    var tbody = document.createElement("tbody");

    var results = xml.getElementsByTagName("Result");
    ...
```

AJAX Callback Function for XML Using DOM (2)

```
... for (var i=0; i<results.length; i++) {
      var line = document.createElement("tr");
      var title = document.createElement("td");
      var description = document.createElement("td");
      var url = document.createElement("td");
      var titletext, descriptiontext, urltext;
      for (var j=0; j<result[i].childNodes.length; j++) {
        var node = results[i].childNodes[j];
        switch (node.nodeName) {
          case "Title":
            titletext = document.createTextNode(
              node.firstChild.nodeValue);
            break;
          case "Summary":
            descriptiontext = document.createTextNode(
              node.firstChild.nodeValue);
            break;
          case "Url":
            urltext = document.createTextNode(
              node.firstChild.nodeValue);
            break;
        }
      }
```

AJAX Callback Function for XML Using DOM (2)

```
... for (var i=0; i<ergebnisse.length; i++) {
      ...
      for (var j=0; j<ergebnisse[i].childNodes.length; j++) {
      ...
      title.appendChild(titletext);
      description.appendChild(descriptiontext);
      url.appendChild(urltext);

      line.appendChild(title);
      line.appendChild(description);
      line.appendChild(url);
      tbody.appendChild(line);
    }
    hits.appendChild(tbody);
  }
}
```

ajaxXML.html

A More Realistic Example

- Using a Web service for post code lookup
  - **http://api.geonames.org/**
    postalCodeLookupJSON?
    postalcode=*pc* & country=*cy*?
    username=*registered_user*
  - Returns a JSON text object containing descriptions about the location
    - » Administrative region names, place name, latitude, longitude
- Example:
  - **http://api.geonames.org/postalCodeLookupJSON?**
    postalcode=80333&country=DE
  - gives the following result:
  - **{"postalcodes":**
    [{"adminCode3":"09162","adminName2":"Oberbayern",
    "adminName3":"München","adminCode2":"091",
    "postalcode":"80333","adminCode1":"BY",
    "countryCode":"DE",
    "lng":11.5668,"placeName":"München",
    "lat":48.1452,"adminName1":"Bayern"}]}

Post Code Example (1)

- HTML:

```
<!html> ...
<body>
  <label for="country">Country</label>
  <select id="country">
    <option value="DE" selected>Germany</option><
    <option value="UK">UK</option>
  </select><br/>
  <label for="postalCode">Postal Code</label>
  <input type="text" id="postalCode" value="82327"><br/>
  <input type="button" id="search"
       value="Search place name"><br/>
  <label for="placeName">Name</label>
       <input type="text" id="placeName" size=28>
</body>
```

- followed by JavaScript...:

Post Code Example (2)

- … followed by JavaScript:

```
<script type = "text/javascript">
  var XMLHTTP = new XMLHttpRequest();
  XMLHTTP.addEventListener
    ("readystatechange", function() {
        if (XMLHTTP.readyState == 4) {
          var p = document.getElementById("placeName");
          var resultobj =
            JSON.parse(XMLHTTP.responseText);
          p.value = resultobj.postalcodes[0].placeName;
        }
    }, false);
```

- ...continued...

Post Code Example (3)

...continued:

```
  document.getElementById("search").
   addEventListener("click", function() {
     var country =
       document.getElementById("country").value;
     var postalCode =
       document.getElementById("postalCode").value;
     if (XMLHTTP.readyState != 0)
       XMLHTTP.abort();
     XMLHTTP.open("GET",
      "http://api.geonames.org/postalCodeLookupJSON?
      postalcode="+postalCode+"&country="+country+
      "&username=XXXX", true);
     XMLHTTP.send(null);
   }, false);


</script>
```

postcode_direct.html

Postcode Lookup “As You Type”

- Using the preceding example, change one line:

```
document.getElementById("postalCode").
  addEventListener("input", funtion() {...}, false);
```

- Continuousy sending requests when a character is typed
- Can evaluate incomplete input
  - Example: UK/LA1 (complete for instance to LA1 4WY)

postcode_live.html

Problems with AJAX

- Back button
  - Browsers do not store dynamically modified pages in history
- Bookmarks
  - It is difficult to set a bookmark at a specific state of a dynamically created flow of pages
  - Option: use document-internal anchors (#)
- Indexing by search engines

Chapter 3: Web Paradigms and Interactivity

Basic Web Paradigms: Documents

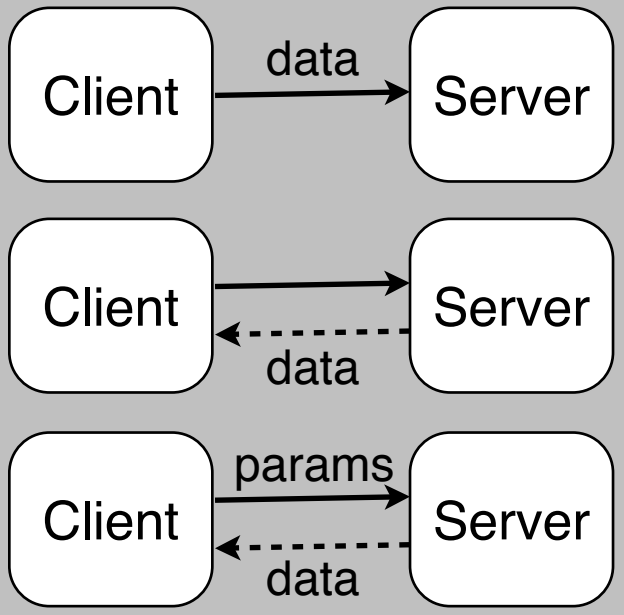
- HTML:
  - Originally intended for scientific papers: Limited structure
  - Purely static
  - Not object-oriented
- HTML5:
  - More flexible structure, graphics output, input elements, media playback
- DOM:
  - Dynamic changes of documents
- CSS:
  - Separation content/presentation, presentation classes
- JavaScript:
  - Dynamic changes, object-orientation

Basic Web Paradigms: Communication

- HTTP:
  - Request-response architecture:
    - » Requests have to be initiated by client
  - Restricted parameter syntax (keyword-value pairs)
  - Synchronicity: Client has to wait for response
- AJAX:
  - Enables asynchronous handling of requests in client
- Basic restriction to request ➔ response remains!
  - “Client-driven” architecture

Types of Client-Server Interaction

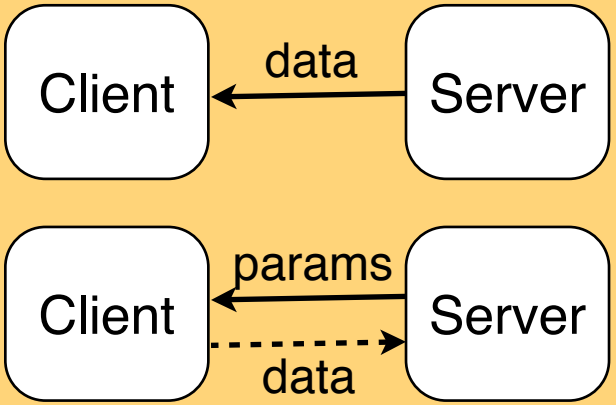
Client-driven



Send data to server
Example 1: Sending shopping cart contents
Other examples: Location update, logging

Pull data from server
Example 2: Very simple request

Pull selected data from server
Example 3: Database query
Manifold other examples



Push data from server to client
Examples: New mail, breaking news, chat

Request data from client
Examples: Status inquiry, security check

Server-driven

Server-Driven Applications in the Web

- Frequent and easy solution: ***Polling***
  - Client sends requests to server in regular intervals
- Disadvantages:
  - Redundant load to client, server, network
  - Changes traffic characteristics
  - Limited time resolution for real-time events
- Alternatives:
  - (a) “Reverse AJAX”/”COMET” – Tricking the Web architecture
  - (b) Going beyond traditional HTTP

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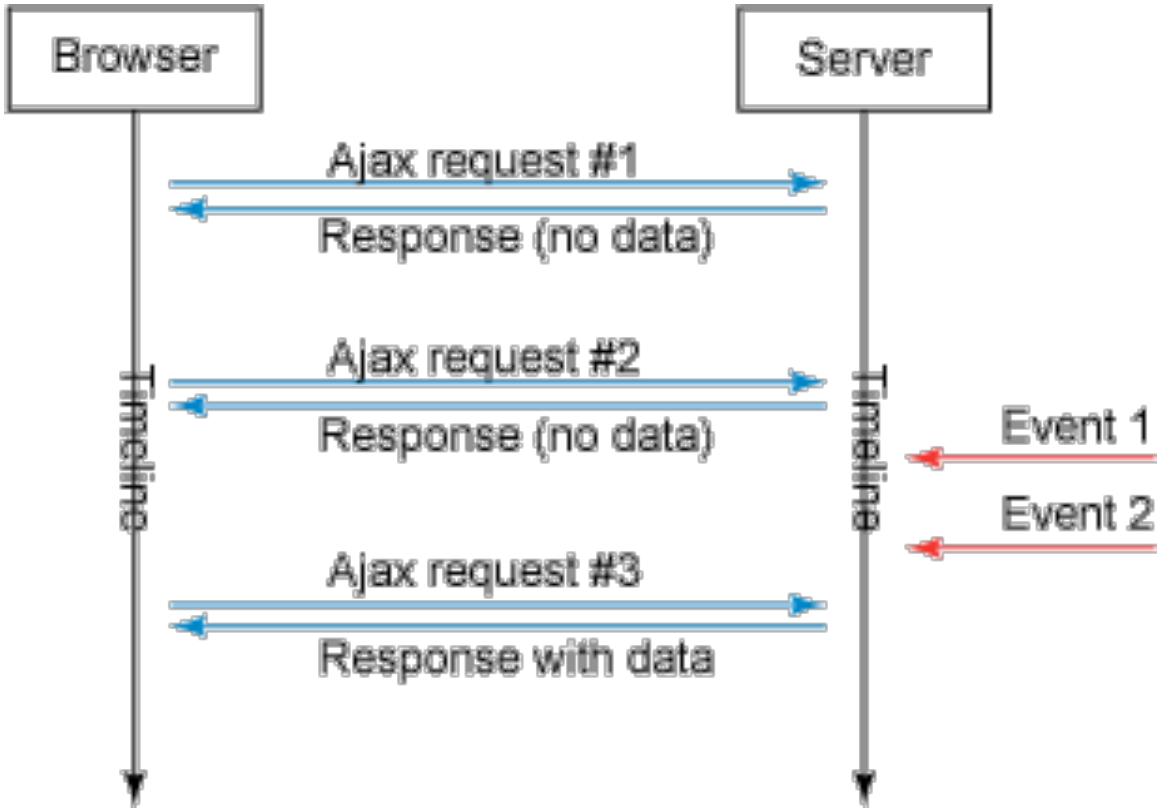
Literature:

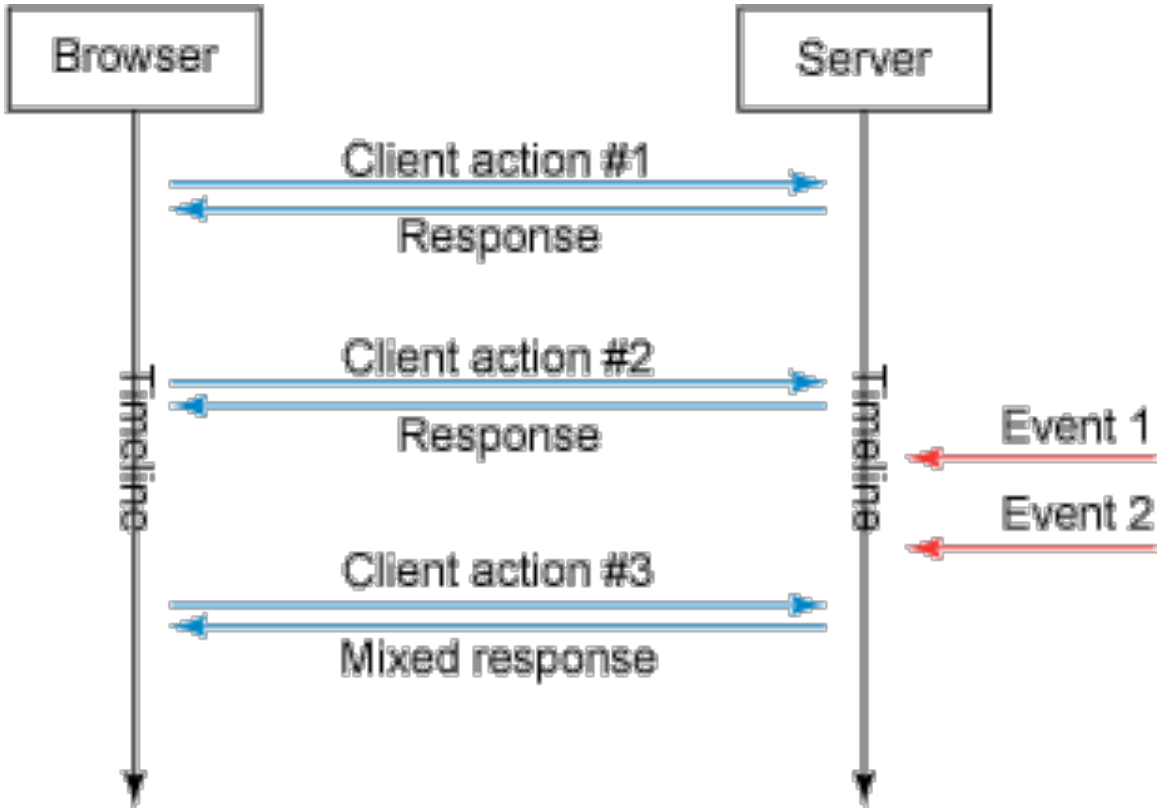
Mathieu Carbou: Reverse Ajax, Part 1: Introduction to Comet, http://www.ibm.com/developerworks/web/library/wa-reverseajax1/

Reverse Ajax with HTTP Polling



- Server event information pulled by client through regular polling
- Easily realizable in JavaScript using “setInterval()”
- High network load, imprecise timing

Reverse Ajax with Piggyback Polling

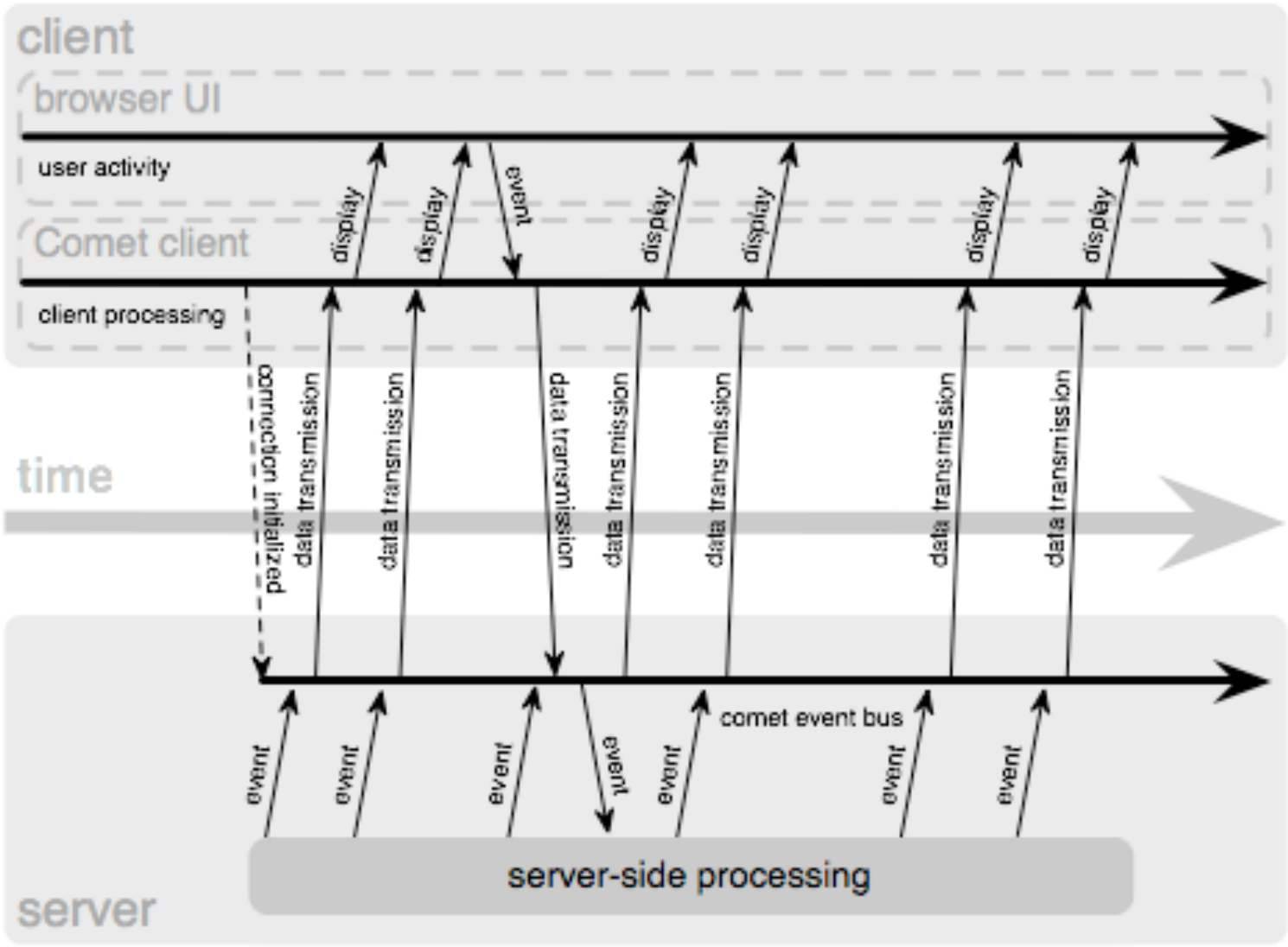


- Assuming different needs for information exchange between client and server
- Whenever a client-triggered request is processed, additional information about latest server-side events is added to the response

Reverse Ajax with the Comet Model

- Proper support for asynchronous server-side events:
  - Requires availability of a channel for the server to push new information to the client
  - Server-client connections needs to be maintained over a long period of time
- Alex Russell 2006 (Blog) http://infrequently.org/2006/03/comet-low-latency-data-for-the-browser/
  - Web Applications exist which use server-side events and long-lived client-server connections (Gmail GTalk, Meebo)
  - "Lacking a better term, I've taken to calling this style of event-driven, server-push data streaming "Comet". It doesn't stand for anything, and I'm not sure that it should."
    (Both Ajax and Comet are brands for household cleaners.)
  - Other terms for the same idea: Ajax Push, HTTP Streaming, HTTP server push
    - » Sometimes also Reverse Ajax...

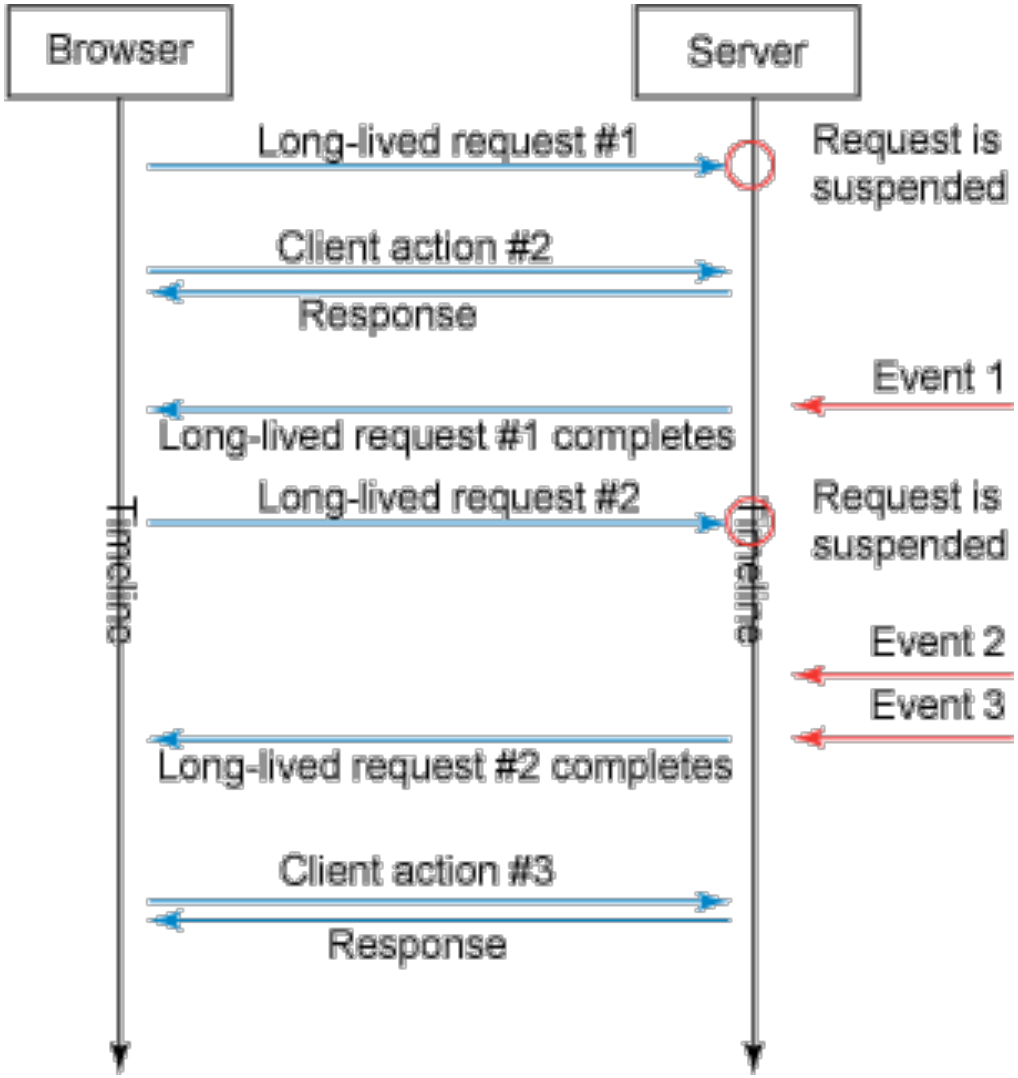
Comet Web Application Model



Connection Management in Comet

- Comet based on *HTTP Streaming*:
  - A single TCP/IP connection is kept open between client and server
  - For instance using the “multipart response” supported by many browsers
    - » Going back to the “server push” feature implemented by Netscape in 1995, e.g. to send new versions of an image by the server
    - » Response is “stretched over time”
- Comet based on *Long Polling*:
  - Standard XMLHttpRequest sent by client
  - Server suspends response until event happens
    - » Specific programming techniques on server required
    - » Storing the request context
  - As soon as client receives response (and processes it), client sends new request (which is suspended again)
  - Relatively easy to realize with current browsers and XMLHttpRequest

Reverse Ajax with Comet



- Client request is suspended at server
- Server responds to the request each time a new server-side event happens

Chapter 3: Web Paradigms and Interactivity

Literature:

Mathieu Carbou: Reverse Ajax, Part 2: Web Sockets,
http://www.ibm.com/developerworks/web/library/wa-reverseajax2/

http://websocket.org

General Idea and General Problem

- Idea:
  - Web client (browser) communicates at the same time and in the same data space with several different hosts
  - See “post code” example
- Security problem: “Cross-site scripting”
  - Web application A gets access to data from Web application B
  - In the worst case including authentication data
- Current principle in browsers:
  - Only one Web application at a time communicates with a browser instance
  - Being relaxed in new approaches (under security precautions)

Web Messaging

- HTML5 Web Messaging
  - Draft by W3C, driven by Google
  - Most recent version October 25, 2011
- Document A, if knowing about another document B, can send a (text) message to document B (on a different domain)
- Specific *iframe* in document A calls **`postMessage()`** referring to domain and window of document B.
- Document B can handle the event in event handler
  - Gets information about origin, ***which needs to be checked***
  - Document B checks format of message and takes additional precautions
- Simple to use, high security risks

WebSockets

- Originated in HTML5 (WHAT Working Group)
  - HTML5 Web Sockets specification
  - Full-duplex communication channel between client and server
  - Establishment (“handshake”) client-initiated, over HTTP
  - One connection for bi-directional communication, very small latency
    - » “sub 500 millisecond” latency
  - Able to traverse firewalls and proxies (port 80)
  - Secure connection can be used (HTTP/S)
- Has been separated out of HTML5
  - API developed by W3C, protocol (“ws:”) standardized as IETF RFC 6455
  - Browser support growing recently
    - » Earlier unsecure version disabled
    - » Secure Websockets: Firefox 6, Chrome 14, Safari 6, Opera 12, IE10
  - Server support growing
    - » e.g. Java servers: Tomcat 7, GlassFish 3.1, JBoss 7, IIS 8, ASP.NET 4.5

WebSocket Client API (JavaScript)

- Connect to an endpoint (WebSocket handshake):

```
var myWebSocket =
  new WebSocket("ws://www.websockets.org");
```

- Associate event handlers to established connection:

```
myWebSocket.addEventListener("open", function);
myWebSocket.addEventListener("message", function);
myWebSocket.addEventListener("close", function);
```

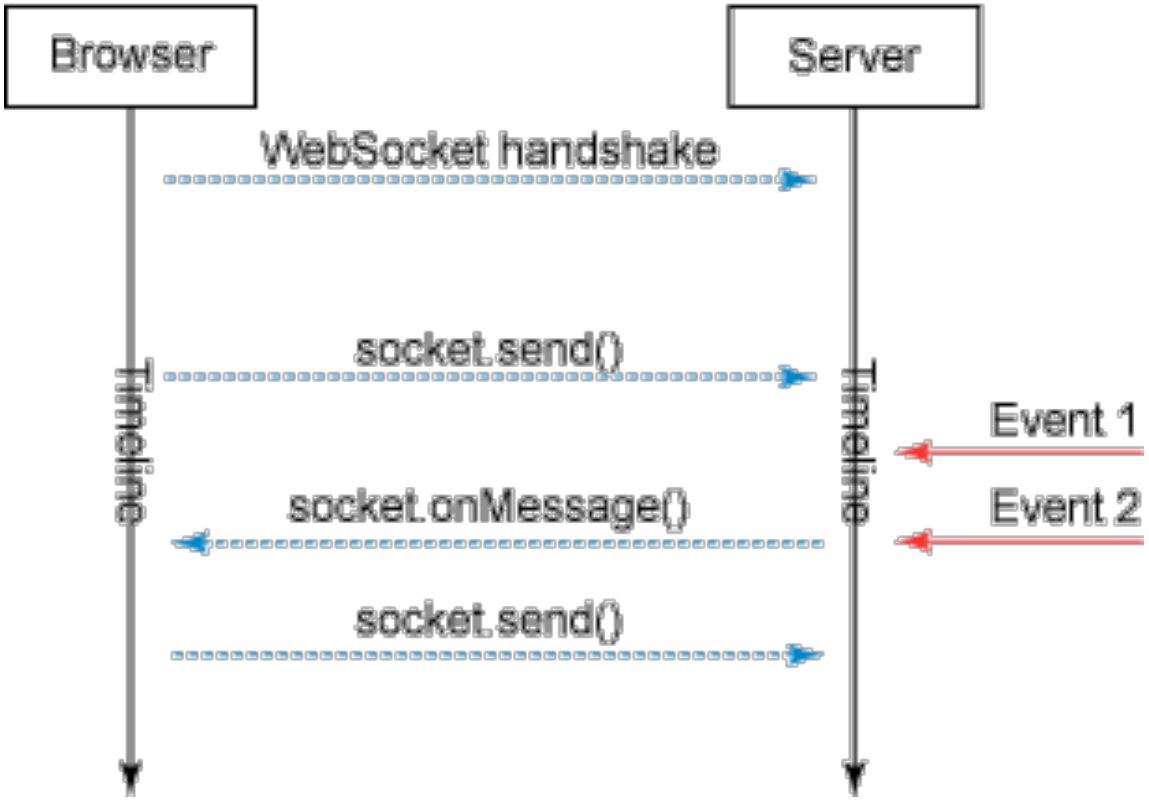
- Send message to server over established connection:

```
myWebSocket.send("hello");
```

- Disconnect from endpoint:

```
myWebSocket.close();
```

Reverse Ajax with WebSockets



- Simple, low-latency solution
- New standard, not yet widely used – probably the way to go in future
- *Abstraction APIs* help to keep programs independent of transport
  - See e.g. socket.IO

Chapter 3: Web Paradigms and Interactivity

Literature:

B. Lawson, R. Sharp: Introducing HTML5, New Riders 2011

Threading in Web Browsers

- Thread = Sequence of instructions to be executed
  - May be in parallel to other threads
  - May be part of a larger process (together with other threads)
- Traditionally, Web browsing is *single-threaded*
- Complex Web applications (and multimedia) require *multi-threading*
  - Example: Asynchronous interaction in Ajax and Reverse Ajax
  - Example: Playing back a movie/sound, being still able to control it
  - Example: Synchronizing a movie with subtitles or animations
  - Example: Long loading time for multimedia document – user has decided to do something else
  - Example: Independent animations on a single page (content and advertisement)
- Web Worker:
  - Specification for light-weight JavaScript threads in browsers
  - Originated by WHATWG, now separated from HTML5
  - Supported e.g. in Safari, Chrome, Opera and Firefox

Principles for Using Web Workers

- Creating a new worker:
  - `var worker = new Worker("my_worker.js");`
- Sending a message to the worker:
  - `worker.postMessage("hello worker");`
- Receiving a message from the worker:
  - `worker.addEventListener("Message", function, false);`
  - `function (event) { … event.data … }`
- What a worker can do:
  - Communicate, including Web Messaging and Web Sockets
  - Send and process Ajax requests
  - Establish timers
  - Basic JavaScript (but ***no*** DOM access)
  - Web SQL databases
  - Web Workers (!)
- Shared Worker: Working with multiple documents