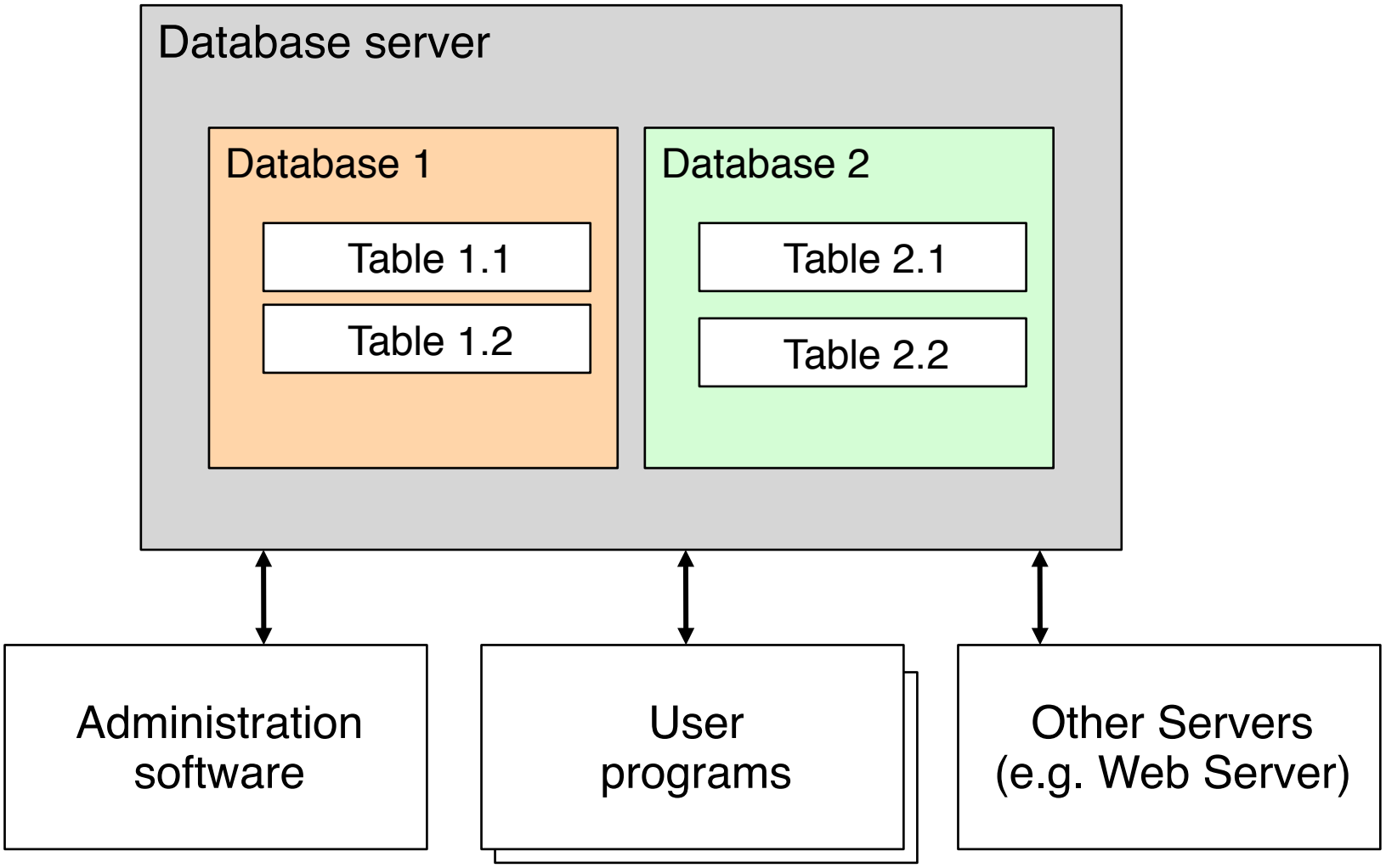
Chapter 2: Interactive Web Applications

Database Management Systems: A Quick Reminder

- Database:
  - Structured collection of data items
  - Stored persistently
  - Provides access to a common data pool for multiple users
- Database Management System (DBMS):
  - Collection of programs for administration and usage of a database
  - Various base models for DBMS:
    - » Old: network model, hierarchical model
    - » Dominant: relational model
    - » Alternative: object-oriented model
- Relational databases:
  - Good methodological support for design of data schema
  - Standardized language interface SQL (Structured Query Language)

Prerequisites and Basic Architecture



MySQL

- Open source software system
  - Frequently used also in commercial context
  - www.mysql.com
- Software package providing:
  - Database server (mysqld)
  - Administration program (mysqladmin)
  - Command line interface (mysql)
  - Various utility programs
- Communication between programs on local host: *socket* interface
  - Bidirectional data stream exchange between programs
  - Similar to files

```
innochecksum                    mysqlaccess.conf
msql2mysql                      mysqladmin
my_print_defaults               mysqlbinlog
myisam_ftdump                   mysqlbug
myisamchk                       mysqlcheck
myisamlog                       mysqld
myisampack                      mysqld-debug
mysql                           mysqld_multi
mysql_client_test               mysqld_safe
mysql_client_test_embedded      mysqldump
mysql_config                    mysqldumpslow
mysql_convert_table_format      mysqlhotcopy
mysql_find_rows                 mysqlimport
mysql_fix_extensions            mysqlmanager
mysql_fix_privilege_tables      mysqlshow
mysql_secure_installation       mysqlslap
mysql_setpermission             mysqltest
mysql_tzinfo_to_sql             mysqltest_embedded
mysql_upgrade                   perror
mysql_waitpid                   replace
mysql_zap                       resolve_stack_dump
mysqlaccess                     resolveip
```

Before Creating Anything in the Database...

- Using a database requires careful *information design.*
- Which are the data to be stored?
- Are there existing data to connect to?
- What is the ***schema*** of the data to be stored?
  - E.g. Entity-Relationship diagrams as a tool
  - Transformation into relational database schema (table design)
- Once a database is filled with data and in use, it is difficult to modify!
  - Database schema design has to be carried out with great care!
- Most important rule: Avoid redundant storage of information
  - But keep performance in mind...

Creating Database Tables (1)

- Prerequisites:
  - Database server running
  - Socket connection between programs intact
  - User accounts with adequate privileges known
- First step: Create ***database***
  - Container for many tables
  - Requires special privileges
  - Example SQL:

    ```
    create database music;
    ```
- Second step: ***Choose used*** database
  - Sets the context for further interactions
  - Example SQL:

    ```
    use music
    ```

Creating Database Tables (2)

- Third step: Create ***tables***
  - According to earlier design
  - Each table should provide a unique identifier ***(primary key)***
  - SQL Example:

```
create table mysongs (code VARCHAR(5), title
VARCHAR(20), artist VARCHAR(20), album VARCHAR(20),
runtime INT);
```

  - Further steps: Defining keys, indices etc.
- Fourth step: Fill tables with ***data***
  - Simplest case: Individual SQL commands
  - Better: Import from structured data file
  - Frequent: Special programs for importing and creating data
  - SQL Example:

```
insert into mysongs
  values ('1','One','U2','The Complete U2',272);
```

SQL Monitor Output

```
mysql> describe mysongs;
+---------+-------------+------+-----+---------+-------+
| Field   | Type        | Null | Key | Default | Extra |
+---------+-------------+------+-----+---------+-------+
| code    | varchar(5)  | YES  |     | NULL    |       |
| title   | varchar(20) | YES  |     | NULL    |       |
| artist  | varchar(20) | YES  |     | NULL    |       |
| album   | varchar(20) | YES  |     | NULL    |       |
| runtime | int(11)     | YES  |     | NULL    |       |
+---------+-------------+------+-----+---------+-------+
5 rows in set (0.00 sec)
```

Queries with SQL

```
mysql> select * from mysongs;
+------+--------------------+------------+-----------------+---------+
| code | title              | artist     | album           | runtime |
+------+--------------------+------------+-----------------+---------+
| 1    | One                | U2         | The Complete U2 |     272 |
| 2    | In the End         | Linkin Park | Hybrid Theory  |     216 |
| 3    | Wheel in the Sky   | Journey    | Infinity        |     252 |
| 4    | Lady in Black      | Uriah Heep | Lady in Black   |     281 |
| 5    | Smoke on the Water | Deep Purple | Machine Head   |     378 |
| 6    | Analog Man         | Joe Walsh  | Analog Man      |     243 |
+------+--------------------+------------+-----------------+---------+
6 rows in set (0.00 sec)
```

```
mysql> select title from mysongs where runtime>250;
+--------------------+
| title              |
+--------------------+
| One                |
| Wheel in the Sky   |
| Lady in Black      |
| Smoke on the Water |
+--------------------+
4 rows in set (0.00 sec)
```

Server-Side Databases, PHP and MySQL

- Special libraries for database access:
  - "Database extensions"
  - Generic for all database systems
- For specific database systems:
  - "Vendor specific database extensions"
- For MySQL:
  - MySQL-specific database extensions to PHP

Connecting to a Database from PHP

- First step: ***Connect*** to server
  - Establish a connection for data exchange between Web Server/PHP plugin and database server
  - Often local (sockets), if both programs on same machine
  - Requires hostname, (database) username, password
  - PHP function: **`mysql_connect()`**
    - » Returns a link (resource) which can be used for **`mysql_close()`**
- Second step: ***Select*** a database
  - Corresponds to the SQL command **`use`**
  - Requires database name (and possibly link to server)
  - PHP function: **`mysql_select_db()`**
    - » Returns Boolean result (success)

Example: Connecting to Database

```
<?php

$link = mysql_connect('localhost','root','demopw')
  or die ('Could not connect: '.mysql_error());
echo 'Connected.<br/>';

mysql_select_db('music')
  or die ('Could not select db.');
echo 'DB selected.<br/>';

...
?>
```

Sending Database Queries from PHP

- Basic idea (as in all programming language/database integrations):
  - SQL queries are given as strings to library functions
- Most important function in MySQL extensions to PHP:
  `mysql_query()`
  - Requires SQL query as parameter (optionally link to server as 2nd param.)
  - "Query" includes also **`INSERT`**, **`UPDATE`**, **`DELETE`**, **`DROP`** (SQL)!
- Return value in case of **`SELECT`**, **`SHOW`**, **`DESCRIBE`** and similar:
  - Result set represented by resource value
  - Special functions to retrieve result data as PHP data structures
  - **`mysql_num_rows()`**
    - » Number of rows returned
  - **`mysql_fetch_array()`**
    - » Reads one row of data and transforms it into an array
    - » Makes the next row available

Example: Reading Data From a Query in PHP

```
<?php
...
$query = 'SELECT * FROM mysongs';
$result = mysql_query($query);

while ($row = mysql_fetch_array($result, MYSQL_ASSOC)) {
   foreach ($row as $element) {
      echo $element;
      echo ', ';
   }
   echo("<br/>");
...
?>
```

dbaccess.php

Creating HTML Output From SQL Query (1)

```
<!DOCTYPE html>

<html>
<head>
  <title>Database table in HTML</title>
</head>

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

dbaccess_html.php

Creating HTML Output From SQL Query (2)

```
...
<body>
  <h1>The following table is retrieved from MySQL:</h1>
  <table>
    <?php
    $query = 'SELECT * FROM mysongs';
    $result = mysql_query($query)
          or die ('Query failed'.mysql_error());
    while ($row = mysql_fetch_array($result, MYSQL_ASSOC)) {
          echo "\t<tr>\n";
          foreach ($row as $element) {
                echo "\t\t<td>";
                echo $element;
                echo "</td>\n";
          }
          echo "\t</tr>\n";
    }
    ?>
  </table>
```

Creating HTML Output From SQL Query (3)

```
...
<?php
  mysql_free_result($result);
  mysql_close($link);
?>

</body>
</html>
```

Chapter 2: Interactive Web Applications

2.1 Interactivity and Multimedia in the WWW architecture

2.2 Client-Side Multimedia in the Web (Example HTML5)

2.3 Interactive Server-Side Scripting (Example PHP)

2.4 Data Storage in Web Applications (Example Database Access in PHP)

2.5 Integrated Server/Client-Side Scripting (Example jQuery/AJAX)

Literature:

D.S. McFarland: JavaScript and jQuery: The Missing Manual, 2nd ed., O'Reilly 2011

http://jquery.com

jQuery

- See jquery.com
  - John Resig 2006
- JavaScript Library to assist with
  - traversal and manipulation of HTML through DOM
  - event handling
  - animations
  - Simple AJAX applications (see later)
- Current versions: 1.10.2 and 2.0.3
  - Examples use 2.0.3
- jQuery is currently the most used JavaScript library
  - 25 Oct 2013: 56.7% of all Websites, 92.4% market share in JS libraries (see http://w3techs.com/technologies/overview/javascript_library/all)
- Further libraries build on jQuery (e.g. jQueryUI)
- jQuery is essentially on large JavaScript file
  - included locally or through a delivery network of servers

Using jQuery

- Include the library into any file where jQuery is to be used
  - Locally: `<script type="text/javascript">jquery.js</jquery>`
  - From jQuery Web site or through various Content Delivery Networks
- jQuery is accessible as a global function and as an object instance
  - Function "`jQuery`", abbreviated as "`$`"
- jQuery includes "Sizzle" engine to traverse and manipulate DOM trees
  - Frequent pattern: `$(`*`selector expression`*`)`
- jQuery provides additional utility functions
  - Frequent pattern: `$.`*`fname`*`(`*`parameters`*`)`
- jQuery supports event handlers
  - Frequent pattern: *`DOMObject.eventname`*`(`*`function`*`)`
  - Convenient pattern: Using local anonymous functions
- jQuery should be executed after DOM tree is ready (not necessarily after loading all content)
  - Event handler for `ready` event

Event Handler for jQuery `ready` Event

- Standard place to put jQuery code, in a script block at the end of page

```
$(document).ready(
    function() {
    ... jQuery Code ...
    }
);
```

Example: Interactive Highlighting in Table

- Assuming HTML and CSS code for table (similar to above):

```
<table>
    <thead>
        <tr>
            <th>#</td>
            <td>Title</td> ...
        </tr>
    </thead>
    <tbody>
        <tr>
            <td>1</td>
            <td>One</td> ...
        </tr>
    </tbody>
</table>
```

```
<style>
   table    {...}
   th, td   {...}
   thead      {
       background-color: black;
       color: white;
   }
   tr.hilite  {
       background-color: grey;
       color: white;
   }
</style>
```

jQuery DOM Selection

- Typical selector arguments for **`$( selector )`**
  - **`document`**
  - HTML element names
  - Identifiers (referring to HTML **`id`** attribute): **`#ident`**
  - CSS classes: **`:.classname`**
  - Special filters: **`:filtername`**
- Path constraints: Space-separated list of selectors
  - Have to appear as (possibly indirect) successors in tree
- Selecting all table rows:
  - **`$( 'tr' )`**
- Adding event handler for **`hover`** event:
  - **`$( 'tr' ).hover(function() { ...hilite... });`**
  - **`hover:`** Same handler called on **`mouseenter`** and **`mouseleave`** event
- Does this select the appropriate parts of the page?

jq_table1.html

Detour: Anonymous Functions in JavaScript

- Named function, e.g. for event handler:

```
function handleHover() {
    ...hilite...
};
$( 'tr' ).hover(handleHover);
```

- Omitting the name of the function, giving function body at calling position:

```
$( 'tr' ).hover(function(){...hilite...});
```

jQuery DOM Manipulation

- jQuery provides functions to
  - modify attributes of HTML elements
  - modify CSS classes attached to HTML elements
  - add or remove parts of the DOM tree
  - retrieve HTML text from DOM tree
  - create DOM tree from HTML strings
- Good practice: Use CSS, assign styles dynamically with jQuery
  - Add or remove class:
    ***object*.addClass(*class*)**, ***object*.removeClass(*class*)**
  - Add class if not present, and remove class if present (toggle):
    ***object*.toggleClass(*class*)**
- Example:

```
$("#mysongs tbody tr").hover(function() {
   $( this ).toggleClass( "hilite" );
});
```

jq_table2.html

Example: Extending HTML Table Using jQuery

- Make rows of the table selectable by adding a checkbox:
  - Add a new column to the table
  - Add an appropriate head entry in table head row
  - Add checkbox data cells to all table body rows
- jQuery code for table head:

```
$('#mysongs thead tr').
  append('
   <th>Select</th>');
```

- jQuery code for table body:

```
$('#mysongs tbody tr').
  append('
   <td style="text-align: center">
     <input/ type="checkbox">
   </td>');
```

jq_table3.html

Restructuring jQuery Code

- Good practice: Store result set of complex selection and re-use it
- Concepts from functional programming for code optimization
  - Functions as objects, passed as parameters
  - E.g. ***collection*.each(*fn*)**:
    applies function ***fn*** to all objects contained in ***collection***
- Example (using tree navigation and tests for HTML elements in DOM):

```
$('#mysongs tr').each(function(){
    if ($(this).parent().is('thead'))
        $(this).append('<th>Select</th>');
    if ($(this).parent().is('tbody'))
        $(this).append('
          <td style="text-align: center">
            <input/ type="checkbox">
          </td>');
    $(this).hover(function(){
        $(this).toggleClass('hilite');
});
```

Method Chaining

- In analogy to composition functional for functions:
  - using adequate result types, functions are easy to be used in *chains*
- jQuery: Most functions return an object compatible to the object on which the function was called
- Simple generic example:

```
$(…).addClass('classname').css(css_prop, css_value);
```

- Executing another jQuery query on result set:

```
collection.find(' selector ');
```

- Running example:

```
$(this)
    .append('
        <td style="text-align: center">
        <input/ type="checkbox"></td>')
    .find(':checkbox')
    .change(event handler for change event);
```

Example: Highlighting Selected Rows in Table

```
.find(':checkbox').change(function(){
   if ($(this).prop('checked')) {
     $(this).parents('tr').addClass('checked');
     numCheckedRows++;
   } else {
     (this).parents('tr').removeClass('checked');
     numCheckedRows--;
 }
```

`parents(`*`element_type`*`)`:
moves upwards in the tree and selects all elements of given *element_type*

jq_table4.html

Animations in jQuery

- jQuery enables time-dependent transitions
  - between CSS property values
  - adjustable in duration and linearity (using non-linear “easing” in/out)
- Animations fit into method chains easily
- Generic animation method: **`animate()`**
- Animations fit into method chains easily
- Shortcut methods for frequent animations:
  - **`show(`*`speed`*`)`**, **`hide(`*`speed`*`)`** for DOM elements
  - simple parameter ***`speed`*** with values **`slow`**, **`normal`**, **`fast`**
- Example:

```
if (numCheckedRows==0) $('#btn').show("slow");
if (numCheckedRows==1) $('#btn').hide("slow");
```

jq_table5.html

Combining PHP, Database Access, jQuery

- jQuery code as part of server page in PHP/MySQL setting
  - Mostly fixed jQuery/JavaScript within HTML page
  - Theoretically possible: Computation of jQuery/JavaScript code within PHP

```
<body>
  <h1>The following table is retrieved from MySQL:</h1>
    <div style="width: 600px">
      <table id="mysongs" style="width: 600px">
        <thead>...</thead>
        <tbody>
          <?php
            $query = 'SELECT * FROM mysongs';
            $result = mysql_query($query) ...;
...       ?>
        </tbody>
      </table>
      <input id='btn' type='button' value='...'></input>
   </div>
</body>
<script src="jquery.js"></script>
<script>
    $( document ).ready(function() {...}
</script>
```

Selecting Information Using jQuery/DOM

- Example: Get the IDs of all checked table rows
  - For instance to put them into a shopping cart

```
$('#btn').click(function(){
   var selIds = $('#mysongs input:checked').
   map(function(){
     return $(this).parents('tr').children().first()
   })
})
```

map functional
(also from functional programming):
Applying a function pointwise to a collection

dbaccess_jquery.php

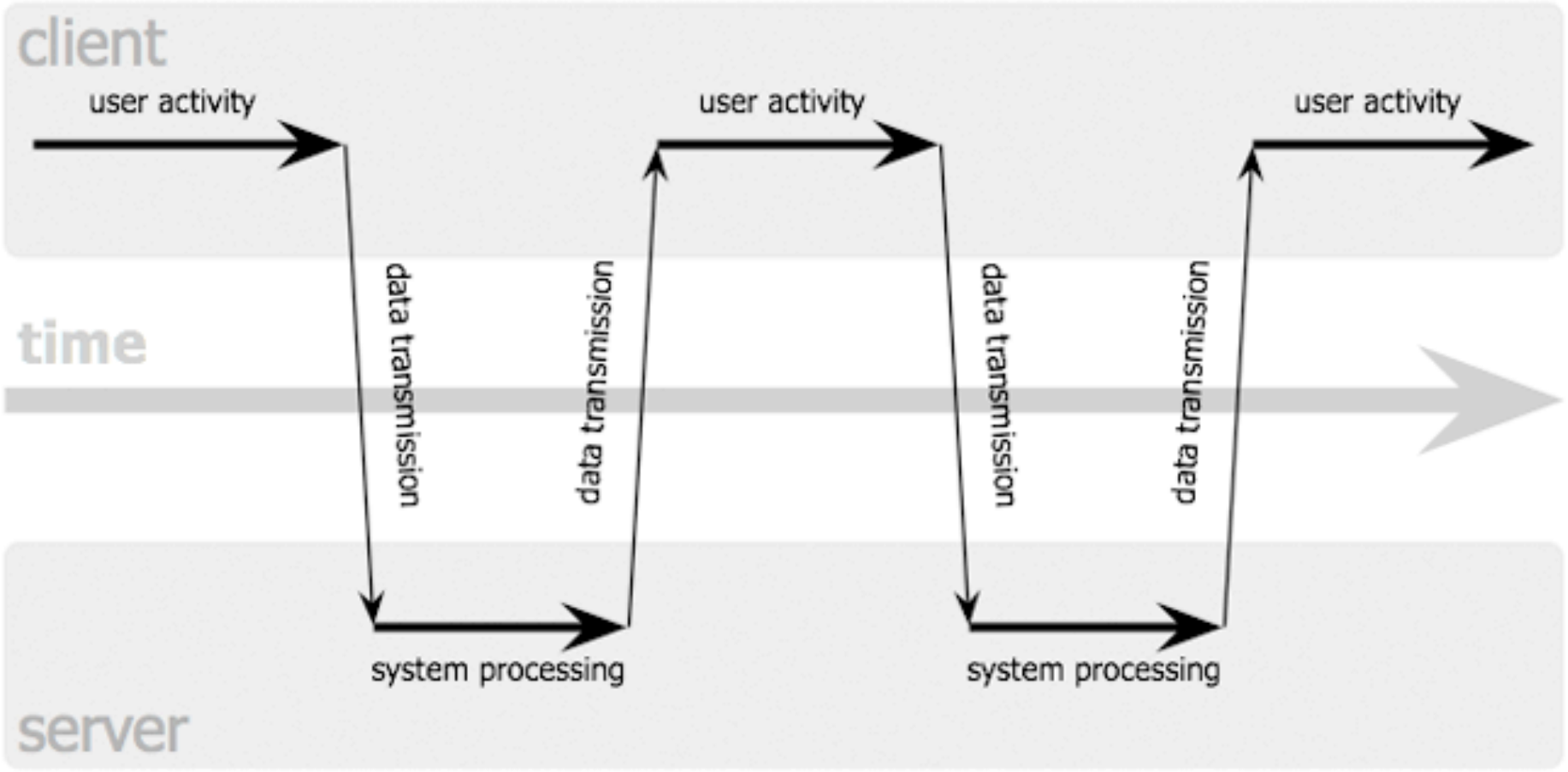
Sending Selected Data to Server

- HTTP traditional way:
  - Filling a form
  - Sending form data (URL-encoded or multipart-encoded)
  - Data has to be key-value pairs
- New forms may evolve (see next lecture)
- Seen from a jQuery perspective:
  - Sending a request is an option in event handling of input elements (here: buttons)
  - “AJAX” can be used for sending data without thinking about HTML forms

Asynchronous JavaScript + XML (AJAX)

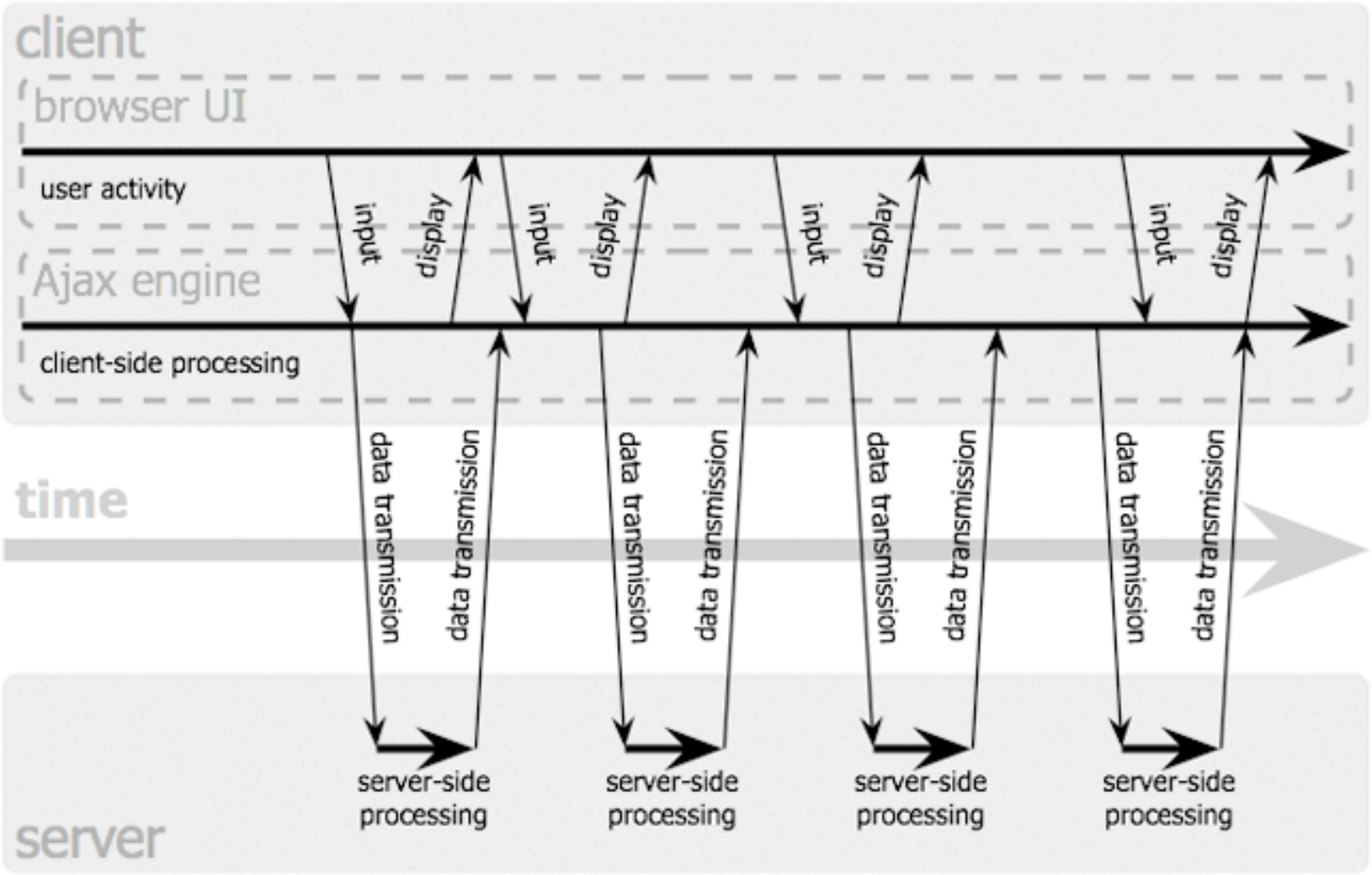
- James Garrett 2005:
  http://www.adaptivepath.com/ideas/essays/archives/000385.php
- Catchy name for an idea which was in use already at the time:
  - Google Suggest
  - Google Maps
- Basic idea:
  - Loading data from server is decoupled from changes in the presentation
- Advantages:
  - User can interact fluidly with the application
  - Information from server is fetched at regular intervals - 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

Classical Synchronous Web Application Model



Jesse James Garrett / adaptivepath.com

Asynchronous Web Application Model



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AJAX and Client-Side Scripting

- AJAX applications are programs executed in the Web browser
  - Require a runtime environment
  - Usually programmed in JavaScript
- AJAX applications need to modify or construct HTML to be displayed in the browser
  - Requires access to loaded/displayed HTML
  - *Domain Object Model* (DOM) is used for accessing and manipulating page content
- jQuery integrates AJAX support
  - Sending requests
  - Evaluating results
    - » Manipulating DOM

Sending Request Using jQuery

```
$('#btn').click(function(){
  var selIdsText = $('#mysongs input:checked').
    map(function(){
      return $(this).parents('tr').children().first()
    }).
    text();

  $.ajax({
    type: 'POST',
    url:  'serverDummy.php',
    data: {selection: selIdsText}
  });
});
```

`text()`:
Creates text from DOM tree
(much more flexible variants)

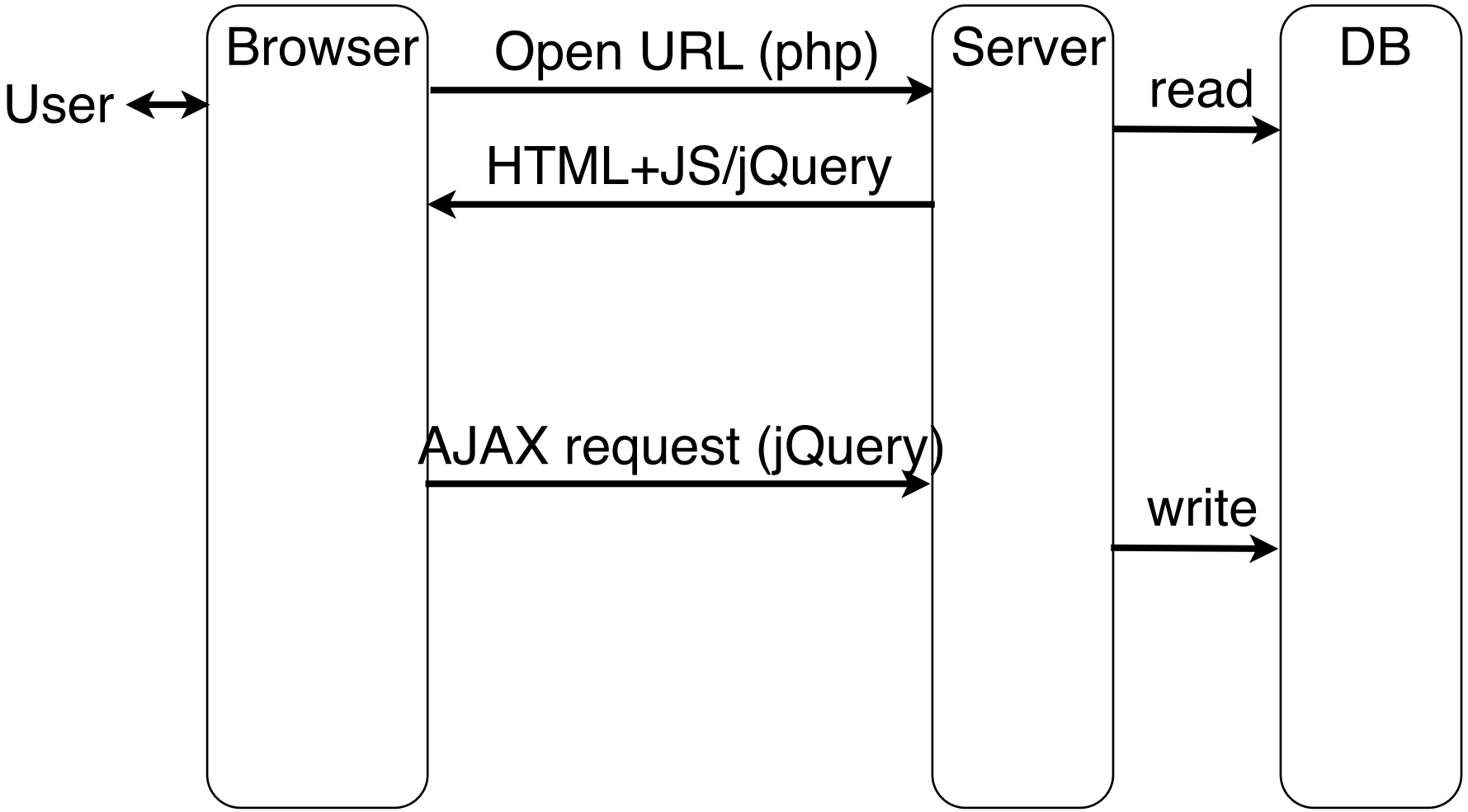
dbajax_jquery.php

serverDummy.php

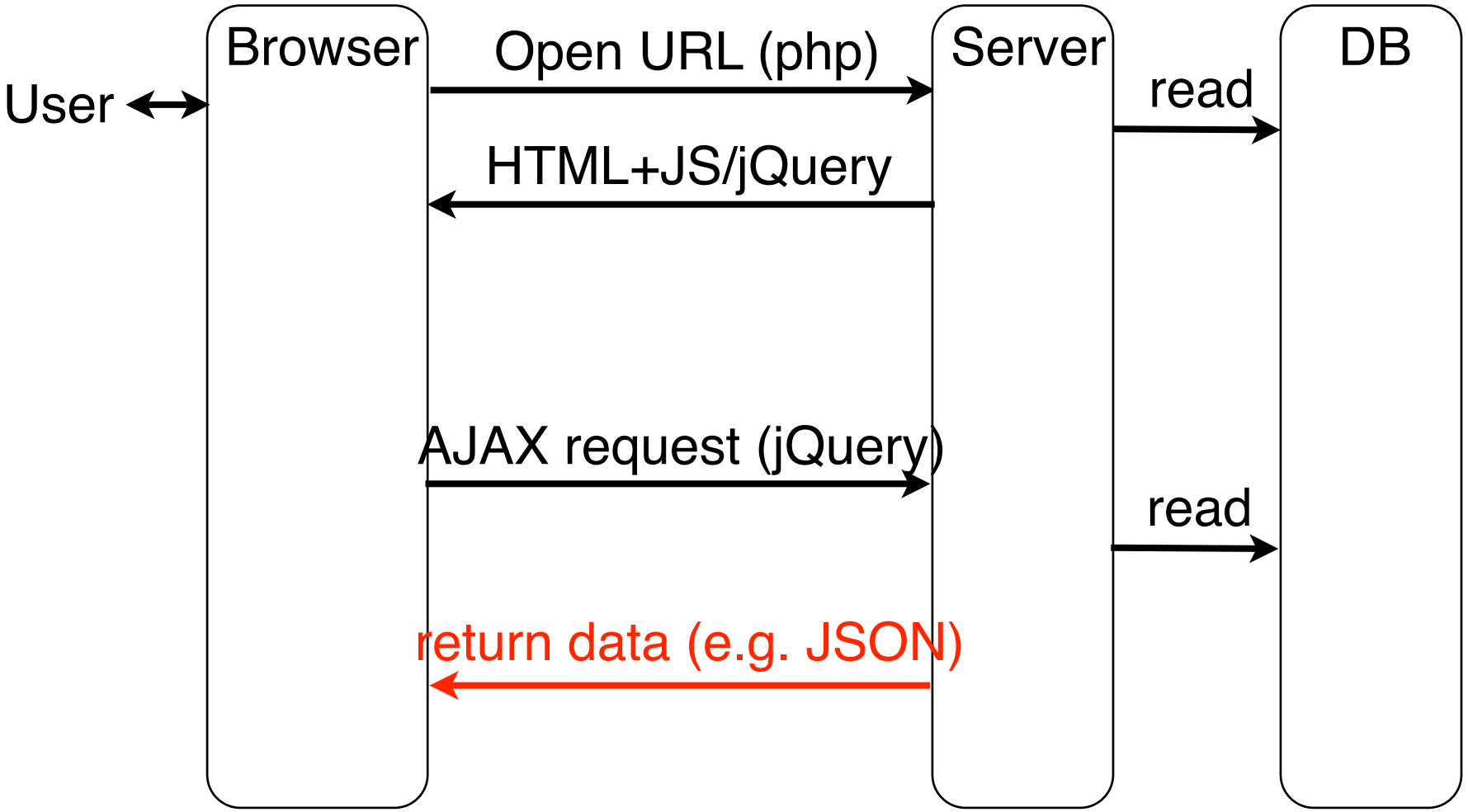
```
<?php
    $value = $_REQUEST['selection'];
    $file = fopen("dummyData.txt", "w");
    if ($file) {
         fputs($file, "selection: " . $value . "\n");
         fclose($file);
    }
?>
```

- Of course, in a realistic setting, data received by the server is processed by operating background systems
  - Here, may want to create a table in MySQL referring to *mysongs* table

See the Overall Picture?



Asynchronous Requests Returning a Result



jQuery AJAX Requests with Result

- jQuery **`ajax`** method
  - (and shorthands **`get`** and **`post`**)
  - creates a request to server
- Standard arguments, like:
  - **`url`**: URL address to send request to
  - settings: Key-value pairs
- Example settings:
  - **`dataType`**: Kind of data expected for answer (e.g. xml, json, html)
  - **`success(data,status)`**:
    JavaScript function to be called in case of successful server response
  - **`error (requestObj, message, errorObject):`**
    JavaScript function to be called in case of server response indicating errors

Paradigm Shift for Servers

- Traditional Web server:
  - Retrieves, computes and sends HTML data mainly
- AJAX-oriented server:
  - Constructs plain string, XML or JSON data as response to client
- Methods, toolkits, libraries remain the same (essentially):
- E.g.:
  - Client requests HTML5/jQuery/PHP page and interacts with it
  - Server sends JSON response for jQuery-initiated request
  - Client (JavaScript/jQuery) has to deal with response format
    - » e.g. parseJSON method