Chapter 2: Interactive Web Applications

Literature:

B. Lawson, R. Sharp: Introducing HTML5, New Riders 2011
S. Fulton, J. Fulton: HTML5 Canvas, O'Reilly 2011

Form Validation, Traditional Style

- Data entered into input forms needs to adhere to specific constraints:
  - Some fields required, some optional
  - Special formats like date, URL, email address
- Checking the constraints (“validating” the input)
  - Performed by client-side script code (JavaScript)
  - Typically an event handler for the “onsubmit” event
  - Only if validation returns true, data is submitted
- Client-side validation saves server time and network traffic
  - Nevertheless, server usually validates received data again!

Example: Traditional Form Validation

```
<script type="text/javascript">
    function validateForm() {
      if (document.blogentry.name.value =="") {
          alert("Name is required");
          return false;
      }
      var emailinput=document.blogentry.email.value;
      var atpos=emailinput.indexOf("@");
      var dotpos=emailinput.lastIndexOf(".");
      if (atpos<1 || dotpos<atpos+2 || dotpos+2>=emailinput.length) {
          alert("Not a valid e-mail address");
          return false;
      }
     return true;
    }
</script>
<form name="blog-entry" onsubmit="return validateForm();">
    <label for="name">Name: </label>
    <input name="name" id="name" type="text"></br>
    <label for="email">Email: </label>
    <input name="email" id="email" type="text">
    <input type="submit" value="Submit">
</form>
```

formvalidate.html

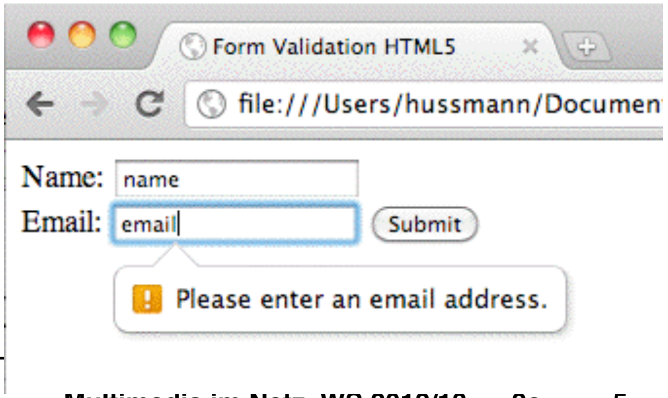
Email validation code taken from w3schools.org

Form Validation with HTML5

- Standard scenarios of form validation are integrated into HTML5 standard
  - Input types: email, URL, date, time, number, range, search, phone number, color
  - Attributes: Required, min, max, step, pattern
- Frequent phenomenon:
  - ***Procedural*** features are transformed to ***declarative*** features
- Using HTML5, JavaScript code can be removed
  - Just using declarative HTML
  - New code is less error-prone
  - New code is more precise (regarding definition of input syntax)
  - New code automatically benefits from upgrades
  - Special devices (e.g. smartphones) can choose best representation
- Transition problem:
  - For “legacy browsers”, traditional code has to remain for some time

Example: Form Validation with HTML5

```
<!DOCTYPE html>

<html>
  <head>
    <title>Form Validation HTML5</title>
  </head>

  <body>
    <form name="blogentry">
      <label for="name">Name: </label>
      <input id="name" type="text" required></br>
      <label for="email">Email: </label>
      <input id="email" type="email" required>
      <input type="submit" value="Submit">
    </form>
  </body>
</html>
```


Form Validation HTML5
file:///Users/hussmann/Documen
Name: name
Email: email
Submit
Please enter an email address.

formvalidate5.html Google Chrome

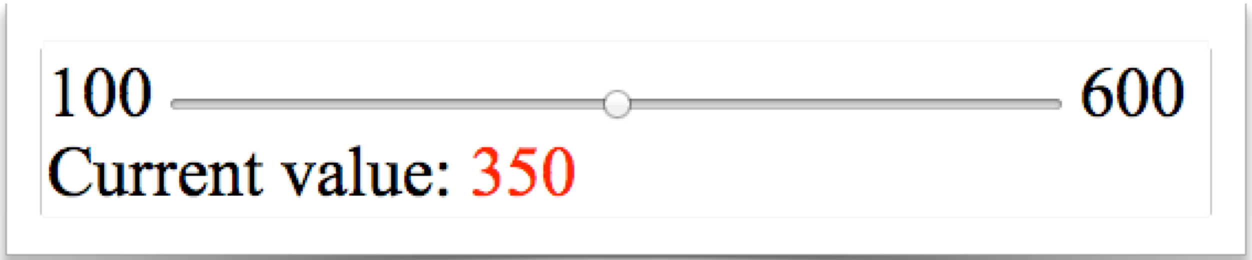
HTML5 Interactive Controls

- Standard controls for interactive applications have been integrated into HTML5
  – "range" element (slider control)
  – "color" element (interactive color picker)
- Potential:
  – Higher client-side (stand-alone) interactivity
  – Typical applications: Drawing, image editing
  – See discussion of "canvas" element below

Example: Slider in HTML5

slider.html

```
<!DOCTYPE html>

<html>
  <head> …
    <style type="text/css"> … </style>
  </head>

  <body
       onload="min.value=slider.min; max.value=slider.max;
         current.value=slider.value;">
    <output id="min"></output>
    <input id="slider" type="range" min="100" max="600" step="10"
      onchange="current.value = slider.value"/>
    <output id="max"></output><br/>
    Current value: <output id="current"></output>
  </body>
</html>
```

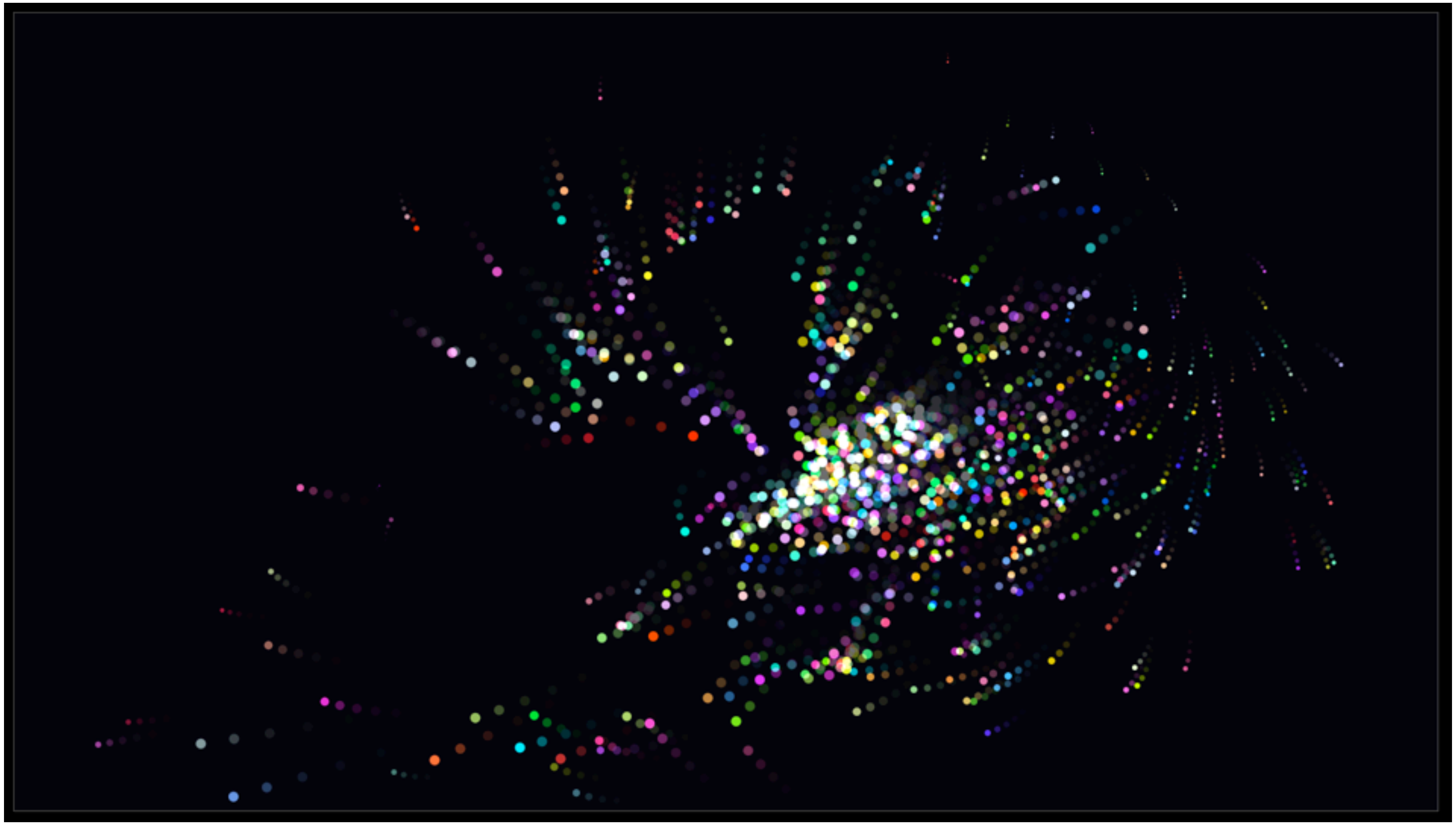


Current value: 350

HTML5 Canvas

- "HTML5 Canvas is an *immediate mode* bitmapped area of the screen that can be manipulated with JavaScript." (Fulton/Fulton)
- *2D Drawing Context:*
  - Object associated with a Canvas object
  - Used as handler in JavaScript to address the canvas (drawing API)
- Typical drawing primitives:
  - Draw shapes
  - Render text
  - Display images
  - Apply colors, rotations, transparency, pixel manipulations, fills, strokes
- Canvas works on (low) pixel level
  - Browser redraws whole canvas each time the Canvas is modified using JavaScript

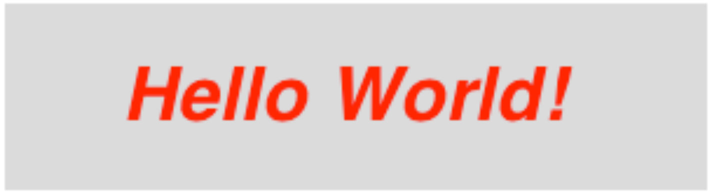
Canvas Demo: Liquid Particles



http://spielzeugz.de/html5/liquid-particles.html

Example: Drawing on the Canvas

```
<!doctype html>
<html>
<head>
    <title>Canvas Hello World</title>

    <script type="text/javascript">
     window.addEventListener("load", drawScreen, false);
     function drawScreen() {
         var c = document.getElementById("theCanvas");
         var ctx = c.getContext("2d");
         ctx.fillStyle = "lightgrey";
         ctx.fillRect(0, 0, c.width, c.height);
         ctx.font = "italic bold 32px sans-serif";
         ctx.fillStyle = "red";
         ctx.fillText("Hello World!", 50, 50);
     }
    </script>
</head>
<body>
    <canvas id="theCanvas" width=300 height=80>
         Your browser does not support Canvas!
    </canvas>
</body>
</html>
```



canvashello.html

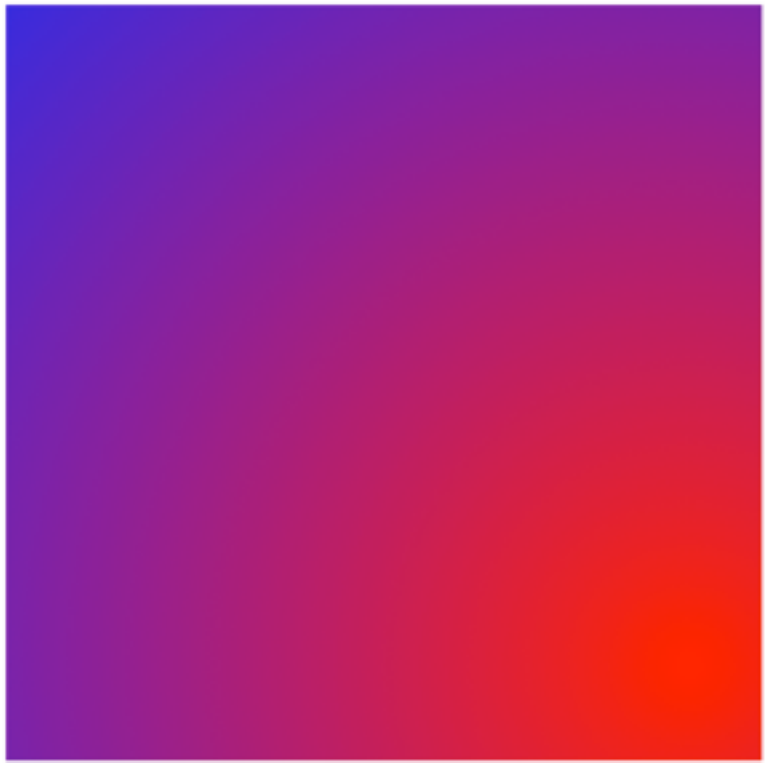
Example: Interactive Gradient (1)

```
<!doctype html>

<html>
<head>
      <title>Canvas Gradient Fill</title>
      <meta charset="UTF-8">

      <script type="text/javascript">
        window.addEventListener("mousemove", drawScreen, false);
        function drawScreen(event) {
          var c = document.getElementById("theCanvas");
          var ctx = c.getContext("2d");
          var mx = Math.min(event.clientX,c.width);
          var my = Math.min(event.clientY,c.height);
          var grad =
            ctx.createRadialGradient(mx, my, 0, mx, my, c.width*1.5);
          grad.addColorStop(0,"#f00");
          grad.addColorStop(1,"#00f");
          ctx.fillStyle = grad;
          ctx.fillRect(0, 0, c.width, c.height);
        }
      </script>
</head>
```

gradient.html

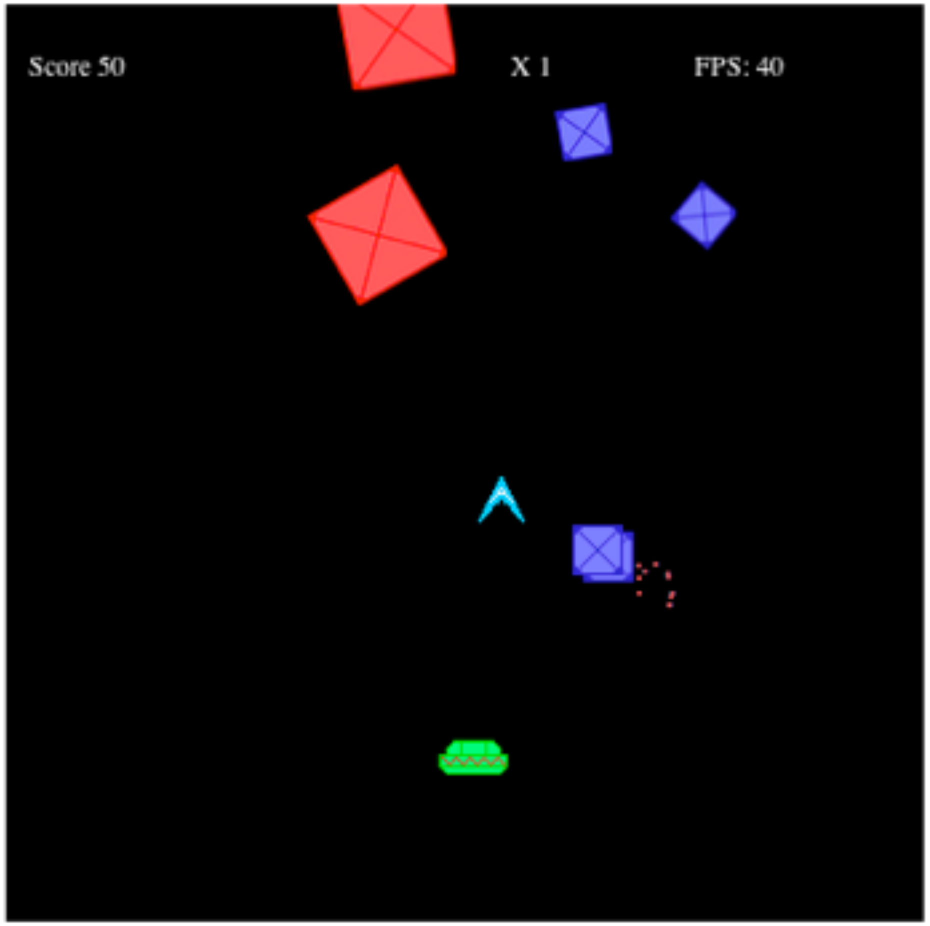
Example: Interactive Gradient (2)

```
...

<body>
      <canvas id="theCanvas" width=500 height=500>
            Your browser does not support Canvas!
      </canvas>
</body>
</html>
```



Interactive Animations with HTML5 / JavaScript

- Example “GeoBlaster” (“Asteroid”-like game by Fulton/Fulton)



Example Excerpt: Animation Principles (1)

- Timer-based loop:

```
const FRAME_RATE=40;
frameRateCounter=new FrameRateCounter(FRAME_RATE);
var intervalTime=1000/FRAME_RATE;
setInterval(runGame, intervalTime );
```

- **`runGame`** function is called again and again in fixed frequency
- For each frame (when in a “play level” game state) **`runGame`** calls:

```
function gameStatePlayLevel(){
     checkKeys();
     update();
     render();
     checkCollisions();
     checkForExtraShip();
     checkForEndOfLevel();
     frameRateCounter.countFrames();
}
```

Example Excerpt: Animation Principles (2)

- For each frame, all objects are updated:

```
function update() {
      updatePlayer();
      updatePlayerMissiles();
      updateRocks();
      updateSaucers();
      updateSaucerMissiles();
      updateParticles();
}
```

- Example: Update of player’s ship:

```
function updatePlayer() {
      player.missileFrameCount++;
      player.x+=player.movingX*frameRateCounter.step;
      player.y+=player.movingY*frameRateCounter.step;
      if (player.x > xMax) {
            player.x=-player.width;
      }else if (player.x<-player.width){
            player.x=xMax;
      }…}
```

Example Excerpt: Animation Principles (3)

- Rendering the player's ship:

```
function renderPlayerShip(x,y,rotation, scale) {
    //transformation
    context.save(); //save current state in stack
    context.globalAlpha = parseFloat(player.alpha);
    var angleInRadians = rotation * Math.PI / 180;
    var sourceX=Math.floor((player.rotation/10) % 10) * 32;
    var sourceY=Math.floor((player.rotation/10) /10) *32;
    if (player.thrust){
       context.drawImage(shipTiles2, sourceX, sourceY,
          32,32,player.x,player.y,32,32);
    }else{
       context.drawImage(shipTiles, sourceX, sourceY,
          32,32,player.x,player.y,32,32);
    }
    ...
}
```

HTML5 Canvas vs. SVG vs. Flash/Silverlight

- HTML5 Canvas:
  - *Immediate* mode (direct drawing on canvas, no structuring of image)
  - Bitmap level
- SVG, Flash, Silverlight:
  - *Retained* mode (internal “scene graph” model rendered to canvas, incremental updates possible)
  - Bitmap or vector level
- HTML5 Canvas & SVG:
  - Open standards, dependent on acceptance by browser manufacturers
- Flash, Silverlight etc.:
  - Closed, proprietary standards (browser plugins needed)
  - Popularity determines “penetration” of plugins to browser population
- In any case, “political” decisions are important:
  - Example: Open standard support in MS Internet Explorer
  - Example: Lack of Flash support on Apple iOS devices (iPhone, iPod, iPad)

Chapter 2: Interactive Web Applications

Data Storage Options in the Web: Overview

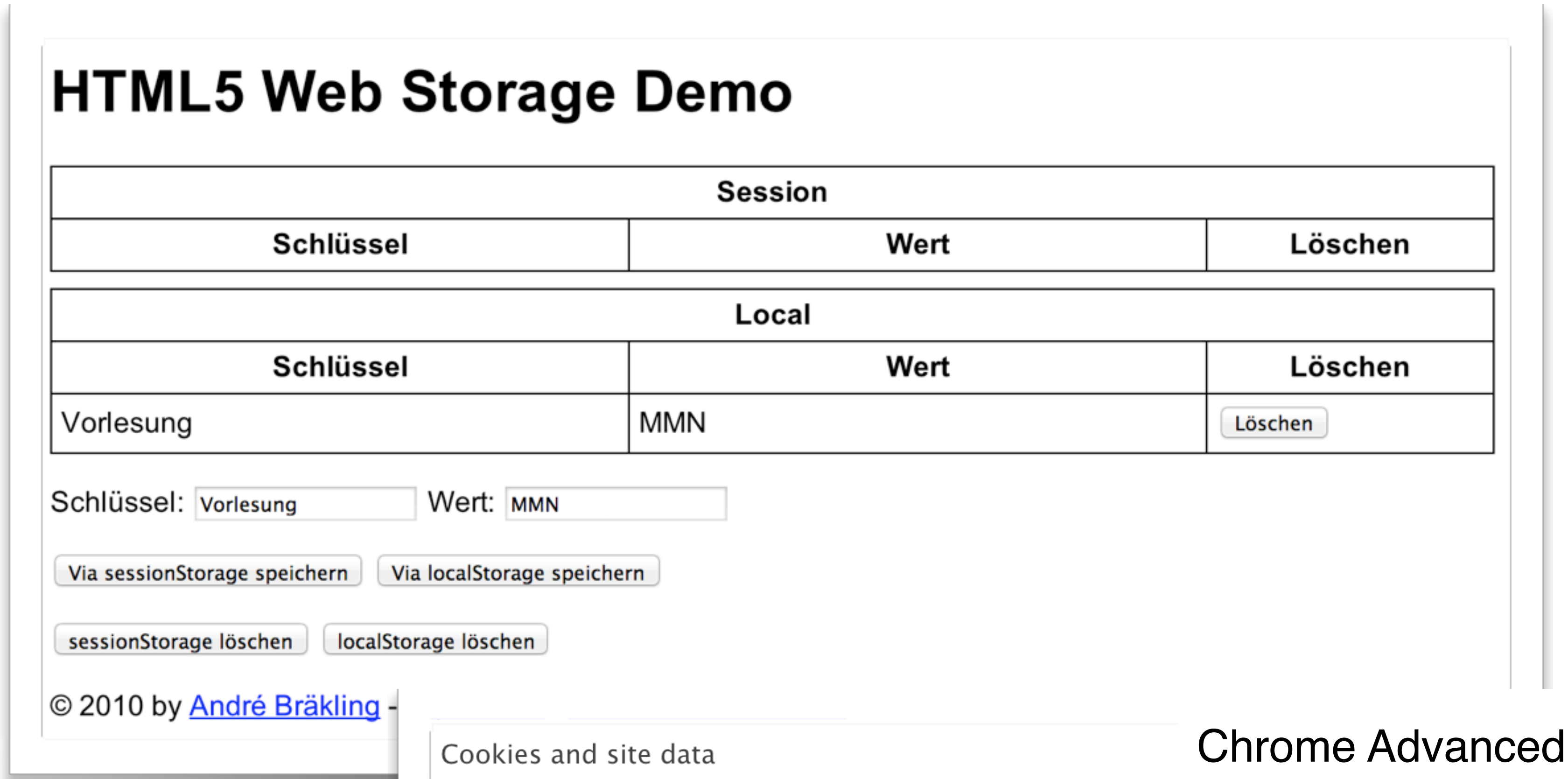
- Client-side storage:
  - Necessary to maintain continuity of client interaction
  - Session level: Linking consecutive request/response pairs
  - Long-term level: Personalization, preferences
  - Implemented in browser
  - Traditional solution: Cookies
  - Modern solutions (HTML5): Web Storage, Web SQL Databases
- Server-side storage:
  - Necessary to get access to and modify global information
  - Implemented on server
  - Simple solution: Server files (see PHP discussion forum example)
  - Powerful solution: SQL database access from server scripts
- Note: Discussion is focused on Relational Databases and SQL due to their overwhelming popularity
  - Object-oriented databases?

Client-Side Storage in HTML5: Web Storage

- Web Storage/DOM Storage:
  - Standardized by W3C, intended as improvement over Cookies
  - Formerly part of HTML5 specification, now separated
- Purely client-side storage
  - Not transmitted to server with each request
  - Javascript code can issue read and write requests
- Types of storage:
  - Session storage: Related to window/tab (!), deleted on window closing or browser termination
  - Local storage: Related to domain and maintained after browser termination
- Data structure:
  - Simple associative array (key/value pairs, both of string type)
  - Similar to Cookies

Web Storage Example

http://www.braekling.de/testlab/html5-webstorage-demo.html



HTML5 Web Storage Demo

Session		
Schlüssel	**Wert**	**Löschen**

Local		
Schlüssel	**Wert**	**Löschen**
Vorlesung	MMN	Löschen

Schlüssel: Vorlesung Wert: MMN

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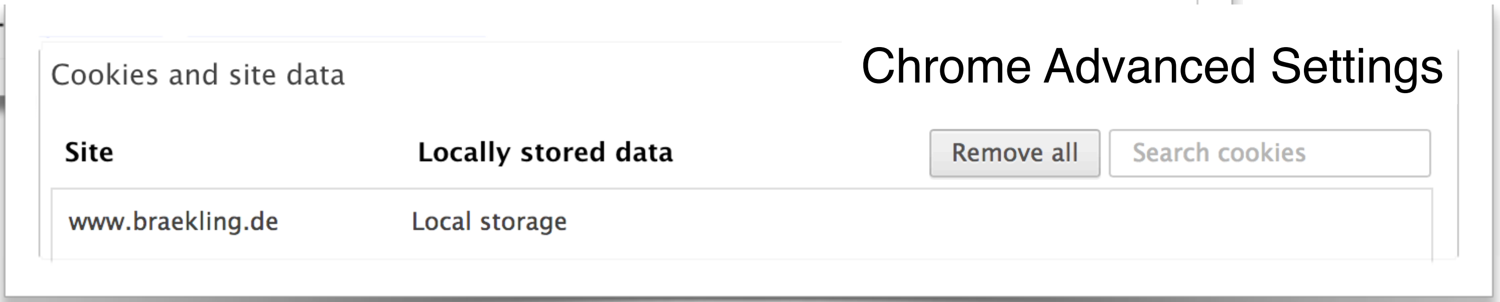


Chrome Advanced Settings

Cookies and site data

Site	Locally stored data
www.braekling.de	Local storage

Web Storage Interface (W3C)

- Interface **`Storage`** (defined independently of implementation language):

```
String getItem(String key);
void setItem(String key, String value);
void removeItem (String key);
void clear();
```

- Top-level browsing context contains two attributes:

```
Storage sessionstorage;
Storage localstorage;
```

- Shorthand notation in JavaScript due to associative array, example:

```
var firstName = localStorage.firstName;
var lastName = localStorage.lastName;
```

- When a storage area changes, an event is fired:

```
StorageEvent storage;
```

JSON Stringification

- What to do if only strings can be stored (somewhere)?
- All data objects (in JavaScript and other languages) can be converted to a String representation
  - XML based
  - Based on JavaScript object constructors: JSON (= JavaScript Object Notation), more space effective
  - **`JSON.stringify():`** Returns string representation
  - **`JSON.parse():`** Converts string representation to JavaScript object
- Example:

```
  {"student": {
    "identification": [
           {"name": "firstname",
            "value": "Max"
           },
           {"name": "lastname",
            "value": "Muster"
           }],
    "grades": […]
    }
}
```

Working Offline in Web Applications

- Web applications often rely on connectivity to the server
  - There are still situations/regions without or with restricted/expensive Internet access!
  - Mobile connections are always in danger of temporary failures
- Working offline with server-based applications:
  - Client needs a significant amount of logic to give sense to offline work
  - Application needs to specify which parts of the application data is to be kept locally *(cached)*
    - » Usually a set of files
    - » *Cache manifest* (= list of files)
  - Browser needs to support access to cached data
    - » interpret cache manifest
    - » maintain application cache

HTML5 Cache Manifest

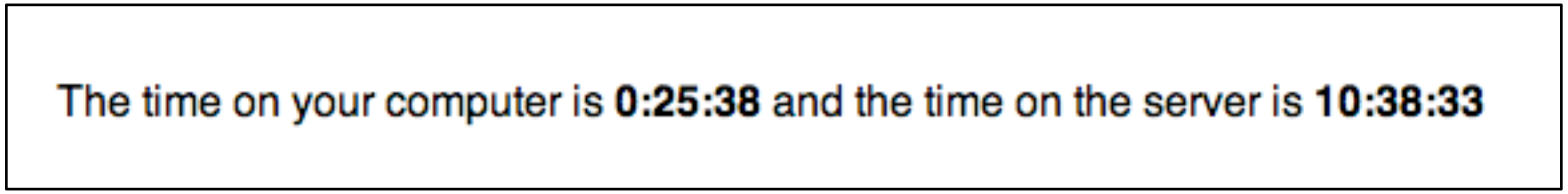
- Cache manifest is a file on the server referenced in the HTML page to be loaded:
```
<!DOCTYPE html>
<html lang="en" manifest="time.manifest">
```
- Cache manifest states the files always to be loaded (even from cache)and the files for which there is an alternative:
```
CACHE MANIFEST
# version 10

CACHE:
index.html
time.js
time.css

FALLBACK:
server-time.js fallback-server-time.js
```

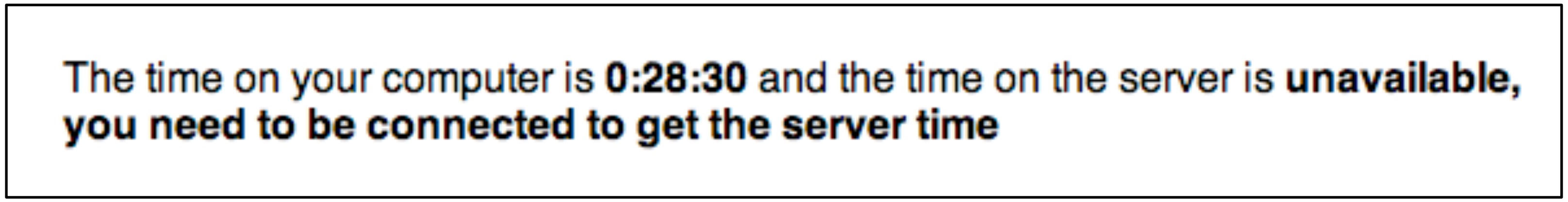
HTML5 Cache Manifest Demo

- If file **`server-time.js`** is available and delivers server time:



The time on your computer is **0:25:38** and the time on the server is **10:38:33**

- If file **`server-time.js`** is ***not*** available, local **`fallback-servertime.js`** is used:



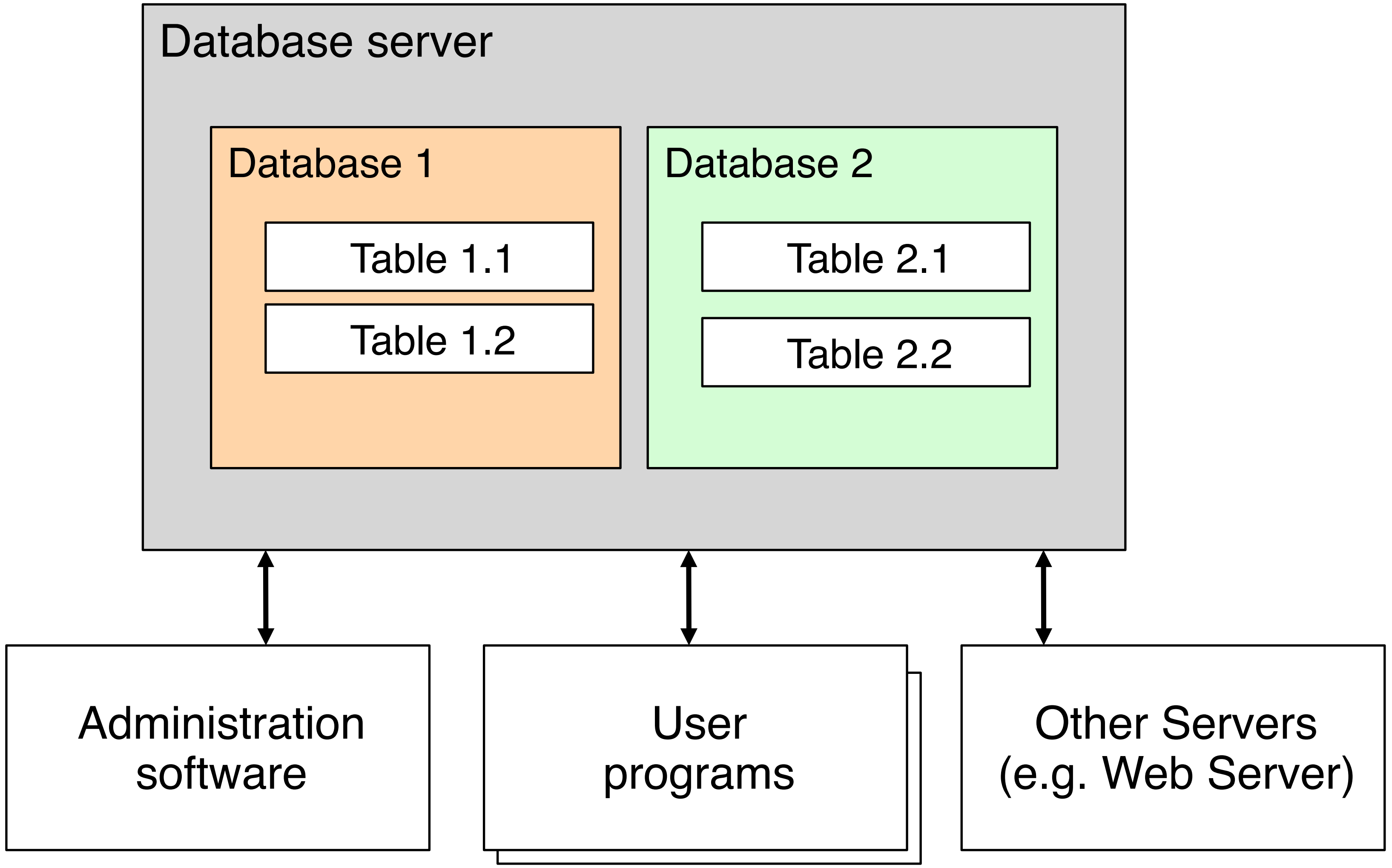
The time on your computer is **0:28:30** and the time on the server is **unavailable, you need to be connected to get the server time**

- Distinction between available files and non-available files is done by the application, adequate reaction is carried out.
- Non-realtime data are retrieved from local memory.

Database Management Systems: A Quick Reminder

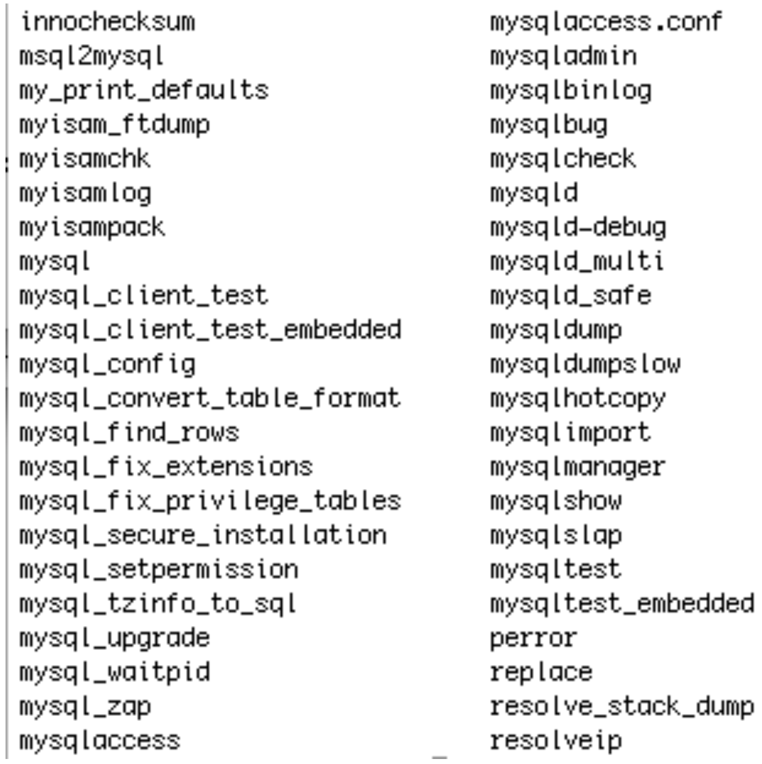
- Database:
  - Structured collection of data items
  - Stored persistently
  - Provides access to a common data pool for multiple users
- Database Management System (DBMS):
  - Collection of programs for administration and usage of a database
  - Various base models for DBMS:
    - » Old: network model, 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?
  - Eg. Entity-Relationship diagrams as a tool
  - Transformation into relational database schema (table design)
- Once a database if filled with data and in use, it is rather difficult to modify!
  - Database schema design has to be carried out with great care!
- Most important rule: Avoid redundant storage of information

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)

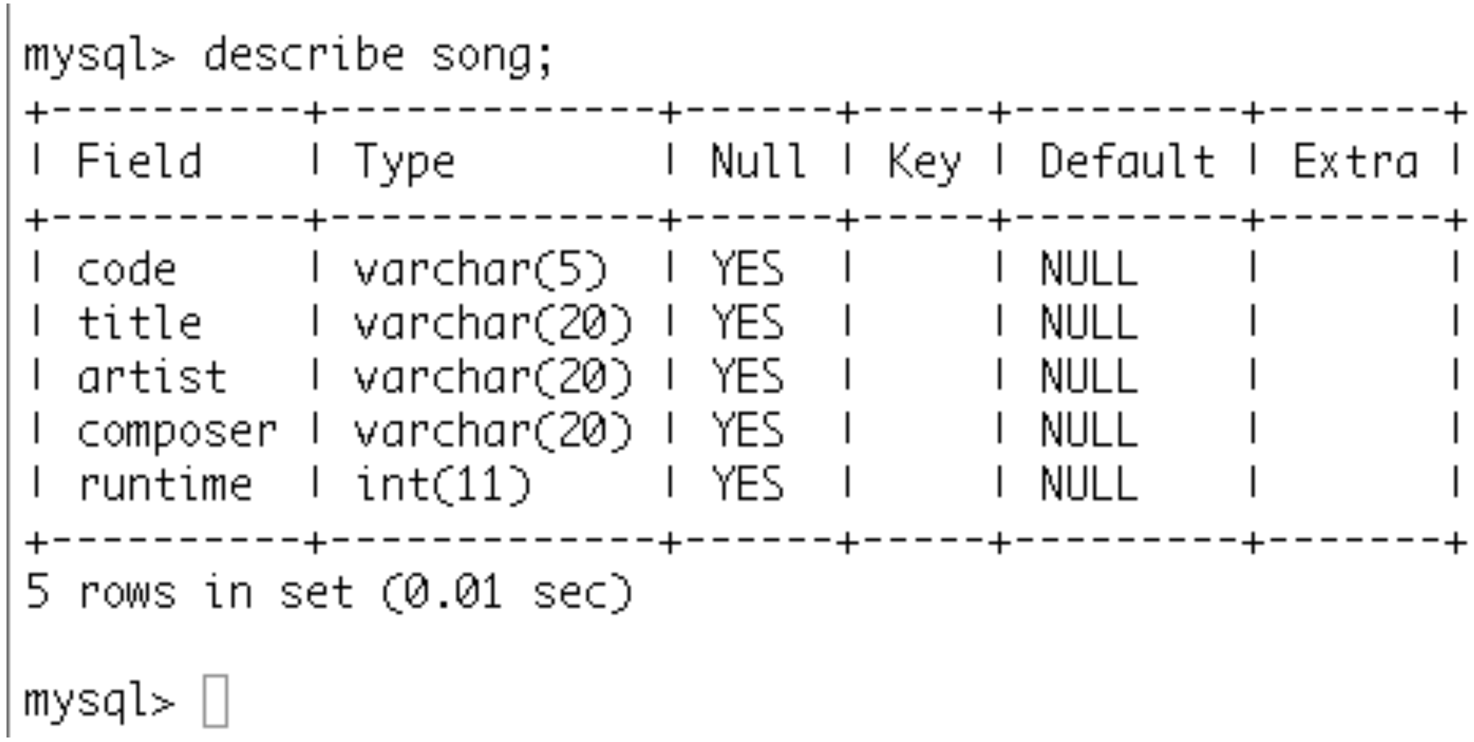
- Third step: Create ***tables***
  - According to earlier design
  - Each table should provide a unique identifier ***(primary key)***
  - SQL Example:

```
create table song (code VARCHAR(5), title VARCHAR(20),
artist VARCHAR(20), composer 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 song
values ('1','One','U2','Adam Clayton, Bono, Larry Mullen
& The Edge',272);
```

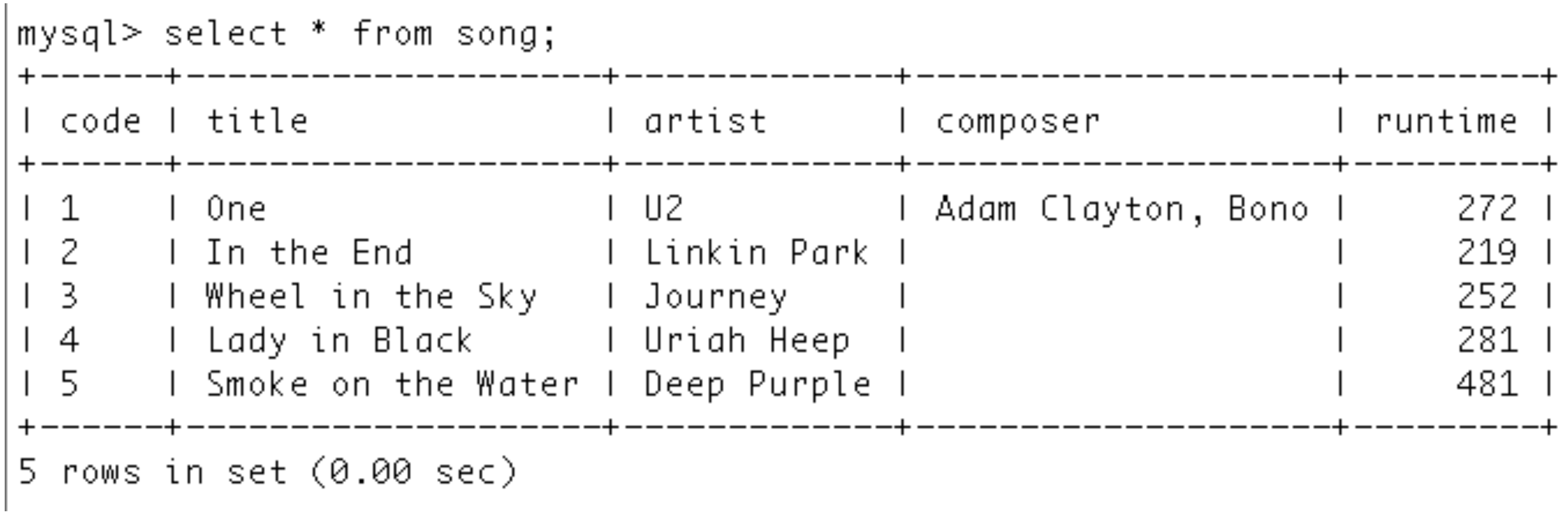
SQL Monitor Output



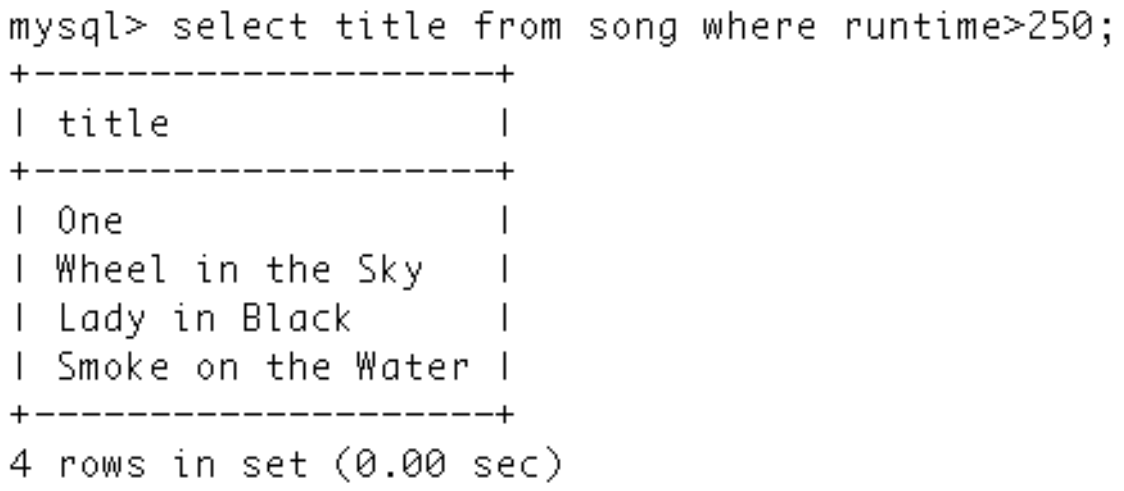
```
mysql> describe song;
+----------+------------+------+-----+---------+-------+
| Field    | Type       | Null | Key | Default | Extra |
+----------+------------+------+-----+---------+-------+
| code     | varchar(5)  | YES  |     | NULL    |       |
| title    | varchar(20) | YES  |     | NULL    |       |
| artist   | varchar(20) | YES  |     | NULL    |       |
| composer | varchar(20) | YES  |     | NULL    |       |
| runtime  | int(11)     | YES  |     | NULL    |       |
+----------+------------+------+-----+---------+-------+
5 rows in set (0.01 sec)

mysql> 
```

Queries with SQL



```
mysql> select * from song;
+------+--------------------+------------+--------------------+---------+
| code | title              | artist     | composer           | runtime |
+------+--------------------+------------+--------------------+---------+
| 1    | One                | U2         | Adam Clayton, Bono |     272 |
| 2    | In the End         | Linkin Park |                   |     219 |
| 3    | Wheel in the Sky   | Journey    |                    |     252 |
| 4    | Lady in Black      | Uriah Heep |                    |     281 |
| 5    | Smoke on the Water | Deep Purple |                   |     481 |
+------+--------------------+------------+--------------------+---------+
5 rows in set (0.00 sec)
```



```
mysql> select title from song 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 song';
$result = mysql_query($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 PUBLIC "-//W3C//DTD HTML 4.01 Transitional//
  EN"
  "http://www.w3.org/TR/html4/loose.dtd">

<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 song';
      $result = mysql_query($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>
```