Database-driven Web Technology (LIX021B05)

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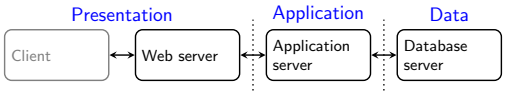
About initial project reports

Your initial report should describe what you are going to implement. It should include,

- the requirements
- your initial database design

You will get feedback within a few days after you submit your report.

The multi-tier (or 3-tier) architecture



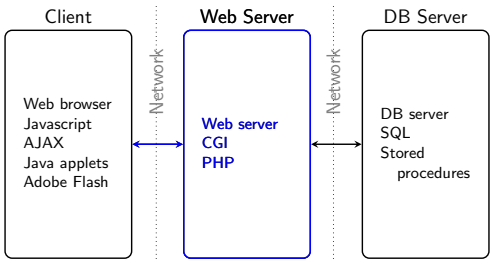
Presentation tier interacts with the user (e.g., ask the seat preference in an airline online check-in system).

Application tier implements the 'business logic' (e.g., check and reserve a seat, possibly using multiple queries and updates).

Data tier stores the data (e.g., retrieve and/or update the relevant data records).

In practice, division may not match the figure above. However separating presentation from application is always a good idea.

Web-programimg model: what runs where



In this lecture we will study the client–server interaction and server-side programming

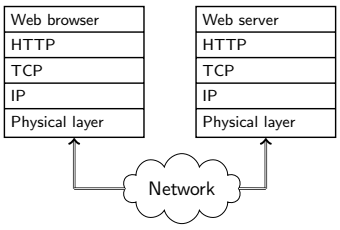
What happens when you click on a link?

C Extract the URL: `http://www.rug.nl/let/informatiekunde`
C Parse the URL: Host: www.rug.nl, Protocol: HTTP, Resource: /let/informatiekunde
C Resolve the host name: 129.125.2.51
C Find the default port number for HTTP: 80
C Open a TCP connection to the IP:port
S Accept the connection
C Send the HTTP request: GET /let/informatiekunde HTTP/1.1...
S Read the request, process it
S Form a response and send it
C Read the response, process it
C Close the connection

This is still an overview, a lot more happens under the hood.

C: Client, S: Server

Layers in communication



- Web server and web browser talks to each other using HTTP.
- The HTTP messages goes through a set of networking layers.
- We are mainly interested in HTTP, some aspects of TCP/IP networking is relevant to web programming.

Three-slide introduction to TCP/IP (1)

- TCP/IP is the name of the network protocol family used in the Internet.
- It is more than TCP and IP. Just to list a few: `UDP`, `BGP`, `DHCP`, `ICMP`, `DNS`, ...
- The IP protocol is connectionless, it does it's best to deliver a network packet to it's destination.
- IP does not guarantee the delivery of every packet.
- TCP works on IP, it is connection oriented. With TCP, you do not worry about the lost packets.

Three-slide introduction to TCP/IP (2)

- The hosts in a TCP/IP network is identified with a unique IP address.
- IP(v4) addresses are 4-byte integers, e.g., 129.125.2.51 (New version of IP, IPv6, uses longer IP addresses).
- DNS maps human readable domain names, like `www.rug.nl` to IP addresses.

DNS can be used for distributing load:
A particular host name can be assigned multiple IP addresses. For each DNS query, a DNS server will issue one of the IP addresses in a round-robin fashion

Three-slide introduction to TCP/IP (3)

- Commonly used services have reserved port numbers, for example 80: HTTP, 443: HTTPS, 22: SSH . . .
- A server typically 'listens' on a reserved port for client connections.
- Clients reserve temporary port numbers.
- Each end of a connection is identified by IP address/port number pairs.
- Connection is typically initiated by a client, any of the parties can close the connection.

Anatomy of a URL

http://www.rug.nl:80/let/informatiekunde
① ② ③ ④

① Scheme indicates the protocol. The rest of the URL may be different depending on the scheme.

② Domain name is the name of the host where the HTTP service runs.

③ Port number can optionally be given in cases where the service do not run on the default port.

④ Path typically identifies the (HTML) files on the server, but can express more than a file name. The interpretation is dependent on the web server.

HTTP: an overview

- HTTP is a request-response protocol. Clients asks for an operation on a resource, possibly with some content, and server responds, likely with some content.
- The requested operation has to be one of 9 HTTP methods, like **GET**, HEAD or POST.
- Response message starts with a status message.
- Both request and response can include additional headers, which provide additional information.
- HTTP protocol does not encrypt the communication, nor has it any mechanism to verify the identity of server or the client.
- HTTPS is an extension of HTTP that uses Secure Socket Layer (SSL).

HTTP requests

```
1  GET / HTTP/1.1
2  Host: www.rug.nl
3  User-Agent: Mozilla/5.0 (X11; Linux x86_64; rv:8.0)  ...
4  Accept: text/html,application/xhtml+xml,  ...
5  Accept-Language: en-us,en;q=0.5
6  Accept-Encoding: gzip, deflate
7  Accept-Charset: UTF-8,*
8  Connection: keep-alive
9  Cookie: acceptedLanguages=en; s_nr=1321910886052 ...
10
```

- First line is the actual request, here using method **GET**.
- The rest of the lines are headers that provide additional information.
- The empty line (10) is important. It signals the end of headers.

HTTP response

```
1  HTTP/1.1 200 OK
2  Date: Wed, 23 Nov 2011 01:11:25 GMT
3  Server:  Apache/2.2
4  Last-Modified: Tue, 11 Mar 2008 11:35:02 GMT
5  Content-Length: 260
6  Content-Type: application/html
7
8  <!DOCTYPE html PUBLIC "-//W3C//DTD HTML ...
9  <html>
10 ...
```

- The first line is the status line.
- Again, server gives us a set of header lines followed by an empty line and the content.
- The response can also indicate a permanent or temporary error, or a redirection message.

HTTP methods

HTTP standard defines 9 methods, but we are only interested in

GET Typically used to get a static content (e.g., file). But it can also be used for dynamic content (we will return to this).

HEAD It is like GET, but server only responds with headers, no content is transferred.

POST is used when client needs to transfer some content. Typically content is the name/value pairs from a HTML form. However, it can be anything that server/client agree on.

Others (for the sake of completeness): PUT, DELETE, OPTIONS, CONNECT, PATCH, TRACE.

HTTP headers

- Both requests and responses may be of interest for server-side programming.
- Request headers include users' preferences, such as Accept-Language or certain information about users' environment that you may want to know, such as User-agent.
- You can set response headers, to communicate with the browsers. For example, Refresh will instruct the browser to reload the page after specified time, or Cache-Control gives you a way to tell the browser if/how long the content can be cached.

HTTP Cookies

- A specific HTTP header field Cookie (in request) or **Set**-Cookie (in response), is widely used for web programming.
- A cookie is a piece of information a HTTP servers asks the client to retain until a specific expiry date.
- The server sends a cookie to a client using, **Set**-Cookie: name=val, expires=datetime, **domain**=d, path=p
- The client (if enabled) sends the matching cookie that are not expired with every request.
- Cookies are typically used for session management, (some form of) authentication, or applications like shopping charts.

A summary so far

- The WWW, and as a result, the web-programming environment works over HTTP.
- HTTP is a request-response protocol.
- A HTTP request is originated by a client (e.g. browser) and includes a method, and a set of headers.
- A HTTP response includes a status code, additional headers, and the content.
- A server-side web-application (whether it is a CGI program, or a embedded interpreter) has access to raw HTTP data sent by the client, and form the response the way it wants.
- You will not typically deal with the raw HTTP messages, but knowing what lies underneath helps.

SQL and programming

- SQL has limited use unless combined with a general purpose programming language.
- SQL has the advantage that it abstracts away the way data is stored from the application.
- However, it cannot do many things that a typical application program would require. Just to list a few:
  - arbitrary computation
  - flexible I/O, user interaction
  - formatted input output
  - graphical presentation of data
- There are a number of ways to combine SQL and general purpose programming
  - On DB side: stored procedures.
  - On application side: embedded SQL, or call-level interfaces
- We will be using call-level interfaces in this course.

A first PHP/MySQL example

```
1  <?php
2      $host="hostname";
3      $user="username";
4      $pass="password";
5      $db="dbname";
6      mysql_connect($host,$user,$pass);
7      mysql_select_db($db);
8      $q = 'select * from book';
9
10     $res = mysql_query($q);
11     echo "<table border=\"1\">";
12     echo "<tr><th>ISBN</th><th>title</th></tr>";
13     while ($row = mysql_fetch_assoc($res)) {
14         echo "<tr><td>${row['ISBN']}</td>";
15         echo "<td>${row['title']}</td></tr>";
16     }
17     echo "</table>";
18     mysql_close();
19 ?>
```


DB access from PHP using PDO

- There are multiple ways of connecting to databases, even multiple methods to connect to the same DBMS (For example, MySQL mysql_ and mysqli_ interfaces).
- We will follow a unified approach through PHP PDO interface.
- PDO allows a unified way to access different database management systems.
- PDO also includes facilities for more efficient and secure database programming.

PHP PDO: a first example

```
1  <?php
2      require_once('db-config.php');
3      $dbh = new PDO("mysql:dbname=$db;host=$host", $user, $pass);
4
5      $qh = $dbh->prepare('select * from book where title like ?');
6      $qh->execute(array('%database%'));
7
8      echo "<table border=\"1\">";
9      echo "<tr><th>ISBN</th><th>title</th></tr>";
10     while ($row = $qh->fetch(PDO::FETCH_ASSOC)) {
11         echo "<tr><td>${row['ISBN']}</td>";
12         echo "<td>${row['title']}</td></tr>";
13     }
14     echo "</table>";
15     $dbh = null;
16 ?>
```


PHP PDO database specification and connection

```
$dbh = new PDO('mysql:dbname=$db;host=$host', $user, $pass);
```

dbtype	DB connection type (e.g., mysql, pgsql, odbc, sqlite)
host	Host name (or IP address) where DBMS runs.
db	Name of the database.
user	Database user name.
password	Password to connect to the DB

- If successful, $dbh is a PDO object that can be used to communicate with the database.
- Note: the syntax changes depending on the database driver in use.

PHP PDO: simple queries

- query() runs the given query string, returns a 'statement object'.
- You can iterate over the object or use fetch() to get the results.
- rowCount(), and columnCount() give the number of columns and rows returned for a query.
- For DDL/DML statements use **exec()** which returns the number of rows affected by the statement.

```
foreach ($dbh->query('select * from book') as $row) {
    print $row['ISBN'] . "\t" . $row['title'] . "\n";
}
```

Note: for both, the SQL statement should be properly escaped.

Input validation

- Not validating user input introduces bugs, and possible security problems!
- Consider the statement:
  insert into book **values** ('$isbn', '$title').
  where we take user input
  The Hitchhiker's Guide to the Galaxy
- The SQL statement, after PHP replaces the values will be:

  insert into book **values** ('0330258648',
  'The Hitchhiker's Guide **to** the Galaxy')

- This is an invalid statement. We want
  'The Hitchhiker\'s Guide **to** the Galaxy'

This is also a security risk (to which we will return later).

Input validation in PDO

- You should always escape user input in your SQL statements.
- You can use quote() method of a PDO object to escape the special characters.

```
$q = "insert into  book values ('"
      . $dbh->quote($isbn) . "', '",
      . $dbh->quote($title) . "')";
foreach ($dbh->query(q) as $row) {
...
```


prepare/execute

- For SQL statements that are used multiple times with different values, an alternative to query()/**exec**() is using **prepare**() and **execute**() functions.
- **prepare**() takes a query string with missing values:
  $qh = $dbh->**prepare**('insert into book values(?,?)');
- **execute**() takes the handle returned by **prepare**() and an array of values, and replaces the ? with the values in the array:
  $dbh->**execute**($qh, array($isbn, $title));
- Alternatively, you can use bindColumn() or bindParam() for binding the results or the parameters to PHP variables.
- **prepare**()/**execute**() automatically escapes the input.

Error Handling

- The database operations do not always get executed successfully. You should check for errors.
- Unless told otherwise at initialization time, PDO objects will throw exceptions.

```
try {
  $dbh = new PDO('mysql:dbname=$db;host=$h', $user, $pass);
} catch (PDOException $e) {
  echo 'Connection failed: ' . $e->getMessage();
  exit;
}
```


Summary & Next week

This week:

- The HTTP protocol, and a bit of TCP/IP.
- HTML cookies, and how to use them in PHP.
- Using databases through PHP (mainly through PDO).

Next:

- Session management.
- A few first notes on security.