Web Architecture and Development

SWEN-261
Introduction to Software Engineering

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HTTP is the protocol of the world-wide-web.

The Hypertext Transfer Protocol (HTTP) was designed to exchange hypertext documents.

Hypertext Markup Language (HTML) is the standard format of these documents.

User

Browser

Web Server

Page HTTP requests

HTTP response (HTML)

click link

renders view

Document

Document

Document
HTTP has a standard set of **verbs**.

- **GET** retrieves **resources**.
- There are several others: **POST, PUT, DELETE** and more.
HTML is a standard document format.

- **Base structure:**
  ```html
  <!DOCTYPE html>
  <html>
    <head>!-- page metadata --></head>
    <body>!-- page content --></body>
  </html>
  ```

- **HTML5 includes many element types including:**
  - **Content:** `h1-h5, p, img, a, div/span, many more`...
  - **Lists:** `ul, ol, li`
  - **Forms:** `form, input, button, select/option` ...
  - **Tables:** `table, thead, tbody, tr, th/td` ...
Web 1.0 applications create "forms" within documents.

- Example simple web form:
  ```html
  <form action='hello' method='POST'>
    <label for='name'>Name:</label>
    <input name='name' placeholder='Enter a name' />
    <button type='submit'>Say hello</button>
  </form>
  ```

- The **POST** HTTP verb sends form data to the action **URL**.

![Diagram showing the request cycle from user to browser to web server](image)
The web server handles each HTTP request.

- A web server must have two types of components:
  - *HTTP route handler* (aka a UI controller)
  - *HTML view templates* (aka a UI view)

- This is an application of the *Separation of Concerns* principle.

- Consider a trivial Hello World web app:
This app happens to need a View and a route Controller for each verb-URL pair.

The \( \text{vm} \) is the map of named attributes passed to the view template.
The structure of a Spark web application.

- Spark is a Java-based, web micro-framework
  - It handles HTTP requests
  - It delegates the HTML generation to a template engine

- Here's the configuration code for the HelloApp

```java
import static spark.Spark.*;
import spark.TemplateEngine;
import spark.template.freemarker.FreeMarkerEngine;

public class HelloApp {
    public static void main(String[] args) {
        final TemplateEngine templateEngine = new FreeMarkerEngine();
        get("/", new GetHomeRoute(templateEngine));
        post("/hello", new PostHelloRoute(templateEngine));
    }
}
```
Here's an example Spark route controller.

```java
import java.util.HashMap;
import java.util.Map;
import spark.*;

public class GetHomeRoute implements Route {
    private final TemplateEngine templateEngine;
    // constructor not shown

    public Object handle(Request request, Response response) {
        final Map<String, Object> vm = new HashMap<>();
        vm.put("pageTitle", "Home");
        return templateEngine.render(new ModelAndView(vm, "home.ftl"));
    }
}
```

We use the convention to name route controllers as VerbUrlRoute.

The View-Model is a Java map of name/value pairs called attributes.

This is the name of the FreeMarker template file.
Here's the model of the example Spark controller.

This is our class.
Here's an example FreeMarker view template.

- A FreeMarker resource is a text file with HTML plus special tags for additional rendering logic.

```html
<!DOCTYPE html>
<head>
</head>
<body>

<h1>HelloApp: ${pageTitle}</h1>

<p>Say hello to someone...</p>

<form action='hello' method='POST'>
  <label for='name'>Name:</label>
  <input name='name' placeholder='Enter a name...' />
  <button type='submit'>Say hello</button>
</form>

</body>
</html>
```

- View logic includes conditionals and loops.
Most webapps need to connect all of a single user's requests together.

**HelloApp: Home**

Say hello to someone...
Name: world

- World

**HelloApp: Greeting**

Hello, world.
Go home.

**HelloApp: Home**

Say hello to someone...
Name: Fred

- World

**HelloApp: Greeting**

Hello, Fred.
Go home.

**HelloApp: Home**

Say hello to someone...
Name: Enter a name...

- World
- Fred
Web application frameworks provide an HTTP cookie that identifies the user.

The response to a user’s first request gets a session cookie.

The browser sends the session cookie on all following requests.
To support keeping track of the names the Hello Post controller must store the name in the session.

- Here's the code

```java
public class PostHelloRoute implements Route {
    private final TemplateEngine templateEngine;
    // constructor not shown
    public Object handle(Request request, Response response) {
        final String name = request.queryParams("name");
        storeName(name, request.session());
        final Map<String, Object> vm = new HashMap<>();
        vm.put("pageTitle", "Greeting");
        vm.put("name", name);
        return tempEngine.render(new ModelAndView(vm, "greeting.ftl"));
    }
    private void storeName(String name, Session session) {
        // on next slide
    }
}
```

Note the use of a private helper method to make the code more readable.
You can define attributes in the Session object which can hold any object with any name.

- Here's the code to store the list of names:

```java
public class PostHelloRoute implements Route {
    public Object handle(Request request, Response response) {
        // code on previous slide
    }
    private void storeName(String name, Session session) {
        List<String> names = session.attribute("names");
        if (names == null) {
            // Initialize it
            names = new ArrayList<>();
            session.attribute("names", names);
        }
        names.add(name);
    }
}
```

- Limit how many attributes you put in the session.
- Pick meaningful attribute names.
Now that we've stored the list of names in the session let's see how to use it.

- Here are the changes to the GetHomeRoute:

```java
public class GetHomeRoute implements Route {
    public Object handle(Request request, Response response) {
        final Session session = request.session();
        final Map<String, Object> vm = new HashMap<>();
        vm.put("pageTitle", "Home");
        vm.put("names", session.attribute("names"));
        return tempEngine.render(new ModelAndView(vm, "home_v2.ftl"));
    }
}
```

- Change to the Home view:

```html
<#if names??>
<ol>
    <#list names as n>
        <li>${n}</li>
    </#list>
</ol>
</#if>
```
The `Session` object is like a Java `Map` object; it can store any number of named elements.

- **The Java `Map` API:**
  - *The `put(key, value)` method stores an element.*
  - *The `get(key)` method retrieves an element, or null if no element is found*

- **The Spark `Session` API:**
  - *The `attribute(name, value)` method stores an element.*
  - *The `attribute(name)` method retrieves an element, or null if no element is found*

- Use the `Session` object sparingly.
Web 1.0 is server-oriented, while Web 2.0 is client-oriented.

- Web 1.0 is a vision of web development in which the server generates the view (the HTML).
- Web 2.0 is a vision in which the client is responsible for generating the view.
  - *This is done with manipulation of a Document Object Model (DOM).*
  - *And with Ajax calls to the server to exchange data*

- A hybrid approach is also possible.
  - *The term project uses a hybrid approach*
  - *You will need to understand how to build Ajax route handlers in Spark*
Ajax is a technique for the browser to call the server without rendering a new page.
Gson can parse the JSON strings in a client Ajax call to Java objects.

- An Ajax Route to insert a new Customer entity:

```java
public class PostCustomerRoute implements Route {
    private final Gson gson;
    // constructor not shown

    public Object handle(Request request, Response response) {
        final String customerJSON = request.body();
        final Customer customer =
            gson.fromJson(customerJSON, Customer.class);
        // TODO: add database insert code
        return "Customer saved.";
    }
}
```

This object will be injected into the instantiated route object when it is constructed.

This will parse the received JSON request stored in `customerJSON` and return a `Customer` object with its attributes that match by name with attributes in the JSON request initialized to the value associated with the matching JSON attribute.
The response to the Ajax call requires the route to convert a Java object into a JSON string.

- Gson is a Google library for JSON
- An Ajax Route:

```java
public class GetCustomerRoute implements Route {
    private final Gson gson;
    // constructor not shown

    public Object handle(Request request, Response response) {
        // TODO: add database lookup code
        return gson.toJson(new Customer(47, "Fred"));
    }
    // JSON would be: {id:47, name:"Fred"}
}
```

- How this route is configured:

```java
public class AjaxSampleApp {
    public static void main(String[] args) {
        final Gson gson = new Gson();
        get("/customer", new GetCustomerRoute(gson));
    }
}
```

This is will generate a JSON response instead of the HTML.
Remember the architecture for the term project

This is where you put the HTTP request handlers and view generation templates.
Now you have seen examples of Server UI components: views and controllers.
These are the responsibilities of UI components.

- **UI Views**
  - *Provide an interface to the user*
  - *Present information to the user in a variety of ways*
  - *Provide a mechanism for user to input data and requests*

- **UI Controllers**
  - *Control the views based on the state of the application*
  - *Query the Application and Model tiers as necessary to get information to present to the user*
  - *Perform simple input validation and data conversion based on input modality, e.g. String to Object*
  - *Initiate processing of user requests/commands possibly providing data the user entered*
  - *Perform data conversion for display by views*
Maven is a build tool for Java applications.

- There have been many build tools over the years: UNIX make, Ant, Maven and Gradle.
- Maven provides these build services:
  - Compile sources files
  - Download third-party libraries (such as Spark)
  - Assemble all files into an archive (JAR or WAR, etc)
  - Run test suite
  - Execute programs
  - Generate project reports
Maven provides a default project structure.

- The source code is in:
  - `src/main/java`: holds your Java code
  - `src/main/resources`: holds all non-Java web resources files and FreeMarker templates

- The test code is in:
  - `src/test/java`: holds your Java test code

- The build area is in the `target` directory.

- The `pom.xml` file provides the Project Object Model
  - A description of your project
  - The third-party libraries to be included
  - Any plugins, such as testing or analysis tools
Maven is run from the command-line or from within your IDE.

- To build and assemble the project:
  \texttt{mvn compile}

- To run a Java program:
  \texttt{mvn exec:java}

- To run the project's test suite:
  \texttt{mvn test}
Browsers have developer tools to help diagnose problems with a webapp.

- View DOM structure
  - *You can edit the DOM or change/add element attributes*

- View the CSS styles assigned to any given element
  - *You can edit CSS rules to see how that affects the visual aspects of an element*
  - *You can add new CSS rules on the fly*

- View the sequence of HTTP requests; including resources and Ajax calls

- View the JavaScript console
  - *There is also a REPL (read-eval-print loop)*