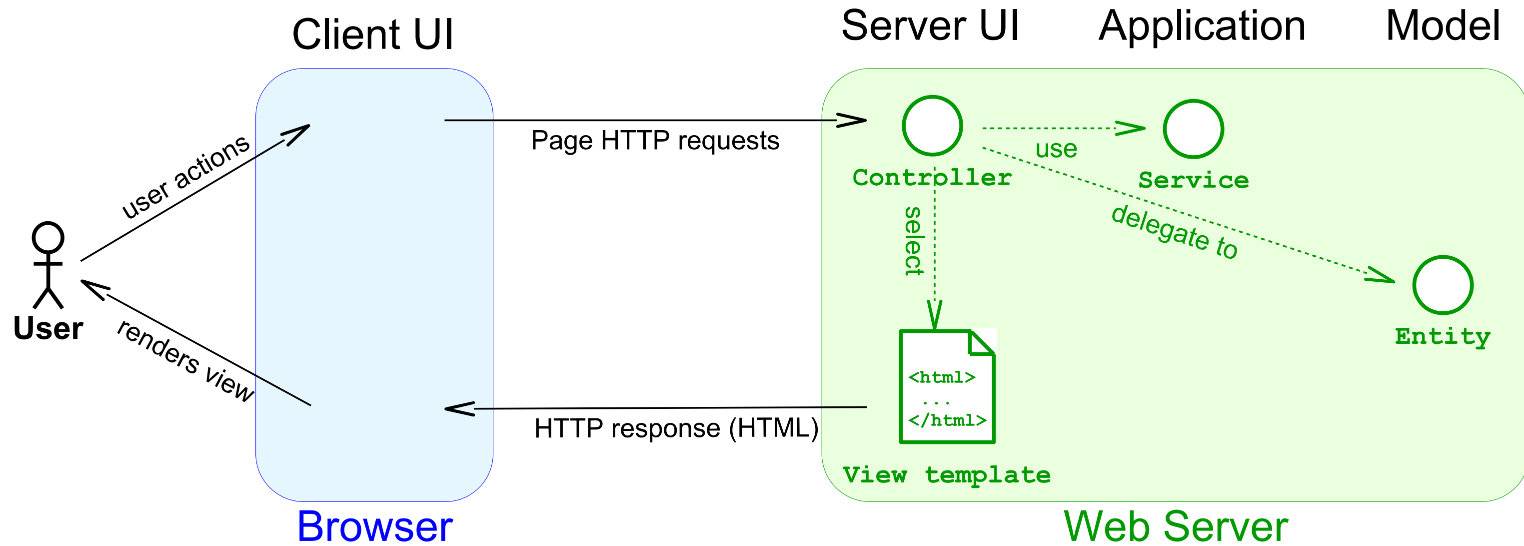
Web Architecture and Development



SWEN-261
Introduction to Software Engineering

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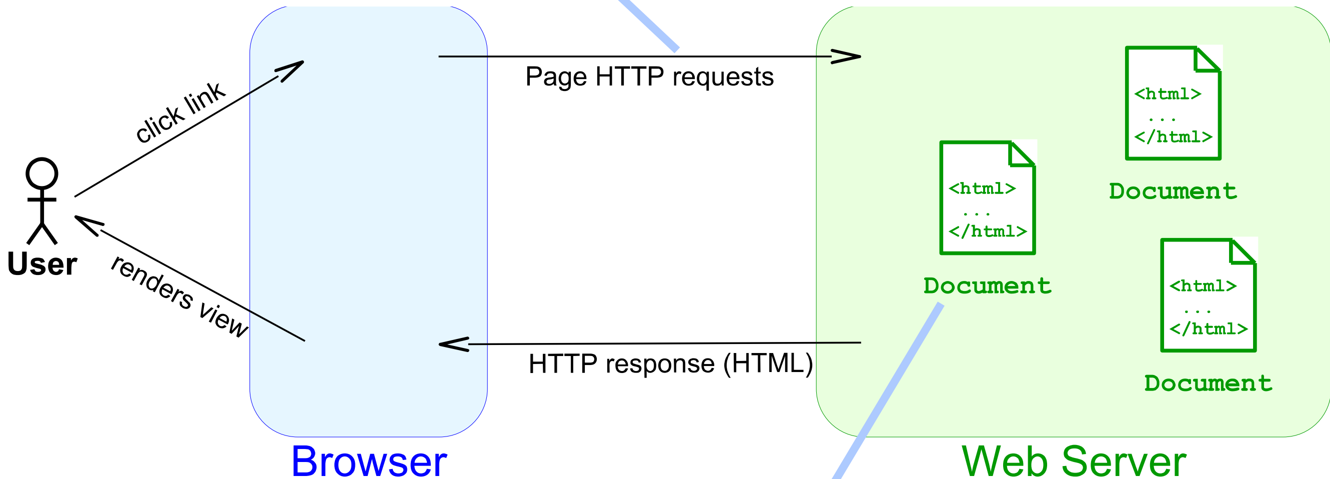
HTTP is the protocol of the world-wide-web.

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



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

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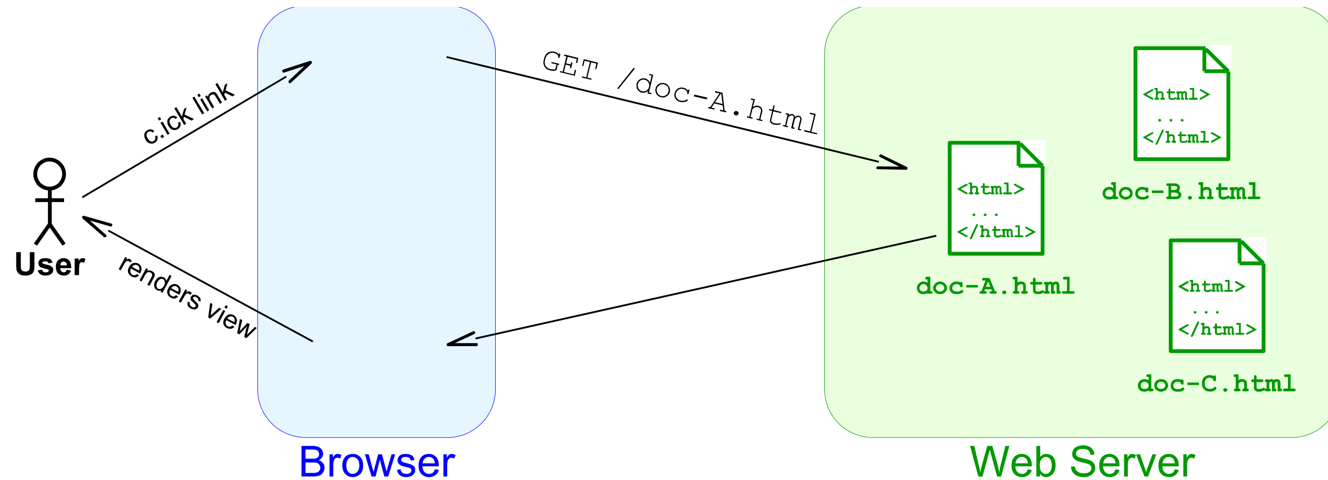
HTTP has a standard set of *verbs*.



- GET retrieves *resources*.
- There are several others: POST, PUT, DELETE and more

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HTML is a standard document format.

- Base structure:

```
<!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` …***

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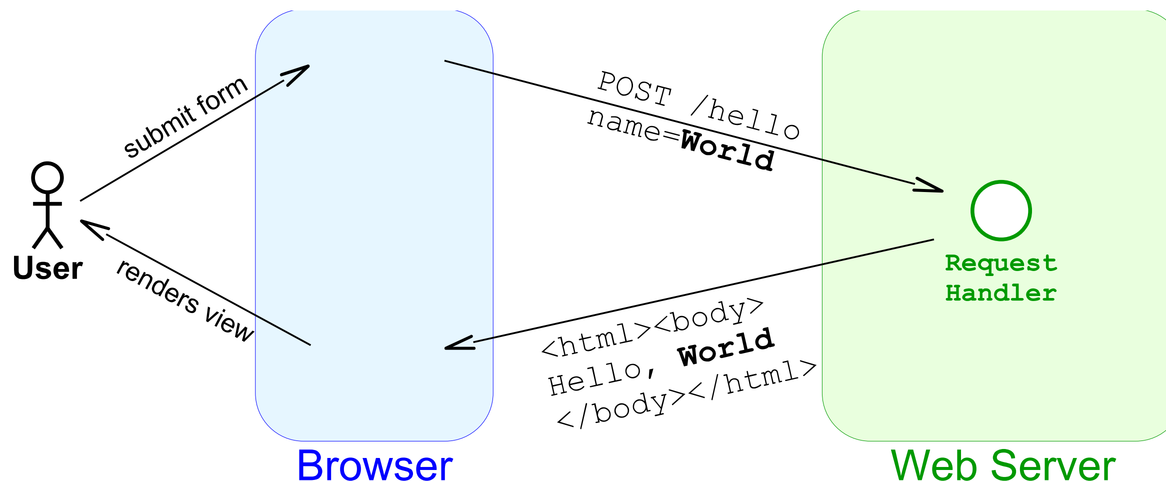
Web 1.0 applications create "forms" within documents.

- Example simple web form:

```
<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.



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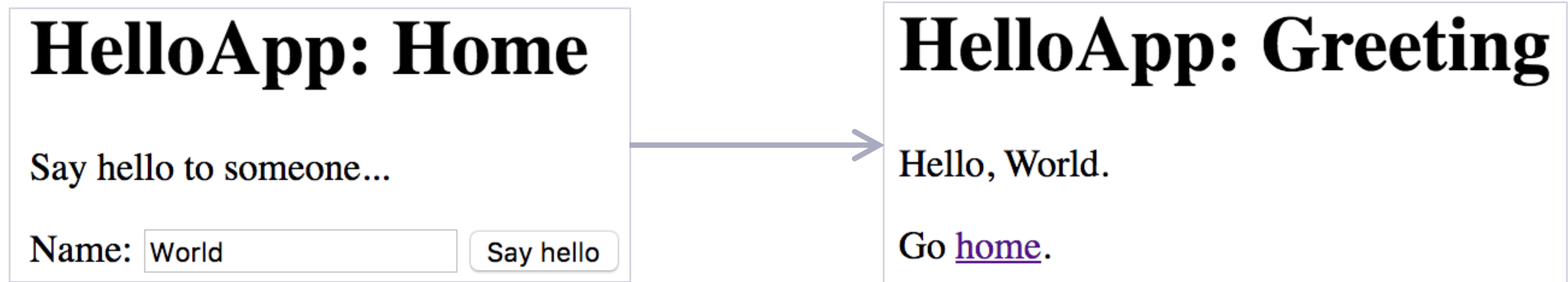
The web server handles each HTTP request.

- 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:



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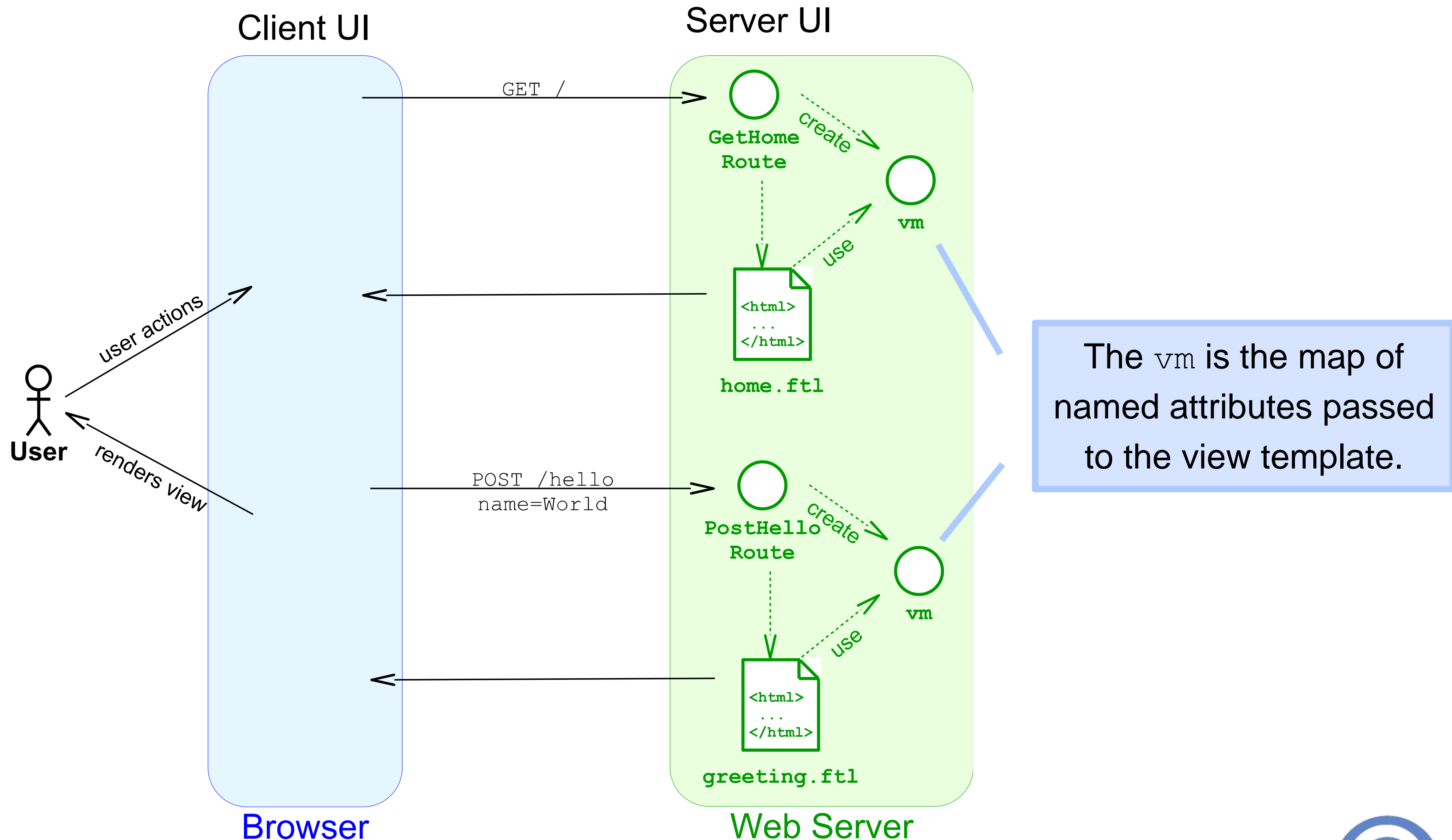
This app happens to need a View and a route Controller for each verb-URL pair.



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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.

```
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.

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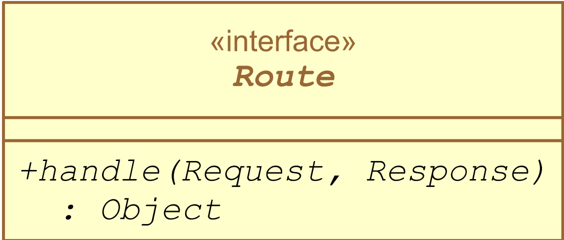
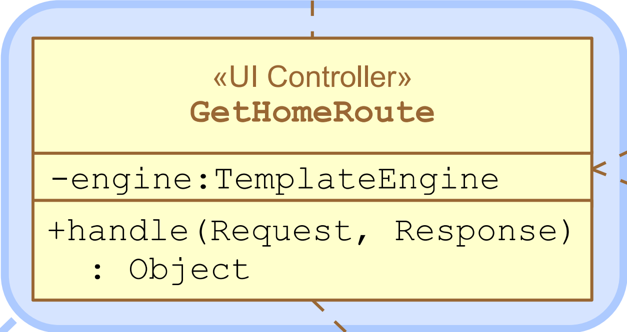
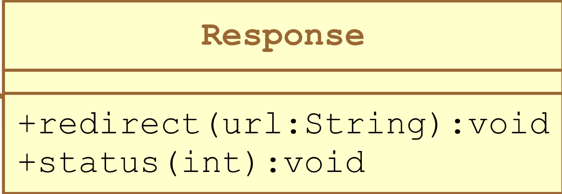
Here's the model of the example Spark controller.

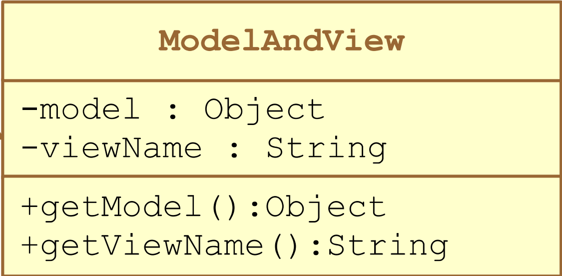


Everything else is part of the Spark framework.





This is our class.



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Here's an example FreeMarker view template.

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

```
<!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>
```

This is the key for an attribute in the *View-Model* map object.

- 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 [Say hello]

HelloApp: Greeting

Hello, World.

Go home.

HelloApp: Home

Say hello to someone...

Name: Fred [Say hello]

1. World

HelloApp: Greeting

Hello, Fred.

Go home.

HelloApp: Home

Say hello to someone...

Name: Enter a name... [Say hello]

1. World
2. Fred

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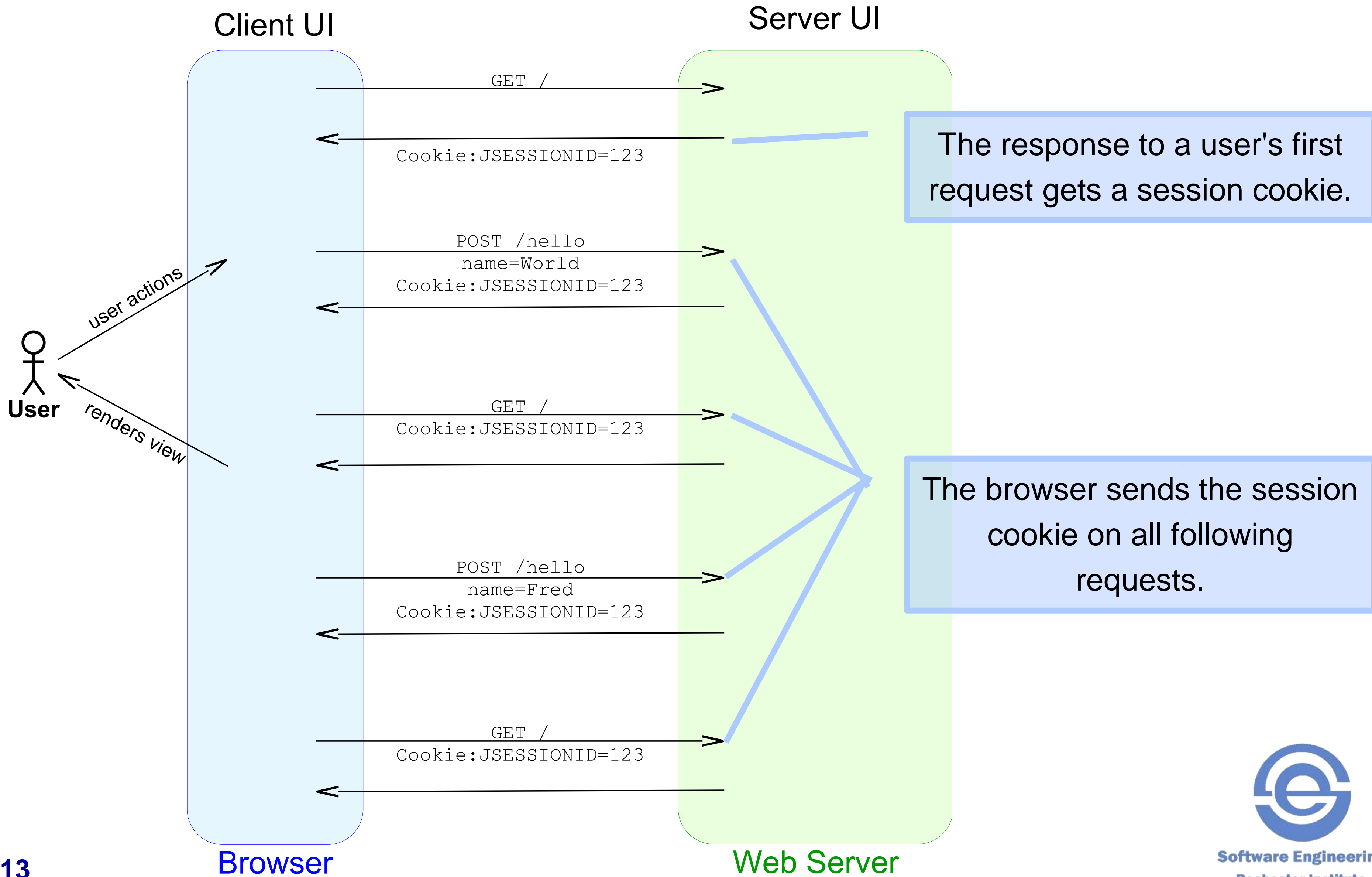
Web application frameworks provide an HTTP cookie that identifies the user.



To support keeping track of the names the Hello Post controller must store the name in the session.

- Here's the code

```
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.

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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:

```
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.

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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:

```
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:

```
<#if names??>
   <ol>
   <#list names as n>
     <li>${n}</li>
   </#list>
   </ol>
 </#if>
```


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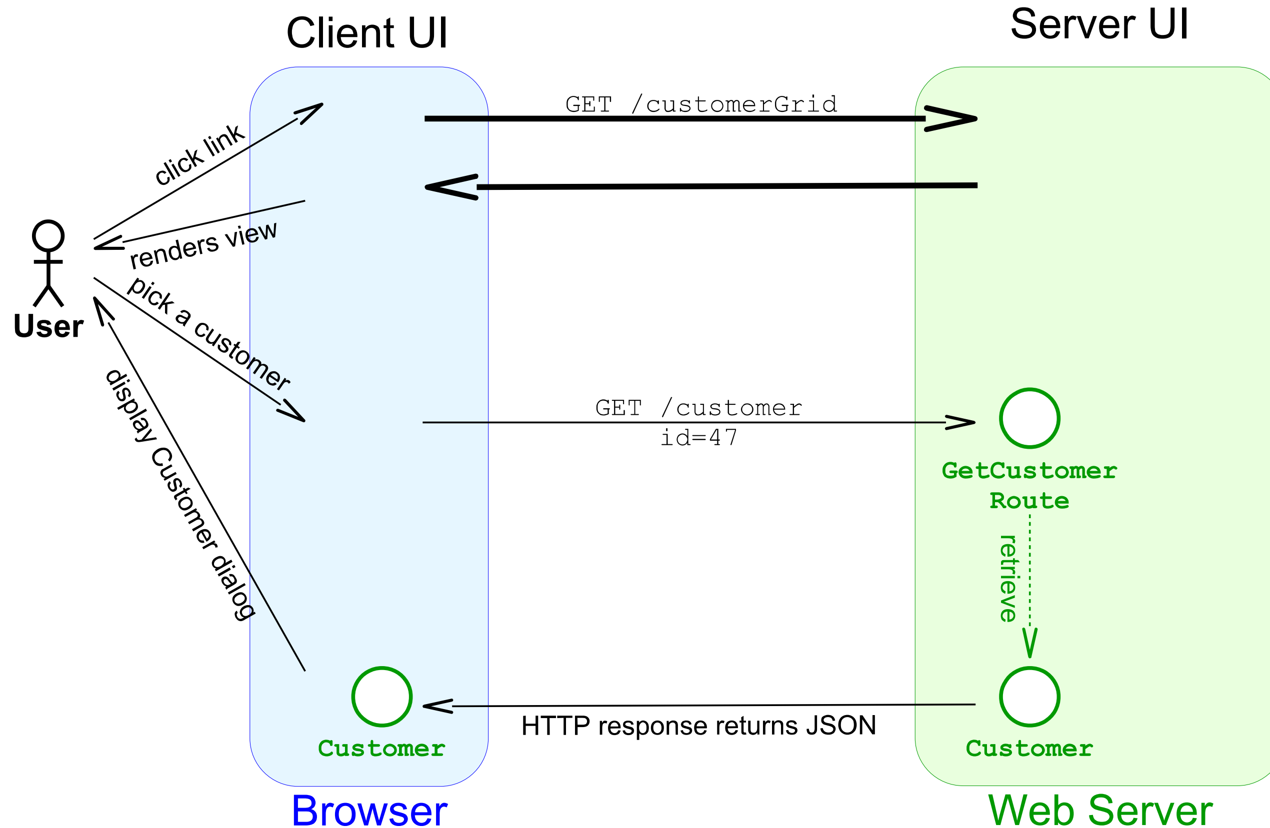
The `Session` object is like a Java `Map` object; it can store any number of named elements.

- 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.



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Gson can parse the JSON strings in a client Ajax call to Java objects.

- An Ajax Route to insert a new Customer entity:

```
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 is 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.

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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:

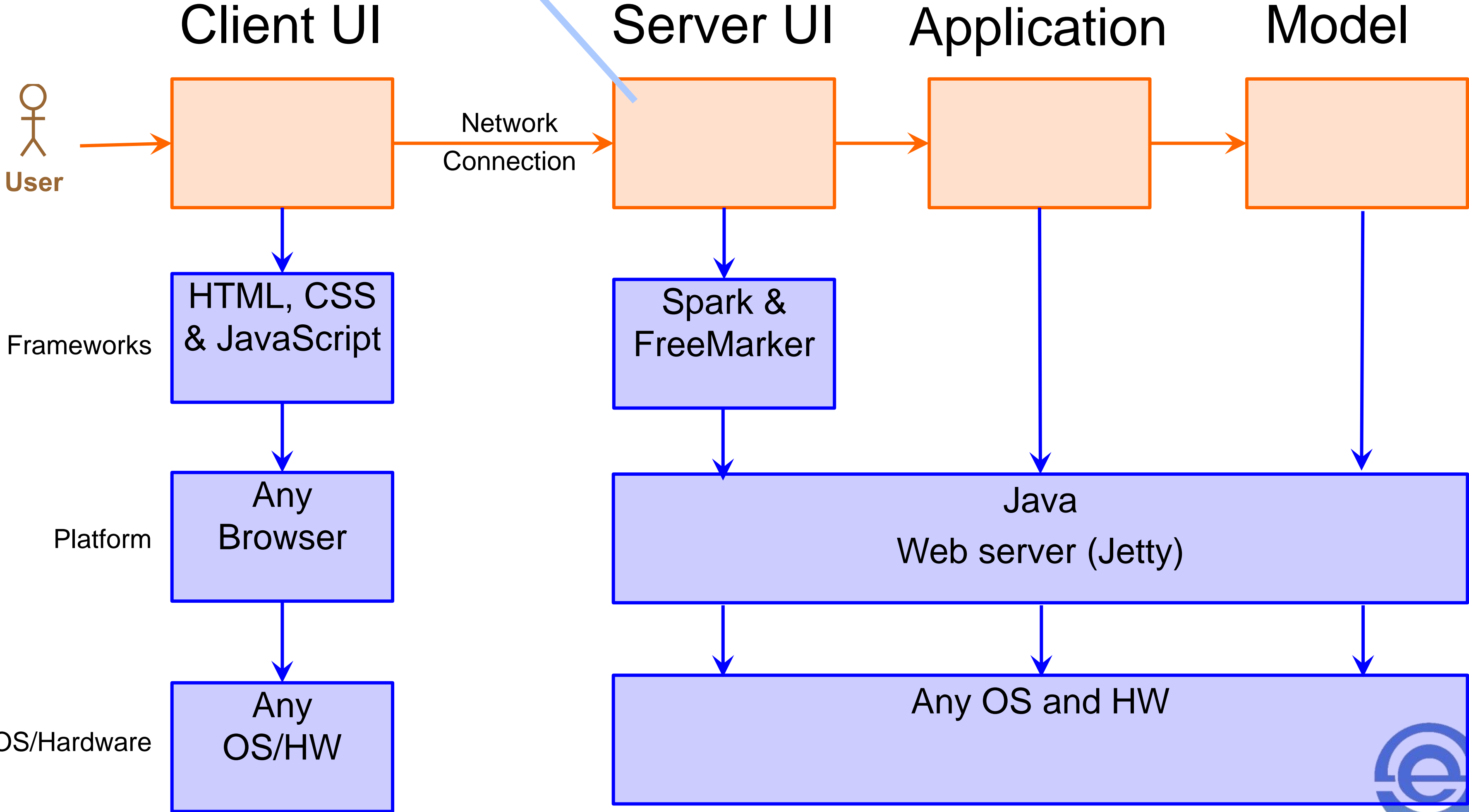
```
public class GetCustomerRoute implements Route {
  private final Gson gson;
  // constructor not shown
  public Object handle(Request request, Response response) {
    // TODO: add database lookup code
    return gson.toJson(new Customer(47, "Fred"));
  }
  // JSON would be: {id:47, name:"Fred"}
}
```

This is will generate a JSON response instead of the HTML.

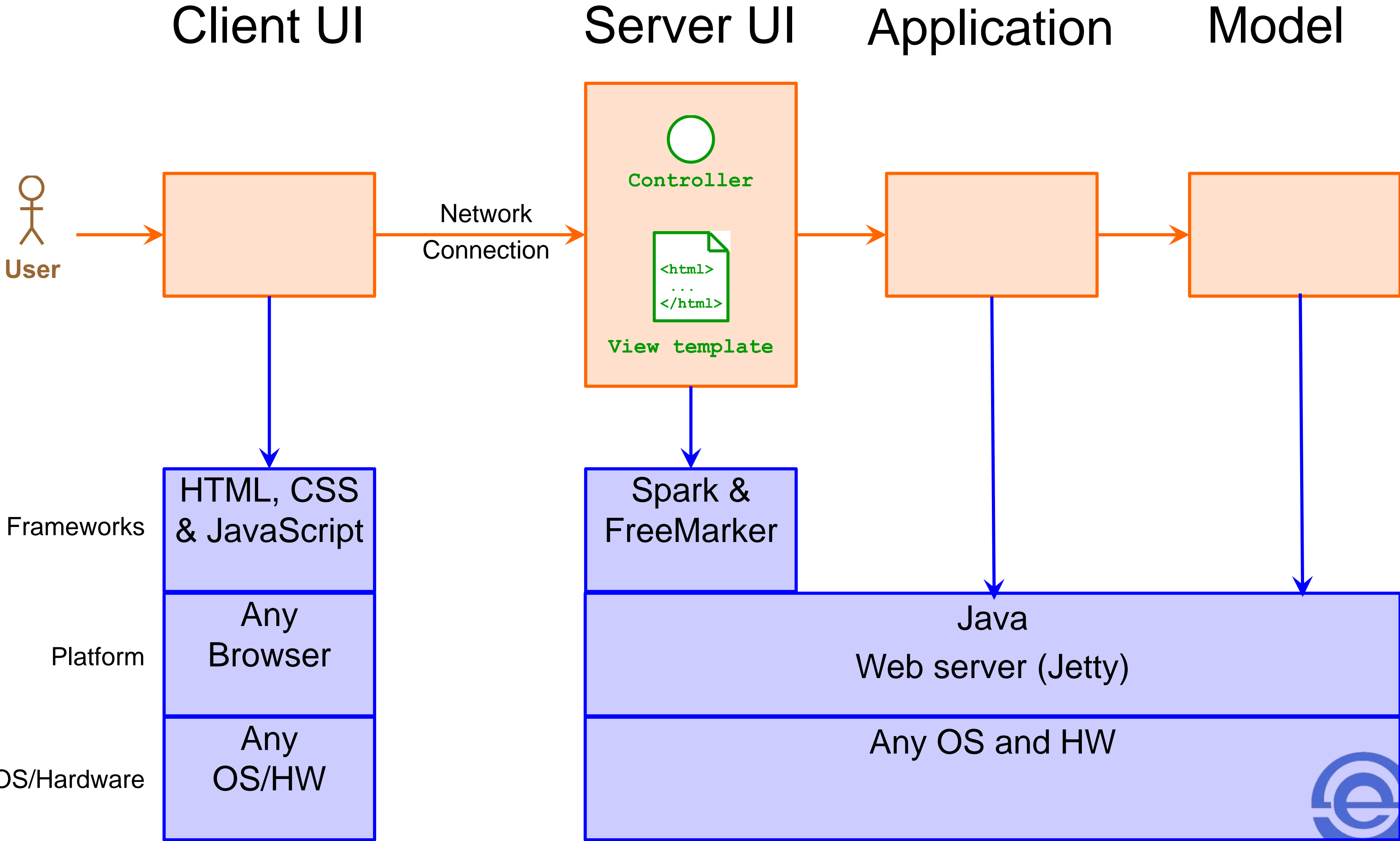
- How this route is configured:

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

Remember the architecture for the term project



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*

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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:
  `mvn compile`
- To run a Java program:
  `mvn exec:java`
- To run the project's test suite:
  `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)***