CS144: Single-Page Application

- Now Web apps are becoming almost like a desktop app, except that it is downloaded from the Web
- Single-page Application (SPA)
  - An app where everything happens on a single page
  - No page reload and wait
    * Even when the browser needs to obtain data from server

Scripted HTTP

- Google suggest example interaction: http://oak.cs.ucla.edu/cs144/examples/google-suggest.html
  - Q: What is going on behind the scene? What events does it monitor? What does it do when the event is detected?
  - Q: When the “typing” event is detected, what does it have to do? How can it let users keep type while waiting for data from server?

XMLHttpRequest

XMLHttpRequest: JavaScript object for asynchronous communication with the server

- Sending a request to server

```javascript
xmlHttp = new XMLHttpRequest();
xmlHttp.open("GET", URL); // method, url
xmlHttp.send(null); // body of the request
```

- open(method, URL) produces request line
- setRequestHeader(header-name, value) adds request header
- send(body) produces request body
- Actual connection to the server is made only when send() is called

- Handling response:
  - Set onreadystatechange to our own event handler
xmlHttp.onreadystatechange = handlerfunction;

- `onreadystatechange` is called whenever a change occurs in the state of the request
  - The current state of the request is available at `readyState` property
    - 0: `UNSENT`. `open()` has not been called
    - 1: `OPENED`. `open()` has been called
    - 2: `HEADERS_RECEIVED`. Headers have been received
    - 3: `LOADING`. The response body is being received
    - 4: `DONE`. The response is complete
- Response from the server is available as `responseText/responseXML` properties
  - `responseText` is text, `responseXML` is XML DOM
- Server response in JSON
  - The server response used to be mainly in XML, but JSON has gained popularity
    - `response = JSON.parse(xmlHttp.responseText);`
    - Once parsed, `response` work just like a regular JavaScript object

**XML (Extensible Markup Language)**

- HTML was hugely successful due to
  - Simplicity -> can be learned easily
  - Text based -> can be edited by any text editor. No need for a special tool
- But, HTML is mainly for human consumption
  - HTML tags are for document structure, not for semantic meaning
    - e.g., `<table>, <ul>`, etc.
- XML: data representation standard with “semantic” tag

```xml
<?xml version="1.0"?>
<Book edition="1">
  <Title>Database systems</Title>
  <Author>Hector Garcia-Molina</Author>
</Book>
```
**XMLHttpRequest Example**

```html
<!DOCTYPE html>
<html>
<head>
</head>
<body onload="init();">
  <b>Your query:</b> <input type="text" id="queryBox"><br>
  <b>Suggestion</b>: <div id="suggestion"></div>
</body>
<script type="text/javascript">
let xmlHttp;

// initialization
function init() {
  xmlHttp = new XMLHttpRequest();
  document.getElementById("queryBox").oninput = sendAjaxRequest;
}

// send Google suggest request based on the user input
function sendAjaxRequest(event) {
  let request = "google-suggest.php?q="+encodeURIComponent(this.value);

  xmlHttp.open("GET", request);
  xmlHttp.onreadystatechange = showSuggestion;
  xmlHttp.send(null);
}

// update the page with the response
function showSuggestion() {
```

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// if the request is complete, display the response from the server
if (xmlHttp.readyState == 4) {
    htmlCode = xmlHttp.responseText.replace(/</g,'&lt;').replace(/>/g,'&gt;');
    document.getElementById("suggestion").innerHTML = htmlCode;
}
</script>
</html>

• Q: What events does the code monitor?
• Q: What does it do when the event is detected?
• Q: When it receives the response from the server, what does it do?
• Q: What URL does it send the request to? Why is not the Google server?

Same-origin policy

• XMLHttpRequest can send a request only to the same host of the page
  – Due to this policy, a third-party site cannot be contacted through XMLHttpRequest
  – Run a “proxy” on the same host, which takes a request and forwards it to the third-party Web site
  – Cross-Origin Resource Sharing (CORS) and JSONP have been developed to get around this restriction
• Cross-Origin Resource Sharing (CORS)
  – The browser can inquire server-approved cross-request domains through Origin: header
  – The server replies the list of allowed domains with Access-Control-Allow-Origin: header
  – Example:

    In request to server
    Origin: http://oak.cs.ucla.edu
In response from the server
Access-Control-Allow-Origin: http://www.google.com

- This allows Javascript code running on a page from oak.cs.ucla.edu to issue a cross-site request to www.google.com
- CORS is automatically taken care of by modern browsers, so there is nothing JavaScript programmer has to do, as long as the servers are configured to allow CORS

JSONP (JSON with Padding)

- A “hack” to get around same-origin policy restriction
- Using JavaScript, set src to the URL to which a request should be sent
  - Same origin policy is not applied to src in `<script src="url">`!
- The response is considered as a JavaScript by the browser and gets executed
  - If the response is in JSON, a JavaScript object is created!
- To be able to use the object inside our code, the JSON response should be “wrapped” with a function call like `myFunc({"x": 10, "y": 20});`
  - `myFunc` is called with the object as the parameter.
- JSONP requires support from the third-party Web site
  - The callback function name is often provided as part of the request

Web Storage

- HTML5 provides `localStorage`: a persistent “storage” to store data locally
- Example

```javascript
// store and retrieve data
localStorage["username"] = "John";
localStorage["object"] = JSON.stringify(obj);
let name = localStorage["username"];  
// iterate over all stored keys
for(let key in localStorage) {
    let value = localStorage[key];
}
```
```javascript
localStorage.removeItem("username");
localStorage.clear(); // delete everything
```

- **localStorage** and **sessionStorage**
  - Associative key-value store
  - HTML5 standard allows storing any object, but most browsers support only string
  - **localStorage** persists over multiple browser sessions
    * Separate storage is allocated per each server
  - **sessionStorage** persists only within the current browser tab
    * Data disappears once the browser tab is closed
    * If two tabs from the same server is opened, they get separate storage

### HTML5 Session history

- **Example:** http://mail.yahoo.com
  - Q: Open an email. When a user presses back button, what will the user expect?
  - Q: Knowing what we know, what is likely to happen?
    * Q: What would have happened if “opening the email” was pointing to a new URL?
    * Q: What would happen if “opening the email” was simple JavaScript code without changes in the URL?

- **Back button**
  - Browser’s back button behavior may cause a serious usability issue unless handled well
  - User expects the previous app state **within** the SPA
  - But browser may actually unload the app and show the previous page in the history

- **Deep link**
  - Q: When a user “saves” a URL, what does the user expect to see when the user visits the URL later?
    * e.g., when the user saved the URL, an email message was open.
• Pre-HTML5 solution: URL fragment identifier
  – Change in URL fragment identifier does not reload a page
    * Navigation within the same page
  – Associate each “state” of the app with a unique URL fragment identifier
  – Back button navigates within the same page without reload
  – `location.hash` corresponds to the URL fragment identifier
    * Update `location.hash` to change fragment identifier of the URL
    * The new URL value is appended to the browser history
    * Set `window.onhashchange` to a custom handler function to change what happens when the fragment identifier changes as a result of history navigation

• Session history API in HTML5
  – `history.pushState(object, title, url)` and `history.replaceState(object, title, url)`
    * Allows saving an “object” as part of browser
    * Appends (`pushState`) or replaces (`replaceState`) browser history
    * When users navigate history through the back button, “pop state” event is triggered
    * Set `window.onpopstate` to a custom handler function to update the app using the “popped object” as a result of history navigation

References

• XMLHttpRequest: https://xhr.spec.whatwg.org/
• XML 1.1 specification: https://www.w3.org/TR/2006/REC-xml11-20060816/
• XML namespace 1.1 specification: https://www.w3.org/TR/2006/REC-xml11-20060816/
• Cross-Origin Resource Sharing: https://www.w3.org/TR/cors/
• CSS Animation: https://www.w3.org/TR/css-animations-1/
• Web Storage: https://www.w3.org/TR/webstorage/