JavaScript:
DOM and Events

Lecture 26
Objects are Everywhere

- Global variables in JavaScript are a lie
- Implicitly part of some "global object", provided by execution environment

See Developer Tools: Console
Window Object

- For JavaScript running in a browser, implicit global object is the window

\[
\gg \ \text{this}
\]
\[
<- \ \text{Window}
\]

- Many properties, including
  - location (url of displayed document)
  - status (text in status bar of browser)
  - history
  - innerHeight, innerWidth
  - alert(), prompt()
  - document (tree of displayed document)

- For JavaScript in a different environment (eg node.js), the global object is different
Document is a Tree

```html
<html lang="en">
<head>
  <title>Something Short and Sweet</title>
  <meta charset="utf-8">
</head>
<body>
  <p>Hello
    Something Short and Sweet
  </p>
  <a href="planet.html">World</a>
  ![img src="pic.png" alt="a globe"]
</body>
</html>
```
DOM: “Document Object Model”

- DOM is a language-neutral API for working with HTML (and XML) documents
  - Different programming languages have different bindings to this API
  - But all are similar to JavaScript’s API

- In JavaScript, tree nodes → objects
  - A tree node (an HTML element, or text node)
    ```html
    <input type="text" name="address">
    ```
  - A JavaScript object with many properties
    ```javascript
    { tagName: "INPUT",
      type: "text",
      name: "address", /* lots more... */ }
    ```
DOM History

- Ad hoc DOM existed from the beginning of JavaScript
  - Core purpose of client-side execution: Enable user interaction with the document
  - Need a connection between programming language (JavaScript) and the document
- DOM 1 specification (W3C) in '98
  - Standardized mapping tree→objects and functions for modifying the tree
- DOM 2 ('00): added styles and event handling
- DOM 3 ('04): fancier tree traversal & indexing schemes
- DOM “4” ('15...):
  - Actually just a “living document”
  - Some non-backwards-compatible changes
Accessing the DOM Tree

- The `document` property of `window`
  - `write()`: outputs text to document body
  - `links`: all links in document
  - `images`: all images in document
  - `forms`: array of forms in a page
    - `elements[]`: array of widgets in a form
  - `anchors`: all anchors in document
  - `getElementById(string)`: find a node
  - `querySelectorAll(string)`: find nodes
  - `etc...`
Document is a Tree

```
<html lang="en">
  <head>
    <title>Something Short and Sweet</title>
  </head>
  <body>
    <p>Hello World!

    <a href="planet.html">
      Something Short and Sweet
    </a>
    <br>
    <img src="pic.png" alt="a globe">
  </body>
</html>
```
Node is a JavaScript Object

- **Properties**
  - `parentNode`, `childNodes`, `firstChild`, `lastChild`, `nextSibling`, `previousSibling`
  - `innerHTML`
  - `tagName`
    - HTML upper case (A), XML lower case (a)
  - `attributes`, `name`, `id`, `class`
  - `style`
    - Hyphenated property in CSS (e.g., “font-size”) becomes camelCase in JavaScript (e.g., “fontSize”)

- **Methods**
  - `appendChild(node)`, `removeChild(node)`, `insertBefore(node)`
  - `hasAttribute(attr)`, `removeAttribute(attr)`, `getAttribute(attr)`, `setAttribute(attr)`
  - `getElementsByTagName(name)`
Demo: Web Console (Reading)

```javascript
> let b = document.body;
> b.tagName; // 'BODY'
> b.childNodes; // collection of nodes
> for (let n of b.childNodes) {
    console.info(n.nodeName)
}
> b.style; // inspect css properties

> let x = document.getElementById("footer");
> x.innerHTML;
> x.childNodes;
```
Demo: Web Console (Writing)

```javascript
> let b = document.body;
> b.style.backgroundColor;
> b.style.backgroundColor = "green";

> let x = document.getElementById("footer");
> x.innerHTML;
> x.innerHTML = "<h2>Hello</h2>"; // bad

> let h = document.createElement("h2");
> h.className = "demo";
> h.textContent = "World";
> x.appendChild(h);
```
How to Find a Node in Tree

1. Hard coding with “flat” techniques
   - Array of children
     
     `document.forms[0].elements[0]`
   - Downside: too brittle
   - If the document structure changes a little, everything breaks

2. Using an element's *name* attribute
   - In HTML:
     
     `<form name="address">  ...
     <input name="zip"... />
     </form>`
   - In JavaScript:
     
     `document.address.zip`
   - Downside: direct path still hard coded
How to Find a Node in Tree

3. Using an element's *id* attribute
   - In HTML
     ```html
     <td id="shipping">...</td>
     ```
   - In JavaScript
     ```javascript
     document.getElementById("shipping")
     ```
   - Downside: element must have (unique) ID

4. Using a *CSS selector*
   - Can find one match or all matches
     ```javascript
     document.querySelector("#shipping");
     document.querySelectorAll(".nav li");
     ```
   - Can search whole tree or subtree
     ```javascript
     elt.querySelector("table"); // from elt
Example

```html
<form id="wheels">
  <input type="checkbox" name="vehicles" value="car" /> Car
  <input type="checkbox" name="vehicles" value="truck" /> Truck
  <input type="checkbox" name="vehicles" value="bike" /> Bike
</form>

let numChecked = 0;
let elt = document.getElementById("wheels");
for (const box of elt.vehicles) {
  if (box.checked)
    numChecked++;
}
```
Interactive Documents

To make a document interactive, you need:

- Widgets (ie HTML elements)
  - Buttons, windows, menus, etc.
- Events
  - Mouse clicked, window closed, button clicked, etc.
- Event listeners
  - Listen (ie wait) for events to be triggered, and then perform actions to handle them
Events Drive the Flow of Control

- This style is *event driven* programming
- Event handling occurs as a loop:
  - Program is idle
  - User performs an action
    - Eg moves the mouse, clicks a button, types in a text box, selects an item from menu, ...
  - This action generates an event (object)
  - That event is sent to the program, which responds
    - Code executes, could update document
  - Program returns to being idle
Handling Events Mechanism

Three parts of the event-handling mechanism

- **Event source**: the widget with which the user interacts
- **Event object**: encapsulated information about the occurred event
- **Event listener**: a function that is called when an event occurs, and responds to the event
Programmer Tasks

- Define an event handler
  - Any function can be an event handler
  - Often need information about the triggering event in order to know what response is needed

- Register handler with source element

- Detect event and invoke handler
  - Ha! Just kidding, you do NOT do this
Simple Example: Color Swaps

This page illustrates changing colors

<form>
  <p>
    <label> background: 
      <input type="text" name="back" size="10" onchange="foo('bg', this.value)" />
    </label>  
    <br />
    <label> foreground: 
      <input type="text" name="fore" size="10" onchange="foo('fg', this.value)" />
    </label>
  </p>
</form>
function foo(place, color) {
    if (place === "bg")
        document.body.style.backgroundColor = color;
    else
        document.body.style.color = color;
}
Event Propagation

- Elements are nested in tree
- When an event occurs, which element's handler(s) is(are) notified?
- First, *propagation path* is calculated: from root to smallest element
- Then event dispatch occurs in 3 phases
  1. Capture (going *down* the path)
  2. Target (smallest element)
  3. Bubble (going *up* the path, reverse of 1)
http://www.w3.org/TR/DOM-Level-3-Events/
Bubbling Up

- Handling is usually done in phase 2 and 3
- Example: mouse click on hyperlink
  - Handler for `<a>` element displays a popup ("Are you sure you want to leave?")
  - Once that is dismissed, event flows up to enclosing `<p>` element, then `<div>` then... etc. until it arrives at root element of DOM
  - This root element (i.e. `window`) has a handler that loads the new document in the current window
Programmer Tasks

- Define a handler
  - Easy, any function will do

- Register handler
  - Multiple ways to link (HTML) tree elements with (JavaScript) functions

- Be triggered by the event
  - Ha! Still kidding

- Get information about triggering event
  - Multiple (incompatible) ways for handler to get the event object
Registering an Event Handler

- Three techniques, ordered from:
  - Oldest (most brittle, most universal) to
  - Newest (most general, least standard)

1. Inline (link in HTML itself)
   ```html
   <a href="page.html" onclick="foo()">…
   ```

2. Direct property (link in JavaScript)
   ```javascript
   let e = ... // find source element in tree
   e.onclick = foo;
   ```

3. Chained (In JavaScript, browser differences)
   ```javascript
   let e = ... // find source element in tree
   e.addEventListener("click", foo, false);
   ```
Inline Registration (pre DOM)

- Use HTML *attributes* (vary by element type)
  - For window: `onload`, `onresize`, `onunload`, ...
  - Forms & elements: `onchange`, `onblur`, `onfocus`, `onsubmit`, ...
  - Mouse events: `onclick`, `onmouseover`, `onmouseout`, ...
  - Keyboard events: `onkeypress`, `onkeyup`, ...

- The *value* of these attributes is JavaScript code to be executed
  - Normally just a function invocation

- Example
  
  `<a href="page.html" onclick="foo()">…

- Advantage: Quick, easy, universal
- Disadvantage: mixes code with content
Direct Registration (DOM 1)

- Use properties of DOM element objects
  - `onchange`, `onblur`, `onfocus`,...
  - `onclick`, `onmouseover`, `onmouseout`,...
  - `onkeypress`, `onkeyup`,...

- Set this property to appropriate handler
  ```javascript
  let e = ... // find source element in tree
  e.onclick = foo;
  ```

- Note: no parentheses!
  ```javascript
  e.onclick() = foo; // what does this do?
  e.onclick = foo(); // what does this do?
  ```

- Disadvantage? No arguments to handler
  - Not a problem, handler gets event object

- Real disadvantage: 1 handler/element
Example

```javascript
let divs =
    document.querySelectorAll("div");
for (let d of divs) {
    d.onmouseover = function() {
        this.style.backgroundColor = "red"
    }
    d.onmouseout = function() {
        this.style.backgroundColor = "blue"
    } // *this* will be the element (div)
    // that listener is registered with
}
```
Chained Registration (DOM 2)

- Each element has a *collection* of handlers
- Add/remove handler to this collection
  
  ```javascript
  let e = ... // find source element in tree
  e.addEventListener("click", foo, false);
  ```
- Note: no "on" in event names, just "click"
- Third parameter: *true* for capture phase
  - Default is false
- Event listener takes 1 argument: event
Example

```javascript
let divs = document.querySelectorAll("div");
for (let d of divs) {
    d.addEventListener("click", function(event) {
        this.act = this.act || false;
        this.act = !this.act;
        this.style.backgroundColor = (this.act ? "red" : "gray");
    });
}
```
Broken: Wrong this with =>

```javascript
let divs =
    document.querySelectorAll("div");
for (let d of divs) {
    d.addEventListener ("click",
        (event) => {
            // wrong this
            this.act = this.act || false;
            this.act = !this.act;
            this.style.backgroundColor =
                (this.act ? "red" : "gray");
        });
}
```
let divs =
    document.querySelectorAll("div");
for (let d of divs) {
    d.addEventListener("click",
        (event) => { // t doesn't use *this*
            let t = event.currentTarget;
            t.act = t.act || false;
            t.act = !t.act;
            t.style.backgroundColor =
                (t.act ? "red" : "gray");
        });
}
Summary

- DOM: Document Object Model
  - Programmatic way to use document tree
  - Get, create, delete, and modify nodes

- Event-driven programming
  - Source: element in HTML (a node in DOM)
  - Handler: JavaScript function
  - Registration: in-line, direct, chained
  - Event is available to handler for inspection