THE UNIVERSITY OF WESTERN AUSTRALIA

Document Object Model

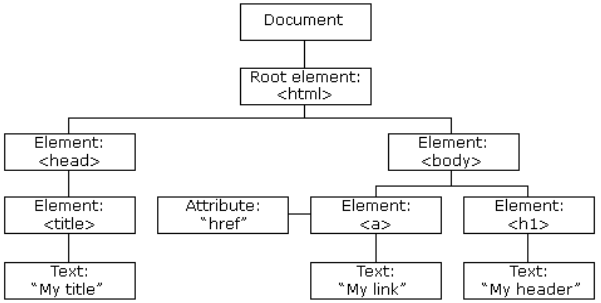
CITS3403: Agile Web Development

Semester 1, 2019

Introduction

- We’ve seen JavaScript *core*
  - provides a general scripting language
  - but why is it so useful for the web?
- *Client-side* JavaScript adds collection of objects, methods and properties that allow scripts to interact with HTML documents
  - dynamic documents
  - client-side programming
- This is done by bindings to the *Document Object Model* (DOM)
  - “The Document Object Model is a *platform- and language-neutral* interface that will allow programs and scripts to *dynamically access and update the content, structure and style of documents*.”
  - “The document can be further processed and the results of that processing can be incorporated back into the presented page.”
- DOM specifications describe an abstract model of a document
  - API between HTML document and program
  - Interfaces describe methods and properties
  - Different languages will *bind* the interfaces to specific implementation
  - Data are represented as properties and operations as methods
- https://www.w3schools.com/js/js_htmldom.asp

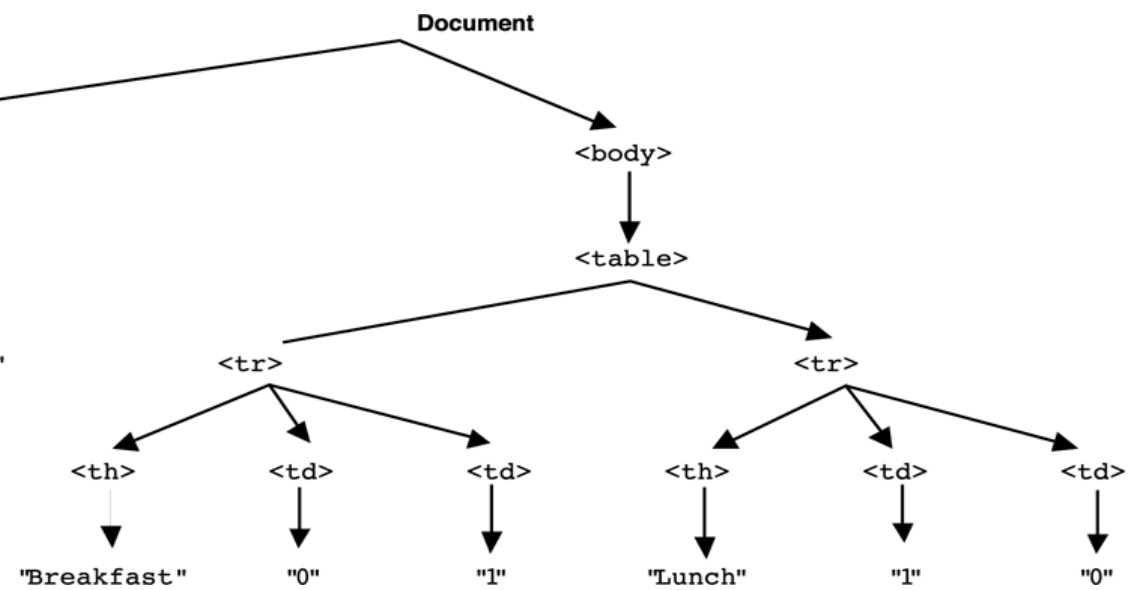
The HTML DOM Tree of Objects



The DOM Tree

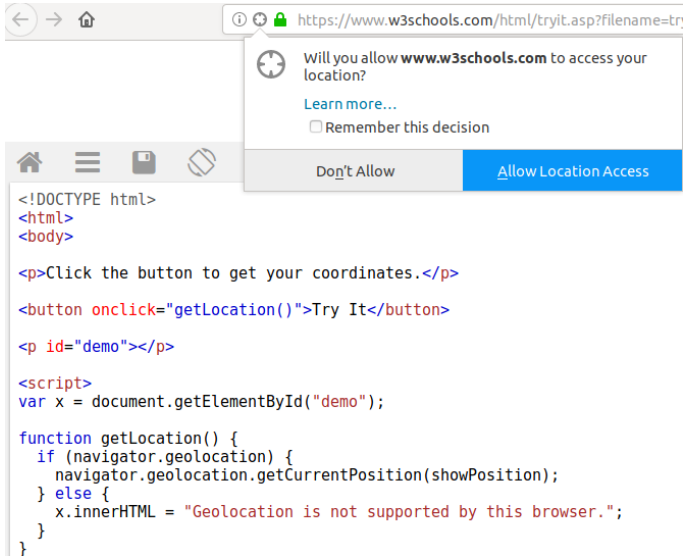
- DOM API describes a *tree* structure
  - reflects the hierarchy in the XTML document
  - example…

```
<html xmlns = "http://www.w3.org/1999/xhtml">
 <head>
  <title> A simple document </title>
 </head>
 <body>
        <table>
                <tr>
                        <th>
                        <td>
                        <td>
                </tr>
                <tr>
                        <th>
                        <td>
                        <td>
                </tr>
        </table>
 </body>
</html>
```

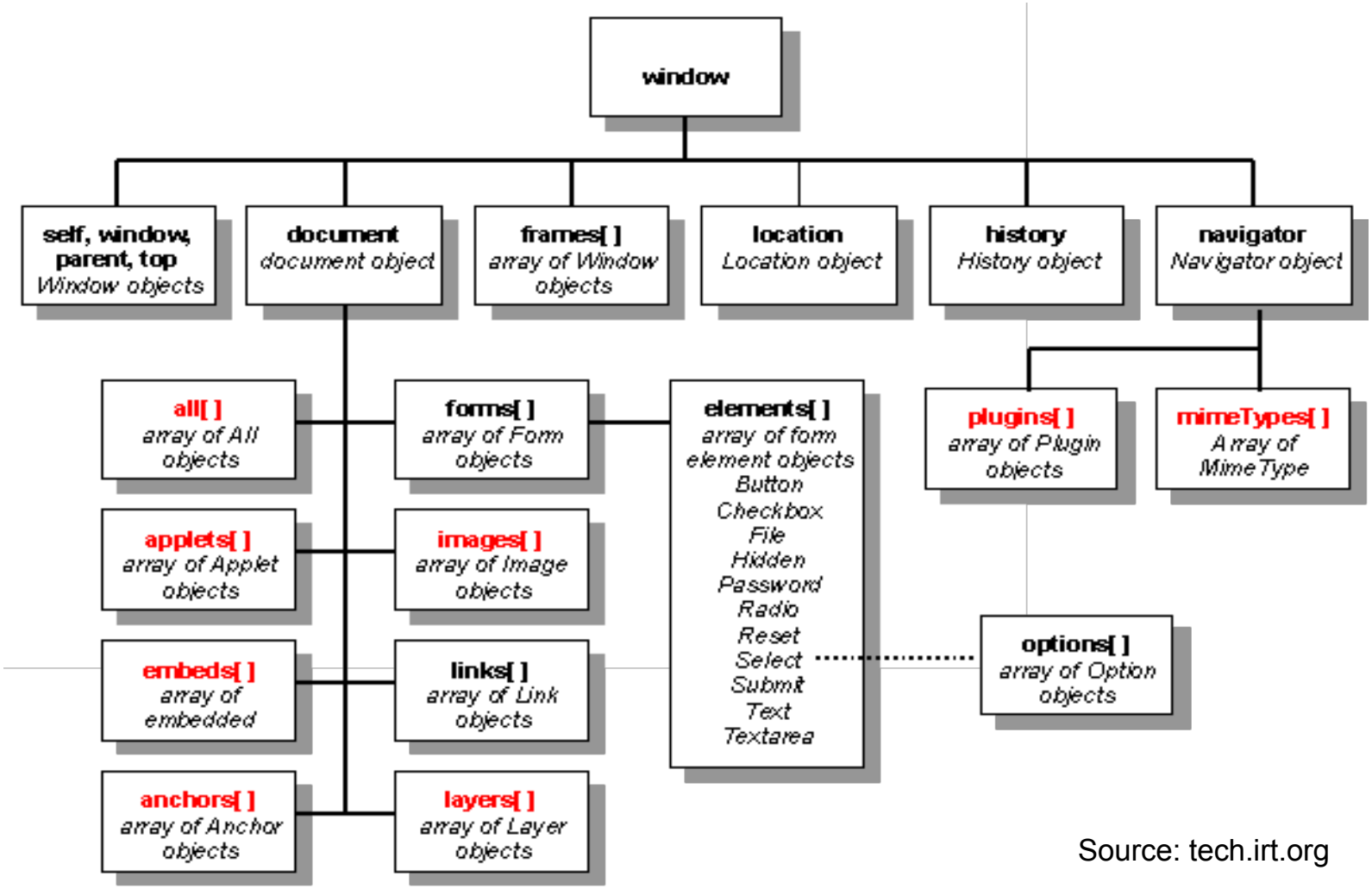


Execution Environment

- The DOM tree also includes nodes for the execution environment in a browser
- Window object represents the window displaying a document
  - All properties are visible to all scripts
  - Global variables are properties of the Window object
- Document object represents the HTML document displayed
  - Accessed through document property of Window
  - *Property arrays* for forms, links, images, anchors, …
- The **Browser Object Model** is sometimes used to refer to bindings to the browser, not specific to the current page (document) being rendered. This includes:
  - Type of browser
  - User's history
  - Cookies
  - Screen size
  - Location (url)
  - Geolocation
  - Local (browser) storage



DOM Tree in More Detail



Source: tech.irt.org

JavaScript and the DOM

- *Elements* in HTML document correspond to *nodes* on the tree
- These *nodes* bind to JavaScript *Element objects*
- *Attributes* of elements become named *properties* of element node objects
  - `<input type="text" name="address">`
  - The object representing this node will have two properties
    - *type* property will have value "text"
    - *name* property will have value "address"
- Node objects can be addressed in several ways:
  - *arrays* defined in DOM 0
    - forms, elements, images, links,…
    - individual elements are specified by index
  - by *name*
  - by *id*

Method 1: Using DOM Address

- Consider this simple form:

```
<form action = "">
    <input type = "button"  name = "pushMe">
</form>
```

- The *input* element can be referenced (assuming this is the first form in the document) as

- This example finds the form element with `id="frm1"`, in the forms collection, and displays all element values:

Example

```
var x = document.forms["frm1"];
var text = "";
var i;
for (i = 0; i < x.length; i++) {
  text += x.elements[i].value + "<br>";
}
document.getElementById("demo").innerHTML = text;
```

Try it Yourself »

Method 2: Using Name Attributes or Type

- Using the name attributes for form and form elements
  - Reference using Java/JavaScript "." notation

- Example

```
<form name = "myForm"  action = "">
    <input type = "button"  name = "pushMe">
</form>
```

- Referencing the input

```
document.myForm.pushMe
```

- In order to work, all elements from the reference element up to, but not including, the body must have a name attribute
- Names are required on form elements by server-side scripts
- You can also select all elements by tag name.

This example finds all `<p>` elements:

Example

```
var x = document.getElementsByTagName("p");
```

Try it Yourself »

This example finds the element with `id="main"`, and then finds all `<p>` elements inside `"main"`:

Example

```
var x = document.getElementById("main");
var y = x.getElementsByTagName("p");
```

Try it Yourself »

Method 3: Using ID

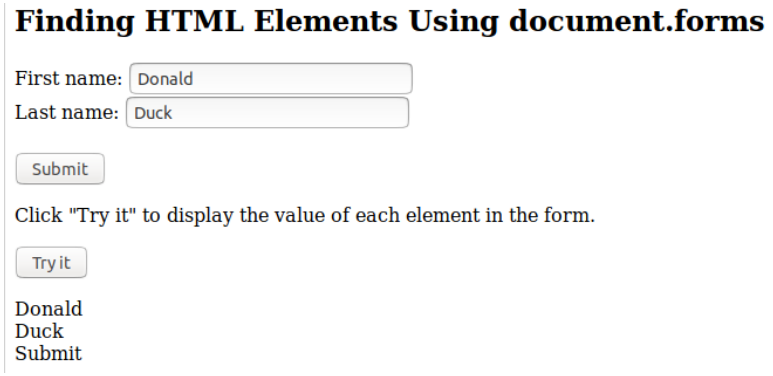
- Using `getElementById` with id attributes (cf CSS)
  - id attribute value must be unique for an element
- Example:
  - Set the id attribute of the input element

```
<form action = "">
  <input type="button" id="on">
  </form>
```

  - Then use `getElementById`

```
document.getElementById("on")
```

```
<!DOCTYPE html>
<html>
<body>

<h2>Finding HTML Elements Using document.forms</h2>

<form id="frm1" action="/action_page.php">
  First name: <input type="text" name="fname" value="Donald"><br>
  Last name: <input type="text" name="lname" value="Duck"><br><br>
  <input type="submit" value="Submit">
</form>

<p>Click "Try it" to display the value of each element in the form.</p>

<button onclick="myFunction()">Try it</button>

<p id="demo"></p>

<script>
function myFunction() {
  var x = document.forms["frm1"];
  var text = "";
  var i;
  for (i = 0; i < x.length ;i++) {
    text += x.elements[i].value + "<br>";
  }
  document.getElementById("demo").innerHTML = text;
}
</script>

</body>
</html>
```



Other Access Methods

- A range of other “short cut” methods may be provided
- Eg. `getElementsByTagName`

```
var tables = document.getElementsByTagName("table");
alert("This document contains " + tables.length + " tables");
```

- Checkboxes and radio buttons have an implicit array, which has their name as the array name

```
<form id = "topGroup">
  <input type = "checkbox"  name = "toppings"
         value = "olives" />
  ...
  <input type = "checkbox"  name = "toppings"
         value = "tomatoes" />
</form>
...
var numChecked = 0;
var dom = document.getElementById("topGroup");
for index = 0; index < dom.toppings.length;index++)
  if (dom.toppings[index].checked]
    numChecked++;
```

DOM Tree Traversal and Modification

- As we've seen each element in an HTML document has a corresponding `Element` object in the DOM representation
- The `Element` object has methods to support
  - *Traversing the document*
    - that is, visiting each of the document nodes
  - *Modifying the document*
    - for example, removing and inserting child nodes

- Various properties of `Element` objects are related nodes, eg:
  - `parentNode` references the parent node of the Element
  - `previousSibling` and `nextSibling` connect the children of a node into a list
  - `firstChild` and `lastChild` reference children of an Element
    - These would be text nodes or further element nodes contained in the element
  - `childnodes` returns a `NodeList` (like an array) of children

Example

```
<script>
// This recursive function is passed a DOM Node object and checks to see if
// that node and its children are XHTML tags; i.e., if the they are Element
// objects. It returns the total number of Element objects
// it encounters. If you invoke this function by passing it the
// Document object, it traverses the entire DOM tree.

function countTags(n) {                          // n is a Node
    var numtags = 0;                             // Initialize the tag counter
    if (n.nodeType == 1 /*Node.ELEMENT_NODE*/)   // Check if n is an Element
        numtags++;                               // If so, increment the counter
    var children = n.childNodes;                 // Now get all children of n
    for(var i=0; i < children.length; i++) {     // Loop through the children
        numtags += countTags(children[i]);       // Add and recurse on each one
    }
    return numtags;                              // Return the total number of tags
}
</script>

<!-- Here's an example of how the countTags(  ) function might be used -->

<body onload="alert('This document has ' + countTags(document) + ' tags')">
This is a <i>sample</i> document.
</body>

<!-- From: JavaScript: The Definitive Guide (4th Ed) -->
```

Example: JavaScript vs DOM

- Blue JavaScript, red DOM…

```
// point anchorTags to a DOM NodeList
var anchorTags = document.getElementsByTagName("a");
// display the href attribute of each element in the NodeList
for (var i = 0; i < anchorTags.length ; i++){
  alert("Href of this a element is : " + anchorTags[i].href + "\n");
}
```

From: The DOM and JavaScript: http://developer.mozilla.org/en/The_DOM_and_JavaScript

DOM Tree Modification

- There are also methods that allow you to modify or construct a DOM tree. eg:
  - The `insertBefore` method inserts a new child of the target node
  - `replaceChild` will replace a child node with a new node
  - `removeChild` removes a child node
  - `appendChild` adds a node as a child node at the end of the children

you can construct part or whole document dynamically!

- This is what front-end frameworks like Angular or React do: they dynamically build the entire document on the client side.
- Document writing methods include:
  - open()
  - close()
  - write()
  - writeln()

```
<!DOCTYPE html>
<html>
<script src="https://ajax.googleapis.com/ajax/libs/angularjs/1.6.9/angular.min.js"></script>
<body>

<div ng-app="myApp" ng-controller="customersCtrl">

<ul>
  <li ng-repeat="x in myData">
    {{ x.Name + ', ' + x.Country }}
  </li>
</ul>

</div>

<script>
var app = angular.module('myApp', []);
app.controller('customersCtrl', function($scope, $http) {
  $http.get("customers.php").then(function (response) {
      $scope.myData = response.data.records;
  });
});
</script>

</body>
</html>
```

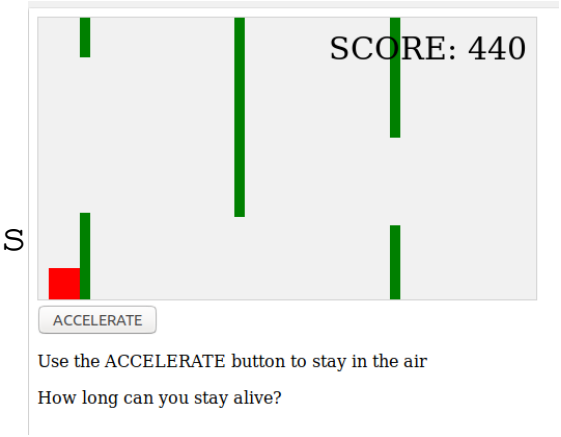
Example

```
<script type="text/javascript">
function createNewDoc() {
  var newDoc=document.open("text/html","replace");
  var txt="<html><body>Learning about the DOM is FUN!</body></html>";
  newDoc.write(txt);
  newDoc.close();
}
</script>

<!-- From: http://www.w3schools.com -->
```

The canvas Element

- The `canvas` Element
  - Creates a rectangle into which bit-mapped graphics can be drawn using JavaScript
  - Optional attributes: `height`, `width`, and `id`
    - Default value for `height` and `width` are `150` and `300` pixels
    - The `id` attribute is required if something will be drawn

```
<canvas id = "myCanvas" height = "200"
        width = "400">
   Your browser does not support the canvas
     element
 </canvas>
```



- This can be used to create interactive animations

and games in just HTML and javascript:

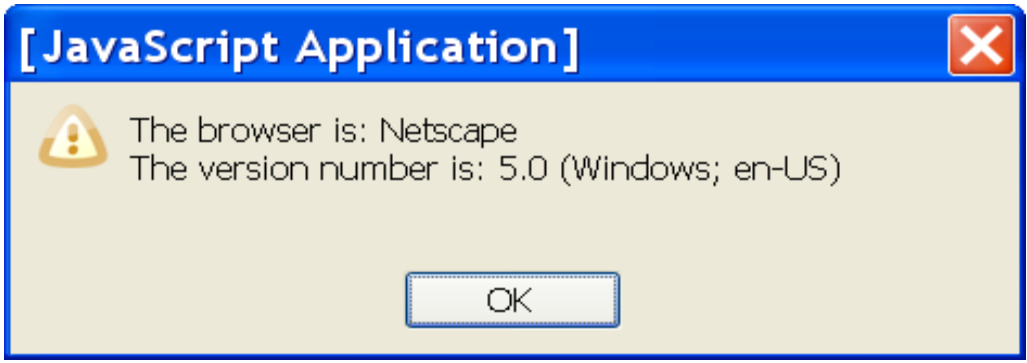
https://developer.mozilla.org/en-US/docs/Games/Tutorials/2D_Breakout_game_pure_JavaScript

https://www.w3schools.com/graphics/tryit.asp?filename=trygame_default_gravity

Example

- The navigator Object
  - Properties of the navigator object allow the script to determine characteristics of the browser in which the script is executing
  - The appName property gives the name of the browser
  - The appVersion gives the browser version

```
<!DOCTYPE html>
<!-- navigate.html
     A document for navigate.js
     -->
<html lang = "en">
  <head>
    <title> navigate.html </title>
    <meta charset = "utf-8" />
    <script type = "text/javascript"  src = "navigate.js" >
    </script>
  </head>
  <body onload = "navProperties()">
  </body>
</html>
```



Navigator

- In addition to the *Document Object Model* there is also a *Browser Object Model* (BOM).
- This is not supported by a fixed standard, but is a set of features most browsers support, to let developers tailor apps for different browser contexts.
- These include:
  - Browser type and version (typically misreported)
  - The language used in the browser
  - The geolocation of the user (https and with user consent)
  - The History of the user.
  - Any cookies associated with the current domain.
- These properties are access through document.navigator.

Navigator Object Properties

Property	Description
appCodeName	Returns the code name of the browser
appName	Returns the name of the browser
appVersion	Returns the version information of the browser
cookieEnabled	Determines whether cookies are enabled in the browser
geolocation	Returns a Geolocation object that can be used to locate the user's position
language	Returns the language of the browser
onLine	Determines whether the browser is online
platform	Returns for which platform the browser is compiled
product	Returns the engine name of the browser
userAgent	Returns the user-agent header sent by the browser to the server

History Object Properties

Property	Description
length	Returns the number of URLs in the history list

History Object Methods

Method	Description
back()	Loads the previous URL in the history list
forward()	Loads the next URL in the history list
go()	Loads a specific URL from the history list

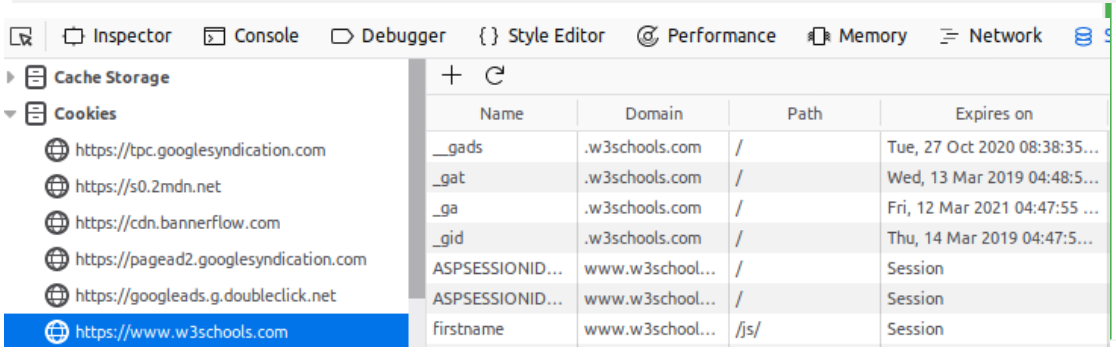
Cookies

- Cookies are a way of websites identifiying returning users. As HTTP requests are stateless, the server normally won't remember any previous requests from a client.
- A cookie is a small text file containing key-value pairs that is stored in the browser.
- The cookie will be sent with a request to the website it is associated with (and only that website).
- Cookies for the current web-page are accessible through the DOM/BOM.
- Cookies are specified with an expiry date or will be deleted when the broswer is closed.

```
document.cookie = "username=John Doe; expires=Thu, 18 Dec 2013 12:00:00 UTC";
```

```
function setCookie(cname, cvalue, exdays) {
  var d = new Date();
  d.setTime(d.getTime() + (exdays*24*60*60*1000));
  var expires = "expires="+ d.toUTCString();
  document.cookie = cname + "=" + cvalue + ";" + expires + ";path=/";
}
```

```
function getCookie(cname) {
  var name = cname + "=";
  var decodedCookie = decodeURIComponent(document.cookie);
  var ca = decodedCookie.split(';');
  for(var i = 0; i <ca.length; i++) {
    var c = ca[i];
    while (c.charAt(0) == ' ') {
      c = c.substring(1);
    }
    if (c.indexOf(name) == 0) {
      return c.substring(name.length, c.length);
    }
  }
  return "";
}
```



Web Storage

- A larger and more secure alternative to cookies is Web Storage (new since HTML5).
- This allows a website to store information about a user within the users browser and retireve it at a later time.
- This can be particularly useful for large forms where there is a chance a session could end before the user submits the form.

```
if (localStorage.clickcount) {
  localStorage.clickcount = Number(localStorage.clickcount) + 1;
} else {
  localStorage.clickcount = 1;
}
document.getElementById("result").innerHTML = "You have clicked the button " +
localStorage.clickcount + " time(s).";
```

Event-Driven Programming

- *Event-driven programming* or *event-based programming*
  - programming paradigm in which the flow of the program is determined by *sensor outputs* or *user actions* (mouse clicks, key presses) or *messages from other programs*
  - not new - from hardware interrupts to multi-process operating systems to distributed programming to Java listeners to Exceptions…
- *Fundamental to web-based programming*
  - client-server model
  - stateless programming
  - controlled from browser (user) end
- Event driven programming drives many of the technologies we will cover in this unit:
  - Sockets
  - AJAX
  - Javascript callbacks

Event-Driven Programming

- Batch program

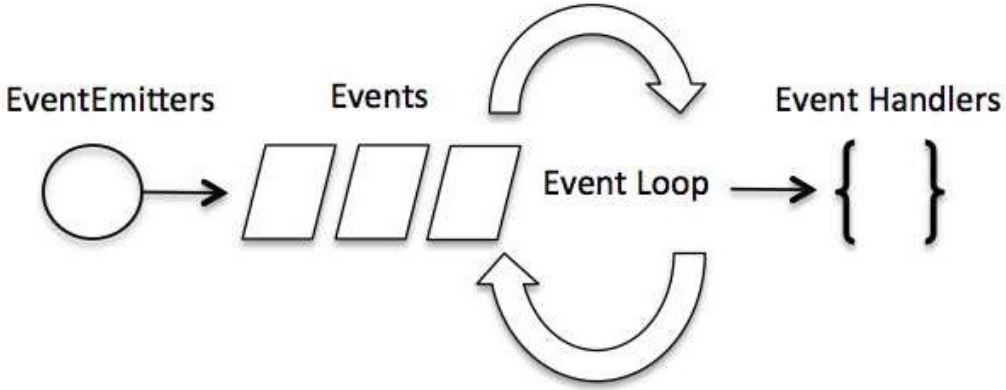
```
read a number (from the keyboard) and store it in variable A[0]
read a number (from the keyboard) and store it in variable A[1]
print A[0]+A[1]
```

  – *synchronous* (program waits for input)

- Event-driven program

```
set counter K to 0
repeat {
  if a number has been entered (from the keyboard) {
    store in A[K] and increment K
    if K equals 2 print A[0]+A[1] and reset K to 0
  }
}
```

  – *asynchronous* (program polls for input)



Event-Driven Programming

- Program “loop” divided into two distinct tasks
  - event *detection*
  - event *handling*
- Application programmer may be freed from event detection (and hence loop) in a number of ways
  - embedded programs may use interrupts - handled by hardware (no loop needed)
  - programming environment or execution environment may do this for you - in our case the browser
  - allows programmer to focus on event handling
- Browser “listens” (polls or interrupts) for events
  - user actions (eg. <enter>, mouse clicks, ...)
  - server responses (eg. page loaded, AJAX responses, calculation, ...)
- When it recognises an event, it invokes the appropriate code to handle the event (*event handler*), passing information about the event as required
- But how does the browser know what code to call?
- For the browser to know what code to invoke for different actions, code elements must be *registered* with, or *bound* to, events
- What defines the events, their meanings, and parameters?
  - the DOM!

Event Registration

- DOM 0 provides two ways to register an event handler:

1. Assign the event handler script to an *event tag attribute*

```
<input type = "button" id = "myButton"
       onclick = "alert('You clicked my button!');" />
```

`onclick` is a tag attribute for the button "click" event

Usually the handler script is more than a single statement and called as a function:

```
<input type = "button" id = "myButton"
       onclick = "myButtonHandler();" />
```

2. Assign the event handler to the appropriate *property of the element's object*

```
<input type = "button" id = "myButton" />
.
.

document.getElementById("myButton").onclick =
                                        myButtonHandler;
```

- statement must follow both handler function and form element so (JavaScript) interpreter has seen both
- note: just function name, not function call (or string)

Events and their Tag Attributes

Event	Tag Attribute
blur	onblur
change	onchange
click	onclick
dblclick	ondblclick
focus	onfocus
keydown	onkeydown
keypress	onkeypress
keyup	onkeyup
load	onload
mousedown	onmousedown
mousemove	onmousemove
mouseout	onmouseout
mouseover	onmouseover
mouseup	onmouseup
reset	onreset
select	onselect
submit	onsubmit
unload	onunload

```html
<!DOCTYPE html>
<html>
<body>

<p>Click the button to display the date.</p>

<button onclick="displayDate()">The time is?</button>

<script>
function displayDate() {
  document.getElementById("demo").innerHTML = Date();
}
</script>

<p id="demo"></p>

</body>
</html>
```

Click the button to display the date.

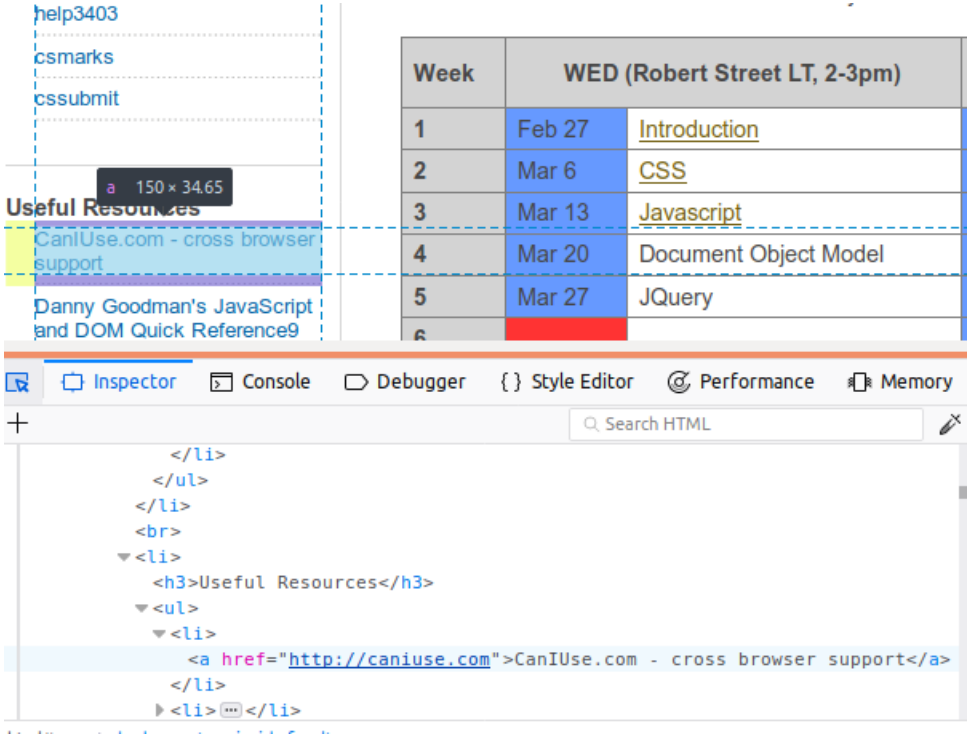
The time is?

Wed Mar 13 2019 13:12:10 GMT+0800

Tag Attributes and their Tags

- Most event tag attributes can appear in several tags
- Meaning (action) depends on both the tag attribute *and* the tag in which it appears. Eg.
  - an element gains “focus” when the mouse is passed over it and left clicked, or user tabs to element
  - lose focus when it passes to another element - called *blurring*
    - different meaning (action) for `<a>` and `<textarea>`

Attribute	Tag	Description
onblur	<a>	The link loses the input focus
	<button>	The button loses the input focus
	<input>	The input element loses the input focus
	<textarea>	The text area loses the input focus
	<select>	The selection element loses the input focus
onchange	<input>	The input element is changed and loses the input focus
	<textarea>	The text area is changed and loses the input focus
	<select>	The selection element is changed and loses the input focus
onclick	<a>	The user clicks on the link
	<input>	The input element is clicked
ondblclick	Most elements	The user double clicks the left mouse button
onfocus	<a>	The link acquires the input focus
	<input>	The input element receives the input focus
	<textarea>	A text area receives the input focus
	<select>	A selection element receives the input focus
onkeydown	<body>, form elements	A key is pressed down
onkeypress	<body>, form elements	A key is pressed down and released
onkeyup	<body>, form elements	A key is released
onload	<body>	The document is finished loading



Handling Events from Body Elements

```
<body onload="load_greeting();">
  <p />
</body>

function load_greeting () {
  alert("You are visiting the home page of\n" +
        "Pete's Pickled Peppers \n" + "Welcome!!!");
}
```

Mouseover events

- Any HTML element can be have a mouseover event associated with it.

```
<!DOCTYPE html>
<html>
<body>

<div onmouseover="mOver(this)" onmouseout="mOut(this)"
style="background-color:#D94A38;width:120px;height:20px;padding:40px;">
Mouse Over Me</div>

<script>
function mOver(obj) {
  obj.innerHTML = "Thank You"
}

function mOut(obj) {
  obj.innerHTML = "Mouse Over Me"
}
</script>

</body>
</html>
```

Handling Events from Text Box and Password Elements

- An important use of events is to validate the content of forms, without using bandwidth and time to access a remote server.
- By manipulating the focus event the user can be prevented from changing the amount in a text input field

Note: this is possible to work around

- Copy the page but leave out the validation code
- Simulate an HTTP request directly with socket-level programming

If the validity of data is important, the server needs to check it

JavaScript Example

```javascript
function validateForm() {
  var x = document.forms["myForm"]["fname"].value;
  if (x == "") {
    alert("Name must be filled out");
    return false;
  }
}
```

The function can be called when the form is submitted:

HTML Form Example

```html
<form name="myForm" action="/action_page.php" onsubmit="return validateForm()" method="post">
Name: <input type="text" name="fname">
<input type="submit" value="Submit">
</form>
```

DOM 2 Event Model

- DOM 2 is defined in *modules*
- The *Events* module defines several submodules
  - *HTMLEvents* and *MouseEvents* are common
- An event object is passed as a parameter to an event handler
  - Properties of this object provide information about the event
  - Some event types will extend the interface to include information relevant to the subtype. For example, a mouse event will include the location of the mouse at the time of the event

blur	The event occurs when an element loses focus	FocusEvent
canplay	The event occurs when the browser can start playing the media (when it has buffered enough to begin)	Event
canplaythrough	The event occurs when the browser can play through the media without stopping for buffering	Event
change	The event occurs when the content of a form element, the selection, or the checked state have changed (for <input>, <select>, and <textarea>)	Event
click	The event occurs when the user clicks on an element	MouseEvent
contextmenu	The event occurs when the user right-clicks on an element to open a context menu	MouseEvent
copy	The event occurs when the user copies the content of an element	ClipboardEvent
cut	The event occurs when the user cuts the content of an element	ClipboardEvent
dblclick	The event occurs when the user double-clicks on an element	MouseEvent
drag	The event occurs when an element is being dragged	DragEvent
dragend	The event occurs when the user has finished dragging an element	DragEvent
dragenter	The event occurs when the dragged element enters the drop target	DragEvent
dragleave	The event occurs when the dragged element leaves the drop target	DragEvent

Event Flow

- DOM 2 defines a process for determining which handlers to execute for a particular event
- The event object representing the event is created at a particular node called the ***target node***
- The process has three phases…
- In the ***capturing phase*** each node from the document root to the target node, in order, is examined.
  - If the node is not the target node and there is a handler for that event at the node and the handler is enabled for capture for the node, the handler is executed
- Then all handlers registered for the target node, if any, are executed
- In the ***bubbling phase*** each node from the parent of the target node to the root node, in order, is examined
  - if there is a handler for that event at the node and the handler is ***not*** enabled for capture for the node, the handler is executed

Some event types are not allowed to bubble: load, unload, blur and focus among the HTML event types

Event Propagation

- As each handler is executed, properties of the event provide context
  - The currentTarget property is the node to which the handler is registered
  - The target property is the node to which the event was originally directed
  - currentTarget is always the object listening for the event; target is the actual target that received the event
- One major advantage of this scheme over DOM 0 is that event handling can be centralized in an ancestor node
- For example, a calculator keyboard will have a number of digit buttons
  - In some GUI frameworks, a handler must be added to each button separately
  - In DOM 2, the buttons could be organized under a single node and the handler placed on the node

```
document.getElementById("myP").addEventListener("click", myFunction, true);
document.getElementById("myDiv").addEventListener("click", myFunction, true);
```

Event Handler Registration

- Handlers are called ***listeners*** in DOM 2
- *addEventListener* is used to register a handler, it takes three parameters
  - A string naming the event type
  - The handler
  - A boolean specifying whether the handler is enabled for the capture phase or not

```
window.addEventListener("keydown", moveSomething, false);


function moveSomething(e) {
    switch(e.keyCode) {
        case 37:
            // left key pressed
            break;
        case 38:
            // up key pressed
            break;
        case 39:
            // right key pressed
            break;
        case 40:
            // down key pressed
            break;
    }
}
```

```
<p>A function is triggered when the user
is pressing a key in the input field.</p>
<input type="text" onkeydown= f(event)”>
<script>
function f(e) {
 alert("You hit the "+e.keyCode+” key");
}
</script>
```