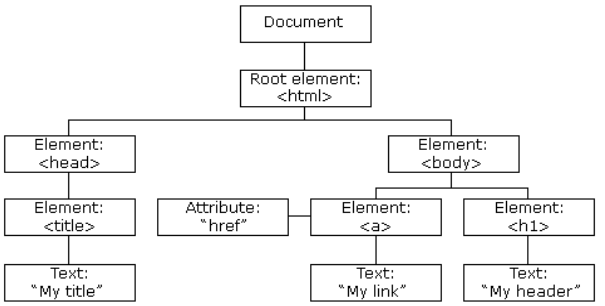

THE UNIVERSITY OF
WESTERN
AUSTRALIA
Document Object
Model
CITS3403: Agile Web Development
Unit Coordinator: Tim French
2023, Semester 1

# 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

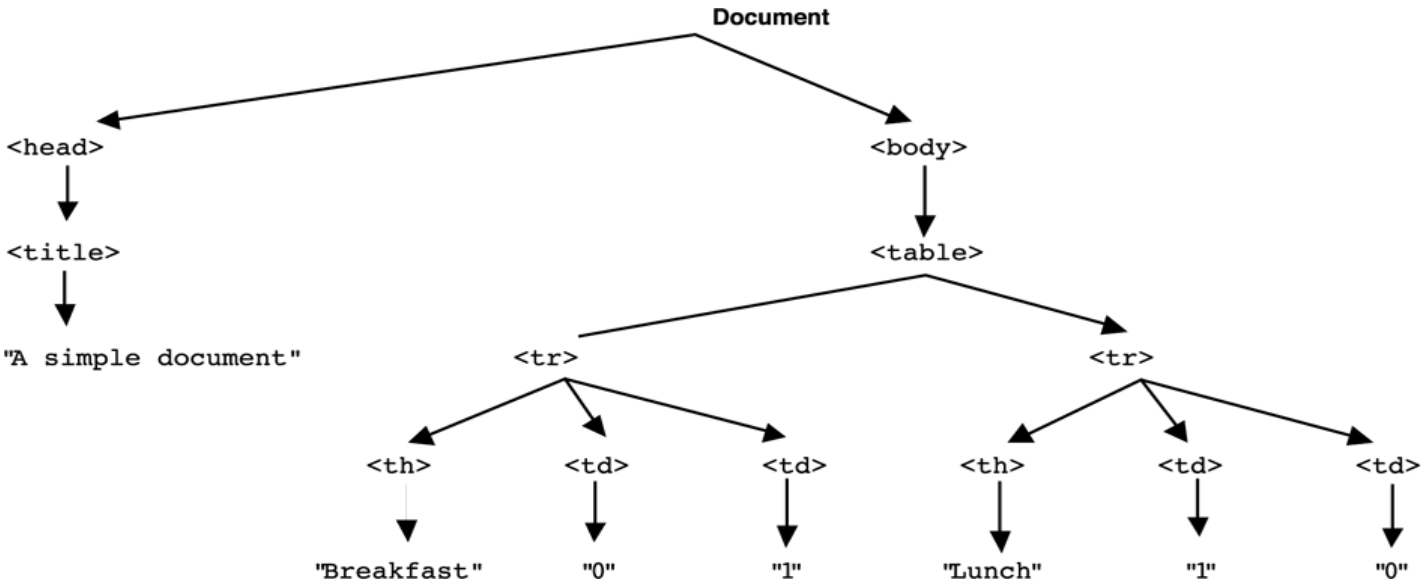
The HTML DOM Tree of Objects



# The DOM Tree

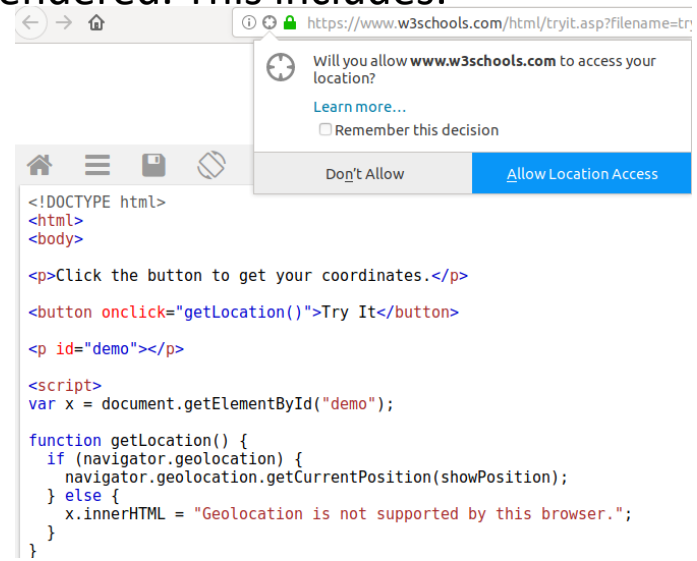
- DOM API describes a *tree* structure
  - reflects the hierarchy in the XTML document
  - example...

```
<html xmlns = "http://www.w3.org/1999/xhtml">
  <head>
    <title> A simple document </title>
  </head>
  <body>
<table>
     <tr>
          <th>Breakfast</th>
          <td>0</td>
          <td>1</td>
     </tr>
     <tr>
          <th>Lunch</th>
          <td>1</td>
          <td>0</td>
     </tr>
</table>
  </body>
</html>
```

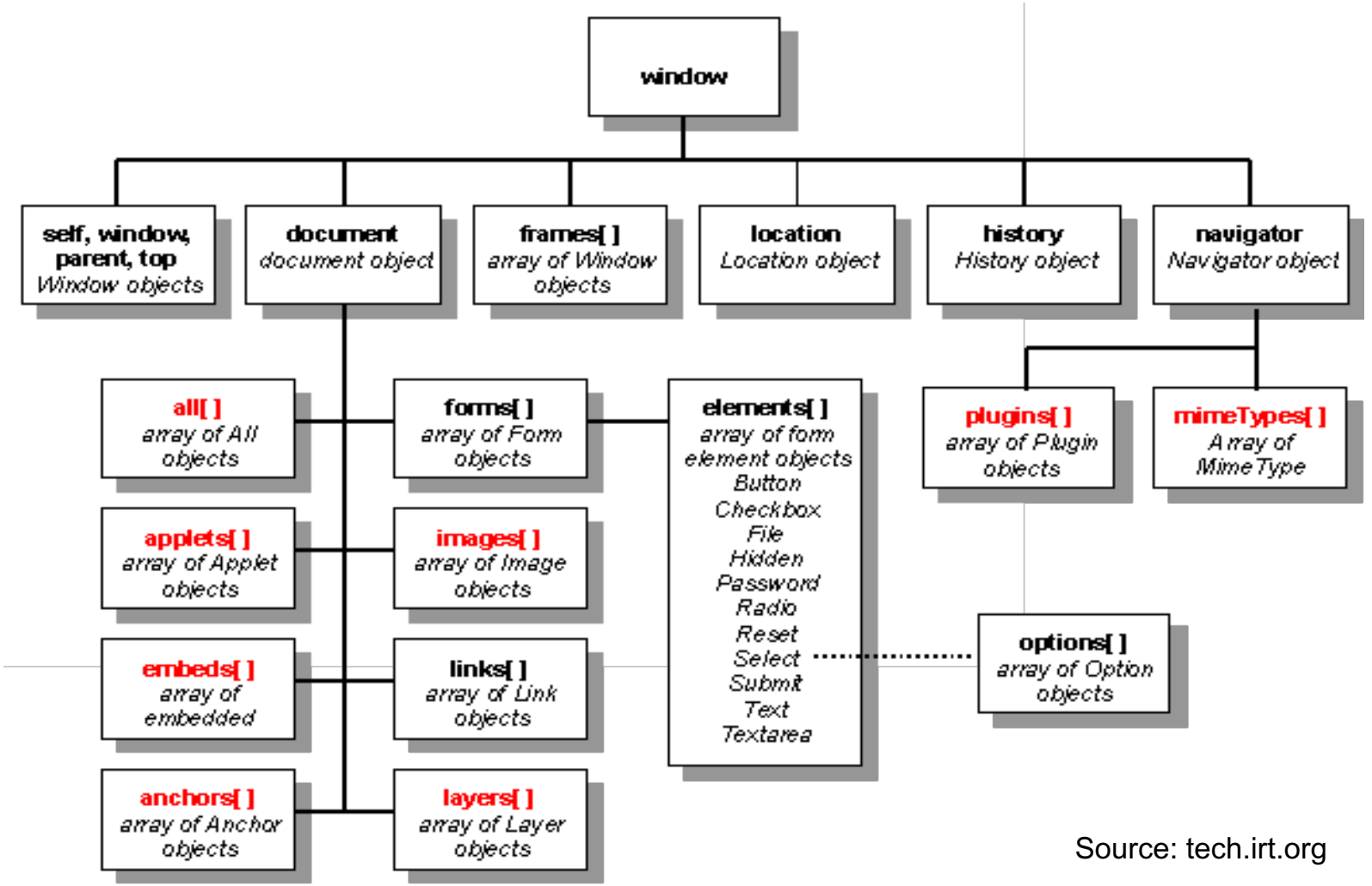


# Execution Environment

- 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

THE UNIVERSITY OF WESTERN AUSTRALIA

- *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.

# Method 3: Using ID

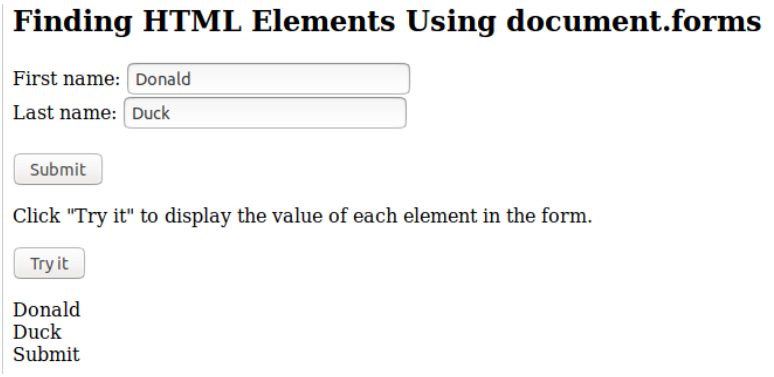
- Using `getElementById` with id attributes (cf CSS)
  - id attribute value must be unique for an element
- Example:
  - Set the id attribute of the input element

```
<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

THE UNIVERSITY OF WESTERN AUSTRALIA

- 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

THE UNIVERSITY OF WESTERN AUSTRALIA

- 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

THE UNIVERSITY OF WESTERN AUSTRALIA

- 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

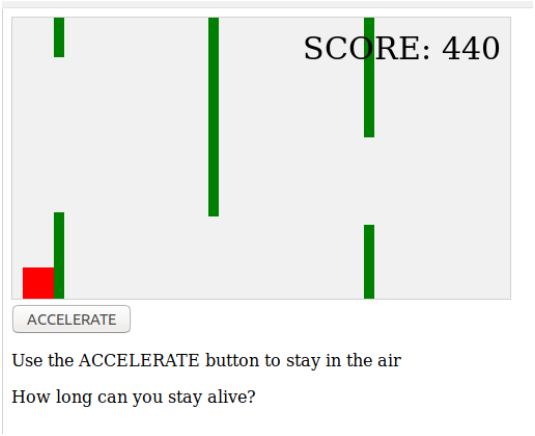
THE UNIVERSITY OF WESTERN AUSTRALIA

```
<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:

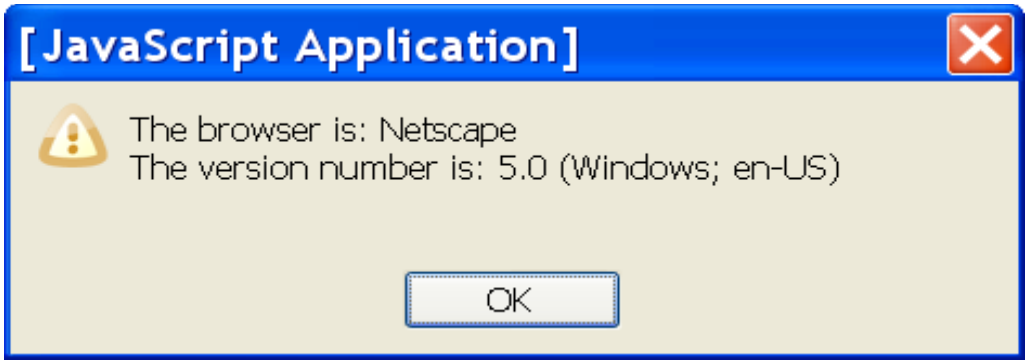
https://developer.mozilla.org/en-US/docs/Games/Tutorials/2D_Breakout_game_pure_JavaScript

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

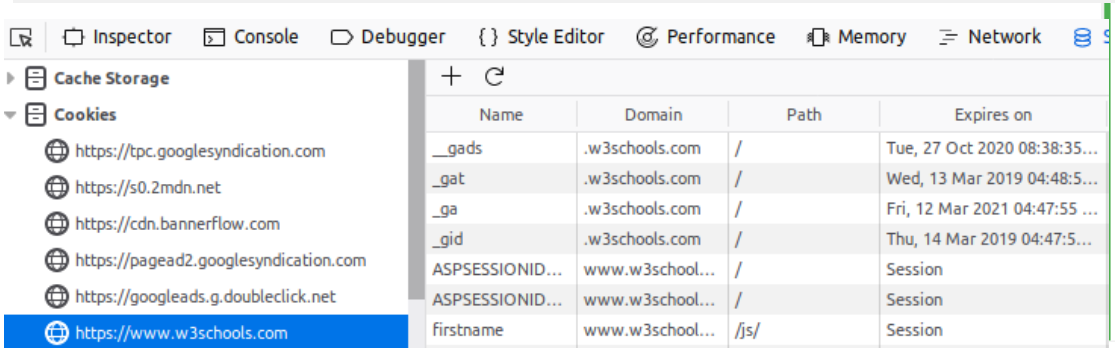
| Method | Description |
|---|---|
| back() | Loads the previous URL in the history list |
| forward() | Loads the next URL in the history list |
| go() | Loads a specific URL from the history list |

# 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

THE UNIVERSITY OF WESTERN AUSTRALIA

- 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

THE UNIVERSITY OF WESTERN AUSTRALIA

- *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

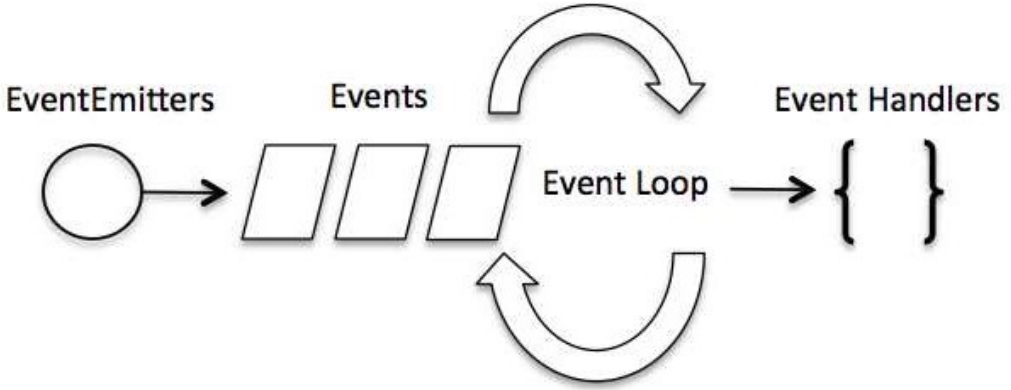
```
read a number (from the keyboard) and store it in variable A[0]
read a number (from the keyboard) and store it in variable A[1]
print A[0]+A[1]
```

  - *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

THE UNIVERSITY OF WESTERN AUSTRALIA

- 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

THE UNIVERSITY OF WESTERN AUSTRALIA

- 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

THE UNIVERSITY OF WESTERN AUSTRALIA

| 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 |

```
<!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.

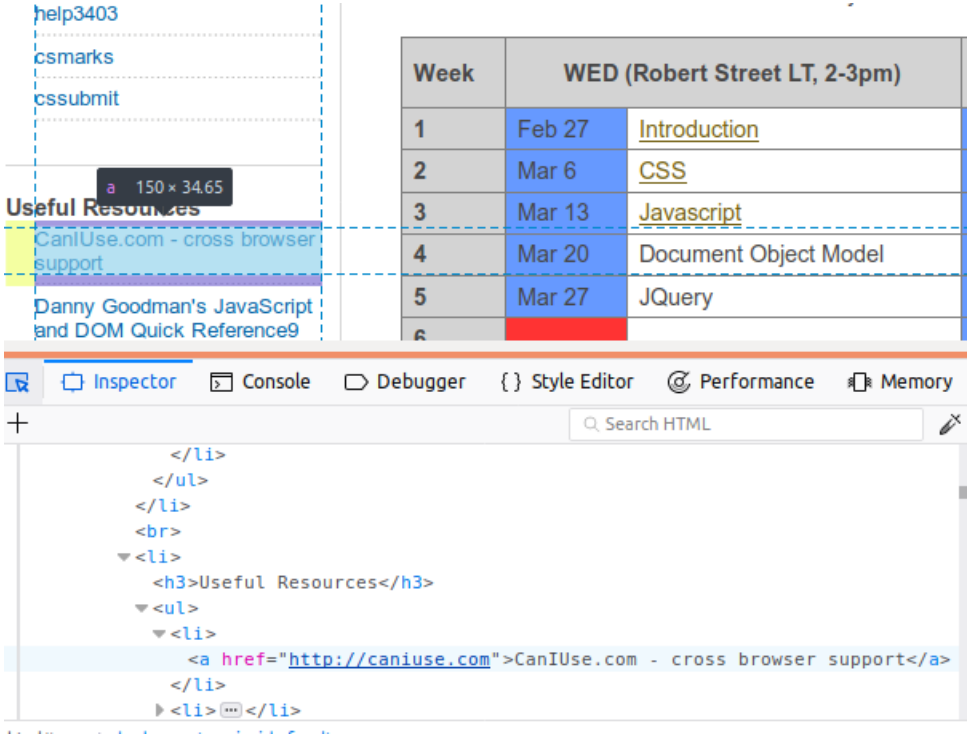
The time is?

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 |



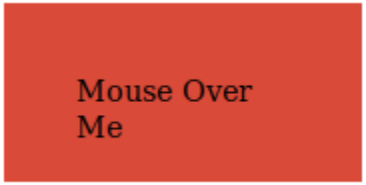
# Handling Events from Body Elements

```
<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

THE UNIVERSITY OF WESTERN AUSTRALIA

- 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

```
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

```
<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

THE UNIVERSITY OF WESTERN AUSTRALIA

- 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

THE UNIVERSITY OF WESTERN AUSTRALIA

- 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

THE UNIVERSITY OF WESTERN AUSTRALIA

- 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

```
<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>
```

```
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;
    }
}
```