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Asynchronous JavaScript Technology and XML (AJAX)

Chrisina Draganova
Department of Computing, Communication Technology and Mathematics
London Metropolitan University
100 Minories, London EC3 1JY
c.draganova@londonmet.ac.uk

Abstract

AJAX is a web development technique for building responsive web applications. The paper gives an overview of the AJAX technique and explores ideas for teaching this technique in modules related to Internet technologies and web development. Appropriate examples for use in lab sessions are also suggested.

1. Introduction

A new type of dynamic web applications with richer interactive and graphical capabilities has emerged recently. These web applications are developed using a technique called AJAX (short for Asynchronous JavaScript Technology and XML), which is based on well-established technologies. While in a traditional web application the user waits for a response and gets an entire page reloaded for each request, with an AJAX web application the user is not aware when the request is sent and he can continue to interact with the web browser. The communication with the web server happens in the background and the response returned to the user's browser contains only a small amount of data, which is used to update the page without reloading.

The constant change in the technologies used to develop web applications requires continuous revision of the web related modules in order to prevent them from becoming obsolete. Before including a new approach or technology in an existing module, several considerations should be taken in account, including the student's background, the cohesiveness with the other technologies already taught in the module, the maturity of the technology, the available resources and the technical support. In addition to these considerations ways of linking the technologies to relevant theoretical concepts in appropriate contexts should be explored to improve the overall student's understanding.

This paper aims to share some ideas of how to introduce the AJAX technique in modules related to web development. The paper is organised in five sections including the introduction. The second section gives an overview of the AJAX technology; the third section includes a practical example demonstrating the basic implementation issues, knowledge and skills required for learning the AJAX technique; the fourth section addresses the educational implications and the last section gives the conclusions.

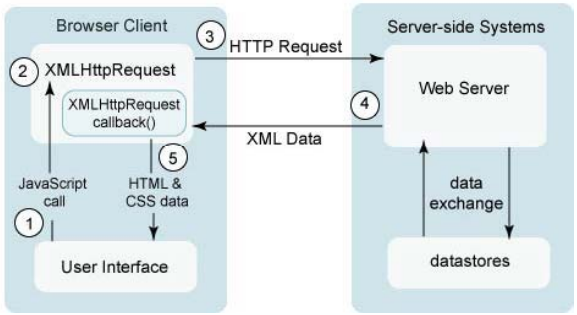
2. AJAX overview

AJAX (short for Asynchronous JavaScript Technology and XML) is a technique, which combines several well-established standards. It enables building more interactive web applications behaving in a similar fashion to traditional desktop applications. James Garret [1] coined the term AJAX in 2005, but the technique was known before as remote scripting with hidden frames or iFrames. Simple examples related to remote scripting without using the new AJAX technique can be found in [2], [3] and [4].

In a typical web application the user action such as submitting a form or clicking a hyperlink triggers an HTTP request, which is sent by the web browser for processing to the web server. The web server processes the request and it sends back a response, which contains an entire web page to be loaded on the user's web browser. While this happens the user is waiting for the response and his interaction with the

web site is blocked. There are many cases where reloading a whole page is not necessary such as real time data validation, auto completion, master details operations, sophisticated user interface controls, refreshing data on a page and server-side notifications [5]. AJAX provides a way of dealing with such cases, based on a model, which enables sending a request to the web server and receiving a response containing only a small amount of data in the background and refreshing only a specific part of the already loaded web page.

The main key to the AJAX technique is the so-called XmlHttpRequest object, which recently became part of the JavaScript technology [5] and all mainstream browsers support it. To build an AJAX solution three technologies are required: HTML/XHTML, DOM and JavaScript [2]. JavaScript language is used to develop the so-called AJAX engine or functionality that handles the communication with the web server, the user actions and the updates of the web page content. The DOM model of the XHTML pages enables dynamic updating of a loaded page and HTML/XHTML languages are used for content representation of the web pages. In addition to these technologies XML can be used as a standard format for data exchange and CSS for defining the style of the XHTML/HTML elements. Figure 1 illustrates how the AJAX interaction model works.



Source [6]
Figure 1

The following sequence of steps occurs in a general AJAX request [6]:

1. The user generates an event (e.g. entering input or clicking a button). This event triggers a call to a JavaScript function.
2. An XmlHttpRequest object is created and configured with a request parameter that includes the ID of the component that generated the event and any value that the user has entered.
3. The XmlHttpRequest object makes an asynchronous request to the web server, i.e. while the request is made the user interface is not blocked. The server processes the request, exchanges any data required from the data store.
4. Although Figure 1 shows that the web server returns XML Data in fact the server can return any fragment of data, which typically is an XML document or a plain text containing the result.
5. The XmlHttpRequest object calls a callback() function, it receives the data and processes the result.
6. The HTML DOM is updated.

Adopting the AJAX model can bring many benefits to the usability of the web applications by making the user interface more responsive, faster and graphically richer [7], [8]. However this approach has some disadvantages such as increased complexity of designing, developing and debugging [8], browser incompatibilities due to the different JavaScript implementations [1] and lack of suitable tools and frameworks for building this new kind of web applications [7].

The main factor for AJAX becoming so popular is the adoption of this technique by **Google** in their projects: **Gmail** - gmail.google.com, **Google Maps** - http://maps.google.com/ and **Google Suggest** http://www.google.com/webhp?complete=1&hl=en. Other popular web sites using the AJAX technique include **Amazon A9** - http://a9.com, **Yahoo! News** - http://news.yahoo.com/, **Yahoo Flickr** - http://www.flickr.com/ and **Orkut** - www.orkut.com. There are also a number of web sites, which use the AJAX technique to develop functionalities typical for desktop applications such as **Writely** - http://www.writely.com/ - web word processor and **Kiko** - http://www.kiko.com/ - online calendar. These applications have raised the expectations of the users from the web and pushed the companies and developers to adopt the new AJAX technique.

3. AJAX example

The best way to demonstrate the AJAX technique and to see the knowledge and skills required for its use is to look at a practical example. One simple and interesting Ajax application is Google Suggest, which implements a typical desktop functionality of suggesting values as the user types. The example given in this section simulates to some degree the behaviour of Google Suggest. It is a simplified version of the "Autosuggest Text Box" from Chapter 7 [2]. It implements the "Typeahead" [2] functionality, which helps the user to type the name of a county in England. More precisely described the functionality includes the following:

- As the user types in a text box the rest of the text box fills with the name of a county that starts with the letters that the user has typed already.
- As the user continues to type the text box automatically adjusts its suggestion.
- The suggested text appears selected (highlighted).

The example can be tested on http://www3.unl.ac.uk:8188/draganov/autosuggest/autosuggest.htm and its source code can be downloaded from [9].
The example consists of three components: an HTML component that gives the user interface, a JavaScript component that contains the AJAX engine and a server side component which handles the HTTP requests/responses and returns the relevant suggestions. In this example XML and CSS are not used in order to focus on understanding the principle steps in using the AJAX technique.

The HTML component contains a text box (see Figure 2) with an event attribute onkeyup set to a call of the JavaScript function handleKeyUp(event, this.id). Two parameters are passed in this function: the event object and the value of the attribute id. As the user types the onkeyup event fires after a change is made to the text box. The autocomplete attribute of the text box must be turned off in order to eliminate the default autocomplete functionality provided by most of the browsers.

```
<p><input type="text" id="txtAuto" onKeyUp = "handleKeyUp(event, this.id)"  AutoComplete = "off"/></p>
```

Figure 2: autosuggest.htm

The JavaScript component consists of three functions (see Figure 3, 4 and 5). For simplicity the code shown in Figures 3 and 4 is applicable only for the Mozilla web browser.

The first function handleKeyUp(objEvent, txtID) detects the character keys using the keyCode property of the event object and calls the second function requestSuggestions(txtID) passing the id of the text box as a parameter.

```
function handleKeyUp(objEvent, txtID) {
        var iKeyCode = objEvent.keyCode;
        // detects character keys
        if (!(iKeyCode < 32 || (iKeyCode >= 33 && iKeyCode <= 46) || (iKeyCode >= 112 && iKeyCode <= 123)) )
            requestSuggestions(txtID);
}
```

Figure 3: handleKeyUp()

The requestSuggestions(txtID) function is the main element in the implementation of the AJAX technique. An XmlHttpRequest object is created and the method open() is called to initialise the object. The open() method takes three arguments: Request Type – GET or POST, URL – a string indicating the URL to send the request to and a Boolean value indicating whether the request would be asynchronous. When this Boolean value is set to true the request is sent asynchronously enabling the execution of the JavaScript code to continue without waiting for a response and the user to continue to interact with the browser. Next an event handler onreadystatechange has to be defined. This event handler is set to anonymous function, which checks the readyState property of the XMLHttpRequest object. There are five possible values of this property, which are described for example in [2]. Every time the readyState property changes its value, the readystatechange event fires and the respective event handler is called. Value 4 indicates that the request has been completed and all data from the response has been received and the connection has been closed. When this happens the function typeAhead(suggestion, txtID) is called passing the text retuned in the response and the id of the text box to be updated when the returned suggestion is not empty. Finally the request is sent by calling the send() method. This method requires a string parameter for the request body. The GET request does not have a body, therefore the parameter passed is null.

```
function requestSuggestions(txtID){
        var objEl = document.getElementById(txtID);
        var httpRequest = null;
        if (objEl.value.length > 0){
          if (typeof  XMLHttpRequest  !=  "undefined")
             httpRequest = new XMLHttpRequest();
          else
            alert("No XMLHttpRequest object available. This functionality will not work.");
          //build the URL
          var sURL = "http://www3.unl.ac.uk:8188/draganov/autosuggest/suggestion.jsp?txtInput=" +
                    encodeURIComponent(objEl.value);

          httpRequest.open("get", sURL , true);
          httpRequest.onreadystatechange =
            function () {
                    if (httpRequest.readyState == 4) {
                  var suggestion = eval(httpRequest.responseText);
                      if (suggestion.length > 0)
                      typeAhead(suggestion,txtID);
                    }
                 };
           httpRequest.send(null);
        }
}
```

Figure 4: requestSuggestions()

The third function typeAhead(suggestion,txtID) changes the value of the text box to the suggested value and selects that part of the text that was not typed by the user.

```
function typeAhead(suggestion,txtID){
        var objEl = document.getElementById(txtID);
        var txtValue = objEl.value;
        objEl.value = suggestion;
        if (objEl.setSelectionRange)  //Mozilla select
            objEl.setSelectionRange(txtValue.length, objEl.value.length);
        objEl.focus();
}
```

Figure 5: typeAhead()

The last component is the server side JSP script. It handles the HTTP request and returns the relevant suggestion. To simplify the example the names of the counties are hard coded in an array. In real applications there will be a database tier that stores the names of the counties. The content type is set to text/plain since only text is sent back. This component could be implemented in any server side scripting language.

```
<%@ page contentType="text/plain; charset=UTF-8" %>
<%
    String txtUser = request.getParameter("txtInput");
    String[]counties = new String[] {"Avon","Bedfordshire","Berkshire","Bbuckinghamshire","Cambridgeshire","Cheshire","Cleveland",
                        "Cornwall","Cumbria","Derbyshire","Devon","Dorset","Durham",..... };
   String suggestion = "";
    int i = 0;
   if (txtUser.length() > 0 ){
       while (i < counties.length &&  ! counties [i].startsWith(txtUser) )
            i++;
       if (i < counties.length)
         suggestion = counties[i];
   }
   out.print("\""+ suggestion + "\"");
%>
```

Figure 6: suggestion.jsp

The implementation of the above example gives an indication of the knowledge, understanding and skills that are required to apply the AJAX technique. The first component requires basic knowledge of HTML. The second component requires good knowledge and understanding of the JavaScript language, event model, HTML DOM, the object-oriented paradigm and HTTP request/response model. It also assumes good programming skills. The last component requires skills in using a server side language and understanding of the development of dynamic web applications.

4. AJAX educational implications

In all of the computing courses offered at London Metropolitan University students are given the option to study modules related to web development and Internet technologies at each level: certificate, intermediate and honours. Each Internet related module builds on the knowledge and skills gained in modules from the previous levels including Internet, programming and database modules.

There are a number of reasons that one can list in support of the idea to incorporate AJAX topics in the Internet related computing modules. AJAX is a popular technique used with open standards and supported by all major browsers. It is focused on enhancing the user experience and consequently its use has expanded rapidly. Since the AJAX approach uses technologies and models that are already covered in the Internet, programming and database modules the students have the necessary prerequisite knowledge and skills to study the AJAX technique. Developing simple AJAX examples does not require any extra technical support and resources. Our previous experience from introducing topics such as Web Services, XML

and mobile web application development shows that students find it interesting and motivating to learn innovative and popular technologies. The benefits from introducing the AJAX approach for the students include: developing broader skills and problem solving techniques in web development, improving understanding of fundamental concepts related to event driven development, data tree structures, DOM, object oriented programming and acquiring knowledge in current trends in web development. Some challenges also could be expected such as overcoming the different level of understanding of the prerequisite concepts by the students, developing more suitable examples and finding an appropriate tool or a framework for rapid development of AJAX applications.

In the certificate level all computing students study two core modules in object-oriented programming with Java. There are two sessions in the second programming module [10], which considers the event-driven paradigm in the context of building GUI applications. In the Internet modules students gain understanding of key principles related to web applications and skills in design and development of static web sites. They are also introduced to the client side scripting language JavaScript, CSS and the XML technology. At this stage in order to prepare the students for using the AJAX technique examples that focus on using the HTML DOM, JavaScript Objects and the event model need to be considered. For instance, the W3 Schools [11] tutorials offer a large selection of appropriate examples.

The intermediate Internet modules cover development of data driven dynamic web sites. On completion of these modules the students are expected to be able to design and develop a multi-page web site allowing interaction with a database. The students gain experience of using a server side language and the HTTP request/response model. The AJAX technique can be introduced at this level by comparing the traditional method for developing dynamic web sites with the AJAX approach. Ideally one lecture followed by a tutorial and a workshop would be sufficient to cover the basis of this topic. Simple AJAX examples demonstrating real time data validation and periodic refresh for a mini chat room application based on the Ajax patterns suggested in Chapter 3 [2], have been developed. Exercises based on these examples that require small modifications are appropriate for the lab sessions to further develop the student's understanding of the AJAX approach.
The examples can be tested on http://www3.unl.ac.uk:8188/draganov/realtimedatavalidation/inputdata.jsp and http://www3.unl.ac.uk:8188/draganov/chatroom/chatroom.jsp, respectively, and their source code can be downloaded from [9]. These examples focus on implementing the basic AJAX engine in order to provide students with understanding of the fundamental idea of the AJAX technique.

In the honours level the module related to the Internet is focused on developing an understanding of enterprise level Internet software application programming issues. It covers in depth a number of topics including architectural design patterns, client-side and server-side programming, database connectivity, XML technologies and Web Services. For the first time the AJAX technique was considered last year in this module [12] in one lecture session. However, introducing the AJAX approach at intermediate level would enable the consideration of more advanced topics at honours level that are related to design patterns, web architectures and frameworks. This approach would be in line with the aim of the module to develop understanding of enterprise web application development. To demonstrate a real application of the AJAX technique students can be given an example of incorporating Google Maps in their web applications using the Google Maps JavaScript API [13]. In addition, more examples that demonstrate the best practices of using AJAX in web applications can be found in The Java BluePrints AJAX Components [14]. At honours level investigation of different tools and frameworks available for AJAX application's development is appropriate [15]. Adopting a tool for rapid development of AJAX functionality would enable the implementation of more complex examples, enhance the student experience and emphasise more the design principles rather than the implementation issues.

5. Conclusions

This paper has presented an overview of the AJAX technique for developing interactive web applications. Ideas of how to introduce the AJAX approach in teaching web development and examples for lab sessions have been suggested.

Incorporating popular technologies into the computing courses appears to motivate the students and in the same time it helps them understand better fundamental theoretical concepts. The AJAX technology requires relatively little new knowledge and can be easily included in teaching web development by focusing on specific parts of existing technologies and demonstrating appropriate applications. The challenge is the constant need of updating the material and selecting relevant examples and tools. However, the experience of learning new technologies and related applications has been rewarding and exciting. The material presented here could be used as an example of embedding emerging technologies in the computing curriculum through existing modules.

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