TOOLS AND TECHNIQUES FOR YOUR MATH ON THE WEB PROJECT

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Introduction. Much has happened in the last year in the area of Math on the Web. Professors, researchers, and others needing to publish mathematical documents to the worldwide web have in the past been mostly limited to using images to display the math within their HTML document or converting the document to PDF. Both of these methods are replete with disadvantages, primarily that they can't be made interactive, and searching, manipulating, and re-using equations is impossible with images or PDF. This paper covers an introduction to MathML (the Mathematical Markup Language that is a recommendation of the Worldwide Web Consortium – W3C), interactive math in web pages, and displaying math in browsers.

Introduction to MathML. First published as a recommendation in April 1998, and revised in February 2001 with the publication of MathML 2.0, MathML is "designed as an XML application, [and] provides two sets of tags, one for the visual presentation of mathematics and the other associated with the meaning behind equations."[1] Although it is possible to write the markup manually, this was never the primary intent. The intent was for specialized tools to "provide the means for typing in and editing mathematical expressions."[2] During its infancy, the realistic and useful implementation of MathML was but a mere dream, it is now true that

- MathML support is available for free in Netscape and Internet Explorer.
- MathML is supported in several major computer algebra systems.
- MathML support is available and improving in widely distributed authoring tools, including the ones surveys show that most students and school teachers use.
- Major scientific publishers are either in the process of incorporating MathML into their work flows or are seriously considering it.
- MathML has been incorporated into other important standardized markup languages, such as Docbook.
- Serious attention is being given to MathML as a means of increasing accessibility to technical documents.

The Markup. As mentioned earlier, one of the two sets of tags provided by MathML is intended for the visual presentation of mathematics. This set of tags is commonly called "presentation markup" or "presentation MathML". Using this set of tags, it is possible to precisely control how an expression will look when displayed. There are about 30 MathML presentation elements which accept about 50 attributes.

The other set of MathML tags is associated with the meaning behind equations. This set of tags is commonly called "content markup" or "content MathML". Content markup facilitates applications other than display, like computer algebra and speech synthesis, and comprises about 120 elements and about a dozen attributes.

Most presentation elements have start and end tags, similar to the way some HTML has start and end tags, for example: `<element_name> ... </element_name>`. A second type of MathML element is an empty element of the form `<element_name/>`. These elements have just one tag. Simple mathematical expressions can easily become quite verbose in MathML, as demonstrated in Figure 1.

$a = b^2 - 4$

```
<math>
 <mi>a</mi>
 <mo>=</mo>
 <msup>
  <mi>b</mi>
  <mn>2</mn>
 </msup>
 <mo>-</mo>
 <mn>4</mn>
</math>
```

```
<math>
 <apply>
  <eq/>
   <ci>a</ci>
   <apply>
    <minus/>
     <apply>
      <power/>
      <ci>b</ci>
      <cn>2</cn>
     </apply>
     <cn>4</cn>
   </apply>
 </apply>
</math>
```

Figure 1. Simple equation, its presentation markup, and its content markup

It's easy to see that although MathML is easily *editable* by hand, it could become very time-consuming to *author* complex expressions by hand. Not only could it take a great deal of time, but there would be a good chance of a syntax error. Fortunately there are some excellent authoring tools available that take much of the work out of authoring MathML.[3]

Interactive math in web pages. Since MathML is text and not a fixed image, it can be manipulated with Java or JavaScript or dynamically processed by other software or applets. The possibilities are endless, but include graphing applets, message boards, interactive whiteboards, and assessment tools. Examples of interactive math can be seen at the Design Science web site.[4]

It is also possible to produce some types of interactive equations by the use of MathML "equation actions". By using actions, the interactivity properties are encoded directly in the equation itself, and do not require JavaScript. The example in Figure 2 illustrates one type of equation action called a "toggle". In this example, the page would display y = ?. When the reader places the mouse pointer over the question mark, the browser's status bar would display a message – in this case "Click for slope-intercept form." Clicking the question mark would change the display to $y = mx + b$.

```
<math>
   <mi>y</mi>
   <mo>=</mo>
   <maction actiontype='toggle'
     dsi:cue1='Click for slope-intercept form.'
     dsi:cue2='Slope-intercept form of a linear equation.'>
     <mrow>
       <mo>?</mo>
     </mrow>
     <mrow>
       <mi>m</mi>
       <mo>&InvisibleTimes;</mo>
       <mi>x</mi>
       <mo>+</mo>
       <mi>b</mi>
     </mrow>
   </maction>
</math>
```

Initial display of the toggle

What the toggle displays after the reader clicks the question mark

Figure 2. Example of a toggle

Displaying MathML in browsers. It is this aspect of the technology that has changed the most over the last year. Capabilities of various browsers to display MathML vary by

Windows

- Internet Explorer[5] 5.5 and later – use MathPlayer[6]
- Netscape[7] version 7 and later – displays MathML natively
- Mozilla[8] version 0.9.9 and later – displays MathML natively
- Any Java-capable browser – use WebEQ Viewer Control[9]

Macintosh

- Internet Explorer – use techexplorer[10]
- Netscape version 4.0 and later – use WebEQ Viewer Control
- Mozilla version 1.1 and later – displays MathML natively
- Any Java-capable browser – use WebEQ Viewer Control

Table 1. MathML display capabilities of major browsers

browser and platform, as shown in Table 1. (Since browser capabilities change often, the information in the table may be out of date by the time you read this.) One thing that should be apparent by looking at the capabilities of various browsers is that if you want to be able to use the latest technology, you should be using a fairly recent version of the browser. It doesn't seem like an unreasonable request on the part of a professor to require students to download the latest version of a particular browser.

Cross-browser authoring. Not everyone has the luxury of knowing what browser will be used to view his or her web page. Fortunately there is a solution – the Universal MathML Stylesheet (UMSS)[11]. The big advantage of using the UMSS is that not only does an author not have to know which operating system or browser will be used to view the page, but browser-specific markup to identify the rendering extension is not needed

either. The stylesheet does require using a browser that supports XSLT transformations, so once again, this requires using a relatively recent browser release. In the event the page is loaded with a browser that doesn't have a rendering engine (say, Internet Explorer 5.5 without MathPlayer), the stylesheet will transform presentation MathML to XHTML + CSS + Javascript, which can be rendered in a standard HTML browser without any extra plugin. "In addition to its use as a fall back option in these client side transformations, this stylesheet could be used as a server based transformation to produce something acceptable on browsers without any XSLT or MathML support."[12]

Templates for creating pages with MathPlayer, for Netscape/Mozilla, or the UMSS are available at http://www.dessci.com/support/tutorials/mathmlinxml/.

Conclusion. Although not perfect (what technology ever *is*?), the implementation of MathML is now a reality for anyone needing to publish web pages with mathematical formulas or equations. Far from the simple static display capability of images and PDF, MathML offers interactivity, searching and retrieval, manipulation by other software, equations that can be re-used in other applications, and many more features that were available only in our dreams a couple of years ago.

References.

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