

Engineering Virtual Environments with X3D

Architecture

A case study of the application of X3D

Robina Hetherington
Liverpool Hope University College



Web3D Symposium 2005

web **3D**
CONSORTIUM

1

Tutorial outline

- Background – the challenges
- Could X3D meet these challenges?
- Relationship of X3D with XML
- Examples



Web3D Symposium 2005

web **3D**
CONSORTIUM

2

The construction industry

- Architects
- How they handle data
- Current software options
 - What is being used
 - New developments



Web3D Symposium 2005

web **3D** CONSORTIUM 3

Architects and 3D visualisations

- Used to create walkthroughs
 - Use something like 3ds max
 - Create a video, avi file
- 3D realtime models
 - Turntool, 3ds max plugin



Web3D Symposium 2005

web **3D** CONSORTIUM 4

Architects and information

- 2 out of 3 firms use PDF to archive drawings and send drawings to contractors
- Over 50% use a variant of AutoCad as their main tool
 - Otherwise there is a wide range of other software being used
- 84% intend to move into 3D soon
 - Building Design 2004, UK survey

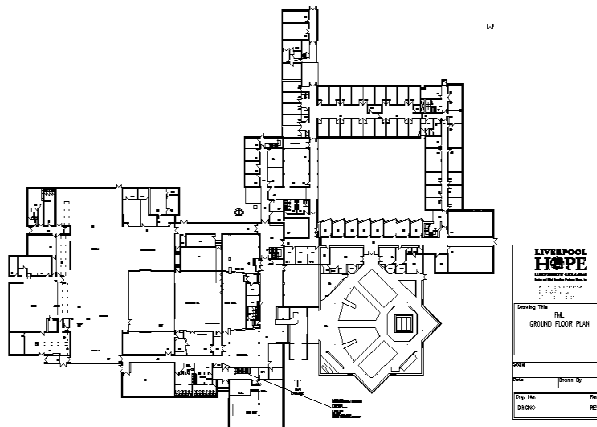


Web3D Symposium 2005

web **3D**
CONSORTIUM

5

What does AutoCad produce?



Web3D Symposium 2005

web **3D**
CONSORTIUM

6

The construction process

- The design
 - 2D, drawings, sheets or
 - 3D, a model
- The specification and quantities
 - A database
- Join these together and you have a BIM system

BIM

- Building Information Management
- Two-dimensional documents are replaced by 3D models, where each section of the building is linked with information regarding its real-world properties
 - Becker (2004)

AutoCad and Databases

- Data contained in an external database table linked with AutoCAD graphical objects
 - OLE, Object Linking and Embedding data
- Labels that display data from selected table fields as text objects in the drawing

AutoCad and the Web

- PDF, plotted to Distiller
- Saved as a raster image, JPEG or PNG
- DWF
 - The electronic drawing set is saved as a single multi-sheet
 - Can be password protected
 - Autodesk Express Viewer
 - Viewed or plotted by anyone with the freely distributed external viewer,

The problem

- 2 distinct data sources
- Proprietary solutions
 - AutoDesk's Revit
- Open source solution
 - X3D?



Web3D Symposium 2005

web **3D** CONSORTIUM 11

AutoDesk's Revit

- BIM system
- *Revit* uses parametric building model
- Information contained in a building database
- Every view (2D, 3D or schedule) is generated dynamically from the database



Web3D Symposium 2005

web **3D** CONSORTIUM 12

BIM Systems v. 2D

- 2D type packages, like AutoCAD, are dumb
 - Endless possibilities
- BIM systems can be limited by a finite number of possibilities
- May require workarounds
- Does allow the full scope of tasks
 - Hunt (2005)



Web3D Symposium 2005

web 3D CONSORTIUM 13

Could X3D meet these challenges?

- X3D is an application of XML
- XML “*industry-specific markup, vendor-neutral data exchange, media-independent publishing*”. W3C (1998)



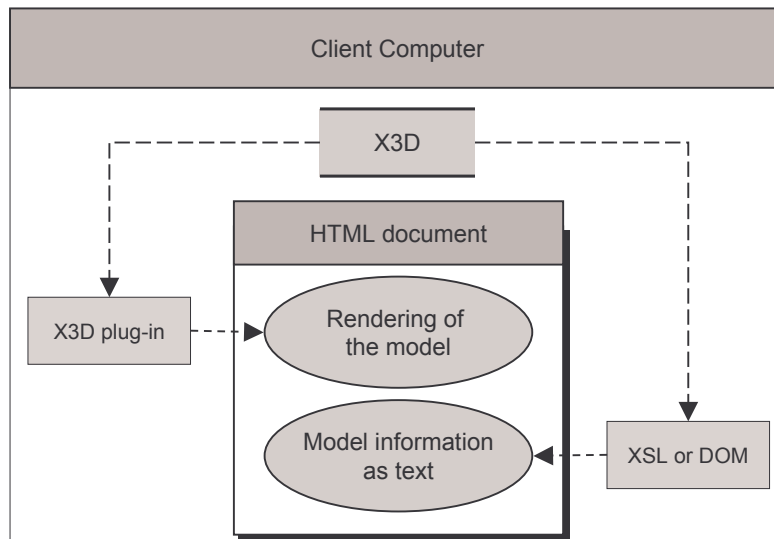
Web3D Symposium 2005

web 3D CONSORTIUM 14

Information Rich Virtual Environments

“...combine the power of VEs and information visualization, augmenting VEs with additional abstract information such as text, numbers, or graphs.”

– Bowman et al (2003)



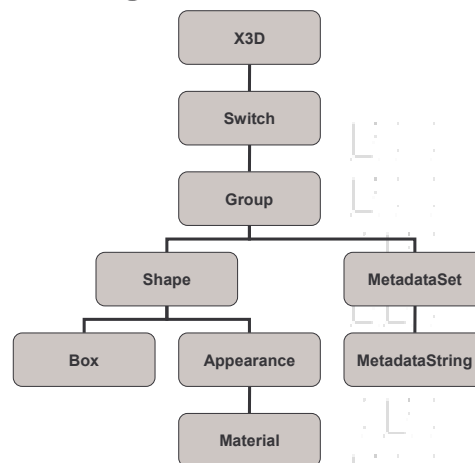
– Hetherington et al 2005

X3D

- X3D to manage content
- Structure of the scene graph
- Embedding/linking of abstract data

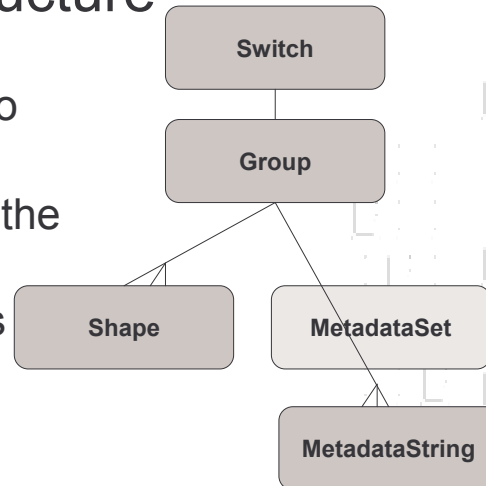
X3D Scene graph

```
<?xml version="1.0" encoding="UTF-8"?>
<X3D profile="Immersive">
<Scene>
<Switch DEF="buildingElement" whichChoice="-1">
  <Group DEF="Foundation">
    :
  </Group>
  <Group DEF="FloorSlab">
    <MetadataSet>
      <MetadataString
        value="The type of concrete..."
        name="Specification" />
    </MetadataSet>
    <Transform translation="0 0 -1.65">
      <Shape DEF="Floor">
        <Appearance>
          <Material
            DEF="Concrete2_mat"
            diffuseColor="0.5 0.5 0.5" />
        </Appearance>
        <Box size="3.8 0.2 3.0" />
      </Shape>
    </Transform>
  </Group>
  <Group DEF="BelowGroundWalls">
    :
  </Group>
  :
</Switch>
</Scene>
</X3D>
```



Structure

- Grouping is key to the method
- **Switch** controls the rendering of the building elements
- One to many relationship



Metadata types

```
1) <MetadataSet name = "" value = "" reference = "" >
2)   <MetadataString name = "" value = "" reference = "" />
3)   <MetadataDouble name = "" value = "" reference = "" />
4)   <MetadataFloat name = "" value = "" reference = "" />
5)   <MetadataInteger name = "" value = "" reference = "" />
</MetadataSet>
```

- 1) Container
- 2) Strings
- 3) Double-precision floating point numbers
- 4) Single-precision floating point numbers
- 5) Integers

- Web3D Consortium

Metadata example

```
<MetadataSet>
  <MetadataString
    name="Specification"
    value="Lots of stuff about the type of concrete"
  />
  <MetadataString
    name="Supplier"
    value="Bloggs and Co"
  />
</MetadataSet>
```

Specification embed or link?

- A linked XML document to contain the specification?
 - A standard specification?
- Or one file that contains everything?
 - Embedded specification

XML and X3D

- XML technologies to provide usable information and displays
- XML technologies to extract, filter, display and calculate data
 - XSL
 - DOM
- Client side solutions
 - Real time interaction, SAI
- Server side solutions

XSL

- There are two components of XSL which work together to filter data:
 - XPath is a method for accessing parts of an XML document
 - XSLT is a method for transforming XML

Client side parsing

```
var xmlDoc = new ActiveXObject("microsoft.xmlDOM");  
xmlDoc.async = false;  
xmlDoc.load("calculationModel.x3d");
```

- Use an ECMAScript function to load the XML/X3D file into the parser as an Active X Object
 - Must be Internet Explorer

XSL example calculation

```
<xsl:variable name="originalstrdimensions"  
  select="@size"/>  
<xsl:variable name="strdimensions"  
  select="normalize-space($originalstrdimensions)"/>  
<xsl:variable name="length"  
  select="substring-before($strdimensions, ' ')/>  
<xsl:variable name="breadth"  
  select="substring-before(substring-  
after($strdimensions, ' '), ' ')/>  
<xsl:variable name="height"  
  select="substring-after(substring-  
after($strdimensions, ' '), ' ')/>  
<xsl:variable name="volume"  
  select="round($length * $breadth * $height)"/>
```

Client side XSL

- Is fine to filter data
- Stonehenge example
- Fine for simple calculations, XSL allows the creation of variables to hold data
- **But** these cannot be updated
 - for example to accumulate the total volumes of an indeterminate number of components

Client side DOM

- ECMAScript
- Walks through the document tree, creating a Array of various types of **Shapes** and **MetadataStrings**
- Writes the filtered/calculated data to the Webpage

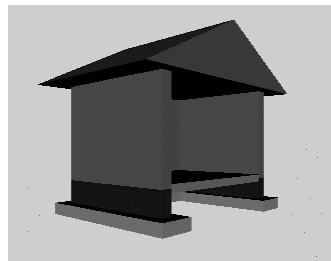
DOM example

```
if (shape[j].geometrytype == SHAPETYPE_BOX) {
    str = str + "<br>----- Box: " ;
    dimx = shape[j].geometry.x ;
    dimy = shape[j].geometry.y ;
    dimz = shape[j].geometry.z ;
    vol = dimx*dimy*dimz;
    totalGroupVol = totalGroupVol + vol;

    str = str + "x = " + dimx + ", y = "+ dimy + ",
z = " + dimz;
    str = str + " :: volume = " +
    Math.round(vol*1000)/1000;
```

What type of numerical data?

- Foundations
 - Volume of concrete
- Walls
 - Length of brickwork
- Roof
 - Area of tiling



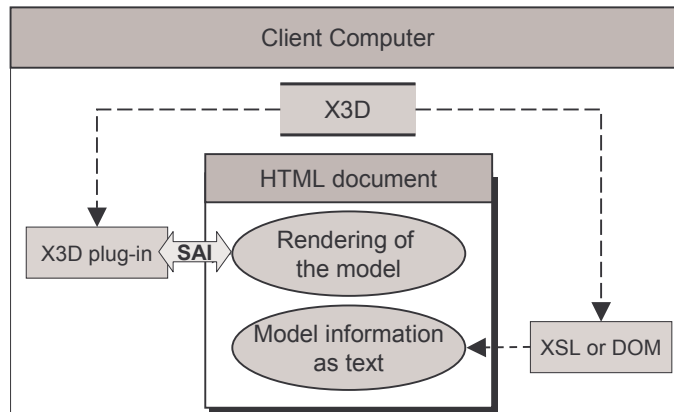
Use of client side DOM

- Collecting useful data
- A number of functions to select different types of calculations
 - Volumes
 - Areas – more difficult
 - Specification
- Requires a strict hierarchy of the model file
- Correct ordering of Groups
- Yet to be tested on complex models
- Only uses boxes and extruded shapes

SAI

- Scene Authoring Interface is an application programming interface (API) for the X3D scene graph.
- SAI scripts work for Script nodes inside the scene, external applets outside the scene in a Web page, Java and EcmaScript

SAI diagram



Switch node

- SAI used to control the value of whichChoice
- Affects the rendering of the groups making up the model

```
<Switch DEF="buildingElement" whichChoice="-1">  
  <Group DEF='Foundation'>  
    :  
  </Group>  
  <Group DEF='FloorSlab'>  
    :  
  </Group>  
< :  
</Switch>
```

SAI examples

- Stonehenge model
 - Shows the archaeological structure in its various stages of development
- Construction model
 - Shows the various stages of the construction process
 - Clickable model to show details of that component



Web3D Symposium 2005

web **3D** CONSORTIUM 35

Next steps Hope campus

- Temporal Modelling Research Group
- Model our campus over time
- Calculate footprints/coverage at different time periods
- Calculate volumes of different buildings
- Tell a history through the changing buildings on the site



Web3D Symposium 2005

web **3D** CONSORTIUM 36

Construction information

- Updating of data on the server side from the client, for example
 - Adding specification
 - Adding scheduling data
 - Providing costs for building elements

Client versus server side

Client

- May be browser specific
- Complete file is downloaded
 - Real time manipulation

Server

- Browser independent
- 'Ready cooked' solutions
- Or a time lag
- Greater control of data

Distribution of data, more challenges

- Ownership of designs and data
- Portable/mobile solutions
- Data transmissions
- Compression of data



Web3D Symposium 2005

web **3D** 39
CONSORTIUM

Questions?



Web3D Symposium 2005

web **3D** 40
CONSORTIUM

References

- Becker (2004) Bye-bye, blueprint: 3D modeling catches on. Retrieved February 1, 2005 from http://news.com.com/2102-1012_3-5390945.html
- Bowman, D. A., North, C., Chen, J., Polys, N., F., Pyla, P. S. and Yilmaz U., 2003, Information-Rich Virtual Environments: Theory, Tools, And Research Agenda, *Proceedings of the ACM symposium on Virtual Reality Software and Technology*, ACM, pp 81 – 90
- Building Design (2004) IT Survey, Get with the Programs, *CMP Information*, (pp 4-11) London.
- Hetherington, R. and Farrimond, B. *The Integration and Display of Architectural Information Using XML and X3D Technologies* 11th International Conference on Human-Computer Interaction jointly with 1st International Conference on Virtual Reality to be held in July 2005, Las Vegas
- Hunt C. (2005) Revit finally comes of Age, *Building Design, CMP Information*, (pp 2-27) London
- Web 3D Consortium <http://www.web3d.org/x3d/specifications/ISO-IEC-19775-IS-X3DAbstractSpecification/Part01/>

Links

- My webspace www.robina.co.uk/x3d
- TurnTool www.turntool.com/
- Flux www.mediamachines.com/
- Revit www.autodesk.com/revit
- AutoCad www.autodesk.com/