Dissertation for MA Degree

Is VRML A Forgotten Language?

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Contents

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Abstract

Since its launch in 1995 VRML has experienced a rollercoaster-ride of an existence, from being hailed as the future of 3D graphics on the web to almost complete obscurity and, several versions later, back into the spotlight as a potentially major player in several areas of the Web and everyday life alike.

This resurgence in popularity is largely due to changes in the way the internet is used; huge advances in related technologies have enabled an infinitely more interactive internet, and pave the way for a renaissance for the likes of VRML and many other web applications released long before their time.

Introduction – Dust Or Magic?

> *'...its possible to anticipate a time, a few decades hence, when people spend more time in remote and virtual realities than in their immediate surroundings, just as today most of us spend more time in artificial indoor surroundings than in the great outdoors.'*
>
> [Hans Moravec, 'Pigs in Cyberspace' 1992]

Anyone who has been involved in, or even just followed the rise of the Internet over the last ten-or-so years will doubtless remember being reliably informed that in the near future no-one would ever need to leave the comfort of their office chair to lead a rich and fulfilling business and social life – online communities based in 'virtual reality' settings would provide areas for work and play, and generally recreate life for you.

Well, we're still waiting for that, although some areas of virtual 'life' have flourished where many have failed to impact. For example, we can buy absolutely anything online, from the weekly groceries to a second hand Aston Martin (eBay item #2484311055; £21,000 – no bids as of 20/07/04!) We can chat face to face with friends all over the world with MSN; we can find out *anything* about *absolutely anything* using text-based search engines like Google, and more often than not, we can verify if the source is reliable.

The common factor in all these (and more) successful internet services is that they are technological extensions of established systems – shopping by mail order has been popular for decades; to talk to someone without being there with them we could use a telephone (albeit not visually, but that could be considered an advantage); and for information, public libraries have been around since 1842 (opened on 28th May in Frederick Street, Salford); and if you didn't want to go out, you could always buy an encyclopaedia (mail order of course) or watch a relevant TV documentary. People are used to these mechanisms – commerce, communication, information – being omnipresent in their lives: we, as 'The Consumer' have been incrementally conditioned to accept these industries into our homes,

and the development of the internet simply (yet monumentally) extended the range and increased the convenience of these services.

The not-so successful areas of the foreseen 'virtual life' are the ones trying to replace or enhance aspects of Real Life that have not been toyed with before. The idea of a shared Virtual Reality experience suffers from many disadvantages at any given point in its development and social acceptance; but one consistent factor is that it is considered somewhat sad to be sat on your own pretending to be out somewhere else, and presumably somewhere more desirable, virtually conversing with people doing likewise. Why not just go?

MSN Messenger and the like work because they fall under the category of replacing an existing technology, not a Real Life experience. Imagine Microsoft released 'MSN-VR' where effigies (or 'avatars' in VR speak) of you and your friends were shown sitting in a bar and you literally had to approach the person you wanted to talk to in order to chat - after the novelty of the 3D had worn off, I'm not sure it would be as popular because it would be making too big a deal of the event. People like to play down the role of the internet in their lives. A quick chat (or quick type as is more often the case) is acceptable. Emulating a night out is not.

Discussing Virtual Reality in this way quickly leads to the age-old question '*Form or Function*?' Quite clearly, 3D interfaces on the Web have been developed, thus far, to indulge our desire for the visually compelling; but is there an argument for 3D representations in any specific areas of our 2D Web? If not in social communication applications, where *would* 3D provide better 'function' than 2D? On a practical level, this sounds absurd – the complexity of 3D is always far greater than 2D, therefore, in hardware and software terms, 2D will always function more quickly and efficiently. So perhaps a better question would be: 'Where would the *application* of 3D graphics provide a distinct advantage over 2D graphical or text-based information?' Web Functionalists will emphatically dismiss 3D graphics on the Web (often, rightly so) as unnecessary hindrances to finding what one is

looking for. That said, many of them don't agree with the current 2D layout of the Web or, indeed, the graphical nature of computers in general. Rebel-in-Chief Ted Nelson comments:

> *'...GUI- Graphical User Interface. This term is absurd. Why? Because there are so many other graphical things possible. ...[Computer scientists] are utterly incapable (on the average) of creating interfaces that most people can use.'* [i]
>
> [Ted Nelson, 'Dust or Magic' Conference, Oxford 2004]

Obviously some people will see no value in virtual-3D at all, but the majority will excuse the fact that *maybe* it takes a little longer to load and forfeits some textual straightforwardness, in favour of something graphically dynamic.

A quick look around the Web reveals as many different 3D applications as there are virtual models – everything from the resurrection of ancient buildings[ii] to models of NASA satellite components[iii], and even a mechanical pencil![iv] My project, accompanying this paper, is an interactive 3D model of Little Clarendon Street in Oxford - a small, yet busy street of bars, restaurants and boutiques - using a mixture of VRML (Virtual Reality Modelling Language), QuickTime VR and 2D graphics[v]. It serves as an interesting guide for tourists and locals alike, letting you get the feel of the street before you visit. In years to come, it will provide an unusual historical snapshot of what the area was like in 2004. I came across VRML as a result of researching the idea for the project; but I have to conclude that this particular application for 3D on the Web lends itself exceedingly well to VRML; and is one of the few instances where 3D achieves what 2D could not.

The majority of 3D models out there however, are random object created largely, it seems, simply for the sake of it. VRML can be used in two ways – from inside looking around a scene (as in my Virtual Street), or outside looking around an object (the majority of arbitrary models, e.g. the mechanical pencil.) There are hundreds upon hundreds of galleries

containing all manner of objects, reminiscent of early clipart sites, only with basic VRML models instead of the familiar blocky graphics.

So 3D or not 3D? What exactly *is* VRML; and does it still have a place on the World Wide Web of today? In the right circumstances VRML could offer a way of conveying information in a virtual three-dimensional manner, without compromising functionality or causing psychological unease. I will examine the history and application of VRML and try to assess whether it is indeed a *forgotten* language, or if, despite recent *neglect*, we are still to see the best VRML (and it's successor X3D) have to offer.

VRML Development

VRML1.0

> *'I winced when I first heard it, for two reasons; because it was so un-poetic, and because, the moment I heard it, I knew it would stick, that we would be stuck with V-R-M-L forever.'*
>
> [Mark Pesce, *Labyrinth* inventor]

The first step along the road to 3D on the Web was taken on 11th February 1994 by San Francisco developers Mark Pesce and Tony Parisi who wrote to Tim Berners-Lee, director of the Web Standards Consortium W3C, explaining their new 3-dimentional web interface which the had named '*Labyrinth*'. Labyrinth interpreted properly formatted ASCII text files containing Cartesian coordinates for object vertices, lighting and viewpoints, RGB colour information, as well as hyperlinks and other information; and displayed them as virtual-3D world, under full navigational control of the user. Berners-Lee invited Pesce and Parisi to write a paper and present their work at a Virtual Reality 'Birds-of-a-Feather' session at the First International Conference on the World Wide Web (25th-27th May 1994 – CERN, Geneva, Switzerland). The paper, entitled 'Cyberspace' outlined the need for a new standard protocol, Cyberspace Protocol (CP) which would work above existing Web protocols and with Labyrinth to add 3D capabilities to standard Web browsers, in particular the newest browsing sensation, *Mosaic*.

During the presentation, conference delegate and HTML pioneer Dave Raggett suggested the name VRML (Virtual Reality Modelling Language) as a standardised alternative to *Labyrinth*, a name which stuck instantly. By the end of the conference, it had been agreed by the attendees that a set of open standards needed to be defined to ensure the survival of VRML – it was,

and still is, a general rule that open-source technologies are accepted more widely, and survive for longer than proprietary systems.

Shortly after the conference, Pesce, along with another attendee Brian Behlendorf persuaded Behlendorf's employers WIRED to allow the pair space on their new web server to implement a VRML forum. It went live on 10th June 1994 and within one month had over 1000 members; the main aim to agree upon a set of standards that could quickly and successfully be implemented for a speedy release of VRML1.0. In August 1994 members of the forum cast a final vote and the following was decided:

- VRML must be a cross-platform standard
- It must work over a low-bandwidth connection (14.4Kbps)
- The language itself would be based on a modified version of Silicon Graphics 'Open Inventor' ASCII text format; providing extensive capabilities for complex objects, lighting and texture mapping
- Because of the time constraint, VRML1.0 would contain NO interactive behaviours other than HTML hyperlinks, but they would be included in version 2.

The Open Inventor was chosen to ensure that 'VRML' was more than just a name- that it also obeyed the universal law of the '**ML'- a hierarchical structure and pre-defined 'node' names (analogous to 'tags' in HTML and XML). VRML files are similar in structure to standard HTML files, although the use of arbitrary words like Separator (in V1.0) to define each object makes the logic difficult to follow.

The opening line is always a page definition for the browser- for VRML1.0, this is

```
#VRML V1.0 ascii
```

and then each element in the world, be it object, light, or viewpoint is defined in turn using values measured in meters (for linear distance) and arbitrary units of 0 – 1 for all other values; such as rotation angle and light intensity.

This typical basic VRML1.0 text describes a world with a red cube and yellow sphere illuminated by a spotlight:

```
#VRML V1.0 ascii
Separator {
    DirectionalLight {                  # Spotlight
        direction 0 0 -1
    }
    PerspectiveCamera {                 # Primary viewpoint
        position 0 0 10
        focalDistance 8
    }
    Separator {                         # Red Cube
        Material {
            diffuseColor 1 0 0          # RGB colour, Red
        }
        Translation {
            translation 4 0 0
        }
         Rotation {
            rotation 0.5 0.5 1 0.9
        }
        Cube {}
    }
    Separator {                         # Yellow Sphere
        Material {
            diffuseColor 1 1 0          # RGB colour, Yellow
        }
        Transform {
            translation 3 0.2 1
        }
        Sphere { radius 2 }
    }
}
```

The VRML1.0c standard was 'frozen' on 26th May 1995 as ISO/IEC 14772 [*see Appendix A for overview*] and work began on improving and expanding the language.

VRML2.0

Efforts to quickly expand the few interactive capabilities of VRML into version 1.1 were abandoned in November 1995, as the newly established VRML Architecture Group (VAG) decided to push straight on with version 2.0, incorporating spatial audio, enhanced environmental settings, multilingual capabilities and, above all, extensive support for Java interaction with VRML worlds. According to Mark Pesce:

> *'If any two technologies seemed destined for each other, they'd have to be VRML and Java... a combination that would provided 3D capabilities for Java and interactive capabilities for VRML'* [vi]
>
> [Mark Pesce, Web Developer Magazine 1996]

The VRML2.0 standard was published on 2nd February 1996 with the following key concepts among the extensive specification [*see Appendix A*]:

- Based on UTF encoding rather than ASCII to allow worldwide character-set compatibility. New file header reads
  `#VRML V2.0 utf8`
  and a MIME type is defined as:
  `x-world/x-vrml`
- Any number of Script and Sensor events can be included
- Instances of elements can be defined (similar to the use of Symbol instances in Flash Actionscript) using the `DEF` statement; and called into any position with the `USE` statement.
- The `WorldInfo` node contains world details such as Title and Copywrite information.
- The `NavigationInfo` node allows restriction on how the user views the world – the view method can be set to walk, fly or examine by the designer.

Our V1.0 example from earlier now looks like this:

```
#VRML V2.0 utf8

     DirectionalLight {                          # Spotlight
         direction 0 0 -1
     },

     DEF Camera01 Viewpoint {                    # Camera
        position 0 0 10
        description "Camera01"
     },

     Transform {                                 # Red Cube
       translation -4 0 0
       rotation    0.5 0.5 1 0.9
       children [
         Shape {
           geometry Cube {}
           appearance Appearance {
              material Material {diffuseColor 1 0 0}
           }
         }
       ]
     },

     Transform {                                 # Yellow Sphere
       translation 3 0.2 1
       children [
         Shape {
           geometry Sphere {radius 2}
           appearance Appearance {
              material Material {diffuseColor 1 1 0}
           }
         }
       ]
     }
```

VRML worlds had evolved. Even at this basic level, the new language structure allowed far greater flexibility of scene, and was easier to visualise than version 1.0. In more advanced scenes, script-driven events such as animated avatars, non-continuous sounds, and a dynamically generated horizon all contributed to the intrigue and immersiveness of the VR experience.

VRML97

A third VRML specification was published in early 1997, with the addition of a set of guidelines defining an External Authoring Interface (EAI). The EAI standardised conversion between VRML worlds (.wrl) and other 3D formats, such as AutoCAD (.dng .dwg .dxg) and 3D Studio Max files (.3ds). Finally graphic designers could use the authoring program of their choice and export to VRML with the guaranteed compatibility only previously available from text editors or dedicated VRML authoring software.

The VRML2.0 and EAI definitions respectively became parts one and two of the VRML97 specification (ISO/IEC 14772-1/2:1997); and this is the version most commonly in use today.

Immersiveness

'As our worlds become smarter, and get to know us better and better, it becomes harder and harder to say where the world stops and the person begins.'

[Andy Clark, 'Natural Born Cyborgs?' 2001]

Seeing Is Believing

We, as humans, are exceptionally good at focussing our attention and immersing ourselves in things we see before us. I use the word 'see' because it is a skill particularly honed to our visual systems: to immerse ones-self fully in a sound or smell or sensation, the natural reaction is to close ones eyes to block out visual data which may conflict with the sensory information (or misinformation) which we are trying to focus on. The influence of visual sensory information is so great it can even fool our brains into selecting *it* as being correct despite overwhelming contrary evidence from our other senses. A recent study by a team at Vanderbilt University, Tennessee used a specially designed 2D image consisting of a set of dots arranged in a circle to look like a sphere, moving in such a way as to recreate a visual illusion called the Kinetic Depth Effect - whereby the sphere appears to be rotating, although it is impossible to say in which direction. On its own, the image causes the brain to perceive motion in each direction 50% of the time. They projected the image into the eyes of their subjects, and coupled it with a real rotating polystyrene sphere, the theory being that feeling the physical sphere rotate would force the brain to accept *that* as the true direction of rotation of the virtual sphere, 100% of the time. In fact, 35% of the time, the perceived visuals overpowered the tactile sense and convinced the brain the image was rotating in the opposite direction to the model, causing 'cognitive dissonance' in the brain.[vii]

This may be a simplified example, but it proves the power of visual sensory information over contrary physical evidence. That is not to say we could trick our brain into feeling a rotating ball at our fingertips with just a moving image, or feel we are walking down a street when we are sat at our computers. That is something VRML, at least, could never hope to achieve. Even today's most virtually immersive technologies, like IMAX cinema - with its full field-of-view screen and multi-point surround sound - cannot make us physically experience the scene. In fact, it is barely more immersive than a good book!

VR and Sensory Memory

The key to immersiveness lies in the way sensory information is passed to the short-term memory. To cope with data from billions of nerve endings, rods and cones, taste buds etc., many compression methods are used within the body. Of particular interest when discussing immersiveness are Selective Attention and Feature Extraction.

> ***Selective attention*** *occurs when we notice important information necessary to meet our basic needs or our own interests.*
> ***Feature extraction*** *would be observing things as unusual, or "out of the ordinary."* [viii]
>
> [www.thinkquest.org]

In VR terms, selective attention can be held by including enough detail and information in the scene to stop the mind wandering or focussing on any of the senses not being targeted. Feature extraction must be avoided at all costs – missing areas of the scene, jumpy graphics and scratchy audio will instantly snap the user out of a state of immersion. It is important not to underestimate feature extraction – referring back to the cinema example, no matter how big the screen or involved the plot, a mobile phone ringing will instantly shatter the illusion for the entire audience.

A good immersive experience - one which runs smoothly from start to finish attracting maximum selective attention and causing no detrimental feature extraction - will be stored in the long-term memory to be recalled at a later date (usually by another feature extraction trigger) as a *real* experience; even if instantly afterwards we remember that it was not. In this way familiarity or empathy (depending on the context) will be established between the viewer and the scene.

However important visual information is to our subconscious, there appears to be a maximum level of immersion achievable using only vision, or indeed vision and sound; and anything beyond that level must also include touch, and preferably, the most difficult sense of all to emulate, the so-called zeroth sense: proprioception.[ix]

But we expect more from a VR scene than immersiveness. There has also to be a purpose, a justification to ourselves for spending extended periods of time not physically interacting with other humans. One solution is for the developers to include those other humans in the VR, to create a networked multi-user VR application. VRML2.0 doesn't inherently support multi-user worlds, but they can be achieved by undertaking what the VRML2.0 Handbook describes as 'some fairly extensive programming'- not a phrase to be underestimated in VRML terms! But what evidence is there that this would lead to the creation of an environment people would want to share?

Social Consequences

There are, of course, no studies relating to the social application of VRML, mainly because currently there *are* no social applications of VRML. There are, however, plenty of applications of, and studies into, networked multi-user 3D gaming; many of which are visually indistinguishable from a decent VRML scene. Computer games fall into the category (as mentioned in the Introduction) of Natural Progression: the *re*volution of the 'Video Game' happened very much offline, more than 25 years ago. The *e*volution continues to this day; from stick tennis to Pac-Man and Space Invaders, through Mario and Sonic, into 3D with Doom and Quake, and now across the Web with game phenomena such as Counter Strike.

Multi-User 3D Applications

But what effect does spending hours in an immersive fantasy environment have on users? A study led by Professor Talmadge Wright of Loyola University, Chicago, into the social consequences of immersive online interaction, used Counter Strike as the basis for research. The Anti-Terrorist team-based shoot-em-up is the world's most popular network game with 2.5 million players worldwide and around 100,000 participating at any one time.[x] Professor Wright took part in games, reviewed in-game chat logs and interviewed players to discover the psychology behind the fighting. He reported that the violence aspect was incidental:

> *'The strategy and tactics used by many regular players and teams, or clans, often makes it seem like a game of chess... The importance of the social side of Counter-Strike was revealed in the constant banter, in-jokes and insults that people exchanged during play... The most common emotion when people are playing is laughter.'*
>
> [Prof. T. Wright, Psychology, Loyola University, Chicago]

The team element of the game makes the time spent playing a social experience; the ability to plan manoeuvres, and chat or joke with team-mates during play eliminates the solitary nature of usual internet use. This is a more important feature than simply sharing the fun. Prof Wright concluded:

> *'Games such as Counter-Strike that rely on trust and co-operation give rise to strong communities and good friendships'* [xi]

To highlight the importance of this 'team' factor, one needs only to examine the effects of straightforward solo Web use- the findings are in stark contrast to the Loyola study.

Solitary Web Use

The ongoing 'HomeNet' study by Carnegie Mellon University, focussing on the effects of solo Web usage among certain demographic groups, ranks the number one use for the internet as 'interpersonal communication' (including email and messenger services); and has repeatedly linked all types of high Internet usage with:

> *'...increases in loneliness and symptoms of depression'* [xii]

not the 'strong communities and good friendships' forged by multi-user applications.

Furthermore, the study concludes:

> *'Greater use of the Internet is associated with declines in the size of participants' social networks, declines in communication within the family and, for teenagers, declines in social support.'* [xiii]

Contrary to popular opinion, it is not necessarily the socially challenged who choose the internet as their main channel of communication; rather, the study proposes, that sustained excessive solitary use can lead to social deficiencies. However, the study also suggests that with time, or as the online services improve, social degradation can slow or even reverse. So

have any of the top social communication applications improved to the point of not mentally harming the user? And would people continue to use such a channel if it really were depressing them?

The HomeNet study was conducted between 1995 and 1999, and there is no question that messenger services, and online social applications in general, have not only increased in popularity (theoretically increasing the potential for larger online friendship groups), but also improved in quality – audio, video and multi-user conversations, file-sharing and 3D gaming which are commonplace now were non-existent in 1995.

Implications for VRML

Depending on the use of VRML in social applications, one can expect varying levels of acceptance by internet users. On the one hand, if the VRML is either not grippingly immersive or limited in its capacities for social interaction, it may not make an impact on, and certainly will not benefit anyone who uses it. If, like Counter Strike, there is relevant purpose for interaction between friends in an environment not available elsewhere; then VRML, indeed, any other associated technology, has a chance of being a success in that area.

Success?

But can immersiveness and social acceptance combine to contribute to success? In established areas of virtual immersion, particularly recreational media (theatre, film, TV) - where VRML could flourish most – acceptance, popularity and therefore success, are heavily linked to immersiveness. The biggest west end productions, highest quality cinemas and most intriguing programmes provide greatest immersion and, barring external factors and partly due to hype (an induced symptom of complete social acceptance), are the greatest successes.

Has VRML Been A Success Already?

It is difficult to gauge success and popularity of non-commercial websites, especially those, as is the case with many sites using VRML, pages without hit counters or any indication as to when they were published. It is fair to say that while VRML is a prominent feature of the Web today, much of the content has been around for a number of years: many pages explain that the VRML world may take time to load over a 28.8Kbps modem, or that Netscape 3 causes problems, or carry some other give-away sign.

This raises another issue concerning the timing of the release of VRML. In 1995, when the VRML1.0 standard was set, there were just 6.5 million computers worldwide with an internet connection[xiv] and the average home user had a machine somewhere in the region of (if I remember my Christmas present correctly!) an 80MHz 586 with 8MB RAM and a 28.8kbps modem. Very few people could even imagine that interactive 3D websites were possible; far less actually had the capability (or patience) to view them. By the time hardware and network technology had caught up with software like VRML (probably around 1997 with 133MHz PII-MMX chips and 56kbps modems as standard); VRML97 was being widely used among the graphics community,

but had evolved to such a point as to be technically impenetrable to the average home user.

VRML Usage

A set of surveys carried out by the Advisory Group on Computer Graphics (AGOCG) between 1994 and 1997 on the use of Virtual Reality in the UK, [*see Appendix B*] consistently expose the principal users of VR as Universities; and the most common hardware configuration to be a PC linked to a VDU or immersive Head Mounted Display (HMD). The use of VRML as a 3D graphic medium on the web grew from zero in 1994, to 5% in 1995 and up to 15% by 1997: then representing the most popular single system of delivery. The biggest decline in use was shown by a system called Superscape, which dropped from 30% in 1994 to just 12% by 1997. [xv] (Superscape, in partnership with Siemens mobile, now focus on a technology called 'Swerve' providing "3D content and technology solutions for the wireless gaming industry."[xvi])

No such public study has ever been repeated in the UK (or elsewhere), which could itself indicate that the peak of VRML, as we know it, has passed. But that may not matter. The Computer Graphics industry, in particular the Web3D Consortium, has developed a plan for the future of VRML, and a new specification is in its final public draft stage. X3D is well on its way.

The Future of VRML– X3D is Already Here

'Here's the way I like to think of it: If it ain't broke… rename it!'

[Tony Parisi, Co-Inventor of *Labyrinth*, 'Keeping Web 3D On Course', 1999]

Since Tony Parisi's keynote speech at the VRML99 conference, work has been in progress on a new specification to fully integrate VRML with all of today's popular web technologies. Known collectively as X3D, the specification is divided into four parts, each covering a different (huge) area. Despite a new name, more familiar syntax, and a few keyword changes within the language to iron out some glitches discovered since 1997; X3D is still essentially based around the same old VRML.

Like all new specifications, X3D is absolutely enormous; far-reaching in scope, and extremely detail-intense. The draft specification (completed on 21st July 2004) is available at Web3D.org; and in the interest of humanity, I will only go into detail about Part 1- describing the absolute basics of X3D.

X3D Part 1- Architecture and Base Components

Part 1 defines keywords, explains referencing conformities and provides extensive information on every type of Component valid in X3D. Among the more outlandish of the 23 Components [*see Appendix A*] are:

- *Networking*: to allow, amongst many other things, multi-user interaction within the same world.
- *Humanoid Animation (H-Anim)*: the movement of every joint of an avatar can be defined, optionally within a time loop.
- *Interpolation*: in the same way MPEG compression encodes key frames and difference frames to reduce data rates, X3D allows interpolation of animation frames to minimize programming time and reduce file sizes.

- *Geospatial*: unbelievably, X3D defines 23 different standard ellipsoids to accurately model the shape of the earth. It also calculates the mean sea level at any given point.

Further X3D

The remaining parts of the specification cover the following areas:

- X3D Part 2- Scene Access Interface (SAI)
  Part 2 defines the Scene Access Interface; how the user(s), the browser, and any number of external applications or scripts can interact with the X3D world.
- X3D Part 3- Encodings: Part 1- XML Encoding
  A major change to VRML97, X3D syntax is in XML format, making it far more intuitive to most Web programmers.
- X3D Part 3- Encodings: Part 2- VRML Encoding
  This part encapsulates all VRML97 specification: the entire ISO/IEC 14772 standard provides the key words and structure to the XML. Backward compatibility is also ensured.
- X3D Part 4- Language Bindings: Part 1- ECMAScript
  Outline of compatibility with ECMAScript.
- X3D Part 4- Language Bindings: Part 2- Java
  Another important extension to the limited (and tempremental) Java capabilities of VRML97.

A third encoding method, Binary Encoding, designed to greatly reduce file sizes of any X3D model, is under review. The X3D Binary Format Working Group, consisting of members from the Web3D Consortium and Sun Microsystems was established on Monday 2nd August 2004.[xvii]

X3D Implementation

To get a feel for X3D files, here is the example from earlier (the red cube and yellow sphere), written in X3D format.

```
<?xml version="1.0" encoding="UTF-8"?>

<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.0//EN"
"http://www.web3d.org/specifications/x3d-3.0.dtd">
<X3D>
<head>
     <meta name='filename' content='shapes.x3d'/>
     <meta name='created' content='31 July 2004'/>
     #...other meta info
</head>
<Scene>
     <DirectionalLight />
     <NavigationInfo headlight='true' type='EXAMINE'/>
     <transform translation='-4 0 0' rotation='0.5 0.5 1 0.9 />
           <Shape>
                 <Box />
                 <Appearance>
                       <Material diffuseColor='1 0 0' />
                 </Appearance>
           </Shape>
     </Transform>
     <Transform translation='3 0.2 1'>
           <Shape>
                 <Sphere radius='2' />
                 <Appearance>
                       <Material diffuseColor='1 1 0' />
                 </Appearance>
           </Shape>
     </Transform>
</Scene>
</X3D>
```

The XML layout makes the code instantly understandable – compare that to the alien-looking array of square- and curly-brackets and repetitive use of the words “Separator” and “Children” in VRML versions one and two.

Additional X3D Profiles

In addition to this newfound conformity, X3D has been purposely developed to co-function with, or as part of, many of the established technologies of modern computing.

X3D generates vector-based graphics, ensuring scalability and, along with the XML syntax, compatibility with all modern 3D modelling packages. An ongoing development called CDF (CAD Distiller Format) will provide potential one-click distillation of high-complexity CAD images down to low-complexity X3D worlds (analogous to the Adobe PDF distiller).[xviii]

X3D can be implemented within the Extensive Modelling and Simulation Framework (XMSF) to produce real-time 3D scenes across a network.[xix]

MedX3D is under development to provide a standard interchange format for medical 3D scans. Multiple types of scans (such as MRI, CAT or Ultrasound) can be combined into one 3D image to give clearer representations of the results. A standard X3D human anatomical model is also under development for use in medical education.[xx]

But surely the biggest assurance that X3D will become the world standard for interactive 3D graphics come from 'ISO/IEC 14496: Coding of audio-visual objects -- Part 8: Carriage of ISO/IEC 14496 contents over IP networks', to be formalised in January 2005:

> *'The Web3D Consortium announced that its X3D® Interactive Profile has been adopted by the Moving Picture Experts Group (MPEG) to bring state-of-the-art, X3D-based, interactive 3D graphics to the MPEG-4 multimedia standard.'* [xxi]
>
> [EmbeddedStar.com, 2nd April 2004]

If only the media industry would catch up with their technology departments, 'X3D' would become as much a household acronym as 'MP3'. Sadly the newest in home-entertainment media formats are *still* based around MPEG-2 compression rather than the superior MPEG-4. The Sony/Philips 'Blu-Ray' and Toshiba/NEC 'HD-DVD' blue-laser optical disc

technologies are fighting to become the new generation of super-high quality video and high capacity (20-54GB per disc) data storage medium. Blu-Ray has even been confirmed as the media platform for Sony's Playstation 3, due for release in Japan on 31st March 2005.[xxii]

So a missed opportunity for both parties, possibly simply due to time constraints- X3D doesn't become standard in MPEG-4 until January 2005, and blue laser discs have been in the shops for over a year[xxiii]. To speculate briefly: there will come a time when games consoles and video devices use format based on the MPEG-4 standard to offer the HCI support (such as Head Mounted Displays and force-feedback systems in bodysuits) and advanced multi-user network capabilities of X3D.

Conclusion

In the years since its conception, VRML has been largely underestimated and frequently neglected and ignored, but never quite forgotten. The quiet ongoing development and use of VRML by Web graphics organisations such as the Web3D Consortium have brought it to the point of integration. An open-source language that follows no standard syntax is of little interest to the majority of potential users; but the coming of X3D as successor to VRML, with its standard XML structure, has paved the way for greater impact in the 3D graphics marketplace, both online and elsewhere.

The fact that X3D is already the basis for research in so many everyday applications - be they medical, technical or for entertainment purposes – shows the potential X3D has to offer. As with all 'new' (read as 'recently popular') technologies, X3D will gain social acceptance as more applications are developed around it, and as public awareness grows.

The incorporation of X3D into the MPEG-4 specification could prove to be the real money-spinner as a wider audience of computer-buffs, gamers and moviegoers begin to accept X3D as being as much a part of visual entertainment as a colour screen.

VRML is alive and well, and at least as popular and widely used as it has ever been, in the guise of X3D.

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Appendix A – Overview of VRML Specifications

VRML1.0[xxiv]

Language Basics

At the highest level of abstraction, VRML is just a way for objects to read and write themselves. Theoretically, the objects can contain anything -- 3D geometry, MIDI data, JPEG images, anything. VRML defines a set of objects useful for doing 3D graphics. These objects are called Nodes.

Nodes are arranged in hierarchical structures called scene graphs. Scene graphs are more than just a collection of nodes; the scene graph defines an ordering for the nodes. The scene graph has a notion of *state* - nodes earlier in the world can affect nodes that appear later in the world. For example, a `Rotation` or `Material` node will affect the nodes after it in the world. A mechanism is defined to limit the effects of properties (`separator` nodes), allowing parts of the scene graph to be functionally isolated from other parts.

Applications that interpret VRML files need not maintain the scene graph structure internally; the scene graph is merely a convenient way of describing objects.

A node has the following characteristics:

What kind of object it is. A node might be a cube, a sphere, a texture map, a transformation, etc.

The parameters that distinguish this node from other nodes of the same type. For example, each Sphere node might have a different radius, and different texture maps nodes will certainly contain different images to use as the texture maps. These parameters are called Fields. A node can have 0 or more fields.

A name to identify this node. Being able to name nodes and refer to them elsewhere is very powerful; it allows a world's author to give hints to applications using the world about what is in the world, and creates possibilities for very powerful scripting extensions. Nodes do not have to be named, but if they are named, they can have only one name. However, names do not have to be unique- several different nodes may be given the same name.

Child nodes. Object hierarchy is implemented by allowing some types of nodes to contain other nodes. Parent nodes traverse their children in order during rendering. Nodes that may have children are referred to as group nodes. Group nodes can have zero or more children.

The syntax chosen to represent these pieces of information is straightforward:

```
DEF objectname objecttype { fields  children }
```

Only the object type and curly braces are required; nodes may or may not have a name, fields, and children.

Node names must not begin with a digit, and must not contain spaces or control characters, single or double quote characters, backslashes, curly braces, the plus character or the period character.

General Syntax

For easy identification of VRML files, every VRML file must begin with the characters:

```
#VRML V1.0 ascii
```

Any characters after these on the same line are ignored. The line is terminated by either the ASCII newline or carriage-return characters.

The '#' character begins a comment; all characters until the next newline or carriage return are ignored. The only exception to this is within double-quoted `SFString` and `MFString` fields, where the '#' character will be part of the string.

Note: Comments and whitespace may not be preserved; in particular, a VRML document server may strip comments and extraneous whitespace from a VRML file before transmitting it. Info nodes should be used for persistent information like copyrights or author information. Info nodes could also be used for object descriptions. New uses of named info nodes for conveying syntactically meaningful information are deprecated. Use the extension nodes mechanism instead.

Blanks, tabs, newlines and carriage returns are whitespace characters wherever they appear outside of string fields. One or more whitespace characters separates the syntactical entities in VRML files, where necessary.

After the required header, a VRML file contains exactly one VRML node. That node may of course be a group node, containing any number of other nodes.

VRML is case-sensitive; 'Sphere' is different from 'sphere'.

Node names must not begin with a digit, and must not contain spaces or control characters, single or double quote characters, backslashes, curly braces, the sharp (#) character, the plus (+) character or the period character.

Field names start with lower case letters, Node types start with upper case. The remainder of the characters may be any printable ascii (21H-7EH) except curly braces {}, square brackets [], single ' or double " quotes, sharp #, backslash \ plus +, period . or ampersand &.

Coordinate System

VRML uses a Cartesian, right-handed, 3-dimensional coordinate system. By default, objects are projected onto a 2-dimensional device by projecting them in the direction of the positive Z axis, with the positive X axis to the right and the positive Y axis up. A camera or modelling transformation may be used to alter this default projection.

The standard unit for lengths and distances specified is meters. The standard unit for angles is radians.

Conceptually, VRML also has a "world" coordinate system as well as a viewing or "Camera" coordinate system. The various local coordinate transformations map objects into the world coordinate system. This is where the scene is assembled. The scene is then viewed through a camera, introducing another conceptual coordinate system. Nothing in VRML is specified using these coordinates. They are rarely found in optimized implementations where all of the steps are concatenated. However, having a clear model of the object, world and camera spaces will help authors.

Fields

There are two general classes of fields; fields that contain a single value (where a value may be a single number, a vector, or even an image), and fields that contain multiple values. Single-valued fields all have names that begin with "SF", multiple-valued fields have names that begin with "MF". Each field type defines the format for the values it writes.

Multiple-valued fields are written as a series of values separated by commas, all enclosed in square brackets. If the field has zero values then only the square brackets ("[]") are written. The last may optionally be followed by a comma. If the field has exactly one value, the brackets may be omitted and just the value written. For example, all of the following are valid for a multiple-valued field containing the single integer value 1:

```
1
[1,]
[ 1 ]
```

VRML2.0[xxv]

File Syntax and Structure

For easy identification of VRML files, every VRML 2.0 file must begin with the characters:

```
#VRML V2.0 utf8
```

The identifier utf8 allows for international characters to be displayed in VRML using the UTF-8 encoding of the ISO 10646 standard. Unicode is an alternate encoding of ISO 10646. UTF-8 is explained under the Text node.

Any characters after these on the same line are ignored. The line is terminated by either the ASCII newline or carriage-return characters.

The # character begins a comment; all characters until the next newline or carriage return are ignored. The only exception to this is within double-quoted `SFString` and `MFString` fields, where the # character will be part of the string.

Field names start with lowercase letters. Node types start with uppercase. The remainder of the characters may be any printable ASCII characters (0x21-0x7E) except curly braces {}, square brackets [], single ' or double " quotes, sharp #, backslash \\ plus +, period . or ampersand &.

Node names (specified using the `DEF` keyword; see the "Instancing" section of this document for details) must not begin with a digit, but they may begin with and contain any UTF8 character except those below 0x21 (control characters and white space), and the characters {} [] ' " # \\ + . and &.

VRML is case-sensitive; "Sphere" is different from "sphere" and "BEGIN" is different from "begin."

URLs and URNs

A URL (Universal Resource Locator) specifies a file located on a particular server and accessed through a specified protocol. A URN (Universal Resource Name) provides a more persistent way to refer to data than is provided by a URL. The exact definition of a URN is currently under debate.

General Node Characteristics

A node has the following characteristics:

A type name. This is a name like `Cube`, `Sphere`, `DirectedSound`, `SpotLight`, and so on.

The parameters that distinguish this node from other nodes of the same type. For example, each Sphere node might have a different radius, and different spotlights have different intensities, colours, and locations. These parameters are called fields. A node can have 0 or more fields. Each node type defines the type, name, and default value for each of its fields. The default value for the field is used if a value for the field is not specified in the VRML file. The order in which the fields of a node are read is not important.

A set of associated events it can receive and send. Most nodes can receive a number of `set_ events` (such as `set_position`, `set_color`, and `set_on`), which tell the node to change the value of a particular field. Most nodes can also send a number of `_changed` events, which indicate that a given field has changed (for example, `position_changed`, `color_changed`, `on_changed`). In the node description, events a node can receive are labelled `eventIn`. The events a node can send are labelled `eventOut`. Exposed fields (using the `exposedField` keyword) have implicit `set_` and `_changed` events.

The syntax for representing these pieces of information is as follows:

```
nodetype { fields }
```

Only the node type and braces are required; nodes may or may not have fields.

VRML97: Part 2 (EAI) Main Objectives[xxvi]

Authorability

Enable the development of computer programs capable of creating, editing, and maintaining VRML files, as well as automatic translation programs for converting other commonly used 3D file formats into VRML files.

Composability

Provide the ability to use and combine dynamic 3D objects within a VRML world and thus allow re-usability.

Extensibility

Provide the ability to add new object types not explicitly defined in VRML.

Be capable of implementation

Capable of implementation on a wide range of systems.

Performance

Emphasize scalable, interactive performance on a wide variety of computing platforms.

Scalability

Enable arbitrarily large dynamic 3D worlds

X3D: Components

Core, Time, Networking, Grouping, Rendering, Shape, Geometry3D, Geometry2D, Text, Sound, Lighting, Texturing, Interpolation, Pointing device sensor, Key device sensor, Environmental device sensor, Navigation, Environmental effects, Geospatial, Humanoid animation (H-Anim), Non-Uniform Rational B-Spline (NURBS), Distributed Interactive Simulation (DIS), Scripting and Event Utility.

Appendix B – Selected ACOGC Findings (1994-1997)

Type of Organisation using VR

	1994		1995		1997	
	f	%	*f*	%	*f*	%
University	30	69	35	60	25	81
Vendor / Manufacturer	6	14	14	24	3	10
Company Research Group	6	14	4	7	2	6
Government Research Group	1	2	2	3	1	3
Other	-	-	2	3	-	-
End User	-	-	1	2	-	-
Individual Researcher	1	2	-	-	-	-
Total	44		58		31	

VR Authoring (not Modelling) Software Packages

	1994		1995		1997	
	f	%	*f*	%	*f*	%
VRML	-	-	5	7	14	15
Superscape	13	30	17	23	11	12
Division DVS/DVISE	3	7	10	14	10	11
Open Inventor / OGL / Performer	2	5	7	10	9	10
In-House System	-	-	-	-	8	9
Sense8	7	16	6	8	7	8
DIVE	-	-	-	-	4	4
Total	25		45		63	

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