Of Standards and Herrings: Tales of Technology and Tumult

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1. Introduction

This letter provides a high-level sketch of the actors, motivations, and dynamics in the 3D content industry, the WWW, and standards organizations. Market Churn has cost investors and consumers. Here using historical perspective, we consider and debunk common falsehoods in the thinking about virtual reality and mixed and augmented reality technology. We parse out the alphabet soup of standards and their organizations and consider how they are scoped. If the dream of portable, shared information spaces is to become a reality, we must cooperate and play well with others in the Web ecosystem.

The last two decades have witnessed several revolutions in consumer electronics and multimedia production. Central to these revolutions has been the relentless march of hardware innovation: improved CPU and network speed, RAM sizes, and rendering speed (GPUs) put the supercomputers of the 1980s in the hands of consumers in the 2000s. While the computer hardware industry has seen several consolidations and disruptive events over the years, it seems remarkably stable when compared with the software and media sectors over this time. In that time, numerous technologies and companies have come and gone.

As proprietary platforms and bankruptcies proliferated, so much virtual world content and destinations were consigned to the bit-bucket, never to be run again. Authors and enterprises suffered from the loss of assets. Venture capitalists suffered from the loss of investment. The boom-and-bust cycles of the 3D Internet also have hurt the consumer and the market in general as fragmentation and obsolescence crippled any mass adoption and growth [1]. Despite these setbacks, 3D content and applications are not only surviving, but flourishing in specific domains where durability, portability, and interoperability are mission-critical.

In this paper, I survey the last 20+ years of Web and interactive 3D technology and offer reflections on the dynamics of communities, standards, and industry. Considering the current state of affairs through the lens of history can provide lessons and direction as to how we can move forward to realize the promise of this new media. In this first Section, I motivate and scope and consideration for this special issue article. Section 2 describes key communities of stakeholders and Section 3 discusses technology ecosystems and the scoping of various specifications and standards; Section 4 provides a historical narrative and reflection on market forces. Section 5 details the standards organizations and Section 6 considers the paths forward for Mixed and Augmented Reality standards.

1.1 The Web

It is hard to understate the impact of open networked information technologies on our modern life. Certainly some readers started their professional life with typewriters and the paper economy and can appreciate this. As the 1990s unfolded, a great optimism lit up society as the World Wide Web (WWW) began to grow and connect communities around the world. The development of technology specifications and standards such as HTTP and HTML enabled a whole economy and ecosystem to be built out of networked information. Hailed as a 'great equalizer' and promising a 'democratization of information', the Web quickly became a cental means for communication and access for a wide variety of users and communities. HyperText and multimedia presented exciting new possibilities for cross-linking information across digital works.

1.2 Cyberspace

The idea of immersive virtual worlds and shared information spaces may have began with Sutherland's paper about 'the Ultimate Display' [2]. However, the notion of a parallel digital world of spatialized information really reached public consciousness through the literary works of William Gibson [3] and Neil Stephenson [4]. Although dystopian in their tone, the potential of networked digital spaces sparked many early technologists, especially youth, who considered it their generation's platform to change to world… or create any number of 'virtual' alternatives.

1.3 Interactive 3D

In these early days, the computing technology for graphics rendering was limited. In the 1950s, the math behind perspective drawing was being worked out and the first computer graphics examples were coming out of engineering applications such as aerospace design and ergonomics. Early interactive drawing algorithms were concerned with the speed of hidden surface removal for rendering 3D objects with 2D lines [5]. Today, GPUs have hundreds of parallel processors and the programmable shader pipeline enables richness and realism to imagery at interactive rates. Dedicated graphics accellerators are now showing up on mobile devices, bringing the rendering power of the workstation to new form-factors: handheld devices or head-mounted displays. Over this amazing trajectory of hardware improvement, software and data formats proliferated. The most persistent has been the internationally-ratified ISO Standards of Virtual Reality Modeling Language (VRML) and Extensible 3D (X3D)[6], which we will describe below.

2 Stakeholder Communities

Considering the growth of the Web and the 3D content industry since the mid 1990s, there are many stakeholders operating throughout the ecosystem. This section reviews some of the main concerns of each and their view of platforms.

2.1 Content Creators

The expressive and creative power of interactive 3D proved both attractive and valuable to many. The flush of excitement sparked a flood of applications and worlds from science, education, archaeology, and simulation to multi-user social worlds. For those whose property and services are actually 3D objects or 3D systems with behaviors, the 3D content itself is the currency. The durability of their assets is critical as well as the security of their intellectual property. The only thing more expensive than creating 3D content is creating it twice (or more) when the technology changes or the company dies.

2.2 Technologists

The computer industry (here hardware and software producers) continually push innovation and novel solutions from real-time rendering techniques to algorithms for big data. Whether it is a prototype or product, architects and developers play a critical role. The evaluation and adoption of new languages and tools typically happens here; while technology strategies can be based on long-term or sustainability thinking, typically they are governed by ease-of—use or short-term rewards.

2.3 Business

Clearly, there is a lot of investment in VR and MAR companies. The current cycle of business boom presents many new (or renewed) opportunities. We should remind ourselves how much money was spent and lost through the hubris of 3D startups, the duplicated effort, and the mis-steps of big corporations. While there are a number of business models in the wide industry of 3D, the players themselves rarely grasp the ecosystem they are in, and rarely play well with others.

2.4 Consumers

Lastly, it is important to recognize this group as stakeholders since the number of Web users continues to skyrocket. End users face many challenges in getting into 3D, from the usability of the user interface to the babel-ization and fragmentation of required installations. While some-early adopters are accessing and experiencing 3D content on the Web, they are often using several different programs, each with its special value (and limitations). The trend toward empowering consumers to be producers face the same challenges for mass market success.

3. Technology Ecosystems

3.1 Content Models

The first ecosystem to discuss is the content model. HTML has a content model. 3D assets (for VR or MAR) must also be described in structured way- in what is commonly known as a scene graph. A scene graph *is* a content model; for example, describing what methods or parameters are supported for different nodes in the scene graph, how Groups and Transforms work in a hierarchy, how lights are scoped, where does texture coordinates or per-vertex color information go. The content can be encoded in multiple ways and programmatically accessed with different languages (next sections).

3.2 Encodings

Data can be encoded in many ways. The encoding determines several important outcomes, especially file size and parsing requirements. For example, a scenegraph may be encoded in a plain text encoding (like utf-8), as an XML document, or in binary. Different encodings can be useful in different circumstances; consider hand editing is easy in a text file but an XML can be validated, but binary may be better for publishing models.

3.3 APIs & Language Bindings

The Application Programming Interface (API) is the set of methods or functions supported by a computer program, software object or hardware device. Typically, APIs are used to structure a system and how it communicates and integrates with other programs. APIs may be bound to different languages; for example, one might program a scene graph with Javascript, Java, Python, or C++.

4. Market Mentalities

Interested readers are referred to the main conferences in the field, where a rich historical record of technology evolution and revolution can be found. Most notable are: the ACM SIGGRAPH / Eurographics conference on Web3D, IEEE VR, and IEEE ISMAR.

Herring Number 1: "Content standard S is slow"

Such statements are Red Herrings because it is the implementation of the standard that has a runtime, not the standard itself. A second difficulty with such a statement is that slow is a relative term and rarely is the difference specified. There are many factors that determine runtime, for example, what data is being included or represented and how it is encoded.

Herring Number 2: "We need a killer app for 3D"

This statement first hinges on the assumption that such a thing could be defined and second, that 3D as a media type would develop similarly to prior examples of 'killer applications' such as email, spreadsheets, or GPS. In the first case, speakers are commonly referring to something that drives mass market consumers: lots of users or revenue. They often ignore the fact that within certain vertical markets, 3D has already established its central value (it is the killer itself).

Herring Number 3: "Company C is the future of the 3D internet"

This is related to the prior herring and is usually a sign that Company C is a subscriber to the 'Highlander Myth': that there can be only one. This is essentially marketing since there is no evidence from any current (or dead) company that such a unilateral approach could work with the Internet, the Web, and their ecosystems.

Herring Number 4: "Technology T is open"

This is a herring often invoked when considering proprietary technology adoption. 'Open' is not the same as 'non-proprietary', 'non-patented', or 'royalty-free'. Being standardized and published openly is no guarantee of intellectual property exposure; look for explicit licensing and open-source implementations.

5 International Standards

Standards are different from specifications in that they are typically developed, evaluated, and ratified by a community and a cooperative process. This section provides an overview of relevant organizations and their standards.

5.1 International Organization for Standardization/International Electrotechnical Commission (ISO-IEC)

The Joint Technical Committee 1 (JTC1) of ISO and IEC: Information Technology was created in 1976 (http://www.iso.org/iso/jtc1_home.html). Its relevant SubCommittees:

- **SC 24:** Computer graphics, image processing and environmental data representation. This is the path Web3D Consortium standards travel (via a Cooperative Agreement; declared royalty-free).
- **SC 29**: Coding of audio, picture, multimedia and hypermedia information. This is the path Motion Pictures Experts Group (MPEG) standards travel. MPEG standards may be patent-bearing.
- **Joint Technical Working Group on Mixed and Augmented Reality** (SC24 + SC29) are standardizing a Reference Model for MAR; this work is declared to be royalty-free.

5.2 World Wide Web Consortium (W3C)

The W3C was founded in 1994 by members of MIT, CERN, and DARPA. They have produced and standardized the content models and APIs that underpin the World Wide Web: HTML, XML, CSS, SVG, and many others. The W3C promotes a royalty-free policy. The Web3D Consortium has an official Liaison relationship with the W3C. https://www.w3.org

5.3 Web3D Consortium

The not-for-profit Web3D Consortium was founded in 1996. Virtual Reality Modeling Language (VRML), Extensible 3D (X3D), Humanoid Animation (H-Anim) are openly published and freely available. They are also declared royalty-free. X3D is several standards covering the Scene Graph, Encodings, and the API respectively. X3D is defined with a modular, component-based architecture that has been extended for CAD, Volume Rendering. Like VRML, X3D is specified with no assumptions about display platform or user interface devices; because of this abstraction, X3D can be rendered with OpenGl, WebGl, DirectX, or even Flash. The X3D scene graph can be encoded in utf8, XML, or binary. The Scene Access Interface (SAI) is the API.for X3D runtimes; Javascript and Java are standardized and several more (C++, Python) demonstrated. http://www.web3d.org/

5.4 Khronos
Founded in 2006, Khronos is a not-for-profit consortium that develops and administers the OpenGL API and related technologies such as as WebGL. While typically focused on the low-level hardware-software rendering layer, Khronos has ventured into content models and encoding standards: Collada (XML-encoded content model) was standardized there. https://www.khronos.org/

5.5 Open Geospatial Consortium (OGC)
OGC was founded in 1994. Recent standards include WebMapService (WMS), WebFeatureService (WFS). The Keyhole Markup Language (KML) was standardized through OGC. Recent Liaison relationships with the Web3D Consortium have produced Web3D Service (Web3DS), which supports X3D and Collada for 3D GIS portrayal. The OGC also standardized Augmented Reality (ARML) describes a content model and API for location-based models using KML and Collada. ARML's front matter declares it contains patented technology. http://www.opengeospatial.org/

5.6 Motion Picture Experts Group (MPEG)
Founded in 1988, this group focuses on the encoding and transmission of multimedia content (video, audio, and 3D data). The codecs and other specifications produced may carry patents and royalty requirements. MPEG-4 Part 11 adopted portions of the VRML and X3D scene graph and included a Binary Format for Scenes (BIFS).

5.7 National Electrical Manufacturer's Association (NEMA)
This organization is the current home to the DICOM standardization activities ('Digital Imaging and Communications in Medicine'). Medical imaging, media storage, application services and display functions are covered by the standard. The description of 3D surfaces in DICOM matches the X3D mesh data types. The Web3D Consortium has an official Liason relationship with DICOM. http://dicom.nema.org/

5.7 Institute of Electrical and Electronics Engineers Standards Association (IEEE-SA)
Has an association that has develops a broad range of standards generally supporting the network: from wireless protocols to medical device communications. https://standards.ieee.org/

6 Mixed Reality: Status & Future Work

6.1 Status
Reflecting on the lessons of history, we can see great savings and efficiencies through the evolution and adoption of standards. The stakeholders in VR and MAR must be educated and demand standards and invest in improving them. The durability, portability, and interoperability of the X3D standard has been shown in multiple implementations over a decade and half with applications such as environmental monitoring [6], medical and volume rendering[7], networks [8], spectrum visualization [9], cities [10], and multi-user mirror worlds [11][12]. Proving the concept early, ARToolkit [13] supported ISO-IEC VRML as the source for 3D models as augmentation. VRML assets and environments still run today and faster than ever. Research into Mixed Reality using X3D for specification began in 2006 [14] with annual innovations from around the world [15] [16]. Work continued, for example, matching lighting [17] and depth [18] between the virtual and real scene. Recent member activities include the extension of the X3D standard for MAR applications, specifically proposing new nodes for the Camera and Tracking Sensors, BackDropBackground and adding additional projection parameters to the Viewpoint node.

6.2 Future Work
While this is a tale of technology tumult, there is one clear lesson from both the lost opportunities and gritty survivors: Cooperate or Die; build partnerships, scope compatible standards, build the ecosystem of Cyberspace.

ACKNOWLEDGMENT
The author wishes to thank all the volunteers and contributors to international technology standards.

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