CAD Export to the Web Using X3D

SIGGRAPH 2013 BOF

Nicholas Polys, Ph.D.
Virginia Tech

Leonard Daly
Daly Realism

Johannes Behr
Fraunhofer IGD

Don Brutzman, Ph.D.
Naval Postgraduate School

Hyokwang Lee
PartDB

Agenda

- The Web3D community & Web3D Consortium
- Value-chain examples – 3D Printing
- CAD Working Group Progress
  - ISO X3D 3.3
  - Validator, tools, examples
  - X3DOM support
- Call for Compression technologies (Open) & June Workshop review

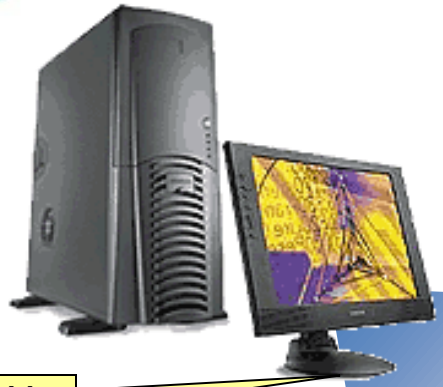
Open Standards for Interactive 3D on the Web

www.web3d.org

- Portability
- Durability
- Interoperability
- Royalty-free
- International recognition and support

web3D CONSORTIUM

The ISO Standards for interactive 3D on the Web



Shared world wide

Shared between applications

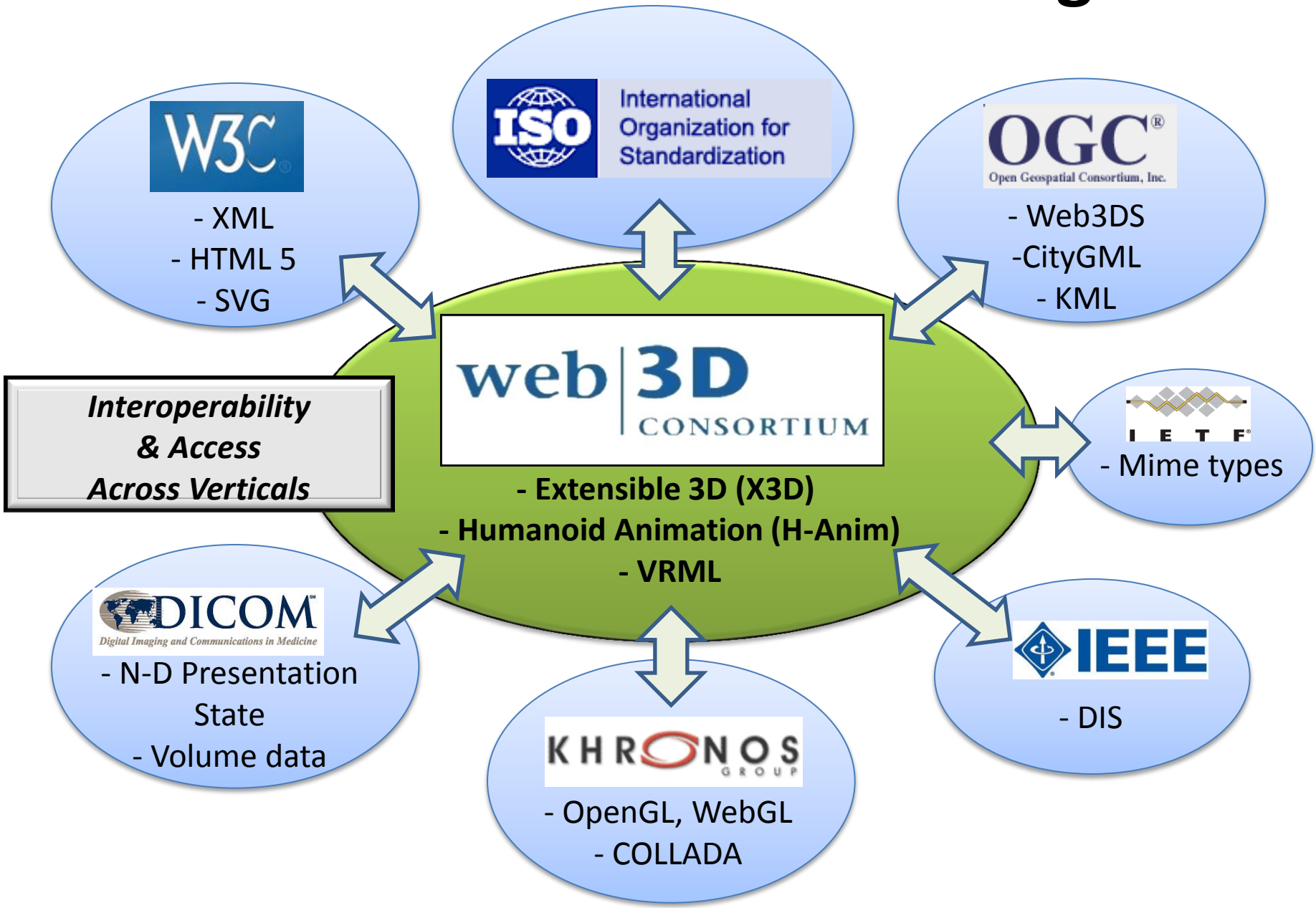
Royalty-free; Numerous implementations including Open source

"X3D enables the communication of real-time 3D across networks and XML-based web services"

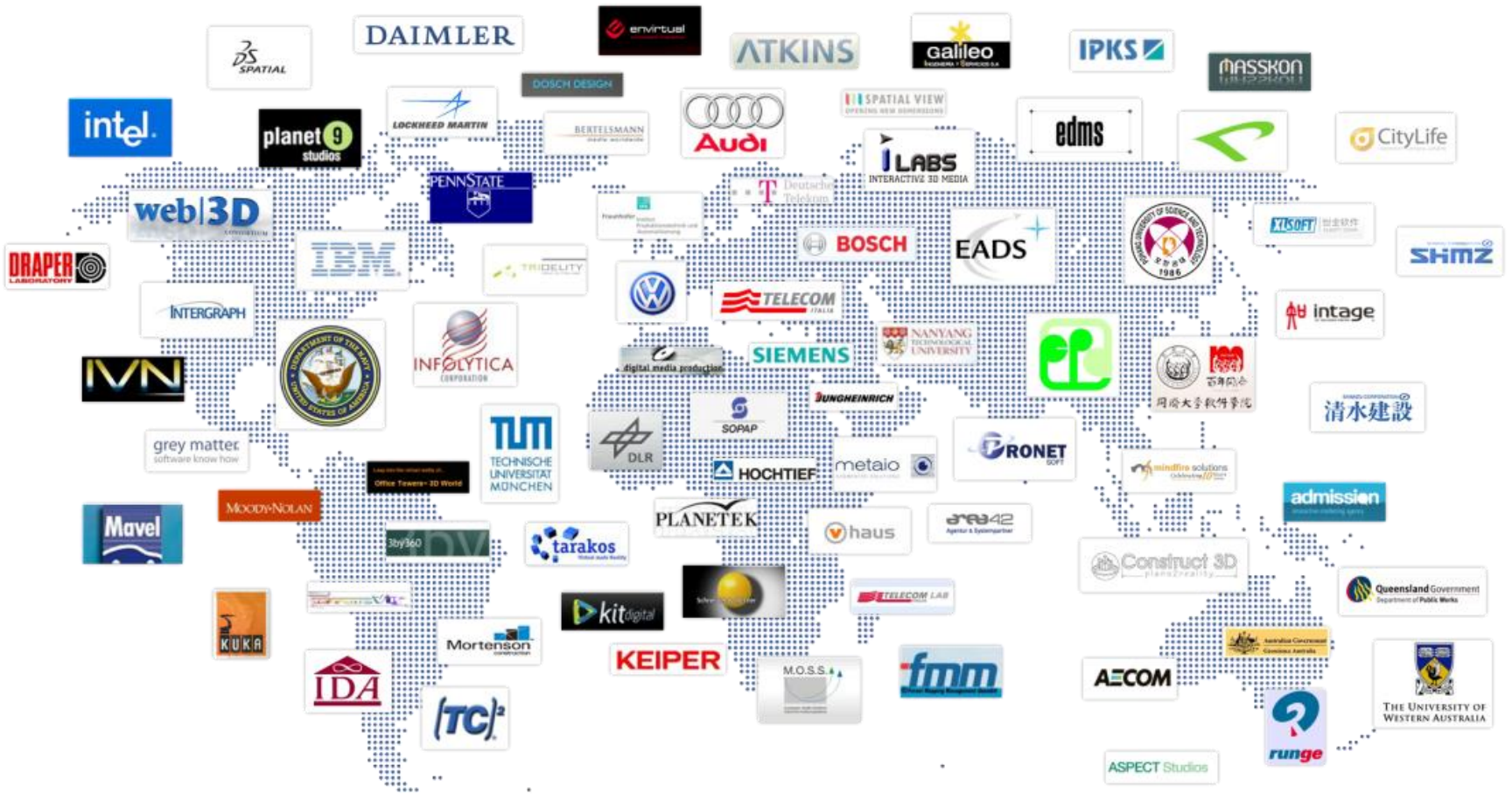
Lasts the Test of Time

Shared between systems

Web3D Collaboration & Convergence

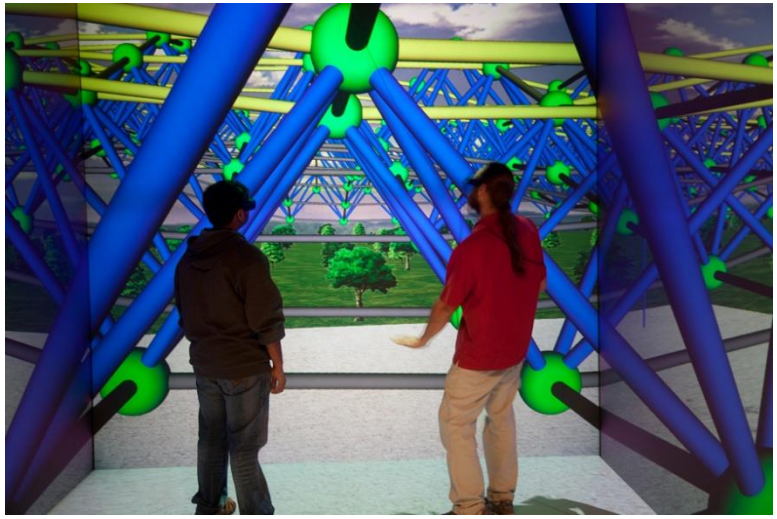


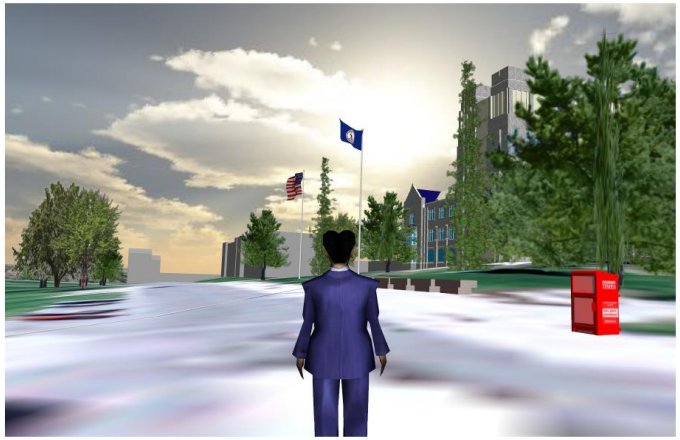
Adoption

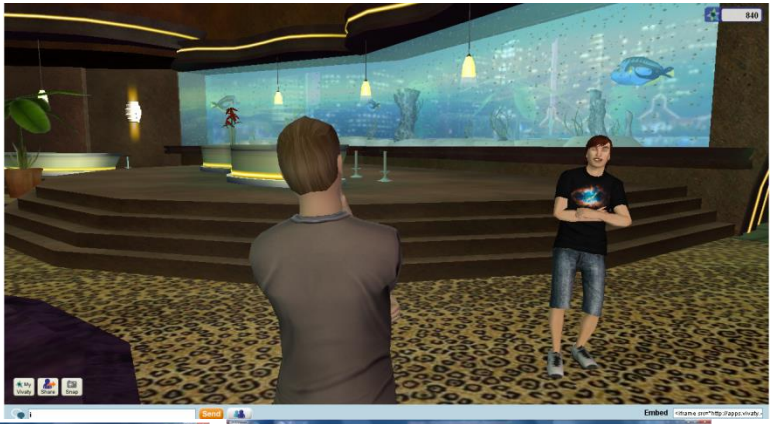


Too many to list them all!

Extensible 3D (X3D) , VRML, H-Anim

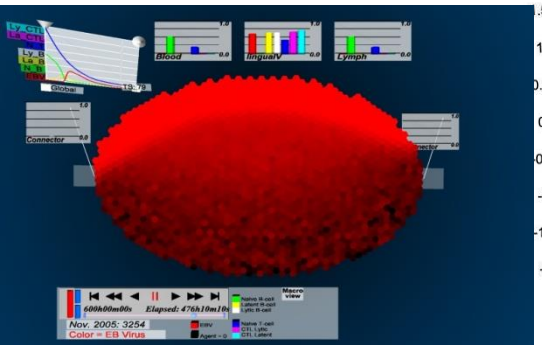


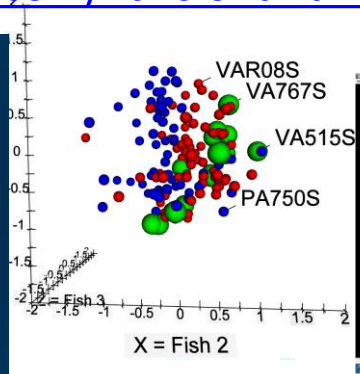


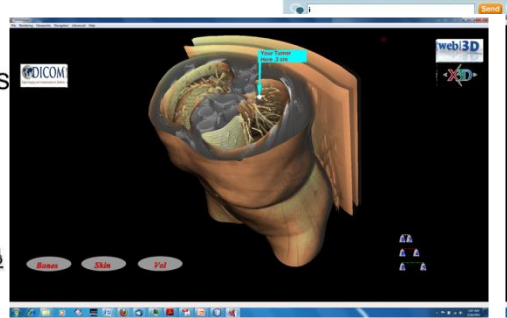


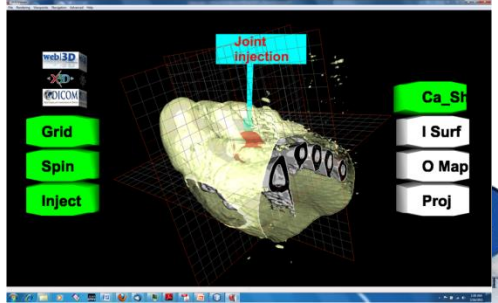
See videos and case studies at web3d.org:

- http://www.web3d.org/realtime-3d/case-studies
- http://www.web3d.org/realtime-3d/videos
- http://www.youtube.com/vtvisionarium









Web3D Community

This means You!

- We all want our assets to be portable and durable
- We all have a stake in a royalty-free future for 3D on the web
- Active Working Groups organized around vertical applications of the X3D spec: CAD, Geospatial, Medical, Augmented Reality
- Join us – we are member-supported organization!

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Events @ SIGGRAPH

- Web3D Booth # 233
- Tuesday
  - BOFs in 201D: CAD, Carto, Medical, TownHall Mtng
- Wednesday
  - BOFs in 201C: X3D Futures w/ HTML5, AR/MR
  - TechTalk (Exhibit Hall 3:45pm)

- ACM 19th Annual Web3D Conference to be Co-located with SIGGRAPH 2014, Vancouver

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Value-chain example – 3D Printing

- Lots of excitement for custom and on-demand manufacture
  - VT Dreams Lab: http://www.dreams.me.vt.edu/
  - Navy use case
  - X3D keychain FOB

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CAD Working Group Progress

- ISO X3D 3.3 CAD Component (clause 32)
  - Specification public and in FDIS
  - http://www.web3d.org/files/specifications/19775-1/V3.3/Part01/components/CADGeometry.html
- NURBS vs. B-Reps deep-dive
  - NURBS can represent the same construct geometries as BREPs, with a lot less complexity

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CAD Working Group Progress

- Online X3D Validator:

https://savage.nps.edu/X3dValidator

- X3D-Edit 3.3:

https://savage.nps.edu/X3D-Edit/

- **X3D basic examples repository:**

http://www.web3d.org/x3d/content/examples/Basic/CAD/index.html

.x3d	XML encoding
.x3dv	Classic VRML encoding
.wrl	VRML97 encoding
.x3db	X3D Compressed Binary encoding
.xhtml	HTML5

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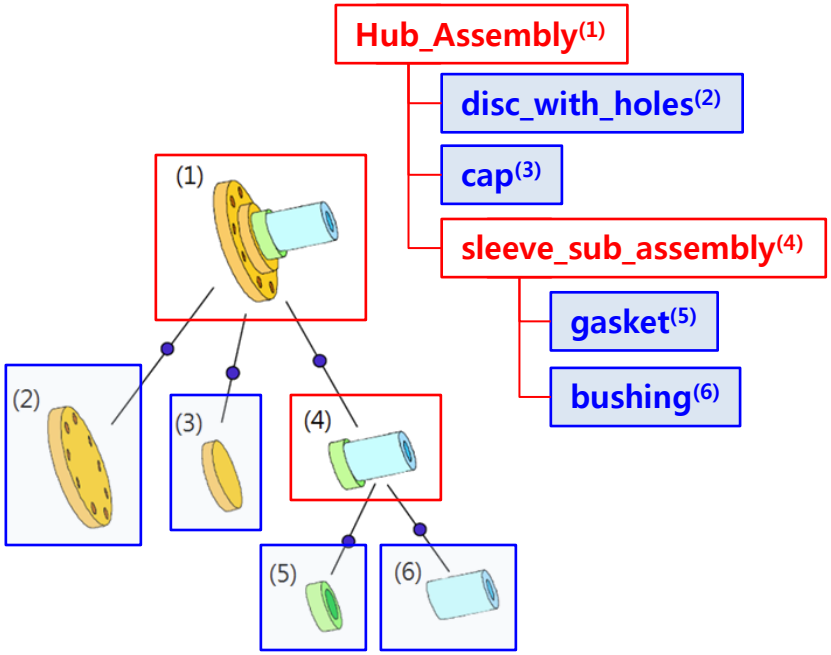
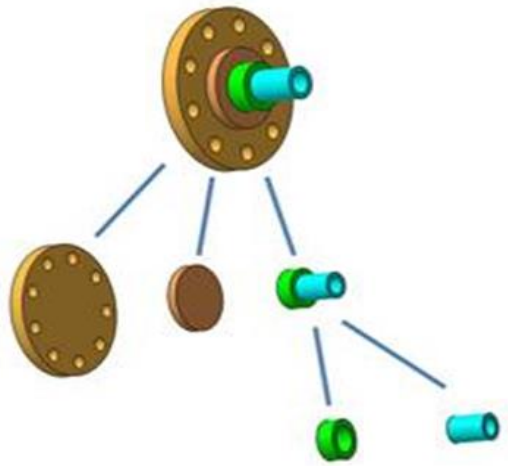
Example: CATIA Hub_Assembly model

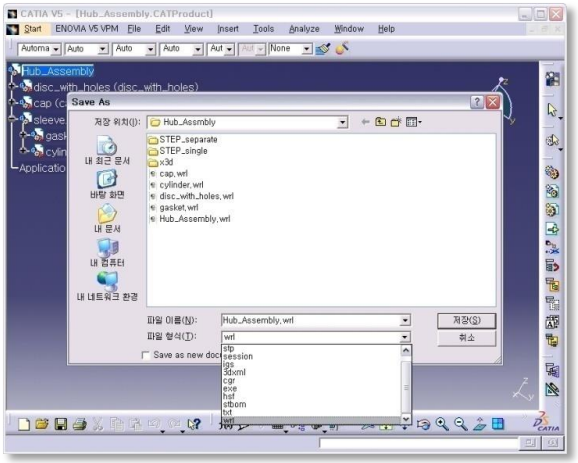


CATIA Hub Assembly
(6 Files)



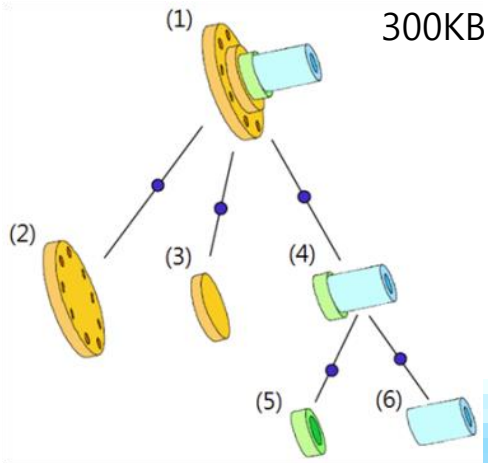
bushing.CATPart	55KB
cap.CATPart	51KB
disc_with_holes.CATPart	109KB
gasket.CATPart	56KB
Hub_Assembly.CATProduct	19KB
sleeve_sub_assembly.CATProduct	14KB
	300KB

Simple Conversion of Hub_Assembly into X3D



300KB

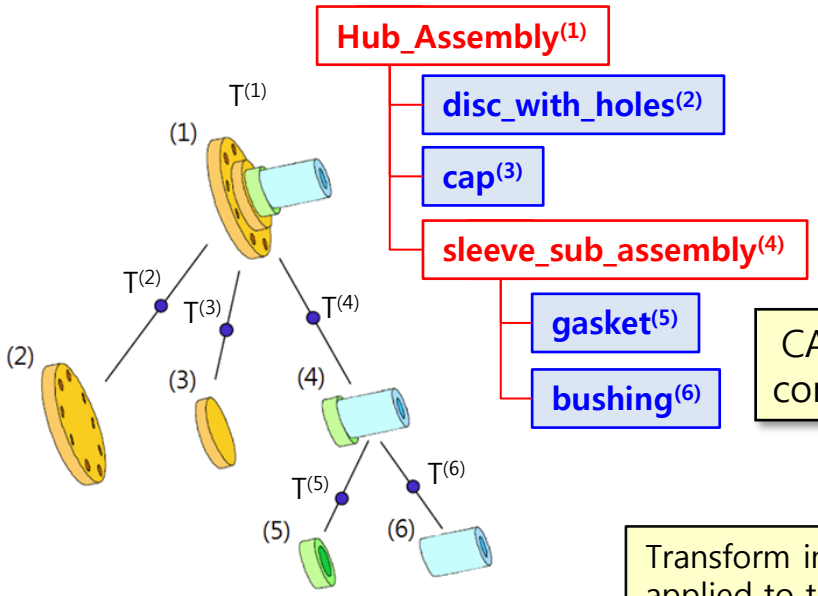
Save as VRML/X3D



Product Structure disappeared!!

Representing a CAD assembly in X3D I

- Product structure : **CADAssembly, CADPart**
- Geometry : **CADFace**



CATIA Hub Assembly
(6 Files)

CAD2X3D conversion

CatiaHubAssembly.X3D

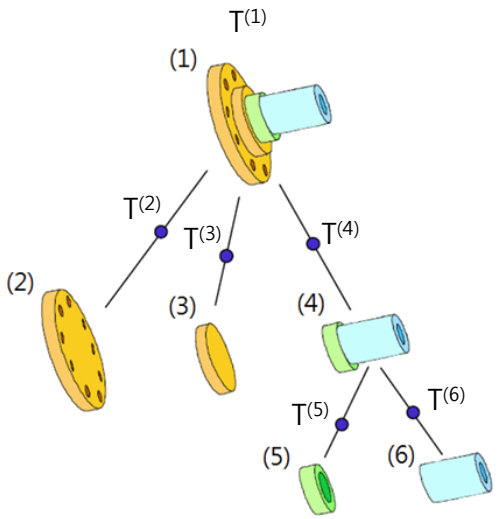
```
<CADAssembly name="Hub_Assembly">
  <CADPart name="disc_with_holes" ...>
    <CADFace> ... </CADFace>
  </CADPart>
  <CADPart name="cap" ...>
    <CADFace> ... </CADFace>
  </CADPart>
  <CADAssembly name="sleeve_sub_assembly">
    <CADPart name="gasket" ...>
      <CADFace> ... </CADFace>
    </CADPart>
    <CADPart name="bushing" ...>
      <CADFace> ... </CADFace>
    </CADPart>
  </CADAssembly>
</CADAssembly>
```

Transform information is applied to the leaf nodes which include geometry information.

ex) $T^{bushing} = T^{(1)} * T^{(4)} * T^{(6)}$

Representing a CAD assembly in X3D II

- Using externally referenced **geometry files(parts) only**
  - One product structure file



CatiaHubAssembly.X3D

Transform
<CADAssembly name="**Hub_Assembly**">

Transform
<CADPart name="**disc_with_holes**" ...>
<CADFace> ... </CADFace>
</CADPart>

Transform
<CADPart name="**cap**" ...>
<CADFace> ... </CADFace>
</CADPart>

Transform
<CADAssembly name="**sleeve_sub_assembly**">

Transform
<CADPart name="**gasket**" ...>
<CADFace> ... </CADFace>
</CADPart>

Transform
<CADPart name="**bushing**" ...>
<CADFace> ... </CADFace>
</CADPart>

</CADAssembly>
</CADAssembly>

Reusable geometry files

CatiaHubDiscWithHoles.x3d

CatiaHubCap.x3d

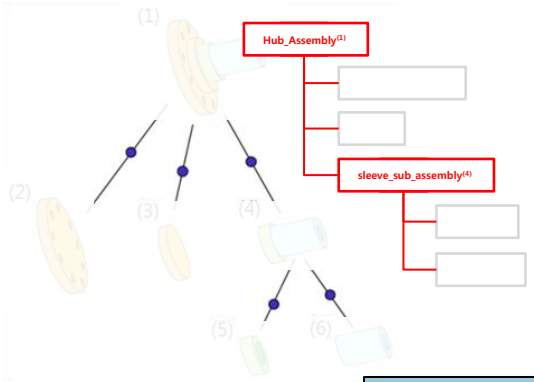
CatiaHubGasket.x3d

CatiaHubBushing.x3d

Example I: CATIA to X3D conversion with product structure conserved

Extraction of product Structure information

Extraction of geometry in multiple files



Mesh reduction and data compression

Integration of product structure and geometry files

Mesh reduction and data compression: Processing geometry data (parts)

VRML File
- Complex scene graph
- High-resolution mesh

Convert VRML into X3D

X3D File
- Complex scene graph
- High-resolution mesh

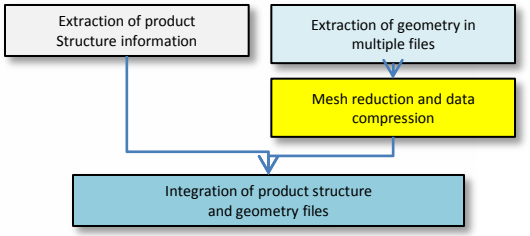
Flatten the scene graph &
Remeshing and simplification

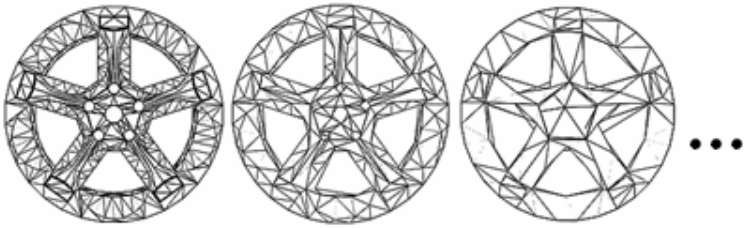
X3D Files
- Simplified scene graph
- Simplified multi-resolution mesh

Remove non-essential node &
Convert X3D into X3DB

X3DB Files
- Simplified scene graph consists of essential node
- Simplified multi-resolution mesh

Faces : 6838





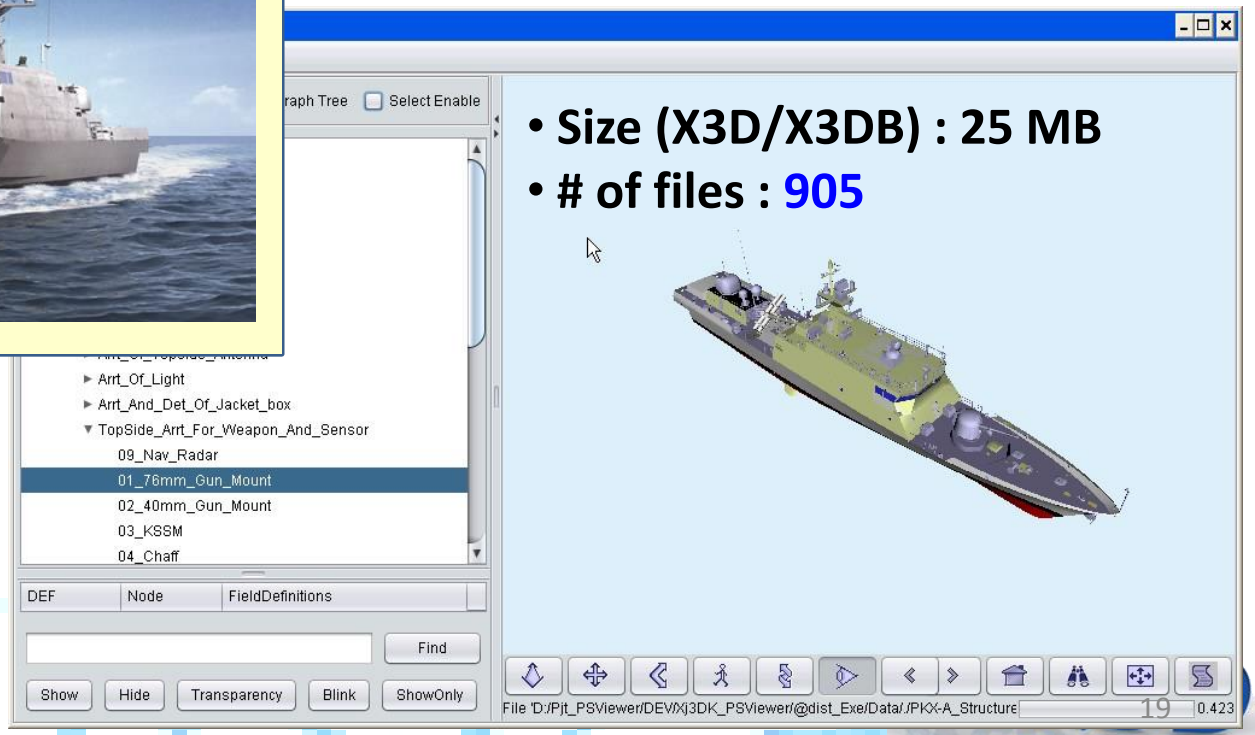
Faces : 3022 / 918 / 500

Result 1

A battle ship
- **Size (CATIA) : 413 MB**
- **# of files : 1023**

cf) 'Save' as a single VRML
=> Size : 385.5 MB

The total number of files decreases as noted earlier in the slide 15.



Result 2

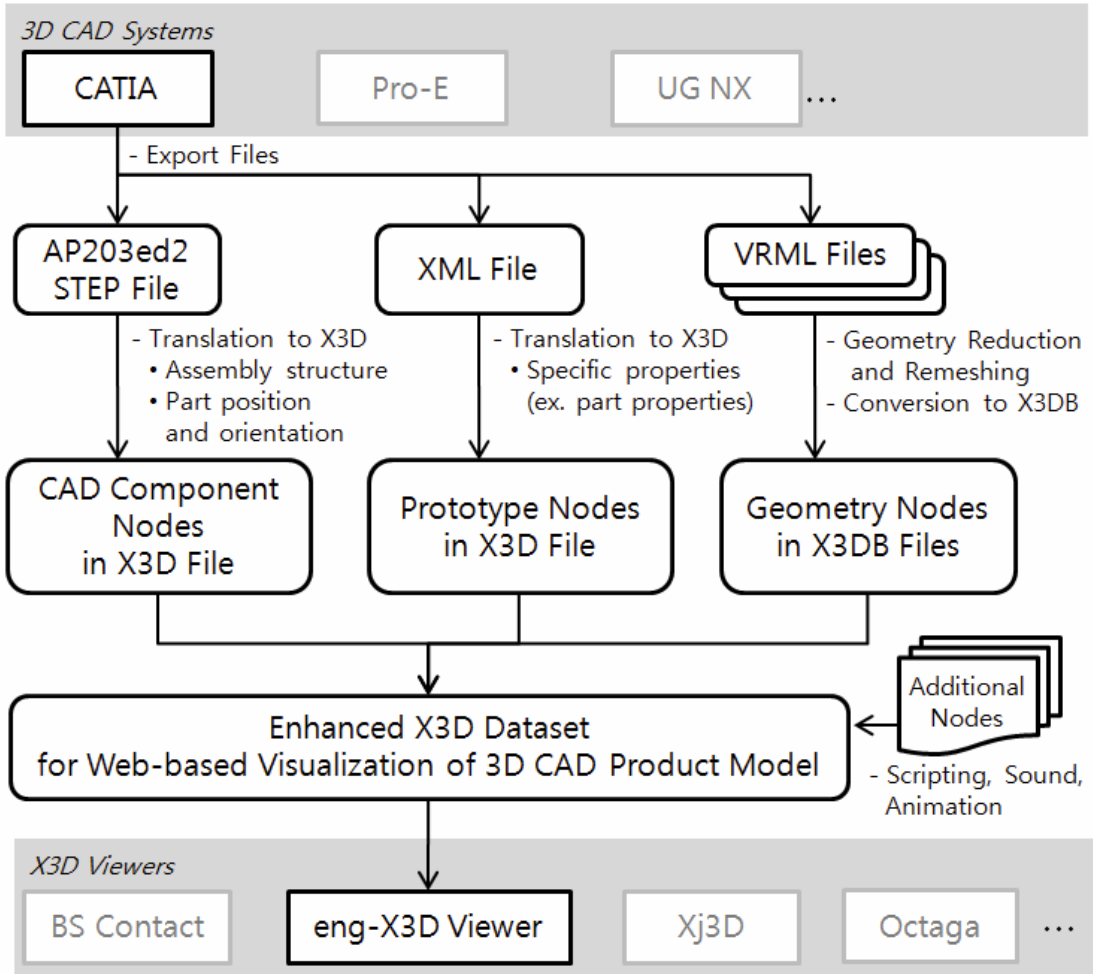
Format	# of files	Size (MB)	Size (%)
VRML's	3890	491	43
VRML's (reduced)	3890	427	38
X3D's	3890	455	40
X3DB's	**3890**	**65**	**6**
3DXML	1	136	12
HOOPS	1	105	9
VRML	1	1,136	**100**
IGES	1	1,934	170
STEP	1	1,287	113

A battle ship

- **Size (CATIA) : 1,154 MB**
- **# of files : 4054**

Example II: STEP-to-X3D conversion of CAD assembly

- Extraction of Product Structure information using STEP



CAD-to-X3D Conversion Process:

Guimok Cho, "Translation of 3D CAD Data to X3D Dataset Maintaining Product Structure for Web-based Visualization", Master Thesis, Chungnam National Univ., Feb. 2011.

CAD Working Group Progress

- X3D Binary Encoding [ISO/IEC 19776-3.2:2011] based on FastInfoset
- EXI in the mix for next iteration
- X3DOM support
  - CAD Component implemented
  - Binary Geometry container
  - Assembly tree browser

Fraunhofer IGD

- Johannes Behr, demonstrating X3DOM and Instant3DHub:
  - Massive models into X3DOM / html5 (tens of millions of polygons, JTOpen models, etc)
  - Assembly/Part browsers & configurators in X3DOM / html5

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Call for Compression technologies (Open)

- Web3D C released an open call for contributions of royalty-free compression technologies
- Work in X3D Binary has helped defined the problem
- **Scope includes: geometry-specific schemes, volumetric data, streaming shapes and animations**
- Available at:

http://www.web3d.org/realtime-3d/working-groups/x3d/compressed-binary/x3d-compressed-binary-encoding-call-contributions

Parametric History

- History of constructive solid geometry elements and operations
- Generative steps can reconstruct and then tessellate the final CAD product state
- Great compression approach that eliminates the need for the storage and transport of explicit vertices!

Web3D 2013

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Review: X3D Compressed Binary Encoding (CBE)

Call for Contributions Workshop

Web3D 2013 Conference

San Sebastian Spain

19 June 2013

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Workshop objective

- 3D graphics compression technology continues to steadily improve. The Web3D Consortium has issued an X3D Compressed
- Binary Encoding Call for Contributions
- We are looking for component technologies that can help improve the current X3D Compressed Binary Encoding Standard
- Geometric or information compression technologies are of particular interest.
- Our goal is to produce a revision in 2013

Workshop agenda

- Introductions
- Project summary and progress updates
  - Existing Compression for X3D and VRML97
  - Polygon Reduction and Geometric Compression
  - Data-Centric Binary Encodings, Network Streaming
  - X3D Implementations and Benchmark Testing
- Quicklooks at new candidate technologies, both proposed and presented at conference
- Next steps, group plans, and timeline for continues progress

Workshop speakers 1

- Web3D Strategies and Liaisons
  - Nicholas Polys and Anita Havele
- X3D Compressed Binary Encoding (CBE)
  - Don Brutzman
- MPEG4 Capabilities and Plans
  - Marius Preda
- Khronos Activities, glTF Transmission Format
  - Neil Trevett

Workshop speakers 2

- MPEG4 Capabilities and Plans
  - Marius Preda
- Khronos Activities, glTF Transmission Format
  - Neil Trevett
- Multi-View X3D Binary Transmission
  - Peter Schickel
- Fraunhofer Technical Capabilities and Plans
  - Johannes Behr

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Workshop Focus

Call for Contributions: X3D Compressed Binary Encoding (CBE)

X3D Compressed Binary Encoding Call For Contributions

Overview

Motivation Merits of the X3D Graphics standard include broad generality for many 3D applications. Lots of work has already been accomplished using the X3D Compressed Binary Encoding (CBE) standard. X3D has numerous coherent approaches already available that meet author requirements for a general Web-based 3D transmission format. We are working to demonstrate and standardize multiple interoperable improvements in 2013.

Approach We are looking for component technologies that can help improve X3D CBE standard. Our goal is to produce a revision in 2013. This standard has two parts:

- 3D graphics compression technology continues to improve steadily. The Web3D Consortium wants to enable progress to interoperate compatibly.
- World Wide Web Consortium (W3C) adoption of the Efficient XML Interchange (EXI) Recommendation makes the possibility of a new X3D encoding appealing.
- Additional technical approaches that might apply to all X3D encodings (something like a 3dTransmissionFormat node) are also of interest

We want to emphasize that each individual contribution is not expected to provide an overall comprehensive solution to all Web-compression challenges. Rather, the X3D Working Group is looking for additional technical capabilities that have the potential to work well together within our proven framework. If your capability might fix into this rich mix, please let us know!

Compressed binary encoding

Two types of compression for .x3db encoding

- XML-centric ISO Fast Infoset
- Geometry-centric for coplanar polygons, quantization of points, colors & normals, etc.

Java3D (Deering) algorithms are default for geometry compression

Alternate geometry compression is allowed... however better baselines are possible

Implementations: XIOT, Xj3D, Instant Reality

X3D CBE Call for Contributions 1

- Prior work is essential, useful and relevant.
  - First-generation X3D Compressed Binary Encoding Request For Proposals (RFP) from August 2003 illustrates this steady evolution.
  - The first-generation process successfully created the current X3D CBE International Standard.
  - This provides a flexible framework for further contributions

X3D CBE Call for Contributions 2

- All submitters must meet certain requirements prior to consideration.
  - Primary: Web3D Intellectual Property Rights (IPR) protections for X3D specification.
  - Patented technologies can be considered, but only when eventual use will be royalty free for X3D use (if eventually accepted).
  - Submitters can restrict access to patented submissions during member-only working group review, if desired.

CBE Requirements (from 2003)

- X3D Interoperability
- Interoperability
- Multiple, separable data types
- Processing performance
- Ease of implementation
- Retrieval, streaming
- Authorability
- Compression
- Security
- Bundling
- Intellectual Property Rights (IPR)

Existing Compression Capabilities for X3D

- Solid foundation exists to continue progress
  - Approved ISO standard Compressed Binary Encoding (CBE) for X3D
  - Based on ISO Fast Infoset (FI) for XML compression, Java3D geometric compression
  - Optional, alternative gzip compression and MIME Type definitions for X3D.
- XML encoding (.x3dz/.x3d.gz), ClassicVRML encoding (.x3dvz/.x3dv.gz) and Compressed Binary encoding (.x3db.gz) file extensions.

Existing Compression Capabilities for VRML97

- Optional, alternative gzip compression
  - Original compression technique of applying gzip to .wrl compressed VRML97 files was called .wrz.
  - This emerged as a common practice when gzip was originally used. No formal specification of .wrz or corresponding mime type was produced.
  - Occasionally authors might also gzip .wrl files while retaining the .wrl file extension.

Critical areas of interest

- Polygon Reduction & Geometric Compression
- Data-Centric Binary Encodings
- Network Streaming
- X3D Implementations & Benchmark Testing
- Looking Ahead – Next Steps

X3D Binary Capabilities & Plans

- X3D Binary Compression Capabilities & Plans updates are maintained online.
- X3D solutions currently support a wide range of author requirements.
- Further improvements and standards-based partnerships are possible for achieving broader industry interoperability.
- We seek next-generation improvements that further advance the technical capabilities of the X3D Graphics International Standard.

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Presentation

Web3D Consortium Strategies

Nicholas Polys, Web3D President

Anita Havele, Executive Director

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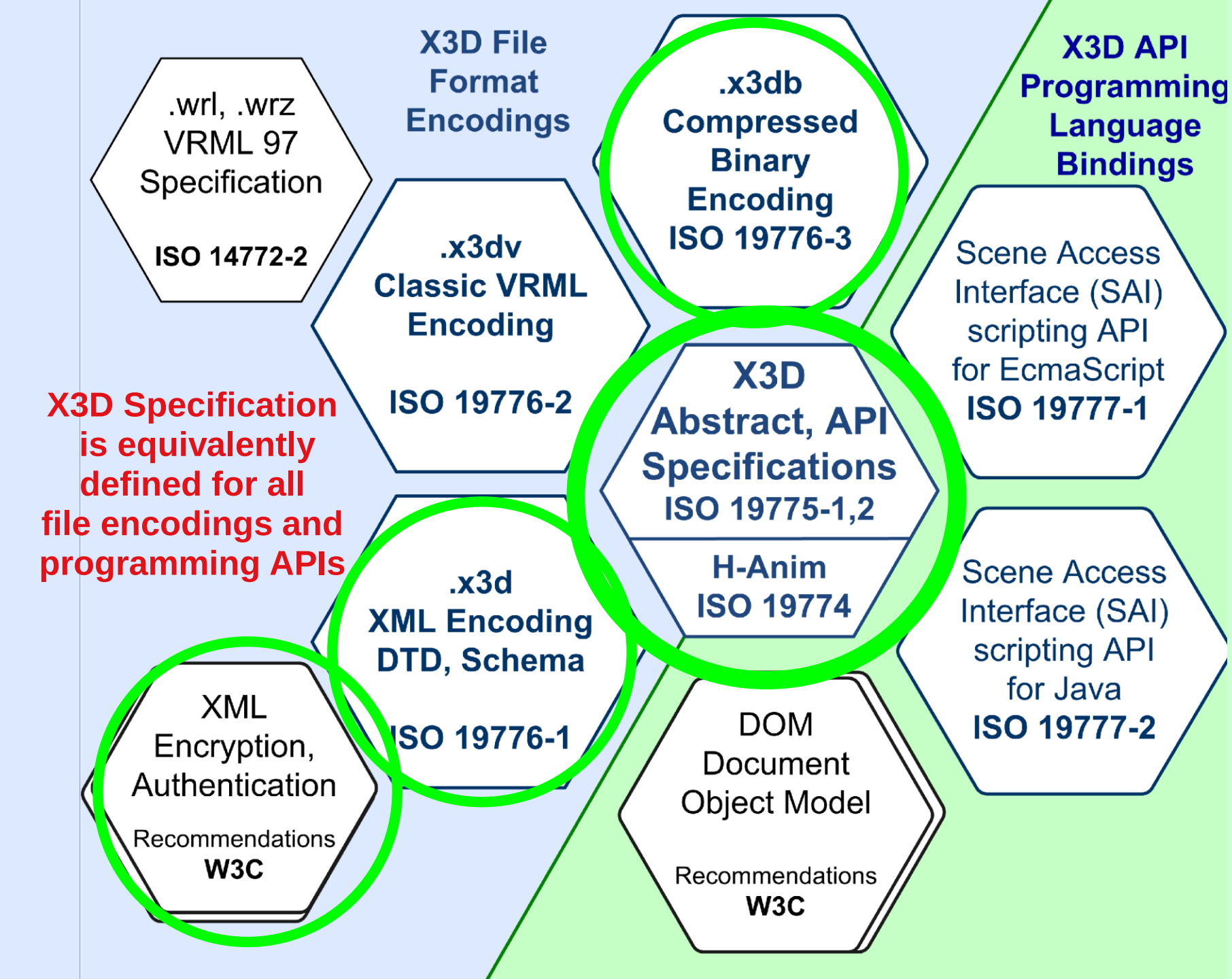
Concepts

X3D Compressed Binary Encoding (CBE)

X3D CBE Topics

- ✔ X3D CBE Call for Contributions
- X3D CBE Specification quicklook
  - Composition framework matches all X3D encodings
  - Node and field compressors
  - CAD Distillation Filters: repeated refinement as X3D
- Geometric compression algorithms
  - Many, we are looking for best combination
- Information/data compression algorithms
  - Fast Infoset (FI), Efficient XML Interchange (EXI)
  - XML security: encryption, digital signature


X3D File Format Encodings
X3D API Programming Language Bindings
.wrl, .wrz
VRML 97
Specification
ISO 14772-2
.x3db
Compressed
Binary
Encoding
ISO 19776-3
.x3dv
Classic VRML
Encoding
ISO 19776-2
Scene Access
Interface (SAI)
scripting API
for EcmaScript
ISO 19777-1
X3D Specification is equivalently defined for all file encodings and programming APIs
X3D
Abstract, API
Specifications
ISO 19775-1,2
H-Anim
ISO 19774
.x3d
XML Encoding
DTD, Schema
ISO 19776-1
Scene Access
Interface (SAI)
scripting API
for Java
ISO 19777-2
XML
Encryption,
Authentication
Recommendations
W3C
DOM
Document
Object Model
Recommendations
W3C

X3D Compressed Binary Encoding

Matched functional capability of X3D encodings

- XML `.x3d`, ClassicVRML `.x3dv`, CBE `.x3db`

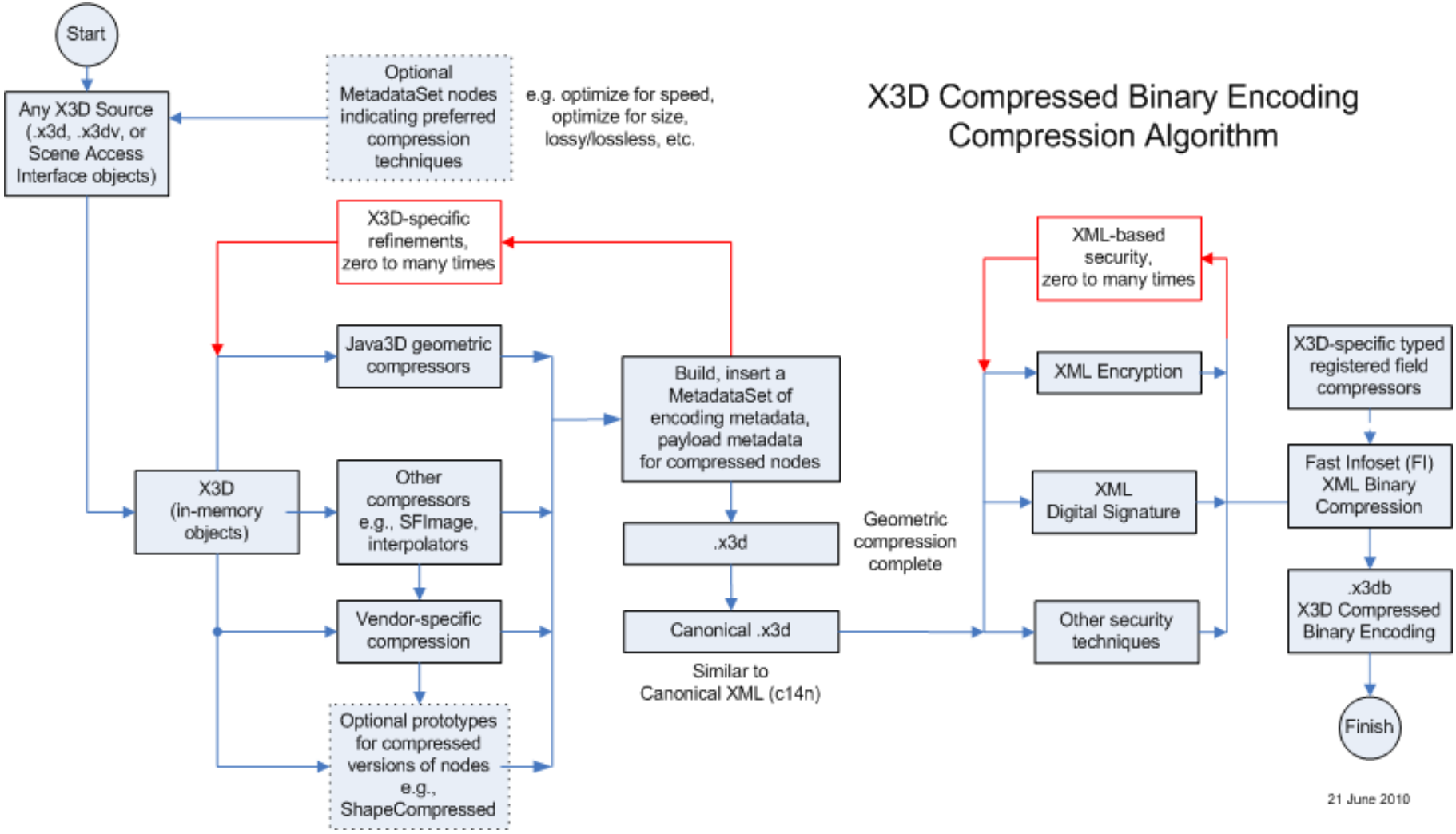
Combines two types of compression

- Geometric compression: polygon reduction, flattening/merging, representation techniques using Java3D compression (Deering algorithms)
- Information-theoretic compression using XML-based ISO standard Fast Infoset (FI)

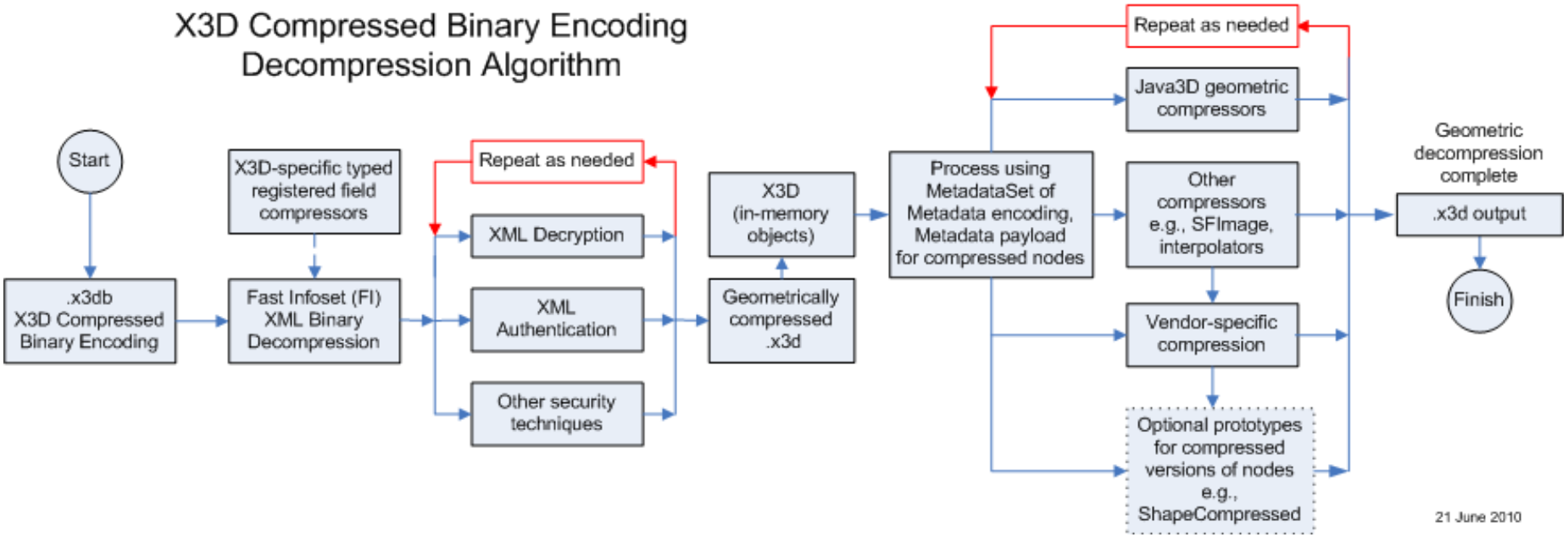
Web3D Consortium, ISO approval late 2010

- Now aligning three independent implementations
- Considering W3C Efficient XML Interchange (EXI) as likely future addition to Fast Infoset

X3D compression algorithm



X3D decompression algorithm



.x3db CBE Implementations

XIOT : X3D Input/Output Tool library

- http://forge.collaviz.org/community/xiot
- Open source C++
- Collaviz Remote Collaborative Visualizer project

Xj3D toolkit

- http://www.xj3d.org, http://xj3d.org/tutorials/filters.html
- Open source Java

Other X3D browsers sometimes experiment

Improved online test suite needed

Efficient XML Interchange (EXI)

W3C XML Binary Characterization

- Established common needs among hard use cases

W3C EXI Recommendation: approved

- http://www.w3.org/XML/EXI

Technical approach: aligns well with X3D XML

- Better compaction + decompression speedup
- Type aware, schema-informed or not
- Adaptive tokenization, compression tables
- Can stabilize on a document type or further refine based on statistical analysis of corpus

Example: EXI compression

THE MOVES INSTITUTE
NAVAL POSTGRADUATE SCHOOL

LT Sheldon L. Snyder

EFFICIENT XML INTERCHANGE (EXI) COMPRESSION AND PERFORMANCE BENEFITS: DEVELOPMENT, IMPLEMENTATION AND EVALUATION

<MOTIVATION>

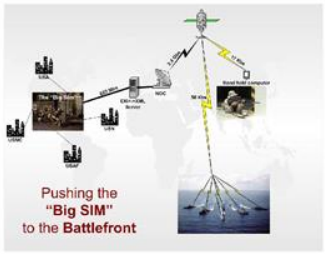
Compact & Efficient XML

Better Compression than other Techniques with Binary Data Binding

http:// http://exificient.sourceforge.net/

Bandwidth Maximization / Deepening The Web

Extends XML use to Low-bandwidth, High- Volume Domains



Standardization and Interoperability

World Wide Web Consortium Member Created

"Best of Breed Solution"

W3C Ubiquitous Web domain

Application To DoD

- DoD is Heavily Invested in XML
- DoD Files are often Numerically Intensive
- DoD Files are often Very Large
- Next Generation of Devices Supported
- DoD Tactical Networks are Bandwidth Limited

I CONSORTIUM

<PROBLEM STATEMENT>

Network Edge Devices Unable To Process Native XML Format (Battery, CPU, Bandwidth)

- XML is VERBOSE
- XML is Text Only = Computationally Expensive
  - String to Numeric Conversions
  - Memory Intensive
  - Power Demanding

Net-Centric Warfare Requires XML

- Every Sailor and Soldier is a Sensor (Low Bandwidth mobile edge)
- System of Systems Interoperability (the DoD Information Warfare vision)

Why Not GZip

- Because it Doesn't Address Processing Efficiencies
- Better Compression can be Achieved for XML

<SOLUTION>

Standardized Compact And Efficient Binary Xml Format: Efficient XML Interchange (EXI)

- Both commercial and open-source implementations available

efficient XML

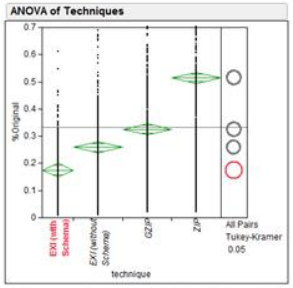
http://www.agiledelta.com/product_efx.html

W3C Endorsed

- Up to Hundreds of Times Smaller, Faster than Native XML
- 100% Compatible with XML, Including Schema-based, Free Form or Multiple-Namespace Hybrid XML

<CONCLUSIONS>

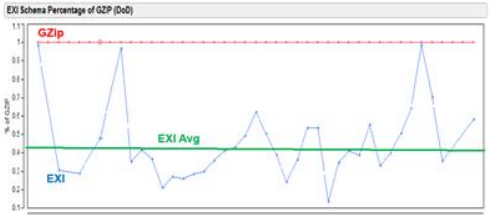
EXI Deliver Statistically Significant XML Improvements



773 XML examples compared in the W3C EXI Test Corpus hosted at NPS

Analysis of Common Compression Techniques at 95% alpha factor
EXI (schema and schemaless) deliver statistically smaller files

EXI has DoD Specific Expectation of Doubling Bandwidth Potential



EXI compared to GZip (standard compression) in the long run average is 42% of GZip = 116% increase in bandwidth potential for DoD

Passes The Litmus Test Of Technology Development

- **More -** Deeper network penetration with all the benefits of XML
- **Better –** Usage with what you already have transparently
- **Faster –** Information exchange

<!-- FURTHER INFORMATION -->

Contacts:
Don Brutzman, brutzman@nps.navy.mil, 831.656.2149
Sheldon L. Snyder, slsnyder@nps.edu

EXI implementations

http://www.w3.org/XML/EXI/#implementations

- Exificient, Siemens AG, open source
- Efficient XML, AgileDelta, commercial
- EXIP, Luleå University, open source
- OpenEXI, Fujitsu and NPS, open source

Web Security standards are compatible

X3D's XML and Compressed Binary encodings allow use of W3C's Security recommendations

- XML Encryption
- XML Digital Signature (for authentication)

demonstrated in NPS thesis, X3D Basic examples, X3D-Edit

- XML Public key infrastructure

Security based on Web standards lets authors and companies protect their 3D model assets

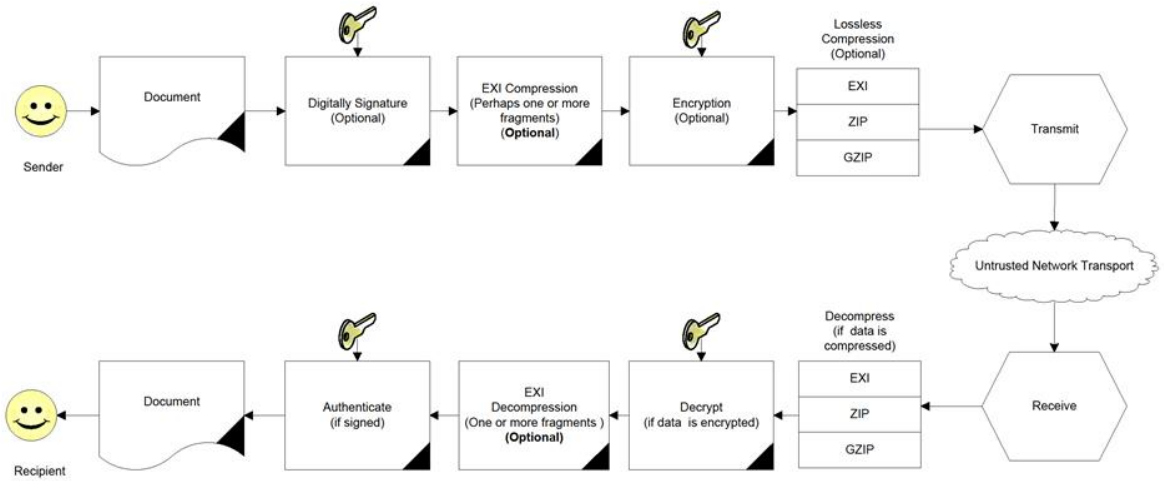
- Rather than "security through obscurity"
- X3D-Edit support uses Apache libraries

Example: digital signature, authentication

THE MOVES INSTITUTE
NAVAL POSTGRADUATE SCHOOL
LCDR Jeffrey S. Williams Sr., USN

DOCUMENT-BASED MESSAGE-CENTRIC SECURITY USING XML AUTHENTICATION AND ENCRYPTION FOR COALITION AND INTERAGENCY OPERATIONS

Master's Thesis, Naval Postgraduate School, Monterey California USA, September 2009



MOTIVATION

Diverse often-changing members of multinational or multiagency coalitions cannot share sensitive data over shared networks because their security policies always differ widely. Document-based security via international Web-based standards is possible using XML Digital Signature, XML Encryption, and Efficient XML Interchange (EXI) compression. Network independence provides a globally interoperable means for secure exchange of messages among trusted partners.

XML Digital Signature provides message integrity, sender authentication, and sender non-repudiation of the message fragment or the document by default. XML Encryption provides confidentiality.

The appropriate application of Web-based XML security provides discretionary access control (DAC) to support the secure dynamic exchange of information, even when used between entities employing dissimilar systems via an insecure transport. The strength of the encryption is simply dependent upon the encryption algorithm chosen.

Common use of international standards promotes trust between organizations because each participant is responsible for choosing and supporting independent sets of tools based upon consistent standards.

RESEARCH QUESTIONS

This work addresses the following questions.

1. Can an XML document that includes XML Encryption and XML Signature Elements provide adequate security commensurate with the security level of the data contained therein?
2. Do the standardized XML Signature, XML Encryption and authentication recommendations satisfy Information Assurance (IA) requirements within the construct of Discretionary Access Control (DAC) while transmitting or sharing data, including different gradients within unclassified classification levels for which each group of users are authorized to view?
3. Can an XML document or message fragment be restricted to showing the appropriate level of allowed data access by automatically checking the credential store local to the machine from which it is being accessed?
4. Do these techniques further apply when used in Web Services and real-time XML chat messaging, as well as X3D visualization and simulation streaming?
5. Can document-level XML security be compatibly applied within both current and projected restrictions and best practices governing coalition and multiagency operations?

METHOD

Protocol Analysis

Evaluation of protocols, ordering, and methodology is based upon W3C Recommendations for XML security to provide adequate protection for unclassified documents.

Interoperability Testing

Testing was conducted for encrypted and signed XML messages across multiple platforms to ascertain its validity using a variety of XML languages. Document exchange included Linux, Windows and Mac OS X operating systems using Internet Explorer, Firefox, and Safari web browsers.

Exemplar

A practical usage of XML Digital Signature, XML Encryption, Compression and XML Authentication is demonstrated within exemplar scenarios and use cases for multinational and multiagency operations.

An open-source document authoring tool is online at https://savage.nps.edu/X3D-Edit with examples at http://web3d.org/x3d/content/examples/Basic/Security

CONCLUSIONS

XML security using XML Digital Signature, XML Encryption, EXI compression and XML authentication provides a viable international solution for securely exchanging unclassified information. This method can work dynamically across an insecure transport between joint, coalition, multinational and multiagency organizations. This work can be applied across a variety of transport protocols including http/https, ssh/sftp, web services and XMPP chat sessions.

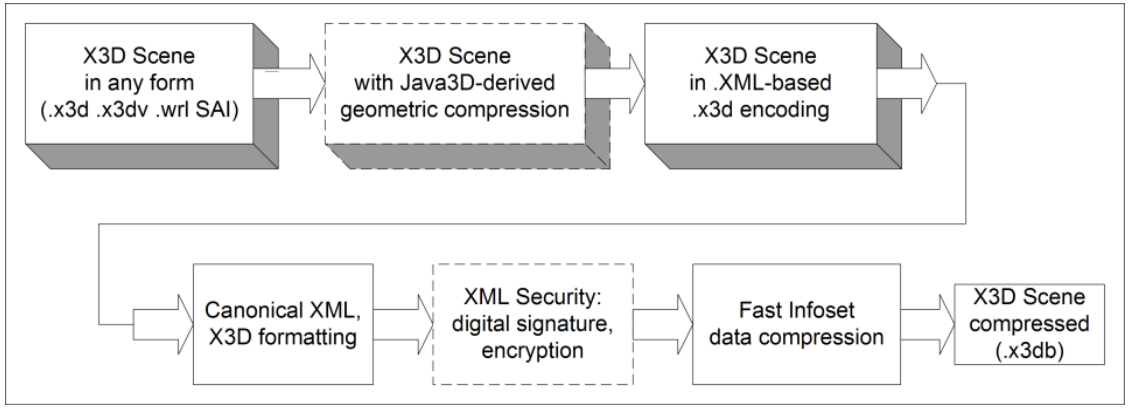
Contact Information

Don Brutzman, PhD. Thesis Advisor
brutzman@nps.navy.mil

Don McGregor Second Reader
mcgredo@nps.edu

Jeffrey S. Williams Information Professional
jeffrey.williams2@navy.mil

X3D compressed binary algorithm and XML Security



X3D compressed binary uses Canonical X3D form

- Strict formatting rules so that files with identical format can be shown to match

Canonical form enables use of XML Security

- XML Encryption
- XML Digital Signature (for author authentication)

Demanding use case: CAD

Open Standards for Real-Time 3D Communication

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Computer Aided Design (CAD)

Executive Summary:

The X3D CAD Working Group is now in its third generation of development effort. We are developing and demonstrating best practices for exporting CAD models to X3D for Web applications.

Billions of dollars are invested in CAD and technical product information. But 3D data created with CAD applications, is difficult to share with other users across the enterprise. Integrating 3D data, such as CAD engineering files, into other applications for sales & marketing or training is time consuming and difficult.

The open standards X3D CAD initiative will let customers access and repurpose complex 3D and technical data and seamlessly integrate it into other common desktop applications across the enterprise. Professionals outside of CAD and engineering will be able to access this graphical data, including animation, materials and textures, to increase productivity, cut costs and generate new revenue streams. This increases the value of the CAD data and reduces costs in other areas. Applications include customer visualization, design communication, training, technical documentation, sales and marketing, and customer support.

The CAD3D Working Group has a defined a file format and data transfer process. The format, CAD Distillation Format (CDF), enables translation of CAD data to an open format for publishing and interactive media. The process includes an open framework pipeline that incorporates tools for decimation of surfaces to constructs that are more common in the non-CAD environments.

web 3D CONSORT

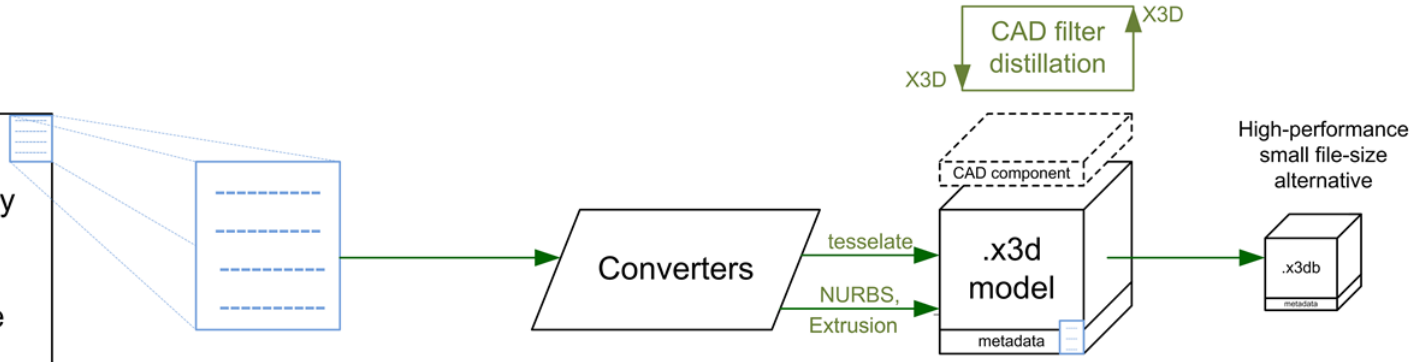
Website link

X3D Conversion Process for CAD Models

18 June 2013

CAD model issues

- Large file sizes, unwieldy
- Proprietary formats
- “Locked in” tool chain, changing and expensive
- Licensing renewal often needed over long term
- Company building CAD tool may go out of business or get acquired and shut down by another
- Engineering max detail, specialized metadata
- Specialized viewers, plugins
- Hard to convert
- Hard to reuse, compose, integrate in applications
- Original purchasers of model data usually unable to reuse what they own



Macro Parametric History

- List of author actions, similar to Do/Undo list
- Controlled vocabulary matching ISO STEP
- About 50 operators
- Constructive solid geometry (CSG)
- Build meshes. surfaces via CAD geometry engine
- Interoperability despite differences in CAD tools

Convert history log, not engineering details

- Retain CAD model product structure
- Use CAD engine or API (e.g. ACIS) to produce conversion
- Compute geometry by converting CSG operators to NURBS
- Polygonal mesh tessellation

Deployable, reusable model

- Can include metadata of interest
- Signable and encryptable via XML Security

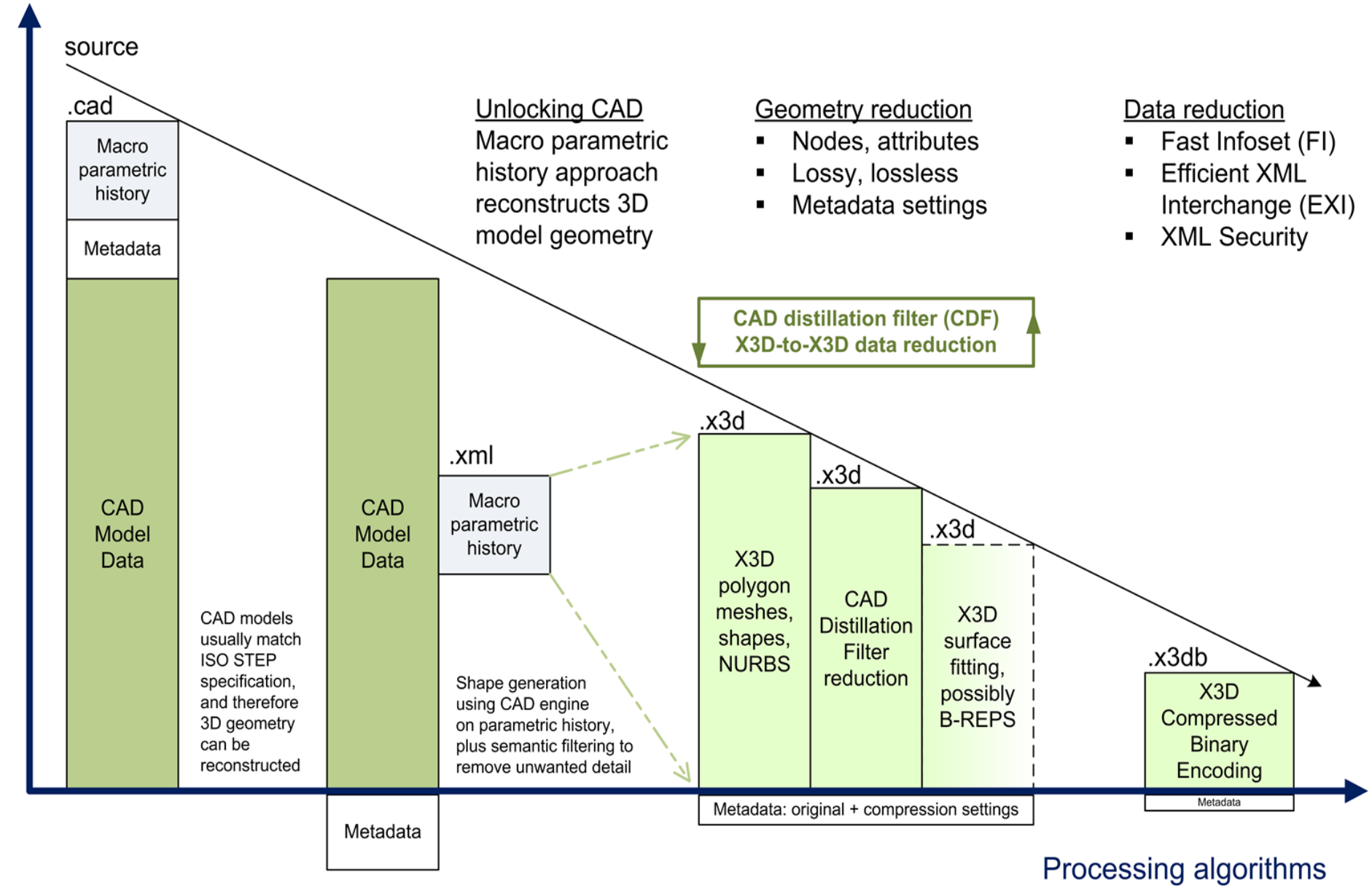
X3D Compressed Binary Encoding

- Geometric data reduction
- Information data reduction
- Secure

Widely deployable for many purposes

X3D CAD Model Data Reduction

18 June 2013



X3D “next specification” strategies

- X3D version 3.3: complete
- X3D version 3.4 plans
  - Evolutionary improvements, proven X3D architecture
  - Working groups defining future goals, requirements
- X3D version 4.0 plans
  - Development efforts are considering potentially major changes, additions to the baseline X3D architecture
    - Adapt, show maximum practical backward compatibility
  - Major technologies under consideration:
    - HTML5/Declarative 3D/X3DOM
    - Augmented Reality Continuum (ARC)

Discussion is productive

- Please contact us or respond publicly if additional technologies need consideration
- X3D futures planning is
  - Topic of 1st Wednesday monthly teleconference
  - Web3D Consortium member-decided activity
- All feedback is welcome
  - Sooner or later, all results get public review before Web3D approval and ISO review

Thanks for considering the possibilities!

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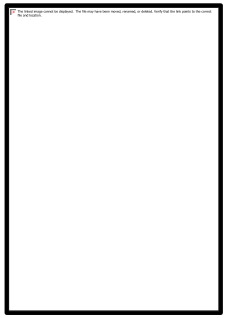
References

References 1



X3D: Extensible 3D Graphics for Web Authors by Don Brutzman and Leonard Daly, Morgan Kaufmann Publishers, April 2007, 468 pages.

- Chapter 3, Grouping Nodes
- http://x3dGraphics.com
- http://x3dgraphics.com/examples/X3dForWebAuthors

X3D Resources

- http://www.web3d.org/x3d/content/examples/X3dResources.html

References 2

X3D-Edit Authoring Tool

- https://savage.nps.edu/X3D-Edit

X3D Scene Authoring Hints

- http://x3dgraphics.com/examples/X3dSceneAuthoringHints.html

X3D Graphics Specification

- http://www.web3d.org/x3d/specifications
- Also available as help pages within X3D-Edit

Contact

Don Brutzman

brutzman@nps.edu

http://faculty.nps.edu/brutzman

Code USW/Br, Naval Postgraduate School
Monterey California 93943-5000 USA
1.831.656.2149 voice

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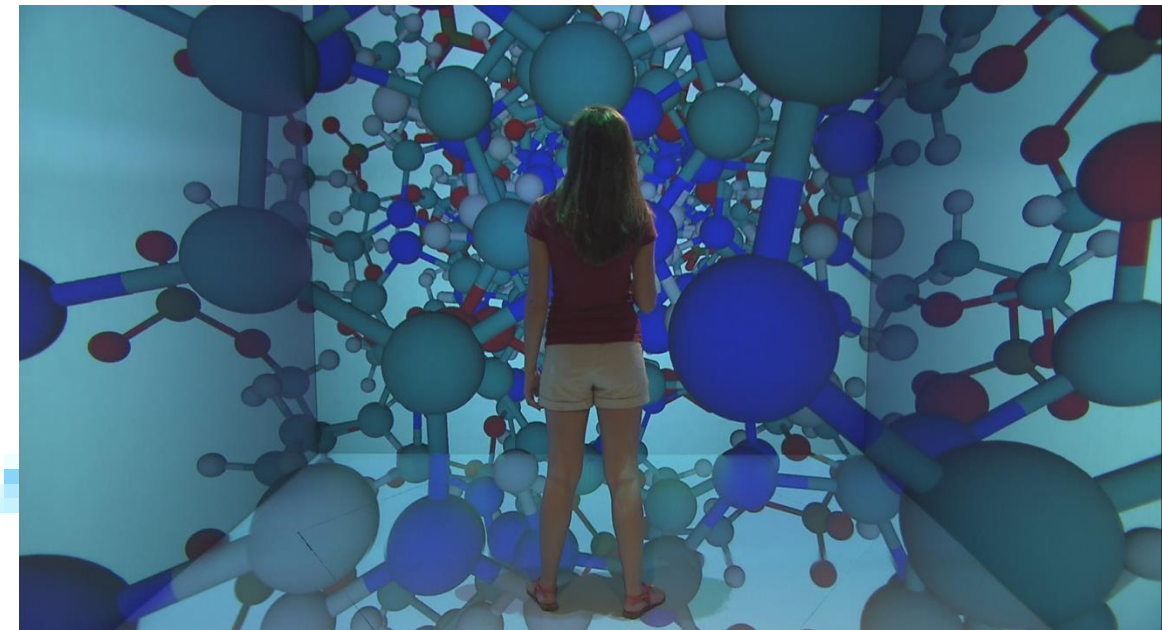

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