X3D Graphics Support for Computer Aided Design (CAD)

"In Theory: theory and practice are the same.
In Practice: they're not."
– Yogi Berra

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Contents

Chapter Overview

Overview

CAD models tend to have complex geometry and metadata, captured in proprietary formats

Long-running efforts to consistently expose heavyweight CAD models as lightweight X3D

- CAD structure and OrthoViewpoint (X3D v3.1)
- Boundary Representations (B-REPS) for geometry
- Parametric History to unlock CAD models as X3D

Various open-source tools, codebases available

- Limited by single X3D browser, diverse tool chain
- Important work continues

CAD Working Group History, first phase 2003-2004:

scene structure

History: first phase 2003-2004

Established CAD X3D Working Group

- Closed to members, considered patented work

Determined common use cases:

- Digital content creation (DCC) creates interoperable X3D web-based models from CAD diagrams
- Architecture Engineering Construction (AEC)
- Interactive Engineering Technical Manual (IETM)

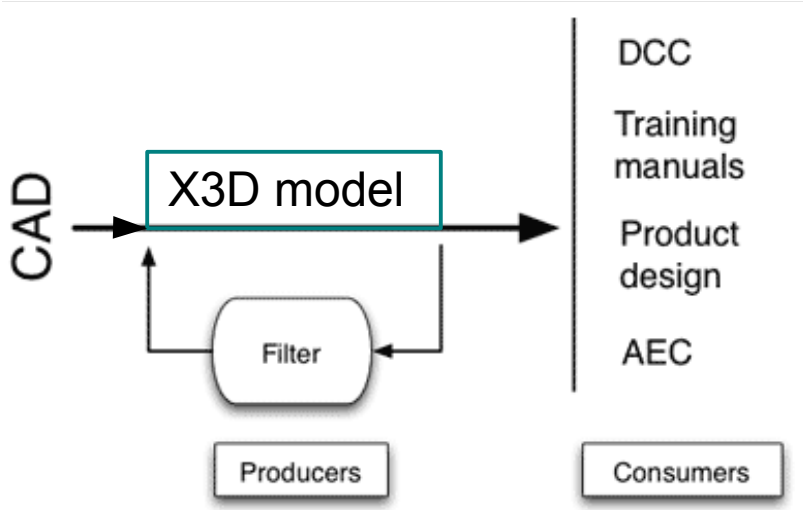
Defined X3D basic scene-graph organizational structure for containing CAD models

- Face, Part, Assembly, Layer

CAD Distillation Filter (CDF) concept

CAD Distillation Filter (CDF) is process that provides successive filtering to reduce and refine a single X3D model

- Each filter can be simple and do one thing well
- X3D in, X3D out. Not a separate format.
- Applicable to wide range of input scenes



CAD Geometry Component

Levels 1, 2 defined as part of X3D v3.1

Level 1. Additional geometry support:

- IndexedQuadSet, QuadSet

Level 2. Structure, viewing

- X3DProductStructureChildNode nodes: CADAssembly, CADFace, CADLayer, CADPart
- OrthoViewpoint, ViewpointGroup

Extensible 3D (X3D)
Part 1: Architecture and base components

32 CAD geometry component

32.1 Introduction

32.1.1 Name

The name of this component is "CADGeometry". This name shall be used when referring to this component in the COMPONENT statement (see 7.2.5.4 Component statement).

32.1.2 Overview

This clause describes the CADGeometry component of this part of ISO/IEC 19775. This includes how 3D geometry is specified and what shapes are available. Table 32.1 provides links to the major topics in this clause.

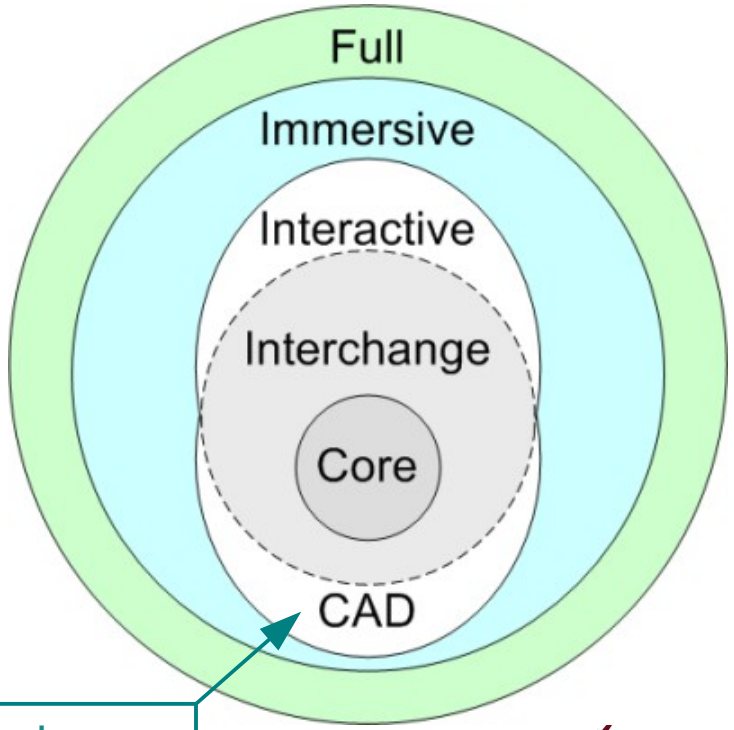
Table 32.1 — Topics

Profiles cover common use cases

Profiles are a collection of components matching common levels of complexity

Profiles are X3D subsets

- Collection of X3D nodes for for author's palette
- *Interchange* suitable for simple geometry conversion
- *Interactive* adds simple user interactivity (clicking etc.)
- *Immersive* matches VRML97, plus a bit more
- *Full* profile includes all nodes



CAD Interchange Profile

Also defined full set of nodes needed for CAD

- Allows lightweight support by tools and browsers
- Improve scene portability and interoperability

Table H.2 — Components and levels

Component	Level	Reference
Core	1	7.5 Support levels
Networking	1	9.5 Support levels
Grouping	1	10.5 Support levels
Rendering	4	11.5 Support levels
Shape	2	12.5 Support levels
Lighting	1	17.5 Support levels
Texturing	2	18.5 Support levels
Navigation	2	23.4 Support levels
Shaders	1	31.5 Support levels
CADGeometry	2	32.5 Support levels

Extensible 3D (X3D)
Part 1: Architecture and base components

Annex H

(normative)

CADInterchange profile

H.1 General

This annex defines the X3D components that comprise the CADInterchange profile. This annex includes not only the nodes that shall be supported but also which fields in the supported nodes may be ignored.

This profile is targeted towards:

- Distillation of computer-aided design (CAD) data to downstream applications.
- Appropriately supporting Geometry and Appearance capabilities data for CAD.

H.2 Topics

Table H.1 provides links to the major topics in this annex.

Support for CAD filters, decimation

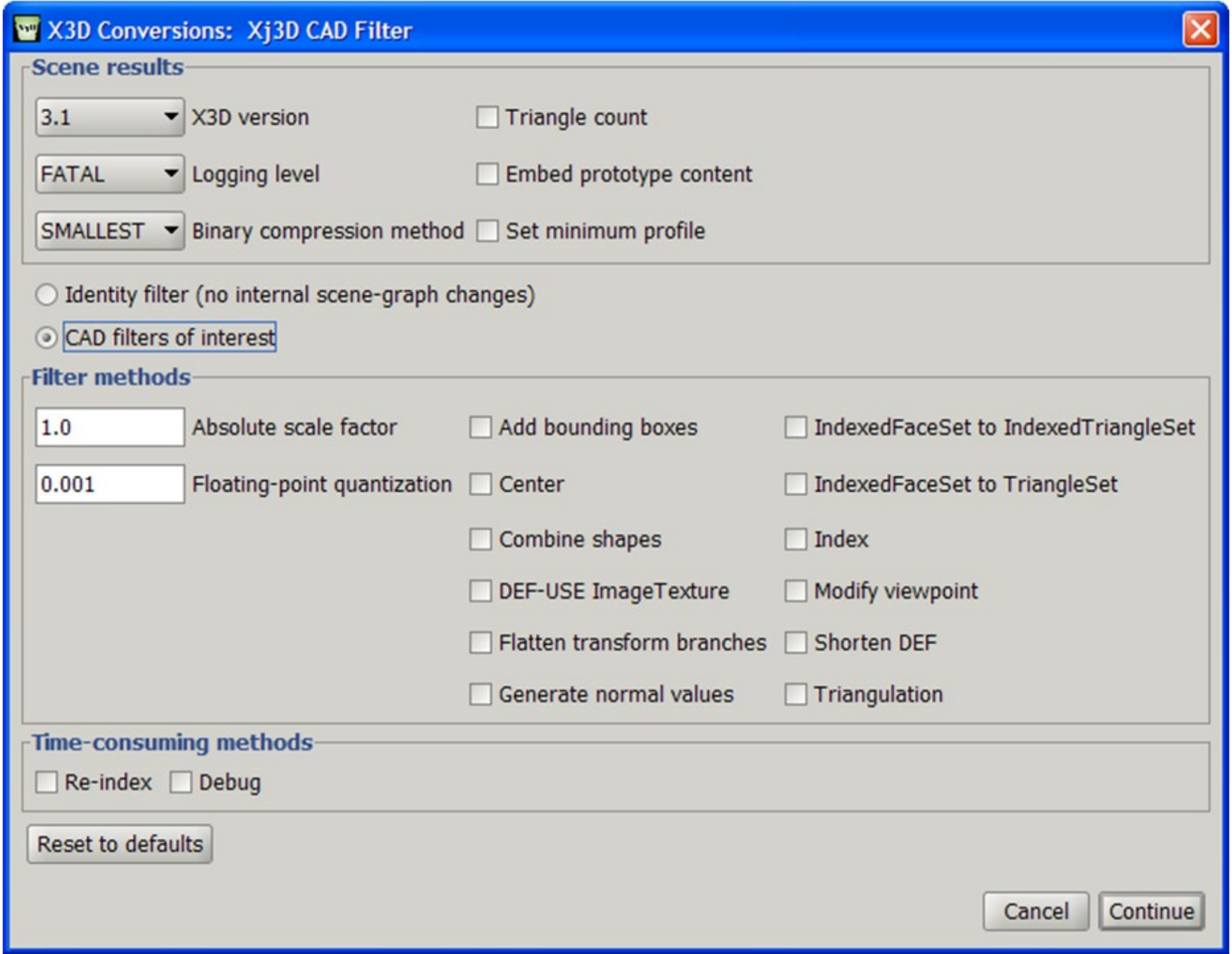
Xj3D supports multiple CAD filter capabilities for geometry simplification and profile reduction

- Can invoke via command line or build script

X3D-Edit authoring tool exposes these filters via user interface

Other tools also exist, may need to be adapted for X3D use. Example:

- Meshlab http://meshlab.sourceforge.net


X3D Conversions: Xj3D CAD Filter
Scene results
3.1
X3D version
Triangle count
FATAL
Logging level
Embed prototype content
SMALLEST
Binary compression method
Set minimum profile
Identity filter (no internal scene-graph changes)
CAD filters of interest
Filter methods
1.0
Absolute scale factor
Add bounding boxes
IndexedFaceSet to IndexedTriangleSet
0.001
Floating-point quantization
Center
IndexedFaceSet to TriangleSet
Combine shapes
Index
DEF-USE ImageTexture
Modify viewpoint
Flatten transform branches
Shorten DEF
Generate normal values
Triangulation
Time-consuming methods
Re-index
Debug
Reset to defaults
Cancel
Continue

VRML97 and X3D v3.0 support

CAD nodes were not included in VRML97

- First approved as part of X3D version 3.1

Nevertheless support for CADAssembly, CADFace, CADLayer, CADPart is possible

- Prototypes written that implement these nodes
- This is possible because they are structural and can be repeated using the VRML97 vocabulary
- Prototype support automatically included in X3dToVrml97.xslt conversion stylesheet, templates CADGeometryPrototypes, CADGeometryExternPrototypes

QuadSet, IndexedQuadSet nodes also provided

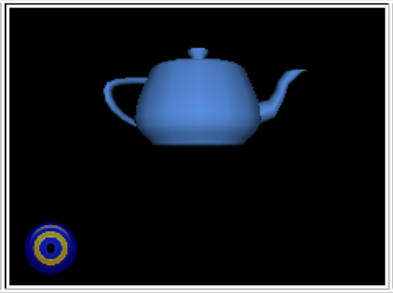
- Quadrilaterals converted to IndexedFaceSet

Teapot.x3d example (header)

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

***Basic, CAD:* Teapot**

Teapot model demonstrating proper hierarchy of CAD nodes.



launch	links
X3D	VRML97
X3DV	XHTML
X3DB	C14N

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.1//EN" "http://www.web3d.org/specifications/x3d-3.1.dtd">

<X3D profile='CADInterchange' version='3.1' xmlns:xsd='http://www.w3.org/2001/XMLSchema-instance' xsd:noNamespaceSchemaLocation=' http://www.web3d.org/specifications/x3d-3.1.xsd '>
    <head>
        <component level='2' name='CADGeometry'/>
        <meta name='title' content='Teapot.x3d'/>
        <meta name='description' content='Teapot model demonstrating proper hierarchy of CAD nodes.'/>
        <meta name='creator' content='Alan Hudson'/>
        <meta name='translator' content=' Xj3D, http://www.xj3d.org '/>
        <meta name='created' content='1 December 2005'/>
        <meta name='modified' content='10 March 2009'/>
        <meta name='reference' content=' http://www.web3d.org/x3d/specifications/ISO-IEC-19775-Amendment1-X3DAbstractSpecification/Part01/components/CADGeometry.html '/>
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        <meta name='subject' content='X3D CAD CADInterchange profile'/>
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        <meta name='license' content='../license.html'/>
    </head>
    <!--
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Index for DEF nodes: APP01, Teapot01-COORD
Index for Viewpoint image: Viewpoint_1

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    -->
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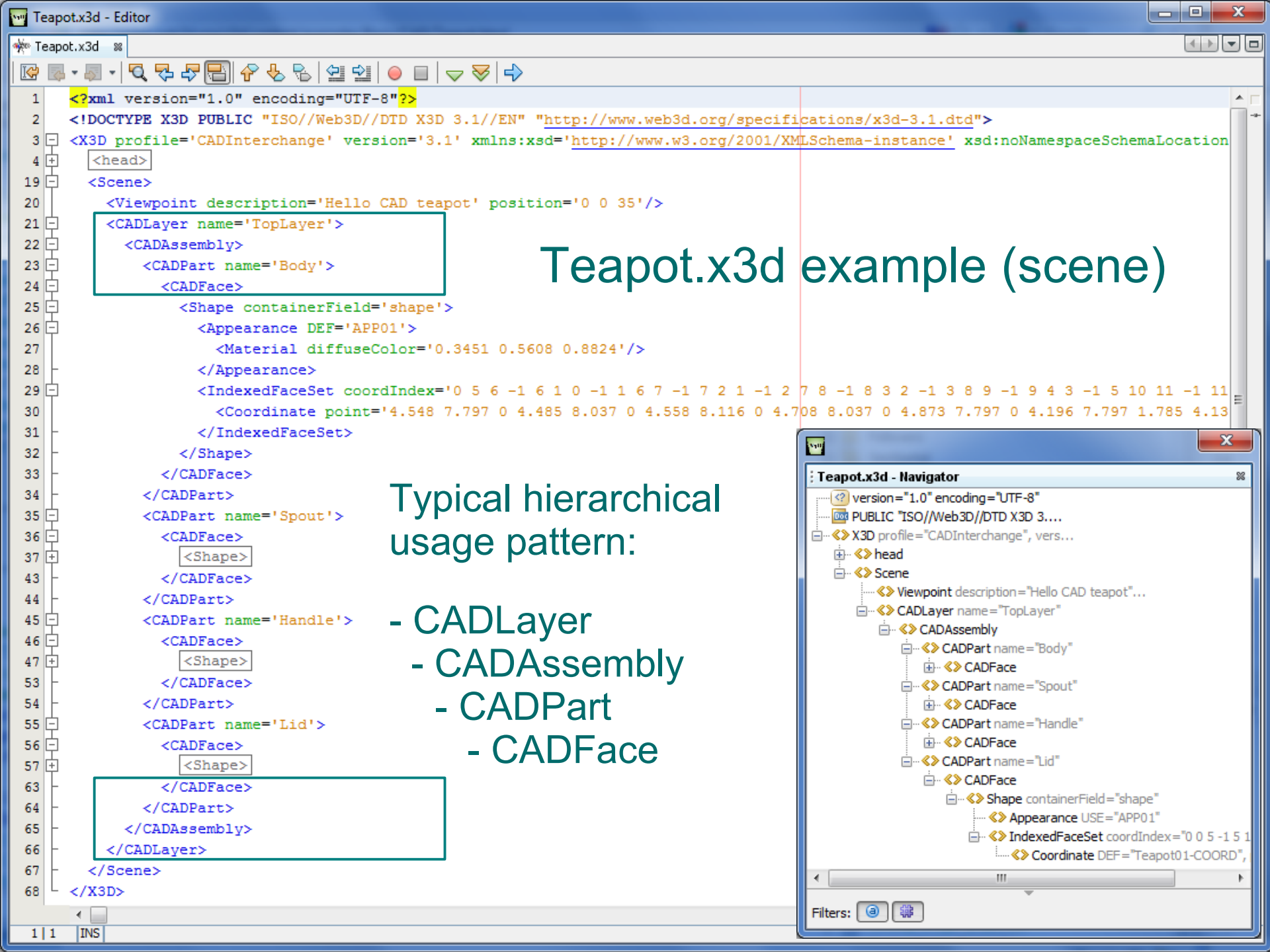


Teapot.x3d example (scene)

Typical hierarchical usage pattern:

- CADLayer
  - CADAssembly
    - CADPart
      - CADFace

Also available: NURBS nodes

Non-uniform Rational B-Spline (NURBS) nodes define parametric surfaces

- Precise, accurate, terse, scalable representations since mathematically defined
- Can be tessellated as high-fidelity polygonal surface at a resolution appropriate to viewer distance
- Difficult to author without special tools
- X3D NURBS nodes include: Contour2D, ContourPolyline2D, CoordinateDouble, NurbsCurve, NurbsCurve2D, NurbsOrientationInterpolator, NurbsPatchSurface, NurbsPositionInterpolator, NurbsSet, NurbsSurfaceInterpolator, NurbsSweptSurface, NurbsSwungSurface, NurbsTextureCoordinate, NurbsTrimmedSurface

CAD Working Group History, second phase 2008-2011:

Parametric History conversions and Boundary Representations (B-REPs)

Work in progress

History: second phase 2008-2010

X3D CAD Working Group evaluated Boundary Representations (B-REPS) for possible addition as X3D CAD Component level 3

- Draft specification available, but accessible to Web3D members only
- Safe haven: IPR contributions encouraged, protected during working group review
- Example implementations by Xj3D, Collaviz
- Need to expose examples, tests incomplete

CAD Interoperability

- Boundary Representations (B-Reps) nodes
  - Draft CAD specification update held by Yumetech
- ISO TC184 technical evaluation details show X3D fully competitive with other approaches
  - (Collada, U3D, JTOpen, some dropped out)
  - Close second-place finish, score 82% of 360 points
- Good prospect of unlocking many thousands (millions?) of existing engineering models using Parametric History authoring log
  - Dr. Soonhung Han, KAIST Icad Laboratory

CAD Parametric History approach

Numerous different CAD formats exist

- No single dominant format
- Formats typically obscure, engineering oriented
- Companies carefully "protect" their customers

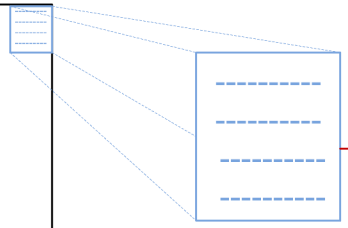
Common denominators nevertheless exist

- History file of author steps thus consistently applies fifty-term vocabulary consisting of B-Reps and constructive solid geometry (CSG) operations
- History log can be converted into common syntax, then reconstruct original geometry
- Current KAIST work targeted to produce X3D

X3D conversion of CAD models

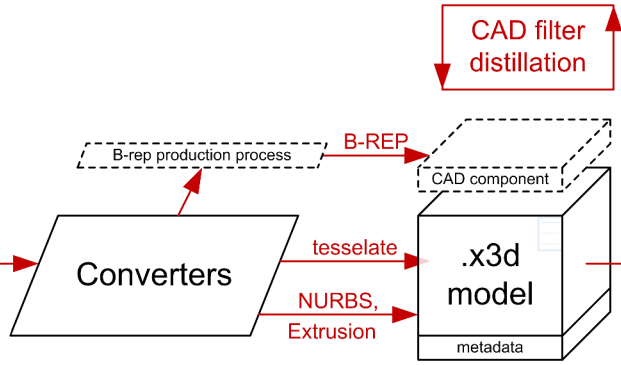
CAD model

- Large file size
- Proprietary format
- “Locked in” tool chain, expensive
- Licensing renewal needed long-term?
- Engineering detail, specialized metadata
- Specialized viewers, plugins
- Hard to convert
- Hard to reuse, compose, integrate



Parametric History

- List of author actions, similar to Do/Undo list
- Controlled vocabulary matching ISO STEP
- About 50 operators
- Constructive solid geometry (CSG)
- Can then build via CAD geometry engine
- Potential interoperability path despite differences between tools



Convert history log, not engineering details

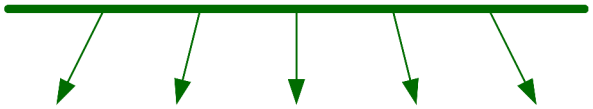
- Use CAD engine or API (e.g. ACIS) to produce conversion
- Compute geometry by converting CSG operators into BREP Boundary Representatons
- Polygonal mesh tessellation also possible

Deployable, reusable model

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

Compressed binary encoding

- Geometric reduction
- Fast Infoset XML reduction



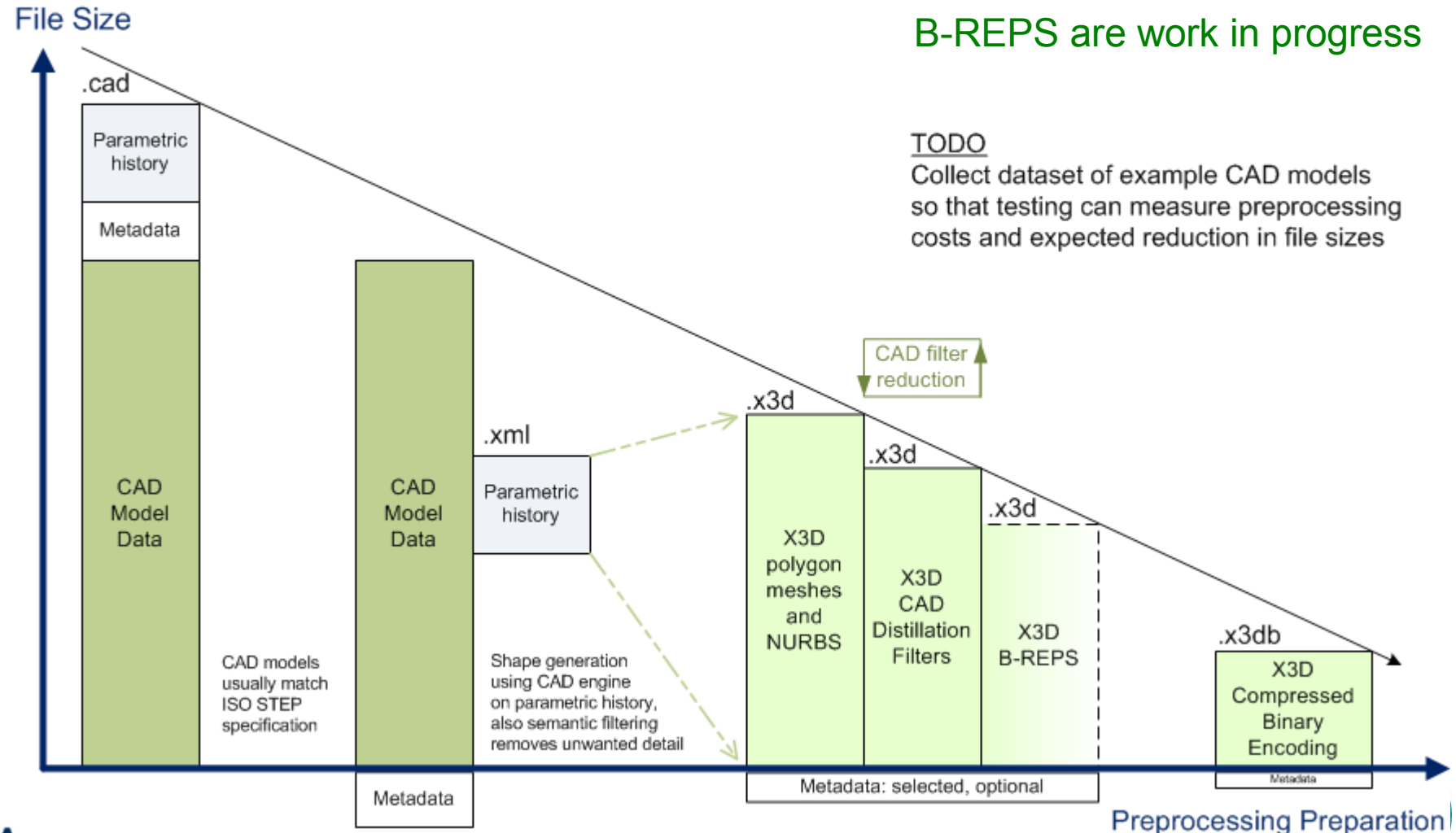
Widely deployable for many purposes

Note: might even embed the Parametric History file as metadata in .x3d model, in order to enable reasonably accurate round-trip regeneration of the original CAD model despite data lossiness.

CAD Parametric History details

- Many CAD models might be saved with parametric history, but some might not (as authoring choice)
- CAD Model Data might include both geometry meshes and procedurally defined surfaces
- Parametric History provides a redundant record of how the geometric CAD model was created
- Parametric History can be used to independently produce a similar or equivalent set of geometry meshes and procedural surfaces
- This generated result effectively match the shapes captured in the CAD Model Data
- This is a more efficient approach than trying to translate every different CAD format into X3D

CAD Model Data Reduction



B-REPS are work in progress

TODO
Collect dataset of example CAD models so that testing can measure preprocessing costs and expected reduction in file sizes

Boundary Representations B-REPs

Boundary representations (B-REPs) are used in solid modeling and computer-aided design for representing shapes

- A solid is represented as a collection of connected surface elements, the boundary between solid and non-solid space

Two parts make up a B-REP:

- Topology: faces, edges and vertices
- Geometry: surfaces, curves and points

Goals for use of B-REPS in X3D

Provide light-weight versions of CAD models

- Engineering data fidelity and metadata detail can often be relaxed

Use in various Web-accessible applications such as training, maintenance, simulation and virtual worlds

- Smaller size means shorter download times and faster rendering; original models are impractical
- X3D can add animation of parts, user interactivity, and composition of models

Boundary representation (B-REP) nodes

Topological nodes

- Edge, EdgeReference, Face, Wire, Vertex, PointBREP, WireBREP, ShellBREP, SolidBREP

Geometrical nodes

- BREPPlanarSurface, BREPSphericalSurface, BREPCylindricalSurface, BREPToroidalSurface, BREPEllipsoidalSurface, BREPConicalSurface, BREPSurfaceOfLinearExtrusion, BREPSurfaceOfRevolution, BREPCircle2D, BREPLine2D, BREPEllipse2D

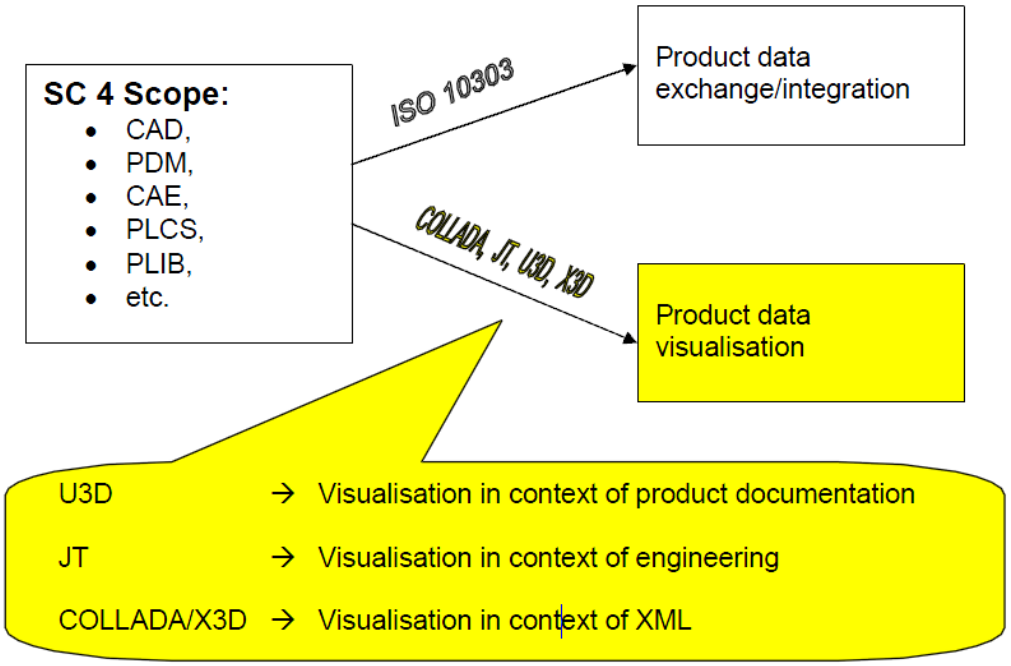
B-REP example snapshots

Proposed architectural design seems complex...

- Indexing scheme
- Inheritance scheme

ISO SC4 Visualization Assessment

- ISO Standards Committee SC4 assessed multiple candidate visualization formats that met industry-defined requirements for product data visualization
- Published April 2009



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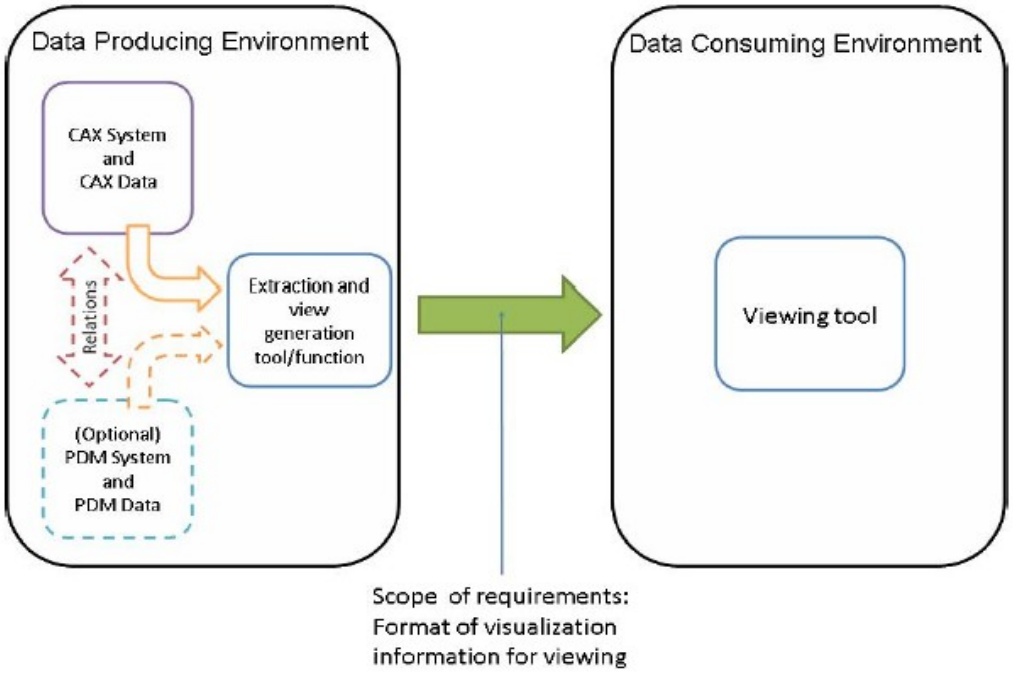
X3D

ISO SC4 assessment scope: product visualization output

Committee didn't assess round-trip conversion since requirements are very different



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X3D

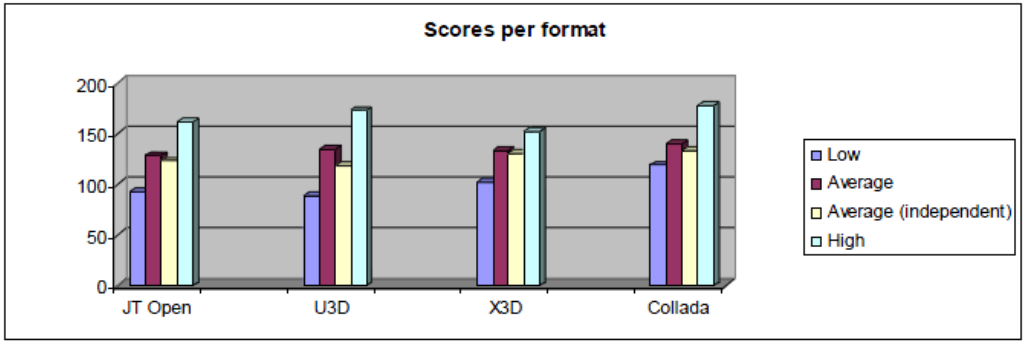
ISO SC4 assessment results

X3D scored close second of 5 entries overall

- Functional coverage assessment 82% of 360 points

Report recommendations:

- It is recommended to accept the format candidates COLADA, JT, U3D and X3D as finally assessed to fulfill the requirements for SC 4 visualisation formats.
- This format is complementary to the standards series ISO 10303 "STEP" concerning the visualization data exchange. It is not recommended to use this format for CAx data exchange or product data exchange.



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X3D

X3D CAD self-assessment report covering 36 SC4 topic areas

Excellent resource describing range of X3D capabilities and also projected extensions

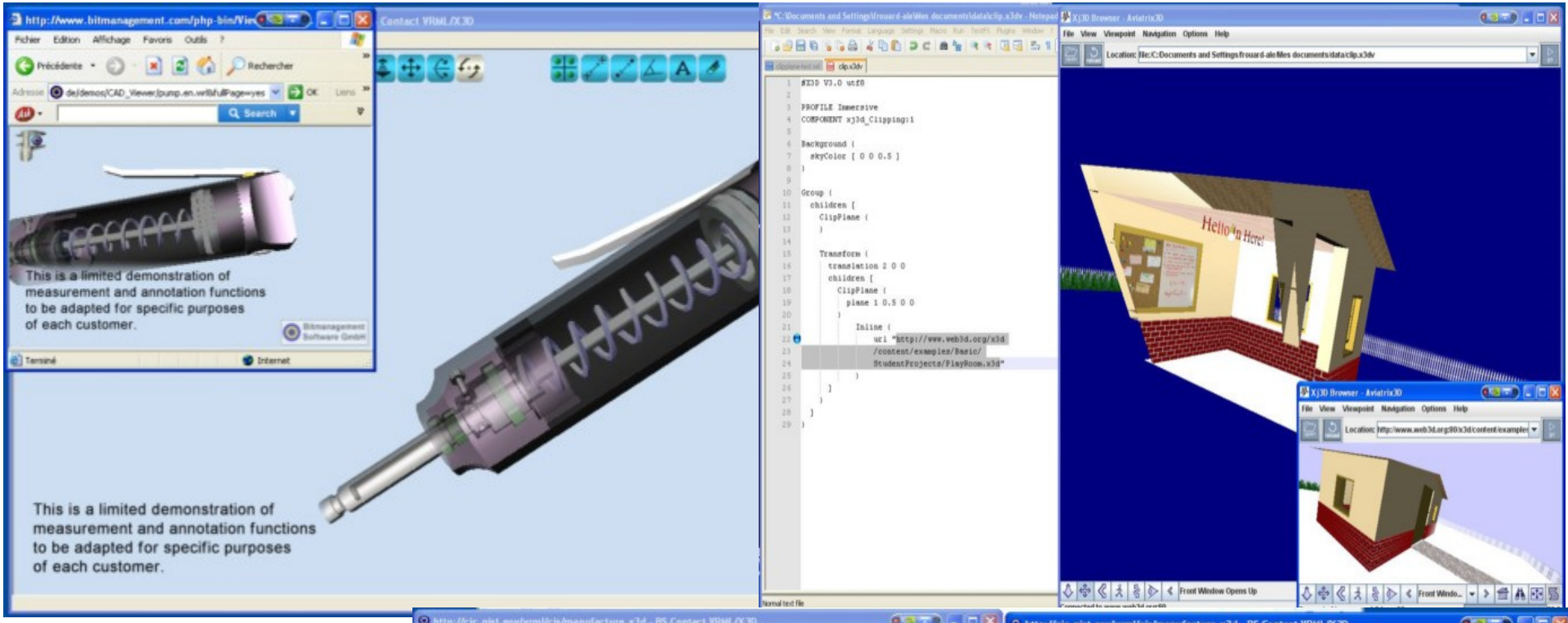
- Produced collaboratively using Web3D wiki for CAD working group
- http://www.web3d.org/membership/login/memberwiki/index.php/CAD

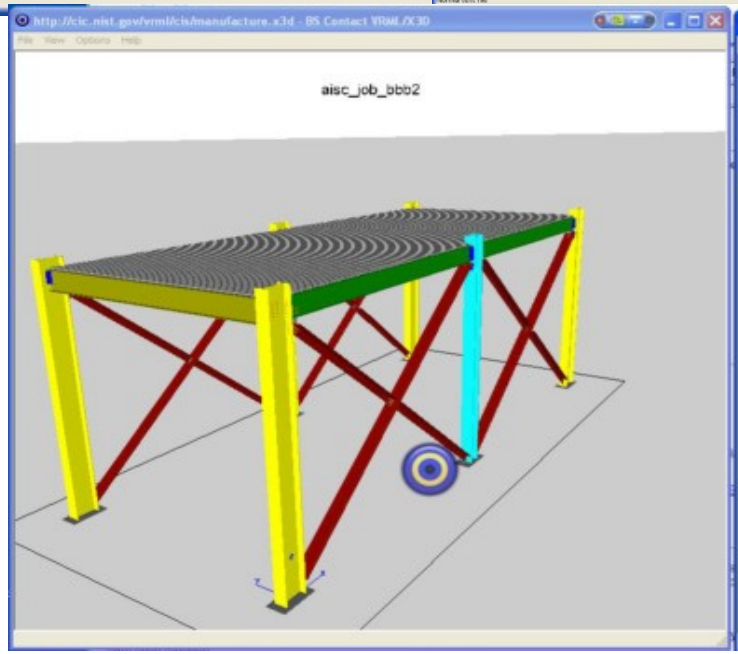
- 1: STEP Consistency
- 2: STEP Mapping
- 3: STEP & Product Life Cycle
- 4: View Geometry, Attributes, Viewing Attributes, Management and other information
- 5: Display selection & editing
- 6: Print/Plot
- 7: Zoom/Pan
- 8: Camera Rotation
- 9: Bill of Material (BOM)
- 10: Screen Capture
- 11: Measurement

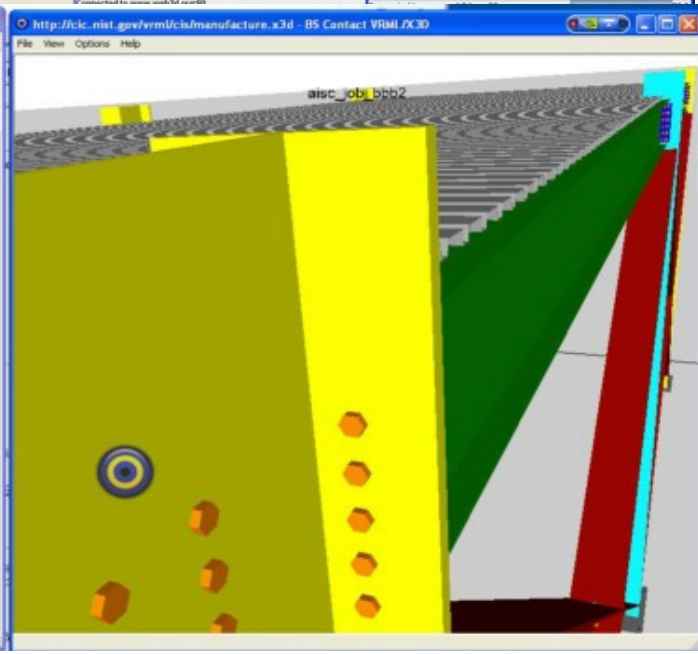
X3D CAD self-assessment topics 2

- 12: Sectioning
- 13: Compare
- 14: Markup
- 15: Collaboration
- 16: Transformation/Manipulation
- 17: Grouping
- 18: Animation
- 19: Annotation Association
- 20: Clearance & Interference Analysis
- 21: View Annotation
- 22: Performance Settings
- 23: Standard View Creation
- 24: Create Reference Planes

- 24: Create Reference Planes
- 25: Area Selection Filter
- 26: Entity Selection Filter
- 27: Visualization File Attributes
- 28: Interrogation
- 29: Instances
- 30: External References
- 31: Accuracy
- 32: Kinematics
- 33: Rendering Modes
- 34: Lighting Control
- 35: Data Format Footprint
- 36: Persistence of Visualization Information







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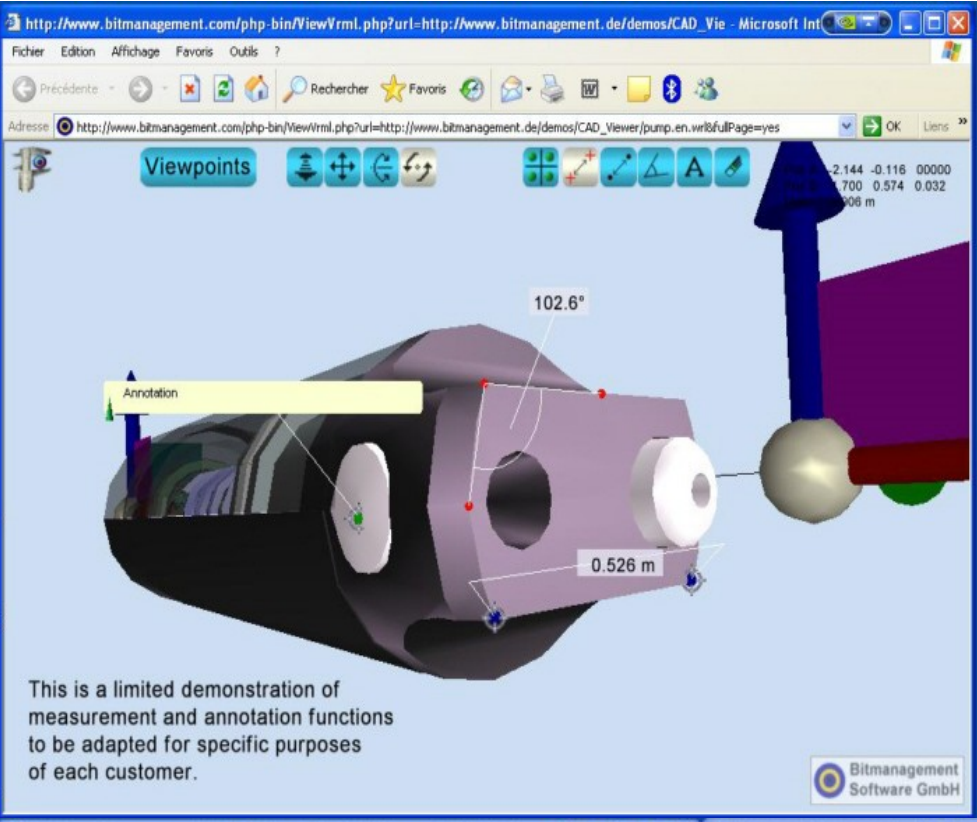
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Annotation
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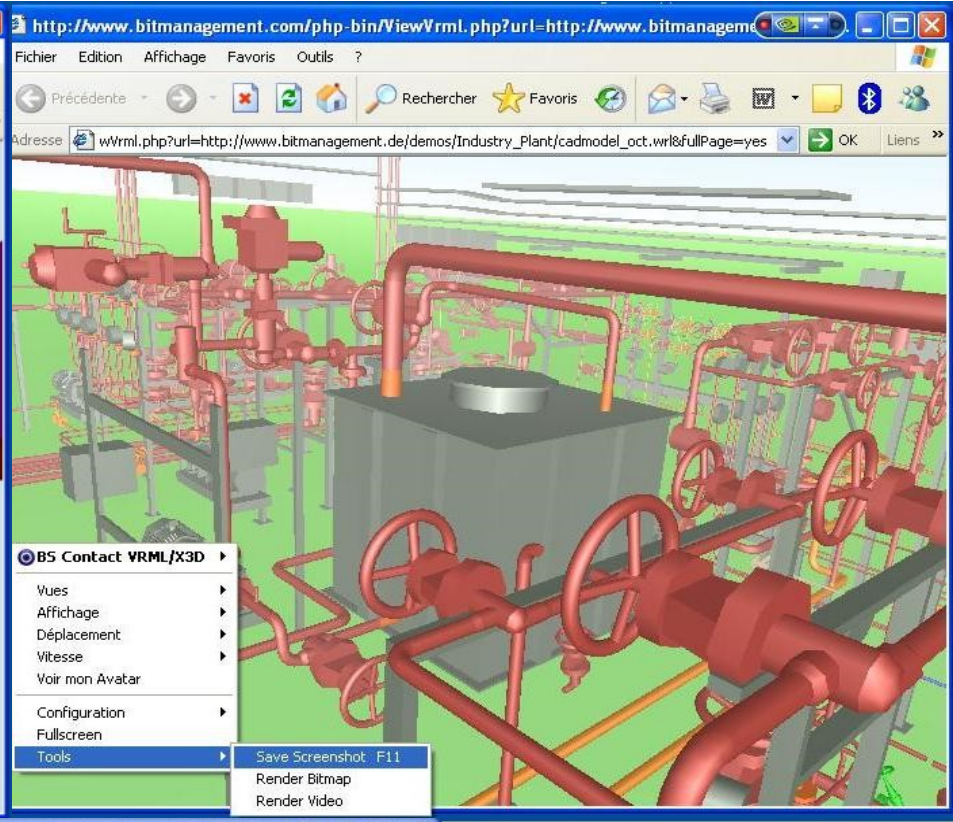
Bitmanagement Software GmbH


BS Contact VRML/X3D
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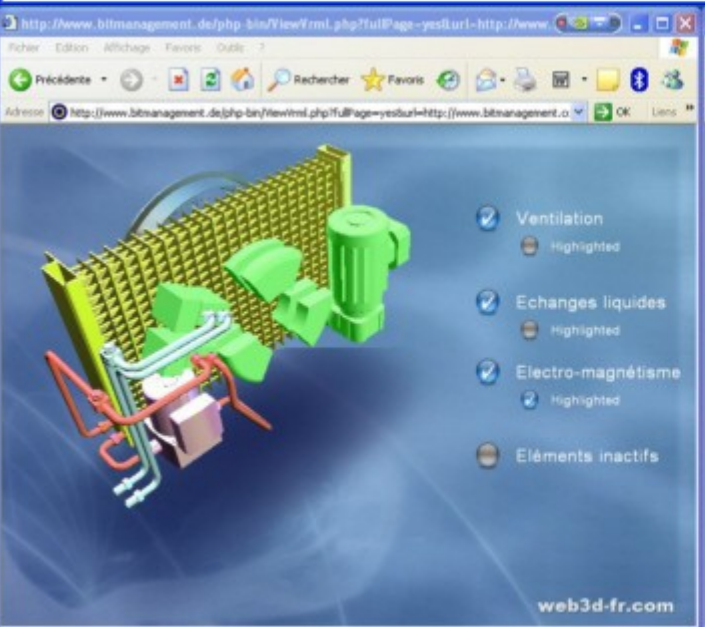
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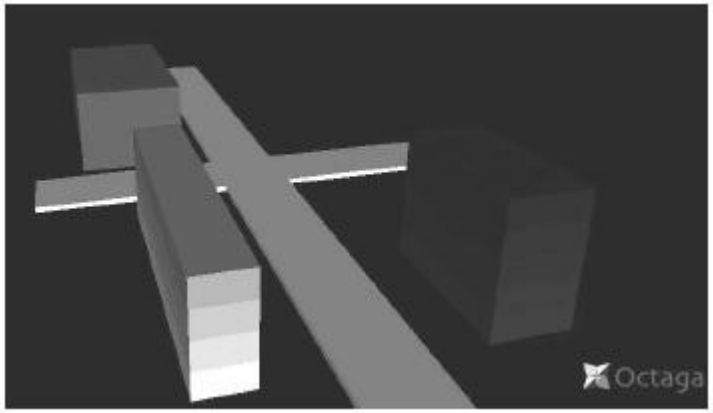
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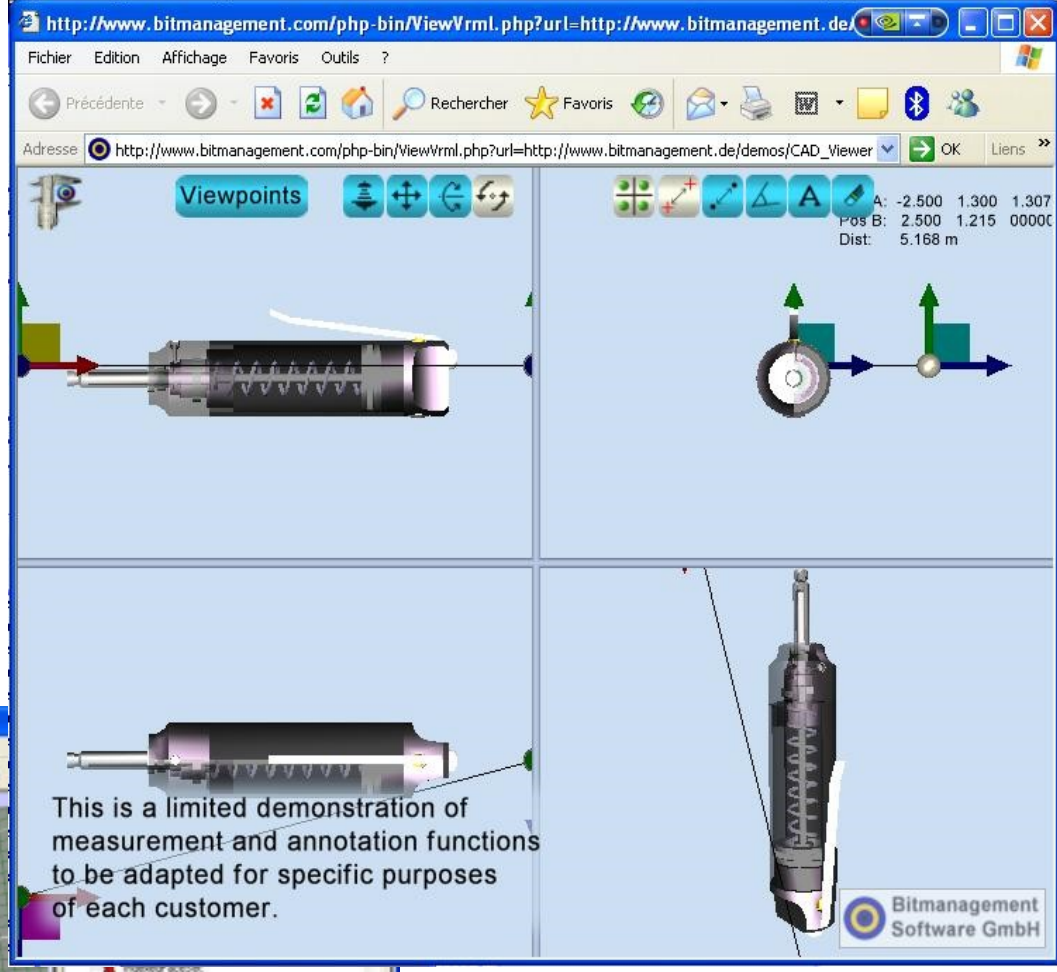
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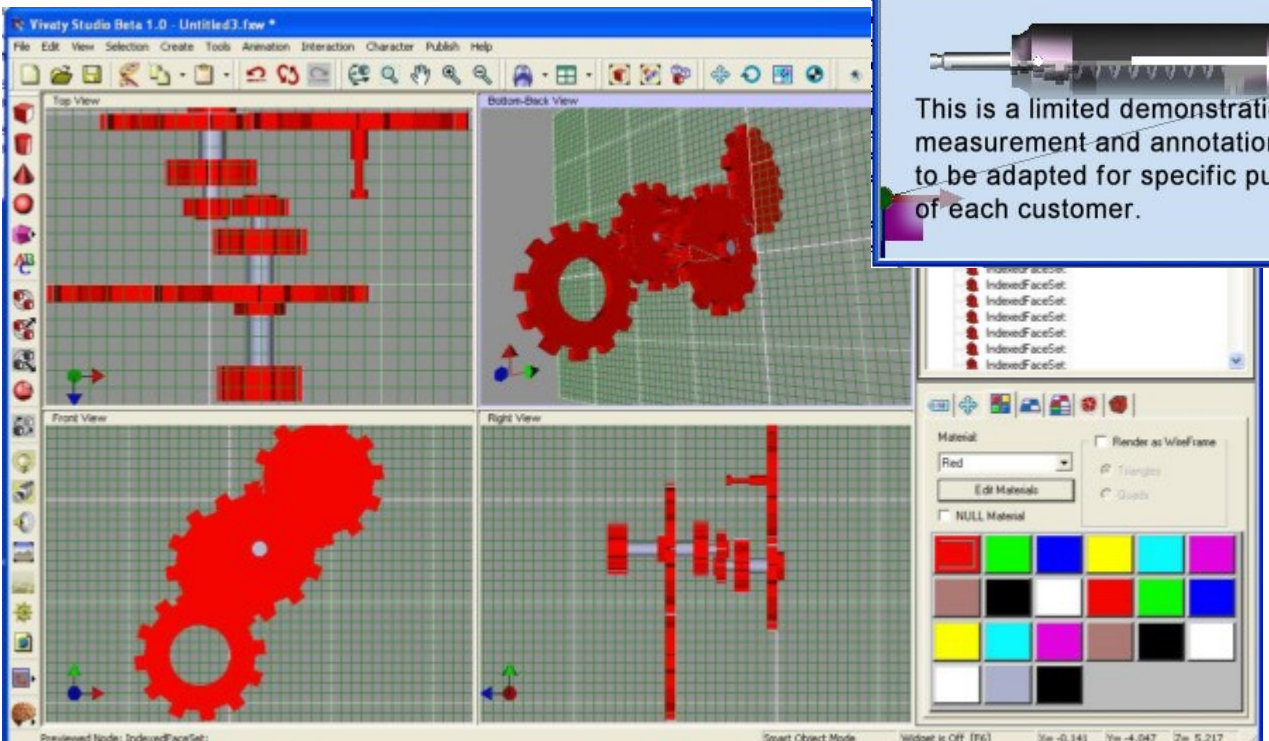
Bitmanagement Software GmbH


Vivaty Studio Beta 1.0 - Untitled3.fxw *
File Edit View Selection Create Tools Animation Interaction Character Publish Help
Top View
Bottom-Back View
Front View
Right View
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Material
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Render as WireFrame
Edit Materials
NULL Material


X3D

Format converters

Tool support is emerging

- Okino Polytrans
- Cadconverter
- Others

Okino Polytrans converter

http://www.okino.com

Okino Computer Graphics

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BOOKMARK

Welcome ProlEngineer® and Other CAD Users!

...An Overview of Using Okino Software for CAD Data Processing.

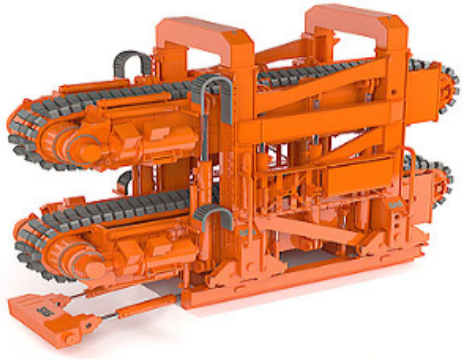
Questions? Email our CAD system software architect right now!

Welcome Pro/E and other CAD users! For well over a decade and a half Okino Computer Graphics has provided the absolute defacto Pro/E conversion system used throughout the world by our user base of tens of thousands of 3D professionals for mission and application-critical applications. We utilize an embedded version of the actual Pro/Engineer software inside of Okino's popular PolyTrans and NuGraf software, allowing for 100% error free import of native, encrypted Pro/E assemblies, part files and instance accelerator files. There is technically no other more ideal or error free conversion pipeline available for native Pro/E data. No intermediate file formats are used nor are reverse engineered CAD toolkits used to access the Pro/E data.

Built on PTC® GRANITE

Please take a moment to review the Okino Granite Importer overview, which explains how the embedded PTC Granite technology relates to this Okino CAD importer pipeline and click here to view Okino's Pro/E importer online help, feature list and option descriptions.

This CAD pipeline solution allows complete Pro/E parts and assemblies to be converted cleanly and professionally to all other major 3D file formats, animation packages and visual simulation programs. It also allows all disparate departments of large enterprise companies (such as engineering, design, marketing and support) to easily exchange product data without the need to rebuild their CAD datasets -- downstream uses include product documentation and manual creation, animation and rendering software, visual communication and review of data, and for accessing easier to manipulate versions of the original CAD datasets.



Okino's Pro/E CAD conversion pipeline is synonymous with moving complex Pro/E assemblies into 3ds Max, Maya, Lightwave, Softimage (XSI) and Cinema-4D for animation and rendering. In addition, Okino's ProE conversion system is used in conjunction with many OEM and third party vendor integrations, and for re-purposing Pro/E assembly data into all major 3D downstream 3D file formats such as Collada, DirectX, DXF/DWG, FBX, HOOPS/DWF-3D, JT Open, NGRAIN, OpenFlight, PLY, Renderman RIB, Rhino/OpenNURBS, SketchUp, Shockwave-3D, trueSpace, U3D, VRML1+2+X3D, Wavefront OBJ, XAML-3D, and XGL.

CadExchanger

http://www.cadexchanger.com

CAD Exchanger, your 3D data translator

Home | Products | Formats | Download | Forum | Contacts | About

CAD Exchanger is a product family aimed to help CAD professionals in a well known yet challenging problem – 3D CAD data conversion.

Supported formats currently include IGES, STEP, ACIS-SAT, Parasolid-XT, STL, VRML, X3D and BRep. However, this is only a beginning and more formats (including Rhino Open NURBS, JT, and others) are underway.

Latest news:

November 25, 2010. **Customer Success Story: Setred**

Setred adopts CAD Exchanger to solve design interchange problems with its partners and subcontractors. Read the full story.

November 23, 2010. **CAD Exchanger 2.0.2** is available

Version 2.0.2 is a maintenance release delivering improvements and bug fixes over v2.0. It also features Parasolid-XT importer (currently as Technology Preview) with addressed feedback from an Invitational Beta program. Please consult the CHANGES file for details and visit the download page to get the release.

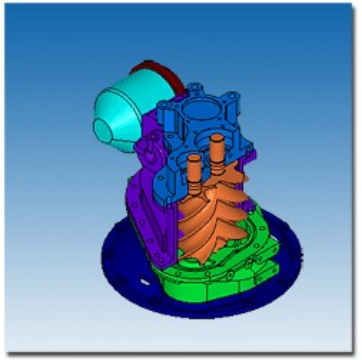
October 26, 2010. **CAD Exchanger 2.0.2 Beta** is available

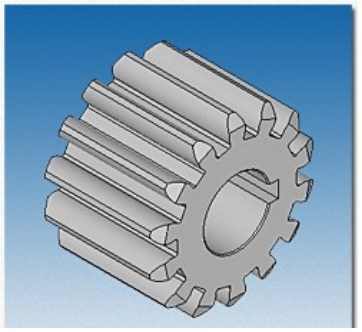
This version introduces Parasolid-XT importer. We decided to follow an effective approach used for ACIS-SAT by first proposing it to Beta customers and addressing their feedback. If you would like to join the Invitational Beta, drop us an email at info@cadexchanger.com. Public release should become available later this quarter or early 2011.

See also news archive.

CAD Exchanger is a dynamically growing project leveraging on success of its delighted customers and users. See for yourself what they have to say.

Try a fully free evaluation version now!





http://www.cadexchanger.com

X3D Resources: Conversions

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

Conversion and Translation Tools

- Okino Polytrans is the premier industry translation tool that can convert many many different file formats (including Collada) to and from X3D, VRML97 and VRML 1.0.
- Xj3D Open Source for X3D/VRML97 includes a command-line X3D translator between XML encoding (.x3d), Classic VRML encoding (.x3dv) and VRML97 encoding (.wrl). These capabilities are also embedded under *Import* and *Export* menus in X3D-Edit. Xj3D can also import Collada files.
- X3D-Edit exposes all Xj3D capabilities. It can also import, edit and validate Collada files.
- InstantReality X3D encoding converter is an online translator between ClassicVrml encoding (.x3dv) or VRML97 encoding (.wrl) to XML encoding (.x3d).
- **XSLT Stylesheets** convert .x3d scenes into alternate formats and encodings. These stylesheets (and corresponding batch files) are bundled in X3D-Edit.
  - Conversion to ClassicVRML (`.x3dv` encoding): X3dToX3dvClassicVrmlEncoding.xslt, X3dToVrml97.xslt -fileEncoding=ClassicVRML and X3dToX3dvClassicVrmlEncoding.bat
  - Backwards compatibility with VRML 97 (`.wrl` encoding): X3dToVrml97.xslt and X3dToVrml97.bat
  - Tagset pretty-printing in XHTML (`.html` encoding), includes cross linking of DEF/USE/ROUTE/etc.: X3dToXhtml.xslt and X3dToXhtml.bat (plus incremental partial-stylesheet lesson examples X3dToXhtmlStylesheetExamples.zip)
  - The X3D stylesheets are checked into version control at http://x3d.svn.sourceforge.net/viewvc/x3d/www.web3d.org/x3d/stylesheets
- BitManagement capabilities include BS Converter for 3ds max and BS Converter for Blender.
- NIST VRML to X3D Translator is written by Qiming Wang. The X3D-Edit 3.1 distribution includes an updated version of the Translator (also .zip and Javadoc) as a bundled source/jar.
- Blender Model Export To X3D using X3D-Edit
- Chisel VRML Optimisation Tool with new version autoinstaller and documentation provided by Halden Virtual Reality Centre. Originally built by Trapezium and maintained by NIST.
- The SwirlX3D Translator is an enhanced version of the Viewer that permits Collada and 3DS files to be imported into VRML or X3D.
- Vivaty has excellent utilities and converters for Google Earth KML/Sketchup, Autodesk 3DS Max, Autodesk Maya, and Unreal. Vivaty Studio also includes Collada import.
- Accutrans 3D by MicroMouse Productions provides accurate translation of 3D geometry between the file formats used by many popular modeling programs.
- Project Rawkee: Open-Source X3D Plugin for Maya by the Archaeology Technologies Laboratory (ATL) of North Dakota State University (NDSU).
- Unreal Realm of Concepts: Unreal to X3D Exporter by Dave Arendash
- VRML 1.0 to VRML97 Converter by Octaga
- Anark is able to export product data into high-precision B-rep and lightweight mesh formats including SolidWorks, Inventor, ACIS, CATIA V4/V5, Parasolid, STEP, NX (formerly Unigraphics), IGES, COLLADA, DWF, X3D, and VRML.
- MeshLab is an open source, portable, and extensible system for the processing and editing of unstructured 3D triangular meshes.
- view3dscene supports VRML/X3D, Collada, OpenInventor 1.0, 3d Studio Max 3DS, Quake 3 MD3, Wavefront OBJ and Videoscape GEO.
- CAD Exchanger is a product family aimed to help CAD professionals in a well known yet challenging problem: 3D CAD data conversion. Supported formats currently include IGES, STEP, ACIS-SAT, Parasolid-XT, STL, VRML, X3D and BRep.

X3D
Compressed Binary Encoding (CBE)

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

At least one other browser company has a partial implementation, work is ongoing

Efficient XML Interchange (EXI)

W3C XML Binary Characterization

- Established common needs among hard use cases

W3C EXI Recommendation

- Public review, last call status

Technical approach

- Benefit 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

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NAVAL POSTGRADUATE SCHOOL
LT Sheldon L. Snyder

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

<MOTIVATION>

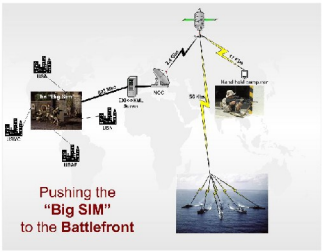
Compact & Efficient XML

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

<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

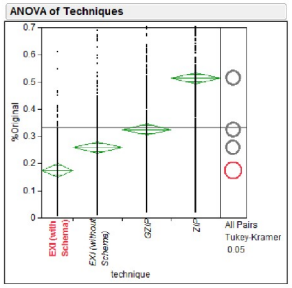
efficient XML
http://www.agiledelta.com/product_efx.html

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>

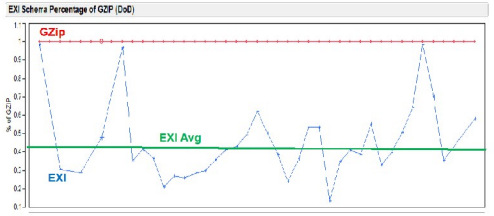
EXI Deliver Statistically Significant XML Improvements



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 -->

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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, included in X3D-Edit tool

- 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

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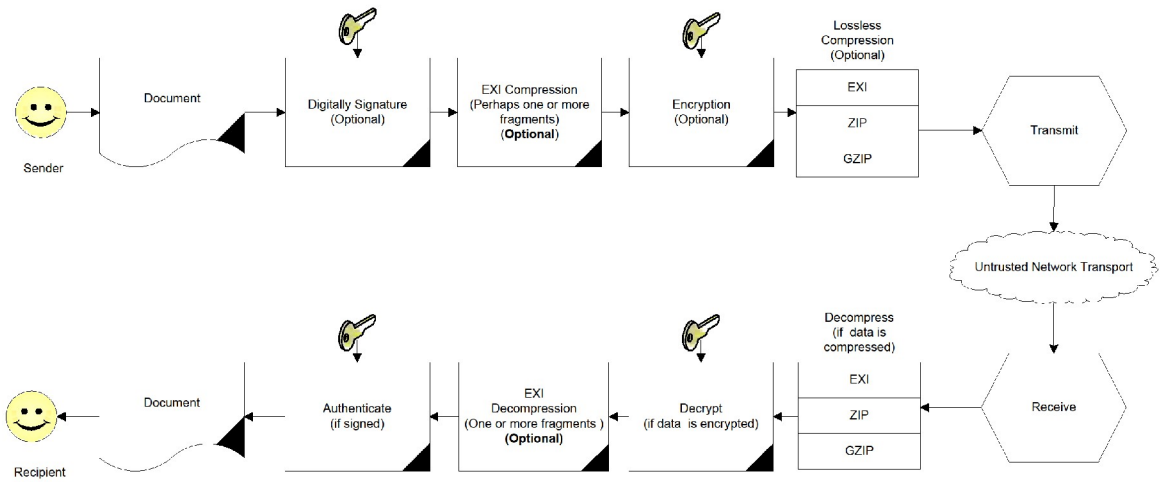
LCDR Jeffrey S. Williams Sr., USN

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

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Concepts: X3D CAD Component

Common fields for X3D nodes

X3DProductStructureChildNode interface

X3DProductStructureChildNode interface indicates that this is a structural node

- CADLayer, CADAssembly, CADPart, CADFace

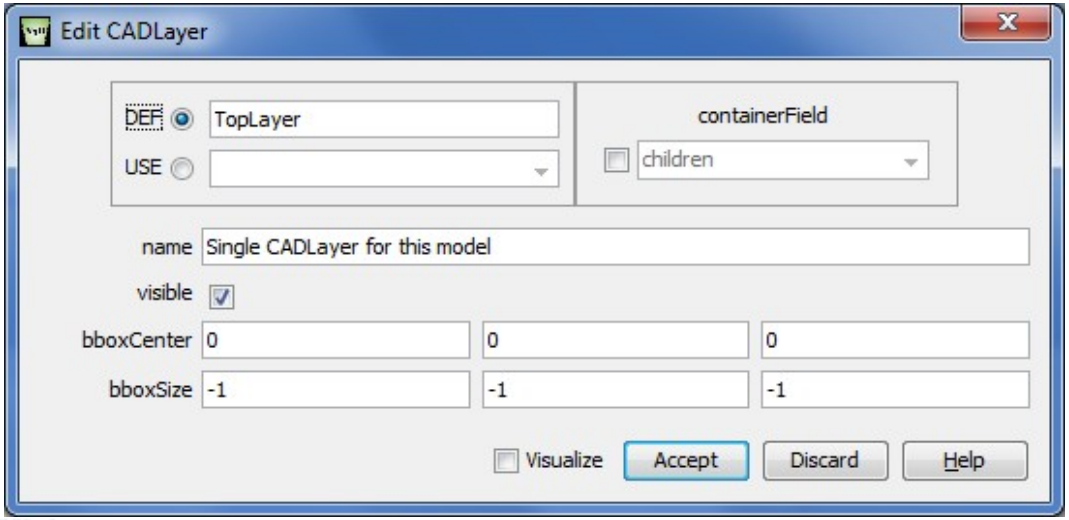
Common field: *name* string (default is blank)

X3D Nodes and Examples

CADLayer

CADLayer is a Grouping node that can contain most nodes

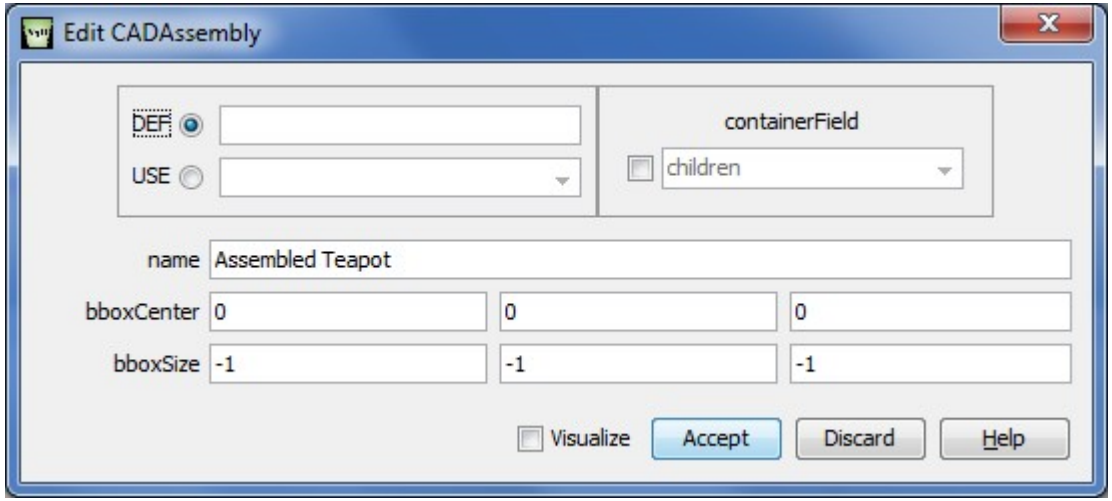
- *visible* field is a boolean array that indicates whether each child is displayed, default is *true*
- Typically contains one or more Assembly nodes
- Can also contain Shapes or other grouped content



CADAssembly

CADAssembly is a Grouping node that contains a set of CADAssembly or CADPart nodes

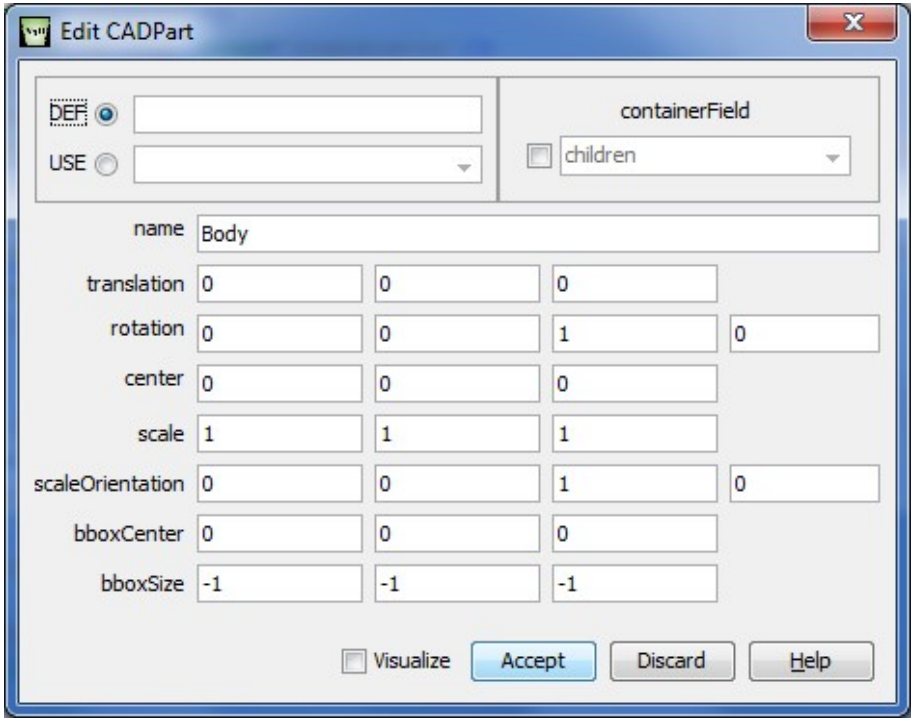
- Thus assembly consists of sub-assemblies and parts
- Design is not intended to hold other content



CADPart

CADPart is a Grouping node that contains one or more CADFace nodes to make a Part

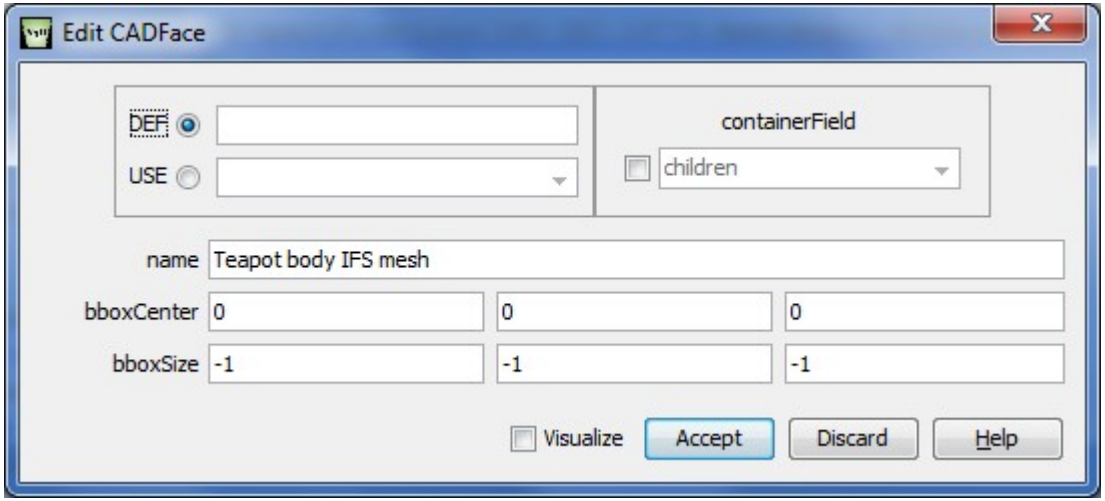
- Also includes Transform fields to locate children
- Design is not intended to hold other content



CADFace

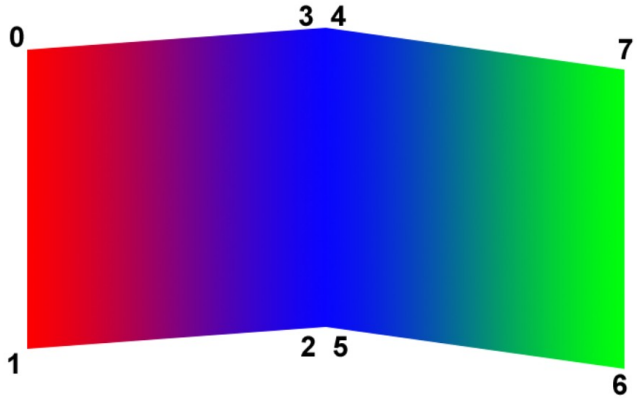
CADFace is a Grouping node that contains a single Shape or else an LOD node

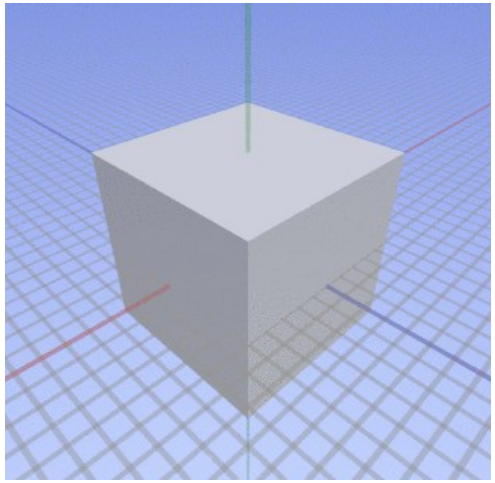
- Holds geometry representing a face of a part
- If child LOD, each level should be single Shape
- Design is not intended to hold other content



Additional nodes

Quadset and IndexedQuadSet are covered in X3D For Web Authors chapter 13





OrthoViewpoint node is covered in X3D For Web Authors chapter 4

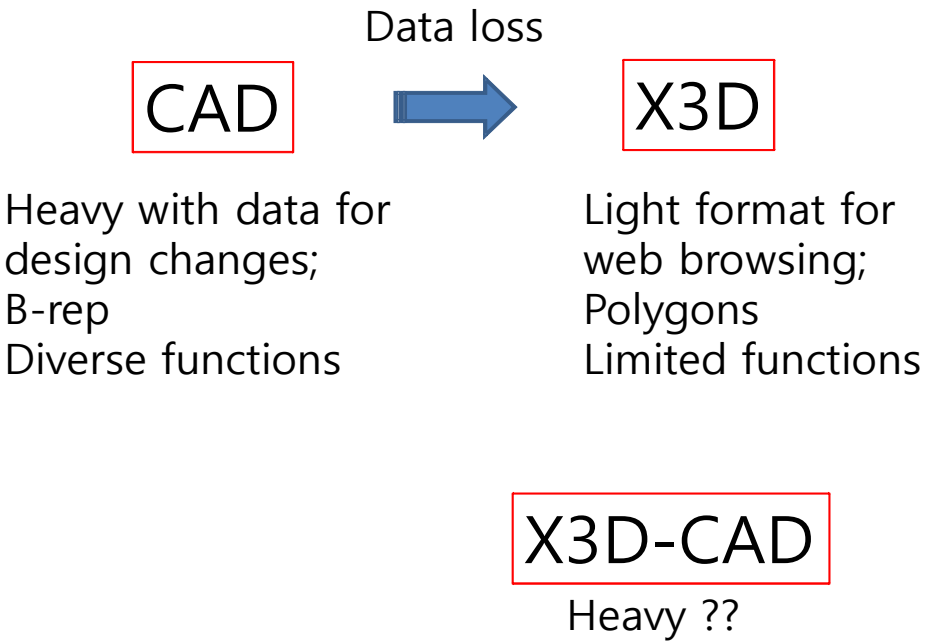
- An orthographic view has all projected lines parallel to the projector from *centerOfRotation* to *position*

Work in progress

CAD working group, Web3D Consortium

Is X3D CAD heavy or light?

from Professor Soonhung Han of KAIST:



This is the right question to explore.

The way to answer it is through testing.

Next steps for CAD working group

Lots of progress has occurred...

Lots of work still to be done!

- Are the B-Rep definitions correct?
- Can authors use them, or are they just for tools?
- Do the B-REP renderers work? B-REP tesselation to polygon export in our converters? What about constructive solid geometry (CSG)?
- Parametric History capability in tool set? Not yet...
- Example CAD models => scenes in version control
- Test corpus to show size & speed measurements
- Best practices for copying CAD model and P.H. metadata
- Demonstrate Parametric History approach
- CAD Working Group needs to be rejuvenated... when?
- What else needs to be considered

Let's plan how to best go forward together

Applications

CAD applications for X3D

Additional Resources

Chapter Summary

Chapter Summary

CAD component allows structuring X3D models to match common structure within CAD models

CAD distillation filters and X3D binary encoding allow large-model reduction to practical levels

- Long-running work in progress

Multiple technical challenges are steadily being addressed

Ongoing work to build repeatable, royalty-free results available for broad use on the Web

Suggested exercises

Test and adapt provided example scenes

Perform geometry reduction of a large mesh

- Using X3D-Edit, Xj3D, MeshLab or any other tool

Repurpose a CAD model using a conversion tool, simplify X3D model further using CDF filters, maintain basic structure using CAD nodes

Add animation to model, publish to Web

Parting thoughts

In theory, theory and practice are the same.

In practice, they're not!

Yogi Berra

Let us show best practices that match theory, by building test examples that demonstrate whether X3D CAD models are heavy or light.

Sponsor, partnership opportunities

Numerous government agencies might benefit if stable Web modeling and delivery was possible for CAD engineering models

- Training, simulation, visualization, outreach, etc.

Most CAD companies selling authoring tools are not highly incentivized to be interoperable

- Numerous incompatible CAD formats

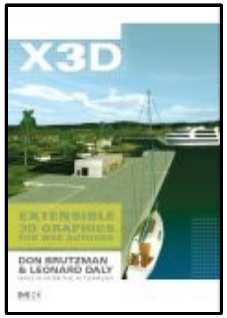
Numerous sponsor, partnership opportunities are available to advance X3D CAD capabilities

- Please contact Web3D CAD Working Group

References

References 1

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



- http://x3dGraphics.com

X3D Resources and X3D Basic Examples Archive

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

web|3D CONSORTIUM

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

References 3

Xj3D Converter shell scripts

- http://www.Xj3D.org

MeshLab tool for 3D triangular meshes

- http://meshlab.sourceforge.net

Contact

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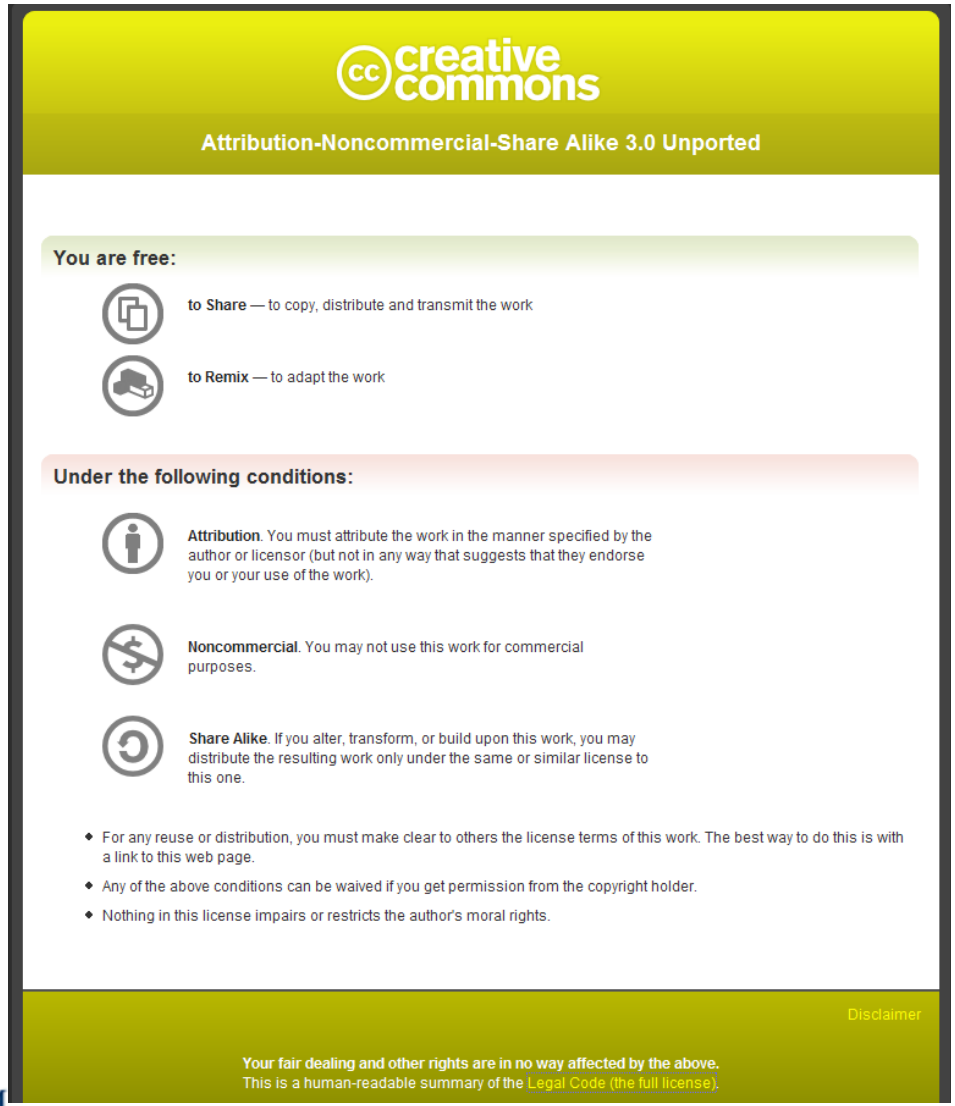

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X3D

Open-source license
for X3D-Edit software and X3D example scenes

http://www.web3d.org/x3d/content/examples/license.html