

# X3D Efficient Binary Encoding (EBE)

Background and Overview

Web3D 2015 Conference

Heraklion Crete, 18 June 2015

Long straight trail has led here...

# Compressed Binary Encoding (CBE) Call for Contributions Workshop

Web3D 2013, San Sebastian Spain

19 June 2013

# 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 continued 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

- Multi-View X3D Binary Transmission
  - Peter Schickel
- Fraunhofer Technical Capabilities and Plans
  - Johannes Behr

# 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)

Original strategy  
continues to  
play out well

## 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 fit into this rich mix, please let us know!

[Website link](#)

# 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.

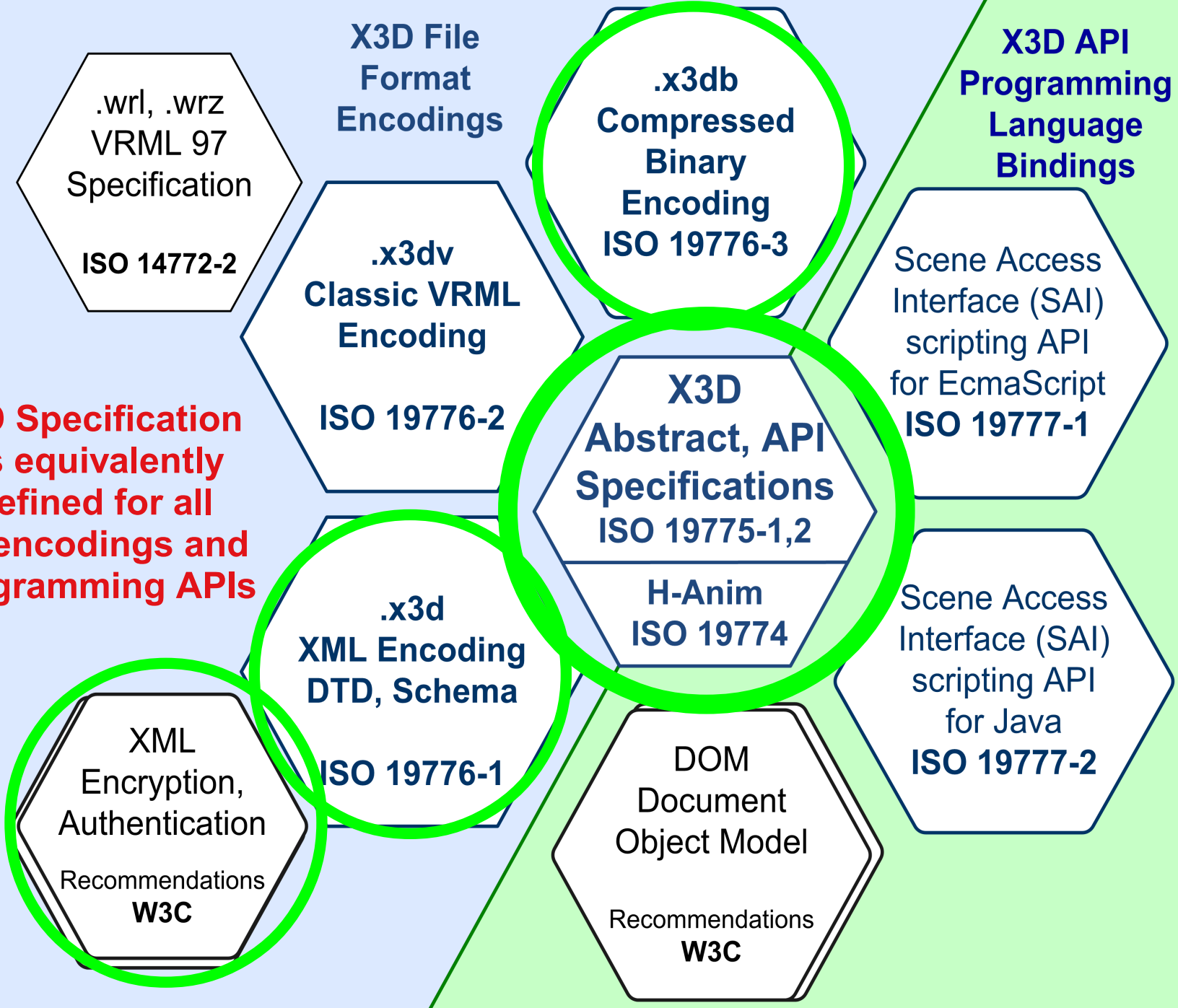
# Concepts

## X3D Compressed Binary Encoding (CBE)

# X3D compression assets: numerous

- ✓ X3D Compression Call for Contributions
- ✓ X3D Compression Specification quicklook
  - Composition framework matches all X3D encodings
  - Node and field compressors
  - CAD Distillation Filters: repeated refinement as X3D
- ✓ Geometric compression algorithms
  - src Shape Resource Container supports our needs
- ✓ Information/data compression algorithms
  - Efficient XML Interchange (EXI)
  - XML security: encryption, digital signature

**X3D Specification is equivalently defined for all file encodings and programming APIs**



# X3D CBE Compressed Binary Encoding

Matched functional capability of X3D encodings

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

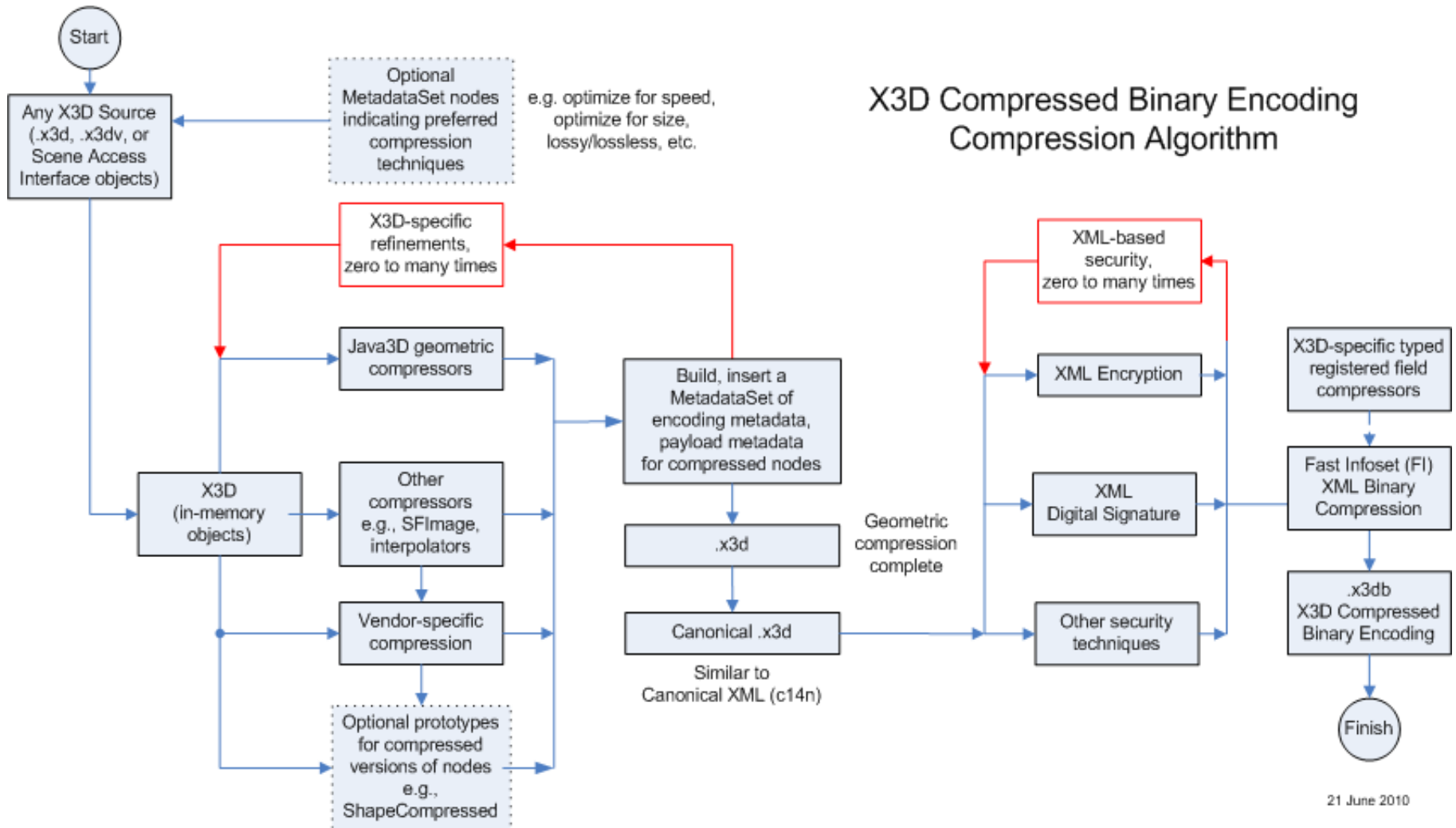
Combines two types of compression

- 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

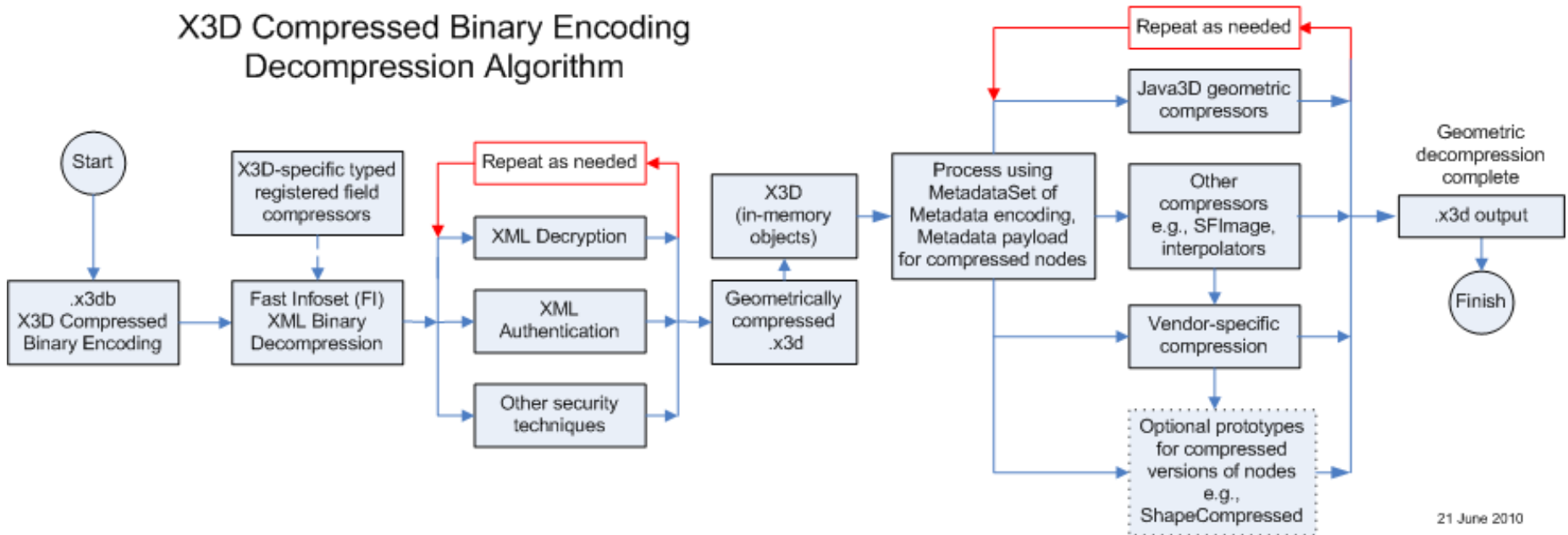
- Now aligning three independent implementations
- Considering W3C Efficient XML Interchange (EXI) as likely future addition to Fast Infoset

# X3D CBE compression algorithm



# X3D CBE decompression algorithm

X3D Compressed Binary Encoding Decompression Algorithm



21 June 2010

# .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>

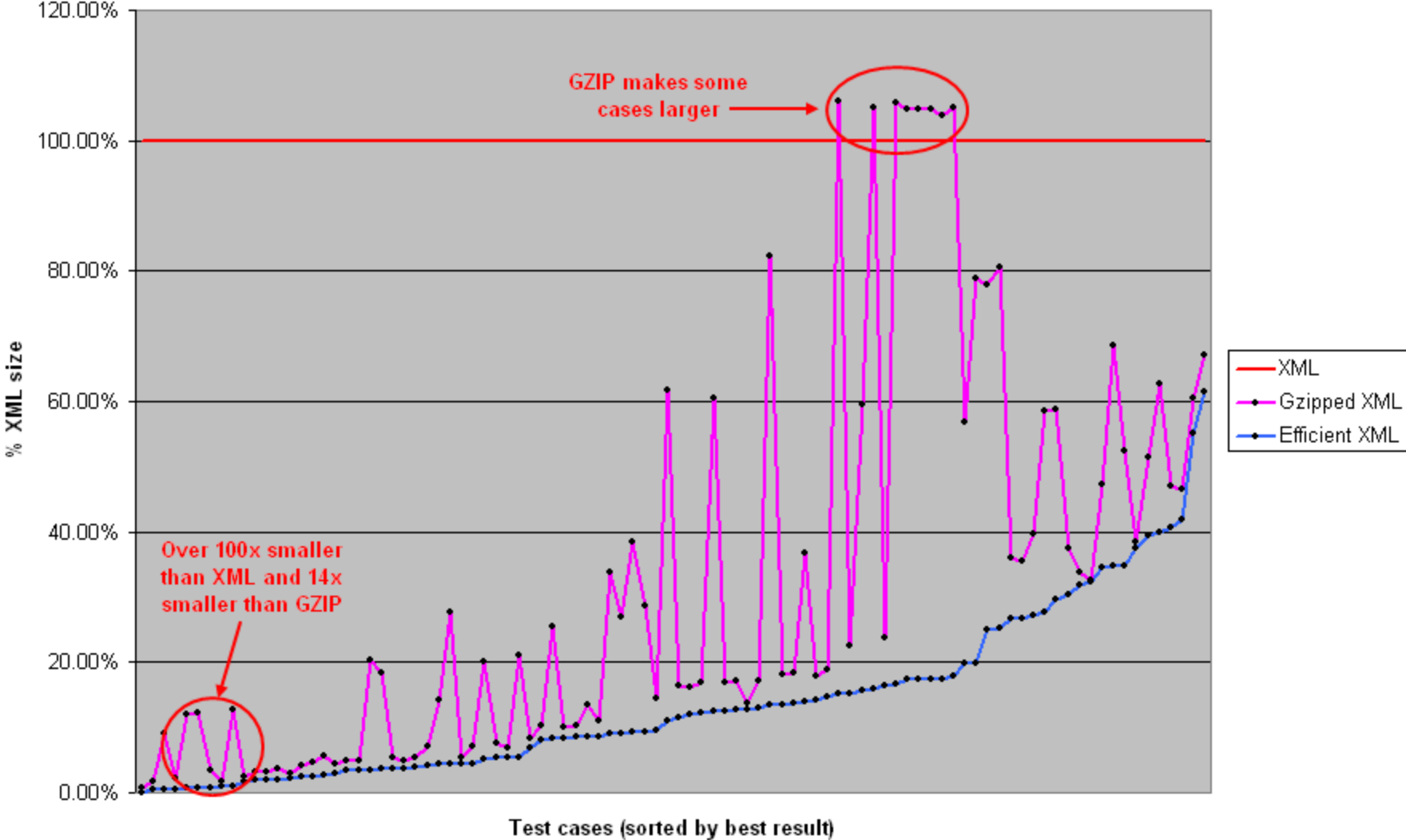
## Technical approach: aligns well with X3D XML

- 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

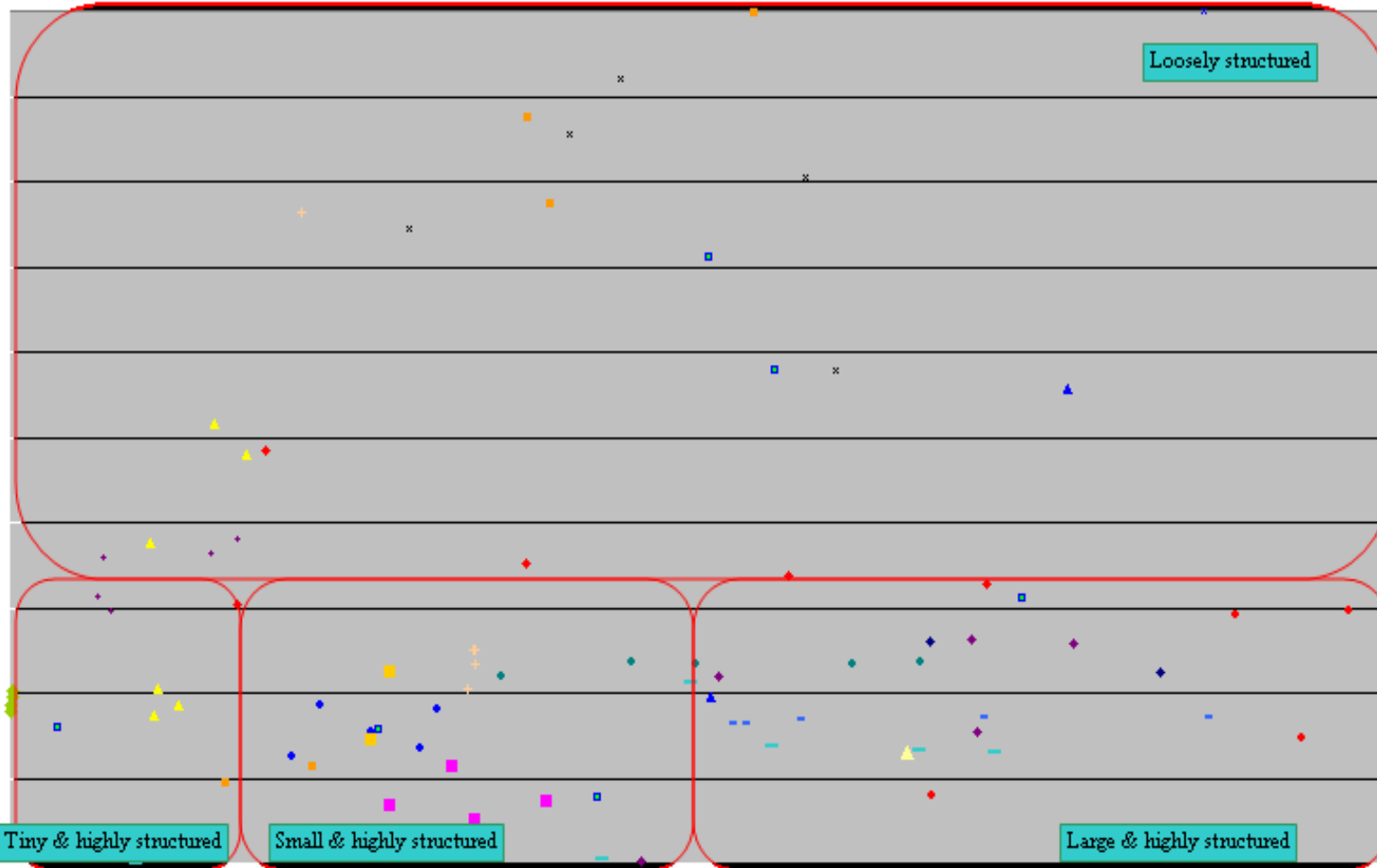
# "Efficiency" means both size + speed

- EXI has demonstrated compaction that always meets or beats the most commonly used compression techniques (zip and gzip).
- Additionally, because EXI decompression goes straight into memory rather than string characters, which then require significant additional parsing, decoding EXI is many times faster than other techniques.
- This approach also reduces memory requirements and power consumption on small devices.
- Because X3D is highly structured and highly numeric, EXI provides major advantages. Alternative bit-centric compression schemes cannot take full advantage of those characteristics.

# EXI Compactness Compared to Gzipped XML



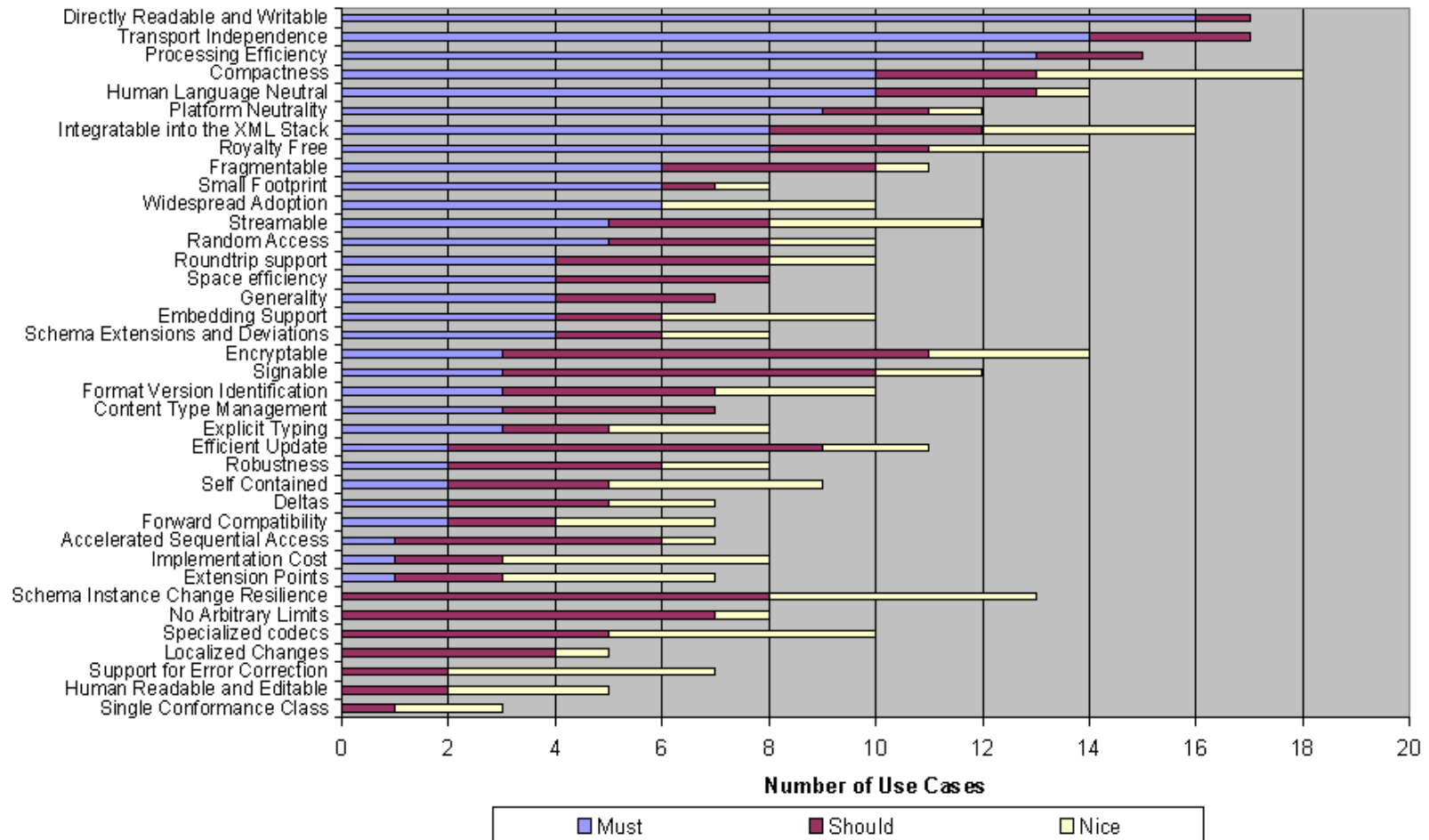
# Broad design coverage of test cases



- ◆ AVCL
- ▲ CBMS
- DataStore
- ◆ FixML
- FpML
- × GAML
- Invoice
- MAGE-ML
- ▲ Misc
- ◆ OpenOffice
- × Seismic
- SVGTiny
- ◆ XAL
- ASMTF
- ▲ EPICS
- Google
- HepRep
- JTLM
- ◆ LocationSightings
- WSDL

# Prioritized coverage of critical properties

Property Demand



# Bruce Hill thesis, March 2015

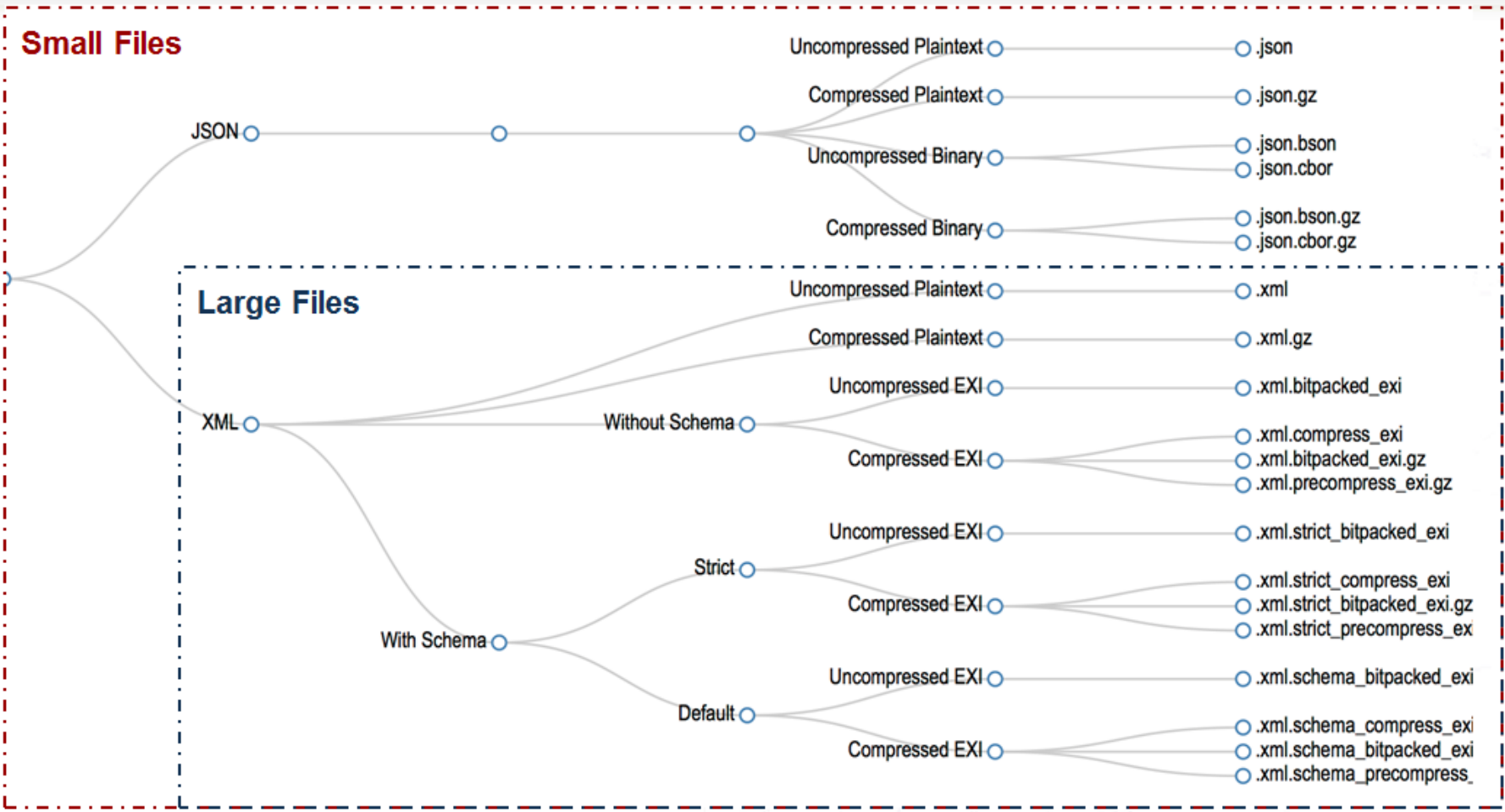
Hill, Bruce, *Evaluation of Efficient XML Interchange (EXI) for Large Datasets and as an Alternative to Binary JSON Encodings*

- Master's Thesis, Naval Postgraduate School, Monterey California, March 2015.
- Links: [catalog](#), [slideset \(.pdf\)](#), [thesis](#).
- EXI configurations properties are significant
- XML Schema is significant: previously a tool for data validation, now a tool for compression
- EXI is generally more compact than JSON-based binary encodings
- EXI performs well on large files

Conclusions



# Encodings Compared



*When in doubt, try every possible combination of options*

# 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-NPS, open source
- Canon recently posted initial exi-js Javascript implementation on GitHub:  
<https://github.com/youennf/exi-js>

Video



A Quick Introduction



# Web Security standards are compatible

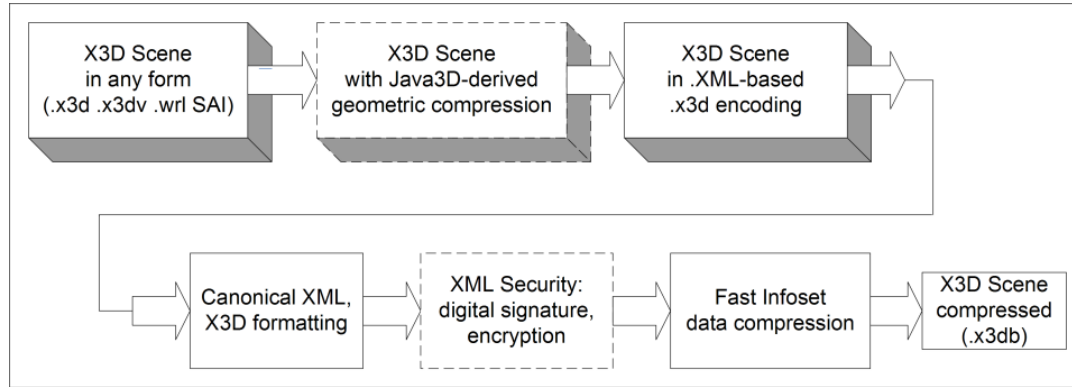
X3D's XML and Compressed Binary encodings allow use of W3C's Security recommendations

- XML Encryption demonstrated in NPS thesis, X3D Basic examples, X3D-Edit
- XML Digital Signature (for authentication)
- 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

# X3D compressed binary algorithm and XML Security



X3D compressed binary uses Canonical X3D form

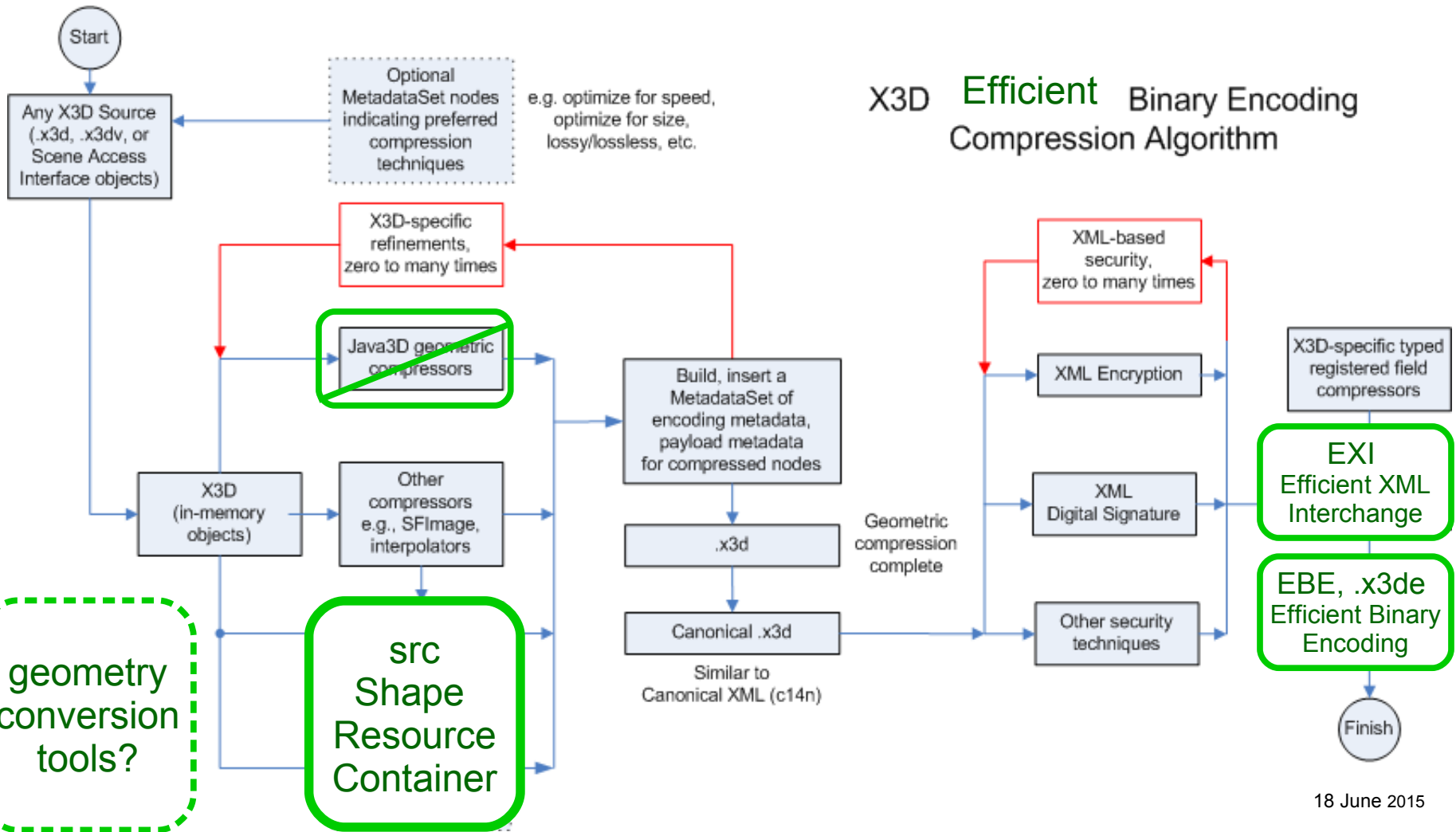
- Strict formatting rules so that files with identical format can be shown to match

Canonical form enables use of XML Security

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

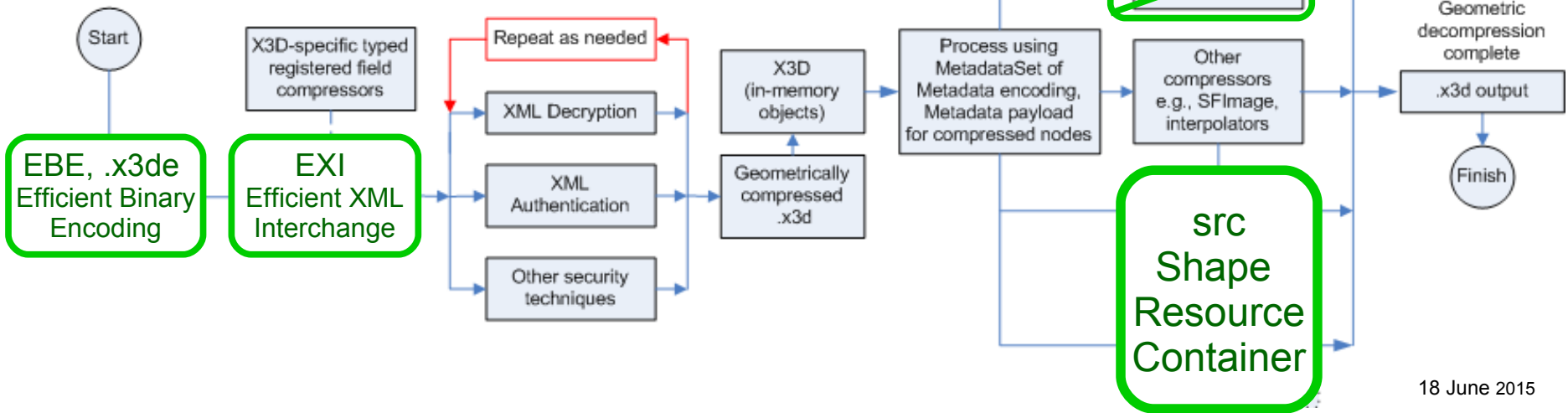
Adding it all up...

# X3D EBE compression algorithm



# X3D EBE decompression algorithm

## X3D Efficient Binary Encoding Decompression Algorithm



18 June 2015

# Anything still missing?

## Specialty compressors

- Volumetric data
- Predictive smoothers for interpolators might be useful for long-form animation streams (e.g. Humanoid Animation H-Anim)

## src Specification Questions

- Separate specification document to aid in re-use?
- Modifications to glTF specification?
- Second implementation?

# Discussion is productive

Please contact us or respond publicly if additional technologies need consideration

X3D futures planning is

- Topic of 1st Wednesday monthly X3Dteleconference
- Web3D Consortium member-decided activity
- Always open to community inputs

All feedback is welcome

- Sooner or later, all results get public review before Web3D approval and ISO review
- Thanks for considering the possibilities!

# References



# References

## X3D Graphics Specification

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

# Contact

**Don Brutzman**

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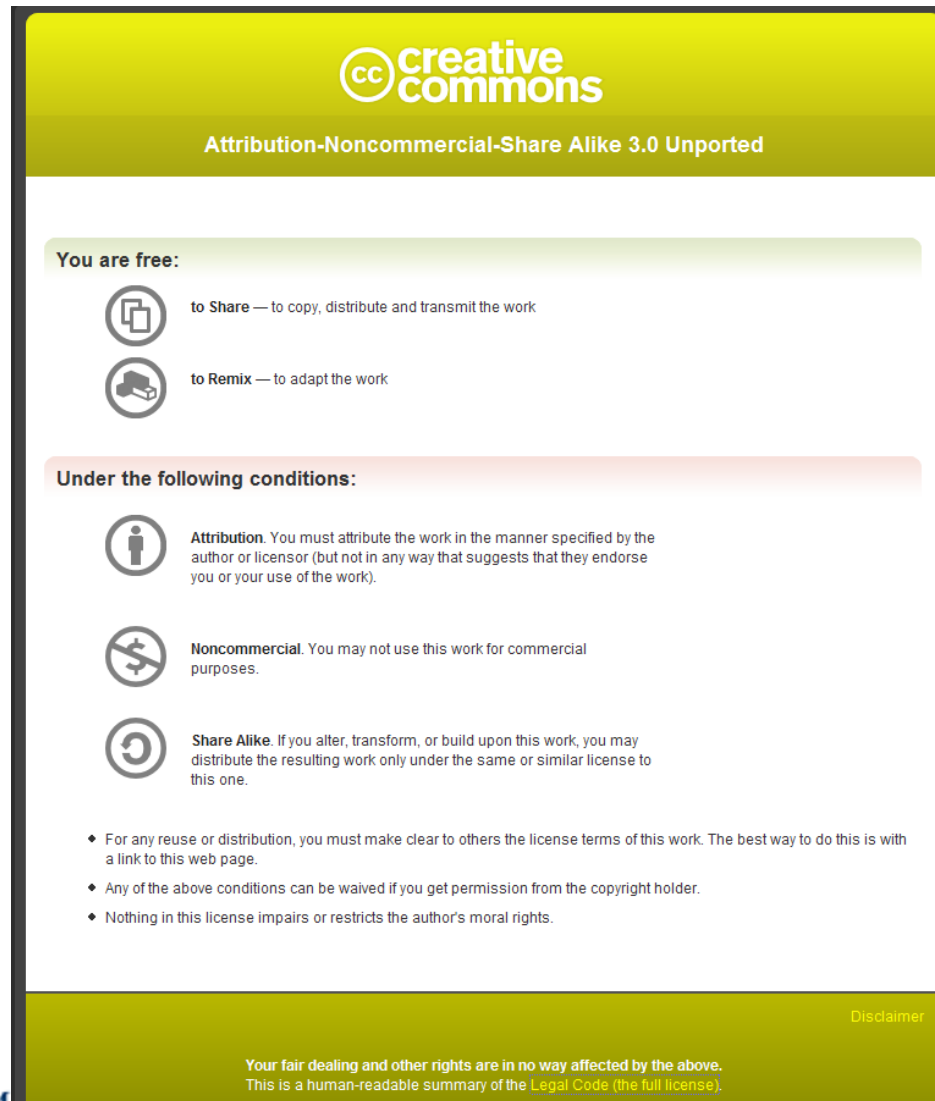
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