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

- 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 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

• 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
• 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

Start

.x3db
X3D Compressed Binary Encoding

Fast Infoset (FI)
XML Binary Decompression

X3D-specific typed
registered field compressors

Repeat as needed

XML Decryption

XML Authentication

Other security
techniques

X3D (in-memory objects)

Process using
MetadataSet of
Metadata encoding,
Metadata payload
for compressed nodes

Repeat as needed

Java3D geometric
compressors

Other compressors
e.g., SFImage, interpolators

Vendor-specific
compression

Optional prototypes
for compressed
versions of nodes
e.g., ShapeCompressed

Geometric decompression complete

.x3d output

Finish

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
- 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

GZIP makes some cases larger

Over 100x smaller than XML and 14x smaller than GZIP
Broad design coverage of test cases
Prioritized coverage of critical properties
Conclusions

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
When in doubt, try every possible combination of options
EXI implementations

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

• Exificarient, 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
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)
- 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

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

Any X3D Source (x3d, x3dv, or Scene Access Interface objects)

Optional MetadataSet nodes indicating preferred compression techniques
e.g. optimize for speed, optimize for size, lossy/lossless, etc.

X3D-specific refinements, zero to many times

Java3D geometric compressors

X3D (in-memory objects)

Geometry conversion tools?

src Shape Resource Container

X3D specific typed registered field compressors

EXI Efficient XML Interchange

EBE, .x3de Efficient Binary Encoding

XML-based security, zero to many times

XML Encryption

XML Digital Signature

Other security techniques

Geometric compression complete

Canonical .x3d

Similar to Canonical XML (c14n)

Canonical .x3d

Build, insert a MetadataSet of encoding metadata, payload metadata for compressed nodes

.x3d

XML-based

Finish

18 June 2015
X3D EBE decompression algorithm

Efficient Binary Encoding Decompression Algorithm

Start

X3D-specific typed registered field compressors

Repeat as needed

XML Decryption

XML Authentication

Other security techniques

X3D (in-memory objects)

Geometrically compressed .x3d

Process using MetadataSet of Metadata encoding, Metadata payload for compressed nodes

Other compressors e.g., SImage, interpolators

Repeat as needed

Java3D geometric compressors

Geometric decompression complete

.src Shape Resource Container

.x3d output

Finish

EBE, .x3de
Efficient Binary Encoding

EXI
Efficient XML Interchange
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

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