X3D Efficient Binary Encoding Progress Summary

X3D Working Group, Web3D Consortium

Don Brutzman
brutzman@nps.edu

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Goals and Approach

• Upgrade X3D Compressed Binary Encoding design to improve capabilities, as listed in Call For Contributions

• Design requirements:
  – Full representational capability for X3D graphics
  – Royalty free (RF), two or more implementations

• Components
  – Shape and geometry compression using
    • SRC, Shape Resource Container by Fraunhofer IGD
    • Streamable progressive mesh at run time
  – Efficient XML Interchange (EXI) compressed XML, compatible with digital signature and encryption
    • W3C Recommendation, multiple implementations available
  – Still needed: typed compressors for interpolators, volumes
X3D Binary Capabilities Timeline

• **Annual.** Web3D has published and reviewed goals and developmental capabilities annually at the Web3D Conferences and SIGGRAPH in 2013, 2014, and 2015.

• **2012.** Efficient XML Interchange (EXI) is a fully approved W3C Recommendation with multiple implementations (both commercial and open source).

• **2013.** We accomplished our strategic goal to define revised X3D Compressed Binary Encoding (CBE) requirements and planned all steps needed to proceed.

• **2014.** We received multiple contributions for geometric compression and progressive streaming for X3D.

• **2015.** Decision: retain existing Compressed Binary Encoding (.x3db) for model stability, add Efficient Binary Encoding (.x3de) for improved capabilities.

• **2015.** Major necessary components are in hand. Now possible to begin in-depth implementation and specification-writing efforts. Still needed:
  – Non-geometric data types like interpolators deserve additional compression options.
  – Volume Compression is less common and may deserve a follow-on Call for Contributions.

• **Target completion?** Given sufficient member contributions, likely 2016.
  – Not “if,” simply “when” all due-diligence efforts are complete.
CAD Distillation Format (CDF)

• Developed by first X3D CAD Working Group
• Allows creation of small specialty encoders suitable for individual X3D data types
• Iterative process
  – Identify and replace sections of scene graph with compressed or distilled alternatives
  – Metadata nodes document revisions, reversability
  – Intermediate, final results remain valid X3D scenes
SRC: Shape Resource Container

- Flexible, highly efficient format for progressive transmission and compositing of 3D asset data
  - Meshes, textures, arbitrary vertex attributes
  - Related improvements shown by image retrieval
- ExternalGeometry node retrieves data via url
  - Alternative to Shape (not to entire scene graph)
  - Data is also sharable by other such Shape nodes
- SRC appears to be useful for all X3D encodings
  - Separate specification, will apply for MIME type
  - Alignment with Khronos binary glTF under review
EXI: Efficient XML Interchange

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

Further tuning possible with EXI Options
• Adaptive tokenization, compression tables
• Can stabilize on a document type or further refine based on statistical analysis of corpus
“Efficiency” means both size and speed

- EXI has demonstrated compaction that always meets or beats all of the most commonly used compression techniques (zip and gzip, Fl, many others).
- 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.
## Comparison .x3db, .x3de

<table>
<thead>
<tr>
<th>Compressed Binary Encoding (CBE)</th>
<th>Efficient Binary Encoding (EBE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>File extension</strong> .x3db</td>
<td><strong>File extension</strong> .x3de</td>
</tr>
<tr>
<td>X3D encoding ISO/IEC 19776-3</td>
<td>X3D encoding ISO/IEC 19776-4</td>
</tr>
<tr>
<td><strong>Geometric compression</strong>: Java3D</td>
<td><strong>SRC Shape Resource Container</strong></td>
</tr>
<tr>
<td>• Deering patented algorithms</td>
<td>• Fraunhofer IGD algorithms</td>
</tr>
<tr>
<td>• Royalty free (RF) status never secured before Sun Microsystems purchased</td>
<td>• Submitted on Royalty Free (RF) basis</td>
</tr>
<tr>
<td>• No progressive mesh or streaming</td>
<td>• Progressive mesh and streaming</td>
</tr>
<tr>
<td>• Suitable for use with all X3D encodings</td>
<td>• Exploring synergy: Khronos Binary glTF</td>
</tr>
<tr>
<td><strong>XML compression</strong>: Fast Infoset (FI), 2005</td>
<td><strong>Efficient XML Interchange (EXI)</strong>, 2011</td>
</tr>
<tr>
<td>• ISO Standard</td>
<td>• W3C Recommendation, best of breed</td>
</tr>
<tr>
<td>• Many other approaches evolved</td>
<td>• XML schema-aware datatype compression</td>
</tr>
<tr>
<td>• <a href="en.wikipedia.org/wiki/Fast_Infoset">en.wikipedia.org/wiki/Fast Infoset</a></td>
<td>• Always beats .zip, .gzip, FI, others</td>
</tr>
<tr>
<td></td>
<td>• Significant performance speedups</td>
</tr>
<tr>
<td></td>
<td>• Shown suitable for small devices</td>
</tr>
<tr>
<td></td>
<td>• <a href="en.wikipedia.org/wiki/Efficient_XML_Interchange">en.wikipedia.org/wiki/Efficient_XML_Interchange</a></td>
</tr>
</tbody>
</table>
Compression algorithm CBE (.x3db)
Compression algorithm EBE (.x3de)
Decompression algorithm CBE (.x3db)
Decompression algorithm EBE (.x3de)
References

• Web3D Consortium
  – http://www.web3d.org

• X3D Compressed Binary Encoding Activity
  – http://www.web3d.org/working-groups/x3d/compressed-binary-encoding-activity

• X3DOM Shape Resource Container (src)
  – http://x3dom.org/src

• Efficient XML Interchange (EXI) compression
  – http://www.w3.org/standards/xml/exi