TC 43 - Universal 3D File Format

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The Ecma International and TC43

- *Ecma International*

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- *TC43 Officers*

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Scope

- *To facilitate the reuse of 3D CAD data by developing global 3D standards intended for downstream 3D visualization applications.*

Programme of work

- *To standardize a Universal 3D extensible file format and infrastructure focused on the repurposing of 3D CAD data for non-engineering and non-design applications, e.g. training and visualization applications. Notable U3D features include binary encoding, domain-specific compression, continuous level of detail, progressive data representation, animation support, and extensibility to address evolving market needs.*

The U3D File Format

- *History of the U3D File Format*
  - 2003 U3D was Established 3D Industry Forum*
  - Since 2004 Associated with Ecma
  - 2005/2006 First Initiative that U3D should become a standard format
- *Philosophy*
  - U3D Specification is Open
  - U3D Reference Code is available as Open Source

    http://sourceforge.net/projects/u3d/
  - No Licensing is required for the format, Apache open source license for reference code

* The 3D Industry Forum has proposed 2005 that U3D should become a standard format, members of the 3D Industry Forum are: 3Dsolve, Actify, ADL Co-Labs, Adobe Systems Inc, Anark, ATI, The Boeing Company, Cinema4D, Dassault Systemes, Discreet, UGS PLM Solutions, Fraunhofer Institute, Hewlett-Packard, Intel Corporation, Lattice, Lego, mental images, Mercury Computer Systems Inc. (TGS), Microsoft, Mindego, NGRAIN, NVIDIA, OpenHSF, Oregon3D, Parallel Graphics, Parametric Technology Corporation, RadTIME, Realviz, Right Hemisphere, Science Applications International Corporation, SGDL Systems, SolidWorks, and Tech Soft America)

Universal 3D Road-map - 2007/2008

- *Planned extensions and improvements*
  - Extension of the current compression module
  - Adding a new Shading Model to the U3D
  - Completion of the Free-Form Surface (NURBS, Bezier, B-Spline) integration
  - Adding Hierarchical Subdivision Surfaces to the U3D Format
  - Adding PMI Support
  - Removing conflicts in the specification and precise definitions

Industry Acceptance of U3D 1/2

- *Lightweight visualization formats are becoming widely used*
  - **U3D allows us to reuse our CAD** models **for downstream documentation that improves visual communication of product data**
  - **Lightweight formats, like U3D, satisfy a number of use cases and complement the complete (heavy) representation contained in STEP**.
- *U3D is an ECMA standard controlled and defined by an industry consortium*
  - It is the only standard format embedded in pdf and understood by the Adobe Reader 7.0+
  - The large install base of Adobe Reader gives U3D instant market penetration at little cost to industry
  - Harmonization between the two standards is a win-win situation for both STEP and U3D

Industry Acceptance of U3D 2/2

- *U3D has been developed for product data visualization*
  - It is not intended to address general consumer multimedia use cases
  - U3D contains geometry and product structure and can visually represent product manufacturing information
- *Widespread market adoption of lightweight 3D is already starting to occur*
  - Boeing strongly supports an open standard format rather than a proprietary or otherwise restricted format
- *Boeing believes that a harmonized combination of STEP and U3D is a compelling open standard solution for viewing 3D product data in a lightweight format*

Functional Highlights

- *Key-frame and bones-based animation*
  - Facilitates animation for applications that repurpose CAD data
- *Extensibility of U3D format*
  - Allows to address market needs quickly
- *Product Meta Data associated with the Data*
- *Pre-computed Continuous-level-of-detail (CLOD)*
  - Enables applications to increase or decrease model complexity based on needed quality or performance
- *Domain specific compression*
  - Allow for reduced file sizes

Structure of the U3D File Format

- *Binary format, little-endian architecture*
  - small file size and efficient file IO
- *Arithmetic encoding with custom context for each entity*
  - small file size

A File is a Sequence of Blocks

- *Declaration blocks define all entities and their relationship*
  - fast loading and quick structure preview
- *Continuation blocks for geometry, animation, textures,...*
  - progressive loading with priorities

Structure Elements of the U3D File Format

- *External file references or all resources embedded*
- *Scene graph with transformations and object instancing*
- *Each block contains data and meta data*
- *Meta data is a list of key-value pairs*
  - Keys are strings.
  - Values are strings or binary data.

Block Types of the U3D File Format

- *File structure blocks*
- *Node blocks*
  - group node, model node, light node, view node
- *Geometry generator blocks*
  - CLOD mesh generator, point set, line set
  - Free-Form object: Bézier and B-Spline, rational and non-rational, trimming curves. Example: NURBS (ratification pending)
- *Modifier blocks*
  - 2D glyph modifier, subdivision modifier, animation modifier, bone weight modifier, shading modifier, CLOD modifier
- *Resource blocks*
  - Light resource, view resource, lit texture shader, material resource, texture resource, motion resource

Existing Support for U3D (1/2)

- *Format*
  - PDF/E (submitted for ISO ratification, includes normative reference to U3D format)
  - PDF 1.7 (submitted for ISO ratification, includes normative reference to U3D format)
- *Playback*
  - Adobe Reader (version 7 and above) (>500,000,000 shipped in the last two years)
  - Adobe Acrobat 3D Office OCX
  - Adobe Photoshop CS III (shipping soon)
  - U3D Sample Player (SourceForge)

Existing Support for U3D (2/2)

Authoring

- Adobe Acrobat 3D (versions 7 shipping, version 8 upcoming)
- Adobe Photoshop CS III (shipping soon)
- Alibre Design – CAD design
- Actify – CAD document creation, collaboration, visualization
- SolidWorks 2008 – CAD design
- Bentley Microsystems – Architectural CAD design, plant design, geospatial
- Right Hemisphere – CAD document creation
- QuadriSpace – CAD document creation
- Immersive Design – CAD document creation
- Lattice Technology – CAD document creation
- Strata – Conceptual design
- Subdo – CAD document creation
- Kaon – Marketing, training materials creation
- VMD – public domain molecular modeling and visualization
- RenderSoft Systems – creation from Sketch-Up models
- 3DXSoftware – CAD document creation

- ***Libraries/Developer Tools***
  - **ProSTEP AG**
  - **Visual Technologies – PDF3D Library**
  - **TechSoft – HOOPS Library**

Attached Supporting Materials

- *Appendix I: U3D - Detailed Technical Information*

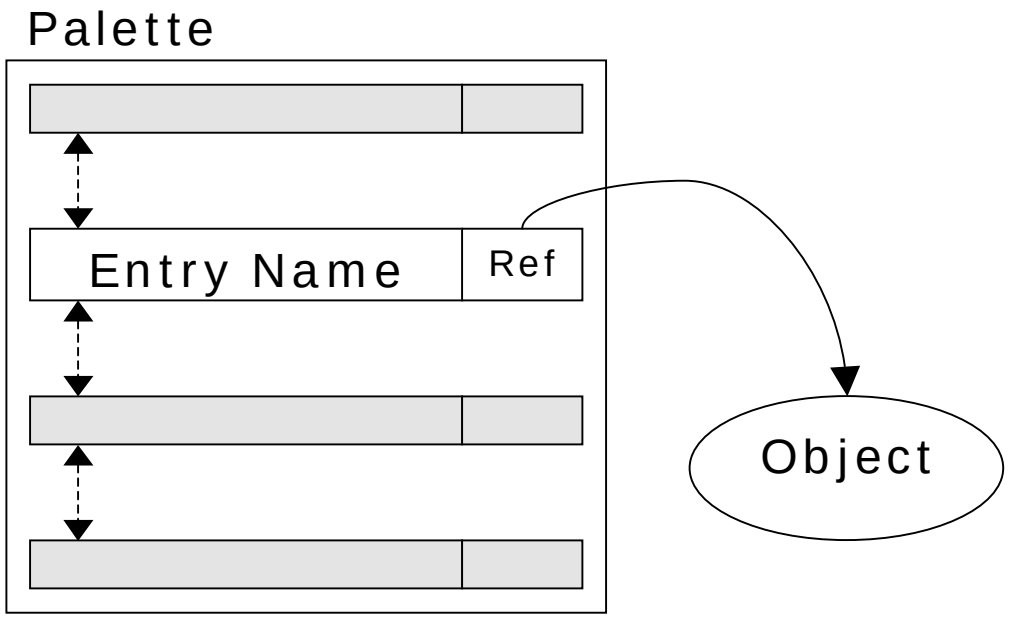
Standard Scope

- *Defines:*
  - Syntax and semantics of the Universal 3D file format, an extensible format for downstream 3D CAD repurposing and visualization, useful for many mainstream business applications.
- *Features include:*
  - Execution architecture that facilitates run-time modification of geometry
  - Continuous-level-of-detail
  - Domain-specific compression
  - Progressive data streaming and playback
  - Key-frame and bones-based animation
  - Extensibility of U3D format and run-time
- *Does not address:*
  - *Rendering of 3D content*
  - *Reliability of the transport layer or communications channel (to be addressed by transport protocols)*
  - *Run-time extensibility of an implementation of the U3D architecture*

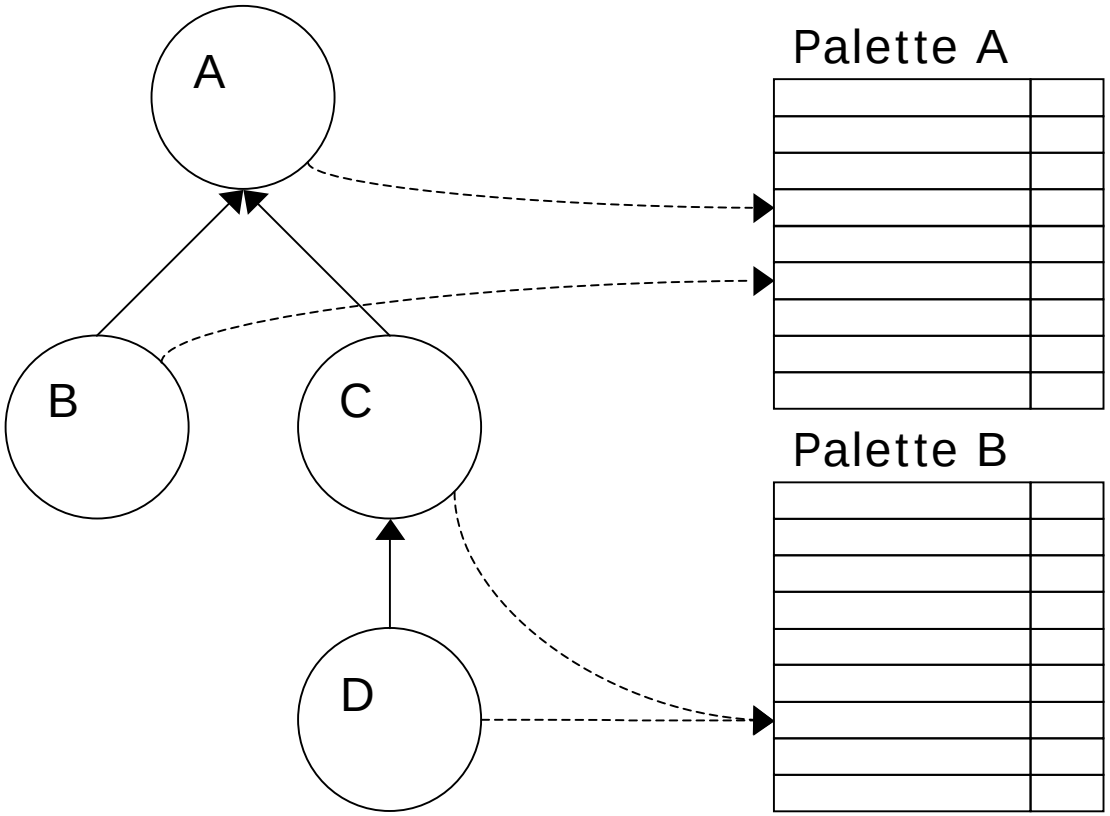
Architecture: Palette

Palette types:

- model resource
  - *CLOD mesh, line set, point set*
- light resource
- view resource
- shader resource
- material resource
- texture resource
  - *JPEG, PNG, TIFF*
- motion resource
- node
  - *group, model, light, view*

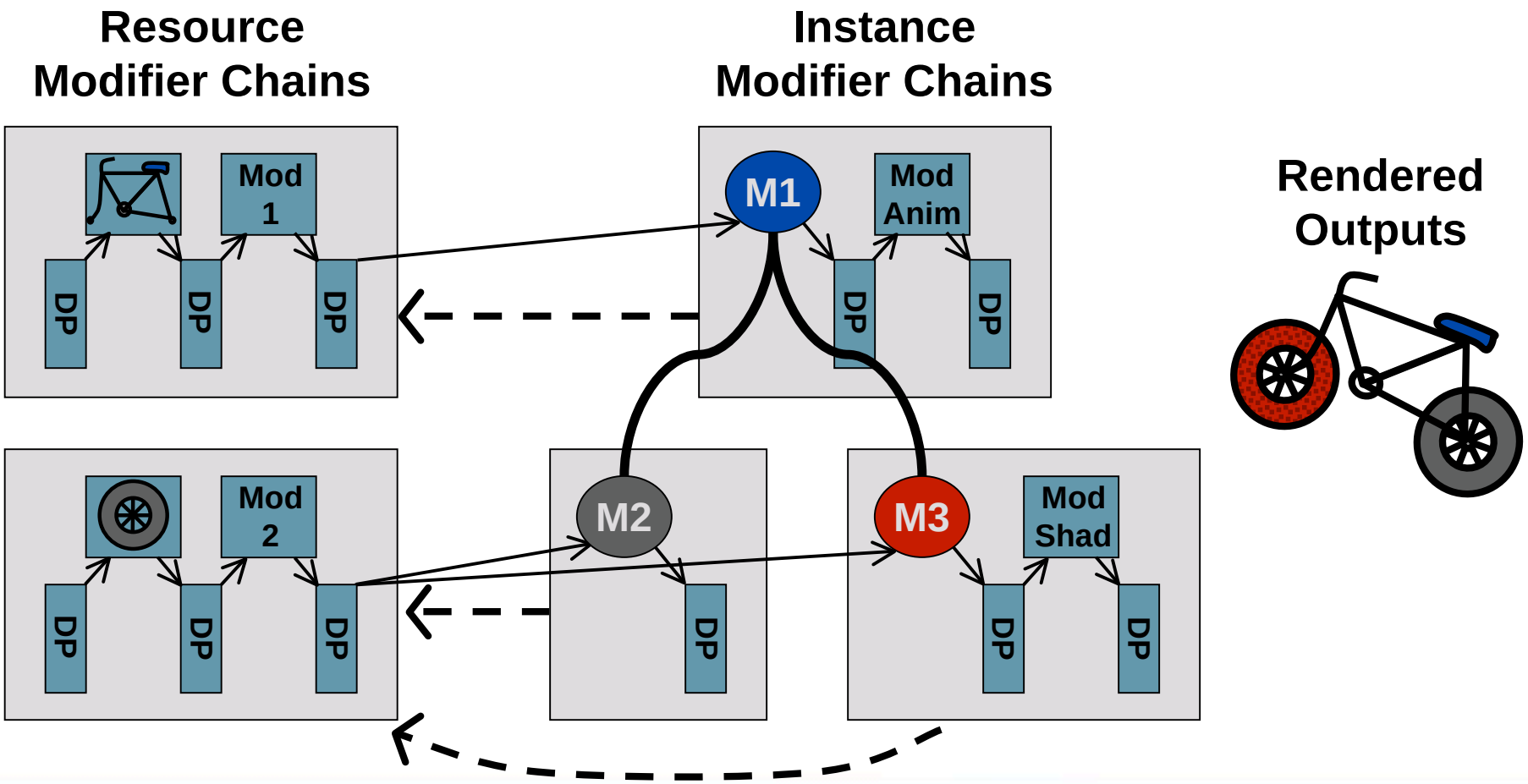


Architecture: Nodes



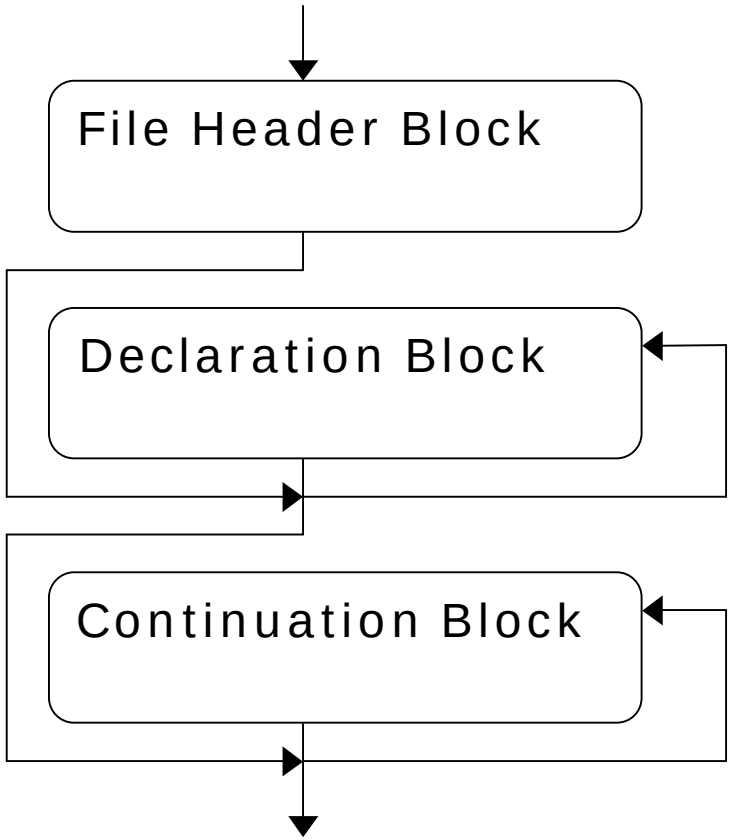
- Nodes have names of palette entries; do not maintain absolute object references for long durations.
- Multiple nodes may use the same resource.
- Nodes have a spatial relationship relative to their parents.
- Which palette is used depends on the type of node.

Architecture: Modifier Chain



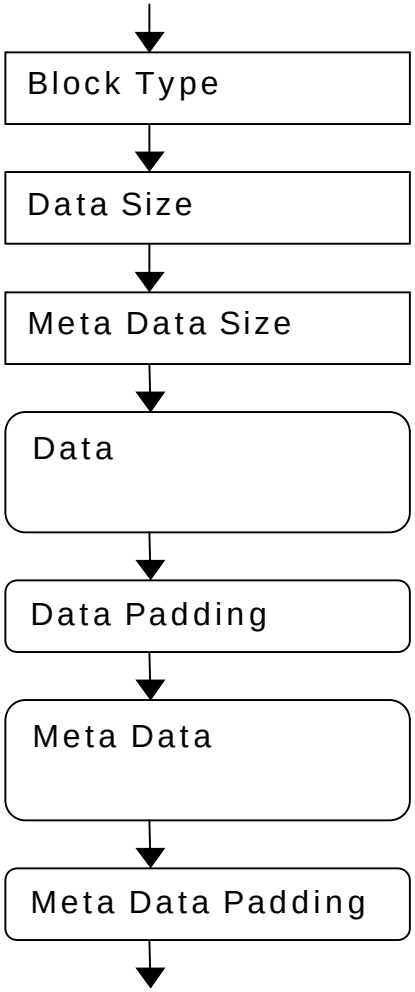
File Format

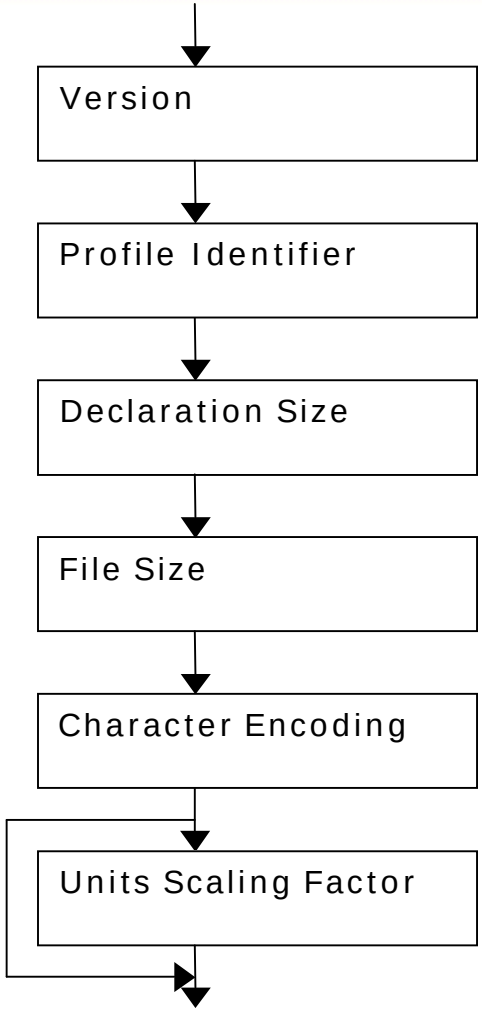
- *Sequence of blocks*
  - Relatively flat
- *All objects represented in declaration section*
- *Most of file size is in continuation section*
  - Geometry
  - Textures
  - Motion



File Format: Low-level Block Structure

- *Block Type identifier (4 bytes)*
- *Data Size (4 bytes)*
- *Meta Data Size (4 bytes)*
- *Data (variable)*
  - Usually starts with Object identifier string
- *Data Padding (0 to 3 bytes)*
- *Meta Data (variable)*
- *Meta Data Padding (0 to 3 bytes)*

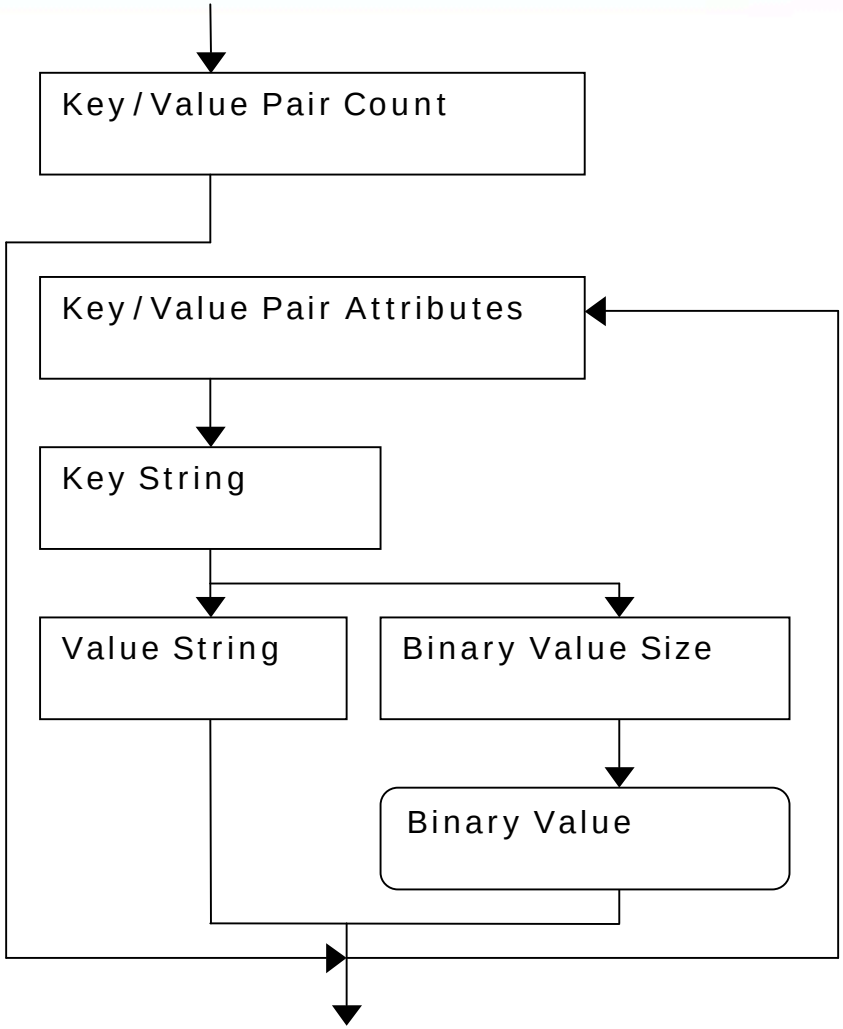




File Format: File Header Block

- *File version*
- *Profile Identifier*
- *Size of declaration section*
- *Size of file*
- *Character Encoding for strings*
- *Optional scaling factor for linear units*

(File header meta data)



File Format: Meta Data Section

- *Every block can contain Meta Data for that object.*

Key/Value Pair Count

- *Sequence of Key/Value pairs*
- *Key is a string.*
- *Value can be either string or binary.*

Bit Encoding Algorithm

- *An arithmetic encoding algorithm*
- *Basic types encoded:*
  - Compressed U32, U16, U8
  - Uncompressed U64, U32, U16, U8, I32, F64, F32, String
- *Compressed types can be*
  - Adaptive based on statistics of previous values
  - Non-adaptive (Static) based on limited range of values

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