

ERCOT Training CIM – Part 2

CIM in a Nutshell

Part 2

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Topics

- Model Exchange
 - File Format Requirements
 - XML Format
 - RDF Schema
- CIM/XML File Types/Formats
 - CIM/XML Full Model Files
 - CIM/XML Partial Model Files
 - CIM/XML Incremental Model Files
- CIM and CIM/XML Tools
 - CIM/XML Display Tools
 - CIM/XML and RDF Validation Tools
 - CIM/XML RDF Schema Generation Tools
 - XML Development Tools
 - ERCOT CIM/XML RDF Tool

File Format Design: Requirements

- NERC required format to be:
 - Both machine and human readable
 - Can be accessed many off-the-shelf tools
 - Is self-describing
 - Takes advantage of current industry standards and widely used
- Additional requirements were needed for certain specialty files such as the Incremental Exchange Files:
 - Represent the differences between two base models.
 - Represent a valid model that can be processed by standard tools.
 - Represent a small difference between 2 large models.

Technology Definition – XML Technology

- **e**Xtensible **M**arku**p** **L**angu**a**ge
 - A text-based tag language, similar in style to HTML but with user-definable tags
 - Based on Standard Generalized Markup Language (SGML), which is ISO 8879.
- Self-describing
- Open industry standard - W3C Recommendation (spec)
 - Broad usage across industries (many XML tools available)
- Cross-platform and vendor-neutral standard
- Easy to use, easy to implement

Technology Definition – XML (Continued)

- It was designed to provide exchange and simplify integration between the internet and other applications.
- The format is currently supported in MicroSoft Word, MicroSoft Excel and All Browsers and many other products
- Used to describe content for data intensive web pages
- Universally accepted format for *metadata* (information about data) and messaging:
 - Object Management Group (OMG)
 - Open Applications Group (OAG)
 - World Wide Web Consortium (W3C)
 - Internet Engineering Task Force
 - IBM, MicroSoft, Oracle, Netscape, etc.

Technology Definition – XML (Continued)

- A format for describing data
- Standard way of sharing structured data
- Largest benefit compared with other message formats is simplicity & openness.
- Web-oriented universal syntax
- XML Schema describes the ordering and inter-relationship of
 - XML elements (i.e., sequence and nesting of tags) and
 - Attributes (i.e., values, types, defaults)
- Is an excellent technology to use for information/data exchange

Technology Definition – XML Basic Syntax

- Starts with XML declaration
`<?xml version="1.0"?>`
- Rest of document inside the "root element"
`<Header>...</Header>`
- All text contained in some element
`<head>Title of the Document</head>`
- Tags are used:
 - To show the structure of a document, so that it can be displayed appropriately
 - To provide information about the document content (metadata)
- Start and end tags must match exactly except for the /

Formatted Poem

The Purple Cow

I never saw a purple cow,
I never hope to see one;
But I can tell you, anyhow,
I'd rather see than be one.

Same Thing In XML

```
<?xml version="1.0"?>
<!DOCTYPE TEI.2 SYSTEM "tei.dtd">
<TEI.2>
<text><body>
<div1 type="poem">
<head>The Purple Cow</head>
<lg>
<l>I never saw a purple cow,</l>
<l>I never hope to see one;</l>
<l>But I can tell you, anyhow,</l>
<l>I'd rather see than be one.</l>
</lg>
</div1>
</body></text>
</TEI.2>
```

Technology Definition – TransformerWinding in XML

```
<xsd:simpleType name="TransformerWinding">
  <xsd:annotation>
    <xsd:documentation>A winding is associated with each defined
terminal of a transformer (or phase shifter).
    </xsd:documentation>
  </xsd:annotation>
  <xsd:restriction base="xsd:QName"/>
</xsd:simpleType>

<xsd:element name="TransformerWinding.b" type="cim:Susceptance">
  <xsd:annotation>
    <xsd:documentation>Magnetizing branch susceptance (B mag).
    </xsd:documentation>
  </xsd:annotation>
</xsd:element>
```

Purpose and Scope – IEC 61970-552-4

- The CIM XML format can be used to exchange any CIM-based information but most exchange content is defined via specific profiles (or subsets) to identify particular exchange requirements.
- CIM XML Format requirements:
 - Both machine and human readable
 - Can be accessed by any tool that supports the Document Object Model (DOM) and other standard XML APIs
 - Is self-describing
 - Takes advantage of current W3C recommendations

Technology Definition – RDF Technology

- “Although we can swap our documents with each other through XML, we still haven’t a clue what they mean.”
 - (“Professional XML Meta Data,” by Kal Ahmed, et al.)
- Resource Description Framework (RDF) is a means to resolve this problem. It defines a mechanism for describing resources.
- For more information: <http://www.w3c.org/RDF>.
- The RDF schema for Model Exchange is fully explained in the IEC 61970-501 Standard
- This framework contains:
 - URI
 - Namespace
 - RDF Schema

Technology Definition – URI

- URI (Uniform Resource Identifier) provides a simple and extensible means for identifying a resource:
 - <ftp://ftp.isi.edu/in-notes/rfc2396.txt>
 - A **Uniform Resource Identifier** (URI) is a string of characters which identifies an Internet Resource.
 - The most common URI is the **Uniform Resource Locator** (URL) which identifies an Internet domain address.

Technology Definition – RDF Namespaces

- Namespaces provide a simple method for qualifying element and attribute names used in XML documents by associating them with namespaces identified by URI references:
 - <http://www.w3.org/TR/REC-xml-names/>
 - The namespace attribute is placed in the start tag of an element and has the following syntax:
`xmlns:namespace-prefix="namespaceURI"`
 - When a namespace is defined in the start tag of an element, all child elements with the same prefix are associated with the same namespace.

Technology Definition – RDF Schema

- RDF Schema is a language for describing vocabularies, for example the CIM vocabulary
- A set of RDF resources (including properties) and constraints on their relationships is part of this language
- A property defines the type, subclass, label and other information about the data.
- A constraint defines the range or domain of the data
- RDF Schema URI unambiguously identifies a single version of a schema
- It provides a mechanism for groups of related resources and the relationships between those resources.
- For more information: <http://www.w3.org/TR/PR-rdf-schema/>

Technology Definition – ACLineSegment in XML/RDF

```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xml:base="siemens">
<xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
<xmlns:cim="http://iec.ch/TC57/2001/CIM-schema-cim10#">
<xmlns:etx="http://www.ercot.com/CIMR11V0/2007/1.0/extensions#"
">
```

```
<cim:ACLineSegment rdf:ID="_
6B1DD5C2CB934E86AC53FFD886E2D1B3">
  <cim:Naming.name>BBD-RSK2</cim:Naming.name>
  <cim:Conductor.bch>2.79</cim:Conductor.bch>
  <cim:Conductor.x>4.3378</cim:Conductor.x>
  <cim:Conductor.r>0.4761</cim:Conductor.r>
</cim:ACLineSegment>
```


Purpose and Scope – IEC 61970-501

- Describes the CIM RDF Schema as used to produce the CIM XML files.
- This standard provides the framework for constructing XML files containing power system modeling information (a.k.a. CIM XML format)
- The standard also provides an overview of an XML document and the CIM Metadata information.
- Example CIM RDF Schema Elements are presented
- A method to generate the CIM RDF Schema is described.

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Full CIM XML Models

- Full CIM XML model files contain a full Power System Model as defined by the CIM or a Profile such as the CPSM.
- The only full CIM XML files in existence today are those files generated based on one of two Profiles – the CPSM or the CDPSM.
- Typically, these files are used by a regulating authority or a neighboring power utility entity that has a desire to update a portion of their model with another entities information.
- The NMMS project will have about 8 different Profiles for the downstream systems such as EMS, MMS, CRR, S&B, etc.

Full CIM XML Models

- Most vendors have developed a full CIM XML model that is used during the EPRI Sponsored Interoperability Tests.
- These files may also be used by the vendor for their demo software or their training sub-systems.
- These files are generally 1-5 Mbytes in size.
- Currently we have a Siemens 100 bus model, an Areva 60 bus model, an ABB 40 bus model, several EDF models and a WAPA 262 bus model.
- Examples of these files will be provided upon request.
- The ERCOT full CIM/XML file is expected to be 500 Mbytes up to 1 Gig

CIM XML Partial Models

- A CIM XML Partial Model file allows the exchange of part of a power system model network.
- Typically these are provided to assist an entity in improving their external model or to add a portion of a model.
- A Partial Model transfer is meant to provide new data – not to change existing data.
- The Data Provider and the Data Receiver must use the same CIM object hierarchy defined in the profile.

CIM XML Partial Models

- Currently all partial model files contain a full substation; however, they may contain any agreed upon level or query definition such as:
 - Company
 - All Substations with a particular Voltage Level
- These files are generally 4-10 Kbytes in size.
- Currently we have 18 Partial Model files.
- Partial Model files in electronic form will be provided upon request.

File Format Design: Incremental File Requirements

- The CIM XML Incremental files are also known as Difference files
- Typically, these files are used by a regulating authority or a neighboring power utility entity that has a copy of the source model and wishes to keep it equivalent to the original source model.

File Format Design: Incremental File Requirements

- CIM XML files for Incremental changes (Difference Models) only need contain the model changes.
- A CIM XML Incremental (Difference) file contains a set of changes between two full power system models.
- The two full power system models must be the same base model but one is the model before the change is made and one is the model after the change is made.

File Format Design: Incremental File Requirements

- Represent the differences between two base models.
- Represent a valid RDF model that can be processed by RDF tools.
- Represent a small difference between 2 large models.
- Delete statements do not contain the statements to accommodate a cascading deletion. This is the responsibility of the receiving entity.

File Format Design: Incremental File Requirements

- Remove operations are not reversible.
- May contain information about itself (authorship, purpose, date, etc.)
- May contain information to protect against conflicts when 2 difference models are created concurrently from the same model (Precondition Statements).

File Format Design: Incremental File Requirements

- The Incremental File may contain 4 types or groups of statements:
 - Header Statements (statements about the difference file itself)
 - Forward Difference Statements (statements found in the new base model but not in the old base model)
 - Reverse Difference Statements (statements found in the old base model but not in the new base model)
 - Precondition Statements (statements found in both the old and new models and considered to be dependencies)
- Any or all of the 4 groups can be empty.

File Format Design: Incremental File Requirements

- To add a resource to a model, use a *Forward Difference* statement.
- To delete a resource from a model, use a *Reverse Difference* statement.
- To update or change a resource in a model, use both a *Forward Difference* and a *Reverse Difference* statement.

Precondition Statements

- Statements that are a subset of both the old and new model and carry no difference information.
- If difference files are applied sequentially, these statements can be omitted.
- The statements are the equivalent of a database locking mechanism to prevent any changes from occurring to those elements.
- Software that processes a difference file should verify that no changes are made to the elements contained in the Precondition statements – or it should warn about incompatible model revisions.
- The Precondition Statements contain data that is in the current model. If the contents of the Precondition Statements are not in the current model, the changes contained in the remainder of the file should be rejected and not put into the model.

Difference File Usage

- To add a resource to a model, use a *Forward Difference* statement.
- To delete a resource from a model, use a *Reverse Difference* statement.
- To update or change a resource in a model, use both a *Forward Difference* and a *Reverse Difference* statement.

Difference File Example

```
rdflib:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:cim="http://iec.ch/TC57/2003/CIM-schema-cim10#"
  xmlns:dm="http://iec.ch/2002/schema/CIM_difference_model" <?xml version="1.0"
  encoding="UTF-8"?>
< #">
  <dm:DifferenceModel about="">
    <dm:reverseDifferences rdf:parseType="Statements">
      <rdf:Description rdf:about="#_C5A3369878B749F7A21C3F9C6FF29867">
        <cim:Conductor.r>1.94408</cim:Conductor.r>
        <cim:Conductor.x>11.90251</cim:Conductor.x>
      </rdf:Description>
    </dm:reverseDifferences>
    <dm:forwardDifferences rdf:parseType="Statements">
      <rdf:Description rdf:about="#_C5A3369878B749F7A21C3F9C6FF29867">
        <cim:Conductor.r>2.578875</cim:Conductor.r>
        <cim:Conductor.x>9.2575</cim:Conductor.x>
      </rdf:Description>
    </dm:forwardDifferences>
  </dm:DifferenceModel>
</rdf:RDF>
```

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CIM/XML Display Tools

- The most popular display tool is XML Spy
 - Developed by Altova - www.altova.com
 - Display the file in a nice indented, readable format
- Newly developed CIM Spy
 - Specifically developed to read CIM XML files
 - Available at CIM User's Group Web Site or from Jun Zhu at Areva
- Microsoft
 - XML Notepad
 - Simple editor
 - BizTalk Server Editor
 - Essentially replaces XML Notepad

CIM/XML & RDF Validation Tools

- CIMValidate
 - Validates an RDF model against a schema
 - Both model and schema are read from XML documents conforming to the W3C RDF Model and CIMXML RDF Syntax Recommendation
 - Generates a summary report of number of instances of CIM classes included in the model
 - Available from sourceforge, cimxml Yahoo egroup, or Langdale Consultants
- CIMVT
 - Validates against an RDF/OWL schema
 - Validates the CIM XML file against a Profile
 - Generates a summary report
 - Available from CIM User's Group or Jun Zhu at Areva

CIM/XML & RDF Validation Tools

- Mercury CIM XML Online Validator
 - Part of Mercury CIM Toolkit
 - Validates an RDF model against a schema
 - Validates the CIM XML file against a Profile
 - Generates a summary report
 - Available from University of Strathclyde web site

CIM/XML & RDF Validation Tools – CIMValidate

- Two commands are Validate and Report
 - Validate - Validates the model against the schema. This is the default if no option is supplied.
 - Report - Generates a summary of the model on the standard output.
- Validate Example Output:
 - A type must be defined as a class
 - The subject must be instance of Naming
 - The subject must be instance of SubControlArea
- Report Example Output:
 - Total statements: 31869
 - 137 ACLineSegment
 - 5 BaseVoltage
 - 660 Bay
 - 676 Breaker

CIM/XML & RDF Validation Tools - CIMVT

- Tool and documentation developed by Areva is available from the CIM User's Group site (<http://sharepoint.ucausersgroup.org/CIM> from the Public Documents/CIM Tools folder.)
- CIMVT is based on open-source Eyeball (<http://prdownloads.sourceforge.net/jena/eyeball-1.3b.zip?download>)
- CIMVT 1.0 was built on the top of Eyeball 1.3. Specifically, it provides:
 - A CIM/OWL schema for CIM validation
 - A CPSM/OWL restriction schema for CPSM-compliance checking
 - An Eyeball configuration proper for CIM/CPSM validation
 - A UI for viewing, sorting and interpreting validation results
- CIMVT was initiated by the CIMug Validation Task Force and it is intended to be released as an open source to benefit the CIM communities.

CIM/XML & RDF Validation Tools – Mercury

- Online Validator provided by the University of Strathclyde's Mercury CIM Toolkit. To use this tool, register at <http://monaco.eee.strath.ac.uk/mercury>
- Allows a user to validate a power system model in CIM format against a pre-defined profile.
- Includes all conditional rules for defining minimum attributes, association and cardinality.
- The validation process takes place in two steps:
 - First stage checks the file for CIM compliance and flags any unsupported classes, attributes and associations
 - Second stage validates the CIM power system model against a profile and provides the user with details on which instances failed to validate and the rules that were not met.

CIM/XML RDF Generation Tools

- Xpetal
 - Generates RDF schema from CIM UML Rose .mdl or .ptl file
 - Generates HTML report from an RDF schema to read in browser
 - Recently enhanced to generate XML schema from CIM
 - RDF Generator (Xpetal) (to convert UML to RDF) and documentation is available at the cimxml egroup site and on the SourceForge web site. The latest version can be obtained from http://www.langdale.com.au/styler/xpetal_

XML Development Tools

- Document Managers utilize and manage schemas and documents
- TIBCO Extensibility
 - XML Console (part of Turbo XML suite)
 - Project management, batch conversion and validation
 - Auto-document generation on schemas
 - XML Developer/Canon
 - Repository
 - Source management and version control
 - Uses RDBMS – Oracle or SQL Server
- Microsoft
 - BizTalk Framework
 - Complete suite of tools
 - Mapping data structures, document tracking, etc.
 - Builds on SQL Server

ERCOT CIM/XML RDF Tool – CIMTool

- This is an Open Source tool that is being developed by Langdale.
- ERCOT is working with Langdale to include the ERCOT requirements in the next release of this tool.
- When complete, CIMTool will:
 - Validate the model against the ERCOT schema
 - Generate the RDF Schema file for the ERCOT schema
 - Reports - Generate a set of reports
- Validation will include:
 - XML and RDF syntax and semantics
 - Domain Range checking
 - Connectivity checks
 - Validation of the CIM Classes, Attributes, Associations and Cardinality
- This tool will be made available to all ERCOT TSPs

Contact for Additional Information

- For copies of the following documents, send an email to mgoodrich@ercot.com:
 - CIM RDF Schema Standard – IEC 61970-501 - PDF Format
 - CIM XML Model Data Exchange Format Standard - IEC 61970-552-4 – PDF Format
 - Example CIM XML/RDF Model Files (specify full, partial, incremental or all)
 - List of Web-sites for XML & RDF information
 - Documentation about the XML tools
 - WWW Links to XML tool sites