Introduction to CIM Software Tools and Methodologies

EPRI Workshop
CIM Role in Smart Grid
for Transmission and Distribution
8-9 September 2010
EPRI, Washington D.C.
The IEC Common Information Model (CIM) - What Is It?

- A set of standards in enable system integration and information exchange based on a common information model
GridWise Interoperability Framework

Role of CIM

1: Basic Connectivity
- Exchange Messages between Systems across a Variety of Networks
- Mechanism to Establish Physical and Logical Connectivity of Systems

2: Network Interoperability
- Understanding of Data Structure in Messages Exchanged between Systems

3: Syntactic Interoperability
- Understanding of Concepts Contained in the Message Data Structures

4: Semantic Understanding
- Relevant Business Knowledge that Applies Semantics with Process Workflow

5: Business Context
- Alignment between Operational Business Processes and Procedures

6: Business Procedures
- Strategic and Tactical Objectives Shared between Businesses

7: Business Objectives
- Political and Economic Objectives as Embodied in Policy and Regulation

8: Economic/Regulatory Policy

Organizational (Pragmatics)
Sample Power System Model
The IEC 61968-1 Interface Reference Model (IRM) Provides The Framework For Identifying Information Exchange Requirements Among Utility Business Functions

All IEC 61968 Activity Diagrams and Sequence Diagrams are organized by the IRM

IEC 61968 Compliant Middleware Services

Electric Distribution Network Planning, Constructing, Maintaining, and Operating

Generation and Transmission Management, Enterprise Resource Planning, Supply Chain, and General Corporate Services
The CIM and Related Standards

• But the CIM standards are more than just an abstract information model expressed in UML

• Profiles for specifying a subset of the CIM classes and attributes for a specific business context at a specific system interface or system interaction

• Implementation models
  – Use of XML to create serialized files and messages
    • RDF Schema-based standards for power system model exchange
    • XML Schema-based standards for information message payloads
  – ETL based on CIM for data base access
    • DDLs for data tables
The IEC Common Information Model (CIM) - What Is It?

• A set of standards in enable system integration and information exchange based on a common information model

• A key differentiator: The CIM standards are based on an electronic information model defined in Unified Modeling Language (UML) representing real-world objects and information entities exchanged within the value chain of the electric power industry
  – Maintained by IEC in Sparx Enterprise Architect modeling tools
  – Provides common semantics for all information exchanges and data access
    • Referred to as Model-Driven Integration (MDI)
Modeling Platforms

- **Enterprise Architect (EA) - Sparx Systems**
  - Add-ins from third parties
  - CIMinEA, CiConteXtor, MD3i, CIM EA
- **Rational Software Architect (RSA) – IBM**
- **Eclipse**
  - Plug-ins from third parties
  - CIMTool, crxcat, JCleanCim, CIMCLipse
We Need An Organizing Framework

- Layered Reference Architecture for TC57
- Based on UN/CEFACT
  - Information Model
  - Contextual Model
  - Message Syntax
    - Rules for Message Assembly
TC57 Layered Architecture

Information and Semantic Models

CIM UML

Information Model
- Generalized model of all utility objects and their relationships
- Application independent

Context

Profile

Contextual layer restricts information model
- Constrain or modify data types
- Cardinality (may make mandatory)
- Cannot add to information model

Message Syntax

Schemas
- XSD, RDFS, DDL

Message/data syntax describes format for instance data
- Can re-label elements
- Change associations to define single structure for message payloads
- Mappings to various technologies can be defined
Example: Power Flow Network Model Exchange

**Information and Semantic Models**
- **CIM UML**
  - Conforms to IEC 61970-301 CIM
  - Information Model
    - Defines all concepts needed for exchange of operational load flow models
      - Reused parts
      - New extensions

**Context**
- **Power System Model Profile Group**
  - Conforms to IEC 61970-452, 453, 456, others
  - Model Exchange Profile
  - Contextual layer restricts information model
    - Specifies which part of CIM is used for static/dynamic model exchange
    - Mandatory and optional
    - Restrictions
    - But cannot add to information model

**Message Syntax**
- **CIM/RDF Schema**
  - Conforms to IEC 61970-501 and -552 CIM XML Model Exchange Format
  - File syntax
    - Can re-label elements
    - Change associations to define single structure for message payloads
    - Mappings to various technologies can be defined
CIM Tools for CIM Power System Models

Information and Semantic Models

- CIMinEA
- JCleanCim

CIM UML validation and auto-generate Word document content

Context

Power System Model Profile Group

Message Syntax

- CIMSpy
- CIMPhony
- CIMvian
- crxcat

CIM/RDFS/XML file browser, editor, validator
CIM Tools for CIM Power System Models

**Information and Semantic Models**
- CIM UML
  - CIMinEA
  - JCleanCim
- CIM UML and network model profile validation
  - CIMClipse

**Context**
- Power System Model Profile Group
- CIM profile and message schema creation and validation
  - CIMTool

**Message Syntax**
- RDF Schema
  - CIMSpy
  - CIMPhony
  - CIMvian
  - crxcat
CIM Tools for CIM Power System Models

Information and Semantic Models

- CIM UML
  - CIMinEA
  - JCleanCim

Context

- Power System Model Profile Group

Message Syntax

- RDF Schema
  - CIMSpy
  - CIMPhony
  - CIMvian
  - crxcat

- CIM profile and message schema creation and validation

- Red – EA
- Blue – Eclipse
- Violet – IE

- CIMConteXtor
- CIM EA

- CIMTool
CIM Tools for Power System Models

- CIM/RDFS/XML file browser, editor, validator
  - CIMSpy, CIMPhony, CIMvian
    - Crxcat (CIM/RDF/XML file concatenator)
- CIM profile and message schema creation and validation
  - CIMTool, CIM EA, CimConteXtor, CIMBench
- CIM UML and network model profile validation
  - CIMCLipse
- CIM UML validation and auto-generate Word document content
  - CIMinEA, JCleanCIM
CIM Tools for CIM Message Payloads

**Information and Semantic Models**
- CIM UML
  - CIMinEA
  - JCleanCim

**Context**
- IRM-based Message Payloads
  - CIMConteXtor
  - CIM EA
  - MD3i

**Message Syntax**
- XML Schema
  - CIMTool
  - CIMBench

- Red – EA
- Blue – Eclipse
- Violet – IE
CIM Tools for XSD Message Payload Generation based on Extended CIM

- **Enterprise Add-ins**
  - MD3i, CIM EA, CimConteXtor

- **Eclipse Plug-ins**
  - CIMTool
Enterprise Semantic Models – CIM + Other Industry Standards

Private UML Extensions → CIM UML → Merge – resolve semantic differences → Other Information Models

Context

Profile

Contextual layer restricts information model
- Constrain or modify data types
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Message Syntax

Schemas XSD, RDFS, DDL

Message/data syntax describes format for instance data
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Role of Enterprise Semantic Model

Enterprise Semantic Model

Open Standards

Business Definitions

Application Information

Process Integration

BPM/Workflow

Business Intelligence

Applications Metadata

Enterprise Integration Platforms

Xtensible Solutions
Building and Using an ESM for Generating Canonicals (XSDs, DDLs, others)

1) Establish Vocabulary
   • Control Content
   • Collaborate
   • Identify and refine semantics

2) Develop ESM
   • Model using vocabulary terms
   • Refine context

3) Generate Canonicals
   • Syntactically and semantically consistent canonical models

Compliments Xtensible MD3i
Let’s Apply to a Utility Project
- Service Oriented Architecture (SOA)

Enterprise Semantic Model

CIM UML Extensions → CIM UML → Merge – resolve semantic Differences → Profile 1

Context

System Interface Design Document

Profiles 1xx System Integrations
Profiles 2xx Network Models
Profiles 3xx Data Warehouse

Interface Syntax

Reusable Services (WSDLs) and Canonical Models

Message XML Schema
- Message payloads

CIM/RDF Schema
- Network models

DDL
- Data tables

MD3i
# CIM Tools

<table>
<thead>
<tr>
<th>Name</th>
<th>Supplier</th>
<th>Purpose</th>
<th>Platform</th>
<th>Description</th>
<th>Source</th>
<th>Actively maintained</th>
<th>Links</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise Architect</td>
<td>Sparx Systems</td>
<td>UML model management and maintenance</td>
<td>Enterprise Architect Add-in</td>
<td>Visual modeling platform used to manage/maintain the CIM model and design artifacts, such as activity/sequence diagrams, profiles, message definitions. - comprehensive UML analysis and design tool - modeling for business, software, systems - full traceability from requirements to deployment - scalable, team-based repository - enterprise frameworks, BPMN, many third party add-ins available</td>
<td>Licensed for fee from Sparx System</td>
<td>Yes</td>
<td><a href="http://www.sparxsystems.com.au">http://www.sparxsystems.com.au</a></td>
</tr>
<tr>
<td>Eclipse</td>
<td>Eclipse consortium of companies. (Originally IBM)</td>
<td>Platform and modeling environment for developing Java-based plugins</td>
<td></td>
<td>Eclipse is: - An Integrated Development Environment (IDE) for Java providing tooling to manage workspaces; to build, launch and debug applications; to share artifacts with a team and to version code; and to easily customize the programming experience - A platform because it is not a finished application per se but is designed to be extended indefinitely with more and more sophisticated tooling built as plug-ins</td>
<td>Eclipse Public License</td>
<td>Yes</td>
<td><a href="http://www.eclipse.org">http://www.eclipse.org</a></td>
</tr>
<tr>
<td>CIM EA</td>
<td>Xtensible Solutions</td>
<td>CIM modeling and design</td>
<td>Enterprise Architect Add-in</td>
<td>CIM EA extends Enterprise Architect to provide a single environment in which users can manage the IEC Common Information Model (CIM), CIM Profiles, and CIM-based artifacts such as RDF and XSD message generation. With CIM EA, users can create and edit CIM Profiles as standard UML models and generate CIM-based artifacts from those models, all within Enterprise Architect.</td>
<td>Freeware</td>
<td>Yes</td>
<td><a href="http://www.cimea.org">www.cimea.org</a></td>
</tr>
<tr>
<td>CIMBench</td>
<td>BTC and EWE, Germany</td>
<td>Develop and generate CIM-based XML schema for message payloads</td>
<td></td>
<td>Used for: - development of CIM-based XML schema - exploring the CIM - comparing CIM models</td>
<td><a href="https://www.btc-ag.com">BTC</a></td>
<td>?</td>
<td>Contact wolfram.krause(at)eewe.de or ralf.walther(at)btc-ag.com</td>
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**CITIC Solutions**
## CIM Tools

<table>
<thead>
<tr>
<th>Tool Name</th>
<th>Description</th>
<th>License</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIMCLipse</td>
<td>Umbrella name for tools used for CIM-related tasks on Eclipse or its plugins</td>
<td>Open Source</td>
<td><a href="http://wwwdi.supelec.fr/software/cimclipse">http://wwwdi.supelec.fr/software/cimclipse</a></td>
</tr>
<tr>
<td>CimConteXtor</td>
<td>CIM UML model-based tool to transform UML model to message schemas</td>
<td>Freeware</td>
<td>[Email to <a href="mailto:contact@zamiren.fr">contact@zamiren.fr</a> for download](mailto:Email to <a href="mailto:contact@zamiren.fr">contact@zamiren.fr</a> for download)</td>
</tr>
<tr>
<td>CIMinEA</td>
<td>Create IEC document content, validation, Rose migration, and model merge</td>
<td>Freeware</td>
<td><a href="http://cimphony.org/cimphony">being replaced with CIMinEA</a></td>
</tr>
<tr>
<td>CIMPhony</td>
<td>Support for RDF, profiles, validation, transformation, Web services, topological processing, geographical visualization</td>
<td>Open Source</td>
<td><a href="http://cimphony.org/cimphony">http://cimphony.org/cimphony</a></td>
</tr>
<tr>
<td>CIMSpy</td>
<td>CIM/RDF/XML file browser, editor, and validator</td>
<td>Freeware under GNU public licenses</td>
<td><a href="http://www.powerinfo.us/WebPages/opensource.html">www.powerinfo.us/WebPages/opensource.html</a></td>
</tr>
</tbody>
</table>
# CIM Tools

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<thead>
<tr>
<th><strong>CIMTool</strong></th>
<th><strong>CIM profile and message schema creation and validation</strong></th>
<th><strong>Eclipse plug-in</strong></th>
<th><strong>Used to:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CIMTool</strong></td>
<td>Langdale Consultants</td>
<td>Eclipse</td>
<td>* read and merge CIM and local UML models in XMI form</td>
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<td></td>
<td></td>
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<td>* browse models and check inconsistencies</td>
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<td></td>
<td></td>
<td>* generate equivalent OWL ontologies</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>* create and edit profiles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* generate XML schemas, OWL and RDFS ontologies for profiles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* validate instances against profiles (including very large CIM/XML instances)</td>
</tr>
</tbody>
</table>

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<tr>
<th><strong>CIMvian</strong></th>
<th><strong>CIM RDF/XML graphical browser and editor</strong></th>
<th><strong>Java code on Eclipse</strong></th>
<th><strong>Tool to visualize and analyse CIM RDF schemas and CIM XML instance files. Single purpose tool to concatenate CIM/RDF/XML files for input into tools that require a single document as input.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>crxcat</strong></td>
<td><strong>Available on CIMug SharePoint METI group site</strong></td>
<td><strong>Java code on Eclipse</strong></td>
<td><strong>Java application to create IEC standard compliant Word documents from UML model. Includes validation of UML model prior to auto-generating Word document. It is intended to be used in conjunction with CIMTool but not dependent on it (?)</strong></td>
</tr>
<tr>
<td><strong>JCleanCim</strong></td>
<td><strong>CIM UML validation cleanup and documentation tool</strong></td>
<td><strong>Open Source</strong></td>
<td><strong>Yes</strong></td>
</tr>
<tr>
<td><strong>MD3i</strong></td>
<td><strong>Methodology and tools to develop CIM-based ESM and generate design-time canonical data models.</strong></td>
<td><strong>Enterprise Architect Add-in</strong></td>
<td><strong>The MD3i Framework is an enterprise semantic modeling methodology combined with a set of design patterns, governance guidelines, industry standard models, and EIM best practices that Xtensible’s customers use to establish and maintain a strategic EIM program. Used to:</strong></td>
</tr>
</tbody>
</table>

**Create and maintain an Enterprise Semantic Model (ESM) based on the CIM**

**Define contexts/profiles**

**Auto-generate canonical models, including XML schemas for message payloads, power system network models, and data models/DDLs for data warehouses based on the ESM**

**Yes**

| **Open Source** | **Yes** | **www.cimtool.org/** | **uisol.com/uisol/CIMvian/CIMvian.htm** | **crxcat***

**Free**

**Freeware**

**jCleanCim**

**xtensible.net/solutions/md3i-methodology**

**xtensible.net/solutions/md3i-methodology**

**xtensible.net/solutions/md3i-methodology**
Concluding Remarks

• Bottom line: CIM standards are different and much more powerful
  – Can be applied in many ways
  – Support many types of functions/applications through combination of reuse and extension
  – Architecture supports future, unknown applications

• Modeling platforms and tools are available to applying CIM standards to utility projects
  – Power system network model exchange
  – System integration with extended CIM
  – System integration, data warehouse, and business intelligence based on Enterprise Semantic Model and SOA best practices

• Key to achieving Smart Grid interoperability vision
Questions?

• Contact tsaxton@xtensible.net
• Thank you