CIM Standards Overview
And Its Role in the Utility Enterprise - Part 2

CIM Users Group
Windsor, England
15 May 2012
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Presentation Contents

• Profiles for business context
• Implementation syntax
• IEC CIM Working Groups and Standards
• CIM as Basis for Enterprise Semantic Model (ESM)
• Case studies
• Where to get CIM information
Next - Context Layer

Information and Semantic Models

CIM UML

Information Model
- Generalized model of all utility objects and their relationships
- Application independent, but defines all concepts needed for any application

Context

Profiles

Contextual layer restricts information model
- Specifies which part of CIM is used for given profile
- Mandatory and optional
- Restrictions
- But cannot add to information model

Message Syntax

Message/File Format (XSD, RDF Schema, OWL)

Message 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

Xtensible Solutions
How the CIM is Applied to Specific Information Exchanges

- The CIM CDM (also referred to simply as the “Information Model”) is partitioned into sub-domains by IEC WGs
  - These groups work hard to maintain a unified semantic model over the whole domain

- The interfaces defined under CIM are defined by Profiles.
  - A profile specifies the information structure of exchanged information by creating contextual semantic models.
    - Contextual semantic models are a subset of the CIM CDM (i.e., they inherit their structure from the CIM CDM)
    - Contextual semantic models could contain information not modeled in the CIM CDM.
      - This is not current CIM practice for standard interfaces (refer to Enterprise Semantic Model discussion)
  - There is typically a family of related interfaces defined within a profile
  - Products implement support for profiles in the form of CIM/XML import/export software or ESB run-time adapters
  - Testing occurs against profiles
  - “CIM compliance” is defined against profiles – otherwise the term is meaningless
Presentation Contents

• Profiles for business context
  – WG13 61970 Profiles for Power System Network Model Exchange
  – WG14 61968 Message Payloads for System Integration
Example Circuit with Full CIM Mappings

- Maps to
  - 17 CIM classes
  - 45 CIM objects

- Could be extended further with addition of objects for
  - control areas
  - equipment owners
  - measurement units
  - generation and load curves
  - asset data
61970 Profiles Currently Defined

- **Equipment**
  - Identifies equipment, describes basic characteristics, and electrical connectivity that would be input to topology processing

- **Schedules**
  - Describes input to functions that derive parameters for a specific point in time

- **Measurement Specs**
  - Describes how SCADA will obtain measurements and what equipment objects are measured

- **Measurement Set**
  - The set of SCADA values for measurements for a particular point in time

- **Topology**
  - The result of topology processing. i.e. Description of how equipment connects into buses and how buses makeup connected systems

- **State Variables**
  - Result of a state estimator or power flow, or the starting conditions of state variables

- **Dynamics**
  - Adds dynamics to static network model for running system simulations

- **Schematic Layouts**
  - Describes how equipment objects are placed on schematic diagrams
61970-452 Static Transmission Network Model Profiles

• Also known as Common Power System Model (CPSM)
• Many Interoperability (IOP) tests since year 2000
• In use in many countries
• 61968-13 distribution model (CDPSM) based on these profiles as well
Plus 61970-451 Measurement and Control and -456 Solved System State Profiles

61970-451 Profile
- Measurement and Control

61970-452 Profiles
- Connectivity

61970-456 Profiles
- State Variables
- Topology

Equipment Model
- Measurement Specifications
- Schedules

Adds SCADA

Adds steady state solution of power system case produced by power flow applications

Dependencies via references to CPSM Part 452
Plus 61970-451 Measurement and Control and -456 Solved System State Profiles

61970-451 Profile
- Measurement and Control

61970-456 Profiles
- State Variables
- Topology

Future 61970-457 Profile
- Dynamic Models

61970-452 Profiles
- Measurement Specifications
- Connectivity

Equipment Model
- Schedules

Adds dynamic models used in system simulation

Dependencies via references to CPSM Part 452
Plus 61970-451 Measurement and Control and -456 Solved System State Profiles

- 61970-451 Profile
  - Measurement and Control
  - Measurement Specifications
  - 61970-452 Profiles
  - Connectivity

- 61970-456 Profiles
  - State Variables
  - Topology
  - Equipment Model
  - Schedules

- Future 61970-457 Profile
  - Dynamic Models
  - Diagram Layout

61970-453 Profile

Add diagram layout info for schematic data

Dependences via reference to CPSM Part 452
Plus 61970-453 Diagram Layout Profile

61970-456 Profiles

- State Variables
- Topology

Measurement Set

Measurement Specifications

61970-452 Profiles

- Boundary Objects
- Common Objects
- Schedules

Equipment Model

Future 61970-457 Profile

- Dynamic Models

61970-453 Profile

- Diagram Layout

Dependences via reference to CPSM Part 452

Add diagram layout info for schematic data
Typical Workflow for Model Exchange

- E1
- T1
- T1.1
- T1.2
- T1.3
- S1
- S2
- S3
- S4
- S5
- S6
- S7
- S8

• Profile
• Full model
• DifferentialModel
• Predecessor
• DependsOnModel

Xtensible Solutions
TC57 CIM Standards for Power System Model Exchange

- **Information and Semantic Models**
  - Conforms to IEC 61970-301 CIM

- **CIM UML**
  - Information Model
  - Generalized model of all utility objects and their relationships
  - Application independent, but defines all concepts needed for any application

- **Context**
  - Conforms to collection of Standard 4xx Profiles

  - Contextual layer restricts information model
    - Specifies which part of CIM is used for given profile
    - Mandatory and optional
    - Restrictions
    - But cannot add to information model

- **Profiles**

- **Message Syntax**
  - Conforms to IEC 61970-552-4 CIM XML Model Exchange Format

  - Message/File Format (XSD, RDF Schema, OWL)

  - Message 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

Xtensible Solutions
Presentation Contents

• Profiles for business context
  – WG13 61970 Profiles for Power System Network Model Exchange
  – WG14 61968 Message Payloads for System Integration
From Information Model to Syntactic Model

Abstract Model

Context/Profiles

Message Assembly

XML Syntactic World

UML World

Information Semantic Model

Message Syntax

Xtensible Solutions

XML: `<?xml version="1.0" encoding="UTF-8"?>
<xsd:element name="MT_EnergyTransaction">
  <xsd:sequence>
    <xsd:element name="Name"/>
    <xsd:element name="Type"/>
  </xsd:sequence>
</xsd:element>`
Working Group 14: Establishing A Common Language For Enterprise Application Integration In the IEC 61968 Series of Standards

- Utility Control Center
- Distribution Automation
- Substation Protection, Monitoring and Control
- RTU Communications
- Network Operation
- Network Expansion Planning
- Customer Inquiry
- Meter Reading & Control
- Records & Asset Management
- Maintenance & Construction
- Operational Planning & Optimization
- IEC 61968 Compliant Interface Architecture

Utility Business Systems (ERP, Billing, Energy trading, other systems)

Corporate LAN

Information:
- http://www.ucainternational.org/
- http://www.iec.ch

Xtensible Solutions
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

External Systems:
- Energy Trading (ET)
- Retail (RET)
- Sales (SAL)
- Stakeholder Planning & Management (SPM)
- Supply chain and logistics (SC)
- Human Resources (HR)

Enterprise Application Integration and Enterprise Service Bus Middleware

External Systems:
- Customer Account Management (ACT)
- Financial (FIN)
- Business Planning and Reporting (BPR)
- Premises (PRM)

Utility Electric Network Planning, Constructing, Maintaining, and Operating

Enterprise Resource Planning, Supply Chain, and General Corporate Services
The Business Sub-Function Level of the IRM for IEC 61968 Scope

- **Application Integration Infrastructure**
  - **Network Operations**
    - Network Operations (NMON)
    - Network Control (CTL)
    - Fault Management (FLT)
    - Operational Feedback Analysis (OFA)
  - **Records & Asset Management**
    - Substation & Network Inventory (EINV)
    - Network Calculations Real Time (CLC)
    - General Inventory Management (GIM)
    - Dispatcher Training (TRN)
  - **Operational Planning & Simulation**
    - Network Operation Simulation (SIM)
    - General Inventory Management (GIM)
    - Switch Action Scheduling (SSC)
    - Power Import Scheduling & Optimization (IMP)
  - **Maintenance and Construction**
    - Maintenance & Inspection (MAI)
    - Construction WMS (CON)
    - Scheduling & Dispatch (SCH)
    - Design & Estimate (DGN)
  - **Network Extension Planning**
    - Network Calculations (NCLC)
    - Project Definition (PRJ)
    - Construction Supervision (CSP)
    - Compliance Management (CMPL)
  - **Customer Support**
    - Customer Service (CSRV)
    - Trouble Call Management (TCM)
    - Point Of Sale (POS)
  - **Meter Reading & Control**
    - Meter Reading (RMR)
    - Advanced Metering Infrastructure (AMI)
    - Demand Response (DR)
    - Load Control (LDC)
    - Meter Operations (MOP)
  - **External Systems**
    - Scheduling & Dispatch (SCH)
    - Field Recording (FRD)

**Xtensible Solutions**
The IEC 61968 Basic Message Structure
Message Header

Message header contains control and descriptive information about the message.
IEC 61968-9: Interface Standard for Meter Reading and Control
Scope/Purpose

• To Define the exchange of information between a Metering System and other systems within the Utility enterprise

• Specifies the information content of a set of message types that can be used to support many of the business functions related to Meter Reading and Control.

• Typical uses of the message types include:
  – Meter Reading and Meter Control
  – Meter Events
  – Customer Data Synchronization and Customer Switching
Scope of Part 9

Area of Direct Impact using IEC 61968-9

- Electric Utility
  - Enterprise Applications
  - Head End Systems
    - IEC 61968-9 Messages
    - Messages defined by IEC 61968-9 and based upon IEC CIM, conveyed using a variety of integration technologies
    - Mappings, translations and/or forwarding as needed

Area Causally/Indirectly Impacted by or impacting IEC 61968-9

- Customer
- Standard or Proprietary Communication Infrastructures
  - Meter
  - Meter or Gateway
  - PAN
    - PAN Device
    - PAN Device
    - PAN Device
  - Messages defined by relevant standards or vendors. May use a wide variety of communication technologies
  - Mapping, translations and/or forwarding as needed
  - Messages defined by PAN/HAN specifications

Xtensible Solutions
Reference Model

- The Reference Model provides examples of the logical components and data flows related to this standard.
- The Meter is treated as an “end device”
- An End Device:
  - Has a unique identity
  - Is managed as a physical asset
  - May issue events
  - May receive control requests
  - May collect and report measured values
  - May participate in utility business processes
- The Reference Model describes the flows between the components.
Part 9 Reference Model

[Diagram of the reference model with various processes and data flows, including Meter, Meter Maintenance, Work Management, Network Operations, Data Collection, Metering System, Outage Management, Meter Data Management, Planning and Scheduling, Customer Information and Billing, and Outage and restoration verification.]
Part 9 Message Types
Typical Message Payload Definition - EndDeviceEvent Message

EndDeviceEvent Messages Convey events related to:
- Sustained Outage Detection
- Momentary Outage Detection
- Low Voltage Threshold Detection
- High Voltage Threshold Detection
- Distortion Meter Health
- Tamper Detection
- Revenue Event
## Work Overview

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<th>Description</th>
<th>Status</th>
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<td>Interface Architecture and General Requirements</td>
<td>IS</td>
<td>Shawn Hu</td>
<td>July 2010</td>
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<td>David Haynes</td>
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<td>Larry Clark and Mark Ortiz</td>
<td>Sept 2010</td>
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<td>Working Draft</td>
<td>Gary McNaughton</td>
<td>In planning and recruitment stage</td>
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Next – Message Syntax

Information and Semantic Models

CIM UML

Information Model
• Generalized model of all utility objects and their relationships
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Message/File Format (XSD, RDF Schema, OWL)

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Implementation Syntax – XML Schema

- XML Syntax
- Example of use of XML Schema
- Mapping Proprietary EMS Interfaces to the CIM
  - Provide enterprise system access to transformer data
eXtensible Markup Language (XML)

- Universal format for structured documents and data
- Provides a syntax for storage and exchange of information
- CIM uses for exchange of message payloads between systems, such as an Outage message from an Outage Management System (OMS) to a Customer Information System (CIS), which are actually XML documents
- Can be transported over multiple, different types of communication infrastructure, such as an Enterprise Service Bus (ESB) or the Internet
- XML uses “tags” that are based on the CIM UML class attributes to denote elements within documents
  - For detailed understanding of XML, refer to W3C Recommendation, “Extensible Markup Language” Version 1.0, October 2000, available at http://www.w3.org/TR/REC-xml
Mapping CIM class structure to XML using XML Schema (XSD)

- An XML Schema of the CIM can be autogenerated from UML models with third party tools
  - A list and description of available tools is on the CIMug SharePoint site
- The CIM classes and attributes are used to define tags
- Then the CIM can be shown in XML as well as UML
- Example is PowerTransformer
Mapping EMS Interfaces to the CIM –
User access to transformer data

• EMS Native Interface attributes:
  – TRANS_NAME – The Transformer’s name
  – WINDINGA_R – The Transformer’s primary winding resistance
  – WINDINGA_X – The Transformer’s primary winding reactance
  – WINDINGB_R – The Transformer’s secondary winding resistance
  – WINDINGB_X – The Transformer’s secondary winding reactance
  – WINDINGA_V – The Transformer’s primary winding voltage
  – WINDINGB_V – The Transformer’s secondary winding voltage
Transformer Class Diagram in CIM
CIM Interface Mapping
- Beginnings of Profile/Message Payload Definition

Two different interface attributes (WINDINGA_R and WINDINGB_R) map to same CIM attribute.

Aggregation changed from 0..n to 2

Multiplicity changed from 0..1 to 1

Equipment

PowerTransformer
name

Conducting Equipment

Equipment Container

TransformerWinding
R
X
windingType

VoltageLevel

BaseVoltage
nominalVoltage

VoltageLevel association via Equipment-EquipmentContainer

Multiplicity changed from 0..1 to 1

EMS
TRANS_NAME
WINDINGA_R
WINDINGA_X
WINDINGB_R
WINDINGB_X
WINDINGA_V
WINDINGB_V
Message Payload in UML

Note:
• Associations changed to aggregations
• Parent classes removed
  • Not required in actual message content
  • Parent classes already known by both sender and receiver
    • Corollary: Only those parts of the CIM used in message exchange need to be supported by interface applications
• End result – modified class structure
  • Example of application of business context to information model
XML Schema for Transformer Message
Sample Transformer Interface
Message Payload in XML

```xml
< CIM:PowerTransformer>
  < CIM:Naming.name>Transformer SGT1</CIM:Naming.name>
  < CIM:PowerTransformer.Contains_TransformerWindings>
    < CIM:TransformerWinding.r>0.23</CIM:TransformerWinding.r>
    < CIM:TransformerWinding.x>0.78</CIM:TransformerWinding.x>
    < CIM:TransformerWinding.windingType>WindingType.primary</CIM:TransformerWinding.windingType>
    < CIM:Equipment.MemberOf_EquipmentContainer>
      < CIM:VoltageLevel.BaseVoltage>
        < CIM:BaseVoltage.nominalVoltage>400</CIM:BaseVoltage.nominalVoltage>
      </ CIM:VoltageLevel.BaseVoltage>
    </ CIM:Equipment.MemberOf_EquipmentContainer>
  </ CIM:PowerTransformer.Contains_TransformerWindings>
  < CIM:PowerTransformer.Contains_TransformerWindings>
    < CIM:TransformerWinding.r>0.46</CIM:TransformerWinding.r>
    < CIM:TransformerWinding.x>0.87</CIM:TransformerWinding.x>
    < CIM:TransformerWinding.windingType>WindingType.secondary</CIM:TransformerWinding.windingType>
    < CIM:Equipment.MemberOf_EquipmentContainer>
      < CIM:VoltageLevel.BaseVoltage>
        < CIM:BaseVoltage.nominalVoltage>275</CIM:BaseVoltage.nominalVoltage>
      </ CIM:VoltageLevel.BaseVoltage>
    </ CIM:Equipment.MemberOf_EquipmentContainer>
  </ CIM:PowerTransformer.Contains_TransformerWindings>
</ CIM:PowerTransformer>
```
XML Implementation Technologies

- XML Schema
  - Used for generation of message payloads for system interfaces in system integration use cases

- RDF Schema
  - Used for exchange of power system models
Big Issue

• “Although we can swap our documents with each other through XML, we still haven’t a clue what they mean.”

• Resource Description Framework (RDF) Is W3C’s Means To Resolve This.
Resource Description Framework (RDF)

- RDF provides a framework for data in an XML format by allowing relationships to be expressed between objects.
- RDF Syntax
  - With a basic XML document there is no way to denote a relationship between two elements that are not a parent or a child.
    - Ex: an association or aggregation/containment, as between Substation and VoltageLevel.
  - Within an RDF document each element can be assigned a unique ID attribute (RDFID) under the RDF namespace.
  - Adding a resource attribute to an element allows references to be made between elements by having its value refer to another element’s ID.
RDF Schema

While RDF provides a means of expressing simple statements about the relationship between resources, it does not define the vocabulary of these statements.

The RDF Vocabulary Description Language, known as RDF Schema (RDFS) provides the user with a means of describing specific kinds of resources or classes.

RDFS does not provide a vocabulary for a specific application's classes, but instead allows the user to describe these classes and properties themselves and indicate when they should be used together.

- Semantics contained in the CIM UML model provide the vocabulary.

RDF combined with RDF Schema

- Provides a mechanism for expressing a basic class hierarchy as an XML schema by specifying the basic relationship between classes and properties.
- This allows a set of objects to be expressed as XML using a defined schema that retain their relationships and class hierarchy.
References

- RDF (Resource Description Framework)
  - For more information: http://www.w3.org/RDF
  - Status: W3C Recommendation 2004-02-10
  - List of documents at: http://www.w3.org/standards/techs/rdf

- RDF Schema
  - Status: W3C Recommendation 2004-02-10
    - http://www.w3.org/TR/PR-rdf-schema

- Namespaces
  - Provides a simple method for qualifying element and attribute names used in XML documents by associating them with namespaces identified by URI references
  - Status: WC3 Recommendation 2009-12-08
    - http://www.w3.org/TR/REC-xml-names

- URI (Uniform Resource Identifiers)
  - Provides a simple and extensible means for identifying a resource
  - Status: Internet RFC August 1998
    - http://www.w3.org/Addressing/
Mapping CIM Class Structure to XML using RDF Schema

- Commonly referred to as “CIM/XML” but correct reference is CIM RDF XML
- 61970-501 specifies the mapping between CIM UML model defined in 61970-301 into a machine readable format as expressed in the XML representation of that schema using the RDF Schema specification language
  - The resulting CIM RDF schema supports CIM Model Exchange profiles, as presented in IEC 61970-452 and others
  - Allows CIM data objects to be mapped, one-to-one, into RDF instance data.
- Part 501 specifies the subset of RDF used for CIM RDF XML
  - Any RDF parser can be used to read CIM RDF XML
  - CIM community developed tools to auto-generate the CIM RDF XML from the CIM UML model
Simple Network Example
Simple Network Connectivity Modeled with CIM Topology

![Diagram of network connectivity with nodes and cables labeled with voltages and power levels.](image)
Siemens 100 Bus Network Model in RDF

Top of RDF Schema version of Siemens 100 bus model

<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:cim="http://iec.ch/TC57/2001/CIM-schema-cim10#" rdf:ID="_E83B07FE54A945539A955FD2DB2CDD4FC"
><cim:Terminal rdf:resource="#_B23175B9692441AFBD2C581E86300550"
><cim:Naming rdf:ID="_BKR-TUR"/><cim:Conductor rch">0.39</cim:Conductor rch>0.1262</cim:Conductor rch><cim:Conductor rch>0.0051</cim:Conductor rch><cim:Conductor rch>5.03</cim:Conductor rch>10.90761</cim:Conductor rch>
ACLineSegment in RDF

Siemens 100 bus model - RDF schema

```xml
<?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#">
  <cim:ACLineSegment rdf:ID="_6B1DD5C2CB934E86AC53FFD886E2D1B3">
    <cim:Naming.name>BBD-RSK2</cim:Naming.name>
    <cim:Conductor.bch>2.75</cim:Conductor.bch>
    <cim:Conductor.x>4.3378</cim:Conductor.x>
    <cim:Conductor.r>0.4761</cim:Conductor.r>
  </cim:ACLineSegment>

  <cim:Terminal rdf:ID="_EB6085D9DF364DA78A884D4D0A571371">
    <cim:Naming.name>T2</cim:Naming.name>
    <cim:Terminal.ConnectivityNode rdf:resource="#_CC312D30C85C4236948A4129AEE3B5F7"/>
    <cim:Terminal.ConductingEquipment rdf:resource="#_6B1DD5C2CB934E86AC53FFD886E2D1B3"/>
  </cim:Terminal>

  <cim:Terminal rdf:ID="_7C8354E0DA247DBB3611E2E8BF8A86D">
    <cim:Naming.name>T1</cim:Naming.name>
    <cim:Terminal.ConnectivityNode rdf:resource="#_D16DB3561444AECBF8157D1E4764E38"/>
    <cim:Terminal.ConductingEquipment rdf:resource="#_6B1DD5C2CB934E86AC53FFD886E2D1B3"/>
  </cim:Terminal>
</rdf:RDF>
```
ACLineSegment in RDF

Siemens 100 bus model - RDF schema

```xml
<?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#">
    <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>

    <cim:Terminal rdf:ID="_EB6085D9DF364DA78A884D4D0A571371">
        <cim:Naming.name>T2</cim:Naming.name>
        <cim:Terminal.ConnectivityNode rdf:resource="#_CC312D30C85C4236948A4129AC53FFD886E2D1B3"/>
        <cim:Terminal.ConductingEquipment rdf:resource="#_6B1DD5C2CB934E86AC53FFD886E2D1B3"/>
    </cim:Terminal>

    <cim:Terminal rdf:ID="_7C8354E0DA247DBB36B112E886E2D1B3">
        <cim:Naming.name>T1</cim:Naming.name>
        <cim:Terminal.ConnectivityNode rdf:resource="#_D16FD6350144AECBF8157D1DE4764E38"/>
        <cim:Terminal.ConductingEquipment rdf:resource="#_6B1DD5C2CB934E86AC53FFD886E2D1B3"/>
    </cim:Terminal>
</rdf:RDF>
```
Containment in RDF

Substation VOL with 230 KV voltage level and Bay 240W79 with Breaker CB

Further down in document
Measurement in RDF

```xml
<cim:Measurement rdf:ID="_5B22599688AC4DE6B99FD8B13C1BA36F">
  <cim:Naming.name>LN    1 MVAr</cim:Naming.name>
  <cim:Measurement.MeasurementType rdf:resource="#_83D7B035901D4D2E80C040609D5ED7EC"/>
  <cim:Measurement.Unit rdf:resource="#_61784D3DA1954750A4E09444BE5206CB"/>
</cim:Measurement>

<cim:MeasurementValue rdf:ID="_FF332A9A82FF43719AAF4E5D4FCF9CD">
  <cim:Naming.aliasName>ICCP ID     24</cim:Naming.aliasName>
  <cim:Naming.name>MVAr</cim:Naming.name>
  <cim:MeasurementValue.MeasurementValueSource rdf:resource="#_F0F5BA1CDE23483A8C80D20A4907A272"/>
  <cim:MeasurementValue.MemberOf_Measurement rdf:resource="#_5B22599688AC4DE6B99FD8B13C1BA36F"/>
</cim:MeasurementValue>
```
Implementation Syntax – WG13 61970

- Part 552 describes the CIM XML format at a level for implementation to support the model exchange requirements in IEC 61970-452
  - This standard relies upon the CIM RDF Schema of IEC 61970-501
  - Includes Difference model
  - Includes file header specification with file dependencies to ensure all prerequisite models exist prior to importing
Basics: Schema from CIM

CIM (in UML) → Enterprise Architect

Enterprise Architect → CIM as XML/RDF Schema

CIM as XML/RDF Schema specifies

Power System Data Exporter

Power System Data as XML/RDF

UML to RDF Transformers

references

specifies
How Are CIM Standards Used?

- Unlike most standards we use
  - Ex: ICCP/TASE.2 Communication Protocol standard
  - Fixed functionality, very **stable**, easy to test **compliance**, but **inflexible**
- CIM standards can be strictly applied and tested for compliance
  - Ex: CIM/XML Power system model exchange
  - Product interfaces can be developed and tested for compliance
  - Subject of several EPRI-sponsored interoperability tests for specific interface definition
Example: Power Flow Network Model Exchange

Information and Semantic Models

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

Context

- Conforms to IEC 61970-452, 453, 456, others
- Power System Model 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

- Conforms to IEC 61970-501 and -552
- CIM XML Model Exchange Format
- CIM/RDF Schema
- File syntax
  - Can re-label elements
  - Change associations to define single structure for message payloads
  - Mappings to various technologies can be defined
Information Model
- Defines all concepts needed for exchange of operational load flow models
  - Reused parts
  - New extensions

Contextual layer restricts information model
- Specifies which part of CIM is used for static model exchange
  - Mandatory and optional
  - Restrictions
  - But cannot add to information model

File syntax
- Can re-label elements
- Change associations to define single structure for message payloads
- Mappings to various technologies can be defined
How Are CIM Standards Used?

- Unlike most standards that we are used to
  - Ex: IDDP/TASE.2 Communication Protocol standard
  - Fixed functionality, very **stable**, easy to test **compliance**, but **inflexible**
- CIM standards can be strictly applied and tested for compliance
  - Ex: CIM/XML Power system model exchange
  - Product interfaces can be developed and tested for compliance
  - Subject of several EPRI-sponsored interoperability tests for specific interface definition
- CIM can also be used as a starter kit
  - Basis for an Enterprise Semantic Model (ESM) which includes other models/semantics from other sources
  - Ex: Sempra Information Model (SIM)
  - Interfaces are usually project-defined, so no standard tests
  - System interfaces are managed and tested for each project
GridWise Interoperability Framework

Role of CIM

- Organizational (Pragmatics)
  - 8: Economic/Regulatory Policy
  - 7: Business Objectives
  - 6: Business Procedures

- Informational (Semantics)
  - 5: Business Context
  - 4: Semantic Understanding
  - 3: Syntactic Interoperability
  - 2: Network Interoperability
  - 1: Basic Connectivity

- Technical (Syntax)

- Relevant Business Knowledge that Applies Semantics with Process Workflow
- Understanding of Concepts Contained in the Message Data Structures
- Understanding of Data Structure in Messages Exchanged between Systems
- Exchange Messages between Systems across a Variety of Networks

Political and Economic Objectives as Embodied in Policy and Regulation
Strategic and Tactical Objectives Shared between Businesses
Alignment between Operational Business Processes and Procedures

Xtensible Solutions
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
- 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
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

Context Refinement

Compliments Xtensible MD3i
Role of Enterprise Semantic Model

Enterprise Semantic Model

Open Standards

Application Information

Process Integration

BPM/Workflow

Business Intelligence

Enterprise Integration Platforms

Applications Metadata

Business Definitions

Xtensible Solutions
Let's Apply to a Utility Project
- Interface Architecture

Enterprise Semantic Model

- CIM UML Extensions
- CIM UML
- Bridge
- Other Information Models

Context

System Interface Design Document

Profile 1
Profile 2
Profile 3

Interface Syntax

Message XML Schema
CIM/RDF Schema
DDL
Ex: Project Interaction Test

Enterprise Semantic Model
- Defines all concepts needed for Enterprise
  - Reused parts
  - New extensions for project

Contextual layer restricts ESM
- Specifies which part of ESM is used for specific system interaction
- Mandatory and optional
- Restrictions
- But cannot add to information model

File syntax
- Can re-label elements
- Change associations to define single structure for message payloads
- Mappings to various technologies can be defined
Project Integration Architecture
Data Architecture – Model

- Reference Models
- SEMPRRA Model
- Messages
- Schemas

Semantic Model

- CIM
- CIS
- Other

Business Entity

- DB Schema
- XML Schema

Xtensible Solutions
Use of ESM to Implement a Service Oriented Architecture (SOA)

- CAISO designed a new power market system
  - Multi-year program that involved many vendors, new systems, as well as numerous legacy systems
    - Includes EMS, Full Network Model, Outage Management, PI Historian, Market Systems, many others
    - External interfaces to Market Participants included
- Integration Competency Center decided on a Service Oriented Architecture (SOA) for the integration framework
  - Require all new applications and systems to be “Integration Ready” with service-enabled interfaces
  - Use only standard CAISO-defined services
  - Payloads based on the CIM
  - Based on Web services
  - CIM and Model Driven Integration (MDI) methodology used to define information exchange
## Interface Examples:

<table>
<thead>
<tr>
<th>Interface Type</th>
<th>Example</th>
<th>Implemented by</th>
<th>Utilized by</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Creation</td>
<td>submitBid(XML)</td>
<td>Vendor</td>
<td>Enterprise</td>
<td>These interfaces are for creating or modifying information within a system of record.</td>
</tr>
<tr>
<td>Information Transfer</td>
<td>publishCleanBidSet(XML)</td>
<td>CAISO</td>
<td>Vendor</td>
<td>These interfaces are for transferring information and releasing custody.</td>
</tr>
<tr>
<td>Information Interest</td>
<td>receiveCleanBidSet(XML)</td>
<td>Vendor</td>
<td>EAI</td>
<td>These interfaces are implemented by vendors to allow systems to receive information as it becomes available. This indicates a subscription type interest in data.</td>
</tr>
<tr>
<td>Information Sharing</td>
<td>getResourceInfo(XML)</td>
<td>Vendor</td>
<td>Enterprise</td>
<td>These interfaces are implemented by the vendors to surface information currently within custody to the enterprise.</td>
</tr>
</tbody>
</table>

(Slide from Stipe Fustar, KEMA)
<?xml version='1.0' encoding='utf-8'?>
<wsdl:definitions xmlns:wsdl='http://schemas.xmlsoap.org/wsdl/'
  xmlns:soap='http://schemas.xmlsoap.org/wsdl/soap/
  xmlns:xsd='http://www.w3.org/2001/XMLSchema'
  xmlns:wsdlsoap='http://schemas.xmlsoap.org/wsdl/soap/
  xmlns:soapenc='http://schemas.xmlsoap.org/soap/encoding/'
  xmlns:tm='http://microsoft.com/wsdl/mime/textMatching/'
  xmlns:mime='http://schemas.xmlsoap.org/wsdl/mime/'
  targetNamespace='http://www.caiso.com/soa/notifyMarketMeterData.wsdl'
  xmlns:tns='http://www.caiso.com/soa/notifyMarketMeterData.wsdl'
  xmlns:typen='http://www.w3.org/2001/XMLSchema'>
  <wsdl:documentation>
    A web service to notify market meter data from OMAR system and provided by EAI
  </wsdl:documentation>
  <wsdl:types>
    <xs:schema>
      <xs:import namespace='MarketMeterData' schemaLocation='MarketMeterData.xsd'/>
    </xs:schema>
  </wsdl:types>
  <wsdl:message name='NotifyMarketMeterDataRequest'>
    <wsdl:parts>
      <wsdl:part name='meterData' element='typen:MarketMeterData'/>
    </wsdl:parts>
    <wsdl:documentation>notify market meter data from OMAR</wsdl:documentation>
  </wsdl:message>
  <wsdl:message name='NotifyMarketMeterDataResponse'>
    <wsdl:parts>
      <wsdl:part name='returnData' element='typen:outputDataType'/>
    </wsdl:parts>
    <wsdl:documentation>acknowledge meter data notified</wsdl:documentation>
  </wsdl:message>
  <wsdl:portType name='NotifyMarketMeterData'>
    <wsdl:operation name='NotifyMarketMeterData'>
      <wsdl:input message='tns:NotifyMarketMeterDataRequest'/>
      <wsdl:output message='tns:NotifyMarketMeterDataResponse'/>
    </wsdl:operation>
  </wsdl:portType>
</wsdl:definitions>
<?xml version="1.0" encoding="UTF-8" ?>

<MarketMeterData xmlns="MarketMeterData" xmlns:caiso="caisoBase" xmlns:cim="cimBase2" xmlns:mdimsg="mdimsg" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="MarketMeterData MarketMeterData.xsd">
  <RegisteredResource>
    <cim:name>1011</cim:name>
    <cim:rtID>123456789</cim:rtID>
    <Meter>
      <cim:name>1809469</cim:name>
    </Meter>
    <Market>
      <cim:timeIntervalLength>
        <cim:value>60</cim:value>
        <cim:units>minute</cim:units>
      </cim:timeIntervalLength>
      <cim:start>2004-07-12T00:00:00-05:00</cim:start>
    </Market>
    <Node>
      <cim:name>PGE3</cim:name>
      <cim:type>none</cim:type>
      <Measurement>
        <cim:positiveFlowIn>1</cim:positiveFlowIn>
      </Measurement>
      <MeasurementType>
        <cim:name>R</cim:name>
      </MeasurementType>
      <MeasurementValue>
        <cim:name>1</cim:name>
        <cim:value>105.9059</cim:value>
      </MeasurementValue>
    </Node>
  </RegisteredResource>
</MarketMeterData>
CAISO Project Statistics

22 Systems
- Dispatch System
- MP Report Interface
- Load Forecast
- Transmission Capacity Calculator
- Real Time Nodal System
- Settlement and Market Clearing
- Bid Interface and Validation

7 Vendors
- Siemens - Market Systems
- ABB - EMS system
- Areva - Settlement System
- Legacy - CAISO system
- Nexant - Congestion Revenue Rights System
- MCG - Interchange Scheduling System
- Potomac - Default Energy Bids
- Default Energy Bids
- Real Time Metering
- Adjusted Metering
- Market Participants
  - Bidding
  - Market Results
  - Settlement
  - Outage Scheduling
  - Dispatch Signals
- Forward Market Nodal System
- EMS
- OASIS
- Interchange Scheduling System
- Congestion Revenue Rights
- Intermittent Resources
- Compliance
- RMR Validation
- Generation Outage Scheduling
- Transmission Outage Scheduling
- Market Quality System (ATF updates)

Appr 130 integrations between the 22 systems
Appr 75 message schemas
Appr 175 service definitions
Appr 450 publisher/consumer testable data transfers between systems
Pacificorp Use of CIM

• PacifiCorp is successfully using CIM to design both interfaces and databases
  – CIM was adopted in 1999 as PacifiCorp’s application integration standard
  – Used for both messaging and database design for new projects
  – Existing interfaces are reworked when the need arises
• Model Driven Integration based on the CIM viewed internally as “Best Practice”
  – Having a common vocabulary reduces semantic misinterpretation
  – Reusing messages minimizes integration costs
  – Minimal knowledge of internal application designs required
  – Xtensible MDI Workbench used for message creation, management, and maintenance
• CIM is here to stay
  – CIM is standard design practice
  – PacifiCorp vendors are getting used to the idea
  – PacifiCorp’s data warehouse is based on the CIM
  – EMS/SCADA system (Ranger) uses a CIM-based data maintenance tool
## CIM Scorecard – Examples of CIM use

<table>
<thead>
<tr>
<th>Business Units</th>
<th>Application/Project</th>
<th>Message(s)</th>
<th>CIM</th>
<th>Pct of message that is CIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Delivery</td>
<td>Substation Measurements</td>
<td>IntervalRead, SubstationEquipment.Measurement</td>
<td>MeasurementList</td>
<td>90%</td>
</tr>
<tr>
<td>Outage Center Call Handing</td>
<td></td>
<td>Retail Access Project</td>
<td>CustomerMeterDataSet, CustomerServiceAgreement, MeasurementList, Document, ActivityRecord, CustomerBilling, BillingDeterminant</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>Pole Attachment System</td>
<td>FacilityPoint, JointUse. Agreement, JointUse.Attachment, JointUse.Notice, JointNoticeRequest, FacilityPoint</td>
<td>AssetList</td>
<td>70%</td>
</tr>
<tr>
<td>Transmission</td>
<td>Transmission Planned Outages</td>
<td>PlannedOutage.Change</td>
<td>PlannedOutageNotification</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Transmission Wholesale Billing System</td>
<td>TransmissionData, STLossData, LTLossData, Scheduling.LoadData, ConsumptionData, InvoiceData</td>
<td>Settlement and MarketClearing</td>
<td>70%</td>
</tr>
<tr>
<td>EMS SCADA</td>
<td></td>
<td>WeatherData</td>
<td>MeasurementList</td>
<td>100%</td>
</tr>
</tbody>
</table>
## CIM Scorecard Cont’d

<table>
<thead>
<tr>
<th>Business Units</th>
<th>Application/Project</th>
<th>Message(s)</th>
<th>CIM</th>
<th>Pct of message that is CIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply/Generation</td>
<td>Availability Information System</td>
<td>GeoThermalPlantGeneration</td>
<td>MeasurementList</td>
<td>60%</td>
</tr>
<tr>
<td>Hydro Information Website</td>
<td>FlowDisplay</td>
<td></td>
<td>MeasurementList</td>
<td>100%</td>
</tr>
<tr>
<td>Generation Equipment</td>
<td>SolutionNotification, Performance, SolutionProject, EquipmentGroupRepetitiveTasks, Inventory.StockingPlan, WorkHistoryDocument</td>
<td>Work History</td>
<td>WorkHistory</td>
<td>90%</td>
</tr>
<tr>
<td>Commercial &amp; Trading</td>
<td>CRS</td>
<td>MarkToMarketData</td>
<td>MarkToMarket (Not in CIM)</td>
<td>80%</td>
</tr>
<tr>
<td>California ISO interface</td>
<td>EDI810</td>
<td></td>
<td>Settlement</td>
<td>50%</td>
</tr>
<tr>
<td>Corporate</td>
<td>Giving Campaign</td>
<td>EmployeeDetails, ContributionPayrollDetails</td>
<td>Employee (erpPerson)</td>
<td>70%</td>
</tr>
<tr>
<td>Sarbanes Oxley Audit</td>
<td>ChangeAuditReport</td>
<td></td>
<td>ChangeAudit (Not in CIM)</td>
<td>90%</td>
</tr>
</tbody>
</table>
CIM Usage

- Many EMS vendors support power system model exchange using CIM/RDF/XML, some with CIM-based databases behind the scenes
- EPRI has sponsored 12 interoperability tests for transmission model exchange and service validation and more recently for planning and distribution
- Utilities have implemented CIM-based integration using EAI technologies
  - Utilities have used the CIM as the basis for developing common messages for integration
- Asset and work management vendors as well as GIS application vendors are supporting CIM/XSD standards
- AMI (Smart Meter) projects use IEC 61968 Part 9 for meter related information exchange
- CIM has been extended into the power market, planning, and dynamic model exchange
- CIM provides a foundation for Service-Oriented Architecture (SOA) and Web service implementations
- Vendors have developed tools to build CIM-based information exchange messaging, ESB and OPC interfaces, and repository applications that can process CIM-aware data
- MultiSpeak is converting to CIM-based UML models and XML
- ENTSO_E is converting power model exchanges and day-ahead forecasts for planning/operational applications to CIM based format
  - Third IOP conducted in July 2011 (first was UCTE IOP in March 2009)
- Many Smart Grid-related activities based on CIM
  - Separate presentations during week
CIM Acceptance

- In use at hundreds of utilities throughout world
  - Used at TSOs, RTO/ISOs, IOUs, and Distribution Utilities
  - In Europe now being adopted by ENTSO-E and TOs
- 80+ applications support CIM standards
- 60+ suppliers sell application/products based on CIM
  - Based on 2007 CIM Reference List published by EPRI
- Endorsed and used by other standards organizations
  - Multispeak, Zigbee, HAN, ENTSO-E, NASBE, OASIS, etc.
- Foundation for information exchange between utilities and/or other external organizations
- Foundation for Model-Driven Integration (MDI) architecture based on an Enterprise InformatiSemantic Model (ESM) within an enterprise
- Key building block in Smart Grid to achieve interoperability
  - 61968/70 are top 2 of 5 priority standards recognized by NIST & FERC in North America
- CIM User Group to deal with questions and issues arising from increased use
Where to Get More Information About the CIM and Related Standards

- Visit CIM User Group (CIMug) Web Site
  - cimug.ucaiug.org or www.cimug.org

- Single site for gaining access to information about the CIM and related standards
  - Includes all standards being developed by IEC TC57 Working Groups 13, 14, 16, and 19

- Now provide access to:
  - Announcements of CIM-related activities and events
  - Calendar of activities
  - Past meeting presentations
  - CIM electronic model in various formats
  - Lists of CIM-related tools and access to open source tools
  - Documents that are publicly available
    - Draft IEC TC57 CIM standards for CIMug members
  - Lists of the CIMug working groups and works in progress as well as minutes of meetings and conference calls
  - CIM issues lists and status of resolution
  - Help desk
  - Discussion forums
  - Links to other CIM-related sites
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
From Information Model to Syntactically Model

• Information Semantic Model
• Context/Profiles
• Message Assembly

UML World

XML Syntactic World

• Message Syntax
• Syntactic Model

• Abstract
• Model
Example of Use of CIM to Define Standard Interfaces
Reference Model with Customer Information

Interface and protocol details of the Service Point are outside the scope of IEC 61968-9

Key

- 61968 Part 9
- Defined by other 61968 Parts
- Outside the scope of 61968

Xtensible Solutions