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

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Presentation Contents – Part 2

• Profiles for business context – Layer 2
• Implementation syntax – Layer 3
• CIM as Basis for Enterprise Semantic Model (ESM)
• Case studies
• Where to get CIM information
Next - Context Layer

Information and Semantic Models

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

Context

**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 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

CIM UML

Profiles

Message/File Format (XSD, RDF Schema, OWL)
How the CIM is Applied to Specific Information Exchanges

• The CIM 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 overall CIM information model (i.e., they inherit their structure from the CIM UML model)
  – 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

- 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
Schedules

Equipment Model

Adds dynamic models used in system simulation
Dependencies via references 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

Future 61970-457 Profile
- Dynamic Models

61970-453 Profile
- Diagram Layout

Adds diagram layout info for schematic data
Dependencies via reference to CPSM Part 452
Typical Workflow for Model Exchange
TC57 CIM Standards for Power System Model Exchange

**Information and Semantic Models**

- **CIM UML**
  - Conforms to IEC 61970-301 CIM
  - *Information Model*
    - Generalized model of all utility objects and their relationships
    - Application independent, but defines all concepts needed for any application

- **Profiles**
  - 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

- **Message Syntax**
  - Conforms to IEC 61970-552 and -501 CIM XML Model Exchange Format
  - *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

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

UML World

XML Syntactic World

Context/Profiles

Message Assembly

Message Syntax

Information Semantic Model

<?xml version="1.0" encoding="UTF-8"?>
<xsd:element name="MT_EnergyTransaction">
  <xsd:sequence>
    <xsd:element name="EnergyTransaction"/>
    <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

IEC 61968 Compliant Interface Architecture

Network Operation

Customer Inquiry

Meter Reading & Control

Operational Planning & Optimization

Maintenance & Construction

Records & Asset Management

Network Expansion Planning

Utility Control Center

Distribution Automation

Substation Protection, Monitoring and Control

RTU Communications

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

Corporate LAN

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

Network Operations
- Network Operations Monitoring (NMON)
- Network Control (CTL)
- Fault Management (FLT)
- Operational Feedback Analysis (OFA)

Records & Asset Management
- Operation Statistics & Reporting (OST)
- Network Calculations - Real Time (CLC)
- Dispatcher Training (TRN)

Operational Planning & Optimization
- Substation & Network Inventory (EINV)
- Geographical Inventory (GINV)
- General inventory management (GIM)
- Asset Investment Planning (AIP)

Network Calculations - Real Time (CLC)

Maintenance and Construction
- Network Operation Simulation (SIM)
- Switch Action Scheduling (SSC)
- Power Import Sched. & Optimization (IMP)

External Systems
- Maintenance & Inspection (MAI)
- Construction WMS (CON)
- Field Recording (FRD)

Application Integration Infrastructure

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)

Meter Data Management IMDM

Scheduling & Dispatch (SCH)

Dispatcher Training (TRN)

General inventory management (GIM)

Construction WMS (CON)

Design & Estimate (DGN)

Maintenance & Inspection (MAI)

Field Recording (FRD)

Network Calculations (NCLC)

Project Definition (PRJ)

Construction Supervision (CSP)

Compliance Management (CMPL)

Meter Reading (RMR)

Advanced Metering Infrastructure (AMI)

Demand Response (DR)

Load Control (LDC)

Meter Operations (MOP)

Customer Service (CSRV)

Trouble Call Management (TCM)

Point Of Sale (POS)

Meter Data Management IMDM

Metering System (MS)

Meter Maintenance (MM)

Meter Data (MD)
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

Enterprise Applications

Electric Utility

Enterprise Integration Infrastructure (e.g. ESB, SOA, …)

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

Meter

Standard or Proprietary Communication Infrastructures

Messages defined by relevant standards or vendors. May use a wide variety of communication technologies

Mapping, translations and/or forwarding as needed

Meter or Gateway

Messages defined by PAN/HAN specifications

Customer

PAN

PAN Device

PAN

PAN Device

PAN

PAN Device

PAN

PAN Device

Customer
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

- **Part 9 Reference Model**

- **Key**
  - **Meter**
  - **Metering System**
  - **Data Collection**
  - **Control and Reconfiguration**
  - **Readings and status**
  - **Controls and signals**
  - **Meter Maintenance**
  - **Configuration, installation, etc.**
  - **Network Operations**
  - **Install, Remove, Disconnect, Reconnect**
  - **Tariffs, parameters**
  - **Work Management**
  - **Demand response signals (e.g. load control, price signals)**
  - **Meter health and tamper detection**

- **Data Collection**
  - **Meter readings**
  - **Readings and status**

- **Customer Information and Billing**

- **Customer Data Set**
  - **On request read**
  - **Transaction records**
  - **Disconnect/reconnect, demand reset**

- **Load curves, Measurement history, etc.**

- **Outage Management**
  - **Power reliability and quality events**
  - **Outage and restoration verification**

- **Planning and Scheduling**

- **Transaction information**
  - **Data obtained by special read**
  - **Meter service request**
  - **Account information**

- **61968 Part 9 Defined by other 61968 Parts**

- **Outside the scope of 61968**
Part 9 Message Types

Diagram of message types including:
- CustomerMeterDataSet
- MeterControl
- LoadControl
- MeterDisconnect
- MeterReconnect
- CreditInformation
- PriceSignal
- MeterConfiguration
- MeterEvent
- TamperDetection
- OutageDetection
- MeterHealth
- QualityOfService
- Threshold
- MeterReading
- VerifyConnection
- RevenueEvent
- CustomerSwitching
- MeterInstallation
- MeterChangeOut
- MeterAssetReading
- InitialRead
- ManualRead
- FinalRead
- MeterServiceRequest
### Information and Semantic Models

**CIM UML**

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**Profiles**

- **Contextual layer restricts information model**
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### 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
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
Xtensible Markup Language (XML)

- Universal format for structured documents and data
- Provides a syntax for 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
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 of use of XML Schema
• Mapping Proprietary EMS Interfaces to the CIM
  – Provide enterprise system access to transformer data
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

“name” from IdentifiedObject

Aggregation changed from 0..n to 2

Multiplicity changed from 0..1 to 1

Multiplicity changed from 0..1 to 1
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
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 Modelled with CIM Topology
Siemens 100 Bus Network Model in RDF

Top of RDF Schema version of Siemens 100 bus model
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="#_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="#_D16FD63501444AECBF8157D1E4764E38"/>
    <cim:Terminal.ConductingEquipment rdf:resource="#_6B1DD5C2CB934E86AC53FFD886E2D1B3"/>
  </cim:Terminal>
</rdf:RDF>
```
ACLineSegment in RDF

Siemens 100 bus model - RDF schema

<?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="#_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="#_D16FD63501444AE5CBF8157D1E4764E38"/>
    <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

```xml
<cia:Substation rdf:ID="277B2933524E43E19DAAAF1D138DC62C4">
  <cia:Naming.name>VOL</cia:Naming.name>
  <cia:Substation.LoadArea rdf:resource="#_BA2173878B0645A7AC8EA57B6249D537"/>
</cia:Substation>

<cia:VoltageLevel rdf:ID="_C20AF84C15E047218D75C47870C34C87">
  <cia:Naming.name>230K</cia:Naming.name>
  <cia:VoltageLevel.MemberOf_Substation rdf:resource="#_277B2933524E43E19DAAAF1D138DC62C4"/>
  <cia:VoltageLevel.BaseVoltage rdf:resource="#_CF8BD1450E26439991F7FE5653D0760"/>
</cia:VoltageLevel>

<cia:BusbarSection rdf:ID="5E0DBC09FE4D4A0DB902FEFF18AA4C30">
  <cia:Naming.name>VOL 2304</cia:Naming.name>
  <cia:Equipment.MemberOf_EquipmentContainer rdf:resource="#_7DBBA5E32C834B6AB08BB6FB07155D46"/>
</cia:BusbarSection>

Further down in document

<cia:Bay rdf:ID="_7DBBA5E32C834B6AB08BB6FB07155D46">
  <cia:Naming.name>240W79</cia:Naming.name>
  <cia:Bay.MemberOf_VoltageLevel rdf:resource="#_C20AF84C15E047218D75C47870C34C87"/>
</cia:Bay>

<cia:Breaker rdf:ID="4A74B55420834E40B85F0304B6F9ADF8">
  <cia:Naming.name>CB</cia:Naming.name>
  <cia:Switch.normalOpen>false</cia:Switch.normalOpen>
  <cia:Equipment.MemberOf_EquipmentContainer rdf:resource="#_7DBBA5E32C834B6AB08BB6FB07155D46"/>
</cia:Breaker>
```
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="_FF332A9A82FF43719AAF4E5DAFCFB9CD">
  <cim:Naming.aliasName>ICCP ID 24</cim:Naming.aliasName>
  <cim:Naming.name>MVAR</cim:Naming.name>
  <cim:MeasurementValue.MeasurementValueSource rdf:resource="#_F0F5BA1CDE23483A8C80D20A4907A272"/>
```
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 for importer to ensure all prerequisite models exist prior to importing
Basics: Schema from CIM

CIM (in UML) → Enterprise Architect → CIM as XML/RDF Schema → Exporter

CIM as XML/RDF Schema specifies Power System Data

Power System Data as XML/RDF

UML to RDF Transformers

Power System Data

references
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

**CIM UML**
- 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 Model Exchange Profile

**Power System Model Profile Group**
- 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

Conforms to IEC 61970-301 CIM
Conforms to IEC 61970-452, 453, 456, others
Model Exchange Profile
Conforms to IEC 61970-501 and -552 CIM XML Model Exchange Format
CIM/XML Model Exchange Format
Example: Power Flow Network Model Exchange

- 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
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

Semantic Formalization
Semantic Consistency

Existing Terminology and Metadata

Complements Xtensible MD3i
Role of Enterprise Semantic Model

- Open Standards
- Application Information
- Process Integration
- Business Intelligence

Enterprise Integration Platforms

Business Definitions

Enterprise Semantic Model

Applications Metadata
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

Profile 1
Profile 2
Profile 3

XML Schema
CIM/RDF Schema
DDL

Xtensible Solutions
Ex: Project Interaction Test

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

Conforms to Utility ESM

Conforms to Profiles defined for each system interaction

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

Conforms to WSDLs and Message XML Schemas

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

CIM

CIS

OTHER

Semantic Model

Business Entity

Business Entity

Business Entity

DB Schema

XML Schema
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) 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, PowerGrid 360)
Typical Web Services

(Slide from Stipe Fustar, PowerGrid 360)
A web service to notify market meter data from OMAR system and provided by EAI system.

-- type elements define input and output parameters
-- a request and response case to use the data type defined in TYPE for payload

- <wsdl:message name="NotifyMarketMeterDataRequest">
  - <wsdl:part name="meterData" element="typeIn:MarketMeterData"/>
</wsdl:message>

- <wsdl:message name="NotifyMarketMeterDataResponse">
  - <wsdl:part name="returnData" element="typeOut:outputDataType"/>
</wsdl:message>
(Slide from Stipe Fustar, PowerGrid 360)
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

Default Energy Bids
Real Time Metering
Adjusted Metering
Market Participants
  - Bidding
  - Market Results
  - Settlement
  - Outage Scheduling
  - Dispatch Signals

Forward Market Nodal System

OASIS
- Interchange Scheduling System
- Congestion Revenue Rights
- Intermittent Resources
- Compliance
- RMR Validation
- Generation Outage Scheduling
- Transmission Outage Scheduling
- Market Quality System
  (ATF updates)

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

- Appr 130 integrations between the 22 systems
- Appr 75 message schemas
- Appr 175 service definitions
- Appr 450 publisher/consumer testable data transfers between systems
Other Case Stories*

• The Green Button Standard
  – Green Button leverages CIM standards in the creation of a common way to share and view energy consumption data

• Consumers Energy
  – Consumers Energy leverages IEC CIM for Enterprise Integration and an enterprise semantic model

• Long Island Power Authority
  – Long Island Power Authority (LIPA) leverages IEC CIM for Enterprise Information Management and semantic integration initiatives

• Sempra Energy
  – Sempra Energy uses CIM to support their OpEx 20/20 and Smart Metering programs, reducing the cost of systems integration, maintenance, and support

*These are described in some detail in the Second Edition CIM Primer
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

Questions

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