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

CIM Users Group
Amsterdam, Netherlands

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Presentation Contents – Part 2

- Layer 2 - Profiles for defining system interfaces
  - IEC 61970 network model exchange
  - IEC 61968 message payloads for system integration
- Layer 3 - Implementation syntax of instance data
  - CIM expressed in XML and RDF Schema
- Value of an Enterprise Semantic Model (ESM) based on the CIM
- Case studies
- Where to get more 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

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

How the CIM is Applied to Specific Information Exchanges

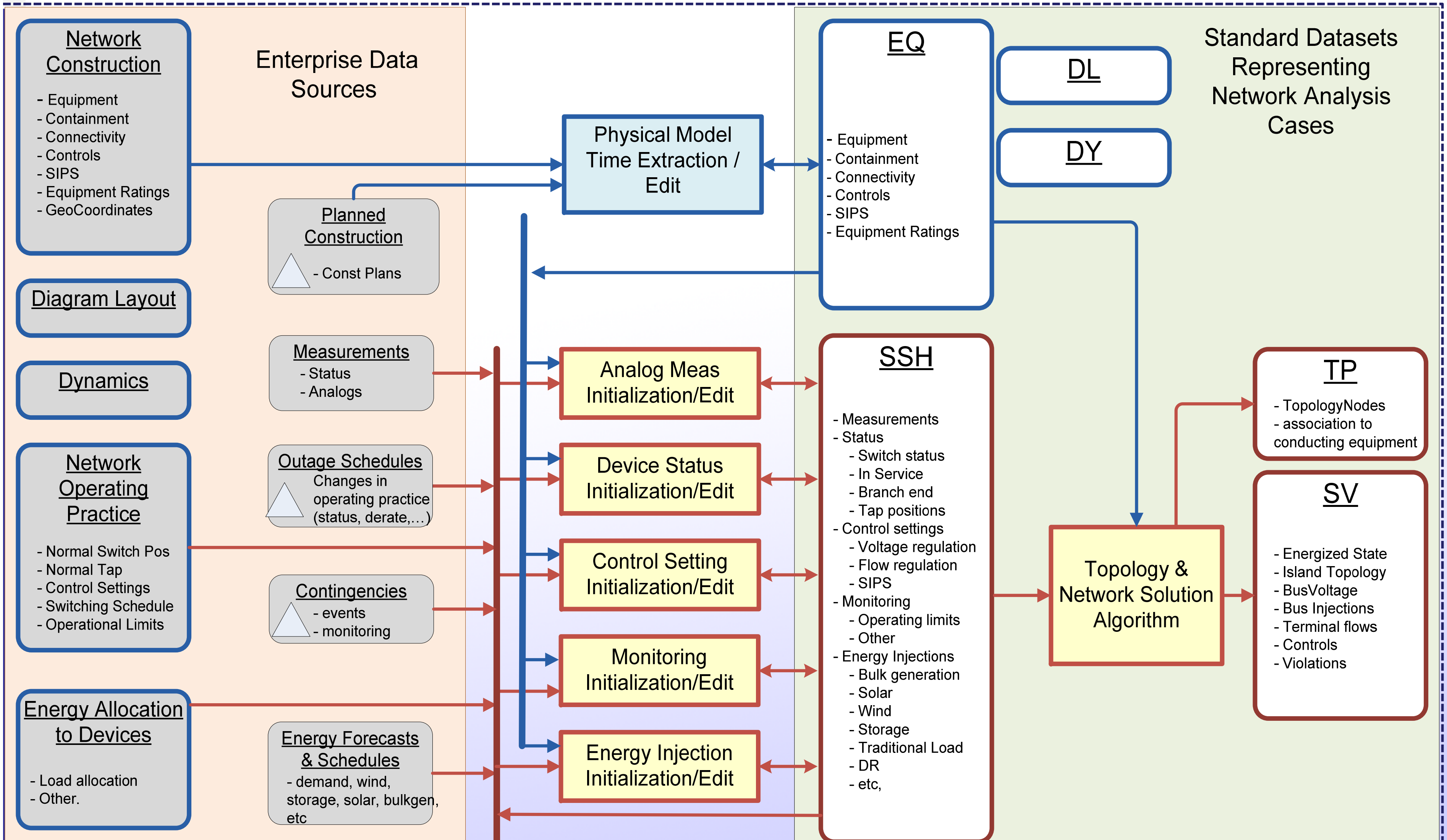
- The interfaces defined under CIM are defined by Profiles
  – A profile specifies the information structure of exchanged information by creating contextual semantic models
    - Contextual semantic models are a subset of the overall CIM information model (i.e., they inherit their structure from the 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

- Note: We saw that the CIM Information Model is partitioned into sub-domains by IEC WGs
  – But these groups work hard to ensure there is a single, *unified* semantic model over the whole utility domain
  – That means any part of the whole UML model can be used to define a system interface
  –

Presentation Contents

- Profiles for business context
  - WG13 61970 Profiles for Power System Network Model Exchange
  - WG14 61968 Message Payloads for System Integration

WG13 Reference Diagram for Power Flow Cases



61970 Profiles Currently Defined

Part 452 Static Transmission Network Model Profiles

- Equipment (EQ)
  - Identifies equipment, basic characteristics, and electrical connectivity of steady state network model
  - 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 EQ with some extensions

Part 456 - Solved Power System State Profiles

- Steady State Hypothesis (SSH)
  - Measurements
  - Status
  - Controls
  - Limits
  - Energy distribution
- Topology (TP)
  - The result of topology processing. i.e. description of how equipment is connected at a particular point in time
- State Variables (SV)
  - Result of a state estimator or power flow, or the starting conditions of state variables

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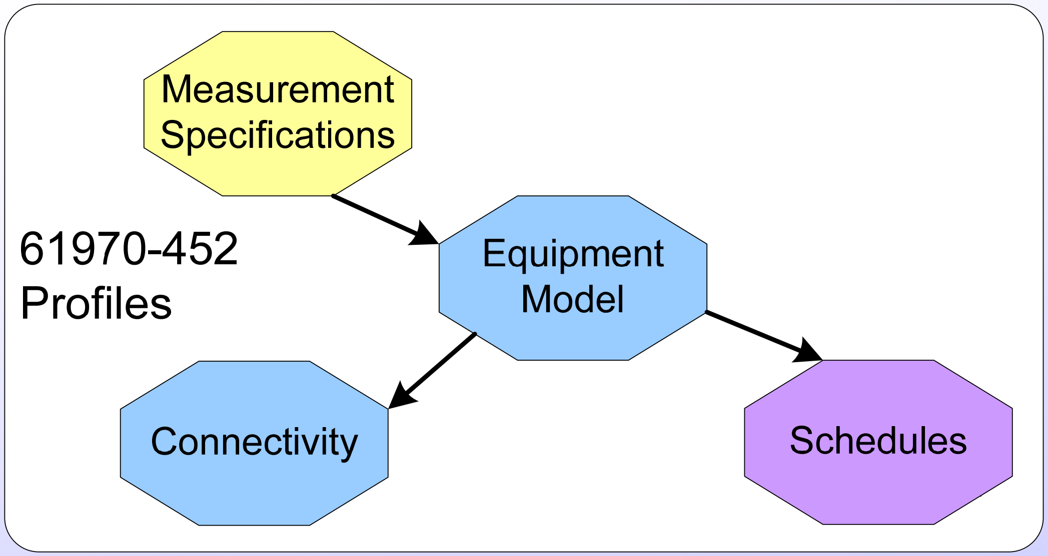
61970 Profiles

- **Part 457** - Dynamics (DY)
  - Adds dynamics to static network model for running system simulations
- **Part 453** - Diagram Layout (DL)
  - Describes how equipment objects are placed on schematic diagrams for display purposes

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



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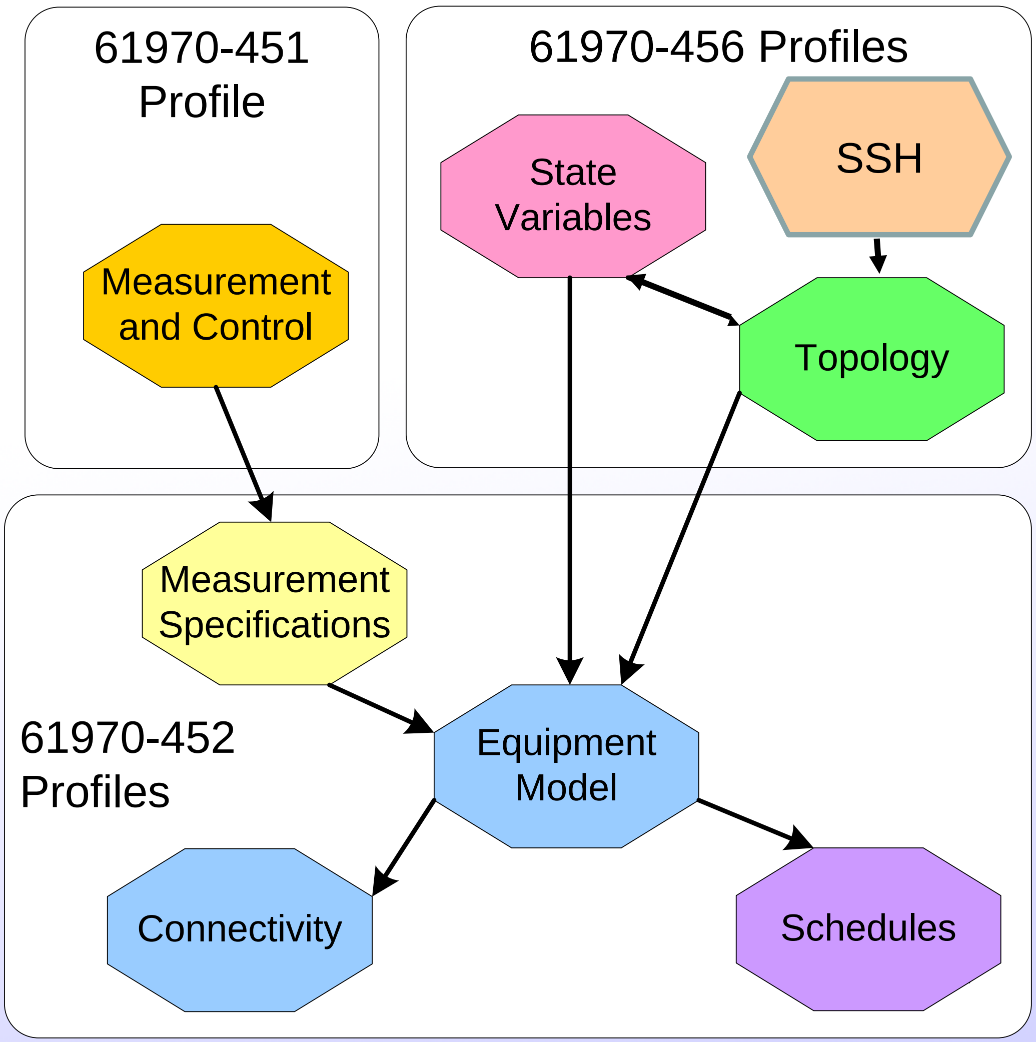
Plus 61970-451 Measurement and Control and -456 Solved System State Profiles



Adds SCADA

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

Dependencies via references to CPSM Part 452

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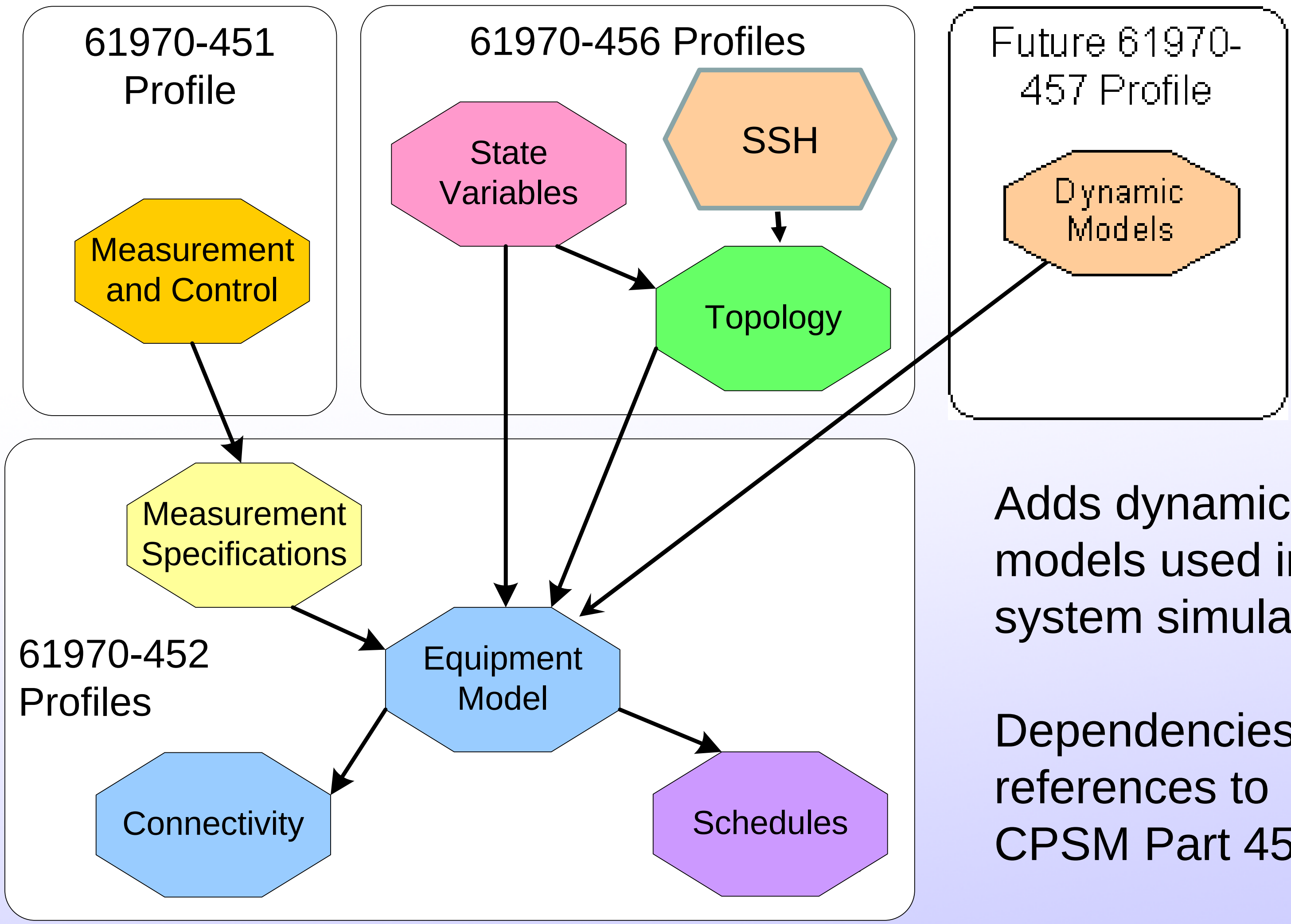
Plus 61970-451 Measurement and Control and -456 Solved System State Profiles



Adds dynamic models used in system simulation

Dependencies via references to CPSM Part 452

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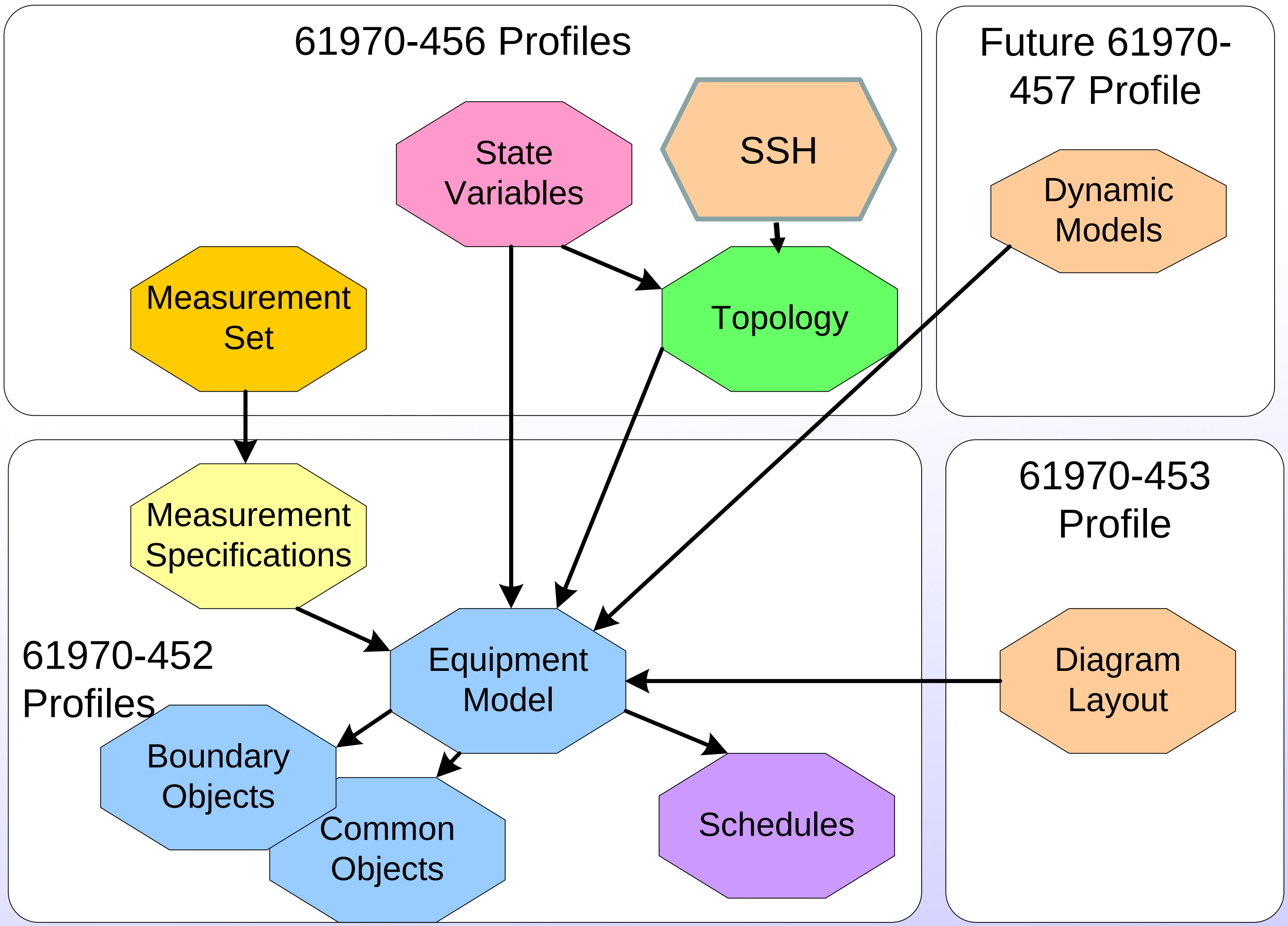
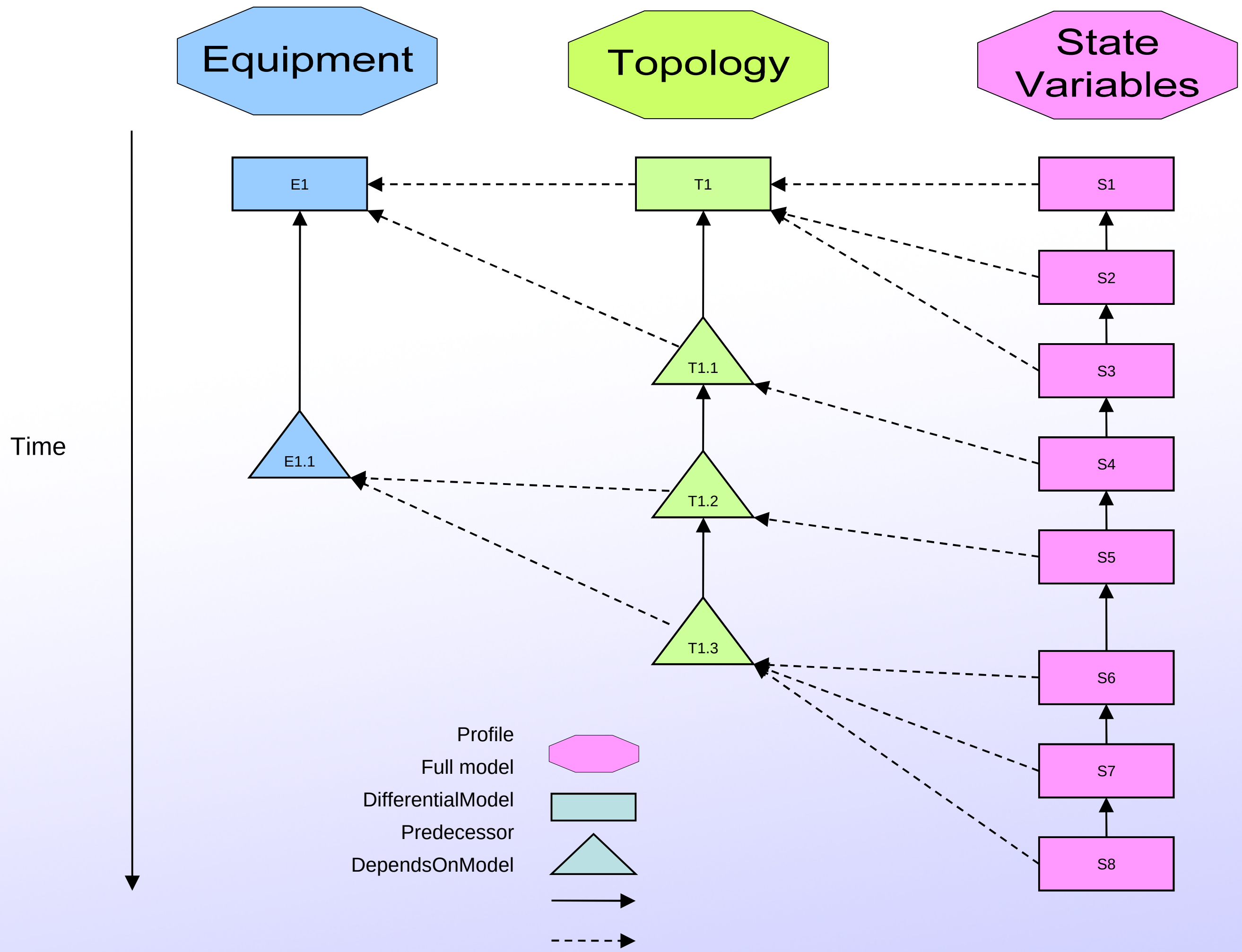
Plus 61970-453 Diagram Layout Profile



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

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

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/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

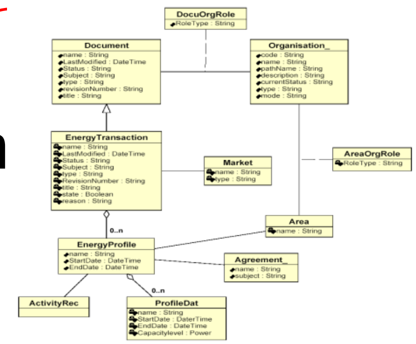
Presentation Contents

- Profiles for business context
  - WG13 61970 Profiles for Power System Network Model Exchange
  - WG14 61968 Message Payloads for System Integration

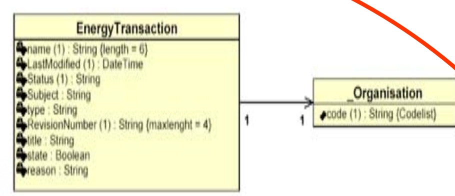
From Information Model to Syntactic Model

Abstract Model

Information Semantic Model

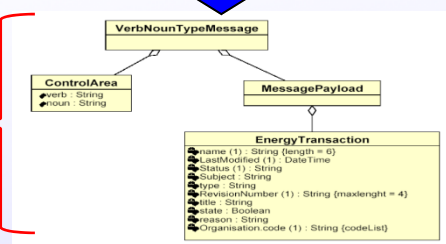


Context/ Profiles



UML World

Message Assembly



XML Syntactic World

Message Syntax

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

Syntactic Model

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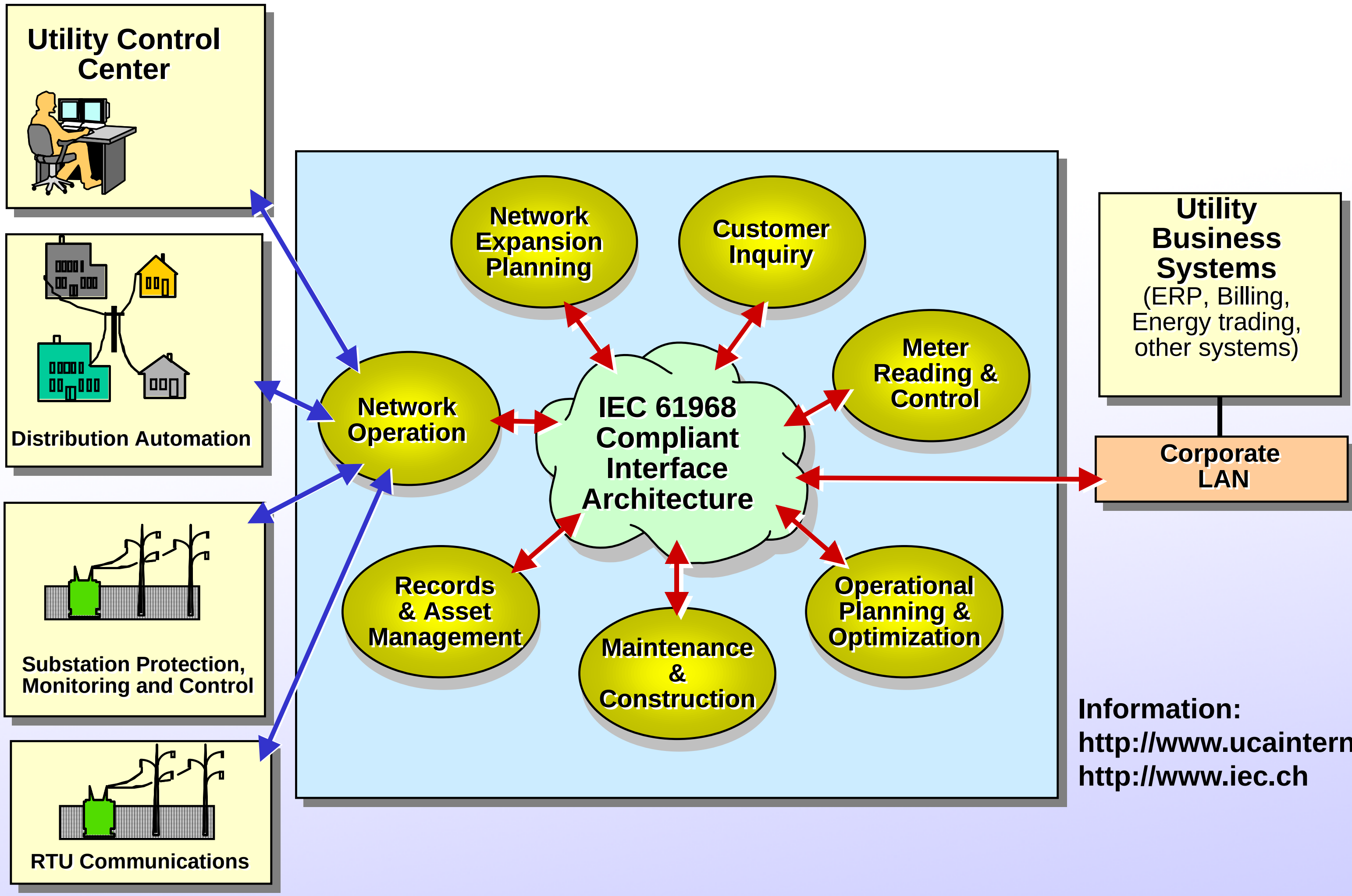
Working Group 14: Establishing A Common Language For *Enterprise Application Integration* In the IEC 61968 Series of Standards



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

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Smart Grid Interoperability

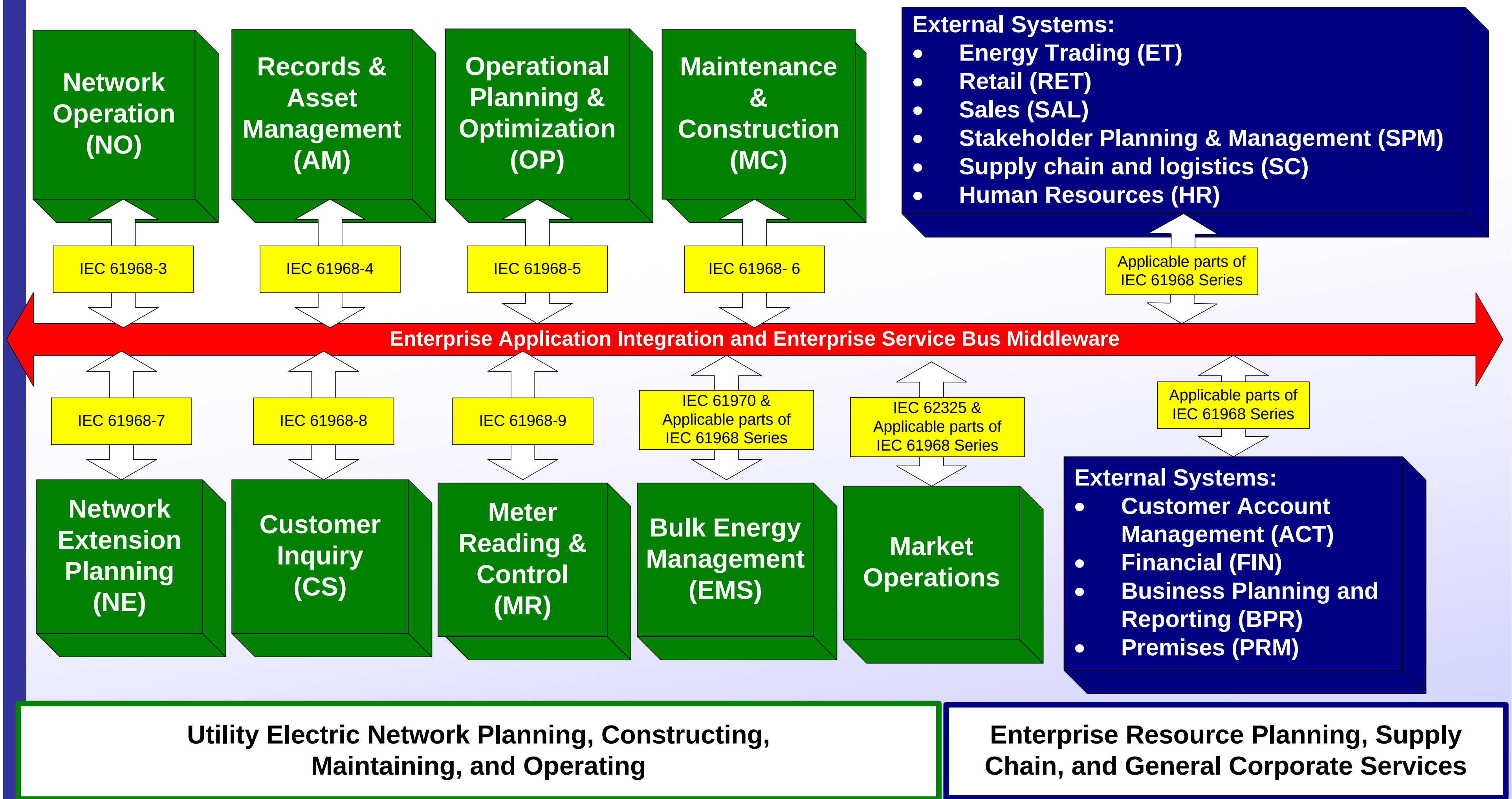
- Ability of systems to **operate in coordination**
  - Ability to exchange and use information appropriately
- Requires **standard interface definitions**
  - Governed by open industry working groups
- Provides **Benefits**
  - Promotes **loosely-coupled** integration
    - Allows incremental functional enhancements
    - Creates market for reusable, compatible components
  - Only **one integration** instead of many
    - To an open, public, standard interface
      - Instead of each proprietary vendor or utility interface

Smart Grid Challenges

- Requires Integration – LOTS of integration
  - Onslaught of new applications and technologies
    - AMI, MDMS, HAN, DR, ADE, etc.
- In a complex IT environment
  - Many custom systems, legacy technologies
  - Typically departmentally controlled – within "silos"
    - Need ability to govern, manage, and share resources
      - at the Enterprise level and beyond (external services)
  - Aging / outsourced systems and IT workforce
  - Historically, extremely low R&D expenditures
    - Must ramp up capabilities quickly

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

<u>All IEC 61968 Activity Diagrams and Sequence Diagrams are organized by the IRM</u>



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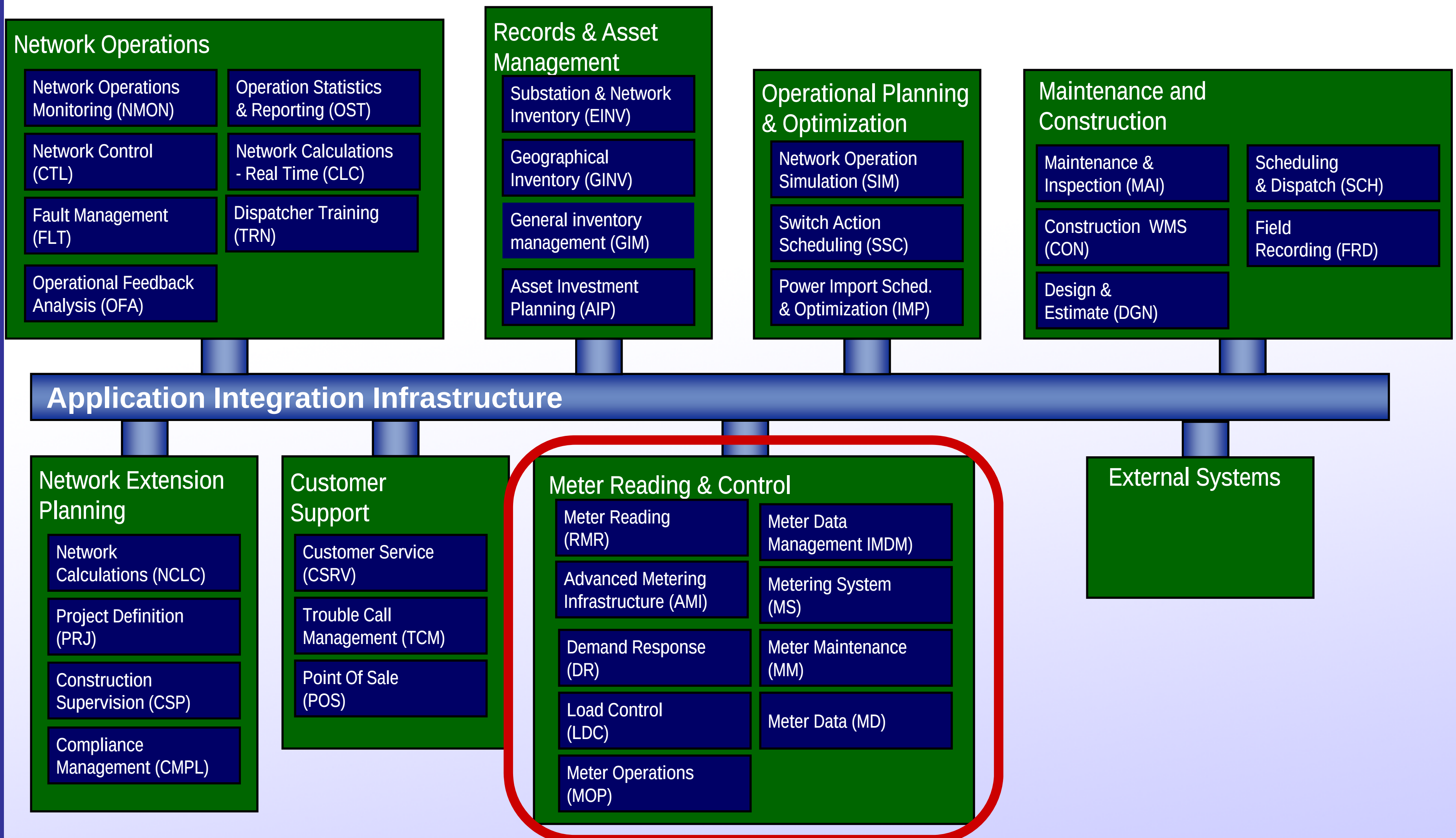
The Business Sub-Function Level of the IRM for IEC 61968 Scope



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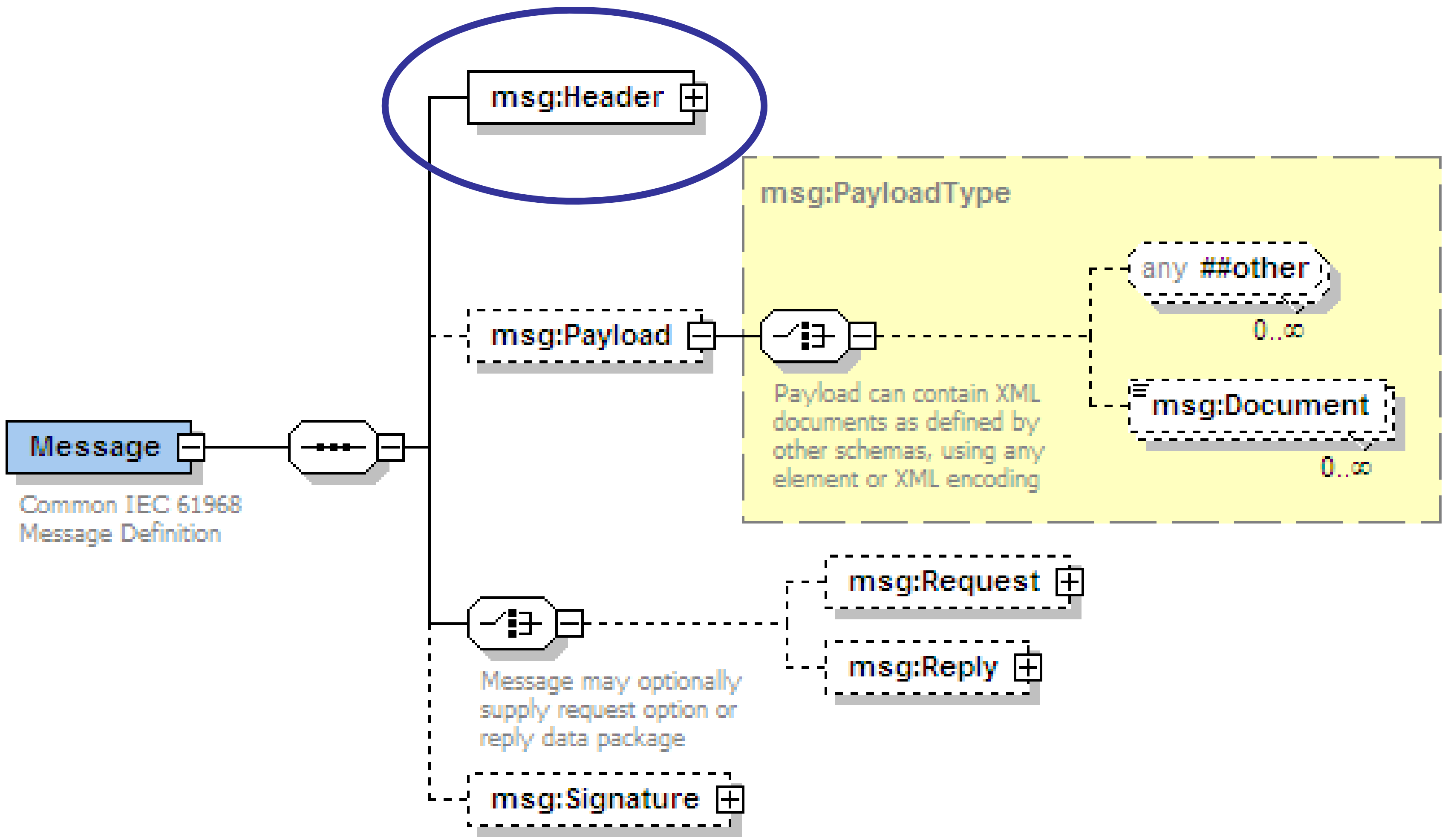
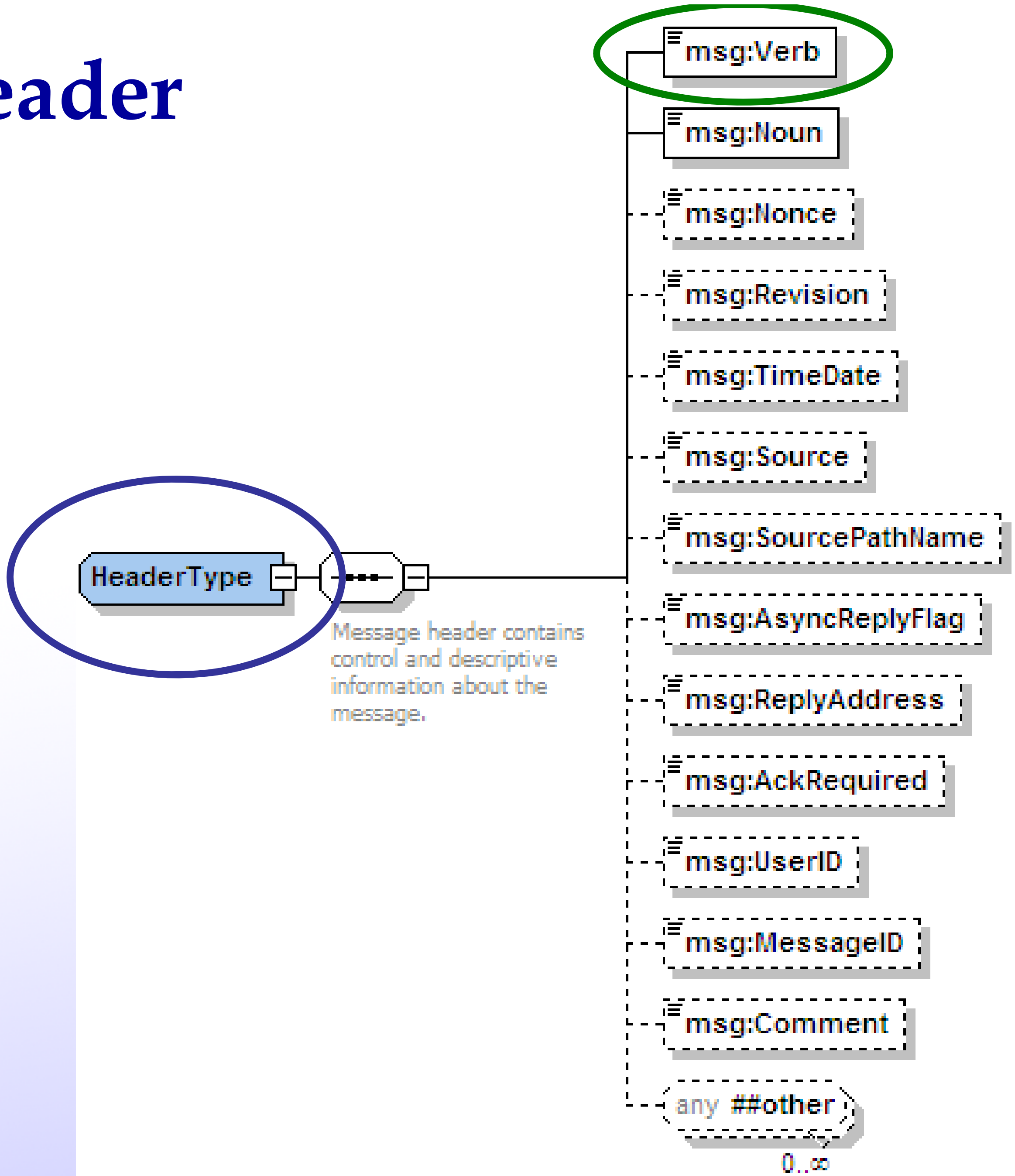
The IEC 61968 Basic Message Structure



Message Header



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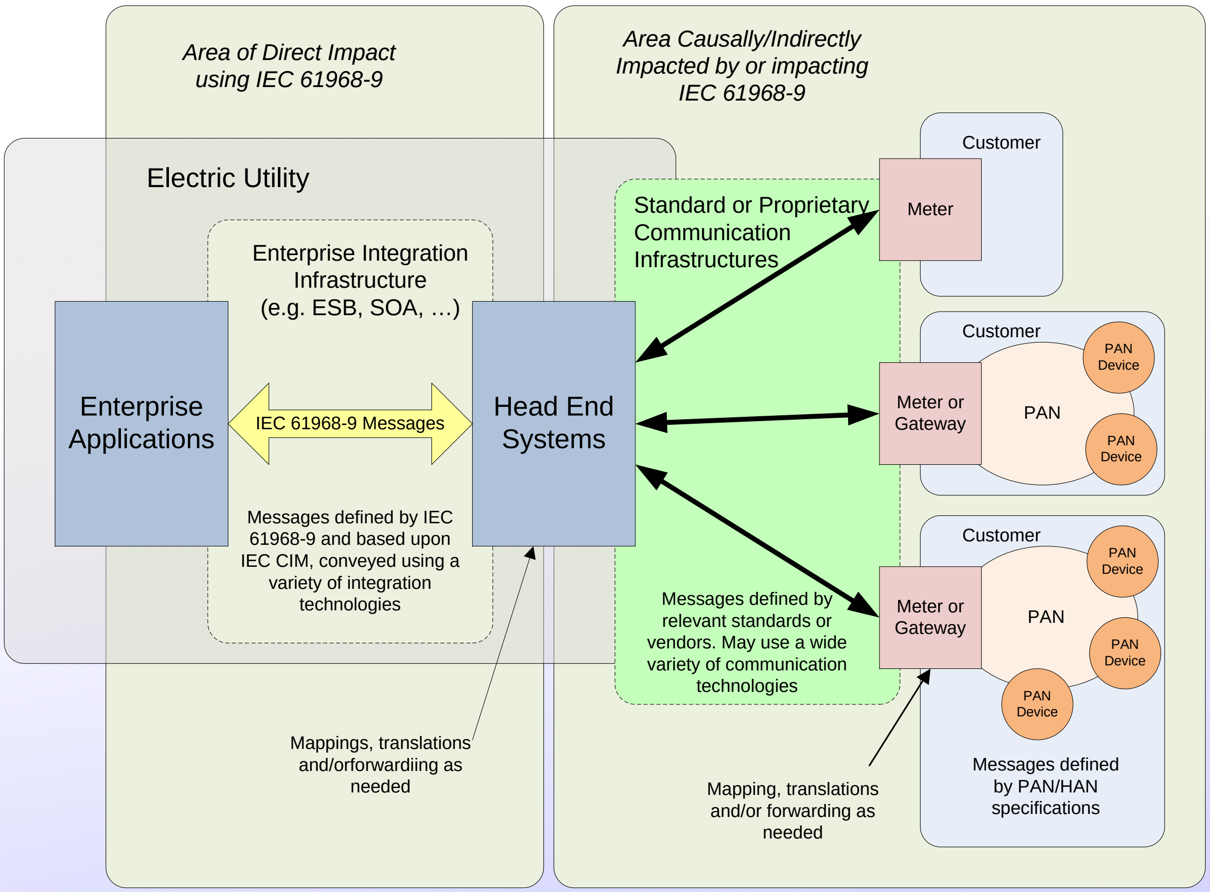
IEC 61968-9: Interface Standard for Meter Reading and Control

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 Merter Reading and Control.
- Typical uses of the message types include:
  - Meter Reading and Meter Control
  - Meter Events
  - Customer Data Synchronization and Customer Switching

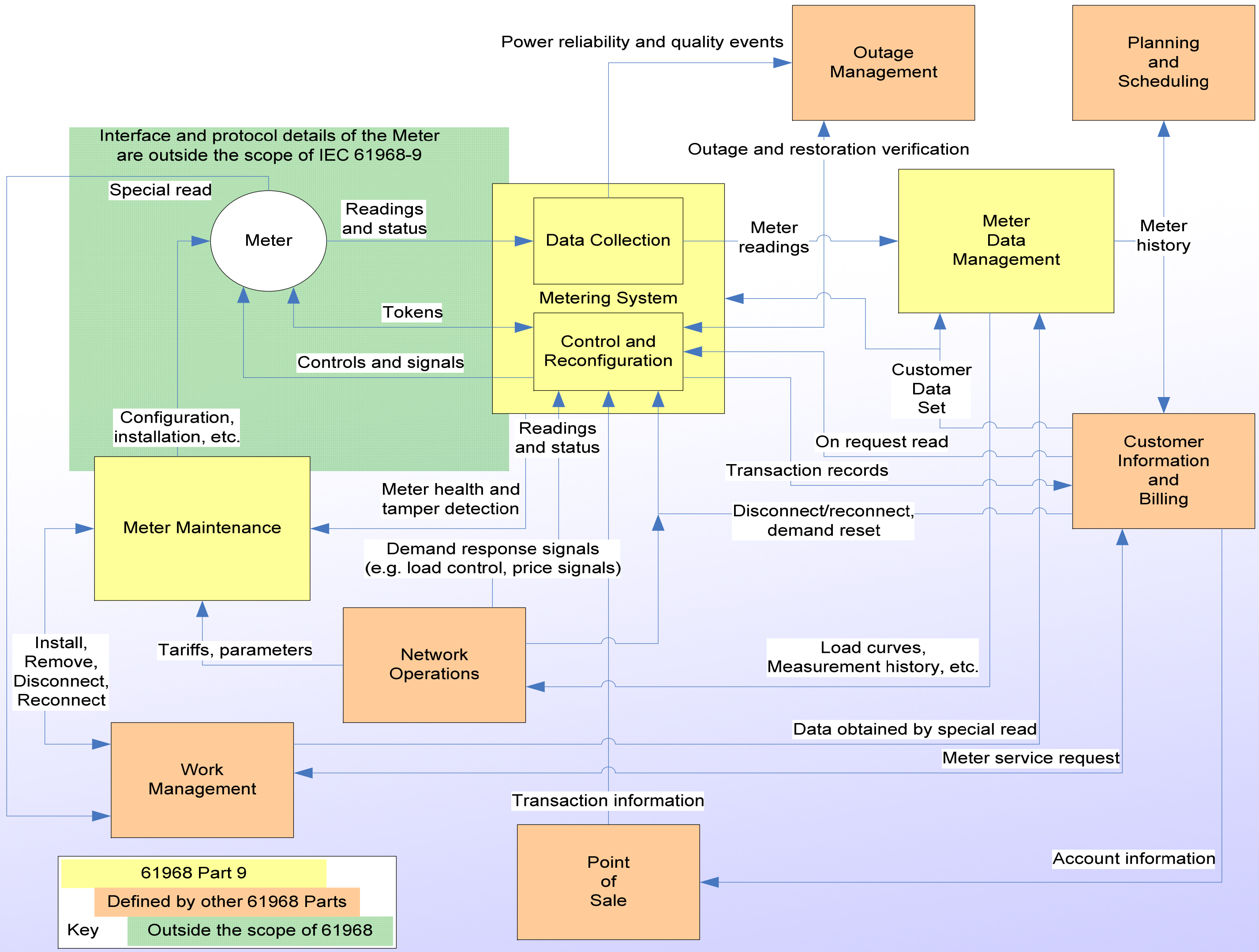
Scope of Part 9



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



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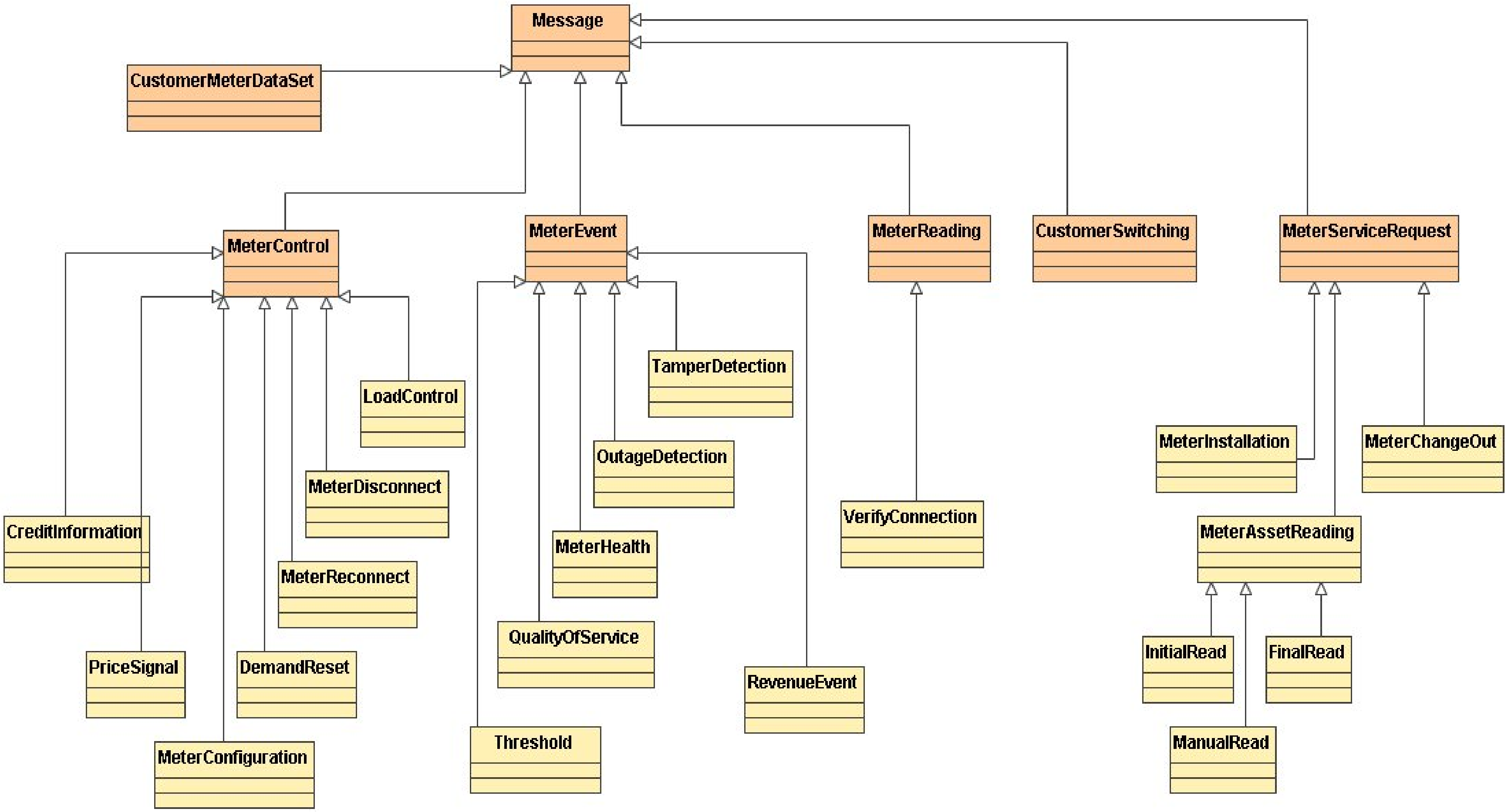
Part 9 Message Types



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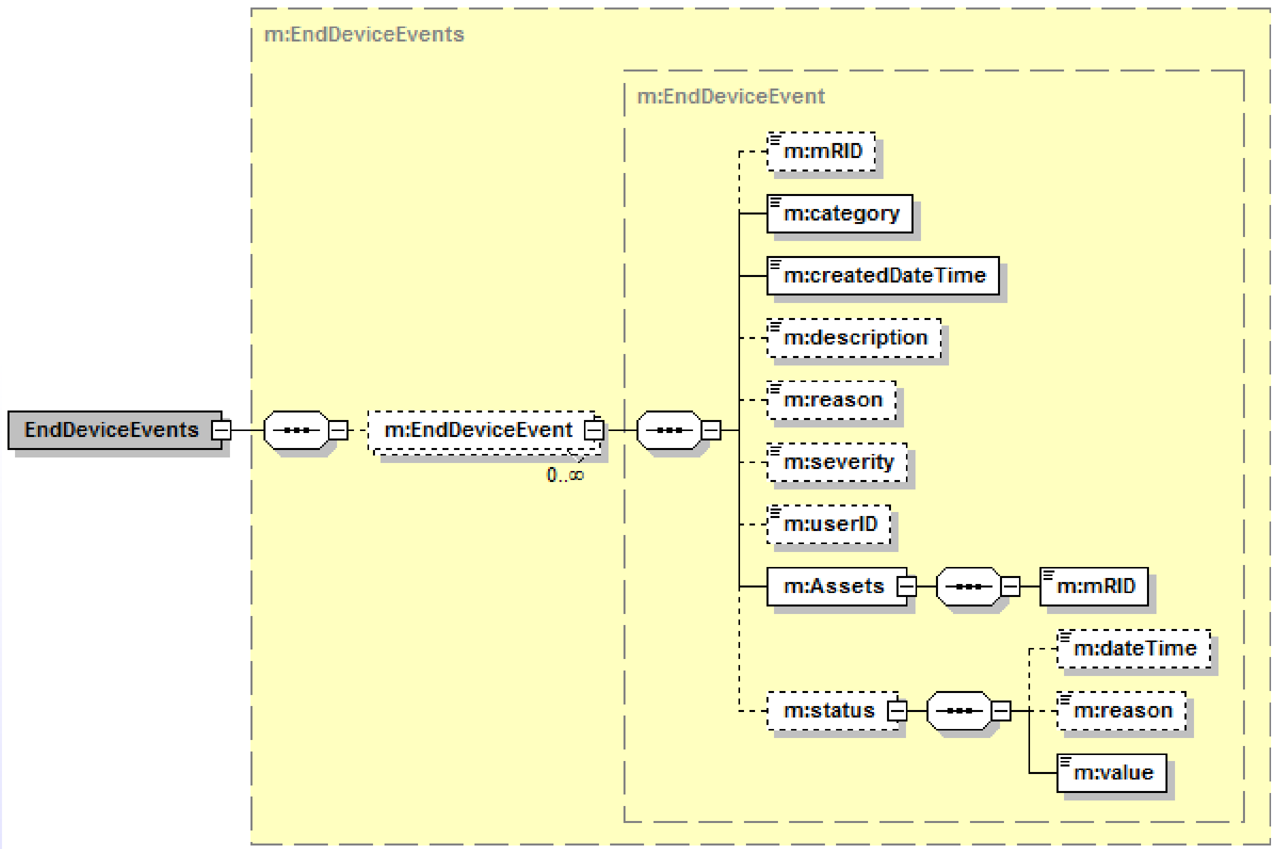
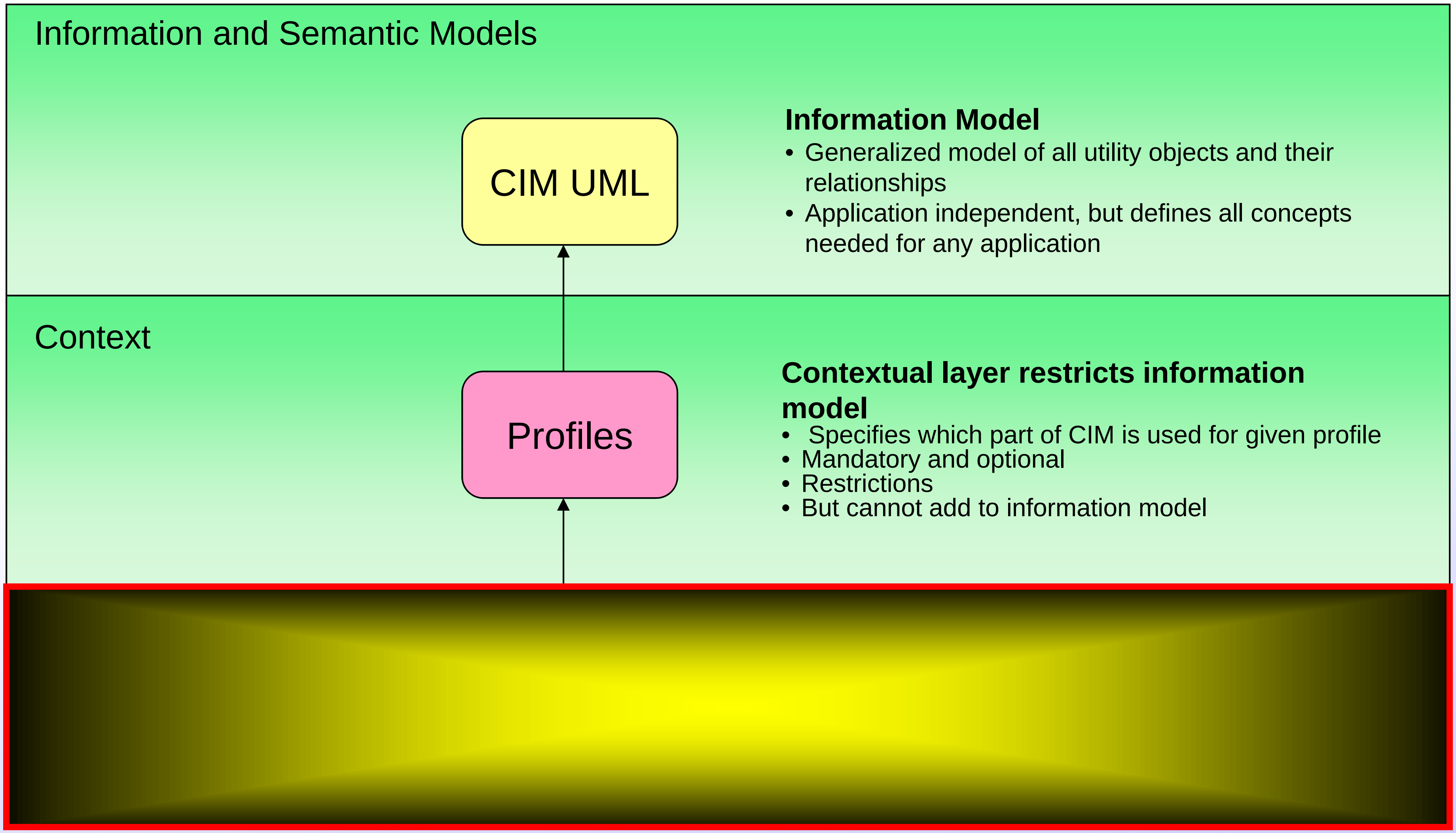
Typical Message Payload Definition - EndDeviceEvent Message

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



Next – Message Syntax



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

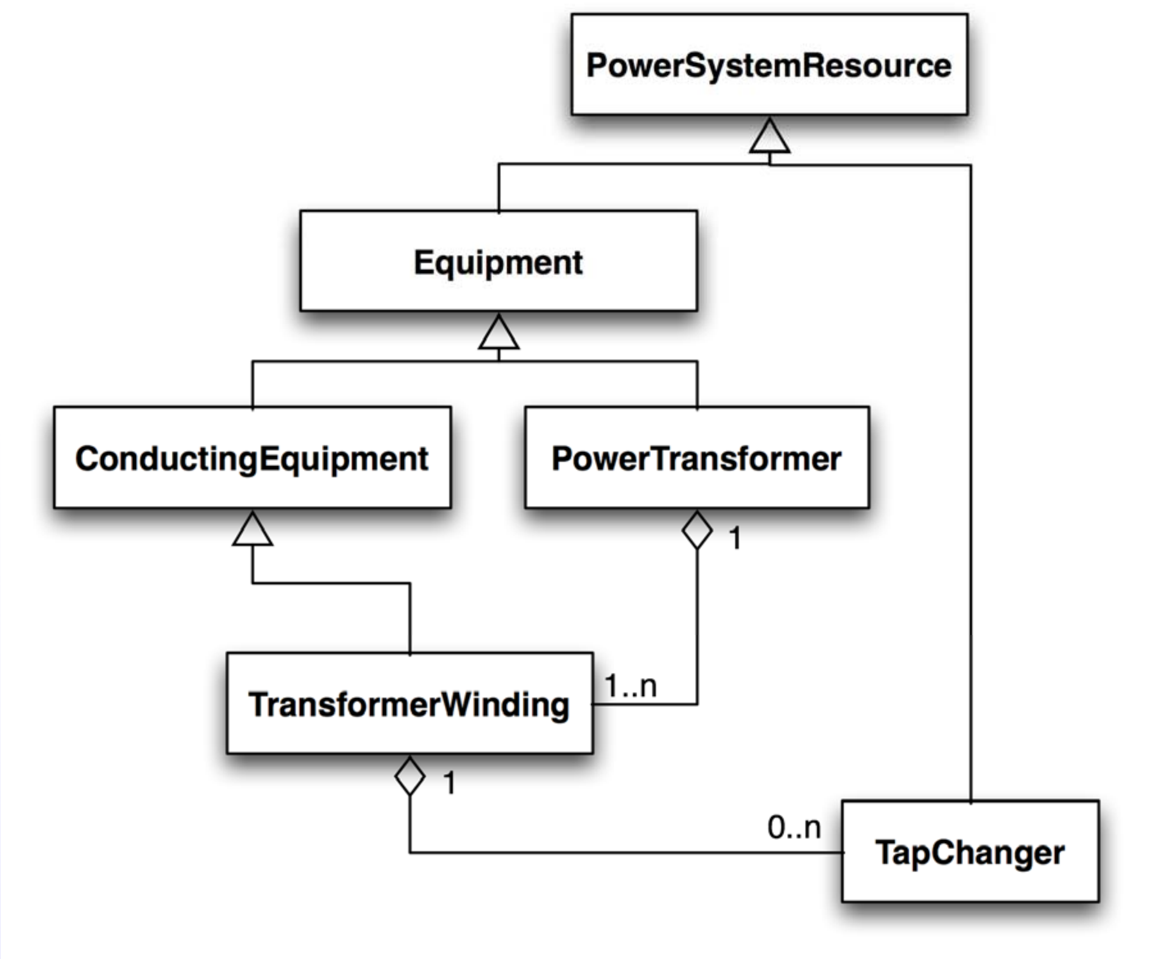
Example of use of XML Schema

- 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 Simplified (Pre-Release 15 model)



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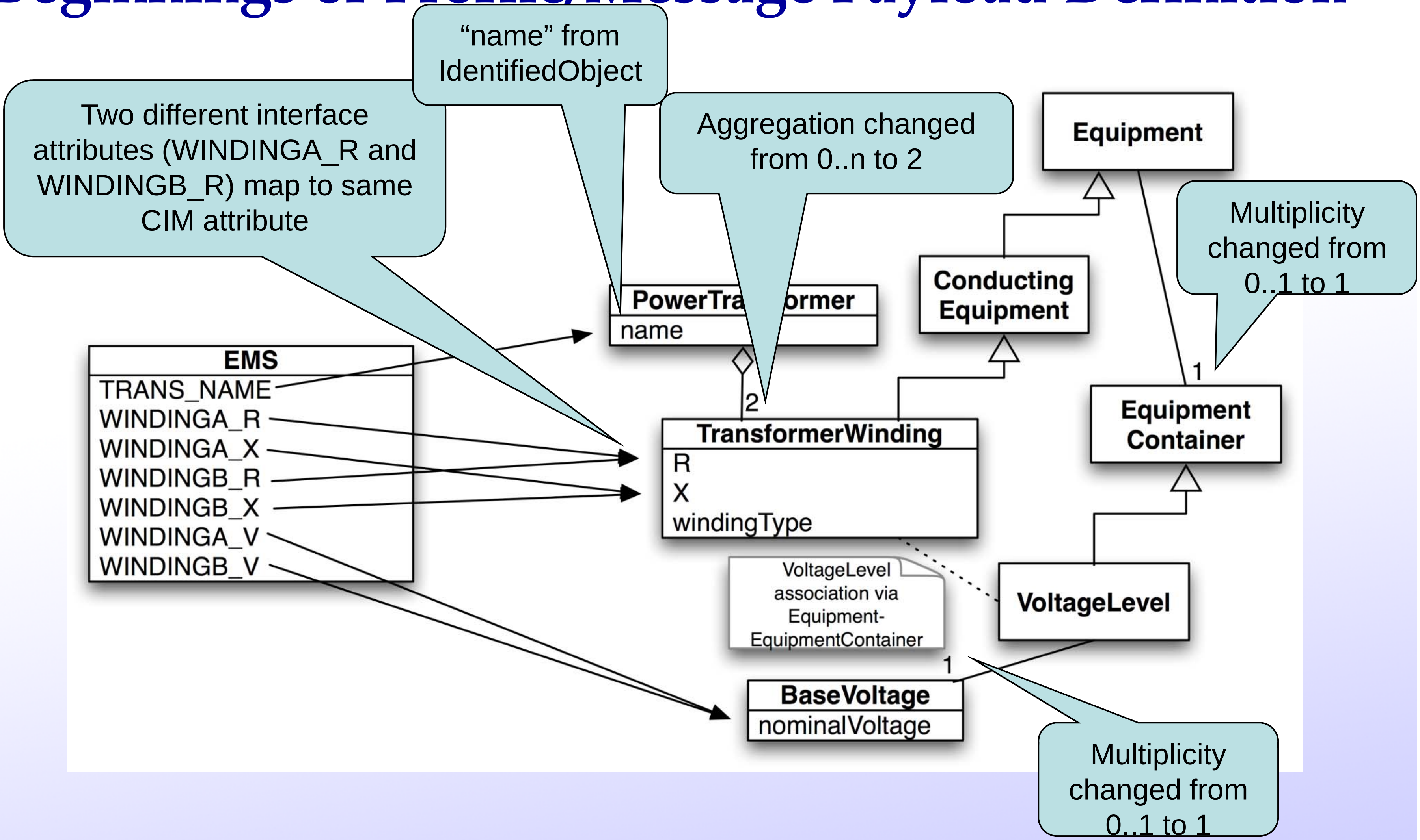
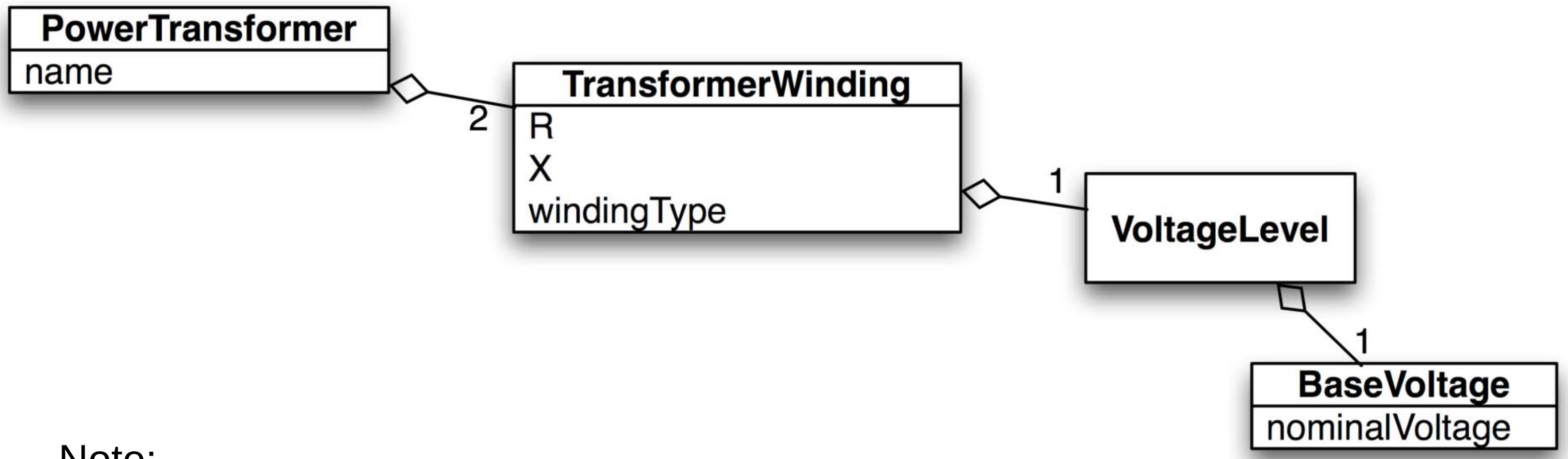
CIM Interface Mapping
- Beginnings of Profile/Message Payload Definition



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


```
<xs:schema xmlns:cim="cimBase" xmlns:xs="http://www.w3.org/2001/XMLSchema">

<xs:element minOccurs="1" maxOccurs="1" name="PowerTransformer">
 <xs:complexType>
  <xs:complexContent>
   <xs:extension base="cim:PowerTransformer">
    <xs:sequence>
     <xs:element minOccurs="1" maxOccurs="1"
         name="Naming.name" type="xs:string"/>
     <xs:element minOccurs="2" maxOccurs="2"
         name="PowerTransformer.Contains_TransformerWindings">
      <xs:complexType>
       <xs:complexContent>
        <xs:extension base="cim:TransformerWinding">
         <xs:sequence>
          <xs:element minOccurs="1" maxOccurs="1"
              name="TransformerWinding.r" type="xs:float"/>
          <xs:element minOccurs="1" maxOccurs="1"
              name="TransformerWinding.x" type="xs:float"/>
          <xs:element minOccurs="1" maxOccurs="1"
              name="TransformerWinding.windingType" type="cim:WindingType"/>
          <xs:element minOccurs="1" maxOccurs="1"
              name="TransformerWinding.MemberOf_EquipmentContainer">
           <xs:complexType>
            <xs:complexContent>
             <xs:extension base="cim:VoltageLevel">
              <xs:sequence>
               <xs:element minOccurs="1" maxOccurs="1"
                   name="VoltageLevel.BaseVoltage">
                <xs:complexType>
                 <xs:complexContent>
                  <xs:extension base="cim:BaseVoltage">
                   <xs:sequence>
                    <xs:element minOccurs="1" maxOccurs="1"
                        name="BaseVoltage.nominalVoltage" type="xs:float"/>
                   </xs:sequence>
                  <xs:extension>
                 </xs:complexContent>
                 </xs:complexType>
               </xs:element>
              </xs:sequence>
             </xs:extension>
            </xs:complexContent>
           </xs:complexType>
          </xs:element>
         </xs:sequence>
        </xs:extension>
       </xs:complexContent>
      </xs:complexType>
     </xs:element>
    </xs:sequence>
   </xs:extension>
  </xs:complexContent>
 </xs:complexType>
</xs:element>

</xs:schema>
```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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.nominaVoltage>400
          </cim:BaseVoltage.nominalVoltage>
      </cim:VoltageLevel.BaseVoltage>
    </cim:Equipment.MemberOf_EquipmenContainer>
  </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.nominaVoltage>275
              </cim:BaseVoltage.nominalVoltage>
      </cim:VoltageLevel.BaseVoltage>
    </cim:Equipment.MemberOf_EquipmenContainer>
  </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

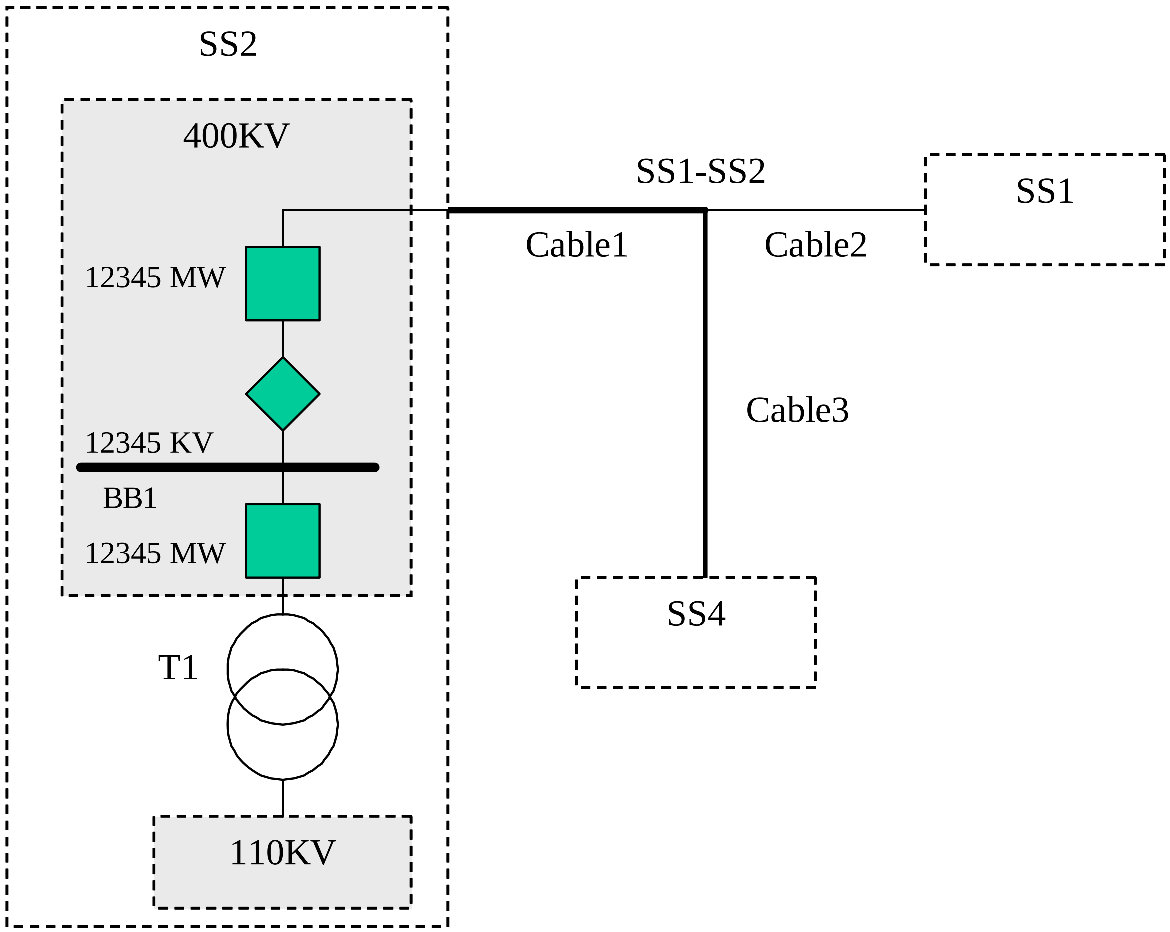
References

- 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/

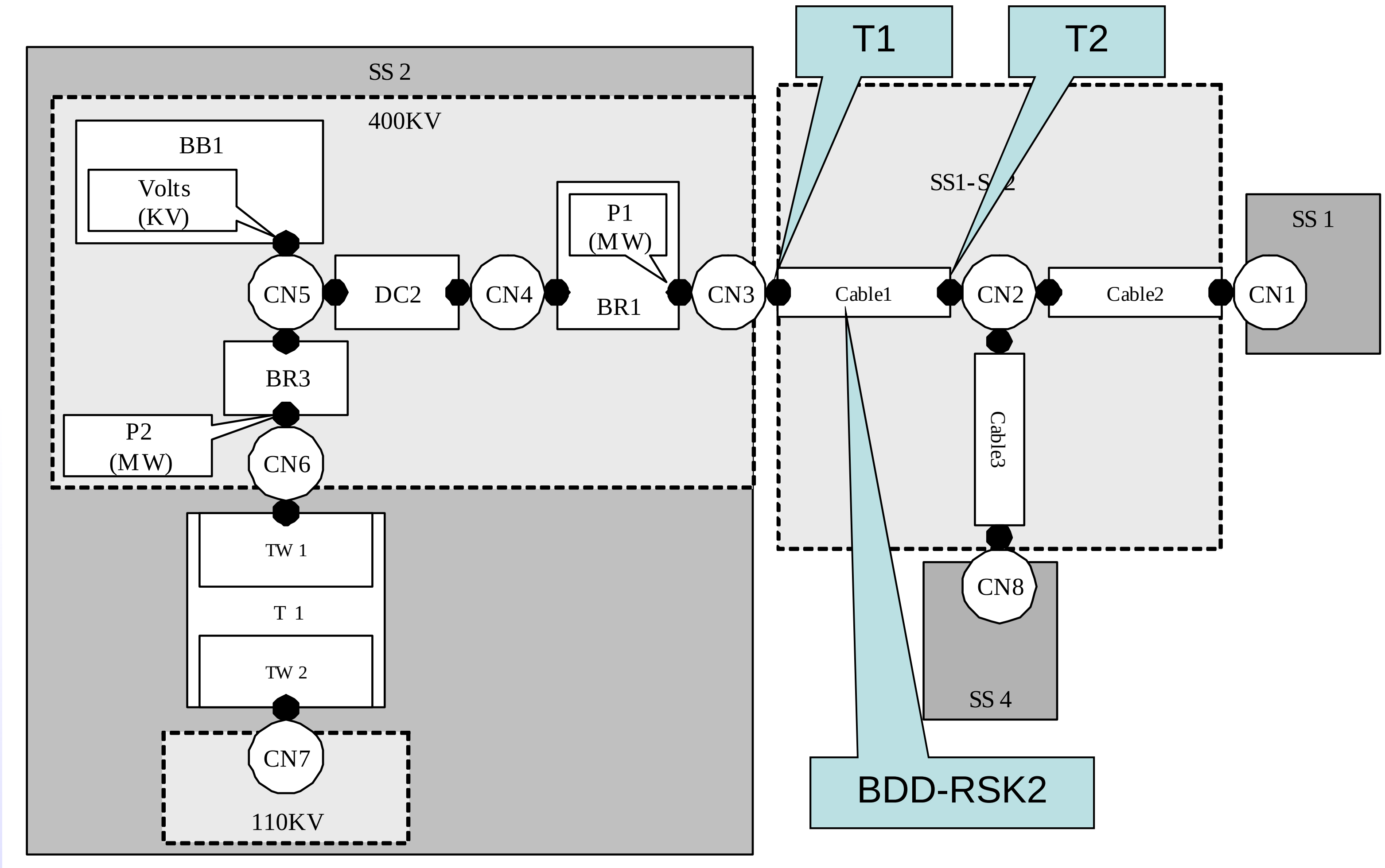
Mapping CIM Class Structure to XML using RDF Schema

- 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



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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 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><cim:ACLineSegment rdf:ID="_E83B07FE54A945539A95FD2DB2CDD4FC">
<cim:Naming.name>BKR-TUR</cim:Naming.name><cim:Conductor.bch>0.39</cim:Conductor.bch><cim:Conductor.x>4.1262
</cim:Conductor.x><cim:Conductor.r>1.0051</cim:Conductor.r></cim:ACLineSegment><cim:Terminal
rdf:ID="_E273D9258F9D42FCA018B274BE6F5FA6"><cim:Naming.name>T2</cim:Naming.name><cim:Terminal.ConnectivityNode
rdf:resource="#_576B6D171B174B8BACB7AFF7289D0434"/><cim:Terminal.ConductingEquipment
rdf:resource="#_E83B07FE54A945539A95FD2DB2CDD4FC"/></cim:Terminal><cim:Terminal
rdf:ID="_B23175B9692441AFBD2C581E86300550"><cim:Naming.name>T1</cim:Naming.name><cim:Terminal.ConnectivityNode
rdf:resource="#_A69ED82F4EB4B65A8840CDD1E064887"/><cim:Terminal.ConductingEquipment
rdf:resource="#_E83B07FE54A945539A95FD2DB2CDD4FC"/></cim:Terminal><cim:Unit rdf:ID="_
5EAAD38A446E429E9905FAC32070D6FC"><cim:Naming.name>Amperes</cim:Naming.name></cim:Unit><cim:ACLineSegment
rdf:ID="_329884C01F6B4DC08492F711088538D6"><cim:Naming.name>CRS-ANY1</cim:Naming.name><cim:Conductor.bch>5.03
</cim:Conductor.bch><cim:Conductor.x>12.90761</cim:Conductor.x><cim:Conductor.r>1.2696</cim:Conductor.r></
```

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="#_D16FD63501444AECBF8157D1E4764E38"/>
      <cim:Terminal.ConductingEquipment rdf:resource="#_6B1DD5C2CB934E86AC53FFD886E2D1B3"/>
</cim:Terminal>
```

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="#_D16FD63501444AECBF8157D1E4764E38"/>
      <cim:Terminal.ConductingEquipment rdf:resource="#_6B1DD5C2CB934E86AC53FFD886E2D1B3"/>
</cim:Terminal>
```

Containment in RDF

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

```
<cim:Substation rdf:ID="_277B2933524E43E19DAAF1D138DC62C4">
      <cim:Naming.name>VOL</cim:Naming.name>
      <cim:Substation.LoadArea rdf:resource="#_BA2173878B0645A7AC8EA57B6249D537"/>
</cim:Substation>

<cim:VoltageLevel rdf:ID="_C20AF84C15E047218D75C47870C34C87">
      <cim:Naming.name>230K</cim:Naming.name>
      <cim:VoltageLevel.MemberOf_Substation rdf:resource="#_277B2933524E43E19DAAF1D138DC62C4"/>
      <cim:VoltageLevel.BaseVoltage rdf:resource="#_CF8BD1450E264399891F7FE5653D0760"/>
</cim:VoltageLevel>

<cim:BusbarSection rdf:ID="_5E0DBC09FE4D4A0DB902FEFF18AA4C30">
      <cim:Naming.name>VOL 2304</cim:Naming.name>
      <cim:Equipment.MemberOf_EquipmentContainer rdf:resource="#_C20AF84C15E047218D75C47870C34C87"/>
</cim:BusbarSection>
```

Further down in document

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

<cim:Breaker rdf:ID="_4A74B55420834E40B85F0304B6F9ADF8">
      <cim:Naming.name>CB</cim:Naming.name>
      <cim:Switch.normalOpen>false</cim:Switch.normalOpen>
      <cim:Equipment.MemberOf_EquipmentContainer rdf:resource="#_7DBBA5E32C834B6AB08BB6FB07155D46"/>
</cim:Breaker>
```

Measurement in RDF

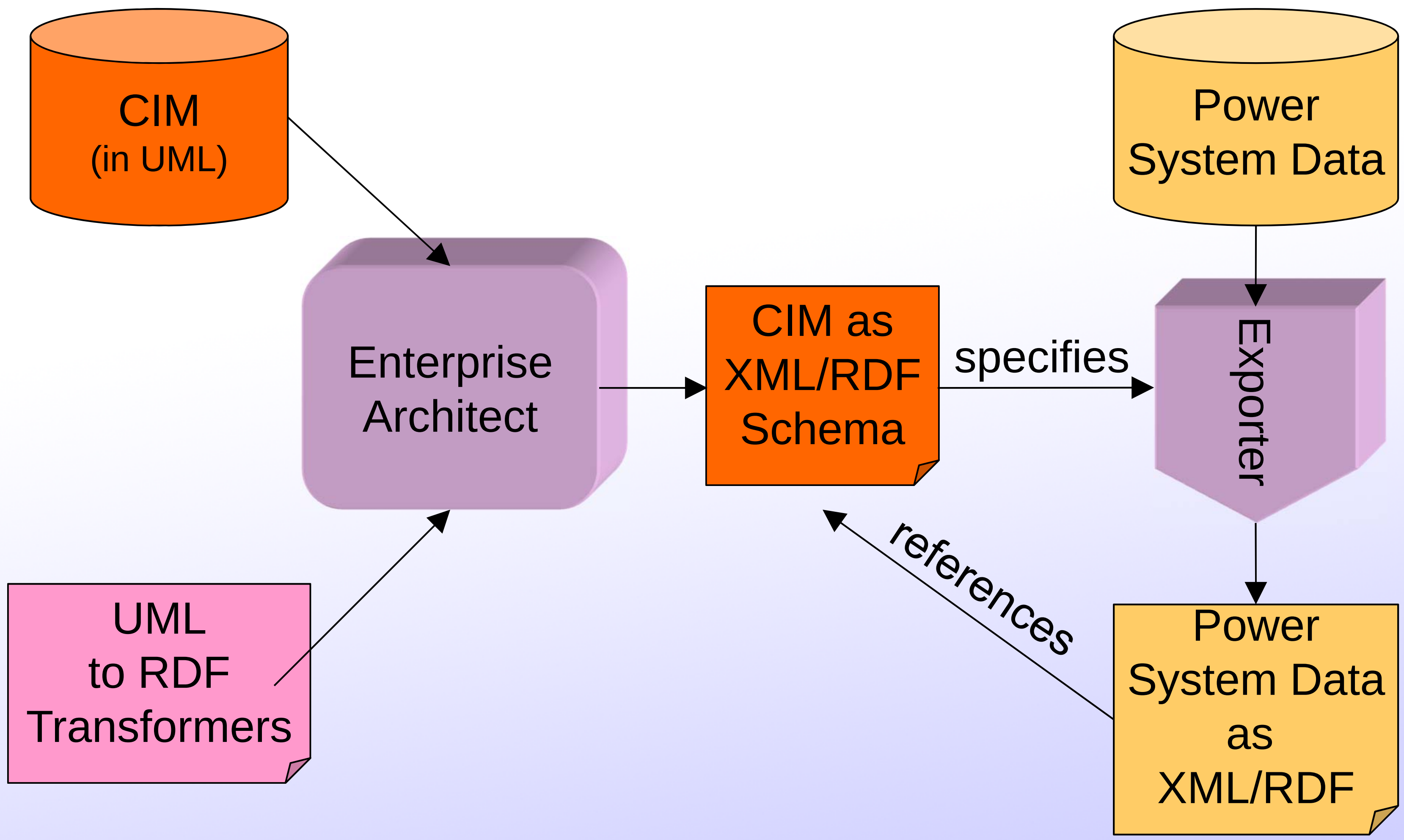
```
<cim:Measurement rdf:ID="_5B22599688AC4DE6B99FD8B13C1BA36F">
     <cim:Naming.name>LN    1 MVAr</cim:Naming.name>
     <cim:Measurement.MeasurementType rdf:resource="#_83D7B035901D4D2E80C040609D5ED7EC"/>
     <cim:Measurement.Unit rdf:resource="#_61784D3DA1954750A4E09444BE5206CB"/>
</cim:Measurement>

<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"/>
     <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 for importer to ensure all prerequisite models exist prior to importing

Basics: Schema from CIM



How Are CIM Standards Used?

- Unlike most standards we use
  - Ex: IEC 60870-6 ICCP/TASE.2 Communication Protocol standard
  - Fixed functionality, very ***stable***, easy to test ***compliance***, but ***inflexible***
- CIM standards can also be strictly applied and tested for compliance
  - Ex: CIM/XML Power system network model exchange
  - Product interfaces are developed and tested for compliance
  - Subject of several EPRI-sponsored interoperability tests (IOPs) for specific interface definition
  - ENTSO-E is best example of the need for strict compliance testing of power system network models and related information exchanges (such as congestion forcasts) via IOPs

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

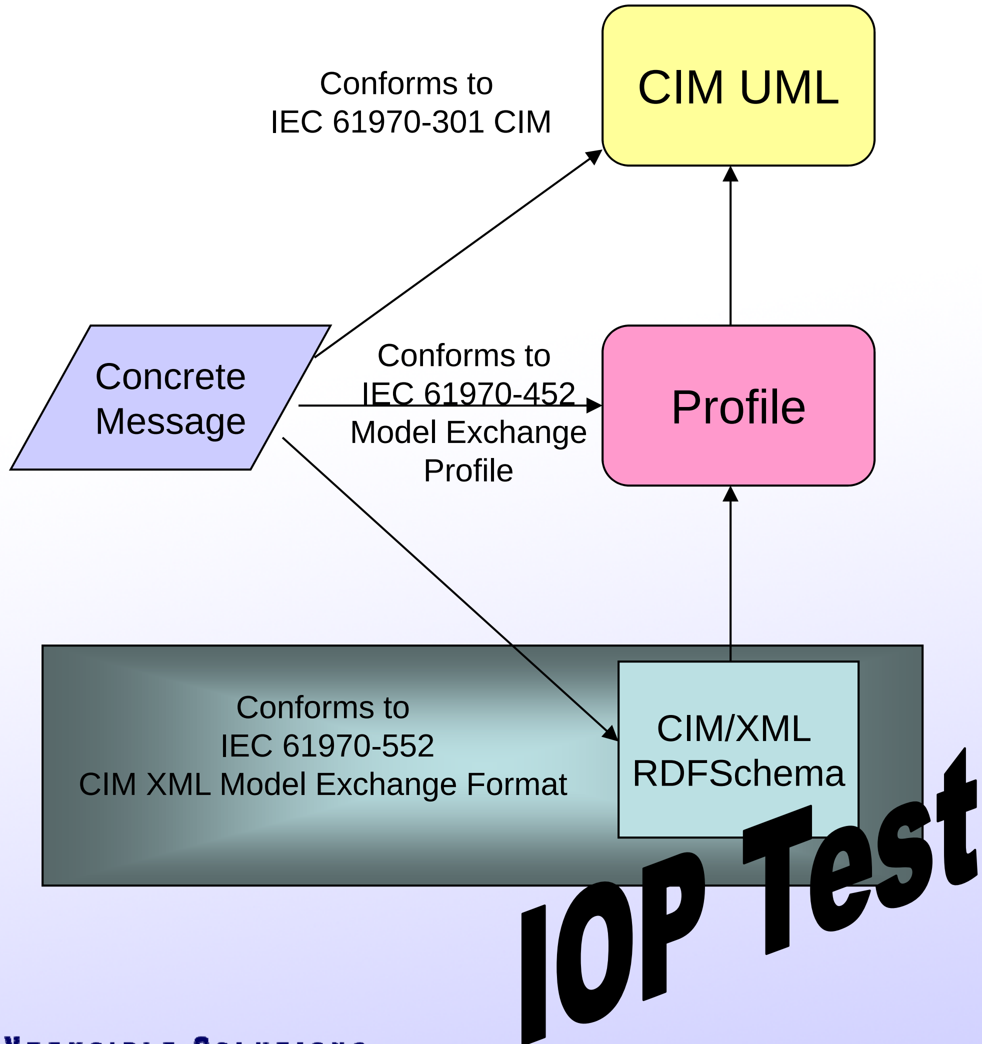
Message Syntax

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

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

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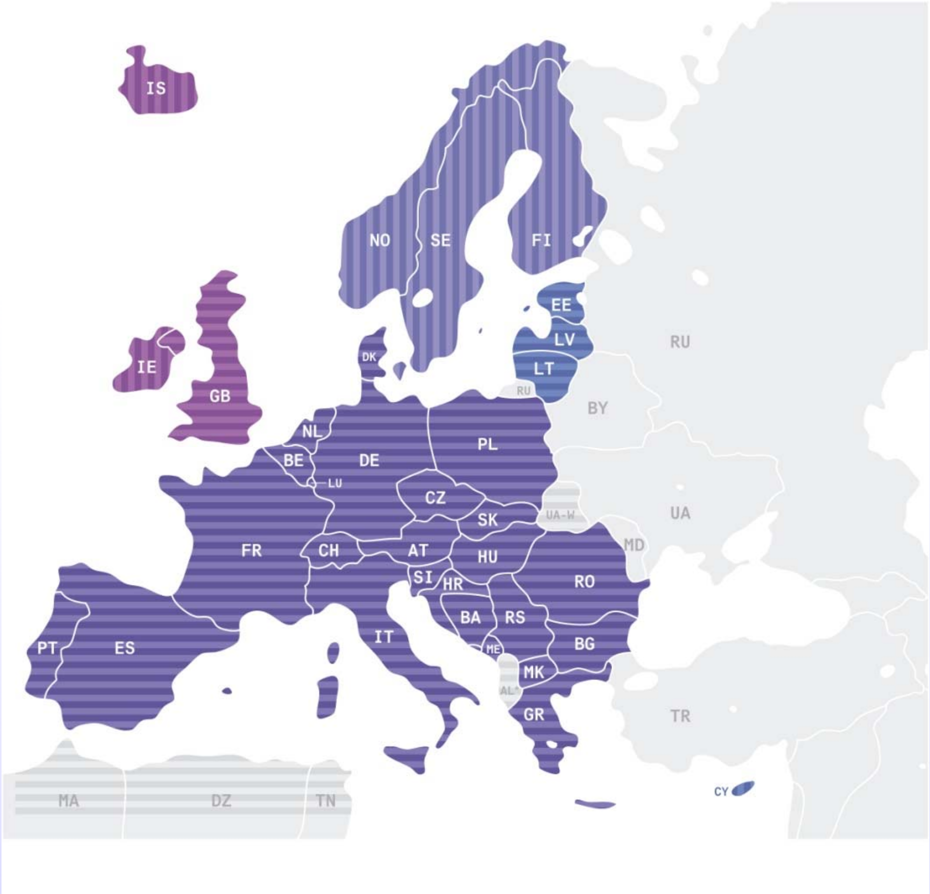
ENTSO-E is THE European TSO platform

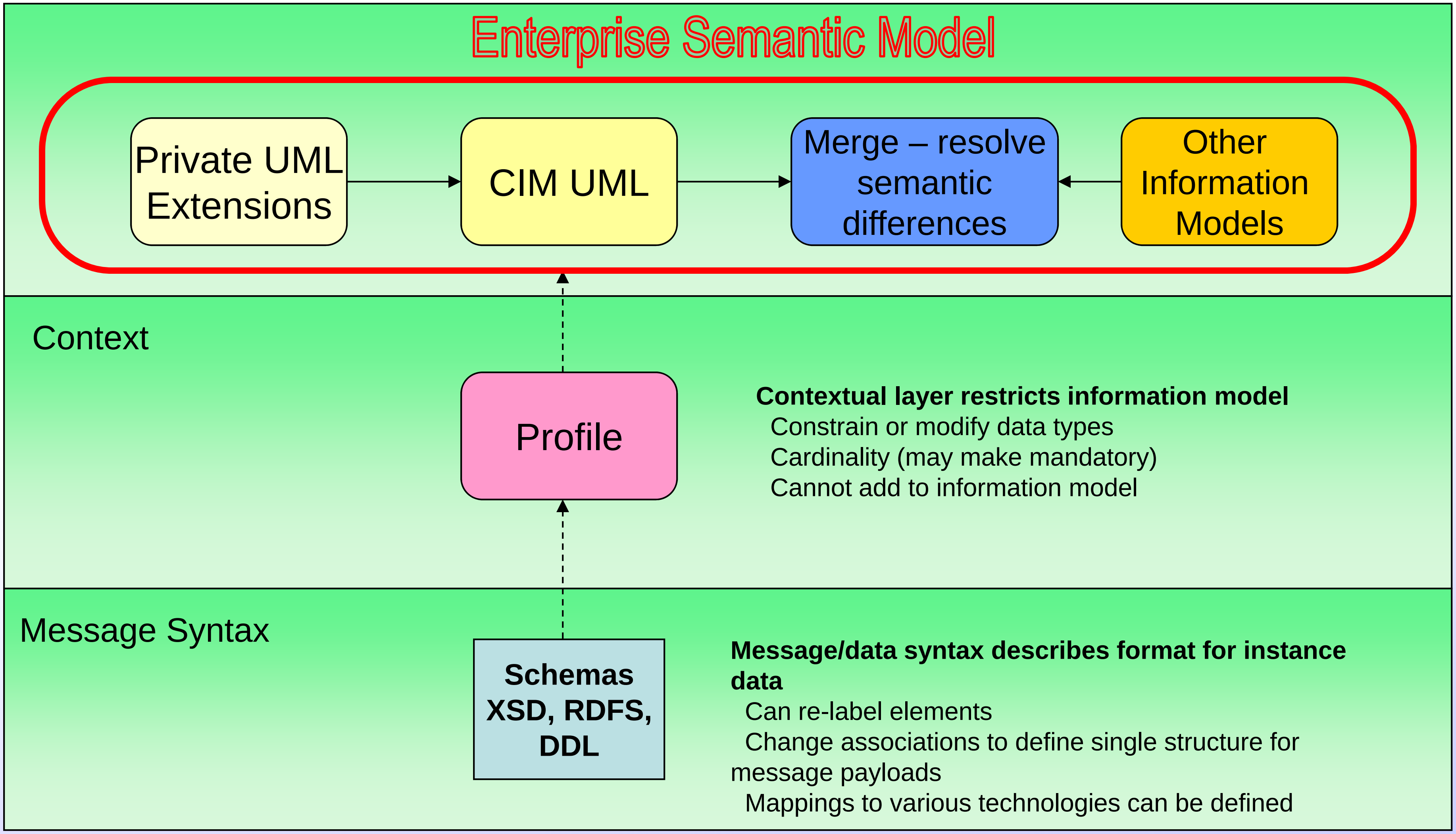
- Founded **19 December 2008** and fully operational since **1 July 2009**
- Represents TSOs from **44** countries
  - **532** million citizens served
  - **880** GW net generation
  - **305,000** Km of transition lines managed by the TSOs
  - **3,200** TWh/year demand
  - **380** TWh/year exchanges
- Replaced former TSO organisations: ATSOI, BALTSO, RTSO, NORDEL, UCTE, UKTSOA
- Migrated to CIM-based network protocols after close liaison with WG13/16 and extensive IOPs with multiple vendors and TSOs



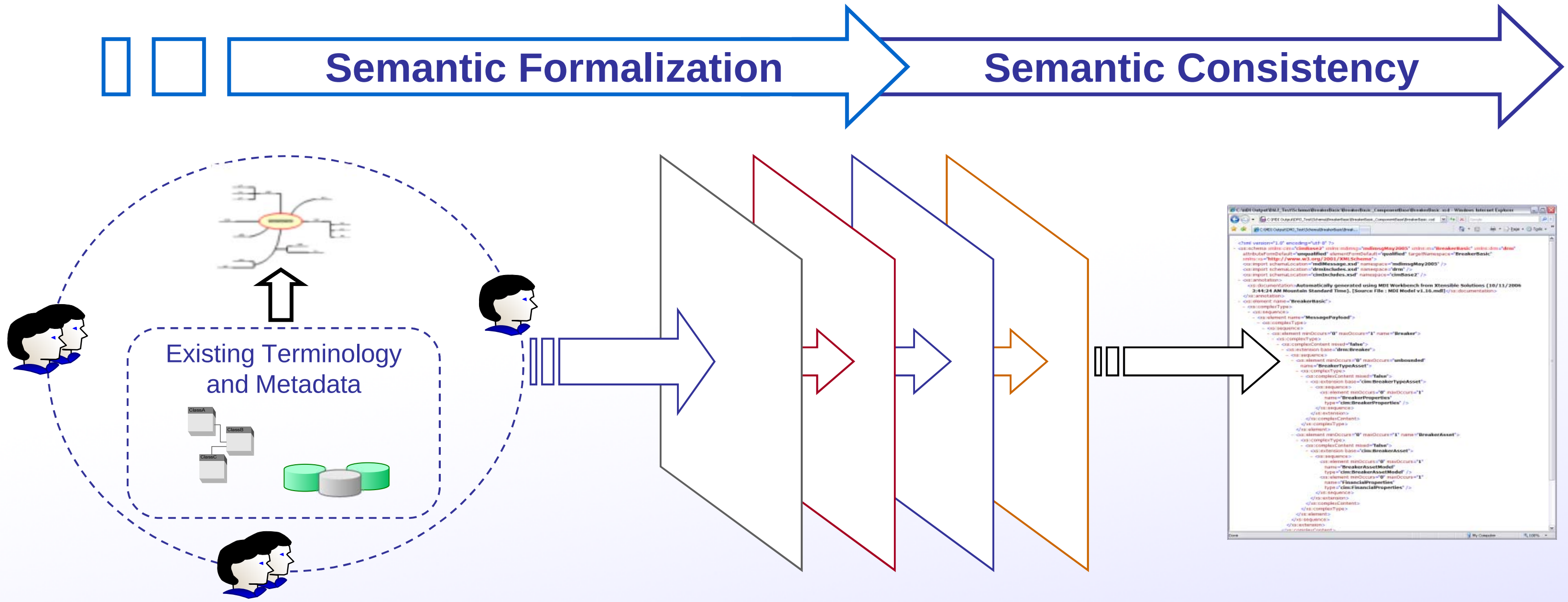
How Are CIM Standards Used?

- 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



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



1) Establish Vocabulary

Control Content
Collaborate
Identify and refine semantics

2) Develop ESM

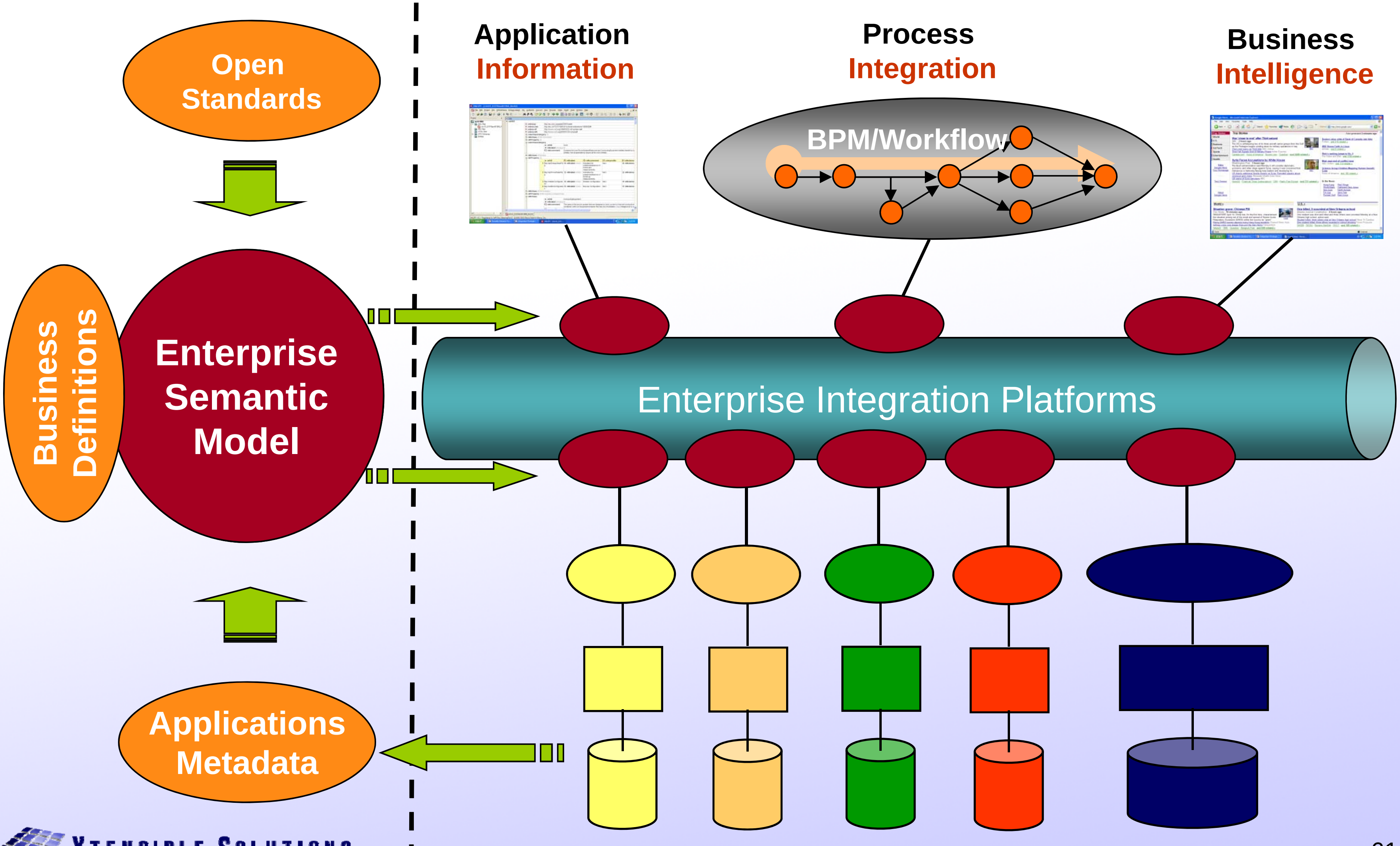
Model using vocabulary terms
Refine context

3) Generate Canonicals

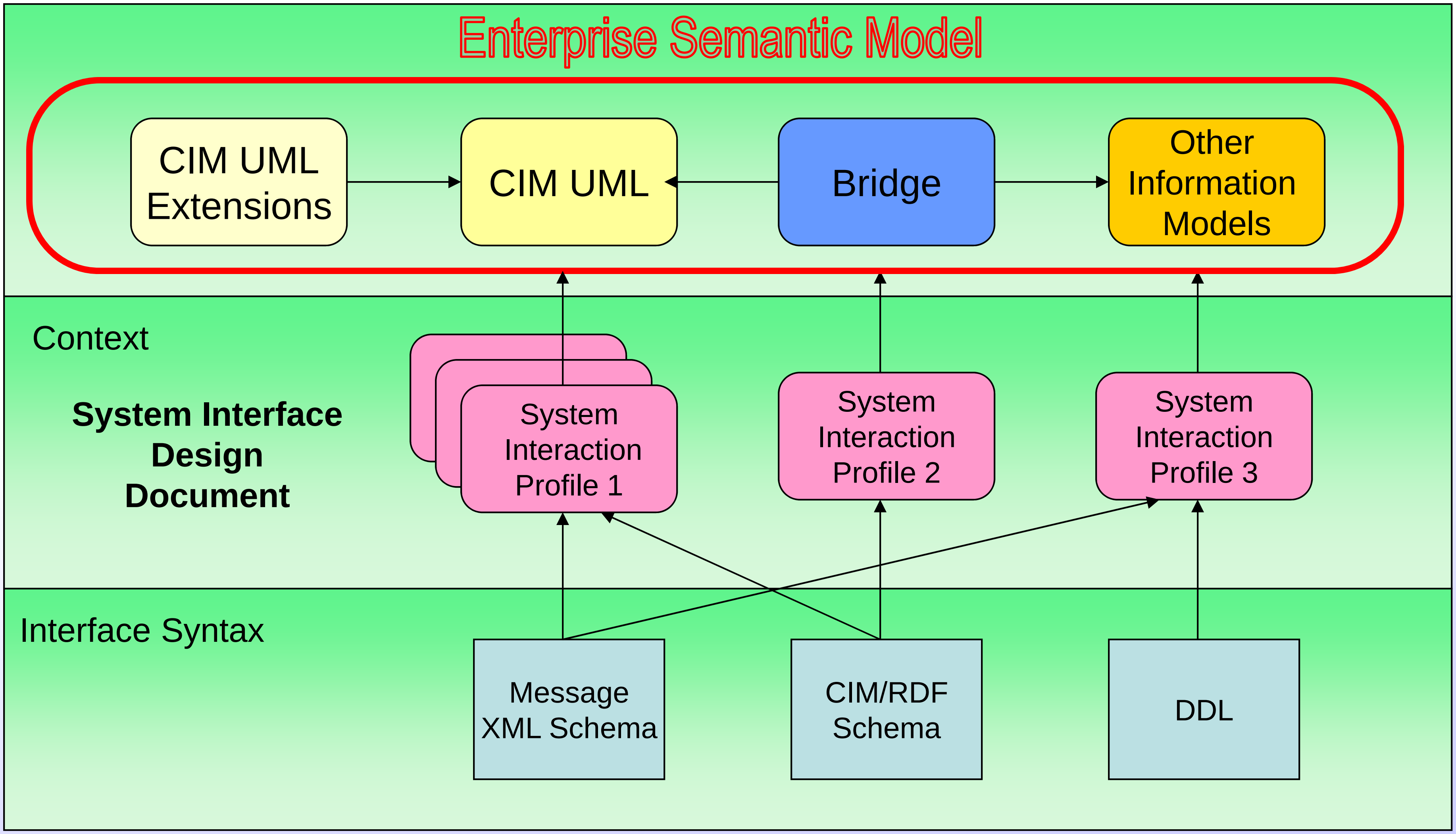
Syntactically and semantically consistent canonical models

Complements Xtensible MD3i

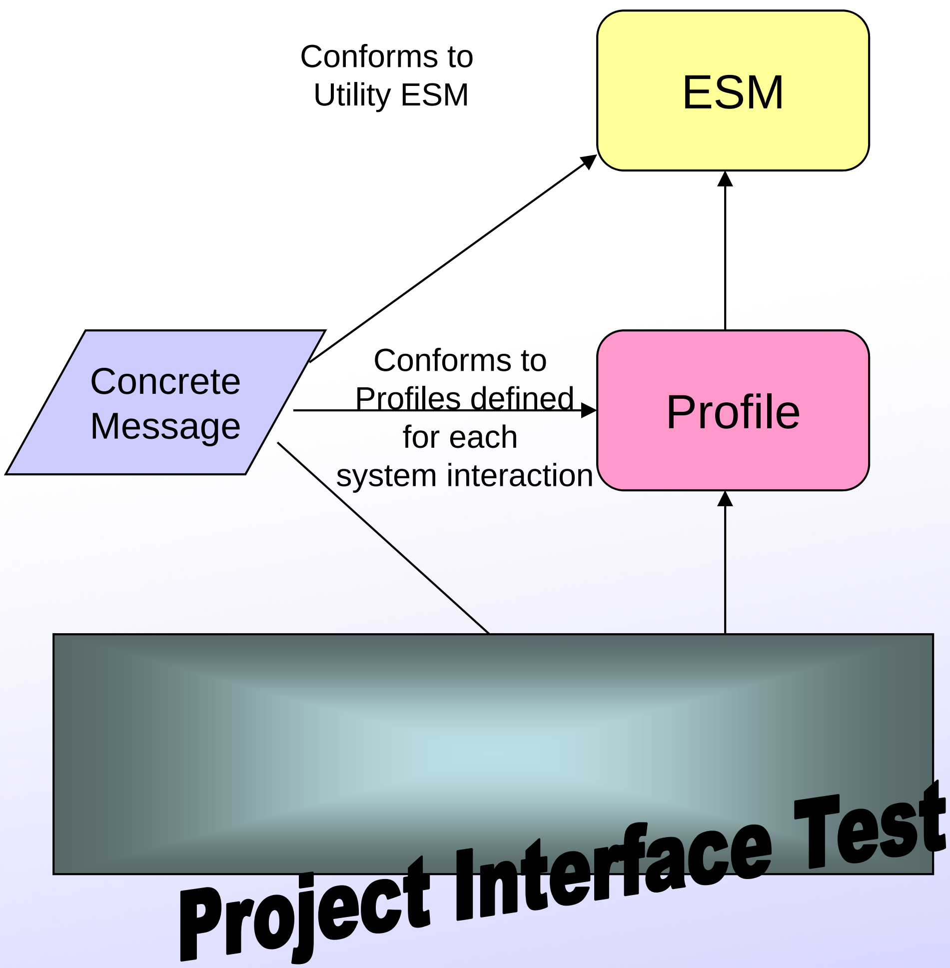
Role of Enterprise Semantic Model



Let's Apply to a Utility Project - Interface Architecture



Ex: Project Interaction Test



Enterprise Semantic Model

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

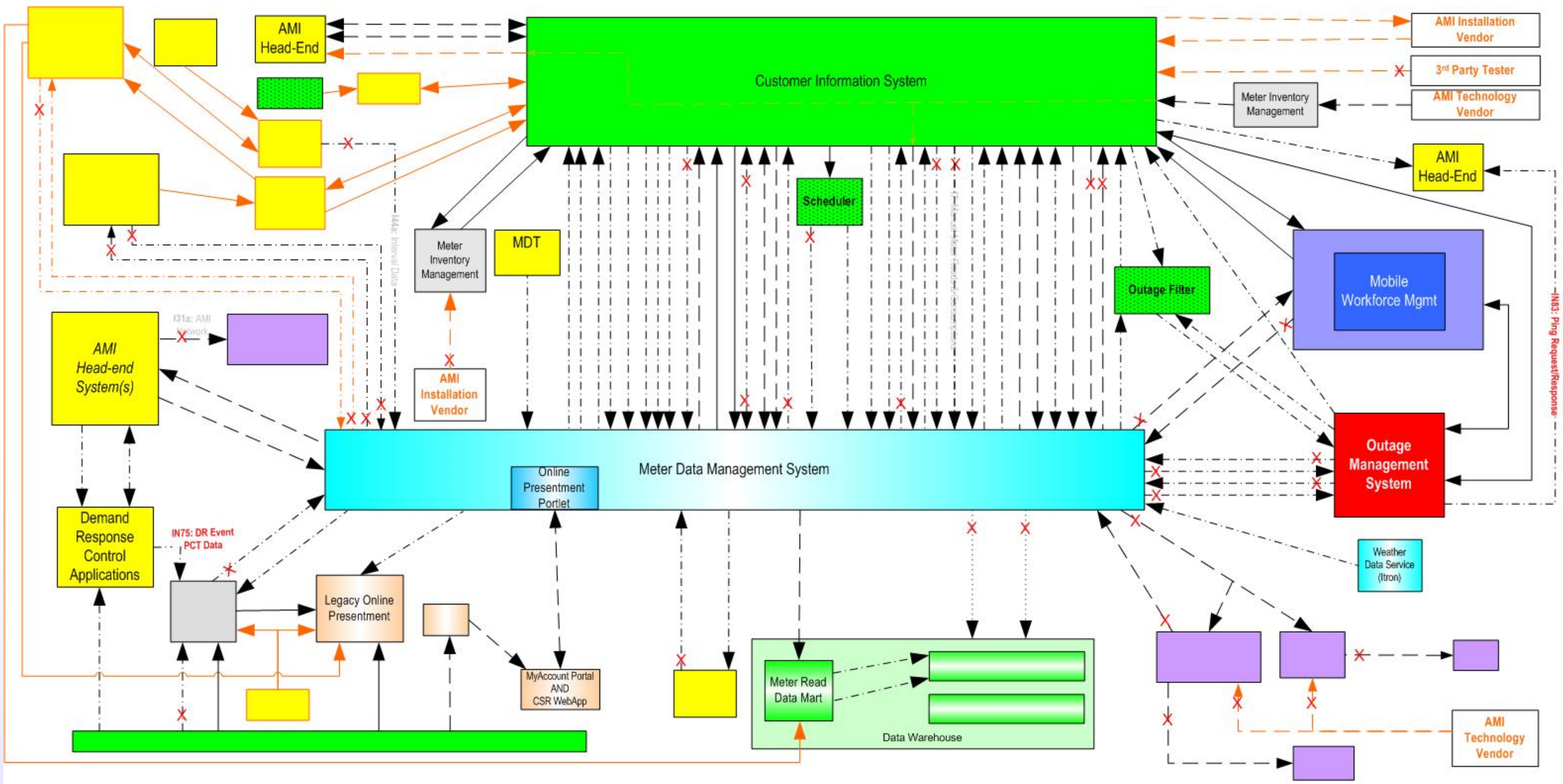
Contextual layer restricts ESM
Specifies which part of ESM is used for specific system interaction
Mandatory and optional
Restrictions
But cannot add to information model

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

SDG&E — A Sempra Energy utility

Smart METER



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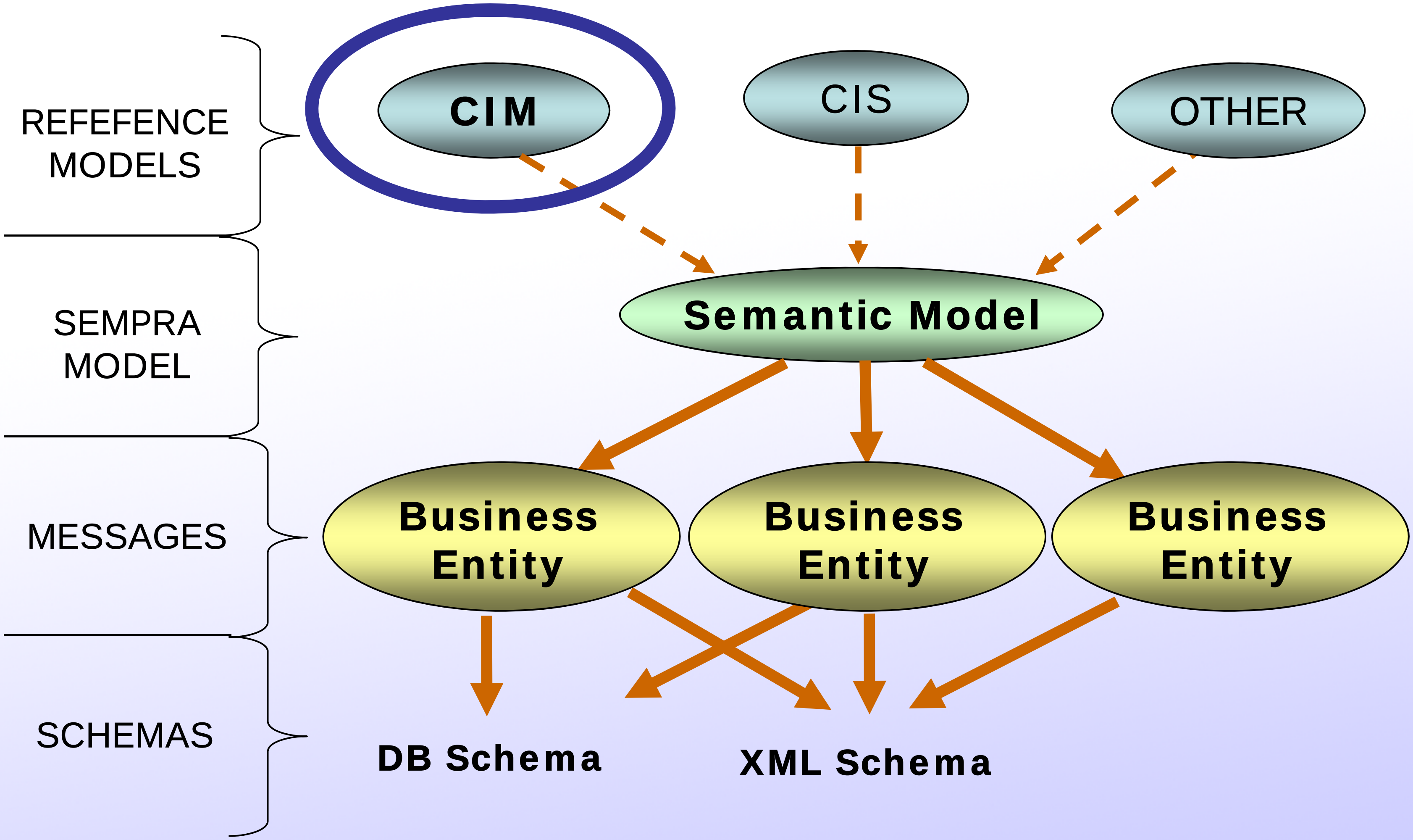
Data Architecture – Model



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

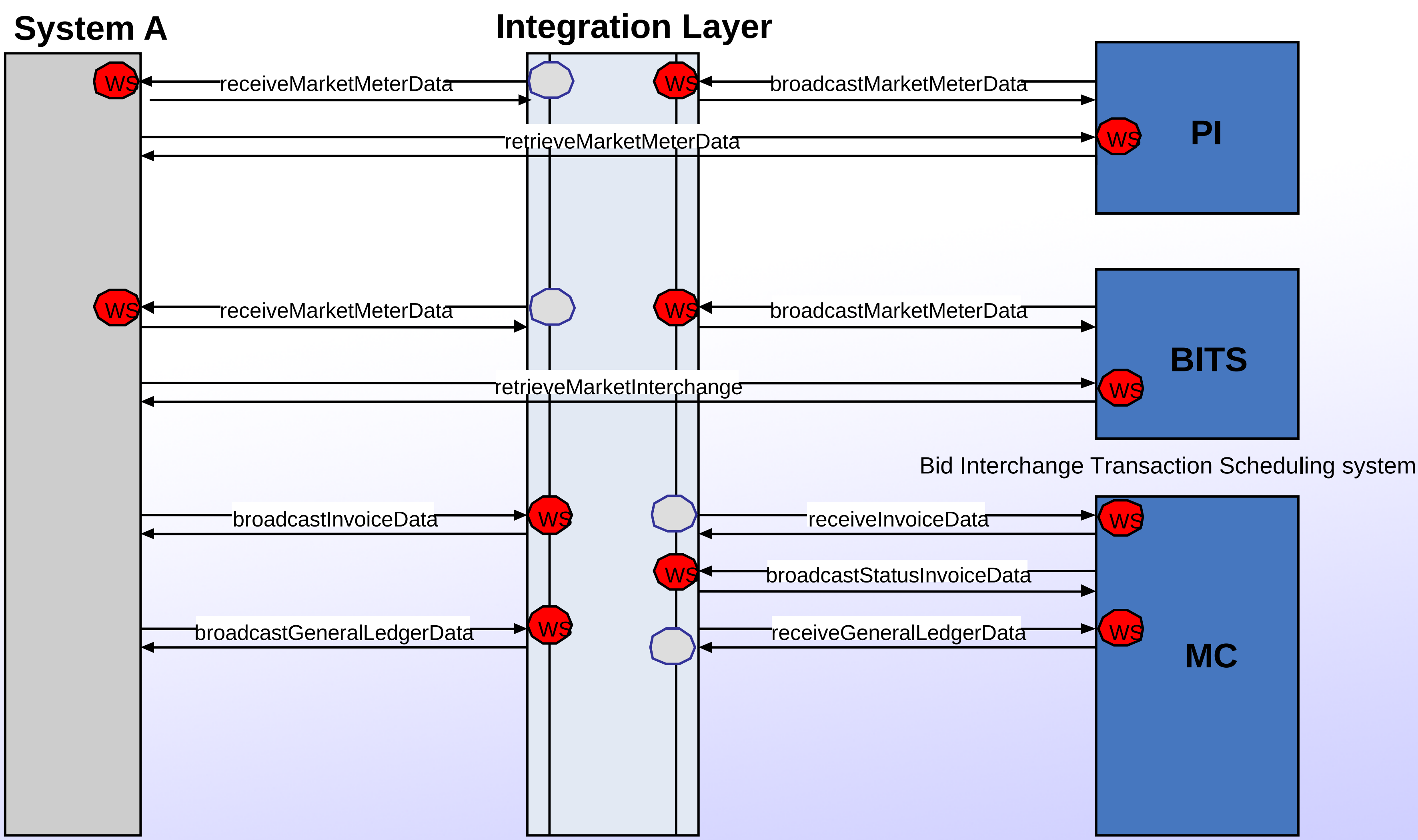
- CAISO designed a new power market system
  - Multi-year program that involved many vendors, new systems, as well as numerous legacy systems
    - Includes EMS, Full Network Model, Outage Management, PI Historian, Market Systems, many others
    - External interfaces to Market Participants included
- 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:

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

(Slide from Stipe Fustar, PowerGrid 360)

Typical Web Services



(Slide from Stipe Fustar, PowerGrid 360)

```xml
<?xml version="1.0" encoding="utf-8" ?>
- <wsdl:definitions xmlns:http="http://schemas.xmlsoap.org/wsdl/http/" xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
  xmlns:wsdl="http://schemas.xmlsoap.org/wsdl/" xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns="http://schemas.xmlsoap.org/wsdl/" xmlns:wsi="http://ws-i.org/schemas/conformanceClaim/"
  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:typeIn="MarketMeterData"
  xmlns:typeOut="StandardOutput">
  <wsdl:documentation>A web service to notify market meter data from OMAR system and provided by EAI
    system</wsdl:documentation>
  <!-- type elements define data types used in this wsdl document using xml schema -->
  <!-- note the namespaces defined matched up with the typeIn and typeOut defined above -->
- <wsdl:types>
  - <xs:schema>
      <xs:import namespace="MarketMeterData" schemaLocation="MarketMeterData.xsd" />
    </xs:schema>
  - <xs:schema>
      <xs:import namespace="StandardOutput" schemaLocation="StandardOutput.xsd" />
    </xs:schema>
  </wsdl:types>
  <!-- message 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:documentation>notify market meter data from OMAR</wsdl:documentation>
    </wsdl:part>
  </wsdl:message>
- <wsdl:message name="NotifyMarketMeterDataResponse">
  - <wsdl:part name="returnData" element="typeOut:outputDataType">
      <wsdl:documentation>acknowledge meter data notified</wsdl:documentation>
    </wsdl:part>
  </wsdl:message>
  <!-- portType elements define the abstract interface of a web service -->
  <!-- to use the message type defined in message above -->
- <wsdl:portType name="NotifyMarketMeterData">
```

(Slide from Stipe Fustar, PowerGrid 360)

C:\Documents and Settings\sfustar\My Documents\CAISO\ICC\Service Management\eXtensible\WO3\Mark

Address C:\Documents and Settings\sfustar\My Documents\CAISO\ICC\Service Management\eXtensible\WO3\Market Meter Data Services\3) instance c


```
<?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">
  - <MessagePayload>
    - <RegisteredResource>
        <cim:name>1011</cim:name>
        <cim:rtoID>123456789</cim:rtoID>
      - <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>
      - <Pnode>
          <cim:name>PGE3</cim:name>
          <cim:type>none</cim:type>
        - <Measurement>
            <cim:positiveFlowIn>1</cim:positiveFlowIn>
          - <MeasurementType>
              <cim:name>R</cim:name>
            </MeasurementType>
          - <MeasurementValue>
              <cim:name>1</cim:name>
            - <cim:value>
                <cim:DOUBLE_TYPE>105.9059</cim:DOUBLE_TYPE>
              </cim:value>
              <cim:type>A</cim:type>
              <cim:timeStamp>2004-07-12T00:00:00-05:00</cim:timeStamp>
            </MeasurementValue>
          - <MeasurementValue>
              <cim:name>2</cim:name>
            - <cim:value>
```


My Computer

7:18 PM

(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

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)

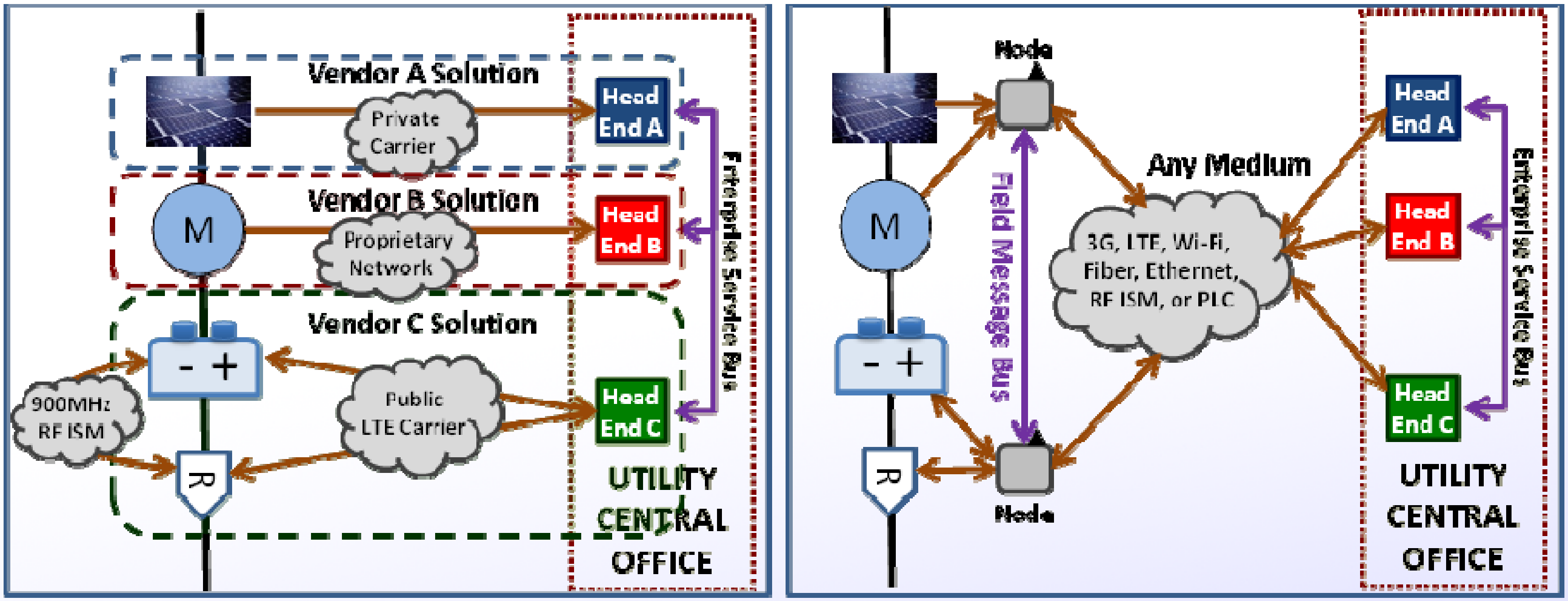
Appr 130 integrations between the 22 systems
Appr 75 message schemas
Appr 175 service definitions
Appr 450 publisher/consumer testable data transfers between systems

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 Third Edition CIM Primer

OpenFMB Distributed Intelligence Vision



Current State: Message Bus at Data Center | Future State: Message Bus in Field and Data Center

- Visit OpenFMB Demo at Duke Energy booth at DistribuTech 2016
  - Initial focus of demo is MicroGrid optimization and islanding transitions

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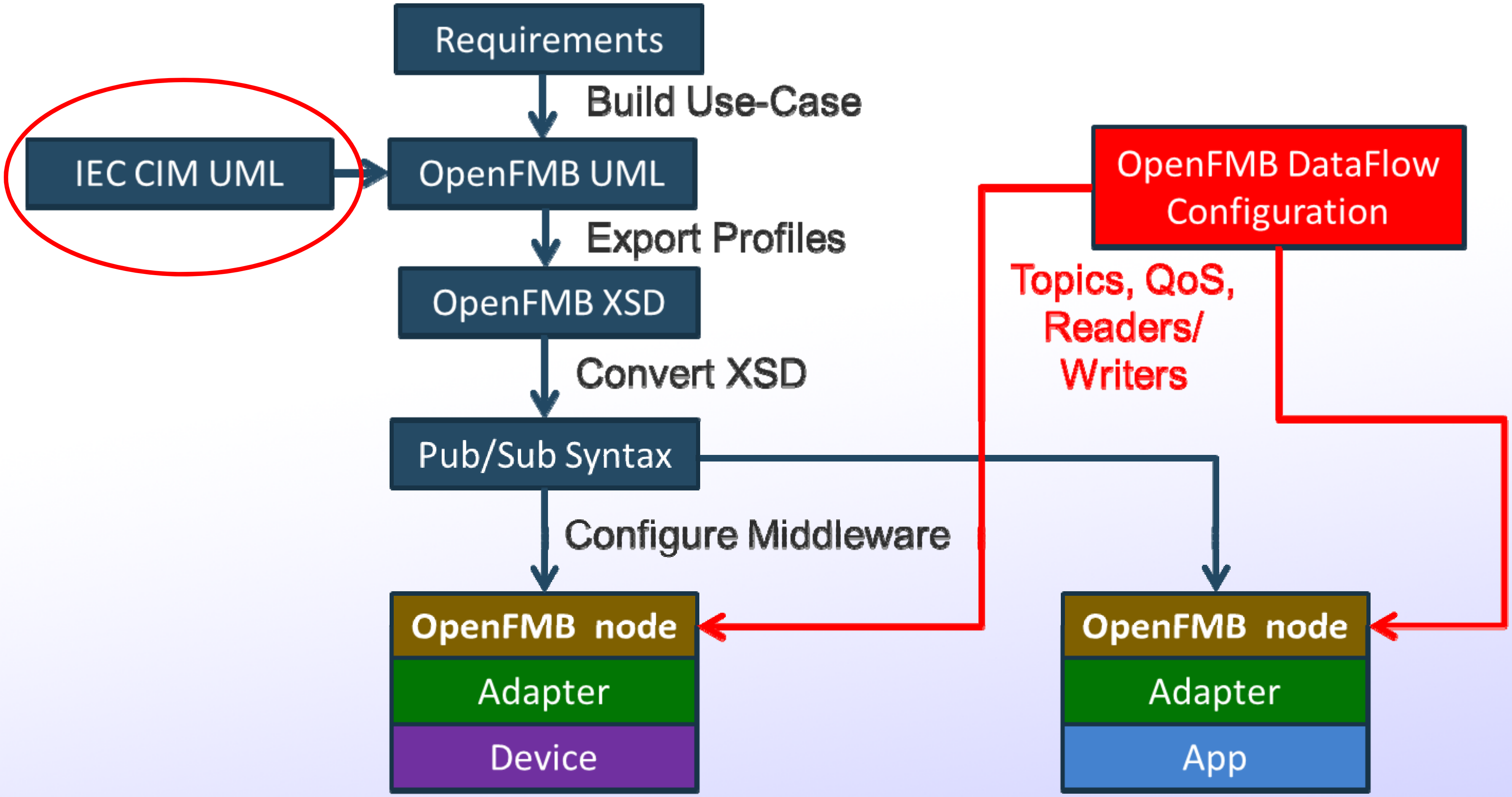
Open Field Message Bus – SGIP PAP

- Framework for distributed intelligent nodes interacting with each other
- IoT (Internet of Things) technologies applied to Smart Grid
- Distributed resources communicating via common semantic definitions derived from the CIM extended as needed
  - enables grid devices to speak to each other, e.g. meters, relays, inverters, cap bank controllers, etc.
- Grid-edge OpenFMBnodes processing data locally for control and reporting
- OpenFMB supports field-based applications that enable:
  - Scalable peer-to-peer publish/subscribe architecture
  - Data-centric rather than device-centric communication including support for harmonized system and device data
  - Distributed logic as well as centralized logic
  - Legacy equipment to be retrofitted for new capabilities, features, and extended life
- Led by utilities (largest IOU, Muni, and Co-op) based on their priorities and interoperability demonstration experience

Overall OpenFMB Design Process



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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
- Many applications support CIM standards
- Many suppliers sell application/products based on CIM
- 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 draft standards being developed by IEC TC57 Working Groups 13, 14, 16, and 19 for CIMug members
    - Published IEC CIM standards available from online store at www.iec.ch
  - Now provide access to:
    - **EPRI CIM Primers and Webinars streamed via YouTube**
    - Announcements of CIM-related activities and events
    - Past meeting presentations
    - CIM electronic UML model in various formats
    - Lists of CIM-related tools and access to open source tools
    - Membership in various Groups, Projects, and Focus Communities
    - CIM issues lists and status of resolution
    - Help desk
    - Links to other CIM-related sites
- IEEE PES Power and Energy CIM Special Edition Jan-Feb 2016 – available now

Gartner/EPRI CIM Survey Results 2013

- 218 respondents completed an online survey in August/September 2013 about their organizations use of CIM standards
- To qualify, respondents had to be knowledgeable about their organizations use and planned use of CIM standards
- Had to be in either an electric utilities company, a university/R&D organization or a technology provider, systems integrator, or consultant to electric utilities clients
- Report available from either EPRI or Gartner

Addressing Objections to the Use of the CIM Standards

- Claim: CIM is not stable
  - Fact: The CIM UML model ***is*** evolving as new applications are identified
  - Fact: Only small part of CIM information model is used for a given interface, so change of information model unlikely to affect specific interface.
  - Solution: Version control - tie interface designs to project specifications, not directly to standard
- CIM is to complex too learn and contains many parts I do not need
  - Fact: The overall CIM UML model is large and complex
  - Reality: A typical interface requires only very small subset of information model
- CIM creates too much overhead in message content
  - Fact: Only instantiated concrete class/attributes are actually sent in a message instance
  - Reality: Message payload is no larger than any XML formatted message
- I don't want to add in an extra step of converting to CIM for system integration
  - Fact: There is an extra step of mapping to CIM for one connection
  - Reality: Consequence of not mapping to a common language is solution that does not scale:
    - n(n-1) instead of 2n connection mappings
- I can't expect my vendors to adopt the CIM model for their interface
  - Fact: Only a few parts of the CIM need to be "Known" by the vendor
  - Reality: Approach is to specify the mappings to a common language (CIM) as part of the interface contract
- I don't want to convert all my metadata to the CIM
  - Fact: CIM is a starter kit
  - Reality: Use CIM as appropriate for building your own ESM – far better than starting from scratch
- CIM does not contain everything I need or in the form I need for my interfaces
  - Fact: CIM UML is extensible
  - Reality: Many utilities still use the CIM as a starting point, using namespaces to maintain traceability

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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