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

CIM Users Group
New Orleans,
Louisiana, USA
22 October2012
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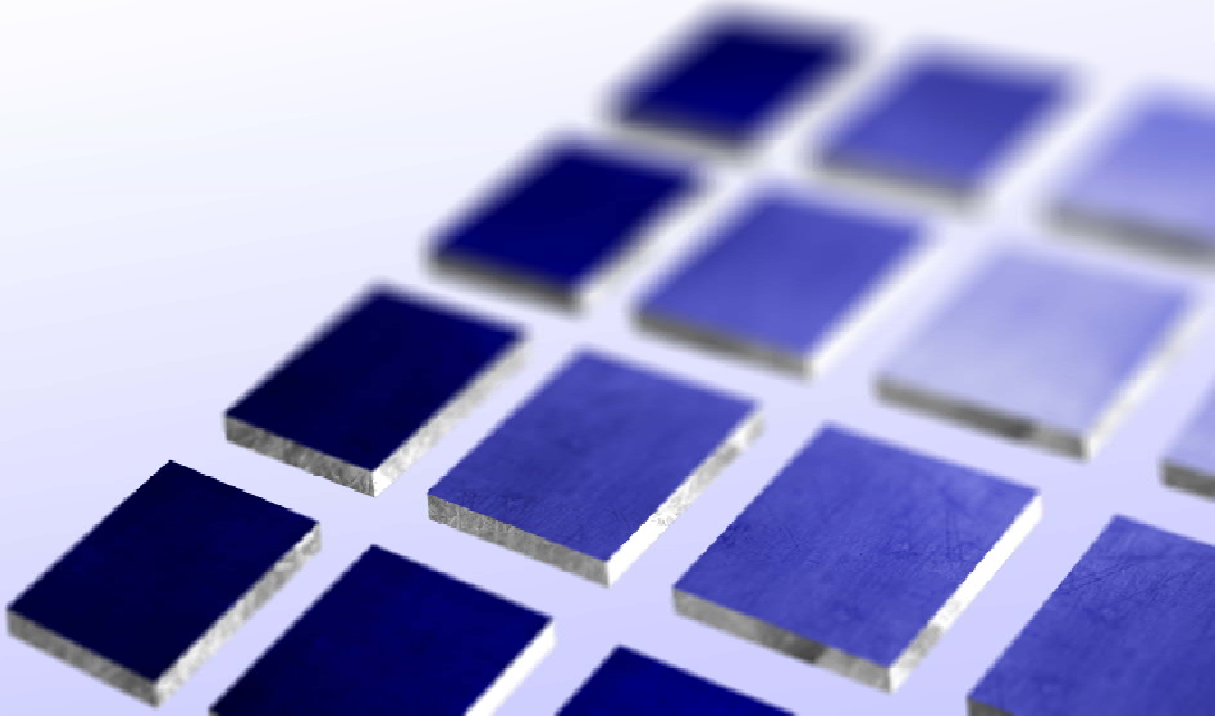
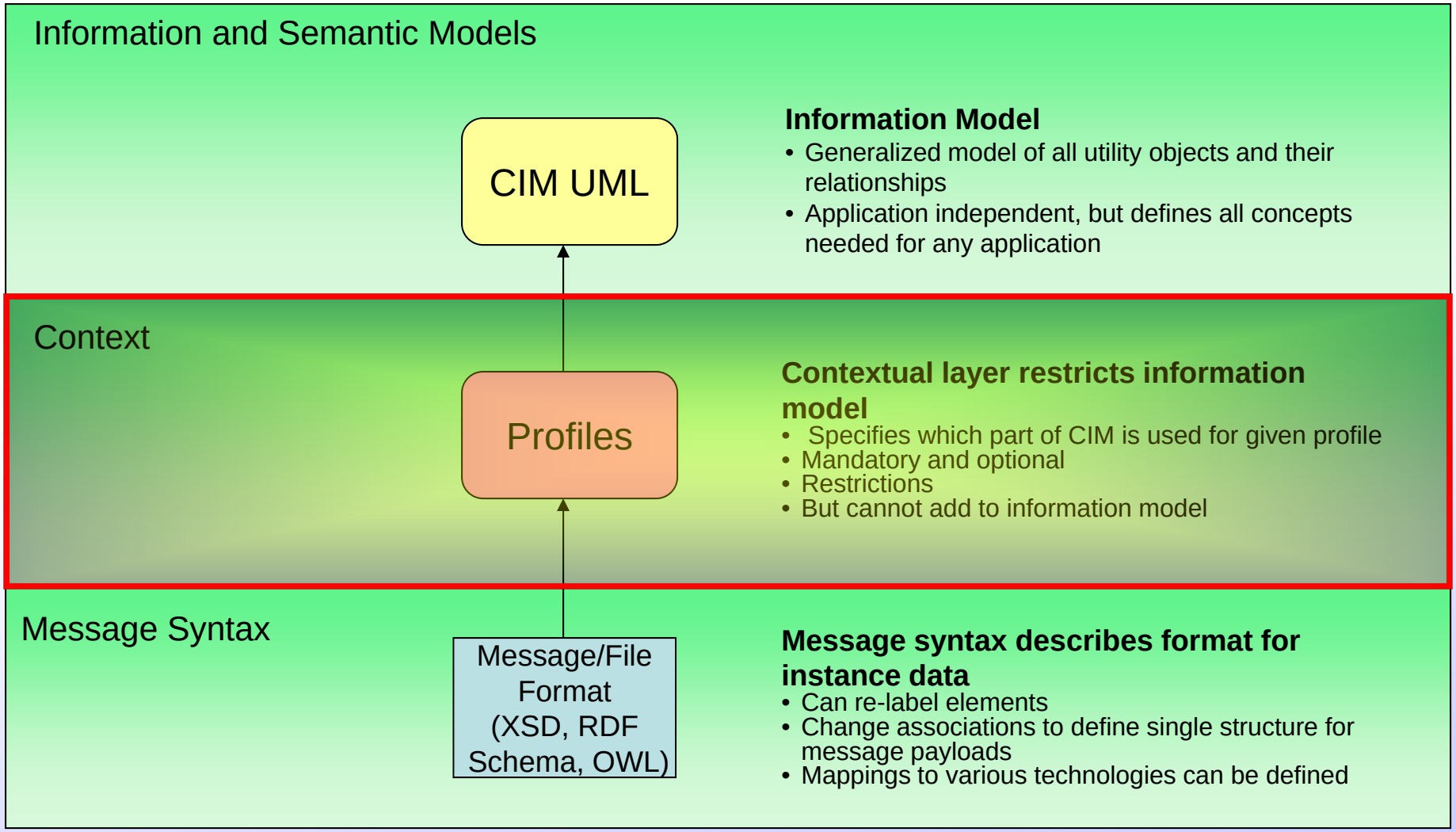


Presentation Contents

- 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



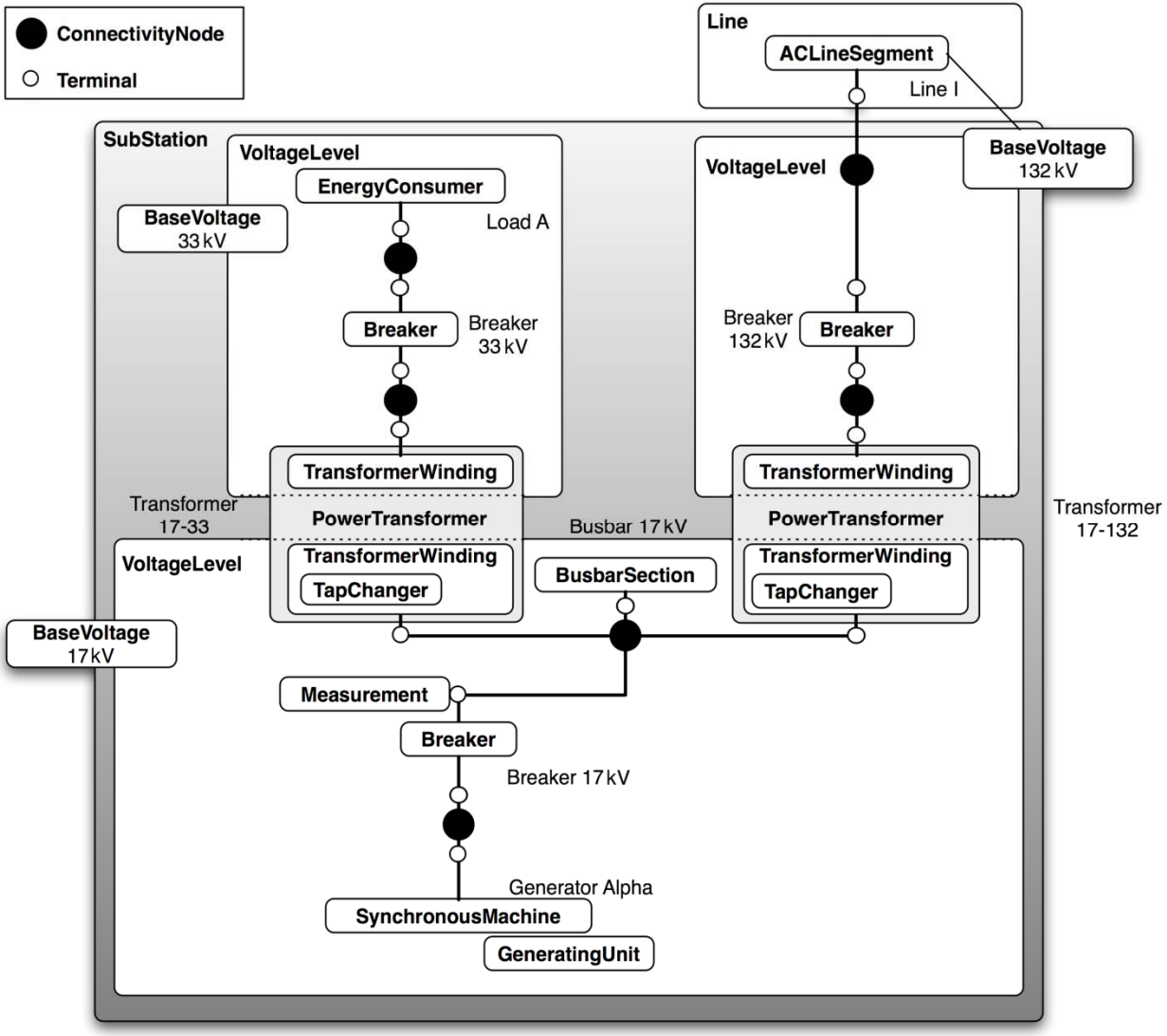
How the CIM is Applied to Specific Information Exchanges

- 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



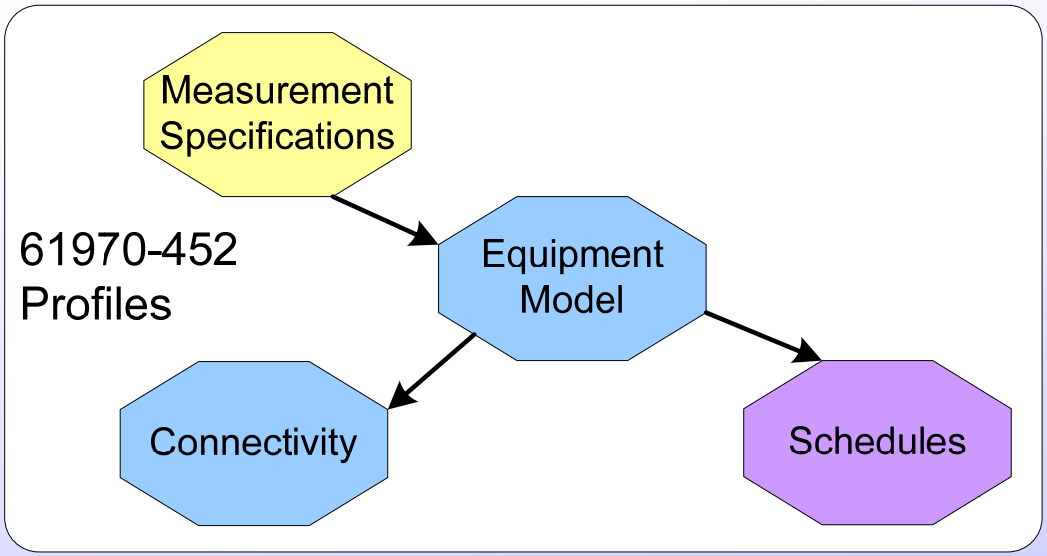
- Maps to
  - 17 CIM classes
  - 45 CIM objects
- Could be extended further with addition of objects for
  - control areas
  - equipment owners
  - measurement units
  - generation and load curves
  - asset data

61970 Profiles Currently Defined

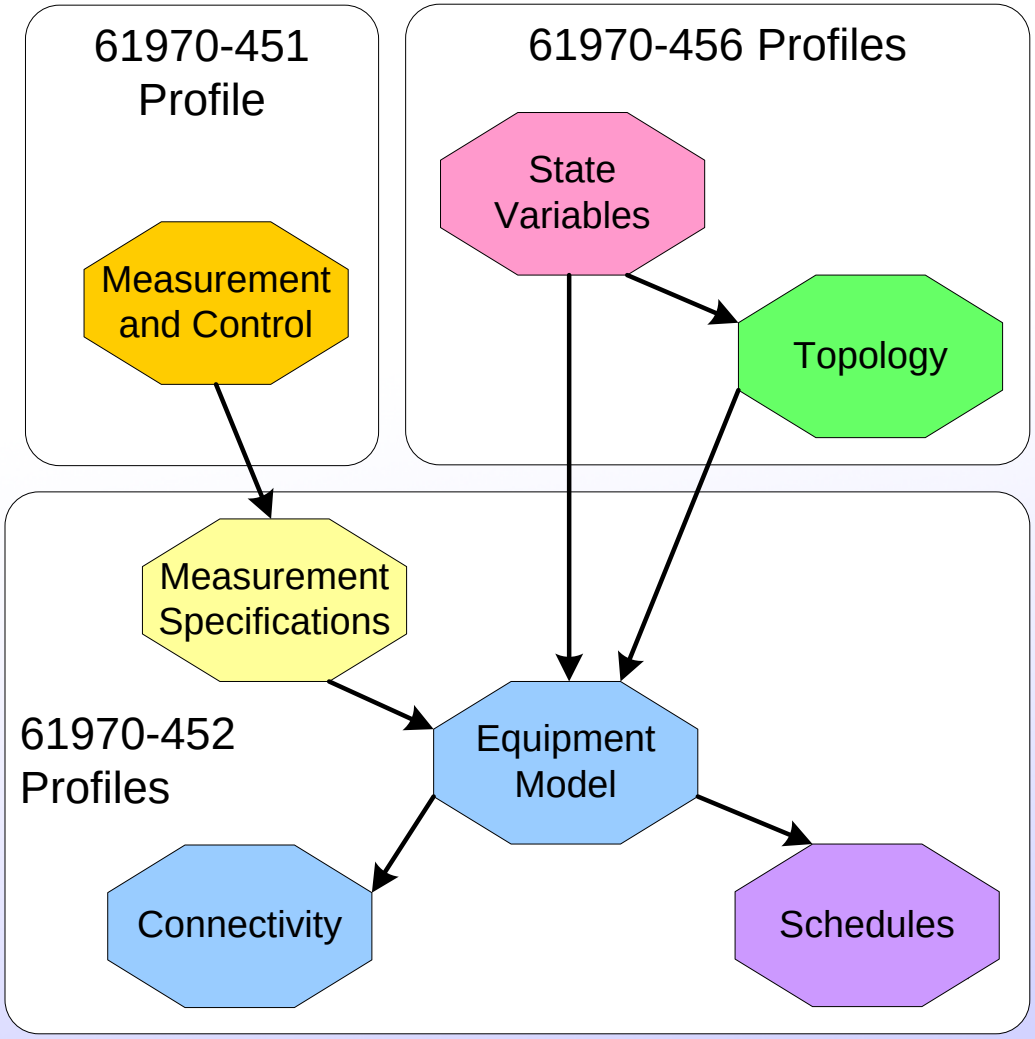
- Equipment
  - Identifies equipment, describes basic characteristics, and electrical connectivity that would be input to topology processing
- Schedules
  - Describes input to functions that derive parameters for a specific point in time
- Measurement Specs
  - Describes how SCADA will obtain measurements 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

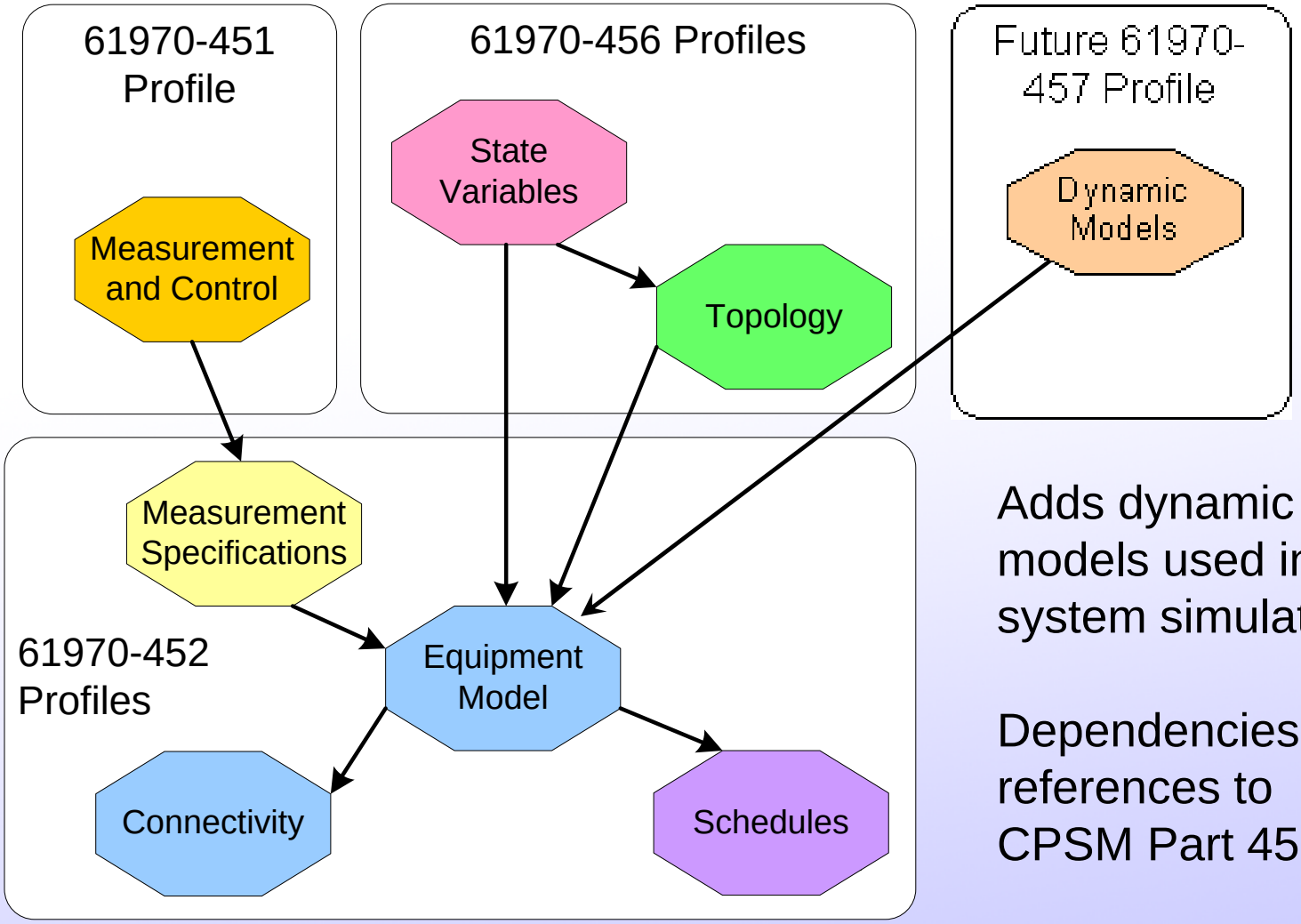


Adds SCADA

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

Dependencies via references to CPSM Part 452

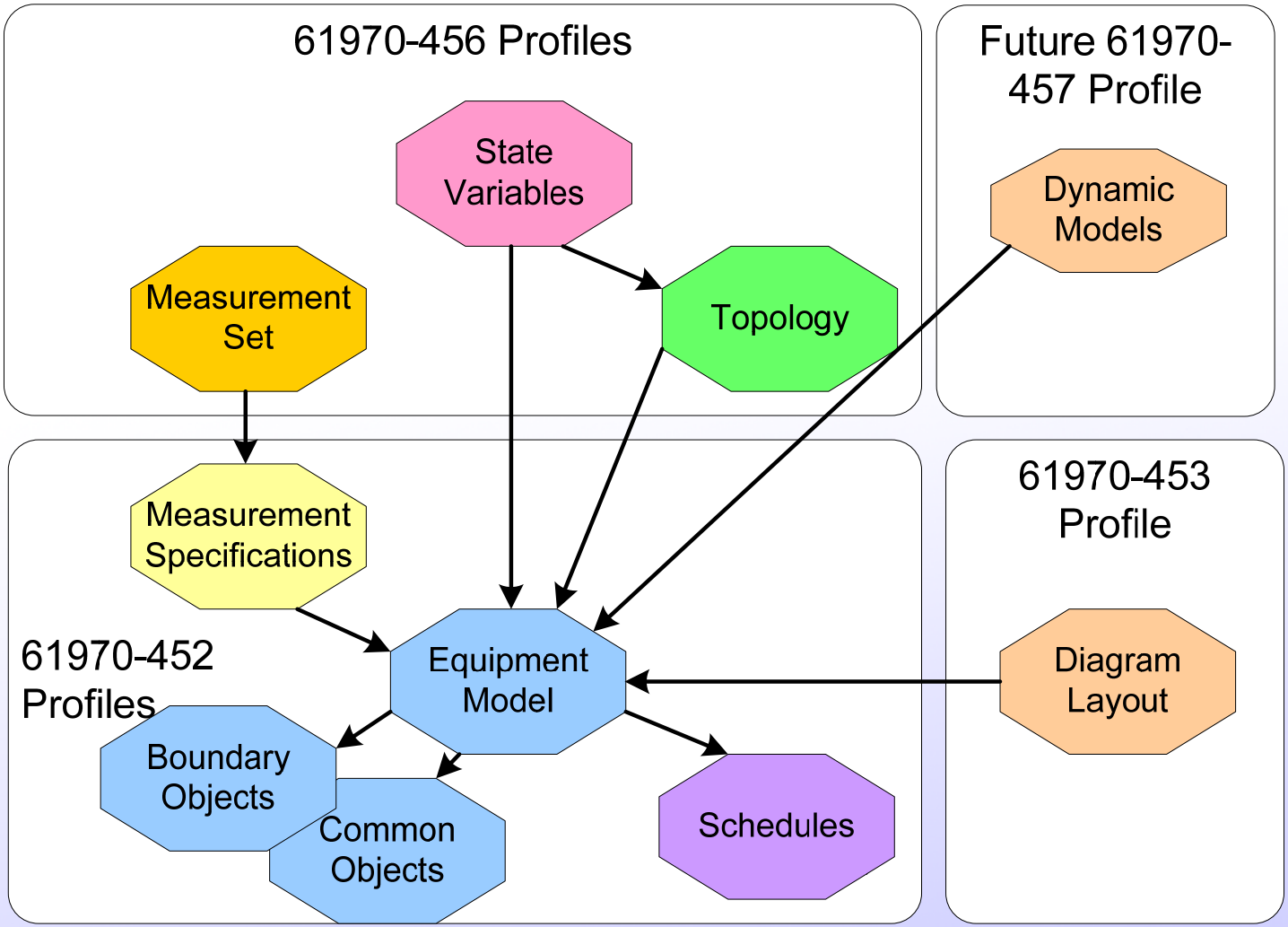
Plus 61970-451 Measurement and Control and -456 Solved System State Profiles



Adds dynamic models used in system simulation

Dependencies via references to CPSM Part 452

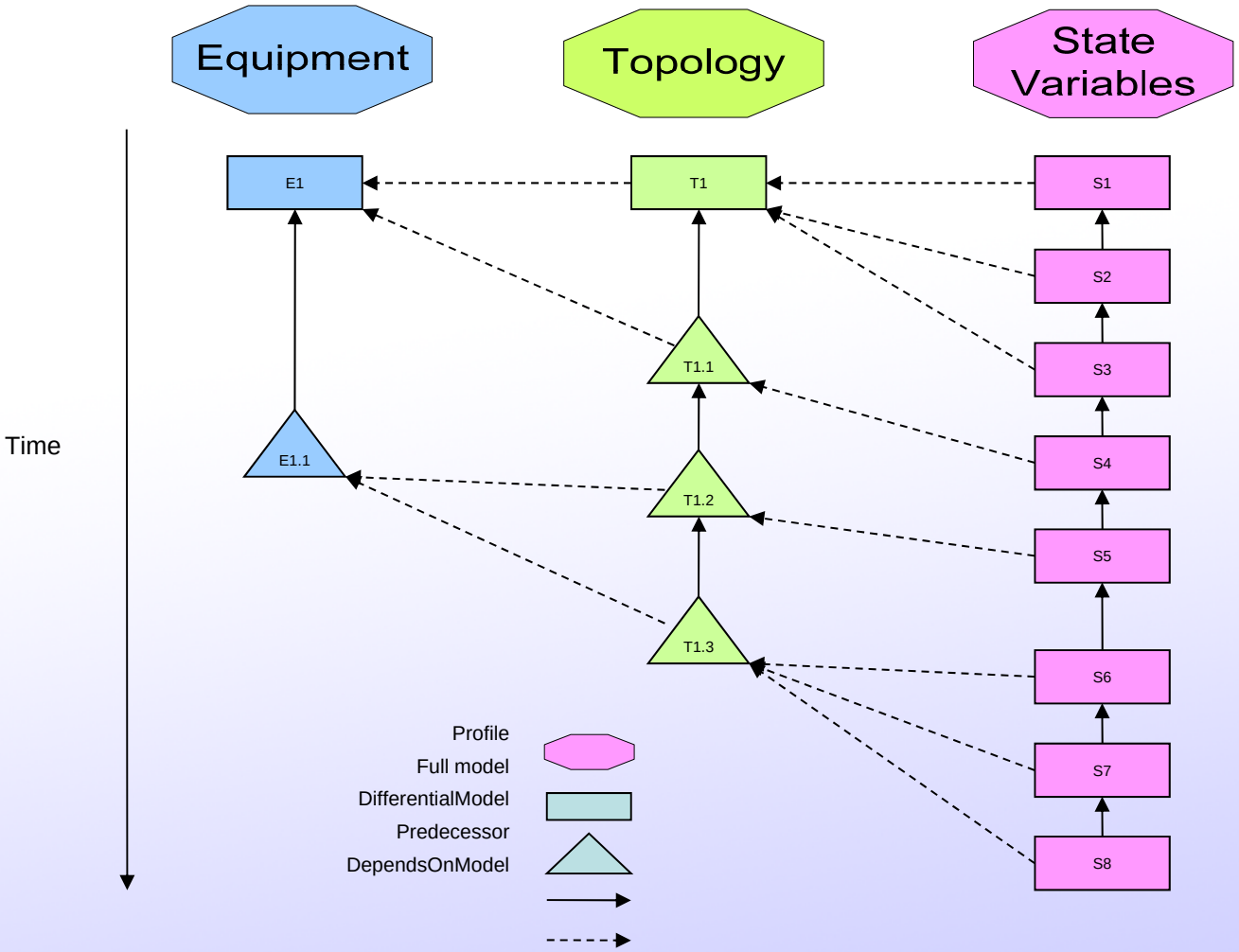
Plus 61970-453 Diagram Layout Profile



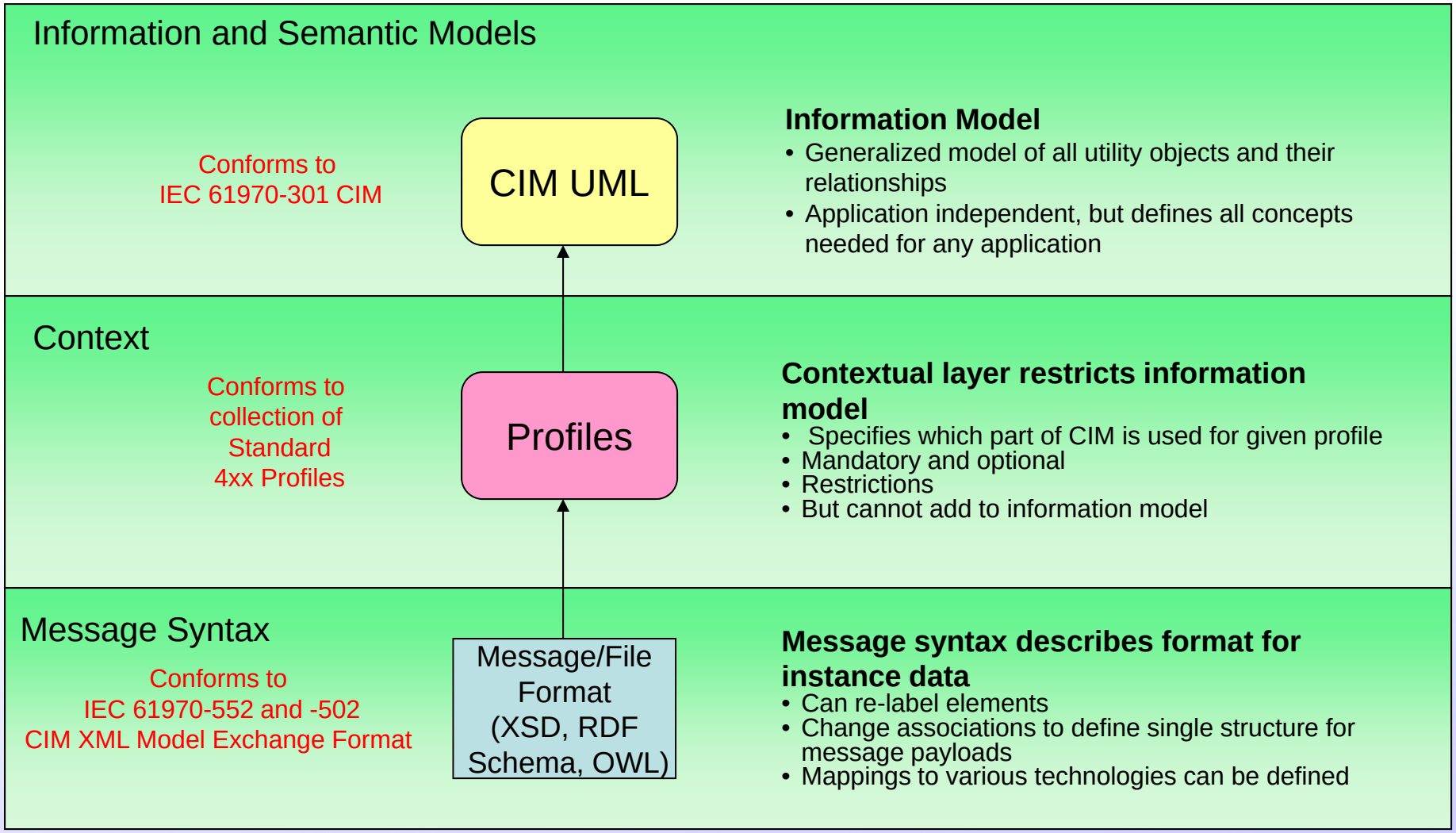
Adds diagram layout info for schematic data

Dependencies via reference to CPSM Part 452

Typical Workflow for Model Exchange



TC57 CIM Standards for Power System Model Exchange

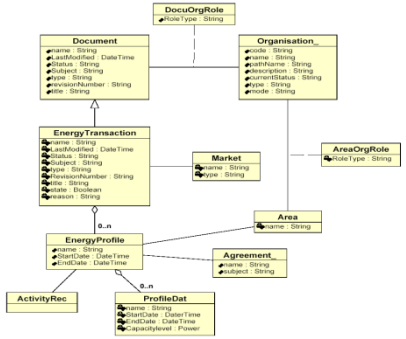


Presentation Contents

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

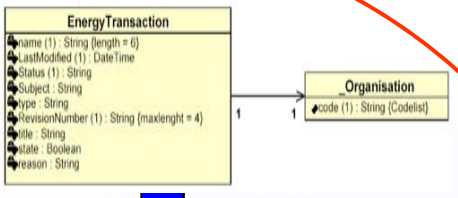
From Information Model to Syntactic Model

Information Semantic Model

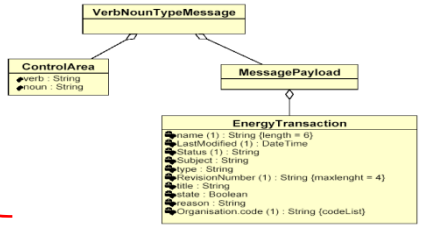


Abstract Model

Context/ Profiles



Message Assembly



UML World

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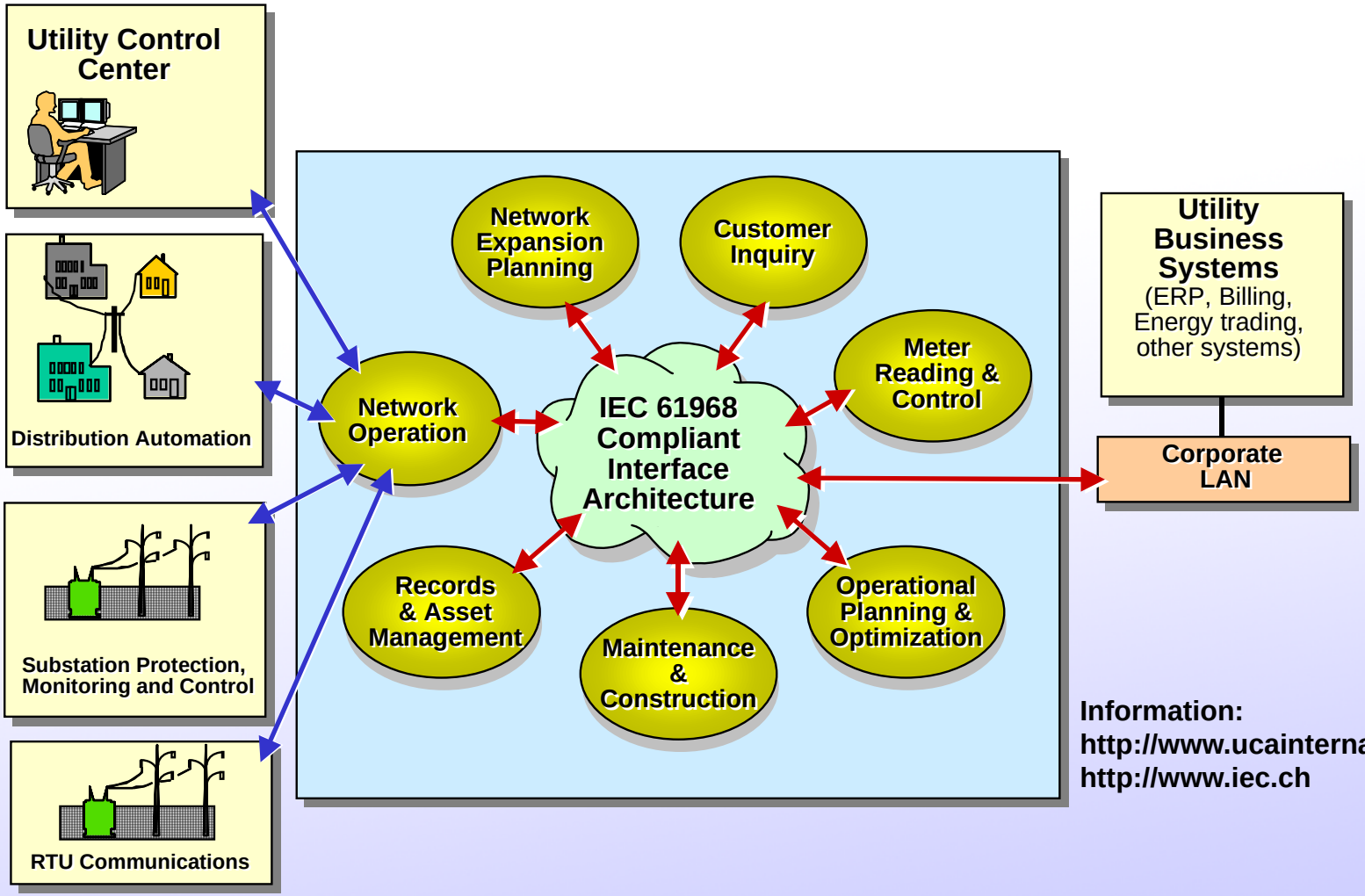
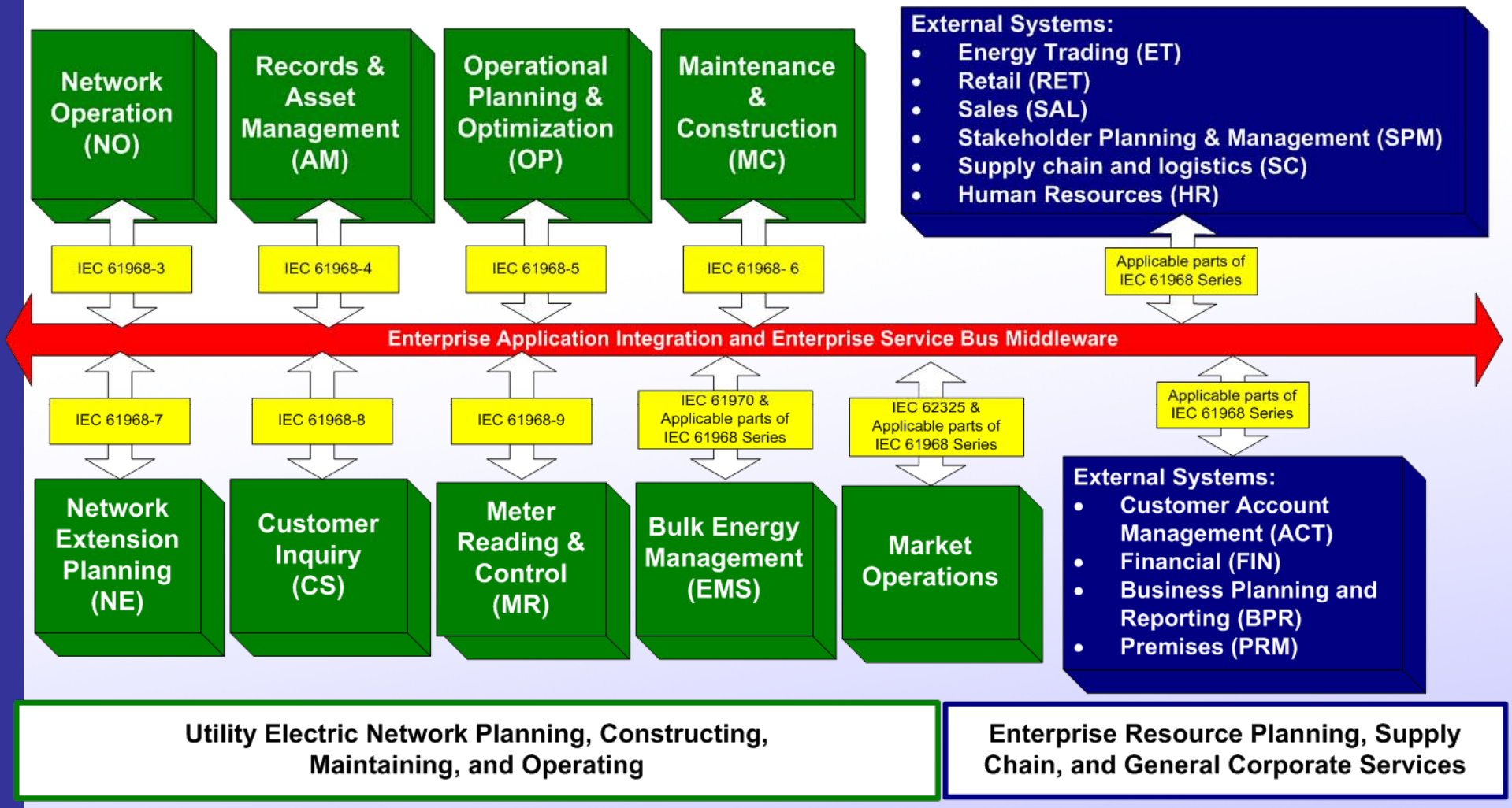
Working Group 14:
Establishing A Common Language For *Enterprise Application Integration* In the IEC 61968 Series of Standards



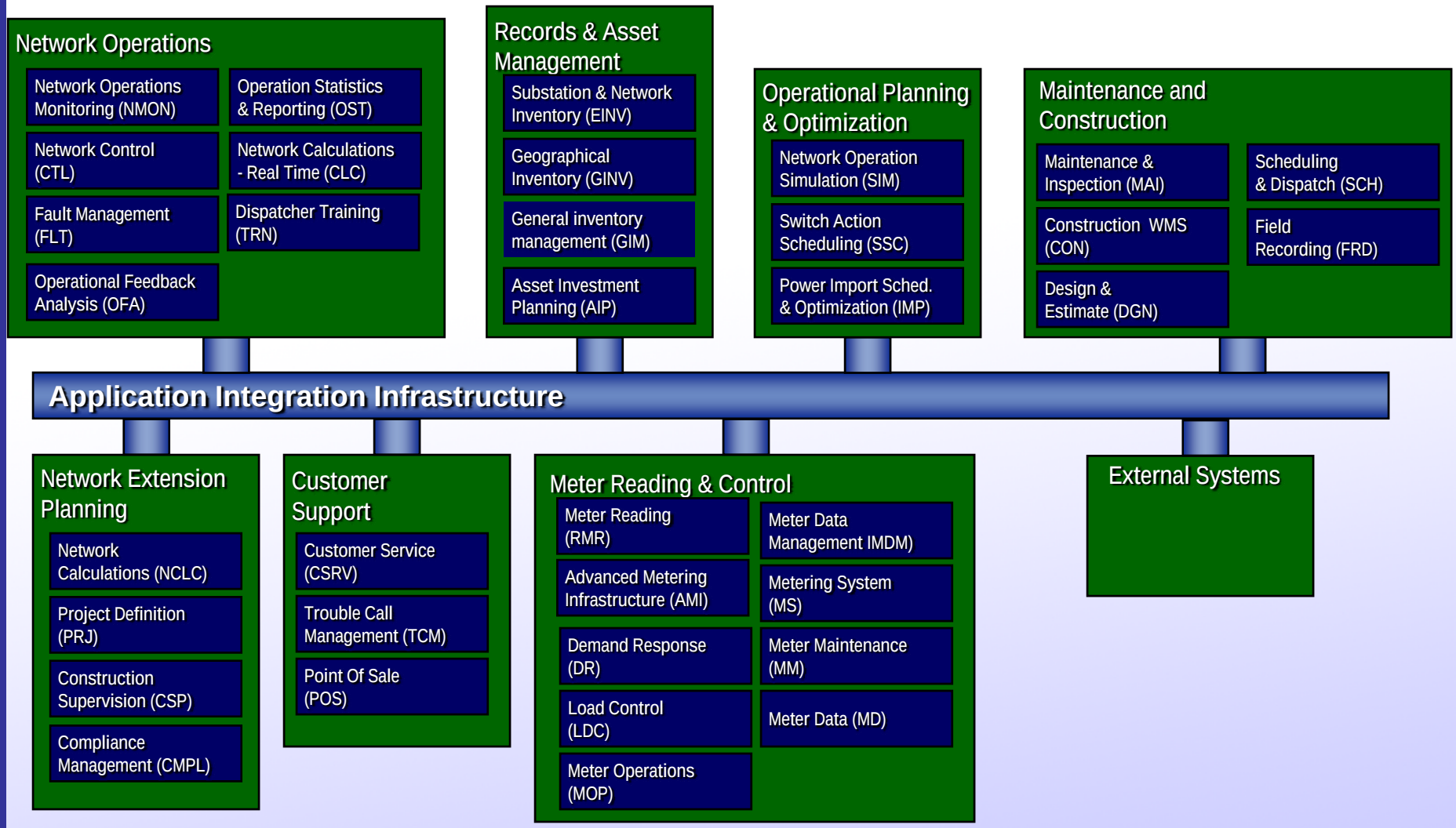
Information:
http://www.ucainternational.org/
http://www.iec.ch

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

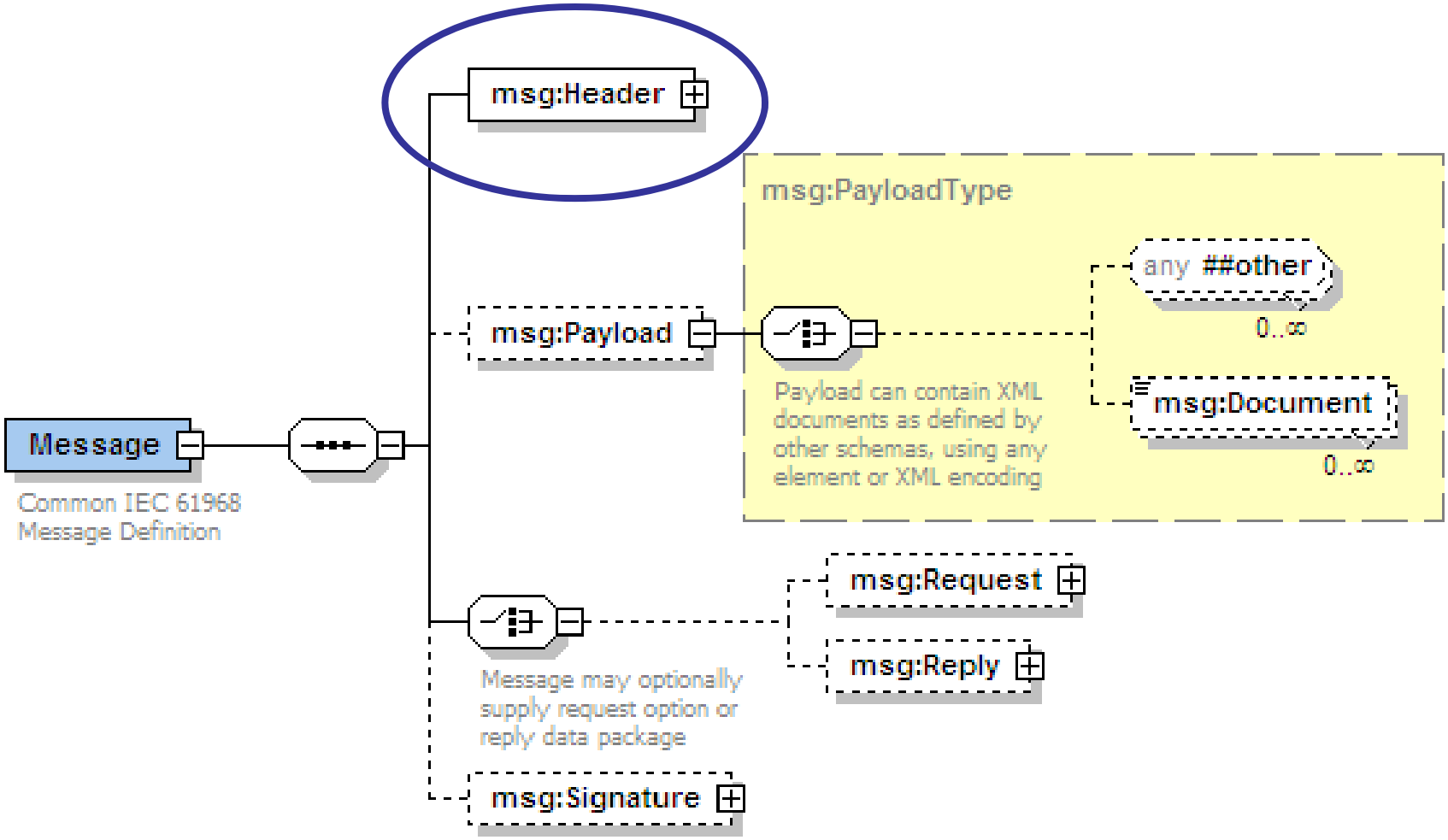
All IEC 61968 Activity Diagrams and Sequence Diagrams are organized by the IRM



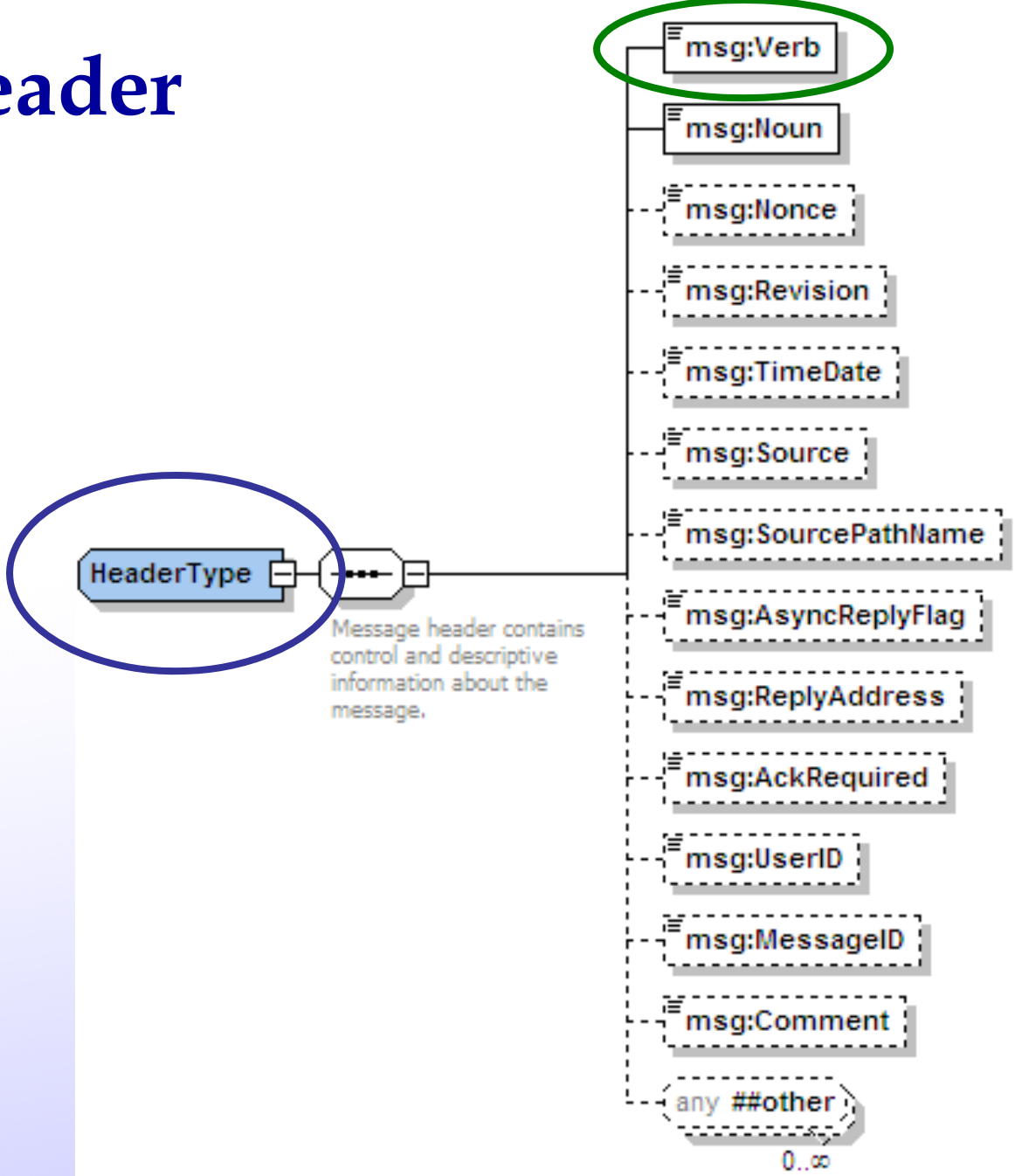
The Business Sub-Function Level of the IRM for IEC 61968 Scope



The IEC 61968 Basic Message Structure



Message Header

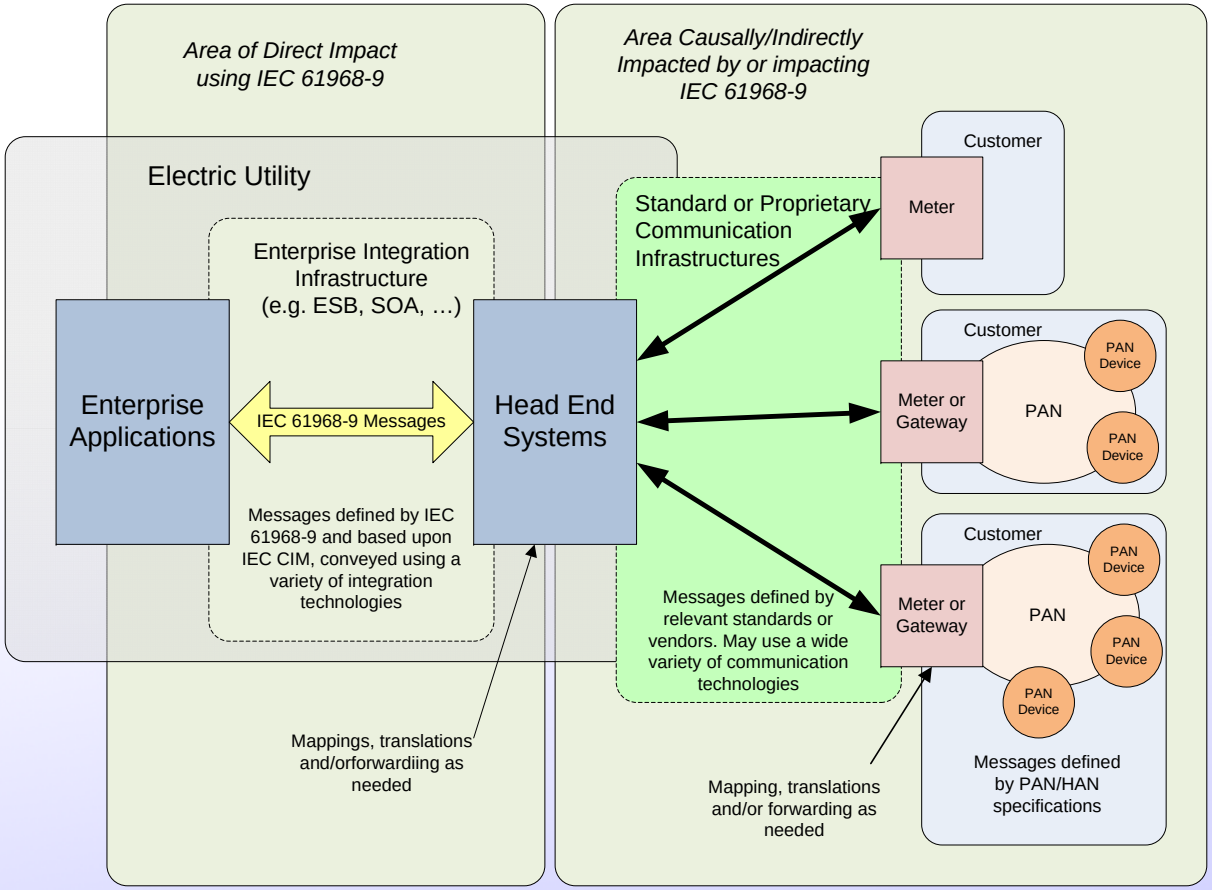


IEC 61968-9: Interface Standard for Meter Reading and Control

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

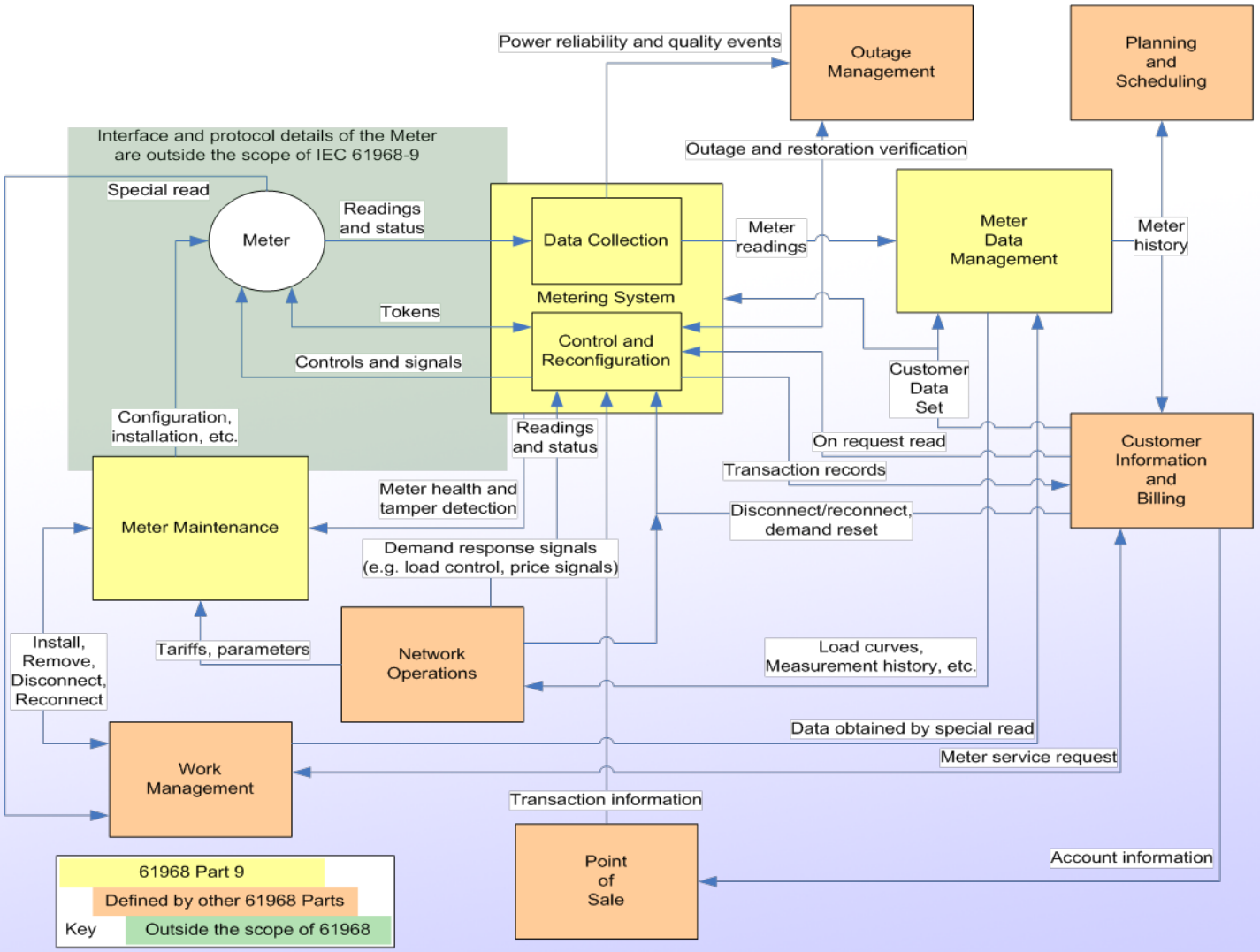
Scope of Part 9



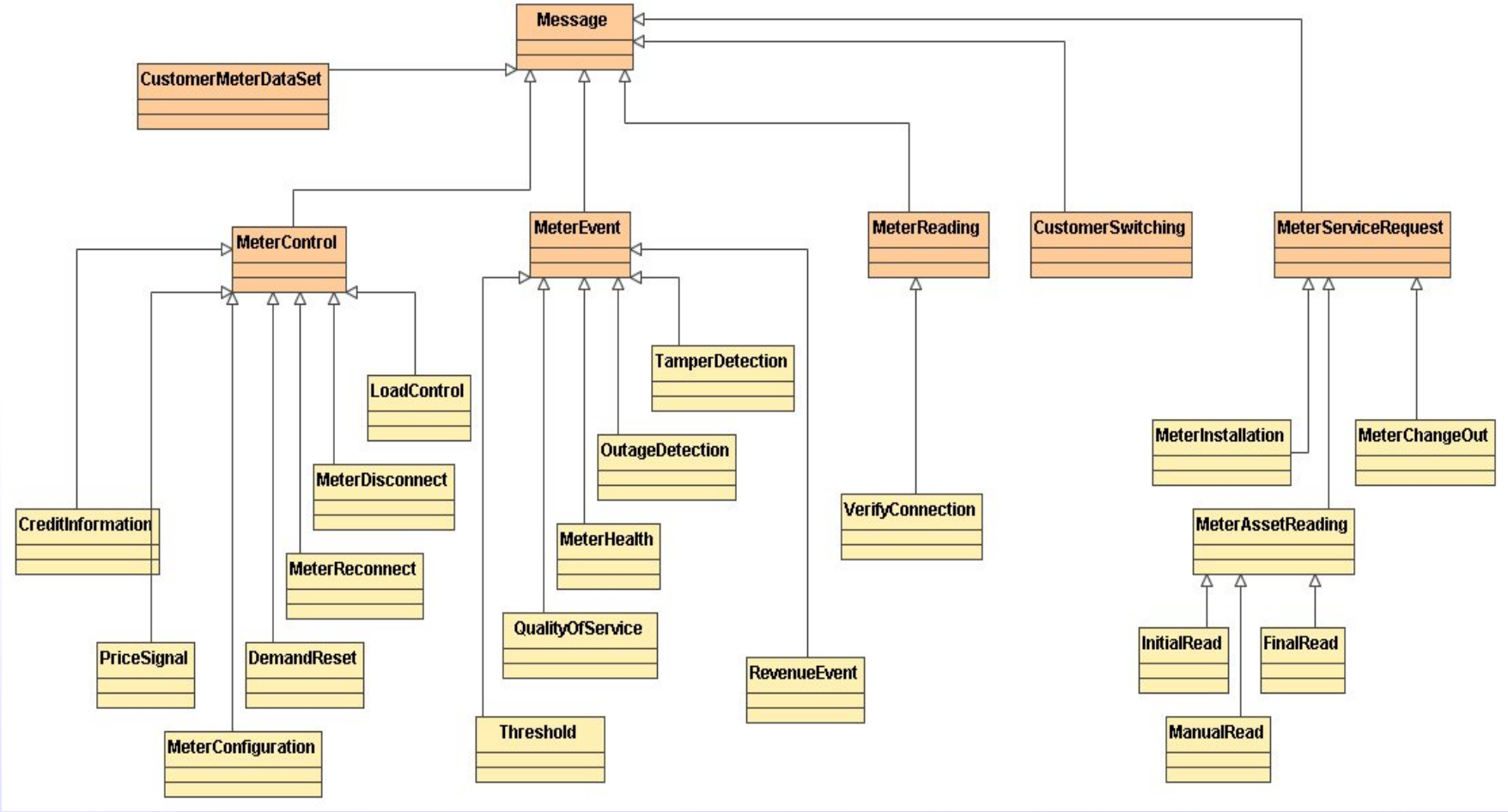
Reference Model

- 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



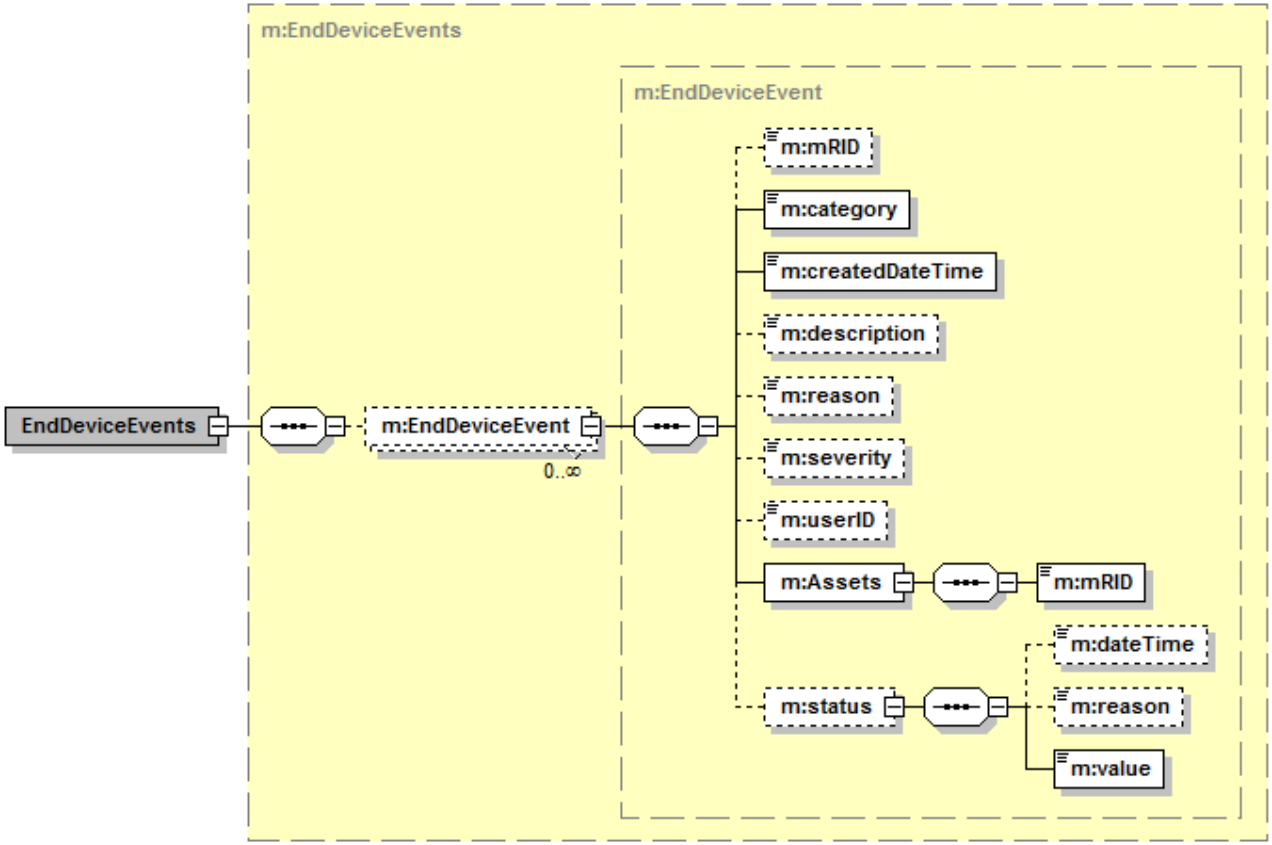
Part 9 Message Types



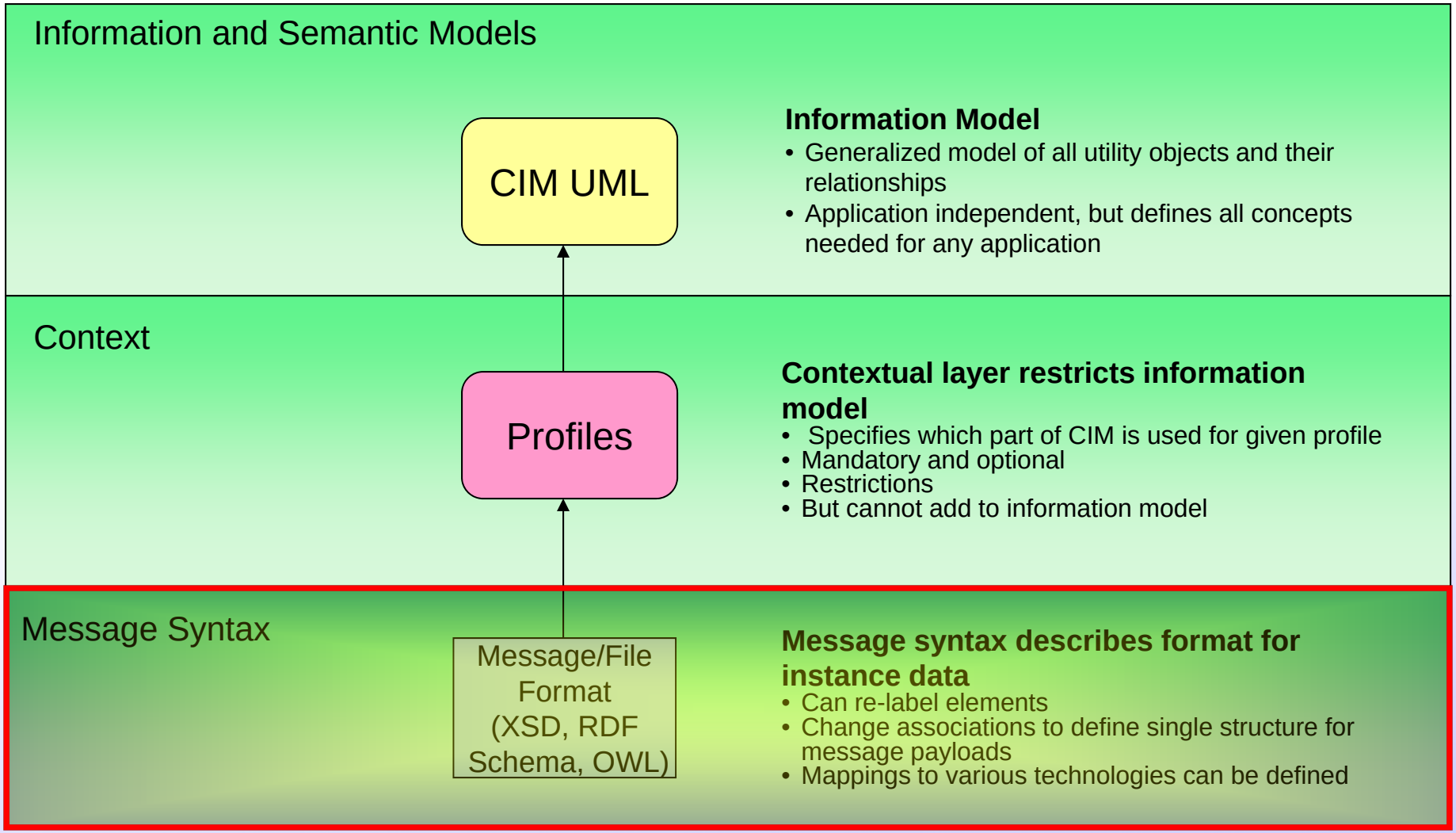
Typical Message Payload Definition - EndDeviceEvent Message

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



Next – Message Syntax



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 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

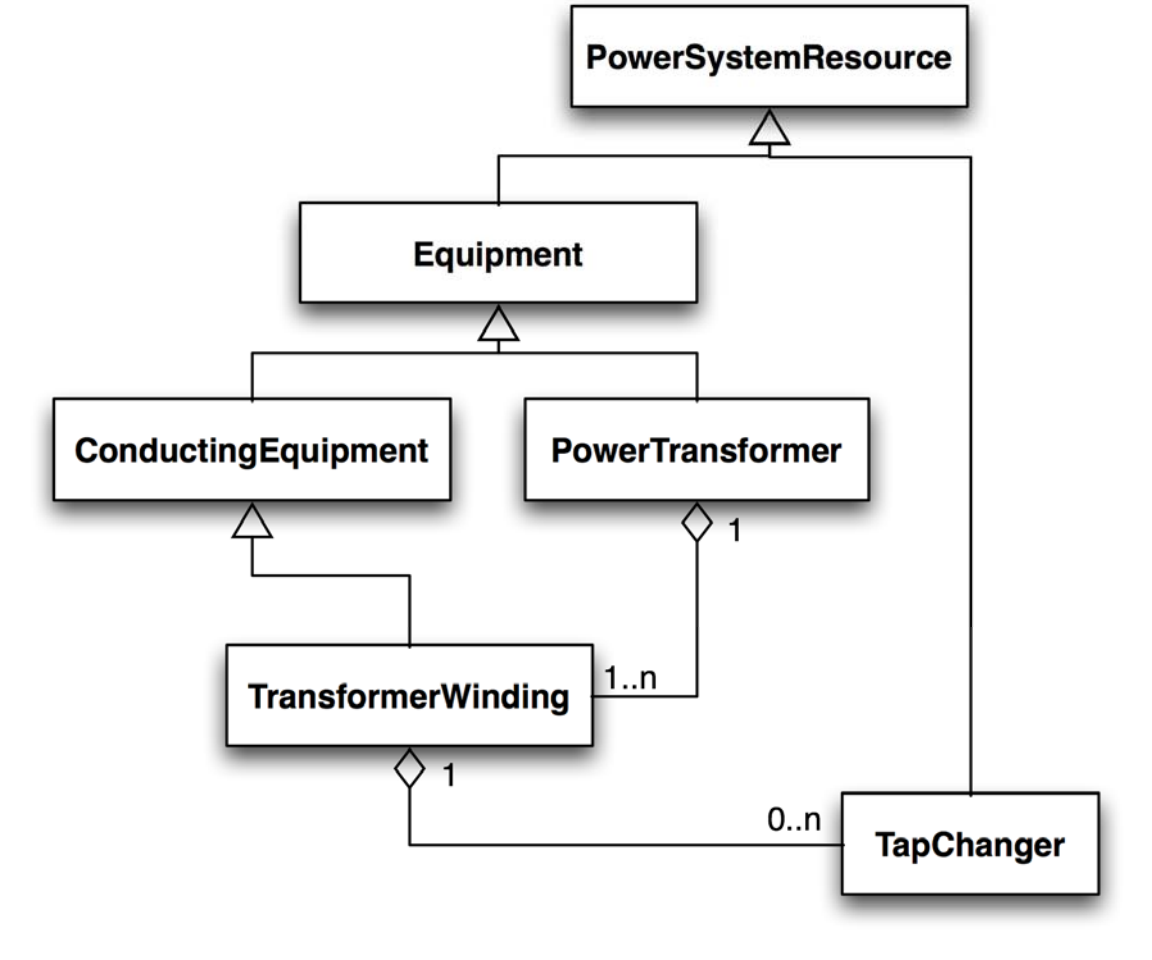
Mapping CIM Class Structure to XML using XML Schema (XSD)

- 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

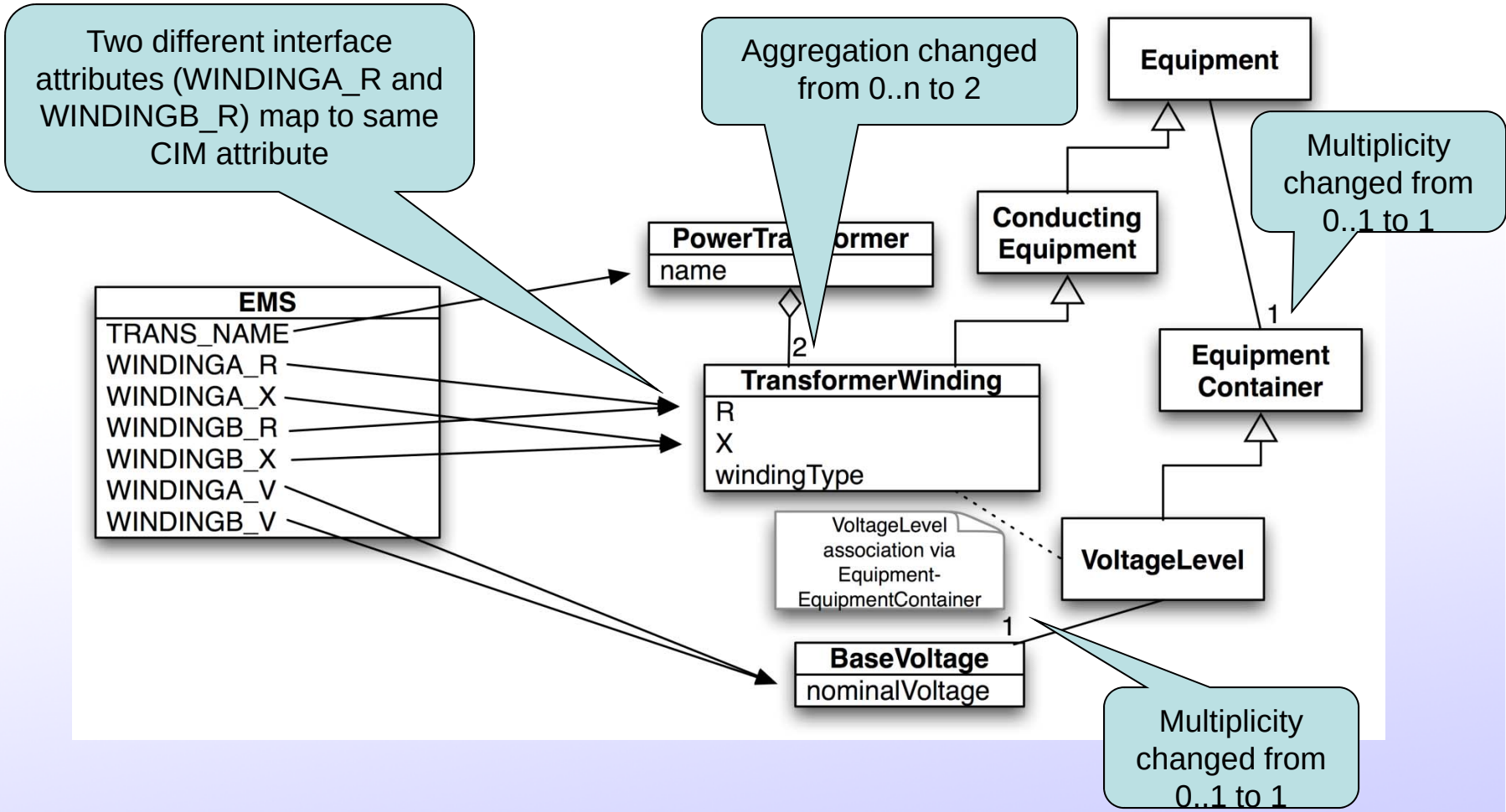
Mapping EMS Interfaces to the CIM – User access to transformer data

- 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

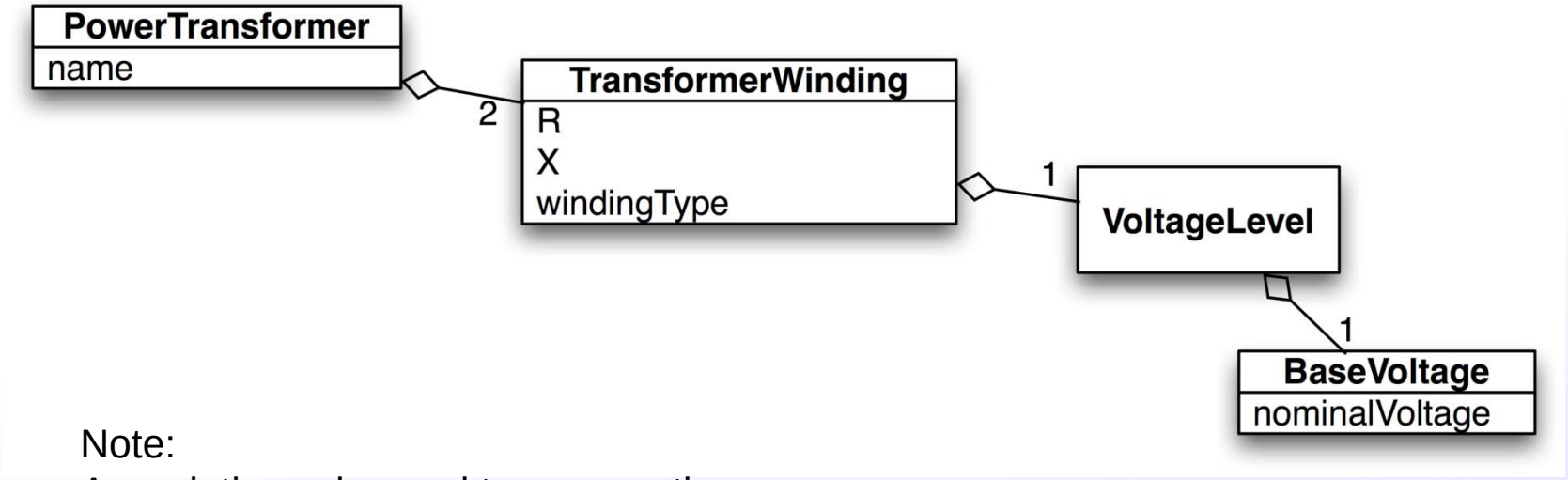
Transformer Class Diagram in CIM



CIM Interface Mapping
- Beginnings of Profile/Message Payload Definition



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>
```

Sample Transformer Interface Message Payload in 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>
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        <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 propertie
  - This allows a set of objects to be expressed as XML using a defined schema that retain their relationships and class hierarchy

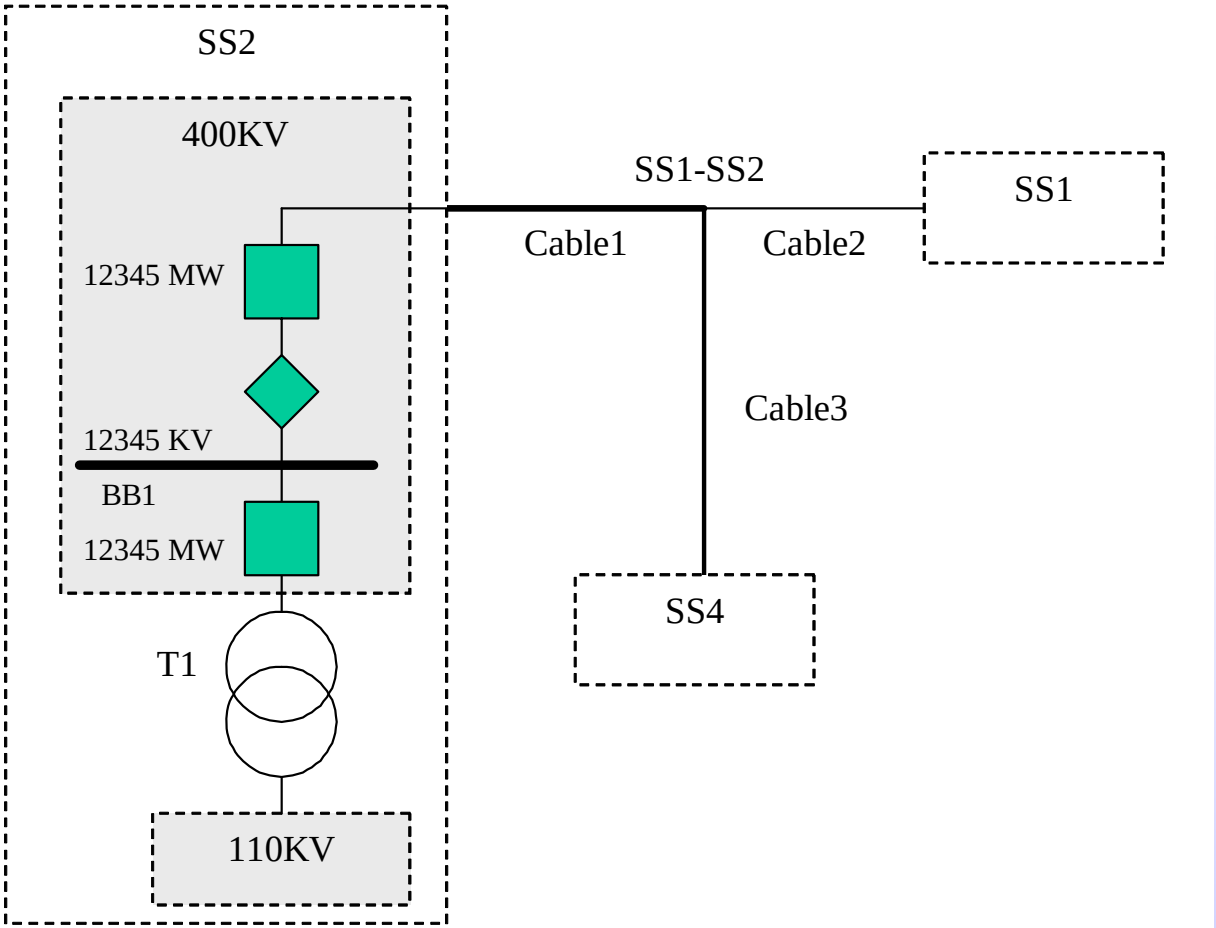
References

- 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/

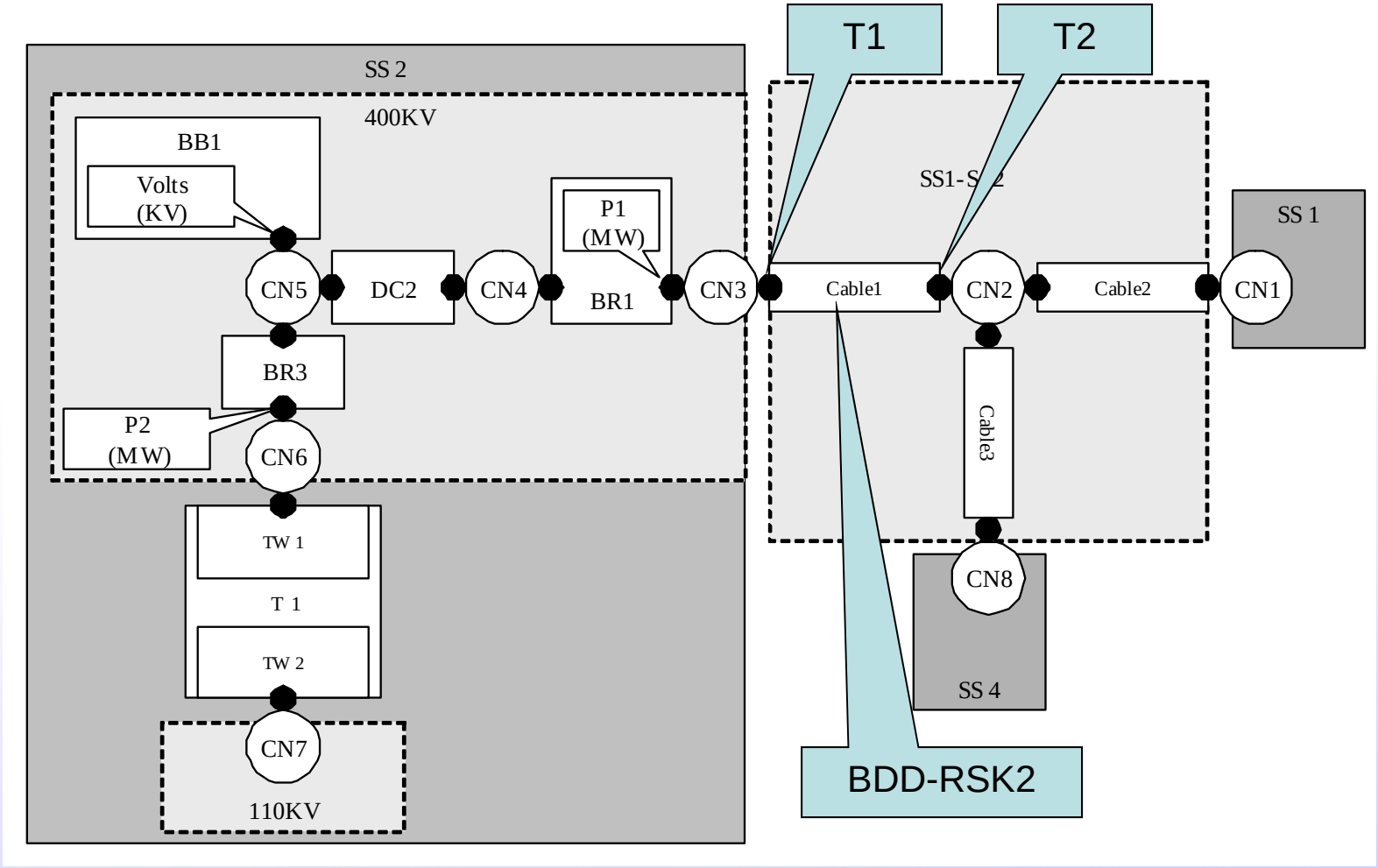
Mapping CIM Class Structure to XML using RDF Schema

- 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

```
<?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

```
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      <cim:Conductor.x>4.3378</cim:Conductor.x>
      <cim:Conductor.r>0.4761</cim:Conductor.r>
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      <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

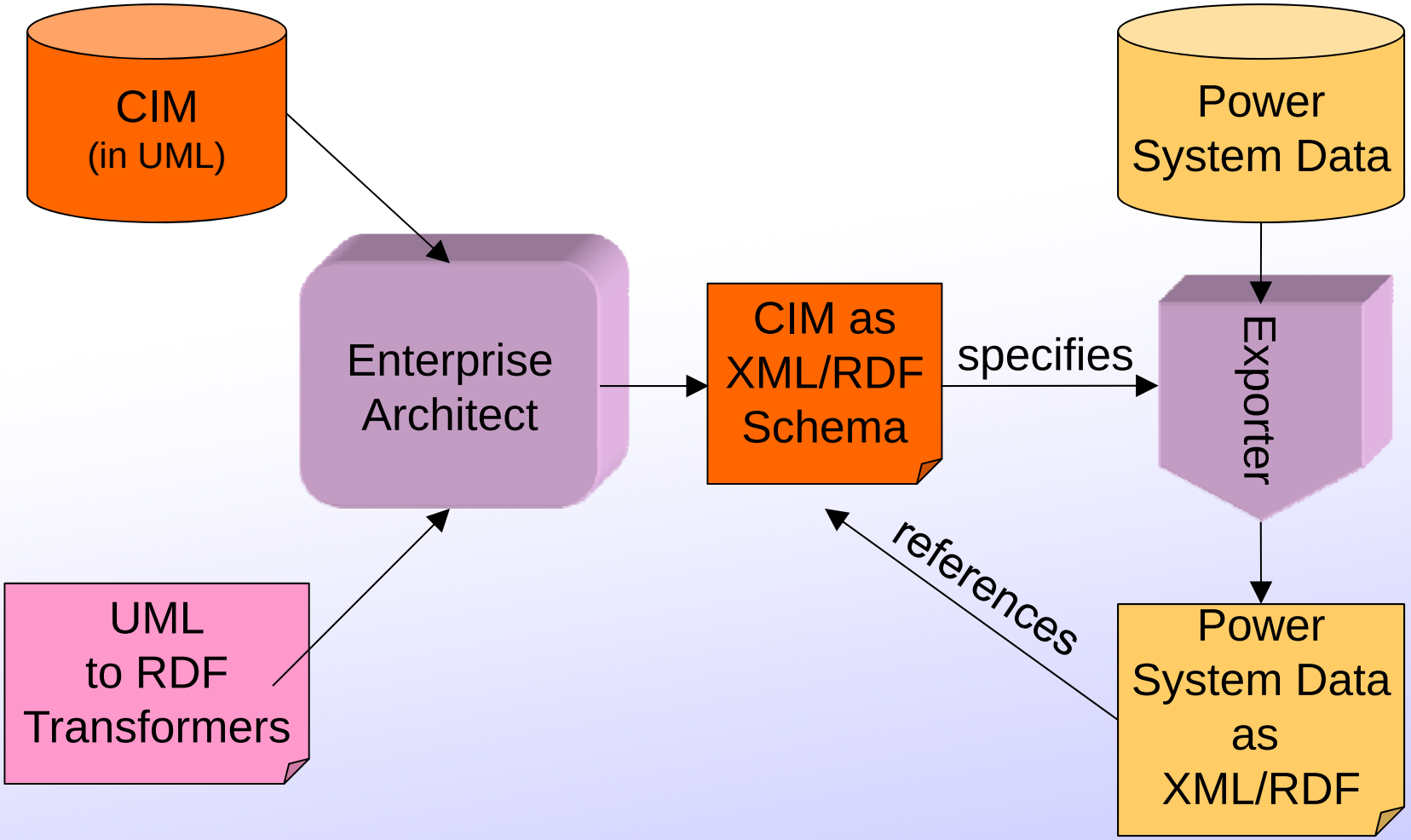
```
<cim:Measurement rdf:ID="_5B22599688AC4DE6B99FD8B13C1BA36F">
     <cim:Naming.name>LN    1 MVAr</cim:Naming.name>
     <cim:Measurement.MeasurementType rdf:resource="#_83D7B035901D4D2E80C040609D5ED7EC"/>
     <cim:Measurement.Unit rdf:resource="#_61784D3DA1954750A4E09444BE5206CB"/>
</cim:Measurement>

<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

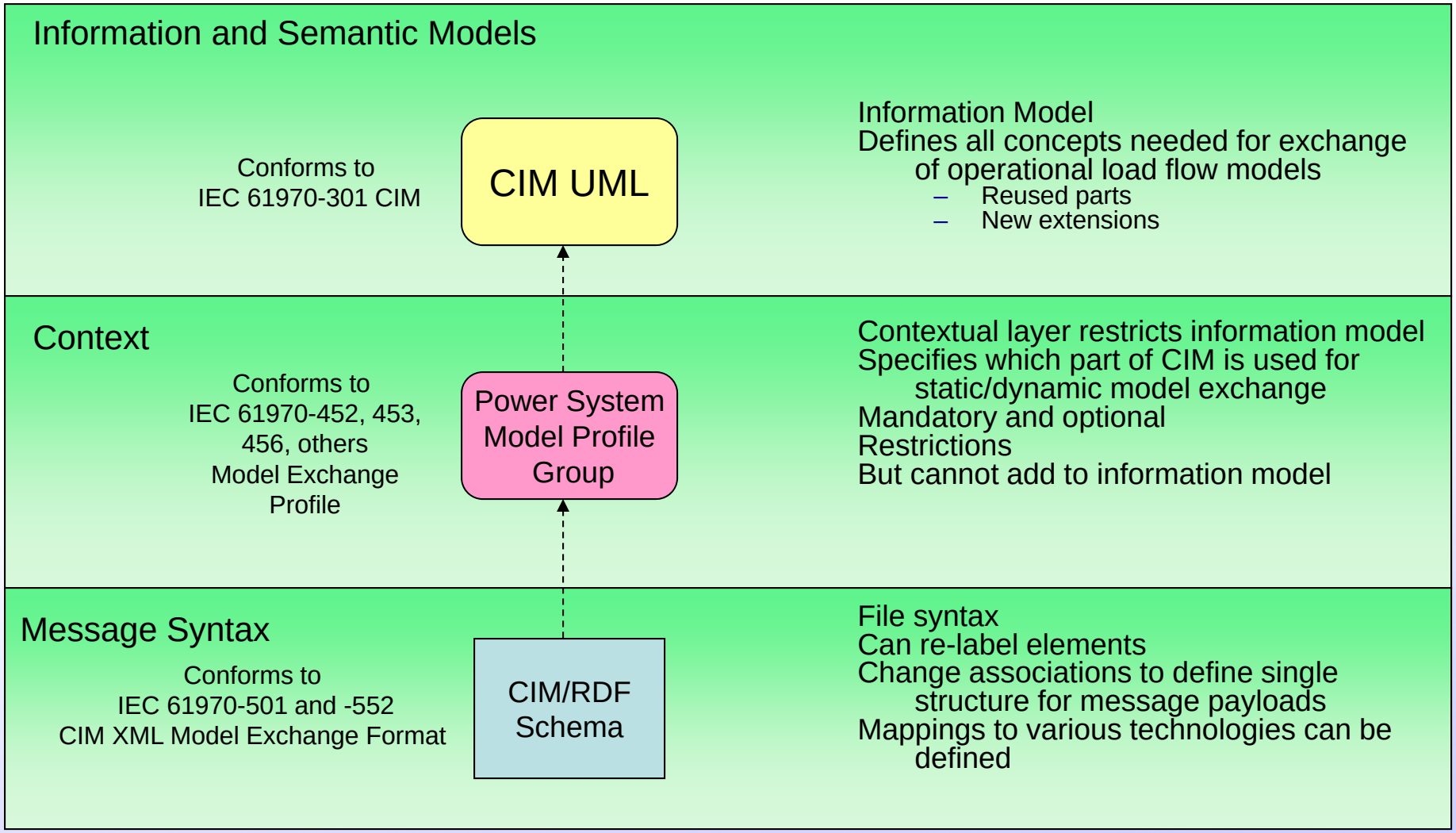
Basics: Schema from CIM



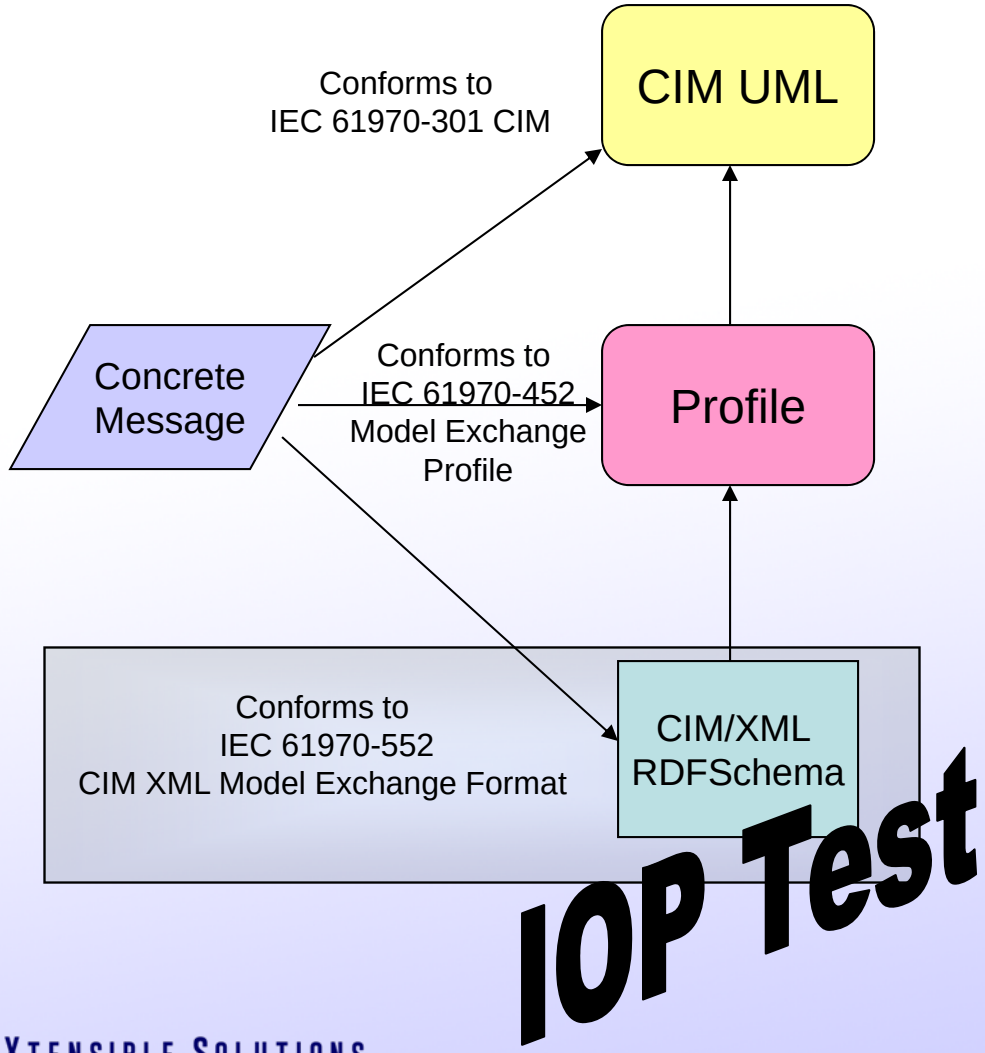
How Are CIM Standards Used?

- Unlike most standards we use
  - Ex: 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



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

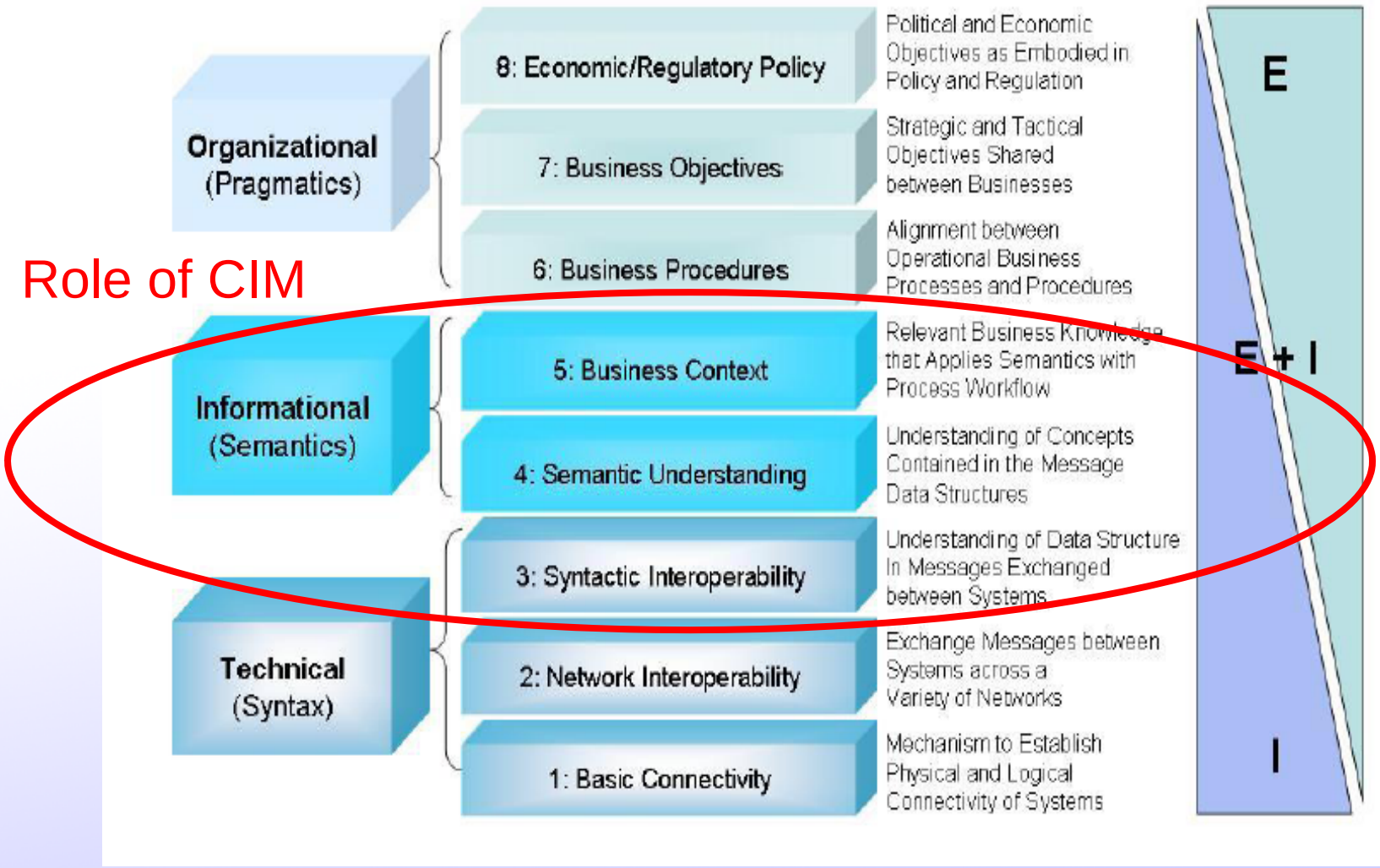
File syntax

- Can re-label elements
- Change associations to define single structure for message payloads
- Mappings to various technologies can be defined

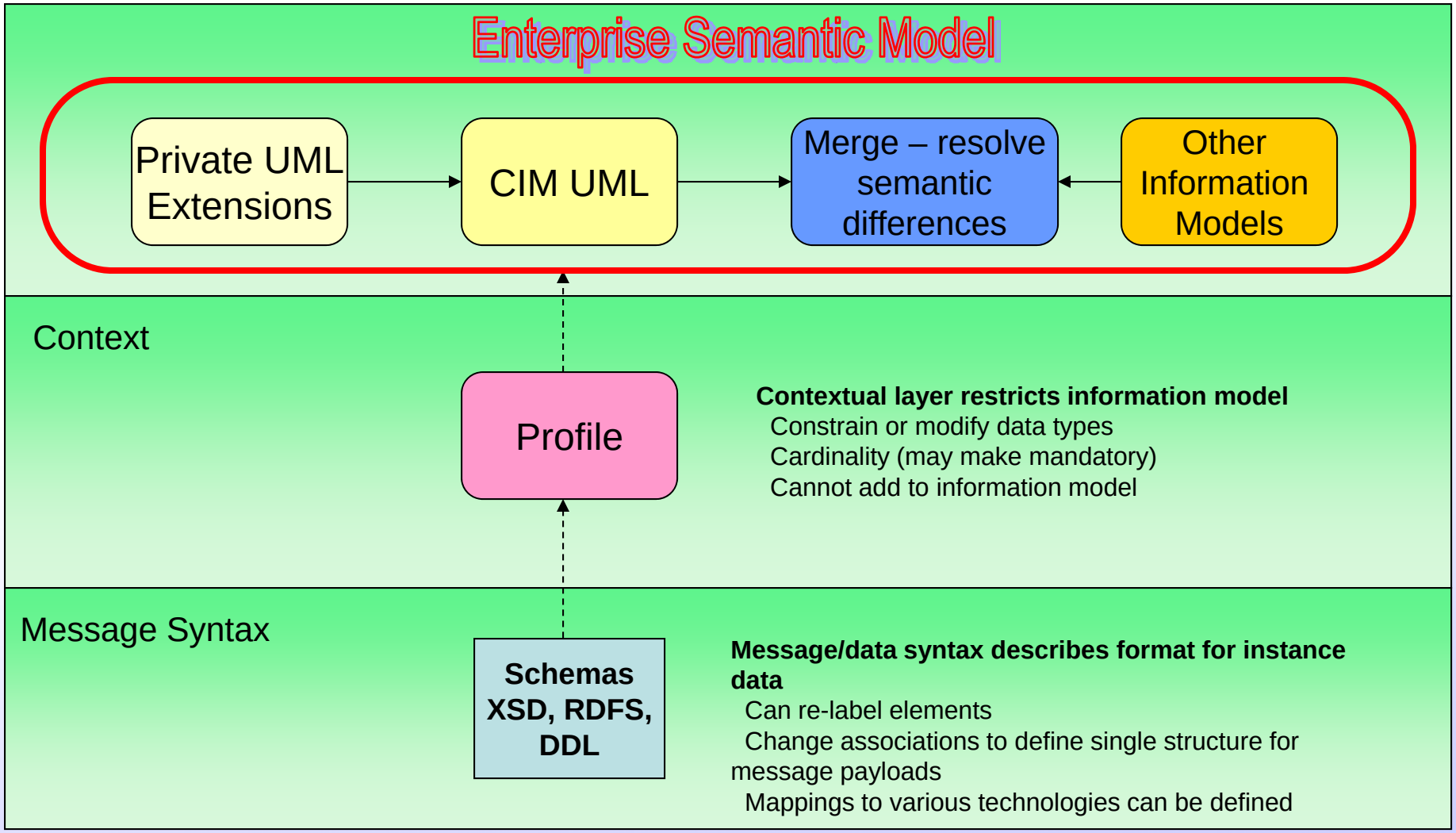
How Are CIM Standards Used?

- 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

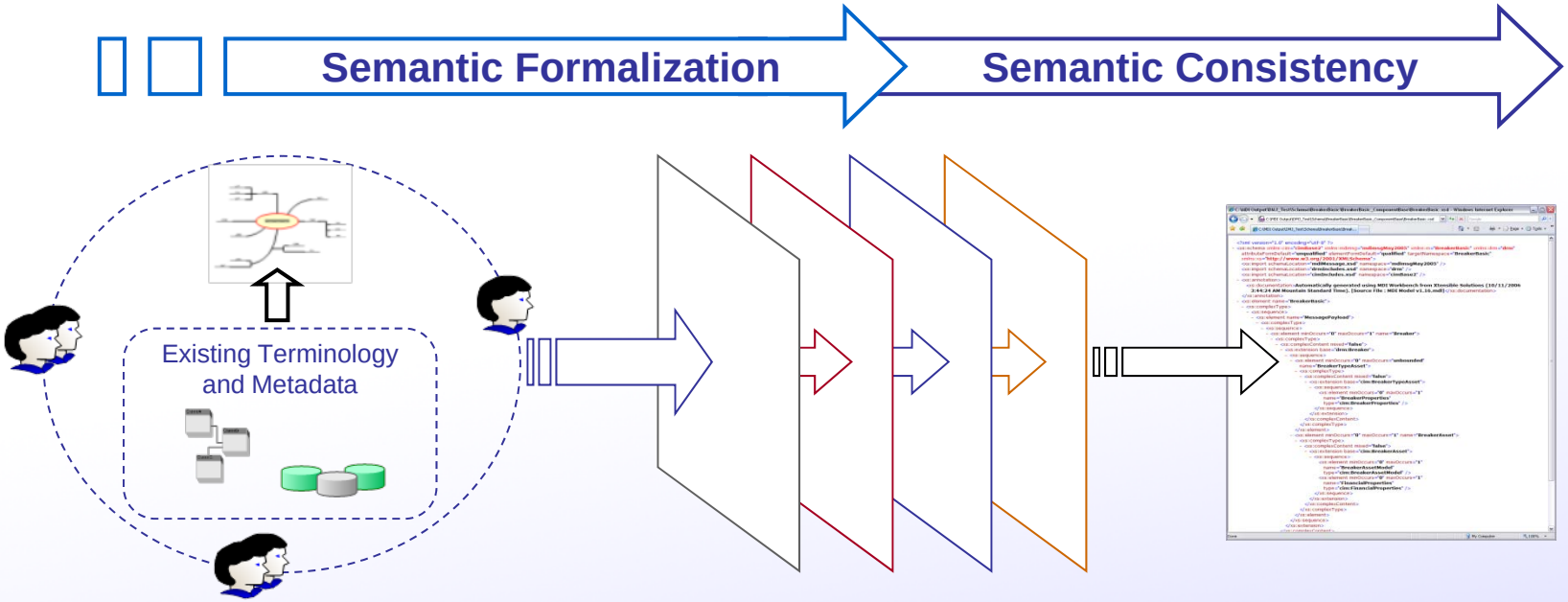
GridWise Interoperability Framework



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

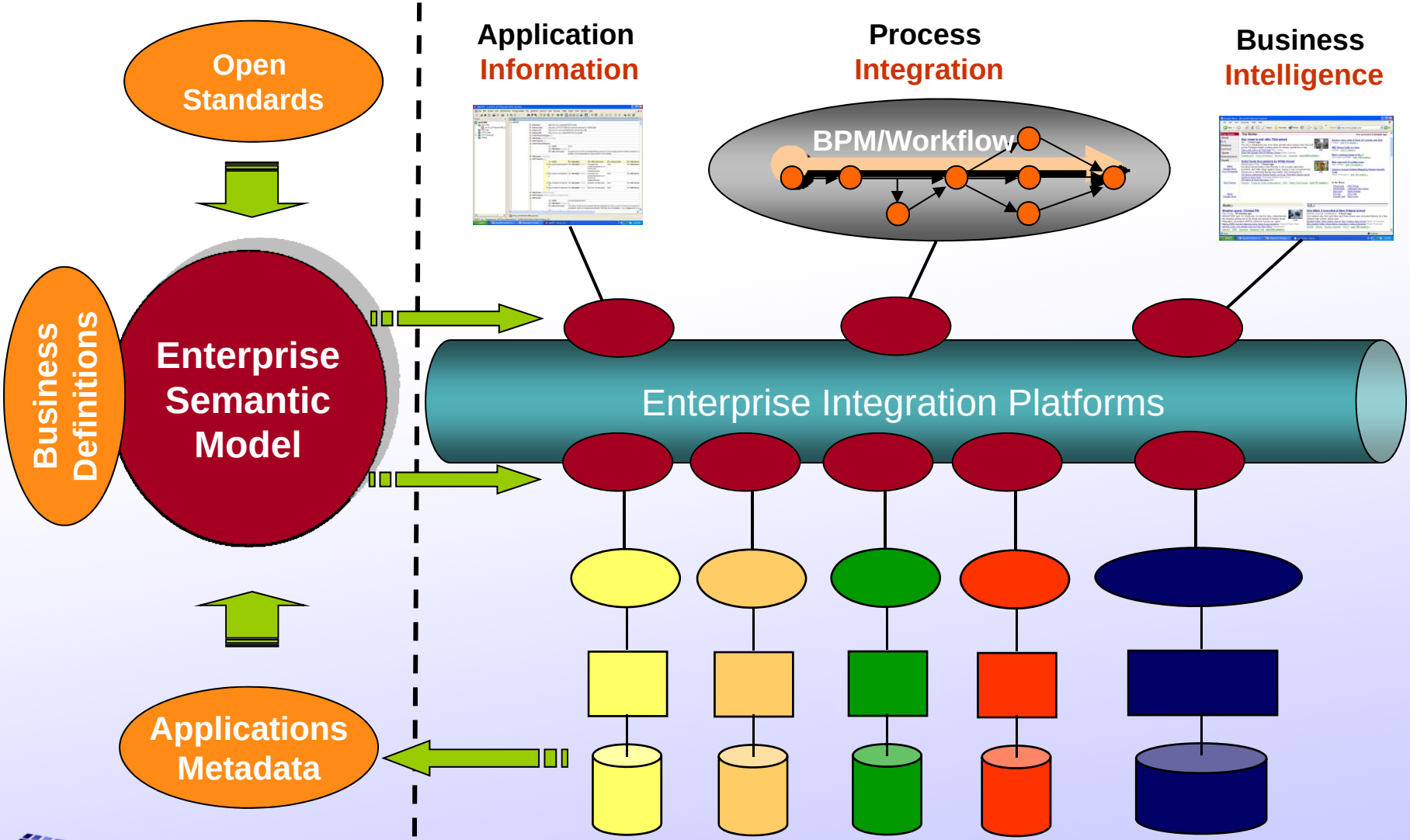
2) Develop ESM
Model using vocabulary terms
Refine context

3) Generate Canonicals
Syntactically and semantically consistent canonical models

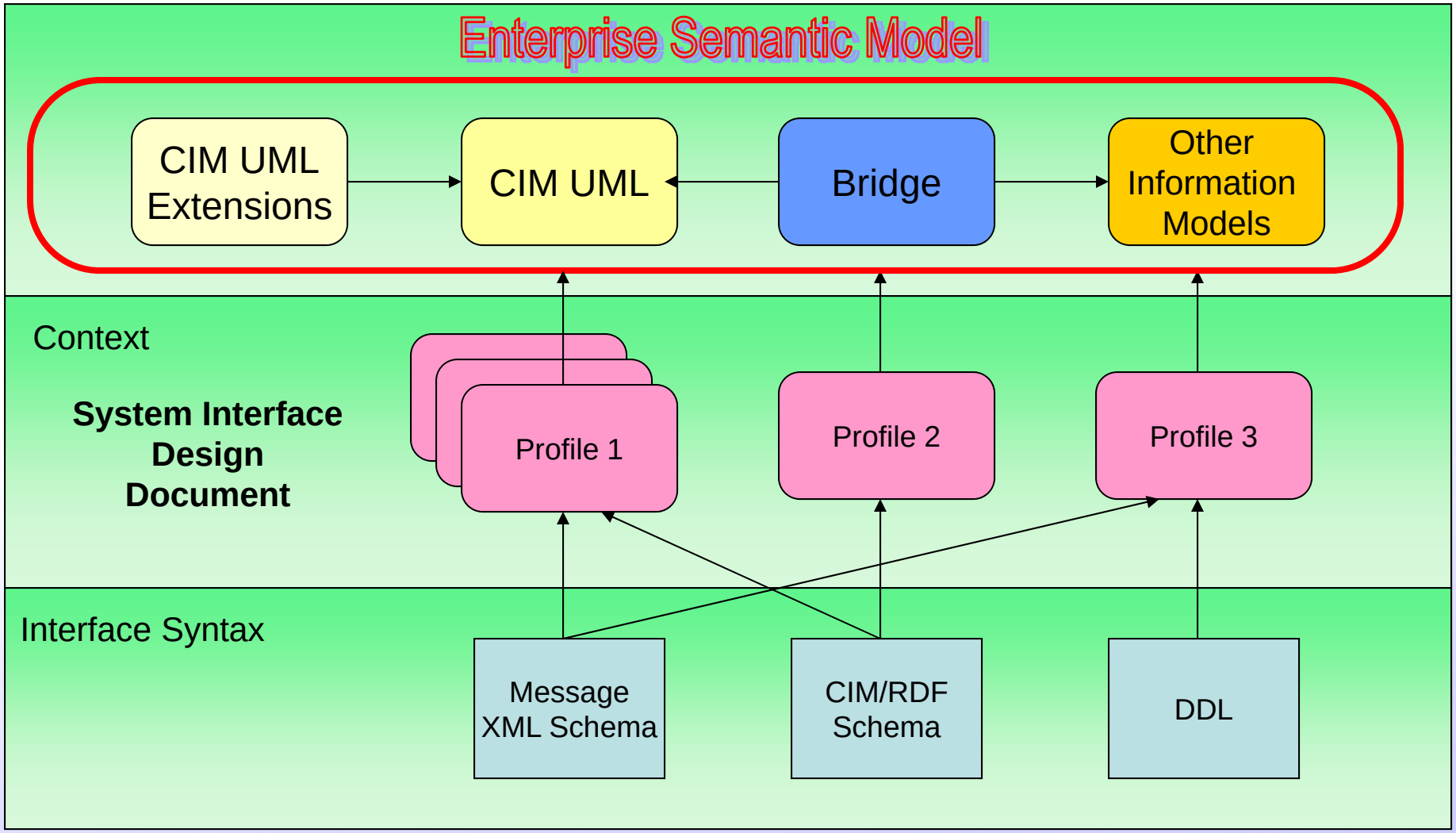
Context Refinement

Complements Xtensible MD3i

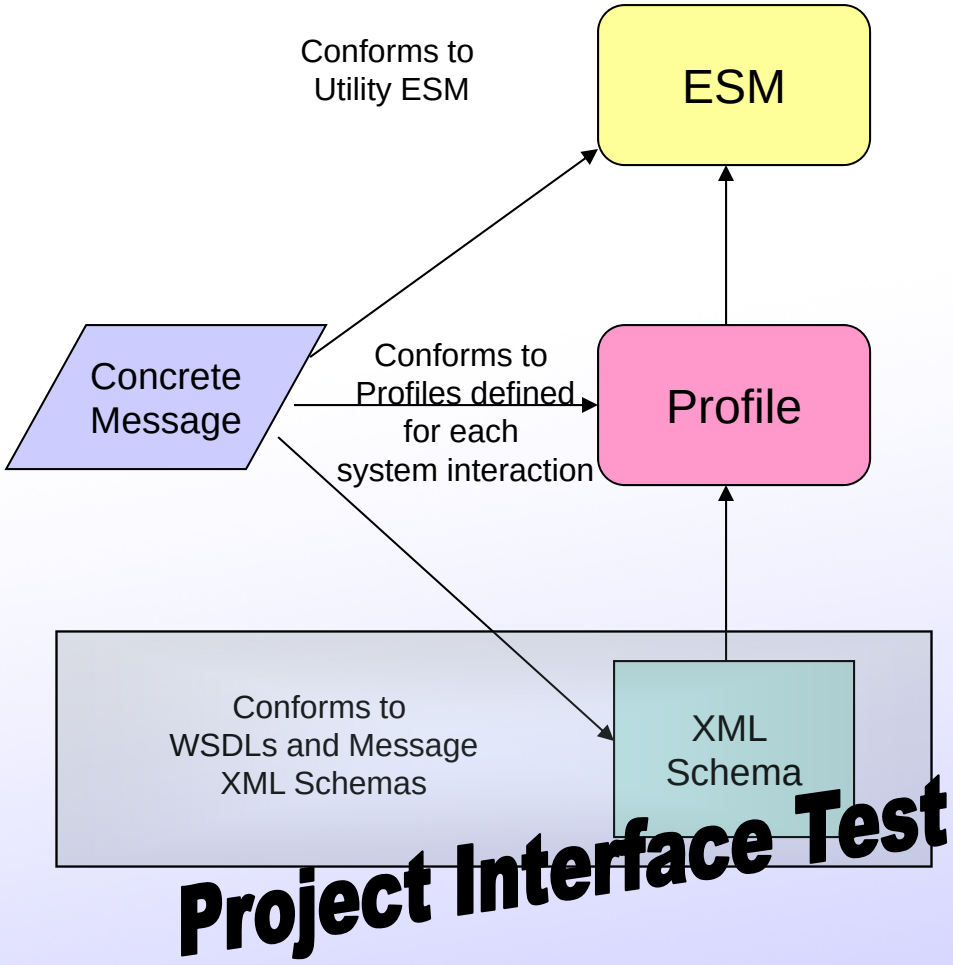
Role of Enterprise Semantic Model



Let's Apply to a Utility Project - Interface Architecture



Ex: Project Interaction Test



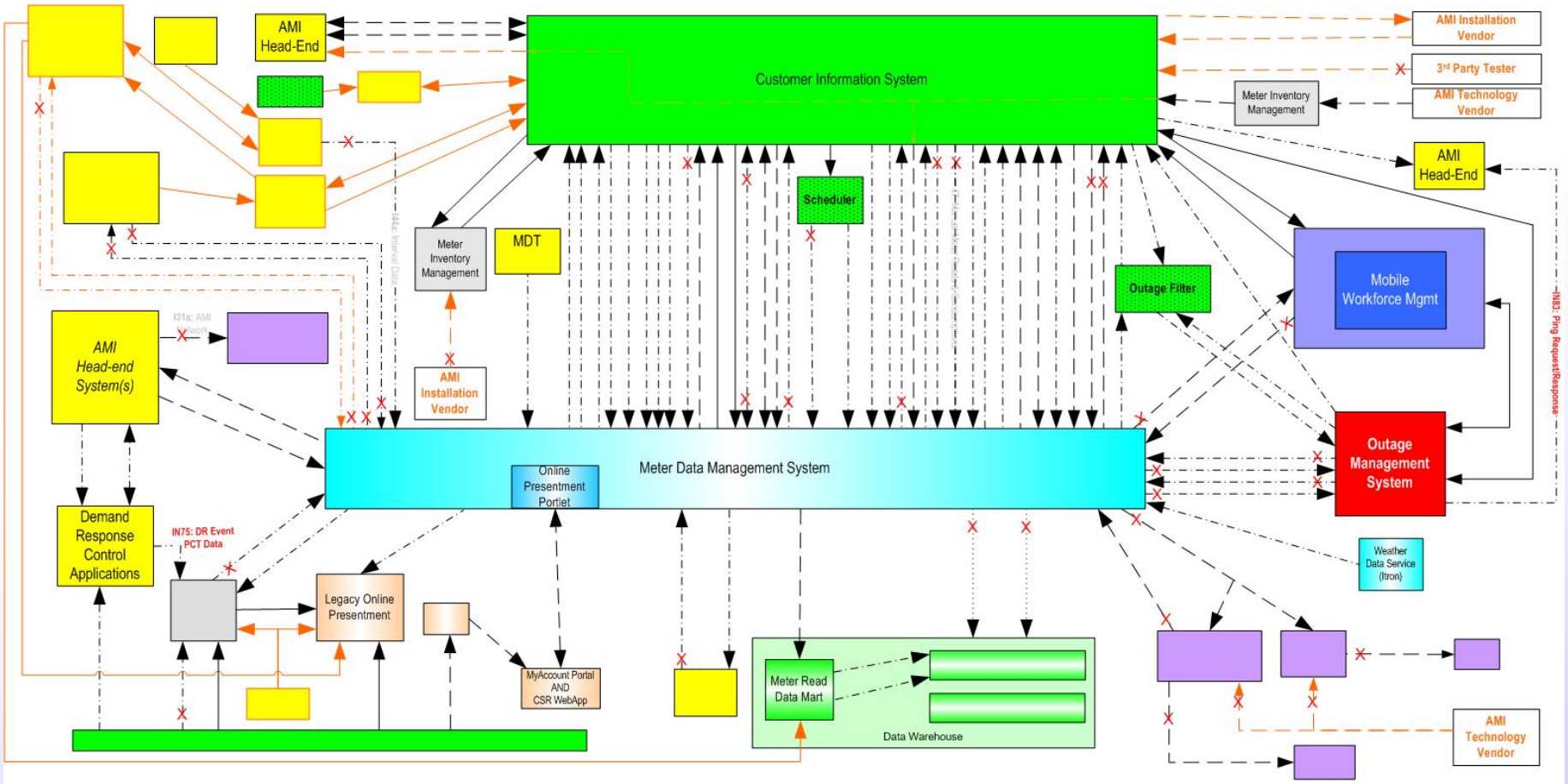
Enterprise Semantic Model

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

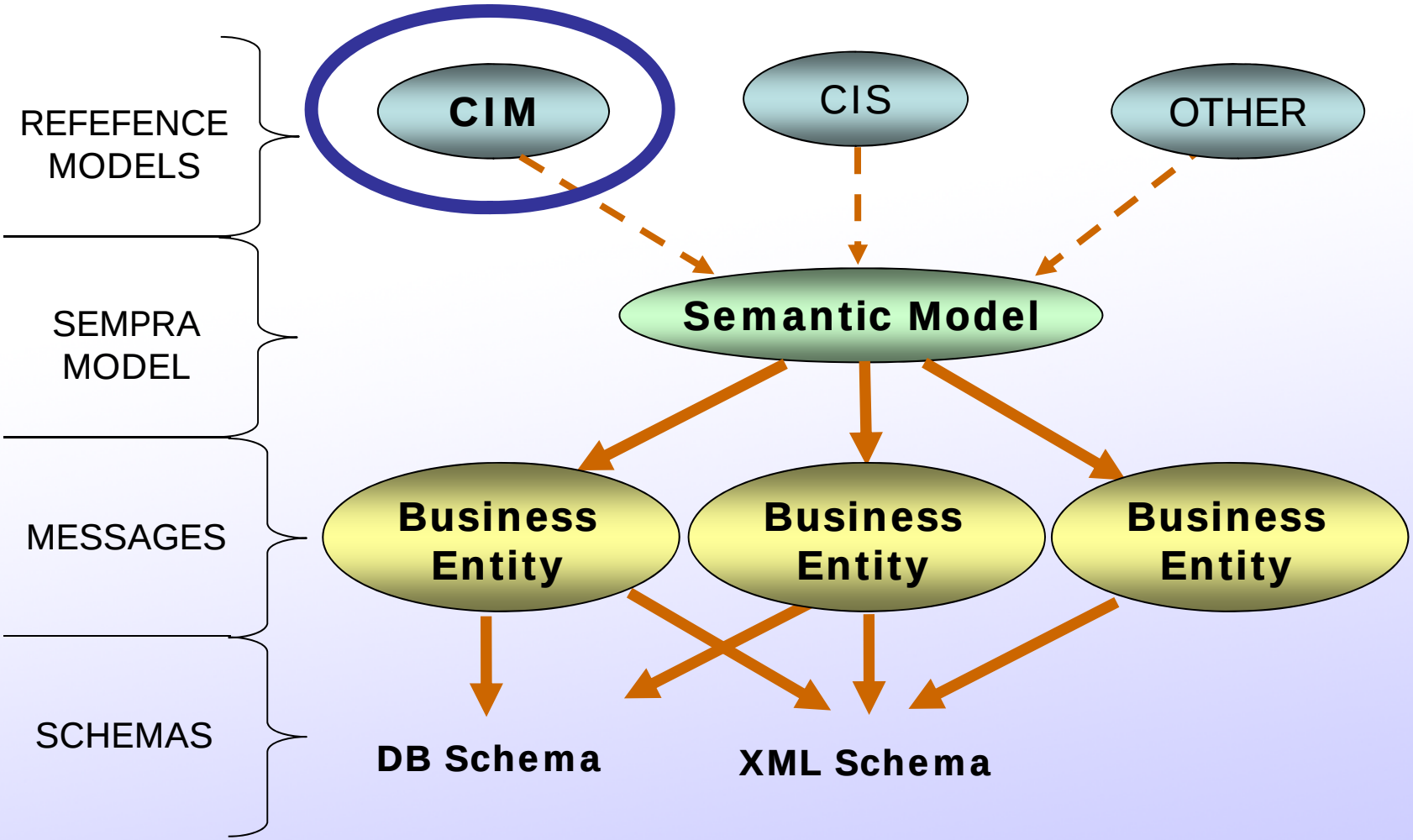
Contextual layer restricts ESM
Specifies which part of ESM is used for specific system interaction
Mandatory and optional
Restrictions
But cannot add to information model

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



Data Architecture – Model



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

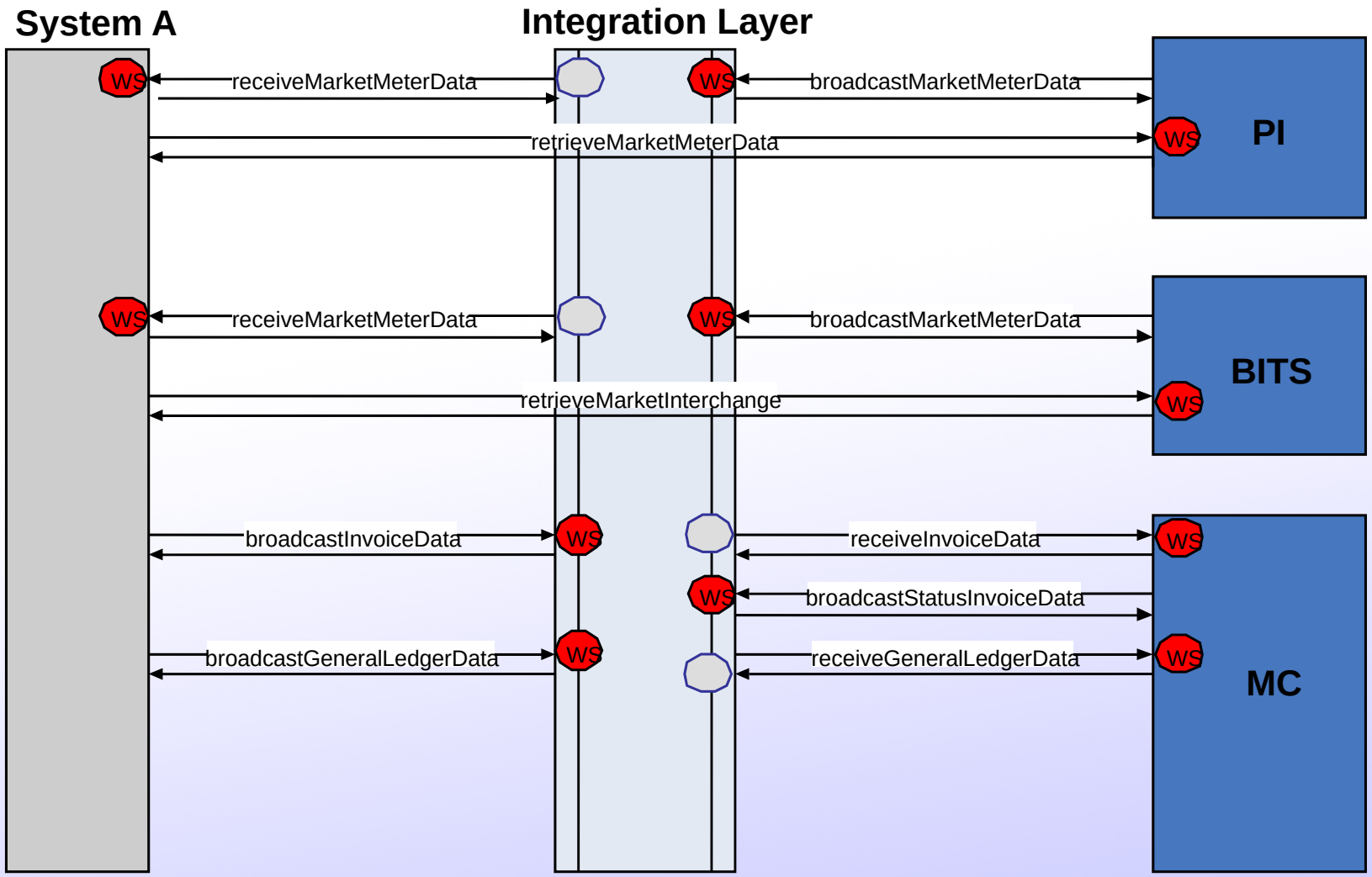
- CAISO designed a new power market system
  - Multi-year program that involved many vendors, new systems, as well as numerous legacy systems
    - Includes EMS, Full Network Model, Outage Management, PI Historian, Market Systems, many others
    - External interfaces to Market Participants included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

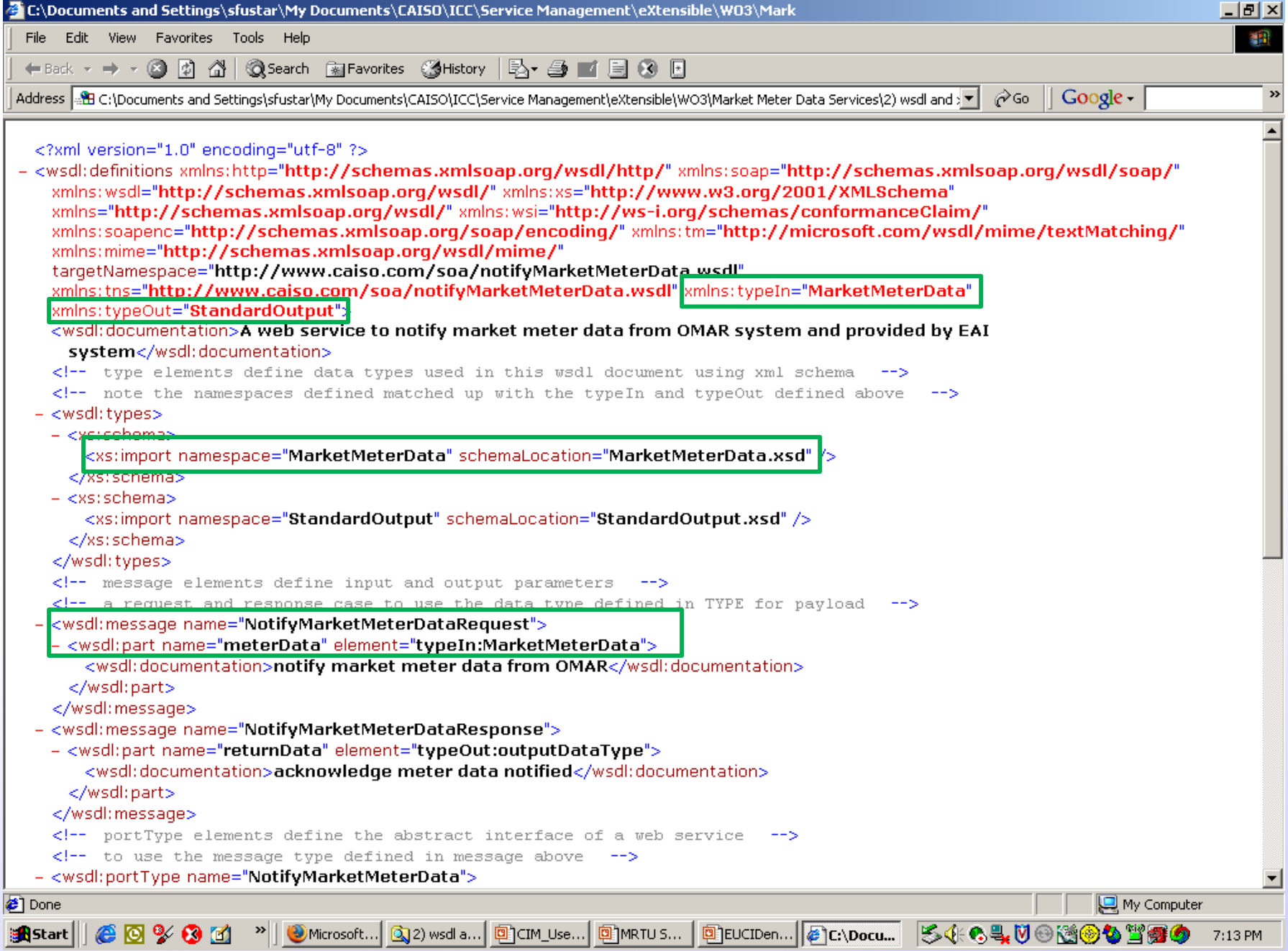
Interface Type	*Example*	*Implemented by*	*Utilized by*	*Description*
Information Creation	**submitBid(XML)**	**Vendor**	**Enterprise**	**These interfaces are for creating or modifying information within a system of record.**
Information Transfer	**publishCleanBidSet(XML)**	**CAISO**	**Vendor**	**These 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)



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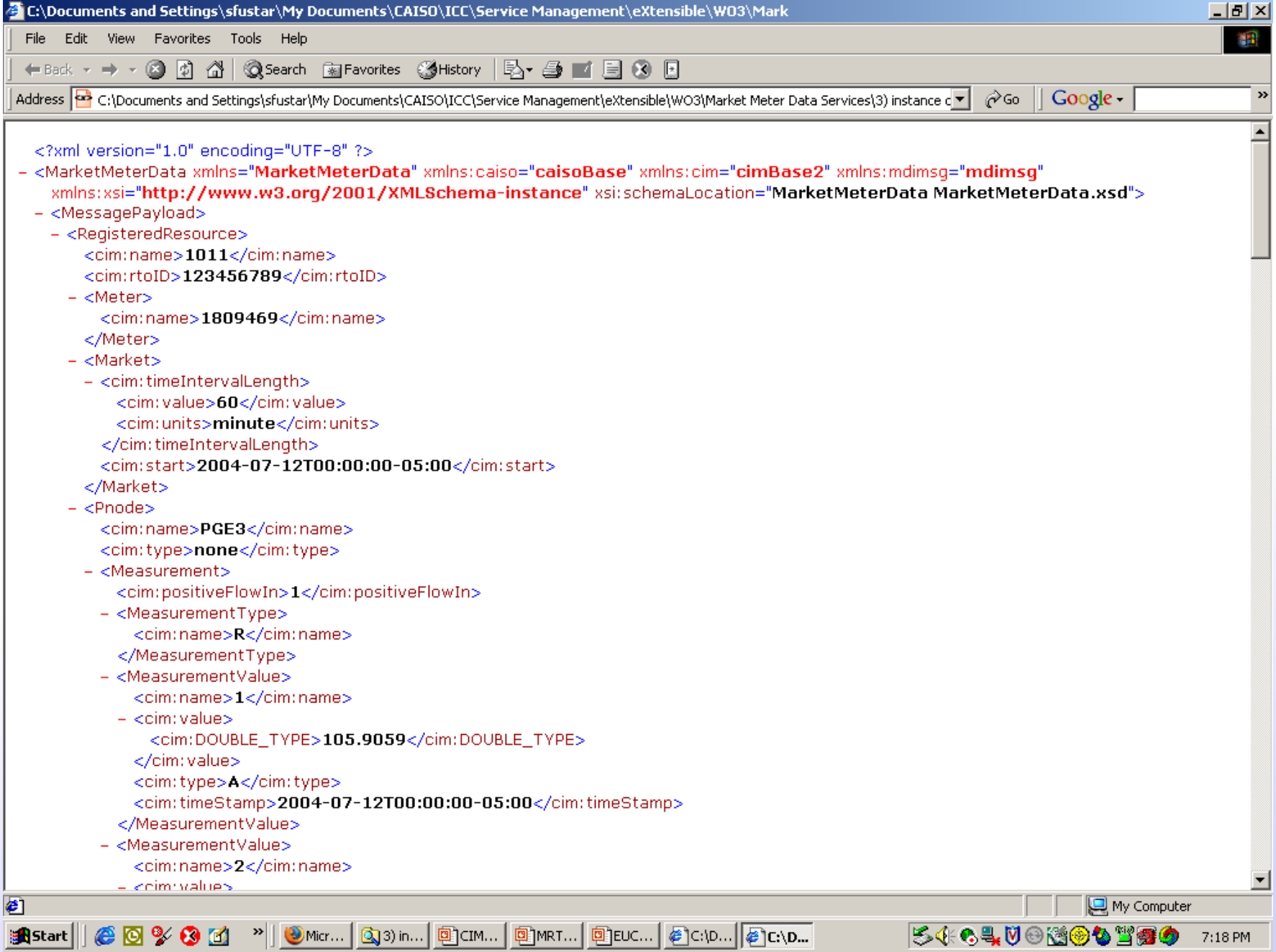

(Slide from Stipe Fustar, PowerGrid 360)

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

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

Business Units	Application/ Project	Message(s)	CIM	Pct of message that is CIM
Power Delivery	Substation Measurements	IntervalRead, SubstationEquipment.Measurement	MeasurementList	90%
	Outage Center Call Handing	TroubleCalls, TroubleReportAlerts, TroubleReportDetails, TroubleReportSummary, Customer Info, Customer Balance, Customer Account Balance	OutageManagement	80%
	Retail Access Project	RegisterReadRequest, BillDeterminant, CustDrop, Enroll.DACust, EnrollmentChange, NonDACust, Reg.ESSRegister, Register.ESS, ESStatusChange, SESSESSRelationshipChange, RegisterReadResponse, CnIConsumption, DAEnrollConsumption, EnrollmentChange, NonDAEnrollConsumption, ESSStatusChange	CustomerMeterDataSet, CustomerServiceAgreement, MeasurmentList, Document, ActivityRecord, CustomerBilling, BillingDeterminant	80%
	Pole Attachment System	FacilityPoint, JointUse.Agreement, JointUse.Attachment, JointUse.Notice, JointNoticeRequest, FacilityPoint	AssetList	70%
Transmission	Transmission Planned Outages	PlannedOutage.Change	PlannedOutageNotification	50%
	Transmission Wholesale Billing System	TransmissionData, STLossData, LTLossData, Scheduling.LoadData, ConsumptionData, InvoiceData	Settlement and MarketClearing	70%
	EMS SCADA	WeatherData	MeasurementList	100%

CIM Scorecard Cont'd

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

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
- 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

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

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