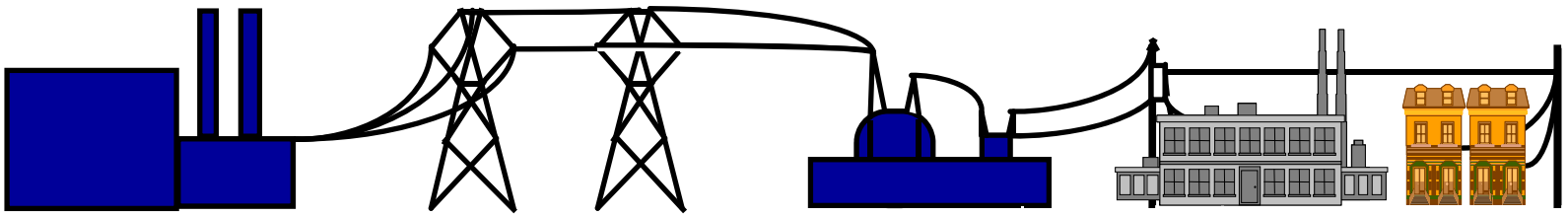
Welcome to the CIM University

Austin, Texas, USA
15 November 2011



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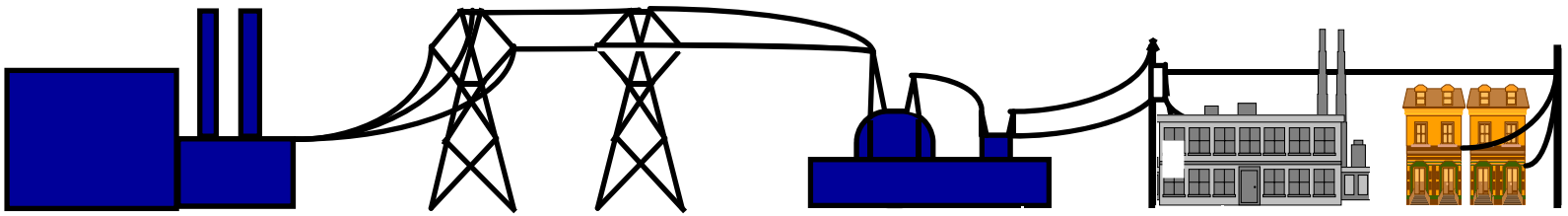
CIM Standards Overview
And Its Role in the Utility Enterprise – Part 1

CIM Users Group
Austin, Texas
15 November 2011
Terry Saxton



Presentation Contents

- Background
- What is the CIM
- How the CIM is used in the Utility Enterprise
- Three Layer Architecture for Using the CIM Standards
- CIM UML model
- 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

The IEC Common Information Model (CIM) - What Is It?

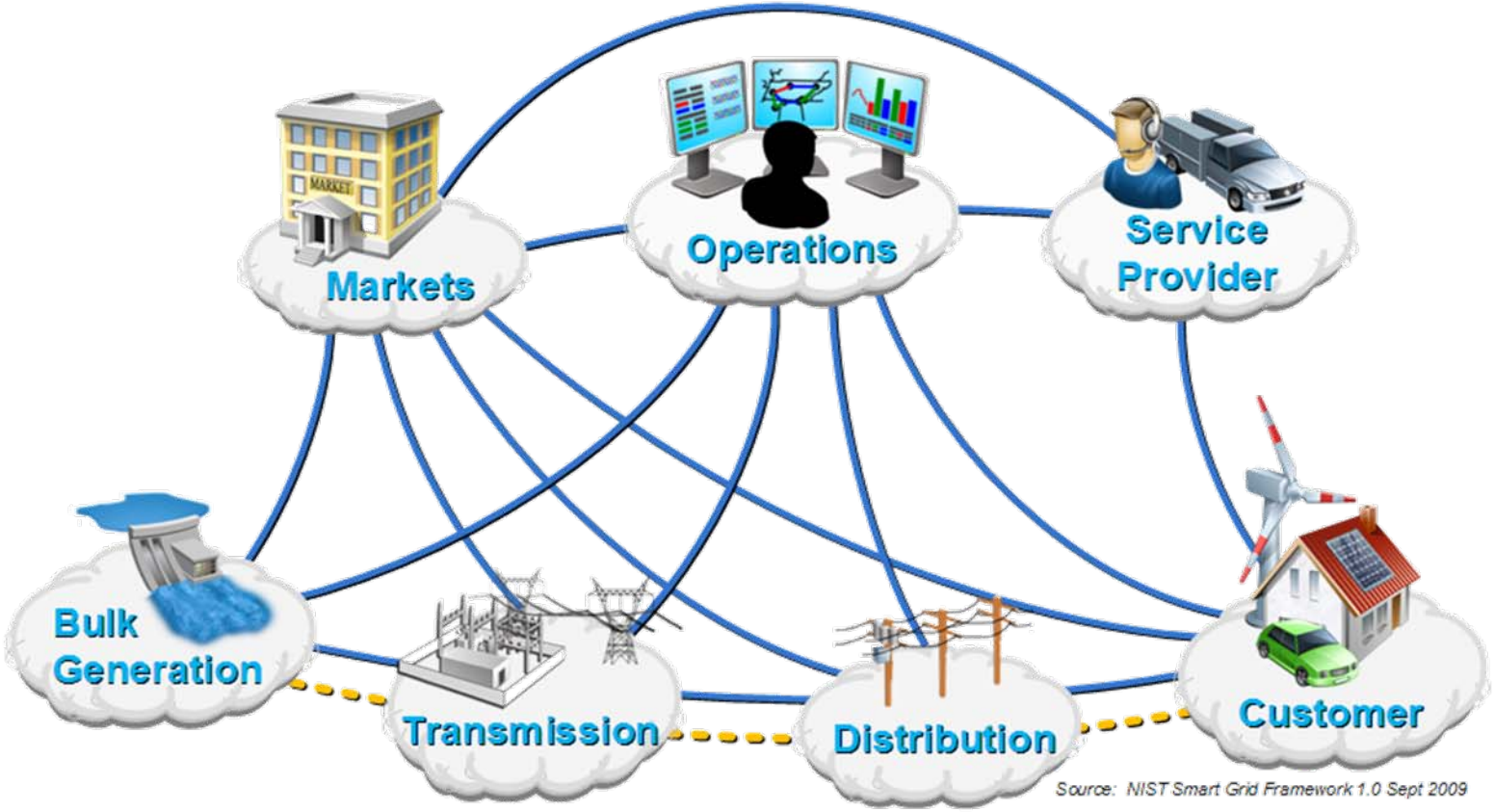
- A set of standards in enable system integration and information exchange based on a common information model
  - Provides a general information model and message/file schemas for messages/files exchanged between systems
- A key differentiator: The CIM standards are based on a Unified Modeling Language (UML) based information model representing real-world objects and information entities exchanged within the value chain of the electric power industry
  - Provides common semantics for all information exchanges

    Referred to as Model-Driven Integration (MDI)
  - Not tied to a particular application's view of the world
    - But permits same model to be used by all applications to facilitate information sharing between applications
  - Maintained by IEC in Sparx Enterprise Architect modeling tools
  - Many tools available generating design artifacts and documentation
  - Enable data access to enterprise data warehouse in a standard way

CIM History

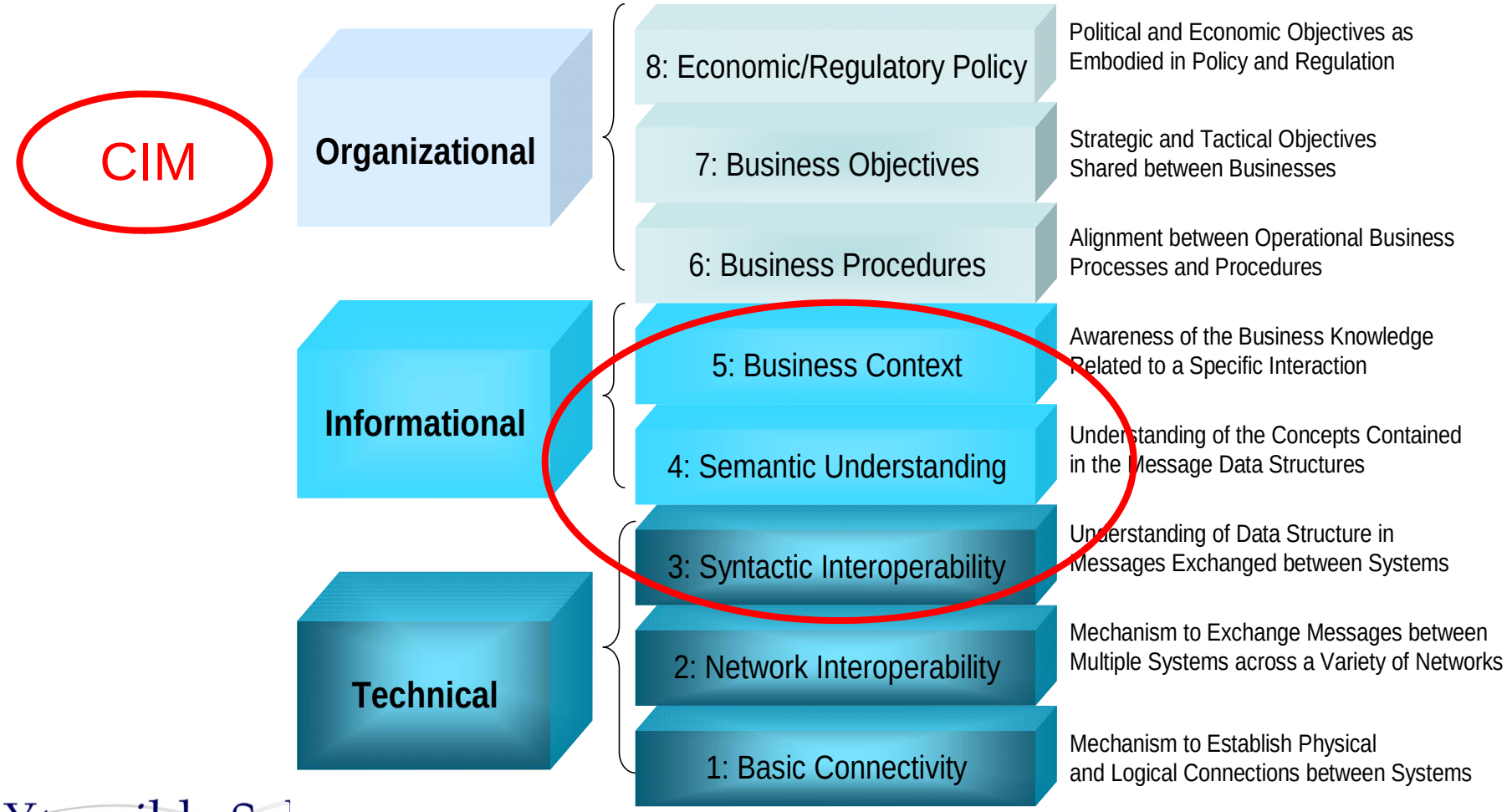
- 1992 – Unified Information turned over a data model based on the EPRI OTS to the CCAPI Task Force with the understanding it would be turned into an industry standard model
- 1993 to 1996 - The CCAPI task force expanded the data model with a primary goal of enabling use of plug compatible applications to help protect utility investment in applications
  - Entity Relationship Visio Diagram with MS Access database
- 1996 – The CIM was turned over to IEC Technical Committee 57, Working Group 13&14, where it is advancing through the standards process. It covers both electric utility transmission and distribution business operations
  - Converted to UML and initially maintained in Rational Rose
- 2000 – NERC mandates CIM and first IOP test
- 2003 – ISO/RTO Council and EPRI sponsored an initiative to expand CIM into Market Operations, a.k.a. CME, followed by extensions for Planning and Dynamics
- 2005 – First edition of IEC 61970-301 CIM Base
- 2005 – CIM Users Group established under UCA Users Group
- 2008 – CIM adopted by UCTE
- 2009 – NIST identifies CIM as key standard for Smart Grid interoperability
- 2010 – ENTSO-E migrates to CIM and holds first IOP test

Conceptual Model

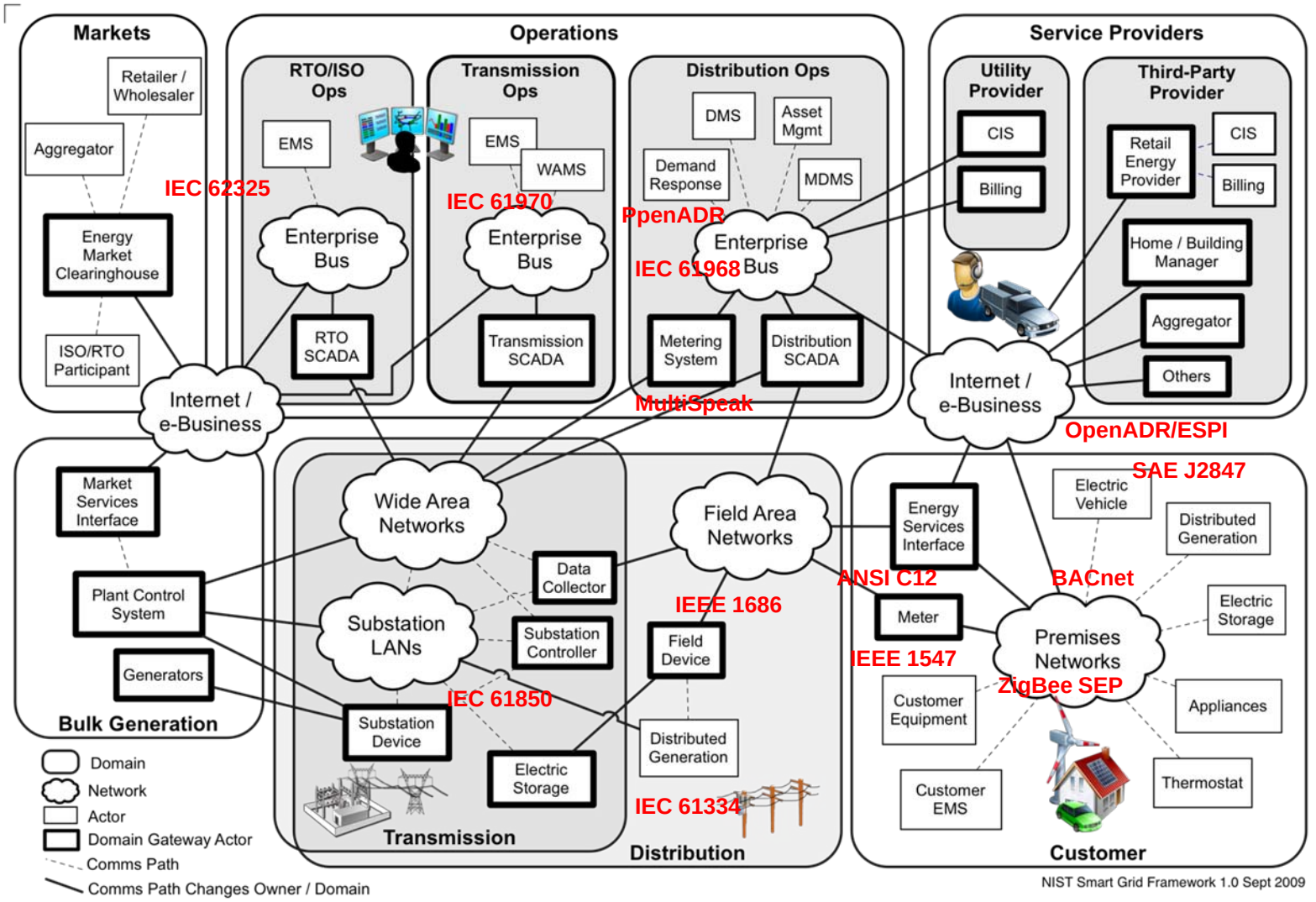


GWAC Stack and the CIM Standards

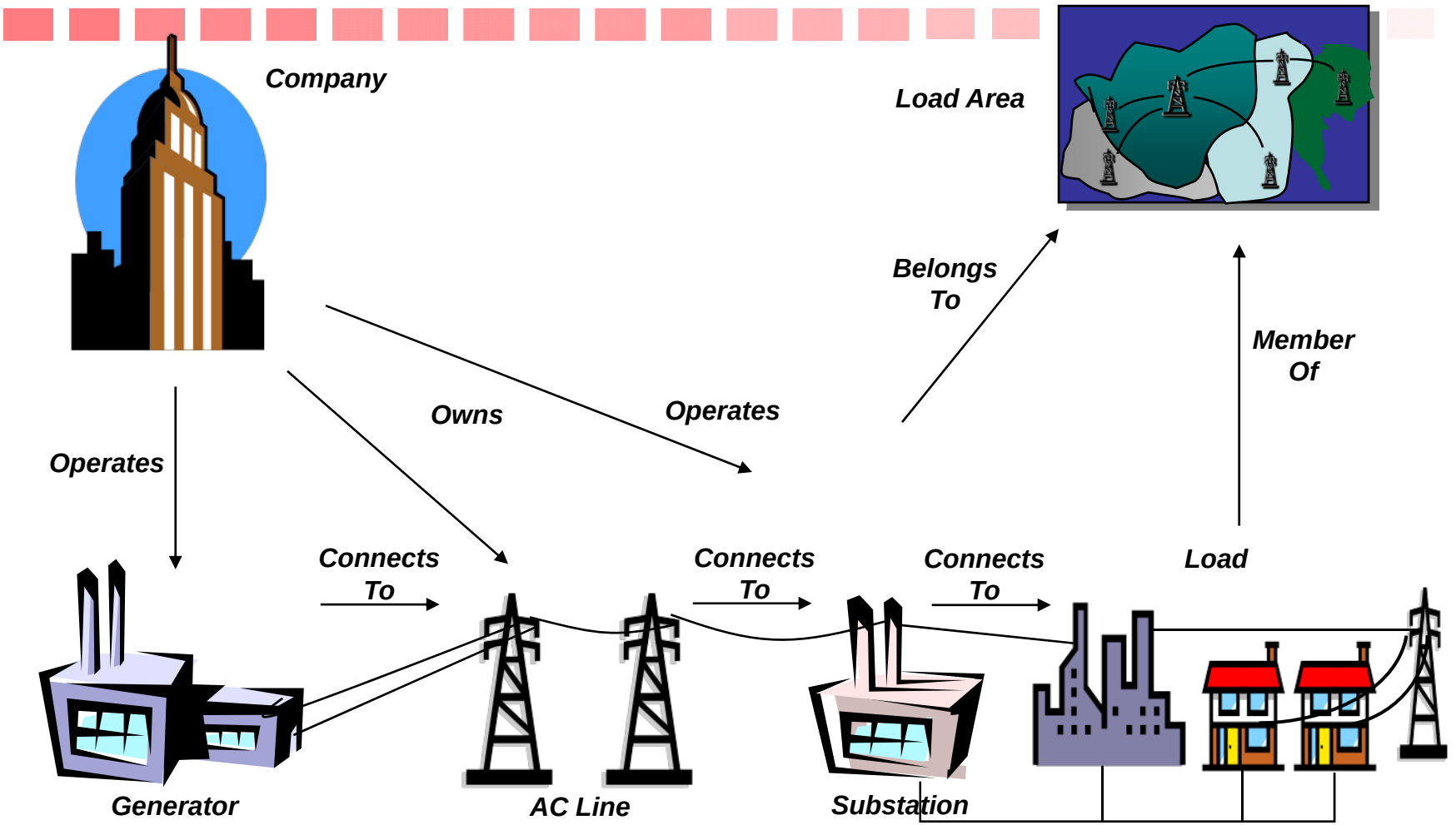
Interoperability Categories



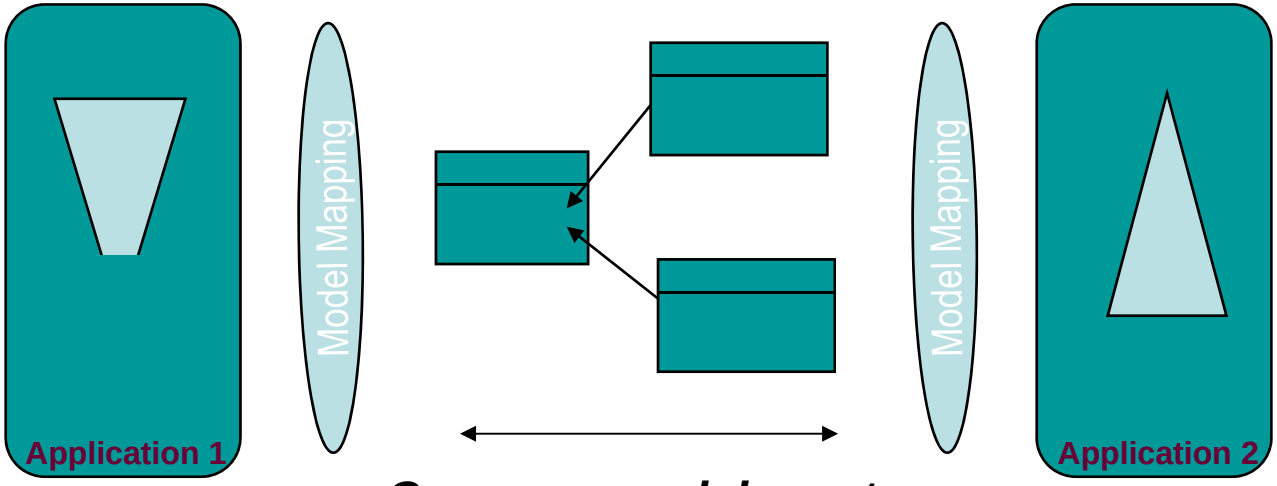
Smart Grid Conceptual Model – Diving Deeper



Sample Power System Model

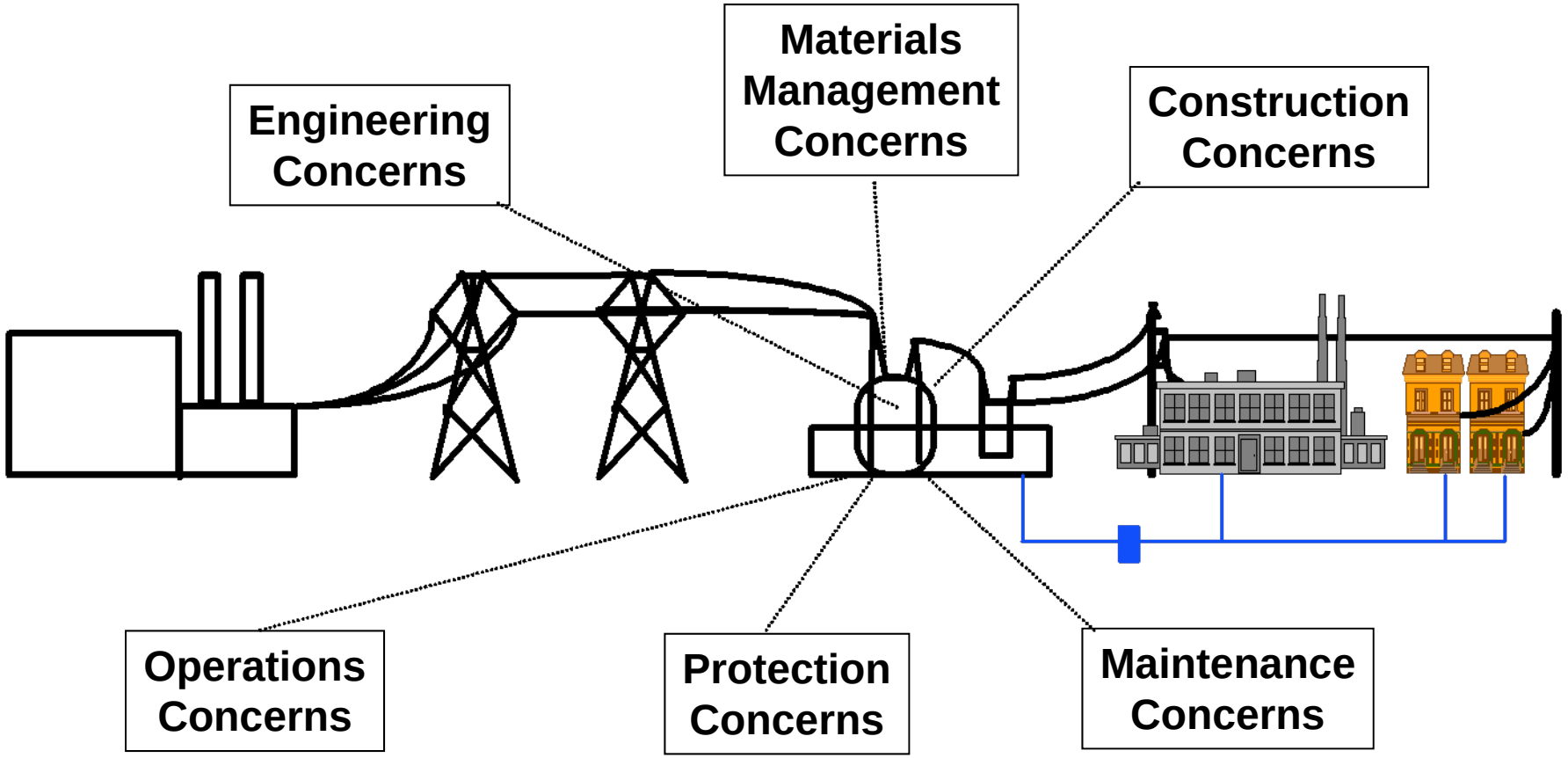


Application of Information Model



Common model creates understanding

The *Common Language* Should Provide Relevant Information To A User Regardless of Source



The Needs of Various Users – Some Same, Some Different

Engineering Concerns

The logical view of how the type of equipment fits (will fit) in the electrical network. Nominal configuration of "as-built" and "future" states.

- Field Name
- Spatial Location
- Version
- Physical Connectivity
- Load Projections
- Capacity Requirements
- Compatible Unit
- Equipment Ratings

Materials Management Concerns

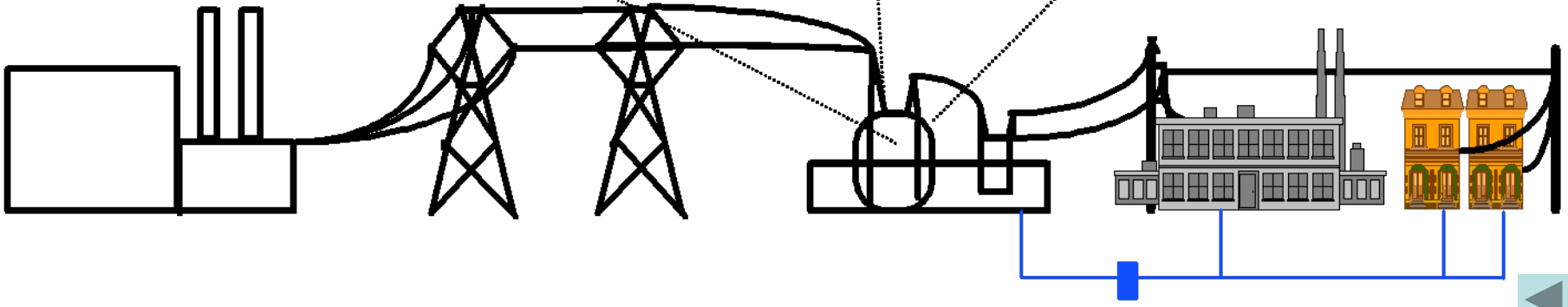
Planning and tracking material requirements for construction and maintenance. Information about physical pieces of equipment.

- Asset Identifier
- Compatible Unit
- Equipment Component Type
- Equipment Manufacturer/Model
- Serial Number
- Location
- Equipment Location History
- Manufacturer Specifications

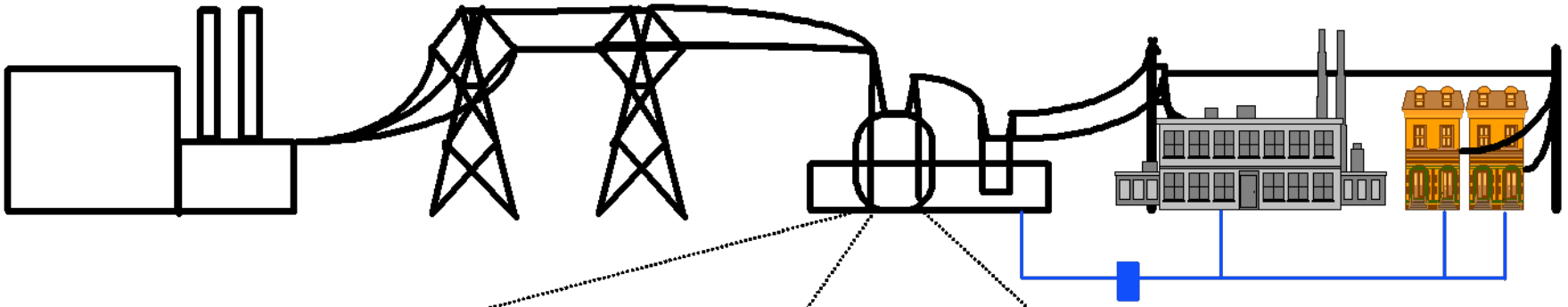
Construction Concerns

Lifecycle information regarding when and how to install equipment:

- Field Name
- Location
- Equipment Manufacturer/Model
- Compatible Unit
- Equipment Ratings
- Work Order
- Work Design
- Installation Schedule &Budget
- Permits
- Manufacturer Specifications
- Safety Requirements



The Needs of Various Users – Some Same, Some Different (continued)



Operations Concerns

Real-time condition of equipment and electrical network necessary to maintain reliable network operation:

- Field Name
- Schematics & Spatial Location
- Electrical Connectivity
- Operational Limits (dynamic)
- Equipment Status
- Clearances
- Network Measurements (voltage, current, frequency)
- Equipment Faults
- Weather Measurements
- Operational Restrictions

Protection Concerns

Setting and configuring relays based on equipment and network protection requirements:

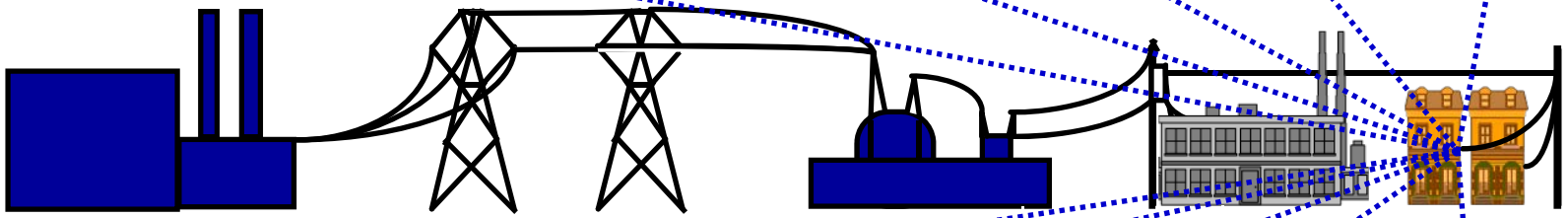
- Field Name
- Schematics
- Electrical Connectivity
- Maximum Capacity
- Zones Of Protection
- Equipment Status
- Clearances
- Network Measurements (voltage, current, frequency, transients)
- Equipment Faults

Maintenance Concerns

Lifecycle information regarding when and how equipment is maintained:

- Field Name
- Location
- Equipment Manufacturer/Model
- Equipment Ratings
- Routine Maintenance
- Testing & Diagnostics Procedures
- Equipment Condition
- Inspection Schedule
- Equipment Repair Records
- Site Service Records
- Maintenance Budget
- Safety Requirements

Exchanging Common Language Messages Among Systems Should Provide Relevant Information To Each System That Is *Harmonious* With All *Other Systems' Information*



Service Connection Request
Blah, Blah, Blah,
Organization,
Blah, Blah, Blah

Work
Blah, Blah, Blah,
Organization,
Blah, Blah, Blah

Asset Catalog
Blah, Blah, Blah,
Organization,
Blah, Blah, Blah

Planned Outage
Blah, Blah, Blah,
Organization,
Blah, Blah, Blah

Crew
Blah, Blah, Blah,
Organization,
Blah, Blah, Blah

Maintenance
Blah, Blah, Blah,
Organization,
Blah, Blah, Blah

Switching Schedule
Blah, Blah, Blah,
Organization,
Blah, Blah, Blah

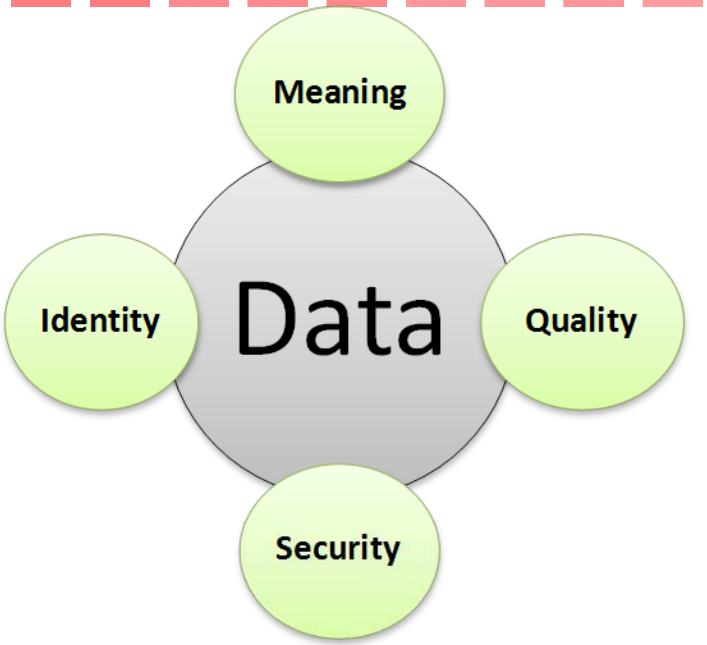
Meter Reading
Blah, Blah, Blah,
Organization,
Blah, Blah, Blah

Load Data Set
Blah, Blah, Blah,
Organization,
Blah, Blah, Blah

Load Control
Blah, Blah, Blah,
Organization,
Blah, Blah, Blah

For example, in each of the message exchanges depicted above, the same Organization is referenced for different reasons. There should be NO inconsistencies about this Organization in them!

Smart Data is Key to Enabling Adaptive Smart Grid Systems



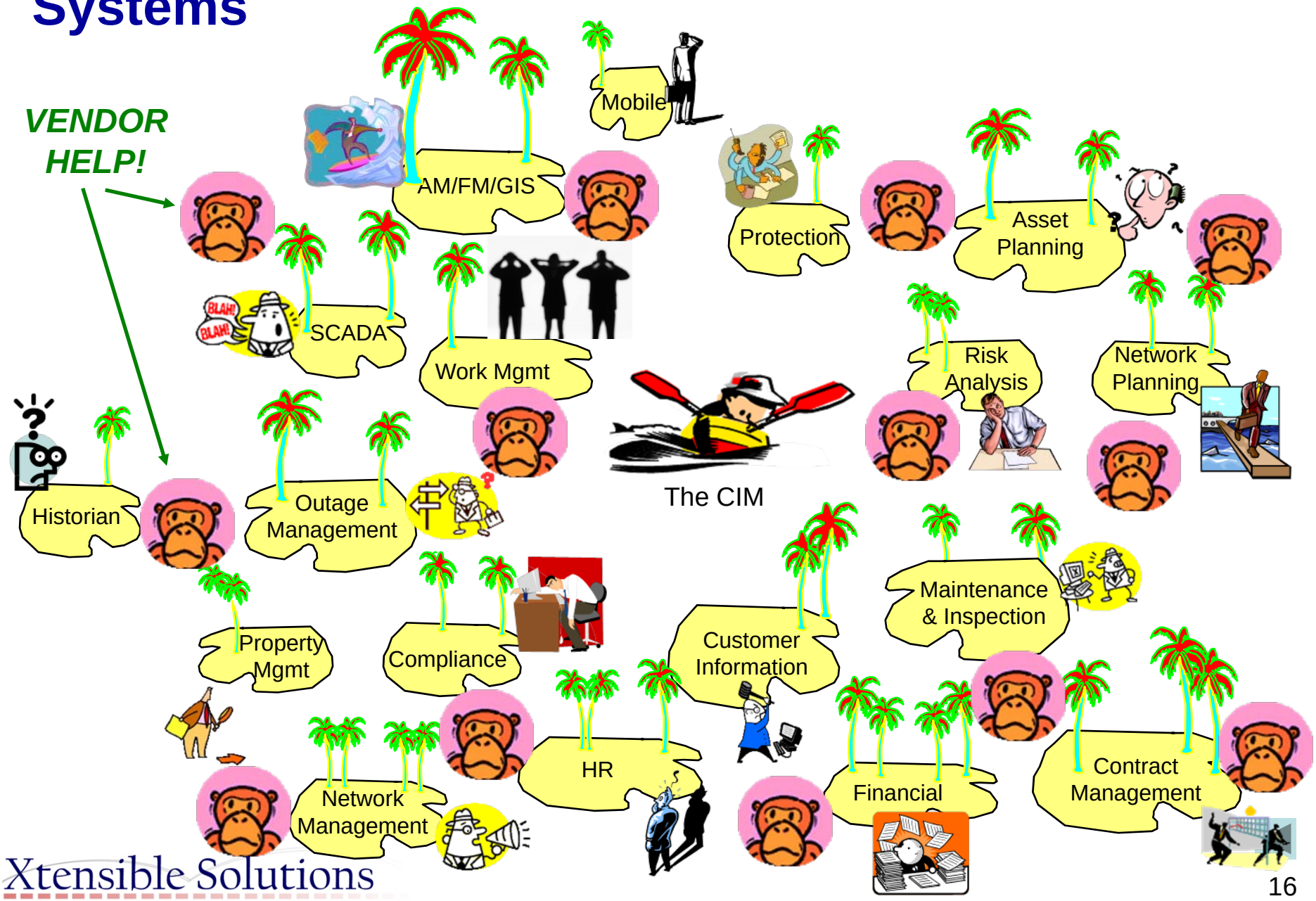
Enables

- Secure and open 3rd party data sharing
- Standards-based data integration and analytics
- Single view of customers, assets, suppliers, and work

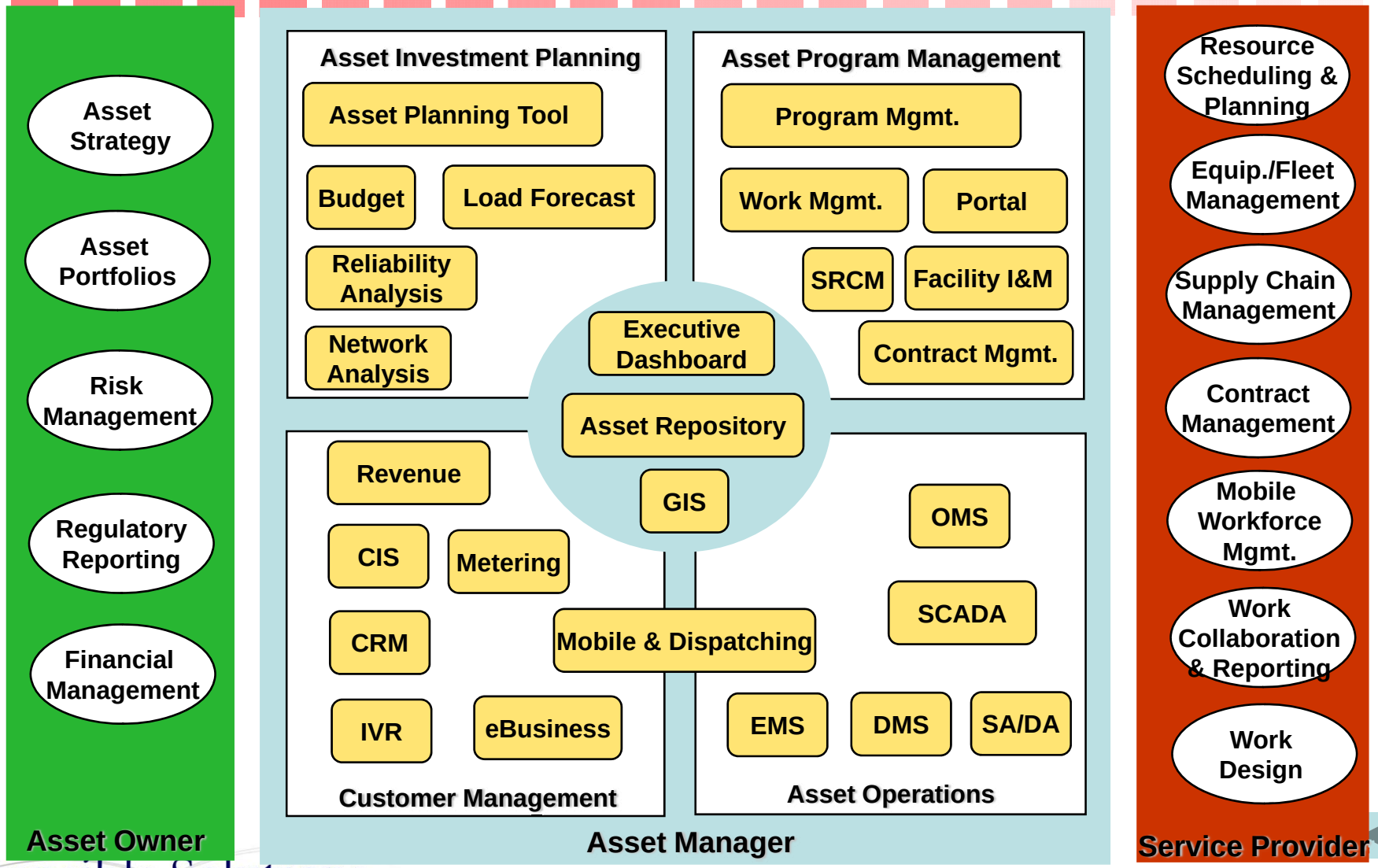
Smart Grid Building Blocks

Only when the data is enriched with consistent meaning, identity, quality and security can it be used to support the future Smart Grid needs.

Information is Needed From Many Individual Systems

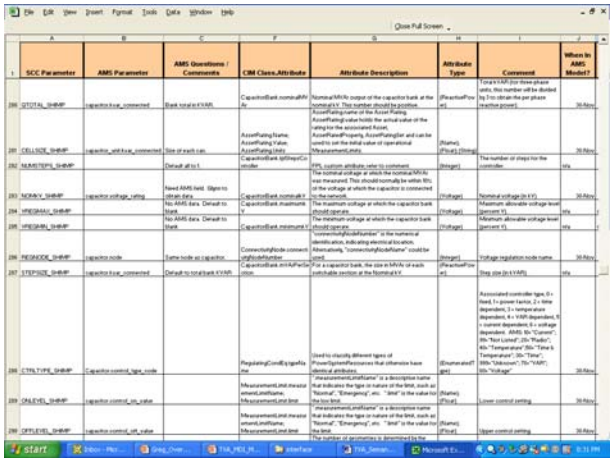


For example, a common language-based logical infrastructure facilitates collaboration among the many applications involved in Asset Management



Application To Common Language Mapping – The Typical Field to Field Process Is Cumbersome

- Individual fields of data models from data sources are mapped to each other
- Approach does not scale well as the number of maps grows exponentially with each new data source
- Mapping is a challenge as ‘mappers’ must have an in depth understanding of all relevant data sources – a tall order!



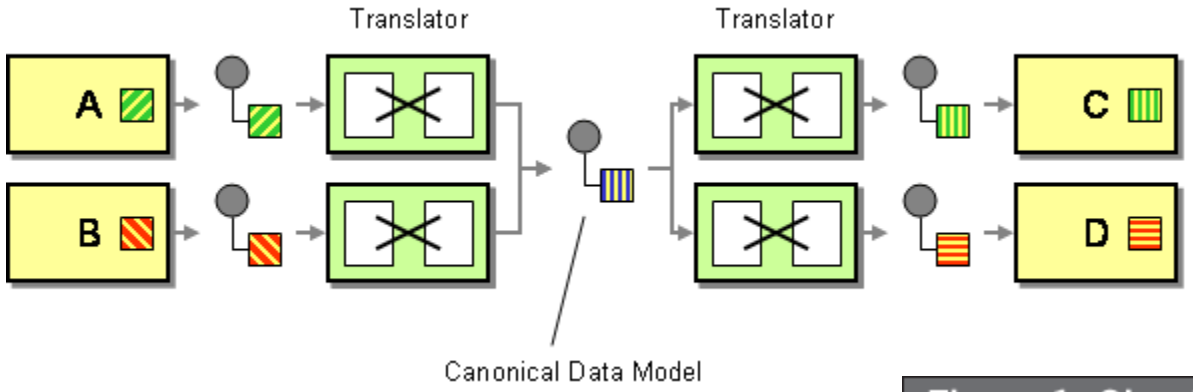
Using A Semantic Model To Simplify & Scale Up The Mapping Process

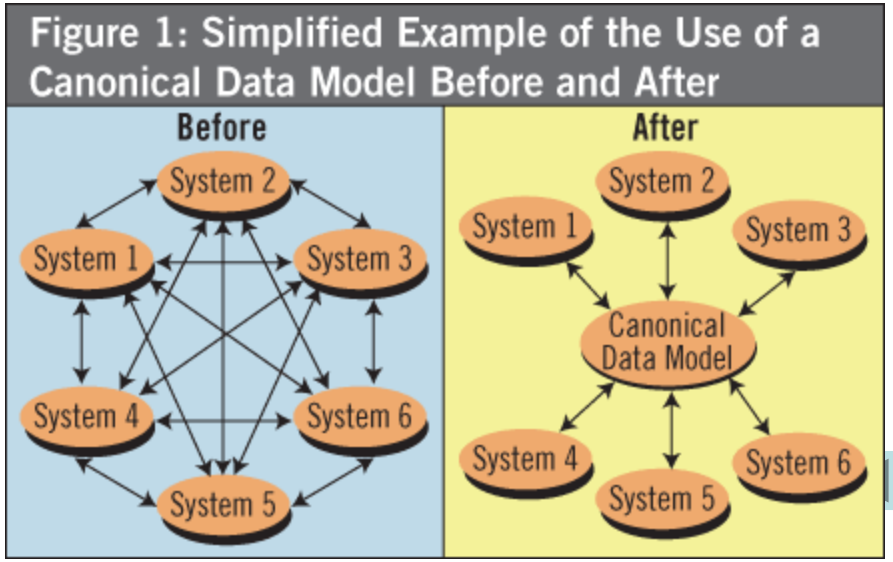
- What is a Semantic Model?
  - The key ingredients that make up a semantic model are a vocabulary of basic terms, a precise specification of what those terms mean and how they relate to each other.
- How is it used?
  - Before making mappings, a model (or an ontology) of a given business domain is defined.
  - The model is expressed in a knowledge representation language and it contains business concepts, relationships between them and a set of rules.
  - By organizing knowledge in a discrete layer for use by information systems, semantic models enable communication between computer systems in a way that is independent of the individual system technologies, information architectures and applications.
  - Compared to one-to-one mappings, mapping data sources to a common semantic model offer a much more scaleable and maintainable way to manage and integrate enterprise data.

[source: TopQuadrant Technology Briefing, July 2003]

The CIM is a *Canonical Data Model* (CDM)

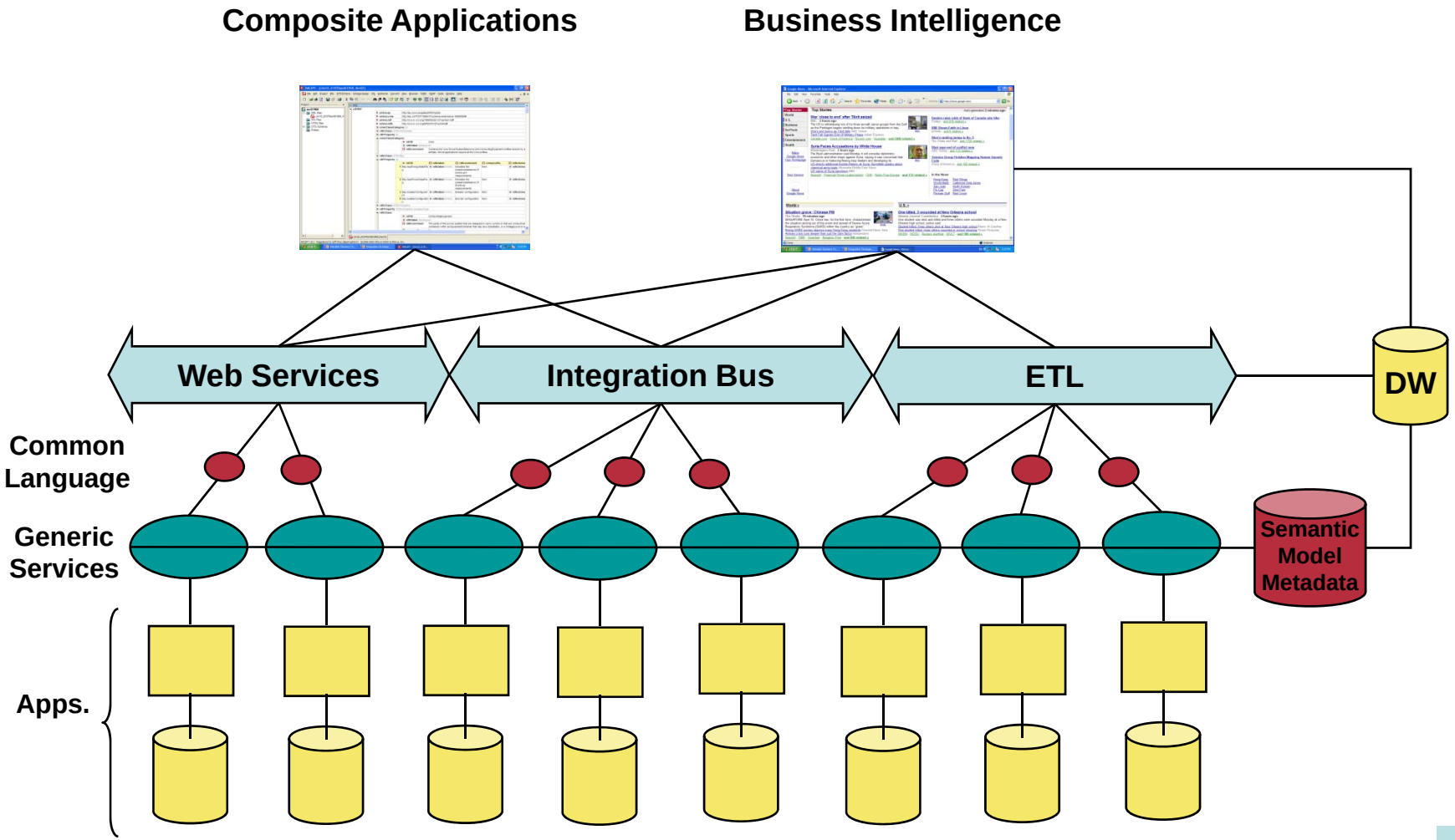
A CDM is a semantic model chosen as a *unifying* model to govern a collection of interface specifications



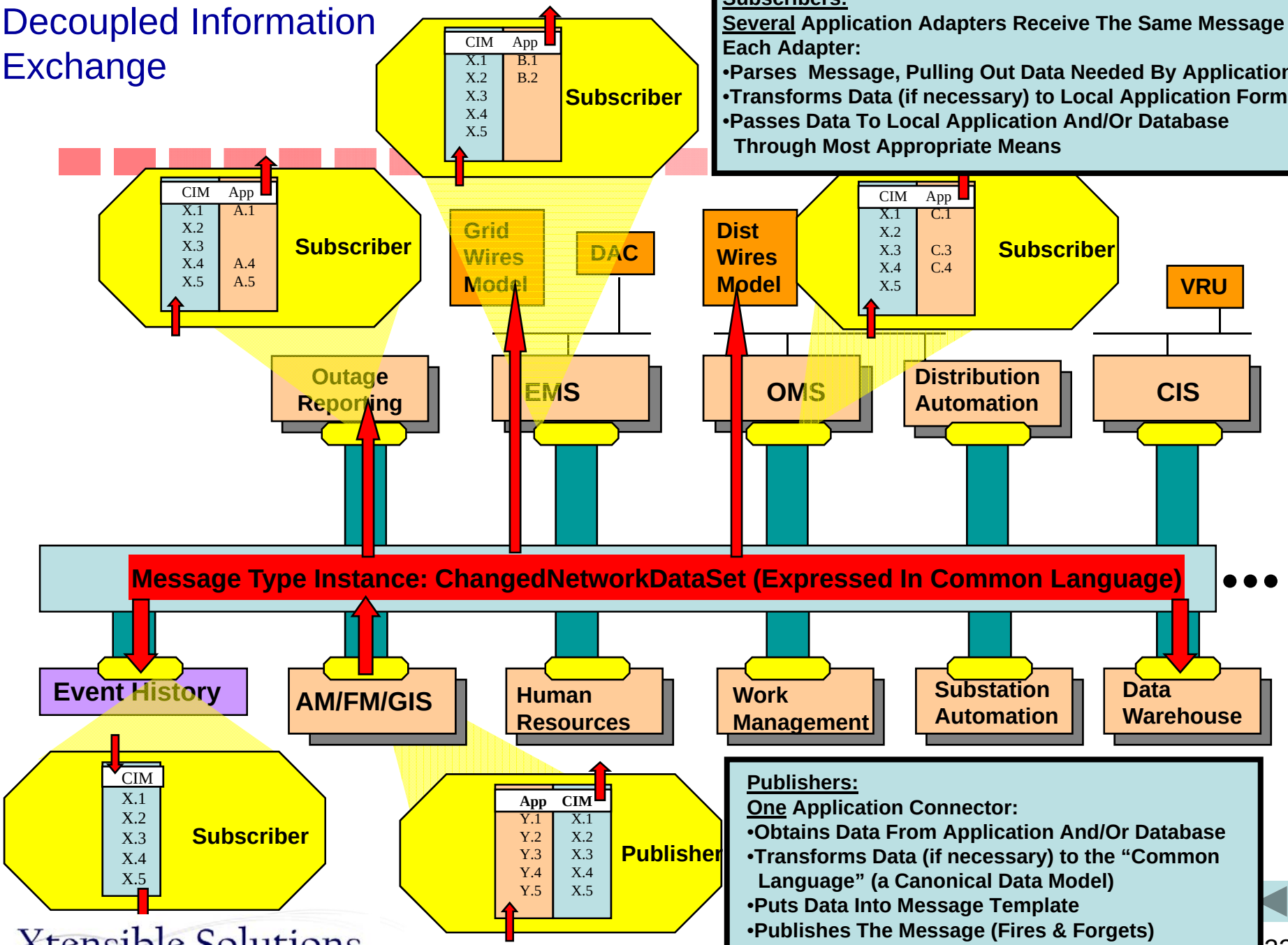


Provided by Jay Britton

The CIM Provides a Semantic Layer in an Enterprise Architecture



Decoupled Information Exchange



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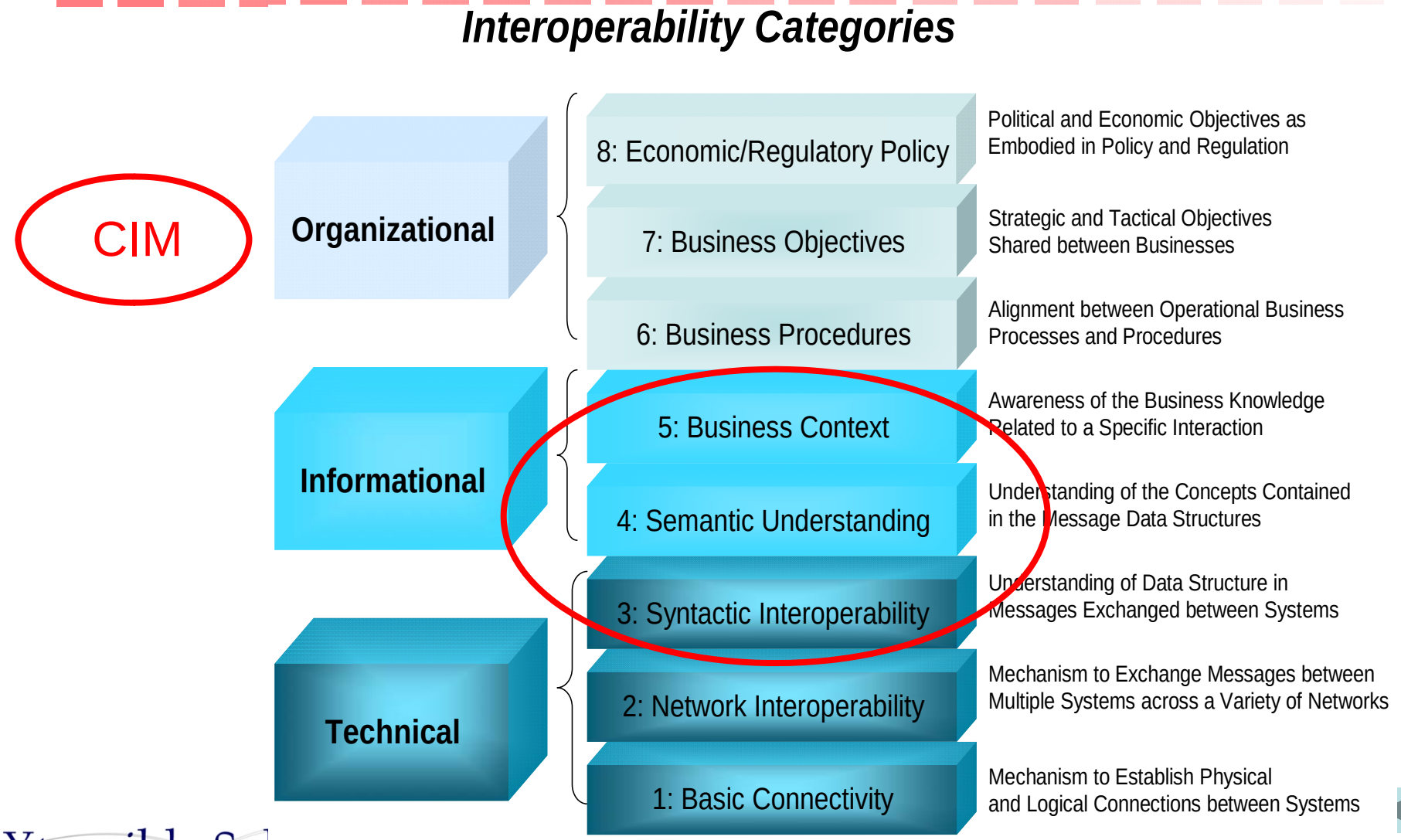
The CIM and Related Standards

- The CIM standards are more than just an abstract **information model** (or CDM) expressed in UML
- **Profiles** for specifying a subset of the CIM classes and attributes for a specific business context at a specific system interface or system interaction
- **Implementation models**
  - Use of XML to create serialized files and messages
    - RDF Schema-based standards for power system model exchange
    - XML Schema-based standards for information message payloads
  - ETL based on CIM for data base access
    - DDLs for data tables

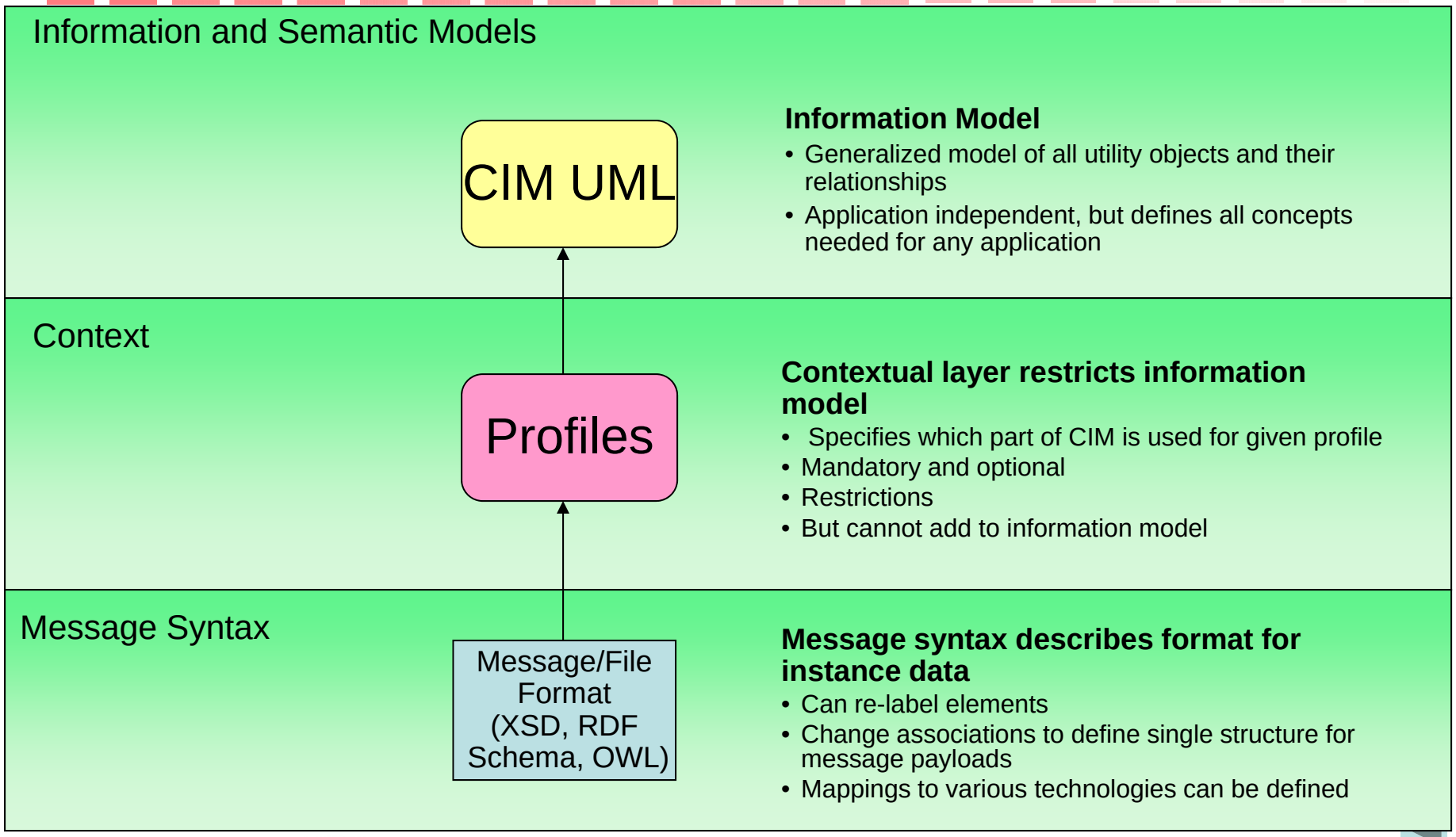
We Need An Organizing Framework

- Layered Reference Architecture for TC57
  - See 62357-1: Reference Architecture for Power System Information Exchange, Second Edition
- Based on UN/CEFACT
  - Information Model
  - Contextual Model
  - Message Syntax
    - Rules for Message Assembly

GWAC Stack – Not an IT Architecture for the CIM Standards

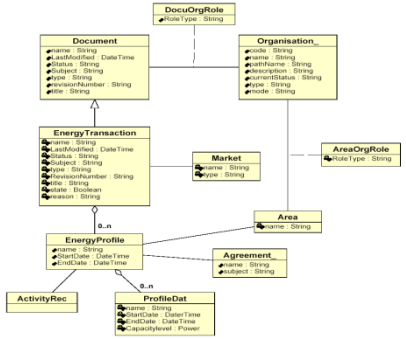


CIM Layered Architecture

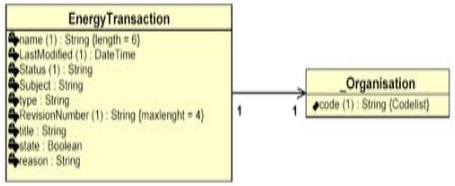


From Information Model to Syntactic Model

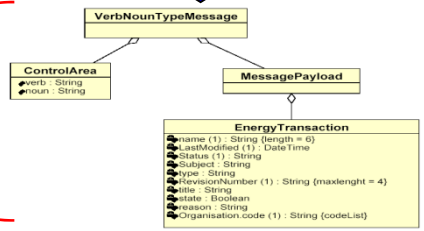
•Information Semantic Model



•Context/ Profiles



•Message Assembly



•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>
```

•Abstract •Model

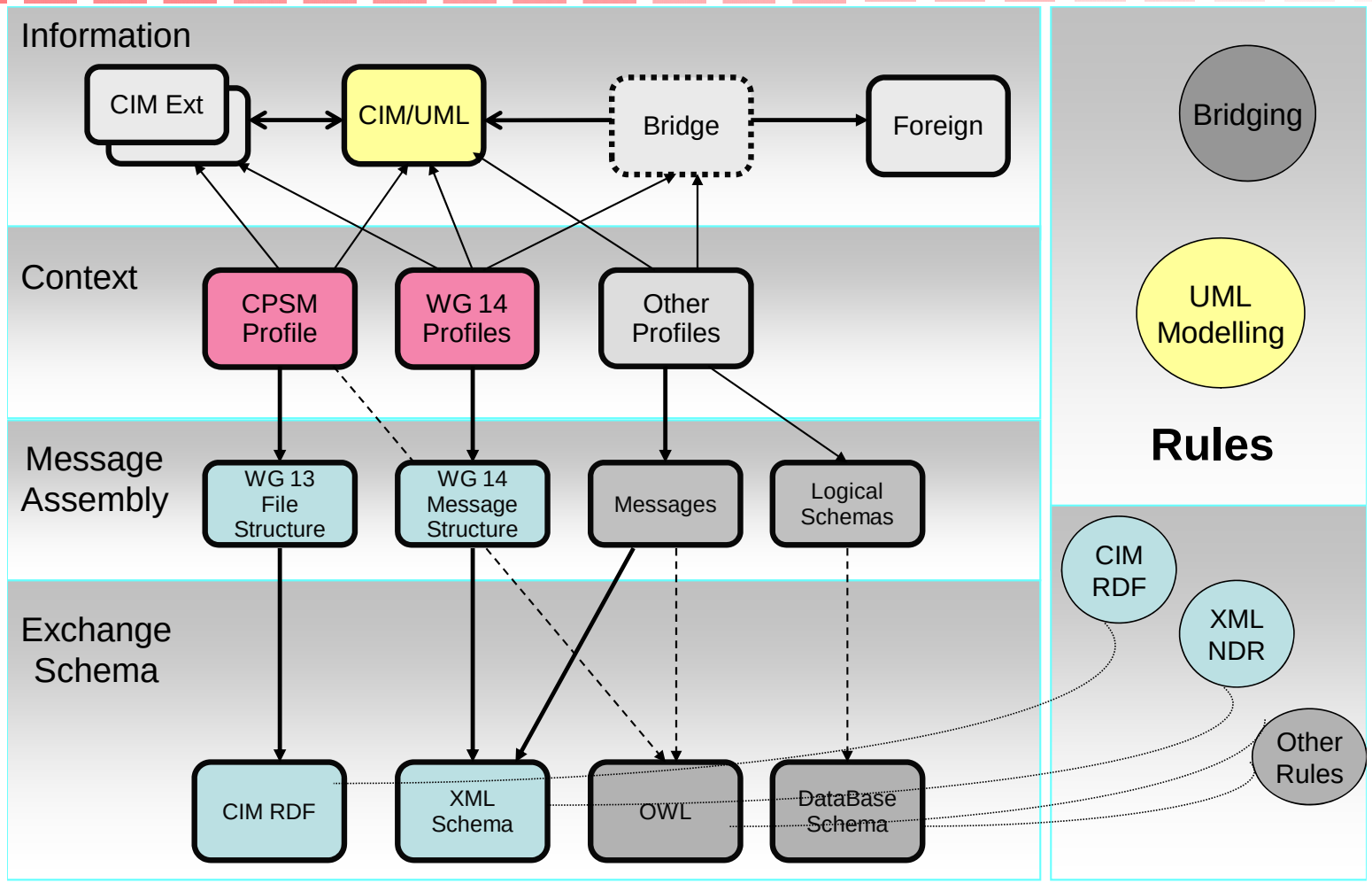
•Syntactic •Model

UML World

XML Syntactic World

Xtensible Solutions

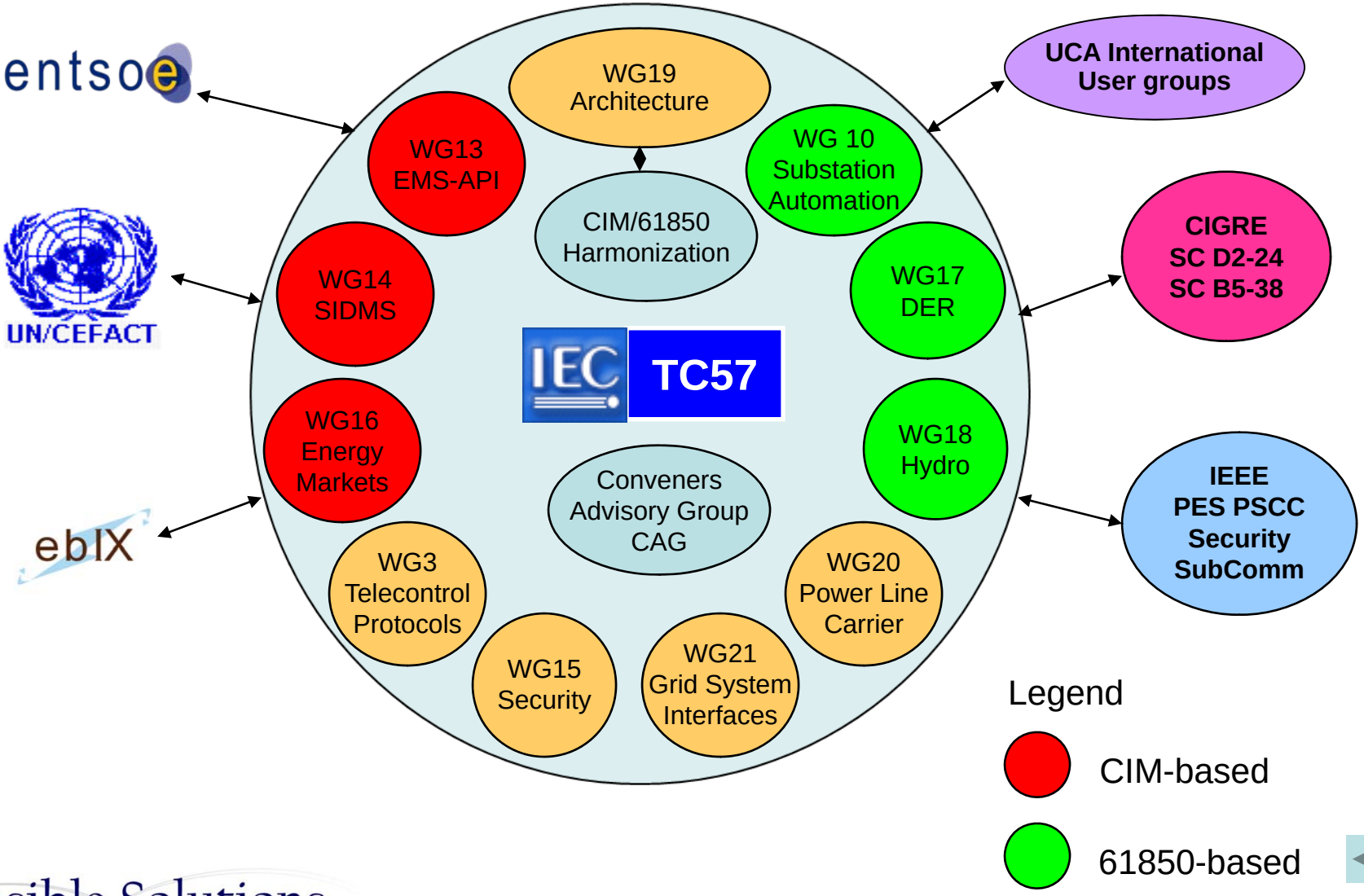
Layered Architecture for CIM Standards



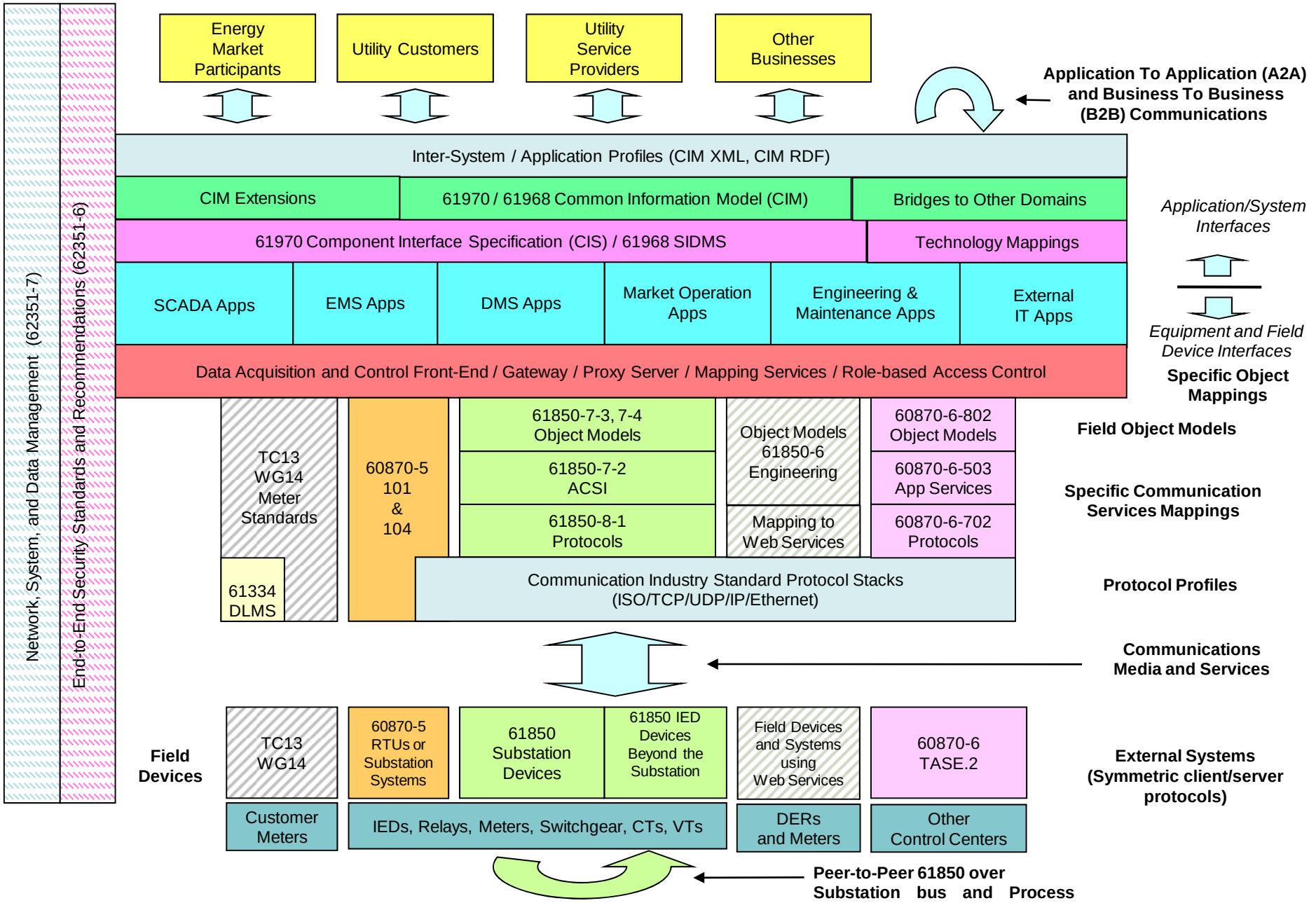
To Summarize

- The CIM is an abstract **information model** standard expressed in UML.
- **Profiles** specifying a subset of the CIM classes and attributes for specific business context
- **Implementation technologies**, such as use of XML to create serialized files and messages
  - Standards for power system models
  - Standards for information message payloads
- Also, the CIM UML can be extended
  - Standard extensions for new functional areas
  - Private extensions for specific utility requirements

•TC 57 Organization and Formal Liaisons

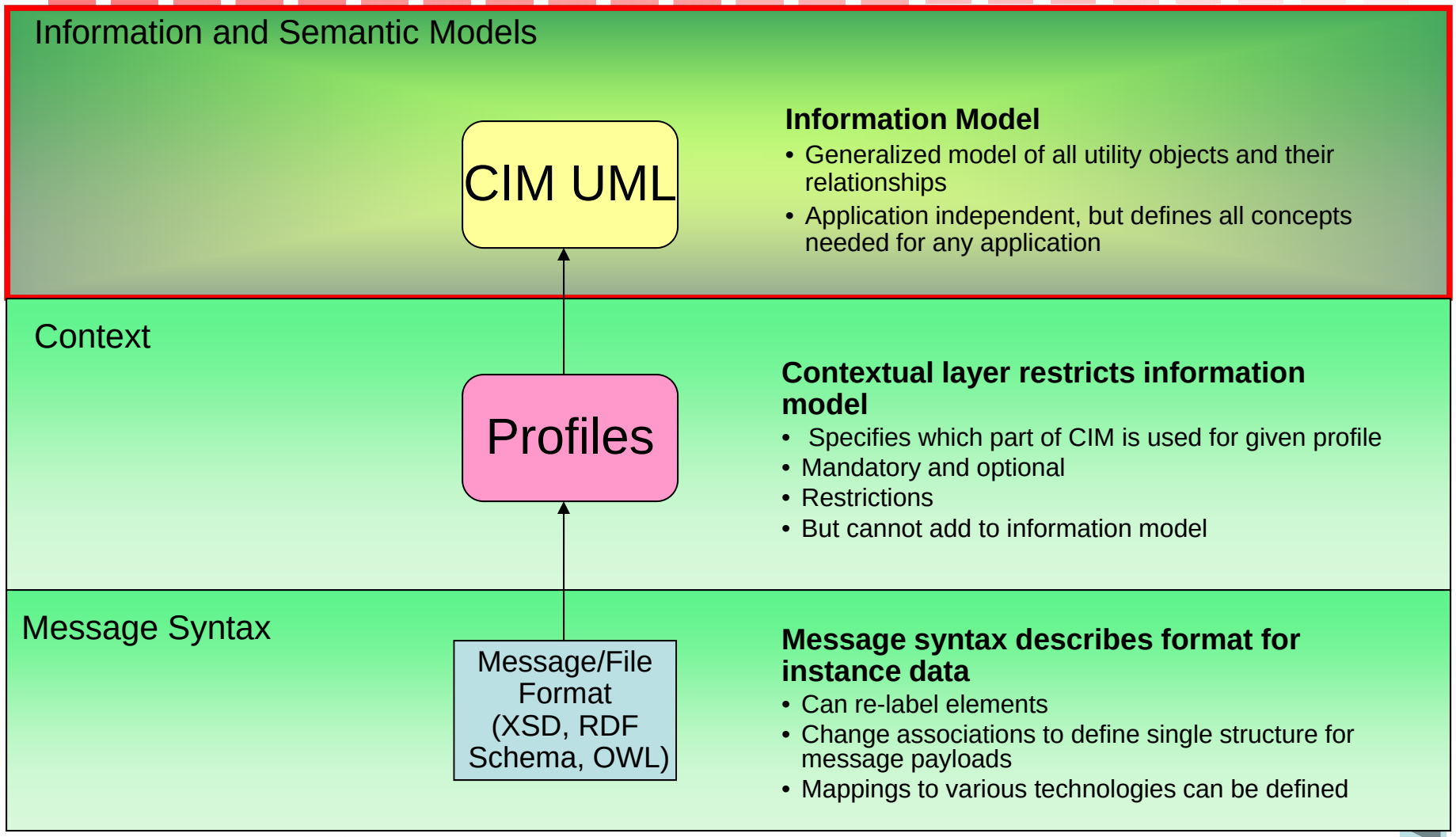


IEC TC57 - Reference Architecture for Power System Information Exchange

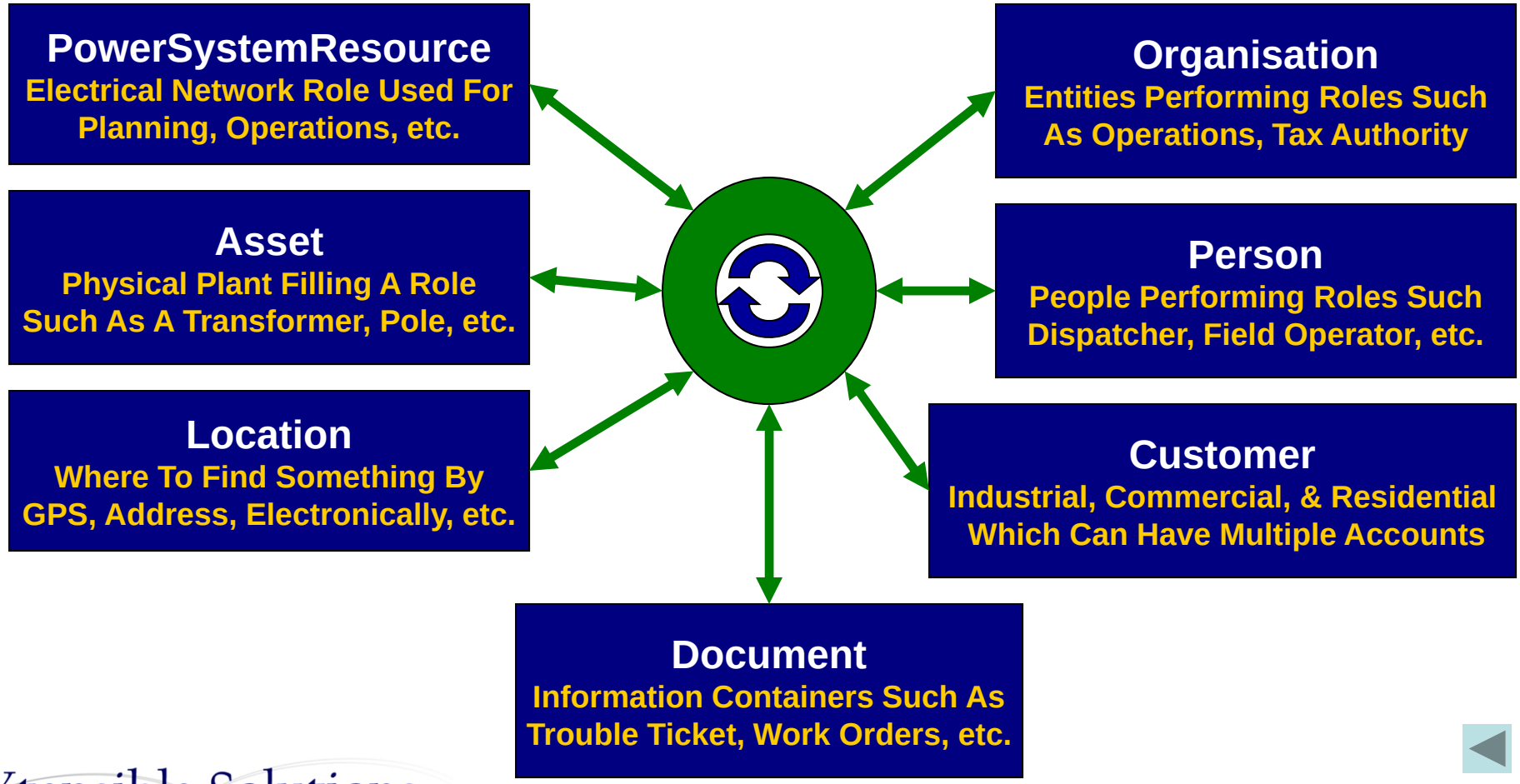


*Notes: 1) Solid colors correlate different parts of protocols within the architecture.
2) Non-solid patterns represent areas that are future work, or work in progress, or related work provided by another IEC TC.

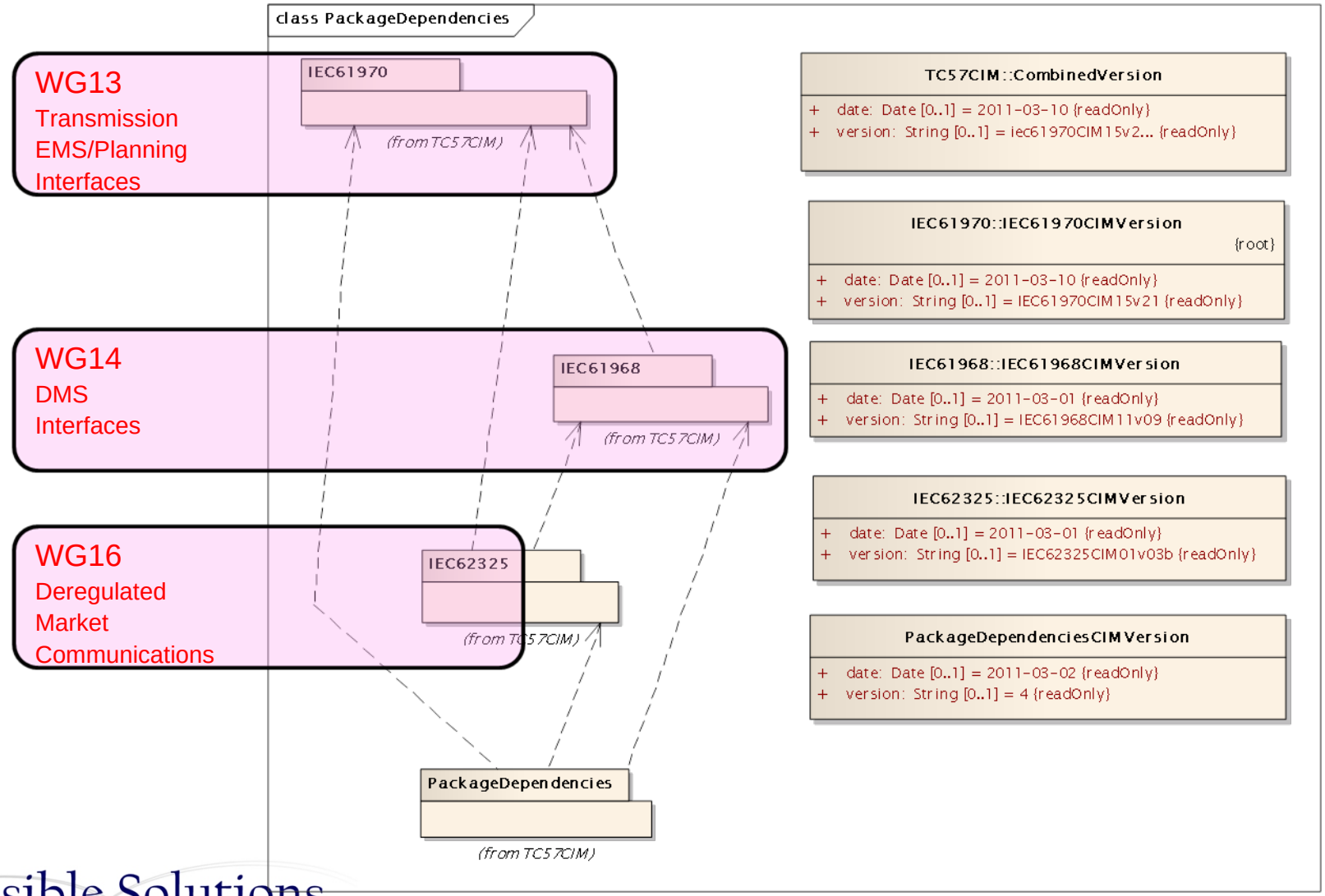
Let's look at each layer of the CIM standards



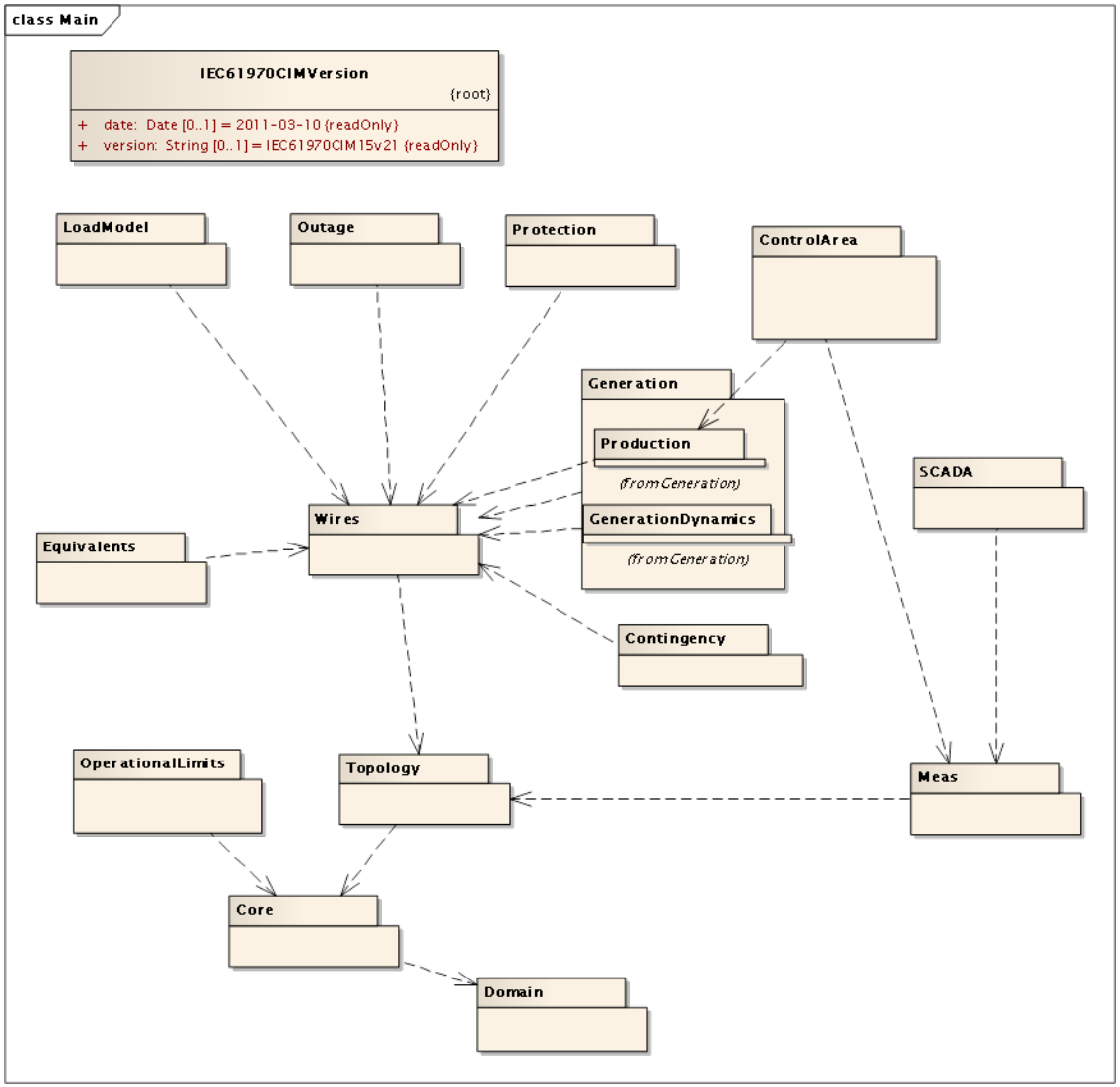
Foundational Relationships Of The CIM



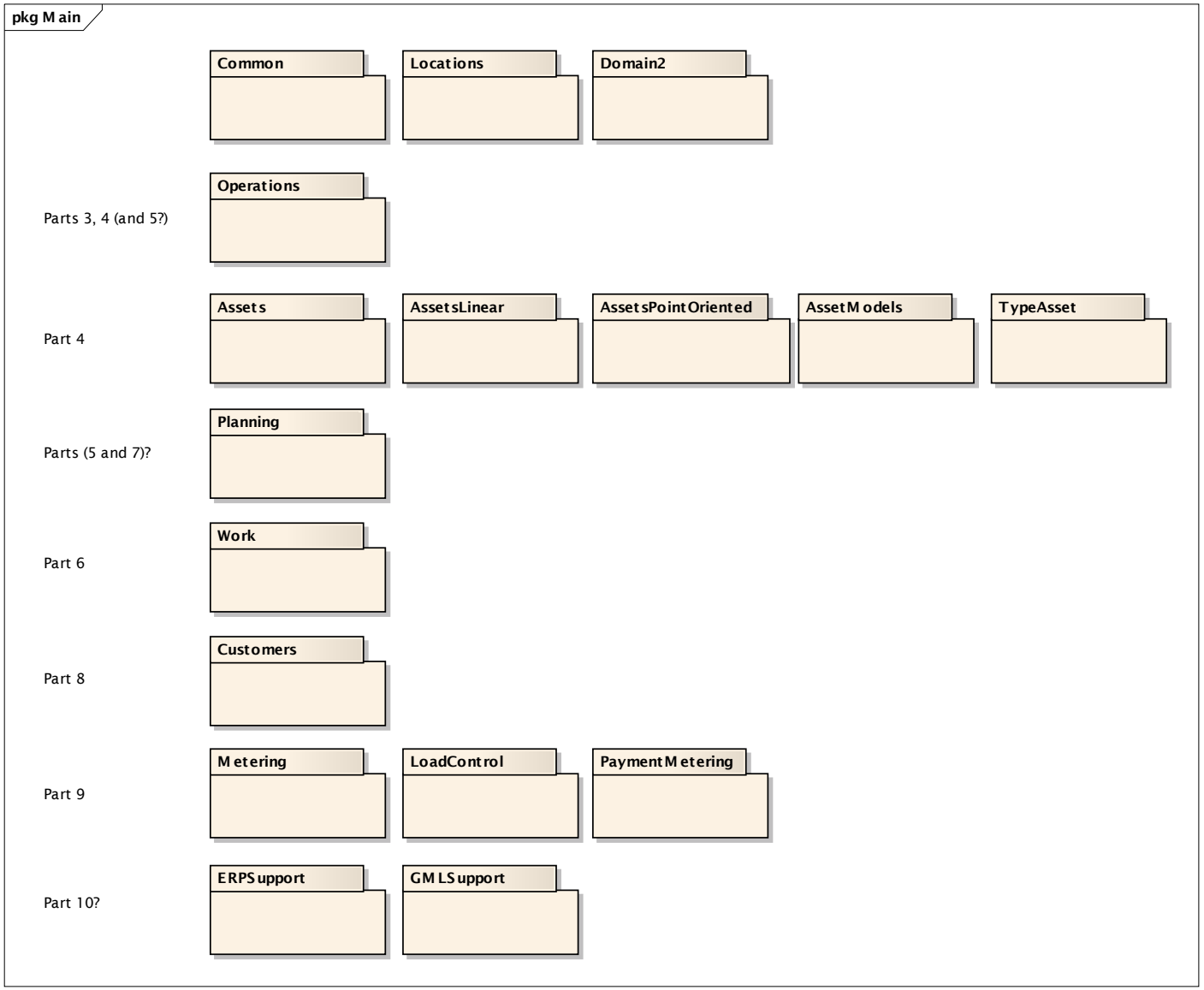
IEC TC57 CIM Packages



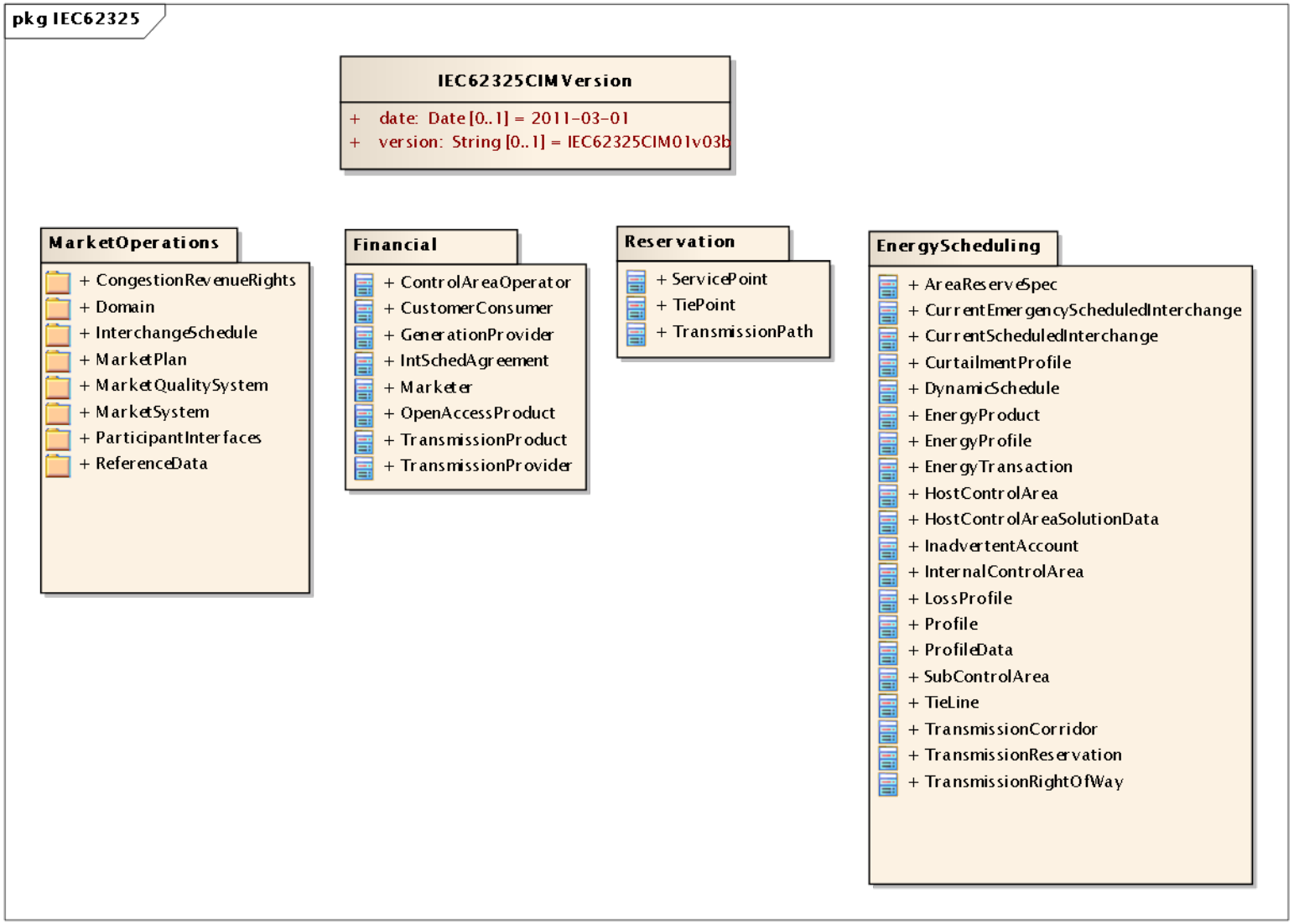
WG13 CIM Packages - 61970



WG14 CIM Packages - 61968



WG16 CIM Market Extensions



CIM UML Release Cycles

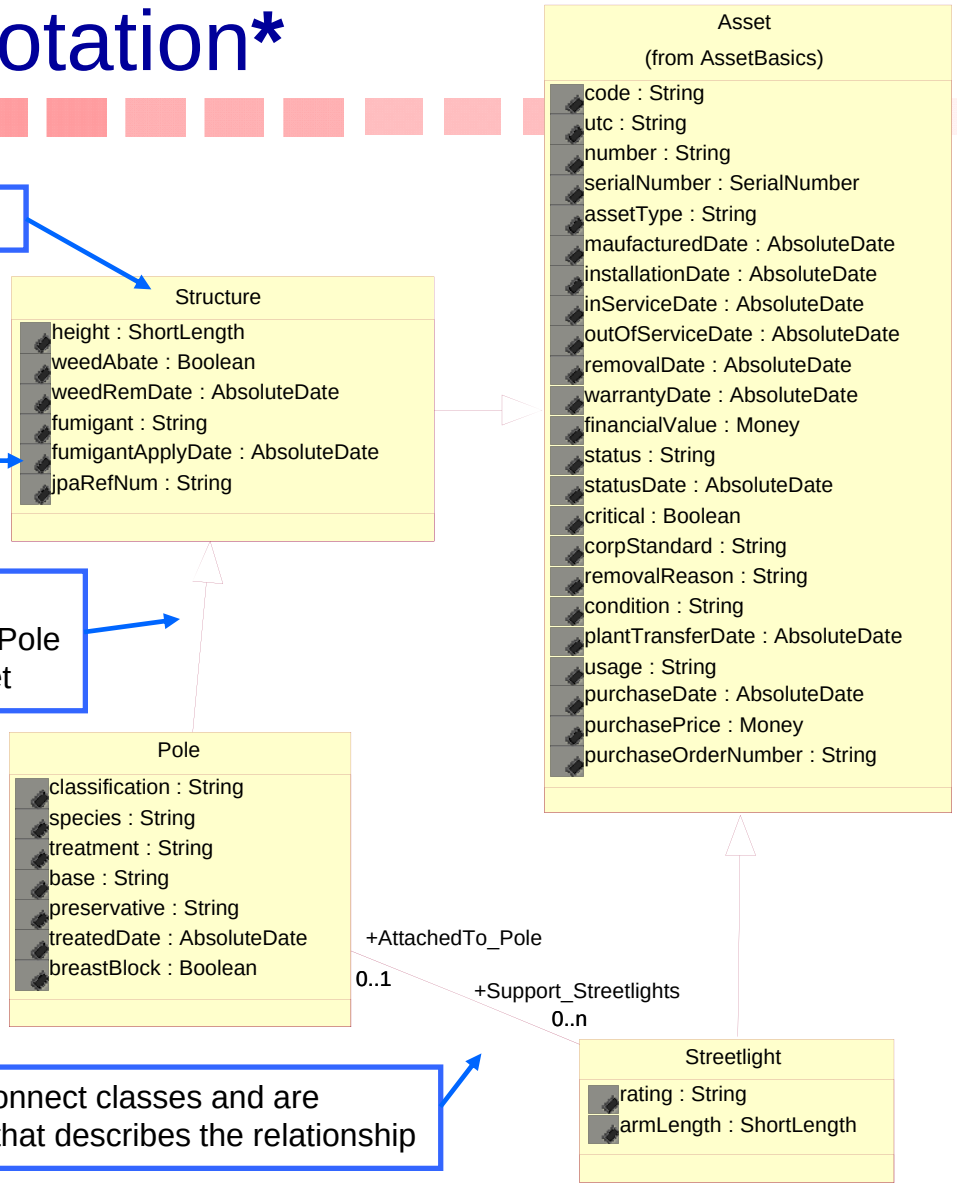
- 61970 CIM UML has annual release cycle
  - Current official annual release is IEC61970CIM14v13
  - Basis for IEC 61970-301 CIM Base Fourth Edition
    - Word document auto-generated from the UML electronic model
  - Information system and Profile documents are synchronized with UML model release
- 61968 CIM UML different update cycles
  - Basis for IEC 61968-11 CIM Distribution Information Exchange Model
- 62325 CIM UML on another update cycle
  - Basis for IEC 62325-301 CIM for Deregulated Markets
- Complete CIM UML available as a combined model on CIMug Sharepoint site: iec61970cim14v13_iec61968cim10v28_combined

The CIM Is Expressed In Unified Modeling Language (UML) Notation*

Class Name usually describes things in the real world

Class Attributes describe significant aspects about the thing

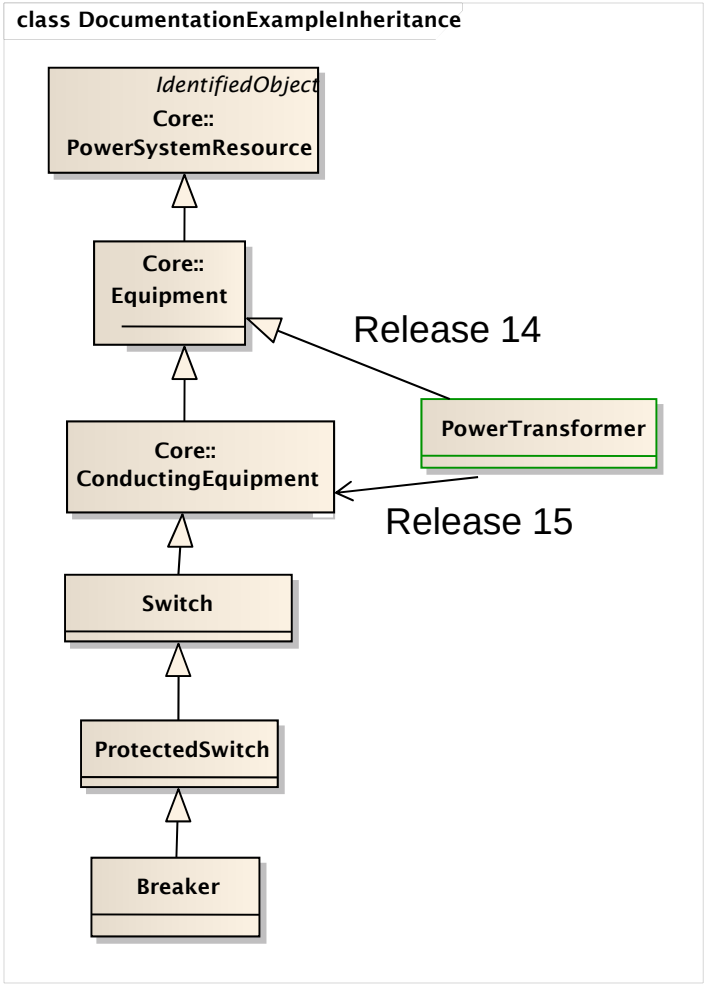
This **Specialization** indicates that a “Pole” is a type of “Structure.” Since a “Structure” is a type of “Asset,” the Pole inherits all of the attributes from both Structure and Asset



* For more information on UML notation (a standard), refer to Martin Fowler’s book “UML Distilled,” Addison-Wesley

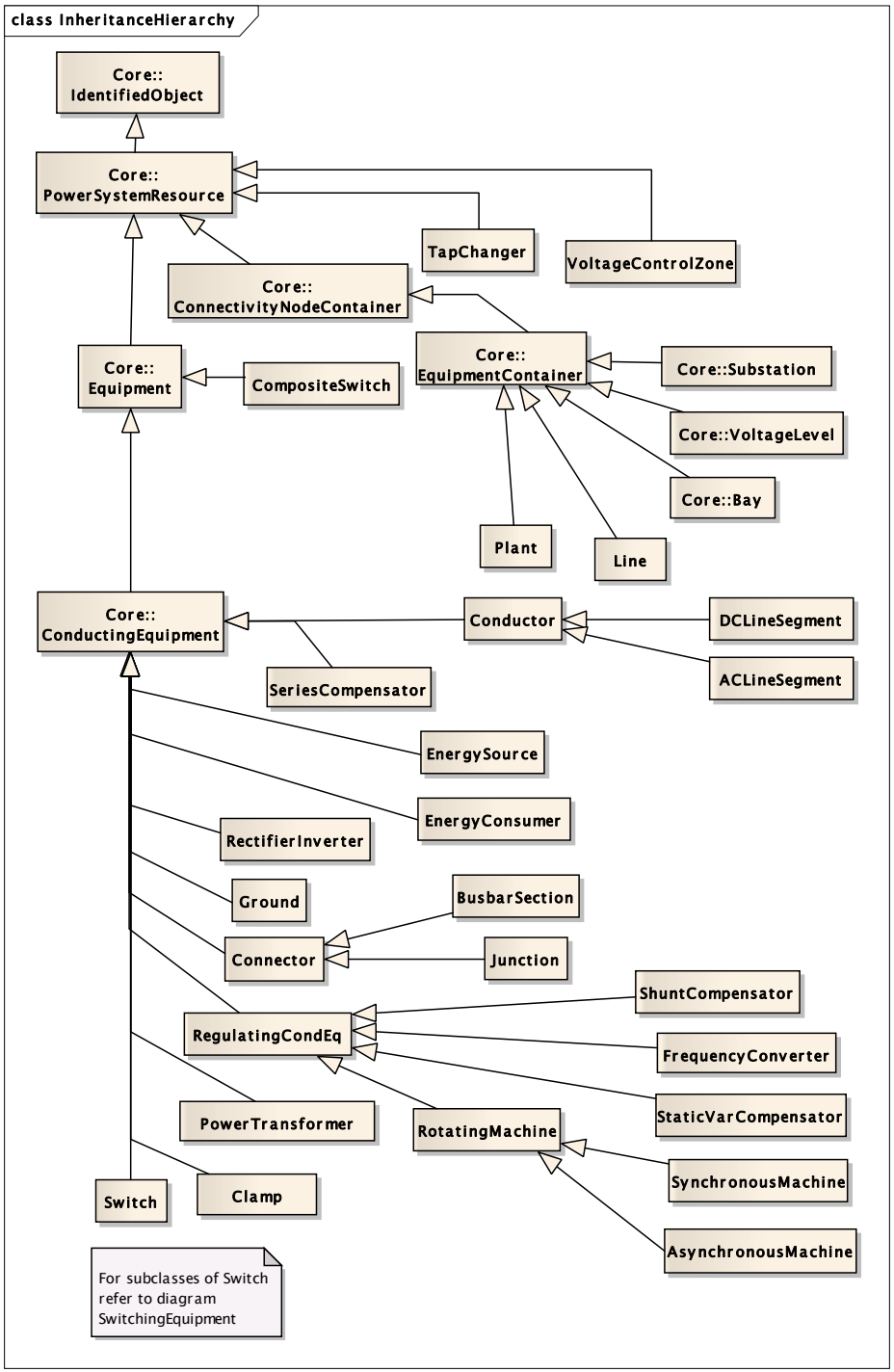
Associations connect classes and are assigned a role that describes the relationship

Concepts: Generalization/Inheritance

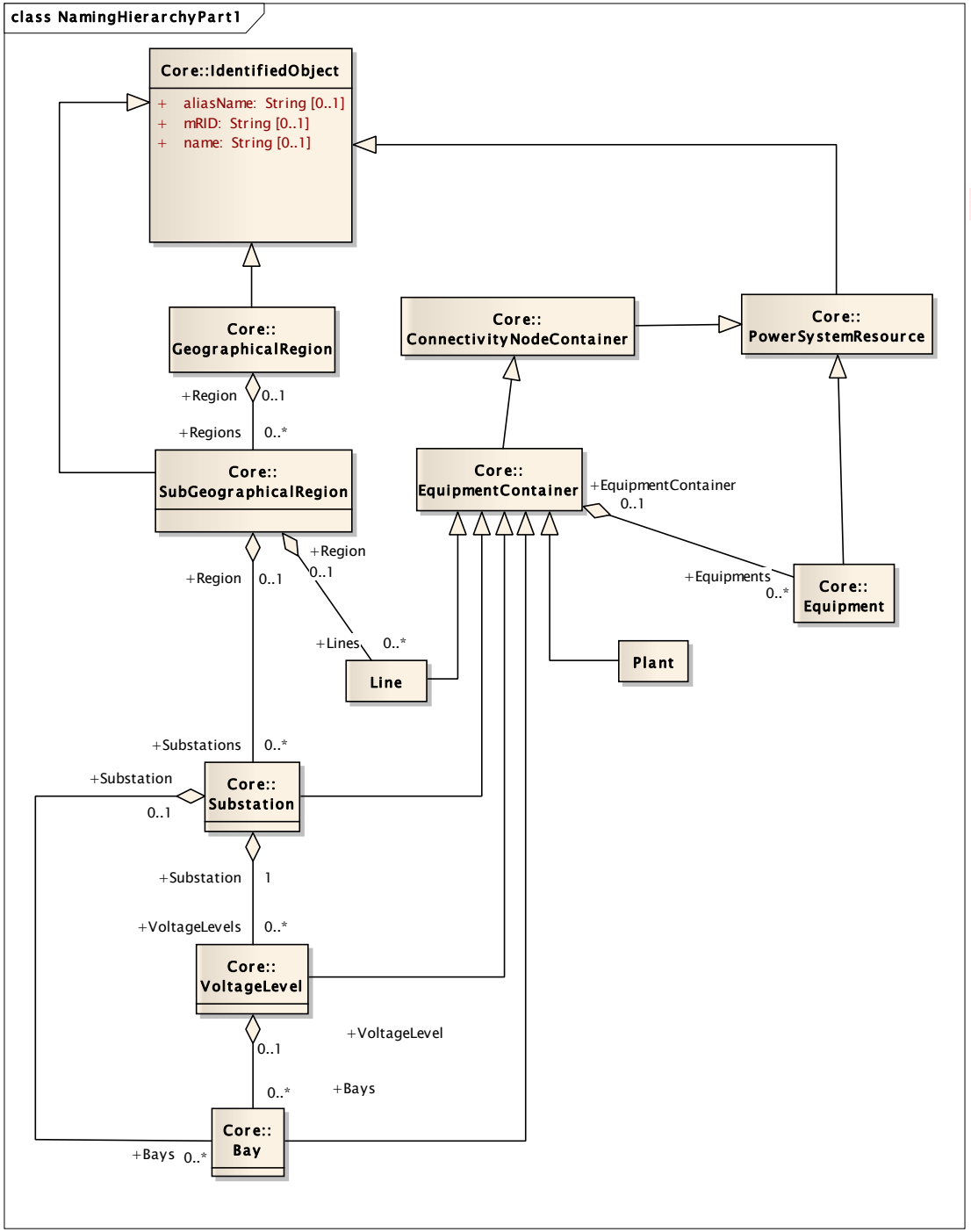


- Breaker: Specialization of ProtectedSwitch
- ProtectedSwitch: Specialization of Switch
- Switch: Specialization of Conducting Equipment
- ConductingEquipment: Specialization of Equipment
- Equipment: Specialization of PowerSystem Resource

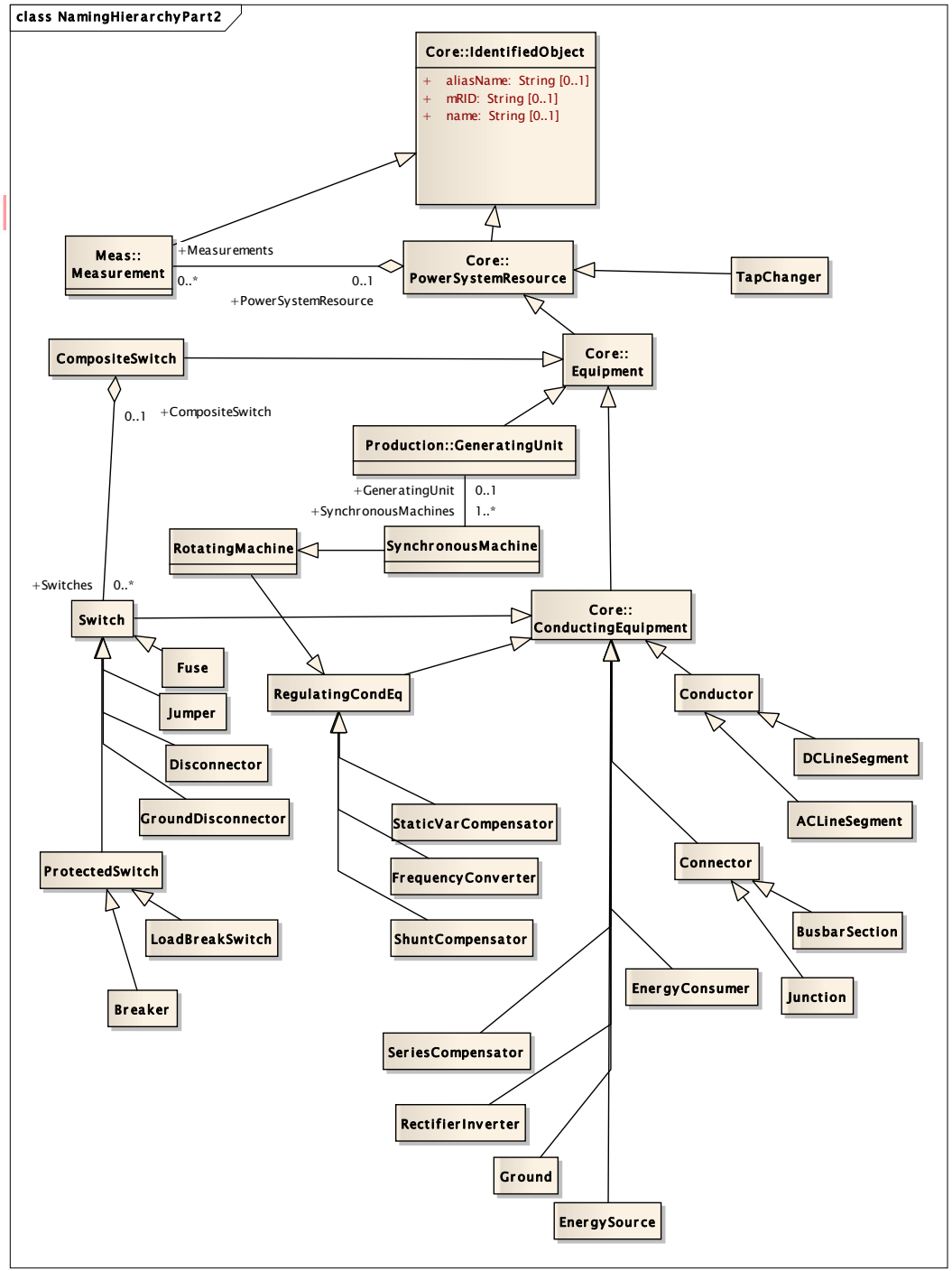
Equipment Inheritance Hierarchy



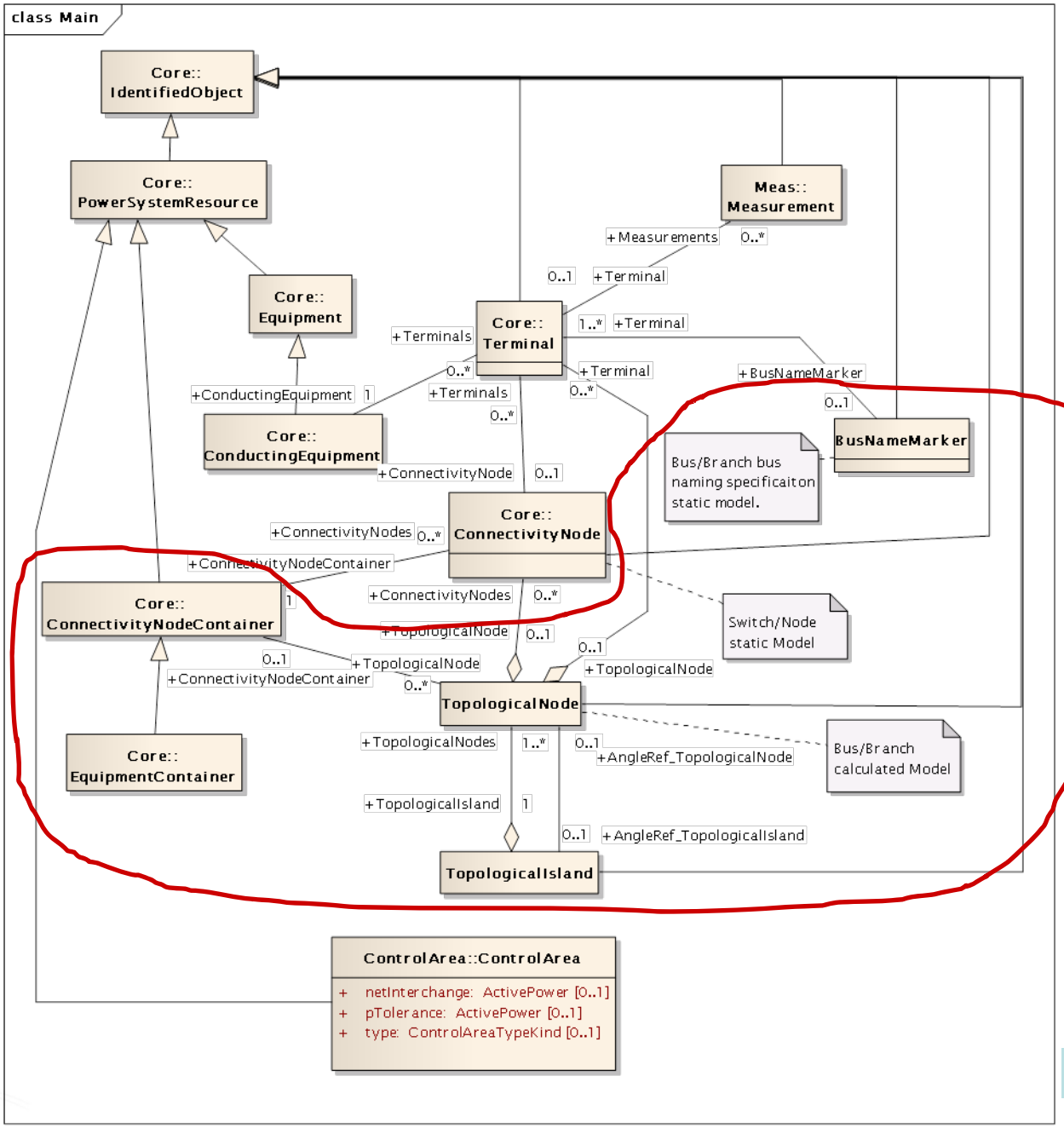
Naming Hierarchy 1



Naming Hierarchy 2



Connectivity and Topology Model

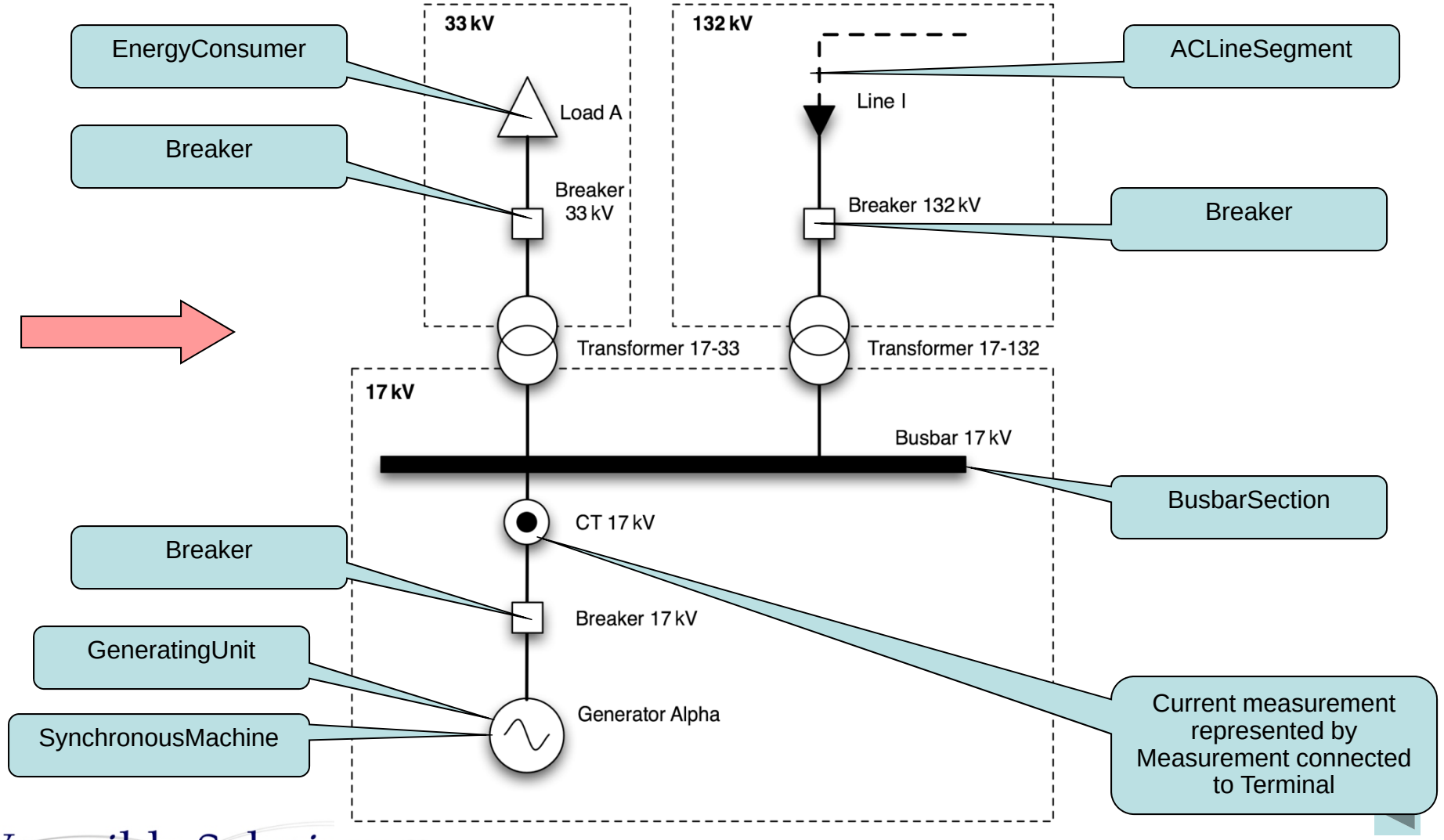


Converting a Circuit to CIM Objects

- Example to show how voltage levels, current transformers, power transformers and generators are modelled
- Circuit contains a single generating source, load, line and busbar. The circuit also contains two power transformers resulting in three voltage levels of 17kV, 33kV and 132kV

Taken from Alan McMorran, *Common Information Model Primer: First Edition.,* EPRI, Palo Alto, CA: 2011, 1024449

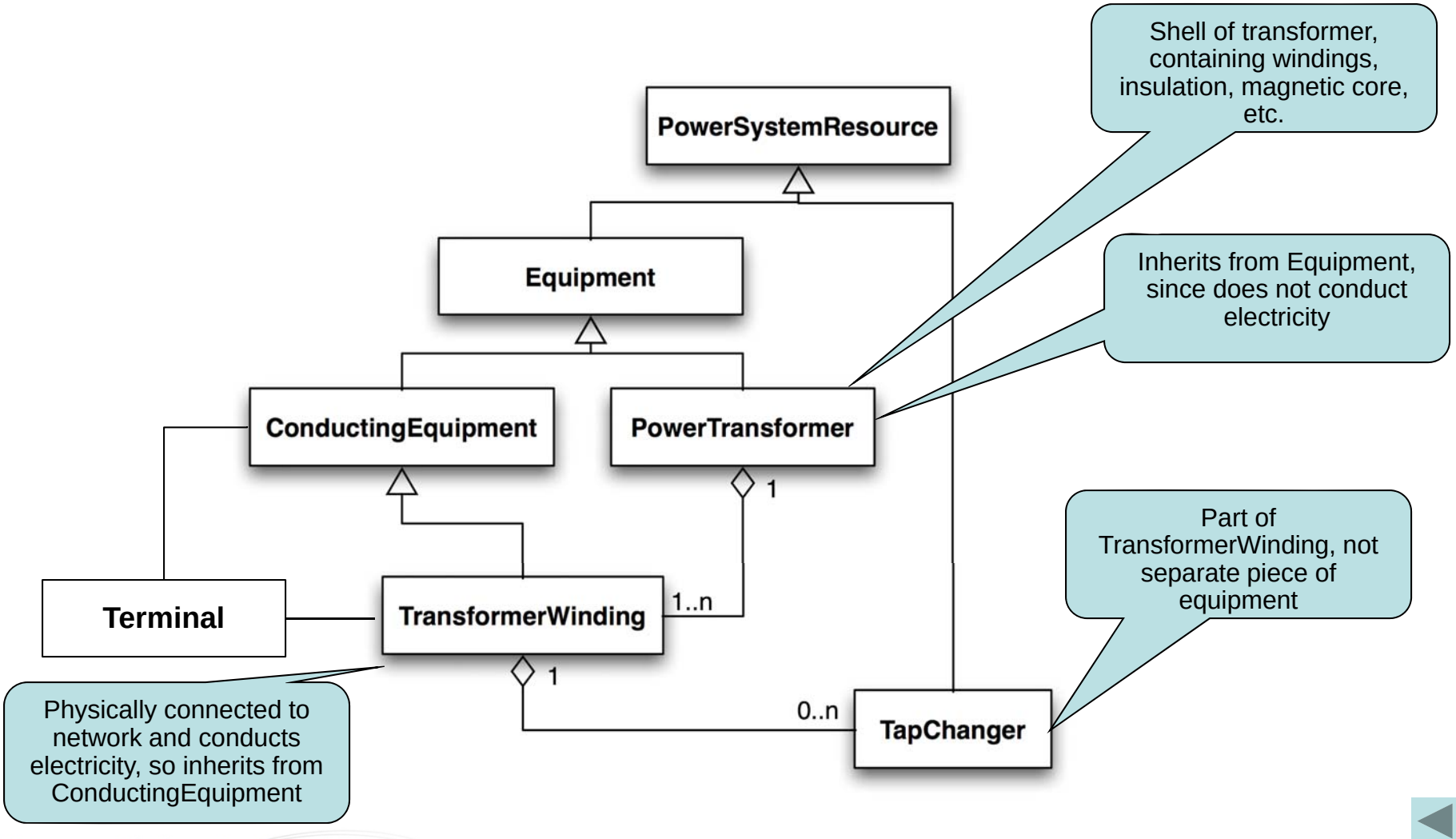
Example Circuit as a Single Line Diagram



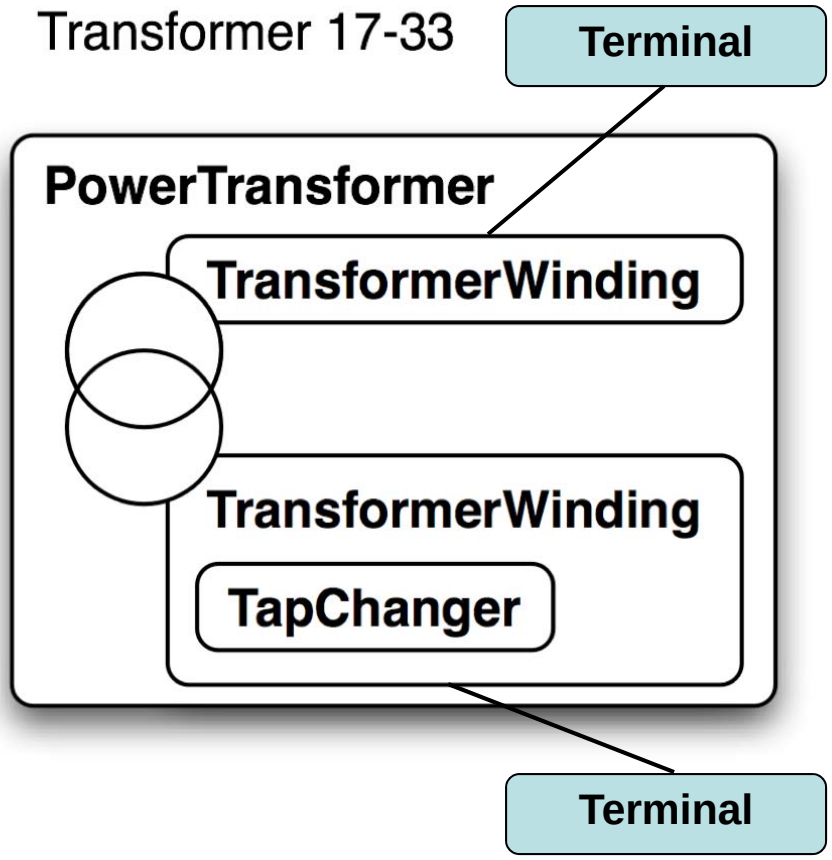
Representing a Power Transformer as CIM Objects

- A power transformer is not mapped to a single CIM class
  - Represented by a number of classes
  - Two-winding power transformer becomes two TransformerWinding objects within a PowerTransformer container
- If a tap changer is present to control one of the windings
  - An instance of the TapChanger class is associated with that particular winding
  - Also contained within the PowerTransformer instance

Transformer Class Diagram - pre CIM Release 15

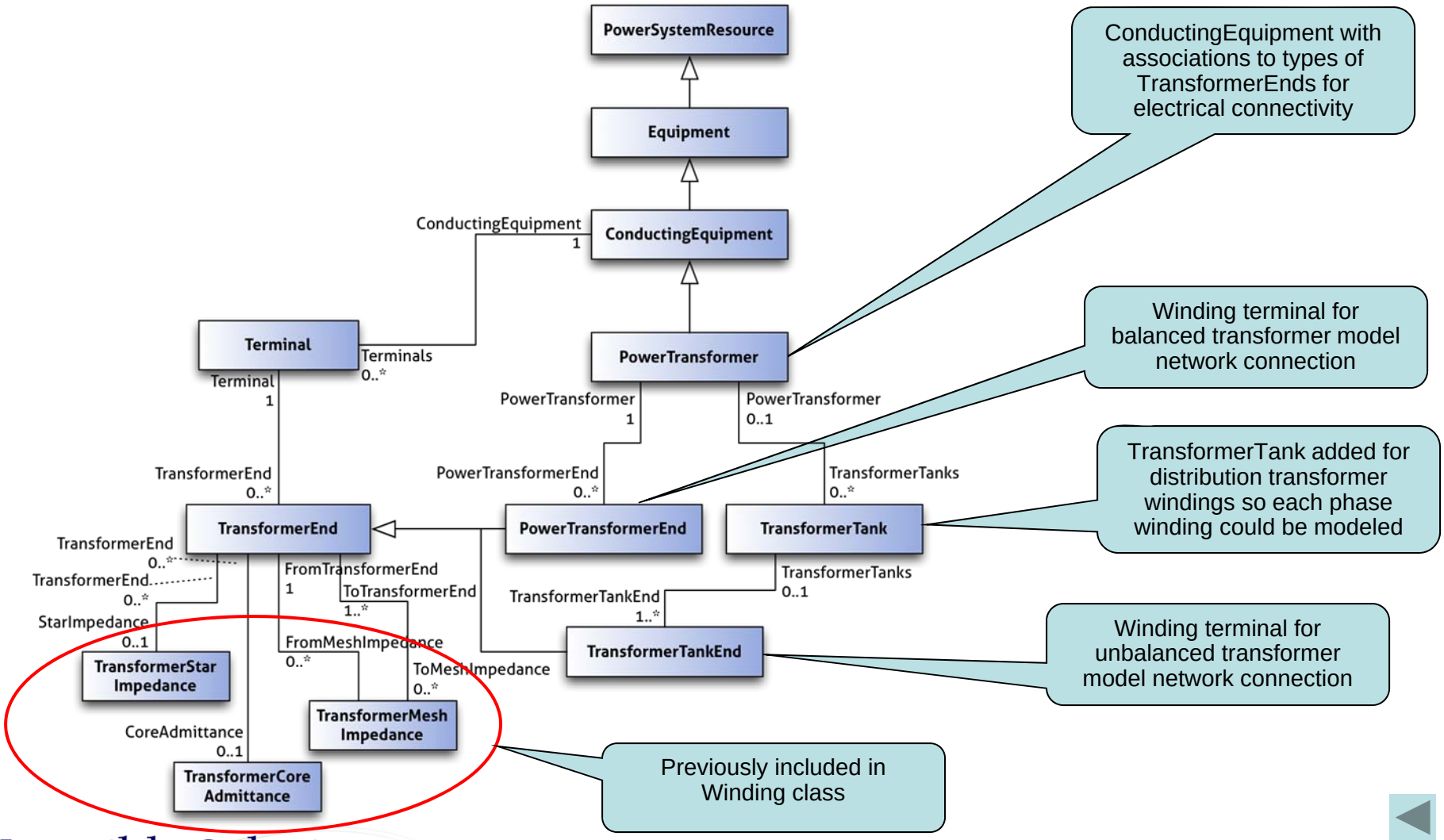


Transformer Instance for Transformer 17-33 - pre Release 15

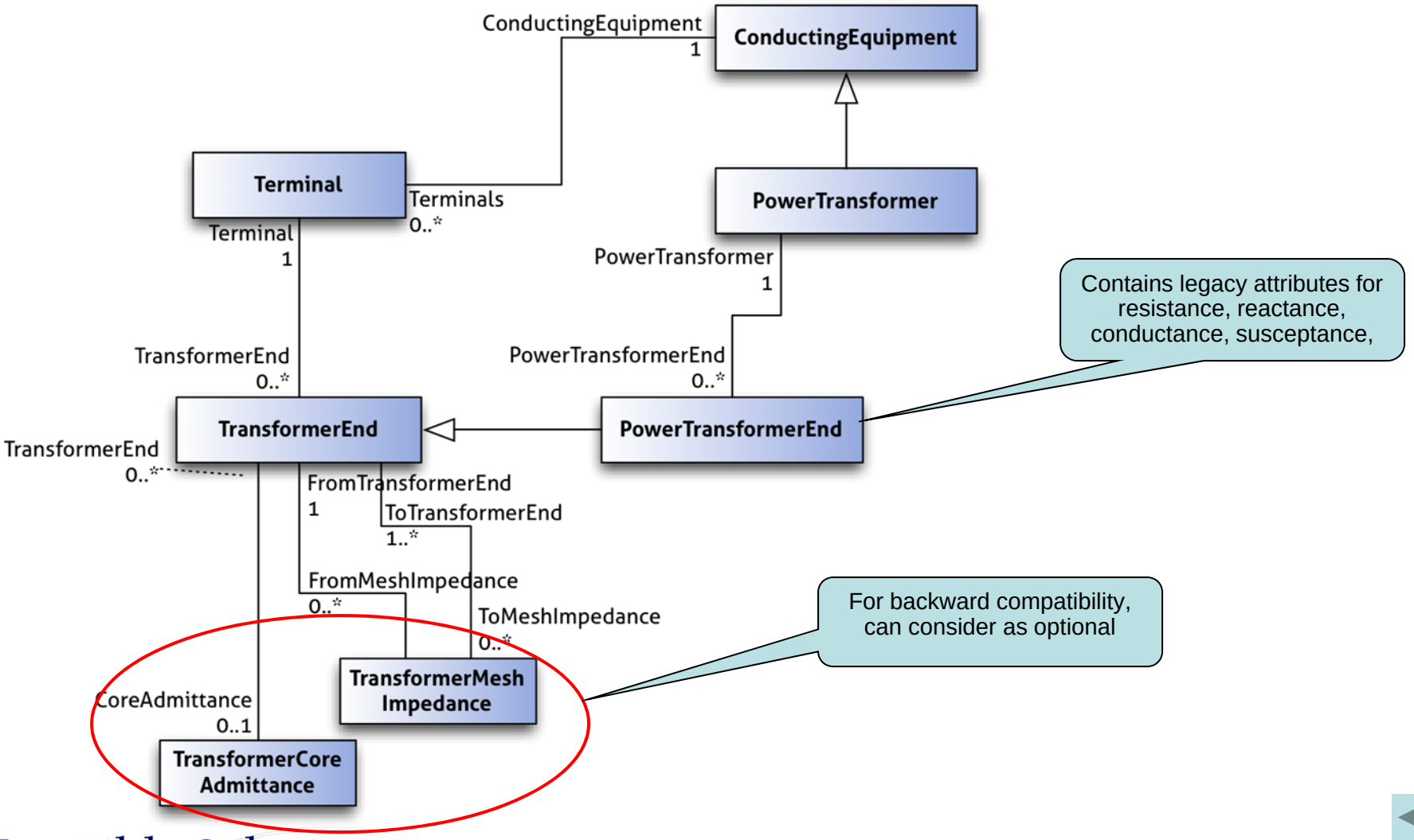


- Transformer 17-33 is represented as four CIM objects
- Connections from the transformer to the network are made from the windings via Terminal

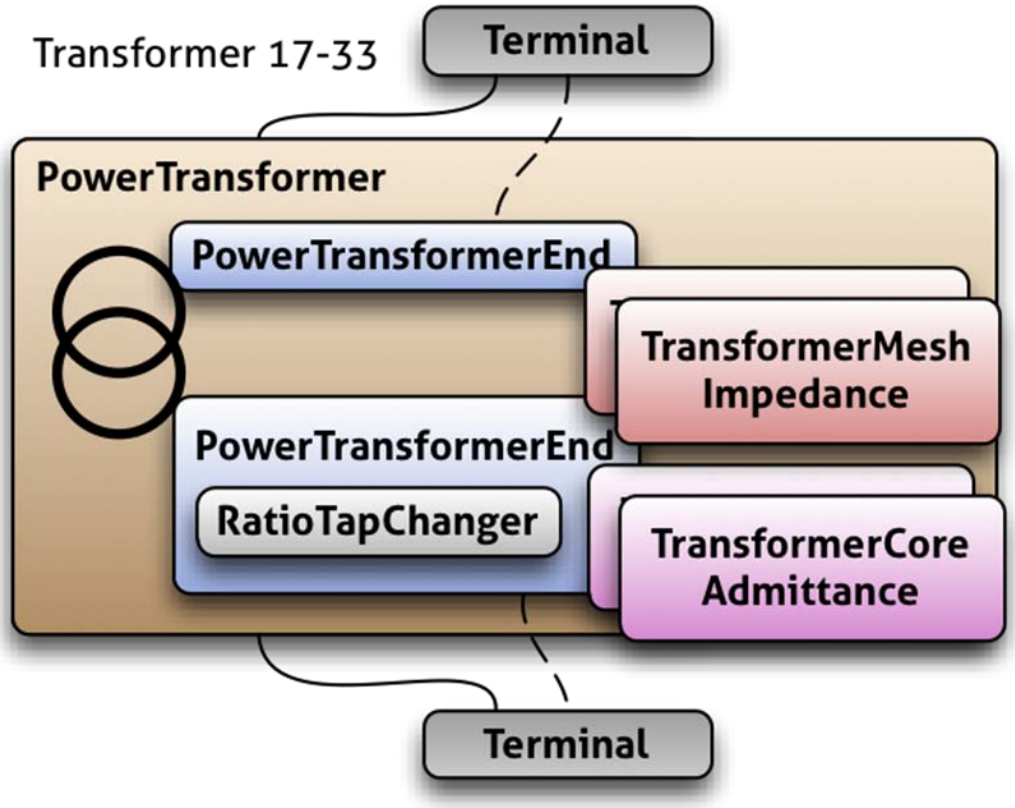
Transformer Class Diagram
CIM Release 15



Balanced Transformer Model

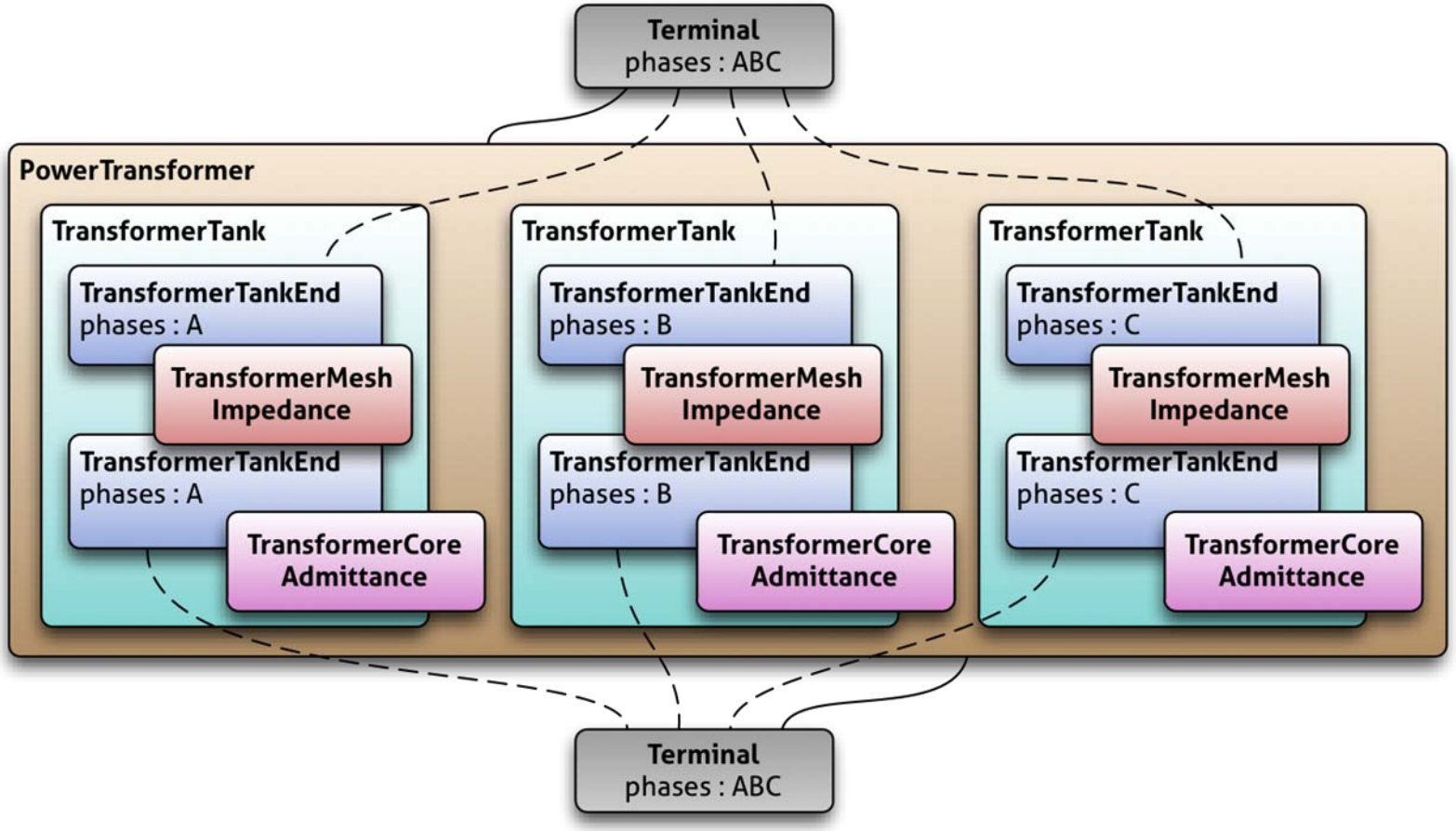


Balanced Transformer Instance for Transformer 17-33 - Release 15

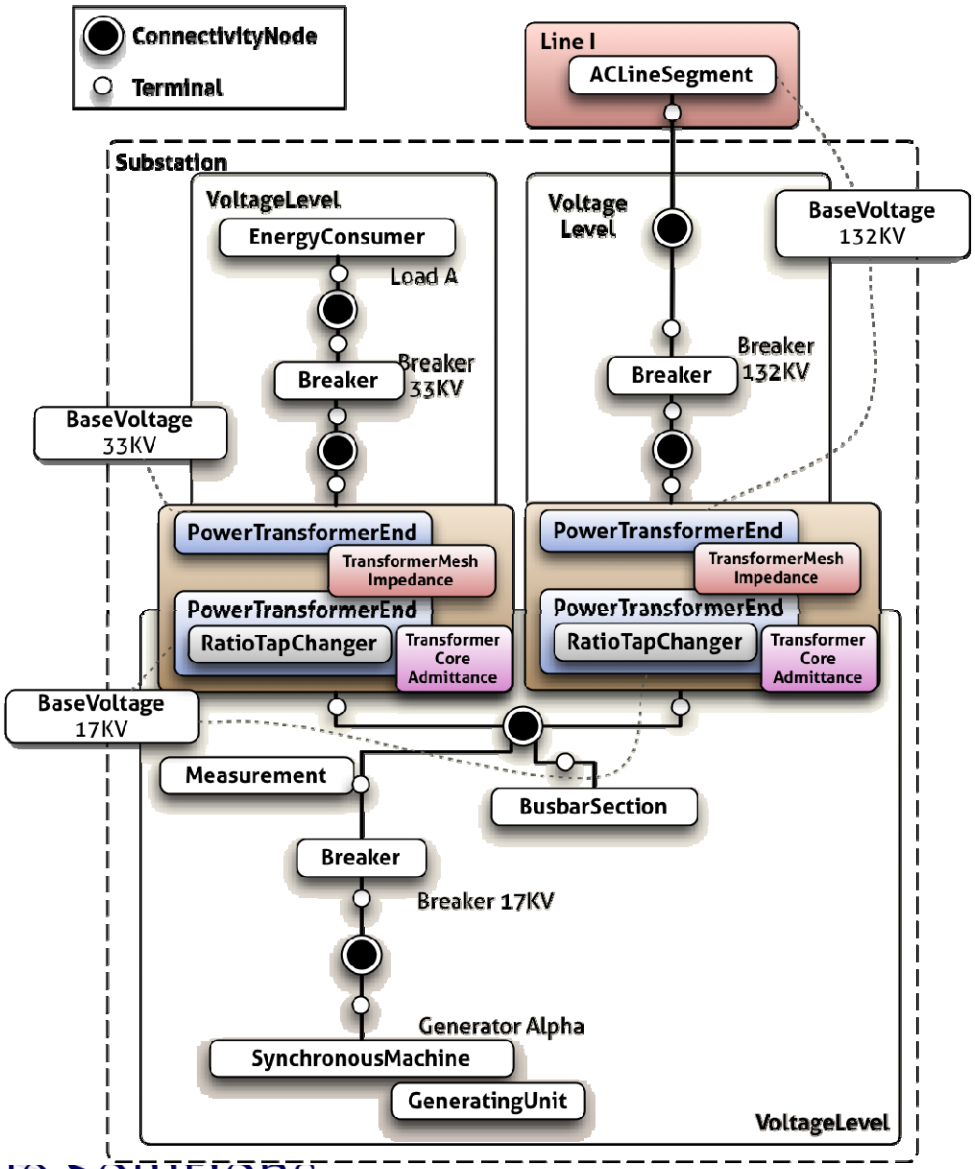


- Transformer 17-33 is represented as four CIM objects plus optional objects
- Connections from the transformer to the network are made directly from the PowerTransformer via association to PowerTransformerEnd

Unbalanced Distribution Transformer with Multiple Tanks Instance Example

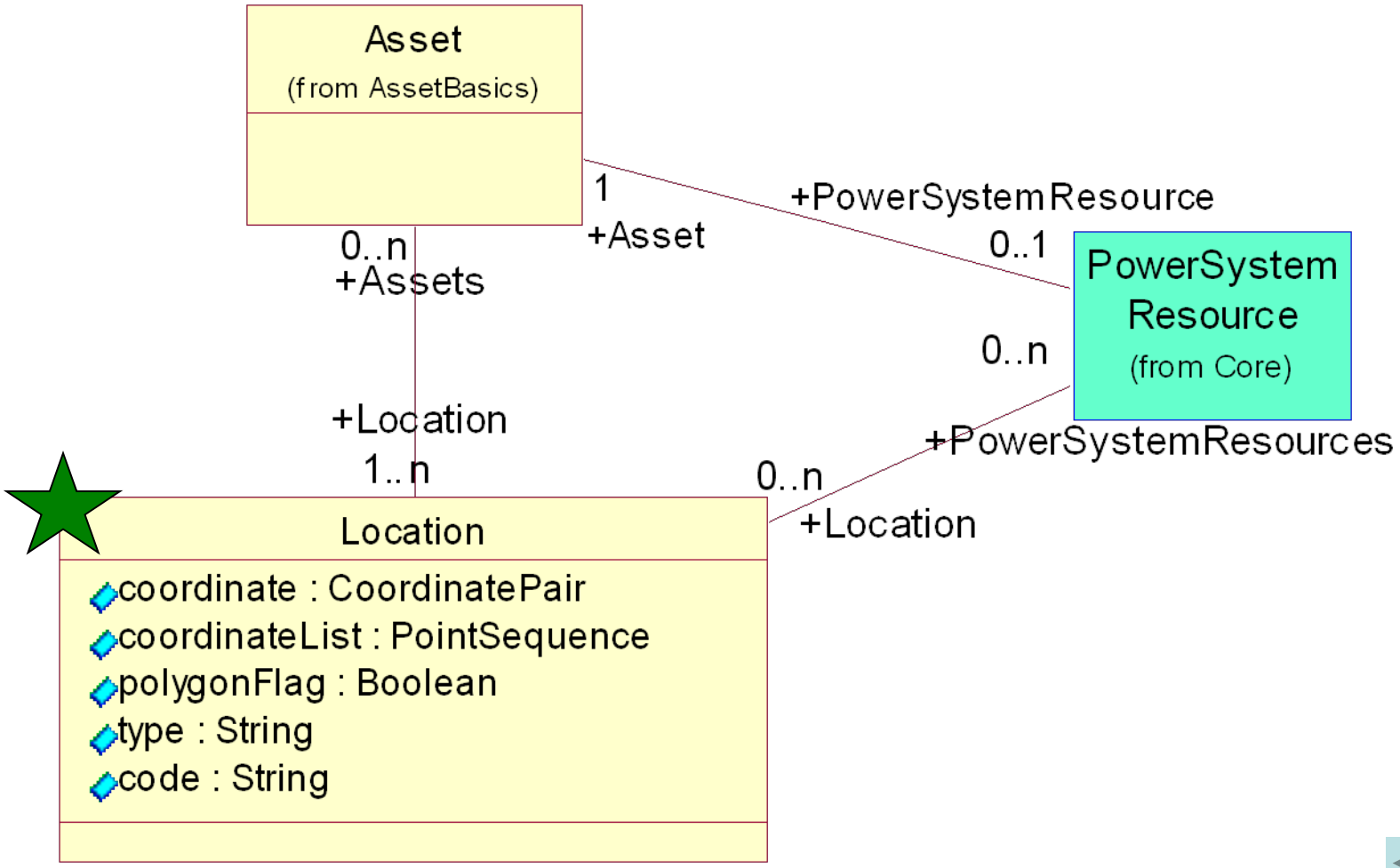


Example Circuit with Full CIM Mappings

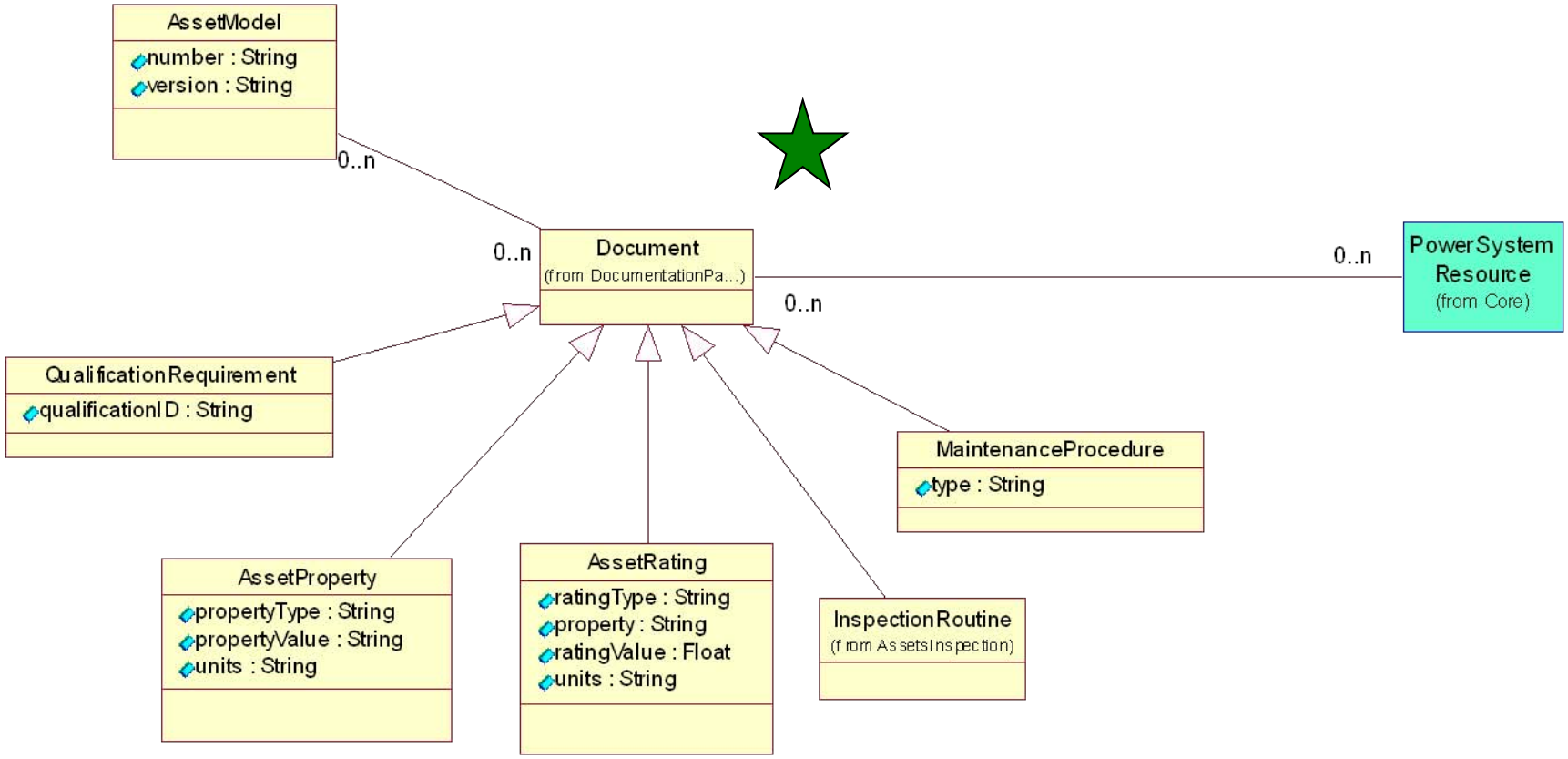


- Maps to
  - 17 CIM classes
  - 45 CIM objects
- Could be extended further with addition of objects for
  - control areas
  - equipment owners
  - measurement units
  - generation and load curves
  - asset data

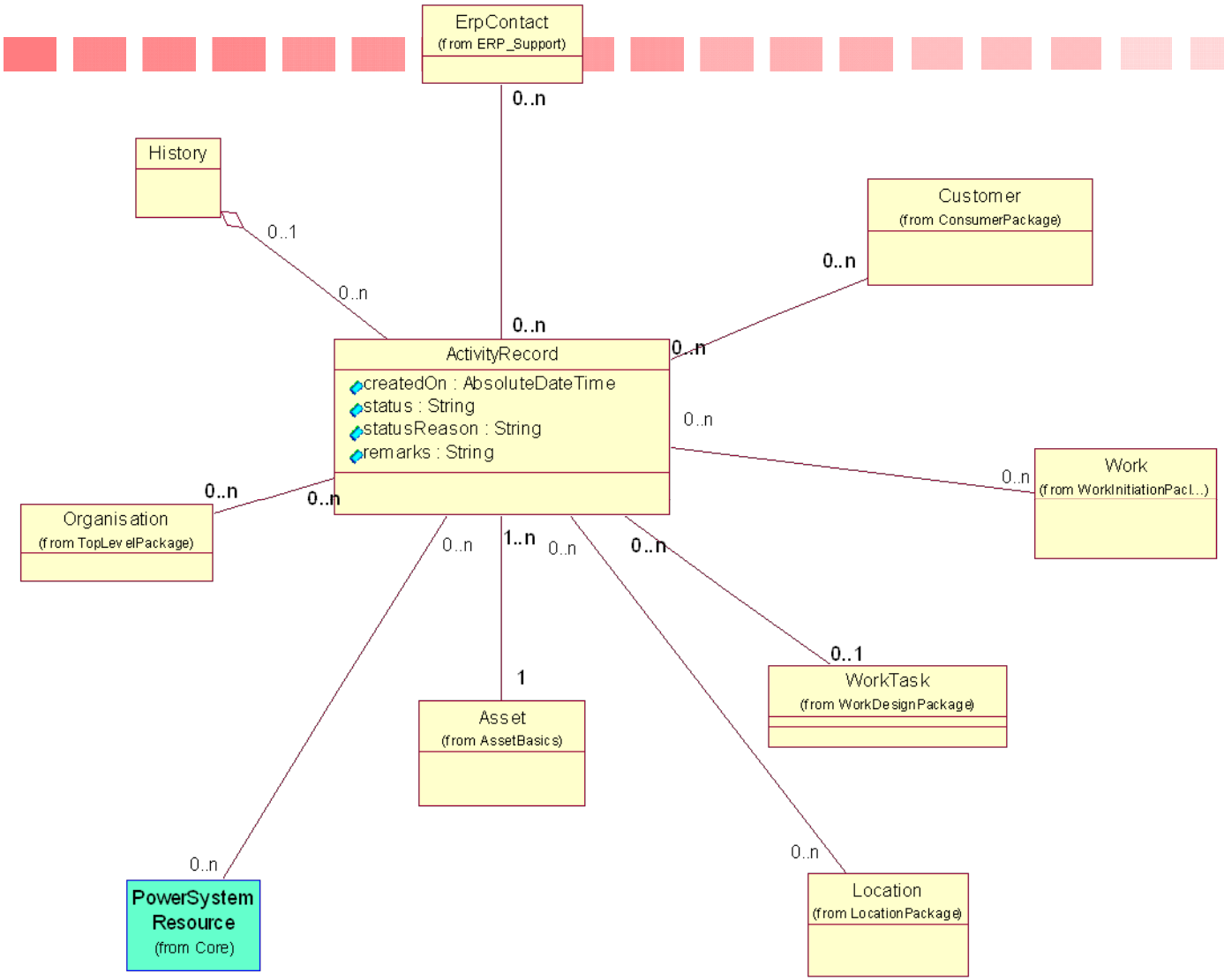
How The CIM Handles Location For Logical Devices And/Or The Physical Asset Performing The Device's Role



Types Of Document Relationship Inherited By All Assets



Activity Records



CIM UML in Enterprise Architect

- The CIM UML model is maintained in Sparx Enterprise Architect (EA)
- Current Official CIM Release 15 UML Model
  - iec61970cim15v33_iec61968cim11v13_iec62325cim01v07
- Go to UML model in EA