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RESEARCH INSTITUTE

# **EPRI CIM and 61850 Harmonization 2010 Project Report**

## **IEC TC57 WG19 Harmonization Project**

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# Why Do We Care About Harmonization?

- Smart Grid initiative is all about interoperability
  - Interoperability Framework with prioritized actions
  - Common Semantic Model
    - 1 of 5 cross-cutting and overarching issues
      - “A common semantic model for application level communications is necessary in several areas of the Smart Grid. Key areas, for example, are the integration of utility Transmission and Distribution field operations with Information Technology and Back Office Systems and ultimately with Customer Premise Systems”
  - Key Actions - Develop a Common Semantic Model
    - “NIST should work with IEC TC57, NEMA, ASHRAE SPC 135, and OASIS to devise a common semantic model (using, for example, XML Schema and XML). The objective will be to unify the models of CIM (IEC61970, IEC61968, MultiSpeak) and IEC 61850 including correspondences with ANSI C12.19 and ASHRAE 135 to form a common representation of information models constructed by these standards efforts for the Smart Grid.”

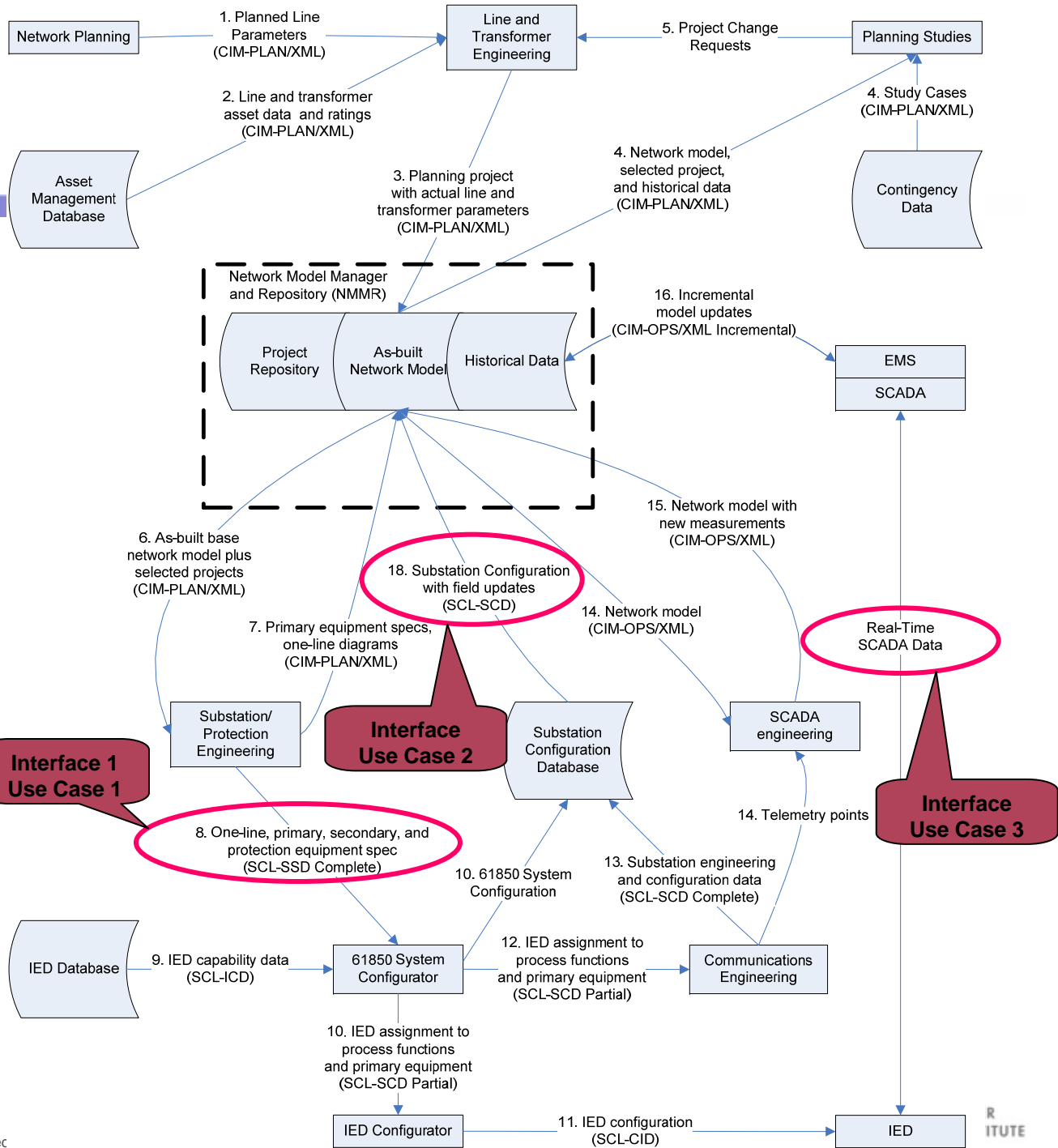
Ref: EPRI Report to NIST on the Smart Grid Interoperability Standards Roadmap, Section 6.1.3, Common Semantic Model, August 10, 2009

# Benefits of Common Semantic Model

- Other benefits of common semantic model:
  - “Extend IEC 61968 and MultiSpeak standards for DER: IEC 61968 needs DER and PEV models, but should be harmonized with the existing DER object models in IEC 61850-7-420, as well as all on-going DER 61850 development. IEC 61850-7-420 has architectural issues to be addressed.”
  - “Extend IEC 61850 standard from substation to control center: Since the data in the substation uses the IEC 61850 information model, this data should be reported to the control center using the same information model. This will also simplify the harmonization efforts between the models of data collected from the field and the CIM.”
- The NIST Roadmap clearly defines the need for a common semantic model and harmonized standards and the desire to use 61850 for communicating from substations and DER to the Control Center and back office systems

# Harmonization Use Case Interfaces

## Based on Network Extension Use Case



# EPRI CIM 61850 Harmonization Project

- Goals
  - Enable the entry and update of substation configuration data once
  - Enable access to real-time data from 61850 devices to directly feed SCADA and back office systems based on the CIM standards
- Approach harmonization through development a harmonized UML model and application of the 3-layer TC57 Reference Architecture
  1. Create UML to permit generation of SCL files from 61850 profile
    - Information layer – extend CIM UML to support generalized 61850 model concepts (but not necessarily part of CIM)
    - Business context layer – to define profiles for generating SCL files
    - Implementation layer – to specify syntax for information exchange
  2. Specify transformation logic to convert between CIM and 61850
- EPRI contracted with Xtensible Solutions and SISCO to complete this project

# Definition of Key Concepts

(Contributed by Jay Britton)

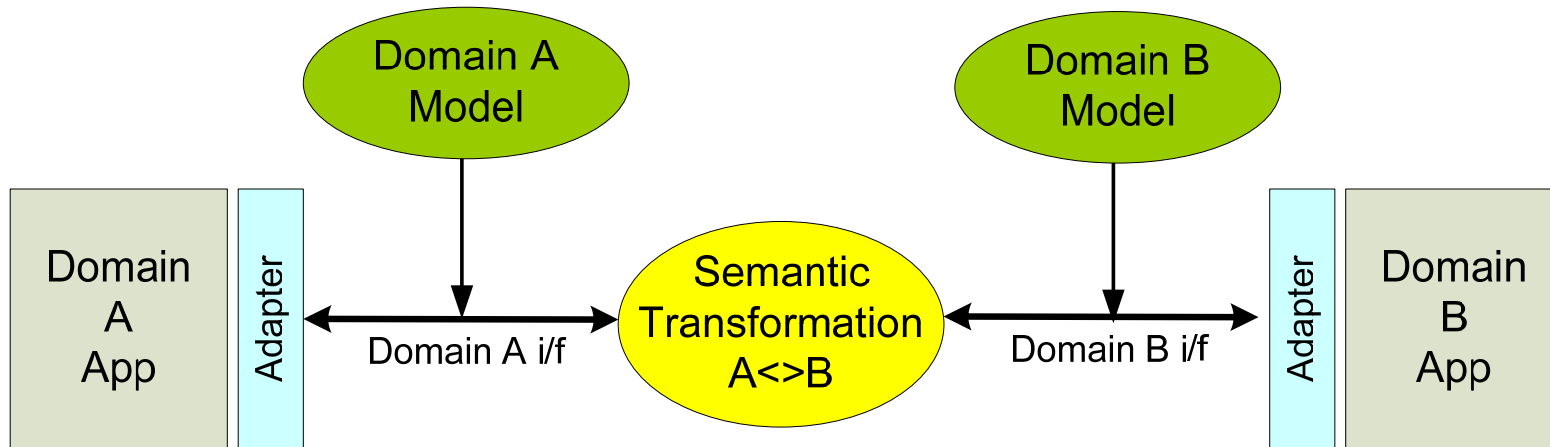
- **Unified Model**

- Merge two models into one normalized model
- Not practical for situations like 61850 - CIM

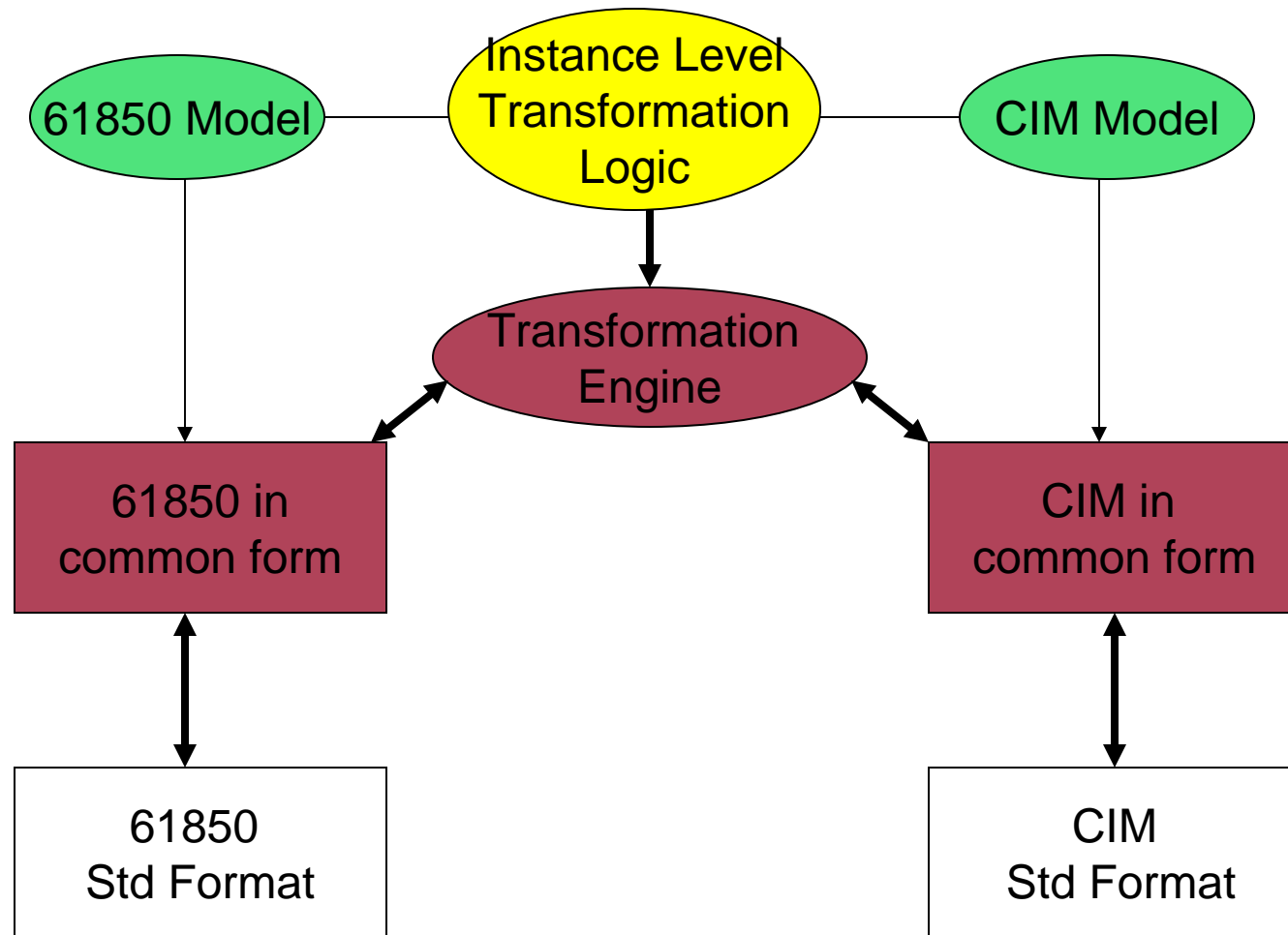
- **Harmonized Models**

- Two models cooperating
- Any interface is either 61850 or CIM – never a mixture
  - *Two CDM-based standards domains are said to be fully ‘harmonized’ if it is practical to write a fully automatic semantic transformation for the duplicated semantics involved in all exchanges between the standards’ problem domains*

# Run-Time Transformation

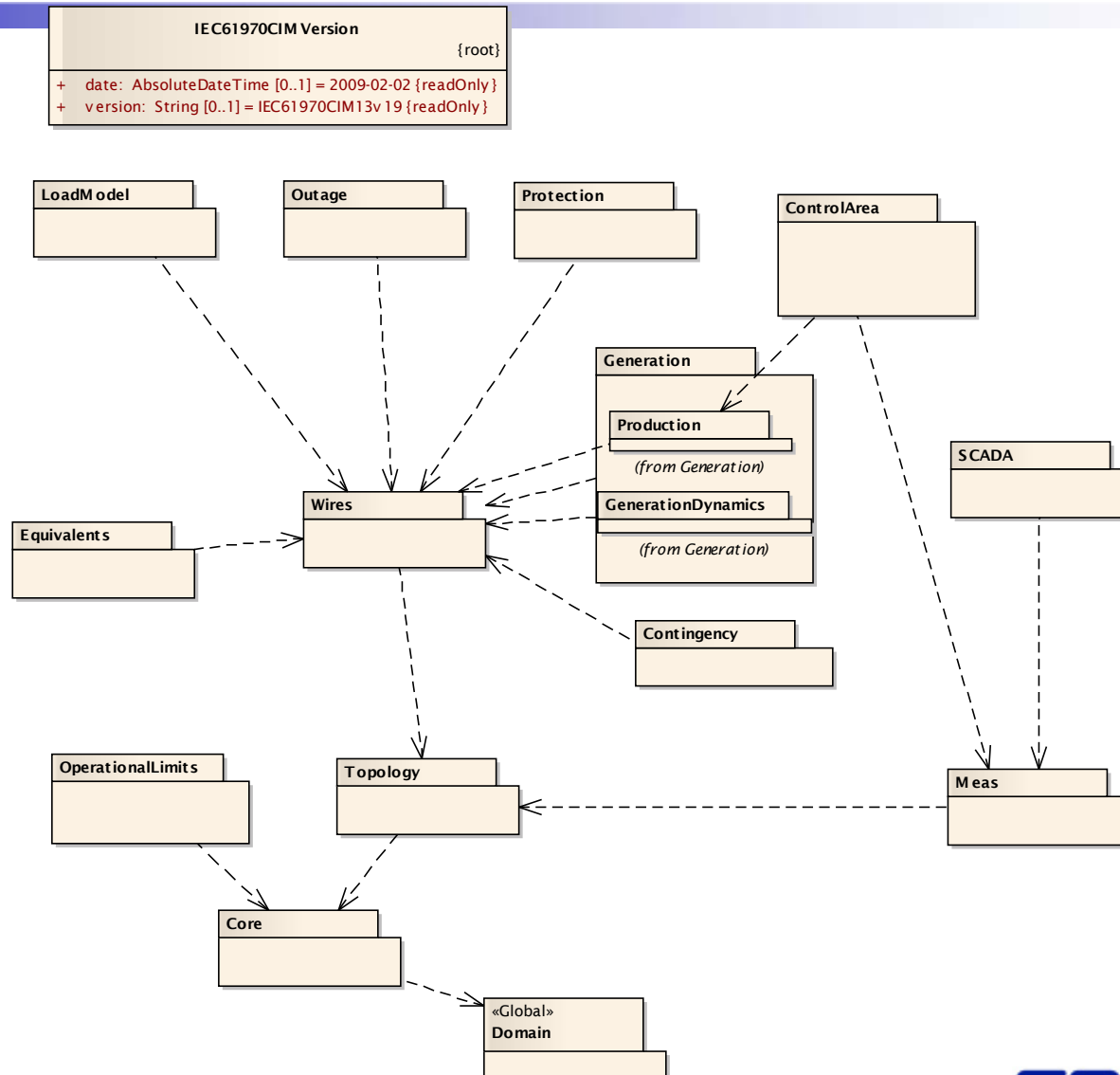


# Meta-Models for Harmonization

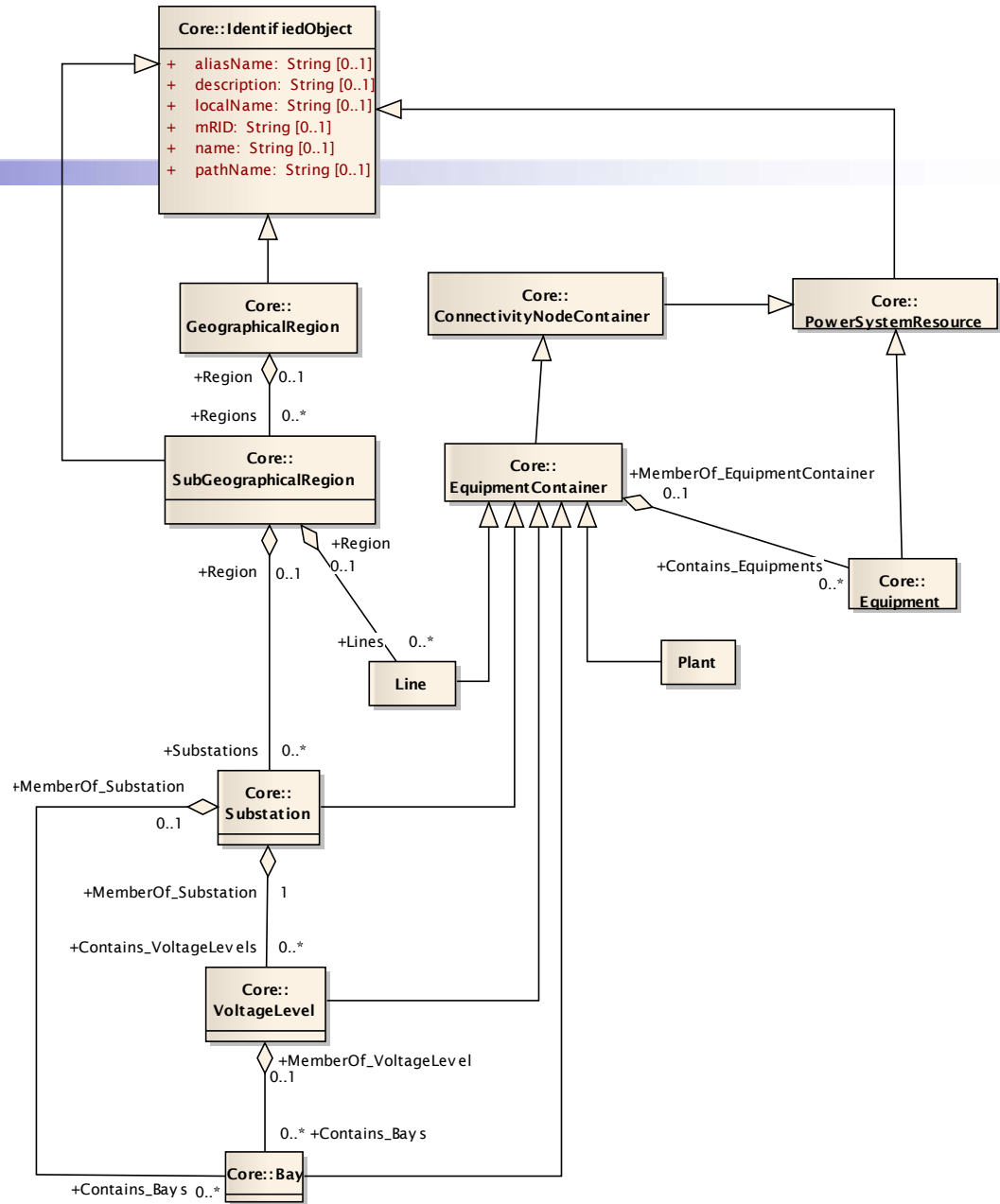




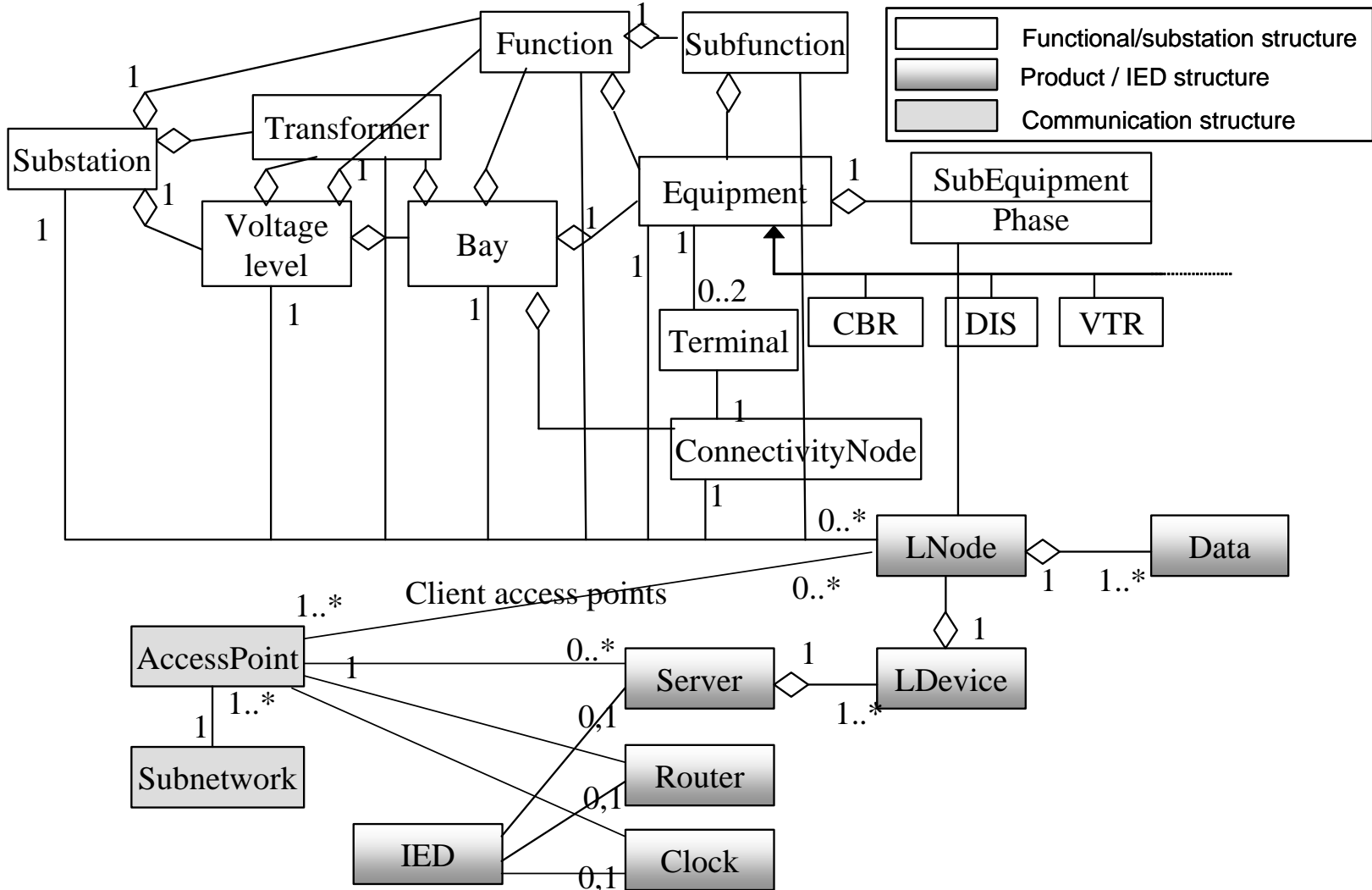
# IEC 61970 CIM UML Model Packages



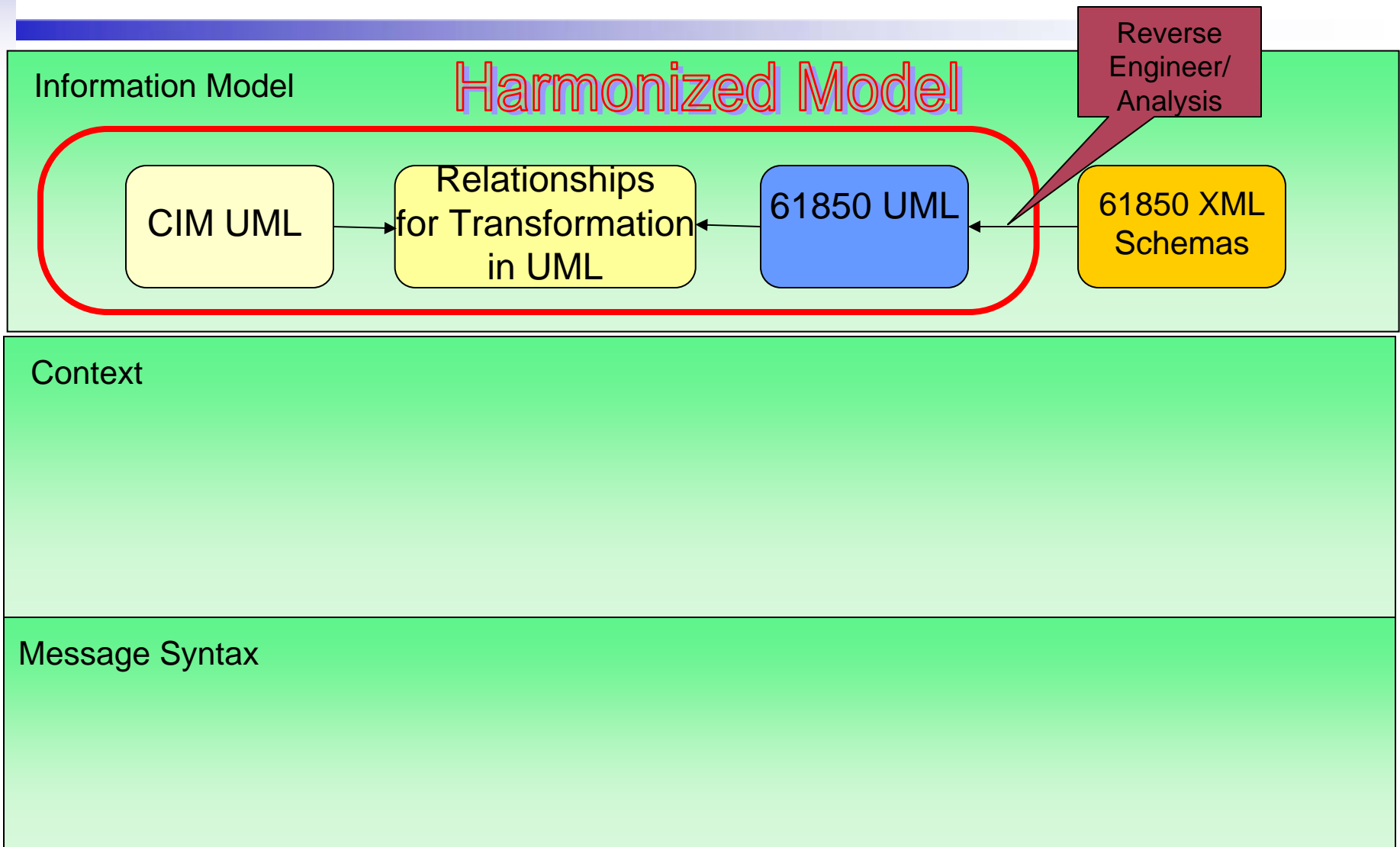
# CIM Equipment Containers



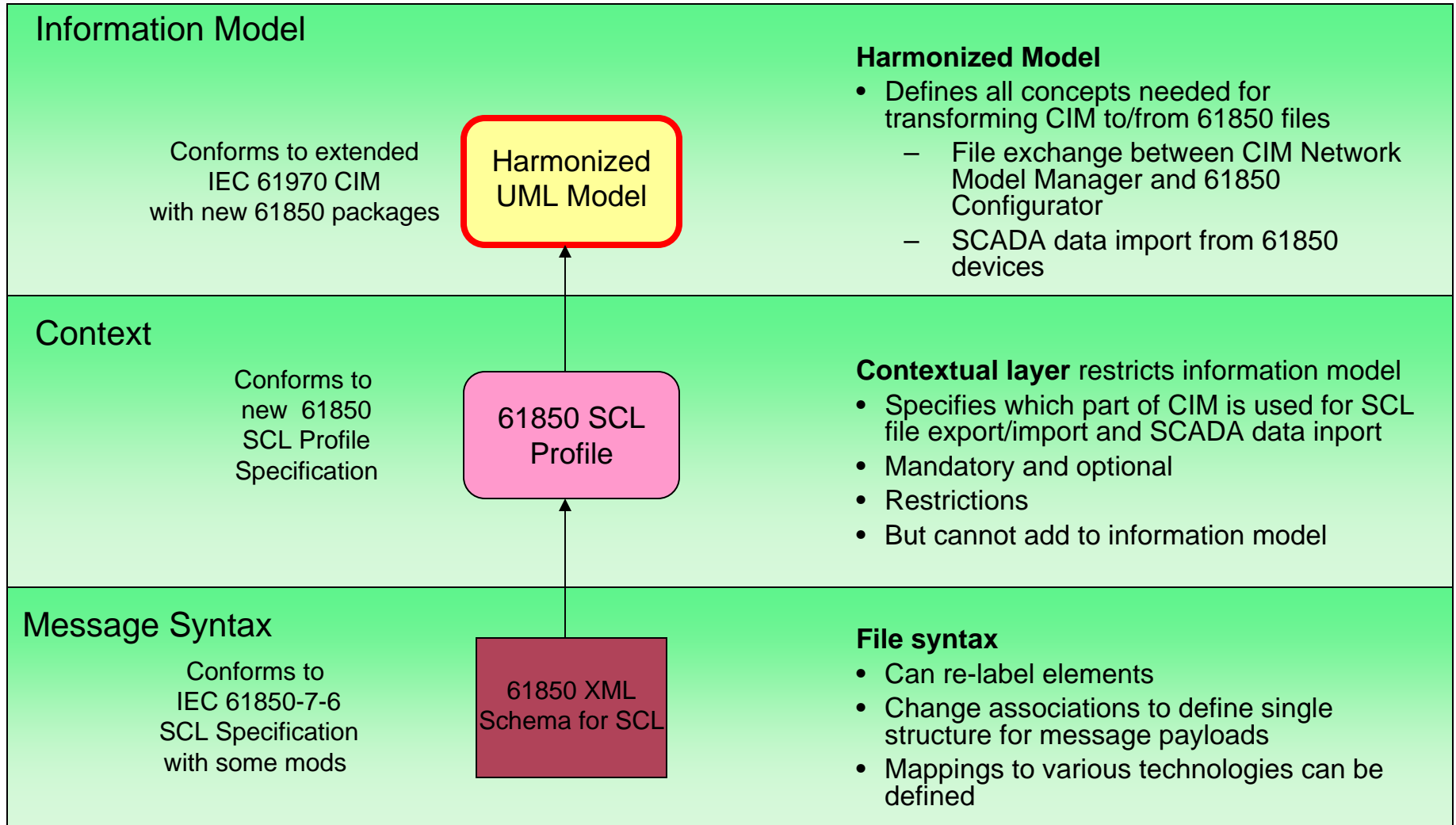
# 61850 SCL Object Model



# Building the Harmonized Model



# Vision: Three-Layer Architecture for SCL File Export and Import



# Harmonization Use Cases

1. Export an SCL SSD/SCD XML file from a Network Model Manager and Repository (NMMR) where the operations/planning model is maintained
  - Single, common model for planning, operations, and substation engineering
2. Update an EMS load flow model maintained in a NMMR from an imported SCL XML file
  - Create the ability to import an SCL file into modeling applications based on the unified model so that a load flow model can be appropriately updated with field changes made by a substation engineer during actual installation or equipment replacement
    - Includes topology updates as well as changes in equipment properties, such as operational limits
3. SCADA data import from 61850 devices

## Terminology

SCL – Substation Configuration Language

- SSD – System Specification Description (Substation – other content optional)
- SCD – Substation Configuration Description (Substation, IEC, Communication)

– Others defined

# Interface for Use Case 1

## Substation/Protection Engineering to 61850 SystemConfigurator

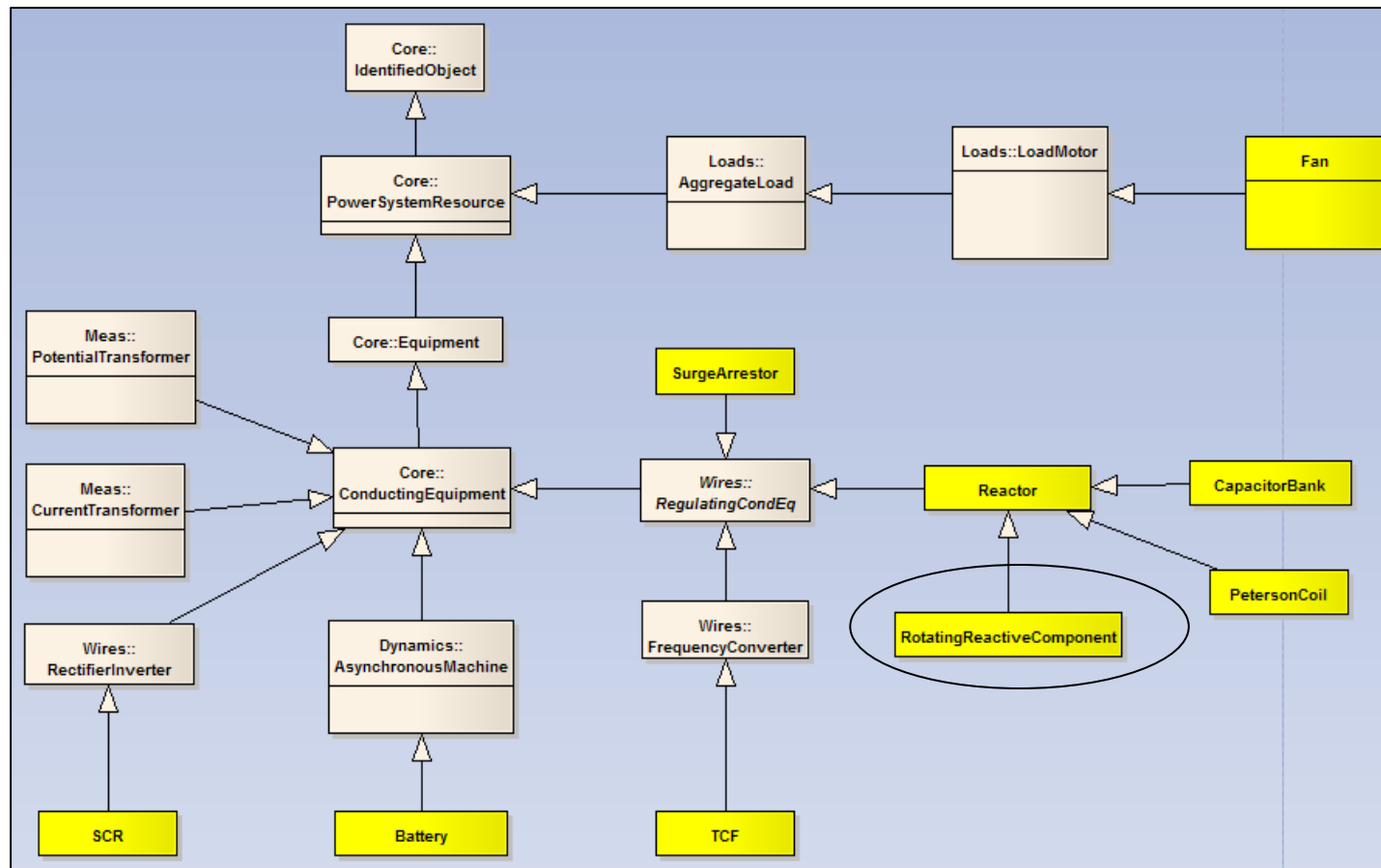
- SCL SSD file type has the following XML elements (attributes not shown)
- Substation Section
  - VoltageLevel
  - PowerTransformer
  - TransformerWinding
  - TapChanger
  - Voltage
  - Bay
  - ConductingEquipment
    - This includes all primary equipment including breakers and switches as needed for an operational model
  - SubEquipment
    - This adds the detail needed for representing 3 phases
  - Terminal
  - ConnectivityNode
    - cnodeName (relative to Bay) added by SS engineer
  - Lnode

# Substation Harmonization

- Substation harmonization
  - Need to agree to common definitions – recommendations made
    - Sources include IEC Glossary, IEC TC57 Glossary, IEC 61970/61968, IEEE Dictionary
  - Update to CIM UML to add missing classes
  - Add new objects/enumerations in SCL to align equipment types with CIM PSRs



# Additional Topological Elements added



- Added

# Added new SCL Items

- To tPredefinedCommonConductingEquipmentEnum, the following enumeration values are proposed to be added:
  - BBS – BusBarSection
  - CND – Conductor
  - CON – Connector
  - EnergyConsumer
  - RINV – RectifierInverter
  - SCMP – Series Compensator
- To tPredefinedGeneralEquipmentEnum, the following enumeration values are proposed to be added:
  - GEN – GeneratingUnit
  - PROT – Protection Equipment

# Alignment looks like:

UML Class		SCL	
Class	Attribute	Abbreviation	Type
BaseVoltage		VOL	tPredefinedCommonConductingEquipmentEnum
Battery		BAT	tPredefinedCommonConductingEquipmentEnum
Bay			tBay
Breaker		CBR	tSwitch
BusBarSection		BBS	tPredefinedCommonConductingEquipmentEnum
CapacitorBank		CAP	tPredefinedCommonConductingEquipmentEnum
Conductor		CND	tPredefinedCommonConductingEquipmentEnum
Conductor	InsulationType=Gas	GIL	tPredefinedCommonConductingEquipmentEnum
ConnectivityNode			tConnectivityNode
Connector		CON	tPredefinedCommonConductingEquipmentEnum
CurrentTransformer		CTR	tPredefinedCommonConductingEquipmentEnum
Disconnecter		DIS	tSwitch
EnergyConsumer		EnergyConsumer	tPredefinedCommonConductingEquipmentEnum
Fan		FAN	tPredefinedCommonConductingEquipmentEnum
Fuse		FUSE	tSwitch
GeneratingUnit		GEN	tPredefinedGeneralEquipmentEnum
Ground			tConnectivityNode with grounded-True
GroundDisconnecter		GNDIS	tSwitch
Jumper		JMP	tSwitch
Junction		CAB	tPredefinedCommonConductingEquipmentEnum
Line			tLine
LoadBreakSwitch		LBS	tSwitch
Motor		MOT	tPredefinedCommonConductingEquipmentEnum
Palsson Coil		EPN	tPredefinedCommonConductingEquipmentEnum
PowerTransformer			tPowerTransformer
ProtectionEquipment		PROT	tPredefinedGeneralEquipmentEnum
Reactor		REA	tPredefinedCommonConductingEquipmentEnum
Rectifier		RNV	tPredefinedCommonConductingEquipmentEnum

UML Class		SCL	
Class	Attribute	Abbreviation	Type
ACLineSegment		LIN	tPredefinedCommonConductingEquipmentEnum
BaseVoltage			tVoltage
Battery		BAT	tPredefinedCommonConductingEquipmentEnum
Bay			tBay
Breaker		CBR	tSwitch
BusBarSection		BBS	tPredefinedCommonConductingEquipmentEnum
CapacitorBank		CAP	tPredefinedCommonConductingEquipmentEnum
Conductor		CND	tPredefinedCommonConductingEquipmentEnum
Conductor	InsulationType=Gas	GIL	tPredefinedCommonConductingEquipmentEnum
ConnectivityNode			tConnectivityNode
Connector		CON	tPredefinedCommonConductingEquipmentEnum
CurrentTransformer		CTR	tPredefinedCommonConductingEquipmentEnum

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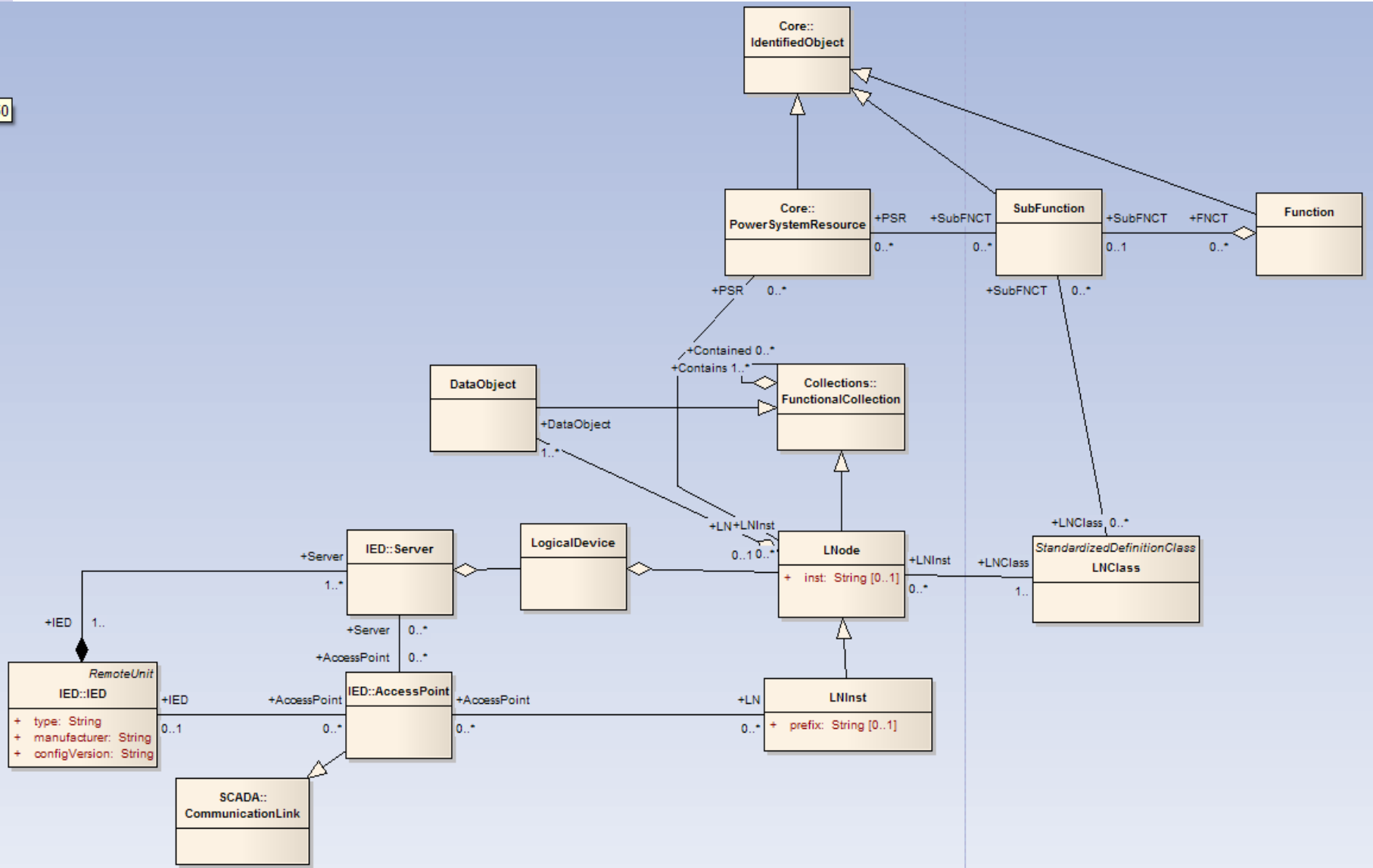
## Interface for Use Case 2

### Substation Configuration DB to NMMR

- SCL SCD file type has the following XML elements
  - Substation Section (same as Use Case 1)
  - IED Section
  - Communications Section

# Proposed linkage of 61850 to PSRs

50



# Harmonization Use Cases

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# Interface for Use Case 3

## 61850 Field Devices to SCADA

- SCADA data/control import/export from 61850 devices
  - SCL SCD file, imported into NNMR/unified model (Use Case 2) has the information to:
    - Define communication addressing for SCADA
    - Define remote points
    - May have definition of limits and deadbands as initial values.
  - Need to be able to use this information to configure the SCADA model and be able to drive the 61850 SCADA acquisition interface
  - Then use harmonized model to unambiguously map 61850 data to CIM representation (and vice-versa)



# Recommendations for Harmonization

- Need persistent IDs – added RDFID (equivalent to rdf:id in CIM XML)
  - SCL files have internal referential integrity through the use of names
  - When merged/imported into a unified model, names “will be” duplicated
  - Use of names also means that it is difficult to pick up changes
- Units need to be aligned
- Measurements
- SCADA and Control
- Communications expanded
- Need to make better use of Profiles (Layer 2) to restrict general CIM model for specific business purpose rather than creating specialized UML models

# Status

- Business use cases and interfaces defined
- Harmonized UML model developed
  - Reuse and extension of existing CIM to add missing 61850 concepts
  - Available on Sparx Enterprise Architect
  - Presented to IEC TC57 as proposal for CIM and 61850 SCL changes
- Preliminary EPRI report published
  - *Harmonizing the International Electrotechnical Commission Common Information Model (CIM) and 61850 Standards via a Unified Model: Key to Achieve Smart Grid Interoperability Objectives*. EPRI, Palo Alto, CA: 2010. 1020098
  - Note needed change from “unified model” to “harmonized model”

# Conclusions

- Extensions to the CIM model and 61850 SCL have been proposed to enable practical transformation. Additionally, there are proposals to enhance some abstract CIM definitions with the more concrete semantics from 61850
- There remain different semantic models for the specification of substation equipment and topology. However, the semantics overlap and where those overlaps occur, the EPRI report has attempted to define these in one place within the proposed UML model
- Transformation between the semantic models of duplicated semantics is specified as text
- In any exchange between the CIM and 61850 worlds, transformation between the semantic models is required
- The CIM and 61850 worlds may continue on relatively independent tracks – they are not unified in the same sense that, say, 61968 and 61970 are unified
- The proposed UML model does represent the opportunity for possible unification in the future

# Plans for 2010

- Address new use case - Asset and Condition Based Maintenance (CBM) application import of data from 61850 substation devices
- Define a profile for exporting SCL SSD files from a common network model manager
- Define profile to import an SCL SCD file into common network model manager
  - Enable modeling applications to be appropriately updated with field changes made by a substation engineer during actual installation or equipment replacement
  - Includes topology updates as well as changes in equipment properties, such as operational limits
- Demonstration and interoperability tests
- Present to SGIP as part of overall SG semantic model
- Develop support for funding to continue the effort

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