The Standards Based Integration Company

Systems Integration Specialists Company, Inc.

Insight in IEC 61850

What is it?

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Topics

- IEC 61850 and Its Relationship to other IEC Standards
- Impact of IEC 61850 on the Engineering Processes of SCADA, Automation, and Protection
- IEC 61850 Profiles and use of networks
- IEC 61850 Modeling
  - Device and Object Models
  - Service/Behavior Models
- Substation Configuration Language

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IEC 61850 and Other Key IEC Standards

What is it with all these “models”?

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Definitions:

Interoperability and Integration

The ability of computer systems to exchange information with other systems and to cooperatively implement a useful process or function for the system owner/user.

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Interoperability and Integration

- Easy to Achieve:

Nearly anything is possible with enough money and development effort

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A Better Way

- Interoperability and Integration without having to program it all yourself:
  - Where applications and devices are inherently capable of interoperating with other systems and performing integrated application functions in a cooperative and distributed manner.
- This is only possible if there are standards to enable it.
  - This work is progressing.
- This is the goal of the IEC TC57 standards

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Standards are Needed

- Standards enable independent developers to reduce the uniqueness of their solutions at the interface points
- Traditionally, this meant the protocols to the devices
- But, this did not address the **integration** dilemma for applications (not devices) that did not use "protocols" as the interface
- Existing protocols provided **interoperability** but little **integration**
- A new level of standardization is needed
- **This is what the IEC TC 57 Standards are about.**

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Strategic Vision for Integration and Interoperability

- Abstract Modeling
  - **Object and Information Models**
  - Abstract Service and Interface Models
  - Self Description and Discovery
  - Technology Independent Design
- Security
  - Applying mainstream standards to TC57 standards
  - Power system specific applications and recommendations

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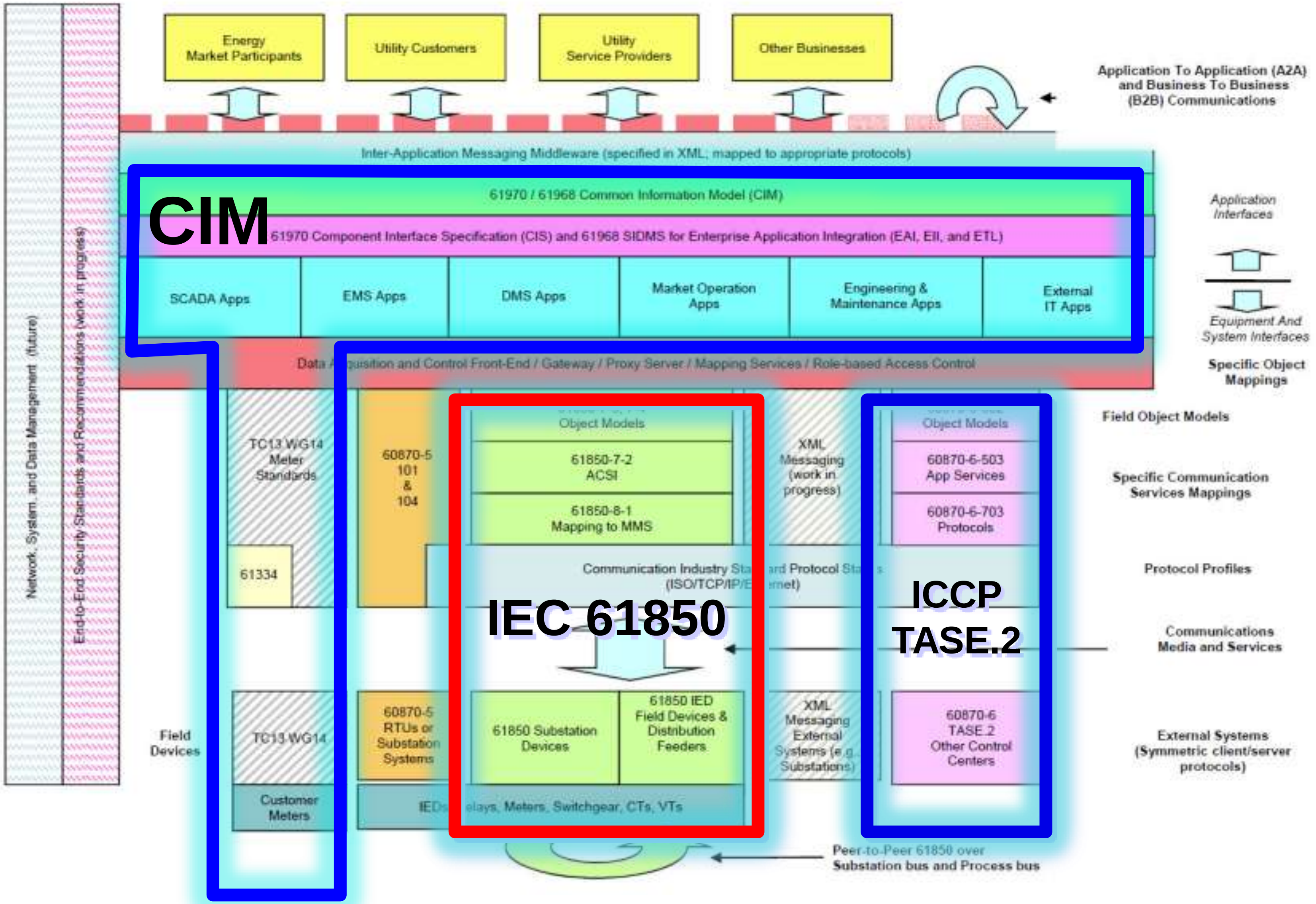
TC 57 Architecture



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IEC TC 57 Technical Committees

- **WG 3** – Telecontrol Protocols
  - **IEC 60870-5-7** – Security for IEC 60870-5 protocols.
- **WG 10** - Power system IED communication and associated data models
  - **IEC 61850** – Communications for power system automation
- **WG 13** - Energy management system application program interface (EMS - API)
  - **IEC 61970** – Common Information Model (CIM) and Generic Interface Definition (GID)
- **WG 14** - System interfaces for distribution management (SIDM)
  - **IEC 61968** – CIM for distribution and model driven messaging
- **WG 15** - Data and communication security
  - **IEC 62351** – Communications Security
- **WG 16** - Deregulated energy market communications
  - **IEC 62325** – CIM for energy markets
- **WG 17** - Communications Systems for Distributed Energy Resources (DER)
  - **IEC 61850-7-420** – IEC 61850 for DER applications
  - **IEC 61850-8-2** – Web service mapping for IEC 61850
- **WG 18** - Hydroelectric power plants - Communication for monitoring and control
  - **IEC 61850-7-410** – IEC 61850 for Hydropower applications
- **WG 19** - Interoperability within TC 57 in the long term
  - **IEC 62445** – Use of IEC 61850 between control centers and substations
  - IEC 61850-CIM harmonization, ICCP-TASE.2 update, naming and design rules for CIM, quality codes.
- **WG 9 and WG 20** – Power line carrier systems for DMS (9) and planning for same (20)
  - **IEC 60495, 60663, 62488** – Power line carrier systems
- **WG 21** - Interoperability within TC 57 in the long term
  - **IEC 62746** – Interfaces and protocol for systems connected to the Smart Grid
- **JWG 16** – DLMS/COSEM – metering protocols (TC13)
- **JWG 25** – Windpower systems (TC 88)

Traditional Protocol Standards

- Specified how you arrange bytes on the wire in order to transfer bytes of data between a device and an application
- **Good News: It worked!** Device communications costs were lowered.
- Bad News: No standard for data representation or how devices should look and behave to network applications.
  - Some Interoperability but not Integration

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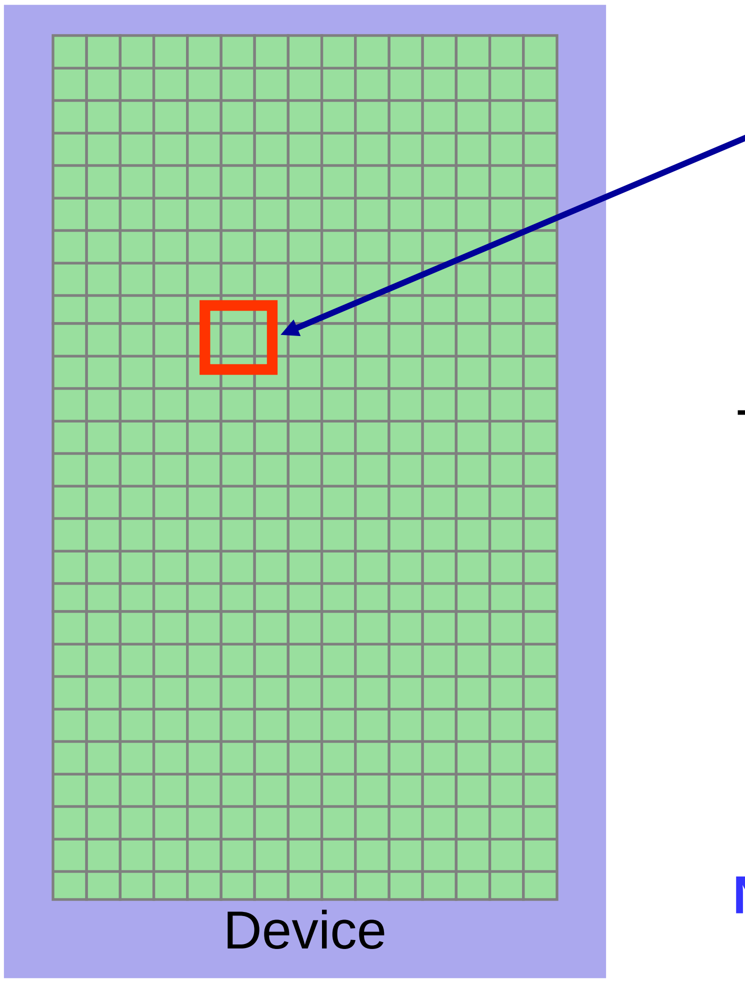
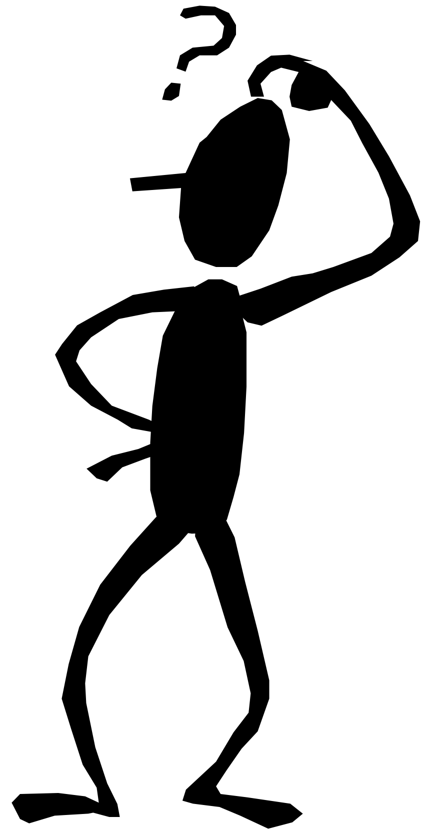
Typical Legacy Protocol Data Model



It is in:
Object #6,
Variation #2,
Index #27

That's intuitive?



I need the Phase A voltage for
the 345KV primary feeder

NO POWER SYSTEM CONTEXT FOR DATA ACCESS

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Behavior Modeling

- Assume Index #25 is always used to store breaker status.
    - Does 1 mean open or closed?
    - Can I write this object to operate the breaker?
    - Where is the select?
    - Is it selected?

- **Even if every device used Index #25 to hold breaker status this still isn't enough to provide integration.**

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A New Approach Needed

- For protocols to provide interoperability at the system level they need to:
  - Specify the bytes/format of the data on the wire
  - Specify the meaning of data
  - Specify the behavior of the data

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IEC 61850: New Approach

- IEC 61850 is a new and innovative approach to substation automation:
  - Standardized Device and Object Modeling
    - Logical Devices, Logical Nodes, Common Data Classes, etc.
    - Extensions unique to specific applications (Hydro, Distributed Energy Resources (DER), Wind power, etc.)
  - Standardized Service/Behavior Modeling
  - Standardized XML for Systems and Device Configuration
  - Standardized Communications Protocols for Specific Use Cases:
    - Station Level Monitoring and Control (substation SCADA) (TCP/IP)
    - Protection and Control – GOOSE over Ethernet
    - Sampled Values – Process Bus over Ethernet
  - Standardized Conformance Test Cases

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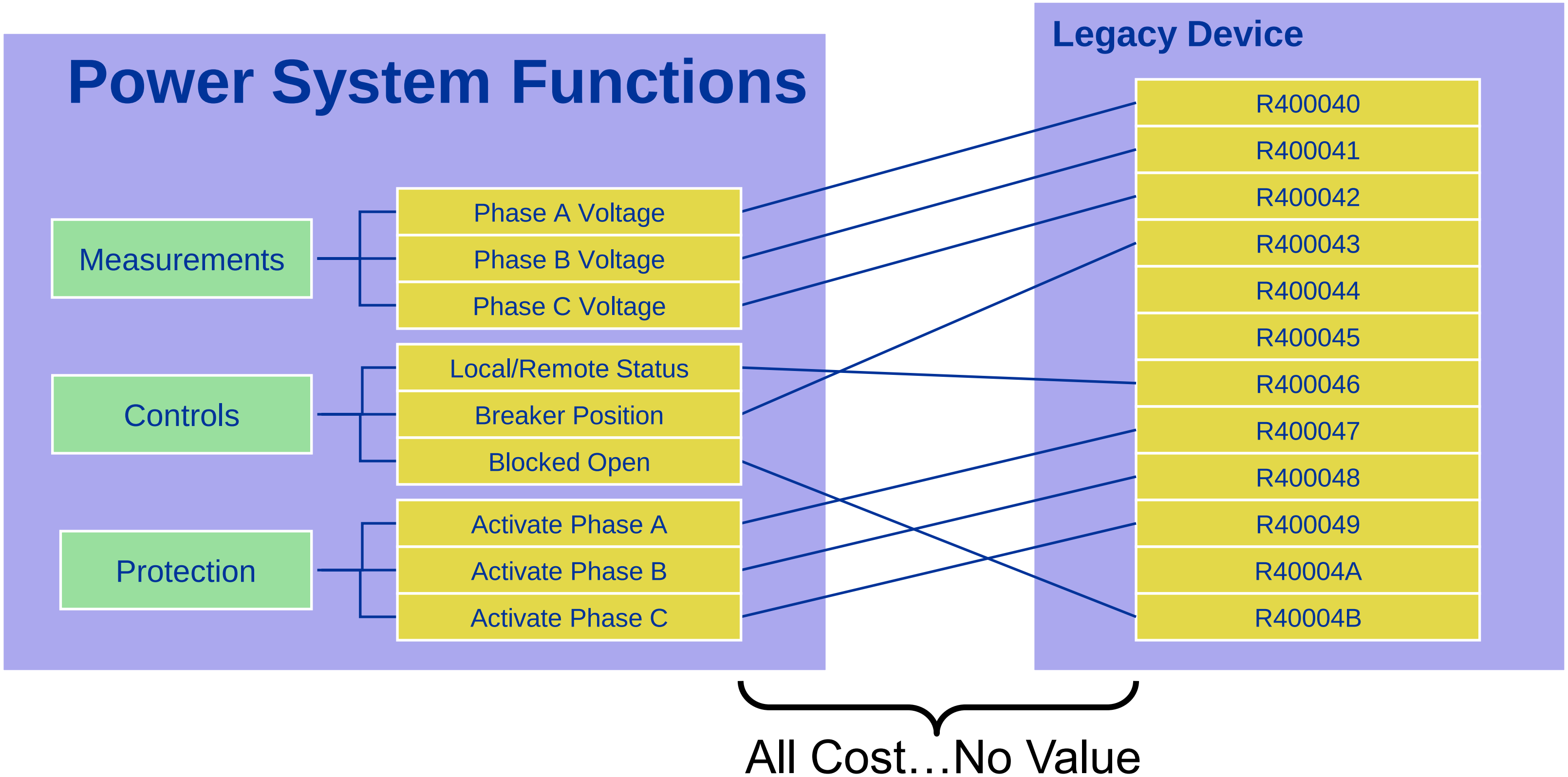
Legacy Object Mapping

- Legacy data objects must be mapped to power system for each different device, application, and vendor.



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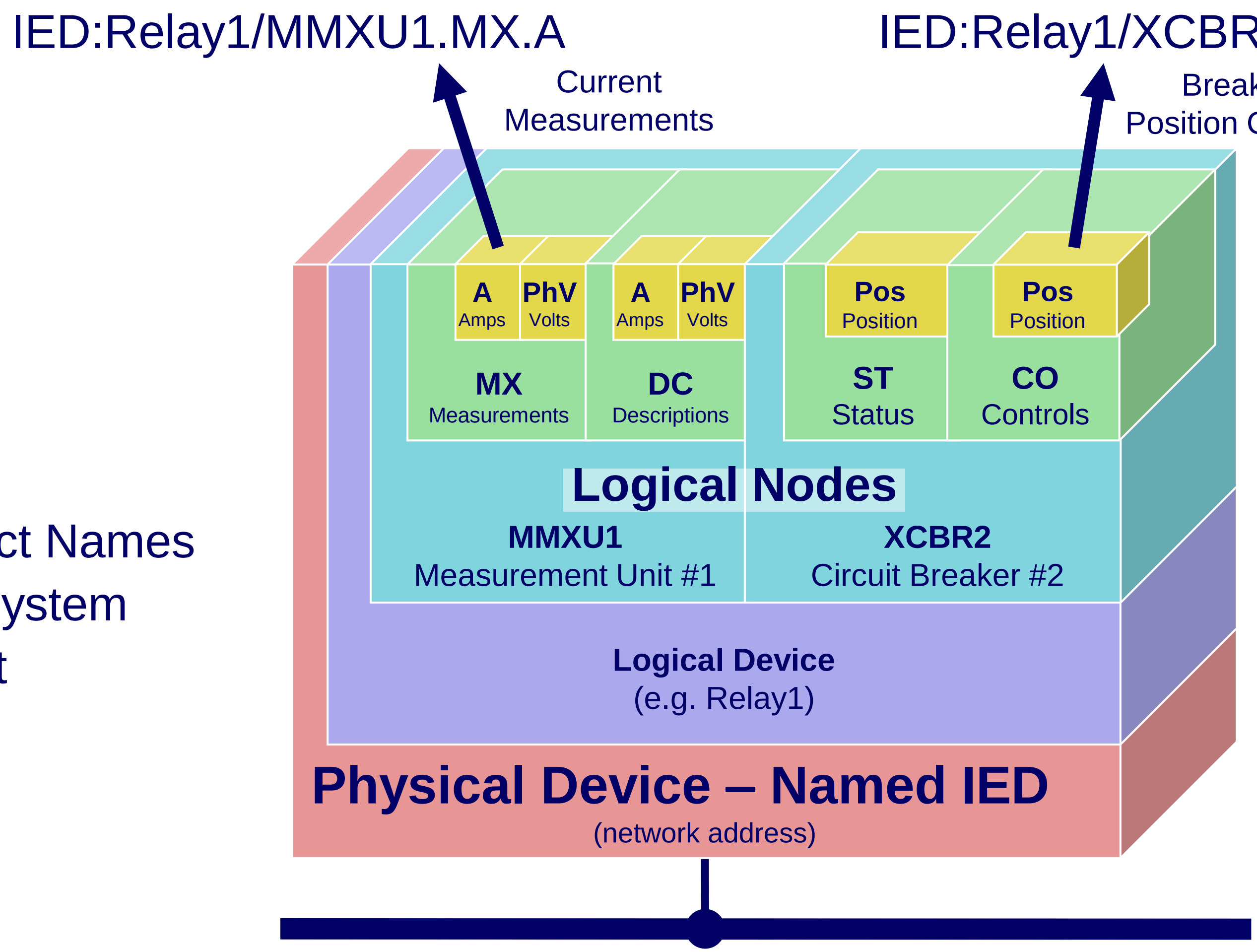
IEC61850 Object Model



IEC 61850 Object Names
Use Power System
Context

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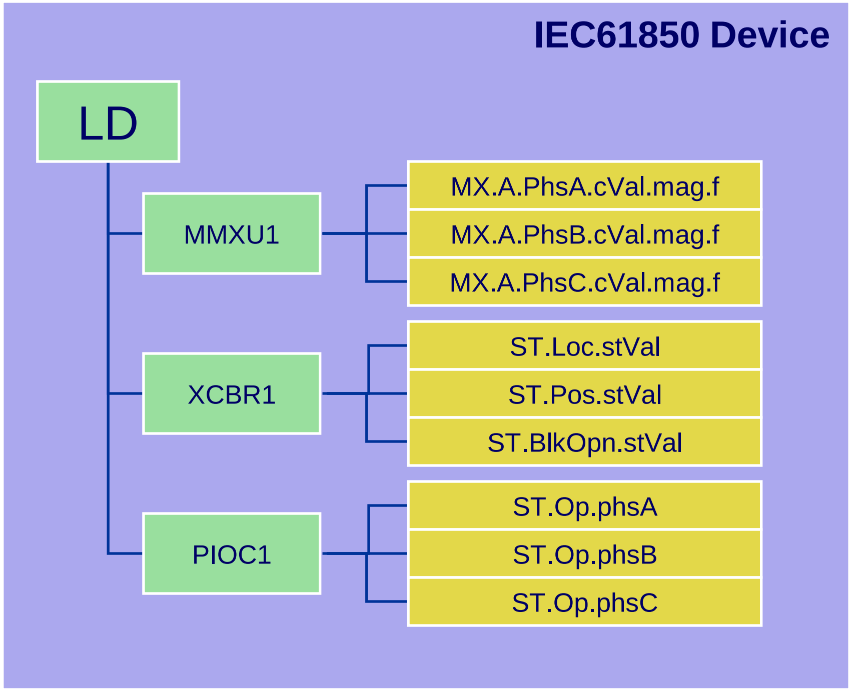
IEC 61850 Object Mapping

- **NO MANUAL MAPPING NEEDED**: IEC61850 objects already portray the power system context.



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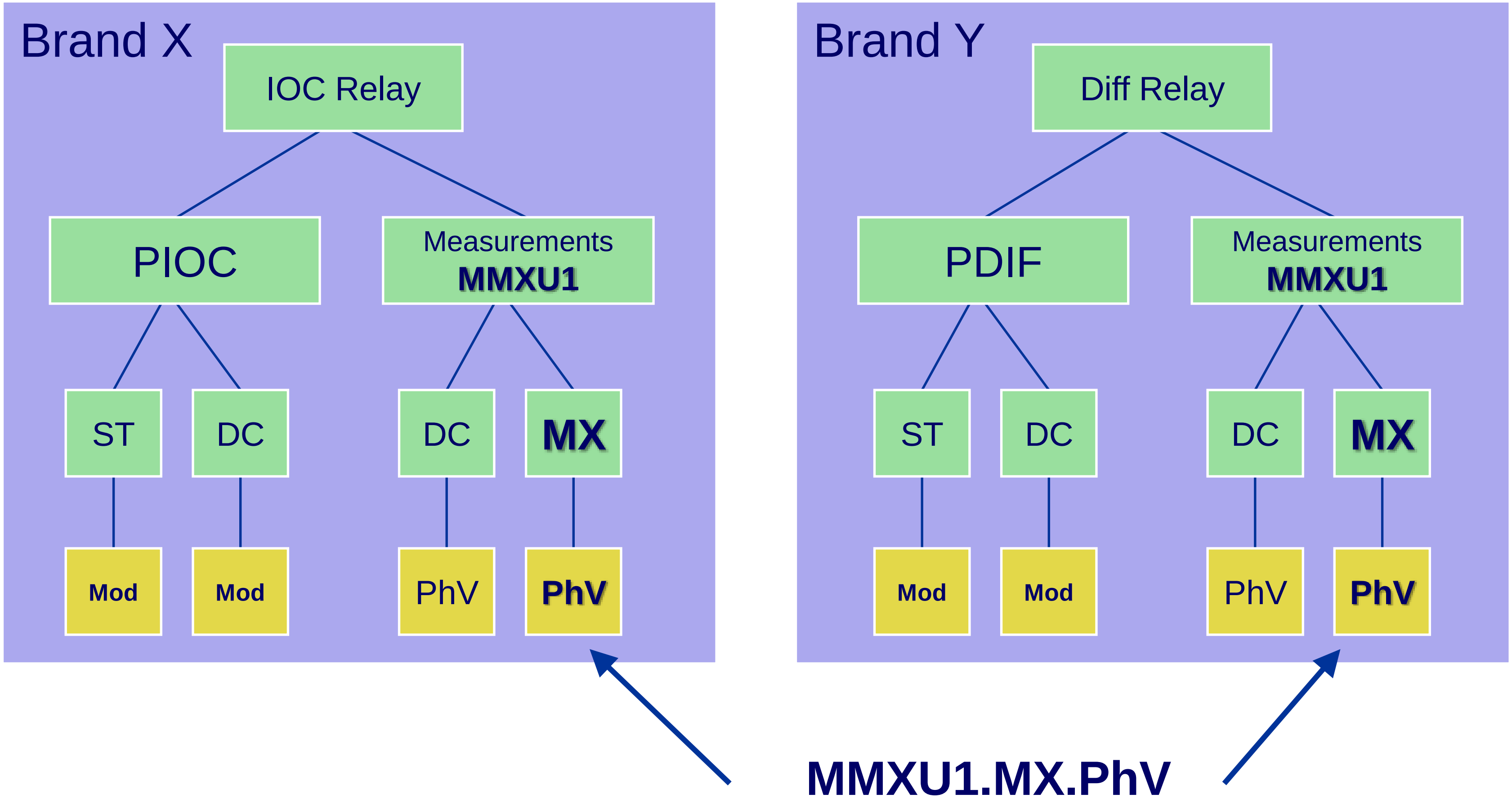
IEC61850 Models Independent of Function and Brand



IEC61850 Name for Phase-to-Ground Voltage Measurements

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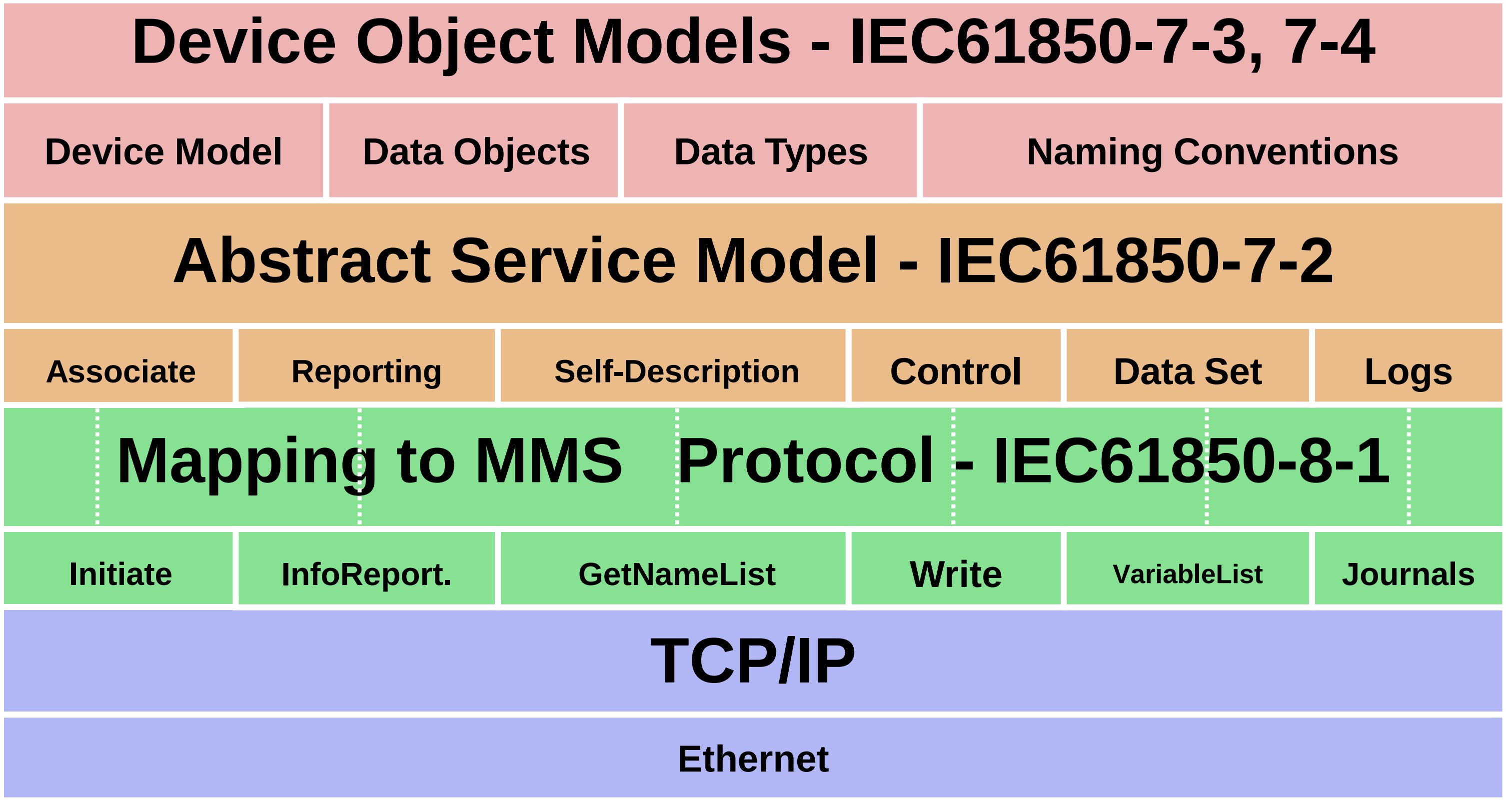
IEC61850 – Layered Standard



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Benefits of Abstraction and Layering

- Abstract models are independent of the protocol and can be used outside of protocol applications (SCADA tag naming convention)
- Enables definition beyond just the bytes on the wire to incorporate naming and behavior
- Each layer can be optimized independently
- Enables protocols to be separated from application functions to enable use of existing standards (Ethernet, TCP/IP, etc.)
- Enables use of the abstract concepts to other protocols/systems in the future as technology changes.

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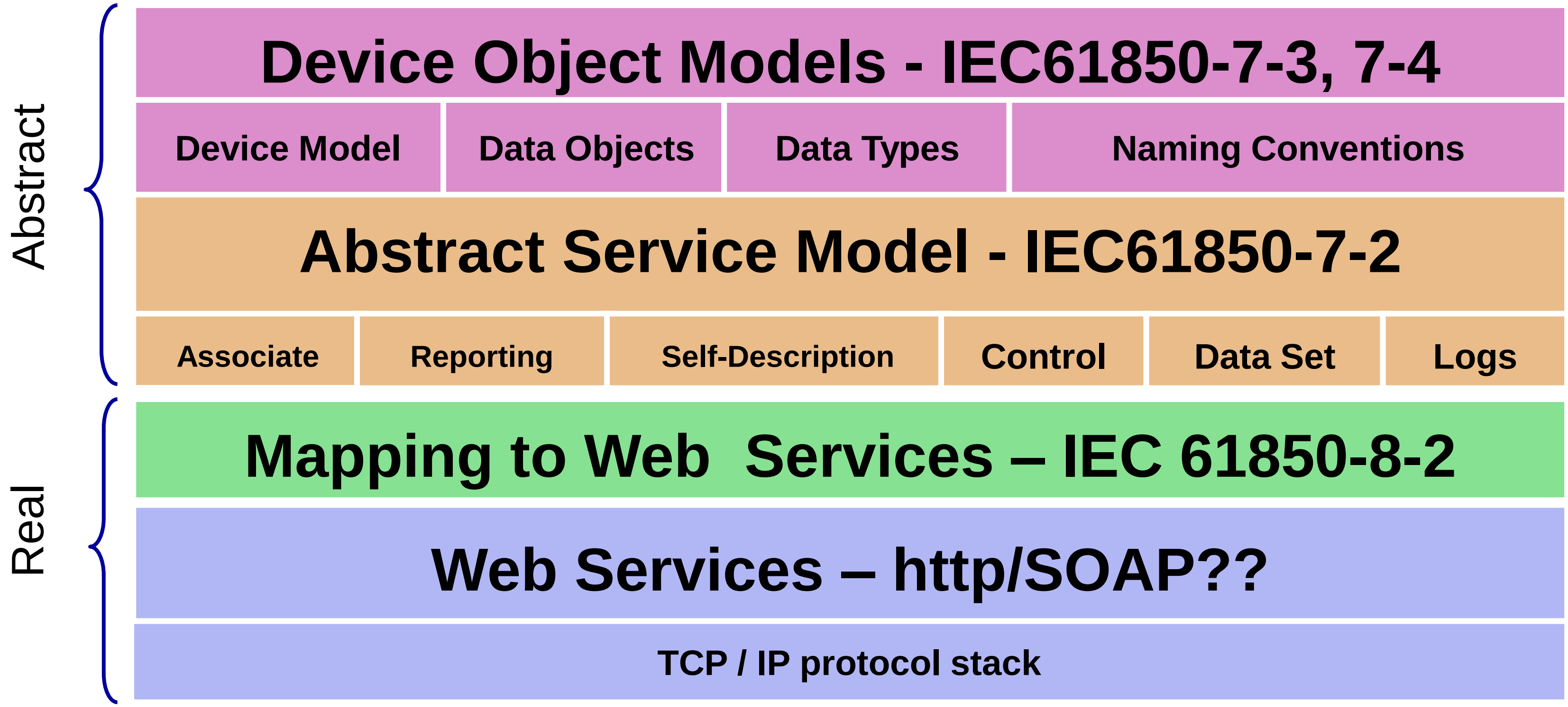
Other Mappings Possible



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What is ICCP?

The Intercontrol Center Communications Protocol (ICCP) is an international standard (IEC60870-6 TASE.2) for the real-time exchange of SCADA data between control centers and external organizations like other utilities, power pools, and power plants.

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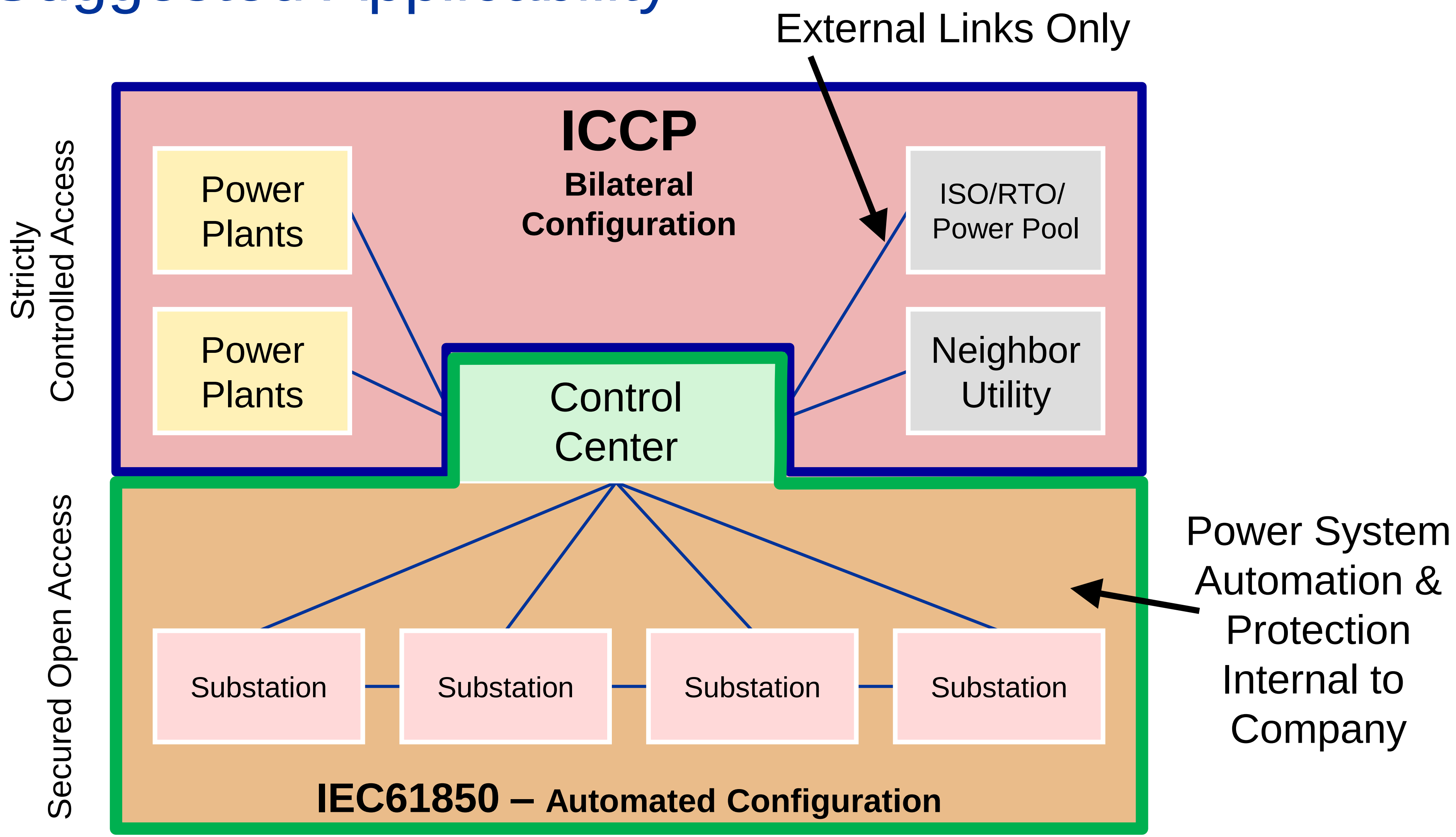
Suggested Applicability



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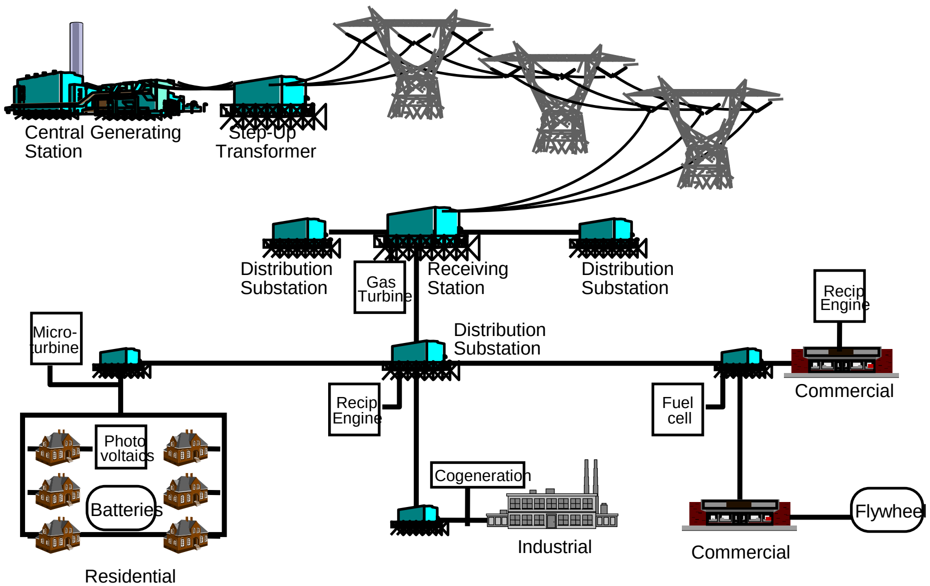
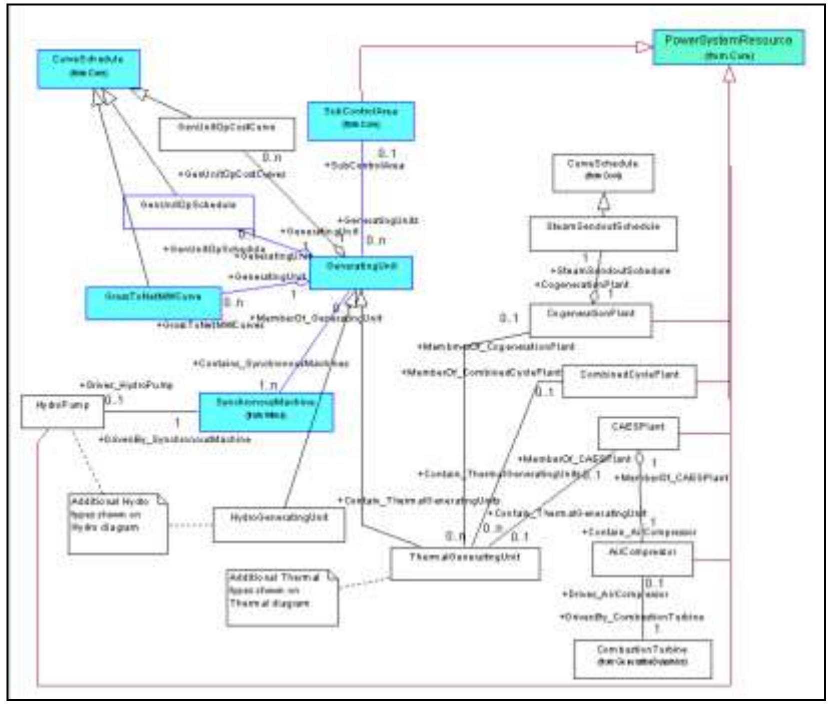
Common Information Model (CIM) is an object-oriented information model of the power system





UML – Unified Modeling Language

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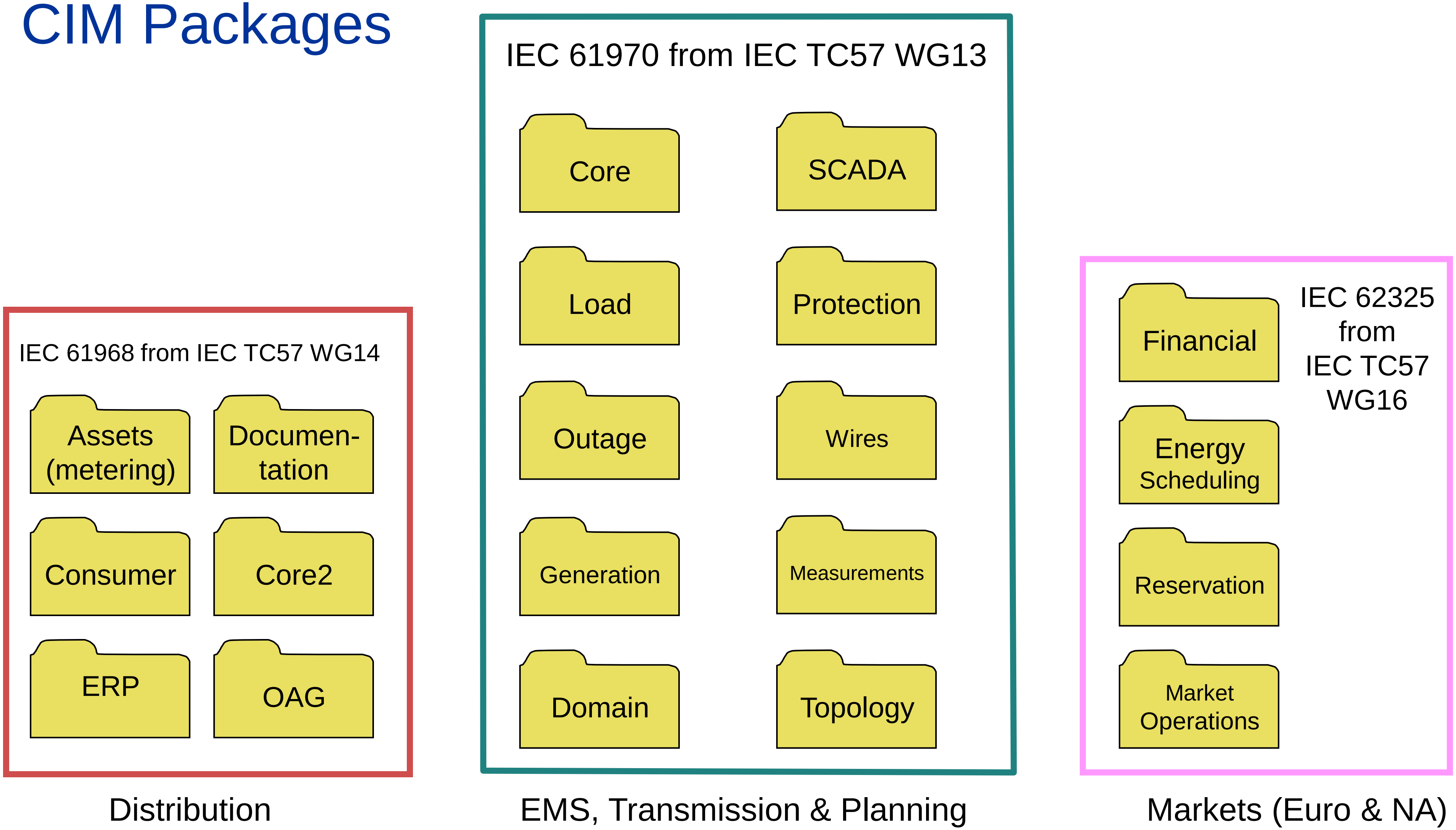
CIM Packages



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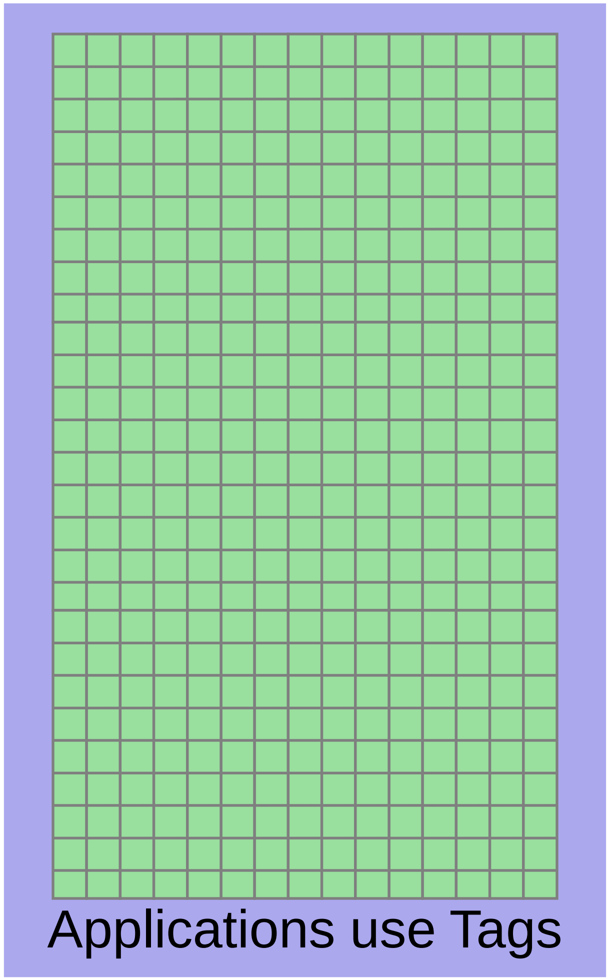
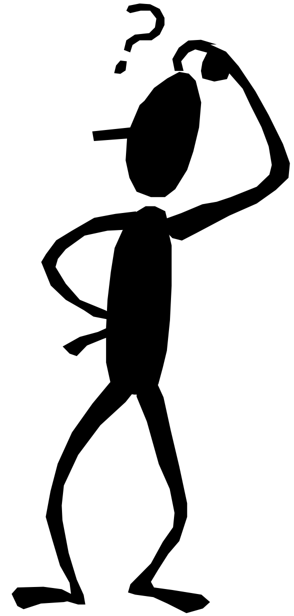
The Legacy Data Model Has Always Worked





Why do I want the “complexity” of the CIM and all this modeling stuff? Tags are simple!

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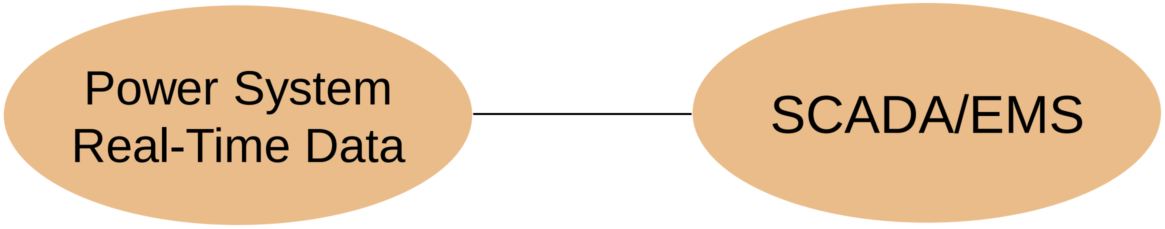
The Problem to be Solved?



A "one-off" point to point link will always be cheaper if the cost to integrate in the future is ignored.

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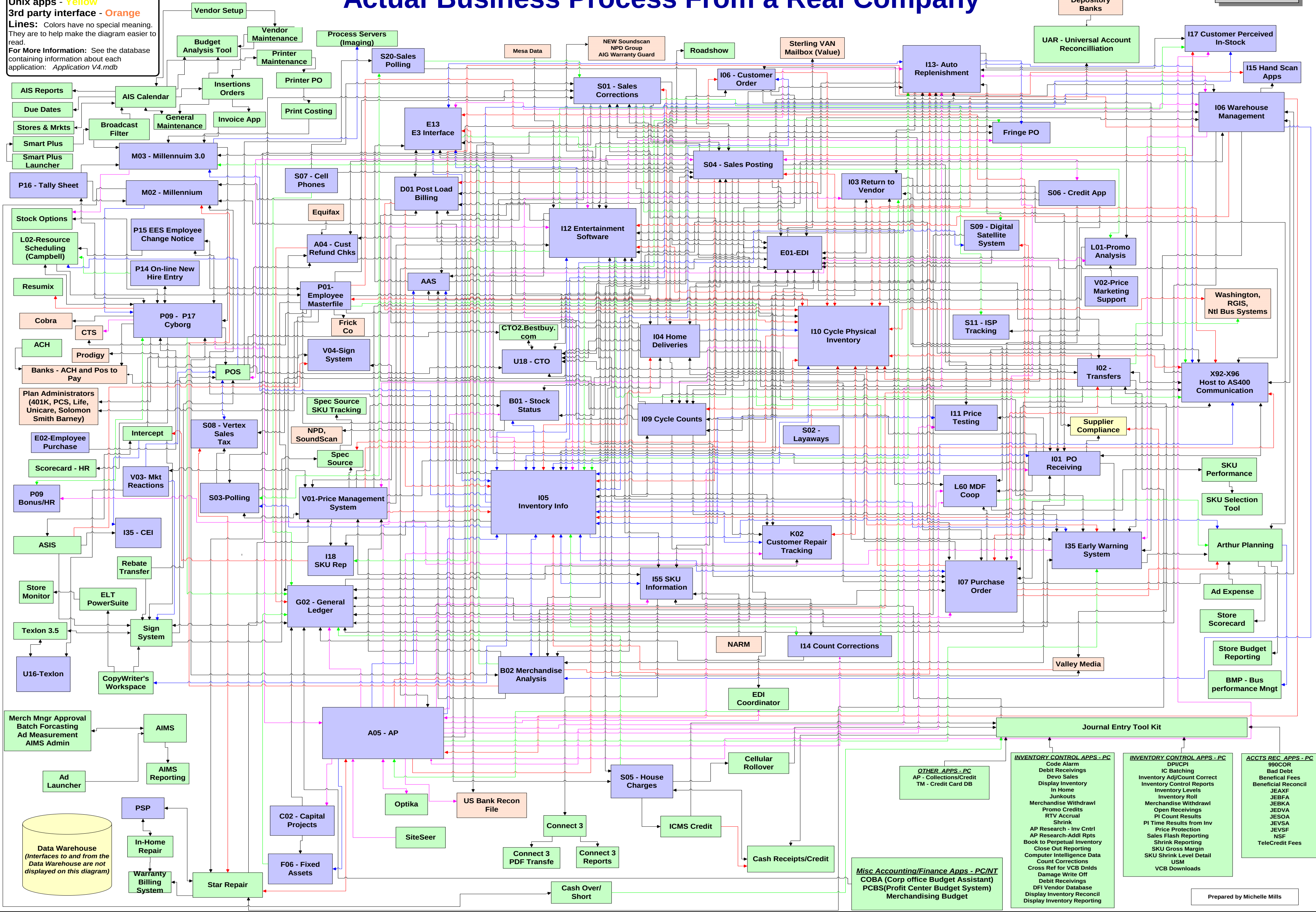
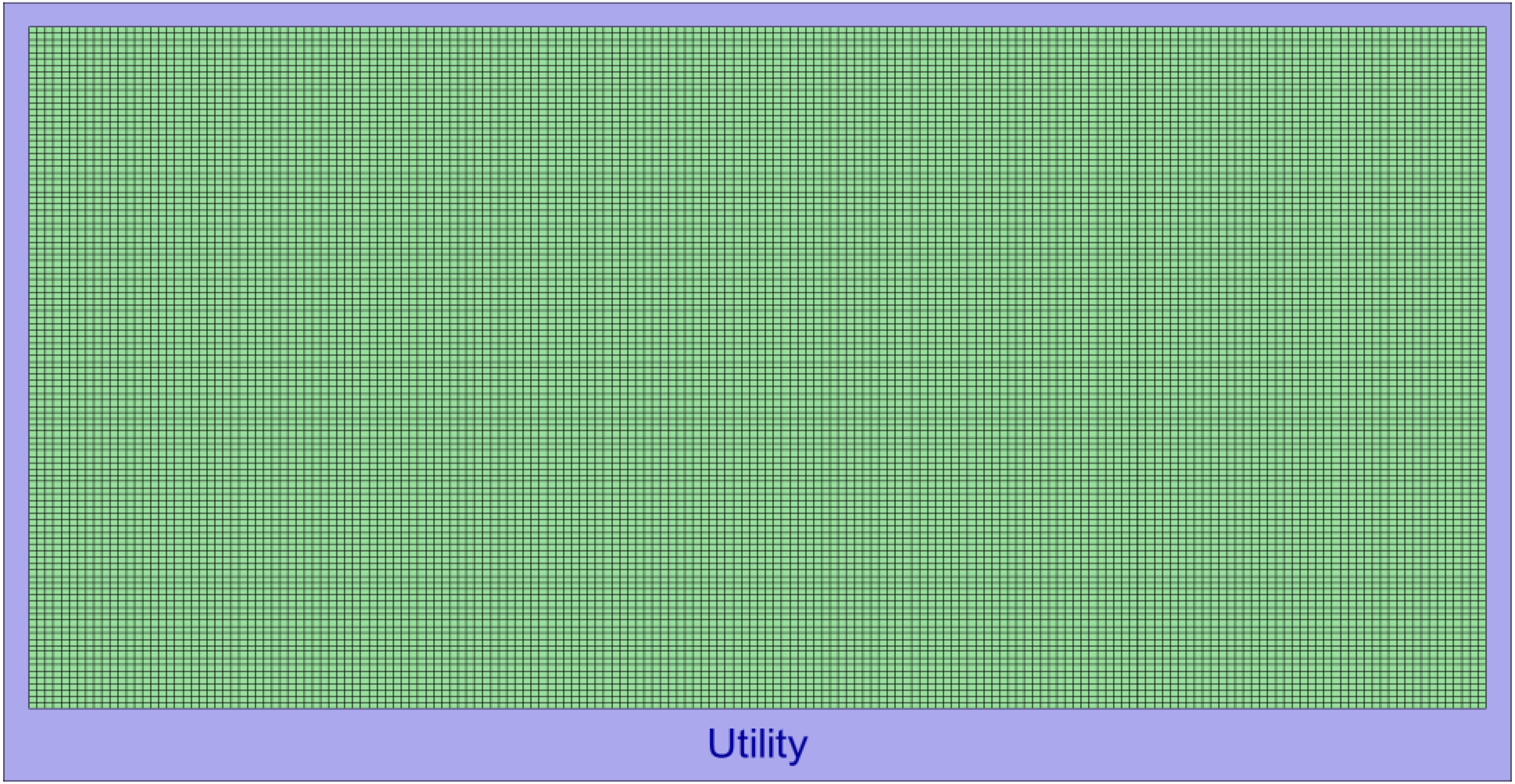
Actual Business Process From a Real Company

Mainframe apps - Blue
PC/NT apps - Green
Unix apps - Yellow
3rd party interface - Orange
Lines: Colors have no special meaning. They are to help make the diagram easier to read.
For More Information: See the database containing information about each application: *Application V4.mdb*



Prepared by Michelle Mills

Scale The Legacy Data Model Up to the Smart Grid



If it takes 15 seconds to configure a tag, it would take 26 man-years to configure 2M meters!

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CIM versus IEC 61850: What they define

CIM

- Detailed Power System Topology
- Asset Model
- Consumer and load models
- Financial
- Scheduling and transactions
- Market operations
- Work management
- SCADA and Measurements
- GIS – Location
- Business Messaging (WG14)
- Interface Services (GID)

IEC 61850

- Power System Topology Model
- Device Configuration Description
- Device Models
- Service Models
  - Reporting
  - Controls
  - Protection
- Performance/Requirements
- Object and Data Naming Conventions
- Protocols

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CIM versus IEC 61850: What they define

CIM	IEC 61850
• Detailed Power System Topology	• Power System Topology Model
• Asset Model	• Device Configuration Description
• Consumer and load models	• Device Models
• Financial	• Service Models ▪ Reporting ▪ Controls ▪ Protection
• Scheduling and transactions	
• Market operations	
• Work management	• Performance/Requirements
• SCADA and Measurements	• Object and Data Naming Conventions
• GIS – Location	• Protocols
• Business Messaging (WG14)	
• Interface Services (GID)	

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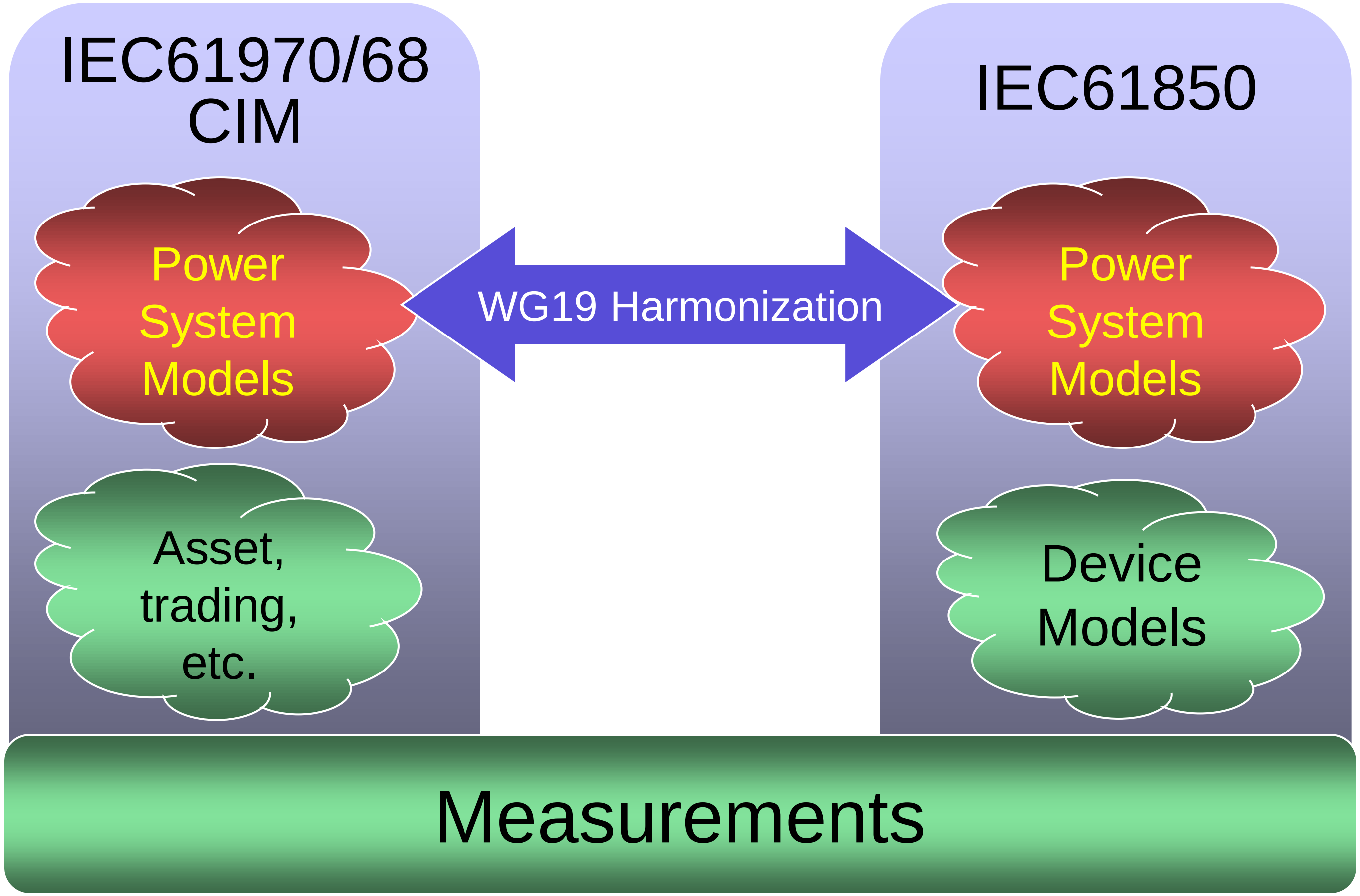
CIM Asset-Power System Models & IEC 61850 Device Models



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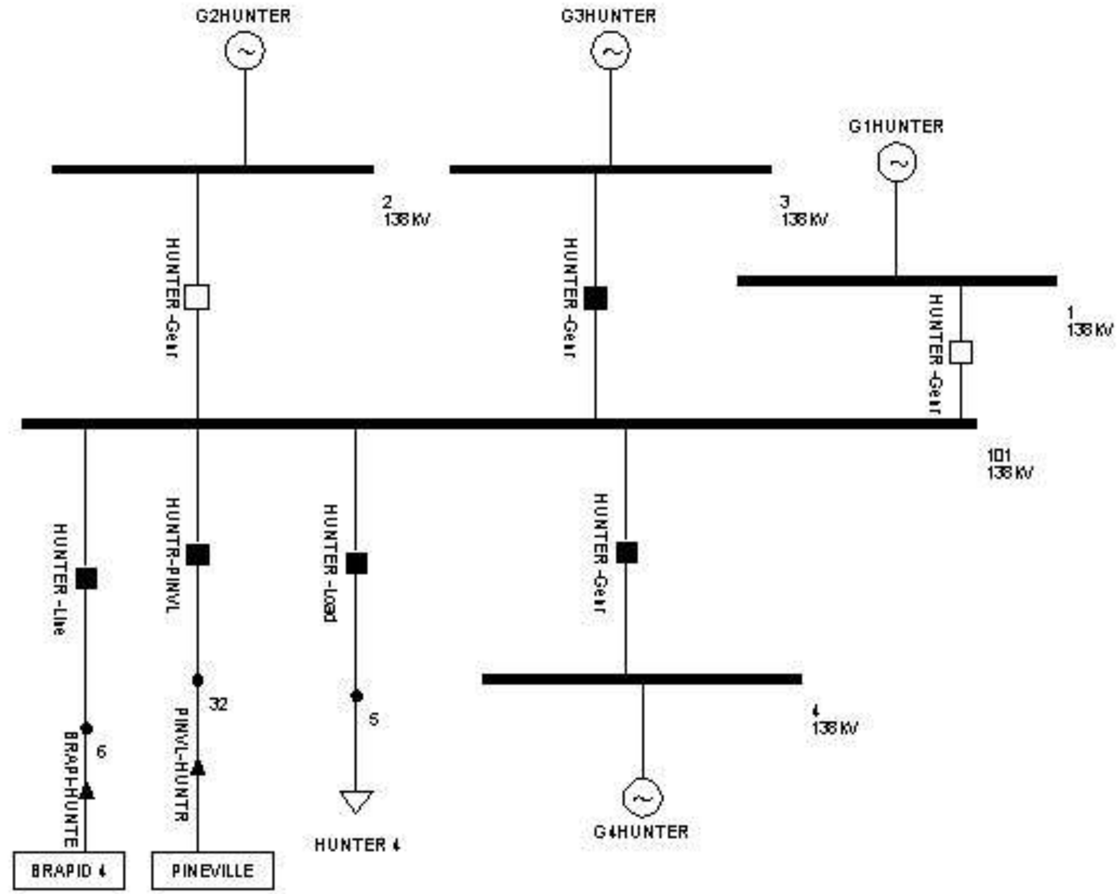
CIM Based Modeling Tool



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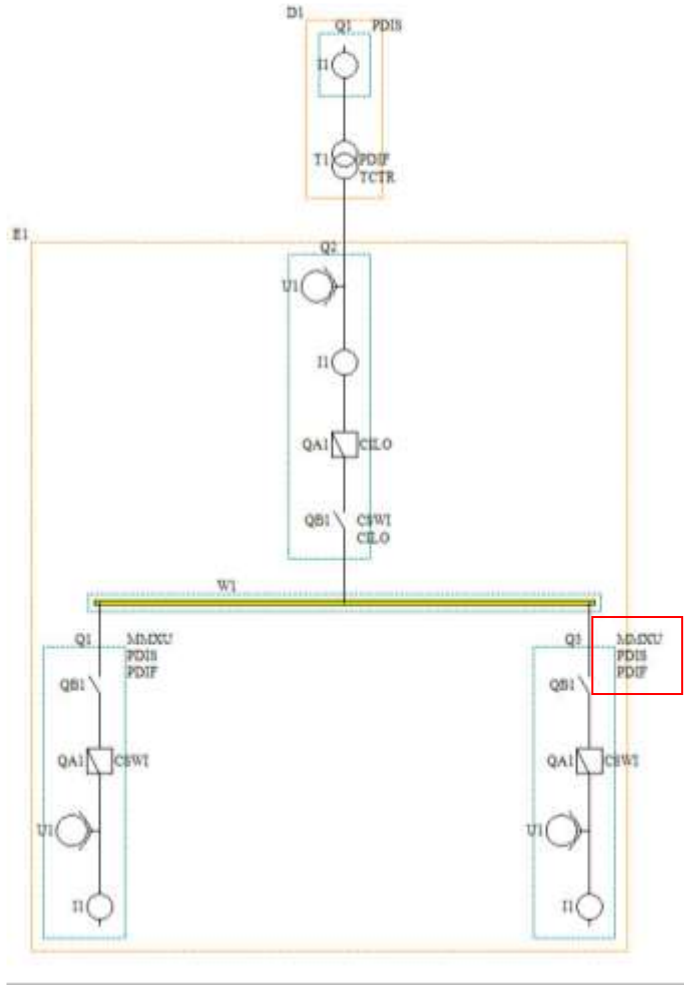
IEC 61850 Based Modeling Tool (SCL)



Logical Node Designators

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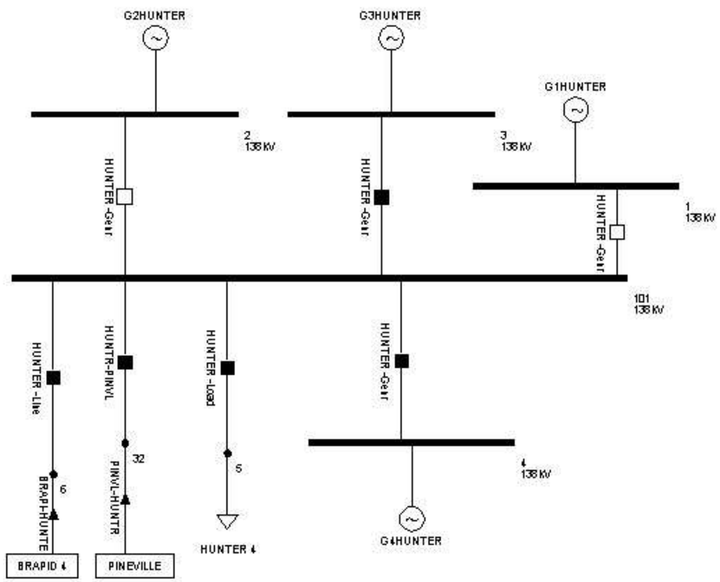
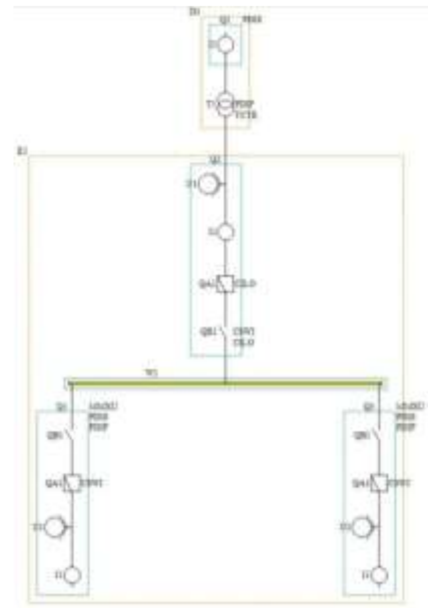
Two Different Purposes – Two Solutions are OK, BUT





- Detailed system wide description
- Model exchange for high-level systems
- Power flow, state estimation, etc.
- Market operations
- Planning and system design

- Substation design and modeling
- Device configuration management
- Protection and device control
- SCADA, protection, & control data exchange

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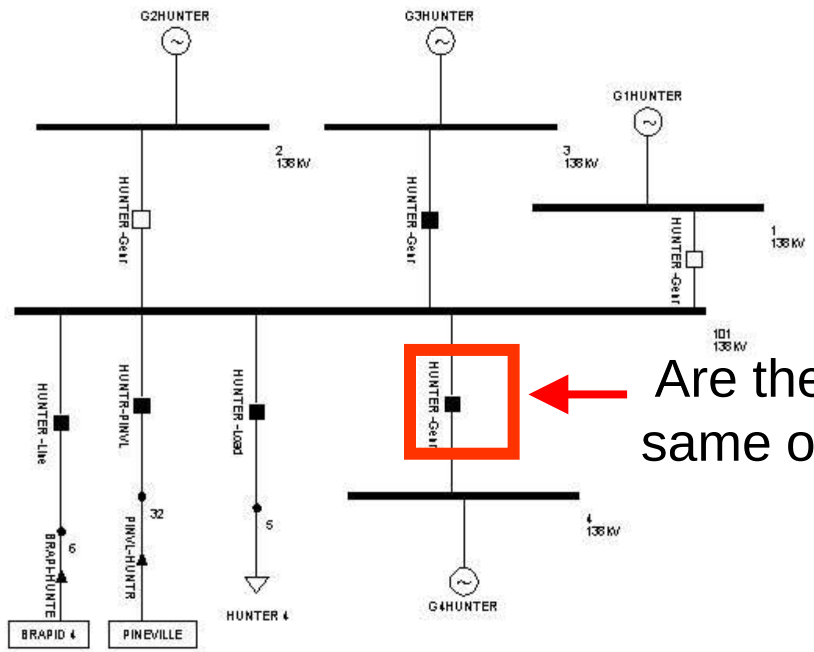
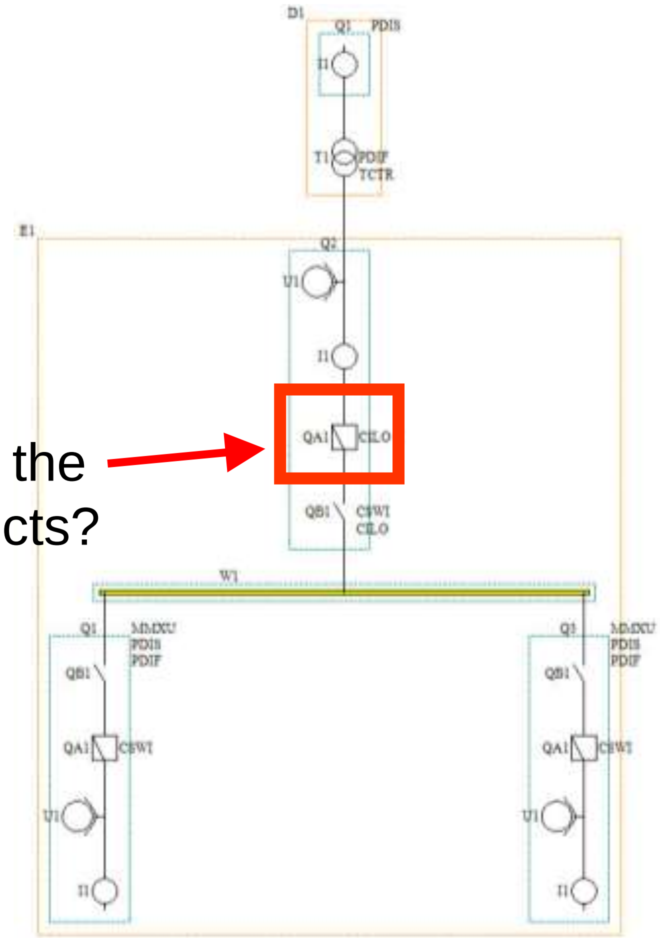
CIM and IEC 61850 Difference in Topology



IEC 61970-301 EMS Diagram

Are these the same objects?



IEC 61850-6 SCL Diagram

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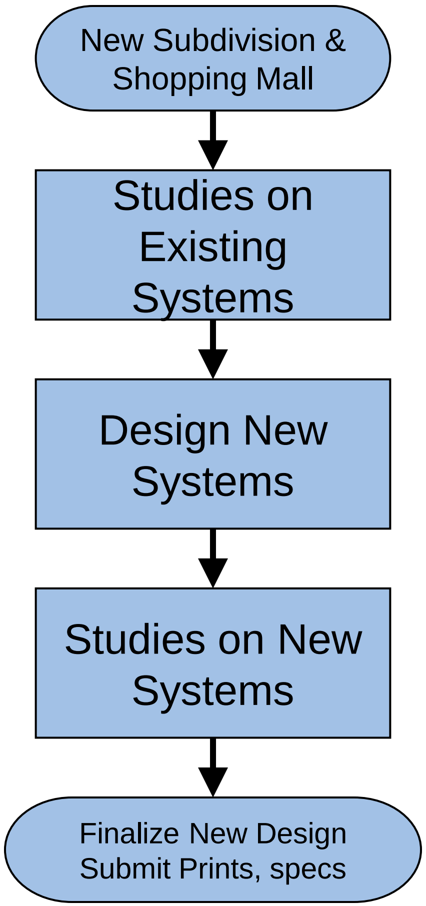
Simplified Planning Process



- Well defined processes and tools for designing new power system extensions, simulating their impact, defining new contingencies, etc.

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Moving Design to Operations

- CIM has improved the ability to move models from planning to operations (and vice-a-versa) in a multi-vendor environment.
  - To be expected through use of standards.
  - Eventually enable wide exchange of planning models like ENTSO-E
- EMS and planning already use a set of tools that have been harmonized to enable the flow of information between them.

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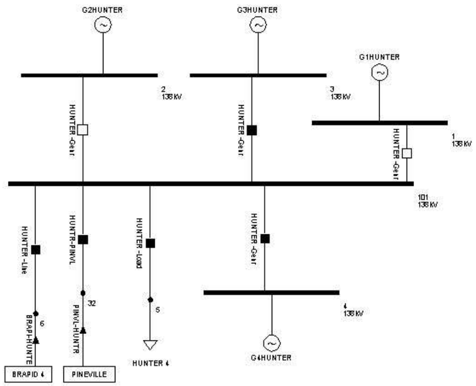
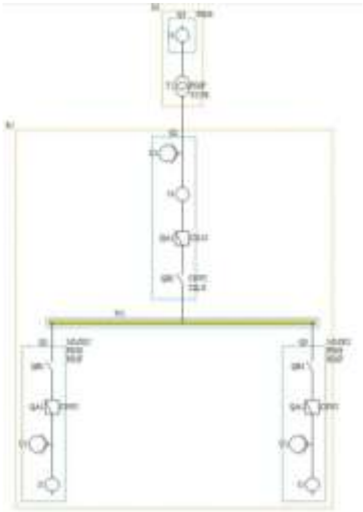
Moving Design to Substations





Substation engineers use a completely different set of tools supporting a completely different set of standards to define the substation automation and protection systems.

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It’s About Productivity

- The effort and knowledge put into the planning and operations models that isn’t embodied in the one-line diagrams is lost and has to be transferred manually into the substation design through the engineering process duplicating previous effort.
- If the tools used a common set of standards the flow of information can be automated enabling topology, SCADA, protection, communications, settings, etc. to be preserved and leveraged through the engineering process.

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The Engineering Process of IEC 61850-4

Beyond the protocol to dramatically improve the effectiveness of designing, building and testing power automation systems.

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Why is IEC 61850 Different?

If adapted fully from engineering to operations, IEC 61850 (and the model-driven) approach is a new process for power system automation and engineering that is designed to dramatically improve the productivity of engineering, implementation, and maintenance of power automation systems.

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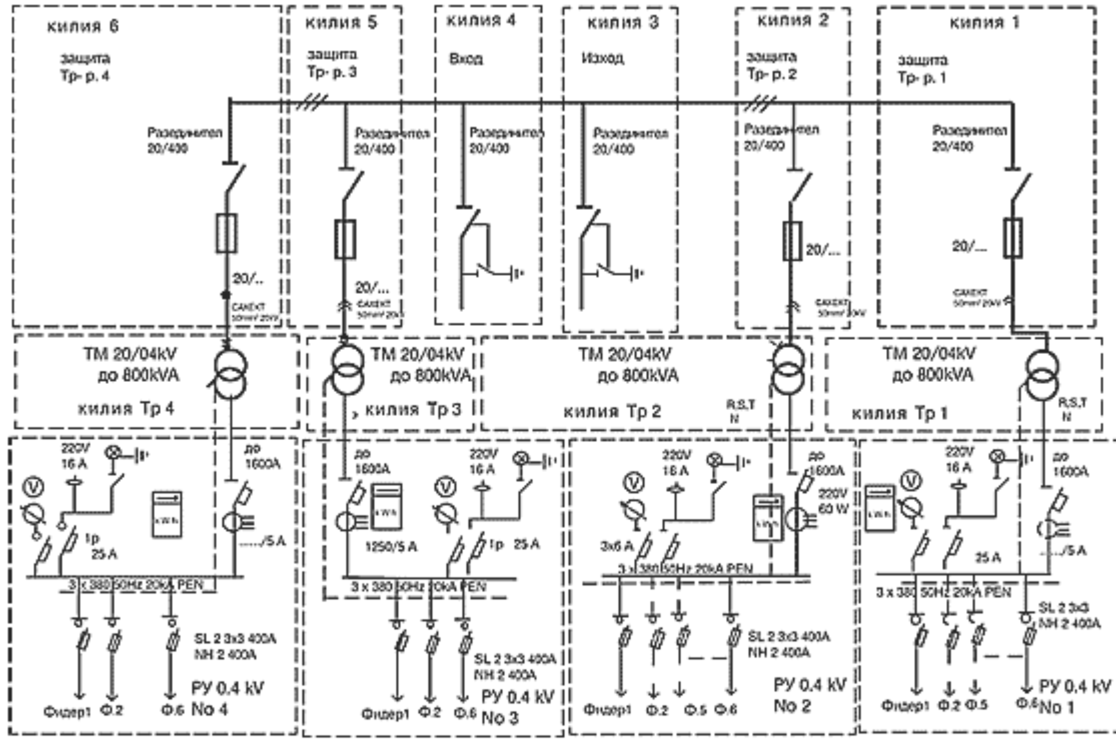
The IEC 61850-4 Engineering Process

It starts with a power system design



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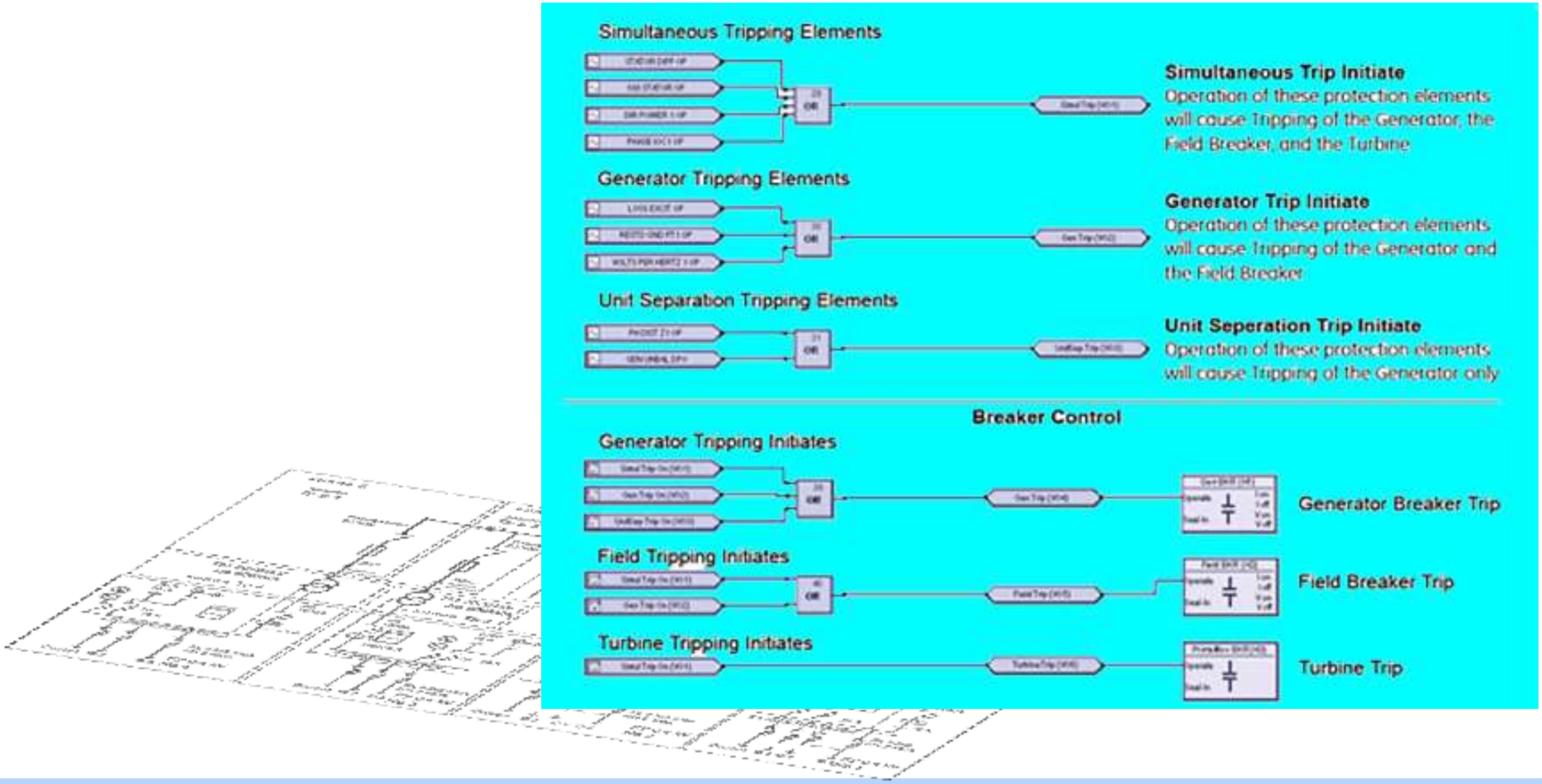
The IEC 61850-4 Engineering Process

The automation and protection functions are defined



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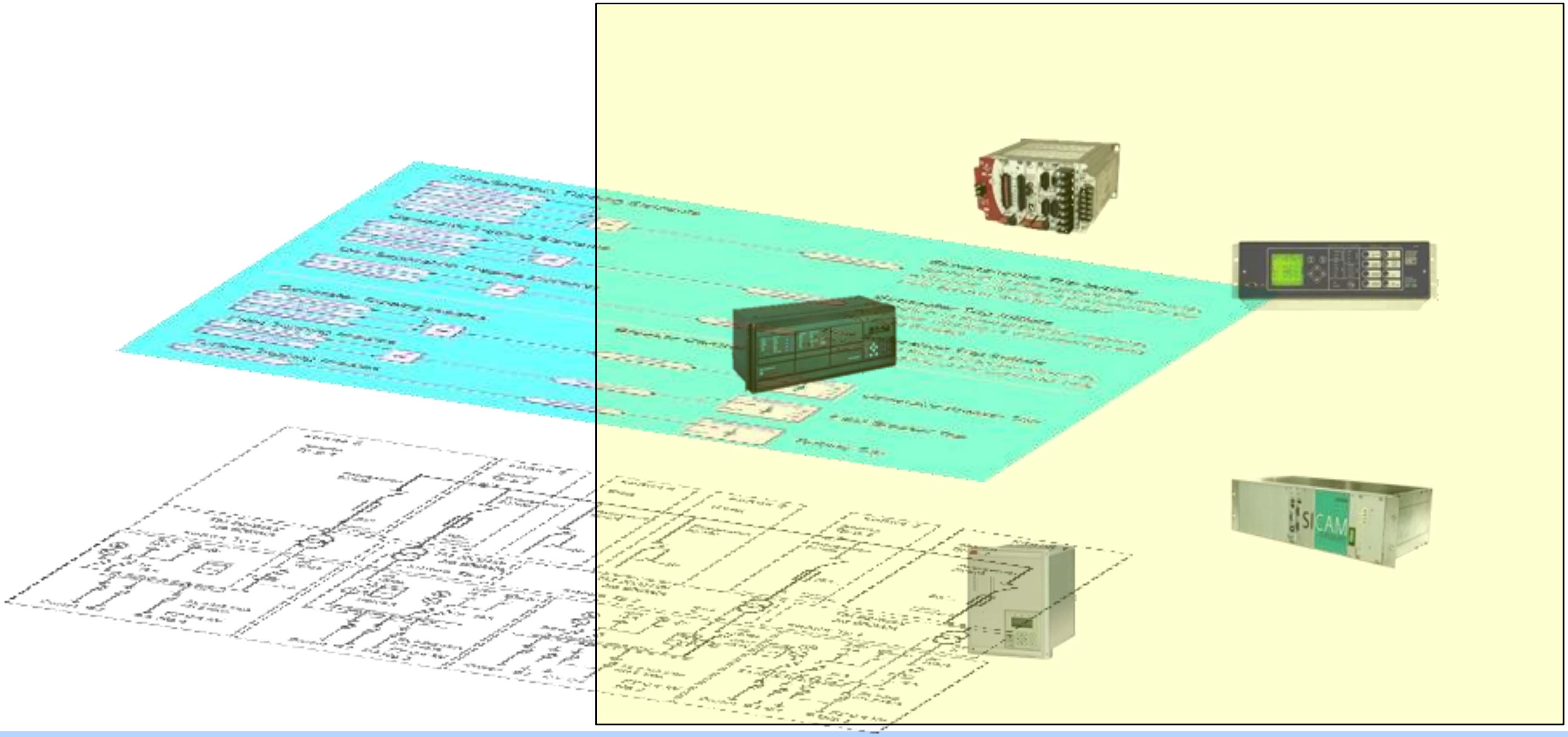
The IEC 61850-4 Engineering Process

IEDs are selected and configuration and programming is defined



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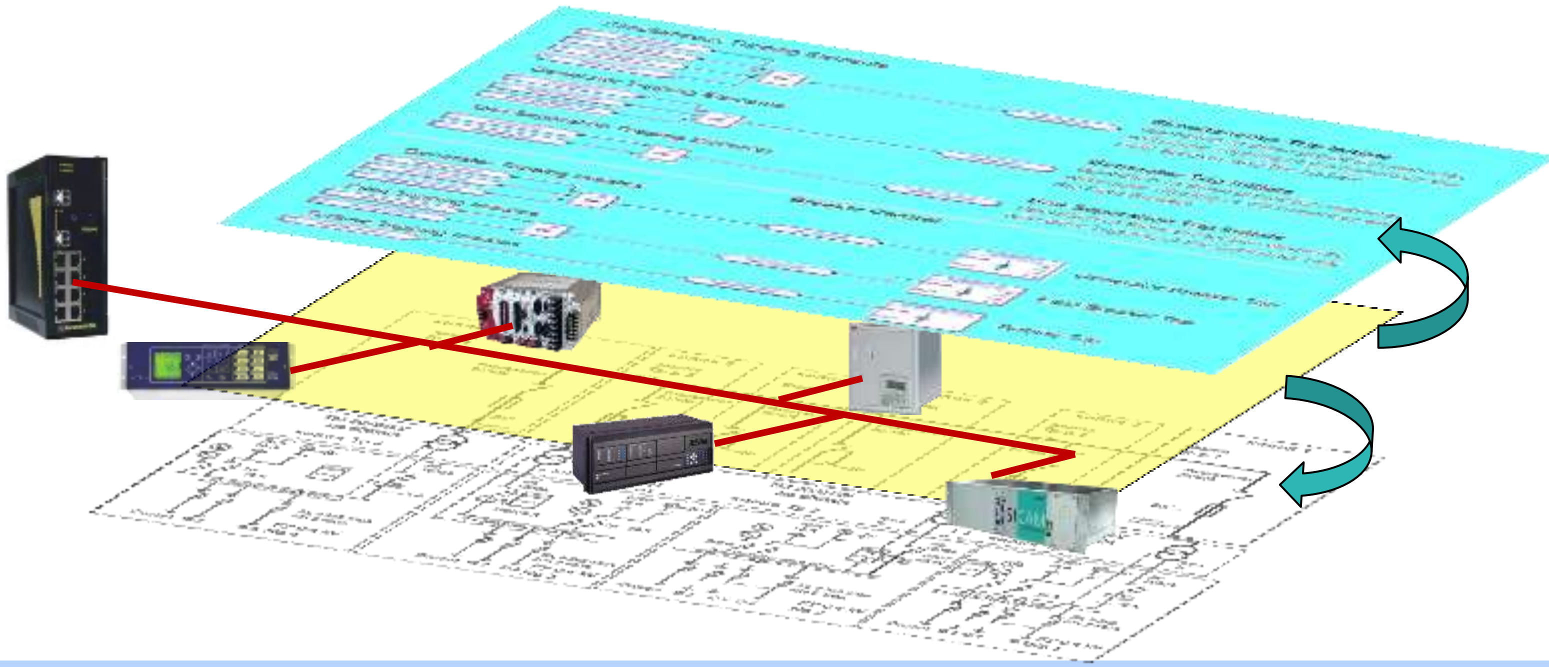
The IEC 61850-4 Engineering Process

The IEDs are tied together via the network to integrate the power system automation and protection functions



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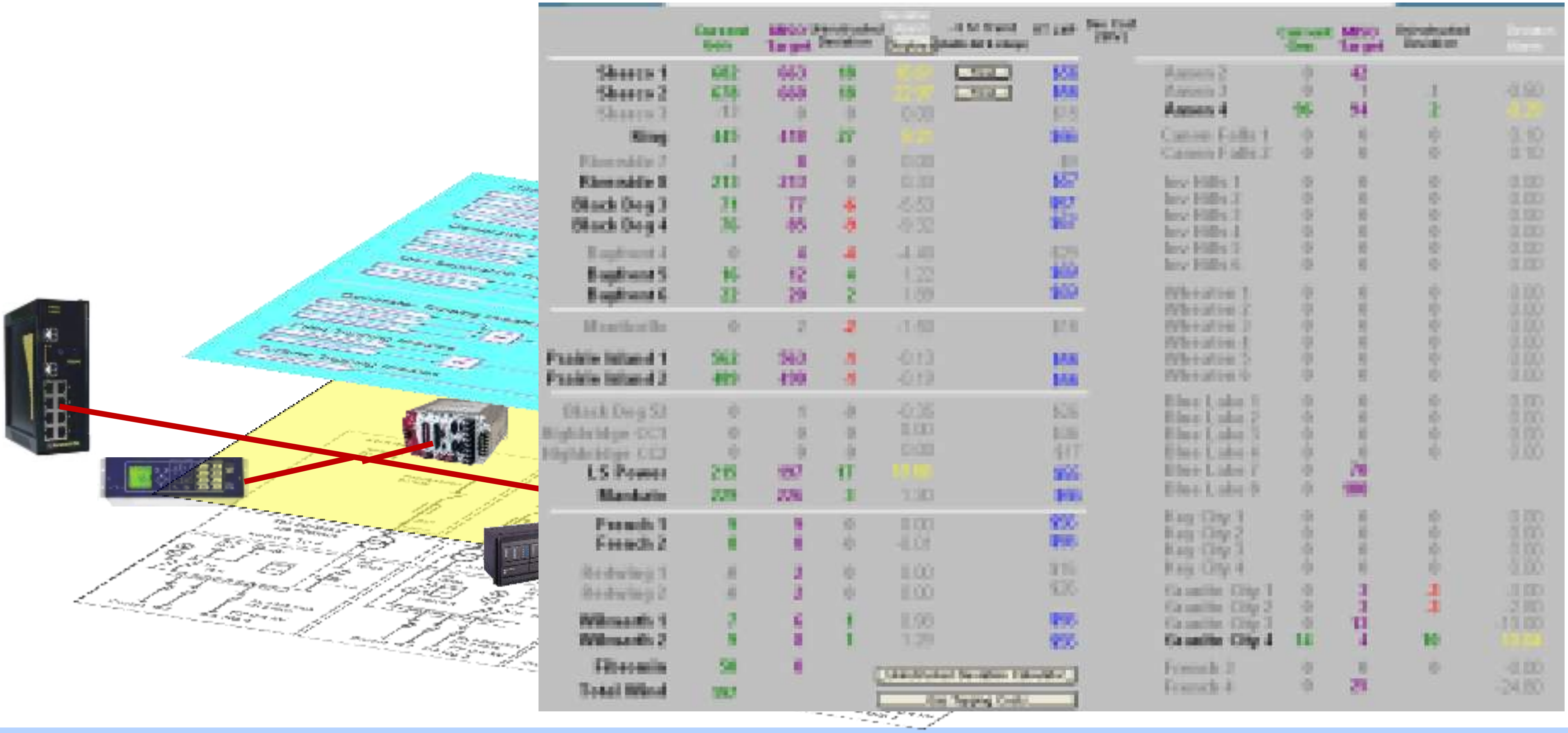
The IEC 61850-4 Engineering Process

Monitoring and visualization enables control of the power system



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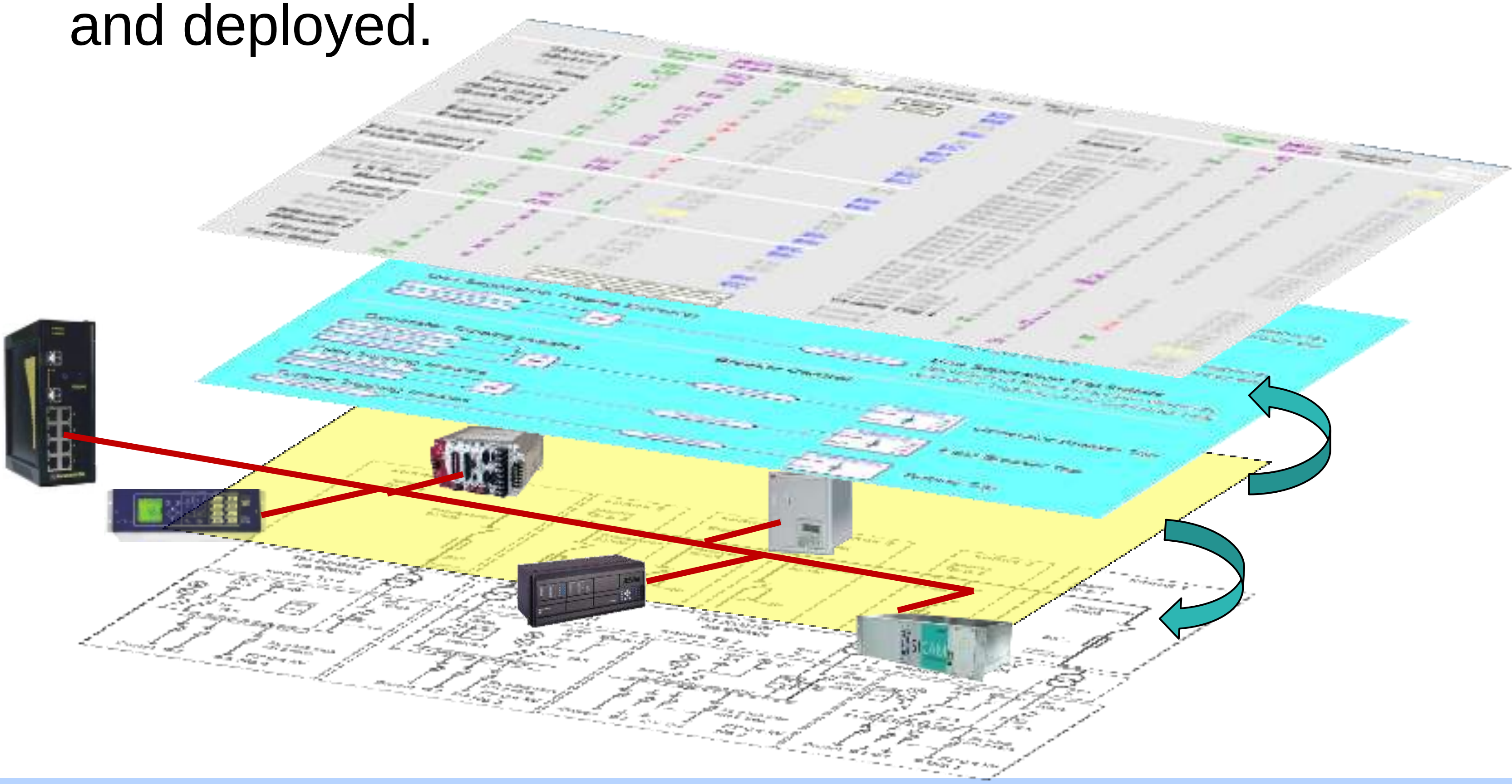
The IEC 61850-4 Engineering Process

The IEC 61850 addresses all aspects of the engineering process that need to be successfully planned, designed, and deployed.



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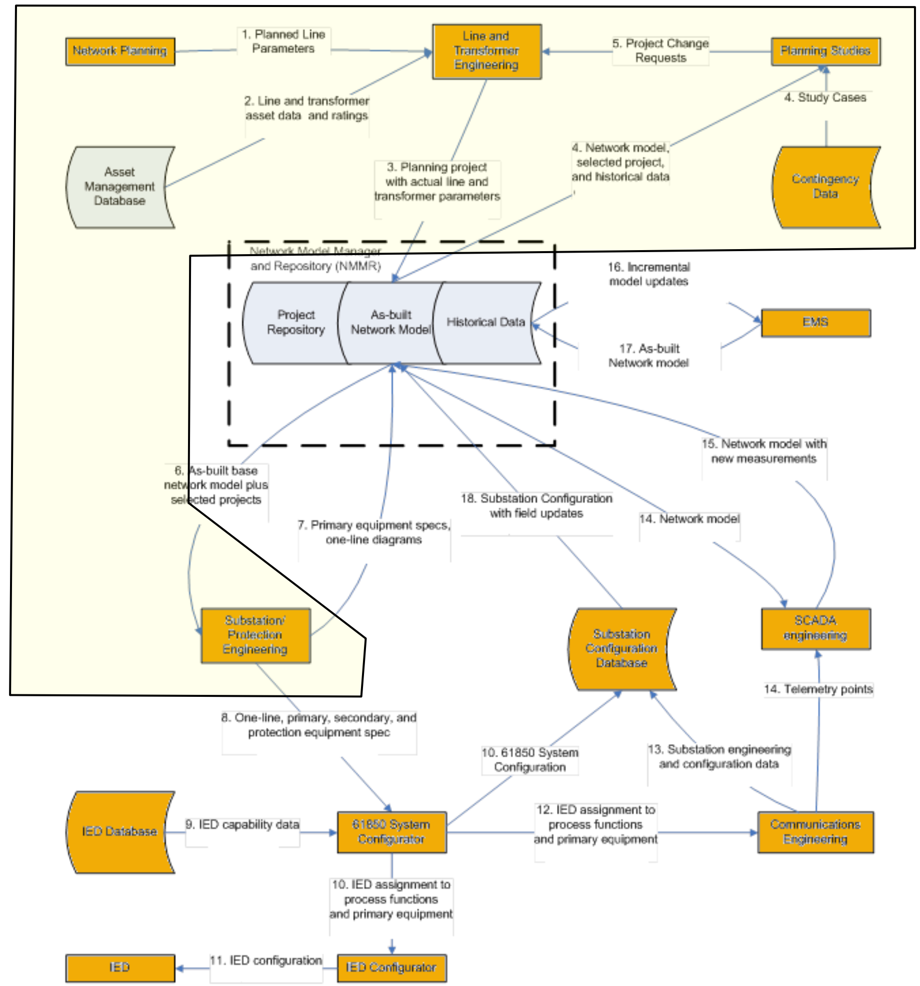
61850 Impacted by all areas of “construction”

The set of utility processes must lead to appropriate:

Power System Resource Selection



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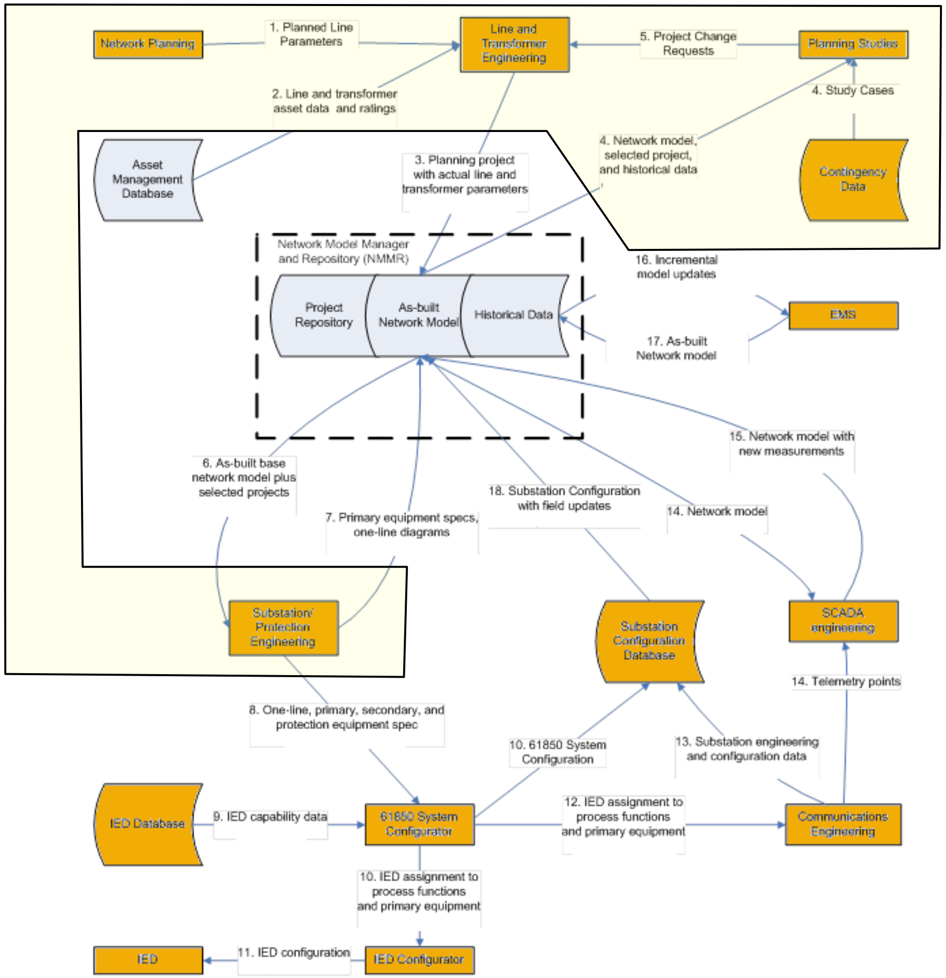
61850 Impacted by all areas of "construction"

The set of utility processes must lead to appropriate:

- Power System Resource Selection
- Power System Topology Design
  - Generates One-lines
  - Rating Information



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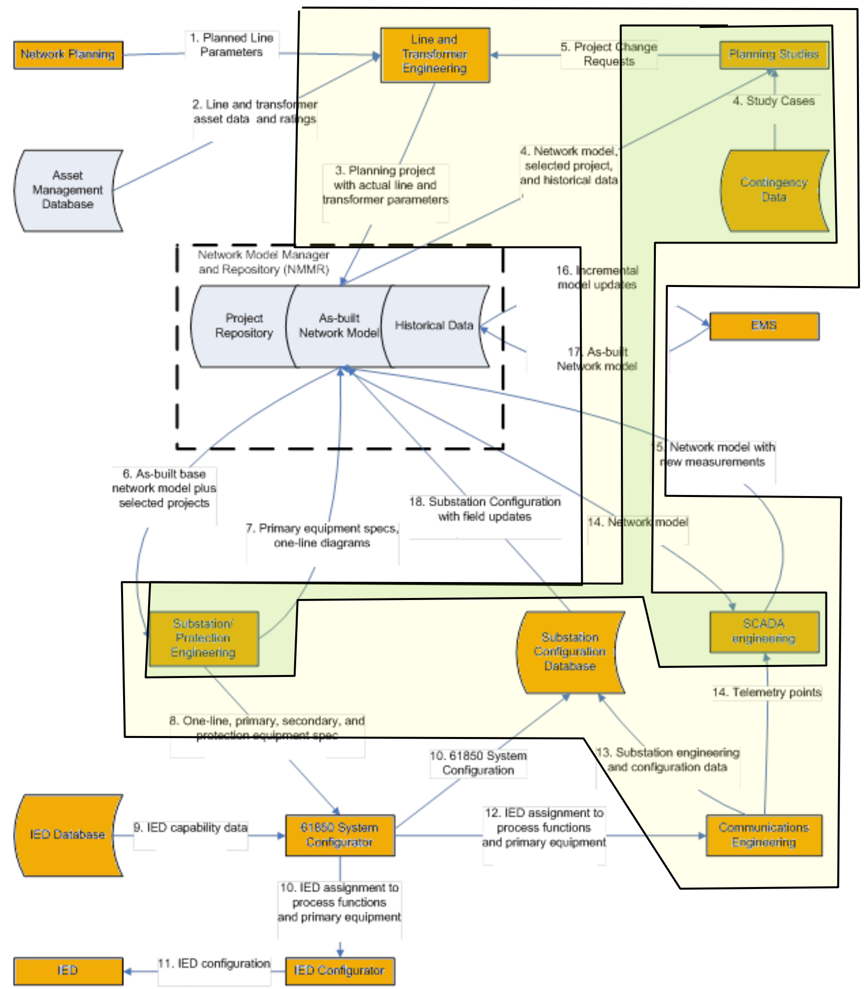
61850 Impacted by all areas of “construction”

The set of utility processes must lead to appropriate:

- Power System Resource Selection
- Power System Topology Design
- IED Selection
  - Automation and Protection Logic



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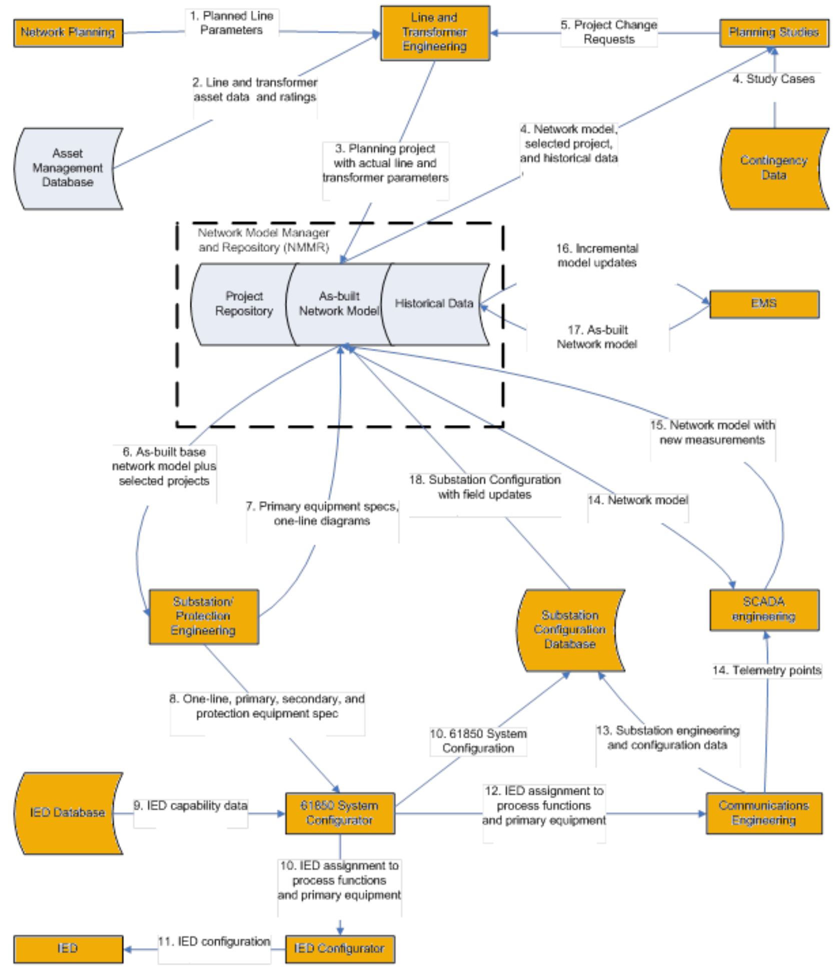
61850 Impacted by all areas of "construction"

The set of utility processes must lead to appropriate:

- Power System Resource Selection
- Power System Topology Design
- IED Selection
- Substation design and wiring



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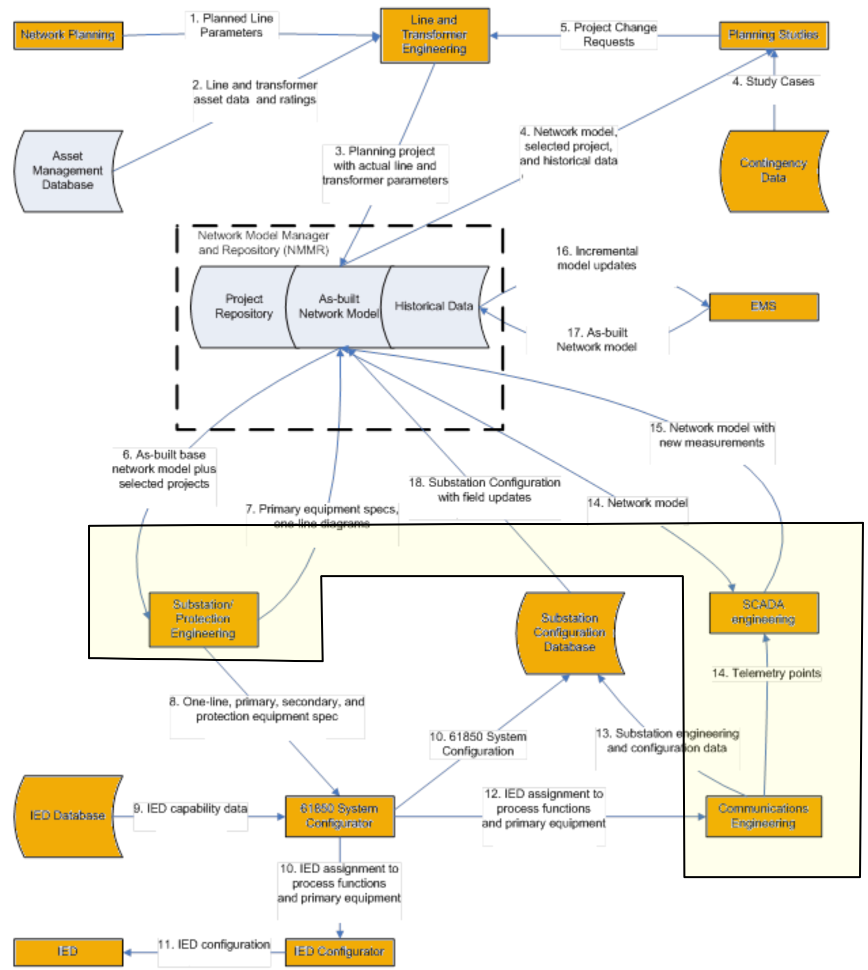
61850 Impacted by all areas of “construction”

The set of utility processes must lead to appropriate:

- Power System Resource Selection
- Power System Topology Design
- IED Selection
- Substation design and wiring
- Communications



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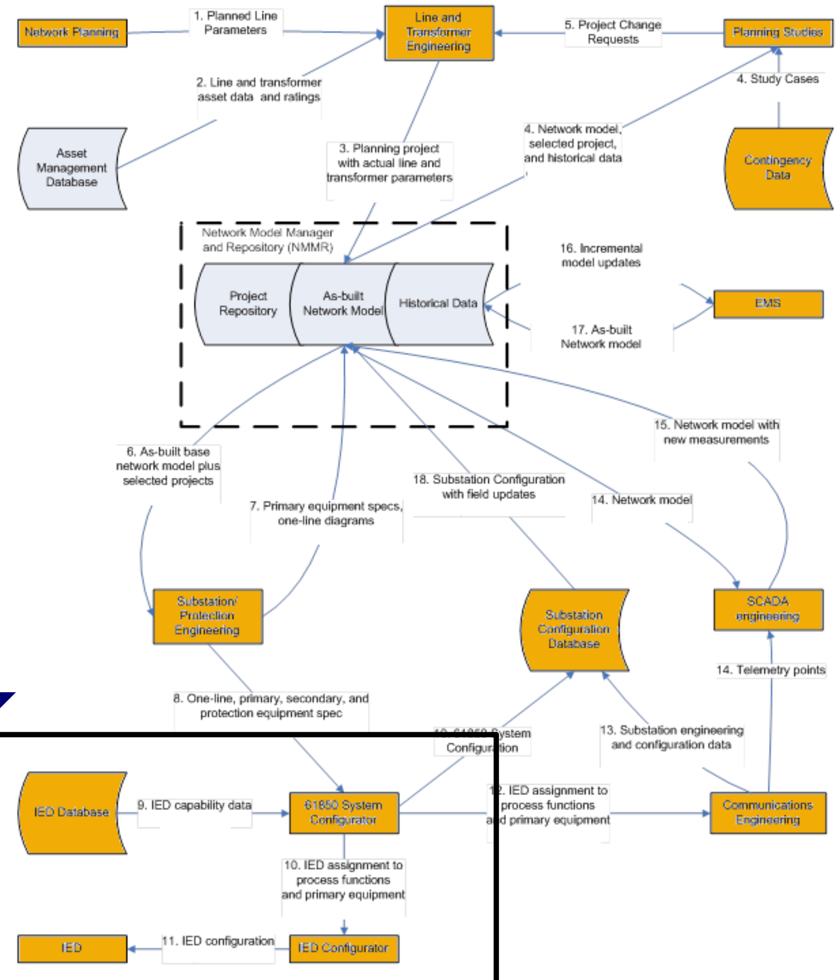
61850 Impacted by all areas of "construction"

The set of utility processes must lead to appropriate:

- Power System Resource Selection
- Power System Topology Design
- IED Selection
- Substation design and wiring
- Communications

Parameterization of IEDs

Domain of 61850 Substation Configuration Files (SCL) and IEC 61850-6 processes



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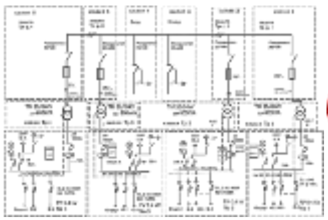
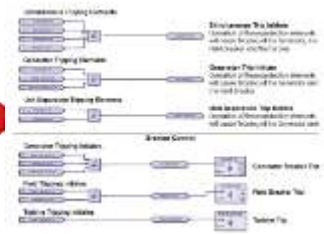
SCL facilitates specification

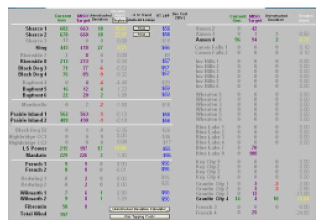




System Specification Description (SSD)

IED Specifications

System Specification Description' (SSD)



Requirements

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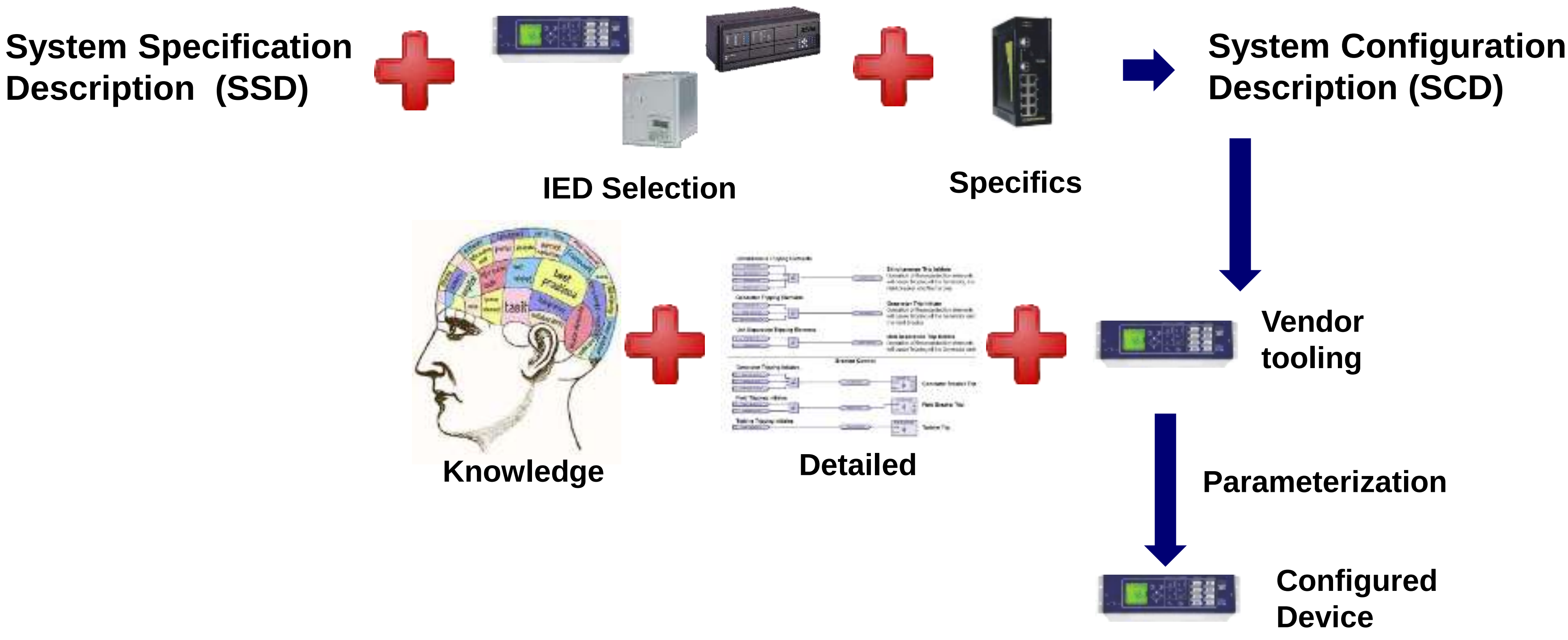
SCL facilitates design and engineering



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SCL facilitates validation

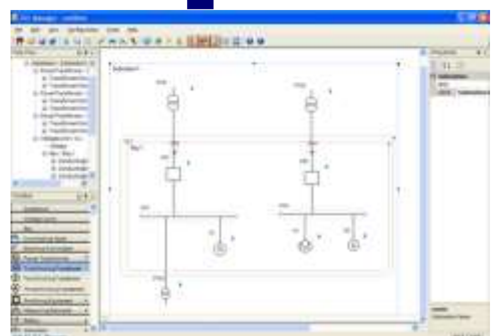
Original System Configuration Description (SCD) file

Substation specific System Configuration Description (SCD) file

Configured Device

Vendor Specific Tooling

Configured IED Description (CID) file



Substation Configuration Tool

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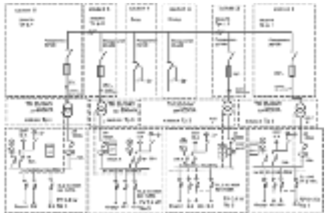
SCL facilitates testing



System Configuration Description (SCD) file

Configured IED Description (CID) file

Partial SAT

Communication testing
Partial FAT

Partial Unit Testing

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IEC 61850 Profiles

How IEC 61850 Works Over Networks.

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Some Terms

- Network Access Methods:
  - Master Slave – a master controls slave access to the network (e.g. DNP3)
  - Peer-to-peer – any entity may send data to any other peer entity on the network without having to coordinate with a master (TCP/IP-Ethernet).
- Client-Server – defines roles between 2 peers that communicate directly with just each other on a network.
- Multicast – A server with data publishes data to the network which delivers the data to subscribing clients without requiring knowledge of the clients to the publishing server.

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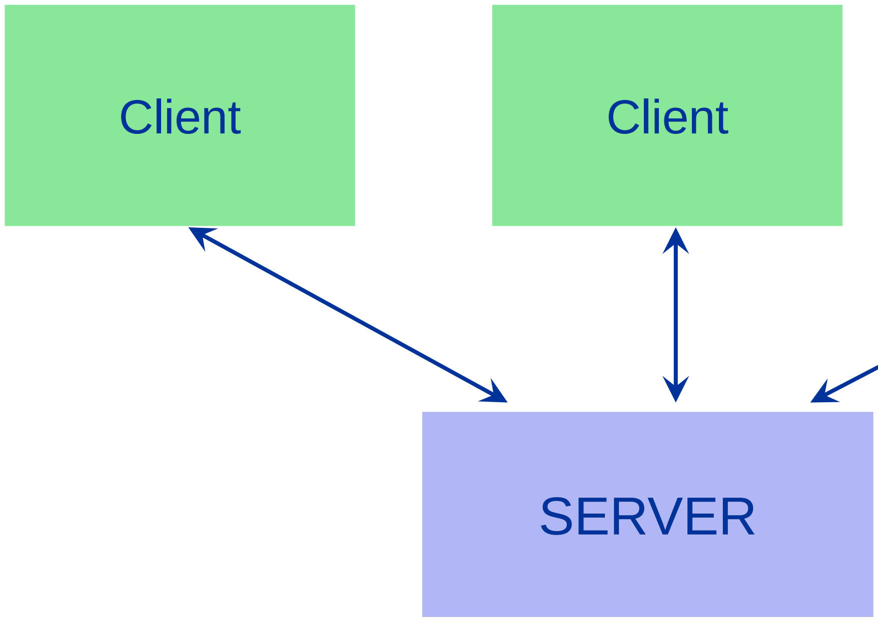
IEC 61850 Client/Server Communications



Peer – to – Peer communications. Either entity may initiate communications to the other entity.

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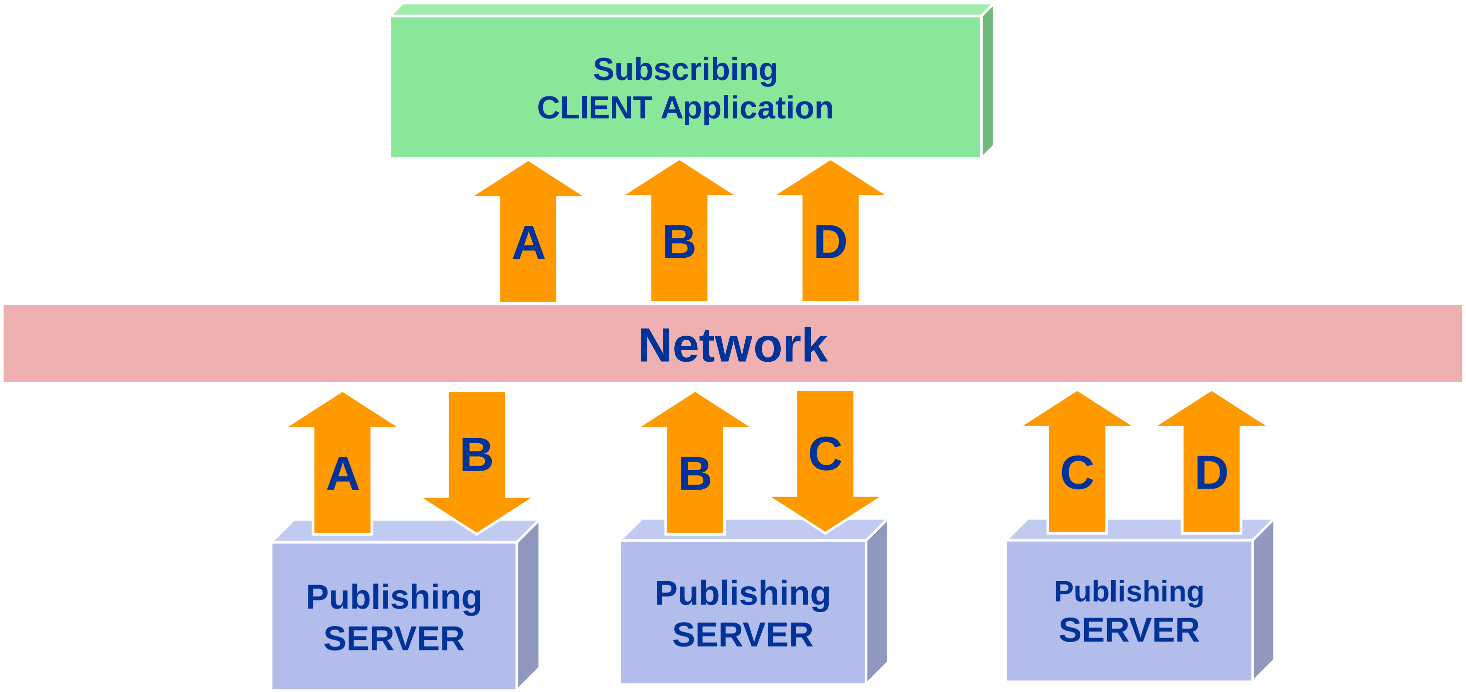
Multi-Cast Application Association



Service: send Data (unconfirmed)

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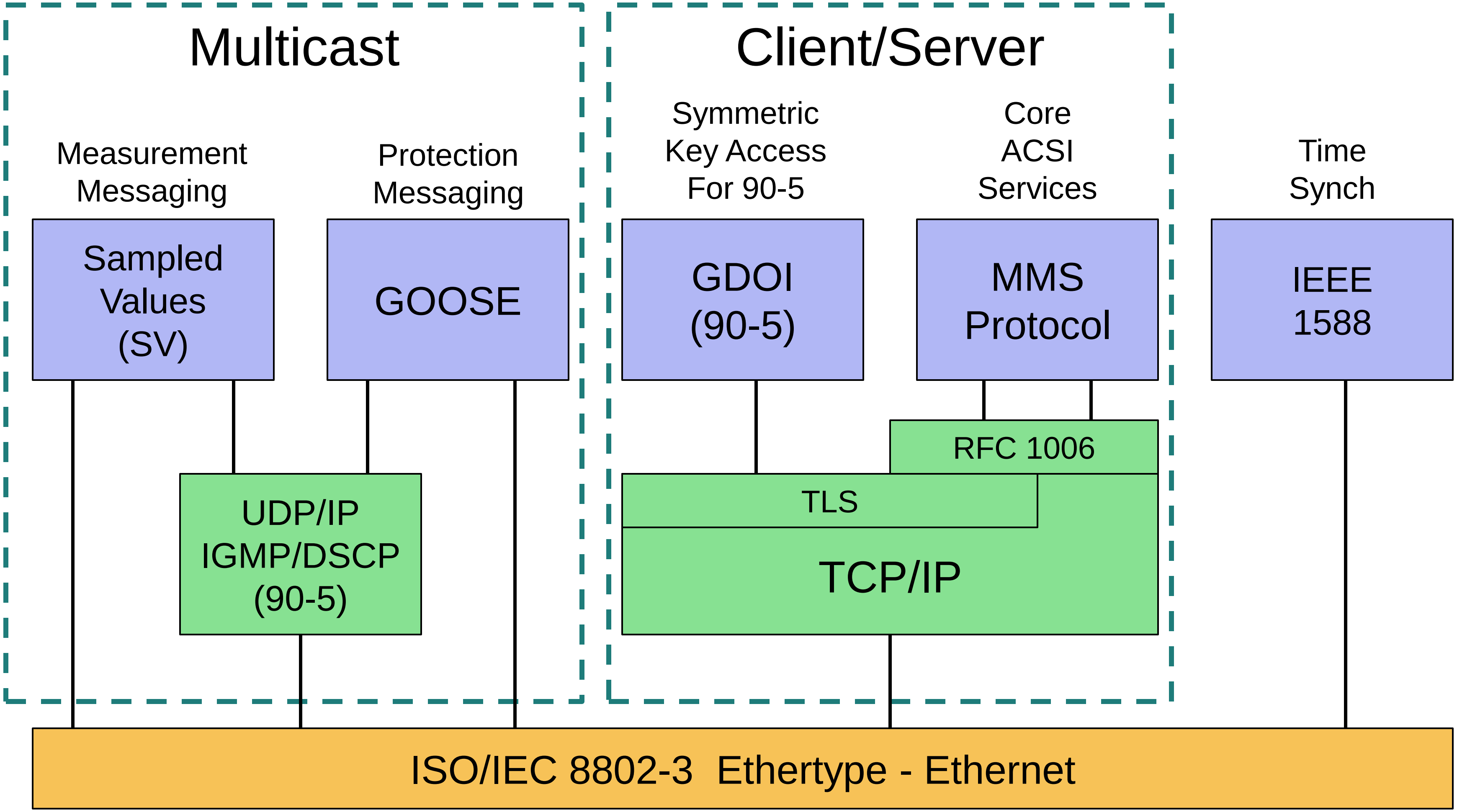
IEC 61850 Profiles



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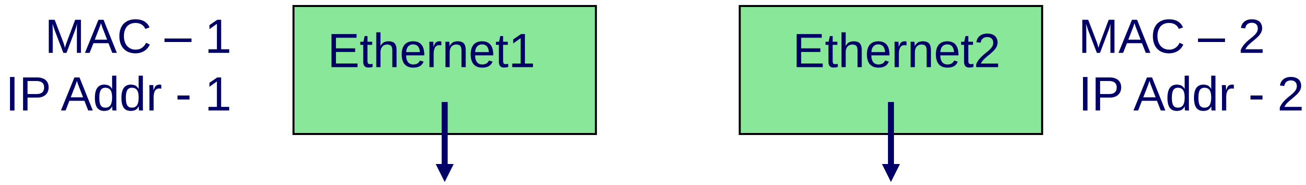
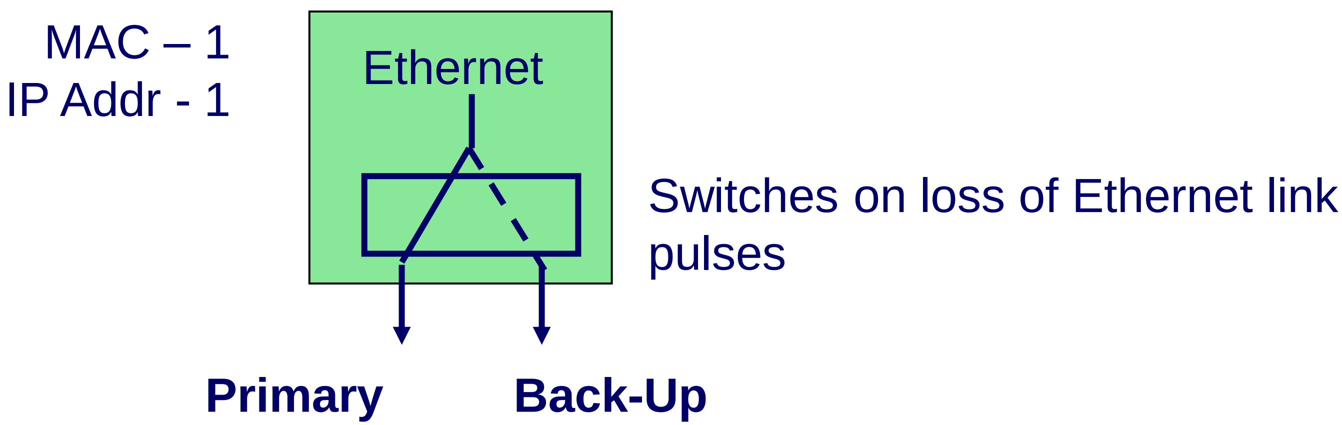
Redundant Port Implementations

Redundant Port: 2 independent Ethernet ports with 2 different addresses



Redundant Media: 1 Ethernet port with switched media



Redundant Media is Common - Easy to Configure for Redundancy

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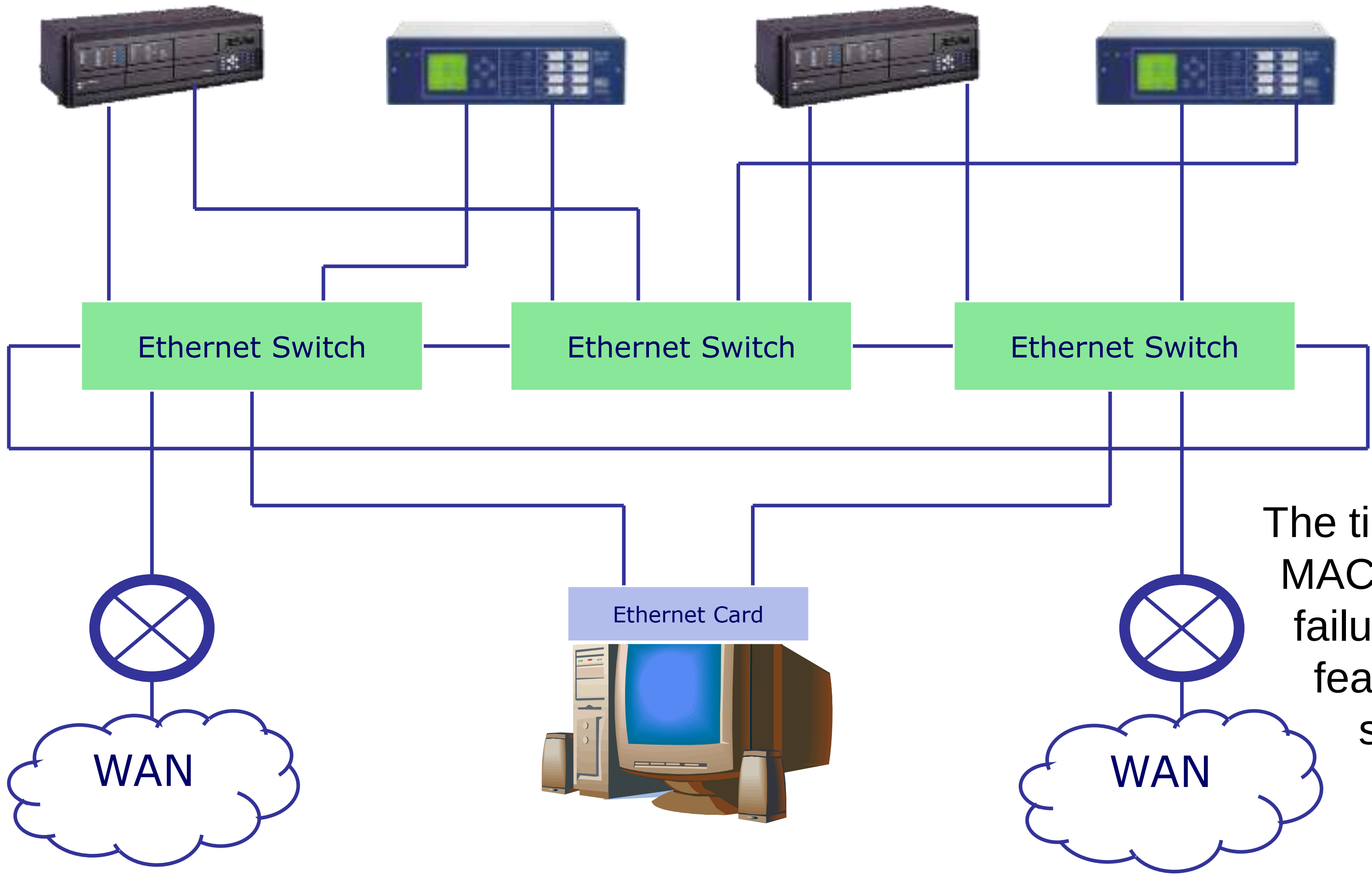
Redundant Network Configuration



The time to rebuild MAC tables after failure is critical feature of the switches

Rapid Spanning Tree Protocol (RSTP) enables network rebuild after MAC failure/change

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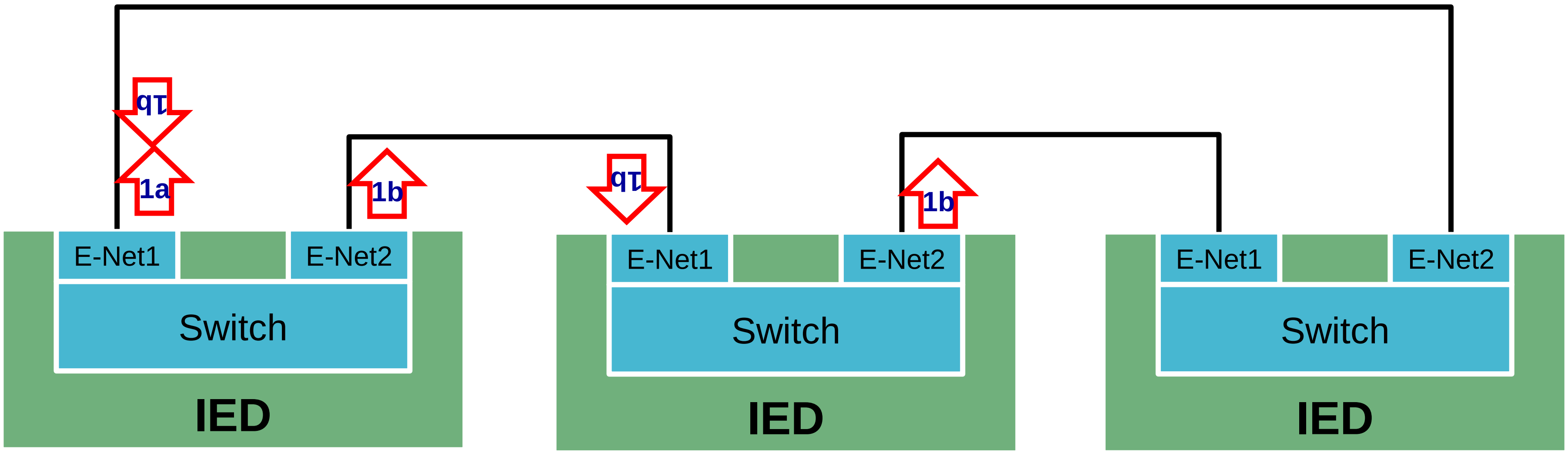
Emerging Approach – Embedded Switching



HSR – High-Speed Redundancy Ethernet uses this kind of approach to avoid the delay of rebuilding the MAC tables on a failure

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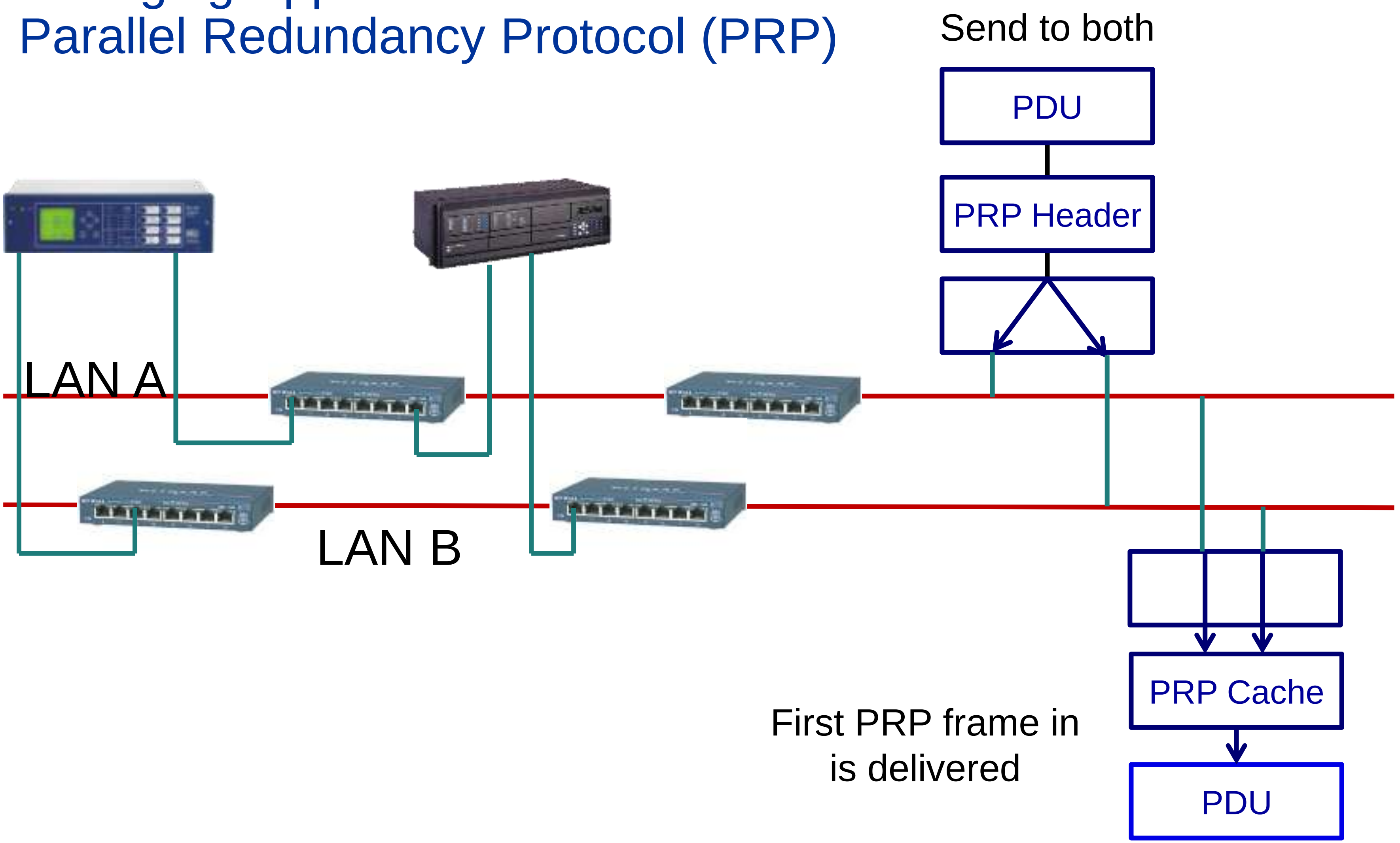
Emerging Approach – Parallel Redundancy Protocol (PRP)



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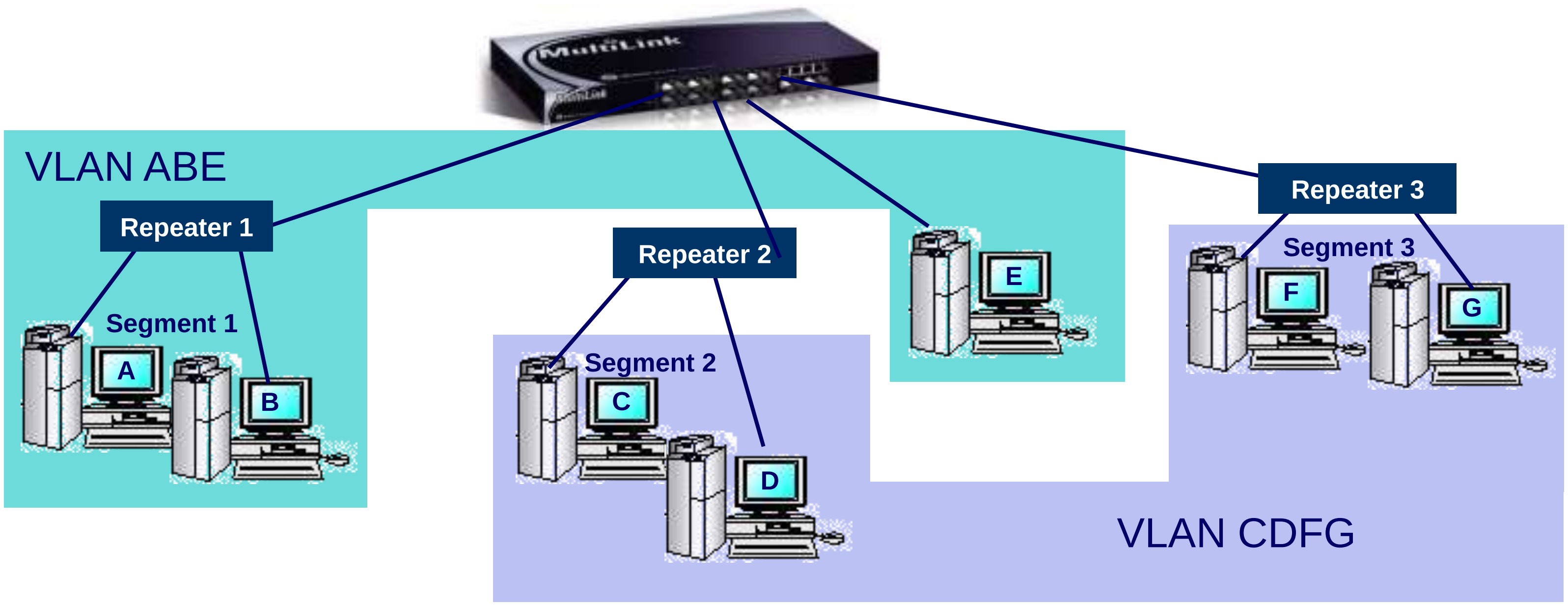
VLANs

- VLANs: Are logical groupings of nodes that reside in a common broadcast domain
  - Virtual because the VLAN is artificially created and the nodes need not be physically located on the same switch or even reside in the same building, but
    - Nodes that are members behave like they are connected together by one layer 2 bridge or switch
    - A router is required to communicate between the two VLANs



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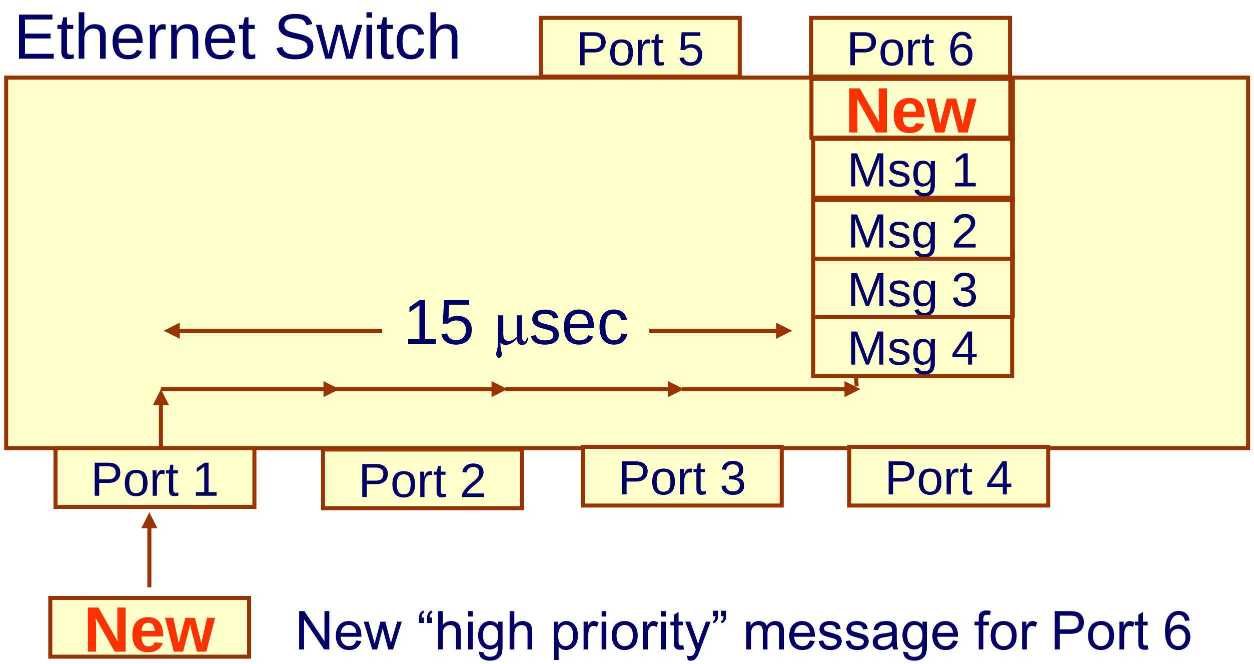
Ethernet Priority

- Ethernet 802.1q provides a priority setting
- “High” priority messages are moved to the priority queue
- Specified in IEC GOOSE and Implemented in GE Multilink Switch



Courtesy of GE Digital Energy

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IEC 61850 Models

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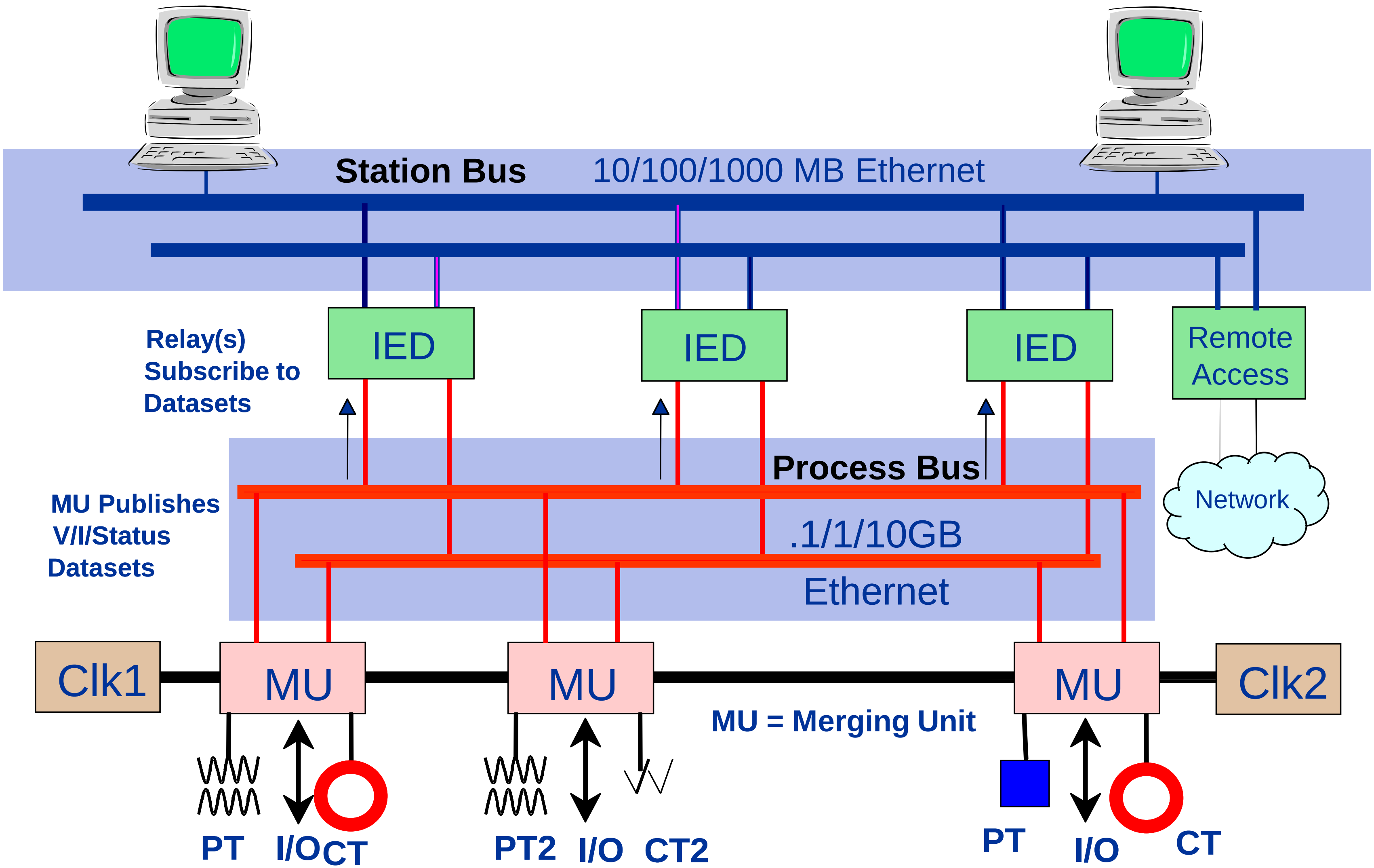
IEC61850 Substation Architecture



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IEC61850 – Communications Parts

- Part 6: Substation Configuration Language (**SCL**)
- Part 7-2: Abstract Communications Service Interface (**ACSI**) and base types
- Part 7-3: Common Data Classes (**CDC**)
- Part 7-4: Logical Nodes (**LN**)
- Part 7-4XX: Other LNs and CDCs
- Part 8-1: Specific Communications Service Mappings (**SCSM**) - MMS & Ethernet
- Part 9-2: SCSM - Sampled Values over Ethernet
- Part 10: Conformance Testing

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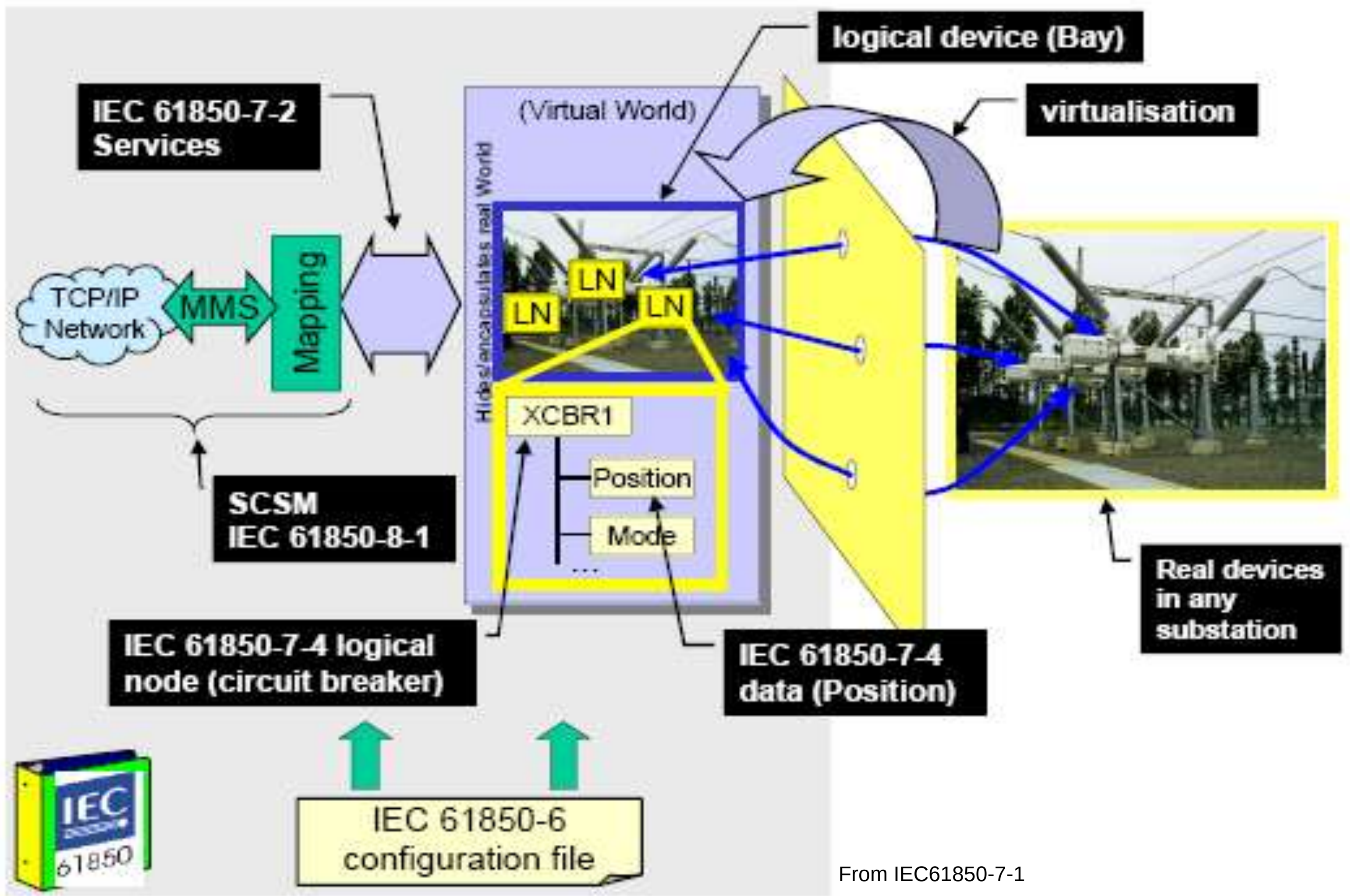
IEC 61850 Virtual Model



From IEC61850-7-1

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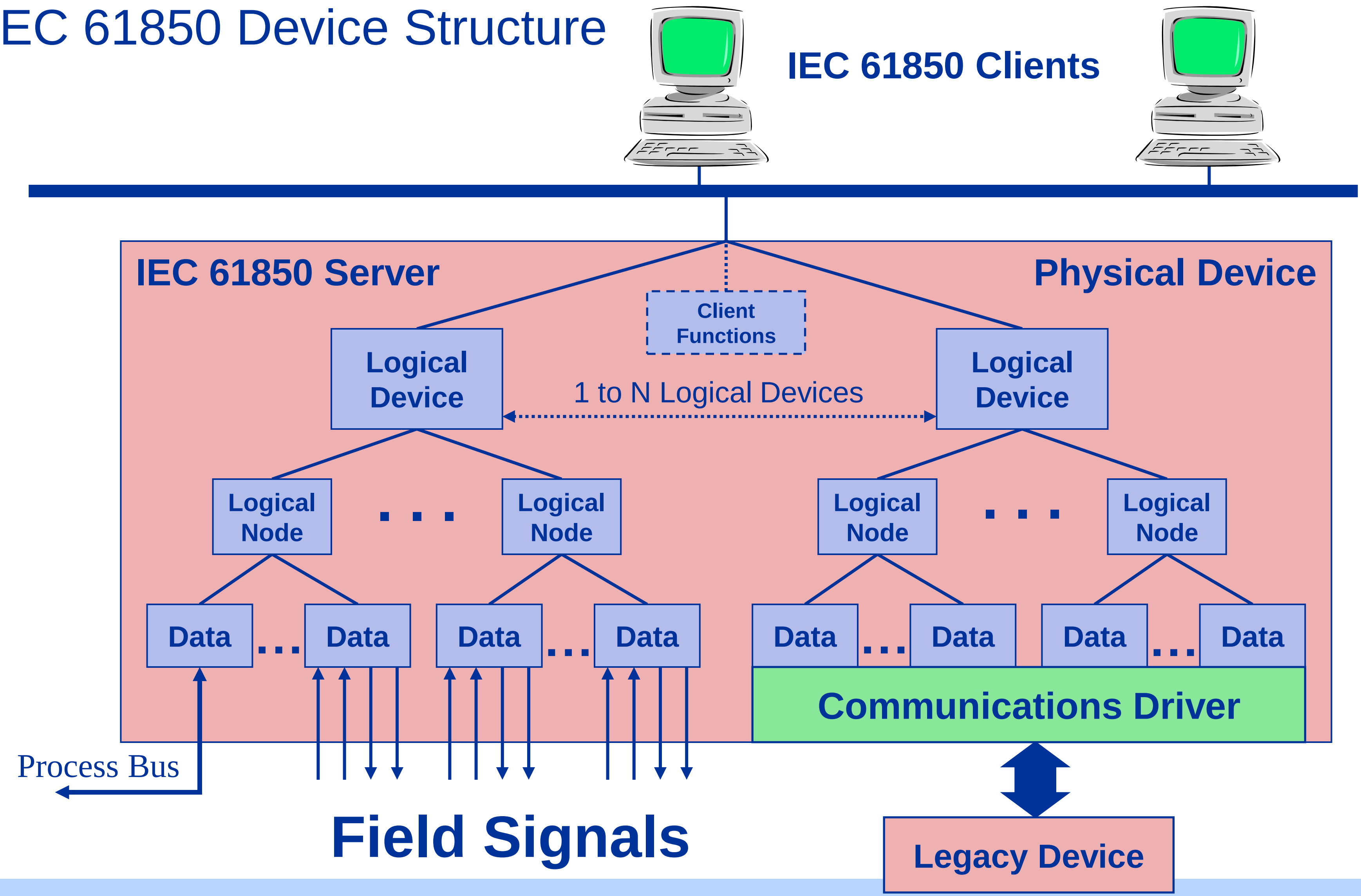
IEC 61850 Device Structure



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Logical Node

- A named grouping of data and associated services that is logically related to some power system function.
- Consists of one or more attributes each of a type defined by a Common Data Class (CDC)

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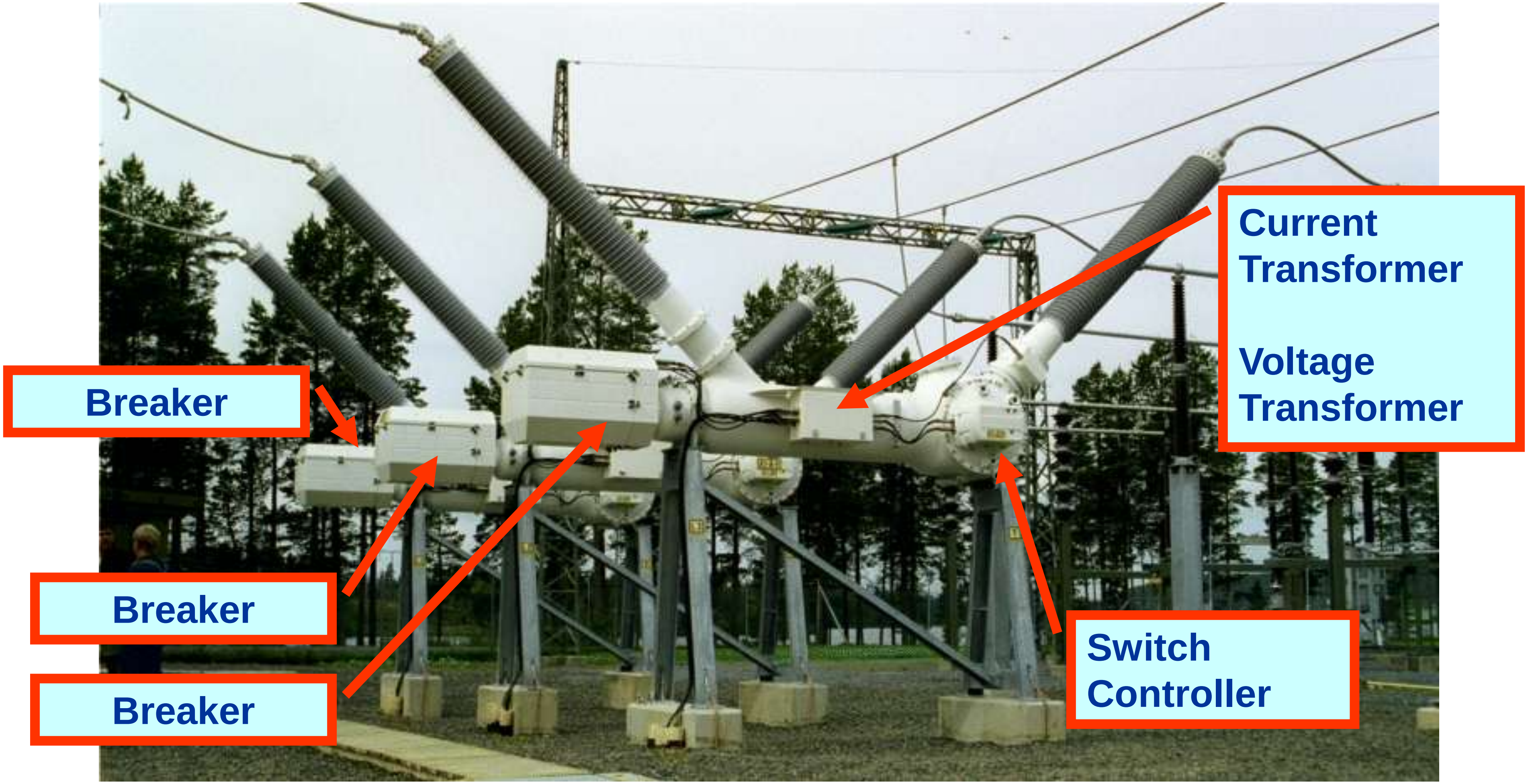
Examples of Logical Nodes



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Common Data Classes (CDC)

- Defines structure for common types that are used to describe DATA objects.

- CDC are complex objects built on predefined simple base types organized into functional constraints (FC)

- Examples:
  - Single point status (SPS) – on/off
  - Double point status (DPS) – on/off/transient
  - Double point controllable (DPC) – state can be changed via controls

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Common Data Classes - Status

Name	Description
SPS	Single Point Status
DPS	Double Point Status
INS	Integer Status
ENS	Enumerated Status
ACT	Protection Activation
ACD	Directional Protection Activation Info.
SEC	Security Violation Counting
BCR	Binary Counter Reading
HST	Histogram
VSS	Visible String Status

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Common Data Classes - Measurands

Name	Description
MV	Measured Value
CMV	Complex Measured Value
SAV	Sampled Value
WYE	Phase to ground measured values for 3-phase system
DEL	Phase to phase measured values for 3-phase system
SEQ	Sequence
HMV	Harmonic value
HWYE	Harmonic value for WYE
HDEL	Harmonic value for DEL

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Common Data Classes - Controls

Name	Description
SPC	Controllable Single Point
DPC	Controllable Double Point
INC	Controllable Integer Status
ENC	Controllable Enumerated Status
BSC	Binary Controlled Step Position Info.
ISC	Integer Controlled Step Position Info.
APC	Controllable Analogue Process Value
BAC	Binary Controlled Analog Process Value

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Common Data Classes – Settings and Descriptions

Name	Description
SPG	Single Point Setting
ING	Integer Status Setting
ENG	Enumerated Status Setting
ORG	Object Reference Setting
TSG	Time Setting Group
CUG	Currency Setting Group
VSG	Visible String Setting
ASG	Analogue Setting
CURVE	Setting Curve
CSG	Curve Shape Setting
DPL	Device Name Plate
LPL	Logical Node Name Plate
CSD	Curve Shape Description

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Single Point Status (SPS)

SPS class					
Data Attribute name	**Type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
DataAttribute					
status					
stVal	BOOLEAN	ST	dchg	TRUE | FALSE	M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
substitution and blocked					
subEna	BOOLEAN	SV			PICS_SUBST
subVal	BOOLEAN	SV		TRUE | FALSE	PICS_SUBST
subQ	Quality	SV			PICS_SUBST
subID	VISIBLE STRING64	SV			PICS_SUBST
blkEna	BOOLEAN	BL			O
configuration, description and extension					
d	VISIBLE STRING255	DC		Text	O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

Attribute Name

Type

Functional Constraint

Trigger Options

Range of Values

Mandatory/ Optional

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Functional Constraints

- There are many data attributes in an object like a breaker that have related use:
  - Control, configuration, measurement, reporting, etc.
- Functional Constraints (FC) is a property of a data attribute that characterizes the specific use of the attribute.
- Useful to functionally organize data attributes to provide structure and context.

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Mandatory/Optional Parameters

- Specifies whether a data attribute is mandatory (M) or optional (O) and under what conditions.
  - PICS_XXXX: Specifies an ACSI service model (e.g. SUBST = Substitution) that if supported then it is mandatory.
  - AC_xxx specifies if the name space differs from that specified for higher-level objects (e.g. private extensions

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Double Point Status (DPS)

DPS class					
Data Attribute name	**Type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
DataAttribute					
				status	
stVal	CODED ENUM	ST	dchg	intermediate-state | off | on | bad-state	M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
				substitution and blocked	
subEna	BOOLEAN	SV			PICS_SUBST
subVal	CODED ENUM	SV		intermediate-state | off | on | bad-state	PICS_SUBST
subQ	Quality	SV			PICS_SUBST
subID	VISIBLE STRING64	SV			PICS_SUBST
blkEna	BOOLEAN	BL			O
				configuration, description and extension	
d	VISIBLE STRING255	DC		Text	O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

2-bit pair in DPS versus boolean in SPS

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Controllable Double Point – DPC

DPC class					
Attribute Name	**Attribute Type**	**FC**	**TrgOp**	**Value/Value Range**	**M/O/C**
DataName	Inherited from Data Class (see IEC 61850-7-2)				
DataAttribute				From IEC61850-7-3	
		control and status			
ctlVal	BOOLEAN	CO		off (FALSE) | on (TRUE)	AC_CO_M
operTm	TimeStamp	CO			AC_CO_O
origin	Originator	CO, ST			AC_CO_O
ctlNum	INT8U	CO, ST		0..255	AC_CO_O
stVal	CODED ENUM	ST	dchg	intermediate-state | off | on | bad-state	M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
stSeld	BOOLEAN	ST	dchg		AC_CO_O
		substitution			
subEna	BOOLEAN	SV			PICS_SUBST
subVal	CODED ENUM	SV		intermediate-state | off | on | bad-state	PICS_SUBST
subQ	Quality	SV			PICS_SUBST
subID	VISIBLE STRING64	SV			PICS_SUBST
		configuration, description and extension			
pulseConfig	PulseConfig	CF			AC_CO_O
ctlModel	CtlModels	CF			M
sboTimeout	INT32U	CF			AC_CO_O
sboClass	SboClasses	CF			AC_CO_O
d	VISIBLE STRING255	DC		Text	O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

Mandatory if control is supported

Optional if control is supported

Direct or SBO

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Control Model (ctlModel)

- 0: Status only. No control allowed.
- 1: Direct control with normal security
- 2: SBO control with normal security
- 3: Direct control with enhanced security
- 4: SBO control with enhanced security

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Logical Node Name Plate - LPL

LPL class					
Data attribute name	**Type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
DataAttribute					
				configuration, description and extension	
vendor	VISIBLE STRING255	DC			M
swRev	VISIBLE STRING255	DC			M
d	VISIBLE STRING255	DC			O
dU	UNICODE STRING255	DC			O
configRev	VISIBLE STRING255	DC			AC_LN0_M
paramRev	INT32	ST	dchg		O
valRev	INT32	ST	dchg		O
ldNs	VISIBLE STRING255	EX		shall be included in **LLN0** only; for example "IEC 61850-7-4:2003"	AC_LN0_EX
lnNs	VISIBLE STRING255	EX			AC_DLD_M
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

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Configuration Revision Parameters

- configRev – Changed whenever at least on semantic aspect of the data has changed within the Logical Device (LD) within which this LLN0 is contained. Left to the “user” (vendor) for other LNs.
  - New LNs
  - New attributes.
- paramRev – Changed when the value of any editable setting (SE) or setpoint (SP) parameter is changed.
  - If changed via communications or local HMI the value is increased by 1.
  - If changed via SCL import the value is increased by 10,000.
- valRev – changed when the value of any configuration (CF) parameter is changed.
  - If changed via communications or local HMI the value is increased by 1.
  - If changed via SCL import the value is increased by 10,000.

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Measured Value - MV

MV class					
Data attribute name	**Type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
DataAttribute					
				measured attributes	
instMag	AnalogueValue	MX			O
mag	AnalogueValue	MX	dchg, dupd		M
range	ENUMERATED	MX	dchg	normal|high|low|high-high|low-low	O
q	Quality	MX	qchg		M
t	TimeStamp	MX			M
				substitution and blocked	
subEna	BOOLEAN	SV			PICS_SUBST
subMag	AnalogueValue	SV			PICS_SUBST
subQ	Quality	SV			PICS_SUBST
subID	VISIBLE STRING64	SV			PICS_SUBST
blkEna	BOOLEAN	BL			O
				configuration, description and extension	
units	Unit	CF	dchg	see Annex A	O
db	INT32U	CF	dchg	0 … 100 000	O
zeroDb	INT32U	CF	dchg	0 … 100 000	O
sVC	ScaledValueConfig	CF	dchg		AC_SCAV
rangeC	RangeConfig	CF	dchg		GC_CON_range
smpRate	INT32U	CF	dchg		O
d	VISIBLE STRING255	DC		Text	O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

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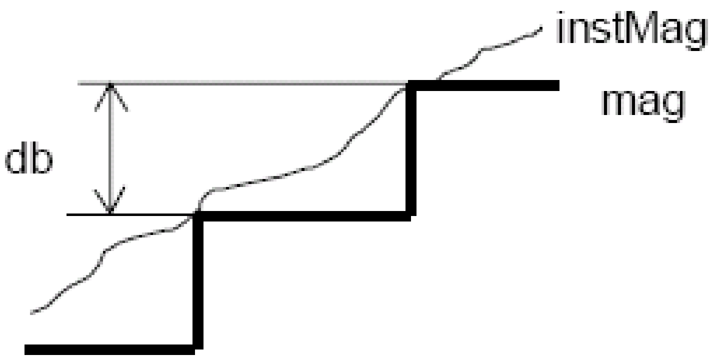
instMag v.s. mag

<table>
<tr>
<td>mag</td>
<td>Deadbanded value. Shall be based on a dead band calculation from instMag as illustrated below. The value of mag shall be updated to the current value of instMag when the value has changed according the configuration parameter db.



NOTE 7 The figure above is an example. There may be other algorithms providing a comparable result; for example as an alternate solution, the dead band calculation may use the integral of the change of instMag. The algorithm used is a local issue.

NOTE 8 This value mag is typically used to create reports for analogue values. Such a report sent "by exception" is not comparable to the transfer of sampled measured values as supported by the CDC SAV.</td>
</tr>
</table>

- Use mag in datasets to trigger a report when data changes
- Use instMag in datasets for reporting data without triggering a report

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Trigger Option (TrgOp)

Specifies the conditions under which reporting on the data attribute can be triggered.

	data-change	BOOLEAN
	quality-change	BOOLEAN
	data-update	BOOLEAN
	integrity	BOOLEAN
	general-interrogation	BOOLEAN

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Sampled Values (SAV)

SAV class					
Data attribute name	**Type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
DataAttribute					
measured attributes					
instMag	AnalogueValue	MX			M
q	Quality	MX	qchg		M
t	TimeStamp	MX			O
configuration, description and extension					
units	Unit	CF	dchg	see Annex A	O
sVC	ScaledValueConfig	CF	dchg		AC_SCAV
min	AnalogueValue	CF	dchg		O
max	AnalogueValue	CF	dchg		O
d	VISIBLE STRING255	DC		Text	O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

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WYE Connected Measurements (WYE)

WYE class					
Data attribute name	**Type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
SubDataObject					
phsA	CMV				GC_1
phsB	CMV				GC_1
phsC	CMV				GC_1
neut	CMV				GC_1
net	CMV				GC_1
res	CMV				GC_1
DataAttribute					
configuration, description and extension					
angRef	ENUMERATED	CF	dchg	Va | Vb | Vc | Aa | Ab | Ac | Vab | Vbc | Vca | Vother | Aother | Synchrophasor	O
phsToNeut	BOOLEAN	CF	dchg	DEFAULT = FALSE	O
d	VISIBLE STRING255	DC		Text	O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

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Complex Measured Value (CMV)

Vector =
mag
&
ang

DataAttribute					
			measured attributes		
instCVal	Vector	MX			O
cVal	Vector	MX	dchg, dupd		M
range	ENUMERATED	MX	dchg	normal|high|low|high-high|low-low	O
rangeAng	ENUMERATED	MX	dchg	normal|high|low|high-high|low-low	O
q	Quality	MX	qchg		M
t	TimeStamp	MX			M
			substitution and blocked		
subEna	BOOLEAN	SV			PICS_SUBST
subCVal	Vector	SV			PICS_SUBST
subQ	Quality	SV			PICS_SUBST
subID	VISIBLE STRING64	SV			PICS_SUBST
blkEna	BOOLEAN	BL			O
			configuration, description and extension		
units	Unit	CF	dchg	see Annex A	O
db	INT32U	CF	dchg	0 … 100 000	O
dbAng	INT32U	CF	dchg	0 … 100 000	O
zeroDb	INT32U	CF	dchg	0 … 100 000	O
rangeC	RangeConfig	CF	dchg		GC_CON_range
rangeAngC	RangeConfig	CF	dchg		GC_CON_rangeAng
magSVC	ScaledValueConfig	CF	dchg		AC_SCAV
angSVC	ScaledValueConfig	CF	dchg		AC_SCAV
angRef	ENUMERATED	CF	dchg	V | A | other Synchrophasor	O
smpRate	INT32U	CF	dchg		O
d	VISIBLE STRING255	DC		Text	O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

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Vector

Vector Type Definition			From IEC61850-7-3
Attribute Name	**Attribute Type**	**Value/Value Range**	**M/O/C**
mag	AnalogueValue		M
ang	AnalogueValue		O

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Logical Nodes

Abstract Representation of a Power System Function

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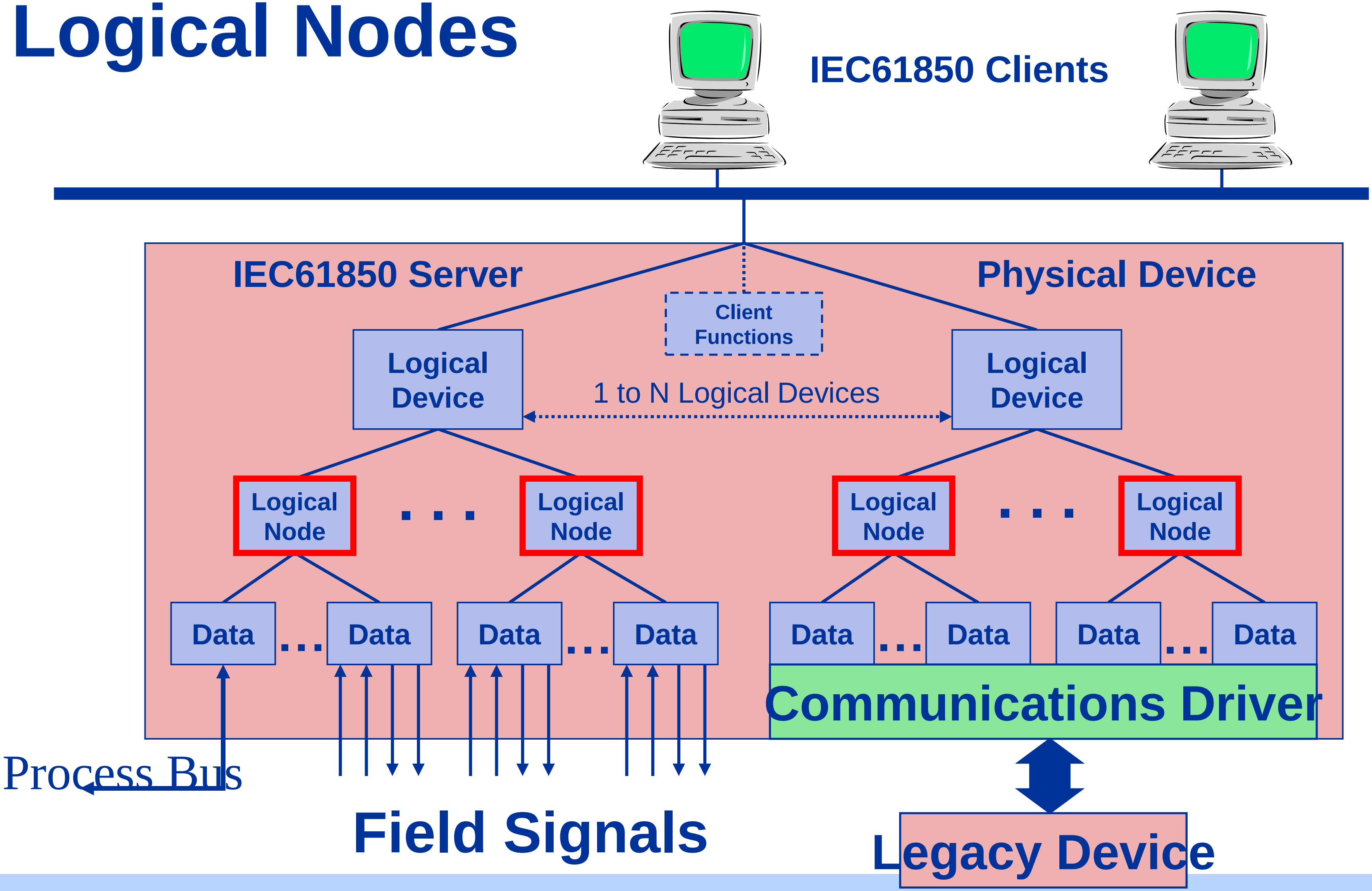
Logical Nodes



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System Logical Nodes “L”

Name	Description
LPHD	Physical Device
LLNO	Common Logical Node MANDATORY
LCCH	Physical Communications Channel Supervision
LGOS	GOOSE Subscription
LTIM	Time Management
LTMS	Time Master Supervision
LTRK	Service Tracking

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Automatic Control Logical Nodes “A”

Name	Description
ANCR	Neutral Current Regulator
ARCO	Reactive Power Control
ARIS	Resistor Control
ATCC	Automatic Tap Changer controller
AVCO	Voltage Control

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Supervisory Control Logical Nodes “C”

Name	Description
CALH	Alarm Handling
CCGR	Cooling Group Control
CILO	Interlocking
CPOW	Point-on-wave switching
CSWI	Switch Controller
CSYN	Synchronizer Controller

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Functional Block Logical Nodes "F"

Name	Description
FCNT	Counter
FCSD	Curve Shape Description
FFIL	Generic Filter
FLIM	Control Function Output Limitation
FPID	PID Regulator
FRMP	Ramp Function
FSPT	Set-Point Control Function
FXOT	Action at Over Threshold
FXUT	Action at Under Threshold

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Generic Function Logical Nodes "G"

Name	Description
GAPC	Generic Automatic Process Control
GGIO	Generic Process I/O
GLOG	Generic Log
GSAL	Generic Security Application

Use only when there is no other power system related LN that can represent the data.

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Interfacing and Archiving Logical Nodes “I”

Name	Description
IARC	Archiving
IHMI	Human Machine Interface
ITCI	Telecontrol Interface
ITMI	Telemonitoring Interface
ISAF	Safety Alarm Function
ITPC	Teleprotection Communications Interface

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Mechanical and Non-Electrical Logical Nodes “K”

Name	Description
KFAN	Fan
KFIL	Filter
KPMP	Pump
KTNK	Tank
KVLV	Valve Control

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Metering and Measurement Logical Nodes "M"

Name	Description
MHAI	Harmonics or interharmonics
MHAN	Non phase related harmonics or interharmonics
MMTR	Metering
MMXN	Non phase related measurements
MMXU	Measurements
MSQI	Sequence and Imbalance
~~**MSTA**~~	~~Metering Statistics~~
MENV	Environmental Information
MFLK	Flicker Measurement
MHYD	Hydrological Information
MMDS	DC Measurement
MMET	Metrological Information

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Protection Logical Nodes "P"

Name	Description
PDIF	Differential
PDIR	Direction
PDIS	Distance
PDOP	Directional overpower
PDUP	Directional underpower
PFRC	Rate of change of frequency
PHAR	Harmonic restraint
PHIZ	Ground detector
PIOC	Instantaneous overcurrent
PMRI	Motor restart inhibition
PMSS	Motor starting time supervision
POPF	Over power factor
PPAM	Phase angle measuring

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Protection Logical Nodes (cont'd)

Name	Description
PSCH	Protection scheme
PSDE	Sensitive directional earth fault
PTEF	Transient earth fault
PTOC	Time over current
PTOF	Over frequency
PTOV	Over voltage
PTRC	Protection trip conditioning
PTTR	Thermal overload
PTUC	Under current
PTUV	Under voltage
PVOC	Voltage controlled time over current
PVPH	Volts per Hz
PZSU	Zero speed or under speed

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Protection Logical Nodes (cont'd)

Name	Description
PRTR	Rotor Protection
PTHF	Thyristor Protection
PUPF	Underpower Factor Protection

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Power Quality Events Logical Nodes “Q”

Name	Description
QFVR	Frequency Variation
QITR	Current Transient
QIUB	Current Unbalance Variation
QVTR	Voltage Transient
QVUB	Voltage Unbalance Variation
QVVR	Voltage Variation

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Protection Related Logical Nodes "R"

Name	Description
RDRE	Disturbance recorder function
RADR	Disturbance recorder channel analogue
RBDR	Disturbance recorder channel binary
RDRS	Disturbance record handling
RBRF	Breaker failure
RDIR	Directional element
RFLO	Fault locator
RPSB	Power swing detection/blocking
RREC	Auto reclosing
RSYN	Synchronism-check or synchronising
RMXU	Differential Measurements

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Sensors and Monitoring Logical Nodes “S”

Name	Description
SARC	Monitoring and diagnostics for arcs
SIMG	Insulation medium supervision
SIML	Insulation medium supervision (liquid)
SPDC	Monitoring and diag. for partial discharges
SCBR	Circuit Breaker Supervision
SLTC	Tap Changer Supervision
SOPM	Supervision of Operating Mechanism
SPTR	Power Transformer Supervision
SSWI	Circuit Switch Supervision
STMP	Temperature Supervision
SVBR	Vibration Supervision

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Instrument Transformer Logical Nodes “T”

Name	Description
TCTR	Current transformer
TVTR	Voltage transformer
TANG	Angle
TAXD	Axial Displacement
TDST	Distance
TFLW	Liquid Flow
TFRQ	Frequency
TGSN	Generic Sensor
THUM	Humidity
TLVL	LMedia Level

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Instrument Transformer Logical Nodes (cont'd)

Name	Description
TMGF	Magnetic Field
TMVM	Movement Sensor
TPOS	Position Indicator
TPRS	Pressure Sensor
TRTN	Rotation Transmitter
TSND	Sound Pressure Sensor
TTMP	Temperature Sensor
TTNS	Mechanical Tension/stress
TVBR	Virbration Sensor
TWPH	Water Acidity

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Switchgear Logical Nodes “X”

Name	Description
XCBR	Circuit Breaker
XSWI	Circuit Switch

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Power Transformer Logical Nodes “Y”

Name	Description
YEFN	Earth fault neutralizer
YLTC	Tap changer
YPSH	Power shunt
YPTR	Power transformer

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Other Power System Equipment Logical Nodes “Z”

Name	Description
ZAXN	Auxiliary network
ZBAT	Battery
ZBSH	Bushing
ZCAB	Power cable
ZCAP	Capacitor Bank
ZCON	Converter
ZGEN	Generator
ZGIL	Gas insulated line
ZLIN	Power overhead line
ZMOT	Motor
ZREA	Reactor
ZRRC	Rotating reactive component
ZSAR	Surge arrestor
ZTCF	Thyristor controlled frequency converter
ZTCR	Thyristor controlled reactive component
ZRES	Resistor
ZSCR	Semiconductor Controlled Rectifier
ZSMC	Synchronous Machine

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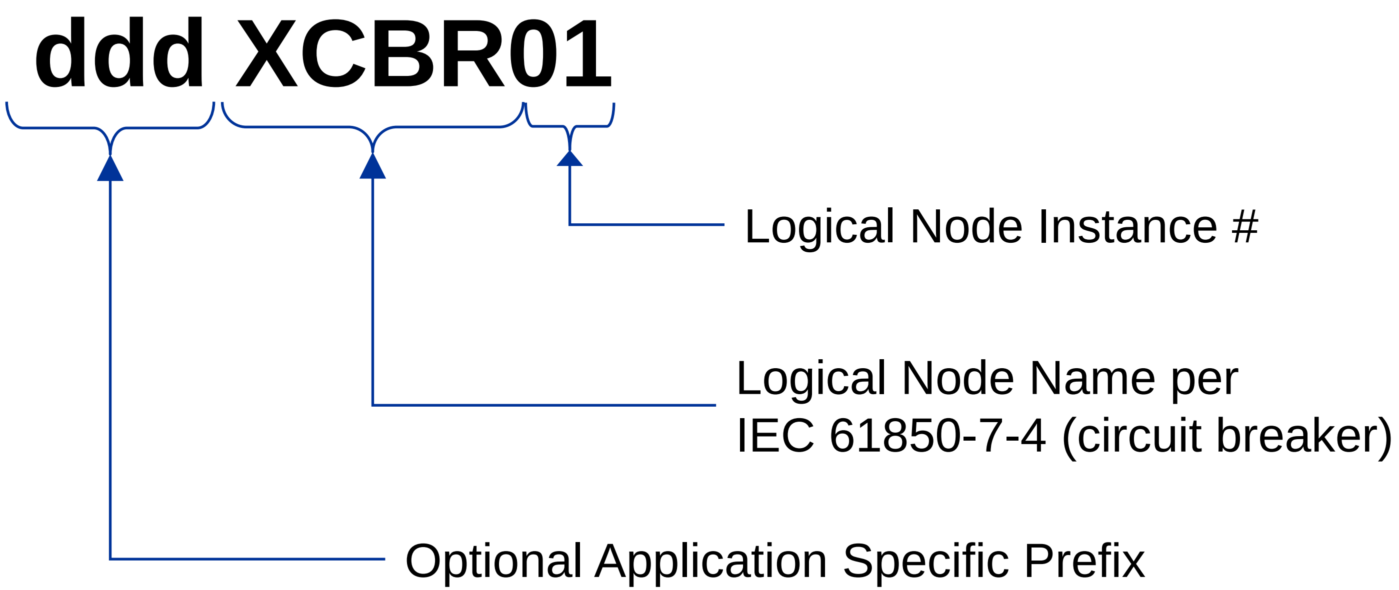
Logical Node Names

- Example for Circuit Breaker:



prefix digits + instance digits ≤ 7 (Ed. 1)
prefix digits + instance digits ≤ 12 (Ed. 2)

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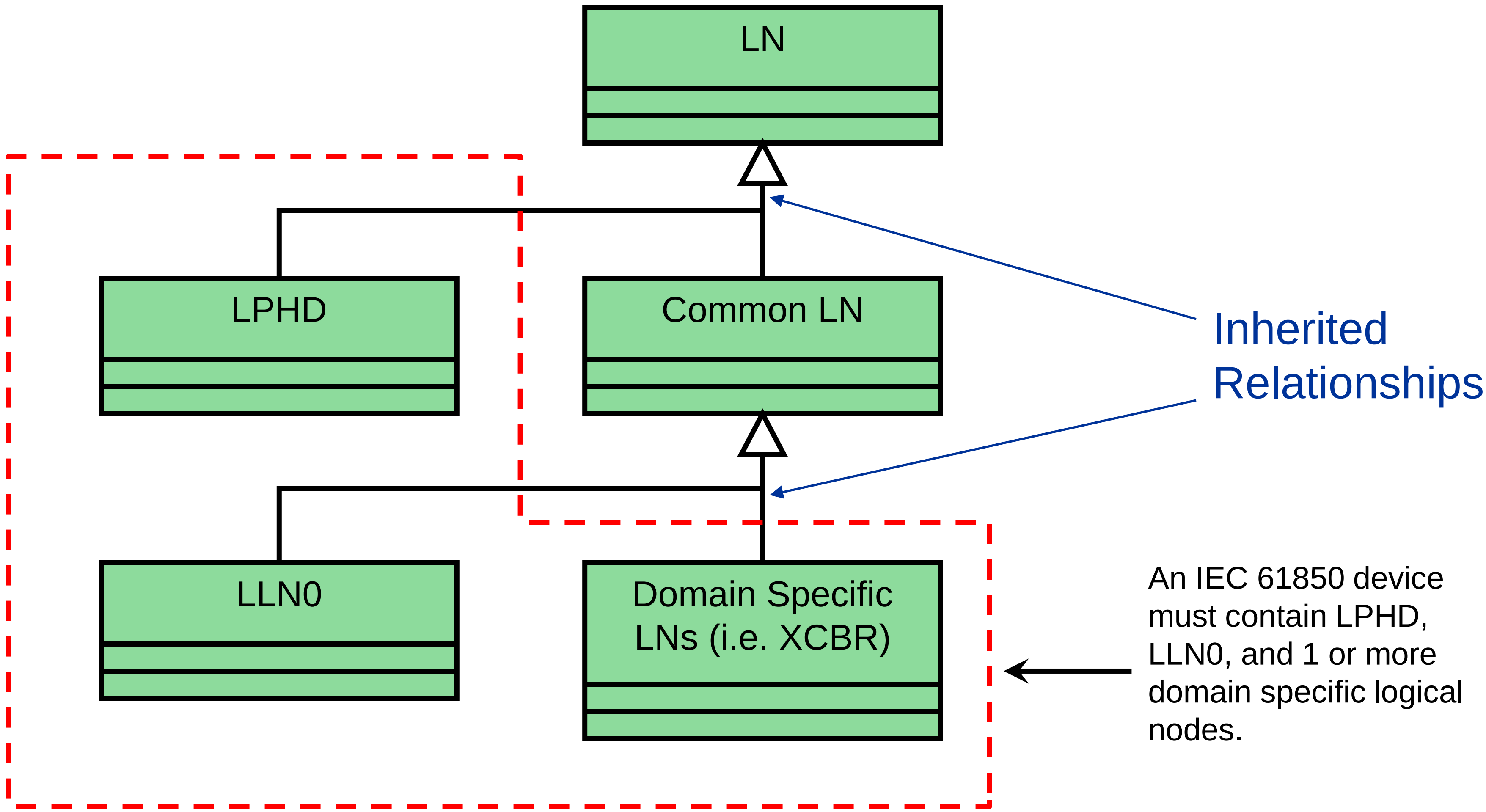
Logical Node Classes



An IEC 61850 device must contain LPHD, LLN0, and 1 or more domain specific logical nodes.

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Physical Device - LPHD

LPHD class				
Data object name	**Common data class**	**Explanation**	**T**	**M/O/C**
Data objects				
Status information				
PhyNam	DPL	Physical device name plate		M
PhyHealth	ENS	Physical device health		M
OutOv	SPS	Output communications buffer overflow		O
Proxy	SPS	Indicates if this LN is a proxy		M
InOv	SPS	Input communications buffer overflow		O
NumPwrUp	INS	Number of Power ups		O
WrmStr	INS	Number of Warm Starts		O
WacTrg	INS	Number of watchdog device resets detected		O
PwrUp	SPS	Power Up detected		O
PwrDn	SPS	Power Down detected		O
PwrSupAlm	SPS	External power supply alarm		O
Controls				
RsStat	SPC	Reset device statistics	T	O
Sim	SPC	Receive simulated GOOSE or simulated SV		O

Common Data Class

Data Object Names

Description

Mandatory/Optional/Conditional

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Common Logical Node Class

Common Logical Node class				
Attribute Name	Attr. Type	Explanation	T	M/O
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
Data		From IEC61850-7-4		
Mandatory Logical Node Information (Shall be inherited by ALL LN but LPHD)				
Mod	INC	Mode		M
Beh	INS	Behaviour		M
Health	INS	Health		M
NamPlt	LPL	Name plate		M
Optional Logical Node Information				
Loc	SPS	Local operation		O
EEHealth	INS	External equipment health		O
EEName	DPL	External equipment name plate		O
OpCntRs	INC	Operation counter resetable		O
OpCnt	INS	Operation counter		O
OpTmh	INS	Operation time		O

ALL other logical nodes contain these attributes even though they are not listed in the other logical node description tables.

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Common Logical Node – LLN0

(Logical Node Zero)

LLNO class				
Data object name	**Common data class**	**Explanation**	**T**	**M/O/C**
Data objects				
Status information				
LocKey	SPS	Local operation for complete logical device		O
LocSta	SPC	Switching authority at station level		O
Loc	SPS	Local Control Behavior		O
OpTmh	INS	Operation time		O
Controls				
Diag	SPC	Run Diagnostics		O
LEDRs	SPC	LED reset	T	O
Settings				
MltLev	SPG	Select mode of authority for local control (True – control from multiple levels above the selected one is allowed, False – no other control level above allowed)		O

The Mode (Mod) and Local/Remote status of this logical node affects all LNs in that Logical Device

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Logical Node Description – XCBR

XCBR class				
Data object name	**Common data class**	**Explanation**	**T**	**M/O/C**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, Clause 22.		
Data objects				
LocKey	SPS	Local or remote key (local means without substation automation communication, hardwired direct control)		O
LocSta	SPC	Switching authority at station level		O
Loc	**SPS**	Local Control Behavior		M
EEHealth	ENS	External equipment health		O
EEName	DPL	External equipment name plate		O
OpCnt	INS	Operation counter		M
Controls				
Pos	DPC	Switch position		M
BlkOpn	SPC	Block opening		M
BlkCls	SPC	Block closing		M
ChaMotEna	SPC	Charger motor enabled		O
Metered values				
SumSwARs	BCR	Sum of Switched Amperes, resetable		O
Status information				
CBOpCap	INS	Circuit breaker operating capability		O
POWCap	INS	Point On Wave switching capability		O
MaxOpCap	INS	Circuit breaker operating capability when fully charged		O
Dsc	SPS	Discrepancy		O
Settings				
CBTmms	ING	Closing Time of breaker		O

Data Object Names

Common Data Class

Description

Mandatory/Optional/Conditional

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Single Point Status (SPS) CDC

(e.g. loc)

SPS class					
Attribute Name	**Attribute Type**	**FC**	**TrgOp**	**Value/Value Range**	**M/O/C**
DataName	Inherited from Data Class (see IEC 61850-7-2)				
DataAttribute					From IEC61850-7-3
			status		
stVal	BOOLEAN	**ST**	dchg	TRUE | FALSE	M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
			substitution		
subEna	BOOLEAN	SV			PICS_SUBST
subVal	BOOLEAN	SV		TRUE | FALSE	PICS_SUBST
subQ	Quality	SV			PICS_SUBST
subID	VISIBLE STRING64	SV			PICS_SUBST
			configuration, description and extension		
d	VISIBLE STRING255	DC		Text	O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

Data Attribute Names

Functional Constraint

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Object Name for Local/Remote Attribute of XCBR1

XCBR1.ST.Loc.stVal

Attribute

Data

Functional Constraint

Logical Node

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Mapping of Names via 8-1

- Section 8-1 maps the IEC61850 LN and Data Object Names to MMS (ISO9506)
- MMS allows only numbers, letters, “$”, and “_” in object names.
- Resulting MMS Object Name:

XCBR1STLoc$stVal

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Object Name for Breaker Position Attribute of XCBR1

XCBR1.ST.**Pos**.stVal

Attribute

Data

Functional Constraint

Logical Node

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Measurement Unit (MMXU)

MMXU class				
Data object name	**Common data class**	**Explanation**	**T**	**M/O/C**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, Clause 22.		
Data objects				
EEHealth	INS	External Equipment Health (external sensor)		O
Measured values				
TotW	MV	Total Active Power (Total P)		O
TotVAr	MV	Total Reactive Power (Total Q)		O
TotVA	MV	Total Apparent Power (Total S)		O
TotPF	MV	Average Power factor (Total PF)		O
Hz	MV	Frequency		O
PPV	DEL	Phase to phase voltages (VL1VL2, ...)		O
PNV	WYE	Phase to neutral voltage		O
PhV	WYE	Phase to ground voltages (VL1ER, ...)		O
A	WYE	Phase currents (IL1, IL2, IL3)		O
W	WYE	Phase active power (P)		O
VAr	WYE	Phase reactive power (Q)		O
VA	WYE	Phase apparent power (S)		O
PF	WYE	Phase power factor		O
Z	WYE	Phase Impedance		O

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Object Name for Phase A to Ground Angle Measurement

MMXU1.MX.PhV.PhsA.cVal.ang.f

Data

Functional Constraint (measurements)

Logical Node

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GOOSE Subscription – LGOS

LGOS class				
Data object name	**Common data class**	**Explanation**	**T**	**M/O/C**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, Clause 22		
Data objects				
Status information				
SbsNdsCom	SPS	Subscription needs commissioning		O
SbsSt	SPS	Status of the subscription (True = active, False=not active)		O
SbsSim	SPS	Subscription wih simulation		O
LastStNum	INS	Last state number received		O
ConfRevNum	INS	Expected Configuration revision number		O
Settings				
GoCBRef	ORG	Reference to the subscribed GOOSE control block		O

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ACSI

Abstract Communications Service Interface

The IEC 61850 Service Model

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ACSI

Abstract Communications Service Interface

- Defines a set of Objects
- Defines a set of Services to manipulate and access those objects
- Defines a base set of data types for describing objects

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ACSI Objects and MMS Mapping

ACSI Object Class	**MMS Object**
SERVER class	Virtual Manufacturing Device (VMD)
LOGICAL DEVICE class	Domain
LOGICAL NODE class	Named Variable
DATA class	Named Variable
DATA-SET class	Named Variable List
SETTING-GROUP-CONTROL-BLOCK class	Named Variable
REPORT-CONTROL-BLOCK class	Named Variable
LOG class	Journal
LOG-CONTROL-BLOCK class	Named Variable
GOOSE-CONTROL-BLOCK class	Named Variable
GSSE-CONTROL-BLOCK class	Named Variable
CONTROL class	Named Variable
Files	Files

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Some ACSI Services

Enable Self Describing Devices

ACSI Services	MMS Services
LogicalDeviceDirectory	GetNameList
GetAllDataValues	Read
GetDataValues	Read
SetDataValues	Write
GetDataDirectory	GetVariableAccessAttributes
GetDataDefinition	GetVariableAccessAttributes
GetDataSetValues	Read
SetDataSetValues	Write
CreateDataSet	CreateNamedVariableList
DeleteDataSet	DeleteNamedVariableList
GetDataSetDirectory	GetVariableAccessAttributes
Report (Buffered and Unbuffered)	InformationReport
GetBRCBValues/GetURCBValues	Read
SetBRCBValues/SetURCBValues	Write
GetLCBValues	Read
SetLCBValues	Write
QueryLogByTime	ReadJournal
QueryLogAfter	ReadJournal
GetLogStatusValues	GetJournalStatus
Select	Read/Write
SelectWithValue	Read/Write
Cancel	Write
Operate	Write
Command-Termination	Write

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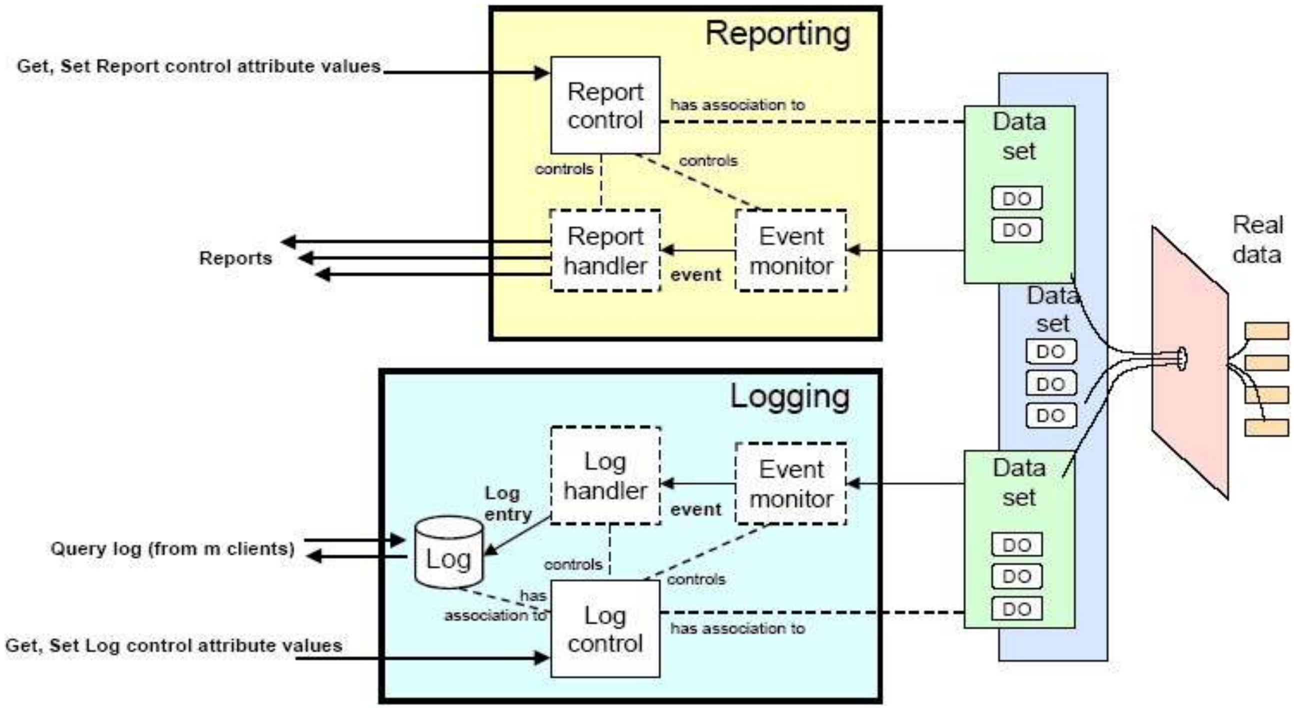
Reporting

- Unbuffered Reporting allows clients to receive data from the server without polling but, if the network connection is lost between the client and server, data is lost.
- Buffered reporting enables the server to retain data if connections are lost enabling the client to retrieve ALL the data.



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Buffered Report Tracking Service – BST

BTS Class						
Attribute name	**Attribute type**	**FC**	**TrgOp**	**r/w**	**Value/value range**	**M/O/C**
Shall inherit all the data attributes of the **CST CDC**						
Specific to the BTS						
rptID	VISIBLE STRING129	SR		r	Service parameter ReportIdentifier is mapped to rptID	M
rptEna	BOOLEAN	SR		r	Service parameter ReportEnable is mapped to rptEna	M
datSet	ObjectReference	SR		r	Service parameter DatSetReference is mapped to datSet	M
confRev	INT32U	SR		r	Service parameter ConfigurationRevision is mapped to confRev	M
optFlds	PACKED_LIST	SR		r	Service parameter OptionalFields is mapped to optFlds	M
bufTm	INT32U	SR		r	Service parameter BufferTime is mapped to bufTm	M
sqNum	INT32U	SR		r	Attribute SqNum of BRCB is mapped to sqNum	M
trgOps	TriggerConditions	SR		r	Service parameter TriggerOptionsEnabled is mapped to trgOps	M
intgPd	INT32U	SR		r	Service parameter IntegrityPeriod is mapped to intgPd	M
gi	BOOLEAN	SR		r	Service parameter GeneralInterrogation is mapped to go	M
purgeBuf	BOOLEAN	SR		r	Service parameter PurgeBuf is mapped to purgeBuf	M
entryID	EntryID	SR		r	Service parameter EntryIdentifier is mapped to entryID	M
timeOfEntry	EntryTime	SR		r	Service parameter TimeOfEntry is mapped to timeOfEntry	M
resvTms	INT16	SR		r	Service parameter ReserveTimeSecond is mapped to resvTms	O

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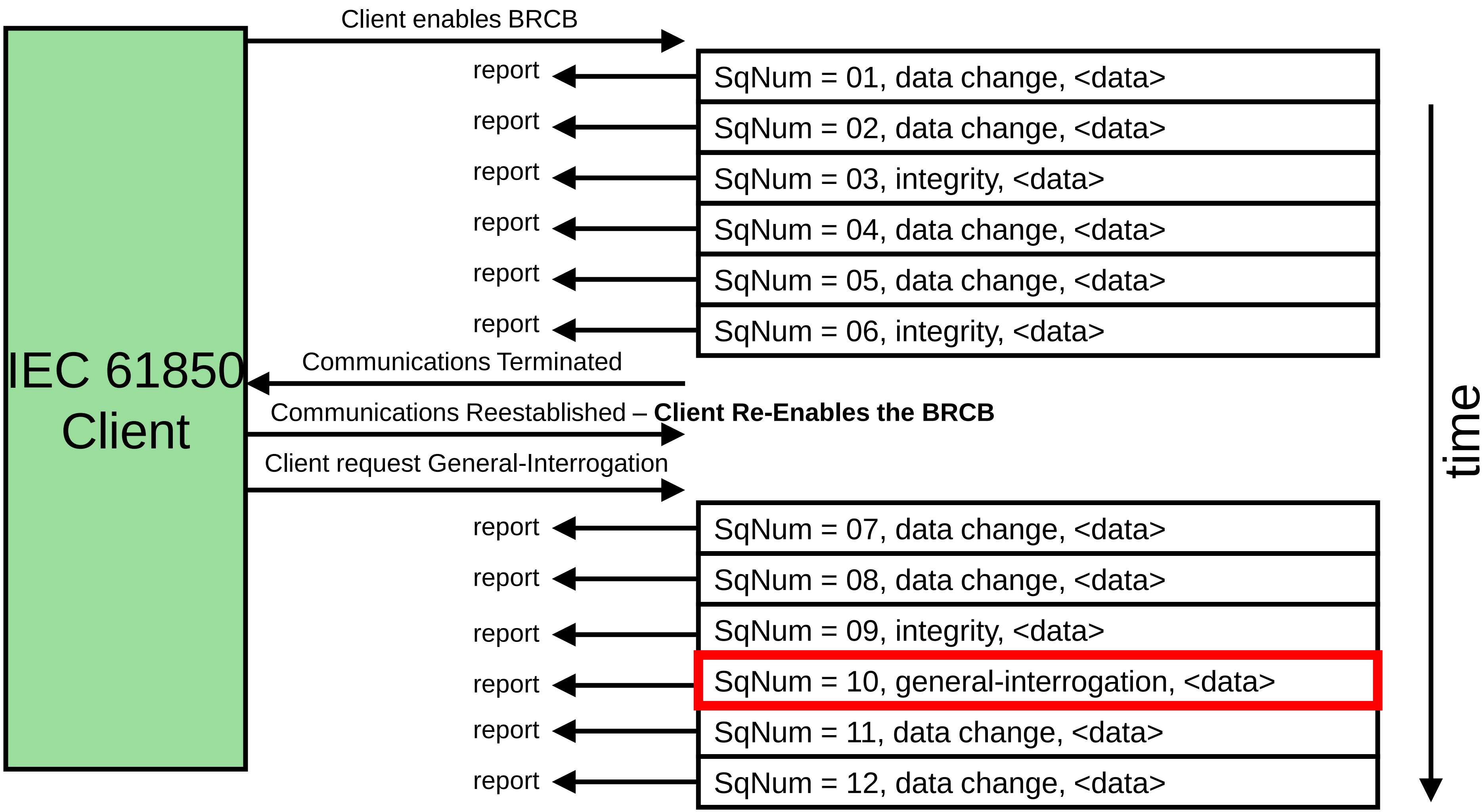
Buffered Reporting with GI Example



SqNum = 10 flags when the GI was issued by the client to identify data that was reported while disconnected.

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Using Modeling to Control Reports

- Requirements:
  - Desire to receive average readings of current measurements on all 3 phases of a feeder and the actual voltage measurement on one phase every 10 minutes.
  - Any under or over voltage or current conditions should be reported immediately.
- Use MSTA for average current measurements
- Use MMXU for actual voltage measurement and range alarms
- Careful selection of attributes (instMag versus mag) and range alarms enable these complex requirements to be handled via client interaction with server.

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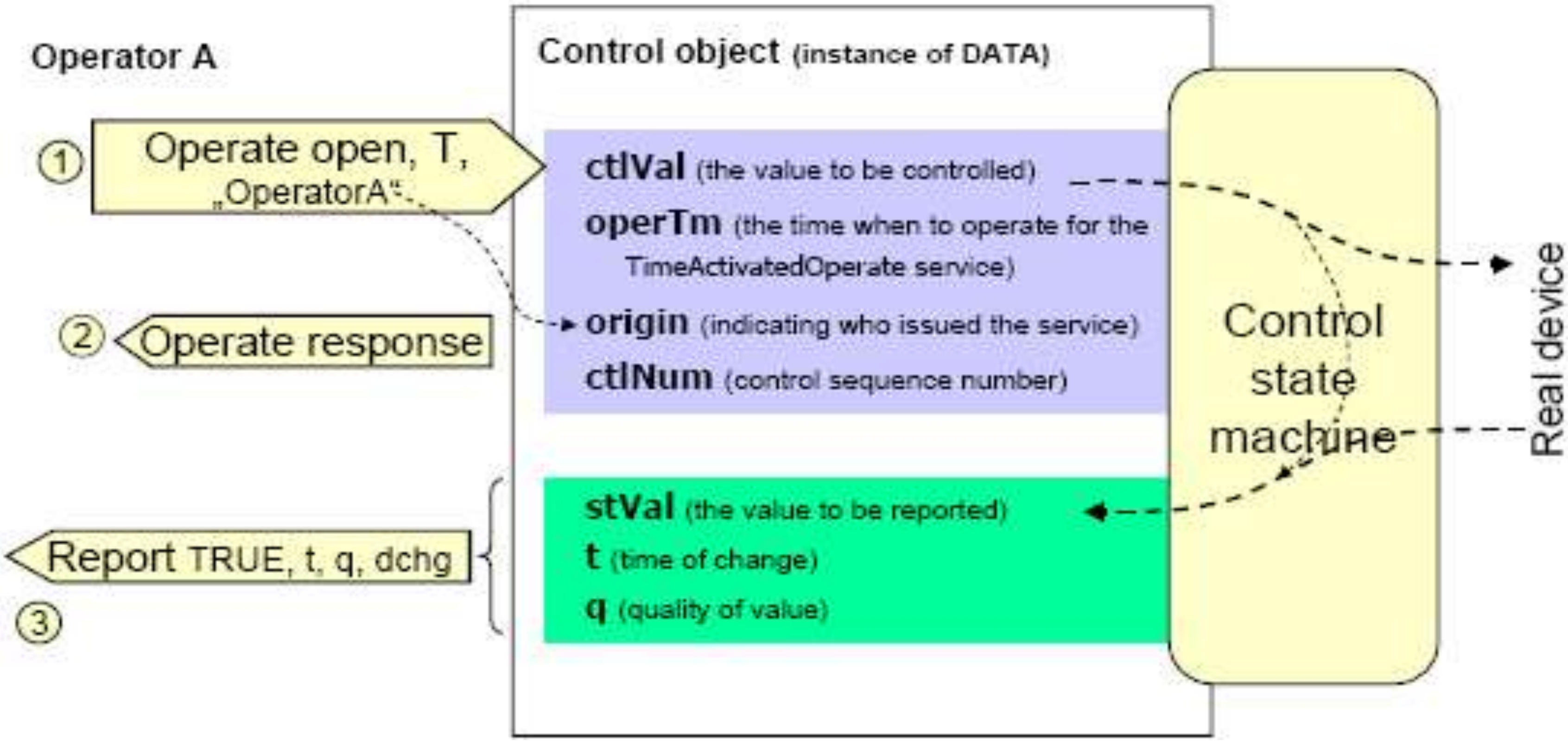
General Control Model



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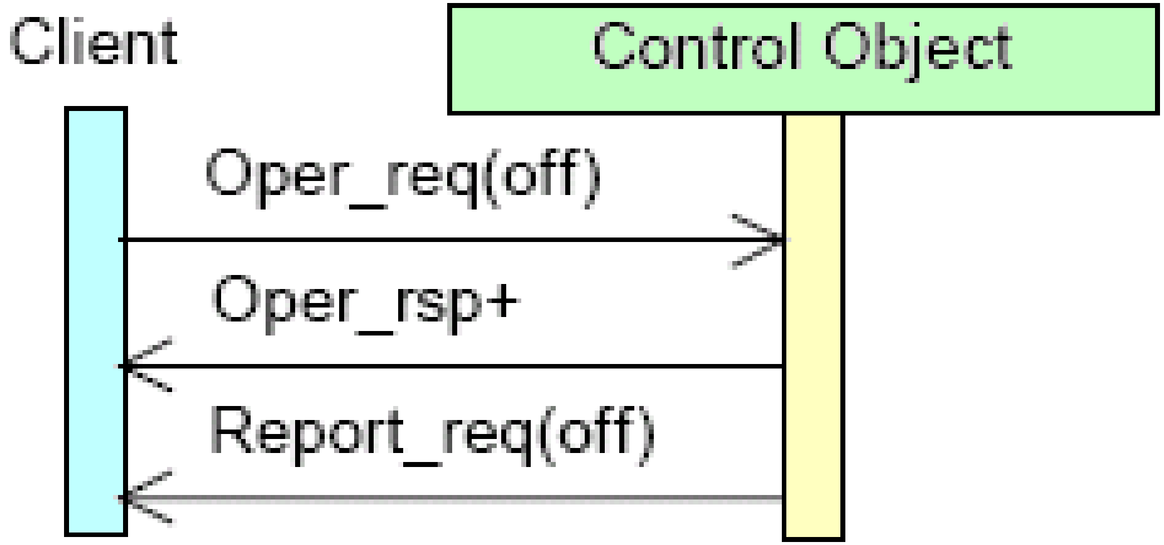
Direct Control with Normal Security



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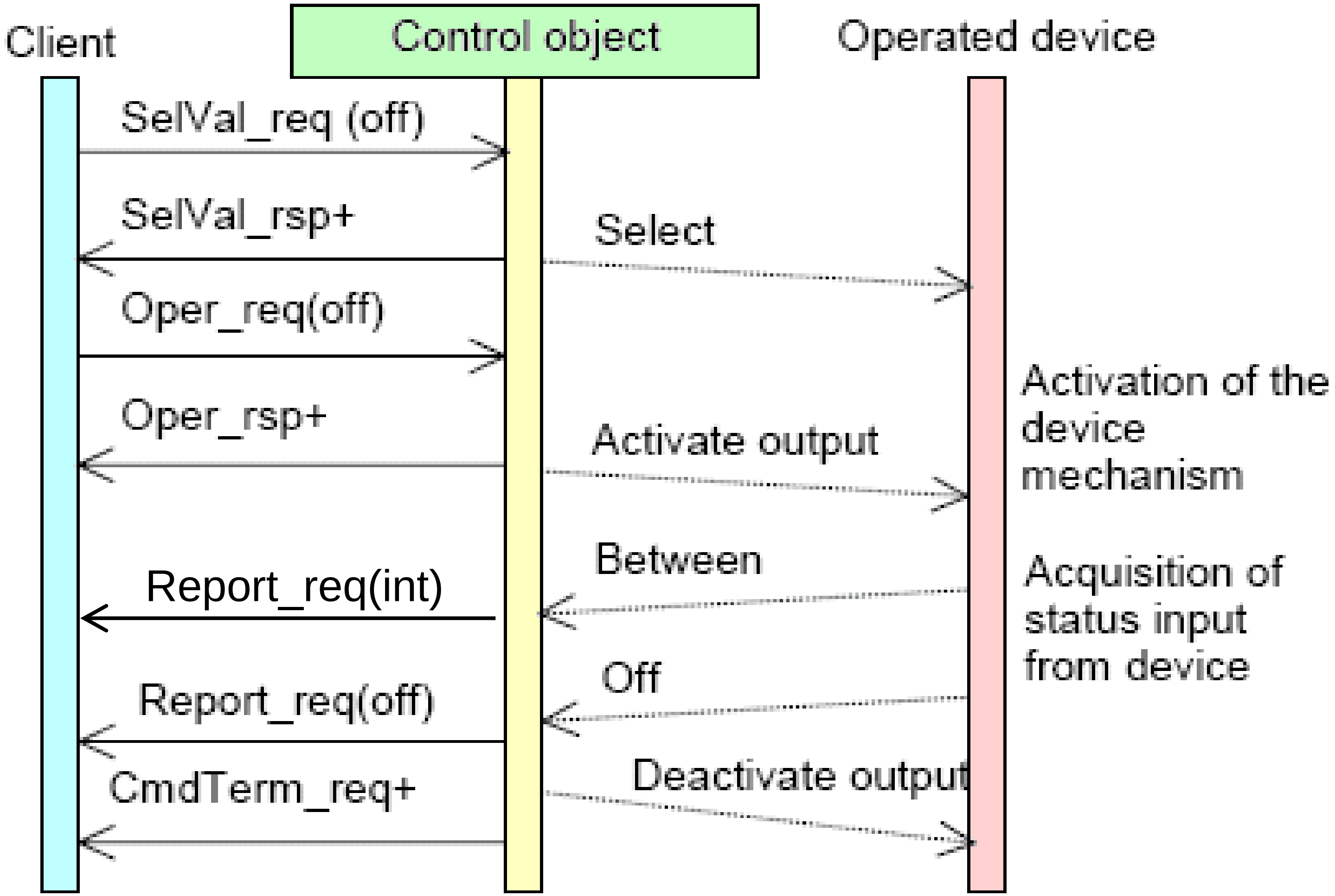
SBO Control with Enhanced Security



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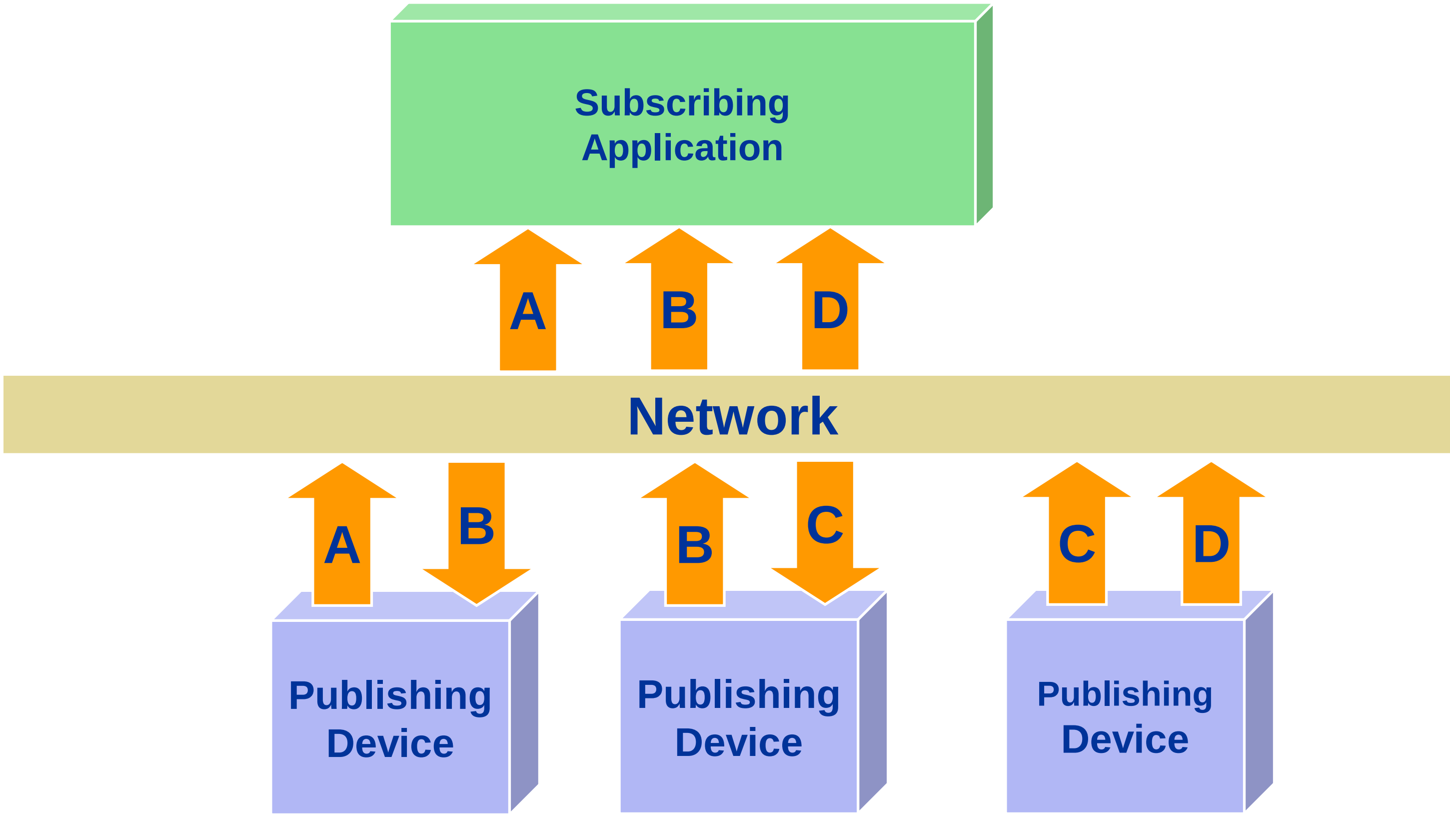
GOOSE Messaging



Applications “subscribe” by listening for data **sent** to a given multi-cast **destination** address

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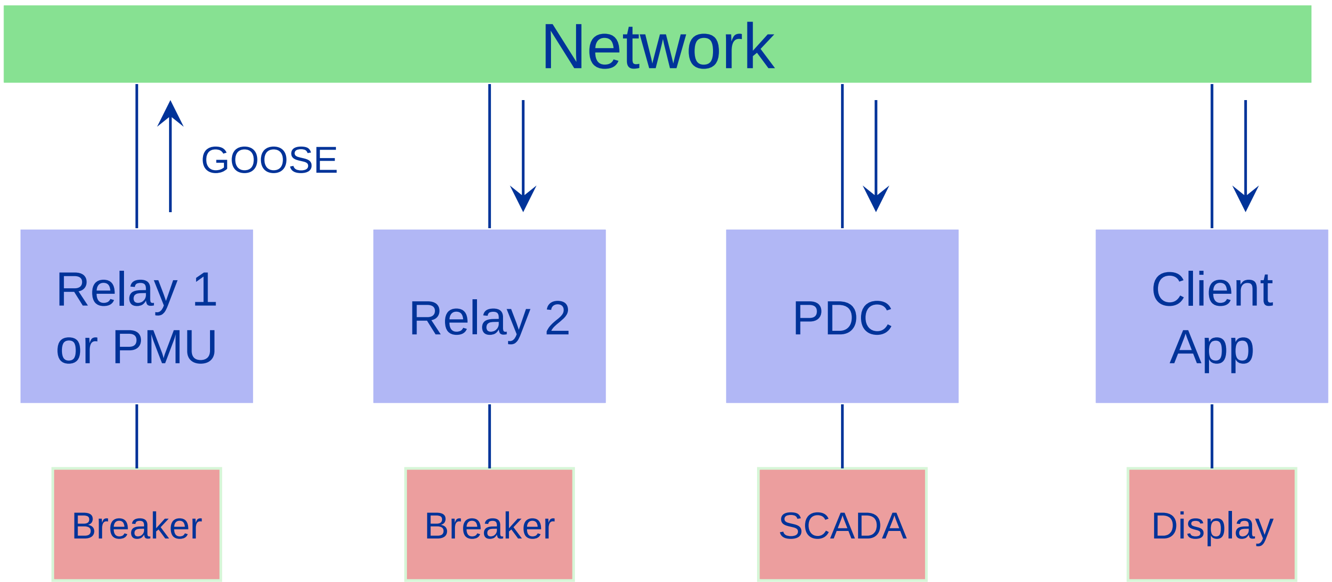
IEC61850 Network Architecture



GOOSE - Generic Object Oriented Substation Event (sends data sets)

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GOOSE Message

Name	Type
gocbRef	GOOSE Control Block
timeAllowedtoLive	How long to wait for next message (ms)
datSet	The name of the data set being sent
goID	ID of the sending GOOSE application (gocbRef)
T	Time of state change
stNum	State Number
sqNum	Sequence Number
Simulation	Simulated Data (true/false)
confRev	Configuration Revision of the GOOSE Control Block (dataset config)
ndsCom	Needs Commissioning (true/false)
numDatSetEntries	Number of data set entries in the message
Data	The data values of the data set in sequence.

Binary encoding of above data

Ethernet Multicast Address Using 802.3 Ethertype or 90-5 for IP Multicast

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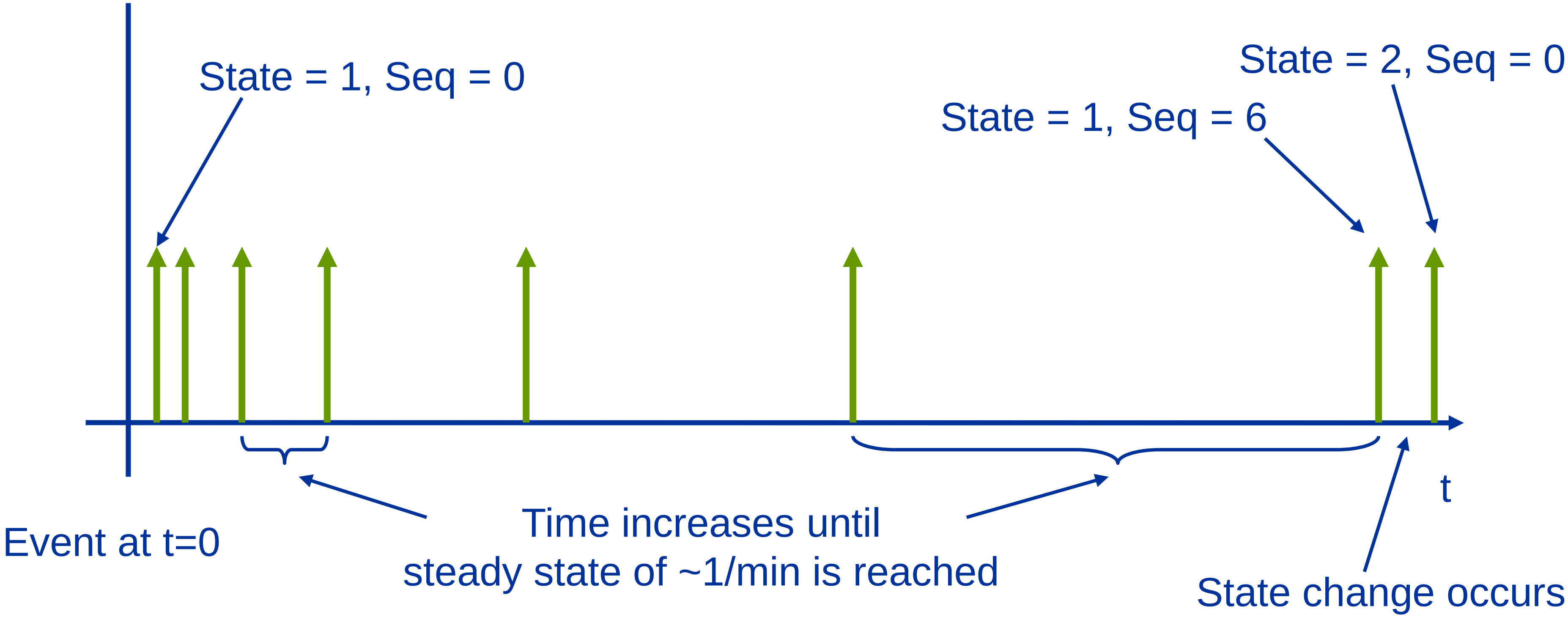
GOOSE is reliable multicast

Each line below represents a GOOSE message



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Sampled Value Messaging

- Unlike GOOSE Messaging, which is event based, SV messaging is stream based
  - Each message contains one or more samples of data taken at a specified sample rate
  - Messages are sent constantly at a sufficient rate to communicate all the samples.

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Sampled Value Message

Name	Type
MsvCBRef	Multicast Sampled Value Control Block
DatSet	The name of the data set being sent
MsvID	System wide unique ID of the sending application
SmpCnt	The number of samples in the message
RefrTm	Time of the first sample
ConfRev	Configuration Revision of the MSV Control Block (dataset config)
SmpSynch	Samples are time are time synchronized (true/false)
SmpRate	Sample Rate
SmpMod	Sample Mode: samples/period, samples/second, seconds/sample
Simulation	Simulated data (true/false)
Sample [1..n]	The sequence of samples (one data set per sample)

Binary encoding of above data

Ethernet Multicast Address Using 802.3 Ethertype or 90-5 for IP Multicast

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Substation Configuration Language

SCL
IEC 61850-6

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SCL – Substation Configuration Language IEC61850-6

- Description language for communication in electrical substations related to the IEDs.

- XML based language that allows a formal description of
  - Substation automation system and the switchyard and the relation between them
  - IED configuration
  - Support for private extensions

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Basic Substation Config. Language (SCL) File Types

- **SSD**: System Specification Description.
  - XML description of the entire system
- **SCD**: Substation Configuration Description.
  - XML description of a single substation.
- **CID**: Configured IED Description.
  - XML configuration for a specific IED.
- **ICD**: IED Capability Description.
  - Description of what is supported by an IED (required for servers).

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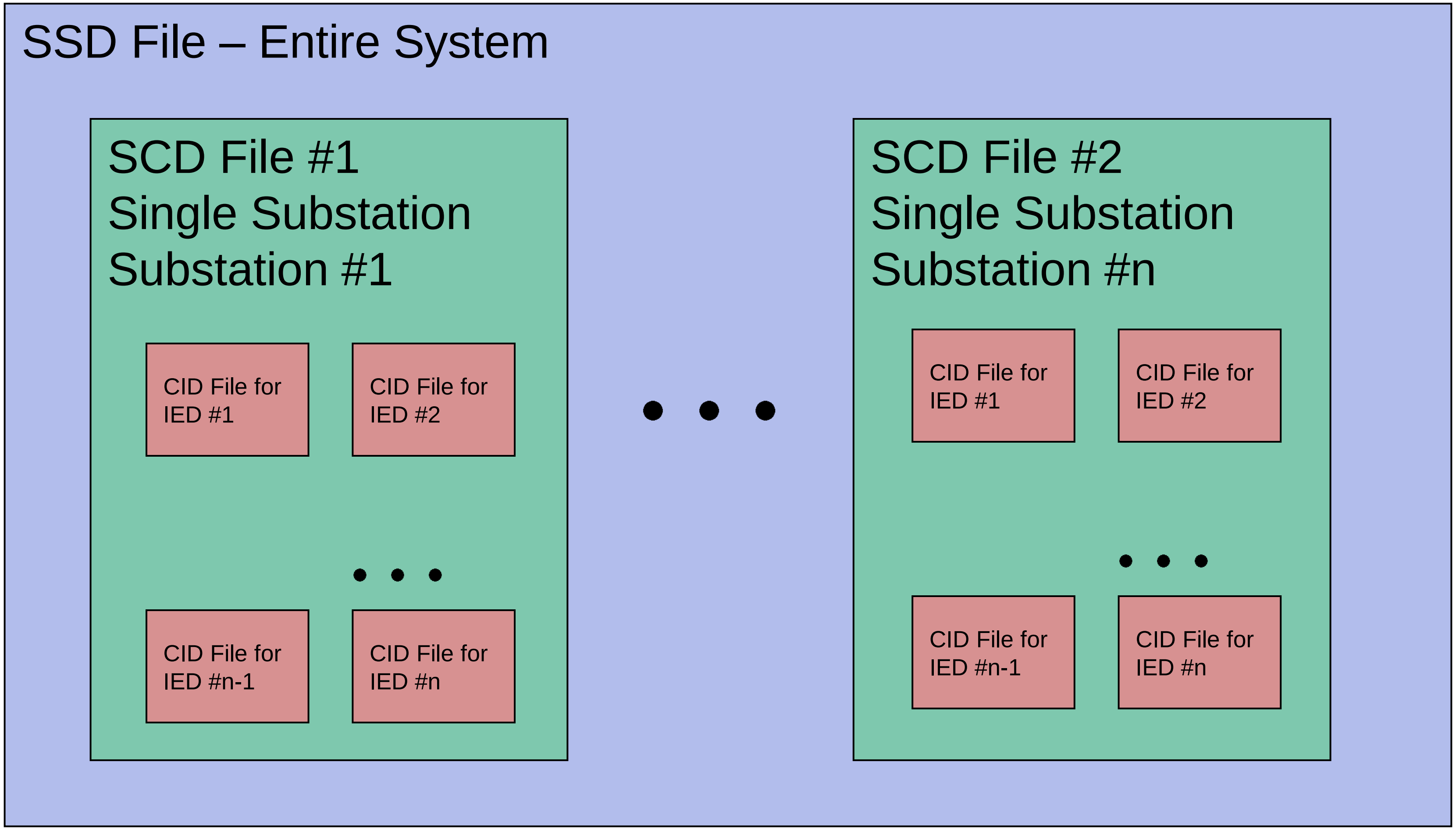
How SCL Files Work Together



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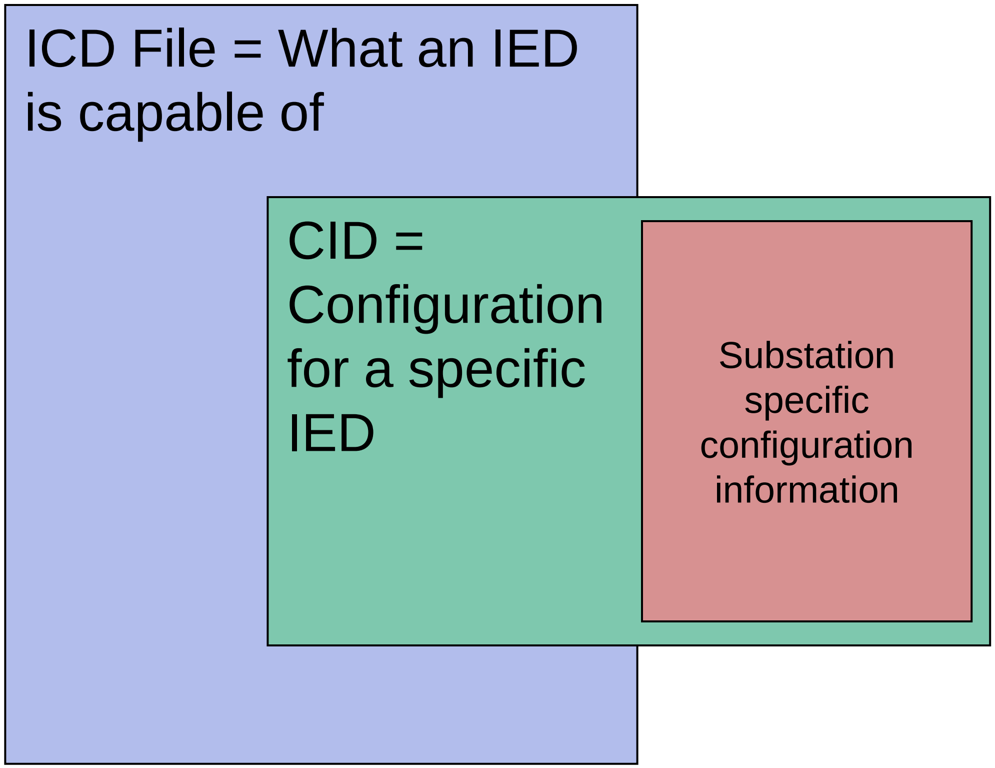
ICD versus CID Files



- CID File = Subset of ICD File Actually Used + Substation Specific Configuration Info.
- Subset:
  - Not all logical nodes, control blocks, I/O, etc. supported by the device are used in a system.
- Substation Configuration Info:
  - Report control block presets
  - Static values for location, and other descriptions.

ICD – IED Capability Description
CID – Configured IED Description

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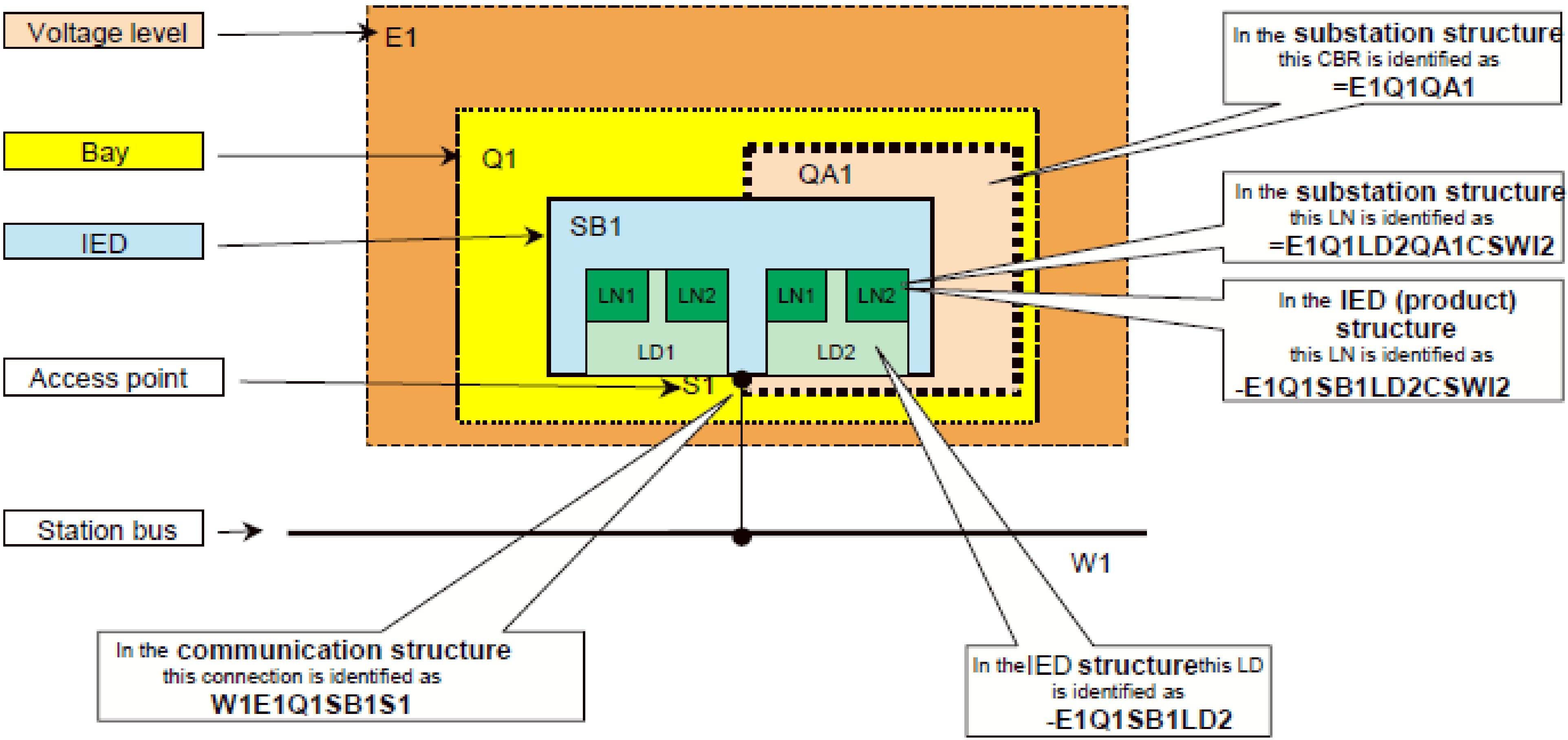
SCL Driven Naming



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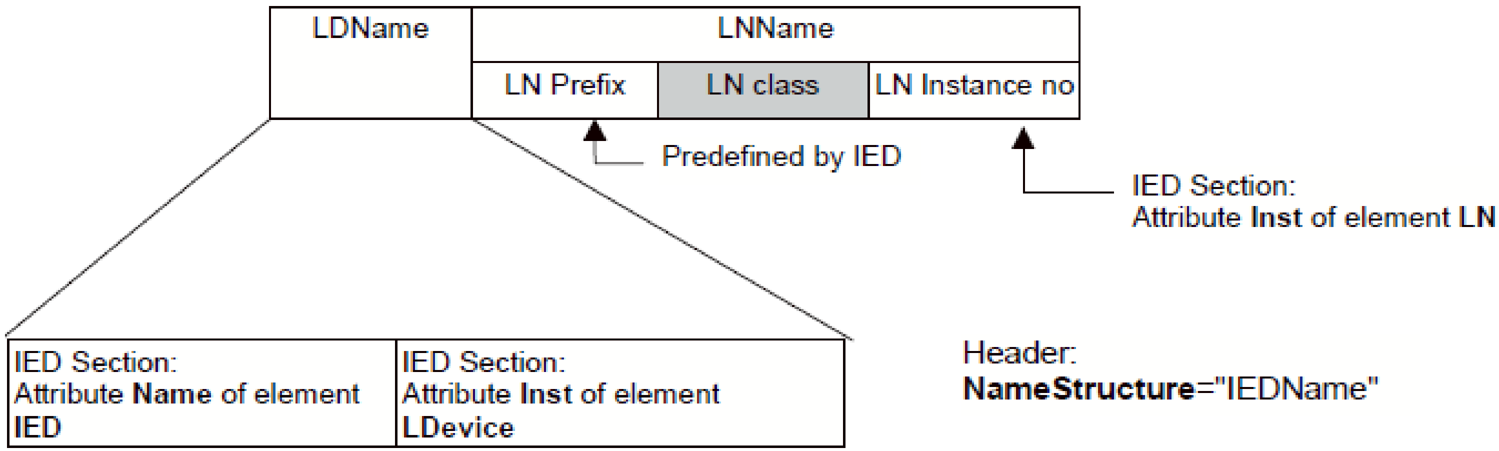
Logical Device and LN Naming = IEDName



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Example of SCL

SISCO_DEMO_IED.txt


```xml
<?xml version="1.0" encoding="UTF-8" ?>
<SCL xmlns="http://www.iec.ch/61850/2003/SCL" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.iec.ch/61850/2003/SCL SCL.xsd">
<Header id="SISCO_DEMO_IED" version="1" revision="2" toolID="WordPad" nameStructure="IEDName"/>
  <Communication>
        <SubNetwork name="StationBus1" type="8-MMS">
              <Text/>
              <BitRate unit="b/s">100</BitRate>
              <ConnectedAP iedName="SISCO_IED_" apName="AXS4MMS_IED">
                    <Address>
                          <P type="IP">192.168.0.194</P>
                          <P type="IP-SUBNET">255.255.255.0</P>
                          <P type="OSI-TSEL">0001</P>
                          <P type="OSI-SSEL">0001</P>
                          <P type="OSI-PSEL">00000010</P>
                    </Address>
                    <GSE ldInst="CTRL" cbName="ControlDataSet1">
                          <Address>
                                <P type="MAC-Address">01-0C-CD-01-F1-04</P>
                                <P type="APPID">0000</P>
                                <P type="VLAN-ID">1</P>
                                <P type="VLAN-PRIORITY">4</P>
                          </Address>
                    </GSE>
```


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SCL Applications

- For users to specify IED requirements.
- For vendors to specify IED capabilities.
- Configure IEC61850 clients w/o IEDs.
- Extract IED configuration from power system design tools.
- Export IED configuration to power system design tools and other applications.

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Questions - Discussion

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The Standards Based Integration Company

Systems Integration Specialists Company, Inc.

Thank You

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