Features and Benefits of IEC 61850

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Agenda

- What is it and how did we get here?
- The role of IEC 61850 in the Utility “Big Picture”
- The relationship between IEC 61850 and DNP3
- What’s so great about it?
- Overview of the various IEC 61850 features
- Things to consider moving forward
- What IEC 61850 means to stakeholders

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IEC 61850

What is it?

- Not just a communications protocol
- A comprehensive standard for the design of substation automation systems and applications
- A collection of multiple protocols, concepts and component standards
- A platform for designing, implementing, and operating utility automation systems
- A method for adding needed context and structure around what historically was simple, unformatted data
- A “way of life” for utility automation

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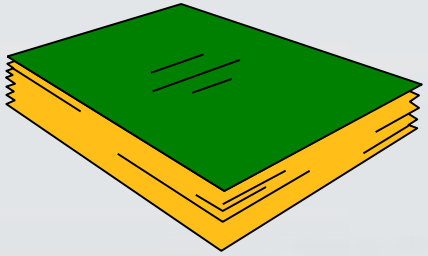
History

- Sponsored by Electrical Power Research Institute (EPRI)
- UCA 1.0 in 1992 - too vague, no TCP/IP
- Many pilot projects, no consensus
- American Electric Power initiative brought focus
- UCA 2.0 was captured as technical report IEEE TR-1550 in 1999
- IEC 61850 became an International Standard in 2004/2005
- UCA included the popular Inter-Control-Center Protocol (ICCP)
- ICCP is a separate IEC standard: Telecontrol Application Service Element (TASE.2), IEC 60870-6



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Utility Field Protocol Evolution

- 100s of Proprietary Protocols
- Mfg. Auto. Protocol-MAP 1984
- MMS ISO9506 1988
- EPRI UCA Architecture 1991
- UCA2.0 IEEE TR1550 1999
- **ICCP IEC60870-6 1996**
- **IEC61850 2003**
- Common Object Models and Security (Future)
- 100s of Proprietary Protocols
- IEC60870-5 IEC TC57 1994
- DNP3 Serial Links 1993
- DNP3 Ethernet ~2000

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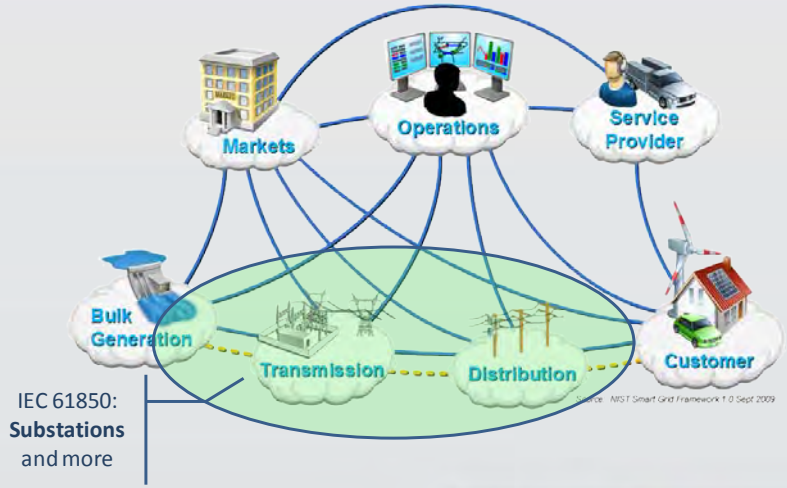
IEC 61850's role in the "Big Picture"

- Identified in the first batch of interoperability standards key to Smart Grid deployment by NIST
- Focused on automation systems utilized in the electric utility transmission and distribution domains
- Provides network options for applications such as:
  - Traditional SCADA applications
  - High speed protection
  - Analog wave form data
    - "Digital PT's and CT's"
    - Phasor Measurement



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IEC 61850 and DNP3

Issue	IEC 61850	DNP3 (IEEE 1815)
Recognized in NIST Interoperability Framework	Yes	Yes
Distribution Feeder Automation	No profile currently exists for low-bandwidth networks	Designed for it
Substation Automation	Yes	Yes
Substation to Control Center	Under development	Yes
High Speed Peer-to-peer	Yes	No
Structured Data and Naming	Yes	Limited. Numbered Points.
Self-Description	Yes	Limited
XML Configuration File	Yes	Yes

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IEC 61850 and DNP3 Evolution

- IEC 61850 has more advanced features
- DNP3 is in use in over 75% of North American utilities
- Can use gateways as an upgrade path
- Can use 61850-7-4 naming to document DNP 3 “points lists”
- IEEE 1815.1 gateway standard under development
  - How to map data
  - How to map services
  - Use case descriptions

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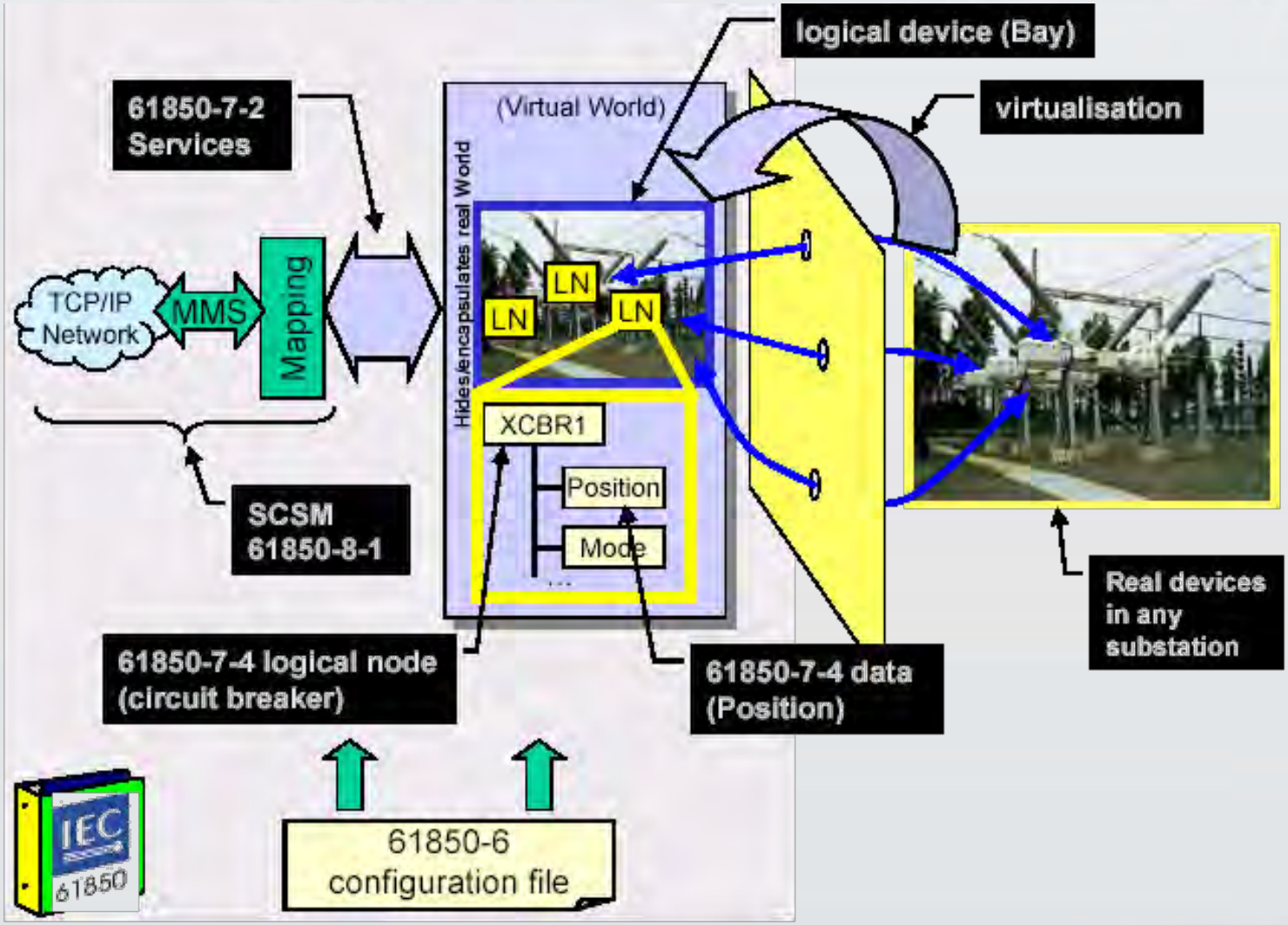
Purpose: to Visualize a Substation



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So What's So Great About It?

Features no other SCADA protocol has had before...

- Self-description and browsers
- Structured data
- Device models, not data points
- Capability for access security
- Fast peer-to-peer communications
- Dramatic reduction of necessary wiring
- Powerful reporting features
- A wide choice of lower layers

Based on "modern" information technology concepts

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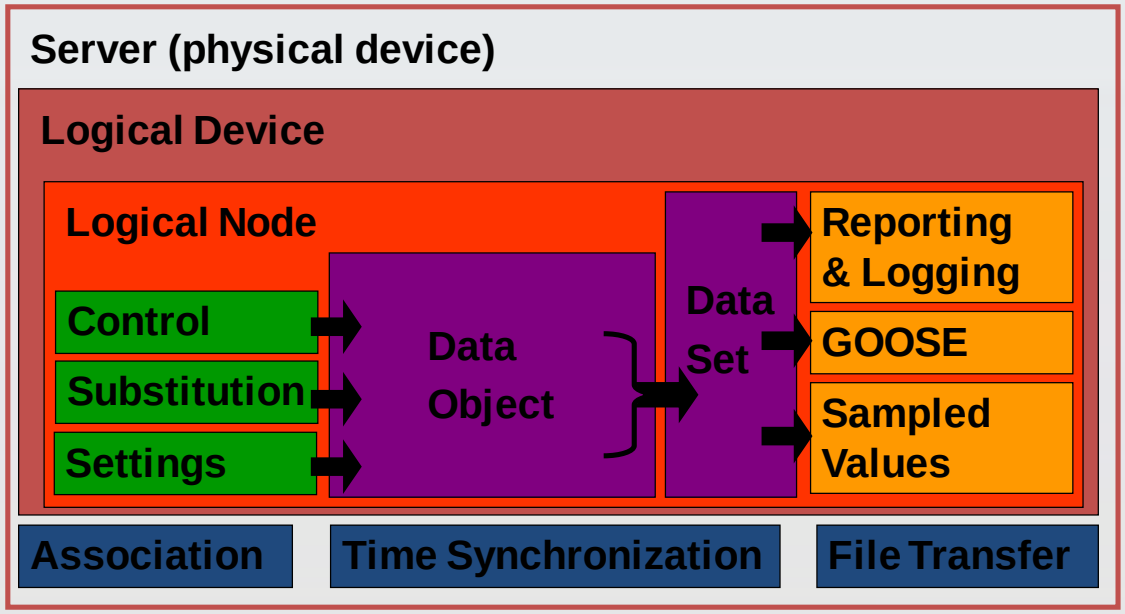
APPLICATION LAYER

- **Services:** What can you do with IEC 61850?
  - Naming
  - Read/Write
  - Self-Description
  - Reporting
  - Controls
  - Logging
  - Files



- **Object Model:** What data can you operate on?
  - Logical Nodes
  - Common Data Classes

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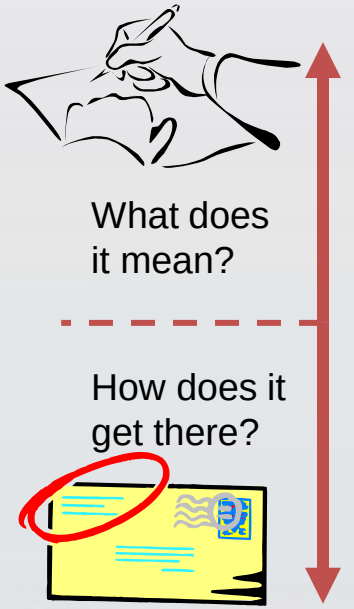
Abstract Communication Service Interface

- Why define abstract services?
  - Isolates the data from the specifics of communications
  - Can be mapped to many protocols
  - 'Future proofing' - allows adoption of future technologies, e.g. web services
  - **All of these are fundamental qualities defined in the NIST Roadmap Architecture chapter**
- What does the ACSI define?
  - Functions and parameters for each service
  - How to build logical devices out of logical nodes
  - How to organize data objects derived from logical nodes



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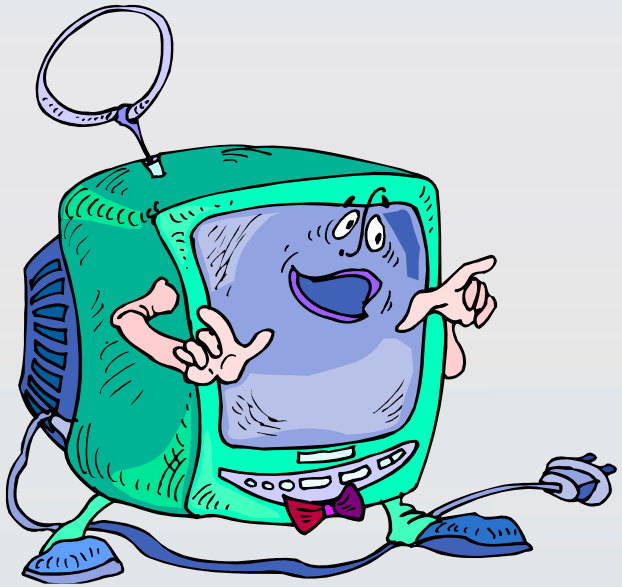
Self-Description

- A device can *tell* its master what data it will report
- Master could *automatically configure* itself for the device!
- At the very least, provide a "*chooser*" of what data to map.
- Includes for each point:
  - Data ***type***
  - Data ***structure***
  - Human-readable ***name***



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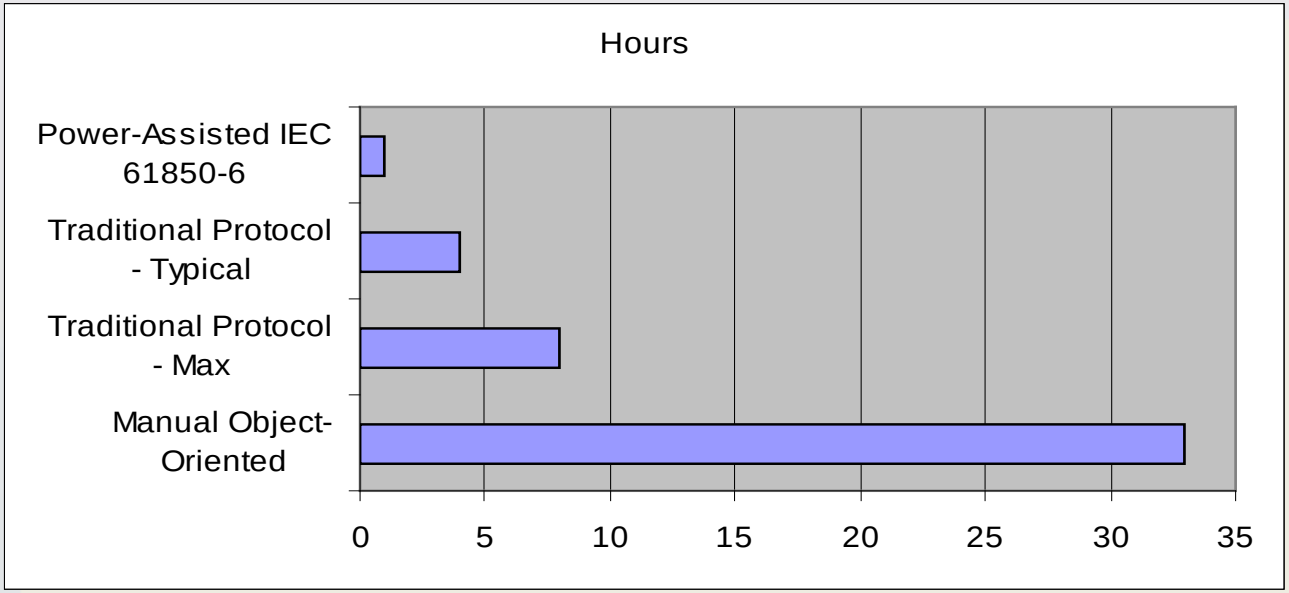
What Self-Description Could Mean…

- A savings of *75%* or more in configuration ***time***
- Major reductions in configuration ***errors***
- It now takes ***three weeks*** to configure a substation, before final acceptance testing!
- "Plug and Play" devices
- SCADA "***browsers***" that don't need a config!

This could cause a Revolution!



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Structured Data - Why We Need It

- Concentrators currently ***lose information***:
  - The name of the ***source*** device
  - The physical and electrical ***location***
  - The ***path*** taken to acquire the data
  - ***Relationships*** between points (e.g. phases)
  - ***Units*** of measurement
- Only the ***type*** of data is retained (e.g. analog)
- Must be ***added back in later*** as description
- Forces system engineer to keep it all in mind

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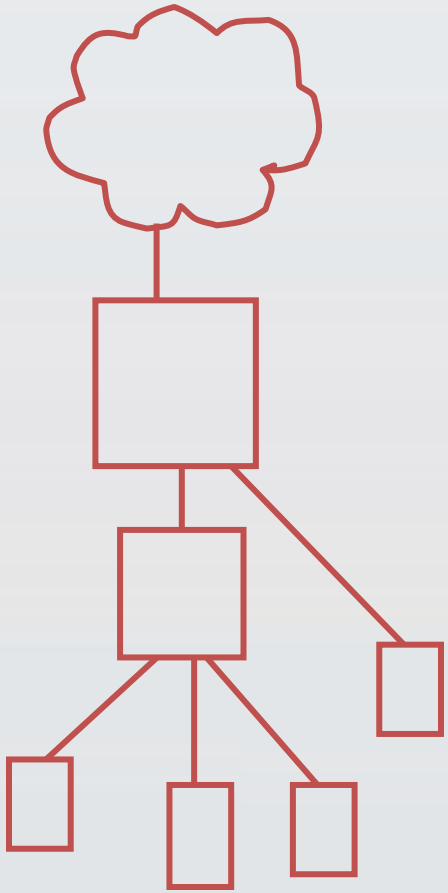
Structured Data in IEC 61850

- Information is *not lost!*
- *Embedded* as part of the name
- *Forwarded* up the chain by self-description
- *Visible* without configuration via browsers

- Reduces current dependence on:
  - spreadsheets
  - tables
  - wiring diagrams
  - system documentation



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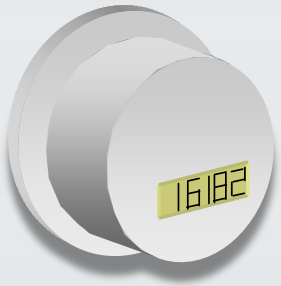
Device-Based Object Models



- Now we can ***standardize data names*** for common device functions, e.g.:
  - Energy Meter
  - Distance Relay
  - Capacitor Bank Controller
  - Transformer Tap Changer
- Vendors are permitted to
  - Use only a ***subset***
  - Add ***superset*** value-added features
  - ***Mix and match*** functions in a device
- Called "***Logical Nodes***"

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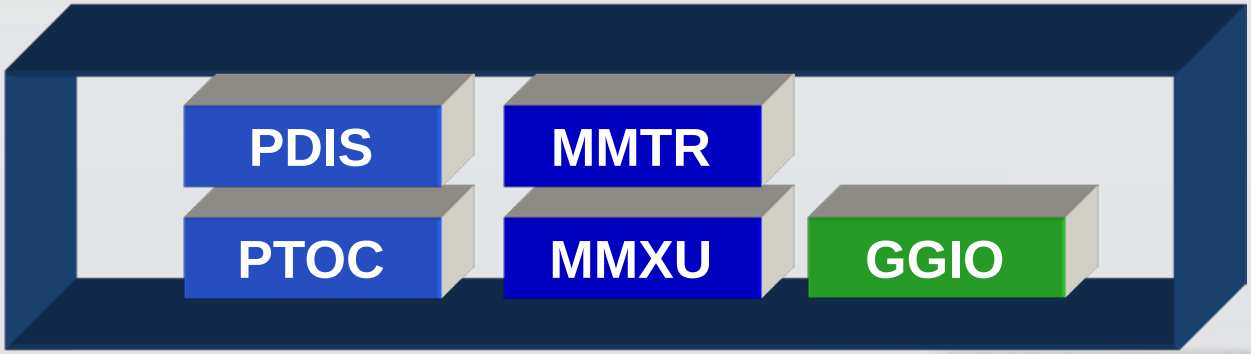
Logical Nodes

- A relay used to perform only one protection function
- Now it may perform several protection functions, e.g.
  - PTOC: Time Overcurrent
  - PDIS: Distance Protection
- May also provide non-protection functions e.g.
  - MMXU: Measurement Unit
  - MMTR: Energy Meter
  - GGIO: Generic Input/Output
- The functions of this real device are built from those of idealized imaginary devices



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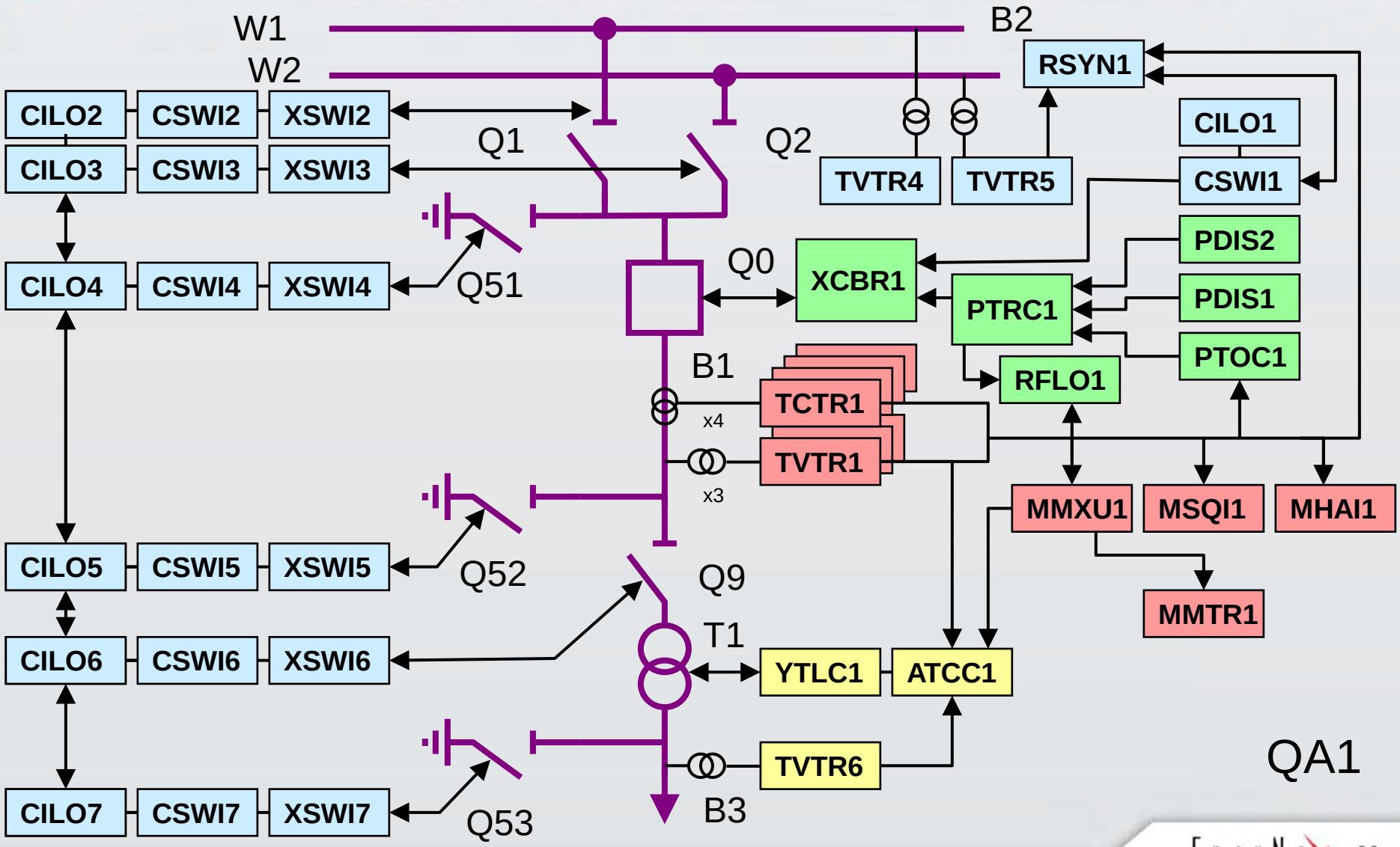
Modeling a Complete Feeder



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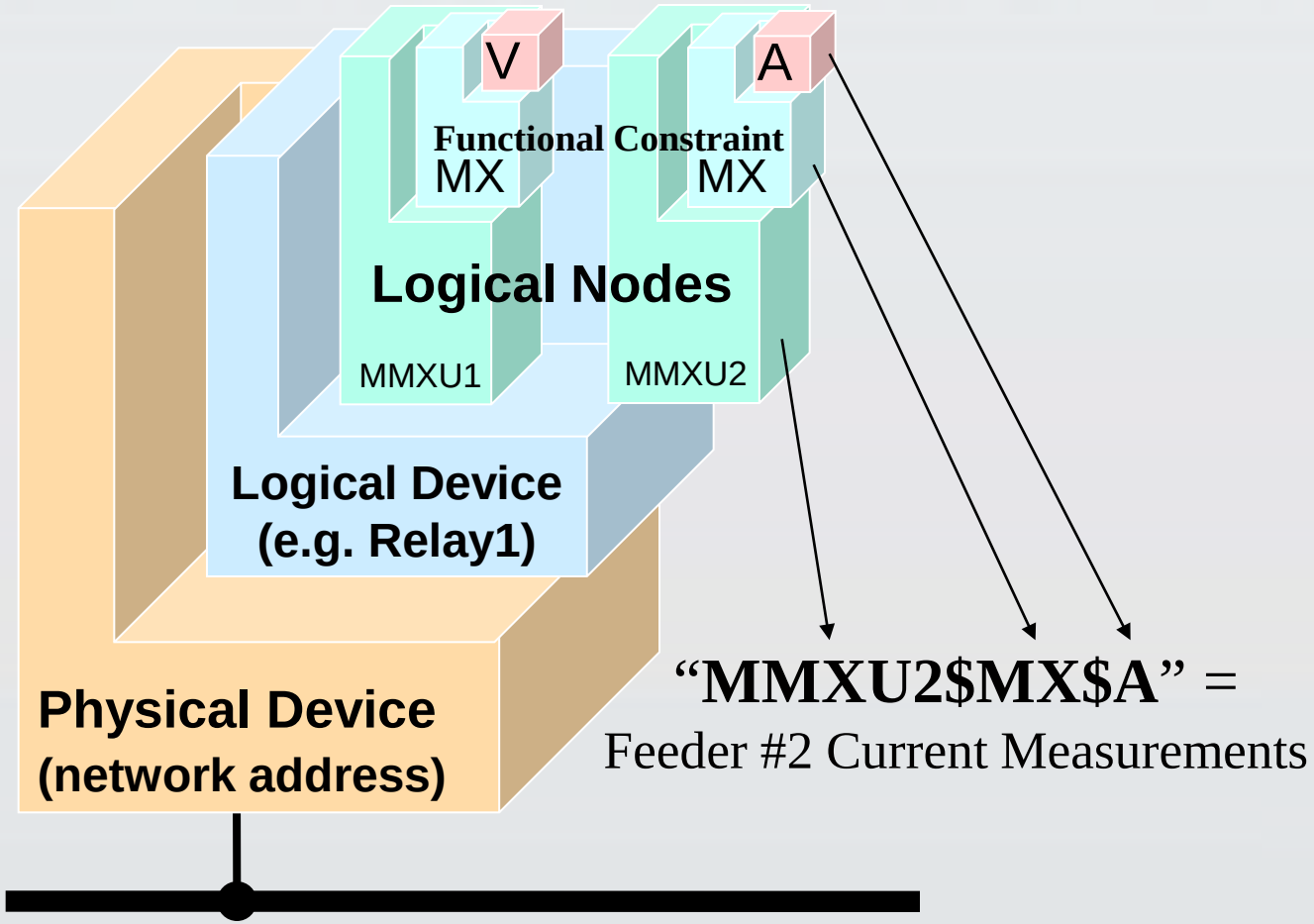
Anatomy of an Object Name



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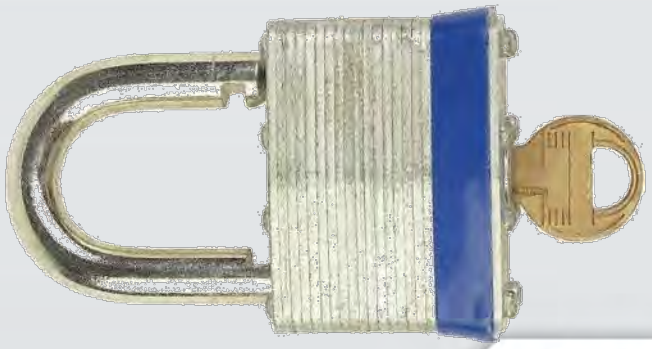
IEC 61850 Security

- Based on IEC 62351 technical specifications
- Digital Signatures at the application (MMS) layer
- Encryption at the transport (TLS/TCP) layer
- Specialized authentication for GOOSE messages
- Software available and in use today
- New work underway for synchrophasors



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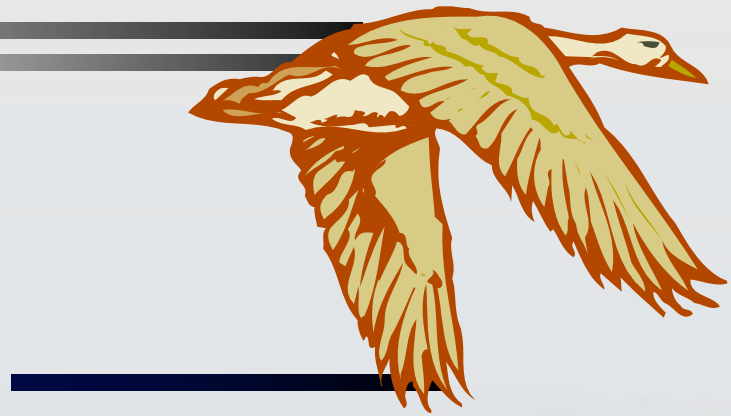
Fast Peer-to-Peer Communication

- Generic Object-Oriented Substation Event (GOOSE)
- Intended to replace relay-to-relay wiring
- Each device multi-casts a selected set of data
- Assumes the message will not get through
- Retransmits immediately, exponential backoff
- Periodic retransmission



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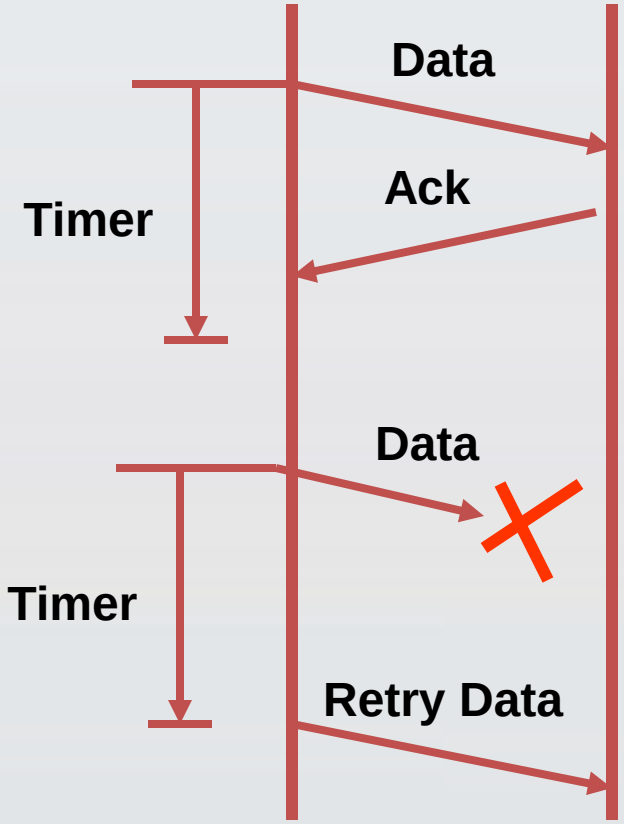
High-Speed or Reliable?

- GOOSE is intended to replace direct relay-to-relay wiring
- Need both:
  - Very high speed (<4ms in transit)
  - Very high reliability
- Traditional protocols use acknowledgements
  - Sender starts timer
  - Waits for response
  - Retransmits if timeout occurs
- In protection applications, this is TOO LATE!



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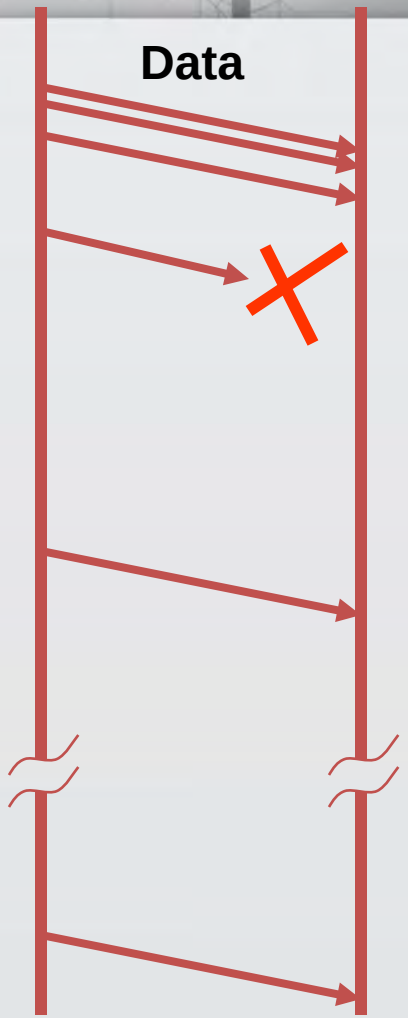
High-Speed AND Reliable!

- GOOSE uses a different approach:
  - ***Assume*** that the first message will not get through!
  - ***Always*** re-transmit the message
  - Depend on the receiver to detect duplicates
- Only one-way traffic needed
  - Exponential back-off
  - Eventually transmits about once every 2 seconds
  - Can continuously monitor state of the channel
- Based on IEEE 802 “multicast” addressing
- Hardware filters out what’s not needed



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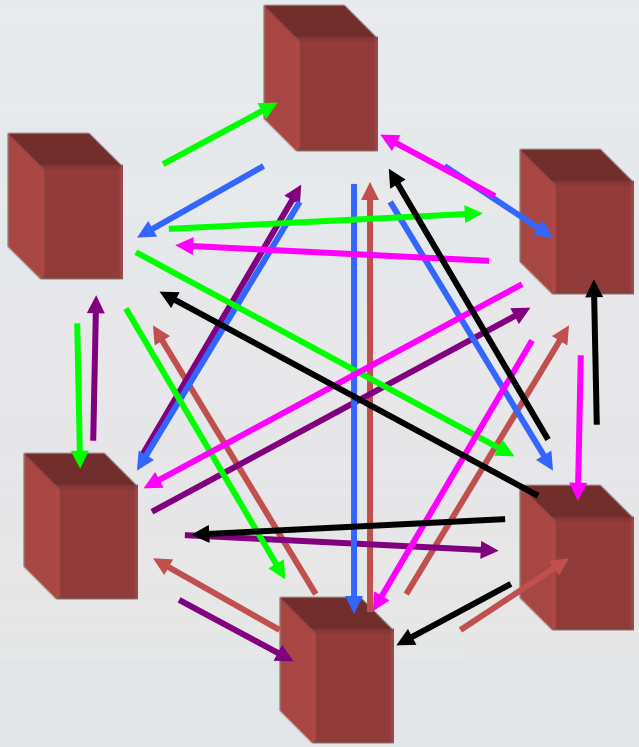
LAN Interlocking and Tripping

- **GOOSE is ideal for interlocking**
  - Multicasting eliminates multiple connections between devices
  - Solves the *n x (n-1)* problem
  - Several simple logic programs replaces one complex one
- **LAN tripping is more controversial**
  - Has been implemented successfully
  - Performance is a key issue
  - Some problems not yet solved, e.g. breaker failure must detect *absence* of a signal in time.
  - Devices may have to be certified



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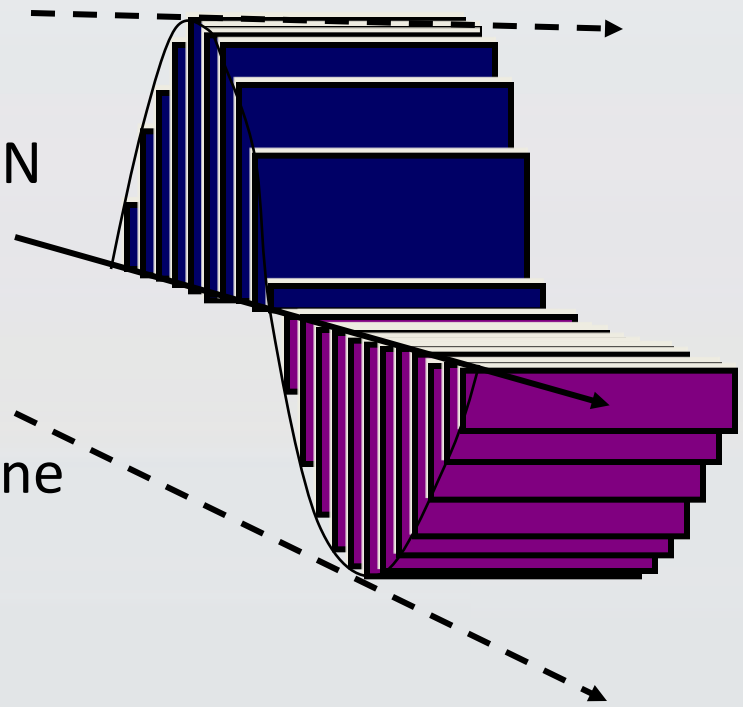
Sampled Values on the LAN

- Takes decentralization one step further
- Separates sampling physically from
  - Measurement
  - Metering
  - Calculation
- Synchronizing breaker closure over LAN
- More flexibility in measurement
  - Any device may measure any circuit
  - "Smart" CTs and PTs ("merging units")
- Some performance measurements done
- Requires Gigabit Ethernet



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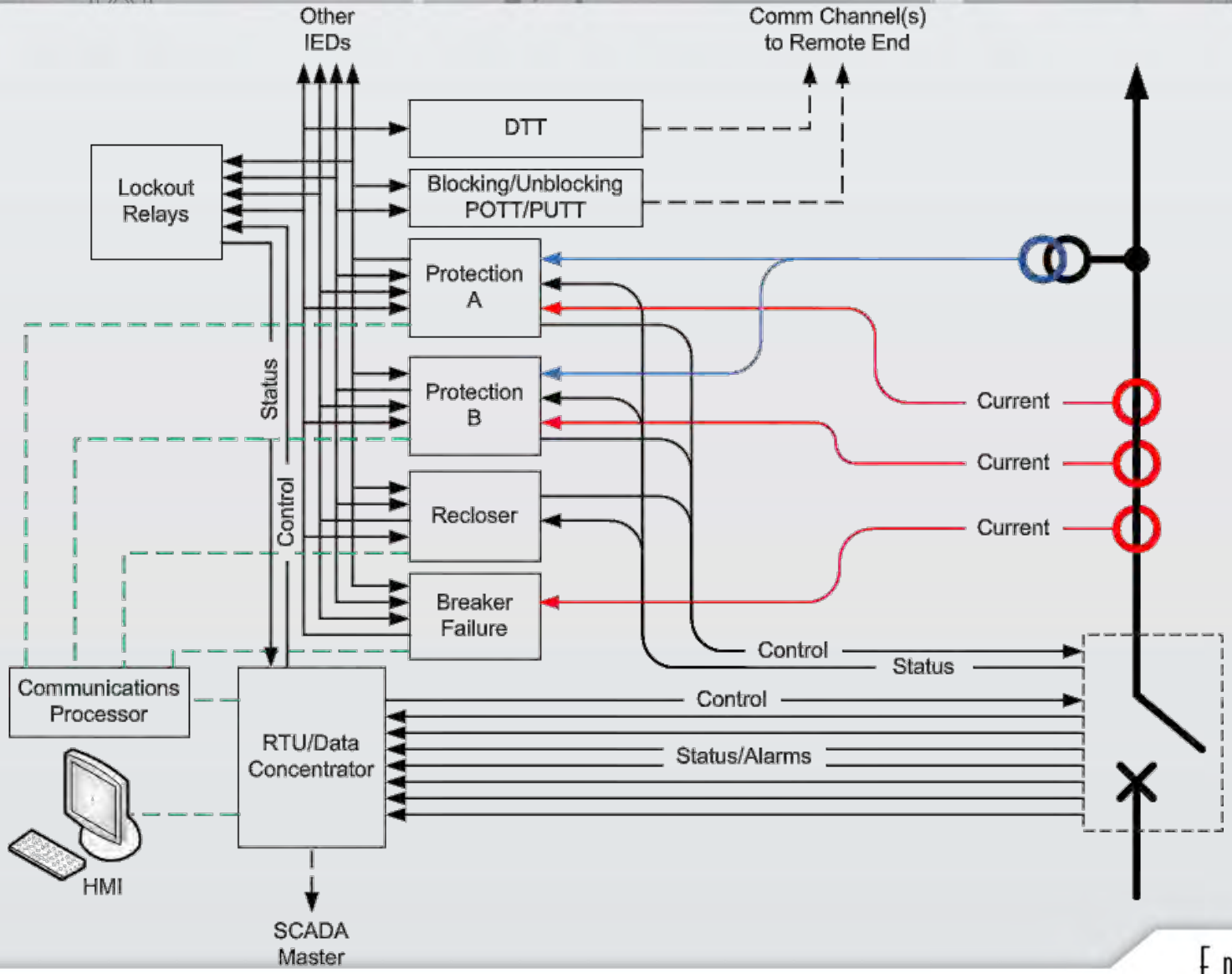
Traditional Architecture



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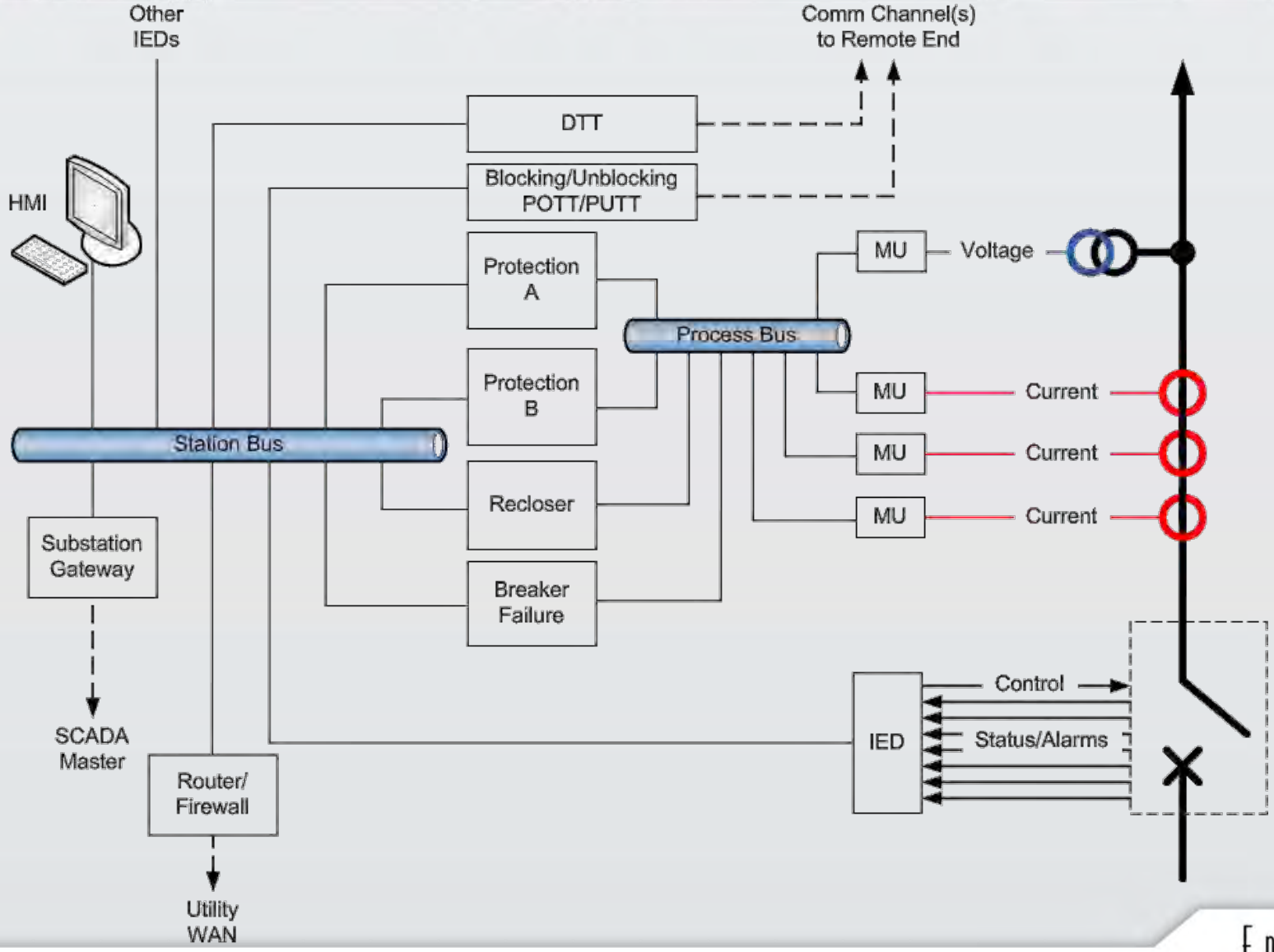
Station & Process Bus Architecture



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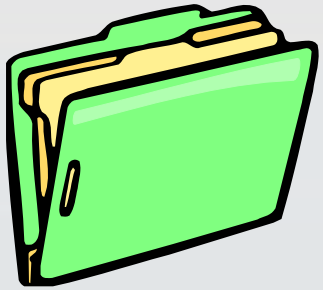
What is “Substation Configuration Language”?

- Standardized file format for substation configuration
- Based on Extensible Markup Language (XML)
- Exchanges files between proprietary engineering tools
- File may describe one IED, or whole substation
- Every IEC 61850 vendor must supply an SCL file
- Format, or “schema” defined in IEC 61850 Part 6
- Can be used as specification language for RFP



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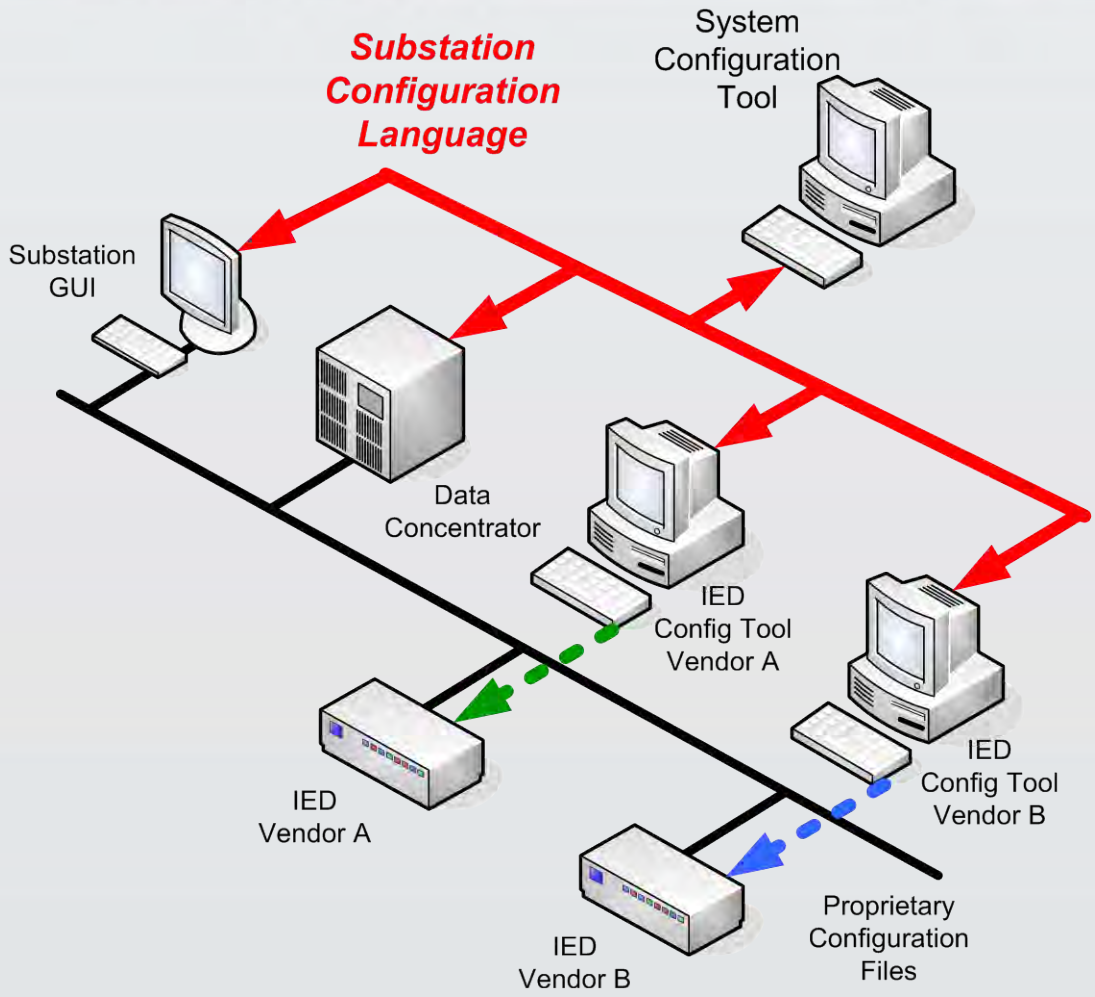
Different Levels of Configuration



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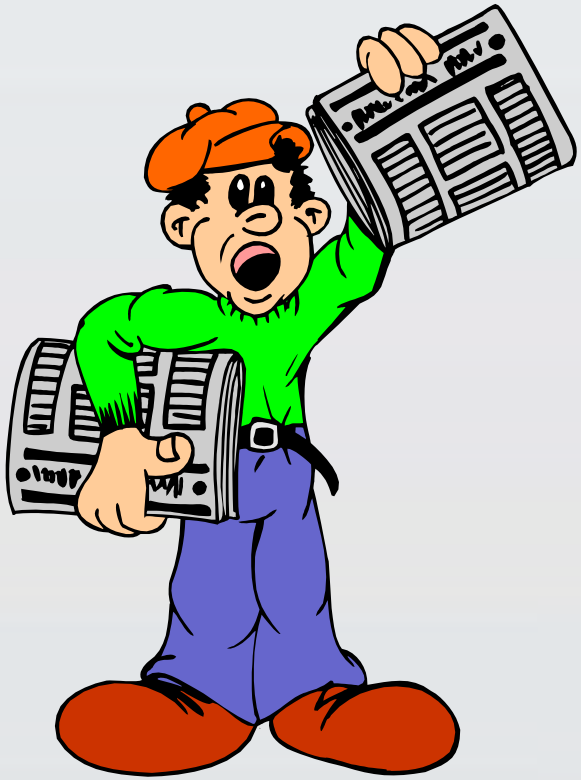
Powerful Reporting Features

- Not based on polling
- Remote device does the work
- Group data into Data Sets
  - configured
  - client-defined
- Can send spontaneous report on:
  - data change
  - periodic report by exception
  - integrity report
  - freezing
  - errors in control operations
- Journals for long-term storage
- Files for bulk data



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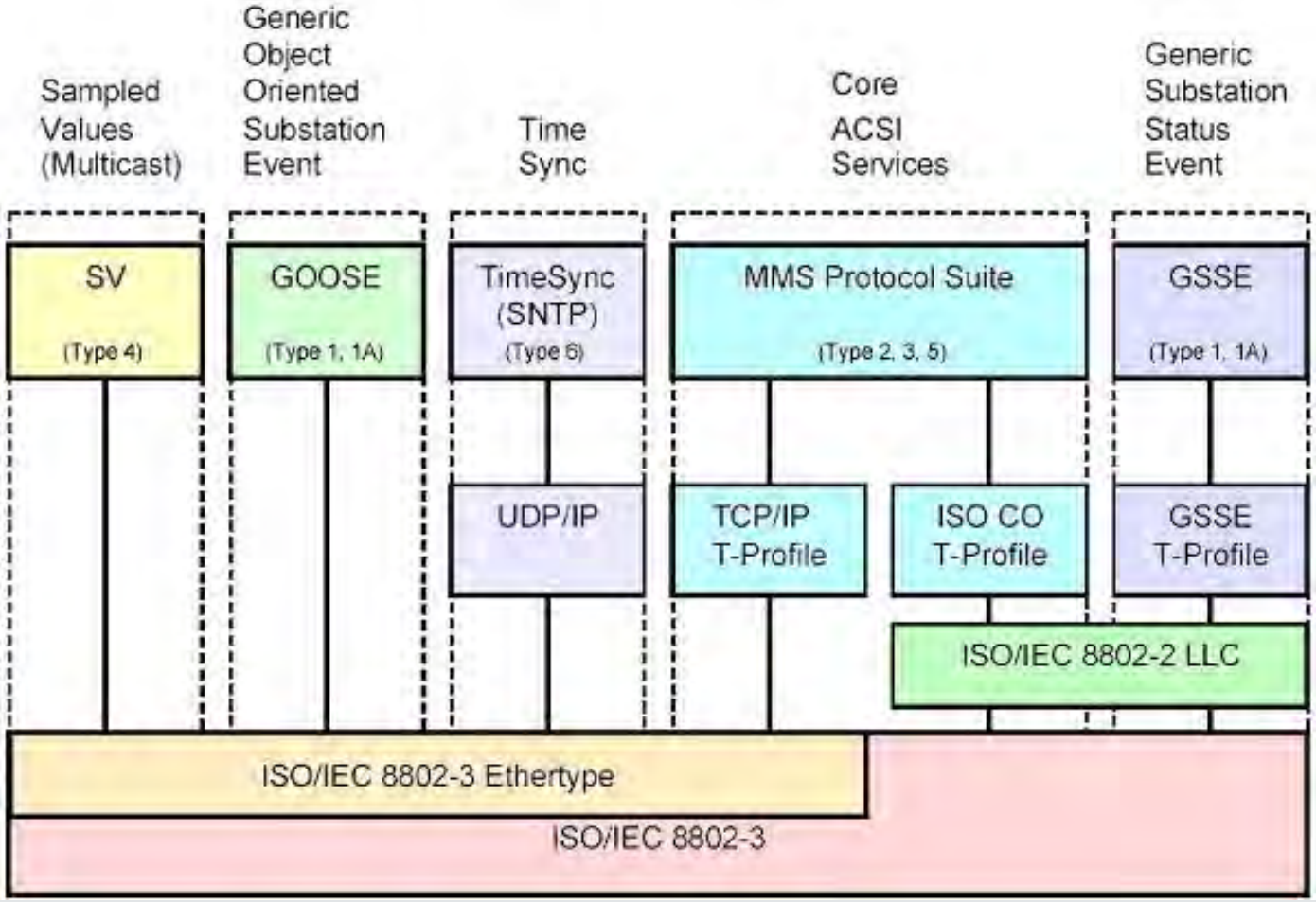
A Suite of Protocols, Not Just One



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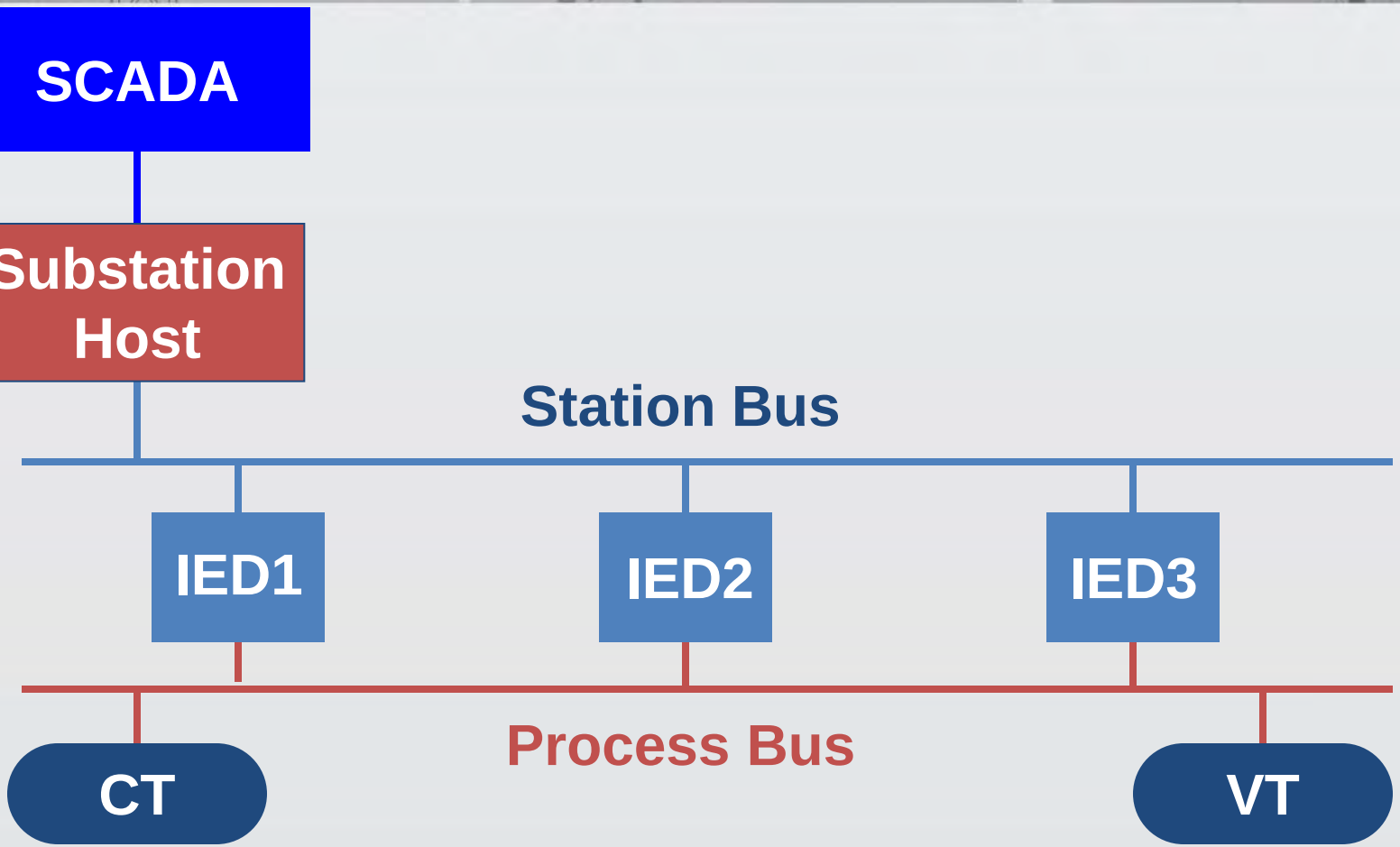
IEC 61850 Architecture



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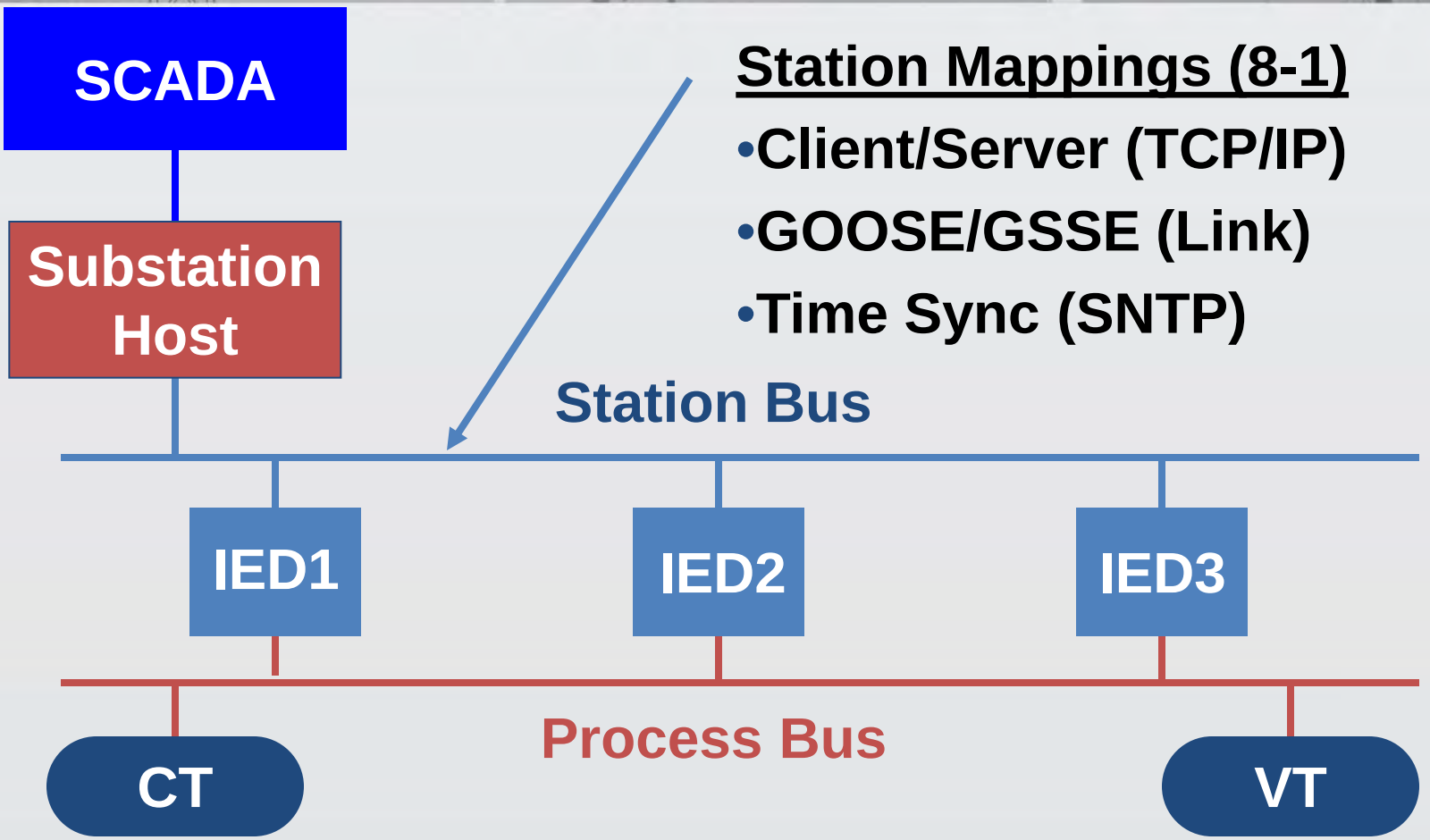
Station Bus Protocols



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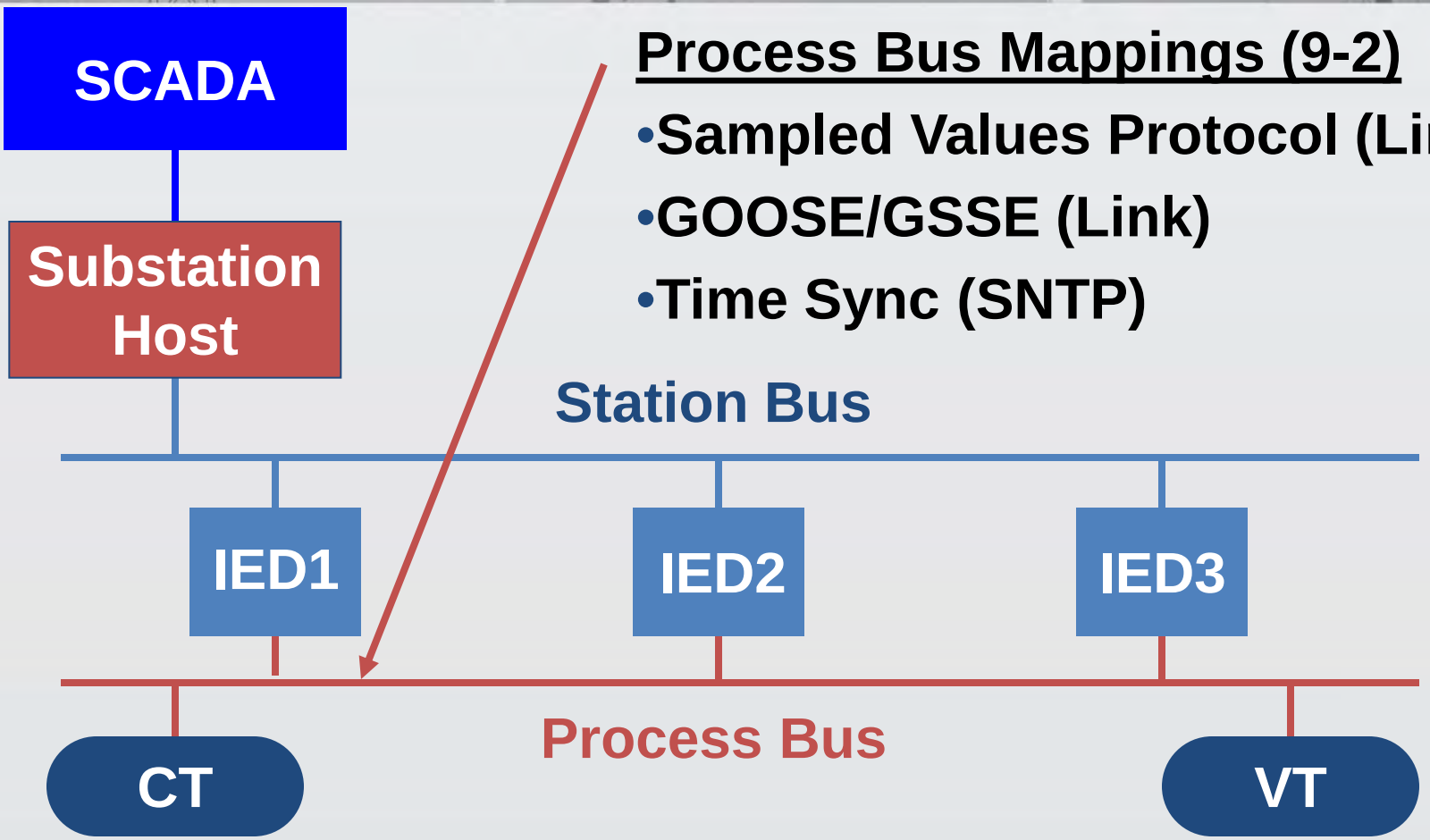
Process Bus Protocols



Process Bus Mappings (9-2)

- Sampled Values Protocol (Link)
- GOOSE/GSSE (Link)
- Time Sync (SNTP)

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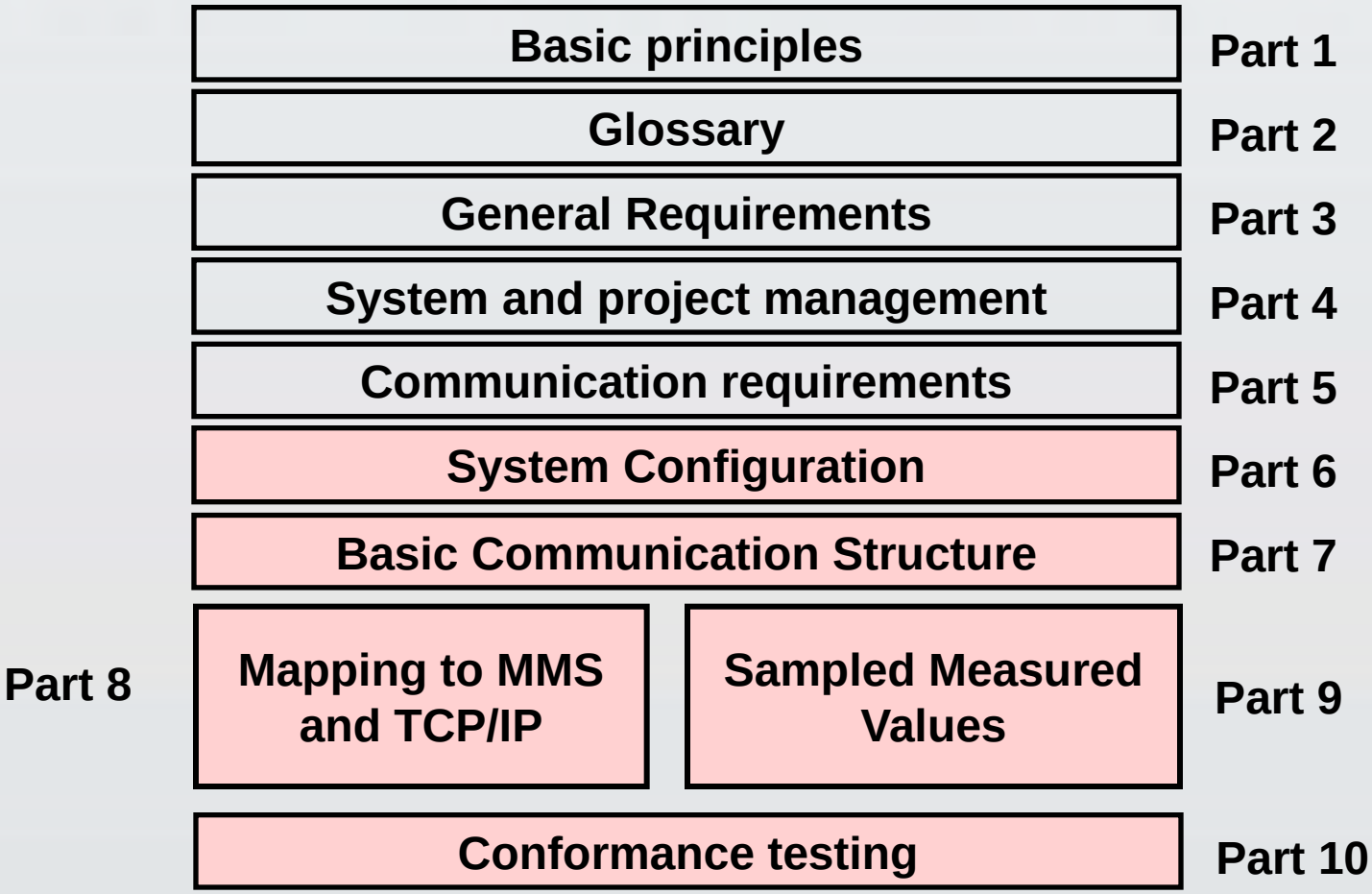
Document Set



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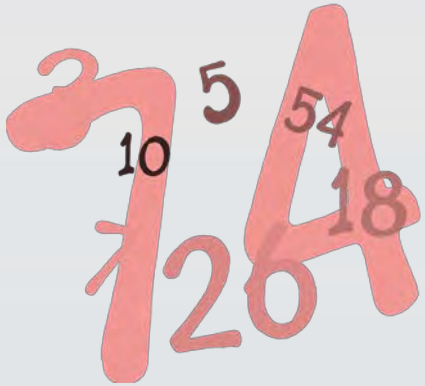
More Parts

- IEC 61850-7-4xx for Object Models
  - IEC 61850-7-400: The original 7-4, substation models
  - IEC 61850-7-410: Hydro Power
  - IEC 61850-7-420: Distributed Energy Resources
- IEC 61850-7-5xx for Users Guides
- IEC 61850-80-x Mapping Docs
  - IEC 61850-80-1 Mapping to IEC 60870-5-101
  - IEC 61850-80-2 Mapping to DNP3 (pending)
- IEC 61850-90-x Interfaces (all pending except 90-1)
  - IEC 61850-90-1 Between Substations
  - IEC 61850-90-2 Substation to Control Center
  - IEC 61850-90-3 Condition Monitoring
  - IEC 61850-90-4 Networking Guidelines
  - IEC 61850-90-5 Synchrophasors
  - IEC 61850-90-7 DER Inverter Models
  - IEC 61850-90-8 Electric Vehicle Models



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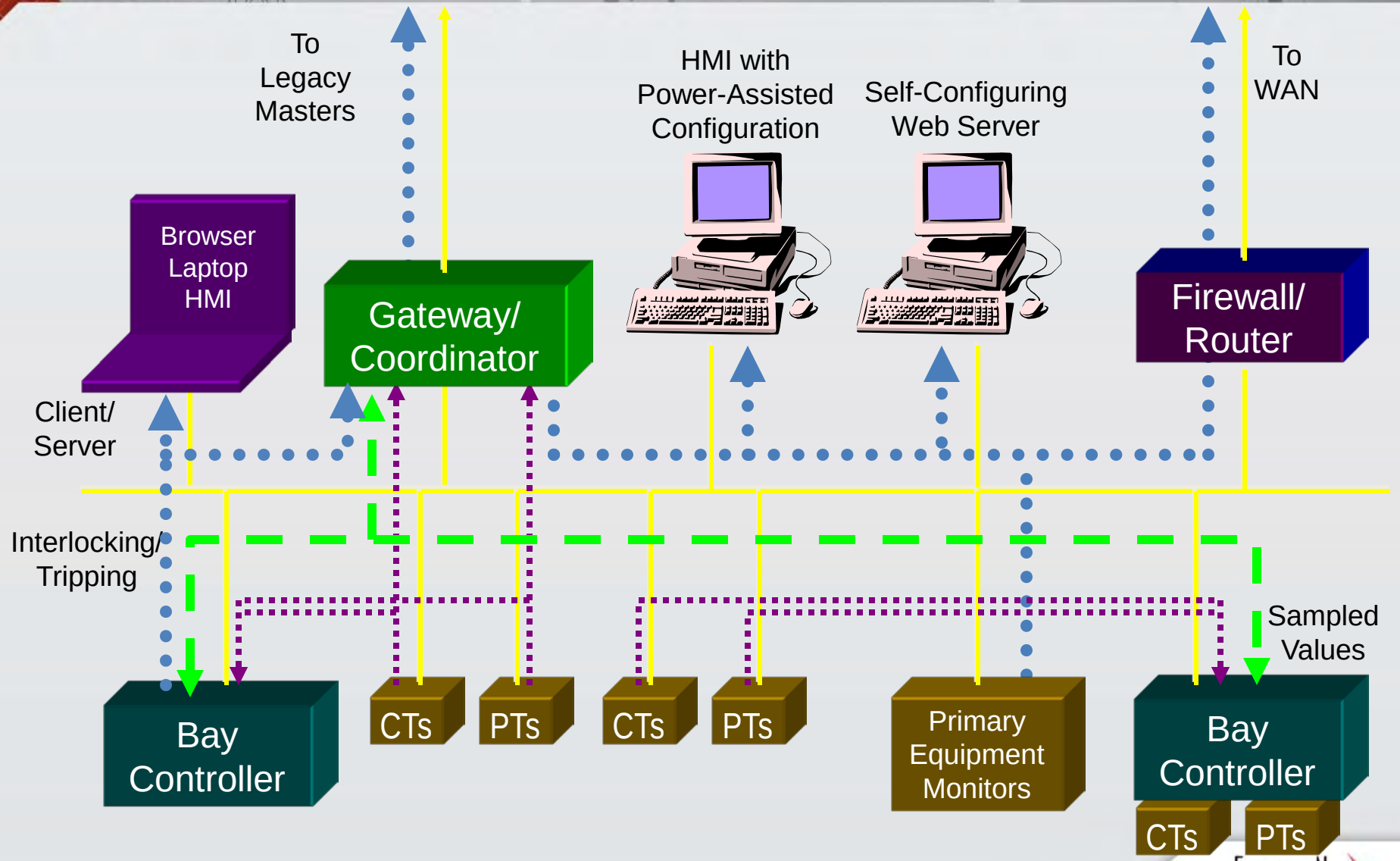
Substation Automation after IEC 61850



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Things to Consider Moving Forward

- Supporting Technologies
  - Ethernet, TCP/IP, Time Synchronization
- Organizational and Process
  - Employee skill sets
    - Networking fundamentals
    - Cyber security fundamentals
  - Organizational interfaces and responsibilities
    - Need to coordinate between operations and IT
  - Documentation
  - Engineering and Maintenance Tools

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What It Means to Stakeholders

- Utility Decision Maker
  - Improved engineering efficiency
  - Benefits of data modeling extend into the utility enterprise
- Utility Engineer
  - New tools and options for designing systems to meet the evolving requirements of a smart grid world
- Regulator
  - High benefit-cost ratio (BCR)
- Vendor
  - Narrower focus on product communication features - more focus on innovation, features, benefits, cost

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Summary – What's New?

- New hardware: smart CTs and PTs, integrated primary eqpt., wiring reduction
- New installation: automatic and power-assisted configuration
- New applications: LAN-based breaker synchronization, interlocking
- New interfaces: casual browser HMIs
- New flexibility: the device nearest the problem does the job
- New philosophy: integrated protection, telecontrol, asset mgmt.

It will take some time, but we have laid the groundwork already!

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For More Information

- IEC and UCA User's Group
  - http://www.iec.ch
  - http://www.ucaiug.org
- Erich Gunther
  - erich@enernex.com
- Brian Smith
  - bsmith@enernex.com
- Grant Gilchrist
  - grant@enernex.com

- http://www.enernex.com/
- Coming Soon – more webinars and multi-day training seminars at our conference facility and labs in Knoxville Tennessee – Stay Tuned!

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