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INDUSTRIAL STRENGTH NETWORKS™

Overview of IEC 61850

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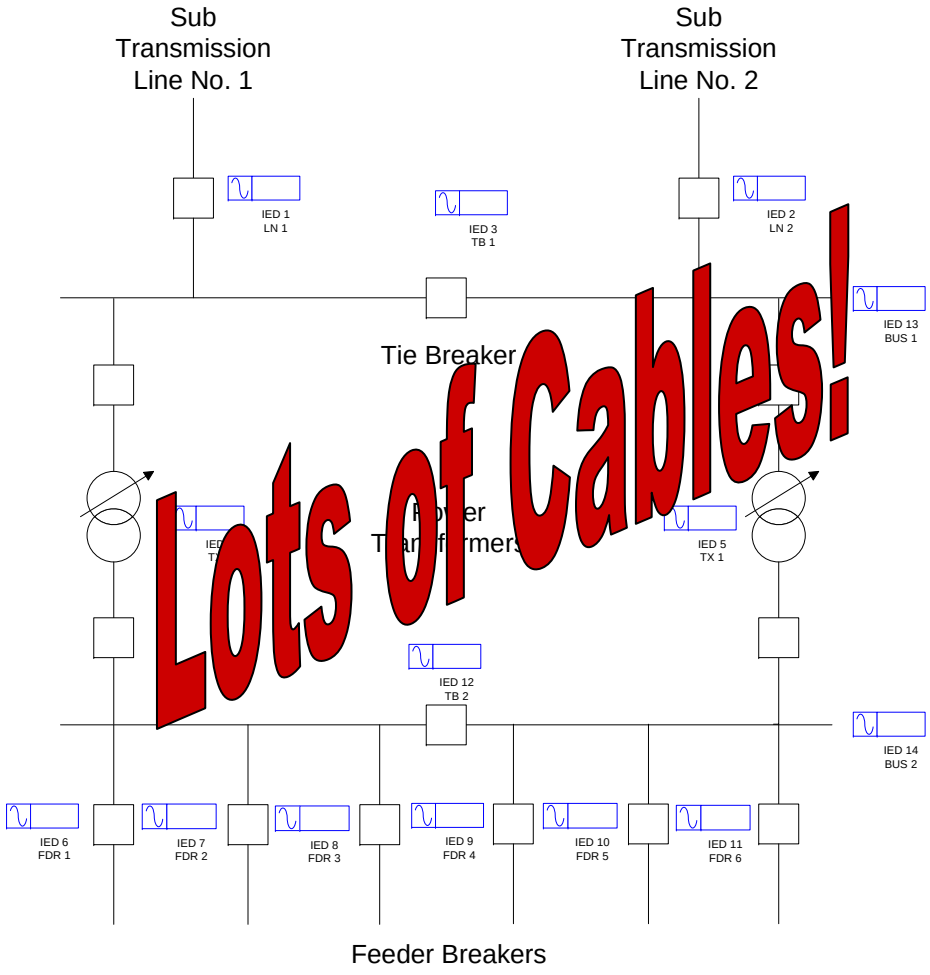
Agenda

1. Evolution of Protection and Control Systems
2. Overview of IEC 61850 Standard
3. Key Benefits of IEC 61850

Evolution of Protection and Control Systems



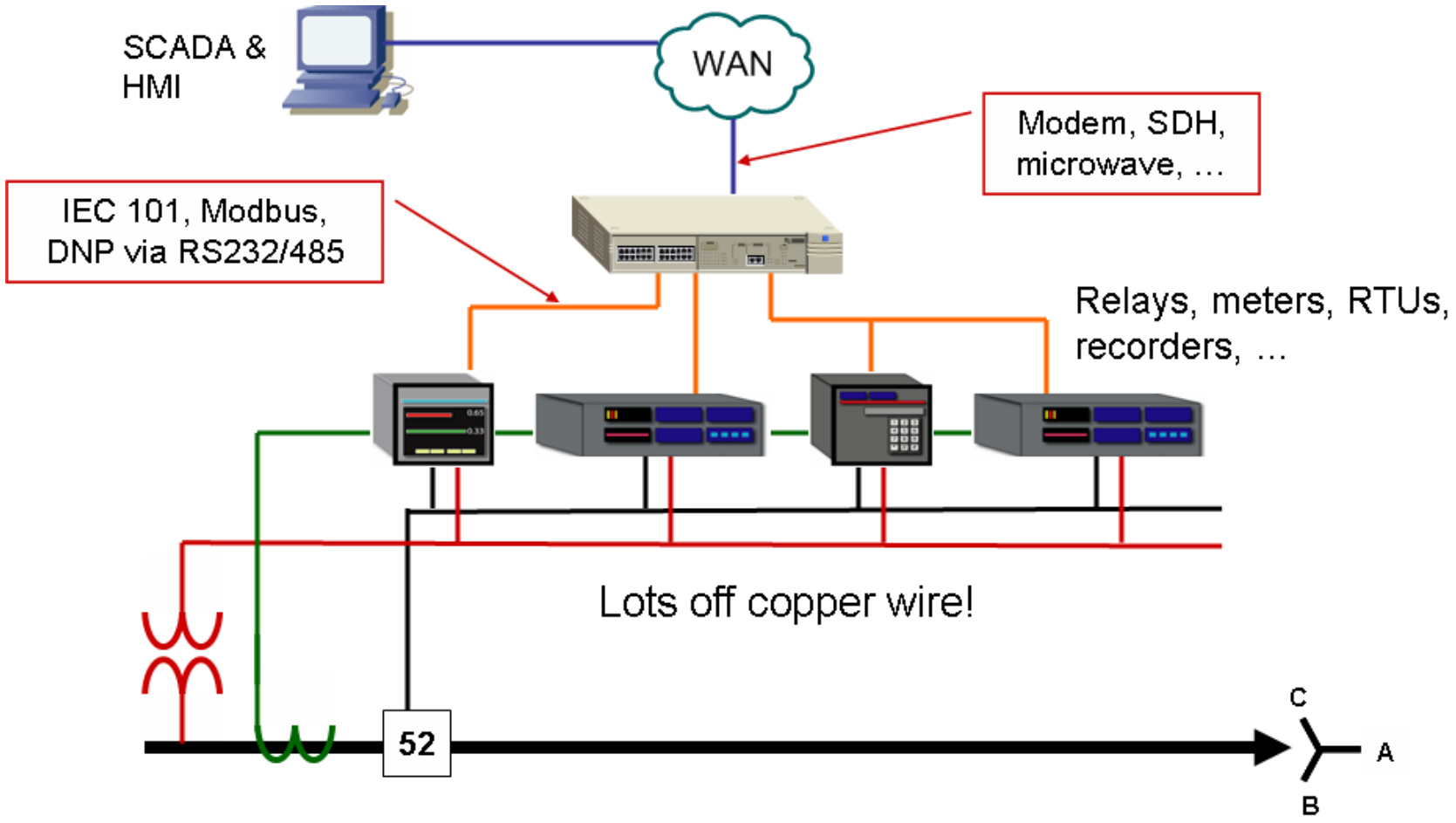

Typical Substation Diagram



Total: At least 50 multi-core cables from the HV equipment to the Control Building

- Information provided to SCADA via communication channels - Automatically:
  - Metering
  - Alarm Status
  - Breaker Status
  - Commands to Operate Breakers
  - Lockout Status
- Information required by Engineering or Maintenance – Accessed by authorized personnel on demand:
  - Protection & Control Status
  - Oscillography Files
  - Sequence of Event Reports
  - Access to view or change setpoints
- New Requirements of IEC61850:
  - Peer to Peer Messages (GOOSE)
  - Digital I/Os
  - Transfer Trips

Substation Network - Past

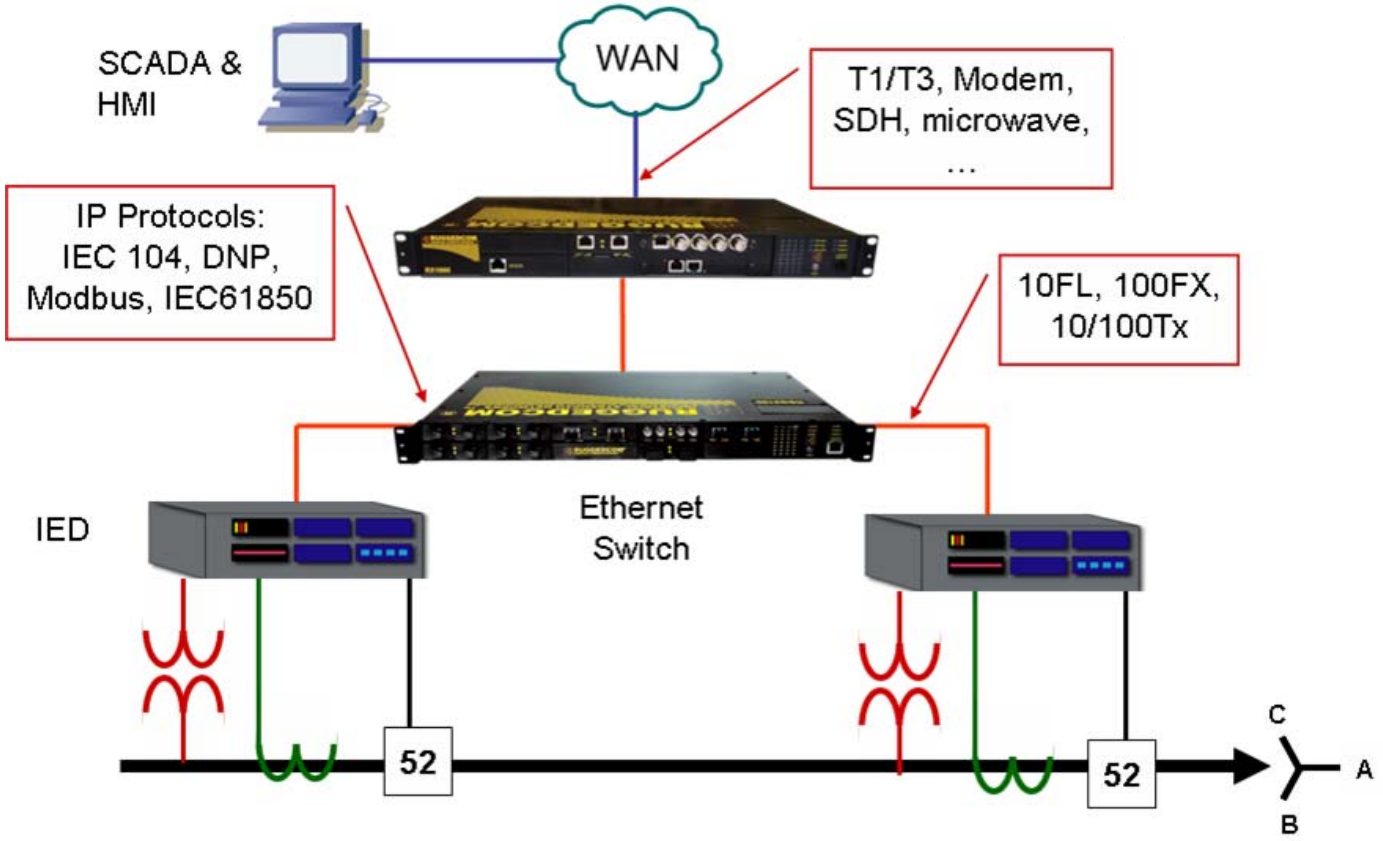


Conventional Wiring in Electrical Substations

Conventional Substation P&C System

Conventional Substation Control Panel

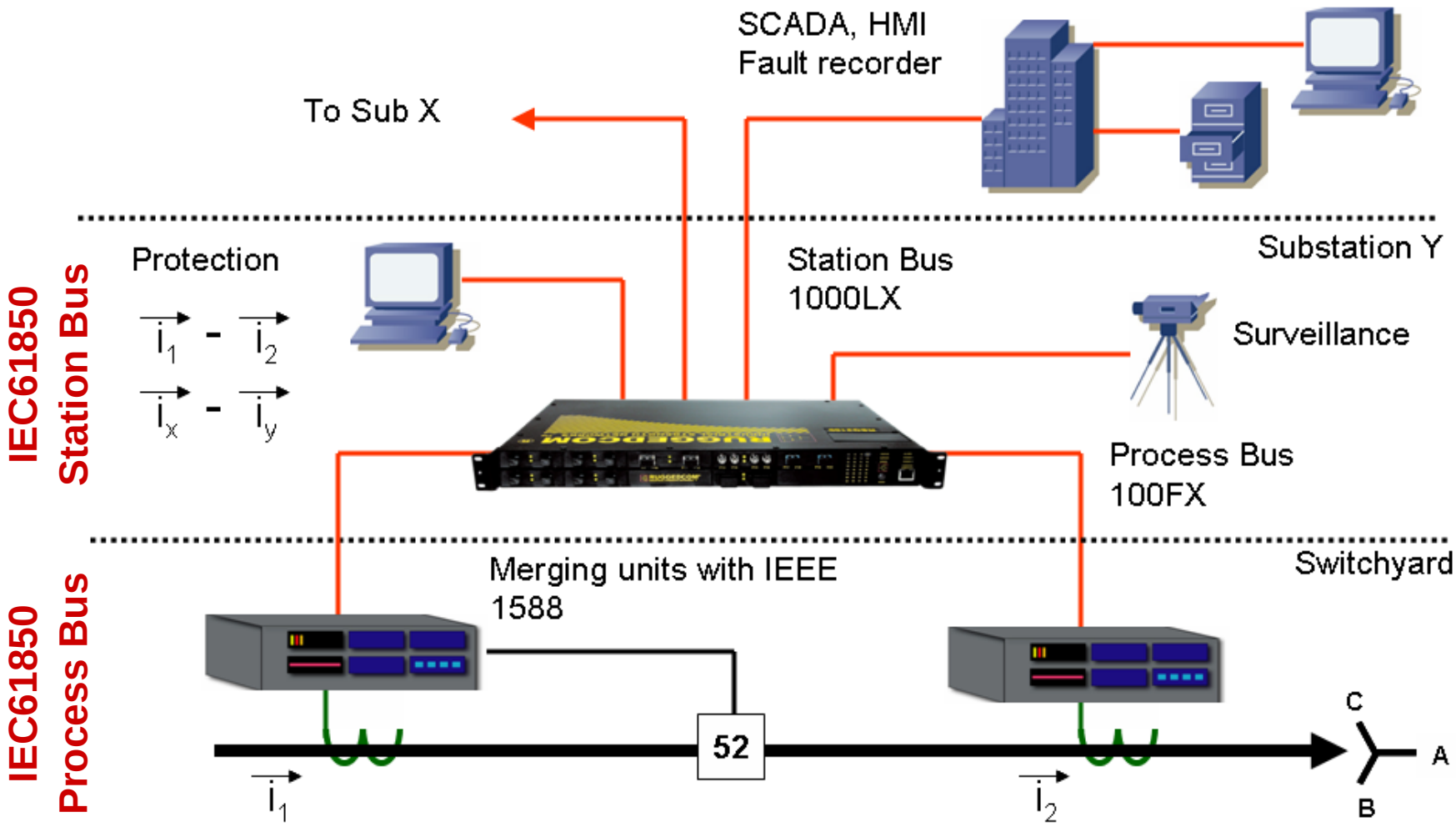
Substation Network - Present



Present Substation P&C System

Still a lot of copper wiring !

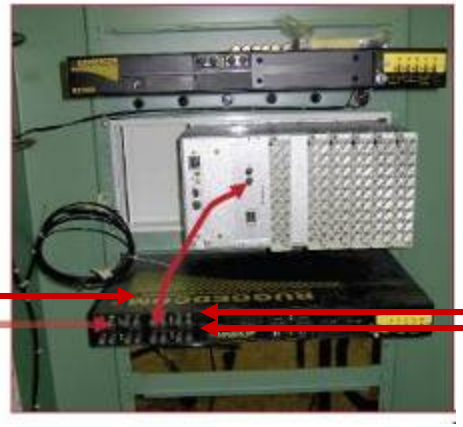
Substation Network - Future



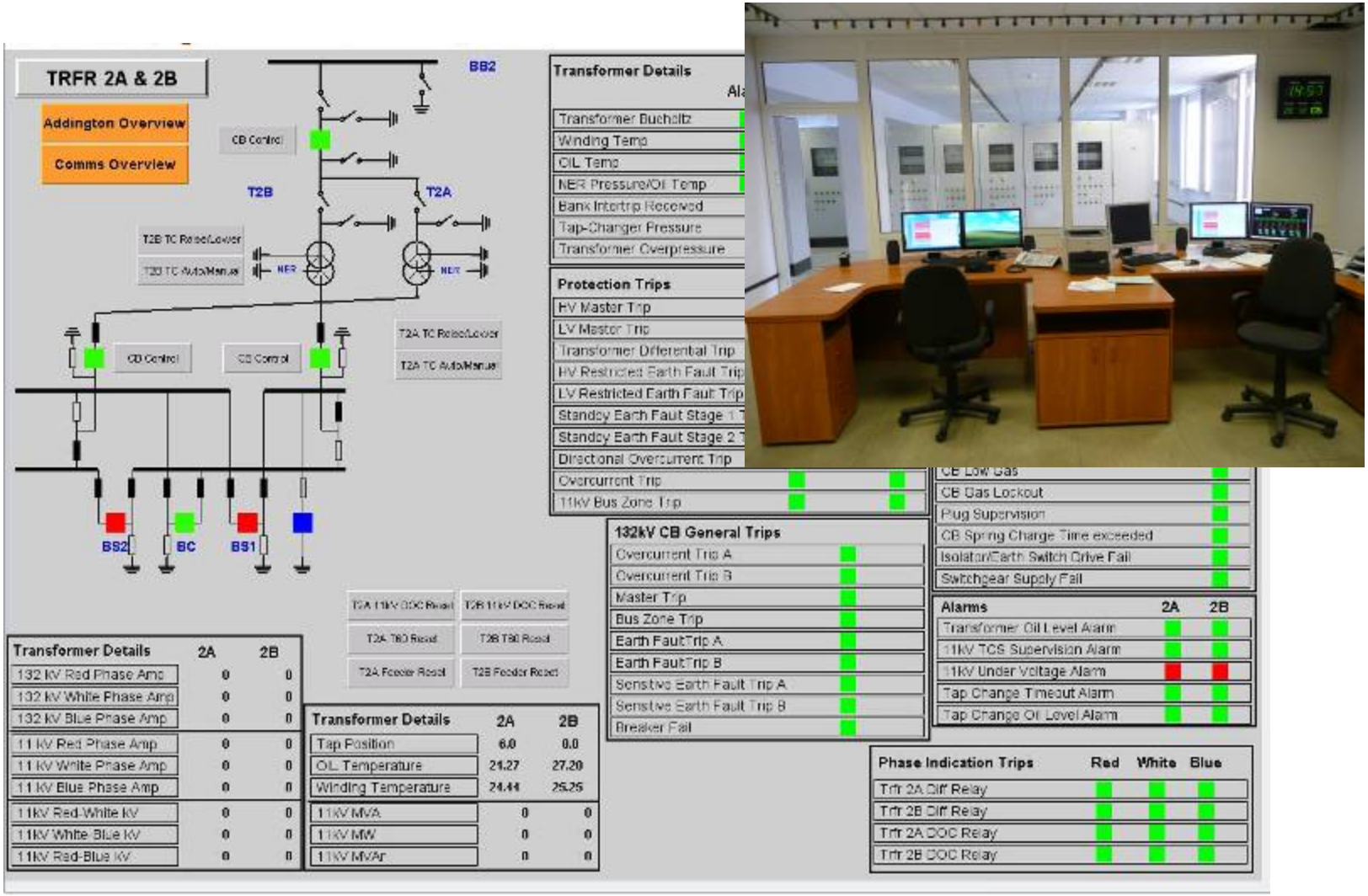
The Future – Digital Switchyard

All digital Ethernet based
IEC 61850 Communications
in the Switchyard

Merging Units and IEDs at
direct proximity to
High Voltage equipment



Modern Substation Automation HMI



Overview of IEC 61850 Standard




What is IEC 61850 ?

- IEC 61850 is **NOT** just a communication protocol
- It is a suite of multiple protocols
- It is an application focused communication architecture
- It is one of the key building blocks for the Smart Grid

IEC 61850 standard defines complete communication architecture in Electrical Power Systems

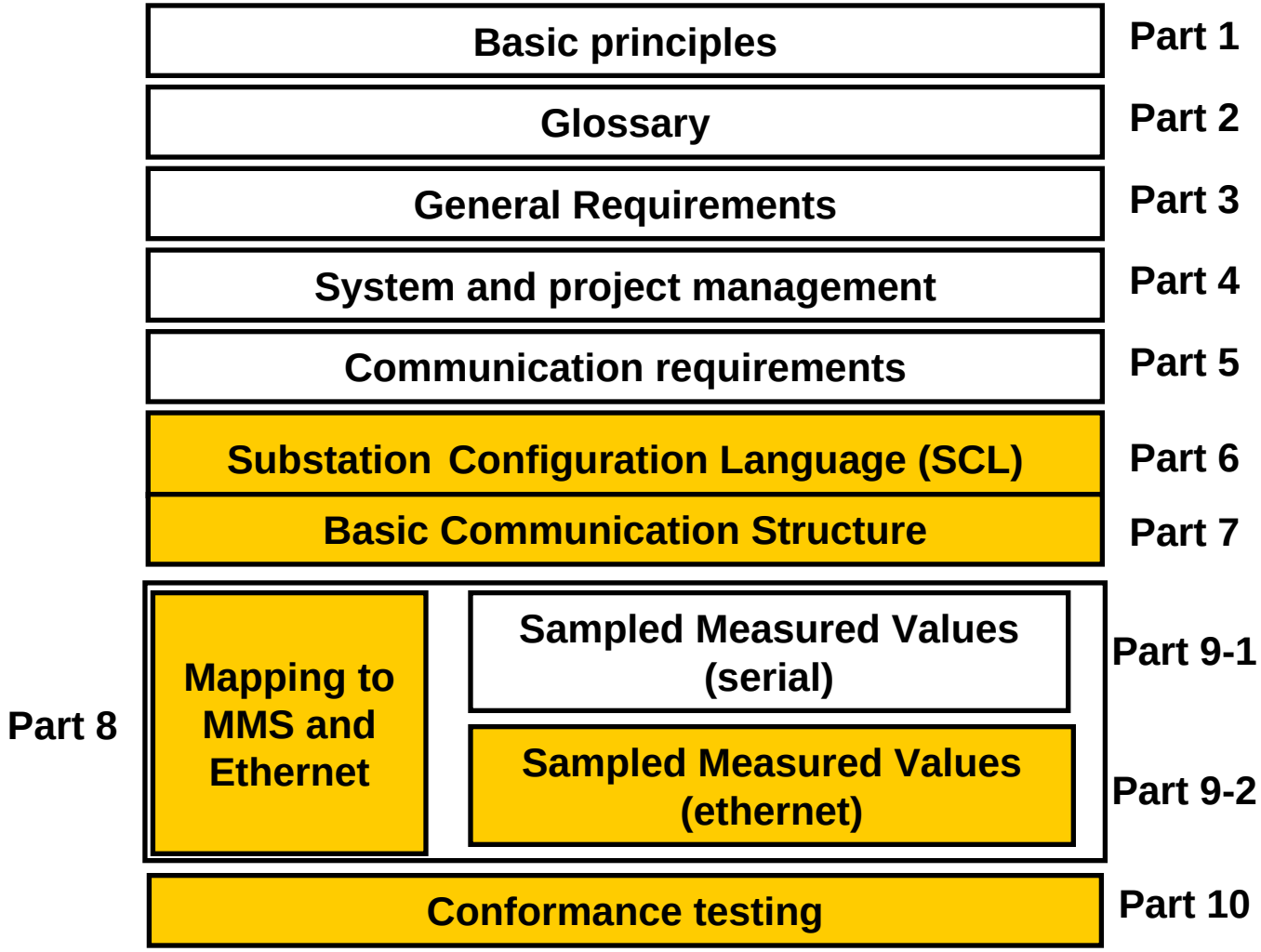
IEC 61850 Key Features

- Uses the strengths of the OSI 7 layer communication model
- Standardized data models for electrical applications
- Defines Data Types and Communication Services
- Models devices, functions, processes and architectures
- Describes Engineering and Configuration Process
- Provides examples of typical applications in electrical substations

IEC 61850 Key Features

- The data is organized in devices in a standardized way
- The devices are ***"self-descriptive"***,
  - either online (MMS protocol) or offline (SCL language)
- IEDs not only provide the data itself but also the information about data types used, its structure and complete naming.

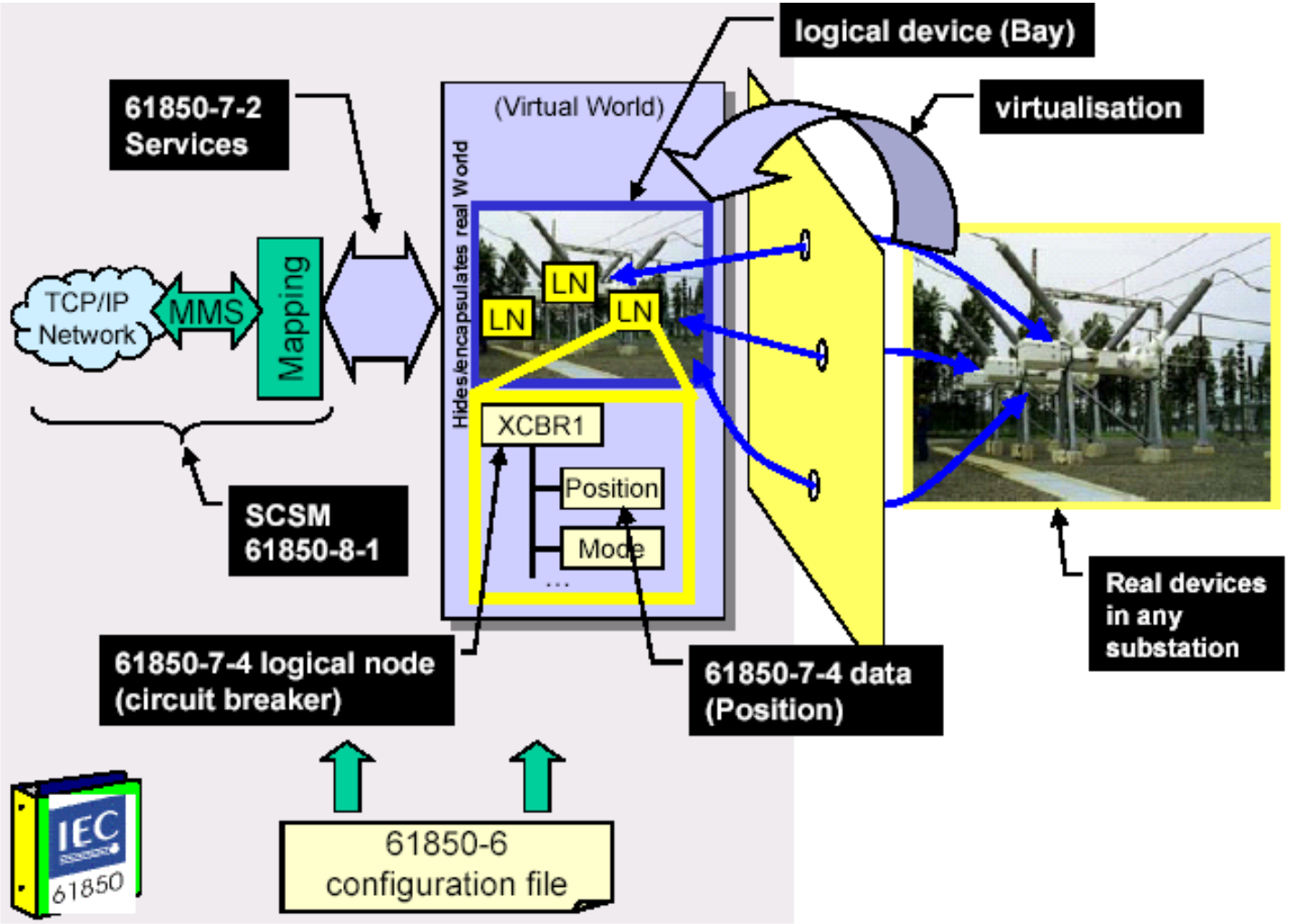
Parts of IEC 61850 Standard Edition I



Data Models and Services

- IEC 61850 Part 7-3 defines a base set of data types for describing objects
- IEC 61850 Part 7-4 defines a set of ***Objects*** (Logical Nodes)
- IEC 61850 Part 7-2 defines a set of ***Services*** to manipulate and access those objects. Services are well defined procedures on how information is exchanged.

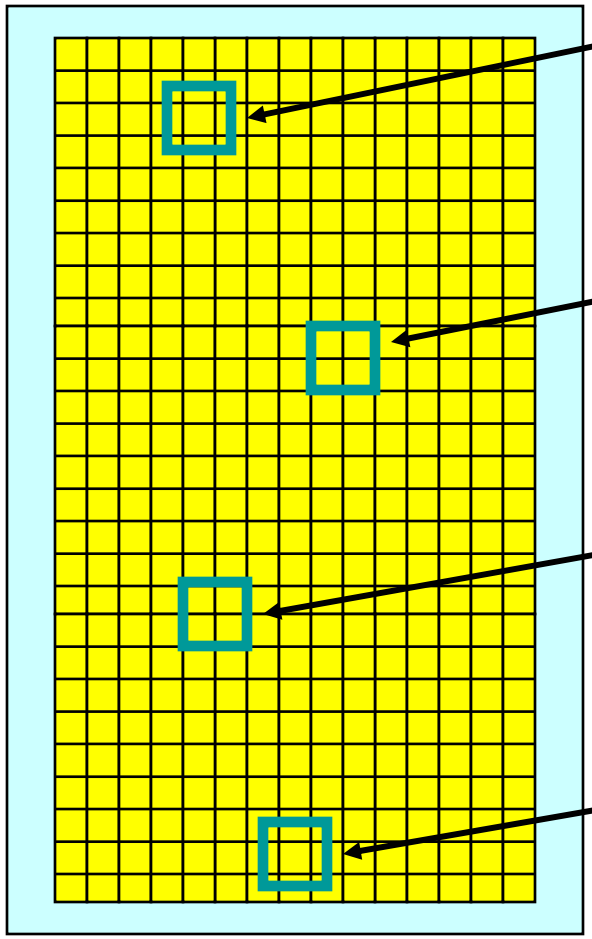
Application Modelling According to IEC 61850



IEC 61850 is Application Oriented

- DNP3.0, IEC-60870-5, Modbus, etc. are industrial generic use protocols and are not application oriented
- In generic industrial protocols we talk about “points” or “addresses” without knowledge what data is behind it
- IEC 61850 is an application oriented architecture, it introduces meaningful semantics
- IEC 61850 defines application specific data like **PTOC (Protection Time Overcurrent)** logical node or **XCBR (Circuit Breaker)** logical node, etc.
- Example of semantic: Position of the breaker XCBR1STPos$stVal

Data Mapping Examples



Data inside the IED

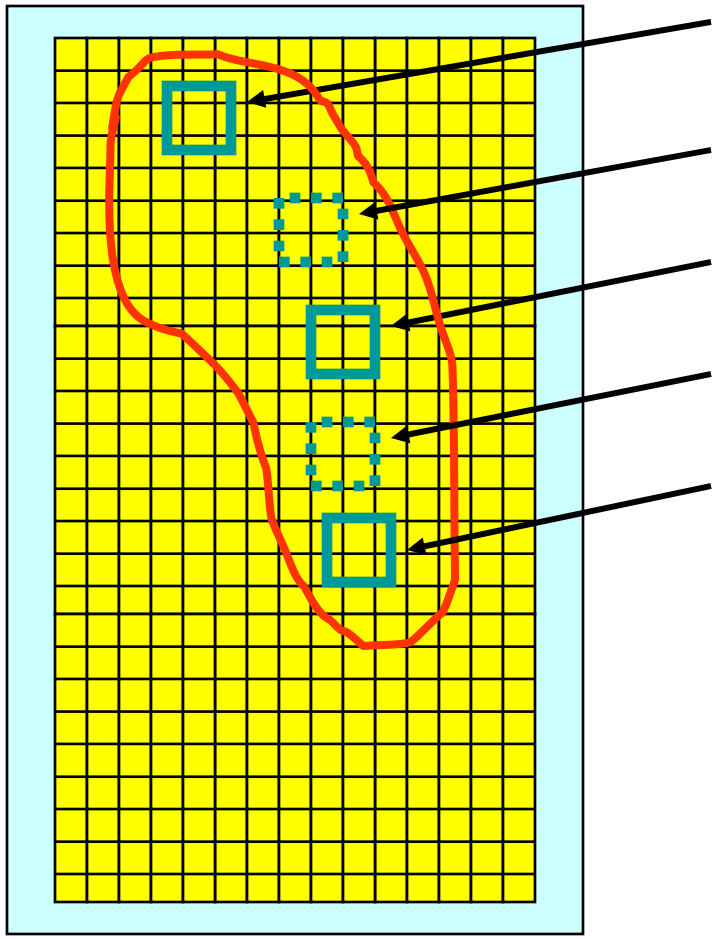
Position of breaker at 345kV feeder #1:
- Modbus: register 0x1C1A, bit 3
- DNP 3.0: object 1.1, point #26
- **IEC 61850: XCBR1STPos$stVal**

Operate the circuit breaker at 345kV feeder #1:
- Modbus: register 0x251A, bits 0, 1
- DNP 3.0: object 12.1, point #10
- **IEC 61850: XCBR1COPos**

Phase A voltage for the 345kV feeder #1:
- Modbus: register 0xB5C7, 4 bytes
- DNP 3.0: object 30.1, point #23
- **IEC 61850: MMXU1MXPhV$phsA$instCVal**

Line frequency for the 345kV feeder #1:
- Modbus: register 0xCC02, 4 bytes
- DNP 3.0: object 30.1, point #27
- **IEC 61850: MMXU1MXHz$nstMag**

IEC 61850 Data Mapping Models Application



Data inside the IED

Position of breaker - XCBR1STPos$stVal

.....

Control of circuit breaker - XCBR1COPos

.....

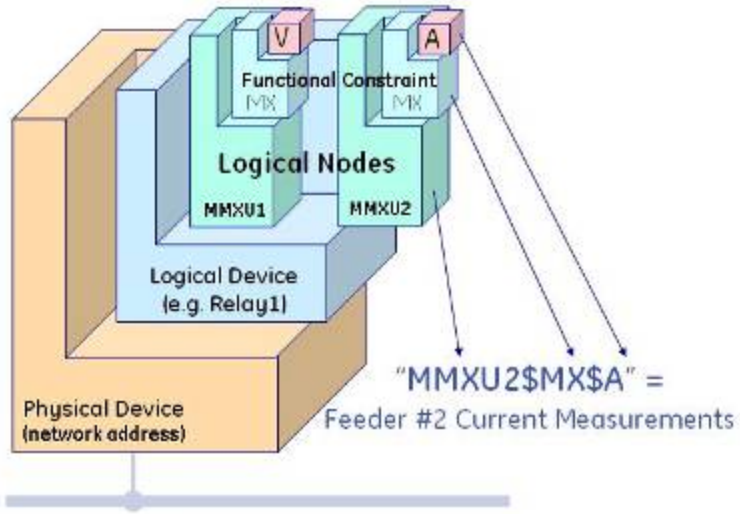
Sum of Switched Amperes - XCBR1MXSumSwARs

XCBR:

- Logical Node Circuit Breaker
- A group of data describing the Breaker
- Data is grouped based on functionality
- IEC 61850 models the application

Logical Node

- Standardizes which elements of specific functions related to power system should be contained in substation devices
- A Logical Node is an abstract model of a real device or function
- A Logical Node is a collection of data that is grouped taking into account its functionality



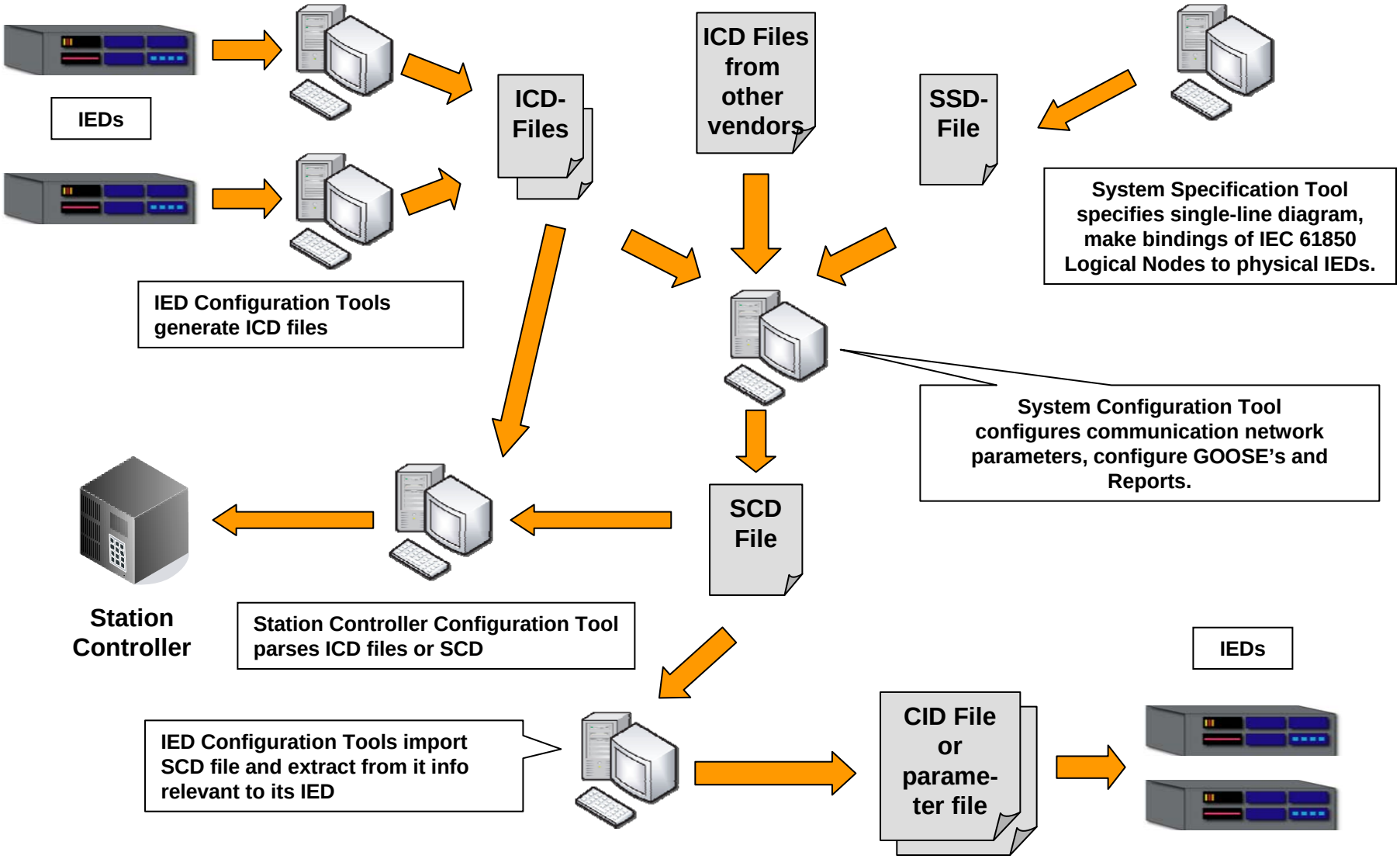
Communication Services in IEC 61850

- GetDataValues/SetDataValues
- Unbuffered Reports
- Buffered Reports
- Control Operations
- Logging
- Time Synchronization
- File Transfer
- Substitution
- GOOSE
- Sampled Values

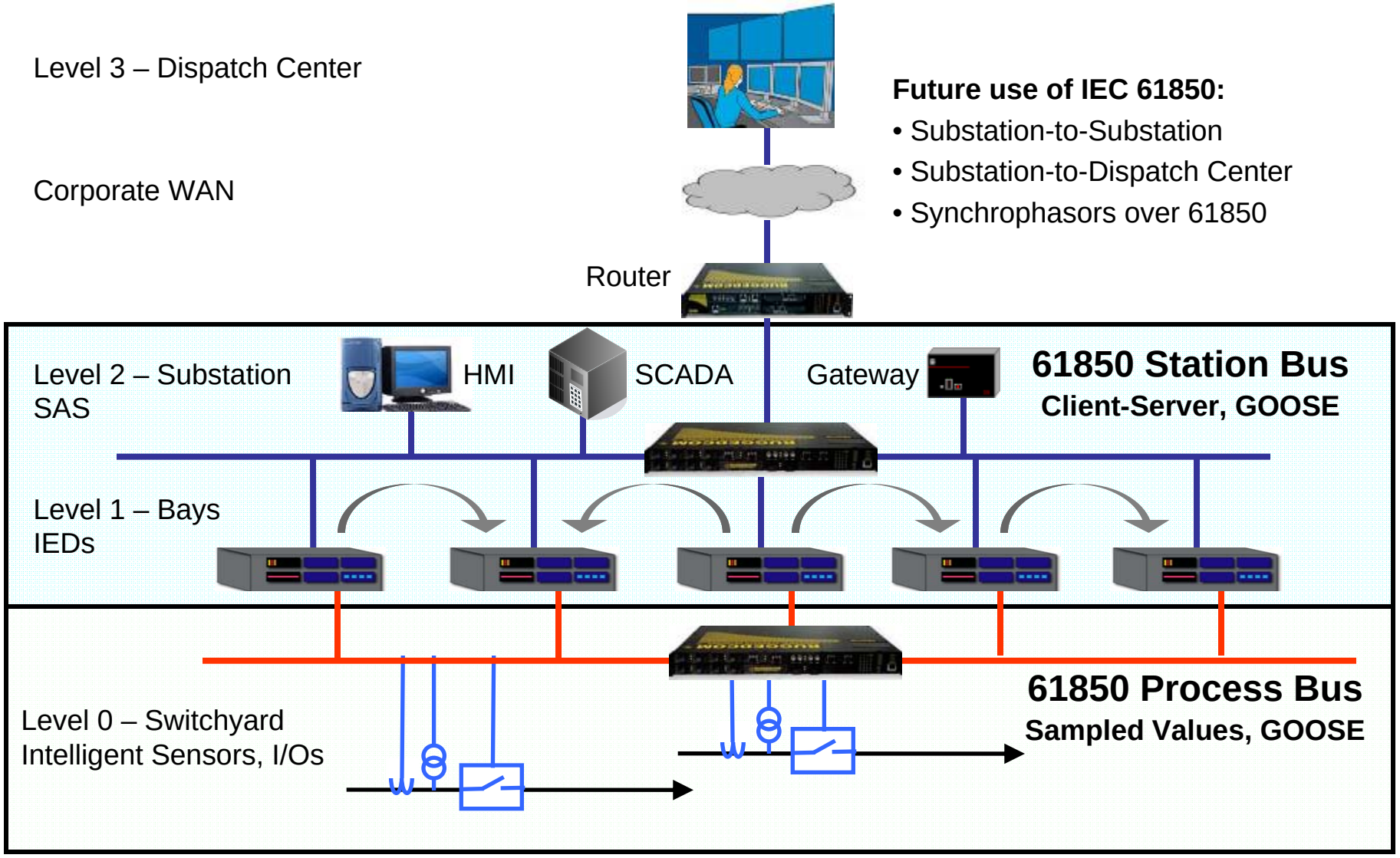
SCL – Substation Configuration Language

- Description language for communication in electrical substations
- Defined in IEC 61850-6
- Based on XML language
- Defines common file format and allows formal description of:
  - Substation automation system and the switchyard and the relation between them
  - Communications parameters
  - IED configuration
- Makes an efficient engineering process of a substation
- Eases the integration process of devices from multiple vendors

Engineering process using SCL

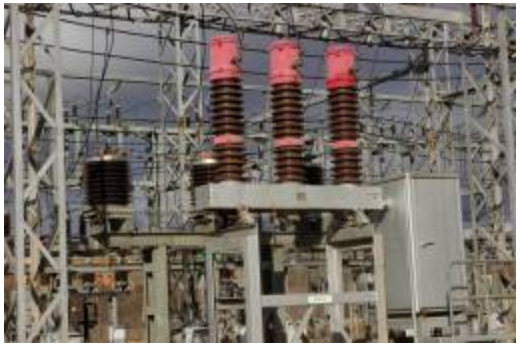


IEC 61850 Architecture



Station Bus and Process Bus

- **Station bus**
  - Communication between IEDs and master stations
  - Data polled by Master from IEDs or asynchronously sent by IEDs
  - Inter IED data exchange through multi-cast GOOSE messages
- **Process bus**
  - Communication between plant equipment (intelligent switchgear, Instrument transformers) and IEDs
  - Exchange of sampled values (digitized measurements)

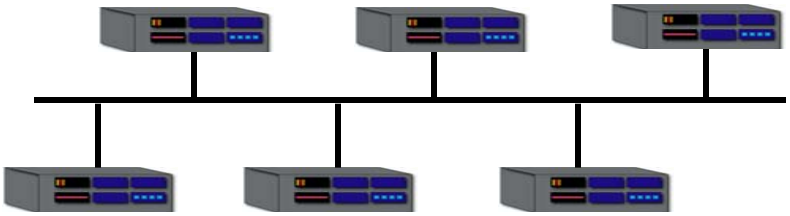


Communication Schemes in IEC 61850

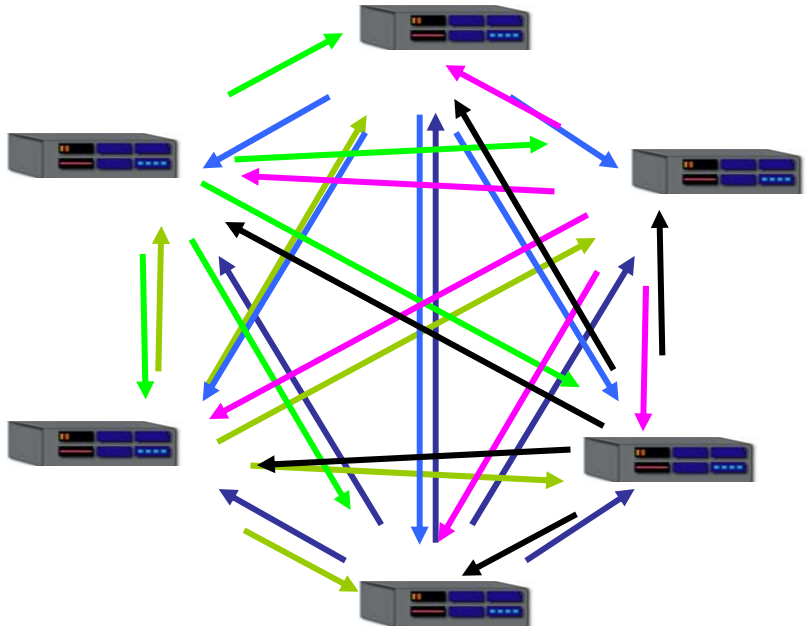
- **Client-Server communication**
  - Information exchange like fault record, event record, measurement values, etc.
  - Data size much greater, can run into kB or MB
  - Uses the full services of the OSI model (MMS over TCP), reliable data transfer
  - Not time critical data
- **GOOSE messages**
  - Time critical data eg. trip, block, interlock, etc.
  - Initiation of data transfer only on occurrence of the event.
  - Compensated by multicasting (repeated transmission)
- **Sampled Values**
  - Time critical data – sampled values of current / voltage signals from non-conventional instrument transformers or IEDs
  - Continuous stream of data, rate determined by the sampling frequency of the data
  - Data size depends on the resolution of the sample
  - Not reliable data transfer (like Goose messages)

GOOSE Usage for Interlocking & Tripping

GOOSE messages
IEDs interconnected via
Ethernet network



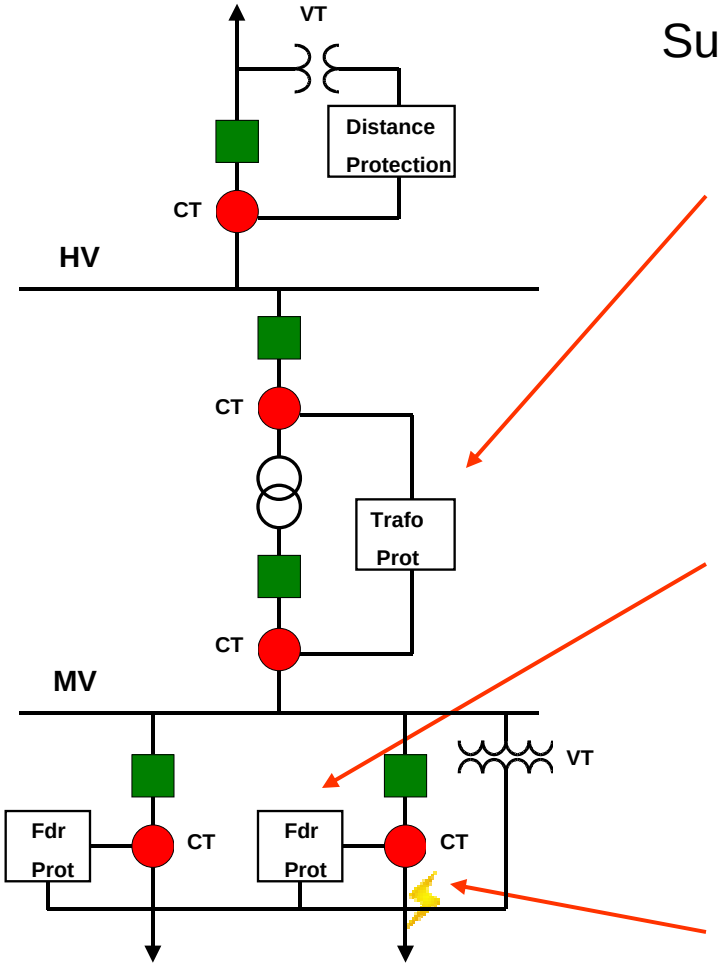
Conventional Hardwired
interconnections



IEC 61850 GOOSE

- Device to multi-device communication
- Layer 2 Multicast message
- Fast transmission of substation events, blocking, permissive signals, etc.
- Also transmission of analog values (voltage, frequency, etc.)
- Limited to LAN segment, for transmitting over router tunneling is needed
- Event driven transmission sent on change of state
- Periodic heartbeat messages to enable detection of device or link failure
- Reliability effected through message retransmission scheme
- Uses VLAN ID and priority tagging

GOOSE Example – False Bus Differential



Substation without dedicated Busbar protection

3. Transformer relay receives the message that feeder had seen the fault. It is a "Block" message preventing tripping the whole busbar.

2. Feeder IED sees the fault and immediately sends a GOOSE message

1. A fault occurs

Process Bus Overview

IEC 61850-9-2

- Digitization of CTs/PTs and connection of Intelligent Switchgear
- Merging Units – electronic interfaces to measured values from switchyard
- Defines communications service mapping of Sampled Values
- SV messages encapsulated in Ethernet and sent via Layer 2 Multicast
- Does not define types of data and number of elements in SV message
- The streams of sampled values generated by Merging Units must be synchronized in time
- The required time synchronization accuracy is few microseconds as IEDs are using sampled values for protection

Process Bus Overview

IEC 61850-9-2 LE (Lite Edition)

- Is an “Implementation Agreement” to facilitate interoperability
- Is maintained by UCA, not by IEC. Is a defacto standard.
- Specifies fixed message format, fixed Data Set with:
  - 4xVoltages & 4xCurrents
- Specifies two sampling rates:
  - 80 samples/cycle and 256 samples/cycle
- Specifies types of Ethernet connectors and physical layer:
  - 100Base-FX with ST, 100Base-FX with MTRJ, 100Base-TX with RJ45
- Specifies 1PPS as synchronization mechanism
- Future revision of IEC 61850-9-2 most probably will add IEEE 1588 time synchronization and more Ethernet connector types and physical layers

IEEE 1588 time synchronization will replace 1PPS

Key Benefits of IEC 61850




Key Benefits of IEC 61850

- **Increases flexibility**
  - by connecting protection, control, measurement and monitoring devices to common Ethernet network within substation
- **Reduces copper wiring**
  - through GOOSE messaging that enables fast and reliable applications like interlocking, distributed bay tripping, breaker failure, etc.
- **Reduces total installation cost**
  - by enabling Process Bus with electronic CT/VTs and intelligent switchgear and by replacing conventional copper wiring by Ethernet digital communications
- **Eases system engineering and integration process**
  - through graphical configuration tools based on SCL language – XML common file format designed for exchange of configuration information.

Key Benefits of IEC 61850

- **Improves application performance and security**
  - through fast Ethernet communications and redundancy (IEC 61850 Edition II)
- **Provides easy way of implementing typical applications**
  - due to standardized naming conventions
- **Saves time and money in setup & commissioning**
  - because of object-oriented structure and high-level services that enable self-description of devices and automatic data discovery.
- **Minimizes costs of technological obsolescence**
  - because of a global acceptance and adoption and future-proof concept of abstract services as well as independence of mapping to protocols

Where IEC 61850 is currently used

- Transmission substations
- Distribution substations
- Distribution automation
- Power plants
- Wind farms
- Railway traction substations
- Substations in industrial plants and big infrastructure:
    - Aluminum
    - Oil&Gas
    - Mines
    - Airports
    - Other

Questions?