SCADA

Supervisory Control & Data Acquisition

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SCADA

SCADA is a system for gathering and analyzing real time data. SCADA systems are used to

1. Monitor
2. Control.

SCADA system enables to operate Sub transmission (33kV/66kV/11kV) electrical equipment remotely. There is various analog & Digital signals report from each grid sub stations

Real-time control is the SCADA system, which acquires data from different sources, pre-processes, it and stores it in a database accessible to different users and applications

SCADA

- SCADA CONCEPTS
- COMPONENTS
- APPLICATIONS
- COST/BENEFITS

SCADA CONCEPTS

CONTROL CENTRE

CONTROLLED PLANT

COMMUNICATION SYSTEM

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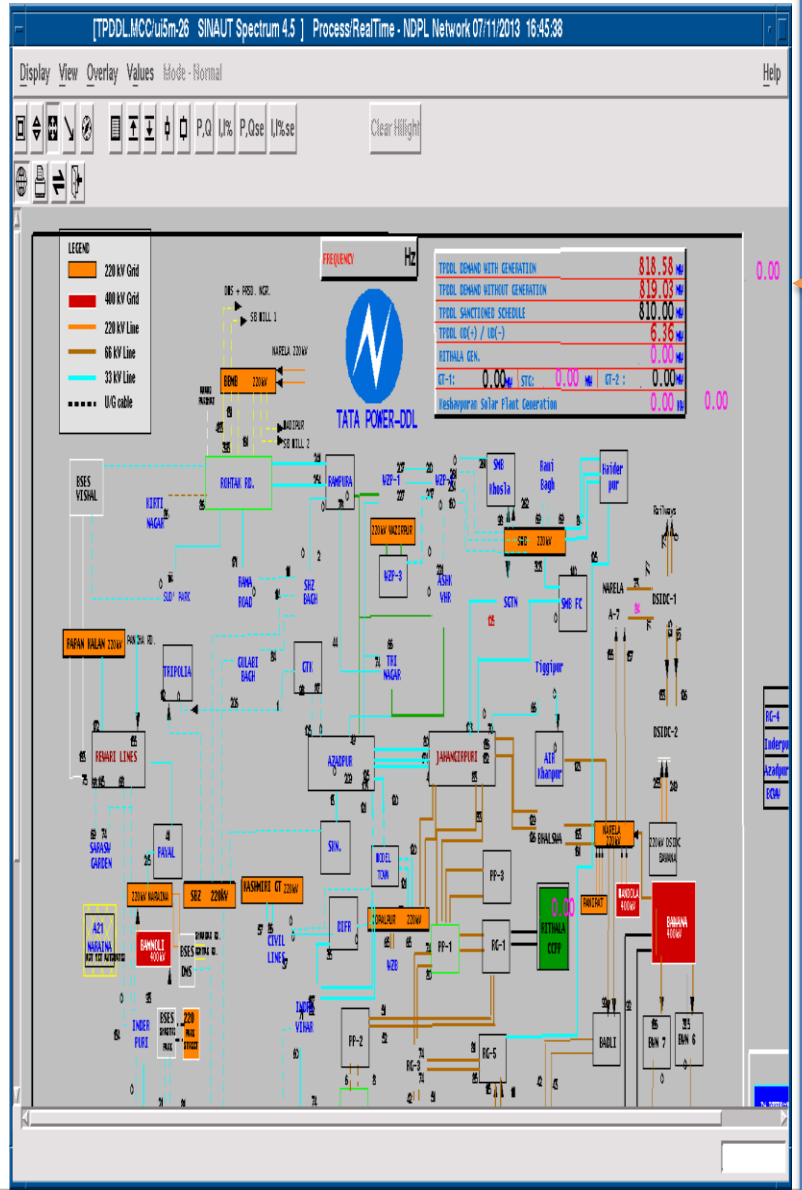
CONTROLLED PLANT

- Remote Terminal Unit (RTU)
- Interfacing panels consisting of
  1) Transducers,
  2) Relays, contactors

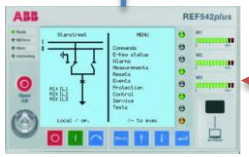
CONTROLLED PLANT



D25 GE

C 264 AREVA

Sicam AK 1703
ACP SIEMENS



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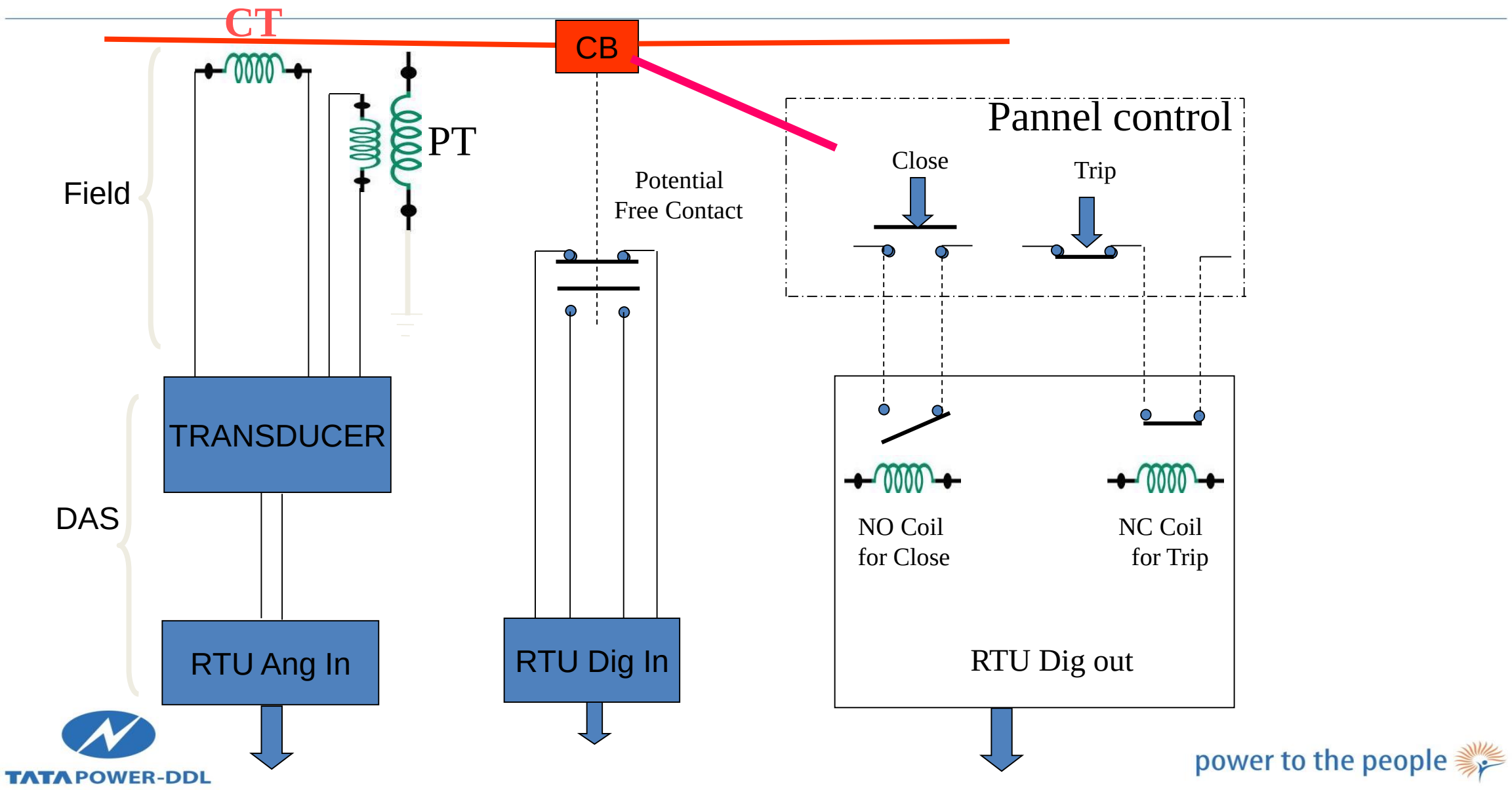
REMOTE TERMINAL UNIT (RTU)

It is an equipment located at the grid substation it works as :-

- Implement the commands of the control center
- Perform data acquisition in respect of
  - Analogs
  - Breaker status

Sicam AK 1703 ACP
SIEMENS

Basic Data Acquisition



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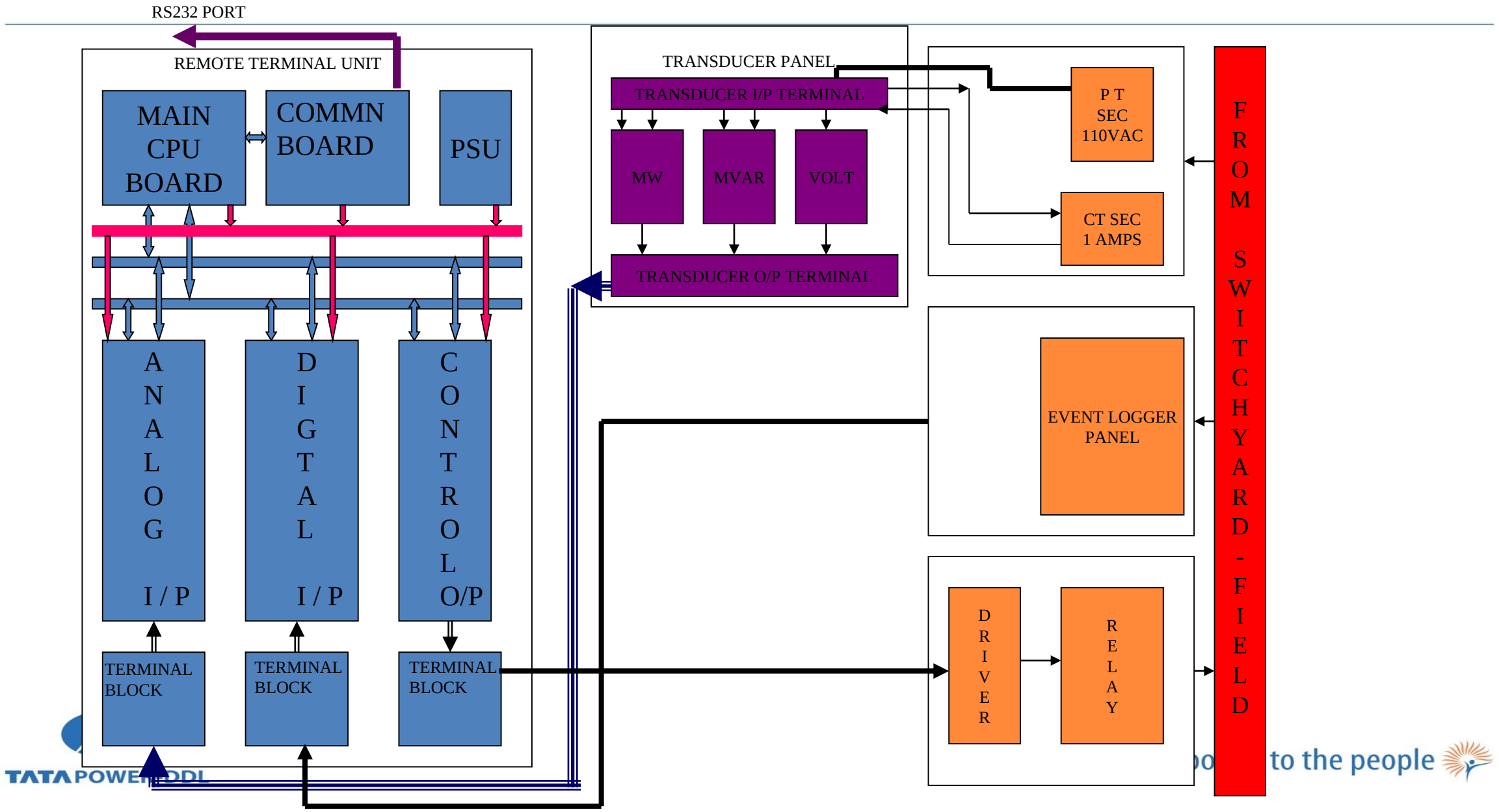
Basic functions

- Analog input cards for acquisition of analog

  Parameters such as voltage, current.
- Digital input cards for sensing breaker status.
- Digital output cards for performing close / trip
- Operation of circuit breakers through Interposing relays .
- Analog output cards (optionally) to drive the Chart recorders to have a continuous plot of Analogs.

HARDWARE CONNECTIVITY DIA FOR SCADA AT SUBSTATON



Bay Control Unit

BCU (Bay Control Unit)

- METERING
  - RMS (V&I)
  - POWER (ACTIVE, REACTIVE, TOTAL)
  - POWER FACTOR
  - FREQUENCY
  - PHASE
  - TAP POSITION (4-20 ma)
  - WINDING,OIL TEMP (4-20 ma)
- MONITORING
  - EVENTS
  - FAULTS
  - STATUS
  - ALARMS
- CONTROL
  - AUTO-RECLOSE
  - CHECK SYNCHRONISM
  - INTERLOCKING
    - PROGRAMMING TOOL (IEC 61131)
  - APPARATUS CONTROL
    - BREAKER
    - ISOLATOR
- PROTECTION
  - OVER-CURRENT
  - EARTH FAULT
  - OVER VOLTAGE
  - UNDER VOLTAGE
- COMMUNICATION INTERFACES
  - FRONT END
    - GRAPHIC TERMINAL
  - IEC 61850
    - CLIENT-SERVER
    - GOOSE(PUBLISHING)
    - GOOSE(SUBSRIBING)
    - SAMPLE VALUES (SUBSCRIBING)

TRANSDUCERS

TYPES

Self powered

Auxiliary Powered

- Convert inputs into low power signals (4.20 milli amps) that can be accepted by the RTU.
- Should have linear characteristics over the operating range.

INTERFACING

- The connection between the controlled plant and the RTU is termed as interfacing.
- Interfacing panel will house transducers, contactors and relays.
- Breaker status sensing is done by the auxiliary switch Normally Open (NO) and Normally Closed (NC) contacts.
- If the only one contact (NO / NC) is used for sensing the status of breaker / isolator, it is called as single bit indication.
- In double bit indication both the NO and NC contacts are sensed.

RTU Types

- Dumb RTUs : Just follow the intent of control center commends.
- Intelligent RTUs : Can perform operations with built in intelligence even when communications with the control center is lost.
- Distributed RTUs : Data acquisition / control is done over a local area net work (LAN).
- Pole top RTUs : Miniature versions with small I / O capacity suitable for controlling equipment online.

INTERFACING CONSIDERATIONS

- Keep sufficient (at least 20%) over range for transducers
- Provide DC auxiliary supply to transducers to prevent loss of indications at control Centre during station supply failures
- Ensure that the cable lengths between the PT, CTs and RTU kept as short as possible to avoid excessive drop.
- When the station area is large and cable lengths are excessive explore the distributed RTU concepts.

INTERFACING CONSIDERATIONS (contd.)

- Ensure perfect earthing of substation
- Connect SCADA earth to the substation earth to avoid differential voltages occuring during faults which are likely to damage the sensitive electronic equipment.
- When the station area is large and cable lengths are excessive explore the distributed RTU concepts.
- Ensure perfect earthing of substation
- Connect SCADA earth to the substation earth to avoid differential voltages occuring during faults which are likely to damage the sensitive electronic equipment.

COMMUNICATION SYSTEM

Communication system selected should have

- Expandability & flexibility
- Reliability
- Two way communication capacity
- Ability to meet data requirement

CLASSIFICATION OF COMMUNICATION

Based on the medium of communication

- Line communications (PLCC, PSTN)
- Optical fibre
- Radio communication (UHF & VHF Links)
- Satellite communications (VSAT)

CLASSIFICATIONS OF COMMUNICATION (contd.)

Based on the method of communication

- Dial up
- one way
- Two way
- Point – to – point
- Point – to - multipoint

CONSIDERATIONS FOR RADIO COMMUNICATIONS

- Require line of sight
- Repetition of signal where there is obstruction or signal strength is low
- Terrain consideration (flat, undulated , contains water bodies)
- Proximity to air ports signal/noise ratios

Indian Government mission

National Optical Fiber Network(NOFN)

A Project to connect 2,50,000 Gram Panchayats(GPs) through OFC

- Approved by GoI on 25.10.2011
- NOFN Project will bridge connectivity gap between GPs and Blocks.

Project to be implemented by NOFN-SPV namely Bharat Broadband Network Ltd (BBNL).

- Envisaged as a Centre-State joint effort .

Govt. of India to fund the project through the Universal Service Obligation Fund (USOF). **Rs. 20,000 Cr.($4B)**

As per a study conducted by the World Bank, with every 10 per cent increase in broadband penetration, there is a 1.4 per cent increase in GDP growth

Indian Government mission

Bharat Sanchar Nigam Limited (BSNL) and other institutions such as RailTel, Power Grid and the Gas Authority of India. For the implementation and execution, the Cabinet has approved the formation of a special purpose vehicle with equity from the Government of India

Bharat Broadband

सुनहरे भारत की ओर

Service Provider	Total Fibre Laid	Cities / Towns Covered	Metros / Tier I Cities*	Other Cities / Towns	Gram Panchayats	Mid Sized Villages	Small Villages
BSNL	614,755 RKm**	All cities & 28 K gram panchayats	●	●	◔	○	○
Reliance	190,000 RKm**	44	●	◔	○	○	○
Airtel	126,357 RKm**	130	●	◔	○	○	○
Tata Communications	40,000 RKm**	60	●	◔	○	○	○
RailTel	37,720 RKm	600	●	◑	◔	○	○
PowerGrid	21,852 RKm	110	●	◔	○	○	○
GAILTEL	13,000 RKm	200	◑	◔	○	○	○

Level of Backbone Infrastructure Coverage : Very High ● High ◕ Medium ◑ Low ◔ No Coverage ○

Source: Analysis Mason[55]

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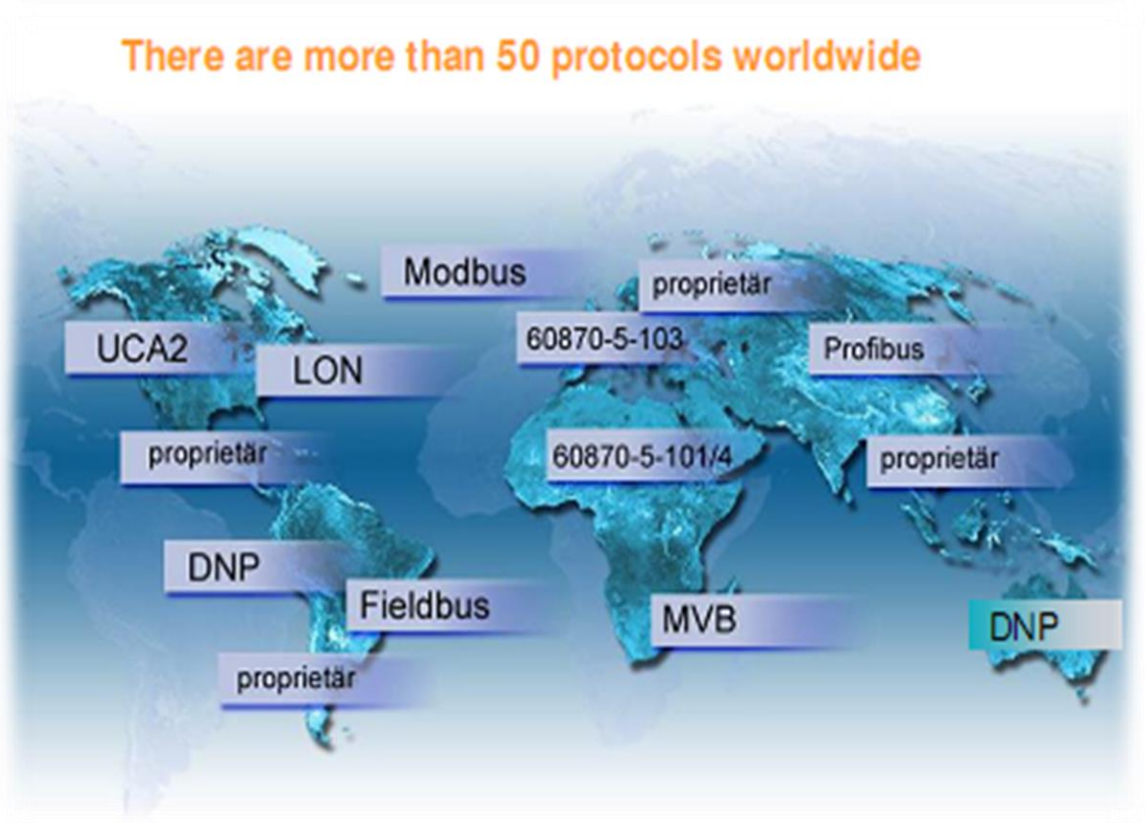
Protocols used in power industry in India

- IEC-103
- IEC-104
- DNP
- MODBUS
- LON
- SPA
- IEC-61850 (latest)



Protocols used in power industry in India

- IEC 60870-5-103 :- It is a standard for power system control & associated communication. It defines a companion standard that enables interoperability between protection equipment and devices of a control system in a substation. The device complying with this standard can send the information using two methods for data transfer.

- IEC 60870-5-104 :- It is an extension of IEC 101 protocol with the changes in transport, network, link & physical layer services to suit the complete network access.

- DNP :- Distributed Network Protocol is a set of communication protocols used between components in process automation systems. Its main use is in utilities such as electric and water companies

Protocols used in power industry in India

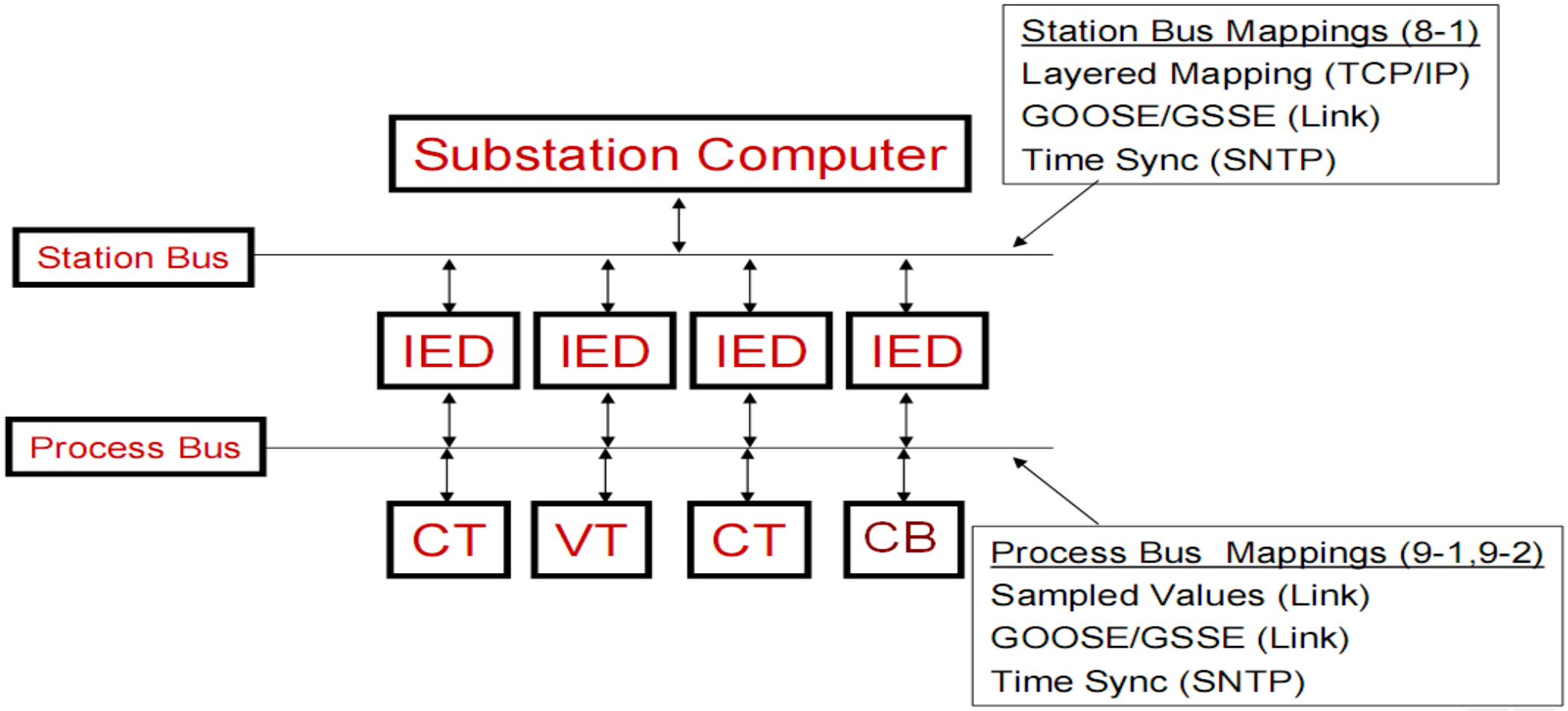
- MODBUS:- **Modbus** is a serial communication protocol originally published by Modicon (now Schneider electrical) in 1979 for use with its programmable Logic controllers (PLCs). It is now a commonly available means of connecting industrial electronic devices.

- LON : **Lon Works** (local operating network) is a networking platform specifically created to address the needs of control applications.

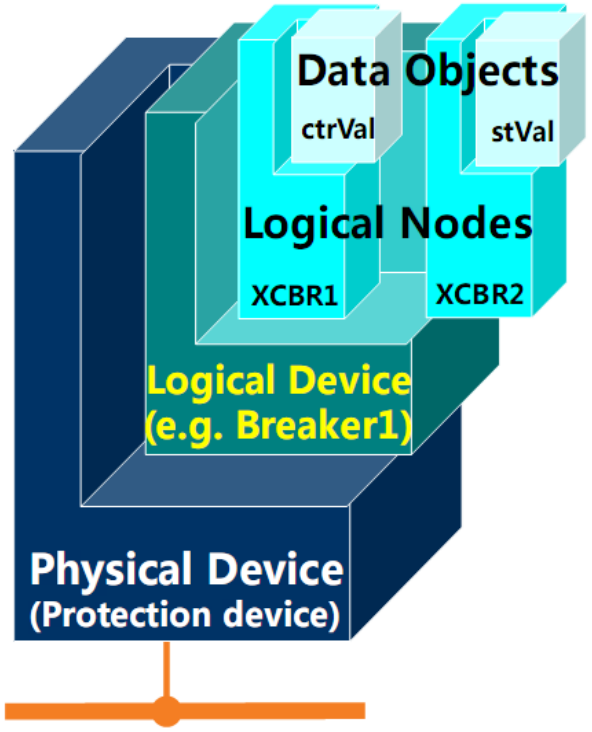
- SPA : SPA-bus is was originally designed as a fieldbus in a distributed protection, control and event reporting system. The system may incorporate slave units as protective relays, control units and alarm units connected over the SPA-bus to a master unit

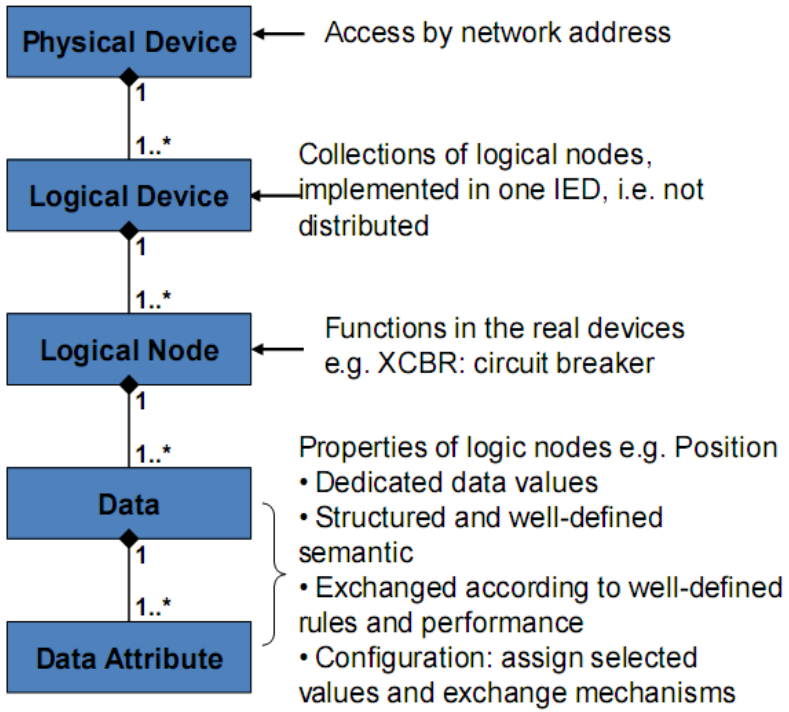
IEC 61850 PROTOCOL LATEST

IEC 61850 SYSTEM ARCHITECTURE

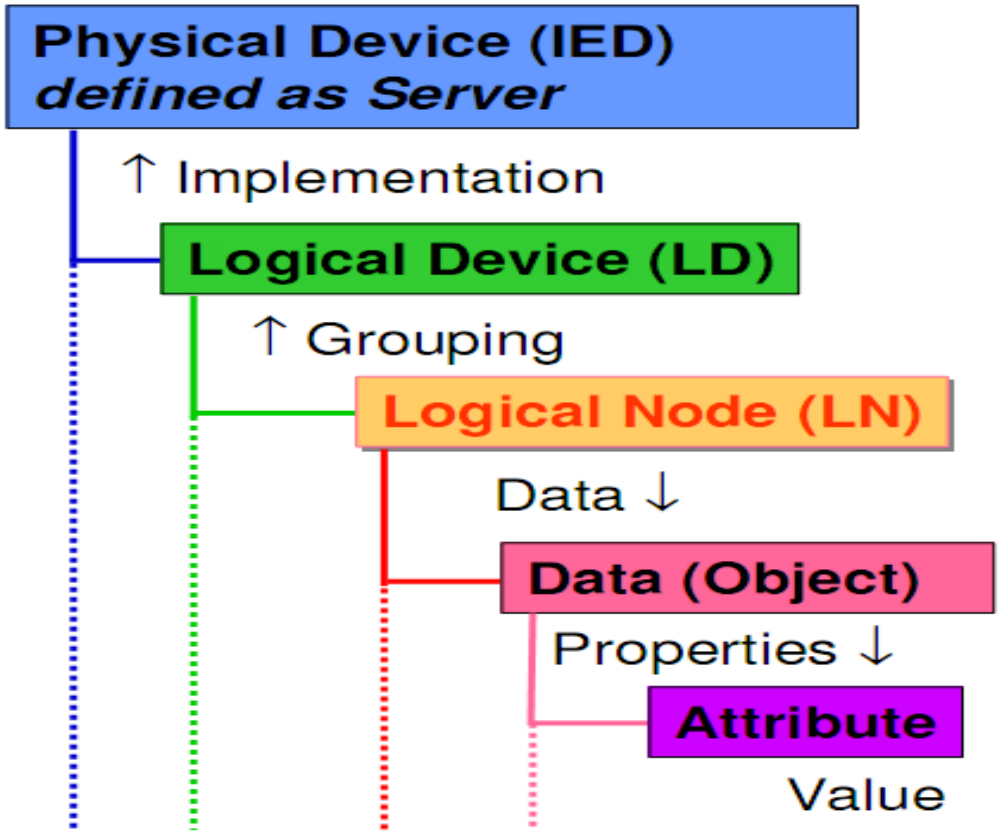


IEC 61850 – CLASS MODEL





Data model : Hierarchy



Bay Unit

Control

CSWI *Switch Control*

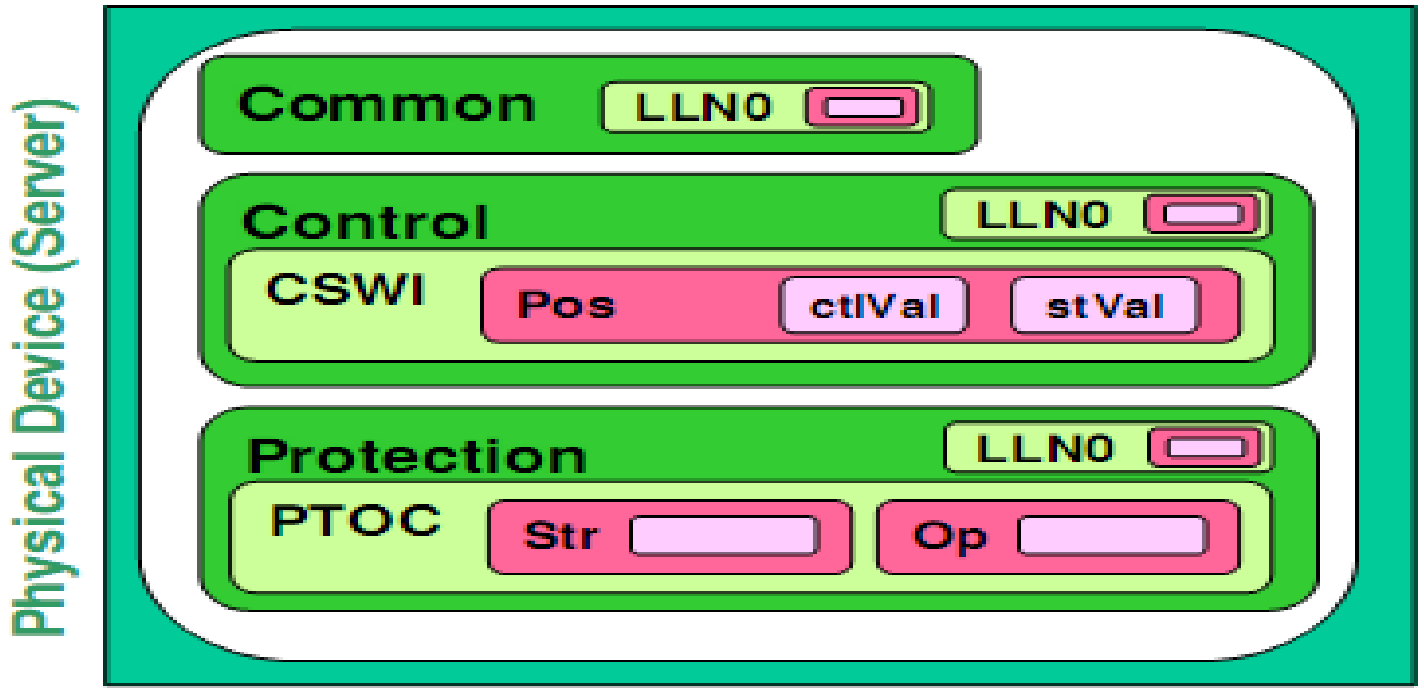
Position

Control Value
off/on
Status Value
intermediate/off/on/bad

Data model : Hierarchical set of objects

Data container with related data

Example: Modeling of a combined Control-Protection device

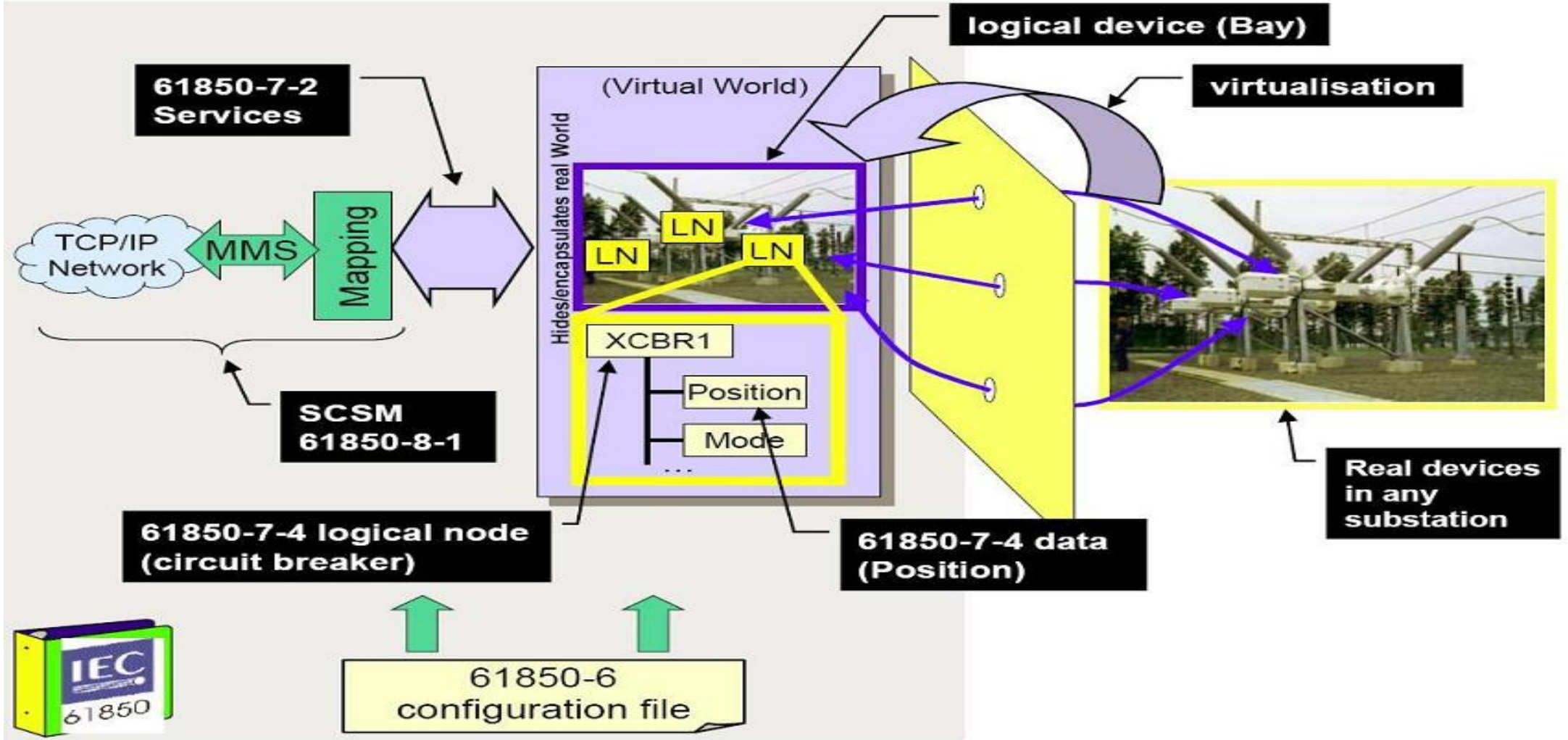


Common
LLN0
Name plate
"Vendor etc."

Control
Switch Control
Position
Control Value
Status Value

Protection
Overcurrent
Start/Pick-up
Operate/Trip

IEC 61850 - MODELLING APPROACH



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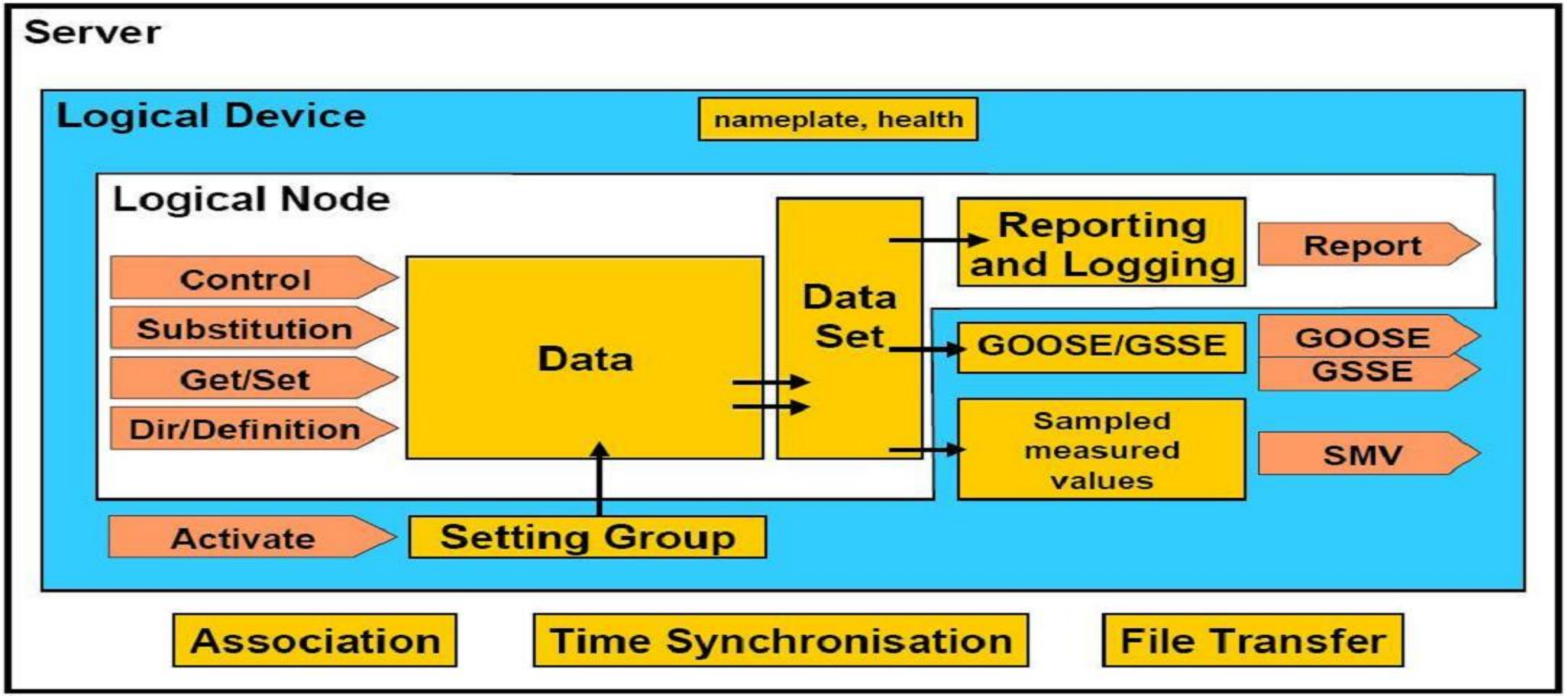
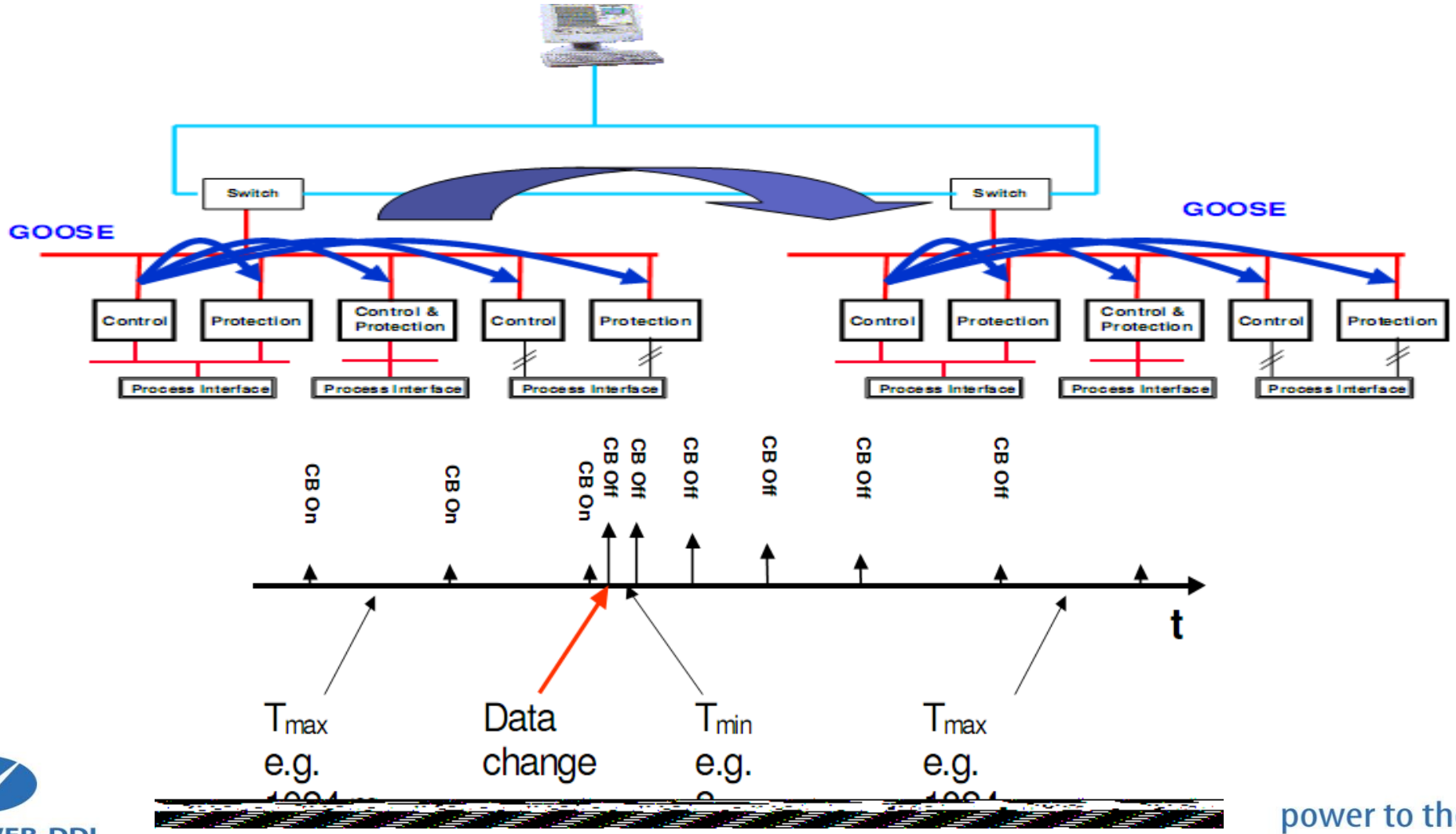
ACSI Server Building Block



Generic Object Oriented Service Event – GOOSE

- System-wide data distribution
  - Device to Device exchange
- Based on subscription / publisher mechanism
- Status / State Oriented
  - Event ID
  - Event Time
- Higher Reliability
  - Periodic refresh
  - Automatic Refresh
  - Sequence Count



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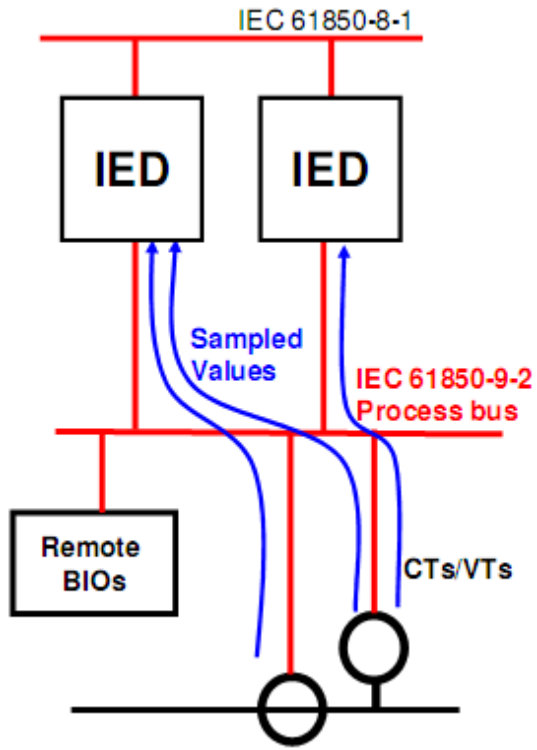
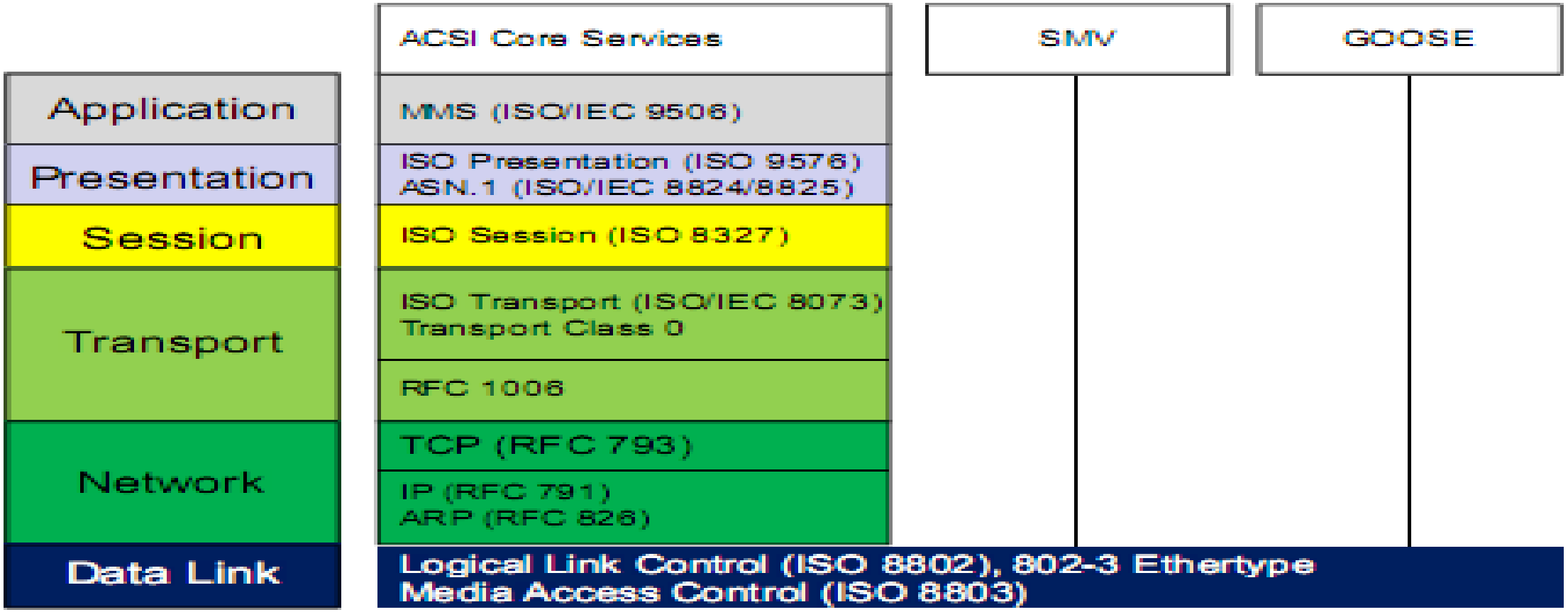
Sampled Measured Values

- ✓ A method for transmitting sampled measurements from transducers
- ✓ Enables sharing of I/O signals among IEDs
- ✓ Supports two transmission methods
  - Multidrop point-to-point service (USVC) over serial links
    - Predefined format and content
    - One direction (Sensor-IED)
  - Multicast service (MSVC) over Ethernet IEC 61850-9-2
    - Information content is fully configurable
    - Status and configuration information can be accessed from IED



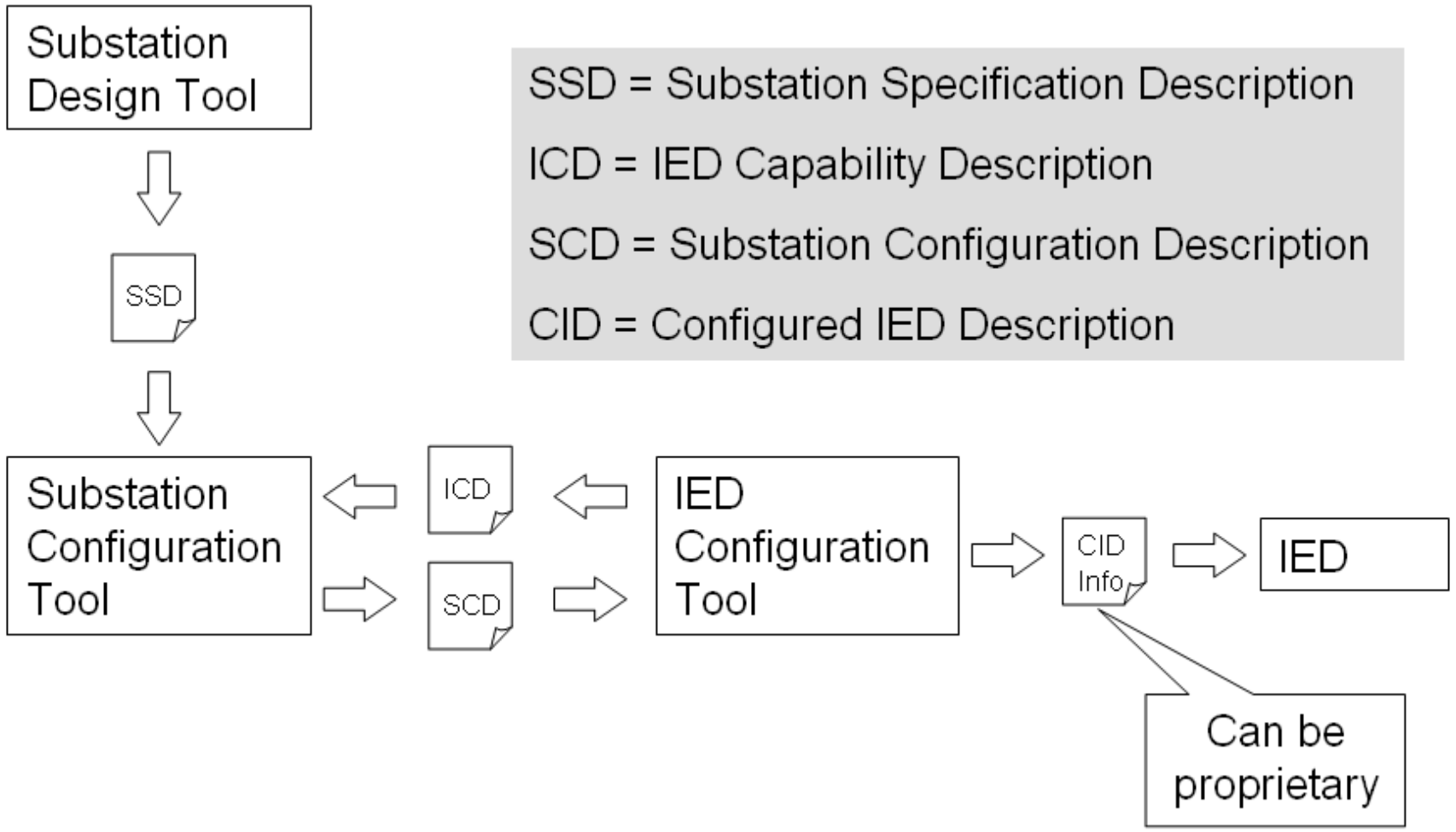
IEC 61850 PROTOCOL STACK



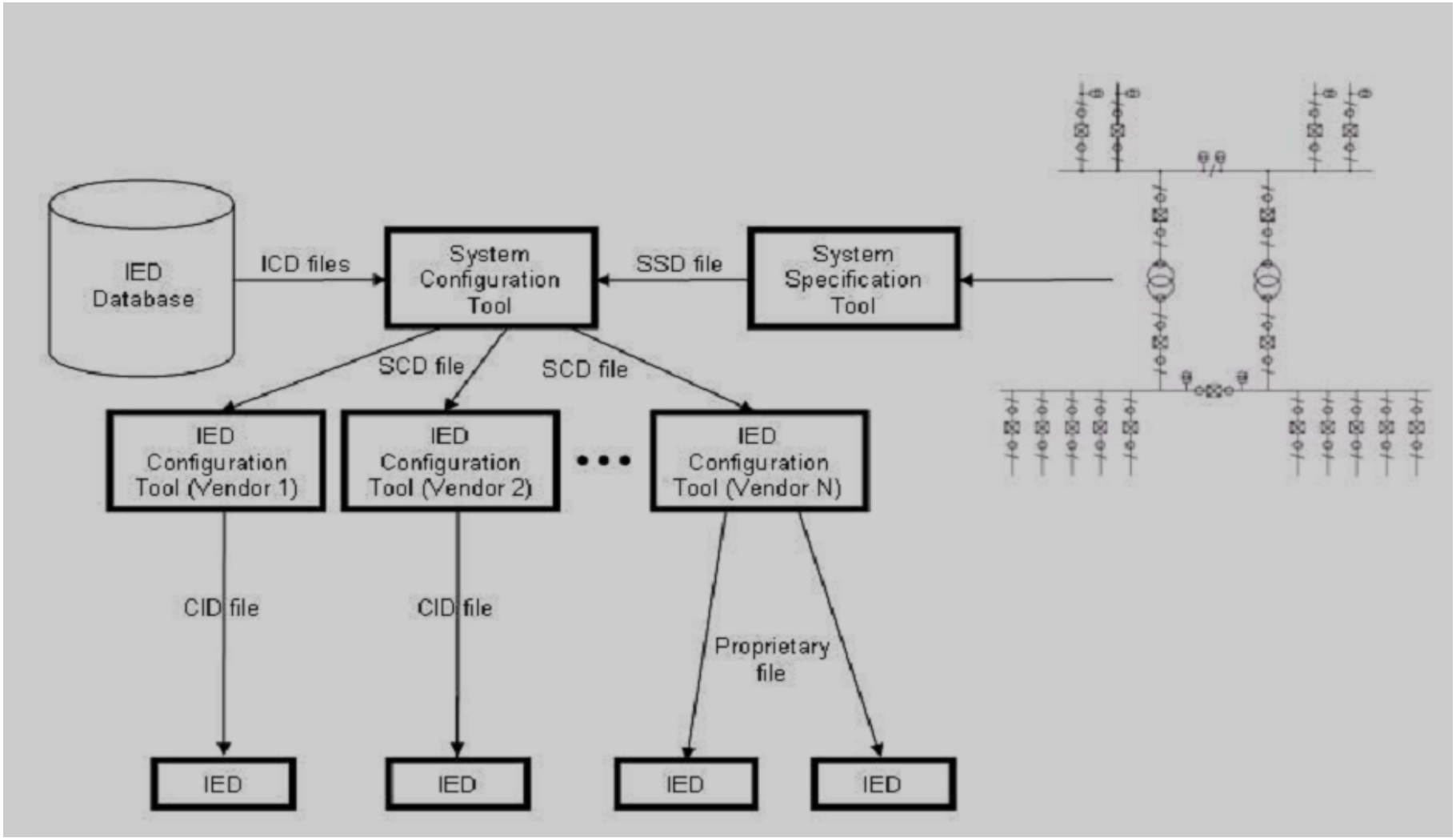
IEC 61850-6 – Substation configuration Language - Files

- .ICD file - IED Capability Description
  - For data exchange from the IED configuration tool to the system configuration tool
- .CID file - configured IED description
  - For data exchange from the IED configuration tool to the IED. It describes an instantiated IED within a project. The communication section contains the current address of the IED.
- .SSD file - system specification description
  - For data exchange from a system specification tool to the system configuration tool. Describes the single line diagram of the substation and the required logical nodes.
- .SCD file - Substation Configuration Description
  - For data exchange from the system configuration tool to IED configuration tools. This file contains all IEDs, a communication configuration section and a substation description section. Also for system products.

IEC 61850-6 – Substation configuration Language



IEC 61850-6 – Substation configuration Language



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CONCLUSION

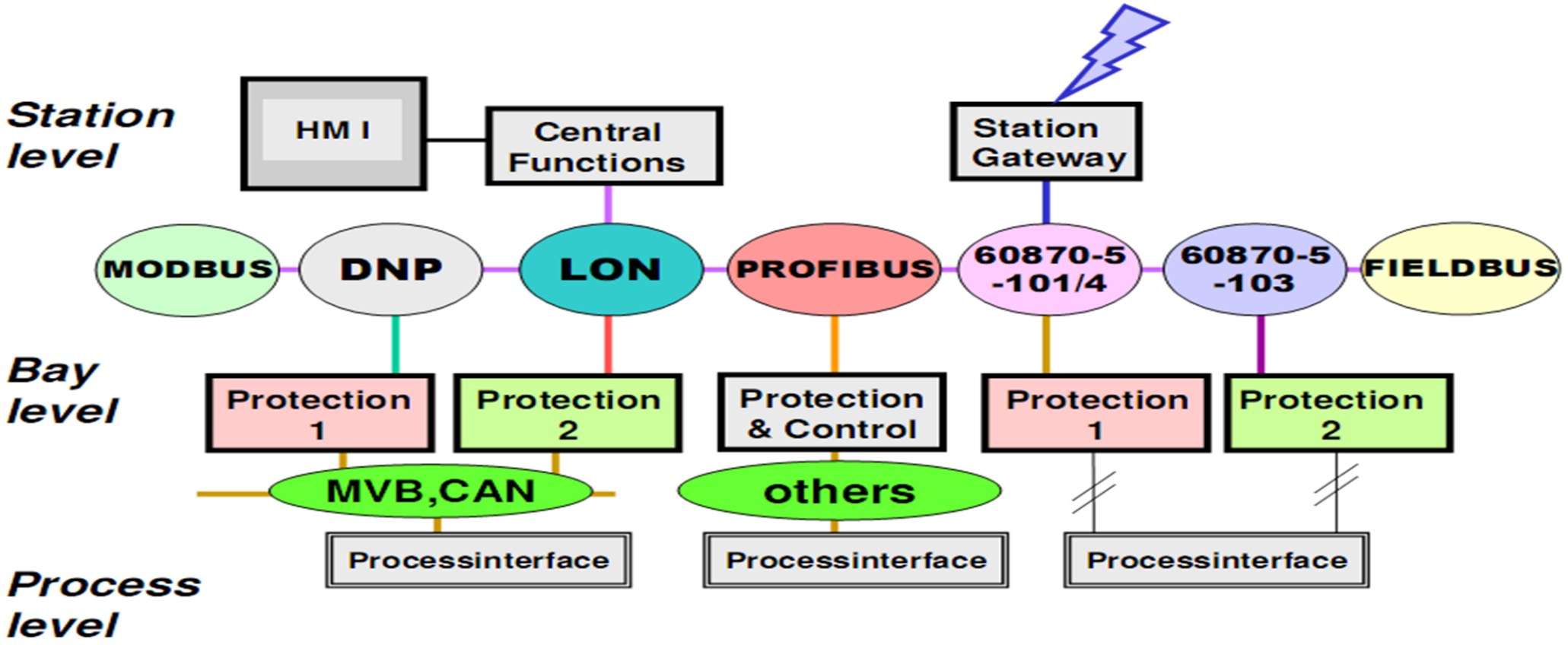
- IEC 61850 is a migration from the analog world to the digital world for substation
  - Standardization of data names
  - Creation of a comprehensive set of services
  - Implementation over standard protocols and hardware
  - Definition of a process bus.

- Multi-vendor interoperability has been demonstrated

- Discussions are underway to utilize IEC 61850 as the substation to control center communication protocol

- IEC 61850 will become the protocol of choice as utilities migrate to network solutions for the substations and beyond.

Situation using different protocols



OTHER APPLICATIONS OF SCADA

SCADA APPLICATION

- Distribution Management System (DMS)
- Outage Management System (OMS)
- Geographical Information System
- Advanced Metering Infrastructure (AMI)
- Network (electrical) model

EMS/DMS Architecture

The hardware and software architecture of the System is presented in this section

Conceptual Configuration

The EMS/DMS is comprised of several component systems:

- Master Control System (MCS)
- Information Storage and Retrieval System (IS&R)
- Backup Control System (BCS), an
- Operator Training Simulator (OTS)
- Program Development System (PDS).

Master Control System

The MCS is the real-time nucleus of the EMS/DMS. The MCS shall be a high-availability system characterized by high-speed data collection and presentation functions. The MCS may collect, process, and store real-time data from different data sources

EMS/DMS Architecture

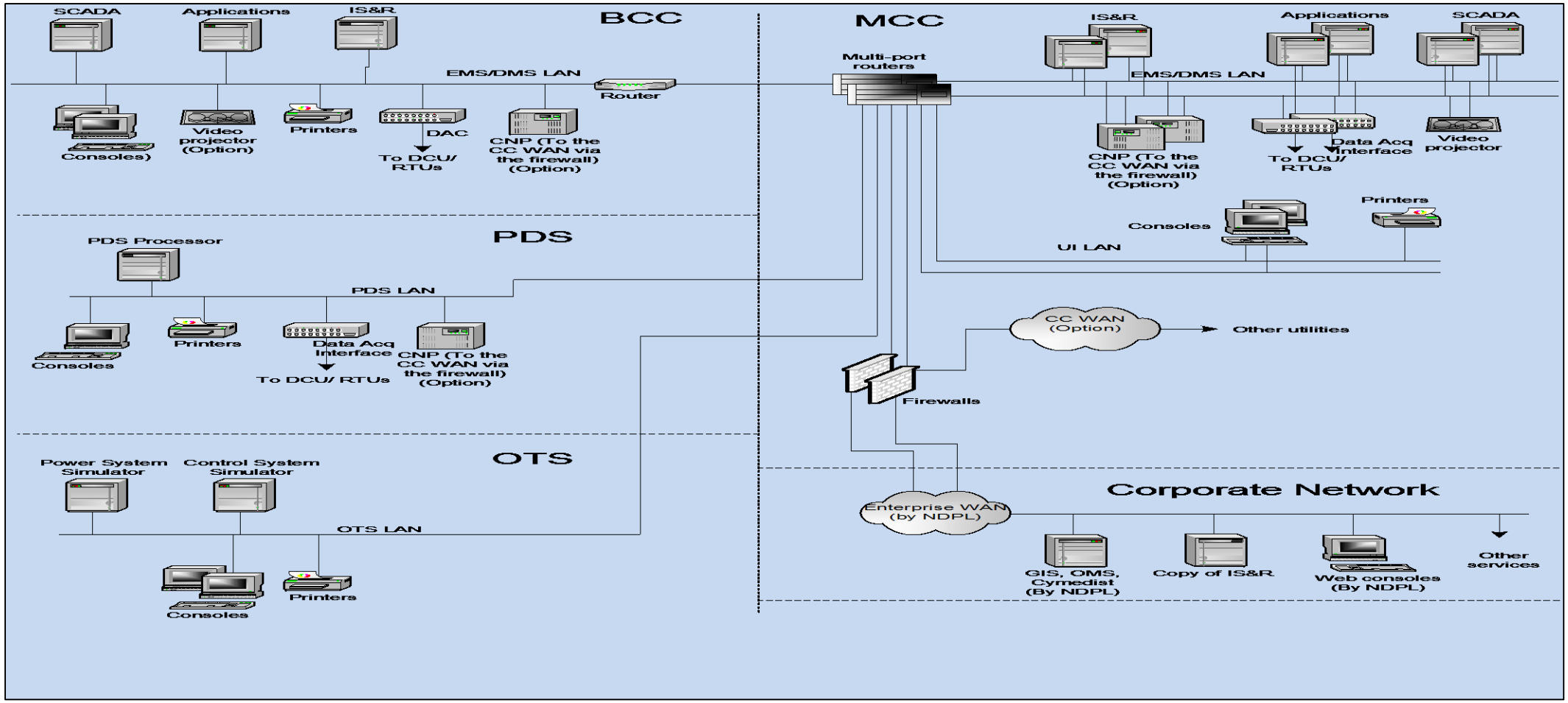
Program Development System

TP-DDL's development and testing of the EMS/DMS applications, database, displays, and reports. The PDS shall be initially delivered with basic database and display generation capabilities.

Operator Training Simulator

The OTS shall execute on hardware dedicated to that functionality. It shall provide the capability to train dispatchers by simulating both the power system and the EMS/DMS.

NETWORK ARCHITECHTURE



NETWORK ARCHITECHTURE CONT…

Name of the Server	Functions on the Server
Information Management (IM) & RAID	Source Data Management Data Maintenance
Real Time Control (RTC)	Data Processing Supervisory Control
Telecontrol Interface (TC)	Telecontrol Interface
User Interface (UI)	User Interface (HMI)

Telecontrol Interface (TC):-

The remote terminal interface of SINAUT Spectrum is the TCI (Tele Control Interface). It is Part of the control center system and communicates with the other subsystems via the local area network (LAN). The control center system is connected to the substations/power Stations via remote terminals units (RTUs). The process data are transmitted via remote terminal units (RTUs) to TCI.

Real Time Control (RTC):-

The RTC server performs the data processing and contains the process data of the SINAUT Spectrum data base.

NETWORK ARCHITECHTURE CONT…

User Interface (UI):-

The UI server is a workstation that supports UI consoles. The console represents the link between the user and the power system. It is used to display information and accept user input. The UI server is mainly used for visualizing and controlling the network.

Information Management (IM) & RAID:-

RAID is used for data base storage however RAID server is connected to two IM (information Management server) through fiber optical cable. There is disk mirror done in storage server to ensure the highest availability. The IM server is the data base master for all servers. Other servers are updated by the IM server at system and upon occurrence of certain events, e.g. data modifications. The historical and future data management is also installed on the SDM server. In the IM server the storage of historical and future data is done.

Type of load management

- Forced Load shedding

  Load shedding of high AT&C loss feeders from SCADA during emergency requirement

- Under Frequency Relief

  Load shedding of scheduled feeder automatically after frequency dropped below defined limit

- Distress Load Relief

  Load shedding of scheduled feeder (after acknowledging pop-up) automatically after frequency dropped below defined limit and TPDDL is Over drawling from grid

- Tie-Line overloading

  Automatic load shedding during overloading of 33kV/66kV line

- Transformer Overloading

  Automatic load shedding during overloading of power transformer

EMS (Energy Management System)

EMS application like Availability based tariff, STLF, Load shedding, Dispatch training simulator etc.

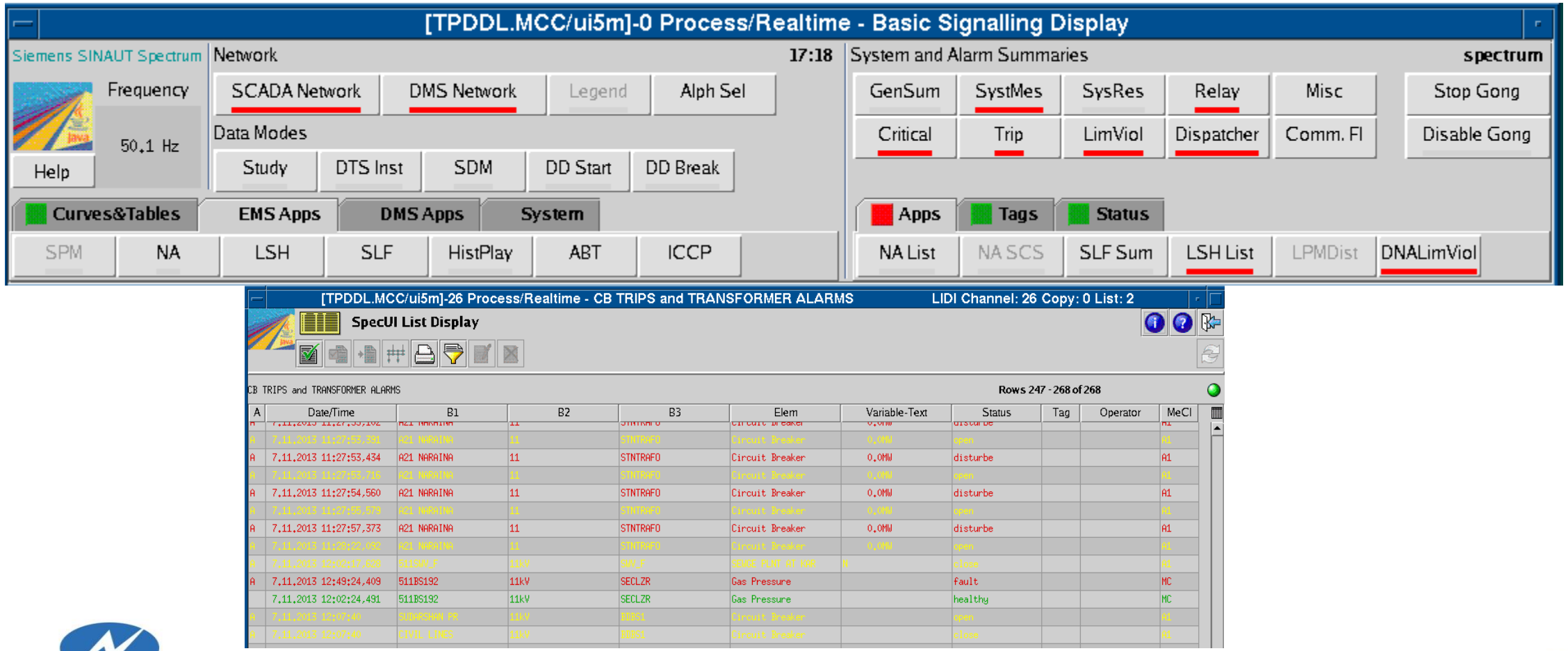
ABT application is used for monitoring UI (Unscheduled Interchange) of TPDDL and TPDDL overdraw/ underdrawal at defined frequency levels.

STLF & load shedding application is used for load forecasting and automatic UFR or DLR shedding respectively

Dispatch training simulator is useful for new operator to train with simulation of fault & tripping etc.

Real-Time Operation

BaSiDi is the main window that appears after login. Various applications, list and network world maps can be open from this displayed



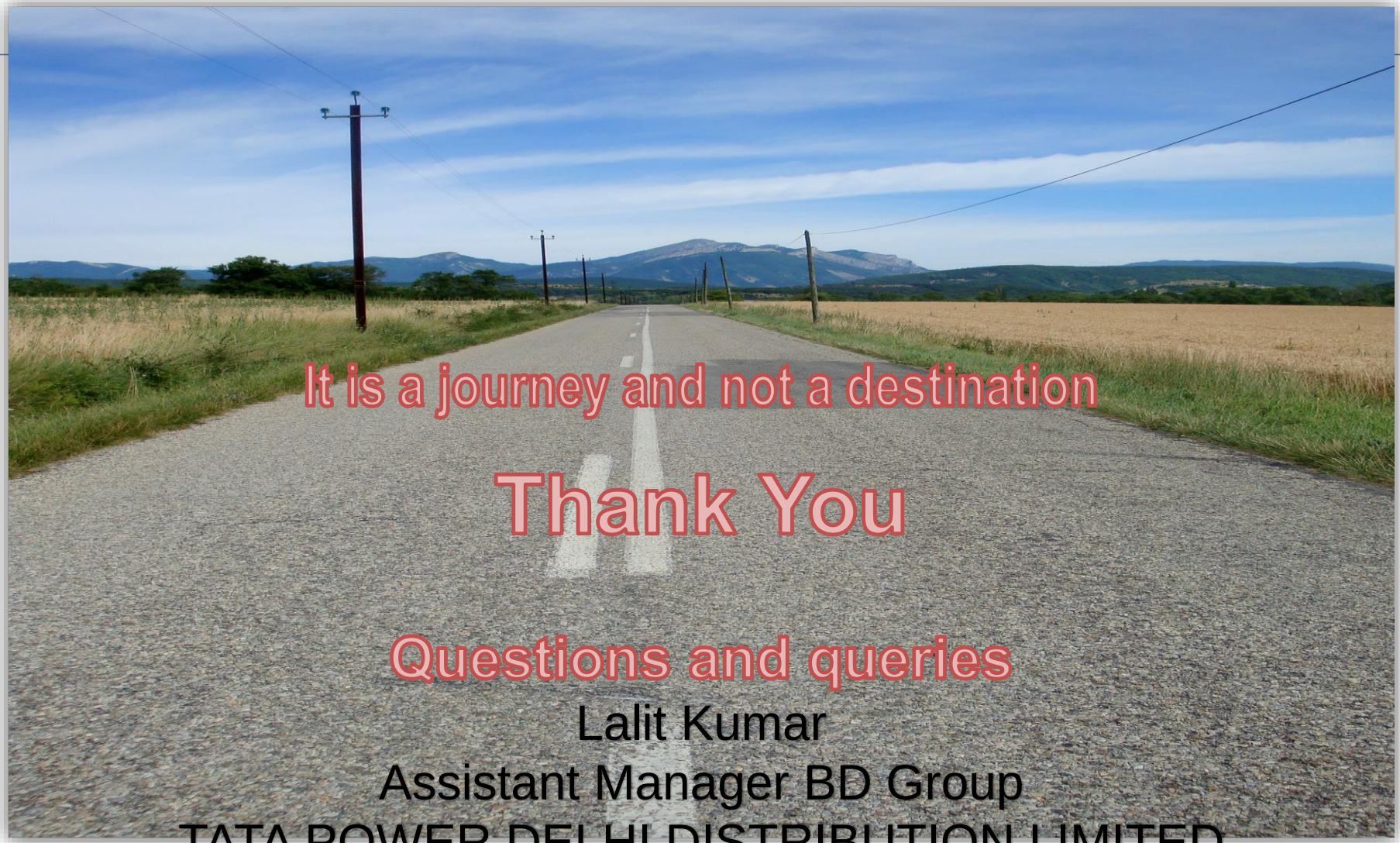
SUMMARIES

(1) NETWORK
- a. SCADA Network
- b. DMS Network

(2) System and Alarm Summaries
- a. GenSum ; b. Relay ; c. Critical ; d. Trip ; e. LimViol

(3) Data Modes
- a. Study Mode
- b. SDM Mode
- c. DTS

(4) Tag & Status Summaries
- a. Tags
- b. Remove from operation
- c. Permit to Work
- d. Control Inhibit Summary



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