SUBSTATION AUTOMATION SYSTEM
BASIC CONCEPTS

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INTRODUCTION

- Substation Automation System (SAS) is a collection of hardware and software components that are used to monitor and control an electrical system, both locally and remotely .
- Substation Autoimation system uses High speed microprocessor based computers and Intelligent Electronic Devices (IEDs).
- These IEDs are installed in strategic locations for collection of system data of substation equipment.

SUB-STATION AUTOMATION SYSTEM – WHY?

- INTEGRATION OF MONITORING , PROTECTION AND CONTROL FUNCTIONS WITH MINIMAL NUMBER OF PLATFORMS / DEVICES.
  - Aims at reduction of operating cost.
  - Increases reliability and flexibility of the power system.
  - Integration of protection & control events helps in accelerating response to problems.
  - Comparatively easy and cost effective maintenance.
  - Equipped with disturbance recording for fault location and power quality assessment features.

Basic Functions of SAS-

- SAS Monitoring Functions includes:
  - Monitoring of switchgear status, transformer tap position & tap changer status etc.
  - Monitoring of control & protection equipments.
  - Monitoring of electrical quantities, e.g. current, voltage, frequency, MW, MVAR etc.
  - Monitoring of station auxiliary supply and DC system.

- SAS Control Functions includes:
  - Controlling of circuit breakers & disconnecting switches.
  - Synchronization checking.
  - Switchgear operation interlocks.

Basic Functions of SAS-

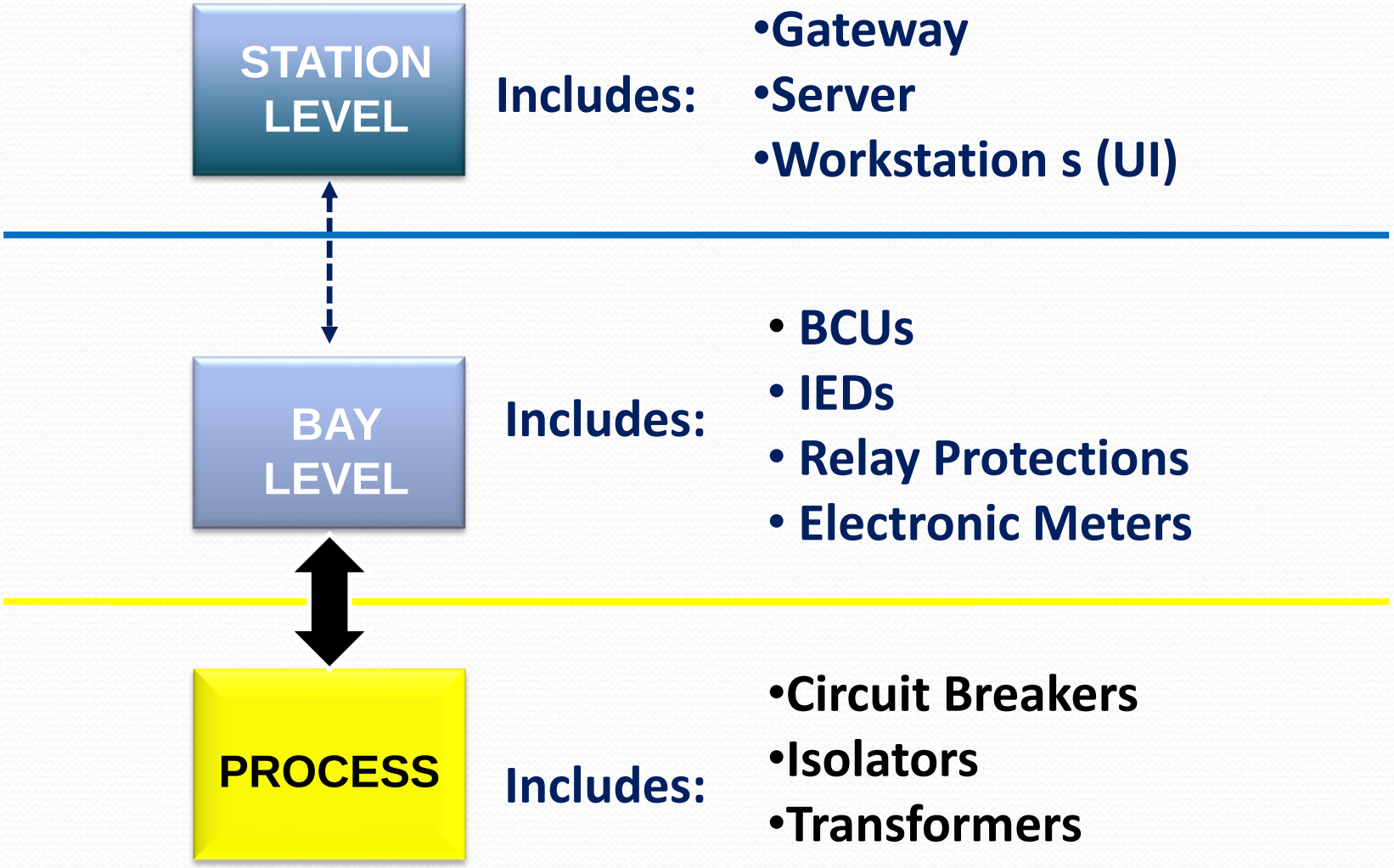
- SAS Recording Functions includes:
  - Recording of monitoring data.
  - Fault, disturbance and event recording.

- Protection Functions includes:
  - Protection of transmission line, power transformer, busbar, distribution feeders, shunt capacitor, shunt reactor etc.

SAS- ARCHITECTURE FEATURES

- Based on decentralized architecture
- Architecture shall be structured in two level – Substation and Bay level
- Located as close as possible to the bay equipments
- IEDs shall provide all bay level functions regarding Control and Monitoring

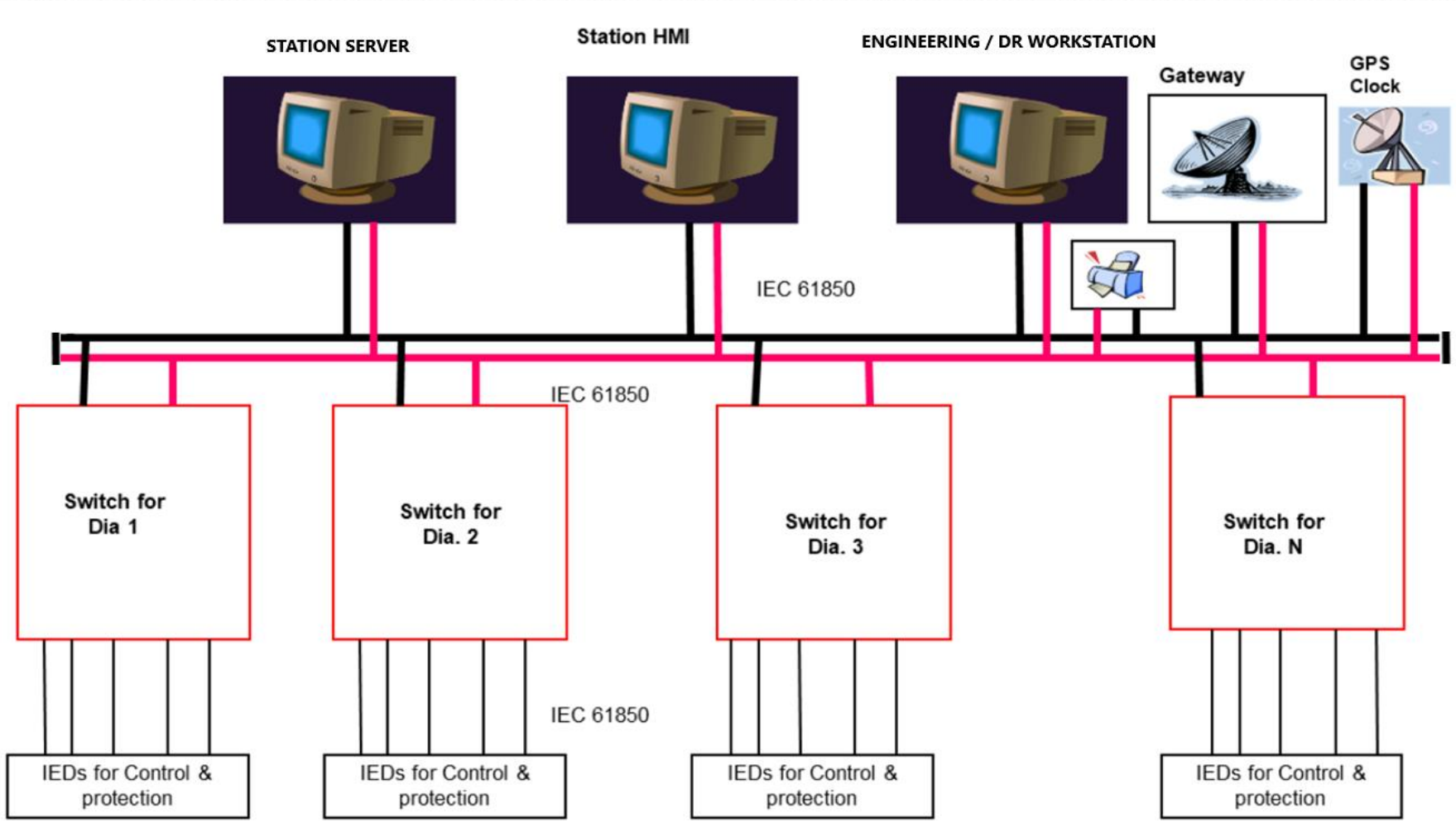
SAS- ARCHITECTURE STRUCTURE



SAS CONTROL HIERARCHY

- BAY CONTROLLER IN SWITCHYARD (For bay level local control)
- LOCAL HMI IN CONTROL ROOM (For substation level local control)
- REMOTE CONTROL CENTRE

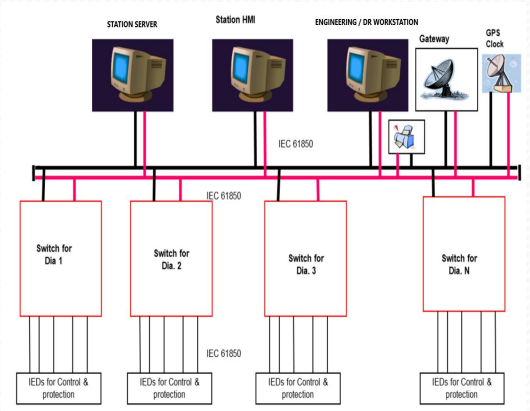
TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM



Operator Workstation:

This is a station HMI (Human Machine interface) device which is used to perform control and monitoring operations for the entire substation using local SCADA application.

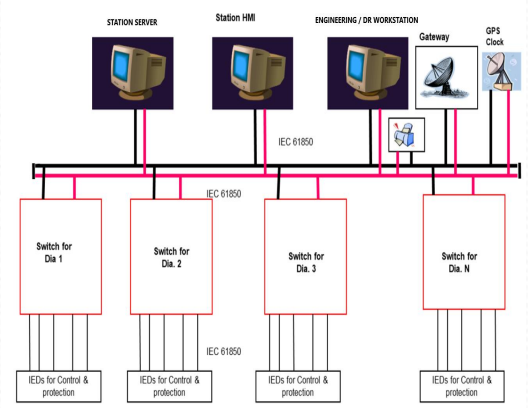
- Features:
  - Single Line Diagram representation of Substation switchgears
  - Control Dialogue with interlocking and blocking feature
  - Measurement dialogues
  - Alarm and Event List
  - System status
  - Select before execute procedure for security
  - Hot standby swap



Engineering Workstation:

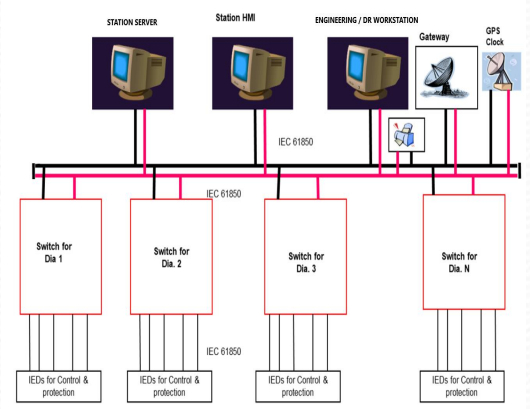
This is a computer device connected to the substation LAN, used for performing engineering tasks such as database creation and maintenance. All the substation network devices maintenance is being maintained and configured from this workstation.

This workstation is also used for collection of Disturbance Recorder files from Protection relays.



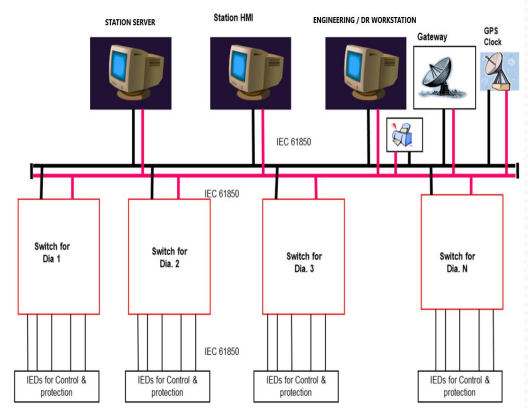
Station Server :

This substation computer is a substation server device providing control and monitoring functions, remote control center interface function, data recording functions, etc. This is one of the most important devices in the SAS system with the emphasis on dependability.



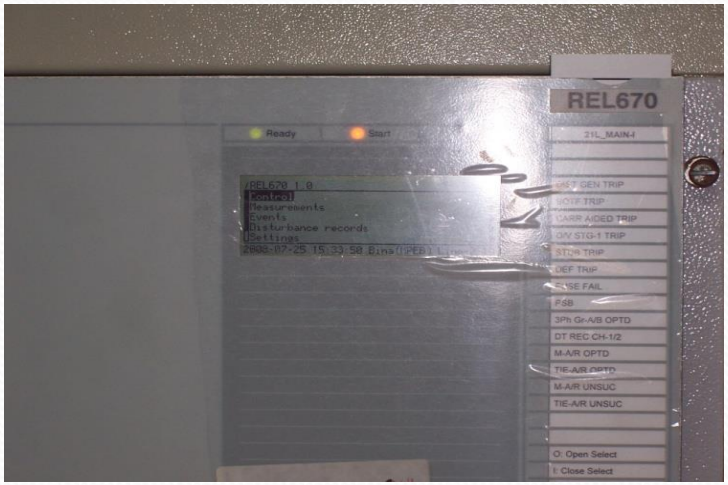
Station BUS :

- This is an intra-substation LAN which is compliant with the IEC 61850 standard for establishing connection with the various IEDs.
- The ring topology used for creation of station bus has following features:
  - Shorter total fiber cable length
  - Redundant communication path
  - In event of a failure in one of the transmission paths, it also provides a reconfigured path at high speed.



USE OF MULTIFUNCTIONAL IEDs

- A SINGLE IED CAN BE USED FOR MULTIPLE FUNCTIONS LIKE DISTANCE RELAY CAN ALSO BE USED FOR
  - OVER/UNDER VOLTAGE PROTECTION
  - AUTORECLOSURE FUNCTION
  - E/F PROTECTION
  - SOTF PROTECTION
  - STUB PROTECTION ETC.



- SIMILARLY, BAY CONTROL UNIT WHICH IS BEING USED FOR ANALOG AND DIGITAL DATA ACQUISITION AND BAY EQUIPMENT CONTROL FUNCTIONS HAS ALSO AUTO VOLTAGE CHECK SYNCHRONISING FUNCTIONS AND AUTO RECLOSURE FUNCTIONS.

BAY CONTROL FUNCTIONS

- Software interlocking
- Synchro-check
- Transformer tap selection
- Operation counters for CBs/ Pumps
- Alarm functions
- Measurement functions
- Local HMI
- Data storage for at least 200 events

AUTHENICATION: USER AUTHORITY

In SAS system, access rights can be defined for different users such as

- Display only
- Normal Operation (Open/ Close)
- Restricted operation (Bypass interlocks)
- Report Generation
- NMS (Network management System) Monitoring

AUTHENTICATION: MAINTENANCE AUTHORITY

- Similarly, In SAS system, access rights can be defined for maintenance and modification of station HMI
  - Allowing Engineering/ Configuration
  - Allowing Entire system management

  Access rights shall be defined by passwords during logging-in

SAS OPERATIONAL ASPECTS

- LESS HARDWIRING RESULTS IN INCREASED RELIABILITY OF THE SYSTEM AND LESSER FAULT DETECTION TIME.

- SOFTWARE ENABLES QUICK APPROACH TO PROCESS THE DATA FOR UNDERSTANDING THE CAUSE OF DISTURBANCE, FOR FAST CORRECTIVE ACTIONS.

- "**ASK BEFORE EXECUTE**" FUNCTIONS RESULTS IN LESS PROPBABILITY OF SWICTHING ERROR BY OPERATOR.

SAS OPERATIONAL ASPECTS

- FACILITY OF AUTOMATIC REPORT GENERATION
- MONITORING OF AUXILIARY SERVICES
- SOFTWARE INTERLOCKING IN ADDITION TO HARDWARE INTERLOCKING AVOIDS DANGOUROUS OR DAMAGING SWITCHGEAR OPERATIONS TO ENSURE PERSONNEL SAFETY.

Communication PROTOCOL -

A Protocol is an language between two devices on how to Communicate. SAS devices communicates using different protocols.

- A protocol is a set of:
  - ✓ Message formats
  - ✓ Services
  - ✓ Procedures
  - ✓ Addressing and naming conventions

PROTOCOL -

A Protocol Defines Messages and Rules to Get the Job Done

It defines and take care of:

- How to establish or end communication
- Who manages the communications
- How to direct/route messages
- How is data represented or protected
- How to control performance
- The types of data supported
- Supported “Commands”
- How to detect “errors”
- How to recover from errors

Communication in SAS-

- Data communication between the control centre and IEDs and among the IEDs becomes an important issue to realize the substation automation functions.
- Various proprietary protocols are used for tele-control purpose, but none of them fully support the interoperability among IEDs supplied by different vendors in the substation.

Communication in SAS- (cont.)

- For Communication within the substation-
- Proprietary Protocols-
  - SPA (ABB)
  - LON (ABB)
  - Profibus (Siemens)
  - DNP3.0 (GE)
- Standard Protocols- IEC 61850 (TCP /IP based)

Communication in SAS- (cont.)

- Communication with Remote control centres via gateways

- Proprietary Protocols-
  - RP570/571 (ABB)
  - 8fW (Siemens)
  - DNP3.0 (GE)

- Standard Protocols-
  - IEC 60870-5-101 (Serial Based)
  - IEC 60870-5-104 (TCP /IP based)

IEC 61850 COMMUNICATION PROTOCOL

- A STANDARD PROTOCOL WHICH SUPPROTS INTEROPERABILITY OF IEDs FROM DIFFERENT MANUFACTURERS.

INTEROPERABILITY IS THE ABILITY TO OPERATE ON THE SAME NETWORK OR COMMUNICATION PATH SHARING INFORMATION AND COMMANDS AMONG IEDS.

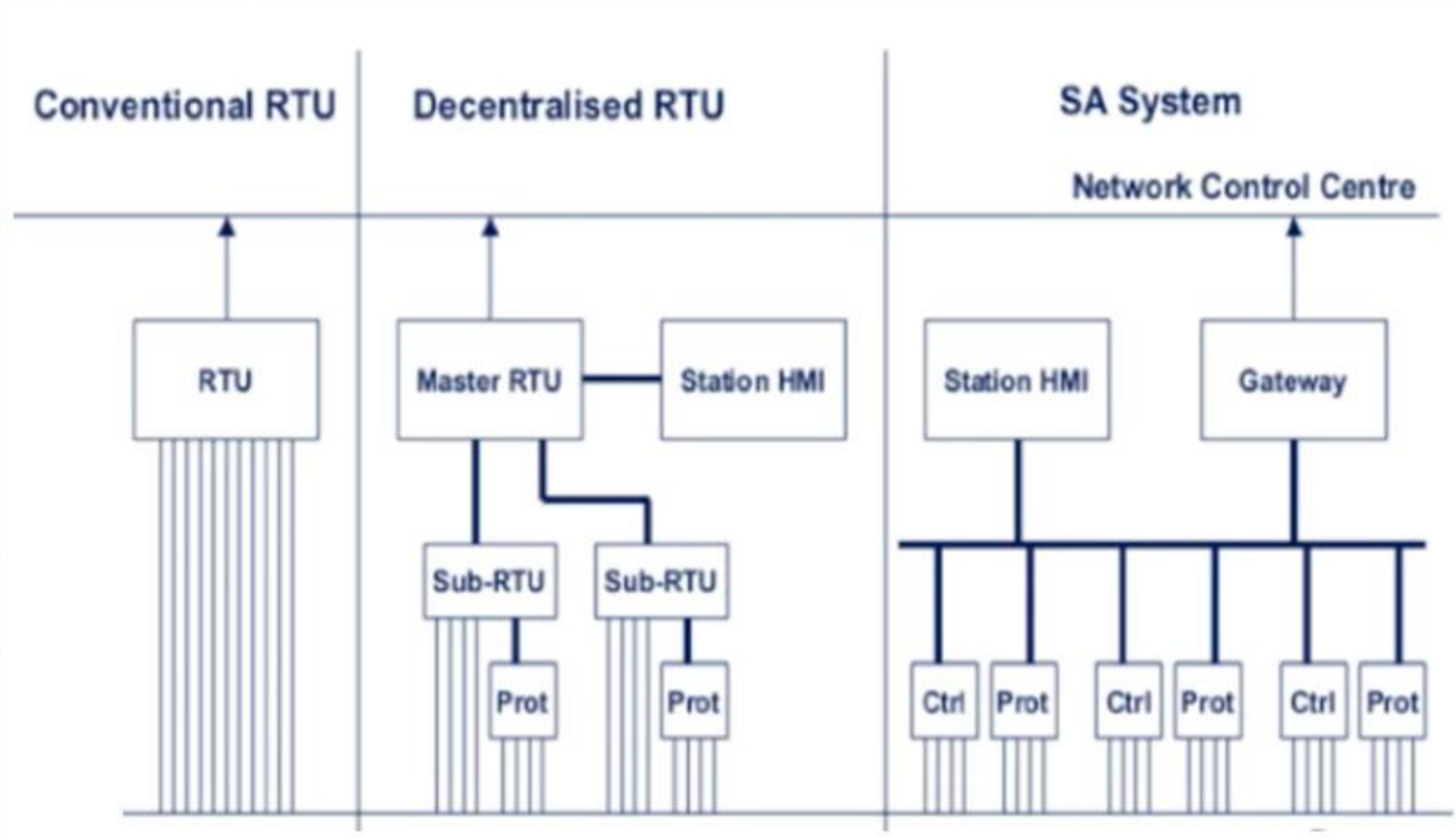
MAIN ADVANTAGES OF IEC61850 COMMUNICATION PROTOCOL

- EXCHANGING INFORMATION AND CO-OPERATION BETWEEN DIFFERENT IEDs OF DIFFERENT MANUFACTURERS.
- ENABLES COMMUNICATION BETWEEN IEDs AND HMI FOR CONTROL AND MONITORING OF SUB-STATION.
- PROVIDES FLEXIBILITY TO ADOPT SUB-STATION ARCHTECTURE IN RESPONSE TO SPECIFIC REQUIREMENT BASED ON AVAILABILITY AND BUDGET.
- PROVIDES ADAPTABILITY WITH FUTURE INNOVATIONS WITHIN SUB-STATION AUTOMATION AND COMMUNICATION TECHNOLOGY.

Brief History of SAS-

- Microprocessor based Remote Terminal Units came into picture in 1984.
- Then in 1994 Intelligent Electronic Devices (IEDs) were introduced in the power system.
- And finally universal SAS standard IEC 61850 communication protocal was introduced in 1997 to build the modern SAS architecture.

SAS ARCHITECTURE DEVELOPMENT-



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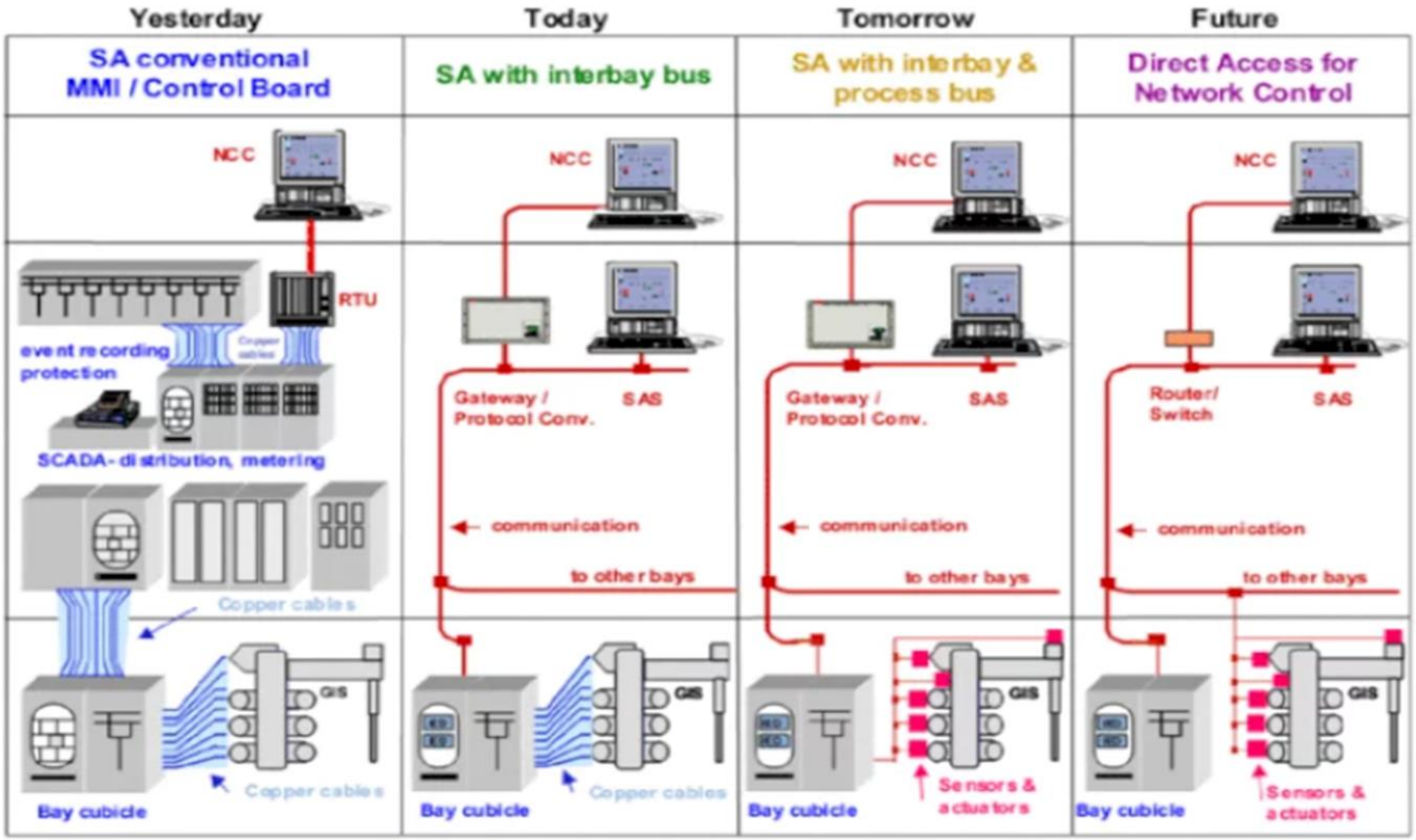

Advantages / Disadvantages of Fibre over copper -

- **Advantage** is that you know as soon as the fiber link is open, it is being monitored in the System and it can trigger an alarm.

- **Disadvantage** for the fiber optic is that you need special tools for checking the continuity and splicing for a break or cut.
  - You need to Purchase tools and train people.

ECONOMIC ASPECTS OF SAS

- REDUCTION IN INVESTMENT COST BY

  1. CONSTRUCTING SMALL CONTROL ROOM BUILDING

  2. REDUCTION OF COPPER CABLE

  3. REDUCED SIZE OF CABLE TRENCHES

  4. BETTER USE OF UNUTILISED SPACE OF SWITCHYARD BY PLACING BAY KIOSK.

CONCLUSION

- POWERGRID HAS TAKEN A STEP TOWARDS ADOPTING NEW TECHNOLOGY REQUIRED TO MEET TOUGH CHALLENGES AGAINST THE VIDE EXPANSION OF TRANSMISSION NETWORK.
- IT WILL ALSO MAKE POSSIBLE TO SUPERVISE THE ENTIRE SYSTEM IN A BETTER WAY WITH THE ULTIMATE GOAL TO IMPROVE THE AVAILABILITY OF TRANSMISSION NETWORK.

THANK YOU ALL