Industrial Automation

Supervisory Control and Data Acquisition (SCADA)

Industrial Electronics

Engr. Sanaullah Ahmad

Lecturer EED

What is SCADA?

Supervisory Control and Data Acquisition

- In this section we would cover

  - Industrial Control System
    - DCS
    - SCADA

Industrial control system (ICS)

- **ICS is a system that:**
  - Measures State of System; and Controls Processes

Industrial control system (ICS)

- **Industries using ICS**

  - Electrical Energy, Power, Wind

  - Oil and Gas

  - Manufacturing, Chemical, Pharma and Others

  - Water Treatment and Waste Management

  - Data

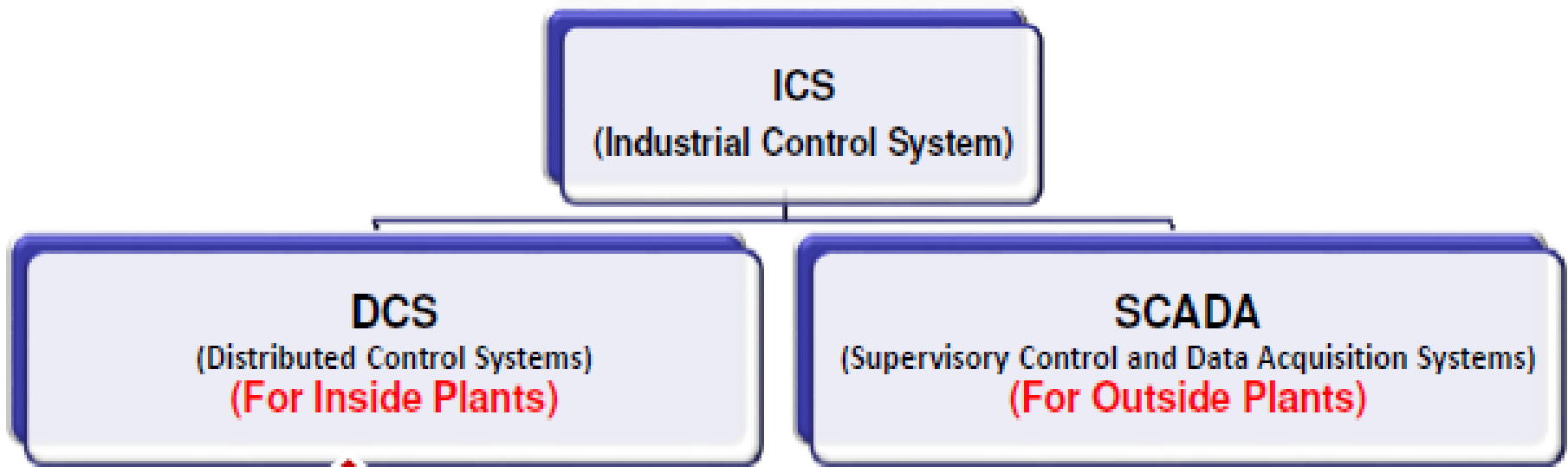| Energy – Power, Wind sector | Oil and Gas | Manufacturing, Chemical, Pharma and Others | Water treatment, Waste Management |

Industrial control system (ICS)

- **Types of ICS**

```
                    ┌─────────────────────────┐
                    │          ICS            │
                    │ (Industrial Control System) │
                    └─────────────────────────┘
                                │
            ┌───────────────────┴───────────────────┐
┌───────────────────────────┐         ┌───────────────────────────────────┐
│            DCS            │         │              SCADA                │
│ (Distributed Control Systems) │     │ (Supervisory Control and Data Acquisition Systems) │
│      (For Inside Plants)   │        │         (For Outside Plants)      │
└───────────────────────────┘         └───────────────────────────────────┘
```
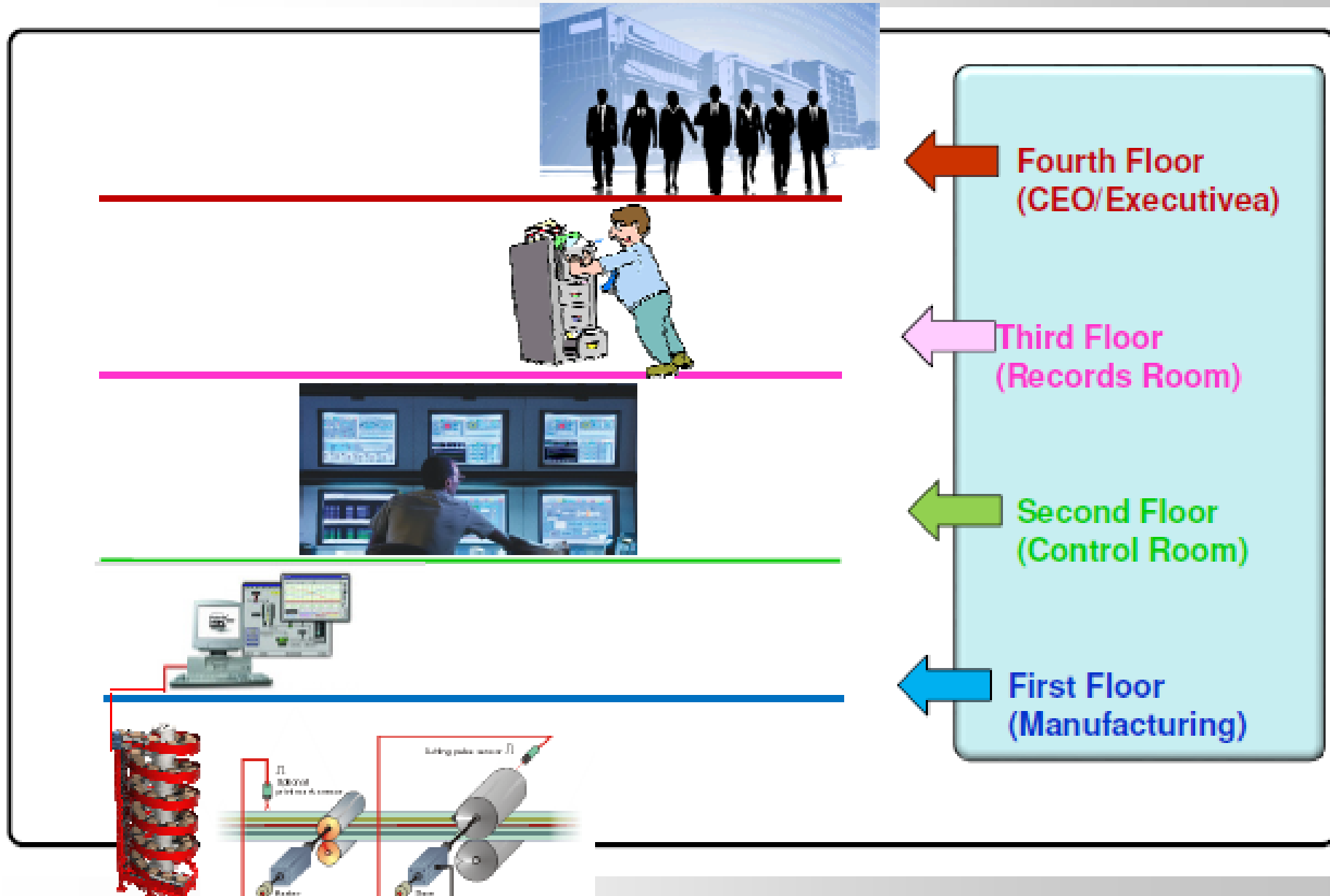
Let's See DCS first

(Understanding SCADA will be easier then)

DCS Hierarchy
(Distributed Control System)

DCS Hierarchy (analogy)

Fourth Floor (CEO/Executivea)

Third Floor (Records Room)

Second Floor (Control Room)

First Floor (Manufacturing)

DCS Hierarchy

SAP Server   ERP Server   Firewall   EPA Database   Alarm Aggregation

ENTERPRISE NETWORK

Data Controller   OPC Server   Firewall   Historian   CCTV Server

PLANT BUS

HMI   HMI   Firewall   HMI   HMI

TERMINAL BUS

Application Server   EWS

CONTROL BUS

PLC   PLC   PLC
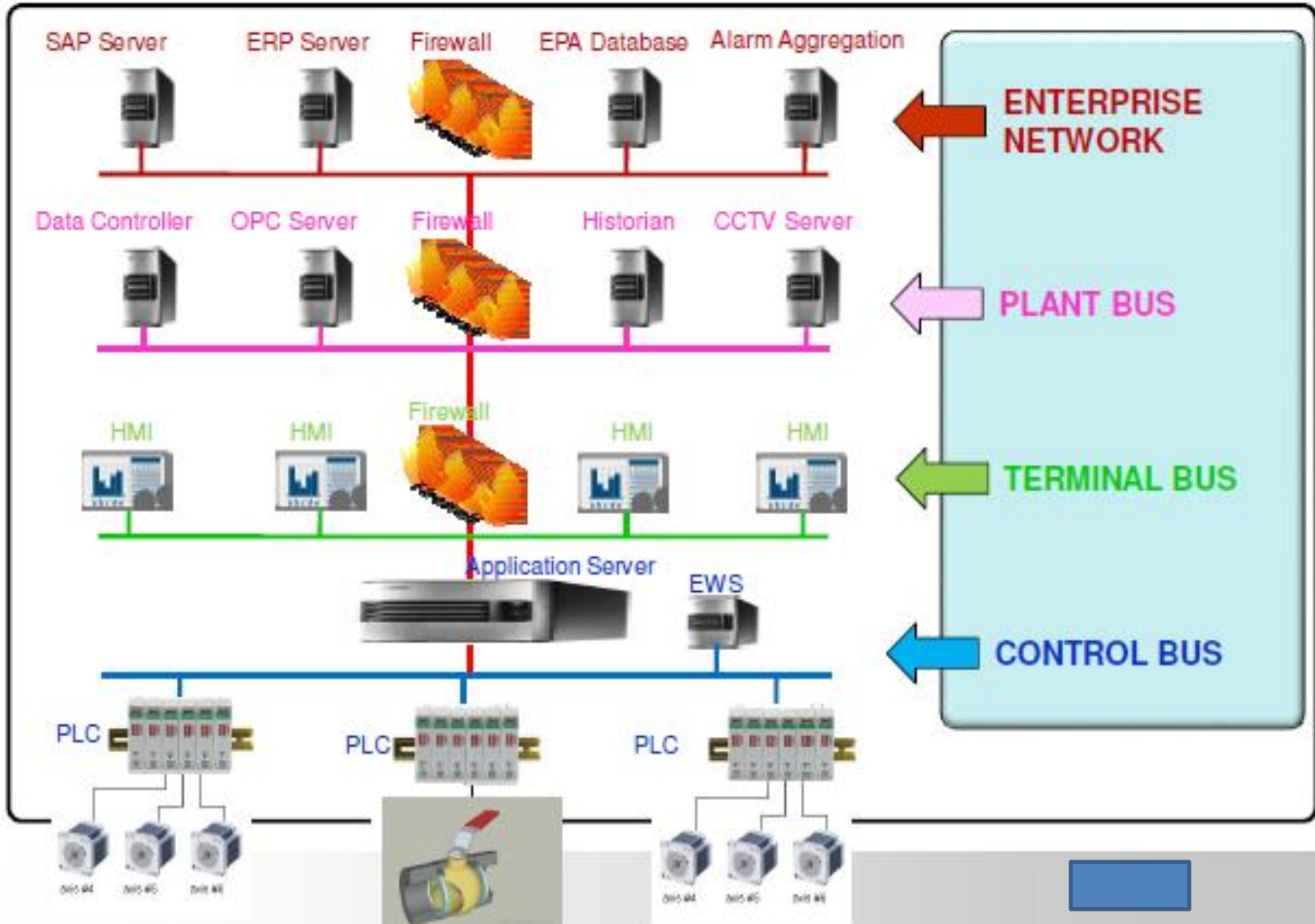
RECAP — DCS Hierarchy
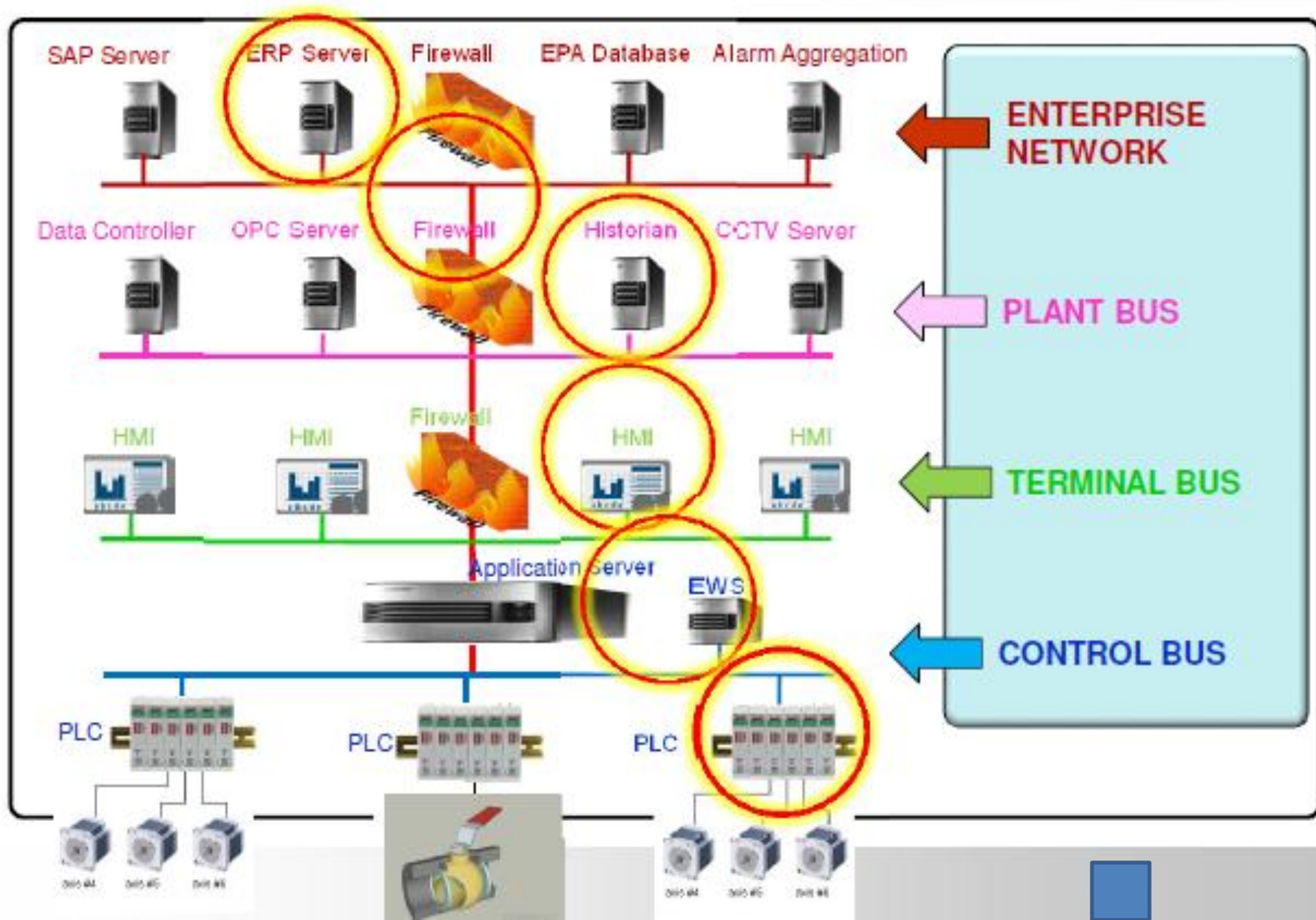
Enterprise Network (EN)

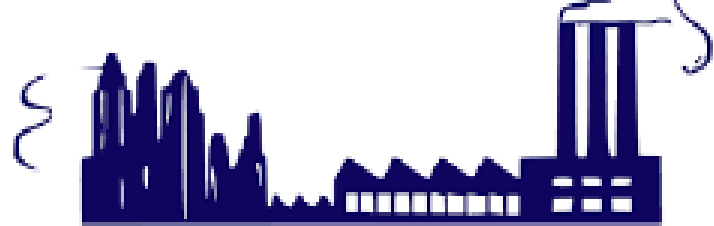SAP Server   ERP Server   Firewall   EPA Database   Alarm Aggregation
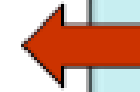
ENTERPRISE NETWORK

Consists of

Let's See *System analyses and Programmed networking;*
Systems, Applications & Products in Data Processing

- SAP/ERP Server

- Firewall   **Enterprise resource planning (ERP)**

Enterprise Network (EN)

- **Functions of SAP/ERP Server**

  - Manufacturing Resource Planning
  - Finance and Accounting
  - Human Resource Planning
  - Supply Chain Management
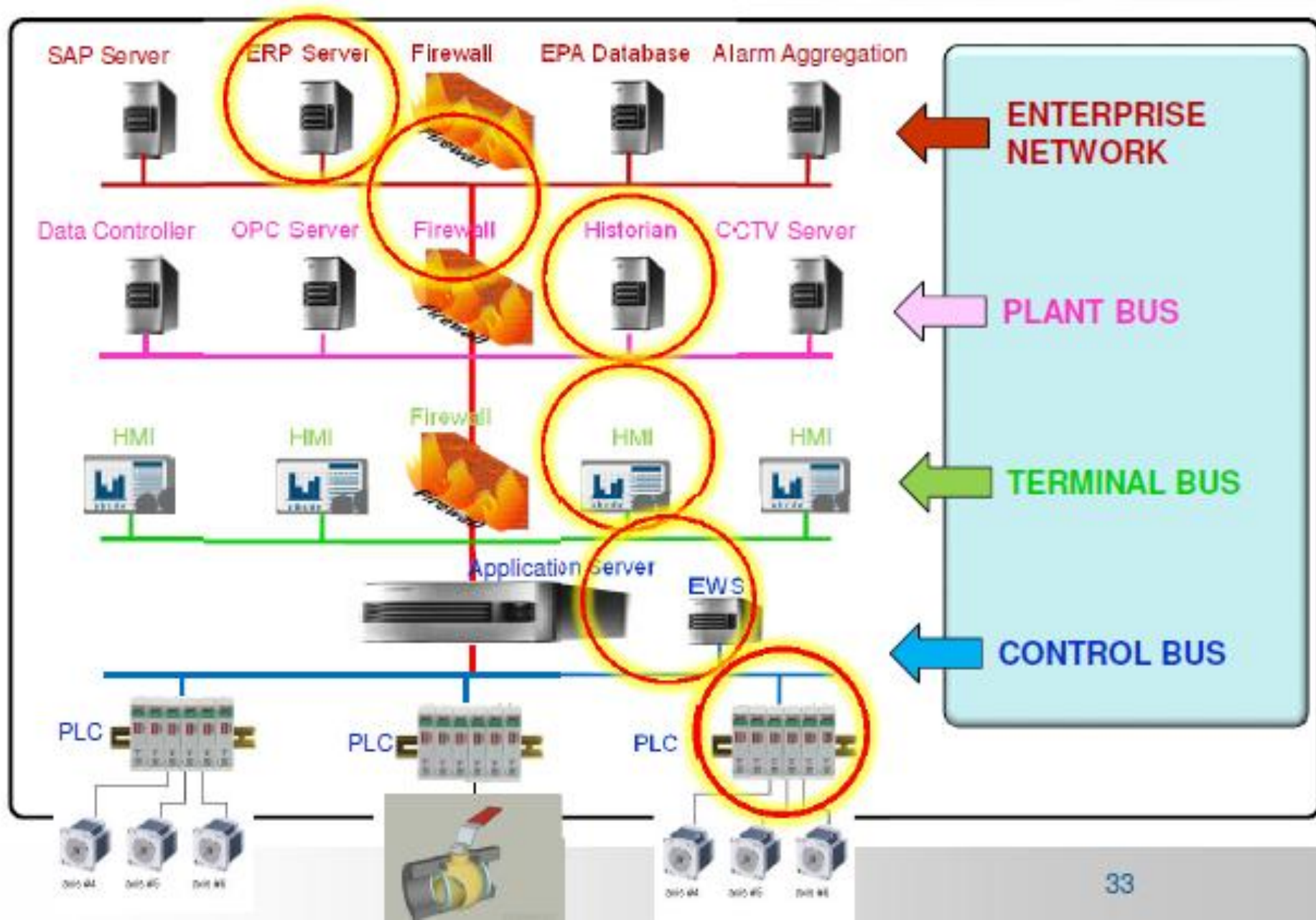 - Customer Relation Management

- **Software Used in The Server**

  - SAP, or ERP
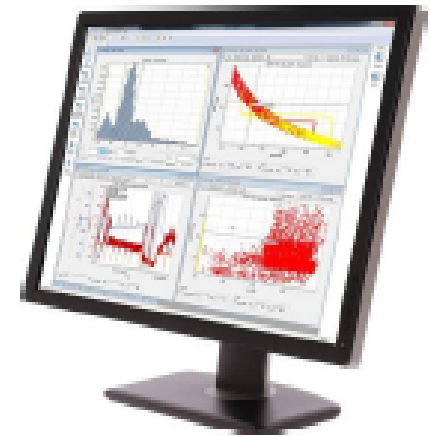
  - (SAP is a Predecessor ERP)

RECAP — DCS Hierarchy

Plant Bus

- **Functions of Historian** (Electronic data recorder)

  - Collects data

    - From PLCs, HMI, and Application Server

  - Stores Data

    - For long period of time, with minimal disk space

  - Also contains

    - Company's health and safety data

   - If something goes wrong, it helps pinpoint what happened when and where

Capable of retrieving data at fast speed

Terminal Bus

HMI   HMI   Firewall   HMI   HMI

TERMINAL BUS

Consists of

Let's See HMI
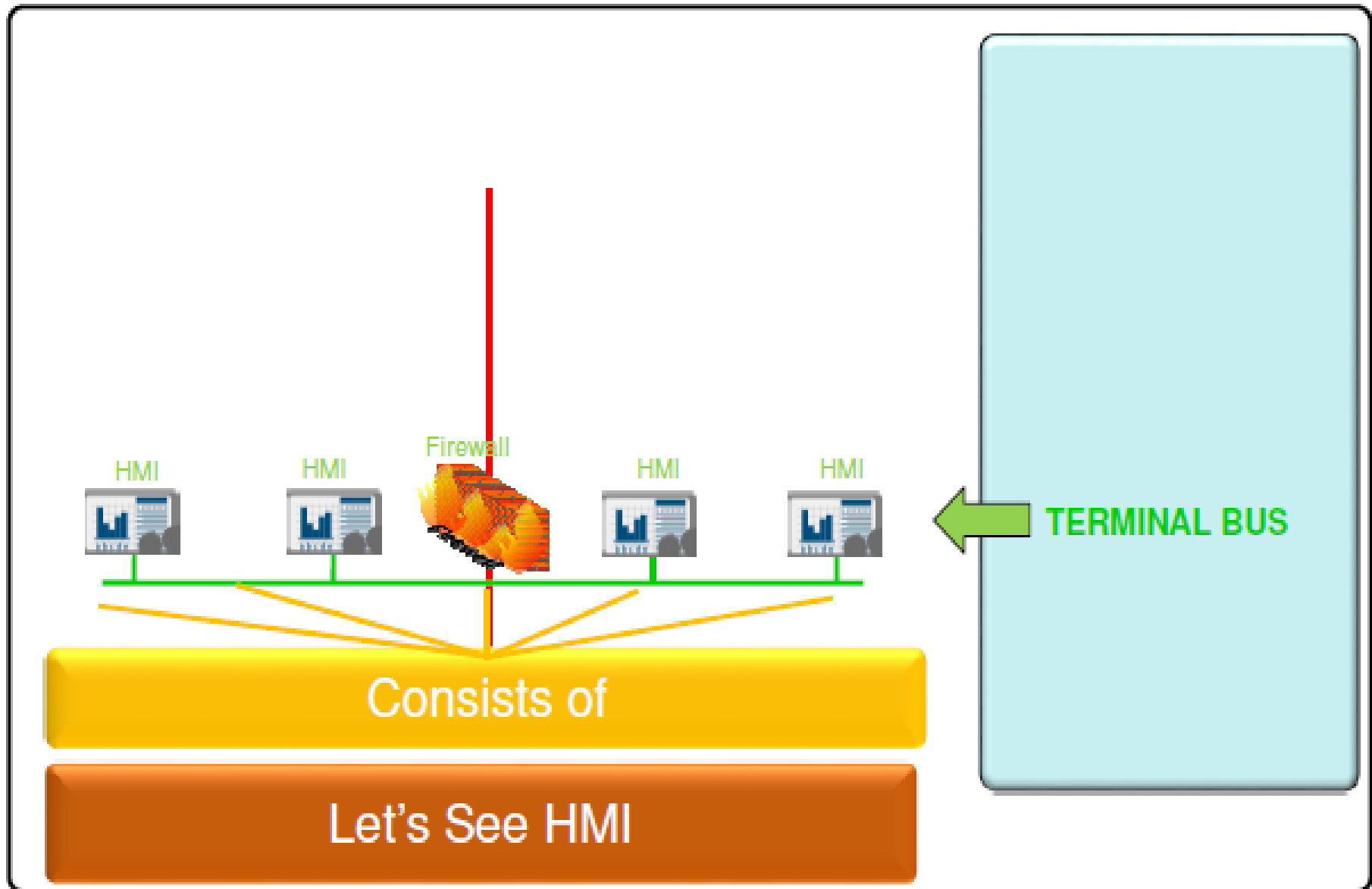
Terminal Bus

- **Human-Machine Interface (HMI)**

  – Does not control the process, but

  – Provides visualization of on-going process

  – Provides interactions between Human & Machine

- **Advantages**

  – Increased system and user efficiency
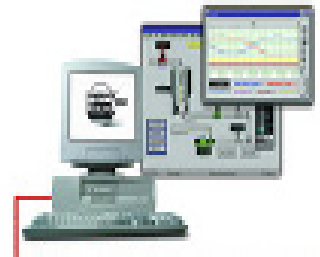
  – Reduction in physical effort for users

Control Bus

Consists of

Application Server

EWS

PLC

CONTROL BUS
Consists of

Let's See

AS, EWS & PLC
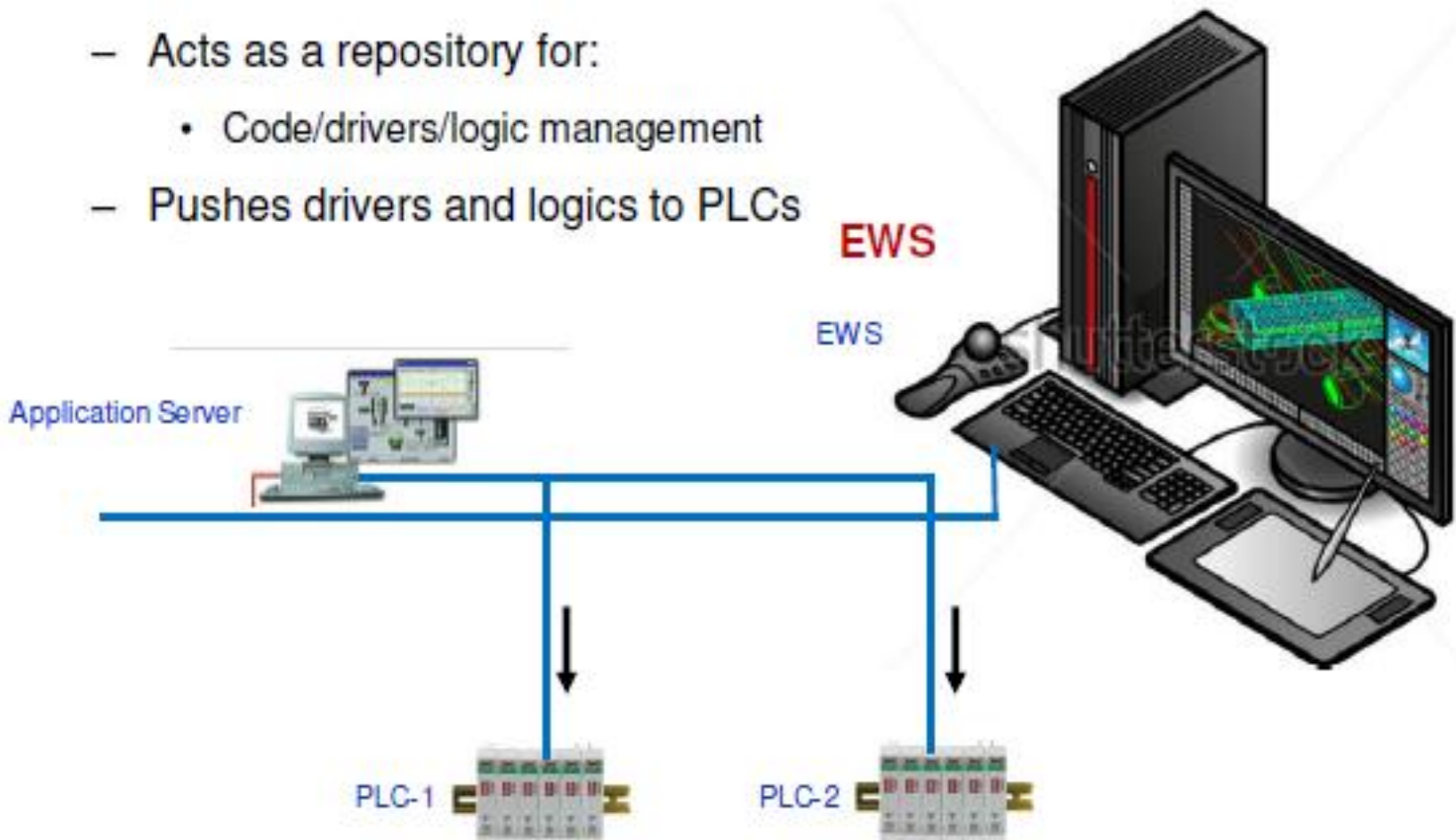
2
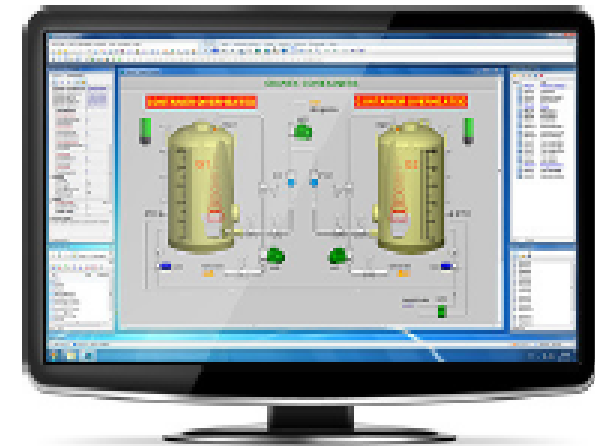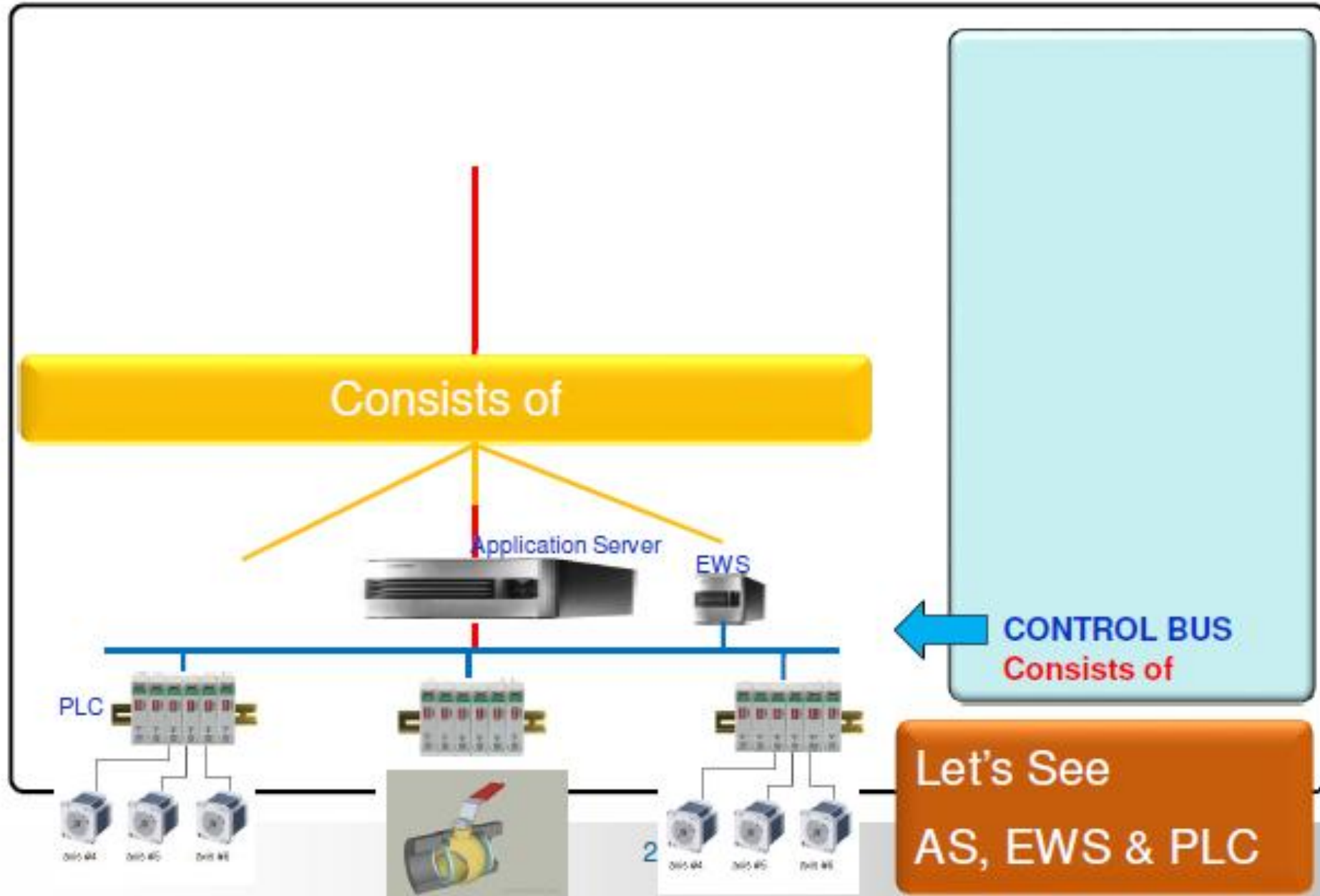
Control Bus

- **Application Server**

- **Functions**

    - Executes installed applications

    - Provides computing-intensive services to the applications

    - Polls data from PLCs, and send it to HMIs for display

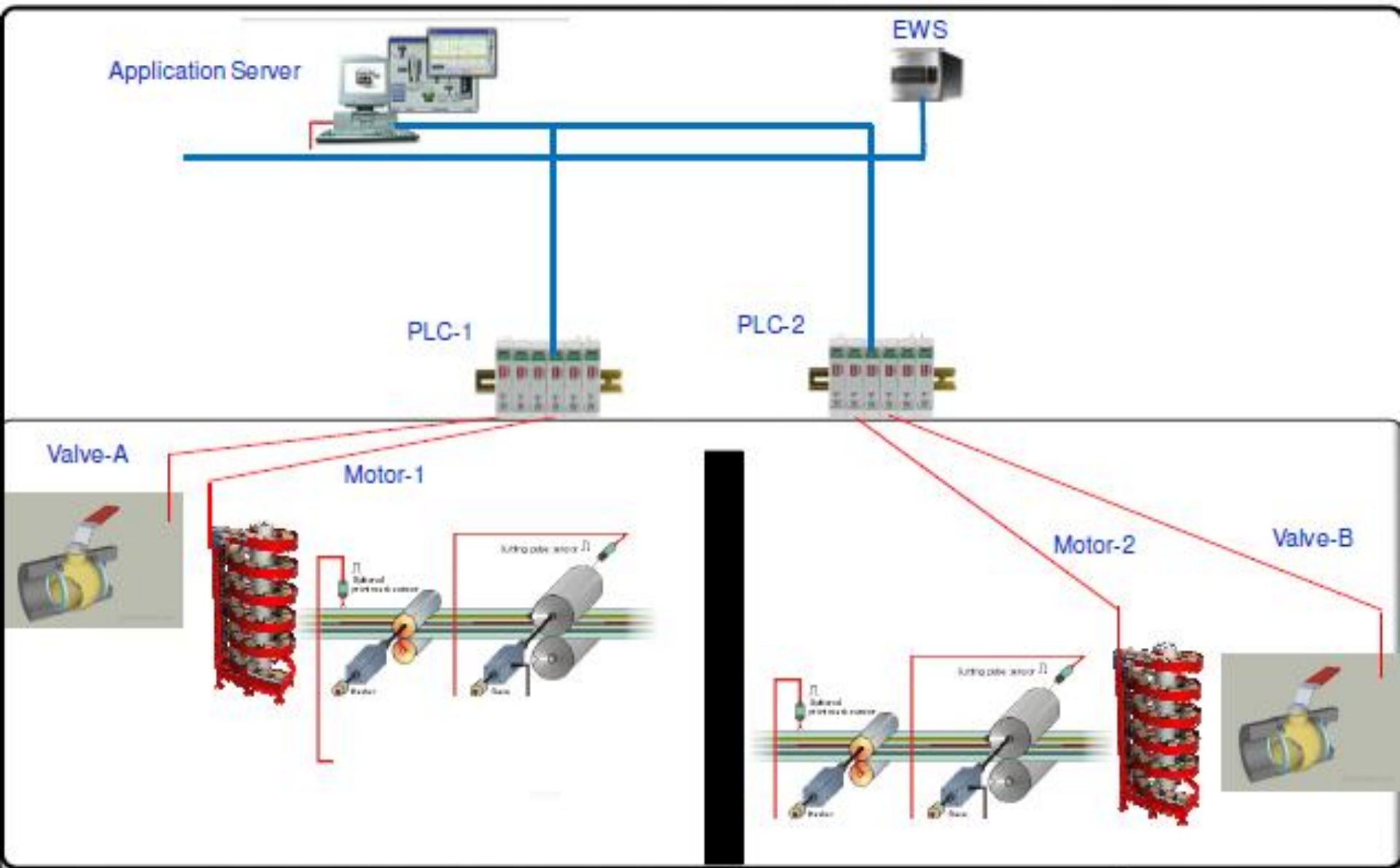   - (Because each HMI is not polling data)

Control Bus

- **EWS**

  - Acts as a repository for:

    - Code/drivers/logic management

  - Pushes drivers and logics to PLCs

EWS

Application Server

EWS

PLC-1

PLC-2

CONTROL BUS
PLC

- **PLC consists of**
  - CPU
  - Multiple inputs & outputs
  - Hardware (memory etc.)

Data Memory	Central Processing Unit (CPU)	Input Devices
Program Memory		Output Devices

Process Actuator

Process Sensor(s)

Programming Module or PC
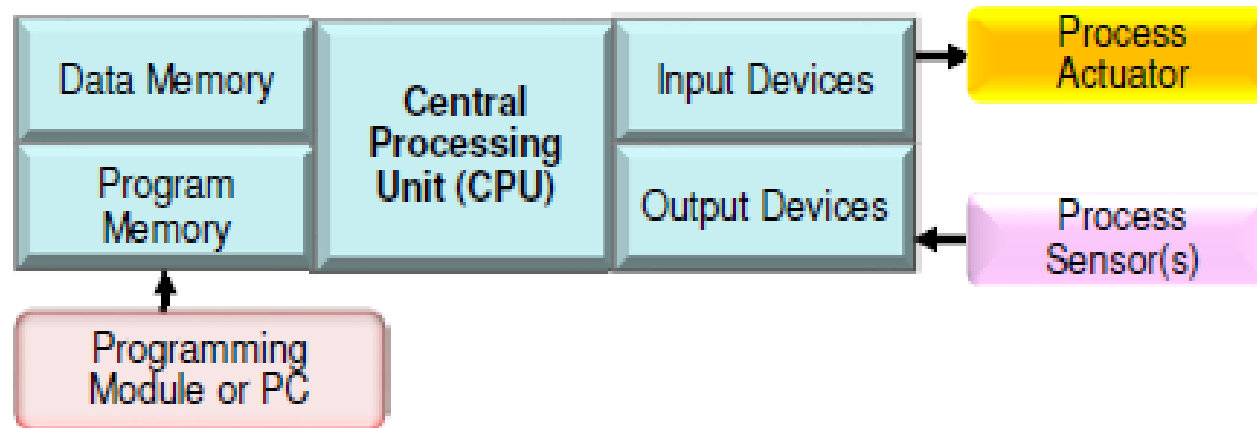
PLCs Protocol

- PLC mainly uses Modbus Protocol

- It was created by MODICON company

- It is based on Master-Slave communication

- It is independent of the physical layer (fiber, radio, cellular, etc.)
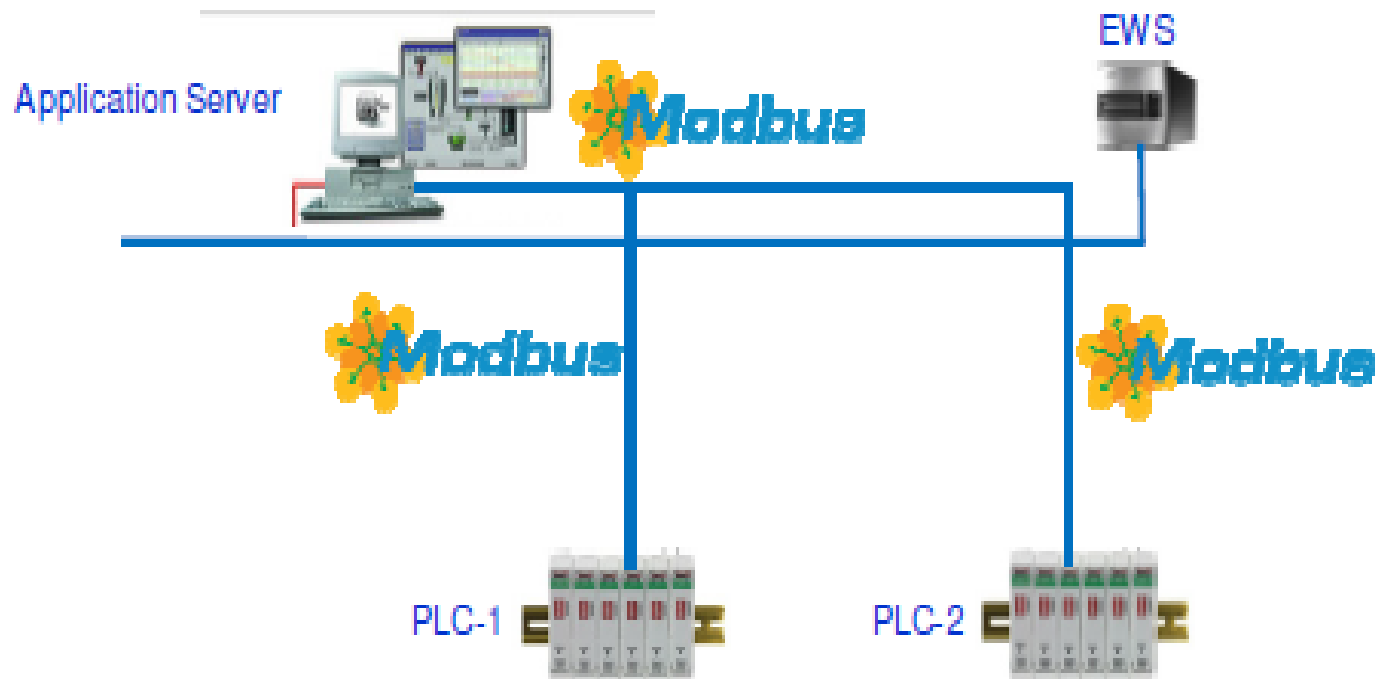
Remote PLC (Using dedicated wires)

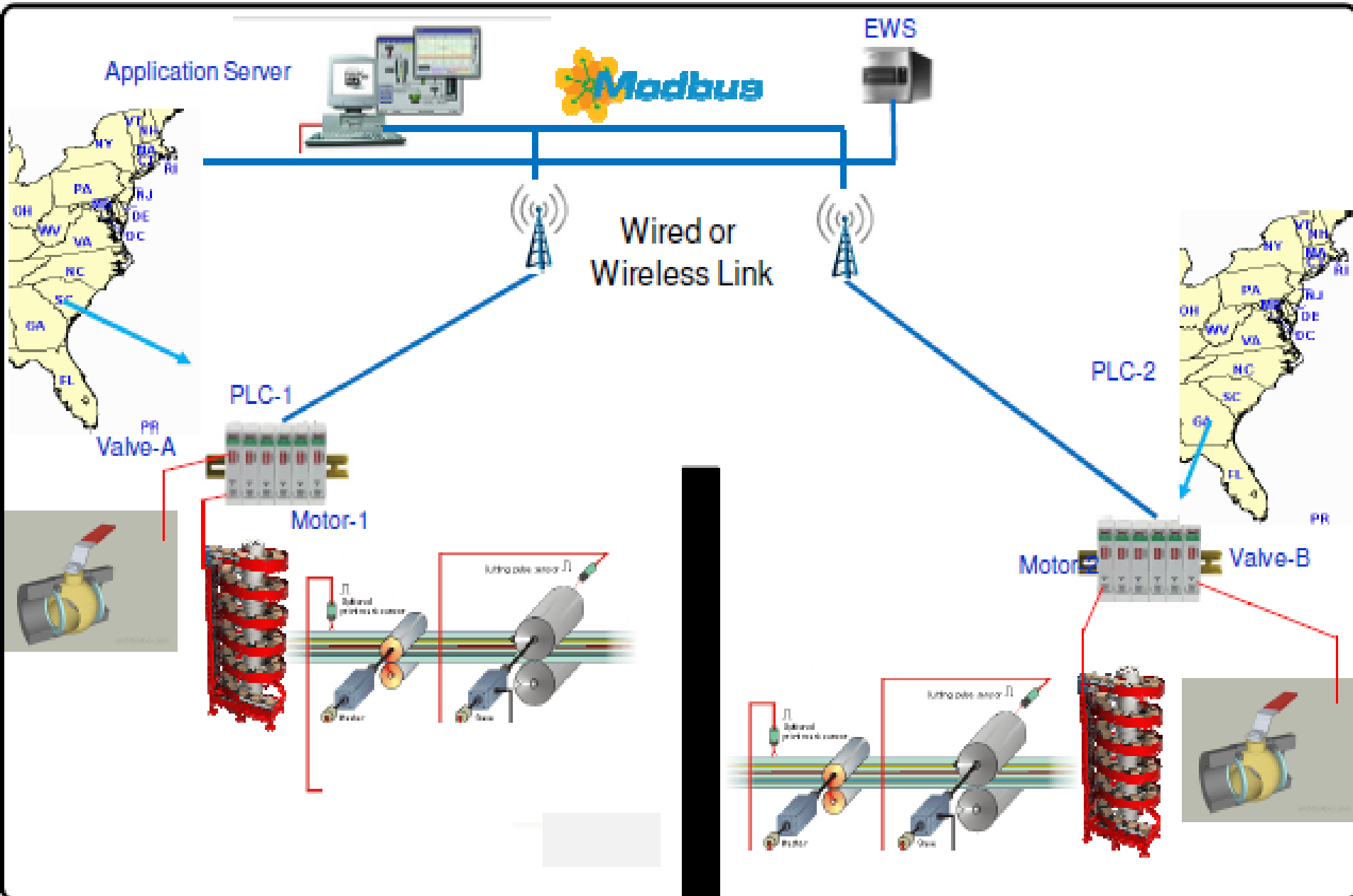# Remote PLC Operation (Using The Internet)

- **Components Needed**

  - Internet (Communication Link)

  - PLC/RTU

  - MTU

  - Modification in protocol
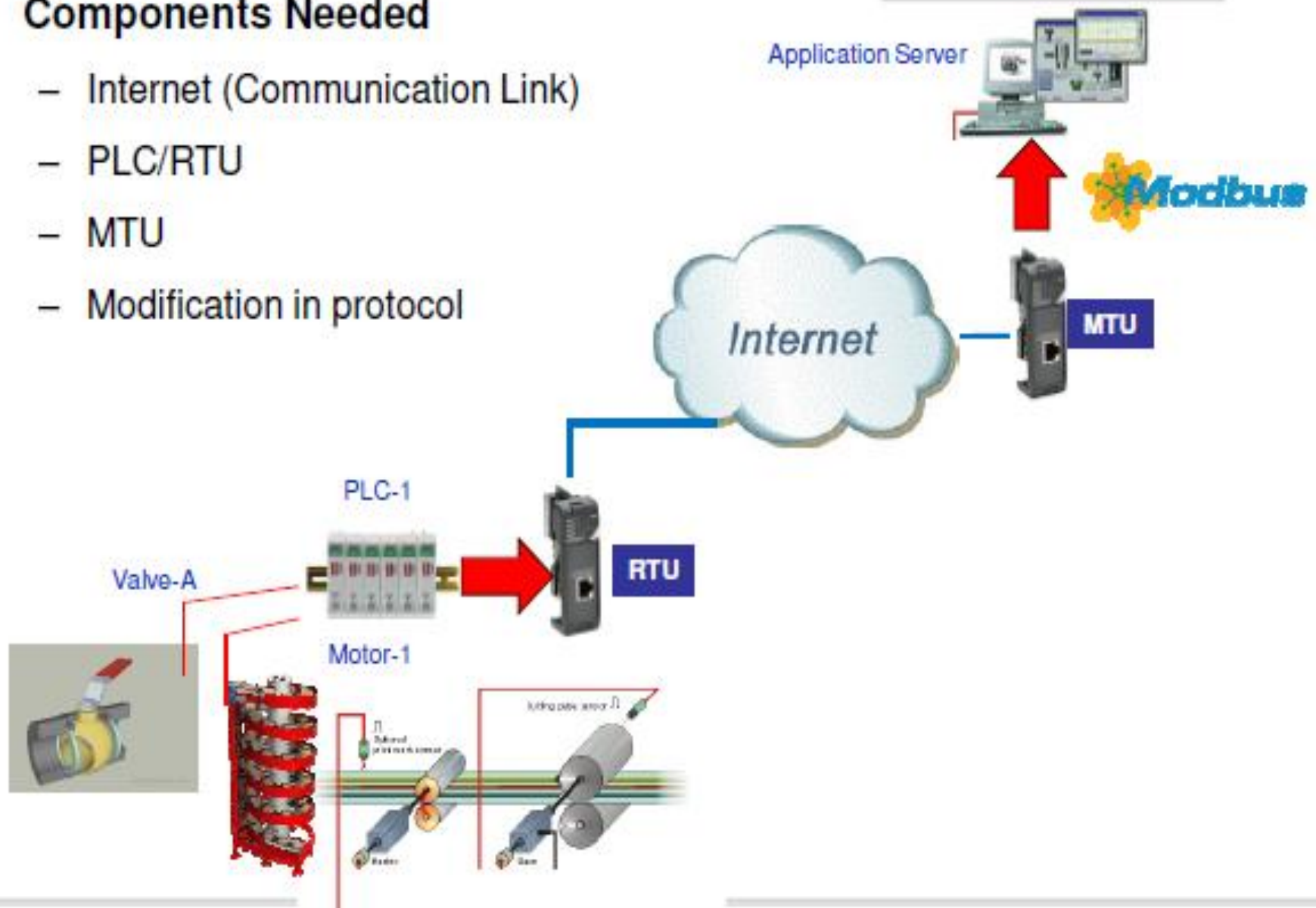
Remote PLC Operation

- **Communication Using**

RTU/PLC with Ethernet Interface

Internet

MTU

MTU = Master Terminal Units (MTUs)
PLC = Programmable Logic Controller
RTU = Remote Terminal Unit

Mr. Hard Hat

- **Mr. Hard Hat**

  - Works for a Water And Power Development Authority (WAPDA)

  - He carries a clip board

  - He goes to locations, W, X, Y, Z, ... to perform field duties, a, b, c, d. . .

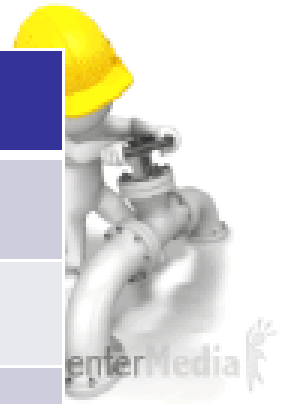# Mr. Hard Hat

Duties of Mr. Hard Hat

S. No.	Date	Time	Location	Motor	Valve
1	May-01	08:00	Street/City A	A-ON	V1-OFF
2	May-02	09:00	Street/City B	B-ON	V2-OFF
3	May-03	10:00	Street/City C	A-ON	V1-OFF
4	May-04	11:00	Street/City D	B-ON	V2-OFF
5	May-05	12:00	Street/City E	A-ON	V1-OFF
.	.	.	.		
.	.	.	.		
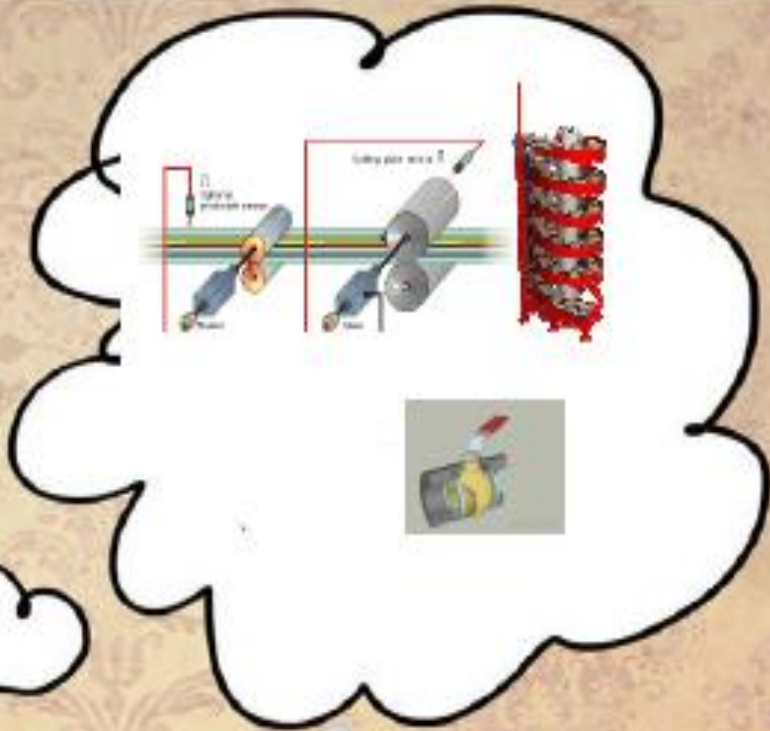
What is "SCADA"?

- **SCADA**

  - "Supervisory Control and Data Acquisition"

  - Real-time, computer based industrial process control systems

  - It gathers & analyzes real-time data to monitor & control industrial equipment

SCADA is a....

Computer equivalent of Mr. Hard Hat,

- Going around and reading gauges,
- Recording values on a clip board,
- Opening valve #173 at 08AM on May 7th,
- Turning on pump #8 at 11:15AM on May 7th etc.

SCADA remotely controls thousands of control points

What are the Functions of SCADA?

- **SCADA Functions**

  - Centrally monitors and controls thousands of industrial equipment, such as

    - Motors, Valves, Pumps, Relays, Sensors, etc.

  - Displays current state of remote process (visualization)

  - Displays alarms/Events log

SCADA and ICS


```
              ┌──────────────┐
              │     ICS      │
              └──────┬───────┘
          ┌──────────┴──────────┐
┌─────────────────┐    ┌──────────────────┐
│      DCS        │    │     SCADA        │
│(For Inside Plants)│  │(For Outside Plants)│
└─────────────────┘    └──────────────────┘
```
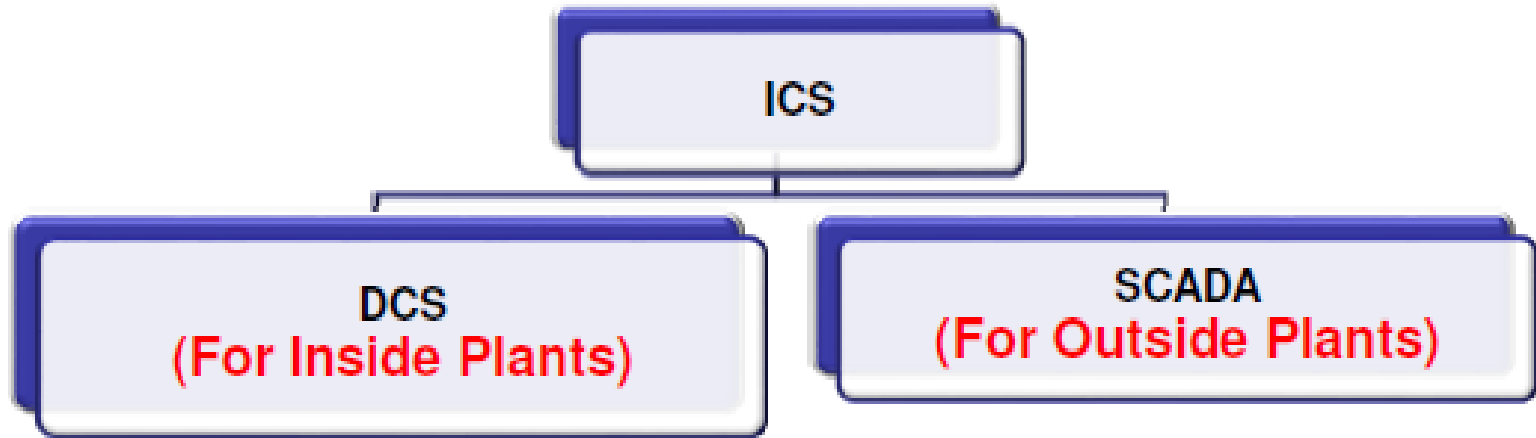
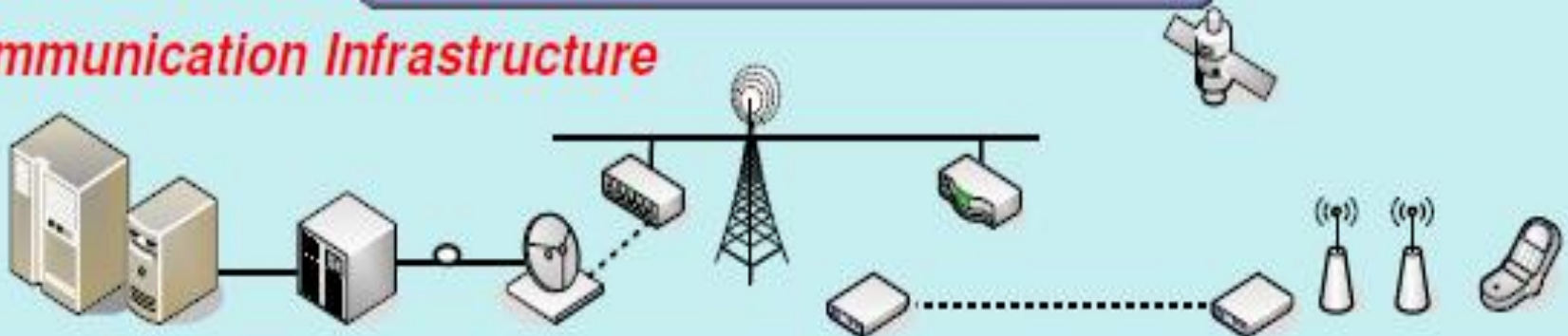Electrical Infrastructure

SCADA

glue =

Communication Infrastructure

Electric Power System and SCADA

- Electric Power system is most complex man made system.

- Comprises of Generation , Transmission and Distribution .

- The losses that occur in the transmission and distribution are very large. This occurs because of inefficient safety, monitoring and control devices that are persisting in present system.
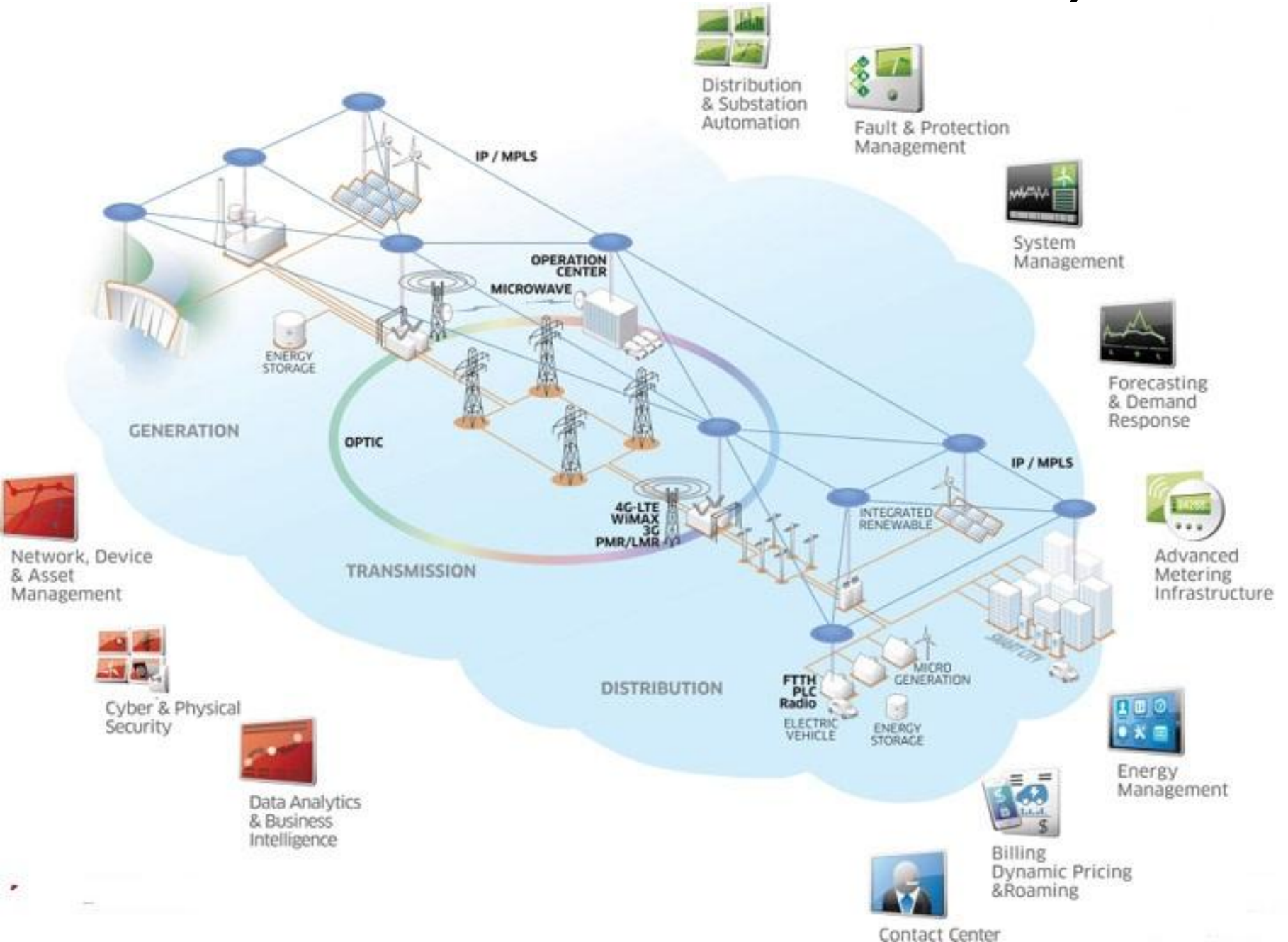
Electric Power System and SCADA

- Nowadays, computer control is one of the most cost effective solutions for improving reliability, optimum operation, intelligent control and protection of a power system network. Having advanced data collection capabilities, SCADA system plays a significant role in power system operation.

Functions of SCADA in Power System

Fault location, isolation and Service Restoration:

- Determining fault and its restoration is difficult task is current grid system.

- With SCADA system old switches are replaced with advance remotely controllable switches.

- RTUs installed will send real time data which help to heal the system more efficiently and quickly manner.

Maintaining good Voltage Profile

• An appropriate schedule for switching on/off of capacitor banks and raise/lower voltage regulator taps will be based on the feeders' reactive load curves in order to get good voltage profiles and reduce energy losses.
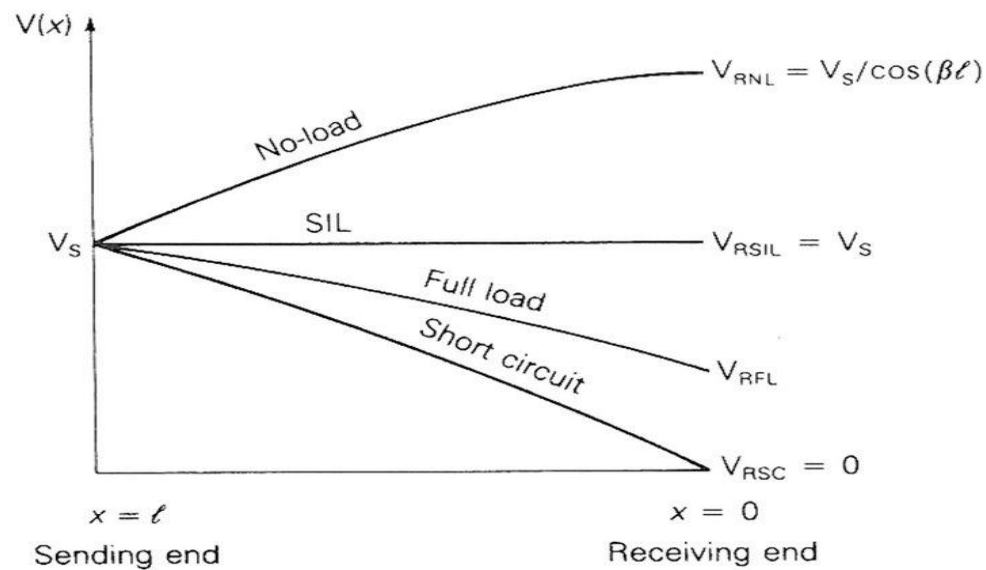
Load Balancing:

- This function will enable the system to calculate total load and distribute or balance equal load among the available transformers and the feeders in proportion to their capacities.

Electricity generation

Energy Consumption
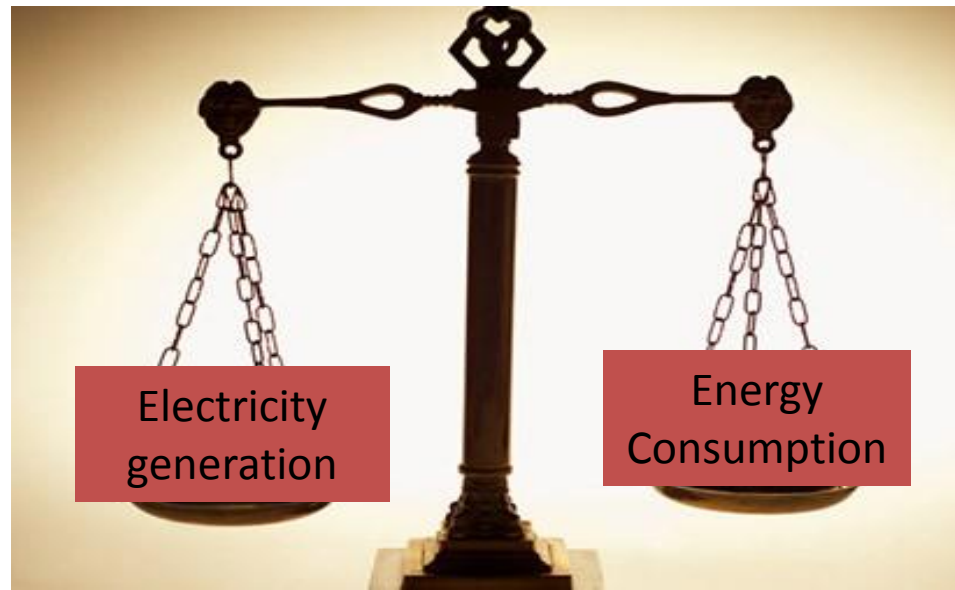
Load Control

- During Peak hours loads need to be shed for long durations. A restriction and control schedule is worked out based on which of the loads at different substations are shed on a rotation basis. This function will automatically shed the loads according to the schedule.

- Frequency-Based Automatic Load Shedding is carried out by software using this function. Appropriate loads are shed by the RTU, based on priorities and actual amount of load whenever the system frequency crosses the pre-set values. This is done as a closed loop function in the RTU

Energy Accounting

- This function helps to predict load patterns at the system, which helps in planning expansion.

- It also helps in detecting abnormal energy consumption patterns of the consumers and identifying high-loss areas. Processing the data obtained by the remote metering function and the data obtained from the substation does this.

Improved Operations Meet Demands

- Modern SCADA systems provide powerful tools that give operators a real-time view into operations in order to optimize the power distribution system for maximum efficiency. Trending tools arrange data in various ways, and graphical interfaces simplify analysis.

- Analyzing trends and historical data helps maintain desired power factors, and voltage levels at a desired levels.
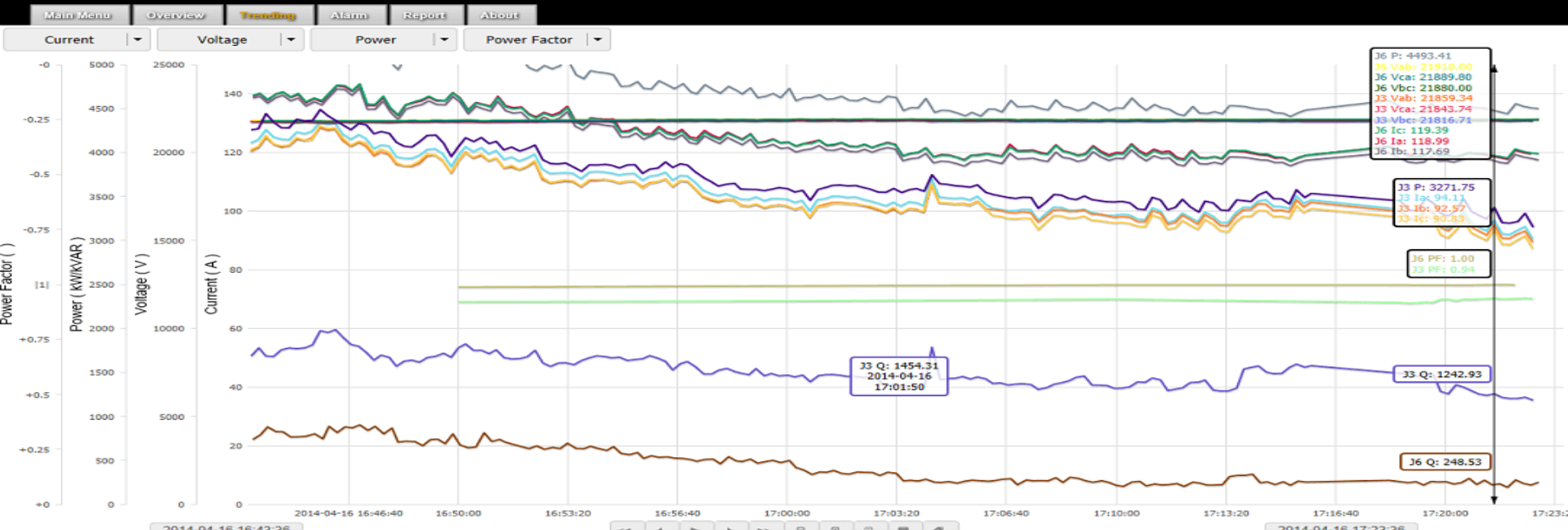
Improve Operations Performance

23 EMER . 10 57 32

MMHE

MMHE - POWER DISTRIBUTION NETWORK

2014-04-16 17:31:00

Login   Guest

Main Menu   Overview   Trending   Alarm   Report   About

Current ▼   Voltage ▼   Power ▼   Power Factor ▼

Power Factor ( )   Power (kW/KVAR)   Voltage (V)   Current (A)

J6 P: 4493.41
J6 Vab: 21910.00
J6 Vca: 21889.80
J6 Vbc: 21880.00
J3 Vab: 21859.34
J3 Vca: 21843.74
J3 Vbc: 21816.71
J6 Ic: 119.39
J6 Ia: 118.99
J6 Ib: 117.69

J3 P: 3271.75
J3 Ia: 94.11
J3 Ib: 92.57
J3 Ic: 90.53

J6 PF: 1.00
J3 PF: 0.94

J3 Q: 1454.31
2014-04-16
17:01:50

J3 Q: 1242.93

J6 Q: 248.53

2014-04-16 17:28:56 044   app.device[L1].statustext   L   L01 DIGITAL POWER METER NOT RESPONDING
2014-04-16 12:52:08.430   app.device[LG2].statustext   LG   LG2 DIGITAL POWER METER NOT RESPONDING   2014-04-16 13:18:01.344

2014-04-16 16:43:36   2014-04-16 17:23:36

2014-04-16 16:46:40   16:50:00   16:53:20   16:56:40   17:00:00   17:03:20   17:06:40   17:10:00   17:13:20   17:16:40   17:20:00   17:23:

How these functions are performed

These functions are performed by four kinds of SCADA components:

1. **Sensors** (either digital or analog) and control relays that directly interface with the managed system.
2. **Remote terminal units (RTUs).** These are small computerized units deployed in the field at specific sites and locations. RTUs serve as local collection points for gathering reports from sensors and delivering commands to control relays.
3. **SCADA master units (MTUs).** These are larger computer consoles that serve as the central processor for the SCADA system. Master units provide a human interface to the system and automatically regulate the managed system in response to sensor inputs.
4. **The communications network** that connects the SCADA master unit to the RTUs in the field.

Engr.Sanaullah