20IS709
Communication Systems For Industrial Networking

SCADA

SCADA Examples

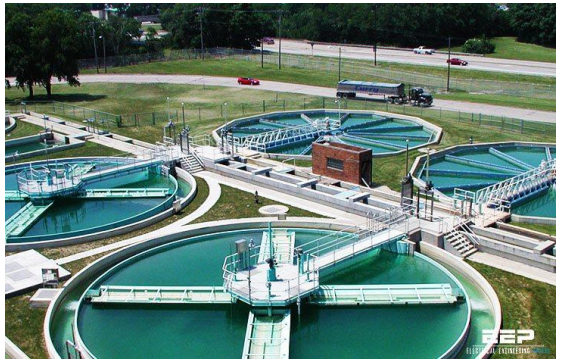
Electrical power generation, transmission and distribution

Manufacturing

Building Management Systems

Traffic signals and security systems

Mass Transit

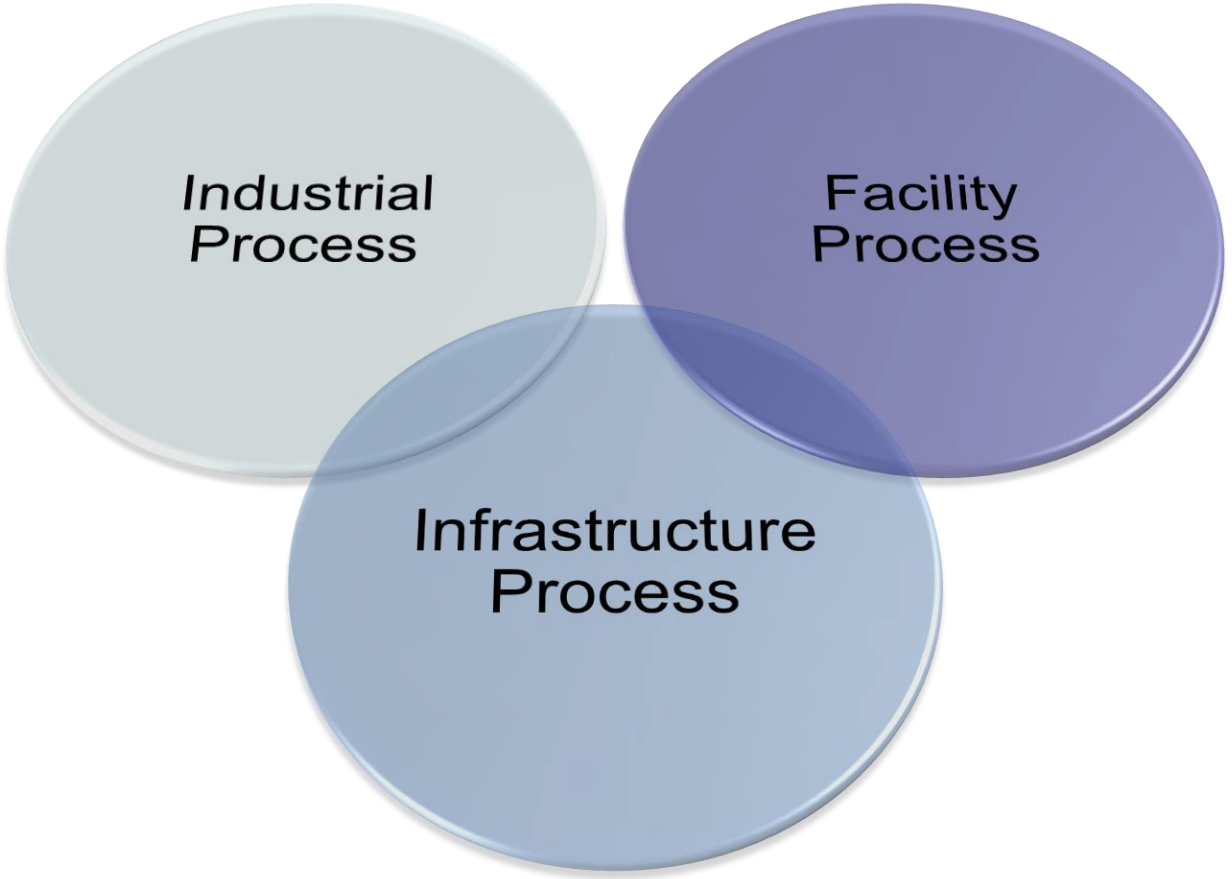


Water distribution and treatment plants monitoring

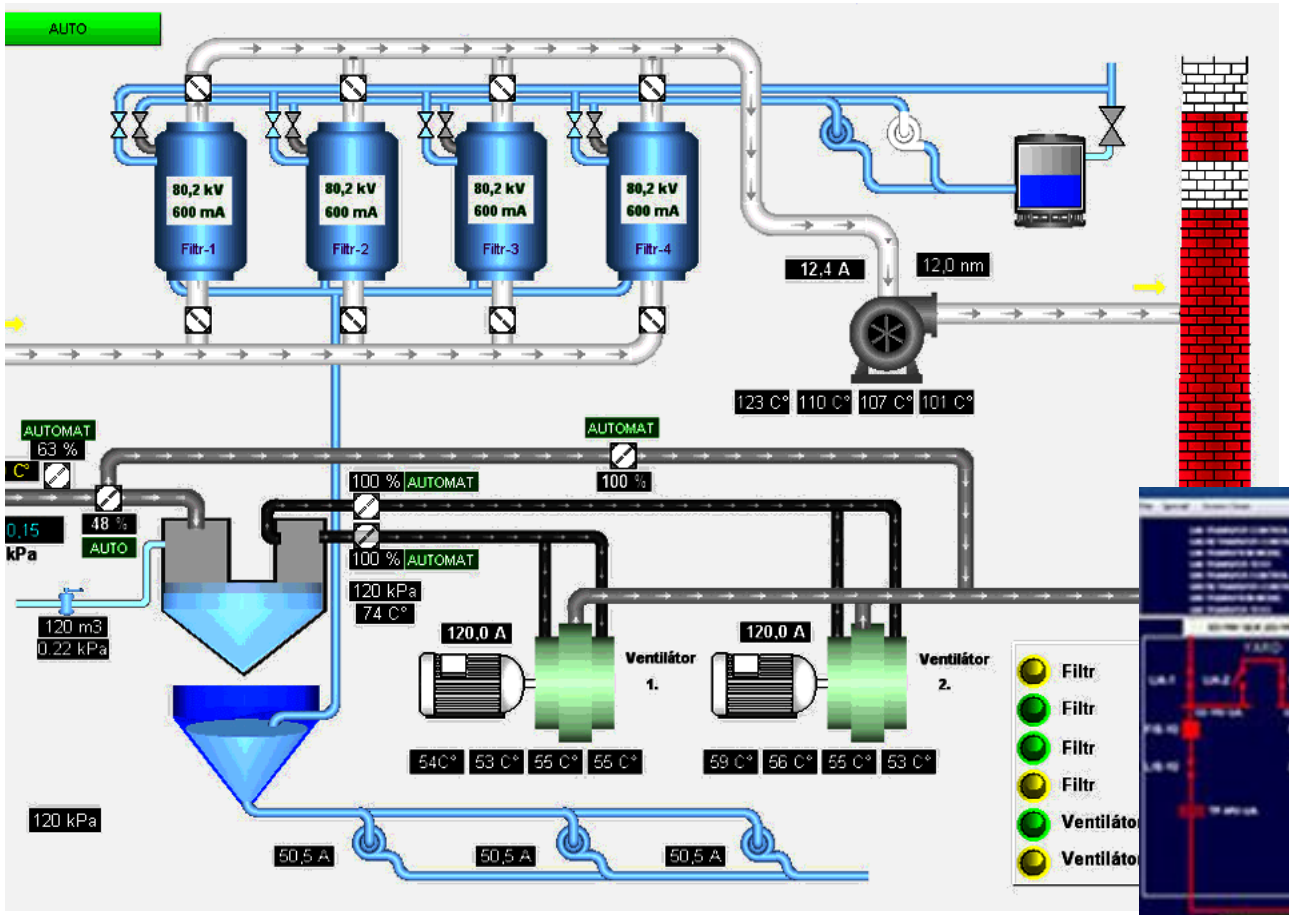
SCADA

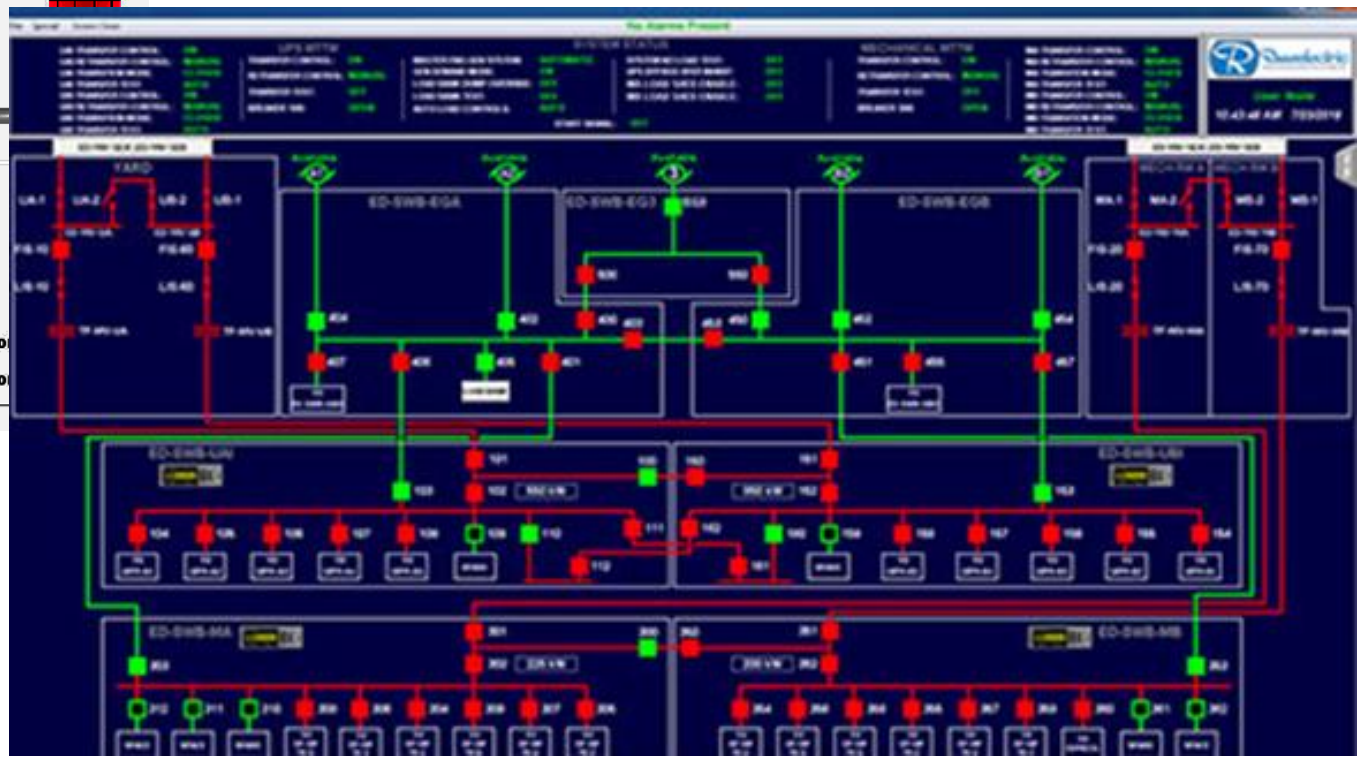
- Supervisory Control And Data Acquisition
- A concept in control engineering employed for monitoring, controlling, acquiring and analyzing real-time data of industrial equipment and process.
- Supervisory control means monitoring & controlling the parameters of equipment.
- Consist of hardware and software elements that are interconnected through communication network for real time data acquisition.

Types of SCADA Processes



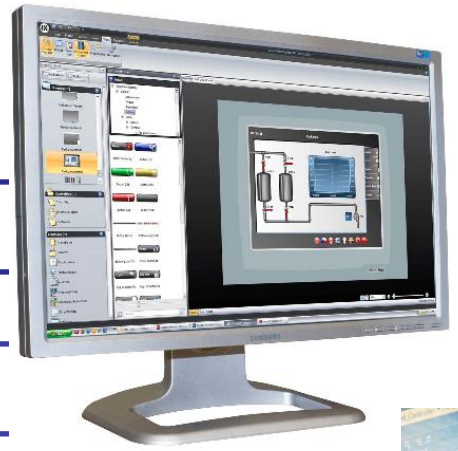
Types of SCADA Processes

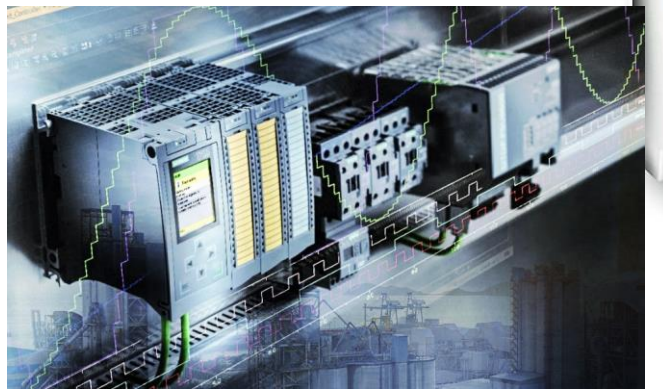




Components of a SCADA system

- Human Machine Interface (HMI)
- Supervisory System
- Programmable Logic Controllers (PLCs
- Remote Telemetry Unit (RTUs)
- Communication Infrastructure

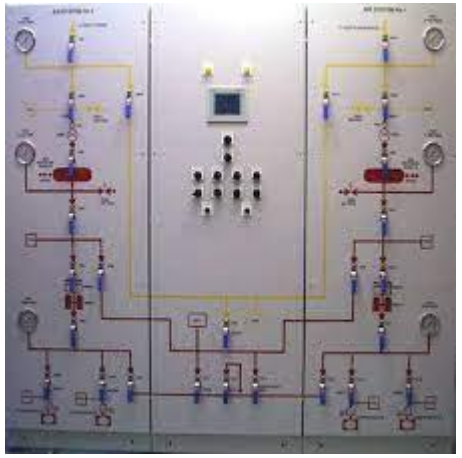




Components of a SCADA system

Human Machine Interface (HMI)

- Communication between operator and machine
- Input - Mouse, keyboard, touch screen
- Output - Screen, audio, mimic board



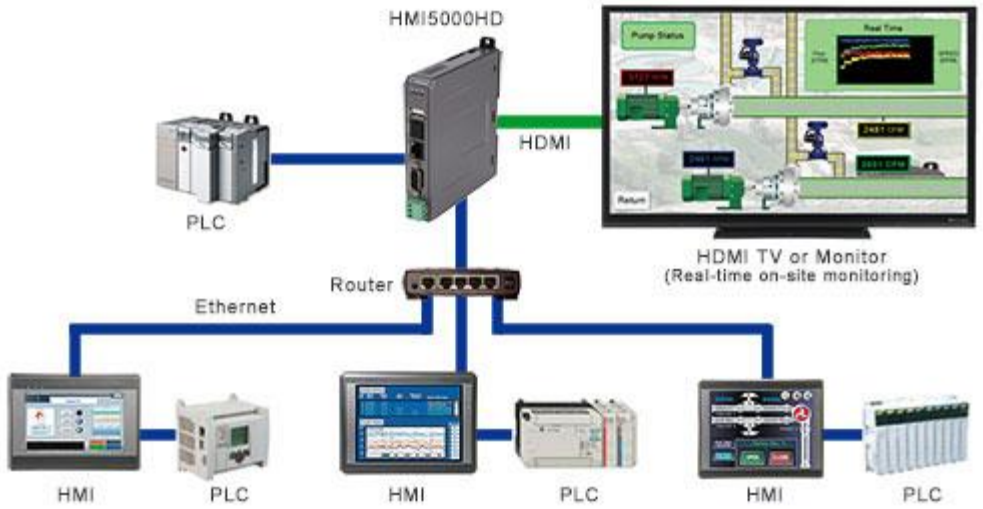
Supervisory System

- Server for communicating between the equipment of the SCADA system
- Master station or supervisory station

Components of a SCADA system

Remote Terminal Units (RTU)

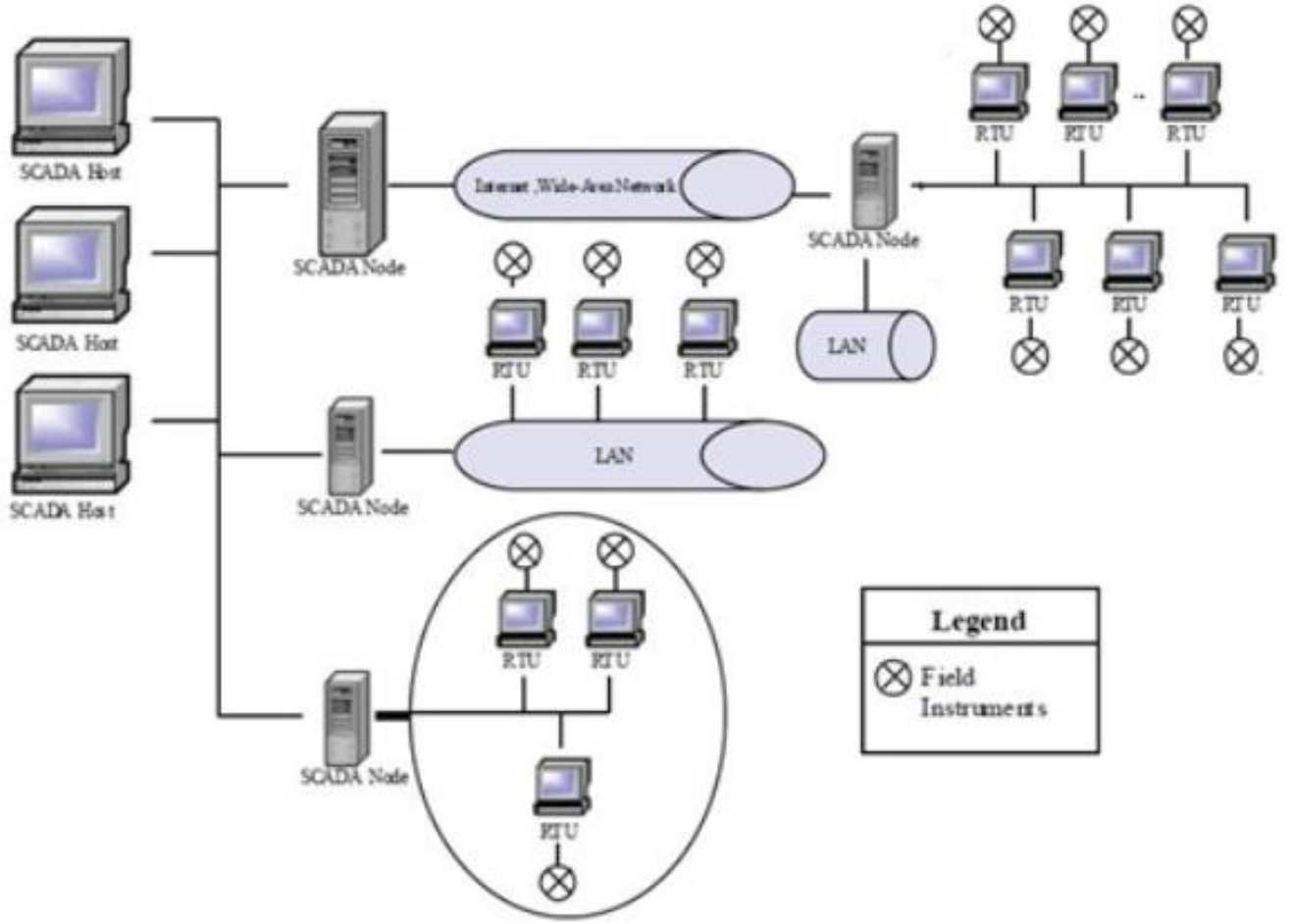
- Microprocessor controlled electronic devices
- Transmit telemetry data to the supervisory system and receive the messages from the master system for controlling the connected objects.



Programmable Logic Controllers

- Collecting the sensor output signals in order to convert the sensor signals into digital data
- Economical, versatile, flexible, and configurable than special-purpose RTUs

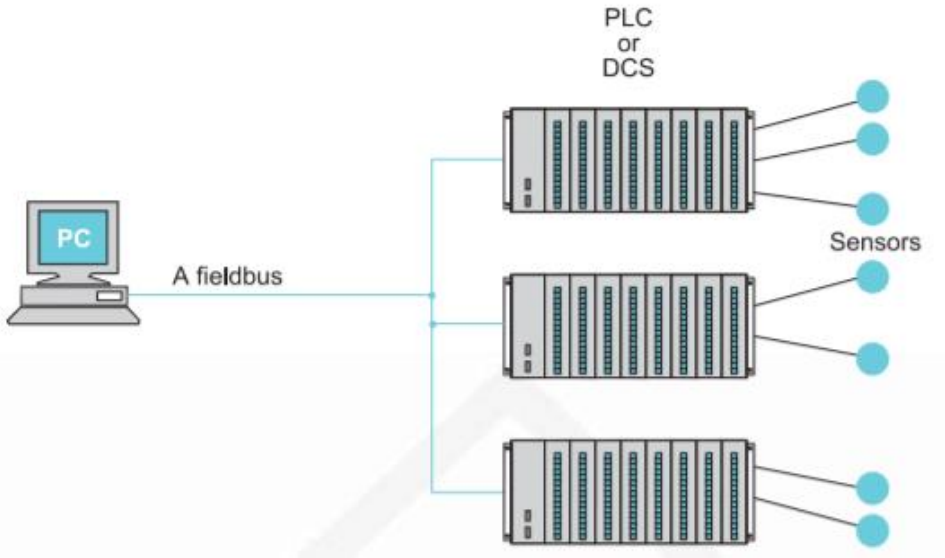
Architecture of SCADA system



Fundamental Principles of SCADA system

Advantages of the PLC / DCS SCADA system are:

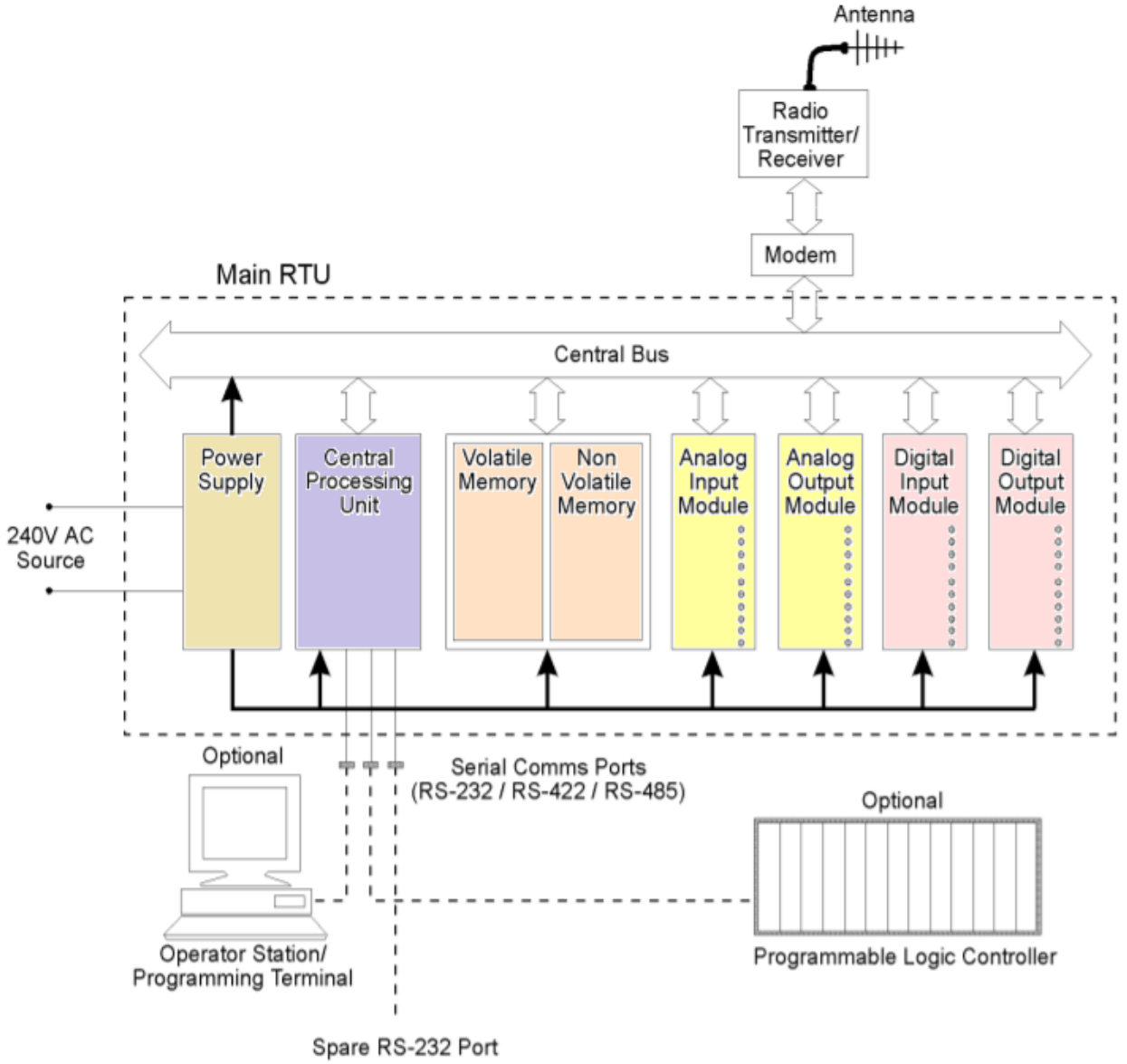
- The computer can record and store a very large amount of data
- The data can be displayed in any way the user requires
- Thousands of sensors over a wide area can be connected to the system
- The operator can incorporate real data simulations into the system
- Many types of data can be collected from the RTUs
- The data can be viewed from anywhere, not just on site



Remote Telemetry Unit

Remote terminal units

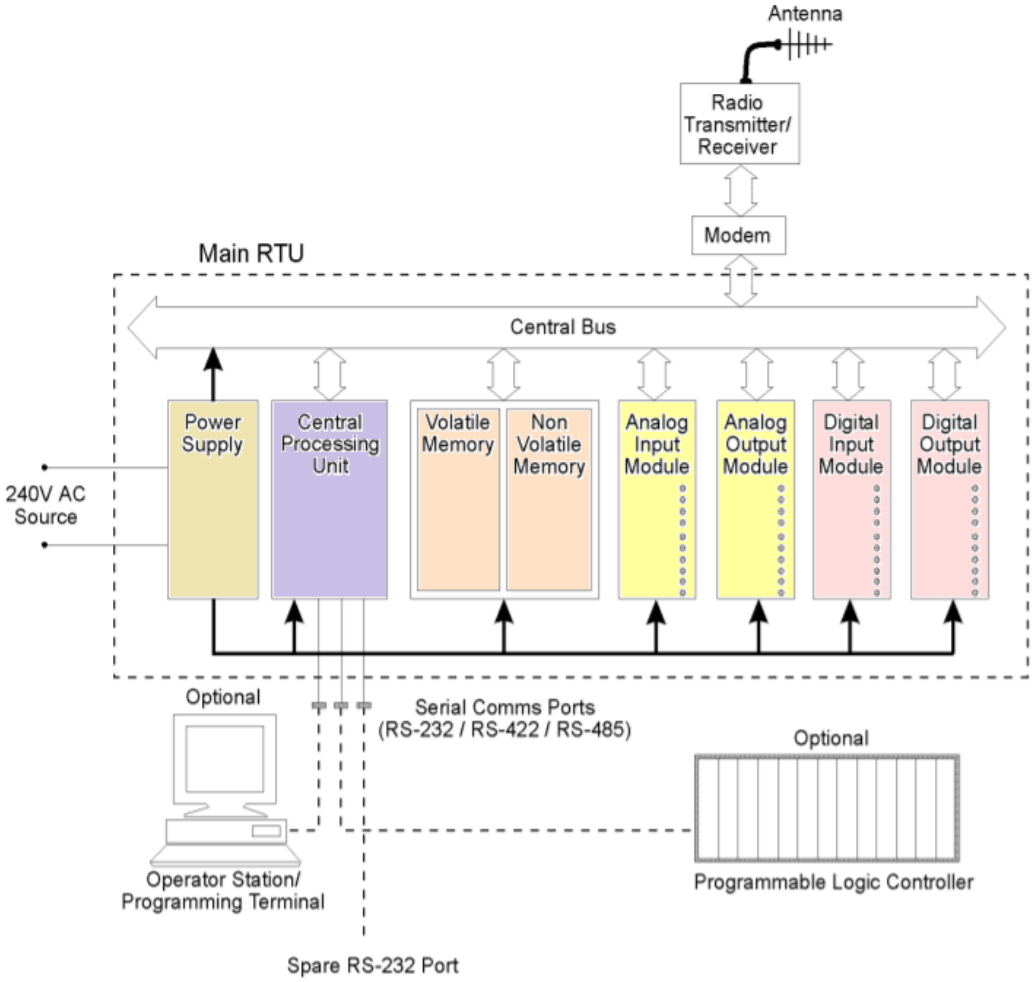
- A standalone data acquisition and control unit, generally microprocessor based, which monitors and controls equipment at some remote location from the central station
- Small sized RTUs generally have less than 10 to 20 analog and digital signals, medium sized RTUs have 100 digital and 30 to 40 analog inputs. RTUs, having a capacity greater than this can be classified as large.



Remote Telemetry Unit

Central Processing Unit

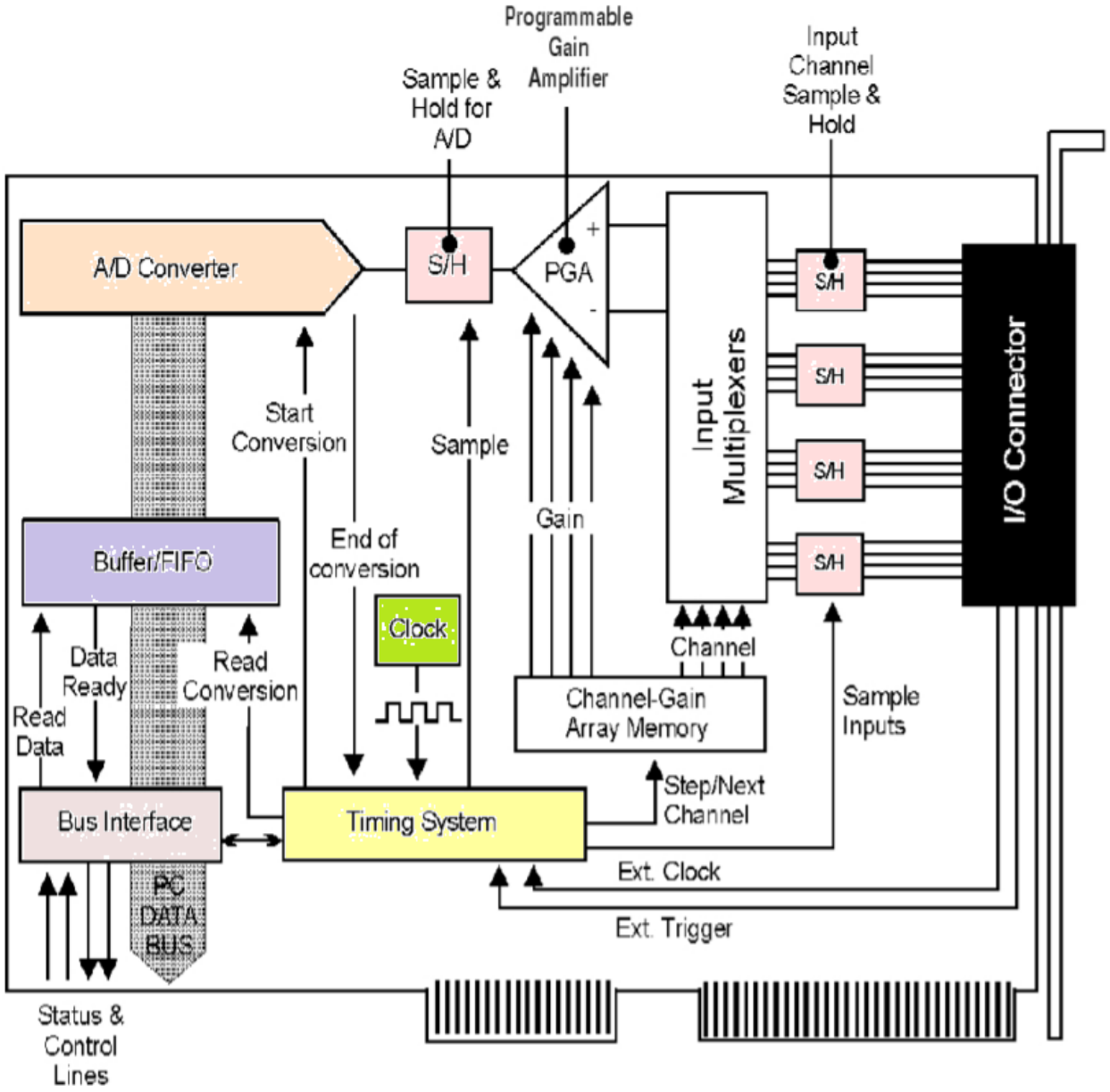
- Microprocessor based (16 or 32 bit)
- Communication ports –two or three ports either RS-232/RS-422/RS-485
  - Interface to diagnostics terminal
  - Interface to operator station
  - Communications link to central site (e.g. by modem)
- Real-time clock
- Watchdog timer



Remote Telemetry Unit

Analog Input Modules

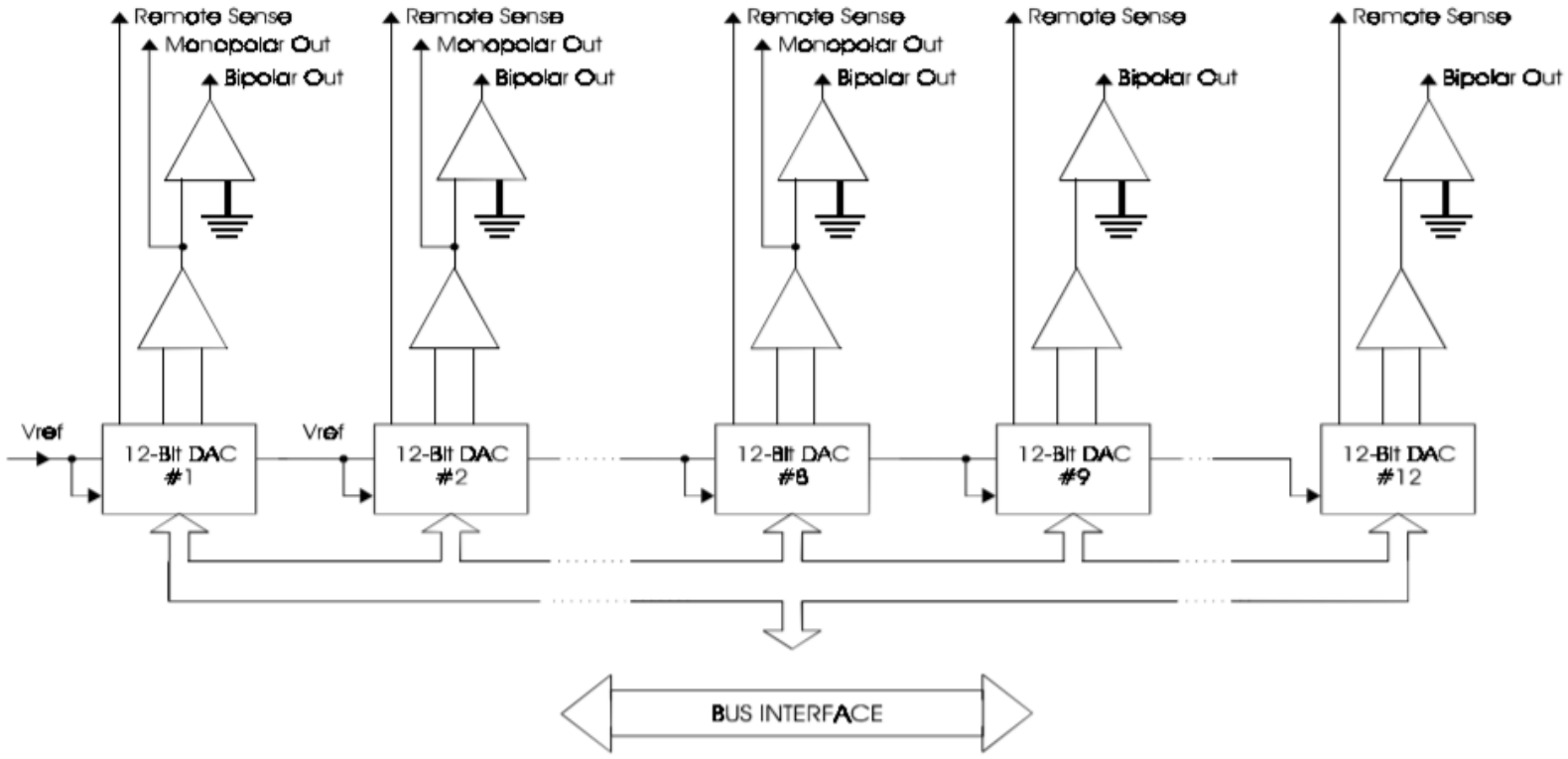
- The input multiplexer
- The input signal amplifier
- The sample and hold circuit
- The A/D converter
- The bus interface and board timing system



Remote Telemetry Unit

Analog Output

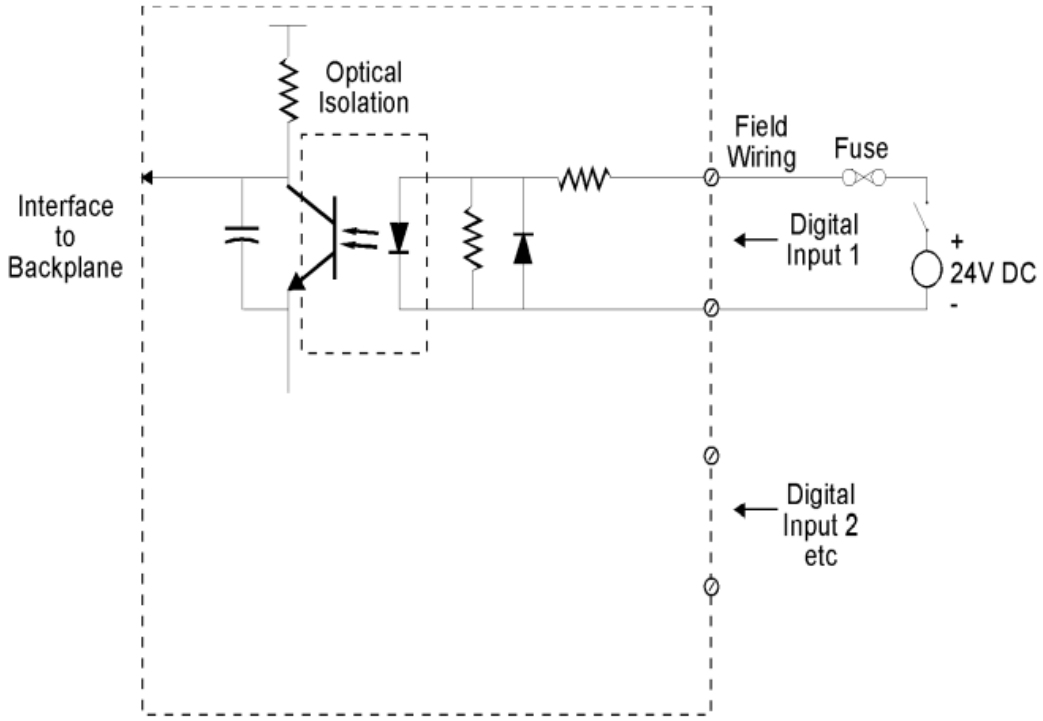
- 8 analogue outputs
- Resolution of 8 or 12 bits
- Conversion rate from 10 µ seconds to 30 milliseconds
- Outputs ranging from 4–20 mA/± 10 volts/0 to 10 volts



Remote Telemetry Unit

Digital input

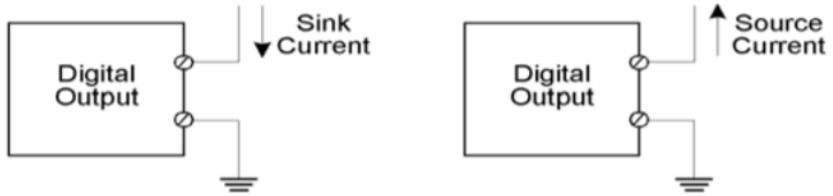
- used to indicate items such as status and alarm signals
- Most digital input boards provide groups of 8, 16 or 32 inputs per board
- Associated LED indicator for each input to indicate current states
- Digital input voltages vary from 110/240 VAC and 12/24/48 VDC
- Optical isolation provided for each digital input

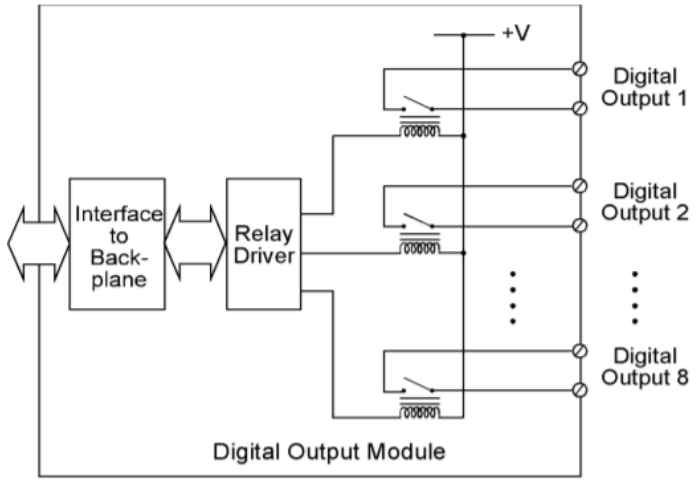


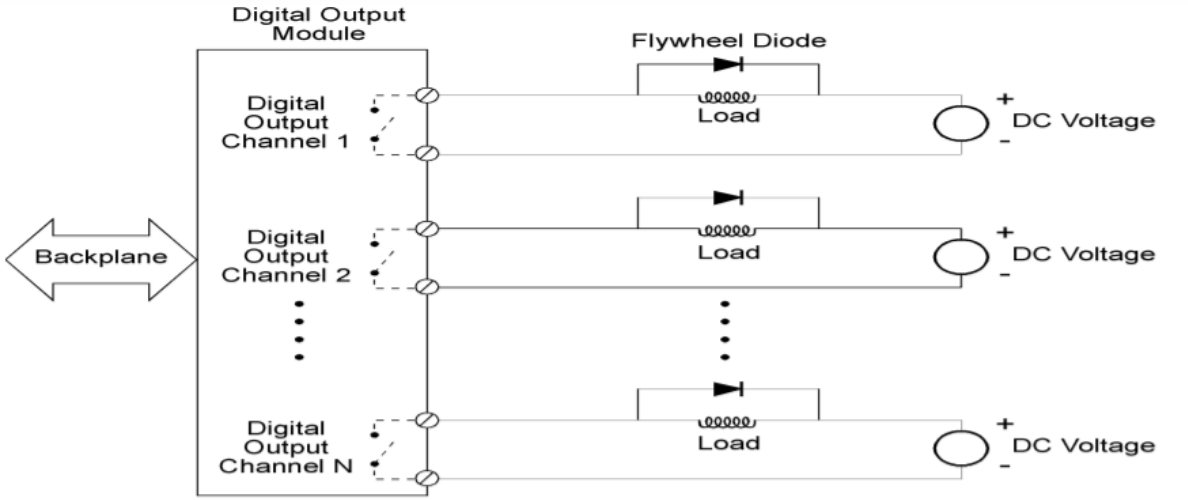
Remote Telemetry Unit

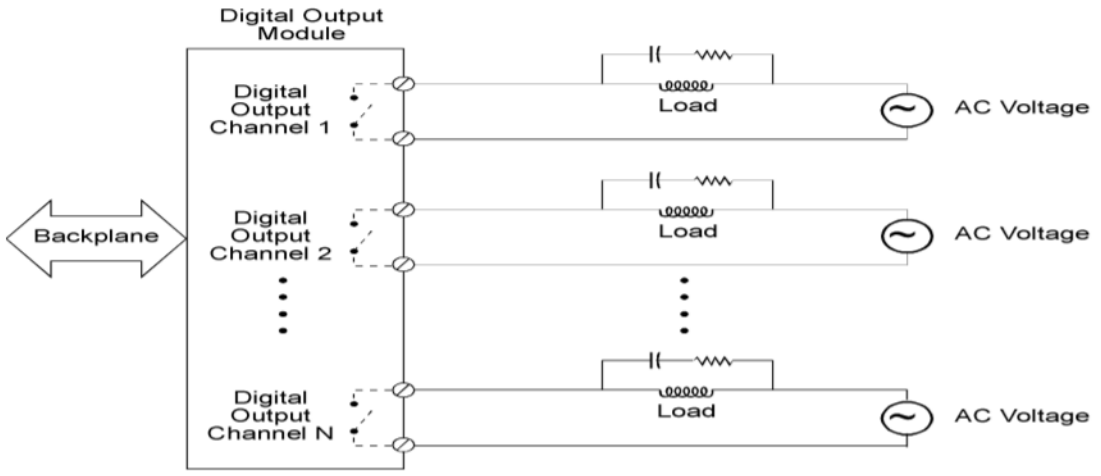
Digital Output

- drives an output voltage at each of the appropriate output channels with three approaches possible:
  - Triac switching
  - Reed relay switching
  - TTL voltage outputs





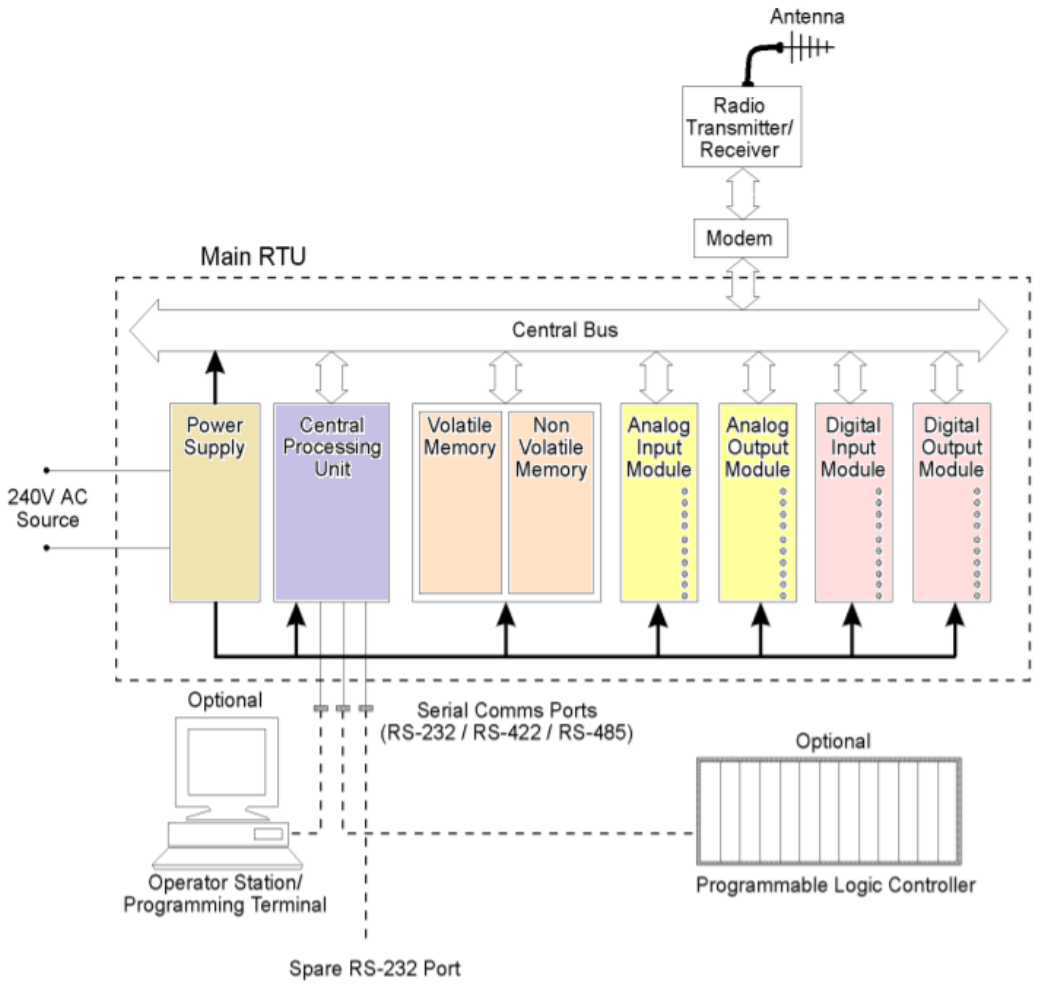




Remote Telemetry Unit

Communication Interfaces

- Flexible enough to handle multiple communication media
- RS-232/RS-442/RS-485
- Dialup telephone lines/dedicated landlines
- Microwave/MUX
- Satellite
- X.25 packet protocols
- Radio via trunked/VHF/UHF/900 MHz



Master Station

- One or more operator stations connected to a communication system consisting of modem and radio receiver/transmitter

Features:

- Operator interface to display status of the RTUs and enable operator control
- Logging of the data from the RTUs
- Alarming of data from the RTU

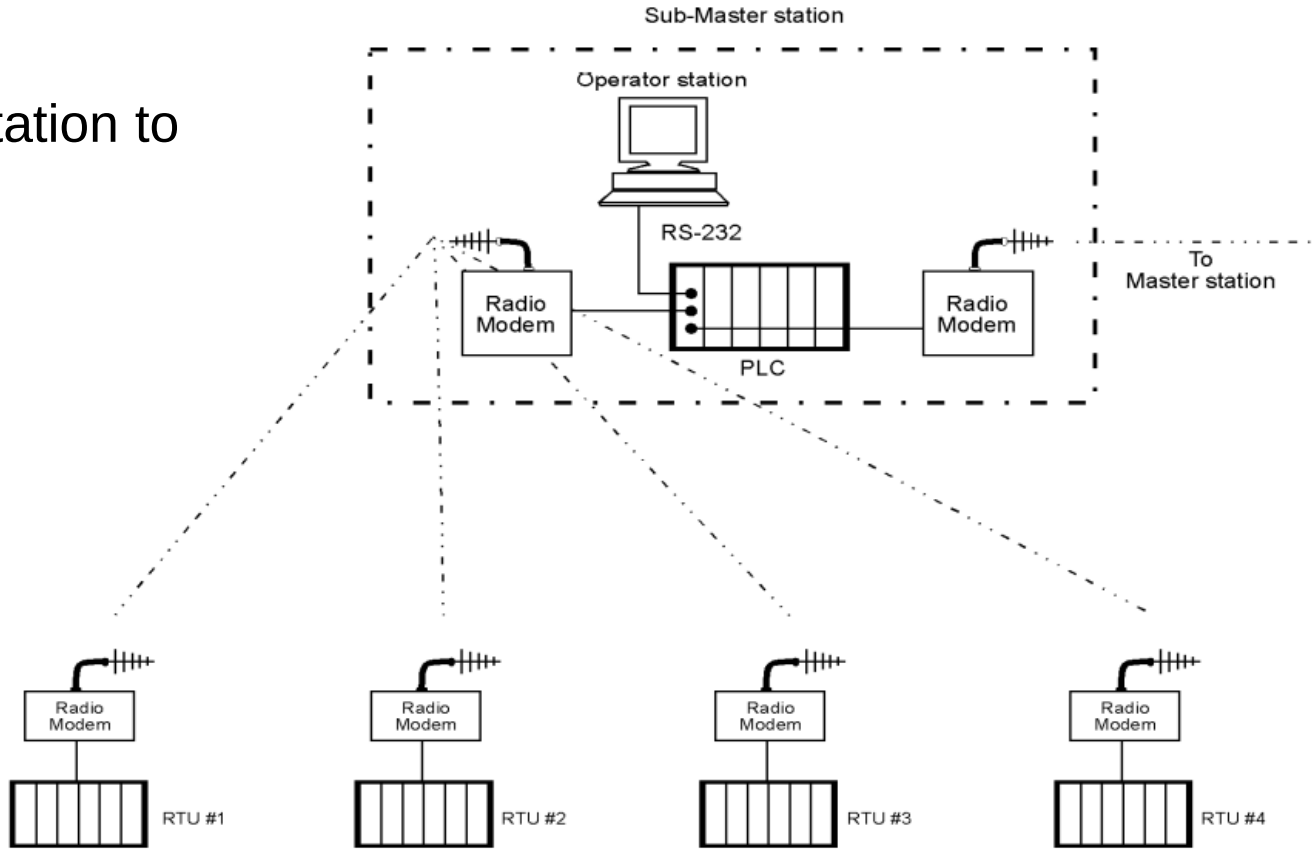
Two main functions:

- Obtain field data periodically from RTUs and submaster stations
- Control remote devices through the operator station

Master Station

Submaster Station:

- Acquire data from RTUs within the region
- Log and display this data on a local operator station
- Pass data back to the master station
- Pass on control requests from the master station to the RTUs in its region



Master Station

Establishment of communications

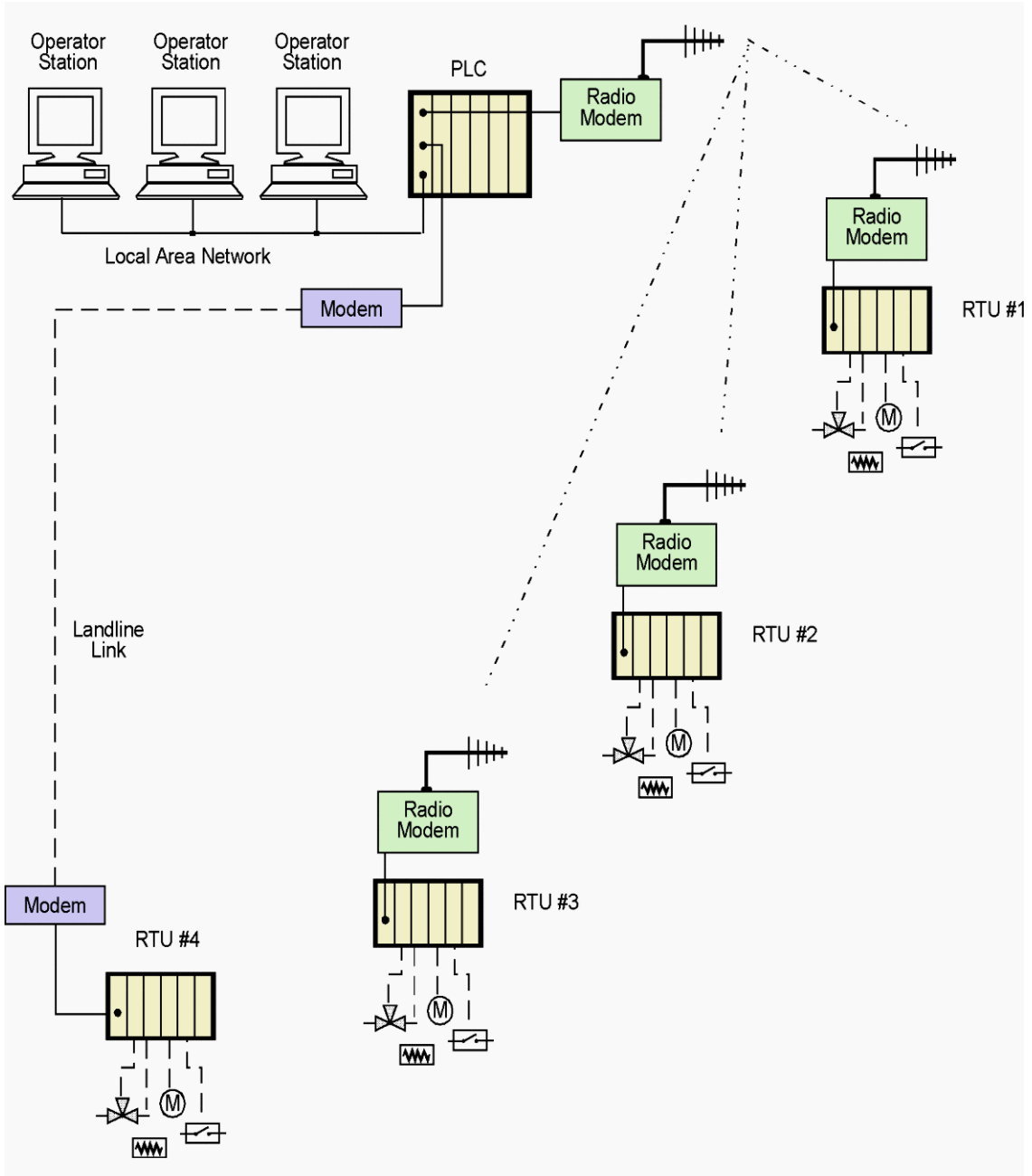
- Configure each RTU
- Initialize each RTU with input/output parameters
- Download control and data acquisition programs to the RTU

Operation of the communications link

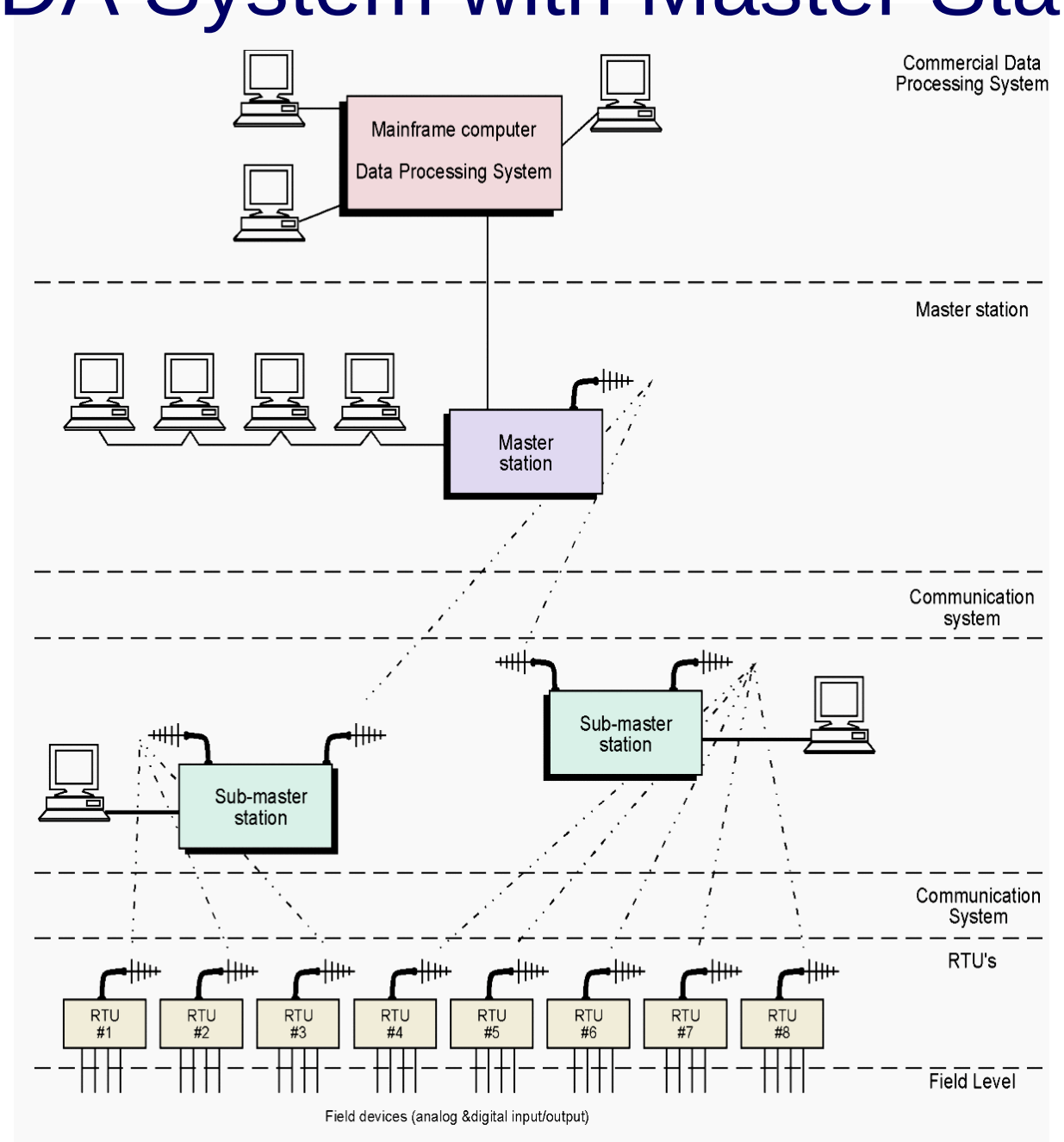
- If a master slave arrangement, poll each RTU for data and write to RTU
- Log alarms and events to hard disk
- Link inputs and outputs at different RTUs automatically

Diagnostics

- Provide accurate diagnostic information on failure of RTU and possible problems
- Predict potential problems such as data overloads



SCADA System with Master Station



Master Station

Software

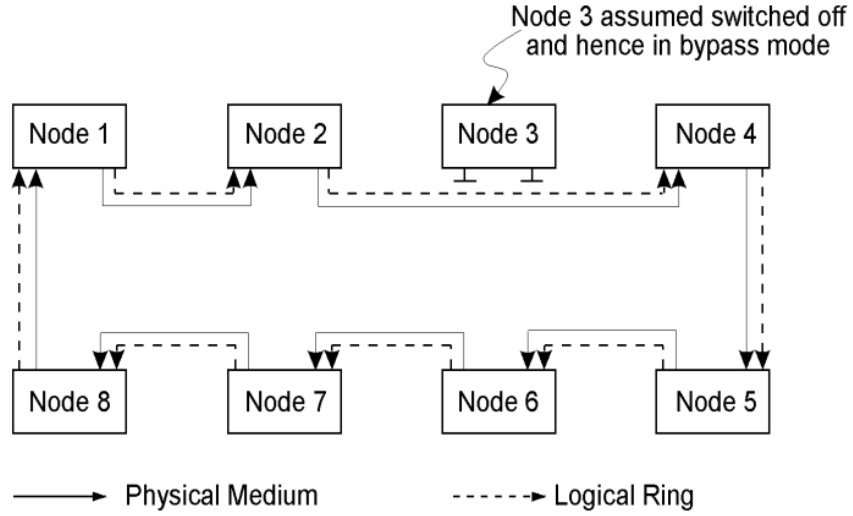
- The operating system software
- The system SCADA software (suitably configured)
- The SCADA application software

System SCADA Software

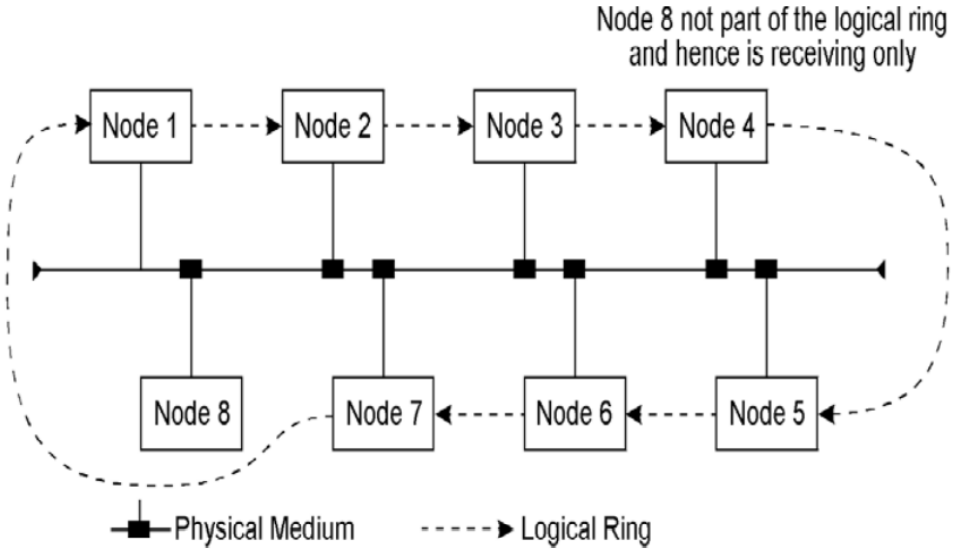
- Data acquisition
- Control
- Archiving or database storage
- The Human machine interface (HMI)

LAN

- 802.3 (Ethernet),
- 802.4 (token bus) or
- 802.5 (token ring)



Token ring system

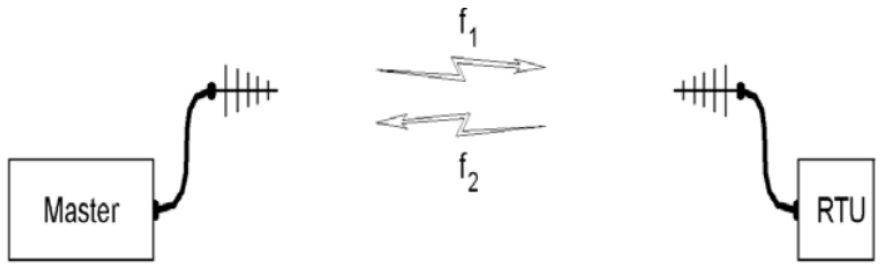


Token bus system

Communication architectures

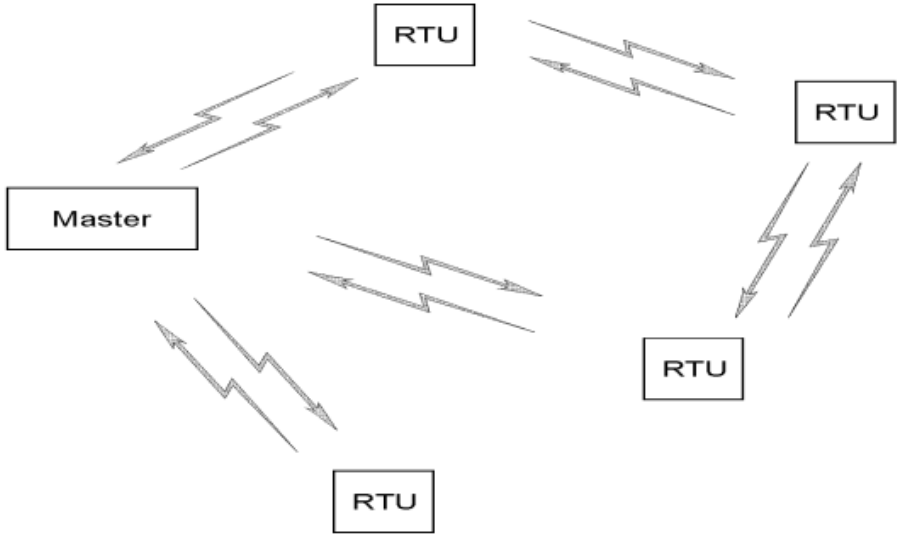
Point-to-point (two stations)

- Data is exchanged between two stations.
- One station can be setup as the master and one as the slave



Multipoint (or multiple stations)

- One master and multiple slaves
- Two slaves transfer data between each other through the master who would act as arbitrator or moderator



Relay Stations

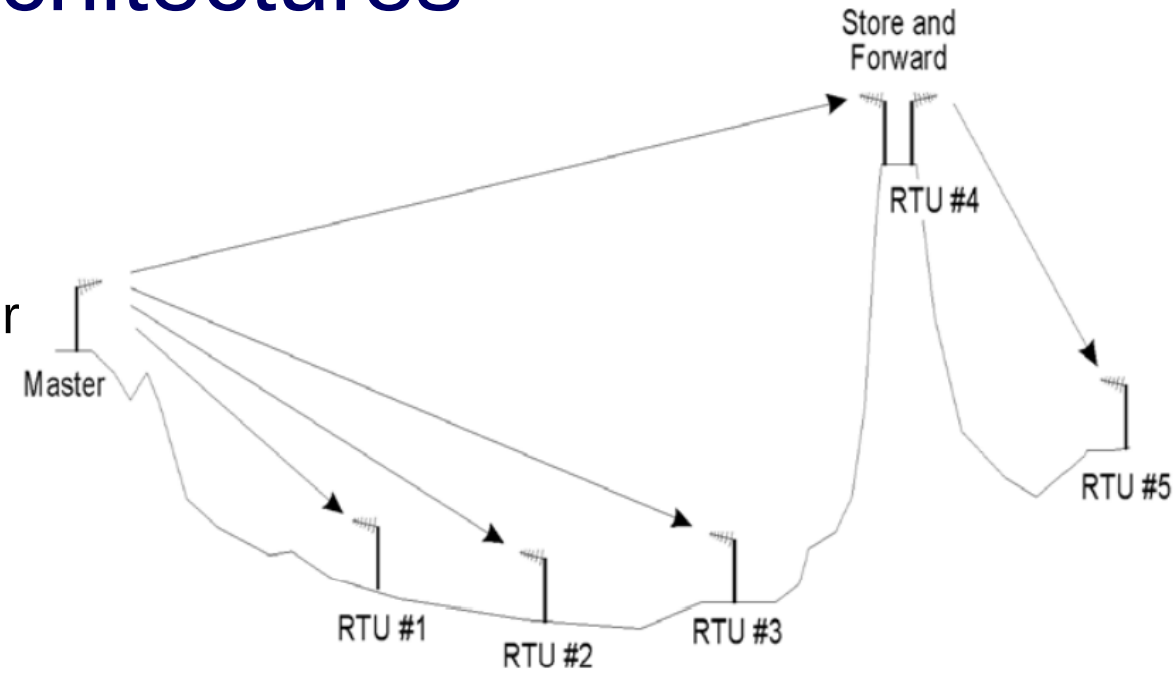
- Store and forward relay operation
- Talk through repeaters

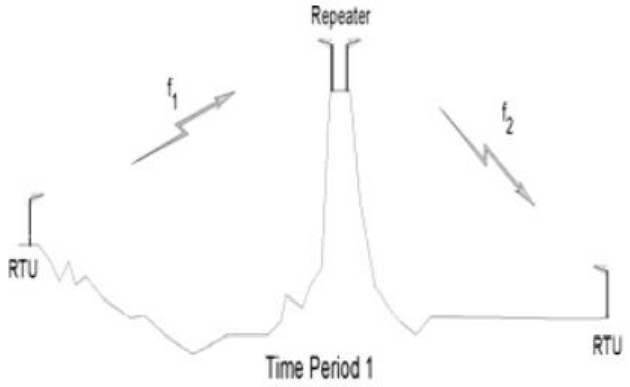
Communication architectures

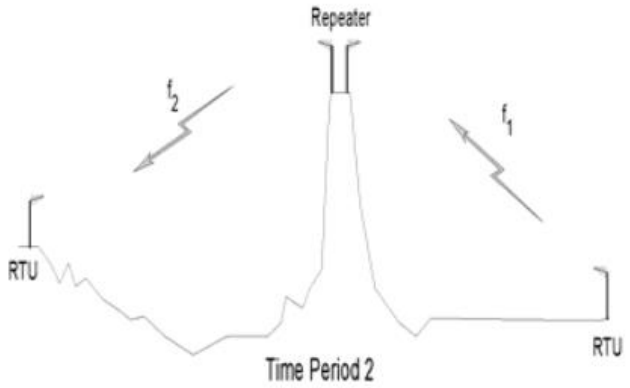
Relay Stations

Store and forward relay operation

- One station retransmits messages onto another station out of the range of the master station







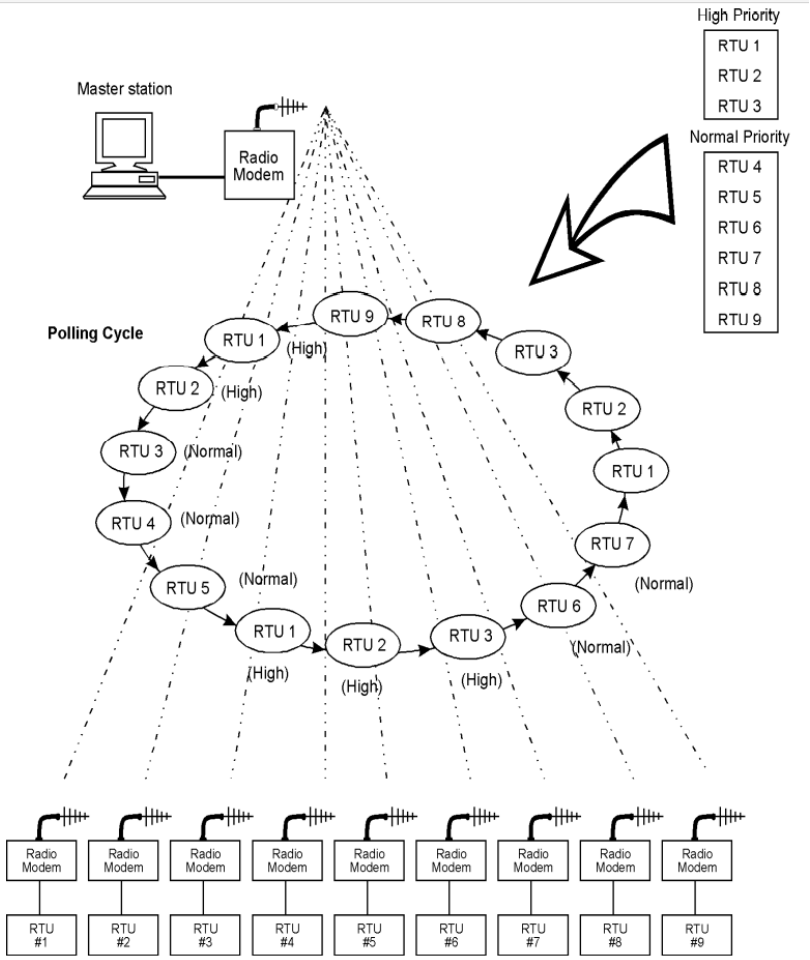
Talk through repeaters

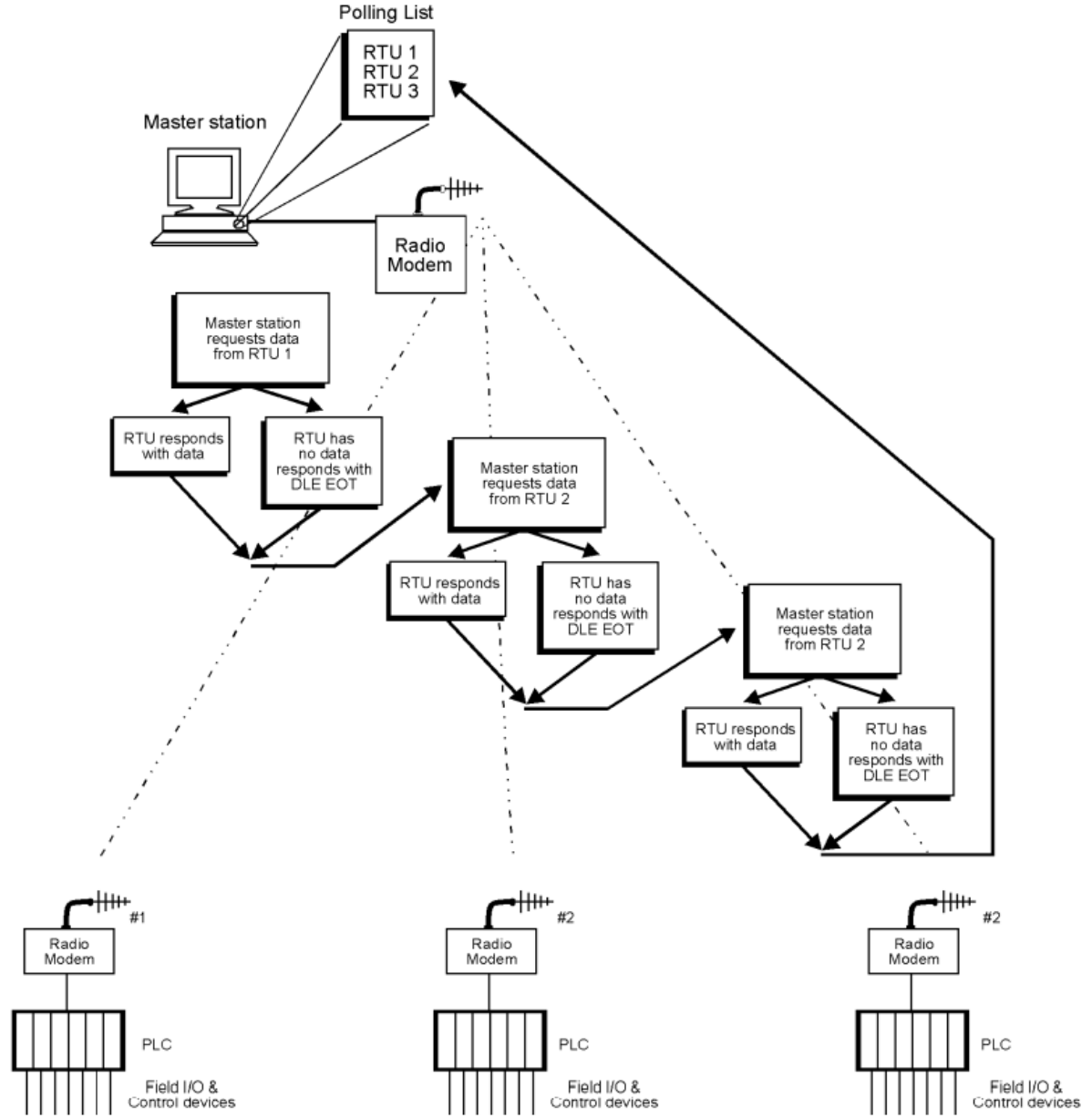
- Retransmits a radio signal received simultaneously on another frequency - situated on a geographically high point.
- The repeater receives on one frequency and retransmits on another frequency simultaneously

Communication Methods

Two main communication philosophies possible

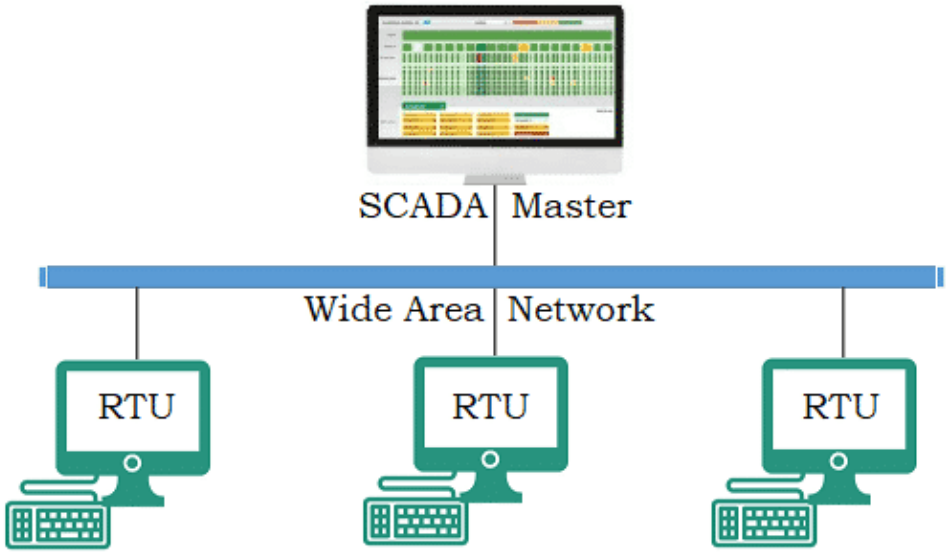
- Polled (or masterslave)
- Carrier sense multiple access/collision detection (CSMA/CD).



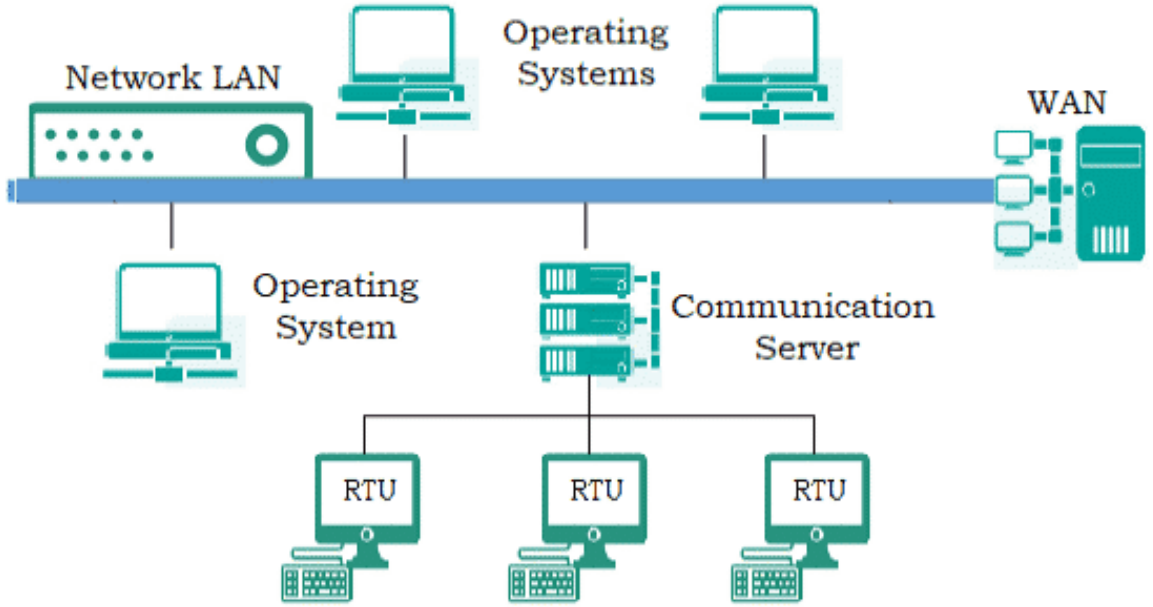


Types of SCADA System

Early or Monolithic SCADA Systems (First Generation)

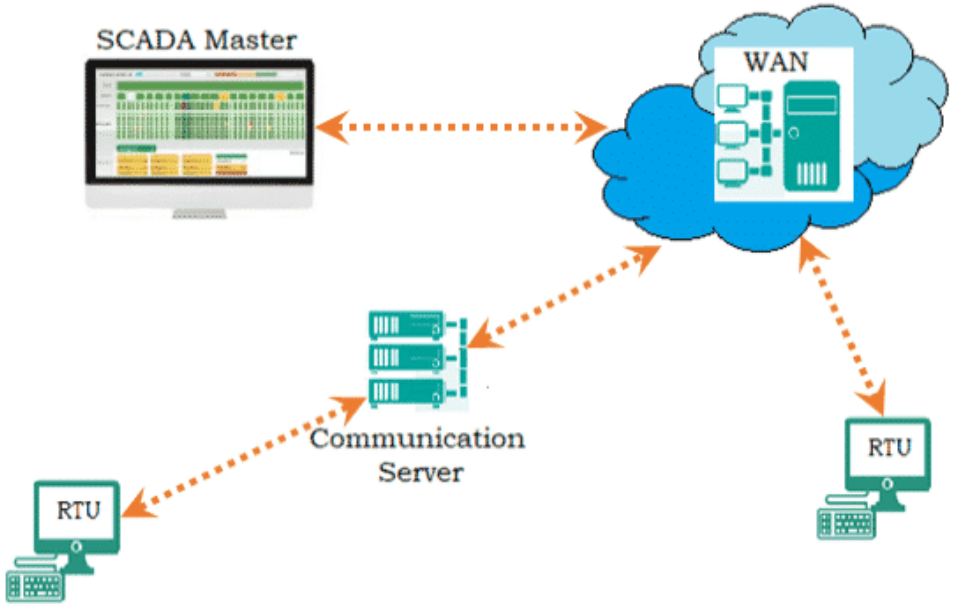


Distributed SCADA Systems (Second Generation)

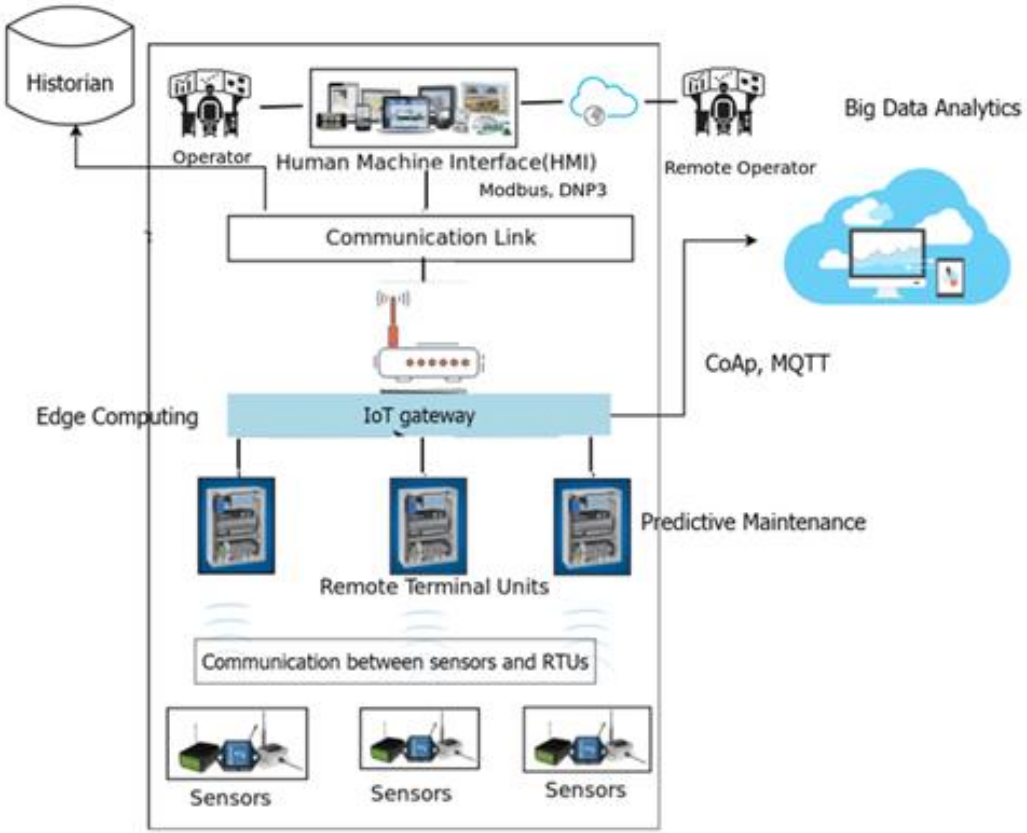


Types of SCADA System

Networked SCADA Systems (Third Generation)



Internet of Things SCADA Systems (Fourth Generation)



SCADA software package

- Key features expected of the SCADA software
  - User interface
  - Graphics displays
  - Alarms
    - Client server architecture
    - Time stamped alarms to 1 millisecond precision (or better)
    - Single network acknowledgment and control of alarms
    - Alarms are shared to all clients
    - Alarms displayed in chronological order
    - Dynamic allocation of alarm pages
    - Adjustable trip points for each analog alarm
    - Deviation and rate of change monitoring for analog alarms
    - Selective display of alarms by category (256 categories)
    - Historical alarm and event logging
    - Context-sensitive help
    - On-line alarm disable and threshold modification
    - Event-triggered alarms
    - Alarm-triggered reports
    - Operator comments can be attached to alarms
  - Trends
    - Client server architecture
    - True trend printouts not screen dumps
    - Rubber band trend zooming
    - Export data to DBF, CSV files
    - X/Y plot capability
    - Event based trends
    - Pop-up trend display
    - Trend gridlines or profiles
    - Background trend graphics
    - Real-time multi-pen trending
    - Short and long term trend display
    - Length of data storage and frequency of monitoring can be specified on a per-point basis
    - Archiving of historical trend data
    - On-line change of time-base without loss of data
    - On-line retrieval of archived historical trend data
    - Exact value and time can be displayed
    - Trend data can be graphically represented in real-time

SCADA software package

- Key features expected of the SCADA software
  - RTU (and PLC) interface
    - All compatible protocols included as standard
    - DDE drivers supported
    - Interface also possible for RTUs, loop controllers, bar code readers and other equipment
    - Driver toolkit available
    - Operates on a demand basis instead of the conventional predefined scan method
    - Optimization of block data requests to PLCs
    - Rationalization of network user data requests
    - Maximization of PLC highway bandwidth
  - Scalability
    - Additional hardware can be added without replacing or modifying existing equipment
    - Limited only by the PLC architecture (typically 300 to 40 000 points)
  - Access to data
    - Direct, real-time access to data by any network user
    - Third-party access to real-time data, e.g. Excel
    - Network DDE, DDE compatibility: read, write and exec
    - DDE to all IO device points

SCADA software package

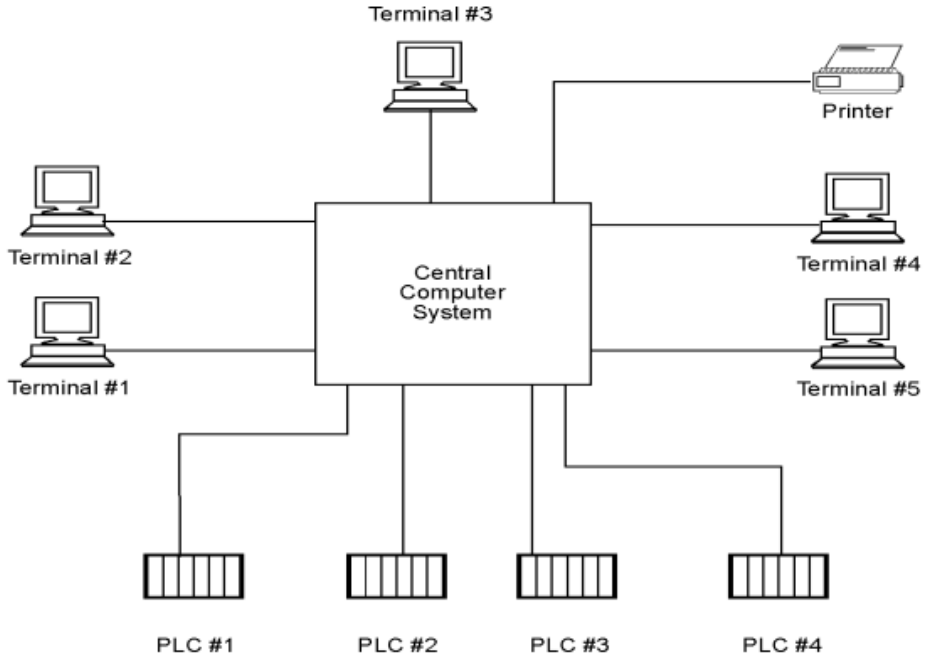
- Key features expected of the SCADA software
  - Fault tolerance and redundancy
    - Dual networks for full LAN redundancy
    - Redundancy can be applied to specific hardware
    - Supports primary and secondary equipment configurations
    - Intelligent redundancy allows secondary equipment to contribute to processing load
    - Automatic changeover and recovery
    - Redundant writes to PLCs with no configuration
    - Mirrored disk I/O devices
    - Mirrored alarm servers
    - Mirrored trend servers
    - File server redundancy
    - No configuration required, may be enabled via single check box, no configuration
  - Client/server distributed processing
    - Open architecture design
    - Real-time multitasking
    - Client/server fully supported with no user configuration
    - Distributed project updates (changes reflected across network)
    - Concurrent support of multiple display nodes
    - Access any data (trend, alarm, report) from any node

- Upgradeable to handle future requirement.
- Modifiable as the requirement change and expandable as the task grows - scalable architecture

SCADA software package

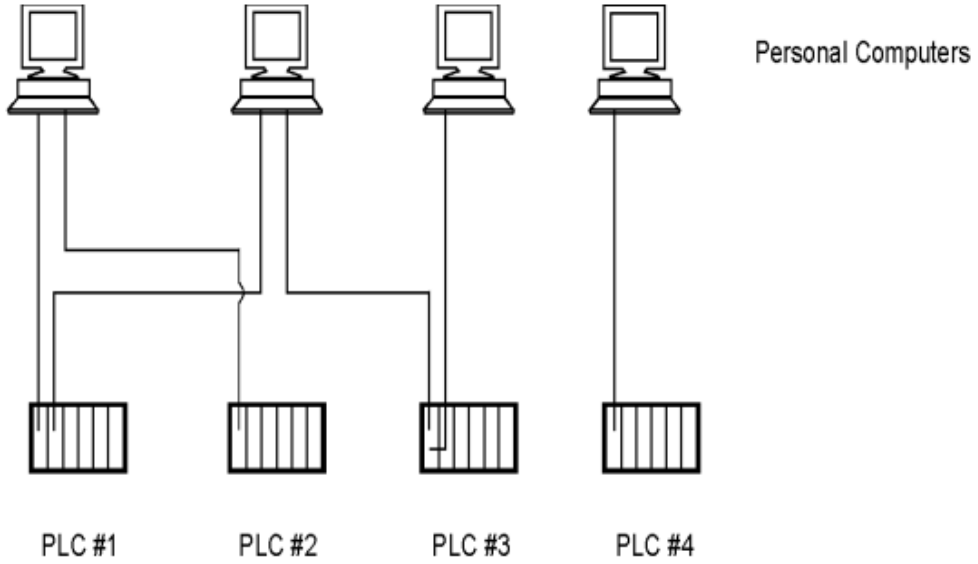
Two main approaches in designing the SCADA system

- Centralized processing



- Single computer or mainframe performs all plant monitoring and all plant data is stored on one database
- Initial up front costs are fairly high for a small system
- A gradual approach to plant upgrading is not really possible due to the fixed size of the system
- Redundancy is expensive as the entire system must be duplicated

- Distributed processing

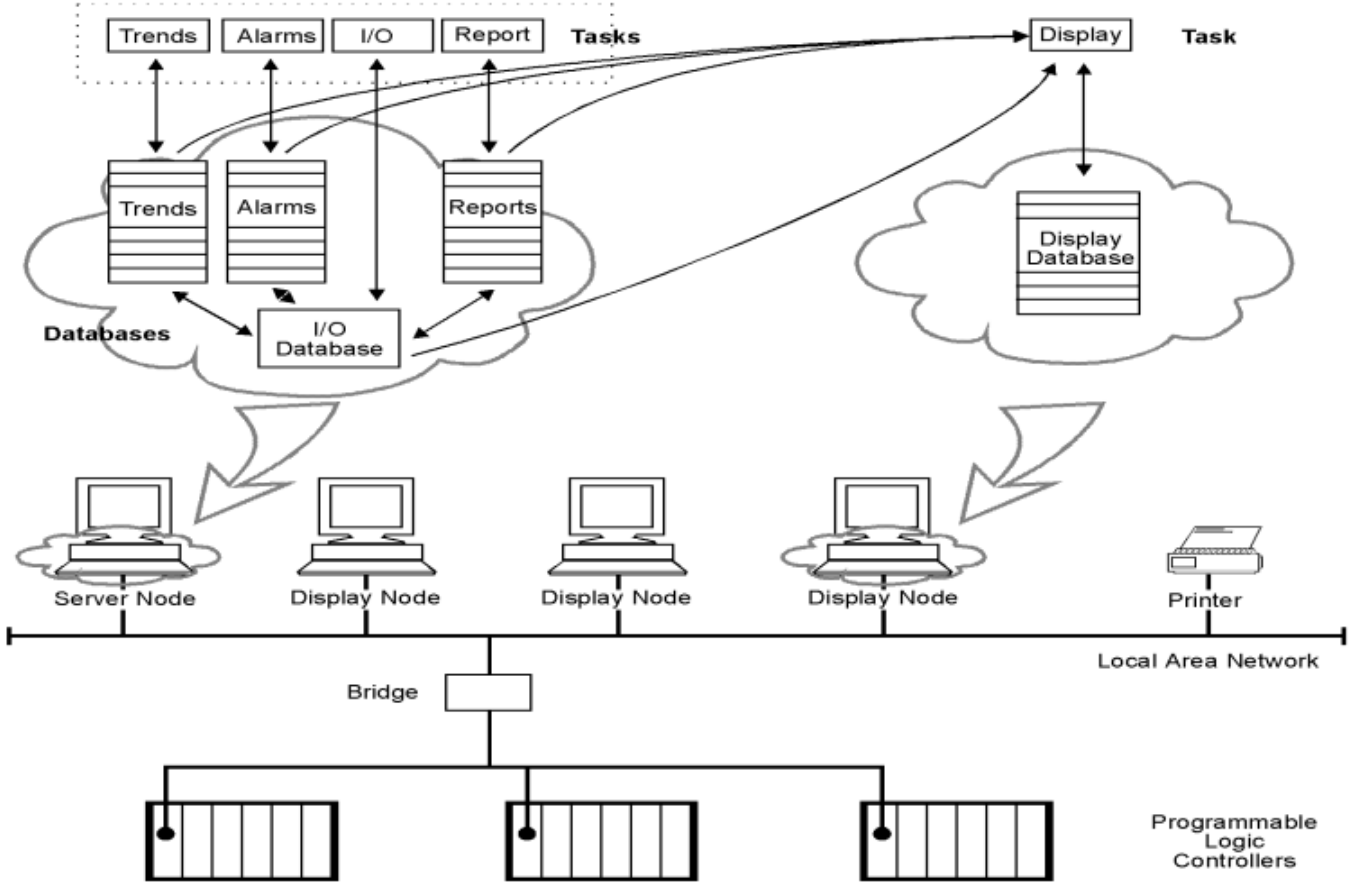


- Shared across several small computers
- Communication between different computers is not easy, resulting in configuration problems
- Data processing and databases duplicated across all computers resulting in low efficiencies
- There is no systematic approach to acquiring data from the plant devices

SCADA software package

Client server approach

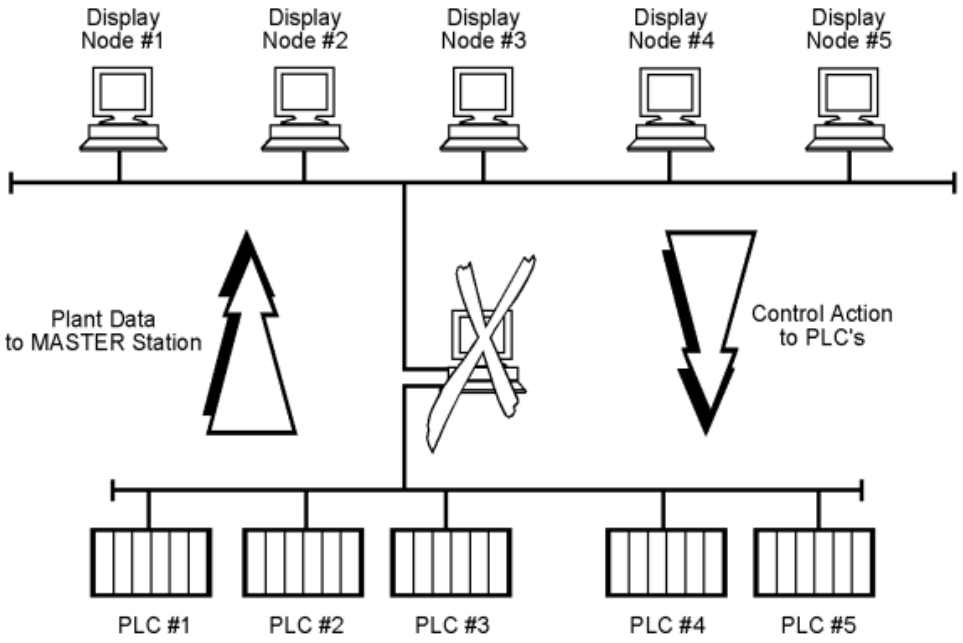
- Server node is a device that provides a service to other nodes on the network - database program
- Client is a node that requests a service from a server
- Display node (or client) requests the data from the control server which then searches the database and returns the data requested, thus reducing the network overhead.

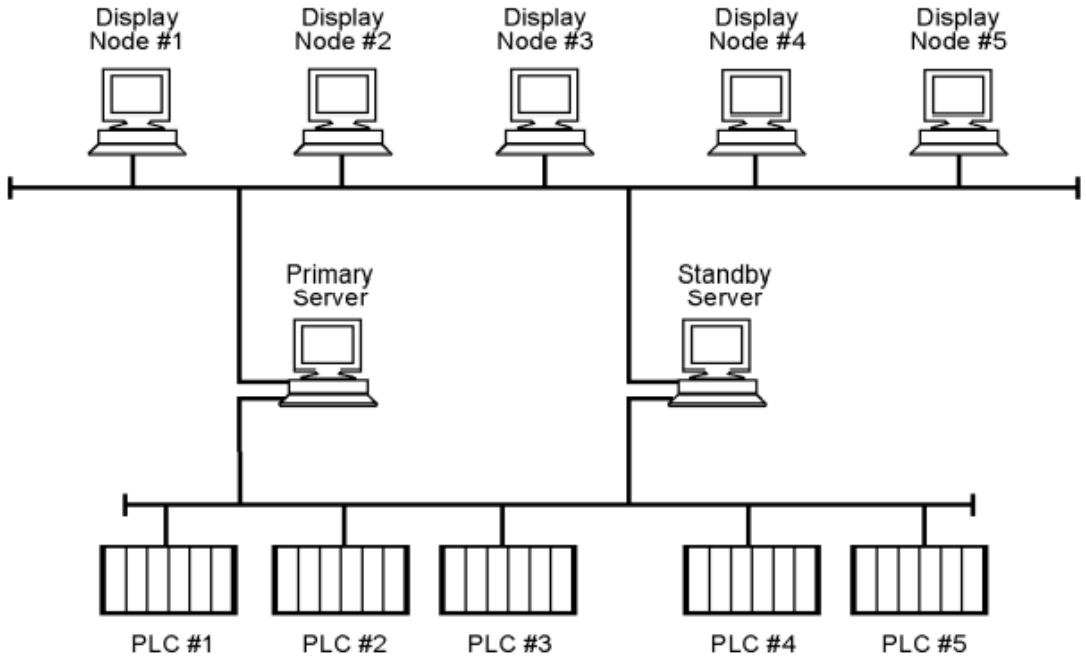


SCADA software package

Redundancy

- For any critical processes or activities in the system, or if the cost of loss of production is high, redundancy must be built into the system.
- Use the client–server approach
- If the primary server fails, the standby server will then take over as the primary server and transfer information to the clients on the network.

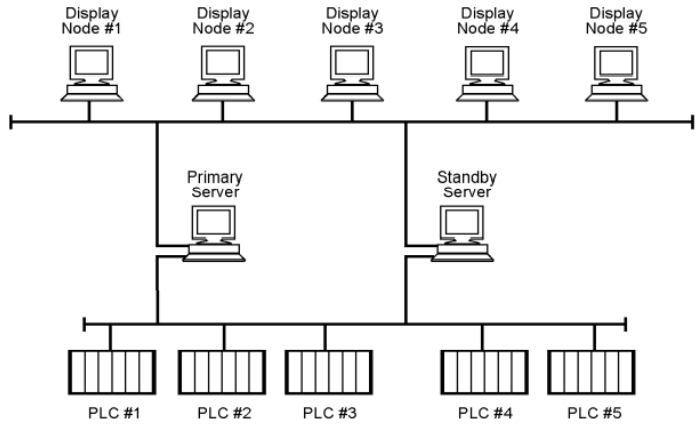


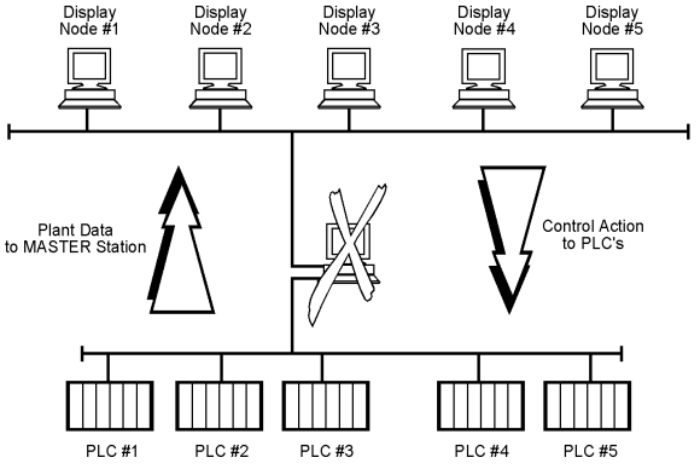


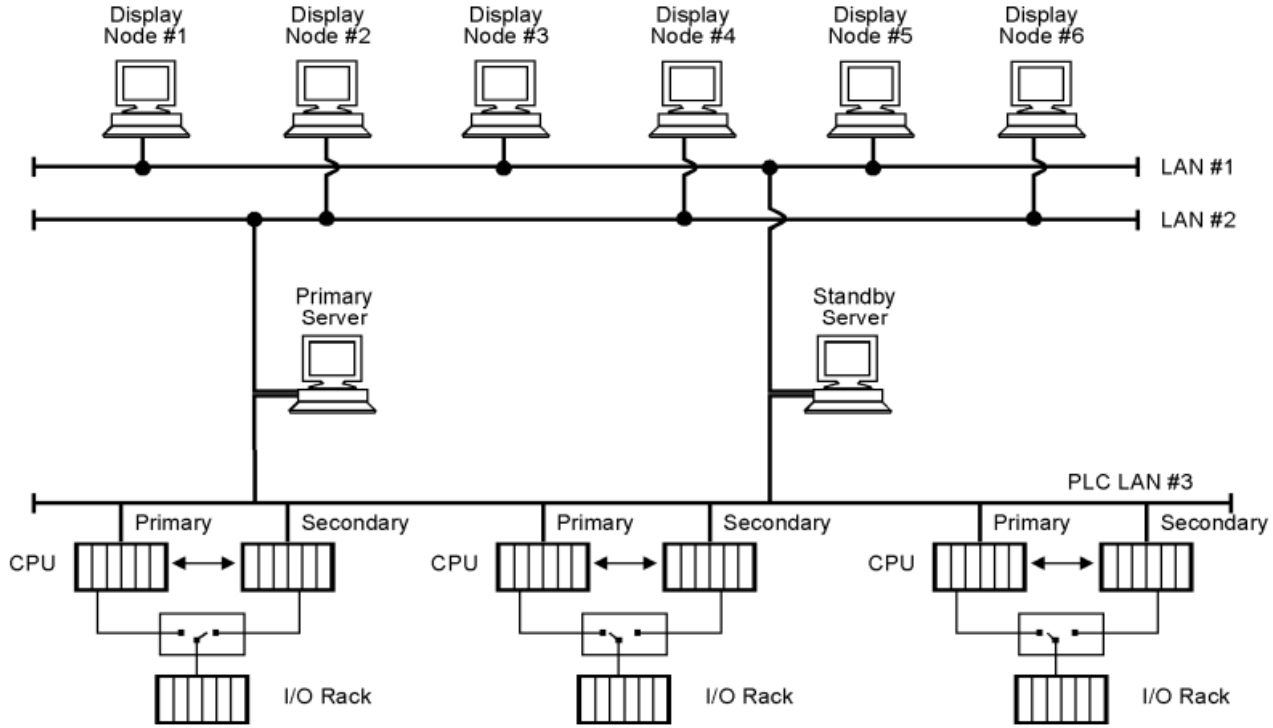
SCADA software package

Redundancy

- For any critical processes or activities in the system, or if the cost of loss of production is high, redundancy must be built into the system.
- Use the client–server approach
- If the primary server fails, the standby server will then take over as the primary server and transfer information to the clients on the network.







SCADA software package

System response time

- Typical speeds that are considered acceptable are:
  - Display of analog or digital value (acquired from RTU) on the master station operator display (1 to 2 seconds maximum)
  - Control request from operator to RTU (1 second critical; 3 seconds non-critical)
  - Acknowledge of alarm on operator screen (1 second)
  - Display of entire new display on operator screen (1 second)
  - Retrieval of historical trend and display on operator screen (2 seconds)
  - Sequence of events logging (at RTU) of critical events (1 millisecond)
- The response is consistent over all activities of the SCADA system.
- Distributed approach to the design of the SCADA system ensures that these response time can be easily achieved

Expandability of the system

- Additional hardware will be of the same modular form, and will not impact on the existing hardware installed.
- Operating system will be able to support the additional requirements without any major modifications.
- Application software should require no modifications in adding the new RTUs or operator stations at the master station.

Reference

1. David Bailey Edwin Wright, “Practical SCADA for Industry”, 1st Edition, Elsevier, 2003.