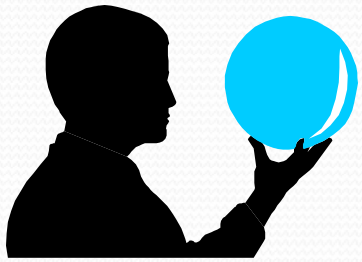
SECTION A

An Introduction to SCADA Fundamentals and Implementation

Supervisory Control And Data Acquisition



SCADA

"Any way you want it"

The best of both worlds from Invensys

The two faces of SCADA

- Traditional SCADA for pipelines, power distribution or anything that spans great distances
  - Typical
  - Stand-Alone
  - Networked
- Local control SCADA for plant or unit operations or any architecture that is within a defined boundary
  - DCS
  - PC based
  - HMI / PLC

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…delivering leading brand solutions, from the production line to the bottom line.

FOXBORO

AVANTIS ASSET MANAGEMENT SOLUTIONS

Wonderware

Validation Technologies

simsci

BaaN

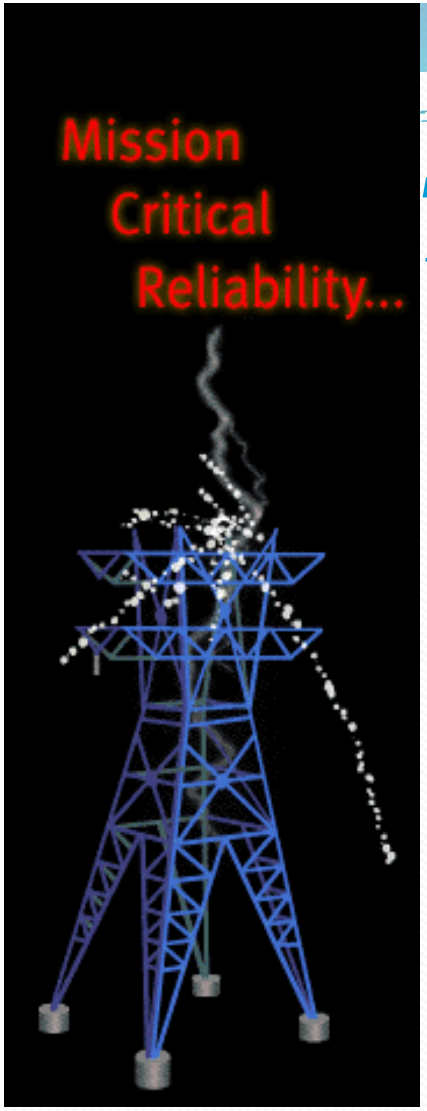
WALSH AUTOMATION

PacificSimulation

esscor

TRICONEX

APV



Typical SCADA Platform

Operator Stations
Microsoft

Programming/Engineering Stations
UNIX or Microsoft

Enterprise PCs

WAN

Duel 100BaseT Ethernet

Communications
Servers

Color Printer

B & W Printer

SCADA/History/Application
Servers

Web Interface Server

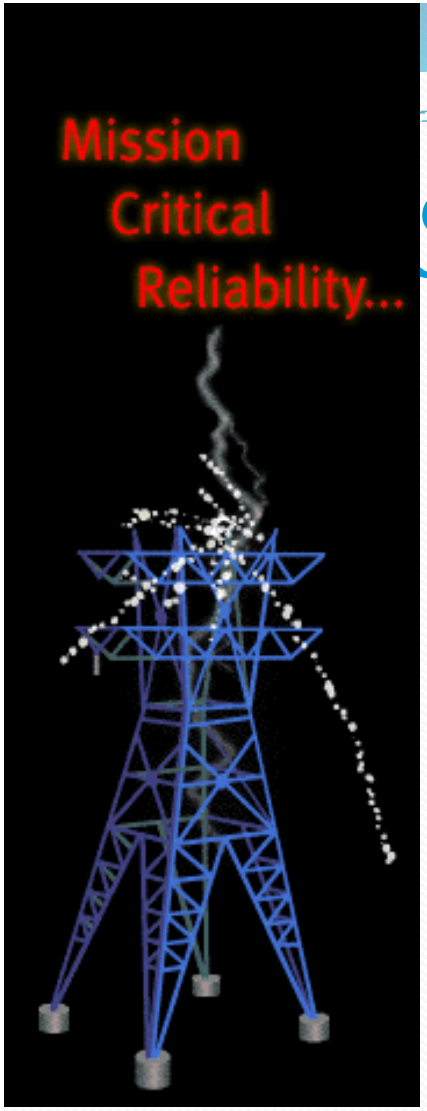
RTU 50

OPTOnet

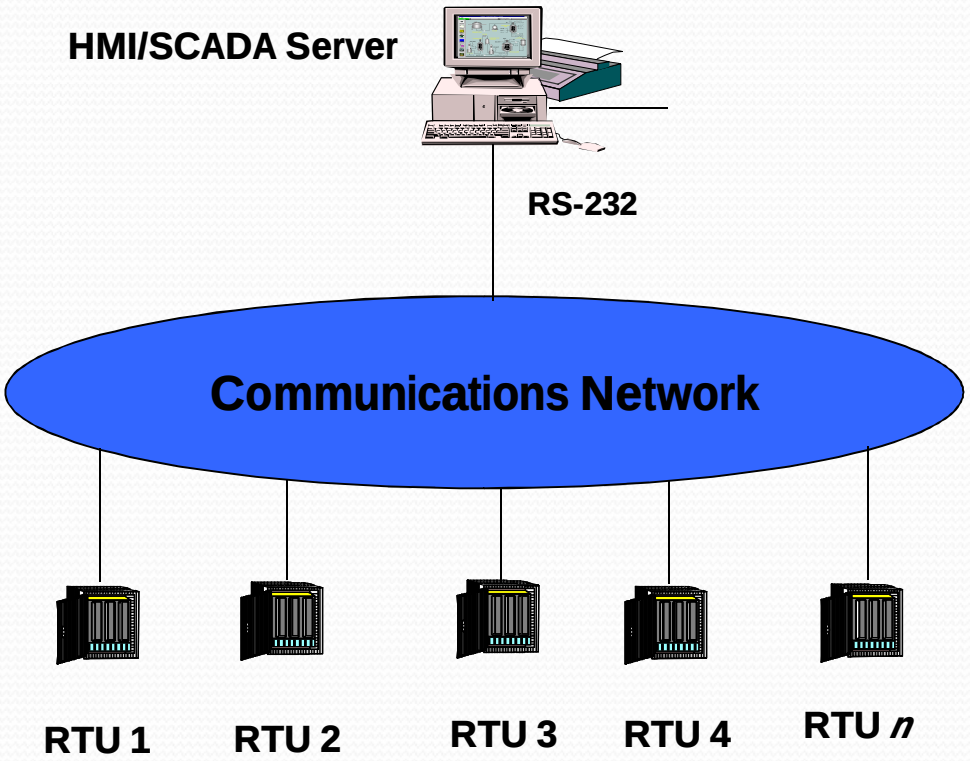
RTU 50

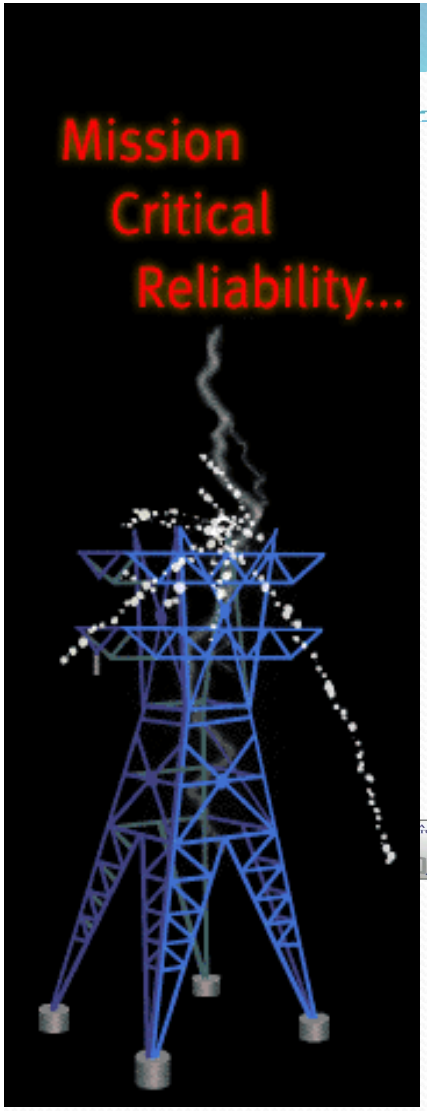
RTU 10

IED



Stand Alone SCADA

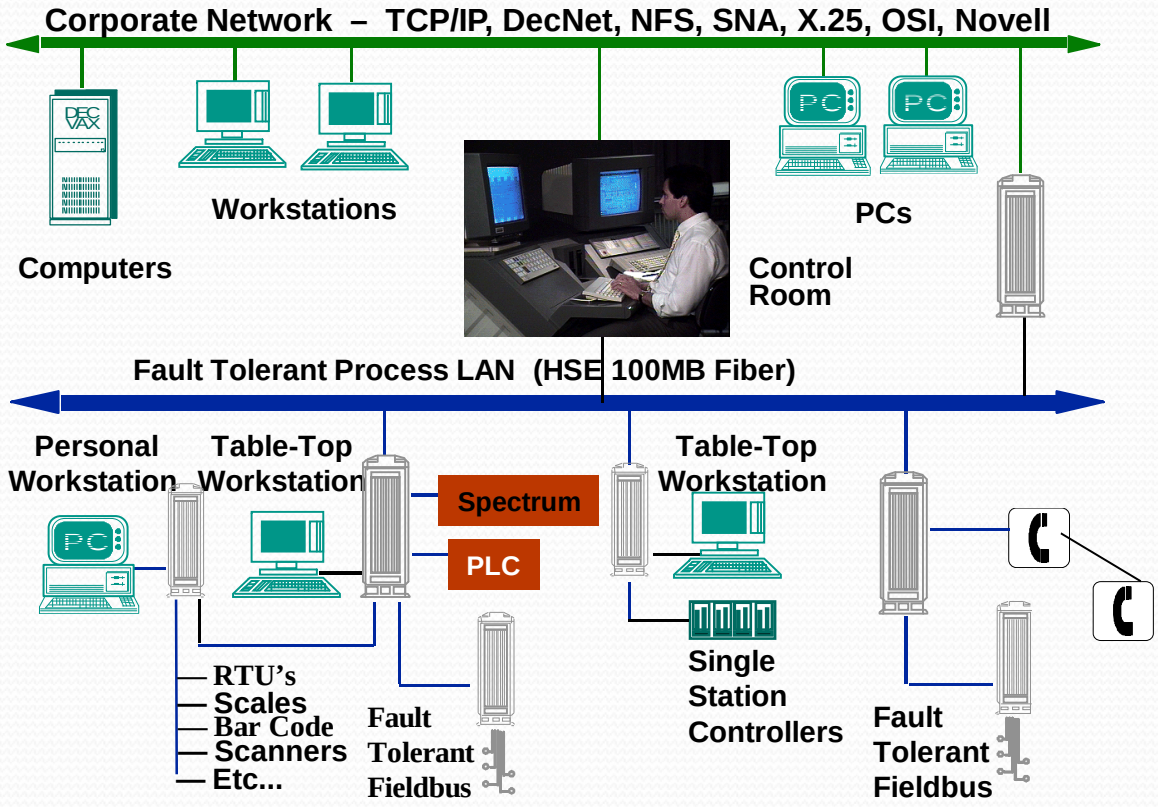




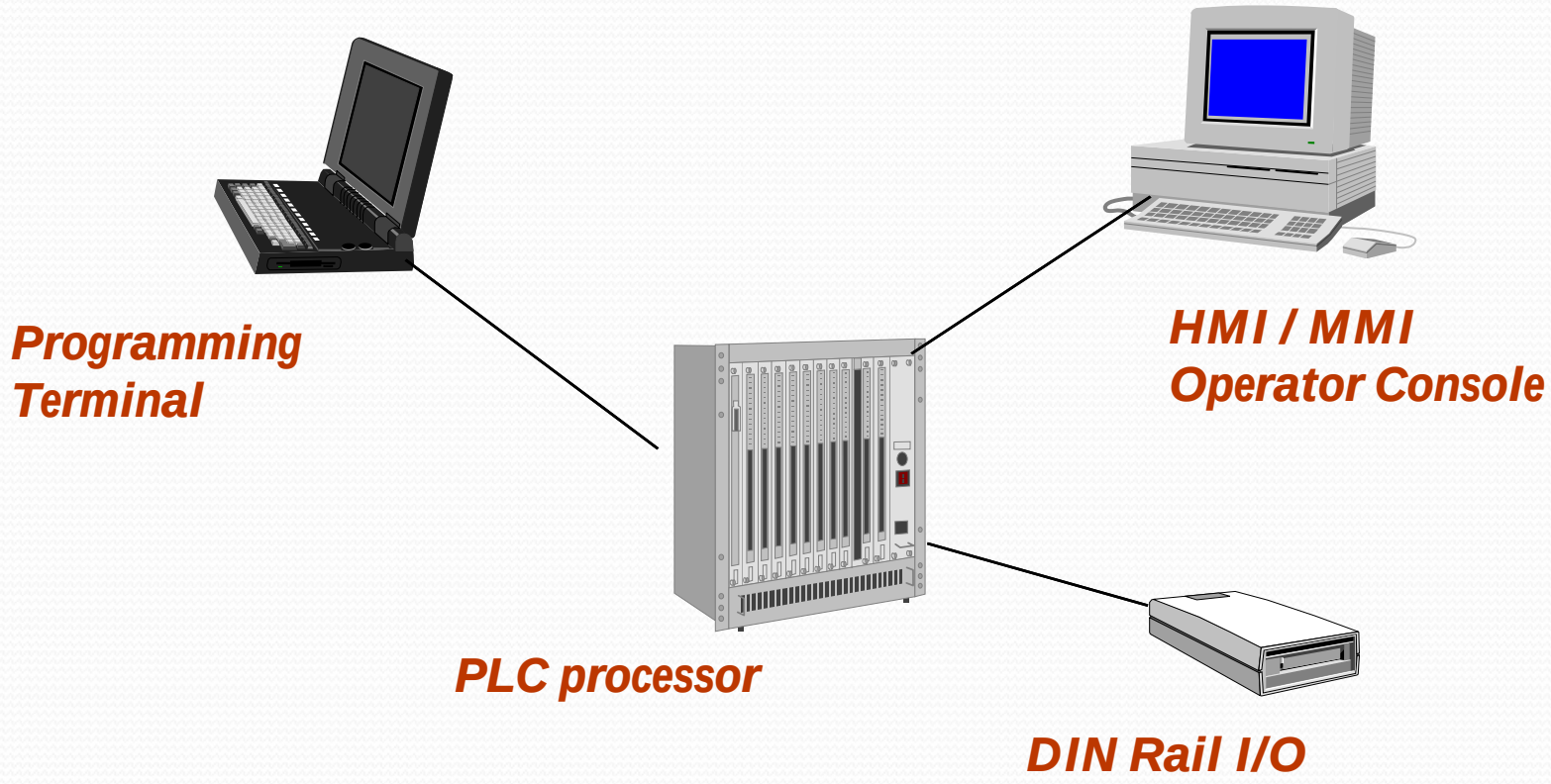
Networked SCADA

Alarm/Event Printer
Report Printer
Print Server
Print Server
SCADA Server Historical Archiving
SCADA Server Data Acquisition
Redundant Ethernet LAN 802.3
Data Concentrator
Fiber Optic Converter
Modem & Radio
Modem & Radio
Modem & Radio
Modem & Radio
Field Data Acquisition & Local control
RTU 1
RTU 2
RTU 3
Serial Line
Serial Line
Serial Line
Fiber Optic Converter
Fiber Optic Converter
Fiber Optic Converter
Fiber Optic Cable

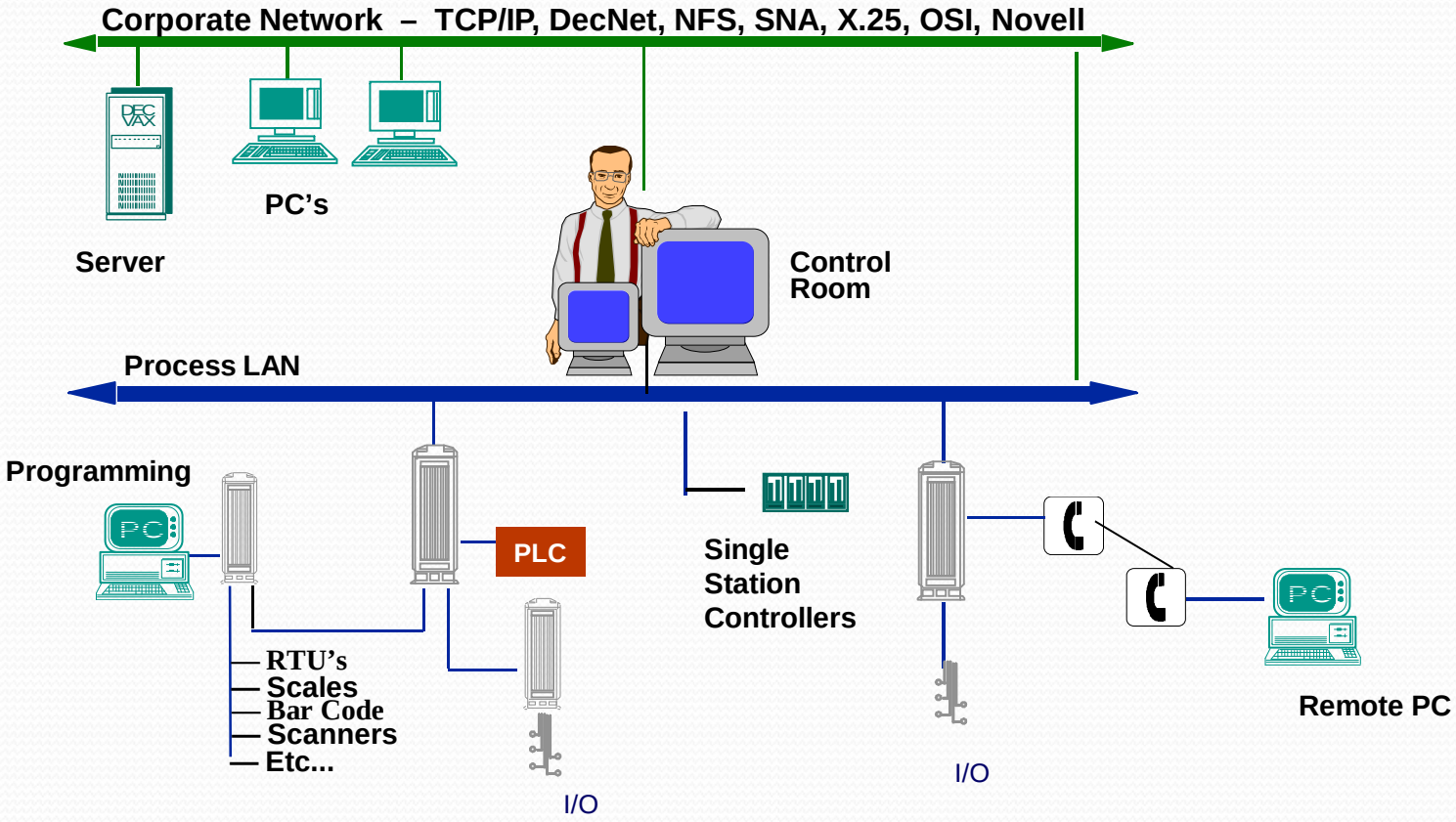
Plant Control (DCS world)



Stand Alone HMI / PLC



Networked HMI/PLC



Today's issues

- ✓ Distributed Control into the field
- ✓ Distributed Computing
- ✓ Distributed I/O into the field
- ✓ Services, Applications, Solutions
- ✓ Industry Standards
- ✓ Configurator tools
- ✓ Asset Management
- ✓ Performance guarantees ($)
- ✓ Life Cycle Costs (scalability / migration / upgrades)
- ✓ Digital bus selection

SCADA control

Electric power generation, transmission and distribution: Electric utilities detect current flow and line voltage, to monitor the operation of circuit breakers, and to take sections of the power grid online or offline.

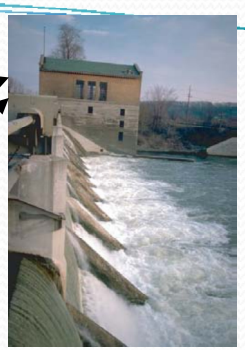
Manufacturing: manage parts inventories for just-in-time manufacturing, regulate industrial automation and robots, and monitor process and quality control.

Buildings, facilities and environments: Facility managers use SCADA to control HVAC, refrigeration units, lighting and entry systems.

Mass transit: regulate electricity to subways, trams and trolley buses; to automate traffic signals for rail systems; to track and locate trains and buses; and to control railroad crossing gates.

Water and sewage: State and municipal water utilities use SCADA to monitor and regulate water flow, reservoir levels, pipe pressure and other factors.

Traffic signals: regulates traffic lights, controls traffic flow and detects out-of-order signals.



WATER DISTRIBUTION SYSTEM

POWER DISTRIBUTION SYSTEM

Remote Telemetry Unit (RTU)

SCADA MASTER UNITS

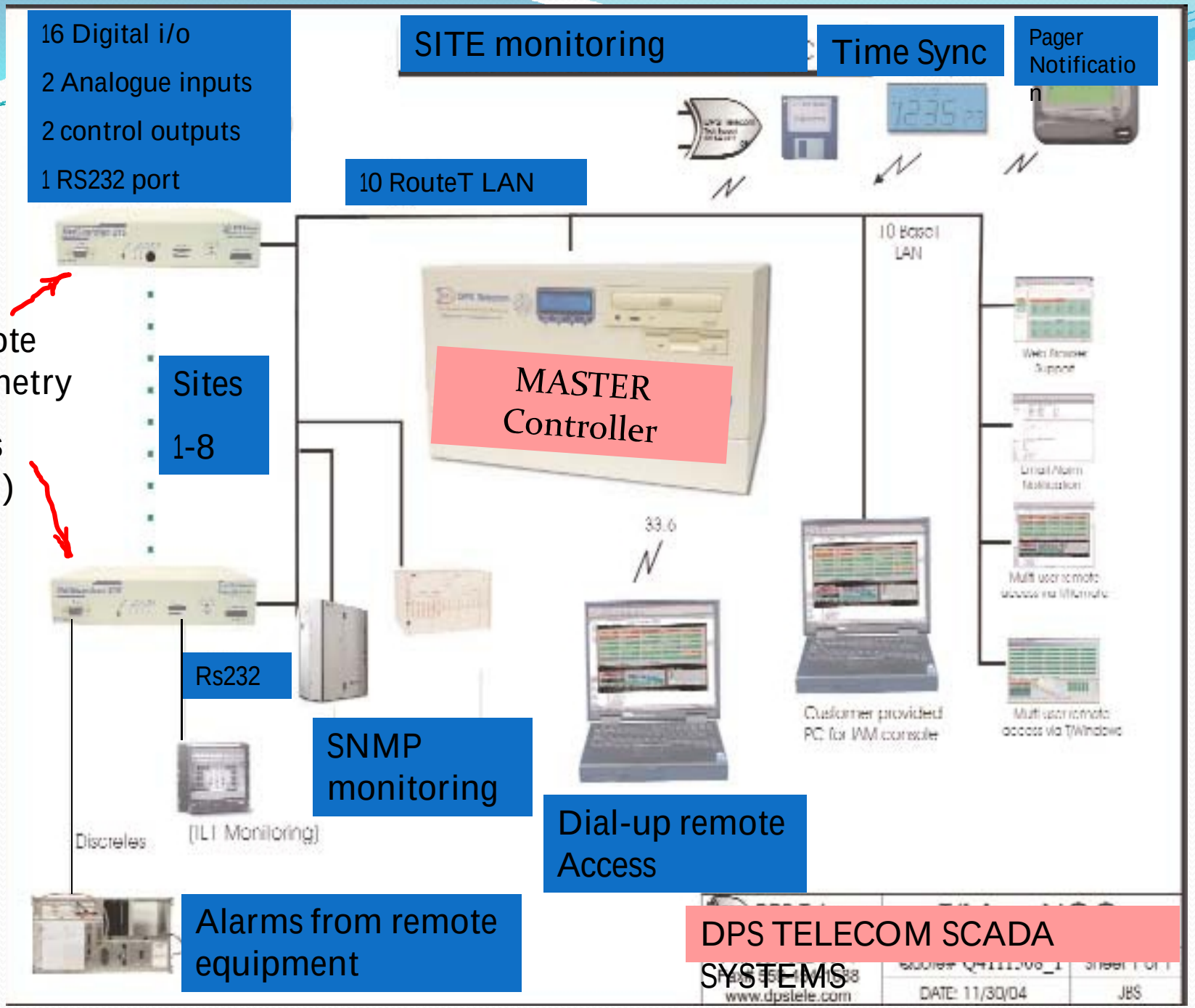
HUMAN COMPUTER INTERFACE

Remote Telemetry Unit (RTU)

TRANSPORT SYSTEM

PETROCHEMICAL PLANT

PROCESS PLANT


16 Digital i/o
2 Analogue inputs
2 control outputs
1 RS232 port
SITE monitoring
Time Sync
Pager Notification
10 RouteT LAN
Remote Telemetry Units (RTU)
Sites 1-8
MASTER Controller
10 Base-T LAN
33.6
Rs232
SNMP monitoring
Dial-up remote Access
Discretes
(IL1 Monitoring)
Alarms from remote equipment
DPS TELECOM SCADA SYSTEMS
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Functions of SCADA

- 1. Data acquisition
- 2 Networked data communication
- 3. Data presentation
- 4. Control.

These functions are performed by four kinds of SCADA components:

1. Sensors (either digital or analogue) and control relays that directly interface with the managed system.
2. Remote telemetry 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. 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.

Data Acquisition

- SCADA system needs to monitor hundreds or thousands of sensors.

Sensors measure:

1. Inputs and outputs e.g. water flowing into a reservoir (input), valve pressure as water is released from the reservoir (output).
2. Discrete inputs (or digital input) e.g. whether equipment is on or off, or tripwire alarms, like a power failure at a critical facility.
3. Analogue inputs: where exact measurement is important e.g. to detect continuous changes in a voltage or current input, to track fluid levels in tanks, voltage levels in batteries, temperature and other factors that can be measured in a continuous range of input.

- For most analogue factors, there is a normal range defined by a bottom and top level e.g. temperature in a server room between 15 and 25 degrees Centigrade. If the temperature goes outside this range, it will trigger a threshold alarm.
- In more advanced systems, there are four threshold alarms for analogue sensors, defining Major Under, Minor Under, Minor Over and Major Over alarms.

Data Communication

A communications network is required to monitor multiple systems from a central location.

•TREND: put SCADA data on Ethernet and IP over SONET.

• SECURITY: Keep data on closed LAN/WANs without exposing sensitive data to the open Internet.

• Encode data in protocol format (use open, standard protocols and protocol mediation)

• Sensors and control relays can't generate or interpret protocol communication - a remote telemetry unit (RTU) is needed to provide an interface between the sensors and the SCADA network.

• RTU encodes sensor inputs into protocol format and forwards them to the SCADA master;

• RTU receives control commands in protocol format from the master and transmits electrical signals to the appropriate control relays.

Data Presentation

SCADA systems report to human operators over a master station, HMI (Human-Machine Interface) or HCI (Human-Computer Interface).

SCADA master station has several different functions:

- continuously monitors all sensors and alerts the operator when there is an “alarm”
- presents a comprehensive view of the entire managed system,
- presents more detail in response to user requests
- performs data processing on information gathered from sensors
- maintains report logs and summarizes historical trends.

Selection of RTU's

RTUs need to:

• communicate with all on-site equipment

• survive an industrial environment. **Rugged construction** and ability to withstand **extremes of temperature and humidity** (it needs to be the most reliable element in your facility).

• have **sufficient capacity** to support the equipment at a site (though should support expected growth over a reasonable period of time).

• have a **secure, redundant power supply** for 24/7 working, support battery power and, ideally, two power inputs.

• have **redundant communication ports** e.g. secondary serial port or internal modem to keep the RTU online even if the LAN fails (multiple communication ports easily support a LAN migration strategy)

• have **nonvolatile memory (NVRAM)** for storing software and/or firmware. New firmware downloadable over LAN to keep RTU capabilities up to date without excessive site visits

• control local systems by themselves (Intelligent control) according to programmed responses to sensor inputs

Selection of SCADA Master

A SCADA master should display information in the most useful ways to human operators and intelligently regulate managed systems. It should :

• have flexible, programmable soft controls to respond to sensor inputs

• allow programming for soft alarms (reports of complex events that track combinations of sensor inputs and date/time statements).

• automatically page or email directly to repair technicians and provide detailed information display in plain English, with a complete description of what activity is happening and how to manage it.

• have tools to filter out nuisance alarms (to prevents operators from loosing confidence and stop responding even to critical alarms)

• support multiple backup masters, in separate locations (primary SCADA master fails, a second master on the network automatically takes over, with no interruption of monitoring and control functions)

• support multiple open protocols to safeguard the SCADA system against unplanned obsolescence.

SCADA for Power Utility Network

- The aim of power network utilities(PNU) software is to provide the electrical utility with tools which will enhance the operation of the system in a very cost effective way.in the present scenario of low budgets for power utilities to produce and distribute quality power at the minimum cost.
- This goal can be achieved by proper operation of the electrical network and at the same time having real time data about state of the network.
- This real time data can then be used for supervisory controlled changes of the network parameters with effective guidance from distribution automation tools.
- The PNU software utilizes the real time SCADA data.
- The real time network topology network component details & user defined strategies to achieve the above mentioned goals.
- PNU uses a combination of mathematical and logical techniques to provide the user with a host of applications for the purpose of distribution automation.

Major components of SCADA:

- 1) A collection of equipments that is provide the operator at remote location with enough information to determine the status of particular piece of equipment or entire substation or a plant or a dynamic network and cause actions to take place regarding that equipment or network without being physically present.
- 2) An arrangement for operator control and separation of remotely located apparatus using multiplexing techniques once a relatively small number of interconnecting channels.
- 3) Collecting Data from remote electrical equipment and controlling then through suitable communication medium.

SCADA Architecture

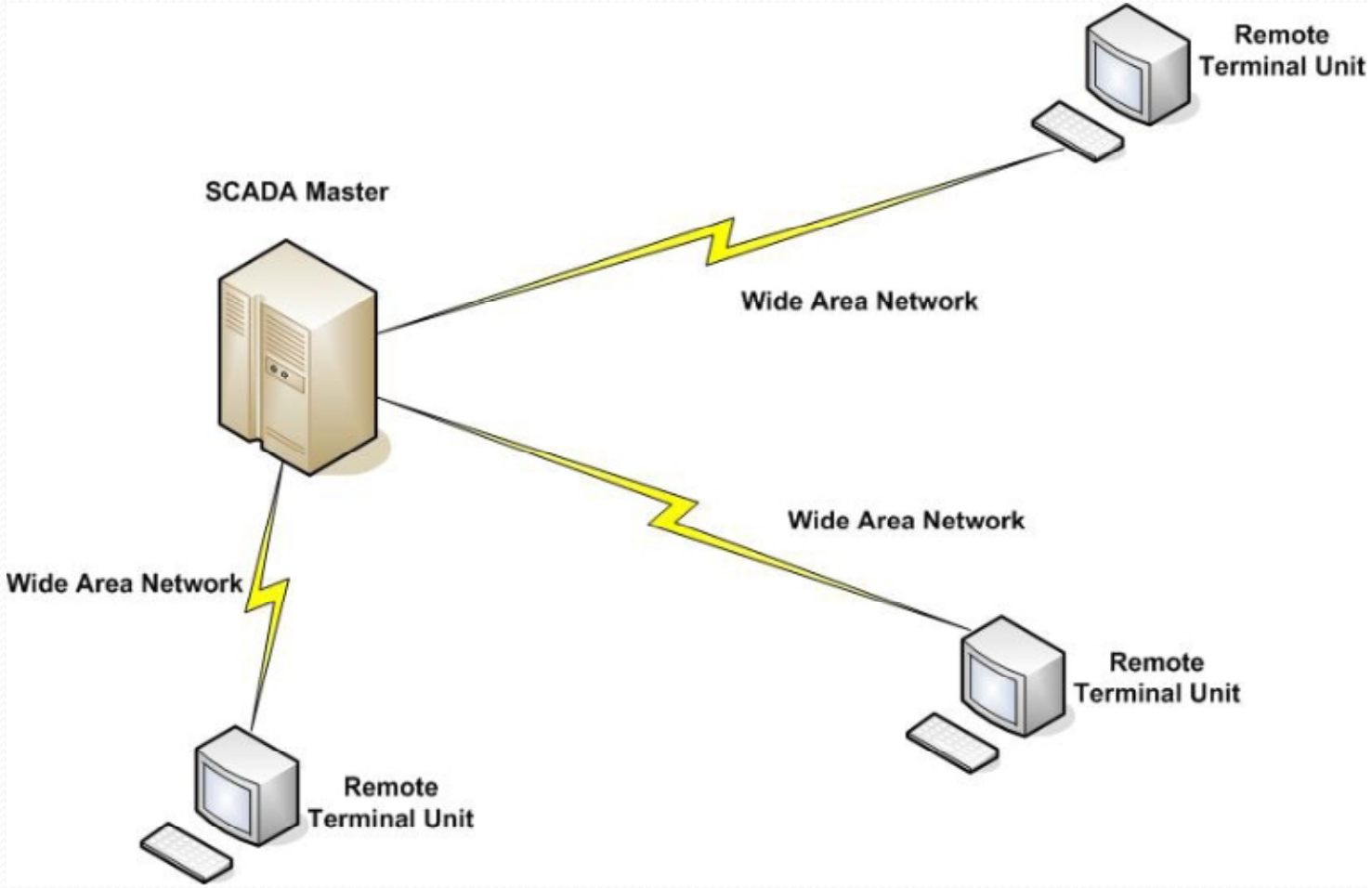
- **First Generation – Monolithic**
- **Second Generation – Distributed**
- **Third Generation – Networked**

Monolithic SCADA Systems

- Standalone systems with virtually no connectivity to other systems
- Communication protocols developed by vendors of RTU equipment
- Protocols have no functionality beyond that required

- Not feasible to intermingle other types of data traffic with RTU communications
- Very limited connectivity to the SCADA master station by the system vendor
- Use of two identically equipped mainframe systems, a primary and a backup

First Generation SCADA System

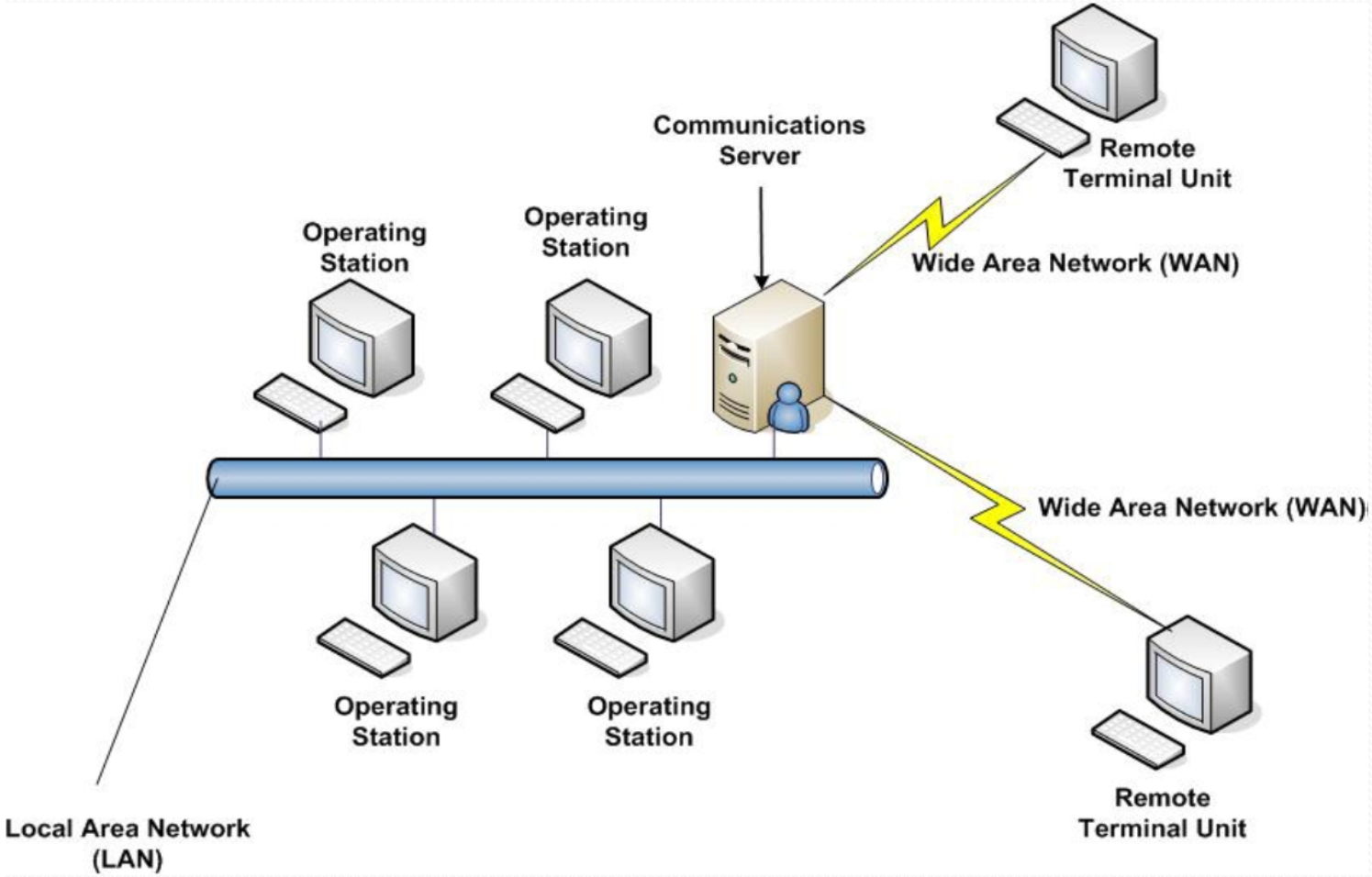


Distributed SCADA Systems

- Vendor controlled, proprietary environment
- Improvement in system miniaturization
- LAN technology to distribute the processing across multiple systems
- Distribution of system functions across multiple systems

- Networks not capable of reaching beyond the limits of the local environment
- Vendor creates its own network protocol
- External communications networks were limited to RTU protocols
- Improves the redundancy and reliability of the system

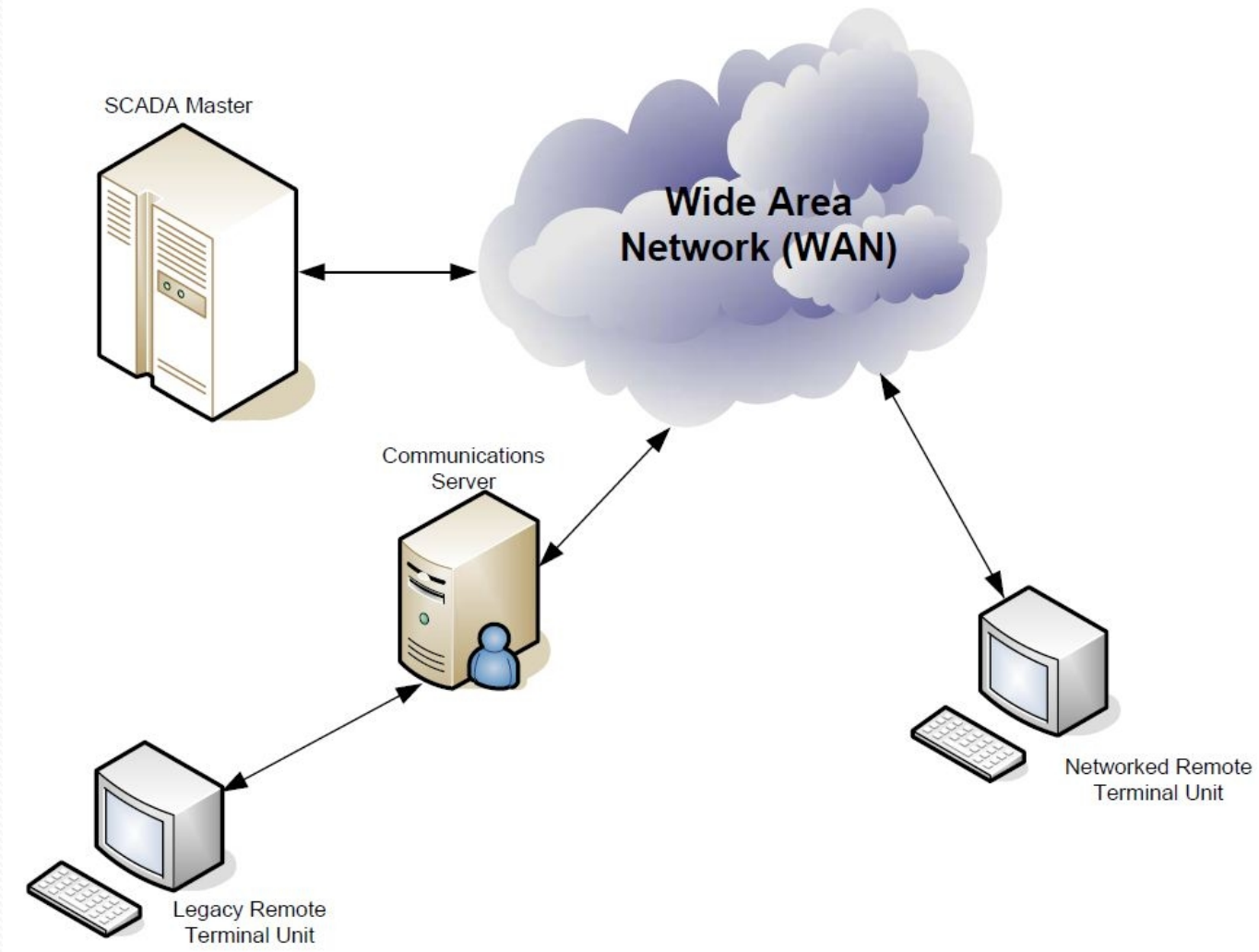
Second Generation SCADA System



Networked SCADA Systems

- Open system architecture
- Multiple networked systems, sharing master station functions
- Utilizing open standards and protocols
- Distribute SCADA functionality across a WAN

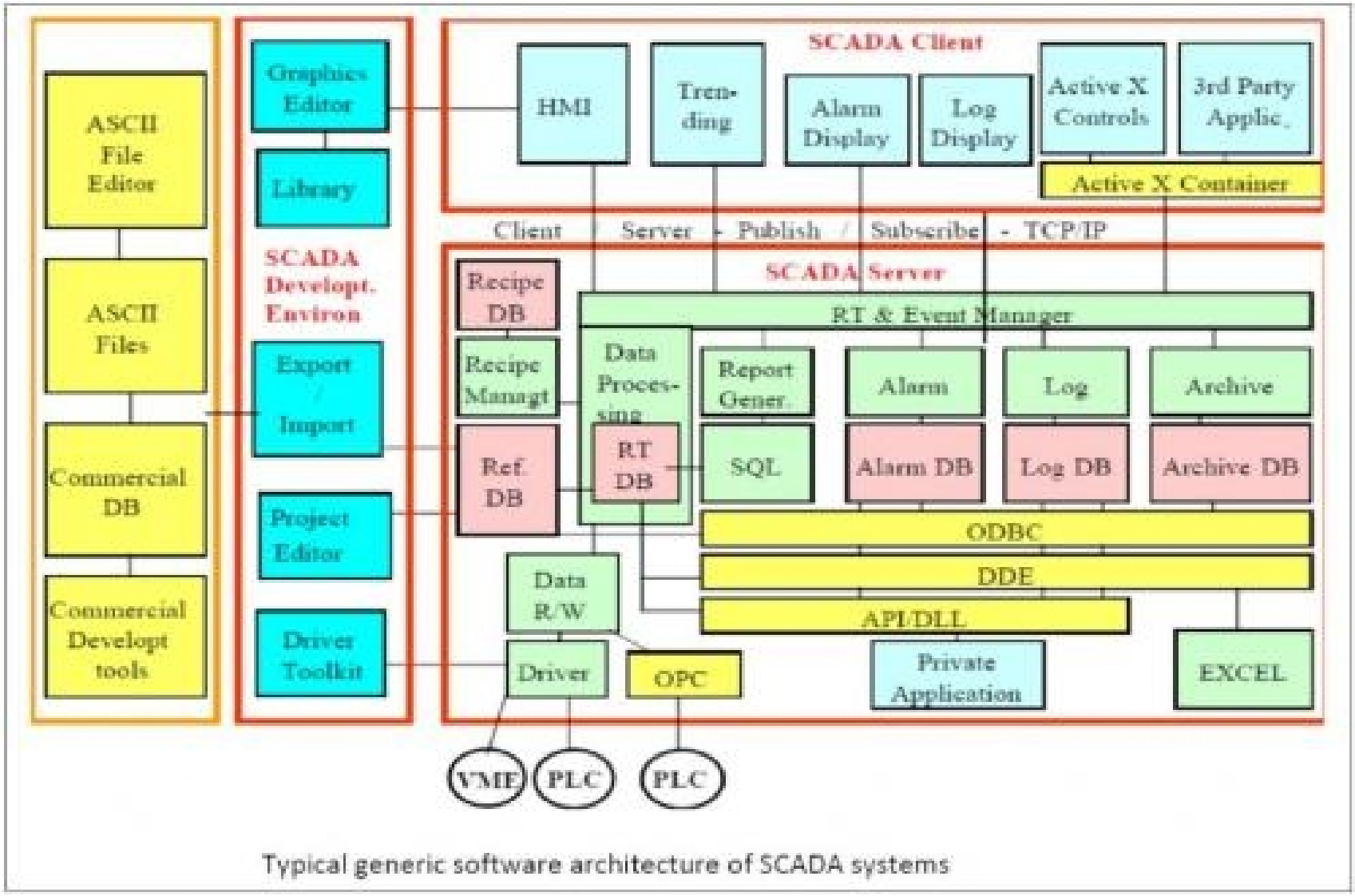
Third Generation SCADA System



Hardware Architecture:

- The generally SCADA system can be classified into two parts:
- Clint layer
- Data server layer
- The Clint layer which caters for the man machine interaction.
- The data server layer which handles most of the process data activities.

SOFTWARE ARCHITECTURE OF SCADA



Typical generic software architecture of SCADA systems

Software Architecture

- Most of the servers are used for multitasking and real time database. The servers are responsible for data gathering and handling. The SCADA system consists of a software program to provide trending, diagnostic data, and manage information such as scheduled maintenance procedure, logistic information, detailed schematics for a particular sensor or machine and expert system troubleshooting guides. This means the operator can sea a schematic representation of the plant being controlled.
- **EX:** alarm checking, calculations, logging and archiving; polling controllers on a set of parameter, those are typically connected to the server.