



# Power Industry Communication Protocol Features and Benefits

IEC-60870-5-101/103/104  
DNP 3 (Serial and Ethernet)  
IEC 61850

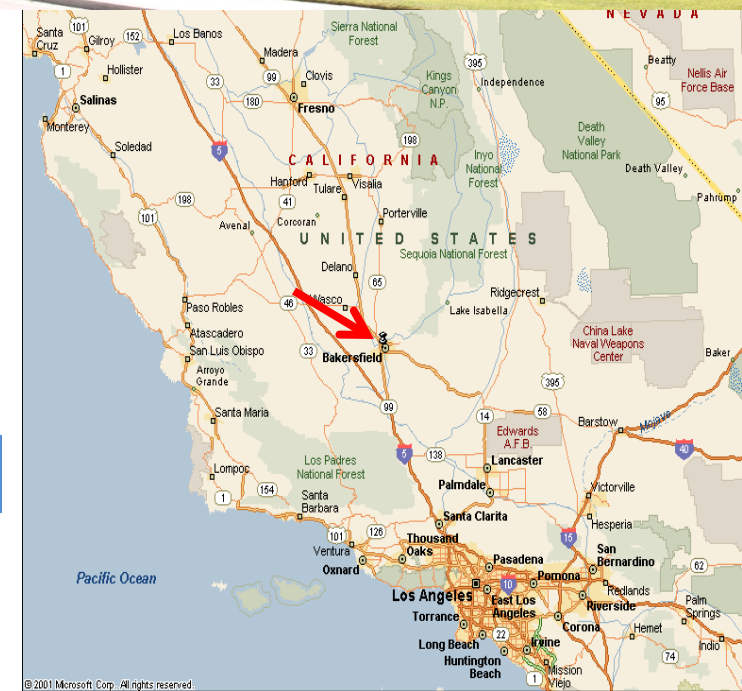
Erik Syme  
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ProSoft Technology, Inc.

**ProSoft**  
TECHNOLOGY

*Where Automation Connects.™*

# ProSoft Technology Company Overview

- ❖ Privately Held Company
  - ◆ Incorporated in 1990
  - ◆ First products in 1988
- ❖ HQ in Bakersfield, CA
- ❖ Global Organization
  - ◆ Over 120 employees worldwide
- ❖ Strong application experience
  - ◆ Industrial communication



# Over +60 Protocols

## ❖ Serial Protocols

- ◆ Modbus
- ◆ DF1, ASCII, DH485
- ◆ DNP3
- ◆ IEC 60870-5-101 & 103
- ◆ Siemens 3964R
- ◆ Johnson Control Metasys N2
- ◆ BACnet MS/TP

## ❖ Specialty Modules

- ◆ 'C' Programmable
- ◆ Gas Flow Computing
- ◆ InChassis PC

## ❖ SCANport modules

- ◆ Profibus
- ◆ Modbus, Modbus Plus
- ◆ Metasys N2

## ❖ Ethernet Protocols

- ◆ EtherNet/IP
- ◆ Modbus TCP/IP
- ◆ IEC 60870-5-104
- ◆ DNP3 Ethernet
- ◆ ASCII Ethernet
- ◆ GE Global Data
- ◆ FL-Net
- ◆ BACnet I/P
- ◆ Open Ethernet Port "C"

## ❖ Fieldbus Protocols

- ◆ HART Multidrop
- ◆ HART Analog
- ◆ Honeywell DE
- ◆ Profibus DPV1
- ◆ Modbus Plus
- ◆ CC-Link
- ◆ Lonworks
- ◆ DeviceNet

# Agenda

- ❖ Power Sector Growth
- ❖ Why use Logix in energy projects
- ❖ What are the advantages of the DNP/IEC protocols that make them a good fit for energy projects
- ❖ Application information
- ❖ Future energy protocol trends (IEC-61850)

# Power Sector Growth

- ❖ The US power sector faces the possibility of \$828 billion to a wide range of capital investments and expenses between 2012 and 2020
- ❖ Energy prices estimated to grow by 37 percent by 2020



# Renewable Energy Trends

- ❖ As of 2010, about 16% of global energy from renewables
  - ◆ 10% coming from traditional biomass
  - ◆ 3.4% from hydroelectricity
  - ◆ New renewables account for 2.8%
    - small hydro,
    - modern biomass,
    - wind,
    - solar,
    - geothermal
- ❖ Grid-connected solar increased 60% annually
- ❖ Wind power growing 30% annually

# Logix PAC in alternative energy

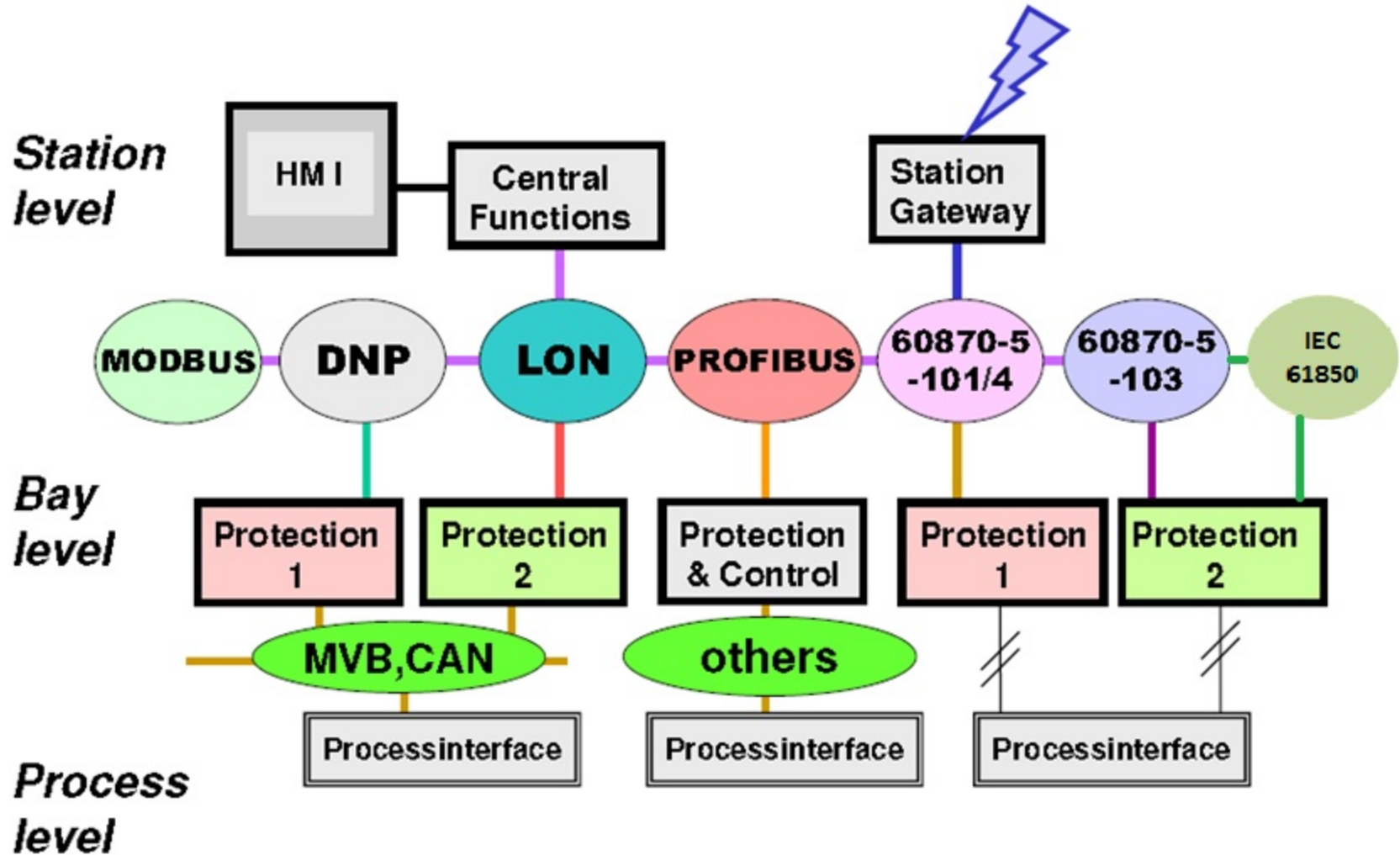
- ❖ Load shedding
- ❖ Substation RTU
- ❖ Data concentration
- ❖ Power monitoring
- ❖ Solar array monitoring and control
- ❖ Wind monitoring and control
  
- ❖ Benefits
  - ◆ Take advantage of Logix features for PlantPAX
  - ◆ Asset management
  - ◆ Library of AOI's and Faceplates for power industry

# Why do energy applications require special protocols?

- ❖ Energy Applications have special requirements
  - ◆ Slave initiated communications by RTU or IED
  - ◆ Data may need to be designated high/low priority
  - ◆ Data may need to be grouped
  - ◆ report by exception
  - ◆ Sequence of events reporting with time stamped event data
  - ◆ Slave to Slave communications



# Protocols used in power delivery today



# Modbus

- ❖ Master-Slave communication model
- ❖ developed by Modicon in 1979
- ❖ Benefits
  - ◆ Well established (over 7 Million nodes in NA and EU alone)
  - ◆ Simple
- ❖ Drawbacks
  - ◆ Inefficient
  - ◆ Simple data types (INT and BOOL)
  - ◆ Static data only
- ❖ Still widely used today!!!
  - ◆ de facto standard in multi-vendor integration



# Food Processing - Solar Power



❖ Seabrook Bros. Farms – 3 megawatt solar array

## ❖ Challenges

- ◆ High energy costs – refrigeration for frozen foods
- ◆ Monitor solar panel power inverters and combiner box status running on a Modbus network with thousands of feet of distance between inverters
- ◆ Monitor generation/usage data and get this information to the PAC and the FactoryTalk® System
- ◆ Avoid the high cost of trenching fiber cable to obtain data from system spanning 43 acres

## *Wireless Modbus*

Rockwell Technology:

- CompactLogix™
- FactoryTalk® ViewPoint



[http://www.dcoenergy.com/project\\_experience.html#20\\_s\\_eabrook\\_farms\\_solar\\_facility](http://www.dcoenergy.com/project_experience.html#20_s_eabrook_farms_solar_facility)

# Food Processing - Solar Power

## ❖ Solution Details

- ◆ CompactLogix™ PAC & FactoryTalk® ViewPoint
- ◆ ProSoft Technology MVI69-MCM ModBus RTU module
- ◆ ProSoft RLX-IFH9S (900Mhz Frequency Hopping Serial) Radios to link communications between Modbus Master and DC power inverters.

## ❖ Benefit

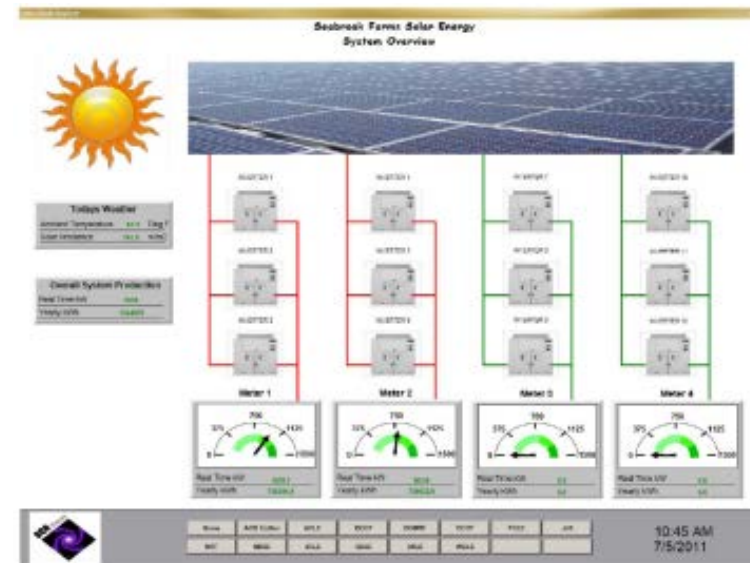
- ◆ Solar system reduces power consumption from the utility company for the plant
- ◆ Precise energy usage monitored remotely
- ◆ CompactLogix™ optimizes power efficiency
- ◆ Over 8 million kilowatt-hours of zero emission, carbon free solar energy on an annual basis



## *Wireless Modbus*

Rockwell Technology:

- CompactLogix™
- FactoryTalk® ViewPoint



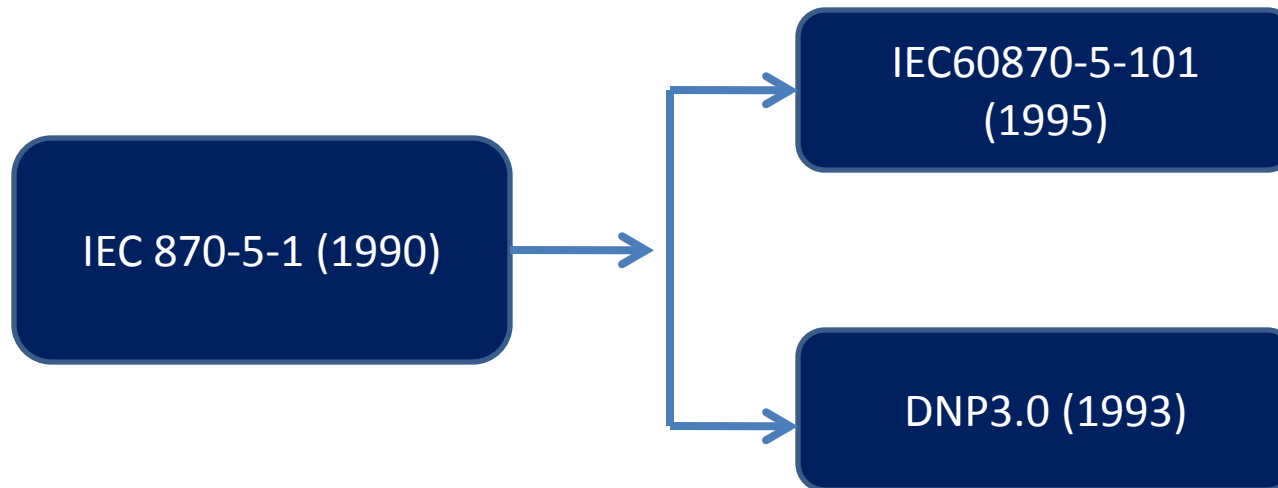
# Limitations of Modbus

- ◆ No time stamp of data values
- ◆ No indications of a disturbance event
- ◆ Master must always ask slave device for data, slave cannot initiate communications to master
- ◆ No common data formats between devices

# IEC 60870-5 and DNP3 Protocol-

- ❖ IEC 60870-5 and Distributed Network Protocol (DNP3) are 2 open protocols that provide interoperability between systems for tele-control applications

## Standard Development





# IEC 60870-5 and DNP3 Protocol-

- ❖ DNP3 dominant in NA , Latin, South Africa and Australia
  - ◆ Water/Waste Water and Oil and Gas
- ❖ IEC-60870-5 protocols Dominant in Europe, Middle East and Asia Pacific

# What is IEC60870-101/103/104

- ❖ **IEC 60870-5-101/103/104** for power system monitoring, control
  - ◆ 101 Serial communication
  - ◆ 103 Protection relays
  - ◆ 104 Ethernet implementation

# IEC-60870-5-101/103/104

- ❖ Supports 2 modes of data transfer.
  - ◆ unbalanced (master initiated message) & balanced (master/slave initiated message)
- ❖ Data is classified into different information objects and each information object is provided with a specific address.
- ❖ Facility to classify the data into high priority (class-1) and low priority (class-2) and transfer the same using separate mechanisms.

# IEC-60870-5-101/103/104

## ❖ Features of IEC 60870-5-104

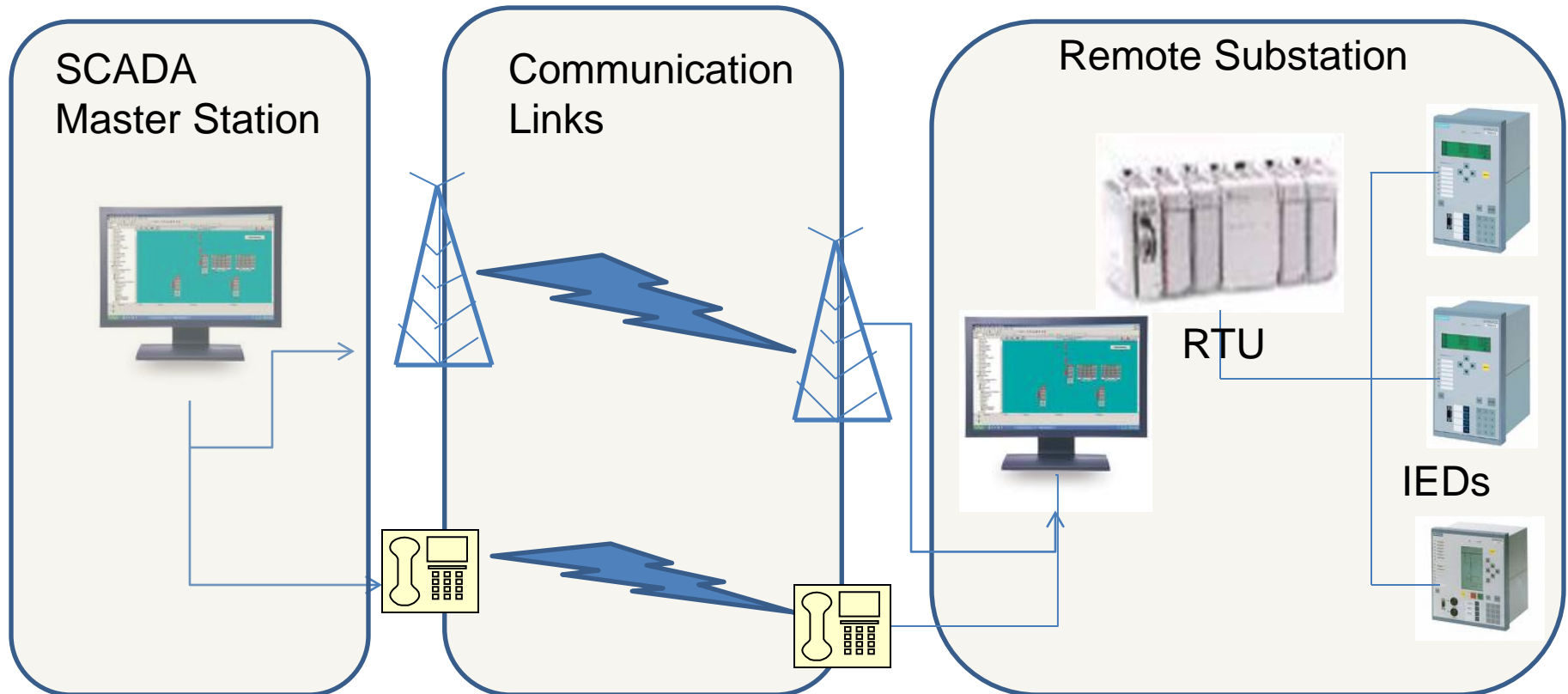
- ◆ Classify data into different interrogation groups (1-16) to get the data according to the group by issuing specific group interrogation command.
- ◆ Cyclic & Spontaneous data updating schemes are provided.
- ◆ Facility for time synchronization

## ❖ Benefits of IEC 60870-5-104

- ◆ Ability to group data by points
- ◆ Monitor and Control directions
- ◆ M\_NA\_SP, M\_NA\_DP, etc...
- ◆ Greater grouping of data based on priority of information (Class 1 and 2).
- ◆ Time stamped data (CP24 and CP56)

# DNP3 Protocol Overview

- ❖ DNP3 is primarily used for communications between a master station and IEDs or RTUs



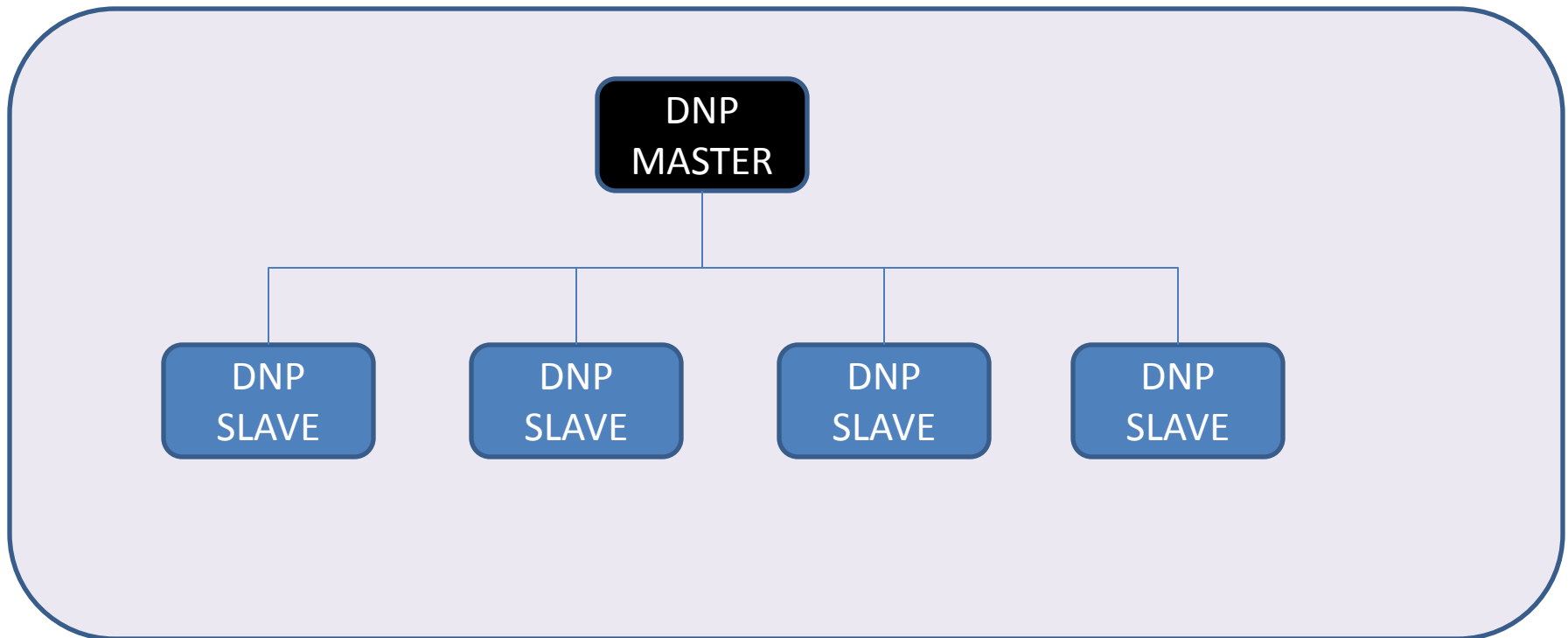
# DNP3 Applications

- ❖ Substation Automation
- ❖ Wind Power Generation
- ❖ Solar Power Generation
- ❖ Oil and Gas
- ❖ Mining and Minerals
- ❖ Water/Waste Water Automation

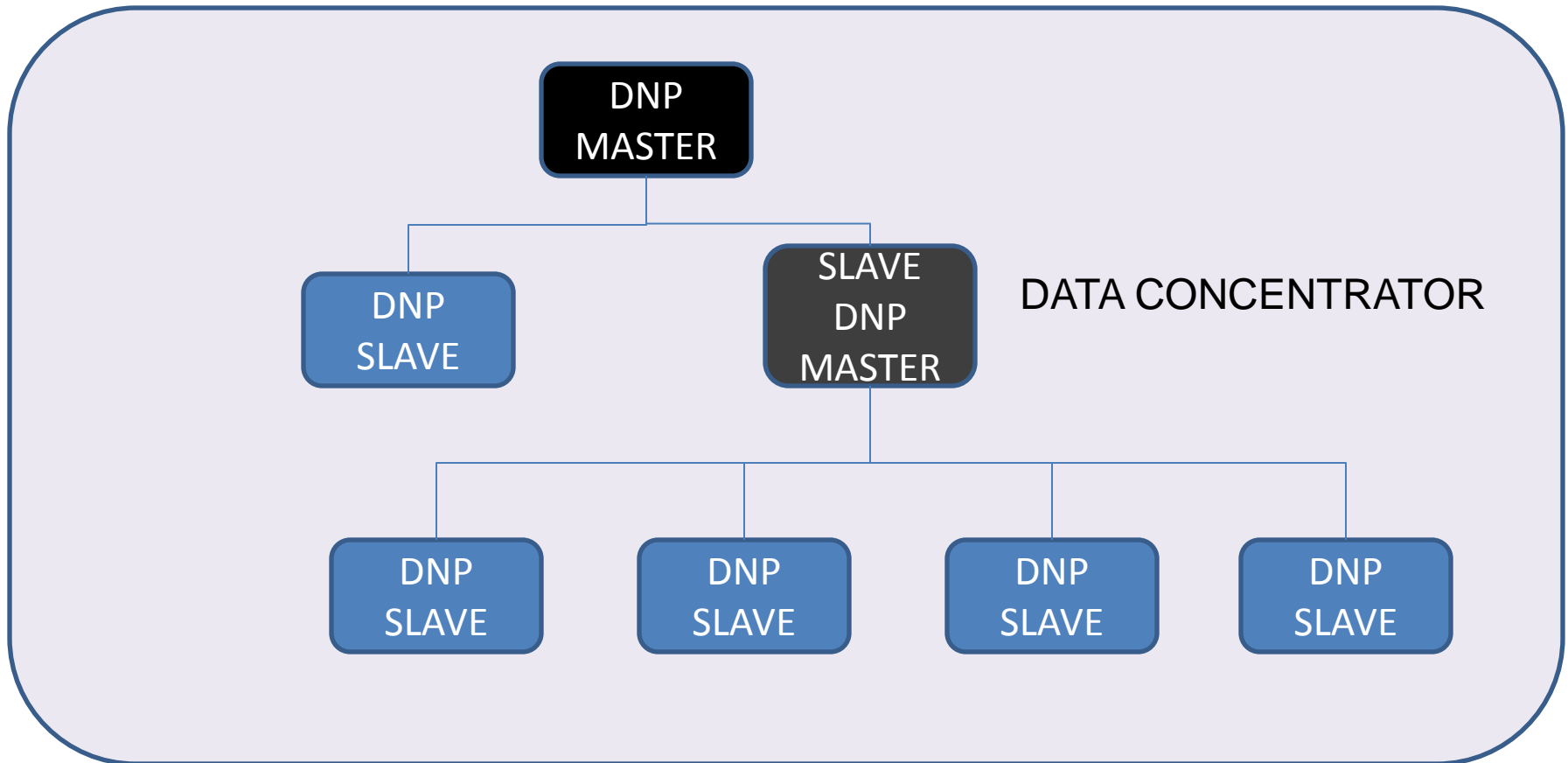


# DNP3 Typical Applications

- ❖ DNP3 is typically used in the following configuration  
MULTIDROP CONFIGURATION



# DNP3 Network Topology



# DNP3 Features and Benefit

- ❖ Complex data types
  - ◆ INT, DINT, REAL, BOOL, dual point Binary, Counters with Quality Flags
- ❖ Time Stamped Event data
  - ◆ Events generated by change of state (BOOL)
  - ◆ By deadband (Analog)
- ❖ Unsolicited Report by exception
- ❖ Group data by class
  - ◆ Class 1, 2, and 3
  - ◆ All static data grouped to Class 0

# Why DNP3?

## Standardization & Interoperability

- ❖ It is an open protocol and is optimized for SCADA communications
- ❖ It provides interoperability between different vendor's equipment
- ❖ It is supported by a substantial number of SCADA equipment manufacturers

# Extensions of DNP3

## Industry-Specific Layers

- ❖ DNP3 is not a static, unchanging protocol. DNP3 allows for extensions to the protocol.
- ❖ Users can define complete data structures, to pass industry specific information, in complete context.
- ❖ This extension of DNP3 standardizes water industry data for:
  - ❖ Asset Management
  - ❖ Incremental Configuration
  - ❖ Device Status
  - ❖ Logging
  - ❖ Alarming

# Hydro Electric

## ❖ Snowy Hydro Upgrade

## ❖ Challenges

- ◆ Upgrade control system from wired relay logic control to a modern PAC with electronic operator interface
- ◆ Maintain reliability
- ◆ Collection of a large amount of real-time operational information
- ◆ Maintain DNP 3.0 connection to SCADA system and protection relays



[http://domino.automation.rockwell.com/applications/css\\_artilce.nsf/0/d5c53a8c7968251186257715005eaf09?OpenDocument&Click=](http://domino.automation.rockwell.com/applications/css_artilce.nsf/0/d5c53a8c7968251186257715005eaf09?OpenDocument&Click=)



# Hydro Electric

## ❖ Solution Details

- ◆ ControlLogix® PAC
- ◆ FactoryTalk AssetCentre
- ◆ PanelView Plus
- ◆ Powermonitor 3000
- ◆ MVI56-DNP



## ❖ Benefits

- ◆ Logix PAC provided redundancy support with high reliability for the system
- ◆ Advanced diagnostics tools allow ability to interrogate more than 40 PACs for changes with FT AssetCentre
- ◆ Obtain up to 10 times the amount of real-time operational data with interface to SCADA system on DNP3 network

# Land Fill Methane Gas to Energy Plant

## ❖ SX Renewable Energy Generation Facility

### ❖ Challenge

- ◆ Convert landfill gas into a 3.2 MW clean energy source
- ◆ Communicate with various power monitor devices on Modbus RTU and on the power breaker side with DNP3

### ❖ Solution Details

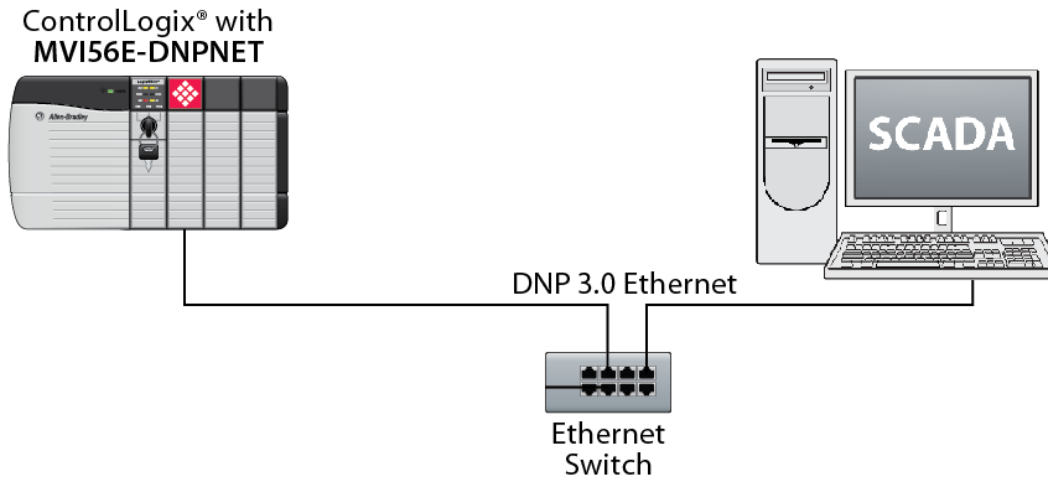
- ◆ CompactLogix™ PAC
- ◆ MVI69-DNP
- ◆ MVI69-MCM



### ❖ Benefit

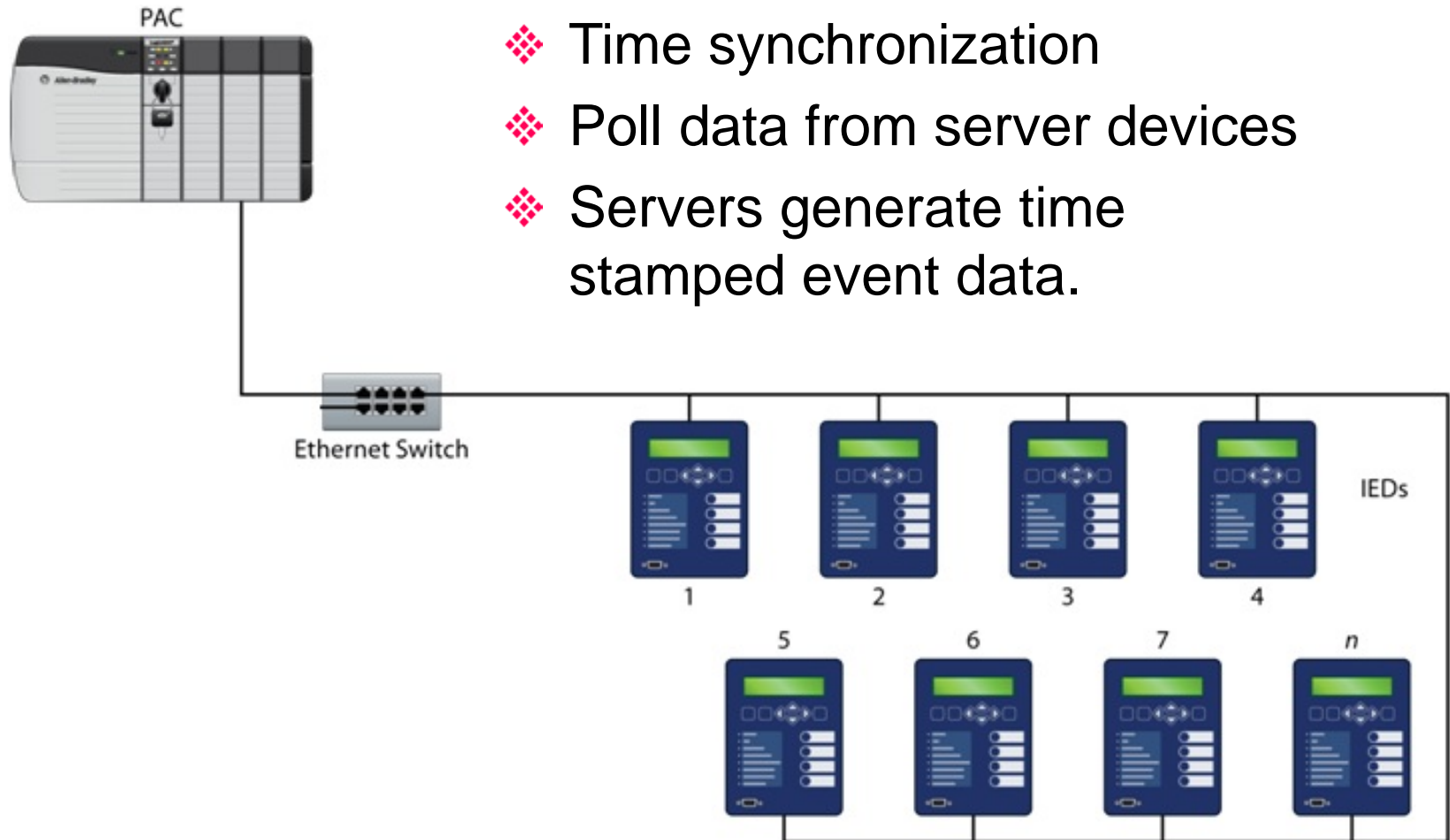
- ◆ The combination of the Logix based PAC and the ProSoft MVI69 series of communications options allowed for communications with both the power monitoring side as well as the breaker side, all while utilizing a cost effective PAC platform

# DNP3 Ethernet Server Application



- ❖ Supports one TCP/IP socket
- ❖ Unlimited UDP sockets for redundancy and communications with multiple clients
- ❖ Buffered event storage for Sequence of Events reporting with time stamp (up to 20,000 events)
- ❖ Unsolicited Report by Exception

# DNP3 Ethernet Client Applications

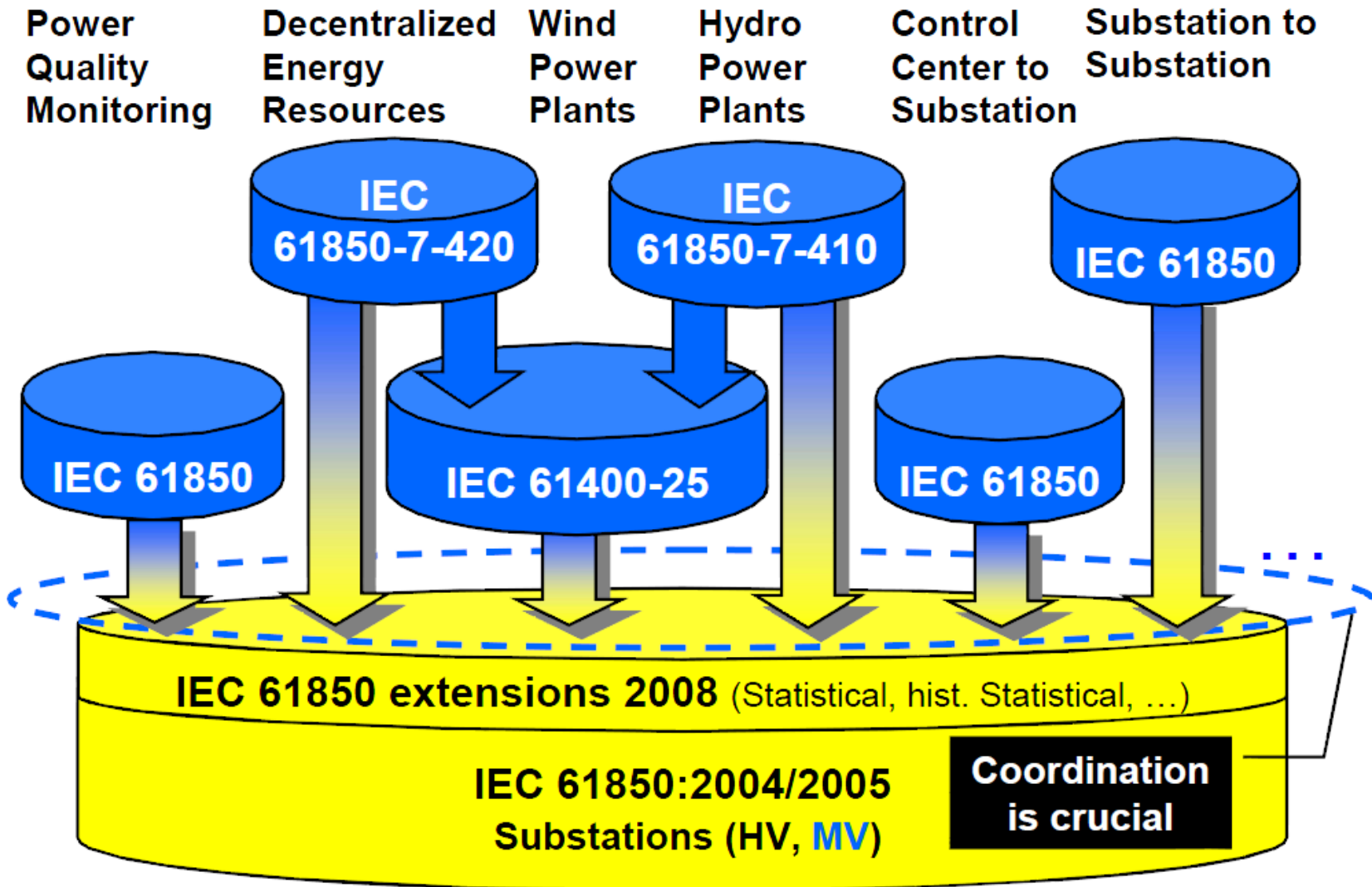


# Motivation From IEC 60870/DNP to 61850

Current Situation is:

- ❖ Take advantage of high speed Ethernet
- ❖ High Cost for data management
- ❖ Loss of Information and functions during each mapping of data
- ❖ Various device MFG had different implementations
- ❖ Many Substation Automation needs to be refurbished
- ❖ New investment in alternative energy meant more devices

# IEC 61850 in other domains



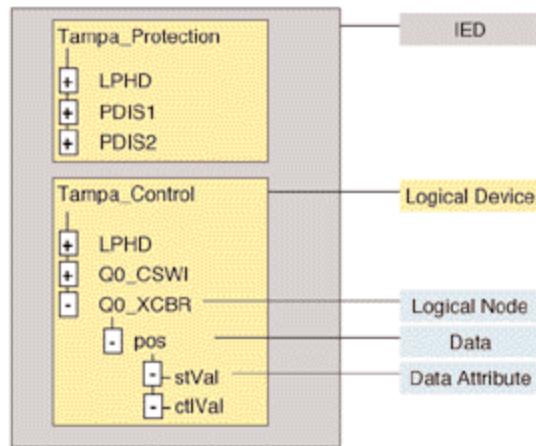
# What is IEC 61850 ?

- ❖ As an international standard for substation automation systems
- ❖ IEC 61850 defines the communication between devices in the substation and related system requirements it uses a publisher-subscriber concept
- ❖ It describes a structure for addressing interoperability of IED's beyond the protocol level
  - ◆ Common configuration language
  - ◆ Standardized object models and naming conventions
  - ◆ Self-describing devices
  - ◆ Standardized meaning of data
  - ◆ Standardized services and device behavior models
  - ◆ Profiles for Control/SCADA, Protection messaging, Transducers and I/O



# Object-Oriented

- ❖ IEC 61850 uses an object-oriented approach with Logical Nodes (LN)



Describes the physical IED

Multiple logical Devices per IED

Multiple “objects” logical Nodes per Device

Data point per logical Node

Multiple Attributes per Data point

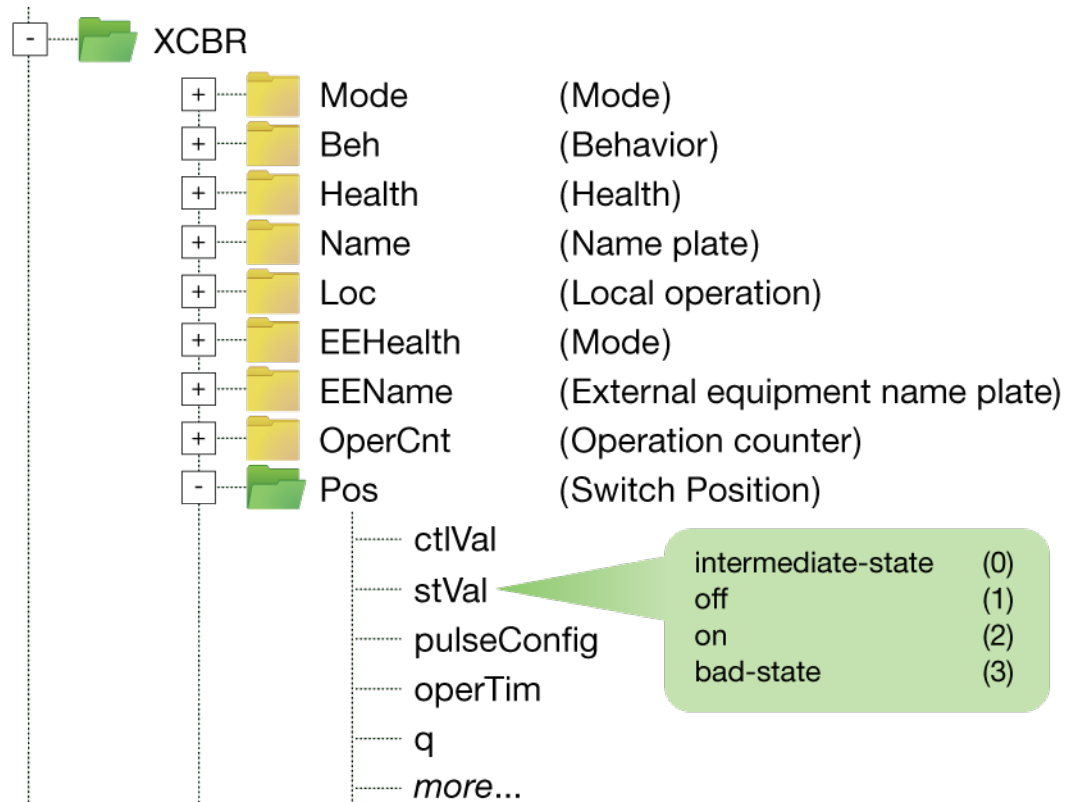
Examples are all data of a *circuit breaker* contained in the Logical Node XCBR. Therefore, the substation or protection engineer identifies those objects. Logical Nodes have data, and all the data have attributes

Attributes are related to the data called Pos, one attribute for diagnostic stVal, which indicates the position of a valve (off, on, intermediate-state, bad-state) and another attribute ctVal for the opening and closing command (values: off, on).



# Accessing Data

- ❖ The Pos “folder” is of type **Controllable Double Point (CDP)** data class. The **CDP data class** consists of 14 data fields (some are mandatory and must always be present, others are optional). The **StVal** field contains the value of the **CB**



# SCL (Substation Configuration Language)

- ❖ Standardized Data Exchange
- ❖ Key for Engineering Challenges
- ❖ Vendor-independent representation of the substation's configuration
- ❖ For example, XCBR = circuit breaker
- ❖ 61850 has a number of SCL-type files:
  - ◆ SCD
  - ◆ ICD
  - ◆ CID

# How will 61850 be used?

- ❖ IEC 61850 will not replace ALL protocols in use now
  - ❖ As in industrial automation different applications require different types of networks
- ❖ IEC61850 was developed to create an open communication environment in substations on the station and process level
  - ❖ Not to solve EVERY communication problem in the energy distribution industry
- ❖ More IED's support the network protocol
- ❖ Many utilities are in the process of migrating from proprietary protocols to the serial IEC-101/IEC-103 or the IEC-104.
- ❖ The application of the new IEC61850 highly depends on customers present situation, and the suppliers migration strategy
  - ❖ What equipment is installed (network support??)
  - ❖ Obsolescence issues to consider
  - ❖ Time/Cost involvement for upgrades

# Substation Data

- ❖ In a typical substation, all data attributes (approximately 100) from each of the IEDs are desired at the PLC
- ❖ Data is desired at the Station PLC (for decision making) and at the SCADA system
- ❖ Examples of data needs:
  - ❖ Data gathered for Condition Based Monitoring purposes, to detect point of degradation of an aging mechanism
  - ❖ Checking SF<sub>6</sub> gas insulation temperature
  - ❖ Alarm data with high precision of accuracy needed, to determine which IED alarmed (GOOSE'd) first
  - ❖ Control of bay-level switchgear -- interlocking & maintenance purposes

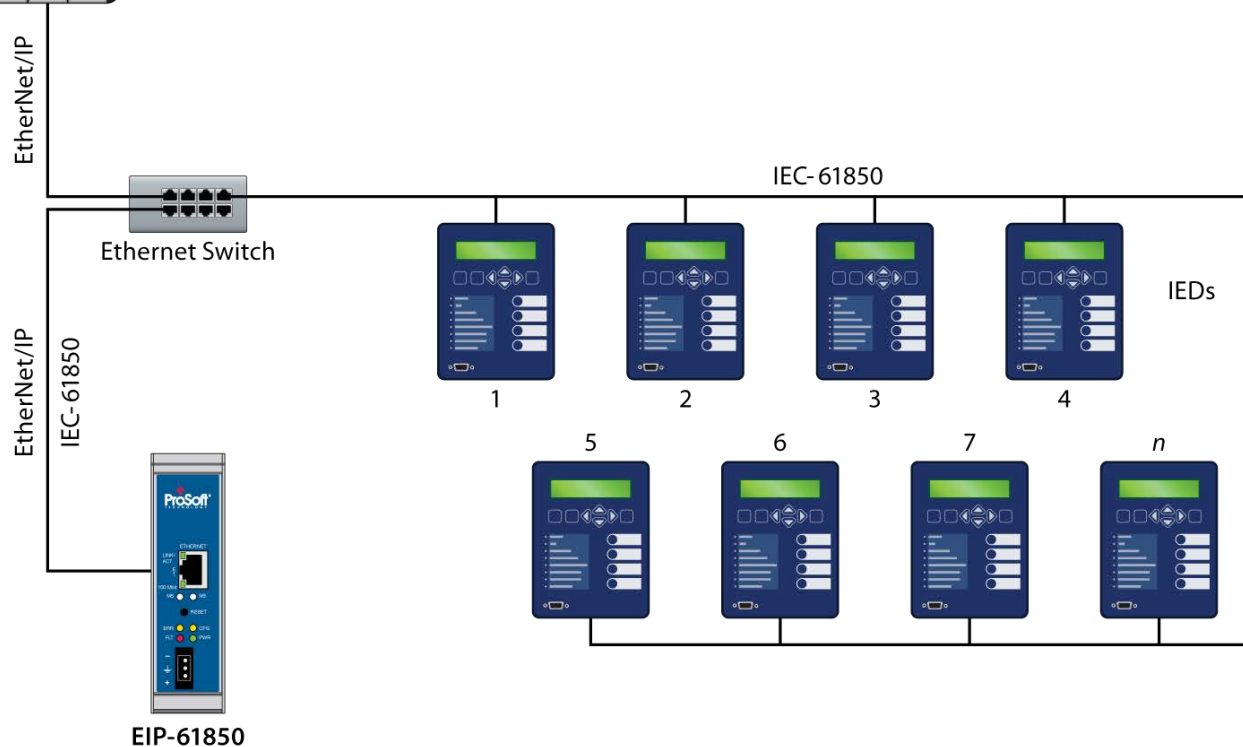
# Typical Applications

## Rockwell Automation PAC

PAC



- ❖ Substation Automation
- ❖ SCADA data collection



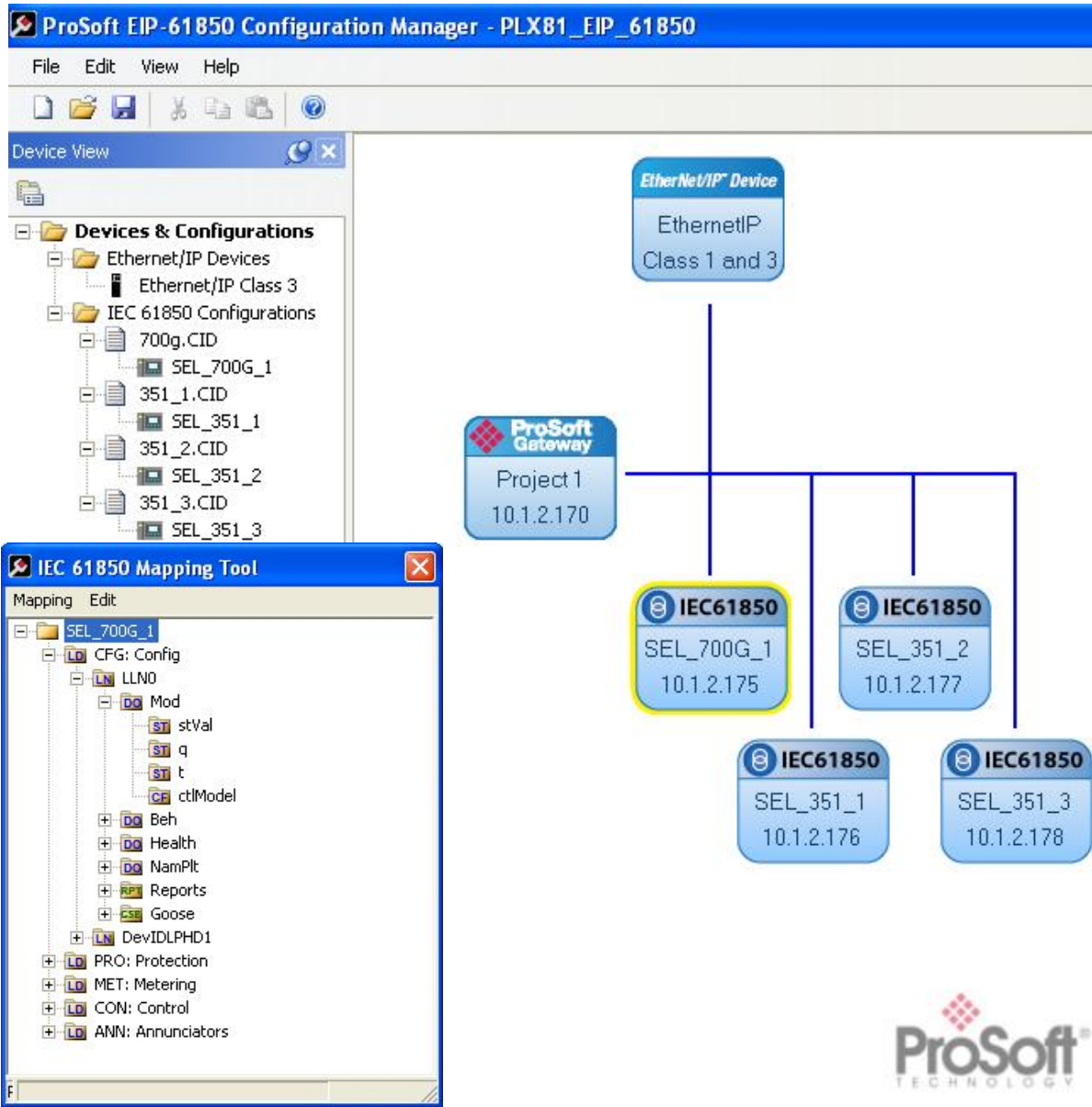
# PLX81-EIP-61850 (IEC 61850 client module)

- ❖ EtherNet/IP I/O Class 1 server
  - ◆ Supports up to 10 EtherNet/IP “Generic Ethernet” I/O connections in RSLogix 5000
- ❖ IEC 61850 Client
  - ◆ Supports up to 20 IEDs
  - ◆ 512 tags/elements per IED max
  - ◆ MMS Read/Write
  - ◆ GOOSE
  - ◆ Reporting (Buffered and Un-buffered Report Control Block)



# ProSoft 61850 Configuration Manager

- ❖ Drag-and-drop tag selection and data mapping.
- ❖ Imports IED/RTU configuration files





# Files created for RSLogix 5000

❖ The configuration utility creates application specific Add-On Instructions and User-Defined data structures to create IED tags and connect them to the I/O tags in your RSLogix 5000 project.

The screenshot displays the RSLogix 5000 configuration utility. On the left, the 'Controller Organizer' shows a project structure for 'Controller test' with folders for Controller Tags, Tasks, MainProgram, Motion Groups, Add-On Instructions, Data Types, and User-Defined. The 'MainRoutine' is expanded to show three AOI instructions: SEL\_351\_1\_AOI, SEL\_351\_2\_AOI, and SEL\_351\_3\_AOI. The main window shows the ladder logic for these instructions, with connections to I/O tags like PLX81\_EIP\_61850:0:1>Data and SEL\_351\_1. Below the ladder logic is a table of data structures.

Name	Value	Style	Data Type
+ SEL_351_1		(...)	SEL_351_1
+ SEL_351_1_AOI		(...)	SEL_351_1_AOI
+ SEL_351_2		(...)	SEL_351_2
+ SEL_351_2_AOI		(...)	SEL_351_2_AOI
+ SEL_351_3		(...)	SEL_351_3
+ SEL_351_3_AOI		(...)	SEL_351_3_AOI
- SEL_700G_1		(...)	SEL_700G_1
+ SEL_700G_1.LLN0_ST_Mod_stVal_001		0 Decimal	INT
+ SEL_700G_1.LLN0_ST_Mod_q_002		0 Decimal	INT
- SEL_700G_1.LLN0_ST_Mod_t_003	DT#2012-04-02-08:01:02.000000 (GMT-08:00)	Date/Time	LINT
+ SEL_700G_1.LLN0_CF_Mod_ctModel_004		0 Decimal	INT
- SEL_700G_1.MVGGIO12_MX_AnIn0_001		0.0 Float	REAL
- SEL_700G_1.MVGGIO12_MX_AnIn0_002		0.0 Float	REAL
+ SEL_700G_1.MVGGIO12_MX_AnIn01_q_003		0 Decimal	INT
+ SEL_700G_1.LLN0_ST_Mod_stVal_004		0 Decimal	INT
+ SEL_700G_1.LLN0_ST_Mod_q_005		0 Decimal	INT
- SEL_700G_1.LLN0_ST_Mod_l_006	DT#1969-12-31-16:00:00.000000 (GMT-08:00)	Date/Time	LINT
+ SEL_700G_1.LLN0_CF_Mod_ctModel_007		0 Decimal	INT
+ SEL_700G_1.LLN0_ST_Mod_stVal_008		0 Decimal	INT
+ SEL_700G_1.LLN0_ST_Mod_q_009		0 Decimal	INT
- SEL_700G_1.LLN0_ST_Mod_l_010	DT#1969-12-31-16:00:00.000000 (GMT-08:00)	Date/Time	LINT
+ SEL_700G_1.LLN0_CF_Mod_ctModel_011		0 Decimal	INT
+ SEL_700G_1.LLN0_ST_Mod_stVal_012		0 Decimal	INT
+ SEL_700G_1.LLN0_ST_Mod_q_013		0 Decimal	INT
- SEL_700G_1.LLN0_ST_Mod_l_014	DT#1969-12-31-16:00:00.000000 (GMT-08:00)	Date/Time	LINT
+ SEL_700G_1.LLN0_CF_Mod_ctModel_015		0 Decimal	INT
+ SEL_700G_1_AOI		(...)	SEL_700G_1_AOI



# Rockwell PlantPAx faceplate

- ❖ PlantPAx faceplate available to pull all data from custom .cid file for SEL equipment
- ❖ Faceplate ties directly to tag values defined in ProSoft generated Add-On Instruction and User-Defined data type

The image displays four screenshots of the SEL 700G faceplate interface, arranged in a 2x2 grid. Each screenshot shows a different view of the equipment's status and controls.

**Top-Left Screenshot:** Shows the main control panel with a status bar indicating "Unable to subscribe to events. There are no servers contain...". Below this, there are several control buttons and indicators, including "Enabled", "Trip", "Differential", "Overcurrent", "Over/Under Freq", "Volts / Hertz", "Loss of Field", "Stator / Field Grd", and "AUX".

**Top-Right Screenshot:** Shows the "RTD Temperatures (Degs)" screen, displaying a list of 12 RTD sensors (RTD #1 to RTD #12) with their corresponding temperature values, all of which are 1.00.

**Bottom-Left Screenshot:** Shows the "X-Side" monitoring screen, displaying a table of electrical parameters:

Amps	Volts	kW	kVar	kVA
		123	23	23
11	22			A
1	2			B
0	-3			C
0	45			N
Volts A-B	45	pf		0.855
Volts B-C	56	Frequency		23
Volts C-A	-44	Residual Volt		34
		Residual Curr		0

**Bottom-Right Screenshot:** Shows the "Trips" screen, displaying a list of trip events and their status. The "RTD Tripped" event is currently active (indicated by a red dot). Other trips listed include Differential Current Alarm, Level 1 Field Grd Protection, Level 1 Sync OverVoltage, Level 1 Sync Undervoltage, Level 1 volts/hertz definite-time, Level 2 Field Grd Protection, Level 2 Sync Overvoltage, Level 2 Sync Undervoltage, Level 2 volts/hertz composite, Neutral - Grd Time Overcurrent, N-Side Lvl 1 Phase Inst Overcurrent, N-Side Lvl 2 Phase Inst Overcurrent, Command - Open Breaker X, and Command - Open Breaker Y.

**Questions?**  
**Discussion...**  
**Thank You!**



# Thank You

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