

Power System Engineering, Inc.

PSE

Substation Modernization

2012 Automation Webinar Series

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Agenda

1 Starting Points

2 Why Modernize?

3 Phased Approach

4 Communication & Security

5 Next Steps

Starting Points

Utilities are coming from many different perspectives

– No one right answer.

Category	States	Comment
Sizes	**Meters**: 5,000 to 100,000+ **Substations**: 5 to 200+	Cost justification varies. Complexity increases with size.
Structure	Cooperative, Municipal, G&T Investor-owned Utility	Different process for justifying expenditure & investment.
Territory	**Rural** with locations spread widely **Urban** with compact service territory	Impacts some of the benefits of automation.
Services	Municipals add gas and water systems to any automation plan.	
Focus	Reliability Reduced Cost of Service Personnel stretched thin	Need to make sure benefits accomplish your goals.

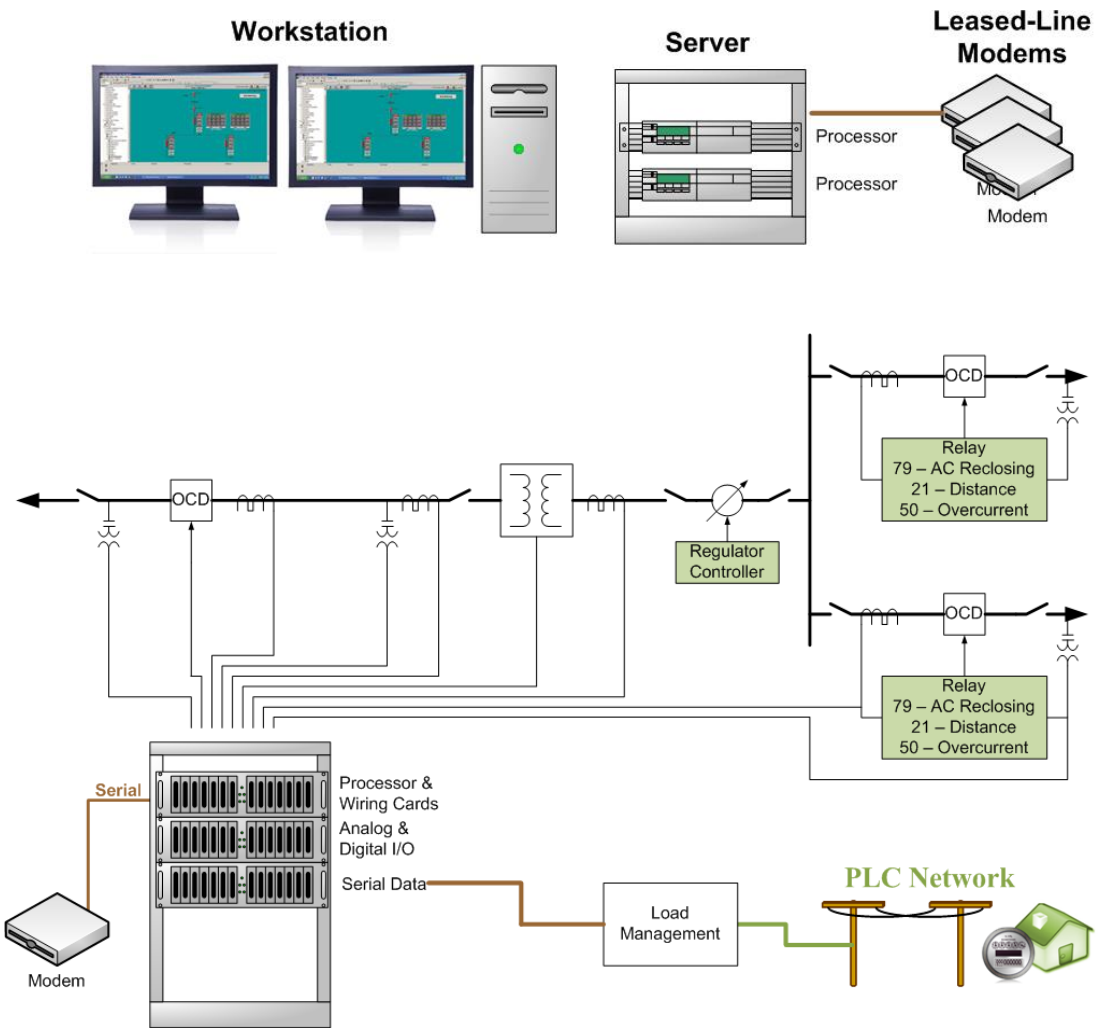
Starting Point – Automation Hybrid

SCADA Master

- Central Server
- Central Workstation
- Legacy Server Hardware
- Proprietary Database
- Leased-line modems

Substation Automation

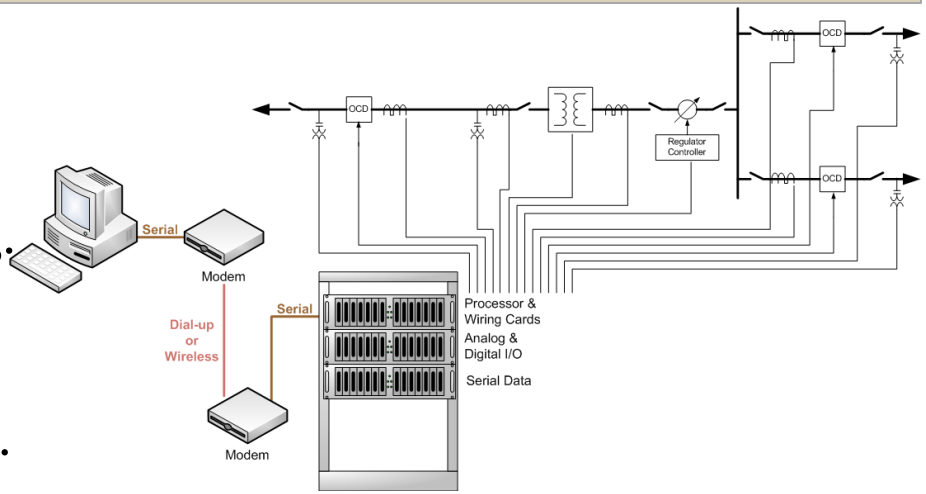
- Legacy RTU – serial proprietary protocol
- New feeder relays
- Regulator control – 10 years old, communicates for proprietary protocol
- Substation also contains a Load Management or AMI interface unit



Role of the RTU

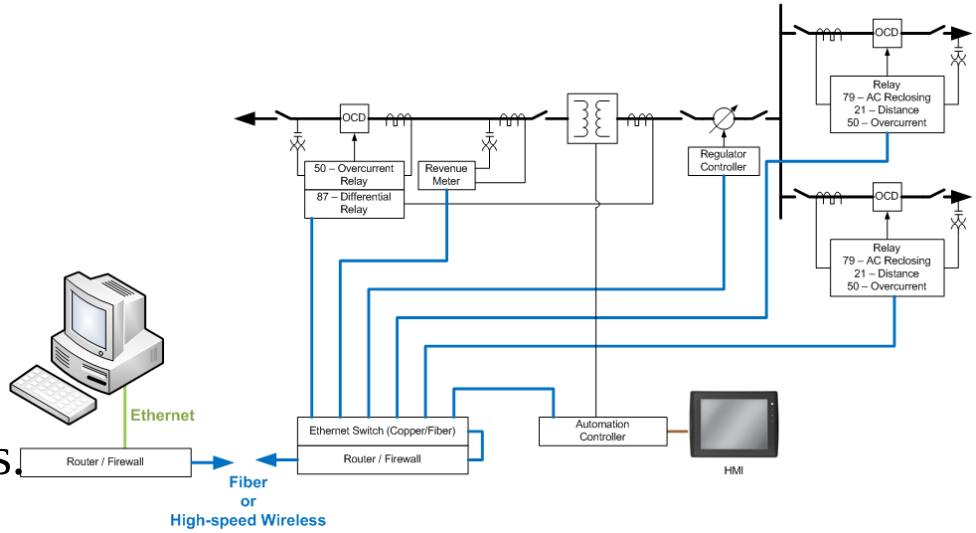
Legacy

- **Capture signals** (analog & digital) from transducers.
- **Data gathering** without decision making.
- **Vendor specific** protocols
- Gather data from serial devices.
- **Constrained** by limited communications.
- **Limited history**, sequence of events.



Modern

- **One of many intelligent devices.**
- **Data gathering** blended with decision making.
- **Standard (DNP3, 61850)** protocols.
- Gather data from legacy transducers & devices.
- **Enabled** by improved communications.
- **Greater history**, sequence of events.



Starting Point – Multi-generation IEDs

Faced with decision on whether to invest in newer IEDs

	Generation 1	Generation 2	Generation 3
Status	Obsolete	Supported	Newest platform
Protocols	Proprietary serial	DNP3 Serial & IP	DNP3 Serial & IP
Settings	Select pre-defined Time-current curves	User customized logic, Time-current curve editing	Advanced editing of Time-current curves
Metering	Current in 5 or 15 minute integrals.	I&V, power, energy, PF, Frequency, harmonic	I&V, power, energy, PF, Frequency, harmonic
Load Profiling	Currents for last 24hr. in 15 min. intervals	Configurable data and many intervals, days of info.	Configurable data and many intervals, days of info.
Event Recorder	Current for last 25 events	Many event types, Last 500 events	Many event types, Last 500 events
Oscillography	No	Yes	Yes
General	Functional, yet … No longer supported Proprietary Basic Configurability Limited information	Functional Well supported Standards-based Flexible Lots of information	

Starting Point – Standards & Protocols

Standards Based

- DNP3.0
- IEC-61850
- Modbus TCP

Proprietary

- Valmet Tejas
- Telegyr 8979
- PG&E 2179

Why does the protocol matter?

- **Manufacturer Flexibility**
  - Support from the manufacturer, staying in business
  - Breadth of product types and features
- **Improvements in protocol**
  - Communication types (Ethernet, report by exception, …)
  - Security

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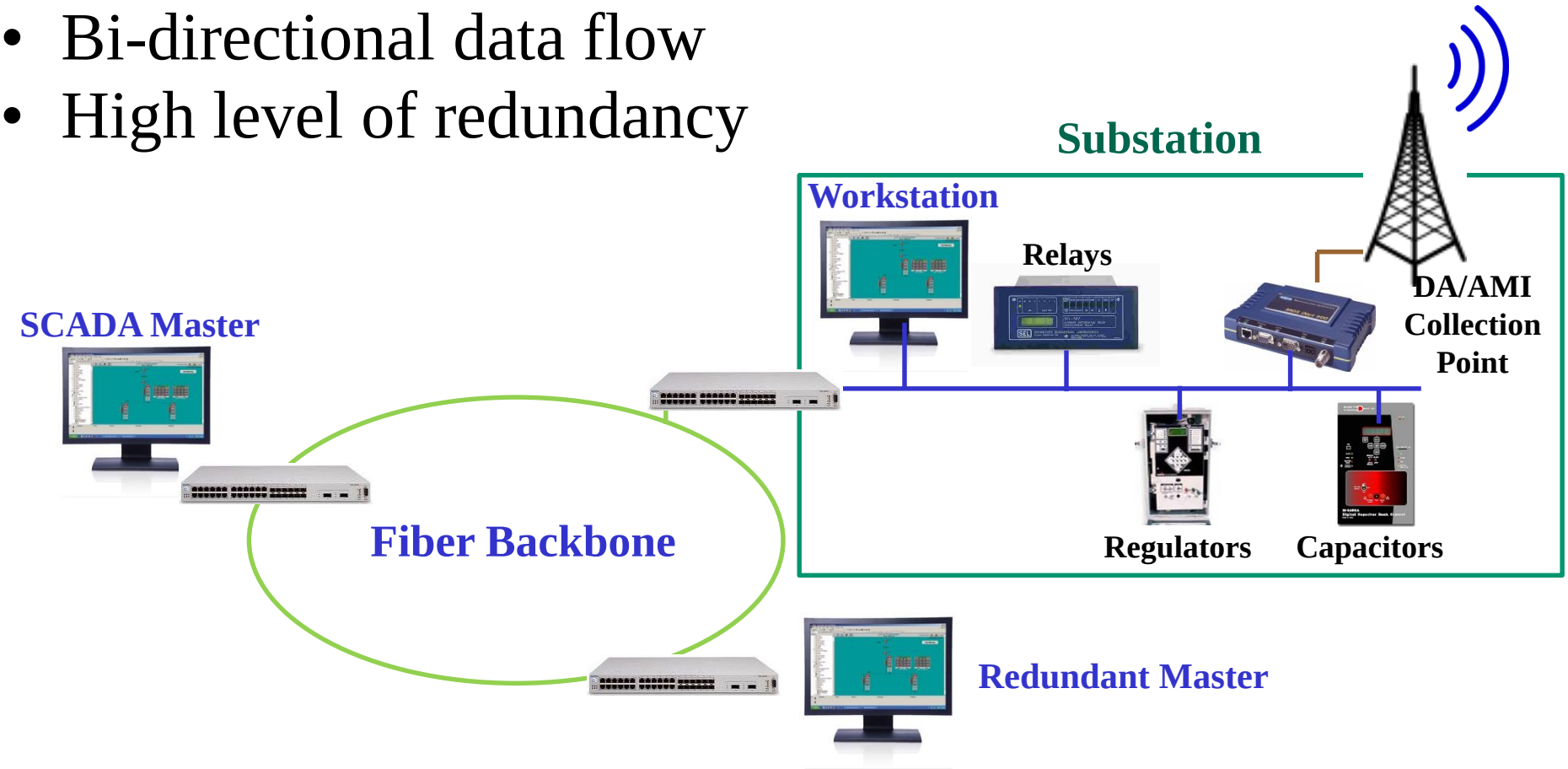
Modern SCADA Architecture

- Intelligent devices remotely accessible
- Bi-directional data flow
- High level of redundancy



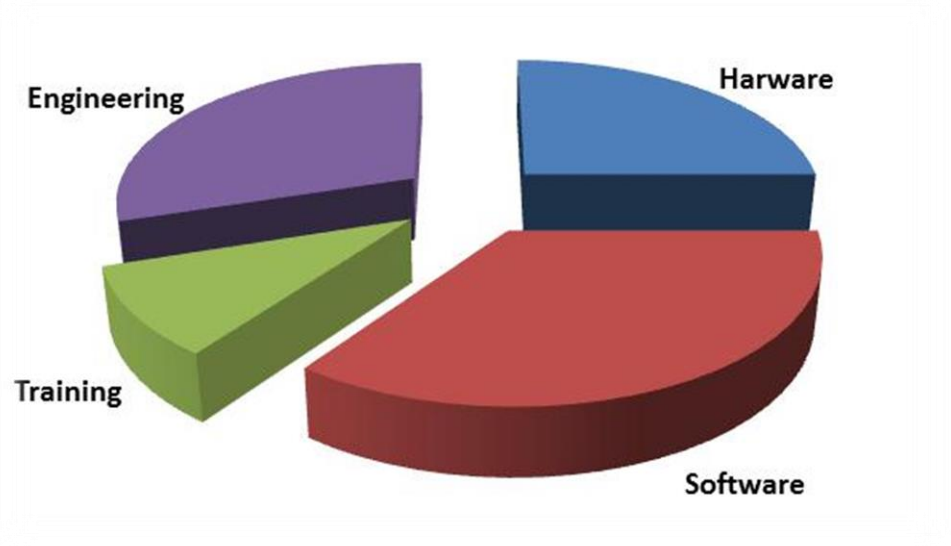
Substation modernization makes sense as part of a bigger picture.

Modern SCADA Masters

SCADA System Components

- Software: License (features) and maintenance
- Hardware: Servers, workstations, network, security
- Engineering: Database and screen design, site testing
- Training: User, upgrade and modification

Representative Cost Break-down



Features to consider:

- Redundant modular hardware
- Firewalls for secure remote access
- Open database for 3rd party integration
- Historian, trending and graphing
- Tagging for secure lockout
- User authentication for access levels
- Web access for infrequent users
- ICCP, MultiSpeak & protocol interfaces
- Security logging for NERC CIP
- Advanced applications

Getting more out of Automation

- **Extend Asset Life**
  - Transformer upgrades or added substations are expensive
  - Actual peak loading provides the best picture on upgrading
- **Enable Restoration**
  - Temporarily run closer to maximum only with real-time data
- **Update engineering models**
  - Assumption: residential vs. industrial vs. commercial load mix
  - Measure power factor variance with time, day and season
  - Measure energy change with voltage reduction
- **Better feeder loading data**
  - Measure individual feeder loading rather than whole bus
  - Measure feeder power factor for better compensation

Better technical information allows better business decisions.

SCADA Benefits Many

Function	Legacy Systems	Modern SCADA	Difference
Customer Service	• Customer reported issues	• Continuous monitoring • Detect before call	• Better customer service
Operations & Dispatch	• Drive through affected area to suspected source	• Field data on location of fault	• More quickly locate source of outage
Maintenance	• Travel to every site • No info between visits	• Gather remotely • Travel when needed	• Less drive time • More information
System Engineering	• Limited system data • Tough to gather data	• Real-time historical information and settings.	• Verify system models with actual load data
Field Engineers	• Meters provide some data within substation.	• Substation HMI shows complete picture • Local control	• See system status and control system from field

Information helps all departments work more efficiently.

Maintaining your system

- Many utilities can **no longer maintain their system**
  - Proprietary implementations: can't update themselves
  - RTUs & SCADA Masters no longer supported
- Newer SCADA systems are **easier to maintain**
  - Friendlier graphical interfaces, easier screen creation
  - Templates for common IEDs
  - Easier to add communication channels
  - Alarm management standardly supported
  - Many trends and graphs are built-in or easily modified

If your system can't grow, your investment has limited value long-term.

Benefits of Standard Protocols – DNP3

- DNP3 Attributes
  - **Open** definition: everyone can implement, interoperate
  - **Flexible**: Binary, analog, counters, data files
  - **Reliable**: Error checking & retransmission built in
  - Support all **media**: Serial & Ethernet / Fiber capable
  - **Prioritized**:
    - Static data & Class 1, 2, & 3 event data
    - Polled & Unsolicited Messaging
  - **Time Stamped**: Recreate events
  - **Security** Enhancements: DNP3 Secure Authentication

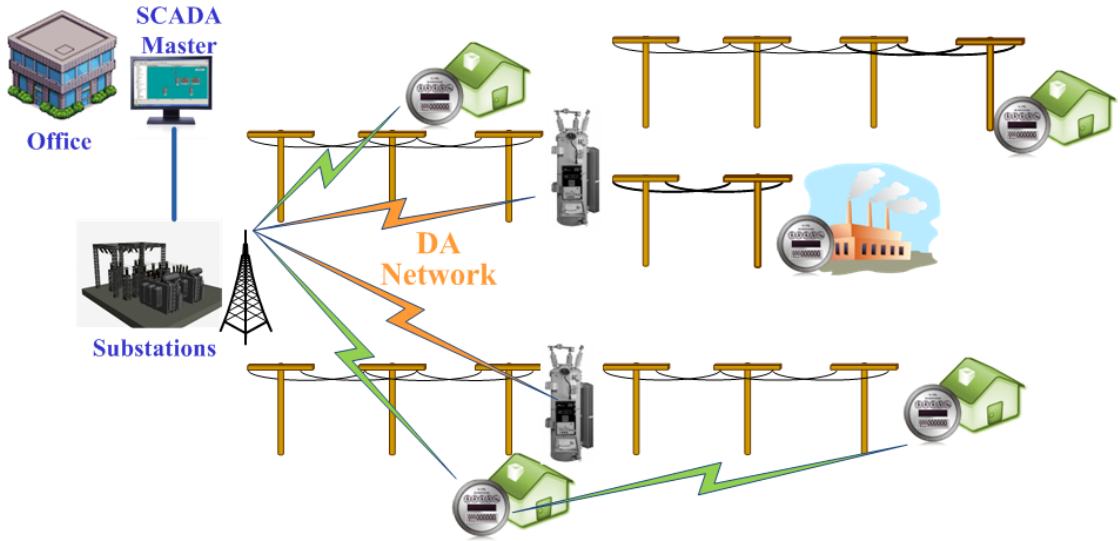
dnp Distributed Network Protocol

Allows vendor independence, enhancements and operational benefit.

Voltage Control Program

Substation Automation forms basis for voltage control

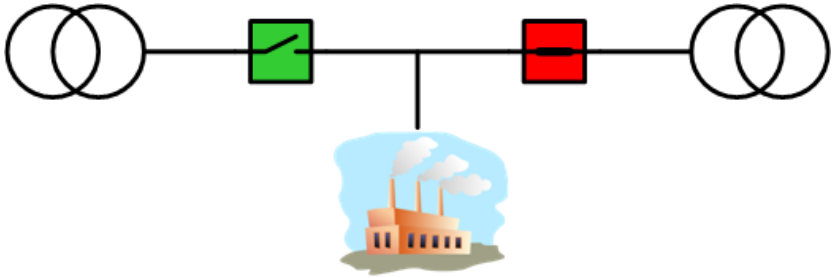
- Benefits
  - Coincident peak price reduction
  - Energy Reduction
- Components of a voltage control program
  - Regulation (Substation and Feeder)
  - Measurement (Meters and Regulators)
  - Control (SCADA or Integrated Volt/VAR Application)
- Considerations
  - Seasonal / Daily Load
  - Metering latency
  - Dynamic network

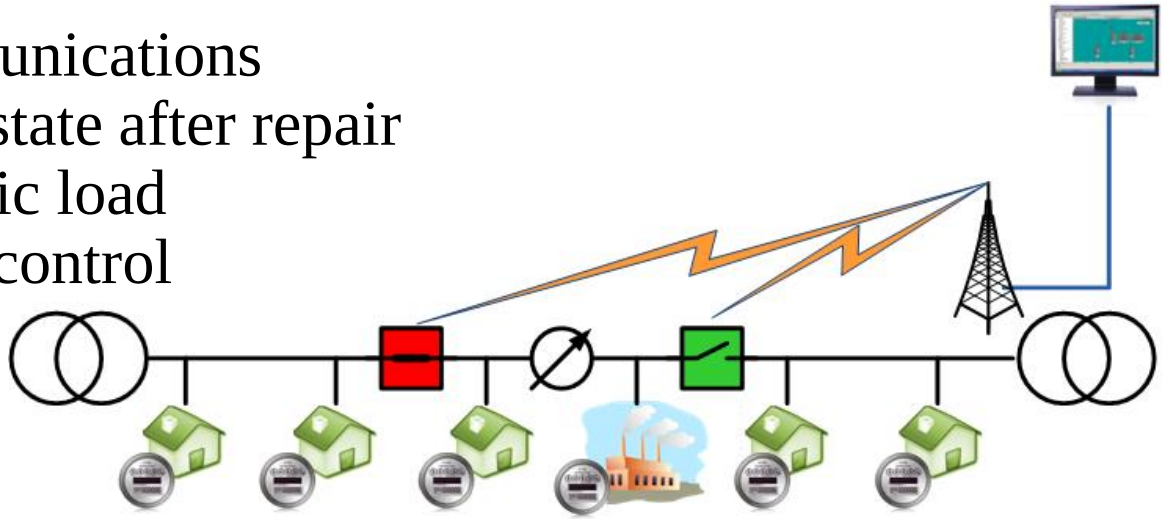


Switching Program

Substation Automation forms basis for switching

- Benefits
  - Increased Reliability (reduced SAIDI)
- Implementation Options
  - Central / Distributed Control
  - Central visibility in real time
- Complexities
  - Maintaining communications
  - Restore to normal state after repair
  - Modeling a dynamic load
  - Switching voltage control





Modernization Benefits

1. **Integration**: SCADA System pulls together many pieces for greater benefit.
2. **Fiscal**: Better information allows better business decisions.
3. **Operational**: Access to information helps all departments.
4. **Maintainability**: Use and expand system
5. **Standards**: Protocols
   a) Vendor independence.
   b) Evolve to improve security and operational benefits.
6. **Platform**: Voltage control and switching programs allow for cost reduction and reliability increases.

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Levels of Automation

	Component	Basic	Median	Advanced
SCADA Master	Hardware	Single PC	Single Rack Server Single PC Workstation	Redundant Rack Servers Multiple PC Workstations
	Applications	Monitoring	Control, Alarm Mgmt., Historian & Trending	Control, Alarm, Historian, Switching, IVVC,
Substation Automation	RTU/Controller	RTU to I/O	Data Concentrator	Minimal – IED direct
	Feeder Protection	Hydraulic	IED Relays	IED Relays
	Feeder Capacitors		Fixed	IED Controller
	Regulation		IED Bus Control or LTC	IED Feeder Controller
	Transformer	Unmonitored	I/O Alarms	IED Monitor
	High Side Protection	Fusing	IED Relays	IED Relays
Substation Support	Substation SCADA		HMI – Local Devices	Full Workstation
	Video			IP Camera
	Local Network			IP Phone, Wireless LAN

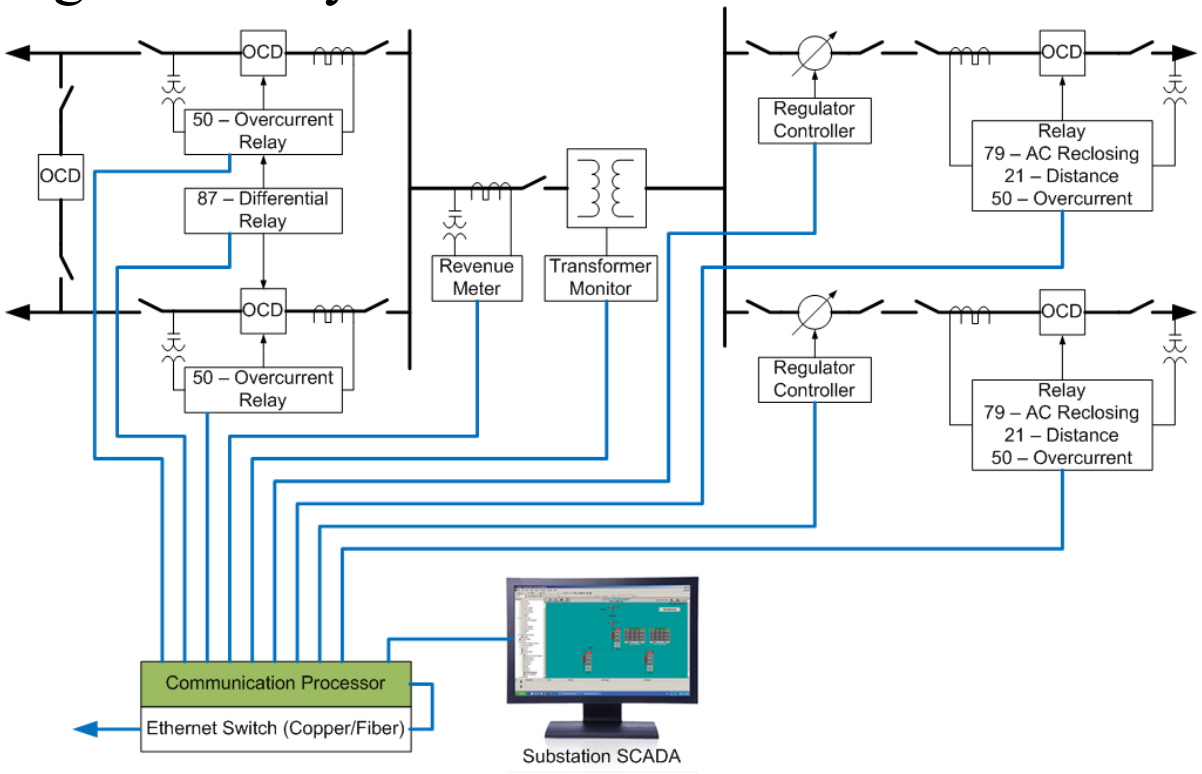
Phased Approach

- Every utility has valuable assets
  - **IEDs**: Relays, regulator controls, meters.
  - **Communications**:
    - **Fiber (Partial) Deployment**: Municipals with community fiber programs
    - **Wireless assets**: Including towers
  - **Other** Systems: that can be integrated with SCADA
    - Automated Metering (AMI/AMR)
    - Outage Management System (OMS)
    - Geographic Information System (GIS)

Maximize the benefit of what you have toward the programs you need.

Substation SCADA – SCADA Lite

- Substation communication processor hosts SCADA directly.
- Lower cost of equipment and deployment.
- Visibility to what's going on locally
- Limited scalability and integration with other applications: AMI, CVR, OMS.
- Local substation control, limited system-wide control.



Local visibility at low cost and complexity.

Data Concentrators & RTUs

- **Trends**
  - Legacy protocols going to DNP3
  - Serial going to Ethernet
  - Heavily I/O monitoring going to IEDs
  - Data concentrators used frequently
  - Increased intelligence, HMI capability
  - PLCs are increasingly finding use.
- **Features of modern platforms**
  - Intelligence – logic and decision making
  - Great at integrating diverse protocols.
  - HMI in some instances (pseudo-SCADA)
  - Security embedded – firewalls, etc.

Card Style RTUs

Automation Platforms

PLCs

Compact Controllers

Substation Migration Example: Starting

SCADA Master

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- Central Workstation
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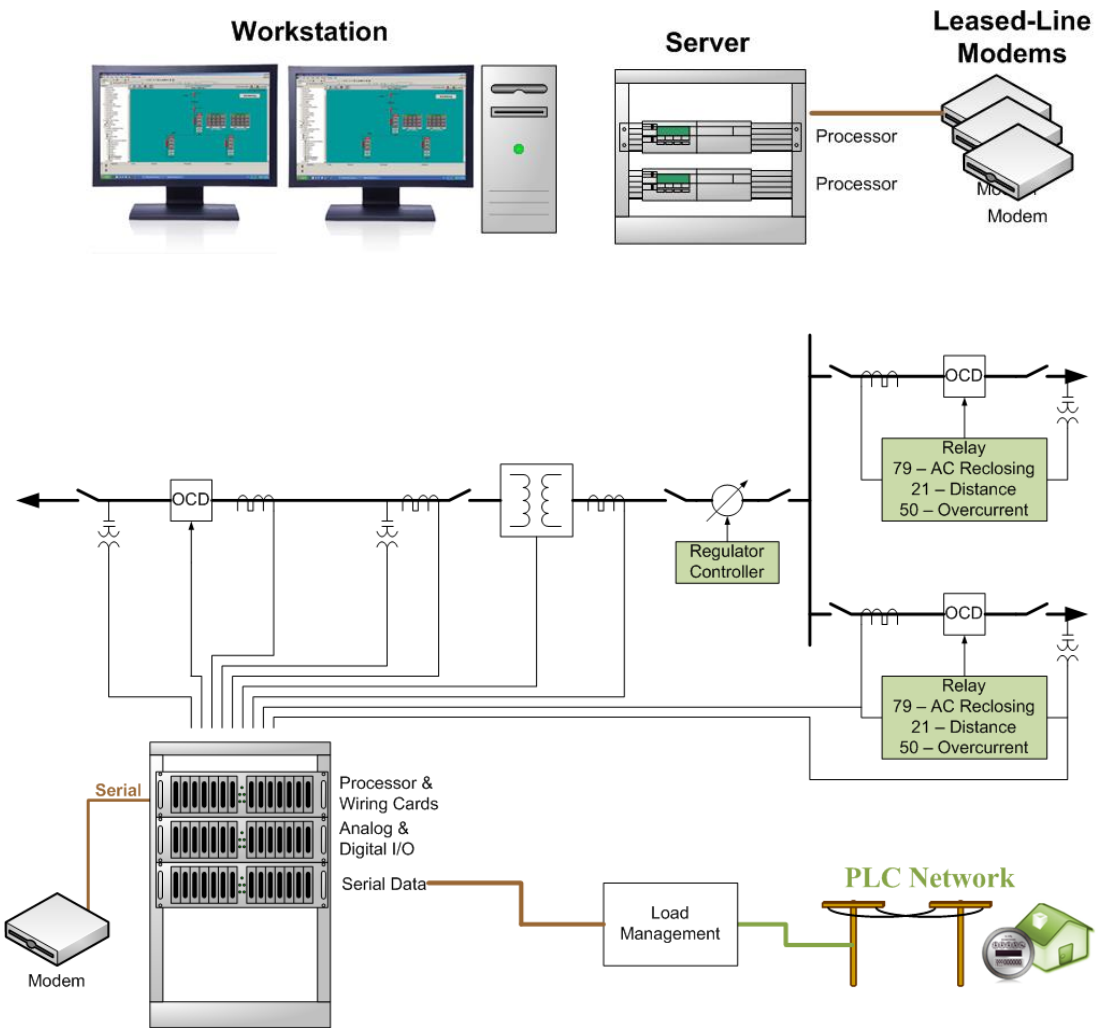
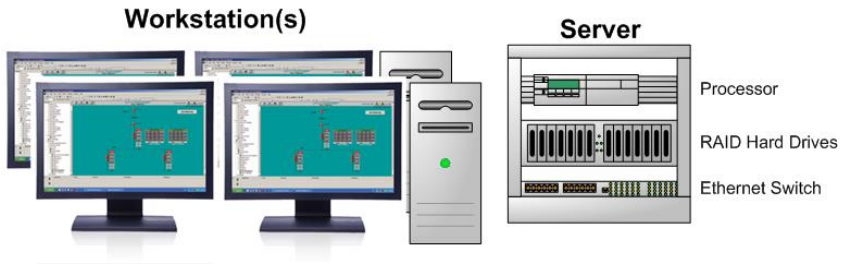


Substation Migration Example: Long-Term

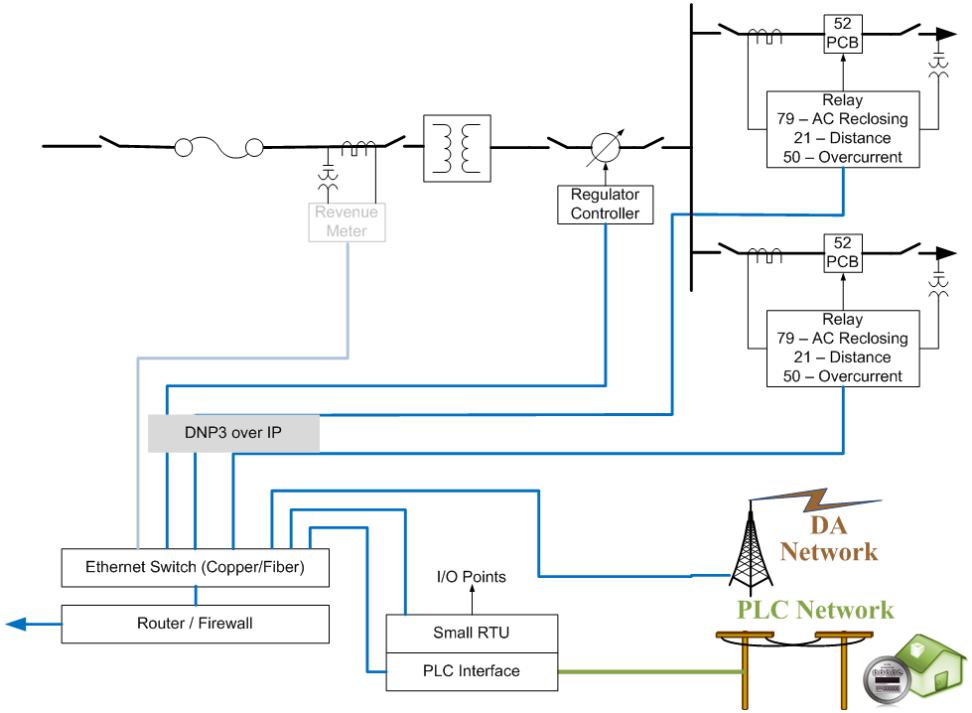
SCADA Master

- Powerful server & workstation(s)
- Monitoring & alarming
- Substation & DA control
- Historian & trending
- OMS/AMI integration



Substation Automation

- Maximize direct connection to IEDs w/ DNP3 over IP
- IED Reclosers
- Minimized RTU
- IED Regulators
- AMI & DA collector point
- Fiber Ethernet in substation



Substation Migration Example: Phase 1

SCADA Master

- Powerful server & workstation
- Monitoring & alarming
- Substation & DA control
- Historian & trending
- OMS/AMI integration

Substation Automation

- Maximize direct connection to IEDs w/ DNP3 over IP
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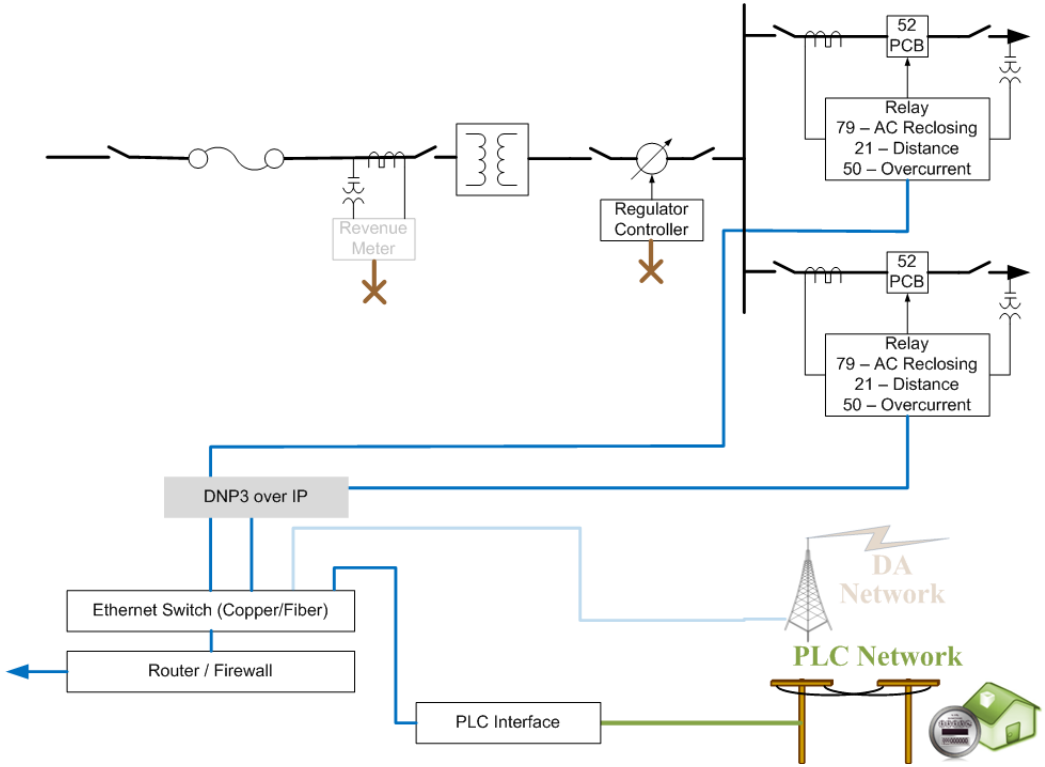

Phased Approach

How we develop the phasing strategy depends on what is most valuable to the utility.

1. **Level**: Automation goal depends on size & programs.
2. **Current assets**: Make the most of what you have.
3. **SCADA Lite**: Consider substation level SCADA.
4. **RTU**: Balance data concentration & RTU role in short-term & long-term
5. **Phasing**: Prioritize the assets with most critical goals.

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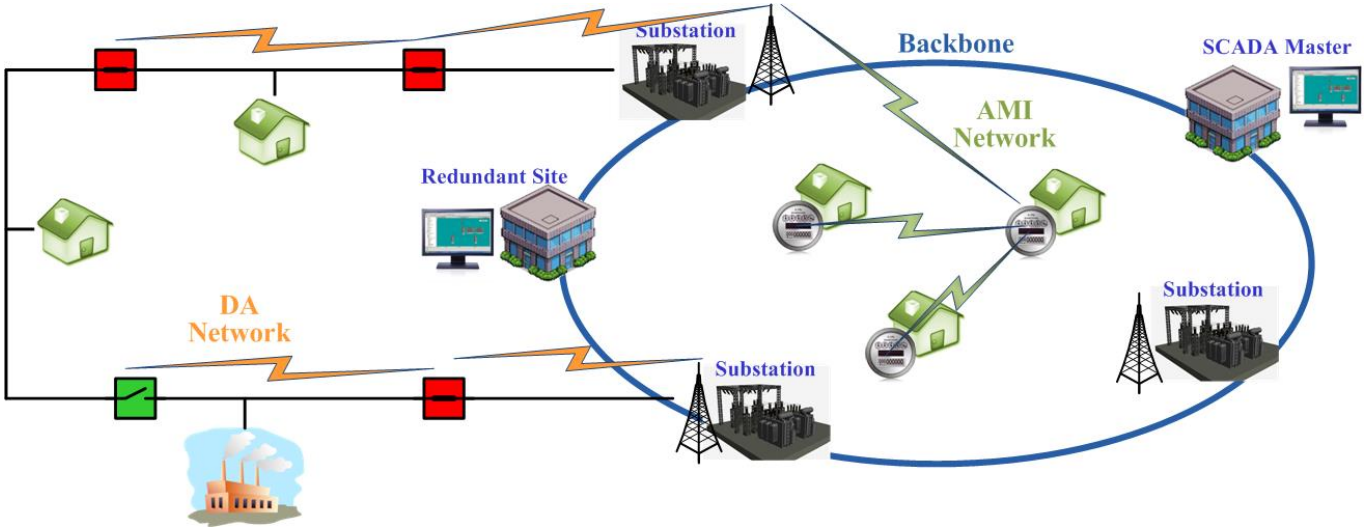
Multi-Tier Infrastructure

Tier		Description	Speed	Coverage	Redundancy
1	Backbone	Connect offices and most substations	High speed 10-100+ Mbps	Ring	Critical
2	Backbone Extension	Connects remote substations	Medium speed 10+ Mbps	Pt. – Pt.	Preferable
3	DA Network	Connect field DA equipment to each other and to a collection point to the SCADA system.	Lower speed 50 kbps to 1 Mbps	Wide-area	Preferable
4	AMI Network	Connect meters to each other and to a collection point.	Lower speed <50 kbps to 1Mbps	Wide-area	Preferable



Bandwidth Requirements

Application	Use Case	Frequency of Use	Latency Target (Sec)	Message Size (bits)	Number of Devices	Throughput (kbps)
AMI	Interval data read	Hourly interval data read 3x per day				
	Outage Notification & Restoration	Primarily major outages.				
	Demand Side Management / Load Control	During load control events				
SCADA	IED Monitoring & Control	Every 2 seconds				
Engineering	Data needed by direct connect to IEDs	1 x per week				
Video Monitoring	Security - sending frames on event	Infrequent				
Distribution Automation	Assumed unsolicited report by exception based on events	Hourly				
Wi-Fi	Substation hotspots for field crew network access	A few times per day				
					Total	

Electric Critical Infrastructure Program

- NERC is responsible for Energy Sector, Electric Segment
- NERC Critical Infrastructure Protection (CIP)
  - Efficiently identify security threats and vulnerabilities
  - Develop policies and procedures to address these threats and vulnerabilities
  - Bolster training and education activities for owners and operators
- Currently focused on "Bulk Electric System"

Version	Status	Purpose
3	Effective Oct. 2010	Allowed utilities to define CAs by a risk-based assessment
4	Approved by NERC Q1 2011; Awaiting FERC approval – latest comment 11/21/2011	Change the way Critical Assets are identified to greatly expand the number of Bulk Electric System assets (generation plants, transmission substations, etc.)
5	FERC required NERC submit by Q3 2012	Complete coverage of FERC Order 706 Critical Assets -> Bulk Electric System Cyber Assets Classifications for control centers, generation plants & transmission substations

Components of Security

- **Encryption**
  - Scrambling data so that it is unreadable to those who aren't supposed to read it.

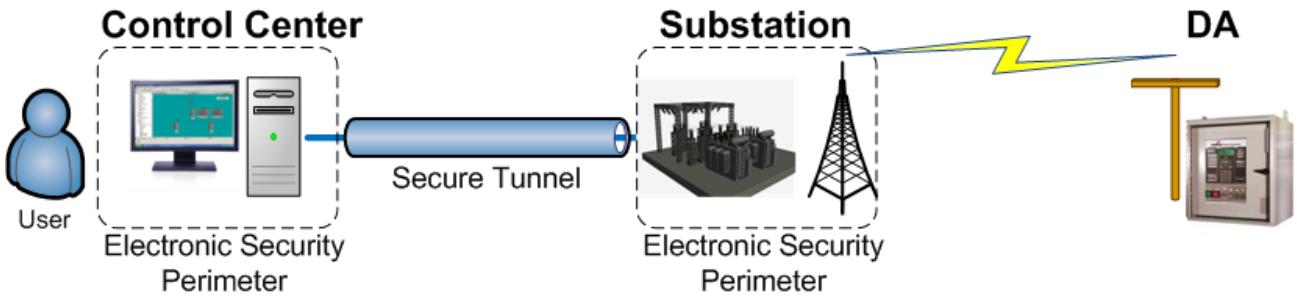
- **Authentication**
  - Verifying that the devices who want to talk to each other are allowed.

- **Integrity Checking**
  - Verifying that messages are not changed from sender to receiver.

- **Intrusion Detection**
  - Detecting if someone or something is trying to break any of the security aspects above.
  - Failed authentication – wrong password
  - Denial of service, replay attack, changed messages

DNP3 Secure Authentication Version 5

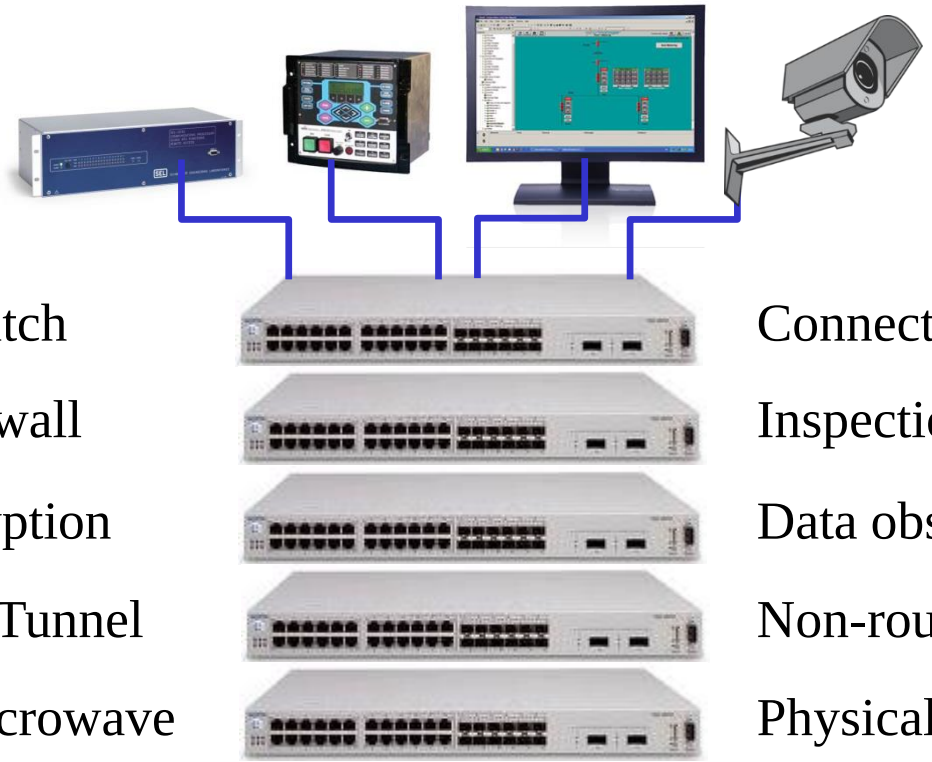
- Addressing the Issue: Securing remote devices



- Authentication: Verify correct User & Outstation
  - Addresses: Spoofing, Modification, Replay
  - Does not address: Eavesdropping & Encryption
- Unauthenticated / authenticated messages (MAC)
  - Control operations critical
- Backward tolerant & upgradable
- Multiple users & auditing (audit trail beyond standard)

Security Scalability

- Essential: Switch and fiber/microwave
- Recommended: Firewall and encryption
- NERC CIP required: MPLS tunnel



Switch	Connectivity
Firewall	Inspection and intrusion prevention
Encryption	Data obscurity and integrity checking
MPLS Tunnel	Non-routable (sub to control center only)
Fiber/Microwave	Physical connection

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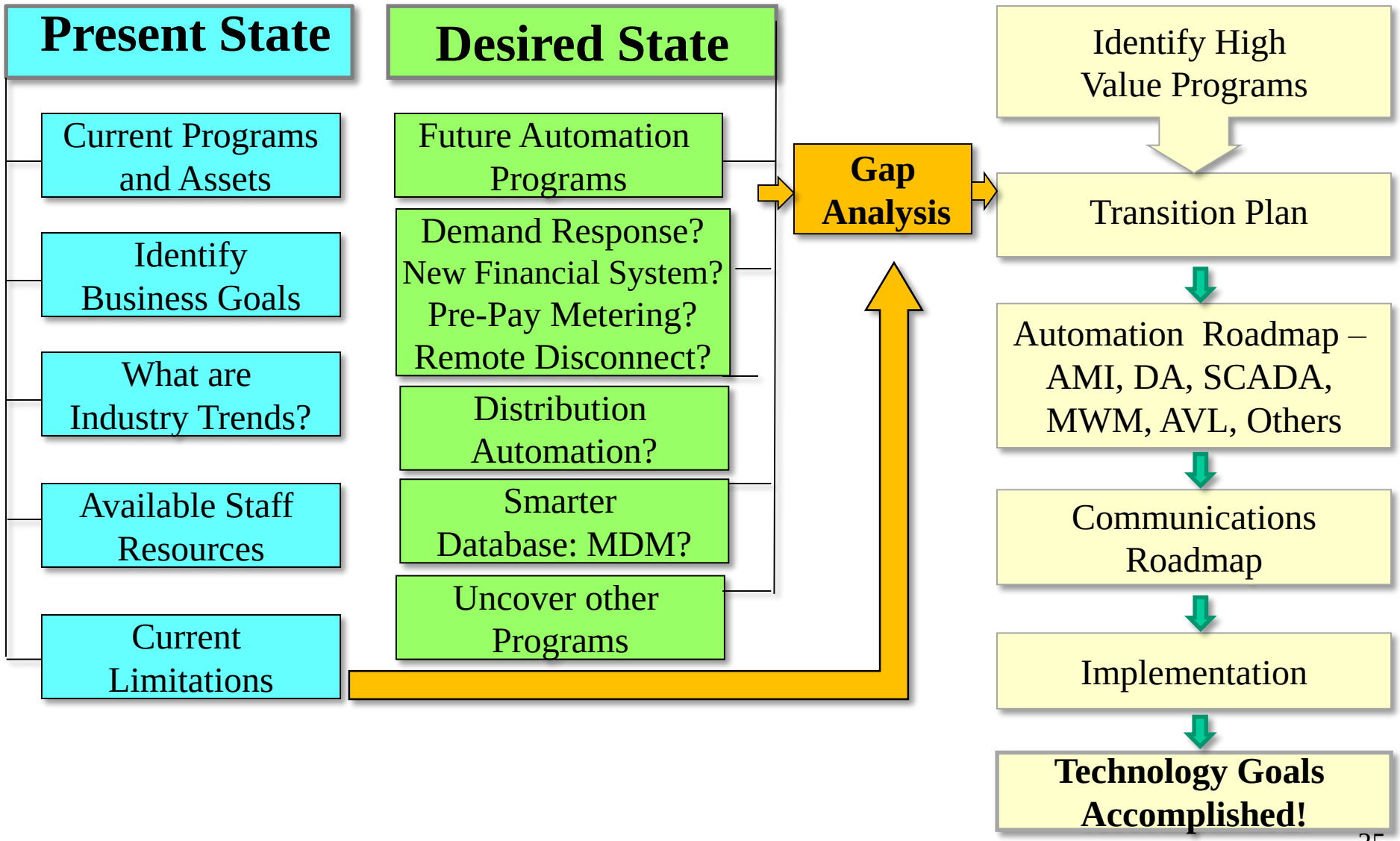
Developing a Technology Work Plan



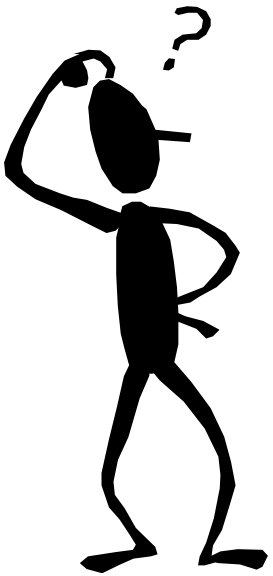
Example TWP Program & Budget Summary

Programs	2011	2012	2013	2014
AMI & Beyond				
Procurement/Design				
Software/Hardware/Vendor installation				
Substation Modernization				
Equipment				
GIS				
Procurement/Design				
Software/Hardware/Vendor installation				
MWM				
Procurement/Design				
Software/Hardware/Vendor installation				
DA				
Procurement/Design				
Equipment				
MDM				
Procurement/Design				
Software/Hardware/Vendor installation				
Communications				
Procurement/Design				
Software/Hardware/Vendor installation				

Modernization Overview

1. **Starting Point**: Hybrid systems, each in unique size and make-up.
2. **Benefits**:
   - Fiscal & operational benefits of improved information.
   - Foundation for voltage & switching programs
3. **Phased Approach**: Incrementally build on existing assets to maximize key programs.
4. **Communications**: Enable secure remote data access
5. **Creating a plan**: Identify the gap & create a plan that balances dollars and resources for all programs.

Questions?



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