Case Study: Implementing Redundant Logic Controllers in Substations

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Importance of Redundancy in Power System Applications

- Interlocking
- Distribution automation controllers
- Microgrid and load shedding
- Power plant control
Aspects of Redundancy

- Controller-to-IEDs
- Controller-to-controller
- Controller-to-control center/SCADA
Communication Redundancy Methods

Technologies which increase data delivery reliability:

- Parallel Redundancy Protocol (PRP)
- Software-Defined Networking (SDN)
- Rapid Spanning Tree Protocol (RSTP)
Controller-to-IEDs Data Collection Management
Both Controllers Actively Collecting
Both Controllers Actively Collecting Data

- Both controllers have the latest data
- Faster failover time
- Must coordinate data sent to SCADA
Controller-to-IEDs
Data Collection Management
Single Controller Actively Collecting

Active
Controller

Active
Controller

IED
IED
IED
Single Controller Actively Collecting

- Must coordinate data collection services between controllers
- No coordination between controllers for sending data to SCADA
- Slower failover time
- System design/limitations may require this approach
Controller-to-Control Center/SCADA

• Will SCADA switch over to individual controllers?
• Coordinate data between controllers to prevent sending duplicate data to SCADA (usually a manufacturer feature)
• Communication path to SCADA
Controller-to-Controller
Operation Behavior Considerations

- Primary-primary vs. primary-backup
- Maintenance mode
- Communications channels
- Active controller criteria
Controller-to-Controller Communications Channel Considerations

- Ethernet or serial
- Protocol used
- One or multiple connections
Controller-to-Controller Communications Channel Configurations

- Serial
- Ethernet

Diagram showing different configurations of controllers communicating through networks.
Criteria for Active Controllers During Complete Loss of Communications

- Both controllers are active
- Disable both controllers
- Default to single controller
Redundant Controller Network
Interface Configurations: WAN Connection

• Shared IP address
  ▪ One unit to outside connection
  ▪ No need to program remote failover schemes

• Unique IP addresses
  ▪ Require outside connections to know about system redundancy
  ▪ Allow for direct engineering access to both units remotely
Redundant Controller Network
Interface Configurations: LAN Connection

• Shared IP address: restricts both controllers from actively collecting data simultaneously

• Unique IP addresses
  ▪ Allow for easy engineering access
  ▪ Allow for independent data collection
Redundant Controller Network Interface Configurations

• Ethernet connections
  ▪ WAN
  ▪ LAN
  ▪ Controller-to-controller

• Serial connection – controller-to-controller
Design Decisions

- Simultaneous controller-to-IED communications
- Controller-to-controller communications
  - Ethernet
  - Serial
- Serial SCADA communications
- Coordinate data between controllers to SCADA
Implementation Experience Design

IEC 60870-5-101
IEC 61850
EIA-232
Ethernet

Controller
Network 1
Network 2
Redundant Relays
Redundant Relays

SCADA
Implementation Challenges

- Multiple communications channel failures
- Defaulting to single controller
Unique SCADA communications with redundant serial channels

IEC 60870-5-101
Questions?