Wireless Solutions for Reliable Distribution System Protection & Control

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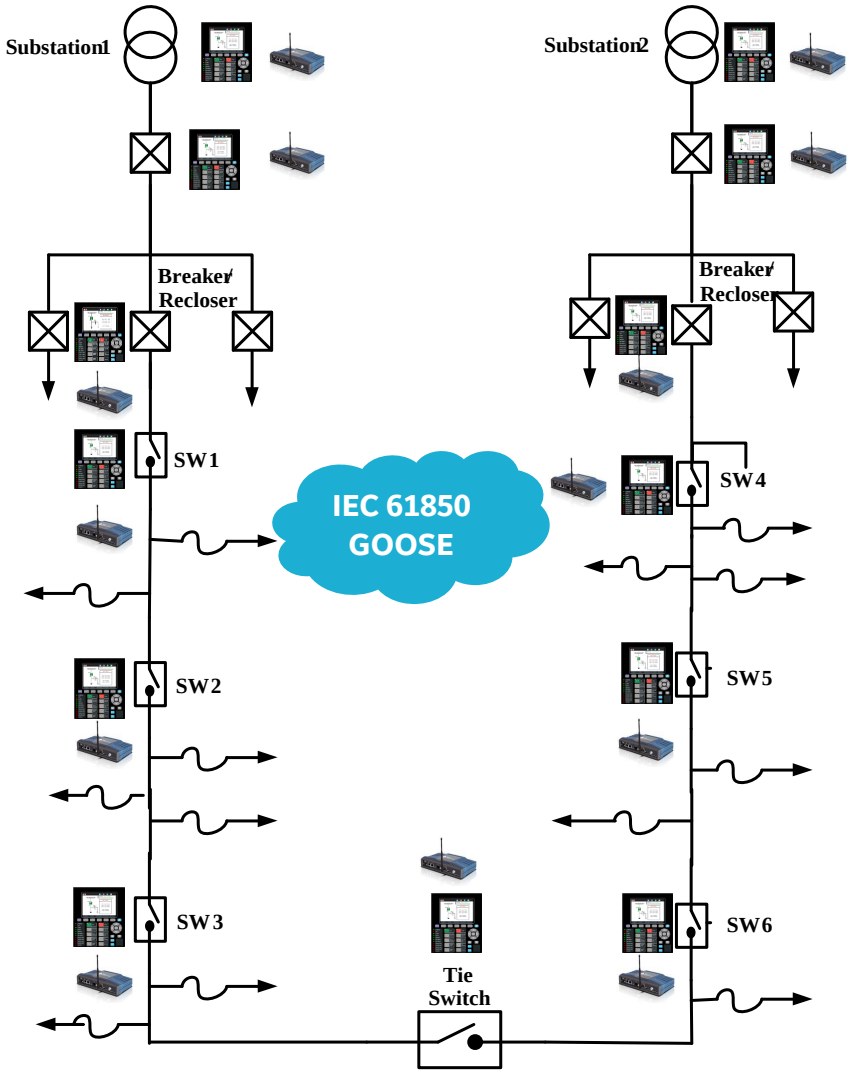
Distribution Automation Applications

Distribution Automation Applications Requirements

- Speed
- Dependable and secure
- Interoperability
- Adequate Bandwidth
- Multiple protocol support
- Communications redundancy
- Reliable power source (battery back-up)

Independent/Peer-to-Peer FDIR

- Fault Detection Isolation and Restoration (FDIR)
- Independent/peer-to-peer messaging using IEC 61850 GOOSE
- Interoperability (non-proprietary)
- Speed of operation (seconds)
- Support for traditional DNP SCADA protocol for control, monitoring and metering



Centralized / Decentralized FDIR

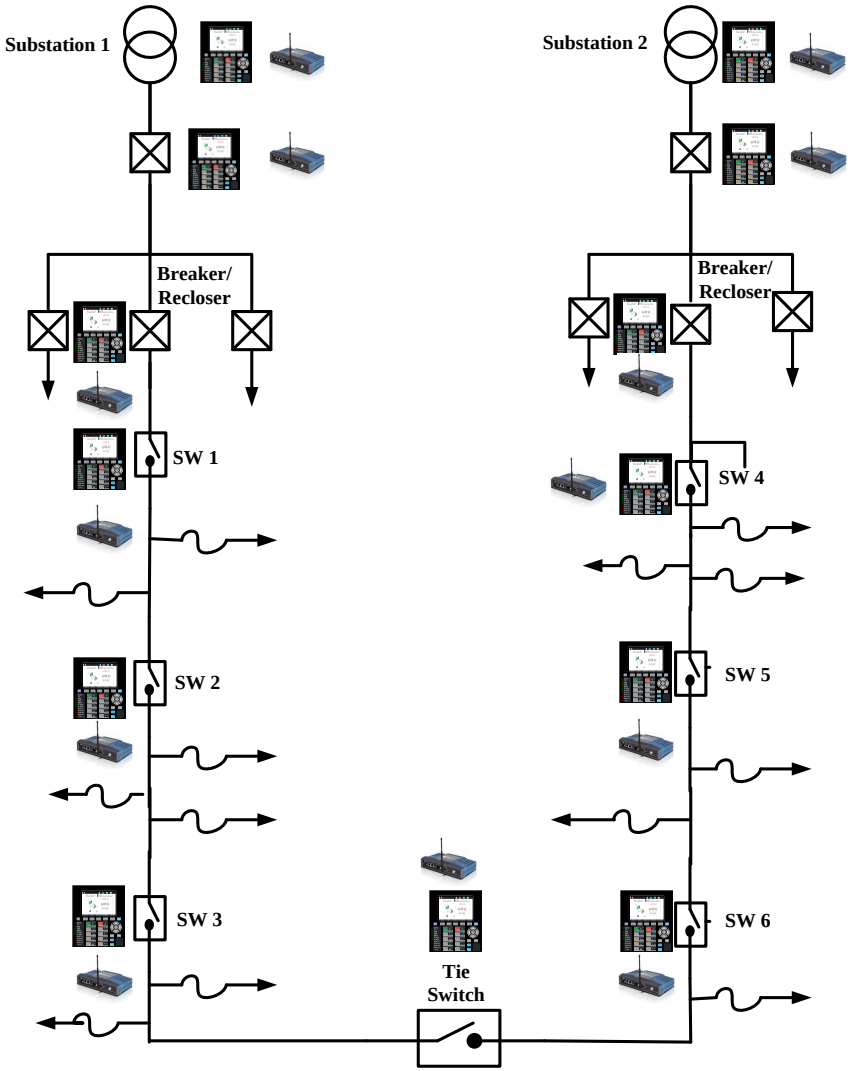
- Communication to nearby substation or control center
- GOOSE can still be used for interoperability
- Speed of operation (seconds)
- Support for traditional DNP SCADA protocol for control, monitoring and metering

Decentralized

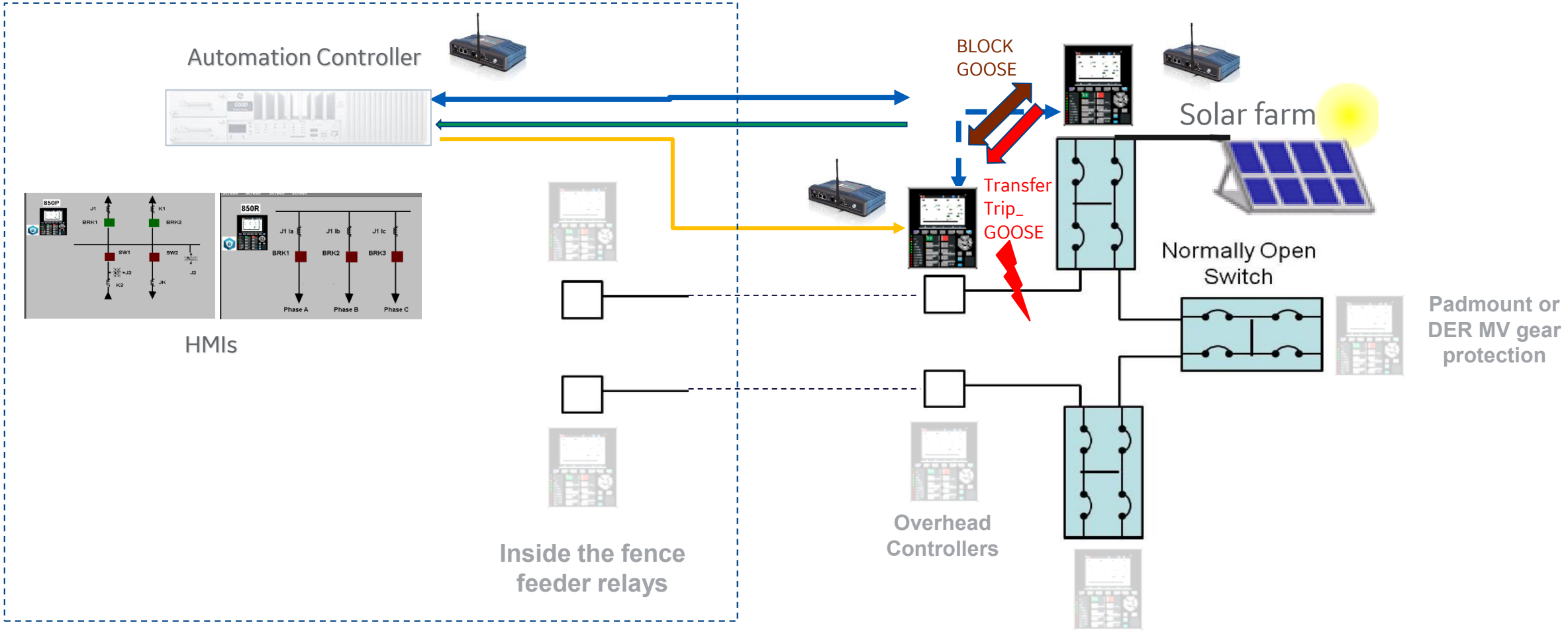
- ✓ Automation Controller at Nearby Substation
- ✓ Reduces complexity
- ✓ Configuration is easy to setup and maintain

Centralized

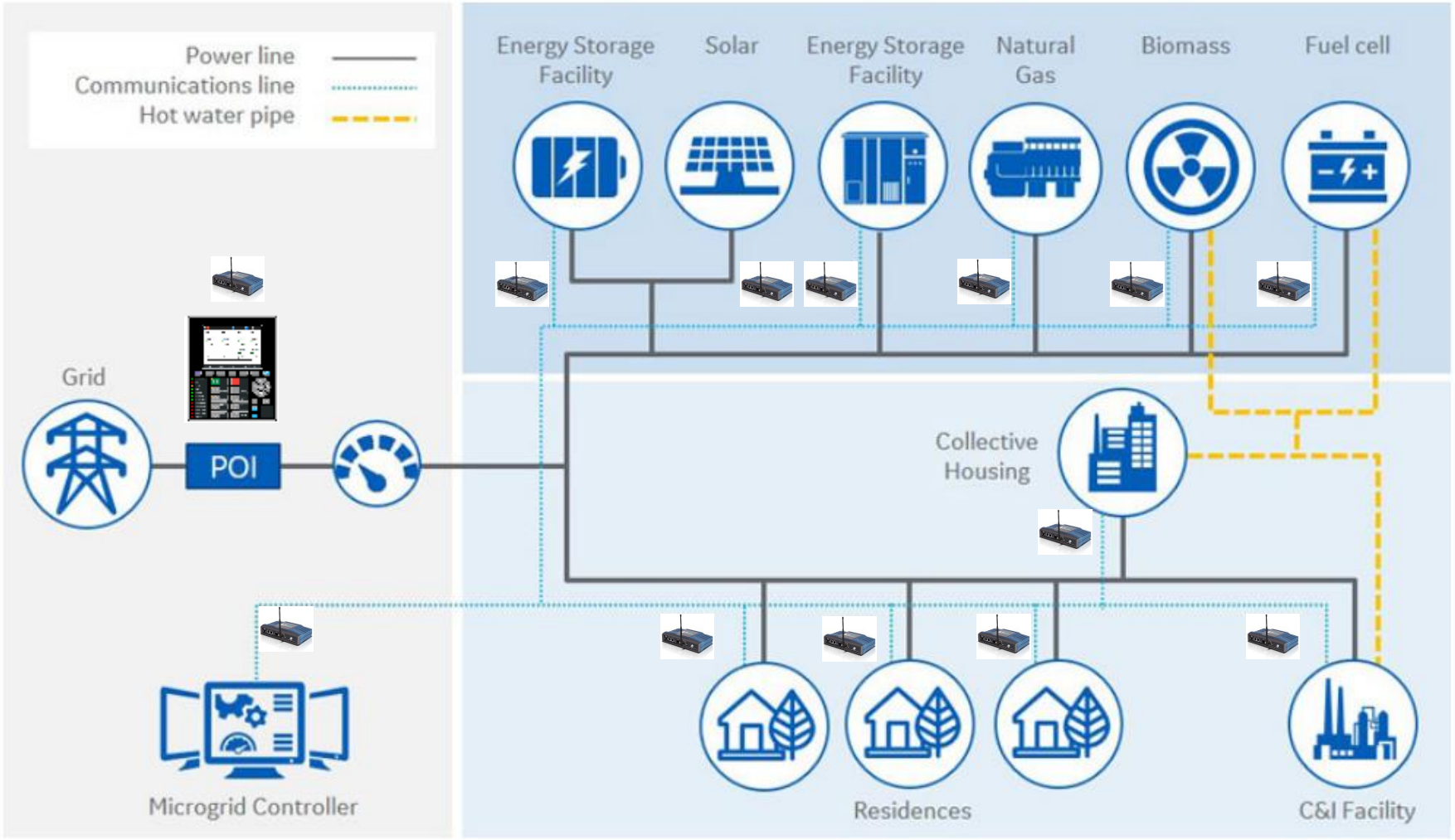
- ✓ Control Center
- ✓ Multiple / complex networks supported
- ✓ Multiple faults can be handled
- ✓ Large amounts of data/devices
- ✓ Load shedding



Distribution Automation with Distributed Energy Resources



Microgrid Control System



- System integration of various DER assets
- Wide mix of protocols used (Modbus RTU, DNP, IEC 61850)
- Speed of operation (milliseconds to seconds)

Wireless Solutions & Architectures

DA Applications: Field Area Network (FAN) Performance Requirements

DA Applications	One-Way Network Latency Between IEDs	Network Reliability Requirement	Network Throughput Per IED	Cyber Security
Peer-to-Peer FDIR	<100 msec	High	1's to 10's of Kbps	High
Centralized FDIR	<200 msec	High	10's of Kbps	High
Decentralized FDIR	<100 msec	High	10's of Kbps	High
DER Disconnect/Trip	<100 msec	High	10's of Kbps	High
Microgrid Control System	<100 msec	High	10's to 100's of Kbps	High
Microgrid Fast Load Shedding	< 10 msec	High	10's to 100's of Kbps	High
Monitoring	1-2 seconds	Low	10's to 100's of Kbps	Low/Medium
Control	1-2 seconds	High	10's of Kbps	High

Notes:

- Network latency between relays is relatively subjective. Its budget is determined as part of a holistic automation scheme. Typical distribution recloser opening/closing may need to occur within seconds of fault detection.
- Effective network throughput per IED can impact latency

DA Applications: Choosing the Right RF Technology For the Application

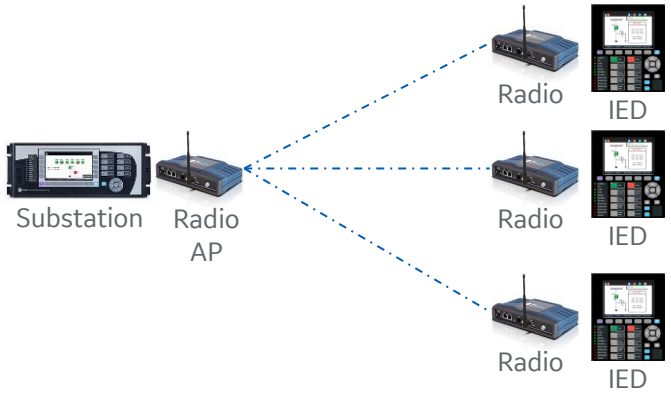
RF Technology	RF Band Ownership	Typical One-Way Latency	Available Throughput Per IED	CAPEX	OPEX	Typical Network Topology
TV White Space	Unlicensed Public	10's of msec	10's of Mbps	High	Medium	P2P, P2MP, Mesh
900 MHz ISM Band	Unlicensed Public	10's of msec	10's of Kbps to Low 1000's of Kbps	High	Medium	P2P, P2MP, Mesh
2.4 to 5.9 GHz ISM Band	Unlicensed Public	10's of msec	1s to 10's of Mbps	High	Medium	P2P, P2MP, Mesh
Narrowband 100, 200, 400, 900	Utility Owned	100's of msec	10's of Kbps	Higher	Medium	P2P, P2MP, Mesh
Upper A Block Wide Band 700 MHz	Utility Owned	10s to 100's of msec	100's of Kbps	Higher	Medium	P2P, P2MP, Mesh
CBRS 3.5-3.7GHz Band	Utility Owned Semi-Public	10's of msec	10's of Mbps	Higher	High	P2MP
Private LTE Bands	Utility Owned or Leased	10's of msec	10's of Mbps	Highest	High	P2MP
Public Cellular	Carrier Owned	10's of msec	10's of Mbps	Lowest	High	P2MP

DA Applications: Common FAN Network Topologies

• Point to Point

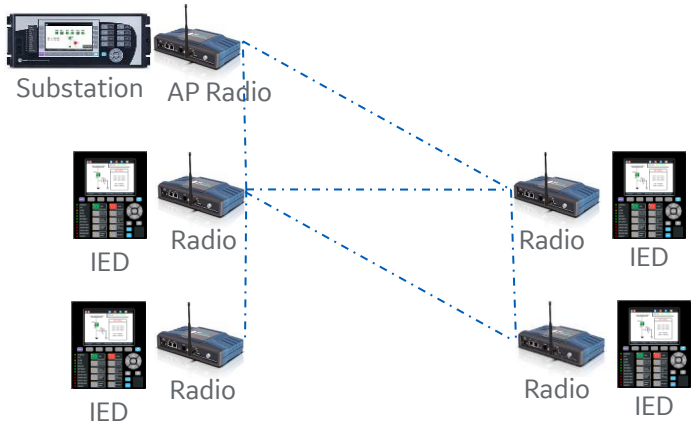
- Simple topology
- Direct long-range communications possible
- Ideal for direct DER/DTT/DGT Applications
- Good for serial, IP, GOOSE

• Point to Multi-Point



- Direct long-range communications possible
- Ideal for a Centralized or Decentralized FDIR
- Peer-to-Peer communications also possible via Access Point (AP)
- Can work well for Peer-to-Peer FDIR with attention to latency
- Good for serial, IP, GOOSE

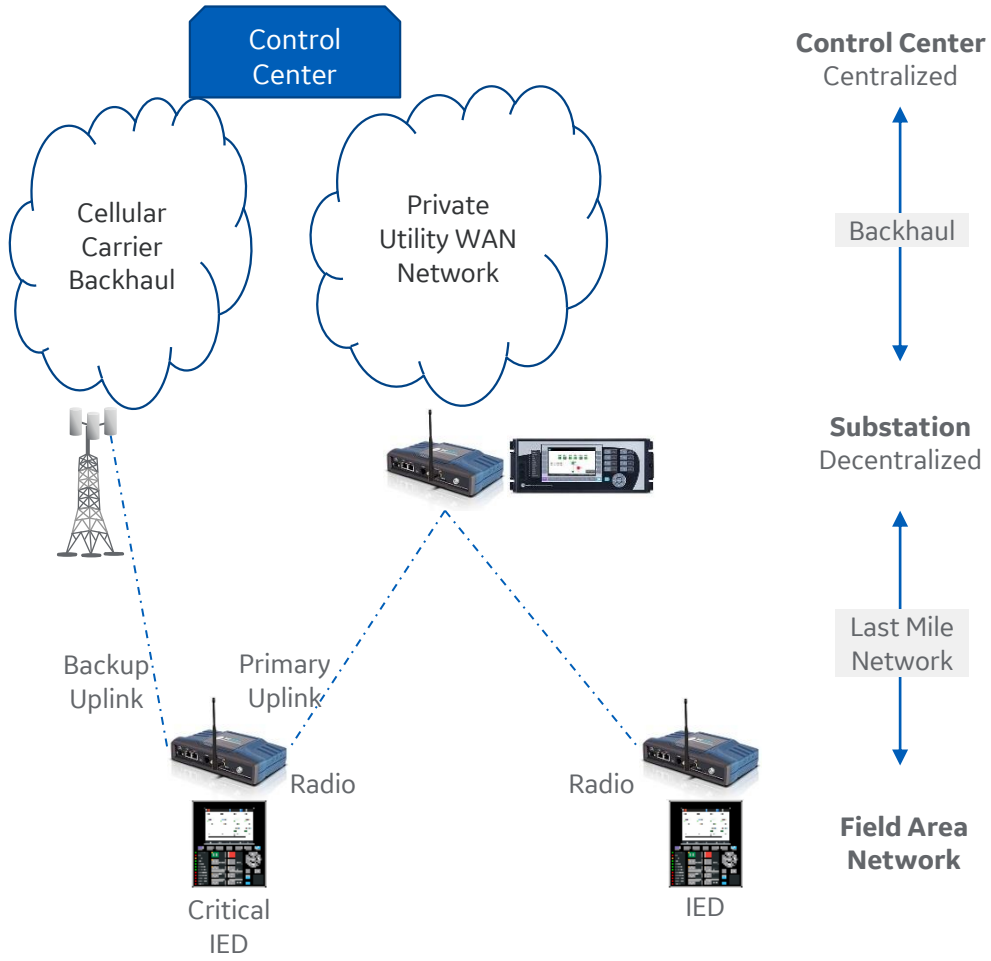
• Mesh or Self-Healing Topologies



- Radios automatically inter-connect based on proximity, line of sight, signal strengths
- Significantly shorter distance between radios, but higher overall network resiliency
- Long-range communications may require several intermediate hops (latency impact)
- Works well for peer-to-peer FDIR
- Good for serial, IP
- GOOSE may work if highly optimized broadband RF network is used

Improving Grid Reliability With FAN Network Design Considerations

- **Radio Device Ruggedness:** Compliant vs certified to substation-hardened standards
- **Radio Device Longevity:** High quality components & design → High MTBF
- **Number of Radio Uplinks/Modems:** Per Remote/IED: Single vs Dual
- **Number of Radio "Paths":** Between remote and Base Station
- **Diversity of Radio Types/Options**
- **RF Band:** Licensed vs Unlicensed
- **Unlicensed Bands:** Media Access Control (MAC), bandwidth and interference mitigations
- **Cellular Uplink Redundancy:** Dual-SIM vs Dual Modems



Improving Grid Reliability With Network Security Considerations

- **Protect Data Transmission**
  - ✓ Encrypt everything at RF, IP and possibly application layers
  - ✓ Key Rotation Algorithms
  - ✓ Certificate Management

- **Protect Communication Devices**
  - ✓ Secure Boot: guard against hardware manipulations
  - ✓ Secure Firmware: guard against firmware manipulations
  - ✓ Secure CPU Processes: monitor CPU for unfamiliar/odd processes
  - ✓ Physical Security: GPS, alarm contacts, video security, etc.

- **Authorized Users and Data**
  - ✓ Users: authenticate and monitor authorized users network usage
  - ✓ Data: block all but known protocols, data types and data formats
  - ✓ Intrusion Detection: automatically monitor data traffic for odd patterns and report it
  - ✓ Intrusion Prevention: automatically block then report odd data patterns (i.e., malformed DNP3 SCADA packets)

Conclusions

Field Area Network technology choice, performance, availability and security play an integral role in improving reliable distribution protection & control operations:

- **Technology choice:** legacy narrowband technologies are holding steady, while broadband technologies such as private and public cellular have been picking up steam
- **Performance**: choices of topology, link speed, and RF technology impact latency and throughput performance of automation applications
- **Availability**: as FDIR, DERs, Microgrids increase in adoption and coordination complexity, improving network availability with multiple uplinks or backup paths becomes more important
- **Security**: adopting technologies recommended by NERC-CIP and other security standards bodies help protect the network and DA applications against intrusion and improve stability

Thank You
Questions?