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Improving Utility Teleprotection via Carrier Ethernet Solutions

The Nature of Utility Networks

The most recognizable aspect of an electric utility network is its transmission and distribution system. Transmission towers, medium- and low-voltage lines and poles, substations, and transformers are familiar sights in our communities, along railroads and roadways and in every neighborhood. Many aspects of our lives depend on this network: home, work, school, shopping, entertainment, and even traffic lights.

Another critical component of this network, though much less visible, is the communication network that utilities deploy. The electric utility network includes many electric grid components and systems that need to communicate to monitor, control, and manage the distribution of electricity from generation facilities to end users. This is a large, complex network that needs to be up and running 24 hours a day, every day of the year. Customers recognize every outage and disruption as it happens.

Communication in Utility Networks

Utility companies maintain a crucial part of the nation's infrastructure, providing essential services to the public, business, and government. Reliable infrastructure communication networks are essential to the reliability of the grid and to safeguarding transmission and distribution assets and utility company employees. Utility-specific applications such as SCADA (Supervisory Control and Data Acquisition), current differential, transfer trip, phase comparison, and advanced metering are an important layer of critical infrastructure communication and must be part of a modern, reliable, self-healing network. Substation automation, the use of computerized devices to reduce human intervention, has caused a leap in the demand for the latest switches and routers and sufficient bandwidth. More recently, security concerns have led utilities to add alarms and video monitoring to their communication network applications.

Utilities provide uninterrupted power via a comprehensive set of control and teleprotection mechanisms. The teleprotection network allows providers to quickly isolate failures and reroute power. Teleprotection mechanisms are networked with an equally resilient, low-latency communication network. Utilities deploy Data Communication Networks (DCNs) in parallel with their generation, transmission, and distribution infrastructures to deliver these applications.
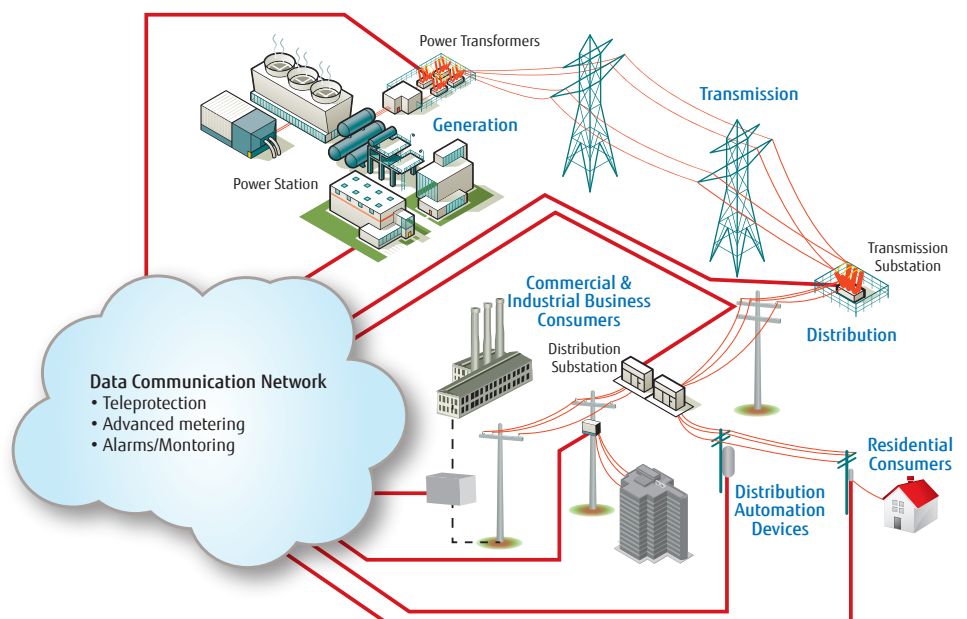

Figure 1: Utility network and DCN

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Data Communication Networks

For the last 25 years, utilities have built DCNs using predominantly SONET networks, and the technology has proven its value. The protocol's versatility is a key advantage, as SONET:

- Supports the variety of services utilities require
- Delivers the performance required
- Supports multiple topologies including linear, star, mesh, and rings
- Is cost-effective at any distance, in any climate, and over any terrain
- Can be deployed underground, aerially, and wirelessly

Characteristics that have contributed to SONET's success include:

- Its connection-oriented and deterministic features
- Low latency
- Fast restoration
- Guaranteed bandwidth
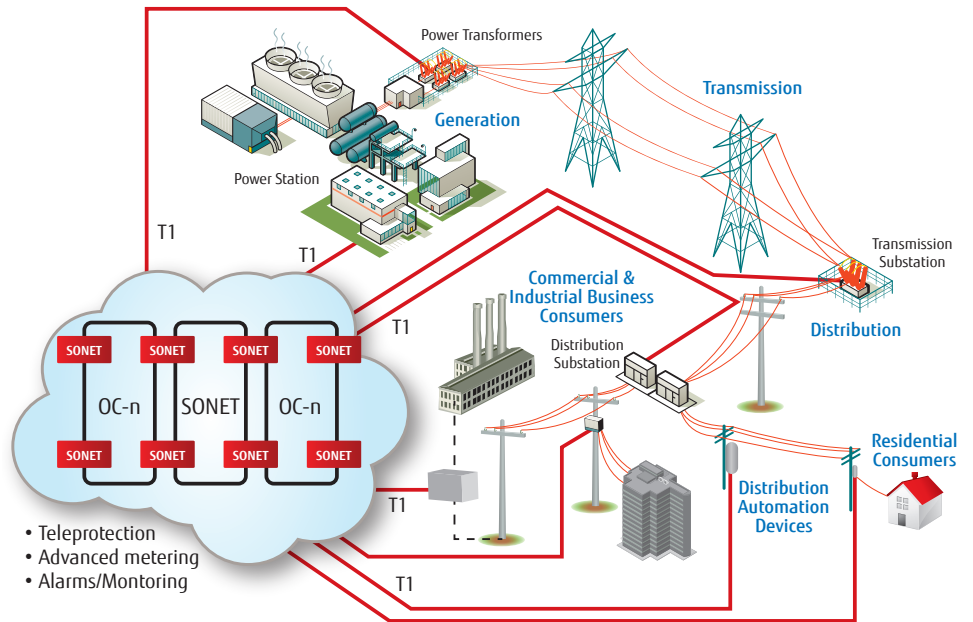- Comprehensive Operations, Administration, and Maintenance (OAM) functions

Evolution of Utility DCNs to Packet Networks

As communication network technology evolves, packet networks have been supplanting SONET in most communication networks. When utilities first implemented SONET networks, packet networks were available only for LAN applications. Since that time, packet networks have evolved significantly. These are key aspects of packet networking's evolution:

- Support of connection-oriented services
- Low latency
- Security
- Guaranteed-bandwidth services
- Standardization of MEF E-Line, E-LAN, and E-Access services
- Monitoring and management capabilities
- Sub-50 millisecond protection switching
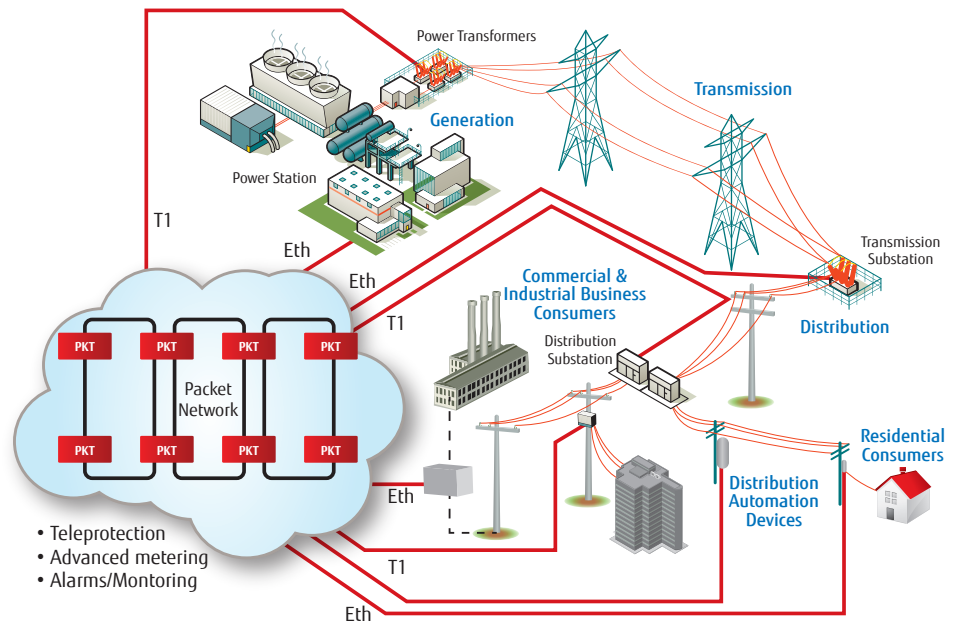- Circuit-emulated services (CES)

Figure 2: SONET network providing a utility DCN

Figure 3: Packet network serving as a utility DCN

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Packet networks used in utility DCNs need to be able to carry T1s and other TDM circuits, as these are still prevalent in utilities. Packet networks are fundamentally asynchronous, and TDM services, such as T1s, are synchronous. Recent technologies such as Structured Agnostic Time Division Multiplexing over Packet (SATOP) provide mechanisms to carry T1s on packet networks. When utilities evaluate packet solutions, one of the more critical aspects is ensuring that they can effectively transport TDM and T1 services.

Evolutionary advances have made packet networks suitable for utility DCNs, and packet networks are now supplanting SONET networks.

Several technologies can implement packet networks, including Multiprotocol Label Switching (MPLS), MPLS-TP, provider bridging, Provider Backbone Bridging (PBB), and Carrier Ethernet, a highly evolved version of Ethernet. These are key features of Carrier Ethernet:

• Support of connection-oriented services
• Low latency
• Guaranteed-bandwidth services
• Standardization of MEF E-Line, E-LAN, and E-Access services
• SOAM enhancements via 802.1ag
• Per-service performance monitoring via Y.1731 PMs
• Sub-50 millisecond protection switching via G.8031 and G.8032
• IEEE 1588 v2 timing

Compared with other packet technologies, Carrier Ethernet provides the same capabilities and features, including traffic management and guaranteed bandwidth.

Carrier Ethernet also provides significant advantages:

• Reduced overhead, preserving more bandwidth for services
• Fewer layers to provision
• Simpler maintenance

For these reasons, Carrier Ethernet is gaining support as the packet technology to supplant SONET networks in utilities.

The Fujitsu Carrier Ethernet Solution

Fujitsu offers a feature-rich Layer 2 Ethernet network portfolio that cost-effectively delivers carrier-grade performance of MEF-compliant E-Line, E-LAN, and E-Access services. For utilities, this portfolio enables cost-effective packet networks that provide teleprotection applications with faster introduction of new services. This functionality includes:

• MEF 10.2–compliant two-rate, three-color policing (single-class or up to eight-class)
• VLAN push, pop, and translate capabilities
• Single or dual tag, S and C tag, and Q-in-Q Switching
• Port, VLAN, P-Bits, and PCP-DE bit Classification
• Per-Port Egress 8-class shaping
• Strict priority, Weighted Round Robin (WRR), and Best Effort Queuing
• IEEE 802.1ag Service OAM Fault Management (SOAM-CFM) and Link OAM (LOAM)
• IEEE 802.3ax Link Aggregation
• ITU-T G.8032 v2 Ethernet Ring Protection
• Y.1731 Performance Measurements
• T1 and OC-3 CES Support

Fujitsu Ethernet Services Platforms

These platforms comprise the Fujitsu Ethernet services portfolio:

• The FLASHWAVE® 7120 Micro Packet Optical Networking Platform, a high capacity, space-efficient shelf that supports core node applications. In addition to CWDM and DWDM mux/demux modules, amps, transponders, and muxponders, the shelf supports three Ethernet cards:
   • PVX 12/2,with 12 Gigabit Ethernet ports and two 10 GbE ports
   • PVX 24/4, with 24 Gigabit Ethernet ports and four 10 GbE ports
   • PVX 80, with eight 10 GbE ports
• The FLASHWAVE 5310, a multiservice Ethernet aggregation device that provides circuit emulation or Ethernet services. This device has four GbE ports on the chassis with three personality modules: eight-port T1, one-port OC-3, and four-port FE/GbE.
• The FLASHWAVE 5305, a market-changing Ethernet access device that cost-effectively facilitates rapid capacity growth from 1 GbE to 10 GbE without a costly equipment forklift. This device is equipped with four SFP/SFP+ ports.
• The FLASHWAVE 5321, an Ethernet aggregation device that supports four 1GbE/10 GbE interfaces. This device is equipped with four SFP+ ports on the chassis and 24 FE/GbE SFP ports.
• The FLASHWAVE 5322, an Ethernet aggregation device that supports 12 SFP+ 1 GbE/10 GbE ports.
• The NETSMART® 1200, a comprehensive, easy-to-use graphical network management solution that facilitates complex network provisioning. The NETSMART 1200 creates high value SLAs to differentiate Ethernet service offerings.

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Benefits of Layer 2 Networks to Utilities

Independent studies indicate Layer 2 Ethernet networks are cost-effective versus MPLS and other technologies when the former deliver carrier-grade, MEF-compliant E-Line, E-LAN, and E-Access services. A key benefit is that Layer 2 Ethernet operates similarly to guaranteed SONET networks. This translates to minimum training and faster adaptation by utility employees who deploy and maintain networks to maintain or improve grid reliability. Layer 2 Ethernet networks help utilities quickly meet new network requirements and provide a roadmap to IP enablement. With this Fujitsu portfolio, utilities can implement cost-effective packet networks that support teleprotection applications.

Summary

Utilities can benefit by replacing SONET networks with packet-based networks. The Fujitsu FLASHWAVE 7120 and FLASHWAVE 5300 platforms provide a Carrier Ethernet solution for cost-effective DCNs that is adaptable to topology variations and new services. This complete, comprehensive solution comprises a variety of devices that support guaranteed bandwidth, multiple classes of service, fast restoration, and per-service performance monitoring.

Figure 4: Fujitsu Ethernet services platforms network serving as a utility DCN