

Grid IQ™ Network Communications Platform

Enabling Utilities to Efficiently Build & Deploy Grid Modernization Systems

GE has been leading the way from the beginning. Our history, knowledge and contributions to the electric industry have been unsurpassed in the last 125 years. Our legacy continues to strengthen with solutions that automate the 21st century Electric Grid and deliver efficiencies for energy generation, transmission, distribution, control and utilization.

To successfully automate and implement a next generation communications network, a major objective for Utilities is to build a secure, future-proof and scalable infrastructure. Based on broad domain industry expertise, GE has designed the Grid IQ™ Network Communications Platform to assist Utilities in achieving this critical objective.

The Grid IQ Network Communications Platform provides an end-to-end infrastructure that creates a common, multi-use network solution across an entire service territory. With real-time connectivity, monitoring and control applications, GE provides Utilities a secure and flexible network with abundant system capacity that efficiently scales to support future applications.

Components of the Grid IQ Network Communications Platform include industrially hardened fiber and wireless communications that stretch from the network edge to the back office, a network management solution that provides advanced management of the entire network, and standards based cyber security surrounding the entire system.

Key Benefits

- Extend and maximize legacy investments by facilitating the migration to next generation, multi-use, all IP technologies
- Increase automation, management and control with an all IP-based network
- Improve the operational efficiency and reliability of grid applications
- Simplify management and reduce costs in a large-scale communications network
- Enable end-to-end security with NERC/CIP compliance

Applications

- Connectivity for Advanced Metering Infrastructures (AMI), Energy Management Systems (EMS), Distribution Management Systems (DMS) and Outage Management Systems (OMS)
- Distribution and substation automation
- Real-time protection and control for Distributed Energy Resources (DER)
- Connectivity for transmission, distribution and SCADA automation applications
- Mobile work force connectivity



Multi-Use Communications

- Minimize CapEx/OpEx by consolidating multiple networks
- Embedded gateways provide easy integration of legacy devices
- Capable of covering large areas within urban, suburban and rural settings
- Secure gateways support Utility protocols

End-to-End Security

- Complies with NISTIR 7628 cyber security guidelines
- Standards based FIPS 140-2 compliant devices
- Role-based access control and event logging

Scalable & Reliable

- Quality of Service (QoS) enables low latency and high availability
- Automated network and configuration management
- Long range, low power battery options

Industrially Hardened Equipment

- All devices IEEE 1613 certified for use in electric power substations
- Extended temperature ranges -30°C to +70°C

Standards Based

- Supports Utility protocols including DNP3, IEC61850, IEC60870 and Modbus
- End-to-end standards based IPv4 Infrastructure

Automating the 21st Century Grid

Automation meets Information Technology (IT) with the current electrical infrastructure, helping Utilities support the energy needs of our 21st century society by optimizing supply and demand.

Power automation technologies, combined with real-time communications, provide knowledge and decision-making tools that save energy, resources, money and the environment. More specifically, the systems enable existing devices to be combined with next generation hardware and software that together, works to:

1. Enable the integration and optimization of more renewable energy, such as wind and solar, and plug-in electric vehicles.
2. Drive significant increases in grid efficiency through Volt/VAR control and peak reduction through demand response.
3. Reduce down time and increase reliability through monitoring.
4. Empower consumers to manage their energy usage and save money without compromising their lifestyle.

These system improvements will be obtained using next-generation grid applications connected on a secure, all IP infrastructure.

The Challenge of Legacy Systems

Legacy power grid networks were constructed using polled, narrowband radio networks that support a single monitoring and control application without the capacity to scale. Limitations of legacy networks include:

- Lack of security
- Limited element management
- Limited system capacity
- Inability of multiple applications to share a common set of end points

The Future of Automated Power Systems

Future systems must leverage legacy systems because they cannot be cost-effectively upgraded or replaced to take advantage of emerging standards. The mechanisms that bridge legacy systems must maximize the benefits of interoperable standards and minimize the delays and expense involved with implementing new standards.

Future systems require open and interoperable networks that enable multi-use, all IP networks. These systems need to provide secure connectivity with sufficient bandwidth, low latency and Quality of Service (QoS) to enable multiple, simultaneous users and grid applications. Although a single IP network is required, a hybrid set of communication technologies needs to be seamlessly integrated to create an end-to-end multi-use communications solution.

The Grid IQ Network Communications Platform

GE's Network Communications Platform enables the mission critical applications required to meet power automation needs. The solution enables Utilities to build a single network infrastructure for connectivity to existing and emerging applications.

A solution capable of connecting the grid requires blending communications technology in a way that meets the varying needs for bandwidth and latency while at the same time providing uniform network management in a secure, end-to-end system.

Network Communication Devices

GE's industrial strength network communication devices are extremely scalable, utilize a common SNMP based network management system, and provide FIPS 140-2 compliant security standards to authenticate and network users. The communication is built using a portfolio of IP-based networking devices, including:

- Fiber and wireless high capacity backhaul products
- Hardened Ethernet switches and serial extension
- Narrowband licensed and unlicensed wireless access technology for non-real-time monitoring and battery powered applications



Furthermore, the solution is integrated on a common management and security platform that enables NERC/CIP compliance across the network.

Network Management Software

New, unified network and element management systems are required to manage larger and more complex multi-use networks that span a Utility's entire service territory. These systems use a policy-based approach to configuring devices and managing QoS and security. These systems also have a rich set of tools to perform fault, configuration, performance and security management, as well as facilitating network planning and risk mitigation.



Consulting, Design & Engineering Services

GE's broad industry knowledge and technical expertise can provide Utilities with the services required to deploy a multi-use communications network.

GE can manage the process from start to finish, generate system specifications, build network infrastructure and work with key strategic partners to help ensure interoperability and adherence to common standards.

Consolidating Networks & Benefits

The Grid IQ Network Communications Platform meets emerging global Smart Grid standards and enables Utilities to manage CapEx and OpEx by consolidating multiple communication networks and enabling the benefits of automating the grid.

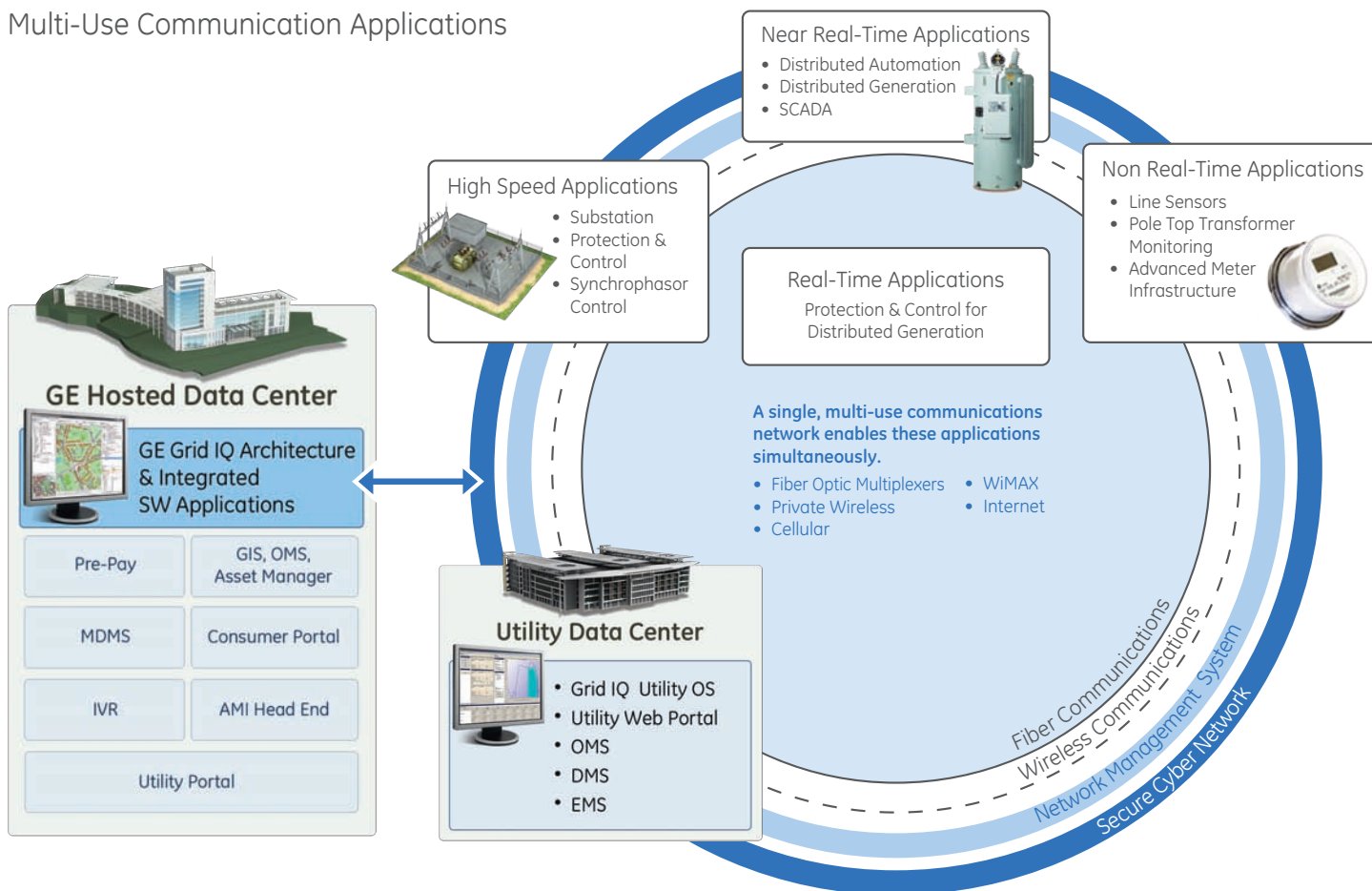
The network simultaneously supports legacy and emerging protocols and applications on a multi-use, secure, IP-based network infrastructure. The infrastructure is built on a flexible set of communication building blocks enabling users to match applications with the required capacity and Quality of Service to minimize total cost of ownership. Additionally, all of the communication building blocks are integrated on a single network management platform and a shared set of security services.

The multi-use, all IP building blocks can be configured to provide connectivity to emerging Smart Grid applications including the pre-integrated GE Grid IQ Utility Operation System and Solution as a Service (SAAS) for AMI, OMS, DMS and EMS systems.

The system includes:

- Real-time fiber and microwave with < 5ms latency, enabling substation protection and control, and high capacity backhaul.
- Real-time WiMAX broadband with < 100ms latency enabling field area protection and control applications, and high speed aggregation.
- Near-real time with cellular, unlicensed and licensed building blocks that enable DA, SCADA and AMI collection applications with the required < 2s latency.
- Non-real-time Low Energy Critical Infrastructure Monitoring (LECIM) that allows very long range and below ground connectivity using battery power in the ISM 2.4 GHz band.
- FAN Gateways enabling systems to securely share data with back office applications using a suite of industry standard protocols including DNP3, IEC61850, Modbus and IEC60870.

Multi-Use Communication Applications



Designing a Solution

GE provides Utilities with strategic consulting and engineering services, simplifying the maze of technology choices and government regulations to support their Smart Grid deployments.

GE leverages decades of global network communication deployments in a variety of applications and within numerous environments including the Energy, Oil & Gas, Water/Wastewater, Public Safety and Transportation industries.

Utilizing GE's Experience

Based on years of experience and participation in hundreds of Smart Grid Request for Proposal (RFP) and Request for Quote (RFQ) processes, GE knows engaging with customers EARLY in the pre-planning process is critical.

Our real-world knowledge provides customers with solutions to effectively address operational needs, while proactively balancing risk management and adhering to compliance requirements.

This experience is translated to provide Utilities a complete turn-key strategy including system design, integration, deployment and data management and analytics to ensure a successful implementation.

Applications

Whether it's a large AMI network deployment or a SCADA infrastructure upgrade, GE has expert-driven, end-to-end, multi-use networks that provide services to a rich set of automated applications, including:

- AMI & Smart Meters
- HAN
- SCADA
- Distribution Automation
- Substation Automation
- Fiber & Wireless Microwave Backhaul

Power automation professionals look to GE to deliver practical systems and solutions that clearly demonstrate measurable results. GE helps its customers confidently deploy scalable, future-proof technologies that improve operations and reduce costs.

Services Capabilities Summary

Technology Strategy

GE works with Utilities to assess the business case for new technologies, perform market and competitive analysis, recommend the best network options, and oversee the RFP process necessary to evaluate and choose vendors.

Network Engineering Services

Integrate Advanced Metering Infrastructures, SCADA and Distribution Automation Systems into a single multi-use system. Design the wireless networks necessary to transmit data from smart devices.

Network Security Design

Provide expertise in all aspects of cyber security, create Grid Automation networks that are secure from end-to-end. Identify and evaluate security gaps and will define security strategies and plans to address any open issues.

Software Services

Integrate Smart Grid network applications and ensures the system has the performance and capacity to run enterprise scale Smart Grid applications. GE's Software Services Integration (SSI) team provides the tools needed to reduce cost and increase energy efficiency.

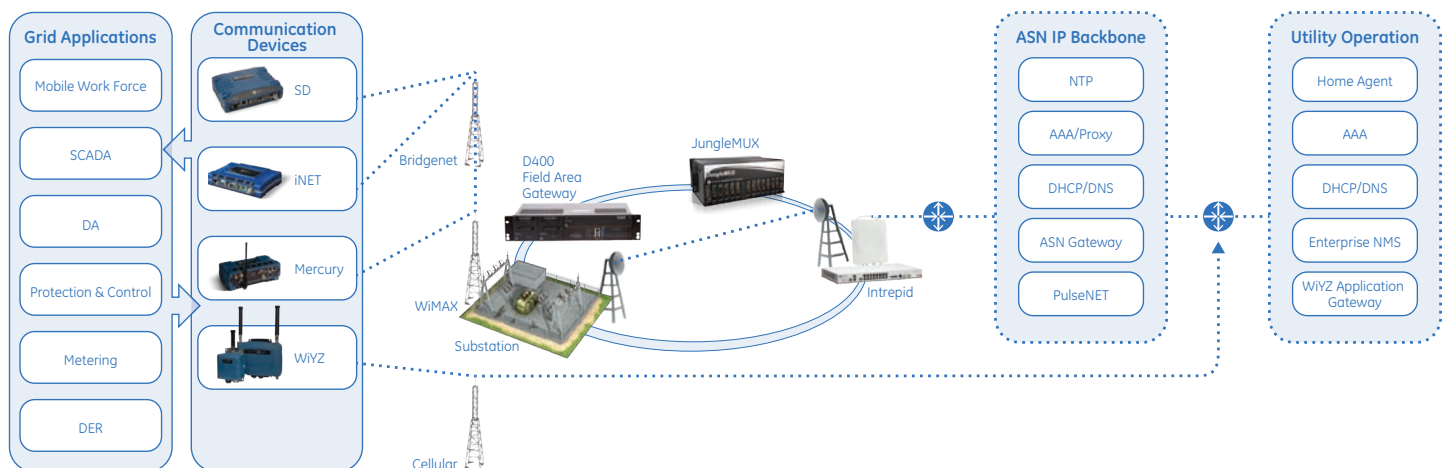
Network Deployment Services

Provide project management, construction management and installation services needed to deploy communication networks for smart meters, SCADA and distribution automation networks in the field, as well as maintain them in the future.

Program Management

Provides certified and experienced Program Management professionals to organize and lead every stage of a Smart Grid implementation to ensure projects are deployed in a timely manner.

Communications Infrastructure for Grid Applications



Managing a Communications Network

GE's MDS PulseNET Enterprise

GE's MDS PulseNET Enterprise Element Management System (EMS) is an industry-leading management application enabling Utilities to manage their communications network.

The MDS PulseNET Enterprise solution provides a unified interface that allows Utilities to manage and control all elements of their network devices with an extensible architecture that effortlessly supports networked products. This provides Utilities the ability to manage the functionality and capability of network devices in a cost effective, reliable and scalable fashion.

The key functionality of the MDS PulseNET Enterprise System is divided into four key areas including Fault, Configuration, Performance and Security Management.

The system contains everything needed to manage a communications network. Scalable enough to serve the largest networks, a single MDS PulseNET Enterprise server can support thousands of network elements.

Designed for simplicity and user friendliness, the MDS PulseNET Enterprise solution delivers granular control over every network element, from provisioning to near-real-time performance monitoring.

The centralized network management system creates scales of efficiency for network operators, allowing them to quickly configure new devices and services. MDS PulseNET Enterprise solution also supports flow-through provisioning and broad integration through programmable APIs. As a high-level security solution, network administrators can use the Element Management System to set customizable alarm thresholds and monitor alarms and events in near-real-time.

Management Characteristics of MDS PulseNET Enterprise

Fault Management

- Real-time and configurable alarm monitoring
- Alarm history log - up to 365 days can be stored
- Graphic representation of alarms and severity levels including corrective action and probable cause
- Alarm synchronization mechanism - including network elements and northbound interface

Configuration Management

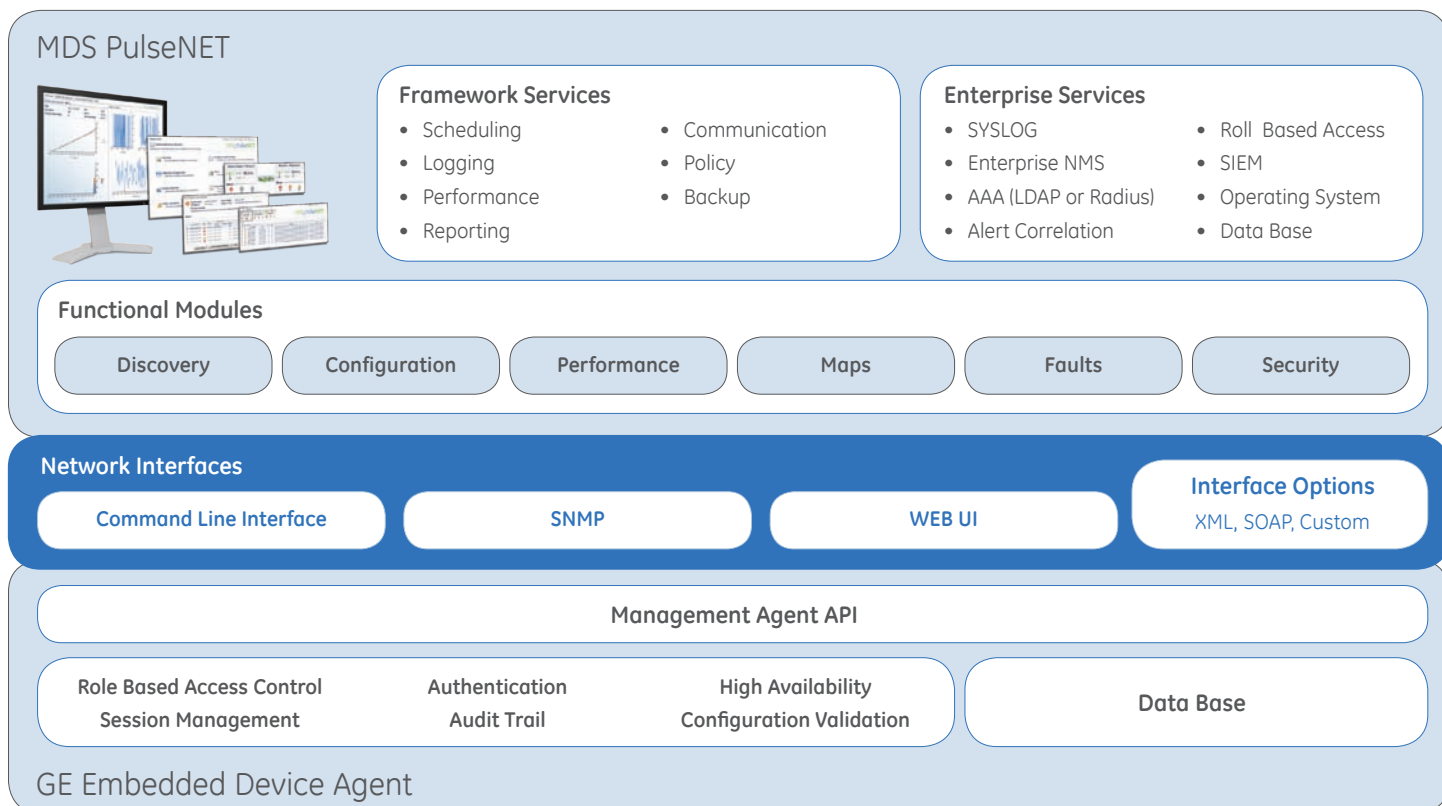
- Transaction and session management
- Auditing and event logging
- Role-based access control
- Authentication over RADIUS and LDAP
- Rollback management
- Replication and high availability

Performance Management

- Personalized reports easily viewed on any available point on the network
- PM collection - user-defined, centralized scheduled network element polling - PMs, inventory, logs and alarm synchronization
- Performance history is maintained on 15-min and 24-hour resolution for up to 365 days

Security

- User-controlled levels and privileges
- Authentication and encryption
- User access control
- NMS/NEs operation audits RADIUS client
- Secured channels and protocols



Mission Critical, Industrial Strength Communications Solutions

Today's complex, converged service networks need powerful, flexible and reliable solutions that scale. GE is a leading supplier of industrial strength, multi-service wireless and telecommunications platforms, providing secure application performance over optical cable, wireless and other media from the network core to the edge. This enables customers to optimize the following attributes:

- **Coverage:** Real-world, non-line-of-sight range measured in miles.
- **Capacity:** More than one thousand devices can simultaneously use the channel to publish data in near-real-time.
- **Coexistence:** Massive processing gain virtually eliminates all interference and keeps the signal below the noise floor, minimizing the effect on other systems.

- **Power Consumption:** Extremely efficient power management allows convention cooling, powerline powering and line, solar and battery powered devices.
- **Industrial Performance:** Wide operating temperature range, -30°C to +70°C, and ready for use in applications requiring UL Class 1, Div 2 or Class 1, Div 1, ATEX or CENLEC hazardous certifications.
- **Secure:** NIST-approved security algorithms provide mutual authentication, integrity protection, confidentiality and high availability.

Communications Solutions Portfolio



MultiLink Industrial Ethernet Switch

Industrial Hardened Ethernet Switches

The MultiLink family is a line of industrial and substation hardened Ethernet switches that provide secure, reliable communications for critical infrastructure devices.

Designed to meet the unique requirements of the protection and control industry, the MultiLink Ethernet switches ensure communications networks are available, fast and secure. Additionally, they provide high speed network recovery of redundant Local Area Networks and include options to extend an Ethernet network to support serial devices and relays.



Multilin D400 Data Gateway

Field Area Data Gateway

The Multilin™ D400 is a hardened field area gateway with advanced security features including remote user authentication, access control and auditing to ensure compliance with NERC/CIP requirements. It provides a full suite of SCADA protocols that allow for direct communications with master stations and collects sensor, status, event and fault report data from serial or LAN-based devices. The D400 provides direct support for industry standard communications ensuring connectivity with new and legacy devices.



MDS WiYZ Platform

Wireless Monitoring & Control

The MDS WiYZ platform is an intelligent data acquisition and networking platform that combines wireless connectivity for sensors, I/O and meters with network infrastructure solutions. An end-to-end solution, MDS WiYZ provides the optimal mix of coverage, capacity, low-power consumption and cost. MDS WiYZ utilizes Low Energy Critical Infrastructure Monitoring (LECIM) that is available in the global and unlicensed 2.4GHz ISM band and the emerging IEEE802.4K standard.

The MDS WiYZ solution leverages of Direct-Sequence Spread Spectrum (DSSS) technology for unlicensed wireless connectivity to provide unmatched range, measured in miles, with exceptional reliability.

The resulting connectivity enables non-real time monitoring and control at a fraction of the cost of traditional wireless solutions.



MDS Mercury Series LAN Extension

Wireless Data Acquisition & LAN Extension

GE's MDS wireless portfolio has a 25-year proven track record of providing a broad range of edge access products for Utility and industrial applications. The MDS platform supports fixed and mobile data on licensed frequencies from 150 MHz to 2 GHz and unlicensed products in the 900 MHz, 2.4 GHz, 4.9 GHz and 5.8 GHz bands.

The MDS products utilize a common feature set across the entire platform and include gateway functionality to legacy protocols, IP/Ethernet, serial, USB and RS-232, as well as a VLAN, DHCP, and FIPS 140-2 compliant security suite and secure device configuration over SNMPv3, NETCONF and HTTPS.

Real-time communications are passed to and from edge devices using the MDS Mercury, an industrial WiMAX / IEEE 802.16e broadband connectivity device. This is supplemented with a near-real time monitoring and control portfolio of licensed MDS SD Series narrowband devices and the unlicensed MDS iNET devices to maximize coverage cost-effectively using available spectrum options.



MDS Intrepid Series
High Capacity Wireless
Backhaul

High Capacity Point-to-Point Wireless Backhaul

The MDS Intrepid Series of point-to-point wireless products provides data speeds of 800 Mbps over SONET/OC3, Ethernet and T1/E1, and interfaces at distances of 20 miles. The ruggedized extended temperature platform supports N+1 space diversity and protected configurations. It has the flexibility to operate in licensed and unlicensed 2.4 GHz, 5.8 GHz and 6 to 38 GHz frequencies with channel sizes from 5 MHz to 80MHz. The scalability and flexibility of the MDS Intrepid Series make it ideally suited for industrial utility applications.



JungleMUX (SONET)

High Capacity Fiber Optic Backhaul

GE is a proven leader in deploying ruggedized optical backhaul systems globally. The JungleMUX SONET and TN1U SDH Multiplexers deliver optical networking solutions with data speeds of OC-48 and STM-16 respectively.

These multiplexers are designed for critical infrastructure in harsh environments. The equipment provides integrated transport and access capabilities for voice, data, Ethernet/IP WAN, video and utility teleprotection traffic combined in a single unit. Element and Network Management is provided by GE's VistaNET software suite.

Smart Grid Communications Solutions

Network Management & Operation Services



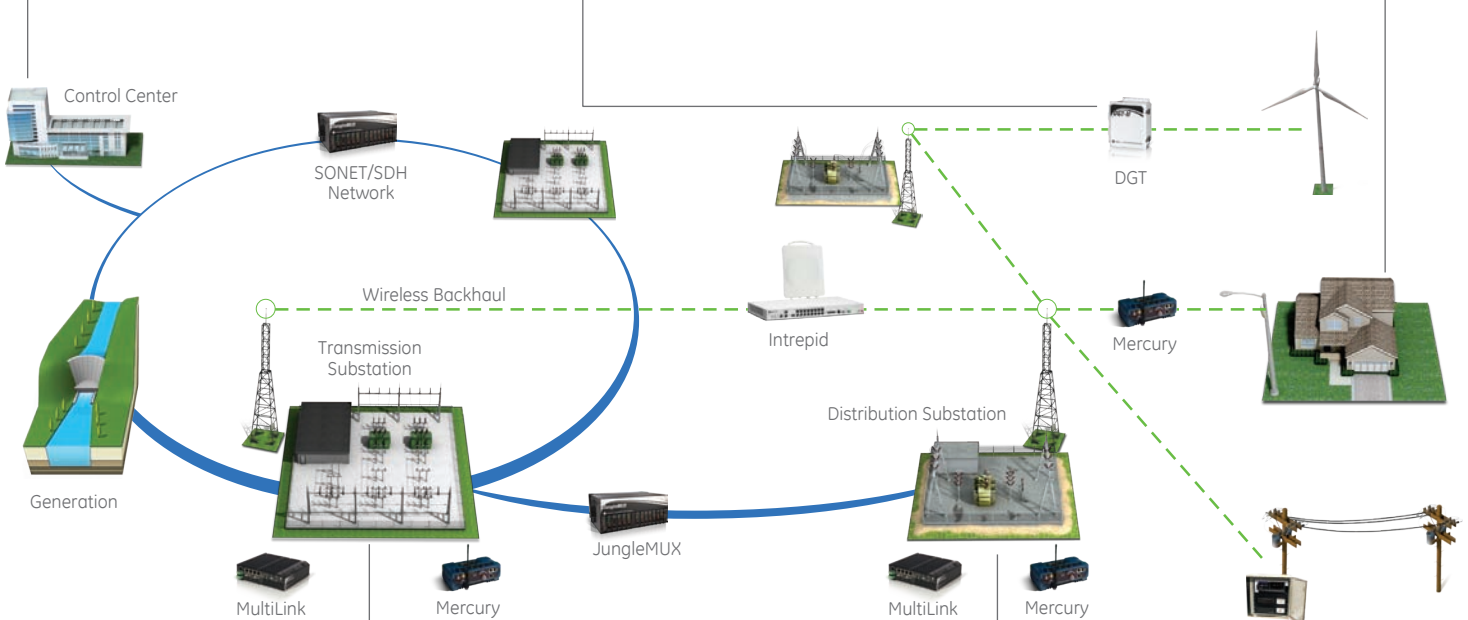
Distributed Generation Interconnect

Digital Energy DGT™ – Wireless fast transfer trip

Advanced Metering Infrastructure (AMI)

Mercury™ Series – Flexible, Secure Standards Based Networking

iNET™ – High Speed, Long Range Wireless



Substation and Backbone Infrastructure

Mercury™ Series – Flexible, Secure Standards Based Networking

iNET™ – High Speed, Long Range Wireless

Intrepid™ – High Capacity, High Speed Wireless

JungleMUX™ – High Capacity, Fiber Multiplexers

Substation LAN

WiYZ™ – Advanced Wireless Data Acquisition and Signal Communications

iNET™ – High Speed, Long Range Wireless

MultiLink™ – Hardened Ethernet switches

Distribution Automation

TransNET™ – Robust, Long Range Wireless

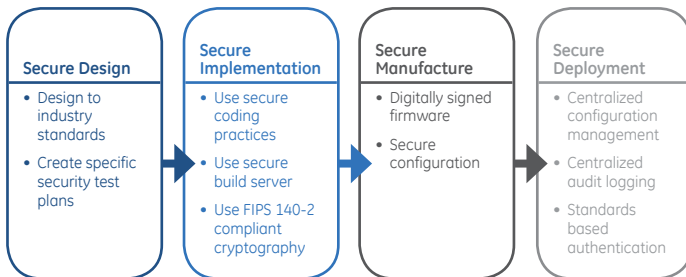
SD Series – Long Range, Licensed Wireless

Building a Secure Network

GE's End-to-End Network Security Approach

Developing an architectural approach to cyber security for emerging Smart Grid automation is complex and tied to emerging NIST and IEC standards and recommendations. To simplify, GE's integrated end-to-end security solutions focus on four important areas of cyber-security:

- Secure Design
- Secure Implementation
- Secure Manufacture
- Secure Deployment



An architectural approach based on these four areas provides information assurance and compliance with the Federal Information Security Management Act (FISMA) regulations. It also supports cost-saving initiatives through secure automation.

The GE multi-use network supports end-to-end security using open standards based security to protect all aspects of device data and enterprise communications, for any connected device. Features include:

Security Event Logging (SEM): Captures all cyber security related events. Serves and classifies data by severity level using standard Syslog data format. Syslog data can easily be integrated with established enterprise security event management systems.

AAA Server Support (Radius/LDAP): Enables integration with centrally managed authentication and accounting of all user activities. Uses industry best practices and standards that meet and exceed NERC/CIP requirements for authentication and password management

Role Based Access Control (RBAC): Allows secure administration of user accounts with mapping to roles. Access to configuration and services can be limited per role in order to meet requirements for "Least Privilege".

GE Security Device Agent: Provides high performance, scalable security demanded by the latest class of IP connected devices supporting low-latency IP services such as VoIP and IP Video. Performance of the agent components is further enhanced by firmware code, which fully leverages the latest generation of multi-core processors and cryptographic hardware acceleration.

GE's Engagement & Leadership on Evolving Standards

Government mandated NERC/CIP and IEC security requirements for critical infrastructure are requiring Utilities to upgrade or replace existing networks.

Regulations are continuously increasing requirements for secure device management, data integrity, confidentiality and event logging. Traditional purpose-built networks lack robust cyber security and often rely on proprietary serial protocols and security through obscurity to protect network data. New Smart Grids will require standards-based security mechanisms that span the power grid.

The applications and communication systems that connect the grid need to align with standards to provide scale and interoperability to the power industry.

There are many standards bodies involved in this process. A few of them include:

- National Institute of Standards and Technology (NIST)
- International Electrotechnical Commission (IEC)
- Institute of Electrical and Electronic Engineers (IEEE)

- Internet Engineering Task Force (IETF)
- American National Standards Institute (ANSI)
- North American Reliability Corporation (NERC)
- World Wide Web Consortium (W3C)

GE has broad cyber security domain experience, an understanding of customer networks and the importance of driving industry standards. GE Energy played a key role in the NIST Cyber Security Working Group and the development of the NISTIR 7628 guidelines, and actively participates in the NERC/CIP standards development.

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