System Overview

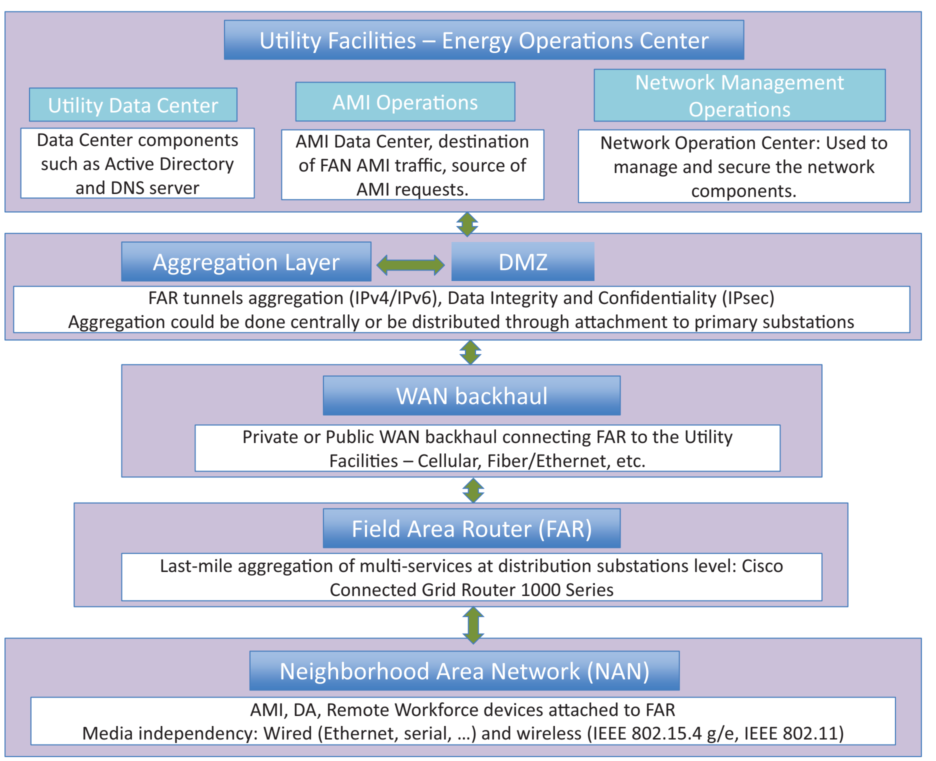
This chapter describes a high-level design review for Smart Grid Multi-Services Field Area Network for Connected Utilities. The specific architectural building blocks for Advanced Metering Infrastructure (AMI) will be discussed in subsequent sections.

This chapter includes the following major topic:

FAN—Places in the Network

This section describes the layers of the architecture and the places in the Field Area Network, as shown in Figure 2-1.

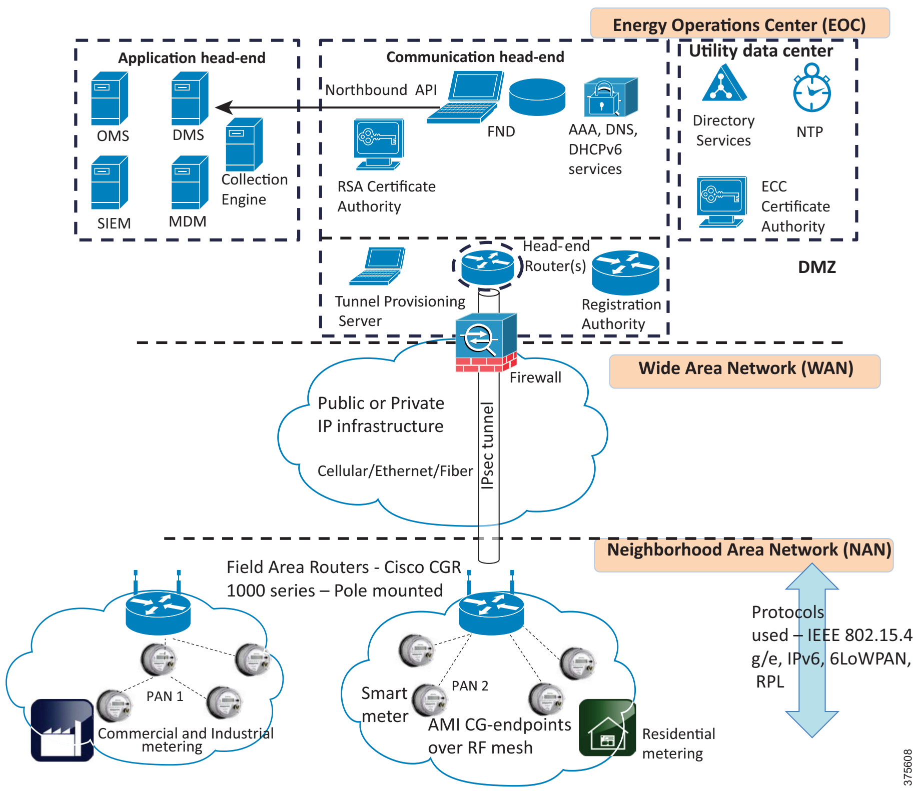
Figure 2-1 FAN—Places in the Network



Advanced Metering Infrastructure Overview

This section describes the building blocks of the Advanced Metering Infrastructure in the Field Area Network. Figure 2-2 depicts the building blocks of AMI and the various tiers are then described.

Figure 2-2 Overview of Advanced Metering Infrastructure



Energy Operations Center

The Network Operations Center (NOC) is referred to as the Energy Operations Center (EOC) in the context of utilities. The Energy Operations Center hosts all applications necessary to operate, manage, and secure the FAN sites and equipment. It is typically located in the Utility facility and may in some cases be co-located with the Utility Data Center. In a multi-service FAN deployment, the EOC will host the applications and associated servers performing the tasks required by AMI, DA, Remote Asset Management, and Remote Workforce Management.

A subset of these application systems necessary for AMI will be referred to as the head-end systems (HES), which consist of servers and specialized application software to operationalize the collection, storage, and processing of meter data to provide an interface for control functions and to manage outage reporting. They can be further classified as application head-end and communication head-end.

Application Head-End

The Information and Communication Technologies (ICT) systems pertaining to electrical operations of the AMI and residing in the EOC are listed below. These systems are collectively addressed as the device application head-end systems.

- **Collection Engine (CE)**—Provides the interface between the AMI system and meter data management, billing, outage management, and load control.
- **Security Information and Event Management (SIEM)**—Protects the system from threats and vulnerabilities by collecting and correlating the entire event logs coming from the collection engine and Cisco devices.
- **Meter Data Management System (MDMS)**—Verifies, stores, and processes billable customer data for the Utility enterprise.
- **Operational Reporting System (ORS)**—A business intelligence tool that collects and correlates data from disparate systems, such as CE, NMS (FND), FAR, and MDMS and reports on overall AMI system performance (communication read and write rates and so on).

Application head-end systems may communicate with the IoT FND, the connected grid's network management system which is a part of the IOK, through its North Bound API.

Communications Head-End

The following are the components that constitute the communications head-end system:

- Head-end Routers—WAN routers located at the Utility AMI data center/EOC that terminate and aggregate IPsec tunnels from FARs. Additional responsibilities include enforcement of QoS and security policies. In the case of IOK, the head-end router is a virtualized CSR 1000V.
- Cisco IoT Field Network Director (FND—formerly called Connected Grid—Network Management System (CG-NMS)) is a network management system to manage the multi-services Field Area Network.
- Certificate authorities, which support RSA and ECC encryption.
- AAA server, to provide authentication, authorization, and accounting.

The network implementation of EOC in the context of a Field Area Network must consider the integration of this new infrastructure with the existing Utility IT enterprise infrastructure. This is particularly important with regard to IP addressing, routing, and security policies.

The connected grid network management components are virtualized and offered as a software package, namely the Cisco Industrial Operations Kit.

Cisco Industrial Operations Kit

The Cisco Industrial Operations Kit is the fully virtualized, pre-packaged software bundle consisting of certain key components of the communication head-end. The IOK consists of the following virtual machines:

- Cisco IoT Field Network Director (FND) with Oracle data base
- Head-end Routers (five in number) based on Cisco CSR 1000V
- Orchestrator with FreeRADIUS
- RSA-based Certificate Authority
- Tunnel Provisioning Server (TPS)
- Registration Authority (RA) based on Cisco ESR 5921

Utility Enterprise Data Center

The Utility Enterprise Data Center houses some of the applications relevant to AMI. It may be co-located with the Energy Operations Center. The architecture assumes established IP connectivity to the Data Center to leverage services such as the following:

- Directory services
- RSA-based Certificate Authority owned by the utility
- ECC-based Certificate Authority
- NTP Server for Time Distribution Services

These services must be accessible by the head-end systems to enable AMI functionality. The IOK leverages the Cisco IOS running on the Connected Grid 1000 Series routers for DHCP services. However, an existing centralized DHCP in the utility data center may also be used.

Wide Area Network (WAN)

The WAN tier is responsible for providing the communications overlay between the Field Area Network (FAN) sites through their Field Area Routers (FAR) and the head-end systems. This may be a private or public network, either owned by the utility itself or outsourced to a service provider. Popular WAN backhaul options are Ethernet, Fiber, WiMAX, and Cellular 3G/4G. Other backhaul types for FARs may be a public or private IEEE 802.11 Wi-Fi smart cities infrastructure or satellite.

The architecture assumes established network connectivity from the NAN to the head-end systems. Security of data forwarded over the WAN is of utmost importance and this requirement is met by incorporation of IPsec tunnels in the design.

Neighborhood Area Network (NAN)

The NAN is the last mile network infrastructure connecting the AMI, DA, and Remote Workforce management devices to the field area routers. The devices include smart meters, electric vehicles, feeder meters, transformer meters, and NAN repeaters. They may be directly attached to a CGR 1000 series router interface such as Ethernet, Serial, or Wi-Fi or may be reachable through an IEEE 802.15.4g/e RF or IEEE 1901.2a PLC Mesh subnet. This infrastructure enables measurement of electricity consumed and produced by prosumers and also provides the foundation for advanced applications like demand response (DR), which provides the opportunity to optimize energy usage during peak periods, and Distribution Automation (DA), which allows distribution monitoring and control. The FARs provide an interface to the WAN backhaul to facilitate communication with the head-end systems.

NANs also serve as a foundation for future virtual power plants, which comprise distributed power generation stations, residential energy storage (for example, in combination with electric vehicle charging), and small-scale trading communities.

In the AMI scenario, the connected grid endpoints in the NAN are the smart meters. In order to implement this solution, this CVD leverages Itron OpenWay Centron meters. These smart meters are IP enabled Grid devices with an embedded IPv6-based communication stack powered by the Cisco IPv6 CG-Mesh SDK.

Refer to the Cisco Developer Network (CDN) to learn more about IP-enablement for partner technologies.

Communication in the Neighborhood Area Network (NAN), which consists of the connected grid end-points, is based on the open standards RF Mesh technology compliant with IEEE 802.15.4g-2012 and IEEE 802.15.4e-2012 and delivers bi-directional communication through an implementation of Internet Protocol suites such as the 6LoWPAN (RFC 6282) adaptation layer, native IPv6 addressing in the network layer, and RPL (IPv6 Routing Protocol for Lossy and Low Power networks), which is the protocol of choice for routing in the 6LoWPAN subnets. RPL route information gets re-distributed in the selected routing protocol for the WAN.

The initial implementation of IEEE 802.15.4g/e CG-Mesh focuses on the 902-928 MHz frequency band available in North America (FCC regulation) and other regions aligned with the FCC or subset recommendations.

Field Area Router (FAR)

The Field Area Router (FAR) acts as a network gateway for Connected Grid End-points, by forwarding data from the meters to the head-end systems. It is a critical element of the architecture as it ties the NAN and the WAN tier together.

The CGR 1000 series routers can be used as Field Area Routers and run on Cisco IOS software. The CGR 1240 is specifically designed for outdoor deployments while CGR 1120 is suited for indoor deployments. The ruggedized, dual stack CGR 1240 acts as a FAR and a FAN gateway. The CGR is a modular platform providing flexibility to support several choices of interfaces to connect to a WAN backhaul, such as Ethernet, serial (RS232/RS485), IEEE 802.15.4g/e WPAN, Wi-Fi, WiMAX, and cellular 3G/4G.

The CGR 1240 is provisioned with a WPAN module, which provides IPv6-based, IEEE 802.15.4g/e compliant wireless connectivity to enable Field Area Network applications. The module is ideal for standards-based IPv6 multi-hop mesh networks and long-reach solutions. It helps enable a high ratio of endpoints to the CGR. The WPAN module is aligned with the Wi-SUN alliance’s objectives for smart utility grids.

The CGR 1240 can act as an aggregation point for a few thousand meters. Capacity planning should be carried out while deploying a field area network in order to determine the number of meters that can be associated with the CGR in a single PAN.