Itron White Paper
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Enabling Cost-Effective Distribution Automation through Open-Standards AMI Communications

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Introduction

Advanced metering infrastructure (AMI) is well recognized as the foundational technology platform enabling the Smart Grid of the future. Often, it is the first milestone in connecting utilities to the Smart Grid. Not only does AMI provide significant features and functions that enable a wide variety of Smart Grid applications, but it brings with it a communications infrastructure that transcends the electric utility service territory, extending the network to the millions of consumers at the edges of the delivery system. With this comes a potential economy of scale to support additional, low-cost monitoring and control applications that historically have not been practical due to communication costs. At the same time, underlying strategic elements that contribute to the vision of the Smart Grid also drive requirements for increased visibility into the status of the power delivery infrastructure and operational awareness for the optimization of the delivery and use of energy.

This combination of conditions has stimulated a revitalized interest in distribution automation (DA), which is being viewed as the next logical Smart Grid milestone after AMI. As a result, utilities are beginning to contrast the cost of a standalone DA infrastructure with that of an AMI solution coupled with a DA deployment that leverages the synergies of a common communication platform.

The ANSI C12.22 protocol is integral to creating that common communication platform. C12.22 is an open standard focused on the application layer of the network. It was designed specifically for communicating utility device data across any network medium. In particular, it is well suited to support high-latency DA devices where:

- Response-time requirements are not as stringent (30 to 90 seconds).
- There is large population of devices.
- Communication costs are a greater consideration.

Standards Definitions

As a reference for understanding this document, a high-level primer with associated definitions follow:

ANSI C12.19

ANSI C12.19 is a standards specification for utility industry end-device data tables. The specification was initially ratified in 1997 and defines the model for passing data to and from end devices. C12.19 ‘tables’ are nothing more than templates for transporting data. It is a form that represents an ordered list of information. One analogy that best describes this is an individual’s income tax return form. A tax form says nothing about how your records should be kept. Your information can be stored on separate sheets of paper, in a binder, in your computer, or in a mason jar. However, the tax form does require that the data be presented properly and in a specific order. Similarly, the predefined tables in C12.19 do not impose how the data is stored. The end device only needs to create the data in the proper form and order when requested to deliver information, and accept information in the proper form and order when it arrives.

ANSI C12.22

C12.22 is primarily an application protocol. It extends C12.19 to support reliable data network communications at the end device. The protocol defines how to transport C12.19-formatted data over a network using the Open Systems Interconnect (OSI) model.

Uses of the protocol include operation over the C12.22 node network, as well as a point-to-point interface between a C12.22 device and a C12.22 communications module (or network adaptor). C12.22 offers a methodology for both session and session-less communications.

In addition, it provides for:

- Common data encryption and security.
- A common addressing mechanism for use over both proprietary and non-proprietary network mediums.
- Interoperability among end devices within a common communication environment.
- System integration with third-party devices through common interfaces.
- Both two-way and one-way communications with end devices.
- Enhanced security, reliability and speed for transferring end-device data over heterogeneous networks.

ANSI C12.22 Within the Interoperability Framework

ANSI C12.22 can be further characterized within the interoperability context-setting framework defined by the GridWise® Architecture Counsel. The framework divides the concept of interoperability into eight key levels. C12.22 focuses on levels 2 and 3, *network interoperability* and *syntactic interoperability*.

Network Interoperability
C12.22 provides network interoperability by abstracting communications to the application layer of the OSI network model. In doing so, it allows for the transport of data over virtually any type of networking medium. Thus a C12.22-compliant message can travel across a radio-frequency mesh network to reach a collection point, then move along a fiber optic network to reach the utility, and then traverse the Category 5 Ethernet cabling inside the utility to reach its destination.

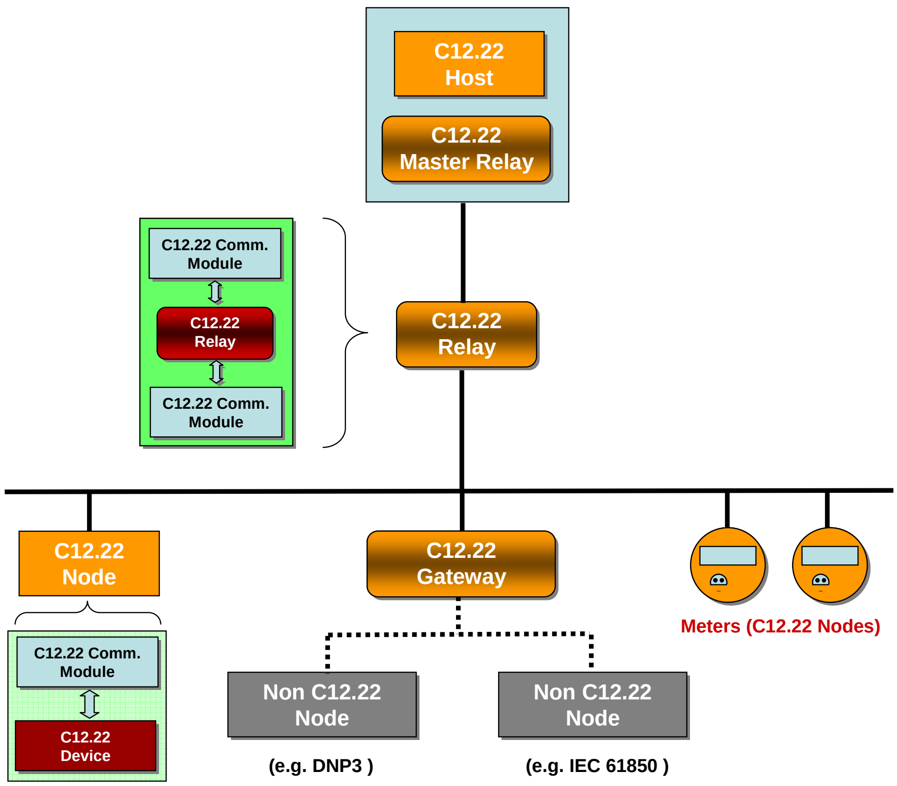
Syntactic Interoperability
C12.22 provides syntactic interoperability through its symbiosis with C12.19 data structures. That standard defines the structure of messages exchanged between systems. Thus different types of devices can exchange information across a network if they all use the C12.19 standard to structure the information they share.

ANSI C12.22 Network Topology

C12.22 protocol spans an entire network and enables multiple types of devices; these types of devices are described below.

ANSI C12.22 Master Relay

A C12.22 master relay operates at the top of a hierarchy of relays. It provides registration services for all devices in its domain. It is also responsible for issuing registration service queries to C12.22 authentication hosts and de-registration service requests and notifications to C12.22 notification hosts when registering a C12.22 node. A C12.22 master relay can also act as a C12.22 host.



ANSI C12.22 Relay

A C12.22 relay is a node that provides address resolution, datagram segmentation and optional message forwarding services to other C12.22 nodes. Address resolution services consist of mapping Layer 7 addresses (ApTitle) to lower layer addresses.

ANSI C12.22 Device

A device hosts one or more C12.22 applications and provides at least one interface to a C12.22 communication module.

ANSI C12.22 Gateway

A C12.22 gateway translates the ANSI standard C12.22 protocol to and from other protocols. Gateways are required when a C12.22 node needs to communicate with non-C12.22 nodes. C12.22 gateways can be attached directly to the non-C12.22 devices or they can provide their translation services through any network segment (DNP3/C12.22 gateway).

ANSI C12.22 Node

A node attaches to a C12.22 network segment and contains a C12.22 communications module, one or more C12.22 applications, and possibly C12.19 data table structures.

ANSI C12.22 Communications Module

A communications module attaches a C12.22 device to a C12.22 network segment. A C12.22 communication module can be physically located inside or outside the C12.22 device enclosure. However, it is physically and logically distinct from the C12.22 device. The interface between the C12.22 communication module and the C12.22 device is completely defined by the C12.22 standard. The combination of a C12.22 device and a C12.22 communication module constitutes a C12.22 node. If a C12.22 communication module contains tables, it is also a C12.22 node.

ANSI C12.22 Application

An application entity that implements a set of services and procedures as defined in the C12.22 standard, permitting one or more well-defined devices (C12.22 host, C12.22 relay, C12.22 device, C12.22 communication module, and so on) to interact within the framework of a C12.22 network. It may also contain C12.19 tables.

ANSI C12.19 Device

A C12.22 node that contains C12.19 data table structures.

Methods of Integrating C12.22 into Distribution Automation Devices

There are three primary methods for integrating C12.22 into distribution automation devices.

Metrology Integration

For leveraging standard radio-frequency LAN communications and electricity metrology, emulating the metrology C12.22 blurt message could be the most straightforward and cost effective approach for equipping DA devices with C12.22 communications. Practical applications would most likely be for non-revenue metering appliances such as transformer and feeder metering and low-cost sensing devices.

C12.22 Device Integration

C12.22 defines an RJ11 connector for the physical layer on local ports. This architecture also allows development of C12.22 communication modules that can interface any C12.22 device to specific networks. A C12.22 device plus a C12.22 communication module arranged in this fashion constitutes a C12.22 node. The C12.22 transport and datalink layers are used between the third-party C12.22 device and communication module. The details of the C12.22 device and C12.22 communications module are defined in Section 6 of the ANSI C12.22-2008 specification.

Gateway Integration

A C12.22 gateway is a C12.22 node that translates the ANSI standard C12.22 protocol to/from other protocols. Gateways are required when a C12.22 node needs to communicate with non-C12.22 nodes. C12.22 Gateways can be attached directly to the non-C12.22 devices or they can provide their translation services through any network segment.

Sample Applications

There are several sample applications for using C12.22 communications for distribution automation.

Smart Fault Indicators

A Smart Gird should supply actual outage and restoration notification at the feeder and lateral level. Fault indicators equipped with C12.22 communications can provide this information. With proper IT integration at the utility back office, circuit segment outage information from the outage management system can be correlated with outage notification from AMI systems to offer more comprehensive understanding of an outage’s scope. Once open standards communications exist at the distribution level, several sources of information open up. Real-time fault detectors record fault current events, by circuit and phase, down to the sensor span level. Fault waveforms and propagation sequencing by sensors can be made available for detailed post analysis. Real-time knowledge of the state of the distribution system is essential for safe automated or manual switching in service restoration work. Better information helps field crews be more efficient in restoring power, which reduces system average interruption duration index (SAIDI) scores. In addition, continuous load monitoring provides accurate data to support short- and long-term decisions on load balance and capacity upgrades.

Capacitor Bank Control

C12.22 can provide the communications protocol for capacitor bank monitoring and remote control in electric distribution systems.

Automated Network Protector Status Indication

C12.22 communication can enable remote monitoring of the events and status of self-powered, electronically-controlled, dropout circuit protectors. These devices eliminate permanent outages that can result when lateral fuses operate in response to momentary faults. These circuit protectors also eliminate momentary interruptions along feeders in cases where a substation breaker opens to save the lateral fuse during a momentary fault.

Automated Throw-Over Status Indication

Remote monitoring through C12.22 communications can be applied to circuit interruption switch events for overhead distribution feeders. This applies to either group-operated or single-pole applications.

Transformer/Feeder Metering

Theft diversion solution that incorporates transformer and feeder metrology integrated with AMI metering and communication technology. This example incorporates distribution transformer meters and feeder meters within the AMI solution architecture to provide the required data to allow for identification of potential diversion. The device will function like a meter and provide profiled energy and voltage measurements that can be used to compare against the aggregate of the meters installed downstream of the distribution transformer. The device can also be used to provide transformer aging data such as temperature.

Demand Response Analogy

Distribution automation shares interoperability aspects with another technology gaining acceptance in the utility world—demand response.

Demand response entails consumers changing their consumption behavior in response to system status or price signals. Informing consumers on time-based rates that the price of energy has changed and allowing consumers to then adjust their consumption is a prevalent form of demand response. Consumers can automate their response, given control equipment that also communicates. One example is a programmable communicating thermostat that receives price signals from the utility and responds to those signals according to the preferences set by the consumer.

So it is with distribution automation as well. Both processes involve communicating information about the power system and providing for automated response based on that information. Both distribution automation and demand response require interoperability to integrate into a utility’s existing and future infrastructure.

The sample distribution automation applications discussed in this paper share similar response latency timeframes with demand response. As such, they can also share similar network infrastructures for communications. Since C12.22 and C12.19 pertain to data structure and communications, they can be integrated into both distribution automation and demand response devices.

Conclusion

As utilities invest huge sums into capital projects to build out the promise of the Smart Grid, they are increasingly demanding open standards in part to protect those investments from obsolescence or overdependence on one vendor’s proprietary technology. In response, the AMI market has undertaken rapid adoption of open standards such as ZigBee®, ANSI C12.19, Internet Protocol, WSDL, SOAP, and more. C12.22 is an open standard communications protocol that can help utilities invest in cost-effective distribution automation.

Itron Inc.

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