NEW TECHNOLOGIES FOR METERING IN OPEN NETWORKS

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ABSTRACT

"Smart Metering" has demonstrated how advances in technology may be used to solve a utility's changing needs in a dynamic market-place. But where Smart Metering is effective at the end-customer metering point, new technologies in multifunction meters provide a broader range of benefits at any metering point within a utility network.

This paper describes how new communications technologies, including local mastering, gateway functionality, web-based presentment, email data transfers and Ethernet support of SCADA protocols, have been used in utilities around the world to provide integrated network control and monitoring. With these technologies, communications costs to remote substations are drastically reduced while increasing the number of monitored points and improving network awareness. It is shown how these communication links can provide billing data, operational data to SCADA systems, and regulatory-compliant power quality information so that the needs of multiple departments are met within a single device.

A description of the necessary device features to simultaneously meet the diverse needs of the energy metering, SCADA and power quality departments is provided; demonstrating how multifunction meters can leverage capital and maintenance costs.

Finally, case studies are presented where utilities leverage "Smarter" meters to automate tasks such as local aggregation and advanced transformer compensation to simplify network analysis and billing. By providing distributed intelligence, local control and the communications infrastructure to reach more metering points, "Smarter Metering" enables utilities to increase awareness, reduce risk, and lower operational costs.

HISTORY OF SMART METERING

Since the introduction of solid-state metering in the early 1990s, features have been added to tariff meters to provide more valuable information than simple energy accumulation. Multi-function meters register active, reactive and apparent energy, Time-of-Use (TOU) meters track energy consumption at different tariff rates, and remote communications options (fixed network or wireless) have been added for Automated Meter Reading (AMR). A device with these features combined has been dubbed a "Smart Meter".

Smart Metering is typically applied at the end-customer metering point, be it commercial or residential. But while this covers the largest number of monitoring points in a utility's network, no additional features are provided where energy flows are largest and operational data most critical: inside the substation.

More powerful meters leveraging developments in the telecommunications and Internet fields provide access to even more information than their Smart counterparts, and simultaneously to mission-critical utility systems.

NEW COMMUNICATION TECHNOLOGIES

To the substation:

Slow (not broadband) Power Line Carrier (PLC) and serial data modem lines have long been used to provide utility departments remote access to substation data. While effective, these media are limited to relatively low throughput rates (typically 9600 bps). Capacitor traps for PLC are expensive to install and maintain, and modem lines are susceptible to electromagnetic noise leading to suboptimal communication rates. For both of these traditional media, complex data types such as digital waveform recordings lead to long connection times and limit a utility's ability to read all of their installed meters in a timely fashion.

By applying the lessons learned by the growth of the world-wide web, TCP/IP has emerged as a high throughput transportation protocol suitable for many new media. Ethernet connections (either twisted pair copper or Fibre Optic) provide dedicated 10 or 100 Mbps channels capable of addressing all devices within a substation simultaneously. With a data transfer rate 1000 times faster than dial-up modem, TCP/IP can support complex data types without introducing communications bottlenecks. Fibre Optic links provide the additional benefit of galvanic isolation, removing a potential failure point from the system.

For remote substations, TCP/IP can be utilized over Satellite radio links or Broadband Power Line Carrier. In either case, the telecommunications industry has provided the necessary equipment to transmit and decode these signals, simplifying installation and removing integration conflicts. The TCP/IP address of the end device is all that is needed to configure the system.

Finally, e-mail may be used as a transportation mechanism. Relying on TCP/IP for transmission of the individual packets, e-mail allows data to flow seamlessly through firewalls without compromising security. The Information Technology industry has developed systems to accommodate the flow of email traffic while maintaining the security of their networks. E-mail is preferred in many cases by IT departments than TCP/IP connections alone because of the enhanced security it offers.

Smarter Meters supporting TCP/IP provide access to all of these communication architectures and the development efforts of the entire communications industry.

Within the substation:

Ensuring a high throughput communications pipeline to the substation is the highest priority in ensuing timely access to metering data. But within the substation, new technologies are also present to reduce the installation cost and take advantage of existing products.

Ethernet and modem gateways allow one Smarter Meter to act as a communication hub; routing messages to other devices in the substation over inexpensive RS-485 serial connections. Using such an architecture, only one device needs to be equipped with either the Ethernet or modem hardware, reducing the overall cost of the metering equipment and allowing access to up to 32 downstream devices. When using an industry standard protocol such as Modbus or DNP, the downstream devices are unaware that the request has been passed through a gateway and behave as though communicating directly to their master software or RTU. Older devices can thus be integrated into a newer communications architecture.

Another means of integrating legacy devices is through local mastering. In this application, a Smarter Meter is used as an RTU; requesting information from other devices and passing it back up to the master software. This opens up possibilities for local data control, such as aggregating feeder readings from multiple devices before transmission back to the master software.

Finally, for systems with transducers without communications features, Smarter Meters may use onboard I/O to import transducer values. These values can be aggregated and scaled before transmission to the master software.

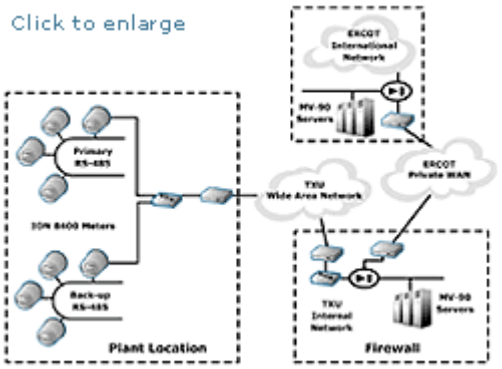

Figure 1. Using gateways within the substation

BENEFITS TO UTILITIES OF NEW COMMUNICATION TECHNOLOGIES

New communication technologies can solve many problems related to data acquisition and speed, but the benefits to utilities are only realized if the information is presented in a ready-to-use format. Integration with existing utility systems is key to meeting this need.

For each user, system or department, Smarter Meters present information in the appropriate format over appropriate media. SCADA and Operations systems require industry-standard protocols such as IEC 61850, IEC 60870-5-101, DNP or Modbus. All of these are SCADA protocols are available over TCP/IP for high-speed direct integration into existing SCADA systems.

Billing systems may require information on energy consumption or demand in protocols such as DLMS, IEC 60870-5-102 or MV90. Again, the developers of the software masters for these protocols have supported data acquisition over TCP/IP.

Key account managers may wish to view load profiles, power quality information or alarms. For each of these, the data format and media is customizable, ranging from pager alerts to emailed reports, to web-accessible graphical views.

Finally, other utility departments may wish to view the information contained in a Smarter Meter. By providing a secure web server on the device, authorized persons can view critical information in real-time from any computer anywhere in the world.

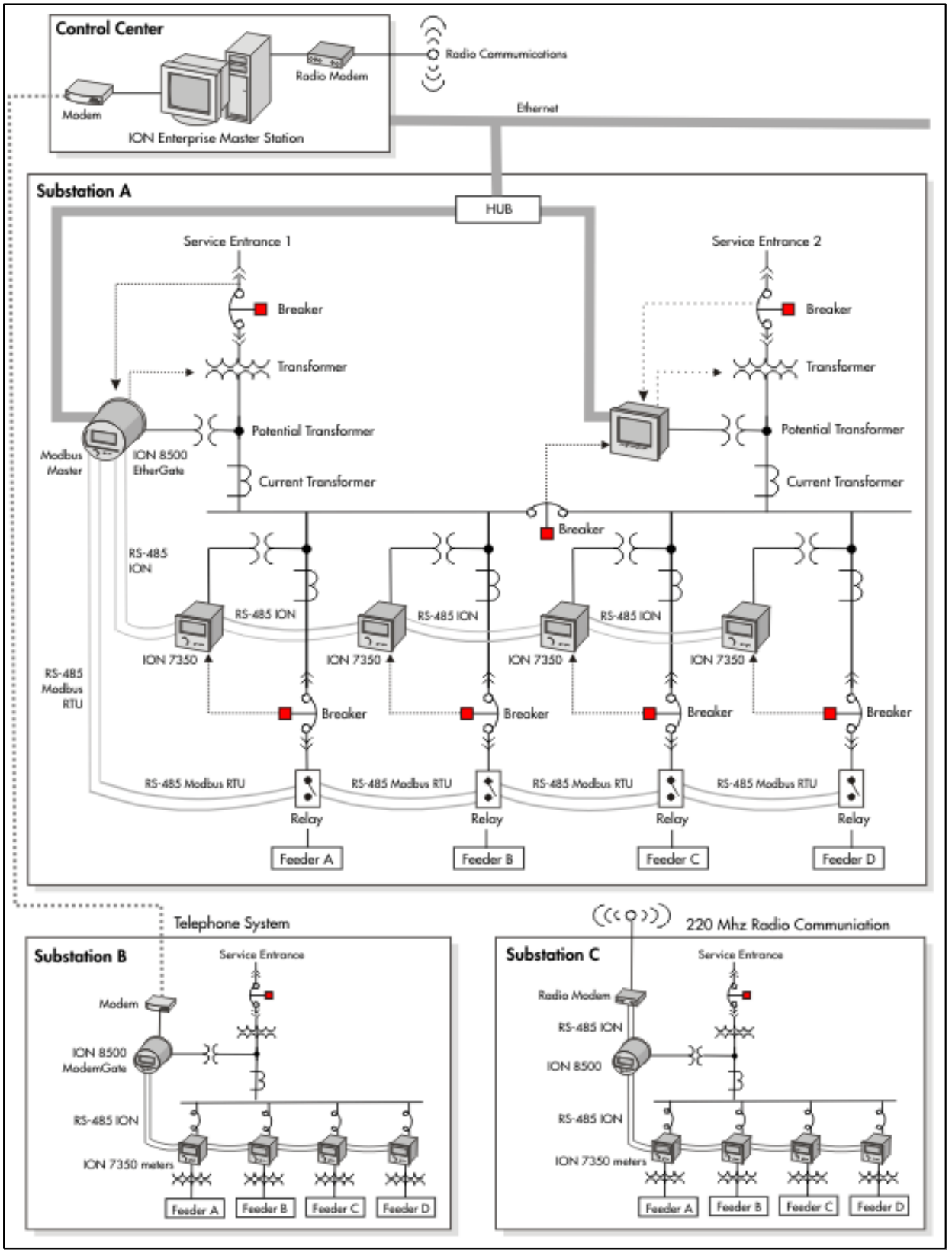

Figure 2. Utilities use new communication technologies to reduce communications infrastructure costs

CASE STUDIES

Using Ethernet to provide data to multiple users

After liberalization, a major Texas utility needed to provide daily settlement data to the Independent System Operator (ISO). The utility chose Smarter Meters with TCP/IP support and gateway functionality. Forty gateway meters connected to the existing utility Ethernet backbone provided high-speed access to over 260 new tariff meters. By using TCP/IP, there is no concern that the utility or ISO data retrieval will interfere with each other and the utility network now supports complex power quality data at any of its monitoring points.

Using satellite to overcome geographical challenges

An electrical utility with a 27,000 square-mile service area needed access to remote substation data. Due to limited existing infrastructure, TCP/IP over satellite links provides access to real-time SCADA data. Transient events, sag/swell events and transformer loading alarms for the substation are sent by e-mail over satellite to PCs and pagers.

Using local mastering to increase efficiency

Managers at a switchyard needed combined instrument/transformer loss compensation and power factor monitoring, plus aggregation and scaling of real-time data. By monitoring transformer and instrument losses on the secondary side, installation costs are reduced without sacrificing accuracy.

The switchyard is a 500kV transmission facility with 10 bays, handling power flowing to and from four different independent power producers, a nuclear facility, and several other substations. Substation bays operate as four loops, with Smarter Meters configured as Modbus Master devices, each gathering real-time data from its loop to perform scaling and aggregation before passing values to a central RTU.

The network fully integrates with the existing billing system and provides a valuable backup function — if the RTU or communication links fail, the data can be retrieved manually from any meter. When generators go online and merchant sites produce their own power, the breakers close and the meters go offline.

CONCLUSION

Applying the new technologies of the telecommunications industry to metering systems allows utilities to increase network awareness and control. Combining these technologies with powerful multi-function metering platforms provides opportunities for utilities to reduce operational risk, solve business needs, and improve network reliability.

BIOGRAPHY

Brian Kingham received his Bachelor degree in Electrical Engineering from the University of Victoria in 1995. He has held a number of positions in Research & Development and Operations before moving to his current role as Utility Market Manager. In this role Kingham defines the company's marketing and product strategy for the utility market.

Figure 3 Information flow from Smarter Meters