Bandwidth Requirements for Smart Meters in Distribution Network for IEC 61850 Implementation

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Abstract— **In power distribution network, smart meter technology is now becoming evident to operate power utilities in a globalize environment and cope with the changing requirement and technologies. Smart meters in distribution network are one of the challenging and subtle tasks to address in order to visualize the distribution network into digital world under communication protocol of IEC 61850. Smart meters, a dedicated gateway to customer home in distribution network, is important because of communication arena is changing day by day. So it is convenient to deploy and incur a cost effectiveness of asset when migration is to be considered since data-intensive applications drive the incremental demand for bandwidth by new communication protocol IEC 61850. This paper presents analysis and crucial need for incremental demand for bandwidth for smart meters in distribution network, the scope of the new communication protocol for IEC 61850.**

I. INTRODUCTION

Power distribution systems have been designed to provide electric services that seemed to satisfy optimum customer's requirement [1]. However, over the last few years, they are expected to support services driven by different forces such as service reliability (i.e. customers expect more and more reliable service each day), quality of service (i.e. customers expect quick responses to service request and accurate estimates of expects duration of service disruption), power quality (i.e. customers are not now interested to tolerate voltage flickers and harmonics), improved productivity (i.e. all utilities are looking to squeeze more value from the existing assets, reducing their operating and capital expenses) that exposed the deficiencies of the infrastructure [1].

Power distribution infrastructure now need "Smart meter in distribution System" which allows utilities and consumers to accrue returns through the convergence of power delivery and information technologies to achieve improved reliability and increased customer satisfaction.

In order to attain smart meter vision, it will require more enabling technologies to enable utilities to harvest values. Communications infrastructure needs to be readily available with the appropriately bandwidth by new communication protocol IEC 61850 to allow data freely transferred among different devices [1].

II. BRIEF OVERVIEW OF IEC 61850

IEC 61850 is an abstract application layer protocol aimed at providing interoperability between a variety of substation and feeder devices. IEC 61850 is based on the requirement and opportunity for developing standard communication protocols to permit interoperability of Intelligent Electronic Devices (IEDs) from different manufacturers. It considers the operational requirements in view of the fact that any communication standard must consider the substation operational functions. However, the communication standard IEC 61850 does not focus on either standardizing the functions involved in substation operation or their allocation within the substation automation systems. It identifies and describes the operational functions used to define the impact of the operational functions on the communication protocol requirements [2].

III. IEC 61850 BASED SCADA SYSTEM

The communication protocol IEC 61850, a comprehensive model for how power system devices organize data in a manner that is consistent across different types and brands of devices. This eliminates much of the tedious non-power system configuration effort because the devices can configure themselves [3].

In order to get an outline of where exactly the IEC 61850 communication standard and a Remote Terminal Unit (RTU) appear in relation to substation automation system (SAS), two typical setups shall be presented. These two scenarios illustrated in Fig. 1 and Fig. 2 shall be referred to as the Remote Terminal Unit (RTU) setup and the Local Area Network (LAN) setup [4].

In the RTU setup (Fig. 1) devices are typically hardwired to the input and output ports of the RTU. In this case, the IEC61850 standard can allow a traditional substation setup to comply with the new standard on the communication side towards the control centre. This might be advantageous if an IEC61850 compliant SCADA system is to be connected to a traditional RTU setup [4].

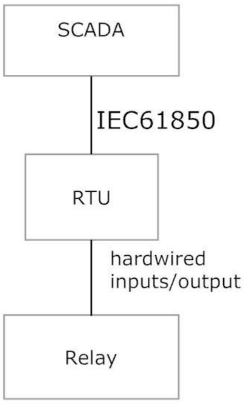

Fig.1 IEC 61850 communication profiles placed in an RTU setup [4].

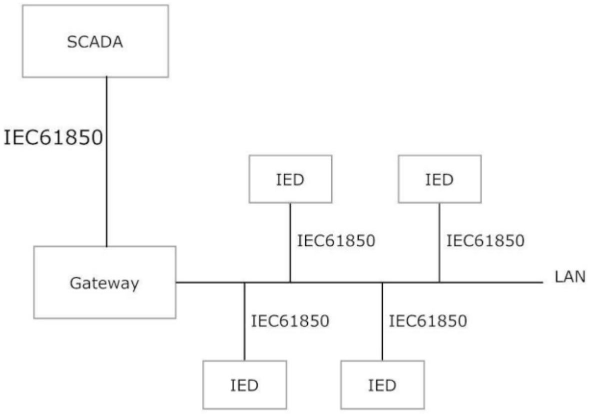

Figure 2 IEC 61850 communication profile placed in a LAN setup [4].

In the LAN setup (Fig. 2), the IEC61850 is used both in the communication between IEDs in the SAS and between the SAS and the SCADA system in which case it is usually between the gateway and SCADA. However, the IEDs may also be able to communicate with the SCADA [4]. The standard may be developed also for smart meter network in distribution system.

In Fig. 3, a supervised connection is set up between devices and is absolutely adequate for commands, messages and fault recording. Network components of automated meter reading and wireless control of distribution switches, different electronic devices (IEDs) like relays, sensors and meters and such diverse equipment as RTUs, LAN and Wide area network (WAN) are built with the IEC 61850 communication protocol. Automated distribution switches are typically controlled by a substation RTUs in the field. SCADA system includes data collection computers at the control centre and RTUs in the field that can collectively monitor and control anywhere from hundreds to tens of thousands of data points.

As discussed earlier, communication protocol IEC 61850 is to facilitate interoperability and it aims to enable logical configuration of the SAS by connecting various types of equipment from different vendors through LAN/WAN. However, the current version of IEC 61850 has many options with regard to logical nodes and has many methods of providing the communication service.

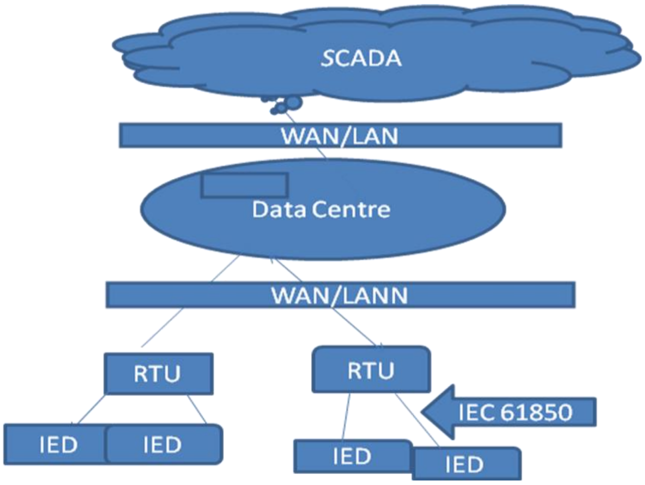

Fig. 3: Architecture of IEC 61850 protocol.

IV. IEC 61850 BASED SMART METERS

Efficient power supply is critical to every nation's economic and social development. Competent power system monitoring and protection is vital. Furthermore, power utilities operate in a more globalised environment and require flexible, future-proof system to cope with changing requirements and technologies. Energy efficiency and electricity demand side management will be a major part of Australia's response to the Garnaut Climate Change report. Smart residential energy metering has become one of the requirements for the contemporary power grid. This can only be achieved through the use of IEC61850.

Smart meter in distribution system with motivations from governments have been aiming to delivery electricity to customers in most energy-efficient and cost-efficient way with collaborative participation from customers. The communication protocol IEC 61850 may account for potentially thousands of devices that will be networked for prospect secondary services such as smart metering, time-of-use scheduling, dispersed generation tracking etc. TCP/IP-based networks can provide communication infrastructure for these devices, a severe security issue will present, as these devices are vulnerable to be compromised by cyber-attackers [5]. Use of the protocol IEC 61850 for supervisory control and data acquisition (SCADA) networks provides an efficient solution to security issue.

Increasing number of IEDs are being located outside of substations and they can be used to support smart distribution system operations. Thousands of IEDs networked together for smart metering, time-of-use scheduling can be used to optimize local operating conditions through distributed and parallel processing with the distribution system control centre. Thus, the distribution system becomes more efficient in managing supply and demand, and more robust to provide auto-recovering.

The TCP/IP-based IEC 61850 protocols could be raised cyber-security issues. The majority of IEDs in the smart distribution system would be located outside of utility facilities; they are at high risk of being physically compromised by cyber-attackers. Cyber-attackers could utilize Internet-based attacks to target and disrupt smart distribution system operations, such as causing sustained outages by preventing auto-recovering operations. The secondary-service entrance-level IEDs are particularly vulnerable to attack since they will likely be multi-connected to allow consumers for remote access to the IED's data and operations. As a consequence, it may be possible for a cyber-attacker to attack the smart distribution system from multiple points by using the consumer's remote access to the IEDs via the Internet [5]. To counter this type of security threats, the IEC 61850 protocol has to be implemented.

The communication protocol IEC 61850 provides some peer-to-peer networking support and possesses adequate address space that utilities can be exercised in the network deployment that ensures no address conflicts. In addition, the IEC 61850 protocol support addresses assignment by a control centre for hundreds of thousands of IEDs. The routing mechanism uses a variable address structure that provides large address space and cyber-security and each IED has a unique network address to avoid network address conflicts [5].

V. BANDWIDTH REQUIREMENT FOR IEC 61850 IMPLEMENTATION

In the digital age, literally thousands of digital data are available in a single IED and communication bandwidth should not be a limiting factor [3]. The TCP/IP based IEC 61850 protocols using to support smart meters in distribution system broadband power services typically the frequency range between 0.5 and 30 MHz should be provided. While nominal data rates of 2 Mbps are now common, data rates over short distances of up to 40 Mbps have been prototyped by some manufacturers. The technology is primarily deployed to interconnect local area networks or wide area network between smart meters in building and SCADA systems currently in use by utilities deploy RTU.

In this digital distribution system, a utility pole hooked up to a special transformer that connects the power lines to high-speed Internet. Hundreds of sensors attached to the lines monitor how power flows through the home and that information is then sent back to the utility company. The process, lets a utility more efficiently manage the distribution of electricity by allowing two way communications between consumers and energy suppliers via the broadband network on the power lines. Based on data they receive from hundreds of homes, utilities can monitor usage and adjust output and pricing in response to demand. Consumers can be rewarded with reduced rates by cutting back on consumption during peak periods and computerized substations can talk to each other so overloaded circuits hand off electricity to underused ones, helping to prevent blackouts [6].

A. Cost Analysis for Data Rate up to 40 MBPS in Distribution System

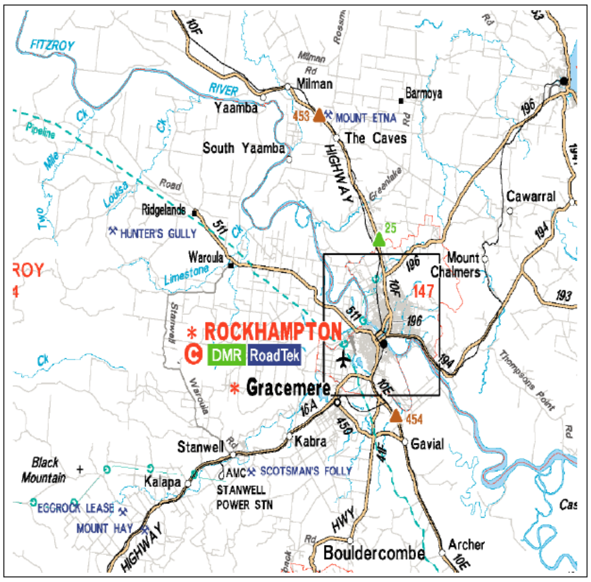

Fig 4 Smart meters in distribution network in Rockhampton.

In Fig. 4 shows Rockhampton area where smart distribution system has become reality for the opportunity of customers to sell and control unused power. Analyses performed as part of business case preparation have established approximated hundreds of installers would be required for a national rollout of smart meters. The number of resources required to support a full smart meter rollout is significant, particularly allowing for large scale rural developments. It is important to note that resource base will be required on an ongoing basis, as the useful asset life for smart meters is determined to be 15 years [7].

A smart meter rollout requires a significant capital investment, it is important to validate the costs and benefits and technology application through industry pilots and technology trials. Technical working groups are supportive to develop and recommend technical specifications, performance requirement and necessary regulatory changes to support the rollout of smart metering in Australia. Technology trials should be implemented through a coordinated national approach to ensure maximum investment return by minimizing duplication. It is envisaged that trials would need to be implemented for a period of up to minimum 3 years with end to end business processes operating to provide validation of technology and return as a proof of concept [7]. To validate costs provided with national business case should be analysed.

1. Meter Cost: The consultants have recognized that there remains significant uncertainty in the costs provided within the smart meters business case and actual costs of these meters could vary considerably from that used in the analysis and it may represent 46 to 62 percent of overall transition costs. This cost should be firmed up during the period of industry pilots, once the finalization of the functionally specification by the technical working group has been completed and endorsed by stakeholder [7].

2. Installation Cost: Installation costs account for 18 to 23 percent of the transition costs for a national smart meter rollout. A high number of metering installations within energy distribution area are likely to occur on asbestos meter board, particularly with older installations. Country Energy is currently planning to move forward with implementation of smart metering pilots and technology trials which will provide further data on incidents of difficult installation [7].

3. Communication Cost: Communications technology has been assumed in the business case for implementing IEC 61850 protocols for urban, rural and remote consumers. While country energy recognizes that these solutions appear to be cost effective but they have not yet been proven in the Australian market [7].

B. Advantages of using Smart Meters for Data rate up to 40MBPS in Distribution System:

The smart meters allow consumers to participate in programs designed to reduce the cost or environmental impact of electric usage and for the utility to verify in real time that usage has actually declined, thus allowing the use of less generation with the resulting reduction in emissions. These capabilities along with our announcement on underground cable fault detection, smart meter solution solve real problem [8].

By imposing Smart meters within distribution network, size of annual network efficiency benefits is substantial, representing a saving of 14 to 18 percent of distributors current annual operating cost requirements. Country energy would recommend the need to proceed with industry pilots and technology trials to validate that the benefits exceed the costs prior to proceeding to an aggressive rollout of smart meters [7].

VI. CONCLUSIONS

Bandwidth is a major factor for utility for being able to monitor the power network more effectively and efficiently. This paper investigated the bandwidth requirement for a typical distribution network. IEC61850 has been studied to identify the bandwidth required for distribution network using smart metering infrastructure to customer home with availability of IEC61850. These modern technologies are used for remote monitoring, setting, control and retrieval of load and fault data at lower installation and commissioning costs, a significant reduction in maintenance cost may also be achieved.

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