Experimental Investigation and Performance Analysis of Freestyle Communication System for Powerlink Queensland Substation Automation

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Abstract- **Invention of digital relays and the dramatic expansion of information technology networks are compelling the utility companies such as Powerlink Queensland to improve their communication infrastructure. As the major transmission network service provider in Queensland, Powerlink always seeks opportunities to improve its service through regularly updating its systems and devices. Freestyle Energy Ltd, Melbourne has proposed Powerlink about the development of a new communication system for data transfer of meter data and IED event reports complying with Powerlink requirements. The new communication system referred as the "Freestyle system" minimally comprises of a web management server, a data concentrator and the Freestyle Microengines. The main objective of Freestyle system is to automatically extract meter data from meters, event report files from IEDs, and network condition status information and email to the end users for further investigation. Freestyle system also supports direct communication to IEDs for remote configuration. A test platform was set up at Powerlink's Test and Development Laboratory and the system was tested for its functionality, reliability and robustness. This paper investigates the performance of proposed Freestyle system so as to ensure it is compatible with Powerlink requirement. The paper also outlines the test outcomes.**

I. INTRODUCTION

Current data transfer methods used in Powerlink to extract meter data and IED data are not efficient or effective. This section examines Powerlink substation communication, the current meter data transfer method and current IED event report transfer method. It also highlights advantages of the Freestyle communication system.

A. Powerlink Substation communication

Powerlink Queensland, located in Virginia, Brisbane, is a government-owned corporation which owns, develops, operates and maintains Queensland's high-voltage electricity transmission network. Powerlink owns and operates a total of 98 transmission substations throughout Queensland. The substations are connected to the control centre via communication links so that the substation functions can be closely monitored and controlled. Figure 1 shows a typical substation communication system.

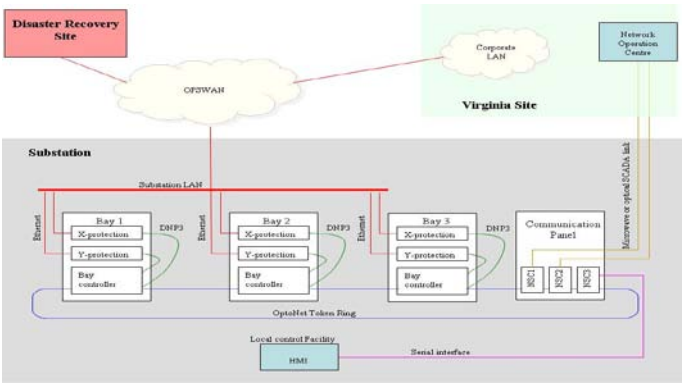

Figure .1 A typical example of Powerlink substation automation system

Supervisory Control And Data Acquisition (SCADA) links are used for real time control and communication between substations and the control centre. An Operational Wide Area Network (OpsWAN) system is used to transfer non-urgent data for asset monitoring and maintenance purposes.

B. Meter data Transfer

The digital meters at a substation monitor electricity usage at every half hour interval. Meter data is saved in the microprocessor memory and transferred daily to the Meter Data Management Agent (MDMA) after midnight for validation. The current method used in meter data extraction relies on a dial up modem, phone line and PSTN networks which are proven to be unreliable. The proposed system utilizes the existing substation LAN and WAN to achieve more reliable and efficient level of service with fewer

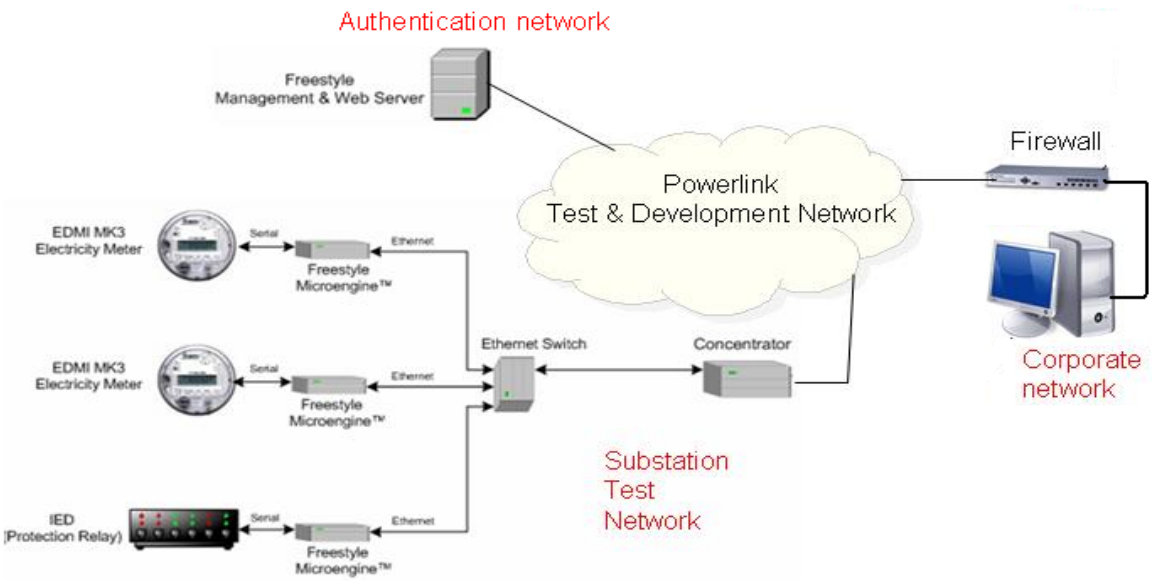

Figure 2. Test Network

C. *IED data transfer*

The IEDs are microprocessor based relays. Beside their relay function of protection and control, the microprocessor collects and saves event reports during faults and in other problematic conditions. The relays can be configured to generate and automatically send disturbance data, to the interface terminals as soon as any of the relays trip. Modern digital relays are capable of generating various files and reports such as oscillography file records, fault reports, configurations files and event reports. An event report reveals how the relay actually responds to the disturbance events according to particular conditions. It contains most of the information through which the external operation and internal states of a digital relay can be observed [1, 2]. At Powerlink, asset management team engineers are responsible for analyzing event report files for repair and maintenance purpose. Currently, asset management team engineers are required to manually extract event data from IEDs via the OpsWAN. This manual extraction process consumes time, resulting in larger system down times. The proposed system develops automatic transfer of event report files from IEDs to the asset monitoring team engineer via email or SMS as soon as the relays trip to achieve faster response time and consequently reducing system down time.

II. METHODOLOGY

A. *Test set up*

A test platform was set up, as shown in Figure 2, using Powerlink test and development network which mimics an actual substation network and the Powerlink corporate network. Powerlink test and development network has three separate local area networks namely; substation test network, authentication network and corporate network which are connected together through firewalls and routers. Freestyle Microengines and a Freestyle data concentrator were connected to the substation test network LAN; the Freestyle management and web server was connected to authentication network and a desktop computer connected to corporate network implemented as a user interface. Two meters and an IED, used for testing, are connected to a substation Ethernet switch via the Freestyle Microengines.

B. *Freestyle devices*

Freestyle Energy Ltd supplied two Microengines, a data concentrator and a management server for testing purposes. The Freestyle Microengine, shown in Figure 3 consists of an 8MB Microchip Flash memory, 5V DC power supply, a serial port and an Ethernet port. The Microengine is controlled by data concentrator and programmed to respond to data concentrator's commands. The reconfiguration including changing settings and updating to a new application for devices connected to the Freestyle Microengines (for example; the meters or IED) can be done remotely via data concentrator [3].

Figure 3. Freestyle Microengine

The Freestyle data concentrator can control and communicate with up to 256 Microengines. The data concentrator also monitors the health of the Microengines implemented in the network. The Freestyle data concentrator uses 4GB non-volatile memory card to ensure reliability and the system is encrypted at the hardware level to provide maximum security [4].

The Freestyle management and web server forms the heart of the Freestyle system. This back-end management server communicates with the data concentrator, stores meter/message data, generates emails and compresses the data. It also provides the user interface to facilitate remote access to data concentrators via the Freestyle management website. Users can view meter data, IED events and also warnings message generated from the system on the website using a single interface. For testing purpose, a laptop with 512Mb memory, 10/100 Ethernet interface and 80 GB HDD was used. A number of tests were conducted to evaluate Freestyle system performance including functionality test, power lost test, network failure test and reliability test.

III. TESTS AND RESULTS

A. *Functionality test*

The Freestyle system successfully passed the functionality tests and the results are summarised in Table 1.

TABLE I
FUNCTIONALITY TEST AND RESULT

Test	Results
a	Proved that Freestyle system can read meter data and forward it to the server
b	Proved that Freestyle system can automatically transfer meter data at predetermined interval Proved that Freestyle system can compressed data into NEM12 file format
c	Proved that Freestyle system can automatically extract and transfer event report files from IED
d	Proved that Freestyle system can monitor IED event at preset interval and update the events at the web
e	Proved that Freestyle system can monitor communication failure between Microengine and IED or meter
f	Proved that Freestyle system can be remotely configured and reprogrammed
g	Proved that Freestyle system can be configured to allow direct access to IED

The functionality tests focused on the following seven functions of Freestyle system

a) Manual meter data reading
b) Automatic meter data reading and daily meter data transfer
c) Automatic data extraction and data transfer of IED
d) IED events checking
e) Communication failure alarm
f) Microengine reconfiguration/application update
g) Remote configuration of IED in “pass through mode”

Functionality test “a” to “f” listed above, were performed using Freestyle web interface application which facilitates user access to Freestyle data concentrator via Freestyle website. Functionality test “g” was done by remotely accessing data concentrator as a root user using terminal emulator application.

B. *Power lost test*

Power lost test was carried out by switching off the main power switch at the Powerlink Test and Development Laboratory causing total power outage for 12 hours. Upon restoration, functionality tests were conducted and the system successfully passed all functionality tests. Therefore, the power lost test proved that Freestyle system could automatically recover and resume its normal operation after power failure.

C. *Network failure test*

During the functionality test, it was proved that Freestyle data concentrator monitors connection between Microengines and its end devices such as IEDs and meters. It also proved that the system generates “loss of contact” emails and delivered them to the user(s) whenever the connection failed. However, network connection failure between Microengines and data concentrator required the data concentrator to reset in order to reestablish the connection.

D. *Reliability test*

In order to test reliability of Freestyle system, the system was left running for a month and daily meter reading emails received were recorded. One of the functions of Freestyle system was automatic daily meter reading. At midnight each day, the system automatically generated one meter reading file from each meter, compressed them to NEM12 file format and emails the results to the user(s).

Figure 4 shows the number of NEM12 files delivered from each meter over 30 days period. It can be seen that the number of NEM 12 files generated from each meter varies from three to zero. Figure 5 shows that the system is working correctly (i.e. delivering one NEM 12 file from each meter) only 39% of the time.

IV. CONCLUSION

The development of modern IEDs in early 1980s and their implementation in substations has enhanced the data obtained from the substations. The quantity of data available has also increased substantially. Utility companies are looking for better ways to access to substation data to improve efficiency

of operation and customer services. The Freestyle system, utilizing the existing WAN and LAN, provides a cost effective and fast data transfer system.

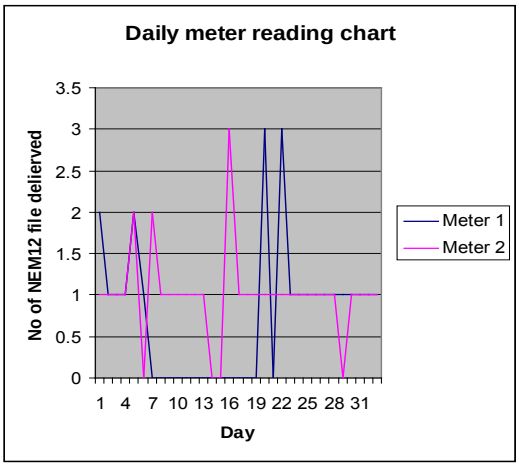

Figure 4. Daily meter reading chart

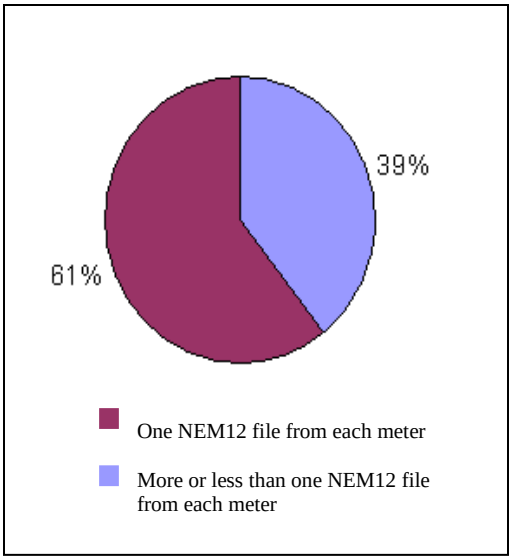

Figure 5. Daily meter reading pie chart

The system can be easily upgraded by installing additional Microengine as the numbers of IEDs and meter devices increases. The test result confirmed that the Freestyle system can provide a single solution for automatic data extraction of meter data and IED event file as well as transferring data to the end user. It also proved that the system supported direct communication to IEDs to enable remote configuration. However, Freestyle system requires significant improvement to meet the reliability and maintainability standard required in transmission substation environment, which is very critical in modern power system. Freestyle system will need to ensure security and integrity of data while not overloading the network as the security is paramount within utility industry, especially transmission meter data using LAN and WAN. With further development, Freestyle innovation has great potential in utility industry. Nonetheless, it is vitally crucial for any utility to experimentally investigate any new systems, protocol or devices before implementing them in the real network.

ACKNOWLEDGMENT

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