Automatic Power Meter Reading System Using GSM Network

H. G. Rodney Tan, *IEEE*, C. H. Lee and V. H. Mok, *IEEE*

Abstract--**The development of a GSM Automatic Power Meter Reading (GAPMR) System is presented in this paper. The GAPMR System is consists of GSM Digital Power Meters installed in every consumer unit and an Electricity eBilling System at the energy provider side. The GSM Digital Power Meter (GPM) is a single phase IEC61036 standard compliance digital kWh power meter with embedded GSM modem which utilize the GSM network to send its power usage reading using Short Messaging System (SMS) back to the energy provider wirelessly. At the power provider side an eBilling system is used to manage all received SMS meter reading, compute the billing cost, update the database, and to publish billing notification to its respective consumer through SMS, email, Web Portal and Printed postage mailing. A working prototype of the GAPMR system was build to demonstrate the effectiveness and efficiency of automatic meter reading, billing and notification through the use of GSM network.**

Index Terms—**Automatic Meter Reading, Digital Power Meter, GAPMR, Global System Mobile, Modem, Short Messaging System.**

I. Introduction

Traditional meter reading for electricity consumption and billing is done by human operator from houses to houses and building to building. This requires huge number of labor operators and long working hour to achieve complete area data reading and billing. Human operator billing are prone to reading error as sometime the houses electric power meter is place in a location where it is not easily accessible. Labor billing job is sometime also restricted and slowed down by bad weather condition. Printed billing has the tendency of losing in the mail box. The increase development of residential housing and commercial building in the developing country such as for example, Malaysia require more human operators and longer working hours to complete the meter reading task. This increases the energy provider operation costs for meter reading. In order to achieve efficient meter reading, reduce billing error and operation costs, Automatic Meter Reading (AMR) system play an important role to address the above mentioned problems. AMR is an effective mean of data collection that allow substantial saving through the reduction of meter re-read, greater data accuracy, allow frequent reading, improved billing and customer service, more timely energy profiles and consumption trends updates, and better deployment of human resource [1]. With the advent of digital technology, analogue electro-mechanical meter is continuously replaced by digital electronic meter. Digital energy meter offer greater convenience to implement and establish automatic meter reading system electronically. Efficiency and reliability of retrieving meter reading in the AMR system was a major challenge. Various AMR methods and technologies using Power Line Carrier (PLC) communications, Supervisory Control and Data Acquisition (SCADA), telephone modem, Internet, Ethernet, Embedded RF Module, WiFi, Bluetooth and ZigBee were established and developed [2][3][4][5][6][7] to provide and demonstrate the solution of efficiency, reliability and effectiveness of AMR. The above mention methods are either too expensive to implement and operate, require complex setup of infrastructure, short operating distant and still require field intervention of human operators or prone to error and reliability issue due to noise in the transmission line or weather condition. With the rapid development of Global System Mobile (GSM) [8] infrastructure and Information Communication Technology (ICT) in the past few decades has made wireless automatic meter reading system more reliable and possible. The GSM Automatic Power Meter Reading System (GAPMR) presented in this paper takes advantage of the available GSM infrastructure nationwide coverage in the country and the Short Messaging System (SMS) [9] cell broadcasting feature to request and retrieve individual houses and building power consumption meter reading back to the energy provider wirelessly. The Store and forwarding features of SMS [10][11] allow reliable meter reading delivery when GSM signal is affected by poor weather condition. The stored SMS is archive in the mobile operator and can be later retrieve for billing verification purpose.

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II. System Overview

The complete system overview for GAPMR system is shown in Fig. 1. The complete system is made up of GSM Power Meters (GPM) installed in every individual consumer unit and SMS Gateway, Application Terminal, Database Server, Email Server, Printer Server, Web server, and E-Commerce Server install at the energy provider side. The system is working in conjunction with the GSM network to retrieve power meter reading using SMS. The GPM is a single phase digital kWh power meter which utilizes the GSM network to send the power usage reading back to the energy provider wirelessly upon request from the energy provider SMS gateway. The GPM is the integration of a single phase Class 1, IEC61036 standard compliance digital kWh power meter and a GSM modem. A SIM card with a unique special service number is require for the GPM to receive and reply its meter reading to the energy provider using SMS. The special service number SIM card is work similar with mobile phone number except it is not mean for voice service. The SIM card service number is also use to identify and retrieve the owner or customer details from the database server for billing purposes.

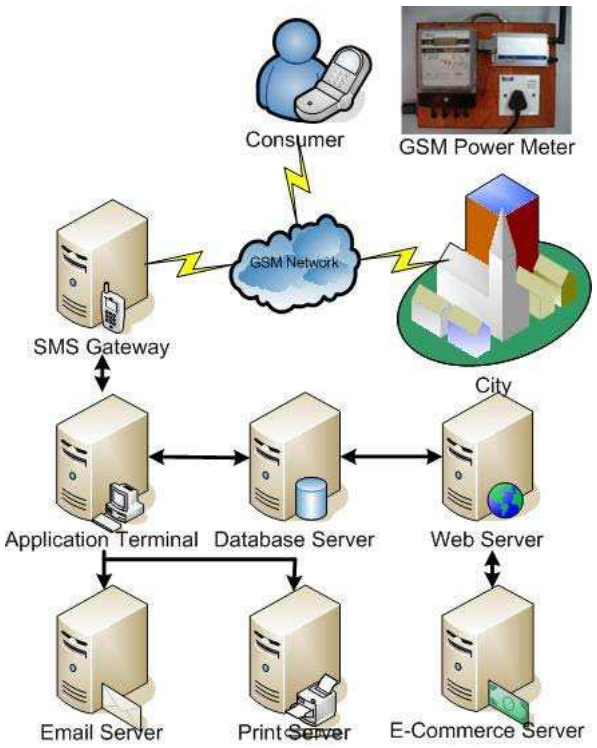

Fig. 1. Overview of GAPMR System

An automatic power meter reading took place upon request by the power provider using SMS at monthly interval. Upon meter reading execution the SMS gateway performs cell broadcasting of request through SMS to all GPM to request for meter reading. Once each individual GSM power meter received the requesting SMS, it will immediately response by composing its consumption reading in six digits kWh with one decimal point unit in SMS format and revert it to the energy provider SMS gateway. The SMS gateway starts to receive the reply meter reading from all the individual GPMs and will store the meters reading information accordingly. The retrieval of all individual meter through SMS for the whole country may take sometime depend on the GSM network traffic and weather condition for the particular GSM cell area. After completion of the meter reading request, the application terminal will starts to retrieve the meter reading from the SMS gateway to store and update to the database server. So after that the application terminal eBilling system will starts to calculate the billing amount for an individual meter based on the tariff rate from the energy provider. The billing notifications are later sent to all the owners through email by the Email Server, SMS to the owner through SMS Gateway and hard copy printing through the Print Server for postal mail for owner who prefer hard copy printing. A Web portal has also been setup at the Web server to provide easy check and payment service. Once the owner received the billing notification from SMS, email or hard copy printing bill, then the owner can access the web portal and able to logon to check their billing detail since the web server is linked to the database server. The owner can choose to pay their bill online using credit as the web server is connected to the e-commerce server that is handling online banking transaction. The owner can also choose to pay their bill by cash at any of the energy provide outlet that have access to the application terminal. The owner can also use their mobile phone to retrieve their power meter reading to verify the billing reading. This can be achieved by just sending a SMS to the owner GPM service number. Once the GPM receive the SMS it will compose the current meter reading and reply to the owner mobile phone through SMS. With this feature the consumer can monitor their power usage anytime and anywhere.

III. GSM Power Meter Design

The design of the GPM is an integration of a single phase Class 1, IEC61036 standard compliance digital kWh power meter, Power to Communication (P2C) Interface board and a GSM modem as shown in Fig. 2.

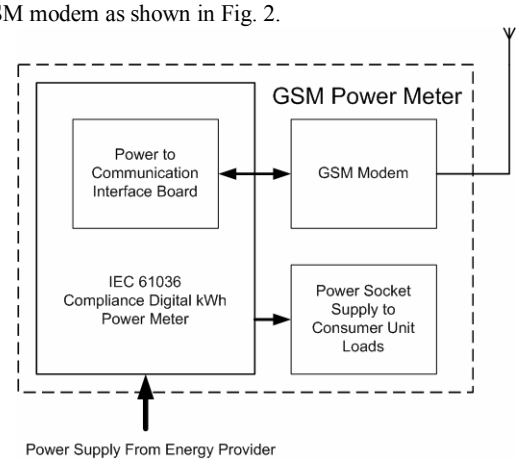

Fig. 2. Block Diagram of the GSM Power Meter

The GSM digital power meter is used to measure the power consumption drawn from the energy provider sub station to the consumer unit in kWh unit. A Static Single Phase Watt Hour Meter ATec12 from ATec is chosen for GPM implementation. The digital power meter was set to display six digits with one decimal point reading in kWh unit and a meter constant of 800 impulse per kWh. The digital power meter has an optocouple meant to couple the impulse count to any external electronic circuitry without direct contact to the digital power meter circuitry. The Power to Communication (P2C) interface board was implemented by two RISC microcontrollers, on the power side the power microcontroller to is used to interface the impulse and synchronize count from the power meter optocouple circuit and store the meter reading into its internal non-volatile EEPROM memory at every single impulse count interval. In the event of power failure the last meter reading information is stored in the EEPROM. Upon power restoration the power microcontroller will be able retrieve the last meter reading and continue to synchronize with the digital power meter. On the communication side the communication microcontroller is used to communicate with the GSM modem using RS232 UART serial communication protocol and the AT command. The serial communication protocol operate at the baud rate of 9600bps, one start bit, eight data bit, one parity bit and one stop bit. GSM modem SIM-T03 from SIMCOM was chosen to be used in the prototype implementation. During normal operation the P2C interface board synchronizes the impulse count and wait for any SMS request from either the energy provider or the consumer. Once a SMS request is receive from the GSM modem, the communication microcontroller will send a request signal to the power microcontroller to retrieve the last meter reading from the EEPROM memory. After obtaining the meter reading then the communication microcontroller will compose the meter reading in standard short message format and revert it back to the sender. The message is consists of six digits with one decimal point kWh unit as shown in Fig. 3. The same message is sent to the energy provider if the request SMS is sent by the energy provider.

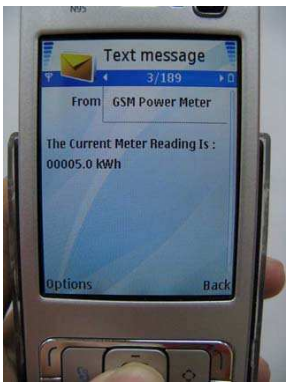

Fig. 3. SMS message shown on a mobile phone

The GPM prototype is shown in Fig. 4. The P2C interface board is embedded inside the power meter with RS232 serial interface linked to the GSM modem mounted on the right hand side of the power meter. The P2C interface board and the GSM modem drawn additional power consumption of 0.5W. A socket outlet is used to power the load to run the power meter.

Fig. 4. GSM Power Meter working Prototype

IV. System Test Approach

For demonstration purposes the GPM and the SMS gateway GSM modem uses an ordinary SIM card phone number. The GPM is power up from a socket outlet and 1000W light bulbs are used to simulate the consumer power consumption load and the meter capture the reading as shown in Fig. 5.

Fig. 5. GSM Power Meter and 1000W Load for Demonstration

At the energy provider side the eBilling system include the database, email, printer and web server software on a single computer together with a GSM modem as a SMS gateway for this demonstration. All the owner details are pre-entry into the database upon registration of the use of GPM shown in Fig. 6 is the eBilling application software Graphic User Interface that displayed the customer information and total bill after requesting, retrieving, and calculating the meter reading into the system.

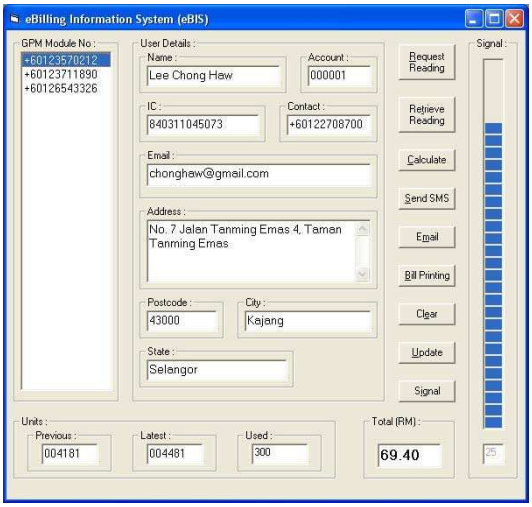

Fig. 6. eBilling System Software Graphic User Interface

The signal status bar on the right hand corner indicates the signal strength from the GSM modem. It helps to determine the perfect time to perform SMS broadcast for the meter reading request. The request reading button is used to broadcast SMS for meter reading request. The retrieve reading button is used to retrieve and to list down the entire customers GPM special service contact numbers from the SMS gateway and to displayed in the GSM Meter Number list box on the left hand corner of the GUI. Click on any of the GPM special service contact number in the list box will display the customer details from the database including the latest meter reading from the customer GSM power meter. The Calculate button is used to calculate the total bill based on the meter reading usage and to display on the GUI. The tariff for billing calculation is based Tenaga National Berhad (TNB) Malaysia. The Send SMS button is used to send the billing notification to the customer via SMS. The Email button is used to send the billing notification to customer through email. Bill Print button is used to print out the bill in hard copy form for postal mail to the customer. The Update button is used to update the customer detail into the database. The Clear button is to clear the display. The billing notification to customer can be sent by SMS, Email and hardcopy as shown in Fig. 7. All the notification is generated by the eBilling system on the computer and the customer information is retrieved from the database.

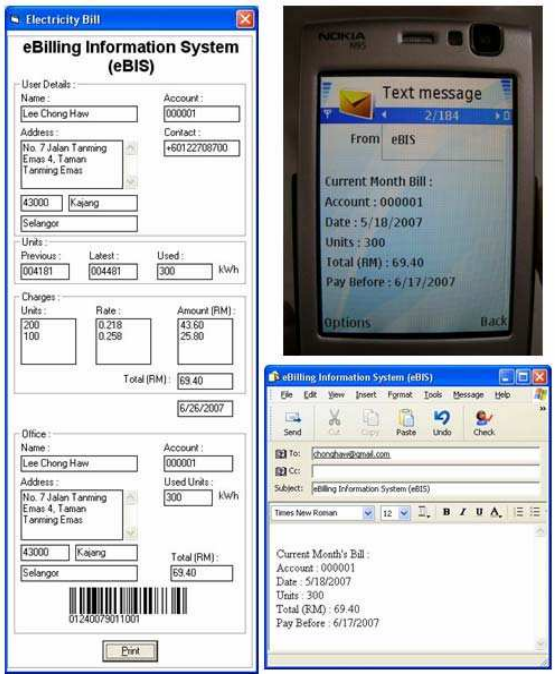

Fig. 7. Printed Hardcopy Bill, SMS and Email Notification

The web portal allows the customer to check and print their billing information and detail through the use of internet. The web portal also allowed the customer to pay the bill online using credit card as the web portal is link to the bank E-commerce server for online transaction. The web portal also allows the customer to request and read their home power meter reading to verify with the billing charges. Once the customer received the billing notification the customer can check and made payment online through the web portal or the energy provider outlet. Fig. 8 shows the customer detail and billing information after login to the web portal. The customer can click on the pay online button to pay the bill by credit card.

Fig. 8. The GPM Web Portal eBilling System

The test shows the complete flow of GAPMR system operation from meter reading, billing, and notification to demonstrate the effectiveness, reliability and efficiency of AMR using GSM network. For demonstration purpose the real E-Commerce server for cash and online payment, real banking credit card transaction is not implemented.

V. Conclusion

A complete working prototype of the GAPMR system was built to demonstrate an automatic power meter reading using GSM network. The GAPMR system takes the advantage of existing GSM infrastructure that have virtually full coverage of all housing and building area across the country which lead to low infrastructure implementation cost, simple and easy installation of GSM Power Meter at consumer side as GSM Power meter is no difference from existing ordinary analogue or digital meter installation. The complete eBilling System required an ICT expertise personnel to setup, run and maintain all the servers. The GAPMR system proven to provides effective, reliable and efficient wireless automatic power meter reading, billing, and notification through the use of GSM network, thus reduce human operator meter reading operation cost.

VI. Acknowledgment

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VIII. Biographies

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