IoT based kWh Meter Recorder System for Electrical Substation

Moh Khozain\textsuperscript{1} and Adhatus S Ahmadiyah\textsuperscript{2}

\textsuperscript{1}Maintenance Department, State Electricity Company (PLN), Jl. Embong Wungu PLN UP2D Jatim, Surabaya, Indonesia

\textsuperscript{2}Informatics Department, Institut Teknologi Sepuluh Nopember, Jl. Raya ITS Kampus ITS Sukolilo, Surabaya, 60111, Indonesia

E-mail: moh.khozain@pln.co.id\textsuperscript{1}, adhatus@if.its.ac.id\textsuperscript{2}

Abstract. The plan to abolish the substation operator raises new problems in reading the electrical energy stand, which at present all State Electricity Company units conduct it manually. This paper aims to provide a cost-effective meter data recording system to replace manual reading. The proposed solution is developed using WI-FI based internet of things (IoT) technology. Our proposed solution is implemented as a meter-recording device installed at the substation. Since deployed in December 2018, this tool works very well. Since it actively supports East Java’s performance in the pilot distribution control unit, it can be implemented in other units.

1. Introduction

At present, the reading of the electrical energy stands at feeders in the substations of all Indonesia State Electricity company units is still conducted manually. Officers or operators need to come to the substation to get meter data as a reconciliation of postpaid energy consumption. When the Supervisory, Control, and Data Acquisition (SCADA) system fails, the operator of the substation needs to read the electrical energy parameters at any time. Manual reading is highly vulnerable to human error because the meter position is higher than the eye, and the recording process is not practical.

However, the effort to automate meter reading at substations faces some challenges. First, the existing system with a multi drop system fails to integrate communication of kiloWatt hour (kWh) meter reading in feeders. The second is the high-cost problem of adding modems and using GSM / GPRS card for communication. The feeder meter serves as the main upstream energy reconciliation facility, instead of a direct transaction point with the customer. Therefore, the development of Advanced Metering Infrastructure (AMI) in the proposed system must be pursued to promote efficient operating costs.

Plans for eliminating the operator of the substation operator can still minimize the occurrence of deviations. It is in line with the unit’s mission and not disrupt the existing SCADA system by the end of 2018, experiencing constraints due to the two problems earlier. Therefore, developing a kWh meter reading system with the IoT WI-FI system is a highly relevant solution [1] since IoT has been an accessible technology lately [2-4].
2. Methodology
The results of data collection in the field have several different brands and types of kWh meters. In one substation, there are more than five kWh meters, some even 50 kWh meters close together. Each kWh meter uses one reader device, but each substation is only enough to use one router, except for a separate substation, two separate buildings need two routers. Figure 1 displays the required equipments for the proposed solution.

![Figure 1: Quality Control Program Flowchart](image)

2.1 Hardware
QR (Queue Reader) is a part that receives data from meters with a variety of protocol meters. The data from the protocol meter convert into a smaller size MQTT data protocol and send to the server with a push system via the Fiber Optic pathway of the existing SCADA system. Since MQTT is a protocol above the TCP/IP level for IoT implementation, data conversion needed to keep sending data to server from interfering with SCADA communication.

ESP32 (shown in Table 1) is a System on Chip that provides Wi-Fi plus Bluetooth 4.2 Solution combo on the 2.4 GHz band using 40 nm technology. Node MCU ESP-32 is a development board kit for internet of things applications. This board consists of a very feature-rich IoT ESP32 module and a USB to-serial CP2102 chip that makes it easy to program this module. One core dedicates to WI-FI and Bluetooth connectivity and the other core dedicates to user applications.

| Items                  | Specifications                          |
|------------------------|-----------------------------------------|
| RF certification       | FCC/CE-RED/IC/TELEC/KCC/SRRC/NCC        |
| Wi-Fi certification    | Wi-Fi Alliance                          |
| Bluetooth certification| BQB                                     |
| Green certification    | RoHS/REACH                              |
| Reliability            | HTOL/HTSL/uhHAST/TCT/ESD                |
| Protocols              | 802.11 b/g/n (802.11n up to 150 Mbps)    |
|                        | A-MPDU and A-MSDU aggregation and 0.4 μs guard interval support |
| Frequency range        | 2.4 GHz ~ 2.5 GHz                       |
The QR block diagram as shown in Figure 2 is designed to be small enough to make it possible to place it securely on 20 kV cubicle panel or stamp meter.

![Block diagram of QR](image)

**Figure 2.** Block diagram of QR

2.2 Web Application

PHP is a scripting language used to create dynamic web pages and is a server-side script language. Dynamic means the displayed web page is processed at the time. The web page requested by the client. This mechanism cause information received by clients is always the latest.

The kWh meter parameter data that has been sent to the server can be displayed informatively via the web application. The master IoT METER web is designed with standard parameters needed for the analysis and evaluation of upstream electricity reading. In the future, it enables easy integration with AMICON, in which a single application monitoring meter data from the base to the ends of the network at the customer. The main parameters of reading data on the web application include the following: (a) Dashboard, (b) Load profile (real-time history data), (c) Detailed readings in real-time (complete with phasors), (d) Flow chart, (e) Voltage graph, and (f) EoB record stand.

Granting access managed by the super administrator in East Java distribution control center - operating unit to be given to certain parts of interest, for example, the UP3 and UP2B energy transaction section, the operation section, and the protection meter of UP2D JATIM. The access restriction is intended to prevent electrical energy transaction data from being misused by unauthorized users.

This innovation is implemented in 105 substations and 711 feeders in the East Java Region with several steps of development. The development plan of this design system integrates the existing AMICON system and balance sheet application as shown in the chart in Figure 3.

![Block Diagram of development system](image)

**Figure 3.** Block Diagram of development system
3. Result and Discussion

In the application of this system uses hardware (tools) and software (web browsers) as shown in Figure 4. The hardware (tool) functions to send the meter data to the Router / Serial Link and send again to the server using the IoT system, which uses the MQTT protocol so as not to interfere with the existing SCADA communication. After the data have sent to the server, the software (web application) processes and displays the data into accurate and easy to understand information.

![Figure 4. Topology of IoT Meter Main Station for two locations](image)

3.1 Hardware Testing and Installation

Wi-Fi components generally consist of Access Point (AP) and Wireless Client that can be integrated with a user's device or external card. AP can be connected to existing LAN network. The individual test results of each meter can be done by checking the success of the Wi-Fi connection from mobile to QR. Through the browser on our cell phone, we can check the success or failure of the connection based on the default IP address of the QR. Meter data settings and naming ID feeders can be done directly in the field, without having to register via the web.

The results of the data transmission test can also be seen from the physical QR, the active QR power indicator light, and the indication for receiving data from the meter. This QR is designed without additional voltage supply to minimize the additional wiring that has the potential for anomalous DC Ground in a 20 kV cell installation.

Some meters have different internal power supplies, QR requirements can be lit normally, that is, 9VDC voltage and QR power consumed by 2 watts. Ports of communication owned by the brand and meter type are also different, so it needs several programming segments.

3.2 Web Monitoring Test

System testing can be known from the features prepared in the web display. The dashboard shows the number of meters the QR has been installed, successful reading, and total points failed to send data. The number of End of Billing (EoB) data records for reconciliation transactions between units is also displayed.

Data load profile, in this case, the web is not taking data from parameters stored by the meter. However, it is retrieving data sent by QR in the form of instant data collection. Each data load profile history can be checked in detail because the source of the data taken is instantaneous reading. Energy measurement data from the load profile can display voltage, current, frequency, cos phi, phasor, and others. Based on these data, the deviation evaluation during reconciliation can be carried out earlier and more quickly.

Based on the results of the overall system implementation test, repeated communication failures occurred (indicated with red highlight in Figure 5). The failure is detected using a certain hardware. When we analyzed, most communication failures are dominated by port number 23, while port number...
1883 works well. After replacing the communication to port number 1883, a more stable communication with success reading of 91% is achieved.

Figure 5. Display of Communication fail

4. Conclusion
The proposed system has proved its easy and safe installation without additional power supply and communication to the router via WI-FI. In addition, it can directly be integrated with existing communication networks without additional routine connection fees because it uses the MQTT protocol that is able to utilize the SCADA line without disrupting the system that is running. The analysis can be done by its monitoring application which displays instant and EoB recording data.

References
[1] Schwartz M-O 2014 Internet of Things with Arduino (England)
[2] S. Gérald. The Internet of Things: Between the Revolution of the Internet and the Metamorphosis of Objects. European Commission Community Research and Development Information Service. Retrieved August 2017.
[3] G.F.Nama, M.Komarudin, H.Priambodo, Mardiana,H.D. Septama, 2014. Electricity, Temperature, and Network Utilization Monitoring at Lampung University Data Centre Using Low Cost Low Power Single Board Mini Computer. In The Regional Conference on Computer and Information Engineering (RCCIE), Yogyakarta Indonesia, pp 184-189.
[4] D.Despa, M.A.Muhammad, H.Gusmedi, N.Amaro. 2017. Sistem Monitoring Besaran Listrik Dengan Teknologi IoT (Internet of Things). Bandar Lampung