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Edge Computing for Internet of Things (IoT) System on Battery Monitoring System (BMS) to Determine State of Charge (SoC) and State of Health (SoH)

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Abstract. The purpose of this study is to measure the State of Charge (SoC) and State of Health (SoH) of the VRLA battery. The method used in this study was to combine the internal parameters of each battery, namely current, voltage, and internal resistance, while the external parameters are temperature, humidity, and pressure. All these parameters were measured using a sensor and then processed by a microcontroller. Data from the microcontroller is sent to edge computing via RS 485 communication with Modbus protocol. To get valid results, not only the data from the measurements but also combined with the data from the datasheet for each type of battery. All of this data will be combined and become a reference in determining SoC and SoH. The benefit of this research is to help determine which battery will decrease SoC and SoH so that the owner can perform predictive maintenance. Broadly, the benefits of research in the area of data center battery management, BTS for on-grid areas.

Keywords: Edge Computing, Internet of Thing, IoT, State or Charge, State of Health.

1. Introduction

With the rapid advancement of technology, nearly any activity can be performed utilizing social media. As a result, it facilitates all human activities, particularly corporate operations. Soegoto noted that in order to be a good entrepreneur, we must gain a larger understanding of entrepreneurship. [1]. Almost everyone now uses social media for both personal and professional purposes. As a result, social media has a significant impact on human behaviors in the digital era. Social media has an impact not just on corporations, but also on education and health. [2]. Social media is a type of media that is used to collect data and address problems that customers understand, particularly for small and medium-sized organizations [3]. To establish the uniqueness of a trademark, communication is required to shape customer views about a brand's attribute [4]. Previous research has found that using social media, particularly for small firms, is a viable marketing technique based on the Attention, Interest, Desire, and Action (AIDA) models. It is a guide for small business owners on how to utilize social media strategically for marketing.

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Furthermore, customer relationship management (CRM) is a strategy that promotes transactional and interactional interactions with customers in order to maximize possible economic rewards such as brand loyalty. Another study found that the majority of 213 articles on the strong association between social media and branding emphasize the importance of techniques for using social media to improve product brands, such as co-branding or franchising [5-7]. Other research indicates that the use of social media is necessary at this time, particularly for accessing data and information that can aid decision making and knowledge expansion. This technology allows entrepreneurs to communicate and transact with customers through various sorts of social networking. Furthermore, as a marketing medium through online advertising brochures, it can assist entrepreneurs in providing product information at a reasonable cost [8-10].

Based on the research case studies mentioned above, we can infer that social media is the most effective approach to promote in the current digital era. This study aims to investigate social media-based corporate growth techniques in the community service sector. To collect accurate data, this study used a descriptive technique, examining digital advertising on social media.

2. Method

Research on batteries, especially to determine the State of Charge (SoC) and State of Health (SoH), has been done quite a lot, but previous research only focused on the internal part of the battery [3,4] and without involving environmental elements that can affect the quality of the battery. Besides, the data processing mechanism still uses a microcontroller that has limited memory and computational latency, and the data is not equipped with analytic data for predictive maintenance [5,6]. For that, the authors researched with a focus on building systems equipped with edge computing, data analytics, and web interfaces for data management to facilitate monitoring, management, and providing periodic reports for predictive maintenance. The following Table 1 shows a comparison of the research results.

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Table 1. Research Comparison Table

NO	Feature	Estimation of State of Charge (SOC) and State of Health (SOH) Using the Kalman filter Algorithm on Lithium Polymer Batteries (2016)	State of Charge (SoC) for Battery Management System (BMS) via Kalman Filter (2017)	Edge Computing for Internet of Things (IoT) System on Battery Monitoring System (BMS) to determine State of Charge (SoC) and State of Health (SoH) (2020)
1	SoC	√	√	√
2	SoH	√	√	√
3	Voltage measurement	√	√	√
4	Current Measurement	√	√	√
5	Battery Temperature	-	-	√
6	Environment Parameter	-	-	√
7	Edge Computing	-	-	√
8	Data Analytics	-	-	√
9	UI Web /Dashboard	-	-	√

2.1. Battery

A battery is a device that can transform chemical energy into electrical energy through electrochemical reactions of oxidation and reduction. This reaction is caused by the transfer of electrons from the negative pole to the positive pole. Batteries are typically made up of one or more cells linked in series, parallel, or combined series-parallel depending on the output of voltage and capacity [1]. Batteries can be grouped into 2. Namely, primary or non-rechargeable batteries are batteries that cannot be recharged. Examples of primary batteries are zinc-carbon batteries and alkaline-manganese batteries. Secondary batteries or rechargeable batteries are batteries that can be recharged continuously. Examples of secondary batteries are lead-acid batteries and lithium-ion batteries [1].

2.2. SoC

SoC is one of the most critical parameters monitored by a BMS. There are numerous methods for calculating a battery's SoC using its cell voltage, current, and temperature. The simplest way is to measure OCV or loaded voltage directly and then estimate SoC based on pre-stored discharge characteristics. However, this method has an impact on the estimate because of modest measurement inaccuracies. [7]. SoC is defined in Equation (1):

$$SoC = \left(\frac{Creleaseable}{Cmax}\right) * 100 \quad (1)$$

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Where dischargeable charge capacity is the maximum charge capacity, and SoC is the ratio given as a percentage.

2.3. SoH

SoH is an indicator of decreasing performance caused by aging in lithium batteries, and it is used to determine the battery's state [7]. We define SoH as follows (2):

$$SoH = \left(\frac{C_{actual}}{C_{fresh}}\right) * 100 \quad (2)$$

In this research, we defined normal as 100% ~ 90% of the rated capacity, warning as 90 ~ 80%, and fault as less than 80% of the capacity.

2.4. Internet of Things

IoT (Internet of Things) is a global infrastructure that provides services for connecting physical objects or virtual objects based on ICT devices wirelessly. Physical objects are objects that are visible and connected to the network in the form of sensors, robots, or home devices. The IoT architecture consists of sensors, controllers, gateways, and ISPs [8,9].

2.5. Edge Computing

Edge Computing is an innovation that can perform computing at the network edge so that computing occurs near the data source. In Edge Computing, the end device not only uses data but also generates data [10]. Using edge computing can shorten the computation delay so that data can be processed immediately, even into a decision. Besides, edge computing can also be an aggregator to sort data, ensure complete and correct data before finally being sent to the cloud server.

2.6. MQTT

MQTT (Message Queue Telemetry Transport Protocol) is a lightweight protocol for data transmission that can be implemented in times of limited latency/bandwidth. This protocol is also quite flexible in the configuration of the devices and services provided [7] (See Figure 1).

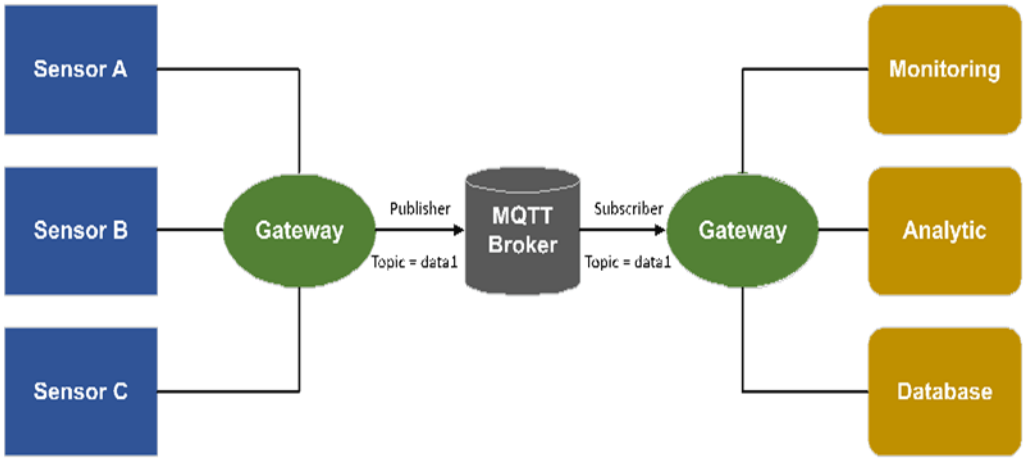

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Figure 1. MQTT Protocol Architecture

MQTT has three actors consisting of publishers, subscribers, and brokers. The concept used in this protocol is published/subscribed, where the message has a topic and is connected to the broker [8].

3. Results and discussion

3.1. System Design

The following is the system architecture, which consists of sensors for each battery, sensors for the environment, and also a module for serial communication using RS 485 with the Modbus protocol. Overall, this system is described in Figure 2 as follows:

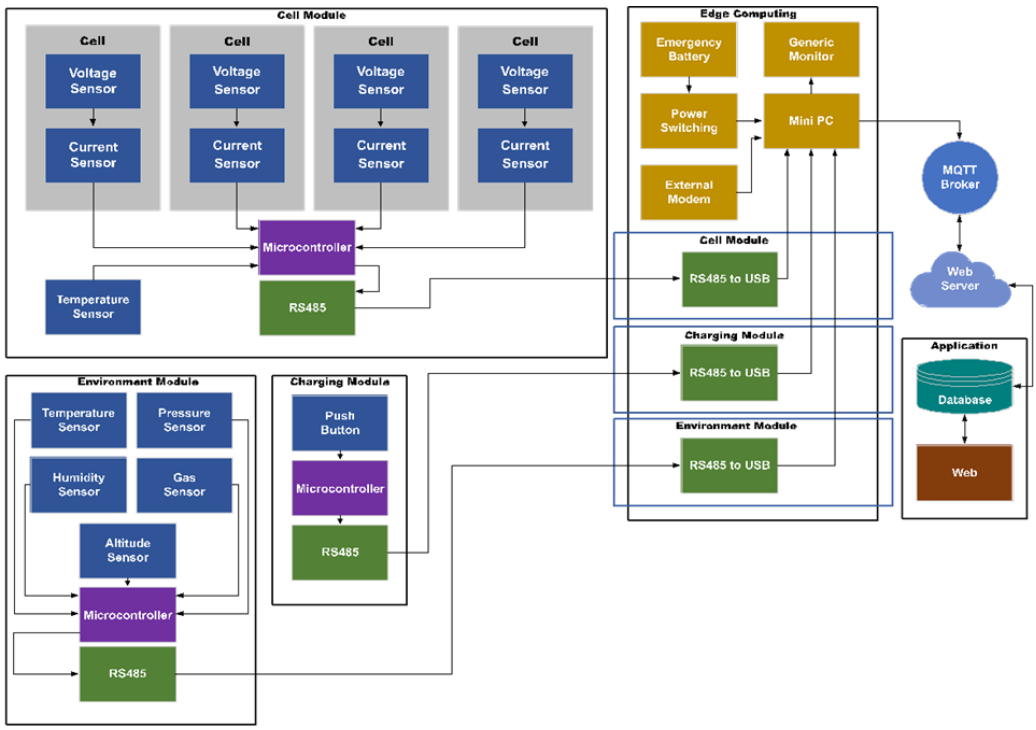

Figure 2. System Architecture

This system is divided into 2 (two) major areas, namely devices and edge computing in the field to monitor battery conditions and the environment, as well as applications running on cloud servers on the web platform. The device for measuring battery parameters is called a cell module, where 1 unit can be used to measure 3 (three) batteries simultaneously. The parameters that are measured are temperature, pressure, and current. Next is the environment module. This unit functions to measure environmental parameters, namely data on temperature, humidity, pressure, and CO gas. All these units are linked to edge computing using RS 485 communication with Modbus RTUs. Data is received by the edge computing unit, sorted, and all incoming data will be processed using sensor fusion techniques [9] (see Figure 3).

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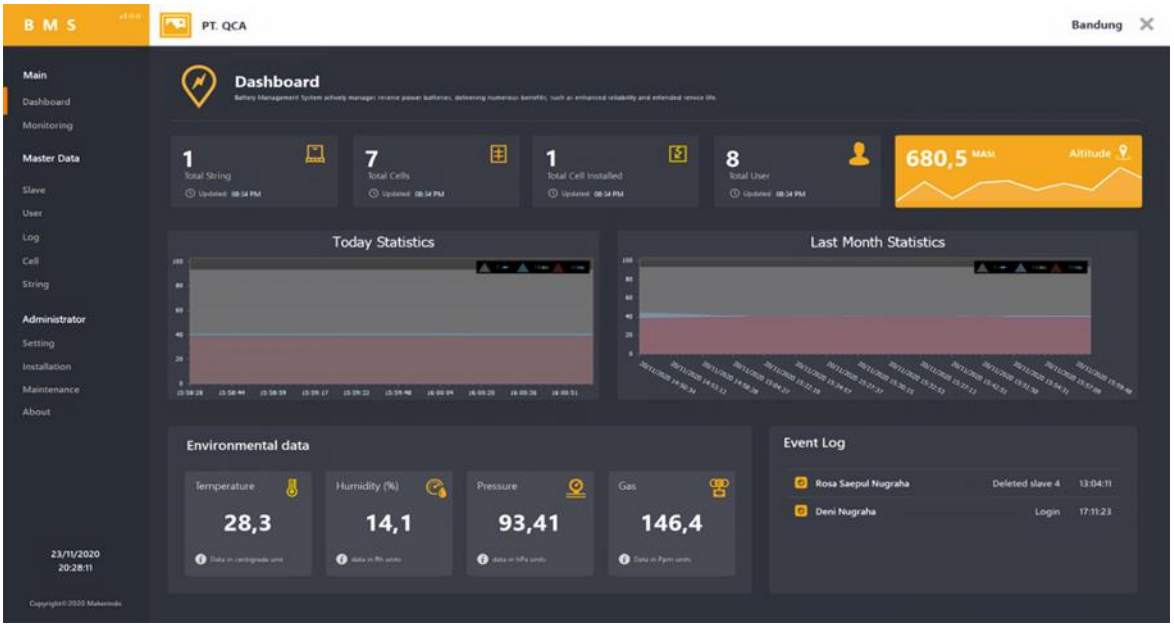

Figure 3. Edge Computing Dashboard

Edge computing is based on desktop applications, but most of the program execution runs in the background, so it has fast execution capabilities and does not affect the display. In the edge computing section, features are provided for device management, from adding, replacing, and identifying damage. In the display section, real-time graphical visualization is provided to provide the latest information for each battery. Edge computing ensures that only data with the correct and complete format will be received from the device, then this data is processed and transmitted to the web server using the MQTT protocol [8,9]. To measure the functionality and performance of edge computing, the following is a comparison of the battery monitoring system without edge computing and with edge computing.

Implementing edge computing in VRLA battery SoC and SoH monitoring systems provides benefits and convenience in an integrated configuration, communication, and monitoring, but this system also has the disadvantages of being more expensive and requires more complex maintenance. To see a comparison of these two areas, it is described as follows:

Table 2. Edge Computing Review

Parameter	Without Edge Computing	With Edge Computing
Main controller	Microcontroller	Mini PC
Filter and aggregator	Not available	Available
Granularity	Not supported	Supported
Storage capacity	Less capacity	Good capacity
Data transfer rate	Slow	Fast
Dashboard	Not available	Available
AI Feature	Less supported	Full supported

4. Conclusion

Based on system testing, using edge computing is proven to provide significant results in data processing, measurement accuracy, and ease in battery management, both from installation, replacement, and predictive maintenance. By combining internal battery data, namely temperature, current, and voltage, with environmental data, namely temperature, humidity, pressure, and CO gas, using a fusion sensor, the SOC and SOH determination of each battery are more accurate. Edge computing also provides easy integration with other platforms, such as web applications using the MQTT communication protocol.

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