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Smart water meter for automatic meter reading

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Abstract. Clean water is one of the main sectors in smart city that need well management. One of the clean water management is utilization of water meters. The smart meter is more suitable applied for smart city. Recent Smart Water Meter allows water authorities to obtain water consumption data remotely. It also provides ability to collect and record the data in real time that can be utilised for multipurpose. However, in Indonesia, the water meters are used only to measure the total volume of clean water consumption for billing purpose only using mechanical water meter and requires labour intensive manual. Currently, many researches on smart meter design have been developed. However, the smart meter only measure and record the water consumption, without ability in which customer can determine the amount of water as needed. This paper describes design and development of smart water metering with Internet of Things. Flow meter is used as a sensor of water flowing through the pipe. The ability of the proposed smart meter is not only to measure and to record the volume water consumed, but also the customer can determine the water desired and required. The volume of water measured by the smart meter is compared with the manual measurement. The result shows that the water measured manually differs slightly from smart meter measurement using water flow sensor. The maximum difference, error, is 0.03 litres. The proposed smart meter has ability to close the main valve once the determined amount of water is reached.

1. Introduction

A smart city is a city area that has integrated information and communication technology in managing and monitoring the city effectively and eficiently[1]. The integration of technology in city management becomes possible with the existence of the internet of things. The management include transportation, energy, health, clean water, waste/disposal.

Among the physical infrastructure in smart cities, the clean water supply network is the most important because water is a very valuable urban resource. However, efficient changes in lifestyle and eating habits, as well as world population growth significantly increase the need for clean water worldwide [2]. The increase of clean water demand is more in urban areas. Thus, supply of clean water becomes challenging. This phenomenon is worsen by climate change. Climate change brings negative impacts not only on water availability quantity but also on water surface quality [3]. Water meter is one of the important devices in the supply water management [4].

Historically, the purpose of water meter installation is customer billing, and then water conservation [5]. The customer cannot gain the amount of water consumed at any time. Therefore, the consumers find it difficult to predict the water consumption at at any time. Information on the use of the amount of water consumed in real time, customers can access their patter water use. Pattern water use allows the consumer to limit their water usage when needed. This leads to water savings. Water meter may lead to supporting water conservation efforts with changes in water use behavior [2]. Controlling of tap water flow is one of the behaviors.

Most countries of the world have been installed fully mechanical water meter that measures total volume of water consumption [6]. In Indonesia, water meter used is the mechanical meters that require labor intensive reading, monthly reading, and tend to be inaccurate reading [7]. The inaccuracy in meter readings is exacerbated by the lack of access to the meter, such as a locked fence, that may adversely affect the customer.

Recently, smart meters have been widely used worldwide to overcome the disadvantage of the traditional meter. The smart meter allows the absence of labor and the reading is done remotely. Reading data can be stored in real time and utilized for various purposes, such as billing and water use patterns.

This paper focuses on the design and implementation of water meter based on Internet of Things (IoT). The proposed water meter applied IoT to send data from flow meter to the server and android of the customer.

The contribution of this project, generally, is twofold: Firstly, the proposed water meter is IoT base, as Automatic Meter Reading. Secondly, it proposed solenoid valve to close the water flow as the volume of water achieved the customer desire or requirement.

2. Related Work

2.1. Flow meter

Flow meter is a device that can detect and measure the fluid based on output of the flow sensor [8]. Flow meter, based on work principle, is classified for differential pressure, positive displacement, velocity, mass, and open channel.

The differential pressure flow meter, including orifice plate, measures the flow rate with the principle of pressure difference, called Bernoulli's principle, which says that there is a relationship between fluid pressure and fluid velocity. The relationship is inversely proportional. One of the implementation of orifice flow meter is in the geothermal industry to measure flow rate of single-phase liquid or steam [9].

Positive Displacement (PD) flow meter, including oscillating piston meters and notating disk meter, has the ability to measure volume directly. On the other hand, other flow meters can work with the principle of measuring the flow rate that will be converted to fluid volume. Using a PD flow meter, the output signal is directly related to the volume of fluid through the flow meter. Digital flow meter for fuel vendor has implemented of PD flow meter [10].

Velocity flow meter include electromagnetic and ultrasonic meter. Electromagnetic meter is based on Faraday’s law that states variation in time of magnetic flux enclosed by the conductive loop generated electromotive magnetic force (EMF) or voltage[11]. The generated voltage is proportional to fluid velocity.On the other hand, ultrasonic technologies are used for volumetric flow measurement, including transmit time meters and Doppler effect meters [12].

2.2. Smart Meters

In more recent times, many researches have developed smart meter. Smart meter can be used for irrigation system, residential and industrial water consumption.

Measuring water need in field is essential for irrigation management system. Design and implementation low cost water flow meter is applied [8]. The design used turbine type flow meter, ATMega89S52 microcontroller, and pump. The pump supplies water to the crops based on the crop requirement. After the required water is fulfilled, the pump will automatically off. The prototype works based on the time when the required water is achieved. The design system allowed the absence of labor to monitor continuously. This leads to a reduction in costs and avoiding plants from damage. However, the limitation of design is the absence of Automatic Meter Reading (AMR). As a result, the water use cannot be monitored and read remotely in real-time.

In [6], a digital meter system has been developed enabling AMR. The meter system utilized turbine type flow meter, ATMega328 microcontroller, and GSM as interface. However, the consumers cannot set the desired or required water to the digital meter.

Enligtened by the design water flow that enable setting of water requirement [8] and the implemented AMR in smart meter [6], the design of low cost smart meter is proposed. The proposed smart meter enables the meter to close the valve automatically when the total water is achieved. Furthermore, to enable AMR, the proposed water meter used Internet of Things to inform the water flow in real time through a smart phone.

3. Proposed design and implementation

3.1. Block Diagram Proposed Water Meter

In the proposed smart meter, data processing is carried out by a microcontroller, Arduino. The data received by the microcontroller is based on the digital output from the water flow sensor. To enableAutomatic Meter Reading (AMR), the Wireless Transceiver is integrated with the proposed smart meter, Internet of Things. This allows the data received by Arduino from the water flow sensor to be sent wirelessly via an internet device and received by the customer on an android device connected to the internet. Once the desired or needed water achieved, the main valve will be closed automatically. The block diagram of the proposed smart meter and flowchart of the system are shown in figure 1 and 2, respectively.

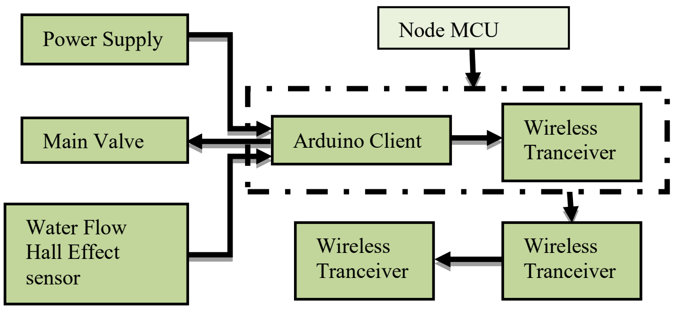

Figure 1. Block diagram of the proposed smart meter

AT89S52 microcontroller is used to monitor sensors. Here we have determined the flow rate with changes in water velocity. Speed depends on the pressure forcing the pipe to pass. Since the cross-sectional area of the pipe is known and remains constant, the average velocity is directly proportional to the flow rate. The relationship between the water flow rate and the average velocity of water flow in the pipe is shown in equation 1 [12].

$$Q = V * A \tag{1}$$

Where Q is the flow rate / total flow of water through the pipe, V is the average velocity of flow, and A is the cross-sectional area of the pipe. Other factors affecting water flow rate in the pipe are viscosity, density and friction of liquids in contact with the pipe.

3.2. Water Flow Sensor

A flow sensor is a device that detects and measures water flowing through pipes which is a necessary component of an efficient flow meter water system that is proposed. Mainly acts as a sensory organ for the brain in smart meter system, providing information for detecting, the amount of water consumed by the consumer. The basic working principle of the Flow meter is based on the output of the flow sensor. The flow sensor used in this proposed system is a sensor with hall effect working principles. As water flows through the rotor, the blades rotate. When the turbine rotates the magnetic field produced and corresponding to the pulse ac is generated which is then converted into digital output. The amount of credit generated per liter can be calculated by software programming. Thus the pulse produces an output frequency that is directly comparable to the volumetric flow rate/total flow rate through the meter. The spesification of flow meter sensor used, called Hall Effect sensor, canbe seen in the table 1 [13].

TABLE I. SPESIFICATION OF WATER FLOW SENSOR

Sensor Parameter	*range*
Sensor type	Hall effect sensor
Working voltage	5 to 18 V DC
Working flow rate	1 – 30 litres/minutes
Working temperature range	-25 to +80ºC
Working humidity range	35% - 80%
Maximum water pressure	2.0 MPa

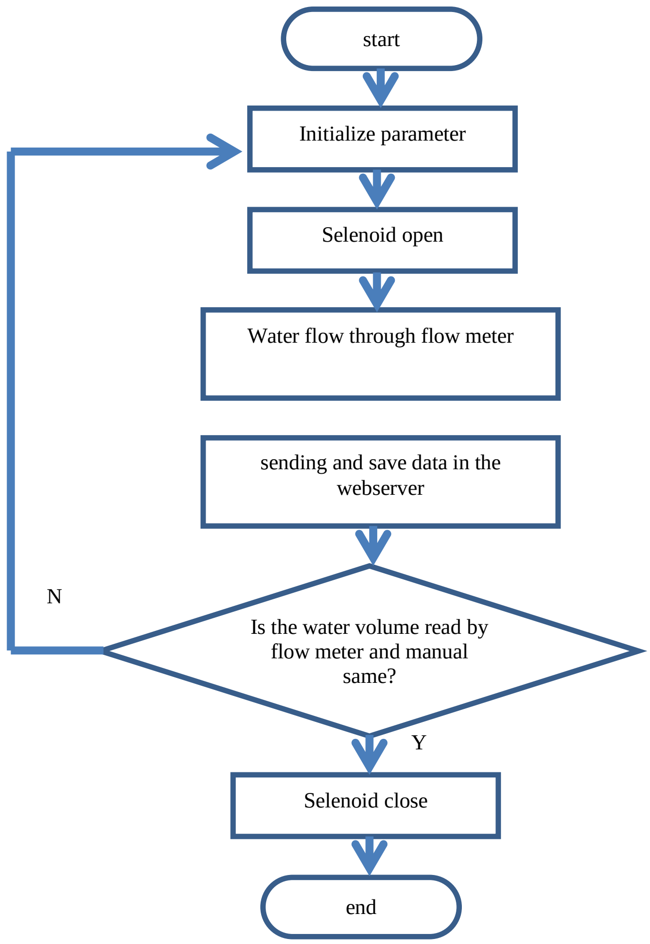

Figure 2. Flowchart of the proposed smart meter

4. Result and Discussion

A water tank and water pump are used to flow the water through the water flow. In this study, the amount of water that passes through the flow meter is compared with manual measurement with a measuring cup. The amount of water flowed is set from 10 to 50 litres in 5 litres increments. The result is shown in table 2.

Identify applicable funding agency here. If none, delete this text box.

Table 2. Comparison flow meter sensor and manual measurement

Measurements (litres)		**Error (Litres)**
Manual	Flow meter sensor	
10	10	0.0
20	19.99	0.01
30	29.99	0.01
40	39.98	0.02
50	49.97	0.03

The flow meter sensor measurement that has been observed slightly deviates from the manual measurement with maximum error 0.03 litres, shown in figure 3. This is caused by the transfer data delay.

This research in line with [14] . The designed system utilizes flow meter, hall efect sensor, in which the output will be an input to the microcontroller, PIC microcontroller. However, the research does not apply Internet of Things, so the data cannot be sent to microcontroller wirelessly. The data shows through the GSM. The result shows that there is no differences between LCD and GSM via readings. In addition, the maximum error of LCD and actual readings is 0.02 litres. Although the error in this study was smaller than the proposed study, this study was a GSM-based smart meter. Currently, internet-based information is developing very rapidly compared to information via GSM.

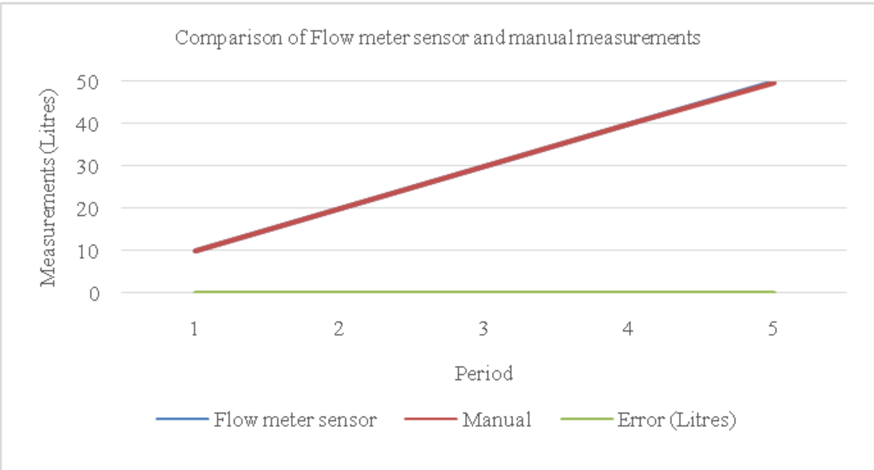

Figure 3. Flow meter sensor

The main valve will closed automatically when the certain amount of water is fulfilled. The amount of water is set at 10, 20, 30, 40, and 50 litres.

The smart meter is equipped with wireless transceiver integrated with microcontroller using node MCU. This module is compatible with smartphones to communicate with the microcontroller using universal asynchronous receiver transmitter (UART) protocol that is already available in the node MCU. The data will send to the web server and consumer can access via certain IP address.

5. Conclusion

The proposed smart water meter is designed using a sensor flow meter with the internet of things, which offers a cost-effective solution for water resource management in smart cities. The use of node MCU allows delivering real time information to the user's smart phone about the amount of water flowing through the sensor. The module of node MCU will send the data to the web server. The result shows that flow meter sensor operates accurately with maximum error 0.3 liters. The smart meter also allows the consumer to determine the water requirement. The main valve will close automatically when the requirement is achieved.

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