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A Solution for Water Factories in Vietnam Using Automatic Meter Reading Technology

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Abstract: *In this paper, I propose a solution for water factories in Vietnam using automatic meter reading technology. I design and prototype water meters and water quality meters for water factories in Vietnam. Water meters differ from conventional meters in that they record the water consumption and communicate that information back to the water suppliers for monitoring and billing without the need for manual readings. Water quality meters monitor multiple parameters relating to water quality such as pH, electro-conductivity, temperature, etc., and transmit these parameters to a server via GPRS network. Therefore, customers and water suppliers can monitor the water consumption, water quality parameters from anywhere via the Internet. I have deployed the solution at Thainguyen water factory in Vietnam. The experiments show that this solution can operate well in the real conditions.*

Keyword: *smart water meter; water quality meter; smart water sensor; solution for water factory*

1. INTRODUCTION

Currently, manual water meter reading is still widely used in Vietnam. This manual method is waste of time and human labor. Automatic Meter Reading (AMR) is the technology that automatically collects consumption, diagnostics, and status of the water meter and transmits the data to a central database for billing, troubleshooting, and analyzing. This technology supports vendors to save the expense of periodic trips to each physical location to read a meter. Another advantage of this technology is that billing can be based on real-time consumption.

In this paper, I present a solution for water factories in Vietnam. This solution has two parts:

The first part, I propose a system model of water quality monitoring. This system automatically collects physical and chemical parameters in the tanks at the water factory. Figure 1 shows the model of water quality monitoring. Every a few hours, the smart water sensors measure different water quality parameters in the tanks. Data is measured, digitized, and transmitted to Server via GPRS network by smart water sensors.

The second part, I propose a system model of smart water metering. This system automatically collects water consumption and transmit the data to a central database for billing. Figure 2 shows the model of smart water metering system. Every month, the

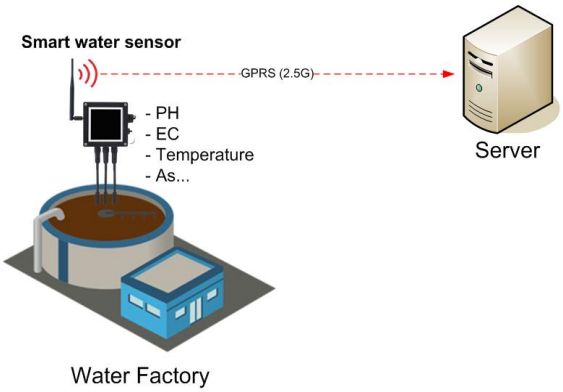

Figure 1: Model of water quality monitoring

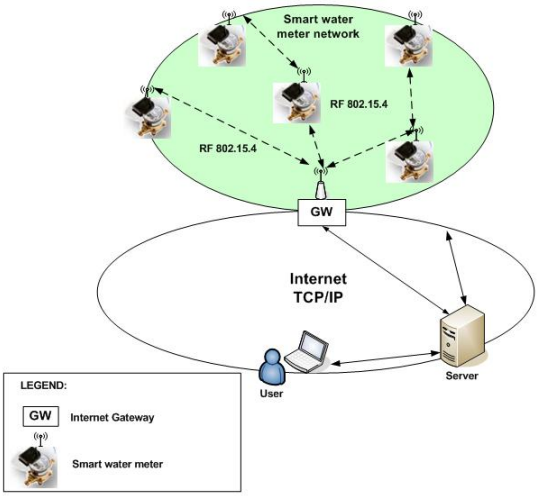

Figure 2: Model of smart water metering: An internet gateway is deployed to collect data from customers

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smart watermeters measure water consumption and send data to an internet gateway via Zigbee/IEEE802.15.4 network. The internet gateway is used in this project to gather all the data from the smart water meters and transmits them to a server at the water factory.

The remainder of this paper is organized as follows. Section 2 shows the related works. Section 3 introduces a design solution of smart water sensor. Design solutions of smart water metering system are presented in section 4, and section 5. In section 6, I present data management software; Finally, I conclude the paper.

2. RELATED WORKS

Advanced metering systems are comprised of hardware and software that create a network between advanced meters at the customer site and a service provider, such as an electric, gas, or water utility. These meters have the ability to transmit the collected data through commonly available networks such as power line communications, WiFi, Zigbee, GSM/GPRS. The meter data is received by the smart meters and sent to the Meter Data Management System (MDMS) that manages data storage and analyses data to provide the information in a useful form to users [1].

The term of Automatic Meter Reading (AMR) came about in the middle 1980s, and more prominently in the early 1990s. The goal of AMR system is to help collect the meter measurement automatically and possibly send commands to the meters. All AMI systems contain AMR functionality.

In [2], authors have provided extensive coverage of the AMR system, starting from discussing the potential benefits and past development stages to giving directions of future generations of AMR. They also presented four major types of AMR communication networks: power line carrier (PLC), cellular network, telephone/Internet, and short range radio frequency such as WiFi, Bluetooth, Zigbee. At present, the wireless technology is widely used in ways, compared with the wired devices the wireless ones are low cost and easy to carry. Besides, the structure of a wireless AMR system is also simple and can save much labor force and resources.

In [3], a prototype demonstrator of a smart water metering solution, developed in cooperation with Telecom Italia Lab, and built upon self-powered nodes in a WM-Bus capillary network at 169 MHz has been presented. The smart water meter collects water consumption through a hall effect sensor and data are transmitted to an aggregator as gateway to the GSM/GPRS network.

In [4], authors have proposed other system based on hybrid systems that can make use of robust networking topologies such as the GSM and ZigBee [4]. In this propose system, ZigBee module will be attached to the meter by using interface board and the data collector will be connected to the central computer by using GSM. With this system, the power company can save cost in doing meter reading and provide better services to their customers.

Broadband over Power-Line (BPL) [5], [6] is another typical medium for data communication over power lines. Bi-directional broadband communication can be achieved by merging BPL technology and smart water meter systems. The BPL-based system has following advantage: no new wire, covering a wide range of convenient connections, the reliability of access and high speed. However, BPL-based system is expensive system because it requires other components such as the collector, concentrator and master station.

3. SMART WATER SENSOR

3.1 Description

Smart water sensor has some functions:

- Automatically measuring different water quality parameters in the tanks such as temperature, electroconductivity, pH, etc. (potentially extended to other types of sensor via expansion ports).
- Automatically sending data to the web server via GPRS network.

3.2 Hardware Solution

Figure 3 shows the block diagram of smart water sensor.

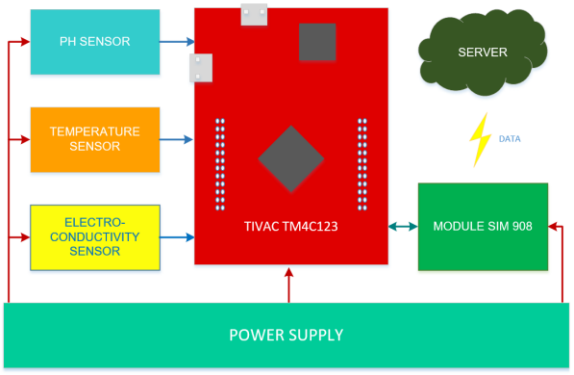

Figure 3: Functional block diagram of smart water sensor

Power Supply: Using LM78M05 and LM2596 that are produced by Texas Instruments. LM78M05 provides an output voltage of 5V for KIT TivaC TM4C123GXL [7] and sensors. LM2596 provides an output voltage of 4.2V and an output current of 3A for Sim 908 module.

Sensors Block: This block includes three sensors

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which are PH, electroconductivity, and temperature sensor. This block is connected to TivaC TM4C123GXL via jumpers.

TivaC Microcontroller Kit: I use a product of Texas Instruments is TivaC TM4C123GXL. This is an ultra-low power microcontroller. TivaC TM4C123GXL receives data from sensors, configures the SIM module, and sends data to the web server via GPRS network.

3.3 Embedded Software Solution for Smart Water Sensor

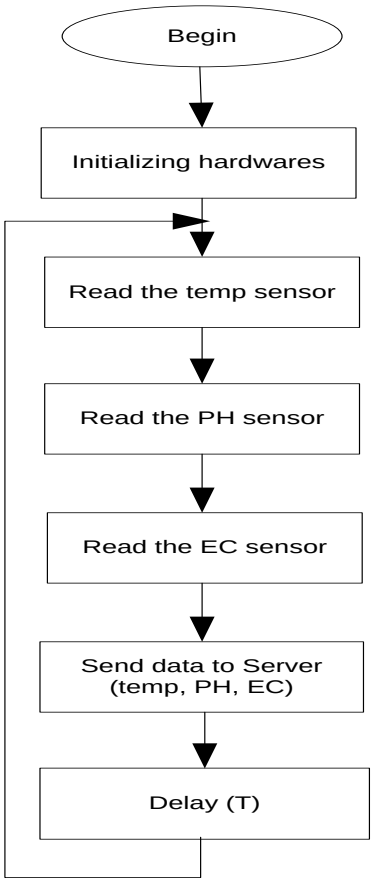

Figure 4: Embedded software algorithm for smart water sensor

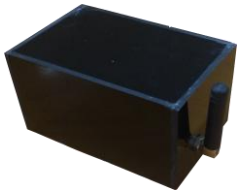

Figure 5: Smart water sensor

Figure 4 illustrates the embedded software algorithm for smart water sensor. Figure 5 illustrates the smart water sensor in the real.

4. SMART WATER METER

4.1 Description

Smart water meter has some functions which are:

- Automatically measuring the water flow.
- Sending the water consumption periodically every month to the Server via Zigbee networks.

4.2 Hardware Solution

Figure 6 shows the block diagram of smart water meter.

Power Supply: Using LM1117 and LM7805 produced by TI. LM1117 provides an output voltage of 3.3V for the microcontroller, LCD and DRF1605H. LM7805 provides an output voltage of 5V for water flow sensor.

TI microcontroller MSP430G2553: I use a chip from Texas Instrument which is MSP430G2553 [8]. This is an ultra-low power microcontroller, and suitable for the smart water meter. MSP430G2553 receives data from flow sensor, sends data to ZigBee networks and controls LCD display.

Water Flow Sensor: Using YF – S201 sensor [9] to measure the water flow. It is connected to MSP430G5223.

LCD Nokia 5110: The water flow is displayed on LCD Nokia 5110 [10].

DRF1605H Module: This is a communication module using CC2530 [11] chip from Texas Instruments with IEEE 802.15.4 communication standards, characteristics of ZigBee technology is a low transmission speed, low energy consumption, and low cost. Therefore, it is suitable for the smart water meter.

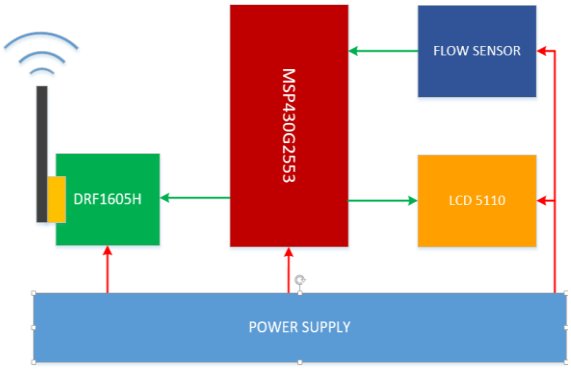

Figure 6: Functional block diagram of smart water meter

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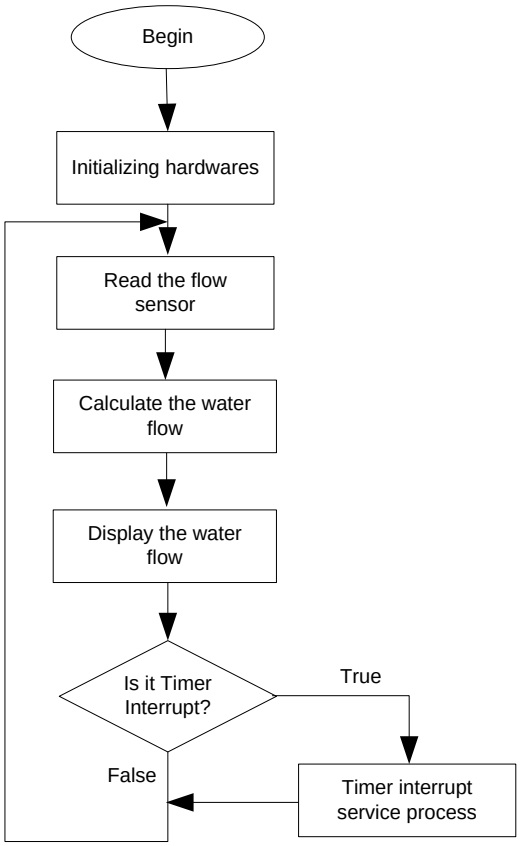

Figure 7: Embedded software algorithm for smart water meter

4.3 Embedded Software Solution for Smart Water Meter

Figure 7 illustrates the embedded software algorithm for smart water meter. Figure 8 illustrates the algorithm of timer interrupt service process for smart water meter. Smart water meter sends data to the internet gateway every month.

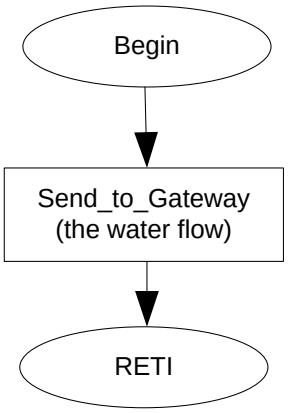

Figure 8: Algorithm of interrupt service routine for smart water meter

Figure 9 illustrates the smart water meter in the real.

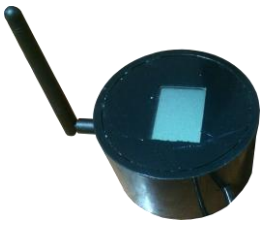

Figure 9: Smart water meter

5. INTERNET GATEWAY

5.1 Description

Gateway automatically collects data from smart water meter and sends data to the web server via an internet connection. Therefore, gateway must support two communication protocols which are Ethernet and Zigbee.

5.2 Hardware Solution

Figure 10 shows the block diagram of internet gateway. The detail descriptions of the blocks in figure 10 include:

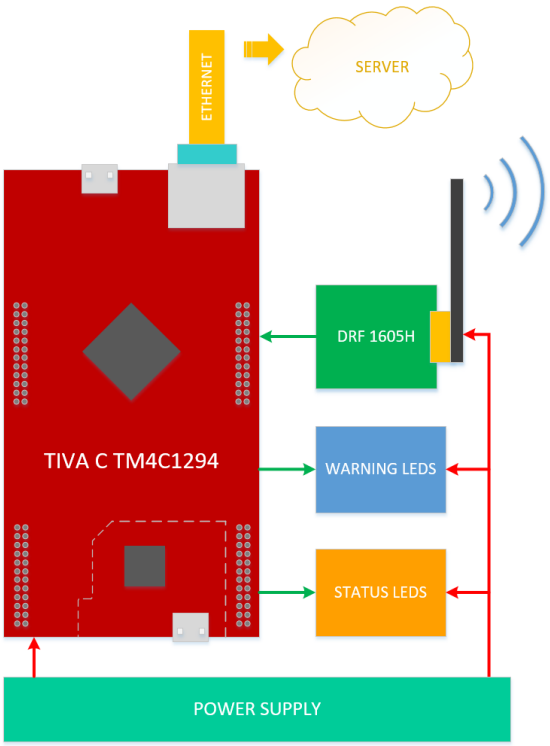

Figure 10: Functional block diagram of the internet gateway

TM4C1294 KIT: This kit is produced by Texas Instruments. The TM4C1294 Kit integrates a variety of peripherals enabling internet of things gateway appli-

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cations [12]. There are a lot of communication interfaces on board such as 10/100 Ethernet MAC and PHY, USB 2.0, and a multitude of simultaneous serial connectivity. TM4C1294 has low cost, low power consumption, large memory, which combines with ethernet interface on board. Therefore, I choose TM4C1294 in the design of the internet gateway.

Power Supply: Using LM1117 and LM7805 produced by Texas Instruments.

DRF1605H Module: It is configured as a coordinator in the ZigBee network. This module is connected to the microcontroller via UART ports.

5.3 Embedded Software Solution for Internet Gateway

Figure 11 illustrates the embedded software algorithm for the internet gateway. Figure 12 illustrates the internet gateway in the real.

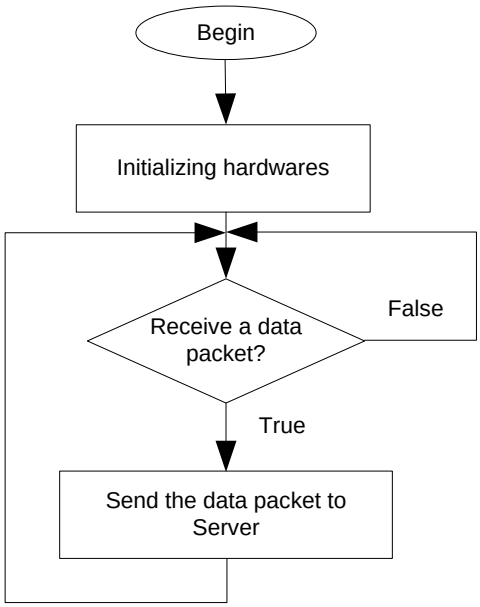

Figure 11: Embedded software algorithm for the internet gateway

Figure 12: Internet gateway

6. WEB APPLICATION

I design a website which is deployed on a web server. Data is stored in a database and updated on the website. Customers and water suppliers can monitor water consumption, water quality parameters everywhere via Internet.

Water suppliers can:

- Manage the smart water meters and customers.
- Monitor the total of water consumption of factory.
- Monitor the water quality.
- Look up the water bill of customer.
- Update the information of customer.

Customets can:

- Monitor the water quality.
- Look up the water bill.

Customers and water suppliers can login the system as shown in figure 13. Figure 14 illustrates the water bill of customer.

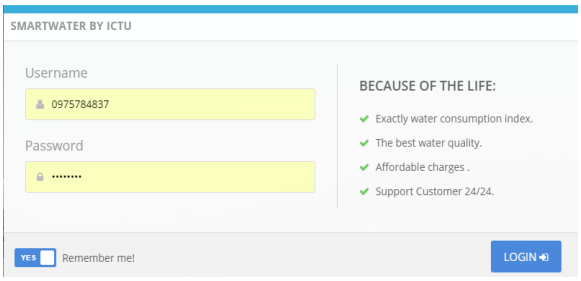

Figure 13: Login the system

Figure 14: The water bill of customer

Figure 15 illustrates the water quality parameters. Customers and water suppliers can monitor these parameters from anywhere via the Internet.

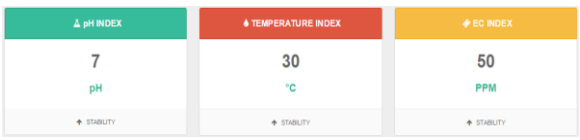

Figure 15: The water quality parameters

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7. CONCLUSION

In this paper, I have proposed a solution for water factory in Vietnam. I designed and prototyped water meters, and water quality meters for smart water application. A website was developed to collect water consumption, water quality parameters. With this solution, customers and water suppliers can monitor water consumption, water quality parameters from anywhere via the Internet. I deployed this solution in Vietnam. The experiments showed that the solution can operate well in the real conditions.

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Author Biography

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