Smart bottle work design using waterflow sensor based on Raspberry Pi and Android

A F Akbar and P Oktivasari
Department of Informatics and Computer Engineering, Politeknik Negeri Jakarta, Depok, Indonesia
E-mail: ti2n_oktivasari@yahoo.com

Abstract. Nearly half of Indonesia's population suffer from dehydration. THIRST Research (2009) proves that Indonesian still have a low awareness of drinking water. Consuming enough water can be a way to prevent dehydration. Smart Bottle application is able to provide amount of daily water needs based on user’s profile that is registered. The problem in calculation of water consumption can be overcome by using Waterflow Sensor calculation data. The Implementation result of Smart Bottle application proves that the water needs of each person can be known, the water that has been consumed can be automatically calculated, and push notification can be a reminder about drinking water to the Smart Bottle users during their busy life. In this paper, hybrid application for android has been implemented using Ionic Framework and Laravel, then send notification using Firebase Cloud Messaging.

Keywords—daily water needs, firebase cloud messaging, hybrid application, water consumed calculation, waterflow sensor.

1. Introduction
Nearly half of Indonesia's population suffer from dehydration. The research results of The Indonesian Regional Hydration Study (THIRST) in 2009 presents that 46.1% of 1,200 Indonesian people in Jakarta, West Java, East Java and South Sulawesi were dehydrated.

Dehydration is a condition in which the body needs water because the amount of water that comes out is more than the amount of water that is consumed. Research from The Tufts University United States (2009), proves that dehydration affects mood and mental performance [1].

Consuming enough water can be a way to prevent dehydration. Water is one of good drinks for health. All human organs need enough water to support daily activities. The problem is that the result of THIRST research proves that Indonesian still have a low awareness in fulfilling the water intake for their body. Besides, the water intake of each person is different. Therefore, Smart Bottle application is expected to solve the problem.

Android application and notification on Smart Bottle will help users to find out information about water needs, such as the amount of daily water needs and as a water-drinking reminder. Application is designed with the concept of hybrid application using Ionic Framework. Ionic is a mobile application framework which is based on HTML5 that can be used to develop Android application with web technologies, such as HTML, CSS, and Javascript. Then, Laravel is used to build REST APIs for
Smart Bottle apps to connect to MySQL database. Push notification as a water-drinking reminder is built using the service of Firebase Cloud Messaging (FCM). APIs from FCM is run automatically using Cron Job on the cloud server. Meanwhile, waterflow sensor is used to calculate the amount of water that has been consumed. This sensor works using the Hall Effect concept.

On the last decade, there were some researches that were related to the topic. Nam Eui Lee, Tae Hwa Lee, Dong Heui Seo, and Sung Yeon Kim [3] did a research which explains that water intake is important for health as it helps building the resilience of respiratory organs, especially among elderly people. Elderly people are unaware of appropriate ways to consume water including adequate intake, timings, and frequency. The research study attempts to guide elderly people to consistently drink appropriate amounts of water. The difference is on its users, that android hybrid application can be used by almost everyone, not only elderly people.

The other research by Hisham AlMajed and Abdelaziz Khamis [3], gives the main objective about developing an android mobile application that solves problems faced by bus drivers and parents when parents do not show up, and when kids wait for a long time. Same technologies are used, but with different purpose.

2. Methodology
Methodology that is used in Smart Bottle application development is Linear Sequential Model, by Roger S. Pressman, which sometimes called as the Classic Life Cycle or the Waterfall Model. The methodology contains methods that are analysis, design, implementation (code), and test (Figure 1).

The first method is analysis that occurs analysis of problems, analysis of needs, and analysis of application workflows. Smart Bottle application is built through some questions, like how applications can provide information about daily water needs based on gender, weight, height, age, and user status. In addition, how information of waterflow sensor calculation can be displayed in real-time on Smart Bottle application and push notification will be sent when Smart Bottle application users need to consume water. Regulation of the Ministry of Health of the Republic of Indonesia No. 75 in 2013 about Recommended Dietary Allowances (RDA) for Indonesian people is used as a base information. Moreover, analysis is done by reading journals, books, and browsing the internet to get information about this topic.

The second method is design. There is a system design of Smart Bottle application which based on the result of analysis method, such as application flowchart, database structure, user interface design, and others. So, design method will give a clear description of the project to be built.

The third method is implementation or commonly called code. Both the results of analysis method and design method will be written in programming language using Sublime Text 3. The application will be connected to cloud database and synchronized with the waterflow sensor through the code program.

The last method is testing. Once code has been generated, the program testing begins. The testing process focuses on the logical internals of the software, which is ensuring that all statements have been tested, and on the functional externals; which is, conducting tests to uncover errors and ensure that the specified input will produce actual results that match the required results.
3. Smart Bottle System

![Block Diagram of Proposed System](image)

Based on Figure 2, the waterflow sensor is controlled by Raspberry Pi, using natural programming language, Python. Raspberry pi gives commands to the waterflow sensor to calculate the amount of water that comes out from the bottle. The result of the waterflow sensor calculation is sent to the cloud database as an information about the amount of water that is consumed by the body. If the connection to the Internet is not available, the data will be stored in the internal Raspberry Pi database and marked with a value of 0 which means that the data has not been sent to the cloud database. Raspberry Pi will try to send the pending data until the connection is available.

The application runs in real-time by making requests every second to the cloud database via a RESTs API that is built using the Laravel Framework. RESTs API is a software interface that consists of a collection of instructions stored in libraries and explains about how to make a software that can interact with other software [7]. The application sends a request data about the amount of water that has been consumed by the users from the database via RESTs API. After the data is obtained from the database that comes from the waterflow sensor, the data will be displayed on the Smart Bottle application that is running on the Android platform.

Cron Job is a facility provided by the control panel of the web hosting company. Cron Job will perform the task according to the specified time settings. Cron Job works by running Laravel script every minute. Laravel script contains a command to find users who have not consumed water for two hours depending on information from cloud database. If there are users that need to consume more water, Laravel script will send push notification to users through the protocol provided by the Firebase Cloud Messaging (FCM), and then the FCM will send a cloud message to users’ device. Firebase Cloud Messaging (FCM) is a service provided by the Firebase to replace Google Cloud Messaging (GCM) to users to be able to receive push notification and create two-way communication between devices [9].

Before push notification can be sent as a cloud message to user's device, The Smart Bottle application stores the token device to the cloud database after the user has successfully logged in. The token device will be used by the Firebase to deliver the cloud messages to the user's smartphone device that needs to be reminded to consume more water.

3.1. Determining Daily Water Needs

Table 1 shows the Regulation of the Ministry of Health of the Republic of Indonesia No. 75 in 2013 about Recommended Dietary Allowances (RDA) for Indonesian people that is used as information of water intake. When users register their account, their account profile is used to determine how many water that they need based on gender, weight, height, age, and their status (normal, pregnant, breastfeeding).
Table 1. Recommended Dietary Allowances (RDA)

| Age   | Weight (Kg) | Height (cm) | Water (mL) |
|-------|-------------|-------------|------------|
| Male  |             |             |            |
| 10-12 | 34          | 142         | 1800       |
| 13-15 | 46          | 158         | 2000       |
| 16-18 | 56          | 165         | 2200       |
| 19-29 | 60          | 168         | 2500       |
| 30-49 | 62          | 168         | 2600       |
| 50-64 | 62          | 168         | 2600       |
| 65-80 | 60          | 168         | 1900       |
| Female|             |             |            |
| 10-12 | 36          | 145         | 1800       |
| 13-15 | 46          | 155         | 2000       |
| 16-18 | 50          | 158         | 2100       |
| 19-29 | 54          | 159         | 2300       |
| 30-49 | 55          | 159         | 2300       |
| 50-64 | 55          | 159         | 2300       |
| 65-80 | 54          | 159         | 1600       |
| Pregnant|         |             |            |
| 1st Trimester | +300 |             |            |
| 2nd Trimester | +300 |             |            |
| 3rd Trimester | +300 |             |            |
| Breastfeeding|     |             |            |
| 1st Six Months | +800 |             |            |
| 2nd Six Months | +650 |             |            |

3.2. Calculating Water Consumed

The working principle of the waterflow sensor is utilizing the Hall Effect phenomenon. The Hall Effect is based on the electro-field effect on movable charged particles [5]. In waterflow sensor testing, the obtained results are presented in Table 2.

Table 2. Experimental Data of Waterflow Sensor

| Experiment | Waterflow Sensor (mL) | Measuring Cup (mL) | Difference (mL) |
|------------|-----------------------|--------------------|-----------------|
| 1          | 304.768               | 300                | 4.768           |
| 2          | 395.246               | 400                | 4.754           |
| 3          | 561.916               | 560                | 1.916           |
| 4          | 201.385               | 200                | 1.385           |
| 5          | 408.083               | 400                | 8.083           |

3.3. Sending Push Notification

Push notification works according to the user consumption logs in cloud database. The Push notification will be sent automatically as a cloud messaging to the users that have not consumed water for two hours and will resend notification in the next 2 hours if the users still have not consumed water. Cloud messaging will be displayed at the top bar of user’s smartphone. There is a delay when the push notification is sent to the user’s smartphone. Table 3 shows how many time that Cron Job needs to send push notification to user’s smartphone.
Table 3. Notification Delay

| No | Sent (from server)   | Received (smartphone) | Delay (second) |
|----|----------------------|-----------------------|----------------|
| 1  | 2017-05-01 10:34:00  | 2017-05-01 10:34:37  | 37             |
| 2  | 2017-05-01 12:35:00  | 2017-05-01 12:35:41  | 41             |
| 3  | 2017-05-01 14:36:00  | 2017-05-01 14:36:29  | 29             |
| 4  | 2017-06-05 09:24:00  | 2017-06-05 09:24:04  | 4              |
| 5  | 2017-06-05 11:25:00  | 2017-06-05 11:25:18  | 18             |

3.4. Analysis of Functional Testing in Determining Water Needs

Analysis of experimental result of determining daily water needs (Table 1) represents that user that can use Smart Bottle application must be at 10-80 years old. Determining process of water needs uses Body Mass Index calculation because there are three classifications of user (underweight, normal, and overweight). This application will give amount of water needs based on user’s height if the user’s classification is underweight or overweight. Then, the water needs which based on user weight and age will be given to the user with normal classification (Figure 3).

3.5. Analysis of Waterflow Sensor Calculation

Waterflow sensor that is used in the project is YF-S201C (Figure 4a) [5]. This sensor works perfectly because according to Table 2, the sensor has an average error value of 1.167%. The Sensor can be said to “running well” if the error value of the sensor is less than 10%.

Figure 3. Determining Result of Water Needs

Figure 4a. Waterflow Sensor on the Smart Bottle

Figure 4b. Experiments of Water Intake Calculation
Based on five experiments, the maximum error value obtained is 2.021% and the minimum value is 0.342%. The experiments have been performed as shown in Figure 4b by comparing measurement results using a measuring cup and calculation result of the waterflow sensor.

3.6. Analysis of Notification Pending

Table 3 shows experiments of push notification that is sent by Cron Job to smartphone (Figure 5a). The average of notification delay is 25.8 seconds. All experiments prove that the maximum of notification delay is less than one minute. The delay occurs because Cron Job process runs in every one minute and it is the fastest schedule time of Cron Job to run continuously.

One benefits of Smart Bottle application is that it makes it easier for people to know how much water that they need. There is a theory about 8 glasses of water per day, but it is inaccurate because you can find many sizes of Bottle as shown in Figure 5b. Therefore, Smart Bottle application also gives convenience to users about how to calculate their water intake automatically. Smart Bottle application can be a friend to you that will always remind you to keep your body hydrated.

The differences between this project and the other research are android hybrid application can be used by almost everyone, not only elderly people. Moreover, Smart Bottle application uses the newest programming framework, such as Ionic app library v2.2.0 version and Laravel Framework 5.2.45 version.

4. Conclusion

Smart Bottle application is able to provide daily water needs information based on the profile of each person that is registered. Then, the problem in the calculation of water consumption can be overcome by using the data of waterflow sensor calculation. The average error value of waterflow sensor is 1.167% with the maximum error value of 2.021% and the minimum error value of 0.342%. Depending on the error value, it can be concluded that the result data of water consumed calculation from waterflow sensor is accurate. Error value accident is caused by unstable water pressure when water comes out from the bottle.

Besides, Cron Job is excellent to remind users in their busy time with the average of notification delay is 25.8 seconds. Notification delay is caused by Cron Job that has to run Laravel script in every once a minute.

In the end, water needs of each person can be known, and water that has been consumed can be calculated automatically, and push notification helps reminding the users to keep the drinking water intake in their busy life.

Acknowledgements

I would like to thank my Department’s colleagues for their continued support, especially the embedded Laboratory Team.
References

[1] D’Anci, Kristen E. Vibhakar, Arjun. Kanter, Jordan H. Mahoney, Caroline R. Taylor, Holly A 2009 Voluntary Dehydration and Cognitive Performance in Trained College Athletes Perceptual and Motor Skills pp 251-269.

[2] Lee, Nam Eui. Lee, Tae Hwa. Seo, Dong Heui. And Kim, Sung Yeon 2015 A smart water bottle for new seniors: Internet of Things (IoT) and health care services Int. J. of Bio-Sci. and Bio-Tech. 7 pp 305-314.

[3] AlMajed, Hisham. Khamis, Abdelaziz. 2017. Development of Location-Based Approaching Notification System Using Android Platform Computer Science and Information Technology pp 107-119.

[4] Reddy, M 2011 API Design for C++ (USA: Elsevier)

[5] Sood, Ria. Kaur, Manjit. And Lenka, Hemant 2013 Design and Development of Automatic Water Flow Meter Int. J. of Comp. Sci., Eng. and App. (IJCSEA) 3 pp 49-59.