Smart Water Meter: PDAM Water Leak Monitoring and Detection Application

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Abstract: PDAM customers' water use is calculated manually, staff have difficulty recording water usage and pipe leaks or water loss often occur. In addition, customers complain about information on the progress of PDAM repairs. Based on these problems, an Android-based smart PDAM monitoring and control system was developed. System development uses a prototype development model. Data collection techniques using interview techniques, questionnaires, and observation. Based on the development results, a PDAM monitoring and control system called Smart Water Meter is produced which can be used to monitor and control PDAM usage effectively and practically. System testing in this study uses ISO 25010 software testing standards in terms of 4 aspects. In the aspect of functional suitability, there were 87 items tested and a score of 1 was obtained. In the aspect of compatibility, the application could run with 4 different applications and the sensor calibration value was 4.7 and the connection between the application and the device was successful. In terms of performance efficiency, the average CPU usage is 2.2 percent with a maximum of 13 percent and the average memory usage is 121.4 MB with a maximum of 151.2 MB and power usage is 33 percent with a maximum of 66 percent. In the aspect of portability, the application can run on 8 types of Android devices. Based on the test results, the application meets all aspects of the tested software testing standards.

Index Terms: Monitoring, control, leakage, prototyping, ISO 25010.

I. INTRODUCTION

To meet the community's need for clean water, Indonesia provides clean water services through the Regional Drinking Water Company (PDAM), PDAM is one of the regionally owned business units, which is engaged in the distribution of clean water to the public.

The problems currently experienced by the PDAM include measuring clean water usage by customers which is still calculated manually[1], manual measurements are at risk of errors in recording water usage for each customer, PDAM officers have difficulty recording water usage because not all customers PDAM was at home when the officers checked, besides that the customer could not find out the amount of the cost of using water. Another problem that often occurs is PDAM officers and customers having difficulty detecting water leaks, water leaks are usually only discovered by officers if there are PDAM customers who complain that water does not flow to the customer's house, or get reports from residents if there is water seepage[2], Another problem is that it is difficult for the PDAM to detect fraud from certain parties in using PDAM water, this causes losses for the PDAM because the water flowing from the center does not match the registered customer's water usage data.

PDAM water use should be under supervision, monitoring and controlling the use of clean water needs to be done so that problems related to PDAM operations can be resolved immediately. make it easier for PDAM customer communities to manage the use of clean water. For this reason, it is deemed necessary to develop an Android-based Smart PDAM Monitoring and Control System application. The developed application can assist PDAM officers in managing the distribution of clean water effectively, recording customers' clean water usage will be made automatically through an application installed on the customer's device that is integrated with the system managed by PDAM officers, thereby facilitating the work of PDAM officers, reducing level of fraudulent use of water, and facilitate the detection of PDAM water leaks.

Development of a PDAM water monitoring and control system using the NodeMCU ESP32 microcontroller, ESP32 as a low-cost, low-power system-on-chip (SoC) series with dual-mode Wi-Fi & Bluetooth capabilities. The previous version of ESP32 was ESP8266[3]. ESP32 reads the value of the water flow sensor, then the data is sent to the mysql database and web server. the application will retrieve sensor data online which is contained in the mysql database or locally via the web server contained in esp32.

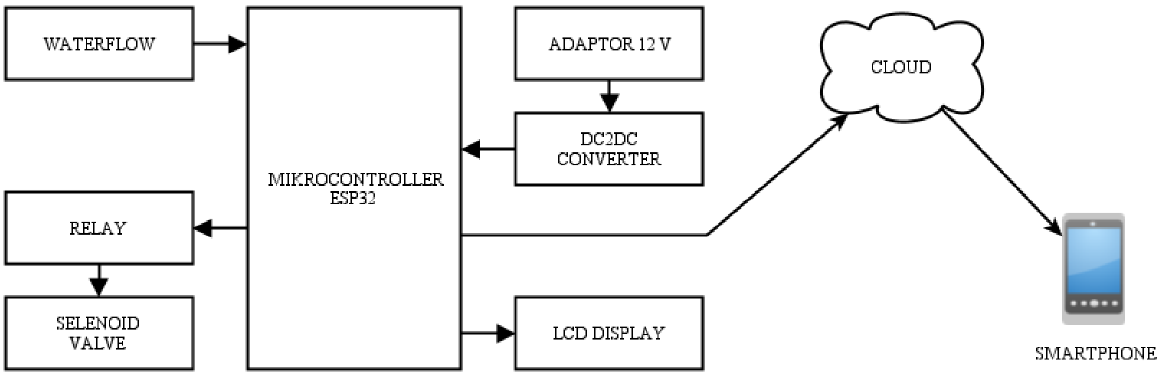


Figure 1. Block diagram of a system

The use of water is measured using a water flow sensor, this aims to measure the volume of water, to be able to find out the accuracy of the measurement, a sensor calibration is carried out[4]. The water flow sensor used is the YF-S201 type. Used to measure the volume of water through the hall-effect transducer inside to detect the amount of water passing through the fluid.

The next tool used is a relay that will be connected to Arduino. This relay is an intermediary device for connecting electronic devices with Arduino[5]. Relay functions to control open and closed switches as needed[6].

To write programs on ESP, developers use the Arduino Integrated Development Environment (IDE) application, one of the official software used for Android application development that is compatible with all Arduino modules[7]. For application coding, the Kotlin programming language is used, one of the official programming languages for Android development, Kotlin is the same as Java, but in function declarations, Kotlin is simpler than Java.

Research that has developed PDAM applications has been widely carried out in Indonesia, some of the research that is relevant for study in this research is the Electric Faucet Control System Prototype on PDAM Water Meters Based on Android Applications[8], Design and Control and Monitoring of PDAM Water Meters Based on the Internet of Things, and PDAM Water Usage Monitoring System in Households Using Android smartphone based NodeMCU Microcontroller[1]. The innovation offered in this development is to combine the systems used by relevant studies and refine them into one system that can monitor water usage, control water, and detect PDAM water leaks.

II. METHOD

The development model used in software development is one of the SDLC models with the type of prototyping model. This model allows the user to provide repeated feedback until the desired product is achieved, so it is very beneficial for users who do not yet understand product flow and design in detail. The drawback of this model lies in the developer's performance which will be denser because they must be prepared to get revisions at each stage of testing the prototype results.

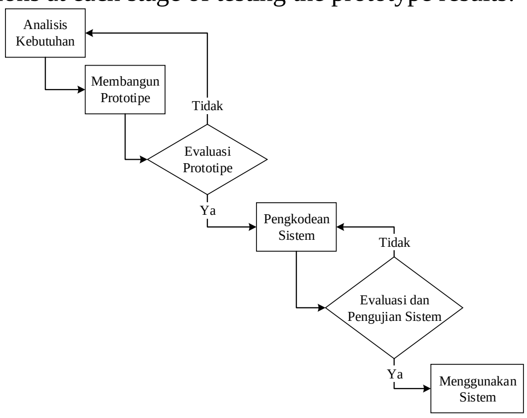


Figure 2. Prototype development model

Requirement Analysis

The results of the needs analysis show that the smart PDAM system has 2 types of users, namely admin and user. Admin is the officer who manages the PDAM, while the user is the PDAM customer.

Building Prototype

The prototype built is to make database design and user interface.

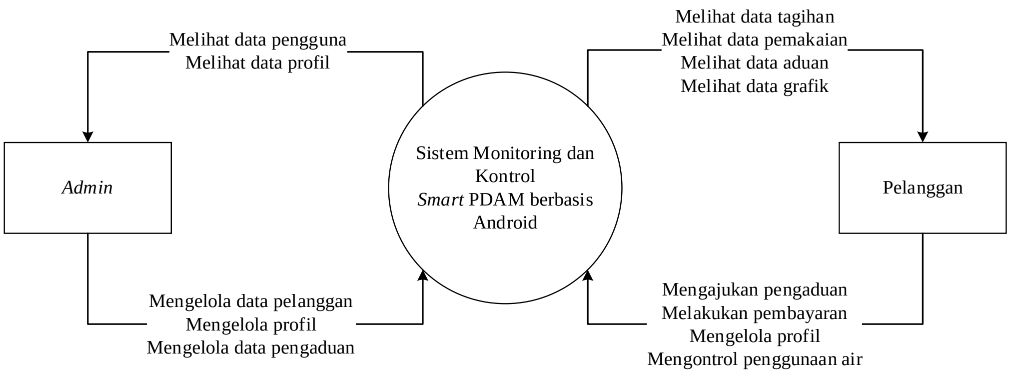
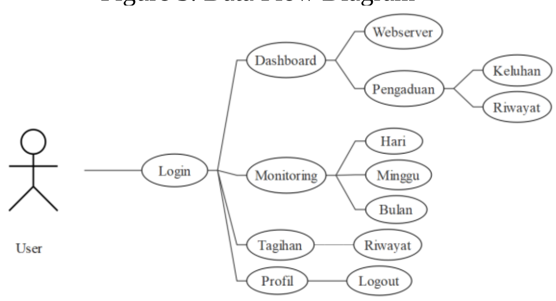


Figure 3. Data Flow Diagram



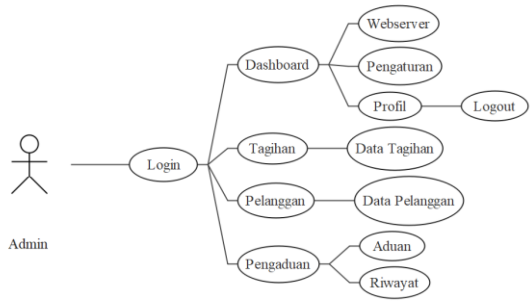


Figure 4. Use Case Diagram User and Admin

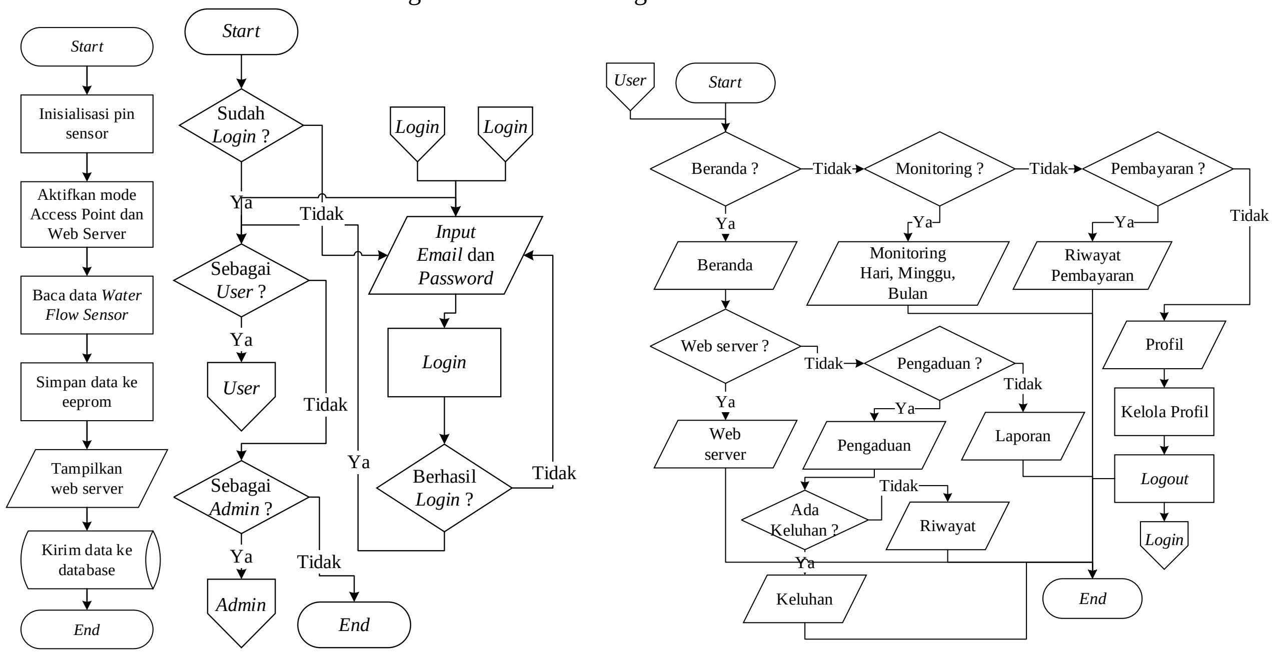


Figure 5. Flowchart System

User interface design in the development of information systems is needed to make it easier for developers to create systems, as well as to provide an idea for potential users of what the user interface will be built for, a good user interface is a user interface that is ready to use, easy to operate and the results are in accordance with needs.

The evaluation carried out by the user resulted in the conclusion that the design offered could be continued to the coding stage. At the system coding stage, prototyping will be translated into the Kotlin programming language using the Android Studio IDE, Visual Studio Code, and Arduino IDE applications. The application testing method uses the ISO/IEC 25010 software testing standard in terms of functional suitability, compatibility, performance efficiency, and portability[9]. This stage is the final stage of the development procedure, the system that has been developed and is successful at the evaluation stage is ready for use.

III. RESULT AND DISCUSSION

After system coding, an application is produced that has been built using the Android Studio application and published on the Play Store, here are some screenshots of the application display.

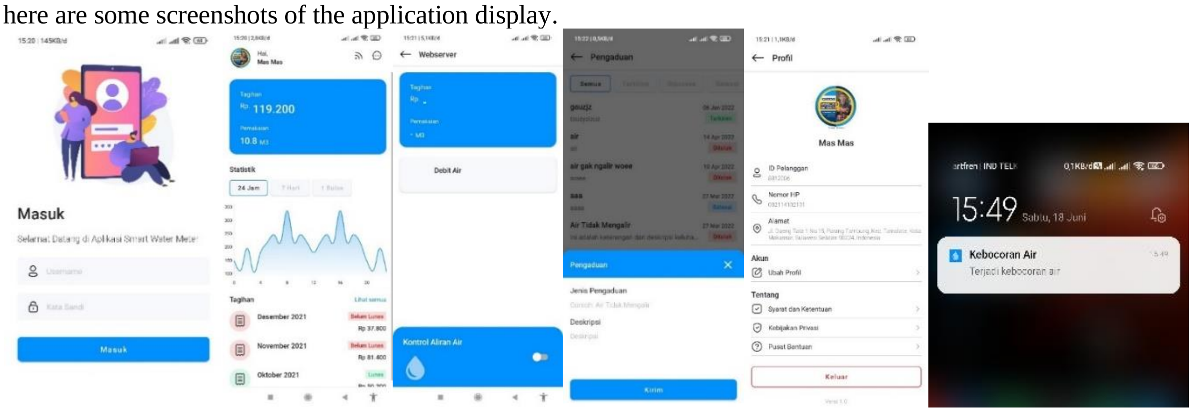


Figure 6. Screenshots of the application display

In the system evaluation and testing stage, the application that has been developed and built is then released in an alpha (trial) version on the Play Store application platform. Applications that have been released are then tested based on ISO 25010 software quality testing standards[10] which consist of functional suitability aspects, compatibility aspects, performance efficiency aspects, and portability aspects.

Test Results for Functional Suitability Aspects

System testing is carried out by involving 2 (two) experts who are experienced in programming and digital control techniques. The expert tests the system directly by trying all the functions contained in the system, then filling in the test values in the questionnaire table by checking the choices that are considered correct. The results of the test questionnaire from the 2 (two) experts are listed in table 1 below:

Table 1. Test Result for Functional Suitability Aspects

Validator	Fitur yang didesain (P)	Fitur yang berhasil diuji (I)	Feature Completeness (X)
Validator Ahli 1	87	87	1
Validator Ahli 2	87	87	1
Rata-rata (∑)	87	87	1

The score results will then be calculated using the formula of the feature completeness matrix where in this formula the functional suitability results are the result of the number of features successfully implemented divided by the total features designed. Based on the formula obtained:

$$Feature\ Completeness\ (X) = \frac{I}{P} = 1$$

$$Feature\ Completeness (X) = \frac{87}{87} = 1$$

$$Feature\ Completeness\ (X) = 1$$

Based on Table 4.2 which is then calculated using the feature completeness formula, a score of 1 is obtained, from this score it can be concluded that the quality of the software in the form of an information system in this study is stated to be good and fulfills the functional suitability aspect.

Test Results for Compatibility Aspects

The compatibility aspect is divided into 2 types of testing according to their sub-characteristics, namely co-existence and interoperability. The testing process on the compatibility aspect uses observation techniques or direct observation. Testing on the co-existence sub-characteristic is carried out by running the Smart PDAM application together with the application on the Android device.

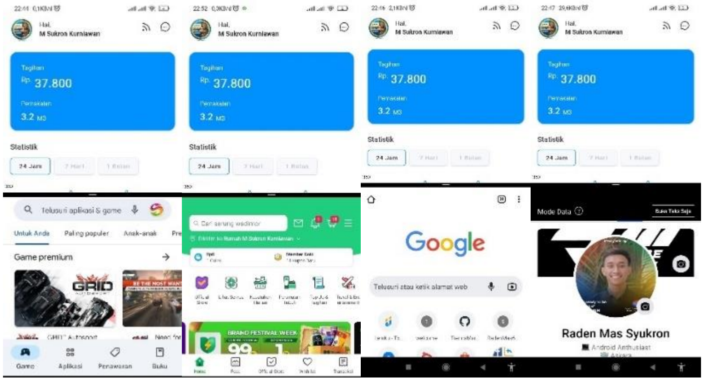


Figure 7. Test Results for Compatibility Aspects

The detailed characteristic test results from figure 7 shown in table 2 below:

Table 2. Test Results for Compatibility Aspects

No	Subkarakteristik	Pengujian	Hasil Pengujian	
			Berhasil	Gagal
1	*Co-existance*	Smart PDAM dan Play Store	1	
		Smart PDAM dan e-commerce	1	
		Smart PDAM dan web browser	1	
		Smart PDAM dan sosial Media	1	
Total			4	

The score results will then be calculated using the formula of the feature completeness matrix in which in this formula the compatibility result is the result of the number of features implemented divided by the total features designed. Based on the formula obtained:

$$Feature\ Completeness\ (X) = \frac{I}{P} = 1$$

$$Feature\ Completeness (X) = \frac{4}{4} = 1$$

$$Feature\ Completeness\ (X) = 1$$

Based on Table 2 which is then calculated using the feature completeness formula, a score of 1 is obtained, from this score it can be concluded that the quality of the software in the form of an information system in this study is stated to be good and fulfills the co-existence subcharacteristic in the aspect of compatibility testing. Tests on the interoperability sub-characteristics are carried out by testing the connection between the smart PDAM application and the smart PDAM tool and looking for a calibration value between analog meters and digital meters that can be controlled through the smart PDAM application. The following are the results of interoperability sub-characteristic testing.

Table 3. Interoperability characteristic test results

Nilai Kalibrasi	Meteran Digital	Meteran Analog	Nilai Awal	Nilai Akhir	Selisih
4.75	100	98	2748	2846	-2
4.78	100	95	2953	3048	-5
4.78	100	111	3048	3159	11
4.76	100	99	3166	3265	-1
4.76	100	98	3265	3363	-2
4.77	100	100	3363	3463	0
4.77	100	98	3463	3561	-2
4.77	100	99.4	3562	3661.4	-0.6
4.77	100	99.5	3661.5	3761	-0.5
4.77	100	101.9	3874.2	3976.1	1.9
4.77	100	100.2	4000.8	4101	0.2
4.77	100	100.7	4101	4201.7	0.7
4.77	100	100.3	4201.7	4302	0.3
4.77	100	101.6	4302	4403.6	1.6
4.77	100	100.9	4403.6	4504.5	0.9
4.77	100	101.3	4504.5	4605.8	1.3
4.77	100	101.1	4605.8	4706.9	1.1
4.77	100	102.1	4706.9	4809	2.1
4.77	100	100.4	4918.2	5018.6	0.4
4.77	100	99.8	5018.6	5118.4	-0.2
Rata-rata	**100**	**100.41**			**0.41**

Based on table 3, we tested the level of accuracy between digital meters and analog meters. This test is carried out by looking for a calibration value on a digital meter whose results are the same as the value produced by an analog meter. This test aims to ensure that the amount of water distributed by the PDAM is the same as the amount of water received by the customer both when using an analog meter and when the meter system has been changed to a digital meter, so that it does not harm the PDAM or the PDAM customers.

Test Results for Performance Efficiency Aspects

At the testing stage of the performance efficiency aspect, the applications that have been built are then tested using the Apptim software. This test is carried out to obtain the feasibility results of the application being developed. The following are the results of testing from the aspect of performance efficiency.

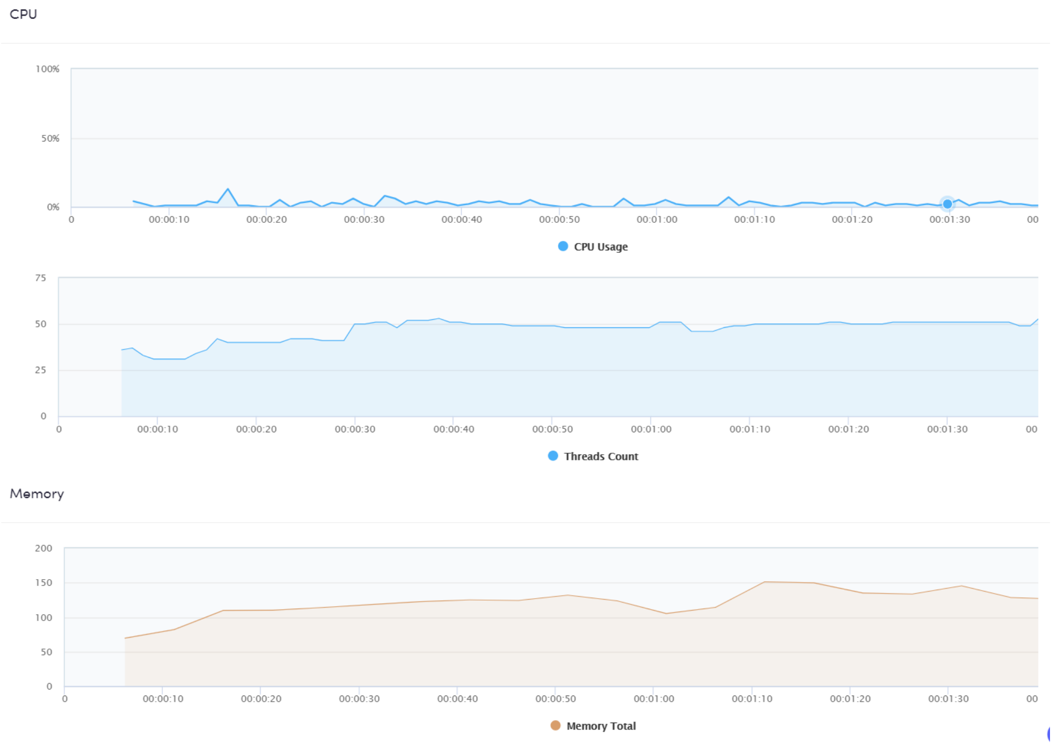


Figure 8. Test Results for Performance Efficiency Aspects

The test results in Figure 9 are more clearly described in Table 4.5 as follows:

Table 4. Test Results for Performance Efficiency Aspects

No	Category	Average	Maximum	Result
1	Penggunaan CPU	2,2%	13%	Batas Rendah
2	Penggunaan Memori	121,4 MB	151,2 MB	Batas Sedang
3	Penggunaan Daya	33%	66%	Batas Sedang

Based on table 4, the results of testing the performance efficiency aspect of the smart PDAM application using the Apptim software show that the average CPU usage is 2.2% with a maximum of 13% (low limit), the average memory usage is 121.4 MB with a maximum of 151, 2 MB (medium limit), and power usage is 33% with a maximum usage of 66% MB (medium limit). During the test, the smart PDAM application did not experience a memory leak or certain damage that could cause the application to force close or launch fail, the test acquisition rate was also at the low and medium limits, no tests were at or exceeded the maximum usage limit, so it can be concluded that the smart PDAM application developed has met the ISO 25010 software quality testing standards on the aspect of performance efficiency.

Test Results for Portability Aspects

At the testing stage of the performance efficiency aspect, the applications that have been built are then tested using the Apptim software. This test is carried out to obtain the feasibility results of the application being developed. The following are the results of testing from the aspect of performance efficiency.

Table 5. Test Results for Portability Aspects

No	Perangkat	Versi Android	Hasil pengujian	
			Berhasil	Gagal
1	Oppo A5	Android 10	1	
2	Oppo A12	Android 9 Pie	1	
3	Oppo Reno4 F	Android 12	1	
4	Poco X3 NFC	Android 11	1	
5	Redmi Note 9 Pro	Android 11	1	
6	Samsung S8+	Android 9 Pie	1	
7	Vivo Y20	Android 11	1	
8	Vivo Y91	Android 8 Oreo	1	
Jumlah			8	0

The score results will then be calculated using the formula of the feature completeness matrix where in this formula the portability result is the result of the number of features successfully implemented divided by the total features designed. Based on the formula is obtained:

$$Feature\ Completeness\ (X) = \frac{I}{P} = 1$$

$$Feature\ Completeness (X) = \frac{8}{8} = 1$$

$$Feature\ Completeness\ (X) = 1$$

Based on Table 5 which is then calculated using the feature completeness formula, a score of 1 is obtained, from this score it can be concluded that the quality of the software in the form of an information system in this study is stated to be good and fulfills the portability aspect.

IV. CONCLUSION

Android-based Smart PDAM monitoring and control application is a system produced to assist PDAM officers in managing the distribution of clean water effectively, recording customers' clean water usage automatically through an application installed on customer devices that is integrated with the system managed by PDAM officers , minimizing customer dissatisfaction with the distribution of clean water due to mismatches between water use and payment, and facilitating the detection of PDAM water leaks. This application was developed based on user needs and relevant literature and then given additional features that are expected to overcome problems related to the current use of PDAM. The features developed are water leak detection, recording of customers' clean water usage is made automatically through an application installed on the customer's device that is integrated with a system managed by PDAM officers, a complaint menu equipped with a complaint progress tracking feature.

At the system coding stage, the results of the prototypes that have been built and evaluated are then translated into the Kotlin programming language using the Android Studio IDE, Visual Studio Code, and Arduino IDE applications. The results of system coding are in the form of an android-based smart PDAM application called "Smart Water Meter". Applications that have been developed are then tested using ISO 25010 software quality testing standards on the aspects of functional suitability, compatibility, performance efficiency, and portability aspects.

Testing the functional suitability aspect involved 2 (two) experts experienced in programming and digital control engineering, namely Mr. Sugeng A. Karim, M.T. as validator 1 and Dr. Satria Gunawan Zain, M.T as validator 2. Based on the instrument in the form of test cases submitted as many as 87 points, the total items that were successful were 87, then calculated using the feature completeness formula, then a score of 1 was obtained, from this score it can be concluded that the quality of the software is the information system in this study is stated to be good and fulfills the functional suitability aspect.

Testing on the compatibility aspect uses observation or direct observation techniques, namely testing the consistency of the application when running with other applications on a particular device (co-existance) and testing the connection between the device and the application (interopability). Based on the test results on the co-existance sub-characteristic, the application results can run concurrently with the 4 types of applications being tested. Meanwhile for the interoperability sub-characteristics, the average calibration result was 4.7, the average water in the digital meter was 100 liters, and the average water difference between the analog meter and the digital meter was 0.41 liter.

Testing on the performance efficiency aspect is carried out using application testing software, namely Apptim. Based on the test results, the results of testing the performance efficiency aspect of the smart PDAM application show that the average CPU usage is 2.2% with a maximum of 13% (low limit), the average memory usage is 121.4 MB with a maximum of 151.2 MB (medium limit), and power usage is 33% with a maximum usage of 66% MB (medium limit). During the test, the smart PDAM application did not experience a memory leak or certain damage that could cause the application to force close or launch fail, the test acquisition rate was also at the low and medium limits, no tests were at or exceeded the maximum usage limit, so it can be concluded that the developed smart PDAM application has met the ISO 25010 software quality testing standards on the aspect of performance efficiency.

Testing the portability aspect is carried out by directly observing applications that run on several Android devices that have different brands and versions of the operating system. Based on the results of application testing, the results obtained are in the form of applications that can be used with 8 types of devices and different operating systems. The test results are then described in table 4.6 which is then calculated using the feature completeness formula, so a score of 1 is obtained, from this score it can be concluded that the quality of the software in the form of an information system in this study is stated to be good and fulfills the portability aspect.

Based on the results of the development of the smart PDAM application that has been tested using the ISO 25010 software quality testing standard in the aspects of functional suitability, compatibility, performance efficiency, and portability, it can be concluded that the Android-based smart PDAM application that has been developed meets the requirements and can be used by users in general.

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REFERENCES

1. F. Faisal and H. Hambali, “Design and Construction of PDAM Water Use Monitoring Based on Internet of Things (IoT),” vol. 2, pp. 31–34, 2022.
2. P. D. Widayaka and L. Jauhari, “PROTOTYPE OF WATER PIPE LEAKAGE DETECTOR USING,” vol. 02, no. 1, pp. 34–38, 2019.
3. D. P. Raagas, D. E. K. M. Melgazo, D. C. S. Ergina, and R. L. Verecio, “Smart water tank system using WIFI-based microcontroller unit,” South Florida J. Dev., vol. 3, no. 2, pp. 2670–2685, 2022, doi: 10.46932/sfjdv3n2-086.
4. S. S. Mulik, A. D. Patange, R. Jegadeeshwaran, S. S. Pardeshi, and A. Rahegaonkar, “Development and experimental assessment of a fluid flow monitoring system using flow sensor and arduino interface,” Lect. Notes Mech. Eng., no. October, pp. 115–122, 2021, doi: 10.1007/978-981-15-6619-6_12.
5. A. E. Amoran, A. S. Oluwole, E. O. Fagorola, and R. S. Diarah, “Home automated system using Bluetooth and an android application,” Sci. African, vol. 11, p. e00711, 2021, doi: 10.1016/j.sciaf.2021.e00711.
6. M. Hasan, “Microcontroller Based Smart Home System with Enhanced Appliance Switching Capacity,” 2018 Fifth HCT Inf. Technol. Trends, pp. 364–367, 2018, doi: 10.1109/CTIT.2018.8649518.
7. M. Fezari and A. A. D. Al Zaytoona, “Integrated Development Environment ‘IDE’ For Arduino Integrated Development Environment ‘IDE’ For Arduino Introduction to Arduino IDE,” ResearchGate, no. October, 2018, [Online]. Available: https://www.researchgate.net/publication/328615543.
8. E. L. Q. Santos, J. C. D. Bautista, M. William, S. E. Christian, J. B. Paloa, and A. B. A. Villaran, “Development of an IoT-based water and power monitoring system for residential building,” vol. 22, no. 2, pp. 744–751, 2021, doi: 10.11591/ijeecs.v22.i2.pp744-751.
9. A. Acharya and D. Sinha, “Assessing the Quality of M-Learning Systems using ISO/IEC 25010,” Int. J. Adv. Comput. Res., vol. 3, no. 3, pp. 2277–7970, 2013.
10. ISO25000, “ISO/IEC 25010.” https://iso25000.com/index.php/en/iso-25000-standards/iso-25010.