IoT Communication System using Publish-Subscribe

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***Abstract*— The development of the Internet of Thing (IoT) application has been very rapid in recent years. Research on IoT optimization continues to be done due to limited IoT resources. This research develops a river condition monitoring system for early warning using IoT with the Publish-Subscribe, communication model. Publisher as the sender of the river and Subscriber condition data as an application used to monitor river condition in the form of video data. The IoT Communication Model developed is the Adaptive Method. The use of the Adaptive method is due to continuous data changes and accepted by the user as monitoring data. An adaptive method is used to make efficient use of IoT resource due to big video data. Test results in this study indicate that the average efficiency of IoT resources is 34.7%.**

Keywords—IoT, monitoring, publish-subscribe.

I. INTRODUCTION

Developments in Internet computing technology are proliferating with the presence of the Internet of Things (IoT). The Internet of Things (IoT) described as a small device connected to the internet and users can control the environment or circumstances beyond the reach of users and small devices interconnected via the Internet in conducting data. Internet of Things (IoT) is a collection of small devices that work together to serve user tasks in combination [1-2]. It binds computing power to transmit data about the surrounding environment [3] [4]. The use of small devices on IoT, one of the shortcomings of the IoT is the resource of the small device.

Research on the use of IoT in monitoring system has done. Monitoring of the building using IoT has been done with low image resolution due to the consideration of the existing bandwidth so that the image quality is less useful [5]. Research on flood monitoring using wireless sensor networks by creating an IoT-based embedded system to reduce power usage and range [6-7]. Some of these studies have a disadvantage that is the excessive use of IoT resource devices that are resource processor and bandwidth.

Another study of IoT for monitoring the use of electrical power in buildings [8]. The research is only up to the accuracy of each level of voltage and current level used in the building, not doing the calculation on the IoT resource. While the use of publish-subscribe method has done on mobile devices by utilizing social media such as Facebook, Twitter and Instagram [9]. The study utilizes the internet network in performing data communication on mobile devices with social media applications. Moreover, also this research is only monitoring continuously by utilizing user or user in doing publish. The subscribed recipient is limited to only those eligible for monitoring data [9]. The resources available in the mobile device are so significant that they are not hindered in monitoring either on the publisher or subscriber side and also cannot perform continuous monitoring because of secondary publisher update data [9]. Monitoring should be done continuously to obtain details of changes in monitoring and also limited resources as they are placed in specific corners to obtain monitoring and monitoring data.

This research develops a data communication model at IoT to monitor river condition. The data communication model used is Publish-Subscribe. There are three important components in publish-subscribe that is publisher, subscriber, and broker. The publisher as the sender of river monitoring data. The subscriber as a user of river monitoring data. The publisher sends data to the subscriber based on event attraction from the subscriber. The event's interest is managed and managed by the broker. Large video data causes resource limitations of IoT devices. To overcome the limitations of resources used the Adaptive method. This Adaptive method controls the delivery of video data based on certain event interest from the subscriber. The adaptive method also arranges data sent to the subscriber is if data same with previous data hence data not sent.

II. PUBLISH-SUBSCRIBE

Publish / Subscribe is a communication mechanism or paradigm for distributed systems. Each node that is on a publish/subscribe network communicates with each other by publishing data and receiving (subscribing) data anonymously. In general, the property required by a publisher to communicate with a subscriber is the name and definition of the data. Publishers do not need any information about subscribers, and vice versa. The publish/subscribe mechanism embraces three principles. The first is space decoupling. This first principle means that the interaction between publishers and subscriber occurs anonymously. Between publishers and subscribers do not know each other's information about each other. The second is time decoupling. It means that publishers and subscribers should not be active at the same time. The publisher can publish

some events even though the subscribers are not currently online [10].

When the subscriber has been active again, then he will get a notification message will be a new event. The publisher can still produce events even though subscriber is not active. The third is Synchronization decoupling. It means that communication between publisher and subscriber occurs asynchronously [11]. Figure 1 shows an overview of the time and space decoupling principles provided by the publish/subscribe mechanism.

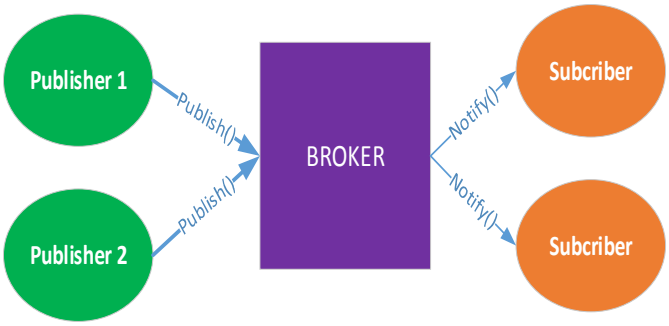

Fig. 1. The publish-subscribe mechanism

Figure 2 shows that the underlying architecture of publish/subscribe consists of 3 components. That is subscriber, broker, and publisher. The subscriber is the party that requests specific data by calling the subscribe function [10]. Subscripts submitted by the subscriber are addressed to the broker to be managed and forwarded to the data provider who publishes the data (publisher) Broker at least performs the following tasks [11]:

a. Stores the subscription

b. Accept and host events published by publishers

c. Connecting the subscriber with the publisher as a qualified data provider provided by the subscriber.

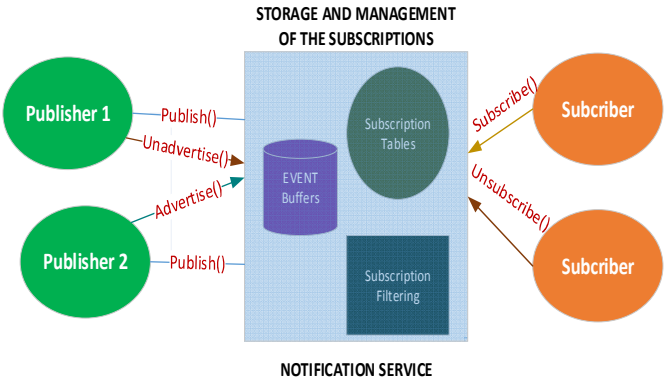

Fig. 2. The underlying architecture of publishing/subscribe

III. DESIGN SYSTEM

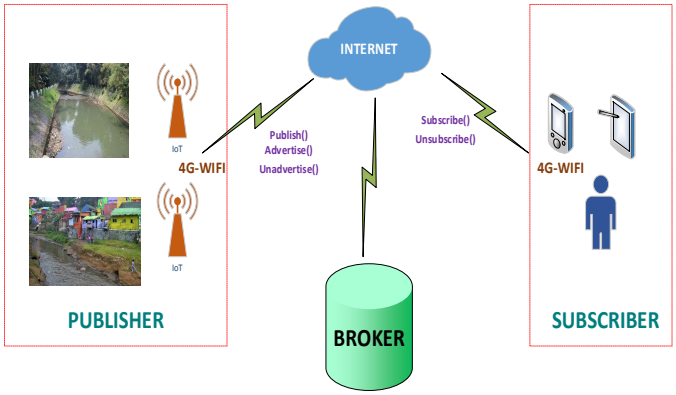

Fig. 3. The working principle of this system

This system uses the Publish-Subscribe system which consists of 3 parts, namely:

- Publisher
- Broker
- Subscriber

Publisher by utilizing IoT device that has a camera to publish the condition of the state of the road at the Universitas Negeri Malang. Publish is done by IoT device using raspberry pi 3 shown in table 1 when there is a change of image data from the previous image taken by device IoT then send to the internet and accepted by the broker with Mosca middleware. For the notification process given to the subscriber of the publisher through brokers and brokers, provide image data required by the subscriber based on data changes on the publisher. The working principle of this system described in Figure 3.

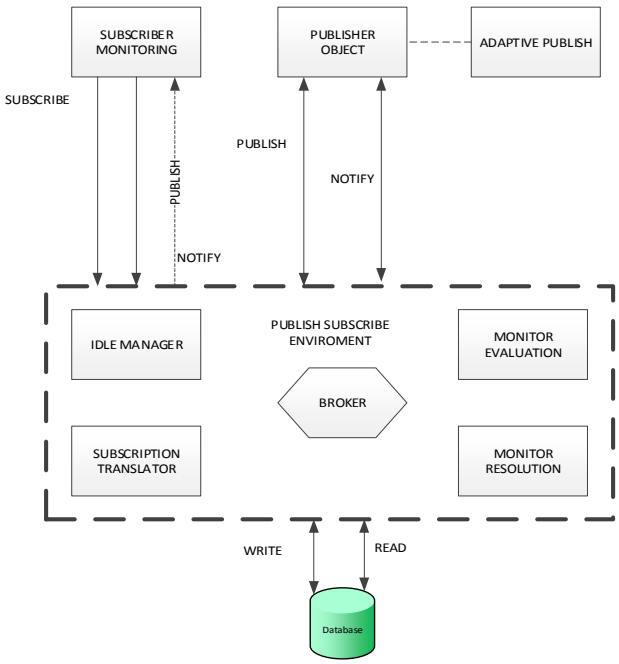

Fig. 4. The interaction between the publisher and the subscribe

TABLE I. SPECIFICATION OF RASPBERRY PI 3

Item	Type
SoC	BCM2837
CPU	64-bit 1.2GHz quad-core ARM Cortex-A53 CPU
RAM	1GB SDRAM @ 400 MHz
Storage	Micro-SD
Wireless	Integrated 802.11n wireless LAN
Ethernet	10/100 Mbps
Bluetooth	Bluetooth 4.1
Video	VideoCore IV 3D
USB 2.0	Four ports
GPIO	40
Power	2.5 Amps
OS	Linux

TABLE II. OPERATORS COMPARISON AND LOGICAL OPERATORS

Operators Comparison	Information
=	Operators equals
<>	The operator is not the same as
>	Greater than
<	Less than
>=	Larger operator equals
<=	Smaller operators equal
Operator Logika	Information
and	Logical AND operator
or	Logical operator OR

The interaction between the publisher and the subscriber can show in Figure 4. The publisher will send the event to the publish-subscribe system in the form of state information. While the subscriber sends subscripts set in the subscription language to the publish-subscribe system, the subscriber will only notify by the interest through the monitoring evaluation process. The subscription translator will translate the existing subscription. Notification to subscriber entity will handle by the broker (implemented with Mosca middleware).

In the adaptive method as shown in Figure 5, there is an idle manager that sets the publisher status to active and does the publish event to the broker or not. A subscriber (monitoring entity) to carry out the monitoring process, requires the necessary rules for communicating. The subscriber can perform monitoring under various conditions defined in the subscription translator module as shown in Table 2, which in this study is limited to location information regarding location, status and status information. Messages sent to the broker translated to then a process of evaluating the suitability of interest.

If the location information content published by the publisher matches the interest of the subscriber, the broker will notify the subscriber. The format of interest protocols is a combination of one or more conditions (merging by using logical operators), in the form of boolean expression. Example of interest format: area = 'G4' (notification of all publishers in G4 area), state = crowded and user = 'publisher1.

Characteristics of interaction in traditional publish-subscribe systems, although information from publishers is not interested in subscriber, publishers will keep publishing event information to the broker's side whenever they get new information. Each broker receives to publish information from the publisher, matching interests to each interest of the subscriber. The publishing process will be performed if there is an interest in the information from the subscriber on the adaptive method. When the publisher is declared idle by the broker, the publisher receives the event to stop the publishing process for a specified period. The publishing process will be active over if there is a match on the location information subscription list from the subscriber. While in publish-subscribe behavior in general, the matching process done for every publishing event received

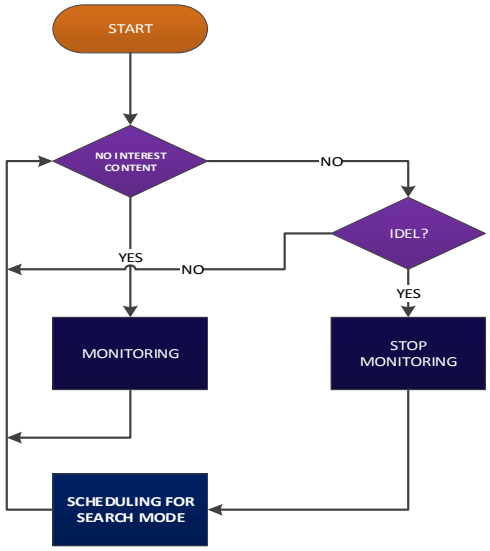

Fig. 5. Adaptive Method

IV. RESULT

Package of state/location information from the sample data, modified with additional protocols so that the event publish process will only occur for the required location information packet only (adaptive method) [12 -13]. In Table 3, we show the different publish events that occur between adaptive and non-adaptive methods in the experiment. For non-adaptive methods, the number of publishing events is not affected by the number of the subscriber. Simulation trials are conducted for 5 minutes with interval distance interval 1 second. So the number of publishing events on non-adaptive methods can be calculated by the number of publisher x 5 (minutes) x 60 (sec). In addition to the number of publish events observed, an observation of some performance parameters, including CPU server usage, server RAM usage, bandwidth usage and latency. The observation of this experiment was conducted to see the effect of the number of publishing events on the efficiency of performance. The trial did on 3G networks and Wi-Fi.

TABLE III. DATA EVENT

Publisher	Adaptive		Non-Adaptive
	5 Subscriber	10 Subscriber	
5	644	644	1500
10	712	1284	3000
15	794	1366	4500
20	864	1447	6000
25	945	1505	7500

TABLE IV. SULT TEST PERFORMANCE

Parameter	Network	Adaptive (Subscriber)		Non-adaptive (Subscriber)		Unit
		5	10	5	10	
CPU	3G	4,3829	6,7407	15,3032	18,2527	%
	Wi-Fi	4,9237	7.5088	13,9963	17,6835	
Bandwidth	3G	1805.975	2872.634	4598.5996	5246.9726	bytes/s
	Wi-Fi	1813.3332	2916.7608	4584.952	5234.6618	

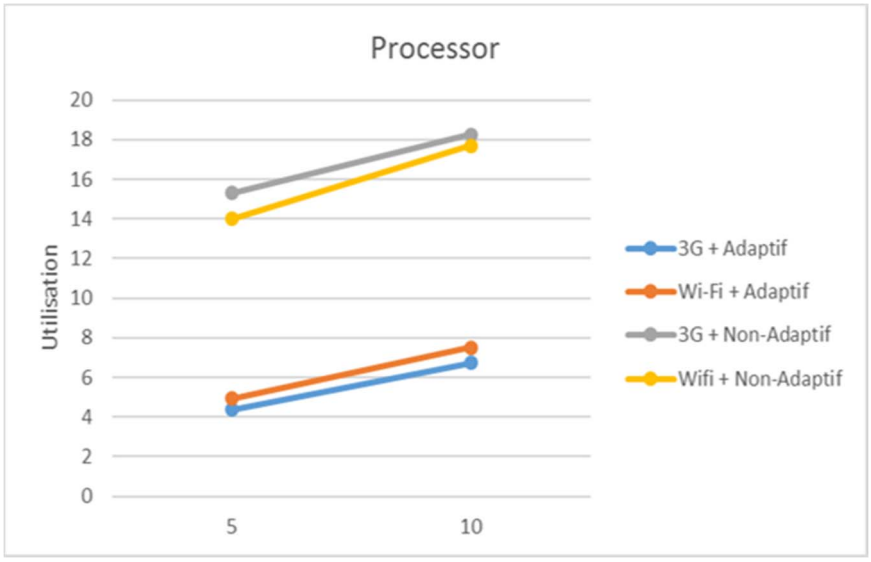

Fig. 6. The graph of efficiency CPU

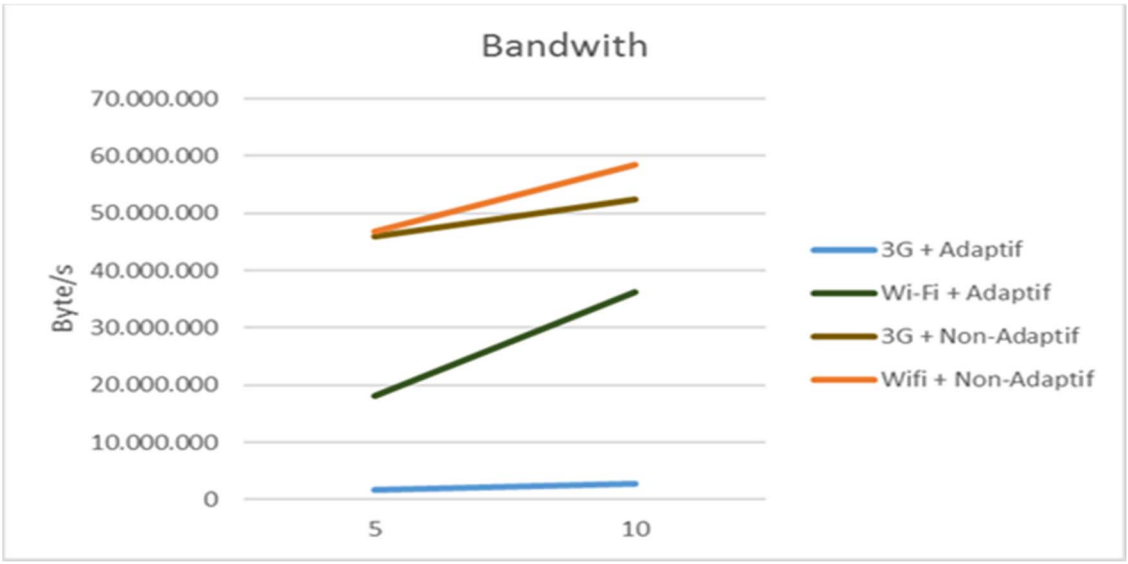

Fig. 7. The graph of efficiency Bandwith

V. DISCUSSION

The results of the performance observations shown in Table 4. The results of the experimental observations show that monitoring on IoT with the publish-subscribe model adaptively obtained for performance efficiency. For comparison of CPU usage with Adaptive model between 3G and wifi obtained efficiency equal to 10,8% by using the 3G connection. As for the use of bandwidth with the model publish-subscribe adaptive model obtained the efficiency of 91.3% using the 3G connection. For comparison of the measurement of CPU performance on the 3G connection between Adaptive and Non-Adaptive obtained by CPU efficiency equal to 66,8% for connection of publish-subscribe adaptive 3G. For comparison of bandwidth measurement on the 3G connection between Adaptive and Non-Adaptive obtained efficiency equal to 95,2% for Adaptive 3G connection. For wifi connection between Adaptive and Non-Adaptive obtained for CPU of 60,7% for Adaptive 3G usage and bandwidth 48,2% for adaptive wifi usage. The graph of efficiency shown in Figure 6 for the performance efficiency of the CPU and Figure 7 for the efficiency of the performance of the bandwidth. The indicated by bandwidth savings of 44-60% and CPU savings of 57-71%. The influenced by the existence of the idle manager module that does the active publisher checking process. In the adaptive method, the amount of location information that published influenced by the presence or absence of location information by the subscriber.

VI. CONCLUSION

This research develops data communication model at IoT to conduct road monitoring at Universitas Negeri Malang by applying adaptive publish subscribe method with attention to subscriber interest in road condition monitoring. The results of this IoT research using the adaptive publish-subscribe method in increasing the efficiency of average CPU usage by 31.76% and the average bandwidth usage is 39.4%. As the number of publishers and subscribers increases in the non-adaptive method, it will increase the usage load. The different from the adaptive method that is only influenced by the interest of information content by the subscriber.

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REFERENCES

[1] Yin Jie; Ji Yong Pei; Li Jun; Guo Yun; Xu Wei, "Smart Home System Based on IOT Technologies," Computational and Information Sciences (ICCIS), 2013 Fifth International Conference on, pp.1789,1791, 21-23 June 2013

[2] Beligianni, F., Alamaniotis, M., Fevgas, A., Tsompanopoulou, P., Bozanis, P., & Tsoukalas, L. H. (2016). An Internet of Things architecture for preserving privacy of energy consumption.

[3] Perumal, T.; Sulaiman, M.N.; Mustapha, N.; Shahi, A.; Thinaharan, R., "Proactive architecture for Internet of Things (IoTs) management in smart homes," Consumer Electronics (GCCE), 2014 IEEE 3rd Global Conference on, pp.16,17, 7-10 Oct. 2014.

[4] Perumal, T., M.N.Sulaiman and Leong C.Y, "ECA-Based interoperability framework for intelligent building. Automation in Construction. 31, 274–280 (2013).

[5] Fadli Sirait. Sistem Monitoring Keamanan Gedung berbasis Rasberry Pi, Jurnal Teknologi Elektro, Universitas Mercu Buana, Vol. 6 No.1 Januari 2015.

[6] Mane, S. S., & Mokashi, M. K. (2015, April). Real-Time Flash-Flood Monitoring, Alerting and Forecasting System using Data Mining and wireless sensor Network. In *Communications and Signal Processing (ICCSP), 2015 International Conference on*(pp. 1881-1886). IEEE..

[7] Afzaal, H., & Zafar, N. A. (2016, October). Cloud computing based flood detection and management system using WSANs. In *Emerging Technologies (ICET), 2016 International Conference on* (pp. 1-6). IEEE.

[8] Lestari, D., Wahyono, I. D., & Fadlika, I. (2017, November). IoT based Electrical Energy Consumption Monitoring System Prototype: Case study in G4 Building Universitas Negeri Malang. In *Sustainable Information Engineering and Technology (SIET), 2017 International Conference on* (pp. 342-347). IEEE

[9] Wirawan, I. M., Herwanto, H. W., & Wahyono, I. D. (2017). Optimasi Publish-subscribe Adaptif untuk Monitoring Keamanan Selasar Gedung G4 Teknik Elektro Universitas Negeri Malang. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *2*(10), 1351-1355.

[10] Eugster, P., Felber, P., A., Guerraoui, R., *The many faces of publish/subscribe.* ACM Computing Survey., 2003

[11] Esposito, C., Cotroneo, D., & Russo, S. (2013). On reliability in publish/subscribe services. *Computer Networks*, *57*(5), 1318-1343

[12] Lopez-Vega, J. M., Povedano-Molina, J., Pardo-Castellote, G., & Lopez-Soler, J. M. (2013). A content-aware bridging service for publish/subscribe environments. *Journal of Systems and Software*, *86*(1), 108-124.

[13] Esposito. 2013. Survey on Reliability in Publish/Subscribe Service. Journal of Computer Network on (pp 1318-1343). ACM

[14] Wahyono, I. D. (2016). SERVICE DISCOVERY BERBASIS BREADTH BLOOM FILTER DI MOBILE AD-HOC NETWORK (MANET). *TEKNO*, *23*(1)..