Development of Monitoring System for Smart Farming Using Progressive Web App

Lukito Edi Nugroho, Andreas Gandhi Hendra Pratama, I Wayan Mustika, and Ridi Ferdiana

Department of Electrical Engineering and Information Technology
Universitas Gadjah Mada
Jalan Grafika No. 2, Yogyakarta, 55281, Indonesia
Email: lukito@ugm.ac.id, andreas.gandhi01@gmail.com, wmustika@ugm.ac.id, ridi@ugm.ac.id

***Abstract*—Indonesia is one of countries well-known as the biggest palm oil producers in the world. In 2015, this country succeeded to produce 32.5 million tons of palm oil, and used 26.4 million of it to export to other countries. The quality of Indonesia's palm oil production has become the reason why Indonesia becomes the famous exporter in a global market. For this reason, many Indonesian palm oil companies are trying to improve their quality through smart farming. One of the ways to improve is by using technology such as Internet of Things (IoT). In order to have the actual and real-time condition of the land, using the IoT concept by connecting some sensors. A previous research has accomplished to create some Application Programming Interfaces (API), which can be used to support the use of technology. However, these APIs have not been integrated to a User Interface (UI), as it can only be used by developers or programmers. These APIs have not been able to be used as a monitoring information system for palm oil plantation, which can be understood by the employees. Based on those problems, this research attempts to develop a monitoring information system, which will be integrated with the APIs from the previous research by using the Progressive Web App (PWA) approach. So, this monitoring information system can be accessed by the employees, either by using smartphone or by using desktop. Even, it can work similar with a native application.**

Keywords—monitoring system, smart farming, palm oil, progressive web app

I. INTRODUCTION

Indonesia is one of the developing countries with the highest agricultural productivity in the world. As recorded in 2014, the agricultural sector has contributed 879.23 trillion Rupiah or 10, 26 % of National Gross Domestic Product (GDP) [1]. It certainly happens because Indonesia is one of the agrarian countries that have a myriad of natural resources (SDA). The plantation sub-sector is the largest contributor for the export value in the nation, even larger than its import value. One of the best commodities for the plantation production is oil palm (Elaeis Quinensis Jack).

As the country with the largest palm oil plantation in the world, Indonesia is the main exporter of crude palm oil, or Crude Palm Oil (CPO). The results of this commodity are used as basic ingredients of cooking oil, margarine, wax, soap, and even bio-diesel fuel in the EU regions [2]. Currently, world palm oil production itself is dominated by two countries in Southeast Asia: Malaysia and Indonesia with the production level of both countries in the range of 85-90% of the total production in the world. Today Indonesia is a country with the largest production of palm oil as well as the largest exporter in the world with total production in 2015 of 32.5 million tons, 26.4 million of which is used for export to other countries [3].

In Indonesia, the monitoring method applied by the supervisors and plantation employees still tends to be traditional that is by directly getting involved to the plantation without any use of technology. Given the so developing growth of Internet of Things (IoT) in Indonesia today, this technology can certainly assist these employees in monitoring the plantation land either off site or on site. The application of the IoT concept has been developed on smart home such as to monitor the house condition, or turning on/off some electrical components. This concept is also to be adapted in transportation sector such as tracker on buses, or bus scheduling. For agriculture and plantations, the application of the IoT concept tends to be at the initial phase and is concentrated on the optimization of land management.

Information Systems for oil palm plantation that has been currently developed still has not dealt with the IoT domain, but still on the basis of the Geographic Information System (GIS) use. The tendency on the existing GIS-based application is still used to monitor the crop and the plantation employees themselves, and administratively, it is still using the manual data input. Hence, there is a need for a more modern method in monitoring to obtain more accurate data by using the sensors applied with the IoT concept. The data later will be presented in the form of Information System (IS) of monitoring oil palm plantation land. By using the sensors installed in certain locations on the plantation land, the supervisors and other plantation employees later are able to monitor the condition of oil palm land from anywhere and anytime by simply looking at the existing information system. In other words, the development of information system in monitoring oil palm plantations is deemed necessary. Through this research, a web-based application that is multiplatform accessible via mobile devices or PC/desktop will be developed. The aims of this research are to develop a web-based IS using the Progressive Web App approach as an interface for monitoring the oil palm plantations, to integrate the user interface (UI) and the existing APIs from previous research to build information system with real-time data, and to test the quality the web-based information

978-1-5090-6477-9/17/$31.00 ©2017 IEEE

system using the black box testing method, and tools such as Lighthouse, and PageSpeed Insight.

II. Previous Work

The utilization of technology in the form of information systems has been developed to support any human needs, one of which is the use of IS as a monitoring device. In 2014, a research on monitoring system was conducted to monitor the environment and climate change by combining technology concepts such as the Internet of Things (IoT), Cloud Computing, Geoinformatics (Remote Sensing (RS), Geographical Information System (GIS) and Global Positioning System (GPS)], and e-Science for environmental monitoring with a case study on the climate change and its ecological effects [4]. This research used multi-sensors and web services for data collection.

In agricultural sector, some researches on the monitoring information system have been conducted in Indonesia. In 2012, a research has developed the android-based information system for oil palm plantation management using GIS and A-GPS. This information system was focused on monitoring the indiscipline of workers' performance in field, crop scheduling, and the retardation level of worker report in field [6]. This information system provided some features to monitor the position of the supervisor by means of A-GPS, land map, supervisor report, and garden assistant to the existing administrator in the office, and reminder related to harvest time. The feature of land map showed a clear monitoring function by showing general plantation information such as plant age, harvest time, land area information, palm oil plantation, oil palm age, and number of workers. In this information system, the report was sent via email and reminder using SMS gateway. The limitations of the development of this android-based information system application were related to the GIS-based data in the form of mapping of oil palm plantation areas and the position of supervisor that had not provided the real-time information related to current land condition or oil palm plantations.

Beside the development of android-based above, in 2015 PT. Cahya Vidi Abadi, a plantation company in Muara Enim, South Sumatra developed a web-based information system [7]. The company implemented Geographic Information System (GIS) in the web-based application development for the calculation and analysis of production yield from oil palm plantation. In this monitoring information system, the admin was able to see the productivity of plantation land through the image of GIS map derived from the input data processing. In addition, the admin was able to see the production data using the graph. However, this information system still did not provide data automatically for being dependent upon the input production data from the admin.

The development of real-time and automatic monitoring system in oil palm plantation using the sensor actually has ever been done by Anisa, *et al*. The research has built Application Programming Interface (API) developed by RESTful method [8]. This API acts as a back-end system interface to prevent any direct data access or application functionality to the database. In this research, the API resulted had a JavaScript Object Notation (JSON) format that can be accessed in the form of a character string of Uniform Resource Identifier (URI). However, this research did not provide a user interface (UI) that can be easily accessed and understood by the users. Therefore, it needs the development of UI and integration with API to be used in monitoring the oil palm plantation in the form of information systems.

III. Research Methodology

A. *User Identification*

The information system of monitoring the oil palm plantation will be intended to be used by users working in the plantation that is the employees of the plantation itself. For this, it needs to identify the user to make it suitable with the need of information system development. This can be done through the making of persona, user story, user scenario, and use case diagram.

The *user story* development was conducted in 2 ways: informal and *specific user story* as seen in Table 1. *User Story* refers to a brief description of the features of an application based on the perspective of someone, generally clients or the uses that later will use the application. [41]

TABLE 1
TABLE OF USER STORY

Type of Persona	***User Story Cards***
Palm Oil Plantation Supervisor (in Office)	As the supervisor of palm oil plantation, I want to be able to see the data of all sensors and nodes on 1 screen. Thus, I can monitor it through a large monitor from the office
	As a supervisor of oil palm plantations, I would like to see daily, monthly and yearly graphs of a sensor to evaluate the plantation condition
	As a supervisor of oil palm plantations, I would like to be able to add or remove existing nodes on the plantation land, and change information such as location and others to facilitate the nodding process itself.
	As a supervisor of oil palm plantations, I want to be able to do controlling in the active sensors to test certain land with certain sensors.
	As a supervisor of oil palm plantations, I would like to see a map of the nodes location map the locations that need to be managed.
Types of Persona	***User Story Cards***
Field Employees of Oil Palm Plantation	As an oil palm plantation worker, I would like to be able to access this information system on a mobile basis with a smartphone so it can be done while in the field.
	As a field worker in oil palm, I would like to be able to see the real-

	time data to be used as a benchmark of the current land condition.
	As a palm oil plantation worker, I would like to see the latest data when being in area where finding signal is difficult to be used as a benchmark of land condition.
	As a palm oil field worker, I would like to be notified about the information of land condition (e.g. the condition is under censorship) to give an immediate action.

B. System Design

Having done the user identification, then high fidelity wireframe was built as seen in Fig 2 about wireframe desktop and mobile version.

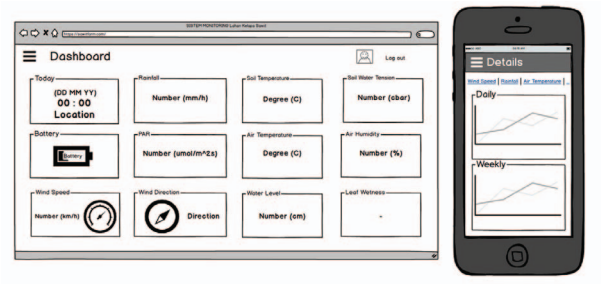

Fig. 2. *Wireframe* of SI Oil Palm Monitoring

Beside the wireframe, in this phase, solution architecture was developed as seen in Figure 3. In the development of information system in monitoring oil palm, the solution architecture is required to show communication in the form of architecture among components that were involved in research, such as users (tailored to persona), access media (hardware), systems, and servers.

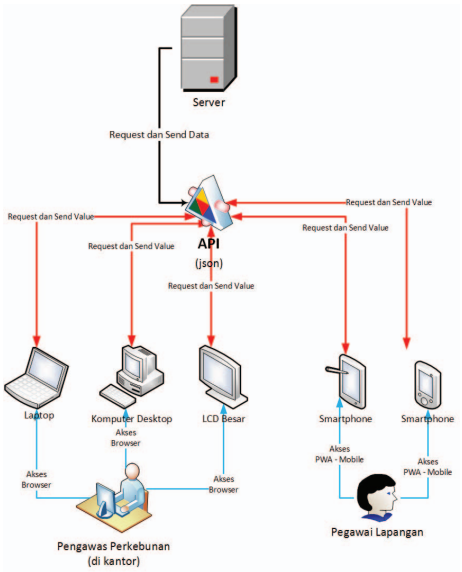

Fig 3. Solution Architecture IS Oil Palm Monitoring

IV. Result and Discussion

A. User Interface Development

The development of UI and features in this research was based upon the result of user identification comprising persona, user story, and user scenario. Principally, the part of *user story*, and user scenarios were made after specifying the persona of the potential users from the information system of oil palm land. Then the user story and user scenario of each persona were developed. Furthermore, wireframe was used as the final design ready to be implemented in the development of web-based information system.

In this research, it can be defined that each persona will receive a different user interface (UI), namely:

• Persona of 'Supervisor of Oil Palm Plantation (in the office) uses the user interface with the version of the desktop for PC/laptop/monitor for monitoring in the office rooms.

• Persona of 'Field employees of Oil Palm Plantation' uses the user interface with the mobile version to be accessed via smartphone.

Although the users will use a different version of UI, principally, the application used to open a web page as the information system of palm oil monitoring is Google Chrome browser (minimum version of 52 and above). The result of UI development in both desktop and mobile version for both personas can be seen in Figure 4.

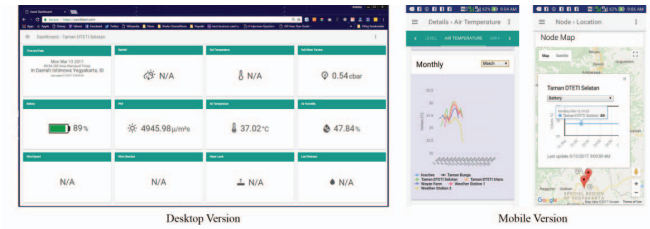

Fig 4. Display of *Desktop* and Mobile IS of Oil Palm

B. Integration of API and UI

The integration of API and UI was conducted by utilizing API that has been developed in previous research. Table 2 shows a snippet of the table about the integration result between API and UI on the Dashboard part of the information system in oil palm monitoring.

TABLE 2
TABLE OF API INTEGRATION

No.	API URL	Request Method	Function
On ***Dashboard***			
1	`https://sawitfarm.com/api/nodes`	GET	To obtain the node data on *database*
2	`https://sawitfarm.com/api/notif/sensornode?node_id=AAAAAA`	GET	To obtain the status of activation from the notification in each sensor (id=AAAAAA is the sample of an id node)
3	`https://sawitfarm.com/api/threshold/by?node_id=AAAAAA`	GET	To obtain the range of *threshold* owned by each sensor in each node (id=AAAAAA is the sample of an id)

4	https://sawitfarm.com/api/current/by?node_id=AAAAAA&timeblock=point&point=current	GET	To obtain the *current* data of all sensors in a node (id=AAAAAA is the sample of an id node)

The integration not only used API with Backbone JS but also used WebSocket technology. The purpose of the use of the WebSocket utilization was to present real-time data with a subscribe model. The application of WebSocket was done on Dashboard, Detail, and Node Location page development as seen in Figure 5.

- On Dashboard, WebSocket was applied to change the new data that was sent by the server to the client when opening the Dashboard page without the need to reload and request back to the server.
- In Detail, WebSocket was applied to provide the real-time data on the Daily graph. Hence, it did not need to reload the pages when the new data was sent from the server to one of Daily graphs to one of sensors owned by a node.
- In Node Location, WebSocket was applied to the graph appearing from the marker, as the graph principally was a Daily chart.

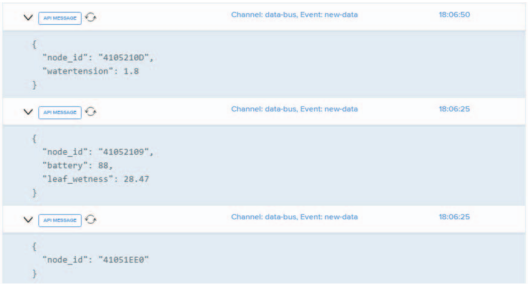

Fig 5. API *Message* on the WebSocket Pusher

C. Application of Progressive Web App (PWA)

PWA implemented in this study aimed to improve the ability of a website to work similar with a native application on mobile devices. If viewed from the side of persona, user story, and user scenario, the development of monitoring information system of oil palm land with the PWA approach aimed to assist the plantation employees in the field.

Some features that can be used with this PWA approach can be seen in Figure 6 about the function of the 'Add to Home Screen' and Fig 7 on 'Push Notification'.

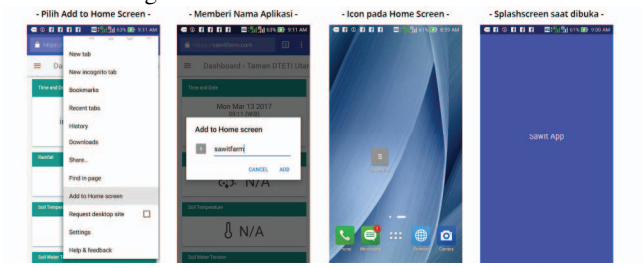

Fig 6. *Add to Home Screen* on the SI Oil Palm

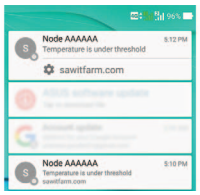

Fig 7. *Push Notification* on IS Oil Palm

D. Test on Black Box, Lighthouse, and PageSpeed Inight

The last part of this discussion is testing IS Oil Palm itself with black box method and devices from Google, namely Lighthouse and PageSpeed Insight. For black box testing, it was found that the result of this functionality testing was good and as expected (successful). The test using Lighthouse can be seen in Table 3.

TABLE 3
TABLE ABOUT LIGHTHOUSE TEST

	Dashboard	Detail	Node Location	Node Configuration	Log History
Overall Score	**94/100**	**95/100**	**92/100**	**96/100**	**90/100**
App Can Load on offline/flaky connections	✓	✓	✓	✓	!
Page Load Performance is fast	!	!	×	!	!
Site is progressively enhanced	✓	✓	✓	✓	✓
Network connection is secure	✓	✓	✓	✓	✓
User can be prompted to Add to Home screen	✓	✓	✓	✓	✓
Installed web app will launch with custom splash screen	✓	✓	✓	✓	✓
Address bar matches brand colors	✓	✓	✓	✓	✓
Design is mobile-friendly	✓	✓	✓	✓	✓
Using modern offline features	✓	✓	✓	✓	✓
Using modern protocols	✓	✓	✓	✓	✓
Using modern CSS features	×	×	×	×	×
Using modern JavaScript features	!	!	!	!	!
Avoiding APIs that harm the user experience	✓	✓	!	✓	✓
Avoiding APIs and	✓	✓	✓	✓	✓

browser inventions					
Accessibility	✓	✓	✓	✓	✓
Other	✓	✓	✓	✓	✓

Meanwhile, the results of PageSpeed can be seen in Fig 8. showing that the results obtained were good.

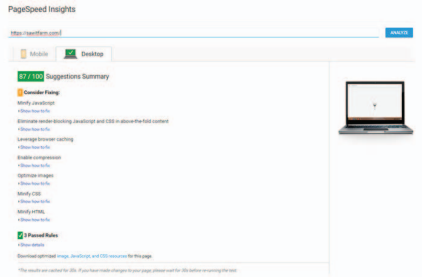

Fig 7. *Push Notification* on IS Oil Palm

V. CONCLUSION

Based on the research that has been done on the development of information system to monitoring the oil palm plantation, a number of conclusions are taken as follows. Web-based information systems to monitor the plantation developed using the progressive web app (PWA) approach can be used by users as a native application with several features. Development with PWA approach provides an easy access for both persona users, i.e. field employees and plantation supervisors in the office as PWA includes the responsive web design that can be accessed through desktop and mobile browser. The integration between APIs in previous research and UI successfully presented data that can be easily utilized by plantation employees in the distant monitoring process through SI. Constraint in the integration of API and UI is related to the nonconformities of API with the specification of UI that have been developed according to user identification. Therefore, it is necessary to modify the API to be used and integrated. Based on testing on functionality using black box testing, SI is already able to provide functionality based on the user needs. Moreover, based on testing the system quality using tools such as Lighthouse and PageSpeed Insight, SI has given a good value on average.

REFERENCES

[1] Ministry of Agriculture, Republic of Indonesia, The Strategic Plan of Ministry of Agriculture in the period of 2015-2019, Jakarta, 2015.

[2] Ministry of Commerce, Republic of Indonesia, "Market Brief 'Kelapa Sawit dan Olahannya'," ITPC, Hamburg, 2013.

[3] Anonym, "Minyak Kelapa Sawit," Indonesia-Investments, 2 February 2016. [Online]. Available: http://www.indonesia-investments.com/id/bisnis/komoditas/minyak-sawit/item166?. [Accessed in 20 December 2016].

[4] S. Fang, L. D. Xu et al.,"An Integrated System for Regional Environmental Monitoring and Management Based on Internet of Things," IEEE Transactions on Industrial Informatics, vol. 10, no. 2, 2014.

[5] R. Hanifah, R. R. Isnanto and Y. Christyono, "Simulasi Sistem Informasi Geografis (SIG) Pamantauan Posisi Kendaraan Via SMS Gateway," TRANSMISI, Semarang, 2010.

[6] S. M. S., A. Mulyana and M. S. Nasution, "SISTEM INFORMASI BERBASIS GIS DAN A-GPS UNTUK PENGELOLAAN PERKEBUNAN KELAPA SAWIT DENGAN MENGGUNAKAN ANDROID," Telkom University, Bandung, 2012.

[7] D. Dwipranata, A. Ranius and Fatmasari, "Perancangan dan Implementasi Sistem Informasi Geografis Berbasis Web Produktivitas Lahan Perkebunan PT Cahya Vidi Abadi Unit Kebun Cahya Selatan," Journal of Informatics, pp. 1-10, 2015.

[8] A. Azis, "Pengembangan RESTful API untuk Sistem Pemantauan Perkebunan Kelapa Sawit," Universitas Gadjah Mada, Yogyakarta, 2016.

[9] P. Bartle, "The Nature of Monitoring and Evaluation - Definition and Purpose," CEC - Community Empowerment Collective, 30 September 2011. [Online]. Available: http://cec.vcn.bc.ca/cmp/modules/mon-wht.htm. [Accessed in 9 February 2017].

[10] UN Habitat, "Chapter 7: Monitoring Information System," [Online]. Available: http://www.fukuoka.unhabitat.org/docs/publications/pdf/peoples_process/ChapterVII-Monitoring_Information_System.pdf. [Accessed in 9 February 2017].