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Agile-Waterfall Hybrid for Prevention Information System of Dengue Viral Infections: A Case Study in Health Department of Jember, East Java, Indonesia

I Putu Dody Lesmana
Department of Information Technology
State Polytechnic of Jember
Jalan Mastrip 164 Jember, Indonesia
dody_lesmana@polije.ac.id

Rinda Nurul Karimah
Department of Health
State Polytechnic of Jember
Jalan Mastrip 164 Jember, Indonesia
rindank6@gmail.com

Beni Widiawan
Department of Information Technology
State Polytechnic of Jember
Jalan Mastrip 164 Jember, Indonesia
beni@polije.ac.id

***Abstract*—Dengue viral infections are one the most important mosquito-borne diseases that have rapidly spread in all regions of Indonesia including at district of Jember, East Java in recent years. They may be asymptomatic or may give rise to undifferentiated fever, dengue fever (DF), dengue haemorrhagic fever (DHF), or dengue shock syndrome (DSS). The number of dengue cases at Jember reported increased from 77 in 2011 to 923 in 2015 and case fatality rate exceeded 1.3 in 2011 and over 1.6 in 2015. The main obstacles of dengue surveillance are occurred due to lack of public response to the onset of dengue viral infections cases in the surrounding environment, reporting cases from the hospitals, clinics, or community health centre have been delayed because of accessibility factor and manual written report. Without the validity of the information from dengue patient data, epidemiological investigation can't provide valuable information to control ongoing outbreaks. To overcome these problems, the development of prevention information system of dengue viral infections plays crucial role in the identifying cases and obtaining information from them to decide what actions must be taken by Health Department of Jember to control and eliminate outbreaks. To build robust prevention information system is used the hybrid model to combine both Waterfall and Agile. Leveraging both the Waterfall and Agile approach ensures the success of the project. It removes the disadvantages of both the models while bringing together the advantages of both. The objective of this paper is to highlight the importance of the hybrid model to successfully develop and implement prevention information system of dengue viral infections at Jember to restrict mosquito-borne spreading.**

Keywords—DF; DHF; DSS; prevention information system; dengue viral infections; Waterfall; Agile; Scrum; Hybrid model

I. INTRODUCTION

Dengue is a mosquito-borne viral disease that has rapidly spread in all regions of Indonesia including Jember located at Province of East Java. They may be asymptomatic or may give rise to undifferentiated fever, dengue fever (DF), dengue haemorrhagic fever (DHF), or dengue shock syndrome (DSS). Dengue virus is transmitted by female mosquitoes mainly of the species Aedes Aegypti to a lesser extent, Ae. albopictus. This mosquito also transmits chikungunya, yellow fever and Zika infection. Dengue is widespread throughout the tropics, with local variations in risk influenced by rainfall, temperature and unplanned rapid urbanization. In the past five years, between 2011 and 2015, dengue incidence in Jember regions have increased 12-fold with significant outbreaks occurring in 2013 according to the Figure 1. Based on Figure 1, number of dengue cases at Jember reported increased from 77 in 2011 to 923 in 2015 and case fatality rate exceeded 1.3 in 2011 and over 1.6 in 2015. In the same time scale as above, the incident rate per 100.000 person-years has increased dramatically from 3.28 in 2011 to 38.89 in 2015.

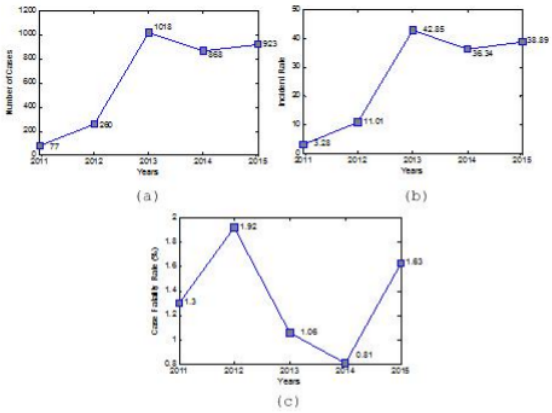

Fig. 1. DHF statistics in Jember between 2011 and 2015: (a) number of cases, (b) incident rate, (c) case fatality rate (%)

Although sporadic dengue fever was known for the last five years, reasons for the preventing and eliminating dengue fever are always encountered the same problem and the unresolved until now at Health Department of Jember. Despite of uncontrolled population growth, unplanned and uncontrolled urbanization, inadequate wastewater management, and lack of effective mosquito control have been implicated in the increased distribution and density of the vector and also the increased spread of the virus, however, without providing adequate surveillance system for monitoring, management and controlling of dengue viral

infections are useless. The obstacles of current dengue surveillance at Health Department of Jember are occurred due to lack of public response to the onset of dengue viral infections cases in the surrounding environment, reporting cases from the hospitals, clinics, or community health centre have been delayed because of accessibility factor and manual written report. Without the validity of the information from dengue patient data, epidemiological investigation cant provide valuable information to control ongoing outbreaks. To solve the problems faced, in this paper we have developed prevention information system of dengue viral infections for Health Department of Jember. To build robust prevention information system is used the hybrid model to combine both Waterfall and Agile.

The Waterfall model has been the ideal choice for software development. In this model, an idea becomes usable software in a sequential process that cascades through the stages of initiation, analysis, implementation, testing and maintenance. The Waterfall model is an approach for developing software that breaks a project into finite phases. One should move to the next phase only when its preceding phase is reviewed and verified. In waterfall model, phases do not overlap as shown in Figure 2.

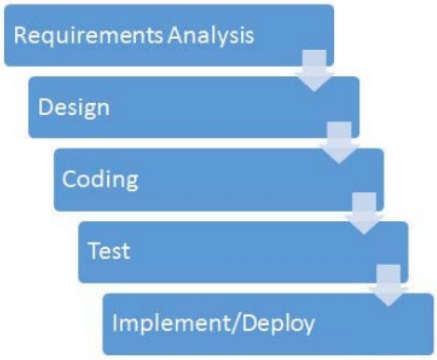

Fig. 2. The phases of Waterfall model

Waterfall model has some advantages to develop software: (1) simple and easy to understand and use, (2) rigid model where each phase has specific deliverables and review processes, (3) documentation and artefacts meticulously maintained, and (4) suitable for projects where requirements are well understood. The limitation of this model is that (1) not suitable for projects where requirements are at a risk of changing, (2) cost of fixing defects is very high when detected at a later stage, (3) not a good model for complex and long projects, and (4) no working software is produced until late during the lifecycle.

Software development process using Waterfall is often blamed for being unable to adapt to the changes which often makes testing products or changing alterations quite impossible. An Agile approach is often considered the solution for this problem. According to [1] report, Agile succeeds three times more often than Waterfall. Because the use of Agile model helps companies work more efficiently and deliver winning results, Agile adoption is constantly increasing. Agile is a set of methods and methodologies that help your team to think more effectively, work more efficiently, and make better decisions. These methods and methodologies address all of the areas of traditional software engineering, including project management, software design and architecture, and process improvement. Each of those methods and methodologies consists of practices that are streamlined and optimized to make them as easy as possible to adopt. Agile is also a mindset, because the right mindset can make a big difference in how effectively a team uses the practices. This mindset helps people on a team share information with one another, so that they can make important project decisions together instead of having a manager who makes all of those decisions alone. An agile mindset is about opening up planning, design, and process improvement to the entire team. An agile team uses practices in a way where everyone shares the same information, and each person on the team has a say in how the practices are applied. Some of the key values to the philosophy behind Agile development processes are as follows: (1) customer involvement in the process, (2) high return on investment (ROI) as working software is delivered frequently, (3) even late changes in requirements can be easily accommodated, and (4) continuous improvement to both product and process. However, disadvantages of the Agile model are lack of emphasis on designing and documentation, and team should be stable and skilled.

Scrum has become rapidly accepted as the most widely Agile model in the world. It provides a good general foundation that can be adapted to fit a very broad range of projects. Scrum is also not limited to software development, but that is where it is most widely used at the current time. Scrum has been collaborated with embedded software development to speed up system engineering process in automotive industry [2]. Scrum implementation is applied to develop Internet of Things-a low-cost wireless monitoring system, that enables air quality referential parameters measurements based on multilayer distributed model with an Arduino platform [3]. Scrum is generally called a framework rather than a methodology because it is meant to provide a framework for organizing the work rather than a more specific, well-defined methodology or how the work should be done. A high-level overview of the Scrum framework and its elements are shown in Figure 4 based on [4].

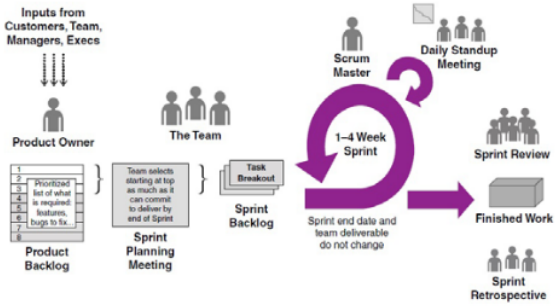

Fig. 3. Scrum framework

Agile and Waterfall are such opposites that it is hard to say which one is better. It really depends on the project, the level of clarity around requirements, and how flexible you can be. If you have a clear picture of what the final product should be, you have fixed requirements that will not change, and you are working on a relatively simple project, some argue that Waterfall is a better choice than Agile. If you do not expect to deal with change, Waterfall is a straightforward, efficient process. The issues with Waterfall come when you have to accommodate changes. If you don not have a clear picture of the final product, you anticipate changes, and you are working on a complex project, Agile is superior. Agile is designed to accommodate new, evolving requirements any time during the project, whereas Waterfall does not allow you to go back to a completed phase and make changes. Leveraging both the Waterfall and Agile approach ensures the success of the project. It removes the disadvantages of both the models while bringing together the advantages of both.

II. Related Work

The development prevention information system of dengue viral infections at Jember must involve the participation of many stakeholders such as Health Department of Jember, Information Department of Jember, community health centre, clinics, hospitals, and society. Each of them has duties and responsibilities in surveillance and epidemiology activities. Success in building information system in a dynamic working area with many participants involved is needed adaptive framework applied to follow the requirement changes. The Waterfall method considers a project as having sequential phases, where each of phases must be finished and accepted before starting the next phase. One of the fundamental problems with the waterfall approach that user recognized was that the entire process was sequential and an error or omission made in one of the very early phases of the project may not have been discovered until the very end of the project which might require huge amounts of rework to the work that had already been done in the early phases of the project. For that reason, more iterative approaches began to evolve that featured more incremental and evolutionary development approaches [4-5].

Iterative development tries to break up large projects into incremental and effort focused primarily on breaking up the development phase into iterations. The purpose for every iteration has limited product release which consists of mainly current version, often partly finished, of the working software [4-5]. During the 1980s and early 1990s, there was a proliferation of approaches designed to further improve the methodologies for large, complex software development project. Agile goes further from iterative development.

The Agile Manifesto clearly condensed all of the earlier agile methodologies into a set of clearly-defined values and principles that are still valid today. The Agile Manifesto values that were published originally in 2001 are: (1) individuals and interactions over processes and tools, (2) working software over comprehensive documentation, (3) customer collaboration over contract negotiation, and (4) responding to change over following a plan [4]. Scrum is a subset of Agile and one of the most popular process frameworks for implementing Agile. It is an iterative software development model used to manage complex software and product development. Table I shows some of the key differences and similarities between the Agile approach to software development and the approach typically used for software development in Waterfall projects.

TABLE I. Key Differences and Similarities Between Waterfall and Agile Software Development

	Waterfall	Agile
Sequential	Yes	No
Flexible	No	Yes
Accommodates change	No	Yes
Define requirements	Yes	No
Deliver quality products	Yes	Yes
Continually evolving	No	Yes
Rigid process	Yes	No
Customer involment	No	Yes

The differences between Waterfall methodology versus Agile can be summed up in two words: rigid versus flexible. Waterfall is a much stricter, rigid process whereas Agile is flexible and continuously evolving [6][7]. We recommend using Waterfall if you do not expect changes in scope and you're working with fixed-price contracts, the project is very simple or you've done it many times before, requirements are very well known and fixed, customers know exactly what they want in advance, and you are working with orderly and predictable projects [4][6-8]. And you should use Agile if the final product is not clearly defined, the stakeholders need the ability to modify the scope, you anticipate any kind of changes during the project, and rapid deployment is the goal [4][6-8].

The Hybrid model aims to combine both the models–Waterfall and Agile. It increases speed and quality by adding Agile methodologies to the Waterfall process. In a Hybrid project, you would break out the research, strategy, and planning phases into tasks and proceed with sprints to complete them. The development phase would be just like any other Agile project, with more information up front. You also do not need to wait for one phase to end to start the following phase, which is traditional in pure Waterfall. With Hybrid, when the project can begin, it should begin [9][10].

III. Research Method

The research method used in this paper is mix research composite with software engineering method. Mix approach is selected in order to tackle a given research question from any relevant angle, making use where appropriate of previous research and/or more than one type of investigative perspective. The next phase for mix is the development of prevention information system of dengue viral infections at Health Department of Jember using Hybrid approach (Waterfall and Agile). Framework of Hybrid model is shown in Figure 4. The first phase of Hybrid model is requirements analysis using PIECES framework [11] (Performance, Information, Economics, Control, Efficiency and Security) to drive and support the analysis, which is a checklist for identifying problems with an existing information system as summarized in Table II.

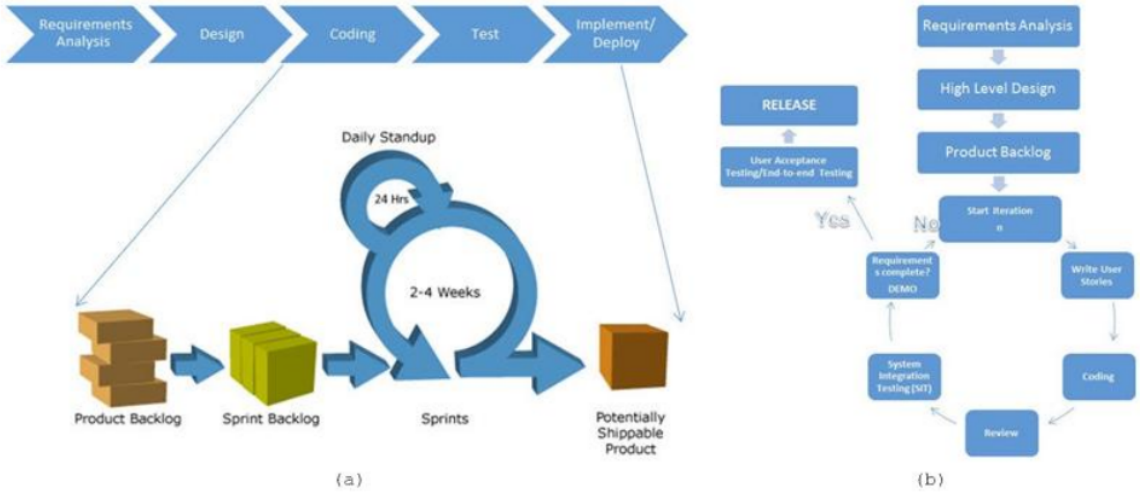

Fig. 4. Agile-Waterfall Hybrid framework: (a) collaborative model, (b) flow diagram

TABLE II. THE PIECES FRAMEWORK FOR REQUIREMENTS ANALYSIS AT HEALTH DEPARTMENT OF JEMBER

Checklist	Identifying Problems
Performance	Response time: - more than 24 hours
Information (and Data)	Outputs: - Lack of relevant information - Information that is not accurate Inputs: - Data is not captured in time to be useful - Data is not accurately captured-contains errors - Data is captured redundantly Store data: - Data is stored redundantly in multiple files - Stored data is not accurate - Data is not well organized - Data is not flexible – not easy to meet new information needs from stored data
Economics	Costs - Costs are unknown Profits - Current marketing can be improved
Control (and Security)	Too little security or control - Input data is not adequately edited - Ethics are breached on data or information - Redundantly stored data is inconsistent in different files - Processing errors are occurring
Efficiency	People, machines, or computers waste time - Data is redundantly input or copied - Data is redundantly processed - Information is redundantly generated People, machines, or computers waste materials and supplies - Effort required for tasks is excessive
Service	- The system produces inaccurate results - The system produces inconsistent results - The system produces unreliable results - The system is not easy to use and to learn - The system is inflexible to change - The system is not coordinated with other systems

The next phase after requirements analysis is to make design/mock-up for the project for preparing to Scrum process. The scrum steps to do as follows:

A. Product Backlog

In first step of Scrum, the product owner is responsible for defining and managing the product backlog on an ongoing basis throughout the project. He can assist in that role by the Scrum master. Because requirements analysis and design had been done in the front, a business analyst may assist the product owner with managing the product backlog. The product owner is also responsible for product backlog grooming. The team (or part of the team including the product owner) meets regularly to "groom the product backlog," in a formal or informal meeting which can lead to any of the following: (1) removing user stories that no longer appear relevant, (2) creating new user stories in response to newly discovered needs, (3) reassessing the relative priority of stories, (4) assigning estimates to stories which have yet to receive one, (5) correcting estimates in light of newly discovered information, and (6) splitting user stories that are high priority but too coarse-grained to fit in an upcoming iteration. The composition of a story is:

- As a <user type> I want to <do some action> so that <desired result>
- <community> I want to <report dengue viral infections suspect> so that <Health Department can take action>
- <community health centre/hospital/clinics> I want to <report dengue viral infections cases> so that <Health Department can take epidemiology action>
- <Health Department> I want to <get dengue viral infections information> so that <do epidemiology action>
- <community health centre> I want to <report epidemiology assessment> so that <Health Department can decide prevention action>

B. Sprint Backlog

Select the activities from the product Backlog that have the highest priority from the Product Backlog as example follow:

- <community health centre/hospital/clinics> I want to <report dengue viral infections cases> so that <Health Department can take epidemiology action>

C. The Sprint

The important phase of a scrum framework is sprint. It is a time division iteration of scrum practices. At the ending of every sprint we get an operational, shippable and potential increment of the product. Each sprint consists of Sprint Planning Meeting, Daily Scrum and the development in Sprint, Sprint Review Meeting, and the Sprint Retrospective.

D. Daily Scrum

In this meeting the team discuss about the effort put into practice from the previous scrum meeting, plan the works that are to be finished before the next daily scrum meeting and talk about the problem that happen in the current Sprint. To measure the ongoing actual velocity of the team against the projected velocity and adjust the projected velocity based on actual results is used a burn-down chart shown in Figure 5.

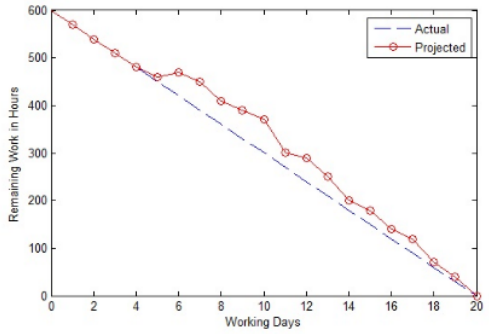

Fig. 5. Burn-down chart of project

E. Sprint Review

After the team demonstrate the product backlog tasks which has been done in the current Sprint. Stakeholders give their opinion towards the improvement of the product. Product owner talk about the product backlog as where it stand and reorder it according to need. The team discusses about what went good and what went bad in the previous sprint to deal with the present situation.

F. Sprint Retrospective

Sprint retrospective is a practice of assessment and examination of area where excellence is needed so subsequent to every sprint before the next sprint the scrum team should examine what is going fit and what is not going well and where the scope enhancement is needed.

IV. IMPLEMENTATION

A. System Design of Prevention Information System of Dengue Viral Infections

This project is developed using 3-Tier Architecture consisting of presentation tier, business logic/application tier, and database tier as shown in Figure 6.

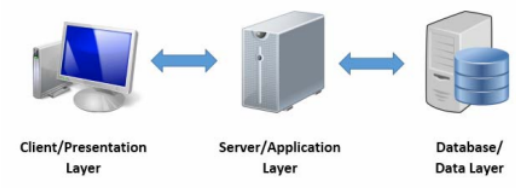

Fig. 6. Architecture of the project

B. Implementation of Prevention Information System of Dengue Viral Infections Services

This project uses MySQL service for database including store procedure, view and materialized view, trigger, PHP as programming language, and Bootstrap for responsive design.

C. Implementation of Login Page

There are three options login in this page as shown in Figure 7. First button, “Login”, is used to sign in for register user (community health centre/hospital/clinics) to report cases to Health Department of Jember. Second button, “Laporan Masyarakat”, is used to community to report dengue viral infections suspect to Health Department of Jember. And the last button, “Registerasi Petugas”, is used to register user from community health centre/hospital/clinics approved by Health Department of Jember.

Fig. 7. Login page

D. Implementation of DenguePatient List

Figure 8 is used to display list of patient from reporting by community health centre/hospital/clinics.

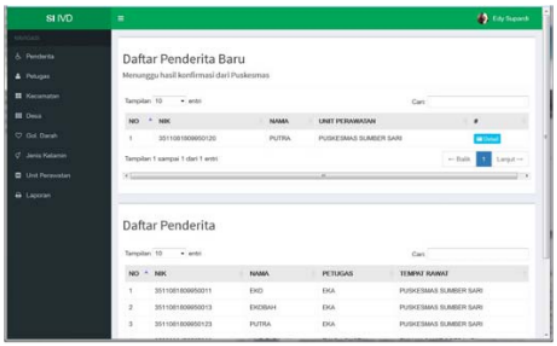

Fig. 8. List of dengue patient

E. *Implementation of Dengue Medical Report and Patient Diagnosis*

Figure 9 shows that list of dengue medical report from all patient reported by health care unit and the diagnosis decision of dengue viral infections such as DF, DHF, DSS.

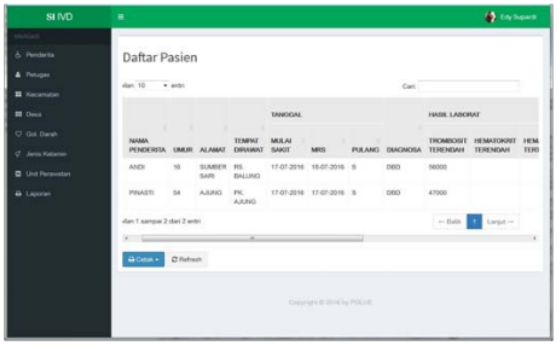

Fig. 9. Dengue medical report and patient diagnosis

F. *Implementation of Community Report*

Figure 10 is used to community to make a report of dengue suspect that found in their surrounding environment.

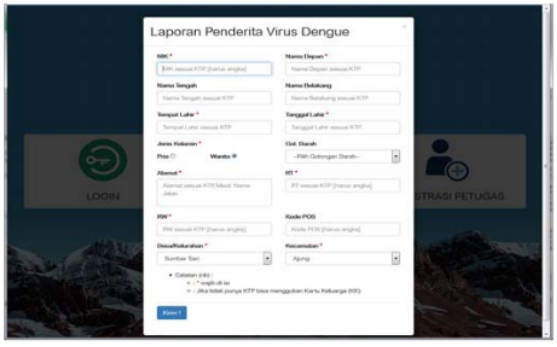

Fig. 10. Community report

V. CONCLUSION

This research presents a Prevention Information System for Dengue Viral Infections for Health Department of Jember. The earlier version of system is still manual report. From the requirements analysis report using PIECES framework, there is many changes in requirements. So, the applied of Waterfall is unable to adapt to the changes which often makes testing products or changing alterations quite impossible. To overcome this problem is used to Agile approach. Meanwhile, Agile must be aware to limited production time and lack of emphasis on designing and documentation. So, the Hybrid model between Agile and Waterfall makes best solution to eliminate flaws of Agile and Waterfall for the project implementation. Leveraging both the Waterfall and Agile approach ensures the success of the project. It removes the disadvantages of both the models; while bringing together the advantages of both.

ACKNOWLEDGEMENT

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