A Strategy for the Development of Disease Surveillance Systems in Resource-Limited Context

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***Abstract*- As the threats to public health have been increasing recently, the need for a better disease surveillance system is unavoidable. An effective strategy for developing a disease surveillance system is therefore required to guide the analyst and designer in preparing the blueprint. This paper provides a development strategy for building a disease surveillance system based on the medical and technological perspective, especially for resource-limited context in which the analysts and designers have to consider several development and implementation challenges.**

I. INTRODUCTION

The emergence of communicable diseases, both for relatively new outbreak such as avian influenza or traditional outbreak such as food and water-borne diseases, have challenge the health authorities to anticipate and provide proper response as quick as possible. It is even exacerbated with the possibilities of biological wars and terrors where infectious diseases are used as the lethal weapons in some war fields by contradictory camps.

With the advancement of transportation means, the outbreak can now spread rapidly. People travel throughout region and country in which they can bring or infected diseases to and from the visited places. It all has made the challenge in facing the infectious and communicable diseases more futile.

Health authorities from around the world have been realize this challenge and try to provide all efforts to anticipate the worst situation. They have considered that any problems to the public health are actually a potential threat to their nation security. This is why a lot of initiatives on the development of disease surveillance systems especially for early warning of disease and outbreak occurrences have been started.

Developed countries have their privileges in developing and implementing disease surveillance systems due to their infrastructure and human-resource readiness. Developing and under-developed countries, on the other hand, have relatively limited infrastructure and lower human-resource readiness.

The aim of this paper is to provide a strategy for developing disease surveillance systems particularly for resource-limited context where the deployment requires several considerations. The strategy is based on both medical and technological perspective.

This paper will be structured as follow. Section 2 reviews the literature on disease and epidemic outbreak tracking systems from technological and medical perspective. Section 3 discusses the strategy for developing and implementing diseases surveillance systems. Eventually, section 4 summarizes this paper.

II. REVIEW ON DISEASE SURVEILLANCE SYSTEMS

Based on medical science perspective, disease surveillance systems can be classified according to the way on how the data are gathered, namely: traditional (diagnostic) and syndromic (pre-diagnostic) surveillance [1].

The traditional (diagnostic) surveillance is a type of disease surveillance where the data that are going to be entered into the system is obtained from the medical authorities (doctors, team of paramedics, etc.) diagnostic results. This type of surveillance provides an accurate report since the gathered data is based on very mature result of paramedic diagnostics which in some cases are strengthened with the laboratory data. However, this kind of surveillance takes a lot of time in waiting the diagnostic result and requires medical authorities' approval for data to be entered into the system.

In contrast to the traditional (diagnostic) surveillance, the syndromic (pre-diagnostic or symptom-based) surveillance does not require diagnostic results from the medical authorities. Instead, it gathers the data based on the syndrome or symptom felt by the patients that are observed by the paramedics (Anamnesis). Although it does not provide report as accurate as the traditional surveillance, it offers quicker report since the data can be compiled and analyzed as soon as the patient observation has been conducted. Another advantage for this type of surveillance is that it does not require the availability of paramedics with certain level of expertise to enter the data into the system, a condition that hinders the deployment of traditional (diagnostic) surveillance for regions having limited medical expert coverage such as in developing and under-developed countries.

From the data gathering perspective, data might be collected using two types of approach, namely: structured and unstructured.

Structured data gathering is a kind of approach where data are collected from the authoritative parties such as paramedics, health authorities, etc. Since the data are gathered by design, the database format can be structured accordingly. However, this type of data gathering implement passive mode, meaning that the system collect data whenever an event occur and reported to the authority. This kind of data gathering can be

deployed for both resource-limited and non resource-limited context.

Unstructured data gathering, on the contrary, collect data from several sources both from authoritative and non-authoritative references. Since the data are collected from various sources, the database format cannot be structured according to the designers' need. This type of data gathering implement active mode, meaning that the system actively collect data anytime it requires from various sources such as mass media, social networking, blog, and media having user generated content. This kind of data gathering can normally be deployed only for non resource-limited context.

Meanwhile, according to technological perspective, disease surveillance systems can be developed and implemented either manually or automatically (meaning electronically). Among the manual development and implementation are: paper-based and communication tool-based surveillance. Paper-based technique is the oldest way of conducting disease surveillance. This technique relies on paper-based reporting from the lowest-level officers/paramedics send over their higher rank colleagues to be compiled and analyzed further. This process is apparently slow (time consuming) and error-prone since it pretty much involves human tasks. However, this technique requires minimal investment and very suitable for places with strongly limited-resources.

The communication tool-based surveillance is an extension to the paper-based technique, in which it involves the use of communication tool such as telephones, facsimiles, radio communication devices, telegraphs, emails, etc for reporting purpose. Although this technique already uses technology, however there still no automation in compiling and analyzing the report. This type of technique is actually similar as the paper-based technique but with making use of the available communication tools without further exploitation on process automation.

The main difference between manual and automatic (electronic) disease surveillance is in the way on handling report compilation and analysis. Manual surveillance requires report dataset to be compiled and analyzed by human. Meanwhile, automatic (electronic) surveillance utilizes technology for the compilation and analysis of report dataset. Hence, automatic (electronic) surveillance systems can result in faster and more accurate report than their manual counterparts due to the use of technology.

There are two types of technology used as the building platform for automatic (electronic) disease surveillance systems: desktop-based and mobile-based system. Although they implement different technology, both rely on web-based platform.

Desktop-based systems normally developed and implemented in a non resource limited context where the environment into which the systems are going to be deployed have a certain readiness level. At least, there are two prerequisites the environment has to provide in order for a desktop-based system can be deployed: infrastructure and human-resource readiness. Infrastructure readiness means that the environment into which the systems will be deployed should have particular instruments where the desktop application can be installed and executed and also sufficient internet connection coverage where the data can be transmitted from all data entry point to the datacenter and vice versa. The instruments can be in the form of PC desktop, laptop, or netbook with sufficient component specifications hence the application can run on top of the particular hardware. Internet connection must be widely available and covering most of the regions where the system is deployed. The connection should also have enough bandwidth hence the data transmission can run over it. Human-resource readiness means that the environment should have person with the capabilities to operate and maintain the system.

Considering the implementation context for desktop-based surveillance systems, thus most of the places which developed and implemented this type of system are those of developed countries (such as European and North American). Only a few developing countries that already deployed this type of system, such as Indonesia with EWORS (Early Warning Outbreak and Response Systems) [2] and Peru (Alerta Disamar) [3].

Mobile-based systems normally developed and implemented in a resource-limited context where the environment into which the system are going to be deployed does not have a certain level of infrastructure readiness, especially in regard to the internet connection coverage. Most developing and under-developed countries, especially those with vast areas or uncentralistic settlement pattern, tend to develop and implement mobile-based system. There are at least two advantages of using the mobile-based system for deploying the disease surveillance system. First, data transmission can be arranged over mobile phone network that even though with a relatively limited bandwidth but have wide coverage. Second, the availability of the instruments (especially that for data entry) which is cheaper and widely available. Another advantage of using mobile phones as the tool for data entry is that most people are getting used to mobile phones hence minimizing the adoption efforts, learning time, and training. It helps the responsible person in mastering the application thus increasing human-resource readiness level.

As the examples of mobile-based disease surveillance systems are: AESSIMS that has been deployed in Brazil, EpiSurveyor which has been successfully deployed in Kenya and other places, and InSTEDD that has been deployed in South East Asia [1].

II. THE STRATEGY FOR DEVELOPING DISEASE SURVEILLANCE SYSTEM

The development of disease surveillance systems, both for resource-limited and non resource-limited context, can adopt a general software system development method. In this paper, a software system development method particularly for requirements engineering called Concern-Aware Requirements Engineering (CARE) method is adopted.

Using the CARE method, concerns are initially elicited from the stakeholders of the proposed system. In regard to the

disease surveillance systems, stakeholders are among others the paramedics who will directly use the system and the health authorities who will use the result of this system. Concerns should also be elicited from the developers who will develop the system. Particularly for this paper, the concerns that will be used as the development consideration are mainly from the developers' perspective. Two concerns that will be highlighted in this case are: infrastructure and human-resource limitation.

By following the CARE method, these concerns will later be manifested as development goals and issues. In this case, the concerns infrastructure limitation will be manifested as a goal to "develop a mobile-based system" whereas the human-resource limitation will be manifested as a goal to "develop a syndromic (pre-diagnostic) based system. The first goal is actually has a positive contribution to the second goal in which the implementation of mobile-based system can reduce the human-resource readiness. A mobile-based system deployment could reduce the learning time where the operators do not require intensive training to get acquainted with the hardware since most people already familiar in using mobile devices than, say, desktop PC.

The decision to implement a syndromic-based surveillance system is based on the consideration of the deployment setting in a resource-limited context where the paramedics are quite limited and mostly concentrated at few places (such as big cities). Hence, the option of implementing traditional (diagnostic) surveillance cannot be accommodated in this context.

Table I summarizes the design decision for developing disease surveillance system for resource-limited context.

TABLE I
THE DESIGN DECISION FOR DEVELOPING DISEASE SURVEILLANCE SYSTEM FOR RESOURCE-LIMITED CONTEXT

Data collection	Data Gathering Type	Technology Platform
Syndromic (pre-diagnostic) surveillance	Structured	Mobile-based system

Such kind of design decision as shown in Table I can later be transformed into system architecture. A mobile-based system is actually a surveillance system in which mobile devices are utilized as the front-end side (entry point interface) from which data are entered. By considering the internet connection limitation, thus data will be transmitted over GSM or CDMA network. In a more advance environment, data transmission can be arranged over 3G, HSDPA or even LTE network.

At the back-end side, the data will be collected at the database server where all its content can be accessed using any any kind of devices owned by the health authorities (desktop PC, notebook, netbook, tablet, etc.) off course by authorized parties. Database can be accessed using desktop-based, web-based, and even mobile-based applications.

This kind of architecture makes the dissemination of information to various parties possible. Data thus can be sent to the person at every level of the institution: entry point officer through mobile-based application, health authorities at all levels through desktop-based or web-based application, and community who want to obtain the information through web-based application.

Figure I depict software system architecture for the proposed disease surveillance system for resource-limited context. This architecture can be used as the referenced model in developing and implementing disease surveillance system in which the connection medium uses mobile network (GSM or CDMA). In practices, this architecture can be manifested by maximizing the utilization of SMS gateway, GSM/CDMA data connection, etc.

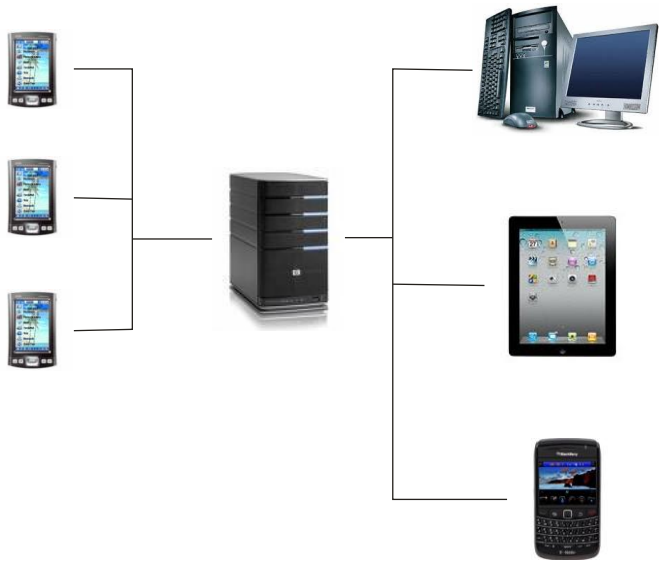

Fig. 1. A reference architecture for disease surveillance systems on a resource-limited context

IV. SUMMARY

A reference architecture for the development and implementation of disease surveillance systems particularly for resource-limited context has been proposed. The reference architecture was proposed based on three analysis perspectives: medical data collection, data gathering type, and technology platform perspective. Based on this analysis, a disease surveillance system for resource-limited context will be properly developed and implemented if following syndromic (pre-diagnostic) data collection, structured data gathering, and mobile-based platform.

In practices, this reference architecture can be translated into several kind of deployment. For example, data transmission medium from mobile devices to database server can use GSM, CDMA, 3G, HSDPA, or even LTE. For the back-end side, various kind of platform such as desktop-based, mobile-based, or web-based application can be use to access the database using different kinds of technology: desktop PC, tablet, mobile devices, etc.

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