Design of the Integrated Health Information System in the District of Bangli

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Abstract— **Healthcare information, technology, product of technology, and information technology that supports the development of healthcare can be resulted from research and development of science and technology. The presidential regulation stated that the components of the healthcare management were grouped into sub-systems that handle the management, information, and regulation regarding the healthcare itself. Therefore, this work was aimed to provide a design of the integrated e-health system in Bangli District, Bali. Enterprise Application Integration (EAI) approach was used in this health information system integration strategic planning. The results provided the identification of the business process and its challenges of the current system. Method of network infrastructure connection was also provided. The design was also covered the future planning of development which based on their priority for the next five years, including the challenges for bigger integration to the systems that were built by departments from other related fields.**

Keywords—Bangli; e-health; enterprise application integration health information system; system integration.

I. INTRODUCTION

The government of the Bangli Regency [1] is one of the local governments that show serious commitment regarding the development of e-Government. It is a form of supports for the central government who aimed at a good, transparent, effective, and efficient governance system by applying the Information and Communication Technology (ICT) within the government managements. The commitment of the government of Bangli Regency in implementing E-government had begun in 2010. It was proven by the establishment of the Information Systems Development Implementation Team in the Bangli Regency. Through the team, Bangli has established the masterplan of e-Government development for the year 2010 until 2015. Further, the team has also provided the continuity of further masterplan of 2016 and forward.

The vast development of ICT, including in Indonesia, has increasingly encouraged the development of both hardware and software for the services or processes that happened within the government itself. The requirements of data processing and further information retrieval are increasingly complex and large nowadays. Those requirements influence on how the data and information are acquired, stored, processed, and distributed or shared within or among institutions. Therefore, the design of modern infrastructure, particularly the computer network and information system, is needed to support the system in providing fast yet accurate data or information.

Currently, the network infrastructure that connected the health institutions in the Bangli Regency is not fully supported by fiber optics. The majority of those institutions still use the existing wireless technology. Although the technology is reliable, it is very vulnerable to interference from outside such as weather or radio signals. However, installing the fiber optics into all of the health institutions in the Bangli Regency is challenging as well due to its geographical position where some of the institutions are located in hills or mountains area [2].

The integration of various systems within the e-Government environment has always been considered been important because it can provide the highest positive impact on the implementation of good governance [3, 4]. Many countries have had planned, implemented, or developed e-Government with various frameworks or integration methods [5, 6]. Implementing e-Government is not an easy task since many challenges; political, technical, economic, social, or organizational; may hamper the efforts in establishing the appropriate systems.

The integration of various services within the governance can also profitable for other areas of services such as in healthcare. E-Health can take advantage of data provided by other government institutions, for example, the data of the residents. Fluent interoperability between interrelated systems becomes very crucial. Therefore, it is important to make a clear and proper planning before implementing the integration process.

This work was aimed to provide documents as a guideline that can be used to determine the direction for planning, structuring, implementing, and developing the ICT infrastructure and information system in Bangli Regency, particularly in the field of healthcare services. It was expected to contribute knowledge for the Office of Health in Bangli Regency in implementing the fiber optic-based network infrastructure and integrated health information systems using the proper and later technology for the next five years. The resulting implementation of e-Health was expected to be able to support the further development of e-Government in the District of Bangli.

II. MATERIAL AND METHODS

A. Related research

Many works related to the integration and interoperability of systems, especially within the healthcare services, had been conducted in Indonesia. However, most of them were still focus on the partial internal integration of the health information itself. Reference [7] conducted research regarding the web service-based application that integrated the community health center with the hospital services. The results obtained from the work were the implementation of integration between the central hospital and its supporting health center using web-based data communication. Reference [8] examined the integration between the laboratory and the central hospital information system using the Enterprise Application Integration (EAI) at dr. Moewardi hospital in Surakarta, Central Java. Reference [9] implemented the integration of the information system in the community health center into the information system of the Health office of Gunung Kidul Regency, Yogyakarta. Although these researches had successfully integrated the existing information system within the relevant departments, the data communication among the community health center had not been done yet.

Some works also integrated the healthcare information system in the health institution to the insurance company or institution. For example, reference [10] had successfully implemented a health insurance policy in Jakarta by taking a case study of the integration of the Jakarta Healthy Card (KJS) program with the National Health Insurance (JKN). This research had taken one step further compared to other integration. However, it still cannot answer the requirements of sharing data between institutions to provide patients-related services.

Research had been done to provide improvements in healthcare services. However, the requirements for further advance works related to clinical trials and research has raised the demand for systems that are ready to enable the process of data sharing. Moreover, in developed countries, the scans that were taken have already in the form of digital images instead of physical films. Therefore, it becomes one of the basic requirements for healthcare institutions to share data among them. It is also the reason for the emergence of the Cross-Enterprise Document Sharing (XDS).

Reference [11] implemented a method for sharing medical images data to provide collaborative medical services based on XDS for imaging (XDS-I) profiles. XDS-I itself is a variant of the XDS profile that is focused on the problem of medical image transfer. With the increasing need for medical images as one of the means used to transfer data better than physical media, the Radiological Society of North America (RSNA) is challenged to be able to develop and implement the transport method [12].

B. e-Government and e-health

In essence, E-government is the use of information technology that can improve relations between the government and other parties, both internals and externals. The e-Government brings many benefits including good services to the community, improves the relations between the government and business institutions or public, community empowerment through easy-accessible information, also a more efficient implementation of government.

Cross-Enterprise Document Sharing (XDS) is an initiation of Integrating Healthcare Enterprises (IHE) to facilitate registration, distribution, and access to electronic medical records of patients between health institutions. XDS provides standard specifications to manage the process of sharing data between health institutions which has now developed further to be able to facilitate the transfer of medical images. XDS itself is designed to be able to accommodate many things related to patient identification, access to information, as well as the structural format or representation of clinical information.

There are several important elements in an XDS profile, which are document repositories and document registry that is located in an affinity domain. A document repository is responsible for storing documents in a transparent, secure, resilient and persistent manner. Whereas a document registry is tasked with storing information or metadata about these documents so that the documents needed for the care process of a patient can be easily found, selected, and accepted. Furthermore, there are also part of the systems that can act as Document Sources or Document Consumers that transmit documents to register or query relevant documents. The integration of health information systems based on the XDS profile scheme can be seen in the following figure.
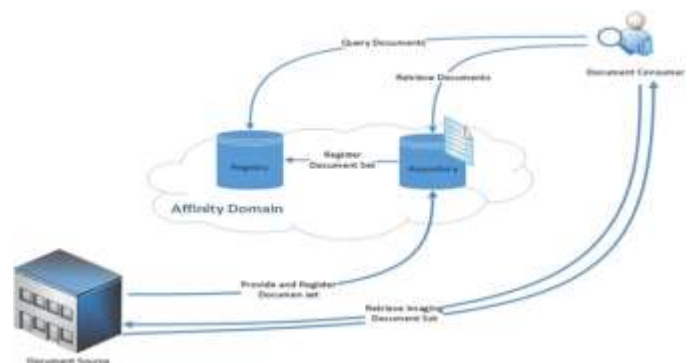

Fig. 1. Image of document transaction scheme based on XDS profiles [13]

C. Method

This work was done by implementing three phases that are the design of network topology and infrastructure, planning of information system integration using the enterprise application integration (EAI) approach [14], and the design of network security. The first phase was indicated by the design of the Metropolitan Area Network (MAN) of the Bangli Regency, the design of data center and the server topology, the topology design of public health departments in Bangli, the design of the connected public health centers, and the design of the network of general hospital of Bangli Regency. The second phase, the EAI-based approach, defined the design of the SOA-based EAI architecture of each element of the health institutions, i.e. the public health centers, general hospital, and the health department of Bangli Regency. Meanwhile, the third phase was

focused on the design of the data transmission security within the designed integrated network.

III. RESULTS AND DISCUSSION

There are eleven public health centers and one general hospital in the Bangli Regency Government. The distribution of those public health centers and hospitals along with the condition of the system and the availability of network infrastructure can be seen in the table below. Most of the public health center utilizes the SIKDA GENERIK, an information system that was built and distributed by the Indonesian health ministry.

TABLE I. THE LIST OF PUBLIC HEALTH CENTER AND GENERAL HOSPITAL IN BANGLI REGENCY

Sub- District	Name of Health Institutions	Information System	NETWORK	
			LAN	Inter net
BANGLI	PUSKESMAS BANGLI 1	SIKDA GENERIK	Y	Y
	PUSKESMAS BANGLI 2	SIKDA GENERIK	Y	Y
	RSUD BANGLI	HOSPITAL IS	Y	Y
SUSUT	PESKESMAS SUSUT 1	SIKDA GENERIK	Y	Y
	PUSKEMAS SUSUT 2	SIKDA GENERIK	Y	Y
KINTAMANI	PUSKESMAS KINTAMANI 1	SIKDA GENERIK	Y	Y
	PUSKESMAS KINTAMANI 2	SIKDA GENERIK	Y	Y
	PUSKESMAS KINTAMANI 3	SIKDA GENERIK	Y	Y
	PUSKESMAS KINTAMANI 4	SIKDA GENERIK	Y	Y
	PUSKESMAS KINTAMANI 5	SIKDA GENERIK	Y	Y
TEMBUKU	PUSKESMAS TEMBUKU 1	SIKDA GENERIK	Y	Y
	PUSKESMAS TEMBUKU 2	SIKDA GENERIK	Y	Y

The existing system was analyzed to understand the business model, network infrastructure, data security systems and the patterns of the management of health information in the Bangli District Health Office. The process of recording medical data for health services in hospitals, health centers within the Bangli District Government Health Office was still partially done. Patient medical record data were stored merely in hospital databases. The public health centers where patients visit has problems within its referring processes between the public health centers or to the general hospital. Furthermore, the problem was also existed in the reporting services from the public health center to the health departments in Bangli Regency.

Several problems were found i.e. the SIKDA GENERIK server was under the management of the Indonesia Health Ministry, the inconsistent access of the system, and the system was not integrated into the general hospital system. These problems caused discomfort from the work processes that were done by the health practitioners and policymakers within the health institutions in Bangli.

The identification of health services and reports using the existing health information system scheme including (1) the medical records of the patients are stored locally in the public health center or the general hospital only. Therefore, when a patient was referred from one institution to another the data acquisition were likely to be done again; (2) there were duplication of medical records causing inconsistent treatment of a patient by different health institutions; (3) the reporting processes were mostly done manually in conventional manner; (4) the reporting of a specific disease from the same patient will be reported several times by different health institution that can caused data inconsistencies; (5) there were privacy and confidentiality concern related to a special diseases that must be kept away from public consumption since the reporting process was still done and delivered manually; and (6) frequent delays of actions caused by the big latency and inaccuracy of the data transfer between health institutions.

The business process of health services with current health information system (HIS) can be described in figure 2. Meanwhile, figure 3 shown the existing network topology for the health systems in Bangli Residency.
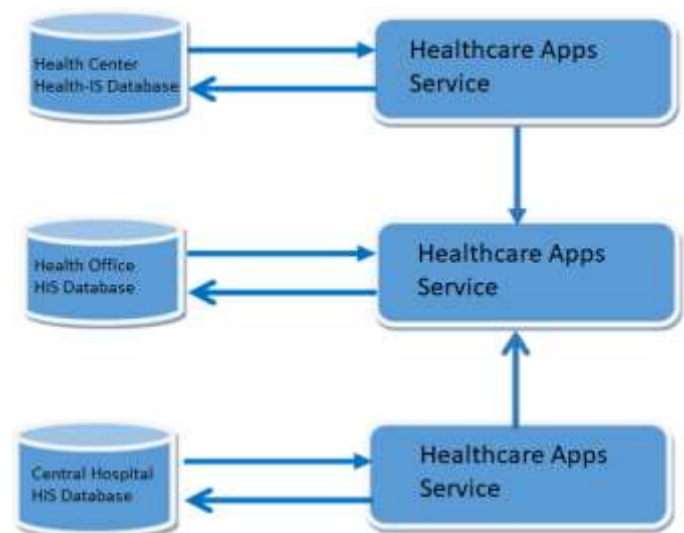

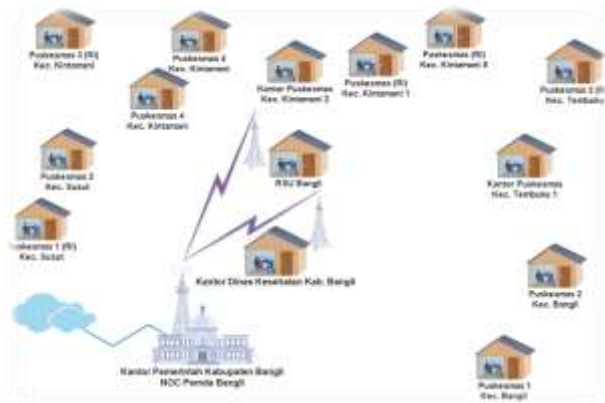Fig. 2. Business process of the health services using current HIS

Fig. 3. The existing network topology and network operation center (NOC) of the health services in Bangli

To support the ICT infrastructure to connect all of the health services in the District of Bangli, several problems have to be tackled first. As shown in figure 3 above, the existing network connection only extend from the data center to the Bangli's health department and general hospital but there are no connections to the public health services. The basic network topology that exists inside the public health services and general hospital can be seen in figure 4 below.
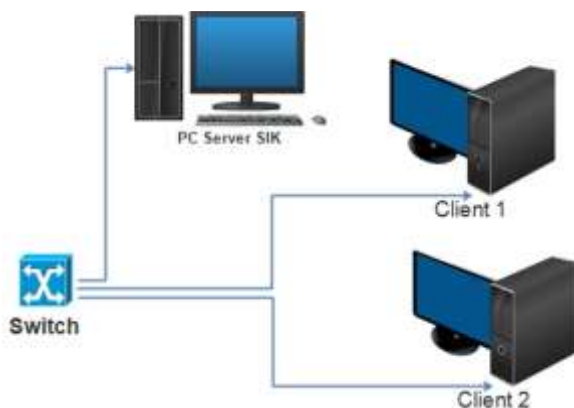

Fig. 4. The basic LAN topology inside the health institutions in Bangli District

The designed network can be described as follow:

1. The network operation center (NOC) room consists of data servers that control all of the connection-based processes from the Health Department, general hospital, and the public health services. It connects the network of health services from all three type of institutions.

2. Health Department holds the secondary important roles in the backbone of the MAN network. All of the business reporting processes will be carried out on the department's side. The connection from the department to the NOC building uses the tunneling techniques, implementing the PPPoE protocol.

3. General hospital become another important role in the backbone route. The health service business processes such as referral of health care from other institution, the

reports are done in the general hospital system in accordance with the need of the management requirements where all data can be access in real time from the NOC servers. The connection also uses the tunneling techniques with the support of PPPoE protocol. In addition, in order to provide a more informative system, the information system of the Bangli general hospital should be better to be equipped with an SMS referral gateway service as well. It is specifically for the emergency referral services such as pregnant mothers that are handled by the remote Midwives. This service is useful in the area where internet connection is scarce.

4. The public health centers are the front line of the health care services in the sub-district and rural areas. The centers' records of the patients' visit and treatments should be able to be synchronized to the data in the Health Department through the designed middleware of the integrated system, therefore the data sharing between healthcare institution can be enabled easily. However, this effort must comply with the applicable regulation. Furthermore, for the safety of specific diseases such as HIV/AIDS, the officers of the service should provide special notification while synchronizing data so that patient data are only available for the authorized actors only through the proper protocols. The connection between health centers and the Health Department (the NOC) also implements the PPPoE protocol so that each center is a PPPoE client.

Therefore, it is important to establish the connection between health institutions in order to provide the connectivity that is required for an integrated system. We have provided the design of the infrastructure and topology of the network of the Metropolitan Area Network (MAN) of the Health Department of Bangli that can see as follow.

Fig. 5. Design of the MAN topology of the Health Department of Bangli

The MAN network will connect to each of the health institutions in the region of the District of Bangli. Most of the health institutions have already connected to the internet, which means that data can be delivered online. The following figure 6

is the design of infrastructure and network topology of the Bangli General Hospital.
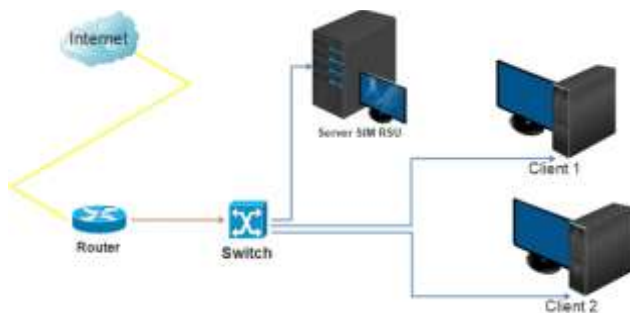

Fig. 6. Design of network topology in the general hospital

Other things that can be observed from the description above are as follows.

1. The health information system running in the Bangli Regency Health Office is currently still not been integrated.

2. Utilization of Health Information Systems has not been utilized properly due to the lack of network technology support from the health centers to the Health Department or the general hospital in Bangli Regency.

3. The data transfer process from the client system from the health center to the Health Department server is mostly still done manually.

4. The Security System and supporting network for the integrated Health Information System process do not yet exist, both on the side of the Health Department and Health Center.

The web services were designed to connect all of the health institution in District of Bangli. Three main groups were involved in this integrated system i.e government agencies, general hospitals, and health services. The connectivity and services shared within the groups are shown in figure 7.
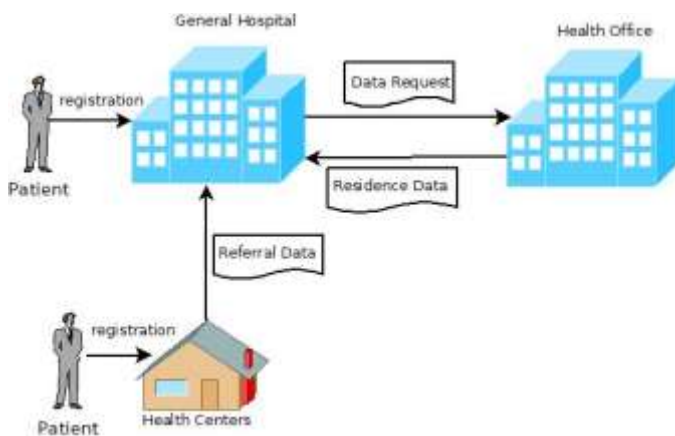

Fig. 7. Processes flows and data shared between institutions

This early stage of implementation has fulfilled the requirements of the stakeholders in those three institutions. However, further developments were required to provide more comprehensive health care services. At the moment, there are several related information systems that are being developed by the government of the District of Bangli. These information systems will be part of the big e-Government in Bangli. Therefore, many features that can be developed within the healthcare information system itself and the integration processes including the healthcare data in the District of Bangli. Furthermore, more stakeholders will be involved in near future. The national insurance system has already had their services that can be useful for the improvement of the healthcare service, not only for the residences of Bangli but also the non-residences from other places in Indonesia. However, clear regulations have to be established in order to implement the integration between the health information system and the insurance system.

The integration of health information system and other related systems required a good security scheme since it exchanges sensitive data. These data should be protected in order to avoid the breach of personal data, especially those that stored in the data center. The data protection scheme can be seen in figure 8 below.
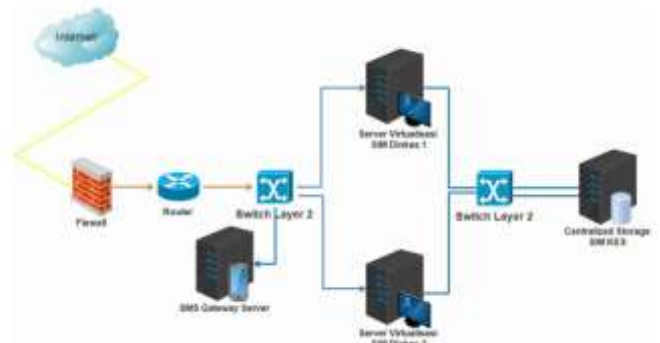

Fig. 8. Scheme of the network and data security in the data center of the District of Bangli

IV. CONCLUSION

Based on the description and analysis, it can be concluded that this research has produced a strategic design of the integration of health information systems and network infrastructure design at the Health Department in Bangli District. This result can be used to plan the implementation of Health Information System Integration in the Bangli District that is integrated with other related institutions. With the network infrastructure design and network topology from MAN topology, VLAN, Health Information System Integration, network security system and Data Center design, the Health Department already has a clear blueprint for the development of the Health Information System and its infrastructure following future technological developments. With the support of health information systems, the design of a good network infrastructure, the database integration process will be better and safer, so that the service process from the Health Department, health centers, and general hospital will be greatly improved.

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