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WORD COUNT 4811
TIME SUBMITTED 12-MAR-2020 11:13AM
PAPER ID 56387524

Bulletin of Electrical Engineering and Informatics
Vol. 9, No. 1, February 2020, pp. 354~361
ISSN: 2302-9285, DOI: 10.11591/eei.v9i1.1825

Interoperability framework for integrated e-health services

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Article Info

Article history:

Received Aug 26, 2019
Revised Oct 31, 2019
Accepted Nov 24, 2019

Keywords:

E-health system
Interoperability
SOA
SOAD
Web service

ABSTRACT

As one of the country with largest population in the world, Indonesia is facing major challenge to serve people in various sectors, one of them is health sector. Utilization of Information and Communication Technology (ICT) has a strategic role in improving efficiency and expanding services access. The main challenge related to data interoperability is the ability to integrate and synchronize data sourced from health information (e-health) systems with different (heterogeneous) platforms. This research aims to build a framework to materialize data interoperability and information exchange among e-health systems. The interoperability is materialized by utilizing service oriented architecture (SOA) paradigm and is implemented using Web Service technology. Service oriented analysis and design (SOAD) is used as method in the system development at the analysis phase and designing phase to generate service portfolio which consisting of three levels: conceptual view, logical view, and physical view. This research intruduces Interoperability Matrix (IM) to describe the modules and entities that involved in the framework design. The framework resulted from this research can be used as reference in e-health systems development in variety of health care applications.

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1. INTRODUCTION

At this moment, Indonesia is in the fourth rank, as one of the largest population country in the world. The role of development sector of Information and Communication Technology (ICT) in Indonesia has been widely perceived by society. In the health sector, application of ICT is known as health information systems (e-health). The decree of the Minister of Health of the Republic of Indonesia, number: 192/MENKES/SK/VI/2012 mentions that e-health system is the use of ICT in health sector, especially to improve health service. Implementation and application of e-health in Indonesia has started since 1985 [1], and over time also adapt to the development of ICT which is most of directed to the aspect of health care service. On the other hand, we come to the era of high-speed technology, characterized by cellular technology, high-speed Internet, and wireless communication [2]. This technology encourages the development of e-health in adopting the development of the technology. Ministry of Health of the Republic of Indonesia in 2004 defines the National Health System (SKN) as a setting that compils the efforts of Indonesian integrated and mutually supportive, to ensure the supremacy of health as

manifestation of general welfare as intended in the opening of Indonesia constitution (UUD 1945). In order to keep this health system target, the management of population database is also one of the aspect that need to be considered. The Ministry of Interior of the Republic of Indonesia has implemented E-KTP, with Citizen Identification Number (NIK) as single reference in population administration [3]. This E-KTP Data as the referral for various services for the society, including in the health sector [4].

In e-health sytem development, wide range of healthcare applications are built by various vendors and run on different platforms. One of the challenge in the context of app development is interoperability, which plays an important role in data and information exchange [5]. As time goes by, healthcare applications begin to shift from paper-based to paper-less with the use of computer. Healthcare organization such as hospital requires relevant data and necessary information in its e-health such as population data, health insurance data, and electronic medical records. Many countries have been actively engaged in development of interoperability for data exchange and electronic transaction among government agencies to provide better public service to its citizen [6]. In e-health system, data associated with the patient is stored in distributed data source [7], which is in organization of health providers such as doctor, hospital, laboratory, and other. These health providers are autonomous, so that data is independently managed by the organization. Therefore, when data will be exchanged between organizations, each organization has agreed to share data with considering objectives, schemes, and agreed data [8].

Interoperability generally is defined as ability of two or more systems or components to exchange information and used the exchange information [9]. Data exchange and information format play an important role in facilitating interoperability. Standardization of data exchange and information format is very important to do [10]. Interoperability allows different information systems and organizations to work together. Interoperability have four levels as shown in Figure 1. The development of data interoperability requires an interface, which is published following specific standard. A system, which does not require the ability of exchange data and information, does not require such interface [12]. Referring to Figure 1, the organizational interoperability level allows performing both internal and external interoperability. Internal interoperability can occur in some data/information sources from an organization, while external interoperability allows the exchange of data perfom by different organizations.

Organizational Interoperability	Business process integration beyond the boundaries of a single organization
Semantic Interoperability	Ensuring the same meaning of exchanged data through predefined and shared meaning of terms and expressions
Syntactic Interoperability	Exchange of information through predefined data format and structure
Technical Interoperability	Technical end-to-end exchange of data among systems

Figure 1. Levels of Interoperability (adapted from [11])

In e-health systems, interoperability is required in process of exchanging data related to patient [13]. In its implementation, minimal interoperability involves two different systems or applications. One application or system serves as data provider, while other applications/systems act as data consumer. Referring to Figure 1, the syntactic interoperability level allows multiple applications that built using different type of programming languages and running on variety of platform can exchange data and information. While the syntactic interoperability level focuses on data exchange mechanism, and at semantic interoperability level, it allows a document to be translated and read on receiver data/information side.

Interoperability can be implemented using Service Oriented Architecture (SOA) approach. SOA is one of the approach to meet the standards of need and quality of software development. SOA cover functionality of a system into services [14]. Then, various applications with different platforms can connect each other and exchange data without having direct connection each other (loosely coupled). SOA is a form of architectural technology, which follows the principles of service orientation [15] by performing approach through dividing large functionality into smaller services with specific objective. Many of that technology can be used to implement SOA architecture, including CORBA (Common Object Request Broker Architecture), DCOM (Distributed Component Object Model), RMI (Remote Method Invocation), and Web Services. Some of these technologies in another side have weakness, for example CORBA, DCOM, RMI is closed (proprietary) so that the development is only on certain platform. While the Web service is open (non-proprietary) and web-based.

The Web service is a communication method between two electronic devices running on computer network [16]. The service, which is owned, by web service is software module provided by service provider [17]. Web Service is based on the concept of SOA, as an alternative solution in development of distributed system. At the beginning of web service development, people use SOAP protocol, until REST protocol was introduced [18, 19]. Figure 2 provides information on the differences between SOAP and REST protocol. Figure 2(a) shows that the SOAP Protocol defines web services as three entities, which are service provider, service registry, and service consumer. Service provider serves the requests of service consumer. While the service consumer in general is an application that consumes web services. Service registry acts as directory, provides number of services, in which there is description of the service provided. Based on the description and documentation provided by this service registry, service consumer can find a service and interact with the service provider. Communication between each entity uses XML notation.

Fielding [20] introduced representational State Transfer (REST) protocol as shown Figure 2(b) Fielding defines REST as a client/server communication where the client requests to the server, and the server sends response to the client. Communication between this client/server is based on the resource which identified as a URI. RESTful Web Services use HTTP methods such as GET, PUT, POST, and DELETE which can be integrated with CRUD operation (Create, Read, Update, and DELETE) in a database operation [21]. In every software engineering methodology, there are steps, which must be followed for system analysis and design. In the development of Service Oriented Architecture (SOA), developers use an approach called Service Oriented Analysis and Design (SOAD), which provides guidance on design implementation of SOA concept through three stages, including Conceptual View (CV), Logical View (LV), and Physical View (PV) [22]. The results of these three steps will be packaged into a service portfolio [23].

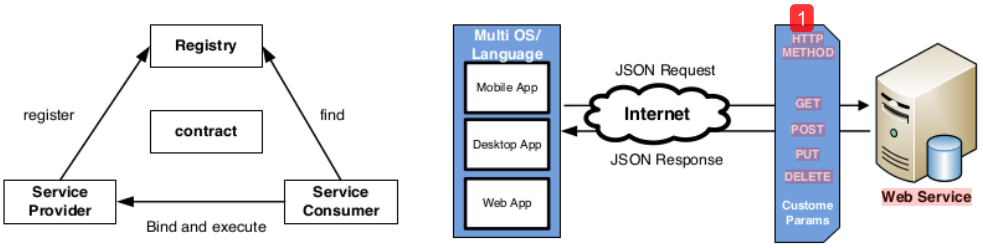

Figure 2. SOAP and REST protocol, (a) SOAP protocol (adapted from [19]), (b) REST protocol (adapted from [3])

Currently, organization in public service in global business environment are challenged by very competitive and rapid changes that demands cooperation between organizations. This challenge leads to software implementation needs, which have high level of interoperability and require cross-organization business process modeling [24]. Business processes is a series of task and activity executed to produce specific output. Intra-organizational business process is a series of activities carried out by a scope of organization, while the carried out cross-organizational business process activity is not only within one organization, but engage with other organizations to achieve common objectives. Business processes need to be documented, optimized, and possible to do business process automation (BPA). Most of the cross-organizational business processes are implemented using an infrastructure such as Web Services [25].

2. RESEARCH METHOD

This work follows SOAD Framework as logical approach for classification and organize information related to the analysis and SOA concept design. This system development step will result portfolio service as information stored for service consolidation. Figure 3 depicts the proposed Service Portfolio.

Steps in CV consist of functional domains, business processes, business services, software services and software components. The CV also illustrates business process activity diagram (BPAD) and subbusiness process activity diagram (SBPAD), which illustrates series of activities in each business process. In LV, the Steps are based on Enterprise Architecture (EA) which is useful for mapping the structure and objectives

of an organization, business processes, data and information structures, applications, and information technology infrastructure, also Service Oriented Architecture (SOA) to design services in the system. LV contains of mapping of business services into service in software design, which is described in the form of Web method/Web services. In the final step of SOAD, it is design in PV, which consists of Presentation Layer, Application Service Layer, Domain Model Layer, and Data Access Layer. Presentation Layer describes Graphical User Interface (GUI) in which there is process of accessing the Web service. Data Model Layer describes class diagram, activity diagram, and sequence diagram related to SBPAD in CV step. Furthermore, the step of Data Access Layer contains operations, which connected to the database, namely: Create, Read, Update, and Delete (CRUD). In PV step is also possible to develop Business Process Execution Language (BPEL).

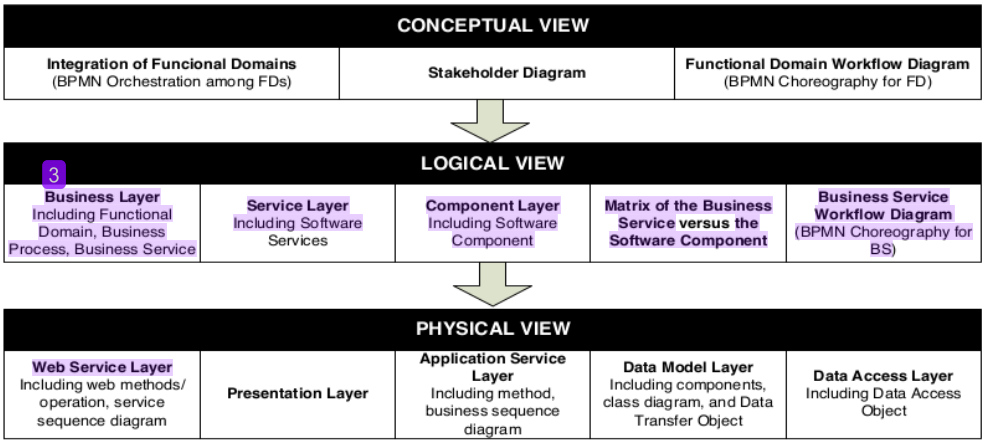

Figure 3. Service portfolio SOAD framework

3. RESULTS AND ANALYSIS

3.1. E-health services module

In this research, the service portfolio is derived from design of interoperability framework for e-health service which can illustrate Service Oriented Architecture (SOA) paradigm in system development. The e-health service includes several computer-based information systems as an effort to fulfill service for patients and information needs for stakeholders, which include some services as can be observed in Figure 4.

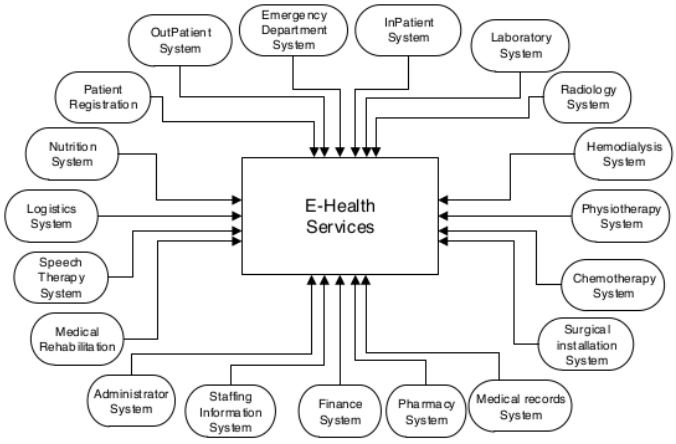

Figure 4. E-health services environme

3.2. Architechtural design

This research work aims to come out with a model of interoperability mechanism for exchanging data and information among several database namely: National Population Database, health insurance database, e-health operated by a health data provider such as hospital. The design of interoperability scenario is presented in Figure 5. Stakeholders in turn, are able to develop applications with different programming languages and platforms. National Population Database and health insurance system can be accessed by providing interfaces in collection of Web services, so that the e-health system can access the data that have been provided.

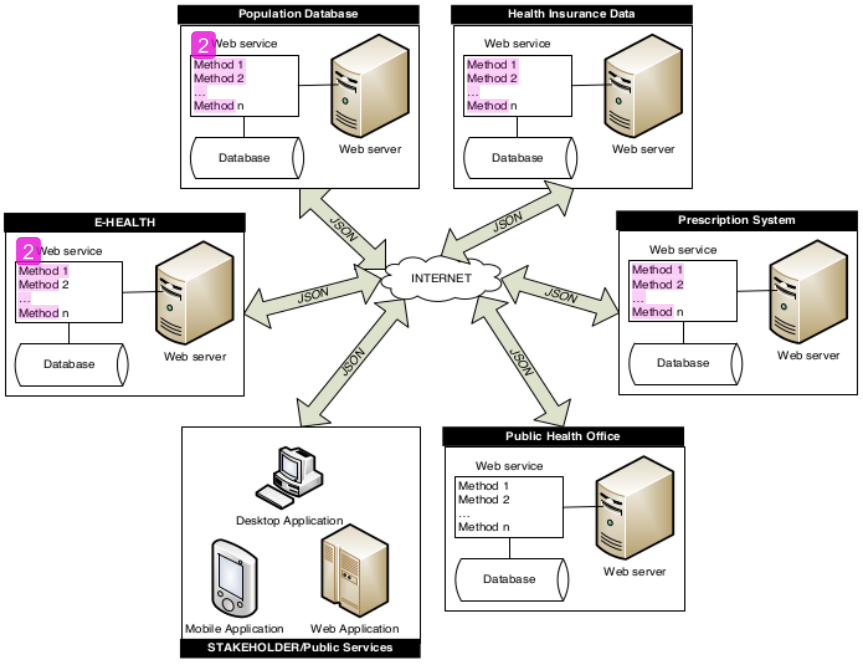

Figure 5. Interoperability of e-health system scenario

3.3. Business process modelling of RESTful web service data exchange

Figure 6 shows a series of business process activities that show the parties who involved in the e-health service interoperability framework. E-health system is the center of health care activities. The e-health system is an application used by hospital, public health center, and health clinic. The Framework is built using RESTful Web service which involving multiple entities including national population data, health insurance data, electronic prescription system, and health service. Furthermore, the already formed framework can be accessed by stakeholders as open system architecture for software developers.

The framework that will be built require connections to RESTful Web Service with predefined mechanism. Once authentication process is received, the dataset which presented by RESTful Web service can be accessed. The Data provided by RESTful Web Service can be accessed by accessing number of services. The number is provided in the routing mechanism in the form of resource address list (URI). To execute URI the HTTP protocol is used and the method is in the form of POST, PUT, GET, and DELETE.

Dataset that is generated both from and to the RESTful Web Service Framework will perform parsing JSON data structure and adjusted by the variable name and data type owned by the software or application that used by e-health System. The process of adjusting variable name and data type used by the e-health system and RESTful Web Service is known as Schema Mapping. This schema can be recognized, because the key-value, which pair in JSON will be adjusted at application level and also at database level.

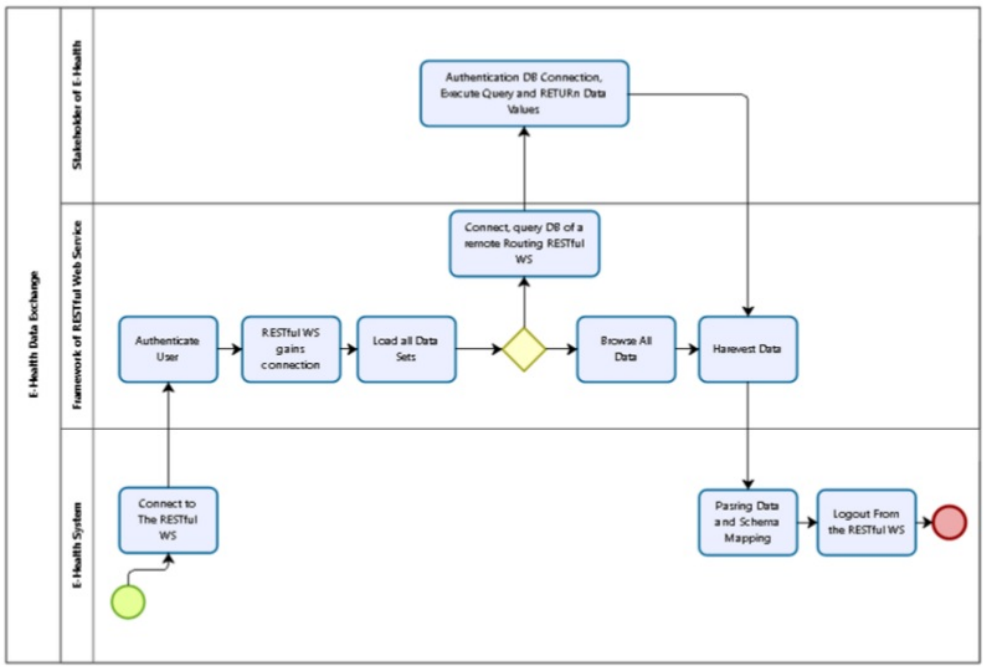

Figure 6. Data exchange of RESTful web service

3.4. Interoperability matrix

In the development of framework interoperability which integrated several entities or modules which involved in the system can be described in an interoperability matrix (IM) diagram. This Diagram can provide entity information or module which serves as service provider and which serves as consumer of the service which has been provided (consumer). Interoperability Matrix (IM) Diagram can be presented in Figure 7. Reffering to Figure 6, interoperability development of e-health service can be described in the form of Interoperability Matrix (IM), describing consumer/provider between entities involved in the framework. Consumer is an entity, which requires data by executing service provided by a provider. Data exchange interoperability requirements can be seen in Table 1.

	E-Health	National Population Database	Health Insurance Data	Prescription System	Public Health Office
E-Health		Consume Patient Profile	Consume Services Insurance	Provide Prescription Data	Provide Report Health Data
National Population Database	Provide Patient Profile		Provide Patient Profile	Provide Patient Profile	
Health Insurance Data	Provide Services Insurance	Consume Patient Profile		Provide Insurance Services	
Prescription System	Consume Prescription Data	Consume Patient Profile	Consume Insurance Services		
Public Health Office	Consume Report Health Data				

Figure 7. Interoperability matrix

Table 1. Data exchange interoperability

From	To	Services
1. E-health	National population database	Health information system which on health institution needs national population data which use as single identity for patient profile. E-health role as entity which ask for service (consumer) while National Population Database act as provider.
2. E-health	Health insurance data	E-health needs insurance service accepted by patient when comes to health institution. In this context e-health acts as consumer while health insurance data acts as provider
3. E-health	Prescription system	Every prescription system's service can create a system which generates its data by e-health. Prescription system becomes electronic refference for prescription by doctor to patient, so this information can be accessed openly for stake holder who needs information of medicine prescription. In this scenario, e- health acts as provider and prescription system acts as consumer.
4. E-health	Public health office	Healthcare data is reported periodically to the head of health office. Those data are result of operational health service exists in every health institution. In this scenario e-health acts as provider and public Health Office acts as consumer
5. National population database	Prescription system	Refference of National Population Database is used as single identity in prescription system. In this scenario the National Population Database acts as provider, while prescription system acts as consumer.
6. National population database	Insurance system	Single identity of National Population Database is used as patient refference who has right to get health service insurance. In this scenario, National Population Database role is as provider, while insurance system role is as consumer.
7. Prescription system	Insurance system	Patien medicine prescription system needs information type of medicine covered by health insurance. So, in this scenario insurance system acts as provider, while prescription system acts as consumer

4. CONCLUSION

This work has resulted a design of framework for interoperability of several e-health services. The SOAD approach is used as system development method which specifies the system in the form of a portfolio consisting of conceptual view, logical view, and physical view. Furthermore, this work described relation between system and integrated entities, and data and information exchange in a form of Interoperability matrix (IM), so the entities/systems, which serve as consumer or provider are clearly identified and can be used as a reference for system development in e-health application domain. In interoperability framework, which has been designed, data exchange between applications can be done using neutral data format such as JSON. The data format can be parsed and adjusted using variable and the data type implemented by software application connected in the framework. The authors plan to conduct a further research work through experimenting development of e-health system using multi-platforms environment including console-based, desktop, mobile, and web.

ACKNOWLEDGEMENTS

The author thanked to all the parties who had given support so that this publication was published. Thanks to the Ministry of Research, Technology, and higher education who have funded this research on the Intercollegiate Cooperation Research Scheme (PKPT) year of funding from 2018 to 2019.

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