# Integrated Model of Cloud-Based E-Medical Record for Health Care Organizations

BENS PARDAMEAN, RIZAL RICKY RUMANDA
Bioinformatics Research Group
Bina Nusantara University
Jl. Kebon Jeruk Raya No. 27, Kebon Jeruk, Jakarta
INDONESIA
bpardamean@binus.edu, ricky.rumanda@live.com

Abstract: This study conducted a research on the implementation of cloud computing in health care organizations, focused on integrated model of patient medical record information system using health care standard information format for data exchange. Health care organizations use variety of IT applications and infrastructures which always need to be updated as a result of rapid growth in health care services. The diversification on how health care organizations maintaining their operations, especially on maintaining patient's medical information resulted the difficulty of accessing patient's data. This study then proposed a design of an integrated cloud-based e-medical record which uses ICD-10 and HL7.

Keywords: E-Medical Record, Health care Information System, ICD-10, HL7, Cloud Computing, SOA

## 1 Introduction

Health care organizations use variety of IT applications and infrastructures which always need to be updated as a result of the rapid growth in health care services. And the cost of IT systems in health care services is very expensive, considering that IT is not their primary activities, and many of health care organizations pass this cost to their patients.

Many of these health care organizations have developed their own or purchased IT systems to support their operations. But, also many of other health care organizations are still use manual or paper-based form in their operations, especially the small-medium health care organizations, because they think that IT investment is costly. The diversification on how the health care organizations maintaining their operations, especially on maintaining patient's medical information resulted in the difficulty of accessing patient's data.

The greater of complexity of the problems in the health care services require better software, distributed computing power, and standardized data sharing [1]. In terms of having low cost IT systems with great capability, cloud computing was introduced in this later years. In 2006, Amazon started the cloud computing solution for their external customers, and launched Amazon Web Services (AWS). In 2007, Google and IBM started a research project on large scale cloud computing. In 2009, Microsoft was then announced their cloud computing system named Windows Azure.

This study conducted a research on the implementation of cloud computing in health care organizations, focused on integrated model of patient medical record information system using health care standard information format and best practice.

## 2 Problem Formulation

E-Medical Records (EMR) involves highly complicated hospital computerization and public does not have complete knowledge about it. It typically generates diverse and large volume of data that come from clinical services at distributed locations by various types of users [2,3]. The lack or incomplete of public knowledge about EMR causes the difficulty of data exchange among health care organizations and it leads to EMR as patients' medical information system must be standardized across many types of health care organizations in integrated system environment.

### 2.1 Methodology

This study performed literature reviews to find previous researches about integrated medical record and the implementation of health care system in the cloud computing. The next step was conducting interviews with health care professionals from various health care institutions to collect data on their current business processes and their expectations on the integrated EMR. Based on those steps, a design of business processes of integrated

cloud based EMR was developed to address the problems (Figure 1).


Figure 1 − Research Methodology

### 2.2 Research Findings

The IT manager from one hospital in Indonesia mentioned that even they are now developing the EMR as a part of the Hospital Management system, but the design of the system was disintegrated. The disintegrated EMR causing some problems in the hospital, especially on the outpatient services area. They found that the outpatient services are slow, because the registration center needs to spend more time to find the patient medical record papers. Often the papers are missing and cause the registration center to create new papers and lost the previous historical medical record.

A staff from Ministry of Health Republic of Indonesia has explained how they manage EMR data from all hospitals in Indonesia. All hospitals in Indonesia must submit all required reports to the Ministry of Health. All of these reports are submitted to them in paper forms or in Excel files. After they received the documents, they need to enter these data into their system in manual way one by one. It takes a very long time to complete this data entry process.

A senior business analyst that developed pharmacy sales software at several pharmaceutical companies in Indonesia had explained the common business processes used by several companies and their concerns about the integration of their software with the EMR, especially on the prescription data. The software they developed was designed to collect sales data from all regions around the country that run in some complex business processes. But, the software could not collect the patients' demography data, so they were unable to perform accurate analysis on the medicines effectiveness.

An IT staff at a health insurance company has explained that they currently face some problems with the accuracy of their customers' health condition. Before they can approve to accept a customer, they usually send them to the laboratory for medical check. This process can give them only a piece of data about the current customer health conditions and they cannot get the exact historical data. A problem also arises when their customer need to claim their medical expenses. Some manual processes must be performed until the customer received the result, whether their claims have been approved or rejected.

## 3 Problem Solution

Only an integrated model of EMR can lead to the health care service quality improvement by strengthen the users' role in managing their own medical care [4]. The use of integrated EMR system will enable data sharing, analysis tools, and infrastructure that can speed up many research, especially in health care services, by enabling new insights and enhancing efficiency [5]. This study had developed a design framework that uses cloud computing to host the EMR application in form of Software as a Service, which provide 3-way of access type and will be used by Government, Hospitals, Doctors, Patients, Pharmacies, and Insurance Companies through the Internet (Figure 2). In EMR system, enabling both local and national data sharing are the most important aspect [6].

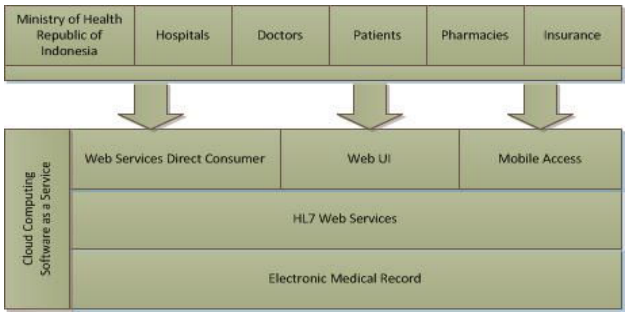


Figure 2 − Cloud Based EMR

Cloud computing in health care services enables the model sharing and scalability to provide more detail of analysis without the need of additional investment in computational infrastructure [7]. This EMR application model, which is hosted in cloud computing environment, also enables the multi tenants' subscription of the EMR within a single application and database.

The interoperability and integration is the essential things in EMR implementation [3]. In order to achieve the data interoperability, EMR system requires communication standards [8]. The design uses HL7 standard for messaging in the form of web services which act as an interface that interact with the available access types. Direct call to web services is a type of access that can be used by the organizations that already have some applications related to the medical record and need to integrate those systems to the cloud based EMR and do not want to replace it. Access through the provided web application can be used by some organizations that do not have medical record

application. The new EMR also can be accessed through mobile application that targets the doctors and patients, so they can use the application anytime and anywhere using their mobile devices.

### 3.1 Standard Code and Data Exchange

International Classification of Diseases, 10th revision (ICD-10) and ICD-10-CM are chosen to be the standard codification in the EMR system. The Ministry of Health Republic of Indonesia is already using this standard to comply with WHO regulations about the health care reporting systems. To keep the new design comply with the WHO standard, the design should continue using the ICD-10 and ICD-10-CM. Besides, the ICD-10 and ICD-10-CM have already been used in all hospitals in Indonesia based on the Ministry of Health Republic of Indonesia's regulation about medical record reporting.

The use of ICD in various health care institutions provides the similar basic schemes that allowing these data to be used in similar way [9]. In some ICD research, it shows that the use of ICD codes when combined with other health care data can accurately identify patients' health diagnoses [10,11,12].

For the data exchange between the entities involved in this new design of EMR, this study proposed the use of Health Level Seven International (HL7) which is widely being adopted by health care institutions in several nation-wide EMR implementations [13]. HL7 creates standards for the exchange, management, and integration of health care information system which enable interoperability of messages and documents in standardized way which also bring efficient communication among different users that assist in sharing health care information which makes the integration feasible [14]. Through the HL7 web services layer, each entity performs data exchange using HL7 message format (Figure 3).

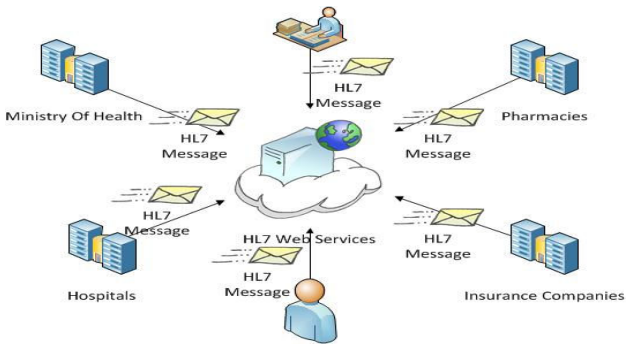


Figure 3 − HL7 Web Services

### Service-Oriented Strategy

The proposed design is to enable the use of EMR by the hospitals which do not have an EMR application or by the hospitals which already have an EMR application or by other institutions that need the EMR data. Service based application is useful to establish collaborative, coordinated health care services, among health care institutions [15]. Based on this requirement, the EMR provides a service layer that is made available in the cloud for the authenticated user. There is an HL7 web services layer that can be consumed directly by the organizations' existing application or be consumed by the provided web or mobile applications (Figure 2).

### 3.2 Data Architecture Strategy

The new EMR application is available in form of Software as a Service, which must enable the multi-tenant application type [16]. There are many health care organizations using this application including hospitals, pharmacies, insurance companies, and many others that have some concerns with the EMR Data.

This study preferred the shared database and shared schema for the data design to be used in the EMR. In this data design, all tenants' data will be stored in one single database and the same set of tables (Figure 4). This approach can guarentee that every tenant uses the same application, same data model, same features, and receive any updates or patches at the same time.

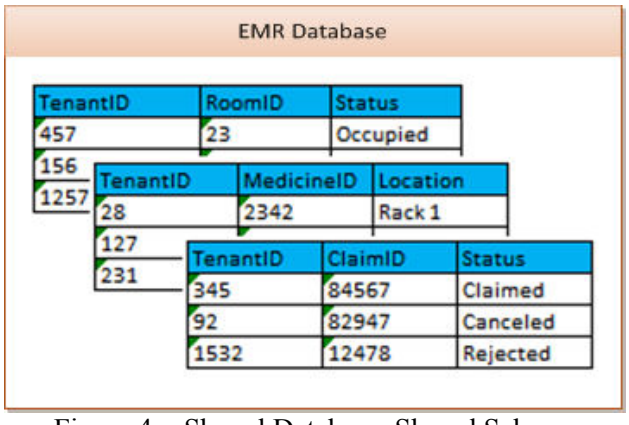


Figure 4 − Shared Database, Shared Schema Approach for EMR Database Design

### 3.3 E-Cloud Patient Registry

When a patient comes to a hospital or clinic, the registration center will query the patient data in the cloud. When they found it, the data will be

downloaded and updated with the new data from the most recent visit to the hospital or clinic, otherwise it will create a new patient data (Figure 5). The registration center is limited to viewing or updating the patient's general data only, such as: id number, name, and birthdate. These general data are provided for identity validation.

By using a centralized cloud based EMR, all historical patients' medical data can be stored in one place and shared among hospitals or clinics. Even though patients are moving from one hospital to another, their data is still being tracked and updated.

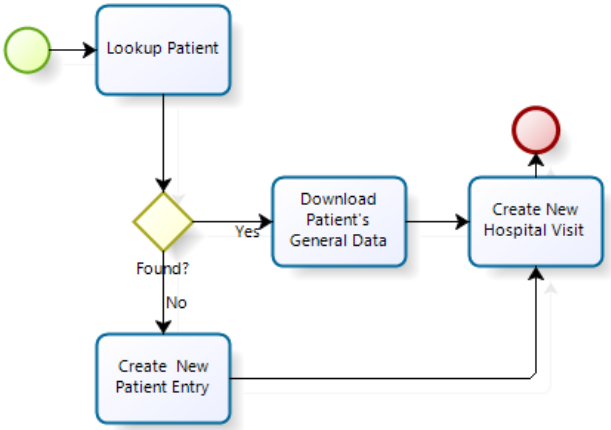


Figure 5 − E-Cloud Patient Registry Process

### 3.4 E-Cloud Outpatient Order

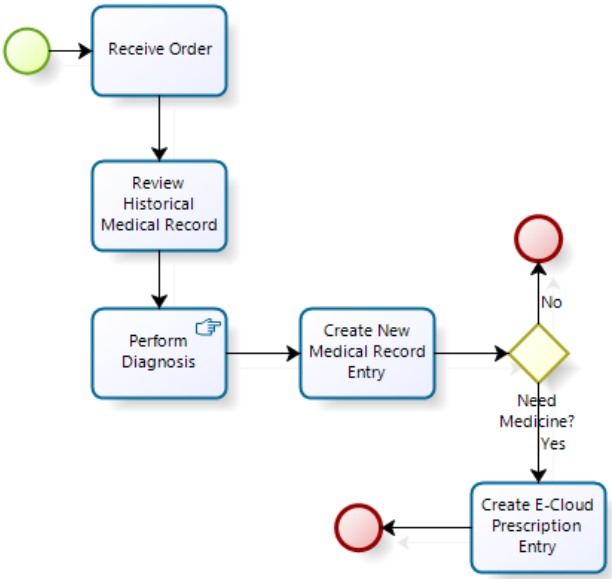


Figure 6 − E-Cloud Outpatient Order Process

Soon after the registration center finished their task, they need to send these data to the associated doctor's tasks queue. The doctor can view the historical patient's medical data, but prohibited to change it. After the doctor performed diagnosis to the patient, the doctor must create new medical record entry based on the diagnosis (Figure 6). When the doctor decides to give the patient some medicine, the doctor is also required to create an electronic prescription entry which also located in the cloud computing. This electronic prescription will be available to all pharmacy outlets which use the system.

### 3.5 E-Cloud Prescription

After the patient finished the medical check, they need to buy the prescribed medicine, if any. The patient just need to mention their prescription number as it is unique in the prescription database. Otherwise, they can provide their id number to the pharmacist, and the pharmacist can query the prescription list that belongs to the patient with the status active or closed in recent order. Next step is the pharmacist and the patient need to decide the valid and active prescription. After they decide the correct prescription, the pharmacist can download the detail of prescription and ask to the patient whether they will order it in full or partial. In partial order, the pharmacist just needs to update the number of items listed in the prescription and it remains in active status, so that the patient can order the remaining items in the prescription. For the full order, it can set the prescription status into inactive or closed, so that the patient cannot order it again (Figure 7).

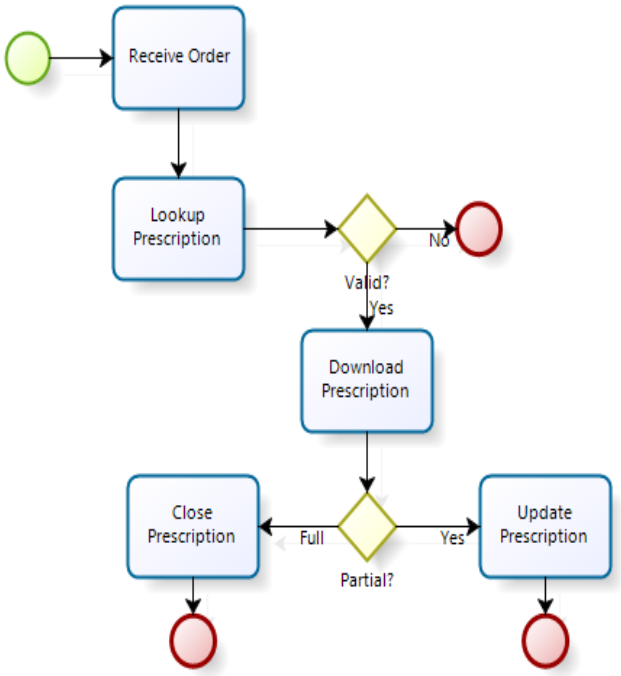


Figure 7 − E-Cloud Prescription Process

ISBN: 978-1-61804-048-0

### 3.6 E-Cloud Underwriting

Insurance company can take advantage from cloud-based EMR, as they can easily retrieve their client medical data for review. When their clients register for insurance package, the insurance underwriter can review their clients' medical data which is stored in the cloud computing. If they cannot found the data, they can create it in the cloud EMR as a patient data and fill only the general data. They are prohibited to modify the patient's medical data. After that, they can perform the risk analysis to decide whether the client's insurance application is approved or rejected (Figure 8).

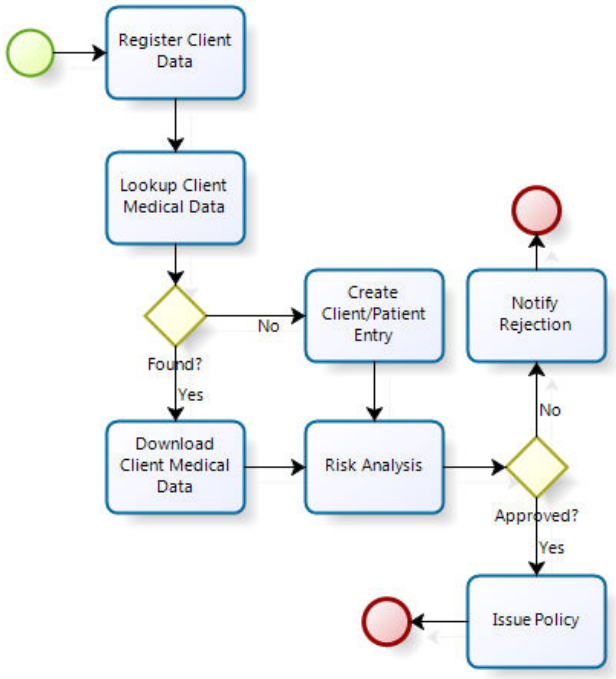


Figure 8 − E-Cloud Underwriting Process

### 3.7 E-Cloud Reporting

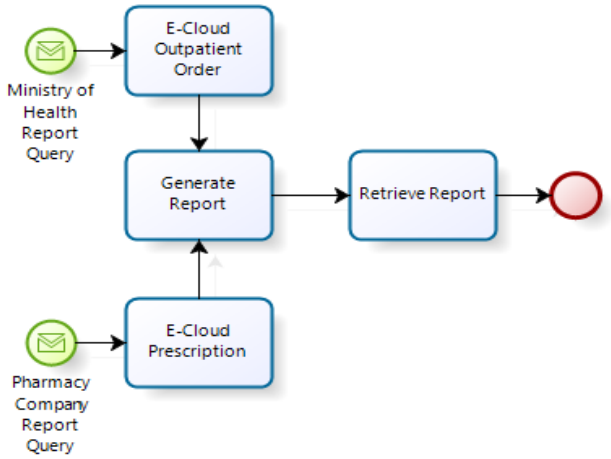


Figure 9 − E-Cloud Reporting Process

By enabling the model sharing, querying and accessing data can be simplified and performance optimized [15]. Now the Ministry of Health or pharmaceutical companies can easily retrieve their report requirement to fulfill their needs. The Ministry of Health can get access to the medical data generated by the E-Cloud Outpatient Order, while the pharmacy companies can get access to the prescription data in the E-Cloud Prescription (Figure 9).

## 4 Conclusion

From the given solution in the previous section, it can be concluded that the use of cloud computing in the EMR design using common international health care standard enables integration among many types of health care organizations whether they already have application or want to develop a new one. It also reducing complex business processes by automating the manual processes.

### References

[1] S. Gao, D. Mioc, X. Yi, F. Anton, E. Oldfield and D. J. Coleman, "Towards Web-based representation and processing of health," *International Journal of Health Geographics,* 2009.

[2] C.-M. Hu, W.-S. Jian, P.-L. Chang and C.-Y. Hsu, "A Web Based Prototype System for Patient Use Confirming Taiwan Electronic Medical Record Templates," in *AMIA 2005 Symposium Proceedings*, 2005.

[3] J. Bisbal and D. Berry, "An Analysis Framework for Electronic Health Record Systems," *Methods of Information in Medicine,* pp. 180-189, 2009.

[4] D. Detmer, M. Bloomrosen, B. Raymond and P. Tang, "Integrated Personal Health Records: Transformative Tools for Consumer-Centric Care," *BMC Medical Informatics and Decision Making,* p. 45, 2008.

[5] E. K. Nelson, B. Piehler, J. Eckels, A. Rauch, M. Bellew, P. Hussey, S. Ramsay, C. Nathe, K. Lum, K. Krouse, D. Stearns, B. Connoly, T. Skillman and M. Igra, "LabKey Server: An open source platform for scientific data integration, analysis and collaboration," *BMC Bioinformatics,* p. 71, 2011.

[6] A. Robertson, K. Cresswell, A. Takian, D. Petrakaki, S. Crowe, T. Cornford, N. Barber, A. Avery, B. Fernando, A. Jacklin, R. Prescott, E.

Klecun, J. Paton, V. Lichtner, C. Quinn, M. Ali, J. Morrison, Y. Jani, J. Waring, K. Marsden and A. Sheikh, "Implementation and adoption of nationwide electronic health records in secondary care in England: qualitative analysis of interim results from a prospective national evaluation," *British Medical Journal,* 2010.

[7] G. E. Ropella and C. A. Hunt, "Cloud computing and validation of expandable in silico livers," *BMC Systems Biology,* 2010.

[8] R. Noumeir and B. Renaud, "IHE cross-enterprise document sharing for imaging: interoperability testing software," *Source Code for Biology and Medicine,* p. 9, 2010.

[9] W. Sermeus, L. H. Aiken, K. V. d. Heede, A. M. Rafferty, P. Griffiths, M. T. Moreno-Casbas, R. Busse, R. Lindqvist, A. P. Scott, L. Bruyneel, T. Brzostek, J. Kinnunen, M. Schubert, L. Schoonhoven, D. Zikos and R. Consortium, "Nurse Forecasting in Europe (RN4CAST): Rationale, design and methodology," *BMC Nursing,* p. 6, 2011.

[10] C. R. Cooke, M. J. Joo, S. M. Anderson, T. A. Lee, E. M. Udris, E. Johnson and D. H. Au, "The validity of using ICD-9 codes and pharmacy records to identify patients with chronic obstructive pulmonary disease," *BMC Health Services Research,* p. 37, 2011.

[11] D. Scheurer, L. Hicks, E. Cook and J. Schnipper, "Accuracy of ICD-9 coding for Clostridium difficile infections: A retrospective cohort," *Epidemiology and Infection,* pp. 1010-1013, 2007.

[12] L. D. Ried, R. Cameon, H. Jia, K. Findley, M. S. Hinojosa, X. Wang and M. J. Tueth, "Identifying veterans with acute strokes with high-specificity ICD-9 algorithm with VA automated records and Medicare claims data: A more complete picture," *Journal of Rehabilitation Research & Development,* pp. 665-674, 2007.

[13] A.-M. Shakir, D. Cardenas, G. Datta, D. Mittra, A. Basu and R. Verma, "Design and Development of Standards (HL7 V3) Based Enterprise Architecture for Public Health Programs Integration at the County of Los Angeles," *International Journal of Health Care Information Systems and Informatics,* pp. 53-56, 2007.

[14] L. Zhang and X. Xu, "A Community Public Health System Design based on HL7 Criterions," *Computer and Information Science,* pp. 148-151, 2011.

[15] H. H. Chang, P. B. Chou and S. Ramakhrisnan, "An Ecosystem Approach for Health Care Services Cloud," *2009 IEEE International Conference on e-Business Engineering,* pp. 608-612, 2009.

[16] F. Chong, G. Carraro and R. Wolter, "Multi-Tenant Data Architecture," Microsoft Corporation, June 2006. [Online]. Available: http://msdn.microsoft.com/en-us/library/aa479086.aspx. [Accessed 1 September 2011].