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A Survey on Use of CDA for Health Information Exchange Based On Cloud Computing System

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***Abstract*—The arrangement of EHR has enhanced nature of care and patient security, however it requires interoperability between HRE at various healing centers. The Clinical Document Architecture (CDA) created is a center report standard that is basic to guarantee such interoperability. In aside from in a modest bunch nations healing centers are hesitant to receive interoperable HIS because of its sending cost. An issue emerges notwithstanding when more clinics begin utilizing the CDA report organize in light of the fact that the information scattered in various records are difficult to oversee. This paper portray our CDA record creation and amalgamation Open API benefit in light of distributed computing, through which clinics are empowered to helpfully produce CDA archives. This CDA record mix framework absorbs numerous CDA archives per persistent into a solitary CDA report which the doctors and patients can peruse the clinical information displayed to them in a sequential request. This CDA archive era and incorporation framework depends on distributed computing and Open API. This guarantees the engineers utilizing distinctive stages can utilize our framework to upgrade interoperability.**

***Index Terms*—Wellbeing data trade, HL7, CDA, distributed computing, programming as an administration**

INTRODUCTION

HEALTH information is defined as information pertaining to the health of an individual or health care provided to an individual and it can support of efficient processes for health care delivery [1]. Electronic Health Record (EHR) is longitudinal collection of electronic health information for and about persons, where In order to ensure successful an operation of EHR, a Health Information Exchange (HIE) system need to be implemented [2]. However, most of the HIS in administration have distinctive attributes and are commonly incongruent [3], [4]. Hence, standardization is essential for effective health information exchange between hospitals. Particularly, clinical archive institutionalization lies at the center of ensuring interoperability.

Health Level Seven has established CDA as a major standard for clinical documents [5]. CDA is a document markup standard that specifies the structure and semantics of 'clinical documents' for the purpose of exchange. The first version of CDA was developed in 2001 and Release 2 came out in 2005 [6]. Many projects adopting CDA have been successfully completed in many

countries [7], [8], [9]. Active works are being done on improving semantic interoperability based on openEHR and CEN13606 [10], [11].

The support of more HIS's for CDA is required for guaranteeing trust in HIE interoperability. The structure of CDA being unpredictable, the generation of right CDA archive is hard to accomplish without profound learning about its principles. Every doctor's facility requires a different CDA era framework since HIS improvement stage for healing center change enormously. Most healing facilities additionally decline to receive new frameworks unless it is completely important for them. Along these lines, barring a couple of nations, for example, New Zealand and Australia, the appropriation rate of HER is low. [13].

A recording of the diagnosis is generated as a CDA document when a patient is diagnosed at a clinic. This CDA document is shared with other clinics if the patient allows it. In India, the concept of a family doctor does not exist, this makes it common for a patient to visit a number of clinics. The exchange of CDA document is prompted: when a physician needs to study a patient's medical history; when referral and reply letters are drafted for a patient cared by multiple clinics; when a patient is in emergency and the medical history needs to be reviewed.

As the number of CDA documents increases the time taken by the medical professional also increases because he has to collect a huge amount of individual files. Thus the decisions to be made by the medical professional is delayed. The integration all of the CDA document into a single document aids the medical personnel in review the patient's clinical history conveniently in sequential request per clinical area and the subsequent care administration can be conveyed more. For now, the method to integrate all the various individual CDA documents doesn't exist yet and expecting a hospital to develop a CDA integration system is not practical.

This paper presents (1) a CDA document generation system that helps generate CDA documents in various platforms (2) a CDA document integration system to integrate multiple CDA documents scattered in different hospitals for each patient. This system has a number of advantages. Firstly, the system enables developers whospecialize in Java, .NET, or C/C++ to continue working on their developer platformsis accessible through an Open API.The existing system in hospitals can simply extendedrather than completely being replaced with a new system. Secondly, it is unnecessary for hospitals to train their personnel to operate on CDA documents because that would be rendered redundant by the system. Documents in the CDA format are produced by the CDA generation service in cloud produces approved by the National Institute of Standards and Technology (NIST) [14]. Thirdly,existing EHR are more likely to consider adoption of CDA in their practices if this service is provided for free or low prices to hospitals.

The organization of this paper isas follows. Section 2 contains detailed explanations on the format of CDA document, cloud computing, and the overall architecture of the system being

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proposed. In Section 3, the efficacy of the proposed system andits contrasts to different HIE systems in various countries is provided.

MATERIALS AND METHODS

In this section the necessary techniques are provided in detail for the design, and the implementation of our CDA generation and integration system based on cloud computing is explained briefly.

The CDA Document

The American Nation Standards Institute approved HL7 Clinical Document Architecture Release 2 (CDA R2) in May 2005. The header includes information about the patient, hospital, physician, etc. provided with a clearly defined structure. Depending on the purpose of the document different subcategories are inserted in a CDA document, and we the Continuity of Care Document (CCD) [16] is chosen since it contains the health summary data for the patient and it enables interoperability. The notable data included in CCD are listed in Table 1.

TABLE 1

Data Items in CCD Header and Sections in the CCD Body

CDA location	Data items
CDA Header	Document Information (creation time, template ID, language code, purpose)
	Patient's information (ID, name, gender, birth date)
	Author's information (ID, name, represented organization)
	Organization's information (name, address, phone number)
CDA Body	Payers
	Advance Directives
	Support
	Functional Status
	Problems
	Family History
	Social History
	Allergies
	Medications
	Medical Equipment
	Vital Signs
	Results
	Procedures
	Encounters
	Plan of Care

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For the integration of the CDA document,theKorean Standard for CDA Referral and Reply Letters (Preliminary Version) format is chosen as the number of clinical documents generated is large [17], [18]. It has the identical structure as the CCD and the types of data contained in the body are listed in Table 2.

Cloud Computing

Distributed computing is a term which alludes to the equipment and the applications conveyed as administrations over the Internet and frameworks programming in the server farms that give those administrations [19].

TABLE 2
Sections in the Korean Standard for CDA Referral and Reply Letters Body (Preliminary Version)

Sections in CDA body	CDA Referral letter	CDA Reply letter
Diagnosis	No	Yes
History of past illness	No	Yes
History of Medication Use	Yes	Yes
Laboratory studies	Yes	Yes
Radiology studies	Yes	Yes
Pathology studies	Yes	Yes
Function Status Assessment	Yes	No
Surgical Operation Note	Yes	No
Relevant Diagnostic Tests	Yes	Yes
Reason for referral	Yes	No
Special Treatments and Procedures	Yes	No
Subsequent Evaluation Note	No	Yes
Plan of Treatment	Yes	Yes

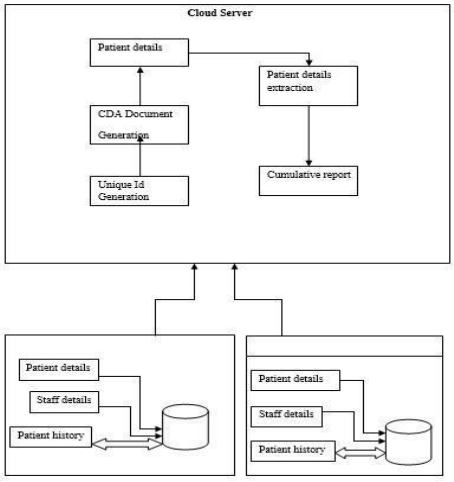

Fig. 1. The architecture of our CDA generation system based on cloud computing.

TABLE 2
Sections in the Korean Standard for CDA Referral and Reply Letters Body (Preliminary Version)

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Radiology studies	Yes	Yes
Pathology studies	Yes	Yes
Function Status Assessment	Yes	No
Surgical Operation Note	Yes	No
Relevant Diagnostic Tests	Yes	Yes
Reason for referral	Yes	No
Special Treatments and Procedures	Yes	No
Subsequent Evaluation Note	No	Yes
Plan of Treatment	Yes	Yes

1) Software as a Service (SasS): This service model provides software to the clients.
2) Platform as a Service (PaaS): Cloud providers supply a computing platform where the clients can deploy applications of theirown, program language of their own.
3) Infrastructure as a Service (IaaS): Here the vendor integrates basic infrastructure like IT systems and database and then rents it out to a client.

In this paper, a widely used cloud service, Amazon Cloud [20], is chosen and the CDA generation and integration system as SaaS.

CDA Generation System Based on Cloud Computing

In Fig. 1 how the architecture of CDA documents can be generated on the health information systems of different hospitals by using the cloud computing-based CDA generation system is shown.

The two hospitals A and B are demonstrated to show how easy it is to generate CDA documents on a variety of platforms if done using cloud. The purpose of each of the components is:

- CDA Generation API generates CDA documents on cloud server.
- CDA Generation Interface receives CDA documents generated in the cloud and uses the API provided by the cloud and also relays the input data.
- The template Manager is responsible for managing the CDA documents that is generated in the cloud.

- CDA Generator is responsible for collecting patient data from hospitals and generating the CDA documents in the template formats as the Template Manager suggests.
- CDA Validator inspects if the CDA document which is generated complies with the CDA schema standard.

The DBMS at each hospital and the HIS are linked as follows. Hospital A, which uses a .Net-based system is connected via ODBC to connect to the DBMS while Hospital B, which uses a JAVA-based system, is linked with Hibernate.

In a hospital, the patient clinical information, hospital, and physician is entered via CDA Generation Interface and sent to the cloud server via CDA Generation API. We utilize SOAP (Simple Object Access Protocol) as transmission protocol for the purpose of enhancing interoperability among different HIS when a hospital sends data to the cloud. CDA Generation API is used to relay the data in the CDA Header/Body. The items that are included in usual CDA Header are: PatientID, Dateof Birth, Gender, FirstName, and FamilyName. In CDA Body, the following items are included:

Problem, Medication prescribed, Laboratory, Immunization provided, and so on. The data to be sent to the CDA Generation API are packaged as a whole in CDA Header Set and CDA Body Set and then relayed to CDA Generator. A CCD template from Template Manager is retrieved by the CDA Generator and the appropriate fields of the CCD template is filled in with the data from the CDA Header/Body Sets. The generated CDA document is inspected by the CDA Validator whether the CDA standards are being satisfied. It is inspected whether there is any missing element or the format is adequately followed. A CDA document is returned to the recipient hospital if no error is found. The different hospitals A and B have application that are coded in different development platforms to extend to generate CDA documents via a cloud server.

CDA Integration System Based on Cloud Computing

The standard for this integration of the various CDA documents is Korean Standard for CDA Referral and Reply Letters (Preliminary Version). The templates which generate a CDA use CCD part of Consolidated CDA which is released by ONC and made by HL7. However, an actually generated CDA has a form of CDA Referral and Reply Letters. The rationale for CDA document integration is as follows [21]. When CDA-based (Health Information Exchange) is enthusiastically used among hospitals, the number of CDA documents concerning to each patient increases in time. For making a decision, the physician needs to spend a significant amount of their time to read these documents. In India the insurance model followed is feefor-service and therefore physician's consultation time spent per patient is very short since. Chronic patients especially are very likely to have been consulted by multiple physicians, in different hospitals. In this case, CDA documents may be scattered in different locations. Therefore, multiple CDA

documents needs to be integrated into single CDA document. If the medical history of a patient is available in a single CDA document, the physician's time can be more efficiently used. This is evident when a patient is being referred to a different hospital or when a referral reply letter is sent. Our survey of physicians shows that displaying each section in chronological order helps improve the quality of care. This paper shows how we integrate CDA documents on a cloud server so that a variety of existing systems can be easily extended to generate integrated CDA documents.

At a hospital application, the CDA documents that are to be integrated are processed through the CDA Integration API of ours. The CDA Integration Interface then relays each CDA document sent to the cloud to the CDA Parser, which in turn converts each of the input CDA document into an XML object and then analyzes the CDA header and the analyzed data is grouped by each patient ID. The CDA Document Integrator then integrates the provided multiple CDA documents into a single CDA document. Following the LOINC values that set apart each section in the CDA document the data in the same section in the document body are merged. The CDA Validator is used to integrate. CDA document is inspected for error in, and the result is returned as string to the hospital that requested CDA document integration. This is because the CDA Integration System and the CDA Generation System are separate entities, and a new CDA document is made after document integration, hence it is necessary to determine whether the new document complies with the CDA document integration, especially whether there is any missing element, or the format is wrong. Error messages, if found, are returned. Then the received string is converted to a CDA document file and saved. CDA Validator validates the data based on the CDA schema. An error is generated when a required field has been left blank or the wrong data type has been used. Example: The CDA document generation time, 'effective Time,' needs to be set, at least, in the YYYYMMDD format such as 20140806.

RESULTS

In this section, we report the results concerning the implementation of CDA generation and integration system based on cloud computing

Construction of a Cloud Computing

Environment and Deployment of CDA Generation and Integration System Based on It We chose Amazon Elastic Compute Cloud (EC2) as the cloud platform for our CDA generation and integration system. Microsoft Windows Server 2008 Base was selected as its operating system. We chose Singapore as the server location. Java (JDK 1.6) was used for CDA document generation and integration system and Tomcat 6.0.26 was selected as the web server platform for service deployment. As discussed in Section 2, we developed the CDA document integration and integration system and deployed the system on the Amazon Cloud Server. Hospitals conveniently generate and integrate CDA documents by exploiting the API offered by our system.

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Generation of CDA Documents on Different Developer Platforms through Cloud

To verify whether the system functions as designed, we requested CDA document generation on multiple systems implemented on different developer platforms via our API. For input data, we used the sample patient data offered by the US EHR Certification Program, Meaningful Use [22]. The data does not pertain to any actual person. It is fictional, and available for public access. The use case scenario and data for CDA document generation are shown in Table 3.

Fig. 3 shows the JAVA-based HIS (Health Information System) indicated in Fig. 1. Fig. 3 is a screenshot of our API when requesting a CDA document generation for a hypothetical hospital that uses Java as its developer platform.

TABLE 3
The Use Case Scenario and Data for CDA Document Generation

Patient name	ManikandanKannan
Date of birth	28/8/1995
Provider's name	Dr. KannanRamadass
Provider's office contact information	555–555–1002, Get Well Clinic, 1002 Healthcare Dr. Portland, OR 97005
Reason for Visit/Chief Complaint	High Fever, 3 days Chills, 4 days Cough with production of yellow-green sputum, 1day
Smoking Status	Current every day smoker, Start: 2014
Medications Administered During Visit	Albuterol 0.09 MG, 3 puffs once
Problems	Pneumonia Asthma AIDS Hypoxemia
Laboratory Tests and Values/ Results	HGB, 14.2 HCT, 55% WBC,7.8 (10^3/ul) PLT,223 (10^3/ul)
Immunizations	Tetanus - diphtheria adult, 1/4/2015 Influenza virus vaccine, 11/1/2013

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We usethe CDA document validation tool provided by US NIST to verify the validity of our CDA documents.

Integration of CDA Documents via Our Cloud Server

We integrated multiple CDA documents of patient referrals and replies by using the API at our server. The use case scenario and patient data used for integration are shown in

TABLE 4
The Use Case Scenario and Patient Data Used for Integration

Patient Characteristics	The patient is a 20-year-old Indian male with a history of asthma which was controlled by albuterol for breakthrough. 8/6/2012
Diagnosis	pneumonia
History of Medication Use	albuterol,inhaled, Inhalant/Respiratory, 2.5mg/3ml NEB 3 times daily PRN wheezing/shortness of breath ceftriaxone, IV, 1 gram IV once daily 08/15/2012
Diagnosis	Costal Chondritis
Procedures	Pulmonary function tests
Laboratory Studies	CO2, 23 mmol/L 08/15/2012
Diagnosis	Angina
History of Medication Use	Aspirin 85 MG Oral Tablet, twice daily
Procedures	EC Procedure Intranasal oxygen therapy
Functional Status Assessment	Memory impairment Dependence on walking stick
Laboratory Studies	Na, 150 mmol/L K, 5.0 mmol/L Cl,102mmol/L CO2,27mmol/L BUN, 23 mg/dL Cr 1.4 mg/dL Glu, 202 mg/dL Troponin T, 0.03 ng/ml

Table 4. The data given above does not pertain to an actual person. It is fictional, and available for public access.

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DISCUSSION AND CONCLUSION

Not exclusively is tolerant security and nature of care enhanced by interoperability between clinics additionally time and assets spent on information arrange change is diminished [23]. Interoperability is dealt with more essential as the quantity of doctor's facilities taking an interest in HIE increments. In the event that even one healing center does not bolster interoperability, alternate doctor's facilities need to change over the information arrangement of their patient data to trade information for HIE. Multifaceted nature for HIE unavoidably increments in extent when the quantity of clinics that don't bolster interoperability.

Changing a current framework includes cost for programming and upkeep and consequently doctor's facilities are hesitant to embrace EHR frameworks that bolster interoperability [24], [25]. The upsides of an API benefit as our own are at the measure of assets that healing centers need to apportion for interoperability is negligible [26]. Along these lines, offering a framework is a decent option for clinics that backings interoperability with distributed computing that have not yet received EHR on account of cost issues.

The CDA archive organization is a clinical data standard intended to ensure interoperability between healing facilities, countless tasks that utilization the CDA report arrange have been embraced in numerous nations.

Our distributed computing based CDA era and joining framework has a couple of particular points of interest over existing tasks. To start with, healing facilities don't need to buy legitimacy programming to create and coordinate CDA records they deliver. Second, our administration is usable by different engineer stages on the grounds that an Open API is to drive our CDA report era and incorporation framework. CDA archives can be effectively produced to bolster interoperability despite the kind of the stage,. Thirdly, CDA report era and coordination framework which depends on cloud server is all the more especially valuable over existing administrations for CDA record if the assortment of CDA archive introduce increments. As of December 2013, there are 54 distinct sorts of CDA reports perceived by US NIST, and the number keeps on developing step by step [45]. With the cloud-based design proposed in this paper, it gets to be distinctly advantageous to produce records that follow new report norms. Hence, the cloud server can promptly give records that go along CDA Release 3 if just the server embraces its model, information sort, and usage rules.

As the quantity of HIE in view of CDA archives expands, interoperability is accomplished, however it likewise brings an issue where overseeing different CDA records per quiet gets to be distinctly badly designed as the clinical data for every patient is scattered in various reports. The

CDA archive combination benefit from our cloud server enough addresses this issue by incorporating numerous CDA reports that have been created for individual patients.

The clinical information for the patient being referred to is given to his/her specialist in sequential request per area so it helps doctors to practice prove based solution. What's more, patients are empowered to utilize the CDA report coordination administration to acquire Personal Health Record (PHR) [36], [37], [38], [39], which contains clinical archives as well as Personal Health Monitoring Record (PHMR) [40] and Patient Generated Document (PGD) [41]. Patients can successfully create and deal with their PHR by utilizing our cloud-based CDA report combination benefit.

The accompanying issues were experienced while building up our CDA record era and mix framework. In the first place, the default dialect of the Amazon Cloud OS is US English and it won't sufficiently deal with Indian dialect in the CDA archives. At the point when SaaS is offered focusing on healing facilities of various dialects, designers should give careful consideration to this issue. Furthermore, our CDA report era administrations API parameter for was of the rundown sort, yet under the C# dialect environment, the parameter was changed over to the string exhibit sort. This is questioned to be brought about by the IDE programming of C#, which naturally makes this sort change. Thus, the returned information should be as bland as conceivable to be made appropriate to whatever number stages as could be expected under the circumstances.

FUTURE ADVANCEMENTS

The CDS integration system explained above has a number of drawbacks which are the following: 1) The system is rendered useless when the identity of the patient is unknown and cannot be quickly deduced in case of a life threatening situation 2) The data transfer and storage is not ensured to be secure and this poses a security threat to the patient's data on the cloud server. This confidential data in the hand of third parties with detrimental intentions can endanger the life of the patient.

Thus a finger print recognition or a password enabled validation system is envisioned to help overcome this obstacle that threatens the patient. A finger print enabled system would render any attack through the internet useless as the patient has to be present in person and in case of an emergency the details can be obtained just by using the patient's fingerprints.

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