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Electronic Health Information Standard for Patient Transfer based on CDA, focused on Patient Information in Small-sized Hospitals (JHCIS)

Pawitchaya Wangkrapong, Tanakorn Suvanprateeb, Suthipong Kusolnumpa,
Worapan Kusakunniran, and Kittikhun Thongkanchorn
Faculty of Information and Communication Technology, Mahidol University, Thailand
E-mail: pawitchaya.wan@student.mahidol.ac.th, tanakorn.suv@student.mahidol.ac.th,
suthipong.kus@student.mahidol.ac.th, worapan.kun@mahidol.ac.th, and kittikhun.tho@mahidol.ac.th

Abstract* — In this paper, the electronic health information standard is a standard prototype which can be used for patient information transfer among hospitals in Thailand, based on Clinical Document Architecture (CDA) in the xml format. The prototype is developed for Java Health Center Information System (JHCIS), which is a healthcare information system developed by the Ministry of Public Health and widely used in small-sized hospitals. This paper proposes a new method for electronic patient transfer in order to replace the traditional way of using paper work. When transferring a patient, his information in the database of the host hospital will be exported into the CDA-based standard file which can be electronically transferred to the destination hospital. Then, the destination hospital can import information in the received CDA-based standard file into its database automatically. The proposed method consists of 3 main processes including: 1) data mapping, 2) CDA revising, and 3) standard prototype implementation. First, data mapping is a process to map components in CDA to contents in the JHCIS database. Second, CDA is revised based on the mapping results, in order to make it suitable for Thai health information. Third, the standard prototype is implemented for patient information transfer, focusing on JHCIS. The program adapters are developed to: 1) export patient health information records in the JHCIS database to be in the format of the revised CDA-based standard, and 2) import patient health information records in the received CDA-based standard files back into the JHCIS database.

***Keywords* — electronic health information standard, patient transfer, CDA, JHCIS**

I. INTRODUCTION

In Thailand, most hospitals are occupied by the federal government. They can be classified into three groups based on their sizes, namely a small-sized hospital, a medium-sized hospital and a large-sized hospital. Different-sized hospitals are likely to use different healthcare information systems (HISs) which are used to manipulate patients' information. For example, JHCIS is widely used in small-sized hospitals whereas HOSxP [1] is widely used in medium-sized hospitals. Among different HISs, patients' information is recorded by using different techniques and also in different data format [2]. This can cause a trouble when patients are needed to be transferred between hospitals that use different HISs. This is because the patients' information cannot be easily transferred/exchanged across different systems that use different data formats, data structures and/or ontologies.

Thus, currently in Thailand, the patients' information exchange is now operated manually by using paper works. There are several drawbacks of this traditional technique including: 1) the patients' information can be lost during the transfer process which may lead to an incorrect treatment, 2) patients may have to unnecessarily undergo the same treatment several time if the treatment records could not be transferred with them to the referred hospital, and 3) the hospitals may have to do duplicate works on the same patient, which is a waste of medical resource.

In fact, there has been an existing way of electronic patients' information exchange via Thai medical standard, namely 43-folders. The 43-folders consists of the following information: outpatient department (OPD), inpatient department (IPD), patient profile (PP), service information including financial statement, and many other information of the patient who is served by each provider organization [3].

All the information is stored in the database (.dbf). This standard, by using a healthcare information system (HIS), can report all services to related departments, provincial and ministerial based on the dataset which results in creating the indicator. It can be used for data analysis, such as the statistic of the patient with the disease. In addition, it helps releasing administrator's burden.

However, the patients' information exchange with Thai medical standard was originally created for financial transaction of the Ministry of Public Health, such as asking for the reimbursement of medical equipment or expenditure. Therefore, the patients' information exchanged via this method is not sufficient for the patient transfer between hospitals. Also, in the 43-floders, there are some pieces of information which are unnecessary for the transfer. Efficiently, only the necessary information for the medical treatment are supposed to be transferred with patient to the referred hospital.

In this paper, the 43-folders standard has been studied as a prototype for designing the proposed Thai medical standard

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with the purpose of the patient's information exchange. This standard has been used and applied on patient's information for decades. It will be easier for users who get familiar with the existing one and then do not need to change the way they store the patient's information.

Moreover, this paper focuses on the Java Health Center Information System (JHCIS) as our HIS used in the implemented system. JHCIS is a healthcare information system that was developed by the Information and Communication Technology Center, Ministry of Public Health. It is widely used in the healthcare stations and small-sized hospitals systematically, comfortably and efficiently [4].

```
<realmCode code="UV"/>
<typeId root="2.16.840.1.113883.10.20.29"/>
<templateId
root="2.16.840.1.113883.10.20.29.1.1"/>
<code code="51855-5"
codeSystem="2.16.840.1.113883.6.1"
codeSystemName="LOINC" displayName="Patient
Generated Document"/>
<title>Patient Generated Document: My Health
Summary</title>
<effectiveTime value="20150128003711"/>
<confidentialityCode code="N"
codeSystem="2.16.840.1.113883.5.25"/>
<languageCode code="en-US"/>
<setId extension="20121126145000"
root="2.16.840.1.113883.19"/>
<versionNumber value="1"/>
```

Fig. 1. The example of a header part in PGD

The JHCIS consists of one server and at least one clients. It database is installed on the server machine. It also interacts with the reports that are required by the federal and local administration [5]. The system was developed using Java language, and MySQL for database management. Actually, all of this are free source software and compatible with multiple operation systems such as Windows and Linux [4].

Furthermore, Clinical Document Architecture (CDA) is applied to our standard prototype. CDA was first named as the Patient Record Architecture (PRA) by HL7 organization which provides a standard for the organization of material within clinical documents for information exchange between systems. CDA is arranged for an exchange model for clinical documents such as discharge summaries, referrals and care provision information notes, in order to achieve an medical record in electronic way [6].

The CDA document is an XML-based document [7] which consists of header and body parts. They derive their machine from the HL7 RIM16 and the HL7 Version 3 (V3) data type. The RIM [8] and the V3 data types provide a commanding mechanism for empowering CDA's incorporation of concepts from standard coding systems such as Systemized Nomenclature of Medicine Clinical Terms (SNOMED CT) [9, 10] and Logical Observation Identifiers Names and Codes (LOINC) [11, 12].

This paper focuses on patients' information. That is the Patient Generated Document (PGD) [13] which is one type of the CDA document. As shown in Fig. 1, the header of PGD contains a machine-readable part which covers the contents about the patient, provider, document type, etc. On the other hand, in Fig. 2, the body contains a human-readable part, a machine-readable part, and an optional encoded part which covers many types of contents such as a clinical report [13].

Our proposed framework for Electronic Health Information Standard (EHIS) for the patient transfer is shown in Fig. 3. The objectives of this work are to export patients' information from JHCIS's database into a CDA-based standard prototype and to import that CDA-based standard file into the JHCIS's database, for the patients' information exchange between hospitals.

```
<patientRole>
      <id extension="999,1"
root="2.16.840.1.113883.19"/>
      <addr use="H">
          <houseNo> … </houseNo>
          <road> … </road>
          <district> … </district>
          <subDistrict> … </subDistrict>
          <province> … </province>
          <postalCode> … </postalCode>
          <country> … </country>
      </addr>
</patientRole>
```

Fig. 2. The example of a body part in PGD

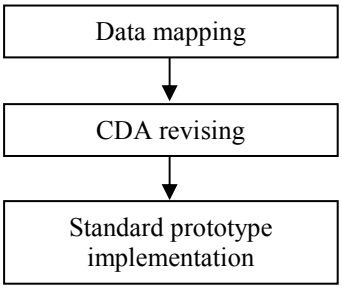

Fig. 3. The proposed framework of EHIS for patient transfer

The data mapping is a process to map the components in CDA with the patients' information in the JHCIS's database. The CDA revising is a process to revise the CDA according to outputs from the data mapping process. Then, the standard prototype will be implemented based on the revised CDA.

The rest of this paper is organized as follows. The data mapping process is explained in section II. The CDA revising process and the standard prototype implementation are proposed in sections III and IV respectively. The expected benefits are mentioned in section V. The conclusions are drawn in section VI.

II. Data Mapping

The mapping table was first created in order to make a further design and a new standard prototype easier to be implemented. However, the mapping table is performed to match the patients' information in the JHCIS's database with the PGD components in the CDA. All the components in the PGD are first listed, then followed by the matched attribute name from the JHCIS's database. Some of the mapped components are shown in TABLE I.

TABLE I. Example of mapped components between PGD and JHCIS

PGD	JHCIS	Description
streetAddressLine	Road	Road
City	Distcode	City/ District
State	provcode	State/ Province
postalCode	Postcode	Postal code
Prefix	Prename	Prefix
Given	Fname	First name
Family	Lname	Last name
administrativeGenderCode	sex	Gender
birthTime	birth	Birth date
maritalStatusCode	marystatus	Marital status
religiousAffiliationCode	religion	Religion
raceCode	nation	Nationality

The mapping result can be one of the following cases. In the first case, the data exists and is recorded in the same data type, in both CDA and JHCIS's database. The direct mapping is applied without any concern. In the second case, the data exists in both CDA and JHCIS's database but with different data formats. When the data is exported from the JHCIS's database into the CDA-based file, the data type must be matched with the one in CDA. On the other hand, when the data is imported from the CDA-based file into the JHCIS's database, the data type must be matched with the one in the JHCIS's database. In the third case, the data exists in the JHCIS's database but not in the CDA. If the data is important for the patient transfer process and/or the continuity of treatment, it needs to be added into the CDA by including the additional tags. In the fourth case, the data exists in the CDA but not in the JHCIS's database. If it is not significantly related to Thai medical information, then it can be ignored. Otherwise, JHCIS should be modified or the additional program should be developed, in order to collect the data from patients.

III. CDA Revising

The CDA standard is revised for the Thai medical standard prototype according to the constructed mapping table mentioned in section II. The revision process must follow the following rules: 1) the tags in the CDA cannot be removed, but it can be ignored if there is no information in the JHCIS's database, 2) if the information exists in the database and is important for the patients' transfer, but cannot be matched to any tags in the CDA, then additional tags will be added into the CDA. For example, as shown in TABLE II, the blood type of the patient is not contained in the PGD-based CDA, thus the "bloodGroup" is added as a new additional tag. More examples are shown in TABLE II.

TABLE II. Example of the created additional tags

Tag name	Description
pid	Citizen identification number
bloodGroup	The blood type of each patient. In this tag, it displays 2 values. The first one is the value of rh factor, where "p" is positive and "n" is negative. The other one is the type of blood. It shows in the form of A, B, O and AB.
education	Level of education
family	Parents' information which includes their name and their citizen identification number
mate	Mate of the patient which includes their name and their citizen identification number
privateDoctor	Private doctor
providerOrganization	Hospital name
hoscode	The unique code used to indicate the specific hospital name.
mu	The number to clearly specify an address of the patient/ relative or the provider organization.

IV. Standard Prototype Implementation

The electronic health information standard (EHIS) needs additional software to generate CDA-based or XML documents. Therefore, in this paper, the term "EHIS adapter" represents the XML converter of the proposed system.

A. System Architecture

There are 2 main functions of the EHIS adapter, which are export and import patient information functions. However, there should be an additional function to connect to the JHCIS's database in order to retrieve the patients' information. Thus, the "connect database" is considered as an extra function of the EHIS adapter system.

The overall system architecture can be described by the graphical representation as shown in Fig. 4. The hospital A can exchange the patient information with other hospitals via the export and import functions. Fig. 4 can be further described about how the patients' information is exported from the JHCIS's database (as shown in Fig. 5**)** and how the patients' information is imported into the JHCIS's database (as shown in Fig. 6).

Fig. 4. Overall system architecture

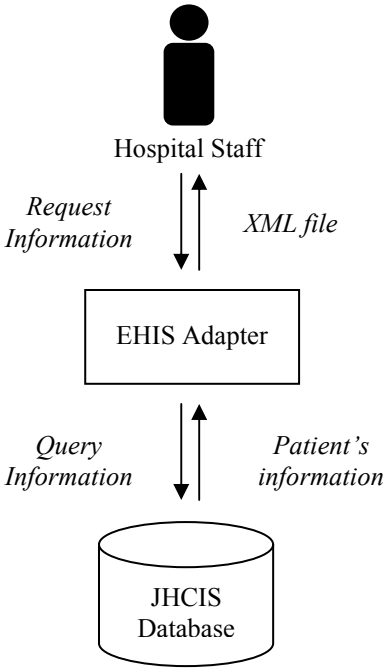

Fig. 5. Architecture of the export function

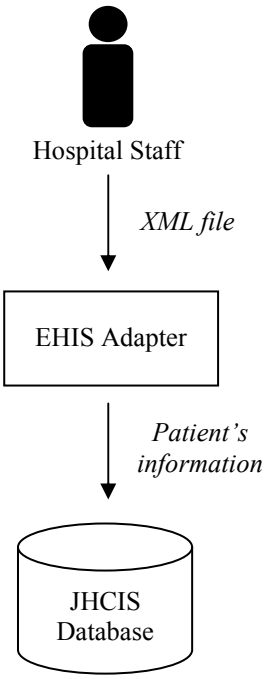

Fig. 6. Architecture of the import function

In Fig. 5, the patient's information is retrieved from the JHCIS's database and then is exported into the CDA file via the EHIS adapter. The CDA file is now ready to be transferred to other hospitals because the CDA will be used as the standard for all hospitals.

In Fig. 6, in the patient transfer process, when the hospital A receives the CDA file from another hospital, all data recorded in the CDA file will be imported into the JHCIS's database in the proper formats via the EHIS adapter. That is, EHIS adapter is required for each type of HIS to connect (i.e. export and import) with the CDA.

However, to access the database, the user needs to input the host's IP address, port number, database name, username, and password for permission to connect to the database function. If the connection is successful, then the user can perform the export and import functions.

B. System Implementation

To implement the standard prototype, desktop virtualization software is necessary to make a clean environment, thus each service will be run separately without any interruption. In this work, the VMware Workstation 11 [14] is used to run the Windows XP Professional which most suits the JHCIS program.

As mentioned, the standard prototype is implemented by creating the adapter, namely "EHIS adapter". It is written in Java, while the patients' information is retrieved from the JHCIS database by using MySQL as a relational database management. The rest of this section are to explain several steps of the EHIS adapter implementation.

1) Network Configuration

Since the server and client are in the JHCIS, the network must be configured for the database (server) connection. Therefore, the IP address of each machine is set to be in the same network group. The IP address of the virtual machine must be also setup by using the VMware Workstation setting menu.

Fig. 7. GUI of the database connection

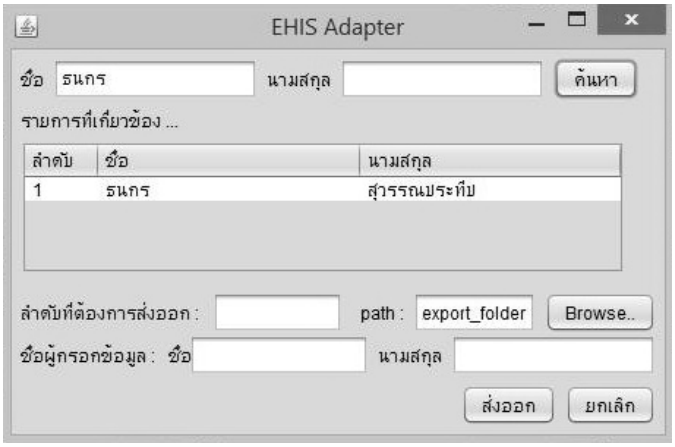

Fig. 8. GUI of the export function

Fig. 9 GUI of the import function

2) Database Connection

The database connection is implemented in order to connect the EHIS adapter to the JHCIS's database. In this function, the user is required to insert the IP address of the server, port number, username, password, and database name, as shown in Fig. 7. If the input information is valid, the connection is successful and the user is later allowed to choose the further functions including import, export, or disconnect from the server.

3) Export Function

Next, the export function is implemented to write the patient's information into the XML-based CDA format. As shown in Fig. 8, the user is allowed to search for patient's information by using the patient's first name or last name, then select the patient whose information needs to be exported.

4) Import Function

In the import function, it is developed to load the patient information from the CDA file into the JHCIS's database. The user is allowed to choose the folder where the CDA file is located. The multiple CDA files are allowed to be selected and displayed. Then, the patient's name in each file will be listed. The user can select the patient that is needed to be imported.

In addition, multiple patients can be exported or imported in one command. The point of this is to reduce the time to manipulate many documents at once.

V. Expected Benefits

This project can provide significant benefits to both patients and JHCIS's users as follows.

1) Benefits to Patients

- The transferred patients will receive the continuous treatments in the referred hospital.
- It will be easier to perform the transferring process, by using the proposed electronic-based patient information exchange, when compared with the traditional way of using the paper-based information exchange. This will encourage the flow of medical treatment transfer. As the result, the patient will have a chance to receive the suitable treatment from the well-equipped hospital via the patient transferring process.

2) Benefits to Users (Hospital Staffs)

- The patient transferring process can be done between different-sized hospitals which may use different HISs.
- The problem of the information loss during the transferring process can be minimized or eliminated by replacing the paper-based information exchange with the proposed electronic-based information exchange.
- The destination hospital does not have to perform duplicate treatments on the same patient, as have been done in the original hospital. This treatment information will be transferred with the patient in an electronic way.

VI. Conclusion

This paper proposes an alternative solution to improve the existing patient transferring process which is based on the paper work, by using the electronic-based information transfer. This will make the patient transferring process easier and more effective. As the result, it will provide a continuous treatment for the patient when he is referred from the original hospital to the destination hospital because the useful treatment and patient records can be transferred with him. The patient will not have to undergo the duplicated treatment, while the destination hospital also does not have to waste the medical resource to perform the duplicated treatment or checkup on the patient as have been done since in the original hospital before the referring process.

The developed program, namely EHIS adapter, could generate a standard prototype based on CDA for the patient information transfer between hospitals. In addition, it can be further developed for the better improvements of the patient information transfer between the small-sized hospital (i.e.

using JHCIS as HIS) and the medium-sized hospital (i.e. using HOSxP as HIS) in Thailand. However, the proposed work in this paper still has to be ensured that it can work for every possible cases of the patient information in the real situations where the EHIS adapter is placed in the real hospitals.

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