

OVERVIEW OF HEALTHCARE INTEROPERABILITY AND HEALTHCARE STANDARDS

Mandara K R¹, Dr. Ramakanth Kumar P² and Puneetha Hegde³

Abstract- Healthcare industry is no more interested in patient health records in a sheet of paper. Healthcare industry is moving towards electronic health records. Like other enterprise, Healthcare industry is also now adopting networked architecture. Patient data must be available to respective physician or lab technician even before patient reach particular person. This requires interoperability between medical devices and need for data transfer standards. In this paper, we have concentrated on healthcare interoperability and healthcare data transfer standards

Keywords – Interoperability, healthcare, electronic health record, healthcare data standards, HL7, DICOM

I. INTRODUCTION

Healthcare Industries are trying to reduce cost and provide better standard of care for each patient. Interoperability between Hospital Information System (HIS) and other clinical devices places a major role in improving patient care. This also introduces complexity to the system, which can be minimized by using better interoperability standards. Interoperability standards include communication, terminology and data standards.

HIS needs to integrate data from different departments like laboratory, radiology, admission wards, medicine supply store etc. The differences in the format of data of different departments makes it difficult to have interoperability with all these systems and HIS. This introduces a need for health care data transfer standard. In spite of many data formats like HTML, XML, CSV,DSV, JSON, Healthcare industry is widely using HL7 as a standard format for transferring clinical information. HL7 is preferred because it provides solution to entire healthcare data and not in particular with the departments. Admission, Order and Result information can be easily modelled in to HL7 messages and can be easily transferred over the network. HL7 is mainly operating at the application layer 7 so HTTP and TCP protocols are mostly used for communication. Since HL7 is working in layer7, data is seamlessly transferred without bothering on underlying layers

II. INTEROPERABILITY IN HEALTHCARE

Interoperability describes the extent to which systems and devices can exchange data and interpret that shared data. Two system to be interoperable, the systems should be able to process the data exchanged in correct format and present it in a way user can understand.[1]

Complete Interoperable health IT environment has to concentrate on standard of interaction between the applications, standard of communication used, standard used for information processing and standard how different vendor applications integrate.

¹ *Dept. of ISE, R V College of Engineering, Bengaluru, India*

² *Dept. of ISE, R V College of Engineering, Bengaluru, India*

³ *Philips Innovation Campus Bengaluru, India*

III. TYPES OF INTEROPERABILITY IN HEALTHCARE

Healthcare interoperability is classified in to different levels. [2]

Level 0 indicates the standalone systems which will not provide interoperability.

Level 1 represents the technical interoperability where two systems are able to communicate using some communication protocol.

Level 2 is a structural interoperability where two systems exchange the data through common protocol and have the same format for data exchange so the meaning of data is preserved.

Level 3 represents semantic interoperability in which two systems are able to interpret the exchanged data in the way it has to be interpreted. This means that the communicating systems are able to understand the data they exchanged.

Pragmatic interoperability is when both the systems are aware of procedures and methods they are employing.

Dynamic interoperability is when the systems are able to detect the state change in their assumptions.

IV. BENEFITS OF INTEROPERABILITY IN HEALTHCARE

A. *Benefit to Individual*

Patients can be benefited from the enhanced quality and safety of care. Interoperability across organizations and geographical borders helps to collect more relevant information [2] about the observed disease pattern and provide the best suggested medicine to the patient.

B. *Preventing further damage to patient health*

If Electronic Transfer Prescription (ETP) is linked to Electronic Health Records, then patient health history can be studied and can prevent harmful drug injections. If all the clinical devices are interoperable, the patient's vital signs from different devices can be collected and viewed at a time. This helps in better decision making about patient health and can prevent any future harm to patient health

C. *Clinical Research*

Interoperability between clinical devices and EMR helps in collecting huge amount of data which includes disease behavior, physician prescription, treatment result, side effects from treatment etc This data is much helpful for clinical research.

D. *Evidence based medicine*

Evidence Based Medicine is the approach of optimizing the clinical decision making by using evidences. Hospital interoperability helps in capturing patient values, Physician experience and research outcomes at a place and provide evidences for better decision making

V. CHALLENGES IN HEALTHCARE INTEROPERABILITY

A. *Heterogeneity in healthcare data*

The major challenge for healthcare interoperability is heterogeneity of hospital data. Hospital data includes text, images, live monitoring data, wave format data etc. Slight change in the data processing of different types of data may cause serious errors in recording patient's data

B. *Incompatible or Legacy systems*

Many of the large hospitals support different clinical systems from different vendors having various functionality. These systems may be incompatible. Providing interoperability in this environment is difficult

C. *Need for collaboration between hospital specialists and IT technical specialists*

As the hospital data is very complex to understand by common people, very high technical skilled persons are required to code the functions for hospitality workflow. IT specialists need help from hospital specialists to understand the clinical workflows.

VI. HEALTHCARE DATA STANDARDS

Starting from 20th century, most of the healthcare industries are using HL7 as messaging standard and DICOM as the imaging standard.

A. HL7

HL7 v2 is syntactic oriented healthcare protocol. It is the most known medical standard for message exchange. It defines different types of message based on different type of data exchanged in different sections of healthcare. HL7 is based on socket communication client and server in which client sends the HL7 message to server and server replies back with standard acknowledgement message. The messages are identified by its control segment. Every HL7 message is constructed with:[1][5]

- **Segments:** There can be one or more segments which contain information related to particular message type.

Eg: PID segment contains patient related information, PV1 segment contains patient visit information.

- **Fields.** Each segment contains many fields of data. Fields are separated by field separators. Fields contain different types of data including strings and numericals.

Eg: third field of PID segment (PID 3-4) contains patient Medical Record Number

- **Separator Characters:** These are the delimiters which separates two values. '|' is a field separator. '^' is a component separator. '&' is a sub-component separator. '~' is a field repeat separator.

- **Message Types:** There are four primary types of HL7 messages. ADT message is for admit and discharge information. ORM message contains order related information. ORU is a result message. DFT message contains billing information.

- **Trigger events:** Most of the events in healthcare field act as a trigger for information exchange. Event emerge at one system and can be handled by the system alone. Trigger event stimulate the system to send all accumulated data in the proper format.

Eg; ADT^A01 is a admit event

```
MSH|^~\&|AA1|AA1|OESEND_PM_PROD||20160715203336||ADT^A01|MSG0154107-
19|P|2.3.1|||||8859/1||
EVN|A01|20160715203336
PID||MPIO8|MRN^^^AA1^MR~MAMar1502^^^VHIS^MA||LName^FName^MName^S^Mr^Dr.||LNMom
^FNMom^^^PfxMom|19870106103300|M|||^Bengaluru^^^India||||M^Married|HIN^Hindu|||||
|||
PV1||E|ICU^Room198^1001|R|123||AttendingDoctor^Doctor0030^^^S^Dr.^AD||MED||R||A2|1|A
DID0030^Doctor0030^Admitting0030^ADMiddle0030^S^Dr.^AD|VisitNum|||||||||||||||||
|||||
```

Figure 1: sample HL7 ADT message

Why HL7?

Before HL7, data exchange between clinical system was through customized interfaces which required high programming skills. The cost of these custom interfaces was too high. HL7 provides a very generic way of information representation. With HL7, two systems can interact even though they speak different languages. It is the first system to allow automatic update on patient. it supports whole organizational requirement instead of departmental requirement. HL7 supports immediate transfer of single transaction along with file transactions of multiple transfers. The standard provides necessary site specific variations with site specific segments(Z-segments). It is the most widely used healthcare interoperability standard in the world.[4]

B. DICOM

DICOM stands for Digital Imaging and Communication in Medicine it defines communication standard for various digital imaging standards. DICOM standard is used at the application level so the format is independent of machines and other protocols. DICOM is adoptable to different medical specialties. The DICOM standard contains DICOM file and DICOM protocol.[3]

- **DICOM file:** All medical images are saved in the form of DICOM file. DICOM file not just holds images but also contains patient information like patient ID, name, patient sex, birthdate etc.
 - **DICOM Networking protocol:** All the hospital imaging application uses DICOM protocol for imaging transfer and archiving. DICOM protocol is mainly used to search for study images of the patient
Devices that supports the DICOM implementation are called as DICOM compliant devices. (Eg: MR devices, CT equipment) The vendor manufacturing the DICOM compliant device must provide a DICOM Conformance Statement. This is a document that describes which are all the DICOM services the device implements. DICOM network is usually a standard LAN and the connecting DICOM devices are called DICOM peers. DICOM is associated with two main components.
 - **Modalities:** These are the image acquiring equipments.
 - **PACS (Picture Archiving and Communication System):** It is an image archiving system.
- DICOM provides various image related services that are useful for medical imaging workflows. List of DICOM services includes:[6]
- Storage service (Using C-STORE)
 - Verification Service (Using C-ECHO)
 - Query/Retrieve Service (Using C-FIND and C-MOVE)
 - Modality Worklist Service (Using C-FIND)
 - Modality Procedure step Service (N-CREATE/N-SET)

DICOM standard is represented in the form of DICOM elements. Each DICOM element is made of a Tag, VR(value Representation),value Length and Value Field.

Tag: Tag uniquely defines the DICOM element and its properties.Tag is made of two numbers which indicates the group and element (Eg: (0008,0008) this indicates the image type)

Value Representation(VR): It is a code with two characters and define the data type of the element(Eg: CS for coded string, UI for Unique Identifier, DA for Date

Value Length: Each DICOM element has length and usually it is even.If elements value is a single character then it is padded with a space (Eg: patient sex has vale 'M' or 'F' whih will be padded with space.

Value Field: It represents the exact value of the field.(Eg:MRN field containd patient's MRN)

Below is the sample DICOM format representation:

```
(0010,0010) | Patient Name | PN | 00000038 |
"LNMarOrder12^FNMarOrder12 "
(0010,0020) | Patient ID | LO | 00000014 | "MRNMarOrder12 "
(0010,0021) | Issuer Of Patient ID | LO | 00000004 | "VHI S"
(0010,0030) | Patient Birth Date | DA | 00000008 | "19811110"
(0010,0032) | Patient Birth Time | TM | 00000006 | "111200"
(0010,0040) | Patient Sex | CS | 00000002 | "M "
```

Why DICOM?

DICOM relies on explicit model E-R model of how patients, images, reports are involved in radiology workflow. This can be easily understood by the manufacturers and users. DICOM protocol is very robust. Each DICOM command is acknowledged hence confirming the receipt of the message. DICOM provides version control in which receiver request the sender to fall back to different object when it is not able to understand the latest version. It negotiates the transfer syntax i.e encoding used to exchange. DICOM presentation service takes care of providing good quality image even when the images are zoomed. DICOM standard also provides better security.

VI. CONCLUSION

In this paper, Interoperability in healthcare and its challenges are discussed. The paper also explains the most widely used healthcare standards for message and image transfer.

REFERENCES

[1] Miguel Miranda,Gabriel Pontes,Antonio Abelha, et.al “Agent Based Interoperability in Hospital Information System”,5th IEEE international conference on biomedical Engineering and Informatics 2012.pp949-953

-
- [2] Bill vargas,Pradeep Ray “Interoperability of hospital Information System: A Case Study”5th International conference on Enterprise Networking and computing in healthcare industry 2003, pp79-85
- [3] Teresa C,Robert J,Pui Lam Yu, “Digital Imaging and Electronic health record syatem:Implementation and regulatorychallenge faced by healthcare providers”,IEEE conference on Applications and Technology 2015
- [4] Kuyeon lee,Juyoung park,Kyungtae Kang, “Development of tele-healthcare syatem based on HL7 standard”, 18th IEEE International symposium on consumer electronics 2014
- [5] <http://www.healthcareitnews.com/news/8-common-questions-about-hl7>
- [6] <http://dicomiseasy.blogspot.in/2011/10/introduction-to-dicom-chapter-1.html>