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Electronic Health Record Storage and interoperability: Archetype Based Solution

Gunjan[a] Saba Khanum[a] Bharti Sharma[a] and Cherag Verma[a]

[a]CSE, IT, Maharaja Surajmal Institute of Technology, Delhi, India

E-mail: Gunjanbeniwal@msit.in, Saba@msit.in, Bhartisharma@msit.in, Cheragverma0001@gmail.com

Abstract: Significant research has been done to achieve syntactic interoperability for exchanging information among disparate EHR's. However, still there is a need to make efforts in the area of semantic interoperability. Our research provides an archetype based solution to achieve semantic interoperability among different EHR based on either openEHR or HL7. Model based on java platform is introduced in this paper, which provides query based communication among different locations to share their clinical data efficiently. Information can be easily accessed from anywhere any time in a suitable format for making proper decisions before and after the treatment of patients.

Keywords: *Clinical data, EHR, Healthcare units, Semantic interoperability.*

1. INTRODUCTION

Electronic Health Record is the systematic digitally stored clinical information provided to the stakeholders for proper treatment of patients [12]. It basically helps to gather information from patient's records like medical history, current diseases and treatment provided, insurance claim, billing information and much more information necessary for treatment and research process [4]. EHR is based on dual model architecture which separates information from knowledge [1, 3, 13]; information is represented by Reference model and Archetype model represents knowledge. Different healthcare centers have different standards like HL7, ISO 13606, DICOM, LIONIC, ICD, openEHR, etc [11] for storing their EHR which need to be shared among health providers. We mainly focus on openEHR and HL7 (Health Level Seven) for providing semantic interoperability.

Interoperability means the ability of healthcare providers working together within and outside the organization for effective delivery of information. There are two types of interoperability [5, 6, 16].

1. **Syntactic interoperability [6, 7]:** Is a way to exchange data among disparate systems in context of different platform, different languages and dissimilar interfaces.
2. **Semantic interoperability [14, 18]:** Allows various healthcare systems to share information which is interpretable and understandable by the receiver. It allows electronic sharing of information among care givers and it improves the safety and quality of healthcare delivery.

There are hospitals following openEHR [17, 19, 20] standards for maintaining patient's records and there are some who follows HL7 [17] standard of EHR. The OpenEHR is the result on concentrated efforts of nonprofit organization [9]; Dual model architecture forms the basis where the Reference model defines a set of entities containing non volatile features of EHR and the one which is Archetype model defining clinical concepts in the form of constrained and structure combination of entities, clinical knowledge is defined. Ontologies has been used which allow the use of terminologies like SNOMED-CT, LIONIC and ICDx. Currently openEHR is used in projects of Australia, Brazil, Netherlands, Norway, Portugal, Russia, Slovenia, UK, etc to maintain the complex medical records.

HL7 was established at the University of Pennsylvania in 1987 [10]. It facilitates exchange, integration, management and support to patient care. HL7 affiliates around 31 countries which include India, Malaysia and Turkey. Hl7 v3 uses XML to serve as a messaging syntax and its consistency with the UML model and OO (Object Oriented) concepts gives it world wide acceptance. There are number of other standards like DICOM, LIONIC, ICD available to provide easy communication. But most the available standards are format specific or department specific. It is integrated with OSI model so that the communication through HL7 is more effective and robust. HL7 can be applied to application layer of OSI model. Because of its flexibility and integration with communication system, it is selected as the research model.

A strong need to exchange information between these hospitals which follow different standards for enabling patient mobility and cross border access to these health providers is already being noticed by heath care systems, for that we have proposed an archetype based solution. We proposed a model to integrate the data of two types of healthcare centers and provide the desired result to the end user.

2. RELATED WORK

Semantic interoperability of health care information among different standards of EHR has been an active research topic and development area. David moner [1] discussed about the tool he proposed for developing archetypes which is being used by IT domain expert and Health domain expert. LinkEHR-Ed tool was introduced based on dual model architecture of EHR for integration and standardization of heterogeneous and autonomous clinical information. During the development of archetype, LinkEHR-ED tool reduces the gap between health domain experts and IT domain expert. This tool is used to work with reference model whereas archetype persistence is achieved by using ADL. For automatic validation of development archetypes from a semantic point of view only semantic manager is responsible. Archetypes are most appropriate approach for enhancing the existing system in order to make them compatible with different EHR standards as these are the main components of data integration [15].

Naeem [2] proposed SOA complaint system, based on HL7 archetype which consists of translations between v2 and v3 along with message generation and parsing process, Web Service Adapter, and mapping of database to HL7 modeling elements. WSDL contract document is described for the result of query performed. HL7 standard provides all the rules for exchanging the clinical data therefore Health Information System will only interact with HL7 interface while sharing data to another HIS or other service requestor. SOA includes Service Contract, Consumer, Provider and Registry. For exchanging/sharing of clinical records across organizational boundaries SOA complaint HL7 is used.

C.Martinez Costa [3] gives an overview of semantic interoperability and proposed a model for converting ISO 13606 archetype into OpenEHR archetype and vice-versa. He used Semantic Web and Model Driven Engineering (MDE) technique for transforming Archetype Definition Language (ADL) into Ontology Web Language (OWL). By using MDE, ADL was transformed into OpenEHR model, and then openEHR model was converted into an intermediate model. This intermediate model was further transformed to ISO 13606 and finally to ADL. Syntactic model was expressed by ADL archetype which was converted to semantic model by using model to model transformation. Then this Semantic model was further converted to OWL with the help of model to text transformation according to EHR ontologies. Poseache convertor was used in protégé

environment for transformation and the model was implemented using Ruby transformation language. Both the standards used of transformation i.e ISO 13606 and openEHR follow dual-model approach which separates information from knowledge by reference and archetype model respectively. By using this proposed model we can achieve semantic interoperability at data level between two widely used standards.

C.Sunil [4] proposed a Health Exchange Software (HIES) system to provide interoperability. Major problem associated with healthcare system are safety, quality, accessibility, efficiency and cost. Barrier to achieve interoperability is the cost needed to re-establish complete medical system. Therefore Standardization is required for classification and sharing of clinical records with respect to ability and quality. HIES provides foundation services for HL7 standard based complex systems. Three processes are proposed to provide interoperable EHR *i.e*. message generation, transportation and receiving process. In message generation process first of all database is referred, converting it to RIM model, making a DOM tree and message is created. By using email, TCP/IP, HTTP and SOAP we can transfer the message safely to the receiver. Finally in receiving process message is parsed, DOM tree is interpreted and data is retrieved from RIM object to store in database. They have used two algorithms DBX and XDB to covert database to XML format and vice-versa for efficient exchange of healthcare information.

Mustafa [5] proposed ISO/IEEE 11073 DIM model to represent medical device observations in an appropriate format which can be used by clinical applications like EHR, PHR, clinical decision support system, etc. ISO/IEEE 11073 DIM model was used to derive HL7 v3 Refined Message Information model (RMIM) of medical device domain from HL7 v3 model. Domain Message Information Model (DMIM) is derived from HL7 v3, with required classes, attributes, relationships for message generation. Then RMIM is derived from DMIM with required attributed, classes and association in messages for their respective sub domains. Once RMIM is obtained, XML transformations can generate different Interfaces based on HL7 like HL7 PHMR, etc.

Yang Gua [6] worked on PEER-TO-PEER (P2P) model which was based on JXTA technology, for P2P network. In this model healthcare units were considered as peer and are assumed to have internet connection, which exchange their data in a fixed amount of time. A request is being sent from one healthcare center to another for acquiring patient's information and if they have information it will be delivered soon. This model covers the interoperability gap and is able to provide a prototype which can efficiently exchange the clinical data. Mehtam [7] defined service oriented approach in which SOA based HL7 v3 was introduced to provide a platform to achieve flexible interoperability. Guidelines of HSSP i.e. healthcare Service Specification Project were used along with BPEL (Business Process Execution Language) to give a business perspective.

Erik Sundvall [8] proposed REST architecture which aims to reduce the need for implementing prototypes based on archetypes based system such as openEHR. It also used to create LIUEEE (Linkoping University Educational EHR Environment), which is used to help the newcomers to learn more about EHR approach and rapid prototyping. REST has three properties: scalability, performance and high availability which help to formalize the data storage and retrieval of data from openEHR system.

In the above related work we can observe that in [4,5,7] authors have implemented models to make HL7 interoperable and in [8] author focused on OpenEHR but cross communication between these two standards have not been focused on. Therefore in this paper an intermediate system is modeled to share or exchange clinical data among two most widely used standards of EHR *i.e*. HL7 and openEHR.

3. RESEARCH METHODOLOGY

In field of medical science we have already achieved syntactic interoperability but semantic interoperability is still not in practice. Data can be transferred from one place to another but that data should be in interpretable format and easily understandable by the receiver; therefore archetype based solution is provided in this paper. A qualitative research approach is used in this work where method investigate the why and how factors for making decision other than what, when and where. We have proposed a model to exchange data from different location without losing its original meaning.

3.1. Proposed architecture

This section provides you the basic architecture used in this model. It consists of clinical datasets maintained among disparate hospitals at different locations following either HL7 or OpenEHR standards. A centralized server is maintained which is connected to different locations. End user who can be a patient or a doctor or any other health service provider will select some criteria to pass a query from any location to the centralized server. Automatic query will be generated through condition based mapping just by selecting some criteria and this query will be transferred to Hl7 interface: tag identifiers will validate the query through attribute mapping and forward the query to centralized server. The queries will be performed in terms of semantic checks based on which the query will split and converted to different forms of standards *i.e*. HL7 or openEHR respectively. Once individual query is generated it will be passed to relative dataset and retrieve the required data. Now in a common cache process area this retrieved data will be combined on the bases of attribute level semantic mapping and results will be provided to the end user in a generic format.

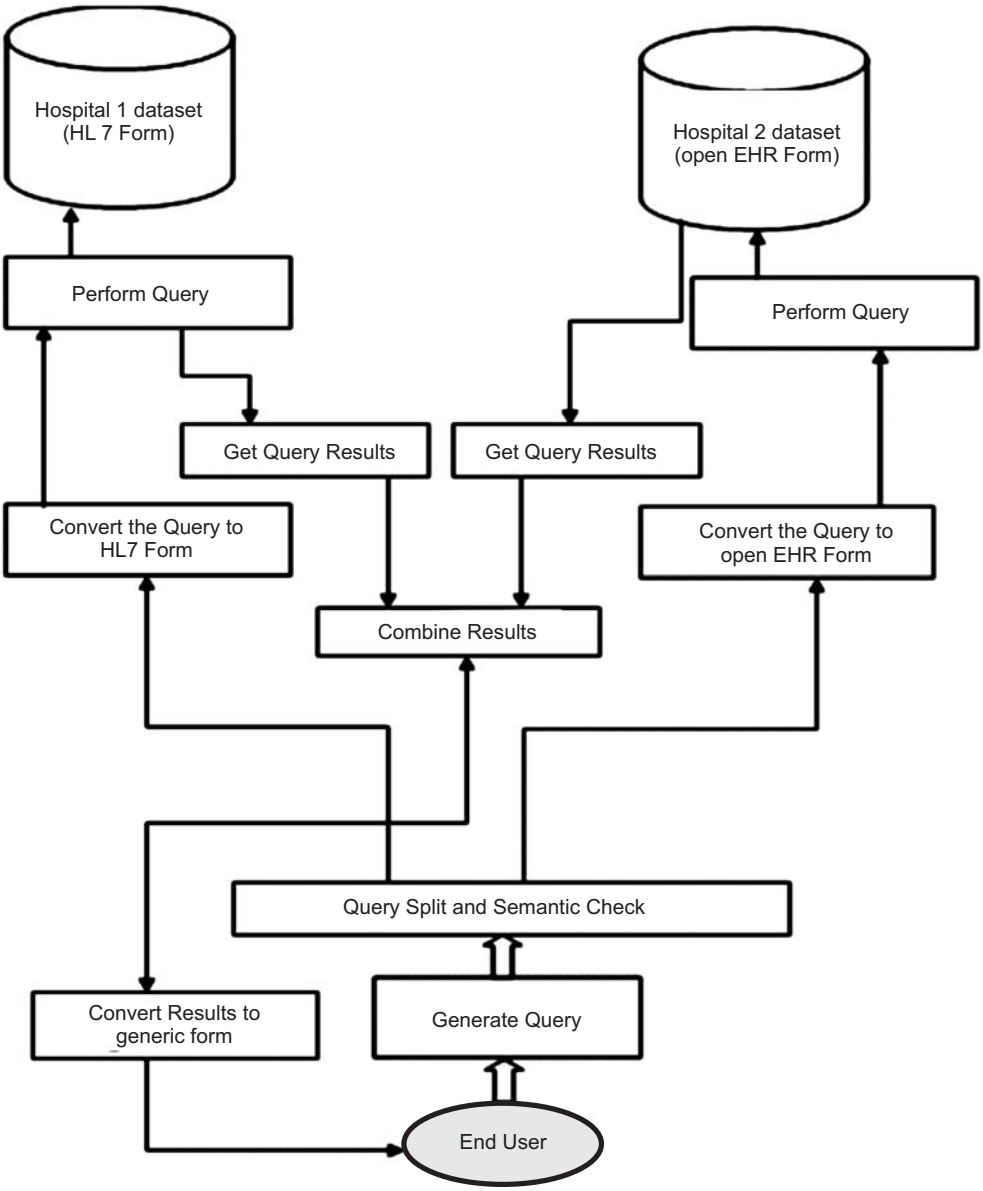

Figure 1: Proposed Architecture

Multiple queries will be performed at centralized server at any point of time and to handle this situation we are using MySQL databases along with xml mapping for the efficient performance on server side. A problem of Bigdata can occur on the common cache area where the results are combined and then provided to the user in a generic format as the data may be very large and for that we can use cloud computing concept. Hadoop which is an open source framework used to store and process big data in a distributed environment can solve the problem of Bigdata in common cache.

Algorithm : Algorithm (Patient)

/* Patient is the actual user that will perform the request from any centralized device to perform the information level mapping under interoperability*/

1. Req = GenerateRequest(Patient)

   [The information access request will be generated by the patient to access the information content related to disease or the patient information]

2. If(CheckAvailabilty(Req))

   [Check whether the required information is available on client side]

   {

3. Info = GetInfo(Req)

   [If the information is available on client side, the query will be performed and the information contents will be provided to client]

4. UpdateStats(Req)

   [The query level statistics will be updated in interoperability table to identify the user requirements]

   }

5. If(CheckAvailabilty(Req,Server))

   [Check whether the required information is available on Server side]

   {

6. Map=MapInteroperabilty(Req,HL7,OpenEHR)

   [provides the mapping between HL7 and OpenEHR system]

7. Info=GetInfo(Req, Server)

   [If the information is available on Server side, the query will be performed and the information contents will be provided to client]

8. UpdateStats(Req,Server)

   [The query level statistics will be updated in interoperability table to identify the user requirements on server side]

9. UpdateStats(Req)

   [The query level statistics will be updated in interoperability table to identify the user requirements on client side]

   }

10. If(CheckAvailabilty(Req,OtherHosts))

    [Check whether the required information is available on Other Hosts available in the distributed environment]

    {

11. Map=MapInteroperabilty(Req,HL7,OpenEHR)

    [it provides the mapping between HL7 and OpenEHR system]

12. Info=GetInfo(Req, Neighbor)

    [If the information is available on Neighbor side, the query will be performed and the information contents will be provided to client]

13. UpdateStats(Req,Neighbor)

    [The query level statistics will be updated in interoperability table to identify the user requirements on Neighbor side]

14. UpdateStats(Req)

    [The query level statistics will be updated in interoperability table to identify the user requirements on client side]

    }

3.2. UML Designs

This section focus on the designs prepared for the proposed model. Use Case diagram represents the actors involved and other departments. In figure2 actor is a stakeholder, which will pass a query to the hospital dataset. Based on the extraction of information provided by the stakeholder in the query, data will be filtered on the bases of certain rules already defined which will help to provide the desired results to achieve interoperability between different EHR standard, HL7 and openEHR

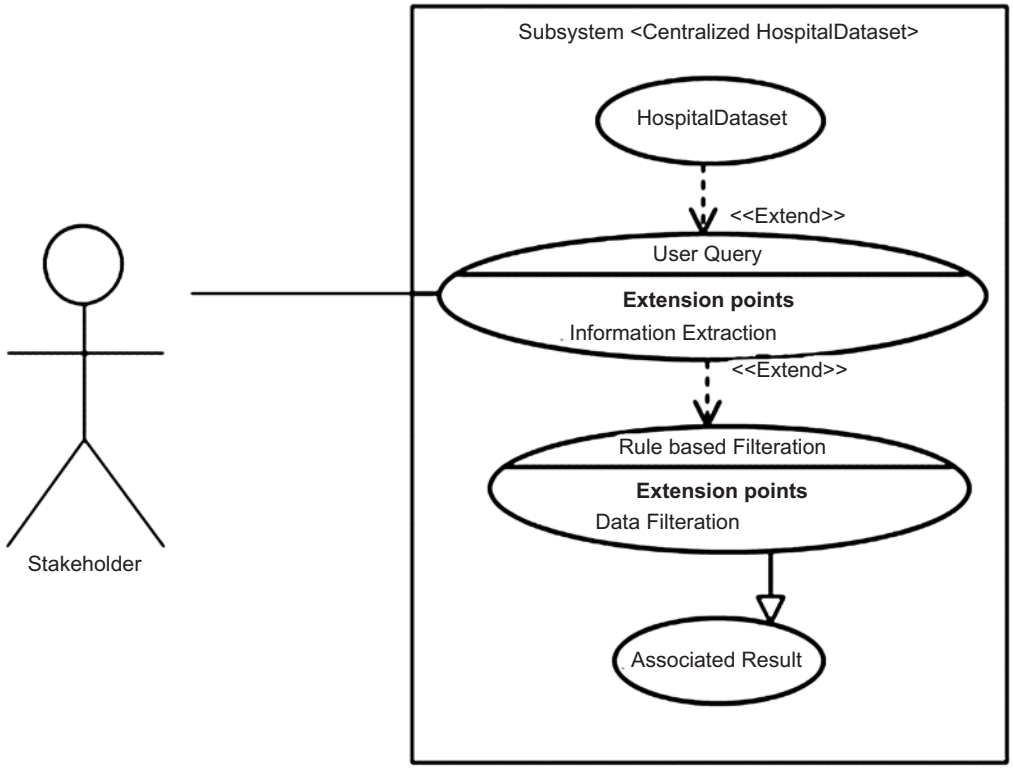

Figure 2: Use Case Diagram

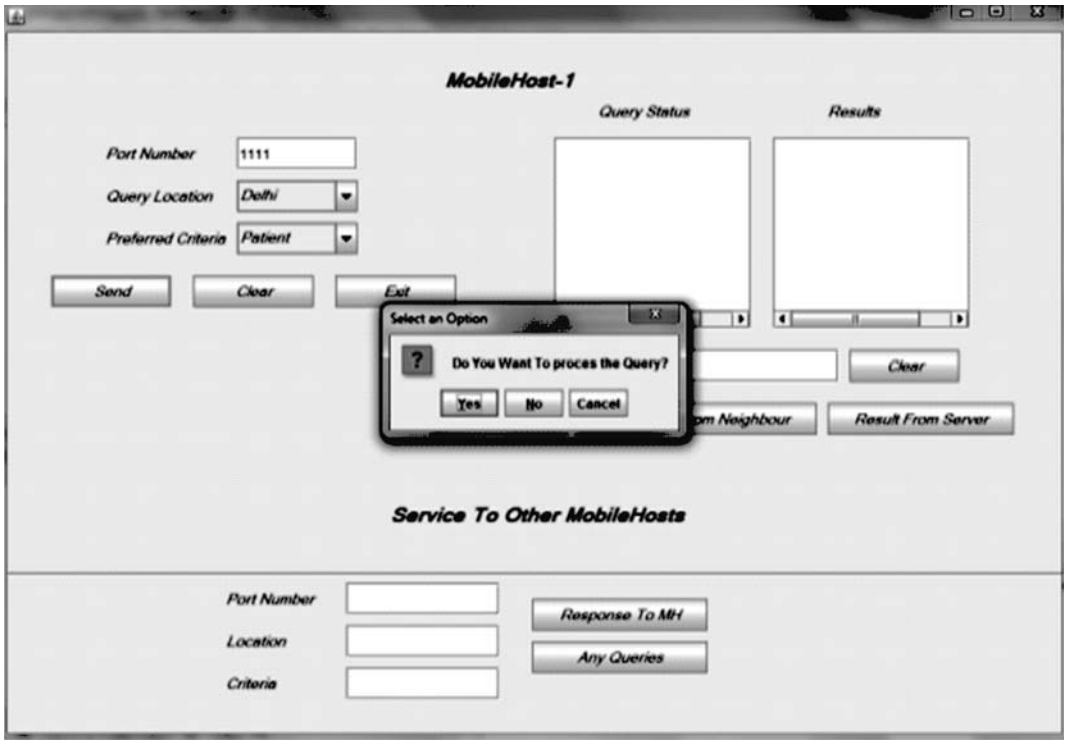

Figure 3: Location interface

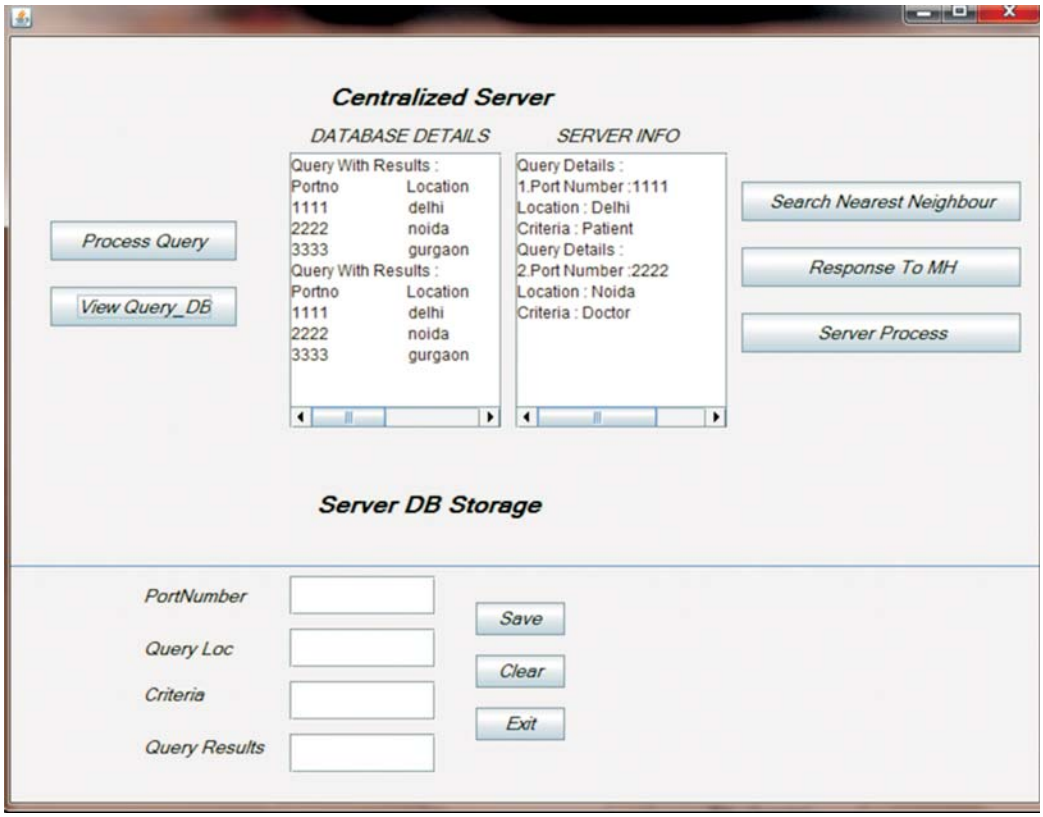

Figure 4: Centralized server interface

Centralize server will initialize the data and location server will generate the query. When query is processed by centralized server interface we can observe the database retrieved from the datasets and can also check the server details. Different queries will be passed from various locations can be integrated at the centralized server and all the data from datasets can also be considered from there for decision making process. Query based combined results will be formed and provided to the end user in a generic format.

Table 1
Patient Database table

Name	*Address*	*Age*	*Symtom*	*Disease*
Anu	H.No.123, ramm appartment, sector 5, dwarka	45	Fever, body pain	Fever
Dhruv beniwal	A-189, sector-15, noida	23	Patches on full body	Skin allergey
Gautam tomar	H.No. 678, sector-15, rohtak	30	Cough, fever,	Chest Congesti
Anita panwar	Shiva appartments, c-21, sector-19, rohini	76	Body pain, weakness	fractured hip
Satish kumar	H.No. 23, main road, sector-23, chennai	55	Headache	Migrain
Ravi sharma	D-90, sector-56, noida	37	Back pain, neck pai	Slip disk
Anita toma	H.No. 34, second floor, sector-30, main road, chennai	43	Vomiting, headache, fever	Fever
Dhruv mittal	Bramha appt, b-29, sector-45, vasana vihar	39	Stomac pain, vomiting	Food poisoning
Gunjan beniwal	3-2, staff flats, c-4, janak puri, new delhi	23	Cough, headache, fever	Fever

4. CONCLUSION

Our proposed model will provide the semantic interoperability between the two EHR standards *i.e*. openEHR and HL7 environment so that cross communication between different stakeholders can be performed. Semantic interoperability is mainly achieved by automatic query generation based on condition mapping on criteria selected by the end user. The representations of the data have been done with respect to the end user so that the generic result outcome can be obtained in interpretable and understandable format. This will improve the efficiency and quality of the healthcare systems and will increase the level of treatment process provided to the patients

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