DESIGNING A NOVAL DOMAIN MODEL FOR HEALTH LAYER 7 REFERENCE INFORMATION MODEL

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY

(Computer Science and Engineering)

SUBMITTED BY

PRABHSHARAN KAUR

University Roll No. 96336582134

August 2012

PUNJAB TECHNICAL UNIVERSITY

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CANDIDATE'S DECLARATION

I, hereby certify that the work which is being presented in the thesis entitled **"DESIGNING A NOVAL DOMAIN MODEL FOR HEALTH LAYER 7 REFERENCE INFORMATION MODEL"** by PRABHSHARAN KAUR in partial fulfillment of requirements for the award of degree of M.Tech. (Computer Science & Engineering) submitted in the Department of Computer Science & Engineering at **GURU NANAK DEV ENGINEERING COLLEGE, LUDHIANA** under **PUNJAB TECHNICAL UNIVERSITY, JALANDHAR** is an authentic record of my own work carried out during a period from Jan. 2011 to July. 2012 under the supervision of **Prof. KULWINDER SINGH MANN**, Department of Information Technology. The matter presented in this thesis has not been submitted by me in any other University / Institute for the award of M.Tech Degree.

(Prabhsharan Kaur)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

(Kulwinder Singh Mann)

The M.Tech Viva–Voce examination of Prabhsharan Kaur (University Roll No.: 96336582134) has been held on ________________ and accepted.

Signature of Supervisor   Signature of External Examiner

Signature of H.O.D

ABSTRACT

The Health Level 7 (HL7) Reference Information Model (RIM) was introduced as an object oriented information model to stabilize the definition of HL7 messages across different application domains. After the heels of HL7's successful version 2, the last version 3, including the RIM, which forms its centerpiece, has received significant attention. The HL7 RIM is a static model of health and health care information as viewed within the scope of HL7 standards development activities. It is the combined consensus view of information from the perspective of the HL7 working group and the HL7 international affiliates and RIM is an essential part of the HL7 Version 3 development methodology, as it provides an explicit representation of the semantic and lexical connections that exist between the information carried in the fields of HL7 messages. The RIM was conceived as a universal reference model for health-care interoperability, covering the entire health care domain. There are multiple existing approaches based on RIM development, in which one of the approaches is HL7v3 RIM based domain information model (DIM) dedicated to clinical engineering. In this paper introduction of a novel Domain Model for Healthcare Information System using the HL7 RIM is achieved as an object oriented information model to harmonize the definition of HL7 messages across different application domains. This system provides the capability to view the most required functions of patient healthcare information which are necessary and support services provided, taken from Meta observations generated at different domains and generate a well-defined Observation Report which goes with aspect of RIM association classes and perform further actions.

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PRABHSHARAN KAUR

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NOMENCLATURE

Abbreviation	Description
API	Application Programming Interface
CEIRM	Clinical Engineering Information Reference Model
CSS	Cascading Style Sheets
DICOM	Digital Imaging and Communications in Medicine
DIM	Domain Information Model
DMIM	Domain Message Information Models
DOM	Document Object Model
DTD	Document Type Definition
EDI	Electronic Data Interchange
HER	Electronic Health Record
EMR	Electronic Medical Record
EPR	Electronic Patient Record
HIMSS	Healthcare Information and Management Systems Society
HCIS	HealthCare Information System
HL7	Health Level Seven

HL7 (CDA)	Clinical Document Architecture
HL7 v2	HL7 Version 2
HL7 v3	HL7 Version 3
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Standardization Organization
LAN	Local Area Network
RIM	Reference Information Model
RImM	Reference Implementation Model
SAX	Simple API for XML
SGML	Standard Generalized Markup Language
SQL	Structured Query Language
UML	Unified Modeling Language
USAM	Unified service Action Model
XMLITS	XML Implementation Technology Specification
XSD	XML Schema Definition
XSLT	Extensible Stylesheet Language Transformations

CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Healthcare systems

Healthcare systems are extremely complex and information demanding area, creating and utilizing a huge amount of healthcare information, which implies an assertion that paper-based records, can no longer reach the requirements of advanced healthcare system (Jalal, 2008). Due to the emergent need to improve healthcare services, which is growing more to organize and deliver high quality services that paper-based records cannot be supported especially with an increasingly complex data entry. There is an increasing desire to improve the ability to access patient record information that is distributed across multiple sites by using the latest Information and Communication Technology (ICT). Computers have been used in healthcare organizations for decades to facilitate the integration and manipulation of patient's data and improve the clinical decision making process to be more promptly, surly and reasonably.

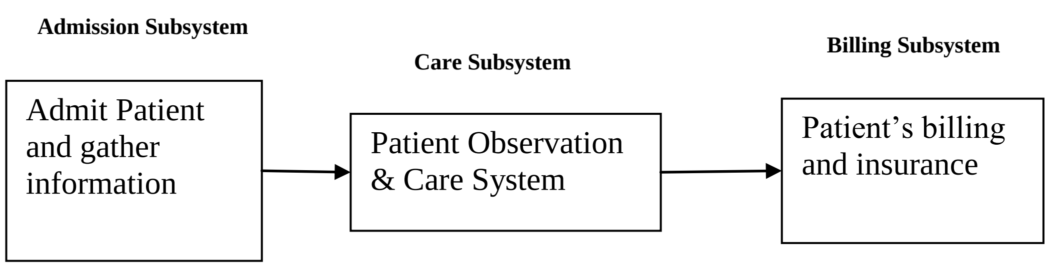

Figure 1.1: HealthCare Information System

During the last decade, the healthcare environment has been enhanced with increased emphasis on preclusion and early recognition of disease at primary and secondary healthcare service, mental health, home care, and continuity of care. In such an active environment, ICT are taking on a primary task and are presently having a major influence on healthcare system. The stimulant for improving the healthcare area, which has been implemented for several years, is anchored in the utilization of ICT. This is required for improved quality and efficiency of healthcare services and the suppression of associated costs. In the context of improving the quality, efficiency and consistency of healthcare service, creating, storing and sharing the patient healthcare information among different healthcare systems has been assigned as high priority in various nations, which can be achieved by using EHR.

The EHR will be constructed and continuously updated from the contribution of one or many EPRs that are created and stored at different healthcare locations such as acute Hospitals, community services, Mental Health and Social Services (Jalal, 2008). Healthcare organizations, medical schools, employers and even the governments have appreciated the significance of computerizing the various components of the patient health records**,** exchange and discuss the various results among them.

Patient's Health Care Information System (HCIS) is a process where the health data are recorded, stored, retrieves and processed for decision making (Ibrahim, 2002). HCIS is responsible for collecting information to be used in the effective planning, development, coordination and evaluation of the individual program.

An information system is required because managers at different levels of management require information in order to achievement, monitor the existing program as well as plan for future development. HCIS includes information on the number of patients seen, the type of cases seen in different seasons, the number of health professionals available, the type and number of drugs available, and like. Based on such information, managers can manage better the health facilities (Ibrahim, 2002). For example, based on such information managers can calculate the patient load etc. It is a decision support system for health management and a system that links information to managerial concern.

The system framework of HCIS consists of various subsystems such as Medical care, Dental care, Communicable Disease Control, Laboratory Services and Blood Bank services.

Steps in developing a healthcare information system:

- Review the existing system
- Define the data needs of relevant units within the health system
- Determine the most appropriate and effective data flow
- Design the data collection and reporting tools
- Develop the procedures and mechanism for data processing and implement a training program for data providers and data users
- Pre-test and redesign the system for data collection, data flow, data processing and data utilization.
- Monitor and evaluate the system and enhance the HCIS.

The objective of the HCIS is to produce quality information to support decision making and increase accessibility (Haazen and Streveler, 2004), improves productivity and provides better quality health care.

1.1.1 Benefits of Healthcare Systems

There are the various benefits (Ibrahim, 2002) are described below:

a. *Better Resource Utilization*: Healthcare Systems allows for better utilization of physicians and related hospital staff; thereby expediting diagnoses. Potential effects include greater satisfaction of providers, patients and their families.

b. *Increased Access to Care*: The use of Healthcare Systems and the Internet allows for faster evaluations, which directly relates to the number of diagnoses and evaluations per time.

Early diagnosis and early treatment creates better health outcomes at reduced direct costs to the health care system.

c. *Increased Productivity of the Health System*: Healthcare Systems allow for the routing of consults to a specialty hospital rather than to a general network hospital or provider. At sites where specialists are not utilized to capacity, the health system can eventually shift the workload to improve utilization. This would allow for better utilization of physicians at remote sites, with the potential for primary care providers providing the needed care with guidance and evaluations from the specialists.

d. *Increase economic productivity*: The provision of adequate healthcare services to the citizens will provide a healthier, happier citizenship. The efficient system will reduce stress and provide better serve for the nation.

1.1.2 Healthcare Systems Functions

Healthcare Information System is built on the foundation of three processing phases: data input, data management, data output (Tan, 2008). The *data input* phase includes data entry and data verification. The *data management* or processing phase includes data storage, data classification, data update, and data computation. Finally, the *data output* includes data retrieval and information display. These seven elements and three phases together define a typical Healthcare Systems as represented in figure 1.2.

Data Entry involves both the generation and collection of accurate, timely and relevant data. Data verification includes involves the verification and validation of gathered data. Data storage involves the data preserving and archiving. Data classification is a critical function for increasing the efficiency of the system when the need arises to conduct a data search.

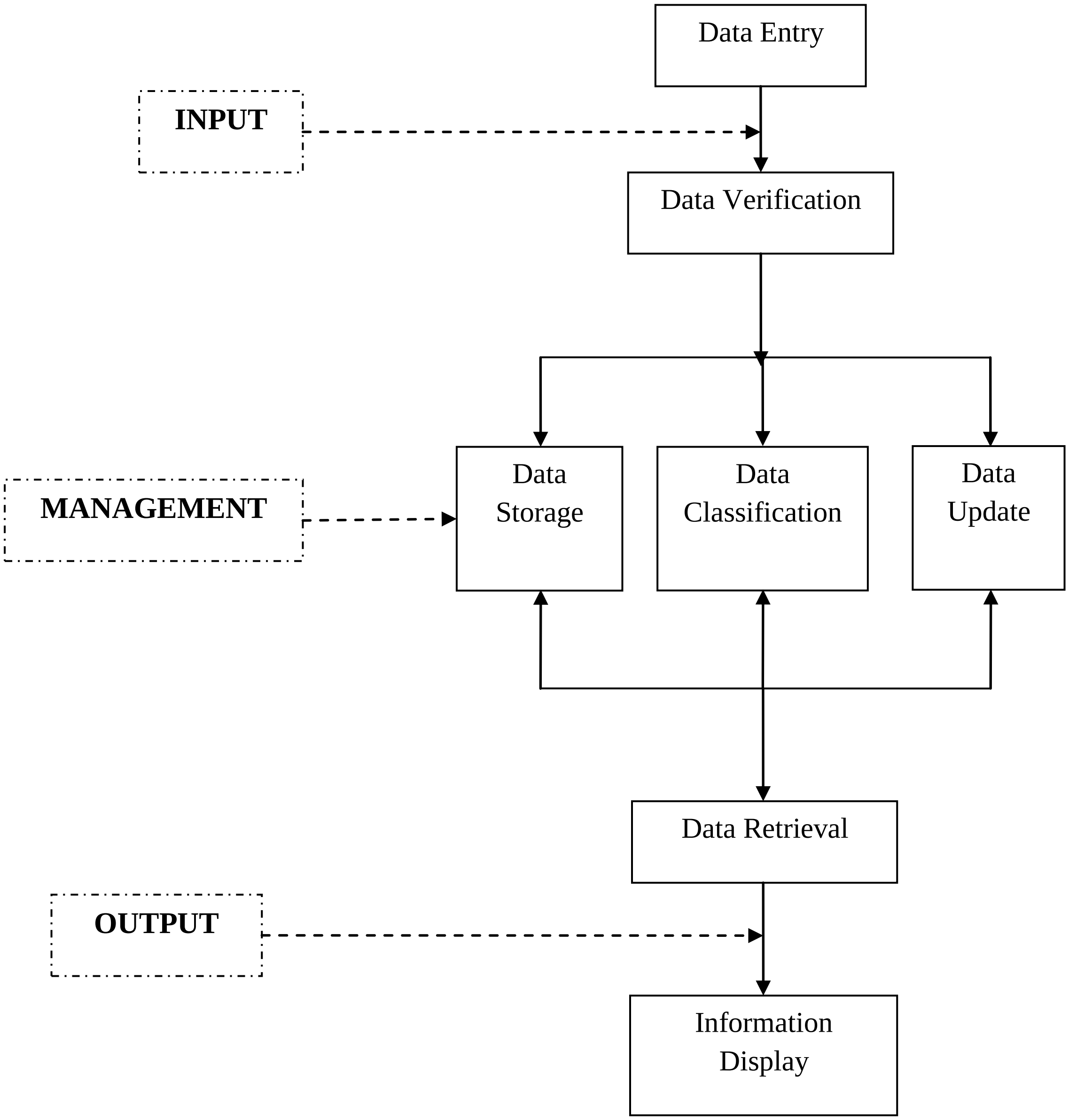

Figure 1.2: Functions of HealthCare System

It provides the greater understanding of how the data will be used after the data have been collected and storage. It also involves various forms of data manipulation and data transformation, such as the use of mathematical models and statistical applications, linear and non linear transformation (Tan, 2008). New and changing information is accounted for the element of data update. Data retrieval is concerned with the data transfer and data distribution. Final, Information Display has to do with how users will interpret the information produced by the system.

1.2 EHR

Electronic Health Record is one of the significant initiatives set out by Healthcare organizations which will inevitably replace the paper record at some point in the near future. The successful national strategies for EHR are assisted by various factors that must be in place in order to achieve the required electronic healthcare records. It is a record in digital format that is capable of being shared across different health care settings, by being abstracted in network-connected enterprise-wide information systems (Schadow et al., 2005). Such records may include a whole range of data in summary form, including demographics, medical history, medication and allergies, immunization status, laboratory test results, radiology images, vital signs, personal stats like age and weight, and billing information. This includes communications infrastructure, interoperable standards and implementation plans. EHR comprises the many of the patient records known as Electronics Patient Records.

A collection of documents concerning a patient is termed a Patient Record. The collection can be made from different sources and created at different times to a patient-related document. The aim of a patient record is to document *when, with whom, why, which* medication was given, *by whom*, with *what result*. It should be possible to follow each step of medical treatment. Medical documentation is usually performed by forms and free-text notes. Additionally, medical-technical documents like scan tests as x-rays or lab reports are appended to the patient record. The main data and information stored in a patient record is outlined as (Lehmann and Meyer, 2002):

- Patient data(i.e. personal data): e.g. name, address, date of birth, sex, age
- Administrative data: e.g. health insurance data, general practitioner, case number
- Medical history: e.g. ailment, symptoms
- Observations(i.e. lab and scan reports): e.g. laboratory values, scanned image values
- Diagnosis: e.g. main diagnose, secondary diagnosis

- Treatment: e.g. medication, surgeries, prescription.
- Nursing documentation: e.g. bedding.
- Discharge note: e.g. recapitulating review and interpretation of medical history along with billing and insurances.

The advantages of EHR systems over conventional patient records are manifold, e.g. no local constraints of usage, fast and diverse processing, retrieval possibilities or user-oriented presentation of data, Increased Efficiency, Improved Documentation and Improved security.

1.3 HL7

Health Level 7 is an ANSI-accredited organization, founded in 1987 for developing organizations dedicated to provide standards for electronic manage, exchange, integration, sharing, and retrieval of electronic healthcare information as well as financial and administrative information along with clinical practice and evaluation of health services between healthcare organization systems, such as Hospitals, Clinics, General practitioner service health systems and others. HL7 provides standards for interoperability that improve care delivery, optimize workflow, reduce ambiguity and enhance knowledge transfer among all of vendors and stakeholders.

The head quarters of HL7 is in the USA and meanwhile other nations like Argentina, Australia, Canada, Finland, Germany, India, Japan, Korea, Lithuania, New Zealand, Netherlands, UK and Taiwan are officially involved as affiliates. The term HL7 arrives from *Health Level 7*, which refers to the top level of the Open Systems Interconnection (OSI) layer protocol (i.e. application layer) for the health environment.

HL7 defines an essential standard for the communication of clinical orders, lab results, radiology reports, clinical observations and several other kinds of clinical data held in EHR. Currently, HL7 is used by almost all of the healthcare vendors and organizations, although a small number of healthcare organizations would now even think constructing a system not including HL7.

Technically, HL7 is defined as structured, message-oriented protocol framework for computer communication between healthcare application systems. However, although HL7 is adaptable to many different systems, it takes a lot of work. Although other standards are existed but the graph of HL7 is higher than all. A survey conducted by Healthcare Information and Management Systems Society (HIMSS) in 2010 provides the percentage of usage of these standards as shown in figure 1.3.

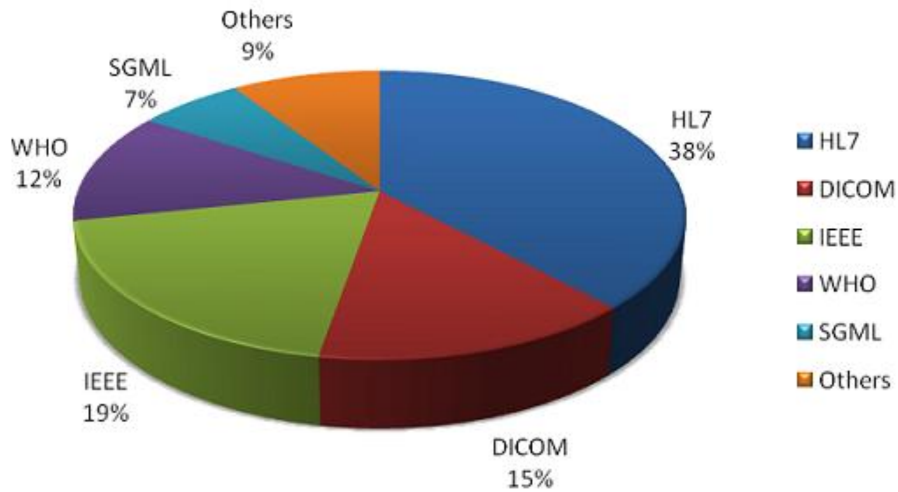

Figure 1.3: Usage of different standards among healthcare providers

Hospitals, doctors, and other healthcare centers around the world require the ability to send and receive healthcare data, including patient information and various observation reports. As a result, vast amounts of healthcare information are exchanged on daily basis .This information is normally stored in some non-standard format. To transmit the information, the data must be converted from one format to another. Since the data is both time and content sensitive, there need to be a transparent solution to resolve the information conversion problem (Yang et al., 2004).

The language that has been developed to overcome these obstacles is HL7. Utilizing the HL7 standard, a protocol designed specifically for health care sector, the issue of data exchange between systems can be addressed.

The HL7 protocol was developed by the Health Level 7 Organization, which consists of grammar and vocabulary that is standardized so that clinical data can be shared amongst all healthcare systems, and easily understood by all. By using the HL7 messaging protocol as a standard, all systems following the HL7 specifications are able to communicate easily with one another, without the need for information conversion

Hospitals and other medical institutions typically use many different types of systems to communicate with one another. Everything, from patient records to billing information is recorded in computer systems. In order for these different types of systems to communicate with each other they use a standard like HL7 (Lebak and Warren, 2004).

Information sent using the HL7 standard is sent as a collection of one or more messages, each of which transmits one record or item of health-related information (Yang et al., 2004). Examples of HL7 messages include patient records, laboratory records and billing information.

1.3.1 HL7 Interface Engine

A HL7 interface engine is an interface or integration engine built for the healthcare industry. It connects legacy systems by using a standard messaging protocol. Because hospitals and other healthcare providers usually have different systems for different aspects of services, they are often unable to communicate with each other. HL7 provide the framework for the exchange, integration, sharing and retrieval of electronic health information (Tran et al., 2007).

The HL7 middleware can connect to medical devices through LAN interface. For interoperability of various medical data, middleware receives raw data from medical device, converts to HL7 data, and creates unsolicited observation message in order to send message to HCIS based on HL7 interface engine (Tran et al., 2007). Because HCIS consists of various clinical subsystems, integrating data is necessary in order to improve patient services, optimize resource management, and support decision-making. In Figure 1.4, middleware components collect raw data from medical devices, convert raw data according to HL7 standard. Then, middleware components send HL7 messages to HCIS.

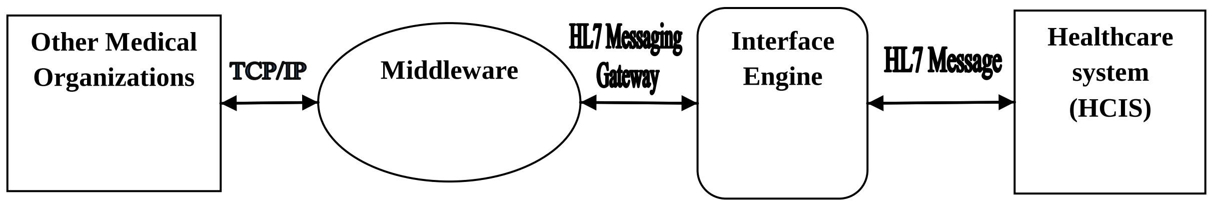

Figure 1.4: System Architecture based on HL7 Interface Engine

1.3.2 HL7 Versions

Different version has already been achieved such as HL7 and HL7 Version 2 (HL7 V2) specifications, which are extensively applied by various healthcare organizations as a messaging standard which facilitate different clinical applications to exchange importance medical and administrative data. The recent modification for HL7 (HL7 V3), is appropriate to various characteristics of clinical and administrative data in healthcare uses, as it covers specifications of abstract data types, Reference Information Model (RIM V. 1.23), vocabulary area, and the additional XML Implementation Technology Specification (XMLITS). Reference Information Model (RIM) for version 3 of HL7 is basically based on sets of messages, each message managing a particular interaction requirement among healthcare teams (Henderson et al., 2001)

However, RIM planned to offer a basic foundation approach for healthcare communication but, opposing to a lot of published knowledge, holds domain knowledge, healthcare procedure and workflow management concepts in one terrific-model. It holds several subjective attributes which are very precise to special domains. This method is possible to cause a style that cannot climb up to the extensive variety of EPRs through all healthcare groups, or provide for the future growth of healthcare information system. It does not provide sufficient way for dynamic search engine for an important part of EPR. Although, the HL7 organization is huge and well supported globally; consequently it may establish a leading influence on the new invention of healthcare applications and their interactions interfaces. The Clinical Document Architecture (CDA) is an additional and more specialization of the structured document framework to accumulate the history of patient information, for instance: inpatient and outpatient clinical information, or emergency department clinical information (Henderson et al., 2001).

Data in an HL7 message are transmitted in fields of well-defined data types. Fields are grouped into segments of related information. Messages may be formatted by using Encoding Rules, which treat segments of a message as record like entities and set off fields and subfield elements by using common delimiters such as a vertical bar (|) and caret (^) (Glossary Of HL7, 2011). Alternatively, HL7 messages may be transmitted by using external protocols such as the extended markup language (XML).

1.3.3 HL7 Messages

HL7 Messages are used to transfer electronic data between disparate healthcare systems. Each HL7 message sends information about a particular event such as a patient admission. The HL7 message type defines the purpose for the message being sent and is present in every HL7 message. Message types are identified by a three-character code, and are used in conjunction with a trigger event (Jun, 2011). Messages are shaped by communication requirements. When ordering, reporting, or informing health care information, the nature of the message is derived from:

- the specific purpose for the communication
- the specific person or organization collecting or retrieving the information
- the health data necessary to meet the request
- the information from the requested service
- the information about a distinct event

1.3.4 HL7 Message Structure

A message consists of a group of segments in a defined sequence, with these segments (or groups of segments) being optional, required, and/or repeatable (Jun, 2011). HL7 messages follow a text-based standard and use three primary concepts: segments, fields, and components. A message consists of one or more segments, each of which contains some number of fields as shown in figure 1.5. Each field can have zero or more components. A five-character declaration at the beginning of the message serves to delimit fields and components, in addition to other functions. Delimiter characters are used to separate the parts of the message.

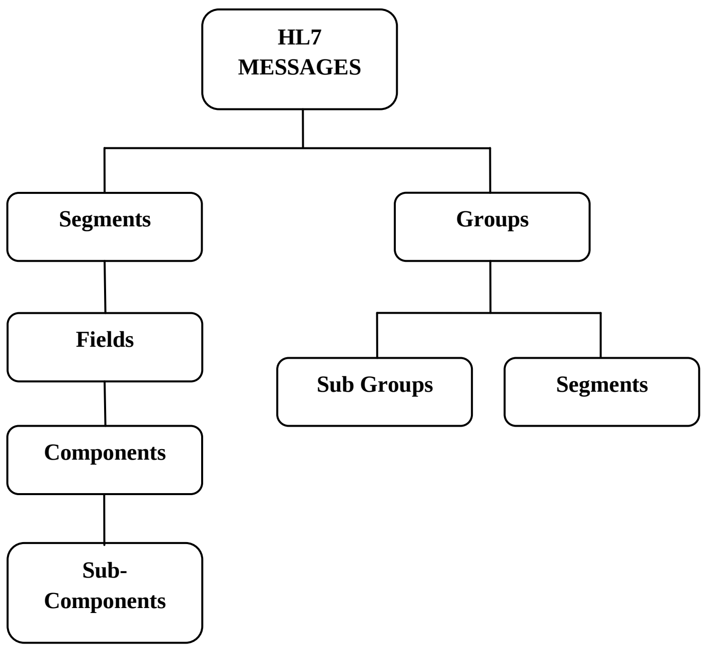

Figure 1.5: HL7 Message Structure

1.3.5 HL7 Benefits

The benefits (Lebak and Warren, 2004) of HL7 are discussed below:

- Increased access to patient data means faster and efficient care. The right information, in the right place, at the right time, aids in decision making and improves patient safety.
- As more health-care delivery organizations continue to exchange data electronically, paper-based data, which is subject to scrutiny by anyone, will become obsolete, and

confidentiality of information will be enhanced

- Information is transmitted once, to the right place at the right time, and as transcription errors are reduced, the quality of the information is improved.
- Information is sent to the right person like provider, helping to eliminate duplicate test and procedure requests
- Information is sent efficiently; this streamlines processes and provides more efficient use of human resources in health care delivery.

1.4 HL7 RIM

The Health Level 7 (HL7) Reference Information Model (RIM) was introduced as an object oriented information model to stabilize the definition of HL7 messages across different application domains. After the heels of HL7's successful version 2, the last version 3, including the RIM, which forms its centerpiece, has received significant attention. The Health Level Seven (HL7) Reference Information Model (RIM) is a static model of health and health care information as viewed within the scope of HL7 standards development activities. It is the combined consensus view of information from the perspective of the HL7 working group and the HL7 international affiliates (Beeler and Schadow, 2004). The RIM defines classes such as Act, Role, Entity, etc. each of which is contained with a rich stock of attributes. When the RIM is applied to a new domain, one then needs to select and code these attributes.

The RIM is one of the complete storage of the HL7 Version 3 development process. An object model created as part of the Version 3 methodology, the RIM is a large-pictorial representation of the HL7 clinical data (domains) and identifies the life cycle that a message or groups of messages will carry. It is a shared model between all domains and, the model formed from which all domains which create their messages. The RIM is an ANSI approved standard.

1.4.1 History of RIM

HL7 was already working on HL7 version 3.0 in 1990, which had convergence with MEDIX as one of the stated goals. The process by which messages are developed from the Information Model, as well as many characteristics of the methodology as a whole was drawn from the work done by Methodology for the development of healthcare messages. Once the outline of the HL7 v3 methodology was in place, and the RIM was envisioned to be at the heart of that methodology, the decision was made to develop the RIM in April 1996 (Beeler and Schadow, 2004).

Table 1.1 Information Models used to develop the HL7 RIM

HL7 Technical Committees	• Admission/Transfer/Discharge • Finance • Medical Records • Meta Observations • Orders/Results • Patient Care • Insurance and Billings
Standards Development Organizations	• DICOM • CEN TC251 • IEEE
HL7 Member Organizations	• IBM Worldwide • Hewlett Packard • HBO and Company • Health Data Services • Mayo Foundation • Health and Human Services

Data Model sources for the initial RIM

The initial RIM was based on a set of data models from HL7 members and other sources (e.g. MEDIX experimental models, vendor data models, provider data models, and data models created by other SDOs). The initial model went through about 8 iterations before there was a model worthy of bringing to the HL7 TSC with the suggestion to use it as the common data model for all HL7 modeling efforts. In 1997 RIM 0.8 was published, followed by the first ever HL7 harmonization meeting. By 1999 the RIM had reached its grandest proportions, 130 classes, 987 attributes, and countless associations.

1.4.2 USAM (1999-2001)

The Unified service Action Model (USAM) II proposal [USA99] came forward as a joint harmonization proposal by multiple committees to simplify the RIM, especially when it came to the large number of classes that dealt with clinical concepts. The proposal aimed to generalize those classes. They have similar attributes and can be combined into one single class. The proposal introduced the Service (Act) and Material (Entity) classes as overarching concepts. The USAM II proposal was based on an earlier USAM proposal which was created in the spring of 1998 (Beeler and Schadow, 2004). The proposal was met with skepticism, until it became clear that the proposed RIM would be much more suitable to be used as the basis for the creation of refined models (e.g. R-MIMs).

Effect on the RIM

The proposal had the effect of collapsing a number of related classes into one class, partly through the introduction of the concept of mood attribute which allowed one single class to be used regardless of how it was used (e.g. to order an activity, to schedule an activity, or to perform an activity).The resulting RIM abstracts what it can into terminology. The complexity of the previous RIM static model still exists, but it has been solved using terminology rather than by classes and attributes.

As a result of USAM proposal (to the left-hand-side of the RIM) and the application of USAM principles (elsewhere in the RIM) the number of classes dropped from 125 to less than 2 dozen. USAM also introduced the postulate that says that there can be only one path to get from class A to class B, in order to simplify the model and to avoid choices.

Contribution

The USAM proposal created the essential RIM structure as we know it today. The 1999-2001 timeframe was essential in the development of the HL7 RIM, from USAM up to the first non-draft RIM. The RIM, simplified by the USAM proposal, and the finalized HL7 v3 methodology also attracted a large number of new volunteers to the HL7 organization to create refined models for use in message specifications.

1.4.3 Current use of the RIM

In 2001 the harmonization process had gone far enough to produce the first non-draft RIM, version 1.0. In 2003 RIM Release 1 was made normative, which became an ISO standard in the 2005-2007 timeframe (Beeler and Schadow, 2004). In 2010 RIM Release 2 became normative. The number of changes to the RIM has been very small over the past few years; it now serves as the basis for all HL7 modeling efforts.

CHAPTER 2

LITERATURE SURVEY

This chapter introduces a number of published literatures and researches on subjects associated to or may have a potential relevance to the work. The collected literature was reviewed to place the research in these fields and the outcomes were too large to be cited comprehensively here.

Gaion Sara et al. (2010) in the paper Design of a Domain Model for Clinical Engineering within the HL7 Reference Information Model suggested Design of a Domain Model for Clinical Engineering within the HL7 RIM. HL7's has successful version 2, latest version 3, including the RIM which addresses important questions about the usability in specialist domains. The RIM defines 'normative' classes such as Act, Role, Entity, etc. each of which is associated with a rich stock of attributes. These attributes need to be selected and code When the RIM is applied to a new domain. Also describes domain information analysis and the modelling phases of the proposed clinical engineering DIM development, using the Unified Modelling Language (UML), Methodology for Model Formulation, Modelling MRO as a Dynamic, Problem-solving Processes, Mapping Domain Information Models to the HL7 RIM.

Menezes Anderson L et al. (2010) in the paper Using Archetypes and Domain Specific Languages on Development of Ubiquitous Applications to Pervasive Healthcare discussed Pervasive healthcare focuses on the use of new technologies, tools, and services, in order to help patients to play a more active role in the treatment of their diseases. Since pervasive healthcare environments demand a huge amount of information exchange, the use of technologies like Health Level Seven

(HL7) and archetypes has been proposed to provide interoperability between applications for these environments. It simplifies the HL7 messages modeling and allows automating most of the messages schema codification.

Voos Javier et al. (2010) in the paper Custom HL7 V3 Message Provider using Web Services Security Features described due to availability of new data transmission technologies and standards for medical studies development, e-health systems have had a sustained adoption in recent years. In this scenario, the health systems are incorporating and increasing the health services offering in response to their needs. It represent a system which transmit medical studies using different communication channels providing an effective use of the medical equipment, the data transmission networks and the human resources availability.

Corepoint Health. (2010) in the paper The HL7 Evolution defined HL7 which has compiled a collection of message formats and related clinical standards that loosely define an ideal presentation of clinical information, and together the standards provide a framework in which data may be exchanged.HL7's Version 3 is used clinical application community. The HL7 standard is often called the 'non-standard standard'.

Mehmood Yasir et al. (2009) in the paper Efficient Metadata Loading Algorithm for Generation and Parsing of Health Level 7 Version 3 Messages described Information technology has started focusing on the healthcare enterprises, for providing better medical care. There exist different healthcare enterprise standards that are used for the communication of medical information across health enterprises providing swift and reliable results. Mostly, HL7 is used for the exchange of medical information between healthcare systems. The main focus of this research work is to make metadata processing efficient in HL7 v3. HL7 v3 is an emerging standard to achieve semantic interoperability with its well defined information models. This format includes metadata information in the form of XML. MIFs are required to load into memory for generation and parsing of messages.

Yang Wei-Yi et al. (2009) in the paper The Design of the HL7 RIM-based Sharing Components for Clinical Information Systems suggested The American Health Level Seven (HL7) Reference Information Model (RIM) consists of six back-bone classes that have different specialized attributes. For the purpose of enforcing the semantic expression, there are some specific mandatory vocabulary domains have been defined for representing the content values of some attributes. In fact, it is a duplicated effort on spending a lot of time and human cost to develop and modify Clinical Information Systems (CIS) for most hospitals due to the variety of workflows. This study attempts to design and develop sharing RIM-based components of the CIS for the different business processes.

Clarke Siobhan and Munnelly Jennifer. (2009) in the paper HL7 Healthcare Information Management Using Aspect-Oriented Programming discussed the heterogeneity of healthcare software system; data from each system is often incompatible inhibiting interoperability. To enable the sharing and exchange of healthcare information interoperability standards must be adhered to. Incorporating HL7 functionality into existing applications requires significant modification and intrusive extensions. Using Aspect-Oriented Programming (AOP), we can introduce HL7 functionality into existing applications without the requirement for modification.

Banfai Balazs et al. (2009) in the paper Implementing an HL7 Version 3 Modelling Tool from an Ecore Model discussed that the main challenge of achieving interoperability using the HL7 V3 healthcare standard is the lack of clear definition and supporting tools for modelling, testing, and conformance checking. Currently, the knowledge defining the modelling is scattered around in MIF schemas, tools and pacifications or simply with the domain experts. Modelling core HL7 concepts, constraints, and semantic relationships in Ecorse/EMF encapsulates the domain-specific knowledge in a transparent way while unifying Java, XML, and UML in an abstract, high level representation.

Jayaratna Priya and Sartipi Kamran (2009) in the paper Tool-assisted Healthcare Knowledge to HL7 Message Translation suggested in the new network-centric healthcare IT environment, standardization of information representation, organization and dissemination is the first step towards achieving semantic interoperability among heterogeneous systems. Propose a tool-assisted approach to support standard compliant message workflow design and lay the foundation for a new tool to support our approach.

Afzal Muhammad et al. (2009) in the paper Interactive Mapping Tool for HL7 RIM-to-Relational Database Using Knowledge Game defined truly dynamic and automated technique for mapping the healthcare schema (hospital, laboratory or any healthcare organization database) to HL7-RIM in order to create the proper motivation for end users to get involved, by Understanding the meaning of messages exchanged and key problem called interoperability issue. This mapping is done through question-answer game.

Tuncay Namli et al. (2009) in the paper An Interoperability Test Framework for HL7-Based Systems described Health Level Seven (HL7) is a prominent messaging standard in the eHealth domain, and with HL7 v2, it addresses only the messaging layer. An Interoperability Test Framework for HL7-Based Systems also details with business process layer, communication layer, Message choreographies between specific roles in specific events. Having alternative transport protocols and descriptive message choreographies introduces great flexibility in implementing HL7 standards, which need for test frameworks. The computer-interpretable test description language developed offers a configurable system with pluggable adaptors.

Kolovou Lamprini et al. (2008) in the paper Reference Implementation Model for Medical Information Systems Interoperability defined Interoperability, in the electronic environment of healthcare enterprises, is required for the effective communication between the various Medical Information Systems (MISs). RIM for Medical Information Systems Interoperability also specifies common communication profiles and interfaces that allow real world events and information to be visibly handled and distributed among MISs without any interference in their structure. It proposes a Reference Implementation Model (RImM), for functional entities of middle platform, the end-to-end services and the internal common messages format.

Huh S. J et al. (2008) in the paper The Study on HL7 Message Modelling Algorithm based on uHealthcare Environment has told Health Level Seven (HL7) is the standard of electronic data interchange in the health domain. An abstract structure algorithm for modeling HL7 message is also described and compared with other existing ones. The entire code is not needed to be compiled while updating message structure, the repetitive requested queries also results no speed down.

Eggebraaten T. J. et al. (2007) in the paper A health-care data model based on the HL7 Reference Information Model defined the development of exiting data in importance as hospitals and medical research centers with the integration of medical information from various sources, a health-care data model based on the HL7 Reference Information Model has developed an abstract information model for health-care data, the HL7 RIM and implementing a physical data model based on RIM.

Teixeira Leonor et al. (2007) in the paper Using Task Analysis to Improve the Requirements Elicitation in Health Information System described task analysis application within the design process of a Web-based information system for managing clinical information, in order to improve the requirements specification, to validate the domain model obtained in a previous phase of the design process (system analysis). To improve the requirements engineering process including users in design process, task analysis is the effective way.

Schadow Gunther et al. (2006) in the paper The HL7 Reference Information Model under Scrutiny defines The Health Level 7 (HL7) Reference Information Model (RIM) as an object oriented information model to harmonize the definition of HL7 messages across different application domains. HL7 version 2, version 3 and the RIM has received significant attention and credit and in turn is increasingly subjected to criticism, the major points that have been raised against the RIM are also discussed but many formal technical criticisms as well as critique about the conceptual design of the RIM are rooted in misunderstandings and differences in point of view.

Rocca Mitra A et al. (2006) in the paper Development of a Domain Model for the Pediatric Growth Charting Process for Use within the HL7 Reference Information Model defines the Health Level 7 (HL7) Pediatric Data Standard (Such standards will facilitate information exchange and may enhance decision support in EMR systems), Pediatric growth charts are the most widely used tools requirements for EMR systems are distinct from those necessary in other medical specialties, to track potential growth problems and development in children.

Smith Barry et al. (2006) in the paper HL7 RIM: An Incoherent Standard described The Health Level 7 Reference Information Model (HL7 RIM) for healthcare interoperability. Even after development work, the RIM is still subject to a variety of logical and ontological flaws, which has placed severe obstacles in the way of those who are called upon to develop implementations. The RIM documentation, as we have seen, is systematically ambiguous.

Schloeffel Peter et al. (2006) in the paper the relationship between CEN 13606, HL7, and openEHR describes the standards for Shared EHRs, gives an overview of the roles of the main interoperability standards and specifications. The relationship between openEHR, CEN 13606, and HL7 CDA is defined. HL7v2.x messaging is an appropriate standard, at least for the short to medium term, for transmission of information from source clinical information systems to a Shared-EHR system.

Huang Chia-Hsin et al. (2006) in the paper XML Evolution: A Two-phase XML Processing Model Using XML Prefiltering Techniques described Two-phase XML processing model based implementation which includes reporting the performance results and showing the source codes of the following systems: the prefiltering technique, DOM-based XPath/XQuery processors with the prefiltering technique, and an interactive SAX parser.

Goossen William et al. (2004). in the paper Development of a Provisional Domain Model for the Nursing Process for Use within the Health Level 7 Reference Information Model discussed The Nursing Terminology, to model and map nursing information into the comprehensive health care information model, the HL7 RIM. The use of such standards to integration nursing knowledge, terminology, processes, and information in electronic health records will enhance acontinuity of care, decision support, and the exchange of comparable patient information. It is examined that how to represent nursing information in the Health Level 7 (HL7) Reference Information Model (RIM).

Goossen William. (2004) in the paper Model once, use multiple times: reusing HL7 domain models from one domain to the other describes a domain information model for perinatology, to map to the Health Level 7 Reference Information Model (HL7 RIM).To achieve a national infrastructure based on the HL7 RIM This model was constructed with the intention to make it reusable for other domains, to better express the domain perinatology model was reused. And generic domain model is used because it which can be adapted easily to other domains.

NISO Press. (2004) ‘National Information Standards Organization’ in the paper Understanding Metadata describes Metadata which is often called data about data or information about information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage. Significance of metadata is to have relevant information, helps in organizing electronic resources, provides digital identification and also helps in preserving useful information.

Jason Lyman et al. (2003) in the paper applying the HL7 Reference Information Model To a Clinical Data Warehouse suggested support to clinical and biologic research with Large-scale data integration by adoptioning standards for the representation and exchange of data. To design the necessary architecture for multi-institutional sharing of disparate biomedical data the potential of the HL7 Reference Information Model is explored for data stored in a loco1 academic clinical & to warehouse information exchange between local data schemas and standards-based conceptual data models for this tools are developed and utilized .

Beeler George et al. (2003) in the paper HL7 Reference Information Model describes use of RIM by HL7. The HL7 RIM is a critical component of the V3 development process. It is the root of all information models and structures Developed as part of the V3 development process which is a model-driven methodology in which a network of inter-related models are developed.

Schadow Gunther et al. (2002) in the paper Secure HL7 Transactions using Internet Mail describes way to send HL7 messages using public Internet mail with HL7 Recommendation. This is done to have a way for communicate with HL7 among independent organizations. This Communication involving physician office practices, rural medicine, or home health care, is inherently transorganizational. Internet e-mail to send a HL7 messages is efficient channel for HL7 communications.

Liou Der-Ming et al. (2000) in the paper Design and Implementation of a Web-based HL7 Validation System suggests the method of implementing a web-based validation system providing HL7 messages test services, which warn the errors in segments, sequences, required fields, field length, components, data types and valid values. This approach is made due rapidly progressing Computer and communication technologies speeds up the electronic medical record (EMR) development and increases the requirement of electronic data interchange (EDI) among healthcare organizations.

CHAPTER 3

PRESENT WORK

3.1 PROBLEM FORMULATION

Nowadays the medical science share their information among various medical agencies based on the HL7 standards to exchange, management and integration of electronic healthcare information, which provide a solution for hospital, clinics, and medical fields. EHR system mainly deals with patient-physician information which follows the standard of HL7.

There are multiple existing approaches based on RIM development, in which one of the approaches is HL7v3 RIM based domain information model (DIM) dedicated to clinical engineering. In this method, the DIM is developed on the basis of workflow of endoscopy repairing process. The *drawback* of this approach is that it lacks the meta-observations and meta-care facilities that must be applied to a health care information system.

Therefore, this research work will provide a framework of Healthcare System using various HL7 v3 RIM functions using the class and activity phenomena, also achieve the methods of store and manage lifelong medical records for interoperability among hospitals along with metadata generation and parsing to avoid unnecessary associations.

3.2 OBJECTIVES OF THESIS WORK

- To design a novel domain model for Health layer seven Reference Information Model (HL7 RIM),
- To generate metadata loading for generation and parsing of HL7 v3 messages.
- To compare and validate this research work with older prospective.

3.3 METHODOLOGY

3.3.1 Data Collection

Data-collection techniques allow us to systematically collect information about our objects of study (people, objects, phenomena) and about the settings in which they occur. The collection of data should have to be systematic. If data are collected haphazardly, it will be difficult to answer our research questions in a conclusive way. Data after change into information is essential for the effective management of any organization (Elmusharaf, 2010). It determining the continuing and future care of a patient, monitoring of health service delivered and makes meta observation - based decision making.

3.3.2 Standardization and Data Integration

Standardization refers to the process of employing best practice, principles and guidelines for the collection and storage of health care data in a uniform manner across various facilities, levels and programs. Standardization applies for the data collection, analysis and transmission.

3.3.3 Data management

A set of procedures to collect, store, analyses and distribute data. Once data are collected, a sound management approach is essential. Firstly, a metadata dictionary is created to accurately describe the data elements (Health Metrics Network, 2008). Next, effective data storage procedures require a well-designed logical structure to permit data retrieval and analysis.

3.3.4 Data Analysis & Information Utilization

The collected data are then processed, analyzed, presented and interpreted to become information. Information is the collection of facts, data and used for further action. Health information is not to gain information but to improve action.

Information system is a system in necessary because managers at different level of management require information in order to monitor the existing program as well as plan for future development and support decision making at each level of organization.

3.3.5 Reporting

The regular reports system in HCIS reporting system will be transmitted at the various managerial levels. Data generation will be done at the physician level, where the health data will be complied and transmitted to the next level (i.e. nursing assistant and user levels) for further compilation.

3.3.6 Meta evaluation

Meta evaluation is evaluation of an evaluation. The program evaluation should be evaluated by those who design and carry it through. As much as program evaluations often are subject to outside scrutiny, criticism, and legal action by program supporters, and meta evaluators, separate concurrent review of the program evaluation process by external meta evaluators can help program evaluators avoid critical mistakes (Sanders, 1994). Documentation of the effective or ineffective application of program evaluation procedures facilitates the proper interpretation of data.

3.4 UML FRAMEWORK OF PRESENT WORK:

The Unified Modelling Language (UML) is a diagramming language or notation to specify, visualize and document models of Object Oriented software systems. UML is not a development method that means it does not tell you what to do first and what to do next or how to design your system, but it helps you to visualize your design and communicate with others (Hensgen, 2001). UML is controlled by the Object Management Group and is the industry standard for graphically describing software. UML is designed for Object Oriented software design and has limited use for other programming paradigms. UML is using different types of diagrams to represent the user's idea. Following types of diagrams are used to represent the overhaul idea and describe the working of metadata generation and metadata parsing of meta observations of the present work of thesis work.

3.4.1 USE CASE Diagram

Use Case Diagrams describe the relationships and dependencies between a group of Use Cases and the Actors participating in the process (Booch et al., 1998).

It is important to notice that Use Case Diagrams are not suited to represent the design, and cannot describe the internals of a system. Use Case Diagrams are meant to facilitate the communication with the future users of the system, and with the customer, and are especially helpful to determine the required features the system is to have.

Use Case

A use case diagram is used to model and identify the functional requirements of a software system. In a use case diagram, all stakeholders and system goals are identified to elaborate how the system is formed (Cockburn, 2000). The main elements of a use case diagram include actor, use case and association (communication link).

When working with Use Cases, it is important to remember some simple rules:

- Each Use Case is related to at least one actor and has an actor.
- Each Use Case leads to a relevant result (a result with 'business value')

Actor

An actor is an external entity (outside of the system) that interacts with the system by participating (and often initiating) a Use Case. Actors can be in real life people (for example users of the system), other computer systems or external events.

In figure 3.1, Patients, Doctors, Nursing Assistants acts as Actors and patient in Hospital, registration, observation, diagnose, billing etc acts as Use cases. All these define simple overhaul representation of HealthCare Information System as Context level Data Flow Diagram. It only describes the participants and major acts taken in the process.

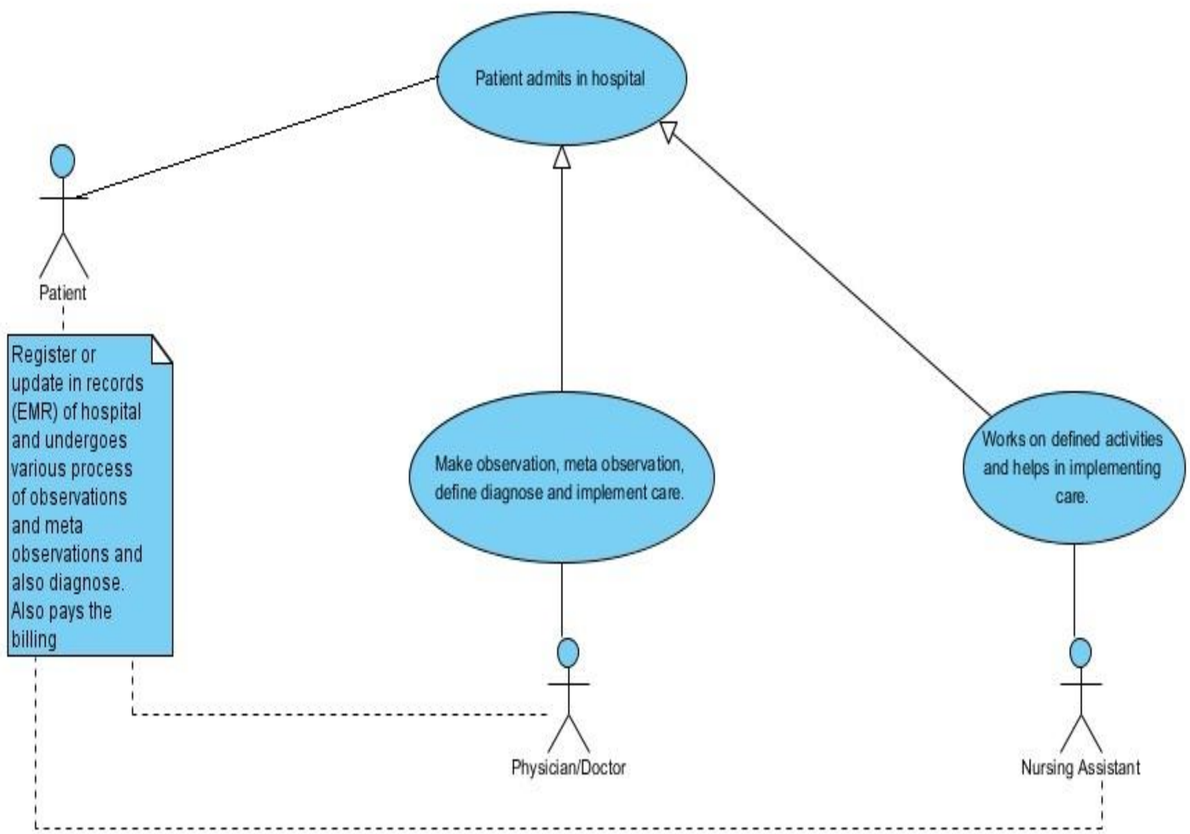

Figure 3.1: USE CASE Model of HealthCare Information System

3.4.2 ACTIVITY Diagram

Activity Diagrams describe the graphical representations of workflows of stepwise activities and actions. Activity Diagrams are a special form of State Diagrams that only (or mostly) contains Activities. Activity diagrams can be used to describe the operational and business step-by-step workflows of components in a system in which all Activities are clearly attached to Objects (Yang, 2009). An activity diagram is essentially a flowchart, showing flow of control from one activity to another. Unlike a traditional flowchart, it can model the dynamic aspects of a system because it involves modeling the sequential steps in a computational process (Booch et al., 1998).

Activity

An Activity is a single step in a process. One Activity is one state in the system with internal activity and, at least, one outgoing transition. Activities can also have more than one outgoing transition if they have different conditions.

Activities can form hierarchies; this means that an Activity can be composed of several detail Activities, in which case the incoming and outgoing transitions should match the incoming and outgoing transitions of the detail diagram (Hensgen, 2001).

Accordingly,

- The different activities performed in the phases of the nursing process are portrayed as *activity states* (a rounded rectangular shape).
- Clinical decisions are *branches* (diamond shapes).
- The beginning and end of the process are visualized as *start and stop states* (black dot, and black dot with white spot, respectively).
- The workflow is represented via the lines with arrows that relate the states and decisions.

Metadata loading for the generation of HL7 v3 messages has lot of problems and challenges which should be handled for the successful generation of messages i.e. it requires lot of memory for complete loading of metadata, beside this, there is possibility that metadata file may include cross references to each other which may result in memory errors like stack overflow etc, The methodology which is presented in this paper provides the way of efficiently loading metadata for the generation of messages.

In new metadata file, first all of the required RIM associations with reference to the entry point are included. Entry point is the point from which a particular metadata file is attached to the referencing message. When RIM associations are inducted into the metadata file, it includes only the required optional associations. When finished with all of associations with reference to the entry point, then classes referenced in these associations are taken as entry point and so on. This process of message generation loads only those associations that are needed by a particular application. This approach will help in efficient space utilization.

In the figure 3.2 of ACITIVITY model the loading of metadata generation and metadata parsing activities are defined which represents the complete flow of data through HL7 3 messages. Therefore, Activity Model diagram is the most necessary UML diagram along with the Class model figure 3.3 which describes the functionality of each class defied in the process along with their associations whether mandatory or optional, all have to be defined in this model of the system and also provide the concept how to use the associations along with the choice of the basic guidelines about associations between different classes in a particular message. Metadata contains all the information about the message i.e. associations among different classes, cardinality of associations, attribution level etc.

Similarly other UML diagrams such as Sequence Diagram in figure 3.4 shows the sequence of the workflow and the timelines among components along with the order of objects to be sent, and Interaction Diagram in figure 3.5 shows interaction and communication between various components of the system along with specific program flow or situation of the message in the system.

All these Diagrams collectively explain the working and contribution of various actors, use cases, activities, classes, associations, objects, operations, instances of object etc in various operative mode of the system. These help in the smooth functioning of the process of Health Care Information System which emphasis on the metadata generation and metadata parsing of HL7v3 messages among system with the constant watch on the Observatory part of the system is required.

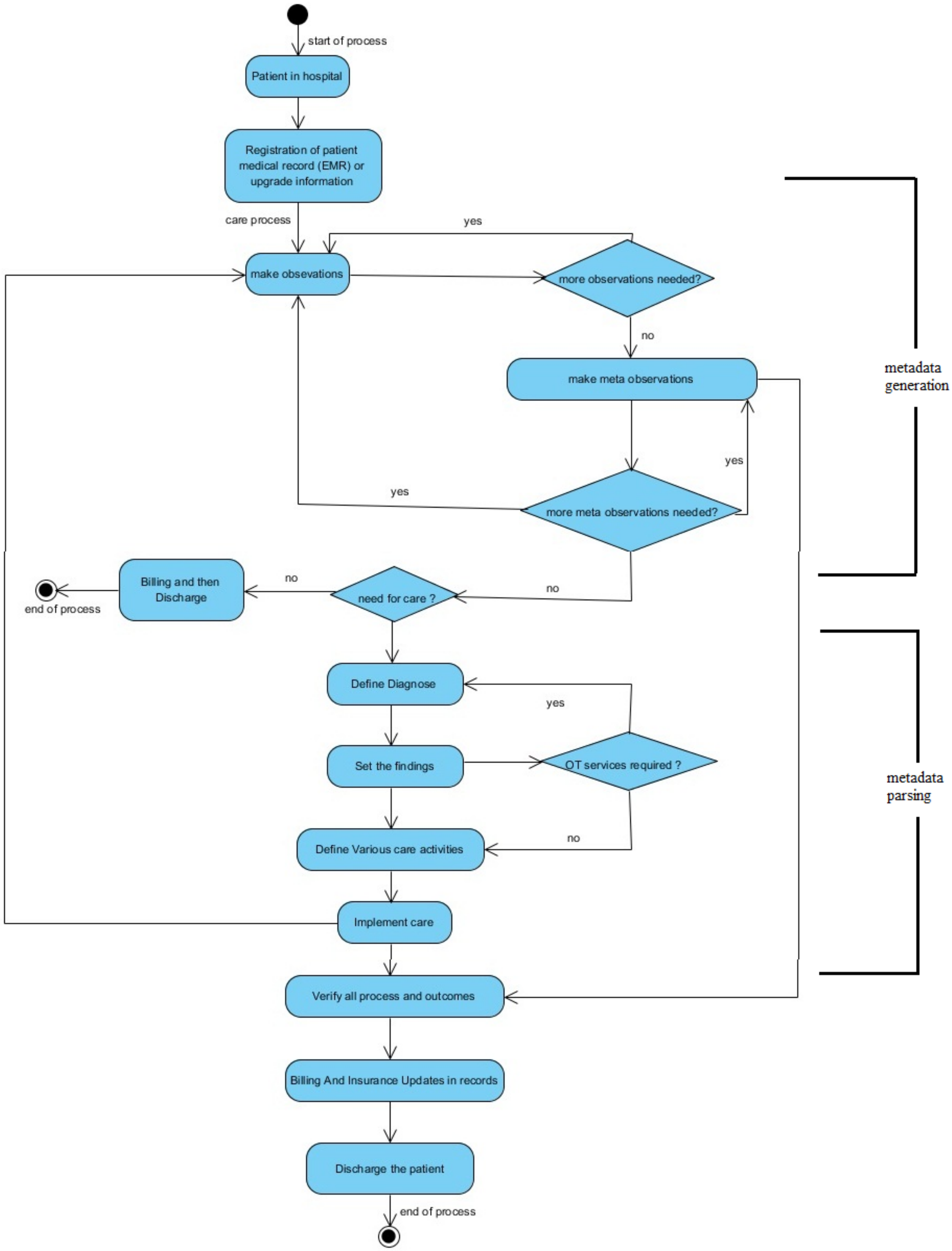

Figure 3.2: ACTIVITY Model of HealthCare Information System

3.4.3 CLASS Diagram

A class diagram models the blueprints of objects required by a system and the relationships between them. Class Diagrams show the different classes that make up a system and how they relate to each other. Class Diagrams are said to be static diagrams because they show the classes, along with their methods and attributes as well as the static relationships between them: which classes know about which classes or which classes are part of another class, but do not show the method calls between them (Booch et al., 1998).

Class

A Class defines the attributes and the methods of a set of objects. All objects of class (instances of this class) share the same behavior, and have the same set of attributes (each object has its own set).

Operations

Operations (methods) are also displayed with at least their name, and can also show their parameters and return types.

Associations

An association represents a relationship between classes, and gives the common semantics and structure for many types of connections between objects. An association represents a family of links. Binary associations (with two ends) are normally represented as a line. An association can be named, and the ends of an association can be adorned with role names, ownership indicators, multiplicity, visibility, and other properties (Booch et al., 1998)

In figure 3.3, UML defines different classes and their relationship along with the functionality of each class. The area represented in pink color defines the metadata generation and further classes define the metadata parsing and completion of the whole process.

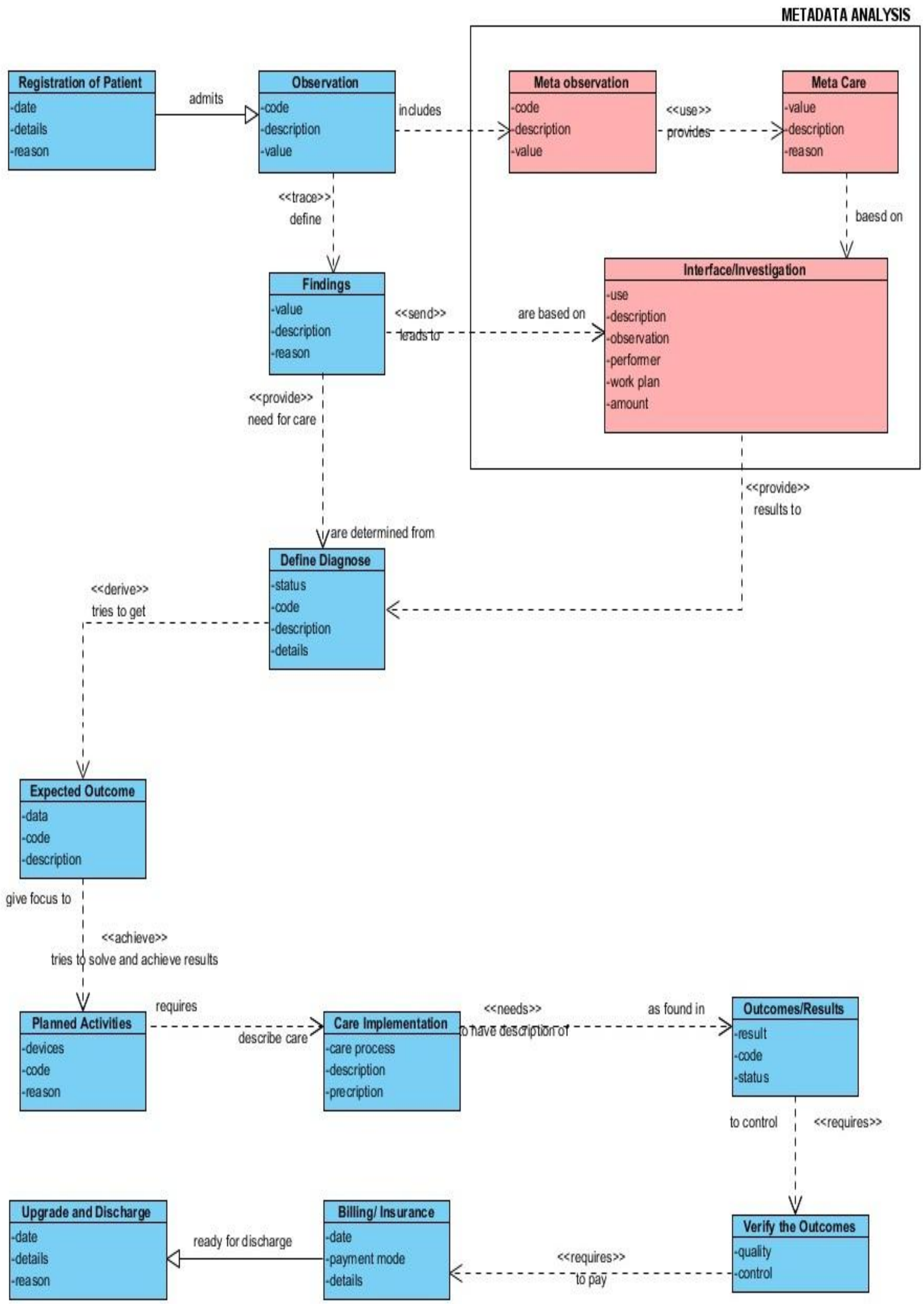

Figure 3.3: CLASS Model of HealthCare Information System

3.4.4 SEQUENCE Diagram

Sequence Diagrams show the message exchange i.e. method call between several Objects in a specific time-delimited situation. Objects are instances of classes. Sequence Diagrams put special emphasis in the order and the times in which the messages to the objects are sent (Hensgen, 2001). Sequence diagram is used primarily to show interactions between objects that are represented as lifelines in a sequential order. More importantly, lifelines show all of their interaction points with other objects in events I the form of arrows with the operation and parameters name.

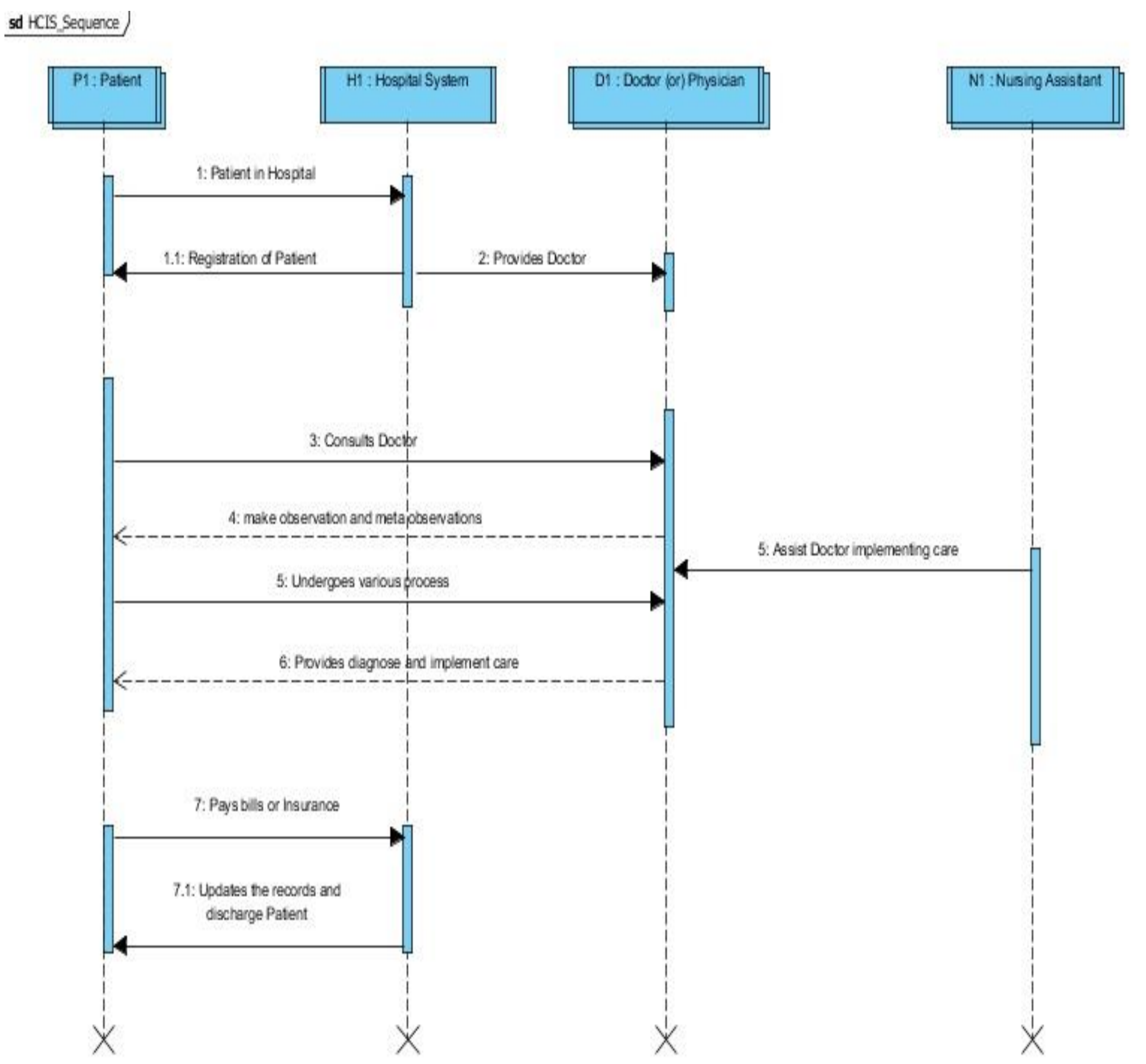

Figure 3.4: SEQUENCE Model of HealthCare Information System

3.4.5 INTERACTION Diagram

Interaction Diagrams show the interactions occurring between the objects participating in a specific situation. This is more or less the same information shown by Sequence Diagrams but there the emphasis is put on how the interactions occur in time while the Interaction Diagrams put the relationships between the objects and their topology in the foreground (Hensgen, 2001).

In Interaction Diagrams messages sent from one object to another are represented by arrows, showing the message name, parameters, and the sequence of the message. Interaction Diagrams are especially well suited to showing a specific program flow or situation and are one of the best diagram types to quickly demonstrate or explain one process in the program logic.

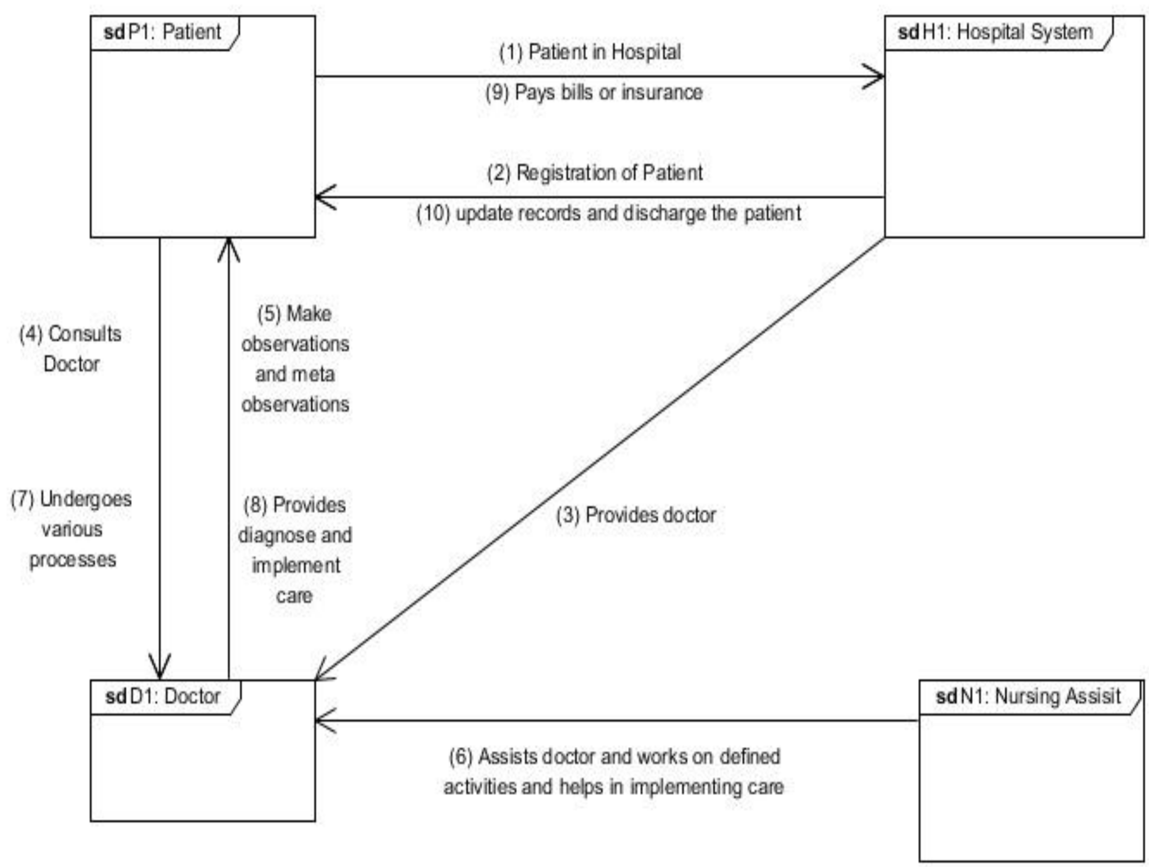

Figure 3.5: INTERACTION Model of HealthCare Information System

3.5 IMPLEMENTATION

The layout of the program is kept simple to reduce the complexity. E.g. a sample HL7 message can be as follow:-

MSH|^~\&|EPIC|EPICADT|SMS|SMSADT|199912271408|CHARRIS|ADT^A04|181

The source code converts the HL7 message format into readable information format in the following way:-

i. The program takes the hl7 message which is saved in the C# file as the patient information.

```
public partial class PatientInformation : Form
   {
      public PatientInformation()
         {
         InitializeComponent();
         }

          private void PatientInformation_Load(object sender, EventArgs e)
         {

         }
   }
```

Similarly for doctor and Nursing Assistant information and other useful gathering this type of C# files are building.

ii. Then it reads the file and checks for the Segment Headers on each file.

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;
using DataMining;
using System.Collections;

namespace Hl7Application
```

iii. When the proper field and components is found. It prints the data from the fields corresponding to each given segment header in the text area provided.

iv. This text area information is stored into the database by generating the queries in SQL Server 2005.

v. The database connectivity is done using the app.Config file in .net framework application in which connection String to SQL Client is established.

```
<connectionStrings>
 <add name="ConnectionString" connectionString="Data Source=My Computer;
 Initial Catalog=HL7Rim;"
 providerName="System.Data.SqlClient" />
</connectionStrings>
```

vi. SQL queries are used to store the information into database tables. Here a type of first table are generated for storing the Patient personal information such as auto generated id, name, date of birth, age, sex, address, family size, occupation, contact no., email id, etc. and second table stores Doctor Information and third table stores Nursing assistant information.

vii. The fourth table store the information of the Event segment such as event type (such as Patient visit), meta observations, date of starting and ending of the event along with the generation of observation report with complete results such as Lab results as test type and test value and also Scan results in the form of image. It uses different Stored procedure for execution of the database properly.

viii. The fifth table stores the diagnose information such as type of disease, type of medicine, amount of medicine given and suggestions etc.

ix. The sixth table stores the information of the billing aspects, such as date, room type, no of days, charges per day and total bill.

x. The Patient Report can be seen as XML format:

```
<NewDataSet>
  <Table>
    <PID>7</PID>
    <PName>Kamala Rani</PName>
    <sex>FEMALE</sex>
    <dob>1976-07-15T00:00:00+05:30</dob>
    <age>35</age>
    <maritalStatus>Married</maritalStatus>
    <Address>H.No:195, Ajit Nagar, Ludhiana</Address>
    <contactNo>88765-12345</contactNo>
    <emergencyContact>88765-12345</emergencyContact>
    <emailID />
    <doctorReff>Avinash Goyal</doctorReff>
    <occupation>Housewife</occupation>
    <organization />
    <employerName />
    <employerContact />
    <raceEthenicity>Hindu</raceEthenicity>
    <nationality>Indian</nationality>
    <guardian>Vijay</guardian>
    <familySize>4</familySize>
    <allowEmailMsg>NO</allowEmailMsg>
    <allowVoiceMsg>YES</allowVoiceMsg>
    <allowSMS>YES</allowSMS>
    <emailMsgIS />
  </Table>
</NewDataSet>
```

xi. The Patient record from the database can be converted into the XML either by using the XML generating tools like STYLE STUDIO EDITIONS 2010.

xii. The XML format can be displayed as the web page. For this a schema (XSD) or Document type definition (DTD) is to be created. These specify the formal description of the elements in XML document and declaration that defines a document type for markup languages. This can be created automatically if using xml generating tools like Style Studio as shown in figure 3.6.

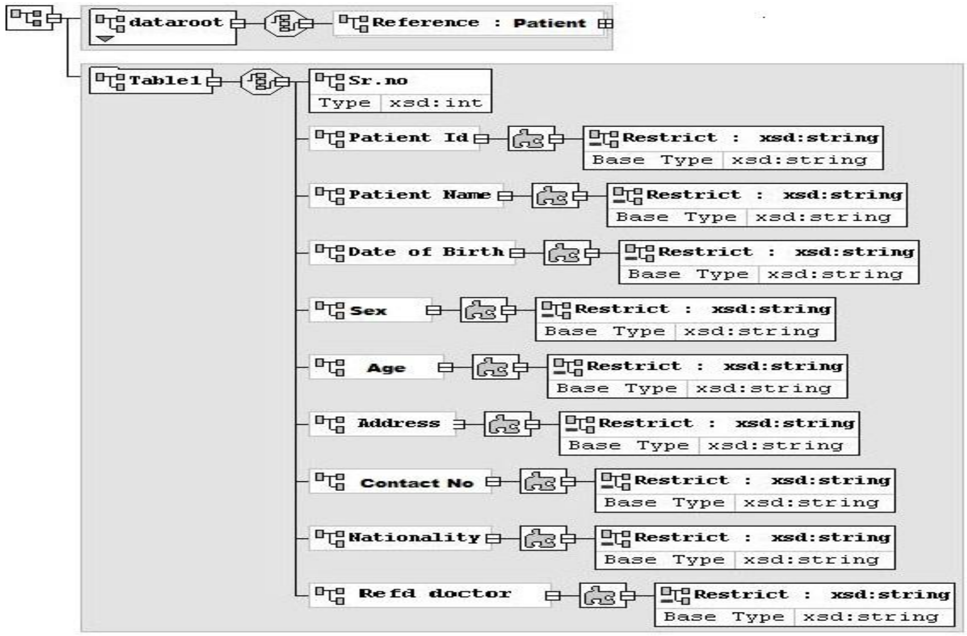

Figure 3.6: XSD for XML Document

xiii. A XSLT/CSS style sheet is created for the XML file which is used for transformation to XML documents used for describing the presentation semantics of a document written in markup language. This will help to display content as the web page as shown in figure 3.7.

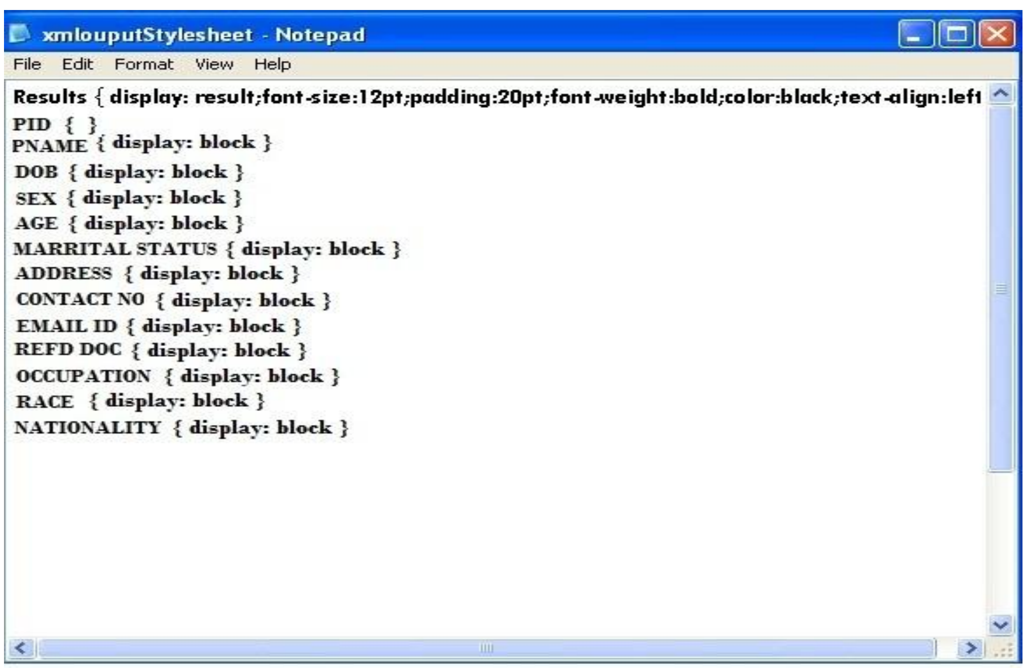

Figure 3.7 Style sheet for a XML Document

3.5 Information Model within HL7 RIM

The Health Level Seven (HL7) Reference Information Model (RIM) is a static model of health and health care information as viewed within the scope of HL7 standards development activities.

The RIM was first defined as a *data model*, where all data elements known from HL7 version 2 and some large electronic health record data models were put on a single information roadmap (Beeler et al., 2004).

In an iterative process of analysis, unification, harmonization and extension of scope, today's RIM emerged as an *abstract model*, which defines the grammar of a language for information in healthcare. The RIM defines classes such as Act, Role, Entity, etc. each of which is contained with a rich stock of attributes. When the RIM is applied to a new domain, one then needs to select and code these attributes.

For example as shown in Figure 3.8, at top level, all data is in a form in which *Entities* (e.g., people places and things, nouns) are related in *Roles* (relators) to other Entities, and through their *Participations* (prepositions i.e. behavior of entity) interact in *Acts* (verbs i.e. health care related activities). Through *ActRelationships*, networks of structurally or logically related Acts are formed, expressing container, rules, judgements, etc. *Role-link*, represents relationship and provide addition attributes of Role.

All classes have specific characteristics (the attributes and values). Classes are related to each other via the relationships (Van et al., 2004). Specialization (adding characteristics) and cloning (duplicating classes and their characteristics) make it possible to create representations of these classes tailored to specific care settings, patient categories, and professional domains.

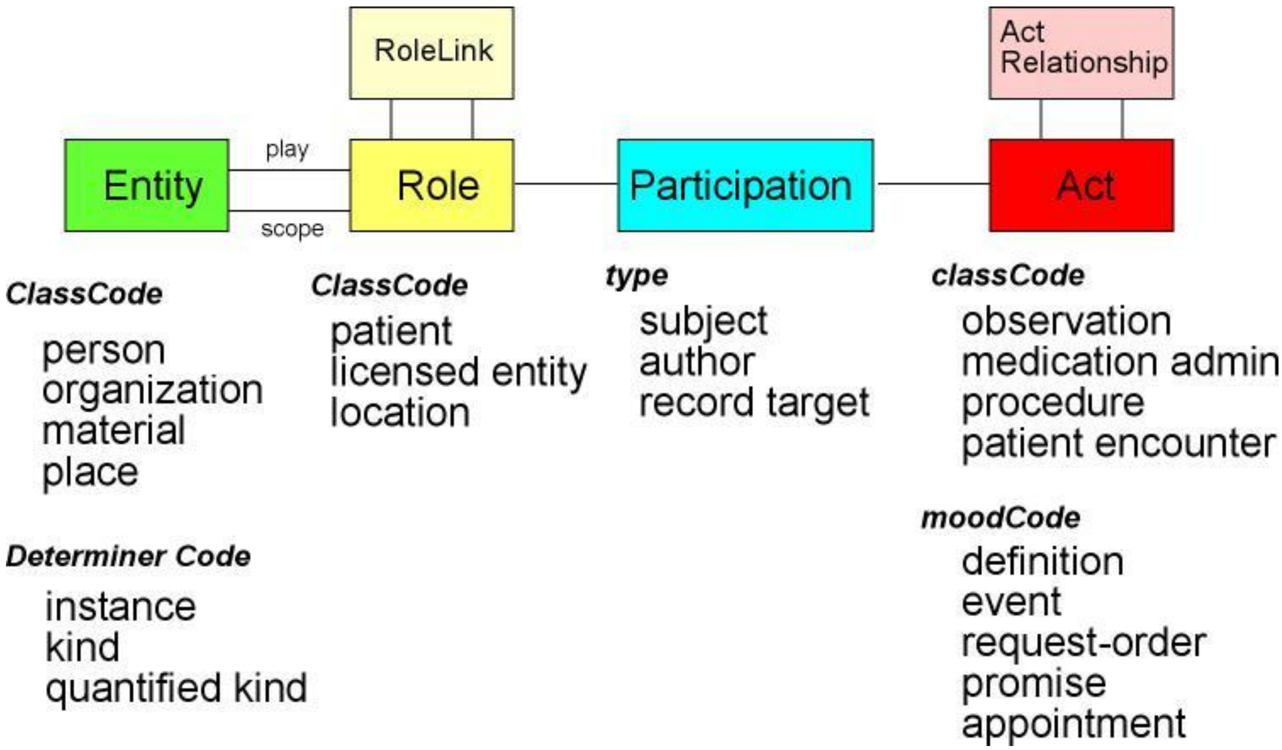

Figure 3.8: Reference Information Model "Backbone" (2004)

The RIM is comprised of six "back-bone" (Beeler et al., 2004) classes:

- **Act** which represents the actions that are executed and must be documented as health care is managed and provided;
- **Participation** which expresses the context for an act in terms such as who performed it, for whom it was done, where it was done, etc.;
- **Entity** which represents the physical things and beings that are of interest to, and take part in health care;
- **Role** which establishes the roles that entities play as they participate in health care acts;
- **ActRelationship** which represents the binding of one act to another, such as the relationship between an order for an observation and the observation event as it occurs; and
- **RoleLink** which represents relationships between individual roles.

Three of these classes -- Act, Entity and Role -- are further represented by a set of specialized classes, or sub-types. In the HL7 representation, classes that represent distinct concepts, but which need no further attributes or associations are represented solely as a unique code in the controlling vocabulary (Benson 2009). Therefore, these three classes include the following coded attributes, which serve to further define the concept being modeled:

- **classCode** (in Act, Entity and Role) represents the exact class or concept intended, whether or not that class is represented as a class in the RIM hierarchy;
- **moodCode** (in Act and Entity) an attribute that distinguishes whether the class represents an instance or a kind of Act or Entity. If the class is a specialization of Act then moodCode further delineates the instance as an occurrence or an intent;
- **code** (in Act, Entity and Role) provides for further classification within a particular classCode value, such as a particular type of observation within the Observation class.

The other three RIM back-bone classes -- Participation, ActRelationship and RoleLink -- are not represented by generalization specialization hierarchies. Nevertheless, these classes represent a variety of concepts, such as different forms of participation or different kinds of relationships

CHAPTER - 4

RESULTS & DISCUSSION

4.1 Domain Information Model for HCIS within HL7 RIM

According to the proposed approach of this thesis work, the CLASS diagram of the Healthcare Information system (HCIS) is already defined in the section of present work with the use of UML. Now, According to flow analysis, after receiving the patient's identity from the counter, the system will confirm if there are the patient's health records or not in the system (Yang et al.,2009). If the system already has the patient's heath record, the system will automatically make appointment for the patient. On the other hand, before make an appointment, it should insert the patient's demographic meta observations to the clinical data base. Different physicians/doctors can use the CIS with the patterns of web pages they prefer. They can design their own observation processes. It decreases the doctor's burden and time to be familiar with the new system.

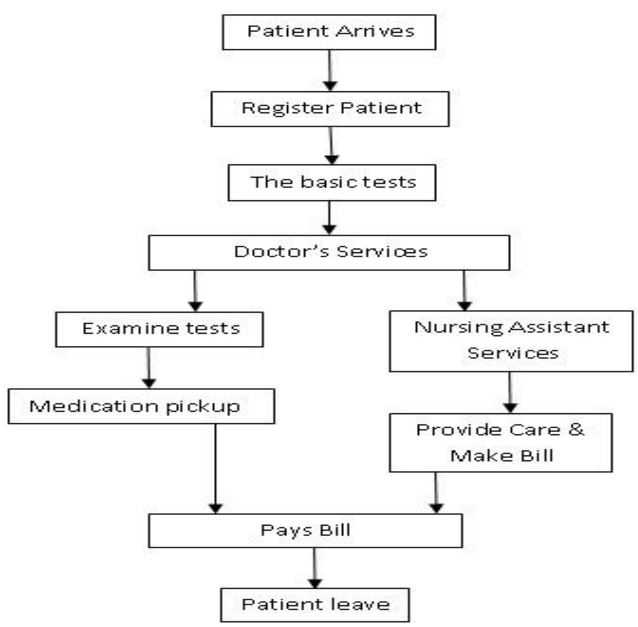

Figure 4.1: General Process of Hospitals

Next it performs all the other necessary operations as shown in figure 4.1 required for the smooth functioning of the system. In the proposed approach, the working groups represented the Healthcare information system as a dynamic sequence of phases, each containing the information specific to the activities of the phase. They used Universal Modeling Language (UML) to represent this domain knowledge in models as discussed earlier. After creating a structural model of the information used at each stage of the HealthCare information process, the working groups mapped that information to the HL7 RIM. They used a hierarchical structure for the organization of healthcare knowledge as the basis for a hierarchical model for "Findings about metadata recording of the patient." The modeling and mapping reported here are exploratory and preliminary, not exhaustive or definitive. This must be done carefully, however, to assure overall consistency with the RIM and to provide interoperability of information within and between information systems (Van et al., 2004).

So, in order to accomplish the task of Domain Information Model for HCIS the new RIM core classes are defined with the functionality same as the RIM backbone classes of the standard.

According to Fig 4.2(A) the RIM core classes presents the actions and functions of Doctor/Physician who treats the patient in a hospital.

For person in hospital i.e. for doctor there are two prospectives:

- Main Doctor or Health Care Professional
- Nursing Assistant or Attender

According to Fig 4.2(B) the RIM core classes presents the actions and functions of patient who goes to hospital for the treatment of its illness and become a health person.

Similarly For person in hospital i.e. for doctor there are two prospectives:

- Indoor patient (admitted to hospital)
- Outdoor patient (visits hospital for treatment but not admitted)

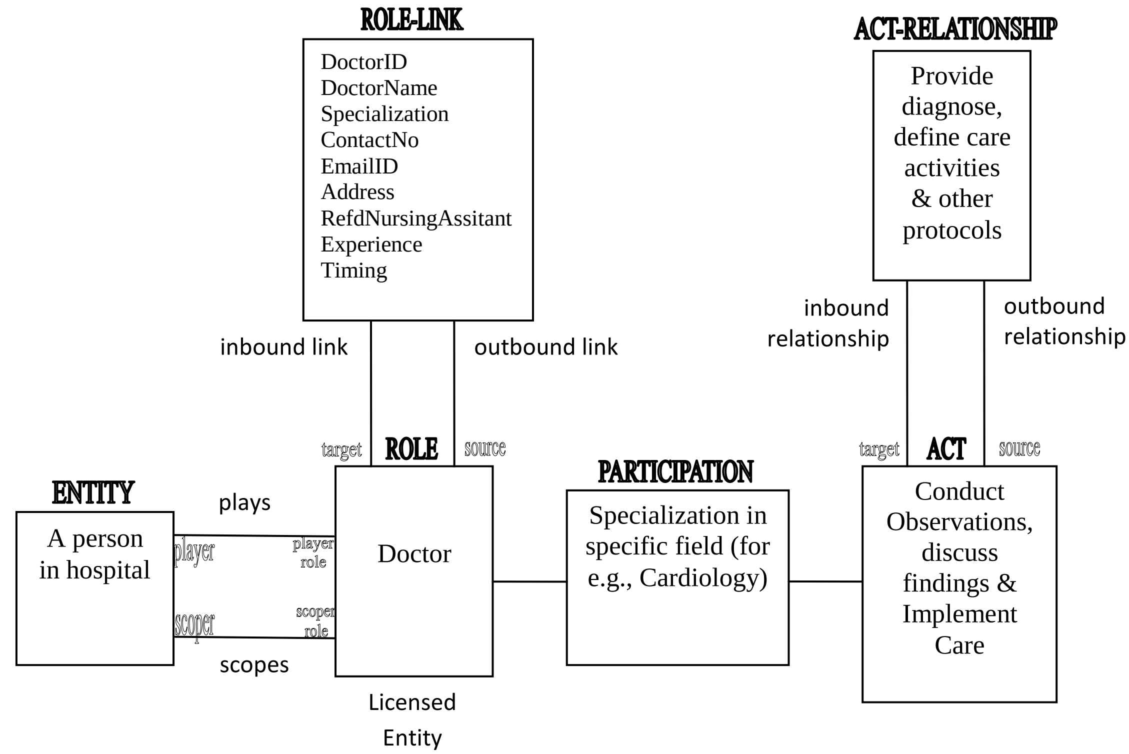

Figure 4.2 (A): Doctor RIM core classes

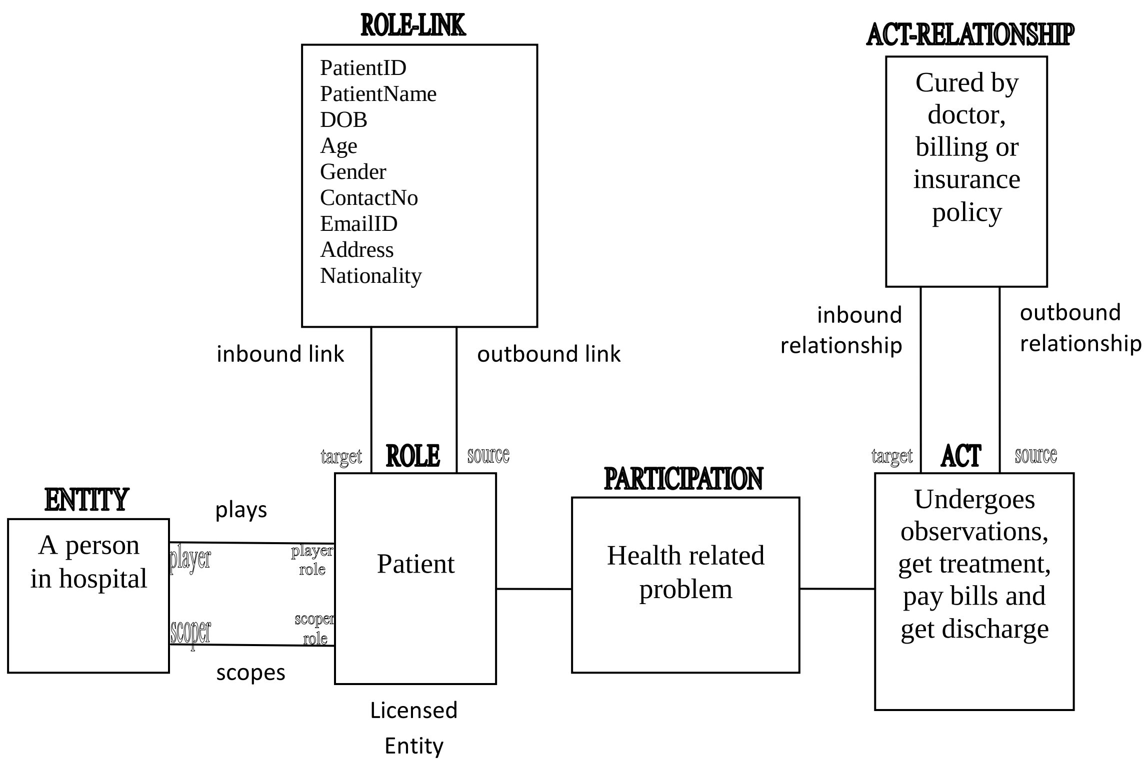

Figure 4.2 (B): Patient RIM core classes

As defined the HL7 RIM was introduced as an object oriented information model to harmonize the definition of HL7 messages across different application domains. When the RIM is applied to a new domain, one then needs to select and code these attributes (Gaion et al., 2010). The HL7 RIM represents the relevant concepts in health care for which information needs to be available and processed and their mutual relationships. The HL7 RIM is described using the Unified Modeling Language (UML), an object-oriented analysis and design method for developing Health care information systems shown in figure 4.3. It explains the RIM 6 core classes' contribution in the aspect of designing a domain model to represent the working and functionality of the Hearth Care Services.

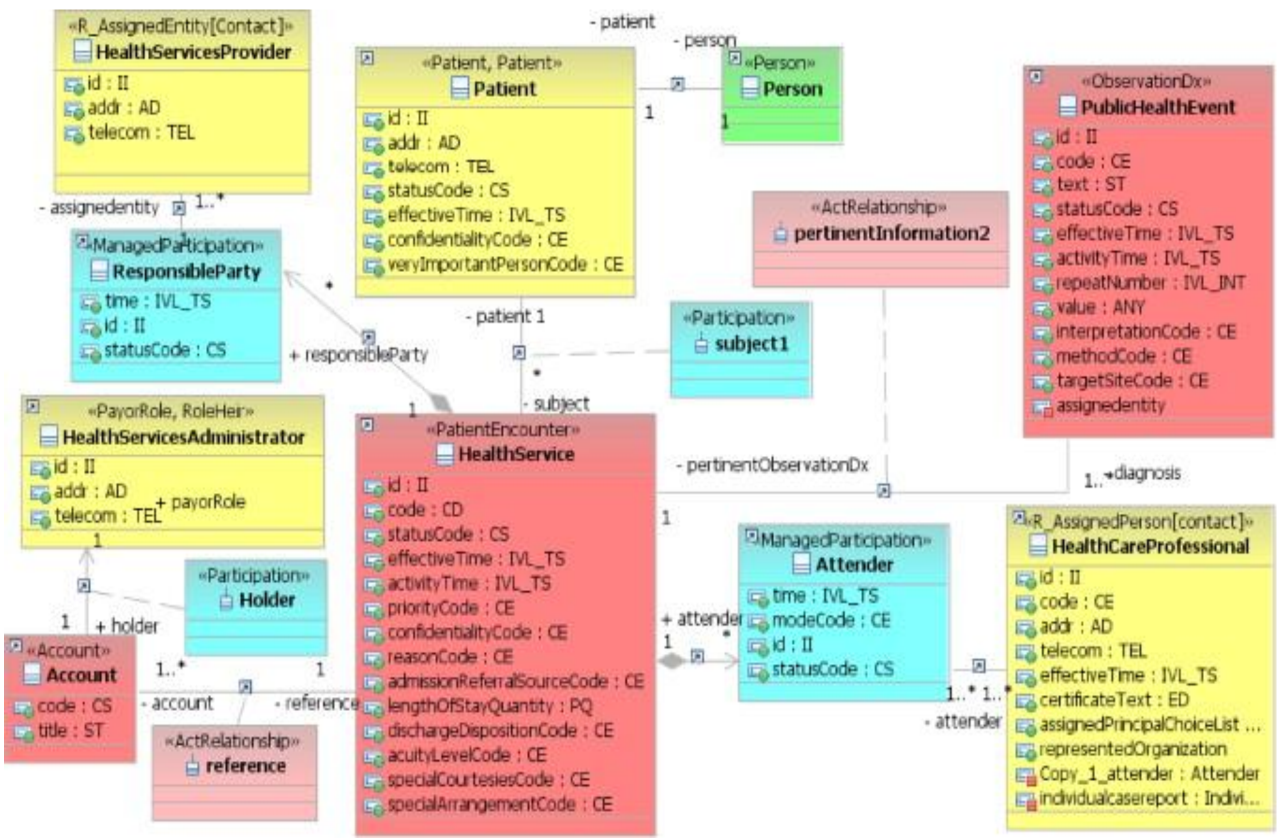

Figure 4.3: The HL7 RIM Model of HCIS

The HL7 RIM model as shown above defines various classes of the RIM standard of HL7 along with their contribution and execution of HCIS. Here 'Person' in green color represent the Entity class, ‘Patient’, ‘HealthCareProfessional’, ‘HealthServicesProvider’ in yellow color represent the Role class along with RoleLink class in light yellow color. The components in blue color represent the Participation class of RIM, ‘HealthServices’, ‘Account’, ‘PublicHealthEvent’ in red color represent the Act class along with ActRelationship class in light pink color. All these color representation shows the contribution and functionality of each class of the HL7 RIM.

4.2 Mapping Healthcare Information System to HL7 RIM Classes

There are multiple existing approaches based on RIM development, in which one of the approaches is HL7v3 RIM based domain information model (DIM) dedicated to clinical engineering. The Clinical Engineering Information Reference Model (CEIRM) focuses on the information needs of clinical engineers at departmental and higher (out of clinical environment) levels, identifying a hierarchy of information. In this method, the DIM is developed on the basis of workflow of endoscopy repairing process. The activities representing the dynamics of the endoscopy repairing process include make inspection, define activities, and implement intervention. The lack of this approach is that it lacks the meta-observations and meta-care facilities that must be applied to a health care information system in clinical engineering.

Therefore, accordingly the next step is to map the contents of the class model and the activity model to the HL7 RIM. The approach was to use Domain Message Information Models (D-MIMs) (Goossen et al., 2004). A D-MIM is a method of representing concepts from a particular clinical or administrative domain as classes, attributes, and roles in the HL7 RIM. The D-MIM functions serve as a bridge in the communication gap between health professionals and information scientists. Goossen 2004 posited that the D-MIM functions as a bridge in the communication gap between health professionals and informaticians. The groups constructed D-MIMs to describe the semantic structure of the information contained in the Healthcare Information System. All the specialized classes representing the *Results* in the assessment phase of the Healthcare information process were considered instances of the RIM class *Meta Observation*. Similarly other activities are considered instances of other class objects. As an exercise, some examples from the hierarchy and domain models were mapped to the HL7 RIM. These comparisons resulted in a table 4.1 containing the classes and vocabulary for the domain information on one hand and their corresponding RIM class and attributes on the other hand. This effort provided a small-scale validation of the approach with examples from two distinct classifications and vocabularies that are relevant for Healthcare Information System.

For *comparison* between existing (Mehmood et al., 2009) and proposed approaches, lot of messages like patient registration, meta observation, diagnose, provide care etc., are generated on different systems and their performance is measured against different parameters like time of processing, memory usage, and correct generation of message. It overcomes the efficiency problems related to time and memory. It improves the metadata loading procedure by loading only required objects rather loading all of the objects in memory. In short, this technique utilizes less memory and provides the complete description of metadata in HealthCare Information System within HL7.

Table 4.1: Examples of Mapping Healthcare Information System to HL7 RIM Classes and Attributes

Activity Example	**HL7 RIM Class**	**Mapping to HL7 RIM Classes and Attributes**
Patient in hospital	Registration	• HL7 RIM ClassCode = REG (Registration) • MoodCode = REQ(Request)
Update information in HER	Registration	• HL7 RIM ClassCode = REG (Registration) • MoodCode = EVN (Event)
Make Observation (Yes/No)	Observation	• HL7 RIM ClassCode = OBS (Observation) • MoodCode = REQ(Request) • Code = type of possible test
Make Meta Observations (Yes/No)	Meta Observation	• HL7 RIM ClassCode = MOB (Meta Observation) • MoodCode = REQ(Request)

Activity Example	**HL7 RIM Class**	**Mapping to HL7 RIM Classes and Attributes**
Lab Test Observations	Findings	• HL7 RIM ClassCode = FIN (Findings) • MoodCode = EVN (Event) • Code = all possible codes as selected items • Value = test type, test name, test value.
Scan Test Observations	Findings	• HL7 RIM ClassCode = FIN (Findings) • MoodCode = EVN (Event) • Code = all possible codes as selected items • Value = image data
Need for Cure (Yes/No)	Meta Care	• HL7 RIM ClassCode = MCR (Meta Care) • MoodCode = REQ(Request)
Define Diagnose	Diagnose	• HL7 RIM ClassCode = DIG (Diagnose) • MoodCode = EVN (Event) • Code = provide the prescription and suggestions to patient
Set the findings	Expected Outcome	• HL7 RIM ClassCode = EOC (Expected Outcome) • MoodCode = EVN(Event)
OT services Required (Yes/No)	Planned Activities	• HL7 RIM ClassCode = PLA (Planned Activities) • MoodCode = REQ(Request)
Define Care Activities	Planned Activities	• HL7 RIM ClassCode = PLA (Planned Activities) • MoodCode = EVN(Event)
Implement Care Process	Care Implementation	• HL7 RIM ClassCode = CIMP (Care Implementation) • MoodCode = EVN(Event) • Code = provide diagnose and check regularly the improvement.
Verify all Process and Outcomes	Outcomes	• HL7 RIM ClassCode = OUC (Outcomes) • MoodCode = EVN(Event)
Pay Bill and Update EHR Records	Billing	• HL7 RIM ClassCode = BIL(Billing) • MoodCode = EVN(Event)
Discharge the patient	Discharge	• HL7 RIM ClassCode = DIC(Discharge) • MoodCode = EVN(Event)

As, the above discussed ACITIVITY & CLASS components of the domain model defines the meta data aspects of the HealthCare Information System using the impacts of HL7 RIM. HL7 messages transform the information from one end to other user ends. The most important and concerned information at this very point is meta observations of the patient conducted by the doctor to analyze the problem and then transmit the Observation report as for complete analysis. The findings of the problem from report will lead the measures that what the problem is, that it will be cured accordingly.

At last but not least, the figures in Appendix A represent the meta observation and report the outputs for better performance of the system. It will also show the XML Generation of Patient Information and Observation and then Parsing of the lab and scan tests Observation to generate the report as XML webpage for the transmission of HL7v3 messages between various users of the system. It provides complete functionality and reliability of the described process within HL7 RIM.

CHAPTER-5

CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

The Health Level Seven (HL7) Reference Information Model (RIM) is a static model of health and health care information as viewed within the scope of HL7 standards development activities. It is the combined consensus view of information from the perspective of the HL7 working group and the HL7 international affiliates. It is the root of all information models and structures developed as part of the V3 development process. The RIM is used by HL7 international affiliates to extend HL7 V3 standards to meet local needs. The RIM consists of classes assigned to one or more subject area packages i.e. Attributes, Relationships, and State Machines are associated with classes. RIM is an information model for health care that broadly covers all aspects of an organization's observational and administrative information. Health-care industry experts created RIM to support the definition of messages used for exchanging health-care information. By deriving a new data model from RIM, capability to take advantage of the expertise of the HL7 organization increases. This proposed approach summarizes our early attempt to reprocess standard healthcare information models for representation of Healthcare Information System. It is based on using the Unified Modeling Language (UML) extensibility mechanisms, providing several advantages such us tooling support, graphical notation, exchangeability, extensibility, code generation, etc., deployable in the next generation of HL7 tools with HL7 specific tags as extensions to the UML model element metadata. The initial findings provide insight to the various challenges ahead and guidance on next steps for validation and adoption of information models in software implementations and it still have a long way to go and more efforts are expected to be devoted to this area.

5.2 FUTURE SCOPE

There are multiple systems in place that support communications for public health labs, the hospital community, and state, and local health departments. However, most of these systems operate in isolation. Numerous benefits will start accruing as parts of the system are built and integrated into the business processes of the local health services. The implementation of a unifying system will further improve access to laboratory metadata and response protocols, advanced capabilities for rapid notification of public health partners, response agencies, the media, and the general public. There will be an enhanced capability to train public health staff and a uniform data exchange standard for exchanging data between the public health partners. HL7's power continues to drive the dynamic potential of technology to meet tomorrow's health information needs. HL7 team works collaboratively with healthcare stakeholders around the world to develop interoperability standards and specifications for electronic health records, personal health records, laboratory data, claims attachments and other initiatives to enhance connectivity in the healthcare system. HL7 interoperability standards will improve care delivery, optimize workflow and enhance the exchange of knowledge among healthcare providers, government agencies, the vendor community, other standards development organizations and patients and also handle future needs. Real-time collection of data from heterogeneous healthcare systems provide access through a ubiquitous Web-based portal that will obviate the necessity of client-side implementations of application systems, provide a mechanism to disseminate critical and public-interest information to the community in general are additional benefits.

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APPENDIX A

SCREEN SHOTS

SCREENSHOTS OF RESULTS:

The screenshots of the final results of the source code applied to a number of messages. The Patient Information will retrieve the information of the Patient (personal, and official) and store it into the database.

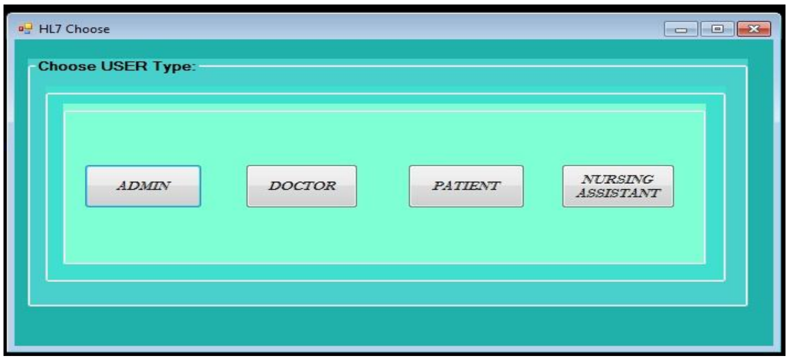


Figure A.1: HL7 form (Choose User Type)

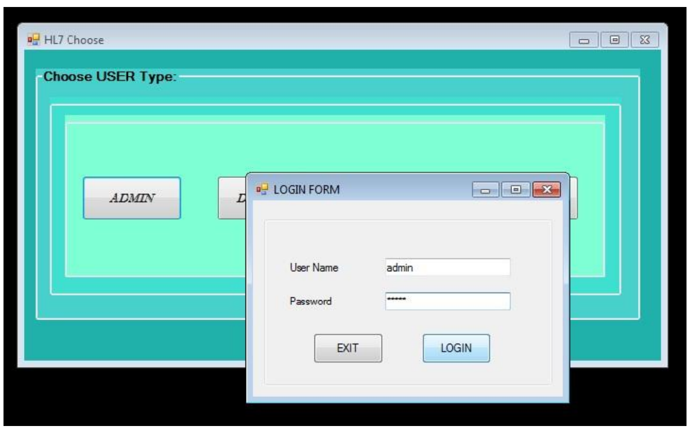


Figure A.2: Login Form

These figures show the choice of user type. Any one of above type is selected and enters the required username and password for further processing of the system.

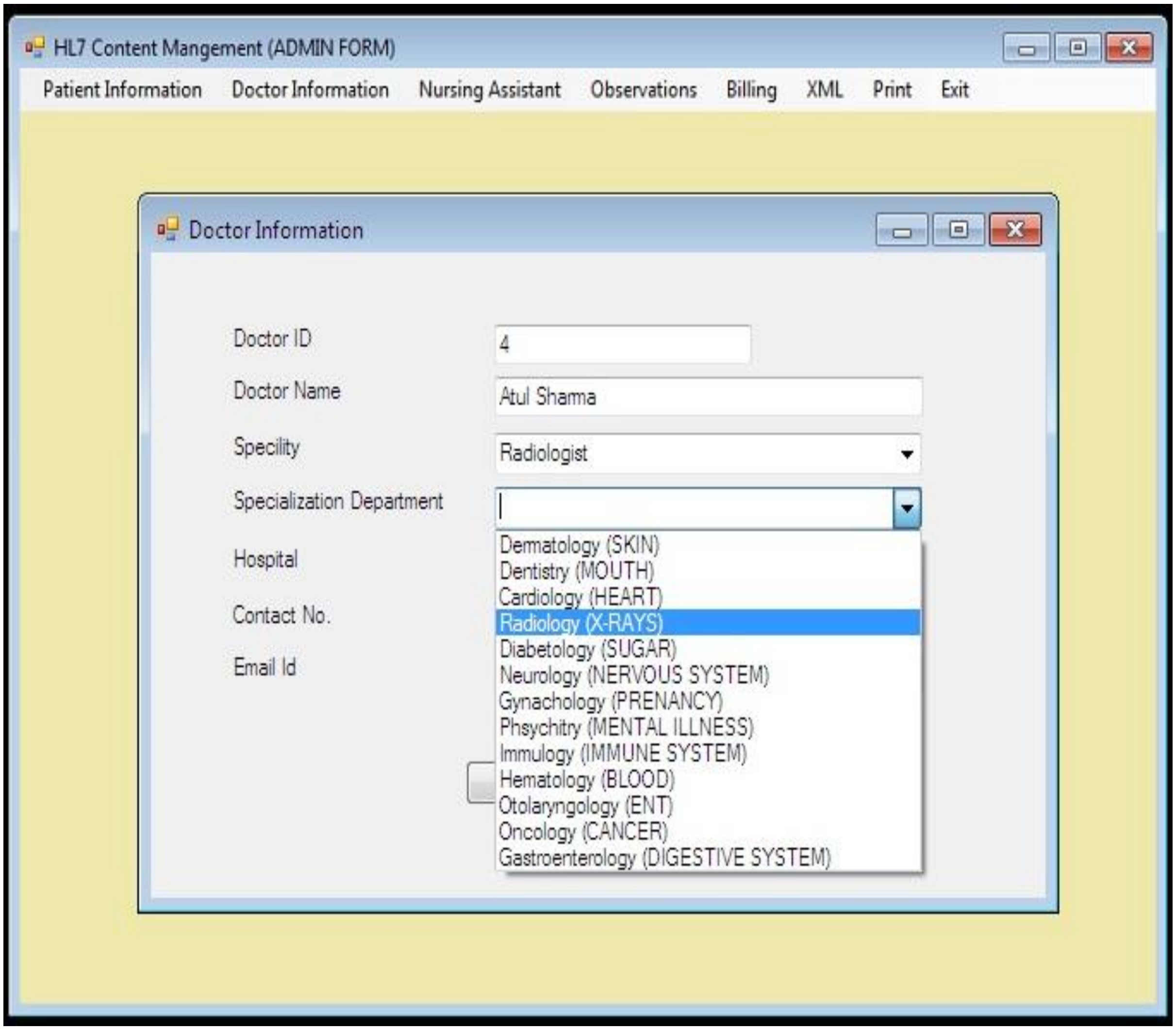


Figure A.3: Main form (HL7 Content Management) with Add New Doctor Information

The Main Form of HCIS is as shown above which consist of various functionalities such to add new Doctor, edit Doctor, similarly to add new Patient, edit Patient, add new Nursing Assistant, edit Nursing Assistant .

This form consists of menu which contains all the required controls to maintain the processing of the build processing system.

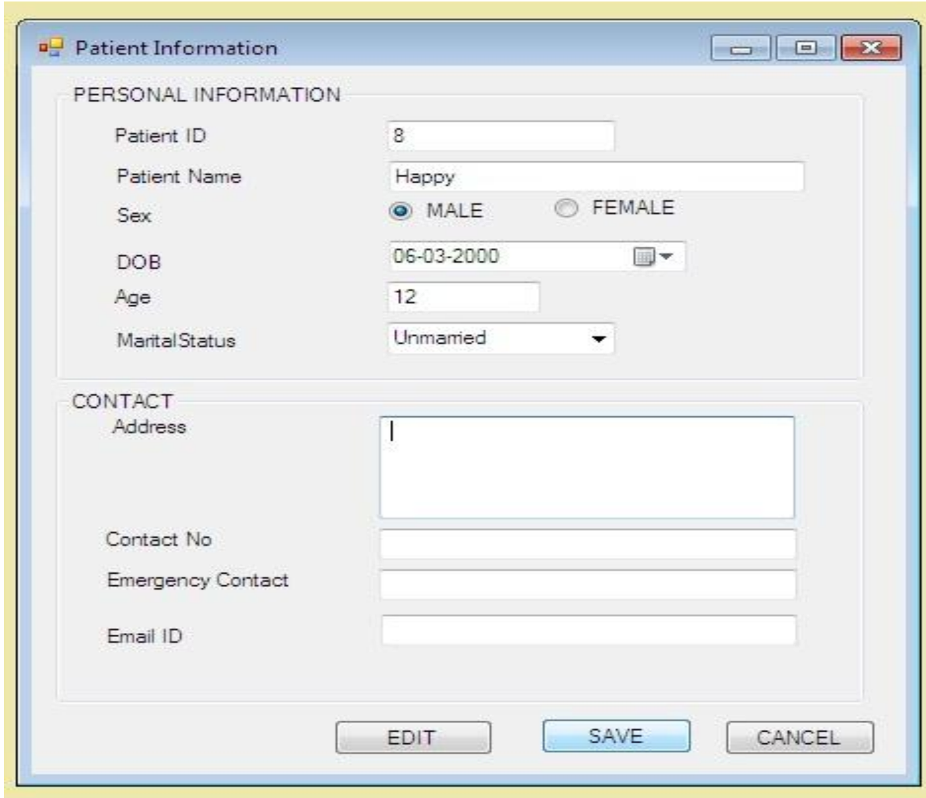


Figure A.4: Add New Patient Information

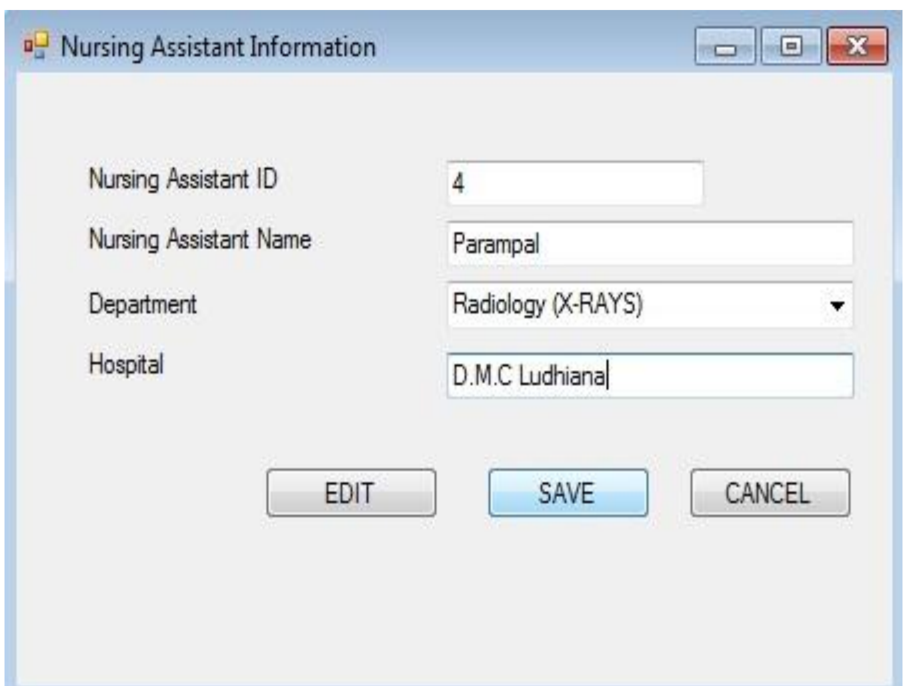


Figure A.5: New Nursing Assistant Information

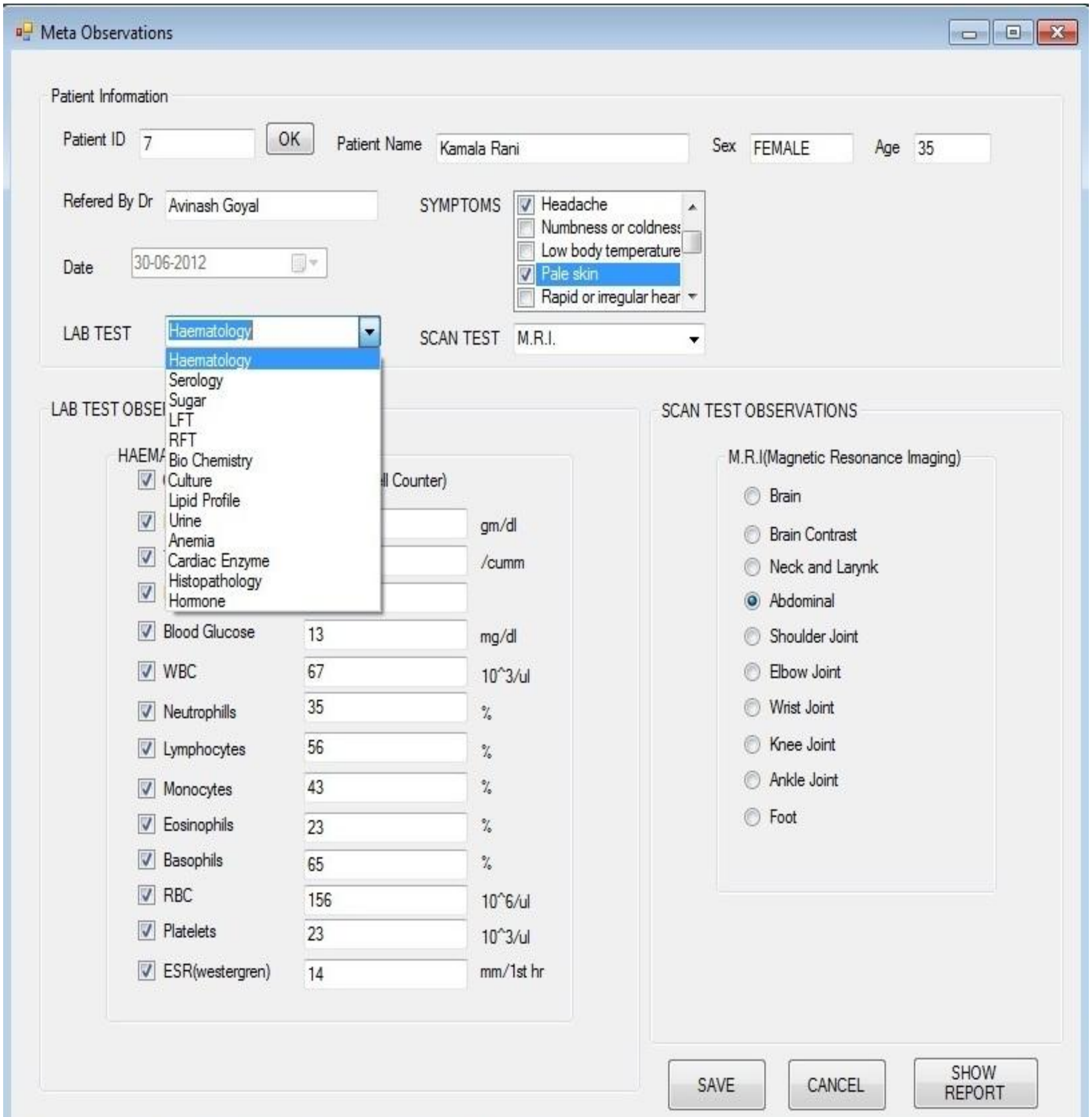


Figure A.6: Meta Observations

Meta Observation is defined with the prospective either chooses test type with all sub tests at a time or choose a single or multiple sub tests according to the requirement of observations conducted by doctor. Here some of the Symptoms are also selected after the doctor's discussion with patient so if it matches with Database Symptom table it will provide an assumed disease could be so that a doctor could take action accordingly.

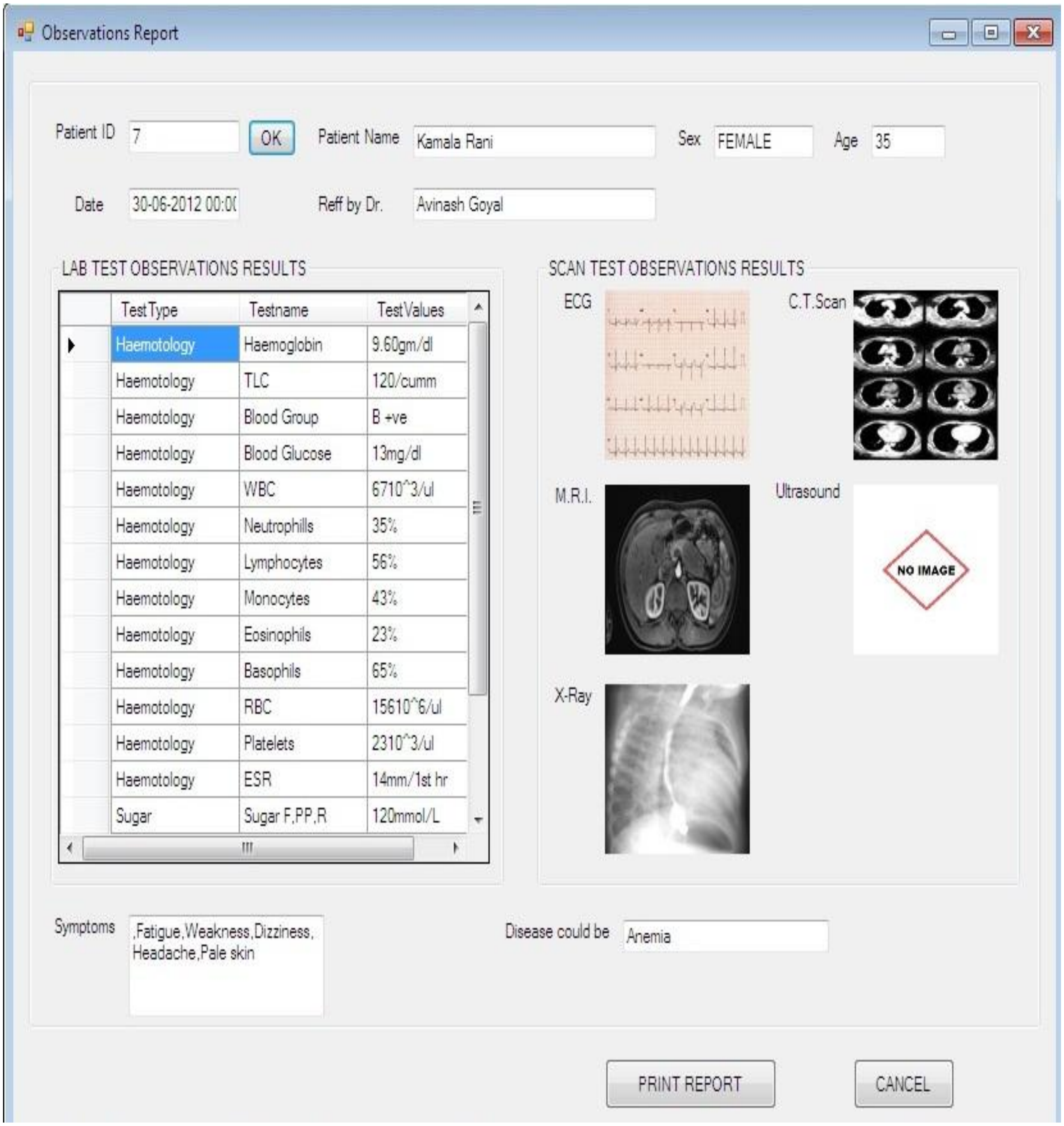


Figure A.7: Observations Report

Observation Report generated which specifies all lab and scan test observations conducted by doctor on a particular table i.e. parsing of the metadata and this also predicts the disease could be from the symptoms defined and observations evaluated.

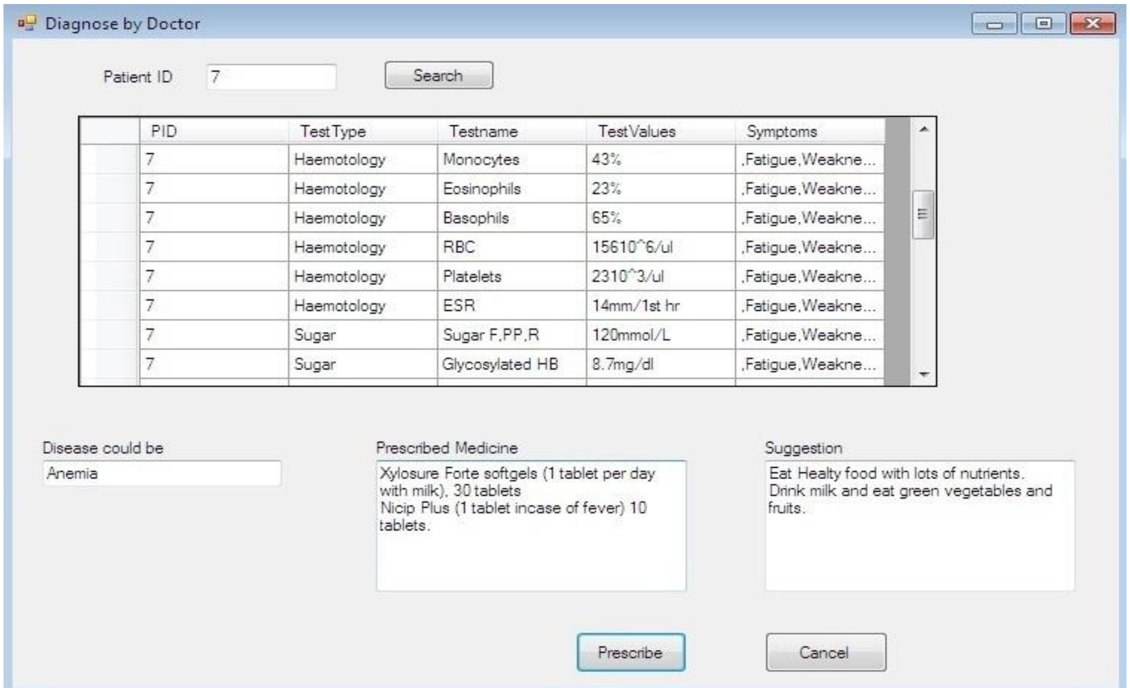


Figure A.8: Diagnose form

This form provides medicine prescription by Doctor to a particular patient to overcome its illness and get proper treatment.

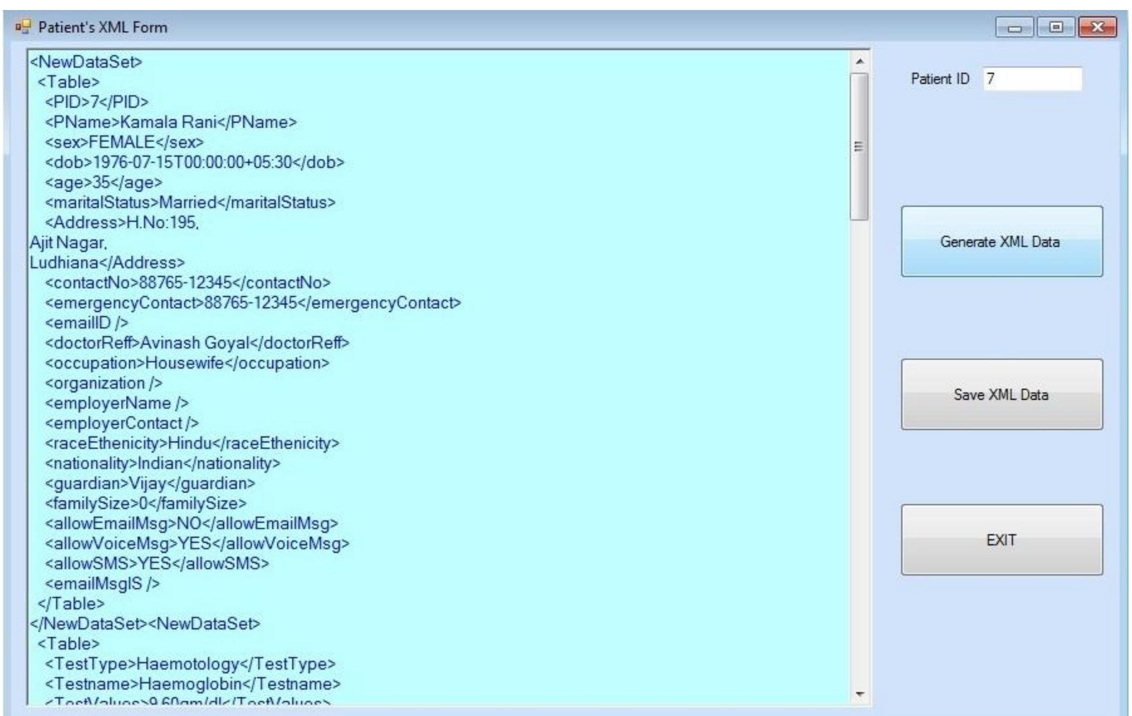


Figure A.9: Generation of Patient's report in XML Format

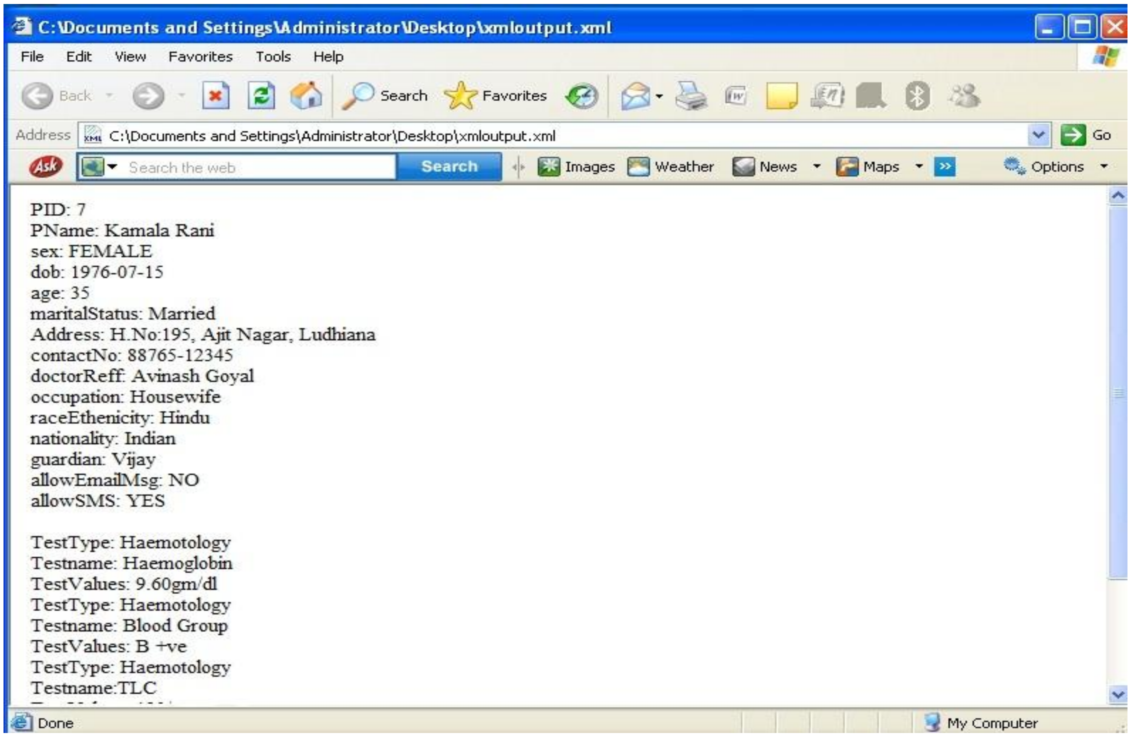


Figure A.10: Patient report as web Page

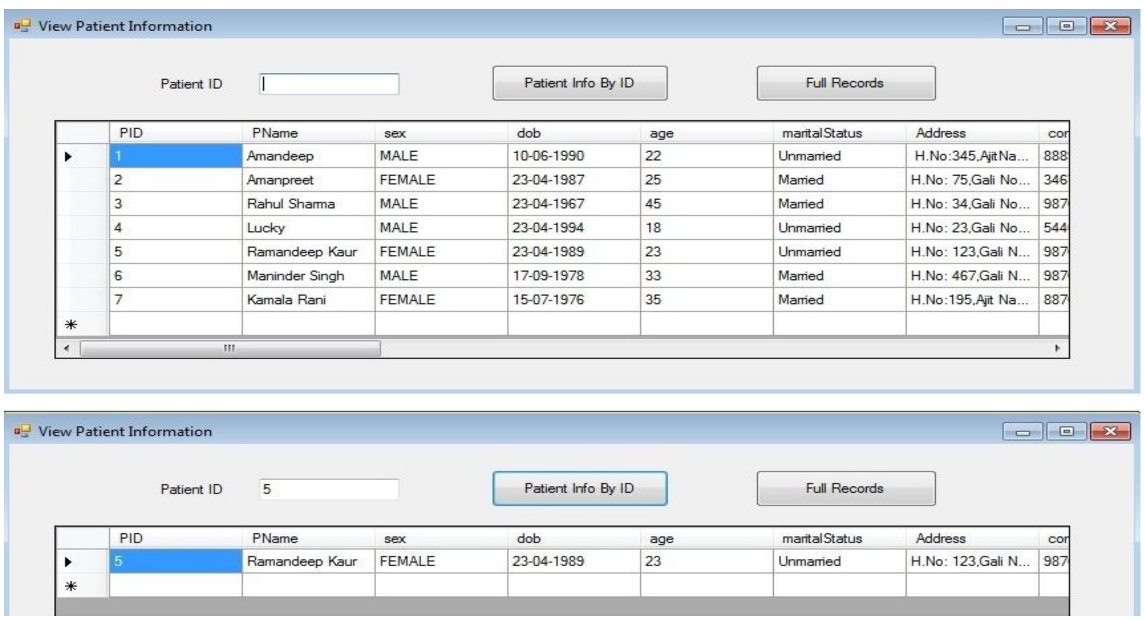
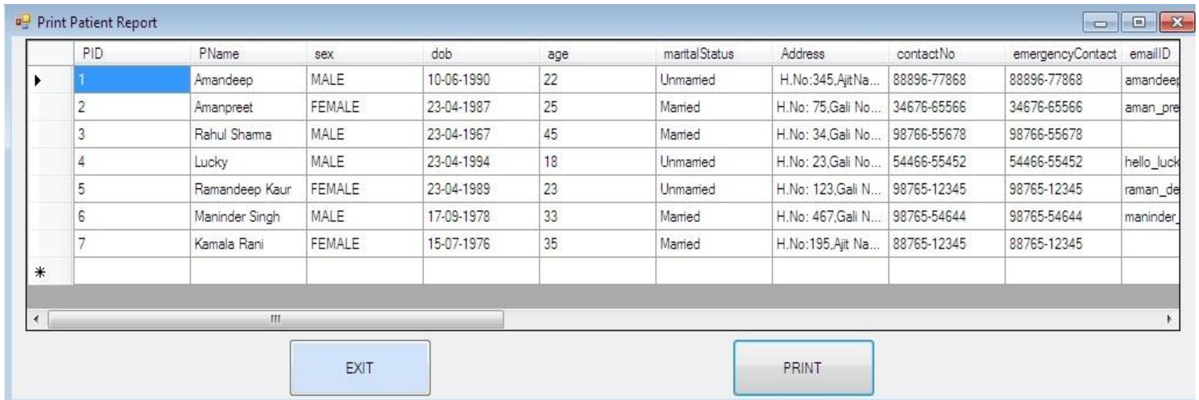


Figure A.11: View Patient Information

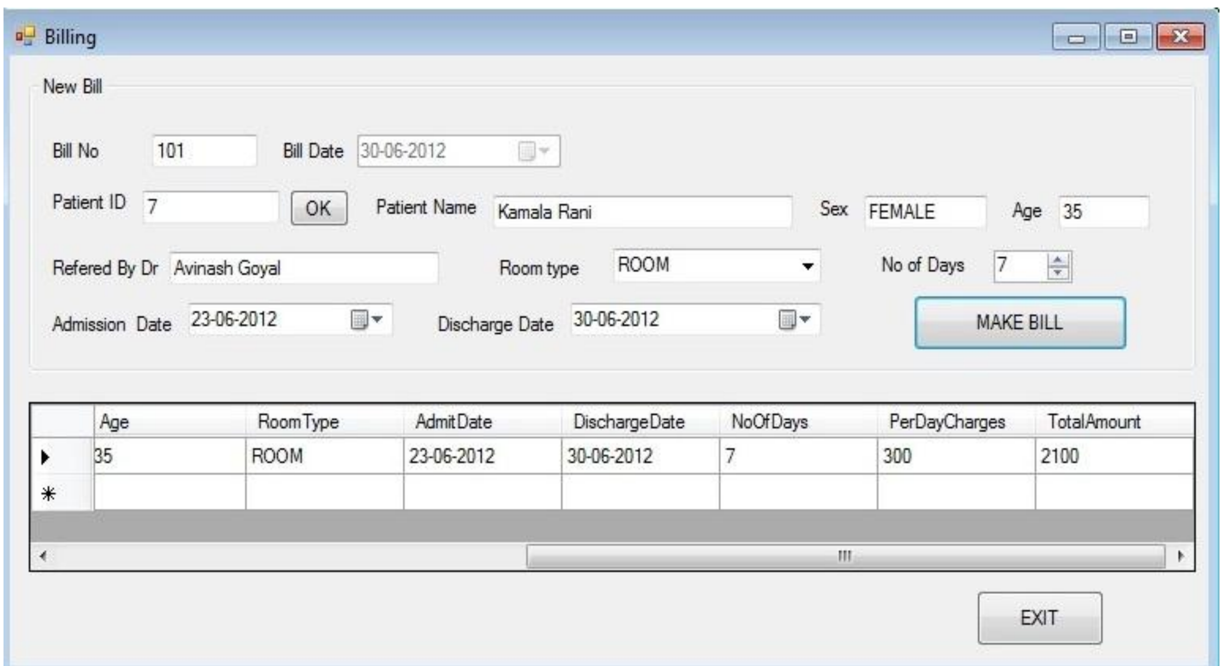
A user can view Patient Information full records present in its database or for a particular patient ID. Similarly a user can view Doctor's information and also Nursing Assistant information records present in the database of the HCIS system.



PID	PName	sex	dob	age	maritalStatus	Address	contactNo	emergencyContact	emailID
1	Amandeep	MALE	10-06-1990	22	Unmarried	H.No:345,AjitNa...	88896-77868	88896-77868	amandeep
2	Amanpreet	FEMALE	23-04-1987	25	Married	H.No: 75,Gali No...	34676-65566	34676-65566	aman_pre
3	Rahul Sharma	MALE	23-04-1967	45	Married	H.No: 34,Gali No...	98766-55678	98766-55678	
4	Lucky	MALE	23-04-1994	18	Unmarried	H.No: 23,Gali No...	54466-55452	54466-55452	hello_luck
5	Ramandeep Kaur	FEMALE	23-04-1989	23	Unmarried	H.No: 123,Gali N...	98765-12345	98765-12345	raman_de
6	Maninder Singh	MALE	17-09-1978	33	Married	H.No: 467,Gali N...	98765-54644	98765-54644	maninder_
7	Kamala Rani	FEMALE	15-07-1976	35	Married	H.No:195,Ajit Na...	88765-12345	88765-12345	

Figure A.12: Print Patients Report

A user (Doctor or NA) can print Patient Record with all specifics, also the Observation, Diagnose reports of the particular Patient. Similarly a patient can also see a complete Observation report and also get print of it.



Age	RoomType	AdmitDate	DischargeDate	NoOfDays	PerDayCharges	TotalAmount
35	ROOM	23-06-2012	30-06-2012	7	300	2100

Figure A.13: Bill Form

To make the bill list of a particular patient from it’s admit date to discharge date with the account of room type.

Figure A.14: View Prescription provided by Doctor to Patient

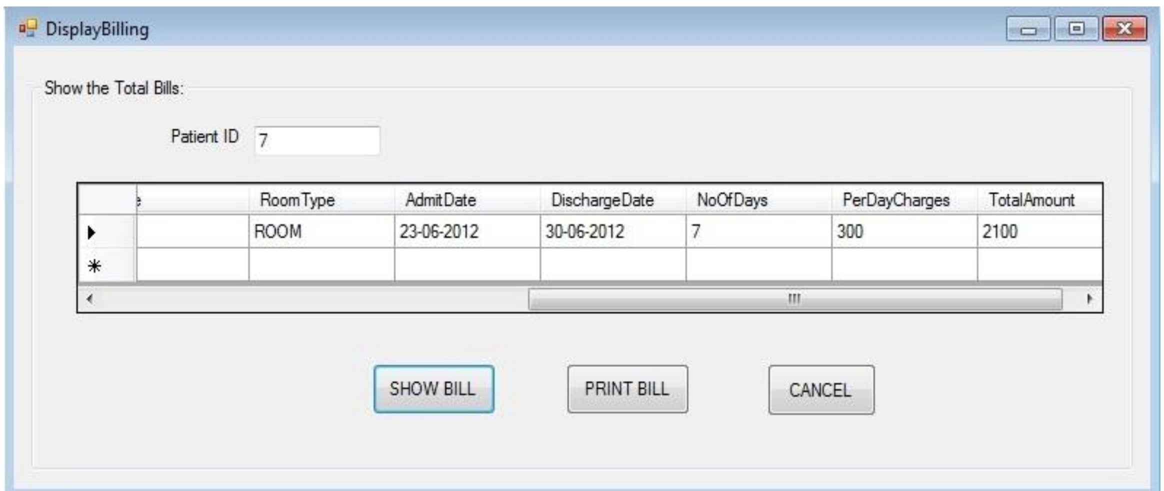


Figure A.15: Display Bill Information to particular Patient