# Project Report

## A. Project Title: Health Life Horizon (HLH): Design and Implementation of Health Level 7 (HL7) for e-Health Services

## B. Project Summary:

The aim of this project was to carry out research in healthcare by developing Health Level 7-based software framework in order to provide health services for diverse communities of the world. The envisaged development of HL7 middleware software was focused on healthcare information systems already in use. The objective is to facilitate e-health services interoperable among various domains in the field such as laboratory, patient administration, pharmacy, billing and accounting etc.

This project is based on HL7 version 3.0 standards because of its distinct benefits over previous versions. HL7 Version 3 is consistent with futuristic specification inherent in UML (Unified Modeling Language) models and object-oriented concepts. It offers an opportunity to provide an open source, vendor-neutral framework comprising generic components, integration mechanisms, together with a process for staged customization to meet not international standards but also the requirements of healthcare delivery organizations.

The project is carried out as per plan provided in the initial proposal from the milestones and deliverables perspective. Due its cutting-edge nature, the project has succeeded to create repute not only at national level rather at international grid as well. One tangible item can be seen in the form of “HL7 Pakistan”. HL7 Pakistan is an affiliate status achieved for Pakistan during the course of this project.

As a requirement, this project continued research and development all together at the same time in a fashion that the results of research incorporated at logical steps. Fortunately the team performed excellently well in research and published papers more than what were expected. Based on the research outputs international HL7 community appreciated the work at various forums. This will remain an honor of this project to have 20+ research papers published, 8 bachelor final year projects show cased and 12 master theses completed. One bachelor final year project (FYP) titled “Semantic Enabled Cloud Based EMR” selected as “The best project for the year 2011”. The team structured for this project formed for this project as two team leads worked under the PI and the rest of team was working with Team Leads on the positions of senior researcher, junior researcher and internees. The structure was worthwhile to accomplish the objectives of the project.
C. Objectives and achievements

■ Original Project Objectives

Research Objectives:
1. To propose appropriate system architecture that gives coherent view of semantic interoperability for various domains of healthcare.
2. To research for transforming the architecture into novel ontology-based system architecture. This research is most challenging as such system is not yet available globally on commercial grade or public domain but research is in progress for realizing semantics/ontology based systems.
3. To identify candidates HL7 messages as a web services in order to propose Service Oriented Architecture (SOA) model to our developed HL7 version 3 system.

Academic Objectives:
4. To gain experience in developing architecture for large (complex) healthcare interoperable system using HL7.
5. To emphasize on research issues on system design and architecture than only implementation. More specifically, based on the requirements, we should emphasize on system design goals, techniques for addressing design goals.
6. To organize a series of workshops and seminars at national level to share the experience for IT students, IT professionals, software developers and medical specialists. IT and software people will get insight into developing such large applications and medical specialists will get familiar with HL7 standards and its application in hospital for e-Health Care provision.

Industrial Objectives:
7. To provide the world with cost-effective, easy accessible open source HL7 version 3 solution that can be used in real environment.
8. To provide the healthcare organizations and hospitals of different countries customizing this solution to their specific requirements with minimum efforts.

Human Resource Development Objectives:
9. To produce IT specialists who can contribute to better health service through modern ICT skills.
10. To train a reasonable number of professionals and researchers as HL7 based IT researchers, developers as well as users of the HL7 application in the medical related discipline.
11. To provide opportunity to the undergraduate and graduate students of IT/Computer Sciences to work on software development in their term/final year projects (FYP’s).
12. To create a bunch of opportunities for young researchers to carry out research in an area that is directly connected with the fundamental needs of community.

Other Objectives:
13. To create experts community in the domain of healthcare information exchange and interoperability, in order to take initiative for affiliation of Pakistan to HL7 organization. The main objective and responsibility of the HL7 affiliates is to perform a range of core activities including the distribution and licensing of the HL7 Standards materials, education, user support and certification of professionals and systems. We envision, through this initiative, Pakistan will stand among countries which are HL7 affiliated.
Objectives Achieved

Research Objectives:

HLH project showed excellent performance in research by publishing more than 20 research publications in well reputed national and international conferences. The outcomes of the research were more than what we were expecting. The comprehensive architecture is published in research paper titled as “Design and Implementation of HL7 V3 Based Open Source Application” in 9th International HL7 Interoperability Conference, Oct 2009, Crete Greece. This architecture is transformed to Ontology based novel system as published in “10th International HL7 Interoperability Conference (IHIC), pp 88-95, May 8-11, 2009, Kyoto Japan”. SOA architecture is designed and is published in “10th International HL7 Interoperability Conference (IHIC), pp 59-63, May 8-11, 2009, Kyoto Japan” and “The 10th International Symposium on Autonomous Decentralized Systems,” 23-27, 2011, Tokyo & Hiroshima, Japan”. Autonomous mapping tool called RSM is published in “11th International HL7 Interoperability Conference (IHIC), May 2010, Brazil” and one in journal of “Information System Frontier - Special Issue on eHealth Interoperability, 3 June 2011”. The system proposed in the papers is developed and implemented. It has been deployed in the real scenario of CITI Lab, Rawalpindi Pakistan. Also some parts are implemented in Shaukat Khanum Memorial Cancer Hospital and Research Center (SKMCH&RC), Lahore Pakistan.

Academic Objectives:

HLH is among the projects that equally fulfilled the academic objectives along with research objectives. Students from undergraduate and graduate programs are engaged for final year projects and master level thesis respectively. The project floated several projects for undergrad students and 8 final year projects are successfully showcased. Among these projects “HL7 compliant EMR (Outpatient Module)” won first position in open house competition at SEECS NUST level in 2011. Other than this, several workshops, seminars, corporate meetings/conferences have been arranged for the students to let them acquaint with advance healthcare technologies. At graduate level, 8 students defended their thesis on the topics coming out of HL7 domain. The HLH team played an instrumental role to facilitate development required for particular thesis topic. One of the countable outcomes in the area of academics is that HL7 is now spread to many universities in Pakistan. HLH team not only supported students from the SEECS NUST rather from other Schools of NUST and universities as well. Two students from EME College NUST and one student from NED university Karachi final year project (FYP) was completed with the consultancy of HLH team members.
**Industrial Objectives:**

The nature of HLH project is more likely to be industrial as it is the need of medical laboratories and hospitals to use on daily basis to share their healthcare information. Deployment at CITI Lab and SKM hospital shows its industry potential. HLH team trained SKM team to let them able to implement HL7 standard on their own rather to rely on HLH for all the times. The system developed for CITI lab is playing a role of reference implementation for other professionals in Pakistan. There are many software houses start working on HL7 based applications and many of them have very close interactions to adhere the HL7 standards in their applications. Elixir Technologies is a well reputed software company collaborating with HLH team making its HMIS system as HL7 compliant. The approaches used in HLH project are up to the mark and the developers in other organizations often consult HLH team for assistance. Based on the reputation of this project, industrialists attracted and initiated several other projects in the domain.

**Human Resource Development Objectives:**

Human resource development was considered with an equal attention during the course of this project. The students, professionals are given the attention to train on advance tools and technologies in the healthcare arena. Students trained in this project are now working in different ICT based companies around the world. Some of the BS students are pursuing their MS studies in different universities nationally and internationally. The same is true with MS students as 3 out of 8 are pursuing PhD study from abroad in the same domain. They were initially trained in this project. Senior resources of the project are now working as Master trainers at various levels and some of them are consultants.

**Other Objectives:**

HLH team will present this great honor all the times to get affiliate status for Pakistan. HL7 Pakistan was dream yesterday and is reality today and this couldn’t be achieved without the support of National ICT R&D Fund and NUST. The team performed excellently and went beyond their capacity to struggle for this achievement.
D. Technology Transfer/Commercialization Approach

In the healthcare arena, today’s need is to address the issues of prompt availability of information at the point of care, reducing medical errors and avoiding un-necessary medical procedures. With proprietary heterogeneous healthcare systems seamless integration has become a big challenge. The explosion in the number of healthcare applications and the global push for information availability are the main factors driving the need for data sharing which may be used by all health care users. In developed countries like US, a regulation has been passed to allocate funds of $40,000 to $65,000, for the physician who will use certified electronic health records. Realizing the need of such standard compliant systems in an under developed country like Pakistan can improve the healthcare standard to a greater extent. HLH provides grounds in building electronic health records, integrate various healthcare information systems for meaningful exchange, saves time and improves operational efficiency. HLH is targeting the local healthcare sector, specifically those clinical labs that use computerized healthcare systems. Keeping in view, the economic condition of Pakistan and the scarcity of standard healthcare systems, HLH will provide a most effective solution to keep pace with international standards usage. HLH project is now in the position to be aligned for commercialization. We have written one proposal of how to be use HLH on commercial grid. The potential in this area is enormous. We have written a proposal on commercialization of HLH with industrial partner.
E. Benefits of the Project

- **Outputs of the project and potential**
  HLH potential beneficiaries include healthcare organizations like hospitals which are using computerized healthcare systems, software vendors (for consultancy), medical laboratories with laboratory information system and doctor offices have basic CPOE (Computerized Physician Order Entry) system.
  The project if properly executed in the real environment it will definitely produce very positive results for the common people in a sense that they will not bother of where they have taken the treatment. Also they will be assisted to avoid tests duplication.

- **Organizational Outcomes**
  
  **Organizational Outcome 1:**
  Once an organization has adapted HL7 standard it can get the following benefits;
  
  - **Reduction in number of interfaces**
    HL7 reduces the number of interfaces to connect to the external world. Fig 1 shows the environment where there is no HL7 standard where the number of interfaces among n organization increases with $2^n$ factor. Developing and maintaining a single interface is much easier and cost-effective compared to maintain too many interfaces. When an organization uses HL7 as a standard for healthcare information exchange, the number of interfaces automatically reduces from $2n$ to just $n$ as shown in Fig 2.

  ![Figure 1: Organization without HL7](image1)
  ![Figure 2: Organization with HL7](image2)
Organizational Outcome 2:

NUST and Pakistan’s credibility has increased considerably in the healthcare community.

Organizational Outcome 3:

*INVENT, “The Entrepreneurial Challenge 2010”*

Winner of first three rounds of INVENT, “The Entrepreneurial Challenge 2010”, a Business Plan Competition organized by IBA; was awarded cash prize of 25000PKR

- **National Impacts** (Please identify the Sectoral/ National benefits arising from the project, if known at this point in time)

  HL7 Pakistan is a tangible national benefit of HLH project that has been achieved with unstinting support of other stakeholders like National ICT R&D Fund, NUST, Isb and SKM, Lahore.

F. **Assessment of Project Structure**

- **Project Team** (Performance of the team and significant departures in either structure or actual man-days utilized)

  The core project team was hired after extensive interviewing and scrutiny. This team was highly professional and motivated which worked on the project. HLH team conducted and participated in many workshops/conferences/corporate meetings etc at national & international level as well, As a result of high quality research undertaken in this project, two HLH team members were offered funded PhD studies in KHU Seoul South Korea.

- **Collaborations** (Please describe the nature of collaboration with other research organizations)

  During the course of this project, we collaborated actively with:

  i. **International Collaboration**

  Research and Development collaboration with:

  - HL7 research activities with HL7 international and other HL7 member’s countries

  ii. **National Collaboration**

  - Between SEECS & Shaukat Khanum Memorial Cancer Hospital & Research Centre (SKMCH & RC), Lahore
  - Between NUST SEECS & Elixir Technologies (Pvt) Ltd.
  - CITI Lab, Rwp
ii. Industrial Collaboration

Research cooperation with NexSource Pakistan (Pvt) Ltd and eHealth Services (Pvt) Ltd

i. Uhealthcard
   - Universal health card on USB that gives global interoperability and freedom of “move” for the medical records.

ii. TeleEMR
   - TeleEMR is a real-time online system which is used to capture all Electronic Medical Record of a patient flexibly. It is combination of Telemedicine and EMR.