STRATEGY FOR IT INFRASTRUCTURE IMPLEMENTATION FOR MAKING A DIGITAL HOSPITAL

[1]VINOD KUMAR, [2]SUSHIL KUMAR MEHER, [3]SANDEEP SHARMA, [4]ANKUR GUPTA

All India Institute of Medical Sciences, Ansari Nagar, New Delhi-110029

Abstract- The developing world faces many health problems i.e. HIV/AIDS, malaria, tuberculosis, recently swine flu and bird flu have threaten the health and lives of millions of people. Lack of infrastructure and trained man power are considered important barriers in providing proper treatment and medical care for diseases group. In this paper we will explain how to plan, design, implement and review Hospital information systems in Hospitals and healthcare projects in the developing countries. We will discuss one of the pilot projects carried out in public hospital of India demonstrating that such systems are possible and can expand to manage hundreds of thousands of patients. Our main focus will be planning and implementation of hardware and network infrastructure for HIS. Finally, we will discuss the importance of the use of open standards and open source software for developing electronic medical record systems rather than reinventing systems in isolation to enable collaboration with the members of the health and wellness value chain on a common goal i.e. improving individual wellness.

Keywords- Implementing EHR, developing countries, electronic medical records, Hospital Information System.

I. INTRODUCTION

The developing world faces many health problems i.e. HIV/AIDS, malaria, tuberculosis, recently swine flu and bird flu have threaten the health and lives of millions of people. Lack of infrastructure and trained man power are considered important barriers in providing proper treatment for these diseases. Now is the era of digitization. The healthcare area too is getting digitize and implementing EMR. We planned and computerized one of the biggest public hospital in India starting from Zero to full digitization. In this paper we will discuss how to plan, decide and implement Hospital information system in developing countries.

To implement Hospital information system (HIS) in any Hospital we have to first think about the Type of hospital, Bed strength, Departments being run, Total patient load, Work culture, Work flow of all the departments, Attitude of the staff and finally, Availability of IT Infrastructure in the hospital.

To digitize any Hospital the local population, staff including Internal and external environment are of important consideration. Another important consideration is availability of finances. If the Hospital doesn't have enough finances the digitization can be planned one time but may be implemented in phased manner. as per our experience to digitize Hospital / implement EHR in phased manner is best (no study performed fact based on personal experience), because staff in the Hospital is quiet rigid in changing its work flow because of its fluency in its manual workflow, he is hesitant to change over from manual to digital may be due to fear of computers (very common among old staff but younger generation is computer savvy), fear of increased work load due to added entry on computer and many more reasons beyond discussion here.

A. Hospital requirements

We identified five customer needs that guide investments to helping the hospital ecosystem to achieve the goal of improving individual wellness.

1. Manage clinical innovation.
2. Enable collaboration with ecosystem partners.
3. Improve quality of patient care.
4. Drive process efficiency to maximize resource effectiveness.
5. Manage regulatory change.

B. Translating customer needs to it requirements

We have to understand the evolution that is occurring in the health care sector, and how the advances in technology will impact this transforming landscape. A focus on next-generation solutions is required. To change the hospital ecosystem we have to focus on three main aspects driving change. They are:-

- Access to information: Delivering quality of care is a top priority for the health industry today—enabling doctors, patients, life sciences research and payers to gain access to information is critical in developing and determining treatments and empowering individuals to maintain a healthy lifestyle.
- Integration among hospital equipments, hospital staff and all the stake holders: Integration also extends from treatment protocols, documentation and in technology.
- Transformation to be bought by digitization: we have to decide and understand the transformation

IT in Hospitals will bring. It is on this journey that the application of technology, people and processes, best practices and know-how is most critical—and represents a primary focus of Hospital Information system innovation efforts.

II. METHODOLOGY

A. Formation of committees:

First of all the hospital administrator has to constitute committees which will decide the process of computerization. these committees should include hospital Administrators, Financial Rep, Technical Rep and user rep from the departments of Medicine, Surgery, Hospital administration, Medical Informatics officer/ IT officer of the hospital, Rep from Nursing Department, Pharmacy Rep, CSSD rep, Store Section rep, anesthesia rep for OT, cook house rep, Emergency dept rep, Lab dept rep etc.

The committees to be formed are:

1. Technical Committee for IT tender specification and selection. Including Hospital Administrator and IT officer. This committee will decide the technical specifications required and scrutinize the solutions presented by vendors against our requirements and will select the best solution for the hospital. The committee will forward its recommendations to financial committee.
2. Financial committee: this committee on the recommendations of technical committee will ask for financial bid from the vendor, and will select best financial vendor as per the law of land.
3. Implementation committee. This committee will be in charge of implementation of HIS. This committee will check the quality of solution being provided by the vendor. and time taken by the vendor to complete the project.

B. Phases of computerization:

the overall digitization of hospital will have three phases i.e.

2.2.1 Planning and GAP analysis
2.2.2 Implementation and
2.2.3 Review for five year

C. Project description

The computerization project for Hospital is divided in different parts.

1. The first part is an integrated software application to manage the daily activities of hospital which would include the institute and the Hospital. This would also include the business intelligence to facilitate the top management of hospital in taking crucial policy decisions and reporting needs.
2. The second part is the Datacenter which would host the application in high availability mode as the work in hospital is of critical nature involving human lives.
3. The third part is to have the whole campus networked in a redundant mode using Wi-Fi, which would take care of any exigencies in the main network to provide the users and uninterrupted working experience.
4. The fourth part is the complete facilities management of the application and the infrastructure for a period of 5 years and beyond if required by hospital.

The software application has four major parts which in turn has various modules and sub-modules. These parts are briefly explained below:

D. Hospital information system:

The Hospital information system must be fully integrated, highly configurable, platform independent Enterprise Information System which allows for scalability and performance, while at the same time ensuring to meet all the needs of a Healthcare Institution and much more. The system not only helps in daily patient care management, but also provides the foundation to foster research and development.

E. Academics and research:

The system is designed to cater to the Medical College which will include Academics, Research, & Examination.

F. Radiology information system & pacs:

This RIS should be the integrated solution and would help the users in the radiology department to store, manipulate and distribute patient radiological data and imagery. The system consists of patient tracking and scheduling, result reporting and image tracking capabilities. This would also take care of Appointment booking, Custom report creation.

G. Back office system:

The back office system is designed to cater to the needs of the users in the General Administration, Finance, Stores, Purchase, Engineering, HR, Training and other Support departments.

H. Time Limits

Complete projects should be given specific time limit for completion. Different modules and project should be given different time limits. The time limit should be decided based on project management principles.Project should complete as scheduled, with available or allotted finances and without compromising the quality.

The RUP methodology for the execution of the project should be followed. The project should be implemented in four different phases, i.e. Inception, Elaboration, Construction and Transition.

I. Hardware & networking

2.4.1 Architecture – Layout

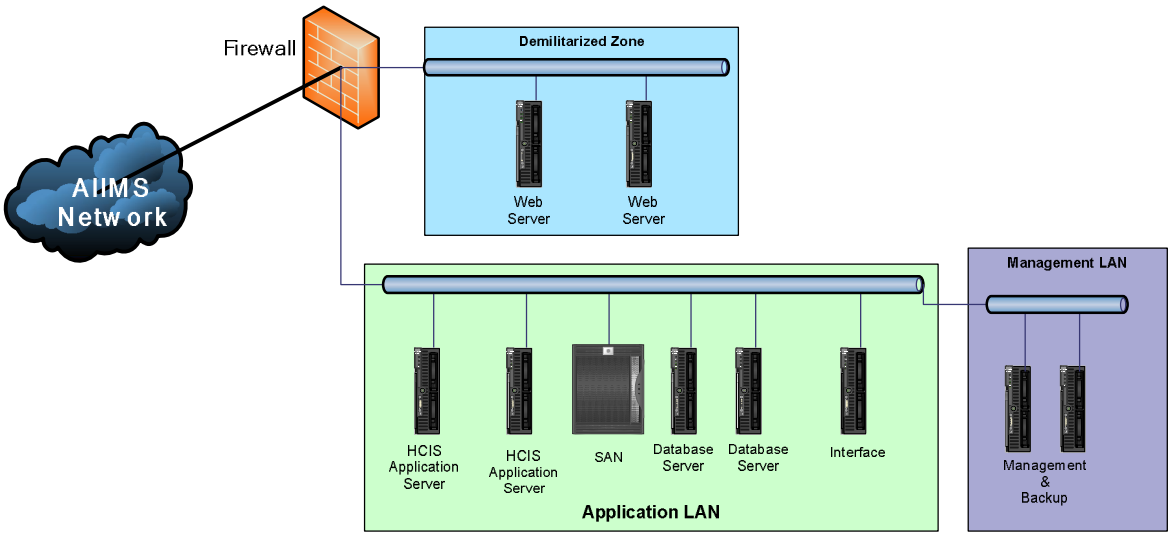
Multi-layered server architecture for in line with the proposed IT architecture and the requirements of the hospital was planned. This architecture have the

following layers with servers and storage distributed among them:

- Data store layer
- Database layer
- Applications layer
- Access layer

The Data store layer, the lowermost layer in the server architecture, predominantly comprises of the Storage Area Network (SAN). A Fibre Channel based, switched SAN for highest reliability and fast access to business critical data. The SAN consists of multiple components like the Host Bus Adapters (HBAs), Fibre Channel switches, Storage controllers and Storage elements like disks and tapes. The SAN is to be built with "No Single Point of Failure" (NSPOF) with all elements having built-in redundancies. It hosts all databases containing business critical information and needs secure and controlled access.

The next higher layer is the Database layer consisting typically of the database servers. Users will not have direct access to the Database servers but will access them through the use of servers in the Application tier so as to provide controlled and secure access to business critical information for authorized users.



J. High availability: server level redundancy – clusters

Over and above the component level redundancy, server level redundancy also takes care to achieve high availability. This ensures high availability of business critical applications and data should there be a server failure due to software failures like operating system or database crashes.

Server level redundancy is achieved by using "clustering" technologies. In a "cluster" there are two or more servers which are similarly or even identically configured. There are different ways of configuring clusters to achieve high availability. They are:

- Active – Standby
- Active – Active
- Multi instance

In Active – Standby type of a configuration there are at least 2 servers one that is actively participating in operations and the other in a hot standby mode waiting for the active server to fail. The active server serves business critical applications and data to the user community. Should it fail the standby server immediately takes over those applications, which were earlier run by the failed server.

Users will face interruption of services for that much amount of time it takes for the standby server to start the application and data. In this scenario, since the standby server is utilized only in case of failure of the active server there is no optimal utilization of resources.

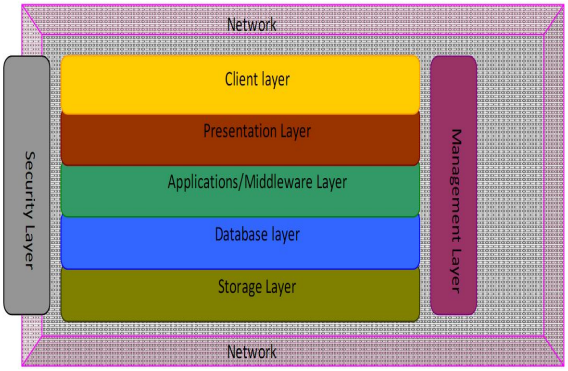
The Active – Active type of a cluster is not very different from the earlier scenario discussed. In this case, both servers are actively taking part in business operations, one server hosting a particular application and the second server hosting a different application. Both servers cannot run the same application. Should one server fail, the other server takes over the application there by providing high availability.

Both servers should be configured with sufficient resources to host both applications simultaneously. In this scenario, resources are optimally utilized. However, depending on the application usage patterns, one server may have a higher load than the second server. Users will still face interruption of

services for that much amount of time it takes for the second server to start the application and data.

The third scenario is the Multi instance type of clusters. In this case, all systems in the cluster can potentially run the same application across multiple servers. However the application must be capable of being run simultaneously on multiple servers. An example of such an application is JBOSS. In this scenario, since all servers in the cluster can run all applications, they share the load of the entire cluster there by most optimally utilizing resources and offer the best scalability of the available clustering technologies.

Users will not face any interruption of application services should there be a failure of one of the servers. Another server is immediately available for the user to connect to and start using the applications, as there is no application startup delay.



2.6 Server Infrastructure Design - Business Application

Following is the proposed Server architecture that will also fulfill the new service requirement of 24x7 interfaces:

The environment should be three-tier architecture, with load balancing enabled within each tier (optional). The design of this architecture enables the entire site to be highly available, highly scalable, and very reliable making the sites performance constant under peak load conditions, also the delivery of OLTP response time was the main criteria for the above architecture. The three-tier architecture follows the application architecture begin distributed in three components, the web server, the application server, the data server with authentication and authorization to the site being accomplished via Light-Weight Directory Access Protocol (LDAP) Directory services.

- Web Server – The web servers runs a single thread process and resides on the De Military Zone (zone) of the Firewall. The web server can be scaled horizontally for improved performance, also has all the static information that needs to serve requests. Each web server is designed to handle high volume transaction after which the performance of the server decreases, and web server farm needs to be scaled by one.
- Application Sever – This applications tier runs the business logic of the site. This server uses JBOSS Application servers to monitor the integrity of each transaction across multiple application modules, which might reside on multiple machines. The Application server logic is so flexible such that each modules of the core business logic can be distributed based on the modules functionality on multiple machines. This enables the horizontal scaling of the core application for optimal performance. The application servers are clustered for high availability of application module.
- Data Sever – The Data tier comprises the data repository of the entire site. The database is MYSQL. The storage subsystem is designed for impressive growth of storage, also for optimum performance under peak conditions. The requirement of Storage Area Network (SAN) was essential for the type of scalability and flexibility it provides a production environment.

The developed HIS is a fully integrated, highly configurable, platform independent Enterprise Information System which allows for scalability and performance, while at the same time ensuring to meet all the needs of a Healthcare Institution and much more. The system not only helps in daily patient care management, but also provides the foundation to foster research and development.

III. TECHNICAL SPECIFICATION

User Interface:

- G.U.I. Core: The set of screens included in the Standard system and that cannot be modified by users, although they can well be a starting point to build new customized interfaces.

- Panel generator: Java implemented component that allows the construction of panels and screens. It is responsible of generating the configurable G.U.I. It therefore generates JSP (dynamic html)

- Configurable G.U.I: Set of screens designed and developed by the customer. It is one of the main points of this architecture.

Frontend software

HIS should not require front end software for running the application; the internet browser is all what should be required for the application to run.

Operating System

- Can run on any platform where Java Environment is present.
- HIS may use Open source Red Hat Linux for servers

Client workstations can work on any operating system like Windows, Mac OS, UNIX versions, Solaris, Linux flavors etc

2.3 Software Application – Hospital Information System

An integrated healthcare information system must be founded on the principles of a single health record, an ordering and referring system, a unique scheduling system, a general workflow tool.

2.3.1 A healthcare information system is based on a series of principles that can be summarized in five main areas:

1. Configuration of the Electronic Health Record as the articulation element of all the value chain of the healthcare system. The basic concept is, understanding clinical decisions as the trigger of resources consumption that must mean a value service to patients or to the population. The Health Record articulates:

- The patient and his/her needs as centre of the system
- The main process of the healthcare organization: prevent, diagnose, treat and rehabilitate
- The relationship between the main process and the supporting processes.

1. The conceptualization of the care process and its implications in the design of the functional processes of the organization and the requirements of the information system that must support it and facilitate it. Care process that must respond to the needs of the care continuum, base of a high quality integrated care, with no risks for the patient.
2. The vision of Clinical Management as convergence point between good care and management practices. The information requirements for clinical management are very complex and sophisticated, because they must include information for clinical and management decision making and require, among other things, guaranteeing the reliability of the data that identify a particular patient, his/her diagnosis, treatment and the professional that makes the clinical decision.
3. The vision of the information system as a generator of decision support information for the different agents that constitute the System or the healthcare organization: population, patients, professionals and management. If the information systems cannot assure this information, in the way each agent requires for their decision making, the project cannot succeed.
4. The security of the entire system, without doubt the most critical point of all healthcare information systems. The identification of the security strategy of the organization, the establishment of security controls, the standards and security guides identification in each level and the security requirements linked to the implementation, integration, operation hardware, software, networks, etc.

2.3.3 The Information System must allow the integration in all the dimensions of the care process:

- Between different parts of the system
- Between different moments in the treatment process of a particular disease.
- Between different parts of the same organization that provide the service.
- Between the different professionals that participate in the care process.
- Between the different specialties of the same profession.
- Between organizations that provide similar services.
- Between the Healthcare system and other systems (e.g. social)
- Between different treatment processes by different episodes, to a same patient.

2.4 Conceptualization

The team should develop suitable integrated system for any Healthcare system in general and any Healthcare organization in particular, has from the adaptation, customization and change management perspective, two main objectives:

- Incorporate care and supporting processes (administrative – economic – Healthcare) and workflow features to the Information System, to integrate the activities of all professionals that take part in the patient's care and facilitate therefore communication among them.
- Optimize and improve the decision making process, allowing each user to have their personal Workstation, with the information and functionalities required, maximizing integration and cohesion of the information.

The final solution, i.e. the combination of the Standard product plus the customization and adaptation to the organization, will be the Healthcare organization Information System.

2.5 Workflow tools should offer a large number of benefits:

- Allow to implement the operative knowledge of the organization
- Allow the automatization of the processes flow and information of any organization.
- Allow tasks to be assigned to appropriate roles, to be carried out in the proper order and time and to include the necessary information.
- A fundamental objective is the productivity improvement and control over work in progress.

- Eliminates the need of many unnecessary meetings, phone calls and internal notes to make routine work happen
- Allows to obtain a higher knowledge of the organization
- Standardizes the way of working
- Tasks can be manual, semiautomatic and fully automated, depending on the degree of human intervention required.
- Allows eliminating administrative intermediate and routine tasks – tasks that are part of a work flow can be executed with minimum intervention if they are protocolized.

IV. RESULTS

The following Modules were implemented in the hospital

4.1 Outpatient department: including Registration, Emergency Registration Process, Appointment & Scheduling and Consultation: facility for each Doctor to view their appointment scheduled, Electronic Medical and Clinical Records of OPD patients, Central Admission.

4.2 In-patient management: including Admission, Bed management, Case notes, Doctor Notes, Nuse Notes etc., Clinical observations, Treatment and Monitoring, Ward and Bed Management, including Bed allocation, Transfer, discharge, Observation Chart, Facility to request for referrals, bed side tests, Bladder Irrigation Chart, Nursing Care plan, Drug Administration Chart, Diet Orders, Drain Chart, Nephrotic Chart, Peak Flow Meter Chart, Peripheral Circulation Chart, Blood Sugar Monitoring, Feed Chart, Partogram Chart, Glasgow Coma Chart, ICU Charts, Nursing Initial Assessment, Code blue screen, Bed side sample collection and tests, Discharge Summary generation, Reports, Transaction Documents and Registers on the above functional processes, Physician rounds using wifi unabled tablet PC, Nursing documentation which includes Nurses note, input/output chart, graphical interpretation of patient vitals, alerts etc and Nurses can also trigger request for transfer of patient to different ward, Bed, etc.

4.3 Emergency ward management

4.4 Diet Management The system also has the provision for the following:

4.5 Disease Profile Management
4.6 Patient Transfer
4.7 Discharge
4.8 Stock Management
4.9 Lab Module
4.10 CSSD module
4.11 Radiology and PACS module.
4.12 Blood Bank module
4.13harmacy Module

V. DISCUSSION

The Hospital Information system is a self sustaining and self integrating patient management and hospital management system. The system should be planned as per standards laid down by the country and utilizing minimum data sets (MDS). The system should be developed as per local population and workflow of the hospital.

the system should be self sufficient to generate hospital reports and statistics for the top and middle level management, so that proper decisions can be taken by them. The special care should be taken off for the downtime of the HIS, and redundancy should be checked.

CONCLUSION

We developed and implemented HIS in major public hospital of India. The system had initial hitches due to staff illiteracy in computers, but now HIS has decreased documentation time of the staff, doctors and nurses. the HIS is well taken by the whole hospital.

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