REQUIREMENTS FOR THE NEW GENERATION OF HOSPITAL INFORMATION SYSTEMS

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Abstract: The aim of this paper is to present some ideas about new directions in hospital information systems' design. They are based on results obtained in the context of joint research with Medical University Sofia, requirements from other hospitals and discussions with industrial providers of such systems. We target investigations, design, organisation and future expansion of a hospital information system, new concepts and methods for continuous acquisition of patient's vital data, transmission, collection and binding of that data for diagnostic and disease tracking purposes, investigations on relevance of life quality and healthcare based on the e-Health technologies and medication and drug tracking. Some of these new investigations are oriented to build data mining background.

1 INTRODUCTION

The aim of this paper is to present results and based on them ideas about new directions for design of Hospital Information Systems (HIS). Part of these ideas is obtained in the context of a joint research project for investigation, design, organisation and future expansion of a hospital information system DAPSEpro. Extending our work in the years and cooperating with other providers and research groups we found some new possibilities for HIS extension and reorganisation.

The primary research started with investigation of current status of installed and operating hospital information systems on the territory of the Medical University Sofia. Elimination of the usual paper-based information exchange to IT-based one is one of the primary topics.

Medical University Sofia is a huge distributed hospital complex. It has tens of different clinics, laboratories and buildings.

Results of this investigation and some of implemented solutions are presented in (Evgeniev et al., 2010). It was focused on the following main problems:

- Distributed, heterogeneous and varying data- Hospital systems collect a diverse variety of patient information represented in many digitized or hard-written types. Creation and support of patient's analyses library is a problem solved under presented project.
- Data validity, security and protection - Data validity is very important to make decision-making process stable and safe. This includes time validity and safety and security of delivery. Data access and privacy are very important and have to provide end-to-end security and validation in the system.
- Tracking patients when they are out of the hospital – technical, medical and economical aspects.
- IT problems of archiving and digitalisation of paper-based images and documents.
- Improvement of analyses of medical images.

In the design and implementation time we found some new targets. They were found to be problems first. After some work they became new targets. Some of this new targets and interrelations encouraged writing of this paper. This paper does not pretend to cover all possible aspects of HIS – problems, solutions and similar but to point to some of them and to share some experience.

2 SYSTEM STRUCTURE

The implemented under DAPSEpro Intelligent Medical Information System's (IMIS) structure and subsystems are shown on figure1. It offers the following features:

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- Unified environment for data exchange between installed apparatus and systems in the hospital;
- Access to the information resources via heterogeneous communication environment (mesh).
- Tracking the full process of hospitalization of every single patient.
- Data collection and storage for every medication and procedures.
- Offers Remote Medical WWW Services for out-of-hospital health tracking and care.
- Management of all procedures and medications.
- Administrative tracking of all patients.
- Remote messaging of medical personnel about health status of selected patients based on remote vital data acquisition and control.

The initial DAPSEpro covers now two clinics – clinics of nephrology and pulmonology. All activities are oriented to answer requirements for supporting Electronic Health Record standards and Bulgarian requirements for health records.

According to figure 1, the Fixed clinical network provides connectivity for all machines and apparatus in the hospital from one side and servers and personnel terminals from the other side.

The Wireless medical sensor network provides access for the medical personnel to data servers and connects sensors and apparatus having wireless possibilities to transfer small amount of data. This makes both people and machines mobile on the clinic's territory.

The Management Server controls all administrative processes and controls access to database server which hosts all records about manipulations, personnel and patients' archives, etc.

The other system elements will be discussed later.

2.1 Successive Parts

Starting with pure technical project supporting administrative and medical activities we found that the usual approach to implement some appropriate solution and after that to study medical personnel how to use it is not enough good. This is near to "brute force" approach what is not applicable to so sensitive area as medicine.

The design group did wide exploration of needs and requirements of the personnel.

Requirements were grouped in several groups. Starting work was oriented to the general administration, patients' health records, clinical orders and result delivery, wireless access to database, fast connection to all available image machines.

These parts were designed and implemented. They offer planned basic functionality and have embedded possibility for extensions.

2.2 New Parts

One unpredicted part of the system was connection of Microbiology laboratory to the hospital system. The Microbiology laboratory has smooth process for cultures analyses and results report based on paper control and tracking. Antimicrobial resistance check is based on the WHONET v.5.5. This forced design of a local system with two-level structure. On the first level are connected all analyses machines having outputs to computer. All analyses results that need human interactions (like microscope analyses) are recorded manually using unified fill-in-the-blanks forms.

The upper level includes WHONET server, local database server and administrative terminals. Network server is positioned over this level and connects laboratory micro-network to the hospital network.

2.3 Questionable Parts

Here we will present some elements of the work which became questionable or simply opened new targets.

2.3.1 Unified Machine and Apparatus Connection

One of the basic tasks for the DAPSEpro was to investigate all available medical machines and to design some hardware abstraction layer (HAL). It should offer functionality making connection of a new machine relatively simple and make possible design and implementation of generalised control and data acquisition interface to the upper system's levels.

Today this part is not finished and do not promise to be finished easily. The problem is that machines from different vendors offer different hardware and software interfaces. Implementation of a HAL in most cases needs simply to position additional intermediating controller to implement hardware and software transformations and logical isolation. This is complicated and expensive task.

2.3.2 Security and Safety

Requirements about data security and safety

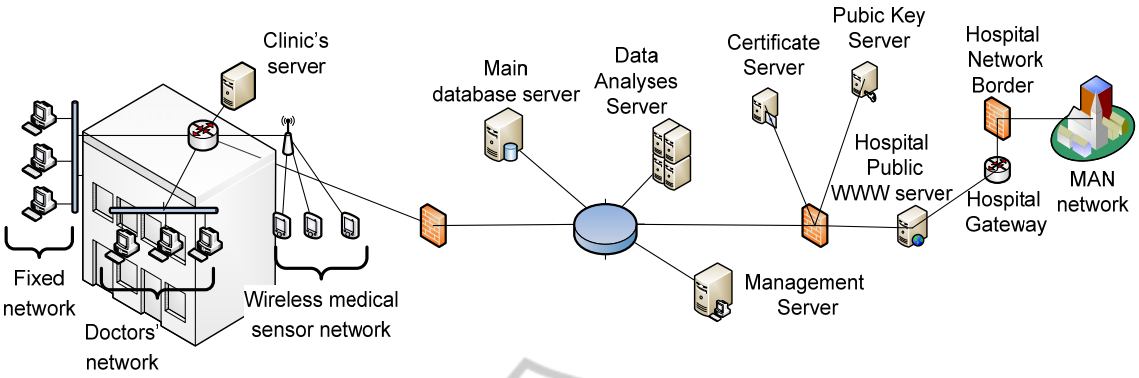

Figure 1: General structure of IMIS.

increased all the time in the implementation process.

HIS requires general security as every operator operating personal data. Here were found the following number of problems:

- Uncontrollable number of access points to the systems. All terminals, mobile access devices and similar are generating hard to solve problem for unauthorized access prevention.
- In the hospital people are in hurry all the time and sophisticated security system requiring slow or repetitive log-in / log-out will be disabled fast.
- Static security is not enough. This type of system needs dynamic security but it is more complex and hard to implement.

Data safety is the next problem. Today IT offers many different solutions. The problem is that data have to be delivered fast and without modifications.

- Data are very sensitive. They include medication orders, results from analyses, diagnoses and so on.
- Data have huge amounts – images and permanent sensors.

2.3.3 Image Analyses

Current approaches for analyses of images from different sources become more important. The new generations of image machines are producing directly digital images. They are mostly in DICOM. This format is a standard for this area but it is a source of new type of problems:

- Generated images are huge and need much disk space.
- Analyses and manipulation of all metrics, comparison and other need deep non-medical knowledge what is not well understood by doctors.

Much more problematic are sources producing output on material carrier (paper, film or other). Even today digitalization of images from paper or films is problematic. There are a number of problems. If the image is simple graphic every flat-bad scanner is enough good. Digitalisation of film images is much more sophisticated. Simple scanning is impossible. The film image has much more details than directly digitised picture. One qualitative scanning can extract all these details from the picture and to present them to the doctors.

- In some previous research we proposed some new approaches to solve the problem with digitalisation of mages from X-Ray and ultrasound machines which were proved in practice. The new step in this work is implementation of dynamic filtering and HDR transformations. Results are very promising but need more work with medical doctors to make results clear and free of artificial artefacts.
- The other challenge is the human-machine interface making analyses, interpretation and control of work close to the understanding of medics.

One new question found by our group was the problem of 3D reconstruction based on one or very few pictures. This approach is different from that one used in computer tomography (CT). The idea is to recover not 360^0 image but part of it. This saves a lot of radiation load of patients. Some results are still available but again work in dynamic filtering and shadows selection/ zoning/ distraction is in progress.

Absolutely new request to us in the time of work was preparation for realistic body model that can be manipulated and modified to be representative for the origin at every stage of his life. This area is new for our group but we started collaborative work with teams from other European universities. The state-of-the-art here is availability of 3D skeletal models and models of some of organs. How all of this will be combined in one representative model and how it will be modified to present changes in someone's body is still open question.

Image collection for long time archives is hard

problem as was mentioned above. A small hospital produces only images in size of 5 to 10 TBytes per year. To keep this amount of data "forever" becomes a problem with many dimensions.

3 OPEN PROBLEMS

3.1 Technical Questions

It is obvious that today HIS are distributed. The problem here is that they are classical mesh systems. They are hierarchical systems of systems. A lot of currently available subsystems have to be integrated in new systems. Constantly part of them has some specifics that need special patches or convertors to enable inclusion.

More problematic is the fact that wireless connection from different mobile devices becomes widely used.

We see two general thing needing theoretical and practical solutions.

1) First is that current distributed HIS architectures generate problems for the medical personnel if it has to acquire data from different sources connected to different servers or subsystems. In many cases this needs to know the exact system structure, to have access rights to its different elements and so. Hospitals are geographically distributed and their divisions have to be connected properly and to look like single object. The addressed solution here is similar to the "cloud". This is the so-called virtual mono machine. The idea is old but can be implemented today because of technological revolution and performance bust. On abstract level the system is represented like a single computer implementing all system's functionality. This is the way the user sees telephone network. All layering, abstractions and networking are hidden inside. Part of this idea is designed and implemented in DAPSEpro system.

This approach has one important drawback. It needs very formal approach on the boundary between the abstract mono-machine and real distributed systems.

The advantages of this approach comparable to "cloud" are much a) better security and b) flexibility for future extensions.

2) The second general problem for solving is the mentioned above mobile access to HIS and medical services. It covers two very different objects – any kind of people's access device (smart phones, tablets and so) and mobile medical equipment (wearable sensors, equipment in ambulances, autonomous devices with wireless connectivity). All this is part of today's mHealth technologies.

Here we have to meet security and safety requirements. They are subject to be increased all the time.

The direction of information exchange is the next thing to be solved. Primarily the main direction was from the sensors and apparata to the HIS. Today the exchange is fully bi-directional. To the mobile user area transferred data of any kind – numerical, images and so. Moreover – there is a special kind of education for students and for patients oriented to modern mobile devices and networking technologies.

All of this emphasizes the understandings of new modalities and identification of opportunities for implementing interoperable devices and systems, and integration available HIS.

3.2 Medical Questions

We mentioned above that IT technologies can provide to the medical society wide stream of new possibilities.

Personal health record covering all aspects of someone's health history is still questionable. Problems are coming from two sources – how and where we can keep records and who needs life long data tracking.

One of the challenges today is remote consultancy. It needs in many cases transfer of imaging and numerical information, held on paper documents and similar. It has to be presented in every HIS.

A special point is drug tracking in the context complex analyses of how they influence patients, combinations, age, gender and other cross-relations.

Mentioned above problems of creation of better body and organ 3D models for every-day diagnosis and health tracking and personal health profile sustain.

3.3 Business Questions

A lot business questions have to be answered when HIS is designed and implemented. They point to the following different aspects:

- The prise for data center – in exploitation time this becomes really expensive.
- Security support – depending on security level planned to reach the price is becoming significant.
- Every-day expenses for hospital activities, patients care, medications, etc. have to be tracked.

- Connections with health insurance companies.
- Interdisciplinary work in the area of general health and mHealth as the way to decrease unnecessary stay in hospitals, preliminary diagnosing, out-of-hospital support.

4 CONCLUSIONS

Here in this paper is presented an implementation of first version of Intelligent Hospital Information System. Together with this presentation are discussed many open problems and new directions for future research. They are discovered in three separate sections. Some new solutions are proposed here, too.

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