INFORMATION AND COMMUNICATION TECHNOLOGY IN HEALTH CARE

Milovanović Dragorad [1]
[1]Faculty of Electrical Engineering, Belgrade

ABSTRACT

Content: Information and communication technologies (ICT) provide efficient health care and improved access to health resources and information. The first part of this paper defines the basic terms and concepts of telematics and telemedicine. In the second part of this paper technological bases, standardization activities and the reference architecture are being systematized. In the final part an ICT infrastructure for an integrated regional health service network is being described, which is designed on the basis of open, multilayered reference architecture and common components. Keywords: ICT, telematics, telemedicine, e-health.

1. Introduction

Telematics in health care includes activities, services and systems that operate at a distance by applying information and communication technologies. The aim is to promote global health services, disease control and health care, but also education, management and research in health care. The concept of telematics in health care (WHO Group Consultation on Health Telematics, 1997.) includes the following functional areas: tele-education, telemedicine, research in health care and health services management.

Telemedicine enables functioning of health care services when distance is a critical factor. Professionals employed in health care are using information and communication technologies in order to exchange valid information for the purpose of diagnostics, treatment and prevention of diseases and injuries, research and evaluation, and continuous education of people in health care. It is considered that the term Telehealth is politically more correct, but terms on-line health and e-health are also being used. It is important to emphasize that e-health doesn't represent a substitute for existing health services, but additional services meant to improve access to existing resources. In recent years, developed countries have shown great interest in e-health solutions.

Health care system is based on the principles of:

- Equality;
- Effectiveness;
- Quality;
- Consistency;
- Patient satisfaction.

On the basis of global principles, basic requirements of health care are:

- Quality of services;
- Efficient use of limited resources;
- Sharing of knowledge;
- Access to medical / health information;
- Time management;
- Cost management.

Health care requirements and significant technological development in the area of computer science and telecommunications had influence on telemedicine which became a very dynamic and multidisciplinary field [1, 2, 3]. Telemedicine gives opportunity to doctor to provide medical assistance, to set the working diagnosis and patients' therapy and to conduct consultations with his colleagues and medical staff that are located elsewhere. The goal of telemedicine is to provide expert medical care in remote areas and to provide effective emergency assistance using modern information and communication technologies. The basic concept of telemedicine is attractive, given that medical expertise is very expensive and that it is desirable to make its concentration [4, 5]. In large medical centers it improves the quality of medical services and in remote rural areas it enables medical expertise.

Continuous progress of computer technologies, along with the development of digital signal processing and network protocols, has contributed to the important application of real time transmission of multimedia data in medicine. However, the term "multimedia" is being used quite loosely to refer to any type of new digital media manipulated and displayed on computers. This term should mark the integrated manipulation of discrete media (such as text and graphics) and at least one continuous medium. Continuous media are time-dependent data manipulated in the specified time intervals, in accordance with the standards. Finally, multimedia communications are dealing with transmission, protocols and services with discrete and continuous media within computer networks.

Multimedia applications create an interactive environment for the health care users. When computer requests information from a remote computer or server, these information is being transported

through a computer network. As the amount of data during the transmission of audio and video signals is large, multimedia information must be compressed (elimination of redundant information and reducing of perceptually irrelevant information) before transport, in order to reduce the necessary bandwidth and lag. In addition to that, restrictions (information loss, delay, jitter...) are being placed to ensure the required reception quality of audio-video signal. Therefore, there is constant demand for improving telecommunications network in order to improve the multimedia transport capabilities. Local area networks (LAN) are used to connect local computers and other equipment, while WAN (Wide Area Networks) connect local area networks [6, 7].

The implementation of telemedicine requires the necessary infrastructure:

- computer networks and software,
- medical workstations,
- specialized medical equipment,
- guidelines for telemedicine on clinics.

Telemedicine encompasses many technologies and user applications which is a problem for the specification of standard solutions. Lack of standards affects:

- Quality;
- Reliability;
- Effectiveness;
- Privacy;
- Investments;
- Safety;

2. Technological basis and standardization activities

Development of advanced information and telecommunication techniques has enabled the design of sophisticated systems in health care. Unfortunately, most of these solutions were developed on an adhoc basis, as closed systems, which make the integration of infrastructure and procedures harder, as well as sharing resources on a wider geographic area. Standard is a document established by consensus and approved by appropriate organizations. It contains rules, guidelines or characteristics of the long-term common activities. The goal is to achieve an optimal level of regulation in the context of medical application (Figure 1).

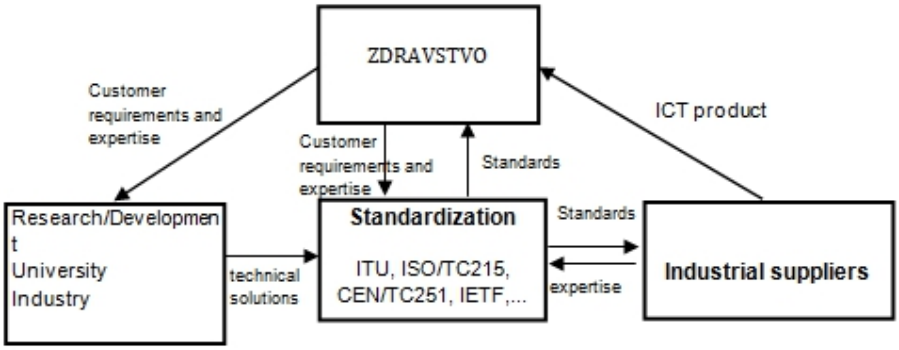

Figure 1 Development of a standardized ICT solutions in health care.

International Telecommunication Union Development Sector ITU-D (March 1994) has formed a unique study group (Question on Telemedicine for developing countries) which deals with application of telemedicine in developing countries. World Health Organization WHO actively participates in meetings organized by the ITU-D, ITU-T, ISO, IEC ... committed to defining the basic problems and the role of these organizations in developing standards in the field of modern health care.

International Organization for Standardization ISO has established a technical committee TC215 (Health Informatics, 1998) with five working groups (WG1 Health records and modeling coordination, WG2 Messaging and Communications, WG3 Health concept representation, WG4 Security, WG5 Health cards). WG2 working group defines the functionality and implementation of medical devices communication, and the exchange of clinical and financial messages (WG2.1 Medical devices interface X73 standard, WG2.2 Architecture, WG2.3 Methodology, WG2.4 DICOM persistent object). The European Committee for Standardization CEN has established a technical committee TC251 (Health Informatics) with four working groups (WG1 Information models, WG2 Terminology and knowledge bases, WG3 Security, safety and quality, WG4 Technology for interoperability). ISO and CEN have joint programs and cooperation with the IEEE (ISO/IEEE 11073).

European Health Telematics Association EHTEL has organized the work (Actor Working Groups: A1 Healthcare authorities, A2 Healthcare professionals, A3 Patients/ consumers/ citiziens association) in the thematic working groups (T1 Standards & interoperability, T2 eHealth, T3 Law/ethics). Industrial association Mobile Healthcare Alliance MoHA has formed a working groups (WG1 Definition and strategies, WG2 EMC, WG3 Security with wireless devices, WG4 Application Standards, WG5 Systems integration, WG6 User issues) in the field of mobile communications and health care. In Japan was founded industrial association JAHIS (Japanese Association of Healthcare Information Systems Industry) in 1994, which has developed nine model of hospital information.

The basic technologies and standards in telemedicine and e-health are:

- Patients Electronic Health Record (ENV13606, GEHR, ...) and data exchange (HL7/CDA, ...)
- Patient Identification Service (OMG PIDS)
- Digital signatures (W3C/IETF XML signatures)
- Medical devices (IEEE1073, DICOM SCP-ECG, POCT, ...)
- Communication of medical devices (IrDA, USB, Fireware, Bluetooth, ...)
- Multimedia Communications (DICOM, CIAS, ...)
- Videoconferencing (SIP, H.323, H.264, MPEG-4, ...)
- External communication media (cable, xDSL, ...)
- Distributed software components (CORBA,. NET, ...)
- User interfaces
- Security
- Terminology

Patients Electronic Health Record

Information and communication technologies allow the contents of medical records to be as complete as possible (including biomedical signals, diagnostic imaging) and facilitates data retrieval and transfer. DICOM Standard (ACR / NEMA Digital Imaging and Communications in Medicine) coordinates the mutual performance of diagnostic and information systems and increases their efficiency. Standard HL7 (Health Level 7) specifies the structure of clinical documents and electronic data exchange between different information systems (HL7 Version 3.0 supports the trigger-events). Legal and ethical issues regarding patient data and safety are complex and therefore subjected to special activities.

Multimedia communication in healthcare

Communication systems in health care are complex: diagnostic images are digital, there are various data acquisition devices, communication between users is complex, multimedia data are archived on a variety of media in different formats and with different access protocols. Multimedia communication in health care is a combination of interfaces and end-users who use multimedia database linked with communication networks. The most important application of broadband communication networks is a linking of diagnostic systems in radiology. PACS (Picture Archiving and Communication Systems) is a closed system that includes data acquisition, archiving, communication and display of diagnostic images of different modalities. Users require an interface that allows direct selection of functions that are necessary in a particular situation [8].

Medical multimedia communication place extreme demands on concepts of multimedia environment developed for a single user. Cohesive design procedures were developed that consider all elements of the system (interface, database, interconnection and management). The procedures are based on understanding of medical procedures and their integration into system design. Procedures for system analysis were developed to evaluate performance, cost-effectiveness and safety. It is estimated that user requirements can be met with existing technology. However, there is a tendency that the proposed solutions tend to meet only the current requirements and ignore future development. As a result we have closed solutions of individual companies that place additional burden on users in the form of high development and maintenance costs. Therefore, standardization process in this area is continuous in so that it could offer a new and better standards for building distributed systems in medicine.

JPEG ISO / MPEG coding standards for still images and videos are dominant compression techniques aimed at reducing the amount of data for archiving or transfer, while maintaining diagnostic quality. IS15444 JPEG2000 (Joint Photographic Expert Group) is standard for compressing and decompressing monochrome and multispectral images. IS13812 MPEG-2 is used to compress video signals to digital television and archiving to DVD media. IS14496 MPEG-4 is standard used for interactive multimedia communications on the Internet. IS15938 MPEG-7 standardizes the interface for searching multimedia content [6].

ITU-T has defined a complete set of standards for video conferencing on all types of networks: H.320 is used for ISDN, H.323 for Internet and H.324 is standard for dial-up telephone network and mobile cellular radio network. The concept of Quality of Service (QoS) is important on multiservice networks. The requirements of medical applications vary in a wide range. If we analyze only one service, QoS requirements can also vary additionally because different service users may have different QoS requirements (which may be changing over time). The quality of service that user actually sees in the communication from end to end, can be described by subjective and objective parameters. On the other hand, for network service provider is important to translate user requirements into technical parameters of network performance, and also the relation between the offered and actual QoS for each user. All these facts indicate the importance of the QoS concept and the difficulties in its definition and implementation. A number of ITU-T working groups work on the standardization of QoS (SG16 QoS mechanisms for H.323 multimedia systems. Quality of speech and video coders, SG12 End-to-end quality, SG13 Network performance, SG4 Management of QoS, SG11 QoS signaling) [7].

The reference architecture

Implementation of the integrated telematics services in health care requires solutions for complex problems: the data are fragmented, services are heterogeneous, safety procedures are complex and there are many standards of interoperability and data exchange. The solution is open and scalable health information infrastructure that is based on the reference architecture. European Committee for Standardization CEN/TC251 specified reference architecture of information systems in health care (ENV12967 Healthcare information system architecture). International Organization for Standardization ISO has defined a reference model of distributed processing (Open Distributed Processing - Reference Model). The organization IEEE has specified the efficient description of complex systems (IEEE1471 Recommended practice for architectural description of software intensive systems).

A common features of the reference model are multi-layer architecture and identifying of the common components that are used for designing of different applications (Figure 2). It is necessary that these components could remain functional even after they are implemented by variety of informational and communication technologies.

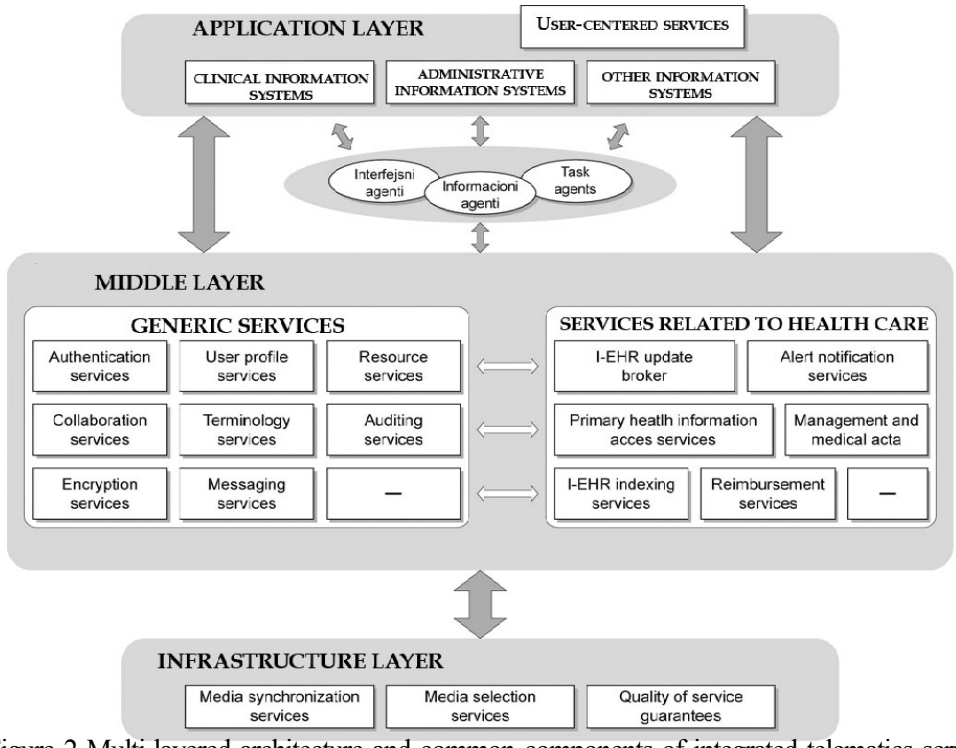

Figure 2 Multi-layered architecture and common components of integrated telematics services in health care [12].

It is possible to identify basic components of integrated services in health care:

• The public interface for efficient data exchange (HL7, DICOM), which supports the functional integration of processes in healthcare.

• Collaborative components that allow medical experts to exchange information about patients during tele-consultations.

• Components for the identification of patients based on demographic data.

• Components for the authentication and authorization of users and services (or applications).

• Components for the encryption of the communication when using sensitive personal information.

• Components for the interaction registration of all components and/or end-user applications and services. Registered data are used for charging for services or data mining.

• Components for the resources location regarding identifying of resource availability and possibility of access.

• Components for user profiling and monitoring of long-term user interest and maintenance of personalized preferences.

• Terminology components for the association of existing coding schemes and information transformation from one form or representation to another.

3. Regional network of integrated health services

HYGEIAnet is the reference regional health network of integrated services on the island of Crete (Greece). It is the result of systematic efforts in providing health care and health monitoring to a relatively isolated community, as well as medical training and education on the island [9]. There were developed systems and services for basic applications:

• Home care (most of the services are associated with children who suffer from asthma)

• Emergency service (developed an integrated system that is currently operational)

• Primary health care (all primary health care centers are equipped with integrated information systems, including electronic patient medical records, laboratory information systems and multimedia communication)

• Health care in hospitals (administrative, financial, clinical and laboratory information systems were developed and installed in regional hospitals on the island)

• I-EHR (system for decentralized review of patient medical records was developed and it enables dynamic composition of information that are archived in heterogeneous clinical information systems)

• Telemedicine (WebOnCOLL is developed, a portal that is used in cardiology and radiology)

• Supervision and monitoring in health care (information system for monitoring, analysis and reporting in primary health care was developed).

Developed applications and services use a common health information infrastructure and components for the localization of the available resources, identification of patients, data exchange... All applications and services use common components that are integrated in different ways, based on the reference architecture and technology infrastructure.

HYGEIAnet is pilot project and model for the development of integrated regional health care networks in Europe [9, 10,11, 12]:

• The reference architecture and a framework for integrating heterogeneous, autonomous and decentralized systems are defined.

• Middle-class multi-layer architecture services are specified.

• Public and stable interfaces and protocols are adopted and/or defined.

• Medical-legal issues are reviewed.

WebOnCOLL uses infrastructure of regional healthcare network on Crete for integrated services of virtual workspace and on-line collaboration. A virtual collaborative workspace supports concepts such as web portal, discussion lists, shared workspace and medical studies. User profiles allow customization of the workspace in regard to the user status, tasks and preferences. Workspaces can be public, private or shared. Virtual workspace saves session information, services results and multimedia objects that were selected or created by user during the session. In addition to session management, reliable collaboration, data availability and persistence are supported [9].
The basic components of any collaboration system are content, communication and management. Content marks objects on which users work, and these could be shared documents, hyperlinks and pointers. During cooperative work users interact with objects, manage their behavior and change their states. Feedback, notification, and perceptions of other users are important aspects of

management.Communication can be synchronous and asynchronous.
Services for Web-based collaboration on the Internet include application sharing, whiteboards, audio / video conferencing, expert directory, e-mail, voice mail, instant messaging, file transfer, webcast, interactive multicast, e-health protocols and digital signatures of clinical documents. WebOnCOLL system architecture is open and based on virtual workspaces and user profiles. The basic components of the architecture are workspace and user profile manager, web server and file system. WebOnCOLL is implemented within the framework of several projects relevant to health monitoring, education and teleworking [9]. Integrated patient health record service EHR-I (Integrated Electronic Health Record) has been developed on the principles of multi-layer architecture (CEN ENV12967) that contains generic services at lower layers (concurrency control, directories, event handling and notification, licensing, security), while services specific to health are located in the middle layer

(patient identification, communication and health data indexing, resource location, authorization, terminology). Programming interface of I-EHR allows user to move through the information space at different abstract levels and to review patient demographics and medical history and to clinically examine diagnostic data [11].

E-health workstations are designed and located in primary health centers or patients' homes. These workstations can be connected with various medical devices, as well as with remote reference medical center. Clinical findings (electrocardiogram, spirometer, diagnostic scanner images...) can be prepared and archived on the workstation and after that an experts at a reference center could be contacted and clinical search could be continued on-line (real-time vital signs, cardiac monitoring...) or video conference consultation could be started. Medical expert selects the form of diagnostic reports, fills it out and signs it with a digital signature [12].

4. Conclusion

Information and communication technologies provide a unique opportunity to improve quality of health care and access to health resources and information. However, heterogeneous information systems and the slow adoption of open standards are the main obstacles in the functional integration of processes in health care. Multi-layered reference architecture and developing applications based on common components are recommended.

Implementation of integrated telematics services in health care is associated with numerous medical and infrastructural limitations: data are fragmented, services are heterogeneous, safety procedures are complex and there are many standards of interoperability and data exchange. Distributed data processing requires the integrity of network data (trigger-events, instant messaging) as well as synchronization protocols. Multimedia communication requires efficient coding and representation of data as well as guaranteed service quality (Quality of Experience?).

HYGEIAnet is a regional network (Crete, Greece) of integrated services in health care that can serve as a pilot project and model for health care networks at national and European level. The base of the infrastructure is an integrated electronic patient medical records and medical workstation linked with diagnostic devices and visible on the Internet as a service portal.

Common research activities are focused on developing innovative methods and tools in the area of medical informatics, e-health, medical imaging and bioinformatics.

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