

THE ROLE OF A COMPUTER NETWORK IN HEALTH INFORMATION MANAGEMENT IN PRIMARY HEALTH CARE INSTITUTIONS

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Abstract: Many primary health care institutions don't have adequate infrastructure network, which prevents the use of modern IT solutions. The process of IT solutions implementing must therefore be preceded by the construction of a suitable network infrastructure. The article presents a proposal to improve the functioning of the primary health care units through the construction of a computer network interacting with a PC application to manage the combined database of doctors, patients and recorded medical events. The use of the application in primary care unit is to enable the performance of electronic medical records, and improve the management of the institution.

Key words: computer networks, e-Health, primary health care institution, computerization of health services, health information management.

Introduction

Nowadays world seems to base upon computers in every branch of everyday life. Health care is one of the sectors where computerization by implementing IT solutions is necessary to facilitate the work of its organizations. The huge number of records containing the health information of hundreds of patients demands a well organized structure and possibility of electronic data interchange to improve the information management and thus the institution management. It is essential to form a system for the purpose of harmonizing and integrating standards that will meet clinical and business needs for sharing information among organizations and systems. This would mean implementing large-scale integrated IT solutions in health care. Management of a primary health care institution in some cases can be referred to as the management of small/medium enterprise (SME). This is a specially important issue due to the fact, that SMEs are currently driving the whole European economy. The aim of this paper is to briefly present the idea of a network for a primary health care institution, including many functional features making the work in this kind of an institution easier and more effective (Polish Journal of Public Health, 2012), enabling better information management.

E-health may be briefly described as products, systems and services of digital form utilized in health care sector that should facilitate the record keeping, information exchange and treatment organisation. Definition of the e-Health provided by the European Commission (*Public Health*, 2013): emphasizes that the tools and services using information and communication technologies (ICTs) that can

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improve prevention, diagnosis, treatment, monitoring and management. When introducing eHealth system many key factors, including financial, technical and social aspects must be considered (Harvey et al., 2014). Many authors indicate the last one as the most important when designing a health information system (Zhang, 2005; Lis, 2012). The project should be then seen more like a human project, where human-centered computing such as usability, workflow, organizational change, medical error, and process reengineering are the tools only. In this article though we focus on selected IT issues within the project.

eHealth in Poland

In Poland, the main healthcare organization is the National Health Fund with its 16 regional branches. In terms of eHealth Poland scores below the EU average with regard to both the availability of ICT infrastructure (computer, Internet) and the use of ICT for different eHealth-related purposes. According to empirica (Poland: Healthcare system and eHealth strategy) 72% of the Polish GP practices use a computer, 62% of practices dispose of an Internet connection. In Poland, broadband connections have not yet arrived in force; they are used in only 32% of the GP practices.

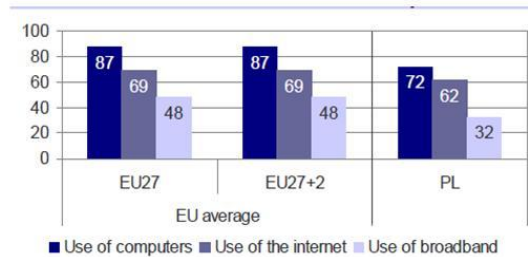


Figure 1. ICT Infrastructure in Polish GP practices in 2007
(Benchmarking ICT use among General Practitioners in Europe, 2007)

The use of eHealth solutions also gives results below the EU27 averages. As it's shown in Fig. 2, the percentage of computers usage in consultation with the patients (11% of the GP practices) is far behind the EU27 average of 66%. According to the survey (Benchmarking ICT use among General Practitioners in Europe, 2007), eHealth performs mainly in the area of administrative and medical patient data storage.

The data shows the big distance between Poland and other EU countries in the terms of eHealth. The key goals and activities for development of an eHealth system in Poland, referring to the EU eHealth Action Plan, are described in *"The Plan of the Informatisation for e-Health for the years 2010-2015"*. It concerns the main strategy points like: facilitating access of citizens to information related to healthcare; making the healthcare system more effective through electronic document flow implementation; medical information system; practical realisation

and development of IT solutions which are compliant with EC's recommendations in the area of Electronic Health Record.

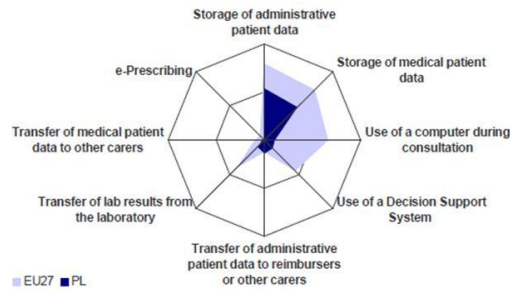


Figure 2. eHealth Use by GPs in Poland in 2007

(Benchmarking ICT use among General Practitioners in Europe, 2007, Country Profile: Poland)

Nevertheless implementing the above key goals on the central level is costly and time consuming (Kędzierski, 2013). Not many primary health care institutions could afford entering this. The same situation appears when considering communication technologies as well as knowledge management (KM) tools (Patalas-Maliszewska and Kłos, 2012). That's why alternative solutions, dedicated to this kind of units is worth considering. In further part of this article, the idea of such a network has been described.

Computer network for a primary health care institution

A healthcare information system is an extensive integrated system which captures, stores, manages and transmits information related to the health of individuals or the activities of organizations that work within the healthcare sector. The basic requirements that should be met by the computer network in the primary health care institution are: serving as the local area network (LAN) enabling utilization of the internal IT solutions and providing communication between particular units of the network, providing stable connection to the Internet. The design of a computer network must refer to the physical properties of the area and buildings where it is to be implemented. Thus some pre-design assumptions have to be made. These assumptions are as follows:

- Computer network in distributed within one building having one or two floors;
 - Number of workstations and peripherals connected to the network in the institution is not bigger than forty eight;
 - Distance between any workstation and distribution point is not bigger than 90 meters;
 - Wireless connection to the Internet within the building is also part of the design.
- According to the above assumptions, Figure 3 shows the scheme of an exemplary building for which the computer network is going to be designed.

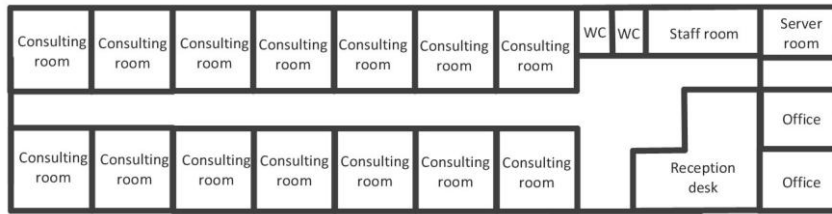


Figure 3. Structure of an exemplary building that can adopt the project

Topological design

The most important criteria when designing a LAN computer network are costs, application, distances between particular components of the system and possible expansion of the network. The primary health care institution requires deploying the star-like computer network (shown on the scheme in Figure 4), where all the devices are connected to a central component which is hub, switch or router. All the data is passed through a central device.

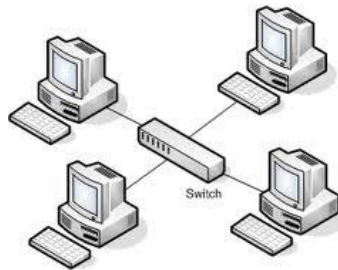


Figure 4. Star network topology scheme

The next important issue concerning computer network design refers to the wired and wireless communication (Tanenbaum and Wetherhall, 2011). Though more and more computer networks utilize the wireless technology, the wired communication is still far more secure, reliable, available and complete which makes it the best solution for the enterprise networks. All the connections between fixed components of the network (particular workstations, printers etc.) are going to be the wired connections. Nevertheless wireless communication will be also a part of this project, some access points will be available in order to make it more competitive in the demanding market.

The main communication medium of the designed computer network for the primary health care institution will be Ethernet which stands for the standard IEEE 802.3 defining the carrier sense multiple access collision detection protocol (Cisco, 2013). When choosing LAN technology, the Ethernet standard has been chosen, especially due to the fact that its compatible devices are common, cheap and easily available (PJMS, 2012).

Figure 5 illustrates the arrangement of particular components of the network and connections between them.

The project of the computer network will contain: router with firewall, Gigabit Ethernet 48-port Switch, Wi-Fi Controller Switch, Wi-Fi Access Points, STP Cabling Category 5e, 48-port STP Ethernet Patch Panel, Server, 1500 VA UPS, 24U 19-inch Rack with the Attachments.

It is worth adding that when designing the wired computer network, two options were considered: traditional cables such as twisted-pair cable (UTP, STP etc.) and optical fibers. The fiber technologies provide bigger capabilities and better performance, but the infrastructure for optical systems is far more expensive. Most of enterprises like primary health care institution would consider it uneconomic. Moreover majority of the devices connected in LANs is maladjusted to be attached to the optical network without special connector and converters. For the purposes of the primary health care institution twisted-pair cables will be the best solution. Taking into account the requirements set by the way of utilization of the computer network one may be sure that by choosing proper type of the twisted-pair cabling fast, efficient and reliable connections within the network can be provided.

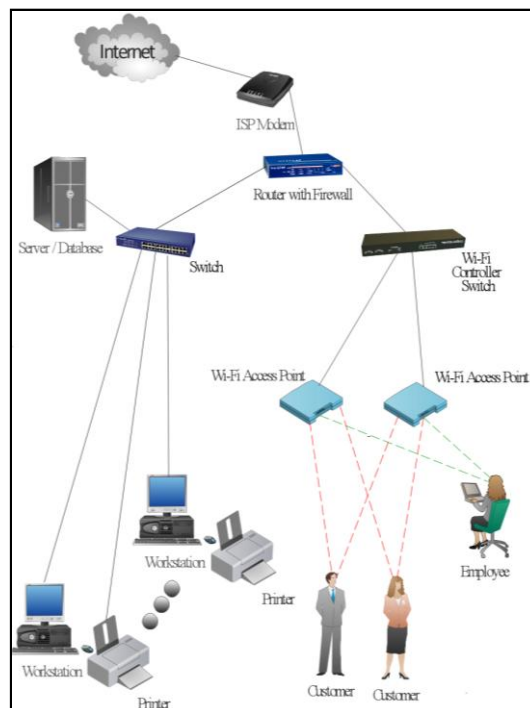


Figure 5. Logical scheme of the designed computer network

The elaborated integrated solution is going to provide the local-area network of the primary health care institution with efficient communication capabilities. It is also adjusted to match the high speed WAN connection to the Internet. Firewall and manageable switch enable pursuing the proper information security policy.

Designed network is expandable and can be easily implemented for a reasonable price.

The described computer network will have a dedicated application as well. It was created with the use of Java programming environment which is a well-known and widely used tool for software development. Application uses Java database connectivity (JDBC) technology to provide the connection with the SQL database which is the place of data storage. SQLite is used as a database for the purposes of the development of the mentioned application.

The application was designed to operate in the client-server mode. Server is supposed to store the database files containing information about doctors, patients and medical records. Employees of the primary health care institution are supposed to use the application installed on the end-user client computers distributed within the building of the institution. Client computers need to operate under Microsoft Windows (XP, Vista, 7, 8) or Linux environment with Java environment version 7 installed.

Designed application is supposed to facilitate the operation of the primary health care institution by enabling user-friendly management of the database of doctors and patients with linked case histories (medical records). User of the application should be able to add, modify, delete and display particular entries. Access to the program has to be secured and the database files need to be stored on a server in an inaccessible place.

The list of the most important interface and functional requirements include:

- Login panel with user authentication,
- Application synchronized with system date and time,
- Database for doctors,
- Database for patients with personal details,
- Database for medical records – case history,
- Possibility of adding, modifying, removing and displaying particular entries,
- Searching options,
- Filtering options,
- Graphical User Interface enabling performing aforementioned operations and managing database entries.

Access security

Access to the application is secured with the aid of a login panel. User authentication is based on the password verification.

The implemented security mechanism includes usage of a hashing algorithm which enables encrypting the password, so that it is not stored as plain text in the database. For the purposes of the application a basic MD5 hashing algorithm was applied. To ensure additional safety hashing incorporates the use of the so called salt. Salt is a sequence of random characters which is added to the plain text

password and the sum of salt and passwords is hashed with MD5. Both salt and hashed passwords are stored in the database.

The verification of the password is a process analogical to the encryption. The user entry is extracted from the database basing on the input username. The password the user entered is combined with the extracted salt, hashed and compared with the hash stored in the database.

Created application utilizes the JDBC connectivity to access the SQLite database. Java Database Connectivity (JDBC) is the industry standard providing connectivity between independent SQL databases and Java programming language. JDBC technology-enabled driver enables sharing corporate data in heterogeneous environment (Oracle, 2014). Utilized database consists of 4 main tables containing detailed information:

- Users (username, password),
- Doctors (name, surname, PESEL),
- Patients (name, surname, PESEL, insurance number, street, city, postal code, mobile phone number, email),
- Medical records (date, author, patient surname, patient name, title, description).

Scheme of the utilized database can be seen in Figure 6.

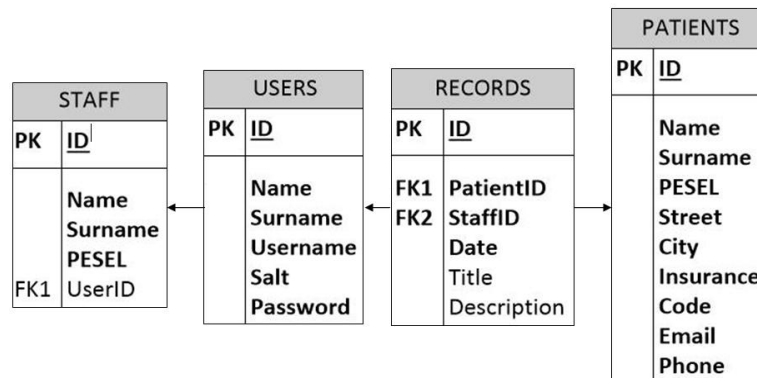


Figure 6. Database structure scheme

Basic functionalities of the created application

In order to run the application user authentication is performed with the aid of the login panel. This view enables also the administrator of the program to access the administrator panel in which new user accounts can be created.

The main window of the application that can be seen in Figure 7 consists of three panels dedicated for doctors, patients and medical records. Each of the panels is composed of the table with database entries and action buttons at the bottom of the window. Actions accessible by pressing the buttons are also available in the Menu Bar. Beneath the Menu Bar the currently logged in user name is displayed on the left and the current date and time on the right.

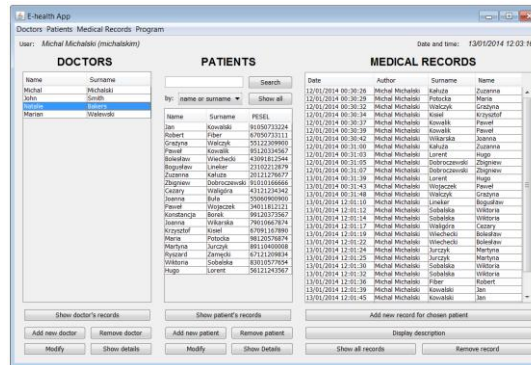


Figure 7. Main window of the program

Application described in this paper is supposed to be developed and adjusted to meet the requirements of the particular case. Future expansion of the developed software is planned in order to provide the application with some new functionalities and make the most of the latest technologies which aims at facilitating the operation of the primary health care institution. As a result, better information management should be possible. New functionalities of the application that can be implemented by expanding the existing software solution are as follows: Timetable for doctors, Email/SMS notifications, reminding clients about visit, Database for medicine, Prescription printing, Statistical analysis.

Some online services are also worth developing. As many authors point out, in health care a special role is played by the e-services (Cotîrlea D., 2011). The most vital ones from the point of view of primary health care institution are: Information about doctors, Access to medical records, Online consultations, Visit registration, Online monitoring, Client feedback (polls, issues etc.).

As soon as online service for clients of the health care institution is set up, there should be considered a database for images providing possibility of easy and direct image exchange between the doctors and the patients. This solution documentation of many cases could be enriched by photographs, x-ray photographs, scans of clinical results etc.

Due to rising popularity of mobile devices such as smartphones and tablets, a mobile version of the application could also be considered. This could facilitate the communication between the doctor of the primary health care institution and the patient. Solution of this kind seems to be especially advantageous for the people regularly visiting such institution because it could facilitate the scheduling of visits, case information exchange etc.

Conclusions

Computerization of the health care sector is an important part of each country's health care policy as this is the requirement to provide the economy with the expected, advantageous enhancements. Many national and international

programmes have been introduced and consequently run in order to hasten the pace of redevelopment. Poland similarly to the other less wealthy European countries is the beneficiary of The European Union's Structural Funds. Nevertheless, it is not enough to effectively pursue countries making the most of the latest technologies and excelling in building the modern information society.

Implementation of the dedicated internal software tools is the solution that could immediately improve the operation of the primary health care institutions and improve their information management system. This is due to the fact that they could be deployed within a short period of time with the aid of relatively small money and they could be adjusted in a way to enable the institution to make the most of its potential of any type. The computer network design is aiming to provide the primary health care institution with the efficient, reliable and relatively inexpensive IT infrastructure that could serve as the main data exchange medium enabling fast operation of the institution and enable electronic record keeping.

The hardware solution is however only the foothold in the process of digitization of the health care institutions. It should constitute the basis for virtualization of the hefty storage and information exchange needs. The utilization of the networking infrastructure in the primary health care institution as a part of a more complex system extorts the creation of the compliant software application which would address the aforementioned needs.

Developed for the purposes of this thesis, exemplary program written in Java programming language utilizes the SQL linked database for doctors, patients and medical records and serves as the perfect management tool enabling record (case history) keeping and storing information about patients and doctors. As dealing with personal data is a part of the operation of the health care institutions it is important to follow the proper information policy by introducing solutions for some security issues. Problems of this kind were also raised in the presented thesis. The most important one refers to the user authentication which enables access to the clients' personal details and case history. User authentication relies on logging in with salted password hashing which is a simple way to assure the basic security level for the protected data.

Future development of the software that has been created in the framework of the presented article is also foreseen. The list of the possible expansions of the application includes prescription handling, timetabling, printing options, statistical analysis and database spreading. In order to facilitate the communication between the employees of the institution and the clients some connected projects could be developed such as the online service utilizing the database resources, mobile applications and file exchange tools. Implementation of the created e-Health computer application does not exclude the possibility of using the software solutions imposed by the superior units as thanks to the utilization of the database of common type, synchronization of data is possible which is the commonly applied practice in institutions of any kind using the internal software tools and software of bigger range simultaneously. Proposed hardware infrastructure together

with developed software tool can be applied in the existing primary health care institutions addressing their real life needs.

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ROLA SIECI KOMPUTEROWYCH W ZARZĄDZANIU INFORMACJAMI DOTYCZĄCYMI PACJENTÓW W JEDNOSTKACH PODSTAWOWEJ OPIEKI ZDROWOTNEJ

Streszczenie: W znacznej części jednostek podstawowej opieki zdrowotnej brakuje odpowiedniej infrastruktury sieciowej, co uniemożliwia zastosowanie nowoczesnych rozwiązań informatycznych i utrudnia zarządzanie informacjami medycznymi, w tym dotyczącymi przebiegu leczenia. Proces wdrażania rozwiązań IT musi być, zatem poprzedzony budową odpowiedniej infrastruktury sieciowej. W artykule przedstawiono propozycję usprawnienia funkcjonowania jednostki podstawowej opieki zdrowotnej poprzez budowę sieci komputerowej współdziałającej z aplikacją komputerową do zarządzania połączoną bazą danych lekarzy, pacjentów oraz rejestrowanych zdarzeń medycznych. Zastosowanie aplikacji w jednostce podstawowej opieki zdrowotnej ma na

celu umożliwienie prowadzenia elektronicznej dokumentacji medycznej, a także usprawnienie funkcjonowania instytucji. W szczególności usprawnienie to dotyczy zarządzania informacjami dotyczącymi pacjentów.

Słowa kluczowe: sieci komputerowe, e-Zdrowie, jednostka podstawowej opieki zdrowotnej, informatyzacja sektora usług zdrowotnych, zarządzanie informacjami medycznymi

計算機網絡在信息管理與患者在基層醫療單位的作用

摘要:在基層醫療單位的很大一部分缺乏網絡基礎設施，從而防止利用現代IT解決方案，使得它難以管理的醫療信息，包括在治療的過程中。實施IT解決方案的過程中，因此必須先進行網絡基礎設施的建設。本文介紹了通過計算機網絡與PC應用程序管理醫生，患者和醫療記錄的事件的綜合數據庫進行交互的建設，提高基層醫療單位的職能的建議。使用在初級保健單位的應用是使電子病歷，並通過提高機構的運作行為。特別是，這涉及的管理信息對於患者的改善

關鍵詞：計算機網絡，電子保健，衛生服務的基層醫療機構信息化，醫療信息化管理