# Scalable Telemedicine Solutions - Research Direction of KCT

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**Abstract**. The paper describes the activity of the Krakow Telemedicine Center (KCT). At first it presents research direction of KCT that concerns: collaborative teleradiology, groupware medical collaboration tools and mobile telemedicine. Different terms of scalability of achieved solutions are taken into account: data format, computer network conditions, amount of patient data stored, number of end users served (patients, doctors, consultants), areas of interest etc. Modern network technologies (VPN) and software concepts for contemporary telemedical systems are also evaluated.

## Introduction

The concept of the Krakow Telemedicine Center activity and its scientific program assume the practical approach to organization of telemedical services in the Małopolska Region in the South of Poland. The paper presents the examples of the most interesting deployment of telemedical services, in which the Center was involved during last three years and pays special attention to the aspect of their scalability.

The gained experience proves that the deployment process of a telemedical service is rather challenging and hard experience. Many external conditions cause that finding flexible and scalable solutions is the basic of achieving a success.

The factors described below were the fundamentals of creating suitable telemedical scenarios within developed tools. One of the most important features are connection parameters to a high speed computer network infrastructure, which translate into different quality of network connectivity between peripheral hospitals and professional reference medical centers.

The application scalability expresses also in the possibility of serving wide range of data formats, efficient storage of data and effective handling of the growing number of system end users. Finally taking into account different areas of interest allows to create applications that are easy to be transferred into other disciplines of medicine.

## Research direction of KCT (Krakow Center of Telemedicine)

The Krakow Center of Telemedicine has been established in Poland in year 2000 as a Center of Excellence under the Fare Project. It is the consortium of leading institutions in the field of informatics and telecommunication from the AGH University of Science and Technology and medical centers associated with Collegium Medicum at Jagiellonian University. The structure of the KCT fulfill all requirements to develop and deploy telemedical services. The goal of the center is to develop scalable solutions for telemedicine applications.

The requirements of contemporary medical services (i.e. improvement of health care, provision of common and continuous access to medical services etc.) correspond with progress in IT technology in the area of global communication, pervasive computing, systems with intelligent environment. The research goals of KCT have been focused on constructing telemedical applications which address innovative and challenging areas of medical informatics such as groupware medical collaboration tools and mobile medicine.

| Name of the system | Main functionality |
|---|---|
| RaDAS | Multimedia database collecting radiology data and providing access via standard Web Browser. |
| DICOM Viewer | DICOM Viewer written in Java providing basic functionality of medical images processing on portable devices such as PDA etc. |
| Konsul, Konsul II | Systems dedicated to teleconsutation in cardiology exploiting possibility of remote installation of medical data on Web Server in reference medical center. |
| TeleDICOM | Experimental system implementing collaborative teleradiology concept. |
| Telenegatoscope | System dedicated for synchronous remote work by two medical experts on the same medical data represented as JPEG files. |
| CAS (Clinical Appointment System) | System providing access by internet to medical services appointment plan for a patient. |
| VideoLibrary | Video Server with collection of medical video clips accessible via internet used for educational purpose. |

**Table 1**. Telemedical tools constructed by KCT

A concept of collaborative teleradiology assumes that a group of medical experts located in different clinics or hospitals work synchronously on the same radiology data, sharing access to them and exchanging comments via computer network. Collaborative teleradiology addresses not only telediagnose but also teleconsultancy issue, providing tools and mechanisms to on-line opinion exchange.

Mobile medicine addresses a mobility aspects taking into account patient, medical data, medical center and emergency team mobility. A functional model of medical care in context of mobile telemedicine assumes wireless communication providing permanent contact between a patient and medical monitoring center.

The performed research results in software systems construction are summarized in table 1. The range of the proposed solutions concerns teleconferences, remote installation of radiological images over a consulting institution web server for further diagnose, remote mobile access to medical databases, and dedicated tools for collaborative synchronous work by group of doctors on the same medical data.

## Terms of scalability

The scalability of the proposed telemedical solutions means the application ability to operate in different technical circumstances. Computer network parameters are the ones of the most significant influence. They include connectivity throughput, network traffic QoS (Quality of Service) guranttee, end-user devices visualization performance, etc. These parameters diversity leads to the range of telemedicine applications from very simple using ISDN or dial-up connection to very advanced based on high speed optical transmission.

The network communication used by KTC uses whole that range of means. High speed connections are available over PIONIER Network (155/622Mbps). The connectivity from peripheral hospitals to Krakow MAN is established using dedicated leased lines operating at 2Mbps speed or ISDN lines running at 128Kbps or 256Kpbs. In situation when mobile access to medical data has to be provided wireless communication has to be used (WLAN, GPRS, Bluetooth technology) [1].

QoS requirements [3] in context of telemedical application are summarized in Table 2. It is easy to see that teleconsultation is most demanding application. because of the need of small delay (less than 100ms) and small jitter. The delay is not significant in case of teleeduction when VoD (Video on Demand ) is used.

Tabela 2. QoS requirements

| Application type | Required throughput | Small delay | Small jitter |
|---|---|---|---|
| Teleconsultation | High | Yes | Yes |
| Telediagnnostic | High | Yes | No |
| Telemonitoring | Low | No | No |
| Teleeducation/VoD | High | No | No |
| Access to EHR | Low/High | No | No |

QoS control and security/privacy issues suggest that the solution suitable for telemedical applications is to build VPN (Virtual Private Networks) [2] over public network.

Another aspect of scalability is taking into account diverse data formats used in telemedical systems (i.e. patient record, imaging, multimedia transfer). As table 1 shows, the developed tools serve JPEG, AVI, DICOM formats.

The increasing amount of patient data stored is the reasons for using effective and scalable data storage technologies. In the same way, the number of end users served (patients, doctors, consultants) influences thoughtful selection of applications software and hardware architecture.

Majority of telemedical applications developed by KCT exploit multilevel software structure typical for portal technology [3]. Modern systems rely on multi-tier architecture. The application of Oracle database at the storage layer makes the system scalable, robust and ready to serve thousands of patients. Simultaneously, the concept of server/thin client paradigm allows for common and widespread access to the system by users exploiting web browsers. On the other hand, the engaging efficient clustered application servers allows not only serving a great amount of clients, but also introduces new advantages such as single sign on, fault control, load balance etc. to the working system.

Scalability of the application could be also considered in the terms of variety of fields of usage. The idea of collaborative teleradiology could be easily expanded to another area of medicine such as pathology, dermatology etc. leading to the concept of CSCW (Computer Supported Collaborative Work) systems in medicine.

## Summary

Telemedicine is a multidisciplinary subject and the deployment process of a telemedical services rather challenging and hard experience. It was clearly identified that practical scenarios require scalable approach. The tools developed by KCT team very well demonstrate this attitude and should result with new generation of medical systems supporting intelligent environment.

## References

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