Virtual Hospital and Telemedicine for Telementoring of the Health Workforce

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ABSTRACT
Ubiquitous access to high-level healthcare (u-Health) especially in extended regions like the Asian-Pacific region requires increasing use of telemedical solutions. A regional cooperation with leading hospitals can be supported by the integration of technological platforms and telemedical services in a Virtual Hospital. By implementing interactive real-time connections with the high-end video communication system WinVicos live interaction with the remote partner becomes possible. Such a permanent link enables services like expert advice for patient care as well as teleteaching, teletraining and telementoring of the health workforce. It is necessary not to focus on the technology but to address the user’s needs by providing a transparent platform and strategies for collaboration in virtual user communities.

Keywords
Tele-Education, Ubiquitous Healthcare, Virtualization of Hospitals, Virtual Medical University

1. INTRODUCTION
Implementation of emerging information and communication technologies into healthcare have lead us to the e-Health era, characterised by new ways of healthcare delivery through a broad range of teleservices [1-6]. However, to fulfil the promise of e-Health and Telemedicine, namely ubiquitous access to high-level healthcare for everyone, anytime, anywhere (so-called ubiquitous Health or u-Health) it requires the real integration of the various technological platforms and medical services in Virtual Hospitals [7-8].

The Virtual Hospital (VH) will provide a heterogeneous integrated platform supporting medical services, such as e-learning, real-time telemedicine and medical assistance. The VH will put special emphasis on the education and training of young medical doctors in clinical and scientific organisations of the network being committed to training and educating health workers, developing networks within the international scientific community and building applied research programs. This will allow young medical doctors even at a remote or isolated location to develop and gain experience in a multicultural and multidisciplinary environment.

The VH will foster regional cooperation between the leading medical centres of the participating countries by establishing a permanent medical and scientific link. Through the deployment and operation of an integrated interactive communication platform, it will provide for medical professionals in the whole area access to the required quality of medical service depending on the individual needs of each of the partner.

The Virtual Hospital also addresses the need for increased education and prevention campaigns, as well as better surveillance, screening and treatment in the region’s countries and territories.

The development of Virtual Hospitals and digital medicine is proposed as a mean to bridge the digital divide also in the Asia-Pacific region and enables introduction of evidence-based medicine for better disease management.

The objectives of real-time education and training in medicine are live transmission directly from the operating theatre. By implementing interactive connections to the “point of action” and remote control of cameras to be viewed on the local monitors, live interaction with and participation in the remote event becomes possible. WoTeSa / WinVicos serves as a tool for such real-time interactive e-learning and distance training in the medical field.

2. METHODS
WoTeSa / WinVicos for real-time interactive video communication
The communication software WinVicos (Wavelet based interactive Video communication system) has specially been designed for a broad range of real-time interactive tele-applications [9]. WinVicos is a high-end interactive video communication software, providing real-time transmission of video streams and still-images, based on IP-protocols. WinVicos is a very easy operable system. There is a main user dialog that is sufficient for the standard actions of the user. This includes calling the video conference partner (address book), remotely changing transmission parameters (bit-rate, frame-rate, frame-size of 128x96–640x480 pixels), as well as speaker- and microphone-volumes. Besides the main user interface up to four video-windows can be shown on the user’s desktop. Another very useful feature of WinVicos is realised by the remote pointers / shared cursors. During a conference WinVicos supports remote pointers in any video or document window. When one connected partner moves his mouse-pointer in one of the transmitted windows the pointer is shown to his remote partner(s).
Additional interactive features include file transfer, application sharing as well as white board and chat functionalities. WinVicos supports real-time communication in both point-to-point (between two partners) and multipoint modes (connecting up to \(2^{10} = 128\) partners). WinVicos has been developed in cooperation with Vedat Guerkan Engineering.

For video compression WinVicos employs a hybrid speed-optimised wavelet-codec. This codec is based on the concepts of Partition, Aggregation and Conditional Coding, therefore called PACC (Deutsche Telekom Patent DE 197 34 542 A1). Audio compression is done by the MPEG Layer 3 compression algorithm – mp3 – developed by the German Fraunhofer Institute. The wavelet-transformation-based PACC codec processes a whole frame at once, without splitting the frames in 8x8 blocks. Therefore the wavelet-codec has no blocking artefacts like the DCT-based H.261 and MPEG-4 codecs. Thus, the image quality is much better at a small bandwidth and there is no need for a de-blocking filter. In order to reduce the temporal redundancies in a video sequence only the difference from one frame to the next is coded. There is no complex motion estimation and compensation. A reason for such a simplification is to use small bandwidth transmission channels of up to 2 Mbps and to use the codec mainly for typical medical applications, i.e. not for fast lateral motions. WinVicos and its PACC codec are software-only systems. Hence improved algorithms, new video coding schemes and additional functionalities can be readily implemented.

WoTeSa – Workstation for Telemedical Applications via Satellite is the hardware on which the WinVicos system is operated. The hardware requirements are met by an IBM-compatible PC with a Pentium® IV processor \(\geq 3\text{ GHz}\); \(\geq 512\text{ Mbytes RAM};\) Osprey Video-capture board(s) (Osprey 100 or 500); a camera with composite and/or S-Video outputs as live video source; a second video camera as document camera for capturing and transmission of non-digital images; standard headset, or microphone in combination with small loudspeakers. Additionally a document camera and video outputs of various medical equipments (histopathological microscope, ultrasound device, etc.) can be connected, thus creating a medical video hub.

3. U-HEALTH AND THE VIRTUAL HOSPITAL

The innovative developments in ICT over the last decade, aiming at the global deployment of u-Health bear the risk of creating and amplifying a digital divide in the world. Therefore there is a need for real integration of both the various technology platforms (Quality of Service) and the various Classes of Services. A virtual combination of applications serves as the basic concept for the development of the Virtual Hospital (VH) [8]. Virtualisation of hospitals supports the creation of ubiquitous organisations for healthcare, which amplifies the attributes of physical organisations by extending its power and reach. Instead of people having to come to the physical hospital for information and services the virtual hospital comes to them whenever they need it.

Through the integration of different telemedical solutions in one platform many medical services can be supported and isolated “island”-solutions are avoided. The transparent implementation enables the various user groups to use the services of the VH such as expert advice, teleteaching and teletraining, telementoring and optimisation of the learning curve without knowledge of the underlying communication infrastructure like satellite and terrestrial links, Grid technologies, etc. (Fig. 1).

By the integration of the platform with the various local and national communication systems medical assistance for tourists and travellers abroad will be supported allowing for shared management of related files (medical images, diagnosis, workflow, etc.).

Figure 1. Interactive teleteaching session with joint discussion of a pathological image between Berlin and Cairo.

The VH aims to facilitate and accelerate the interconnection and interoperability of the various platforms and services being developed by different organisations at different sites through a real integration. This integration must also take into account the social, human and cultural dimensions and strive towards common approaches but open and respectful of cultural differences: multi-lateral cooperation instead of aid.

The methodologies of the VH are medical-needs-driven instead of technology-driven. They supply new management tools for virtual medical communities. The VH provides a modular architecture for integration of different telemedical solutions in one platform. VH will provide for medical professionals in the whole region access to the required quality of medical service depending on the individual needs of each of the partners.

The possibility to get support from external experts, the improvement of the precision of the medical treatment by means of interactive telecommunication systems, as well
as online documentation and hence improved analysis of the available data of a patient, contribute to an improvement in treatment and care of patients. The VH will support a wide implementation of evidence-based medicine and will thus contribute to global improvements in healthcare.

4. QUALIFICATION OF THE HEALTH WORKFORCE: FROM E-LEARNING TOWARDS U-LEARNING

ICT principally allow for the creation of virtual universities and schools for e-learning and distance training of the Health Workforce [10-11].

Already in the EMISPHER project [12] a virtual medical university has been created hosting real-time broadcast of lectures, live surgical operations and pre-recorded video sequences etc., as well as web-based e-learning applications. The target population is comprised of medical students (both undergraduate and postgraduate) university hospital staff, general practitioners and specialists, health officers and citizens (Fig. 2).

![Figure 2: Interactive Multipoint Teleteaching Session between Palermo, Algiers and Berlin.](image)

Each of the leading medical centers provides pedagogical material and modules for synchronous and asynchronous e-learning in their medical specialties. Some of the multimedia teaching material needs to be presented in real-time. Live transmission of surgical operations from operating theatres, lectures, etc. from one site to one or several sites simultaneously (point-to-point or multipoint) are possible in the network (Fig 3.).

![Figure 3: Interactive teleconsultation with live transmission from the operating room between Berlin and Algiers.](image)

Where the term e-Learning merely reflects ICT-enabled methods of education, it bears the risk of putting the means (technology) in the focus rather than the goals (ubiquitous access to education). We therefore suggest using the term u-Learning, thus focussing again more on the users and their needs, rather than the technologies required for its realisation [13].

In the following we address a number of factors that appear crucial for successful deployment of u-Learning:

- **Integrated heterogeneous networks** with seamless transitions between the various segments (satellite, terrestrial, wireless, mobile, ad-hoc, etc.).
- **Transparent (or invisible) platform** technology layers: the user does not need to bother with technical details.
- **Tailored services** for the various segments of users (scholars, students, young professionals, senior professionals, etc.) and scenarios (first education, vocational training, CME, etc.).
- **Personalised avatars for Assisted Cognition**: Assisted Cognition, where novel computer systems enhance the quality of life of people, is a powerful tool for personalised services. Personalised avatars that function as virtual dialogue partner, acting and reacting in a task-oriented, user-specific, personalised and situation-dependent manner, can guide the user to the required information. Artificial intelligence can support the communication between users and content providers and/or instructors.
- **Intelligent data mining tools**: In order not to get lost in the vastly expanding content jungle and to be able to find the most suitable content, efforts in the field of intelligent data mining are required (e.g. standardised ontology, etc.).
- **Strategies for improved and wide-spread technology acceptance**: E-literacy should be increased among all people, as it will be a prerequisite for continuous participation, in the future even more than it is already today. Drivers
for technology acceptance must be recognised and explored on individual level (e.g. platform knowledge and power), structural level (e.g. platform formality and intensity) and relationship level (e.g. transparency, commitment and reputation).

- **Strategies for collaboration in virtual communities**: Successful collaboration in virtual communities depends strongly on the synergy between technology and people. The challenge is to create and keep alive a feeling of teamwork, although the participants are geographically dispersed and do not meet face-to-face. Key factors for this are trust building and the construction of shared goals [14].

- **User-centric continuous evaluation**: Going beyond technological evaluation, it is important to address if the services indeed match the users’ needs. Special emphasis should be given here to evaluation from the students’ point of view, as they will increasingly act as customers.

### 5. CONCLUSION

The use of specifically designed networks and platforms for real-time telemedicine enables expert advice, telementoring and teletraining contributing significantly to the acceleration of the qualification process of the health workforce and finally to the continuous improvement of patient care.

Parallel to the development of Telemedicine itself this process should be accompanied by the increase of broadband services in rural areas enabling a bridging of the digital divide, satellite services available everywhere enhancing the safety of citizens, service costs containment and improvement of prevention strategies.

### 6. REFERENCES