Telementoring as a Service

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Abstract

Increasing number of ubiquitous mobile devices in daily routine encourages software design adaptations. Hardware/software independence, minimized end user efforts to maintain the compatibility of their preferred devices with the software systems are very important properties in the rapidly updating technological world. As a support for this claim, a concept of service based surgical telementoring system is presented and illustrated by a prototypical implementation. It proves the fact that technological progress is reaching the level allowing the redesign of telementoring systems to be provided as a service in a hospital's network, using only web browser as a client.

Keywords:* *telementoring, SOA, telestration, service, WebRTC

Introduction

Recent global focus and increasing numbers of publications on telementoring shows a growing interest of the researchers on poorly explored remote surgical mentoring techniques [1], [2], [3]. Rising level of life dynamics, advancing ICT, aging society and predicted shortage of surgical work force [4] make us rethink the concepts of education, mentoring, medicine. Tele-education, telementoring and telemedicine are the concepts, spinning in the heads of many researchers nowadays. The optimistically-minded have no doubt about the benefits "tele" feature brings; publications prove the cost and time gains of telementoring techniques in comparison with traditional mentoring [5], Doarn describes them as "a natural fit" in surgery [6]. However, telemedical research is still in its infancy and the benefits need a proper knowledge base to support the sound claims.

This paper explores the concept of telementoring in a wider scope, proposing a novel outlook to the implementations of telementoring systems. Our goal is to push the technology towards being available as a service in a global health network.

The paper is structured as follows: after overviewing the state of the art of developing telementoring solutions, we highlight the drawbacks which could be resolved by changing the software architecture design pattern. Conceptual architecture together with the details regarding the prototypical implementation is presented. The limitations of current solution are emphasized.

Telementoring as a Service

This section is an attempt to draw the high level of abstraction guidelines for delivering telementoring as a service.

Service Oriented Architecture

The concept of software as a service is not a new one. Service Oriented Architecture (SOA) is a well-established software architecture design pattern, based on the idea of developing platform-agnostic computational elements accessed by a lightweight client. Due to uniform data exchange protocol between the service and the client (usually web browser) cross platform, browser and hardware compatibility is highly increased [7].

State of the art of telementoring systems

Notwithstanding the global trend towards the use of mobile devices, telementoring systems remain conservative. Stationary mentoring posts, restricted hardware and software platforms are still common features of nowadays remote guidance systems [8]. A lack of research in employing mobile environments and devices as a medium for enabling ubiquitous support service was identified [9]. Hypotheses of the potential, brought by the introduction of the mobility to the domain are to be supported.

Telementoring systems are based on video conferencing (VC) solutions as a foundation. They are developed having client-server architecture in mind. Providing video channel between the two parties is a fundamental feature of VC. Client software is mandatory to make the system run. However, the variety of software platforms, versions of client application, the need to install extra software and constantly update it results in a headache for IT administrators as well as the end users.

Looking from the technological perspective, the choices for delivering video content to the remote client are limited. Table 1 represents a comparison of most popular current video streaming technologies with respect to 3 main aspects: necessity to install third party software on client side, variety of supported platforms and compatibility with HTML5 video specification. Web Real-Time Communications (WebRTC) gets the highest score based on our comparison as the technology for the novel concept – telementoring as a service.

Service-based mentoring

The main idea behind the attempt to push the mentoring systems to the service layer is to increase the availability of the system and minimize the burden experienced on the remote client side. The goal is to enable telementoring on any device mentors use in their daily routine without the need to install and update any third-party software to maintain the device's compatibility with the mentoring system. Software normally supplied with the machine should be sufficient for the purpose of telementoring. In other words, we propose a browser-based telementoring system prototype.

The main advantages, service based mentoring provides in comparison to the traditional approach are:

- No hardware/software dependencies;
- No extra software install/update on the client side (Flash player, Silverlight, plugins, etc…);
- No network customizations and dedicated networks;
- Centralized control of the mentored procedures (automatic recording, scheduling, participant management, etc.)

Adapting the advantages of SOA to enhance telementoring is a way to eliminate the drawbacks introduced by current state-of-art of developing remote guidance solutions.

Table 1 - Comparison of video streaming technologies

Technology	Software on the client side required	Platform support	Supported as an input for HTML video tag
Real Time Messaging Protocol (RTMP)	Yes	Multiplatform	No
Real Time Streaming Protocol (RTSP)	Yes	Multiplatform	No
Microsoft Smooth Streaming	Yes	Multiplatform	No
HTTP Live Streaming (HLS)	No	iPhone, iPad and iPod	Yes
Web Real-Time Communications (WebRTC)	No	Multiplatform	Yes

WebRTC based implementation

Web Real Time Communication (WebRTC) is an open source framework providing a set of Javascript APIs for real time peer-to-peer media interaction between browsers. Briefly speaking, it enables the development of video conferencing systems using only Javascript and HTML5 [10]. The systems runs inside a WebRTC enabled browser and introduces no additional burden to the user (installation, updates and customization).

To prove the concept of telementoring as a service an open source WebRTC implementation (easyRTC, developed by Priologic) was customized to meet the requirements of the end users. The prototype consists of:

- One way (Operating Room -> remote expert) video link;
- Two ways (Operating Room <-> remote expert) audio link;
- One way (Operating Room <- remote expert) live video annotation link.

Architecture of WebRTC based telementoring system is represented in Figure 1. The mentoring session is initiated by OR client connecting to the WebRTC server. After remote client connects to the server, it is provided by shared session data and peer-to-peer connection between two clients is established. The remote expert is enabled to follow the live video from the operating room, interact with local surgeon verbally and telestrate on live video content.

Discussion

The conceptual and prototypical results presented in the paper are still in their infancy. The developed prototype is very dependent on relatively new and still evolving technologies, having limited support. Currently it is the main weakness of the implementation. Taking the perfect position for keeping up with technological progress as well as ensuring the quality of the service is a challenge. On the one hand, controlling the technological variables, we are dependent on, slows down the application of newest achievements in WebRTC and HTML5 technologies. On the other - adapting to the rapid progress interferes with the stability of current setup.

WebRTC promises fundamental changes in the way video conferencing is used. Minimized infrastructure maintaining burden for the end users, easy integration with current web-based systems is pushing VC technology to a higher level of availability [10]. Increased compatibility enables the inclusion of ubiquitous mobile computational devices as endpoints of the link. Looking from the telementoring perspective, especially in emergency cases, shortening the response time of the mentor is of critical importance. Easy accessible mentoring service, having no client side prerequisites is a step forward.

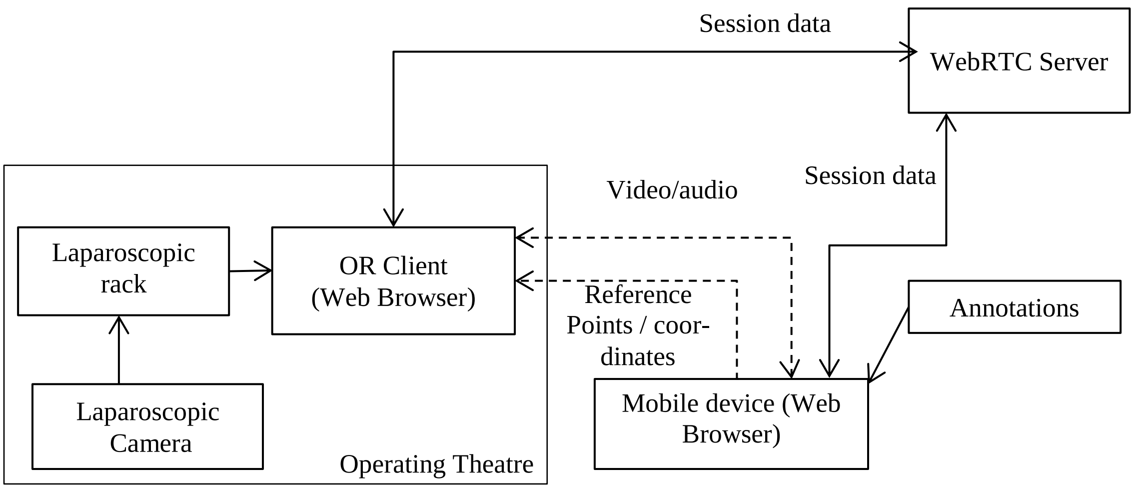

Figure 1 - Architecture of a WebRTC based telementoring system

In a more general perspective, the new winds, WebRTC brings to the VC arena, open the new ways for telemedicine to evolve. Simplified process of establishing an audio-video link between the patient and the clinician forms the premises for tele-emergency service. A similar 24/7 VC systems was developed by Trondsen et al. for emergency telepsychiatry consultations. Conventional VC software solutions were installed in predefined consultancy posts to ensure high availability of the service for the patients [11]. This and other similar research identify the possibility of establishing a VC based virtual emergency clinic [12]. If the patient is able to start the VC session with the clinical service provider as easy as entering the symptoms into an online form, patient side acceptance of this technique should increase.

The use of this service may be limited to non-critical emergency cases, for instance when only a consultation is sufficient. It should also minimize the workload of general practitioners (GPs) by "filtering" the cases and treating one part of them online, avoiding the visit to the hospital. The other part, who were suggested for a GP visit, could be diagnosed and treated faster, as the symptoms would have already been recorder by the virtual tele-emergency clinic, forwarding the patient to the clinician meeting his needs the best and scheduling the meeting according to the clinical condition. Assumptions regarding cost effectiveness, minimized work load of GPs and shorter duration between patient's decision to see a doctor and start of the treatment are just a few of many positive outcomes.

Application of the discussed technologies in telemedical domain has not been done before. However, telementoring approach has already found its supporters among the clinicians. Even though current state of the art of telementoring applications suffers from the technology-related drawbacks, the "clinical outcomes and educational benefits" have some proof already [1]. Technological changes in the established software architectures in VC and telementoring promise a "hassle-free one-click" service. The expected outcomes are exciting; however, a more detailed research is necessary for proving the sound claims.

WebRTC based telementoring software prototype testing results show that we still lag behind if compared with the well-established technologies (Table 1) from the performance perspective. Video encoding/decoding process should highly improve to ensure a wider range of supported resolutions, higher quality and lower latency. WebRTC employs a highly efficient VP8 video codec, however, not being a "de facto" standard it suffers from the absence of hardware acceleration, meaning that video processing is done on a software level. It is especially well noticeable on mobile platforms. However, it is only a matter of time until technological promises of WebRTC and HTML5 will be completely fulfilled making them strong competitors in the video conferencing and telementoring arena.

Conclusion and Future Work

The paper presented an out-of-the-box concept of surgical telementoring. The approach takes advantage of the newest achievements in reshaping the established state of the art of video conferencing. Following the latest VC trends enables telementoring research to stay on the cutting edge of technology. However, keeping up with the dynamics of the developing infrastructure is always a challenge.

Lab testing of the developed prototype is in progress. Results supporting the claims made in the paper are being collected.

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