Video-to-Video E-Health Applications Supporting Medical Use Cases for Remote Patients

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Abstract. Information and Communication Technologies (ICT) relevant to health and healthcare systems can rise their effectiveness, expand quality of life and "reveal" innovation and novelty in modern health-related markets, thus implicating options for further growth. The broadly used term "e-Health" regularly implicates the use of ICT in health products, services to improve health of citizens, efficiency and productivity in healthcare delivery, and the economic and social value of health, *in general*. In this end, the LiveCity Project aims at empowering the citizens of a city to interact with each other in a more productive, efficient and socially useful way, by using high quality video-to-video (v2v) over the Internet. In this work, the LiveCity platform for e-Health is presented, along with two use cases for remote patients telemonitoring and emergency cases.

Keywords: e-Health, emergency, telemonitoring, video-to-video (v2v) communication.

1 Introduction

Over the past few years the vast advances on both wired and wireless technology has changed the face and aim of many service providers, including social ones. The uses of Internet and Video-to-Video (v2v) applications have provided users across the globe with the ability to overcome significant obstacles on their communication, including geographical and language barriers. Furthermore, the integration of Future Internet (FI) application in sectors of social welfare has become a subject of extensive

research from many organizations. One of these sectors, which can be significantly enhanced by the use of FI technology, is the health care [1].

Despite the advancements on medicine and health care systems, the rates of treatment failures remain significantly high for some cases where their treatment could be relatively easy. This is attributed mainly due to the inability of the patient to be physically present to the hospital and/or his difficulty to conform to the treatment ([2], [3]). Also, serious medical incidents are often failed to be addressed successfully due to delays between the incident and the provided treatment.

There are several systems that have managed to integrate successfully ICT applications to the health-care domain ([4], [5]). However, none of the aforementioned systems tackle the problem of high quality video calls across multiple devices. Existing video platforms that can be used for realizing v2v services do not provide the facility to integrate additional features. Furthermore, many of these platforms fail to guarantee the necessary data protection or QoS such applications require [6]. The LiveCity project aims on creating a set of plugins that integrate high quality video streaming that is used for the communication between patients and health care providers, while ensuring both security and high Quality of Service (QoS) ([7], [8]).

The rest of the paper is organized as follows: Section 2 provides an overview of the network infrastructure used for the realization of two different use cases. Section 3 and Section 4 present these use cases along with their respective applications. Finally conclusion remarks and directions for future research are drawn in Section 5.

2 LiveCity E-Health Platform

The LiveCity Network allows the communication of different plugins and provides the infrastructure for achieving high quality end-to-end video streaming. Furthermore, since this network is designed to accommodate use cases addressing serious medical conditions, as well as patient monitoring, the network incorporates a series of encryption and security mechanisms. These mechanisms implement state-of-the-art secure communication channels and protocols, thus ensuring data protection and preventing the extraction of sensitive medical information.

To guarantee the high quality bidirectional video streaming between two individual plugins, the network has integrated a QoS mechanism, called as “Virtual Path Slice” (VPS) engine. The VPS engine is a network resource reservation mechanism. It can be accessed through a specialized interface installed on every end-user plugin and allows the on-demand bandwidth reservation for providing constant bandwidth during video calls.

Figure 1 provides an overview of the underlying infrastructure of the related LiveCity network.

- The Client Plugin provides a simple Graphical User Interface (GUI) that exposes a series of commands that a user can give to the v2v Module. Also this plugin is responsible for presenting both local and remote video feed to the user.

- The v2v Module is the software component that is integrated to each Client Plugin and works as an intermediate layer between the end-user device and the v2v server. It is responsible for handling the communication between each plugins and the server, as well as, for initiating and maintaining the video stream during an active video session. Furthermore, the v2v Module is responsible for interacting with the VPS engine and request specific bandwidth reservation for a video call.

- The v2v server is the main message dispatcher between the individual plugins connected to the LiveCity network as well as the means of authenticating different connection requests. Finally, the v2v server integrates the aforementioned encryption mechanisms ensuring the protection of data.

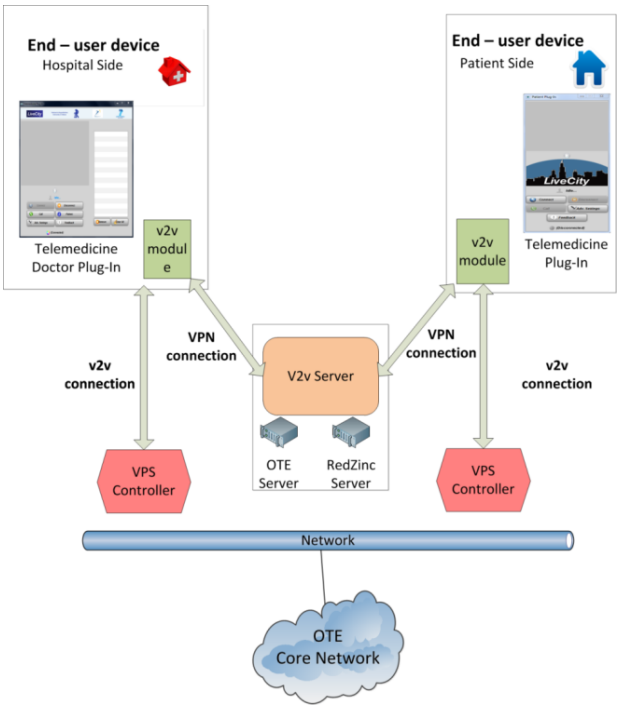

Fig. 1. Network Infrastructure

3 Video Solution for Patient Tele-Monitoring

3.1 Use Case Description

This use case allows the direct video-to-video connection between different healthcare providers and patients. Through the use of LiveCity Telemedicine plugin, a doctor can communicate and interact with patients, on remote or inaccessible locations, providing useful advice to persons in need. Furthermore, the use of public Internet as a main design axis renders the application easy-to-use, without the need of specialized hardware or software.

This use case was materialized for the monitoring of glaucoma patient in coordination of the Attikon Hospital in Athens, Greece and the National and Kapodistrian University of Athens.

3.2 Application

This LiveCity Telemedicine plugin provides two different end user applications, one addressing the need of the doctor and the other the needs of the patients.

Both applications have a simple, user oriented graphical interface, which exposes all the core functionality provided by the v2v module. By pressing the respective buttons, a user can connect or disconnect from the LiveCity network, provide his opinion and feedback regarding the application and reconfigure it.

The plugins also allow the modification of the characteristics of the transmitted video through a settings interface. To accommodate inexperienced user, four standardized profiles have been implemented that allow different quality of the transmitted video ranging from 360p to 1080p (Full high definition-HD). When a video call is active between two clients, each one can modify its respective settings of the received image in order to obtain better video and audio quality.

Despite their common functionality, the *Doctor Telemedicine plugin* differentiates from the one targeting patients, since it provide the means for establishing a direct video-to-video communication with connected patients. Furthermore, it can "adjust" the remote video that is transmitted from the patient by determining higher or lower video profile. Finally, this plugin allows the doctor to retrieve a snapshot of the patient as complement information to his examination.

On the other hand, the *Patient Telemedicine plugin* aims on providing a notification system that allows the immediate notification of the doctor, when a patient requires his assistance via the application or a SMS (Short Message Service). Finally, this plugin does not provide the aforementioned functionality for changing the remote video received from the doctor or for retrieving a snapshot of the video feed.

4 Video Solutions For Emergency Use Cases

4.1 Use Case Description

This use case aims at accommodating patients in emergency medical situation, such as heart attacks or strokes, during the "golden hour" (that is the critical time period when a patient is transferred, e.g. via an ambulance, to the nearest emergency center of a hospital for immediate medical care). Through the use of video-to-video application, emergency personnel in ambulances can communicate directly with qualified personnel to the hospital and ask for proper advice. With this kind of communication the time to provide important treatment is significantly reduced, thus increasing the chances of patient's successful recovery.

4.2 Application

This use case was materialized through the use of specialized equipment for the emergency personnel, while the hospital side used commodity laptops and simple xDSL[1] lines.

This specialized equipment is a wearable backpack computer that consists of off-the-self items and provides all the necessary components for achieving high definition video transmission thought wireless networks. It is comprised by:

- A microcomputer which acts as the main component for transmitting the video feed to the hospital as well as for receiving the audio feed from the hospital.
- A modem that allows the connection of the backpack computer to any wireless network.
- A simple 4 button interface that allows the immediate issue of commands to the computer.
- The necessary hardware (HD camera, headset) for receiving and transmitting the best possible quality of video and audio.

The software used on this use case was designed as a command line interface mainly for energy efficiency reasons. It receives input through the buttons and provides audio feedback to the user. Upon activating the backpack, it connects to the hospital side allowing the immediate communication between the two ends. Finally, a set of additional commands can be issued from the user that allows him to notify the hospital side, requesting immediate attention.

[1] The term "xDSL" stands for any type of Digital Subscriber Line access technology.

5 Conclusions

Fueled by advances in mobile and wireless communications, the last decade has seen an unprecedented proliferation in the service delivery and devices interconnection across the globe. This is particularly important towards the vision of "Smart Cities", where physical infrastructure is complemented by the availability of intellectual and social capital, increasing both urban competitiveness and quality of life. However, before such a paradigm shift can be realized, significant challenges need to be resolved to support remote communications with high QoS / QoE (Quality of Experience) "anywhere and anytime", thus serving remote patients.

Such gaps are investigated by the EU-funded LiveCity Project ("*Live Video-to-Video Supporting Interactive city Infrastructures*"). In this paper, we presented the LiveCity platform and two respective e-health use-cases. The first use case builds upon the use of v2v for remote telemonitoring of glaucoma patients while the second one analyzes the benefits of v2v for emergency cases. In the next steps, we plan to analyze the results of these two ongoing pilots.

Acknowledgments. The present article has been structured in the context of the LiveCity Project and has been supported by the Commission of the European Communities - DG CONNECT (FP7-ICT-PSP, Grant Agreement No.297291).

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