Cloud-based collaborative Healthcare Architecture for Diabetes in Champagne-Ardenne

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Abstract – Cloud technologies have emerged drastically as we can see cloud applications in every day's life (e.g. virtual machine, storage, file-sharing, etc.). Recently, healthcare organizations are also connected and can thus deploy the cloud technologies in order to improve user experience or Quality of Experience (QoE). In this paper, we propose an architecture that can be implemented in medical center such as hospitals, clinics, or even at patient's home. Advantages of such system are real-time monitoring of patients' status, real-time consultation with general practitioners or specialists, real-time management of appointments and alert of severe cases. With advanced support of available technologies, the quality of medical treatment can be greatly improved in terms of cost, rapidness, and efficiency. Moreover, the proposed solution, which is compatible with existing infrastructure, can be integrated and maintained with ease.

Keywords: Cloud, Video conferencing, Web conferencing, Tele-medicine, Tele-presence.

I. INTRODUCTION

Today's healthcare is changing from traditional ways of handling patients to a connected and real-time manner. Hospitals and clinics are connected and can provide accessibility and connectivity to users such as healthcare teams, patients and their family. At the same time, networking and multimedia technologies have increased in performance. Various video codecs become available, for example, H.264/SVC and its capability of adaptive streaming using basic and enhancement layers or H.265/HEVC and its high compression and resolution. As for network technologies, virtualization is becoming increasingly interesting thanks to its flexible capability to adapt to changes in environment. Virtualization empowers applications to a new era.

As for the medical concern, this paper focuses, more specifically on diabetes problematic in Champagne-Ardenne region, France. In fact, according to the statistics, this region is facing a huge number of diabetes (around 60,000 cases) whereas the number of specialist is extremely small (around 20 specialists). Therefore, the region currently encounters the problem of handling all these cases due to a scarcity of specialist. Most of the cases are followed-up by general practitioner. In order to manage all the cases more efficiently, we propose in this paper to connect different actors together via the Internet using the powerful capacities of cloud technologies to improve quality of experience (QoE) and their facility of control and management at end user.

The rest of this paper is organized as follow. Section II presents the architecture, its components and functionalities. Section III presents typical use cases needed by healthcare organization. Section IV discusses the feasibility and facility of integration and management of the system. Finally, Section V concludes this paper.

II. PROPOSED ARCHITECTURE

A. Architecture

In this subsection, we describe the architecture along with different components and their functionality. Fig. 1 depicts the proposed architecture (along with components/actors for use case) that provides a secured and high-quality connection among different entities.

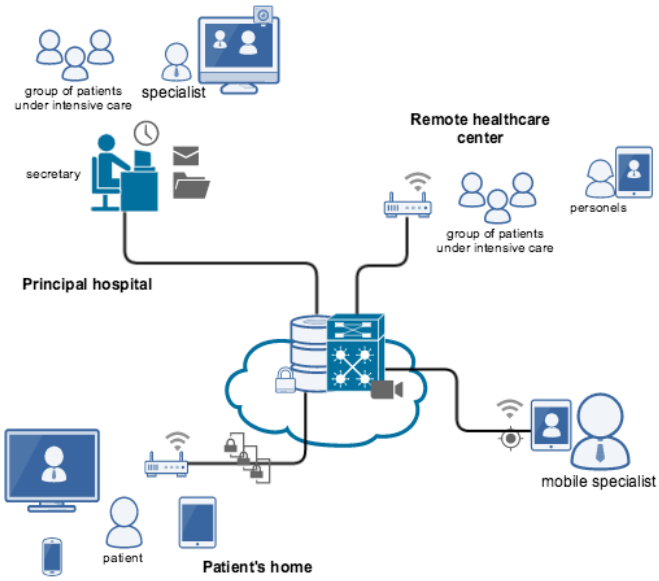

Figure 1. Cloud-based collaborative health-care architecture

B. Component

In the following, we present some representative components both at network-oriented and end-user oriented aspect.

- *Virtual video bridge* has the role to connect end points together and process video transmission. With

virtualization, it can dynamically adapt to network condition (expand/reduce capacity) in real-time manner.

- *Secured database* has the role to store information sharing between actors. It is secured within either local area network or a secured server in the cloud; we can expect the same security as in banking domain.
- *End-user terminal* has the role to display information to end-user; it can vary in size, e.g., smart TV, tablet, mobile phone, watch, etc.
- *Connected object* has the role to collect the information, e.g., glucometer, blood pressure meter, weight scale, etc.

III. USE CASE

In this section, we describe different use cases of the proposed architecture both at the healthcare organization side and the patient side.

1) Real-time monitoring and record sharing

In general, diabetic patients have to test their insulin rate several times per day and write manually each record in a booklet at home. In order to facilitate the procedure, the system can provide a connected glucometer that has a capability to transmit information immediately and automatically after the test. This information will be recorded in a secured database and can be consulted by related actors such as patient, nurse, general practitioner, or specialist. The system can further create alarm to notify healthcare center if something wrong happens.

2) Tele-consultation and Tele-presence

As mentioned earlier, in Champagne-Ardenne region, there are very few specialists comparing to the number of diabetic patients. Moreover, these specialists are situated and grouped within main cities such as Reims, Châlons-en-Champagne, and Troyes where principal hospital centers are located. Actually, diabetic patients have to travel to one of these cities in order to get examined and this visit is repeated periodically. For younger patients, this is not an issue; however, for older and fragile patients, other solutions are needed in order to protect them from complication. Therefore, one important functionality of our system is the capability to provide high-quality visio-conferencing and web-conferencing [1].

The visio-conferencing connection is more complicated to establish, it requires more resources and high-end equipment; therefore, we can reserve this solution between medical hubs such as hospitals and healthcare centers. This provides a high-quality video that we can use, for example, for discussion between specialists on a specific case or meeting with severe-case patient. Another solution is web-conferencing that requires less resources and infrastructure. It can be established easily anywhere using either existing network connection or mobile connection from cellular networks. Since, user will not get perfect quality, we can reserve this solution for simple appointment and general discussion between end users. Moreover, for the healthcare center where nurses and medical personnel have to visit every day to check the status of serious cases, one can deploy the mobile system [2], which can be used to discuss with mobile specialists anywhere they are.

3) Appointment management system

In order to manage appointments and calendar of practitioners, the system provides two capabilities. First, for each practitioner, the system reserves a virtual consultation room for consultation. Second, practitioner can be identified in real time their status and geographical location (via GPS, for example). In case of emergency, it would be easier and faster to get an available person for an operation, for example.

IV. INTEGRATION AND MANAGEMENT FACILITY

One important criteria of a success in deploying new solution relies much on its ease of integration and maintenance. In our proposed solution, the implementation is effortless, as the entire infrastructure will be hosted at the provider (or cloud provider). This means that the service provider will install and maintain materials and connections. The end users (hospitals, clinics, or patients) only have to take care of their medical concerns and not the technical ones.

The IT manager can, with ease, monitor and control the infrastructure using any terminal since the control flows are routed via the cloud. Nevertheless, the traffic is routed locally and hence guarantees high security similar to other traffic existing actually on the local network. This management via the cloud can be achieved, for example, with solutions such as Cisco Meraki [3].

V. CONCLUSION AND PERSPECTIVES

This paper presents a novel architecture for collaborative healthcare where different actors can interact with each other in real time. This system empowered by virtualization technologies can improve efficiency in handling diabetic patients. We illustrate various use cases along with the capability and feasibility of deploying solutions. Technologies are available; the necessary steps are the integration and the measurement of user experience of such system.

In the future, this architecture can also be generalized to other chronic disease such as Cancer as well. Moreover, it will be crucial to evaluate user experience (end-user impression of the usage of the system).

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