Telemedicine - Internet of Multimedia Things (IoMT)

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Contents

1. Introduction
Internet of things (IoT) has been focused recently in developing applications due to its functionalities as well as capabilities of operating in remote areas [1]. According to the traditional IoT applications, remote devices are mainly used for collecting environmental information from vicinity such as temperatures, atmosphere, deep of water or motion detection. Most of these data are acquired periodically. As its growth of popularity, the necessity of applying multimedia in IoT application is also needed to be considered. However, [1] describes that real-time multimedia application based on the traditional IoT architecture is facing many problems and has various limitation.

Because of that, [1] proposes a new architecture design to integrate multimedia with Internet of Things effectively. The define the concept Internet of Multimedia Things (IoMT). According to [1], Internet of Multimedia Things is can be intercepted as the global network that connects multiple multimedia devices which could be identifiable and accessible to obtain multimedia content or to remotely control actions. The concept also strongly mentions the communication with services and other multimedia or non-multimedia devices. It should be noted that the term IoMT in the context of this report is different with Internet of Medical Things (also IoMT), which focuses mainly on applying IoT technologies to eHealth solutions.

Based on the proposed architecture IoMT, this report focuses on analysing the multimedia and communication techniques of a telemedicine application which is implemented from the four main stages in the operation of IoMT. The section 2 of this report is divided into three main parts. The first part looks into the description of telemedicine application, the second part discusses multimedia techniques that are used in the application, and the final part exams the communication techniques of the application. The third section is about the conclusion of the telemedicine application that is based on the design of Internet of Multimedia things.

2. Telemedicine using IoMT
2.1. Telemedicine Application

With the purpose of enhancing the feasibility of remote treatment in eHealth for everyone living in under-developed nations, especially in rural areas, in the first scenario, the application focuses on using real-time multimedia contents to interact between patients living in a remote area and doctors [1]. It is considered helpful in the case that the clients or patients do not have the conditions of living in the city or staying in the hospital for treatment in long-term. With the help of modern multimedia devices such as smart phones or IP cameras, the patients could stay at their home while doctors, living in the city, are still able to access and monitor their remote patient's condition as well as medical records. These medical records with information about the history of patients are stored in the database which is usually located in the multimedia-aware cloud. Also, by using cameras in the remote area, the application can transmit real-time video data of patient's everyday activities to doctors. Based on real-time data, doctors can provide feedbacks to the patients in order to help them improve their lifestyle, or it could be effective that by observing elderly people's everyday activities, doctors could be able to detect a disease at the early stage and provide corresponding measures. Besides, patients could also be able to get access to the treatments from the doctor based on their records in an effective way.

By applying small sensor devices, the application also provides the functionality of identifying a particular disease or detecting the level of pollution using the collected data from the vicinity of the remote environment. It could also enable the application to measure the condition of patients remotely. For example, using a temperature sensor to measure the condition of the patient and send the collected data back to doctors to receive feedbacks as well as advice as soon as possible.

The situation that is described earlier is used for the first scenario of the application that patients living in remote areas need to get access to the treatments of doctors living in the city. In the second scenario, it is the case that patients staying in the hospital could be observed by doctors living in a remote area by using multimedia devices. The collected data help doctors to early detect any abnormal symptom of the patients in order to take necessary actions to address the problem.

Moreover, the telemedicine application also facilitates patients to communicate with doctors directly by using real-time video streaming technology. Any questions from clients could be answered clearly or doctors could examine the condition of patients by asking them questions. In general, the telemedicine application focuses more on the communication and observation of daily activity of patients from doctors in a hospital or remote locations using multimedia devices. Its objectives are to monitor the patient's condition and help them get access to the treatments in a cost-effective way.

2.2. Multimedia Techniques

In multimedia applications, it is essential for the raw video streaming content to be encoded for transmission process. In the scenario of broadcasting video, the coding framework focuses on the process of encoding video only once and for each time the video is demanded, the compressed video will be decoded. This process requires a more complexity of encoder side and a simple decoding process on the other side of the system. In contrast, in IoMT applications in general or the telemedicine application, seems to be more similar to the uploading process rather than broadcasting. It could be explained that it is different from the broadcasting process in which a central server is responsible for transmitting video content to multiple devices. In the case of IoMT applications, it is the process that multiple sensor network devices recode the multimedia content and send it back to the cloud server or multimedia-aware cloud system. Because of this, a new collection of requirements on video encoding is proposed in [1].

- Simple encoder: it is suggested that the complexity of computational encoding process should be executed at the cloud server due to the limited power and capability of small sensor objects.
- Tolerance in errors of transmission: it is said that error resilience is an essential aspect of the application.
- low-energy and high-speed data: ZigBee has been a good solution for IoT applications for transferring sensor data over the internet in recent years due to its efficiency in power consumption. However, according to [2], ZigBee only supports the maximum speed of 70 kbps, which is not sufficient network bandwidth for transmitting the video content over the internet in case of IoMT applications. IEEE 802.11 protocol for transmitting data with high-speed link is also considered but it does consume a significant energy resource.

- Multimedia streaming delay: due to the problem of multipath fading in network transmission, interleaving process at the sender and the process of reconstructing at the receiver affects real-time delay of the transmission.

Based on these stringent requirements, the multimedia techniques of the telemedicine application are classified into three primary classes. The first one is compressive sensing, the second one is conventional data encoding, and the final one is the distributed data encoding.

2.2.1. Conventional video coding

In a broadcasting network scenario, the multimedia-aware cloud of telemedicine application has the responsibility of transmitting video content to the devices of doctors for broadcasting. In this type of video encoding, H.26x and VPx are the two main choices for video compression. These standards focus mainly on reducing the temporal and special redundancies in video frames.

In 2003, H.264/AVC is developed for compressing video data. The standard is based on the transformation of block-based to reduce the spatial redundancy and predictive coding. In 2013 the next generation H.265 is implemented. According to [3], the new standard achieves a higher performance in distortion rate due to the increase of block size, which uses 64x64 instead of 16x16. The Intra-frame coding is also improved significantly by adjusting the number of prediction directions up to 35.

Google also develops VP9, which is a popular encoding standard for transmitting real-time video content. This standard has several common features of H.264 and H.265 including the 64x64 block size and improve the computational performance of motion vector. However, the number of prediction directions in VP9 is only 10 as compared with H.264 and H.265.

According to the result of [1], H.265 encoding standard provides the average bit-rate savings of 43.3% which is more than that of VP9. It was also reported that VP9 encoder produces 8.4% of the average bit-rate overhead using the same objective when comparing with the H.264 encoder. Based on the result, it should be noteworthy that H.265 is preferred as the coding standard for IoMT applications.

2.2.2. Distributed video coding

In this second type of video coding, it is about the transmission of the multimedia content of multiple sensor devices to the cloud center. According to the result of Shannon, the rate of lossless for X and Y is less than H(X,Y) which is the entropy of the two encoders. PRISM is one of the implementations for distributed video coding. It is the combination of the compression efficiency of intra and inter coding. At the decoder end of the application, the blocks of a frame in skip class could be recovered by the next blocks in the previous frames by using the traditional decoder. A new architecture from Stanford was also proposed. This architecture divides the sequence of video in Group of Picture (GOP). It is suggested that H.264 is used to encode the first GOP and WZ encoding standard is used for the rest of GOP.

2.2.3. Compressive sensing

According to the theory, it is said that a signal that can be compressed could be created based on the measurements of linear and incoherence. Due to that, there are various video encoding approaches have been created. One of the common and simplest methods is to consider video as a sequence of compressed images. In that case, each of the frames will be compressed independently at the encoder, sent to the decoder and then reconstructed eventually. However, it could be seen that the technique does not take advantage of the temporal redundancies in the sequence of frames. Because of that, many methods have been applied in order to achieve a better rate of data compression and performance of reconstruction process. For the improvement of reconstruction algorithm, it is necessary to keep the encoder as simple as possible while the values of temporal correlations are used at the receiver end during the process of reconstruction.

2.3. Communication Techniques

According to the proposed design of Internet of Multimedia Things in [1], the operation of the application is divided into four primary stages, namely, Multimedia Sensing, Reporting and Addressability, Multimedia-Aware Cloud, and finally Multi-Agent Systems. Each of these four stages comprises a set of different tasks to execute at each step. This section analyses the operation at each step as well as its communication with each other in the application.

2.3.1. Multimedia Sensing

Based on IoMT definition, the telemedicine application can integrate with multiple multimedia devices to transfer the collected data to the server and these multimedia devices can interact with each other and can be accessed by unique IP addresses [1]. These devices are intercepted as small objects with only limited energy and it is required to use efficiently in order to increase its lifetime. To accomplish that, the firmware application for these small devices is required to be able to perceive the vicinity of the environment so as to acquire only necessary information from the remote location. For example, camera node devices should be able to detect motion so that it only starts to record when it detect the activities of the patient, if the patient is sleeping, the devices could stop the record to save power resources. Similarly, temperature sensors only collect and sends data to cloud server when there is a change in the degree of temperature.

2.3.2. Reporting and addressability

It could be said that the multimedia data transmission from sensor devices to cloud server requires a strict bandwidth management [4] [5]. In the case of real-time video streaming, it could be considered as a key point in developing an IoMT application since the data is continuous and requires the network throughput is at least as large as the bit rate of the video streaming. In order to communicate over the network, it is necessary that the IoMT telemedicine application should be able to use communication standards that are similar to TCP, UDP, HTTP, IP, etc. It is important to notice that these standard protocols are not suitable for small sized devices that requires efficient usage of energy. In other words, the existing protocols for communication over the internet require a large number of power resources while low-complexity sensor devices are supported by low power battery. For example, so as to ensure the reliability service of the transport layer, retransmission and packet acknowledgments are required, this process costs a significant amount of time for transmitting the complete data [6]. Based on that, it is believed that these communication protocols are not adaptable for real-time multimedia transmission of sensor devices.

In order to address the problem of communicating over low power devices, the groups of IETF CORE working have created and proposed a collection of communication protocols that are considered suitable for these sensor devices, which is named as Internet Protocol for Smart Objects (IPSO) [1]. In the newly defined set of protocols, ROLL RPL is used as the routing protocol instead of RIP, which is responsible for constructing routing table to instruct packets moving from the incoming links to the corresponding outgoing links. In the network layer, 6LoWPAN is used instead of IPv4 and IPv6 for encapsulating segments in the transport layer and creating datagrams to transfer over the internet. Moreover, it is seen in IPSO protocol suite that instead of using HTTP, FTP, etc in the application layer, CoAP is used for transferring real-time multimedia content over the internet. **Table 1** summaries the comparison of the traditional protocol suite (TCP/IP) and the proposed protocol suite (IPSO).

2.3.3. Multimedia-aware cloud

According to [1], the multimedia-aware cloud is traditionally considered as a super computer with the purpose of processing a large amount of transmitted multimedia data from sensor devices. In case of IoMT, due to the requirements of communication between different devices in the network, the concept is integrated with the process of data integration between devices. In other words, it is required that a multimedia aware-cloud needs to be able to interconnect the heterogeneity of network, applications, devices, and services. Also, it is noteworthy that multimedia-aware middleware should also be responsible for supporting different multimedia services of the telemedicine application such as video calling between patients and doctors for questions and answers, real-time multimedia streaming for observing daily activities of patients and data storage for storing video content to a large database system.

2.3.4. Multi-agent systems

From the operation of multimedia-aware cloud, the application acquires multimedia resources. It is the time to decide what the application should do with these resources. It depends on the objective when developing the application. In the telemedicine application, the main objective is to monitor the client's everyday activities and help clients get better treatment. In order to accomplish that, the application needs the process of data mining and data analytics for the recorded information of patients so that the system could be able to analyse the condition of patients as well as predict the incoming events. For this reason, an automatic computer system which is defined as an agent is created in order to fulfill desires of the application. In fact, an agent is an automatic system that can work independently with the other agents to execute a task for completing an operation. It could be said that two or more autonomous agents can work in two separate processes with the purpose of accomplishing the common objective for application [1].

A multi-agent system is defined as a system that contains multiple autonomous computer programs that are independent and able to cooperate with each other to accomplish common tasks based on the demand of users. the system can also have the capability of making decisions based on the collection of commands from users, satisfying the available resources and the current permitted services [7].

3. Conclusion

The telemedicine application based on Internet of Multimedia Things architecture plays an important role in providing the necessary treatments for patients living in the remote area and essential tool for receiving feedbacks from doctors living in the remote location. The application is the combination of different components interacting with each other. Cooperating multimedia sensors for collecting real-time data such as temperature and video streaming content. Reporting and addressability provide approaches for transferring data using low-power and limited-capability devices. Multimedia-aware cloud component as a super computer for processing information of incoming streaming data from sensors or requests from doctors for accessing video content online. And finally, Multi-agent system for processing collected data including data mining and data analyzing for future prediction of the patient's condition.

IP Layers	TCP/IP protocol suite	IPSO protocol suite
Application layer	HTTP, FTP etc	CoAP
Transport layer	TCP, UDP	UDP
Network layer	IPv4, IPv6	6LoWPAN
Link layer	Wi-Fi	ZigBee

Table 1. Comparison of traditional and proposed protocol suite *[1]*

4. References

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