An optimized communication for emergency health situations

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Abstract

Emergency situations require specific needs in particular in terms of communications, data transmission and sharing. Of particular concern are the transmissions of the patient's medical history to the emergency physician, the transmission of medical streaming data collected by devices (ECG, stethoscope …) to the emergency services. This will make it possible to get real time second opinion from experts, but also to retrieve medical history of the patient, and to initiate a medical file with objective data as collected for that emergency. The relevance is to benefit from a second opinion in real time; the physician can remotely consult the patient's medical history, or add new information.

Protocols exists to transfer medical information. Thus, according to the state of the art, nowadays, we assist to the emergence of communication protocols adapted to medical domain: the Bluetooth device medical profile. Likewise, Dicom is a commonly format use to transfer medical data (images) on the network.

Nevertheless, new needs appear that are not considered in the existing protocols. For instance, the case of the stethoscope or auscultation sounds has not been considered. So, we propose to use the existing protocols (Bluetooth medical device profile, Dicom) and to integrate these data that are not considered today.

It should allow to homogenize the communications medium and better share auscultation sounds. The final aim will be the creation of the "School of Auscultation" whose goal is to reposition auscultation as a fundamental non invasive exam, thanks to the new technologies.

1. Introduction

Emergency situations require specific needs in particular in terms of communications (between the emergency physician and the hospital), data transmission and sharing. Of particular concern are the transmissions of the patient's medical history to the emergency physician, the transmission of medical streaming data collected by the devices (ECG, stethoscope …) to the emergency services. This will make it possible to get real time second opinion from experts, but also to retrieve medical history of the patient, and to initiate a medical file with objective data as collected for that emergency. The relevance is to benefit from a second opinion in real time, the physician can remotely consult the patient's medical history, or add new information so that the hospital can better prepare the patient's coming.

Thus, it is relevant to define protocols for the transmission and exchange of medical data.

Protocols for transmission and exchange of medical information have been made available for long; we can quote the Bluetooth Medical Device Profile that allows to connect an e-health device to a computing unit; Dicom standard that allows to transmit medical imaging on the network and provides readers widely used by medical professionals.

These standards have been developed based on the consideration of existing tools such as ECG, RMI, echocardiography, endoscopy… We are proposing to consider modern tools such as digit auscultation to be introduced into these standards [1,2,3].

Bluetooth is omnipresent today: on computer, on PDA… The patient has easily access to device equipped with this technology. On the other hand, physicians are more and more equipped with materials allowing to read Dicom files.

2. Communication protocols

Amongst the huge amount of medical related standards we consider in this paper to two ones that are the most relevant for our architecture that are Bluetooth and Dicom.

2.1. Bluetooth device medical profile

More and more small device for healthcare, such as glucose-meter, spirometer, ECG (electrocardiogram)... are equipped with wireless technology, in most of the case with Bluetooth radio technology.

Up to now, the Bluetooth technology is mostly focused on mobile phones. It starts addressing new markets in particular in medical environment. This led to the publication by the Bluetooth Special Interest Group (BTSIG) of a new profile dedicated to the pairing process between a medical probes and a processing unit. This profile is called Medical Device Profile (MED)[4, 5].

Devices considered by the MED profile

Medical probes that are considered are also called device or measurement equipment. They can be non-steaming such as glucose meter, thermometer, spirometer, blood pressure meter, streaming such as ECG and EEG, or both such as oxymeter (cf. table 1). The computation engine can be a PC, PDA (personal digital assistant), cellular phone,…

Table 1. list of the device types and categories

Device Type	Category	Data Type
Pulse Oximeter (SpO2)	Physiological	Streaming & Non-Streaming
EKG/ECG (3 lead)	Physiological	Streaming
EEG	Physiological	Streaming
CO2 meter	Physiological	Non-Streaming
Blood pressure meter	Physiological	Non-Streaming
Weight scale	Physiological	Non-Streaming
Heart rate monitor	Physiological	Non-Streaming
Glucose meter	Physiological	Non-Streaming
Cholesterol monitor	Physiological	Non-Streaming
Fluid balance	Physiological	Non-Streaming
Breathing intake	Physiological	Non-Streaming
Thermometer	Physiological	Non-Streaming
Peak Flow Meter	Physiological	Non-Streaming
Spirometer	Physiological	Non-Streaming
Calorie Monitor	Fitness	Non-Streaming
Pedometer	Fitness	Non-Streaming
Fall detector	Positional	Non-Streaming
Bed Sensor	Positional	Non-Streaming
Environmental Sensors	Environment	Non-Streaming
Medication Compliance Device	Compliance	Non-Streaming

One of the most important point in the medical device profile is the simplicity of connection. The simulation connection of several devices, and will provide means to synchronise them.

In addition, the reconnections are made easy to avoid to physician to lose time. Security and quality of services are guaranteed through the management of the lost of connection, retransmission of not transmitted data.

Use cases

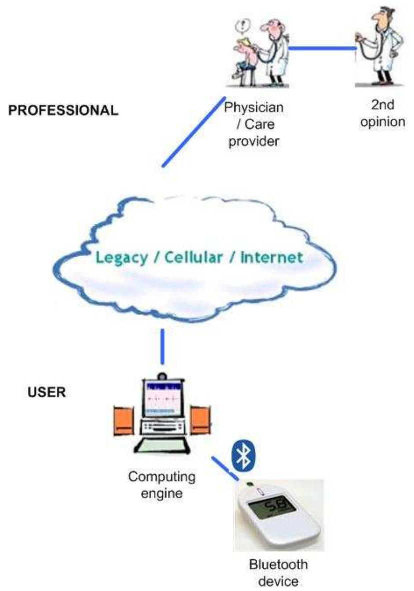

Figure 1. example of Medical Profile use with transmission to a professional

The profile proposes five use cases:

- *Chronic Disease Management or Patient Recovery:* As described on figure 1, the patient can realize the measurement of a physiological parameter thanks to a Bluetooth device. The sensor is connected to a computing engine that is in charge of the transmission of the information to a physician for analysis. It can also be imagined that a glucose-meter records and sends the data through a mobile phone. If the glucose level is too high or to low, the phone could directly call emergency to better prevent serious complications.
- *Fitness and Workout Tracking*: A fitness enthusiast uses a Bluetooth sensor (such as a heart rate monitor, a calorie counter…) to collect health data during a workout or throughout daily activities. The data is transmitted immediately or once per day to a computation engine that tracks the progress over time, customize fitness goals…
- *Medication Management:* the patient uses a pill dispenser equipped with Bluetooth. If he doesn't take his drug, an alert is send to the patient's care provider or family; an SMS can also be send to the patient himself.
- *Health and Wellness Management*: a generally healthy individual uses punctually a Bluetooth sensor to collect data about his general health. The data are transmitted to a computing unit, and then through a secure network to a central database where it can be shared with the patient's care provider. The care provider that receives the information can use it to help the patient maintain a good quality of life or to manage the patient's health goals such as cholesterol to help keep their medical costs down.
- *Remote Biosensor Measurement*: the patient turns on their medical kit which is connected to a PC or set-top box through the Bluetooth technology. He can initiate a remote call with his physician. And the latter can remotely initiate a measurement from any of the devices in the kit (blood pressure, SpO2 …), initiate a sound recording from the stethoscope, download readings from an attached peripheral (ECG, glucose meter, etc…), query status of the kit (battery level, error logs, etc…).

Streaming and non-streaming devices

The specifications provide several examples that are carrying streaming or non-streaming type information.

Examples of streaming type devices are ECG (EKG), EEG, SPO2. Examples of non-streaming are blood pressure, heart rate monitor, glucose meter, cholesterol monitor. In addition to these medical sensors, wellness and fitness sensors have also been considered in the MED devices. There are all non streaming type and are as an example weight scale, calorie monitor, pedometer. Emergency or abnormal situations are covered by the consideration of sensors such as fall detector, bed sensor…

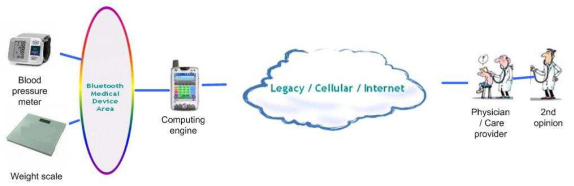

Figure 2. Medical Profile use - streaming and non streaming data – sharing of data with remote care provider

The figure 2 displays a scenario where different devices transmit data to a computing engine (a PDA). And the computing engine shows an example of scenario in which both streaming (pulse oximeter) and non-streaming (weight scale) devices are transmitted to a computing unit (a computer). Then, it is possible to share the information with a physician for a second opinion or for a more complete analysis.

2.2. DICOM

DICOM (**D**igital **I**maging and **C**ommunications in **M**edicine) is a standard of communication, viewing and archiving in medical imaging. This format groups the information in data sets; for instance a X-Ray image will also contain the patient's name. This format is described so as to associate related information together with the image in such a way that image can't be mistakenly dissociated from the information.

A Dicom object is made up of attributes (with items like name, id …) with a particular attribute that contains the image. A single Dicom object can only contain one attribute containing pixel data. For many modalities, this corresponds to a single image. But the attribute may contain multiple "frames", allowing storage of multi-frame data. For instance, three- or four-dimensional data can be encapsulated in a single Dicom object.

Dicom has been widely adopted by hospitals and is making inroads in smaller applications like dentists' and general practitioners' offices. Thus, Dicom is a format commonly used to transmit and display other medical information. Besides, physician and medical centers are more and more equipped with Dicom readers. This allows physician to dispose of images with information, comments, etc…

Dicom is currently used for X-Ray images, RMI… And the format Dicom ECG is being developed [6].

Dicom ECG

Since 2000 the widely used Dicom standard has included rules for diagnostic ECG, but for a long time, no ECG manufacturer had marketed electrocardiographs that support the Dicom waveform standard. In 2006, the first ECG manufacturer announced its adoption of the Dicom standard for diagnostic electrocardiographs. Diagnostic 12 lead Dicom ECGs sent to Dicom network servers can be reviewed on Dicom workstations in conjunction with typical Dicom images like cardiovascular angiographic x-ray and cardiac US images. Thanks to the Dicom format, the physician has access to comprehensive medical information that provides essential decision support for evaluating patients. The implementation of a vendor neutral Dicom solution allows healthcare providers to connect a variety of electrocardiographs from different vendors to Dicom servers and no proprietary ECG management system for ECG data will be required [7, 8, 9].

To summarize, it can be said that:

- Dicom is used for X-Rays, MRI (magnetic resonance imaging)…
- Dicom ECG is developing
- Today, physicians don't dispose of a standard format to transmit and share auscultations' signals.

3. New needs for new signals

The problematic we highlight here is the fact that some new signals, such as digital auscultation signals and visual representation of an auscultation, aren't considered today. So, we propose to start from the existing protocols and to expand the reflections on these new signals.

3.1. Communication sensor/ computing device

There is a need of collecting signals in streaming mode using non invasive and convivial device. Among the device not considered in the Medical Device Profile we can quote the stethoscope for the capture of auscultation sounds and the spirometer; the latter is only considered up to now in non-streaming mode to provide for the numerical analysis of the lungs capacity. Volume and flow are missing and should be included in the streaming mode.

To take the signals in a way that is as less intrusive as possible (for the physician or for the patient), the most ergonomic solution is based on the use of a wireless connection between the device and the processing unit to avoid the need for wire between the sensor and the processing unit.

Choice of Bluetooth technology

Bluetooth allows to transmit data and voice over short distances and uses high frequency signal. It is commonly used to link different wireless devices: mobile phone with a handset, a computer with a printer, a keyboard of a mouse. This economical technology starts to be commonly used for medical equipments (the frequencies used are authorized in medical environment). Therefore, the choice of Bluetooth technology for the link between the probe and the processing unit is obvious nowadays.

Besides, using Bluetooth technology allows to use wireless, low bulky and transportable devices; this is an important advantage for equipment that are used in emergency situations.

Streaming type signals that we are considering (spirometry and digital auscultation) were not considered by BTSIG during the study of the Medical Device Profile. This is one of our goal in this story to define and contribute for this new type of signals to be considered by the Bluetooth technology.

3.2. Transmission of the information on the network

Similarly, the new streaming mode signals that we are introducing have also not been considered by the Dicom standard.

Semiology and in particular the mention of auscultation point is a very important element to be able to characterize an auscultation sound. A sound will not have the same signification in term of diagnosis or pathology, depending on the point on the chest where it has been registered. Collect sounds without complementary information is not pertinent to establish a pertinent analysis and exploitation of the sounds. Thus, to each recorded sound it is necessary to associate additional information such as:

- identification of the patient
- identification of the health professional
- date of auscultation, in order to be able to follow a pathology in the time and to realize statistics about its evolution

- pathology of the patient (type, severity,..) and the certitude of the diagnosis
- description of the auscultation point
- presence of known markers such as crackles, wheezes,..

Parts of the elements that have been mentioned above are already included and well documented in the Dicom standard. This is in particular the case for naming and dates. Elements that are specific to an auscultation are missing. These are : the auscultation sound, the auscultation point, the markers, the pathologies related to pneumology and cardiology.

Consequently, we propose to extend the Dicom format to auscultation sounds, so that these signals can also be transmitted on the network and shared in a standard format and with the associated information. It aims at making available for the medical community the new works that are made around the auscultation and to better share sounds for a better diagnosis.

4. Perspectives

Share auscultation sounds

Making available for physician easy tools to collect and share auscultation sounds, will be useful for a better diagnosis, for asking a colleague for second opinion, studying and patient's monitoring.

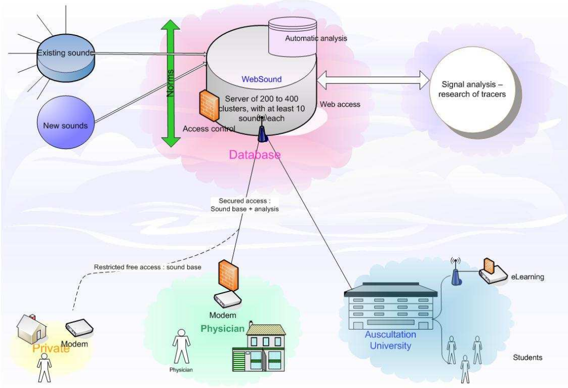

Figure 3. Auscultation's School in the ASAP project

Creation of an Auscultation's School

ASAP or "Analyse de Sons Auscultatoires et Pathologiques" is a 3-year-long French collaborative project. It is part of a collaborative telemedecine platform called « MERCURE » (Mobile Et Réseau pour la Clinique, l'Urgence ou la Résidence Externe). Mercure (figure 1) deals with projects for remote monitoring and clinical context thanks to modern tools principally coming from the News Technologies of Information and Communication.

The ASAP project, deals with a worldwide database for respiratory sounds, statistical analysis of "pathological" sounds, search of new markers, set up of a medical school for auscultation and a worldwide experts network.

An aim of the "School of Auscultation" is to reposition auscultation as a fundamental non invasive exam, thanks to the new technologies.

5. Conclusion

Our ambition is that, in a relative near future, physicians, whatever their geographical position (in their office, in ambulatory, in the hospital,…), and patient will be able to perform auscultation on a local or remote base through the use of a communicant tool to capture, analyse and transmit auscultation sounds in real time or differed time. Thus, in emergency situations, the physician will have a better access to the previous patient's medical records; he will be able to save vital parameters, exchange remotely information with a colleague for a real time second opinion… The hospital will be able to access to the information concerning a patient in emergency situation before his arrival, and consequently anticipate the medical resources or personals needed to better and faster take the patient in charge.The first step of the project will offer sharing of auscultation sounds to improve the knowledge of auscultation. The next step, based on analysis of relevant sounds that have been collected during the first step will make it possible to develop tools to help establishing diagnosis.

6. Grant

ASAP project (convention ANR n°2006 TLOG 21 04).

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