

Proposition of Health Care System Driven by IoT and KMS for Remote Monitoring of Patients in Rural Areas: Pediatric Case

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Abstract— The objective of this article has been emphasized on pediatric TV in order to contribute to the reduction of the infant and child mortality rate in rural areas, which remains high today. To do this, we combine the intelligence of WoT with the power of WebRTC. This platform, based on the WebRTC Kurento multimedia server and the Web of Things (WoT), allows Pediatric Doctors and patients, child accompanied by his mother to perform remote consultations. Kurento Media Server (KMS) allows you to create media processing applications based on the pipeline concept. The Web of Things (WoT), considered a subset of the Internet of Things (IoT), focuses on standards and software frameworks such as REST, HTTP, and URI to create applications and services that combine and interact with a variety of network devices.

For good communication, the system relies on the optical fiber network of the State Computer Agency, which interconnects all the structures of the Senegalese state. Nurses and general practitioners and specialists will rely on this network to collaborate effectively for the benefit of patients.

Keywords— WebRTC, pediatric, WoT, KMS.

I. INTRODUCTION

In Africa, particularly in Senegal, rural populations have difficulty access to health services, especially specialized care, which is concentrated only in Dakar, level 3 hospitals. The majority of specialist services such as pediatrics, ophthalmology and cardiology are available at Level 2 hospitals, it must be emphasized that state-of-the-art technology remains the prerogative of Dakar. In addition, the medical desertification in rural areas continues to grow and it becomes difficult to find general practitioners in some disadvantaged areas. This imbalance poses a real problem of access to health care and consequently of public health.

However, there is a great disparity between urban and rural areas. Of 1000 children surviving their first birthday, 31 die before their fifth birthday, in rural areas against 14 in urban areas [1]. But also the cost of care already high is increased by the costs of travel and accommodation, which makes it unbearable for most patients. Democratization of access to care is therefore a major challenge.

Faced with medical desertification in rural areas, imbalance in access to healthcare, telemedicine is a solution that many countries are adopting. Telemedicine, which is a sub-domain of e-health, is defined as a form of remote medical practice using information and communication technologies [2].

Recent research in the field of e-Health has concluded that several vital parameters can be monitored using Arduino, raspberry pi and biometric sensors [3, 4, 5]. Others have focused on WoT and WebRTC [6, 7, 8]. We are particularly interested in the relationship between WebRTC and WoT, especially in the case of e-health based on the core of the Kamailio-IMS network [9].

This platform, based on the WebRTC Kurento multimedia server and the Web of Things (WoT), allows doctors to perform remote consultations for the benefit of patients. Kurento Media Server (KMS) allows you to create media processing applications based on the pipeline concept. The Web of Things (WoT), considered a subset of the Internet of Things (IoT), focuses on standards and software frameworks such as REST, HTTP, and URI to create applications and services that combine and interact with a variety of network devices. To prove the relevance of our approach, we described a scenario of consultation between a specialist physician and a patient. The patient and the medical specialist could interact interactively on the platform.

The rest of the article is structured as follows: Section II describes the technologies used for the implementation of the proposed platform. Section III d presents the architecture of the proposed model. Section IV presents the e-health scenario. Section V outlines the methodology for implementing the K-2I-E-health platform. Finally, Section VI provides the conclusion and future work.

II. TECHNOLOGY

The idea proposed in this paper is to set up a telemedicine solution to help rural populations access quality health care services, especially mothers. This solution is based on the most powerful WebRTC multimedia server of the moment, Kurento, the Kamailio-IMS platform and the Web of Thing.

A. Kurento Media Server

Traditional WebRTC applications are standardized so that browsers can communicate directly without the mediation of third-party infrastructures. This is sufficient to provide basic multimedia services, but features such as group communications, stream recording, streaming, or transcoding

are difficult to implement. For this reason, the most interesting applications require the use of a multimedia server.

Kurento is an open source WebRTC multimedia server that allows you to create media processing applications based on the pipeline concept. Media pipelines are created by interconnect modules called Media Elements. Each Media Element provides a specific feature. Kurento Media Server (KMS) contains Media Elements capable of recording and mixing streams, computer vision, etc.

Kurento Media Server offers the capabilities of creating media pipelines through a simple JSON-RPC-based network protocol. However, to further simplify developer work, a client API that implements this protocol and directly leverages Media Elements and pipelines is provided. Currently, the Java and JavaScript client API is ready for developers [10].

Taking into account the integrated modules, the Kurento Toolbox is detailed in Figure 1.

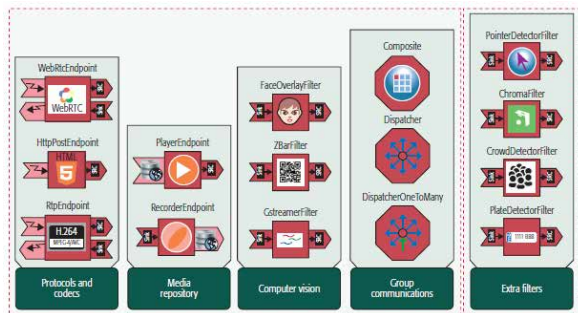


Figure 1. Kurento Media Elements toolbox

B. Web of Thing

The Web of Things (WoT) is a specialization of the Internet of Things (IoT). On the one hand, it provides an abstraction of the connectivity of smart objects. On the other hand, WoT adds a standard web standards-based application layer to simplify the creation of IoT applications. In IoT, the communication protocols are multiple (MQTT, CoAP, ARMQP ...), which creates groups of users.

The main interests of using WoT instead of IoT are the simplicity of development using APIs, standardization and simple coupling. The idea is that all intelligent objects can communicate using a Web language through an API. This API can be present in the smart object itself or in an intermediary that can act on behalf of the smart object [11].

C. Kamailio and IMS Module

Kamailio is a project initiated by SER. This is a SIP server. Starting from version 4, it has integrated the IMS modules, what offers the possibility of using it as a platform to build an IMS core network. According to 3GPP, IMS has become the standard for the use of voice and other multimedia services on LTE networks and other IP networks in an efficient, secure and reliable way. It bridges the gap between circuit-switched voice services and IP technologies to open the door to the development of multimedia services. IMS uses the SIP protocol for multimedia management. Many mandatory SIP

extensions are integrated to manage security and reliability. This management is implemented in the session control functions (CSCF).

The interactions between the different CSCF functions with elements such as PCRF, HSS, OCS and OFCS are carried out thanks to the DIAMETER protocol. DIAMETER is a protocol whose operation is based on the AVP (Attribute-Value-Pair). It is responsible for managing authentication and authorization. Because IMS is based on open standards, it is easy to use vendor platforms. KAMAILIO can be used as an IMS core network, an IMS module can be used as Proxy-CSCF. The control layer connects to the application servers (AS) in the service layer and to the user equipment (UE) via the transport layer. The CSCF-Proxy (P-CSCF) acts as the point of contact with the UE for access to the main network service; Examination-CSCF (I-CSCF).

D. ADIE optical fiber network

The State of Senegal through the State Computer Agency (ADIE) has built since 2002 a fiber optic network interconnecting 12 of the 14 regional capitals of the country to allow the various structures of the State of exchange information As shown in Figure 2 below [12].

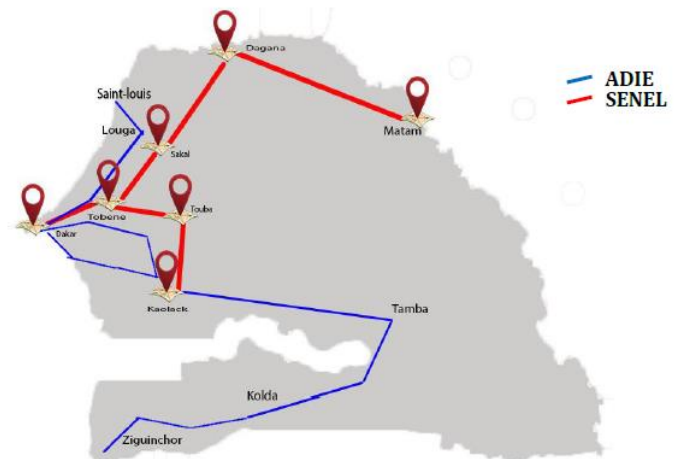


Figure 2. ADIE TF Network

III. GENERAL ARCHITECTURE

To develop the full potential of WebRTC and IMS, we propose an innovative use, which allow to extend their limits. It consists of adding new features to control, manage, and send data from the connected objects available in the WebRTC, Kamailio, and IMS endpoint environment. The goal during a WebRTC multimedia session is to be able to accede to the sensors and send data on the other side of the communication in real time and also to benefit from simple calls with IMS-IMS, IMS users. -KMS and KMS-KMS.

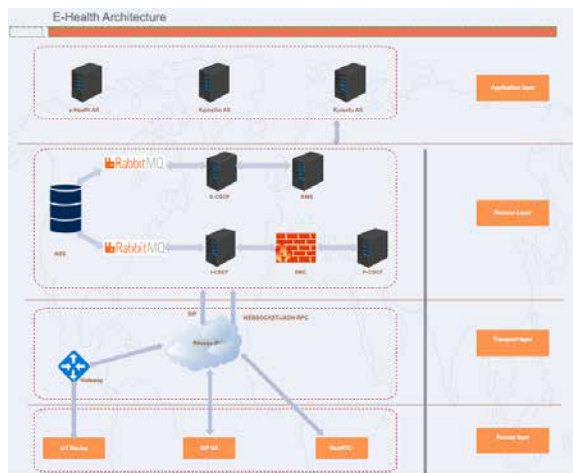


Figure 3. General Architecture of the Proposal

IV. E-HEALTH SCENARIOS

The core Kamailio-IMS network and the Kurento multimedia server will be deployed on a server within the ADIE network. The server will be accessible to clients connected to the ADIE network and also to clients outside the network, but connected to the Internet. There are two cases:

For the proposed system the following sensors are used:

A. Clients connected to the ADIE network without the need for internet

In this case, the mother moves to a hospital equipped for this purpose. Within this structure are computers, tablets or mobile phones connected to the ADIE network.

In urban areas too there is the same device ready to receive a call from the mother for a pediatric consultation with a pediatrician. Once the administrative formalities are completed, the call is launched under the supervision of a nurse and communication is established between the doctor and the mother. Figure 4 shows the communication mechanism between the mother and the specialist (Pediatrician) through the network of ADIE without internet connection.

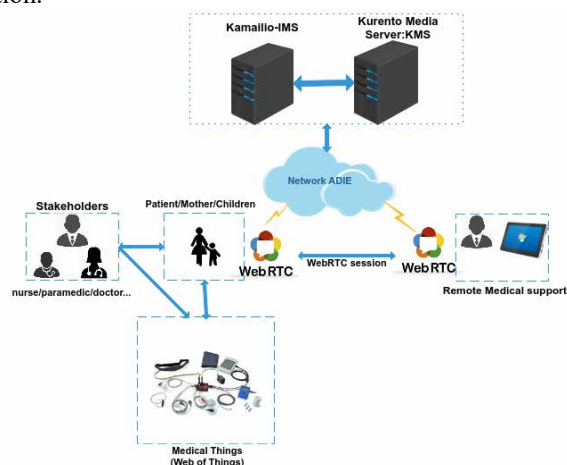


Figure 4. E K-2I-E-health architecture without internet connection

B. Clients external to the network with internet connection

The only difference with the previous case is that the mother does not move to a technically equipped hospital. Using her smartphone, tablet or computer connected to the internet, she can connect to the system and make or receive a call respectively to or from the pediatric specialist after the administrative formalities are completed. The illustration of the communication is given in Figure 5.

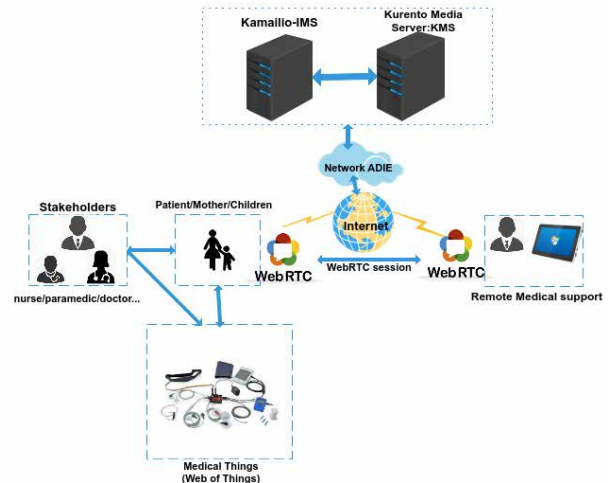


Figure 5. K-2I-E-health architecture with internet connection

V. IMPLEMENTATION

A platform using Node.js, Kamailio-IMS and KMS is implemented in this paper. On the one hand, it allows to establish a multimedia communication between two users by simply using their browser or their SIP account. On the other hand, it allows users to accede to the data from predefined connected objects. The proposed architecture is composed of three separate entities: WoT, API and Web Application

A. WoT

The first part is the WoT part. Each endpoint is considered a gateway to its set of smart objects. In addition, each user has control over these objects. The NODEMCU ESP8266 aggregation node (Raspberry) is not responsible for reading the sensors. It simply provides a gateway between the user and the sensor network, and then performs data analysis. The sensor node is the lowest level of a sensor network. It is responsible for collecting information from the sensors, performing user actions, and using communication mechanisms to send data to the aggregation node (see Figure 6).



Figure 6. WoT architecture

The ESP8266 gateway can then communicate with the sensors using one of the well-known communication protocols (Lora, Zigbee, Bluetooth, WIFI ...). In the current platform, a DHT11 humidity and temperature sensor is used. The latter is connected to the NODE MCU gateway (ESP8266) which sends the sensor data using WIFI.

In the case of e-health scenarios, all we need is portable medical sensors. They can communicate via any protocol, since the WoT summarizes the complexity of the connectivity of objects.

Using the current architecture, an implementation of the remote clinical examination is possible, where a doctor communicates with a patient using Kurento Media Server. The specialist or generalist doctor has access to a set of sensors. Then he can send the information collected by these sensors to students in real time using the K-2I-E-health platform. Finally, these data can be analyzed and commented by the actors. Figure 7 shows the wiring of the Node MCU Gateway with the DHT11 temperature and humidity sensor.

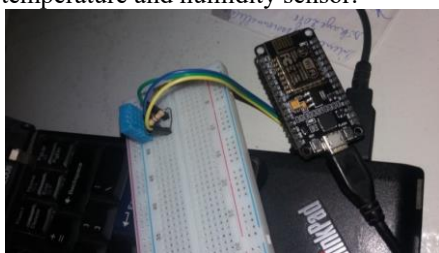


Figure 1. wiring the ESP8266 with the DHT11

B. API

We have developed a REST API capable of retrieving information collected by a connected medical device and storing it in a MongoDB database. MongoDB belongs to the NoSQL family Document-store, developed in C++. It is based on the concept of a key-value pair. The document is read or written using the key. MongoDB supports dynamic queries on documents. Since this is a document-oriented database, the data is stored as JSON, BSON style [13].

According to recent work [14, 15, 16], NoSQL database systems are non-relational databases designed to provide great accessibility, reliability and scalability to huge data. NoSQL databases can store unstructured data such as e-mails and multimedia documents. MongoDB has many security risks that can be overcome by a good, secure cryptographic system. [17].



Figure 2. Authentication and login on the K-2I-E-health

The web application can also collect information from the database and display it. Connected users can then view sensor data. Figure 9 shows that actors can access to the temperature and humidity sensor information. The same mechanism is applicable to any other sensor.

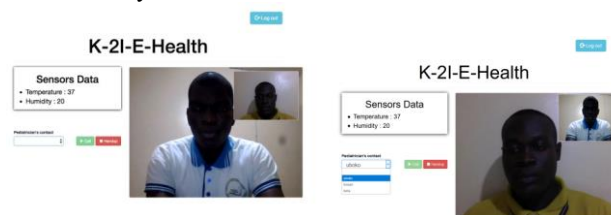


Figure 9. Communication between teacher and student

Figure 10 shows the authentication and communication steps between the students and the teacher on the K-2I-E-health platform.

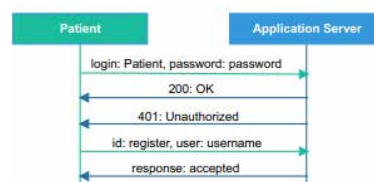


Figure 10. Patient Authentication on the K-2I-E-health Platform

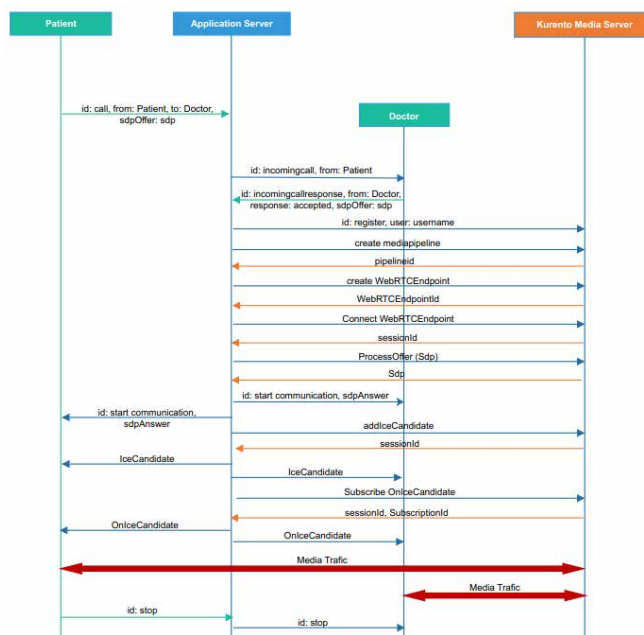


Figure 11. Diagram of communication between Patient and Doctor on the K-2I-E-health platform

VI. CONCLUSION

In this article, we propose a system for implementing a telemedicine solution to help rural people access to quality care services, including mothers. This solution is based on the WebRTC multimedia server, Kurento, the Kamailio-IMS platform and the Web of Thing.

With this platform K-2I-E-health, it will be possible for a mother to be consulted by the best specialists of the country without leaving her locality. The solution is technologically based on WebRTC and IMS. It will involve as actors: pediatricians, nurses and mothers.

The medical specialists, once received the patient's biometric data, make a decision and prescribe an appropriate treatment remotely regardless of the location using the country's fiber optic network. Our system significantly reduces expenses and increases the quality of life of patients. As modern life becomes more intense and serious diseases appear, sustained treatments become more necessary.

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