National Integrated Network For Remote Monitoring Of Patients In Benin

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Abstract*—Background: The Benin health system has challenges including: (i) the need to provide quality health care at low cost to a growing population, (ii) the reduction of patients' hospitalization time, (iii) and the optimization presence time of the nursing staff. Such challenges can be solved by remote monitoring of patients. Methodology: To achieve this, five steps were followed. 1) The identification of the different characteristics of the WBAN systems and the physiological parameters monitored on a patient. 2) The modeling of the national RIMP architecture in a cloud of Technocenters. 3) Cross analysis between characteristics and functional requirements identified. 4) The simulation of the functionality of each Technocenter through: a) the choice of design approach inspired by the life cycle of V systems; b) functional modeling through SysML Language; c) the study of the choice of communication technology and different architectures of sensor networks. 5) An estimate of the material resources of the national RIMP according to physiological parameters. Findings: The main result is that it has designed a National Integrated Network for Patient Monitoring (RNIMP) remotely, ambulatory or not, for the Benin health system. Conclusion: The implementation of the RNIMP will contribute to improve the care of patients in Benin. The proposed network is supported by a repository that can be used for its implementation, monitoring and evaluation. It is a table of 36 characteristic elements each of which must satisfy 5 requirements relating to: medical application, design factors, safety, performance indicators and materiovigilance.

***Keywords*— architecture, requirements, hospital, patient, repository, RNIMP, simulation, SysML, system, technocenter.**

I. INTRODUCTION

The health system in Benin faces challenges including: (i) the need to provide high-quality, low-cost health care, rapid growth, (ii) the reduction hospitalization time for patients, (iii) and optimization of the nursing staff presence time [1]. For a good sanitary opening of the population including the rural one, any health policy in Benin must consider the 5295 villages and city districts which are organized in 546 boroughs, 77 communes, 34 health zones, and 12 departments. To face these challenges, we can use the new communicating tools and objects through the development technologies in the areas of Telecommunications, Networks and Information Processing. Among these communicating objects, we are interested in sensors. Indeed, in recent decades, thanks to the Advanced Embedded Systems and Wireless Technologies (SETSF), the Sensors Wireless Networks (WSN) are frequently used in medical applications. Hence the emergence of Medical Wireless Sensor Networks (MWSN) used in Wireless Body Area Network (WBAN) systems, to improve the quality of care and record medical monitoring of patients.

The MWSN are characterized by their sensor nodes mobility, easy deployment and self-organization. Therefore, the MWSN are very convenient for monitoring elderly, the disabled, people at risk and people with chronic diseases and to monitor their living environment [2]. By [3] [4] [5] today, the MWSN are used to monitor vital parameters such as temperature, blood pressure or heart rate. The MWSN in the WBANs improve patient quality of life, real-time patient follow-up and emergency decision-making [6] [7].

In the implementation of RCSFM, the approaches are different according to the literature. The authors in [8] present a people monitoring network architecture accessible via Internet called INSIGHT. Access collected data can be local or remote. The parameters monitored can be reconfigured remotely. The authors justify the use of a single-hop architecture to reduce energy consumption. IEEE 802.15.4 physical layer for the network deployement. The bit rate is 250 kbps and the radio range is 100 meters. TmoteSky platforms are used in experiments. The B-MAC layer (MAC Berkeley) according to [9] is used to manage access to the medium. To conserve energy, the nodes send data to base station and spend the rest of the time in sleep mode. For this, a data reporting technique is used to define the delivery intervals. In addition, the HPL (Hardware Presentation Layer) power management module and « watchdog timer » timers are used. The authors in [10] present one of the first experimental deployments of WSNs for remote monitoring on Great Duck Island. The authors propose a multilevel architecture, each providing a data management service. Two types of topologies are used: multi-jump (mesh) and a jump. In the one-hop architecture, a node called Sensor patch is

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used to send the data to a PDA (Personal Digital Assistant). The latter relays the data to reach the base station. This station makes data available on the Web. The communications are bidirectional between the nodes. To reduce power consumption, the sensors are put into sleep mode (off the radio and the processor (MCU)). A low power MAC protocol « MAC Low power" » is developed, and hierarchical routing protocols are used. The authors in [11] proposed a monitoring system called WHMS. IEEE 802.15.4 standard is the Intra-WBAN communications support. They have developed several types of medical sensor nodes: accelerometers, ECG, pulse oximetry and reconfigurable breathing sensor. A PDA equipped with LINX transceiver is used to relay data to supervisor.

In [12] the authors present an energy efficient communication protocol for the WBAN. IEEE 802.15.4 standard is the communications support. The platforms used are of Telos type. The authors propose protocol based on a cyclic awakening of the nodes: « duty cycle ». The protocol is based on a wake cycle called SFC (Super Frame Cycle). In their experiments, the SFC period is set to 1 second. They evaluated the energy consumed by listening, transmission and sleep modes. The different consumptions measured are: 1.53 mA in sleep mode, 17.4 mA in transmission mode and 19.7 mA in listening mode. According to [13] the authors proposed a sensor network, energy efficient, applied in the military context. The surveillance system is based on inter-sensor cooperation and the organization of tasks in the network to detect and trace the positions and movements of people and vehicles. The platforms used are of the type: Mica 2. They used remote monitoring cameras controlled by a laptop, to propose a solution that allows to reduce the delay and improve the reliability of the data (minimization of the number of alarms erroneous due to false readings). A synchronization module of the clock of the nodes with the base station is also implanted. The selection of these nodes is done according to the quantity of their energy reserves. Then the authors propose two models to control the cycles of sleep and awakening of the nodes.

The authors in [14] present the necessary steps to build a surveillance system in the habitat. They propose a model called « Frisbee ». This model is based on the creation of regions consisting of heterogeneous sensors that follow a given target. To save energy, nodes that are far from the target go into sleep mode. When an event is detected, soldier nodes « sentries » support the mission to wake other sleeping nodes. Only the network area close to the event is in the active state. Whenever the target moves, the "soldier" nodes send wake-up signals to others (who must be in the listening state). To recover solar energy, the nodes are equipped with photovoltaic panels. They can be extinguished remotely via a developed control software. Localization and synchronization algorithms, as well as a mechanism that allows the deletion of duplicate notifications are also proposed. According to [15] a new approach is presented to secure the exchanges between the sensor nodes of a WBAN. The problem addressed is related to the confidentiality and integrity of the data. The question is: how do the nodes of a WBAN know that they belong to the same patient? To answer this question, the authors proposed a solution based on a « biometrics » approach. It is an identification technique based on the physiological or behavioral characteristics of the individual. This approach makes it possible to identify the sensor nodes and to secure the distribution of the encrypted key. It is based on symmetric cryptography. The choice of this biometry is based on heartbeat information called « interpulse interval (IPI) ». This solution achieves a high level of security with less calculation and memory. It is an identification technique based on the physiological or behavioral characteristics of the individual. This approach makes possible to identify the sensor nodes and to secure the distribution of the encrypted key.

The authors in [16] have designed different types of sensor nodes for the WBAN (ECG, EEG, pulse, glucose). The mechanical and thermal energy recovery means are used as supplements to solar energy (piezoelectric generators and thermal generators). The nodes of the WBAN are put in specific locations of the body to better recover the energy (from the temperature of the body). According to their experiments, an energy of 100 μW can be recovered by the batteries. In [17] the authors present the study and design of an actimetric monitoring telemonitoring system. The architecture of the authors is a WBAN network. Works [3] present the detection of attacks in a WBAN remote medical surveillance system. According to [18] the evaluation of connected objects in health applications was presented. It shows the impact of connected objects on a sanitary system and their importance in the prevention of diseases. The work of [19] show that the success of these health surveillance systems depend on data collecting and processing, to understand the environment of a subject, so that contextual care can be given to them. We note that the challenges for any medical surveillance system lie in the proper design of the network architecture. This is the goal of this work. It aims at Modeling an Integrated Patient Monitoring Network (RIMP) in the Benin health system, through the use of wireless medical sensor networks in WBAN systems. In the remainder of this manuscript, we present the methodology adopted for the work, the results obtained, the analysis of the results, the discussion and the envisaged perspectives.

II. MATERIAL AND METHOD

A. Material

In addition to resources from the literature, we used: MS Visio for network architecture, SysML for modeling, a Dell computer with 8 GB of RAM and 2 TB of disk, data on the health pyramid of Benin. In addition, we are based on the model of the WBAN remote medical surveillance system, shown in Fig. 1, and the model of a WBAN comprehensive medical surveillance system is divided into five subsystems. [20] as shown in Fig. 2.

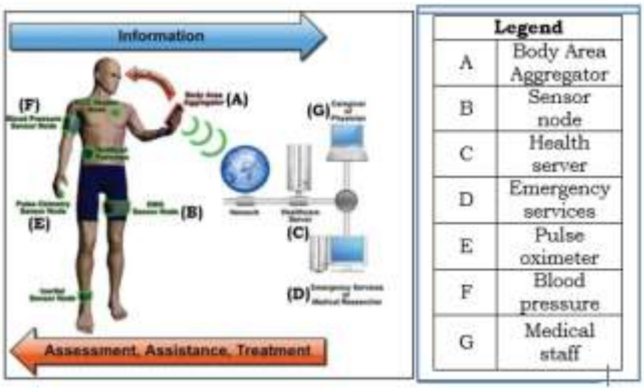

Fig. 1: WBAN monitoring system

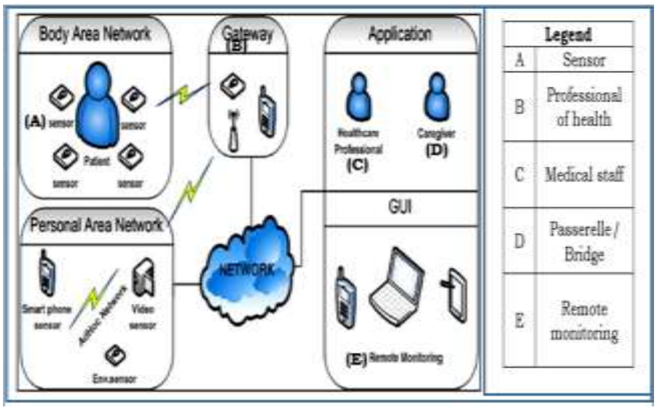

Fig. 2: Architecture of a medical surveillance system

Several medical sensors are deployed on the patient's body to measure several physiological parameters. These nodes are sensors capable of harvesting and transmitting environmental data in an autonomous manner. The position of these nodes is not necessarily predetermined.

Method

A five-step methodology was followed. 1) The identification of the different characteristics of the WBAN systems and the physiological parameters that can be monitored on a patient. 2) Modeling the national architecture of the RIMP, in the form of a cloud of Technocentres at 6 levels (National, Departmental, Health Zone, Communal, Borough, Village and City District). 3) Cross analysis between characteristics and functional requirements identified. 4) The simulation of the functionality of each Technocentre through: a) the choice of design approach inspired by the life cycle of V systems; b) functional modeling through Language SysML; c) the comparative study of the choice of communication technology and different architectures of sensor networks. 5) An estimate of the material resources of the national RIMP according to physiological parameters.

III. Results

The identification of the different characteristics of WBAN systems. We have listed in Table I, a total of 36 characteristics of WBAN systems.

Modeling Requierements

These characteristics constitute a repository for the design of a functional WBAN network of a technocenter, noted $f_c(\mathrm{WBAN})$. Thus the design function of a WBAN network is a function: of the requirement function of the medical application of the WBAN noted f_{EXappM} ; of the design factor function, noted $f_{\mathrm{facco}}(\mathrm{WBAN})$; of the communication technology function, noted f_{com} and sensor architecture function, noted f_{arch}. The mathematical model of designing a functional WBAN network can be written as following equation. (1) :

$$f_c(WBAN) = \begin{cases} f_{EXappM}(WBAN) \\ f_{facco}(WBAN) \\ f_{com} \\ f_{arch} \end{cases} \quad (1)$$

with

$$f_{EXappM}(WBAN) = \sum_{i=1}^{n} EXappM(i)$$

$$f_{facco}(WBAN) = \sum_{j=1}^{n\prime} facco(j)$$

$$f_{com} = \sum_{k=1}^{m} protocol(k)$$

$$f_{arch} = \sum_{l=1}^{m\prime} topology(l)$$

The $\boldsymbol{EXappM(i)}$ are the member elements of the WBAN medical application requirements.

The $\boldsymbol{facco(j)}$ are the elements of the WBAN design factors.

The design of a functional WBAN network aims to optimize care in the health systems and thus to have a smart hospital (technocenter). We can therefore deduce, the existence of a patient monitoring function noted $\boldsymbol{f_{suvpat}}$ and a smart hospital function, noted $\boldsymbol{f_{hosintel}}$. Thus the patient

TABLE I. CHARACTERISTICS IDENTIFIED FOR WBAN SYSTEMS

36 Characteristics identified for WBAN Systems					
N°	***Designations***	***N°***	***Designations***	***N°***	***Designations***
1	National Architecture	13	Robustness	25	Reliability
2	Local architecture	14	Usability	26	The passage ladder (scaling)
3	Dimension	15	Ergonomics	27	The flow
4	Environment / Obstacle	16	Energetic efficiency	28	The Deadline
5	Building material	17	interoperability	29	The Gigue/Jip
6	Size to watch	18	Precision	30	Loss rate
7	Mobility Management	19	Miniaturization	31	Life time
8	Respect for private life	20	Reduced detection time	32	The availability
9	Securing data	21	High security	33	Confidentiality
10	Low cost of deployment	22	Tolerances to breakdowns	34	Integrity
11	Easy installation	23	Sensitivity to Data Loss	35	Access control
12	Flexibility	24	High sensitivity	36	Authentication

monitoring function, noted $\boldsymbol{f_{suvpat}}$ is the equation (2) formed by the performance indicators function, noted $\boldsymbol{f_{inper}(WBAN)}$ and the design function, noted $\boldsymbol{f_c(WBAN)}$ added to the security function, noted f_{sec} , which is paramount in patient monitoring. So equation (2) :

$$f_{suvpat} = \begin{cases} f_c(WBAN) \\ f_{inper}(WBAN) \end{cases} + f_{sec} \qquad (2)$$

One of the major constraints of WBAN network operation is energy. We then establish that the smart hospital function, noted $\boldsymbol{f_{hosintel}}$ is expressed by the system of equation (3).

$$f_{hosintel} = \begin{cases} \max f_{suvpat} \\ \min f(\,energie) \end{cases} \qquad (3)$$

A. *Cross analysis between characteristics and functional requirements identified*

We establish then in Table II, the binary matrix of the requirements (I_i) and characteristics of the requirements (I_{i_j}) . To do this, we have added to the previous requirements, that relating to the Materiovigilance to guarantee the maintenance and minimize the potential risks of the network. Thus we release the different validation matrices of a well-designed WBAN network.

TABLE II. THE BINARY VALIDATION MATRIX OF A FUNCTIONAL WBAN NETWORK

N°	Referential characteristics of a WBAN network	I_1		I_2		I_3		I_4		I_5		Comments
		Requirement of medical application of WBAN		*Key Design Factors for WBANs*		*WBAN security requirement*		*WBAN Performance Assessment Indicators*		*Materiovigilance*		
1	National Architecture	1	0	1	0	1	0	1	0	1	0	
2	Local architecture	1	0	1	0	1	0	1	0	1	0	
3	Dimension	1	0	1	0	1	0	1	0	1	0	
4	Environment / Obstacle	1	0	1	0	1	0	1	0	1	0	
5	Building material	1	0	1	0	1	0	1	0	1	0	
6	Size to watch	1	0	1	0	1	0	1	0	1	0	
7	Mobility Management	1	0	1	0	1	0	1	0	1	0	
8	Respect for private life	1	0	1	0	1	0	1	0	1	0	
9	Securing data	1	0	1	0	1	0	1	0	1	0	
10	Low cost of deployment	1	0	1	0	1	0	1	0	1	0	
11	Easy installation	1	0	1	0	1	0	1	0	1	0	
12	Flexibility	1	0	1	0	1	0	1	0	1	0	
13	Robustness	1	0	1	0	1	0	1	0	1	0	
14	Usability	1	0	1	0	1	0	1	0	1	0	
15	Ergonomics	1	0	1	0	1	0	1	0	1	0	
16	Energetic efficiency	1	0	1	0	1	0	1	0	1	0	
17	interoperability	1	0	1	0	1	0	1	0	1	0	
18	Precision	1	0	1	0	1	0	1	0	1	0	
19	Miniaturi-zation	1	0	1	0	1	0	1	0	1	0	
20	Reduced detection time	1	0	1	0	1	0	1	0	1	0	
21	High security	1	0	1	0	1	0	1	0	1	0	
22	Tolerances to breakdowns	1	0	1	0	1	0	1	0	1	0	
23	Sensitivity to Data Loss	1	0	1	0	1	0	1	0	1	0	
24	High sensitivity	1	0	1	0	1	0	1	0	1	0	
25	Reliability	1	0	1	0	1	0	1	0	1	0	
26	The passage ladder (scaling)	1	0	1	0	1	0	1	0	1	0	
27	The flow	1	0	1	0	1	0	1	0	1	0	QdS
28	The Deadline	1	0	1	0	1	0	1	0	1	0	
29	The Gigue/Jip	1	0	1	0	1	0	1	0	1	0	
30	Loss rate	1	0	1	0	1	0	1	0	1	0	
31	Life time	1	0	1	0	1	0	1	0	1	0	
32	The availability	1	0	1	0	1	0	1	0	1	0	
33	Confidentiality	1	0	1	0	1	0	1	0	1	0	
34	Integrity	1	0	1	0	1	0	1	0	1	0	
35	Access control	1	0	1	0	1	0	1	0	1	0	
36	Authentication	1	0	1	0	1	0	1	0	1	0	

B. *Assessment of physiological parameters monitorable by a network of sensors*

Medical sensors are used to monitor 16 different groups of parameters Table III relating to: physiological variables, physical activities and movements of a person, that the data are decentralized by sanitary zone and then to interconnect the sanitary zones to have the RIMP. As a result, we see that the RIMP-B is a continuation of the RIMP

TABLE III. PHYSIOLOGICAL CHARACTERISTICS MONITORABLE WITH SENSOR NETWORKS

N°	Physiological sources or characteristics	Sensor type, Methods, Technologies
1	Combining bioelectrical (EEG) and biooptical (NIRS) neurophysiological measurements	A (M3BA) & (NIRS) technology & Brain-Computer Interfaces (BCI) [21]
2	(Real life environnement) EEG : monitoring	Ear EEG Dry-Contact Electrode [22]. BCI and NeuroFeedback (NF) [23]
3	Decoding of covert somatosensory attention (SAO)	somatosensory attentional orientation [24]
4	Pulmonary function testing (PFT) :	Depth (and) Microsoft Kinect V2 RGB-D sensors. [25]
5	HCT of VAD patients	Machine learning model to accurately predict the blood-analog viscosity during support of a pathological circulation with a rotary ventricular assist device (VAD). [26]
6	Identifying disease biomarkers (Precision Medicine)	Biomedical Big Data analytics & multi-omic data & –Omic information into electronic health records (HER) [27]
7	Glucose Monitoring in Individuals With Diabetes	Percutaneous glucose sensors with sending information by wirelessly [28]
8	[Monitoring frail elderly patients with chronic disease(s) and patients with diabetes.]: blood pressure, weight, blood glucose and SpO2,	Interoperable End-to-End Remote Patient Monitoring Platform Based on IEEE 11073 PHD and ZigBee Health Care Profile [5]
9	Person's physical activity (PA) monitoring	Smartwatch ZGPAX S8 [29]
10	38 features extracted from HRV, SC, and EEG SIGNAL (SKIN conductance (SC) : 16 / heart rate variability (HRV): 16 /SKIN CONDUCTANCE (SC : 16))	A wearable physiological sensors system (Sensors-Type : IMU, EDA, SpO2, ECG, EDA, Microphone, Accelerometer, Proximity, Respiration, EMG, EEG) [4]
11	Photoplethysmographic (PPG) signals : SpO2	ESPRIT-MLT:[30]
12	Cardiorespiratory system : Obstructive sleep apnea (OSA) detection (PaCO2), (SaO2), (ABP), (HR), (Vt), SpO2 , virtual oxygen saturation state (VSO2))	Wearable sensor measurement signals(sensors :One-lead ECG, SpO2) with the mathematical models-Gaussian processes [7]
13	Activities of Daily Living (ADL) : energy balance, and quality of life (understanding)	Insole Based, Wrist Worn Wearable Sensors (SmartStep and Wrist Sensor) and ADL Sensors : Bi axial accelerometers, magnetometer, pressure sensors, heart rate sensor, visual sensors [6], Complex Network Analysis [31]
14	Hemoglobin (HbT), concentration and tissue oxygen saturation (StO2)	Wearable optical device [32]
15	Detection of Nocturnal Scratching Movements in Patients with Atopic Dermatitis	Accelerometers and Recurrent Neural Networks [33]
16	Detect the onset and duration of freezing of gait (FOG)	Inertial Sensors (Accelerometers, Gyroscopes), electromyography (EMG) sensors, force resistive sensors, video-based gait analysis. [34]

social inclusion of the elderly or living with disabilities.

From the point of view location, as in Fig.1, the sensors can be placed at 17 different locations on a patient's body. [6] [21].

From the point of view monitoring physical activities, sensors can monitor 63 kinds of physical activity in a person's body.

From the point of view social inclusion, the network of medical sensors can monitor elderly people and living people with one of the 6 disabilities, namely: Cognitive disability, Disability in general, [2].

From the point of view technologies and applications or services, 22 technologies and 75 applications / services are available according to the literature [2], for the deployment of medical sensor networks.

C. The modeling of the RIMP national architecture in the cloud Technocenters form

The health system of Benin is organized thirty and four (34) health zones. Each health zone is subdivided into: village health unit (UVS), district health center (CSA), municipal health center (CSC) and zone hospital (HZ). Let's call a health data monitoring center by technocenter. Thus, the modeling of the Benin Integrated Patient Monitoring Network (RIMP-B), is to model first each health zone, so by Health Zone (RIMP-ZS).

Let i_n be the number of communes constituting a sanitary zone with $i_1, i_2 \ldots\ldots i_n$ the communes.

Let $j_{n'}$ be the rounding number of each commune of a health zone with $j_1, j_2 \ldots\ldots j_{n'}$.

Let $k_{n"}$ be the number of villages in each district.

Let TC_{i_n} the municipal technocentres representing the CSCs of a health zone and $TA_{i_n j_{n'}}$ technocenters of districts representing the CSA of the districts of each commune with $i_{1\ldots\ldots} i_n ; j_1 \ldots\ldots j_{n'}$.

For example:

For TC_{i_1} the technocenters of the first commune of a sanitary zone, we have $TA_{i_1 j_1} \ldots\ldots\ldots TA_{i_1 j_{n'}}$ technocenters of the boroughs of this commune.

Let $TV_{i_n j_{n'} k_{n"}}$ be the village technocentres representing the UVS of each district with i_n going from de i_1 to i_n ; $j_{n'}$ going from j_1 to $j_{n'}$ and $k_{n"}$ going from de k_1 to $k_{n"}$. For example: for i_1 and j_1 we have them $TV_{i_1 j_1 k_1}$ to $TV_{i_1 j_1 k_{n"}}$.

Let TZ_l be the technocentres representing the monitoring centers of the health zones with l ranging from 1 to 34. Because Benin's health system has 34 sanitary zones. The Technocenters cloud of the Integrated Patient Monitoring Network of a health zone (RIMP-ZS) is shown in Fig.3.

Let TD_m the departmental technocenter regrouping the technocenters of the zones (TZ_l), representing the departmental health departments (DDS). We then have the technocentres cloud of the Departmental Integral Patient Monitoring Network (RIMP-DDS), shown in Fig. 4.

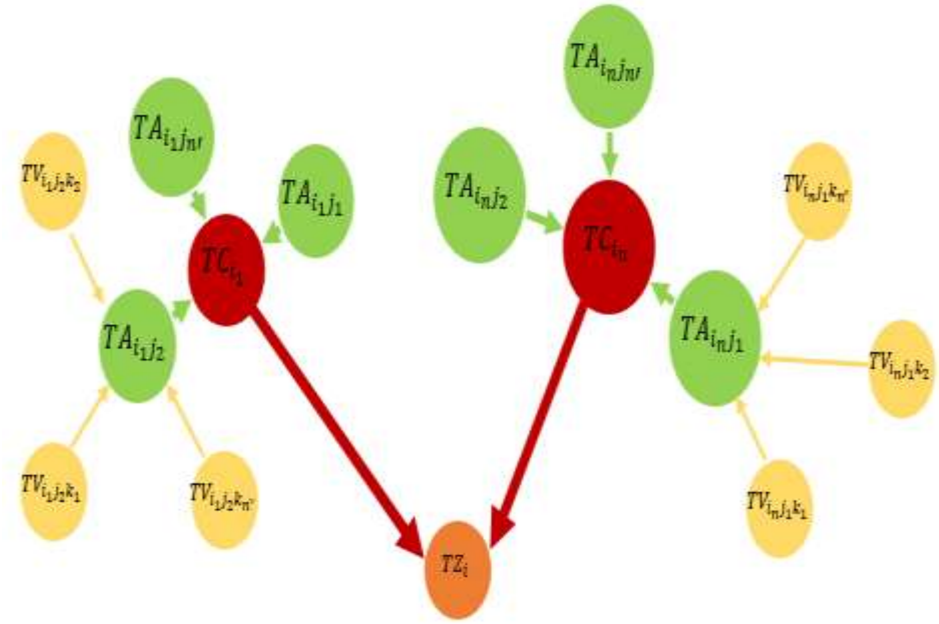

Fig. 3: Technocenters cloud of the Integrated Network for Patient Monitoring of a Health Zone (RIMP-ZS)

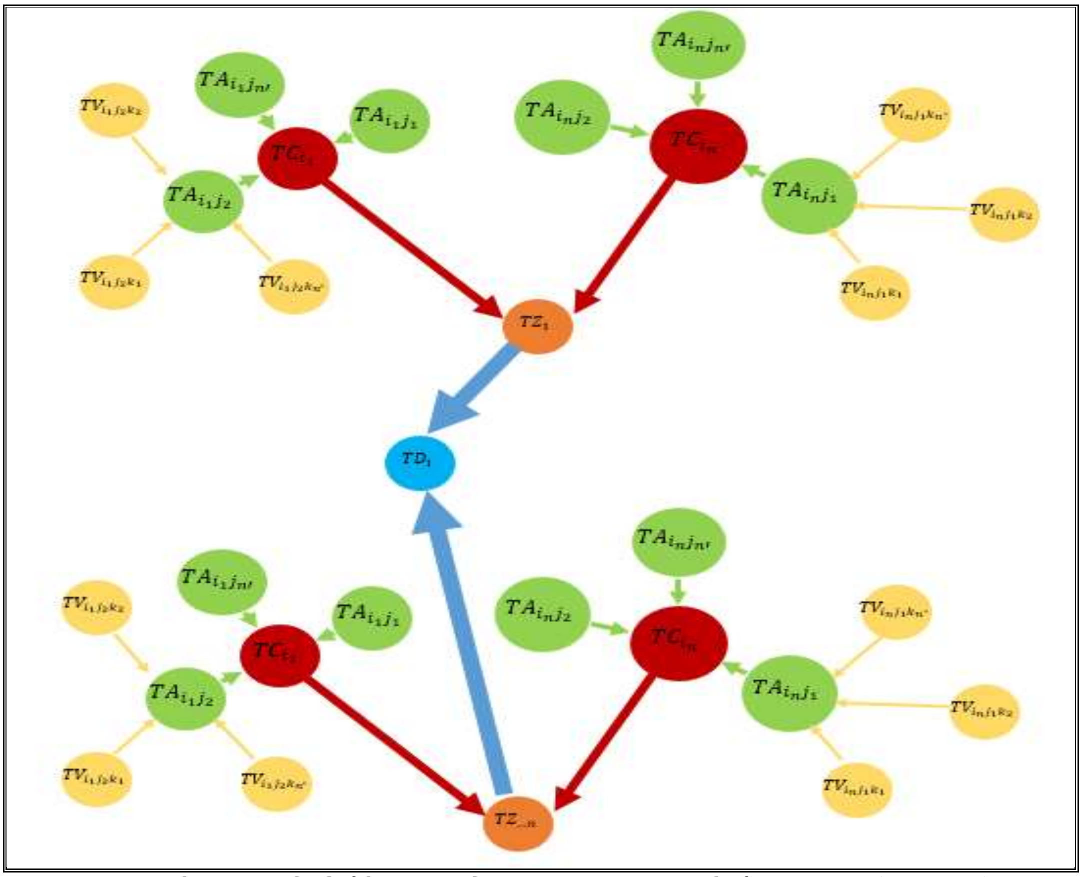

Fig. 4. Technocenters Cloud of the Integrated Patient Monitoring Network of a Department (RIMP-DDS)

A series of these clouds gives the national network shown in Fig. 5.

D. The simulation of the functionality of each Technocentre: software architecture

The software architecture of the smart hospital shown in Fig. 6, shows the various management software modules from the patient embalmed that will allow better monitoring.

This architecture also shows the exchanges between the different servers. The data server Fig. 6 is responsible for collecting the data (physiological and actimetric parameters) and storing them in a technocenter database via the acquisition module and / or the network. This same module sends this data to the display module in order to follow the patients in real time and to display the alerts in case of detection of critical cases. The omics data are sent to the calculation server via the send / receive module and stored in a second database (zone, departmental, national). The delayed calculation module retrieves these data in order to generate the thresholds of the behavioral deviation, nocturnal agitation, prolonged immobility, residence time in the bathroom, difference between physiological parameters and others. These thresholds of the different physiological parameters are therefore sent directly to the database of the local technocentre. This is to allow the diagnostics module to compare them with the current data and generate alerts (on the real-time application and phones) in case of overruns.

E. Estimation of the material resources of the national RIMP according to physiological parameters.

An analysis of the different parameters that can be monitored with the population size of each village (or city district), shows that the size of the RIMP resources would be unique for each health zone. Moreover, the size of the RIMP would also depend on the different services offered by each branch of the sanitary system. (UVS, CSA, CSC, HZ). An estimate of the RIMP material resources would then be a function of the different elements involved. Let's designate by f_{mat} the material resources function. This function f_{mat} is size dependent T data to monitor which itself depends on the size N population and number of sensors N_c placed on the patient. This hardware function also depends on the number of simultaneous data access $(Np + Ncm + Nadm)$, with Np the number of patients, Ncm the number of the medical profession and $Nadm$ the number of administrative technocenters. Function f_{mat} would be equal to equation (4).

$$f_{mat} = f(T, Np, Ncm, Nadm) \qquad (4)$$

IV. ANALYSIS AND DISCUSSION

In the face of the challenges of the Benin health system, our solution aims to make it efficient from the villages to the cities. The solution aims a powerful health system allowing to anticipate in view of several data that it will provide. The implementation of this solution will go through several stages (from the analysis of ICT potential in the 5295 villages and city districts to the technological choice).

Several design factors for WBAN networks (scalability, quality of service (QoS), power consumption, wireless technology) should be considered [22]. Many works in the literature deal with the application of WBAN networks for health [16] [11] [8] [18].

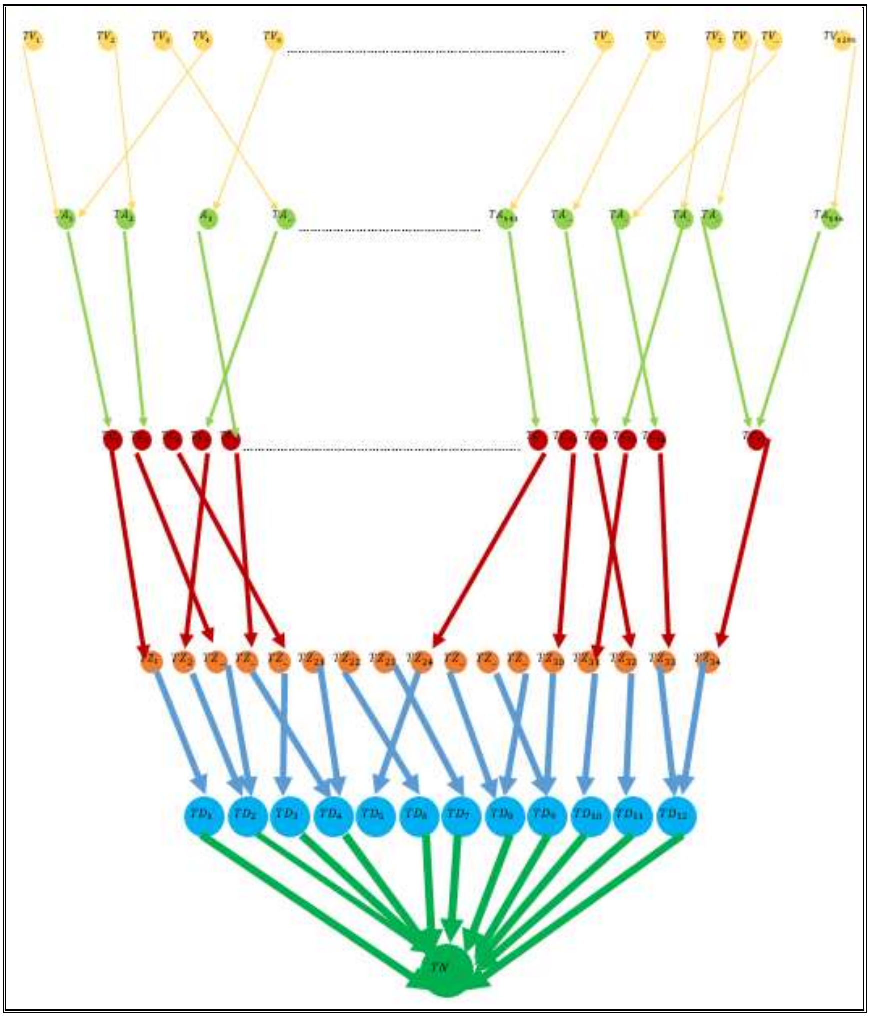

Fig. 5. Technocenters cloud of the Benin Integrated Patient Monitoring Network

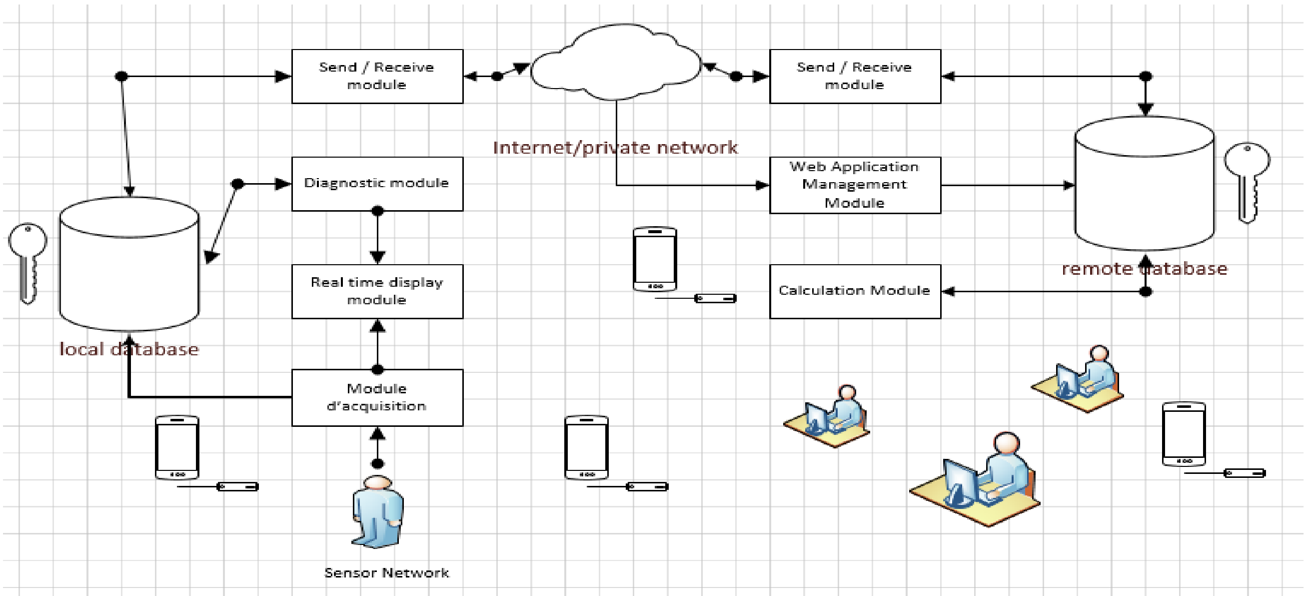

Fig. 6. Software architecture of the smart hospital

This work presents on the one hand the characteristics and the requirements of the medical application of WBAN networks, and on the other hand the characteristics and design factors of these networks.

The design of WBAN networks also involves security requirements. (WBAN and traditional networks have the same) security requirements [19].

These works are different from ours since we propose a repository of 36 elements according to five requirements that the design must follow for the patient monitoring network. In addition, each requirement is a matrix block that serves as a compass for the design and / or evaluation of a patient monitoring system. (Several technologies have been used in) WBAN networks for patient monitoring. security threats or attacks can occur such as: modifying and listening to medical data, activity detection and location, counterfeit security system is needed on different block [19].

Our repository takes this into account in terms of security requirements. Network data flows and capacity are among the parameters that impact network performance. high-speed wireless technology choice provides benefits to meet network scalability and increased numbers of people being monitored. On the other hand, with some technologies we have low energy consumption but significant delays (generation) and / or low transfer rates.

The chosen technology will have flow and energy consumption compromission. Several technologies are used in patient monitoring architectures to provide multiple services [23] [17].

That is why we have started to identify all the technologies used with the different services. From there we got a roadmap for any surveillance system with the different possible positions where the sensors can be put on a patient body. Here is expressed the strength of this work.

Compared to several works in literatures where technological choices are proposed [24] [20] [17] [25], our work presents a basic model for setting up a patient monitoring network, especially in the case of the Benin health system.

V. CONCLUSION

Wireless Medical Sensor Networks (MWSN)/WSN are a revolution in wireless computer networks. Choosing a technology will depend strongly on the solutions offered and the vision of the proposer. Features such as power, data flow and parameters related to scope, cost, security and number of nodes should be considered. In the case of Benin, the need to have a health system that responds to the many challenges and considers the population at the base is no longer to demonstrate.

This justifies the guidelines of this work which proposed a reference system for the implementation of a patient monitoring system, which modeled a network for the Benin health system.

This work also presented a point of the sensors and the different physiological parameters that can be monitored according to the services offered. The implementation of this proposed RIMP-B will go through several stages.

Future work will consist of a field survey across the country to:

1) Validate the data of the sanitary cartography;
2) Identify ICT potentials and different constraints of each localized health mapping;
3) Propose the different technologies to be used in each health locality for the proper functioning of technocenters;
4) Propose an algorithm for calculation the material resource applicable to each level.

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