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Internet of Things: A Healthcare Ubiquitous-Based Approach for Medical Seizure Prevention

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Abstract

Wireless body area network (WBAN) is a forthcoming technology which interconnects devices all around a body. Related to Wireless sensor networks, this smart technology is closely connected to many fields such as health, gaming and sports. Due to its polyvalent functions, many tiny electronic connected devices offer a research horizon capable of resolving several issues, especially in the internet of things such as healthcare, smart buildings, edge computing and so on. Due to their performance for designing and implementing complex wireless sensor network architectures, multi agent systems can be used to face wsn's limitations such as resources, topologies, sensed data computation, and so on. This paper proposes a new multi-agent systems-based approach applied on a ubiquitous healthcare system, helping medical staff to diagnose and prevent health seizures.

Keywords: Internet of Things, Wireless Body Area Network, Machine Learning, Multi-agent systems, Seizure detection, Healthcare.

Introduction

Because of the recent advancements in electronics and computing sciences, the development of efficient smart sensors becomes handy. This gave a powerful boost to the development of technology in the service of humanity in goal to enhance one's quality of life[1]. Nowadays, many fields are closely connected to wireless sensor networks viz. Healthcare[2], military[3] and entertainment[4]. Sensors are responsible of exchanging sensed data among network nodes and then send all data or targeted ones to base station. To monitor vital body parameters and movements, developing small-devices that needs short-range and large data rates considers many technical challenges to perform well. Designed for this purpose, Wireless body area networks are a typical variety of Wireless Sensor Networks that can interact with Internet Of Things to incorporate a limited number of tiny sensors implanted on, in or around bodies in order to gather vital data. It uses proprietary PHY and MAC protocols[5] simultaneously with existing WPAN standards. The literature discusses mainly two used technologies: the IEEE 802.15.4 Zigbee standard and the IEEE 802.15.6 BAN standard[6]. WBAN is getting attention worldwide for contributing to health care infrastructures in order to monitor and enhance patients' physical and mental conditions. In case of any emergency, people, especially elderly and patients with complex chronic diseases cannot frequently visit doctor(s) because of their motion trouble, indeed require Ubiquitous HealthCare (UHC)[7]. Despite the continuous research and development efforts from both industry and researchers, wireless sensor networks face many problems such as network topologies, power consumption and limited resources[8].

Therefore, the reminder of this paper can be organized as: After this brief introduction, Section 2 represents the IEEE 802.1 wireless personal area networks standards. Section 3 deals with the main healthcare monitoring process. Section 4 introduces and handles the applicability of the proposed architecture based on a muli-agent system. Current work has been concluded in section 5.

IEEE 802.15 WPANs

The 802.15 group of IEEE standards specifies a diversity of wireless personal area networks (WPANs) for different applications. The current list of active projects can be found on[9]. This group is divided into ten task groups with different specificities. We describe briefly the three commonly used ones:

IEEE 802.15.1:

The first task group of WPAN is based on Bluetooth technology[10]. It supports ad hoc, terrestrial and wireless standard for short-range communication. Moreover, it defines PHY and MAC characteristics for wireless connectivity. Designed for low cost devices, this technology includes three classes supporting variable ranges from one to 100 meters.

IEEE 802.15.4:

Zigbee is a low tier, ad hoc, terrestrial and wireless standard based on 802.15.4 standard. It is used to create a PAN with small and low-power digital radios. Its low power consumption limits transmission distances to 1–10m line-of-sight, depending on power output and environmental characteristics. This standard proposes three topology types out of four supported by 802.15.4. These common topologies are illustrated in Fig. 1. The Zigbee standard defines the network layer architecture for star, tree and mesh network topologies and affords in the application layer, a framework for application programming.

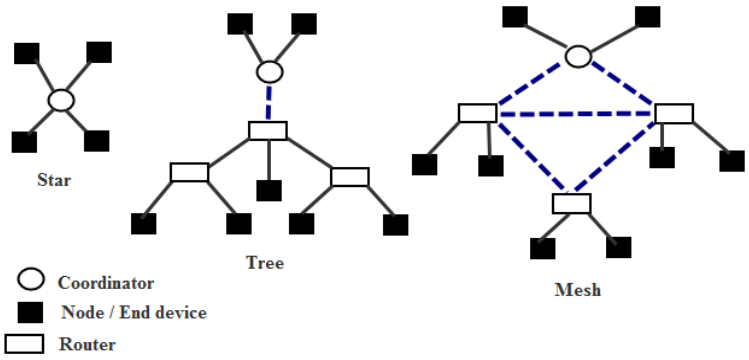

Fig. 1 Zigbee standard's topologies

IEEE 802.15.6:

BAN task group is formed in November 2007 to focus on a low-power, low-complexity and short-range wireless standard. With its special design, it aims to optimize devices and operated on, in, or around bodies. The task group serves a variety of applications including medical (e-health) and also entertainment (gaming, sports). This makes the communication much easier and more comfortable. Figure 1 describes a wban architecture where sensors gather and communicate vital data to a sink.

Health monitoring using wireless body area networks

In the few past years, thanks to the significant advances in MEMS, agent-based technologies have convinced many researchers to focus on using these systems. The aim is to provide smart solutions capable of solving the main problematic areas of the internet of things. Indeed, several works deal with wireless body area networks and multi agent systems as a part of the IOT challenges. A Wban consists of a multitude of different bio-sensors, gathering vital data:

- Ecg - Electrocardiogram
- Emg - Electromyography
- Eeg – Electroencephalography
- Blood pressure & glucose
- Movement - Activity
- Pressure – feet steps.

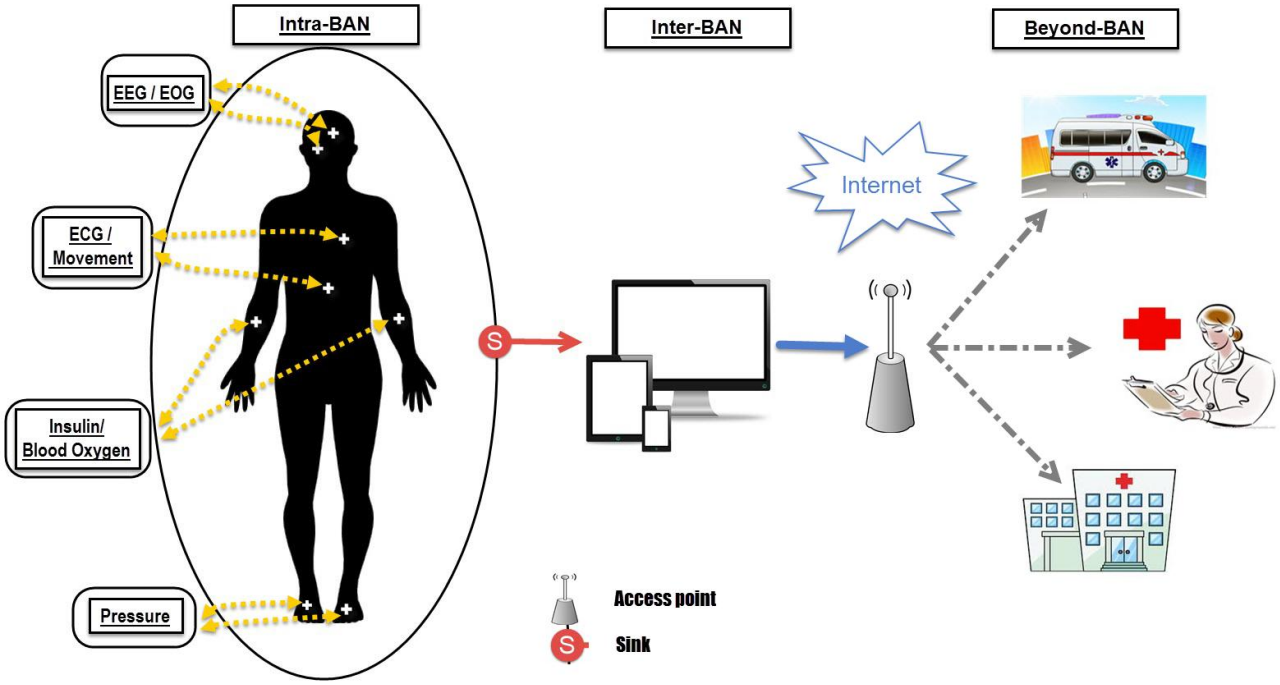

Fig. 2 Wban architecture for healthcare monitoring

Fig. 2 shows a wban architecture specially dedicated to healthcare monitoring system supervised by one ore many qualified members of the medical staff.

Agent Architecture

The wireless body area network architecture is managed with the help of a multi-agent system. All agents have their own goals, and can communicate to rich the final aim which is sending a signal to the doctor. This architecture is depicted as follows:

Patient Sink Control Agent

This agent is a real-time sensing data gatherer. All bio-sensors can communicate and sense data separately or together. It depends on both medical needs and anomalies.

Database Storage Agent

This agent is responsible of storing sensed data. A data-reduction is also necessary to target the needed information and improve the storage efficiency. In order to optimize data analysis process, retaining the meaningful parts of the global knowledge is crucial. Data are reorganized in a transactional or/and a decisional database.

Data Analyst Agent

This agent is responsible for analyzing stored sensed data. It has three major roles:

1. Consult the medical rules reference.
2. Apply a data mining algorithm (#Apriori) on the database in order to discover interesting relations between parameters. Learning the association rules provides us an idea of using different measures of interestingness. It will compare the results with the consulted medical rules (written by the doctor).
3. Communicate these targeted rules to the Broker Agent.

Broker Agent

The main role of this agent is to prevent the doctor if a rule's support and confidence are greater than a defined minimum threshold.

At the end of the process, if the doctor considers the necessity of updating the medical rules reference, this medical support will be fulfilled with the new learned rules. It will help for an ulterior data mining learning process.

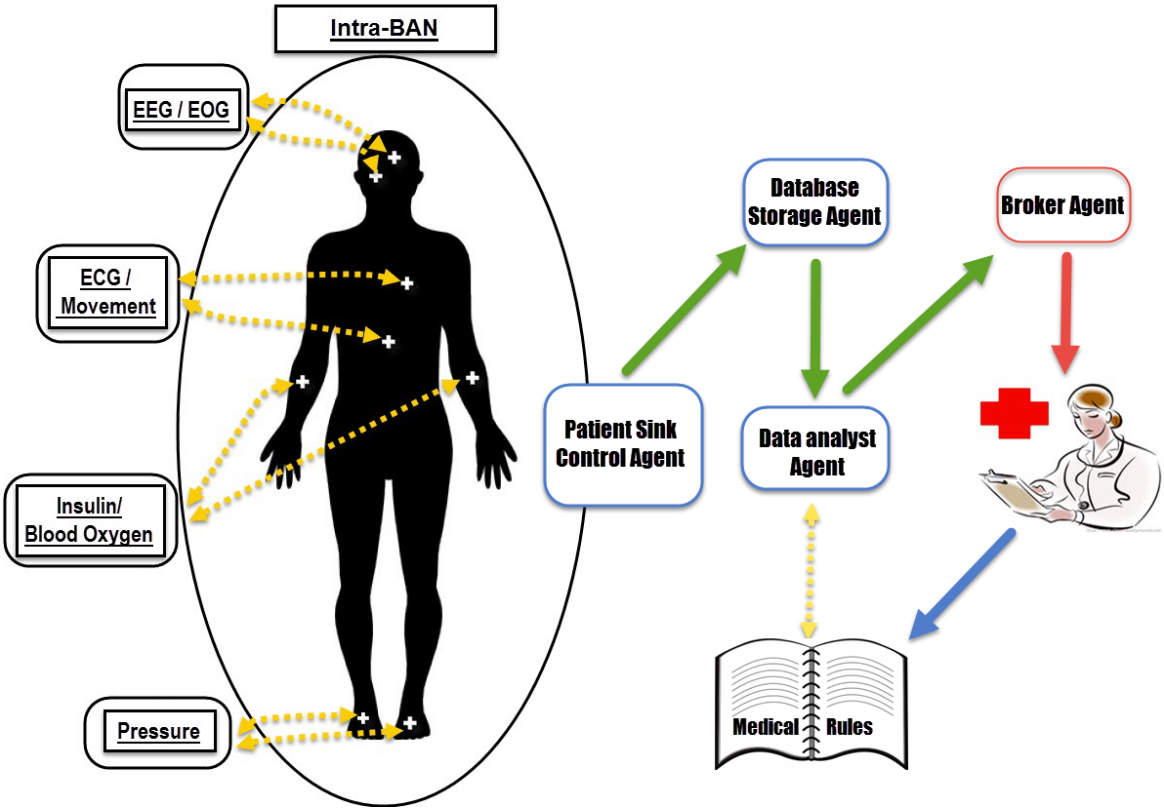

Fig. 3 Multi-Agent based monitoring architecture system

The proposed architecture is shown in figure 3. It contains the explained process, from gathering data to fulfill the new learned rules.

We present the used algorithm used in the proposed architecture, table.1 shows the used algorithm in this architecture.

Algorithm

--- Begin

Step 1: Input = Real-time gathering of bio-sensed data from the wireless body area networks sensors.

Output = Communicate the information to the Database Storage Agent.

Step 2: Input = Bio-sensed parameters.

- Apply a data reduction to only keep the targeted information.
- Transformation into a Transactional || decisional database
- Learn the association rules using the Apriori data mining algorithm
- Compare the new rules with the medical

rule's reference
*If (Rule(k) =! *Reference Rules)*
then
Output = Communicate the rules to the Broker Agent.
Step 3: Input = Learned rules + fixed support and confidence thresholds.
If (Support(i)>Threshold || Confidence(i)>Threshold)
then
Output = Prevent the doctor of the rules.
Step 4: Fulfill the medical rules reference with the new rules if the necessity is considered by the doctor in goal to enrich the learning process.

Loop (Go to **Step 1**).

---- End

#Applied_Apriori_Algorithm

// Initialization :

```
Db=Database; min_sup=minimum support;
Fre_It= Frequent Items; T=transaction;
Counter=Number of candidates in Gen_Cand;
---- Begin

For(k=2 ; Fre_It(k-1)!=0 ; k++)
{
  Gen_Cand=candidates generated from Fre_Itk
  Foreach (T in Db)
     do
     {
       Counter++;
       Fre_Itk = Gen_Candk
     }
}
return

---- End
```

Table 1. Proposed approach + Apriori Algorithm

Conclusion and future work

The wireless body area network architecture is managed with the help of a multi-agent system. In this paper, we introduced an agent-based approached capable of handling the healthcare process form gathering bio-sensed data to generating association rules. The role of the doctor is crucial because it is needed to fulfill and update the medical reference in order to enrich the learning process. This paper can be useful for a common usage to understand the key concepts of WBANs used standards in a healthcare monitoring system. As a future work, the challenges of this approach will be examined and an application oriented Internet of Things will be done. In order to do so, this approach can be combined with other techniques such as the expert systems algorithms. A multiple sequence of forward and backward chaining can be processed using inference rules to extract more data. in order to trigger new inferences.

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