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A Comparative Study of ANT+ Technology-Based Healthcare Systems

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Abstract: ***Wireless Body Area Network has become major point of focus. It requires ultra-low power consumption because of limited available resources. Many standards are developed to meet this requirement such as zigbee, Bluetooth, ANT+ etc. Recently, ANT+ technology has become more popular because of its strength and flexibility. An ANT+ protocol is mainly used to provide health related services. In this article, we are focus on ANT enabled systems in health care domain and make a comparative study which shows all the existing system's functionality and perspective.***
Keywords: Advanced and Adaptive Network Technology (ANT), health care, ANT+ protocol, medical monitoring devices, wireless body area network

I. INTRODUCTION

In this rapidly growing world, various countries are having same health issues for instance rapid urbanization/industrialization, ageing of population and sickness that is non-communicable. In the recent years, wireless technology detects environmental data from certain area of observation and applies collection and aggregation approach on it. One major focus of Wireless Body Area Network (WBAN) is to improve health care. According to World Health Organization (WHO), 63 million of deaths happen just because of non-communicable diseases such as hypertension, mental disorders, diabetes and heart attack. Regarding 7.5 million deaths happen due to high blood pressure in Pakistan [1]. WHO evaluates that because of cardiac disorder, about 17.5 million of death happened. It is approximated that 6.7 million deaths happened because of stroke and 7.4 million are because of congestive heart failure/disease. To diagnose patients on time and reduce health issues, a system is required which detects health issues before critical condition arises.

In recent years, mobile technology has become trendier. A smart phone acts as a central device to communicate and to deliver information in everyone's life. Because of its remarkable growth in latest intelligent devices, smart phones are expected to be more closely embedded in our daily routine life [2]. Health monitoring industries make it possible to integrate mobile phone system with different sensors and also enable communication with other external sensors that allow new applications to capture health related conditions from sensors to smart phones by following communication protocol such as Wi-Fi, Bluetooth, Zigbee, ANT+ etc.

ANT+ is an admired communication protocol which is designed to permit communication between self powered devices. The purpose is to easily collectable, robotic tracking and transferring of information of individual's body parameter by using a sensor. The capability of transferring information between sensors is carried from Advanced and Adaptive Network Technology (ANT) [3]. ANT is proprietary protocol due to its ultra low energy utilization which is responsible to transferring of data from one device to another wirelessly in more automatic and flexible way [4].

The protocol relies on Wireless Personal Area Network (WPAN) because it easily captures, communicate and monitor data by tracking sensor. Ant+ protocol is used to monitor body related factors, sports and fitness services, home activity monitoring and captures data related to medical or health within the range of 20 meters.

It uses low bandwidth as it splits its bandwidth in the range of 125 channels which is equal to 1MHZ and its interval of broadcast message is less or equal to 150 microseconds for 8 bytes of data. The protocol also permits interoperability among devices, introduces data structure and handles special network keys to determine different networks [3]. ANT+ protocol enabled sensors uses coin cell battery which has long battery life. It reduces the headache of battery replacement because it also uses low power utilization. It transmits its data in 8 bytes data packets by using radio frequency channels. ANT+ protocol is mainly used for health care domain for example sports and fitness purpose, smart home environment. The protocol has the facility of small stack size, more extensible, adaptable, handling difficult network topologies and assisting reconfiguration of ad-hoc network. Currently ANT+ technology is offered for different purposes and devices such as Multi sport speed and distance, bicycle power, Heart rate monitor, temperature and weight scale etc [3].

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In ANT protocol, channel is established by pairing two devices: one is known as slave and the other is called master. In case of channel establishment, both devices need to agree upon same message period, frequency, and unique channel ID of master. ANT uses Flexible and Interoperable data Transfer (FIT) scheme to save and share data. ANT-FS (File Share) is used to transfer FIT file between two ANT permit devices wirelessly. For confidentiality purpose, ANT-FS works with a unique network key. Section II discusses some ANT+ technology systems. Section III shows some comparative study between these systems and in the last Section IV, we conclude and discuss our perspectives and suggestions.

II. LITERATURE REVIEW

There are introduced many systems that use ANT+ technology to assist people about their health. The system proposed in [5] examines a health monitoring system whose aim is to capture patient's health condition remotely for the purpose of later prediction and analysis. This ontology provides flexible and scalable architecture, desktop interface and auto configuration by getting and transmitting person's real time information using wearable device. To provide health services, the author mainly focused on heart patients by capturing its heart rate, distance, temperature, cadence and footsteps. For analysis purpose the encoded and integrated information is then converted into FIT files which is later available for download by other authorized applications. The system is basically web based and mainly focused on heart patients. The author further extends their system in by using three kinds of ANT+ sensors profile such as temperature, heart rate and foot pad [6]. The system allows users to auto sensor setting features by using XML file. Manager module is developed in this ontology which enables data acquisition. ANT libraries assist to transmit data from ANT USB stick. For device identification, ANT controller is used which distinguish device according to its device profile and event messages are proceeded. Each device profile has a particular timer which depends on its message rate. For data transmission the authors use socket.io which is JavaScript library to send data in real time. For storage purpose, the system uses MongoDB, a non-relational database having a flexible schema and scalable features. By introducing web-based data acquisition system, the authors provide interoperability along many factors: data structure, interpretation, device connectivity, transmission and storage [6].

The authors in [7] present a home E-health care system which uses ANT based biofeedback and gait analysis system for the purpose of managing balance for gait and post stroke associated psychoanalysis patients. The system uses 2 ANT enabled sensors like foot pressure sensor and a transceiver unit which is placed in shoes. A central node is also used which is joint with transceiver unit which may be attached with a chest belt. When ANT enabled sensors are in active mode, they transmit their signals to an android based mobile device. For fall prevention, the system is able to produce signals like audio warning through personal server like smart phone [5][7].

Cardiac early monitoring has become a major subject. Approximately 23 million people died in the world with heart failure [8]. According to our research, at recent years the situation has been altering by introducing cheap and reliable home treatment systems that have come to the market and sooner the patients must be treated at home instead of hospitals [9-10]. Several systems are developed to know about cardiac arrest and early detection from cardiac disorder [11-12]. In [13] the researchers propose a health monitoring application for aged people. The main focus of the researchers is to detect cardiac disorder. For data monitoring the system uses ANT+ technology to capture real time data. An algorithm is also generated in which patient's doctor or care-taker sets some standards and patient's min and max heart rate is defined to detect cardiac disorder. A cardiac belt is also placed to subject's chest to distinguish real time monitoring. In case of any disorder occur the ANT+ enabled sensor transmits signals and a toast is displayed to smartphone in which the application is installed. But the system is just to detect cardiac disorder by using a sensor which is not enough for patient [13].

In another system [14] the researcher introduces a healthcare system which aims to monitor patient's heart rate, temperature and position in real time and if any serious condition occurs it sends medical help and stop vehicle by using a controller. The system's output can be displayed in three ways which are android mobile application, LCD and website or webpage. Data communication for android based application uses ANT+ and Bluetooth technology and for websites, it transfers data through GPS and ANT+ protocol. The researcher sets interval for normal ECG state is among 70bpm (bit per minute) to 80bpm which is not suited to all type of user profile.

There are numerous systems which are working on many features of ANT sensors. Such systems [15] introduced DFC (Digital Fitness Connector) which allow patients to monitor their physical condition in real time or post workout which is compatible for numerous smart phones and health related sensors.

It provides users to choose health and fitness devices of their own choice. The authors detect some problems from their research and realize that many existing systems restrict users to take facility from open-air physical activity like jogging and some systems using GPS and accelerometer to detect user motion have various issues.

By suggesting DFC, the authors tried to overcome these problems. The system allows users to capture, store and transmit physical data in real time. It acts like a center to take signals from ANT sensors and send it to mobile device with the help of an extra gadget.
The author in [16] expresses data transmission, storage and visualization in both windows based and android based platform. The main object of the researcher is to look at the problems of data collection and connection from ANT+ sensors. Collected information is sent in the form of FIT file and it is visualized in application screen. The researcher used a standardize database by using SQLite. SQLite is an embedded database which is free to use and allows program to run without downloading database management system. The database is easy to use, flexible and embedded in android platform without having separate server database [17]. The author monitors two ANT+ sensors which is heart rate and temperature in real time and has the flexibility to add more sensors in later work. After measuring data, heart rate, temperature and time stamp is stored in FIT file. For window application, visual studio is used for this purpose by using ANT USB stick. There is another system which is developed by using both platform android based and window based. The researcher in [18] developed a system to facilitate patient by measuring patient's blood pressure and weigh scale values. The system is able to capture data from ANT+ sensors and the sent it to smart phone device. At the same time the collected data is then send to medical entity such as doctor or care-taker through internet for further analysis. The medical entity is capable to contact the patient if needed. On the other hand, the data can be saved in remote server for later review. So, the author also maintains the patient's history. For sensor maintenance, threshold value is set to detect critical/ emergency condition. The author also provides message service to send feedback to the patient which user can see his own smart phone or on web application.
For data transmission and storing purpose a unified framework is needed. The authors in [19] introduces a framework for data collection and storage. The data structure is admitted by scientific society because it handles heterogeneous nature of sensors, and provides re-usability and sustainability of data. The system introduced data format known as NIX for storing and encapsulating ANT+ device data. NIX model contains a number of factors like Data array, tag, dimension, multi tag, block, group and source. Each factor has its own attributes [20]. The system [19] requires trouble-free data transmission, storage, long term record maintenance, consistency and data security. The examiner examines, store and display heart related data by using ANT+ heart strap and android device. The data is stored in NIX format which contains Meta data and data of sensor.
Some other health related issues occur because of rehabilitation. Rehabilitation is the process of guiding or giving training to patients which help them to improve their health. For disease anticipation, rehabilitation is an important activity. The authors in [21] introduce an automatic system to capture user's activity. The system captures data by using smart phone and ANT+ enabled footpad sensor to measure distance, speed and step count of a user. The collected data is stored locally in phone's own memory or in SD card. Periodically the application connects to internet, the stored data is securely uploaded to remote server for analysis purpose and dynamically feedback is produced. The system also introduces web interface which have three approaches that are user, professional and administrator. In user mode, user is allowed to read education and examine dynamically created report of user's activity. On the other side, professional mode is used to access user's data and also able to download it. In the last administrator mode, web administration has the authority to settle accounts and control access etc. The system is used to provide feedback to user about their step count of single day and single week. The basic purpose of the system is to provide validation and verification by which researcher suggests that the system is feasible, logging and storing activity correctly, collected data is accurate and representation is undertaken.
Cadence measurement in sports field is also crucial to help athletes and coaches to make their training in an optimal manner. Lack of cadence information may create troubles for athletes in case of muscular injury, poor performance, and lack of proper knowledge. So feedback should be needed to improve athlete's future performance [22]. According to the system in [23], the examiner works on physiological efficiency by using ANT+ technology. The system aims to develop an application to measure real time cadence from accelerometer sensor. For this purpose, the author uses ANT enable technology and microprocessor which detects motion by auto on and off facility on sensor device. In microprocessor, cadence calculation was established and output is sent through ANT technology to an ANT+ compatible sensor device such as a watch. The information is transmitted in real time and able to download for later use. The examiner observes that heart rate and cadence response are narrated to each other, so the cadence monitoring can increase physiological demand and improve athletes training.
There are many other communication protocols available such as ANT+, Zigbee, Bluetooth etc. according to the comparative analysis of these protocols, many researchers have their own perspectives. In [24], the researcher studies ANT+, Zigbee and BLE (Bluetooth low energy) protocols. The author's main focus is to monitor bike rider's muscular exhaustion/ tiredness by using appropriate and speedy communication technology. The author mainly influences on software architecture, network complexity, protocol and wireless technology for data transmission in short range. The researcher assumed that zigbee (IEEE 802.15.4) is a short-range technology which has low cost, size and easily accessible but the standard is not available for smart phones.

For ANT technology, it is assumed that it is reliable, low power usage and short-range technology for sensor and mobile phones. ANT+ is the nearest challenger of BLE and offers more facility to easy join or leave set of connections at any moment of time. On the other hand, BLE technology is adopted from Bluetooth. BLE is basically design for ultra low power usage to improve battery time. It is more reliable, forceful, efficient and free license protocol. BLE utilize hopping scheme which carrier frequency is 2MHZ wide communication band that avoid collision [25]. According to the researcher [24], BLE is better than ANT+ technology. In case of frequency jamming, BLE is more complex to jam for particular network as compared to ANT. By frequency jamming in case of channel interference, ANT technology becomes susceptible. On the other side the authors in [26] have an opposite opinion. The authors examine that Bluetooth technology is not able to hold a huge number of devices and consumes higher energy than zigbee. The main goal of the researcher is to measure performance of bicycle by tracking its speed and cadence wirelessly. To analyze cyclist performance, zigbee is widely preferred because it's secure, less bandwidth consumption, low power usage and flexible range of communication. The authors use two transmission standards ANT+ and zigbee. To monitor data in real time, the researchers use two nodes: sensor and coordinator. Sensor node is attached to bicycle and its visual representation is shown to computer screen which is attached to coordinator node. The literature study concluded that there are many ANT enabled applications that are developed. Whether it is a web based or application based, the purpose of these applications is to help users to measure their body parameters at their own comfort place by decreasing expensive appointment to hospital and increasing life expectances.

III. COMPARISON

Authors	Diabetes	Blood pressure	Heart Rate	Real time	PROTOCOL	ANT FS	Alerts	maintaining	Target	Sensor handling	Platform	storage locally or remotely
Mehmood& Culmone, 2015	No	No	Yes	Yes	Yes	Yes	No	Yes	Elderly Heart patient	Heart rate, footpad and temperature.	Web based	locally
Mehmood & Culmone, 2016	No	No	Yes	Yes	Yes	Yes	No	Yes	Heart patient	Heart rate, footpad and temperature.	Web based	Locally and remotely
Johansson, Shen, & Xu, 2011	No	No	No	Yes	No	No	Yes	Yes	Stroke patients	Sole integrated gait sensors.	Android based	Locally
Merrouche, Makhlouf, Saadia, & Ramdane-Cherif, 2018	No	No	Yes	Yes	No	No	Yes	No	Heart patients to detect cardiac disorder such as tachycardia, Bradycardia or cardiac arrest.	Cardiac belt.	Android based	Locally
Priya, 2016	No	No	Yes	Yes	No	No	Yes	No	Vehicle activity monitoring	Temperature and heart rate sensors.	Android and web based	Remotely
Gupta & Jilla, 2011	No	Yes	Yes	Yes	No	No	No	Yes	Gadget usage like DFC.	All type of Garmin and Suunto sensors.	Android based	Locally
Tang, 2010	No	No	Yes	No	Yes	Yes	No	Yes	Heart patients.	Heart rate and temperature sensors.	Android and Web based	Locally

Petry, 2013	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Aging patients.	Blood pressure and weight scale sensors.	Android based	Remotely
Rowlands et al., 2013	No	No	No	Yes	No	No	No	Yes	Foot step count	Garmin Footpad sensor.	Android and web based	Remotely and SD card.
Peter and Roman 2017	No	No	Yes	Yes	No	No	No	Yes	Data structure for storing ANT data	Heart strap	Android based	Locally

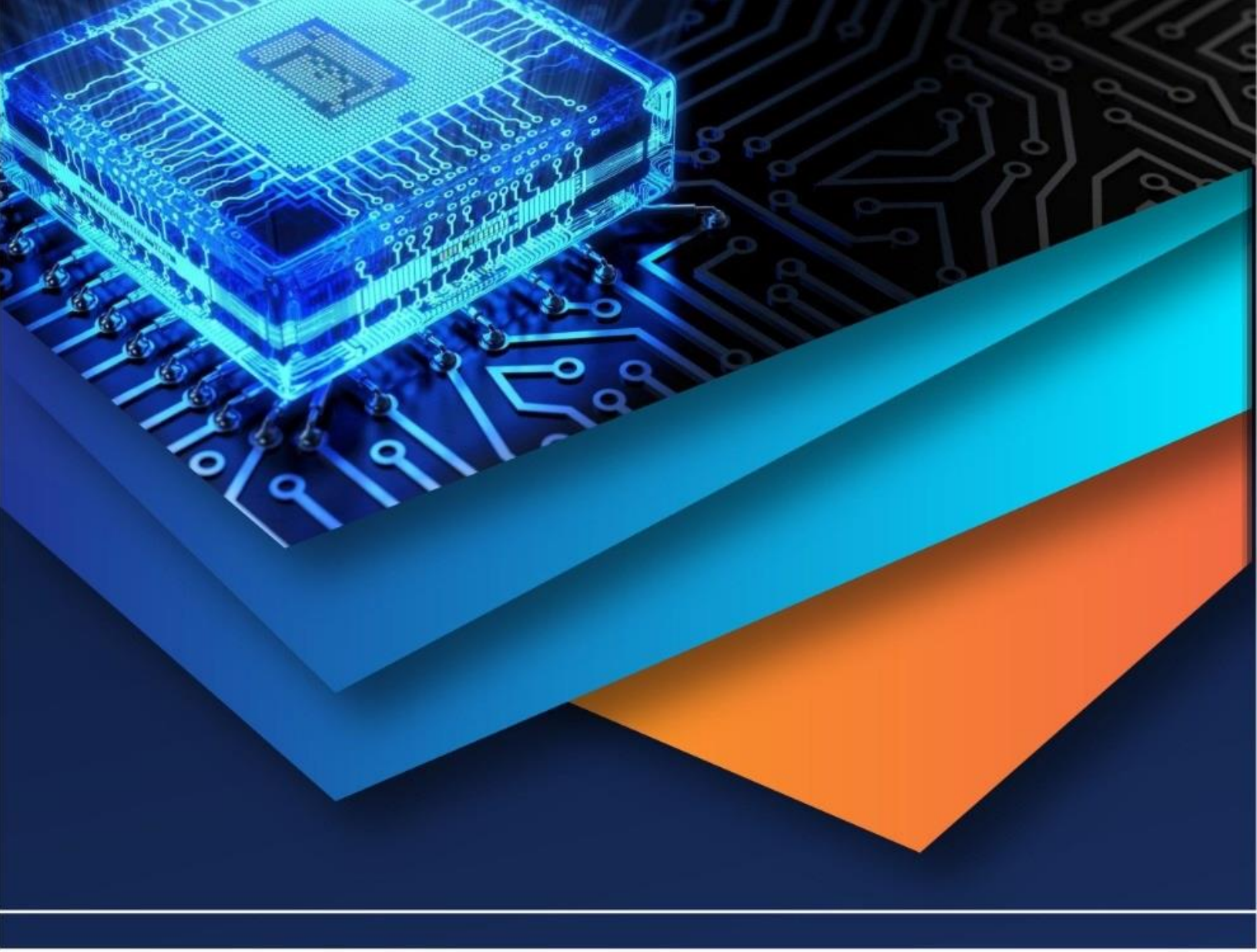
IV. CONCLUSION

Because of rising population, many non communicable diseases may become the major cause of death. Nowadays, health monitoring systems have become more popular. In conclusion, we presented ANT+ technology-based health monitoring systems and make a comparison between them. As a result, we conclude that most of the systems are developed for heart patients, some of them are developed to monitor blood pressure and daily footsteps. We suggest to consider other common diseases too, for example there is no any sound single system which is developed for diabetic patients and it should be considered in modern research studies.

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