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Wireless Sensor Network: an emerging entrant in Healthcare

Devendra Gurjar[1], Md. Iftekhar Alam[2], Prof B B Tiwari[3], Prof G N Pandey[4]
[1](Wireless Communication and computing, IIIT Allahabad, India)
[2](Wireless Communication and computing, IIIT Allahabad, India)
[3](Dean R&D, Electronics & Communication Engineering, IIIT Allahabad, India)
[4](HOD, Bio-Medical Engineering, IIIT Allahabad, India)

Abstract: *Today wireless sensor technology holds a remarkable position in each field like healthcare, war and environment. There is a strong need to collect physiological data and sensor networking in healthcare to focus on health-related applications of wireless sensor networks. In this review we introduced some representative applications in the healthcare arena and depict the challenges which innovate to ensure the privacy and security of medical data. The recent enhancements in WSN have given rise to many application areas in healthcare and introduced a new field Wireless Body Area Networks, Which aim to improve different aspects of our lives using vesture and non-vesture sensor devices. Humans can be tracked and monitored, Even if it is with the consent of the person involved but certain social issues arise from this type of application scenario. The issues can be privacy, security, legal and other related issues. In this paper we detail our experiences to explain several prototypes and discuss the driving force behind home health monitoring and focus on how current (and future) technologies will enable automated home health monitoring. A sensor node consist small microprocessor integrated with number of sensors.*

Keywords *- wireless sensor network (WSN), wireless body area network (WBAN), healthcare, MEMS, sensor motes, SIDS.*

I. INTRODUCTION

Wireless Sensor Network (WSN) [1] [2] [3] is used to solve different problems, consisting of spatially distributed devices to monitor physical or environmental conditions [4] in cooperative way. Sensor Nodes consist of hardware (microprocessor, memory, battery, MEMS sensor, antenna, etc.) [5] [6] along with software, RF protocol [7] and operating system [8]. There are potential opportunities for WSN in healthcare, unfortunately they are still in infancy because so many problems taken place when adopting this technology. Monitoring of all patients due to cost of wired diagnostic equipment is very difficult and costly, this tends to use of cost effective wireless system having cell phone architecture. There are some funded hospitals and academic research projects in this area. Few companies have started or had success to build the equipments which fulfill the health care requirements still a lot of work on this area needs to be done. In many applications most of wireless sensor devices limit their performance to save power so that it can function for long time period without replacing the batteries but here, no need of ultra-low power because of opportunities for charging batteries. Besides the power constraint so many things to take into consideration like infrastructure, lack of standards, security, and data volume and integrity. The incorporation between medical requirement and wireless sensor can be easily understood by the help of fig. 1 which explains medical problems and its solution with the working concept of wireless sensor network. In general application of WSN first it gathers the data from its motes then central processor interprets the sensor data with available database to find the solution for given query. There are three basic functions of WSN [9], sensing the data, communicating and processing the problem through central processor. In some application control signal is generated with the help of actuator (another important element of WSN). In healthcare doctor will take all decisions like central processor.

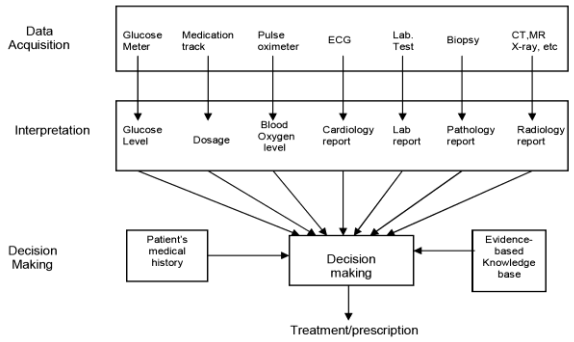

Fig-1 Different levels of medical practice

This paper focuses on the combination of available specialized medical technology with wireless network i.e. for patient monitoring; we use wearable accelerometer with wireless card. This is a wonderful example of the integration of two technologies. Generally the ratio of patient to specialized doctor is very high [10] in that way wireless technology is more effective in clinical trial with the saving of medical expenses, time and face to face appointments. One thing that is important before integration of two advance technologies is its interoperability. Merging of two technologies require event ordering, time stamp, quick response (in emergencies), and better synchronization. System need higher order of reliability and robustness for accurate diagnosis [11] because the operation in buildings results further interference due to walls of hospital resulting degradation in reliability. System should be intuitive and easy to operate otherwise it become wastage because the tendency of elder patients is to reject the technology having any kind of wear and tear.

II. BACKGROUND

A. *Medical Sensing:*

There is history of using sensors in medical care and public health from a long time. These instruments embed for use in clinics, homes, hospitals. Doctors monitor physiological and physical health condition which is critical to detect, diagnosis and treatment without these sensor. [12] Medical sensor combines different transducers where patient can be monitor through electrical, chemical, thermal and optical signal. In fact modern medicine would not be effective without using of sensor i.e. thermometer (for temperature measurement), electrocardiography (EKG), blood pressure monitor, and other image sensors [13]. In the same way location and proximity sensor can be used for finding the present location for improving the delivery of patient care as well as security. Broadly there are three main areas where advancement in sensing technologies is taking place.

- *Sensing modality:*

Sensors measure one form of energy and convert into some meaningful quantity and process it to convey some information, in that way modality refers to raw input used by the sensors [14]. The modality of sensor may be light (visible, infrared, X-rays), sound, pressure, temperature etc. Specific modality of sensor can apply only for specific application which provides suitable treatments in healthcare.

- *Size and cost:*

Some medical sensors are too costly and complex to be used outside of clinical environment. After recent advancements and research in the area of microelectronics and computing have made many forms of medical sensing more widely accessible at their homes, or other living space. The first type of its category is portable medical sensor which is used for blood pressure, blood glucose monitors at home, other one is ambulatory medical sensor these sensors are used to continuously measurement of physiological parameter while some one busy in one's daily routine life. It monitors fitness enthusiasts, health conscious individuals.

B. *Wireless sensors platform:*

It consist of devices performing mainly three operations first one is intelligence which greatly reduce computer hardware and second one is sensing for which micro electronics mechanical (MEMS) is used and the last one is wireless communication capability, low cost CMOS based RF instruments is implemented on single device for communication. The functioning of wireless sensor network can be understood by the help of fig 2. In this fig A, B and N are wireless motes which gather information from different places. Data acquisition layer measures real world condition and convert into digital numeric value that can be manipulated by computer. Destination controller handles routing and ensures the reliable data delivery to the base station and wireless transceiver are responsible for providing communication link to the system.

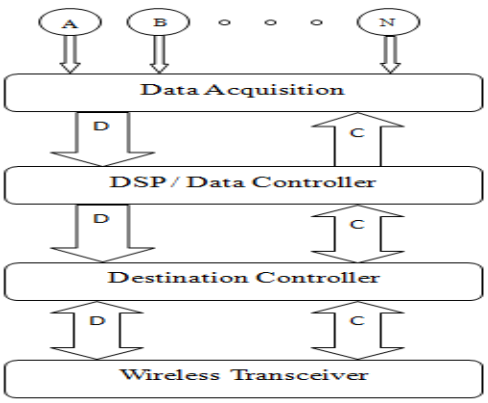

Fig-2 Wireless sensor network functional architecture

Motes typically use 8 bit microcontrollers with a small RAM of 10 kb and ROM of 100 kb. Flash memory is used to store the programs and other external storage. Size of flash memory depends on the application requirements. These devices operate at about 10 MHz with the power consumption of few mW. Operations of WSN is time triggered, it awake for small time period and rest of time it is in idle condition so that the power consumption become less and save more power, in idle mode it consumes only 1 µW because of less handling power and can be used for long term applications.

Fig-3 Evolution of sensor hardware plateform

Motes are equipped with low power communication devices working on IEEE 802.15.4 ZigBee module and data rate between 10 and 250kbps, consume about 20-60 mW and support communication range from 10 to 100 meters. [15]

- *Wireless Body area network:*

WBAN [17] is a ubiquitous and affordable healthcare technique which used for fitness monitoring in the sense of speed, temperature, pacing information, heart rate, respiration monitor etc. There is no specific standard for WBAN but it generally work on ZigBee [16] when less bit rate required, for higher data rate requirement it works on either IEEE 802.15.3a or IEEE 802.11 a/b/g. There is broad range of possible devices which can connect through a single WBAN network depend on as much one can carry but the thing which should not exceed to a limit is total system load which must be less than 500 kbps. WBAN system have so many medical applications. It can be used to have vital patient data when linked with bedsite monitor. Many patient can be monitor through a single healthcare advanced monitor typically it can handle five similar type of WBAN network but (total traffic/ patient < 10 kbps). This system have low power devices. The target is to provide communication technology which consume only 10% of power compare to total device.

III. HEALTHCARE APPLICATIONS

A number of healthcare application enabled by wireless sensor network technology like physiological monitoring, measuring and report vital sign of a person, motion and activity monitoring, there are a number of application for continuous monitoring of activity at different level and can measure limb movements, muscular activity and also it can be apply for giant analysis.

- *Monitoring in mass casualty disasters:*

Mass casualty disaster have different types, it may be extreme heat weather or extreme cold weather or may be the situation of flood, earthquakes, fires or wild fire, these disasters are charactorized under the natural disasters. There are some technical hazards like building collapse and major industrial accidents. This refers to provide an emergency medical services to monitor multi casualty incident, in this situation it is required to provide medical resource to large number of patient, there is need to improve the assessment of the first responder's health during such multi casualty situation. This technology effective here in terms of increased portability scalability and automatic report to the concerning team. It will also help to track this disaster and allow effective control with coordination of available resources. It can provide continuous information to concerning authority or department.

- *Sleep safe:*

Infants belonging to age of one month to one year get sudden death due to unexplained disease sudden infant death syndrome (SIDS). There is no proper reasons for SIDS casualties but several factor which affect the incidence of SIDS. If the infants sleep on their stomach the risk of SIDS increased. Research says infant sleeping on their stomach risk increase up to 12.9 times to die with SIDS than normal death. Generally doctors suggest their parent to put their infants to sleep on their back but practically it is very difficult for parent to continuously monitor their child sleeping position so we need an automation. By taking care of infant position the SIDS can be reduce incidence up to 40%. SIDS is a big problem not only for developing countries also for developed countries, approximately 2500 deaths per year due to SIDS, the death probability of infant is

maximum in the age of between 4 to 7 months. For automatic monitoring of infant a simple device is built based on wireless sensor network

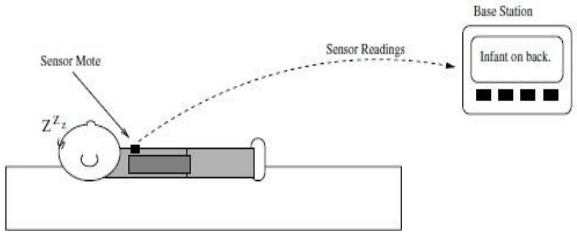

Fig- 4a Monitoring of infant sleeping position

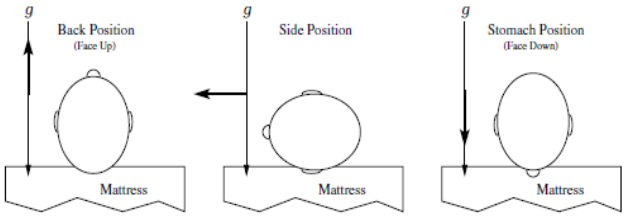

Fig- 4b System detect infant three position with gravity (g)

This system detect the sleeping position of infant. When infant is detect to be lying on their stomach system will alert to the parents and assure safe sleep of child. The sensitivity of delay can be adjusted by taking risk factor from the parents. This system mainly consist two sensors one is attach with infant clothing and other one act as base station. Existing motes work on TinyOS program having accelerometer to detect the direction continuosuly. Base station Tmote and a laptop will ready to give alert to the parents if any thing going wrong.

- *Monitoring health of Fire fighter or other rescue man:*

Fire department responds to emergencies every 20 second. The number of on duty fire fighter deaths still remains 100/ year, even though fire fighter technology has improved in last three decades, 50% deaths are due tosudden cardiac arrest caused by stress and 24.1% injuries due to physical and psychological strain with having to carry 75 pounds worth of tools. Because of this statistic we need real time monitoring of fire fighter heath. Irregularities in the heart rate can signal imminent cardiac failure so detection of these abnormalities and releiving the fire fighter can prevent casualties. A wireless heart rate sensing system named fireline can be used for real time heath monitoring. This device consist of WSN Tmote, a custom made heart sensor board and three reusable electrode. These component are integrated in shut whorl under the user protective clothing. The sensor based wireless motes and battery packed in to cases that are sewn into inner right slew of the shirt. The wires and electrode are attached to each side of the shirt and ground electrode is attached to stomach

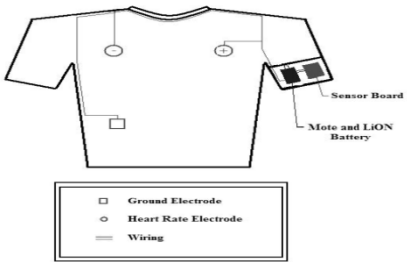

Fig -5a advanced dress for rescue man with sensor and electronic hardware

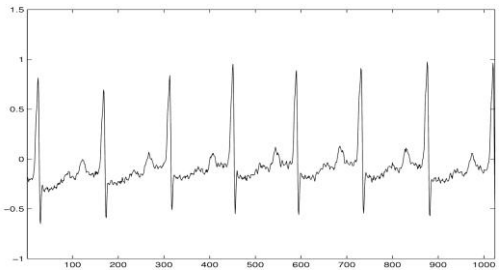

Fig -5b EKG waveforms measured using advanced dress

Every 10 ms a voltage signal is sampled by embedded from the heart and this form an EKG waveform as shown in figure. The measurement is transmitted from sensing mote to base station mote which attach to a laptop monitor by the commander.

IV. TECHNICAL CHALLENGES

The application of the Wireless Sensor Networks, due to their inherent constraints, causes a variety of technical challenges/difficulties in whichever field they are deployed. The challenges can be core computer system based, like scalability, reliability and efficiency. On the other hand, they can also be data related problems, like security. Some core challenges are enumerated below-

- *Trustworthiness:*

Wireless Sensor Networks suffer traditionally due to their energy and bandwidth constraints. Add to that the unreliable wireless media, and a serious problem is at hand, the trustworthiness of sensitive data, being received from a sensor network. This really becomes a problem in healthcare applications, which impose strict requirements on end-to –end reliability and data delivery. For example, the measurements from a pulse oximetry [18] application must deviate at most 4% from the actual oxygen concentrations in the blood. Another factor that is an impediment in the acceptable quality of service of WSN's is that the medical facilities, where some of these systems will be deployed, are very harsh environments for radio frequency (RF) communications. This harshness is due to the fact that these facilities have structural factors, like metal doors, as well as deliberate effort to provide radiation shielding, for e.g. in operation theatres. Moreover, devices that use 802.15.4 radios are susceptible to interference from Wi-Fi networks, Bluetooth devices, and cordless phones. The impact of obstacles and interference is exacerbated by the fact that most wireless sensor network systems are constrained to low power radios to enhance system lifetime. The other implication is the reduced throughput of the system. Since the theoretical maximum throughput of IEEE 802/15/4 radios is 250 Kb/s (which is much less in practice due to MAC protocols and multi hop comm.), such a standard, considering real time applications like activity monitoring, would only be able to support a small number of devices, or only a subset of the measurements can be delivered at a given time. The quality of data collected from A WSN, in some cases, can be compromised not by sensor faults and malfunctions, but by user actions. WSNs in healthcare should thus provide metadata that inform the consumer of the quality of the data delivered.

- *Privacy and Security:*

WSN's in healthcare is used to determine the activities of daily living. Thus, WSNs also pose opportunities to violate privacy. In addition to policy and database query privacy violations, WSNs are susceptible to privacy attacks that gain information by observing the radio transmissions of sensors to deduce private activities, even when the transmissions are encrypted. The privacy of a network can be compromised by a FATS (Fingerprint and Timing based Snooping) attack, in which an eavesdropper listens on the sensors' radio to collect the timestamp and fingerprints of all radio transmissions. Then the eavesdropper uses multiple phases of inference to deduce the location and type of each sensor. Thus, the various private user activities and health conditions can be inferred. A related fundamental problem is the dealing with security attacks. The security problem in WSNs is exacerbated due to the transient and permanent random failures which are common to the WSNs, which can be exploited by attackers. The solution to this security problem lies in the large amount of redundancy prevalent in the WSNs. This redundancy creates great potential for designing WSN systems that continuously provide their target services despite the existence of failures or attacks.

- *Resource Scarcity:*

WSNs are encumbered with low powered components, which work with modest resources, in order to increase their battery lifetimes. These limitations pose a number of challenges for the system design. The software must be designed carefully with these resource constraints in mind. The scant memory calls for use of lean, event driven models, and thus, precludes traditional OS design. A modest amount of on-board processing must be done so as to reduce the data transmissions required. The application code, also, should be written such that it complies with the node's limited energy budget, limiting radio communication and data processing to extend the battery lifetime.

V. CONCLUSION

In the light of above presentation in this paper, it is concluded that wireless sensor technology is very helpful in medical application in different scenario by taking some examples. WSN can play important role to contribute so many things for improving life of patients with the reduction in cost. In some application this technology may seem costly i.e. IIIT Allahabad spent 12 lacks for just monitoring the activities at Sangam Allahabad. At the same time it dominates efficiently in the monitoring of rescue men applications. The future has been predicted when wearable sensor devices would be an integrated part of daily life activities. This will

change common human life tremendously. There is always tradeoff between social issues like security privacy and legal. As electronics instrument become cheaper and compact, reduced health care cost hence huge incentive for hospitals and patients. Study of discussion on WSN found overall positive.

REFERENCES

[1] J.D. Kenney, D.R. Poole, G.C. Willden, B.A. Abbott, A.P. Morris, R.N. McGinnis, and D.A. Ferrill, "Precise Positioning with Wireless Sensor Nodes: Monitoring Natural Hazards in All Terrains", 2009 IEEE International

[2] Dargie, W. and Poellabauer, C., "Fundamentals of wireless sensor networks: theory and practice", John Wiley and Sons, 2010 ISBN 978-0-470-99765-9, pp. 168–183, 191–192

[3] JeongGil Ko, Chenyang Lu, Mani B. Srivastava, John A. Stankovic, Andreas Terzis, and Matt Welsh,"Wireless Sensor Networks for Healthcare" Proceedings of the IEEE | Vol. 98, No. 11,November 2010

[4] Coye, M., Haskelkorn, A., & Demello, S. 2009. Remote patient management: technology-enabled innovation and evolving business models for chronic disease care. Health Affair, 28(1), 126-135.[5] R. Bose, "Sensor Networks- Motes, Smart Spaces, and Beyond" Proc. IEEE, 2009.[6] I. A. Akyildiz et. al., "A Survey on Sensor Networks", IEEE Communications Magazine, Aug. 2002

[7] Wolter Lemstra , Vic Hayes , John Groenewegen , The Innovation Journey of Wi-Fi: The Road To Global Success, Cambridge University Press, 2010, ISBN 0-521-19971-9

[8] A. Dunkels, B. Gro¨onvall, and T. Voigt, BContikiVA lightweight and flexible operating system for tiny networked sensors,[in Proc. 29th Annu. IEEE Int. Conf. Local Comput. Netw., Nov. 2004, pp. 455–462

[9] A. Wood, L. Selavo, and J. Stankovic, BSenQ: An embedded query system for streaming data in heterogeneous interactive wireless sensor networks,[in Proc. 4th IEEE Int. Conf. Distrib. Comput. Sensor Syst., Santorini Island, Greece, Jun. 2008, pp. 531–543.

[10] Robinson, Simon (1 May 2008). "India's Medical Emergency". *Source: Time US*. Retrieved 2011-09-2

[11] G. Virone, A. Wood, L. Selavo, Q. Cao, L. Fang, T. Doan, Z. He, and J. A. Stankovic, BAn advanced wireless sensor network for health monitoring,[in Proc. Transdisciplinary Conf. Distrib. Diagnosis Home Healthcare, Apr. 2006, pp. 95–100.

[12] J. Ko, T. Gao, R. Rothman, and A. Terzis, BWireless sensing systems in clinical environments: Improving the efficiency of the patient monitoring process,[IEEE Eng. Med. Biol. Mag., vol. 29, no. 2, pp. 103–109, Mar./Apr. 2010.

[13] ieee.org - CCD in CMOS Padmakumar R. Rao et al., "CCD structures implemented in standard 0.18 µm CMOS technology"

[14] Munguia Tapia, E., Intille, S.S., Lopez, L., Larson, K.: The design of a portable kit of wireless sensors for naturalistic data collection. In: Fishkin, K.P., Schiele, B., Nixon, P., Quigley, A. (eds.) PERVASIVE 2006. LNCS, vol. 3968, pp. 117–134. Springer, Heidelberg (2006)

[15] J. He, H. Li, and J. Tan, BReal-time daily activity classification with wireless sensor networks using hidden Markov model,[in\ Proc. 29th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., Aug. 2007, pp. 3192–3195

[16] "ZigBee Wireless Networking", Drew Gislason (via EETimes)

[17] Ullah, Sana and Higgins, Henry and Braem, Bart and Latre, Benoit and Blondia, Chris and Moerman, Ingrid and Saleem, Shahnaz and Rahman, Ziaur and Kwak, Kyung (2010). "A Comprehensive Survey of Wireless Body Area Networks: On PHY, MAC, and Network Layers Solutions". *Journal of Medical Systems* (Springer Netherlands) **36** (3): 1–30. doi:10.1007/s10916-010-9571-3. ISSN 0148-5598. PMID 20721685

[18] Optoelectronic sensor in medical applications. Ray King, TAOS INC.