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ROLE OF WIRELESS SENSOR NETWORK AND COLLABORATIVE SENSING IN WEARABLE DEVICES - IMPLEMENTATION AND CHALLENGES

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Abstract: **A Wireless sensor network can be defined as a network of devices especially that can sense and communicate the information gathered from a monitored field through wireless links. The acquired data is forwarded through multiple nodes, and with a gateway, the data is connected to other networks. WSN is a wireless network that consists of base stations and numbers of nodes, here nodes refers to the sensors. These networks are used to monitor physical or environmental conditions like sound, pressure, temperature and collectively pass data through the network to the main location. The WSN is incorporated into the wearable devices for various applications using various protocols the connect each node of the network. This paper describes the technology of implementing a WSN in a wearable device and the challenges imposed in working on the network.**

Keywords – WSN; sensing; routing protocols; wearable devices.

I. INTRODUCTION

Wireless Sensor Networks (WSN) are quickly becoming the most productive and cost-effective way of gathering data from the environment, and are considered one of the most important technologies of the twenty-first century in the field of pervasive systems. WSNs certainly cover a huge number of spatially distributed, little, battery-operated, embedded devices that are networked to caringly collect, process, and transfer data to the operators, and it has controlled the capabilities of computing & processing. WSNs certainly cover a huge number of spatially distributed, little, battery-operated, embedded devices that are networked to caringly collect, process, and transfer data to the operators, and it has controlled the capabilities of computing & processing. The communication between nodes can be done with each other using transceivers. In a wireless sensor network, the number of nodes can be in the order of hundreds/ even thousands "Zornoza et al.(2017) in their work on wearable devices". In contrast with sensors, Ad Hoc networks will have fewer nodes without any structure.

A sensor network is said to be collaborative if the nodes forming the network are sensing elements and should satisfy the following conditions.

1. It is an information providing system with live sensing and offers query processing within the nodes.
2. Since it is a network multiple heterogeneous systems should be integrated as a unit.
3. As they are integrated the functionality of acquiring and processing data is done collectively and hence referred to as collaborative networks. Each node observes a cross-section of the field independently.

With multiple sensors participating in a single sensing operation initiated by an emitting sensor, joint sensing can increase the sensing region of an individual emitting sensor and generate multiple sensor measurements simultaneously. Collaboratively analyzing based on the massive data that come from different objects and different time points can help to obtain efficient and cost-effective solutions to achieve safe, highly efficient and eco-friendly industrial production/service.

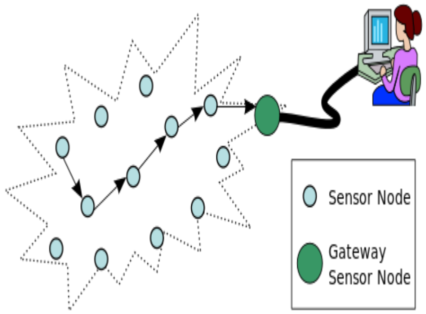

Fig.1.1 WSN connectivity

The wearable technology began from the invention of smartwatches. Wristwatches were created in the late 1600s but were worn mostly by women as bracelets. Over time, the watch becomes smaller and more precise and throughout history, many wearables were designed and introduced to the market.

Next to watches computers were targeted to be fabricated as wearable devices. In 2008, Ilya Fridman incorporated a hidden Bluetooth microphone into a pair of earrings. Around the same time, the Spy Tie appeared a stylish necktie with a hidden color camera. In 2009, Sony Ericsson teamed up with the London College of Fashion for a contest to design digital clothing.

In 2014, graduate students from the Tisch School of Arts in New York designed a hoodie that sent pre-programmed text messages triggered by gesture movements.

II. NEED FOR WEARABLE DEVICES:

- This technology influences the field of medicine, education, business, transportation, disability, aging, finance, music, gaming, etc.,
- The hand-free nature of wearable devices makes it very useful for business.
- It becomes easy to track the rescue team during emergency operations to ensure safety.
- Smart glasses and smart watches helps the researchers, engineers and technicians to be efficient in their work due to the hands-free access.

III. TECHNOLOGY

Most of the time the wearable devices are used for monitoring the health of an individual. In that case, it is necessary to monitor the heart rate, body temperature, breath rate and so on. So the respective sensors are incorporated with the help of wearable devices "Nabi et al. (2012) in their observation on wireless body area networks". While wearables can collect data in aggregate form, they have yet to analyze or make conclusions based on this data.

Wearables cannot account for the differing health needs of an individual; they can only collect data. Because of this, wearables are used primarily for information about general well-being but not for making decisions about one's health.

Today, there is a growing interest to use wearables not only for individual self-tracking but also within corporate health and wellness programs. Given that wearables create a massive data trail which employers could repurpose for objectives other than health, more and more research emanate that also studies the dark side of wearables.

The minimization of the size of sensors and electronic circuits based on the use of microelectronics has played a key role in the development of wearable systems. One of the major hurdles to the adoption of sensing technology, especially for wearable applications, has been the size of the sensors and front-end electronics that, in the past, made the hardware to gather physiological and movement data too obtrusive to be suitable for long-term monitoring applications.

Recent developments in the field of microelectronics have allowed researchers to develop miniature circuits entailing sensing capability, front-end amplification, microcontroller functions, and radio transmission. This makes it easier for the deployment of hundreds of node in a network.

IV. WORKING OF WSN HARDWARE

The WSN is composed of numerous sensors as tiny nodes. Thread and ZigBee can connect sensors operating at 2.4 GHz with a data rate of 250kbit/s. Many use a lower frequency to increase radio range (typically 1 km), for example Z-wave operates at 915 MHz and in the EU 868 MHz has been widely used but these have a lower data rate (typically 50 kb/s). In many applications, a WSN communicates with a Local Area Network or Wide Area Network through a gateway. The Gateway acts as a bridge between the WSN and the other network. This enables data to be stored and processed by devices with more resources, for example, in a remotely located server. A wireless wide area network used primarily for low-power devices is known as a Low-Power Wide-Area Network (LPWAN).

V. ROUTING PROTOCOLS

Wireless Sensor Network are generally small-size, low-energy and low-range un-attenuated sensor nodes "Favoutis et al. (2018) in their work emphasis on extending battery life of wearable sensors". The process of turning on and off is done with the help of duty cycle may result in high network latency, routing overhead, and neighbor discovery delays due to asynchronous sleep and wake-up scheduling. Simulation experiments demonstrated the validity of this novel approach in minimizing routing information stored at each sensor "Latr B. et al, (2007) in their work on multi-hop networks".

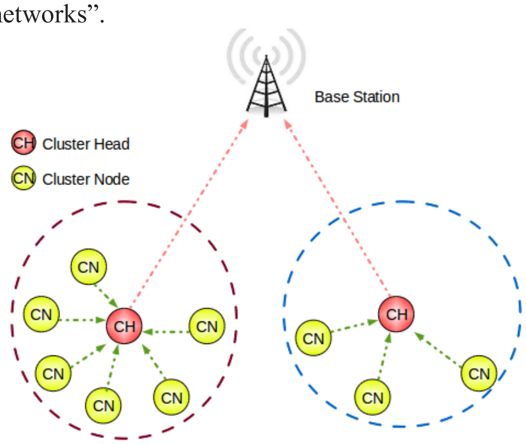

Fig.2.1. Clustering routing protocol

OPERATING SYSTEMS:

Operating systems for wireless sensor network nodes are typically less complex than general-purpose operating systems. They more strongly resemble embedded systems, for two reasons. First, wireless sensor networks are typically deployed with a particular application in mind, rather than as a general platform. Second, a need for low costs and low power leads most wireless sensor nodes to have low-power microcontrollers ensuring that mechanisms such as virtual memory are either unnecessary or too expensive to implement. It is therefore possible to use embedded operating systems such as eCos or uC/OS for sensor networks. However, such operating systems are often designed with real-time properties.

TinyOS is perhaps the first operating system specifically designed for wireless sensor networks. TinyOS is based on an event-driven programming model instead of multithreading. TinyOS programs are composed of event handlers and tasks with run-to-completion semantics. When an external event occurs, such as an incoming data packet or a sensor reading, TinyOS signals the appropriate event handler to handle the event. Event handlers can post tasks that are scheduled by the TinyOS kernel some time later.

VI. APPLICATIONS

DIFFERENT TYPES OF WEARABLE DEVICES IN TODAY'S MARKET:

1. SMART WATCHES: These devices work more than just telling the time for users. It shows the notification on the call, messages, emails, social-media updates and so on.
2. FITNESS TRACKER: It helps to keep track of the number of steps the user walks continuously and uses this information to report accurate data on calorie burn and exercise done by the user.
3. HEAD MOUNTED DISPLAY: This wearable takes the user to a world of virtual reality and provides new visual information directly into the user's eyes.

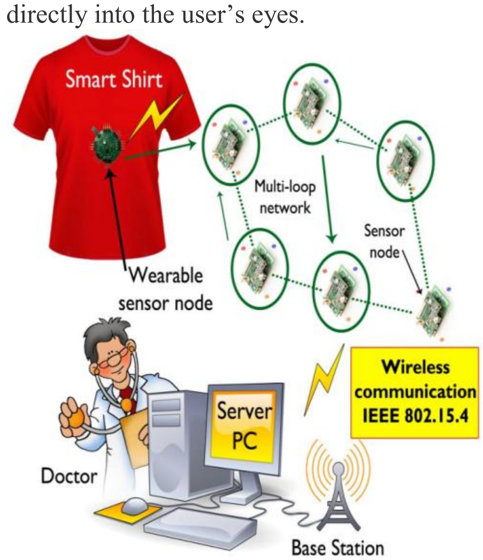

Fig.3.1. working model of a smart shirt

4. SPORTS WATCHES: It is similar to the fitness trackers that is especially for sports personnel to track the individual's pace, heart rate, etc., which comes with a GPS tracker.
5. SMART JWELLERY: These jewelries are designed as the earrings or necklaces to notify the users of their text messages, calls or emails when their phone is out of their range.
6. IMPLANTABLE: These wearable electronics are surgically implanted under the skin used for medical reasons like tracking contraception's, insulin levels etc.

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VII. LIMITATIONS

CHALLENGES IN WEARABLES:

The biggest challenge in wearable devices is the short lifetime because of the customer engagement. Bad quality, pain to sync with smartphones, poor battery life, uncomfortable and awful design, UX problems, are some of the functional reasons which degrades the quality of device. Like mobile technology, wearable technology is considered as a disruption in the world of business, however, the growth and popularity of a technology always comes with concerns on the problems and difficulties in the area of data_security and privacy. Since the devices are worn frequently it may gradually damage the device causing the reduction in the quality.

VIII. PROBLEMS IN WSN:

Communication failures are a common problem of WSN. Another issue is heterogeneity. Since WSN may consist of a large number of small and rather different nodes in terms of sensors, computing power, and memory. The large number raises scalability issues on the one hand, but provides a high level of redundancy on the other hand. Also, nodes have to operate unattended, since it is impossible to service a large number of nodes in remote, possibly inaccessible.

Limited **computational power and memory size** is another constraint that affects the amount of data that can be stored in individual sensor nodes. So the protocol used to connect the sensor nodes should be simple and light-weighted as it will be difficult to handle huge data at the same time. Communication delay in sensor network can be high because of limited communication channel shared by all nodes within each other's transmission range.

Self-Management is the nature of many sensor network applications that they must operate in remote areas and harsh environments, without infrastructure support or the possibility for maintenance and repair. Therefore, sensor nodes must be self-managing in that they configure themselves the nodes should be able to control and adapt themselves according to the field in which they are operated.

Sensor nodes are randomly deployed over the region without any **infrastructure** and prior knowledge of topology. In such a situation, it is the wok of the nodes to identify its connectivity and distribution between the nodes. Many sensor networks, once deployed, must operate without human intervention, that is, configuration, adaptation, maintenance, and repair must be performed in an autonomous fashion.

Attenuation limits the range of radio signals, that is, a radio frequency (RF) signal fades while it propagates through a medium and while it passes through obstacles. As a result, an increasing distance between a sensor node and a base station rapidly increases the required transmission power.

Therefore, it is more energy-efficient to split a large distance into several shorter distances, leading to the challenge of supporting multi-hop communications and routing. This challenge is further transferred to networks that employ duty cycles to preserve energy. That is, many sensor nodes use a power conservation policy where radios are switched off when they are not in use. As a consequence, during these down-times, the sensor node cannot receive messages from its neighbors nor can it serve as a relay for other sensors. Therefore, some networks rely on wakeup on demand strategies to ensure that nodes can be woken up whenever needed.

A **sensor's hardware constraints** also affect the design of many protocols and algorithms executed in a WSN. For example, routing tables that contain entries for each potential destination in a network may be too large to fit into a sensor's memory. Instead, only a small amount of data (such as a list of neighbors) can be stored in a sensor node's memory.

Many wireless sensor networks collect **sensitive information**. The remote and unattended operation of sensor nodes increases their exposure to malicious intrusions and attacks. While there are numerous techniques and solutions for distributed systems that prevent attacks or contain the extent and damage of such attacks, many of these incur significant computational, communication, and storage requirements, which often cannot be satisfied by resource constrained sensor nodes.

Some real time sensor application are very time critical which means the data should be delivered within a **certain period of time** from the moment it is sensed, otherwise the data will be unusable and thus will be discarded .So this must be a QOS parameter for some applications.

IX. CONCLUSION:

The inherent nature of WSNs makes them deployable in a variety of applications. They have the potential to be everywhere, on roads, in our homes and offices, forests, battlefields, disaster struck areas,

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and even underwater in oceans. This paper surveys the application areas where WSNs have been deployed such as military sensing, traffic surveillance, target tracking, environment monitoring, and healthcare monitoring. The paper also surveys the various challenges of WSNs that may occur in the near future as when deployed in underwater acoustic sensor systems, sensing based cyber physical systems, time critical applications, cognitive sensing and spectrum management, and security and privacy management.

With all the advances in sensor networks from the hardware to the network protocols to the al gorithms, it is in some ways surprising that sensor networks are still not mainstream (like the Internet, cell phones, WiFi, etc.)

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