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Integration of Wireless Sensor Networks with the Internet of Things: A survey

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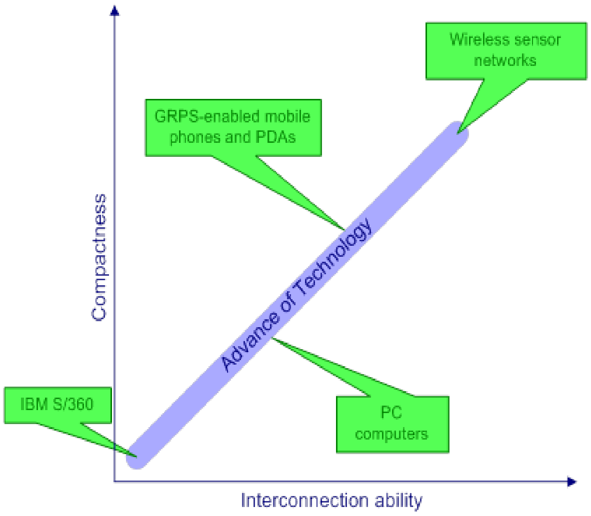
Abstract:-Today Wireless Sensor Networks are used in a plethora of applications ranging from underwater to on land applications hence making them very feasible. These networks can even be integrated into the Internet of Things, where through the use of sensors, the entire physical infrastructure is closely coupled with information and communication technologies, where intelligent monitoring and management can be achieved via the usage of networked embedded devices These networks use sensors which are miniature in size. Applications which use these wireless sensors need continuous monitoring of the environment. To maintain the duration of the network for a long time the available energy should be used to a maximum extent. Each layer of the protocol stack will have their own methodologies to conserve the energy, where the network layer emphasizes on the routing protocol .The process of communication in these networks consumes more energy when compared to the process of sensing and processing and hence the necessity to develop an efficient routing protocol with simulations to provide the highest throughput and improve the network life time of these wireless sensor networks.

Keywords- Energy Efficiency; Internet of Things, Routing Protocols; Sensors, Wireless Sensor Networks

I. INTRODUCTION

Recent advances in wireless communications, micro sensor technology and embedded microelectromechanical systems have led to the development of small, low-cost, distributed sensors devices that possess sensing, signal processing and wireless communication capabilities. The sensors used in these networks are basically small computer systems that have high interconnection capability. The graph below shows the comparison of the Wireless Sensor Networks along with the other technologies.



The Wireless sensor network (WSN) promise great benefits in terms of flexibility, cost and range .They can be used in a wide variety of applications like climate monitoring, home automation and industrial applications. Etc. The fig 1.1 shows the general architecture of the wireless sensor networks. As we can see these networks deploy a lot of sensors based on the requirement of the network. The sensor nodes are generally used in an Adhoc environment and use the open air medium to communicate with each other .They are able to monitor physical environment, compute data from the environment without human interaction and transmit this information to the core network. Internal to the architecture of the WSNS these sensors should communicate with each other and also to the external base station sensor node which has similar energy, memory and process capacity. Due to these reasons it is desirable to develop a reliable routing protocol to deal with the routing issues of mobile sensor nodes and with the challenges such as energy depletion and latency of data transmission from nodes to base station.

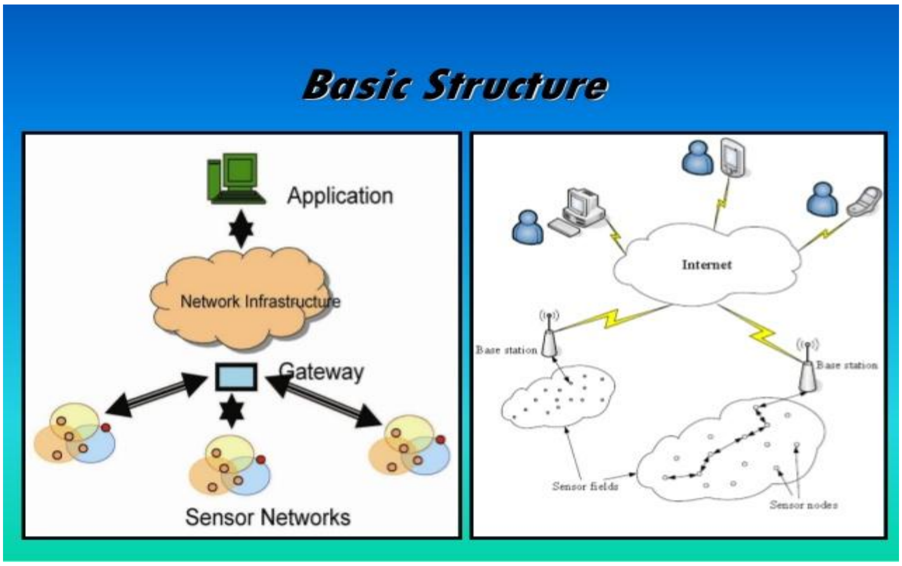


Fig 1.1 General structure of a WSN

These sensors can be integrated into a homogeneous or heterogeneous environment which will lead to the classification of the WSN'S into two categories which are:
Homogeneous WSN- where all the sensor nodes have the same capability but have the problem of scalability
Heterogeneous WSN-Here the network is partitioned into clusters and the clusters are placed under a cluster head. The cluster heads have a better capability when compared to sensor nodes and act as an intermediary between the sensor nodes and base station.

II. CONCERNS PERTAINING TO WIRELESS SENSOR NETWORKS:

Energy saving, real-time, reliability and self-organizing are the main concerns in WSN .The Wireless Sensor Networks faces some challenges which are as follows:In these networks, the nodes are typically operated by battery power, making energy consumption of paramount importance to increasing the network lifetime. The large number of sensor nodes involved in such networks and the need to operate over a long period of time require careful management of the energy resources.Real-time is a very important constraint in WSNs, because real-world conditions can introduce explicit or implicit time constraints. These networks are supposed to sense signals in the environment, and concepts like data freshness" are important in its applications. This way, in some application, temporal validity in data collect by nodes can expire very quickly. In some scenarios the raw data gathered from the source nodes must be aggregated and transmitted to the sink within a specified latency constraint.Recent studies show that data fusion and data aggregation is particularly useful in eliminating the data redundancy and reducing the communication load. Although, in dense wireless sensor networks, these techniques are also an important tool used to increase application reliability and decision dependability.
Self-organizing sensor networks have been proposed to support dynamic scenarios and facilitate large-scale, real-time data processing in complex environments.

III. CONSIDERATIONS FOR ENERGY SAVING IN WSN

A sensor network is very much different from infrastructure-based network. A device used in such a network is always resource constrained. This is a major factor affecting design of an energy-efficient MAC protocol. A sensor network also employs a wide range of procedures and requirements that vary according to applications. Application awareness is one of the major criteria for sensor network. Hence MAC protocols should be flexible enough to entertain the need of specific application area while being energy efficient.
Energy saving mechanisms also depend on many other design and deployment factors. These factors are very crucial and ultimately affect the overall working of a MAC protocol. Some considerations while designing energy efficient MAC protocols are as follows:

i. Network topology and Deployment strategy.
ii. Antenna mode.
iii. Controlling mechanisms.
iv. Delay.
v. Throughput.
vi. Quality of service (QoS) requirements.
vii. Number of channels to be used in communication.

1. **Motivation to integrate the WSN with IOT**

- By citing the definition of Internet of Things which is "a proposed development of the Internet in which everyday objects have network connectivity, allowing them to send and receive data". A 'thing', in the Internet of Things, can be a person with a heart monitor implant, a farm animal with a biochip, an automobile that has built-in sensors to alert the driver when tire pressure is low -- or any other natural or man-made object that can be assigned an IP address and provided with the ability to transfer data over a network.
- WSNs are expected to be integrated into the "Internet of Things", where sensor nodes join the Internet dynamically, and use it to collaborate and accomplish their tasks. Hence we need to develop a protocol to accomplish the same and also develop and integrate the architecture of WSN with the architecture of the internet.

2. **Changes that may be incorporated to the Wireless sensor Networks to adapt to the requirement of the Internet.**

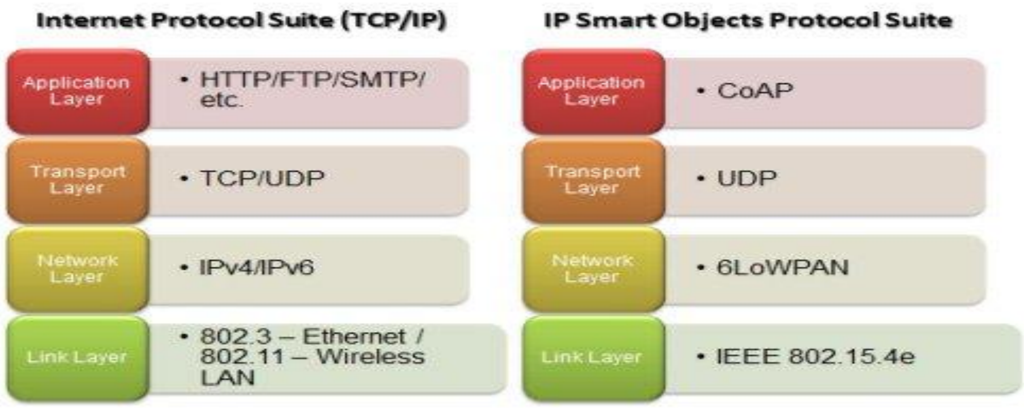


Fig 1.2:TCP/IP stack and IP Smart Objects Protocol Stack

Fig 1.2 shows the comparison of the protocol stack of the TCP/IP and IP Smart objects. The following observations have been made and these changes may be incorporated to the Wireless Sensor Networks

5.1 Network topology and Deployment strategy

Network topology and deployment vary widely. They may be hierarchical, star, or cluster based, single hop or multihop, dense or sparse, and so forth. A network may be static in nature or dynamically changing due to mobile nodes. Topology can always affect energy consumption by a sensor node. Practically, a star topology may be more energy efficient than hierarchical topology and hence maybe used

5.2 Antenna modes

Antenna may be omnidirectional or directional. Use of directional antenna can reduce energy consumption significantly in certain networks. The antennas used by the sensors in the Wireless Sensor Networks are usually omnidirectionl antennas but since the antennas of the mobile devices must be small and light weight .The Planar inverted-F antennas (PIFA) are a good choice for mobile communication because they are small, powerful, and efficient. These antennas can cover multiple frequency bands for cellular devices, Wi-Fi, and Bluetooth® technology — which makes them a great choice for IoT compatible objects and devices.Alternatively phased array antennas maybe used as they have the ability to steer a radiation beam toward wanted directions. They overcome the limit of angular dependency of the high gain antennas.

5.3 Modulation scheme to be used for communication

The 64-QAM used by IEEE802.11a/g/n maps 6 data bits into each transmitted symbol. This provides a high spectral efficiency when combined with OFDM. The disadvantage of using 64-QAM is that the receiver requires a higher signal to noise ratio (SNR) to demodulate the signal than comparable systems using BPSK and QPSK. This means that in general high order modulations require higher transmit power to achieve the same bit error rate (BER) as a low order modulation like BPSK and QPSK. The IEEE 802.15.4e uses BPSK and OQPSK (similar to QPSK) so that devices with low power consumption may be used .In contrast to the TDMA scheme used in the WSNs ,the IEEE802.15.4e uses the Time slotted Channel Hopping (TSCH) mode such that the devices used can support a wide range of industrial applications. This scheme uses time synchronization to achieve ultra low-power operation and channel hopping to enable high reliability. Thus IEEE802.15.4e can be seen as the latest generation of ultra-lower power and reliable networking solutions.

5.4 Sensing area and transmission range

Besides the above factors, sensing area and transmission range also are deciding factors in energy-efficient MAC design. To save the valuable energy in a sensor network, researchers have used various energy saving mechanisms. The IEEE 802.11 standard is also known as - WLAN/Wi-Fi is a set of low tier, terrestrial, network technologies for data communication. It operates on the 2.4 GHz and 5 GHz Industrial, Science and Medical (ISM) frequency bands and it comes in many different variations like IEEE 802.11a/b/g/n.

The IEEE 802.15.4 standard is commonly known as ZigBee, but ZigBee has some features in addition to those of 802.15.4. It operates in the 868 MHz, 915 MHz and 2.4 GHz ISM bands.

IEEE802.11 supports both adhoc and infrastructure mode of operation whereas the IEE802.14 supports only the adhoc mode of operation.

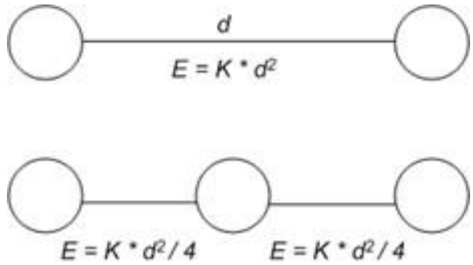
The IEEE 802.15.4 which operates at a data range to the maximum of 75m as compared to the data range of 120m-240m of the IEEE 802.11 standard (depending on the variations)which proves to be an advantage. Shorter range communication has lower power requirements, enables equipment to be smaller and the potential for frequency reuse is very good.

3. MAC energy aware protocols

a. Energy Aware Protocols Are Used At The Mac Layer (Energy Efficient Medium Access).

b. Basic Principle: Energy Required For Signal Transmission Is Proportional To D^{A} Where D – Distance Between Two Nodes And A – Attenuation Factor (Medium Dependent)

c. For Optimum A = 2, Transmitting A Signal To ½ Of Distance Requires ¼ Of Energy: $(½ D)^{2} = ¼ D^{2}$ → If A Protocol Can Find A Node On ½ Distance To Target, Which Can Supply Additional ¼ Of Energy To Transmit The Signal Through The Remaining Half, ½ Of Energy Is Saved! $(½ D)^{2} + (½ D)^{2} = ¼ D^{2} + ¼ D^{2} = ½ D^{2}$



For the Internet of Things the protocol that may be used is 6LOWPAN protocol. The 6 stands for IPV6 on which this protocol is based. Lo stands for Low Power and WPAN is Wireless Personal Area Networks. Since this protocol is an integration of the IP6 and Low power WPANS smallest devices with limited processing capabilities can be included in the Internet of Things .It supports the star ,mesh and combination of star and mesh topologies. Hence for future applications we may develop this protocol further.

IV. CONCLUSION

From the above comparisons it is very clearly observed that as a future scope the architecture of the Wireless Sensor Networks may be modified to integrate with the Internet of Things.

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