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WIRELESS SENSOR NETWORKS: AN OVERVIEW

Ms. Poonam Thakur, Prof. R. M. Pethe
Deparment of Electronics and Communation Priyadarshini Institute of Engineering and Technology Nagpur , Maharashtra, India, poonamthakut1803@gmail.com
Deparment of Electronics and Communation Priyadarshini Institute of Engineering and Technology Nagpur , Maharashtra, India, rahul2480@gmail.com

ABSTRACT
Wireless sensor network with a large number of sensor nodes can be used as an effective tool for gathering data in various situations. Wireless Sensor Networks (WSNs) consist of small nodes with sensing, computation, and wireless communications capabilities. Many routing, power management, and data dissemination protocols have been specially designed for WSNs where energy awareness is an essential design issue. In wireless sensor network sensors play an important part, as sensing is one of its central roles? A number of characteristics are important when choosing the right sensor for an application. Sensors can be classified according two to basic criteria: principal by which they function, and by the function the sensor performs. Mechanical sensors detect mechanical properties and actions. Temperature sensors are some of the most widely used, and a variety of temperature sensors exist. Pressure sensors, Humidity sensor, Soil sensors, Chemical, bio, and radiation sensors play an increasing role in a many WSN applications. Microcontroller based hardware is used to design the nodes with different sensors and it will be simulate by using software and implement few rules as a protocol for transmission the data and receive the data from sensor to sink node. This collection of data is arranged in a proper format in sink node and given to the host Computer.
Keywords -Wireless sensor network , Sensors , Microcontrollers Routing.

I. INTRODUCTION

The emerging field of wireless sensor networks combines sensing, computation, and communication into a single tiny device. Through advanced mesh networking protocols, these devices form a sea of connectivity that extends the reach of cyberspace out into the physical world. As water flows to fill every room of a submerged ship, the mesh networking connectivity will seek out and exploit any possible communication path by hopping data from node to node in search of its destination. While the capabilities of any single device are minimal, the composition of hundreds of devices offers radical new technological possibilities.[1]

The challenges in the hierarchy of: detecting the relevant quantities, monitoring and collecting the data, assessing and evaluating the information, formulating meaningful user displays, and performing decision-making and alarm functions are enormous [2].

The power of wireless sensor networks lies in the ability to deploy large numbers of tiny nodes that assemble and configure themselves. Usage scenarios for these devices range from real-time tracking, to monitoring of environmental conditions, to ubiquitous computing environments, to *in situ* monitoring of the health of structures or equipment. While often referred to as wireless sensor networks, they can also control actuators that extend control from cyberspace into the physical world. The most straight forward application of wireless sensor network technology is to monitor remote environments for low frequency data trends. For example, a chemical plant could be easily monitored for leaks by hundreds of sensors that automatically form a wireless interconnection network and immediately report the detection of any chemical leaks. Unlike traditional wired systems, deployment costs would be minimal. Instead of having to deploy thousands of feet of wire routed through protective conduit, installers simply have to place quarter-sized device. (Fig. 1).

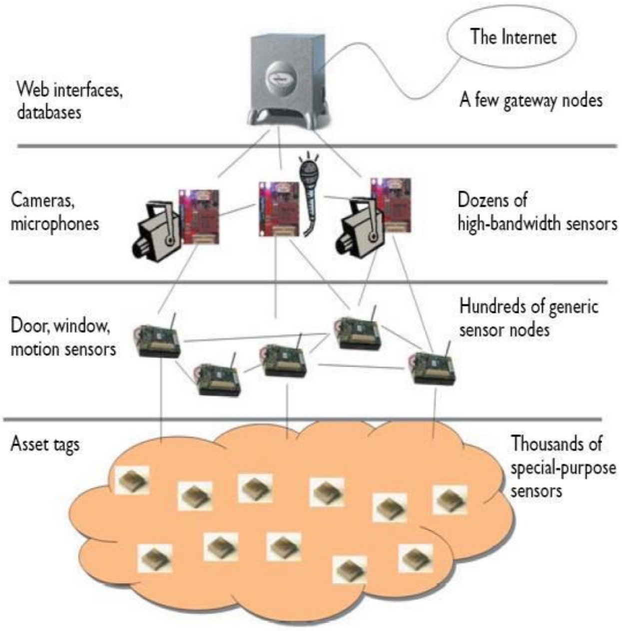

Fig 1: Architecture of Wireless Sensor Network

II. COMMUNICATION NETWORKS

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A. Network Topologies

In computer networking, *topology* refers to the layout of connected devices. This article introduces the standard topologies of networking. Network topologies are categorized into the following basic types: bus, ring, star, tree, mesh. More complex networks can be built as hybrids of two or more of the above basic topologies.

Bus networks (not to be confused with the system bus of a computer) use a common backbone to connect all devices. A single cable, the backbone functions as a shared communication medium that devices attach or tap into with an interface connector. A device wanting to communicate with another device on the network sends a broadcast message onto the wire that all other devices see, but only the intended recipient actually accepts and processes the message.

Ethernet bus topologies (Fig. 2) are relatively easy to install and don't require much cabling compared to the alternatives. 10Base-2 ("Thin Net") and 10Base-5 ("Thick Net") both were popular Ethernet cabling options many years ago for bus topologies. However, bus networks work best with a limited number of devices. If more than a few dozen computers are added to a network bus, performance problems will likely result. In addition, if the backbone cable fails, the entire network effectively becomes unusable.

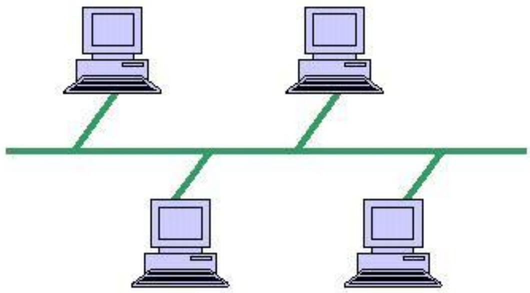

Fig. 3: Ring Topology

Token Ring is a data link technology for local area networks (LANs). It operates at layer 2 of the OSI model.

Unlike all other standard forms of LAN interconnects, Token Ring maintains one or more common data frames that continuously circulates through the network. These frames are shared by all connected devices on the network as follows:

• a frame (packet) arrives at the next device in the ring sequence that device checks whether the frame contains a message addressed to it. If so, the device removes the message from the frame. If not, the frame is empty (called a *token frame*).

• the device holding the frame decides whether to send a message. If so, it inserts message data into the token frame and issues it back onto the LAN. If not, the device releases the token frame for the next device in sequence to pick up

• the above steps are repeated continuously for all devices in the token ring.

Token Ring was developed by IBM during the 1980s as an alternative to Ethernet. Starting in the 1990s, it significantly decreased in popularity and gradually was phased out of business networks as Ethernet technology began to dominate LAN designs. Standard Token Ring supports only up to 16 Mbps.
In the 1990s, an industry initiative called High Speed Token Ring developed technology for extending Token Ring to 100 Mbps equal to Ethernet, but insufficient interest in the marketplace existed for HSTR products and the technology was abandoned.

Many home networks use the star topology (Fig 4). A star network features a central connection point called a "hub" that may be a hub, switch or router. Devices typically connect to the hub with Unshielded Twisted Pair (UTP) Ethernet. Compared to the bus topology, a star network generally requires more cable, but a failure in any star network cable will only take down one computer's network access and not the entire LAN. (If the hub fails, however, the entire network also fails.)

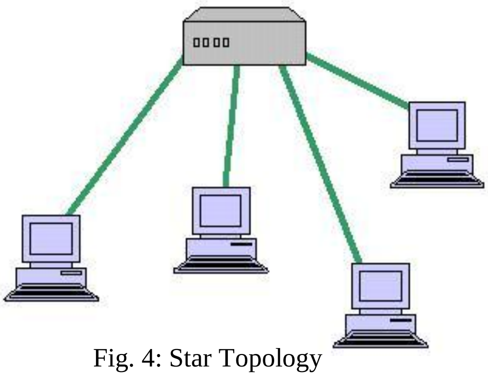

Fig. 4: Star Topology

Tree topologies integrate multiple star topologies together onto a bus. In its simplest form, only hub devices connect directly to the tree bus, and each hub functions as the "root" of a tree of devices. This bus/star hybrid approach supports future expandability of the network much better than a bus (limited in the number of devices due to the broadcast traffic it generates) or a star (limited by the number of hub connection points) alone.

Mesh topologies involve the concept of routes. Unlike each of the previous topologies, messages sent on a mesh network can take any of several possible paths from source to destination. (Recall that even in a ring, although two cable paths exist, messages can only travel in one direction.) Some WANs, most notably the Internet, employ mesh routing. A mesh network in which every device connects to every other is called a full mesh [3]. (Fig. 5)

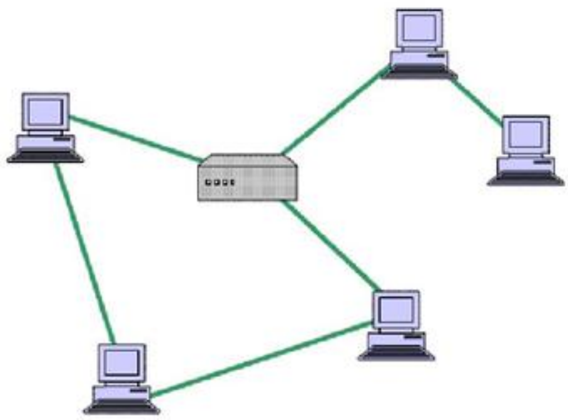

Fig. 5: Mesh Topology

III. WIRELESS SENSOR NETWORKS

The concept of wireless sensor networks is based on a simple equation:

Sensing + CPU + Radio = Thousands of potential applications

As soon as people understand the capabilities of a wireless sensor network, hundreds of applications spring to mind. It seems like a straightforward combination of modern technology. However, actually combining sensors, radios, and CPU's into an effective wireless sensor network requires a detailed understanding of the both capabilities and limitations of each of the underlying hardware components, as well as a detailed understanding of modern networking technologies and distributed systems theory. Each individual node must be designed to provide the set of primitives necessary to synthesize the interconnected web that will emerge as they are deployed, while meeting strict requirements of size, cost and power consumption. A core challenge is to map the overall system requirements down to individual device capabilities, requirements and actions. To make the wireless sensor network vision a reality, architecture must be developed that synthesizes the envisioned applications out of the underlying hardware capabilities.

To develop this system architecture we work from the high level application requirements down through the low-level hardware requirements. In this process we first attempt to understand the set of target applications. To limit the number of applications that we must consider, we focus on a set of application classes that we believe are representative of a large fraction of the potential usage scenarios. Additionally, we must provide a detailed background into the capabilities of modern hardware. (Fig. 6)

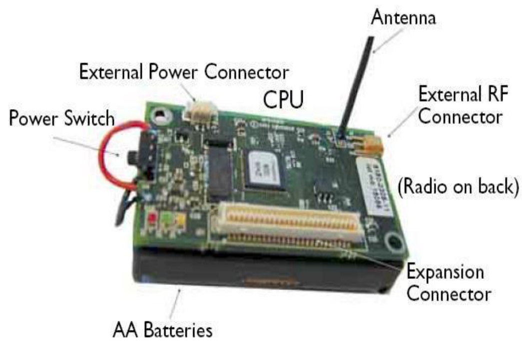

Fig. 6: Wireless Sensor

A. IEEE 1451 and Smart Sensors

Wireless sensor networks satisfy these requirements. Desirable functions for sensor nodes include: ease of installation, self-identification, self-diagnosis, reliability, time awareness for coordination with other nodes, some software functions and DSP, and standard control protocols and network interfaces [16].

There are many sensor manufacturers and many networks on the market today. It is too costly for manufacturers to make special transducers for every network on the market. Different components made by different manufacturers should be compatible. Therefore, in 1993 the IEEE and the National Institute of Standards and Technology (NIST) began work on a standard for Smart Sensor Networks. IEEE 1451, the Standard for Smart Sensor Networks was the result. The objective of this standard is to make it easier for different manufacturers to develop smart sensors and to interface those devices to networks.

B. Smart Sensor and Virtual Sensors

The figure shows the basic architecture of IEEE 1451 [5]. Major components include STIM, TEDS, TII, and NCAP as detailed in the figure. A major outcome of IEEE 1451 studies is the formalized concept of a Smart Sensor. A smart sensor is a sensor that provides extra functions beyond those necessary for generating a correct representation of the sensed quantity [7]. Included might be signal conditioning, signal processing, and decision-making/alarm functions. A general model of a smart sensor is shown in the figure. Objectives for smart sensors include moving the intelligence closer to the point of measurement; making it cost effective to integrate and maintain distributed sensor systems; creating a confluence of transducers, control, computation, and communications towards a common goal; and seamlessly interfacing numerous sensors of different types. The concept of a Virtual Sensor is also depicted. A virtual sensor is the physical sensor/transducer, plus the associated signal conditioning and digital signal processing (DSP) required obtaining reliable estimates of the required sensory information. The virtual sensor is a component of the smart sensor.

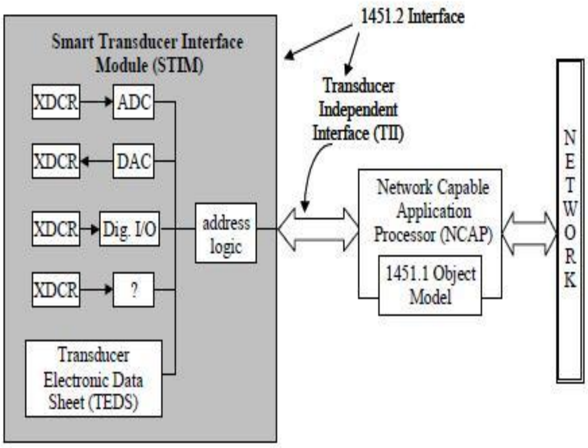

Fig. 7: The IEEE 1451 Standard for Smart Sensor Networks

TABLE I
SENSORS FOR SMART ENVIRONMENT

Measurements for Wireless Sensor Networks		
Properties	**Measuring Parameter**	**Transduction Principle**
Physical Properties	Pressure	Piezoresistive, capacitive
	Temperature	Thermister,thermo-mechanical, thermocouple
	Humidity	Resistive, capacitive
	Flow	Pressure change, thermister
Motion Properties	Position	E-mag, GPS, contact sensor
	Velocity	Doppler,Hall effect, optoelectronic
	Angular Velocity	Optical encoder
	Acceleration	Piezoresistive, piezoelectric, optical fiber
Control Properties	Strain	Piezoresistive
	Force	Piezoelectric, piezoresistive
	Torque	Piezoresistive, optoelectronic
	Slip	Dual torque
	Vibration	Piezoresistive, piezoelectric, optical fiber, Sound, ultrasound
	Tactile/contact	Contact switch, capacitive

Presence	Proximity	Hall effect, capacitive, magnetic, seismic, acoustic, RF
	Distance/range	E-mag (sonar, radar, lidar), magnetic, tunneling
	Motion	E-mag, IR, acoustic, seismic (vibration)
Biochemical	Biochemical agents	Biochemical transduction
Identification	Personal features	Vision
	Personal ID	Fingerprints, retinal scan, voice, heat plume, vision motion analysis

IV. SIGNAL PROCESSING AND DECISION MAKING

The figure showing the IEEE 1451 Smart Sensor includes basic blocks for signal conditioning (SC), digital signal processing (DSP), and A/D conversion. Let us briefly mention some of the issues here

A. Signal Conditioning

Signals coming from MEMS sensors can be very noisy, of low amplitude, biased, and dependent on secondary parameters such as temperature. Moreover, one may not always be able to measure the quantity of interest, but only a related quantity. Therefore signal conditioning is usually required. SC is performed using electronic circuitry, which may conveniently be built using standard VLSI fabrication techniques in situ with MEMS sensors. A reference for SC, A/D conversion, and filtering is [11].

A real problem with MEMS sensors is undesired sensitivity to secondary quantities such as temperature. Temperature compensation can often be directly built into a MEMS sensor circuit. In the figure above showing a 3x3 array of IGEFET sensors, there is shown a 10th IGEFET- this is for temperature compensation. Temperature compensation can also be added during the SC stage as discussed below.

A basic technique for improving the signal-to-noise ratio (SNR) is low-pass filtering, since noise generally dominates the desirable signals at high frequencies. Shown in the figure is an analog LPF that also amplifies, constructed from an operational amplifier. Such devices are easily fabricated using VLSI semiconductor techniques.

The time constant of this circuit is $\tau = R2C$. The transfer function of this filter is $H(s) = ka/(s+a)$ with 3 dB cut-off frequency given by $a = 1/\tau$ rad. and gain given by $k = R2/R1$. Here, s is the Laplace transform variable. The cut-off frequency should be chosen larger than the highest useful signal frequency of the sensor.

Alternatively, one may use a digital LPF implemented on a computer after sampling. A digital low-pass filter transfer function and the associated difference equation for implementation is given by

Digital filter: $\hat{s_k} = K \frac{z+1}{z-\alpha} s_k$ Difference equation:

$\widehat{s_{k+1}} = \alpha s_k + K(s_{k+1} + s_k)$

Here, z is the z-transform variable treated as a unit delay in the time domain, s_k is the measured signal,

and $\hat{s_k}$ is the filtered or smoothed variable with reduced noise content. The filter parameters are selected in terms of the desired cut-off frequency and the sampling period. It is often the case that one can measure a variable s_k (e.g. position), but needs to know its rate of change v_k (e.g. velocity). Due to the presence of noise, one cannot simply take the difference between successive

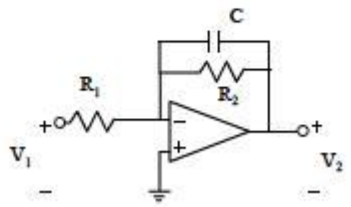

Fig. 8: Analog low-pass filter

Values of s_k as the velocity. A filtered velocity estimate given by $V_{k+1} = \alpha v_k + K(s_{k+1} - s_k)$ both filters out noise and gives a smooth velocity estimate.

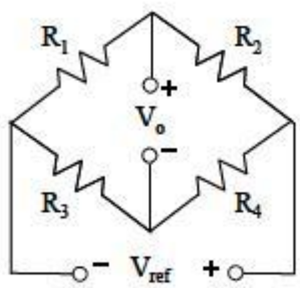

Fig. 9 Wheatstone bridge

Often, changes in resistance must be converted to voltages for further processing. This may be accomplished by using a Wheatstone bridge [6].

Suppose R_1= R in the figure is the resistance that changes depending on the measurand (e.g. strain gauge), and the other three resistances are constant (quarter bridge configuration). Then the output voltage changes according to $\Delta V0 = \frac{Vref \Delta R}{4R}$ We assume a balanced bridge so that $R_2=R_1=R$ and $R_3=R_4$. Sensitivity can be improved by having two sensors in situ, such that the changes in each are opposite (e.g. two strain gauges on opposite sides of a flexing bar). This is known as a half bridge. If R_1 and R_2 are two such sensors and $\Delta R_1 = -\Delta R_2$, then the output voltage doubles. The Wheatstone bridge may also be used for differential measurements (e.g. for insensitivity to common changes of two sensors), to improve sensitivity, to remove zero offsets, for temperature compensation, and to perform other signal conditioning Specially designed operational amplifier circuits are useful for general signal conditioning [7]. Instrumentation Amplifiers provide differential input and common mode rejection, impedance matching between sensors and processing devices, calibration, etc. SLEEPMODE amplifiers (Semiconductor Components Ind., LLC) consume minimum power while asleep, and activate automatically when the sensor signal exceeds a prescribed threshold.

V. DECISION MAKING AND USER INTERFACE

Many simulation software are available to design different format of protocols and their topologies. So as per the protocols and topology we can use advanced DSP, intelligent user interfaces, decision assistance, and alarm functions. These hardware sensor nodes and their simulation are decision making and user interface device which can be easily operate by other user and the data collected by host computer is easily used and arranged by normal user.

VI. CONCLUSION

It has been concluded that wireless sensor network is used to transmit and receive large scale energy data for long distance communication. In this paper we mentioned the types of topologies used in WSNs and Communication network and the parameters and their properties for designing nodes which are placed at remote location. These notes can collect data from and send it to sink node. Sink node is used to collect data priority wise and send it to host server (computer).

In future it has been observed that the size of node is too much small and it has been used for large time to send large amount of data in various application for example Agriculture, Biomedical, Environmental condition, Autonomous industry, Control Panel devices, in Automobile and many more where we required real time response to avoid some accidents and other problem which can be prevented by using Wireless Sensors Network and their topologies, Protocols and simulation.

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