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Study of Smart Sensors and their Applications

Mrs. Manali Chaudhari[1], Prof. Srinu Dharavath[2]

P.G. Student, Pune University, G.S. Moze college of engineering, India[1]

Prof. Srinu Dharavath, Department of Computer Engg., G. S. Moze College of engineering, India [2]

Abstract: This paper gives the brief idea about the basic structure, standards, applications and some recent developments in smart sensor technology in different fields. Smart sensors as compared to the sensors can sense along with special purpose computing devices which are connected in sensor networks. Critical devices can be monitored as well as managed remotely by using wireless sensor networks which yields better performance of system with better decision making abilities and better control. The new advances in wireless technologies are emerging in varies fields like supply chain logistics, monitoring of systems, data collection and application controls. The main purpose of smart sensor networks is to reduce human intervention and management control in different systems. Wireless devices including actuators, sensors and gauges can now be monitored wirelessly.

Keywords: Wireless Sensor Network, Sensors, Smart Sensors, Smart Sensor Network, Virtual Sensors, WSSN

I. INTRODUCTION

Sensor node combines the sensing and computing abilities of devices which are connected through wireless communication. The network of such sensor nodes provides data as well as performing and controlling various tasks and functions. While implementing sensor nodes in simple or complex networks, the size and cost of individual sensor node is of vital importance. When sensor nodes are used in the networks of environmental data collection, target tracking and surveillance it yields various applications along with time-space context. Sensor networks can also be used for supporting and preventing rapid response during events and post recovery along with analysis after event.

Large number of sensor nodes could be installed to benefit the environment in practical e.g. riverbanks, roads, buildings, coastal areas etc. New sensor nodes can be deployed depending upon the area of interest on demand or at random in specified area. A smart sensor node is a combination of sensing, processing and communication technologies.

II. STRUCTURE OF SMART SENSOR

The basic architectural components of smart sensor node are shown in the figure 1 . Changes in parameters are sensed by sensing unit, digital signals are generated by signal conditioning circuitry from electrical signals. Analog to digital conversion is performed and this input is given to processing units or application programs. Task processing is done by memory unit and communication with base station or sensors or sinks in WSN is done by transceivers.

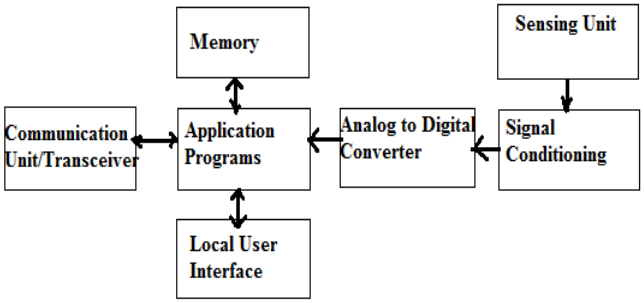

Figure 1: Basic Architectural Components of smart Sensor Node

Five main parts of sensor node are:

●The central unit: It is in the form of microprocessor which manages the tasks.

●Battery: Is the source of energy

●A Transceiver: Interacts with the environment and collects data.

●Memory: Used as storage media for storing data or processing data.

●Communication module: It includes transceivers and forwards queries and data to and from central module. Energy efficiency in all parts of sensor network is very crucial for long network lifetime. Nodes in the sensor network cooperates and spreads the data processing task and sends the processed information to sinks. For reducing the overhead of power supply of each and every node, Radio Frequency Identification (RFID) chips with no batteries are developed.

Sensors are used to monitor different parameters related to lighting conditions, noise levels, humidity, vehicle movement, soil makeup, mechanical stress levels, presence or absence of certain type of objects and other properties.

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Sensor node mechanisms can be thermal, visual, acoustic, radar, magnetic or seismic. Self identification and self diagnosis is possible for sensor node. The three ways by which the mechanisms of sensor node works are:

●Towards a predefined target by a line of sight (e.g. visual sensors)

●With Space and time relationship to target (e.g. Seismic sensors)

●By a wave like propagation with possible bending (e.g. acoustic sensors)

Unlike address-centric networks, sensor networks are data centric. In such a network, queries are directed to a region containing a cluster of sensor nodes rather than specific sensor addresses. Data in a cluster which is of similar kind is collected and aggregated locally. That means aggregator node performs the functions of summarizing and analysing the aggregated data in a cluster which helps to reduce the communication bandwidth. Level of Accuracy is increased by aggregating the data which concludes data redundancy giving failure of node. Figure 2 shows the data collection and aggregation of sensor network.

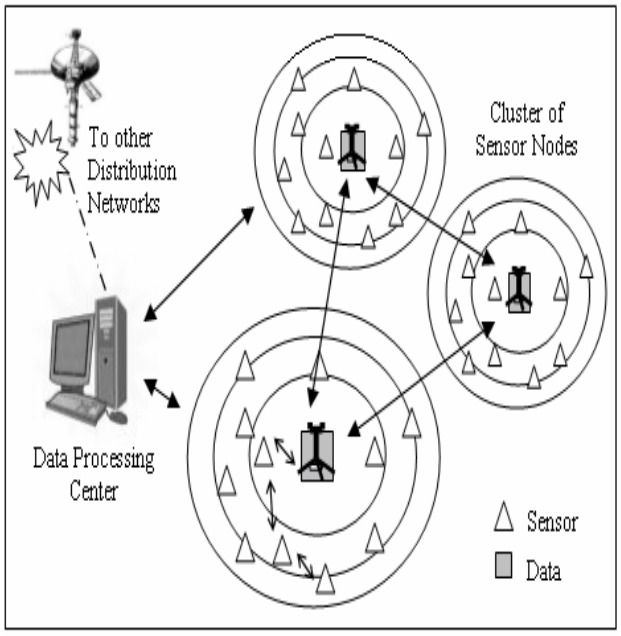

Figure 2: Data Collection and Aggregation in WSN [1]

III. STANDARD OF SMART SENSOR NETWORK

Other than sensing some other desirable functions of sensor nodes are reliability, self identification, ease of installation, time and co-ordination knowledge with other sensor nodes and standard control protocols and network interfaces [IEEE 1451 Expo, 2001]

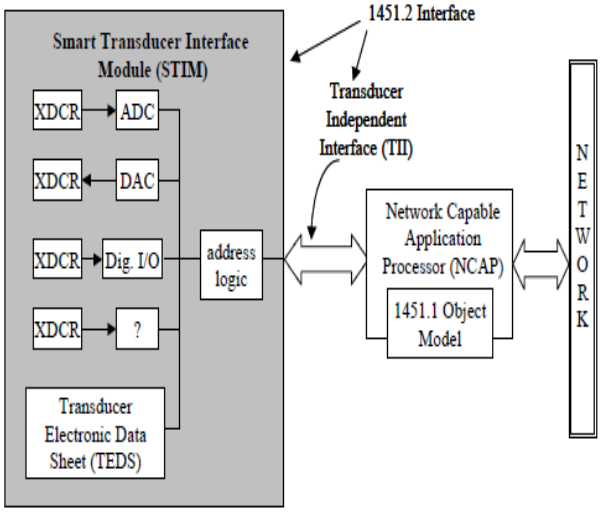

Figure 3: The IEEE 1451 standard for smart sensor network. [5]

In 1993 the IEEE and National Institute of Standards and technology (NIST) began to work on a standards for Smart Sensor Notworks. IEEE 1451, the Standard for Smart Sensor Networks was the result. Developing smart sensors and their interfaces with devices to networks have become easier by using these standards.

● Smart Sensor , Virtual Sensor : Basic Architecture of IEEE 1451[Conway and Hefferman 2003] is shown in the figure. Major components are TEDS, TII, STIM and NCAP as shown in the figure 3. IEEE 1451 gave the formalized concept of Smart Sensor. A smart sensor provides extra functions beyond those necessary for generating a correct representation of the sensed quantity [Frank 2000].

Smart Sensor's general model is as shown in the figure 4. Smart Sensor's objectives include integrating and maintaining the distributed sensor system yielding cost effectiveness, measuring smartly and intelligently, creating a common platform for computing, controlling and communication toward a common goal and interfacing various sensors of different types.

A virtual sensor is the physical sensor/transducer, plus the associated signal conditioning and digital signal processing (DSP) required to obtain reliable estimates of the required sensory information. The virtual sensor is a component of the smart sensor.

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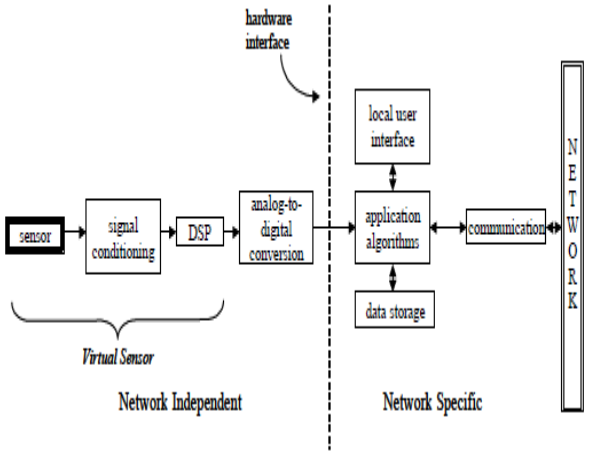

Figure 4: A General model for smart sensor [IEEE 1451 Expo, 2001] [5]

IV. APPLICATIONS

This section briefly explains the areas of applications of WSN and Smart nodes but not limited to the list.

A. Flood and water level monitoring system:

In order to cope with natural disasters like earth quakes and floods in a fast and highly coordinated manner, the system which gives information about concerned situation is important. WSN technology has newly emerged which can handle these types of disasters. But deploying these kind of sensor networks for flood monitoring requires lots of potential

B. Environmental monitoring

Environmental monitoring system is very important in analysing the important data for forecasting weather and even for measuring the possible environmental threat, that to be prevented before they occur. Environmental monitoring system involves collecting of information from a large geographical area by which even minute variations in the environment can be calculated. Seabird habitats can also be monitored using WSN.

C. Traffic Monitoring and Controlling:

The need for having an efficient traffic controlling and monitoring system is very demanding. Deployment of smart sensors along with the roadside made many developed countries possible to collect live data or to monitor irresponsible vehicle violating the speed limit. Placing sensor nodes at the identified spots with the addition of wireless communications could help for the development of a smart traffic monitoring system.

Apart from above mentioned system, a simple traffic signal system could also be equipped with intelligent sensing devices at the road intersections. The smart sensing device would gather information of upcoming objects towards the intersection; perform scheduling to determine the time-to-wait (TTW) interval for signals to be changed. Time-to-wait is determined by the time gap between different crossing objects. Hence, automated signal changing would never keep the motorist waiting in one side for a longer time.

D. Energy saving in artificial lighting:

Saving energy in smart environment systems is one of the main goals of smart environment research. Wireless sensor networks (WSNs), large networks of embedded devices, containing microcomputers, radios, and sensors open new methods and approaches to saving energy. WSNs are used to retrieve data on lighting conditions. Several approaches have been proposed to save energy in this scenario. One approach considers inhabitant preferences about lighting and learns them in order to automatically adjust lighting to satisfy these preferences. A theoretical computation of how many lumens are provided by our artificial lighting setup can be made.

E. Remote system monitoring and equipment fault diagnostics:

WSN provides feasible and cost-effective sensing solutions for these types of systems. Large scale efficiently monitoring system can provide complete; information on the conditions of system components, including generation units, transformers, transmission lines, motors, etc., in a remote and online manner.

F. Transport and logistics:

An intelligent transportation system (ITS) can be defined as "the application of advanced and emerging technologies (computers, sensors, control, communications, and electronic devices) in transportation to save lives, time, money, energy and the environment" (ITS Canada, 2009). The ITS can be categorised into *intelligent infrastructure* and *intelligent vehicles* (RITA, 2009).

G. Industrial Applications:

In industrial field, machines or equipment are monitored ans controlled for checking pressure, overall health, humidity, temperature and also vibrations. When critical information about any parameter is achieved the nodes communicates with each other and sends the information to network where it is processed and then predictive maintenance is carried out according to the parameter values.

H. Precision agriculture and animal tracking:

In precision agriculture, sensor networks can be used to soil monitoring, climate monitoring, insect-disease-weed monitoring as well as plant/crop monitoring.

V. RECENT DEVELOPMENTS IN WIRELESS SMART SENSOR NODES

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A Smart lighting sensor solution for smart cities:

These smart lighting sensors measures ambient light (luminosity) with a new set of directed sensor probes. These Smart Lighting devices are also capable of monitoring conditions inside tunnels or building or outside in the streets and also has temperature and humidity sensors.

B E-Health Sensor Shield:

The e-Health Sensor Shield users to perform biometric and medical applications where body monitoring is needed by using 9 different sensors: pulse, oxygen in blood (SPO2), airflow (breathing), body temperature, electrocardiogram (ECG), glucometer, galvanic skin response (GSR- sweating), blood pressure (sphygmomanometer) and patient position (accelerometer).

C Encryption Libraries – AES/RSA Cryptography for Sensor Network:

Encryption Libraries sensor platforms in order to ensure the authentication, confidentiality (privacy) and integrity of the information gathered by the sensors. For that different cryptography algorithms including AES 256 and RSA 1024 have been implemented in the libraries.

D 3G connectivity to ZigBee, Wi-Fi, and Bluetooth sensors:

The new multiprotocol router for wireless sensor networks designed to connect Wi-Fi, Bluetooth and ZigBee sensors to the Internet through 3G connectivity. These allows to send the information gathered by hundreds of sensor nodes at the same time, bandwidth of 5.5 Mb/s more than 10 times faster than compared with traditional GPRS gateways

E iPhone and Android Devices Detected by Smart Sensors:

Any Smartphone (iPhone,Android) in the area can be detected by this new technology by measuring Wifi and Bluetooth activity; allowing to know in real time people and presence of vehicle. Applications of this new technology go from street activity measurement to vehicle traffic management.

VI. CONCLUSION

In recent technologies, WSN has got the spotlight on it because of its unbeatable potential, significance and wide range of application areas. As wireless sensor technology has evolved, it has become possible to predict the future by using Smart environment which was not possible in the past. "Smart Sensors" is Wireless Sensor Network's one step further. This paper is mainly focused on the study of smart sensors and their possible and existing usage in various fields.

The future work for Smart Sensors can include but not limited to Smart Grid for improved electric power efficiency, Smart Antenna for satisfying demands for drastic high data rates for certain users with high quality of service, Smart Highways for handling traffic and accident related issues.

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BIOGRAPHIES

Manali Chaudhari received her B.E. (CSE) degree from Bharti Vidyapeeth's Women's College of Engineering in and pursuing M.E. (CSE) degree at Pune University at G.S. Moze College of Engineering center. Her areas of interest are Wireless Networks and Mobile communications.

Prof. Srinu Dharavath received his B.Tech (CSIT) from JNTUH and M.Tech (AI) degree from Hyderabad University (HCU). Currently he is working as Asst. Prof. in G.S. Moze College of Engineering, Pune. His area of interest is Artificial Intelligence.