IMPACT: International Journal of Research in
Engineering & Technology (IMPACT: IJRET)
ISSN(E): 2321-8843; ISSN(P): 2347-4599
Vol. 3, Issue 7, Jul 2015, 1-8

BRIEF REVIEW ON IEEE 1451 STANDARD FOR DEPLOYING RECONFIGURABLE SENSOR INTERFACE IN WSN

VIJAYKALA

Department of Computer Science and Engineering, BMS College of Engineering, Bengaluru, Karnataka, India

ABSTRACT

Wireless Sensor Networks (WSN) is gaining popularity in our daily lives because of its wide range of applications, such as health care monitoring, industrial applications, control networks, etc. Nowadays WSNs are integrated into Internet of Things (IoT); where sensor nodes connect to internet dynamically and thus WSN accomplish their tasks. With the increase in the number of sensors, an efficient reconfigurable sensor interface is required to integrate WSN with IoT. This paper discusses the parameters, which are required to design a reconfigurable sensor interface device for WSN utilizing IoT architecture. IEEE 1451 standards are adopted for this design. An intelligent data acquisition system can be deployed with the advent of reconfigurable smart sensor interface using current work.

KEYWORDS: IEEE 1451 Standards, Internet of Things, Sensor Interface Device, Wireless Sensor Networks

INTRODUCTION

Sensor is a device which allows us to detect the environmental parameters of any form of energy. Sensors provide output in the form of electrical or optical signal, whose values represent the changes or events in quantities of the environmental energy. Applications include manufacturing and machinery, airplanes and aerospace, cars, medicine and robotics. Due to its diversified areas of applications, creating a network of sensors is essential to monitor and control the environmental parameters, for example, monitoring the temperature is necessary in theatres, school buildings, or any other closed areas, so in these cases, the sensor network system can enable the water sprinklers to lower the heat once the temperature value exceeds optimal room temperature. Communicating with sensors within a network wirelessly reduces the complexity of wired networks and also wireless communication utilizes the frequency bandwidth efficiently. Environmental data is collected regularly from large number of nodes in these WSNs and transmits this data to central data sink as shown in Figure. 1 [1].

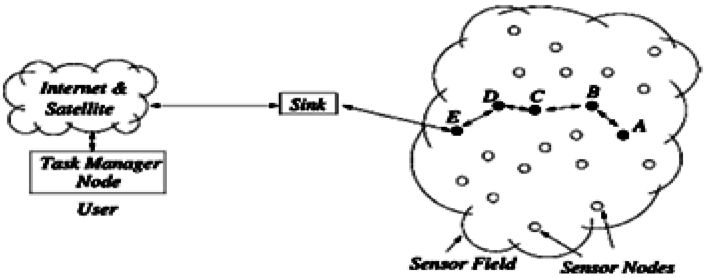

Figure 1: WSN

Hundreds to thousands of sensor nodes are connected in a wireless sensor network with very less distance between adjacent nodes and low application data rate. More number of opportunities can be set up in real environments for WSNs. WSN, in recent years became an emerging field in wide range of applications including health monitoring applications, environmental observation, forecasting system, battlefield surveillance, robotic exploration, monitoring of human physiological data etc. The sensors in a wireless network can be placed at different places with numerous usages and each sensor has the capability to sense different attributes like moisture, temperature, humidity, pressure etc [2].

A radio channel is implemented to transfer the data to base station such as an access point to a fixed infrastructure or a laptop or a personal handheld device, due to the limited memory of the sensors and these sensors are deployed in difficult-to-access locations [3]. Power supply to the network can be provided by battery, which is the main source of energy and also power is consumed from environments like solar panels and these are dependent on the appropriateness of the location of the sensors. Actuators are incorporated in the sensors depending upon the application and type of sensor.

Data acquisition from the WSN leads us to store and process the data. Since the data acquired from WSN is large, which we call as Big Data, must be stored and manipulated very carefully. This data can be used for monitoring and controlling applications with the help of Internet of Things (IoT). With IoT, the objects which we use every day that surround us will become dedicated actors of the internet by generating and consuming very large information. IoT encapsulates devices which are related to technological world, such as cars or fridges, and foreign objects to this kind of environment such as plantations, woods or livestock. As the technology is advancing at certain steady pace for IoT, it will be possible to produce quantitative and qualitative leap in various domains like healthcare, home automation, entertainment, logistics, and so on [4].

As the numbers of application areas are increasing rapidly with the advancement in WSN and IoT, it is required to support different types of sensors in WSN. Data from these sensors are collected using a hardware controller device in data acquisition system (DAS); controller device can be microcontrollers or programmable logic devices (PLDs) or field-programmable gate arrays (FPGAs) [5]. But the major challenge in obtaining the data from various sensors lies in configuring the hardware controller device, because the controller device must support more number of sensors, and also any type/number of sensors can be integrated with the device so that very little time will be consumed to attach and detach any type/number of sensors easily without reconfiguring the controller device or designing new controller device. To solve this multi-sensing challenge, chiefs from industry and government organizations such as Institute of Electrical and Electronics Engineers (IEEE), U.S. National Institute of Standards and Technology (NIST), the U.S. Department of Energy Laboratories, instrumentation manufacturers, sensor manufacturers and other organizations got together and created the IEEE 1451 family of standards [6].Qingping Chi et.al in [7], they have employed complex programmable logic device (CPLD) as controller for interfacing the sensors and acquiring data from sensors, where the controller can be reconfigured accordingly whenever a new sensor is added or removed by using IEEE 1451.2 protocol.

WSN ARCHITECTURE

Miniaturization helps manufacturers to design and develop smaller sensor devices, thus the sensor network can be created anywhere on land, underground, and underwater. Depending on the environment, the challenges and constraints of sensor networks differ. There are five types of WSNs namely terrestrial WSN [1], underground WSN [8, 9], underwater WSN [10, 11], multimedia WSN [12], and mobile WSN [3]. Whatever might be the type of sensor network, the architecture of these WSNs includes both operating system design and hardware platform. The operating system used in these resource constrained wireless device is TinyOS [1].

The major components of WSN are shown in Figure. 2 [8]:

- Sensor Field – The area where sensor nodes are deployed.
- Sensor Nodes – These are the sensors which are responsible for acquiring information and routing this information back to sink.
- Sink – This is a kind of sensor node which performs tasks such as receiving, processing and storing data from other sensor nodes. Messages which are needed to be sent from the sensors in a WSN can be reduced using sink node and this node is also used to reduce the energy requirements.
- Task Manager (Base Station) – This is the rationalized point of control within the WSN, which is used to extract information from the network and sends control data back to the network.

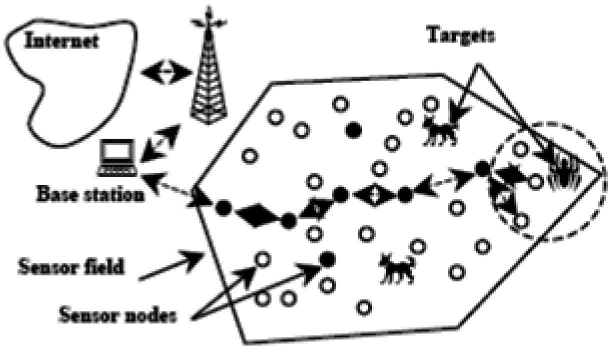

Figure 2: WSN Architecture

Considering the types of WSNs and its architecture, designing and developing a smart sensor deployment is quintessential requirement for the deployment of WSN. This enables plug and play at the transducer level, supports multiple sensing, simplifies the creation of networks, etc. By enabling internetwork in WSNs, the functionality of application areas can be extended further to simplify our day-to-day activities.

IEEE 1451 STANDARD TO DESIGN AND DEVELOP SMART TRANSDUCER INTERFACE

In recent years, the demand for wireless sensor networks is growing at a rapid pace due to its wide range of application areas. This led the researchers to focus on functionality, definition and communication protocol standards for smart transducers. The IEEE and NIST have established IEEE 1451 set of standards for a Smart Transducer Interface for Sensors and Actuators in an effort to overcome the incompatibility problems that occur while interfacing smart transducers to controller devices, microprocessor-based systems, Fieldbus and control networks [13]. The key concept of these standards is to define an architecture that enables transducers to connect into any real-time distributed control network in a true 'plug-and-play' manner, such that automatic system identification and configuration is aided.

The device which converts energy from one form into another is called as transducer. A transducer may be either a sensor or an actuator. A sensor is a transducer which generates an signal in electric form proportional to either physical or biological or chemical parameter, whereas an actuator is also an transducer which accepts an signal in electric form an performs a physical action [14]. A device that integrates analog or digital sensor or actuator element, communication interface and a processing unit is known as Smart Transducer [15]. A smart transducer consists of a hardware or software device consisting of small, compact unit containing an actuator or sensor element, a communication controller, a microcontroller and the related software from signal conditioning, diagnostics, calibration and communication [16].

Smart transducer model and its respective IEEE 1451 smart transducer architecture are shown in Figure. 3(a) and figure 3(b) respectively.

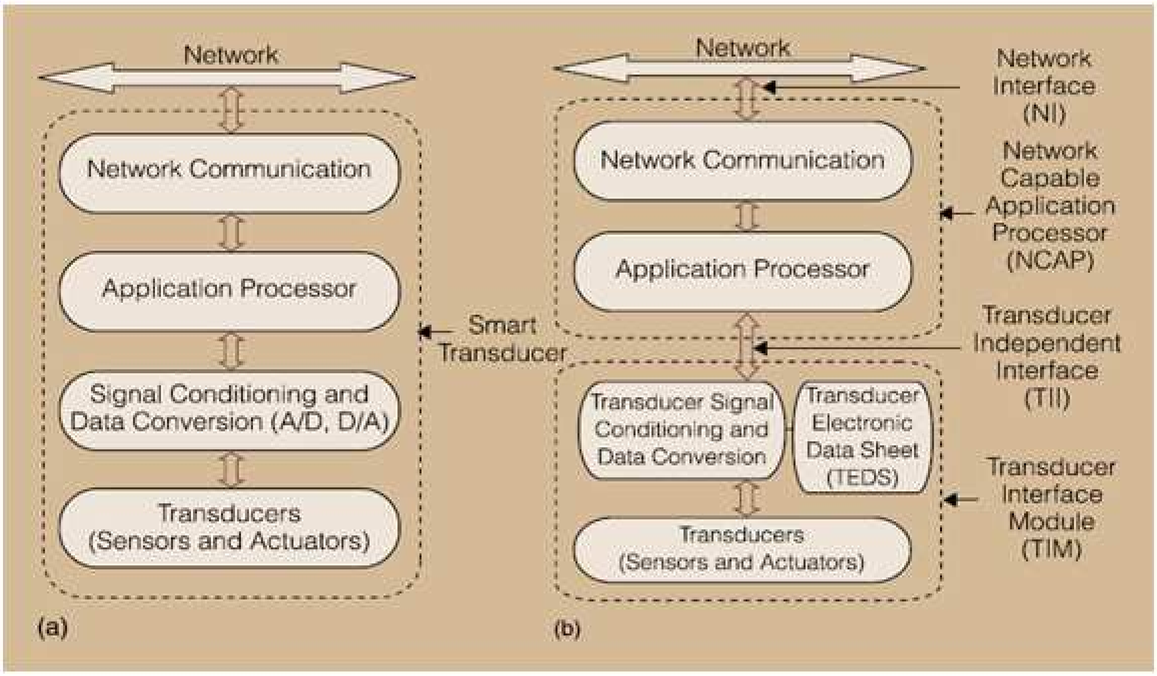

Figure 3: (a) Smart Transducer Model (b) This Architecture Adds TEDS and the System Partition into NCAP and TIM, with a TII

The functionality of IEEE standards simplifies the integration of the transducers in a networked environment [17]. Thus this standard for smart transducers would have the capabilities of self-description, self-identification, self-diagnosis, location-awareness, self-calibration, time-awareness, data *p*rocessing, reasoning data fusion, alert notification, standard-based data formats, and communication protocols. This IEEE standard architecture includes Transducer Electronic Data Sheets (TEDS) and the partition of the system into two major components – a Network Capable Application Processor (NCAP), Transducer Interface Module (TIM), and a transducer independent interface (TII) between the NCAP and TIM.

NCAP is a network node which integrates application processing and network communication functions. TIM comprises of transducer signal conditioning and data conversion with number of sensors and actuators in a combination up to 255 devices [14]. These components are useful for Micro-Electro-Mechanical-System (MEMS) devices or for large mix of sensors and actuators. TII defines a protocol and communication medium for transferring sensor information. This interface gives a set of operations such as write, read, read and write messages, write and read responses, etc. This network interface defines a network communication protocol for NCAP communications to the network.

The IEEE 1451 family of standards is composed of - IEEE 1451.0, IEEE 1451.1, IEEE 1451.2, IEEE 1451.3, IEEE 1451.4, IEEE 1451.5, and IEEE 1451.7 [18].

- **IEEE 1451.0** – This standard is developed in year 2007, which is an IEEE Standard for Smart Transducer Interface for Sensors and Actuators. This standard implements common functions, communication protocols, and Transducer Electronic Data Sheet (TEDS) Formats.
- **IEEE 1451.1** – This standard is developed in year 1999, which is an IEEE Standard for a Smart Transducer Interface for Sensors and Actuators. This standard provides Network Capable Application Processor (NCAP) Information Model.
- **IEEE 1451.2 –** In year 1997 this standard is developed, which describes IEEE Standard for a Smart Transducer Interface for Sensors and Actuators. Transducers to Microprocessor Communication Protocols & TEDS Formats are developed in this standard.
- **IEEE 1451.3 –** This standard presents IEEE Standard for a Smart Transducer Interface for Sensors and Actuators, which implements Digital Communication & TEDS Formats for Distributed Multidrop Systems. This standard is deployed in year 2003.
- **IEEE 1451.4 –** This standard is developed in year 2004, which is an IEEE Standard for a Smart Transducer Interface for Sensors and Actuators. This standard gives Mixed-Mode Communication Protocols & TEDS Formats.
- **IEEE 1451.5 –** In the year 2007, IEEE Standard for a Smart Transducer Interface for Sensors and Actuators is developed for Wireless Communication Protocols & TEDS Formats.
- **IEEE 1451.7 –** IEEE Standard for Smart Transducer Interface for Sensors and Actuators is developed for Transducers to Radio Frequency Identification (RFID) Systems Communication Protocols and TEDS Formats.

The main objectives of IEEE standard are [19]:

- Enables ‘plug-and-play’ at the transducer level by providing a common communication interface for transducers.
- Simplifies the creation of networked smart transducers.
- Supports multiple sensing abilities.
- Ease the support of multiple networks.
- Reduces human error because automatic transfer of TEDS data to the network eliminates the entering of sensor parameters by hand, which will cause errors.

APPLICATIONS OF WSN WITH IOT

WSN application field of areas can be organized into two main classes: monitoring and tracking as shown in Figure. 3 [1]. The applications which are included in monitoring category are indoor/outdoor environmental monitoring, power monitoring, health and wellness monitoring, factory and process automation, inventory location monitoring, and seismic and structural monitoring. Whereas tracking applications include tracking animals, humans, objects, and vehicles. There is more number of applications which are relevant to WSN with IoT, but only few application areas have been deployed and approved in real environment.

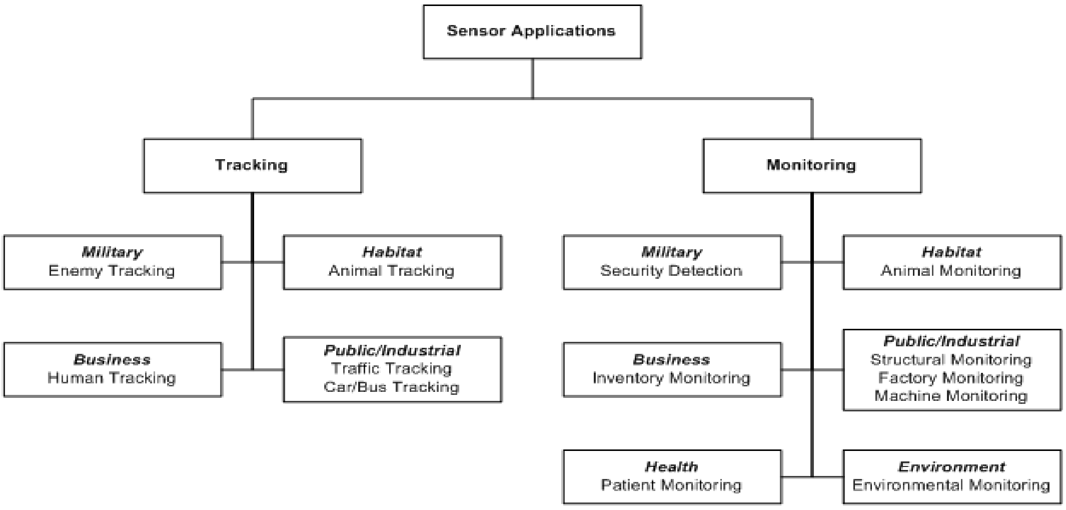

Figure 4: Applications of WSN

CONCLUSIONS

In conclusion, smart sensor interface with the capability of reconfiguring on basis of IEEE 1451 standard proves to be designing more efficient WSN, utilizing IoT environment. Sensor data can be collected intelligently on applying IEEE 1451 protocol. STIM and its corresponding NCAP, with the advent of TII in configuring the sensor nodes along TEDS enables sensors to be controlled smartly by using controller device for data acquisition, and processing the data reliably and efficiently. Thus functionality of WSN by changing the sensors accordingly can be well established by developing reconfigurable sensor interface.

FUTURE WORK

By utilizing IEEE 1451 standard, a reconfigurable smart sensor interface can be designed efficiently. Microcontroller is used as core controller device, controlling the inputs from the sensors and outputs the values to real-time sensor data usage applications. The data obtained from sensors can be used to monitor and control the environmental parameters, house-hold appliance behavior, and so on.

REFERENCES

1. I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci, Wireless sensor networks: a survey, *Elsevier Computer Networks*, pp. 393–422, 2002.
2. Ankita, A Survey on Wireless Sensor Network based Approaches, *International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 4,* Issue 4, 2014.
3. Jennifer Yick, Biswanath Mukherjee, Dipak Ghosal, Wireless sensor network survey, *Computer Networks Elsevier*, 2008.
4. Cristina Alcaraz, Pablo Najera, Javier Lopez and Rodrigo Roman, Wireless Sensor Networks and the Internet of Things: Do We Need a Complete Integration?, *Computer Science Department,University of Malaga, Malaga, Spain.*

5. Saeed Samadi, Interface Design Techniques for Electronic Nose Sensors: A Survey, *CENTRIC 2013 : The Sixth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services, IARIA*, 2013.
6. James Wiczer, Smart Interfaces for Sensors, *Proceeding Sensor Expo* 2001.
7. Qingping Chi, Hairong Yan, Chuan Zhang, Zhibo Pang, and Li Da Xu, A Reconfigurable Smart Sensor Interface for Industrial WSN in IoT Environment, *IEEE Transactions On Industrial Informatics, Vol. 10*, No. 2, 2014.
8. I.F. Akyildiz, E.P. Stuntebeck, Wireless underground sensor networks: research challenges, *Ad-Hoc Networks*, 2006.
9. M. Li, Y. Liu, Underground structure monitoring with wireless sensor networks, *Proceedings of the IPSN*, 2007.
10. I.F. Akyildiz, D. Pompili, and T. Melodia, Challenges for efficient communication in underwater acoustic sensor networks, *ACM Sigbed Review*, 2004.
11. J. Heidemann, Y. Li, A. Syed, J. Wills, W. Ye, Underwater sensor networking: research challenges and potential applications, in: *Proceedings of the Technical Report* ISI-TR-2005-603, USC/Information Sciences Institute, 2005.
12. I.F. Akyildiz, T. Melodia, K.R. Chowdhury, A survey on wireless multimedia sensor networks, *Computer Networks Elsevier*, 2007.
13. Kang Lee, IEEE 1451: A Standard in Support of Smart Transducer Networking, *IEEE Instrumentation and Measurement Technology Conference*, 2000.
14. Eugene Y. Song and Kang Lee, Understanding IEEE 1451 - Networked Smart Transducer Interface Standard, *IEEE Instrumentation & Measurement Magazine*, pp. 11-17, April 2008
15. W. Elmenreich and S. Pizek, Smart transducers—Principles, communications, and configuration, 2009.
16. Smart Transducer Interface Specification, June, 2007.
17. IEEE STD 1451.0-2007, IEEE Instrumentation and Measurement Society, TC-9, *The Institute of Electrical and Electronics Engineers, Inc.*, 2007.
18. IEEE Standard for a Smart Transducer Interface for Sensors and Actuators, *IEEE Standards Association*, 2009.
19. Richard L. Fischer and Jeff Burch, The PICmicro® MCU as an IEEE 1451.2 Compatible Smart Transducer Interface Module (STIM), *Microchip Technology Inc.*, 2000.