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EMBEDDED SENSOR NETWORK

Kavitha.S

Professor, Department of ECE, Hindusthan Institute of Technology, Coimbatore, India.

E-mail: kavithamani2003@gmail.com

Abstract

Sensors are quite important in the current world. Sensors advance society in a number of areas, including the monitoring of environment as well as human health, safety, and security. Advanced military, agricultural, medical, and disaster management areas frequently employ sensor nodes to streamline monitoring by humans. Due to the fact that sensors are frequently utilised in non-human environments and for monitoring purposes of terrestrial areas, a computer hardware and software combination known as an embedded system is created for this purpose. An embedded sensor network is a network that is positioned in the real world and communicates with it. The significance of embedded sensors in a network and how they operate are covered in this research.

Keywords: Wireless Sensor Network (WSN), Energy efficiency, Real- time monitoring and control

1. Introduction

Embedded Sensor Networks (ENSNs) are networks of sensors that are embedded in physical objects or deployed on the surface of the Earth. They are used to collect data about environmental conditions, human activity, and other phenomena. ENSNs can be used for environmental monitoring, security, and agricultural purposes. ENSNs have a number of advantages over traditional sensor networks. They are smaller and more lightweight, making them easier to deploy and maintain. They can also be embedded in difficult-to-reach locations, such as inside buildings or under water. ENSNs can also be used to collect data from multiple sources at once, making them more versatile than traditional sensor networks. Embedded sensor network is a type of sensor network where the sensors are embedded in the devices they monitor. Sensor networks are often used to monitor physical or environmental conditions in

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real-time. Sensor networks can be used for a variety of purposes, such as monitoring the health of plants, monitoring air quality, or tracking the movement of vehicles. Sensor networks are also used to collect data about events or activities.

Sensor networks are different from traditional sensor systems. A traditional sensor system consists of a collection of individual sensors that are placed at strategic locations to measure specific variables. Sensor networks, on the other hand, consist of a large number of sensors that are scattered throughout an area or device. The sensors in a sensor network are usually connected to a Central Processing Unit (CPU) or other type of controller so that the data they collect can be analyzed. Another difference between embedded sensor networks and traditional sensor systems is the way data is collected. In a traditional sensor system, data is collected by individual sensors and then sent to a central location for analysis. In an embedded sensor network, however, data is collected by the sensors and then sent directly to the CPU or controller. This type of system is often more efficient because it eliminates the need for a middleman (i.e., the collector). Overall, embedded sensor networks are similar to traditional sensor systems in that they both use sensors to collect data about events or activities. The main difference between them is how data is collected and processed.

2. Architecture of embedded system:

An embedded system is a computer system designed for a specific task or function. It is embedded within a larger device or system, and is responsible for controlling and monitoring its operation. The architecture of an embedded system typically consists of the following components:

1. Microcontroller or microprocessor
2. Memory
3. Input/output interface
4. Power supply
5. Real-time clock
6. Peripherals

Microcontroller or microprocessor: This is the CPU of the system, which is responsible for executing the software instructions and controlling the system operations. It can be either a microcontroller or a microprocessor, depending on the complexity of the system.

Memory: Embedded systems require memory to store software code, data, and system configuration information. There are different types of memory used in embedded systems, such as Random Access Memory, Read-Only Memory, Electrically Erasable Programmable Read-Only Memory, and Flash memory.

Input/output interfaces: Embedded systems typically have a range of input/output interfaces to interact with the external environment. These interfaces include analog-to-digital converters, digital-to-analog converters, sensors, actuators, communication interfaces (such as UART, SPI, I2C), and display devices.

Power supply: Embedded systems require a power source to operate. The power supply can be either a battery or an external power supply, depending on the system requirements.

Real-time clock: Some embedded systems require accurate time-keeping to perform their functions. A real-time clock is used to maintain an accurate time base for the system.

Peripherals: Depending on the system requirements, additional peripherals such as timers, watchdog timers, and interrupt controllers may be included in the architecture.

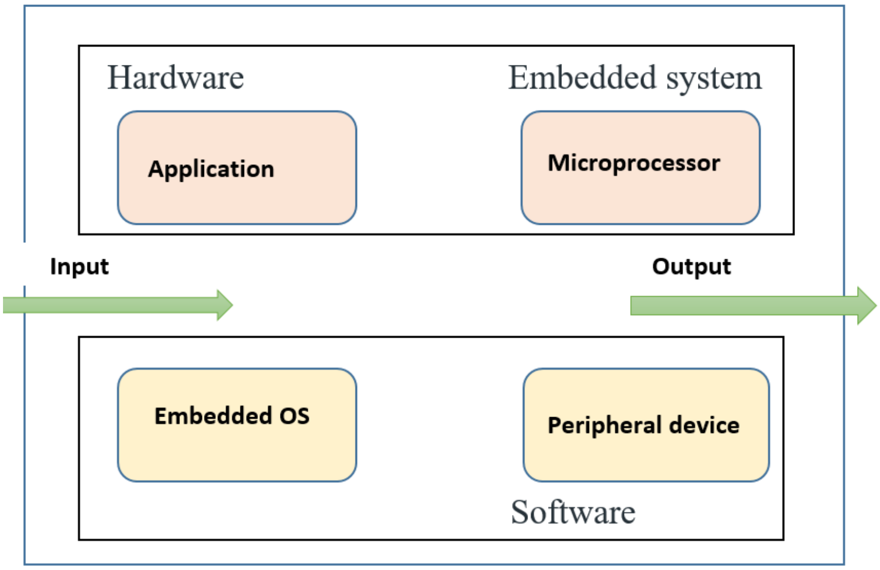

Figure 1. Architecture of Embedded Sensor Network

The architecture of an embedded system is optimized for the specific application, and may differ significantly from the architecture of a general-purpose computer system. The design of an embedded system requires careful consideration of the system requirements, power consumption, cost, and performance.

3. Working principle

The working principle of an embedded sensor network involves multiple sensor nodes that are deployed in a physical environment to gather data on various parameters such as temperature, humidity, pressure, light, sound, or motion. The nodes are connected wirelessly to each other, forming a network that can communicate with a central control unit or gateway. Each sensor node typically consists of a sensor, a Microcontroller Unit (MCU), and a wireless transceiver. The sensor measures the physical or environmental parameters and generates an analog signal, which is then converted to a digital signal by an analog-to-digital converter within the MCU. The MCU then processes and analyzes the data, applies any necessary filtering or signal processing techniques, and stores or transmits the data as required.

The wireless transceiver allows the node to communicate with other nodes in the network or with a central control unit. The transceiver uses a wireless protocol such as Zigbee, Bluetooth, or Wi-Fi to transmit the data, which can then be aggregated and processed by the central control unit. The central control unit may also send commands to the nodes to change their behavior, such as adjusting their sampling rate or changing their operating mode. The embedded sensor network can be used for a variety of applications, including environmental monitoring, industrial automation, healthcare monitoring, and home automation. By deploying multiple nodes in the environment, a detailed and comprehensive view of the environment can be obtained, allowing for more informed decision-making and improved efficiency.

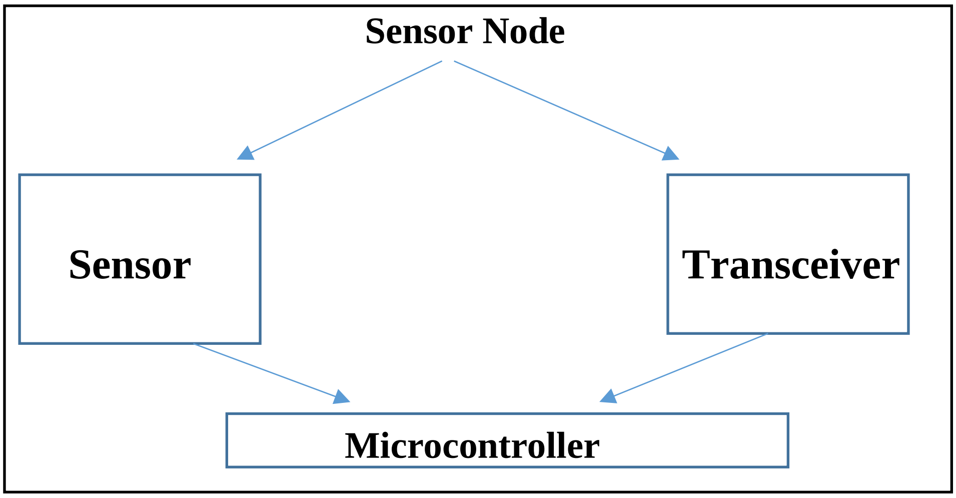

Figure 2. Embedded sensor in a sensor network

The sensor node consists of a sensor and a transceiver (or transceiver module), which are connected to a MCU. The MCU controls the operation of the sensor and the transceiver, processes and analyzes the data collected by the sensor, and communicates with other nodes and the control unit.

In addition to the basic components shown in the diagram, a sensor node may also include other components such as a power source (e.g., battery, solar panel), memory (e.g., flash memory, RAM), and additional peripherals (e.g., LEDs, switches, actuators) depending on the specific application requirements.

4. Protocols

Here are various commonly used protocols that can be used in embedded sensor networks depending on the specific application requirements.

Zigbee: Zigbee is a low-power, low-data-rate wireless networking protocol that is commonly used in embedded sensor networks. It operates on the IEEE 802.15.4 standard and supports mesh networking, which allows nodes to communicate with each other via multiple paths.

Bluetooth Low Energy (BLE): BLE is a wireless networking protocol that is designed for low-power devices. It is commonly used in applications such as health and fitness tracking, smart home automation, and location tracking.

WirelessHART: WirelessHART is a wireless networking protocol that is used in industrial applications, such as process control and monitoring. It is based on the HART communication protocol and is designed to provide reliable, low-latency communication in harsh environments.

MQTT: MQTT (Message Queuing Telemetry Transport) is a lightweight messaging protocol that is commonly used in IoT applications, including embedded sensor networks. It is designed to be simple and efficient, and supports low-bandwidth, low-power devices.

CoAP: CoAP (Constrained Application Protocol) is a lightweight application-layer protocol that is designed for use in resource-constrained devices and networks, such as embedded sensor networks. It supports efficient communication between devices using HTTP-like methods.

Overall, the choice of protocol depends on the specific application requirements, including the desired range, data rate, power consumption, and reliability. It is important to carefully evaluate the strengths and weaknesses of each protocol before selecting one for a particular application.

5. Discussion

5.1. Advantages

Embedded sensor networks offer several advantages over traditional sensor networks. These include the ability to deploy sensors quickly and easily, the ability to scale up or down as needed, and the ability to integrate sensors into existing systems. Embedded sensor networks are also more cost-effective than traditional sensor networks. This is because they require fewer sensors and less infrastructure than traditional sensor networks, and they can be deployed in smaller areas than traditional sensor networks.

5.2. Disadvantages

Embedded sensor networks have a few disadvantages. First, embedded sensor networks are typically less reliable than traditional networked systems. Second, embedded sensor networks are often less efficient than traditional systems when it comes to data collection and analysis. Finally, embedded sensor networks are often more expensive than traditional systems.

5.3. Limitations

One limitation is that embedded sensor networks are typically limited to a certain range of distances from the sensors. This can be a problem if the sensors need to be close to the objects they are monitoring, or if the objects need to be close to the sensors in order for the sensors to collect data. Another limitation is that embedded sensor networks are typically limited to a certain range of speeds. This can be a problem if the sensors need to be able to collect data quickly, or if the objects need to move around quickly.

6. Literature survey

Kok et al., [1] presented a method to locate persons in public settings while preserving social distance by utilising an embedded system with a sensor from the ultrasonic detection technology. This method will alert people to maintain their social gap.

In [2], Magnetic Induction (MI)-based techniques were introduced by Liu Guanghua et al. Wireless underground sensor networks, were regarded as a component of the full-coverage 6G wireless system.

Marco Zappatore et al., [3] claimed that, due to the enormous heterogeneity of IoT platforms, there are currently still no standardised and long-lasting solutions for integrating various data prosumers with various data sources.

A real-time remote monitoring system for patients who are at risk was presented by Prama Debnath et al. [4]. When a patient is admitted to an intensive care unit or operating room, the proposed device measures their body temperature, heart rate, blood pressure, oxygen saturation level, and electrocardiogram signals.

In order to enhance the functionality of an ophthalmic instrument created for the Pupillary Light Reflex measurement, Giovanni Gibertoni et al., [5] explained and compared the adoption of several vision-based classification algorithms from various fields, including Machine Learning, Deep Learning, and Expert Systems.

Pallavi sangra et al., [6] talks about energy-preserving techniques to cut down on energy use. In relation to smart healthcare, many energy-saving procedures have been suggested for lowering energy usage, including intelligent techniques, duty cycling techniques, collision resolution techniques, and edge techniques.

Aditi Arora et al. [7] focused on the classification of normal and abnormal optical coherence tomography using the Visual Geometry Group (VGG16) Convolution Neural Network model for early detection and quick appropriate medical care of the aforementioned eye illnesses. OCT imaging is a high resolution imaging technology that can be used to capture the tiny structures inside the human eye.

Reducing the patient crowd in the waiting room can be achieved by shortening the lines, according to Emmanuel Ayo et al. [8]. The research offered a method for scheduling patient appointments utilising a mobile application and fuzzy logic implemented in MATLAB.

Mahbub et al., [9] recommended farming solutions for agri-farm fields and cattle farms based on embedded systems, the Internet of Things, and wireless sensor networks.

“Wireless Sensor Networks: A Survey" by Ian Akyildiz et al., (2002) provided a comprehensive survey of wireless sensor networks, including their architecture, protocols, and applications. It also discusses the challenges and research issues in the field.

“An Overview of Wireless Sensor Networks Applications and Security Issues" by Nael Abu-Ghazaleh, Wendi Heinzelman, and Ahmed Al-Hamadi (2004) provided an overview of applications for wireless sensor networks, including environmental monitoring, healthcare, and military applications. It also discussed the security issues and challenges in the field.

Philip Levis et al., designed TinyOS, an operating system specifically for sensor networks in 2005. It discussed the design principles, programming model, and performance of the system.

"A Survey on Sensor Networks" by Ian F. Akyildiz, Weilian Su, and Yimin Wang (2002) provided a survey of sensor networks, including their architecture, communication protocols, and applications. It also discussed the open research issues and challenges in the field.

"Energy-Efficient Communication Protocol for Wireless Microsensor Networks" by Wei Ye, John Heidemann, and Deborah Estrin (2002), elaborated the design principles and performance of the protocol, and concluded that it can significantly extend the lifetime of sensor networks.

7. Conclusion

In this study, the sensor network and embedded sensor network and their processes have been discussed. It can be concluded that, although embedded sensor networks offer several advantages over traditional sensor networks, embedded sensor network has to improve further to achieve better efficiency and efficient communication for better performance, and must mainly concentrate on the battery performance for their long lasting performance.

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