Wireless Sensor Networks Technology

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Introduction

The process that started with the first social revolution, in which people formed the agricultural society by sedentary life, is followed by the industrial revolution. The industrial revolution emerged as three major changes (Bulut & Akcaci, 2017). With the first industrial revolution, steam, water power, and mechanization made a significant contribution to economic development. This situation has caused a series of radical changes in economic, cultural, political, and social fields all over the world, especially in Europe (Baser, 2011). With the Second Industrial Revolution, the widespread use of electricity and the increase in mass production resulted in a significant increase in productivity in production. With the beginning of the Third Technology Revolution, developments in fields such as computers, microelectronics, nuclear, genetics, and laser continued. In this period, the development of mechanical and electronic fields, along with digital technology, was followed by programmable devices and computer technologies. The rapid development of information and internet technology has made this period known as the information revolution (Bulut & Akcaci, 2017). Societies that can catch these revolutions early have turned into a structure based on the development and export of technology. In this way, modern societies have gained significant economic power (Karasekreter, 2020).

With the information technology revolution, all public institutions and private sectors entered the restructuring process, the technological transformation was experienced in every field and an information society was formed (Bulut & Akcaci, 2017). Since 2011, the stage of the information society has emerged as Industry 4.0. Industry 4.0, called the new industrial revolution, is a concept that was first introduced in 2011 at the Hannover Fair held in Germany. The concept of the "Internet of Things (IoT)" is one of the important definitions of this era. (Bulut & Akcaci, 2017). The concept of IoT was used for the first time by Kevin Ashton in the presentation made on behalf of Procter and Gamble (P&G) company in 1999. The concept of IoT was used for the first time by Kevin Ashton in the presentation made on behalf of Procter and Gamble (P&G) company in 1999. In the report published by the International Telecommunication Union (ITU) in

2005, the concept of IoT was officially announced (Bayuk & Oz, 2017). Machines have become coordinated thanks to new developments in computers, electronics, and internet technologies. IoT covers the systems that do not interact with humans and are connected to the internet through data sharing over the internet in order to meet the needs of people.

Today, thanks to the integration of devices with the internet, it perceives the needs of the users and communicates with smart devices over their systems, and meets the needs of the users. With the Internet of Things, objects with different ID addresses use the Internet infrastructure to process the data over the virtual platform. It consists of 5 basic layers: detection layer, network layer, middle layer, application layer, and business layer. IoT detection layer Radio Frequency Identification (RFID), ZigBee, QR code reader, etc. consists of different sensing devices. This layer generally performs the processes of obtaining and defining certain information through all kinds of sensors. The collected information includes temperature, humidity, location, vibration, and dust, etc. it could be. The information obtained by different sensors is transferred to the upper layer (Arslan & Kirbas, 2016).

The developments in robot technologies, big data, artificial intelligence, IoT, and sensors, which are the new terms of the industry, have led to the emergence of intelligent systems. The use of smart systems is increasing day by day with the technological developments, current applications, and opportunities offered by IoT. Smart home automation systems, smart factories, environment, and agriculture/livestock automation systems, security analysis systems, etc. There are many examples of IoT. Artificial intelligence, whose popularity is increasing with Industry 4.0, is increasing day by day due to technological developments. By combining the main elements of production such as monitoring, coordination, and control with sensing, computing, and communication technologies, the Cyber-Physical System has emerged as a whole system managed by wired or wireless combined technology, and Industry 4.0 is accepted as the most important technology (Uludag & Ucar, 2018).

Wireless Sensor Networks (WSN), one of the technologies that Industry 4.0 has brought, by placing sensors with sensing ability in different areas, in these areas temperature, humidity, light, sound, pressure, pollution, noise level, vibration, object movements, etc. It refers to wireless networks that contain independent tools to detect situations and monitor environmental conditions. WSN's have limited energy resources. Despite these disadvantages, they have advantages such as reliability, accuracy, flexibility, cost efficiency, and ease of installation. WSN has many application areas such as military systems, remote control systems, and medicine. For example, WSN's can be effective in disaster areas where they are placed in disaster situations. Accurate and timely location detection in WSN's is of vital importance in rescue operations (Bayuk & Oz, 2017).

One of the advantages of WSN's is that they operate unattended in harsh environments where monitoring by humans is risky, inefficient, and sometimes impossible. For this reason, it is expected that the sensors will be randomly placed by a relatively uncontrolled drop by a vehicle, eg helicopter, and temporarily form a collective network. Considering the short life of battery-operated sensors and the possibility of having damaged nodes during deployment, it is expected that there will be a large number of sensors consisting of hundreds or even thousands of sensor nodes in WSN's. Designing and operating such a large network requires architecture and management strategies. In these networks, since the energy of the sensors is limited and the batteries cannot be charged, it becomes important to design algorithms based on energy and to extend the lifetime of the sensors (Abbasi & Younis, 2007).

Wireless Sensor Networks

With the development of sensor technology, multifunctional sensor elements can be designed in small sizes, with low power consumption. These elements are; sensing, data processing, and communication among themselves. WSN's are composed of sensor nodes working with limited resources. Each sensor node has the ability to measure quantities such as temperature, humidity, pressure around it, perform simple calculations, and communicate with other nodes or base stations around it. As an example, the architecture of WSN's is shown in Figure 1.

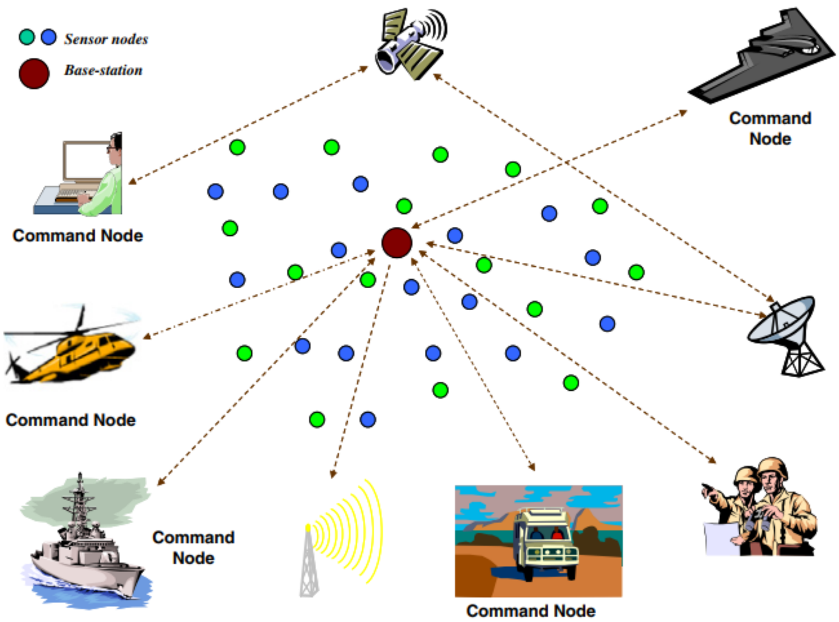

Figure 1. Wireless Sensor Network Example (Abbasi & Younis, 2007)

The overall architecture of WSN's can be explained at two main levels. The first is the sensor nodes equipped with sensing capabilities, and the second is the collection of sensing devices acting together to create the WSN. It is extremely important to understand the structure of the sensor node in WSN's (Alshahrani, 2018).

The Architecture of Detection Device: Sensing Node

WSN's, as mentioned earlier, consist of several independent small sensing units equipped with the necessary resources to measure current conditions. The basic sensing unit is called a node in WSN's. The task of the nodes, which are the basic building blocks of WSN's in general, are responsible for perceiving and measuring the characteristics of the current conditions, recording the measured values, and transmitting the recorded information to the base station. A node basically consists of a power supply, a processing unit or controller, sockets for connecting sensors, an analog-to-digital converter (ADC), onboard memory to store data, and a transceiver to communicate with other nodes. Figure 2 shows the basic block diagram of the sensor node (Alshahrani, 2018).

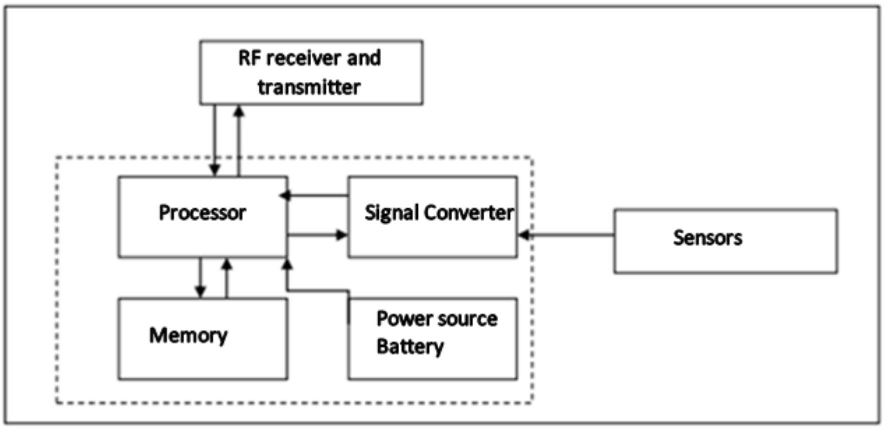

Figure 2. Block Diagram of the Sensor Node (Amin, 2016)

Controller/Processing Unit

It is the main processing unit of the node. It is responsible for the timely execution of all operations and transactions in the node. It performs various tasks such as data processing, checking the functionality of all components, reading/writing data to memory, and collecting data from the ADC. Since energy consumption control is important in node designs, the selection of the microprocessor/microcontroller to be used should be done meticulously. MSP 430 series and Atmel Atmega can be counted among frequently used processors/controllers (Karasekreter, 2020).

Receiver - Transmitter

Wireless connection of each node is important since the nodes are located in remote locations in SSAs. It is the unit that enables the wireless transmission of the detected data to another node or the signals from another node to be analyzed and transmitted to the control unit. Infra-red, wireless communication with radio frequencies is possible. Infrared technology operates in a rigid topology where two communication devices must be in the line of sight of each other. Due to this strict limitation, infrared communication is not used in WSN's. Radio frequency communication is preferred instead. Radio frequency technologies such as ZigBee, Bluetooth, and Wi technology are used in CSA's. Figure 3 shows the ZigBee module that performs the data transfer process.

Figure 3. ZigBee Module

Sensors

Advances in microelectromechanical system technology have made it possible to develop various sensors to measure various physical properties of the environment in which they are placed. Sensors, mechanical, thermal, chemical, etc. in the external environment. It is the unit that detects the changes and sends them to the processing unit. Thanks to the ADC modules, the detected analog signal is converted into digital and transmitted to the processing unit. The temperature sensor produced to measure the ambient temperature is shown in Figure 4.

Figure 4. LM35 Temperature Sensor

Energy Source

In WSN's, nodes are randomly distributed to areas inaccessible to humans. Since it is not possible to operate the nodes continuously connected to an energy source, batteries are used. Batteries are the basic requirement for keeping a node operational. Since the nodes are placed randomly in a large number of geographically difficult regions, changing them frequently and in some cases impossible. That's why nodes need to have long-lasting batteries to get longer network life. Conserving the energy of the node is very important in WSN's. Strategies are being developed to reduce a node's duty cycle and prevent unnecessary data generation. Figure 5 shows the energy sources used in WSN's.

Figure 5. Energy Sources Used in Sensor Nodes

Wireless Sensor Networks Structure

WSN's may be released or deployed in an area to provide information on current conditions. The sensors form a network to communicate with each other and also to send information with the base station or base station in the network. The base station transmits the information to other systems where it is used for analysis. WSN's do not have a predetermined infrastructure. Therefore, the network needs to be set up specially. In WSN's, nodes may have limited mobility but are usually in a fixed position. Unlike wired networks, which have special hardware that directs network traffic, each node acts as a router in WSN's. In WSN's, each node communicates directly with other nodes within its transmission range and uses other nodes to transmit messages to nodes outside its transmission range.

In WSN, energy efficiency is one of the most important criteria that should be emphasized. There are two main factors affecting energy efficiency. The first of these is the determination of media access protocols between nodes. The other is the way the data is transmitted to the base station. Figure 6 shows the architecture of WSN's.

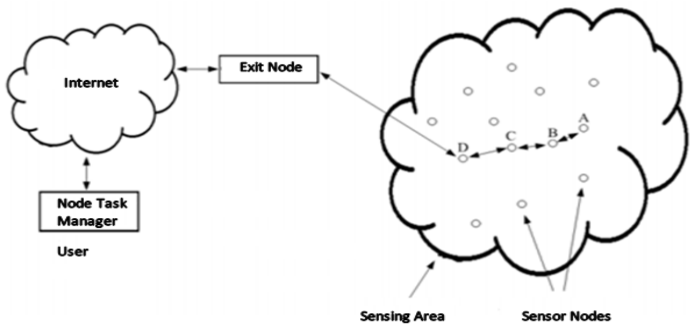

Figure 6. WSN's Architecture

WSN Structures

Network structures created in WSN applications can be examined in two parts as regular distributed networks and irregular distributed networks. This difference is related to the type of application and the geographical conditions of the area to be applied (Karasekreter, 2020). WSN's are used in home automation for various purposes such as security, control, and speech. Temperature, light, and humidity, etc. in home automation. Networks established to measure values, agricultural practices, hospitals, networks established from sensors placed regularly in factories can be shown in a regular distributed network. An example of a smart home system consisting of sensors placed to detect different events is shown in Figure 7.

Figure 7. Smart Home System in Which Various Sensors are Placed

Sensor nodes form WSN by irregularly scattering by means of a vehicle in hard-to-reach areas for sensing and data collection. For military purposes, random distribution of sensor nodes is suitable for monitoring open-air mobility and forest fires. Such applications can be defined as WSN's with an irregularly distributed structure. An example of WSN in distributed structure is given in Figure 8.

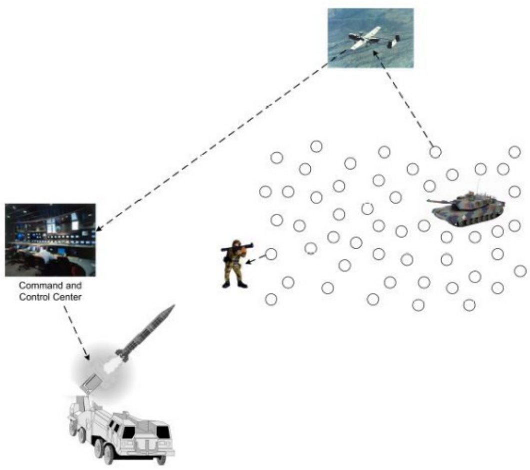

Figure 8. Distributed WSN's

WSN's can consist of thousands of sensor nodes over a wide geographical area or indoor area. Nodes are unevenly distributed across the region. The "D" variable shown in Figure

9 is the distance between any two nodes. Suppose R is theoretically the circular wireless range of a node. The maximum distance condition D<2R between any two nodes in the network should be sought.

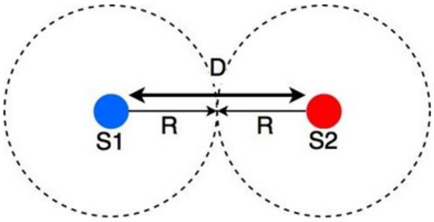

Figure 9. Distance Between any Two Nodes

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To Cite This Chapter

Unlu, T., Basciftci, F., & Karasekreter, N. (2021). Wireless sensor networks technology. In M. Ozaslan & Y. Junejo (Eds.), *Current Studies in Basic Sciences, Engineering and Technology 2021*(pp. 32–41). ISRES Publishing