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INTELLIGENT TRANSPORTATION SYSTEMS and TRAFFIC MANAGEMENT in WIRELESS SENSOR NETWORKS

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ABSTRACT

Wireless Sensor Networks are the source of intelligent systems today. With the development of sensor nodes that form Wireless Sensor Networks, these systems can be easily used in our daily life. In this study, intelligent transportation systems and traffic management with Wireless Sensor Networks are described. Within the scope of intelligent transportation systems, vehicle sensors, road sensors, weather sensors and environmental sensors are mentioned. Within the scope of Traffic Management, dynamic signalization systems are mentioned. It is estimated that the work done will be beneficial to readers and practitioners.

Keywords: Wireless sensor networks, sensor node, zigbee, intelligent transportation systems, traffic management

1. INTRODUCTION

Sensors that detect the information such as temperature, humidity and light in the environment are called sensor nodes. Sensor nodes have the ability to calculate, detect, and communicate. These nodes perform the measurement task with cooperation. The networks that sensor nodes create are called Wireless Sensor Networks. Sensor nodes that form Wireless Sensor Networks are the source of intelligent systems. Two features of the sensor nodes are available. First, the desired sensor can be integrated into the sensor node. The second feature is that wirelessly transmitted data can be sent to remote stations. The system developed in this way can be monitored and controlled from time to place and from time to time. Because of all these features, sensor nodes constitute the infrastructure of the systems required for a smart city. In Libelium webpage (2017), authors state that systems that can be done with Wireless Sensor Networks are as follows: Smart Parking, Structural health, Noise Urban Maps, Smartphones Detection, Eletromagnetic Field Levels, Traffic Congestion, Smart Lighting, Waste management, Smart Roads, Forest Fire Detection, Air Pollution, Snow Level Monitoring, Earthquake Early Detection, Landslide and Avalanche Prevention, Potable water monitoring, Chemical leakage detection in rivers, Swimming pool remote measurement, Pollution levels in the sea, Smart Grid, Radiation Levels, Supply Chain Control, Smart Product Management, Quality of Shipment Conditions, M2M Applications, Smart Industrial Control, Smart Agriculture, Smart Animal Farming, Home Automation, Smart Health and more....

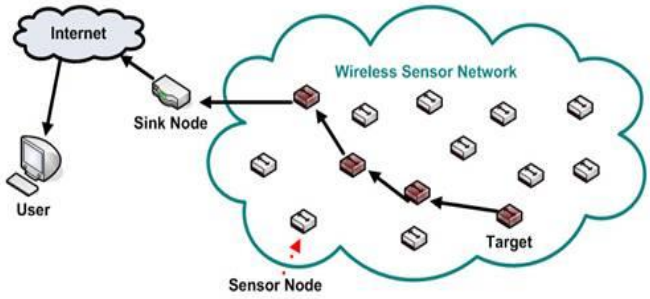
Systems developed with Wireless Sensor Networks can be prepared at half the cost of existing technologies. It is possible with these applications to increase the quality of life and raise the standard of living of people from every angle without distinguishing the lower, middle or upper part.

The rest of the article is as follows. In the second part, we talk about wireless sensor networks and ZigBee technology, in the third part, intelligent transportation systems that can be developed with Wireless Sensor Networks, and in the fourth chapter, traffic management that can be developed with Wireless Sensor Networks. The last part of the article contains the general conclusions of the study.

2. WIRELESS SENSOR NETWORKS

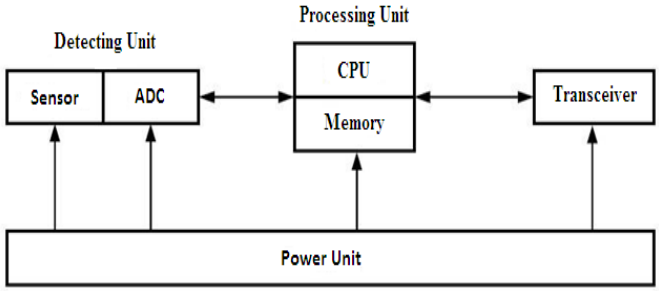
Ali et al. (2015) and Dener (2016) state that Wireless Sensor Networks consist of small-sized sensor nodes installed on the environment. These nodes carry, by collaborating in a physical ground, what they learn from the physical world to the virtual world platform. It is shown in figure 1.

Figure 1: Wireless Sensor Network



Challoo et al. (2012) state that wireless sensor nodes can use Wi-Fi, Bluetooth or ZigBee as wireless communication module. It is possible to choose according to the feature of the application to be made. While the distance of Bluetooth is low, ZigBee and Wi-Fi are more. The energy of the network established with Wi-Fi is exhausted after hours; the energy of the network established with Bluetooth after days and the energy of network established with ZigBee are exhausted after years. However, the network established with Wi-Fi and Bluetooth is more complex, while the network established with ZigBee is less complex. ZigBee's standard is IEEE 802.15.4, Bluetooth's standard is IEEE 802.15.1, and Wi-Fi's standard is IEE 802.11. ZigBee's data rate is 250 Kbits/s, Bluetooth's data rate is 723 Kbits/s, and Wi-Fi's data rate is 11 to 105 Mbits/s. Jun (2011) states that sensor nodes consist of, as shown in the figure 2, a detecting unit, a processing unit, a transceiver and a power unit. All constituents are explained below.

Figure 2: Constituents of Sensor Node



The main function of the detecting unit is to physically measure data in the detection and target zone. Khemapech et al. (2005) state that analogue voltage or signal is generated by the detector as a result of the event being monitored. Hill (2003) states that the continuous data is digitised by an ADC – Analogue to Digital Converter and then is sent to the processing unit for analysing. The processing unit plays a significant role in the management of the collaboration between the detectors in order to accomplish pre-described tasks. There are some families in this unit such as microcontrollers, microprocessors and field-programmable gate arrays – FPGAs. Interfaces such as Non-volatile Memory and ADCs can be integrated on to a single integrated circuit. Akyildiz et al. (2002) state that the processing unit needs a memory to run its tasks and minimizes the number of messages sent by means of local processing and data collection. There are three main communication channels in sensors; Optical Communication (Laser), Infrared and RF – Radio Frequency. Laser consumes less power compared to Radio and provides more security, however, requires line of sight and is sensitive to the atmospheric conditions. Feng et al. (2002) and Vieira et al. (2003) state that the infrared does not require an antenna as Laser does but broadcasting capacity is limited. RF is easy to use but an antenna is needed. The power consumption is a significant weakness in sensor networks. Any power saving arrangements could help to prolong the life of a sensor. Oliveira et al. (2011) state that the batteries used in sensors can be categorised in two groups; chargeable or non-chargeable. Generally in severe conditions, it is impossible to change or charge the battery.

3. INTELLIGENT TRANSPORTATION SYSTEMS

In extraordinary natural phenomena such as storms and earthquakes that occur suddenly, people must move from one point to another. Fuel consumption and vehicle emissions must be minimized and the loads must be delivered. The real-time vehicle and location information should provide the most advantageous journeys in terms of time and cost. Tufan (2014) states that the creation of such transport systems may seem a difficult target. In fact, accidents must be reduced to a minimum by warning drivers about any situation, such as weather conditions, traffic congestion, potential other hazards, etc. Establishing a transport system that allows maximum use of system capacity can be considered as a difficult goal to achieve. However, the use of technologies produced by today's scientific developments for a safe, efficient and sustainable transportation system in different fields is generally defined as Intelligent Transportation Systems. Strategy Development Presidency (2014) states that detection technologies used in intelligent transportation systems are mentioned below. These technologies include sensors that provide support for safe driving to the driver, and road and weather sensors.

3.1. Vehicle Sensors

Strategy Development Presidency (2014) states that sensors mounted on vehicles and providing safe driving support with functions such as lane detection, parking, blind spot warning, vehicle tracking distance warning.

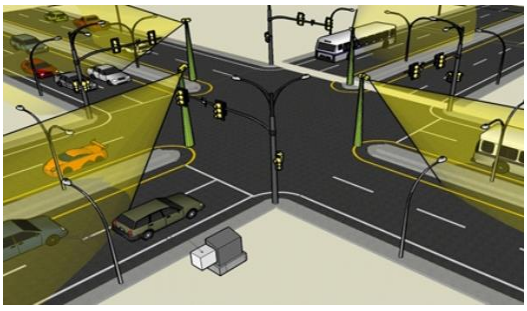
Figure 3: Vehicle Sensors (Mercedes-Benz 2017)

Thanks to these sensors, safe driving can be more. With the lane detection sensors, the vehicle will have increased its travel rate from its own lane. By creating an alert on lane changes, accidents will be reduced. Parking and blind spot warning sensors will prevent small accidents that may occur, and traffic congestion due to the park will be eliminated. Vehicle tracking distance sensors will also be used to maintain the officially designated tracking distance.

3.2. Road Sensors

Strategy Development Presidency (2014) states that it is the sensors that manage the intersections and adjust the signaling times, collect the data necessary to determine traffic flow information on the main arteries and peripheral roads throughout the city, and to direct traffic infrastructure for more efficient use.

Figure 4: Road Sensors (Memurlar 2017)



Nowadays, especially in big cities, the number of vehicles has increased considerably. Good coordination is necessary to ensure alignment in a region where there are thousands of vehicles. This coordination is primarily provided by traffic lights. However, the fact that the duration of the traffic lights at an intersection is fixed increases the traffic intensity. This means that the duration of the traffic lights must be dynamic for each intersection. In addition, this dynamism should be ensured at every hour of the day, and signaling times should be adjusted according to traffic intensity.

3.3. Weather Sensors

Strategy Development Presidency (2014) states that it is a powerful and versatile sensor that measures atmospheric conditions, live monitoring of ground temperatures, humidity and temperature.

Figure 5: Weather Sensors (PCE 2017)

Dynamically changing the maximum speed on the road by following atmospheric conditions such as rain and snow will both warn the drivers and reduce the rate of traffic accidents. In addition, when the temperatures of the ground are informed, it will be ensured that the drivers have already been informed and can take precautions in the event of icing or frost.

3.4. Environmental Sensing Systems

Strategy Development Presidency (2014) states that these are short and long range radar systems, imaging systems and software.

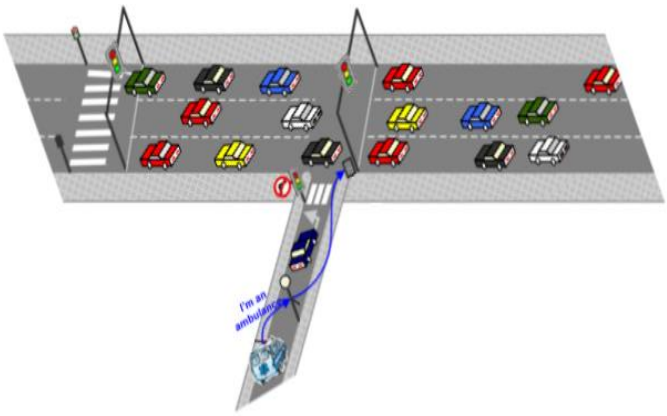
Figure 6: Environmental Sensing Systems (TETA 2017)

With the help of short and long range radar systems, vehicles passing the maximum speed within the region can be detected and automatic warning messages can be sent to these vehicles. Along with the imaging systems and software, however, the plates of vehicles which are in or out of a zone must be automatically detected and alerted to the necessary units in an emergency.

4. TRAFFIC MANAGEMENT

Traffic management, operation and supervision is the application of Intelligent Transportation System that provide efficiency in traffic, increase the quality of service and reduce traffic congestion. Strategy Development Presidency (2014) states that with these systems, it is aimed to inform drivers about dangerous situations, to take preventive measures in a timely manner, to give information about routes coming from dynamic traffic information systems and route going and to provide continuity in traffic flow.

Figure 7: Traffic Management (Selvarajah et al. 2012)



Effective traffic management ensures maximum comfort for people in traffic. Vehicle drivers do not expect much in traffic. In case of emergency such as ambulance, fire brigade, police car, gendarmerie in the traffic, it is also possible to set the transition priority of vehicles on the road.

5. CONCLUSION

Sensor nodes play an important role in an effective intelligent transport system and traffic management. In the vehicles, on the roads, with the help of the sensors in the environment, the information in the environment is gathered and the behaviors to be done together with the analysis software arise. The resulting information is sent back to the sensors, allowing the air route, speed and signaling times to be changed via the two-way communication. Thanks to effective management, traffic congestion and traffic accidents are reduced. This decrease also indirectly reduces air pollution. Increasing people's standard of living, facilitating people's lives with intelligent technologies can be considered as the advantages of intelligent transport systems.

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