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Intelligent Transportation Systems Using Short Range Wireless Technologies

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Abstract

In this paper, we propose using ZigBee for Intelligent Transportation System (ITS). Most of the accidents these days are caused because of drivers not knowing the upcoming traffic hurdles like curves, traffic signals, railway lines and etc. If drivers come to know about the upcoming signals, curves, and railways lines etc the accidents can be avoided. The aim is to provide drivers with intelligent roads so that they can receive the information about the curves and the traffic signals ahead. After receiving the information about the signals ahead, drivers will be careful; this will help avoid the road accidents. Many researches are taking place in the world in the field of ITS and many useful systems are also built but no system is built using this remarkable ZigBee technology. ZigBee is low cost as compared to other short range wireless technologies which will help reduce the total cost of the system, enabling this system to be deployed in developing countries as well.

Keywords: ITS, Short Range Wireless Technologies, Wi-Fi, GPS

1. Introduction

Most of the accidents on the roads occur today because drivers are not aware of upcoming traffic hurdles like traffic signals, curves and railway lines etc. Similarly in mountainous areas where there is lots of rain and snow throughout the year, driving is a tough job. In order to make driving on roads easy, an efficient system is required which informs drivers about upcoming traffic hurdle before a safe distance so that drivers can be careful. There are many researches going on in the field of ITS and already many systems are available but these systems are very expensive which make these systems very difficult to install in developing countries [1,2]. Furthermore these systems require high Power to operate which make these systems difficult to install in areas where there is no power available [2].

This research brings an idea of using short range wireless technology “ZigBee” in Intelligent Transportation Systems. ZigBee is inexpensive which reduces the total cost of the system [3]. Similarly its low power consumption makes it useable in areas where there is no power available.

2. Objective

The main objective of the research is to provide drivers with intelligent traffic system which will help by providing important information about the traffic while they are on the road. In the snowy areas drivers are unable to see the traffic signals when it’s snowing and get an idea about the curves and traffic signals when they are at it which results in road accidents [4]. So in order to overcome this difficulty the idea is to provide the information about the upcoming traffic signal before a safer distance so that drivers are careful.

The core of the research is to provide ITS solution using ZigBee [3]. So most of the experiments are conducted with the ZigBee apparatus and using the RSSI (Received Signal Strength Indicator) value received from Host to Sensor. The purpose of using ZigBee for ITS is that at mountains there can be problem of electricity and at those places installing ITS can be really expensive. In order to provide ITS at those places we need some technology that saves power and price. ZigBee is best for this purpose and fulfils these needs efficiently.

3. System Description

Figure 1 illustrates the concept of this research. Because of the weather conditions most of the times, traffic hurdles become very dangerous and cause road accidents e.g.

slippery at curve or invisibility of traffic signals due to fog or heavy snow. In such conditions drivers get aware of these traffic hurdles when they are at it and won't be able to stop the car which results in accidents. This research will emphasize on warning (informing) drivers of upcoming traffic hurdles before actually reach- ing them [5].

The above diagram shows a traffic system which informs drivers about the traffic hurdles. On each traffic hurdle a ZigBee Sensor is installed and each car is equipped with a ZigBee Host. Whenever car reaches the range of the ZigBee Sensor (for this research we considered this range to be 100 m), the communication between the ZigBee Sensor and Host starts, the ZigBee Sensor sends the signal (in the form of bits) to the ZigBee Host informing about the type of hurdle ahead along with the distance to the hurdle. The ZigBee host after receiving this information will display this information on a screen to driver. Driver then can take appropriate action after getting informed [3].

Below are the traffic hurdles we are considering in this research;

1) Road stops.
2) Railway tracks (Railways lines).
3) No Entry roads.
4) Traffic signals.
5) Curves.
6) Brake indicators

No. 6 in above listing is a special case. For this case to work the cars have to communicate with each other so that they get notified about the brakes applied by the car in front. This case is more of a future plan which we are planning to research and not covered in this research paper.

4. Flow of Information

In this system a ZigBee sensor is installed at each traffic hurdle that contains all the information about that hurdle e.g. Hurdle ID, Distance from ZigBee Host etc. Each car in this system is equipped with ZigBee Host. As soon as car enters the communication range of the traffic hurdle, ZigBee Host in the car starts communicating with ZigBee Sensor at the traffic hurdle [5,6].

Figure 2 shows the information flow between the car and the traffic hurdle, in this case the Traffic Signal. The numbers 1~5 are described below;

1).Car (ZigBee Host in the Car) sends its ID to the Sensor at Traffic Signal.

2).Sensor acknowledges the ID.

3).Car asks for the information about the upcoming traffic hurdle.

4).Sensor sends the information about the traffic hurdle.

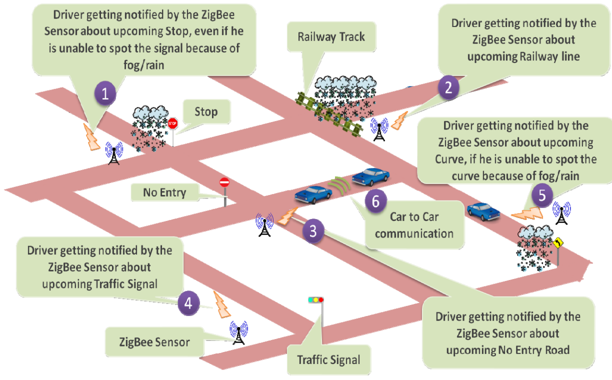

Figure 1. ITS using ZigBee as a communication Medium.

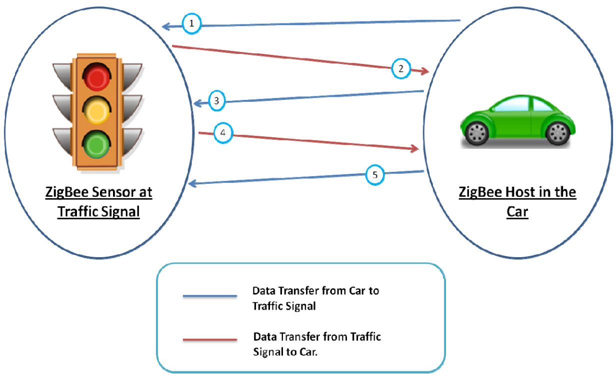

Figure 2. Flow of information between Car and Traffic Signal.

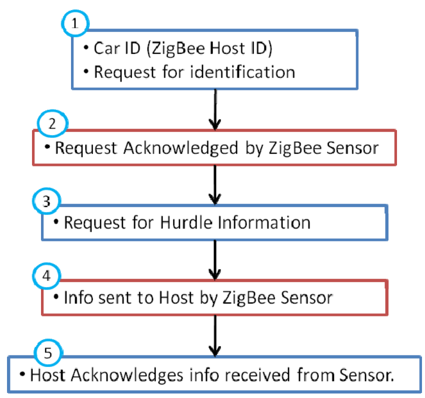

Figure 3. Flow chart depiction of Figure 2.

5).Acknowledges the information received from traffic hurdle.

Figure 3 is an easy to understand flow chart depiction of **Figure 2**.

5. Why ZigBee?

ZigBee is a short range wireless technology from IEEE 802.15.4 family. ZigBee is low power and low cost as compared to other short range wireless technologies of its class. Below is ZigBee comparison with other short range wireless technologies [3].

As shown in **Table 1** ZigBee is low power and very inexpensive as compared to other short range wireless technologies. ZigBee devices can work for years without worrying about replacing batteries, which makes it an excellent choice to be used in mountainous areas where power is a major concern.

Below are the major reasons why ZigBee is considered for such system;

1).ZigBee is Low cost

2).ZigBee is inexpensive

3).Data rate is enough to transfer information between Car and the Hurdle.

4).ZigBee is not much affected by the signals of other short range wireless technologies.

6. Conducted Experiments

Different experiments were performed to check whether ZigBee is suited for such systems or not. There are different researches going on in which ZigBee is used as In-Vehicle communication medium but using ZigBee as Vehicle-to-Vehicle or Vehicle-to-Infrastructure is a totally new concept. Below are the conditions in which experiments were performed;

1).Maximum distance between ZigBee Host and Sensor is 100m.

2).A suitable height of 2 m is used for ZigBee Host and Sensor.

3).Experiments are conducted against different Speeds of Vehicle (10~60km/h).

4).Two set of experiments were conducting to check ZigBee suitability in Intelligent Transportation Systems [6,7].

- Experiments to check RSSI (Received Signal Strength Indicator) value from ZigBee Host to ZigBee Sensor.
- Experiments to check Data Transfer between ZigBee Host and ZigBee Sensor.

Below are the details of experiments along with collected data.

6.1. Experiments for RSSI

Two different experiments were conducted to check RSSI value between ZigBee Host and ZigBee Sensor. The value of RSSI is calculated in dBm. The communication between Host and Sensor is ideal if RSSI value is 0, but that is not possible because of different factors affecting the value, like noise, air elements and weather etc.

1).ZigBee communication on straight road with clear line of sight (LoS).

Table 2 shows the data collected for Experiment 1, for checking RSSI value between Host and Sensor on straight roads with clear LoS [8]. For each speed of car, RSSI value is checked twice and then average RSSI is calculated. Data in **Table 2** shows that speed of vehicle has almost no effect on RSSI value between the Host and the Sensor.

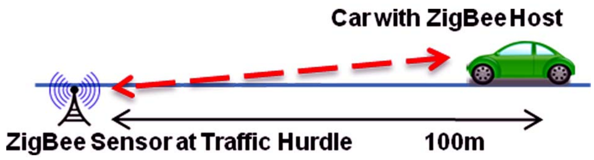

Figure 4. ZigBee Communication on straight road with LoS.

Table 1. Wireless Technologies Comparison.

Proerty	Wireless Technologies Comparison		
	Wi-Fi	*Bluetooth*	*ZigBee*
Data Rate	11Mbps	1Mbps	250kbps
Nodes	20 - 250	7	65536
Range	100m	10m	30~100m
Power	High power	Medium Power	Low Power
Cost	Very high	$10 ~ 15	As low as $3

Table 2. RSSI on Straight Road with LoS.

Car Speed	RSSI on Straight Road with clear LoS		
	RSSI (1) *dBm*	*RSSI*(2) *dBm*	*RSSI* (*Avg*) *dBm*
10 km/h	–58	–57	–57.5
20 km/h	–58	–58	–58
30 km/h	–58	–57	–57.5
40 km/h	–63	–62	–62.5
50 km/h	–58	–58	–58
60 km/h	–57	–58	–57.5

2).ZigBee communication on curve with clear line of sight.

Table 3 shows the data collected for Experiment 2, for checking RSSI value between Host and Sensor on curves with clear LoS. For each speed of car, RSSI value is checked twice and then average RSSI is calculated. On curves mostly the cars are driven slowly so experiments are conducted against the speed of car up to 30km/h.

The data in **Table 3** shows that even in the case of curve, the speed of the vehicle has no significant effect on RSSI value between the Host and the Senor.

6.2. Experiments for Data Transfer

Three types of experiments were conducted to check the eligibility of ZigBee for ITS. Experiments are conducted using Data Transfer sequence shown in **Figure 2**. The arrangement of the experiments for Data Transfer is similar to that of experiments for RSSI. ZigBee Host is installed inside the car and ZigBee Sensor is installed at the traffic hurdle, but this time Data Transfer rate between Host and Sensor are examined [9].

1).Data Transfer on straight road with clear line of sight.

Table 4 shows the data collected for Data Transfer experiments. The distance is the distance between the Host and the Sensor. The data (max. of 7 bytes) is sent from Host and received at Sensor vice versa. If all the data sent from Host is received at Sensor and vice versa, the error percentage is 0.00% as shown in above table [4,9].

2).Data Transfer on curves with trees as hurdles (No line of sight).

Table 5 shows the data which is still quite encouraging although there are a few errors, but the average shows that every 6 times data is sent 4.67 times it is received. If the data is received even only once the communication between the Host and the Sensor can be done easily and the information about the upcoming traffic hurdle can be easily transferred to the car [4].

1).Data Transfer on curves with Buildings as hurdles (No line of sight).

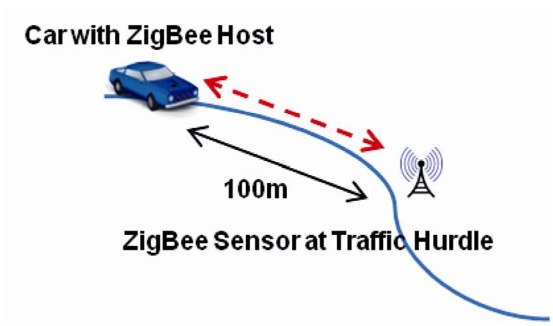

Figure 5. ZigBee Communication on curve with LoS.

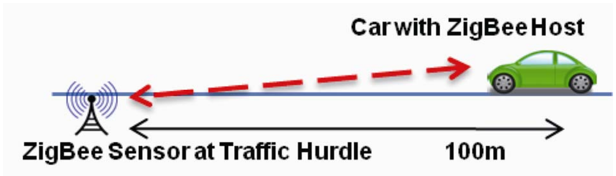

Figure 6. Data Transfer on straight road with clear LoS.

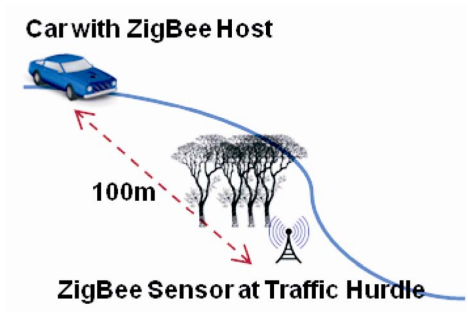

Figure7. Data Transfer with no LoS (Trees as Hurdle).

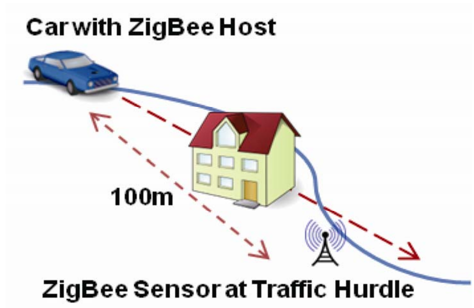

Figure 8. Data Transfer with no LoS (Building as hurdle).

Table 3. RSSI on curves with LoS.

Car Speed	RSSI on curves with clear LoS		
	RSSI (1) *dBm*	*RSSI* (2) *dBm*	*RSSI* (*Avg*) *dBm*
10 km/h	–54	–56	–55
20 km/h	–55	–55	–55
30 km/h	–58	–57	–57.5

Table 4. Data transfer on straight road with LoS.

Distance	Data Transfer on straight Road with clear LoS		
	No. of times sent	*No. of times received*	*Error (%)*
100 m	6	6	0.00%
100 m	6	6	0.00%
100 m	6	6	0.00%

Table 6 shows the Data Transfer between the Host and the Sensor with building as a hurdle between them. In this case two types of experiments were conducted. Experiments with 100 m range showed higher error percentage and experiments with 50 m range showed lesser error percentage.

The data in **Table 6** shows although the data transfer is done in case of buildings as hurdle but there is high percentage of error.

If we consider the distance of 50 m, then error rate is less but that will also reduce the "Safe distance" before which driver gets to know about the upcoming traffic hurdle, in this case 50 m [2].

Table 5. Data Transfer on curves with trees as hurdle.

Distance	Data Transfer on curve with no LoS		
	No. of times sent	*No. of times received*	*Error (%)*
100 m	6	6	0.00%
100 m	6	5	16.67%
100 m	6	5	16.67%
100 m	6	3	50.00%
100 m	6	5	16.67%
100 m	6	4	33.33%
Average	6	4.67	22.22%

Table 6. Data Transfer on curves with building as hurdle.

Distance	Data Transfer on curve with no LoS		
	No. of times sent	*No. of times received*	*Error (%)*
100 m	6	3	50.00%
100 m	6	2	66.67%
100	6	1	83.33%
Average	6	2	66.67%
50 m	6	5	16.67%
50 m	6	4	33.33%
50 m	6	6	00.00%
Average	6	5	16.67%

7. Experiment Outcome

7.1. Outcome for RSSI Experiments

Below are the conclusions from the experiments done to check the RSSI value for Host and the Sensor;

1).Larger the distance between the Host the Sensor, the smaller the value of RSSI and difficult it is to communicate.

2).Vehicle speed has no significant effect on RSSI value.

3).Weather has no significant effect on RSSI value.

4).With clear line of sight it is easy for Host and Sensor to communicate with each other.

5).Distance is not the only factor to affect the RSSI value, noise, air pollution and other factors in the air can also affect RSSI value.

7.2. Outcome for Data Transfer Experiments

Below are the conclusions from the experiments done to check the Data Transfer between the Host and the Sensor;

1).Larger the distance between the Host and the Sensor, difficult it is to send/receive the data.

2).The bigger and denser the hurdles between the Host and the Sensor, the more the error rate.

3).The straighter the road, the better it is to send/receive data between the Host and the Sensor.

4).Speed of case has no significant effect on data transfer rate.

5).Weather has no significant effect on data transfer rate.

8. Proposed Solutions to the Problems

Experimental data shows there is problem in communication between ZigBee Host and Sensor if there are hurdles like trees or buildings. To overcome this problem ZigBee relays can be used which can increase the range of communication. The arrangement can be to put a ZigBee relay between ZigBee Host and the ZigBee sensor which will help transfer data from Host to Sensor and vice versa.

Different experiments using ZigBee relays are still under way and are not covered in this paper [2,3].

9. Summary

Intelligent Transportation Systems using short range wireless technologies as a communication medium is an effort to make driving easy. This research is based on a concept that drivers get to know about the upcoming traffic hurdles like traffic signals, curves, railway lines etc before actually reaching at them. This will avoid accidents on road which are caused by sudden confrontation with traffic hurdles. Similarly this system can be very helpful in mountainous areas where there is snow and fog and drivers are actually unaware of upcoming traffic hurdles. ZigBee is a short range wireless technology used in this research because it's very inexpensive and consumes very low power as compared to its other peer short ranger wireless technologies like Bluetooth and Wi-Fi. Since this system is more important for mountainous areas where there is no power in some cases, ZigBee will help with its low power consuming attribute. Although ZigBee is a short range wireless technology but it provides enough range to transfer data from car to traffic hurdles and vice versa. Because of its low cost, this system can be used in developing coun- tries as well.

Conducted experiments show some encouraging results, which show that ZigBee with its low power, low cost and enough data transfer rate is a good choice for Intelligent Transportation Systems of this class.

10. Acknowledgements

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