Zigbee Technology: Emerging Sensor Network Based Short Distance Data Communication Protocol

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Abstract: Wireless sensor network based communication can be achieved by the means of distinctive channel. The characteristic of this channel is to allow single node to transmit data at a time. Organization of such kind of channel leads to establishment of MAC protocol. IEEE 802.15.4 based standard ZigBee supports data transfer from the sensor nodes to the control system. ZigBee is used for the applications which require low power, low cost of establishment and long battery life.

In accident avoidance system for long route vehicles prolonged life of the batteries, security of data and low latency is very important, and could be achieved using ZigBee. The sensors embedded on the dashboard of the vehicle will communicate with network by transmitting data. The communication among the sensors and the nearby router will be established using ZigBee. ZigBee has been developed to meet the emergent demand for wireless networking between several low power devices. In this paper we proposed comparative study of short distance communication protocol.

Keywords: MAC Layer, PAN (Personal Area Network), Sensor Node

I. INTRODUCTION

Media Access Layer

Medium access control (MAC) protocol play an important role to facilitate successful operation of the network. MAC functionality is provided by the lower sub layer of data link layer. It provides facility of shared medium access.[1]A sensor node consumes energy in three ways: Sensing the data, processing the data and data communication.[1] A node consumes 3J of energy to transmit 1 kb of data up to the distance of 100m. MAC protocol will be helpful in proving expanded life to sensor network. Network may be subjected to frequent change in size; network design should be such that it should be should be able to accommodate change in its size. MAC layer provides capability to network to handle the change in size and topology. [1][5] Utilization of available bandwidth is very important for effective communication between the sensor nodes and the network.

MAC layer also performs the task of avoiding collision of data packets. When multiple data node sends data at the same time collision may occur. Collision may results in corruption of data packets. Also sometimes it may leads to retransmission of data packets.[1][5] Successful delivery of the data packets is very important when data transmission from sender to receiver is concerned. So, there is need to manage data transmission in such a way that loss of data is up to minimum extent.

As per our proposed accidents avoidance architecture [4] the entire architecture can be divided into three zones: Activity zone, Notification zone and Control zone. Activity zone is the area where actually fatality occurs or the zone in which the abnormality is been detected. Fig.1 represents the parameters that to be monitored by the smart dashboard of the vehicle showing abnormality. In case abnormality been detected the sensors embedded on the dashboard of the vehicle will generate notification and it will be sent to vehicles in the vicinity of 500m and to the nearby PAN coordinator. This short distance communication is efficiently being handled by MAC layer Protocols.[2][4]
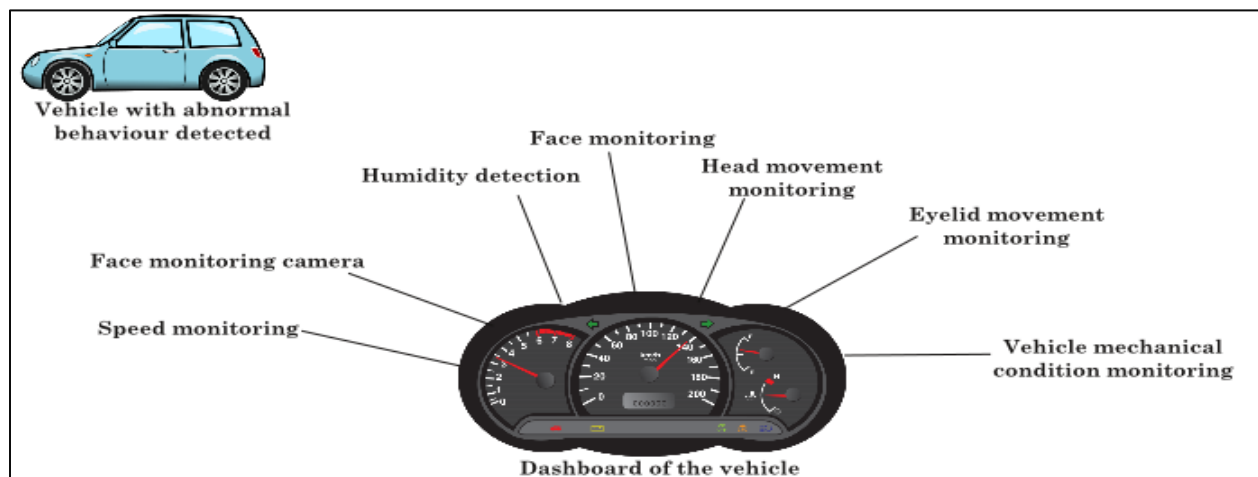

Fig.1. Parameters monitored by the sensors embedded on smart dashboard

II. MEDIA ACCESS LAYER PROTOCOL

Fig.2. represents classification of Medium Access Control Protocol. MAC layer protocols can be classified as Contention- free Protocols and Contention - Based Protocols. In contention based protocols nodes do not require to follow the same time. A node doesn't require any resource reservation. Whenever a node receives a data packet to transmit, it contends with its neighboring node to get access to the shared medium. Periodic access to the channel is not guaranteed. Examples include Aloha, CSMA, MACA and MACAW.[6][13]

In Contention free protocols facilitate user to use same radio channel without prior co-ordination. Two nodes need to be un-aware of each other. When both the nodes attempt to send data to the same destination node the result will be collsion of data at the receiving node. This hidden node problem can be overcome by using RTS-CTS handshake protocol. Contention free protocols can

be further classified as fixed assignment channelization and dynamic assignment channelization. In fixed assignment channelization each node is assigned with fixed amount of channel resources, so nodes do not need to be worry about sharing of channel resources. Protocols associated with fixed assignment channelization are: FDMA (Frequency-division multiple access, TDMA (Time division multiple access) and CDMA (Code division multiple access). Dynamic assignments gives priority only to those nodes which are ready to transmit data.[9] It doesn't gives priority to idle nodes. Dynamic assignment include Polling, Token passing, Reservation based.[5][6][14]

In contention based techniques there is no central control. When a node has data to send it compete for taking control of the medium. This technique works efficiently under light and moderate load but reduction in performance will be observed under heavy load condition. Contention based protocols will include Aloha, CSMA (Carrier sense multiple access), MACA (Multiple access with collision avoidance), MACAW (MACA wireless).[6][9]
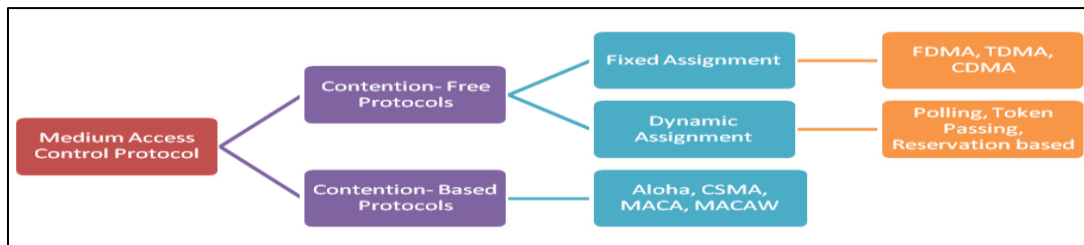

Fig.2. MAC protocols Classification [2]

III.   ZIGBEE 802.15.4 BASED STANDARD

Here Table.1. represents comparative study of various wireless technological options available for transmission of data packets. This transmission of data packets from sensor nodes to the router can also be termed as short distance communication. In proposed architecture for short distance communication energy efficiency, coverage range, power consumption and battery life is very essential to keep in consideration. Comparative study from Table.1 shows that ZigBee is the best technological option for wireless sensor network. It provides battery life to a sensor node for approx 100-1000 days. It is higher than that of Bluetooth and Wi-Fi. Transmission range of ZigBee is higher than the Bluetooth and Wi-Fi. When it comes to power consumption ZigBee provides low power consumption by the sensor nodes. It provides prolonged life to a sensor node. Zigbee supports maximum cell nodes that is more than 65000.[2][3][8]

Parameter	ZigBee	Bluetooth	Wi-Fi
IEEE standard	802.15.4	802.15.1	802.11
Battery Life (Days)	100 to 1000	1 to 7	1 to 5
Transmission Range	100 + meters	10 meters	100 meters
Power Consumption	Very low	low	high

Frequency	2.4 GHz (worldwide)	2.4 GHz	2.4 to 5 GHz
Data rate	20,40, and 250 Kbits/s	1 Mbit/s	11 and 54 Mbit/s
Nominal TX power	(-25) – 0 dBm	0 – 10 dBm	15 – 20 dBm
Number of RF channels	1/10; 16	79	14
Channel bandwidth	2 MHz	1 MHz	22 MHz
Type Of Modulation	BPSK (+ASK) , Q – QPSK	GFSK	BPSK,QPSK, COFDM,CCK,M-QAM
Co-existence mechanism	Dynamic frequency selection	Adaptive frequency hopping	Dynamic frequency selection, transmit power control (802.11h)
Basic cell	Star	Piconet	BSS
Extension of basic cell	Cluster tree, Mesh	Scatternet	ESS
Maximum number of cell nodes	>65000	8	2007
Encryption	AES block cipher	E0 stream cipher	RC4 stream cipher (WEP)
Data protection	16 bit CRC	16 bit CRC	32 bit CRC

Table.1. Difference among ZigBee, Bluetooth and Wi-Fi technologies [2][3][8]

For short distance communication it is been considered as the efficient standard in wireless network. It is preferred for the sensor based devices which are smaller in size and consumes less energy. Example: Medical equipment's, TV remote etc. [4]

A. ZigBee Architecture

Operating frequencies for the ZigBee WPAN (Wireless Personal Area Network) operates at 868 MHz, 902 to 928 MHz and 2.4 GHz. ZigBee Technology supports transfer of simple data like that from sensors.[10]

ZigBee defines MAC layer and physical layer to handle many devices at low data rate. ZigBee network can be classified into three categories named as: ZigBee coordinator, reduced function devices and Full function devices. Full function devices can act as coordinator, router and as an end device. [9] Reduced function device can't work as coordinator or as a router. It can only act as end device. Transfer of data between the coordinator and the other devices can be done in two modes: Beacon enabled mode and second is non-beacon enabled mode. In beacon enabled mode a beacon is sent by the coordinator for synchronization. Beacon is generated by MAC layer. When there is no data communication between nodes and routers the co-coordinators enters into sleep state. At times these coordinators wakes up and sends beacon frames. On receiving the beacon frames the end devices synchronizes their clocks. A node can send data to coordinator using CSMA-CA. The coordinator allocates particular time to each device to send data called guaranteed time slot. The biggest advantage of beacon enabled mode is low duty cycle and large battery usage.[9]

In non-beacon enabled mode the coordinator will not send beacon frame. The device which wants to communicate with coordinator will not send beacon frame. The device which wants to

communicate with the co-coordinator will send the data on the channel seeing that channel is free. [9]

As per our proposed architecture [4] PAN (Personal Area Network) coordinator will be fully functional device. It is responsible for network establishment and control. Routers will act as reduced functional devices. It will be helpful in forwarding the data packets. It is also responsible for linking different components of the network. Sensor nodes will act as end devices. The will communicate with network coordinator via routers. [12]
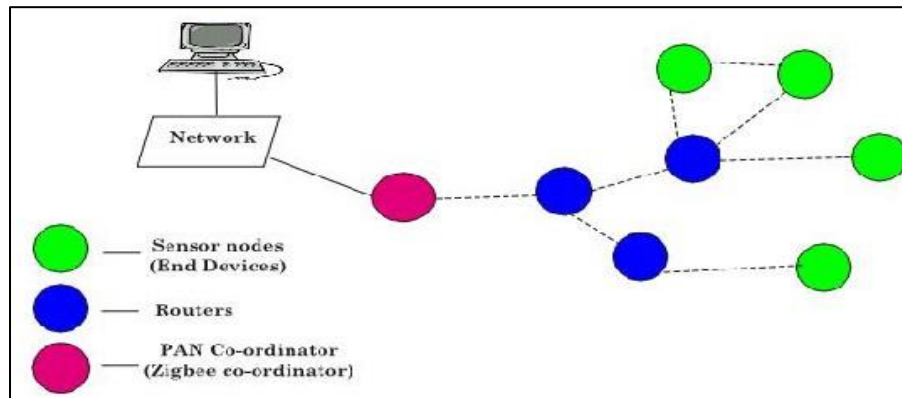

Fig.3. ZigBee Architecture [12]

IV.   SHORT DISTANCE COMMUNICATION USING ZIGBEE

Fig. 4 represents that in a wireless sensor network the data packets transmitted by the sensor nodes to routers. In our previous paper with the title "Wireless sensor network based Accident avoidance architecture for the fleet of long route vehicles".[4], pictorial representation of the dashboard has been mentioned. This dashboard is embedded with various kinds of sensors like: Humidity sensor, alcohol detection sensor, ultrasonic sensor, smoke detection sensor, eye blinking sensor, head movement detection sensor, speed monitoring sensor. To transmit the data packets from the sensor node to the router requires certain wireless technological options. In proposed system of data communication requires communication standard which must be low cost, low powered, cost effective, easy to deploy. Sensor node requires powers to operate. These nodes can be discharged easily if no proper communication technological option is opted for communication/transmission of data packets. As per comparative study mentioned above ZigBee can be considered as the suitable option for data packets transmission or short distance communication in our proposed architecture.[4]
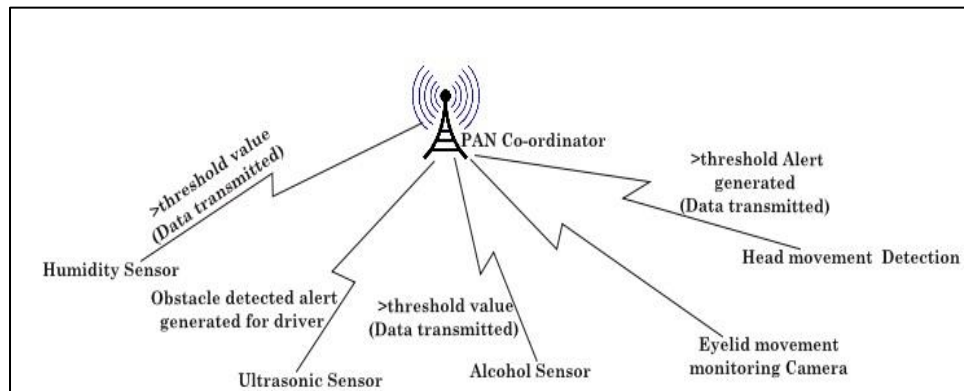
Fig.4. Short distance communication using ZigBee Protocol

V. CONCLUSION

In this paper analysis of various MAC protocols for short distance communication is been done. It is found that ZigBee protocol could be one of the best possible solution in designing of Accidents avoidance architecture for the fleet of long route vehicles.

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