International Journal of Engineering Research and Technology.
ISSN 0974-3154 Volume 11, Number 11 (2018), pp. 1661-1683

http://www.irphouse.com

A New Method for Pedestrian Alerts

Arvind Vishnubhatla

Electronics and communication Department,
Gokaraju Rangaraju institute of engineering and Technology,
Hyderabad, India.

ABSTRACT

The anxiety caused by traffic congestion negatively impacts the conduct of driving function on the road. The incidence of heavy traffic necessitates extra awareness about surroundings and forces the need to adhere to safe driving rules.

The busy lifestyle causes people to always be in a hurry and end up driving recklessly. This coupled with flow of irregular traffic causes people to get impatient.

The use of car's horn can be used effectively to prevent accidents and untoward incidents.

Pedestrians in a hurry generally ignore all types of honks.

A new method of alerting is proposed where whenever a driver sees a group of pedestrians obstructing the road, he initiates a command from his steering wheel. This wirelessly sends a message to all pedestrians who have their watches vibrating. This signal warns them of an approaching vehicle.

They can form themselves into a single file at the side of the road.

Keywords: Pedestrian, wireless, alert, vibration

I. INTRODUCTION

The capacity of the road cannot keep up with the growing demand causing extreme traffic congestion. This causes vehicles to be fully stopped for long periods of time causing drivers to get impatient and frustrated. The flow of traffic is irregular and the road is choked with cars and pedestrians where people try to negotiate in a hurry causing panic.

Auto Wallahs and bikers are determined to maintain their speed , trying to squeeze in from either side. People are not concerned on the correctness of their approach but they just want to get ahead.

The traffic just crawls on the road. The road is narrow at many places. The available width is reduced by the cars parked on the road.

To facilitate various works people resort to digging of roads without warning signs and safety measures, threatening road users, more so during night hours.

In some of the roads there is no footway or footpath. Instead of walking in a file people walk in groups covering the already narrow portion of the road.

People usually honk the horn when they are trying to make their presence felt. This generally happens when they are irritated with pedestrians or other cars in front of them. Mostly pedestrians do not look either way when they cross the road or they intentionally walk slowly. This also applies to motorcycles, bicycles and dogs. It becomes difficult to tell people that you're already there

The use of car's horn can be used effectively to prevent accidents and untoward incidents.

The indiscriminate dumping of C&D waste is a major concern for municipal bodies across India resulting in water and air pollution. This unplanned dumping puts the life of citizens in danger affecting even storm water drainage.

Figure 1. Dumping of C&D waste.

The areas of the road along popular shopping malls are choked with Parked vehicles.

The lack of driving sense prevents people from putting ON indicators while taking left or right. This keeps you guessing causing you to have to pull over sometimes.

Figure 2. Spilling over of sewage on the road

The spilling over of sewage on the road after rains further narrows the usable portion of the road.

Small children are blissfully ignorant of road traffic and are distracted by the games they are playing and cause road safety problems. This causes a lot of nuisance for people trying to drive in that area.

Figure 3. Children playing on the road

Roadside vegetable vendors encroach upon the road on either side.

Figure 4a. Roadside fruit and vegetable vendors.

Figure 4b . Roadside fruit and vegetable vendors.

Major and minor drains running through the city cause a serious threat to road conditions especially during rainy season.

Figure 5. Drains on the Road

In rainy seasons water gets accumulated thereby cutting down the usable portion of the road.

Animals cross the road in search of food without any thought of traffic.

Figure 6. Animals on the road

If due to any oversight people get run over it leads to mob fury where students end up protesting and torching buses and vehicles .Police have to resort to lathicharge to control the stone throwing mobs.

Figure 7. Mob Fury

Figure 8. Pedestrians on the Road.

Figure 9. Pedestrians crossing the Road without traffic signs

Figure 10. Pedestrians scramble to work without heeding to traffic signs

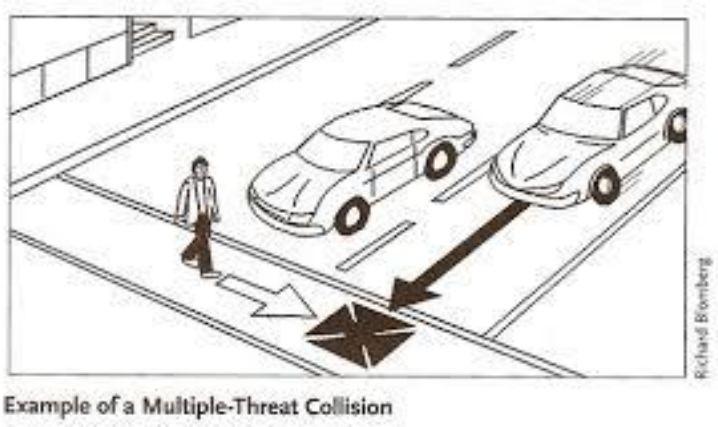


Figure 11. Unaware Pedestrian is exposed to multiple threats

II. DESIGN THINKING

We use design thinking to solve complex problems. The first step is to get an understanding of the problem at hand. Here a lot of information regarding the design problem is obtained. Then based on these observations the information is put together to get the requirements for the product at hand. This gives the problem statement. Now the ideas are used to define the features of the product. The next step is to generate viable solutions.

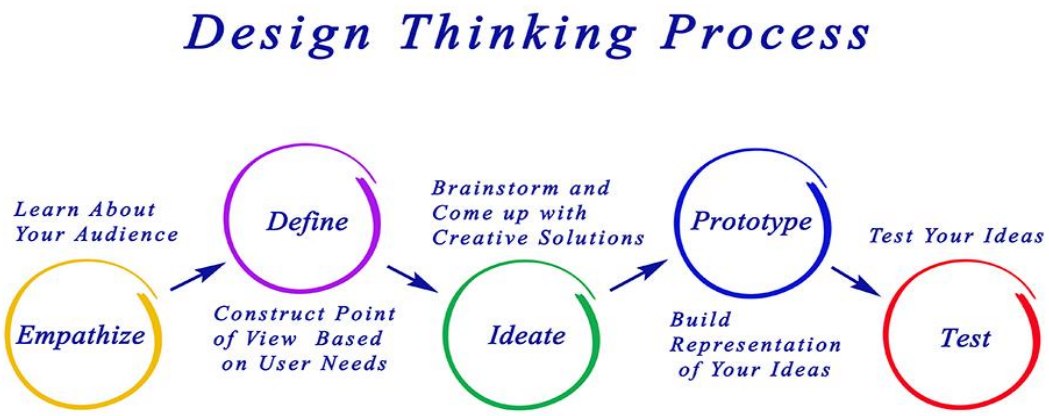


Figure 12. Design Thinking Process

III. ABOUT THE METHOD

A new method of alerting is proposed where whenever a driver sees a group of pedestrians obstructing the road, he initiates a command from his steering wheel. This wirelessly sends a message to all pedestrians who have their watches vibrating. This signal warns them of an approaching vehicle.

Here the vehicle is in the role of a broadcaster. In this role, all the vehicle does is transmit data to its surroundings. By encapsulating useful data in its advertising packet it sends data for all the receivers to see. As the only role is to broadcast to others, it does not need a receiver and does not need to accept connections.

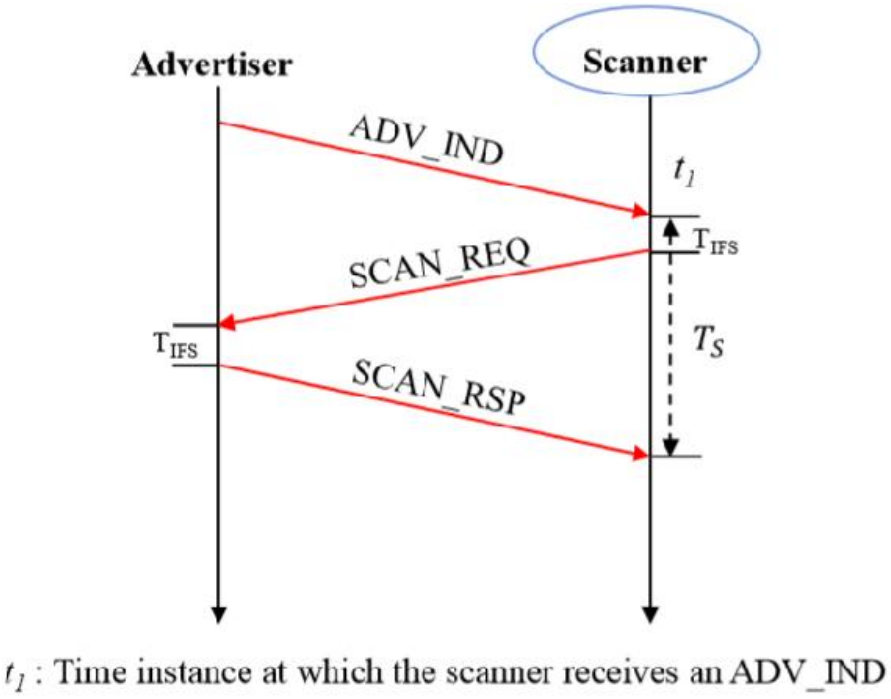


Figure 13. Advertiser Scanner message sequence chart

Notation	Meaning
T_{ADV_IND}	Transmission time of ADV_IND message
T_{SCAN_REQ}	Transmission time of SCAN_REQ message
T_{SCAN_RSP}	Transmission time of SCAN_RSP message
T_{IFS}	Inter Frame Space
T_S	Control message handshaking time ($=T_{SCAN\_REQ} + T_{SCAN\_RSP} + 2T_{IFS}$)

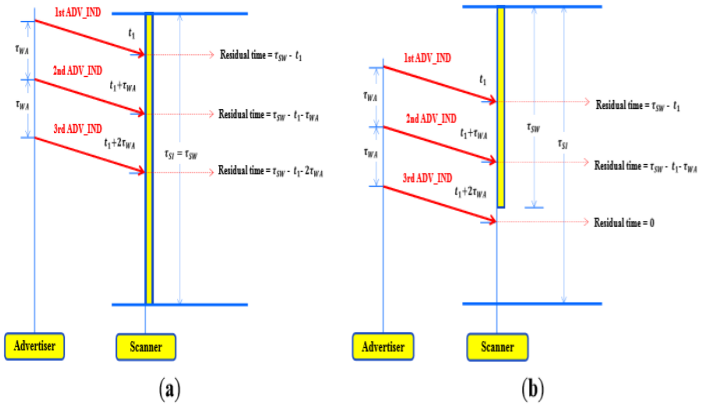


Figure 14. Continuous and Discontinuous scanning

The pedestrians are the opposite of the broadcaster. They passively listen to advertising packets and process the data. They do not need a transmitter as they do not need to send anything to the vehicle.

Different types of wireless networks, those created by cellular networks, Wireless LANS and personal area networks exist. All these play a part in developing wireless solutions. PAN technologies play a vital role in forming the type of wireless solutions which are relevant for our application.

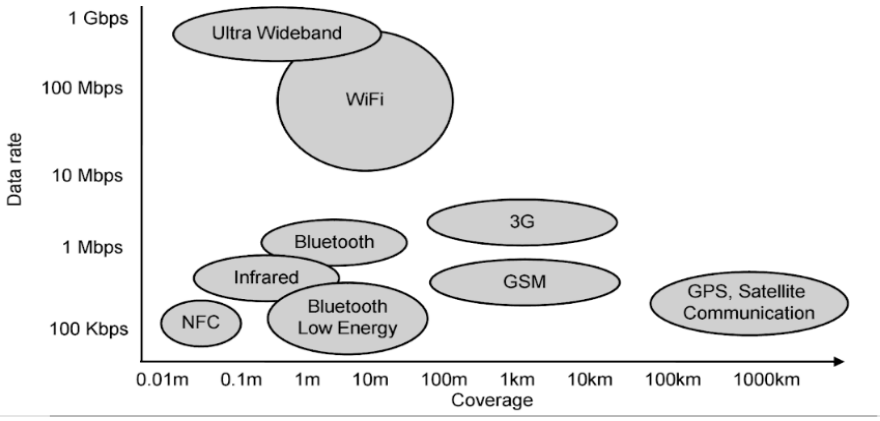


Figure 15. Speed Vs Coverage for various wireless technologies

The institute of Electrical and Electronic engineers (IEEE) has constituted seven task groups, one of them being Bluetooth. This is a wireless technology for short distances. Bluetooth Low energy(BLE) (also known as bluetooth smart) has been crafted to consume less power than Bluetooth.

	BLE	Wi-Fi	Zigbee
Frequency Band	2.4GHz	2.4GHz / 5GHz	2.4GHz
Modulation	GFSK	OFDM, DSSS	DSSS
Range	<100m	<300m	< 100m Point to Point, More with Meshing
Network Topology	Scatternet	Star	Mesh
Data Rate	1Mbps	11Mbps, 54Mbps, 150Mbps+	250kbps
Peak Current Consumption	<15mA	60mA RX, 200mA TX	19mA RX, 35mA TX
Standby Current	< 2uA	< 100uA	5uA

Figure 16. Feature comparisons with various wireless technologies

The physical layer (PHY) contains the circuitry required to send digital signals over the air. The physical layer sends data to the link layer. This uses the 2.4Ghz (ISM) band where the bandwidth is divided into 40 channels with 2Mhz of spacing.

These 40 channels are further subdivided into three advertising channels (37,38,39) and thirty seven data channels. The data transmission is at 1 Mbps with 1 bit per symbol using gaussian frequency shift keying (GFSK). BLE makes use of single packet format for both advertising and data transmissions. Four components, namely the preamble, access address, protocol data unit and cyclic redundancy check form the packet. The sequencing and timing of packets is managed by the link layer. The aggregation and direction of data streams is managed by logical link control and adaptation layer protocol(L2CAP). The security manager helps to encrypt and authenticate the packets and is responsible for device pairing and key distribution.

The generic attribute profile (GATT) manages the size of data exchange between devices. The generic access profile (GAP) helps to configure the different operating modes namely advertising and scanning. The functions of initiation, establishing and management of connection are performed by GAP.

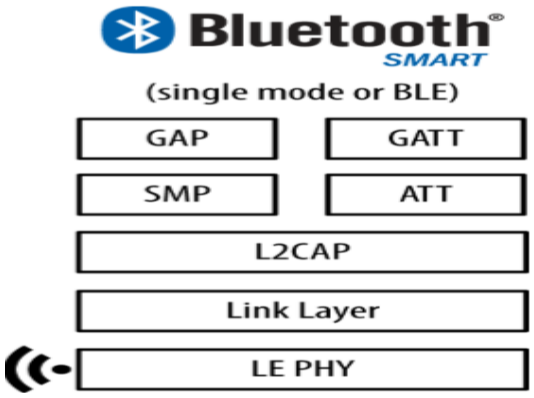


Figure 17(a) Different layers of Bluetooth low energy

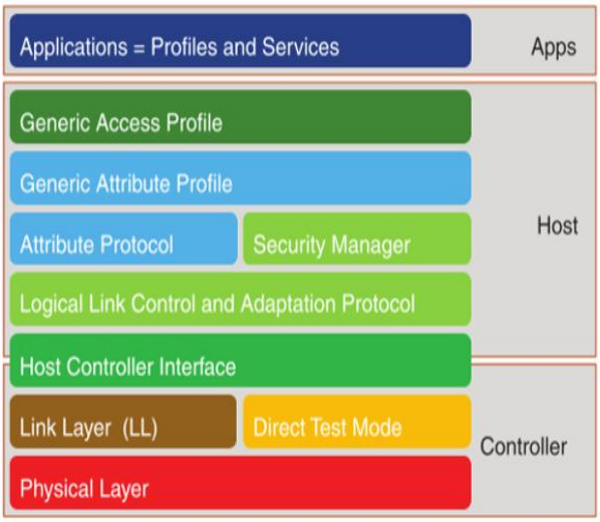


Figure 17(b) Different layers of Bluetooth low energy

Our application does not need bidirectional communication and other features like security, encryption and quality of service. Here we just need the BLE advertising mode where the status of just a few parameters is needed. Hence we can use a subset of the total protocol stack to save power.

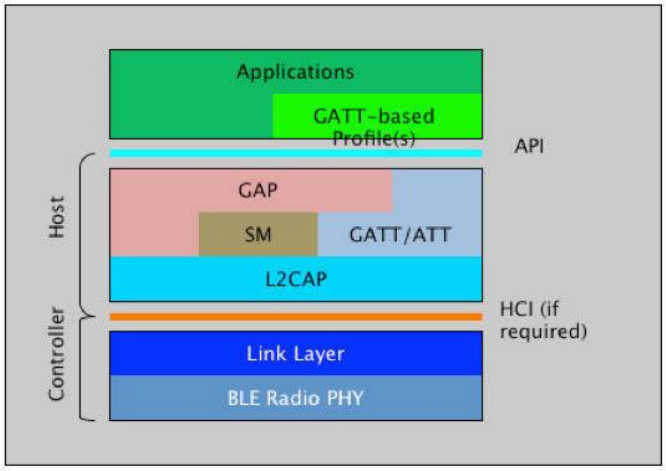
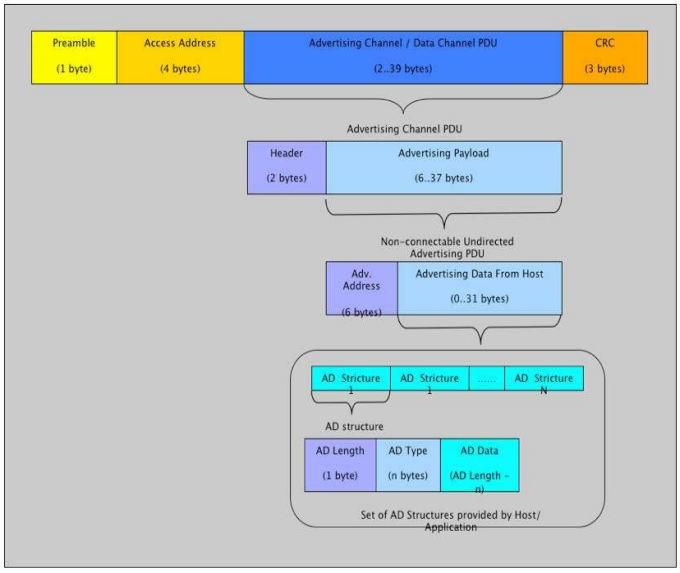


Figure 17(c) Subset of the protocol stack to save power



17(d) Device's discovery and connection establishment information;

To prevent the pedestrians from ignoring the car horns and causing run over by the vehicles, the cars and two wheelers will be equipped with a Class 1 Bluetooth devices transmitting at 100 mW having a standard range of 100 meters or 328 feet. Class 1 devices are recommended because the vehicles have plenty of power.

Figure 18. Pedestrian , run over by a vehicle.

Whenever a driver sees a group of pedestrians obstructing the road ,he initiates a command from his steering wheel. This wirelessly sends a message to all pedestrians, over bluetooth a wireless technology in the ISM band that provides communication and networking between short range devices. These devices using bluetooth protocol are developed to cater to low cost.

A frequency hopping method in 2.4Ghz radio band is used to communicate between the car and the nearby pedestrians. The car is equipped with a communication module employing a short range communication module which is intended to communicate with a large number of communication devices worn by pedestrians.

Feature	Value
Frequency band	2.4GHz (2402Mhz - 2480MHz
Modulation	GFSK, 1 Mbps
Modulation index	0.5
Channel spacing	2 MHz
Advertising channels	3
Data channels	37
Frequency hopping	Adaptive FHSS

Figure 19. Features of Physical Layer

Feature	Value
Minimum TX power	0.01mW (-20 dBm)
Maximum TX power	10 mW (10 dBm)
Minimum RX sensitivity	-70 dBm (BER 0.1%)

Figure 20. Bluetooth low energy radio requirements

TX power	RX sensitivity	Range
0 dBm	-70 dBm	~30 meters
10 dBm	-90 dBm	100+ meters

Figure 18. Bluetooth low energy radios typical range

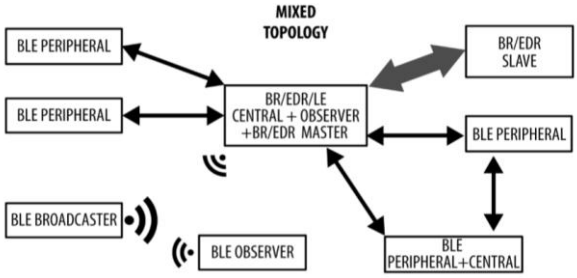


Figure 21. Mixed Topology

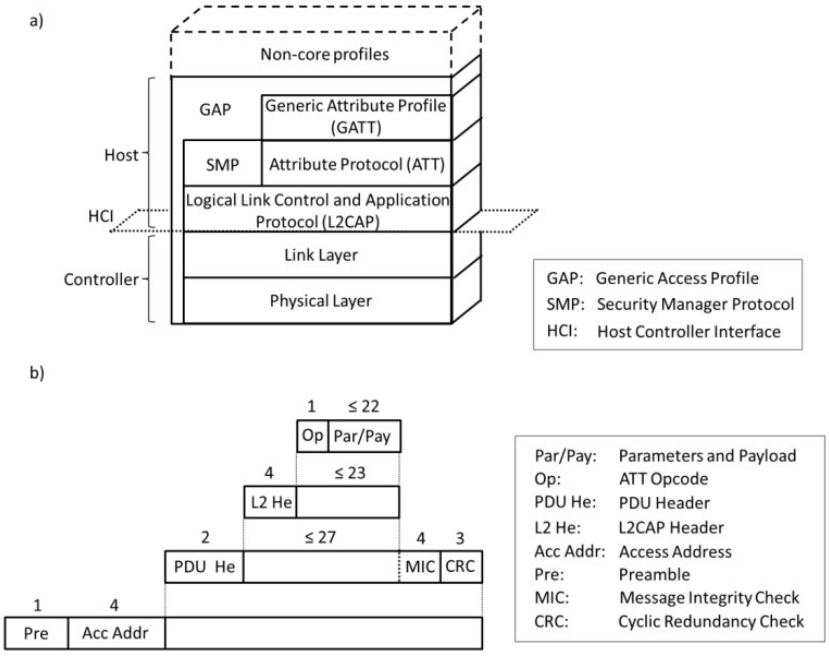


Figure 22. Bluetooth Low energy Layer Hiearchy

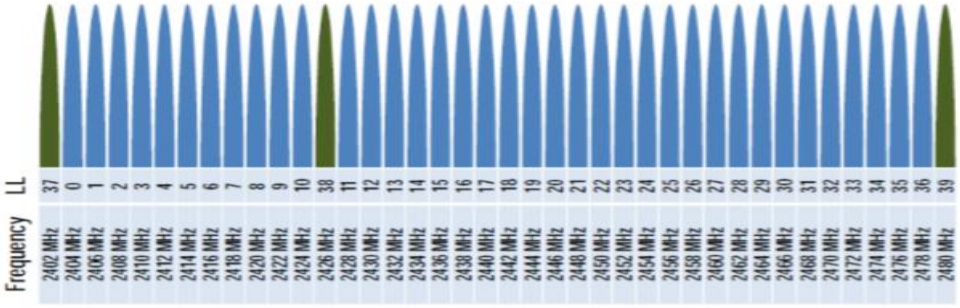


Figure 23. Link layer channels

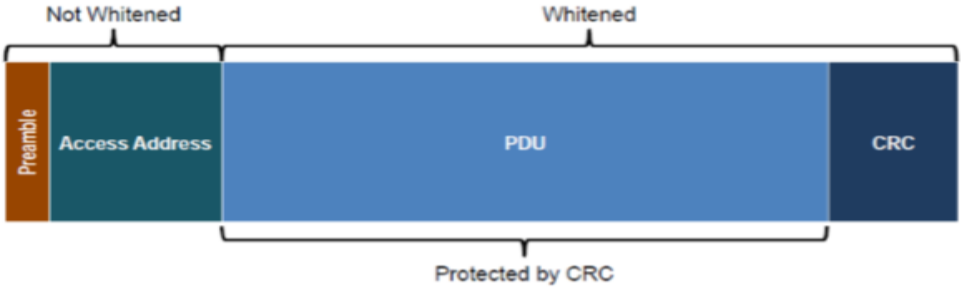


Figure 24. Packet format

- **Preamble:** either 010101010 or 101010101
- **Access address:** advertisement packets use a fixed access address of 0x8E89BED6. Data packets use a random access address depending on the connection.
- **PDU:** protocol data unit depends on the packet type.
- **CRC:** a 24-bit CRC checksum is used to protect the PDU.

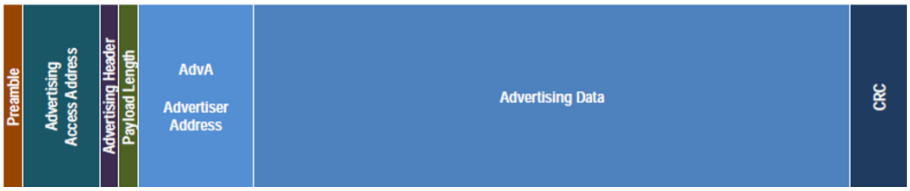


Figure 25. Advertisement packet structure

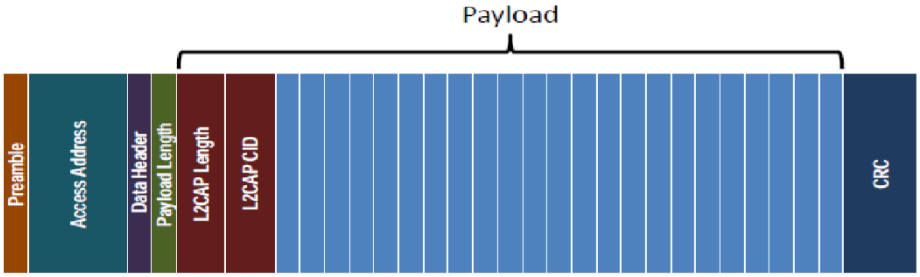


Figure 26. Unencrypted Data Packet format

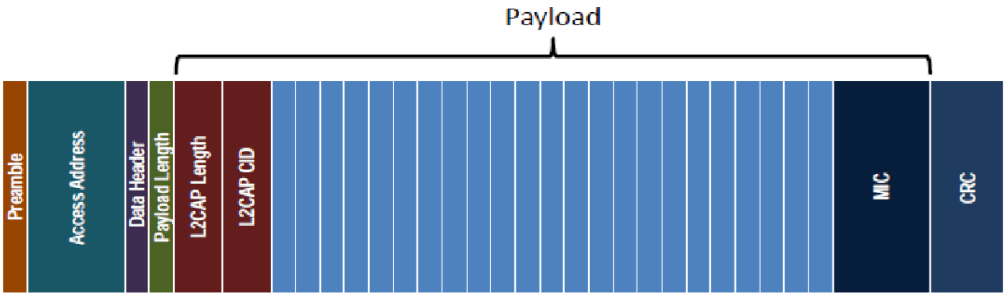


Figure 27. Encrypted data packet format

Four device roles are envisaged in the Bluetooth 4.0 specification. These are advertiser, scanner, master and slave.

Advertiser: This role is able to broadcasts advertisement packets. However it is not able to receive them.

Scanner: Devices in this role listen to advertisement packets sent out by advertisers. Can try to connect an advertiser.

Master: A device that is connected to one or several slaves

Slave: A device that is connected to a master. Can only be connected to one master at a time

Broadcast Connection

The defined roles for a broadcast connection are Broadcaster and Observer. It may be noted that in a Broadcast connection messages are one way. The messages are one to many , i,e from the vehicle to many pedestrians. ADV_IND is the packet type that is used to broadcast the data,

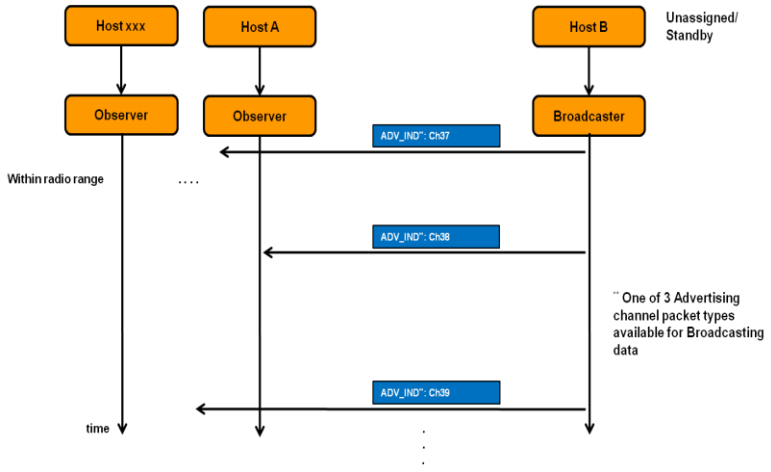


Figure 28. Message sequence chart (Broadcast Application)

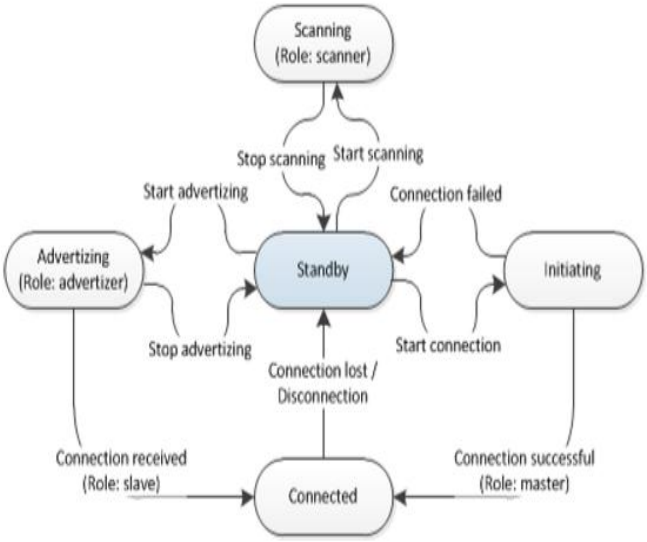


Figure 29. Bluetooth States

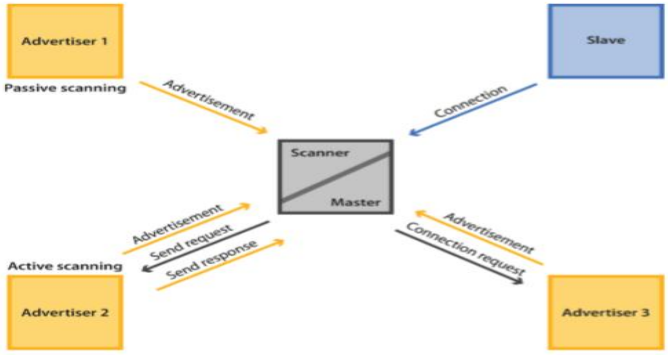


Figure 30. Bluetooth Connection States

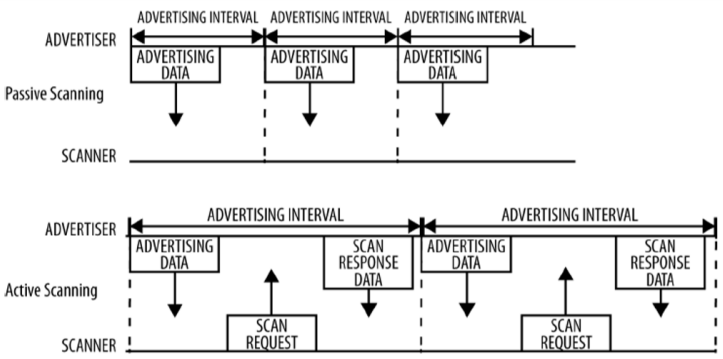


Figure 31. Advertising Intervals

Class	Max output (dBm)
1	+20
1.5	+10
2	+4
3	0

Figure 32. Informative Tx power classes in LE

Purpose	PDU content	PHY			Advertising	Comment
		LE 1M	LE 2M	LE coded		
General advertising extended	ADV_EXT_IND	yes	no	yes	primary	Indicates secondary advertising. Points to an AUX packet
AUX packet	AUX_ADV_IND	yes	yes	yes	secondary	Contains secondary advertising data
Periodic advertising	AUX_SYNC_IND	yes	yes	yes		Fixed interval
Chain of data	AUX_CHAIN_IND	yes	yes	yes		Large data volumes

Figure 33. Additional extended advertising messages in line with V5

In passive scanning mode the advertiser simply broadcasts advertisement packets on the advertising channels and a scanner simply listens to incoming advertisements.

Typically in passive scanning scenario,advertiser sends three advertisement packet one on each advertisement channel separated by 150us. Scanner only listens to one advertisement channel at a time, but keeps switching between the three advertisement channels.

The advertisement events are separated by a time called advertisement interval, which can vary from 20ms to 10240ms. In addition a random delay is added to the advertisement interval to avoid interference with other devices.

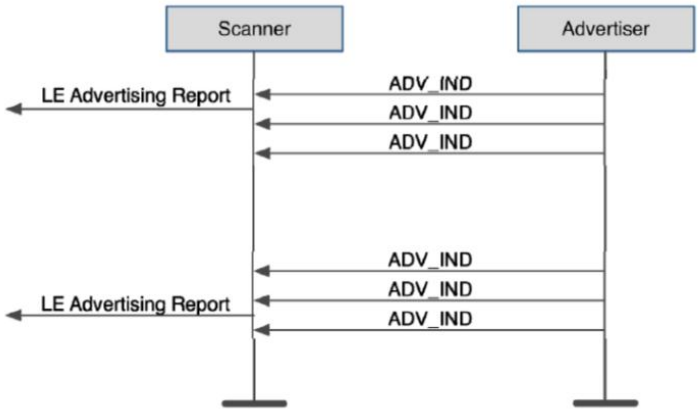


Figure 34. Message sequence charts between advertiser and scanner.

The advertisement packets typically contains information like, discoverability and connectability modes , the address of advertiser, TX power level Supported services and application data

The car transmitter is in the advertising state and transmits the message "Car in Vicinity'' to other devices in the vicinity. Periodically user data can be sent to the scanner.

The destination device is a watch like device having a microprocessor. It has a Bluetooth® low energy radio configured to receive notifications from a transmitter and actuating a vibration motor to alert the end user

All pedestrians are required to wear a communication device, which is either built into a watch or a standalone device to be worn on the wrist to alert the wearer to a transmitted message. On invoking the device from the vehicle the pedestrians will have their device vibrating. This signal warns them of an approaching vehicle.

Upon such a signal occurring, the device actuates the probe to prod the wearer's wrist .The pedestrians can then form themselves into a single file at the side of the road.

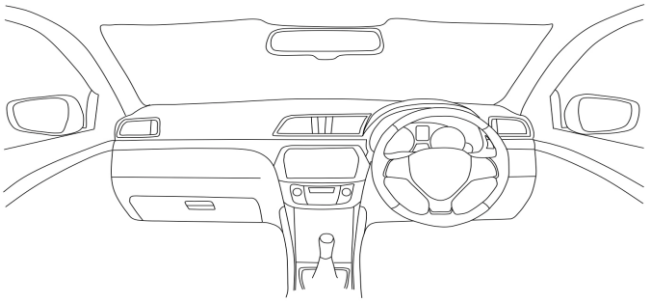


Figure 35. Bluetooth hardware installed in the car for pedestrian warning.

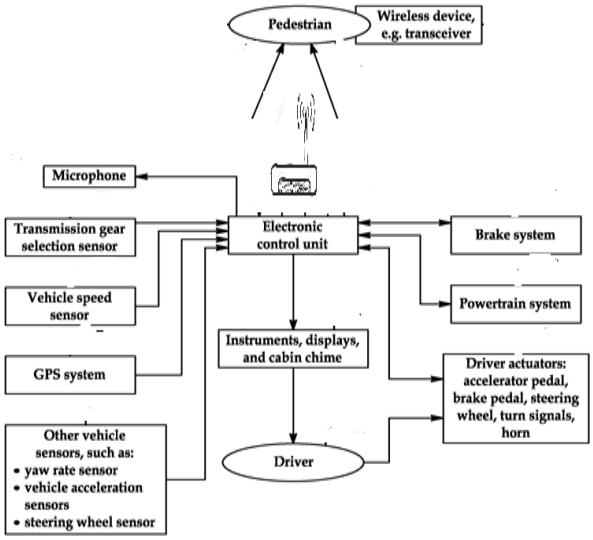


Figure 36. Bluetooth for pedestrian warning.

Figure 37. Bluetooth for pedestrian warning.

Figure 38. Vibrating watch for pedestrian warning

Figure 36. Vibration device for pedestrian warning

Figure 39. Vibration device for pedestrian warning

IV. ANALYTICAL INFERENCES

The probability of successful discovery has been exhaustively analysed in [8] where the following events are analytically studied.

The proportion of time that BLE device takes before waking up for scanning is called as duty cycle $\rho = \tau SW/\tau SI$.It may be noted that $0 \leqslant \rho \leqslant 1$.

Initially 1 advertiser and 1 scanner are considered with 3 adverting channels. This is E1 intersection with E4.

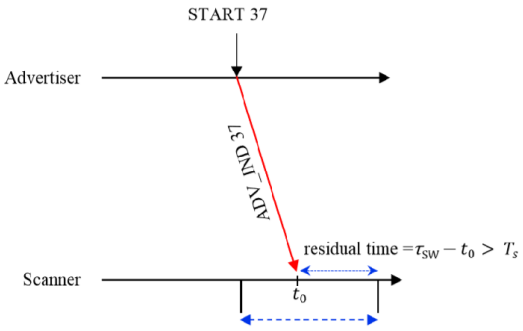


Figure 40. One advertiser and one scanner

On receiving ADV_IND The probability that the scanner interacts with advertiser is ${}_3C_1\left(\frac{1}{3}\right)^2$.

Event	Meaning
E1	S1 is synchronous with A1
E2	All of S2, S3,... and SN are not synchronous with A1
E3	All of A2, A3 …, and AM are not synchronous with S1
E4	S1 has enough time to reply to ADV_IND until ScanWindow is finished
E5	All of S2, S3,... and SN are sleeping or do not have enough time to reply to ADV_IND until ScanWindow is finished
E6	S1 does not receive ADV_IND from A2, A3 …, and AM in an interval [t1 − Ts, t1 + Ts]

Figure 41. Events for analysing probability of discovery

Given that TS (=TSCAN_REQ + TSCAN_RSP + 2TIFS),the probability of discovery on that first advertisingchannel is

$$\alpha_1 = PROB(E1 \cap E4) = 3C_1\left(\frac{1}{3}\right)\left\{\rho - \left(\frac{T_s}{\tau_{SI}}\right)\right\}$$

In general the probability of discovery on the kth advertising channel is

$$\alpha_k = \left(\frac{1}{3}\right)\left(\left\lfloor (k-1)\frac{T_{WA}}{\tau_{SI}}\right\rfloor + \rho - (k-1)\frac{T_{WA}}{\tau_{SI}} - \frac{T_s}{\tau_{SI}}\right), (k = 1,2,3)$$

$$PROB(E1 \cap E2 \cap E4) = 3C_1\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)\left\{\rho - \left(\frac{T_s}{\tau_{SW}}\right)\right\}$$

A more general case for an M:N Network with (N+M) BLE devices, where M devices (called A1, A2, …, AM) act as advertisers and the other N devices (called S1, S2, …, SN) work as scanners is analysed.

$$\text{ROB}(E1\cap E2\cap E3\cap E4 = 3C_1\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)\left(\frac{\tau_{SW}-T_s}{\tau_{SI}}\right)=\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)\left(\rho-\frac{\tau_S}{\tau_{SI}}\right)$$

$$OB(E1\cap \bar{E}2\cap E3\cap E4\cap E5) = 3C_1(\frac{1}{3})(\frac{2}{3})(\frac{\tau SW-Ts)}{TSI}\left\{\sum_{k=1}^{N-1}N-1C_k\left(\frac{1}{3}\right)\left(\frac{\tau_{SI}-\tau_{SW}+T_{IFS}}{\tau_{SI}}\right)\left(\frac{2}{3}\right)\right.$$

$$=\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)\left(\rho-\frac{\tau_S}{\tau_{SI}}\right)\left[(3-\rho+\frac{\tau_{IFS}}{\tau_{SI}})-2^{n-1}\right]$$

$$OB(E1\cap E2\cap \bar{E}3\cap E4\cap E6) = 3C_1\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)^{N-1}\left(\frac{\tau_{SW}-T_s}{\tau_{SI}}\right)\left\{\sum_{k=1}^{M-1}M-1C_k\left(\frac{1}{3}\right)^{k}\left(\frac{\tau_{SI}-2T_S}{\tau_{SI}}\right)\left(\frac{2}{3}\right)^{M-1-k}\right\}$$

V. DISCUSSION

The new method of pedestrian alerts is a simple and feasible method. This has been illustrated by analytical models. It is goes a long way to alleviate the existing traditional way of using horns. It is very cheap to implement.

REFERENCES

[1] Gao-Ting Jian,Alan Liu,Chang-Han Yu , "A multiagent based warning system for pedestrian safety," 2014 International Conference on Advanced Robotics and Intelligent Systems (ARIS) **DOI:** 10.1109/ARIS.2014.6871524

[2] Klaus David ,Alexander Flach , CAR-2-X and Pedestrian IEEE Vehicular Technology Magazine Page(s): 70 - 76.

[3] Anubha Kumari ,Deepshikha ,B A Satish, "Automated traffic control for pedestrian safety," in 2017 International Conference on Innovative Mechanisms for Industry Applications (ICIMIA) 21-23 Feb. 2017 DOI: 10.1109/ICIMIA.2017.7975589.

[4] Akshay Kumar,Amarveer Singh,Ekambir Sidhu, "Smart-cap for pedestrian safety" 2015 International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 18-19 Dec. 2015 DOI: 10.1109/ICCICCT.2015.7475346

[5] Hojin Jung,Seong Kyung Kwon,Haengju Lee,Sang Hyuk Son, "Traffic Caution System for Pedestrian Safety," 2016 IEEE 22nd International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA), DOI: 10.1109/RTCSA.2016.60.

[6] Christoph G. Keller ,Thao Dang,Hans Fritz ,Armin Joos,Clemens Rabe ,Dariu M. Gav, "Active Pedestrian Safety by Automatic Braking and Evasive Steering," IEEE Transactions on Intelligent Transportation Systems (Volume: 12, Issue: 4, Dec. 2011, pp. 1292 - 1304, 30 June 2011 [DOI: 10.1109/TITS.2011.2158424

[7] Zhenyu Liu ,Lin Pu ,Zhen Meng ,Xinyang Yang ,Konglin Zhu ,Lin Zhang"A novel pedestrian-oriented forewarning system for vulnerable pedestrian safety". 2015 International Conference on Connected Vehicles and Expo (ICCVE), 19-23 Oct. 2015 DOI: 10.1109/ICCVE.2015.63

[8] Keuchul Cho,Woojin Park, Moonki Hong , Gisu Park , Wooseong Cho, Jihoon Seo and Kijun Han , Lin Zhang, "Analysis of Latency Performance of Bluetooth Low Energy (BLE) Networks".Sensors 2015,15,59-78;doi:10.3390/s150100059