Ideas on collision detection in vehicles using WSN

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***Abstract*: As traffic and population is increasing, it's monitoring and automation is finding a scope for development and it is emerging as a lucrative field for research and development. Intelligent transportation systems (ITS) are advanced applications which aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks. Realizing its enormous potential in automation, this review work was built around ITS and its applications. As ITS majorly involves the Wireless Sensor Networks, it was also explored to some extent. Various architectures were explored and compared to deduce the strengths and weaknesses of proposed solution.**

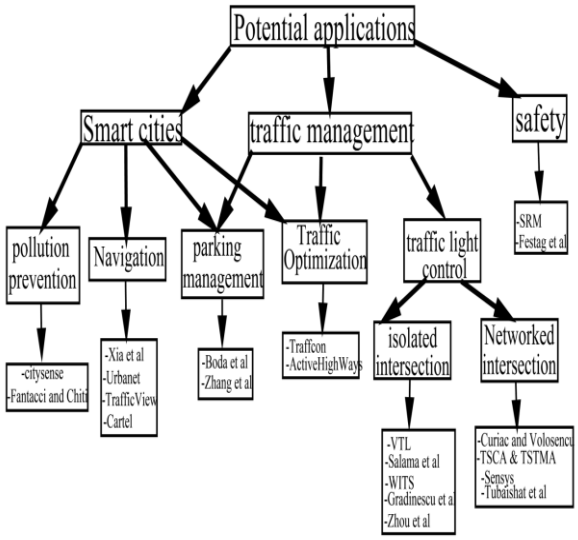
***Keywords* – WSN, Collision Detection**

I. INTRODUCTION

Intelligent Transport Systems (ITS), a combination of Information Technology and telecommunications, allows the provision of on-line information in all areas of public and private administration. ITS can be applied to road transport to improve efficiency and safety through the provision of on-line information to drivers in their vehicles and by equipping the vehicle with computerized systems which assist the driver (e.g. following and lane keeping).It also improves the efficiency of transport by use of electronic systems to improve traffic control and enforcement of traffic rules and regulations. ITS will have beneficial effects on the environment by reducing air and noise pollution on highways and by helping to create traffic free zones in cities. This paper is categorized in six sections. The first section being introduction, second section details the review process adopted for this literature survey, third and fourth section gives the brief about the various issues which came up during review and their common findings along with comparative tables with associated strengths, weaknesses and unique features of each. Fifth section concludes with the scope and sixth sections lists down the references used.

II. CHALLENGES TO BE SOLVED BY I.T.S

A city is said to be smart if investments in human and social capital and traditional and modern communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory action and engagement [1]. Intelligent transportation systems are advanced applications of smart cities which aim to provide innovative services relating to different modes of transport and traffic management in order to enable various users to be better informed and make safer, more coordinated, and "smarter" use of transport networks. There are many challenges that can be overcome by ITS. This section briefly summarizes them.



ITS Classification in WSN

Traffic Congestion

Traffic congestion occurs as use of a road increases. It is characterized by slower speeds, longer trip times and increased vehicular queuing. Congestion is caused by three main reasons [2].

1) Traffic incidents such as accidents, construction activities, bad weather, etc.

2) Fluctuations in normal traffic because of increased in number of cars on the road due to special events or otherwise.

3) Physical conditions of the road such as bottlenecks, etc.

The first step towards solving this challenge is to count vehicles on a road segment. ITS minimizes traffic congestion

by informing driver, traffic management and road planning departments about live traffic conditions as well as traffic patterns. Driver can plan their route using less congested roads. ITS helps traffic management
and city planners in planning better road networks.

Accidents and Emergency Conditions

According to [3], 1.24 million deaths have been reported worldwide due to road accidents. Causes include intoxicated drivers, over speeding, road side distractions and bad weather. ITS solutions help to identify driver behavior have been researched on by [4].

Emission and Environmental Pollution

Auto-emission is one of the biggest contributors of CO2, CO, NOX and un-burned hydrocarbons. The main reasons
are lack of engine tuning, inconsistencies in engine health checks and adulteration in fuel. Advances in sensor technology have made it possible to detect the presence of such pollutants through the vehicle exhaust.

City planners are using ITS to identify vehicles whose engine health has deteriorated. Regular health checks have been introduced by traffic authorities enforcing vehicle owners to maintain a healthy vehicle engine.

Finding a Parking Space

According to [5], one of the major factors causing traffic is caused by drivers looking for a parking space. Various solutions have been proposed that guide the driver in finding a parking space [5]-[9].

Route Planning

Drivers want to take their vehicles from point A to point B, optimally. Change in traffic patterns and unforeseen obstacles such as accidents, road blocks, traffic jams, constructions work hinder this requirement. This causes waste of fuel and time. Global Positioning System (GPS) helps identify ones location on a map. ITS uses GPS
and Vehicular Ad hoc networks (VANET) [10] concepts to assist drivers in making informed routing decisions [11].The challenges presented above can be tabularized into three classes: enhancing user experience, efficiently.

III. OTHER ISSUES AND SOLUTION APPROACHES

After an exhaustive review process, the 19 research papers could be categorized in following three issues:

1. ITS Architecture
2. Traffic Monitoring and Control
3. Vehicle collision avoidance

Findings Of Its Architecture

a)Generally all proposed architectures are based on Wireless Sensor Networks. Three kinds of nodes viz., vehicle unit, road side unit, and street or intersection unit are used for inter communication of vehicle with
networks.

b) Either mobile nodes on vehicle (Mobile Adhoc network: VANET) or stationary nodes on road sides to sense vehicle have been used in all the techniques to collect traffic information.

c) WSN based ITS[4], named as WITS gave a setup of ITS using the basic methodology of road side units and vehicular units. This technology took the advantage of peculiar features of the WSN being low energy
consumption, small size, non-cable and full-road coverage which helped in achieving efficient ITS networking. However it was limited by the requirement of every vehicle to be equipped with the sensors.

d) UTOSPF [10], Urban Traffic Open Shortest Path First technique which is a novel distributed system based on WSN and OSPF protocol collected real-time traffic information from roads. While using all merits of WSN, the use of OSPF protocol concepts strengthened UTOSPF by making it autonomous, distributed, simple, inexpensive, highly scalable and totally independent of vehicles movement. This technology was only implemented to find optimal paths, but, this structure could also be used to detect and send other trafficinformation.

e) DRGS[11], Dynamic Route Guidance System, emerged to be another set up for capturing real time traffic information for route guidance , also used the features of wireless sensor networks, as it strengths. The major limitation of DRGS was broadcasting if data to all drivers despite of its irrelevance to some.

f) It has also been proposed to combine the WSN and VANET[3] technology to complement each other's limitations .This approach combined the strength of both networks and emerged to be a wise solution for ITS. However, it was limited by the need of new protocol and equipment design.

IGCS[16], Intelligent Guiding and Control System based on Wireless Sensor Network Technology showed its merit over few, as it used mobile wireless sensors inside the vehicle, instead of fixed WSN nodes and
was inexpensive set up. But, the response time of the system depended on the speed of network transmission and the operating database performance

Strengths

a) All technologies were based on WSN (WITS, UTOSPF, DRGS, IGCS etc.), utilizing its features like low energy consumption, small size, non-cable and full-road coverage which helped in achieving efficient ITS networking.

b) UTOSPF, Urban Traffic Open Shortest Path First technique used OSPF protocol concepts to make it autonomous, distributed, simple, inexpensive, highly scalable and totally independent of vehicles movement.

c) DRGS, Dynamic Route Guidance System, emerged to be another set up for capturing real time traffic information for route guidance using inexpensive sensors.

d) IGCS, Intelligent Guiding and Control System superseded few techniques, as it used mobile wireless sensors inside the vehicle, instead of fixed WSN nodes and was inexpensive set up.

Weaknesses

a) WITS were limited by the requirement of every vehicle to be equipped with the sensors.

b) UTOSPF was only implemented to find optimal paths, but, this structure could also be used to detect and send various other traffic information.
c) DRGS, was broadcasting if data to all drivers despite of its irrelevance to some.
d) Proposed to combine the WSN and VANET technology to complement each other's limitations was constrained by the need of new protocol and equipment design.
e) In IGCS, response time of the system depended on the speed of network transmission and the operating
database performance.

DISCUSSION

a) Generally, a Wireless Sensor Network set up for Intelligent Transport System, is composed of following subsystems:

- sensing subsystem – road side units, on-board sensors (magnetic, ultrasound, accelerometer, Bluetooth)
- distribution subsystem – intersection units, access units on roads, Traffic information Centers
- Decision making and execution subsystem – data traffic monitoring and control by Master Node and Computer system, TMC.

b) Many architectures were proposed like WITS, UTOSPF, DRGS, IGCS, WSN based ITS along with its prototypes in some, and simulations in others.
c) [Fernando Losilla, et al,2012] stated the key requirement of combining WSN and
VANET, as WSN had their main weakness in the constrained use of scarce available energy which was a minor issue in VANET.
On the contrary, achieving high technology penetration rates in VANETs in order to boost performance was not straightforward, but the installation of WSN nodes on selected roads was a simpler task. A combination of both could enable that power consuming tasks such as dissemination of data rely on VANET nodes meanwhile WSN nodes offer a permanent monitoring of a given location, allowing the system to work properly even if the penetration rate of VANET was low.
d) In this light, [Djamel Djenouri, 2013] have proposed WVSN, wireless vehicular sensor network which seems to be a self- consistent technology.
e) [Hemjit Sawant, et al, 2004] have in turn proposed a system using Bluetooth for inter vehicular communication, for exchange of information like collision detection, congestion detection etc. which was sensed by an inexpensive on-board millimeter wave radar. Though this approach reduced the infrastructure cost directly, it did not consider the challenges of integrating this with the WSN set up.

Findings Of Traffic Monitoring & Control, And Vehicle Collision Avoidance

Four papers were reviewed under this category, which is related to the previous, but focuses on traffic monitoring and control. The common findings could be listed as below:

STRENGTHS

a) Passenger Management System Based on Face Recognition for Intelligent Transport [18]could give 20 times faster than existing technologies. It was enhanced using wireless network giving it remote control features.
b) Intelligent Vehicle Monitoring System using Wireless Communication[17]was a novel approach to ban messaging while driving,
c) Intelligent Transport Management System using wireless sensor networks and dedicated traffic servers could improve and reduce response time for a server to consider the user request and give reply
d) Bluetooth and Sensor Networks for Intelligent Transportation Systems[2] was practically implementable and user friendly. It did not attract more infrastructure cost.
e) Wireless Vehicular Sensor Network technology[3] was proposed to prevent vehicle crashes and avoid frontal collisions. The strength of this solution was that it was based on WVSN which was a combination of WSN and VANET technology. This could complement each other's weaknesses.
f) It could give information of probable collision before 2 seconds when entering in that zone.
g)Several algorithms [5]presented to calculate collision time based on current speed and estimated time intervals and implemented using WSN in ITS, returned faster simulation results.

WEAKNESSES

a) In passenger management using face recognition, remote monitoring was practically irrelevant in dynamic and overcrowded vehicle Using GSM and GPS for traffic rule imposition, like stopping driver to message, was limited by the fact
that it required lot of training to stakeholders, and supporting infrastructure for this application. It could have been more preferred if local mobile jammers were used.
a) ITS using WSN was limited by security and reliability of the network performance.
b) The Bluetooth technique did not consider several issues, such as, communication
efficiency, integration of the vehicle-based ad hoc WSN with road side infrastructure.
c) WVSN This application was limited in its scope of only dealing with frontal collision, and not rear-end or sideways.
d) Design of vehicle collision detection system was specifically designed only for frontal collisions, others were ignored.
e) Proposed algorithms were not practically implemented.
f) Proposed system included entire ITS system for specific application. Other features could be implemented.

DISCUSSION

a) Many approaches were given to control and monitor the traffic which were managing passengers in crowded vehicles

using faster face detection, enforcement of traffic rule to stop messaging while driving,
use of Bluetooth sensor to detect shortest path etc.
b) Various algorithms were defined using best first search algorithm to define shortest path time, and guide the driver to take up congestion free path.
c) The IGCS [16] system set up discussed in above category also proposed to guide the driver in case of congestion and heavy traffic.
d) All the systems and approaches discussed lead to the conclusion that various opportunities could be explored to inbuilt intelligence in transport system.
e)The passenger management system [18]was designed and tested and results could fetch 20 times faster face detection. This could manage public in crowded transport vehicle efficiently. On other hand, using GSM and GPS to detect mobile phone usage was a good approach to improve traffic safety. Other papers which emerged out to be techniques to detect congestion free path found their application in increasing traffic scenario, and the one based on Bluetooth was feasible and practically implementable.
f) For collision avoidance small sensors (magnetic sensor and accelerometer sensor)[3] were used which could replace the infrastructure-based systems in rural and suburban areas, where the deployment of such infrastructure was constrained. It gave an alternative solution for unsophisticated vehicles that were not equipped with aboard computers. It used the WVSN infrastructure for communication.
g) Second approach of designing several algorithms based on overlapping ratio between two collision time intervals, current speed of vehicles, and hybrid of two led to development of a system which could report collision warning to drivers at least two seconds before entering intersection, thus preventing collision. Out of theses proposed algorithms, first algorithm based on overlapping ratio between two collision time intervals was suggested to be most robust, giving minimum number of false warnings.

IV. WSN ARCHITECTURES FOR TRAFFIC MONITORING

Network architecture for ITS applications using WSN technology changes from an application to another, depending on the needs and the cost. Information exchange can be performed either through ad-hoc communication, or using infrastructure, or hybrid. We also distinguish two types of sensors: on-road sensors and onvehicle sensors. The combination of sensor types and communication paradigms gives birth to various wireless sensor network architectures for ITS applications:

Ad-hoc paradigm:

In this paradigm sensors do not have a specific backbone but they exchange and forward collected data in an ad-hoc manner. Node deployment can be classified into:
(i) On road sensor network, where all sensors are implanted shallowly inside the carriage or on poles next to the road. In this case, sensors are static. Sensors communicate in a multi-hop way (without using any infrastructure).
(ii) Vehicular sensor network, where all sensors are included in vehicles. In V2V (vehicle-tovehicle*)* communications, mobile nodes directly communicate to each other without any need of infrastructure [7-10]. Vehicles exchange information helping to avoid severe situations like traffic jam and enhancing drivers' security. Decisions can be taken even locally or cooperatively.
(iii) Hybrid ad-hoc sensor network, which is more robust and combines the two previous deployments. Both on-road and in-vehicle sensors, exchange traffic information to cooperatively take correct and real-time decisions for traffic optimization and driver safety [11, 12].

Infrastructure-enabled monitoring:

In this kind of communications all the above sub classes can be found but in the presence of base stations (BS) that can be also relayed to each other or to servers and Internet through either wireless or wired links. This includes wifi, Wimax, cellular, DSRC [13], and sensors.
(i) On-road sensors with Base Stations [14],
(ii) Vehicular sensors with Base Stations
(iii) Hybrid on-road and on-vehicles sensors withBase Stations. The BS makes decisions and notifies actuators. The BS may also communicate to take global decisions.
4.3 Hybrid ad-hoc and infrastructure-enabled monitoring: In this paradigm, static on-road and mobile onvehicle sensors and devices communicate using available infrastructures (wifi, Wimax, cellular, BS) or using multi-hop ad-hoc communications in the absence of infrastructure. This kind of architecture is the most efficient and takes advantage of all the available architectures.

V. CONCLUSION

It emerged from the review that WSN was a cost effective and compatible technology to in- build intelligence in transport system as it could make ITS autonomous, adapting, efficient and reliant. Wireless Vehicular Sensor Network Technology (WVSN) emerged out as a solution to mitigate weakness of standalone WSN and VANET. Various ITS architectures came up while the different papers were reviewed viz. WITS, UTOSPF, IGCS, DRGC, Bluetooth Technology, etc. All were similar differing in the type of sensors, location of sensor,
and communicating channel. The review of few papers pertaining to the traffic management in ITS, highlighted the enormous scope of WSN inn ITS, may it be passenger management, route guidance, detection of shortest path, detection of traffic jams, imposition of traffic rules, remote access to dynamic vehicles and passengers, collision avoidance and many more. The scope which emerged out during this literature review was the acute requirement of stronger, energy efficient and secure protocol design for WSN. A protocol for the WVSN infrastructure also requires

to be looked into. The limitations of each technology and solution approaches defines a new scope of study, yet to be explored.

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