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Implementation and Comparison of the Improved Traffic Congestion Control Scenario

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Abstract*— *Wireless Sensor Networks can help to mitigate the problem of congestion in cities. Congestion occurs, when the road infrastructure cannot cope with the increased demand for the particular road segment. This paper presents a congestion control system, which uses sensors installed on the road side units to monitor the data and the cars also having the capacity to collect data from the road infrastructure, will report the data to wireless traffic lights. Each wireless traffic light has its own server capable of processing data and broadcasting the information about the alternative route selection and degree of congestion among servers in another traffic zones. Cars equipped with the navigators have the capability to receive feedback from the wireless traffic lights and other cars in other traffic zones in a city and dynamically adjust their routing paths to control congestion.

Keywords*— *Wireless Sensor Network; VANET; Intelligent Transportation Systems; Traffic Zone; Road Side Units; Vehicle to Vehicle communication; Vehicle to Infrastructure communication.

I. INTRODUCTION

1.1Intelligent Transportation System (ITS): Wireless Sensor Networks is an ad-hoc Network . It consists of sensor nodes deployed in physical and environmental conditions. These sensor nodes are deployed in large or thousand numbers and collaborated to form ad hoc network, these networks are capable of sensing the environment means collecting the data, processing the data and reporting data to collection sink (Base Station). Some of the application areas of Wireless Sensor Networks are monitoring, health, military survival, transportation, intelligence; home etc**.** Intelligent Transportation system is the collaboration of various vehicles which communicate to each other to improve road safety and provides the travellers better travelling experience. Vehicular communication is the main technology for addressing problems in ITS due to its capabilities to improve the safety and efficiency through various applications built upon it [10]. Many industries and institutes are putting more emphasis on ITS because of the following reasons: It Includes vehicle to vehicle (V2V) communication so that vehicles can effectively communicate with each other and exchange messages and vehicle to infrastructure (V2I) which carries out communication between vehicles and the road side units (RSUs) by exchanging messages between vehicles and RSUs. Sensing devices installed on the vehicles can used to discover the road condition, pedestrian detection, collision occurrence etc. and can also be used to forward these messages to the RSU, after that RSUs send data to wireless traffic lights (WTLs), which analyse and process data and after processing send the data to RSUs by V2I communication. ITS research and development technologies are based on a high scientific and engineering level: agent-based and vision-based technologies. Traffic monitoring, control, simulation, communication, location-based services, driving safety assistance, etc [16] are some of the application areas of the ITS.

1.2 VANETs: VANET stands for vehicular ad hoc network which is the special case of the MANETs constitute vehicles equipped with advanced wireless communication devices and self controlled networks built up from moving vehicles [2], where vehicles follow a specified path over predefined road infrastructure. VANET is a type of ad hoc WSN where the vehicles communicate without any pre-define. Each vehicle is equipped with advanced communications units to communicate with other vehicles and RSUs with the help of V2V and V2I communication resp. The safety and delay are two crucial aspects in ITS. The safety messages must delivered to each neighbouring node in the network without any delay. Safety messages are divided into two categories: periodic (beacon), event-driven safety messages. The periodic messages are the messages which are delivered to the neighbouring vehicles after a fixed time stamp about the speed and direction of the vehicle and the event driven are the messages which are delivered when a particular event is triggered.

Features of VANETs are given below [7]:
- Wireless clients in a VANET are vehicles and RSUs.
- Movement of vehicular nodes sometimes can be very fast.
- The motion of the vehicular units is also restricted by the road type and infrastructure.

- Vehicular nodes act as a transceiver, which are having the capacity of receiving and transmitting the safety messages at the same time in a highly dynamic environment.
- Vehicular density varies from the time to time depending upon the period.

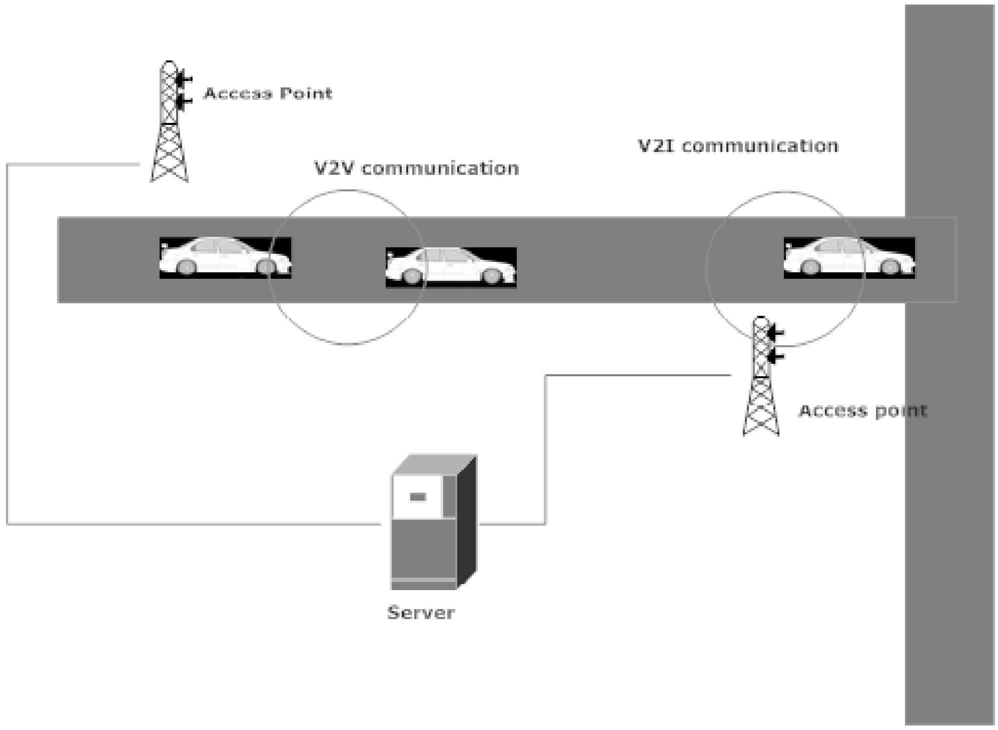

Fig. 1 Communication Architecture of VANET

1.3 Car Congestion: Congestion occurs when the road infrastructure does not cope with the increase demand of the infrastructure. Car congestion generally may occur because of accidents and various unfavourable weather conditions. Traffic delays and congestion are the major source of the inefficiency, fuel consumption, wastage of time and pollutants. So, efficient measures must be taken for the detection and avoidance of the congestion. Car congestion generally occurs during the rush hours of the day. In order to address the congestion problems, the traffic flow in a particular segment has been studied during the rush hours in terms of three main components [2], these components are flow rate, density and velocity. As the congestion occurs, causes the following problems [7]:

- Vehicle queuing causing delay in moving of vehicles and pedestrian.
- Increase in environmental pollution due to the emission of pollutants and unnecessary fuel consumption.
- Increase the time to reach to the destination.
- Reduction in the safety due to various human errors.
- Decrease peace in the residential areas and pollution.

In this section, we presented detailed overview of WSN based intelligent transportation/traffic system. In section 2, we present detailed description of the related works on intelligent traffic system. In section 3, we present the purposed work and in section 4, we have concluded the work.

II. LITERATURE REVIEW

In the literature, many works have been conducted on congestion detection, congestion control and congestion mitigation in WSNs. Vehicles in the running state monitor the data and store the data by using collect and store approach until they are not able to communicate to the wireless gateway or to the server.

WSN have been presented in almost every domain due to their effectiveness and low cost, but still it has to come across certain constraints. WSNs are used in solving the traffic congestion problems, where road infrastructures become slow with the rapid increase in the number of cars on the particular road segment. The traffic control decisions provided by the road infrastructure are efficient, correct and use the route selection based on local areas [5]. Transportation systems have become an essential part of the human life. As people have become more dependent on the transportation system, transportation systems have to face more opportunities and challenges in the real life. So transportation systems must be intelligent enough to make critical decisions. Reference [14] presented the overview of various components of ITSs, their essential features and how these components are contributing to increase the safety and effectiveness of the surface ITSs. This paper has presented the division of the surface ITSs systems into six components namely advanced traffic management system, advanced traveller information system, advanced vehicle control system, advanced public transportation system, commercial vehicle operations, advanced rural transportation system according to their different-different application areas to ensure the road safety. Reference [10] presented the reliability issues in ITSs. Intelligent Transportation system is the collaboration of various vehicles which communicate to each other to improve road safety and provides the travellers better travelling experience and comfort. This paper highlighted the reliability challenges being faced and also described their pre and post analysis in ITSs and their solutions to ensure the reliability. Reference [16] has introduced the various ongoing research projects in the ITSs. This paper also discussed the various applications areas of the ITSs. The main purpose of this paper is to improve the road safety and effectiveness of the road infrastructure, providing better travelling experience to the travellers. The information exchanged during V2V and V2I communication can be bogus or can be compromised due to masquerading, man in middle, DOS attacks [11]. This is a summing up process. Initially data from the individual nodes is collected and their trust level is computed. Similar to individual nodes, data is collected from various nodes and their prior knowledge is being calculated. Bayesian inference is used to determine trust level, when prior knowledge about events is available, whereas Dempster-Shafer theory handles properly high uncertainty about events. Both of these approaches lead to data stability. After the monitoring and aggregation of the data, the next step is used to select the optimum route so that the delay can be minimized and the number of vehicles reached at their destination may be increased will results in the control of the pollution. There are many algorithms like Dijkstra, A-star, D-star, Bellman–ford and many other algorithms which can be used for the shortest path selection so that the cars can reach their destination at time. Reference [2] proposed congestion control algorithm in different congested city scenarios for event-driven safety messages because all the congestion control algorithms are not applicable in case of event driven safety messages. One of the main challenges is the degradation of the communication channel. Some of the congestion control algorithms are not efficient in congestion control mechanisms. Reference [6] presented a mobility model presenting both macroscopic as well as microscopic models for communication based on social network theory. Macroscopic mobility model takes into account the volume, density i.e. the whole network instead of the individual vehicles, based on the social relationship between the various vehicles has been presented. Mobility model creates movement patterns by taking into consideration the social relationship between individual vehicles, social relationship that might change depending on the simulation time. The new mobility model has been presented, allows the vehicular simulator to generate all the information related to the microscopic, as well as the macroscopic levels, with results showing close resemblance to the real world movement of vehicles. Fuzzy based traffic control systems are used as an approach towards the development of the mathematical model to control congestion. The main goal of the controller is to decrease the average delay time in the whole traffic network. The phase sequence and phase length mechanisms are used in decision making processes [13]. Fuzzy logic based approach is also used for the development of the intelligent traffic light, applied to multiple lane intersection in an urban area in order to control congestion in a particular city. The developed controller system is based on the cooperating and distributing mechanisms with the neighbouring intersections, to inform the other TZs about the various traffic conditions and alternative road's selection. Congestion control mechanisms consist of congestion detection and avoidance. Once the congestion has been detected and congestion status of the roads has been determined. The next step is to select the alternate road, so that the vehicles on the congested road may follow the alternate road. A-star algorithm which is commonly used in the transportation industry because of its flexibility it reduces the computational time [15]. A shift register based approach on hardware model, which is more efficient and have less computational complexity than the software model. Due to the continuous increase in the number of the vehicles on a particular road segment, the potential threat and the amount of the accidents have been increased [7]. WSNs are aiming to equipping components to reduce the amount of threats due to the rapid increase in the amount of vehicles and for the demand of the road segments. Reference [12] has presented applications of wireless sensor network towards the development of the effective system to control and maintain efficient traffic flow in a particular traffic zone. VANETs are the mobile network where various vehicular nodes combine together through wireless communication. VANETs are developed for the safety and comfort of the travellers by providing the infrastructure updates to the travellers. WSNs generally perform three main tasks: sensing, aggregation, controlling. Vehicles are used as sensing agents. WTLs are used as an aggregator, which collects the data from all sensing components and aggregates it to reduce network band width. All controlling and computational operations are performed by server. The architectural effective and protocol based effective data aggregation schemes are used[8]. Since data aggregation is very effective technique because it reduces the redundant data by adopting various de-duplication methods. The most important factor in WSNs is the life time of the sensor nodes. Data aggregation helps in increasing life time by aggregating data collecting from the various nodes. Congestion control mechanisms vary in respect of the priorities of various events. The collected information messages have varying priorities. Reference [1] introduced event-driven, measurement-based and MAC blocking based algorithm. This paper has presented the comparative analysis of various congestion control algorithms which are used to mitigate the problem of congestion on the basic of strength and weaknesses. Intelligent wireless traffic lights are used as gateway between the vehicle and the servers which are connected to the traffic lights and used to perform all computational tasks. Reference [5] proposed a solution for congestion control using not only the sensors deployed within the road infrastructure, but the vehicles also collect data. The traffic control decision i.e. the alternative route selection, provided by the RSUs. In this paper the entire city has been divided into the traffic zones and each TZ is provided with intelligent WTL which is connected to the server which helps in taking load balancing and route adjustment decisions. Server maintains the route table which contains three types of information related to each vehicular node 1) known road segment 2) cost associated with each road segment 3) the segment that a vehicle must follow. In this paper cars sense the road infrastructure, pass the information to other vehicles and to the RSUs because the cars pass each other only in a few seconds can't totally rely on the V2V communication so V2I communication is also suggested in this paper. Reference [3] presented a traffic model, where vehicles receive in support information about various traffic conditions in to a traffic model. The data is being collected by the vehicles being transmitted to the WTL, which is connected to the central server which generates decisions regarding dynamic travelling routes adaptation. In this paper degree of congestion has been presented. The degree of congestion may vary between 0 and 255, depending on the load on the particular street segment. 0 represents an empty street, while 255 represents a heavily congested street. The average speed calculation equation of the cars is also given by this model. The data is aggregated and send to WTLs. The data may be malicious and may be attacked by some attackers and may carry false information, so various trust based notions are being used. Reference [4] has highlighted the various effects of the traffic data flows and time delays on the urban environment. This paper has also presented the various simulation based laboratory experiments to determine the traffic throughput to mitigate the traffic congestion in an urban environment.

III. PROPOSED WORK

3.1 Proposed Algorithm:

1 The network is deployed with the finite number of sensor nodes on the roads and with finite number of smart cars and servers.

2 The smart cars can move freely on the road

```
        If (Accident happens between two cars==true)
        {
         (Adjacent smart car. Alternat roadSearch ())
        {
        AlternateroadSearch ()
        {
        A. The one of the best road is selected among all the possible roads.
        B.To select the best path, min and max variant of ACO are used, which are based on the time and distance
        function. The road which is having minimum distance and congestion status is selected as the best path.
         }
        Information flooding about the new road ()
          {
        a. The car which selects the optimal path first, sends the information about the road's congestion status to the
        nearest car and the sensor node and sensor node further sends the information to the nearest server.
        b. The servers of the different roads segments communicate with each other and other cars get information about
        the road from the road side sensors.
        }
Else
{
Performing normal vehicular routine.
}
}
```

3.2 Alternate Road Search Algorithm:

S is the Source Point and D is the Destination Point. The Vehicle node is in a city scenario where roads are rough and traffic is moving on both sides of road. This algorithm will derive the alternate roads search algorithm which will help the vehicles to reach to the destination efficiently.

1. To obtain the shortest path from the source to the destination, divide the city in to N segments, named N1, N2 ……Nn.

2. Select N an intermediate point, such that N is a segment from N1 to Nn and N is in the same direction of destination D.

3. For each segment N1 to Nn, we find the Destination Point in same direction of destination in the city N, named Dm. Find the entire possible paths between source S1 to intermediate destination Dm named P1, P2…Pm.

4. For each path from N1 to Dm, calculate the **congestion status**.

5. Select the path with minimum congestion level and include the series of paths from source to destination to determine the complete path.

6. Finally, we get a search path P1, P2, P3 up to Pn as the efficient and robust path series to move to the Destination.

7. for each path P1 to Pn, Start from Node Si to Di.

Move from Source Node to Destination:

a) Check (if (Node's speed <average speed))

If (Congestion=true)

Find expected delay caused because of Congestion

b) If (Expected Congestion > Threshold Value)

Find the alternate path with cost closer to existing and select this path as the new path.

8. End.

3.3 Alternate road selection flow chart:

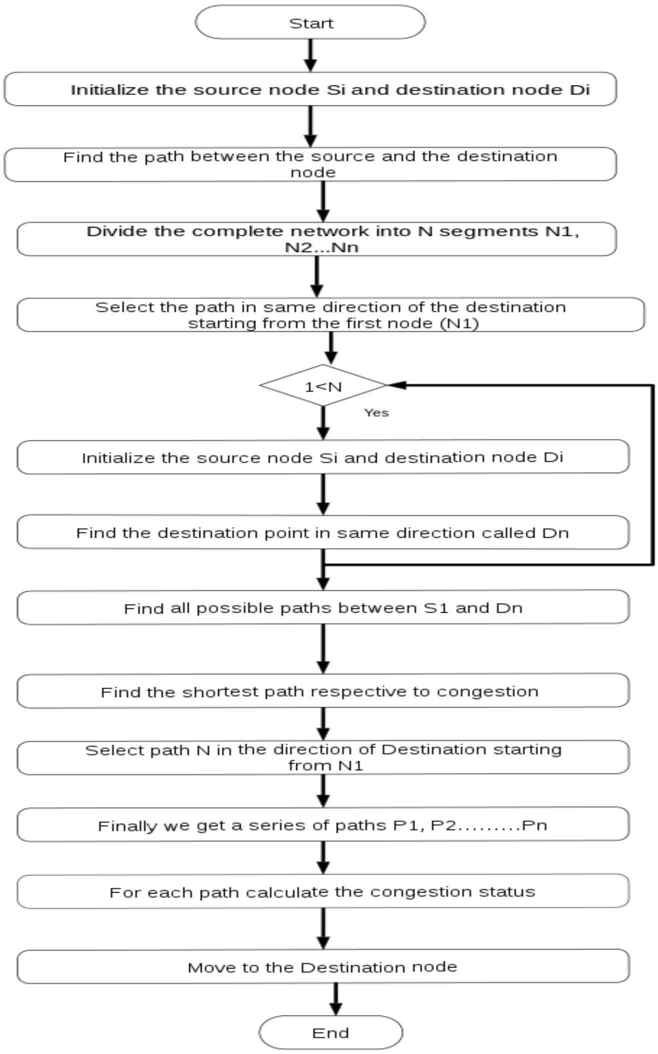

Fig. 2 Alternate road selection flow chart

IV CONCLUSION

In this paper we proposed a traffic system designed to solve traffic congestion problems by collecting traffic data from the road infrastructure, aggregating it into useful information at the wireless traffic lights and providing feedback to cars similar to ideas from networking protocols. It uses cars to collect traffic data from the road infrastructure and several WTLs that are able to aggregate and take decisions as to how to influence the routes the cars are driving. Whenever a road segment starts to provide lower average speeds for vehicles passing through, a routing algorithm provides alternatives routes, less congested and providing better time figures to reach destinations.

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