Implementation and Comparison of the Improved Traffic Congestion Control Scenario

A Dissertation Proposal

Submitted by

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To

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In partial fulfillment of the Requirement for the

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Mr. Mandeep Singh

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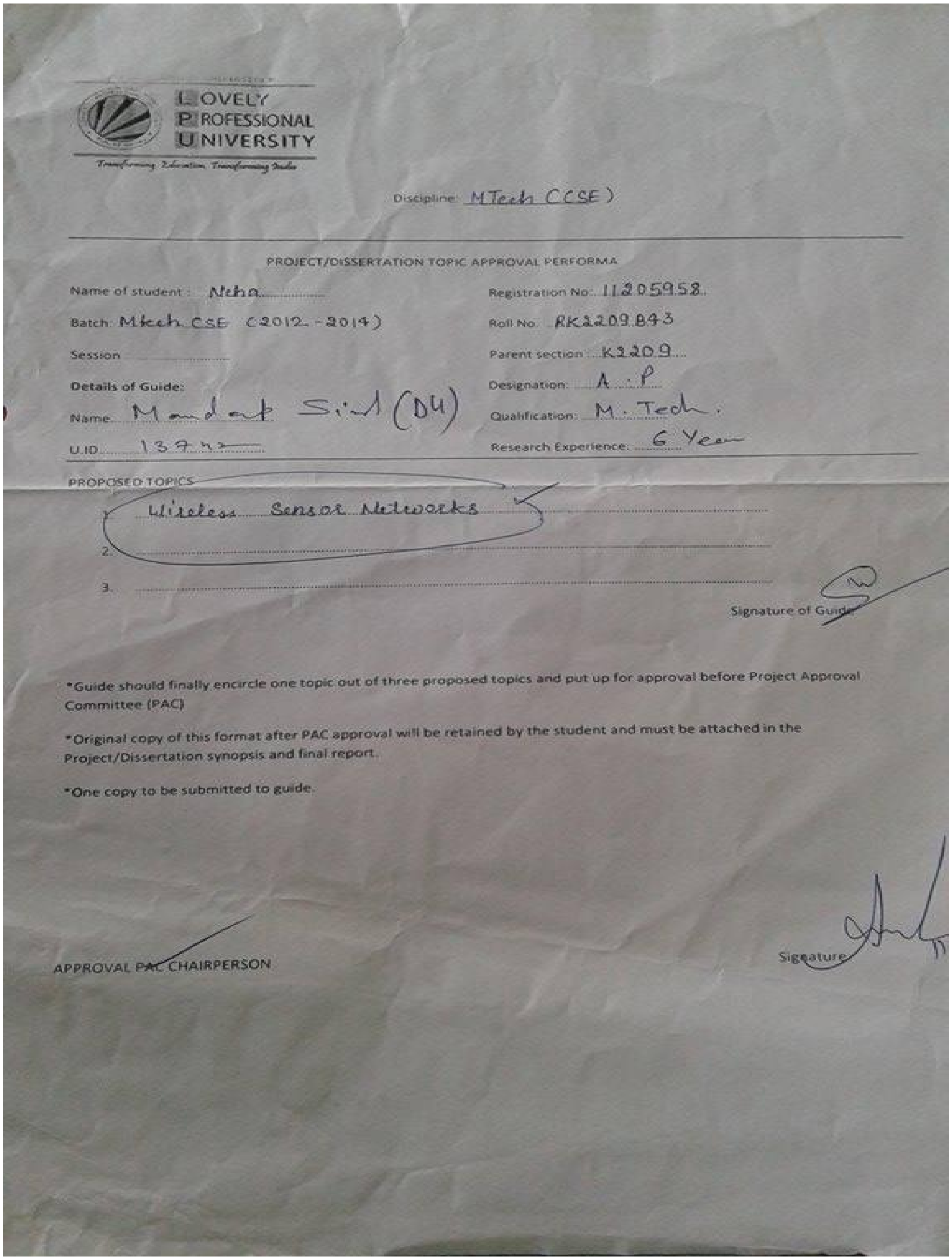
PAC FORM



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ABSTRACT

Wireless Sensor Networks can help to mitigate the problem of congestion in cities. Congestion occurs when the road infrastructure does not handle the increased demand for the particular road segment. We have implemented and compared a traffic congestion control system that attempts to significantly reduce the time consumed by the vehicles in the congested network scenario. This work has been accomplished by V2V communication among the vehicles using bio-inspired based V2V communication based on ant colony optimization, where vehicles behave as a data leader and handover the generated congestion status information to another virtual data leader and rebroadcast the generated traffic congestion status information among the vehicles in the same congested traffic scenario. As a result of the effective V2V communication among the vehicles, by knowing the congestion status of particular road segment the follower vehicles select the alternate road in the direction of the same destination at an initial stage resulting into less congested network scenario.

DECLARATION

I **Neha** hereby declare that the dissertation proposal entitled, **“Implementation and Comparison of the Improved Traffic Congestion Control Scenario”,** submitted for the M.Tech Degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

Date:

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CERTIFICATE

This is to certify that Neha has completed M.Tech dissertation-II proposal titled **"Implementation and Comparison of the Improved Traffic Congestion Control Scenario"**, under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of the dissertation proposal has ever been submitted for any other degree or diploma.

The dissertation proposal is fit for the submission and the partial fulfillment of the conditions for the award of M.Tech in Computer Science & Engineering.

Date:

Signature of Adviser

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I am very fortune to have unconditional support from my family. Lastly, I thank almighty, my parents, brother, sister and friends for their constant encouragement to get my education supported me in all the achievement throughout my life. Above all, I pay my reverence to the almighty God.

Neha

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CHAPTER 1

INTRODUCTION

Technology innovation of engineers during the 20th century has brought a revolutionary change in the human life style. When we fly over the city at sea we see the earth is full of foot prints made by the engineers. One of the industries infrastructures not seen directly in the plan because it is buried in the ground, but it is most complex. Its size is large in our market and it has enabled us to change our life style by entering the information. This industry of renewed information is named as the network communication industry. Communication systems in wireless networks consist of three basic components i.e. the radio signals, network structure and data format. According to basic OSI reference model the radio signals operate in the first layer i.e. the physical layer. The network structure involves network interface adapters and the base stations which are used for sending and receiving the radio signals. In the wireless network all the computers are inter- connected and communicate with each other invisibly, but by emission of electromagnetic energy in the air. The most widely used transmission support is through radio waves.

1.1 WIRELESS SENSOR NETWORKS

WSN is an ad-hoc Network (Maraia, 2011). 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 networks. These sensors are capable of sensing the environment means collecting the data, processing the data and reporting data to collection sink (Base Station). Rapid advancements in wireless communication have enlarged the developments and the deployments of the tiny sensor nodes. The architecture of wireless sensor network is shown in the figure 1.1. The sensor nodes are scattered in the environment. Each sensor node is capable of sensing the data and routing the sensed information back to the base station. Base station communicates to the user through the task manager deployed at the base station. The design of the sensor networks is influenced by the various factors. These factors may include operating environment, production cost, fault tolerance, hardware constraints, scalability, sensor network topologies, power consumption and transmission media (Akyildiz, 2002). The density range of the deployed sensor nodes vary from fewer to the larger sensors depending upon the type of the application. Some of the sensor nodes fail due to power- shortage, physical constraints and environmental constraints. The cost of single sensor node contributes to the cost of whole sensor network. For the deployment of the sensor nodes topology maintenance is mandatory. In WSNs the life-time of the sensor nodes depends on the battery life. The malfunctioning of various sensor nodes cause the topology maintenance and which will further results into power management and conservation. The sensor node performs data aggregation and processing and data transmission.

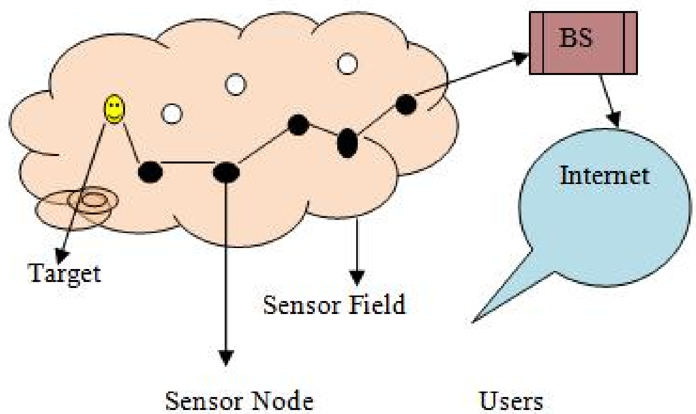

Figure 1.1: Architecture of Wireless Sensor Network (Maraiya, 2011)

A sensor node generally consists of four basic components (Akyildiz, 2002) as shown in Figure 1.2 a sensing unit, a processing unit, a transceiver unit, a power unit and also contains other application oriented components which depend upon the type of the application being used. These all components are composed into a capsule named as node. A sensing unit is also the combination of two components sensor and ADC. Sensor is used to sense the environment and ADC is used to covert analog signal to digital signal because digital signal is much easier to process, contains lesser noise than the analog signal. Processing unit also has two components processor and storage, processor is used for the processing collected data to convert it into useful information and storage unit is used for the storing information so that it can be used in future. There are two main components of WSNs: wireless access point, wireless clients. Wireless access points are the stations which are directly attached to wired network. This component acts as a man in middles in between wired and the wireless world. The access point is installed in way to maximize the coverage area. The second component is the wireless client which provides the network interface. When wireless client enters into the coverage area it gets attached to the access point, if it has the appropriate credential and if it is allowed to access.

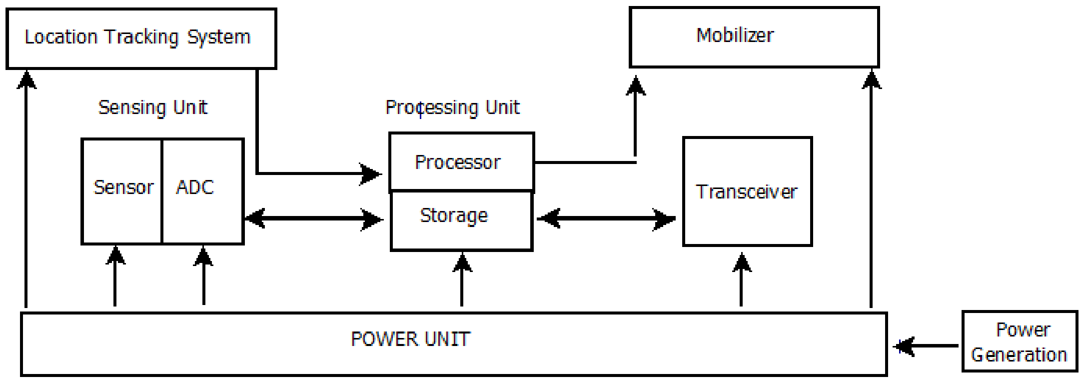

Figure 1.2: The Components of a Sensor Node (Akyildiz, 2002)

The speed of WSNs depends upon the distance, as clients move away from the access points their speed goes down corresponding to compensate the distance. 802.11 define WSNs into two categories: infrastructure type and ad hoc. In infrastructure type the wireless clients are connected to the wired network with the help of the wireless access points. The second type is the ad hoc type where the wireless clients form a network and communicate to each other.

1.1.1 Wireless Communication

Wireless communication is the communication between various points without the help of any wired network. The most common mean of communication is the radio waves. Radio is based on the basic physical law known as Maxwell's equation identified by James Clerk Maxwell. Change in magnetic field produces an electric field. When alternate current passes through the wires or any other physical media, some of the energy escape into the space outside the physical media, which is known as alternate magnetic field. The form of energy produced in the transition between electric and the magnetic is called electromagnetic radiation or the radio waves. So radio wave may be defined as the radiation of electromagnetic waves through the space. The primarily used standards for wireless network communication are the IEEE 802.11 family, Hyper LAN and Bluetooth. Some of the terminologies used in the wireless communication are given below:

1.1.1.1 IEEE 802.11 Family: IEEE developed a family of specifications named 802.11 and 802.11x for wireless LAN (WLAN) technology in the year 1997.

- **802.11**: This standard is applicable to wireless LANs and provides 1 or 2 Mbps transmission in the 2.4 GHz band using either direct sequence spread spectrum (DSSS) or frequency hopping spread spectrum (FHSS).
- **802.11a:** This standard is an extension to 802.11standard and is applicable to wireless LANs providing transmission speed up to 54-Mbps in the 5GHz band. 802.11a standard uses an orthogonal frequency division multiplexing encoding scheme instead of FHSS or DSSS which is used in 802.1 standard.
- **802.11b :** This standard is an extended version of 802.11 that is used for wireless LANs and provides 11 Mbps transmission in the 2.4 GHz band. 802.11b standard uses only DSSS. The data rates 2, 3, 5 and 11 mbps are automatically adaptable to variable signal strength.
- **802.11g:** This standard is applicable to wireless LANs and is used for short distance transmissions up to 54-Mbps in the 2.4 GHz bands.

1.1.1.2 Hiper LAN: Hiper LAN stands for high performance radio LAN. It defines two types of networks: 1 Hiper LAN1 uses 5GHz band and offers a data rate of 10-20 Mbps. 2 Hiper LAN2 uses 5GHz band and offers a data rate up to 54 Mbps. There are different forms of electromagnetic radiations which are characterized by their frequencies. These include infrared radiations, ultra violet light, radio waves, visible light, gamma rays and X rays. All these types of different frequencies of electromagnetic radiations come from the electromagnetic spectrum. Radio frequency increases and approaches to the frequency of light, takes more propagation characteristics of light. Signal usage in wireless LANs ranging from 900MHz to 18 GHz are not limited as happens in case of light signals, but it does not pass through physical barriers as easily as typical radio broadcast band signal 1600 KHz to 100 MHz. Wireless LAN network covers around 10 to 100 meters wide and provides high speed connection between the hosts. Wireless LAN provides the flexibility of moving the computers without being wired to a particular network.

1.1.1.3 LAN Technology Methods: In LAN technology generally two methods are:

- **Infrared LANs:** Diffuse infrared light produced by a light emitting diode (LED) can be used for data communications. At the transmitter end LED converts electric signal into the infrared signal. At receiver end photodiodes attached to LED convert the infrared signals into electrical signals. In this system transmitter and receiver on both sides is called transceivers. Infrared receivers are used to detect the power of optical signals the systems use them are simple in design no frequency conversion and cost effective. All the transmitters and receivers are placed at higher than 2.5 meters to avoid interference. The entire signal at satellite on the ceiling is called a quasi-diffuse transmission. The infrared method uses the on-off keying mechanism to carrier signal. One bit signifies ON and for a zero bit signifies OFF. Multi subcarrier method is used for data stream to be transmitted t divided up into series of fixed length blocks. Frequency shift keying is simply to use of two different frequencies to represent is 1s and 0s. Pulse phase modulation used to position of the impulse in time varies depending on the amplitude of the input signal.

- **Radio Frequency:** Wireless radio frequency in LAN is different in many ways from wired one. In wireless LAN, indoor medium radio frequency has advantage of multi-path effect. According to the multi-path effect the radio signals use different paths and this causes it to spread out in time many copies of the signal will arrive at the receiver slightly shifted in time.
- **Bluetooth:** Bluetooth specifies a 10m radio range and supports up to 7 devices per piconet. Each piconet has its own piconet. The radio frequency is centered at 2.45GHz. Bluetooth recognizes any other device in radio range. It easily supports connectivity-aware applications (B.F. Erasaras).

1.1.1.4 IEEE 802.16: The IEEE 802.16 group for wireless metropolitan area network. The IEEE 802.16 standard defines the wireless MAN (metropolitan area network) air interface specification. Wireless broadband access standard can supply the missing link for the last mile connection in wireless metropolitan area networks. Wireless broadband access is installed like a cellular system using the base station that service a radius of several kilometers. Base station does not necessarily have to reside on a tower. Base station antenna can be located on a rooftop of a tall building. The IEEE802.16 is designed to operate in the 10-66 GHz spectrum and it specifies the physical layer and medium access layer of the air interface BWA systems. At 10-66 GHz range transmission requires line-of-sight (LOS). IEEE 802.16 is working group number 16 of IEEE 802 specializing in point to multipoint broadband wireless access. The IEEE 802.16 working group created a new standard known as Wi-MAX for broadband wireless access at high speed and low cost which is easy to deploy and which provides a scalable solution for extension of fibre-optic backbone. WiMAX base stations can greater wireless coverage about 5 miles with LOS (line of sight) transmission within bandwidth up to 70 Mbps (RoyChaudhary, 2014).

- **IEEE 802.16a:** The IEEE 802.16a standard allows users to get broadband connectivity without the need of direct line of sight with the base station. IEEE 802.16a specifies three air interface specifications and these options provide vendors the opportunity to customize their product for different type of deployments.
- **WiMax:** The idea of WiMax has been taken from 802.16 family. WiMax is a type of wireless system that is specially designed for metropolitan area networks. WiMax supports non-LOS channel, scalability, QOS and high data rates. WiMax offers a metropolitan wide coverage. Wi-Max interoperability for microwave access is currently one of the most attractive technologies in wireless networks. WiMAX is based on RF technology called orthogonal frequency division multiplexing which is very effective means of transferring data when carries of width of 5MHz or greater can be used. Below 5MHz carrier width, current CDMA based 3G systems are compatible to OFDM in terms of performance. Some of the main characteristics of WiMax are Scalable Orthogonal Frequency Division Multiple Accessing, Adaptive Antenna Systems, Adaptive Modulation Coding, Quality of Service, Security, mobility, multi-vendor inter-operatability etc. WiMax provides both line of sight and non- line of sight types of wireless services. In case of non- line of sight a small antenna on user's system connects to the antenna on the tower or on the work station. This is commonly used for lower frequency range from 2GHz to 11 GHz and is quite similar to wifi technologies. In LOS fixed antennas on the base station are in line of sight. LOS supports higher frequency ranges up to 66 GHz.

1.1.2 Wireless Sensor Network Applications

Wireless Sensor Networks are actively used in almost every monitoring system. Some of the major applications of the WSNs are given below:

- **Agriculture:** WSNs are very important in agricultural applications in terms of sensing temperature, humidity, sunlight, radiations, total amount of energy absorption by the plants, precision agriculture, pesticides control, weedicide control, irrigation control etc.
- **Disaster Relief Operations:** Wireless sensors are widely used in disaster relief applications. These applications include detecting and preventing forest fires, pipe leakage detection, radiation leakage, landslide detection, natural disasters detection and warning systems.
- **Smart City:** Wireless sensor deployment is crucial for making a city smart. Wireless sensors are used for detecting atmospheric pollution, noise pollution, parking management systems, traffic control, industrial automation systems, vehicular flow and congestion control systems, parking guidance and parking monitoring systems.
- **Healthcare Monitoring:** WSNs are widely used in the monitoring of patients' activities in homes or hospitals.
- **Intelligent Building:** WSNs are used in the monitoring of building structures, railway tracks, road networks, bridges etc. WSNs are widely used in monitoring the cracks or structural damages in building structures, calculating the strengths of bridges and roads.
- **Biodiversity Mapping:** Wireless sensors are widely used in habitat monitoring of various wildlife animals.
- **Global Positioning Systems:** WSNs are used in various global positioning systems which can be used for object tracking systems, information service systems, passenger forecasting systems, and business processing systems**.**

1.2INTELLIGENT TRANSPORTATION SYSTEM

Intelligent Transportation system is the collaboration of various vehicles which communicate with each other to improve road safety and provides the travelers better traveling experience. Vehicular communication is one of the main technology used for addressing problems in ITS due to its capabilities to improve the safety and efficiency through various applications built upon it (P.Patil, 2012). Many industries and institutes are putting more emphasis on ITS because of the following reasons: It Includes V2V communication so that vehicles can effectively communicate with each other and exchange messages.V2I which carries out communication between vehicles and the road side units by exchanging messages between vehicles and RSUs. Sensing units installed on the vehicles can also used 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 WTLs, which analyze and process data and after processing send the data to RSUs and by V2I communication RSUs send the data to the vehicles. 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 (Y. Xinping, 2012) are some of the application areas of the ITS. ITS is a very wide range of technologies and applications that are used to maintain system's security, reliability and efficiency. ITSs differ in terms of technologies they adopt. Some of the intelligent transportation technologies are car navigations, electronic toll collection, speed detection cameras, bus lane cameras, red light cameras, automatic number plate recognition, traffic control systems and weather information. ITSs can adopt various communication technologies. Short range communication can be performed with the help of 802.11 family protocols, dedicated short range communication standards and wifi protocols. For long range communication global system for mobile applications (GSM) or 3G, WiMax (IEEE 802.16 family) can be used. Sensing technologies may include microchips, RFIDs and intelligent beacon sensing technologies. Intelligent transportation system technologies include electronic toll collection systems, automatic road enforcement and automatic speed surveillance (Qi Luo, 2008). Some of the objectives of the ITSs are to improve the safety, efficiency in the transportation systems and moving steps towards the green environment. ITSs are generally subdivided into six inter-related systems areas (White, 1995):

Three of which are technology oriented:

- Advanced Traffic Management Systems (ATMS)
- Advanced Traveler Information Systems (ATIS)
- Advanced Vehicle Control Systems (AVCS)

Three are applications oriented:

- Advanced Public Transportation Systems (APTS)
- Commercial Vehicle Operations (CVO)
- Advanced Rural Transportation Systems (ARTS)

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 (Pandhar, 2014), 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-defined infrastructure or there is no client or server communication. Each vehicle is equipped with advanced communications units i.e. AUs to communicate with other vehicles and RSUs with the help of V2V and V2I communication resp.

1.3.1 VANET Communication Architecture: The communication architecture of the VANETs is divided mainly into three parts.

- In vehicle communication.
- Vehicle to vehicle communication (V2V) or inter vehicle communication.
- Vehicle to infrastructure communication.

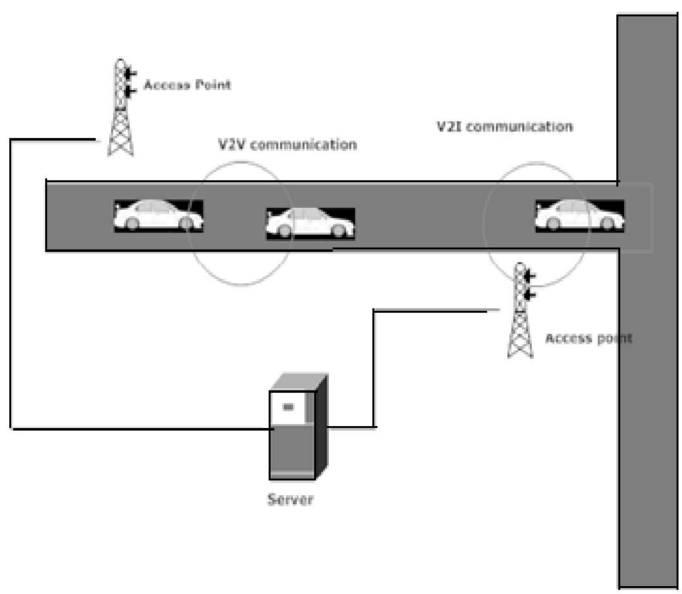

Figure 1.3: Communication Architecture of VANETs

- **In Vehicle Communication:** In vehicle communication consists of the communication between the application units (AUs) and the sensors installed in the different parts of the vehicles. In vehicle communication is used for various applications like in comfort applications, entertainment applications and various alerts– warnings applications.
- **Vehicle to Vehicle (V2V) Communication:** Vehicle to vehicle communication includes the communication between the various vehicles interconnected by wifi connectivity using 802.11 family standards. This communication may include the information regarding speed, path, congestion status, road's status etc.
- **Vehicle to Infrastructure (V2I) Communication:** V2I communication includes the communication between the vehicles and the road side units (RSUs) interconnected by wireless technologies. Road side units may include sensors deployed on roads and on the WTLs.

The safety and delay are two crucial aspects in ITS and in VANETS. The safety messages must delivered to each neighboring node in the network without any delay. Basically, we divide safety applications in two categories: periodic (beacon), event-driven safety messages. The periodic messages are the messages which are delivered to the neighboring 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. The sensed data and the communication messages must be secure. This data can be attacked or altered by the intruders. These attacks may include denial of services (DOS) attacks, bogus information, masquerading attacks, cheating with sensor information. Some of features of VANETs are given below (khaimar, 2010).

- 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.

- Vehicles have unlimited transmission power because a large amount of information is being sensed, processed and transmitted by the vehicular unit.

1.4 CAR CONGESTION

Congestion occurs when the road infrastructure cannot cope with the increased demand of the infrastructure. Car congestion generally occurs because of accidents and various unfavorable weather conditions. Traffic delays and congestion are the major source of the inefficiency, fuel consumption, wastage of time and pollutants. Car congestion generally occurs during the rush hours of the day when the road infrastructure cannot meet the increase in road infrastructure. In order to address the congestion problems, the traffic flow in a particular road segment has been studied during the rush hours in terms of three main components (Darus, 2011), these components are flow rate, density and velocity. As the congestion occurs, it causes the following problems (S.Woo-Jin, 2009):

- 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.
- Vehicle queuing causing delay in moving of vehicles and pedestrian.

1.4.1 Traffic Control System: Traffic control system is the collaboration of the cars having sensors installed on them for environmental sensing, WTLs acting as access points used for data aggregation from various cars and connected to a centralized server either through wired or wireless connections. The cars and WTLs are connected to each other through wifi connections and severs in each segment are connected through the WiMax connections. To support effective traffic optimization the traffic systems implement the three main phases namely traffic monitoring, data aggregation and traffic system development, traffic controlling using data feedback technique and effective route adaptation techniques. The cars are supposed to receive the information related to a limited area in the network. To support the traffic optimization the servers do not send the information related to all road segments.

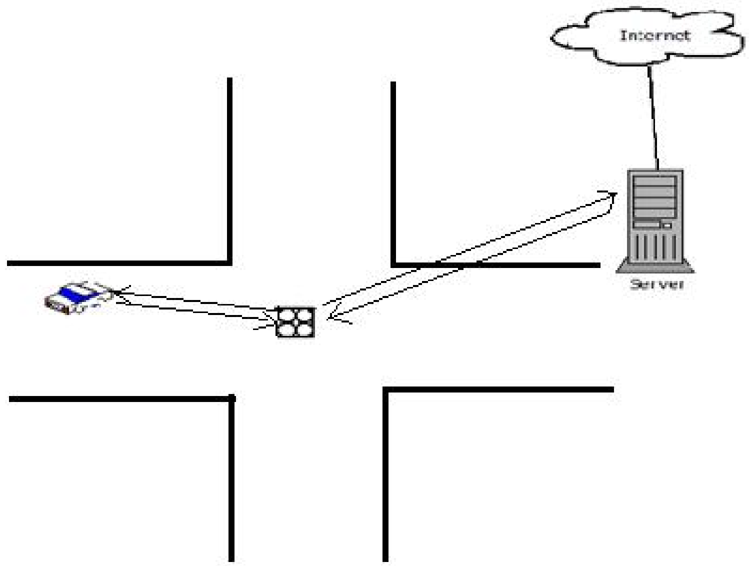

Figure 1.4: Entities interaction within the System (Dobre, 2012)

The servers compute the traffic information related to all road segments but send the information related to road segments having congestion status above than a predefined threshold value. In the cars are not able to communicate directly to the WTLs through the Wifi communications. They can pass the information to the WTLs by using high speed WiMax or 3G techniques, but this will increase the network cost. So collect-store-deliver approach can be used. The cars store the collected data in the local memory until they are not able to transmit the data to the WTLs. The collected data may be compromised or may be attacked by the intruders so various trust based notation can be used to maintain the data integrity. In order to optimize the communication overhead and cost, the servers do not send the information of all road segments. The servers send only the information of those road segments whose congestion status exceeds the predefined threshold value. Traffic model is represented by a directed weighted graph, where road-segments represent edges and the intersections represent the nodes. Each road segment contains the weight that is the cost associated with that road segment. The cost is defined in terms of the time taken to cross that particular road segment.

Congestion status of the road segments can be calculated using the following traffic model:

Congestion status (CS) = $255*(1- v_m/v_{max})$, $v_m <= V_{max}$………………..(1)(Dobre, 2012)

$0, v_m > v_{max}$

The value of CS varies between 0 and 255. 0 represents no congestion and 255 represents high congestion level. Here v_m is the average velocity of the road segment and v_{max} is the maximum velocity of the road segment. The average speed computation formula is given below:

$v_m = v_{cruise} * (1 - n_r/n_{max} * f_{min}/f)$……………………………………..…(2) (Dobre, 2012)

In the above equation v_m represents the average car velocity and v_{cruise} is the cruising velocity between the consecutive stops. n_r is the number of the red light cycles. If the car crosses the intersection without any stop on the intersection then the value of $n_r = 0$ and v_m has the maximum velocity i.e. v_{cruise}. Otherwise f and n work simultaneously. f is frequency of the cars passing through a particular road segment and f_{min} is the minimum frequency of the cars passing a particular road segment. In this system the central server is used to manage the data related to the whole network scenario which may become bottleneck and may lead to single point failure. The idea of above traffic system has been expanded to the decentralized approach, where the whole network has been divided into the traffic zones (TZ). Each traffic zone is under the control of a separate server. These servers are responsible for load balancing by sending different traffic updates related to different traffic zones to different cars.

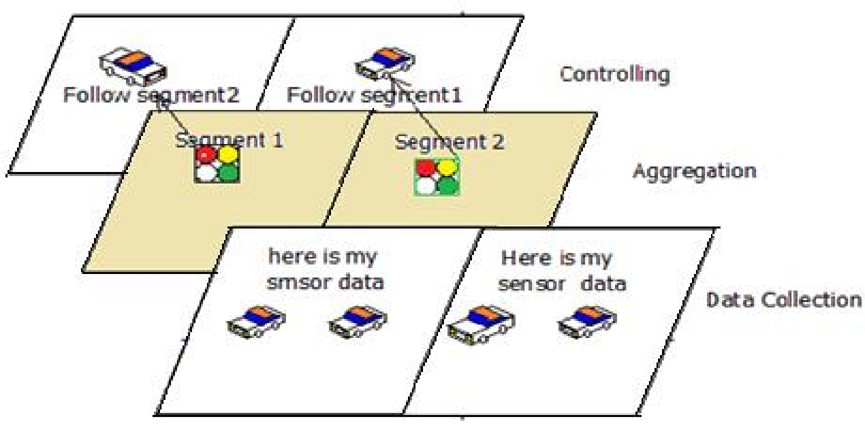

Figure 1.5: Traffic System Architecture (Fratila, 2012)

Each server feedbacks only the local traffic update to the cars to instruct them how to get into next traffic zone. This approach provides computational scalability. Each server is responsible for monitoring only local area, aggregating data and generating traffic model only for a particular traffic zone. The advantage of communication is in terms of reduced traffic data processing and scalability at the server.

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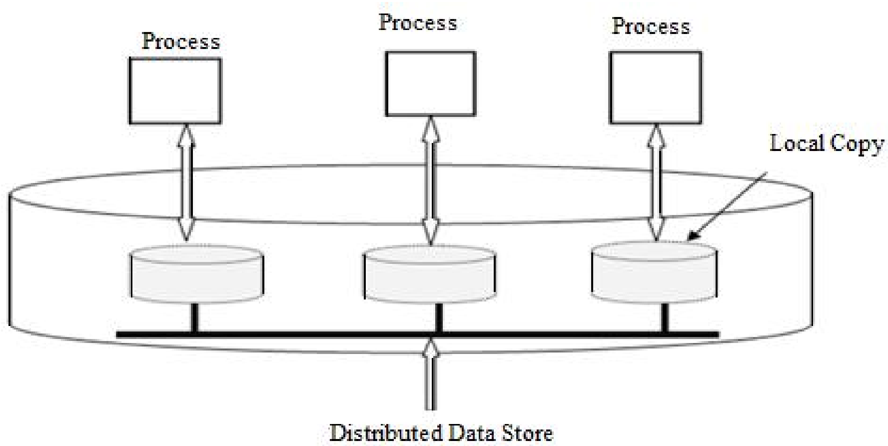

Figure 1.6: Architecture of Distributed Data Systems

The biggest issue with the decentralized based traffic approach is the load balancing. The servers used in decentralized manner should be efficiently replicated and should be updated. In order to balance the load various replication techniques have been employed to achieve scalability and information availability. Data replication is the most used technique in distributed and decentralized systems. Various optimistic replication techniques are used to achieve high availability and scalability

1.4.2 Optimal Path Selection: With the help of the collected data from the road infrastructure, AUs installed on the cars are capable of finding the optimal route for their vehicles and can inform the nearby vehicles about their optimal path selection and can adjust their paths towards the optimal route. Various search algorithms like A-star, D-star, Bellman-ford for shortest path selection can be used. Ant based approaches can also be used. In this work Ant based approach using min-max variants have been suggested.

1.4.3 ACO Bio Inspired Approach: Ant communication is performed with the help of chemical called pheromones. Ants lay down pheromones along the path they move and communicate with the other ants in the network. Other ants in the network sense the pheromone concentration in the network and follow the path with the highest pheromone concentration. Pheromone trails starts evaporate with the passage of time, thus lose its attraction power. As more ants keep following the same path, the pheromone concentrations keep increasing because ants lay down pheromone on the same path. As shorter is the path higher will be the pheromone concentration.

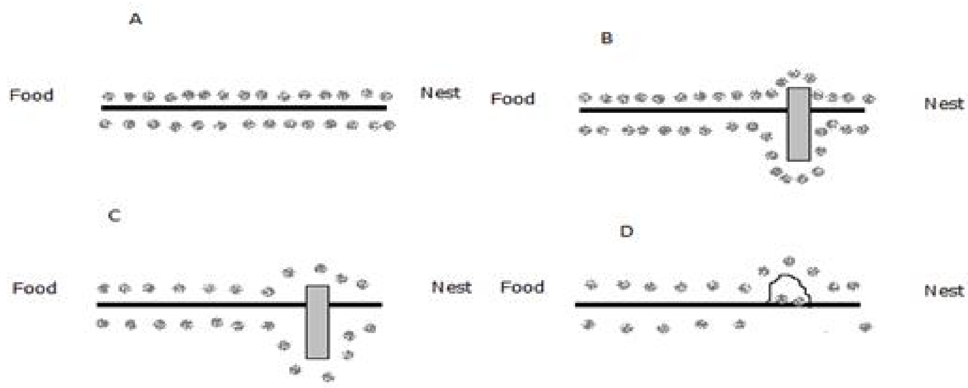

Figure 1.7: Ant Behaviour (Singh, 2013)

Consider the above scenario as in figure 1.7, in case A, ants are in the pheromone trail between nest and food. In case B, an obstacle interrupts the trail. In case C, ants search two alternate paths to go around the obstacle, as compared to other sides in case D ants form a new pheromone trail along the shortest path. If no evaporation has occurred, the pheromone concentration will be higher towards the path chosen by the first ant. This path would be highly attractive to other ants. If an ant finds a good path from food to nest or from nest to food then other ants follow that path and positive feedback eventually encourages all the ants follow a single path. ACO is an optimization technique used to accelerate the algorithmic processes. Similarly in the wireless sensor networks, ACO is basically used to optimize the communication processes. This approach is used by the sensor nodes to find the optimized path over the network. Ants lay down the pheromones on the travelled path, so follower nodes can follow these pheromone trails to communicate on this optimized path. Number of times ants travel down the same path and back again and evaporate the pheromones more time. A shorter path gets marched over faster and thus the pheromone density remains high as it is laid on the path as fast as it can evaporate. The ACO has attracted the attention of large number of researchers and a number of applications are using this concept. Stigmergy is the communication method in which different systems communicate with one another by modifying their local environment in which they are coordinating. Two main characteristics of stigmergy that differentiate it from other communication methods are:

- Stigmergy is an indirect, non-symbolic form of communication mediated by the environment. All nodes exchange information by modifying the environment.
- Stigmergy information is local, only visited nodes have the access to the information.

Some properties of algorithms used in the ant colony optimization are given below (Gunes, 2002):

- **Dynamic Topology:** This property is responsible for the ill performance in various routing algorithms. But in the case of ant colony optimization, meta-heuristic is based on agent systems and work with the individual ants. It provides high adaptation to the current topology of the network.
- **Local Work:** The ant colony algorithm uses the meta-heuristic approach which is based on the local information.
- **Link Quality:** It is possible to integrate the connection and link quality into the concentration of pheromone especially into the evaporation process. It will improve the decision process with respect to the link quality.
- **Multi-Path Support:** Each node has routing table with entries for all its neighbours with pheromone concentration. The decision rule selects the next node in based on the pheromone concentration on the current node.

1.4.4 Ant Colony Routing Algorithm: In the ant colony optimization meta-heuristic for mobile ad-hoc networks and describes the ant colony algorithm (Singh, 2013). It can be constructed into three phases.

- **Route Discovery Phase:** In this phase route is discovered. For the creation of new routes the use of forward and backward ANT is required. In this process, FANT works as an agent which establishes the pheromone track to the source node from the destination node. Similarly BANT constructs a track to the destination node. FANT process has small packets with unique sequence numbers. All the nodes have the capability to distinguish duplicate packets on the basis of the sequence number and the source address of the FANT. Forward ant is broadcasted by the sender and will be relayed by all the neighbours of the sender. For first time when a node receives a FANT, it creates a record in the routing table maintained in each node. The routing table maintains the information regarding destination address, next hop, and pheromone value. The node interprets the source address of the FANT as destination address, the address of the previous node as the next hop and computes the pheromone value depending on the number of hops the FANT needed to reach the node.

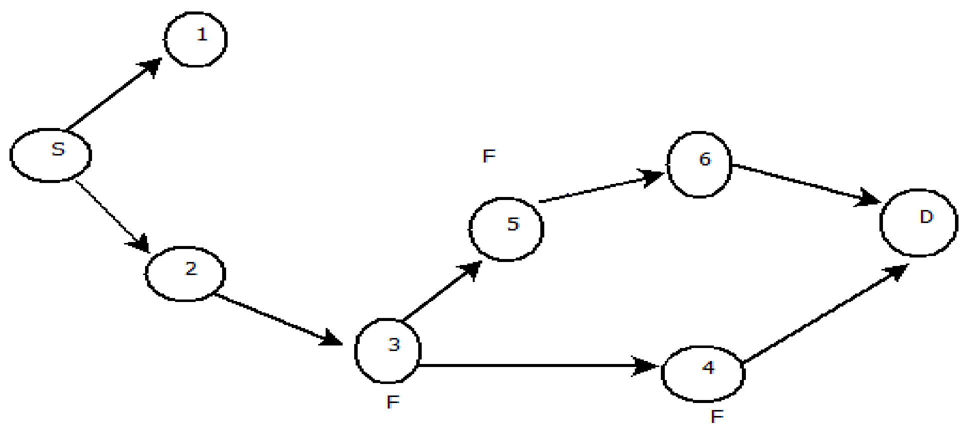

Figure 1.8: Route Discovery Phase ants send from source(S) to destination (D). It initializes their routing table on the basis of pheromone values (Gunes, 2002)

- **Route Maintenance Phase:** The second phase of ant colony routing algorithm is called a route maintenance phase, which is responsible for improvement in the route communication. Once the FANT and BANT establish the pheromone tracks for the source and destination nodes, subsequent data packets are used to maintain the path.

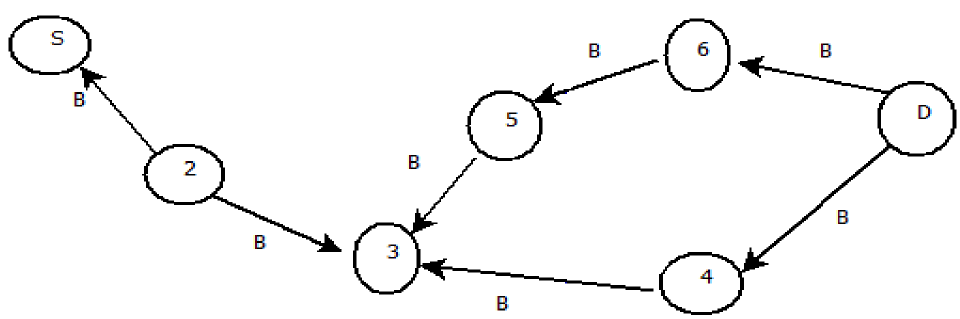

Figure 1.9: Route Discovery Phase the backward ant (B) do same task in the backward ant. It is send by the destination node toward the source node (Gunes, 2002)

In this case when the FANT reaches to the destination, it is processed in a special way. The destination extracts the information of FANT and destroys it. It also creates BANT and sends it to the source node. The BANT performs the same track establishment task as FANT establish a track to this node. When the sender receives the BANT from the destination node the path is established and data packets can be sent.

- **Route Failure Handling:** In the third step, ARA handles routing failure caused due to node mobility and is very common in mobile ad-hoc networks. ARA recognizes a route failure through a missing acknowledgement. Some times when a node gets a route error message for a certain link, first deactivates link by setting the pheromone value to 0. After this the node searches the alternative nodes from the routing table. If any path exists, it sends the packet via this path. Otherwise the node informs all its neighbours, assuming that they can relay the packet.

In VANETs many challenges occur in order to broadcast information in the whole network. The broadcasting with carrier sense multiple access with collision avoidance (CSMA/CA) mechanism present in the 802.11 p protocol standard has become fatal, because this protocol standard lacks acknowledgement. In order to cope with highly dense network scenario, various suppression techniques are used to reduce end to end delay. In order to acquire the high data decimation rates and to reduce end to end delay the farthest vehicle in the communication range becomes the rebroadcast candidate. In case of dense network scenarios, the vehicles have a large number of opportunities to connect to each other. In case of effective propagation of the data message, the vehicles must decide which action to perform. The actions include receiving, storing and forwarding of the data message. The final decision taken by the vehicles depend upon the amount of the knowledge stored by the vehicles. For example a vehicle must exploit the knowledge of its neighbourhood. The vehicle must be aware of the knowledge of the data message being carried by its neighbours. After exploiting the knowledge of the data being carried by the vehicles, the vehicles must calculate its interest in that knowledge regarding the geo-graphical co-ordinates of the vehicle.

1.5 ORGANIZATION OF THESIS

This thesis work is organized into chapters which include specific information. The organization of chapters is given below:

Chapter 2 illustrates the literature review related to the WSNs, ITS and various congestion detection and avoidance techniques.

Chapter 3 describes the present work which consists of problem formulation, research hypothesis, objectives and research methodology.

Chapter 4 starts with the introduction of the tools used in this thesis work and ends with the implementation and results analysis of the thesis.

Chapter 5 discusses the conclusion and future scope of the research work done.

CHAPTER 2

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–store-deliver approach until they are not able to communicate to the wireless gateway or to the server.

Chelsea C.White et. al.(1995) presented the overview of various ITSs components, their essential features and how these components are contributing to increase the safety and effectiveness of the surface ITSs. This paper has suggested the efficient ways to reduce the congestion problem caused by the rapid demand of the multi-lane infrastructure. This paper has presented the division of the surface ITSs systems into six components according to their different -different application areas to ensure the road safety.

Ian F.Akyildiz et. al.(2002) has presented the various research issues, interests and developments in the field of WSNs. This article has also presented the different application areas of WSNs and various technical issues the researchers are finding in this area of WSNs. This paper has also presented the basic architecture, protocols of the WSNs.

Maxim Raya et. al.(2008) has shown the notion of the data trust. This paper has proposed a framework for trust establishment. 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 by various nodes and their prior knowledge is being calculated. In this paper, 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 on time.

A.Gainaru et. al.(2009) presented a mobility model for both macroscopic as well as microscopic models for communications based on social network theory. In this paper macroscopic mobility model has been presented which 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. The 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 vehicle simulator to generate all the information related to the microscopic and the macroscopic levels, with results showing close resemblance to the real world movement of vehicles.

Azura Che Soh et. al.(2009) has presented a fuzzy based traffic control system that controls traffic in a multiple lane infrastructure in an urban city environment. The phase sequence and phase length mechanisms are used in decision making processes. This paper has presented the fuzzy logic based approach on the development of the intelligent traffic light, applied to multiple lane intersections 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 neighboring intersections, to inform the other TZs about the various traffic conditions and alternative road's selection.

Woo-Jin Seo et. al.(2009) presented the A-star algorithm which is commonly used in the transportation industry because of its flexibility it reduces the computational time. This paper proposed a shift register based on hardware model, which is more efficient and have less computational complexity than the software model. In this paper the author has presented shift registers which comprise of a group of flip flops having their input and output terminals are connected in a linear fashion.

Vaishali D.Khaimar et. al.(2010) presented the number of the vehicles that have increased on a particular road segment. 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. 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.

Abhijit Sharma et. al.(2011) 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. This paper has presented its applications in various areas for example Traffic Signal Control, City Traffic Congestion Control, Urban Traffic Control System, Safe Driving and Parking Assistance. VANETs are the mobile network where various vehicular nodes combine together through wireless communication. VANETs are developed for the safety and comfort of the travelers by providing the infrastructure updates to the travelers.

Kiran et. al.(2011) has presented the architectural based effective data aggregation scheme and also discussed protocol based network architecture. 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.

Mohamad Yusof Darusol (2011) presented congestion control algorithm in VANETs. In this paper author also has discussed the equal priority of the various event driven safety messages. This paper exposed the various existing congestion control algorithms used to solve the problem of congestion. 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.

Cafalin Fratila el. al. (2012) proposed a solution for congestion control using not only the sensors deployed within the road infrastructure, but also the vehicles can 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.

Ciprian et. al.(2012) 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 is calculated in the range of 0 to 255. 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.

Prithviraj Patil (2012) 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 travelers better traveling 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. The author has divided the paper into three sections. First section describes various safety and awareness applications. Second section has describes various issues in reliable communication. Third section describes various issues in validation and verification of various distributed applications.

Yan Xinping et. al.(2012) has summarized the history of ITSs. This paper also 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 traveling experience to the travelers.

Halit Eren et. al.(2013) 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. This paper has also presented a supervisor control and data acquisition system which integrates mathematical traffic flow control model, traffic light cycle determination, and programmable logic controller. Mathematical Traffic flow model is implemented using the determination of flow rate, density and the average velocity of the vehicles on the particular road segment. Cycle length at each intersection is calculated by determining each vehicle’s distance from the intersection and by determining vehicular flow on each road segment. Programmable logic controllers are developed by determining various theoretical requirements of the vehicles.

Mohamad Yusof Darusl et. al.(2013) 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 for the degradation of the communication channel. Some of the congestion control algorithms are not efficient in congestion control mechanisms. This paper has presented an efficient congestion control algorithm to improve the reliability of the communication channel.

CHAPTER 3

PRESENT WORK

3.1 PROBLEM FORMULATION

The whole scenario defines the congestion problem occurred due to the message propagation delay in the VANETs. Sometimes any event happens on the road causing the jamming of the road infrastructure, so that all the vehicles have to wait for the wireless traffic light decision about the optimal road selection. In this scenario, migration of the infrastructure based wireless traffic light to the infrastructure-less virtual wireless traffic lights based on the self-organizing bio-inspired network has been proposed. Using efficient V2V communication capabilities of the modern vehicles with the help of DSRC, proposed traffic control approach can be ubiquitously adopted. In this proposed self-organizing V2V communication approach, vehicles have the capability to communicate with each other and determine effective congestion control decisions by exchanging the information like congestion status, velocity, positions of the vehicles. The proposed technique operates in a decentralized manner without the help of any central control system under the assumptions that each vehicle has its own decision making capability about the effective route selection, congestion status determination and broadcasts the congestion status, velocity and position information to the vehicle following the same route. In the proposed work, efficient data propagation technique has been proposed which are inspired by ant colony optimization, where vehicles serve as traffic lights, virtually perform traffic light functions, take part in the vehicular data leader selection process, traffic light message generation, handover the traffic light information to the other vehicles following the same route, so that effective congestion control decisions can be taken at earlier stages. The efficient data propagation scheme is based on the following assumptions:

- All vehicles are equipped with the same geographical position system.
- All vehicles are equipped same mobility analyzer to keep track of the mobility of the other vehicles.
- All vehicles are equipped with DSRC radios.
- All vehicles have the capability of V2V and V2I communication.
- The effect of non-LOS has not considered.

- Each vehicle has the capability of congestion status calculation.
- The intersectional control starts with the leading vehicle at the intersection.
- Each vehicle gets its unique id when it enters the vehicular network.
- When there is conflict between the selections of leading vehicle the leading vehicle is selected based on their unique id.
- Vehicle entering first gets the first sequence number vehicle entering second gets the second sequence number and so on.

3.1.1 Scope of Study

In the vehicular ad-hoc network to number of vehicles communicate with each other and also communicate with the infrastructure side around the road. Due to this proposed system, the congestion delay problem has been mitigated to a certain level. On the other side number of servers are placed on the side of roads, where information is updated time to time with the help of distributed system replication and data consistency are maintained in all the servers, so congestion occurrence does not block the whole road-infrastructure, but changes the traffic to alternative road-segments.

3.2 OBJECTIVES

In this present research work, following research objectives are defined.

- Vehicular network and deployment of the vehicles on the road infrastructure.
- Specification of the vehicle to vehicle and vehicle to infrastructure communication parameters.
- Vehicular Ad hoc Network Formulation.
- Existing environment formulation and output generations.
- Proposed environment formulation and output generations.
- Result analysis and comparison of the existing and the proposed environments performance on the basis of number of vehicles in the network at the end of simulation and end to end delay.

3.3 RESEARCH METHODOLOGY

In this proposed work we have defined the network with a new intelligent algorithm to perform the vehicle to vehicle communication. In this proposed work, vehicular leader will inform the follower vehicles about congestion status so that they can perform the decision regarding the route change at an earlier stage. The intelligent bio inspired based algorithm is suggested in this work. The data message is propagated to the follower vehicles regarding the congestion status of the road segment. So that the vehicles identify the alternate route at an early stage, result into the less congested network scenario.

3.3.1 Formulation of Hypothesis: The research hypothesis defines the research questions with respective to which the research is carried on. These research questions are presented to achieve the research objectives related to the present work. Some research questions are defined in this work also. Some of these research questions are given as under:

- What parameters will be taken to define the intelligent vehicles?
- Which network scenario will be implemented to simulate the present work?
- Will the presented bio inspired algorithm improve the network reliability?

3.3.2 Research Design: Software development for vehicular networks is quite tough process because of the highly dynamic, high data rates, high transmission power generated because of the mobile nodes causing end to end delay. In order to reduce the complexity of the scenario and reduction in the number of system failures, simulation is very much important before any actual implementation of the scenario. Moreover, simulations are dynamic, cheap and flexible and make it feasible to analyze the single parameter variations. The simulation's results reliability is directly proportional to the actualization of the simulation's parameters and the correctness of the models used in the scenario simulation. In the mobility model which of mobility models used in network simulation for synthetic models and traces. Traces are real-time system's mobile structures, which depend upon the number of parameters used in the simulation. More the number of the parameters used more will be system's accuracy. Traces help in the easy creation and representation of ad hoc networks. The rules that describe the node's movements can vary according to the model we use to simulate the environment. As road segments are connected at some intersection point in the urban city. The traffic lights can be programmed statically or dynamically at the intersection to control the traffic and to avoid hazards over the network. Such network can be multi-lane depending upon the network infrastructure. To perform the required procedure vehicles need to capable with following features:

- Vehicles pass the higher priority congestion status information to its follower vehicles.
- It will pass the information regarding the distance from the congestion event's location.
- It has to define the lane change information if lane is already changed by the vehicles.
- It has to pass the velocity and position information to the follower vehicles.
- The whole research design has been presented with the help of the flow chart represented below:

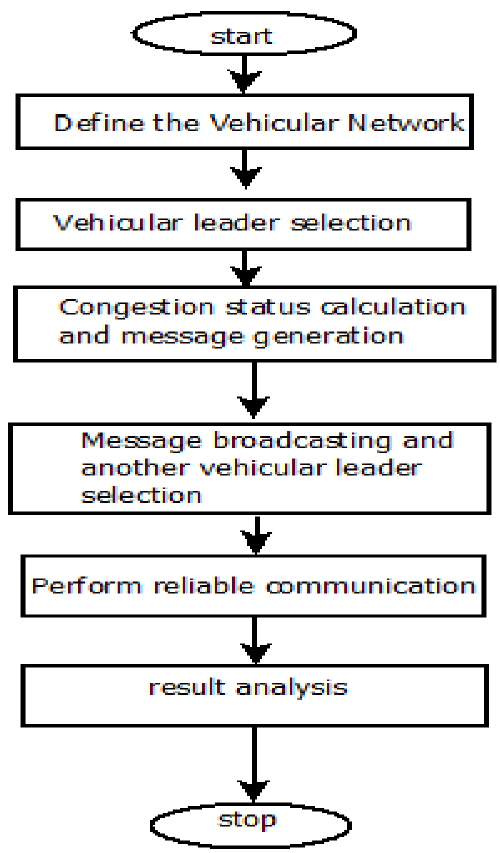

Figure 3.1: Flow Graph of the Proposed Research Design

3.3.3 The Proposed Algorithm: The proposed algorithm has been divided into four phases namely network creation, Vehicular leader selection, data message generation, Vehicular information handover candidate selection.

Step1: Is the leading vehicle =true

Step2: If the congestion status calculated by the leading vehicle is greater than threshold value

{

Formula to Calculate the Congestion Status:

Congestion Status calculated by each car = {

$255 * (1-V_m/V_{max})* imp$, if $V_m <= V_{max}$

0, if $V_m > V_{max}$

}

V_m is calculated by the following formula

$V_m = V_{cruise} (1- (n_r/ n_{max}) *(f_{min}/f))$

The parameters used here are:

V_m=average travelling speed of that car on the road segment

V_{max}= maximum allowed travelling speed on the road segment

V_{cruise} = average cruising speed between two consecutive stops at red light or until the car crosses the intersection

N_r= number of red light cycles that the vehicle waited on

N_{max} = maximum number of red light cycles

F_{min}= minimum frequency cars can pass by an intersection

Imp = the impatient factor of the driver

(i) Then generate data-message(vehicle-id, message-id, vehicle's geographical-coordinates, time-stamp, events-geographical-coordinates, priority list).

(ii) Send the data message to the farthest vehicle in the same directional sector (following the same lane).

(iii) Timestamp allocation of data message for the leading vehicle and send the data message to the rest of vehicles in the communication range.

(iv) Repeat the above steps until the message has been propagated in the whole network.

}

Step 3: else

{

Generate the beacon (Vehicle Id, message-Id, vehicle's geographical co-ordinates, message-list).

}

Step 4: Calculate the data propagation time taken in location based as well as in density based approach.

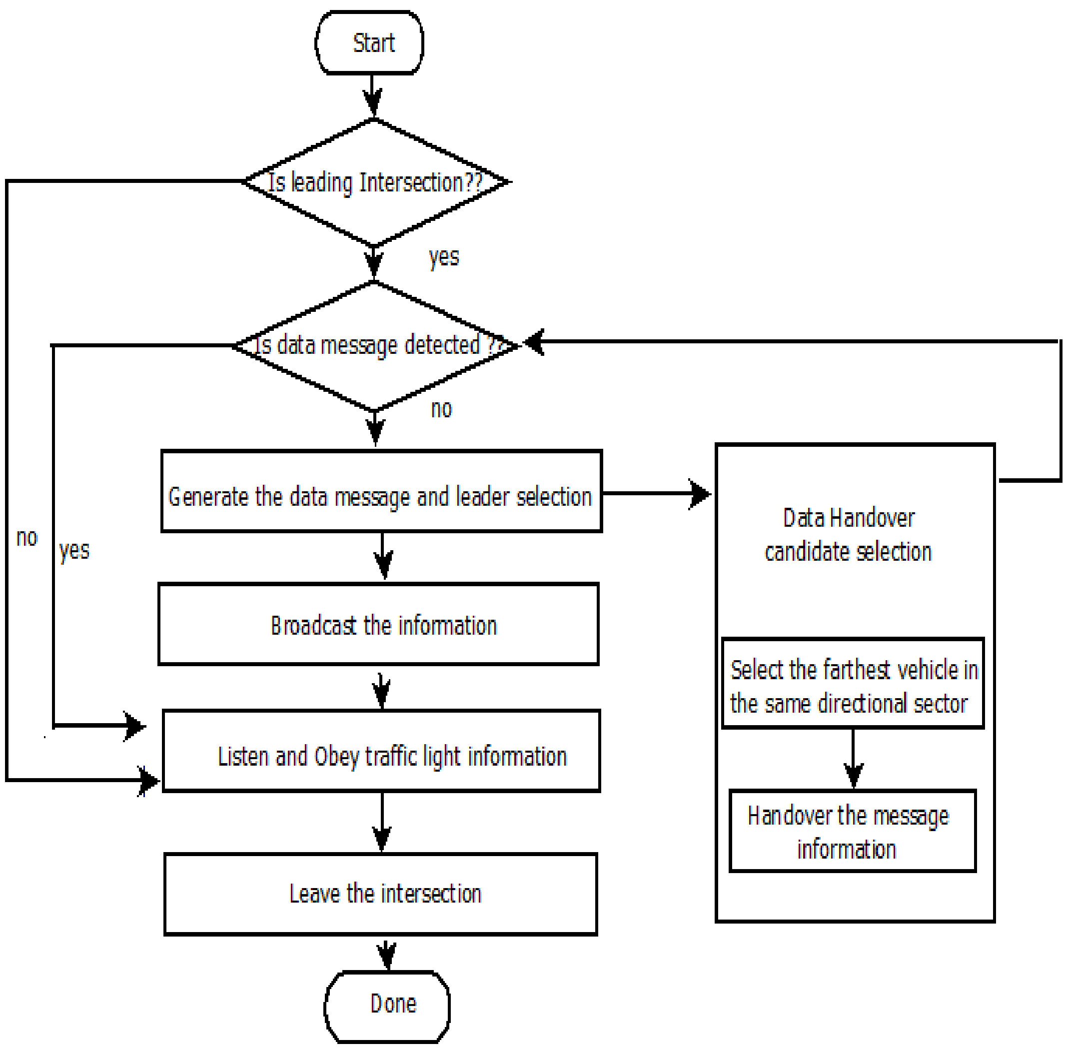

Figure 3.2: Flow Graph of the Proposed Message Propagation Approach

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 TOOLS

The VANET applications have become an interesting and popular research topic in wireless sensor networks. In this thesis work MOVE (web), SUMO (web) and NS-2 (web) simulators have been used to generate real world mobility and traffic models for real-time VANET simulations. MOVE is built on the top of the open source micro-simulator SUMO tool and is used to generate outputs which are used by NS-2 simulator. Real world nodes movements are used to produce the simulation's results. The overall design of the thesis implementation from the software engineering perspective has been given in the figure 4.1. The detailed description of the various simulation tools used in this thesis work has been given below:

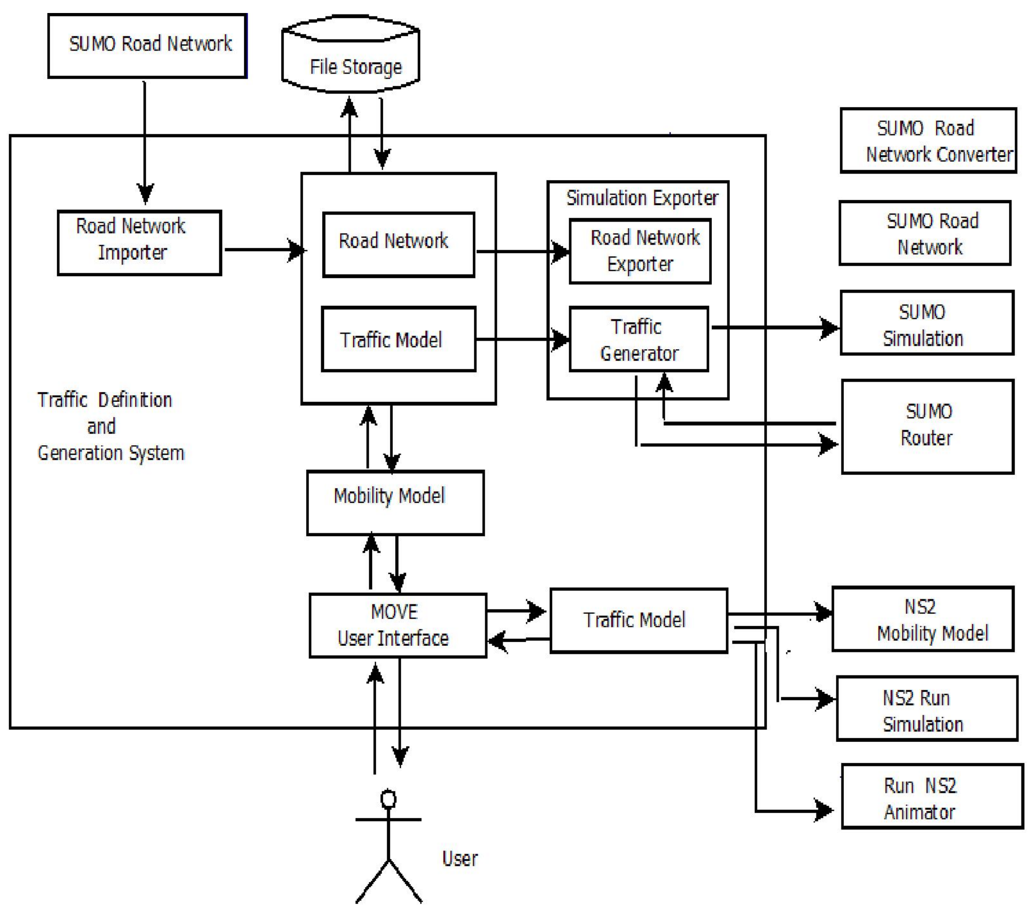

Figure 4.1: System Architecture

4.1.1 MOVE: MOVE (MObility model generator for VEhicular networks) is a GUI tool based on java, which is built on the top of another traffic simulator named SUMO(Simulation of Urban Mobility). In the present thesis work the MOVE tool has been used to generate realistic VANET application. MOVE consists of two main components: Mobility Model and Traffic Model. Mobility Model is a graphical user interface used for generating mobility model simulations for SUMO. Network Traffic Model takes SUMO based traces as input and generates network traffic model which is used by NS2 and QualNet.

4.1.2 SUMO: SUMO (Simulation of Urban MObility) is a highly portable open microscopic road traffic simulator specially developed for the traffic simulation community by the employees of Institute of Transportation systems at the German Aerospace Centre. SUMO is an XML script based tool, which allows the users to create own road scenarios by defining their own road scenarios, employing various network, flow and vehicle definitions. SUMO is highly portable and is compatible with both windows and linux. Various applications have been developed in SUMO.

4.1.3 NS2: Network Simulator (version 2) named as NS-2 is an event driven simulator that is useful in analyzing the dynamic nature of various communication networks. NS2 supports the simulation of both wired and wireless networks. NS2 provides its users to develop its various protocols and simulate dynamic behaviours. Due to its modularity and popularity NS2 is widely used in various research projects since its birth in the year 1989.

NS2 consists of two main languages C++ and OTCL (Object Oriented Tool Command Language). C++ defines the internal working mechanisms of various scenarios where as OTCL is used to set up the simulations by the configuration of the various objects as well as their discrete events. After simulation setup, the NS2 is used to produce either Text-based or Animation-based outputs. For the graphical analysis of these outputs, tools named NAM (Network Animator) and xGraphs are widely used.

4.2 EXPERIMENTAL IMPLEMENTATIONS

The performance of the overall scenario is evaluated with the help of simulations which are produced by SUMO, MOVE and NS2 simulators. The proposed methods and the existing methods are simulated and analyzed in the same road scenarios. The experimental implementation of the proposed as well as the present system is presented in this section. Steps involved in the implementation process are given below:

4.2.1 Starting up with MOVE: MOVE is a java based GUI tool which can be started by typing the following commands in the linux terminal.

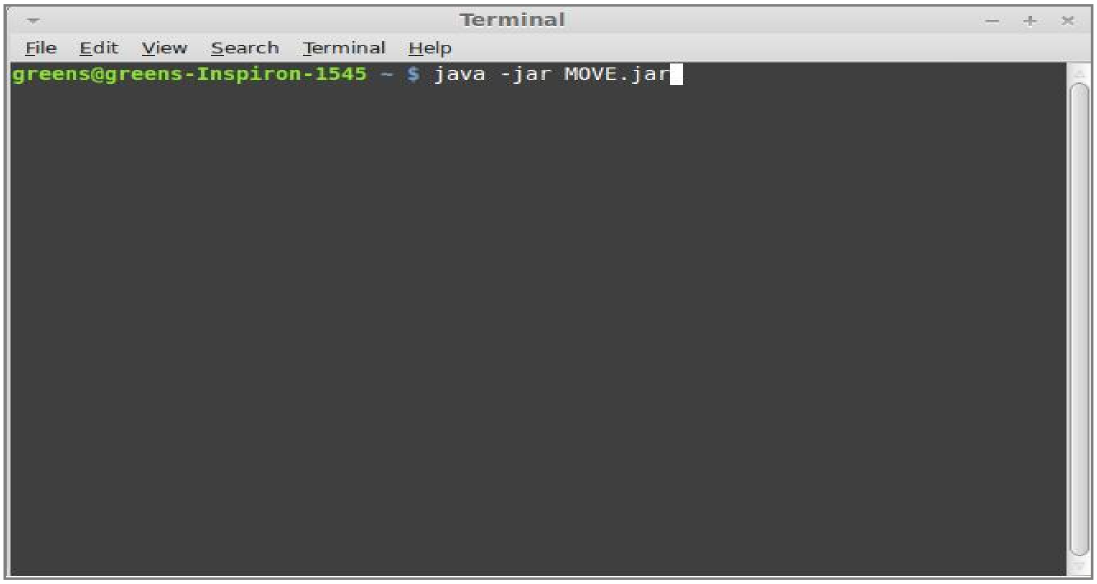

Figure 4.2: Command to Start MOVE

After the execution of the above command shown in the figure 4.2 following GUI will be appeared from where we can select the Mobility Model as well as the Traffic Model.

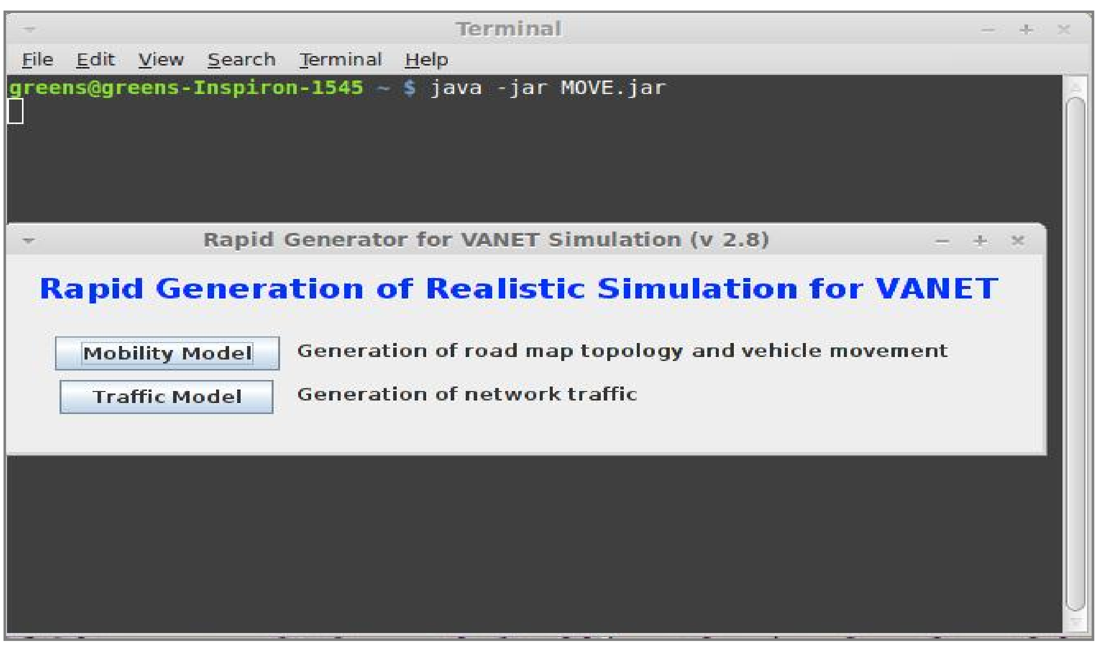

Figure 4.3: MOVE GUI

4.2.2 Mobility Model Generation: Mobility Model generator is selected by selecting the Mobility Model option on the MOVE main menu. MOVE consists of three main modules: map editor, vehicle-movement editor, simulation.

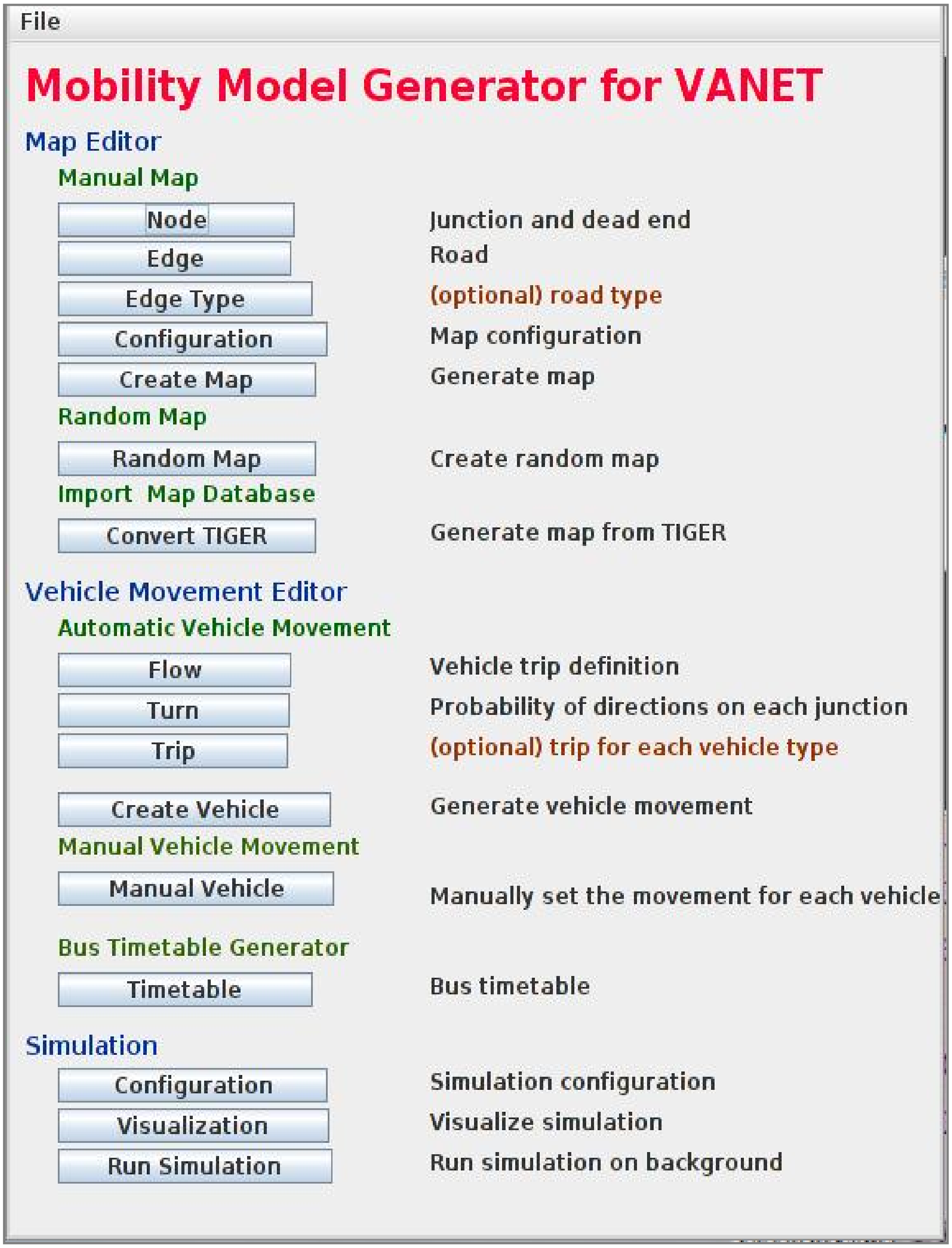

Figure 4.4: Mobility Model Generator

4.2.2 Map Creation: There are two methods for generating the road network. First method is by the importing the other formats and converting these formats by SUMO road network converter into the required SUMO format as shown in the figure 4.5. Second method is by manually creating your own network scenario by specifying your own configurations for both nodes and for the edges and input those through the SUMO network converter to produce your own road network. Both cases produce the same .net.xml network file.

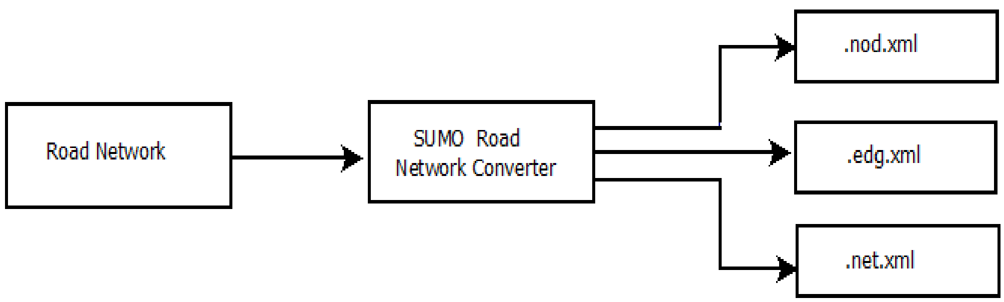

Figure 4.5: Conversion of other formats into SUMO format using SUMO Road Network Converter

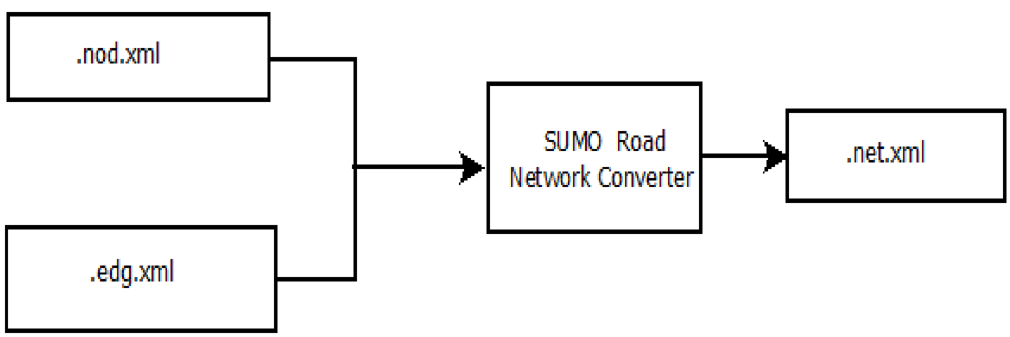

Figure 4.6: Generation of the Road Network from the XML files

In this thesis MOVE simulator is used for manually configuring the nodes and edges to generate road network. By clicking on the node menu on the mobility model Map Nodes Editor window is opened, where nodes dimensions are defined. After defining the node dimensions and the type the node file is saved as <filename>.net.xmal. Map Nodes Editor for both the present and the proposed system.

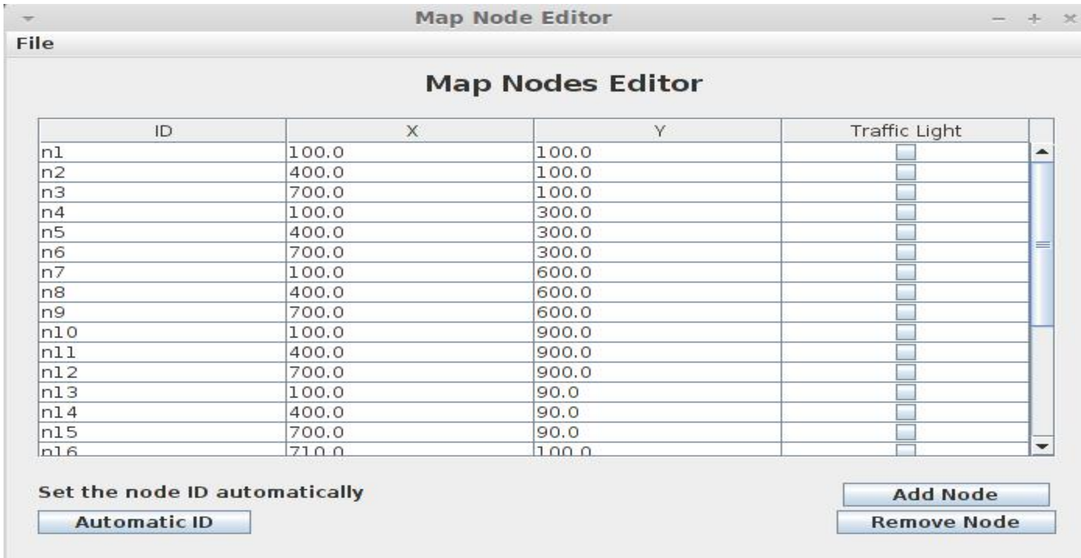

Figure 4.7: Map Road Editor

By clicking on the edge menu on the mobility model Roads Editor window is opened, where edge connections are defined for various nodes. In the Road Editor Window no of lanes, speed and priority of the various edges can be defined. After defining the node dimensions and the type the edge file is saved as <filename>.edg.xmal. Roades Editor for both the present and the proposed system.

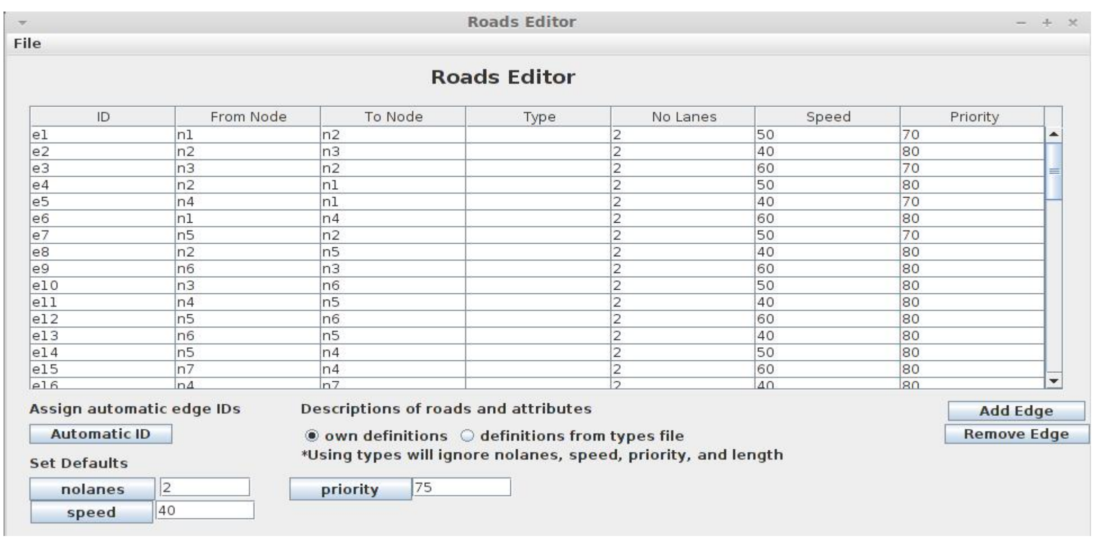

Figure 4.8: Edge Creation from Map Road Editor

Map is generated by specifying the nodes and edges configuration files and saving the file as <filename>.net.xml.

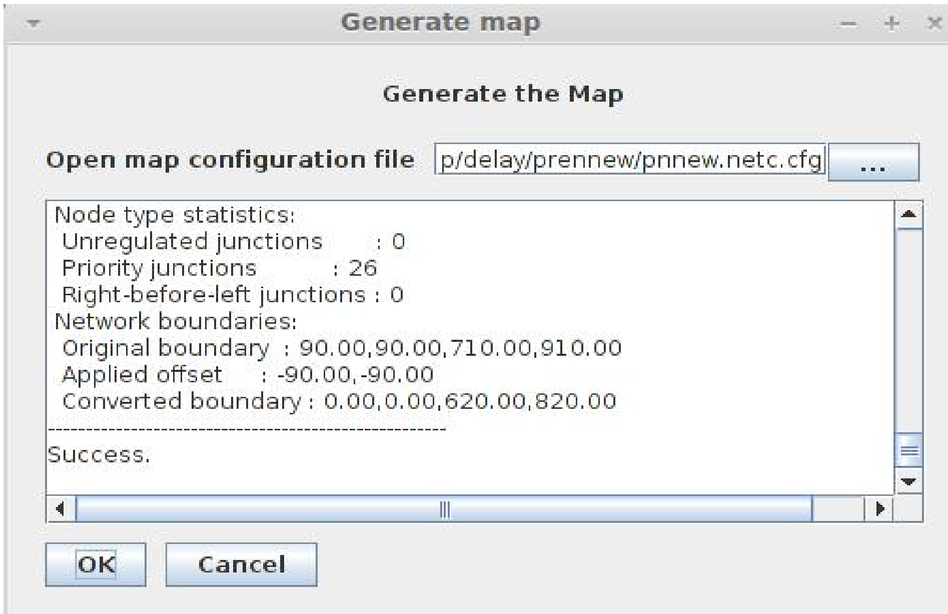

Figure 4.9: Generation of the Road Network by Configuring the Nodes and the Edges

Figure 4.10 left shows the road network generated by the nodes and edges configuration files as shown in the figure 4.7 and in figure 4.8 using the above configuration importer as in figure 4.9. Right side shows the internal node representation of the generated road network.

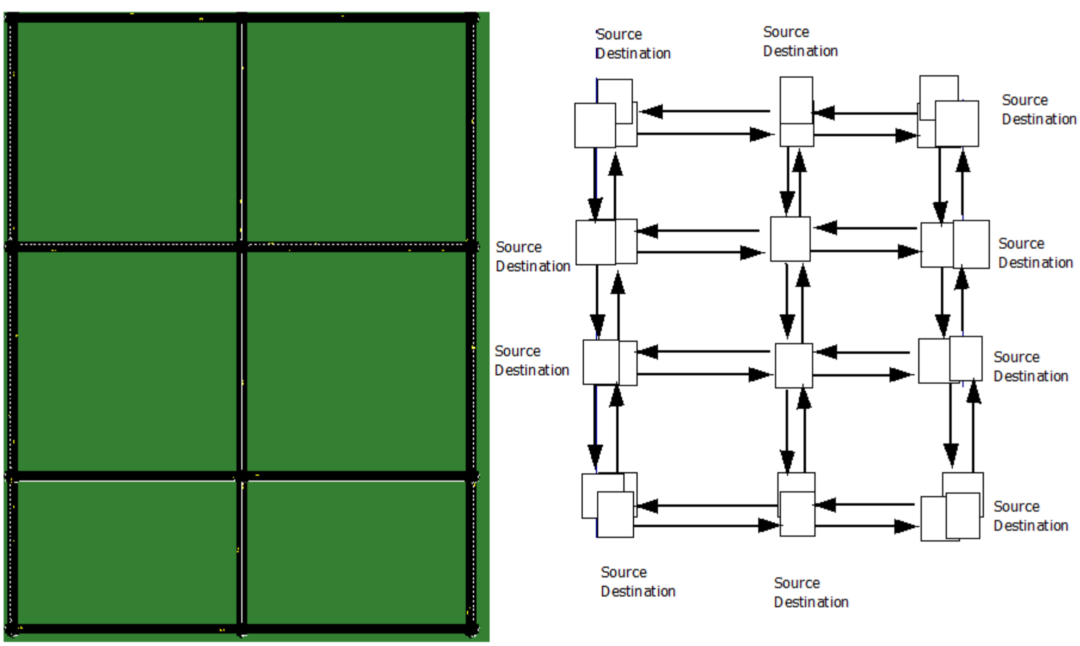

Figure 4.10: Graphical Representation of Road Network (left) and internal (right) Node Representation

4.2.3 Vehicle Routes Generation: After the success of map creation the vehicular routes are created. For the creation of the vehicular route <filename>.flow.xml and <filename>.net.xml files are required which are used to generate the vehicular route.

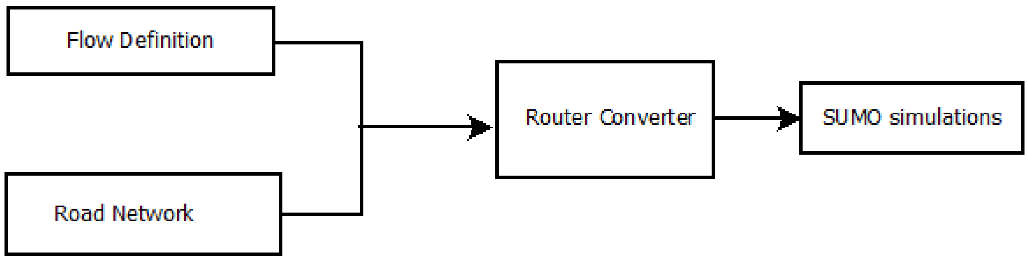

Figure 4.11: Conversion of the Flow Definitions and Road Network into SUMO Simulation format using SUMO Route Converter

Flow movements for the various vehicles can be generated by simply selecting the flow menu from MOVE GUI. Various flow ids can be generated either manually or automatically by specifying the edge connections and number of vehicles flowing through each edge. Flow file can be saved as <filename>.flow.xml.

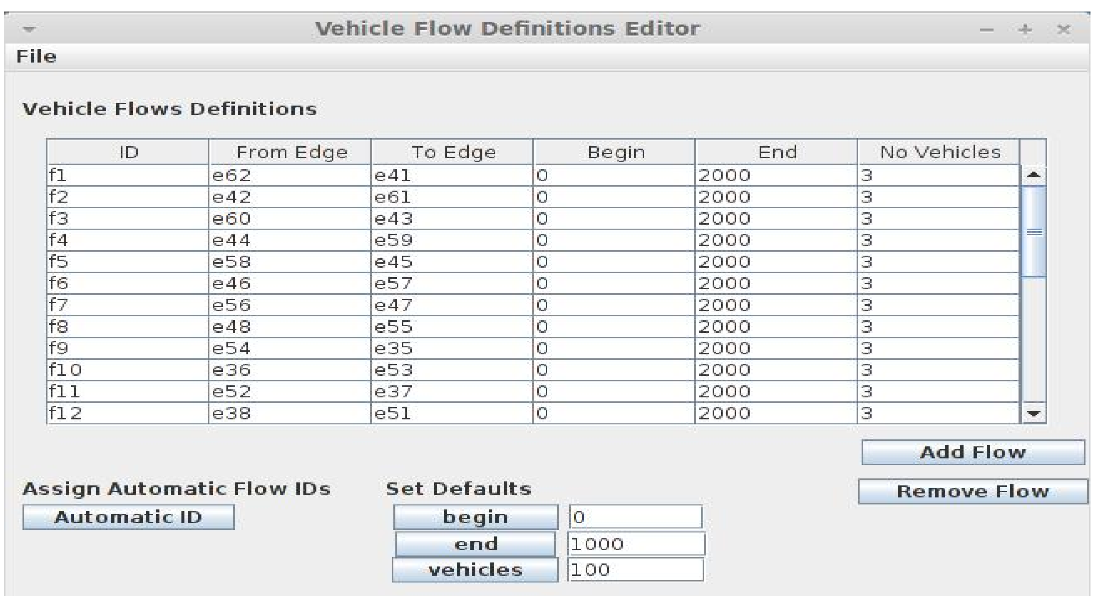

Figure 4.12: Flow Generation from Vehicle Flow Definitions Editor

Vehicles are created by selecting create vehicle menu from the figure 4.4 MOVE main menu. Vehicle's movements are created by selecting the flow definition file and road map file and saved as by <filename>.rou.xml.

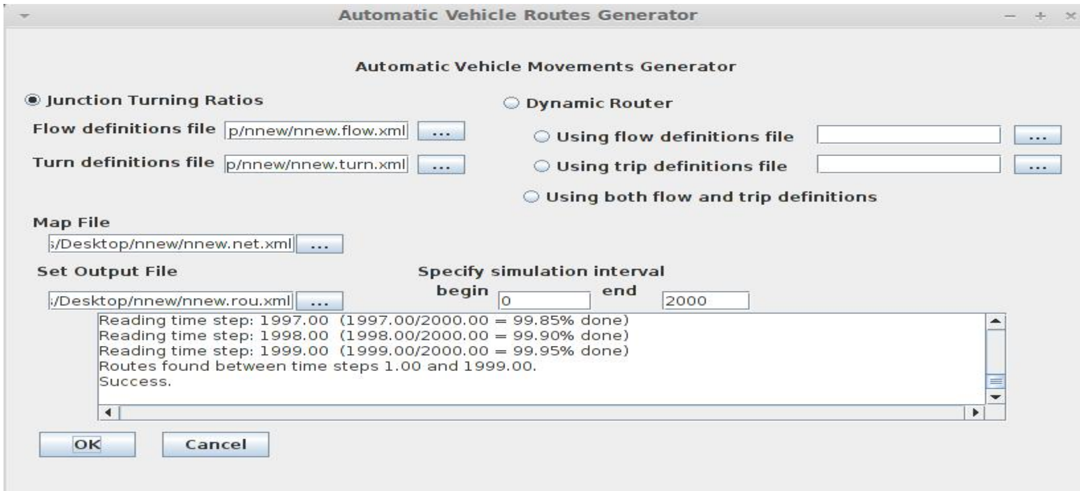

Figure 4.13: Vehicles Creation from Automatic Vehicle Movement Generator

4.2.4 Simulation Scenario: After the successful creation of the road map and vehicular movements, these configurations are needed to specify the configuration for the simulation scenario. "Configuration" is selected from the figure 4.4 MOVE main GUI and after specifying the <filename>.flow.xml and <filename>.rou.xml and by specifying the start and end of the simulation interval. Then the file is saved as <filename>.sumo.cfg.

Figure 4.14: SUMO Configuration File Creation from Traffic Simulator Configuration Editor

Now the visualization of the generated traffic congestion scenario can be selected from the visualize menu from the figure 4.4 MOVE GUI. The resultant map for the proposed and the present system is shown in the figure 4.13 as given below:

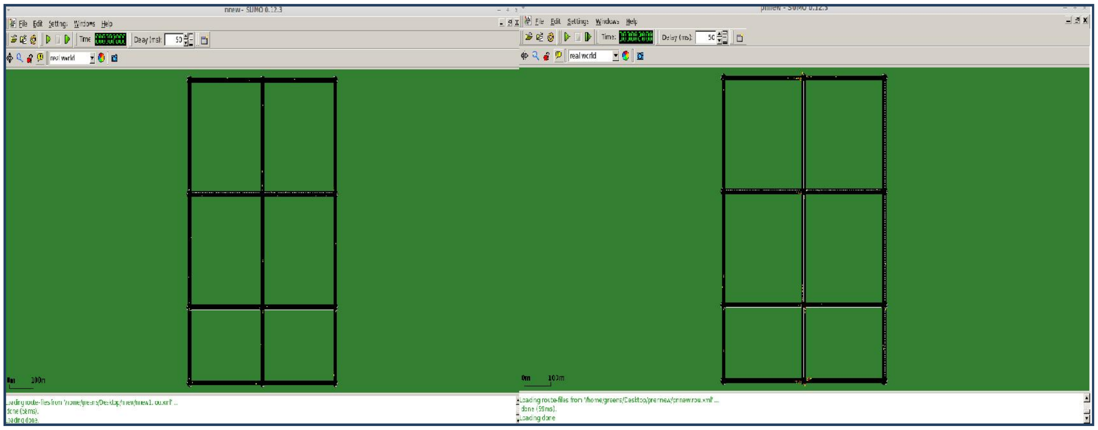

Figure 4.15: SUMO Traffic Configuration Generation from Traffic Simulator Configuration Editor

4.2.5 Network Traffic Generator: SUMO trace file is used to generate the network traffic model required by NS2.It provides all the configurations of NS2 TCL files. For the generation of the TCL file MOVE trace file and its map file is required. By selecting File->Import MOVE trace file and after that by selecting <filename>.move.trace filename and <filename>.net.xml filename the trace file can be generated for NS2.

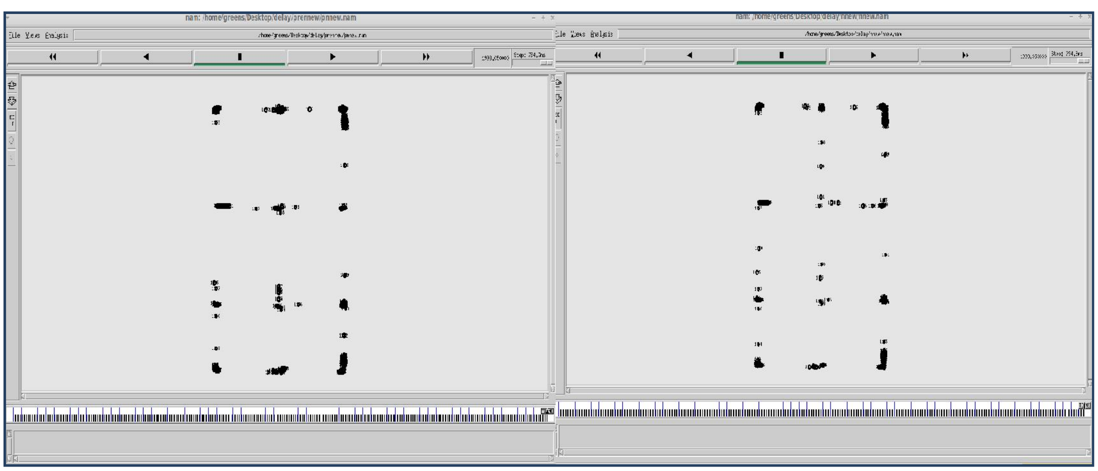

Figure 4.16: NAM generated for the present (left) and the Proposed (right) from Network Traffic Simulator

4.3 MISCELLANEOUS SUMO APPLICATIONS

SUMO is not a single application that is used to create simulation, but it is a complete software package which consists of various applications which are used for setting up various simulation environments. This simulation package consists of following inbuilt applications. The applications which are used for implementing this thesis work are given below:

Application	**Application's Description**
SUMO	The command line application with no visualization and microscopic simulation.
GUISIM	The microscopic simulation with GUI.
NETGEN	Generates the network from the edge, node and type files.
NETCONVERT	Imports networks, generates road networks from various road networks and converts them into the SUMO format.
DUAROUTER	Computes the fastest route throughout the whole network scenario.
JTROUTER	Compute the routes using junction turning ratios at each intersection.

4.4 SIMULATION RESULTS AND ANALYSIS

Results are obtained in this section. The analysis is being done on the basis of simulation set up by the MOVE and SUMO simulators.

4.4.1 Simulation Setup:

A grid view map of area 672m x 872m has been created with the help of MOVE and SUMO simulators.

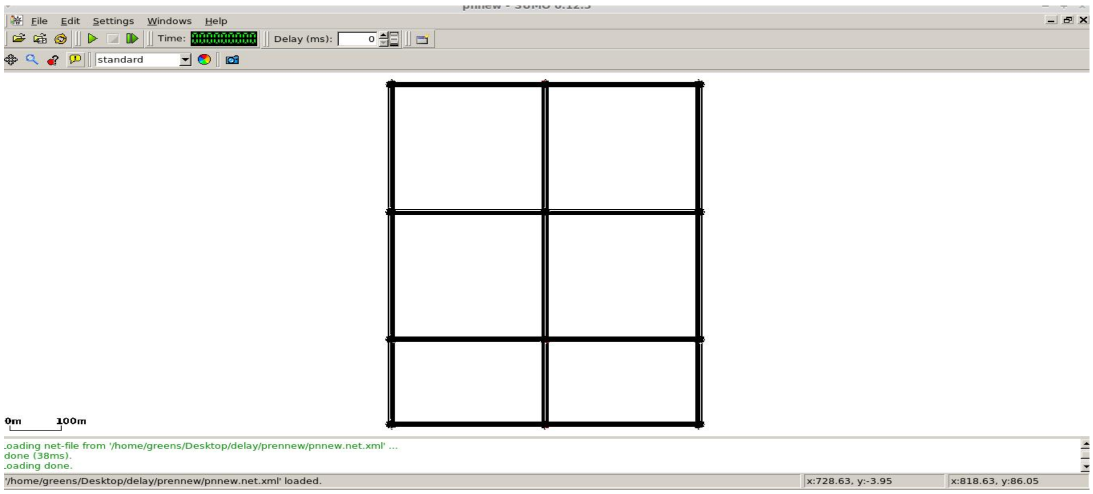

Figure 4.17: Generated Map

4.4.2 Simulation Results

The simulations results are generated on the network generated in the figure 4.17. The simulations are run for two cases case1 and case2. Case 1 is generated for the available congestion control technique which consists of congestion avoidence in decentralized manner. Case 2 is generated for the proposed traffic congestion avoidence approach which removes congestion upto a certain level in the decentralized system and presents efficient data propagation approach.

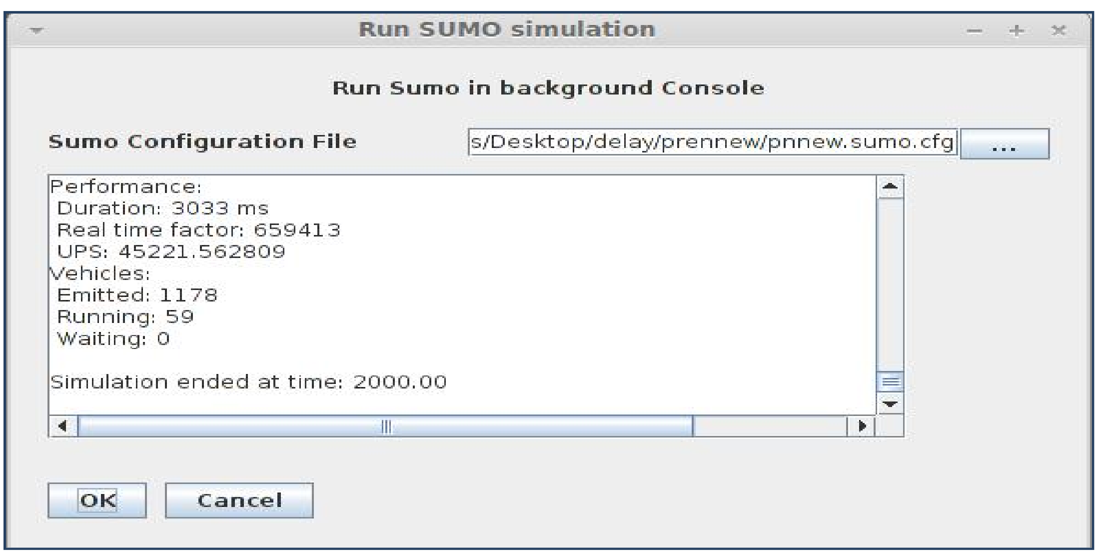

Figure 4.18: Representation of Performance and Congestion for the Vehicular Environment for Case1

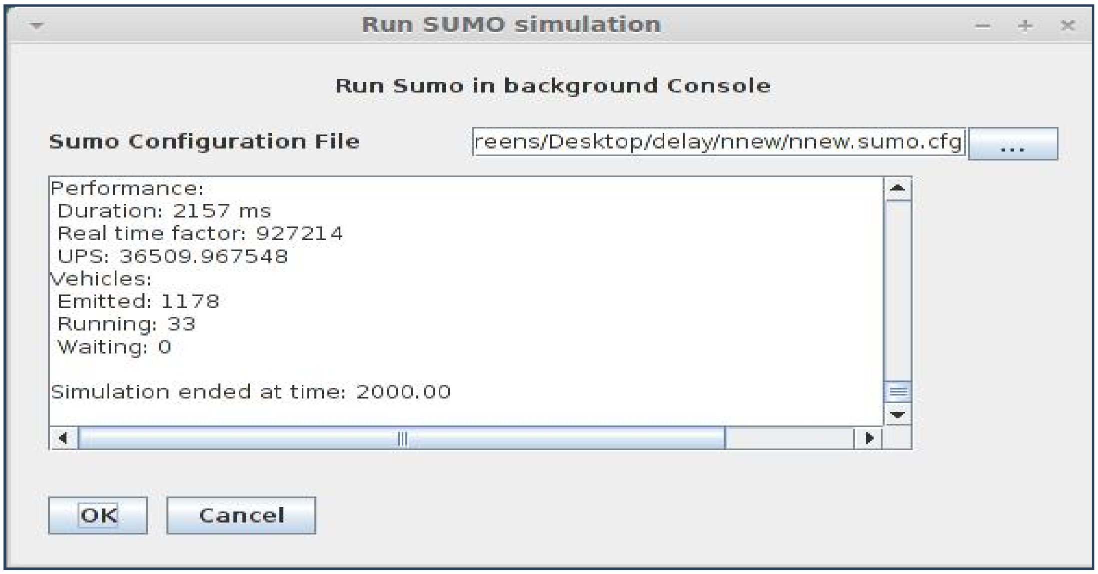

Figure 4.19: Representation of Performance and Congestion for the Vehicular Environment for Case2

By Comaparing the simulations in case 1 and case 2, It is clear that the performance of case 2 in terms of duration i.e. time taken by the vehicles to leave the intersection and congestion in terms of number of vehicles in the environment at the end of simulation time.The results are also analysed with the help of *.tr files which are created with help of .TCL files. The results are obtained on the execution of the .TCL files. The simulation set up for generating the average end-to-end delay is given in the table below:

Table 4.1: Simulation Set Up

Routing Protocols	AODV, AMD
No. of nodes	1178
Traffic Type	TCL
Channel Type	Wireless Channel
Mac Type	IEEE 802.11
Simulation time	2000ms

Window size	20
Scenario	Urban
Queue Length	50

Average End to End Delay: Average end to end delay is defined as the average time consumed by the data packets to propagate from the source node to the destination node. The delay includes the various delays introduced by the routing protocols during the route discovery, route handling, message propagation, and queuing and transfer time. The average end to end delay graph has been generated using AODV and AMD routing protocols and presented in the figure given below.

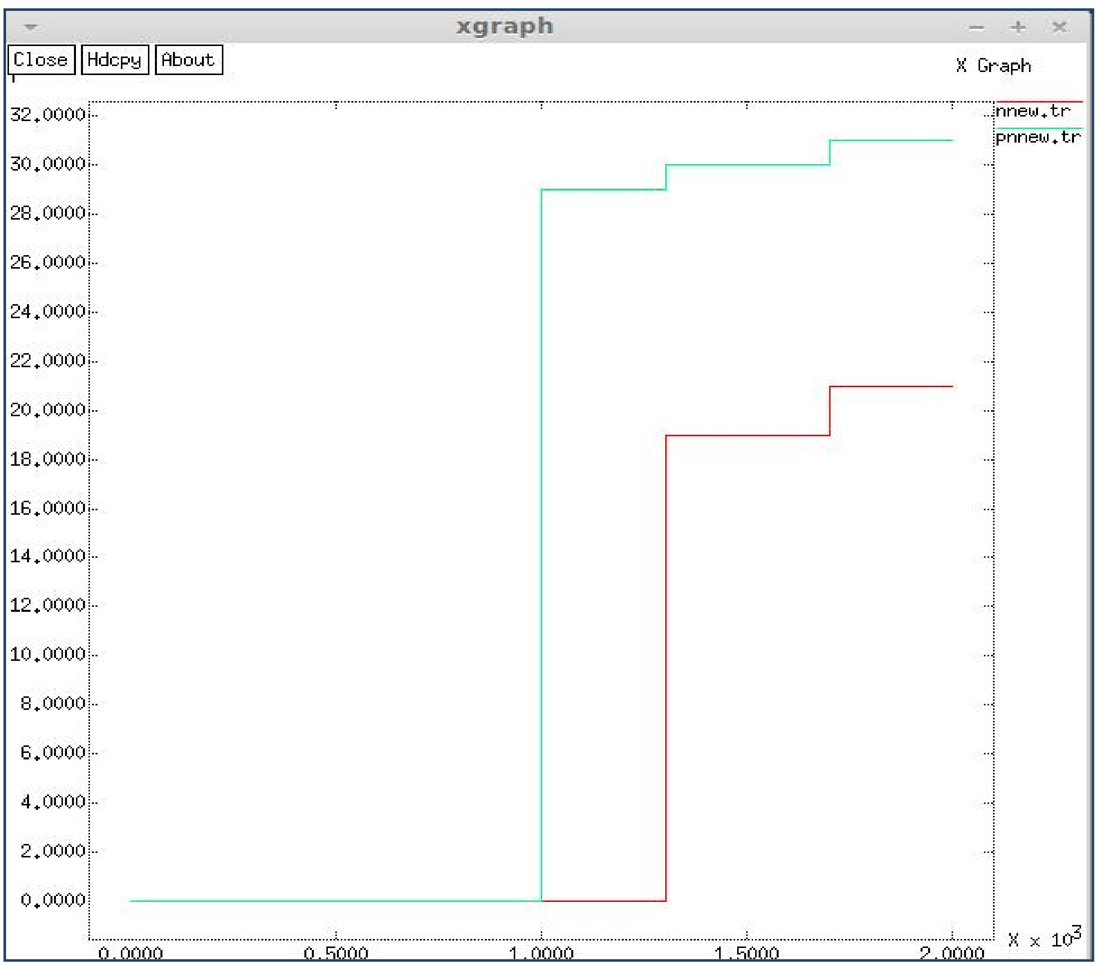

Figure 4.20: Average End to End Delay calculated using AODV and AMD Routing Protocols

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

This chapter presents the concluding remarks regarding the proposed system and also presents the future work that can be done in the same direction. In urban city environments, traffic congestion is the main challenge for the traffic management. To deal with this problem, we have implemented a simulation environment that meets the traffic congestion problem. In this work we have 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 traffic light gateways that are able to aggregate and take decisions as to how to influence the routes the cars are driving.

5.1 CONCLUSION

In this work we have implemented and compared a traffic congestion control system that attempts to significantly reduce the time consumed by the vehicles in the congested network scenario. This work has been accomplished by V2V communication among the vehicles using bio-inspired based V2V communication based on ant colony optimization, where vehicles virtually behave as a wireless traffic light and handover the generated congestion status information to another vehicular data leader and also broadcast the generated traffic congestion status information among the vehicles in the same congested traffic scenario. As a result of the effective V2V communication among the vehicles, by knowing the congestion status of particular road-segment the follower vehicles select the alternate road in the direction of the same destination at an initial stage. The results presented in the previous chapter show a significant reduction in the time consumed by the vehicles in the congested city scenario. From the results calculated from the previous chapter the delay reduction has been calculated for the previous and proposed system and considerable delay reduction has been obtained.

5.2 FUTURE SCOPE

There are many research areas where this work can be expanded. We introduce some of areas where existing research work can be integrity. This work can be implemented for complex modeling scenarios and dynamic driving behaviors incorporating multi-lane environments, multi entry and exit point scenarios moving closer towards the real world scenarios. This work can be used for complex hybrid protocols incorporating V2V and V2I communications. The varying congestion parameters can be used in efficient routing protocols. In this thesis work vehicle's U-turn has not been considered, so future work may take U-turns into consideration.

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APPENDIX A: QUESTIONNAIRE

Question 1: What do you mean by wireless sensor network?

Answer: WSN is an ad-hoc Network. It consists of sensor nodes deployed in physical and environmental conditions. These sensor nodes are deployed in a large or a thousand numbers and collaborated to form ad hoc networks, these networks are capable of sensing the environment means collecting the data, processing the data and reporting data to collection sink (Base Station).

Question 2: What are the types of wireless sensor network?

Answer: WSNs is divided into two categories: infrastructure type and ad hoc. In infrastructure type the wireless clients are connected to the wired network with the help of the wireless access points. The second type is the ad hoc type where the wireless clients form a network and communicate to each other.

Question 3: What are various communication technologies used in wireless communications?

Answer: IEEE 802.11 family, Hyper LAN, Bluetooth, IEEE 802.16, WiMax, GSM, 3G are some of the technologies used in wireless communications.

Question 4: What is intelligent transportation system?

Answer: Intelligent Transportation system is the collaboration of various vehicles which communicate with each other to improve road safety and provides the travelers a better traveling experience.

Question 5: What is VANET?

Answer: 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, where vehicles follow a specified path over predefined road infrastructure.

Question 6: What are the different types of communications used in VANETs?

Answer: The communication architecture of the VANETs is divided mainly into three parts.

i. In vehicle communication.
ii. Vehicle to vehicle communication (V2V) or inter vehicle communication.
iii. Vehicle to infrastructure communication.

Question 7: What is ant colony optimization?

Answer: Ant colony optimization is a probabilistic approach used for solving computational optimization problems. ACO is based on the pheromone trail laying and trail following behavior of the ants. In distributed environment, the pheromone trail behaves as numerical and computational information which ants use to find their optimal path.

Question 8: What is end to end delay?

Answer: It is defined as the average time taken by the data packets to propagate from the source node to the destination node. The delay is introduced by the routing protocol during the route discovery, route handing, message propagation and transfer time.

APPENDIX B: GLOSSARY OF TERMS

Average speed: Average speed is the ratio of the speed of all the vehicles to the total number of vehicles in a particular road segment. The average speed (v_m) is given by the following formula:

$v_m = v_{cruise} *(1-n_r/n_{max} * f_{min}/f)$

Congestion status: It is the degree used to represent the congestion on a particular road segment. It is calculated by the following formula:

Congestion status (CS) = $255*(1- v_m/v_{max}) * imp$, $v_m <= V_{max}$

0, $v_m > v_{max}$

Cruise speed: It is the cruising speed between two consecutive red light cycles.

Maximum speed: Maximum speed is the maximum velocity achieved by the vehicles in a particular road segment.

Optimal path: Optimal path is the path having minimum cost. Cost may be the time taken to cover the particular road segment or may be defined as the congestion status of the road segment.

Stigmergy: Stigmergy is an indirect, non-symbolic form of communication mediated by the environment. All the insects exchange information by modifying the environment.

APPENDIX C: ABBREVIATIONS

Abbreviation	Meaning
AU	**A**pplication **U**nit
ACO	**A**nt **C**olony **O**ptimization
ADC	**A**nalog to **D**igital **C**onverter
ARA	**ACO R**outing **A**lgorithm
BANT	**B**ackward **ANTus**
CS	**C**ongestion **S**tat
FANT	**F**orward **ANT**
GUI	**G**raphical **U**ser **I**nterface
IEEE	**I**nstitute of **E**lectrical and **E**lectronic **E**ngineers
ITSs	**I**ntelligent **T**ransportation **S**ystems
LAN	**L**ocal **A**rea **N**etwork
MANETs	**M**obile **A**d hoc **NET**works
MOVE	**MO**bility Model for **VE**hicular Network
OTCL	**O**bject **O**riented **T**ool **C**ommand **L**anguage
RSUs	**R**oad **S**ide **U**nits
SUMO	**S**imulations for **U**rban **MO**bility
TCL	**T**ool **C**ommand **L**anguage
TZ	**T**raffic **Z**one
WSNs	**W**ireless **S**ensor **N**etworks
WTLs	**W**ireless **T**raffic **L**ights
VANETs	**V**ehicular **A**d hoc **NET**works
V2I	**V**ehicle to **V**ehicle
V2V	**V**ehicle to **I**nfrastructure
XML	e**X**tended **M**arkup **L**anguage