TASK ALLOCATION IN EDGE BASED VANET

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DECLARATION BY THE SCHOLAR

I hereby declare that work reported in the M.Tech dissertation entitled "TASK ALLOCATION IN EDGE BASED VANET" submitted at Jaypee University of Information Technology, Waknaghat, India under CSE and IT department is an authentic record of my work carried out under supervision of Dr. Shailendra Shukla. I have not submitted this work elsewhere for any other degree or diploma.

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CERTIFICATE

This is to certify that thesis report entitled **"TASK ALLOCATION IN EDGE BASED VANET"**, submitted by Anchal Kaundal in partial fulfillment for the award of degree of Master of Technology in Computer Science & Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been made under my supervision.

This report has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

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Date: Signature:
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ABSTRACT

As we know that in last ten years there is huge use of cloud for the storing, computation and for the historical data analysis. In present days there is more than 23 billion devices connected to cloud. These devices produced huge amount of data day-by-day. Due to the continuous generation of the data by the devices will leads to congestion in cloud, this congestion will create delay in the sharing of information or data this will affects the real time applications like VANET, health care. In this thesis work I proposed an architecture for VANET where the computation of the data shared by vehicles is done within local mesh network of the RSU's. For the computation of the data tasks must be allocated to the RSU's. Task allocation is important to remove many problems in distributed environment (e.g. WSN's, VANET etc.) like use of resources in a convenient way, best allocation of resources as they are limited, etc. In this work we also give a genetic algorithm for task allocation in RSU's. This allocation algorithm shows that how the tasks are divided within the limited amount of the RSU's. The proposed task allocation using genetic algorithm gives 22.38% improvement in terms of fitness value and 8.34% improvement in terms of cost of energy consumption.

In this thesis work the chapters are organized as follows:

Chapter 1: Chapter one outlines the basic concepts of the wireless sensor networks, task allocation in wireless sensor network and its importance. It also briefs about VANET and its types of architectures and also about the topologies of the network.

Chapter 2: Chapter 2 gives the literature review of the related work done in the area of task allocation, VANET and wireless sensor network.

Chapter 3: Chapter 3 gives the methodology related to the proposed model, algorithm for the task allocation in RSU's and architectural model of VANET.

Chapter 4: It gives brief about the simulation tool. Experimental results and analysis is also explained in this chapter.

Chapter 5: Chapter 5 gives you the conclusion of the work done in this thesis report and also its future scope.

CHAPTER 1
INTRODUCTION

1.1 ABOUT WIRELESS SENSOR NETWORK:

In recent few years Wireless Sensor Network (WSN) withdraw huge attention world-wide. Wireless Sensor Network is group of sensor nodes which worked together to monitor the environmental conditions such as temperature, pollution level, traffic etc. These sensor nodes have potential of sensing, computation and also have communication capabilities. These sensors have limited amount of assets specifically power, computation and storage [1]. The main source of power for these sensors is battery. The above specified restrictions made it more necessary that one design protocols for sensor networks that can take into consideration these limitations. In Wireless Sensor Network there is distribution of many sensors for the surveillance of the area or reason where there is requirement of surveillance of actual time information or data [12]. The Wireless Sensor Networks are of two types Structured WSNs and unstructured WSNs [2]. In structured WSNs some of the sensor nodes or all the sensor nodes are setup in the fixed locations but in unstructured WSNs sensor nodes are deployed randomly in the environment.

Scenario 1 for the sensed data by the sensors: In intelligent traffic light monitoring system, cars are equipped with RFID and GPS. Their identity and location are send continuously to the base station that is RSU's. This RSU's will divide the data or task among the RSU's. The RSU's will now compute the traffic at the next traffic light by exchanging data with each other about the location of the vehicles and will send it back to the vehicle about traffic at the next Stoppage/Light.

Scenario 2 For the Images data: When the vehicles are taking images of the road for the traffic level indication, then then the images are sent to the base RSU of that vehicle and that will allocate the task that is divide the data and allocate it to the other RSU's. The RSU's will compute the image data and check whether there is traffic ahead or not and then it will send it back to other vehicles in the corresponding location about the traffic ahead.

1.2 TASK ALLOCATION:

Firstly, the question arises that, what is task? Task is a computational and communication activity. In WSNs, there is limited amount of energy for the sensor nodes. So, in In-network processing some of the tasks or processes need more energy for its processing or computation. This type of needs cannot be fulfilled by the single sensor nodes. Due to this reason Task allocation problem occurred. Task allocation is defined as assigning the tasks to the sensor nodes and "scheduling of computation and communication activities". Here the question arises that, what happen when the task is allocated to single node? If we assign the task to a single node then there is energy consumption of that node and this will leads lost in the number of the nodes in the network and it also effects the processing speed.

Task allocation is very useful for the reduction in the cost of execution of the tasks. To solve task allocation problem the task is divided into subtasks and these subtasks are allocated to the nodes. The main advantages of task allocation are:

1. Almost equal distribution of the load within the computational devices.
2. Use minimum amount of energy.
3. Use of resources efficiently.

There are many task allocation algorithms like BPSO (Binary Particle Swan Optimization), MBPSO (Modified Binary Particle Swan Optimization), Genetic Algorithm etc.

1.3 ABOUT VANET (Vehicular Ad Hoc Network):

Task allocation is one of the key aspect in VANET (Vehicular Ad Hoc Network). VANET the main module of ITS (Intelligent Transport System). Now in current days Google and many other corporations are working on increasing the safety of the roads and improves the traffic efficiency and to enable some other services like collision detection and collision warnings and prevention from the accidents [13]. All these parameters belong to ITS. The main objectives of Intelligent Transport Systems are as follows [5]:

- Improvement in traffic safety.
- Reduce the time of travelling.
- Reduce the cost for the travelling.
- Make transport system more effective.

VANETs are also known as Inter-Vehicle Communications (IVC) or Vehicle-To-Vehicle communications (V2V). VANETs are designed by applying the principles of MANETs (Mobile Ad Hoc Networks), we can also call it as a subclass of MANETs [4]. Vehicular Ad Hoc Network (VANET) is a strategy to expand the security of roads. According to a federation of Communication Consortium frequency value for V2V, V2R, R2V is 5.850-5.925 GHz [5].

An Intelligent Transport System (ITS) is a very important application in the domain of the Internet of Things (IoT) [2]. In modern World Vehicles, there is presence of huge number of actuators, sensors and other communication devices such as GPS (Global Positioning System) etc. for making the driving experience more comfortable [15]. The one of the main module of ITS are VANETs (Vehicular Ad Hoc Networks).

VANET is mainly created by communication between two or more vehicles i.e. (V2V) or between and (V2I) (Vehicle and an Infrastructure) [4] (these are also known as Road side infrastructure unit RSUs) [4]. These are the units which makes vehicles to communicate and also known as On-Board Units (OBUs) [3].

Types of communications between vehicles [4]

1) Direct Communication.
2) Indirect Communication.

1) Direct communication: In direct communication vehicles are directly connected with each other as there is no presence of obstacle between them. In this type of communication between the vehicles there is very less chances of loosing he

integrity of the data. Figure 1.1 showing the Direct communication between the vehicles.

2) Indirect communication: In indirect communication if there is any presence of obstacle then vehicle communicate with other vehicle within its range and that vehicle is directly or indirectly connected to the destination vehicle. In this type of communication there is lot if chances of having attacks on the communicated data. Figure 1.2 is showing the indirect communication of the vehicles.

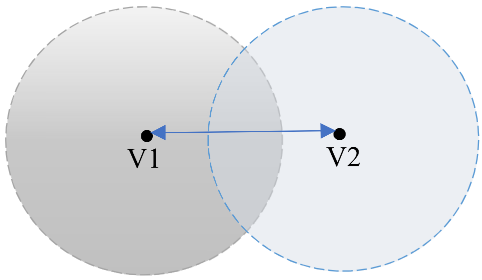

Fig: 1.1(Direct communication between vehicle V1 and V2)

These are some applications of VANET [3][16]

1) On board navigation.
2) Traffic monitoring.
3) Traffic flow control.
4) Safety applications (warning message about emergency case).

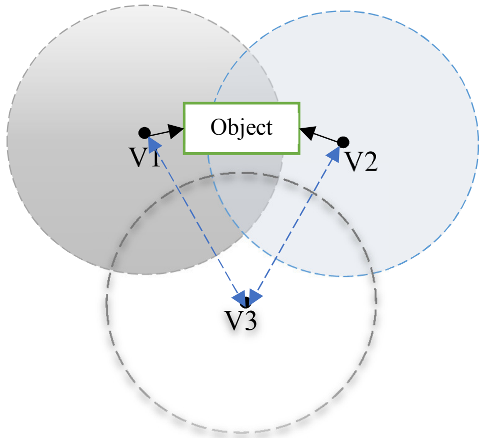

Fig: 1.2 (In-direct communication)

There are three possible architectures of VANETs [16]

1) Cellular/WLAN (Wireless Local Area Network).
2) Ad Hoc.
3) Hybrid.

Cellular/WLAN (Wireless Local Area Network): In this type of architecture the vehicles are connected with each other wirelessly through RSU's (Road Side Units). Figure 1.4 is showing the cellular architecture of the VANET.

Ad Hoc Architecture: In this type of architecture vehicles on the roads are directly of in directly connected with each other on a wireless network. Figure 1.5 showing the Ad Hoc architecture of the VANET.

Hybrid architecture is combination of Cellular and Ad Hoc architecture. In cellular architecture vehicles are connected through wireless local area network like cellular network and in Ad Hoc architecture vehicles are directly or indirectly connected with each other without any other without use of cellular network [16]. Now in present days there is common use of hybrid architecture in VANET. Figure 1.3 is showing the hybrid architecture of the VANET.

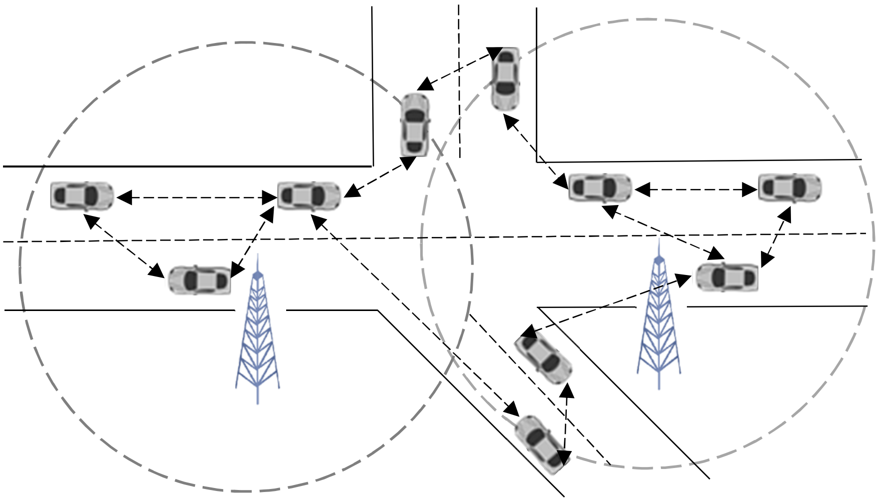

Fig 1.3: Hybrid Architecture of VANET

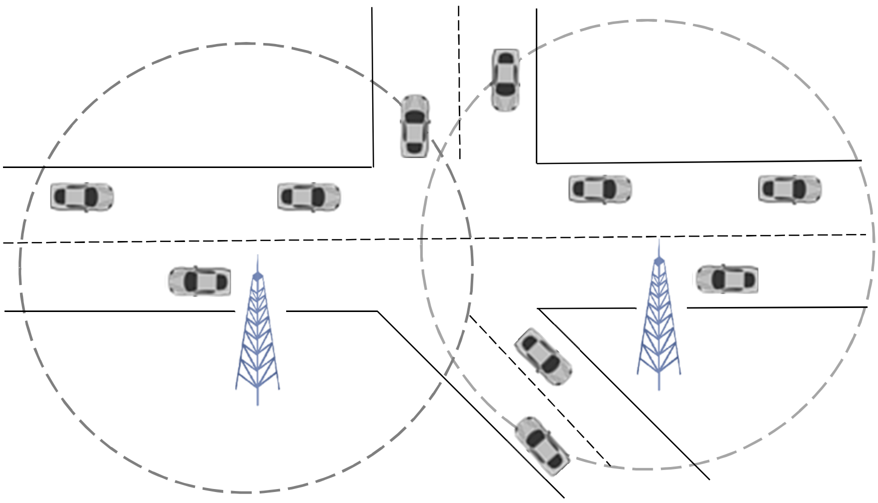

Fig 1.4: Cellular Architecture of VANET

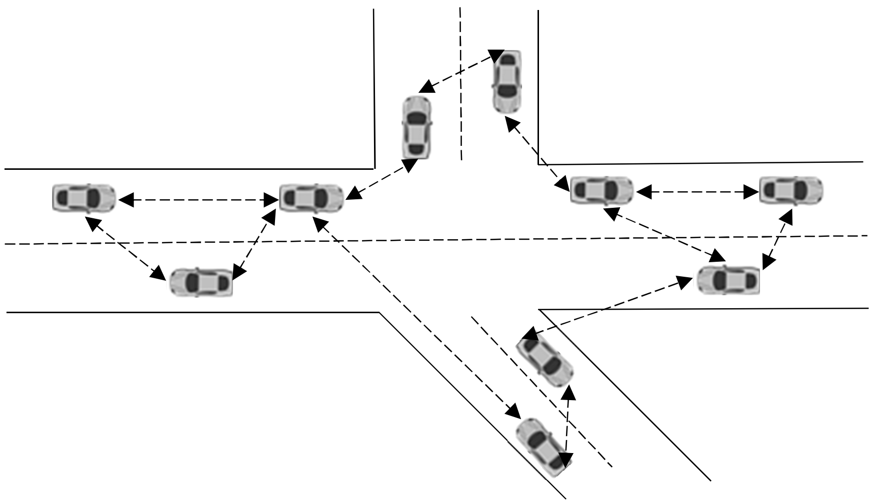

Fig 1.5: Ad-Hoc Architecture of VANET

Now in present days vehicles are connected with each other or with Internet to get or to provide information about road and traffic conditions. “In traditional cloud computing services are between edge devices and the cloud” so the vehicular ad hoc network connected was with cloud. Hussain et al. [6] gives the architecture where vehicular ad hoc network using cloud computing for the real time information of the traffic and other services like broadcasting of information or used for entertainment.

WIRELESS SENSOR BASED SYSTEM:

DATA GATHERING VIA SENSOR BASED VANET [19]: The data or information not only gathered from neighbor vehicles in S-VANET but this data also gathered from other sources of data like traffic management, radios, satellite’s etc. These sensor devices are placed beside the roads. The data gathered by the vehicles is in the form of images, temperature, humidity in the atmosphere etc. Now this type of data need computation. So, the data is sent to the upper layer (Layer 2 in proposed architecture) for computation purpose. In this layer data is divided for the evaluation. This divided data is known as task in this layer. The main problem occur in this layer is how to allocate those tasks to the computational devices. So, there is need of task allocation algorithm for computation of the data.

VANET IN WIRELESS SENSOR BASED SYSTEM:

In last few years there are many sensor devices comes into existence which gives short range connection wirelessly and they not cost too much that is they are not expensive like ZigBee etc.

Kumar et.al [19] gives an Hybrid VANET model that is they combine the Vehicular Ad-Hoc Network with the Wireless Sensor Network to aware all other vehicles which are connected to that network about the wild life on that road to increase the safety in the travelling. Figure 1.6 shows the detection of the wildlife on the road with sensors that is Hybrid VANET and Figure 1.7 detection of slippery road with WSN.

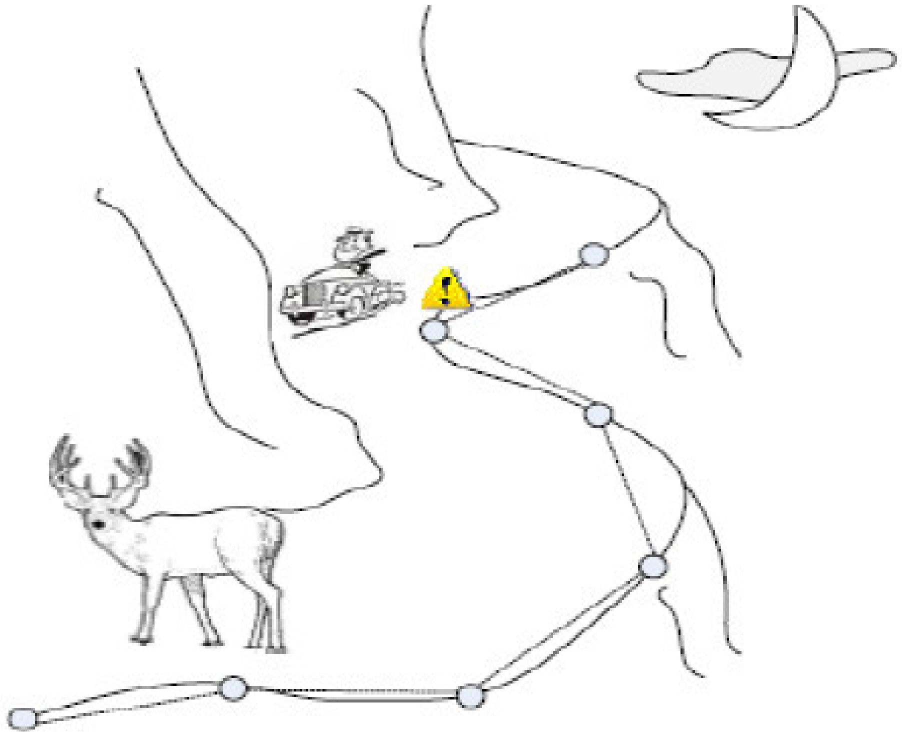

Fig 1.6: Wildlife detection with the sensors in Hybrid VANET [19]

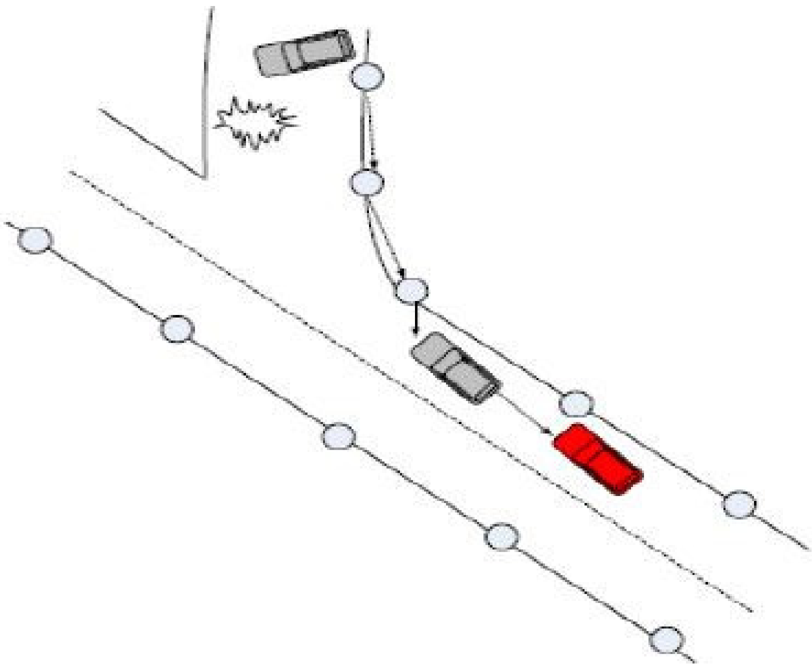

Fig 1.7 Detection of slippery road with the WSN in VANET [19]

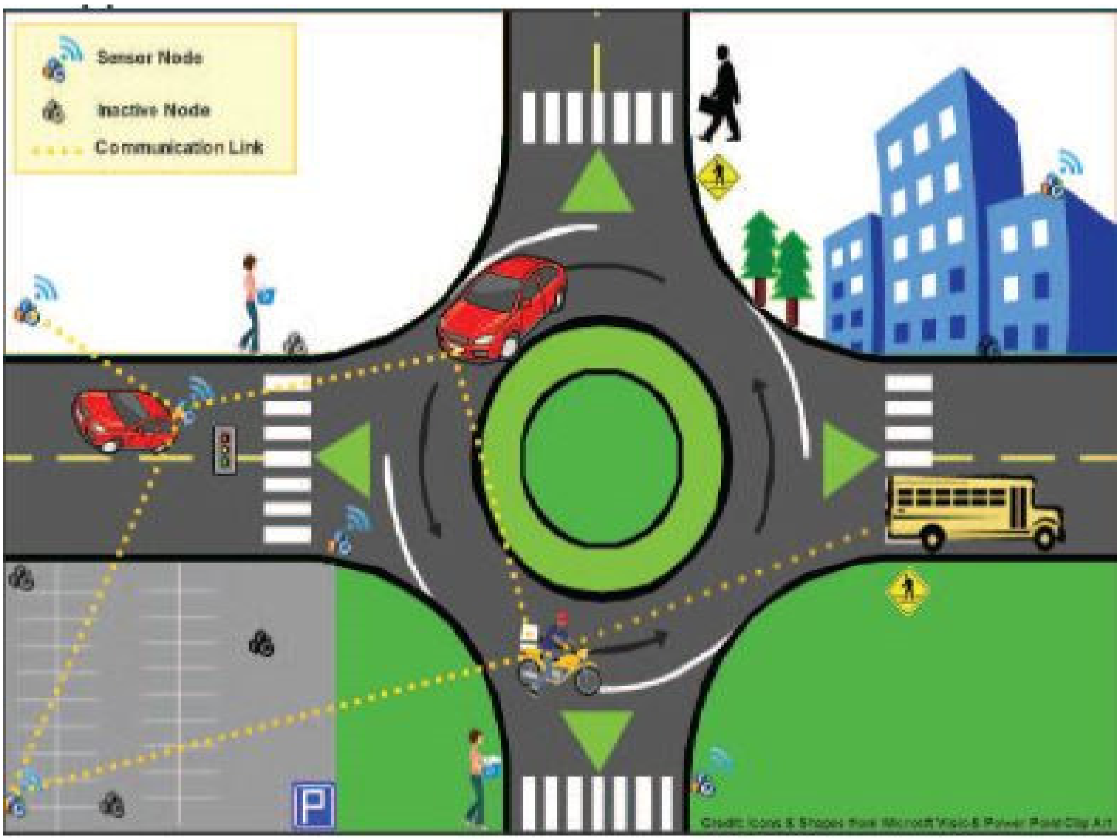

Fig 1.8: S-VANET Architecture [18]

1.4 ABOUT NETWORK TOPOLOGIS:

In this work I proposed an architecture for VANET and which is divided into three layers Layer 1, Layer 2, Layer 3. In layer 2 I use mesh topology in the RSU's network.
There are six types of topologies in the network:

1.4.1 Bus topology.
1.4.2 Star topology.
1.4.3 Ring topology.
1.4.4 Mesh topology.
1.4.5 Hybrid topology.

1.4.1 Bus topology: In this topology all the devices or remote stations connected with each other through the bus. Bus is a single physical cable line where the devices are connected. All type of transfer or transmission of data is done through bus. This network topology is mostly used in making the connections of the computers. This network topology also called as multidrop bus, linear bus and horizontal bus [14]. Figure 1.6 is showing the Bus topology of the network.

1.4.2 Star topology: In star topology devices or remote stations are connected to each other with centrally located server or a computer called hub by wired connection. When the information or data is communicated by any device or remote station the information or data will go through hub before it will reach to the destination. Hub not only managed single message but it can also manager multiple messages at a given time. The min advantage of this network is if there is loss of connection of one node then there is no effect on the whole network [14]. Figure 1.7 is showing the Star topology of the network.

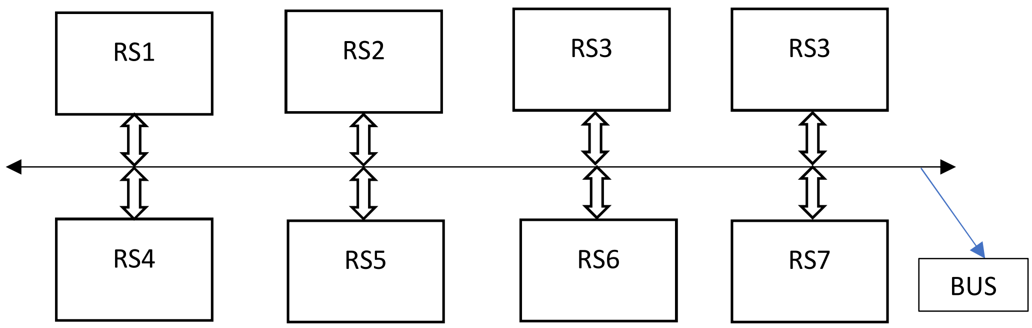

Fig 1.9: Bus Topology

1.4.3 Ring topology: In this topology devices or remote stations are connected in a circular loop. There is point-to-point connection between every two devices or remote stations. This topology of network has unidirectional transmission of data or information. This type of network topology also known as the loop. In this topology the direction of the transmission may by be clockwise or anti clock wise [14]. Figure 1.8 is showing the Bus topology of the network.

1.4.4 Mesh topology: Mesh topology is a topology of a network where the device or remote stations are directly connected with each other. If there are "n" number of devices in mesh network then there should be (n-1) connection making ports should be present in each device or remote station. There are many benefits of mesh topology that there is less amount of traffic in the network, more reliable etc. If there is any connection failure then that failure will not create any disaster because there is already direct communication link between other devices [14]. Figure 1.9 is showing the Bus topology of the network.

1.4.5 Hybrid topology: Hybrid topology also known as mixed topology, is basically combination of all other network topology mentioned above [14]. For example: combination of star and bus topology is a hybrid topology. Advantages of hybrid topology are:

- Easy to diagnose and troubleshoot problems in hybrid network.
- More scalable.

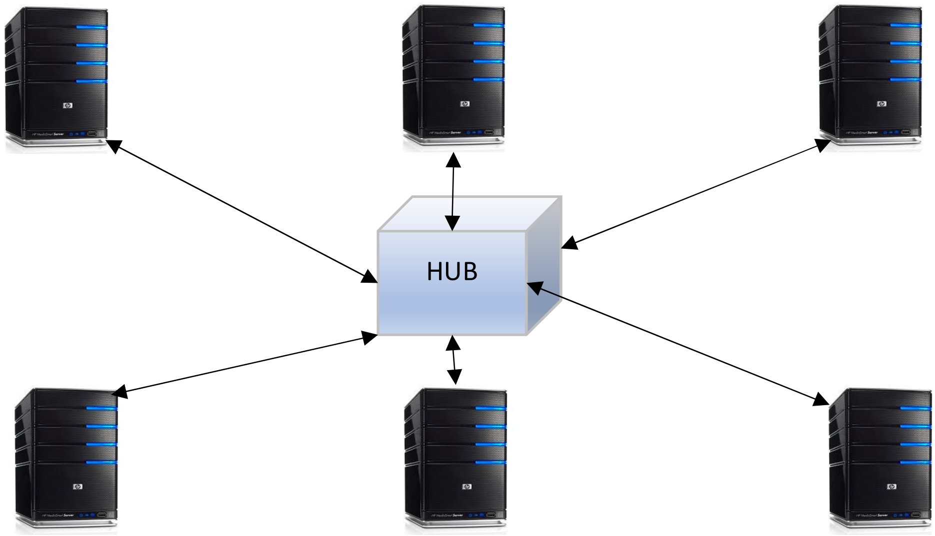

Fig 1.10: Star Topology

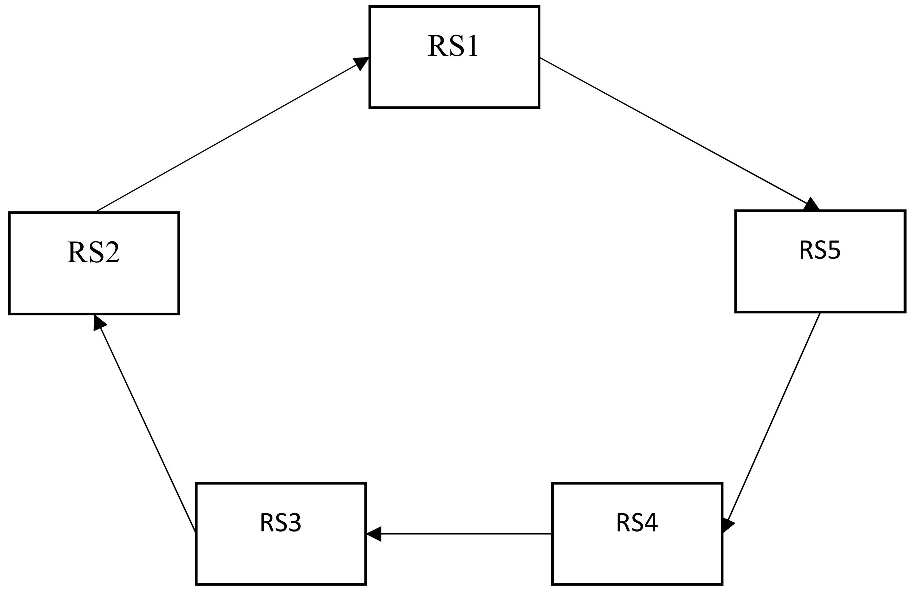

Fig 1.11: Ring Topology

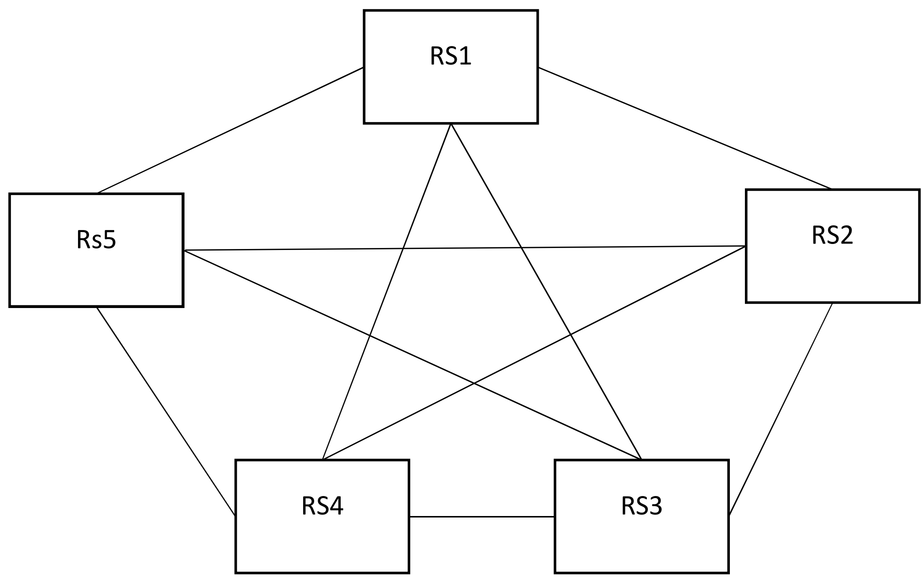

Fig 1.12: Mesh Topology

1.5 ABOUT EDGE MESH:

Sahani et al[13] proposed Edge Mesh computing model. They divide the computing model into three levels End device level, Edge device level and cloud level. Figure 1.10 showing the model of Edge Mesh.

End Device Level:

End device level there are devices called End devices which have the ability of sensing of data and changing it according to the requirement. This level comprises of two fundamental parts Sensing and Actuation, these two functionalities are upheld by these devices. These devices are connected with Edge Mesh Level.

EDGE MESH LEVEL:

In Edge mesh layer there are two types of devices are present in it that are Edge devices and Routers. They are interconnected with each other by mesh network. Routers are used to just route the information/data to the edge devices. Edge devices are connected to the cloud or to the end devices. The device which do the processing and make valid connection between various end devices. Mesh level is again divided into sub-levels Edge devices, Routers and Mesh wide level there are various functionalities of these levels.
Functionality parts of Mesh wide level are

- Data sharing.
- Task management.
- QoS provisioning.
- Security and Privacy.

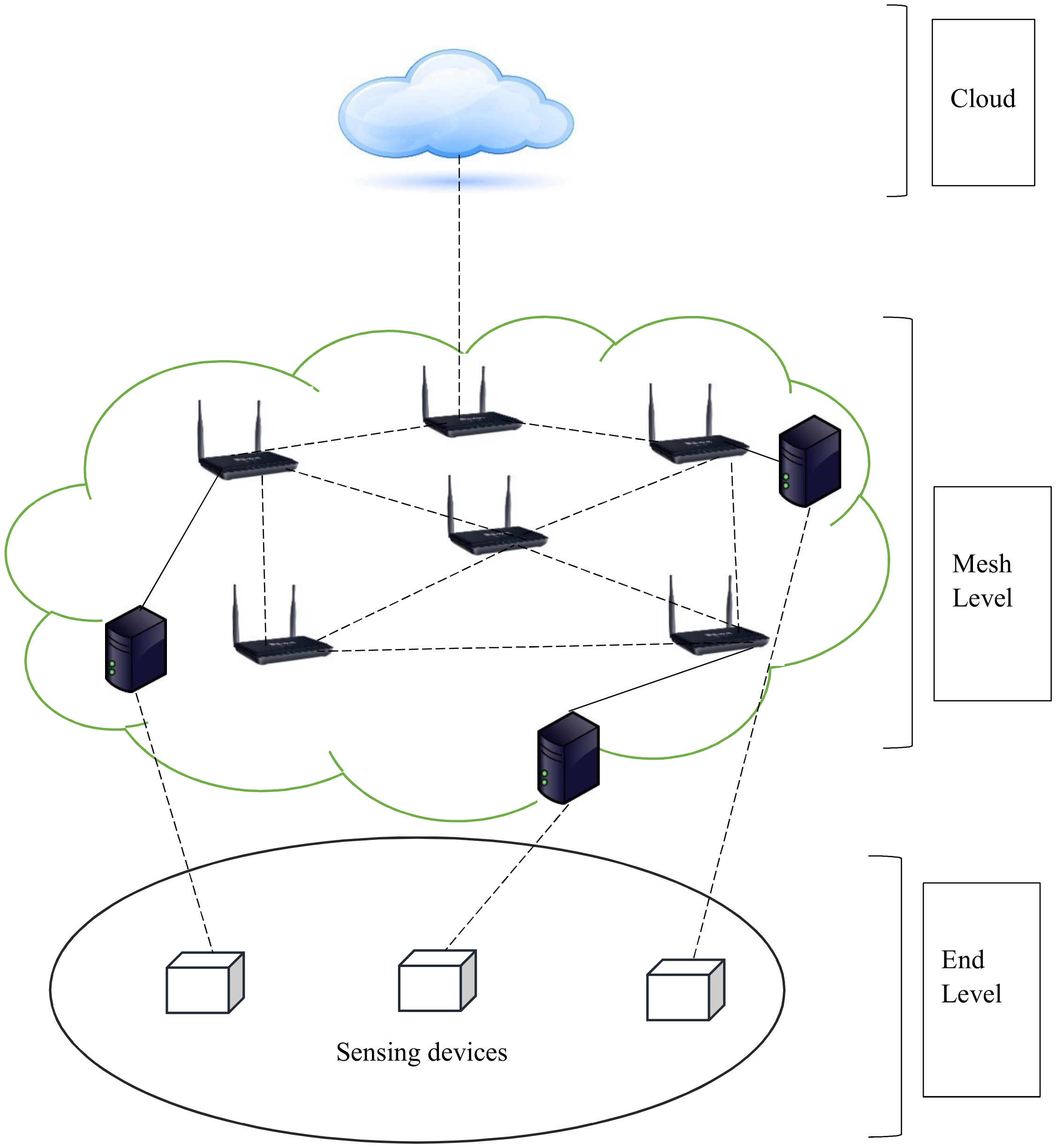

Fig 1.13: Model of Edge Mesh

Data Sharing:- The functionality of Data sharing component is not only to share the data but it also notice that which data is to be shared, how the data will be shared and also know that shared data is in right format and understood by the devices.

CHAPTER 2

LITERATURE SURVEY

2.1 RELATED WORK:

Raut et.al[5] give the concept smart city they mainly explain one objective i.e. Intelligent Transport System. They showed an architecture of VANET and explain its characterstics and also explain its safety and non safety applications. They concluded that if there is any damage in RSUs of VANET then there is no use of any traffic control techniques.

Sahni et.al[13] proposed a new computing model called Edge Mesh. They designed this model for the fast computation of the data. This model consists of three levels End device level, Edge level and Cloud level. In their model there are four types of devices End devices, Edge devices, Routers and Cloud. All type of computation is done on the Edge level. In their work they also proposed a task allocation algorithm for task allocation in the Edge level and to deploy distributed intelligence in the network.

Vidyarthi et.al[7] used genetic algorithm (GA) for the task allocation in Distributed Computing System (DCS). In genetic algorithm they used swapping of strings for the crossover operation. They done the mutation process by changing 0 to 1 and 1 to 0 randomly in task allocation matrix but they do mutation in such a way that number of 0's is equals to number of 1's in the matrix. They implemented their algorithm in C language and got the better results as compared to Shatz algorithm[8].

Kaminski et.al[9] compares and evaluate three different task allocation algorithm Full Search (FC), Window Stack Based Algorithm (WSBA), Random Node Check (RNC) in the dynamic mesh network. The simulate of these algorithms done on Python. The authors concluded that WSBA algorithm give the best results as compare to RNC and FC.

Yang et.al.[10] proposed modified version of Binary Particle Swarm Optimization algorithm. In this they use different-different parameters to check the performance of the algorithm the parameters are energy consumed by the device, total time taken by the task to execute, life time of a network. They also use mutation process of genetic algorithm in their modified version of BPSO.

Hussain et al.[6] proposed an VANET architecture that is they implies that they use cloud for Vehicular Ad hoc network. In their work they divide proposed architecture in three parts that is Vehicular cloud, Vehicles using cloud and inter vehicle cloud. They also give overview of issues in cloud that is security and privacy.

Soleymani et al.[4] gives fizzy logic to improve the security in the VANET (vehicular Ad Hoc network). In their work they five different-different algorithmic modules for the authentication of the vehicles like algorithm to check the lifetime of the message, algorithm to check the experience of the vehicle. They also implement they algorithm with fog nodes and get good results on the basis of Accuracy level (AL (with the help of fog nodes)), EL (Experience Level), PL (Plausibility Level). They used Euclidian distance formula to find distance between static vehicles and for moving vehicle they used RSSI (Received signal strength indicator).

Yick et al.[2] does the survey on wireless sensor networks. They give an overview that what problems or issues comes in the wireless sensor network. They divided the applications of wireless sensor networks in two types that is for the tracking purpose and for the monitoring purpose. Some of the application comes under tracking are tracking of enemies on boundaries, tracking of animals present in forests and farms etc. Some of monitoring applications are tracking of pressure, temperature comes under environment monitoring, factory, machine monitoring etc.

Kumar et.al [19] gives an Hybrid VANET model that is they combine the Vehicular Ad-Hoc Network with the Wireless Sensor Network to aware all other vehicles which are connected to that network about the wild life on that road to increase the safety in the travelling. In their work they deployed the WSN beside the roads. The used clustering to divide vehicles with On-Board-Units and sensor nodes deployed beside the roads. The clusters consist of mixtures of vehicles and sensor nodes.

Table 2.1: Summary of related work

Reference No.	Author	Paper Title	Objectives	Advantages/Merits
[5]	Chandrashekhar. M. Raut and_Satish. R. Devane	Intelligent transportation system for smart city using VANET	To improvise QoS in case of failure of communication in VANET with the support of RSU's.	They give an architecture of VANET and also analyses the problems will come in the VANET in future.
[13]	Yuvraj Sahni, Jiannong Cao, Shigeng Zhang, Lei Yang	Edge Mesh: A New Paradigm to Enable Distributed Intelligence in Internet of Things	1. To create new model for fast computation of the data or Information. 2. To provide distributed intelligence in the network. 3. Not only depend on the centralized	They proposed a new model called Edge Mesh computing model for the fast computation of the data or information.

			server for computation.	
[7]	Deo Prakash Vidyarthi_, Anil Kumar Tripathi, Biplab Kumer Sarker, Kirti Rani	Comparative study of two GA based task allocation models in distributed computing system	Get minimum turn around time in distributed computing system with the help of genetic algorithm.	In some para meters they get the good results but on other parameters the get very high valued results that are not good.
[9]	Rafal Kaminski, Leszek Koszalka, Iwona Pozniak-Koszalka_, Andrzej Kasprzak	Evaluation and Comparison of Task Allocation Algorithms for Mesh Networks	Comparison of three algorithms and check whether which algorithm is which algorithm is best for task allocation in mesh network.	In this work they concluded that WSBA (window stack based algorithm)is best among other two.
[10]	Jun Yang, Hesheng Zhang_, Yun Ling_, Cheng Pan, Wei Sun	Task Allocation for Wireless Sensor Network Using Modified Binary Particle Swarm Optimization	To design an algorithm for task allocation in devices by modifying the BPSO (Binary Particle Swarm	They generate or design modified version of BPSO algorithm with the help of genetic algorithm.

			Optimization) algorithm.	
[6]	Rasheed Hussain, Junggab Son, Hasoo Eun_, Sangjin Kim, Heekuck Oh	Rethinking Vehicular Communications: Merging VANET with Cloud Computing	To shift the VANET to cloud that is VCC (Vehicular cloud computing).	They proposed an VANET architecture with the cloud and divide that architecture in three parts: VC (Vehicular cloud), VuC (Vehicles using cloud), HVC (Hybrid vehicular cloud (Inter vehicle cloud)).
[4]	Seyed Ahmad Soleymani, Abdul Hanan Abdullah, Mahdi Zareei, Mohammad Hossein Anisi, Cesar Vargas-Rosales, Muhammad Khurram Khan, Shidrokh Goudarzi	A Secure Trust Model Based on Fuzzy Logic in Vehicular Ad Hoc Networks With Fog Computing	The main objective of authors is to make Vehicular ad hoc network more secure using fog computing.	They provide different-different Authentication modules for the Vehicles like check the experience level of vehicle, lifetime of message produces by the vehicle.
[2]	Jennifer Yick, Biswanath Mukherjee, Dipak Ghosal	Wireless sensor network survey	The main objective of the authors is to do survey on	In their work they discuss different-different types of wireless sensor

			current scenarios and applications of the wireless sensor network.	network like under water sensors, wireless sensor networks which are present deep down the ground.
[19]	Amrish Kumar and Mr. Shri Niwashn	Implementation of VANET in Transportation using Wireless Sensors	The main objective of their work is to use the wireless sensor network in the VANET.	In their work they deployed the short-range communication devices like ZigBee etc. beside the road. They use random clusters to partitioned the sensor nodes and vehicles in different groups.

CHAPTER 3
METHODOLOGY

3.1 PROBLEM STATEMENT:

As we all know that now days there is a lot of devices connected to the cloud and all type of processing, storage etc. is done on the cloud. As mentioned above there will be 34 billion devices connected to the internet in 2020 and produce huge amount of data which will possess various limitations like congestion, latency problem, etc.

Due to increase in vehicles day by day world - wide. According to a research by Gartner it is also predicted that in 2020 there will be one out of five vehicles on the road are connected with the internet so, there will be 250 million vehicles in the VANET. So according to conclusion of these researches there will be lot of congestion in the cloud because all the computation done in the cloud. This will also lead to delay in the transmission of the information in VANET.

The already existing architectures of VANET relies typically on cloud for their functionality [5]. So, in coming years there will be problem in the validity of the information in VANET (because of delay in information passing). So, in order to overcome these forthcoming problems in VANET, we shift the computation of the data in VANET to the lower level i.e. computation of the data will not be done on cloud. Cloud will used to store the historic data and will used for historic data analysis.

As mentioned above computation of the data or information will not done on the cloud, so the computation will be done on the layer 2 as given in the figure 1.10. Now there is occurrence of another problem that is how task will be managed or computed in lower level because single device cannot manage the task (some tasks have huge requirement that will be not fulfilled by the single device) this task management problem also known as task allocation problem. So, due to this reason there must be a solution to manage the tasks.

In this work I proposed a task allocation algorithm for the task allocation in the RSU's with the help of genetic algorithm.

3.1.1 REPRESENTATION OF TASK ALLOCATION PROBLEM:

We defined our task allocation problem in RSU's as directed acyclic graph (DAG) G(ST, Dep) here ST is set of tasks that is {1,2,3,4,5….m} and Dep are the dependencies. Figure 3.1 showing the graphical representation of task.

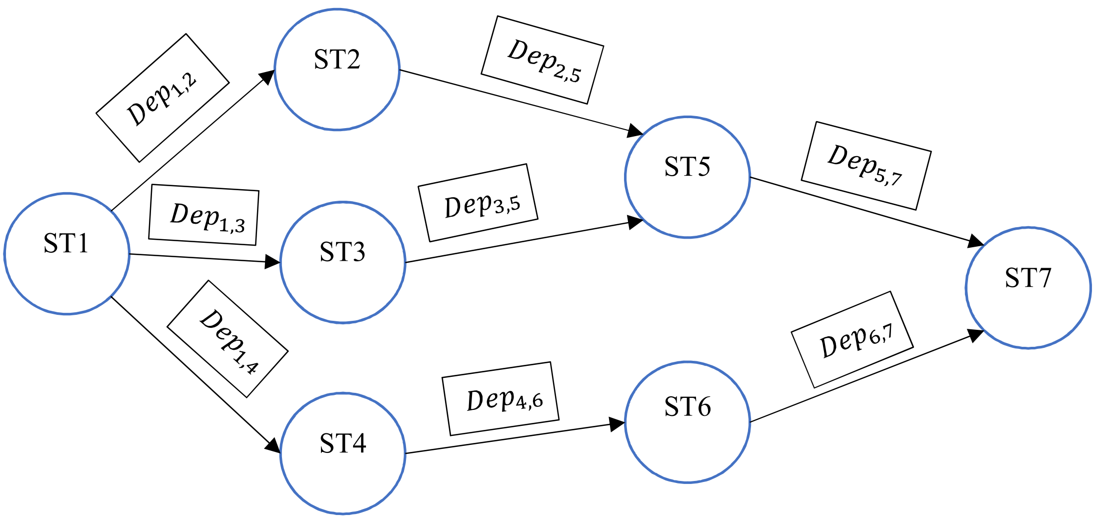

Fig 3.1: Graphical representation of task graph.

In this work I have developed an algorithm for the task allocation when the tasks are divided into sub tasks that is tasks are not independent they depend on each other.

3.2 PROPOSED SOLUTION:

As we have already discussed that the already existing architectures of VANET relies typically on cloud for their functionality [5]. So, in coming years there will be problem in the validity of the information in VANET (because of delay in information passing) so to overcome these problems I have proposed modified architecture for VANET with mesh network combined in it. Figure 3.2 is showing the proposed architecture of the VANET.

This architecture is basically consist of three layer i.e:

1. Layer 1.
2. Layer 2.
3. Layer 3.

In this model we made assumption that RSU's are connected in mesh network with each other.

Layer 1: This layer consists of vehicles, cameras, traffic lights and other sensing devices. In this layers vehicles are wirelessely connected with each other (Directely or Indirectely [4]) with the help of OBU's (On Board Units).

Layer 2: This layer consists of RSU's. According to [11] RSU's are used together with the vehicles as an access point to circulate the information in the network. But in our model, we considered that RSU's are the devices which can do computation and transmission of the information or data. These devices can be provided by the service providers of that area. These RSU's are connected in a Mesh Network. In mesh network stations (RSU's) are connected directly with each other. In this layer computation of tasks is done which comes from the layer 2. The data is in the form of images which is saved in the form of matrix so, the data comes in the form of matrix is in numeric form which is easily computed by the RSU's. There will be very rare congestion in this network because each and every RSU is connected wirelessly with each other. Here in this layer task allocation is done for in RSU's that is tasks are divided in such a way that there will be less consumption of the energy in the RSU's.

Layer 3: This layer is known as Mass Storage layer. It consist of Cloud. The term which is titled as a cloud is reffered as a getting the information or data from other computers by accessing them and also accessing the software progams by the means of connectivity of the network. We know that cloud provide many resources like huge storage space, fast communication, development tools etc. Cloud is also used for Historical data analysis in this proposed architecture.

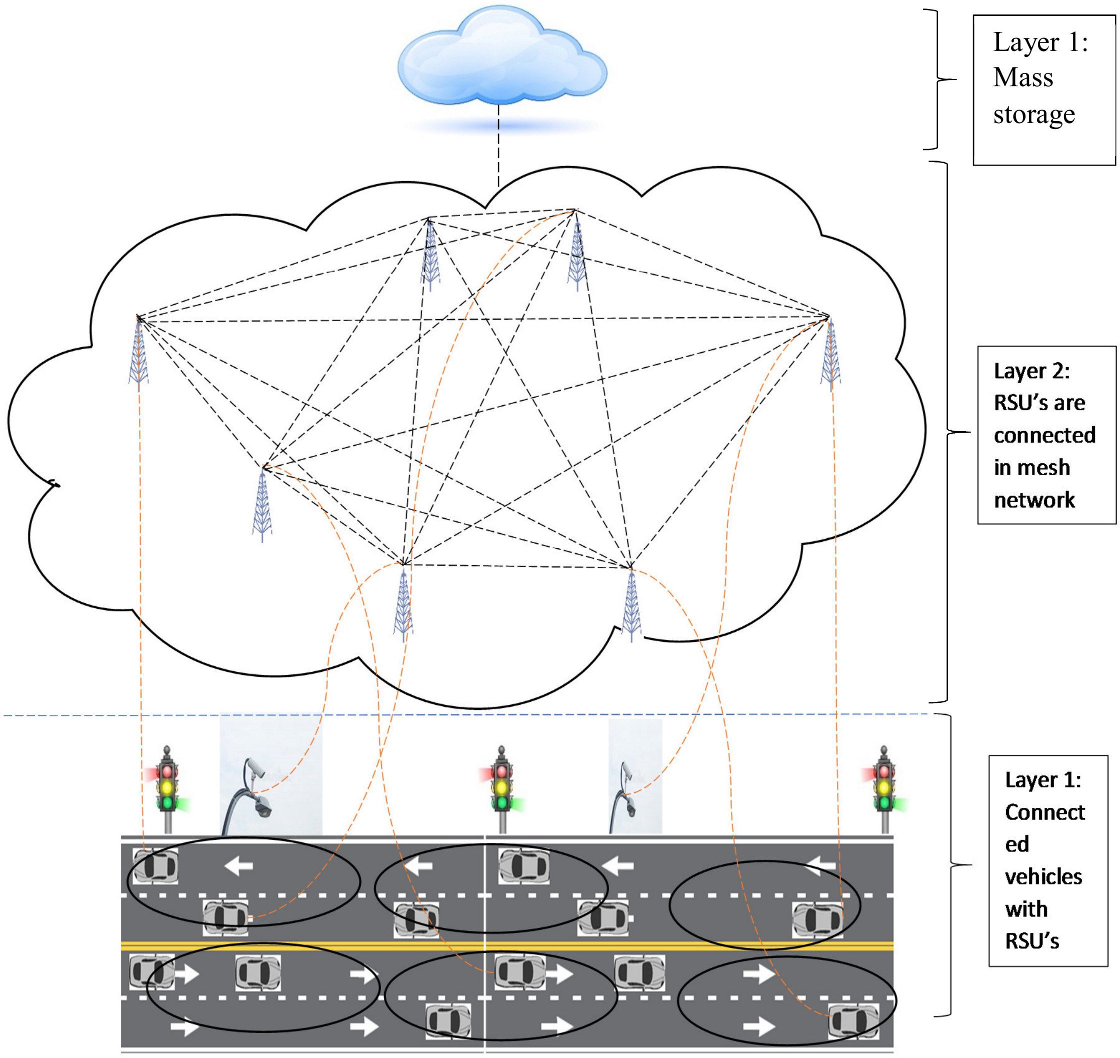

Fig 3.2: Proposed architecture

3.2.1 SOLUTION FOR TASK ALLOCATION PROBLEM:

This section describes that how the task will be allocated in mesh network of RSU's. For the task allocation we use Genetic algorithm. "Genetic algorithms are based on the process of evolution by natural selection which has been observed in nature". In genetic algorithm we can get the results according to our requirement with the help of fitness function and after getting the fit individual by using fitness function we again get the fittest offspring from the newly generated population.

3.2.1.1 ABOUT GENETIC ALGORITHM:

Genetic algorithm is an approach to formulize bounded optimization and unbounded problems relies on natural criteria of the selection. These criteria of selection are acquired from biological progression. Genetic algorithm gives outperforming results to find output of complex searching problems. Genetic algorithm is used to find optimal result by applying different-different processes or operations within the algorithm. Genetic algorithm is also used to create algorithms in the area of computers or networks like allocation of the tasks, algorithm for scheduling and another algorithm relies on optimization.
There are different types of processes involved in the Genetic Algorithm that is:

1. Initialization process.
2. Evaluation process.
3. Selection process.
4. Crossover operation.
5. Mutation process.

1. Initialization process: In this process there is initialization of population is done that is in this process there is creation of the initial population. The size of generation of initial population is not fixed. It can be of any size that is very few amounts of

generation of population to huge amount of generation of population, population size can be in thousands. This process of generation of population is done randomly.

2. Evaluation process: In this process each and every member of initialized population is evaluated. The evaluation is done on the basis of our own requirements like in biological terms we need persons from the generated population have height more than five feet's and in case of generation of an algorithm for networks for task allocation the fitness is depends on the energy consumption in the whole network. In this process we create a function called fitness function as per our own requirements.

3. Selection Process: In order to improve whole fitness of the population we use selection process. This process is done after evaluation process. In this process we select the best population from the newly generate population after fitness function. The main idea of this process is to do more filtration in the population. In the generation of task allocation algorithm there is selection procedure called as Roulette Wheel selection is commonly used.

4. Crossover operation: In cross operation process is basically a probability to get fittest individual after crossover process. In this process we generate new population of the individuals by combining the two or more than two individuals which is selected after the selection process. The newly generated individual is also known as the offspring of the individuals from where they are generated.

5. Mutation Process: In this process now, we added some small amount randomness in the newly generated population after crossover operation. The main reason of the adding randomness in our population is that whenever we combine or associate the new generation generated after crossover process the it will give us our initial population in return. Figure 3.3 is showing the processes in Genetic Algorithm

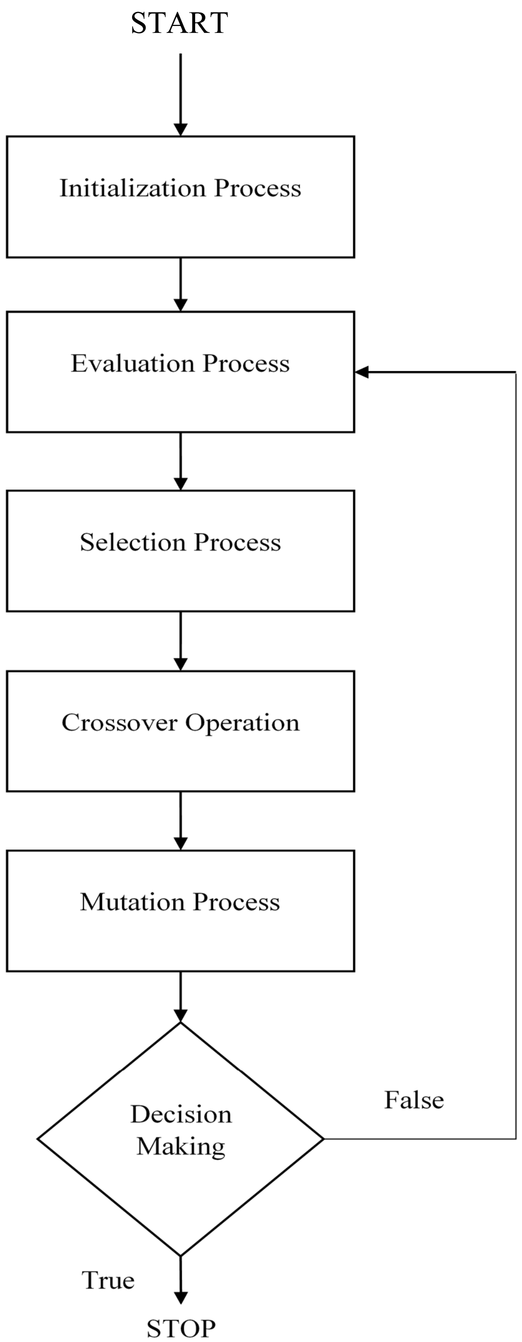

Fig 3.3: Workflow of processes in genetic algorithm

Algorithmic steps of Genetic Algorithm:

STEP 1: Create initial population Randomly (p_{size}) with the help of 2-D array (matrix) this will shows us where the tasks is processing.
STEP 2: Now find the cost of the devices by using cost function.
STEP 3: Find fitness function which is just inverse of cost function i.e. less the cost value greater the fitness value.
STEP 4: Selection is done in this step. We have done selection randomly.
STEP 5: Crossover operation is done on the selection. It is done by swapping some of the last rows with first rows of another selected matrix.
STEP 6: In this step mutation is done. Mutation is done by exchanging rows (within a matrix).
STEP 7: Repeat steps from 2 to 6 as per the desired iterations ($\mathrm{NUM_{iter}}$).

3.2.1.2 TASK ALLOCATION WITH GENETIC ALGORITHM (PROPOSED):

In this algorithm we use communication energy as a fitness function. Initially the population of zero's and one's is created randomly in the form of matrix (E_{pq}). In this population matrix (p ≥ q) because number of tasks always greater than the number of RSU's and E_{xa} are the elements of the matrix (E_{pq}).

Task Graph: In task graph representation of tasks and their dependencies is on directed acyclic graph (DAG) i.e. G(ST, Dep) where ST is task {1,2,3,4,5,6,7,…,m} and Dep is dependencies between them [3] Fig 3.1.

Communication Network Model: In our given architecture for VANET the RSU's are connected in mesh network so all the data can be shared frequently. So due to mesh network data can be send to (n-1) RSU's (n is number of RSU's). Representation of graph is given by NG(R,D_{dis}) where R is a set of RSU's in a network {RSU1, RSU2, RSU3,…,RSUn} and Q_{dis} is distance between RSU's.

Waiting queue of a Task: In waiting queue there are tasks waiting for their execution when there is already a task running in the RSU only one task is executed at a given time.

Table 3.1: Variables used and their explanation

t_x	Task x
p_x	Computation load for execute task x
e_a	Average consumption power of a RSU
vel_a	Speed of processing of a RSU a_a
e_{bit}	Energy required to operate each bit of data on a device
e_{amp}	Transition coefficient
Q_{dis}	Distance between two RSU's
$L_{x,s}$	Size of data in bits transferred from RSU s to process task t_x
abs(a-s)	Use to determine that a_a and a_s are same RSU
abs $(c_{xa} - c_{ya})$	Tasks are processed on same RSU
$Dep_{y,x}$	Size of data in bits transferred in between task t_y and t_x (dependencies)
Y_x	Total devices on which data (input) is divided for task t_x
Z_x	Number of tasks executed before execution of task t_x

Cost Function [13]:

i) Total cost of processing all tasks is:

$$\text{Totalcost}= \sum_x \sum_a E_{x,a} \qquad (1)$$

ii) Total cost of processing task t_x on RSU a_a is:

$$X_{x,a} = \sum(X_{compt}, X_{comn}, X_{cot}) \qquad (2)$$

Here X_{compt},X_{comn},X_{cot} are costs of executing a task t_x on RSU a_a, cost of communicating information for task t_i executed on RSU a_a, cost of communicating information for task t_i from its predecessor task.

iii) Cost of processing a task t_x on RSU a_a

$$X_{comp} = e_a\ (P_x /\ vel_a) \qquad (3)$$

iv) Cost of communicating information for task t_x executed on RSU a_a: In this cost function if a and s are device then $X_{(comn,trans)}, X_{(comn,rec)}$ become zero so, X_{comn} also becomes zero.

$$X_{comn} = X_{comn,trans} + X_{comn,rec} \qquad (4)$$

$$X_{(comn,trans)} = \sum_s(((e_{ebit} + (e_{amp} * (Q^2_{dis\ (as)})) * L_{x,s}) * \text{abs(a} - \text{s)}) \qquad (5)$$

{for s=1 to Y_x}

$$X_{(comn,rec)} = \sum_s((e_{bit} * L_{x,s}) * (\text{abs(a} - \text{s)})) \quad \{\text{for s=1 to } Y_x\} \qquad (6)$$

v) Communication cost from predecessor task: In this cost function if two tasks are processed on same device then $X_{(cot,trans)}, X_{(cot,rec)}$ become zero so, X_{cot} also becomes zero.

$$X_{cot} = X_{(cot,trans)} + X_{(cot,rec)} \qquad (7)$$

$$X_{(cot,trans)} = \sum_y (((e_{bit} + e_{amp} * (Q^2_{(a,y)})) * Dep_{(y,x)}) * (\text{abs}(\text{c}_{\text{xa}} - \text{c}_{\text{ya}}))) \qquad (8)$$

{for y=1 to Z_x}

$$X_{(cot,rec)} = ((e_{bit} * Dep_{(y,x)}) * (\text{abs}(\text{c}_{\text{xa}} - \text{c}_{\text{ya}}))) \qquad (9)$$

{for y=1 to Z_x}

Crossover Operation: Members selected for the crossover operation is $GEN_{gap} * NUM_{iter}$. Crossover operation is done by selecting two matrices randomly from selected members and then change the positions of elements with each other position where (p > q). Figure 3.4 showing the procedure of crossover operation.

Mutation: In our given algorithm the mutation is done within single matrix by selecting a row of the matrix randomly and swapping that selected row with $(n-2)^{th}$ row of the matrix. If randomly selected row is $(n-2)^{th}$ row then the selected row is swapped by first row of the matrix.

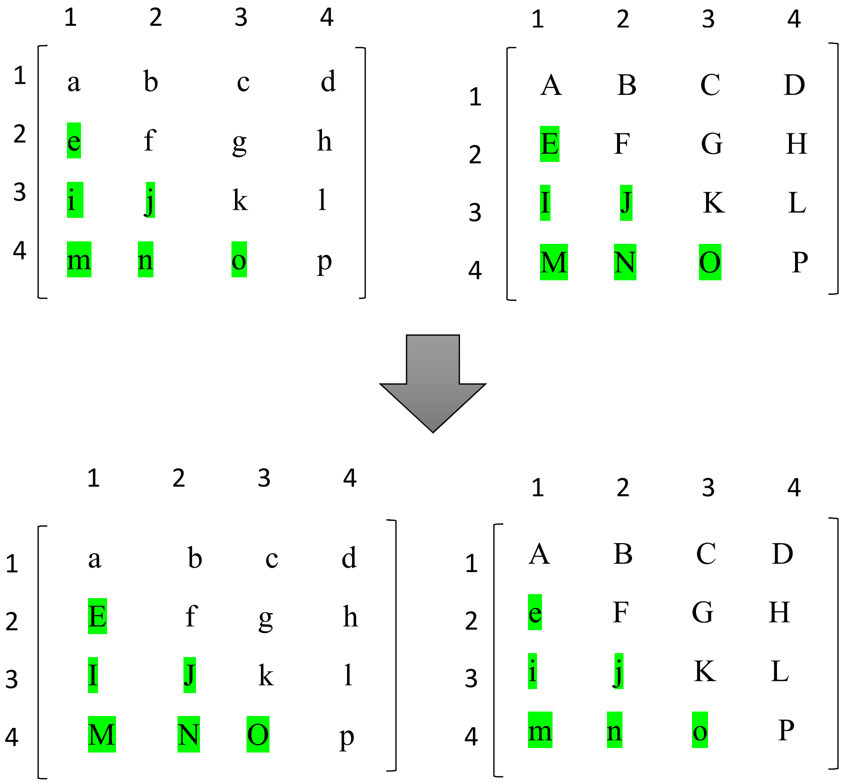

Fig 3.4: Crossover operation

In the proposed genetic algorithm, the inputs are GEN_{gap}, P_{size}, MUT_{rate}, NUM_{iter}.

PSEUDOCODE OF PROPOSED ALGORITHM:

i) R← Randomly generated population (P_{size});
ii) Initialize generation to one.
iii) if (generation<= $\mathrm{NUM}_{\mathrm{iter}}$)
iv) {
v) Totalcost← Totalcostfxn();
vi) Fitnessofpopulation← inverseoftotalcost();
vii) Selection← random selection from Fitnessofpopulation();
viii) Set x← 1;
ix) While(x< $\mathrm{GEN}_{\mathrm{gap}}$*$P_{size}$)
x) {
xi) Crossover operation();
xii) Increment x by 3;
xiii) }
xiv) Mutation();
xv) }

CHAPTER 4

EXPERIMENTAL RESULTS AND ANALYSIS

4.1 TOOL USED:

In this work MATLAB R2016a is used as a tool to perform simulation of the proposed algorithm and to carry out results.

MATLAB short for MATrix LABoratory came into existence in 1970, is a software platform for performing varied potential tasks such as Image processing, data plotting in 2-Dimension and 3-Dimension, employment of algorithms and animations, platform and language independent interface with programs, etc. MATLAB is widely used due to its simplicity and time saving programming [17].

Windows in MATLAB R2016a:

- Command Window.
- Graphics Window.
- Editor Window.

Command Window: Figure 4.1 shows the screen sort of the Command window.

Fig 4.1: Command Window

Graphic Window: Figure 4.2 shows the screen sort of the command window.

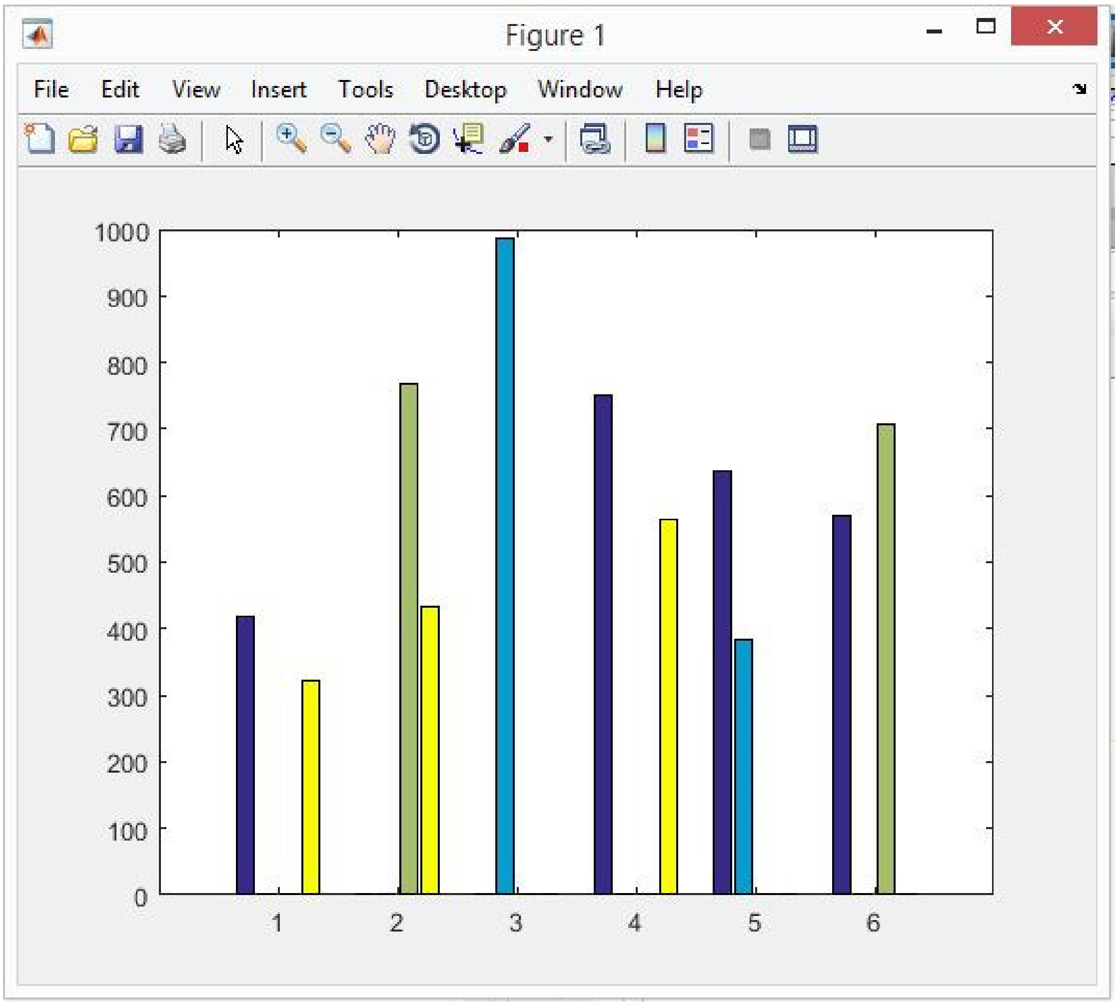

Fig 4.2: Graphic Window

Editor Window: Figure 4.3 shows the screen sort of the Editor window.

Fig 4.3: Editor Window

Features of MATLAB: There are lot of features in MATLAB, some of the feature of MATLAB are Manipulation of data and Reduction, Mathematical computations, Graphical representation and virtualization of object in 3-D and 2-D. Figure 14 shows the feature of MATLAB. Figure 4.4 showing features of MATLAB.

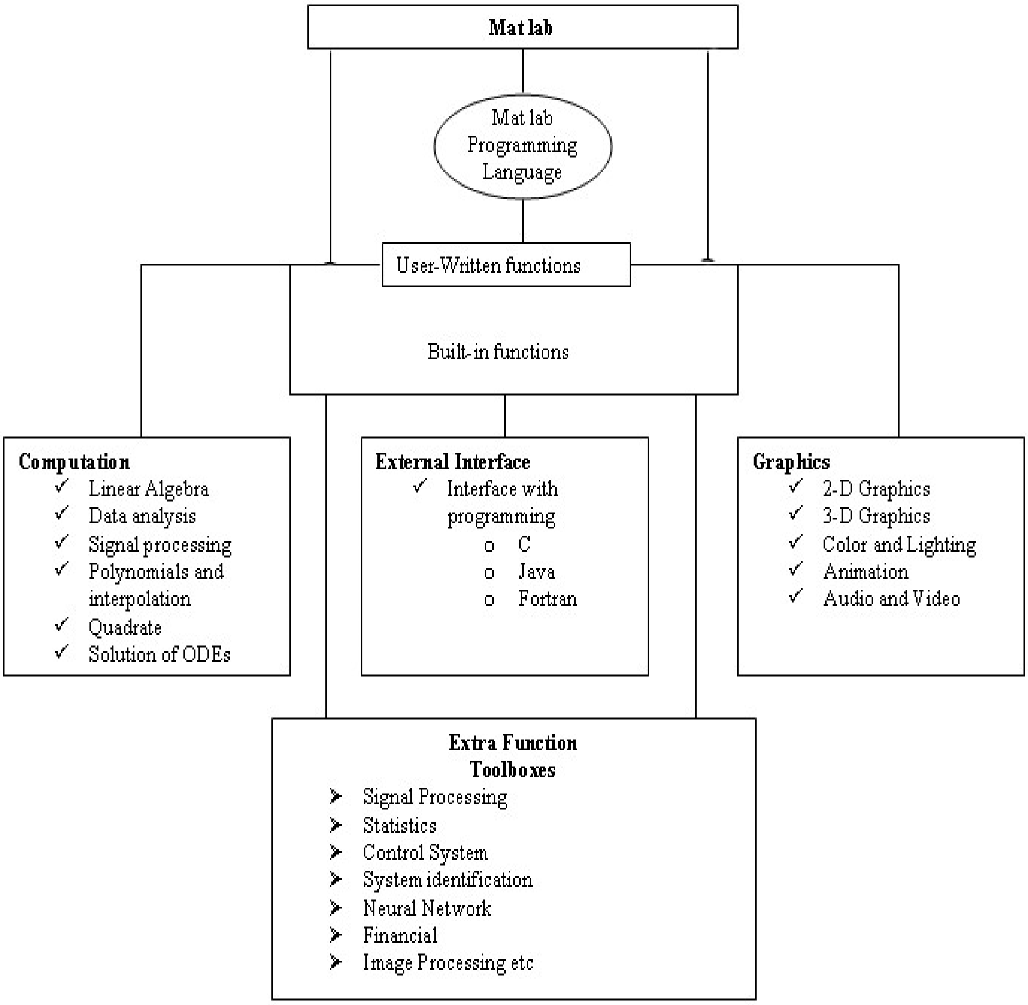

Fig 4.4: Features of MATLAB

4.2 IMPLEMENTATION AND EXPERIMENTAL RESULTS:

Firstly, proposed algorithm is applied in the second layer of proposed architecture where the RSU's are connected in mesh network. The proposed algorithm is simulated in MATLAB (R2016a). In this work population of zero's (0) and one's (1) is created randomly in the form of matrix and added constraint that only one task is executed in the RSU at a given point of time. In this matrix of task allocation number of tasks are greater than number of RSU present in the network. In this task allocation matrix, one represents the execution of the task and zero represents no task is executing on that node.

After creating the population randomly, we find the fitness of the task allocation matrix with the help of fitness function. Fitness value is just the inverse of the cost value of task allocation matrix as mentioned above in chapter 3.

Now after getting the cost value and fitness value from fitness function we applied the selection procedure. In this given algorithm we done the selection procedure randomly, so new fittest individuals are produced.

After selection crossover operation is performed between every two or more newly generated individuals as shown in chapter 3. Now new offspring are produced. These new offspring are our newly generated population. In this population we do mutation operation. Now we repeat the steps for thirty times and after that we get the results.

We run this algorithm for thirty times and get the cost value and the fitness value before and after crossover operation and mutation.

ENVIRONMENTAL SETUP:

We set our environment according to the parameters given in [3]. Here bandwidth is 250Kbps, energy required to process each bit of data on a device (e_{ebit}) is 50nJ/b, transmit amplifier coefficient (e_{amp}) is 10p/J/m^2, energy consumption of device a (e_a) is between [4,10] (milli Watt), uniform distribution of computation load (p_x) is between [300,600] (KILO CLOCK CYCLES), uniform distance between the devices ($Q_{dis(a,s)}$) is between [1,500] meters, we take amount of data in bytes send from every input data source ($L_{x,a}$) in between the range of [300,1000] and is uniformly distributed, speed of processing of a device (vel_a) is between [30,100] (MILLION CYCLES PER SECOND). Now the parameters for genetic algorithm are population size (P_{size}) is 20, generation gap ($\mathrm{GEN_{gap}}$) is 0.8, mutation rate ($\mathrm{MUT_{rate}}$) is 0.04, number of iteration ($\mathrm{NUM_{iter}}$) is 30.

Table 4.1: Showing results of each run.

Run Count	Time (sec)	Cost Before Crossover and Mutation	Fitness Before Crossover and Mutation	Cost after Crossover and Mutation	Fitness After Crossover and Mutation
1.	0.000833	0.0765	13.0676	0.0673	14.8479
		0.0572	17.4873	0.0673	14.8549
		0.1414	7.0742	0.0674	14.8409
		0.0800	12.4993	0.0674	14.8409
2.	0.000682	0.0791	12.6434	0.0664	15.0675
		0.0940	10.6418	0.0663	15.0741
		0.0842	11.8825	0.0665	15.0415
		0.0781	12.7974	0.0665	15.0415
3.	0.000643	0.0519	19.2776	0.0921	10.8632
		0.0484	20.6601	0.0922	10.8503
		0.1275	7.8388	0.0921	10.8546
		0.1055	9.4805	0.0914	10.9414
4.	0.000678	0.0770	12.9868	0.0548	18.2555
		0.0718	13.9226	0.0548	18.2328
		0.0674	14.8459	0.0547	18.2896
		0.0634	15.7650	0.0547	18.2782
5.	0.000689	0.0815	12.2628	0.0623	16.0432
		0.0768	13.0174	0.0623	16.0432
		0.1294	7.7283	0.0619	16.1620

		0.0640	15.6198	0.0622	16.0695
6.	0.000747	0.0655	15.2785	0.1080	9.2554
		0.0796	12.5694	0.1080	9.2554
		0.1040	9.6134	0.1077	9.2824
		0.1296	7.7181	0.1087	9.2790
7.	0.000687	0.1033	9.6831	0.1513	6.6112
		0.0425	23.5144	0.1511	6.6182
		0.0756	13.2291	0.1512	6.6147
		0.1632	6.1258	0.1511	6.6199
8.	0.000731	0.0747	13.3930	0.0395	25.3288
		0.0791	12.6392	0.0395	25.3288
		0.0792	12.6310	0.0394	25.3973
		0.0427	23.4079	0.0394	25.3973
9.	0.001475	0.1328	7.5275	0.0773	12.9431
		0.1212	8.2485	0.0773	12.9431
		0.0770	12.9831	0.0772	12.9483
		0.0966	10.3468	0.0772	12.9483
10.	0.000738	0.0746	13.4062	0.0619	16.1463
		0.0753	13.2841	0.0621	16.0968
		0.0688	14.5260	0.0620	16.1265
		0.0740	13.5078	0.0620	16.1265
11.	0.000714	0.0903	11.0790	0.0422	23.7223
		0.0506	19.7684	0.0419	23.8839
		0.0966	10.3522	0.0425	23.5431
		0.0509	19.6331	0.0422	23.7022
12.	0.000723	0.0744	13.4450	0.0508	19.6720
		0.1004	9.9571	0.0509	19.6498
		0.1203	8.3133	0.0511	19.5615
		0.0608	16.4394	0.0511	19.5505
13.	0.000713	0.0618	16.1757	0.0882	11.3439

		0.0905	11.0543	0.0882	11.3387
		0.1040	9.6129	0.0880	11.3439
		0.0998	10.0168	0.0879	11.3748
14.	0.000712	0.0753	13.2716	0.0961	10.4006
		0.0907	11.0306	0.0963	10.3866
		0.1081	9.2508	0.0960	10.4146
		0.1100	9.0901	0.0963	10.3866
15.	0.000704	0.0794	12.5435	0.0532	18.8106
		0.0800	12.5055	0.0533	18.7624
		0.0553	18.0768	0.0532	18.7865
		0.0726	13.7773	0.0534	18.7264
16.	0.000692	0.0420	23.8050	0.0587	17.0396
		0.0817	12.2378	0.0589	16.9768
		0.0561	17.8277	0.0588	17.0186
		0.0808	12.3698	0.0588	17.0081
17.	0.000715	0.0650	15.3862	0.1103	9.0646
		0.0848	11.7906	0.1101	9.0831
		0.0652	15.3277	0.1102	9.0739
		0.1268	7.8894	0.1101	9.0800
18.	0.000706	0.0445	22.4468	0.0442	22.6427
		0.0421	23.7422	0.0440	22.7293
		0.2108	4.7430	0.0441	22.6600
		0.0551	18.1584	0.0442	22.6254
19.	0.001008	0.0730	13.6970	0.0480	20.8278
		0.0717	13.9462	0.0480	20.8407
		0.0729	13.7182	0.0478	20.9187
		0.0584	17.1105	0.0477	20.9448
20.	0.000746	0.0978	10.2259	0.0757	13.2187
		0.0568	17.6159	0.0755	13.2466
		0.0791	12.6443	0.0755	13.2373

		0.0924	10.8229	0.0757	13.2094
21.	0.000656	0.0856	11.6767	0.1100	9.0900
		0.1652	6.0525	0.1102	9.0733
		0.0801	12.4837	0.1101	9.0805
		0.1240	12.4837	0.1102	9.0781
22.	0.000702	0.1453	6.8808	0.0941	10.6321
		0.1472	6.7952	0.0939	10.6448
		0.0918	10.8948	0.0939	10.6448
		0.1167	8.5678	0.0939	10.6490
23.	0.000721	0.0570	17.5377	0.0341	29.2831
		0.0463	21.5761	0.0342	29.2395
		0.1106	9.0419	0.0340	29.3926
		0.0421	23.7257	0.0341	29.2831
24.	0.000645	0.0518	19.3227	0.0580	17.2370
		0.0427	21.2019	0.0577	17.3459
		0.1321	7.5673	0.0578	17.2863
		0.0660	15.1504	0.0578	17.2863
25.	0.000730	0.0648	15.4250	0.0636	15.7308
		0.0586	17.0723	0.0636	15.7149
		0.0663	15.0718	0.0636	15.7229
		0.0735	13.6037	0.0636	15.7229
26.	0.000680	0.0543	18.4269	0.1153	8.6732
		0.0583	17.1646	0.1152	8.6808
		0.0877	11.4081	0.1153	8.6707
		0.1273	7.8558	0.1152	8.6833
27.	0.000743	0.1907	9.1182	0.0716	13.9638
		0.0578	17.2881	0.0718	13.9231
		0.1380	7.2462	0.0717	13.9383
		0.0861	11.6118	0.0717	13.9434
28.	0.000714	0.0668	14.9748	0.1304	7.6703

		0.0591	16.9163	0.1302	7.6797
		0.0800	12.5003	0.1302	7.6781
		0.1469	6.8062	0.1302	7.6781
29.	0.001078	0.0705	14.1816	0.0496	20.1748
		0.0998	10.0184	0.0496	20.1748
		0.0774	12.9274	0.0497	20.1375
		0.0581	17.2045	0.0495	20.1873
30.	0.000745	0.0663	15.0809	0.0573	17.4651
		0.0547	18.2898	0.0572	17.4973
		0.1231	8.1216	0.0573	17.4651
		0.0627	15.9458	0.0568	17.5947

Table 4.2: Average of the results of each run.

Run Count	Average Cost before Crossover and Mutation	Average Fitness before Crossover and Mutation	Average Cost after Crossover and Mutation	Average Fitness after Crossover and Mutation
1.	0.08878	12.5321	0.06735	14.8462
2.	0.08385	11.9912	0.06643	15.0562
3.	0.08332	14.3142	0.09195	10.8774
4.	0.0699	14.38	0.05475	18.264
5.	0.08792	12.1571	0.06218	16.0794
6.	0.09468	11.2948	0.1081	9.26805
7.	0.09615	13.1381	0.1512	6.616
8.	0.06892	15.5178	0.03945	25.36305
9.	0.1069	9.7765	0.07725	12.9457
10.	0.07318	13.681	0.062	16.12403
11.	0.0721	15.2082	0.0422	23.71288
12.	0.08898	12.0387	0.05098	19.60845
13.	0.08902	11.7149	0.08508	11.35033
14.	0.09602	10.6608	0.09618	10.3971
15.	0.07182	14.2258	0.05328	18.77148
16.	0.06522	16.5601	0.0588	17.01078
17.	0.08545	12.5984	0.11018	9.0754
18.	0.08812	17.2726	0.04412	22.66435
19.	0.069	14.618	0.04788	20.883
20.	0.08152	12.8272	0.0756	13.228
21.	0.11372	10.6742	0.11012	9.080475
22.	0.12525	8.2846	0.09395	10.64268
23.	0.06412	17.9704	0.0341	29.29958
24.	0.07315	15.8106	0.05782	17.28888

25.	0.0658	15.2932	0.0636	15.72288
26.	0.0819	13.7138	0.11525	8.677
27.	0.11815	11.3161	0.0717	13.94215
28.	0.0882	12.7994	0.13025	7.67655
29.	0.07645	13.583	0.0496	20.1686
30.	0.0767	14.3595	0.05715	17.50555

Table 4.3: Results of algorithm.

Performances Matrices	Genetic Algorithm
Average fitness value before crossover and mutation	13.34374
Average fitness value after crossover and mutation	15.40487
Average time taken for execution (ms)	0.758333
Total cost of communication before crossover and mutation (J)	0.08481
Total cost of communication after crossover and mutation (J)	0.074283

Figure 4.5 and 4.6 compares the average cost and average fitness value before and after crossover and mutation respectively. From the graph of figure 4.5 and 4.6 it is clear that the cost is less after crossover and mutation while fitness is greater after crossover and mutation as compared to without crossover and mutation process.

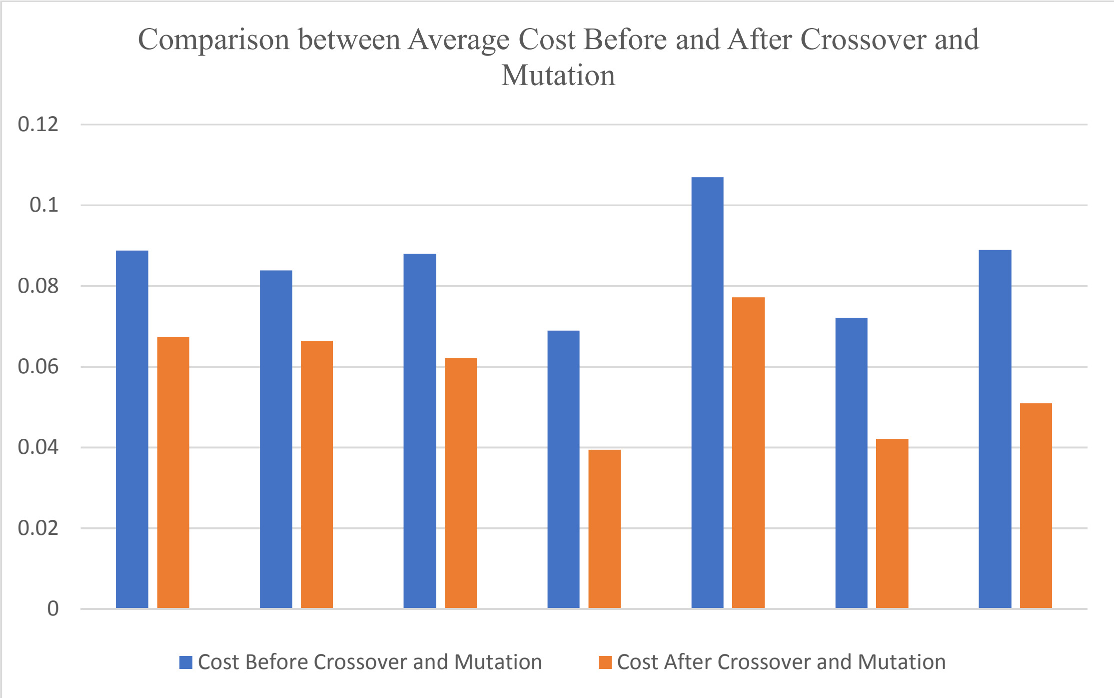

Fig 4.5: Comparison between Average Cost Before and After Crossover and Mutation

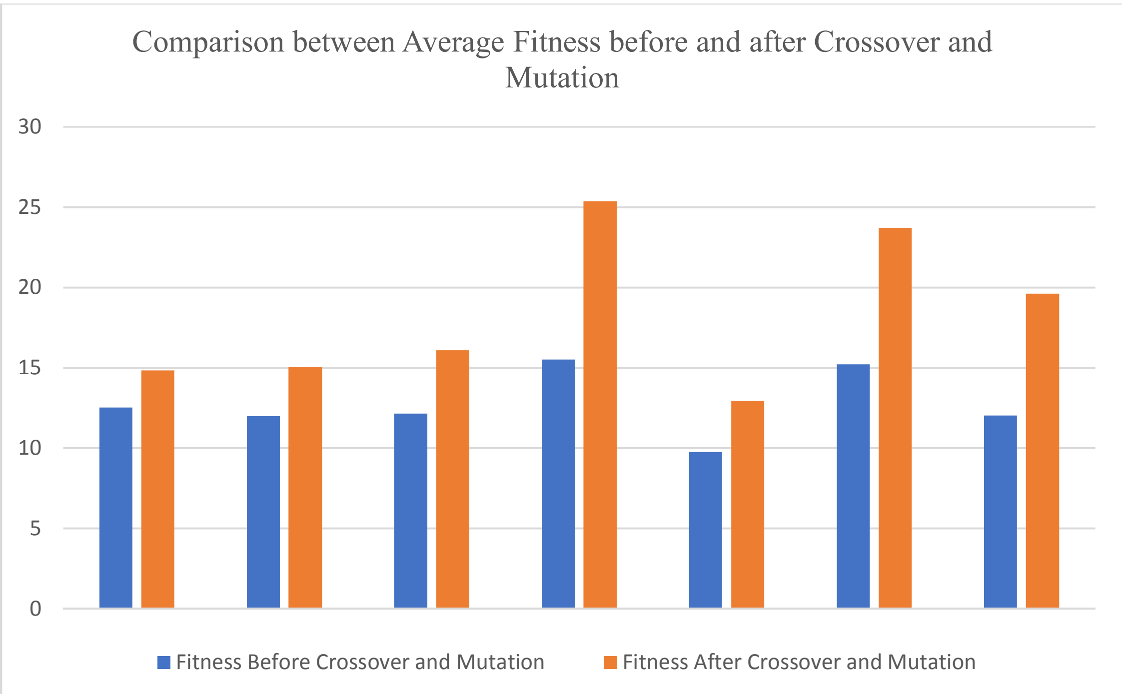

Fig 4.7: Comparison between Average Fitness before and after Crossover and Mutation

CHAPTER 5
CONCLUSION AND FUTURE SCOPE

In this thesis work I proposed an architecture for VANET for the better performance when there will be congestion in the cloud network. In this architecture the RSU's are connected in mesh network and computation of the tasks also is done by the RSU's. In this paper we also show that how the tasks are allocated to the RSU's for the computation. This task allocation is done by using genetic algorithm. In this genetic algorithm we use communication energy as a cost function. As a result, we get less cost after applying the proposed algorithm as compared to random task allocation.

In the future the proposed VANET architecture can be embedded with Hungarian algorithm for the improvement of the algorithm.

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