A Fabric System Oriented Cluster Algorithm to implement a Smart IOV Environment

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A thesis submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in Electronics and Communication Engineering.

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Declaration

It is hereby declared that the thesis submitted is our own original work while completing degree at Brac University. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution. We have acknowledged all main sources of help.

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Abstract

The Internet of Vehicles (IOV) is a comprehensive architecture for wireless communications between vehicle to vehicle, vehicle to human, vehicle to the road, and vehicle to the Internet. It allows vehicles to share information, efficiency, and safety with others as well as infrastructures using Vehicular Ad-Hoc Networks (VANET). This integration of VANET with the Internet of Things (IoT) has made the concept of IoV an emerging technology for smart cities for reducing car accidents, increasing car safety, creating an eco-friendly system and more. Being a young technology, it comes with a variety of challenges and among them, the routing protocols are a significant one that has been focused in this work. The routing protocols have been designed concerning the IoT architecture and not IoV which offers a significant challenge in routing packets as vehicle acting nodes are mobile and continuously changing position making their data to vary instantaneously and periodically. This leads to inefficient delivery of data packets from one source position to their destination. If a packet data is transferred efficiently, then it is not effective in delivery rate; failing in long-distance data transmission or a long delay in transmission. Routing protocols that are both efficient and effective require huge monetary investment. Keeping in mind all three factors - efficiency, effectiveness, and monetary resource utilization, we proposed a clustering algorithm that is based on the weight of a particular node, and also GPS positioning of all vehicle nodes will be used. The modern age has gifted us with vehichles; such as drones, cars etc; that are fitted with communication sensors. We believe that our research on clustering algorithms will provide a solution to one of the challenges of the IoV infrastructure and would help reduce the cost significantly. Overcoming these challenges will be a big step for not only the automotive industry but would also provide a new vision in communication technology. We believe it would help in generating new revenues contributing to the global economy.

Keywords: Internet Of Vehicles, Cluster-head, sub-cluster head, RSU, packet transmission.

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List of Acronyms

IOT	Internet Of Things
IOV	Internet Of Vehiscles
RSU	Road Side Unit
CH	Cluster Head
SC	Sub Cluster
SCH	Sub Cluster Head
MST	Minimum Spanning Tree
QoS	Quality of Service
VANET	Vehicular Ad-HOC Networking
MANET	Mobile Ad-HOC Networking
AODV	Ad-hoc On-Demand distance Vector
DSDV	Destination Sequenced Distance-Vector
3D	Three Dimension
DSR	Dynamic Source Routing
V2V	Vehicle-to-Vehicle
I2V	Infrastructure-to-Vehicle
V2I	Vehicle-to-Infrastructure

Chapter 1

Introduction to IOV and its Protocols

Part 1.1 Introduction:

The world of IOV is rising at an equivalent speed of IOT.IOT has made certain significant strides and as many researchers contributed to it significantly, it has given rise to a lot of branches. IOV is an example of such; because IOV is a concept derived from IOT most of the protocols that it follows, are protocols that were originally made or specifically designed for IOT. Here, at first we will look at these at protocols, discuss how they were modified for IOV and also give a brief on how we came upon our protocol.

The IOV network is very dynamic and very different from the mobile networking or a stationary device network. Its maintenance and stability is dependent upon the stability changes. Because of its dynamic nature, Mobile Ad-Hoc Networks (MANETs) that are currently in play for IOT is not specifically suited for IOV. IOT protocols were modified and are now being implanted accordingly for IOV. IOV protocols can be categorized in a number of ways based on different perspectives. We came to the understanding that based on protocols, it is best to classify this protocols into 3 groups. They are as follows:

- Topology Based Protocols
- Position Based Protocols and
- Cluster Based Protocols.

All of the mentioned protocols have their own sub categorized protocols. For instance, topology-based ad-hoc routing protocols, such as ad-hoc on-demand distance vector (AODV) or destination sequenced distance-vector (DSDV). Moving onto, position-based protocols, here a greedy approach which is categorized in three classes: 1. Progress-based, 2.Randomized-based 3. Face –based were used. Cluster based protocols, to the naked eye looks quite similar to each other for which reason they are not sub categorized instead each protocol is given a different name based on its unique quality; this quality is usually a parameter of the devices. Certain qualities would include speed, bandwidth, location and more. All the qualities have their strong suites as well as certain drawbacks for IOV network protocols. Topology-based ad-hoc routing protocols issue is that they are not appropriate for highly dynamic scenarios. Position-based protocols overcome the problem in topology-based protocol have but it needs geographical positions of nodes. Moreover, a major problem with its sub categorized protocol is that they are not easily converted to 3D context even though it has a high delivery rate. Clustering protocols are not suitable for large area networking which is very much essential here despite the fact that clustering protocols provide more stability. Moreover it can also be considered as cost ineffective. Despite the fact that it provides the most speed and high data rate.

Considering all the concepts, ideas and hurdles of all the protocols, and after reviewing and reading quite a significant number of papers; we came up with a clustering based protocol that should tackle the hurdles and should prove to be specifically suited for IOV. Our clustering protocol focuses on the fact that data transmission should be efficient without any packet losses; it should be effective for lengthy transmissions and the protocol also be economic. As per IEEE specifications, an antenna for a cluster formation in IOV has a range of 50~300 meters radius. For our proposal, we will consider a transmission range of 200m for urban areas. In rural areas, the transmission range increases to 1km. However, for now we will only show calculations for urban areas. To maintain stability of the network, fixed clusters are formed using such parameters and sub-clusters are formed based on the networking nodes. The protocol is specifically designed to address a 3-D environment where nodes have the ability to move in any direction it wishes. Here, nodes refers to the vehicles or moving objects that require connection to the network for efficient movement. There are a lot of application our proposal may have an impact. For instance, information regarding vehicular movements, general traffic conditions, or even advertisement from the Internet based on current location. The most lucrative of all is control over wireless links in order to enable autonomous driving. The most vital however would be efficient route formation for emergency vehicles like ambulances and police vehicles. In the following segment we look into the works thus far made into the field and papers we thought were necessary and vital for reviewing to support our proposal.

Part 1.2 Related Works:

We looked into a number of IOV protocols and reviewed them the best to our ability. Our initial paper review is on **[1]**. We outlined the essential as follows.

SECTION 1.2.1

Background: The objective is to show how the considered protocols behave in a different environment that they were not designed for. The environment consists of a randomly generated set of nodes in a cube of side length 1000 units and transmission range of 250 units. Four different cardinalities for the set of nodes in the network: 50,100, 150, and 200 nodes were considered in order to evaluate the protocol performance variation. Mobility models that were proposed in the past were considered. For instance, Drone networks were not focused, rather VANET. For each cardinality of the set of nodes, four mobility constraints were chosen, in terms of pause time: 5, 20, 40, and 100 s, during which the node remained stationary, before resuming to move toward a new destination in the 3-D space. The metrics of interest used to assess the protocols were:

1) Packet Delivery: The average ratio of the data packet delivered to the destination to those generated by the source.

2) Path Dilation: In other words, “Stretch factor” corresponding to the average ratio of the number of hops traversed by the packet to reach the destination, to the minimum path length from source to destination.

Simulation Results:

Pause time of 5s: The delivery rate in low density scenarios (50 nodes) is quite low for position-based protocols, especially when employing the GFG scheme, while AODV and DSR perform at an acceptable level. When increasing the number of nodes, the packet delivery rate of the position-based protocols increases as well. In terms of path dilation, position-based protocols achieve the worst performance. The outcomes were quite expected as the schemes solely depend on local knowledge. However, the topology-based protocols perform remarkably well, with packets traversing a path of length close to the optimal length.

Pause time of 20s: A little growth in the delivery rate for AODV and DSR and for the position-based protocols could be seen. Position-based approaches present a reduction of values, whereas packets in the topology-based schemes traverse almost the same number of hops as in the case of pause time of 5s. In general, AODV and DSR had very good performance indexes both in terms of delivery rate and path dilation.

Pause time of 40s: DSDV performs quite well in terms of delivery rate as compared to the prior configurations. Also, the position-based approaches show better delivery rates than the case of pause time pf 20s/ In general, AODV and DSR seem to be the best protocols constantly ensuring high delivery rate and low path dilation.

Pause time of 100s (Static network) : In a static network, the delivery rate is expected to very high for all the routing protocols, else, it is due to the unreliable nature of the wireless link.

Performance of Routing Protocols in realistic urban environment:

The case considered was a potential deployment of heterogeneous, general purpose IoV network consisting of static sensors at traffic intersections, lamps, moving cars and flying drones in an urban environment.

Conclusion:

1. With an average of 10% of the packets reaching the destination, DSDV has the lowest performance in terms of delivery rate. This is due to node mobility causing path disruptions.
2. AODV, DSR along with DSDV achieved a good performance in path dilation.

SECTION 1.2.2

The 2nd paper we reviewed is **[2]**. Our findings are as such:

Background: Geo-routing protocols are considered appropriate for VANETs for their simplicity, efficiency and scalability. Because of a significant number of proposed Geo-routing protocols, it is quite necessary to have a comprehensive collection of materials in order to provide a solid framework for a research paper's investigation. In the past few years, several surveys have been conducted and published trying to discuss routing protocols for VANETs. The paper talks about some of the research issues, the state of the art urban geo-routing protocols along with an overview of them, and draws some conclusions.

Research issues:-

Issues with urban VANETs:

a. Growing road traffic problems that have a significant impact on congestions, safety and environment.
b. Lack of reliability with Advanced Driver Assistance Systems (ADAS) using sensor based information.
c. Disruption in the communication signals due to buildings and hence disconnection between information exchanging vehicles.

Due to these issues, traditional geo-routing protocols of MANETs and VANETs are facing new problems. Therefore, each protocol tries to address one or more of these research issues and to contribute in that direction. The problems are,

1. *Network overhead* that is basically caused by the high number of messages sent in the network. Some protocols try to avoid it by employing preferred Group Broadcasting (PGB) and others by not considering beacon messages that do not comply with the standards.

2. *Network connectivity problems* happen due to non-uniform distribution of vehicles in urban areas. The common solution here is to estimate the traffic density but different protocols propose different ways of obtaining traffic density information.

3. *Consistency of information* , link stability or path lifetime problems happen due to fast
unpredictable movement of vehicles. Most protocols apply various movement predictions to predict future position of vehicles, while others use fuzzy logic, combine reactive and geo-routing, weight vehicles or consider communication channel conditions.

4. *Route maintenance* is required as a result of frequent disconnections. Proposed solutions: "guards", marking or weighting the street and sending update messages.

5. *Partitioned networks* are usually observed in urban VANETs due to non uniform distribution of vehicles. Common solution is "carry-and-forward".

6. *Delay in delivering data packets* to the destination can happen due to the aforementioned characteristics of urban VANETs. Common approach would be to decrease the number of hops by applying simplified perimeter forwarding, auto-adjust-ability and predictions.

7. *Local maximum* happens when there is no neighbor vehicle closer to the destination than the forwarder vehicle itself. Possible solution would be to apply the perimeter forwarding. Also, other probable solutions would be considering connected dominating sets, considering anchor points, and taking advantage of traffic density information.

8. *Load balance problems* happen due to unfair distribution of resources between vehicles. Probable solutions would be congestion detection and applying metrics of vehicles.

9. *Malicious vehicles* could also be an issue in future. Some protocols suggest applying a filtering process and setting up trust values for vehicles.

10. *Cross-link* or loop happens when a message crosses the same junction for a second time but in a different direction. A few protocols have mechanisms to check for loops and avoid that.

II. Geo-routing protocols

Considering the available protocols, they can be categorized into two groups,

1. Delay Tolerant (DT) applications
2. Delay Intolerant (DI) applications

Furthermore, from the activity point of view, they can be divided into:

1. Pro-active
2. Re-active

This work focuses on the **re-active protocols for DI applications** , which work without RSUs. Geo-routing protocols may use different inputs in addition to position information of vehicles like direction of vehicles, velocity of vehicles, digital map, traffic density information and channel quality information to decide about the next forwarder.

A. Direction and Velocity of Vehicles:

MoVe: Proposed by LeBrun, Motion Vector (MoVe) where two different strategies for routing are presented that use the movement information to make a decision for forwarding. MoVe assumes that vehicles are equipped with a GPS receiver and use a HELLO RESPONSE technique to identify neighbors.

GyTAR: Proposed by Jerbi, Improved Greedy Traffic Aware Routing Protocol (GyTAR) implies that dynamically selects the next intersection through which the packet should be forwarded. In contrast to source routing, here the intersections are selected one after each other. Having the pre-loaded digital maps that provides a street-level map, GyTAR can calculate the number of the vehicles located between each two intersections.

CAR: Proposed by Naumov, Connectivity-Aware Routing (CAR) takes advantage of the information of beacons. CAR employs the Preferred Group Broadcasting (PGB) to broadcast a path discovery packet.

MOPR: Proposed by Menouar, Movement Prediction-based Routing (MOPR) employs the velocity, position and direction information of vehicles to predict the position of them in the near future to estimate the link stability.

Fcar: Proposed by Wang, Fuzzy Control AODV based Routing (Fcar) employs the fuzzy logic and fuzzy control method to make routing decisions with multiple selection criteria. Fcar uses life time of the path, percentage of vehicles with the same direction, location of vehicles and their speed to evaluate a path.

JARR: Proposed by Tee Junction-based Adaptive Reactive Routing (JARR) assumes that vehicles are equipped with location service performing adaptive beaconing. JARR tries to estimate the density of paths to be used while sending packets from one intersection to the other one.

HLAR: Proposed by Al-Rabayah, Hybrid Location-based Routing protocol (HLAR) addresses the issue of the communication link breakage, combining the features of reactive routing with location-based geographic routing.

GSPR-MV: Proposed by Tu, Greedy Simplified Perimeter Routing with Moving Vector (GSPR-MV), tries to improve the poor performance of GPSR and predicts the near future positions of mobile nodes before forwarding the packet based on the position, direction and velocity information of vehicles.

LPRV: Proposed by Balico, Localization Prediction-based Routing for VANETs (LPRV). Has the key feature of the LPRV algorithm to exploit the knowledge of vehicles to predict future locations as a metric to forward data packets without the need of exchanging any extra control Message.

EHTAR: Proposed by Lo, Enhanced Hybrid Traffic Aware Routing (EHTAR) where a dynamically elected functional vehicle called Junc-Tracker located at each intersection is used to explore the real-time vehicular and network traffic information of each road.

MBMPR: Proposed by Lin, Map-based multi path routing protocol (MBMPR) uses GPS, digital maps, and sensors to find an optimal forwarding path. Also, there is a congestion detection mechanism to handle the load balance problem at intersections.

WNPRP : Proposed by Chinnasamy, Wagon Next Point Routing Protocol (WNPRP) for VANETs tries to find the location of the next hop from the source and applies a filtering process to make sure that the malicious vehicles do not interfere.

SRCP: Proposed by Togou, Stable and Reliable CDS-based Routing Protocol (SRCP) is a position-based routing scheme that takes advantage of topology information stored at bridge vehicles to select the most stable paths (high connectivity and low delivery delay).

STAR: Proposed by Giudici, Spatial and Traffic Aware Routing (STAR) reduces the number of local maximum considering the traffic density in routing decisions.

MORA: Proposed by Granelli, Movement-based Routing Algorithm (MORA) employs a weightingfunction for vehicles to have a better link stability.

RPGR: Proposed by Qureshi, Road Perception Based Geographical Routing (RPGR) deals with distance, direction, and mid-range forwarder vehicle with traffic density to forward the data towards destination.

DIR: Proposed by Chen, Diagonal Intersection based routing (DIR) considers frequent beacons. The idea is to construct a series of diagonal intersections between the source and destination vehicles. *IDVR:* Proposed by Shi, Intersection Dispatch-based VANET Routing (IDVR) suggests two improvements to position-based protocols.

1.A fixed vehicle located at an intersection is used for monitoring the connectivity of all the branches, so that only paths with the highest connection quality are selected based on the Far reaching Detection Method (FDM).

2. A store-and-forward system used to solve the problem of sudden link disconnections.

TROUVE: Proposed by Kerrache, Trusted Routing protocol for Urban Vehicular Environment (TROUVE) allows finding the shortest and most trusted path, calculating the link stability between two vehicles based on the speed variation of them. TROUVE can be divided into two parts:

1. The estimation of real-time trust and traffic. To achieve this, every vehicle maintains the local information about their neighborhood and a local intrusions detection system.

2. Data routing through the most reliable and trusted path.

B. Digital Map and Traffic Information:

A-STAR: Proposed by Seet, Anchor-Based Street and Traffic Aware Routing (A-STAR) chooses the sequence of intersections from street map information employing Dijkstra. It also uses the information of the bus lines in the city to choose the paths with high connectivity,

ACAR: Proposed by Yang, Adaptive Connectivity Aware Routing (ACAR) selects an optimal path in an adaptive way based on the statistical traffic and real-time density data that are collected by an on-the-fly collection process.

RIVER: Proposed by Bernsen, Reliable Inter-Vehicular Routing (RIVER) is a position-based protocol with an optimized greedy strategy. It performs an active real-time traffic monitoring and employs the other passively collected data to rate the reliability of the streets.

GeoSVR: Proposed by Xiang, Geographic Stateless VANET Routing (GeoSVR) consists of two core algorithms:

1. An optimal forwarding path algorithm to eliminate the problem of local maximum and sparse connectivity

2. A limited forwarding algorithm to address the unreliable wireless channel issues.

GPCR: Proposed by Lochert, Greedy Perimeter Coordinator Routing (GPCR) uses a repair strategy consisting of two parts.

1. Non-coordinator vehicles again employ the restricted greedy forwarding to forward the packet along the street towards the next intersection.

2. Coordinator vehicles use the right-hand rule to choose the street which is the next one counter clockwise from the street from which the packet has arrived.

GpsrJ+: Proposed by Lee, in GpsrJ+, it is not requisite to always forward the packets to intersections. It also includes the IDs of the road segments on which neighboring vehicles are located, in beacon message to be able to perform a prediction and taking advantage of on-board topological maps.

RBVT-R: Proposed by Nzouonta, RBVT-R employs a beaconless distributed receiver-based election of next hop with a modified Request/Clear To Send (RTS/CTS) technique in which vehicles prioritize themselves based on the distance to destination, received power and distance to sender.

To-Go: Proposed by Lee, Topology-assisted Geo-opportunistic routing (To-Go) considers the road topology via 2-hop beaconing and uses opportunistic packet forwarding in order to increase the packet delivery ratio.

GeoCross: Proposed by Lee, GeoCross consists of greedy forwarding and perimeter forwarding modes like GPSR. GeoCross focuses on cross-links which arise at intersections without coordinator vehicles.

EIPG : Proposed by Garrosi, Enhanced Intersection-based Perimeter Geo-routing protocol (EIPG) inherits the restricted greedy forwarding of GpsrJ+ but employs a new intersection-based perimeter forwarding in order to avoid the problem of Wrong Street Estimation (WSE).

C. Prediction and Estimation:

A group of geo-routing protocols like MoVe, GyTAR, MOPR, IDVR, GSPR-MV, LPRV, EHTAR and MBMPR employ prediction and estimation techniques to improve their performance.

D. Channel Quality Information: Some of the geo-routing protocols like TO-GO, GeoSVR and EHTAR take the channel load and quality information into account.

E. CAMs and Number of the Hops: According to Intelligent Transport Systems (ITS), CAMs, beacon or hello messages are exchanged in VANETs between vehicles to make each other aware of their existence, position and motion state. Each CAM is transmitted in a single hop to the vehicles located in the direct communication range of the originating vehicle.

GRANT: Proposed by Schnaufer, Greedy Routing with Abstract Neighbor Table (GRANT) suggests that vehicles add an Abstract Neighbor Table (ANT) to the beacons. ANT works as the core of GRANT while separating a plane into different areas and representing one neighbor per area.

CONCLUSION: Geo-routing protocols are quite appropriate for VANETs because of their simplicity, efficiency and scalability.

SECTION 1.2.3

For our next review paper we chose **[3]**. We were able to comprehend certain interesting points from the paper.

Background: Road traffic is constantly rising that yields numerous problems such as congested roads, road safety issues and environmental effects. Stand-alone driver assistance systems have several benefits ranging from maintaining safe speeds to safe distance. These benefits can further be boosted by means of cooperation between vehicles. The development of ITS aims to enable the Vehicle-to-Vehicle (V2V), Infrastructure-to-Vehicle (I2V) and Vehicle-to-Infrastructure (V2I) communications to reduce the number of accidents and to provide a safer traffic environment, exchanging traffic information among the ITS stations. V2I and I2V are defined as the "direct Vehicle to road Infrastructure communication using a wireless local area network such as standardized in EN 302 571. The geo-broadcast routing decisions can be made either as sender-based decision making or distributed decision making. Neighbor knowledge method is a well-known sender-based method that requires information of one-hop neighbors employing beacons or Cooperative Awareness Messages (CAMs). The distributed decision making methods can be divided into:

- Simple flooding method i.e. all nodes rebroadcast the messages
- Probability-based method, in which, receivers determine whether they rebroadcast or not using probabilistic parameters, e.g. counter based method using random back-off
- Area-based method, in which receivers determine whether they rebroadcast or not, based on their positions, e.g., delay-based scheme using the distance to the sender or directed flooding defining a forwarding zone.

The proposed Unicast assisted Geo Broadcast (UAG) can be summarized into the following steps:

- ✓ Select the intersection-based or road-based approach, choose the target positions within the geo-region, and calculate the FBC.
- ✓ Make copies of the message and geoUnicast each copy to a selected target position employing the modified EIPG2 i.e. considering both right-hand and left-hand rules.
- ✓ Any vehicle within the geo-region that receives a geo Unicasted message will broadcast the message.
- ✓ Any vehicle within the geo-region that receives a broadcasted message will only rebroadcast the message if it is qualified to be a rebroadcaster.

Performance evaluation/Simulation:

Simulator: OMNeT++ and SUMO are coupled employing Traffic Control Interface (TRaCI). OMNeT++ works based on the documentations of ETSI regarding ITS and SUMO generates random networks of vehicles with random trips and mobility routes.

Algorithm:

$$\mathbf{PL = PL0 + 10\gamma \log10\ d/d0 + \chi g}$$

Here, P L → total path-loss in dB.

P L0 → total path-loss at the reference distance of d0.

γ → path-loss exponent.

d → the length of the path.

χg → random variable with zero mean to count for fading attenuation in dB.

Conclusions:

1. Simple flooding shows the best performance in terms of reachability at a cost of lower scalability, i.e. high overhead in the network.

2. After simple flooding, UAG shows a good performance that is better than UGAD's performance.

3. Intersection-based UAG shows a slightly better performance in comparison with road-based UAG.

4. Simple flooding shows the worst performance in terms of scalability.

5. After simple flooding, UGAD shows an acceptable performance that is better than simple flooding's performance.

6. Intersection-based UAG and road-based UAG show the best performance in case of scalability.

7. Road-based UAG shows a slightly better performance in comparison with intersection based UAG.

SECTION 1.2.4

We further look into another geo-routing protocol by **[4]**.

Background: In this paper, Intersection-based Perimeter Geo-routing has been proposed for urban VANETs. EIPG inherits the restricted greedy forwarding of GpsrJ+ but employs a new intersection-based perimeter forwarding in order to avoid the problem of Wrong Street Estimation (WSE). Based on the simulation study, EIPG shows a significant improvement in comparison to GpsrJ+, in terms of Packet Delivery Ratio (PDR), end-to-end delay, and network overhead. Also, EIPG only requires the information of single-hops, i.e. the direct neighbor vehicles, to avoid the unnecessary overhead caused by the extra information included in the beacon messages of GpsrJ+ and is more compatible with the standard Cooperative Awareness Messages (CAM).

ENHANCED INTERSECTION-BASED PERIMETER GEO-ROUTING In perimeter mode and at intersections, GPCR and GpsrJ+ try to find the next road segment in order to forward the packet, employing the right-hand rule. At first, they calculate the centre points of all the road segments around an intersection, assuming that it is possible to extract the coordinates of any road segment's two ends from the available digital map. Then, having the position information of the coordinator vehicle, they calculate the θi for each road segment, which is the angle that the edge ei, from the coordinator vehicle to the road segment i's center point, forms with the X-axis (the West-East horizontal direction). After that, they calculate α, which is the angle that the edge from the coordinator vehicle to the previous sender vehicle, forms with the X-axis. Finally, they choose the road segment with the smallest θ_i which is bigger than α.

Performance evaluation/Conclusions:

Simulator: OMNet++ and SUMO.

1. EIPG has a better packet delievery ratio than GPSR, GPCR and GpsrJ+.
2. Performance increases with increasing number of vehicles.
3. Shows up to 9% improvement in comparison to GpsrJ+, in terms of end-to-end latency.
4. In terms of routing overhead, EIPG improves GpsrJ+ by about 26% on average.
5. Employs only the information of one hop, therefore do not employ the prediction mechanism of GpsrJ+ to avoid this overload.

SECTION 1.2.5

For our 5th paper, we review a clustering algorithm put forward [5]. We noted the following observation:

Background: The paper is an overview of the cluster. This paper, focuses only on clustering protocols and its relation with IOV. Initially the paper classifies the clustering schemes into 3 particular categories;

1)Classic MANET Clustering protocols,

2) Weight-Based Clustering protocol,

3) Location-Based Clustering protocol.

Such protocols are classified even further as we will see here. The paper proposes an advanced protocol, developed using the concepts of Weight-Based Clustering algorithm only its more efficient because of its added parameter the Mobility Report,(MR). Thus, naming it Efficient Weight-Based Clustering Algorithm and Mobility Report, WECA-MR. The paper, describes its network model and then gives a brief overview of what the MR is, and the equations related with it in finding MR. the paper then moves onto the algorithms required, for such clustering to be carried out. Moving forward, we see a theoretical analysis of the algorithm and simulations carried out in the most preferred communication application Network Simulator2, NS2. Finally, it concludes on the statement that this protocol is highly efficient for highway clusters. IOV's major challenge is its mobility. Vehicles are extremely mobile and therefore, any cluster formed is usually a temporary differential time. It basically means, the same cluster formed at the moment, will probably not be the same the very next second. Giving rise to a new cluster at every instant. This gives rise to a lot of dynamic topologies. Thus, a very efficient, effective and reliable routing solution is extremely important. A definition of clustering; it is a process of dividing the whole network into smaller sized groups called clusters. In most clustering algorithms, the clusters have a Cluster Head, CH; one or more nodes that act as gateways between clusters and many other nodes that act as Cluster Members, CM; and the cluster often has a Backup Cluster Head, BCH, for cases of CH leaving the cluster. Now, as seen clustering algorithms face challenges of their own. The primary challenge for any clustering algorithm in IOVs are:

(i) Stability of the cluster, and

(ii) Maintenance of the cluster structure.

Now, let us look into the protocols as described by the papers:

First, Classic MANET Clustering Protocols.

i) Lowest ID protocol,

ii) Highest Degree protocol,

iii) Weight Clustering Algorithm, WCA; developed with help of weight of the previous two algorithm.

Second; Weight-Based Clustering Protocols.

i) TDMA-MAC scheme from VANET,

ii) Mobility-Based approach for Dynamic Clustering in VANETs, best suited for urban city scenarios.

iii) Mobility Aware Single-Hop Clustering Algorithm, MOSIC, best suited for highways.

iv) Self-Organized clustering Structure, best suited for security.

The final protocol category described in the paper are Location-Based Clustering Algorithm:-

i)Lightweight Hierarchical Cluster-Based Location Service, HCBLS; for Urban environments.

ii) Position Sensitive Clustering Algorithm, PSCA.

iii) Cross-layer Algorithm, basis Hierarchical & Geographical information and dissemination method.

The paper proposed Efficient Weight-Based clustering Algorithm using Mobility Report for IOV is called WECA-MR. This algorithm is well suited for vehicles on highways. Moreover, this protocol focuses only on Vehicle-to-Vehicle communication, V2V. The proposed algorithm is based on the metrics' used in the Classic Weight-Based Clustering Protocols; which includes;

1) Degree, and 2) Average Distance.

With a newly introduced metric referred as Mobility Report; this metric includes other mobility metrics' of the vehicle. The metrics' are:

1) Velocity, and 2) Acceleration.

WECA-MR; is specifically designed for when the situation arises, that a Cluster Head, CH, leaves the cluster. Thus, a new election process for the cluster to elect the cluster head can take place. Despite the high mobility and dynamic situation. However, makes an assumption of the environmental scenario to be a two-way highway road (one for each direction). Nonetheless, for the model to properly function the vehicles, as in the nodes, must be equipped with:

1) Vehicle Unique ID in the network.

2) A GPS device, along with the vehicle road map set on it. To obtain information of its real-time location, instantaneous velocity and location of neighboring nodes.

3) A wireless interface. For communication with other nodes.

4) Reports its required metrics' to the neighboring nodes via broadcasting of "HELLO messages".

The vehicular network is modelled theoretically on a graph in the format G(V,E). V vertices represents the set of vehicles in the network. And, the E is the set of EDGE or communications link between the vehicles/nodes. Moreover, there is a link (i; j) to E, if and only if vehicles i and j are mutually in the coverage area of each other:

set (i; j) to E => distance(i; j) _< min(Tri; Trj).

Where Tr_i and Tr_j are the transmission range of vehicles i,j respectively.

First, it looks into Combined Weight, the Weight, W_i ; of a node i is calculated. This includes the metrics NODE DEGREE, and AVG. DISTANCE.

i)Node Degree: It is the size of the set of single-hop neighbors of node i, N_i, where:

$$N_i = \{j \in V \mid j € (i; j) \in E\}$$

Consequently, the degree of node I is defined as follows;

$$deg_i = |N_i|$$

Needless to say, a node with a higher degree is more likely to be elected as CH because degree represents the connectivity links.

ii) Avg. Distance Indicator: The average distance indicator, AD_i, is between a node or its single-hop neighbors. Unlike, the node degree; here, the minimum the average distance of a node the greater is its possibility to be elected as the CH. AD_i is calculated as the cumulative mean square distance to its single-hop neighbors, N_i; divided by its degree, deg_i as shown in the following equation.

$$AD_i = \frac{1}{deg_i} \sum_{j=1}^{deg_i} \sqrt{(x_i + x_j)^2 + \ (y_i - y_j)^2}$$

Therefore, the DI_i of node i is calculated using the following eqn:

$$DI_i = \sqrt{(\ln(\frac{AD_i}{\max D_i}))^2}$$

Here, Max D_i represents the maximum distance between node i and its neighbors.

The most important metrics for this clustering protocol, the Mobility Report; is now looked at in more detail. A higher MR for a node would mean it is very likely to be chosen for CH. Initial calculation is of velocity, $v_{i,}$ amongst the two metrics'. To calculate v_i, the distance travelled by the particular node i is calculated, denoted by d_i. Then, we calculate the velocity of the node. And, finally we move onto relative velocities. The equation for velocity calculation is as follows:

Let us assume that P1(x1, y1) is the position of node, i at time T1 and P2(x2, y2) is the position of node i at time T2. d_i is the distance traveled by the node i over time Δt. (Δt = T2 - T1);

$$d_i = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

Followed by velocity calculation:

$$v_i = \frac{d_i}{\Delta t}$$

Let us now assume, v_1 is the velocity of node i at time T1 and v2 is the velocity of node i at time T2. a_i is the acceleration of the node i over time Δt.(Δt = T2 - T1). Consequently, the acceleration of node i is computed as follows:

$$a_i = \frac{\Delta v_i}{\Delta t} \text{ ; } \Delta v_i = |v_1 - v_2|$$

Based on the exchanges of velocity and acceleration metrics between neighboring nodes using periodic messages, each node calculates its relative velocity (Rv) and relative acceleration (Ra) with respect to its single-hop neighbors. They are calculated as follows: [$Rv_{(i,j)}$ is the relative velocity of node i with respect to node j].

$$Rv_{(i,j)} = \ln(1 - \frac{|v_i - v_j|}{v_{max}})$$

Where: v_{max} is maximum velocity allowed on the road.

$ARv_{(i,Ni)}$ is the average relative velocity of node i relative to its single-hop neighbors (N_i). It is defined as follows:

$$ARv_{(i,N_i)} = \frac{\sum_{j=1}^{deg_i} Rv_{(i,j)}}{deg_i}$$

$Ra_{(i,j)}$ is the relative acceleration of node i relative to node j; calculated as follows:

$$Ra_{(i,j)} = \ln\left(1 - \frac{|a_i - a_j|}{a_{max}}\right)$$

Here: a_{max} is maximum acceleration allowed according to v_{max}.

$ARa_{(i,\, Ni)}$ is the average relative acceleration of node I relative to its single-hop neighbors (N_i). It is defined as follows:

$$\mathrm{AR}a_{(i,N_i)} = \frac{\sum_{j=1}^{deg_i} Ra_{(i,j)}}{deg_i}$$

And, after all this we calculate the MR of node i:

$$MR_i = ARv_{(i,N_i)} * \mathrm{AR}a_{(i,N_i)}$$

Finally the Combined Weight W_i is calculated as follows:

$$W_i = (C_1 * deg_i) + (C_2 * DI_i) + (C_3 * MR_i)$$

Here; C_1 , C_2 & C_3 are coefficients with values $C_1 = 0.3$, $C_2 = 0.2$ & $C_3=0.5$. Thus they all sum up to 1. The algorithm considers the MR to be the most important metrics thus assigning it with the highest coefficient.The paper then describes the algorithms of cluster head election and cluster formation, in a step by step process.

Step1: Vehicle initialization; initially, all vehicles are assigned a state, the "Undefined state, US". After which, "HELLO" messages are broadcasted to its single hop neighboring nodes. The message consists of the node i's id, velocity, acceleration, transmission range and 2-D position; after they are calculated. The message is in the format "HELLO(id_i, v_i, a_i, Tr_i, P_i)".

Step2: WEIGHT Calculation and REQUEST message broadcasting; after a neighboring node receives the broadcasted message, the new nodes calculates the parameters for weight calculations. This includes degree, distance indicator and Mobility report. The next step is the broadcasting of REQUEST message; it is in the format "REQUEST(id_i, W_i)".

Step3: Cluster Formation; after a node receives the request packets, it compares its weight with all its single-hop neighbors. The node with the maximum weight (after comparison with all), elects itself as the CH and therefore broadcasts "ANNOUNCE" message to its neighbors; finally waiting for the others to reply.Otherwise, if a node does not have the maximum weight; it elects the node with the maximum weight to be the CH. The nodes updates itself with the CH's id as the CH. And waits for an "ANNOUNCE" message from the CH. In the case, of two nodes with the same highest weight, the node with the lower id will be elected for CH.

Step4: "ANNOUNCE" message sending; After receiving the "ANNOUNCE" message from supposed CHs. It compares; the id of the node that it selected as its CH, with the ids of the ids of the CHs that send the "ANNOUNCE" message. Upon finding the match, the node sends a "REPLY" message to the Cluster Head notifying it as the CH of the cluster that the node is in it and defines itself in the Cluster Member state.

Step5: Updating the CH Table; for each "REPLY" message received by a CH; the CH updates or adds the sender's node to its cluster members list.

Step6: Backup Cluster Head Election; after the cluster formation, the CH elects a Backup Cluster Head based on the list of cluster members it has. The member with the highest weight value gets elected as the BCH. Then, the CH sends a message to the BCH ; SET_BCH.

So far we have only understood how a cluster and node will become the part of the protocol. Now in similar fashion, the paper showed how the cluster is maintained for stability.

1) CH leaving Discovery: after a cluster is formed; the CH and the BCH establish a private communication link. This link allows the CH to sends periodical messages to the BCH about its state. If the BCH does not receive the messages periodically it considers the CH to have left the Cluster. Thus, it changes its state to the CH. Then the new CH broadcasts a "UPDATE" message to the cluster members, notifying them of its new state. The new CH, then selects a new BCH using the previously defined algorithms. In the case the old CH tries to join the cluster, it must join the cluster in an undefined state and go through the whole process again.

2) Leave a cluster: the CH and the CMs remain in constant contact via periodic messages. This periodic messages allows the CH to understand the state of all the CMs. In the case that a CM leaves the cluster, the CH considers those and notifies the BCH that a particular node has left the cluster. The BCH thus updates itself of the member leaving the cluster.

On the other hand, if a cluster member stops receiving messages from the CH, the member changes its state to undefined state.

3) Joining a Cluster: when an undefined node starts to approach a cluster; the undefined node sends a message to the CH reporting the CH of its velocity. If, the velocity of the undefined node is less than or equal to the average velocity of the cluster members; the CH allows it to become the member of the cluster. And, reports this change to the BCH. Thus, the BCH updates its list of CMs.

Conclusions: The whole scenario was simulated in Network Simulator 2. Very helpful and effective for IOV networking models. The cost implementation also seems fair. The paper's proposal of this new Efficient Weight-Based Clustering Algorithm using Mobility Report; seems a very good solution for highway scenario IOVs. Its algorithm even though simple but is proven to be very effective on highways. Especially the fact that it takes into account of cluster formation based on CH leaving and joining of new clusters is quite distinct. The factors it took into consideration are as follows:

1) CH lifetime: this metric refers to the period between which the vehicle state is in CH until it changes to US state. Longer CH lifetime leads to reliable communication with minimized overhead.

2) CM lifetime: this metric refers to the period between which the vehicle state is in CM until it leaves thecluster and becomes US. Longer CM lifetime shows the efficiency and reliability of the maintenance method used.

3) Clusters number: typically, the smaller number of clusters is, the more efficient the proposed scheme is.

4) Clustering overhead: is the number of control messages sent by each node during cluster initialization and cluster maintenance phases.

We reviewed more papers for our proposal and understood how all the protocols functions. Based on our reviewed papers and experience gathered; thus far we came to the conclusion of giving more focus on clustering algorithms.

Part 1.3 Objective of Thesis:

The goal of our research is to come up with an advanced modern clustering protocol. We made our proposal keeping in mind of a 3-D environment. Mainly because, the future is bound to produce more airborne vehicles like drones. The protocol is designed for multi-directional node movement with a single RSU. The RSU will also allow us to keep track of all node movements without interruption unless the node itself doesn't prompt. We will be able to continuously route data packets; from all nodes whenever required with as little delay as possible. The entire dynamic scenario would then seem to have gotten a stable form due to our protocol; which is our main objective. To obtain the goals mentioned, we made all our simulations in the renowned software Network Simulator 3, NS3. This is a widely accepted software and network simulations are reliable.

Part 1.4 Organization of the thesis:

Chapter-1 is basically introducing chapter. It comprises of different previous works, overview of all the protocols and a look at the ideas of the IOV world. Moreover, their is a brief of the proposal that will be introduced for the thesis.

Chapter-2 is the full description of our system with diagrams that help to understand the overall proposal.

Chapter-3 includes the algorithm of the proposal; the simulation performed in network simulator 3 alongside the results obtained.

Chapter-4 contains the summary of all the previous chapters and future works.

Chapter 2 Proposed Protocol

Part 2.1 Cluster initialization

Road Side Unit parameter and cluster area: As per the IEEE 802.11 access point parameters; it has a transmission range of 50m~300m radius. For our proposal, we will consider a transmission range of 200m for urban areas. In rural areas, the transmission range increases to 1km. However, for now we will only show calculations for urban areas.

The width of a single road lane considered is 6.75m (varies from 5.5m~7.3m)[UK standards]. Therefore, based on the number of lane our area of a cluster will vary as follows:

For, 1 lane- 400m*6.75m*1=27000m^2

2 lane- 400m*6.75m*2=5400m^2

3 lane- 400m*6.75m*3=8100m^2

n lane- 400m*6.75m*n=2700*n m^2

We have developed a cluster algorithm that uses a single RSU for multi-directional roads. Therefore, the RSU will be placed at the center of the street.

Formation of Clusters: According to the proposal, circular clusters of fixed area will be formed based on the location of the Road Side Units (RSUs) and the number of lanes of the road. The RSU placement will be as such that there will be overlapping zones between adjacent RSU cluster areas. As shown in the figure 1. Once a node enters an intersection area, the new cluster or the cluster it has entered into will now start the required processes as detailed out later on.

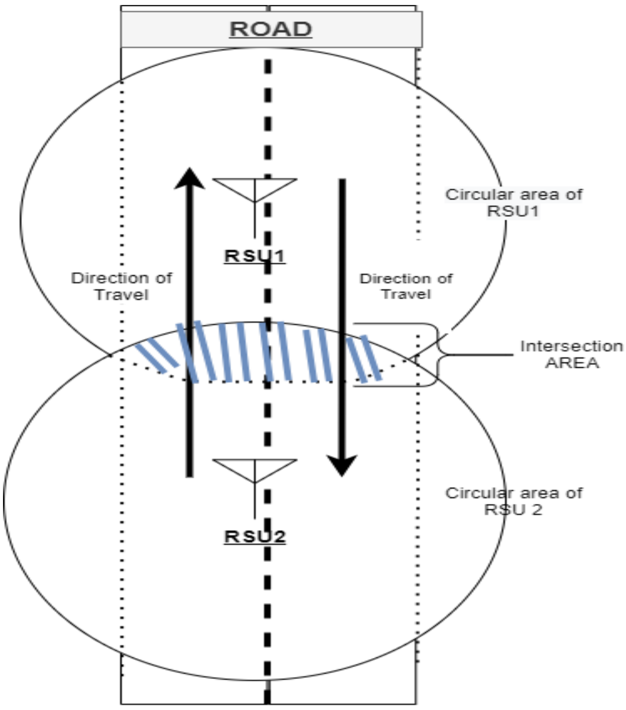

Figure 1

It has always been quite challenging for researchers and scholars to come up with an efficient selection process with maximizing the durability of cluster heads. As it is often associated with a great deal of energy loss, we too have tried to give our maximum attention to that and have come up with this unique idea. The idea is not only cost effective but also efficient in time and specifically suited for a continuously changing traffic node position. According to our proposition, each cluster will consist of the followings:

~ 'N' number of sub clusters.

~ Each sub cluster will have its own Sub-cluster head.

~A cluster head will be elected from the sub cluster heads (based on our proposed algorithm).

~And an RSU(Road Side Unit) at the center that will be responsible for the area of the cluster and also will act as our reference point.

Part 2.2 Sub-Cluster initialization and Election Process

Moving onto our sub-cluster formation; a sub-cluster formation depends on a node radius transmission range. All nodes have a pre-assigned unique node ID, provided they have the ability to stay online on the network. As soon as, the node enters a cluster, it will receive a unique cluster ID from the RSU, corresponding to that cluster area. The node will have its radial distance calculated as well as its average velocity. And, after the completion of the sub cluster formation, it will receive its unique sub-cluster ID.

Election Process: As mentioned, to elect a cluster head we would first need to complete the election of sub-cluster heads. A cluster area depending on number of road lanes can have a decent coverage area. Therefore, it would be completely unreasonable to assume that there will be only 1 sub-cluster inside the cluster area. Thus, our first step is to elect sub-cluster heads. Once all the sub-cluster head is elected it moves onto cluster head; the process is detailed out in the coming steps. Ultimately, we would get our cluster head. The election process are outlined in steps as follows:

1. Adjacency Matrix Calculation: the very first thing that will be calculated is adjacency matrix of all nodes entering a cluster area. This process is continuous and will occur every time a new node enters a cluster. Now, at any given time or scenario, the nodes having the highest number of adjacent nodes will be elected as the sub cluster head based on the equations formed. Adjacency matrix formation depends on connection changes with other nodes. Consider the following scenario (figure 2).

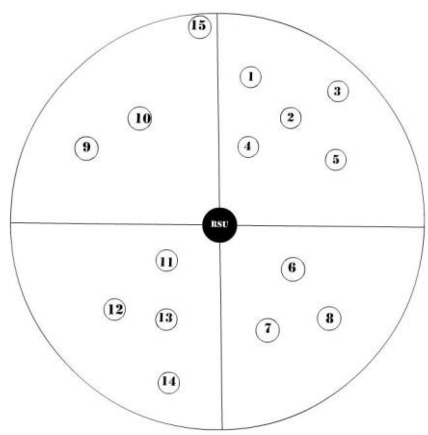

Figure 2 Initial State of all nodes at any given time in a cluster

Here, 5 sub-clusters are formed after adjacency matrix calculation and each sub clusters have different number of nodes. The adjacency matrix calculation is shown manually in table-1. After that the sub-cluster's node that has the lowest weight/Sub-cluster head_Param, SCH_Param will be chosen as the sub-cluster head. Based on the following equation:

$$SCH\_Param = \frac{SC\_size}{Connected\ Nodes}$$

The adjacency matrix table (Table-1) and calculation of all the nodes are shown as follows.

Node	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
2	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
3	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
4	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
5	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
7	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
10	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
12	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
13	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0
14	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1

Calculations:

SubCluster:1

Node 1: SCHParam = 5/3

Node 2: SCHParam = 5/4 (SCH1)

Node 3: SCHParam = 5/3

Node 4: SCHParam = 5/3

Node 5: SCHParam = 5/3

SubClaster:2

Node 6: SCHParam = 3/2 (SCH2)

Node 7: SCHParam = 3/1

Node 8: SCHParam = 3/1

SubCluster:3

Node 9: SCHParam = 2/1 (SCH3) (Node 9(h) < Node10(h))

Node 10: SCHParam = 2/1

SubCluster:4

Node 11: SCHParam = 4/2

Node 12: SCHParam = 4/2

Node 13: SCHParam = 4/3 (SCH4)

Node 14: SCHParam = 4/1

SubCluster:5

Node 15: No Connection (interference zone)

After the above processes are completed, we will have a cluster that will be similar to that of figure-3.

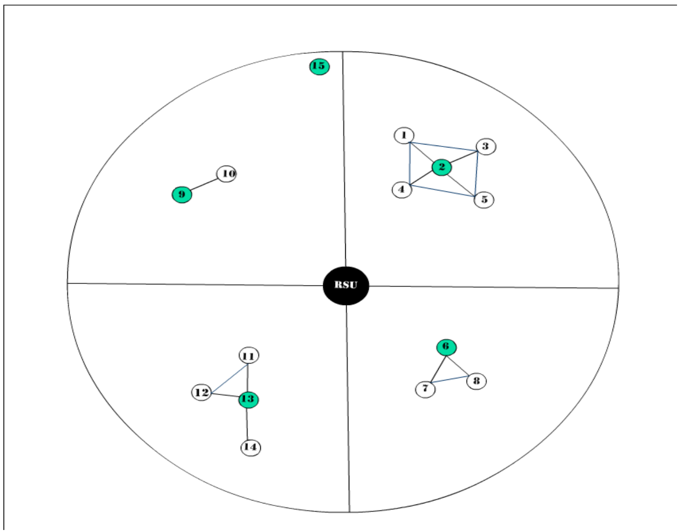

Figure 3:Sub-clusters formed after adjacency matrix calculation

Here, in **sub-cluster 1**; we have 5 nodes and node 2 has the highest number of connections with other nodes. Therefore, it is elected as the sub-cluster head.

In **sub-cluster 2** we have 3 nodes. All the nodes are connected to each other, however, the 'd' parameter that will be discussed later on is minimum for node 6 as compared to the other nodes. Therefore, it gets elected as the sub-cluster head. If we had 2 nodes at the same 'd' parameter value, we would have taken into account the velocity, the node having the lower velocity among the 2; would be elected as the sub-cluster head.

In **sub-cluster 3**; we have only 2 nodes obviously, both are connected to each other. That is why the node having the minimum 'd' value, node 9, is elected as sub-cluster head.

In **sub-cluster 4**; we have 4 nodes and node 13 has highest connectivity, therefore it is elected as the sub cluster head of cluster 4.

In **sub-cluster 5**; we only have 1 node (node 15), this node is in the intersection zone. It forms its own sub cluster and is therefore automatically the sub-cluster head. However, it is in a handover state between 2 clusters therefore it will be taken into account mainly by the cluster it is entering into.

2. **Formation of Minimum Spanning Tree (MST)**: This is a method that follows the Dijkstra's algorithm[6]. Here, the sub cluster heads will be connected to its corresponding sub-cluster nodes in a certain manner, so that there is no loop formation. It will work on the basis of minimum possible edge weight. All the connections will be as such that a shortest path will be formed for packet transfer. This is done for efficient packet routing. Consider the following sub-clsuter (Figure-4) for an example:

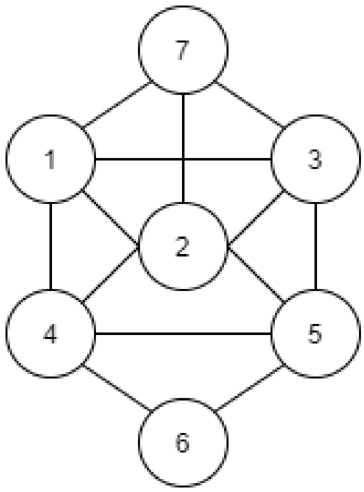

Figure 4

Here, we are able to determine using adjacency matrix that node 2 has the highest number of connections with other nodes. Thus, it will be determined as the sub –cluster head. Therefore, all packet transmissions will occur through this particular node 2. The MST calculation for node 2 is as follows:

Node	Predecessors	Distance
1	2	1
3	2	1
4	2	1
5	2	1
6	2,4	2
7	2	1

Table 2 MST for Node 2

After the MST calculation is completed, the sub-cluster connections from figure-3 will obtain the spanning tree in figure-4. This will ensure the shortest path for a packet to travel from any sub-cluster to the sub-cluster head.

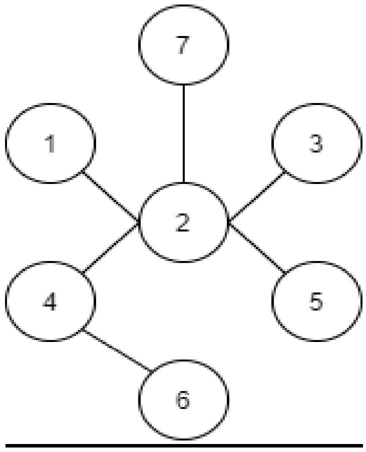

Figure 5

Therefore, we will obtain the above spanning tree, Figure-5, for our packet transmission in that particular sub-cluster. Similarly, the MST will be carried out for all the sub-clusters as well.

3. **Cluster Head Selection**: after the completion of the above processes; Cluster Head Election will be initiated. For each sub-cluster head, the RSU will calculate the radial distance, ‘d’, and then its average velocity, ‘v’. ‘r_{ref}’ is 90% of the radius value. For better understanding refer to the following diagram Figure 6.

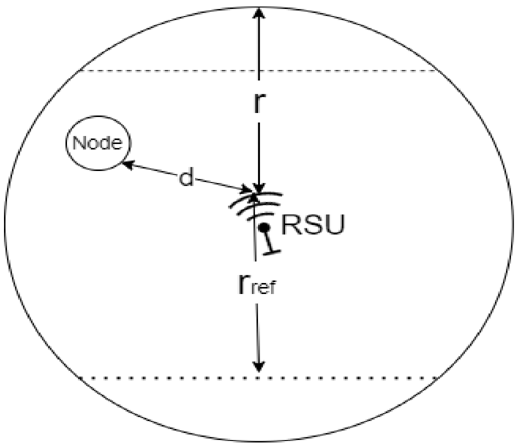

Figure 6

Note; we want our CH to have a minimum distance from the center as well as having a low velocity compared to the other nodes. That is, why we select the minimum "SCH_Weight" valued node as our cluster head. As per the equation from the 4th part of the algorithm.

$$SCH\_Weight = C_1 \mathrm{d} + C_2 \log_{10}[\frac{v}{v_{avg}}]$$

Here, we assume the co-efficient values, C_1 and C_2 as 0.3 and 0.7 respectively.

$$C_1 + C_2 = 1$$

The velocity of the node will be given much higher priority as compared to the distance parameter. Therefore, the co-efficient value of distance parameter is assigned as 0.3. Keep in mind, we want the minimum weighted sub-cluster head as the cluster head. Therefore, if velocity of the node is less than average velocity of all nodes, we should have a negative value after logarithmic calculation and vice versa. Thus, reducing the weighted value. And, eventually if it has the lowest weight value it will be elected as the cluster head. equation:

CH= Minimum SCH_WEIGHT

If everything goes as per description, we will have the following scenario, Figure 7.

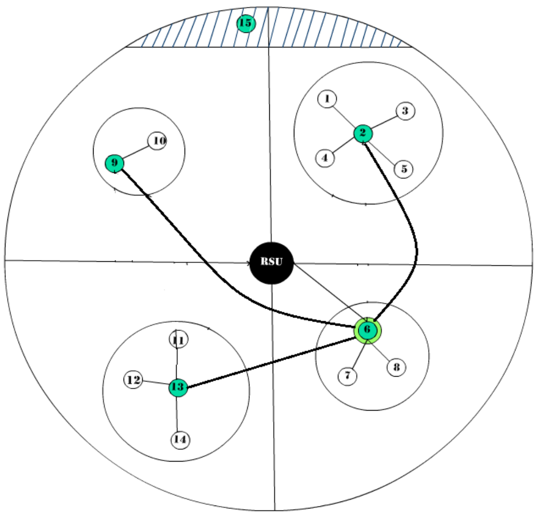

Figure 7

The sub cluster heads (2, 9 and 13) are all connected to the cluster head (6). The cluster head (6) is connected to the RSU. The connections formed because of MST inside the sub-clusters are shown as well.

Part 2.3 Backbone System Model & Unwonted Scenarios.

In situations where a sparse network occurs, i.e a fixed cluster area having no links or nodes; the RSU will take over. The RSU is connected to the backbone of the network, this allows the system to use the internet and in turn allows for packet routing despite the absence of nodes inside a cluster area.

We obtained this particular idea from the referenced article [7]. See Figure 8, The backnbone network architecture .

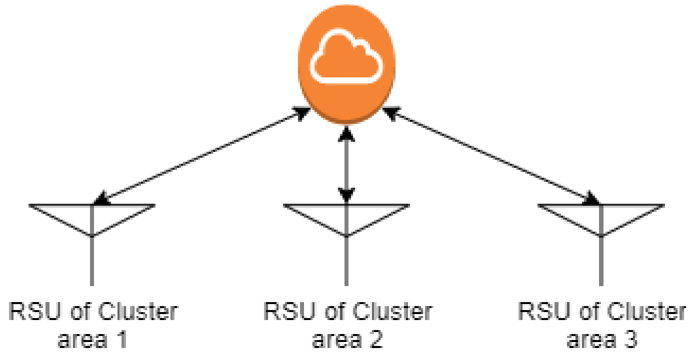

Figure 8

An important feature of the protocol is the "dead time". That is, the time before a new cluster head selection is started, provided that the cluster head does not reply back to the RSU within this time. Ii will be denoted as 'dead_T'. This is done alongside all the calculations so that if at any given time a cluster head is not responding an immediate action can be taken. Instead of assigning a fixed time interval for a cluster head election, we opted for assigning a variable time based on the cluster head's average speed, because the network scenario is dynamic. The equation is as follows:

$$dead\_T = \frac{r_{ref}}{2 * v_{avg}}$$

The mentioned processes should also be quite sufficient to tackle any other unwonted scenarios if it arises. Also keep records of scenarios where packet dropped occur in massive amount or frequent connection took place and inform accordingly.

Part 2.4 Packet Routing and Selection Process Initialization.

Packet Transmission (Transmission of standardized packets of data from one transmission node to another node rapidly by the network system): We have decided to incorporate "Dijkstra's Algorithm" for packet transmission, the adjacency matrix is based upon this algorithm. The paper has already shown how the spanning tree will be formed. This route will be used for packet transmission. All our clusters and sub-clusters will be assigned an unique cluster ID and sub cluster ID respectively. All online nodes will have a pre-assigned node ID. This unique IDs should also provide a security aspect for the clustering algorithms as well. Packets will contain, the destination addresses denoted using the IDs. Packet transmission will occur in two processes; we classify them as follows:

i) Inter packet transmission, and

ii) Intra packet transmission.

i) Inter Packet Transmission: if a packet needs to be transmitted from one cluster to another cluster; such transmission are referred as Inter packet transmission. If the packet contains a different Cluster ID as compared to the one that packet is currently residing in. Then the packet will be forwarded to that cluster via a cluster head to cluster head. If necessary, the packet transmission will be done via the backbone network architecture.

ii) Intra Packet Transmission: if a packet needs to be transmitted from one node to another node within the same cluster or sub-cluster. The packet will have the destination cluster ID matching to the one that the packet is residing in. If the sub-cluster ID is different from the one it is residing in, it will be routed based on that ID. At first, the packet will be routed to its sub cluster head node from its node. Then it will travel to the cluster head and then to the sub cluster head of the sub cluster that it wants to reach. And finally to the node it wants to arrive at. If not, then a packet might need to be transferred from one node to another node within the same cluster; in that case the node ID will be taken into consideration. Based on the unique IDs; the packet will be routed to its particular destination.

Selection Process Start: Here, we have opted for a continuous online network[10]. The process needs to be continuous and must be carried out every time a node enters a cluster area. The algorithm will continuosly update adjacency matrix table and MST will vary accordingly; if any changes are to be done. This ensures the election process to be swiftly completed and therefore maintaining a stable spanning tree all throughout. The First 2 steps in the election process not only helps in electing the cluster head but also at the same time forms our route for packet transmission inside clusters. That is why this process is more efficient when compared with other routing protocols; which deals with continuously changing scenarios that require immediate actions.

Chapter 3 Algorithm And Performance Evaluation.

Part 3.1 Algorithm

Algorithm 1: Getting ClusterID Primary info

If no ClusterID or different ClusterID:
node Broadcast "hello"
RSU reply with: "hello", ClusterID
If RSUconnected to node:
Calculate d
Calculate v_{avg}
Calculate hello_time = r_{ref} / 6*v_{avg}
[r_{ref}=0.9*r]
Calculate dead_time = r_{ref} / 2*v_{avg}

Algorithm 2: Creation of Adjacency Matrix

For node 1 to i:
For node 1 to j:
If (d(i)<r_{ref}) and (node j reply true):
A[i][j] = 1
Else:
A[i][j] = 0

Algorithm 3: Creation Subcluster and SCH

For node 1 to i:
Calculate MST [Using Dijkstra]
Calculate MSTsize
Calculate MSTnodes
For node 1 to j:
connected_nodes = A[i][j] + connected_nodes

For node 1 to i:
Calculate SCH_param = MSTsize/connected_nodes
If (node(i) have same MSTsize, MSTnodes):
SubclusterID = existing_ SubclusterID
else:
SubclusterID = existing_ SubclusterID
For SubclusterID 1 to i:
for node in subcluster(i):
SCH = node(i)_with_lowest_SCH_param

Algorithm 4: Electing CH

If (no CH or (CH_d>r_{ref}) or (CH_response_time > dead_time))
for SCH 1 to i:
SCH_weight(i) = C1*d(i) + C2*log(v/v_{avg}) [C_1=0.3, C_2=0.7]
CH = lowest SCH_weight
else:
CH = existing_CH

Algorithm 5: packet routing

If (ClusterID, SubclusterID of source and destination node equal):

Forward through SCH_MST to node
If (ClusterID of source and destination node equal):

Forward through SCH_MST to SCH_MST to node
else:
find source ClusterID and destination ClusterID MST [Using Dijkstra]
forward through CH_MST to SCH_MST to node

Part 3.2 Performance Evaluation

We opted for a simulation environment that was formed in Network Simulator 3. The simulator is specifically designed for testing out routing protocols. In fact, the simulator has pre-built codes stored, for certain widely known protocols. However, given the fact that we have proposed a new routing proposal that can incorporate 3-D scenarios; we had to work from scratch to create our code for the simulator. Table-3 represents the basic parameters of our simulation.

Parameter	Value
Number of Nodes	50,100
Mobility Model	Random
Propagation Model	Constant Speed Propagation Delay
Propagation Loss Model	Friis
Mac	AdhocWifiMAC
Mac Standarad	802.11b
Bps	2Kbps
Node Speed	20 m/s
Simulation Time	200 sec
Area	200x1000 m^2

Table 3: Simulation Parameters

For performance evaluation, there is no specific measurement as to how it can be evaluated. However, we decided to calculate packet rate delivery and received packets amount; at specific number of nodes and pause time in specific scenarios and in the end also analyze the network flow. We compared our results against certain other base protocols such as DSDV, DSR and OLSR. In the graphs, it is noticeable that all our simulation of any protocol starts after 100 seconds. This is because all systems requires a 100 seconds time to initialize. The pause time refers to the node pause time; after the pause time the mobility of the nodes changes. The network flow refers to the flows in-between 2 nodes, here we only showed the average flow output between 2 nodes. The results obtained are shown in the following graphs.

I. Packets Received and Rate at 0 second pause time.

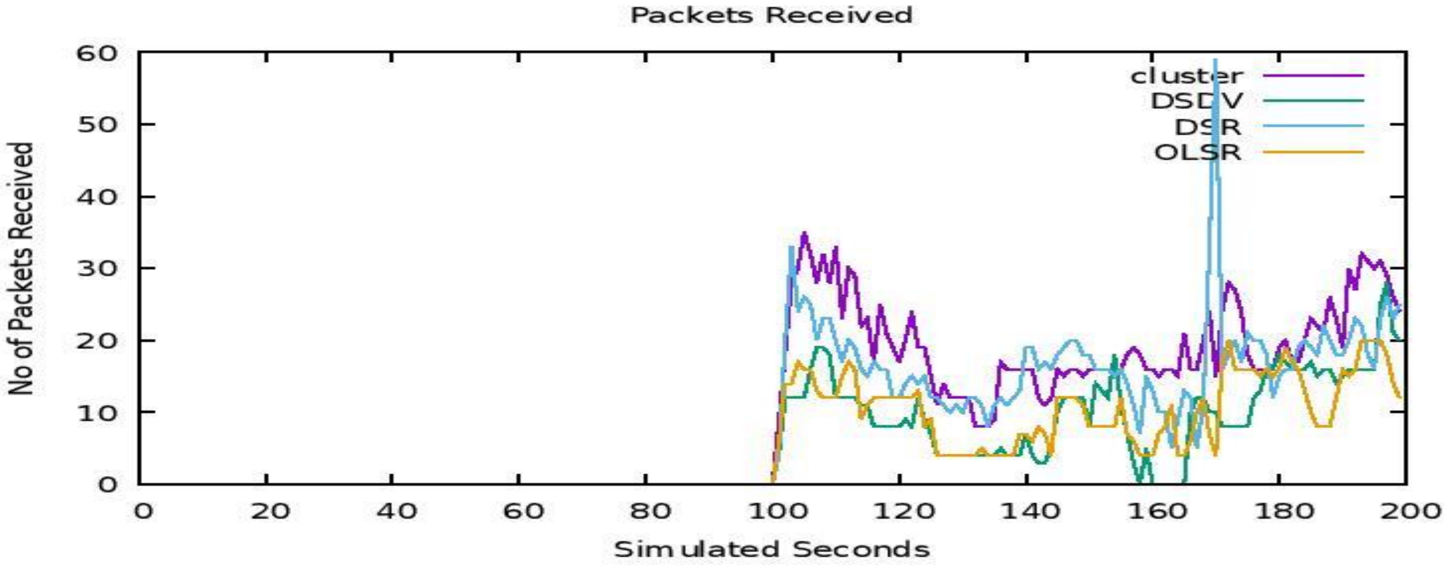

Figure 9 Number of Packets Received VS
Time in seconds after simulation initiation

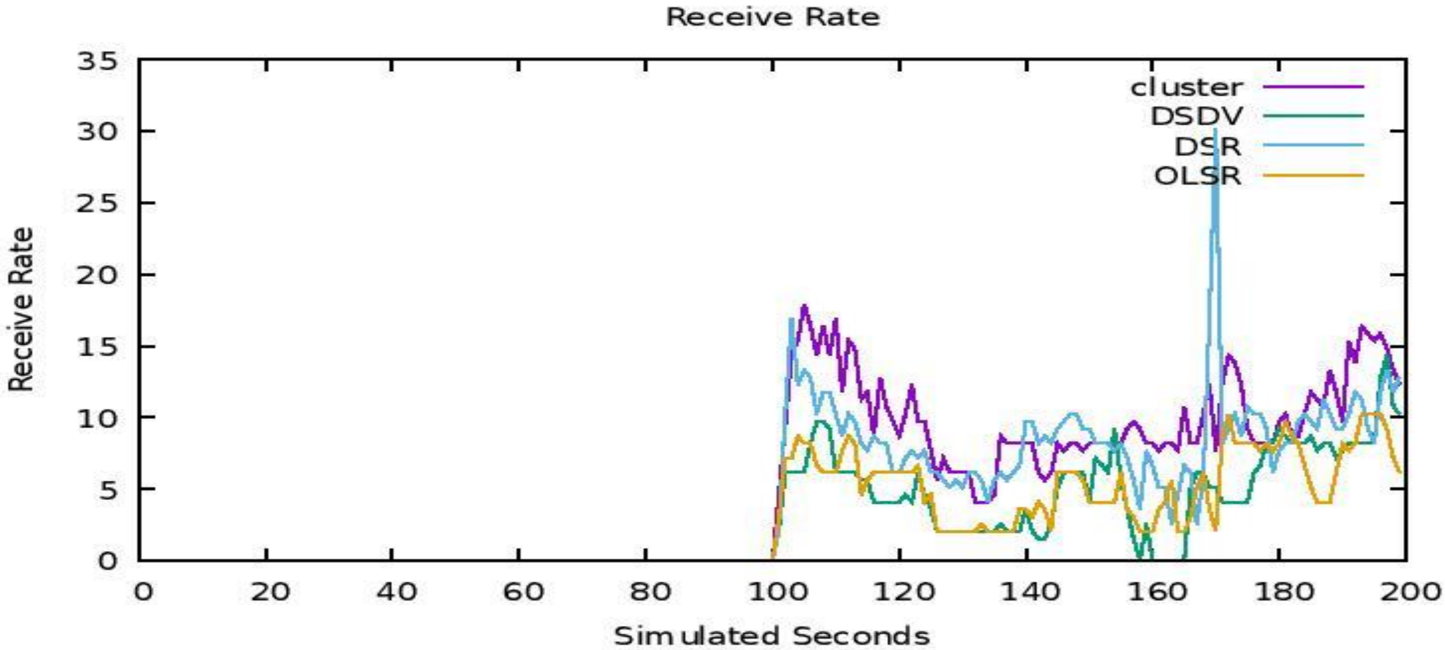

Figure 10 Packets Receiving Rate VS Time
in seconds after simulation initiated

In I, we have simulated an environment with 0 second pause time for nodes. The protocols in comparison are DSDV, DSR and OlSR against our proposed cluster protocol. In the graphs, it is clearly seen that our protocol was able to outperform the other protocols. Except at one point, where there is a high peak for a small time of DSR. In overall performance, the proposed cluster protocol still outperforms for the rest of the simulation.

II. Packets Received and Rate at 10 second pause time.

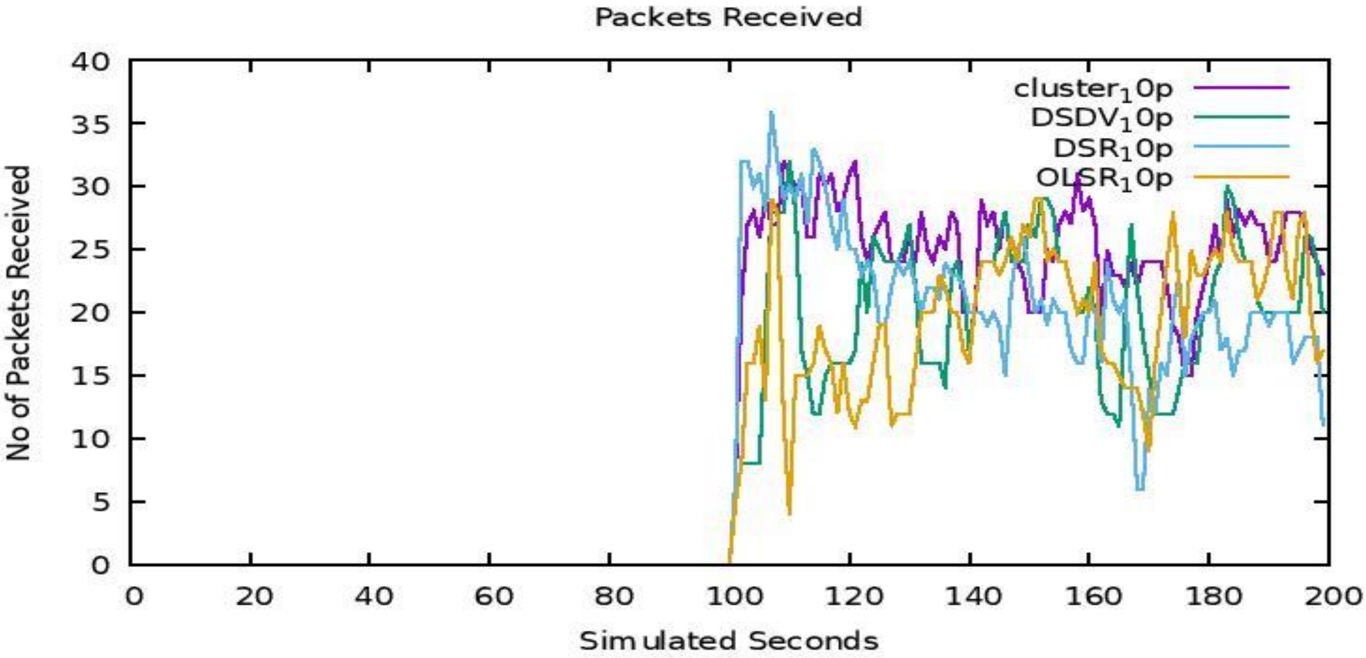

Figure 11 Number of Packets Received VS
Time in seconds after simulation initiation

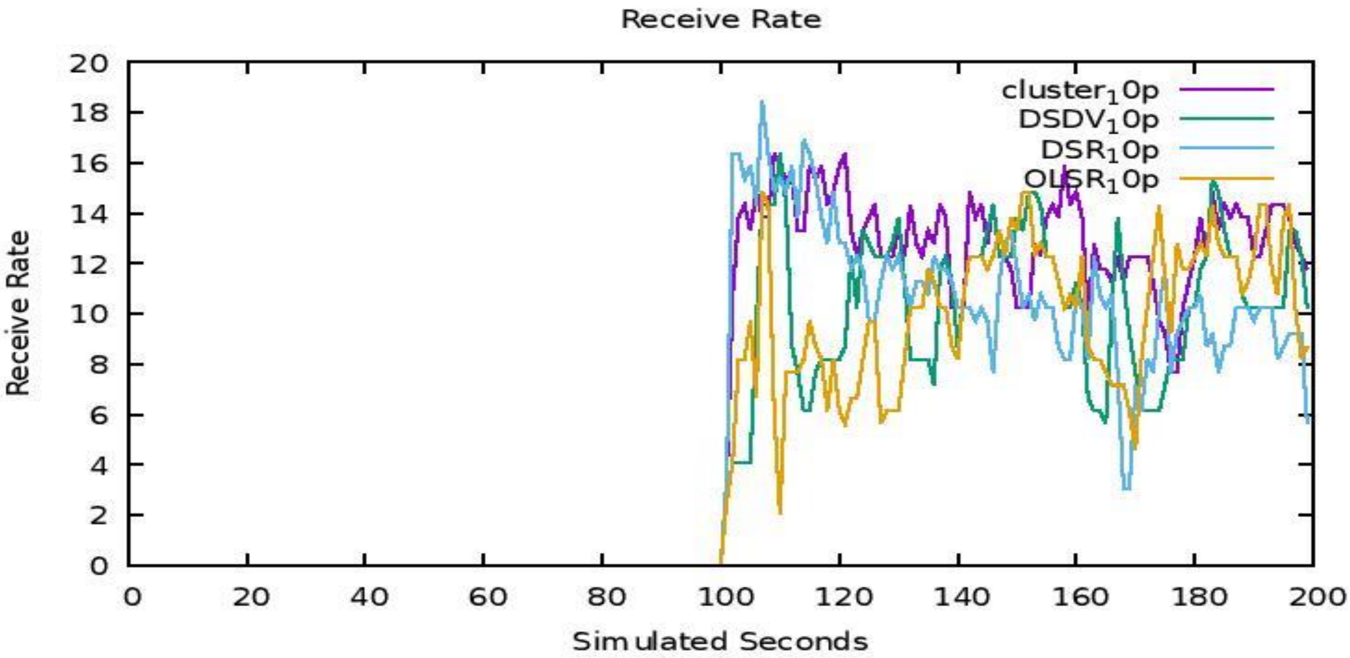

Figure 12 Packets Receiving Rate VS Time in
seconds after simulation initiated

In II, we have simulated with a 10 second node pause time environment. The protocols in comparison are DSDV, DSR and OlSR against our proposed cluster protocol. Here, in the initial 10 seconds, after the systems starts running, DSR does outperform the proposed cluster protocol but it does not maintain its stability and falls below its margin after 10 seconds. Whereas, our proposed cluster protocol maintains its consistency and keeps a smooth packet receiving rate. After 40 seconds, the other protocols does start to perform better, almost reach the performance level of the our proposed cluster protocol but they fail to maintain its consistency and maintain stability in their performance. Whereas, our proposed clustering algorithm not only maintains its consistency but also shows better performance all throughout.

III. Packets Received and Rate with 50 nodes.

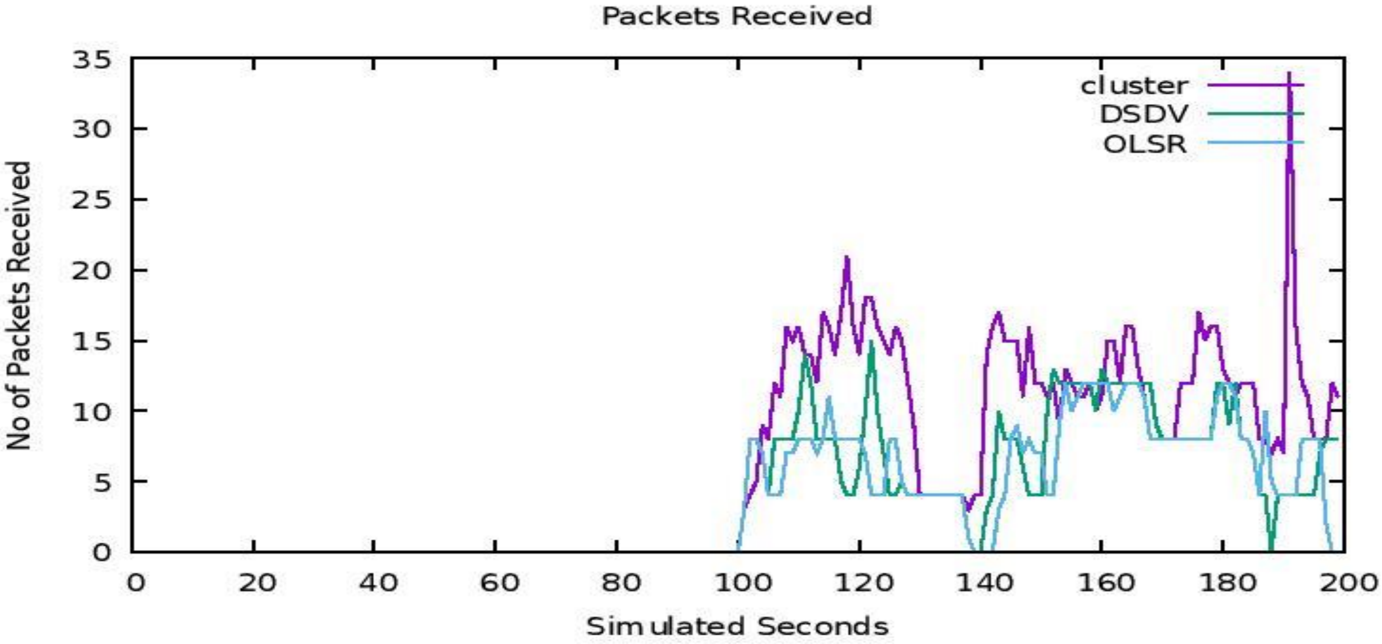

Figure 13 Number of Packets Received VS Time in seconds after simulation initiation

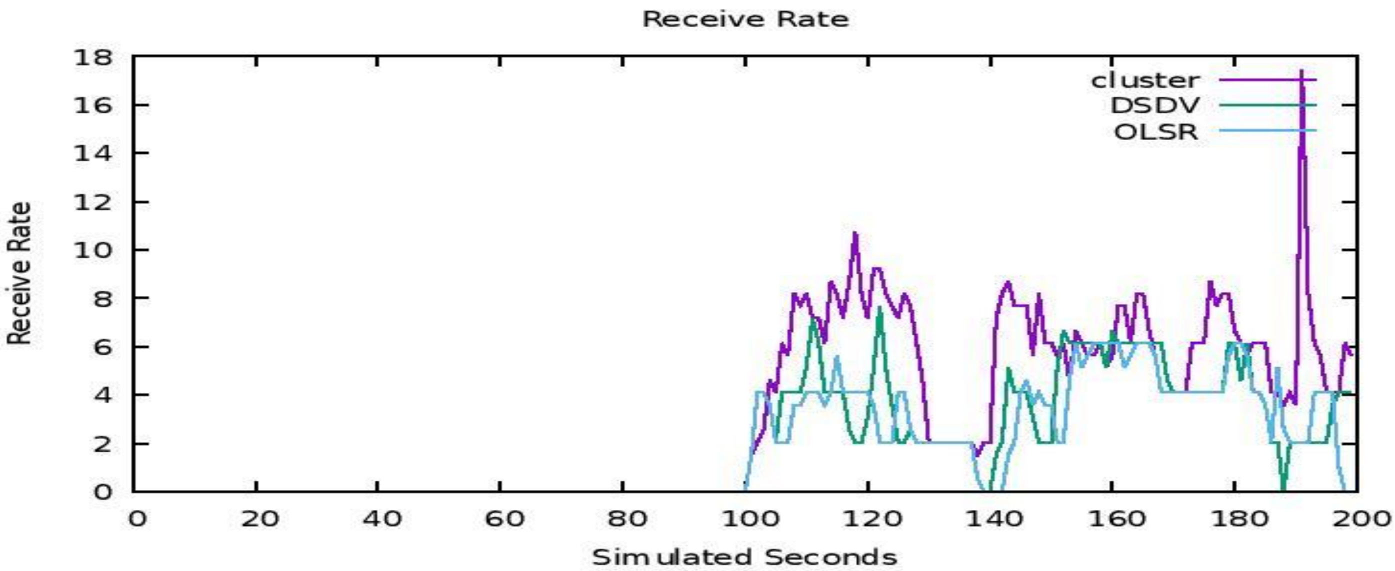

Figure 14 Packets Receiving Rate VS Time in seconds after simulation initiated

In III, we have simulated everything with 50 nodes; the protocols measured are DSDV and OLSR. The graph clearly shows our cluster protocol outperforms the other two protocols and also shows a decent amount of packet flow in the overall network.

IV. Packets Received and Rate with 100 nodes.

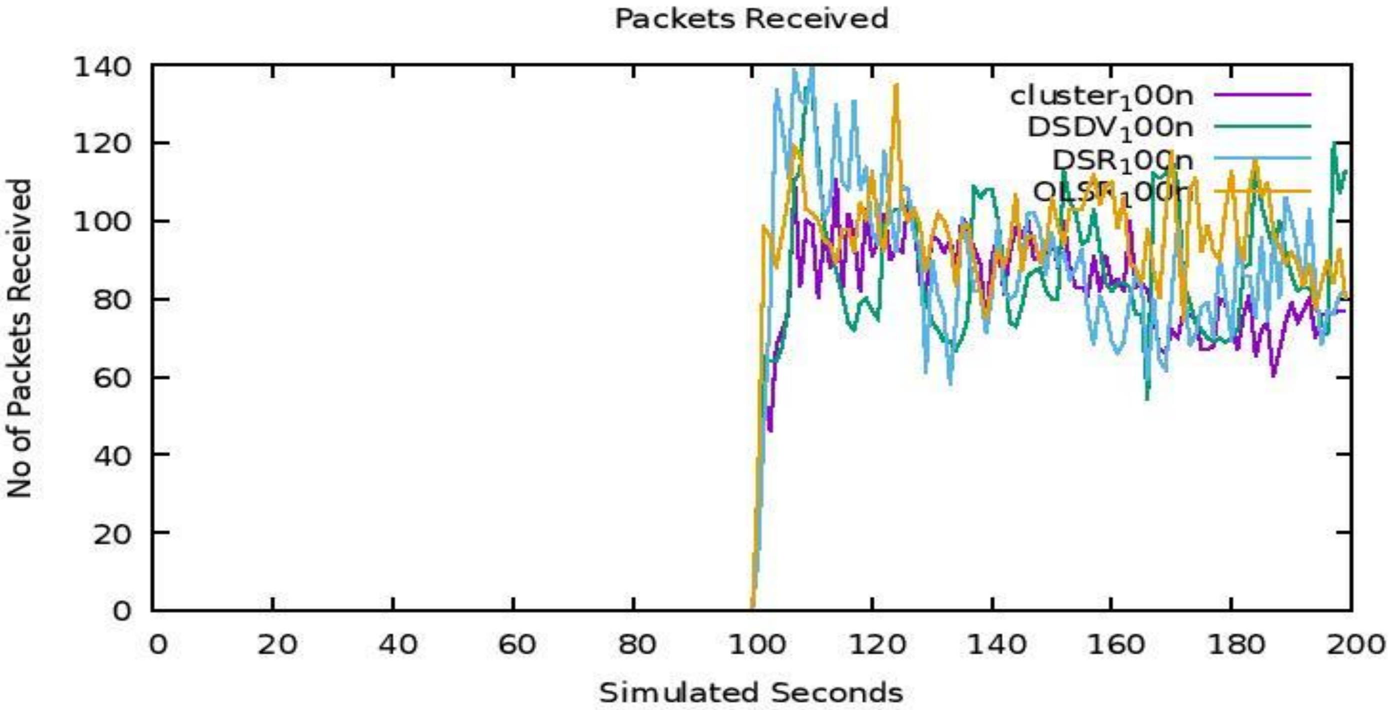

Figure 15 Number of Packets Received VS
Time in seconds after simulation initiation

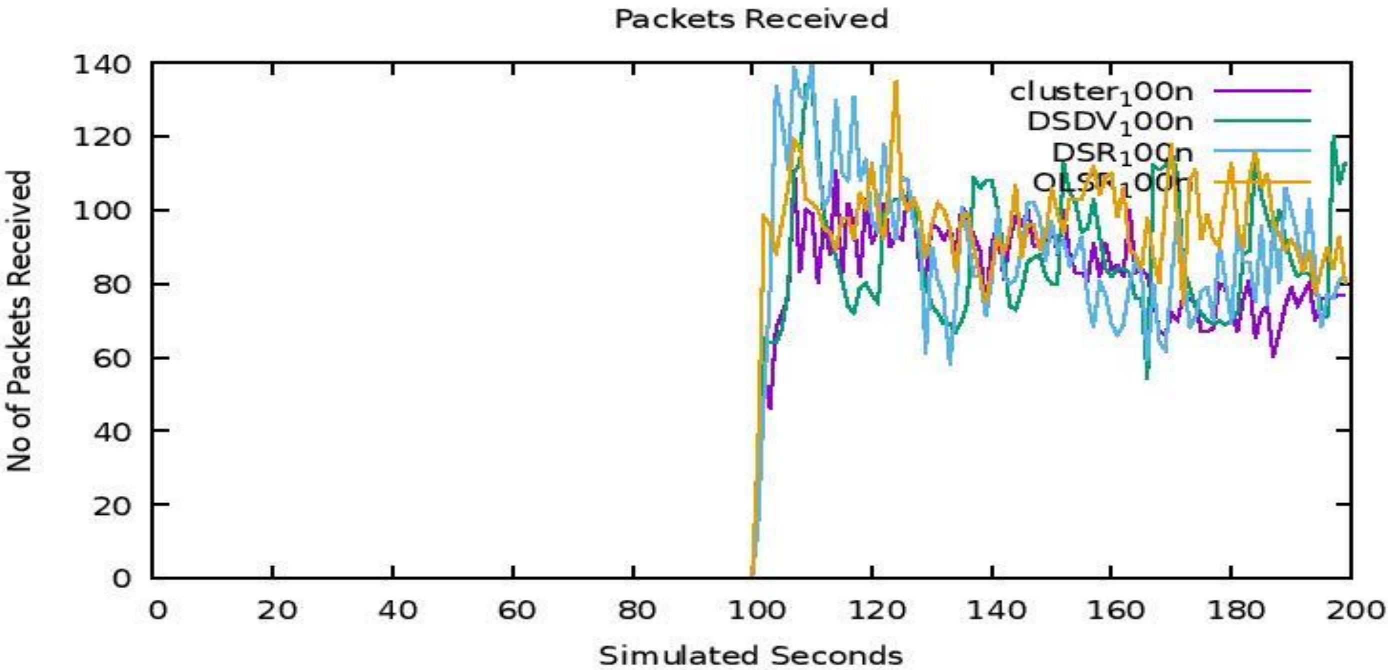

Figure 16 Packets Receiving Rate VS Time
in seconds after simulation initiated

In IV, the environment has a greater number of nodes, 100 nodes. The protocols in comparison here are DSDV, DSR and OLSR against our cluster based protocol. With greater number of nodes the performance level of all the protocol does face a certain hurdles and it falls. So let us look at the protocols performance one by one. Firstly, the DSDV protocol shows greater performance than all the other protocols except for DSR. However, as time passes it fails to maintain its consistency; the performance drops and again rises. Overall because of so much inconsistency, packets received is not as smooth as it should be and for long periods of time the performance falls below other protocol's performance. Moving onto DSR, the DSR protocol initially like DSDV performs extremely well but similar to DSDV its performance also drops below our cluster proposed protocol. The protocol fails in maintaining consistency and after 40 seconds the protocol has massive ups and downs in the performance. Finally, the OLSR protocol, clearly at start the protocol was not able to outperform the other protocols. But after 20 seconds, the protocol outperformed all three protocols and also maintained consistency in performance. Here, it can be observed that there is no heavy fluctuations like DSDV and DSR. Therefore, in this parameter the OSLR showed great compatibility. The proposed cluster protocol here maintained an average performance. The increased number of nodes took processing time which led to congestion at times and eventually resulted in packet drops at certain times. However, our proposed cluster even though here did not perform at optimum but it also did not fall below par. It maintained an average network and also unlike the other protocols its fluctuations was the least as compared with all the others.

V. Network Flow only for the cluster protocol.

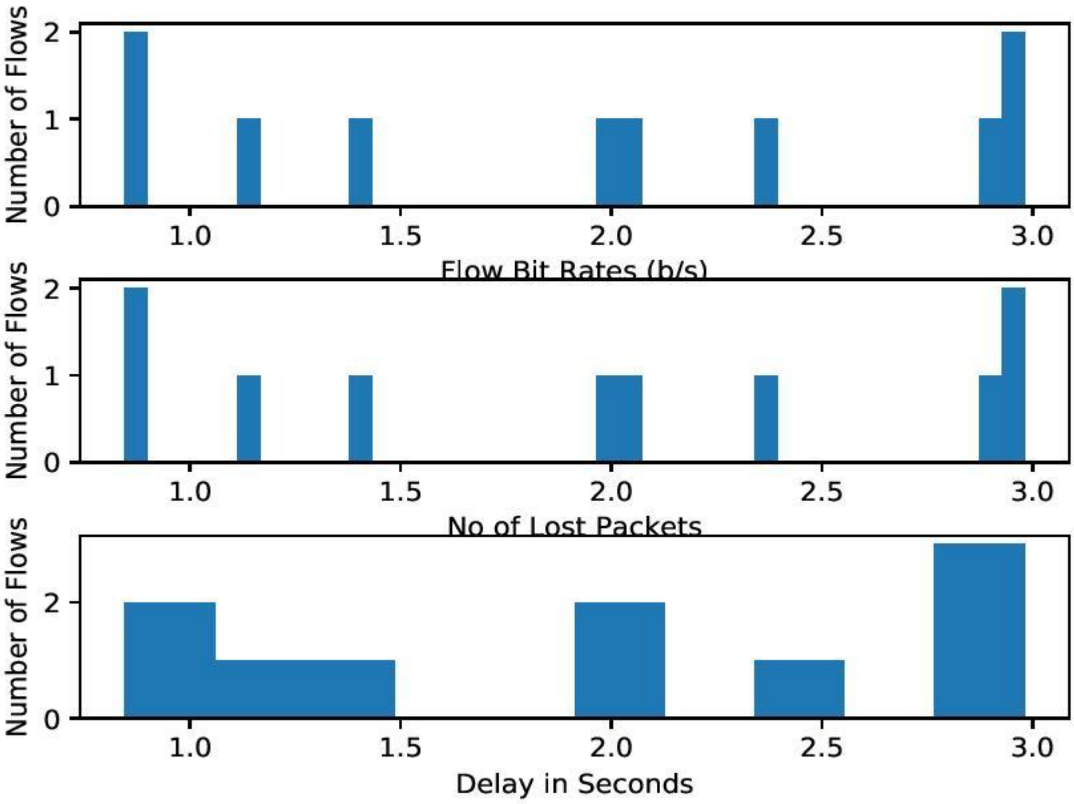

Figure 17 Number of Flows VS
i. Flow Bit rate, ii. Packets lost
and iii. Delay

In V, we show the Flow between two nodes. Here, we only showed an average output obtained from different scenarios. The main thing to look at here is the time delay. The overall time delay is very small irrespective of the flows. This shows that the packets will be delivered swiftly when required in emergency cases. The packet loss is also very low and happens only when there is spike in flow bit rate.

Considering all the factors we can without a doubt state that our proposed protocol maintained the most stability. It had the least packet loss and the time delay is very small in comparison with others. However, each protocol has the potential to play to its strength and outperform the other. Nonetheless, our proposed cluster protocol showed above average performance in almost all scenarios and in its strength circumstances outperformed the other protocols.

Chapter 4 Future works and Conclusion.

Part 4.1 Future works

We have made pushed some significant boundaries in coming up with the protocol. However, we do feel that there are certain areas that can have more research done to it. If given the opportunity, we want to work on the following aspects to develop the protocol much further and make it much advanced.

1 The security aspect: for security we added unique node ID, this should act as a level 1 security. In cases, where another node user or external person somehow is able to know the node ID it will be able to hack the internal node device. For which reason, password/encrypted node ID would seem to be a viable solution.

2 Cluster placement here for the paper we considered our RSU placement like mobile station antennas. Mobile station antennas also cover the road/areas where moving nodes cannot get access due to lack of space or various reasons. Moreover, roads are usually straight and narrow but lengthy; even the turns are at most times 90 degrees to one another. Therefore, unlike mobile base station it is not necessary to place RSUs everywhere. An area wise research and analysis should give us a resource effective area wise distribution pattern for RSU placement.

3 Our proposal focuses mainly on the protocol. Provided we gather the knowledge of what data is necessary or will be involved inside a data packet. It will be very helpful for researchers to understand the Bandwidth necessary and tweak future protocols accordingly.

4 Our proposal is specifically suited for urban or city areas based on the IEEE 802.11 access point parameter or RSU. The mentioned RSU has a range of over 1 Km in rural or open areas. We are willing to observe the scenario of our algorithm in rural areas. This should further help us to come up with efficient protocol particularly based for rural areas.

5 Besides sparse network error being resolved; response problems from certain links will also occur on a time to time basis. Effective response link is an area that lacks research.

Part 4.2 Conclusion

In this paper, we have looked through all the viable and existing methods for a reliable IOV scenario. We have reviewed papers and understood that every protocol has certain significant difference and plus points that enables them to achieve the purpose. Hopefully, the paper was successful in shedding light in the technical difficulty aspects of the IOV world as well as how the introduced proposal will tackle the issue. We focused on an efficient transmission IOV system in terms of time and node availability. We carried out our proposal simulation in a well known and widely accepted simulator “Network Simulator 3, NS3”. We believe that our proposal will have significant strides for entertainment purposes, as well as for emergency purposes. In conclusion, VANET protocols are a complex and challenging topic that requires a certain amount of time and dedication for development. Hopefully, IOVs are bound to play a vital role in the future world; with the help of future researches it will be a significant research area.

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