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Delay and Energy Optimized Safety Information Dissemination Scheme in V2I Networks

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Abstract: Intelligent Transport System (ITS) is a transport system that uses communicating technologies such as cellular network communication, digital video broadcasting and adhoc wireless communication to link people on the road, vehicles with aim of solving various traffic related issues. Vehicle to infrastructure (V2I) communication is an important research area to develop cooperative self-driving support system using DSRC technology. V2I develops an environment friendly system that also accelerates the fuel efficiency by establishing high quality links between vehicles to roadside infrastructure. It is a system to prevent and help drivers to overlooking or missing the red lights at junctions. V2I system along the road side and intersections continuously transmit the traffic signal information to vehicles by warning the driver about red lights and thus help us to prevent road rule violations. ITS helps to prevent drivers' oversight about signals right/left turn collision avoidance and timely activation of brake system. In the proposed work we used a three-layer Vehicle to Infrastructure (V2I) network architecture to collect and disseminate the safety information using static and dynamic agents. These methods help us to quickly selecting high quality error free links to forward the data packets. In a highway road scenario with moderate traffic density, the proposed system gives an improved performance in terms of coverage area, lossless transmission and reduced latency. Finally, qualitative comparison is made with present V2I system and found significance improvement in its performance metrics. The outcome of the proposed system improved by 23%, 13%, 15% compared to the existing system in terms of end-to-end delay, communication overhead and energy consumption respectively considering V2I network architecture.

Index Terms: V2I, Multi Agent, RSU Agency, Routing node (RN), High quality link, Link Quality Network, Protocol (LQNP), End to End Delay etc.

1. Introduction

Vehicular ad-hoc networks (VANETs) providing new possibilities to improve traffic safety and information dissemination efficiency. Vehicle to infrastructure (V2I) communication performs the sharing of identified hazardous events to the neighbor vehicles either through unicast or point to multipoint (PMP) or broadcast communication methods, where transmission by single vehicle will be received by multiple receivers. Here the vehicle communicates with the infrastructure to take intelligent decisions when vehicles are driving in difficult situations like heavy Fogg, rain, or scenario like difficult to see cyclists, pedestrians crossing road, when these events are shared in advance with all neighbors to overcome the damage together is called cooperative intelligent transportation system (C-ITS). The infrastructure may be a signal at the intersections, digital signboard along the road or special equipment's called road side units (RSU). RSU can amplify and route the received signals from the source vehicles to send them even further. The C-ITS used in connected vehicles focuses on digital technology for the information sharing via wireless communication channels.

Major research objectives are to broadcast safety information in a vehicle-to-infrastructure network architecture with a shorter end-to-end latency and a higher throughput rate by reducing communication overhead. A centralized V2I architecture is used to deploy existing commercial systems for gathering and delivering safety traffic information. These systems use beaconing and message aggregation techniques in dissemination, where as they fail to segregate safety and non-safety events thus increases the communication overhead leading to larger time delay. Moreover, these systems capture the data in highways with a specific vehicle density. Hence In this work the LQNP (Link Quality Network

Protocol) protocol is suggested to provide more highway coverage and a more efficient dissemination process in a V2I architecture with a guaranteed end-to-end latency. The performance ties of the following system are a restriction when the vehicle density is quite high, such as above 90 vehicles per kilo meter. In this approach we segregate the information as safety and non-safety events based on BDI model and communication links are established in a network using higher RSS (radio signal strength) levels thereby ensuring the strong connectivity during the information dissemination. As a result, the improved performance related to end-to-end latency and energy usages are achieved in suggested V2I communication scenario.

In the present work multiple software agents are used to detect safety events like accident on the road and reliable target vehicles for information forwarding. Communication paths are established using sustainable links based on RSS levels. As a consequence, messages will be transmitted with the specified end-to-end latency across high-quality communication lines.

2. Related Work

Vehicular Ad-hoc Network (VANET) offering feasible solution for the current complex transportation issues. Vehicles on the road detects the hazardous conditions and capable of cooperatively share the information to overcome the further damage is an evident example for the ITS. ITS comprises of set of technologies and applications and their aim is to improve the transportation safety and mobility. It will increase the people productivity and reducing the harmful effect of the traffic. One of the most important reasons for such harmful effect on traffic is road congestion and accidents. Millions of people lost their life and got injured due to road accidents. Timely dissemination of these events can reduce the further consequences. It is a global problem that we need to address these issues. ITS will help us to improve the road safety by deploying suitable dissemination algorithms. Dissemination of safety information now attracting great deal of attention from researchers, academia, and industrials, in order to improve the vehicle traffic conditions, but they also ultimately make the transportation sector more convenient, effective. Critical time constraints present in broadcasting of information such as post-crash notification, cooperative collision warning, lane change assistance, emergency electronic brake light, left/right turn assistance, traffic signal violation warning etc.

Many works on information dissemination has been proposed by the researchers to tackle the packet transfer delay. The detailed survey on dissemination by focusing on the important issues of privacy and data security is discussed in [1], where the data forwarding strategies uses the fixed infrastructure or centralized administration. It employs an adaptive strategy to disseminate critical warning information, taking into account the incident zone area and local vehicle density, as well as emergency messages from vehicles within two hops. Uniform traffic with two road lanes is one of the mobility situations. In [2], priority-based traffic flow scheme vehicles are provided with the Sequence ID based on the speed, direction and opposite side front of vehicles. The wireless communication module (NRF24L01) and Arduino module is used for sustainable traffic management by incorporating continuous supervised and disciplined way of dissemination protocol. Despite the relevance of current solutions, we first observe that a data downlink distribution plan outlining how to quickly send the safety message from the remote server to the cars in the targeted region is lacking. In reality, for a standard VANET-based centralised system, this is a difficult task. Currently, efficient urban transportation management needs huge traffic data, such as sensors and cameras, dispersed over broad urban areas, which VANET technology and traditional centralised intelligent transportation systems are unable to handle. The data searching algorithm extracts the crucial data about the road parameters and then distributes with neighbor's using GDSOM-P2P algorithm [3,4]. In [5,6], considering highway road scenario the real time traffic management is performed by analyzing the V2I communication using agent-based model that consists of heavy weight static cognitive (based on Belief Desire Intention: BDI) and light-weight mobile agents. It executes push (gather/store and disseminate) and pull (gather/store) operations based on the information relevance. The vehicle pre-emption technique increases the capabilities of emergency message dissemination with central traffic management database connected by multi-hop wireless technologies. The various dashboard controls on the logical platform architecture provides the dataflow control based on the DSRC connectivity [7].

The authors illustrated the potential of V2V and V2I in a Het-Net environment using Wi-Fi, DSRC, and LTE to ensure the best possible use of existing communication choices while minimizing the backhaul communication infrastructure while taking in to account connected vehicle application requirements [8]. In [9], the suggested method has significant implications, including resolving the constraints of K-means based clustering and improving the accuracy of clustering as a critical tool in data mining and expert systems. Systematic reading and study of the examined literature relevant to V2I communication yielded highly useful insights such as motives, problems, issues and suggestions in relation to V2I systems and performance measurements considering traffic data and methods [10,11]. Adaptive load balancing scheme (RBO-EM) for efficient data dissemination to get improved end to end delay is discussed in [12]. In [13], the Secure Cryptography-based Cluster Mechanism (SCCM) for MANET is discussed. To develop the AOMDV routing protocol, it included the following stages: safe routing, encryption, signature generation, signature verification, and decryption.

For lossless transmission of data two typical systems are the global timeout scheme and the anti-packet dissemination scheme, where control messages are provided in social-based end-to-end and local-based ad-hoc ways

[14]. vehicular networks are subject to a variety of security risks posed by hacked nodes during dissemination, and typical security measures cannot be utilised to defend against internal assaults from compromised nodes due to resource constraints. The most effective security techniques for protecting vehicular networks are the trust and reputation evaluation system. The Dempster Shafer theory is used to develop a trust assessment method. The evaluation procedure is based on two types of trust: direct and indirect trust, with the latter having a higher importance [15]. The improved results in terms of connection overhead and transmission speed proved the effectiveness of fragmentation method.

In Present day, modern vehicles are equipped with the advanced sensors, navigational systems, (LTE) long term evolution facility, wireless fidelity (Wi-Fi), infrared communication unit, inherently provides the provision of selecting stable connectivity wireless interface during the information dissemination process [16]. The vehicles state prediction algorithms in such architecture support for lossless and assured packet delivery in the presence of congested traffic. The work presented in [17], where multihop cluster-based forwarding reduces the number of clusters by calculating the relative mobility metric thereby decreasing the frequent handoff between base stations and the vehicles. The reactive cluster range formation based on the network strength significantly reduces the excessive usage of network resources [18,19]. This feature establishes the dual interface link supporting duplex communication mode for efficient dissemination.

The key parameters of energy consumption, PDR, and stable connectivity demonstrate the superior working architecture. When the receivers are priori unknown and presence of high mobility leads to frequent topology change needs an efficient routing table. Hence the mechanism for instant updating of routing tables using periodic network partition are discussed in [20]. Implosion is the shortcoming of broadcasting where there is no restriction of multiple nodes sending same packet to same destination, here neighbor node receives the duplicate packet and the problem of overleaf where two nodes sense same event and send to same receiver [21]. such Resource blindness in which flooding does not care about energy. The energy aware dissemination of safety information is discussed in [22]. Road safety services and convenience services are disseminated using different transmission technologies such as digital video broadcasting (DVB-H), universal mobile telecommunications systems (UMTS) and wireless access in vehicular environment (WAVE). DSRC employees the exponent-3 model and cost HATA model for line of sight communication where path loss calculation determines the height of RSU antenna. This phenomenon is validated by the inter vehicle and RSU path loss calculation results. The required system data rate is achieved by performing packet stamping with low level and high-level factor of reachability before initiating the dissemination. In DVB sufficient numbers of frequency channels are used in highway scenario to provide the downlink stream of data flow in required rate [23,24].

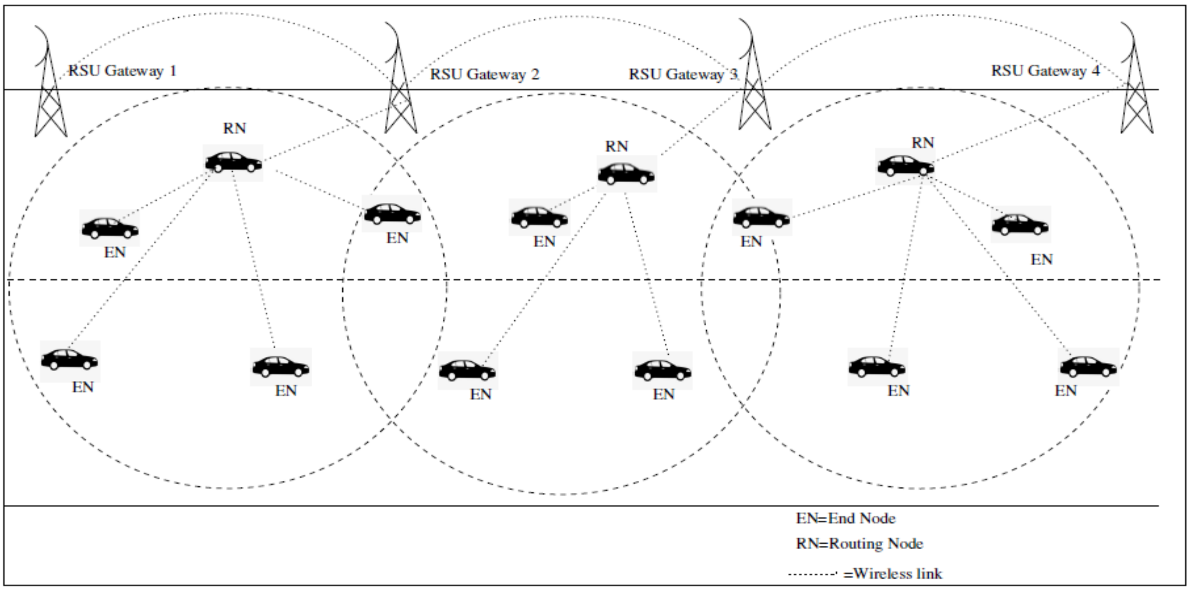

Fig.1. V2I communication scenario in VANETs

The information offered in this article allows for the development of novel methods to the problem of calculating the needed bandwidth of the tactical control link's access node in the information and telecommunications network. The relevance and usefulness of this work is based on the fact that, in the context of constant improvement of fighting forms and techniques, there is a high dynamism of changes in the states of tactical information and communications systems [25, 26].

The dissemination protocol for reliable communication using fragmentation method is discussed in [27], where connectivity hole can stop the broadcasting process in high density network. Forwarder task will be assigned once the new node enters in the communication range which will schedule the rebroadcasting interval by considering the duplicate packets arrival rate. In the absence of forwarder node, the connectivity hole refrains the transmission. This method, however, may result in a high packet dropping rate and significant route loss. As a result, retransmission of messages would waste time and bandwidth, particularly in high-density traffic environments. Through extensive simulations in Python with different vehicle mobility input, we demonstrate higher performance of the proposed architecture as compared to previously published hybrid designs and other dissemination strategies like as flooding and cluster based forwarding. The suggested design also provides for greater application dependability, as measured by the data packet delivery ratio, at the cost of increased LTE utilisation, as measured by the number of cluster heads in the network.

3. Proposed Work

In the proposed work, two main tasks are performed by the module's node agency and RSU agency using multiple static and dynamic agents. Link Quality Network Protocol (LQNP) used in the proposed work is a multihop wireless protocol that provides the rapid broadcast of safety information in a vehicle to infrastructure (V2I) architecture. The nodes in the network under considerations may be one of three types discussed below. The communication mechanism handles the traffic in tree type structure among its enable devices. The LQNP protocol is described by the architecture shown in figure (1), it consists of three tiers of nodes namely Road Side Unit (RSU), Routing Node (RN) and end nodes. Packet routing will be performed by RSU and RN, whereas mesh enabled end nodes connects the RSU through the routing nodes for information dissemination. The network scenario consists of hundreds of nodes and multiple routing nodes and RSU for redundancy and work load sharing. Any end nodes may be configured to function as RN based on its distance and Radio Signal Strength (RSS) level. A LQNP end nodes initially operates in power sleep simplex mode for battery operation and will not perform the redistribution of information, the node is awaked by external stimuli or clock.

3.1. Our Contributions

There are several techniques to disseminate safety information. In this section, we contribute regulated safety information dissemination and it includes the following set of actions.1) Design of static and dynamic cognitive agents for safety information collection and distribution purpose. 2) Utilization of BDI (Belief Desire Intension) model to identify the critical and non-critical events about road hazards. 3) Establishment of congestion free wireless links for information transmission based on the RSS levels of receiving vehicles. 4) Mobile agents are triggered for information collection about target vehicles and dissemination based on the error free bandwidth-oriented links is performed by the static agents. For example, in the available set of links the static agent always searches the higher bandwidth link for dissemination.

To illustrate the significance of the proposed work, city traffic with regulated traffic control network scenario is used for simulation and found considerable improvement in the end to end delay of packet. It has the supervisory control over the dissemination by the cognitive agents which has higher penetration rate of dissemination in covering more targets.

3.2. Cognitive agent-based safety information dissemination scheme

In this section, we describe the functions of static and mobile agents used to enhance the data dissemination process. The algorithms for node classification and node search are explained with mathematical description along with proposed network scenario.

Network Scenario: The proposed network scenario consisting of number of high dense vehicles on the road with considerable distance of separation. Each vehicle is equipped with GPS navigational facility, event capture sensors, communication facility (TX and RX) and processing unit. All the vehicles are assumed to follow the road lane directions and able to communicate with neighbors using the 802.11 communication standard. Clusters are formed based on the relative geographical area in the direction of vehicle moments and considered the city environment with curvature road lanes and top buildings. The equipment's used in the onboard system of the vehicles are assumed to support the agent-based platforms. The agent programs run on each vehicle are platform independent and solve the compatibility issues. Each end nodes have the mobile agent, static agent and knowledge base expert system which supports for information forwarding through reliable communication channel. The codes used for agents communicate with other agents for better cooperation to achieve the specified goal.

The three-tier architecture of node pattern namely low tier end nodes, middle layer routing nodes and top layer Gateway node (RSU) incorporates the different tasks managed by static and mobile agents. The RN node performs the link searching process and identifies the reliable congestion free links based on the mobility, bandwidth utilization, link speed and type of the communication standard used. The RSU infrastructure collects the downstream data by RN and uses probabilistic model of node searches algorithm to locate the distant targets for wide coverage of safety information. The routing of information through RN ensures the participation of fewer nodes in the communication process based on the RSS levels. The end nodes detect a critical event using sensed parameters and BDI model that runs on each node classify the safety and non-safety information and forward through reliable RN. RN joins the network by verifying the invitation, and redistributes invitation to all low tier end nodes to join the network. Large autonomous network will be formed within seconds of powering up the RN Gateway. RN Gateway and end node devices broadcast periodic beacon packets to signal their existence and connection availability. HELLO packets, also known as beacon packets, include device address (UID), system identity (SID), radio frequency channel, and device network level information (Hop Level).

Table 1. RSS threshold with connection possibilities

RSS Levels	Vehicle Mobility	Predicted Connections
30 db	80 km/hr	70 %
40 db	80 km/hr	60 %
50 db	80 km/hr	50 %
60 db	80 km/hr	40%

The routing node (RN) selection is performed on the bases of hop count, relative mobility, distance from the RSU and communication capability of connecting the heterogeneous networks. Multiple RN nodes provide the load sharing and information back up facility in case of existing link failures. The onboard systems on end nodes are configured with the acceptable RSS level, which ensures the connection establishment link with the RSU. This method ensures all connectivity links with higher stability factor because only strong RSS level can participate in the communication. Considering the present network scenarios, the estimated relation between RSS levels and associated connectivity possibilities for vehicle density of 100 in road length of 1000 meters are mentioned in table 1.

3.3. Software Agents

An intelligent agent is a self-contained entity that uses its knowledge base to achieve its objectives. Software agents are self-contained programmes that run on a host's agent platform. Agents employ their own knowledge base to accomplish certain tasks without interfering with the host's operations. Mobile agents are modular, adaptable entities that may be built, moved, deployed, and destroyed in real time. Mobile code should be platform agnostic, meaning it can run on any remote host in a mixed network environment. The proposed dissemination protocol has node agency, RSU agency and RN agency schemes which uses different types of static and dynamic agents that are Node Information Retrieval Agent (NIRA), Vehicular Manager Agent (VMA), RSU Vehicular Manager Agent (RVMA), Dissemination Agent (DA).

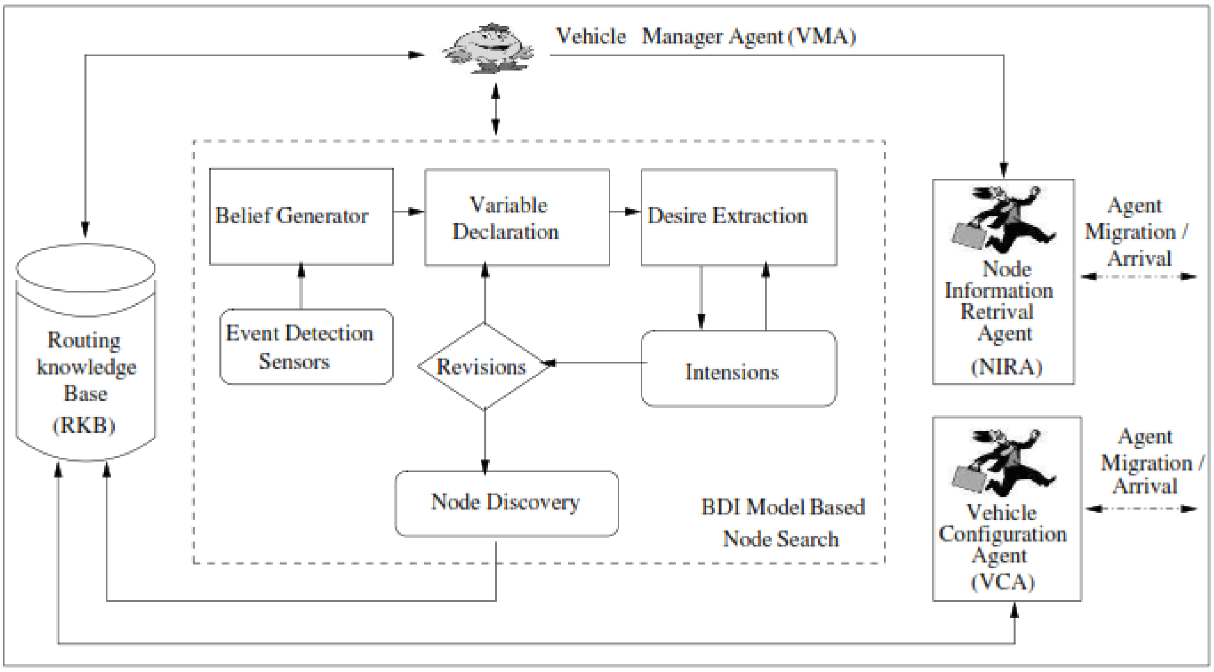

Fig.2. Node Agency Functional Model

The proposed cognitive agent (BDI)-based structure is comprised of three main components. (1) Beliefs are the agent's recognized information about the sensor's detected parameters and the vehicle's present condition. Example: "The output of the wiper speed sensor and the wheel speed sensor is HIGH; indicates heavy rain is falling." Norms are a term that may be used to describe beliefs. (2) Desires are entities that explain the motivations of an agent as a result of its nature or kind. (3) Intentions reflect tasks coming from users who have successfully passed conditional aspects; as far as it knows, is capable of doing these responsibilities and has pledged to do so. Declaring an occurrence to be heavy rain is an example (by considering desire set and also once again examining the set of readings from the related sensors).

Some of the benefits of the BDI architecture are listed below. (1) Cognitive agents have the ability to swiftly adapt and learn in a VANET context. (2) Because the vehicle environment is always changing, assumptions about the environment in the BDI architecture may be updated on a frequent basis. (3) A choice can be made autonomously on available possibilities in relation to an occurrence. (4) The BDI model establishes commitments and takes action based on complete commitment to intentions, and (5) the BDI model gives an explicit model of cooperation, which is important for VANETs.

Definitions

Belief Generation: Beliefs are generated from the installed sensors and considered with respect to the node parameters. The information tuple consists of source ID, Destination ID, TTL, RSS level, mobility and distance are considered for data collection agent. Since for the node agency the node with distance and mobility are crucial parameters for the RN selection, beliefs are updated with these parameters.

Desire update: Node parameters of distance and mobility are crucial for the selection of RN node; the desires are identification of nodes with distance and mobility Parameters.

Intention based on desires: Based on the parametric values for mobility and distance for all the data base collected in the interval t, the lowest value of k in KNN model generates the intention of lowest value of distance and mobility.

Cluster mobility pattern: It is defined as the collective pattern of vehicle movement in a cluster.

Lane Intersection pattern: It is collective segments of lane intersection points with one another.

3.4. Node Agency

Node agency will be deployed in each vehicle and RSU which will invoke the invitation commands to the lower tier nodes, on acceptance of this request the end nodes become the member of cluster. Events are detected by onboard sensors and BDI model will classify the critical and non-critical events and if the events are critical then Vehicle Manager Agent (VMA) triggers Node Information Retrieval Agent (NIRA) for information forwarding. Mobile agent NIRA in each cluster migrates to reach all nodes in the connection range and collect the information of each vehicle about RSS threshold, SID and UID, position of node, velocity and relative distance from the RSU etc. which creates traffic data as knowledge base about vehicle velocity, position and level of existence. All these agents within the network, synchronizes the interactions among the end nodes, RN and RSU units. The functional blocks of node agency are shown in Fig.2.

- **NIRA (Node Information Retrieval Agent)**: It is mobile agent which will be triggered by VMA at regular intervals to update the node status in knowledge base. It hosts the HELLO packets in the cluster by reserving bit in the header for acknowledgment status. This agent collects the acknowledgment status by end nodes and RN in the coverage range. Thus, it forms the network of high-quality links by establishing the connectivity among three tiers of nodes. NIRA refreshes the HELLO packet broadcasting once every 5ms for updating latest network topology dynamics. The low refresh rate assists to catch all critical events by the updated topology nodes.
- **RKB (Routing Knowledge Base)**: This is centralized data storage system holding the network node status. This is continuously updated by NIRA and guide the VMA for end node detection. This data will be accessed by RN gateways to perform optimum routing. The knowledge base will be updated by every 10 msec. RKB develops the collection of data in tree hierarchical structure for quick uplink information dissemination. It uses the BDI software model for data integrity.
- **VMA (Vehicle Manager Agent):** VMA runs on every end node and triggers mobile agent NIRA and updates the knowledge base about vehicle status parameters. It controls and coordinates the functionalities of BDI model. It has the knowledge of all parameters of node such as node position, mobility, RSS level and conditions of the road. VMA deployed with BDI model runs on collected information for belief generation.

A. K-Nearest (KNN) Neighbor Algorithm

The suggested prototype seeks to employ Machine Learning algorithms to learn from prior occurrences, allowing for effective data broadcast with a guaranteed end-to-end latency, as well as the prediction and prevention of forward and rear-end collisions. Safety data is gathered from numerous vehicles on the road, which operate as nodes, communicating their distance to the RSU at regular intervals. The system next applies the KNN Classifier to the obtained data and predicts probable safety and non-safety events. Safety occurrences are taken into account for distribution, whereas non-safety events are ignored. As a result, bandwidth is effectively utilized for reliable consistent communication.

It is a non-parametric instance-based classification algorithm, it searches the node using computation approximation by majority parametric values and value of K. The KNN algorithm the decides the criticalness of information. Here select the number K of the neighbours in a cluster and calculate the Euclidean distance of K number of neighbours as follows

$$d(p,q) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + - - -(q_n - p_n)^2} \quad (1)$$

In equation (1), take the K nearest neighbours as per the calculated Euclidean distance and among these k neighbours find the RSS level for each node to satisfy the condition RSS>=Threshold value.

$$d(p,q) = \sqrt{\sum_{i=1}^{n} (q_1 - p_1)^2} \quad (2)$$

Count the number of the nodes in each cluster and extract the safety data in each category. Assign the system ID and device ID to selected node which is having RSS maximum. By calculating the Euclidean distance shown in equation (2), we got the nearest neighbours as three nearest neighbours in category A and two nearest neighbours in category B. KNN runs this formula to compute the distance between each RSS level of node under consideration and the threshold RSS level. It then finds the probability of high-quality links of a node to RN among all available nodes present in the cluster which is presented in equation (3)

$$p(Y = j \mid X = x) = \frac{1}{k} \sum_{i=A} I(Y^i = j) \quad (3)$$

where X is output class, k is the neighbour distance and I (Y) is the decision boundary. The node discovery by the mobile agent with respect to available information tuple is given by equation (4),

$$E(d) = (X, X_i) = \sqrt{\sum_{i=1}^{n} \left(X_j - X_{ij}\right)^2} \quad (4)$$

Three tier architecture of the V2I model have less end to end delay E(d) calculated considering the intermediate nodes given by Xij and reduced congestion due to the usage of software static and dynamic agents. The mobile agents can migrate from the nodes and creates the data base, which is retrieved by the RSU for timely intelligent routing and forwarding information. present system using agent based forwarding method can have flexibility in routing, supporting heterogeneous communication for fast delivery of message.

We presented that the proposed model is efficient for following V2I kind of applications: Blind Spot Monitoring (BSM), Electronic Stability Program (ESP), Forward Collision Warning (FCW), Automatic Emergency Braking (AEB), Lane Departure Warning System (LDWS) and Brake Assist System (BAS) information gathering and access, safety information dissemination, and heterogeneous connectivity services.

3.5. RSU Agency

It uses the static and dynamic agency components namely RVMA, KBES, ICA and DA for its optimum functionality. Here the system finds the target identification, route discovery, and establishes the error free links. The different agency components are shown in Fig.3 and are defined as follows

- **KBES (Knowledge Base Expert System):** It is the data centre storage area where the routing node information and optimum hops to the target nodes are fetched and updated by the IFA. VMA uses this data during safety information dissemination after route discovery. The information like RN Id, Node id, TTL time stamp and available bandwidth.
- **IFA (Information Fetch Agent):** It is a mobile agent which will be triggered by RVMA at regular intervals to collect the information about RN nodes, RSU and available bandwidth for error free dissemination. IFA agent is a mobile agent that configures the end nodes on the air with RSS level threshold setting, data communication modes and required packet TTL intervals. This provides the flexible operating modes of system function. It uses four byte addressing scheme for the header excluding the payload. IFA agent in connection with the KBES synchronizes all the events triggered by three level network nodes that are associated with regional cluster.
- **RVMA (RSU Vehicle Manager Agent):** It is a static agent deployed in RSU having the responsibilities of coordinating the activities of information dissemination. It triggers the IFA to collect the information about target vehicles based on the pre stored route maps and finding the error free route based on the probabilistic node searching algorithm. It uses the knowledge base data to take the appropriate decisions on route calculation and triggers the safety information dissemination. This unit is in charge of finding a suitable neighbor based on the node's geographic location, vector data, and anticipated future direction. It discovers

adjacent nodes by sending HELLO messages. To locate an acceptable neighbor for data forwarding, the next-hop selection method is employed.

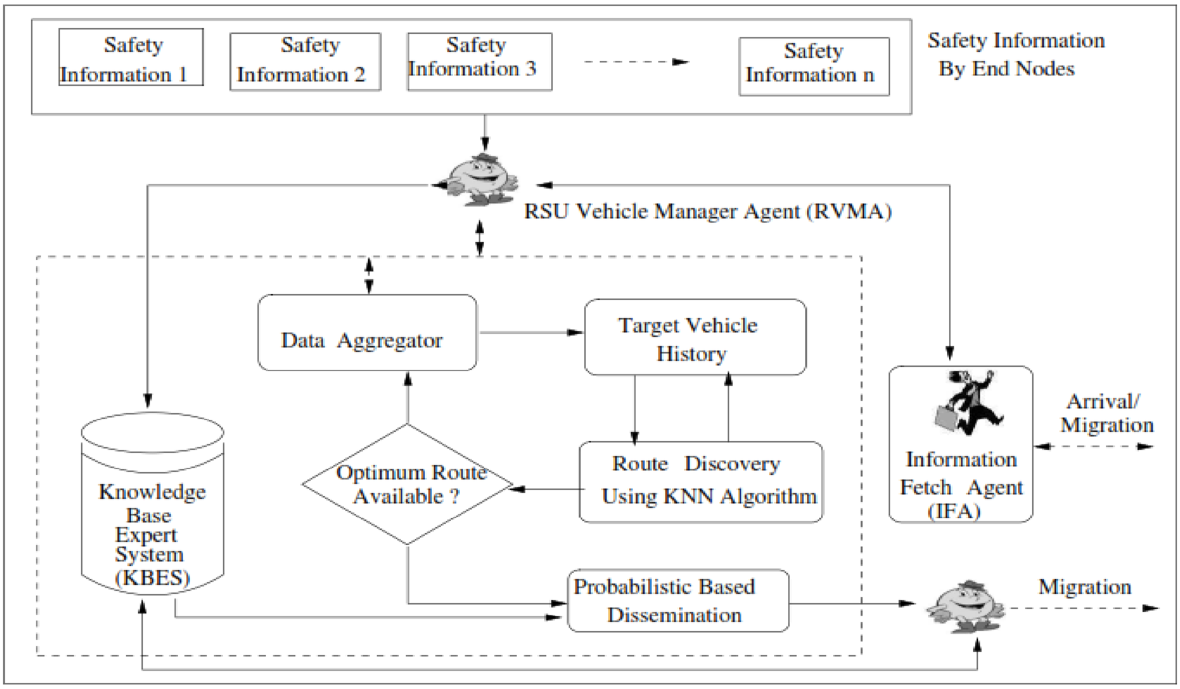

Fig.3. RSU Agency Functional Model

A. Probabilistic model for data dissemination

Assume that n nodes are spread randomly over an area of a X b square meters. Because each node's transmission range is expected to be l, the network dimensions are a and b, with a,b > l. The source and destination nodes are S and D, respectively. Equation (5) may be used to compute the probability P of a node A being within transmission range of S can be calculated by equation (5) as

$$P = \frac{\pi l^2}{ab} \tag{5}$$

The probability of having m neighbours (from (n-1) of S can be calculated through the following equation (6):

$$P_M(m) = \binom{n-1}{m} P^m (1-p)^{(n-1-m)} \tag{6}$$

where m is a binomial random variable and E[m] represents the average number of neighbours for any node in the network. We can find the probability distribution function (PDF) by interchanging the variable u = l2 from the arbitrary variables z and w. Since z and w are independent, the PDF of u can be calculated by equation (7)
where E[m] is the average number of neighbours for every node in the network and m is a binomial random variable. By substituting the variable u = l2 for the arbitrary variables z and w, we may get the probability distribution function (PDF). The PDF of variable "u" may be computed using equation (7) as

$$f_U(u) = f_Z(z) * f_W(w) \tag{7}$$

we can calculate the expected number of hops using equations (8) & (9), that is, E[l] and E[k]:

$$\text{E[l]} = \int x f_r(x) dx \tag{8}$$

$$E[k] = \left[\frac{E[r]}{l}\right] \tag{9}$$

Table 2. Vehicle Sensors and Corresponding Safety Applications.

Safety Events	Examples	Detecting Sensors	Sensor States	Action
Pre Crash Sensing	Over speed vehicle movement , Approaching emergency vehicle warning etc.	Image sensor, Speed sensor, Body pressure sensor,Resettable crash sensor,Tyre pressure sensor.	Low/High	Migration
Post Crash Sensing	Vehicle Accident, remote accident information to hospital, etc.	Speed sensor, Engine pressure sensor, Body pressure sensor, Resettable crash sensor, Tyre pressure sensor.	Low/High	Migration
Dangerous Road and Environmental Conditions	Blind curve warning, narrow/low bridge warning, heavy rain situation heavy fog situation	Wiper speed sensor Image sensor, Rain sensor, Rain light sensor, Tyre pressure sensor.	Low/High	Migration
Driving Assistance Applications	Vehicle detection and registration, visibility enhancing, breakdown warning, stolen down tracking	Break sensor, Vehicle detection and registration sensor, Image sensor.	Low/High	Migration
Transit Vehicle Alert	Vehicle status reporting, road signals, digital mirrors, etc	Speed sensor, Vehicle detection and registration sensor, IR sensor	Low/High	Migration
Rescue Station Location, Hospitals, Fuel Station	Vehicle Detection and Registration, GPS based road maps, Navigational Applications, and Helpline Data Centres.	GPS, Predifined Route Information	Low/High	Migration

The node communication range is denoted by d. The average amount of overhead packets is what we're looking for. The amount of control packets (route request and reply) transmitted throughout the network is referred to as routing overhead. Request ID and sender address of route requests are taken into account to avoid repetition. The route request packet is stated in equation and will disseminate to the depth of E[d] and is represented in (10).

$$INTC(A,B) = 4\int_{\frac{R}{2}}^{d} \sqrt{r^2 - x^2}dx \tag{10}$$

We denote the transmission range of A and B as SA and SB, respectively, and the shared area as INTC (A, B). If R is the distance between A and B, then the intersection can be found by equation (11)

$$E_{E[k]} = 4 \times 3^{E[k]-1}\left[\sum_{n=2}^{4}\left[(n-1-i) - \sum_{j=1}^{E[k]-1} N_j\right]p.C_i\right] \tag{11}$$

The expected number of total route request broadcasts can be calculated by

$$E[\text{ Broadcast }] = \sum_{i=1} E[k]N_i \tag{12}$$

Equation (12) provides the available routes to the number of distant targets with a smaller number of hops based on the probability of previous dissemination.

3.6. Safety Events and Vehicle Identification

Mobility patterns of the vehicles due to varying traffic dynamics and road behaviour lead to the complexity in vehicular information dissemination. The two major challenges in dense highway traffic scenario are broadcast storm and intermittent connectivity. In the proposed scheme we are presenting communication routing protocol that disseminates safety information alleviating the intermittent connectivity and broadcast storm issues. Moreover, we analyse the protocol in terms of design consideration and protocol development. Self-optimizing: As the principal connection for data transmission, the communication channel always offers the least number of hops and the greatest link quality. This form of network optimization operates as a background task in all end nodes in the cluster. Mesh networks constantly adapt to changing surroundings with varying link quality to discover the best routing. LQNP's Network Addressing Scheme: The protocol uses a flexible addressing scheme with a four-byte System Address (SID) and four-byte unique addressing (UID). The four-byte System ID identifies cluster to which it is attached. All end nodes in cluster must share the same four-byte SID. The different sensors installed in vehicle detect the critical events such as vehicle crash, adverse environmental conditions, severe traffic congestion and harmful curved paths etc. and generates the safety information based on header wake up configuration settings consisting device id (UID) and network id (NID) and sequence number. After dissemination the end nodes may either wait for settable interval of time or turn it in to sleep mode.

The set of safety information's for possible road hazards is tabulated in Table 2, where different sensors are used to detect the safety application events [5]. Based on the BDI model and node classification algorithm the safety information will be disseminated by node agency platform using the NIRA and VMA. The routing node establishes congestion free links based on RSS levels of end nodes. The information arrived at RSU gateway agency will search the possible target nodes using probabilistic node search algorithm for the information forwarding with less amount of end to end delay. RSU agency will use IFA and RVMA agents to perform the above tasks.

A. Features of Proposed Model

The well-defined procedural steps in algorithms aid in the construction of programming and make the relationship between input and output parameters easier to comprehend. The following are some of the key aspects of the suggested model:

- **Node Hierarchy:** During node classification process, broadcasting higher level of RSS level for accepting the connections, creates fever communication links in network which leads to error free information dissemination.
- **Dynamic Connections:** End nodes in Mesh networks that are self-healing constantly check alternate connections by comparing the hop level and signal quality of received HELLO packets. If the primary link fails, the device will immediately switch to an alternate route if one is available. If the device's alternate routing is likewise unresponsive, it will go into a condition where it looks for new routing options.
- **Cognitive Agents:** Cognitive agents' perspective in the dissemination process initiates the faster end to delay during packet transfer. Information is preserved in the knowledge base until the valid connection is established thus this scheme ensures the guarantee of service.

B. Algorithm Properties

The characteristics of proposed algorithm are well-defined in terms of sequence of actions performed, during information dissemination. Some of the useful properties of algorithm are as follows,

Property 1: The dissemination process is secure and fast because of high performed link participation in the communication. The system has lower control overhead during connection set up due to the simple registration set up with finite size HELLO packets.

Property 2: The knowledge base provides the nearby digital data centers along the road and traffic signal centers for enhanced target coverage which significantly increases the packet delivery. and congestion in the network. The set of actions in the node agency is described in the following algorithm 1.

Property 3: This algorithm tends to minimize the delay by reducing the frequent handover using RSU wired communication which provides the stable connectivity for dissemination.

Property 4: Automatic registration process of cluster members, RN and on-air configuration of end nodes for RSS thresholds gives the better control over the speed and congestion in the network. The set of actions in the node agency is described in the following algorithm 1.

Algorithm 1 Functioning of Proposed Algorithm

1: Begin
2: Event detection by sensors;
3: Classify safety and non-safety information using BDI model
4: **if** Desire: Safety data generated from set of beliefs **then**
5: Intension: Forward the information to the routing node using mobile agent;
6: **else** wait for the safety data generation by end nodes;
7: Find Euclidean distance of K number of neighbors;
8: Update the belief set
9: **if** K is non zero; **then**
10: Perform switching by Routing Node;
11: **else**: begin with line number 1;
12: Find the number of target vehicle;
13: **if** PM(m) the probability of targets presence is non zero; **then**
14: Enable Information fetch Agent;
15: Perform the dissemination;
16: **else** wait for the expected number of targets in coverage range;
17: Calculate the expected number of hops using;
18: E[k] $=\int x f_r(x) dx$
19: **if** Routing node is present in target cluster; **then**
20: The expected number of total route request broadcasts can be calculated by;
21: $E[\text{ Broadcast }] = \sum_{i=1} E[k]N_i$
22: **else**: begin with line number 1;
23: Update the Knowledge Base Expert System
24: Disable Information fetch Agent;
25: End

4. Simulation

A VANET simulation environment for the proposed model has been developed using Developer C++ software to evaluate end to delay and large number of targets coverage with the Restricted Mobility-Based LQNP protocol. The LQNP provides the smart method of broadcasting using BDI machine learning algorithm. Mobility patterns of the vehicles due to varying traffic dynamics and road behavior lead to the complexity in vehicular information dissemination. The two major challenges in dense highway traffic scenario are broadcast storm and intermittent connectivity. In the proposed scheme we are presenting communication routing protocol that disseminates safety information alleviating the intermittent connectivity and broadcast storm issues. Moreover, we analyze the protocol in terms of design consideration and protocol development. Self-optimizing: The communication path always provides the least number of hops and the highest link quality is always present as the primary connection for data delivery. A network optimization of this type runs continuously as a background task in all end nodes in the cluster. In case of changing environments with changing quality of link, mesh networks dynamically adapt to find optimum routing.

4.1. Simulation Procedure

The simulation input parameters are summarized in Table III. Simulation procedure for the proposed scheme is as follows:

1. Generate VANET network scenario in given road length of 10KM by deploying the vehicles based on geographical clusters.
2. Each vehicle maintains a data structure to store information as specified by scheme. (RSS level, mobility and distance from RN node.)
3. Generate the mobile and static agency to deliver the safety information and vehicle parameters to the RN node. (Agents are implemented as objects).
4. Apply mobility to vehicles.
5. Randomly generate the vehicle parameters at each vehicle and select RN members using the agency.
6. Use agency to identify RN and announce the intersection mobility pattern.
7. Compute the performance of system.

4.2. Performance Metrics

Some of the performance metrics evaluated are Packet Delivery Ratio, Energy Consumption, Dissemination Delay, Number of vehicles per cluster, Target Coverage, Hand-off Delay and Success Rate.

- **Energy Consumption**: It is defined as the amount of energy required during the connection set up and packet transfer. It is expressed with respect to individual node and is measured in millivolts (mV).
- **Packet Delivery Ratio**: It is defined as the total number of packets received to the total number of packets sent in defined time interval. We considered one TTL duration as the maximum time interval to record the PDR. It is measured in percentage.
- **Dissemination Delay**: It is the additional time to be considered if far end node is not detected in the first segment. It increases with the higher numbered segments. It is also called connection overhead delay. It is measured in millisecond.
- **Hand-off Delay:** It is the amount of delay involved in handover of packets from end mobile agent to RN nodes, RN nodes to RSU and RSU to RSU. It is the cumulative delay of all three. It is measured in millisecond (ms).
- **Success Rate:** The amount of successful detection of targets nodes and performing the dissemination with minimum end to end delay. It is with respect to connection establishment. It is measured in percentage.
- **Path Loss:** The transmit power to receive power ratio is used to calculate route loss. The decline in power density (attenuation) of a signal energy as it propagates across the nodes is known as path loss or path attenuation. The analysis of the proposed design includes a significant amount of path loss. It is expressed in decibels (dB).
- **Intra Cluster Routing Delay:** This is the overall time it takes to conduct a handshake, register end nodes, and switch packets between end nodes and RN nodes within a cluster. It is timed in microseconds. It entails the detection of safety information, as well as forwarding delays between end nodes and gateway processing delays.
- **Inter Cluster Routing Delay:** It's the overall time it takes to transport packets from one cluster's RN to another cluster's RN. Milliseconds are used to measure it. This entails detecting dependable gateways based on bandwidth and cluster forwarding delay.
- **Energy Overhead:** It is defined as the ratio of each node's mobility to the total number of vehicles participating in the end-to-end path. It is expressed in milliwatts.

- **Cluster Head Selection Delay:** It is defined as the total time necessary to choose and assign a cluster Head (CH) as a Routing Node (RN). It is measured in milliseconds. It can be selected at random depending on factors such as distance from the gateway and associated RSS level. The selection has a significant impact on network lifespan.

4.3. Result Analysis

Simulation using C++ is performed with few runs of dissemination attempts under varied mobility and RSS levels. The urban traffic with 4 lanes moderate traffic case is considered for vehicle density of 10/km. The agent function delays are negligible. For moderate road traffic the RN registering process involves the random selection based on the distance from RSU. The existence of few RN suffers from the backup or alternative connection facility. This considerably lengthens the time it takes for information to disseminate, but PDR stays unaffected. The OBU, which is equipped with GPS in end nodes, continually updates the RN with observed events as well as the categorization of safety and non-safety messages. Each node starts by detecting events over a sparse distance of 200 meters in the azimuth direction. To execute the node registration in the data base, routing, and information dissemination for target coverage, a simulation time of about 400 ms is required. Based on the transition interval delays, the three degrees of priority are designated as "worst," "optimum," and "best."

The suggested algorithm's simulated data for energy consumption under various RSS and mobility levels is shown in figure 4. When the number of nodes is around 50, the proposed algorithm achieves better results with a lower energy consumption of 45 mv, so in a highway scenario, the existing vehicle density provides a significant reduction in energy consumption, whereas for higher mobility levels, the energy overhead rises by 20 ms which is acceptable value compared to the existing RBO-EM (Reduced Broadcast Overhead Emergency Message) scheme.

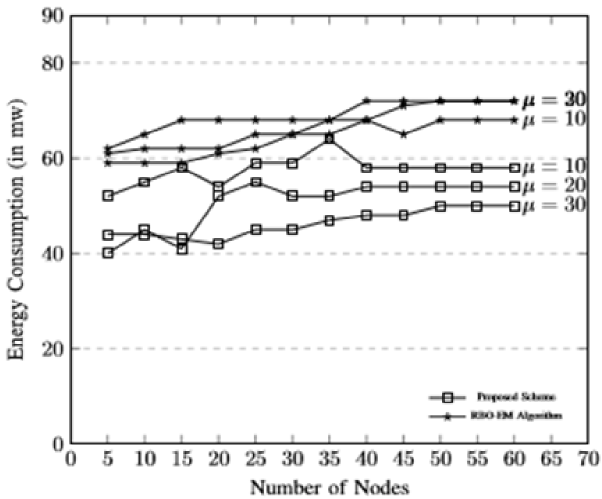

Fig.4. Energy Consumption in mv Vs. Number of Nodes

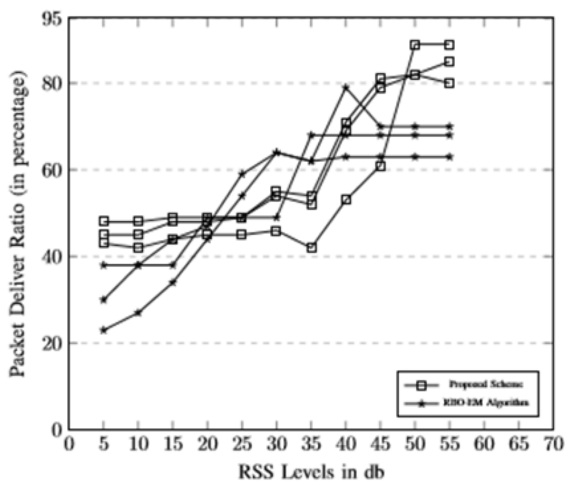

Fig.5. PDR Vs. RSS Levels

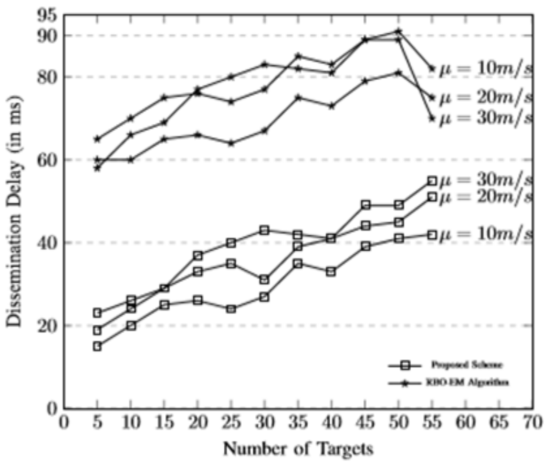

Fig.6. Dissemination Delay Vs. Number of Targets

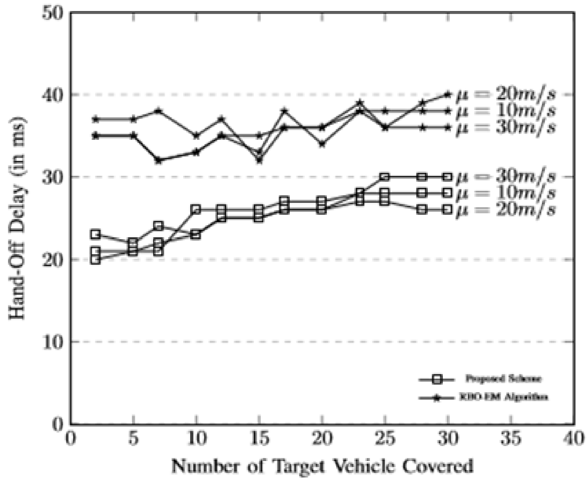

Fig.7. Hand-Off Delay in ms Vs. Number of Target Vehicle Covered

The packet delivery ratio measures the proportion of successful transmissions to total transmissions. It is depicted in figure 5 as a percentage, taking into account of various RSS levels. The higher the RSS level, the greater the likelihood of communication participation and the lower the overhead latency. As a result, despite changes in mobility, PDR has enhanced values. For the RSS range of 40dB and mobility of 30 m/s, more than 80 percent of vehicles participate in generation of quality links to adopt the reliable dissemination model. The nature of curves for other models have lower bent due to the absence of quality links in the communication path and delays involved in hand on process. The random waypoint and random direction mobility model are considered for improved outcome for the proposed model, where lower mobility have stationary effect for sustainable data transfer ratio. The fairness index is decreasing in steps for upper mobility levels.

The figure in 6 represents the dissemination delay with various number of targets. To accomplish reachability for a wide number of targets, the cognitive multi agents and probabilistic dissemination method are used. Because of the increased bandwidth usage, the dissemination delay rises slowly as the number of target nodes grows. In comparison to the present RBO-EM system our proposed work has the better values by 25 percent which is shown in the figure 6.

The simulated data for the handoff delay computation is shown in figure 7. At intermediary nodes, there is a handshaking and queuing delay. Based on the simulation findings, it can be concluded that the overall performance of the proposed task is unaffected by the handoff delay because its value is low and there are many high-quality wireless links, hence fever nodes participate in the hand off process. This delay is nearly consistent for varying degrees of mobility levels, which exhibits the stable operation.

Figure 8 depicts a graph of success rate vs. number of nodes, with the depiction of simulated results resembling a significant increase in success rate for a high number of nodes. The greater likelihood of receiving nodes with higher RSS levels, which will build strong connection between the communication nodes, causes the curve to climb.

From the figure 9, it is clear that the path loss is almost constant due to the fever hand off and existence of stable connectivity. For the vehicle density up to 50 which is desirable in urban scenario, the proposed system gives the improved results in case of data integrity and the data losses incurred during dissemination process is negligible comparison to the other existing systems. At worst case during peak hours of traffic around 45 dB is recorded in the simulated results. In compared to other current systems, the data losses suffered throughout the dissemination process are low. The simulated findings show that during peak hours of traffic, the noise level is about 35dB less compared to the RBO-EM scheme.

Figure 10 and 11 depicts the intra cluster and inter cluster routing delays with various RSS values. The increase in overhead is between 20 to 30 ms in both cases, as seen in the graph. This value is mostly reducing with higher RSS levels, since this builds strong connection linkages and speeds up the routing process during information dissemination. Because the suggested network scenario is extremely decentralized and dispersed, with hundreds of nodes joining and leaving on a regular basis, it is simple to test a method by deploying it on real-world networks and assessing its performance.

From figure 12, it is observed that the proposed work has negligible overhead delay in terms of inter cluster communication as the delay of maximum 20ms is observed under different vehicle mobilities. When it comes to information dissemination, the number of target vehicles covered is an essential element since it indicates the information's reachability. Due to the reduction in latency for congestion-free high-quality links, the suggested approach performs better in terms of overall end-to-end delay inV2I networks. The amount of available bandwidth between RSUs decides this delay. The target vehicles' coverage ranges have a direct influence on the delay's performance. The cluster head selection delay with vehicle speed curves under different mobility levels are shown in figure 13. Where due to the increased mobility, the number of trustworthy nodes selection will grow, increasing the energy overhead. For the purpose of calculating energy overhead, a suitable set of mobility levels of 10, 20, 30 m/s are considered. The energy overhead grows as the degree of mobility increases, regardless of the number of nodes in the network (as shown in the graph). In compared to RBO-EM algorithm, the suggested approach has a lower total energy overhead, which helps to extend the lifetime of the network.

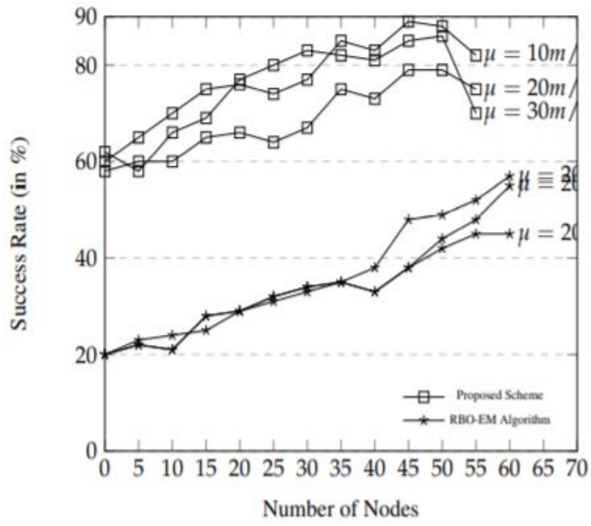

Fig.8. Success Rate Vs.Number of Nodes

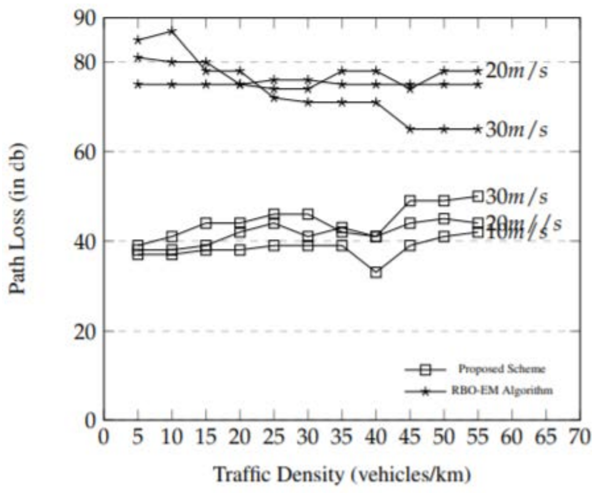

Fig.9. Path Loss in db Vs.Traffic Density

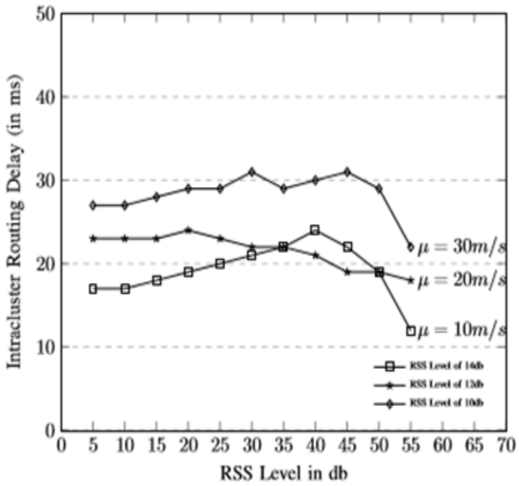

Fig.10. Intracluster Routing Delay Vs. RSS Level in db

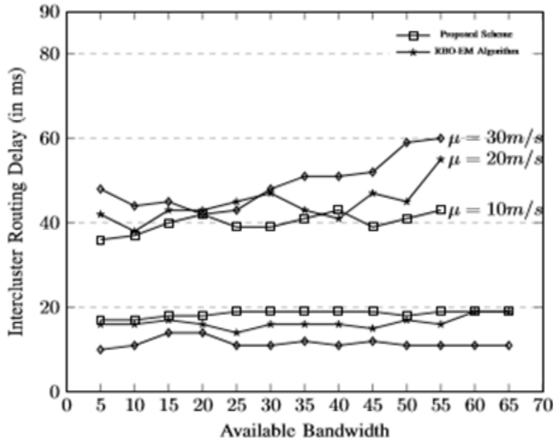

Fig.11. Intercluster Routing Delay Vs. Available Bandwidth

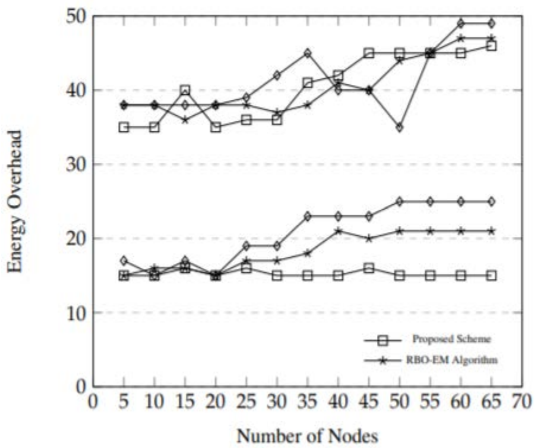

Fig.12. Energy Overhead Vs.Number of Nodes

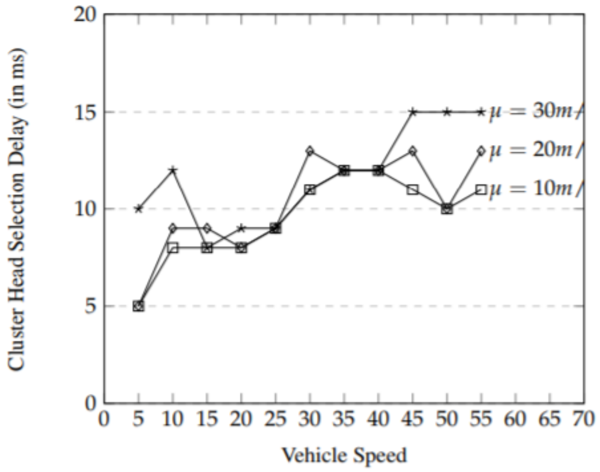

Fig.13. Cluster Head Selection Delay Vs. Vehicle Speed

5. Conclusion

In this research work, we are establishing the V2I communication network with high quality network links for a lossless and safe delivery of safety information. The usage of agents provides the timely updating of vehicle statistics. In addition, the presence of global navigational system in OBU helps to provide time synchronization and distributed dissemination management. The three-tier node architecture in the proposed scheme helps to build the fair consistent communication facility along with instant creation of large coverage area for quick dissemination of safety information. The improved network performance parameters such as end to end delay, energy consumption and less resource usage enhances the productivity of V2I system. The proposed LQNP protocol's performance is assessed using a variety of datasets and compared to two well-known data dissemination techniques. The comparison shows that the suggested LQNP protocol performs better in terms of data integration and security during the broadcast of safety information. The present novel multi-layer V2I communication model is simulated in python as well as Dev. C++ platform and it gives satisfactory results with significant improvement of 23%, 13%, 15% compared to the existing system in terms of end-to-end delay, communication overhead and energy consumption respectively. The simulation results in the highway road scenario with dynamic node mobility settings show that the suggested technique can manage larger network loads with less data dissemination overhead, resulting in a shorter end-to-end latency.

Future scope includes to work with lower node density for single lane road environments. The static and mobile agent maintains and refreshes the knowledge base for timely coordination across the V2I interface, allowing the system to adapt to changes in real time.

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