Time for relative velocity optimal time approach in internet of vehicle communication

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Abstract. In the present era of Internet of Vehicles recommending or developing an optimal routing protocol and its architecture has the potential to reduce the overhead is considered to be the biggest task to attain the scalability and adaptability. This paper propose an architecture that meets the network standard and evolves as per the defined software for driving the “Internet of Vehicles” over dynamic networks that partitions the data and control planes in the proposed protocol. Based on speed of vehicle and distance between nodes we proposed Time for Relative Velocity (TRV) road aware system that enhances the performance over infrastructure oriented vehicular network that partitions roads into distinct segments based on multi hop method for exploring the cellular networks and their relay controlled messages with minimal latency. We also propose a mathematical model to implement dynamic vehicle topology by estimating various paths and selecting the shortest one and further suggest the same to the controller. And the results attained in this paper denote the performance obtained by implementing the proposed protocol which consumes very little routing overhead and almost negligible failure rate.

Keywords: Internet of Vehicles, Time for Relative Velocity, Road aware System, dynamic routing.

1. Introduction
In the present era of human life the best or the worst part is that the whole world is moving in and around internet and its usage and with respect to the usage of internet in the field of transportation is a new facility being utilized at a higher pace. As per Indian statistics attained from road transportation India due to bad traffic and minimal connectivity service leads to around 3500 deaths per state in a year and on an average millions of people are injured or physically disabled. And to overcome this we provide a solution by including the transport service using a network for providing the enhanced communication process where the boosting technologies being implemented in and around transport system has lead the researchers to a greater extent.
The “Internet of Vehicles (IoV)” is a special category where the network comprises of distinct types of vehicles which has the potential to communicate with each other using “Vehicular Adhoc Network” [1] as the IOV provides a provision to interact with drivers in a dynamic manner in distinct methods such as “Vehicle to Vehicle (VtV)” [2], “Vehicle to Infrastructure (VtI)” [3], “Vehicle to Cloud (VtC)” [4] and “Vehicle to Personal Device (VtPD)” [2] [7] through these the services are provided by exchanging the information in this four ways distinct ways.

In this paper we use “IOV Master of Control (MoC)” for providing flexibility towards various services that tends to design the network application is used over MoC at a central location where the network program is explored to a greater extent for providing central view in a distributed network for distinguishing data from control pane [5]. And by combining the MOC and IoV we developed a network which can be used to establish communication between two distinct vehicles.

In the proposed system the routing protocol is implemented using IoV environment that is capable of providing flexibility and adaptability using the MOC approach which works over the cellular network for filtering and controlling the messages with dropped latency can be transmitted by moving to the controller for defining the enhanced topology in dynamic system which also is capable of reducing the failure paths in a given network by using the brink controller [6].

2. Related work

The IoT become revolution in all technology areas and on base of IoT the moving vehicle can able to communicate as like network nodes which called as V2V.In the network advancement these nodes become as part of internet as well they work for relay nodes, routers ,repeaters and other units so that this communication called as Internet of Vehicles (IoV). Y. Li and M. Chen [7], discussed about “Network function virtualization (NFV)” and “Software defined Networking” methods that are considered to be the corresponding approaches that provides us with unique methods to manage and control the networks where the SDN technology provides us with the required platform to test as well as implement the novel innovative ideas that explores various mechanisms over a distributed network in an centralized view [8].J. Contreras-Castillo [9], explained the IoV technology that is growing rapidly to a maximum by allowing the various agencies and researchers for implementing effective Vehicular Communication that tends to contribute towards the “development and deployment of Intelligent Transportation System (ITS)” [10]. And some of the restricted “properties of IoV are listed that includes higher computation ability and connectivity that comprises of greater internet speeds for implementing the predictable mobility and variable network density” [11]. S. Zeadally [12], provided information on “VANETs” that comprises barriers of restricted battery power with the capability of random motion and processing capabilities where as IoV is distinct when compared the model of “Vehicular Ad-hoc networks (VANETs)” that comprises of the centralized fundamental management capabilities that are suitable to be implemented [13]. S. An, B. Lee and D. Shin [14], discussed about “Intelligent transportation system (ITS)” which attracted most of the attention of various researchers to propose their services and applications related to various routing protocols using the ITS infotainment services by which QoS can be achieved using the routing operation being used in this system as most of the approaches tend to implement the appropriate “QoS based protocol routing system” [15]. The imprecision or enhancement of “Vehicle Routing Mechanism (VRM)” is implemented based on the soft time window scenario which is implemented accurately using the “Brain storm optimization” [16] algorithm in coloration with the “Ant colony optimization algorithm”. These two algorithms are used to improvise the IBSO algorithm which is based on the reduction process of the algorithm cost.

| Reference | Method adopted | Pros | Cons |
|-----------|----------------|------|------|
| Hassan, A.N., et.al., [17] | “IVD based protocol for routing connectivity aware routing (IVD-CAR)” | “This method is better than CSR and A-CAR” | “Impact of higher traffic parameters are not studied” |
### 3. Problem Formulation

Generally or specifically, every vehicle signal range occupies some area on the road within that range vehicles can able to communicate directly without the help of other RSU in the network. The vehicle signal overlapping areas are creating more efficient communication between those vehicles. So that if source signal area and destination signal area are overlapped then the can transfer the data directly. In the other case the destination sometimes reach after few hops means the source node next hop will be a network support node. Network support nodes also should transfer and receive the data based on nodes signal coverage and node communications only.

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**Figure 1.** The signal coverage of nodes that overlaps to create communication
Here every source node occupies their signal coverage in network circular area based on node strength. Figure 1 shows Internet of Vehicle communication with signal coverage area of each node. Consider \( r_1 \) as radius of source vehicle coverage space. The next hop node can be a destination or any network node and the next hop node coverage signal range radius \( r_2 \) where source node wants to reach in a shortest path. The node communication in the networks moves on less number of hops and in a shortest optimal paths. Here we calculated the communication area between source to destination or next node. In the Figure 1 shows the two nodes signal coverage overlapped to create communication area. The coverage area calculated in Area1 and Area2 to avoid the repeated space by dividing with the line C. The angle of source node towards the destination in the respect of coverage area has taken as \( \theta \) and the angle of destination towards source node has taken as \( \beta \). The line C partitioned the total area into two tringle areas which given as:

\[
C = \sqrt{2r_1^2(1 - cos\theta)} + \sqrt{2r_2^2(1 - cos\beta)}
\]  

(1)

\[
Area1 = \frac{C_r_1 sin\theta}{2}
\]  

(2)

\[
Area2 = \frac{C_r_2 sin\beta}{2}
\]  

(3)

The total area between source and destination where data can transmit in a direct communication given as: \( Area = Area1 + Area2 \).

\[
Area = \frac{C_r_1 sin\theta + C_r_2 sin\beta}{2}
\]  

(4)

The direct straight line distance from source to destination \( L \) which calculated from the above mentioned triangle theorems given as:

\[
L = r_1 sin\theta + r_2 sin\beta
\]  

(5)

The signal coverage area changes rapidly with respect to direction of vehicles move and speed of the vehicle. Generally all road ways are not constructed in a straight line or straight turnings some roads have curve moving. Accordingly the moving directions also change even the nodes should be in the communication network. Figure 2 shows the direction of vehicle moving according to how to calculate the speed and coverage area in the network. In the figure 2 shows two vehicle speeds on ground are \( V_{AG} \) and \( V_{BG} \). The ground relative speed given as \( V_{AB} = V_{AG} + V_{BG} \).

Figure 2. Two vehicle speeds on ground are \( V_{AG} \) and \( V_{BG} \).
The velocity Magnitude given as:

\[ V_{AB} = \sqrt{V_{AG}^2 + V_{GB}^2} \]  

(6)

The angle between two vehicles Direction given as:

\[ \theta = \cos^{-1}\left(\frac{V_{AG}}{V_{AB}}\right) \]  

(7)

The vehicle communicated in a distance with radio signals so that relative speeds in the radio communication using cosine law given as:

\[ |\vec{V}_r| = \sqrt{V_A^2 + V_B^2 - 2V_AV_B\cos\theta} \]  

(8)

The analysis with respect to cosine law, vehicles run in any direction like opposite, same direction and with some angles.

Case 1: The vehicles run on same direction with same velocity then relative speed given as:

\[ V_A = V_B = V, \text{ where } \theta = 0 \]

\[ |\vec{V}_r| = 0 \]  

(9)

Case 2: The vehicles run on same direction with different velocity. Here \( V_A \) will be \( \alpha \) times greater than \( V_B \). Then relative speed given as:

\[ V_A = \frac{1}{\alpha}V_B \]  

(10)

\[ \alpha V_A = V_B \]  

(11)

\[ |\vec{V}_r| = V_A(\alpha - 1) \]  

(12)

Case 3: The vehicles run on opposite direction with same velocity then relative speed given as:

\[ V_A = V_B = V, \text{ where } \theta = \pi \]

\[ |\vec{V}_r| = 2V \]  

(13)

Case 4: The vehicles run on opposite direction with different velocity. Here \( V_A \) will be \( \alpha \) times greater than \( V_B \). Then relative speed given as:

\[ \alpha V_A = V_B, \text{ where } \theta = \pi \]

\[ |\vec{V}_r| = V_A(\alpha + 1) \]  

(14)

Case 5: When both the vehicles having the same velocity with right/left turn direction.

\[ V_A = V_B = V, \text{ where } \theta = \frac{\pi}{2} \]

\[ |\vec{V}_r| = V\sqrt{2} \]  

(15)

Case 6: When both the vehicles having different velocity right or left turn direction. Here \( V_A \) will be \( \alpha \) times greater than \( V_B \). Then relative speed given as:

\[ \alpha V_A = V_B \text{ where } \theta = \frac{\pi}{2} \]

\[ |\vec{V}_r| = V_A\sqrt{1 + \alpha^2} \]  

(16)

In smart cities all RSUs and vehicles are part of the network. For a vehicle the number neighbour nodes calculated based on the vehicles or Road Side Units in signal coverage area of that node. It simple the node between source to destination come under the set of neighbour nodes. These nodes are providing network to reach destination also from the above calculation we can find the distance from source to destination based on the average number of hops. The \( D_l \) shows the distance from source node to neighbour node within the signal coverage area. The \( L \) shows the total distance from source to destination. The total number of neighbour node given as:
\[ N_H = \frac{D_L}{L} \]  
(17)

The Time for Relative Velocity (TRV) calculated based on the relative speed and distance from source to destination given as:

\[ T = \frac{r_1 \sin \theta + r_2 \sin \beta}{|V_r|} \]  
(18)

4. Compared protocols:
The evaluation of the proposed methodology TRV comprises of total transmission time between two nodes done with some set parameter which presented in the table 1. The entire process of our proposal system compared with “Hybrid road-aware routing protocol (HRAR)” . The HRAR implemented in the VANETs and provided optimal results. This protocol more efficient in smart vehicle communication system in the VANETs. Here the source node transfers the data in the network to reach destination. The data initially received by the gateway nodes then gateway nodes search for shortest path to reach destination node. By passing the data in a number of hops finally data reach at destination. This process performs well when there is no SDN implementation in IoT. Our proposed TRV run on same process in addition with SDN based controllers then the entire execution process transferred into software defined control system in the network.

The routing overhead is very less compared to HRAR because the routing control information transferred not directly from the physical nodes. Most of the time the control plane and data plane observe the thing about failure of message, delivery and acknowledges. Here the using of RSUs will be very less compared to the HRAR. The total delay in our model quite better because the number of processing nodes is reduced which leads to reduce the number of hops and congestion in the network. The increasing or decreasing of vehicle speed affected on end to end delay in HRAR but the proposed method is not affected much. In this paper we also verify the impact of the speed attained for an average vehicle and its performance is deliberately verified in the proposed TRV with respect to the ratio of packets that are delivered and the outcome of it is identified to be the distinct RSUs that comprises of distinct node speeds and our proposed TRV outperforms when it is compared with the best protocol which is HRAR at a minimum and maximum vehicle speeds[24-26]. It is identified by the study that an increase in RSU’s used leads to increase in road utilization or its coverage when we consider the performance aspect when it is compared with the existing delivery methods. This process leads us to escalate the speeds attained from source vehicle to its neighboring one in a rapid way by using the proposed methodology due to which there is a maximum possibility that the packet will be delivered by utilizing the intermediate vehicles for imparting the successful delivery of the packet.

Figure 3 experimental result explained how effect of packet delivery ratio with respect to vehicle speed changes between HRAR and proposed TRV. Figure 4 experimental result of changes delay in delivery of packet according with vehicle speed compared between HRAR and proposed TRV.

\[
\text{Table 2. List of Parameters for implementation.}
\]

| Parameters       | Value                           |
|------------------|---------------------------------|
| Number of vehicles | 20–100                          |
| Area             | 1200 m × 1200 m                 |
| Simulation time  | 300 s                           |
| Transmission range | 450 m                           |
| Vehicles speed (min) | 0–4 m/s                        |
| Vehicles speed (Max) | 5–25 m/s                       |
| Channel frequency | 5.9 GHz                         |
| Data packet size | 512 B                           |
| Receiver sensitivity | −71.65 dBm                     |
| Traffic type     | User datagram protocol          |
5. Conclusion
In this paper we have proposed TRV a relative speed and distance between nodes for Internet of Vehicles which allowed to optimal transmission process based on the architecture which has the potential to reduce the overhead and is scalable and adaptable. In this paper we proposed an architecture that meets the network standard and evolves as per the defined software for driving the “Internet of Vehicles” over dynamic networks by partitioning the data and control planes in the proposed theorems. Initially we proposed a mathematical road aware theorems that enhances the

| Antenna type | Omni-directional |
|--------------|------------------|
| Simulation scenario | roads with various intersections |
| Nominal bandwidth | 27 Mbps |
| MAC, PHY parameters | IEEE 802.11p |

**Figure 3.** Results attained for TRV and HRAR protocol ratio.

**Figure 4.** Results attained for TRV and HRAR protocol for evaluating delay.
performance over infrastructure oriented vehicular network and partitions roads into distinct segments based on multi hop method for exploring the cellular networks and we also compared the proposed TRV with existing protocols and we verified the ratio of packets delivered in the proposed TRV which is more feasible than existing once.

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