A SURVEY ON VEHICULAR SOCIAL NETWORKS

PROJECT REPORT - COMMUNICATION NETWORKS

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ABSTRACT

In this report, we delve into the topic of vehicular social networks. Approximately 1.35 million people die from road crashes every year, which amounts to around 3,700 people on a daily basis. In addition, 20 to 50 million people suffer from long term and short term disabilities due to vehicular transportation accidents. Due to this, it is of prime importance that we apply existing technology in communication networks, autonomous vehicles, and social media phenomena to create a comprehensive protocol or framework to ensure better safety as well as better entertainment applications for passengers. This will help create an automotive experience with better traffic flow and safety. Researchers are trying to merge the social aspects into vehicular ad hoc networks to provide novel methods for message exchange in dynamic environments resulting in vehicular social networks. Human factors play a role in vehicular ad hoc networks to enhance safety and entertainment. We present the main features of vehicular social networks, as well as their challenges and applications. Through this survey, we hope to examine different concepts that would make this new generation of vehicular transportation a reality, one where driverless cars have wireless capabilities connected to the cloud, thus making traffic lights obsolete.

***K*eywords** Vehicular Social networks · Next Generation Vehicles · Vehicular ad hoc networks · Social-based applications

1 Vehicular Ad Hoc networks

Before we dive into Vehicular ad hoc networks, we must first understand the terms opportunistic and ad hoc networks. **Opportunistic networks** are those networks which use the store, carry, and forward methodology. Here, nodes store a message, and carry it until a link is available. Once available, the message is forwarded. Hence, communication in this type of network can take place without the availability of end-to-end message routing paths. On the other hand, **Ad hoc networks** are those that are dynamically created between two nodes when they are in proximity with one another. This is a decentralized type of network in which each node forwards or routes data for other nodes, and lacks complex infrastructure since devices create and join networks dynamically on-the-fly.

Vehicular Ad hoc networks (VANETs) are a particular class of Mobile Ad Hoc Networks (MANETs), with added constraints of high vehicle velocity, hostile propagation environments as well as quickly changing networking topologies. Along with this, there is an added element of opportunistic routing of information, in order to improve the ability of vehicles to transmit information amongst themselves.

Vehicles form two kinds of links in vehicular opportunistic ad hoc networks:

- **Vehicle to vehicle links (V2V)**, which are built dynamically as the vehicles move. Here, any vehicle can become the next hop to enable end-to-end communication, and hence do not need pre-existing infrastructure.
- **Vehicle to infrastructure links (V2I)**, which are links created between vehicles and road-side infrastructure equipped with wireless capabilities like cellular base stations and wireless access points.

Both these links provide many applications. For instance, vehicles employ V2V links to transfer information on destination path and traffic data amongst one another, and use the V2I links to receive traffic information from roadside units on potential traffic issues further along the route.

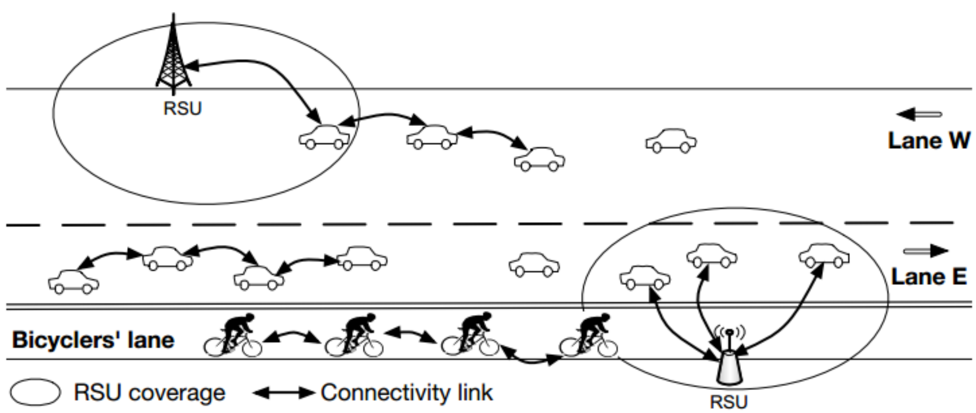


Figure 1: Schematic of a vehicular ad hoc network. Vehicles (i.e., cars and bicycles) are mobile nodes, which communicate via V2V links. V2I links are formed on-the-fly.

For example, figure 1 demonstrates the schematic of a vehicular ad hoc network with a companion wireless network infrastructure, consisting of two roadside units (RSUs), and two types of vehicles: cars and bicycles. These connectivity links (consisting of both V2V and V2I) shown in the schematic allow for packet exchange, and form dynamic networks. These dynamic networks can be tapped to disseminate information amongst bicyclers using V2V links about available paths, the status of a possible ongoing race, and the prevalent weather conditions. The V2I links could be used to check on the existing traffic by cars travelling on the road as well [1].

2 Next Generation Vehicles

VANETs are a foundational concept based on which the Next Generation Vehicles (NGVs) will function in the future. These will be enhanced by the several wireless access technologies that are used for vehicular communication, like IEEE 802.11, WAN interface cards like LTE, personal area networks like bluetooth as well as Global Navigation Satellite Systems (GNSS) for tracking and positioning of vehicles. Apart from this, the use of better sensors and better ways of communication can create a new vision for the car of the future. Keeping this in mind, we can enlist the features for NGVs:

1. **Safety driving**

   Vehicles will be far more safe in the next few years, primary due to added systems that can detect collisions, provide warnings via V2V and V2I communication links, and provide real-time updates on the environment. This is made possible due to the added protocols like IEEE 802.11 and LTE, as well as outside sensors like radar and cameras.

2. **Autonomous driving**

   Self driving cars have been all the rage over the past decade ever since the Stanley robot won the Darpa Grand challenge in 2005. The precipitous improvement since then has been due to better LiDAR, GPU's, as well as better computer vision and deep learning algorithms for mapping of environments.

   The rise of autonomous vehicles in the last few years has expanded our view of the future of vehicular transportation. In the next few years, we shall see fully self-driving vehicles, capable of communicating with each other over the cloud, and supporting each other by providing better information to each other for processing and making better driving decisions that humans can make.

3. **Social driving**

   As described in the earlier sections, vehicles will form social networks on the fly, and form clusters based on social relationships. NGVs will have social networks that make sharing amongst vehicles with common interests feasible. An example of this would be the sharing of open parking spaces at a crowded event, or sharing of information about blocked roads.

4. **Mobile applications**

   To keep drivers and passengers connected with each other while driving, internet browsing, online gaming, and video streaming are few of the applications present in mobile that would make long commutes much more bearable.

5. **Electric Vehicles**

   The future of vehicular transportation is electric. Fully electric vehicles as well as gas-electric hybrids with emission-free driving will dominate the market due to better mileage and lower harmful effect on the environment.

A summary of the vision of NGV's, with its challenges and capabilities can be seen in figure 2

The use of human-computer interaction can increase security in NGV's. A large number of accidents occur due to the scattered attention of drivers caused by the introduction of distractions within the vehicle like smartphones. This is because of the reduced reaction times when a driver removes one or both hands from the steering wheel instead of paying attention to the road. The solution to this are In-Car-Communication-Systems (ICCS), which allow drivers to interact with their bluetooth enabled smartphones, which gives them access to the critical applications of a smartphone without losing focus on the road. The Multimodal Interface for Mobile Info-communication (MIMI) is a prototype multimodal ICCS which incorporates the use of speech input using a button on the steering wheel. The future of NGVs include exploiting the use of speech control and gestures as well as using the visibility of objects in the car using mirrors to simulate a wide range of functions.

Adding to these systems, entertainment applications within the car aim to enhance the experience of drivers and passengers like Cadillac Cue [3], which provides a navigation and entertainment system bundle rolled into one. It is equipped with an LCD touchscreen display and allows passengers to enjoy a range of apps present on a smartphone. Another interesting system is OnStar's remote

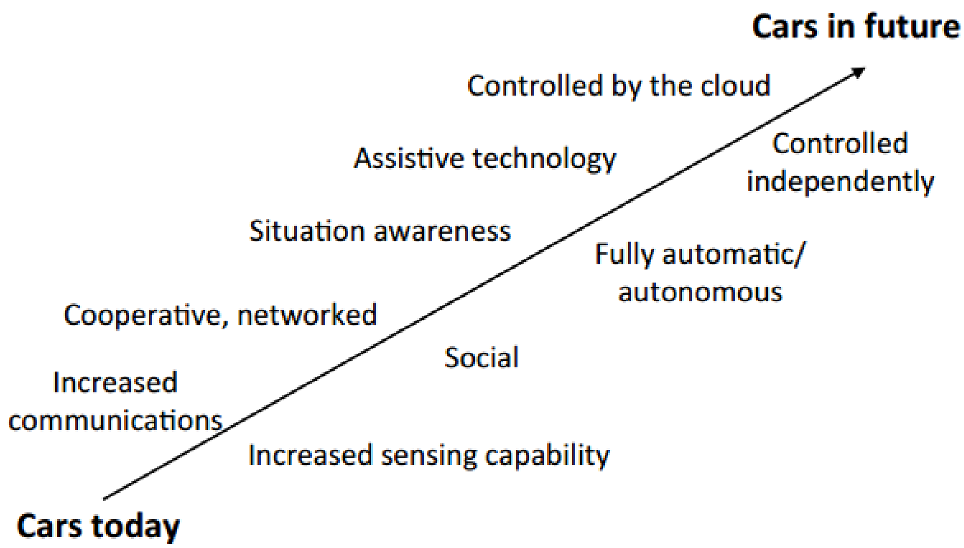


Figure 2: Vision of Next Generation Vehicles.

link[4], which creates a secure connection between a mobile and an On-Star equipped vehicle to allow the car to be controlled using the smartphone. A similar system has been developed by our very own Robotics Research Centre at IIIT Hyderabad called ‘Talk to the Car’ [5], which allows our self driving car, Swahana to be given directions on where to go solely through voice inputs.

2.1 Packet exchange in Next Generation Vehicles

Next-Generation vehicles exchange packets depending on a social similarity score. A high similarity score determines that both the nodes (vehicles) have common interests and characteristics. The drawback of this forwarding process is the low efficiency of data delivery. Addressing this drawback, the forwarding algorithm incorporates situational-based scores along with similarity scores to increase the efficiency of data delivery.

Using Next-Generation Vehicles to forward packets gives rise to the following major issues:

1. The lack of integration of sensors with multiple protocols.
2. Security and privacy-related issues.

Upcoming sensors incorporate multiple design choices and protocol integration. But in vehicular social networks security and privacy issues have not received enough recognition and are poorly investigated even today. Researchers have proposed various approaches to address these issues. In this section, we discuss these approaches in detail and gain a better understanding of them.

Packets forwarded between nodes may contain corrupted data and can be fake. There is a need for establishing trust among vehicles ensuring that the data received is trustworthy. Abbani et al. [2] formulated a model based on trust principles. This model focuses on the following aspects of VSN security:

1. Formation of Social groups: A node can become a part of a group only if it has similar characteristics with the group.

2. Trust evaluation: A node's behavior, participation, and interaction in a group determine its level of trust.
3. Decentralized architecture: Nodes exchange group update and management automatically.

Each received message in vehicular social networks must contain an encrypted identity of the sender and score determining its level of trust. One of the approaches incorporates the use of certificates to exchange encrypted messages. The degree of trust and reputation obtained by the user acts as a reward and encourages them to forward trustworthy content and maintain good behavior.

A major privacy threat is the forwarding of a user's location data. Exchanging public locations such as malls or gardens are acceptable as compared to the forwarding of confidential locations such as home or office that can be dangerous. Researchers have proposed many protocols such as Social-based PRivacy-preserving packet forwardING (SPRING) [3], Social-Tier-Assisted Packet (STAP) [4], and Social spot-based Packet Forwarding (SPF) protocol [5] that deploy RSUs in public locations often visited by users. Users disseminate packets in these RSUs that are later picked up by the receivers, disabling them from tracing back to the source.

3 Merging Social Networking to Vehicular Ad hoc networks - Vehicular Social Networks

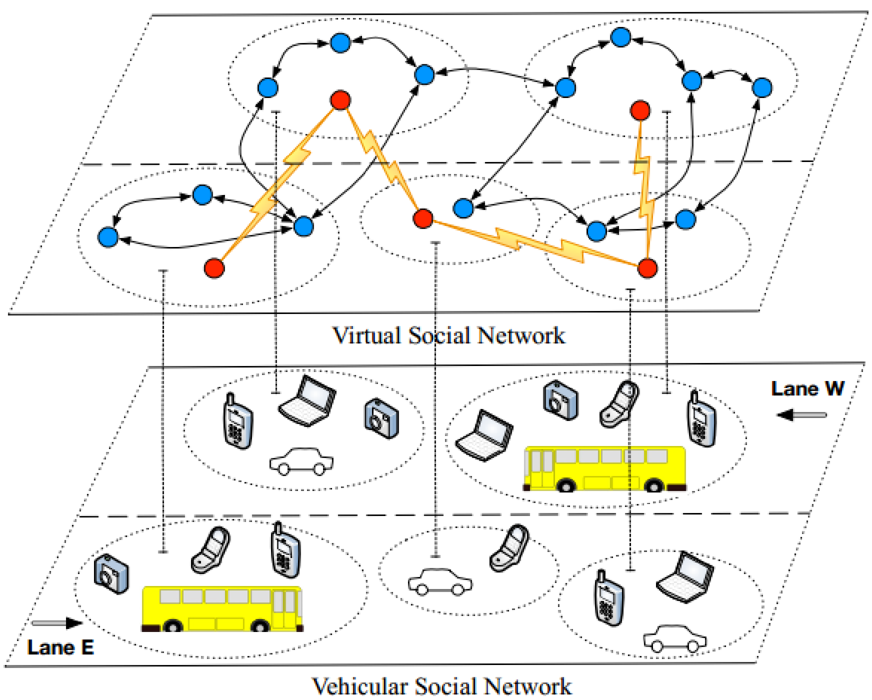


Figure 3: Vehicular Social Network and Virtual Social Network

The opportunistic networks described earlier can be compared to social networking as well. Different applications of social networking using human factors like mobility, user preferences, data and location sharing are of importance in VANET applications. This forms a different paradigm called Socially-aware networking, which combines the social relationships of the stakeholders in the system to form better networks called mobile ad hoc social networks, and the existing VANETs to form **Vehicular Social Networks (VSN)**.

Hence, a VSN can be a group of individuals who have common interests and preferences in the context of temporal and spatial presence of vehicles in a road environment. There is a lot of value that can be shared by vehicles with other users: location and common destinations of interest, traffic information like accidents, as well as valuable information on road conditions like slippery roads and low visibility conditions. Thus, VSNs can be a bridge to enhance the sharing of information amongst all vehicles in a given environment, and thus realizing a better warning system and experience for drivers and passengers. Mobile devices form larger social connections via the internet as opposed to vehicle links, which are location dependent. Social-aware networking is a two-fold paradigm that conceptualizes the following:

- Social relationships are stable
- Transmission links are temporary and vary more frequently

We can visualize this in figure 3.

The two social levels of Vehicular Social Networks and Virtual social networks are depicted here. The vehicles in red circles make social ties based on mobility and common interests, whereas the mobile devices in blue circles form an electronic social network when they are close to each other. The virtual social networks here are formed based on the inherent social ties, and hence do not change over time. In contrast, the vehicular social networks are formed based on the spatio-temporal ties between them, and change rapidly due to the fast-moving nature of vehicles.

The BEEINFO (Artificial BEE Colony inspired INterest-based FOrwarding) system presented in [6] describes a routing mechanism that classifies communities into different categories on the criteria of interests. This is done by recording information of vehicular densities of passing communities through mobile nodes. The densities recorded shows the number of nodes belonging to a community, and can serve to select next-hop forwarders in a better manner. We can now examine the example of a VSN along with the BEEINFO system in an urban scenario.

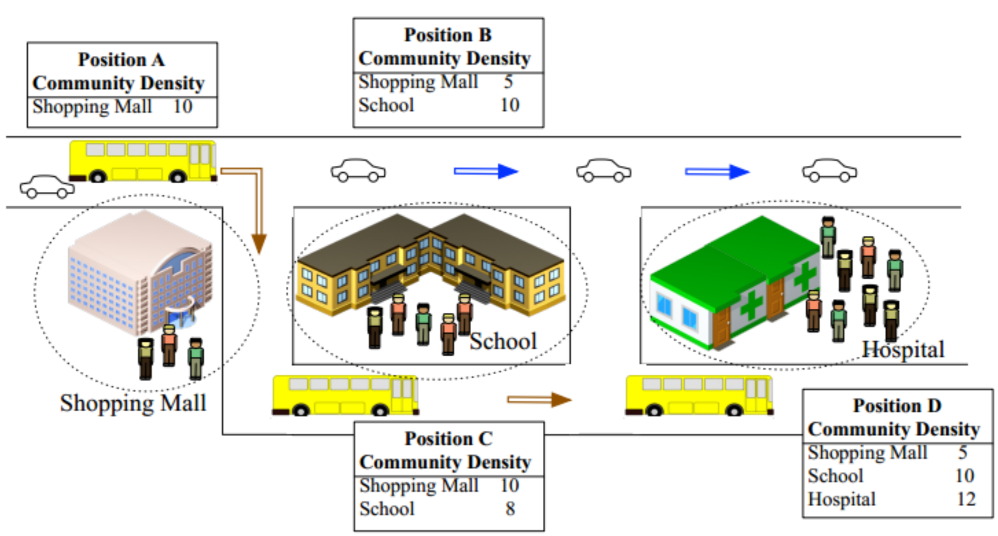


Figure 4: VSNs imitating bees' awareness

In figure 4, we can consider three different communities in relation to a shopping mall, a school, and a hospital. The bus follows the brown arrows through the hospital and school, while the car follows the blue arrows through the other three spots. Both the car and bus pass the shopping mall in B and C, but the bus approximates a higher density value than car in the shopping community (10 > 5), but lower in the school community (8 < 10). Hence, for message dissemination, the bus will forward information better to the shopping mall community while the car will forward information better to the school community. This is the same process used in selecting a person to forward information in a community, the more two people meet, the better their social tie is, which is demonstrated in this example.

Based on this, a VSN comprises two layers:

- A physical layer provided by the ad hoc network
- A social networking framework running on top

Hence, a VSN requires mutual cooperation between the social aspects and physical network operations. We can consider another VSN in an urban environment.

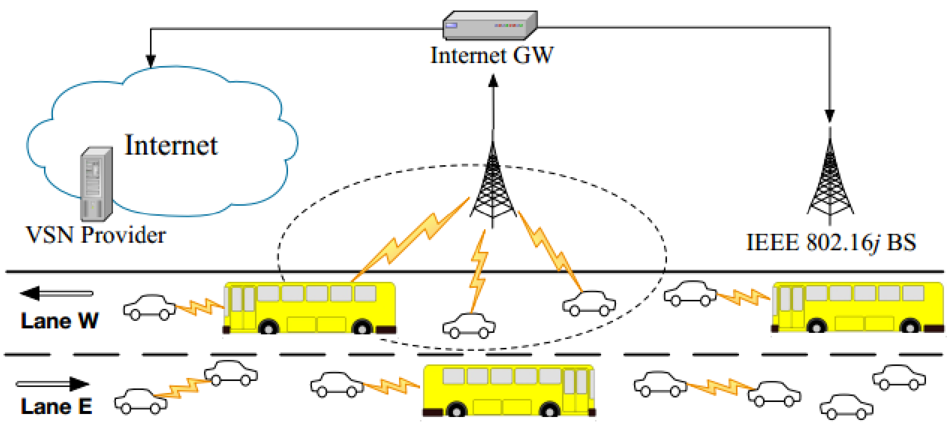


Figure 5: VSN in Urban scenario

Here, the figure 5 shows the schematic of a VSN in an urban environment with vehicles moving in opposite directions in the two lanes. The vehicles are relay stations (RSs) carrying multiple users which provide connectivity to the white vehicles in its coverage, which are the subscriber stations (SSs). The roadside base stations (BSs) are connected to the internet through internet gateways, and serve many moving RSs. Apart from this, the VSN provider is also connected to the internet, and enables users to register and employ the use of a web based portal for accessing social networking services.

As we can see from the aforementioned examples, VANETs are networks that are constantly evolving, with constant change in network dynamics over time. Hence, we must examine how to build opportunistic links while the vehicles are moving dynamically. **Social network analysis (SNA)** is a tool that can be employed here, which takes into consideration relationships between individuals or nodes and their ties with each other. This can be visualized as a graph G(V,N) where V is the set of nodes and N is the set of edges. We can define the following metrics to define how important any given node is:

- **Degree centrality**
  This describes how many direct connections a node v has to its neighbours, and is given by:
  $$d(v) = \sum_{j \in V, j \neq v} l_{vj} \tag{1}$$
  Here, l_{vj} is the link from the node v to its neighbours j. This metric defines how popular a node is, which is dependent on how many neighbours it has. A node with high degree centrality would possibly be chosen as a next-hop forwarder since it has a higher chance of being in contact with other nodes.
- **Betweenness Centrality**
  This describes the number of shortest paths passing through a node v, and is given by:
  $$BC(v) = \sum_{s \neq v \neq t | s,v,t \in V} \frac{\rho_{st}(v)}{\rho_{st}} \tag{2}$$
  Here, ρ_{st} is the number of shortest paths from node s to t, and $\rho_{st}(v)$ is the number of shortest paths from s to to t passing through node v. This metric defines how important a node is by using the proportion of the number of shortest paths passing through it to the number of shortest paths. The node with a higher betweenness centrality has a higher number of shortest paths amongst the node pairs passing through v.
- **Closeness Centrality**
  This describes the inverse of the distance of node v to every other node j in the network $d_{v,j}$, which implies that the node v has the shortest paths to the other nodes in the graph. It is given as:
  $$CC(v) = \left[\sum_{j \in V, j \neq v} d_{v,j} \right]^{-1} \tag{3}$$
  Hence, this metric describes how central a node is in terms of its proximity to the other nodes. The decision to use a more central node described by this metric in a VANET ensures the wider delivery of a message within it.
- **BRidging Centrality**
  This describes whether a node v is located in between highly connected regions. It is the product of BC(v) and the bridging coefficient b(v), where b(b) describes how well a node v is located between high degree nodes.
  $$BRC(v) = BC(v) \cdot b(v) \tag{4}$$
  $$b(v) = \frac{d(v)^{-1}}{\sum_{i \in N(v)} d(i)^{-1}} \tag{5}$$
  Here, $N(v)$ is the set of neighbours of node v.

  We can now define a graph that represents a part of a vehicular network in a highway scenario, with connected clusters through a relay node. Here, a cluster is a set of vehicles that are connected with one-another. This can be represented as a subgraph where there exists a path between any pair of nodes. In the image below, C1 is the cluster driving north to south, and C2 and C3 move in dedicated lanes from south to north. The undirected graph shown has a number of nodes (V) = 13 nodes, and number of edges (E) = 18 edges.

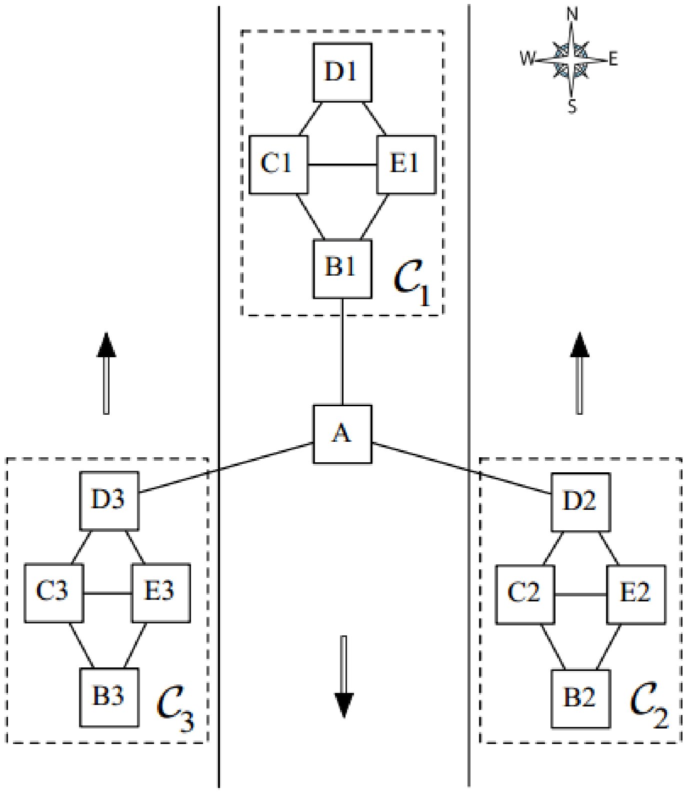


Figure 6: Graph comprised of different nodes in a Vehicular Social Network

From the schematic, we can discern that all the clusters are connected to one-another through node A. Hence, we can extrapolate that A is the relay node since it ensures that the three clusters are connected to each other. Now, the centrality metrics can be defined and are collated in the table shown below:

Here we demonstrate by calculating the different centrality metrics for node A. A has 3 neighbors (B1, D3, and D3). There are total 66 shortest path from which 48 pass through A. In figure 5, node A has 3 neighbor that have degree centrality 3 ($b(v) = \frac{1}{3} = 0.333$).

$$d(A) = 3 \tag{6}$$

$$BC(A) = \frac{48}{66} = 0.727 \tag{7}$$

$$CC(A) = 0.5 \tag{8}$$

$$BRC(A) = BC(A) * b(A) = 0.73 \cdot 0.333 = 0.243 \tag{9}$$

Nodes	d	BC	CC	BRC
A	3	0.73	0.5	0.243
B1	3	0.41	0.41	0.136
C1	3	0.076	0.32	0.021
D1	2	0	0.26	0
E1	3	0.076	0.32	0.021
B2	2	0	0.26	0
C2	3	0.076	0.32	0.0304
D2	3	0.41	0.41	0.205
E2	3	0.076	0.32	0.030
B3	2	0	0.26	0
C3	3	0.076	0.32	0.030
D3	3	0.41	0.41	0.205
E3	3	0.076	0.32	0.021

We notice that node A has the highest value of betweenness centrality with 0.73, closeness centrality with 0.5, and bridging centrality with 0.243. This shows the importance of A in the example given, and that VANET graphs display small world properties, i.e. a majority of the node pairs are linked by at least one short connection.

Defining the best metric for the nodes is still a challenge, and varies from application to application. They are largely used when designing routing protocols in VSNs, so as to ensure a higher delivery ratio and shorter end-to-end delays. Data packet delivery ratio refers to the total number of packets delivered out of the total packets sent. To improve the data packet delivery ratio and reduce end to end delay, nodes employ a combination of the metrics described in the previous section. Forwarding algorithms select the next node by determining the degree centrality as this increases the reach of the packet. This node can rebroadcast the received packet to a denser network. Nodes also employ traditional performance networks such as delivery delay, bandwidth, and delivery ratio while selecting the next hop. The forwarding logic differs in different scenarios and applications. For instance, during the dissemination of traffic and safety information, a smaller delivery delay is required. A larger delivery delay in such a scenario can result in an accident. Nodes that do not have a small delivery delay constraint exchange packets depending on metrics that best suit their application. A vehicle's type also affects its sociability aspect. For instance, taxis and buses cover a larger geographic range and are good for forwarding packets to a larger demography.

3.1 Social features in VSN

Flooding traffic situations can create clusters of vehicles to share data. One issue in a cluster with a lot of vehicles results in broadcast storming due to redundant links. Broadcast storm is repetition of a broadcast package even though all the nodes have already received the packet. This redundant broadcast of messages stalls the network and results in over utilization of a node's resources. Due to rapidly changing network topology there is a need to reduce broadcast storms. As a solution to this researchers develop a Sociological Pattern Clustering algorithm that exploits their tendency to share similar routes. Human mobility, preferences, and selfish status affect the VSN network.

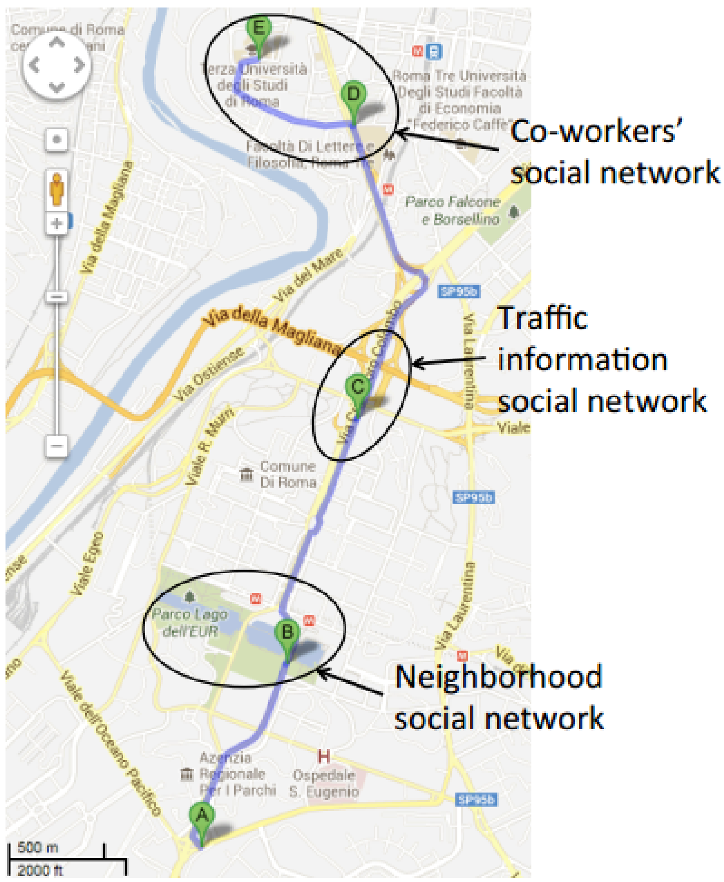


Figure 7: Path of a vehicle. Illustration of VSN

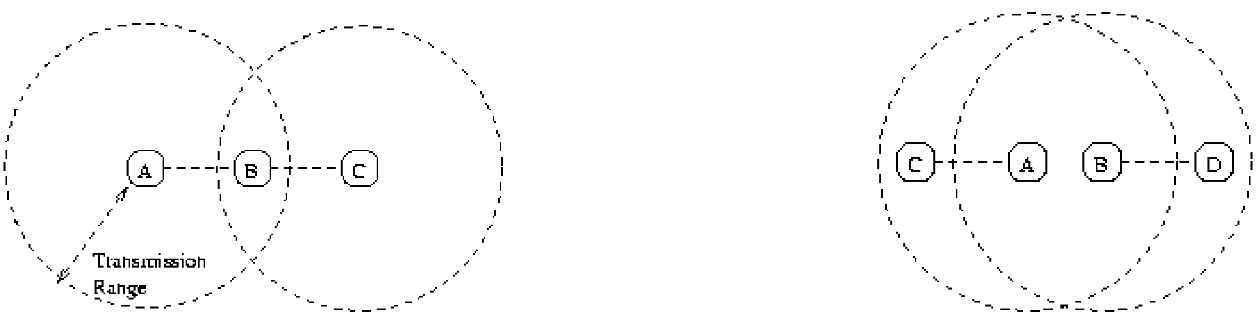
3.2 Differences between VSNs and OSNs

Vehicular social networks, as opposed to online social networks, are formed dynamically. Vehicular social networks require nodes to be present within a certain proximity at a given time. VSNs form temporary social ties as compared to OSNs. Nodes in a VSN interact with other nodes of similar interest. Moreover, nodes form content-based networks enabling them to receive relevant data (eg., traffic, and weather information). We demonstrate an example of a VSN for clarity. Consider a vehicle that travels every day from home to the office. This vehicle encounters multiple networks on the way (depicted by position B, C, and D in figure 7). At position B, the vehicle can share and receive relevant content (eg., the opening of a new museum or place of attraction). At position C, the vehicle receives traffic-related information from other vehicles and RSUs.

Online social networks are centralized and have data stored on a central system. In VSNs, data is decentralized, and the ties formed on-the-fly enable packet sharing. Communication in VSN is temporary and exists until nodes are in proximity.

3.3 Networking in Vehicular Social Networks

Ad hoc networks are built dynamically which makes it difficult to deliver packets without any collisions. In this section, we describe the networking issues involved in VSNs and some protocols that solve them. In ad hoc, the concept of hidden and exposed terminals becomes very crucial and it becomes challenging to design protocols to avoid collisions. We demonstrate this with figure 8.



(a) Hidden terminals

(b) Exposed terminals

Figure 8: Issues in Ad hoc networks

VSN protocols use **request-to-send (RTS**) and **clear-to-send (CTS)** processes to deal with these issues. In this process, a source node sends a request-to-send (RTS) packet to the destination node and awaits a clear-to-send (CTS) response. The **Urban Multihop Broadcast (UMB)** [7] is one such protocol that is used to disseminate messages to RSUs that are out of reach from the source. It operates in two modes, the intersection mode, and the directional diffusion mode. During the **directional diffusion mode**, the node finds the farthest node from its position to transfer the packet to diffuse (rebroadcast) it further. The **intersection mode** aims to build repeaters at node intersections for the broadcasting of important packets. When a packet encounters an intersection, the intersection broadcasts this packet in all directions as it has the best line view of road segments (eg., in the presence of high buildings.). UMB avoids collision by using different channels for control (eg., RTS, and CTS) and data signals.

Another issue that VSNs have to deal with is routing a packet from source to destination in a dynamic environment. The **Greedy Perimeter Stateless Routing (GPSR)** [8] protocol chooses nodes that are closest to the destination node for transmitting packets. In this protocol, each node contains information about its geographic location. During the route discovery process, **beacons** (messages) are sent to nodes at a distance of one hop from the source. Beacons provide identification and location of neighboring nodes. In GPSR, forwarding is achieved using greedy-based and perimeter-based algorithms. In the greedy approach, packets are forwarded to nodes closest to the destination node in its vicinity. In the scenario where this node is not able to forward the packet, the perimeter-based routing algorithm forwards the packet to nodes away from the destination.

4 Vehicular Social Network applications

Advantages of VSNs give rise to a large number of applications. For instance, consider a situation where a number of fans are approaching a stadium to watch a cricket match. Data relating to traffic congestion, road accidents, and team-based content are shared among vehicles. Since all the vehicles are travelling to the same destination, applications such as **Clique Trip** [9] allows users to connect among themselves during the journey. This also automatically changes vehicle routes enabling them to stay connected with each other.

NGVs perform vehicle diagnosis and checks can also warn users to change their schedule depending on the vehicle's state, avoiding accidents. **GeoVanet** [10] is a query/reply protocol enabling users to query in a VSN and expect a reply within a bounded time. For example, consider a tourist searching for interesting places to visit. He/she can query information about a new tourist spot from nearby vehicles and get its address. In GeoVanet the aim is to receive the maximum amount of data in a given amount of time. VSNs also enable traffic monitoring for smart cities. Traffic analytics enable users to avoid travelling in congested times.

Vehicular Social Networks also allows tagging that alerts users when a friend is along the way. About 30% of traffic in busy areas is due to the lack of a vacant parking slot. Searching for vacant parking lots adds to the traffic congestion that increases the global carbon emissions. **Carbon-Recorder** [11] mobile social application allows users to track daily carbon emissions. Carbon-Recorder raises awareness among drivers of the increasing carbon emissions and encourages them in reducing it. It also helps researchers collect data for vehicle traffic management, carbon emissions, and user behavior analysis.

VSNs also enable decentralizing computation tasks among different nodes. This represents the crowdsourcing concept that allows multiple nodes to compute smaller tasks to solve a larger complex problem together. This increases resource efficiency and reduces time spent by cruising vehicles. For instance, while finding a vacant parking spot crowdsourced data from different vehicles along with the navigation system allows users to find a parking spot quickly without wasting fuel. Another instance of this is **MobiliNet** [12], which combines cellular infrastructure like smartphones and tablets with mobile internet access in order to perform interlinking between people and vehicles alike. The system supports planning and forms social groups among people driving on routes, and forms a service referred to as the "Internet of Mobility". The system allows for connecting users together through which carpools can be made for future trips, and provides for estimating a traffic situation based on the historical data. This system is a precursor to the current implementation of **Google Maps**, which crowdsources data from all the phones using its service on the roads, and provides real-time route planning based on the traffic present on a particular intersection. This system is of great use and helps in conserving unnecessary travel time for passengers.

CarSpeak [13] is an example of a communication system for autonomous driving. The system adopts an approach of mapping the regions along the road using 3-D point cloud scans from a LiDAR sensor. These scans are shared amongst other cars in the vicinity using an octree data structure, which allows regions to be stored along with its point cloud data efficiently at different resolutions so that the data can be zoomed in and out for seeing small objects in a scene. Each node in the tree is called a cube, as shown in 9, and each cube can be accessed quickly and efficiently for accessing a particular part of the scene.

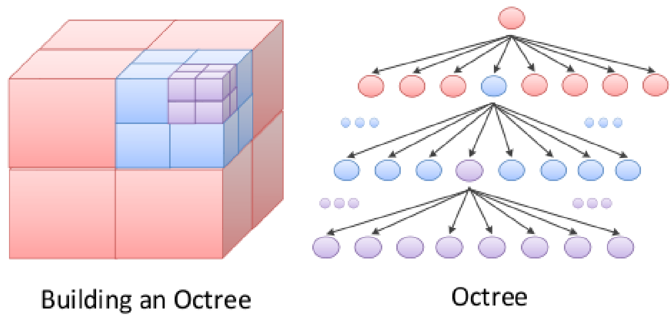


Figure 9: Representation of regions using Octree

Carspeak takes a content-centric approach for sharing information, i.e. it adopts a content centric MAC based protocol for sending data, and objects in a scene compete for medium access instead of different senders competing for access like conventional protocols like 802.11 and 802.11+Naming. The content-centric MAC handles both internal and external requests to add to a region in the octree. When the MAC receives a request from its own car, it performs a broadcast to the other vehicles over a wireless medium, and when the packets with the regions arrive, the system vets the data, checks if the request has timed out or not, and adds it to the octree. The MAC also actively listens to track external requests for data in the regions of the car's octree, and to identify what regions are observed by the vehicles in the network created. Furthermore, the octrees are compressed to allow for better transmission across the vehicles to increase the speed of the real-time system. This system provides better safety, since the autonomous vehicles now have data they didn't have previously, and can see across corners as well as see vehicles and pedestrians that are otherwise occluded by other objects.

5 Conclusion and future directions

In this report, we display a survey of Vehicular Social Networks. VSNs are very crucial in reducing accidents due to human error and achieving the goal of building self-driving cars. They present new paradigms to perform communication that is yet to be explored. We describe the major differences between VSNs and OSNs and display ways to shorten the gap between them. This report also discusses the different research approaches for packet security and compares them. We present different metrics used by forwarding algorithms to select the next node.

VSNs have gained interest in the automobile industry, the research community, and social application providers but still, encounter various issues. There is a requirement of novel protocols that resolve these issues. Sociologists and psychologists need to formulate an incentive mechanism encouraging users to increase their level of trust and forward trustworthy data. The development of new sensors that minimize interaction between the user and onboard services, integrating a variety of protocols is necessary. Moreover, handling of data must be with care and requires communication engineers to design more secure protocols.

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