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Grouping vehicles in Vehicular Social Networks

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Abstract: ***As vehicles have become intelligent objects, creating social friendships among them is justifiable. Internet of Vehicles (IoVs) and Vehicular Ad-hoc NETworks (VANETs) are associated terms that are recently highlighted to improve the transportation systems. Intelligent vehicles that can communicate with each other are the main component of vehicular networks (VNs). Indeed, they have resources for that intelligence: CPU, transceiver, sensors and memory. On the other side, social networks (SNs) are also brought to light to mainly study the human relationships. In this context, gathering these vehicles in social groups is reasonable to share their information by bridging VN and SN in a multidisciplinary research direction called vehicular social networks (VSNs).This paper will present a model to group vehicles in two types of social groups. Casual groups and permanent or formal groups will be discussed to increase social ties among vehicles that have the same interests. The results will be analyzed to clarify the most important factors that affect such these relationships.***

Keywords: Casual groups, Formal groups, IoV, Multidisciplinary, VANET, VSN.

1. INTRODUCTION

The transportation systems have been increasingly developed due to the advance technologies. IoV and VANET have strongly contributed to improve the transportation systems. Intelligent vehicles that can independently make decisions are the main reason for such development. Each vehicle has ability to learn and make decision because of its components such as CPU, memory, sensors and transceiver. These components help vehicles to communicate and share their information with each other. However, the main difference between IoV and VANET is that IoV exploits the internet services to share the experiences of vehicles. Not this only, IoV needs a global ID for each vehicle whereas VANET does not require such that ID [1, 2]. From these viewpoints, considering vehicles as social object is reasonable as long as they possess such these intelligent characteristics. Nonetheless, vehicular networks still suffer from some constraints that should be taken in account. Indeed high mobility and unpredictable behavior make VNs unstable networks and complex systems. On the other hand, social networks (SNs) have also a positive effect in improving several fields such as business, healthcare, personal benefits and etc [3]. Social objects such as human can share their experience through SNs. SNs can be divided into two main types; offline SN and Online SN [4]. In offline SNs, social objects can communicate through traditional offline social tools such as meetings. While in online SNs they can contact with each other through online social tools such as Facebook and Twitter. According to the same criterion, VSNs can be also divided into offline VSNs and online VSNs. As long as VANET does not require the Internet services, it can be considered offline VSN. IoV, on the other side, can be seen as online VSN while it requires the Internet services. This paper will work on offline VSNs to make vehicular social groups depending on their interests. Nevertheless, online VSNs are also a rich research field which needs to pay attention in the future works. The main idea behind this paper is how to create social groups of intelligent vehicles in order to share their information and experiences in offline. Although collecting data in offline SNs is a difficult task [3], offline VSNs provide availability of data. In offline SNs, collecting data needs to ask individuals either to fill forms or directly answer the questions whereas VSNs do not need such these procedures. In fact wirelessly communication among vehicles facilitates the task of collecting data. This paper is organized in seven main sections including the introduction. The next section is related to the society impact of the project. Literature review will be discussed in the third section. The fourth section highlights the grouping techniques in SVNs. The proposed model is stated in the fifth section. Results will be analyzed in the sixth section. Lastly conclusion will be summarized in the final section.

2. AIMS AND NATURE OF THE PROJECT

It is strongly believed that combining SNs with VNs will have an impact on improving the transportation systems. Several applications may benefit from this combination. All vehicles that are interested in a common behavior can share their experience to make the best decision. Vehicles that travel frequently to the same distention can share their knowledge with each other. Avoiding obstacles, for example, can be achieved by this scenario. So grouping vehicles in social communities may help to obtain a smoothly road traffic. Traffic jam, on the other hand, can be avoided by sharing vehicles' information. Not these only, entertainment applications can be applied in VSNs. Friends can share games and videos during their traveling through VSNs. Figure 1 shows the main applications of SVNs. These applications are ranging from safety applications to comfort applications. Besides, recommendation systems can be presented in VSNs.

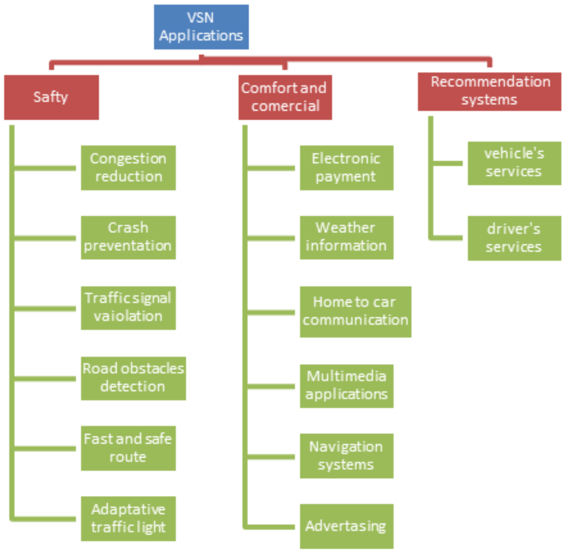


Figure 1 Applications of VSN

Furthermore, this paper contributes in growing scholarly knowledge of the efficient grouping of vehicles. It will grow the scholarly knowledge in using VSNs to share information for improving the transportation systems.

3. LITERATURE REVIEW

To the best of knowledge this paper is the first to investigate grouping vehicles as social objects. Since the emergence of intelligent vehicles that have possibility to communicate with each other, vehicles have become ready to be social objects. Several challenges have been emerged associating with this research direction. However, the main challenge is how to create the relationships between vehicles. In this section will discuss the concepts of grouping in social network and the principles of bridging SNs and VNs. Investigating the related works that have been done so far will be a part of this section

3.1. Grouping Social Objects in SNs

Identifying social groups is a main challenge in sociology. A cohesive social group is a collection of social objects that are considered as nodes in graph. These nodes are connected in bi-directional links or edges that represent the relationships between nodes. There are many studies that have been proposed to address subgroups in social networks. These studies depend on methodologies such as the degree centrality and heuristic methods. Besides, natural language processing can be used to identify subgroup of people in social networks. By analyzing conversations, nouns and phrase can be used to address characteristics of communities [5]. Degree centrality (DC) is widely used in SNs to compute the degree of each node. Betweenness centrality (BC) is to measure number of shortest paths to others that a certain node has. Closeness centrality (CC) is to indicate how long the shortest path for each node. Equations (1-3) define these three metrics of centrality [5].

$$DC(i) = \frac{\deg(i)}{n-1} \qquad \ldots..(1)$$

n indicates to the number of nodes in the graph, deg(i) refers to the number of neighbors of node i.

$$BC(i) = \sum\nolimits_{j \neq k \neq i}^{n} \frac{\delta_{jk}(i)}{\delta_{kj}} \qquad \ldots..(2).$$

$\delta jk(i)$ refers to the number of shortest paths between two nodes (j and k) passing through i. all shortest paths between them is referred by δjk.

$$CC(i) = 1/\sum_{j \neq i}^{n} D(i,j) \qquad \ldots..(3).$$

D(i,j) defines the distance between two nodes (i and j). Figure 2 shows a snapshot of graph representing SN, whereas table 1 illustrates these three centrality metrics for each node in figure 2.

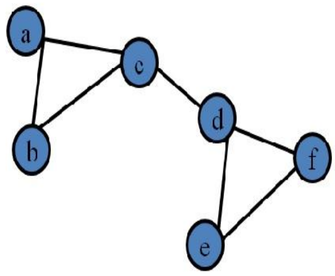


Figure 2 a snapshot of SN represented as a graph

Table 1 some centrality metrics of the nodes in fig 1

Node	DC	BC	CC
A	2	0	0.1
B	2	0	0.1
C	3	6	0.125
D	3	6	0.125
E	2	0	0.1
F	2	0	0.1

On the other hand, author in [6] has suggested a profit aware grouping method. It depends on skills of individuals who can cooperate to accomplish sets of tasks. This grouping team can increase the total profit of the task that can be completed by the team. A new people grouping has been proposed in [7] basing on a global similarity of users taking in account their constraints and importance in the social network. Grouping pedestrians has been presented in [8] depending on evolving track interaction network (ETIN). Tracks of pedestrians are represented as nodes whereas their behavior as weighted edges. Even though many researchers have been paying their attention toward grouping in social networks, it is still an open challenging research issue [5].

3.2. Bridging SNs and VNs

This paper considers vehicles, like human who build social relationships, as social objects which are interested in a common interest to share their experiences. However, limited papers have been suggested to bridge SNs and VNs so far. In [9] the concepts have been presented for bridging both SNs and VNs. Maglaras, L.A. and et al have discussed privacy and security issues of the new multidisciplinary research direction. Authors in [10] have suggested another attempt. A novel voting method has been proposed to overcome the problems of cascading and oversampling. As they are widely known in SNs, the techniques which have been used in SNs are borrowed. A vote is given for each vehicle according to how close this vehicle to the event. Authors in [11] have presented a new video social network over VANET. A service is provided for passengers who are interested to exchange their videos during traveling. In the similar event, a recommendation system has been proposed in [12] to give a recommendation for passengers who like joining their friends during trips. In [13], a study to investigate SNs in wireless sensors networks (WSNs) and VNs has been presented. Authors have used centrality metrics of SNs in WSNs to control their topology. The most related works are still limited attempts due to several challenges of this new multidisciplinary research field that requires to be clearly addressed,. Therefore, more clarification is needed to highlight the new direction's land-markers.

4. GROUPING VEHICLES IN VSNs

Grouping, in general, is associating term with clustering and classification which is also similar to pattern recognition task. It, in general, can be divided into two main types according to availability of prior knowledge. In classification, for example, groups' nature is known in advance. Therefore, it is just to assign a new member to appropriate group. This is why it is called supervised learning. The big issue is when there is no idea about the nature of groups. In this event, there is a need to unsupervised learning to identify the unknown groups [5]. Clique analysis finds links that connect members in a clique that should have directly connected links to every node else in the clique. This way of grouping is directly related to the nature of relationships among members. On the other hand, clustering is less direct but has efficient of computation. It depends on similarity or distances. Several distance measures can be used in this context such as Euclidean, cosine, hamming distance measures [5].

However grouping vehicles in VSNs has a different story. As it is previously mentioned VSNs have constraints that should be considered. High mobility and unpredictable behavior are the main constraints of VSNs. Moreover, there is no stable topology for VNs due to high mobility. On the other side, there are factors that affect grouping vehicles such as density of vehicles and range of communication. In the two following subsections, two ways for grouping vehicles in VSNs will be discussed. The first one is related to the permanent groups of vehicles whereas the second is associated to the temporary groups of vehicles.

4.1 Formal Groups

A group of social objects is simply defined as a set of members that have the similar interests. Social objects may be people, organizations, vehicles etc. identifying groups in social networks is still challenge especially when there is no prior knowledge about these groups and members' interests. In SVNs, vehicles that have similar interests can be gathered in a group. A big question mark is there, what are the similar interests of vehicles. According to these similar interests vehicles can be gathered in two main groups. These are Permanent or formal groups and temporary or casual groups. The latter will be discussed in the next subsection while the former means grouping vehicles that have relationships over a long time. These relationships can be created either by authorization of drivers or automatically by vehicles themselves. People friends can help their vehicles to create relationships if they have similar interests. For example, staff of company can authorize their vehicles to be member of the same group. Family members, people neighbors, schoolmates are examples of drivers who travel to the same place every day. They can help their vehicles to create relationships in a formal group. Not that only, vehicles can automatically to create relationships with each other without drivers' help. Because these vehicles may park at the same place for many times, they can have the similar interests. For example two vehicles which always park at the same shop's park may have the same interests, even if their drivers do not know each other. However, a threshold is needed to identify how many times vehicles see each other in the same place to create a relationship. In these two scenarios with drivers' help or without, vehicles can be gathered in permanent groups or formal groups.

4.2 Casual Groups

Vehicles are temporally grouped according to temporary interests. The interests here are in some sense related to the behavior of vehicles. Set of vehicles that have the same temporary behavior can be gathered in a one casual group. Destination may be a temporary behavior so vehicles that have been traveling toward the same direction cab be in a casual group. Speed is also can be considered as temporary interests. Communication range should be also taken in account in casual grouping process. In this context, it can be said all vehicles that have the same direction and in the same communication range can be gathered in a casual group. It is similar in some sense to the relationships of people who are waiting at bus stop or in a line. They have also the same temporary interests that enable them to create a temporary relationship regardless of whether they know each other before or not. To understand these concepts, the below example which is taken from the proposed model is to explain principles of creating a casual group of vehicles. As it is shown in figure 3, the vehicles are grouped in the casual groups according to their direction and communication range. The color of vehicle indicates to its formal group. All vehicles that have the same direction and in the allowed range will be grouped in a single group no matter to what formal group they belong. Nonetheless, in figure 3 the vehicles with color green and yellow are not grouped with the three-vehicle connected group and the two-vehicles connected group respectively, even if each one of them is in the range of the corresponding connected group. That is because they have opposite direction.

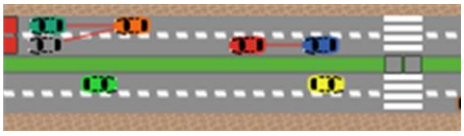


Figure 3 casual vehicular groups

The idea behind casual groups is not only to interact between vehicles in the same group. It is also help in efficiently sharing information of formal groups. As it is clear in figure 3 one casual group can contain vehicles from several formal groups.

4.3 Affecting Factors on Grouping

Behavior of vehicles and their drivers are the main factors that affecting formal groups. Drivers can play a role in creating formal groups. As it is discussed in subsection of formal groups, there are two ways to create permanent relationships of vehicles. Indeed the permanent relationships can be created either by drivers' authorization or by the frequently same behavior of vehicles. This is related to formal grouping scenario.

Nonetheless, the casual grouping scenario has a different story. Density of vehicles, their directions, and communication range are the main factors which are considered in creating casual groups. Regarding vehicles' density, it is known that the number of vehicles is not fixed all the time. It is variable depending on the time. It is high at the peak time or during emergency period whereas it is much less during late night [14]. In addition, the density is not the same in urban, rural, and highway. In urban, density of vehicles is always higher than in rural and high way. So creating casual groups is mainly affected by density of vehicles. In fact, high density may increase the number of members of a group as will be seen in the result's section.

Not density only can affect casual grouping, communication range has a significant impact on this way of grouping. In this context there are many wireless standard technologies which are designed for wireless networks. Table 1 shows the most familiar wireless technologies to wirelessly achieve the communication process. Each one has different characteristics to be suitable for different cases [15-17].

Table 2 some wireless technologies

Wireless technology	Data Rate	Range	Data type
Bluetooth	Low data rate 1 mbs	Short distance 10m	images or files
WiFi	54 Mbs- 6 Gbs	100 m	Video, audio or files
Wibree	Very low	Short distance	Small files
ZigBee	256 Kbs	75 m	Small files

However, since VNs have certain characteristics such high mobility and high changing in topology, a suitable radio technology is needed to meet their requirements [18, 19]. In this context, USA has developed dedicated short range communication (DSRC) which is a standard short medium range communication for Vehicle to Vehicle (V2V) and Vehicle to roadside unites (V2R) [20, 21]. They allocate frequencies spectrum 75 MHz at 5.9 MHz for DSRC. It has seven channels with 100 MHz wide for each channel. DSRC depends on wireless standard IEEE 802.11a [22]. American Society for Testing and Metrials (ASTM) has presented ASTM-DSRC that has mainly basen on 802.11 MAC layer and IEEE 802.11a physical layer. However, according to Sourav Bhoi and Pabitra Khilar, IEEE 802.11a has a main issue due to its data rate (54 Mbps). This is why IEEE 802.11a has renamed to IEEE 802.11p. Table 3 illustrates the features of DSRC which is used in USA, Japan and Europe [20, 23]. On the other hand, IEEE 1069/802.e is another wireless standard. The IEEE 802.11a operates on physical layer management, the IEEE 1609.1 operates on the application field, the IEEE 1609.2 supplies a security mechanism, and the IEEE 1609.3 operates on WAVE management and the IEEE 1609.4 control the logical link control layer. As a result communication range can affect casual grouping process. The wide range can provide large casual groups of vehicles. This is related to the concept of giant component in graph theory. It means the largest group of connected nodes. Giant component indicates to the connectivity of the entire network. Since the connectivity is defined as the number of nodes that can be removed to obtain the totally connected nodes. Besides, communication range is also can contribute to increase the number of links for each vehicle.

Table 3 DSRC used in USA, Japan, and Europe

	USA	Jap.	Eur.
Features	ASTM	JARIP	ECS
Communication	Half duplex	Half duplex	Half duplex
Frequency	5.9 MHz	5.8 MHZ	5.8 MHz
Band	75MHz	80MHz	20 MHZ
Channels	7	DL 7, UL 7	4
Channel	10MHz	5MHz	5MHz
Data rate	3-27Mbps DL/UL	¼Mbps DL/UL	DL500Kbps UL256 Kbps
Range	1000 m	30m	15-20m

5. PROPOSED MODEL

The proposed model contains two main steps. The first step is to build formal groups whereas the second is related to create casual groups.

5.1. Formal Social Grouping Algorithm

The formal social grouping algorithm (FSGA) is proposed to incorporate the social behaviors of drivers. So, new parameters are considered in this algorithm such as drivers' habits and historical behaviors of drivers. FSGA builds a social profile for each vehicle including all social places which are visited by that vehicle. In this context, social behaviors of vehicles are collected by Road Side Units (RSUs) in historical data. RSUs are deployed at each entrance and exit of park. The algorithm assumes that each social place such as university, school, super market, company etc. has at least one park. Each vehicle will send a message to the corresponding RSU when it enters and exits a park. As a result historical data for each vehicle will be available that indicates to the social profile of that vehicle. Depending on these social profiles the algorithm will gather vehicles that have a similar behavior in one formal group. To understand FSGA the next definitions will hopefully give a good imagination of FSGA's work.

Algorithm1: FSGA

Input
- *Let $P = \{p_1 \ldots\ldots P_m\}$ the set of parks in a given urban region*
- *Let $V = \{v_1 \ldots v_n\}$ the set of vehicles that are traveling during a time period*
- *Let $T = \{t_1 \ldots\ldots t_k\}$ the set time periods.*
- *The time of the system will be divided into K=6 periods*
  - *Predawn (up until 7 am)*
  - *Early morning (7 am- 10 am)*
  - *Late morning (10 am- noon)*
  - *Afternoon (noon – 4 pm)*
  - *Evening (4 pm- 7 pm)*
- *Night (after 7 pm)*

Output Number of permanent social groups of vehicles

Begin

1- For each v_i entering a Park
2- *Send a message to the corresponding RSU including the ID of the vehicle, the ID of the park and the time period as triple (V_i, P_j, T_k).*
3- *End for step1*
4- *From collected historical data Social Patterns (SPs) will be driven.*
5- *For each v_i*
6- *Assign v_i to the corresponding SP*
7- *End for step5*

End

According to the SFGA, the number of formal groups is equal or less than the number of SPs.

5.2. Casual Social Grouping Algorithm

According to the previous discussion casual social grouping algorithm (CSGA) is designed for grouping vehicles in temporary groups. It mainly depends on temporary vehicles' interests such as distention or direction and communication range.

Algorithm 2: CSGA

Input
- *Let $V = \{v_1 \ldots v_N\}$ the set of vehicles that are traveling in a certain urban region. Where N ranging (50..200)*
- *Let $T = \{t_1 \ldots \ldots t_K\}$ the set of time units.*
- *Let communication rang R ranging (15..100)*

Output Number of social groups of vehicles

Begin

1- *For each time unit t_k Do*
2- *For each vehicle v_i Do*
3- *v_i asks its neighbors to create a casual group if they are in the allowed R and have the same direction#*
4- *Kill links of the neighbors if they are out of range or change their direction.*
5- End for step2
6- End for step1

End

For each specific parameter such as communication range and density of vehicles the connectivity of the entire network is investigated. To achieve this task GraphStream is available [24]. It is a Java Library for analysis graphs. It receives events from NetLogo ver 5.3.1 which is a brilliant tool to simulate agent behavior [25, 26]. Figure 4 illustrates this bi-directional way to test the proposed model. This cooperation between NetLogo and GraphStream provides a good understanding to both behavior of individuals (vehicles) as agents and the entire network as a graph.

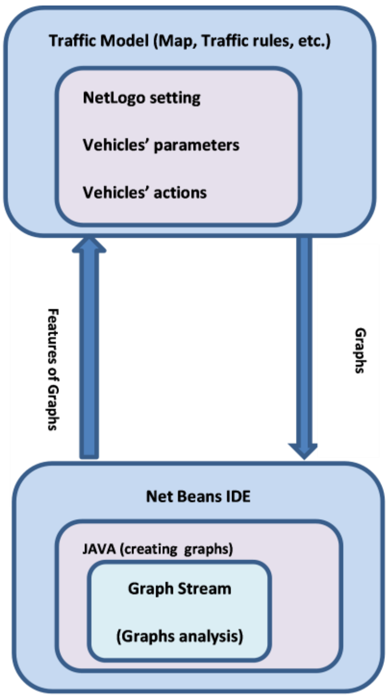


Figure 3 the proposed model

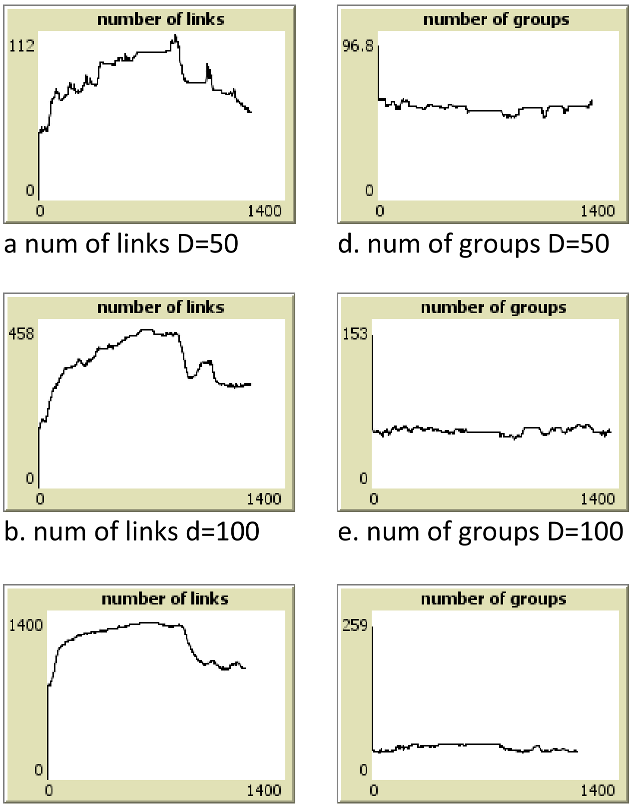
6. RESULTS

The proposed model is tested under some conditions. Table 4 illustrates the most important parameters. On the other hand, the road traffic model consists of six streets. Three of them are horizontal with length 2 km and the remaining three are vertical with length 1 km each one has four lanes two for either direction. There are nine traffic lights one at each intersection which is created by crossing of the one vertical street and another horizontal street.

Table 4 parameters of the proposed model

Number of vehicles	Variable 50,100 and 200
Communication range	Variable 15,50 and100
Speed	10-60 Km/h
Number of runs	10 for each scenario
Channel type	Wireless
Radio standard	IEEE 802.11p

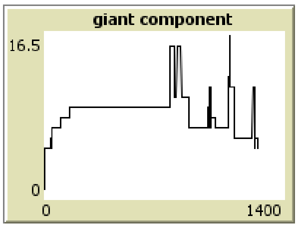
At each run, the number of links is computed for each value of affecting parameters: density D and range of communication R. Another result computed is the number of groups (casual groups). As it is seen from results how D and R have a significant effect on the number of groups. As it is previously mentioned giant component which represents the connectivity of the entire network can be affected by D and R.
Figure 5 (a-f) illustrate the effect of D on the grouping process.



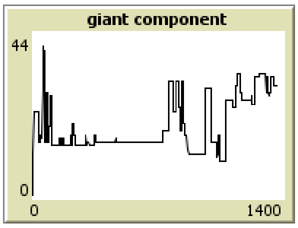
a num of links D=50
d. num of groups D=50
b. num of links d=100
e. num of groups D=100
c. num of links D=200
f. num of groups D=200

Figure 5 the effect of D with fixed R=100 on the number of links and number of groups

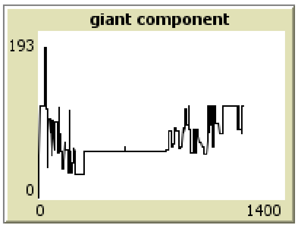
Moreover, figure 6 (a,b and c) shows the effect of D with fixed R=100m on the giant components.



a giant component D=50



b. giant component D=100



c. giant component D=200

Figure 6 the effect of D with fixed R=100m on giant component.

On the other side, results obtained from GraphStream, which is used to analyze graphs obtained from NetLogo, emphasize that there are significant effects of (N) and (R) on some metrics as shown in figure 7. It indicates to the graphs of casual groups when N= 200 vehicles and R=100m. From these graphs, it is obtained that Connected Components is 9, Diameter of giant component is 10.0 Density of giant component is 0.05646464646464647, and Average clustering coefficient of giant component is 0.8040006860171921.

Figure 7 graphs of vehicles' groups

7. CONCLUSION

As vehicles are immigrating to the next generation, the transportation systems will be improved due to these advance technologies. Nonetheless, vehicular social networks may be an amazing research direction for the next era. In fact, it is expected that bridging both VNs and SNs will be brought to light in the soon future. Therefore, the techniques of both social and vehicular networks are going to be combined. They are a main basic of this new research field. Since intelligent vehicles can interact with each other, collecting them in social groups is justifiable. The main project's contribution is in growing scholarly knowledge of VSNs. Sharing information in social groups is more reliable in sense of trusting information. So an efficient grouping of vehicles has been proposed to share information among vehicular social groups. This work of grouping vehicles will hopefully be a milestone of sharing information among social vehicles.

Acknowledgments

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