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MESSAGE FROM COMMSOFT TC CHAIR

The Technical Committee on Communications Software (TC-COMMSOFT) examines methods and techniques devoted to advancement of the formal methods and tools, use of system analysis and design, methodology for development of communications protocols as well as application of general Software Engineering approaches for the purpose of development of communications applications. The issues addressed by the TC-COMMSOFT include domain-specific languages and practices of using them. Developing of "middleware" between networks and applications and the usefulness and usability of it is also a topic.
In this volume, we have selected 2 papers on VANETs.

Location Services for VANETs

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***Abstract*—This paper proposes a location service deployed on RSUs (Road Side Units) for unicast routing over VANETs in urban environment. The proposed approach is able to measure the connectivity of a route. We propose then a new metric called Link Connectivity (LC) with measures this connectivity. As we have implemented our proposal using OMNET++ simulator and we have conducted extensive simulations with various scenarios to evaluate its scalability and robustness against frequent topology changes. As a conclusion, the proposed mechanism provides significant performance improvements in terms of packet delivery ratio, end-to-end delay and overhead when it is compared to some other known proposals.**

***Index Terms*—VANETs, Location-based Services, Geographic Routing Protocols, Mobility.**

1. Introduction

A mobile ad hoc network (MANET) is composed of mobile nodes connected by wireless media without any centralized infrastructure. MANET need efficient algorithms in order to improve the network performances in terms of connectivity, link scheduling and routing. Vehicular Ad Hoc Networks (VANETs) are a subset of MANETs. VANETs differ from MANETs about the paths they follow: they only move on roads since MANETs could move without any restriction. For this reason, routing algorithms over VANETs have to be adapted. Indeed, the identification of an optimal path is usually based on metrics as route computation of shortest path between the source and the destination. In MANETs, optimal path identification is more complex, it should take into account path failures, desertion, obstruction, etc... In addition to that, in VANETs, the higher level of node's mobility and the short-range communications causes frequent network topology changes. Then messages cannot be easily delivered to destination nodes. Moreover, the mobility of the vehicular nodes are constrained by the roads topology. Contrary to Wireless Sensor Networks, the nodes are not so constrained in terms of energy, computing power and location since the devices are carried by vehicles.

This paper proposes a location service for unicast routing over VANETs. This latter is specifically suited for city environment wherein the high-speed mobility of vehicles may cause rapid changes in vehicles density because it is able to find not only the position of the target vehicle, but also the best path with higher connectivity between the source vehicle and the target vehicle. Moreover, the best path is composed of a sequence of intersections obtained using the city digital map and vehicular traffic in the network by applying Dijkstra's shortest path algorithm on a sub-network which contains the vehicles with connectivity link upper than a given threshold. The paper is organized as follows. Section 2 is dedicated to related works; Section 3 details our contribution which is mainly a location service which could be deployed in an urban area on RSUs. In section 4, we give performance evaluations based on simulations achieved on the OMNET++ simulator. Section 5 concludes the study and gives some directions for future works.

2. Related Works

In the literature there are two ways to handle location services: A flooding-based technique which is a reactive or a proactive service or a synchronization-based technique which is based on a quorum method or a hierarchy method. The flooding proactive approach is simple to be implemented but generates a high overhead load since each node should send its position to the whole network. The flooding reactive approach reduces the overhead but introduces higher latency since when anode needs to send a message it needs first to have the response to its location request sent over the network. The synchronization-based technique aims to split the network into groups which are not disjoint as in the quorum approach or which are hierarchical with disjunction as in Grid Location Service (GLS) [1]) or without disjunction as the Hierarchical Location Service (HLS) [2] or its extension in [3]. Most of these approaches are difficult to be implemented in real VANETs deployment since they generate either higher overhead or higher latency. In this paper, we propose a simple approach to provide a location service in urban environments which could be implemented easily. Routing protocols must choose some criteria to make routing decisions, for instance the number of hops, latency, transmission power, bandwidth, etc. The topology-based routing protocols suffer from heavy discovery and maintenance phases, lack of scalability and high mobility effects. Therefore, geographic routing are suitable for large scale dynamic networks. The first routing protocol using the geographic information is the *Location-Aided Routing (LAR)* [?]. This protocol used the geographic information in the route discovery. This latter is initiated in a *Request Zone*. If the request does not succeed, it initiates another request with a larger *Request Zone* and the decision is made on a routing table.

The first real geographic routing protocol is the *Greedy Perimeter Stateless Routing (GPSR)* [?]. It is a reactive protocol which forwards the packet to the destination's nearest neighbor (Greedy Forwarding approach) until reaching the destination. Therefore, it scales better than the topology-based protocols, but it does still not consider the urban streets topology and the existence of obstacles to radio transmissions.
Another geographic routing protocol is the *Geographic Source Routing (GSR)* [?]. It combines geographical information and urban topology (street awareness). The sender calculates the shortest path (using Djikstra algorithm) to the destination from map location information. Then, it selects a sequence of intersections (anchor-based) by which the data packet has to travel, thus forming the shortest path routing. To send messages from one intersection to another, it uses the greedy forwarding approach. The choice of intersections is fixed and does not consider the spatial and temporal traffic variations. Therefore, it increases the risk of choosing streets where the connectivity is not guaranteed and losing packets.
Like GSR, *Anchor-based Street and Traffic Aware Routing (A-STAR)* [?] is anchor-based. However, it reflects the streets characteristics. A connectivity rate is assigned to the roads depending on the capacity and the number of bus using it. This metric is used in addition to traditional metrics (distance, hops, latency) when making routing decisions. As a consequence, the streets taken by busses are not always the main roads where connectivity is ensured and the greedy approach does not consider the speed and direction for the next hop selection. This is why *improved Greedy Traffic Aware Routing (GyTAR)* [?] was designed as a geographical routing protocol adapted to urban environments and managing the traffic conditions. A sender selects dynamically an intersection (depending on the streets connectivity) through which a packet must be forwarded to reach the destination node. Between intersections, an improved greedy approach to forward packets is used. This latter is based on the neighbors' speeds and directions. GyTAR takes advantage of the urban roads characteristics, selects robust paths with high connectivity and minimizes the number of hops to reach an intersection. However, the main GyTAR drawbacks are that the connectivity information may be maintained by the infrastructures (RSSU: Road Side Service Unit) and it has a weak performances in spare networks.

3. Proposed Location Service

In this paper, we propose a location service based on the cooperation of fixed RSUs (Road Side Units). We assume that an RSU is located on each junction, and every vehicle has a static digital map to get the position of all RSUs. Indeed, each vehicle also has knowledge of its geographic position by using its GPS, speed and heading. This allows the vehicle to find the closest RSU in order to request a route to the destination.

3.1 Location System

A location system is a set of distributed and interconnected RSUs through the network as shown in Figure 1. Each RSU plays the role of a location server and maintains a part of all vehicles information.
This information of vehicles will be periodically shared with all other location servers. The role of a location server is not only the maintenance of vehicle information but also the participation in finding the pertinent route between two nodes.

3.2 Link Connectivity Metrics

Firstly, we define Link function as a metrics which measures the remaining communication distance between two consecutive vehicles as follow:

$$Link(v_i, v_j) = \begin{cases} R_{tr} - dist(v_i, v_j), & if\ dist(v_i, v_j) \leq R_{tr} \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

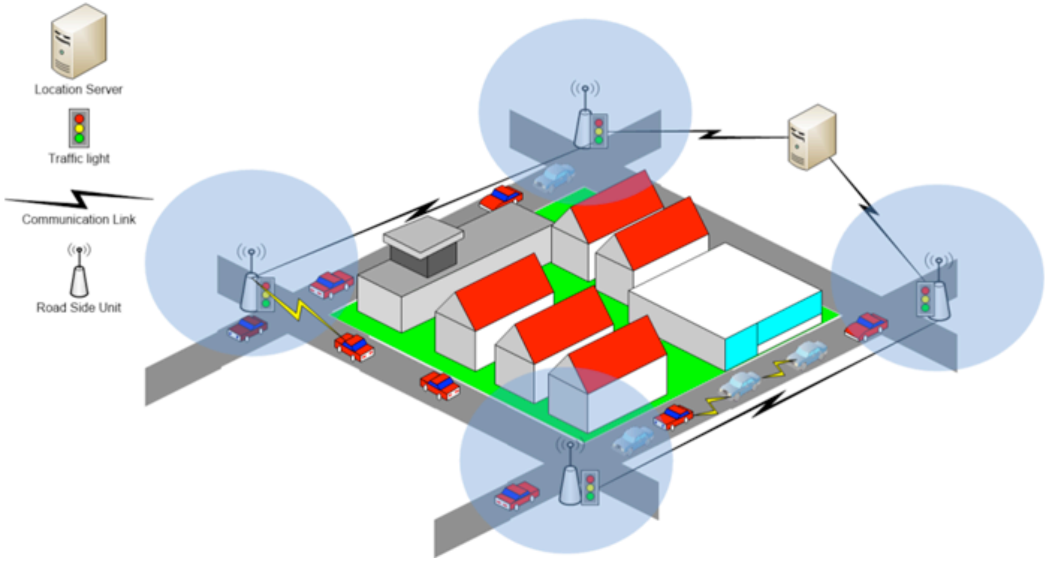

Figure 1 Location System Communication Network

Accordingly, the Mean Link denoted ML between all vehicles in the same road can be expressed as follows:

$$ML_{road} = \frac{Link(J_n, v_1) + \sum_{i=1}^{N-1} Link(v_i, v_{i+1}) + Link(v_N, J_m)}{(N+1)} \quad \textbf{(2)}$$

N and v_i represent respectively the number of vehicles on a given road and the i^{th} vehicle on such a road. J_n and J_m represent the junctions that are at the road extremities.

Moreover, Link connectivity (LC) is a function related to a road in order to measure the link connectivity of a given road. Formally LC can be computed as follows:

$$LC : E \rightarrow [0,1[\qquad LC_{road} = \frac{ML_{road}}{R_{tr}} \quad (3)$$

3.3 Route Selection based on ML

The proposed metrics ML is useful to select an appropriate route from a source to a destination. The location server maintains vehicles information, it has information about all vehicles in the network. According to all these vehicles information, the location server can represent the network as a graph $G = (V; E)$ composed of a set V of vertices (junctions) and a set E of edges (roads). Each edge has as a weight the ML of its related roads.

Algoritm.1 gives details about the selection of a route from Node S to Node D. The algorithm starts with checking if any route between these two nodes has been already calculated and saved into the routing table. If this route is not available, we will only consider the subgraph of the system where each edge is weighted with a value greater than a required threshold. In other words, the threshold represents the lower link connectivity under which a road could not be selected in the routing process.

In fact, if the threshold is too low, the road is supposed not appropriate to be a part of the derived. When a route is found, it will be used to send a message from a source to a destination using a greedy mechanism.

4. **Simulation and Routing Performance Results**

In this section, we evaluate the performance of EGyTAR and our routing scheme in terms of packet delivery ratio, end-to-end delay, and routing overhead. The both protocol are implemented our proposal over the OMNET++ simulator.

4.1* Packet Delivery Ratio*: Figure 2 shows the packet delivery ratio as a function of traffic density. As shown in Figure 2, our protocol achieves higher packet delivery ratio than EGyTAR protocol. Furthermore, the packet delivery ratio of EGyTAR increases slowly as the network density increase, which means that EGyTAR cannot take all the advantages of the network density. The reason behind this is that Junction Selection Mechanism in EGyTAR uses only the density of traffic between two consecutive intersections, this mechanism does not have an overview of all traffic density of the network, which may lead to choosing the path from source to destination that is not the best according to the traffic density. Moreover, since our protocol scheme uses

Algorithm 1 : Best path algorithm

Begin
- Con_{Thr} : *Connectivity threshold*
- LS_i : *Location Server i*
- $LC(e)$: *Link Connectivity of edge e*
- $Node_s$: *Source node*
- $Node_d$: *Destination node*
- *G(V,E) : Network graph*
- $G_{Sub}(V_{Sub}, E_{Sub})$: *Subgraph of G*
- $REQUEST_{Route}(Node_s, Node_d)$: *Request route from* $Node_s$ *to* $Node_d$;
- $REPLY_{Route}(Node_s, Node_d)$: *Reply route from* $Node_s$ *to* $Node_d$;
- $Route_{s-to-d}$: *Route from* $Node_s$ *to* $Node_d$

$REQUEST_{Route}(Node_s, Node_d)$;
LS_i receives a $REQUEST_{Route}$ message from $Node_s$ to $Node_d$;
LS_i checks if there is a route between these two nodes in the routing table;
$Route_{(s-to-d)} = Routing_{table}(Node_d)$;
if ($Route_{(s-to-d)} \neq NULL$) **then**
  Send $REPLY_{Route}$ message to $Node_s$;
  return $Route_{(s-to-d)}$;
else
  $Con_{Thr} = 0$;
  $V_{Sub} = V$;
  Clear Buffer;
  repeat
    $E_{Sub} = \{e | e \in E \wedge LC(e) > Con_{thr}\}$
    /* *Shortest path between* $Node_i$ *and* $Node_d$ *from the graph* G_{Sub} */
    Path = $Shortest_{Path}(Node_i, Node_d, G_{Sub})$;
    if ($Path \neq NULL$) **then**
      Put(Buffer,Path); /* *Put the found path in buffer* */
    end if
    $Con_{Thr} = Con_{Thr} + 0.05$;
  until ($Path = NULL \vee Con_{Thr} \geqslant 1$)
  if (Buffer not empty) **then**
    $Route_{(s-to-d)} = Buffer(Size(Buffer) - 1)$; /* *Path with higher connectivity* */
    /* *Using Improved Greedy Forwarding* */
    Send $REPLY_{Route}$ message to $Node_s$;
    Update($Routing_{table}[Node_d]$);
    /* *When the timeout of a route down, delete Entry of* $Node_d$ *from routing table* */
    $Start_{Timer}(Node_d)$;
    return ;
  else
    return Path not found;
  end if
end if
End

all traffic density of the network to calculate the shortest path from the source to the destination with a higher connectivity, this allows the packet to travel along the route from the source to destination with the highest connectivity.

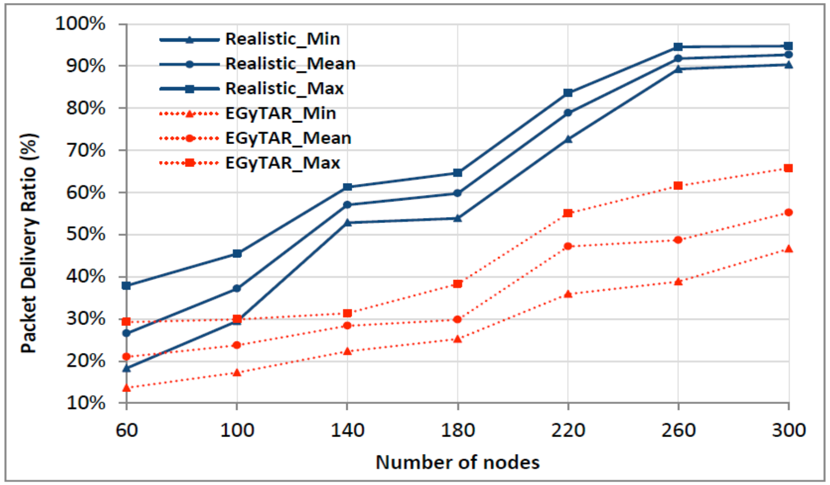

Figure 2Packet Delivery Ratio

***4.2* End-to-end Delay**: Figure 3 illustrates the average end-to-end delay. Generally, there is not as much as difference observed between the two protocols. Our protocol scheme shows slightly higher delay, this is may be due to the delay induced by route request and route replay. However, it uses higher density paths and delivers more packets than EGyTAR.

4.3 **Routing Overhead:** In Figure 4, we report the routing overhead measured in terms of the size of all control massages. Figure 4 clearly shows that our protocol scheme outperforms EGyTAR. This is due to the high number of control messages denoted as Cell Density Data Packets (CDP) in EGyTAR as described in [8]. The number of CDP packets increases as the number of nodes increases, which causes more routing overhead. In the contrast to our protocol, the routing overhead decreases as number of nodes increases. The reason behind this is that the number of route request messages decreases when the traffic density increases. This is due to the link quality between source node and RSU which depends on the traffic density.

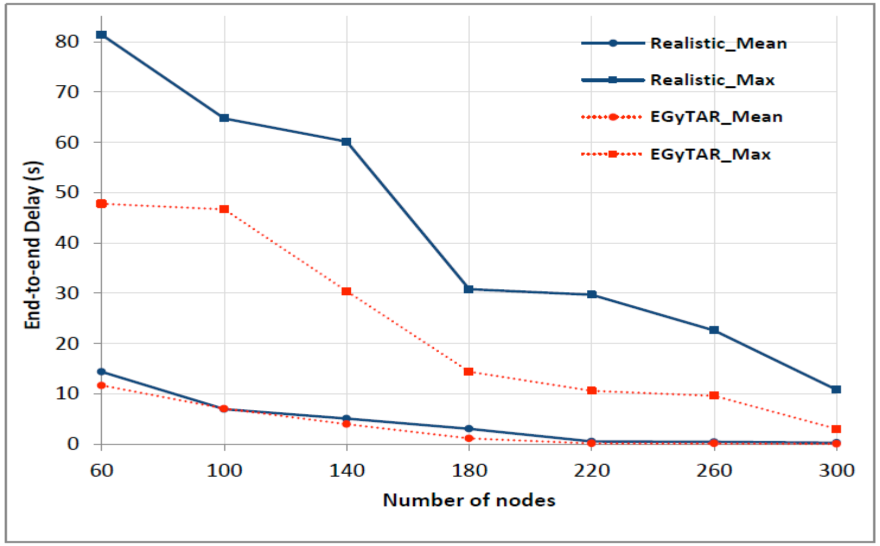

Figure 3End-t-end Delay

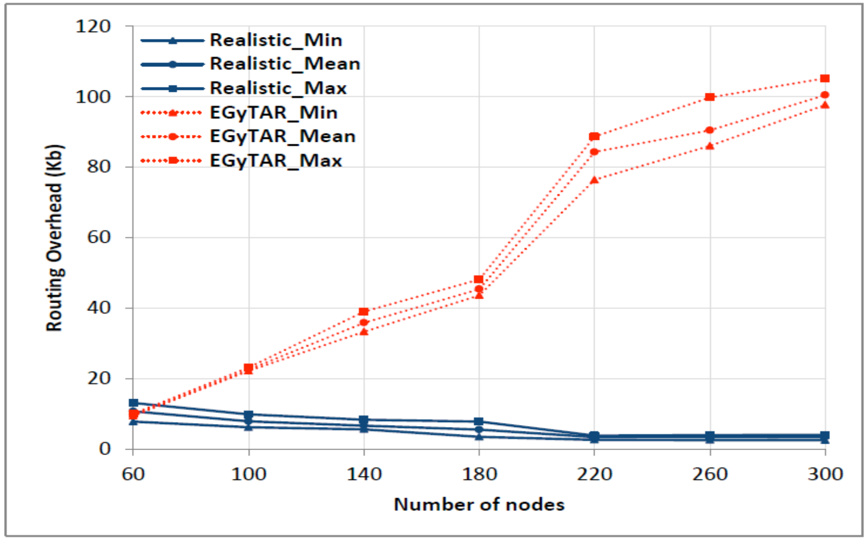

Figure 4Routing Overhead

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Biography

NEBBOU Tawfiq received his Master degree from University of Science and Technology Oran, Algeria (U.S.T.O) in 2014. He is a PhD student in the field of Networks and Distributed Systems at the faculty of Sciences, University of Tlemcen-Algeria. His research interests are in Vehicular Ad-hoc networks (VANETs), Location Services and geographic routing protocols in VANETs.

Mobility Management in VANETs: Survey

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Abstract: The emergence of vehicular networks: vehicle-to-vehicle communications (V2V), vehicle-to-infrastructure (V2I) and Vehicle-to-Everything(V2X) has enabled new applications such as Cooperative Intelligent Transport Systems (C-ITS), real-time applications (for example, autonomous driving), road traffic management applications and comfort applications. However, these networks are characterized by a high level of mobility and dynamic change in the topology, which generates scattered networks. To address this problem and ensure a high level of performance, a new concept: Heterogeneous Vehicular Networks (HVN) was created and consists in a hybridation of the vehicular network(IEEE 802.11p) and cellular networks(3G/LTE/4G). In this paper, we have explored the different existing data relaying mechanisms between vehicular and cellular networks, and we proposed an classification of handover mechanisms on which we can base in order to propose efficient handover applicable in Heterogeneous Vehicular Networks (HVN) for connected vehicles deployment which are predecessors of autonomous vehicles.

Keywords: C-ITS, VANETs, Handover, HVN, Cross-layer.

1. Introduction

Vehicular networks are emerging networks that connect vehicles with each other and with the road infrastructure. They allow to implement security applications (collision avoidance, works prevention, etc.), real-time applications (autonomous driving), intelligent transport systems applications (traffic management, proposal detours, etc.), comfort applications (automatic toll highways, connecting to the online media, etc.). Vehicle needs a near-continuous connection to fully function. Since connected vehicles will take time to spread and equipping the road with RSUs is long and expensive, it is intuitive to use other networks available in the vehicle such as passengers' mobile phones networks in addition to the IEEE 802.11p network. The cellular network (3G, LTE, 4G) is the ideal candidate thanks to its wide deployment and accessibility (examples of smartphone available in most vehicles).

When both of vehicular and cellular networks are available, the vehicle will be able to switch between vehicular and cellular network or vice versa depending on the quality of service(QOS) and vehicle's user preferences. This process is called handover and has to be very faster as possible in order to maintain the vehicle connectivity. We have made exploration and classification of those handovers mechanisms mainly focusing on their advantages and disadvantages.

In this classification, we have considered the most important criteria such as communications technologies, handover execution process, handover decision actor and the layers involved in the handover process. Alongside, we also provide some examples of most recently used and proposed solutions,implementation, standardization and challenges as a guidance to the readers and researchers.

The paper is organized as follows: the section 2 presents the classification of the principles handover mechanisms in which we firstly present the handover mechanisms where the mobile is the main decision actor, in section 2.a, we present the handover mechanisms which are based to the network approach, section 2.b is about the recent hybrid and distributed handover approach. Finally, section 3 concludes the paper and gives some perspectives for our future works.

2. Handover mechanisms approach and classification

Depending on the location and area in which the handover has to be managed, we can classify the mobility management(i.e mobility handover) in two classes:

- Global mobility management in which the main mobility manager known as Home Agent(HA) is located in the core layer of this architecture and is managed in a centtralized manner. Examples: MIPv4, MIPv6, NEMO, etc …
- Local mobility management in which the mobility is managed locally(preferably in the multi service Edge layer) in a small region named mobility domain and is assumed to be distributed managed. Examples: PMIPv6, DMM, FDMM.

Our classification of main existing handovers mechanisms is illustrated in table below and their description is given in following sub sections.

Criteria	Categories	Description	Examples
Technologies & Frequency	Horizontal	Intra-system	Wifi
	vertical	Inter-systems	Wifi to LTE
Execution	Hard	Break Before Make	MIPv4[1], MIPv6[2]
	Soft	Make Before Break	PMIPv6[3,4]
Decision actor	MN based	Mobile	MIPv4,MIPv6
	Network based	Network	NEMO[5],PMIPv6
	Hybrid	mobile assisted by Network and vice-versa	DMM variables
Involved layers	1 layer	L3 or L4	NEMO,MIPv4
	Cross-layer	L2-L3, L2-L7	FDMM
Architecture	Centralized	Control plan and data plan	NEMO,MIPv4,MIPv6
	Distributed	data plan or both plans	P-DMM, FDMM

Table1 : Main handover categories

a. Host-based approaches

In these approaches, the mobile(UE) is the main triggerer of the handover. The mobile makes handover decisions and informs the network about it. However it is still be the network which takes the final decision based on radio resource available in target cell. In this way, the mobile detect the beginning of disconnection, decide whether the handover is necessary or not. If handover has to take place, the mobile will select the candidate network based on the specific parameters that are involved in the decision phase of handover, and then inform all these relevant information to the network (refering to the Home Agent) which evaluates the availability of the resources on the candidate target (Visited Agent). Host-based protocols and their main characteristics are:

- MIPv4 : IPv4 based mobility protocol. His main problems are: triangular routing which always passes through the HA and presents high latency and therefore, packets loss. The HA also becomes a single point of failure.

- MIPv6 : IPv6 based mobility protocol. It improves the IPv4 latency thanks to his CoA auto-configuration. However it remains with the problem of overhead when the mobile is trying to inform his new address to all his correspondents. MIPv6 can works in two different mode: with route optimization or without it.

b. Centralized and Network-based approaches

In this case network makes handover decisions. The advantages of network and centralized approach resides in its simplicity and capabilities of the central anchor to follow user movements by simply rerouting the packets over tunnels created with current access router of the mobile (MN). In this handover model, the network handles handover decisions and management on behalf of the mobile. This allows to make the handover transparent to the mobile. Compared to hosted-based approaches, the primary features of network-based (e.g: PMIPv6) goals [11] are :

- Support for unmodified MNs: Unlike MIPv6, a network-based approach should not require any software update for IP mobility support on Mns.
- Support for IPv4 and IPv6: Although the initial design of a network-based approach uses an IPv6 host, it is intended to work with IPv4 or dual-stack hosts as well.
- Efficient use of wireless resources: A network-based approach should avoid tunneling overhead over a wireless link; hence, it should minimize overhead within the radio access network.
- Handover performance improvement: A network-based approach should minimize the time required for handover.

This concept assumes a good stability of the mobile network. Examples of network-based protocols are Network Mobility (NEMO), Proxy MIPv6 (PMIPv6), Fast MIPv6 NEMO (FMIPv6 NEMO). However,in these approaches, the mobility anchor (HA, MAG, LMA) represents a single point of failure and poses
scalability issues (cardinal point for the control and data plane for millions of users), which also leads to suboptimal paths between MNs and their communication peers [8]. As stated in [7], centralized mobility solutions are prone to several problems and limitations: longer (sub- optimal) routing paths, scalability problems, signaling overhead (and most likely a longer associated handover latency), more complex network

deployment, higher vulnerability due to the existence of a potential single point of failure, and lack of granularity on the mobility management service (i.e., mobility is offered on a per-node basis, not being possible to define finer granularity policies, as for example per-application).

c. Distributed and hybrid approaches

The current mobile network are often centralized-based. These is notably the case of LTE in which every packet from external networks have to be routed through the SGW and PGW which aggregates different packet from different mobility flow. Those centralised model pose some scalability issues due to traffic and signaling handling. However The deployment of extremely dense radio networks addresses the need to expand the network capacity, offering an increased bandwidth per user per unit of area [8]. It is why a Distributed Mobility Management (DMM) is very essential in order to provide a flatter mobile network which might permit traffic to be routed without traversing core links unless necessary, which is supposed to be the case in 5G in order to support the IOT adressing needs. The main concept behind DMM solutions is bringing the mobility anchor closer to the MN.

The Distributed Mobility management presents lot of advantages and gives promising solution of avoiding the centralized approaches problems by :

- providing efficient mobility management
- assuring scalability, optimal routing and without single point of failure
- taking advantages of cross-layer by using for example the IEEE 802.21 standard known as Media Independant Handover (MIH) for handover on layer 2 et PMIPv6 for layer 3 handover.

Requirements of DMM are specified in RFC 7333 [7] with a high comparison between centralized and distributed approaches. DMM practices and analysis gap are detailled in RFC 7429 [12]. Recently, some DMM based solutions has been proposed

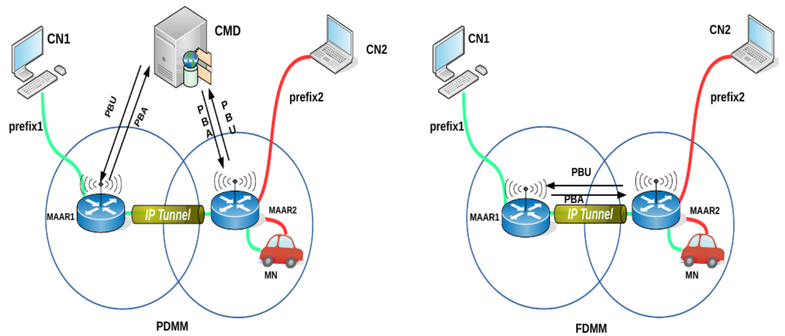

Figure 1: Partial DMM and Fully DMM illustration

and can be classified into two groups of approaches [9], [10] as illustrated in figure 1:

- Partial Distributed Mobility Management(P-DMM) in which the control plan remains centralized while the user data plan has been distributed.
- Fully Distributed Mobility Management (F-DMM) in which both the control plan and user data plan are distributed and are executed at the edge of the network.

In [6], F. Giust et Al. have made an comparison of performance for different network-based solutions.They have carried out an analytical evaluation on Network-Based IPv6 Distributed Mobility Management solution. They have highly considered the scalability and reliability problems of hierarchical and centralized mobility approaches by primarily taking into account the signaling overhead, the data packet delivery cost and the handover latency and comparing the results to those of the standardized network-based centralized mobility protocol: Proxy Mobile IPv6. In order to validate their analysis, they made a proof of concept of the design using an experimental setup with an implementation of the DMM solution and a performance assessment on handover latency was made in this work.

3. Conclusion

Mobility management is still one of the most challenging task in Intelligent Transportation Systems. Many studies about handover management in cellular and WLAN networks have already been carried out since long time. However, they can not be applied as there are in VANETS. In this paper, we proposed a survey and classification of those existing handover mechanisms. We have described some of them, starting by the host-based handover approaches in which the mobile(UE) is the main actor, then we described the network-based approaches where the network handles the mobility management on behalf of the mobile, and finally we described the distributed approaches where we gave their advantages compared to centralized mobility management approaches.

In our future work, we will study the possibility of enhancements of those distributed mobility management approaches in order to propose efficient mobility management mechanisms to be used in connected vehicles deployment.

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- Special Interest Group on "Communication softwares for Vehicular AdHoc Networks"
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- Special Interest Group on "NFV and SDN technologies"
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- Special Interest Group on "Security in Software Communication"
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Dr. Yessica Saavedra Yessica Saavedra
Address theoretical, conceptual and technological aspects of communication

- Special Interest Group on "Big Data"
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Address new trend on Big Data and Communication software

- Special Interest Group on "Designing Future Optical Wireless Communication Networks-DETERMINE"
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