

A Survey on Qualitative Analysis of Directional VANET MAC Protocols

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ABSTRACT

Since vehicles' trajectories are so complex and dense traffic changes in nature frequently, the VANET (Vehicles Ad-hoc Network), using Omni-directional Antenna, has many channel collisions (or overlapping) on Data Link phrases (MAC layers). It is not easy to keep a good seamless communication status for VANET because of its unpredictable network environment. Among VANET research, Directional Antenna have been proposed as one of the most common systematical solutions to reduce (or to mitigate) this miss-communication problems by narrowing communicational ranges and making use of its customized error-detection process. However, even though Directional Antennas help VANET keep good seamless communication, many VANET researchers have reported that Directional VANET still has miss-communicational problems – this has led to problems like 'Directional Hidden Terminal Problem', 'Deafness', 'Un-accuracy Lobe Scopes' and 'High Deployment Cost' being reported in various papers. To establish well-organized design assessments for a good Directional VANET MAC protocol to overcome these problems, we rearranged and grouped current Directional VANET qualitative criteria from several current survey papers using these categories- 'Directional Discovery', 'Directional Forwarding' and 'Directional Handover'. In addition, based on the results of the following analysis, we show the essential design concerns that need to be looked at in order to develop a well-designed Directional-VANET MAC protocol.

Key words: VANET, Directional Antenna, MAC protocol, Survey study.

1. INTRODUCTION

Recently since our mobile network has been sophisticated and its networks' traffics have also been heavier rapidly, it is much difficult to keep seamless network services if we have insisted to use only one certain modern network technology such as MIPv6, MANET. So, among Network researchers, they have started to modify (or conflate) current network protocols to overcome this problems as getting these strengthens and avoiding these weakness for example H-MIPv6, Ad-hoc, F-MIPv6. At this point of view, VANET(Vehicle Ad-hoc Network) is designed as one of advanced MANET for supporting stable network services among high mobility objects such as urban vehicles. First, compared with MANET, because VANET has self-route configuration, VANET is able to make (of find) suitable data forwarding path timely without any additional network devices. Second, VANET is possible to support good communication services on high-density environment such as urban local loads by maximizing

communication channel usages and simplifying connecting process [1].

Although VANET can support and cover these limitations of vehicle mobile networks up via Layer 3(Network Layer) sides, there are still some systematic limitations in Layer 2(Data Link) side to be operated as Vehicle Network Protocol because of its few and limited communication resources-'Channel Collision (overlapped scanning scopes)', 'Ineffective Channel management'. To be detail, first, Omni-directional Antenna, being used in typical VANET network, is not suitable with Urban Load Environment because of its large communicational range. Usually, because the nodes' antenna ranges are frequently widespread (large) than Urban Load's sizes, there are many communication overlapping problems-missing forwarding packets, miss-delivering- especially in the crossroads. In other words, under typical VANET networks, there are many data transmission collision problems and hidden terminal problems during communication phrases because of VANET's excessive large antenna scopes. Secondly, as most current VANET protocols are designed based on IEEE 802.11p standard, it is almost impossible to cover up high mobility. To be specific, IEEE 802.11 standards require many handover steps and its rules is so stick for keeping a good seamless

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communication condition. This fact would become one of good advantages for strong security or high QoS(Quality of Service) services if the communication objects are normally moving people or bicycles whose mobility is under 50km/h. But, if the object is urban vehicle whose speed is over 50km/h, IEEE 802.11 standard is not suitable to be used. So, among network researcher, they have concerned that additional supporting system (or policies) for quick VANET handover process and they have studied and proposed many various types of VANET protocol and its mechanisms as much so far.

Directional Antenna has been issued among Network Researcher to mitigate hidden terminal problems as narrowing Antenna scopes. Directional Antenna is able to point out (narrow) intended objects unlike Omni-directional one, just broadcasting messages to un-certain nodes, when communication initiations phase. So, the node using directional antenna is just one of the realistic ways to reduce communication-initiation cost and to keep a seamless communication service as much by focusing on listening and transmitting selected and intended communication candidates, not all of neighbor nodes. It means not only the node is possible to reduce energy consumptions, but also, it is able to avoid channel collision and overhead problems as much.

Unfortunately, Directional Antenna has also similar network problems to communicate among vehicles because of its narrowed scopes and too complex structures- 'Directional Hidden Terminal Problem', 'Deafness', 'Un-accuracy Lobe Scopes' and 'High Deployment Cost'. Firstly, actually, keeping a certain corn lobe scopes is almost impossible because Radio wave is not always fixed action pattern (Inaccuracy Lobe scopes problem). Second, 'Directional Antennas' Corn type of radio lobe scopes' may be good to focus on intended node's candidates, but its few scanning scopes would cause hidden terminal problems because it is easy to miss or not to find suitable neighbor nodes to forward packets on schedule. Also, if node select wrong-direction node as its neighbor node, the communication process would not be success to be finished on schedule or to be delayed for a long time (Deafness problem). In addition, so far, because of its too complex structure and management on the deployment and so high implement costs, there is not any specific and realistic proposal of VANET protocol using directional antenna, not brief ones.

2. PROBLEM FORMULATION

Even though directional antenna is able to reduce discovery (or seeking) and transmission cost as narrow coverage scopes, there are still probable problems systematically- 'directional hidden problem', 'deafness', and 'lobe accuracy'. Also, on deployment side, directional antenna has two implemental limitations: 'complex structure', 'high arrangement cost' [2]-[4].

2.1 Inaccuracy lobe scope and pattern

Systematically, directional antenna has two beam-formed scopes (or areas) that main lobes and side lobes when its radiations. According to current academic literatures, the main

lobes whose shape seems like a corn is used for uniform data gaining on transmission. Also, the side whose scope is like a sphere is for constant data gaining. But, in a real simulation, it is almost impossible to measure and manage the physical beam-formed area of these lobes timely, the network principles (proposals) of current literatures is so difficult to be proved significantly.

Also, like Omni-directional antenna, directional antenna is possible to have overlapped transmission coverage and data transmission collision if its transmission ranges is much extended for stable network connection in disjointed and bridge roads. In this paper, because we cannot handle with physical (or systematical) directional signal management and the issue is out of scope in our filed, we will not mention and propose the solution or ideas to improve the problem.

2.2 Directional hidden terminal problem

Basically, since directional antenna has narrowed and intended beam-forming network coverage on communication, there are new and unexpected hidden terminal problems – 'hidden terminal due to asymmetry in gain' and 'hidden terminal due to unheard RTS/CTS'.

- 1) Hidden terminal because of asymmetry in gain: in real world, having and keeping a typical size of directional network coverage is so difficult, each nodes has their own directional transmission scopes and whose sizes are different from each other. So, if a sender has much greater network range than receiver on transmission, hidden terminal problem is possible to be occurred inexpertly. Of course, directional antenna allows sender (or receiver) to have intended and filtered transmission objected compared with Omni-directional one, but there are still transmission limitation because of not covering network area completely.
- 2) Hidden terminal due to unheard RTS/CTS in gain: Ironically, since a sender node using directional and particular antenna has directional discovery (or transmitting) ranges, receiver whose direction is different angle could not have CTS/RTS message from sender on time. Because VANET also is based on IEEE 802.11p, if the process of CTS/RTS sharing, the data transmission is impossible to be proceed.

2.3 Deafness

Typically, Deafness problem is caused by not replying ACK message from receiver on time because receiver is so far (or in out of scope because of its high mobility) from sender. Of course, major reason of this problem is caused by VANET' 1.5 dimensional communication way also. According to literature, increasing waiting time to get reply message from sender is defined as 'back off time' [5]. So, increasing 'back off time' is possible to describe that any node is impossible to transmit (or to communicate) with each other because of certain node's un-limited 'back-off-time'. The VANET network is in 'deadlock' status, which is one of the most terrible and critical statuses in network communication.

Deafness due to directional channel monopoly: when the channels of receiver are already used or reserved fully from other neighbor nodes whose direction is different from a sender, the deafness problem is occurred because the sender is impossible to send any message to receiver until receiver's communication. This problem is possible to be happened in regular VANET network using Omni-directional, but the possibility in directional is much higher and frequently.

- 1) Deafness due to persistent DATA: Because of unknown reasons- 'receiver's high mobility or small network ranges', the sender is possible to receive reply DATA on time and just be waiting until getting the message untimely. It means the sender is in 'deafness' status and other node whose destination is this sender are also impossible to communicate with.
- 2) Deafness because of in-correct direction: in real world, even though the receiver is not reserved and idle status to communicate with, the deafness problem is occurred from a sender because their positions are not in the same angle and direction like directional hidden terminal problem.

2.4 High deployment cost and complex

Because of too complex its implementation, the detail specification or mechanisms of directional antennas have not developed and implemented in real world even though it has lots of benefits (advantages). So, until now, any literature (or proposals) have mentioned about these implemental cost problem and real maintenance method detail and specifically. Because of not scope in our research files, computer science, we also will not mention and propose the solution about that issue like other literatures unfortunately.

3. METHODOLOGY

There are three survey papers which mention Qualitative Criteria for VANET since 2006. Also, we concern some Criteria for MANET (or Sensor Network) as one of the baseline for Directional VANET because VANET is one of advanced MANET protocol we'd mentioned before. But, unfortunately, these Criteria would be not suitable and so limited to measure Directional VANET protocols' effectiveness because they are assumed to use Omni-directional Antennas. It means we need to re-arrange (or modify) these criteria or re-establish new Qualitative Criteria for determining well-designed Directional VANET MAC protocol. Therefore, at this section, we will review Qualitative Criteria for VANET and MANET protocol from current Survey papers and mention their suitability for Directional VANET and their customizing (New Criteria) if they are not enough to be used. In addition, we will mention the suitability of current Directional VANET MAC protocols based on our measuring table (New Criteria for Directional VANET).

3.1 Current qualitative criteria and literature

As major basis of our proposal, we reviewed (studied) three survey papers whose topic is the introduction of Directional VANET and its major concern to be used – One is P.Sai Kiran(2006) papers and another is H.Menouar(2006). Actually, we knew that these papers are so outdated and not fresh because they are published on 2006, but there are not any literature papers to discuss what Criteria (or agreements) are to measure the suitability of Directional VANET protocol proposals exactly and detail compared with these papers. Of course, to prove the superiority of their proposal, many network researchers have made their own Qualitative Criteria in their papers, but these measuring standards are so subjective and not being persuasive.

P. Sai Kiran (2006) mentions in his paper that well-designed Directional VANET MAC protocol is able to manage idle channel resources effectively and also has a good tracking function of high mobility consequences as much. So, He insists two hardware concerns ('Antennas type' and 'Directional sensing and Back up') and two software concerns (directional RTS/CTS and DATA/ACK transmission) when MAC protocol design[2]. Another survey paper for Directional VANET MAC protocol concern (H. Menouar, F. Filali, and M. Lenardi, 2006) defined these Qualitative Criteria more generally based on 802.11p basis (essential requirements) such as : 'Based on', 'implementation maturity', 'mobility', 'reliability multicast/broadcast', 'time synchronization'. Both papers' criteria would be well-established and seems like enough to assess Directional VANET MAC Protocols' avidities (suitability) but, there are no mathematic and objective references why they are meaningful and persuaded. In other words, we could not find any objective references to prove their assumption to be used as our basis. Lastly, the other survey paper (2006) for Directional VANET whose authors are L. Demirkoi, C. Ersoy, and Falagoz seems like so similar with former ones, but some criteria are different and interested than others to us because they thought Nodes' trajectory information concerns (historically and geologically) such as 'communication patterns' and 'adaptively to changes'. Other criteria schemes like 'Time sync', 'Implementation type', 'Antenna Type' are same meanings (definition) as former papers. Table 1 shows our analysis results that we collect and revision qualitative criteria of current survey papers after its comparison [3], [6], [7].

Table 1. Comparison table of current qualitative criteria for directional wireless network

Category	Criteria Name	Associated with Problem
Deployment	Antenna Type	Inaccuracy Lobe scopes and pattern
Deployment	Directional Sensing and Backup	Inaccuracy Lobe scopes and pattern
Transmission	Directional RTS/CTS	Directional hidden terminal problem/ Deafness
Transmission	DATA/ACK Transmission	Deafness

Deployment	Based on	High deployment cost and complex
Deployment	Implementation Maturity	High deployment cost and complex
Transmission /Deployment	Mobility	Directional hidden terminal problem
Transmission	Reliability Multicast /broadcast	Directional hidden terminal problem
Transmission	Time Synchronization	Deafness
Transmission	Communication Pattern	Deafness. Directional hidden Terminal problem
Transmission /Deployment	Adaptive to changes	Directional hidden terminal problem
Deployment	Type (implementation)	High deployment Cost and complex
Transmission	Time sync	Deafness

3.2 Directional qualitative criteria for directional VANET

For following facts, we need to establish new qualitative criteria for directional VANET network because of unique characteristics- fewer discovery or transmission scope and few data transmission process. We already mentioned the limitations of directional VANET MAC protocol to be deployed and operated in previous session. But, since these survey papers did not researched about our topic, 'Directional VANET networks', we also need to re-organize current challenges (limitations). P. Sai Kiran(2006) mentioned that Directional Mobile Ad-hoc has majorly 2 kinds of limitations to be implemented and operated – 'Inaccuracy lobe control', 'Unreliability Connection' and 'Deafness on transmitting' Another paper (L. Demirkoi, C. Ersoy, and Falagoz, 2006) defined more general limitation what directional VANET network has, but these limitations are almost the same concepts or definitions as P. Sai Kiran's ones.

Here are qualitative criteria for directional VANET protocol design what we propose in this paper.

- 1) Directional Discovery → New directional hidden problem
- 2) Directional Handover → Deafness problem
- 3) Directional Forwarding → New hidden problem, Deafness both

3.2.1 Directional discovery to find good communication candidates

Generally, in wireless network environment, seeking and connecting neighborhood nodes is one of the most important pre-concerns for suitable network services. If a certain network protocol would not be well to determine its neighborhood nodes to do handover process in time (waiting time) even though it has lots advantages to be used, there are no reasons (or grantee) that this protocol is possible to do good network services at one time. So, in many wireless network protocols (such as MIPv6, Sensor, and MANET), the process of

discovery (find) candidate node to forward data (or service) is concerned majorly and is also described detail.

To sum up, in wireless communication finding a good forwarding nodes (at this paper, we call it neighborhood node) within waiting time is one of the most important measurement factor to find a well-designed wireless network protocol. So, in VANET network using directional antenna, the node that wonder to start to communicate with has a good discovery ability (or supporting mechanism) to find a suitable and stable neighborhood nodes as its forwarding point as much. Unfortunately, because of its narrowing scope than Omni's one, proposed VANET using directional antenna has been failed to find its forwarding (or communicating) candidates within time limitation. Also, at the opposite case, so many candidates in transmission scope, the proposed Protocol has a good selection process (or algorithm) among neighbor nodes (candidates) as concerning additional qualitative criteria- node's trajectories (direction), traffic dense, Group information of Neighbor Nodes (Clustering).

Since directional VANET has confined and limited discovering scopes to find FN(Forwarding Nodes) compared with omni one, VANET needs to have its own discovery algorithm which is able to concern directional antenna's limitations and also concerns the candidates(detected neighborhoods) trajectories(Directionality) on choosing FN. Therefore, we concern this criteria is as one of the most measurement factors to find well-designed directional VANET MAC protocols.

3.2.2 Directional handover to evolve communication

After finding (or determine) forwarding candidates, the node to communicate needs to select a suitable neighbor node and to start to link (connect) its node to communicate as sharing communication message such as CTS/RTS messages in VANET network. However, because of the communicated node's high mobility, this handover process should be done within acceptable time limitation (based on 802.11.p), this time would be very short. But, since not only there are so many unexpected and unstable situations in directional transmission scope, but also basic rule of communication in wireless network (CSMA/CD) is fair competition, this handover process has not been easy-going (stable) well following node's expectation. To sum up, because of directional antenna's limitation- un-accuracy lobe pattern and direction, frequent topologies changes, additional handover algorithm (or mechanism) which concerns the node's directional mobility must be needed to keep good seamless communication.

3.2.3 Directional packet forwarding to keep seamless communication

As we mentioned before, even success to connect (to sink) good forwarding node or its clustering group within on time, we could not grantee successful data transmission (or forwarding) during transmission because of nodes' unexpected mobility or various risk factors such as dense traffic, high mobility speed, wrong trajectories. We already define this type of transmission problem as 'Deafness' at previous secession 3.

To overcome (or predict) this problem, our proposed directional VANET protocol should have additional (or customized) seamless connection supporting algorithm or mechanism such as directional ACK message from receiver based on 802.11 p standard. Also, the proposed protocol has a certain time limitation (or period) for missing sink-nodes during transmission phrase. This problem must make communicated node being in deafness situation because it avoid other communication requests and just be in waiting states until ACK messages from destination node. To sum up, to solve (overcome) this problem, adding the policy of time limitation into Data transmission algorithm need to avoid miscommunication problem as much.

Compared with typical VANET using omni-directional antenna, directional one has so confined but much longer communicational ranges because of its antenna's corn type lobe. It means that confined directional seeking scope is helpful to avoid the problem of communication interference on the opposite sides. And also, directional VANET is able to let a certain node to make communication group whose direction is the same way as the node easily by concerning its directionality. So, directional handover and data forwarding mechanism would be needed than typical wireless' ones if the node is able to use directional network infrastructures.

3.2.4 High implementation and deployment cost

Current survey papers frequently mention that the major reason, why directional Antenna is not concerned on wireless network even it is able to give communicated node lots of advantages, is lots implementation and deployment costs than other typical network protocol proposals. Furthermore, to control (handle) directional antenna and its management process, additional control network mechanisms which would be complex architecture (and process) than other ones. It also requires additional deployment budget. However, since this problem is so relative with systematical and hardware issues which is not easy to handle with, we think this problem seems like out of scope, not major our concern.

We'd already mentioned the reason why directional VANET requires high deployment and maintenance costs compared with omni-ones clearly. Because of directional antenna's high cost and its complex architecture, directional VANET network require lots deployment costs and maintenance costs. Therefore, we will not mention about this problem in this paper.

4. FINDING: QUALITATIVE ANALYSIS OF TYPICAL DIRECTIONAL WIRELESS NETWORKS

As we'd mentioned at methodology session, we think current survey papers for Directional VANET networks is not able to support for network researchers (developers) the good guideline or baseline of well-designed Directional VANET MAC protocol (or solution) because of these ambiguous and general information. So, we re-arranged these criteria and re-define new qualitative criteria as our assumption. At this session, to verify our assumption, we analyzed these protocols'

architecture and process algorithms to check whether our own criteria are not be concerned (supported) or not.

As its result, our Qualitative Criteria for Directional VANET would be able to determine the problems (weak-supporting a certain area) of current Directional VANET protocol more clearly than other surveys' ones. For example; D-MAC (Directional MAC protocol for VANET) is able to support directional RTS/CTS process as modifying 802.11p handover specification and algorithm (VANET Protocol standard) to add directional characteristics, but it did not mention about how to response other limitations such as 'deafness due to no idle communication channel'. Like this analysis, in this chapter, we will review and analysis 4 directional VANET MAC protocol or directional Mobile Ad-hoc protocol with our methodology's criteria. Like this example, in this session, we review five kinds of Directional VANET MAC protocol as using our Qualitative Criteria and also, we put some advices to be better at each review as showing Pro-Cons analysis commends.

4.1 Dynamical control assignment protocol (DCA)

As one of advanced slotted multiple channel protocols, DCA is designed for maximizing communication channel usages by separating Handover (CTS/RTS) and Transmission (DATA/ACK) Channel independently. Its architecture would give node having many opportunities to get idle communication channel because of its effective channel management. It means this protocol is also useful to have a good time synchronization on communication, but there is no mention about how to protect (or support) other's our concerns- 'Deafness due to persistent DATA' and 'Hidden problem due to un-head CTR/RTS' [6], [8].

- 1) The concern of Directional Discovery: Current CTS/RTS messages, but not so much concern
- 2) The concern of Directional Handover: Not concern, just only use typical wireless handover process
- 3) The Concern of Directional Forwarding: Typical Data/ACK process

4.2 Soft channel reservation for VANET

A. Nasipuri (1999) proposed advanced 802.11p communication channel management scheme (policy) to support maximizing channel usages on data transmission by tagging a certain channel before communication. In this network, all nodes have monitored their communication channel usages timely and also have selected and tagged their idle communication channel. So, if a node has been requested to communicate, the node is able to evolve data communication process immediately without any waiting time because of using reserved communication channel. But, like DCA, there is not any supporting policies or mechanism for un-head (or incorrect) RTS/CTS problem and unlimited ACK waiting time problem even though it would give a good time sync and channel scheduling. However, the concept, reserving idle communication for immediate communication evolving, is one

of the good schemes to maximize VANET communication resources [8].

- 1) The concern of Directional Discovery: Majorly concern as supporting Channel reservation
- 2) The concern of Directional Handover: Not much concern, current VANET's RTS/CTS process
- 3) The Concern of Directional Forwarding: Not concern, 802.11p Data/ACK message handshake process

4.3 Directional MAC for VANET protocol (D-MAC)

The major concept of D-MAC is there are two kinds of communication scopes (antenna)-'Omni-directional' and 'directional' both. To be detail, when a node send RTS message to evolve communication process as using omnidirectional antenna and then node selected and block the certain transmission area, which received CTS messages from neighbor nodes. The figure 1 shows how to process D-MAC protocol [9], [10].

- 1) The concern of Directional Discovery: Current Omni-directional Antenna for discovery, not so much concern
- 2) The concern of Directional Handover: D-RTS/D-CTS messages process, majorly concern for direction
- 3) The Concern of Directional Forwarding: Not concern, 802.11p Data/ACK message handshake process

Adding directional characteristic into CTS/RTS process is one of the good solutions to overcome 'un-headed (or missing) communication signals and process, but there requires two independent antenna management mechanism and its resources (channel) controlling system. It means this protocol requires lots of implementation costs than other protocols and also there are still the limitations to be used: 'Time synchronization' and 'not concern channel secluding' [2], [4].

4.4 Adaptive multi-channel MAC protocol for dense VANET network

The major difference of Adaptive Multi-Channel MAC protocol is that it has additional channel selection scheme for maximizing channel usage - 'Beam Table' like table 2. Like other VANET protocols, because this protocol is also designed based on 802.11p standard, it is impossible for a node to do any multiple communications with other nodes after connection. So, to keep seamless and low-delay communication, useful channel management algorithm or (process) must be necessary. As this following fact, to determine (or monitor idle communicational channel among nodes timely, this protocol use 'Beam Table' which has presented the communication channel usages [11]-[13].

In Directional Handshake side, this proposal is helpful to determine idle communication channel and start (evolve) communication initiation process immediately if source node has known their forwarding nodes' information (geographical data and nodes' IP address). It means that if the node did not discovery its neighbor nodes to handover, this protocol would

have the same limitations as other directional MAC protocols' ones.

- 1) The concern of Directional Discovery: Supporting Directional Antenna for discovery, not so much concern
- 2) The concern of Directional Handover: Use Beam-table to monitor idle communicated candidate timely
- 3) The Concern of Directional Forwarding: Not concern, 802.11p Data/ACK message handshake process

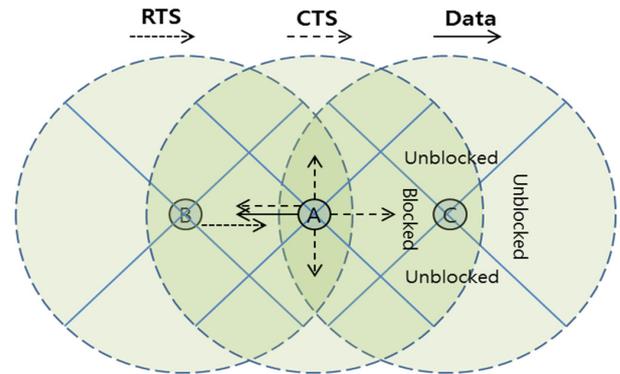


Fig. 1. directional discovery process of D-MAC protocol

Table 2. Beam table of VMCAC protocol

Channel Beam	172	174	176	178	180	182	184
1	1	0	0	0	0	0	1
2	0	0	0	0	1	0	0

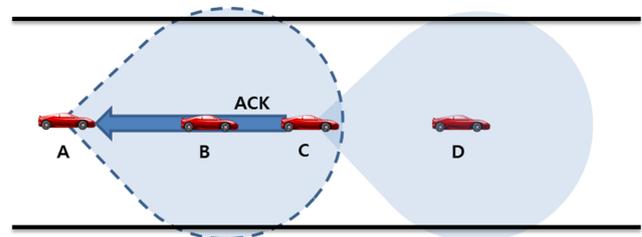


Fig. 2. Directional broadcasting on the road

4.5 Distance-based directional broadcast protocol for VANET (DDBV)

Da Li (2007) proposed a customized VANET protocol which concern directional antenna, but his protocol is focusing on how well and easy to send directional RTS message among nodes (vehicles), not directional data transmission and its management [14]. However, since the major reason of deployment directional antenna is accruing and discovering available neighborhood nodes to transmit as much, DDBV protocol is useful to solve directional hidden problems, specially 'deafness'. Furthermore, in this paper, authors proposed two kinds of detail broadcasting concepts based on two scenarios- 'in the road' and 'in the intersection'. Like figure 2, if the node wonders to forward its packet during moving in the road, the node just sends its broadcast message in the direction of antennas. And then, based on receiving its ACK (in this case, we assumed it as CTS message), the node

choose the best neighbor which is located in the edge of its transmission scope and start to forward its packet immediately.

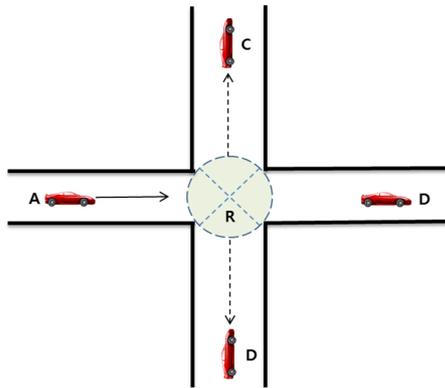


Fig. 3. Intersection repeater

However, in the intersection, because it is so difficult to determine neighbor vehicles' direction unless its trajectories is not determined before approaching, the author mentions (or proposes) additional directional monitor which has all node's directional (geographical) information around intersection like figure 3. Unfortunately, because this proposal requires lot initial processing time and resources to calculate huge amount of geographical information, the proposal, the deployment of intersection traffic monitor, is not suitable to be used in the dense traffics environment.

- 1) The concern of Directional Discovery: Use Directional Antenna to discovery node within the lobe, but no additional supporting algorithm for directional risk (limitation) problem
- 2) The concern of Directional Handover: Concern distance and direction (trajectory) factor on selection forwarding node (vehicle), but majorly typical VANET handover process
- 3) The Concern of Directional Forwarding: Not concern, 802.11p Data/ACK message handshake process

5. CONCLUSION

In this paper, majorly we mention the major design concerns (limitation) of VANET MAC protocol using directional antenna via qualitative analysis of current protocols from literature. To be detail, because of complexity of its structures and implementation, there are some hardware (or physical) limitations to be used –For example unstable transmission scopes, high deployment costs. But these problems are kinds of out scope of Computer Science departs, we did not discussed even though these approaches are one of the most effective way to solve. For following reason, we focused and established our own criteria and analysis the communication process among nodes such as ‘directional handover’, ‘directional forwarding’, and ‘directional broadcasting’. According to our analysis, current VANET network or other mobile network (such as MANET, Mobile Ad-hoc) have not concerned these following qualitative factors

when they are designed, just only concern general systematical or architectural sides, for example, Antennas types, implementation type and its cost, etc. So, their proposals (qualitative analysis) are so general, ambiguous and there are not any clear descriptions about that. So, we re-organized and re-analysis current VANET MAC protocols and Mobile ad-hoc MAC protocol as using our own criteria. Table 3 shows our comparison analysis of current Directional VANET protocol.

For example, at D-MAC protocol case, it has lots opportunities to find communication nodes' neighborhoods like Omni-directional ones and also it is able to control directional data transmission process as using d-RTS/CTS messages as much. So, we can mention that it is better performances at directional discovery and its forwarding than others. Also, because of choosing its transmission area using directional antennas, it is able to have directional antenna controlling. As like this review, we researched and analyzed current MAC protocol as using our own criteria. Table 4 also shows us our other qualitative analysis based on directional MAC protocol's limitation. These algorithms compared with DD (Directional Discovery), DPT (Directional Packet Transmission), DH(Directional Handover), and DAC (Directional Antenna Controlling) in table 3 and they compared with Dh (Directional hidden terminal problem), Dd (Directional deafness problem), Ic (Implementation complexity), and Dc (Deployment costs).

As this survey study, we need to find and to analysis current proposal of VANET protocol and other wireless protocol using directional antenna, special MAC protocol based on the customized Methodology based on current MANET and Ad-hoc network's ones. And then, in this paper, we established the essential scheme of well-developed VANET MAC Protocol and its algorithm via showing some visual charts, analysis matrix and tables. Of course, before showing our findings, we mentioned how to gather our analysis data and our criteria and its description compared with other wireless networks' schemes such as DRSC, Ad-hoc, MANET to mentions the scheme of well-designed VANET MAC protocol, One of our conclusion in this paper. Thus, we proposed our VANET MAC protocol criteria using directional antenna and its mechanism via several visual ads and descriptions as one of good examples for our survey conclusion.

Table 3. Comparison analysis of directional VANET protocol

	DD	DPT	DH	DAC
Dynamical Control Assignment Protocol (DCA)	Low	Medium	Medium	Not concern
Soft channel reservation scheme for VANET	Not concern	Medium	Medium	Not concern
Directional MAC for VANET protocol (D-MAC)	High	Not concern	Medium	Concern
Adaptive Multi-Channel MAC protocol for	Not concern	Medium	Not concern	Not concern

dense VANET network				
Distance-based Directional Broadcast Protocol for VANET (DDBV)	Concern	Not concern	High	Not concern

Table 4. Current MAC protocols' qualitative review relative with directional problem

	Dh	Dd	Ic	Dc
Dynamical Control Assignment Protocol (DCA)	Medium	High	High	Not concern
Soft channel reservation scheme for VANET	High	Low	Medium	Not concern
Directional MAC for VANET protocol (D-MAC)	High	Low	High	Not Concern
Adaptive Multi-Channel MAC protocol for dense VANET network	High	Medium	Medium	Not concern
Distance-based Directional Broadcast Protocol for VANET (DDBV)	Medium	Low	High	Not concern

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REFERENCES

- [1] S. Basagni, M. Conti, S. Giordano, and I. Stojmenovic, *MAC Protocols for VANET, Book: Mobile Ad Hoc Networking: The Cutting Edge Directions*, Wiley-IEEE Press, 2013.
- [2] I. Demirkol, C. Ersoy, and F. Alagoz, "MAC protocols for wireless sensor networks: a survey," *Communications Magazine, IEEE*, vol. 44, no. 4, 2006, pp. 115-121.
- [3] H. Menouar, F. Filali, and M. Lenardi, "A survey and qualitative analysis of mac protocols for vehicular ad hoc networks," *Wireless Communications, IEEE*, vol. 13, no. 5, 2006, pp. 30-35.
- [4] A. Dorin, *Seminar Paper: MAC Protocols for VANET_ A Survey and Qualitative Analysis*, 2010 Freiburg University Ad-hoc network Seminar, 2010.
- [5] P. S. Kiran, "A Survey on Mobility Support by Mac Protocols Using Directional Antennas for Wireless Ad Hoc Networks," *Ad Hoc and Ubiquitous Computing*, 2006. ISAUHC '06. International Symposium, 2006, pp.148-153.
- [6] A. Nasipuri, S. Ye, J. You, and R. E. Hiromoto, "A MAC protocol for mobile ad hoc networks using directional antennas," *Proc. WCNC' 2000*, p. 1214.
- [7] Hongning Dai, Kam-Wing Ng, and Min-You Wu, "An Overview of MAC Protocols with Directional Antennas in Wireless ad hoc Networks," *ICWMC 2006*, Bucharest, Romania, 2006.
- [8] Z. Huang, C. C. Shen, C. Srisathapornphat, and C. Jaikaeo, "A busy-tone based directional MAC protocol for ad hoc networks," *Proc. MILCOM 2002*, 2002, p. 1233.
- [9] T. Korakis, G. Jakllari, and L. Tassiulas, "A MAC Protocol for Full Exploitation of Directional Antennas in Ad Hoc Wireless Networks," *Proc. 4th ACM Int'l. Symp., Mobile Ad Hoc Networking and Comp., Annapolis, MD*, 2003.
- [10] Masanori Takata, Masaki Bandai, and Takashi Watanabe, "Performance Analysis of a Directional MAC for Location Information Staleness in Ad Hoc Networks," *ICMU2005*, 2005, pp. 82-87.
- [11] X. Xie, B. Huang, S. Yang, and T. Lu, "Adaptive Multi-Channel MAC Protocol for Dense VANET with Directional Antennas," *Proc. CCNC 2009*, 2009.
- [12] X. Xie, F. Wang, K. Li, P. Zhang, and H. Wang, "Improvement of Multi-Channel MAC Protocol for Dense VANET with Directional Antennas," *Proc. WCNC 2009*, 2009, p. 1.
- [13] Xu Xie, Furong Wang, Kewei Li, Peng Zhang, and Hao Wang, "Improvement of Multi-Channel MAC Protocol for Dense VANET with Directional Antennas," *Wireless Communications and Networking Conference 2009*, vol. 1, no. 6, 2009, pp. 5-8.
- [14] J. D. Li, H. Huang, X. Li, M. Li, and F. Tang, "A Distance-Based Directional Broadcast Protocol for Urban Vehicular Ad Hoc Network," *Proc. Int'l Conf. Wireless Comm. Networking and Mobile Computing (WiCom '07)*, 2007. p. 1520.



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