

# Vertical Handover in Vehicular Ad-hoc Networks – A Survey

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**Abstract-** Vehicular Ad-hoc Networks (VANET) representing the preferred network for Intelligent Transportation System (ITS) based on Dedicated Short Range Communications (DSRC) for Vehicle-to-Vehicle communications. In Vehicular Ad-hoc Networks continuous connectivity is a great challenge, due to high vehicle speed and ever changing topology of the network. Future vehicles will be fully networked and equipped with On-board computers with multiple network interface cards and emerging wireless technologies. With Vehicle-to-Vehicle and Vehicle-to-Infrastructure mode users can access the internet. Due to heterogeneous wireless access, Vertical handover is needed to maintain continuous connectivity between the vehicles and infrastructures. This survey paper gives an overview of vertical handover process and review some related studies.

**Keywords:** VANET, V2V, V2I, Heterogeneous, Vertical Handover.

## I. INTRODUCTION

Continuous connectivity in Vehicular Ad-hoc Networks (VANET) is a great challenge. In future most of the vehicles equipped with On-board units, shall be able to communicate with each other and with the nearby wireless infrastructure. VANET supports two types of communication mode: Vehicle-to-Vehicle communication and Vehicle-to-Infrastructure communications. V2V communications is for the direct and multi hop communication, between the vehicles. V2I communications is the communication between vehicles and road side units. V2V is based on dedicated short range communications and V2I is mainly based on GPRS, WiFi or WiMAX.

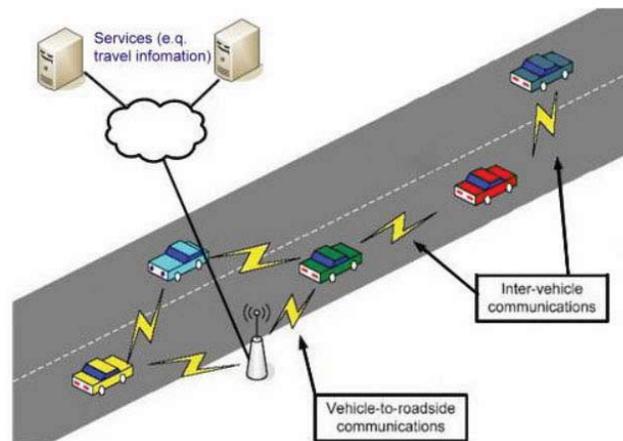


Figure 1 – Vehicle-to-Vehicle and Vehicle-to-Infrastructure Communications

VANET has two types of applications: Safety related and Non safety related. Safety related applications such as collision alert, emergency warning, road condition warning etc. Non safety related applications such as entertainment, web browsing, mobile commerce etc. Many internet related applications require seamless connectivity or continuous internet connectivity. The problem of seamless connectivity becomes even more challenging as vehicles moves across overlapping heterogeneous wireless environment. In such case frequent and not always necessary switched from serving network to a target network may occur, often degrading the network performance.

The switching mechanism from serving network to target network is called vertical handover (VHO) can be driven by the vehicle or by the infrastructure, and is executed according to a well defined decision criteria. Handover is also known as handoffs, is an event taking place whenever a mobile node moves from one wireless cell to another, without loss or interruption of services. When a handover occurs within the same wireless access technology is known as horizontal handover. Handover occurs among heterogeneous wireless access technology refers to Vertical handover.

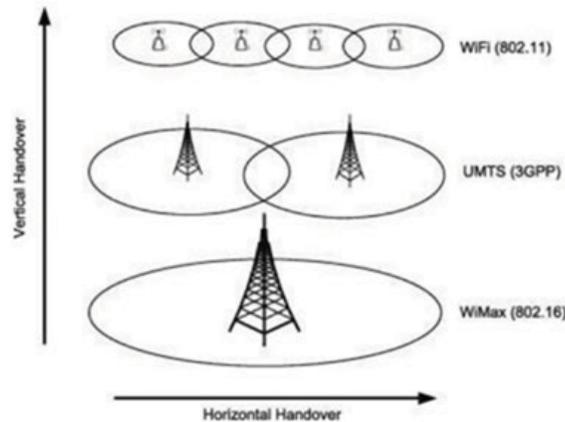


Figure 2 - Horizontal and Vertical Handover Scenarios

The rest of the paper is organized as follows. The handoff requirement and various parameters are analyzed in section II. Vertical handover overview and advanced methods of vertical handover decision algorithms were discussed in section III. Literature reviews are presented in section IV. Concluding remarks are given in section V.

## II. HANDOVER REQUIREMENTS AND PARAMETERS

### A. Handoff Requirements-

Handoff may affect many aspects of wireless networks such as Quality-of-Service (QoS), and the capacity of the network. There are a number of desirable features and requirements to reduce the effects of a handoff

- The latency of the handoff must be low
- The total number of handoffs should be minimal
- The effect of handoff on QoS should be minimal
- The additional signaling during the handoff process should be minimized

In order to achieve the desired features of handoffs the designers must take into account the factors that affect the handoff process

- Wireless Technology
- Cellular Structure
- Topographical Features
- Mobility
- QoS

### Vertical handover mechanism

Future wireless networks adopt a heterogeneous broadband technology model to guarantee seamless connectivity in mobile communications. A vertical handover is a process preserving users connectivity on-the-move

and following changes of network. VHO schemes can be classified on the basis of the criteria and parameters adopted for initiating a handover from a serving network to a new target network.

### *B. Vertical Handover Parameters-*

The decision for vertical handoff may depend on various parameters like Bandwidth, Received Signal Strength (RSS), Signal to interference ratio (SIR), cost, latency, security, velocity, battery power, user preferences, service capacities and Quality of service (QoS). During handover different parameters are monitored and decide when the handover is necessary. Different researchers have given different views and techniques to achieve vertical handoff. In order to design a Vertical Handoff (VHO) mechanism for Vehicular Ad-hoc Networks, it is essential to study the existing VHO mechanisms. The study of existing mechanisms will assist in the identification of important parameters for VHO mechanism. As of now, a few approaches for VHO have been found in the literature.

#### Received Signal Strength (RSS):

RSS is the most widely used criterion because it is easy to measure and is directly related to the service quality. Majority of existing horizontal handover algorithms use RSS as the main decision criterion, and RSS is an important criterion for VHD algorithms as well, but it is not enough for a complete decision. It is the strength of the signal received, as the RSS of the neighboring network rises above the threshold the Vertical Handoff is feasible i.e. the handoff takes place if and only if RSS of the BS or Access Point (AP) is above the threshold.

#### Available Bandwidth:

Bandwidth is a measure of the width of a range of frequencies. It refers to the data rate supported by a network connection or interface. It measures how much data can be sent over a specific connection in a given amount of time. In order to provide seamless handoff for QoS in wireless environment, there is a need to manage bandwidth requirement of mobile node during movement. Bandwidth is generally known as the link capacity in a network. Higher offered bandwidth ensures lower call dropping and call blocking probabilities; hence higher throughput. Bandwidth handling should be an integral part of any of the handoff technique.

#### Network Throughput:

Network throughput refers to the average data rate of successful data or message delivery over a specific communications link. Network throughput is measured in bits per second (bps). Maximum network throughput equals the TCP window size divided by the round-trip time of communications data packets. As network throughput is considered in dynamic metrics for making decision of VHO, it is one the important requirement to be considered for the VHO.

#### Network Load:

Network load is to be considered during effective handoff. It is important to balance the network load to avoid drop in quality of services. Variation in the traffic loads among cells will reduce the traffic carrying capacity. To provide a high quality communication service for mobile nodes and to enhance a high traffic carrying capacity when there are variation in traffic network load must be paid attention.

#### User Preferences:

When handover happens, the users have more options for heterogeneous networks according to their preferences and network performance parameters. The user preferences could be preferred networks, user application requirements (real time, non-real time), service types (Voice, data, video), QoS (It is a set of

technologies for managing network traffic in a cost effective manner to enhance user experiences for wireless environments) etc. User Preferences can also be considered for VHO in next generation wireless networks.

Cost:

A multi criteria algorithm for handoff should also consider the network cost factor. The cost is to be minimized during VHO in wireless networks. The new call arrival rates and handoff call arrival rates can be analyzed using cost function. Next Generation heterogeneous networks can combine their respective advantages on coverage and data rates, offering a high QoS to mobile users. In such environment, multi-interface terminals should seamlessly switch from one network to another in order to obtain improved performance or at least to maintain a continuous wireless connection. Therefore, network selection cost is important in handoff decisions.

Speed:

It is the speed at which the Mobile Terminal (MT) is moving. In vertical handoff algorithms, the speed factor has a large and important decisions binding effect than traditional handoff decision algorithms horizontal handoff. When the users travel at high speed within a network coverage area is discouraged the idea to initiate vertical handoff process because after a short period of time the user will have to go back to the initial network because it will get out from under cover network host.

Power Consumption:

The wireless devices running on battery need to limit the power consumption. If the battery level decreases, switching for a network to another network with low power consumption can provide a longer usage time. The power requirement becomes a critical issue especially if the hand held battery is low. In such situations, it is preferably transferred to an attachment point, and this will extend battery life. The attachment to the closest AP or BS is known to consume the least power for individual mobile devices at a given instant. So if battery level is low the MT must handoff to the closest AP or BS provided RSS is above threshold. The number of users also increases the congestion and in turn even the nearest AP or BS consumes more power.

### III. VERTICAL HANDOVER OVERVIEW

Vertical handover involves changing the data link layer technology used to access the network. Vertical handover processes are split into three phases

- Handover Initiation phase
- Handover Decision Phase
- Handover Execution Phase

*Handover Initiation phase* collects wireless network information. The information's collected from this phase is used for making decisions in the handover decision phase. The following information are collected during initiation phase

- *Availability of neighboring network links* such as Throughput, Packet loss ratio, Handoff latency, Received Signal Strength (RSS), Noise Signal ration (NSR), Signal to Interference Ratio (SIR), Bit Error Rate (BER), Distance, Location and QoS Parameters.
- *The device Status* such as Battery power, Speed, Resources and Service class
- *User Preferences* such as Budget and Service required

Table 1 - Information Parameters for VHO process

Layers	Parameters
Application	User preferences (eg. Cost, Provider) Context information (eg. Speed) QoS Parameters (eg. Bandwidth offered, Delay, Jitter)
Transport	Network Load (eg. Bandwidth available)
Network	Available Foreign Agents Network Pre-authentication Network Configuration Network Topology Routing Information
Data link	Radio Access Network Condition Link Parameter Link Status
Physical	Available Access Media

Table 1 shows various information parameters for vertical handover process under OSI layers.

*Handover Decision Phase* based on the gathered information, this phase is in-charge of deciding when and where to trigger the handover. To make best decision the information gathered must be evaluated by many parameters obtained from different resources. Vertical Handover Decision Algorithm (VHA) is used to evaluate the parameters involved under each criteria.

#### Vertical Handover Decision Algorithm

Decision in horizontal handover is different with decision of vertical handover. The horizontal handover decision involves networks from the same link layer technology. The vertical handover decision involves the network from different radio access technology (RAT). In horizontal handover process single parameter of Received Signal Strength is enough to trigger handover, but in vertical handover, more parameters are needed to decide handover accurately. Number of handover is a fundamental parameter in handover due to resource management. Unnecessary handover may reduce the network performance in terms of throughput and network occupancy. Compared to single-criteria decision making, Multi-criteria may increase the handover delay as it considers several parameters to decide the handover.

#### Advanced methods of vertical handover decisions

Vertical handover decision methods are classified into five categories

*Decision function based strategies*, where the network with the lowest cost is chosen as the target network. Number of cost function in the algorithm depends on the number of parameters to be considered.

*User centric strategies*, where a vertical handover decision is driven by user preferences, mostly in terms of monetary cost and QoS.

*Multiple attribute decision strategies*, where the decision is made using multiple attribute decision making (MADM) algorithms. MADM method include Simple Additive Weighting (SAW) and Techniques for Order Preference by Similarity to Ideal Solutions (TOPSIS).

*Context aware strategies*, where the handover decision is based on the signal quality and additionally based on the knowledge about the context information of the device and network.

*Fuzzy logic and neural network based strategies*, usually combine with MADM strategies to decide best target network.

*Handover Execution Phase* performs the actual transfer of the current session to the new access network takes place. This phase should also guarantee a smooth session transition process.

#### IV. LITERATURE REVIEWS

There are several works which have been carried out in the area of handoff latency optimization and in particular that of VANET. The vertical handover approach for VANET is proposed by Yan et al. in [3]. The authors discuss a vertical handover algorithm based on the prediction of the traveling distance of a vehicle within a wireless cell. Their main result consists on minimizing the probability of unnecessary handovers. Such probability is constructed, among other details, by considering a speed ratio. The ratio is between the instantaneous speed of a vehicle, and a value,  $V_{max}$  (maximum speed), function of the technologies radius cell coverage, and of the average handover latency. Other recent works deal with VHO decisions in VANETs, as a solution to V2V limitations. Some of those algorithms for VHO decisions are based on physical parameters (like the received signal strength, and the handover latency. In [4], for example, the authors have looked at how to reduce the loss of throughput in vehicular networks. Their valid ideas are limited to horizontal handovers in WLAN networks though, and so to homogeneous scenarios. One approach to limit vertical handover drawbacks have been analyzed; among all, the work of Chen et al. [5] in which a novel network mobility protocol for vehicular ad hoc networks is presented, aiming to a reduction of both handoff latency and packet loss rate. Olivera et al. [6] instead, propose the Always Best Connected paradigm for vertical handovers in VANETs. This mechanism operates at the network layer, and achieves a seamless connectivity between WLAN and UMTS networks.

#### V. CONCLUSION

Reliability and timely information delivery are highly concerned factors in vehicular ad-hoc networks. A better handover mechanism plays a vital role in the handover process between the vehicles nodes during the vehicles are running on the road. Research into vertical handover decision algorithm in heterogeneous vehicular network is still a challenging area. The main difficulty is devising an algorithm which is truly useful in a wide ranging contributions and user preferences. In this paper, we review the necessary procedures involved in a VANET handoff process. The various handover requirements and the important factors that affect the handover process are discussed first. Various parameters involved in VHO process were discussed. Advanced methods of vertical handover decisions are investigated. Vertical handover strategies can be applied to assure VANET connectivity. Various metrics can be adopted to trigger handover decisions including RSS measurements, QoS parameters, and mobile terminal location information. Most of the research is based on single criteria handover decision making algorithm. Researchers can combine various handover parameters and create multi criteria based handover decision making algorithm for effective handover process.

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