Vehicular Network Handover Algorithm in Heterogeneous Environment (VNHAHE)

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Abstract: **As we are in the era of wireless communication then vehicular communication is a major part of it. Multiple wireless access technologies i.e. Wi-Fi, WiMAX, UMTS and some advanced processor on device, make the device capable in communication. Normally an user can easily able to access the data from internet but while moving from one place to another there is problem of seamless data connection. To maintain data connection alive in such condition some special or modified vertical handover techniques are required. In this paper we discuss on such technology which able to provide seamless connectivity during mobility of user. It combines surround context information and rout, which improve performance of handover.**

Keywords: **Vehicular network, MIHF, VHO, Handover algorithm, Wi-Fi, WiMAX, UMTS.**

1. INTRODUCTION

Availability of diverse wireless access technologies such as Wireless Fidelity (Wi-Fi), Worldwide interoperability for Microwave Access (WiMAX), and Universal Mobile Telecommunications System (UMTS) allows users to stay “always on”. Nowadays, mobile computing is demanded to perform multiple of our every-day tasks, which can be as simple as reading the news, or as complex as medical monitoring applications. Due to the mobility offered by the aforementioned technologies, users not only demand continuous connectivity but also QoS for their communications. [1]

Now these days vehicles being improved in safety manners as well as enhanced feature. Behind this different communication technology and embedded systems are exists, which are fast processor units, GPS system, WiMAX, Wi-FI, UMTS interfaces, to make stronger the communication system in vehicles.[2] Lots of issues are come into account when heterogeneous wireless technology used in communication between vehicle to vehicle and vehicle to infrastructure like Vehicular Network. Therefore IEEE 802.21 standard released to provide continuous communication between these. [3]

As we mentioned earlier that vehicles are going to improved these days, not only for sending security related messages but also for entertainment services like use of internet, social networks etc, hence there should guarantee to fulfill these applications. For that purpose lots of solution have been proposed related to considering single wireless technology. In this paper we are going to discuss a handover algorithm called Vehicular Network Handover Algorithm in Heterogeneous Environment (VNHAHE), not a novel but slightly modification of other handover algorithm. It considers surround context and route information of vehicle according with IEEE 802.21standard. The main purpose of this technology is to provide suitable access network along the route.

Rest of the paper focus as follows: Next section present related proposals in literature. Second and Third provide the brief introduction about VHO and MIHF (Media Independent Handover Function) based on IEEE 802.21 standard respectively. Consideration of VNHAHE algorithm presented in next section. Last one presents the conclusion and future work related to VHDAs.

2. PROPOSED LITERATURE

Horizontal handovers assisted by GPS information have been already studied and proposed by different authors, [4][5] presenting the advantages of geolocation within a single type of wireless network. Recently, works considering GPS support for the decision-making process when performing VHO among multiple access technologies were presented. Ylianttila [6] proposed using the GPS in order to manage the current location of the mobile device to hand over among Wi-Fi and UMTS cells, performing the decision-making based on the Received Signal Strength (RSS). Inzerilli. [7] present a decision-making process aided by the GPS in orderto avoid the ping-pong effect when performing VHO at the boundaries of the cells. A more recent proposal is presented by Gu.[8] using a Position Prediction Mechanism (PPM) in order to predict the future position of the mobile device, and obtaining network information for the decision-making process from the advertisement packets. However, authors propose predicting the future position based on GPS information alone. Concerning network information, as far as we know, none of the previous proposals collects the networking information using the Media Independent Information Service (MIIS) offered by the IEEE 802.21 standard. The MIIS offers very powerful and detailed information about the Points of Attachment (PoAs) (i.e. Base Stations (BSs) and Access Points (APs)), network preferences, billing information, and handover policies.

In our proposal we not only use GPS-based coordinates, but also combine coordinates, maps, surround context information and routes to dynamically calculate and recommend the optimal pathway from one place to another. That information is then used as an input to the IEEE 802.21 services to select the best network to hand over to along the proposed pathway.

3. VERTICAL HANDOVER OVERVIEW

An accurate VHO process should take into account and care about the service continuity, network discovery, network selection, security, device's power-management and Quality of Service (QoS) issues, focusing mostly on the latter. Several proposals [9],[10],[11] split the VHO process into three parts: i) Handover information gathering, ii) Handover decision, and iii) Handover execution. Figure 1 shows the interactions among the three phases required to implement handover in heterogeneous networks. Table-I shows the information parameter concern to the VHO process. Which describe task of the communication layers relevant to VHO process.

TABLE-I: Information parameters concern to the VHO process.

Layers	Parameters
Application	User Preferences (e.g. cost, provider) Context information (e.g. speed) Location information (e.g. geolocation) QoS parameters (e.g. bandwidth offered, delay, jitter) Security alerts (e.g. notification)
Transport	Network load (e.g. bandwidth available)
Network	Available foreign agent Network pre-authentication Network configuration Network topology Routing information
Data-link	Radio access network conditions Link parameters Link Status
Physical	Available access media

2.1 Handover Information Gathering: The handover information gathering phase collects not only network information, but also information about the rest of the components of the system such as network properties, mobile devices, access points, and user preferences. For that reason this phase receives different names: Handover information gathering, System discovery, System detection, Handover initiation, Information discovery or simply Network discovery. In this phase, the information is collected to be used and processed for making decisions in the handover decision phase.

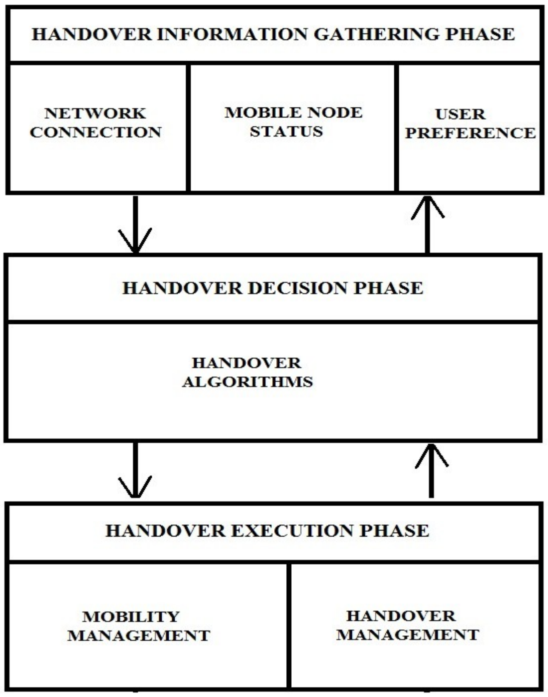

Figure 1: Handover management procedure

The information typically collected is the following:

- Availability of neighboring network links by offering information such as throughput, cost, packet loss ratio, handoff rate, Received Signal Strength (RSS), Noise Signal Ratio (NSR), Committed Information Rate (CIR), Signal to Interference Ratio (SIR), Bit Error Ratio (BER), distance, location, and QoS parameters.
- The mobile device's state by gathering information about battery status, resources, speed, and service class. User preferences information such as budget and services required. Section 3.4 describes this phase along with the techniques used by the different proposals to perform the data gathering task.

2.2 Handover decision: The handover decision phase is one of the most critical processes during the handover. This phase is also known as System selection, Network selection or Handover preparation. Based on the gathered information, this phase is in charge of deciding When and Where to trigger the handover. The When decision refers to the precise instant in time to make an optimal handover, while the Where refers to selecting the best network fulfilling our requirements for the switching In a homogeneous network environment, deciding When to handover usually depends on RSS values, while the Where is not an issue since we use the same networking technology (horizontal handover). In heterogeneous networks the answer to these questions is quite complex. To make the best decision the information gathered must be evaluated taking into account many parameters obtained from the different information sources, i.e., network, mobile devices, and user preferences. Vertical Handover Decision Algorithms (VHDAs) are used to weight up and evaluate the parameters involved under each specific criterion.

2.3 Handover execution: This phase performs the handover itself; besides performing the handover, it should also guarantee a smooth session transition process. In order to perform the VHO different handover strategies cooperate with control signaling, and the IP management protocols. This phase is usually known as Handover execution, but it also receives the name of VHO assessment [12], Handoff Implementation or Handoff performing. Concerning VNs, the performance of each phase must be focused on the distinctive characteristics and features of such type of networks. The information gathering phase must consider the dynamism of the available information at the devices and the network. Making decisions based on highly dynamic information with a given degree of the device's mobility requires a quick and reliable decision algorithm. Finally, the execution of the VHO must be carefully controlled to achieve accuracy by considering the geographical location, the selected network and the precise time.

4. MEDIA INDEPENDENT HANDOVER FUNCTION (MIHF)

The MIHF protocol defined by the IEEE 802.21 standard establishes the messages exchanged between peer Media Independent Handover (MIH) entities for handover, offering a common message payload across different media (802.3, 802.11, 802.16, Cellular).The standard refers as lower layers to the technology dependent components, and as upper layers to the requesting modules. These lower layers can be accessed by different functions to retrieve information to detect, prepare and execute the VHO, while the upper ones demand that information; therefore, the latter are also referred to as Media Independent Handover User (MIHU). The MIHF offers a Service Access Point (SAP) to both lower and upper layers in order to exchange the service messages. The general design principles of the standard are based on [13]:

- MIHF is a logical entity that facilitates handover decision-making. MIH users make handover decisions based on inputs from the MIHF.
- MIHF provides abstracted services to higher layers. The service primitives defined by this interface are based on the technology-specific protocol entities of the different access networks. The MIHF communicates with the lower layers of the mobility-management protocol stack through technology-specific interfaces. Figure 2 presents the reference model showing the position of the MIHF in a protocol stack, and the interaction of the MIHF with other elements of the system. All exchanges between the MIHF and other functional entities occur through service primitives, grouped in SAPs.

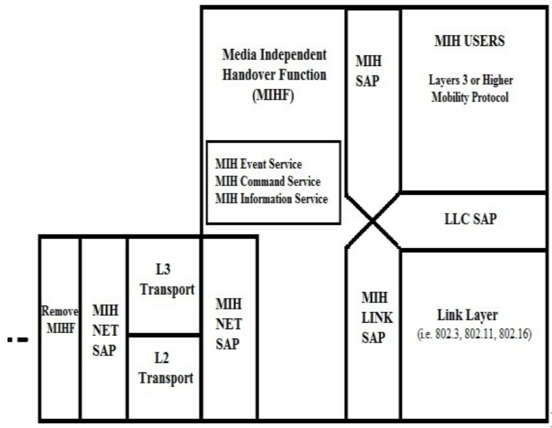

Figure 2: MIHF reference model

- Higher layer mobility management protocols specify handover signaling mechanisms for vertical handovers. Additionally, different access network technologies have defined handover signaling mechanisms to facilitate horizontal handovers. The definition of such handover signaling mechanisms is outside the scope of the standard. The role of the IEEE 802.21 is to serve as a handover facilitating service, and to maximize the efficiency of such handovers by providing private link-layer intelligence and network information.

The basic services offered by the MIHF are briefly described below:

4.1 Media Independent Event Service (MIES): This service detects the changes on the lower layers, e.g., changes on the physical and data link layer. The MIHF notifies events occurring in the lower layers to the MIHUs as they have requested. The MIES covers events such as:

- State change events (link up, link down, link parameter changes).
- Predictive events (link going down).
- Network initiated events (load balancing, operator preferences).

4.2 Media Independent Information Service (MIIS): The MIIS allows the MIHF to discover its network environment by gathering information that the upper layers use to make decisions. The information elements refers to the list of available networks, location of PoA, operator ID, roaming partners, cost, security, QoS, PoA capabilities, and Vendor specific information, among others.[14]

4.3 Media Independent Command Service (MICS): The MICS allows the MIHU to take control over the lower layers through a set of commands. With the information gathered by the MIES and MIIS, the MIHU decides whether to switch from one PoA to another [15]. The commands allow not only to execute the handover, but also to set different parameters in the lower layers elements. Depending on which entity has the handover control, some services are more useful than others. The following commands are typically used by the MICS:

- MIH Handover Initiate. Used between network and mobile device.
- MIH Handover Prepare. Used between the old network (PoA) and the new network.
- MIH Handover Commit. Used between network and mobile device.
- MIH Handover Complete. Used between network and mobile device and network to network.

5. THE VNHAHE

Concerning Vehicular Networks (VNs), when a vehicle passes through different PoAs along the route, a VHDA could decide to join/leave different coverage areas for a very short period of time due to the speed and route chosen to reach the destination. Thus, an adequate VHDA for vehicular environments must evaluate all the surrounding PoAs (cell information and coverage) not only to choose the one whose performance best fits the applications' requirements, but also the one which offers a more reasonable coverage within the route to make the VHO worthwhile.

The VNHAHE takes the most of the current OBUs, such as continuous power supply, multiple networking interfaces, GPS information, maps and routes, combining the different data sources with the network information provided by the IEEE 802.21 standard. Figure 3 presents the flow diagram of the VNHAHE Algorithm, which is mainly divided into following parallel components: Networking Section, Neighbor Section, and Decision-making Section. We now proceed to describe each branch.

Networking Section: The networking branch is in charge of sensing the different wireless network interfaces available at the OBU. This process is done by a process that periodically sends and receives information about the network status (e.g. Router Advertisement (RA) an Router Solicitation (RS)). To interact with the interfaces, VNHAHE uses the IEEE 802.21 services, i.e. Media Independent Event Service (MIES) and Media Independent Command Service (MICS) to check the link status and received reports When an event occurs in the physical/link layer, the interfaces receive a trigger event (LINK DETECTED) launching different sequence processes (decision-making, VHO execution); through the MIES, different events are notified to the upper layers in order to execute the different actions associated with a VHO process. Moreover, any further actions defined by the upper layers are executed by the lower layers using the primitives stated by the MICS.

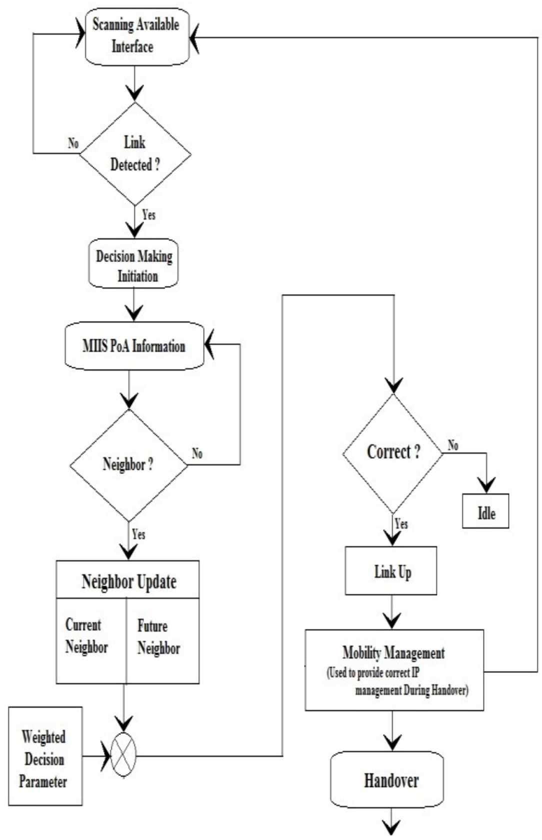

Figure 3: VNHAHE algorithm

Neighbor Section: The Neighbor Section branch introduces novel features by considering surround context information. All the surrounding information is gathered into two data storage elements: Current Neighborhood and Future Neighborhood. Each of these storage elements are periodically filled-in with information about the current and future PoAs available (cell information and coverage), respectively. Every Sensing Period seconds, the branch executes a query to the GPS module requesting the current geolocation and the future geolocation within the next Prediction Window seconds. The response contains a geolocation within the map with the route that the vehicle is taking to reach the destination. Based on those geolocations a request is performed to the PoA information database, powered and made available by the Media Independent Information Service (MIIS) of the IEEE 802.21. A list of current and future available PoAs is retrieved and locally stored at the OBU to be used by the decision-making branch. The MIIS PoA information database offers information such as the ID of the network, the ID of the PoA, its geolocation, coverage, monetary cost per MB, and BW offered. The local data storage containing current and future neighborhood information is filled-in with the PoAs' information only if the current and future geolocations, within Prediction window seconds, are inside the coverage area described in every PoA registry. To determine the coverage condition Equation 1 is used, which considers the geolocation of a vehicle at a certain time, and the PoA's geolocation described at the MIIS PoA information database. Moreover, the local storage not only retrieves the MIIS information, but it also calculates the useful coverage time under each PoA coverage by combining the GPS information about the route on the map and the MIIS information. The useful coverage is affected by different issues such as whether the route tangentially crosses the coverage area, the times for reaching/leaving a coverage area, or the existence of overlapping coverage areas along the path, as shown in Figure 4.

$$d = \sqrt{(X_{vehicle} - X_{PoA})^2 + (Y_{vehicle} - Y_{PoA})^2} \dots (1)$$

A major parameter to take into account when performing a VHO is the latency taken by whole VHO process, since a high latency could be a symptom of packet loss and service disruption, thus downgrading the application performance.

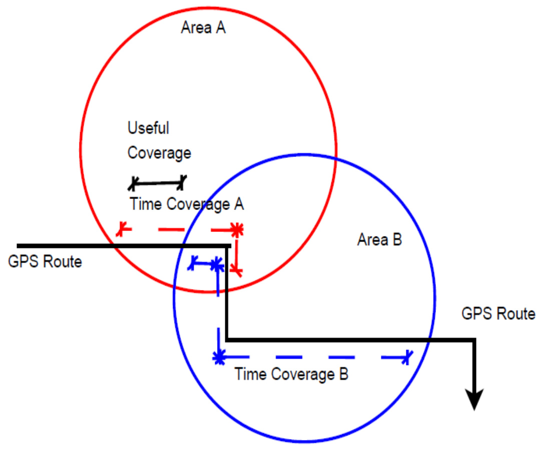

Figure 4: GPS route & coverage area considerations

Equation 2 describes the different latencies that are implied in a VHO process, where V HOL2 is the latency referred to the association process at the link layer, while V HOL3 is related to the IP level processes (i.e. IP address negotiation between the interface and the PoA). Finally, V HOMIP is the time taken by the Mobility for IP (MIP) protocol for notifying and upgrading the home and foreign IP addresses when managing mobility.

$$VHO_{Lat} = VHO_{L2} + VHO_{L3} + VHO_{MIP} \dots (2)$$

The VNHAHE algorithm takes VHO Lat into account as a main decision parameter. In order to perform an adequate neighborhood discovery task, the most adequate values for the Sensing Period and the Prediction Window variables must be selected. Therefore, based on Equation 2, we made the following considerations:

i) To guarantee an accurate decision-making process, VNHAHE must gain awareness of, at least, some minimum future neighborhood information within the amount of time defined by Equation 3, where α is the relative percentage of the Useful Coverage Time (see Figure 4) during which the system is able to tolerate the adverse effects of VHO (which implies both packet loss and latency).

$$CellCoverageTime_{min} = \frac{VHO_{Lat_{max}}}{\alpha} \dots (3)$$

ii) An optimum Sensing Period must be smaller than the Cell Coverage Time, as show in Equation 4. This means that, before the current neighborhood information becomes deprecated upon reaching the Cell Coverage Time, the Sensing Period must assure fresh information about the future neighborhood. This parameter is related to how often the information must be collected.

$$Sensing\ Period_{opt} < CellCoverageTime_{min} \dots (4)$$

iii) Based on the Sensing Period, Equation 5 presents a minimum Prediction Window which guarantees an accurate process of Neighbor Section. This parameter is related to how much information must be collected; therefore, an adequate window size must double the amount of Sensing Period time in terms of future information.

$$PredictionWindow_{min} = 2 * CellCoverageTime_{min} \dots (5)$$

However, depending on the features and performance of the OBU, the optimum Prediction Window can be determined according to the Equation 6, where β is a multiplier that can be tuned according to the OBU and the system performance, expected to take values in the range of 1 to 2

$$PredictionWindow_{opt} = \beta * PredictionWindow_{min} \cdots (6)$$

By taking all the aforementioned parameters into account, the Current and Future Neighbor shall offer precise and coherent information.

Decision-making Section: Finally, the selection of the destination network (by choosing a PoA to hand over to) is made at the decision-making branch. This process evaluates all the gathered information and, based on the useful coverage area criteria, the candidate PoA which best fits the application requirements are chosen. For testing purposes, VNHAHE currently considers the cell coverage information (stored locally as the Current and Future Neighborhoods) in order to allow or deny the VHO execution (i.e. LINK UP IEEE 802.21 primitive). The main VNHAHE's decision logic, which considers the cell coverage time, allows handovers to take place only when the VHO Lat time is less than _ percent of the Useful Coverage time. Remember that β, as mentioned before, is the maximum relative time during which the system supports handover-related losses. Considering the scenario of Figure 4 4.5, when a vehicle arrives to the coverage area A, the wireless network interface triggers a LINK DETECTED event, starting the whole VNHAHE process. If we based the decision on the Time Coverage A, not considering the immediate future, we could make a mistaken decision, since the vehicle will leave the coverage area A almost immediately to join the coverage area B, and so the VHO would be worthless. Therefore, a decision must be taken considering the Useful Coverage Time, instead of the mere coverage area advertised by the IEEE 802.21 MIIS. Finally, when a VHO process takes place, the new address is notified to the network elements by using MIPv6, which manages the mobility issues.

When VHO processes are performed within a VNs context, many mobility and location issues must be considered. The intrinsic characteristics of the VNs, such as dynamism, speed, and very changing contexts, turn the VHO into a very challenging process.

Other features of the VNs, such as availability of geolocation through the GPS, and the lack of power restrictions due to the continuous energy supply, allow the devices to improve the gathering of context information in order to perform an accurate switching decision, thus improving the VHO process. Based on this, we can work on modified VHDA In this algorithm we can combine GPS information (both geolocation and navigation), underlying network information (realistic propagation models), as well as network architecture information, in order to optimize the network selection process, a critical element of the VHO process. For this VHDA process, we take account some underlying network considerations which are taken into account when the VHDA is performing the decision-making process.

6. CONCLUSION

Wireless communications are continuously being improved, mainly due to factors such as user demand trends, more sophisticated mobile devices in terms of both capabilities and physical/design issues, market trends, and specially by the broad deployment of different access technologies. The automobile industry is also being constantly improved, taking advantage of wireless communication enhancements, and offering improvements in different areas such as safety, entertainment, and comfort. Vehicular Networks (VNs) have to deal with the multiple issues such as connectivity loss, handover delay, and Quality of Service (QoS) fluctuations, caused by the high mobility associated with cars when moving from one place to another, thus driving through the coverage areas of different technologies. In order to maintain a continuous connectivity and to avoid those adverse effects, Vertical Handover (VHO) techniques must be adopted.

In this paper we have discussed about a VHDA, called Vehicular Network Handover Algorithm in Heterogeneous Environment (VNHAHE), which combines GPS based geolocation, map information, surround context information and route calculation, with the functionality of the IEEE 802.21 standard. For the decision-making process, VNHAHE takes advantage of both current and future geolocation of the vehicle (within the route and map layout), along with the networking information provided by the different services of the IEEE 802.21 standard. The purpose was to choose the most suitable access network along the route when following the pathway from one location to another. There is lots of modifications are available about the work that can increase more suitability to user during vehicular communication.

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