2010-09-07

On Modeling Speed-based Vertical Handovers in Vehicular Networks "Dad, slow down, I am watching the movie"

Esposito, Flavio; Vegni, Anna Maria; Matta, Ibrahim; Neri, Alessandro. "On Modeling Speed-based Vertical Handovers in Vehicular Networks 'Dad, slow down, I am watching the movie'", Technical Report BUCS-TR-2010-032, Computer Science Department, Boston University, September 7, 2010. [Available from: http://hdl.handle.net/2144/3807]

https://hdl.handle.net/2144/3807

On Modeling Speed-Based Vertical Handovers in Vehicular Networks

“Dad, slow down, I am watching the movie” [*]

Flavio Esposito[♮] Anna Maria Vegni[‡] Ibrahim Matta[♮] Alessandro Neri[‡]
flavio@bu.edu *amvegni@uniroma3.it* *matta@bu.edu* *neri@uniroma3.it*

[♮] Computer Science Department
Boston University,
Boston, MA

[‡] Department of Applied Electronics
University of Roma Tre,
Rome, Italy

September 8, 2010

Technical Report BUCS-TR-2010-032

Abstract–Although vehicular ad hoc networks are emerging as a novel paradigm for safety services, supporting real-time applications (*e.g.*, video-streaming, Internet browsing, online gaming, etc.) while maintaining ubiquitous connectivity remains a challenge due to both high vehicle speed, and non-homogeneous nature of the network access infrastructure. To guarantee acceptable Quality-of-Service and to support seamless connectivity, vertical handovers across different access networks are performed.

In this work we prove the counterintuitive result that in vehicular environments, even if a candidate network has significantly higher bandwidth, it is not always beneficial to abandon the serving network. To this end, we introduce an analytical model for a vertical handover algorithm based on vehicle speed. We argue that the proposed approach may help providers incentivize safety by forcing vehicular speed reduction to guarantee acceptable Quality-of-Service for real-time applications.

---

[*] In *Proc. of IEEE Globecom 2010 Workshop on Seamless Wireless Mobility (SWiM 2010)*, December 6-10, 2010, Miami FL, USA.

1 Introduction

In Vehicular Ad hoc NETworks (VANETs) vehicles endowed with sophisticated "*on-board*" equipment communicate with each other, and with the wireless and cellular network infrastructure by means of several network interface cards (*i.e.*, IEEE 802.11, WiMAX, UMTS, HSDPA, and so forth [1]).

Future networked vehicles represent the future convergence of computers, communications infrastructure, and automobiles [2]. An envisioned goal is to embed human-vehicle-interfaces such as color reconfigurable head-up and head-down displays, and large touch screen active matrix liquid crystal displays, for high-quality video-streaming services [3]. Passengers can enjoy their traveling time by means of real-time applications, *e.g.*, video streaming and online gaming, using individual terminals next to their seats (Figure 1 (*a*)).

To guarantee the delivery of acceptable Quality-of-Service (QoS) in such environments, Vehicle-to-Infrastructure (V2I) communications represent a viable solution. However, V2I protocols still lack seamless connectivity: when vehicles encounter an area with overlapping wireless networks, a decision on whether or not a connectivity switch should be executed has to be taken. The mechanism preserving *on-the-move* user's connectivity is defined as Vertical Handover (VHO) [4].

In this paper we show that in VANET scenarios with a heterogeneous network access infrastructure, bandwidth gains are tightly coupled with the protocol overhead —handover latency— and the speed of the vehicle. Leveraging on this consideration, we propose a new speed-based, QoS-oriented Vertical Handover algorithm for vehicular networks. In the rest of the paper we refer to our algorithm as S-VHO. The idea of using the vehicle speed as assessment criterion for vertical handovers has been floated before [5, 6]. However, our emphasis lays on real-time applications for VANETs. As a baseline of comparison for our simulations, we consider the recent work of Yan *et al.* [5], whose algorithm is based on both the Received Signal Strength (RSS) level and the terminal speed, and we show that our S-VHO algorithm outperforms their approach, in terms of throughput, delay, jitter, and overhead (number of vertical handovers).

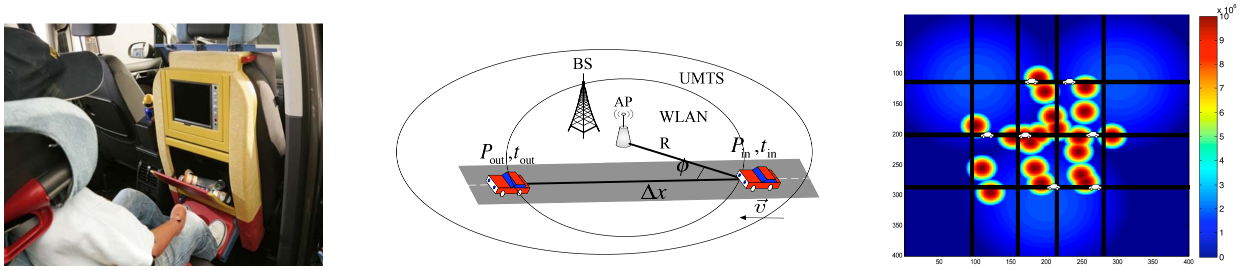
The paper is organized as follows. In Section 2 we present an analytical model useful to compute a *speed upper bound* used by our S-VHO algorithm, described in Section 3. Analytical and simulation results are shown in Sections 4, and 5, respectively. We discuss some related work in Section 6, and in Section 7 we conclude our paper.

2 Analytical Model

In this section, we present the counterintuitive result that in heterogeneous vehicular networks, connectivity switches are justified only when the vehicle speed satisfies a given *speed upper bound*. To compute this bound we need to formally define (*i*) a valid handover in VANETs, (*ii*) the cell crossing time (*i.e.*, the time a vehicle spends inside a wireless cell), and (*iii*) the handover latency.

Definition 1 (Valid Handover in VANETs): *A vehicle crossing an area covered by at least two wireless networks performs a valid handover if, and only if, the handover results in a throughput increase.*

Note that there exist two main types of handover, horizontal—when the two cells involved in



(*a*) (*b*) (*c*)

Figure 1: (*a*) Video-streaming applications for *on-the-move* users, (*b*) Manhattan mobility model for a VANET scenario with heterogeneous overlapping wireless networks, (*c*) Simulated VANET scenario.

the process belong to the same technology—and vertical—when the two cells belong to different technologies. Although Definition 1 holds for any type of handover, in this work we focus on vertical handovers between WLAN and UMTS, and vice versa.

Our model assumptions are depicted in Figure 1 (*b*). A vehicle is moving at speed $\vec{v}$ in a vehicular environment with a network infrastructure composed of several overlapping heterogeneous wireless access networks, partially covering the road. The vehicle's trajectory follows a Manhattan mobility model, and it is constrained by the road, composed of straight lanes. Moreover, each vehicle is assumed to be equipped with an *on-board* Global Positioning System (GPS) network interface card, so that the vehicle position is ubiquitously known.

Definition 2 (Cell Crossing Time): *Given a vehicle V, traversing an area covered by a wireless cell C at constant speed $|\vec{v}|$, the cell crossing time of V in C, denoted as ΔT, is the overall time that V can spend under C's coverage.*

Denoting by t_{in} the time at which a vehicle enters in an area covered by a wireless cell, we model the exit time from the same cell as:

$$t_{\text{out}} = t_{\text{in}} + \frac{\Delta x}{|\vec{v}|}, \qquad (1)$$

where Δx is the distance covered inside the wireless cell in the time interval $\Delta T = t_{\text{out}} - t_{\text{in}}$. In particular, if we denote as $R \in \Re^{+} \setminus \{0\}$ the radius of the omnidirectional wireless cell, and as $\phi \in [0, \pi]$, the angle between the vehicle's line of sight with the base station and the vehicle motion direction, by simple geometric consideration we obtain $\Delta x = 2R\cos\phi$.

Since we have assumed that each vehicle is equipped with a GPS receiver, the coordinates $P_{\text{in}} \equiv (x_{\text{in}}, y_{\text{in}})$ of the entrance, and $P_{\text{out}} \equiv (x_{\text{out}}, y_{\text{out}})$ of the exit point of the new (candidate) cell, with respect to a coordinate system centered in the cell centre, are easily calculated so that Δx is known. It follows that the *cell crossing time* is expressed as [1]:

$$\Delta T = \frac{\Delta x}{|\vec{v}|} = \frac{2R}{|\vec{v}|} \cdot \cos\left[\arctan\left(\frac{y_{\text{out}} - y_{\text{in}}}{x_{\text{out}} - x_{\text{in}}}\right)\right]. \qquad (2)$$

---

[1] This computation is directly performed by the vehicle by assuming constant vehicle speed, and knowledge of the new cell radio coverage.

Given the above assumptions and definitions, we can model the throughput Θ that a vehicle would experience by remaining connected with the Serving Network (SN), during the *cell crossing time* ΔT, as a function of the bandwidth B_{SN}, assumed to be constant during ΔT. Namely, we have:

$$\Theta = \Delta T \cdot B_{\mathrm{SN}}. \tag{3}$$

Note that so far we have only modeled the throughput in a VANET network where vehicles are covered by a single service network. We now extend the model to heterogeneous environments by capturing network switches as well.

Definition 3 (Handover Latency): *Given a vehicle V, traversing an area covered by at least two wireless cells, the handover latency L is the time interval during which V does not receive any data due to control plane (socket switching) signaling messages exchange.*

Let a vehicle be connected to a SN, entering the wireless range of a Candidate Network (CN). In this heterogeneous scenario, we model the data delivered between the two time instants t_{in} and t_{out}, as a positive range function $\gamma : \Re \rightarrow \Re^{+}$, defined as:

$$\gamma = \alpha \cdot \left(B_{\mathrm{CN}} - \delta\right)\left(\Delta T - L\right) + \left(1 - \alpha\right) B_{\mathrm{SN}} \Delta T, \tag{4}$$

where α is an indicator function, such that $\alpha = 1$ when a vertical handover is executed, and zero otherwise. Note that when $\alpha = 1$, γ is equivalent to the throughput obtained in the CN, while for $\alpha = 0$, γ is the throughput in the SN.

Function γ captures the data loss due to the vertical handover latency L. Since during the traveling time of a vehicle it is desirable to maximize throughput, our technique initiates an handover only when it is "valid", that is, when $\gamma_{|\alpha=1} > \gamma_{|\alpha=0}$ and so when the inequality

$$B_{\mathrm{CN}} > \frac{B_{\mathrm{SN}}}{1 - L/\Delta T} + \delta \tag{5}$$

holds. In (5) $\delta \in \Re^{+}$ is a *hysteresis factor* introduced to avoid vertical handover occurrence when the two competing networks have negligible bandwidth difference. From (5), we note how switching decisions may not be necessary even though the bandwidth B_{CN} is higher than B_{SN}. Switching becomes necessary only if the time that the vehicle will spend in the cell with higher bandwidth is long enough to compensate for the data loss due to the switching overhead, namely, only if $L < \Delta T$ holds. This observation leads to the conclusion that the throughput is influenced not only by the bandwidth of the considered technologies, but by a larger set of parameters: the crossing time, the vehicle speed, and the overhead of the control-plane protocols adopted (handover latency). We formalize this intuition with the following:

Theorem (Speed Upper Bound): *Given a vehicle V, traveling with an average speed $\vec{v}$ in a heterogeneous vehicular environment for a distance Δx, a valid handover for V occurs if $|\vec{v}|$ is bounded as follows:*

$$|\vec{v}| < \frac{\Delta x \left(B_{\mathrm{CN}} - B_{\mathrm{SN}} - \delta\right)}{(B_{\mathrm{CN}} - \delta) L}. \tag{6}$$

Proof: the claim follows from (5), and from the definition of average speed of a vehicle: $\vec{v} = \Delta\vec{x}/\Delta T$. □

In the rest of the paper we show how the above result is useful in designing V2I protocols, as well as to promote vehicle safety applications. Providers may in fact offer lower data rate in those areas where the speed limit is lower, to induce vehicles to maintain lower speeds, in order to experience acceptable QoS levels —low jitter and high throughput— throughout valid handovers.

3 Speed-Based Vertical Handover Algorithm

We now present our S-VHO algorithm, and then discuss a related solution, *i.e.* Speed Probability-Based VHO (SPB) [5], which we compare against in our simulations. In both solutions, the speed of the vehicle is used as handover assessment criterion.

Consider Algorithm 1. Our S-VHO accepts three inputs (*i*) the vehicle speed $\vec{v}$, (*ii*) the ingress time t_{in} of the vehicle into a wireless cell, and (*iii*) the GPS location information P_{in}, and then returns the handover decision variable $\alpha \in \{0, 1\}$.

Let a vehicle connected to a SN, entering into an area with also a CN coverage. When (5) holds, the cell crossing time ΔT is computed as shown in (2). S-VHO decides if an handover would be valid or not by comparing ΔT with the threshold for valid handovers ΔT^*, such as [2]

$$\Delta T^* = \frac{\Delta x}{v^*} = \frac{2R\cos\phi \; L\,(B_{\text{CN}} - \delta)}{\Delta x\,(B_{\text{CN}} - B_{\text{SN}} - \delta)}. \tag{7}$$

After each handover execution, the algorithm enters in idle mode for an inter-switch waiting time period, T_w. For example, if a vehicle travels at 15 m/s, a 10 seconds inter-switch waiting time results in 150 meters covered by the vehicle, before the algorithm is re-activated. This shrewdness is necessary to avoid a high handover frequency that may occur when vehicles travel on a border line between two wireless cells (*ping-pong* effect [7]).

The SPB technique instead focuses on an adaptive handover mechanism, based on the evaluation of a handover probability P_{ho}, obtained from power measurements [5]. The handover decision is taken by comparing the handover probability with a fixed probability threshold P_T, that depends on both the vehicle speed and on the handover latency. In particular, a handover from UMTS to WLAN is executed if

$$P_{ho} = \frac{\lambda \cdot RX_{th} - RX_{\text{W}}}{\lambda \cdot RX_{th} - RX_{th}} > \frac{v}{\frac{2R}{L} - \frac{2R \cdot B_{\text{U}}}{L \cdot B_{\text{W}}}} = P_T, \tag{8}$$

where λ is a coefficient whose larger value means more difficulty to perform handover, RX_{th} is the threshold value of RSS denoting the successful packet receipt, RX_{W} the currently measured RSS in WLAN, R is the WLAN cell radius, L is the average handover latency between WLAN and UMTS, while B_{U} and B_{W} are the data rate of UMTS and WLAN, respectively.

In the rest of the paper we show how, although both approaches consider data rates and handover delays, Equation (8) of SPB, using RSS (fluctuating) measurements, does not explicitly estimate throughput gains, and sometimes confuses the handover decision suggesting throughput gains from switching when there are none.

---

[2] This is computed using the speed bound v^*, obtained from inequality (6), and considering that $\Delta T^* = \Delta x/v^*$.

```
Input:   $\vec{v}$, $t_{in}$, $P_{\text{in}}$
Output:  $\alpha$ (handover decision)
while inside area with at least two overlapped cells do
    if $(B_{\text{CN}} > B_{\text{SN}} / \left(1 - \frac{L}{\Delta T}\right) + \delta)$ then
        $\alpha \leftarrow 1$ (VHO executed)
        set a decreasing counter to $T_w$ [s].
        while $T_w > 0$ do
            idle mode
        end
    else
        $\alpha \leftarrow 0$
    end
end
```

Algorithm 1: Speed-based Vertical Handover Algorithm.

4 Analytical Results

In this section we dissect the impact of both the handover latency, and the hysteresis effects on the *speed upper bound* computed in Section 2 with some analytical results.

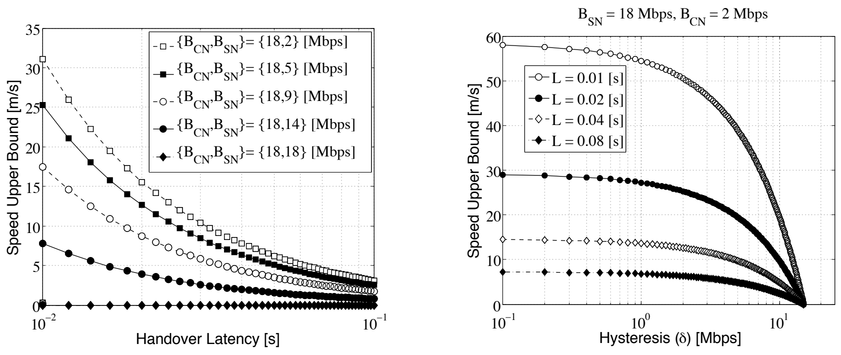
In Figure 2 (*a*) we show the impact of the handover latency on the *speed upper bound*, for a given bandwidth ratio of available technologies. The bandwidth ranges were chosen according to WLAN [8], and UMTS [9] requirements. The hysteresis factor δ was set to zero to isolate the impact of the single parameter L (handover latency), and the range of speed was bounded by 35 m/s, being a common highway speed limit.

The first take-home message confirms the validity of our model, revealing that for higher values of handover latency, the speed bound (*i.e.* the maximum speed at which vehicles experience valid handovers) decreases. This makes sense since vehicles traveling at higher speed may not spend enough time under higher data-rate cells to justify the degraded performance introduced by the handover overhead of the signaling messages.

The second result comes by observing the *epigraph* —the set of points above the drawn curves. Any point belonging to the epigraph represents no performance gain in initiating handovers, even if the CN has higher bandwidth than the SN. In contrast, for any point in the *hypograph* —the set of points below the curve— valid handovers occur. As a limit case study, note how the curve with zero bandwidth gap has empty hypograph; this follows directly from the definition of valid handover: an handover cannot be valid when the data rates are equal.

In Figure 2 (*b*) we show the impact of the hysteresis δ [Mbps] on the speed bound, given the handover latency L [s]. We considered the hysteresis range to be $\delta \in [0, B_{\text{CN}} - B_{\text{SN}}]$ and we have simulated the case $B_{\text{CN}} - B_{\text{SN}} = 16$ [Mbps], a typical gap in data rates between UMTS and WLAN [8,9] . It is useful to note that $B_{\text{CN}} - B_{\text{SN}}$ is the maximum δ after which no valid handover would occur.

The message for this simulation setting concerns the difference in the hypographic area for different values of L: when the handover latency increases, the hypographic area significantly reduces. From this observation, it follows that handover latency should be taken into account when designing protocols for seamless connectivity in VANET, instead of considering only physical



(*a*) (*b*)

Figure 2: Performance of Speed Upper Bound. Impact of (*a*) handover latency, and (*b*) hysteresis.

parameters or speed of the vehicles.

5 Simulation Results

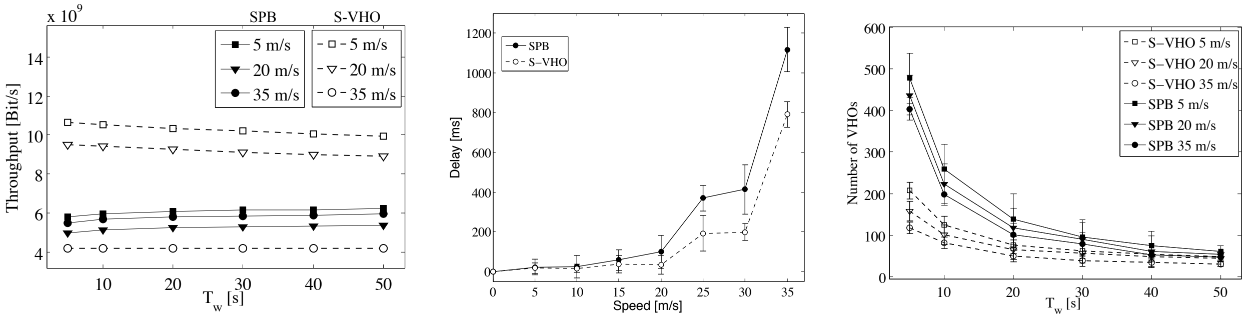
In this section we report on network performance, *i.e.* throughput, delay, and jitter, as well as the number of vertical handovers obtained using our event-driven simulator. Details of the simulator can be found in [10].

Simulation Scenario: A vehicle enters from a random location and is restricted to travel along a grid of streets and intersections, following a path inside a grid. Figure 1 (*c*) depicts one of the simulation scenarios, in terms of data rate distribution from three UMTS base stations, and twenty WLAN access points, in a region of 2 km^2. Typical data rate values have been considered for UMTS and WLAN, respectively [8, 9] and network parameters have been set according to [11]. The location of each wireless cell has been generated uniformly at random, and a vehicle moves in this RSS-variable area with speed in the range $[5, 35]$ m/s. A vehicle downloads a series of video frames during its journey.

Network Performance: In Figure 3 (*a*) we show the throughput as cumulative received bits in a downlink connection for both S-VHO and SPB techniques, versus the *inter-switch waiting time*. The effectiveness of S-VHO is clear when vehicle speed is below a given limit (*e.g.*, 20 m/s). On the other hand, SPB does *not* appear sensitive to either speed or inter-switch waiting time, and its throughput is limited. Note however, the S-VHO throughput drops when the vehicle speed exceeds the desired limit.

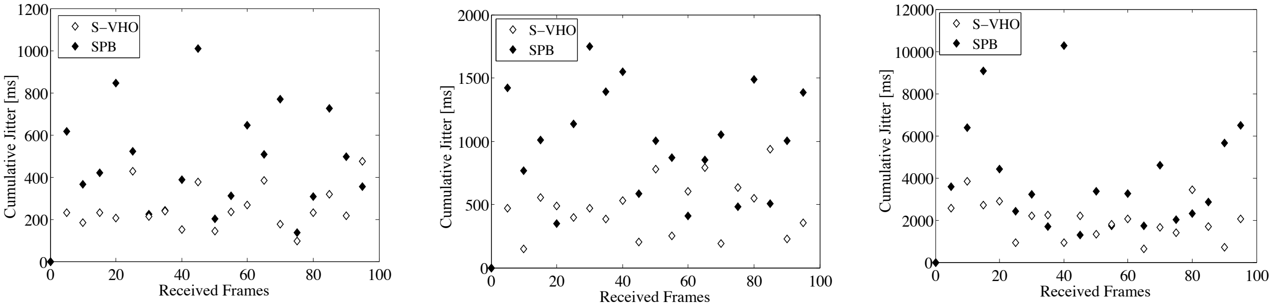
Figure 3 (*b*) shows, with 95% confidence intervals, how the average frame delay for both S-VHO and SPB increases for higher speeds. This is because there is not enough time to download the next frame before the signal from the SN gets too weak. Moreover, S-VHO experiences lower delays compared to SPB, since, on average, it performs less handovers.

Jitter performance from S-VHO and SPB have been compared in Figure 4 (*a*), (*b*), (*c*), for different values of speed, and a fixed inter-switch waiting time value of $T_w = 10$ [s]. Each point represents the cumulative jitter, defined as the difference between maximum and minimum frame delay, averaged over 100 simulations. As we can see, jitter increases with speed since two frames



(*a*) (*b*) (*c*)

Figure 3: (*a*) Throughput averaged over 100 simulations for S-VHO (white markers), and SPB (black markers). (*b*) Packet delay increases less rapidly with vehicle speed when using S-VHO. (*c*) Number of Vertical Handovers for S-VHO (white markers), and SPB (black markers) algorithms.



(*a*) $|\vec{v}| = 15$ m/s, $T_w = 10$ s (*b*) $|\vec{v}| = 25$ m/s, $T_w = 10$ s (*c*) $|\vec{v}| = 35$ m/s, $T_w = 10$ s

Figure 4: Cumulative jitter experienced by a vehicle averaged over 100 simulations, for different speeds —note the scale difference among different graphs. Higher speed implies higher jitter, unless the number of unnecessary handovers is reduced (S-VHO).

may be more often coming from different wireless networks, and also because the cell crossing time decreases when the speed increases.

Overhead (Handover Frequency): Figure 3 (*c*) depicts, with 95% confidence intervals, the average number of handovers for different values of inter-switch waiting time $T_w \in [0, 50]$ s. As expected, the number of vertical handovers decreases when the system is idle for longer periods (T_w increases). Since our simulations count all the handovers (valid or invalid), the gap between the S-VHO and SPB curves represents the number of invalid handovers that are executed not taking into account the handover latency L.

6 Related Work

A VHO decision is usually taken on the basis of (*i*) physical parameters, *e.g.* RSS level [7], and (*ii*) QoS metrics [12]. QoS-based vertical handover algorithms mostly suggest that the user connectivity should be switched to a candidate network, whenever the bandwidth is higher than the currently experienced in the serving network, in order to improve perceived received quality [13]. Although this strategy seems reasonable, in vehicular environments it may fail due to the speed and the time that the vehicle is going to spend in the new cell. In VANETs, vehicles move at high speed, therefore handovers should be performed on the basis of specific factors as vehicle mobility pattern, and locality information, rather than standalone QoS requirements. Past solutions have partially but not fully considered these aspects. In [14], the authors deal with a novel network mobility protocol for VANETs, to reduce both handover delay and packet loss rate, while Olivera *et al.* [15] proposed the Always Best Connected paradigm, to achieve seamless connectivity between WLAN and UMTS networks. Our method instead focuses on a vehicle-controlled VHO, due to smart *on-board* computer equipped with GPS connectivity [1]. The idea of handover decisions based on both vehicle speed and handover latency was previously introduced in [11]. We augment our contributions by extending the algorithm's usefulness to real-time applications, completing the performance evaluation, and significantly extending the analytical results. We focus more on jointly improving three QoS metrics (*i.e.* delay, jitter, and throughput), while keeping small the number of vertical handovers.

7 Conclusions and Future Work

We have presented, via analytical modeling and a simulation study, a counterintuitive result for vertical handovers in heterogeneous vehicular ad hoc networks, that is, when a vehicle encounters a candidate network with higher data rate, a connection switch will not necessarily result in a throughput improvement.

Our proposed technique uses both handover latency and cell crossing time estimation to simultaneously improve throughput and delay, and it is driven by the vehicle' speed: vehicles are required to maintain a given speed limit to maintain acceptable levels of throughput, delay and jitter. The results presented in this paper are helpful for both the research community, when designing novel VANET protocols for real-time applications, and the business community, as they suggest how providers could enforce speed limits and therefore safety while delivering real-time services as video-streaming or online gaming.

We plan to extend our analytical model into more realistic scenarios, removing the simplifying assumptions of constant bandwidth across the coverage area, constant velocity and predictable vehicle motion. Moreover, experiments comparing our handover algorithm with other QoS-based approaches (using real data sets) are left for future work.

References

[1] H. Moustafa and Y. Zhang (Eds.), *Vehicular Networks: Techniques, Standards and Applications*, Auerbach publishers, 2009.

[2] R. Lind et al., “The Network Vehicle-a glimpse into the future of mobile multi-media”, *IEEE Aerospace and Electronic Systems Magazine*, vol. 14, no. 9, pp. 27–32, Sept. 1999.

[3] “Backseat child navigation concept for kids”, available online at http://www.slipperybrick.com/.

[4] G.P. Pollini, “Trends in handover design”, *IEEE Communication Magazine*, vol. 34, no. 3, pp. 82–90, 1996.

[5] Z. Yan, H. Zhou, H. Zhang, and S. Zhang, “Speed-Based Probability-Driven Seamless Handover Scheme between WLAN and UMTS”, in *MSN*, Wuhan, China, Dec. 10-12, 2008.

[6] D. Kwak, J. Mo, and M. Kang, “Investigation of handoffs for IEEE 802.11 networks in vehicular environment”, in *ICUFN*, Hong Kong, June 7-9, 2009, pp. 89–94.

[7] S. Balasubramaniam and J. Indulska, “Vertical Handover Supporting Pervasive Computing in Future Wireless Networks”, *Computer Communication Journal*, vol. 27, no. 8, pp. 708–719, 2003.

[8] “IEEE Standard for Information Technology Telecomm. and Information Exchange between Systems. Local and metropolitan area networks. Part 11: Wireless LAN MAC and PHY Layer Specifications”.

[9] J. Laiho et al., *Radio Network Planning and Optimisation for UMTS*, 2nd edition, Dec. 2005, Chapter 6.

[10] A.M. Vegni, *Multimedia Mobile Communications in Heterogeneous Wireless Networks -Part 2*, PhD thesis, University of Roma Tre, March 2010, available online at http://www.comlab.uniroma3.it/vegni.htm.

[11] A.M. Vegni and F. Esposito, “A Speed-based Vertical Handover Algorithm for VANET”, in *Proc. of 7th Int. Workshop on Intelligent Transportation*, Hamburg, March 23-24, 2010.

[12] A.M. Vegni, M. Carli, A. Neri, and G. Ragosa, “QoS-based Vertical Handover in Heterogeneous Networks”, in *Proc. of 10th Int. Symp. on Wireless Personal Multimedia Comm.*, Jaipur (India), Dec. 3-6, 2007.

[13] A.M. Vegni et al., “A Combined Vertical Handover Decision Metric for QoS Enhancement in Next Generation Networks”, in *WiCOM*, Marrakech (Morocco), Oct. 12-14, 2009, pp. 233–238.

[14] Y.S. Chen, C.H. Cheng, C.S. Hsu, and G.M. Chiu, “Network Mobility Protocol for Vehicular Ad Hoc Network”, in *Proc. of IEEE Wireless Comm. and Networking Conf.*, Budapest, April, 2009.

[15] J.A. Olivera et al., “VANBA: a simple handover mechanism for transparent, always-on V2V communications”, in *Proc. on IEEE 69th Vehicular Technology Conference (VTC2009-Spring)*, April 26-29, 2009.