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GAME-THEORETIC NASH-EQUILIBRIUM AND ECMDP-RANKING POLICIES FOR VERTICAL HANDOVER DECISION WITH EMERGENCY BRAKING IN VANETS

P. VETRIVELAN[1] S.SIVA MAHARAJAN[2] AND P. NARAYANASAMY[3]
[1] Research Scholar, Anna University, Chennai, India
[2] PG Student, Rajalakshmi Engineering College, Chennai, India
[3] Professor, Department Of Information Science And Technology, Anna University, Chennai, India
E-mail: [1] velanresearch@yahoo.com, [2] sivamaharajan90@gmail.com, [3] sam@annauniv.edu

ABSTRACT

A Vehicular Ad-hoc Networks (VANETs) is a technology that uses moving vehicles as nodes in a network to create a mobile network. Vehicular communications like V-2-V and V-2-I with vertical handover decision process has to consider the speed limits and other real-time constraints such as lane-changes, emergency braking along with QoS parameters such as bandwidth, delay, jitter, bit error rate and cost. The proposed handover mechanism uses a game-theoretic Bayesian Nash-equilibrium based algorithm to select the network indicated by the Nash-Equilibrium point and uses a Extended Constrained MDP (Markov Decision Process) based algorithm with speed constraints in case of a tie between the networks.

Key words: *WiFi, WiMAX, LTE, MIHF, Bayesian Game, MDP, VANETS.*

1. INTRODUCTION

The recent advances in wireless networks have led to the introduction of a new type of networks called Vehicular Networks. Vehicular Ad Hoc Network (VANET) is a form of Mobile Ad Hoc Networks (MANET). VANETs provide us with the infrastructure for developing new systems to enhance drivers' and passengers' safety and comfort. VANETs are distributed self-organizing networks formed between moving vehicles equipped with wireless communication devices. This type of networks is developed as part of the Intelligent Transportation Systems (ITS) to bring significant improvement to the transportation systems performance.

Each Vehicle Node is equipped with WAVE (IEEE 802.11p) protocol known as OBUs (On Board Unit). There are mainly two types of communications scenarios in vehicular networks: Vehicle-to-Vehicle (V2V) and Vehicle-to-RSU (V2R or V2I). The RSUs can also communicate with each other and with other networks. Vehicular Networks are expected to employ variety of advanced wireless technologies such as Dedicated Short Range Communications (DSRC), which is an enhanced version of the WAVE (IEEE802.11p) technology suitable for VANET environments. The DSRC is developed to support the data transfer in rapidly changing communication environments. The basic VANET communication scenario is shown in Figure 1.

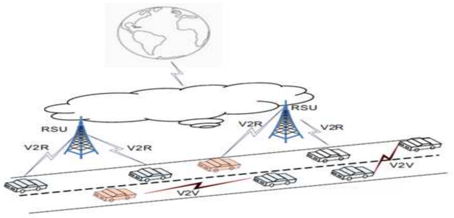


Figure 1: Basic Vanet Scenario

VANET applications are Safety applications, Cooperative Collision Avoidance (CCA), Emergency Warning Messages (EWM), Cooperative Intersection Collision Avoidance (CICA), Traffic Managements, Advertisements, entertainment and comfort applications like Electronic toll collection.

A new MAC protocol known as the IEEE 802.11p is used by the WAVE stack. The IEEE 802.11p basic MAC protocol is the same as IEEE 802.11 Distributed Coordination Function (DCF), which uses the Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) method for accessing the shared medium. The IEEE 802.11p MAC extension layer is based on the IEEE

802.11e (IEEE, 2003) that uses the Enhanced Distributed Channel Access (EDCA) like Access Category (AC), virtual station, and Arbitration Inter-Frame Space (AIFS). Using EDCA, the Quality of Service (QoS) in the IEEE 802.11p can be obtained by classifying the data traffic into different classes with different priorities. The basic communication modes in the IEEE 802.11p can be implemented either using broadcast, where the control channel (CCH) is used to broadcast safety critical and control messages to neighboring vehicles, or using the multi-channel operation mode where the service channel (SCH) and the CCH are used. The later mode is called the WAVE Basic Service Set (WBSS).

In the WBSS mode, stations (STAs) become members of the WBSS in one of two ways, a WBSS provider or a WBSS user. Stations in the WAVE move very fast and it's very important that these stations establish communications and start transmitting data very fast. Therefore, the WBSSs don't require MAC sub-layer authentication and association. The provider forms a WBSS by broadcasting a WAVE Service advertisement (WSA) on the CCH. The Protocol architecture of IEEE802.11p DSRC as shown in Figure 2.

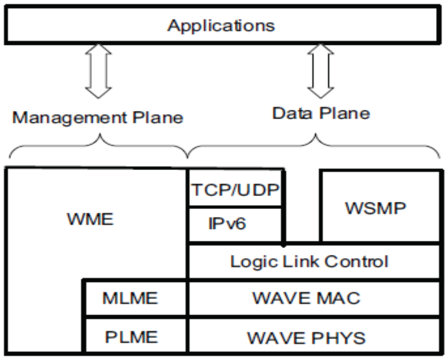


Figure 2: Protocol Architecture Of IEEE802.11p

V2V uses DSRC based WAVE protocol for collision avoidance messages and V2I uses WiMAX or UMTS/LTE networks for lane-changes /assigning vehicle priorities.

The remainder of this paper is organized as follows: Section II describes an overview of VANETs vehicular mobility issues. Then real-time mobility framework for interworking V-2-V and V-2-I communications are presented in Section III. The network selection based on game-theoretic Nash-equilibrium and ECMDP ranking approaches are presented in Section IV and in section V respectively. Section VI describes the conclusion and future work.

2. VEHICULAR MOBILITY ISSUES

The survey contains information about VANET mobility models, several architectures for mobility management, integration of network and traffic simulator, performance issues in VANET. Several issues and parameters were considered.

Vaishali D. Khairnar et al., [1] has analyzed mobility models for vehicular adhoc network. Mobility model is important characteristic of vehicular networks. Mobility models can be commonly classified into macroscopic models, mesoscopic models, and microscopic models. The Random way-point model evaluates its effect in VANETs by ns-2 simulations. *Ricardo Fernandes et al* [2] presents A tool for simulating heterogeneous vehicular networks. The existing microscopic traffic simulator, DIVERT, has been extended by adding NS-3 support resulting in a very tightly integrated simulator. Hybrid approaches provide a fully integrated framework with the ability to simulate both the mobility and network components.

TABLE 1
VERTICAL AND HORIZONTAL HANDOVERS

Parameters	Horizontal Handover	Vertical Handover
Access Technology	Not Changed	Changed
QoS Parameters	Not Changed	May be Changed
IP Address	Changed	Changed

Salman Durrani et al., [3] propose a new equivalent speed parameter and develop an analytical model to explain the effect of vehicle mobility on the connectivity of highway segments in a VANET. They prove that the equivalent speed is different from the average vehicle speed and it decreases as the standard deviation of the vehicle speed increases. *Jens Mittag el at* [4] addresses the network simulators typically abstract physical layer details (coding, modulation, radio channels, receiver algorithms, etc.) while physical layer ones do not consider overall network characteristics (topology, network traffic types, and so on). In particular, network simulators view a transmitted frame as an indivisible unit, which leads to several limitations.

Hadi Arbabi et al., [5] proposed highway mobility in vehicular network and they described the first implementation of a vehicular mobility model integrated with the networking functions in ns-3. *Mate Boban el at* [6] studied about vehicle as obstacle in vehicular network. The impact of vehicles as obstacles on vehicle-to-vehicle (V2V) communication has been largely neglected in VANET research, especially in simulations. Useful models accounting for vehicles as obstacles must satisfy a number of requirements, most notably accurate positioning, realistic mobility patterns, realistic propagation characteristics, and manageable complexity.

Evjola Spaho et al., [7] present a simulation system for VANET called CAVENET (Cellular Automaton based VEhicular NETwork). In CAVENET, the mobility patterns of nodes are generated by 1-dimensional cellular automata. *Claudia Campolo et al.,* [8] investigated the feasibility of V2R communications, by considering the 802.11p/WAVE features and capabilities. In order to increase the number of vehicles able to make the best of a short-lived RSU coverage, the proposed a solution that exploits both the repetition of BSS advertisements during the CCH interval and the piggybacking over beacons to spread the BSSs parameters.

Valery Naumov et al., [9] report on a investigation of the effectiveness of AODV and GPRS in an inner city environment and on a highway segment. This evaluation is based on traces obtained from a microscopic vehicle traffic simulation on the real road maps of Switzerland.

David R. Choffnes Fabi et al., [10] analyzes ad-hoc wireless network performance in a vehicular network in which nodes move according to a simplified vehicular traffic model on roads defined by real map data. This research work indicate that the packet delivery ratio for common topology-based ad-hoc routing algorithms varies significantly between an environment using a model of vehicular movement confined to real roads and one using the random waypoint model.

Syed et al., [11], “Dynamic Implementation of Network Selection,” IEEE Conference on Local Computer Networks”, LCN 2010. The paper describes about benefit function and penalty function. The decision for network selection is based on reward.

K.Radhika et al., [12] , “Vertical Handoff Decision using game Theory approach for Multi-mode Mobile Terminals in Next generation Wireless Networks,” IJCA, volume 36-No.11, Dec 2011. The paper focuses on vertical handover decision on multi-mode terminal using Nash-equilibrium based game theory approach. The decision includes the various QoS parameters for network selection.

3. REAL-TIME MOBILTY MODEL

Vehicular Ad-Hoc Network (VANET) communication has recently become an increasingly popular research topic in the area of wireless networking as well as the automotive industries. The goal of VANET research is to develop a vehicular communication system to enable quick and cost-efficient distribution of data for the benefit of passengers' safety and comfort. While it is crucial to test and evaluate protocol implementations in a real world environment, simulations are still commonly used as a first step in the protocol development for VANET research. Several communication networking simulation tools already exist to provide a platform to test and evaluate network protocols, such ns-3, ns-2, OPNET and Qualnet.

One of the most important parameters in simulating ad-hoc networks is the node mobility. It is important to use a realistic mobility model so that results from the simulation correctly reflect the real-world performance of a VANET. For example, a vehicle node is typically constrained to streets which are separated by building, trees or other objects. Such obstructions often increase the average distance between nodes as compared to an open-field environment. Many prior studies have shown that a realistic mobility model with sufficient level of details is critical for accurate network simulation results.

Vehicular node mobility is represented by mobility model Mobility models represent the movement of mobile users, and how their location, velocity and acceleration change over time. Such models are frequently used for simulation purposes when new communication or navigation techniques are investigated**.** Mobility of vehicular nodes is crucial issue in VANET. Mobility of vehicular node represented by mobility models. The widely used mobility model for vehicular adhoc network is Random waypoint mobility model. This mobility models for vehicular ad-hoc networks do not provide realistic vehicular node movement scenarios. The Random Waypoint Mobility Model includes pause times between changes in direction and/or speed. A vehicular node begins by staying in one location for a certain period of time (i.e., a pause time). In Random waypoint mobility model, once this time expires, vehicular node chooses a random destination and a speed that is uniformly distributed between *[minspeed, maxspeed]*. The vehicular node then travels toward the newly chosen destination at the selected speed. Upon arrival, the vehicular node pauses for a specified time period before starting the process again. This mobility model ignore many real time constrains such as traffic signal, speed limit and so on.

The proposed solution for this problem is resolved by introducing new real-time mobility framework. Real-time mobility framework include real world constraints such as traffic signal, speed limit, number of lanes (whether interstate highway, national high way), speed will increasing/ decreasing, while intersection of street vehicular node turn left/right/go straight, vehicle over taking behavior and also it support bidirectional highway.

The Vehicular ad-hoc network (VANET) provide communications between various moving vehicles. The proposed vertical handover technique can be used with a classic VANET model or a hybrid one. The hybrid VANET model considered in this paper has EEBL (Emergency Electronic Braking lights) and IDM (Intelligent Driver Model).EEBLs main aim is to provide warning messages when the deceleration parameter of the VANET node goes above a certain threshold.

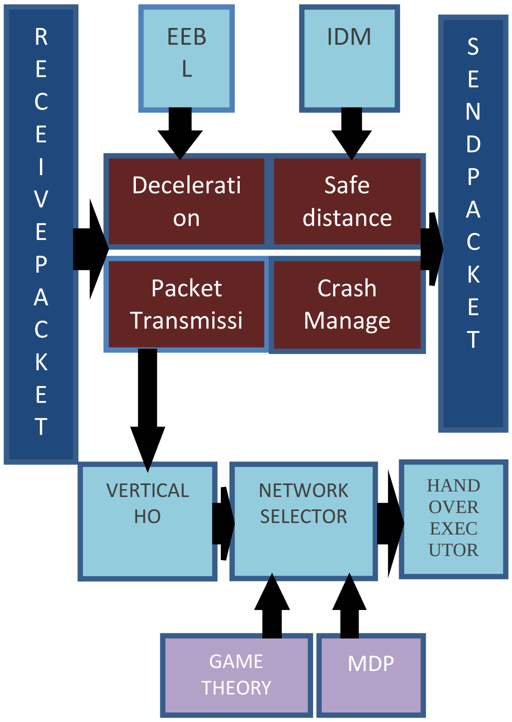


Figure 3: Real-Time Mobility Model

The threshold is fixed by considering various parameters like width of the road, density of the cars in the road at that time, etc. The nodes which are at the back receive the packets and reduce their speed as to avoid accidents. Similarly the intelligent driver model (IDM) model helps to avoid crashes by setting the acceleration of the current node as average of the acceleration of the current node and the node at its front. It resets the acceleration whenever the acceleration of the front node is lesser than its own acceleration. Similarly it computes the safe distance component which is nothing but the distance in front of the node which is free of any other vehicle. Such models are frequently used for simulation purposes when new communication or navigation techniques are investigated**.**

In this paper the VANET node with the EEBL ,IDM models undergoes the Vertical handover using Game theory and Constrained MDP (Markov Decision Process).In Game theory we particularly selected the Bayesian Game which uses probability. First the network is selected which provides the best Nash equilibrium among other networks considering the various QOS parameters. If the Nash Equilibrium point is not obtained by applying the Bayesian Game, a sub-optimal solution is presented which uses a Constrained MDP solution of ranking the networks by giving those rewards as a function of benefits and penalties. The Constrained MDP uses speed based constraints and has a SUB (Speed Upper Bound) value for each network. The reward for a network increases by 1 when the SUB value is greater than the speed of the vehicle. The SUB calculation uses various parameters like the distance covered by the network (dx) Hysteresis offered by the network against HO (H) and Latency of the network during HO (L) .The usual tie breaker using benefits and penalties has not considered the speed of the vehicle .But the proposed tie breaker module considers all the QOS parameters and also the speed of the vehicle.

The proposed mobility framework is shown in Figure 3. Each vehicle is equipped with 802.11p based DSRC unit. Vehicles communicate with neighbor vehicle for collision avoidance / warning, safety like applications using WAVE protocol. Also vehicles information communicated to Infrastructures (WiMAX or LTE) for assigning vehicle priorities and lane-changes applications.

The vertical handover decisions for network selection are implemented using game-theoretic Nash-equilibrium and extended constrained Markov Decision Process (ECMDP) approaches are presented in section IV and in section V respectively.

4. GAME-THEORETIC NASH-

EQUILIBRIUM NETWORK SELECTION

Game theory techniques were adopted to solve many protocol design issues like resource allocation, power control in wireless networks. When a mobile host is under the coverage of more than one wireless network, it performs network selection iteratively to achieve best quality of service with minimum cost.

Steps for choosing the network

1. Consider there are m {1,2…..m} networks

2. The parameters such as bandwidth (B), jitter (J), delay (D), velocity (V), and error-rate (E) are considered.

3. fb,i , fd,i , fv,i , fj,i , fe,i values are calculated using Bayesian Game.

4. Using these values pair wise matrix is calculated.

5. Using the pair wise matrix the Nash equilibrium point is find.

6. Network Utility ratio:

$$QNU_i = \frac{U_i}{\sum_{k=1}^{m} U_k} \quad \textbf{(1)}$$

where $U_i = f_{B,i} * f_{D,i} * f_{V,i} * f_{P,i} * f_{E,i}$

7. Bayesian theorem:

$f_{b,i}=\{1.5,\ \text{if } _{bi}>=b_{th}$
$1+0.5(b_i-b_{req})/b_{th}-b_{req},\ \text{if } b_{req}<=bi<b_{th}$
$\}$ **(2)**
$f_{d,i}=\{1.5,\ \text{if } di>=d_{th}$
$1+ 0.5(d_{req}-d_i)/d_{req}-d_{th},\ \text{if } d_{th}<d_i<d_{req}$
$\}$
$f_{v,i}=\{1.5,\ \text{if } _{vi}>=v_{th}$
$1+0.5(v_i-v_{req})/v_{th}-b_{req},\ \text{if } v_{req}<=v_i<v_{th}$
$\}$
$f_{j,i}=\{1.5,\ \text{if } j_i>=j_{th}$
$1+ 0.5(j_{req}-j_i)/j_{req}-j_{th},\ \text{if } j_{th}<j_i<j_{req}$
$1+0.5(j_i-j_{req})/(j_i-j_{th}),\ \text{if } j_i>j_{req}$
$\}$
$f_{e,i}=\{1.5,\ \text{if } e_i>=e_{th}$
$1+ 0.5(e_{req}-e_i)/e_{req}-e_{th},\ \text{if } e_{th}<e_i<e_{req}$
$\}$

8. Cost:

User Vs Pay:

$$UP_j=C_j*Q_j \quad \textbf{(3)}$$

C_i- Cost per bit of the ith network
Q_j-QOS requirement of the jth user

Where $Q_j = \{1,\ \text{if } b_i>b_{req}, d_i<d_{req}, v_i>v_{req}, j_i<j_{req}, e_i<e_{req}$
∞, otherwise} **(4)**

9. The pair wise matrix is calculated based on the Network utility of the network (i), cost (j) such as(i,j).

10. If there is no equilibrium, then the sub optimal solution is evolved using MDP.

11. In ECMDP, Speed is included as one of the parameter.

Benefit and Penalty functions are calculated for each of the network that are presented.

12. The reward value for the network is calculated.

Reward of i^{th} network= benefit of i^{th} network – penalty of i th network

13. Each network having **SUB** (Speed upper bound) value. Speed of the vehicle is checked with the SUB value.

The network utility is computed using Equation (1) which in turn uses Equation (2). The cost of the network is as follows the Equations (3) and (4).

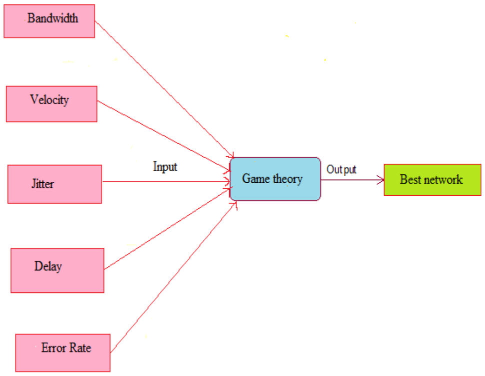


Figure 4: Decision Criteria

Every decision making mechanism requires essential and relevant input information in order to choose the best value network as shown in Figure 4. Using the information each player calculates the utility of all the available networks and chooses the one which has the highest probability of satisfying the requests of the player. The equilibrium is achieved when the player is able to choose the network which is suitable for it.

The sample QoS' offered, threshold and requested values are given in Tables 2 to 4. Also the cost for each network is given in Table 5.

	Bandwidth(mbps)	Delay (msec)	Velocity(Kmph)	Jitter(m sec)	Error rate (Per 10^8)
Wi-Fi	50	160	10	200	200
WiMAX	70	120	20	60	150
LTE	150	80	30	30	100

Table 2: Offered Qos Parameters

B_{Th}	D_{Th}	V_{Th}	J_{Th}	E_{Th}
80	100	60	50	150

Table 3: Qos Threshold Parameters

QoS Parameters	Bandwidth (Mbps)	Packet Delay (msec)	Velocity (Kmph)	Jitter (msec)	Error rate (per 10^8)
Conversational	10	200	5	60	400
Streaming	25	300	5	60	400
Interactive	15	300	5	200	250
Background	20	400	5	300	250

Table 4: Qos Required Parameters

Network	WiFi	WiMAX	LTE
Cost	0.2	0.4	0.6

Table 5: Cost Per Bit Offered By Each Network

Traffic Class	Wi-Fi	WiMax	LTE-A
Conversational	0.2549,8	0.1600,8	0.5850,0.6
Streaming	0.2638,8	0.1723,8	0.5638,0.6
Interactive	0.1352,8	0.3114,0.4	0.5532,0.6
Background	0.1761,0.2	0.3362,0.4	0.4875,0.6

Table 6: Pair-Wise Matrix

It is observed from the pair-wise matrix as shown in Table 6 that the equilibrium is achieved for various traffic classes and hence the decision can be made optimally.

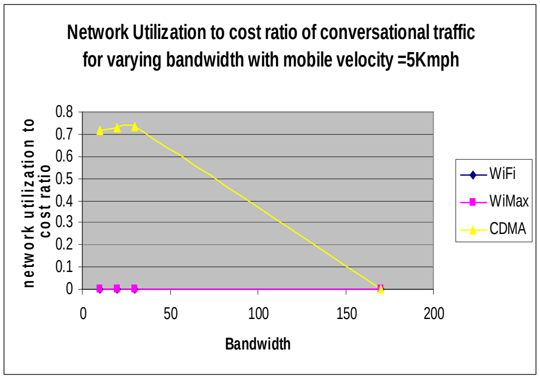


Figure 5: Bandwidth Vs Network Utility Ration At Constant Velocity

The graph shows that Network-Utilization ratio are relatively high in LTE network which is shown Figure 5 when the speed increses it becomes infinity.

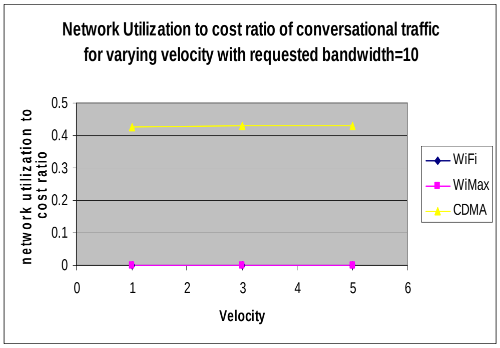


Figure 6: Velocity Vs Network Utility Ratio At Constant Bandwidth

The graph shows that Network-Utilization ratio are relatively high in LTE network which is shown Figure 6. The solution in pair-wise matrix having more than one acceptable value, hence use extended constrained MDP (ECMDP) approach as presented in the subsequent section.

5. ECMDP NETWORK SELECTION

The computed handover latency and hysteresis values are used for handover as tabulated in Table 7.

Network	Bandwidth (Mbps)	Delay (msec)	Velocity (Kmph)	Jitter(msec)	Error rate(per 10^8)	Distance covered dx(Km)	Hysteres Against Ho L(msec)	During Latency HO L(msec)
Wifi	1	160	10	200	200	1000	0.5	70
Wimax	0.5	120	20	120	150	1200	0.6	50
LTE	0.2	80	60	30	100	1400	0.2	100

Table 7: Handover Latency And Hysteresis

The network reward is computed using benefit and penalty functions. The obtained network Vs reward results are shown in Tables 8 and 9.

Benefit Functions:

1. Bandwidth Benefit Function

$f_b(s,a)$= 1 if b_i=max{bk} i=a
0 if b_i=max{bk} i!=a
b_a-b_i/max(b_k-b_i) if b_i!=max{b_k} $b_a>b_i$
0 if b_i!=max{b_k} $b_a<=b_i$ **(5)**

Let i(currently connected ntwork)=LTE
let a = choosing Wifi,
$f_b(s,a)$ = 1
let a = choosing Wimax
$f_b(s,a)$ = 0.3/0.8
= 0.375

2.Delay benefit function

$f_d(s,a)$= 1 if d_i=min{d_k} i=a
0 if d_i=min{d_k} i!=a
d_i-d_a/min(d_i-d_k) if d_i!=min{d_k} $d_a<d_i$
0 if d_i!=min{d_k} $d_a>=d_i$ **(6)**

----

a = wifi
$f_d(s,a)$ = 0
a = wimax
$f_d(s,a)$ = 0

----

3. Velocity benefit function

$f_v(s,a)$= 1 if v_i=max{v_k} i=a
0 if v_i=max{v_k} i!=a
v_a-v_i/max(v_k-v_i) if v_i!=max{v_k} $v_a>v_i$
0 if v_i!=max{v_k} $v_a<=v_i$ **(7)**

----

a = wifi
$f_v(s,a)$ = 0
a = wimax
$f_v(s,a)$ = 0

4.Jitter benefit function

$f_j(s,a)$= 1 if j_i=min{j_k} i=a
0 if j_i=min{j_k} i!=a
j_i-j_a/min(j_i-j_k) if j_i!=min{j_k} $j_a<j_i$
0 if j_i!=min{j_k} $j_a>=j_i$ **(8)**

----

a = wifi
$f_j(s,a)$ = 0
a = wimax
$f_j(s,a)$ = 0

5.Error benefit function

$f_e(s,a)$= 1 if e_i=min{e_k} i=a
0 if e_i=min{e_k} i!=a
e_i-e_a/min(e_i-e_k) if e_i!=min{e_k} ea<ei
0 if e_i!=min{e_k} $e_a>=e_i$ **(9)**

----

a = wifi
$f_e(s,a)$ = 0
a = wimax
$f_e(s,a)$ = 0

---

6. On including speed of the vehicle,

Let the speed of the vehicle (SOV) be 8Kmph

Formulae:

If SUB> SOV
Then $f_s(s,a)$ = 1
Else
$f_s(s,a)$ = 0

Calculate Speed upper bound for Wifi
SUB = $d_x(b_a-b_i-H)/(b_a-H)L$
Wifi = 1000(1-0.2-0.2)/(1-0.2)
70 = 10.71

Therefore, fs(s,Wifi) = 1

Calculate Speed upper bound for Wimax

SUB = $d_x(b_a-b_i-H)/(b_a-H)L$

Wimax = 1200(0.5-0.2-0.2)/(0.5-0.2)50
= 8

Therefore, f_s(s,WiMax)=0

TOTAL BENEFITS:

f(s,wifi) = 0.8
f(s,wimax) = 0.375

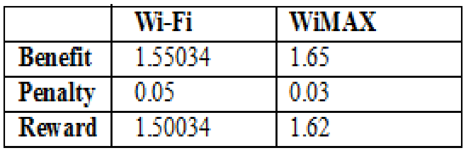
Penalty:

let switching cost penalty function of Wifi be,
g(s,a) = 0.05
and call dropping penalty function be
q(s,a) = 0.02

let switching cost penalty function of Wimax be,

g(s,a) = 0.03
and call dropping penalty function be
q(s,a) = 0.001
penalty function:
h(s, a) = g(s, a) + r*q(s, a) let r(0,1) be 0 **(10)**

h(s,wifi) = 0.05
h(s,wimax) = 0.03



	Wi-Fi	WiMAX
Benefit	1.55034	1.65
Penalty	0.05	0.03
Reward	1.50034	1.62

Table 8: Network Vs Reward (Example-1)

So here **WiFi** is best to choose.
Wifi benefit: i=LTE a=choosing Wi-Fi

1. fb(s,a)= 1
2. fd(s,a)= 180-160/180-120=20/60 = 0.33
3. fv(s,a) = 0
4. fj(s,a) = 30/110 =0.272
5. fe(s,a) = 20/70 = 0.2857
6. fs(s,a) = 1

Wifi total benefit: 1.55034

Wimax benefit

1. fb(s,a) = 0.375
2. fd(s,a) = 1
3. fv(s,a) = 0
4. fj(s,a) = 1
5. fe(s,a) = 1
6. fs(s,a) = 1

Wimax total benefit = 1.65

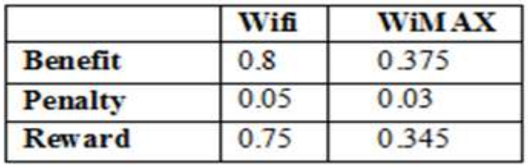
Penalties:

let switching cost penalty function of Wifi be,
g(s,a) = 0.05
and call dropping penalty function be
q(s,a) = 0.02

let switching cost penalty function of Wimax be,
g(s,a) = 0.03
and call dropping penalty function be
q(s,a) = 0.001
penalty function:
h(s, a) = g(s, a) + r*q(s, a) let r(0,1) be 0

h(s,wifi) = 0.05
h(s,wimax) = 0.03

REWARDS:
WIFI = 1.55034-0.05=1.50034
WIMAX = 1.65-0.03=1.62



	Wifi	WiMAX
Benefit	0.8	0.375
Penalty	0.05	0.03
Reward	0.75	0.345

Table 9: Network Vs Reward (Example-2)

So it's advantageous to choose WiMAX.

The speed vs reward performance graph is shown in Figure 7. The benefit and penalty was calculated using Equations (5) to (9) which in turn compute the reward. Then the ranking was done based reward, hence the vertical handover decision was implemented using MATLAB simulator.

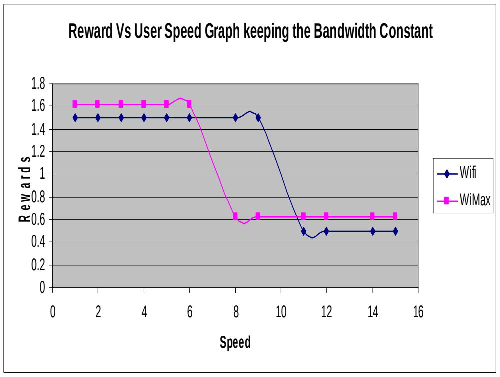
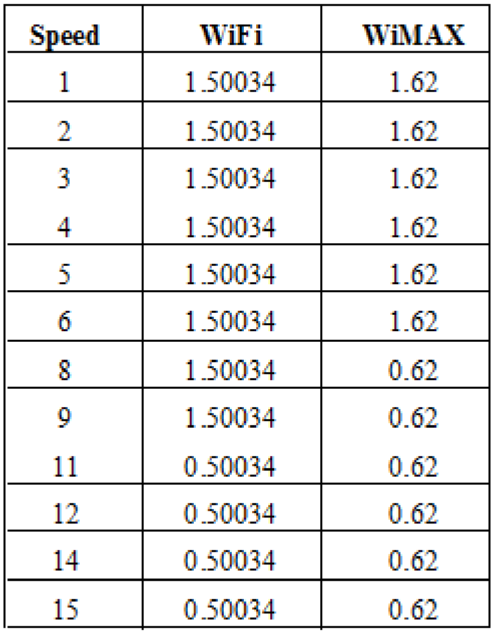


Figure 7: Speed Vs Reward

The intelligent driver model (IDM) is incorporated with the real-time mobility framework. The handover decision could be done based on speed limits Vs reward as shown in Table 10. The IDM calculates the safe distance and then enables the deceleration modules and then applies the emergency braking using emergency electronic braking lights (EEBL) if required.



Speed	WiFi	WiMAX
1	1.50034	1.62
2	1.50034	1.62
3	1.50034	1.62
4	1.50034	1.62
5	1.50034	1.62
6	1.50034	1.62
8	1.50034	0.62
9	1.50034	0.62
11	0.50034	0.62
12	0.50034	0.62
14	0.50034	0.62
15	0.50034	0.62

Table 10: Speed Vs Reward

6. CONCLUSION AND FUTURE WORK

The vehicle-to-vehicle (V-2-V) and vehicle-to-infrastructure (V-2-I) communications was done using WAVE on onboard unit and WiMAX/UMTS on roadside unit. The horizontal and vertical handover decisions were made effectively using the Nash-equilibrium solution point and the ECMDP ranking approach used when sub-optimal solution arrived. Also the safety and emergency braking are implemented based on IDM. The IEEE 80.21 MIHF based network scanning has great impact resulting to reduced handoff latency.

In future, enhanced systems will be considering more real-time constraints like congestion-free mobility in the narrow roads or high density roads for implementing vehicular mobility models. Safety and emergency reporting messages must be delivered on time with higher priority.

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