

Performance Analysis of Vertical Handoff in Heterogeneous Wireless Networks Based On Game Theory

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Abstract

Future generation wireless networks are heterogeneous that will coexist and need a common IP core to offer a distinct range of high data rate multimedia services to end users since the networks have characteristics that complement each other. Users need a various multi-homed personal wireless devices will have the option of accessing their desired services via different available Networks. A major issue is need a seamless vertical handoff across the multi-service heterogeneous wireless access networks therefore mobile users roaming across different wireless networks. Network selection is a challenging task and is necessary when users want to migrate between heterogeneous networks and will influence the performance metrics of importance, for both service provider and subscriber. In this paper game theory based performance analysis of Vertical Handoff between WLAN-WiMAX integrated networks using Boltzmann-Gibbs based CODIPAS-RL algorithm through which better performance is obtained. The performance parameters such as Packet Error Rate (PER), throughput and delay for selecting a network are obtained.

Keywords- Game Theory, AODV, WLAN Heterogeneous Networks, WiMAX, LTE, UMTS, Boltzmann-Gibbs, CODIPAS-RL.

Introduction

There is an enormous and fast development in the wireless communication nowadays because there is an increase in number of mobile and internet users. Beyond third generation (3G) is expected to include heterogeneous wireless networks that will coexist. One such new technology is the heterogeneous network which refers to the integration of different Radio Access Technology (RAT) such as Bluetooth, WLAN, WiMAX, UMTS, LTE, WBAN etc. These diverse wireless networks have its own bandwidth, coverage area, data rate, mobility, Received Signal strength (RSS), technology etc. The evolution of heterogeneous networks will increase the growth in development of a diverse range of high-speed multimedia services, such as location-based information services, mobile entertainment multimedia services, e-commerce, and digital multimedia broadcasting.

Wireless Networks include high bandwidth, low latency, and ubiquitous coverage. However, none of the current wireless technologies can simultaneously satisfy these needs at low cost. Intuitively, the larger bandwidth and ubiquitous coverage is desirably need of a mobile user are well satisfied if it can freely hand over to any discovered networks to maintain its services at all times.

The architecting and implementation of IP core multiple service wireless networks will allow seamless intersystem roaming between heterogeneous wireless access networks and packet data-switched wireless communications. A major challenging issue in the IP core networks is seamless vertical handover across wireless networks. Here vertical handoff is the basis for providing continuous wireless services to mobile users roaming between the heterogeneous wireless networks. Hence multimode mobile terminals will have to seamlessly roam across the various access networks and maintain network connectivity since no single network can provide ubiquitous coverage and high Quality-of-Service

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(QoS) provisioning of applications. Basically there are two approaches for selecting a network. In Network-Centric Approach (NCA) [1], a common centralized controller allocates network resources to the connections in the service area. Moreover, the users should act in a mutually cooperative and obeying the decision made by the central controller. Hence, to have a better performance, network selection can be performed by User Centric Approach (UCA). In this approach, game theory based network selection algorithms are used at the user terminal. This approach is distributed in nature and has low implementation complexity and low communication overhead. In user centric approach users they can select the network according to their level of satisfaction.

Related Works

Several challenging research has been done related to the network selection during handoff mechanism for heterogeneous networks. The limitation in the traditional selection has been studied extensively in the past. The current trend is Self-Selection Decision and Game based algorithms [2, 3] for network selection and for efficient handoff. Cost function based algorithms [4, 5, 6] have been proposed to combine the metrics such as monetary cost, security, power consumption and bandwidth in cost function. The handoff decision is made by comparing the result of the function for candidate networks. Different weights are assigned to different input metrics depending on the network conditions and user preferences.

A better and improved velocity and position based handover algorithm [7, 8] has been presented to decrease the number of unnecessary handoffs by using geographical position and velocity information estimated from GSM measurement data of distinct signal strengths at Mobile Station(MS) received from Base Station(BS). In user mobility based algorithms [8, 9] use velocity information is a critical one for handoff decision. In the overlay network systems, to increase the system capacity, umbrella cell approach is used It consists of micro or pico cells are allocated for slow moving users and a bigger macro cells are assigned for fast moving users by using velocity information. It decreases the number of dropped calls. Received Signal strength (RSS) based VHD algorithms [9, 10, 12] proposed and developed various schemes to compare RSS of the current point of attachment with that of the candidate point of

attachments. They are relative RSS, RSS with hysteresis, and RSS with hysteresis plus dwelling timer method. Relative RSS is not applicable for VHD, since RSS from various types of networks cannot be compared directly for handoff decision due to the disparity of the technologies involved.

In RSS along with hysteresis type, handoff is performed whenever the RSS of new BS is larger than the RSS of old BS by predefined threshold value. In RSS with hysteresis plus dwelling timer method, whenever the RSS of new BS is higher than the RSS of old BS by a predefined hysteresis, a timer is set. When it reaches a certain specified value, handoff is processed. This type minimizes Ping pong handoffs. In this proposal other criteria have not been considered. In the papers [11, 12] proposed a Bandwidth based algorithms for vertical handover. Here handoff decision is made based on available bandwidth for mobile terminal.

A bandwidth based VHD method is mainly presented between WLANs and WCDMA network using Signal to Interference and Noise ratio (SINR). This approach provides higher throughput than RSS based handoffs since the available bandwidth is directly dependent on the SINR. But it may add excessive handoffs with the variation of the SNR. These excessive handoffs may reduce by use of heuristic based VHD on the Wrong Decision Probability (WDP) prediction algorithms [13]. The WDP is calculated by combining the probability of unnecessary and missing handoffs.

Heterogeneous Wireless Access Networks

The future generation wireless heterogeneous networks are expected to be exclusively IP-based and converged core network. The evolving of these networks will seamlessly integrate various types of wireless access networks including the following:

- Wireless Body Area Networks (WBANs), subcategory of wireless sensor network technology targeted at monitoring physiological and other parameters surrounding human beings and animals.
- Wireless Personal Area Networks (WPANs), such as Ultra Wide Band (UWB) and Bluetooth, that provides range-limited Ad hoc wireless service to users.
- Wireless Local Area Networks (WLANs), such as 802.11x (Wi-Fi), that provide high-throughput connections for stationary or quasi-stationary wireless users without need of costly infrastructure.

- Wireless Metropolitan Area Networks (WMANs), such as 802.16x (WiMAX); offer mobile wireless services requiring high data rate transmission and strict maintain QoS requirements in both indoor and outdoor environments.
- Wireless Wide Area Networks (WWANs), an example Universal Mobile Telecommunications System (UMTS), offer relatively long-range cellular voice and limited-throughput data services to users with high mobility. .
- WLAN network is basically 802.11 standards which provide less coverage and high data rates (54Mbps). In WiMAX, larger coverage and good data rates. The design goal is to provide the user the best available QoS at any time. The main benefit of heterogeneous networks is the effective utilization of available bandwidth to meet demands for high performance applications such as multimedia, video, video-conferencing, global mobility and service portability. Mobility management is the main essential issue that supports the roaming of users from one system to another. So, the mobility management process strongly considers the dynamic reselection of network as its major task. Multi mode mobile terminal is used to select a network from the converged networks. Some of the approaches used for better network selection process are Multi Attribute Decision Making (MADM) algorithm, fuzzy logic based approach, mathematical approaches such as Analytical Hierarchy Process (ARH) and Grey Relational Analysis (GRA).

Proposed Dynamic Decision Model for VHO

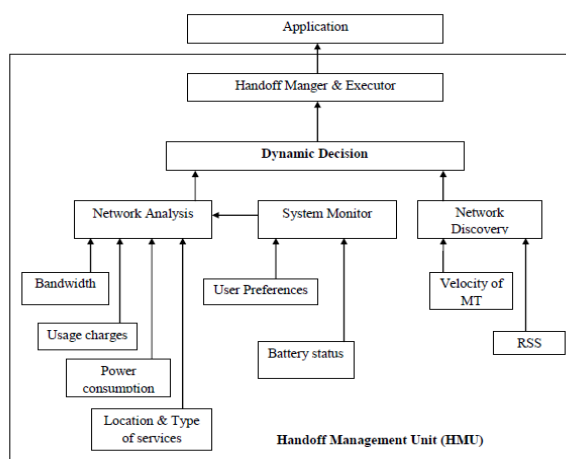


Fig1: Proposed Dynamic Decision Model (DDM) For Vertical Handoff

Selecting a required network from the converged overlay networks according to the user's requirements is called network selection. Fig 1 is an improved proposed model for vertical handoff. The dynamic decision for handoff mainly on the outcome of the network selection or discovery and network analysis based on the several desirable input parameter like RSS, velocity, bandwidth, power consumption, location etc. This paper presents the network discovery between WLAN and WiMAX. Initially the user device faces the problem of selecting a network from a number of RANs [15] that differ in technology, coverage, bandwidth, pricing scheme, etc., belonging to the same or different service providers. Network selection process is usually carried out in three levels. It starts with collecting the required information that really impact on the final decision. The information might be user preference, service application, and network status. In the second step is using the collected information as inputs to an efficient handoff algorithm that aims to keep the user always best connected? The last step is making handover decision according to the algorithm's output.

Game theory based selection algorithms are used for network selection to initiate hand off decision in a dynamic environment. The network selection algorithms used in this paper are Bush Mosteller based CODIPAS-RL and Boltzmann Gibbs based CODIPAS-RL. Network selection using Bush Mosteller based CODIPAS-RL was discussed in [3]. Boltzmann Gibbs based CODIPAS-RL is implemented for routing in dynamic environment and its performance is found to be better than Bush Mosteller based CODIPAS-RL. Hence in this paper Boltzmann Gibbs based CODIPAS-RL is used for network selection process.

Network Selection Algorithms

Game theory is the study of mathematical models of conflict and cooperation between intelligent rational decision-makers. This tool used in understanding and modeling competitive situations. The main elements of a game are: the set of players, the set of actions, and the set of payoffs. The players in the game are the mobile users and/or the networks. Players seeking to maximize their payoffs can choose between different strategies, such as: available bandwidth, subscription plan. The payoffs can be estimated using utility functions based on various

decision criteria: monetary cost, energy conservation, network load, availability, etc.

Bush Mosteller based CODIPAS-RL

Reinforcement learners' use their experience to choose or avoid certain actions based on their consequences [3]. Actions that led to satisfactory outcomes will be repeated in the future, whereas actions that led to unsatisfactory experiences will be avoided. In Bush and Mosteller based reinforcement learning, players will decide the actions i.e., the strategy of each player is defined by the probability of undertaking each of the two actions available to them. Based on the action, each player determines the corresponding payoff (utility) and updates the action.

The probability of selecting an action a_j is given in eqn.(1). Where λ_j is the player j 's learning rate

($0 < \lambda < 1$), $S_{j,t}$ is the stimulus for the action a_j , t given in eqn. (2) and its value lies in the range $[-1, 1]$. The increase in values of stimulus or learning rate will increase the changes in network selection probability.

$$x_{j,t+1}(a_j) = x_{j,t}(a_j) + \lambda_j S_{j,t}(1 - x_{j,t}(a_j)) \quad (1)$$

$$S_{j,t} = \frac{u_{j,t} - M_j}{\sup_a |U_j(a) - M_j|} \quad (2)$$

Where, $U_{j,t}$ denotes the perceived utility at time t of player j , M_j is aspiration level of player j . Based on the action, payoff of user is determined using eqn. (3)

$$\hat{u}_{j,t+1}(a_j) = \hat{u}_{j,t}(a_j) + v(t) * (u_{j,t} - \hat{u}_{j,t}(a_j)) \quad (3)$$

Bush Mosteller based CODIPAS-RL considers present action of user j as well as the actions of other users. So it requires more memory and hence the time required for network selection using Bush-Mosteller based CODIPAS-RL is high.

Boltzmann Gibbs based CODIPAS-RL

The Boltzmann-Gibbs based learning scheme [3] (also called softmax) achieves equilibrium in small number of iterations itself i.e., time taken for network selection is less when compared to Bush Mosteller based CODIPAS-RL also computational capabilities and memory requirements are less. This is because Boltzmann Gibbs based CODIPS-RL produces the expected utility and makes decisions without the

knowledge of their opponents. The Boltzmann-Gibbs distribution is given by

$$B_{j,\epsilon}(\hat{u}_{j,t})(a_j) = \frac{e^{\frac{1}{\epsilon_j} \hat{u}_{j,t}(a_j)}}{\sum_{a_j \in A_j} e^{\frac{1}{\epsilon_j} \hat{u}_{j,t}(a_j)}}, a_j \in A_j, j \in K \quad (4)$$

eqn.(4) attains equilibrium when $1/\epsilon_j$ is large which denotes the rationality level of player j . The probability of selecting an action a_j is given in eqn. (5)

$$x_{j,t+1}(a_j) = x_{j,t}(a_j) + \lambda_j \left(\frac{e^{\frac{1}{\epsilon_j} \hat{u}_{j,t}(a_j)}}{\sum_{a_j \in A_j} e^{\frac{1}{\epsilon_j} \hat{u}_{j,t}(a_j)}} - x_{j,t}(a_j) \right) \quad (5)$$

Based on the action in (5), each player determines their payoff given in eqn.(6) and updates the action,

$$\hat{u}_{j,t+1}(a_j) = \hat{u}_{j,t}(a_j) + v(t) * (u_{j,t} - \hat{u}_{j,t}(a_j)) \quad (6)$$

Assuming that each player does not know their payoff, but only knows the estimation of average payoff of other actions. Hence the user takes a decision based on the average payoff to update the action. The steps for selecting a network are given as follows:

Step 1: Assume users are initially connected to a network and calculate the payoff in current network

Step 2: Check for the alternate networks where users can connect

Step 3: Determine the payoff and action of the users based on Boltzmann-Gibbs CODIPAS-RL.

Simulation Results

Simulation for integrated WLAN-WiMAX network using CODIPAS-RL is carried out for the specifications as shown in the Table 1

Table 1 Simulation settings of WLAN-WiMAX networks

Medium Access Protocol	MAC/802.11
Radio Propagation Model	Two Ray Ground
Routing protocol	CODIPAS-RL
Bounding box size	537 by 100
Packet size	256 bytes

Interface Queue(WLAN)	Queue/Drop tail
Interface Queue(WiMAX)	Queue/Drop tail
Queue Length	50

Based on the specification simulation setup has been done in NS2. The performance of the system (WLAN and WiMAX) has been carried out in isolated mode and integrated mode. The Packet Arrival Rate (PAR) as shown in the fig 2

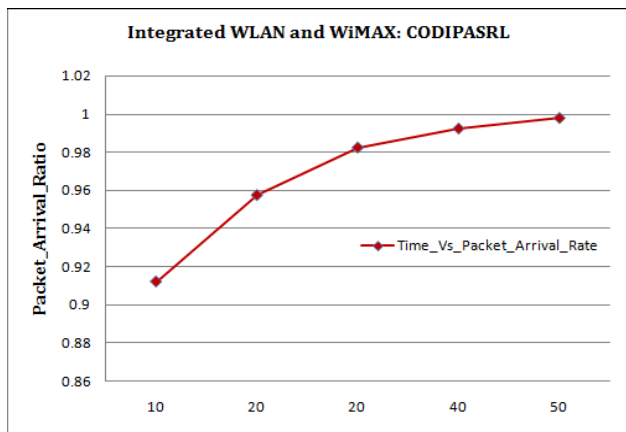


Fig 2: Packet Arrival Rate of integrated WLAN-WiMAX CODIPAS-RL

Fig.3 and 4 show the throughput of the system before and after integration.

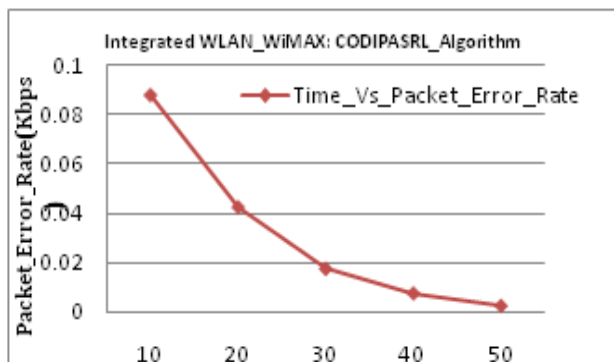


Fig 3: Packet Error Rate of Integrated WLAN-WiMAX Network (CODIPAS-RL)

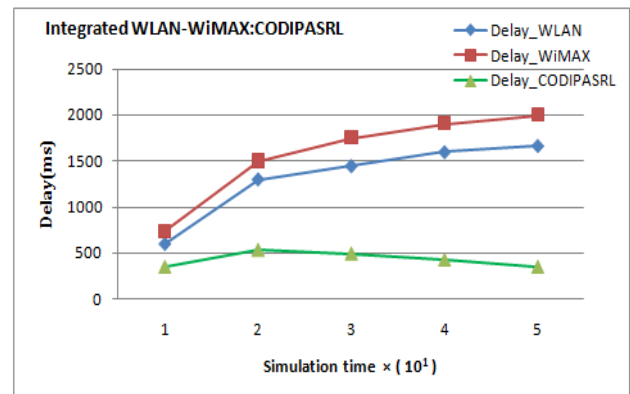


Fig 4: Comparison of WLAN, WiMAX, CODIPAS-RL Delay Parameter

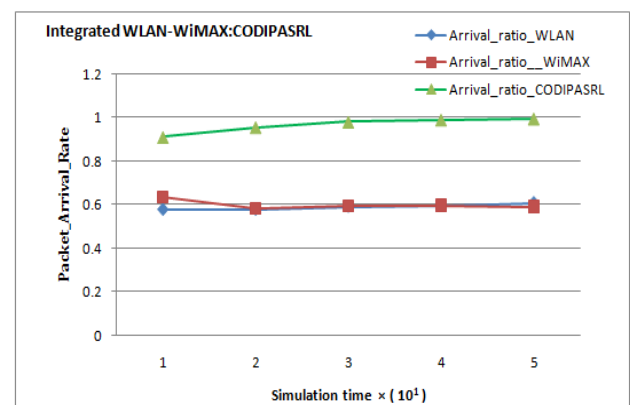


Fig. 5: Comparison of WLAN, WiMAX, CODIPAS-RL Packet Arrival Rate Parameter

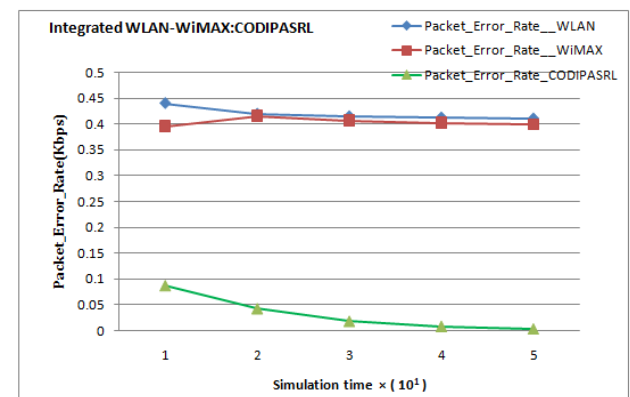


Fig 6: Comparison of WLAN, WiMAX, CODIPAS-RL Packet Error Rate Parameter

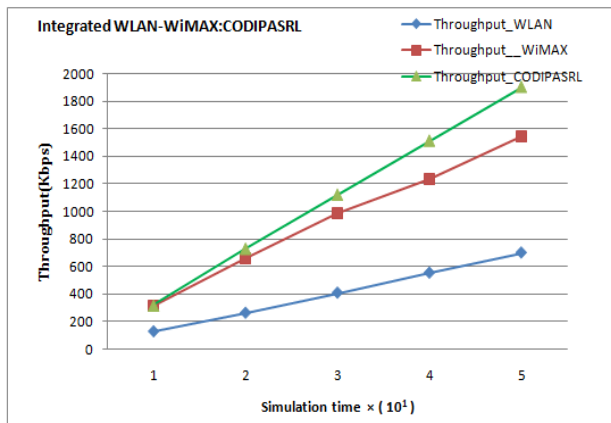


Fig. 7: Comparison of WLAN, WiMAX, CODIPAS-RL Throughput Parameter

Throughput Comparison of Proposed Algorithm between Static and Mobile Environment as shown in table 2

Table 2: Performance Comparison of Throughput

Throughput			
	WLAN	WiMAX	INTEGRATED WLAN-WiMAX
STATIC	185.25	298.38	1549.09
MOBILE	92.02	34.85	410.05

Conclusion

Network selection is performed using the proposed Boltzmann Gibbs based CODIPAS-RL because this algorithm performs network selection faster than the existing Bush Mosteller based CODIPAS-RL. i.e., Boltzmann Gibbs based CODIPAS-RL takes 60 iterations whereas Bush Mosteller based CODIPAS-RL requires 200 iterations for selecting a network. The simulation results show that the network in integrated mode outperforms the network in isolated mode for the QoS parameters Packet Error Rate (PER), Delay and Throughput.

In static environment, the compared results shows that the throughput related to the integrated WLAN-WiMAX Wireless networks using CODIPAS-RL is more than the isolated WLAN, WiMAX networks. In mobility environment the throughput is relatively less than the static environment.

References

- [1] Manzoor Ahmed Khan, Hamidou Tembine and Athanasios V. Vasilakos, "Game Dynamics and cost of Learning in Heterogeneous 4G Networks", *IEEE Journal on Selected Areas in Communications*, vol. 30, no. 1, pp.198-214, Jan. 2012.
- [2] Wang, S. Fan, C. Hsu, C. H. Sun, Q. Yang, F. "A Vertical Handoff Method via Self-Selection Decision Tree for Internet of Vehicles" *IEEE Journal*, Volume:PP, Issue: 99 pp 1 to 10, March 2014
- [3] H. Tembine and A. P. Azad, "Dynamic Routing Games: An Evolutionary Game Theoretic Approach", *IEEE conference on decision and control and European Control Conference*, pp.4516- 4521, Dec.2011
- [4] F. Zhu, J. McNair, "Multiservice vertical handoff decision algorithms", *EURASIP Journal on Wireless Communications and Networking*, 2006.
- [5] N. Nasser, A. et al, "Handoffs in fourth generation heterogeneous Networks", *IEEE communications magazine*, pp 96- 103, 2006.
- [6] N. Nasser, S. Guizani, E. Al-Masri, "Middleware vertical handoff manager: a neural network based solution" *Proceedings of the 2007 IEEE International Conference on Communications (ICC'07)*, Glasgow, Scotland, pp 56 71-5676, June 2007.
- [7] Nilakshee Rajule et al, "Survey of vertical Handover Decision Algorithms", *International Journal of Innovations in Engineering and Technology (IJJET)*, Vol. 2, pp 362-368, 2013.
- [8] F. Zhu, J. McNair, "Optimizations for vertical handoff decision algorithms" *IEEE Wireless Communications and Networking Conference (WCNC'04)*, pp 867- 872, 2004.
- [9] C. Chi, X. Cai, R. Hao, F. Liu. Modeling and analysis of handover algorithms, *Proceedings of the 2007 IEEE Global Telecommunications Conference (GLOBECOM'07)*, Washington, DC, USA, pp 4473-4477, 2007.
- [10] Juang. R. T, H. P. Lin and D. B. Lin, "An improved location-based handover algorithm for GSM Systems", *Wireless communications and networking conference*, pp 1371-1376, 2006.
- [11] Q. Y. Song and Abba S Jamalipour, "Network Selection in an Integrated Wireless LAN and UMTS environment using mathematical modelling and computing techniques", *IEEE Wireless Communications Magazine*, pp.42-48, June 2005.
- [12] D. E. Charilas and A. D. Panagopolous, "Multiaccess Radio Network Environments," *In IEEE Vehicular Technology Magazine*, vol.5, no.4, pp.40-49, Dec 2010.

[13] Q. T. Nguyen- Vuong, Y. Ghami- Doudane and N. Agoulmine, "On utility models for access network selection in wireless heterogeneous networks," *In IEEE Network Operations and Management Symposium (NOMS)*, 2008.

[14] H. Tembine and A. P. Azad, "Dynamic Routing Games: An Evolutionary Game Theoretic Approach," *IEEE conference on decision and control and European Control Conference*, pp.4516-4521, Dec.2011.

[15] H. Tembine, "Dynamic robust games in MIMO systems," *IEEE Transactions on systems Man and Cybernetics*, vol.99, no.41, pp.990-1002. Aug. 2011.

[16] Ramona Trestian, Olga Ormond and Gabriel-Miro Muntean, "Game Theory- Based Network Selection: Solutions and Challenges", *IEEE communications surveys and tutorials* ,pp.1-20, May 2011.

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