

Quality Dependent Vertical Handover Decision Algorithm for Fourth Generation (4G) Heterogeneous Wireless Networks

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Abstract

Future wireless networks must be able to coordinate services within a diverse-network environment. One of the challenging problems for coordination is vertical handoff, which is the decision for a mobile node to handoff between different types of networks. While traditional handoff is based on received signal strength comparisons, vertical handoff must evaluate additional factors, such as monetary cost, security, power consumption, network conditions, and user preferences. In this paper, several optimizations are proposed for the execution of vertical handoff decision algorithms, with the goal of maximizing the quality of service experienced by each user.

Keywords: Vertical handover, Heterogeneous wireless networks, Handoff decision parameters, User Preferences.

1. Introduction

Growing consumer demand for access to communication services anywhere and anytime is accelerating the technological development towards the integration of various wireless access technologies. Such integration combines islands of access networks into a seamless system, referred to as Fourth Generation (4G) wireless systems [1].

In a typical 4G networking scenario, handsets or mobile terminals with multiple interfaces will be able to choose the most appropriate access link among the available alternatives these include (IEEE 802.11 Wireless Local Area Network (WLAN) ,IEEE 802.16 Worldwide Interoperability for Microwave Access (WiMAX), satellite systems and Bluetooth). For a satisfactory user experience, mobile terminals must be able to seamlessly transfer to the “best” access link among all available candidates with no perceivable interruption to an ongoing conversation (which could be a voice or video session). Such ability to handover between heterogeneous networks referred to as seamless vertical handovers [2].

Traditionally, handoff research has been based on an evaluation of the received signal strength (RSS) at the mobile node. However, traditional RSS comparisons are not sufficient to make a vertical handoff decision, as they do not take into account the various attachment options for the mobile user. Other factors, such as, monetary cost, network conditions, mobile node conditions, Security , Power Consumption, monetary cost user preferences, etc., must be considered, as well as the capabilities of the various networks in the vicinity of the user. Thus, a more complex, adaptive and intelligent approach is needed to implement vertical handoff protocols to produce a satisfactory result for both the user and the network.

This paper presents an analytical vertical handover initiation model based on different network parameters. The handover performance evaluation criterion of Interest is to maximize the quality of service, increase the user satisfaction and reduce the cost of the network.

The remaining part of this paper is organized as follows. In Section 2, Introduction to vertical handover and management process 3, Vertical handover decision function 4, Cost Factor calculation 5, Result analysis and discussion finally, conclusion is provided in section VI.

2. Vertical handover

2.1 Overview of Handover process and Vertical handover

Handover is the process of maintaining a user’s active sessions when a mobile terminal changes its connection point to the access network (called “point of attachment”), for example, a base station or an access point. Depending on the access network that each point of attachment belongs to, the handover can be either horizontal or vertical [5]. A horizontal handover takes place between

points of attachment supporting the same network technology, for example, between two neighboring base stations of a cellular network. On the other hand, a vertical handover occurs between points of attachment supporting different network technologies, for example, between an IEEE 802.11 access point and a cellular network base station.

VHD (Vertical handover decision) algorithms help mobile terminals to choose the best network to connect to among all the available candidates.

2.2 Handover Management Process handover

There are three handover management process [6] .We briefly explain each of them below.

Handover Information Gathering: used to collect all the information required to identify the need for handover and the subsequently initiate it. It can be called also handover initiation phase or system discovery.

Handover Decision: used to determine whether and how to perform the handover by selecting the most suitable access network (taking into account some criteria such as user preferences) and by giving instructions to the execution phase. It is also called network or system selection.

Handover Execution: used to change channels conforming to the details resolved during the decision phase.

3. Vertical Handoff Decision Function

In this section we propose a vertical handoff decision function (VHDF). VHDF is used to measure the improvement gained by handing over to a particular network i .

As discussed earlier, handoff decisions parameters help determine which of the available networks is best suited for data transfer. Because of their importance, we choose the following network parameters for VHDF:

Cost of service (C): The cost of the different services to the user is a major issue, and can sometimes be the decisive factor in the choice of a network. For different networks, there would be different charging policy, therefore, in some situation the cost of a network should be taken into consideration in making handover decisions.

Security (S): For some applications, confidentiality or integrity of the transmitted data can be critical. For this reason, a network with higher security level may be chosen

over another one which would provide lower level of data security.

Power consumption (P): Vertically handing off to a high power consuming network is not desirable if the mobile terminal's battery is nearly exhausted or the battery's lifetime is relatively short [3].

Network conditions (B): Available bandwidth is used to indicate network conditions and is a major factor, especially for voice and video traffic. Available bandwidth is a measure of available data communication resources expressed in Kbit/sec. It is a good indicator of the traffic conditions in the access network.

Network performance (F): In some cases interference or unstable network connections might discourage a handoff decision.

4. Quality Factor Calculation

Handover Cost Function (HCF) is evaluated for any network that has been approved for consideration by the Handover Necessity Estimation. The network with the highest calculated value for HCF is the most desirable for the user based on his specified preferences (which were obtained through the User Interface and translated by Policy Transfer) [4]. The network quality Q_i , which provides a measure of the appropriateness of a certain network; i is measured via the function:

$$Q_i = f\left(\frac{1}{C_i}, S_i, \frac{1}{P_i}, B_i\right), \quad (1)$$

In order to allow for different circumstances, there is an apparent necessity to weigh each factor relative to the magnitude it endows upon the vertical handoff decision. Therefore, a different weight is introduced as follows:

$$Q_i = f\left(w_c \frac{1}{C_i}, w_s S_i, w_p \frac{1}{P_i}, w_b B_i\right), \quad (2)$$

Where, w_c , w_s , w_p and w_b are weights for each of the network parameters. The values of these weights are fractions i.e. they range from:

$$0 \leq w_c, w_s, w_p, w_b \leq 1, \quad (3)$$

And total of the weights must equal to 1.

$$w_c + w_s + w_p + w_b = 1, \quad (4)$$

Weights of different parameter are calculated as per the user preferences and power level of the mobile terminal. Four importance level are defines High, Medium, Low or None. The larger the weight of a specific factor, the more important that factor is to the user and vice versa. Since each network parameters has a different unit, it is necessary to normalize them in the cost function. The final normalize equations for n networks are

$$Q_i = \frac{W_c \left(\frac{1}{C_i}\right)}{\max\left(\left(\frac{1}{C_1}\right), \dots, \left(\frac{1}{C_n}\right)\right)} + \frac{w_s(S_i)}{\max\left((S_1), \dots, (S_n)\right)} + \frac{W_p \left(\frac{1}{P_i}\right)}{\max\left(\left(\frac{1}{P_1}\right), \dots, \left(\frac{1}{P_n}\right)\right)} + \frac{w_b(B_i)}{\max\left((B_1), \dots, (B_n)\right)} \quad (5)$$

Assume that the mobile terminal detects a new network. It calculates the network quality Q_i for its current network and for the newly detected network. The weights would already have fixed (but different) values that assign priorities to the various characteristics. VHDF simply calculates Q_i based on Eq. 5. The network with the highest Q_i is the preferred network. If the newly detected network receives a higher Q_i , vertical handoff takes place; otherwise, the device remains connected to the current network.

5. Result Discussion and Discussion

In this section, we provide the evaluation metrics used to analyze the performance of the Vertical handover decision (VHD) scheme as well as the numerical output and analysis.

In our work we consider three networks with different Bandwidth, power consumption, Security and monetary cost. Here we take two WLAN networks and one UMTS network. The network parameter table is shown in below.

Table 1: Network Parameter for performance evaluation

Network ID	1	2	3
Type	WLAN	WLAN	UMTS
Bandwidth (data rate)	2 Mbps	1 Mbps	384 Kbps
Monetary Cost (Rupees/min)	3	2	5
Security Level	1	2	7
Power Consumption	3	2	1

A performance parameter called user satisfaction is adopted to compare the results of consistently choosing one access network with using cost factor Calculation. The User satisfaction is calculated by adjusting the method in [4] to add more network parameter and their weights. Weights are calculated by applying the different importance levels and power of the network.

User's Satisfaction =

$$\frac{\text{Preferred_bandwidth} - \text{Actual_bandwidth}}{\text{Actual_bandwidth}} * W_b + \frac{\text{Preferred_cost} - \text{Actual_cost}}{\text{Actual_cost}} * W_c + \frac{\text{Preferred_security} - \text{Actual_security}}{\text{Actual_security}} * W_s$$

Where Preferred_bandwidth, Preferred_cost and Preferred_security are the preferred values of the network parameter specifies by the user. Actual_bandwidth, Actual_security and Actual_power level are the actual values of the network parameters. Preferred_bandwidth, Preferred_cost and Preferred_security are set to be fixed values of 500kbps, 5 rupees/min and 3 respectively.

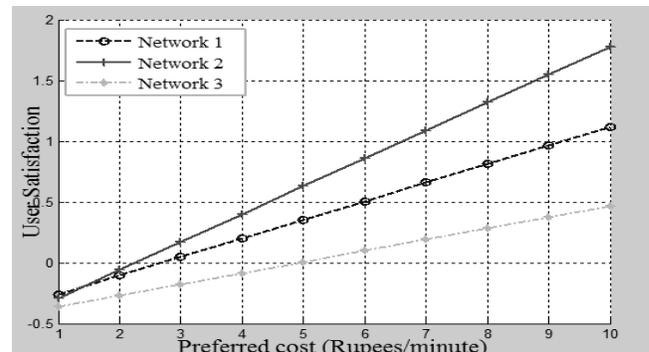


Figure 1: User's Satisfaction based on different preferred monetary costs.

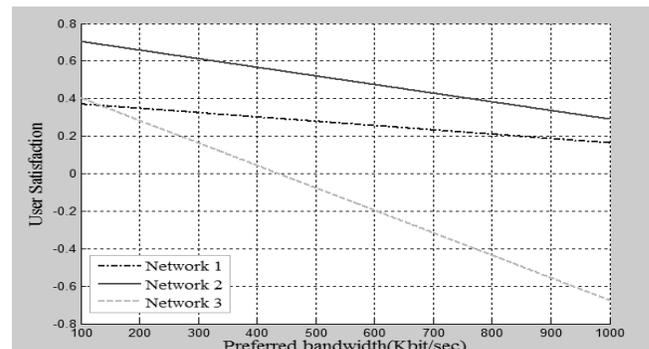


Figure 2: User's Satisfaction based on different preferred bandwidth.

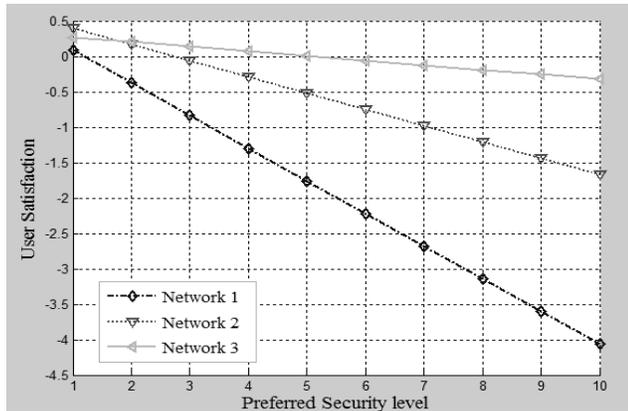


Figure 3: User's Satisfaction based on different preferred security level.

6. Conclusion

In this paper, a method to select the handover target network is presented. This method is combination of weight distribution and cost factor calculation. Weights of various network parameters are generated based on user preferences and the power level of mobile terminal, and cost factors of candidate networks are calculated using a cost function. The network with the Highest Q_i and lowest cost is selected as the handover target network. This method is able to maximize the user's satisfaction level by choosing the one access network.

References

- [1] I. F. Akyildiz, J. Xie, and S. Mohanty. A survey of mobility management in next-generation all-IP-based wireless systems. *IEEE Wireless Communications*, 11(4):16–28, 2004.
- [2] W. Mohr and W. Konhauser. Access network evolution beyond third generation mobile communications. *IEEE Wireless Communications Magazine*, 38(12):122–133, 2000.
- [3] N. Nasser, A. Hasswa, and H. Hassanein. Handoffs in fourth generation heterogeneous networks. *IEEE Communications Magazine*, 44(10):96–103, 2006.
- [4] A. Hasswa, N. Nasser, and H. Hassanein. Tramcar: A contextaware cross-layer architecture for next generation heterogeneous wireless networks. In *Proceedings of the 2006 IEEE International Conference on Communications (ICC'06)*, pages 240–245, Istanbul, Turkey, June 2006.
- [5] F. Zhu and J. McNair. Multiservice vertical handoff decision algorithms. *EURASIP Journal on Wireless Communications and Networking*, 2006(2):52, April 2006.
- [6] M. Kassar, B. Kervella, and G. Pujolle. An overview of vertical handover decision strategies in heterogeneous wireless networks. *Computer Communications*, 31(10):2607–2620, 2008.
- [7] R. Tawil, G. Pujolle, and O. Salazar. A vertical handoff decision scheme in heterogeneous wireless systems. In *Proceedings of the 67th Vehicular Technology Conference (VTC'08 - Spring)*, pages 2626–2630, Marina Bay, Singapore, April 2008.

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