SINR Based Vertical Handoff Algorithms : A Survey

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Abstract

The future wireless network integrates different access networks like cellular network, wireless local area network; metropolitan area network and personal area network all are capable of providing enhanced services to mobile users. In such converged systems, the seamless and efficient handoff between different access technologies (vertical handoff) is essential and remains a challenging problem. Vertical Handoff Decision algorithms widely employed in cellular systems, which use a threshold comparison of one or more specific metrics such as received signal strength (RSS), carrier-to-interference ratio (CIR), signal to interference and noise ratio (SINR), and bit error rate (BER) to trigger a handoff decision process. In most of the studies RSS is used as the main handover decision criterion. For guaranteed QoS, the vertical handoff algorithm must be QoS aware, which cannot be achieved with the use of traditional RSS criteria. Using the RSS as the handoff indicator, we are not achieving the best possible performance of the integrated wireless networks. The SINR (Signal to Interference and Noise Ratio) based vertical handoff can guarantee multimedia QoS specifying the achieved date rate for end user inside vertical handover zone. SINR based vertical handoff provides higher average throughput for end users as well consistently offer the end user with maximum available bandwidth compared to the RSS based vertical handoff, where performance differs under different network conditions. In this paper, a survey on SINR based vertical handoff decision algorithms is given. In the end, major existing problems and future research direction are discussed.

Keywords: *SINR, HWN, Vertical Handoff Decision, RSS*

1. Introduction

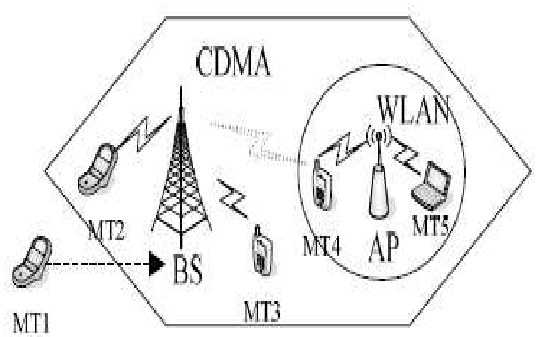
For seamless communication, integration of wireless local area network (WLAN) and third generation (3G) cellular networks (CN) such as wideband code division multiple access (WCDMA) system should be error free to achieve the next generation wireless networks (NGWN) [5]. The next generation (4G) wireless networks is envisioned as a convergence of different wireless access technologies providing the user with the best anywhere anytime connection and improving the system resource utilization. The integration of Wireless Local Area Network (WLAN) hotspots and third generation (3G) cellular network has recently received much attention. While the 3G-network will provide global coverage with low data-rate service, the WLAN will provide high data-rate service within the hotspots. Although increasing the underlay network utilization is expected to increase the user available bandwidth, it may violate the Quality-of-Service (QoS) requirements of the active real-time applications. Hence, achieving seamless handoff between different wireless technologies, known as vertical handoff (VHO), is a major challenge for 4G-system implementation [6]. All previous studies on vertical handoff are using *Received Signal Strength* (RSS) as the basic handoff decision indicator, in which handoff decisions are made by comparing the RSS with the preset threshold values. However, the achievable data rate of a mobile device is a function of received *Signal to Interference and Noise Ratio* (SINR), which is proportional to the distance between Access Point (AP) and Base Station (BS) to the mobile user, as well as the current interference level in the network. Using RSS based vertical handoff, a mobile device will handoff to another network, when it cannot receive the pre-established minimum receiving power from the original network. Use of RSS based vertical handoff in integrated WLAN and WCDMA networks to support multimedia services cannot provide the user with the multimedia QoS throughout, as the vertical handoff algorithm itself is not QoS aware. This may result in premature handoff from a WLAN to WCDMA, even though the user achievable data rate from WLAN is still much higher than it may get from WCDMA. Using the RSS as the handoff indicator, we are not achieving the best possible performance of the integrated wireless networks. To provide seamless handover between WLAN and WCDMA, a SINR based vertical handoff that can support multimedia QoS with adaptive data rate is desirable. The new vertical handoff algorithm not only can support the user with multimedia QoS and allow them achieving the maximum throughputs during vertical handoff, but also makes the load balancing between WLAN and WCDMA systems practical [8].

In this paper, following a brief introduction of Heterogeneous Wireless Network and vertical handoff techniques for heterogeneous networks, the current existing algorithm of vertical handoff decision based on SINR is described and summarized. The existing problems and future research directions are also discussed.

2. Background

2.1 Heterogeneous Wireless Network (HWN)

Wireless local area network (WLAN) and code division multiple access (CDMA) cellular networks are widely used to offer Internet services to users. WLANs offer relatively high data rates in smaller areas (hotspots). On the contrary, CDMA cellular networks support low data rates in a much wider area of coverage that enables ubiquitous connectivity.



MT:Mobile Terminal
BS:Base Station
AP:Access Point

Fig 1. Heterogeneous Wireless Networks [3]

The complementary characteristics of WLANs and CDMA cellular networks make it attractive to integrate these two wireless access technologies as a heterogeneous wireless networks (HWN), as shown in figure1. The operator's HWN would exploit the better characteristics of the different access technologies in terms of coverage, efficiency, or profitability [3].The Heterogeneous networks are expected to become a main focus in the development toward the next generation wireless networks.

2.2 Handoff Strategies

Users will expect to continue their connections without any disruption when they move from one network to another. This important process in wireless networks is referred to as handoff or handover. The BSs are the infrastructure (i.e., antennas, towers) that is deployed by the cellular operator to provide service in a geographic area. The handover process has been considered and studied among wireless networks using the same access technology (e.g., among cells of a cellular network), this kind of handover process is defined as horizontal handover (HHO). The new handover process among networks using different technologies is defined as vertical handover (VHO) [1], as shown in figure2. Vertical handoffs occur when a user changes association from one type of access network to another while maintaining an active session. If we consider heterogeneous wireless networks such as the B3G (Beyond 3 Generation) networks, with BSs from cellular networks using one access technology and access points (APs) from WLANs using a different one, we can say that a VHO is the mechanism by which an ongoing connection is transferred from one BS to an AP and vice versa. VHOs required in a B3G network environment have to be designed by considering the tradeoff among several technical objectives such as low latency, power saving, and required bandwidth. Furthermore, the handover decision in this case becomes a more complex process than in homogeneous wireless networks because of the additional parameters, besides the signal strength, that have to be considered [1].

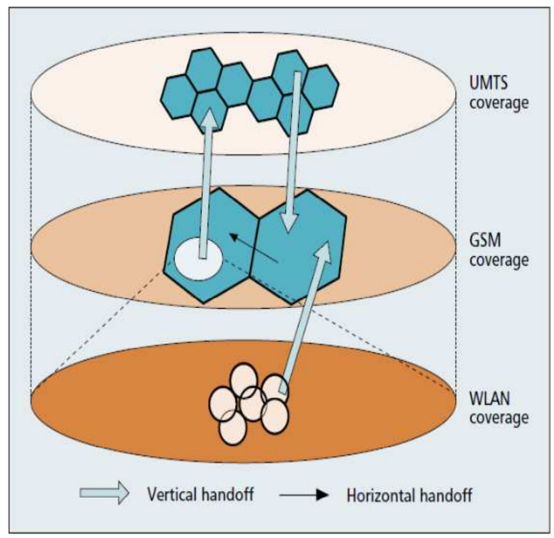


Fig 2. Vertical handoff and horizontal handoff of a mobile terminal [7]

3. Vertical Handoff

When mobile user transfers from one network to another the quality of service (QoS) offered by the network decreases under certain predefined quality level. This transfer mechanism is known as vertical handoff (VHO). The vertical handoff occurs in two ways. When the mobile user moves into the network that has higher bandwidth and limited coverage, vertical handoff request is initiated. This type of vertical handoff is called downward vertical handoff (DVH). When the mobile user moves out of its serving higher bandwidth network to the network with low bandwidth the handoff request initiated is called upward vertical handoff (UVH) [5].

3.1 Handover process

System discovery: During the system discovery phase, mobile terminals equipped with multiple interfaces have to determine which networks can be used and the services available in each network. The networks may also advertise the supported data rates for different services.

Handoff decision: the mobile device determines which network it should connect to. The decision may depend on various parameters including the available bandwidth, access cost, transmit power, current battery status of the mobile device, and the user's preferences.

Handoff Execution: connections need to be re-routed from the existing network to the new network in a seamless manner. This phase also includes the authentication and authorization, and the transfer of user's context information [4].

4. SINR Based Vertical Handoff Strategies

4.1 Combined SINR Based Vertical Handoff Algorithm

Yang et al. [8] presented a bandwidth based VHD method between WLANs and a Wideband Code Division Multiple Access (WCDMA) network using Signal to Interference and Noise Ratio (SINR). The SINR calculation of the WLAN signals is converted to an equivalent SINR to be compared with the SINR of the WCDMA channel

$$\gamma_{AP} = \tau_{AP}\left[\left(1+\frac{\gamma_{BS}}{\tau_{BS}}\right)^{\frac{W_{BS}}{W_{AP}}} - 1\right] \qquad (1)$$

SINR based handovers can provide users higher overall throughput than RSS based handovers since the available throughput is directly dependent on the SINR. Combined effects of both SINR from WLAN and WCDMA are being considered to decide on the handoff. It show that SINR based vertical handoff provides higher average throughput for end users comparing with the RSS based vertical handoff with various thresholds settings, and also can adapt to different network conditions, such as different noise level and load factor. It improves the overall system throughputs It introduces excessive handovers with the variation of the SINR causing the node to hand over back and forth between two networks, commonly referred to as ping-pong effect. In this paper other network parameter like traffic cost, network utilization are not taken into consideration.

4.2 Context Aware Vertical Soft Handoff Algorithm

This paper [11] proposes a context-aware vertical soft handoff algorithm (CAVSH) for heterogeneous wireless networks. CAVSH considers four key context parameters of both user and system e.g. user required bandwidth, user traffic cost, access network utilization, and user received SINR are fused to make the handoff decision as shown in figure 3. Soft handoff in WCDMA systems allows multi connection between the user and base stations during handoff, in contrast to single connection in hard handoff. The paper based upon comparative study of vertical hard handoff algorithm (CSVH) and vertical soft handoff algorithm (CAVSH). With the combined throughput using multi connection in vertical soft handoff (CAVSH), the system has much lower dropping probability, comparing with the vertical hard handoff (CSVH).During the vertical hard handoff (CSVH), the user is only allowed to connect with one BSs or APs that provides the maximum throughput. However, the vertical soft handoff (CAVSH) supports multi connections and allows the user traffic be split amongst different BSs and APs. BSs or APs with lower cost can be added to user’s active set and support part of the user’s traffic, even though these BSs and APs cannot provide the full user required bandwidth. Using the soft handoff mechanism, the user’s traffic can be split amongst multi-connections from different BSs and APs, with multi-attribute QoS consideration [11].

4.3 Multi-Dimensional Adaptive SINR Based Vertical Handoff

To provide seamless vertical handoff with multi-attribute QoS support, a MASVH algorithm proposed in [9] which uses SINR, user required bandwidth, user traffic cost and utilization of each WLAN Access Point (AP) and WCDMA Base Station (BS). The additional handoff criteria can be associated with the SINR value during the SINR conversion between different access networks, with a minimum addition computation cost. The algorithm follows the steps of a combined SINR based vertical handoff algorithm (CSVH) [8] but additional multi-attributes are derived as shown below:

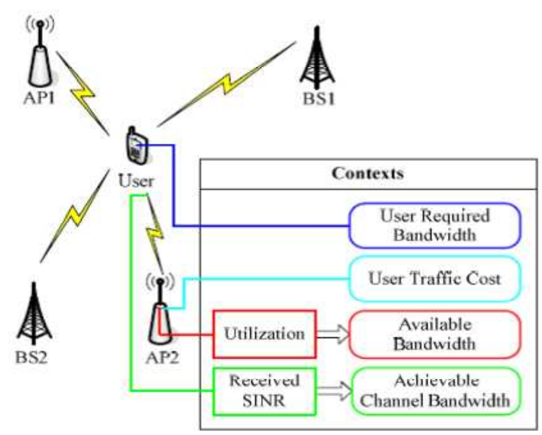


Figure 3.User and System Contexts [11]

- *User Required Bandwidth:*

For a required bandwidth R_i for a user i, the minimum receiving SINR from BS ($\gamma_{\min,i}$) can be calculated as:

$$\gamma_{min,i} = \tau_{BS}\left(2^{\frac{R_i}{W_{BS}}} - 1\right) \quad (2)$$

- *User Traffic Cost*

In order to directly associate the cost value with the SINR value, the cost per bit (c) is converted to cost per SINR (C_{SINR})

$$C_{SINR} = \tau_{BS}\left(2^{\frac{C}{W_{BS}}} - 1\right) \quad (3)$$

- *Access Network Utilization*

Let U be the system utilization vector, represented by the percentage of utilization of each candidate BS and AP:

$$U = U_{BS} \cup U_{AP} \quad (4)$$

- *Handoff Decision*

The integration of all criteria leads to the index of the best BS or AP from the candidate set $A(1)$ for user i, and is determined by:

$$Max\left(S_i - \gamma_{min,i} \middle| c_{SINR} \quad * e^{kU}\right) \quad (5)$$

It used the combined effects of SINR, user required bandwidth, user traffic cost and utilization from participating access networks to make handoff decisions. MASVH algorithm improves the system performance in terms of higher throughput and lower dropping probability, as well as reduces the user traffic cost for accessing the integrated wireless networks. A parameter k was used in MASVH algorithm to adjust the weight of utilization attribute in the multiple attributes, but how to find the optimal parameter k under different conditions was not discussed, and the relations of multiple attributes in the handoff decision and what is the proportion of each attribute according to the traffic characteristics and the system load were not investigated either.

4.4. An Improved TOPSIS Vertical Handoff Algorithm

In this paper [10], focus is on SINR(Signal to Interference plus Noise Ratio) ,AHP(Analytic Hierarchy Process) and information Entropy weight method based TOPSIS (SAE-TOPSIS) vertical handoff algorithm which uses the combined effects of SINR with SINR value from one network being converted to equivalent SINR value to the target network for getting the same data rate, user required bandwidth, user traffic cost and available bandwidth of the participating access networks to construct the attribute matrix and make handoff decisions for multi-attribute QoS consideration according to the features of the traffic. The information entropy method is employed to derive the objective weights of the evaluation criteria and on the basis, the comprehensive weight is obtained. TOPSIS algorithm makes decision according to the attribute matrix and weight vector. So the attribute matrix is as following:

$$R_a = \begin{bmatrix} S - \gamma_{min} \\ 1/C_{SINR} \\ U \end{bmatrix} \quad (6)$$

In the weight determining process, entropy method is adopted in combination with AHP in order to get more scientific and reasonable index weights. The AHP comparison matrix is as given below:

$$G_{c=} \ (g_{ij})_{l*l} \quad (7)$$

The relative weights of the factors are achieved through calculating the eigenvector of the matrix Gc. Four traffic classes defined by 3GPP are considered: conversational, streaming, interactive, and background. The SAE-TOPSIS algorithm for streaming traffic class achieves the highest throughput performance because the available bandwidth attribute has the most weight in the handoff criterion and so the network which has the most available bandwidth is selected considering the load balance [10].

5. Conclusions

In this paper, the present SINR based vertical handoff decision algorithm of heterogeneous network is summarized. SINR based handovers can provide users higher overall throughput than RSS based handovers since the available throughput is directly dependent on the SINR. SINR based vertical handoff algorithm can consistently offer the end user with maximum available bandwidth. SINR based does handoff actually when it is necessary. But RSS based sometimes does unnecessary handoffs under interference and noisy condition even though the signal strength in current network is still greater than the threshold. The decision algorithms which take comprehensive network parameters like user required bandwidth, user traffic cost, access network utilization, improves the system performance in terms of higher throughput and lower dropping probability. In converged wireless systems, efficient vertical handoff management between heterogeneous networks is critical to the overall system performance. Research into vertical handover decision algorithms in heterogeneous networks is still a challenging area.

6. Possible Research Direction

Designing of new handover decision policies and algorithms relating to soft, hard and hybrid handovers can be part of future research. In future work more adaptive methods can be implemented for SINR based VHD algorithm based on different conditions and user preferences. Focus can give towards analyzing handoff latency and reducing the number of handoffs.

References

[1] Enrique Stevens-Navarro, Ulises Pineda-Rico, and Jesus Acosta-Elias: "Vertical Handover in beyond Third Generation (B3G) Wireless Networks", International Journal of Future Generation Communication and Networking,vol.1,no. 1, pp 51-58, Dec 2008.

[2] Chandravva Hebbi,S.V.Saboji "Vertical Handoff in Heterogeneous Wireless Mobile Networks", First International Conference on Networks & Communications,2009,pp 66-71.

[3] Deng Qiang, Xie Dong-liang, Hu Bo, Shi Yan ,Chen Shan-zhi , "Joint Admission Control through Vertical Handoffs in Heterogeneous Wireless Networks", Mobile Congress (GMC), 2010,Global IEEE,pp 1-5

[4] Pramod Goyal, and S. K. Saxena, "A Dynamic Decision Model for Vertical Handoffs across Heterogeneous Wireless Networks", World Academy of Science, Engineering and Technology 41 2008,pp 676-681

[5] K.Ayyappan, R. Kumar, "QoS Based Vertical Handoff Scheme for Heterogeneous Wireless Networks", International Journal of Research and Reviews in Computer Science (IJRRCS), Vol. 1, No.1,pp 1-6

[6] Ahmed H. Zahran and Ben Liang,"Performance Evaluation Framework for Vertical Handoff Algorithms in Heterogeneous Networks", pp 1-6, May 2005.

[7] S Y Hui & K H Yeung, "Challenges in the Migration to 4G Mobile Systems", IEEE Commuications, vol 41, no 12, Dec 2003, pp 54-59.

[8] K. Yang, I. Gondal, B. Qiu and L. S. Dooley, "Combined SINR Based Vertical Handoff Algorithm for Next Generation Heterogeneous Wireless Networks", Globecom 2007, Washington, US, 2007.

[9] K.Yang, Gondal,B.Qiu, "Multi-dimensional adaptive SINR based vertical handoff for heterogeneous wireless networks",IEEE Com.Letters,June 2008, pp 438-440

[10] Liu Sheng-mei, Pan su, Xu Ming-hai, "An Improved TOPSIS Vertical Handoff Algorithm for Heterogeneous Wireless Networks",IEEE International Conference on Communication Technology (ICCT), pp. 750-754,Jan 2010.

[11] Kemeng Yang, Iqbal Gondal and Bin Qiu, "Context Aware Vertical Soft Han doff Algorithm For Heterogeneous Wireless Networks", IEEE Vehicular Technology Conference, 2008, pp1-5.