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An efficient handover and channel management approach in integrated network

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***Abstract* - To support ubiquitous wireless service, one possibility is to integrate the narrow-range WiFi network with the WiMax wide-range network. Under that, resource allocation algorithms and conducting energy-efficient handovers are critical issues and the focus in on these parameters. Due to the limited availability of spectrum and shared nature of wireless medium, design of efficient resource allocation mechanisms to provide the crucial Quality-of-Service is a major issue involved. In order to ensure fair access and efficiency of bandwidth usage in wireless integrated networks, resource allocation algorithms should be well designed. To achieve this, a *Prioritized Resource Sharing algorithm* is proposed. To save the energy, a *handover scheme with geographic mobility awareness* (HGMA) is proposed by considering the past handover patterns of mobile devices.**

***Keywords* – Handover, Algorithm, WiMax**

I. INTRODUCTION

The architecture for the next generation of wireless networks aims to integrate multiple networks and benefit from the resulting synergy. The most commonly studied integrated networks includes cellular network combined with WLAN. Although 2.5 and 3G cellular data services offer wide area Internet connectivity, these services do not provide the broadband speeds to which users have become accustomed. WiMax on the other hand, can provide high speeds along with the quality of service. Service providers can offer their subscribers a more complete suite of broadband services in more places, by combining WiMax and WiFi technologies. However, due to the limited availability of spectrum and shared nature of wireless medium, design of efficient resource allocation mechanisms to provide the crucial Quality-of-Service (QoS) requested by the subscribers is a major issue involved in the integration of both these networks.

II. PRIORITIZED RESOURCE SHARING

For our system model we consider a tightly coupled architecture based on WiMax and WiFi networks as shown in Fig. 1. In this architecture there is a WiMax base station encompassing multiple WiFi hotspots. The WiMax BS connects to the Internet and acts as the backbone to the WiFi network. The WiMax subscribers referred as subscriber stations, communicate directly to the WiMax Base Station (BS) whereas the WiFi users have to use a special access point (AP) to communicate with the WiMax BS. This special access point is named as *WiFi -WiMax Bridge* (WWB). The WiMax interface is used for communicating with the BS, and WiFi interface for communicating with WLAN stations. Since the range of WiFi users are much smaller than the WiMax counterparts and the access mechanism of WiFi (random) and WiMax (time slotted) are different, the WWB acts as a link for WiFi users to reach the WiMax BS. The WWB aggregates all the WiFi user traffic and requests the WiMax base station for a service. The traffic from WiFi- WiMAX bridges are just referred to as WiFi users/traffic since they forward the aggregated WiFi requests and the traffic from WiMax subscriber stations is referred to as WiMax users/traffic. In the current work, we focus on the prioritization of these two different traffics and the corresponding changes in channel utilization and blocking of traffic. We assume that each cell has a total of N channels. The admission control residing in the BS manages the resource N between the two types of traffics.

In PS scheme as shown in Fig. 1 both the WiMax and WiFi users are allowed to access all the channels if they are free on first comes first serve basis like in CS scheme. This allows the users to use the full capacity of the system.

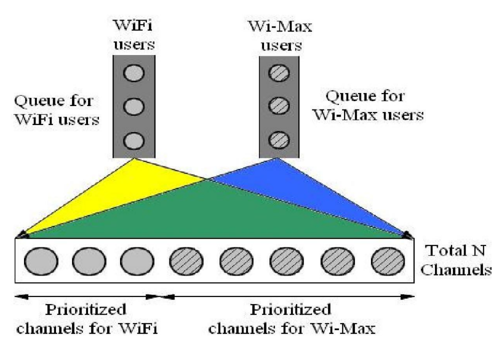


Fig. 1 : Prioritized Resource Sharing

In PS scheme, QoS is achieved by *prioritizing* the channels to WiMax and WiFi users according to their respective QoS requirements rather than strict reservation. In Fig.1, WiMax has five prioritized channels and WiFi has three, but all the eight channels can be accessed by any user if they are available. It is important to note the difference between the terms *shared*, *reserved* and *prioritized*. *Shared* means that the channels can be accessed by anyone, on a first come first serve basis. *Reserved* means that the channels are allocated to a particular class and no use of any other class can access them. *Prioritized* means that the channels can be accessed when they are free but a user can be terminated and queued to accommodate other class of users if certain pre-defined criteria is met. Channel reservation or prioritization does not mean that particular channels (band) are allocated to a class of users. It means that a certain number of channels are allocated and not any band in specific.

III. WIMAX-WIFI INTEGRATED NETWORK ARCHITECTURE

The system architecture of a WiMAX-WiFi integrated network has two tiers, as shown in Fig. 3. We assume that both these WiMAX and WiFi networks belong to the same service provider. Each MD is equipped with dual 802.11b/g and 802.16e interfaces, but it only needs to turn on one interface at time.

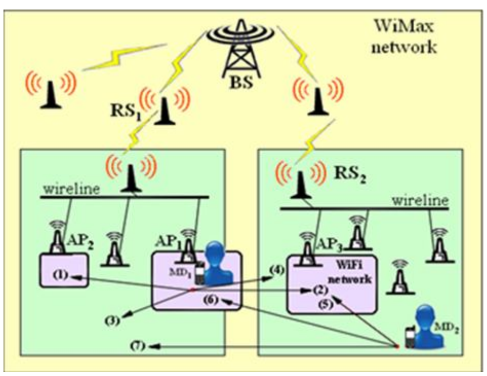


Fig. 2. WiFi-WiMax Architecture

There are seven handover cases in the WiMAX-WiFi integrated network, as numbered by 1–7 in Fig:

1) MD1 handovers from AP1 to AP2. AP1 and AP2 have the same parent RS1.
2) MD1 handovers from AP1 to AP3. AP1 and AP3 have different parent RSs.
3) MD1 handovers from AP1 to its parent RS1.
4) MD1 handovers from AP1 to another RS2.
5) MD2 handovers from RS2 to its child AP3.
6) MD2 handovers from RS2 to another AP1.
7) MD2 handovers from RS2 to RS1.

Where MD-Mobile device, AP-Access points, RS-Relay station.

In cases 3 and 4, the MD has to switch to the WiMAX mode. In cases 5 and 6, the MD can switch to the WiFi mode to save energy. The above cases can be categorized into two classes. The *HOAP class* contains handover cases 1–4, where an MD moves out of its current AP. The *HORS class* contains handover cases 5–7, where an MD moves out of its current RS.

IV. THE HGMA SCHEME

In the literature, research efforts [6], [7], [8], [9], [10] have focused on how to conduct handovers between a low bandwidth cellular network and high-bandwidth WLANs. These results may not be directly applied in our WiMAX-WiFi integrated network because both WiMAX and WiFi are high-bandwidth networks. The HGMA scheme is better explained by the figure below.

A. When to Trigger a Handover

In the HOAP class, the MD will periodically measure the average RSS from its associating AP. Typically, a low RSS will trigger an MD to start a handover process. To alleviate the ping-pong effect when an MD is around cell boundaries due to temporal RSS dropping, we propose adaptively adjusting the observation period to

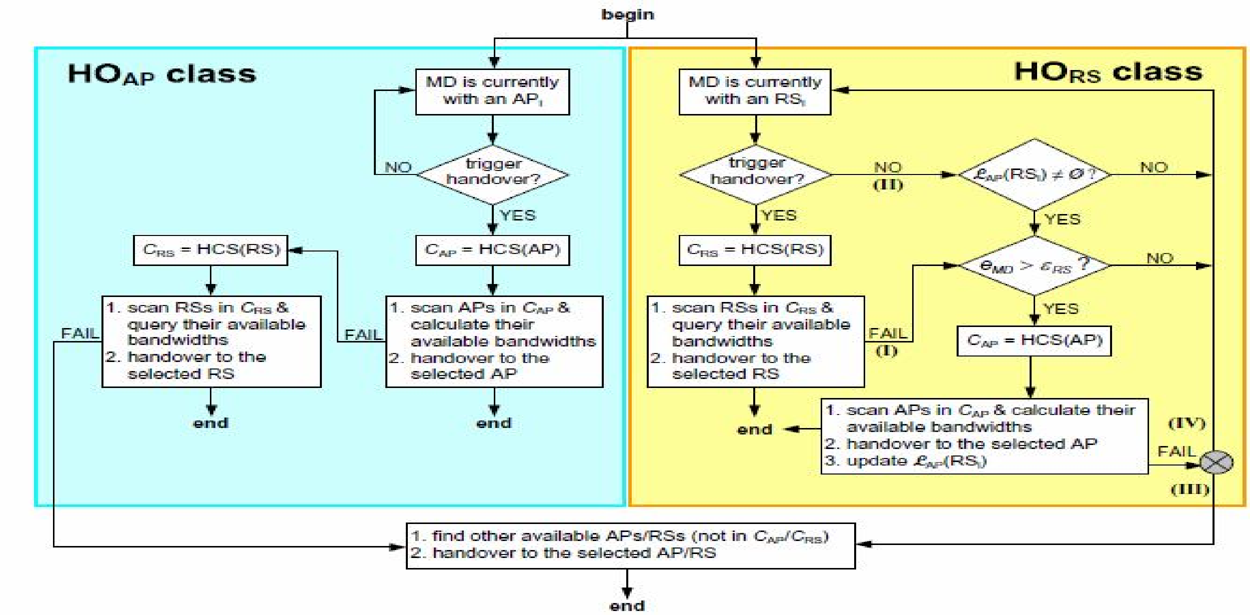


Fig. 3. The HGMA scheme

$$T_{AP}(V) = \frac{V_0(AP)}{V} \times T_0(AP)$$ where, $V_0(AP)$ is the average speed of the MD when it is within WiFi networks, V is the MD's current speed, and $T0(AP)$ is a constant representing the MD's average observation period. When the average RSS is below the handover threshold for a period of TAP (V) time, it means that the MD is very close to the coverage boundary of that AP. Thus, the MD has to trigger a handover event. Similarly, in the HORS class, the MD will continuously measure the average RSS from its associating RS. When the RSS is below the handover threshold for a period of TAP (V) time, it means that the MD is very close to the coverage boundary of that AP. Thus, the MD has to trigger a handover event. Similarly, in the HORS class, the MD will continuously measure the average RSS from its associating RS. When the RSS is below the handover threshold for a

Period of $T_{RS}(V) = \frac{V_0(RS)}{V} \times T_0(RS)$ time, a handover event should be triggered.

V. EXPERIMENTAL RESULTS

In this section, we present some simulation results to verify the effectiveness of the proposed HGMA scheme. Our simulations are conducted by the IEEE 802.16 modules based on ns-2 [17]. The physical layer adopts an OFDM (orthogonal frequency division multiplexing) module and the radio propagation model is set as two-ray ground. For WiFi networks, we consider an *association failure probability* p = 0.2 ~ 0.4. When an AP suffers from a higher p (due to reasons such as contention), it will cause MDs to associate with it with a lower probability. We consider two types of network topologies. In the *dense* topology, each RS has 10 child APs. In the *random* topology, each RS has arbitrarily 0 to 10 child APs. Each MD will consume 5% of its energy every five minutes. We rank an MD's remaining energy by levels. When fully charged, the energy level is γ, where $\gamma \in$ N. The calculation of energy level is as follows:

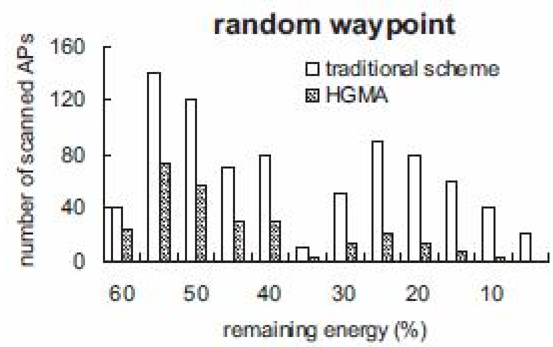
$$\frac{current.remaining.energy}{fully.charged.energy} * \gamma$$

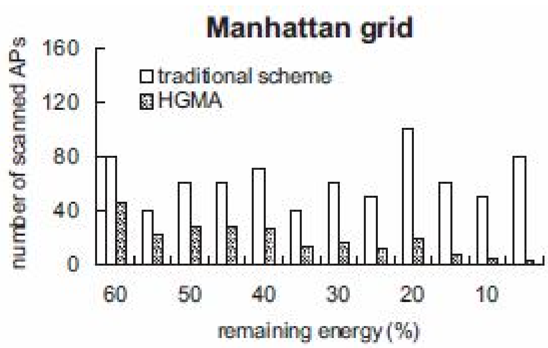
We set ε_{RS}=1 and W_v=W_t=1/2

The BonnMotion tool [18] is adopted to generate two types of mobility models of MDs. In the *random waypoint model*, an MD randomly chooses one destination to move to, with an average speed of [0,1]m/s. When the MD reaches its destination, it pauses approximately 120 seconds and then selects another destination to move to. In the *Manhattan grid model*, MDs move on a number of horizontal and vertical streets in an urban area. The speeds of MDs range from 0.5 to 1 m/s, with a maximum pause time of 120 seconds. Each MD may change its direction when it reaches an intersection, with a turning probability of 0.5. In our simulations, we set $V0(AP)$ = 0.5m/s, $V0(RS)$ = 1m/s, and $T0(AP)$ = $T0(RS)$ = 100 μs. We mainly compare our HGMA scheme with the traditional handover scheme, where a handovering MD will scan all APs/RSs around it.

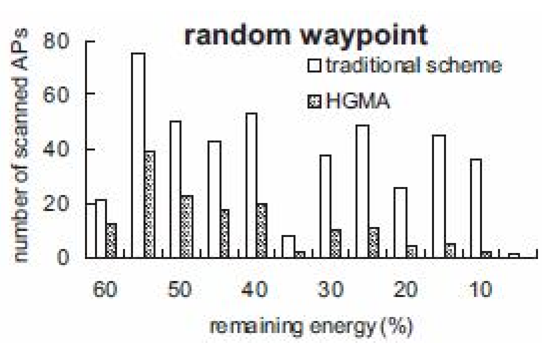
A. Number of Network Scanning

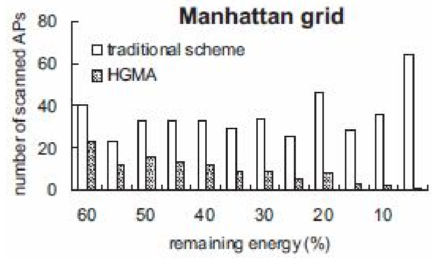
Fig. 3 shows the average number of APs scanned by MDs. Clearly, the average number of APs scanned by MDs in the dense topology is larger than that in the random topology because the former has a lager AP density. The traditional handover scheme will ask MDs to scan all possible APs around them, even though they have low remaining energy. On the contrary, HGMA allows MDs to scan less APs when they have low energy. In this way, the energy of MDs can be conserved. When comparing these two mobility models, we can observe that HGMA will cause more scans in the random waypoint model than in the Manhattan grid model when there are more than 45% of remaining energy. This is because the random waypoint model has a less regular mobility pattern, causing lower predictability, and a higher *n*exp value is used. With the Manhattan grid pattern, the candidate APs/RSs are more predictable. Table II summarizes the average reduction of the number of APs scanned by MDs in our HGMA scheme. We can observe





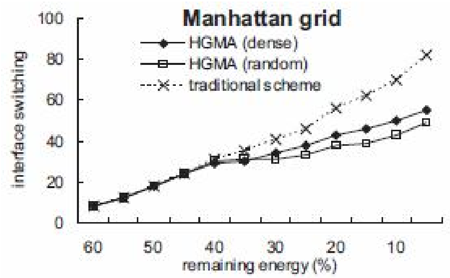
(a) dense topology





(b) random topology

Fig. 3: Average number of APs scanned by MDs.



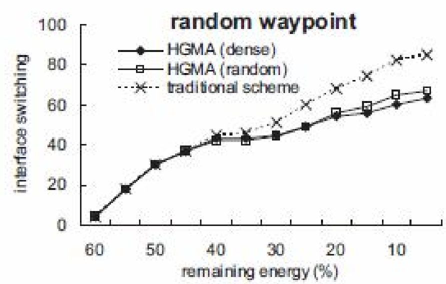


Fig. 4: Cumulative number of interface switching.

B. Cumulative Number of Interface Switching

Fig. 4 shows the cumulative number of interface switching of MDs. When MDs have more than 40% of remaining energy, HGMA has almost no effect on interface switching. This is because it encourages those MDs associating with RSs to handover to WiFi networks when they have more energy. However, when MDs have less remaining energy, HGMA will prevent them from frequently switching network interfaces. From Fig. 4, we can observe that HGMA causes the least interface switching under the Manhattan grid model due to the predictable GM feature. In average, HGMA can reduce about 30% of the number of interface switching.

C. Cumulative Number of Handovers to APs

Fig. 5 shows the cumulative number of handovers to APs. When the failure probability *p* increases, the number of handovers to APs will decrease. From Fig. 5(a), we can observe that HGMA can still perform well even with a larger *p*. This is because the AP density is large enough and thus MDs can easily find an AP to handover to. On the other hand, in Fig. 5(b), the improvement of HGMA is less significant when *p* is larger. This is because MDs may not always find suitable APs in their neighbourhood. However, when MDs move in the more regular Manhattan grid model, HGMA can increase the possibility that MDs associate with WiFi networks. Table III gives the improvement of the number of handovers to APs by HGMA. In average, HGMA can increase 64.1% and 16.1% of probability for MDs to associate with APs when *p* is set to 0.2 and 0.4, respectively.

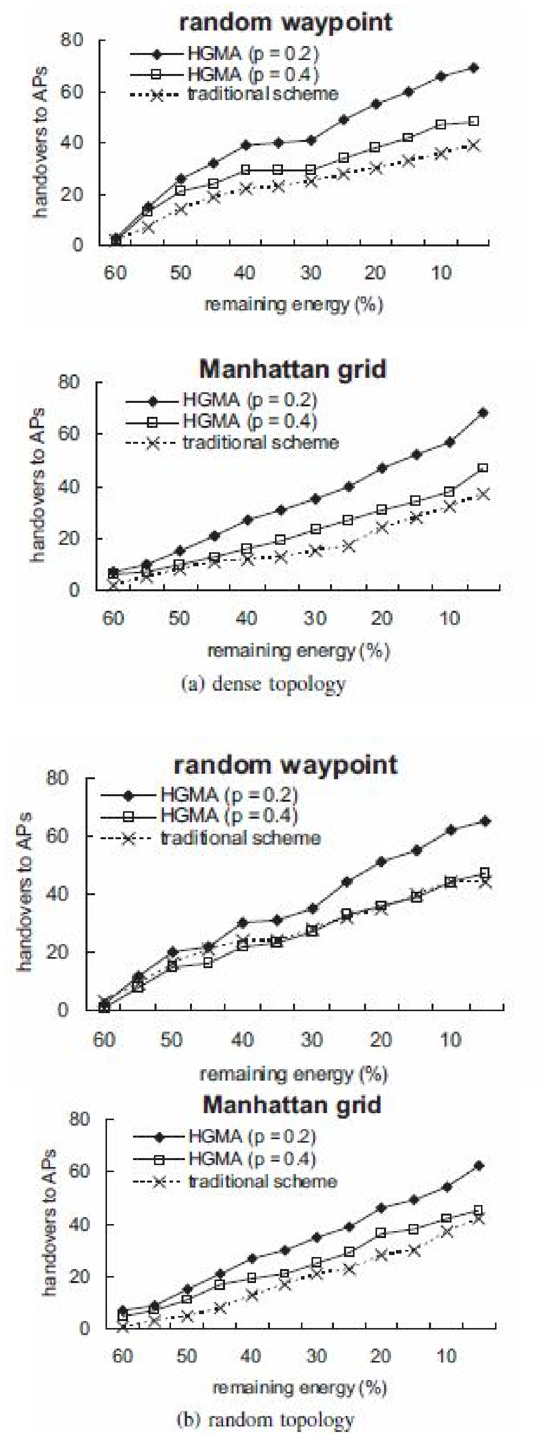


Fig. 5: Cumulative number of handovers to APs.

VI. CONCLUSION

In this paper, we have discussed about WiMAX-WiFi integrated network architecture and the corresponding handover scenarios. We have proposed an energy-efficient HGMA handover scheme. By eliminating unnecessary handovers, reducing the number of network scanning, and avoiding too many interface switching, our HGMA scheme can significantly conserve the energy of MDs related to handover. Design of efficient resource allocation algorithms is very important in integrated networks in order to ensure efficient bandwidth usage and fair access to all the participating networks. In this paper, *Prioritized Sharing* (PS) algorithm is proposed for resource sharing in WiMax-WiFi integrated networks.

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