Journal of Theoretical and Applied Information Technology

www.jatit.org

RSS MEASUREMENT FOR VERTICAL HANDOFF IN HETEROGENEOUS NETWORK

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ABSTRACT

Next generation wireless network is envisioned as a convergence of different wireless access technologies providing the user enhanced connection any where any time to improve the systems resource utilization. It is likely that WLAN/HIPERLAN will become an important complementary technology to cellular networks and typically used to provide hotspot coverage where there is a high density of users. In such converged systems, co-existence of heterogeneous access technologies with largely different characteristics like data rate for cellular network (2 Mbps), WLAN 802.11b (11 Mbps) and HIPERLAN (54 Mbps) results in handoff asymmetry that differs from the traditional intra-network handoff (horizontal handoff). The seamless and efficient handoff between different access technologies (vertical handoff) is essential and remains a challenging problem. In this paper, it is devised to evaluate the performance of vertical handover in terms of received signal strength measurement with suitable propagation model in heterogeneous network for hotspot communication and it is validated by simulations.

Keywords: *Heterogeneous wireless networks, Wireless LAN, HIPERLAN, Vertical Handoff, Path loss, Received signal strength measurement.*

1. INTRODUCTION

The development and proliferation of wireless, mobile technologies has revolutionised communications. Ubiquitous connectivity, however, has yet to be achieved, especially for data services. A future wireless network is expected to consist of different types of wireless networks, each providing different access bandwidth and coverage level. The trend is to utilize high bandwidth wireless local area network (WLAN) resource for mobile users in hotspots and switch to cellular networks (CN) when the coverage of WLAN is not available or the network condition in WLAN is not good enough. The switching over between WLAN/HIPERLAN and cellular network is referred as vertical handover (VHO). By combining wide coverage next-generation cellular systems and high bandwidth WLAN/HIPERLAN, users can utilize most of resources in wireless communication.

In next-generation heterogeneous wireless systems, one of the major challenges is seamless vertical handoff. Handoff takes place either due to progress of mobile units or due to unfavorable conditions inside an individual cell or between a numbers of adjacent cells [1, 2]. To determine the handoff, parameters used are received signal strength, signal to noise ratio and bit error rate [3].Handoff suffers from ‘ping pong’ effect when mobile users are near the boundaries of adjacent cells or WLAN/HIPERLAN - cellular boundary. This would result in frequent handoff between the networks. The connection reliability can be improved by using an appropriate path loss model. Hence, choice of path loss model plays an important role in the performance of handoffs. Therefore propagation models are useful in predicting signal attenuation or path loss. This path loss information is used as a controlling factor for system performance or coverage so as to achieve better reception [4].

Vertical handoff includes three sequential steps namely handoff initiation, handoff decision and handoff execution. Handoff initiation is concerned with measurement of received signal strength. Handoff decision monitors the current network connection, recognizes the need for handoff and selects the appropriate network or base station (BS)/access point (AP) to handover. Handoff execution establishes the connection with new network. In this paper, an efficient vertical handoff decision is taken between cellular and WLAN/HIPERLAN network based on RSS measurement.

The work is organized as follows. Section 2 describes the RSS measurement using propagation model for wireless networks such as CN, WLAN, and HIPERLAN. Section 3 deals with the performances of networks in terms of path losses and received signal strength. Section 4 discusses the vertical handover scheme Section 5 concludes with the performance of the heterogeneous network vertical handoff scheme.

2 RSS MEASUREMENT USING PROPAGATION MODEL

In mobile communication, micro cells are generally small, providing a coverage range in meters, and used for indoor communication. Propagation models have been determined for hotspot communication for the wireless access technologies like cellular network, WLAN/HIPERLAN [5]. These propagation models are based on extensive experimental data and statistical analyses to compute received signal level in a given propagation medium and are used for handoff initiation. The usage and accuracy of these propagation models depends on propagation environment [6].

Received signal strength is the measurement of power present in a received radio signal. Signal must be strong enough between base station and mobile unit to maintain signal quality at receiver. The signal gets weaker as mobile moves far away from BS/AP and gets stronger as it gets closer to. BS/AP Handoff decision is based on received signal strength from current BS to neighboring BS of CN or AP of WLAN. The received signal strength for different types of wireless networks like cellular network, WLAN and HIPERLAN are calculated and explained in subsequent sections.

2.1 CELLULAR NETWORK

Micro cells are cells that span hundreds of meters to a kilometer or so and are usually supported by below rooftop level base station antennas mounted on lamp posts or utility poles. They are deployed in streets in urban areas where tall buildings create urban canyons. The propagation characteristics are quite complex with the propagation of signals affected by reflection from buildings, ground and scattering from nearby vehicles [7]. For obstructed paths diffraction around building corners and rooftops become important. Bertoni et al have developed various empirical path loss models based on signal strength measurements and they perform very similar to the Okumura-Hata model for a variety of situations.

The path loss in dB for cellular network in micro cell environment is given by

$$\begin{aligned} PL = 135.41 + 12.49 \log(f) - 4.99 \log(h_{bs}) \\ + [46.84 - 2.34 \log(h_{bs})] \log(d) \end{aligned} \quad (1)$$

where d is distance in kilometer, f is frequency in MHz and h_{bs} is effective base station antenna height in meters.

The received signal strength for cellular network is expressed in dBm as

$$P_{CN} = P_t + G_t - PL - A \quad (2)$$

where, P_{CN} is received signal strength of CN in dBm, P_t is transmitted power in dBm, G_t is transmitted antenna gain in dB, PL is total path loss in dB and A is connector and cable loss in dB.

2.2 WIRELESS LOCAL AREA NETWORK

Wireless local area network is becoming increasingly popular in corporate, residential and hotspot environments. The most prominent standard in use today is IEEE 802.11b which provide bit rates of 11Mbps and IEEE 802.11a provide bit rates of 54 Mbps. Operators with cellular network could add WLAN as an additional service, enabling them to provide their customers with the access possibilities especially for the areas where there is a high density of users [8].

Log-linear path loss propagation model with shadow fading is given by

$$PL = L + 10\,n\log(d) + S \qquad (3)$$

where L is constant power loss, n is path loss exponent with values between 2 to 4, d represents the distance between the mobile node and WLAN access point (AP) and S represents shadow fading which is modeled as Gaussian with mean μ=0 and standard deviation σ with values between 6-12 dB depending on the environment.

The received signal strength for WLAN is expressed in dBm as

$$P_W = P_t - PL \qquad (4)$$

where, P_W is received signal strength of WLAN in dBm, P_t is the transmitted power,

When RSS is below a certain interface sensitivity level the mobile terminal is unable to communicate with the AP.

2.3 HIPERLAN

High Performance Radio LAN (HIPERLAN) is one of the wireless broadband access networks, which will provide high speed communication between mobile terminals and various broadband infrastructure networks. HIPERLAN provide channel data rates up to 54 Mbps over short ranges up to 200m. The Propagation model uses geographic data (terrain, building, foliage and ground) [9] to calculate the power in radio channel.

Path loss indoor propagation model with shadow fading is given by

$$PL = 46.7 + 20\log(d) + S \qquad (5)$$

Path loss outdoor propagation model with shadow fading is given by

$$PL = 46.7 + 20\log(d) + 0.3\sqrt{d} + S \qquad (6)$$

where d is the distance between the mobile node and access point and S is the outdoor log normal shadowing.

The received signal strength for HIPERLAN model is expressed in dBm as

$$P_{HL} = P_t - PL \qquad (7)$$

where, P_{HL} is received signal strength of HIPERLAN in dBm, P_t is transmitted power in dBm and PL is total path loss in dB

3 PERFORMANCE ANALYSIS

The performance of different types of wireless networks like cellular network, WLAN and HIPERLAN are calculated in terms of path loss and received signal strength using the parameter shown in Table 1.

Table 1: Simulation Parameter

Parameters	Values
Base station transmitter power	33 dBm
Base station antenna height	30 m
Transmitter antenna gain	17.5 dB
Threshold level for mobile	-102 dBm
Base station transmission band Frequency	(869-894) MHz
Duplexer loss	1.5 dB
Connector and cable loss	5 dB
Maximum downlink loss	161.8dB
Access point transmitter power	20 dBm
Path loss exponent (Urban cellular radio)	3
Mobile threshold level (CN to WLAN)	-80 dBm
Mobile threshold level (WLAN to CN)	-85 dBm
Standard deviation (indoor)	7 dB
Standard deviation (outdoor)	8dB

Path losses for various wireless networks such as CN, WLAN and HIPERLAN networks at hotspot area are calculated using propagation model and shown in Table 2. The path loss for cellular network based on Bertoni micro cell mode1 was calculated using equation (1). Maximum allowable uplink loss for Nortel S8K transceiver is 161.5 dB and maximum allowable downlink loss is 161.8 dB. Path loss at 500 meter is 151.9 dB which is less than threshold value is shown in *Figure1*. WLAN path loss was calculated using log linear propagation model as given in equation (3).Path loss was calculated for n=3 for shadowed urban cellular radio. At 200 meter path loss was 97.73 dB for n=3 as shown in

Figure 2. HIPERLAN path loss was calculated using (5) for indoor propagation and shown in *Figure2*.

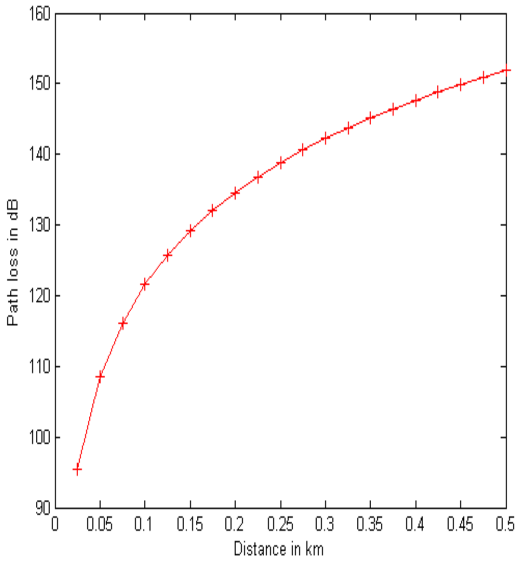

Figure1 Path loss Vs Distance (CN)

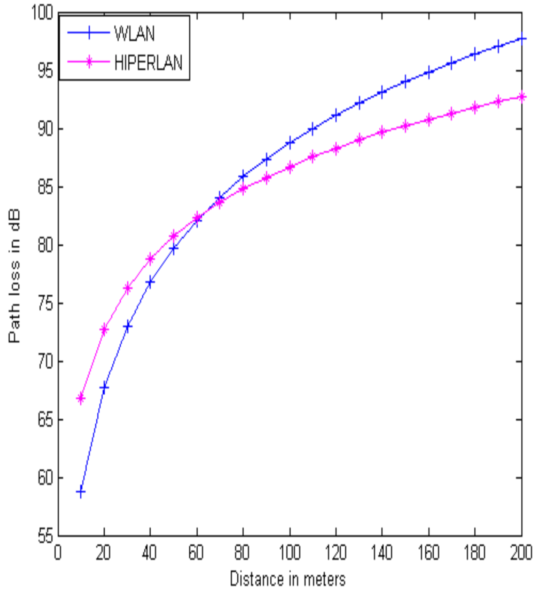

Figure2 Path loss Vs Distance (WLAN/HIPERLAN)

Table 2: Path loss in dBfor CN/WLAN/HIPERLAN network

Range	**WLAN**	**HIPERLAN**	**Range**	**CN**
		Indoor/ outdoor		
50 m	79.67	80.68 / 82.8	200 m	134.6
100 m	88.70	86.70 / 89.7	300 m	142.3
150 m	93.98	90.22 / 93.9	400 m	147.7
200 m	97.73	92.72 / 96.6	500 m	151.9

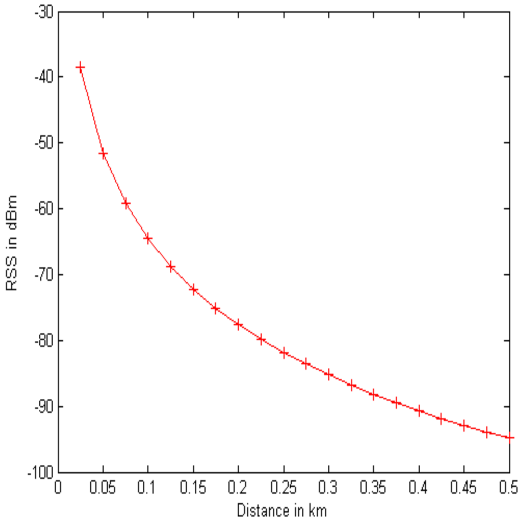

Figure 3 RSS Vs Distance (CN)

From *Figure3*, it can be observed that coverage extent of the cellular network cannot exceed 500m since the obtained RSS is well within the specified threshold limit. Similarly the maximum coverage range for WLAN, HIPERLAN is 200m. However, the coverage of WLAN is the function of the propagation environment. The received signal strength for cellular network was calculated using equation (2) and shown in *Figure 3*.The RSS at distance 500 meter is -94.88 dBm which is with in the threshold value of mobile -102 dBm. The received signal strength for WLAN was calculated using (4) and shown in *Figure 4*. At distance 200 meter received signal strength was -77.73 dBm for path loss exponent n=3 which is with in the threshold level for mobile handover from WLAN to CN -85 dBm. HIPERLAN network received signal strength was calculated using (7) and shown in *Figure 4* for indoor. At distance 200 meter received signal strength was -72.7 dBm which is less than the threshold level for mobile handover from WLAN to CN -85 dBm.

Table 3: RSS in dBm for CN/WLAN/HIPERLAN network

Range	**WLAN**	**HIPERLAN**	**Range**	**CN**
		Indoor/ Outdoor		
50 m	-59.67	-60.68 / -62.8	200 m	-77.61
100 m	-68.70	-66.70 / -69.7	300 m	-85.25
150 m	-73.98	-70.22 / -73.9	400 m	-90.67
200 m	-77.73	-72.72 / -76.6	500 m	-94.88

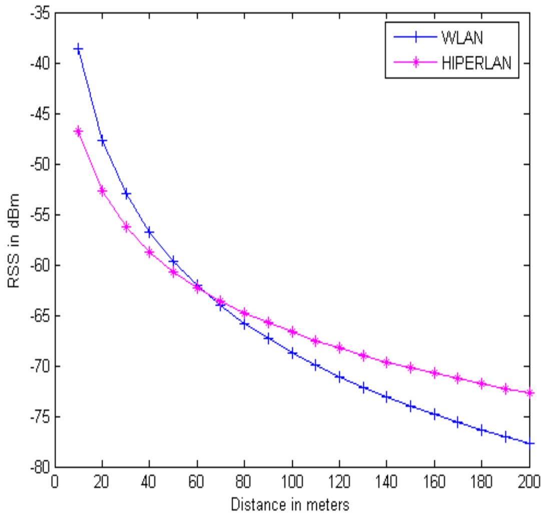

Figure 4 RSS Vs Distance (WLAN/HIPERLAN)

3 VERTICAL HANDOVER SCHEME

In interworking system, mobile user experiences horizontal handoffs with single network, also vertical handoffs between different networks. The vertical handoffs from WLAN to CN are different from those from CN to WLAN. Similar to horizontal handoff, vertical handoff from WLAN to CN are mainly initiated when the user is not in coverage area. As WLAN user is moving away from AP, RSS decreases. When user detects that RSS from WLAN is below threshold, mobile will initiate a handoff request. If CN has sufficient resources to accommodate it will accept the request, otherwise it will drop the request. In this case, user is totally disconnected from interworking system.

The handoffs from CN to WLAN are triggered to seek low-cost or high-speed services or to reduce CN congestion. Since WLAN has rather small coverage and usually locates within a single CN cell, the user requesting a vertical handoff from CN to WLAN is always within the coverage area of CN. If WLAN accepts the handoff request, the user will break the connection with CN and start to communicate with WLAN. Even if WLAN denies the handoff request, the user can still remain in the original connection with CN as it is still within the coverage of CN cell. That is, user is always connected to the interworking system. There is no real blocking for the vertical handoff from CN to WLAN.

The measured criteria of signal level and distance for both radio access networks cannot be directly compared since monitored links come from different access network, so different thresholds of two different technologies are defined for RSS and distance. Therefore, R_{cn} and R_w are the RSS handover thresholds for CN and WLAN access network respectively and D_{cn} and D_w are the handover thresholds. The $r_{cn}(x)$ and $r_w(x)$ are current RSS for CN and WLAN at the position of x and correspondingly $d_{cn}(x)$ and $d_w(x)$ are the current distance. Threshold level for mobile R_{cn} in cellular network link is usually -102 dBm. The threshold level is-80dBm for mobile R_w to handover from CN to WLAN (mobile in) and threshold level is-85dBm for mobile R_w to handover from WLAN to CN (mobile out).

Handover from the CN to WLAN/HIPERLAN will occur when the following relation is satisfied.

$$r_W(x) \geq R_W \text{ and } d_W(x) \leq D_W \tag{8}$$

Because high priority given to WLAN, handover in this direction will occur without considering RSS and distance criteria on CN link once condition(8) is satisfied. On other hand, when user is using WLAN link, handover from WLAN to CN will occur when the following relation (9) is satisfied,

$$r_W(x) \leq R_W, r_{cn}(x) \geq R_{cn} \text{ and } d_{cn}(x) \leq D_{cn}, \tag{9}$$

Handoff criteria in this direction should consider the RSS on the cell link should be beyond the handover threshold R_{cn} and the distance to BS should be below the handover threshold D_{cn} when the CN cell is to be the target network

5 CONCLUSION

In converged wireless networks, efficient handoff management policies in hotspots are critical to overall system performance. This paper mainly focuses on RSS measurement using suitable propagation model for heterogeneous network employing cellular, WLAN and HIPERLAN. In hotspot area, vertical handover between CN to WLAN (mobile in) and WLAN to CN (mobile out) are analyzed. Performance of vertical handover decision is studied especially in hotspot regions where due attention has to be provided. In addition to this the coverage extent of WLAN/HIPERLAN and CN is also computed by comparing the actual RSS with mobiles threshold settings.

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