Vertical Handoff Algorithm for Heterogeneous Wireless Networks

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Abstracts

Different wireless networks satisfy different users. The proposition of a single unified handoff approach is to offer the end user the quality of service (QoS) required. In this paper, vertical handoff between wireless fidelity (Wifi) and Universal Mobile Telecommunication System (UMTS) networks is investigated using MATLAB program 7.4 in order to maintain constant throughput during handoff. Three different propagation models are used. The variation of throughput with distance, received signal strength with distance and the effect of different speeds in macro and microcells are dealt with.

Keywords: Vertical handoff, Throughput, Speed, Micro and Macro cells.

خوارزمية المناقلة العمودية للشبكات اللاسلكية غير المتجانسة

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المستخلص

الشبكات اللاسلكية المختلفة تلبي متطلبات مختلفة للمستخدمين. إن الغاية المتوخاة هي توفير طريقة واحدة عامة للمناقلة ذات جودة خدمات للمستخدم. في هذا البحث تم دراسة المناقلة العمودية بين شبكتين نوع Wifi وشبكة UMTS باستخدام البرنامج MATLAB 7.4 وذلك لغرض إدامة إخراج ثابت خلال المناقلة باستخدام ثلاثة نماذج للانتشار. المحاكاة تركزت على تغير الإخراج مع المسافة ، وقوة الإشارة المستلمة مع المسافة وتأثير الإخراج مع المسافة لسرع مختلفة في خلايا ماكرو Macro ومايكرو Micro.

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1. Introduction:

For reliable wireless communication, the integration of two heterogeneous mobile network (for example Wifi and UMTS system) to be error free and maintain constant throughput for the next generation multimedia wireless networks [1- 4].

Handoff is the process of maintaining a mobile user active connection as it moves within the wireless network. Mobility in networks is managed by two different strategies, horizontal handoff and vertical handoff. Horizontal handoff [5] is usually between two access points (AP's) or base stations (BS's) using the same wireless access network technology. Vertical handoff is between two networks, access points or base stations using different access technology (heterogeneous networks). One of the popular systems is the integration of the IEEE 802.11 Wifi network and cellular network like UMTS or global system for mobile (GSM). These systems coexist and many cellular devices support dual frequency interface for Wifi and cellular access, Wifi coves hotspot area and provides greater bandwidth but low mobility, whereas cellular network provides low bandwidth but high mobility. Therefore, vertical handoff provides a combination of high bandwidth and high mobility[2]. An incorrect handoff may degrade the quality of services (QoS) and even break current communication.

2. Analysis of Vertical Handoff Strategies:

The maximum data rate for a given carrier bandwidth and signal to interference pulse noise ratio (SINR) can be determined using Shannon capacity formula [1].

$$R = W \ \mathrm{Log}_2 \left(1+\frac{\gamma}{\Gamma}\right) \qquad \ldots (1)$$

Where:

R is the maximum available data rate in (bps).

W is the carries bandwidth in (Hz).

γ is the SINR received at user end for UMTS or Wifi in (dB).

Γ is the dB gap between uncoded QAM and channel capacity, minus the coding gain.

Let R_{AP} and R_{BS} be the maximum achievable down link data rates while the user is connected with Wifi and UMTS, respectively Using equation (1), the following equations results[2].

$$R_{AP} = W_{AP} \ \mathrm{Log}_2 \left(1+\frac{\gamma_{AP}}{\Gamma_{AP}}\right) \qquad \ldots (2)$$

$$R_{BS} = W_{BS} \ \mathrm{Log}_2 \left(1+\frac{\gamma_{BS}}{\Gamma_{BS}}\right) \qquad \ldots (3)$$

Where, γ_{AP} and γ_{BS} are the received SINR for Wifi and UMTS, respectively. The interest is the relationship required between γ_{AP} and γ_{BS} while offering the same downlink data rate to the user by Wifi and UMTS. For equal R_{AP} and R_{BS}, the relation between γ_{AP} and γ_{BS} obtained as follows:

$$\gamma_{AP} = \Gamma_{AP}\left[\left(1+\frac{\gamma_{BS}}{\Gamma_{BS}}\right)^{\frac{W_{BS}}{W_{AP}}} - 1\right] \quad \ldots (4)$$

In equation (4) the values of the parameters considered are:

The carrier bandwidth for Wifi (W_{AP}) is 1 MHz[6] and for UMTS (W_{BS}) is 5 MHz[5].

Γ_{AP} is 2 dB for Wifi and 16 dB for UMTS[2].

Having the relationship between the maximum achievable data rate and the received SINR for both Wifi and UMTS makes the SINR based vertical handoff applicable. The model is based on Wifi and UMTS integration architecture using tight coupling[7][8] in which the Wifi is connected directly to the Radio Network Control (RNC) via the interworking unit (IWU) as in Figure (1).

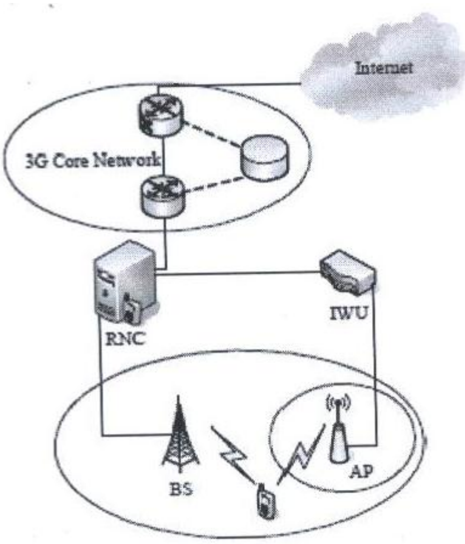


Figure 1: Wifi and UMTS integration architecture [7][8]

The SINR ratio can operate under active and passive modes. In active mode, the user is continuously seeking for maximum bandwidth from the two integrated networks. The user keeps measuring the received SINR for Wifi and UMTS, conducting the γ_{AP} and γ_{BS} conversion and sending the handoff request to the RNC based on SINR comparison results. In the passive mode, the measurement of user receiving SINR from both Wifi and UMTS are periodically send to the RNC directly in which the handoff decisions are made according to the SINR values, the user specific quality of service (QoS) requirements as well as the cell congestion conditions.

The passive mode obviously is preferable from the network operators point of view because of the comprehensive handoff strategies with the ability of traffic and load control for both Wifi and UMTS. The active mode has the advantage of self detection, resulting in less handoff delays and can also be deployed for cells under low load condition.

3. System Model:

The downlink traffic is considered, since it requires higher bandwidth than uplink especially for multimedia services such as video streaming using high speed downlink packet access (HSDPA) channel while connected with UMTS.

The SINR $\gamma_{APJ,i}$ received by user i from Wifi A_{Pj} can be represented[1] as:

$$\gamma_{APj,i} = \frac{G_{APj,i}\ P_{APj}}{P_B + \sum_{\substack{k\in AP \\ k\neq j}} G_{APK,i}\ P_{APK}} \quad \ldots (5)$$

Where:

P_{APj} is the transmitting power of A_{Pj}.

$G_{APj,i}$ is the channel gain between user i and A_{Pj}.

P_B is the background noise power at user receiver end.

The SINR $\gamma_{BSj,i}$ received by user i from UMTS can be represented[1] as:

$$\gamma_{BSj,i} = \frac{G_{BSj,i}\ P_{BSj,i}}{P_B + \sum_{KEBS} G_{BSK,i}\ P_{BSK} - G_{BSj,i}\ P_{BSj,i}} \qquad \dots (6)$$

Where:

P_{BSK} is the total transmitting power of BSK.

$P_{BSj,i}$ is the total transmitting power of BS_j to uses i.

$P_{BSj,i}$ is the channel gain between uses i and BS_j.

Three proposition models are used:

a- Okumura-Hata model is used in urban area for coverage calculation, it depends on extensive measurements made by Okumura and mathematically modeled by Hata[9] as.

$$L = 46.3 - 33.9\,Log_{10}(f) - 13.82\,Log_{10}(h_b) - a(h_m) + (44.9 - 6.55\,Log_{10}(h_b))Log_{10}\,d \qquad ..(7)$$

Where:

L is the propagation loss in dB.

f is the operating frequency in MHz.

h_b is the BS antenna height in meters (3m – 200m).

h_m is the MS antenna height (1m – 10m).

d is the distance between BS and MS in Km.

$a(h_m)$ is a correction factor for mobile antenna height in meters and is given as

$a(h_m)$ $(1.1\ Log_{10}f - 0.7)\ h_m - (1.56\ Log_{10}f - 0.8)$

b- UMTS 30.03 pedestrian microcell model[10]:

This model is valid for worst case propagation encountered by pedestrian use in microcell.

$$L = 40\,Log_{10}(d) + 30\,Log_{10}(f) + 49 \qquad \dots (8)$$

Where:

d is the BS to MS separation in km.

f is the carries frequency in MHz for Wifi.

L is the propagation loss in dB.

c- UMTS 30.03 vehicular macrocell model[10]:

This model is applicable in urban area. Where buildings are of nearly uniform height.

$$L = 40(1 - 4\times10^{-3}\,\Delta h_b)Log_{10}(d) - 18\,Log_{10}(\Delta h_b) + 21\,Log_{10}(f) + 80\,dB$$

Where:

L is the propagation loss in dB.

f is the carrier frequency in MHz.

Δh_b is the BS antenna height measured from the average rooftop level in meter.

The following common conditions and assumptions are used[1-3].

For UMTS HSDPA:

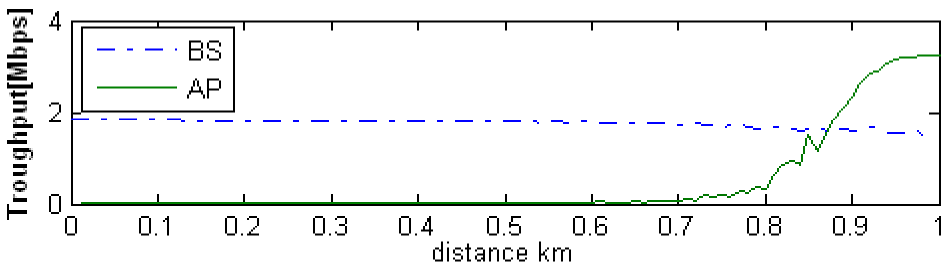
- BS transmit to only one user via HSDPA channel at a time with maximum available power to achieve the optimal physical rate.
- Maximum BS transmit power is 40 dBm.
- BS transmitting antenna height is 25 m.

- Frequency is 2 GHz.
- User end background noise power is – 101 dBm for Wifi.
- Maximum AP transmitting power is 20 dBm.
- AP transmitting antenna height is 3 m.
- Background noise power is – 96 dBm.
- Frequency is 2.4 GHz.

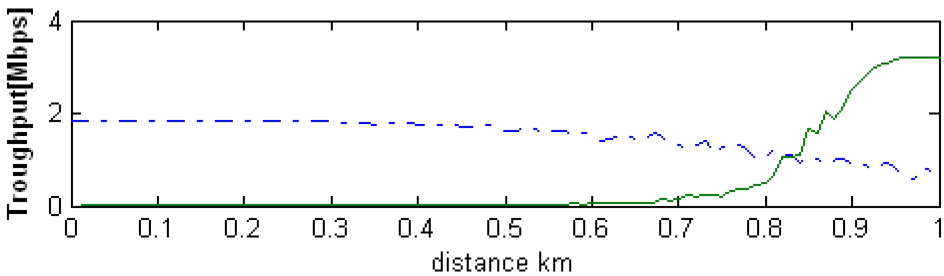
4. System Simulation and Results:

The performance of different vertical handoff algorithms at the system level evaluated. MATLAB-based simulator developed which is suitable for investigating the heterogeneous wireless network performance under different radio resource management strategies. The system simulated consists of 7 BS's and 12 AP's placed at each UMTS cell boundary. The UMTS cell radius is 1000 m.

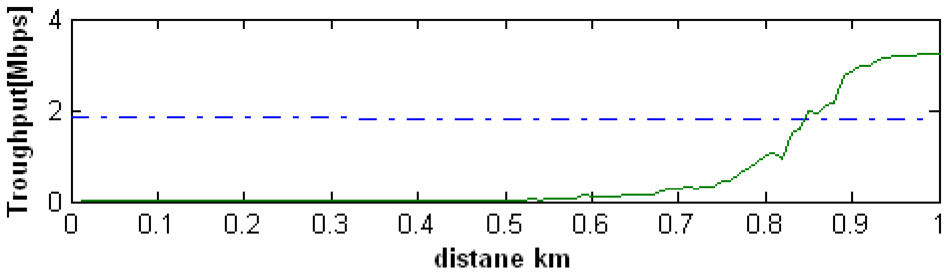
Figure (2) shows the variation **of throughput with distance for the three models considered. Figures 2a and 2c maintain** constant throughput and stable handoff in macrocell while figure 2b is not efficient due to the variable throughput and unstable handoff.



a- Okumura-Hata model



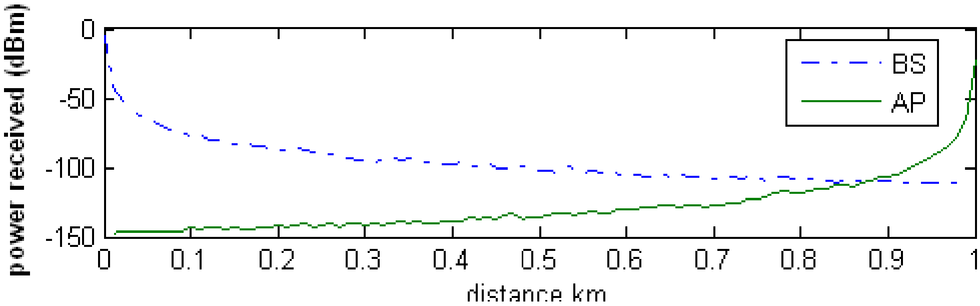
b- UMTS 30.03 pedeestrain microcell model



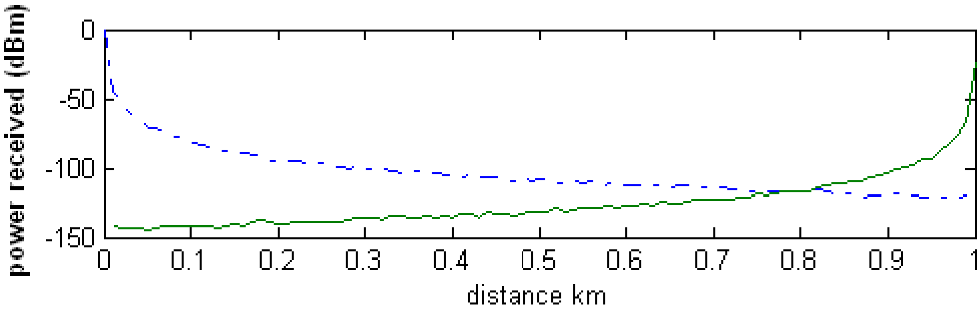
c- UMTS 30.03 vehicular macrocell model

Figure 2. Throughput vs. distance for models a, b, and c.

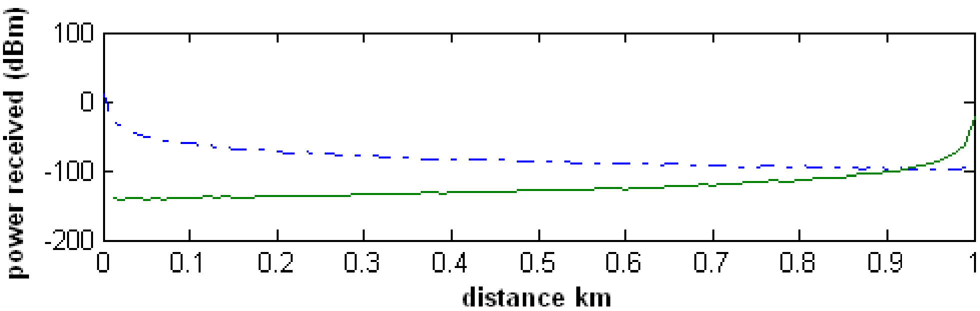
Figures (3a), (3b) and (3c) show the power received by MS from BS and AP, in figure 3a, handoff is executed at received power of – 110 dB at a distance of 110 meters from AP, figure 3b at – 115 dBm at a distance of 200 m and in figure 3c at – 890 dBm at 80 m from AP. It can be seen from figure 3 that the power from AP decrease more rapidly with distance as compared to the power from BS.



a- Okumura-Hata model



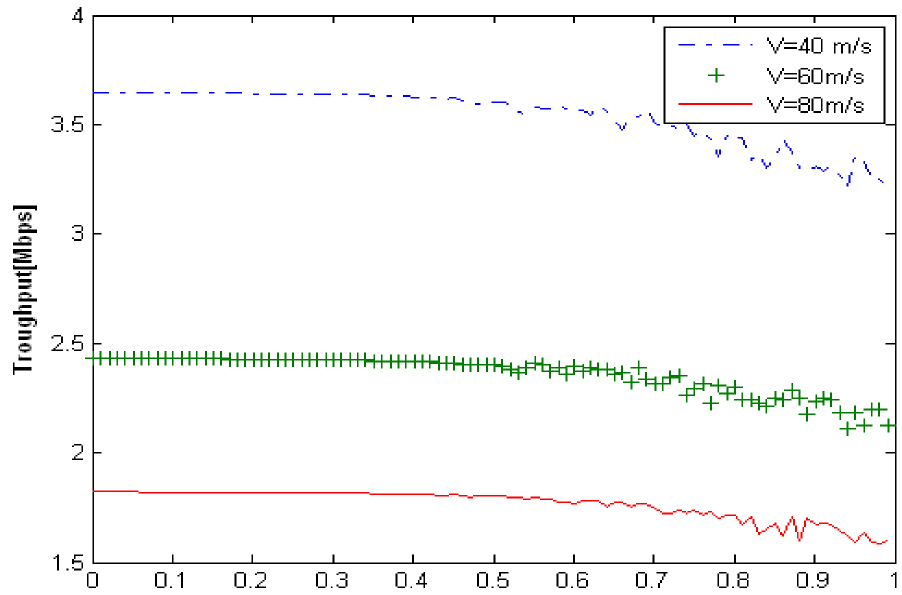
b- UMTS 30.03 pedestrian macrocell model



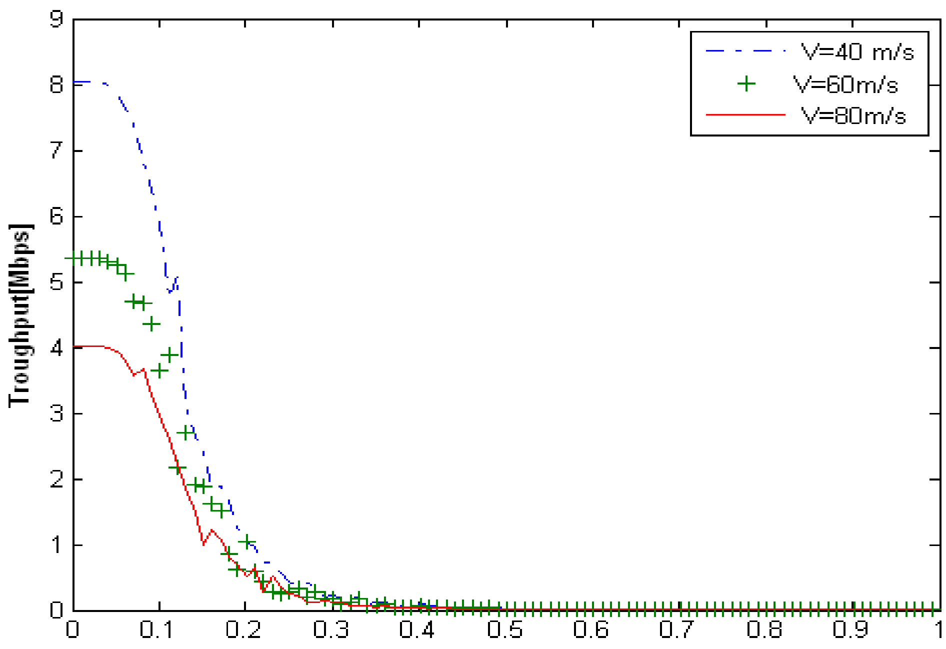
c- UMTS 30.03 vehicular macrocell model

Figure 3: Received power vs. distance for models a, b, and c.

Figures (4a), (4b) show Akumura-Hata model variations of throughput versus distance for different end user's speed. In Figure (4a), the throughput is nearly constant for the three speeds shown up to 500 m from BS and decrease with increasing speed. While Figure (4b) the throughput is constant at 50 m distance from AP and then decrease sharply with distance as compared to Figure (4a), also throughput decrease with increasing speed.



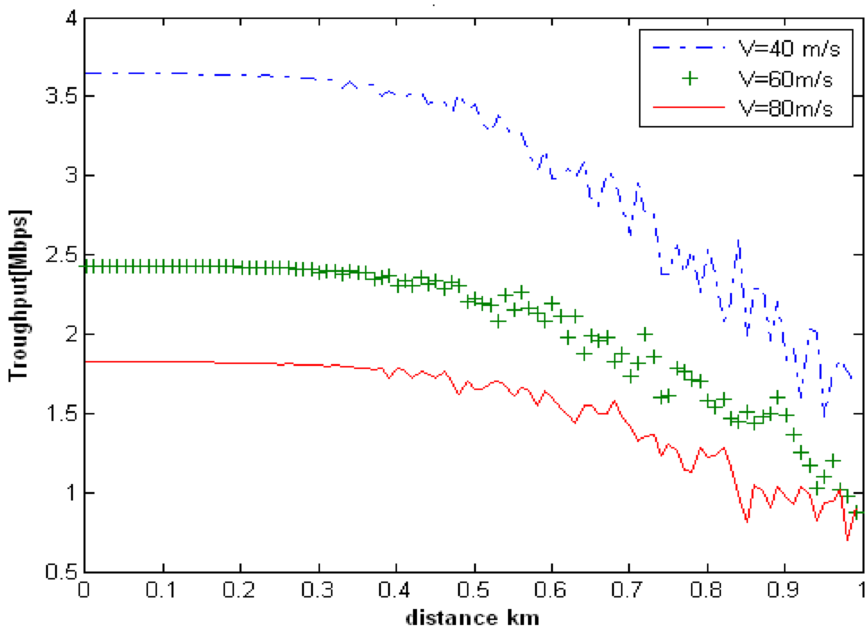
a- Effect of speed in UMTS



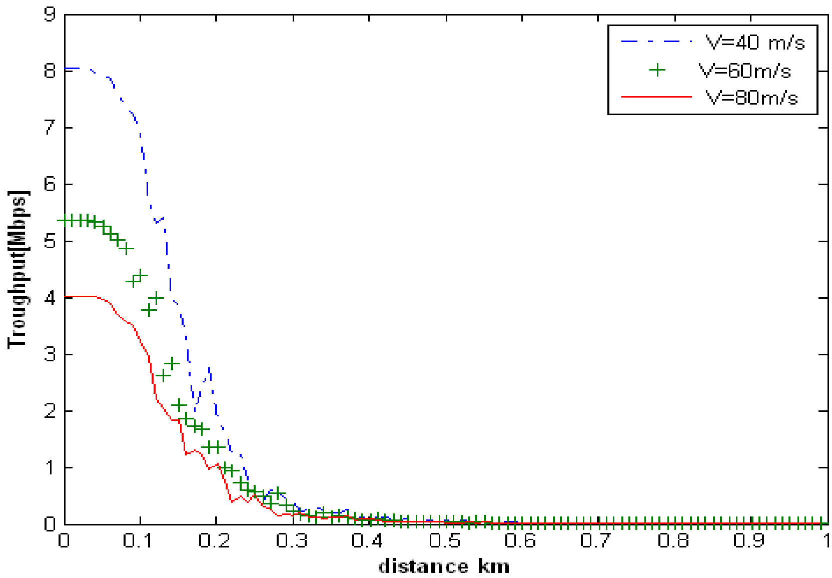
b- Effect of speed in WiFi

Figure 4: Throughput versus distance for BS and AP
Using Okumura-Hata Model

Figure 5 is for microcell model, in Figure (5a), throughput is constant for a distance of 400-450 m from BS and decrease with increasing speed, Figure (5b) for AP the throughput is constant to 40 m distance from AP and decrease rapidly with speed.



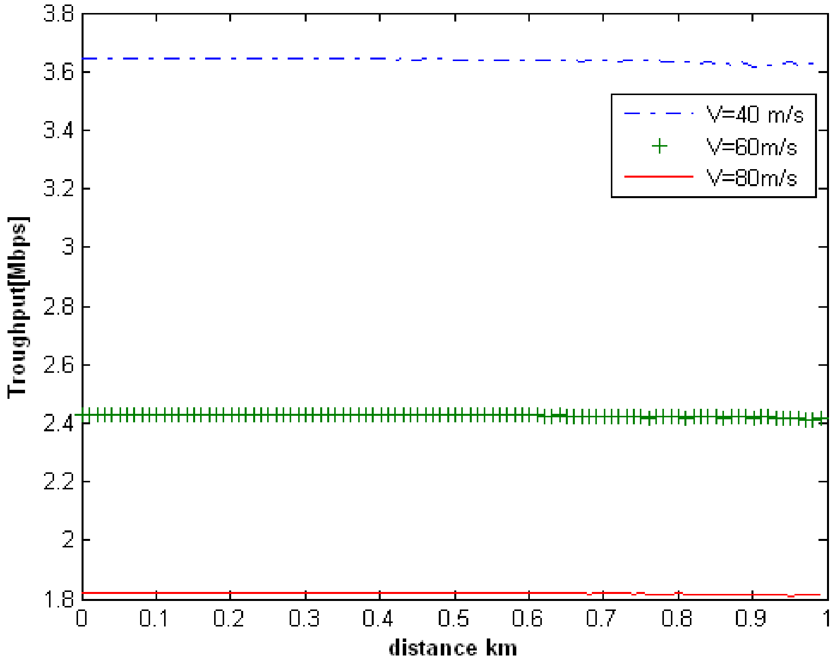
a- Effect of Speed in UMTS



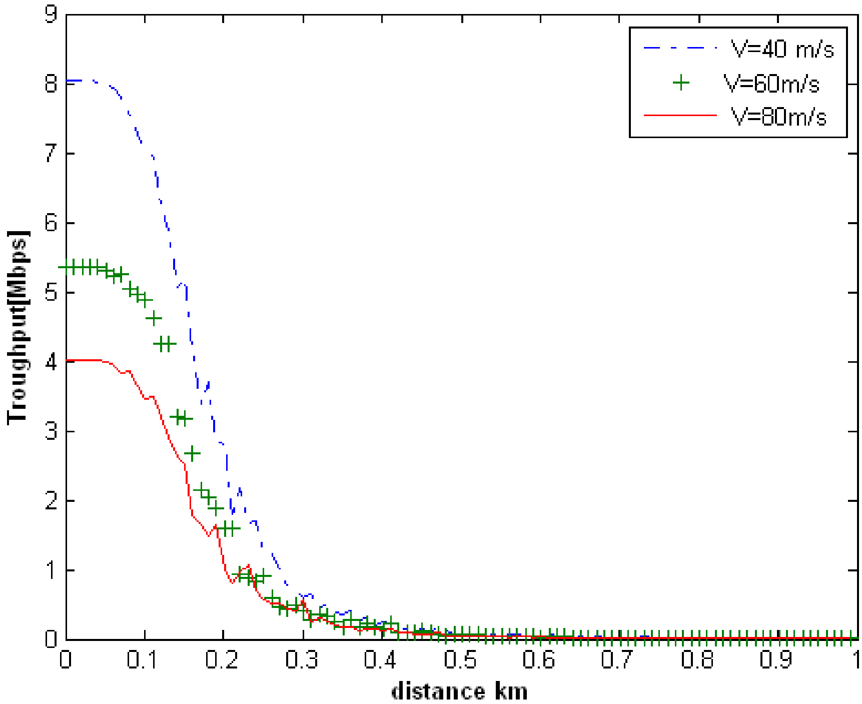
b- Effect of Speed in WiFi

Figure 5: Throughput versus distance for BS and AP using microcell model (b)

Figure (6a) is for macrocell model, the throughput is nearly constant for distance increase from BS, while Figure (6b) the throughput is constant to 70 m from AP and decreases rapidly with increasing speed.



a- Effect of speed in UMTS BS



b- Effect of speed in WiFi AP

Figure 6: Throughput versus distance for BS and AP
using macrocell model (c)

5. Conclusions:

The vertical handoff between access network in the next generation multimedia wireless networks is dealt with using three propagation models. In order to provide multimedia QoS inside the integrated network environment. The results obtained indicate that Okumura-Hata and UMTS 3003 vehicular models agree quite well for throughput with distance, power received with distance.

For an MS moving from BS towards AP, the throughput received power remains nearly constant, while for MS moving away from AP toward BS, both the throughput and the received power decreases rapidly.

The effect of speed on throughput for the three models show that the decay in throughput is Wifi is much steeper than in UMTS.

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