A RSS Based Adaptive Hand-Off Management Scheme In Heterogeneous Networks

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Abstract

Mobility management, integration and interworking of existing wireless systems are important factors to obtain seamless roaming and services continuity in Next Generation Wireless Systems (NGWS).So it is important to have a handoff scheme that takes into account the heterogeneity of the network. In this work we propose a handoff scheme which takes handoff decision adaptively based on the type of network it presently resides and the one it is attempting handoff with through some predefined rules. It also relies on the speed of the mobile terminal to make a decision of the handoff initiation received signal strength (RSS) threshold value. Finally simulations have been done to show the importance of taking these factors into account for handoff decisions rather than having a fixed threshold value of handoff for different scenarios.

Keywords: *Received Signal Strength(RSS). Next Generation Wireless Networks (NGWS), Heterogeneous Wireless Networks, Quality of service(QoS), Wireless LAN(WLAN), HIPERLAN.*

1. Introduction

With the rapid development of wireless technologies, the wireless networks have become more and more popular. Rapid research and development has led to the creation of different types of networks like Bluetooth, IEEE 802.11 based WLAN, Universal mobile telecommunications system (UMTS) and satellite networks. These networks can be integrated to form Next Generation Wireless Systems that always provides the best possible features of different networks to provide ubiquitous connectivity. By connecting to any wireless access network, users can get many kinds of internet services out of doors. In wireless networks, mobility management provides mobile users to continuously get the internet service when they move between different subnets based on their service needs. With this heterogeneity, users will be able to choose radio access technology that offers higher quality, data speed and mobility which is best suited to the required multimedia applications.

It is quite obvious from the discussion that it is an important and challenging issue to support seamless mobility and also QoS in order to support global roaming of mobile nodes (MN) in the NGWS. Handoff management is one of the most important features of mobility management. It is the process by which users keep their connections active when they move from one base station (BS) to another.

In NGWS, two types of handoff scenarios may arise, horizontal handoff and vertical handoff [1], [2].

Horizontal handoff is defined as handoff between two BSs of the same network i.e. handoff between homogenous networks where one type of network is considered.

Vertical handoff takes place between two BSs that belong to two different networks i.e. between heterogeneous networks and, hence, to two different Gateway Foreign Agents.

The large value of signaling delay associated with the intra and intersystem handoff calls for the need of efficient threshold value of proper parameters for the support of delay-sensitive and real-time services. The delay in handoff is due to the several processes that have to take place for the handover of a MT from one BS to another. The handoff process involves two steps : Discovery and Reauthentication.

The two steps mentioned above for a successful handoff introduce latency issues. These issues are as follows:

- Probe Delay – This is the amount of time it takes the client to complete a scan of available networks and to build its priority list.
- Authentication Delay – This is the amount of time it takes for the client to re-authenticate to the AP it chose from its priority list following any one of the different algorithms available.
- Re-association Delay – This is the amount of time it takes for the client to signal the AP that the handoff is complete.

There are five main handoff initiation techniques mentioned in [3], [4]:

Received signal strength, relative signal strength with threshold, relative signal strength with hysteresis, and relative signal strength with hysteresis and threshold, signal to interference ratio based handoff. In our paper we will mainly focus on the received signal strength based handoff techniques for handoff initialization.

In received signal strength, the RSSs of different BSs are measured and the BS with strongest signal is chosen for handoff.

In this paper a heterogeneous wireless access environment consisting of AP(WLAN,HIPERLAN), BS(Cellular Network) is considered as shown in Figure 1. A mobile node with multiple transceivers can get connected to these networks simultaneously.

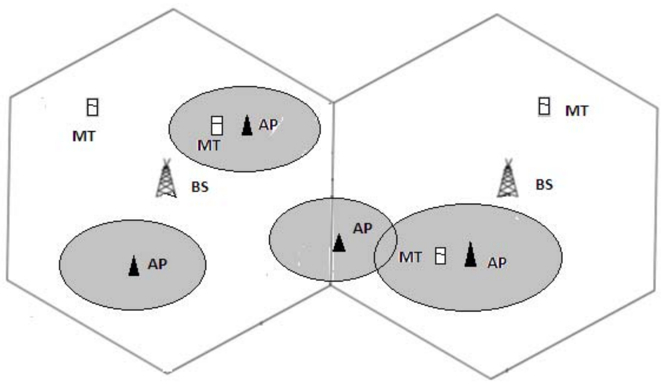


Fig 1: A Heterogeneous Network consisting of Cellular Network and WLAN and HIPERLAN

We consider a geographic area which is totally covered by CN and is partially covered by WLAN and HIPERLAN Access Points.CN and WLAN, HIPERLAN are complementary to each other and hence we focus on the handoff scenario between these networks. A MT can be in the coverage area of a cellular network BS at one instant and be connected to the corresponding BS, but due to its mobility it can move over to the coverage area of a WLAN or HIPERLAN AP which lies within the CN coverage area. in some cases the coverage area of BS of CN can also overlap. Thus it is important that at any point of time the MT is connected to the proper attachment point (BS or AP) for service continuity, to enhance QoS factor of the network and also to keep the network congestion free. So it is important to have a proper handoff scheme between these networks. So it is quite obvious that multiple networks are involved I vertical handoff scheme.

2. Related Work:

Work has been done to integrate WLAN/HIPERLAN/Cellular Network. Most of the work done is on architectures and mechanisms to support seamless mobility, roaming and vertical handoff. A vertical handoff decision method that simply estimates the service quality of available networks and selects the network with best quality is proposed in [5]. Different handoff algorithms that use received signal strength (RSS) information to reduce handoff latency and handoff failure probability are proposed in [6], [7], [8]. However, these algorithms are limited to handoff between third-generation (3G) cellular networks and WLANs, and do not take into account handoff between different networks. A novel mobility management system is proposed in [9] for vertical handoff between WWAN and WLAN.

To achieve seamless mobility across various access technologies and networks, an MN needs information about the wireless network to which it could attach. Also, it is necessary to transfer information related to the MT from the current attachment point to the next one. The Candidate Access Router Discovery (CARD) protocol [10] and the Context Transfer Protocol (CXTP) [11] have been proposed to enable this procedure. Their key objectives consist of reducing latency and packet loss, and avoiding the re-initiation of signalling to and from an MT from the beginning.

3. Proposed Work:

In this section we want to find the different received signal strength threshold value for handoff and also a proper scheme of handoff between neighboring cells in the Cellular Network (CN) , between cellular Wireless Local Area Network(WLAN) and cellular network and vice-versa , between High Performance Radio LAN (HIPERLAN) and cellular network and vice-versa. Received signal strength is a measure of the power present in a received radio signal. It determines the connectivity between a Mobile Terminal (MT) and Base Station(BS) or Access Point(AP).The Received Signal Strength(RSS) should be strong enough between BS/ AP and MT to maintain proper signal quality at the receiver. RSS gets weaker as a MT moves away from a BS/AP and the opposite happens when the MT moves closer to the BS/AP. So as MT goes away from the current BS/AP it is connected to handoff becomes necessary with its neighboring BS of CN or AP of WLAN. The RSS threshold value for handoff between different networks will be calculated in this section using formula of RSS for different networks.

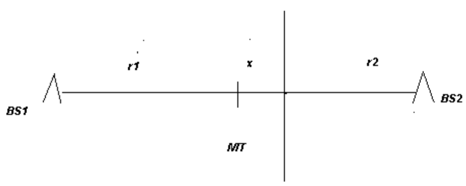
The threshold value of RSS depends on a few factors:

1. The velocity of the MT.
2. The latency of the handoff process.
3. The type of network the MT is presently in and the type of network with which the MT is trying to initiate handoff.
4. The size of the CN/WLAN/HIPERLAN cell the MT is presently residing.

If the same threshold value of RSS is used irrespective of the handoff scenario then that will increase the probability of false handoff initiation which increases unwanted traffic resulting in the blocking of other calls. Also it will increase the probability of handoff failure resulting in dropping of ongoing calls. So a different threshold value of RSS is used depending on the scenario of handoff.

CELLULAR NETWORK

Let r1 be the distance of the BS from the cell boundary of the cell the MT is presently situated .let x be the distance of the MT from the cell boundary of the present BS. Here hexagonal cells are considered. So as the MT moves towards the cell boundary RSS decreases from the first BS and it increases if the MT moves closer to the primary BS. We want to use RSS value to define a threshold, so that when the RSS drops below this threshold value handoff is initiated with the neighboring BS.



MICROCELL

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

PL=135.41+12.49*log(f)-4.99*log(hbs) + [46.84-2.34*log (hbs)]*log (d)

Here f=frequency in MHz
d =distance in kilometres
hbs =effective base station antenna height in meters

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

Pcn =Pt + Gt -PL-A

Here Pcn =received signal strength in CN
Pt=transmitted power in dB
Gt=transmitted antenna gain in dB
A=connector and cable loss in dB

Now if the MT is at a distance x from the boundary of a WLAN cell whose size is a then we get that
d= (.866*a-x).
So we get that the path loss is given by
PL=135.41+12.49*log (f)-4.99*log (hbs) + [46.84-2.34*log (hbs)]*log (.866*a-x)
If the MT is having a velocity v and the latency of handoff is T then for handoff failure probability to be zero the time taken by the MT to reach the boundary of the cell from the initiation of handoff t>=T. We take t=T to fulfill both the criteria of zero handoff failure probability and minimum false handoff initiation probability.
So x=v*T
So the received signal strength threshold is given by
Pcnth=Pt+Gt-[135.41+12.49*log (f)-4.99*log (hbs) + [46.84-2.34*log (hbs)]*log (.866*a-(v*T))]-A
If received signal strength decreases beyond this threshold value then the MT initiates handoff with its neighbouring BS or AP.

WIRELESS LOCAL AREA NETWORK (WLAN)

Log linear path loss model is given by
PL=L+10*n*log(d)+S
Here L=Constant power loss
n=Path loss exponent (values range between 2-4)
d=Distance between the MT and the WLAN AP in meters
S=Shadow fading which is modeled with mean m=0 and standard deviation σ with values between 6-12 dB depending on the environment.
PL=path loss in dB

Now if the MT is at a distance x from the boundary of a WLAN cell whose size is a then we get that
d= (.866*a-x) and x=v*T by similar arguments given in case of cellular networks.

The received signal strength for a WLAN is expressed in dBm as
Pw=Pt-PL
Here Pw =RSS of WLAN in dBm

The threshold value of signal strength for WLAN is given by
Pwth=Pt-[L+10*n*log(.866*a-(v*T))+S
If the RSS is below this threshold value then the MT will initiate a handoff with the neighboring WLAN AP or the Cellular network BS.

HIGH PERFORMANCE RADIO LAN (HIPERLAN)

The propagation model for HIPERLAN considers geographic data (terrain, building, foliage and ground) 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
Path loss outdoor propagation model with shadow fading is given by
PL=46.7+20*log (d) +.3*√ d+ S
Here d=distance between the mobile terminal and the AP
S=log normal shadowing its standard deviation=7 dB for indoor and 8 dB for outdoor
PL=path loss in dB

ISSN (Online): 1694-0814
www.IJCSI.org

By the same argument as in case of WLAN if the MT is at a distance of x from the boundary of a cell of size a then d= (.866*a-x) and x=v*T.
Hence PL=46.7+20*log (.866*a-(v*T)) +S (For indoor propagation model)

PL=46.7+20*log (.866*a-(v*T)) +.3* √ (.866*a-(v*T)) + S (For outdoor propagation model)

The received signal strength for HIPERLAN is expressed as
PHL=Pt-PL
Here PHL=Received signal strength of HIPERLAN in dBm
Pt=Transmitted power in dBm.
So received signal threshold value for indoor propagation model is given by
PHLinth=Pt-[46.7+20*log (.866*a-(v*T)) +S]
For outdoor propagation model this threshold value is given by
PHLoutth=Pt-[46.7+20*log(.866*a-(v*T)) +.3* √ (.866*a-(v*T)) + S]
In this case also handoff is initiated after RSS decreases beyond this threshold value.

- **HANDOFF SCHEME**

In our proposed scheme the MT will not start handoff execution every time after RSS has fallen below a certain threshold level. We define certain rules for handoff to take place. Let
RSS1= The RSS of the MT from the BS or AP it is presently connected.
RSS2=the RSS from the BS or AP the MT is attempting handoff.
RSSth(m,n)=RSS threshold value for handoff from network m to network n.
Our proposed handoff execution scheme is as follows:
i)When the MT is currently connected to a Cellular Network BS and is attempting handoff with a WLAN or HIPERLAN AP. Then handoff initiation will take place only when

RSS2 >RSSth(n,m)

m=Cellular Network n=WLAN/HIPERLAN

Handoff in this direction only consider the RSS of the network with which it is attempting handoff and not the RSS of the present network because the CN is the largest network in our case and WLAN / HIPERLAN are within the CN. Handoff of this kind takes place to decrease the congestion in the larger Cellular Network, which handles heavy traffic.
ii)When the MT is currently connected to a WLAN or HIPERLAN AP and is attempting handoff with a cellular network BS or another HIPERLAN/WLAN AP, then handoff initiation will take place when

RSS1<RSSth(m,n) and RSS2>RSSth(n,m)

m= WLAN/HIPERLAN

n= Cellular Network/WLAN/HIPERLAN

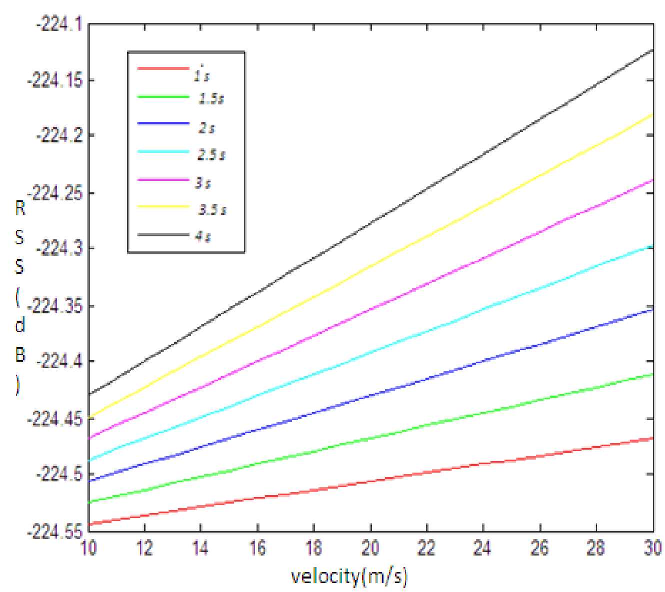
Handoff in this direction consider both the RSS of the present network and the network it is attempting handoff with, because if the handoff does not take place properly then the connection will be lost and hence handoff in this direction has more priority.
iii) When the MT is currently in a Cellular Network and is attempting handoff with another BS of the Cellular Network ,then handoff initiation takes place when

RSS1<RSSth(m,n)

m=n=Cellular Network

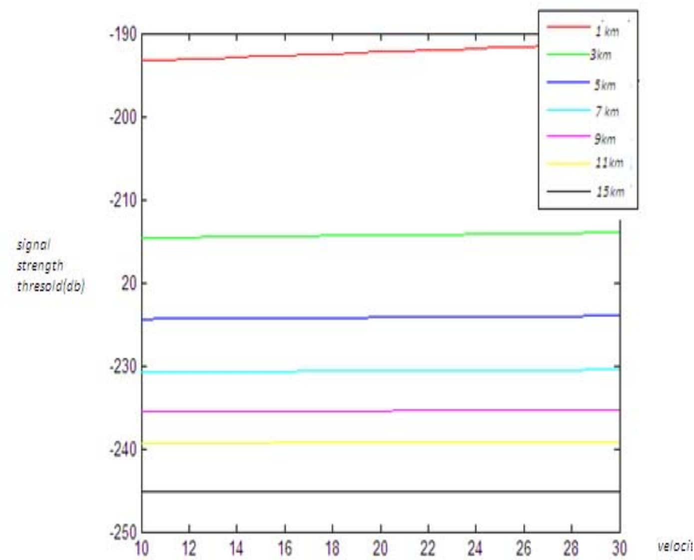
4. Simulation Results:

First we see that for a microcellular network the magnitude of received signal strength threshold decreases as the velocity of the MT increases for same value of handoff latency. This clearly shows that the RSS threshold should be dependent on the velocity of the MT.
The simulation below shows the dependence of RSS threshold on the velocity of MT for different values of handoff latency.



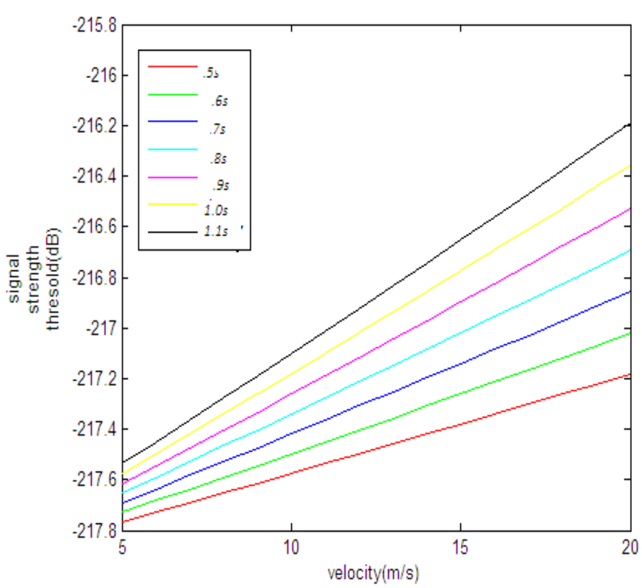
RSS THRESOLD VS VELOCITY OF MT IN MICROCELLULAR NETWORK (DIFFERENT LATENCY)

It can be also seen that the RSS threshold value differs based on the size of the cell the MT is currently residing for same value of velocity. The simulation below shows that for smaller cells the magnitude of RSS threshold value is less that is the handoff is to be initiated closer to the BS.

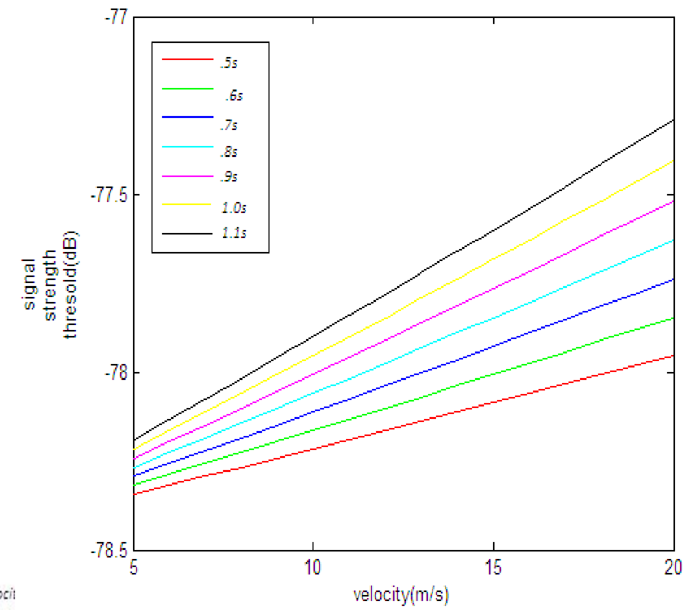


RSS THRESOLD VS VELOCITY OF MT IN MICROCELLULAR NETWORK (DIFFERENT CELLSIZE)

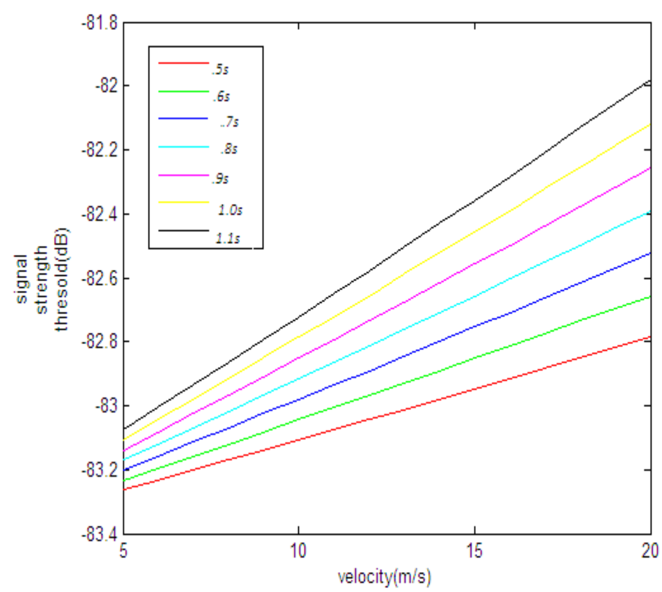
There is a strong dependence of RSS threshold value for handoff on the velocity of the MT for other kinds of networks also. But the dependence is different for different networks and also the threshold value is different for same handoff latency in different kinds of network. This is shown in the simulation results given below.



RSS THRESOLD VS VELOCITY OF MT IN WLAN NETWORK (DIFFERENT LATENCY)



RSS THRESOLD VS VELOCITY OF MT IN HIPERLAN (INDOOR) NETWORK (DIFFERENT LATENCY)



RSS THRESOLD VS VELOCITY OF MT IN HIPERLAN (OUTDOOR) NETWORK (DIFFERENT LATENCY)

All these results stresses the fact that having a fixed threshold value of RSS for different scenario will severely hamper the performance of the network, increasing congestion, reducing the QoS.

5. Conclusion :

In this paper we explore the different handoff scenarios that can take place in NGWS. We have also proposed a scheme in which the handoff decision will depend on the type of network the MT is presently in and also the type of network it is attempting handoff to ensure least amount of handoff failure probability, thus providing sufficient QoS for delay sensitive and real time services. Effective handoff schemes also ensure minimal false handoff initiation probability, which leads to congestion and hence dropping of calls. Our simulation results shows how the received signal strength threshold for handoff varies according to different networks for the same value of MT velocity. This is the main point we want to convey in our paper.

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