Performance Optimization of Handover between Heterogeneous Networks

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***Abstract*— In the near future, WLANs are expected to complement cellular networks. While Cellular networks like 2G and 3G gives users high mobility but less data rate (2 Mbps), WLANs provide much better data rate (54 Mbps) but less mobility. If we see from a user's point of view, if these two networks converge it will help to extract the combined benefits of both the systems, hence the need of a seamless and efficient vertical handoff procedure. The proposed model aims towards the convergence of WLAN, 2G and 3G networks.**

***Keywords*— 2G, 3G, WLAN, Vertical Handoff, Propagation Model.**

1. Introduction

Handover between different heterogeneous networks is done to retain the service provided to the User Equipment while it moves from coverage zone of one network to another. The mobile UE does the measurement of neighbour cells to select the best candidate cell. Inter-Radio Access Technology Handover performs inter-RAT HO evaluation based on the UE GSM measurement reports. There are three handover situations described below: 2G to 3G inter-RAT HO, 3G to 2G inter-RAT HO and CN to WLAN HO.

1.1 IRAT GSM to WCDMA HO: IRAT from GSM to WCDMA can be performed even if the radio conditions are good. 2G to 3G speech HO is triggered due to radio quality, capacity or priority reasons [1].

1.2 IRAT WCDMA to GSM HO: The UE measures 2G neighbour cells. The triggering conditions include signal quality, CPICH Ec/Io value and cell load presented by UL interface level seen by Node B. The best cell among all neighbour cells fulfilling the HO criteria gets selected for Handoff.

1.3 Cellular Network(CN) to WLAN:The convergence of WLAN and cellular data will provide users with wireless higher bandwidth data access in localized hotspots and to enable users to have normal data rates using CNs in non-hotspot zones.

2. Handover issue

Smooth handover between different systems should be taken as a basic requirement. Multiple authentications taken by various systems are annoyed. How to keep service continuity during handover across different systems is an issue. Increased handovers due to small cell sizes introduce a potential source of increased Dropped Call Rate (DCR), even when handover success rate remains unchanged [6].

For UEs in connected state which are moving out of cell coverage, handovers are required to move their Radio link from one cell to another. It is preferred to retain an UE in the same layer (macro or small cell) as handover is performed, unless there is a requirement to move from one layer to the other. Same layer handovers use the normal coverage-based intra-frequency handover framework existing in Macrocell network.

In Handover procedures in 3GPP HetNet, the UE starts a handover procedure based on signal and time thresholds defined and transmitted to it by its serving cell. These signal and time thresholds are the HO hysteresis, Time to Trigger (TTT) and Cell Individual Offset (Oc). Oc is a vector quantity sent to UE by the serving cell and it contains the offsets of the serving cell (Oc(s)) and neighbour cells (Oc(n)). All UEs in that cell must apply this parameter value to determine whether the measures RSRP satisfies the condition of the event named "Event A3". This event implies that UE sends a measurement report (MR) which triggers the handover [1]. Oc values can either be positive or negative. The measured RSRPs are filtered and Oc values are added to them to determine the cell ID. The following relationship is used to determine the Cell ID.

$$\text{Cell ID}k = \arg[\max(\text{RSRP}i + \text{Oc})]$$

The challenge is to configure the cells optimally with these parameters so that the HO success rate and DCR is kept close to their targets. This is tough to achieve in urban regions due to a problem called as the "traffic-light" problem [2]. In this problem, UEs stopping in intersections may handover to a nearby picocell for a few tens of seconds (duration of red signal in traffic light) and then handover again to the macro cell.

2.1 Coverage-based (CB) Handover:

As an active mobile device moves out of coverage of its hosting cell (macro or small cell), it must be handed over to another cell for the purpose of service continuity. Most common handover is the small cell to macro handover[5]. UEs that are connected to small cells may continue to perform handover to other small cells till they reach into a boundary small cell. This is when the UE needs to be handed over to a macrocell which provides coverage in the same area.

The reverse, i.e. macro to small cell handover is also possible but not always needed. As a UE that is connected to a macrocell moves, it can maintain its connection by performing handovers to other macrocells; it does not need to handover to small cell even if small cell coverage is available in that particular area. Below are given two situations when macro to small cell handover is desirable:

1. Macro-coverage Gap: When macro layer has a coverage gap that is covered by a small cell, the UE connected to macro layer must be handed to small cell when it enters that region, or else there will be a break in the continuity.
2. Cell-edge/Weak Macrocell Coverage: In areas like cell-edge region, where the small cell signal is comparatively stronger than the macrocell signal, the macro-connected UEs can be handed over to the small cell.

2.2 Load-based (LB) Handover:

Macrocells support load-based handovers. In case of small cells, when a microcell gets overloaded, it gets relief by handing over some UEs to the macro layer. Small cells can be configured in such a manner so that if requirement occurs, they can perform LB handover to macrocells. This is to be noted that LB handover is applicable only for small cells in hotspot regions.

There are two possible types of handovers:

i. Intra-frequency Handover: This is needed when macro cell and small cell layer use the same frequency. In this handover, no new inter frequency measurements or reporting is required.

ii. Inter-frequency Handover: This is needed when macro cell and small cell layer are on different frequencies. Inter-frequency measurements and reporting configuration is needed for target frequencies in this case.

3. VERTICAL HANDOVER PROCESS

Vertical handoff from WLAN to cellular network like GPRS, EDGE or UMTS is initiated when the user is not in coverage area [3]. RSS gets weakened as WLAN user gets away from AP. The UE sends a handoff initiation request to cellular network once it detects the parameters reach the threshold values of WLAN. The cellular network will only accommodate the request if it has sufficient available channels or else the user gets disconnected immediately.

Cellular network to WLAN handoff occurs in order to facilitate any of these: lesser cost exploitation, higher data rate services or to minimize excessive network congestion. Generally, the user requesting vertical HO from cellular network to WLAN is within a single cell of cellular network as WLAN coverage includes much smaller area [4].

4. PERFORMANCE ANALYSIS & SIMULATION RESULTS

The simulation setup consists of WLAN hotspots within existing cellular network and is applicable for dense urban environment where bandwidth obligation reaches its peak. A deterministic propagation model is proposed which involves the following parameters provided in the table:

TABLE I
INITIAL POSITION OF THE USER [3]

Parameters	Values
Range/Radius of Cellular Cell in meter	1000
Range/Radius of WLAN AP in meter	500
Power of Cellular BS in dB	50
Power of WLAN AP in dB	100
Gain of Cellular BS + Antenna	50+5
Gain of WLAN AP + Antenna	100+5
Cellular Threshold Level (CN-WLAN) in dBm	-80
AP Threshold level (WLAN-CN) in dBm	-120
Path Loss Exponent	3.5
Speed of Cellular user in m/s	5
Speed of AP user in m/s	5
Number of Cellular users	1
Number of AP users	1

A. Model Algorithm

1. Scan and list down the available networks and identify what type of networks are they i.e. whether Cellular networks (CN) 2G/3G or Wireless LAN (WLAN).
2. Identify the current network and gather the threshold values of the parameters required for Handoff.
3. Scan the currently available parameters of the network and also the current parameters of other available networks. Their network dependent weights are also considered.
4. If existing connected network is sufficient, then it will display a message that no handoff is required, or else, handoff to some other network will be displayed.
5. If handoff is required, then it will ask whether the mobile node resource is rich or poor. If resource is poor, No handoff is performed at that instant. If rich, it performs handoff with the chosen network from the available network pool.
6. If handoff triggering takes place, then:
   i. Dynamic Call Blocking probability is calculated and a graph is displayed NDCBP vs. Network.
   ii. Extended Vertical Handoff Decision is evaluated and a graph is obtained EVHDF vs. Network.

B. Input Parameters

The following values are asked as input in the proposed model to deduce the output values of New Dynamic Call Probability and Extended vertical handover function:

1. Number and type of available networks
2. Threshold current available bandwidth
3. Threshold received signal strength
4. Threshold velocity of mobile station
5. Threshold estimated time MS will be in present network
6. Threshold battery power of MS
7. Threshold cost of network to MS
8. Current available Bandwidths of all available Networks
9. Received signal strength of all available networks
10. Velocity of MS for all available networks

11. Estimated time MS will be in all available networks
12. Battery power of MS in all available networks
13. Cost of network to MS in all networks
14. Security level in all available networks
15. Mean number of request arrivals per unit time
16. Mean number of calls serviced per unit time

C. Equations involved

Let, C=Cost of Ith network, P=Battery power of MS, V=Velocity of MS, RSS=Received Signal strength, BW=Bandwidth , wc=Cost of Service, ws=Security Parameter, wp=power consumption, wnc=Network conditons, wnp= Network performance

To evaluate the first step decision function to find the eligible set of networks out of the available networks with values greater than threshold

X(1,i)=((BW(1,i)-bi)>0)&&((V(1,i)-Vi)>0)&&((T(1,i)-Ti)>0)&&((P(1,i)-Pi)>0)&&((C(1,i)-Ci)>0)&&((RSS(1,i)-RSSi)>0)

To evaluate the Extended Vertical Handoff Decision Function for the network pool previously selected as eligible

EQ(1,i)=((wc(1,index)*(1/Ct(1,i)))/min(Ct,[],2))+(ws(1,index)*S(1,index)/max(S,[],2))+(wp(1,index)*pj(1,index)/max(pj,[],2))+(wnc(1,index)*Dj(1,i)/max(Dj,[],2))+(wnp(1,index)*fj(1,index)/max(fj,[],2))

D. Graphs obtained

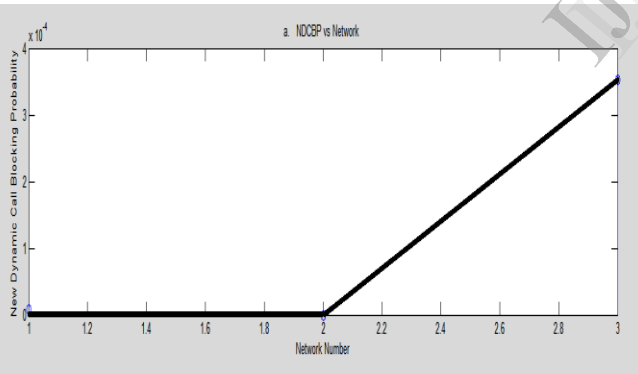

Fig. 1 Plot showing New Dynamic call blocking probability when handing over from WLAN to 2G to 3G.

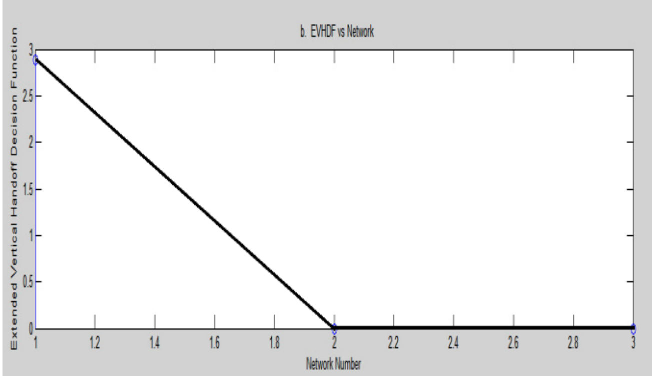

Fig. 2 Plot showing Extended Vertical Decision Function vs. Network when handing over from WLAN to 2G to 3G.

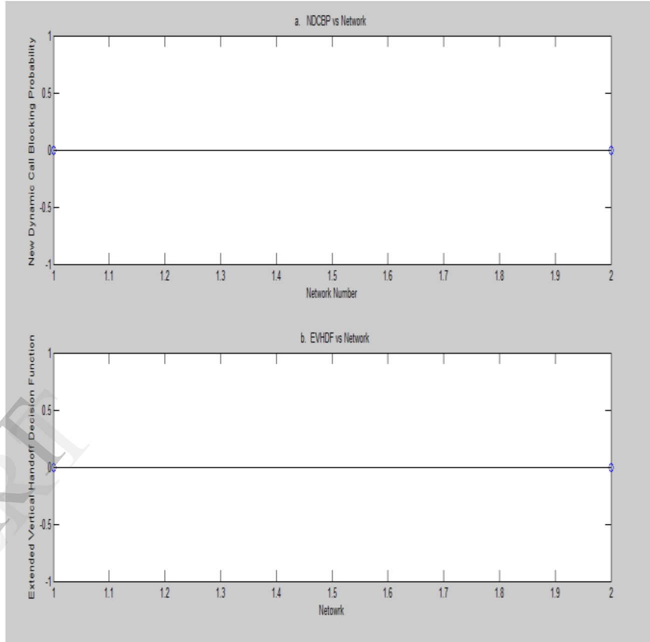

Fig. 3 Plot showing NDCPF and EVHDF vs. Network when handover takes place from WLAN to 3G.

5. CONCLUSIONS

This paper gives a simulated analytical model by implementing a seamless VHO procedure for handoff transition between 2G, 3G and WLAN based on user input.. In this algorithm, I have used a number of uninterrupted beacon signals whose signal strength from WLAN, EDGE or WCDMA falls below the predefined threshold value in order to perform VHO. Further task is to simulate the number of Hos performed, time spent in each network, Dropped user ration for each user in each network.

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