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Vertical Handoff Decision Model for Next Generation Network Based on Cost Function

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***Abstract*— The next generation Wireless network (NGWNs) allows the mobile node to access in different wireless network for a high rate of services. Therefore, In future there will be a need to have decision algorithm to decide, which is the best network for a specific application that the user needs . In this paper we propose a vertical handoff decision algorithm to decide the "best network" interface and "best time" moment to handoff. In this a score function is calculated based on static factors (e.g. Band width , power consumption ,link cost) and dynamic factor (e.g. Congestion , received signal strength, MT velocity, duration of a mobile node in a particular network)to make the vertical handoff decision. This model increases the user level of satisfaction based on cost function and also improve the whole system performance by reducing the unnecessary handoffs.**

***Keywords*- Vertical Handoff Decision(VHD),Next Generation Wireless Networks(NGWNs), Horizontal Handoff (HHO),Vertical Handoff (VHO).**

I. INTRODUCTION

In the near future the NGWNs will be the integration of various wireless access technologies and the users of wireless technologies and mobile network will not be bound by a subscription of one network. They can choose one of the available network depending upon the user need and running application. The development of wireless network together with mobile technologies have resulted in NGWNs networks. The coexistence of heterogeneous technologies with largely different characteristics creates a decision problem of determining the best available network interface. The decision to decide the best network may be based on static factors such as bandwidth of each network, power consumption of each network and usage charges of network. However, dynamic factors must be considered in handoff decision such as received signal strength, network load or congestion on the network, mobile node velocity etc.

In Heterogonous wireless networks handoff can be separated into two parts: Horizontal Handoff(HHO) and Vertical Handoff (VHO).The Horizontal handoff occur between the same wireless technologies(WLAN to WWAN).

On the other hand, Vertical handoff occurs between two different network technologies(WLAN to GPRS). Consequently, handoff is the process by which the mobile node monitors active connection while moving from one access point to another or it is the transfer of services from one base station to another base station.

This paper is organized as follows. Section II Explains the criteria involved in VHD .The vertical handoff model is described in section III. Section IV. Explains the algorithm for vertical handoff module Simulation results are proposed in section V. and conclusions are given in section VI.

II. THE MOST IMPORTANT CRITERIA INVOLVED IN THE VERTICAL HANDOFF DECISION

The criteria involved in vertical handoff are very important aspect to achieve continuous, uninterrupted mobility scenarios.Figure1 Shows the most important criteria proposed in the literature for VHD algorithms in order to get more performance.

The essential aspects of each criteria are :

A. Received *Signal Strength (RSS)*

Most existing horizontal handoff use RSS as primary decision criteria for VHD algorithms .but it is not enough for a complete decision.

B. Available Bandwidth

This criteria is used for identification of network traffic conditions and is especially important for delay sensitive applications.

C. Power Requirements

Mobile devices run on battery, So they must have limited power consumption .If the battery level is low then switching from a network to another network with low power consumption can provide a longer usage time.

D. Security Cost

Cost of services is a deciding factor in choosing a network. Broadband wireless internet services providers and cellular service providers have variety of service plans to influence the likely choice of network and thus handoff decision.

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E. User Preferences

Preferences or choice of a user to access a specific network is one of the most important criteria for handoff decision. Quality of Service, Transmission rate, error rate, congestion, bandwidth can be measured to decide which network can provide good Quality of service and continuous connectivity.

F. Speed

It is a very Important decision criteria for a handoff. When the user travel at high speed then switching to a new network with small coverage area is not beneficial because mobile node remain there only for very small duration.

G. Handoff Latency

The time elapses between the last packet received via the old access router and the arrival of the first packet along the new access router after a handoff. This is called handoff latency. Handoff latency should be minimum because it affects the Qos.

H. Network Load Balancing

Network load is to be considered during effective handoff. It is important to balance the network load to avoid overloading of the network.

I. Network Throughput

Network Throughput refers to the average data rate. Handover to the network which has higher throughput is desirable.

A good handoff decision algorithm should have both dynamic and non dynamic metrics. However, it is important to consider maximum number of static and dynamic requirements during VHO .But it is difficult to include all the metrics in a single decision model due to complexity of the algorithm.

In this work, We propose a vertical handoff model to select the "best network " at" best time" to handoff, In this , a score function is calculated to make the vertical handoff decision based on static factors(e.g. Link bandwidth, power consumption and cost) and dynamic factors (e.g. Received signal strength, congestion on the link (network load), duration of a mobile node (MN) in a particular network). The results show that the proposed vertical handoff model can adequately perform vertical handoff to the best network at the best moment.

III. Vertical Handoff Model

This section presents the proposed flexible configuration vertical handoff decision model. A handoff control center (HCC),analyze the collected information from the network interface and their base station(BS).

It took the handoff decision and also provides the connection between the network interface And the upper layer applications.HCC is made up of five components: Network Analysis(NA),Network Discovery(ND),Vertical Handoff Decision (VHD),Vertical Handoff Execution(VHE)and System Monitor(SM).Network Analysis module monitors the status of each network interface (i.e. offered bandwidth, usage charges, power consumption of link) and it analyze the each network by calculating the static score for the network. System monitor module provide system information (i.e. battery status and user preferences) to network analysis module. Network discovery module discovers all the available network to which a mobile node can connect at a particular time intervals, monitors the velocity of mobile station (MS) and the received signal strength (RSS) of the base station. It also calculate the duration of a mobile node in a particular network with the help of velocity (V=D*T).Where T denotes the estimated time of mobile node to stay in a particular network, V is the velocity of mobile node and D is the coverage area of a network.

By Introducing the duration of a mobile node in a particular network ,we can eliminate Ping-Pong effect and can also reduce unnecessary handoff. For example: If a mobile node is moving at a very high speed then switching to a WLAN from cellular network will not be beneficial because mobile node will stay for a very short duration in a WLAN. Depending upon all these information, it select the candidate networks and assign them priorities.VHD module takes the decision to select "best network" based on the input from Network Analysis, Network Discovery and System Manager modules. After that ,the mobile node is connected to the selected network in a execution phase.

IV. The Algorithm For Vertical Handoff Decision Module

The vertical handoff decision algorithm is divided into three phases:-Network Discovery Phase, Network Analysis phase and Network Selection &Execution Phase. The flow chart for the proposed handoff decision model is shown in figure 1.The various phases of proposed handoff decision module can be explained as follow:

A. Network Discovery Phase :

i. Search all the available network to which a mobile node can connect add them into list.
ii. Record the received signal strength of all the network.
iii. Record the velocity of the mobile node.
iv. Calculate the duration of a mobile node in a particular network with the help of coverage area and velocity.
v. Remove the network which have RSS below the threshold RSS_t on the network.

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vi. Calculate and assign the priorities to all the candidate network based on difference between RSS & its threshold RSS_t and the traffic load on a network.
vii. Continue with network analysis phase.

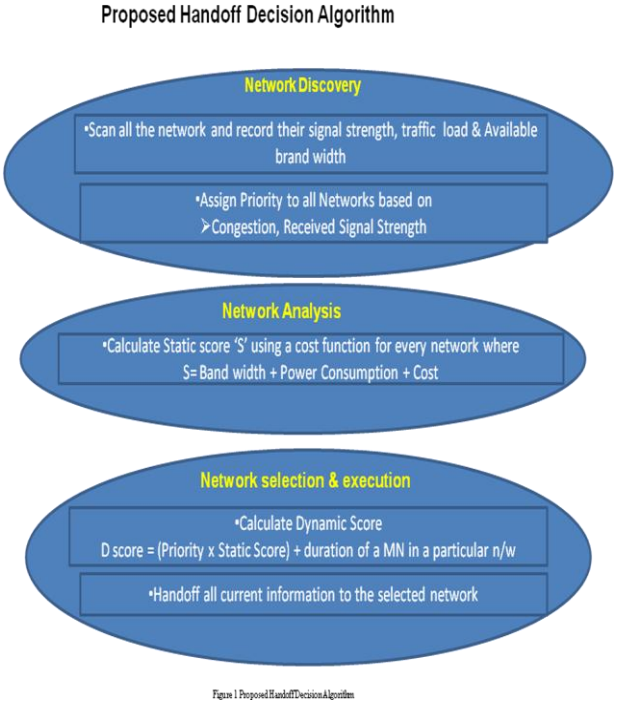

Figure 1 Proposed Handoff Decision Algorithm

B. Network Analysis Phase:

i. Collect the system information like battery status and user preferences from system monitor and then determine the weight factor for bandwidth, cost and power consumption.
ii. Calculate static score (S) using a cost function for every network.
iii. Continue with Network Selection & Execution Phase

C. Network Selection & Execution Phase:

i. Calculate a dynamic score (D_{SCORE}) by multiplying the priority of each candidate with its Static Score(S) and adding the duration of a mobile node in a particular network.
ii. Select the network with highest value of D_{SCORE}.
iii. Handoff all the information to the selected network, If the selected network is different from current network.

The discovery phase is used to discover the candidate network by removing all the unwanted networks from the available networks. The Analysis phase is used to analyze the network depending upon the user preferences which is expressed in terms of weight factors.

The Selection Phase is used to select the best network and executing the handoff to the selected network. The functioning of various components of Handoff controlling centre (HCC) can be explained as follows:

A. Network Discovery / System Monitor (SM) :

The system monitor provides the information like current battery status, user preferences for various networks based on the offered bandwidth, usage charges and power consumption by their interface card. These preferences are expressed in terms of weight factors and passed to the Network Analysis Module to calculate the score function.

B. Network Analysis Module (NA) :

The network is analyzed based on a static score (S) function. The Static Score (S) can be defined as a function of the following parameters-Offered bandwidth (B_n), power consumption in a particular network (P_n) and the usage cost of the network (C_n).

Therefore,

$$S_n = F(B_n, P_n, C_n) \text{----------(i)}$$

Where S_n is Static Score .Which is a function of bandwidth, power and cost .This score function is the sum of normalized parameter. Normalization is needed to ensure that the sum of the values in different units is meaningful.

To Understand, Let us consider that there are factors which are used to calculate the score. Then the final score of the interface(i) will be a sum of K weighted functions.

$$S_i = \sum W_i * F_{i,j} \quad \text{/(The Si lies between 0 to 1 \& summation of Wi is 1)/ --(ii)}$$

Where

W_j = weight factor of j
F_{ij} = normalized score of interface i for factor j.

For our Proposed Model :

$$S_{ib} = W_b F_{b,,i} + W_p F_{p,i} + W_c F_{c,I} \text{ ----- (iii)}$$
$$F_{b,i} = e^{\alpha}{}_i / e^{M}, \quad (\alpha \geq 0 \ \& \ M \geq \alpha) \text{ ----- (iv)}$$
$$F_{p,i} = 1 / e^{\beta}, \quad (\beta \geq 0) \text{ ---------- (v)}$$
$$F_{c,i} = 1 / e^{y} \text{ ----------(vi)}$$

Where

W_b = Weight factor for offered band width .
W_p = Weight factor for power consumption by network interface.
W_c = Weight factor for usage cost.
F_{bi} = Normalized score of interface i for offered bandwidth
F_{pi} =Normalized score of interface i for power consumption

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F_{ci} = Normalized score of interface i for usage cost.

The coefficients can be calculated via a look up table or well tuned function as below:

$\alpha = \min (Xi , M) / M$, (M is maximum bandwidth)---(vii)

$\beta_i = 2 / Y_i$ ----------(viii)

Note : equation (v) & (vi) use the inverse exponential function for calculated F_{pi} and F_{ci} to bound the result between zero and one(F_{pi} & F_{ci} = 0~1 i.e. these function s are normalized). For calculating F_{bi} a term M is used in the denominator to normalized the function, where M is the maximum link capacity among all available interfaces.

C. Network Selection & Execution

This module identify all the candidate network by removing the unwanted network from all the available networks and assign them priority.

A candidate network is the network whose received signal strength is higher than its threshold received signal strength and the velocity of the mobile node is lower than its velocity threshold.

1) Candidate Network Selection :

A candidate network is the network whose received signal strength is higher than its threshold received signal strength and the velocity of the mobile node is lower than its velocity threshold.

Candidate Network = { $RSS_i > rSS_{Ti}$ & $V_{MN} < V_{Ti}$ }/ (RSS of WLAN should be greater than the threshold RSS level o WLAN and the velocity of a MN should be smaller than threshold velocity of WLAN)/

Let us assume

N = { n1, n2, n3, ---------nk} is the set of available network interfaces.

VT = { V_{t1}, V_{t2}, V_{t3}, ----V_s} is the set of threshold values of velocities for a mobile node for the respective network interface.

RSS_T = { rss_{t1}, rss_{t2}, rss_{t3}-----rss_{tk}} is the set of threshold values of received signal strength of respective network interface.

RSS_{Diff} = { Rss_{D1}, Rss_{D2}, Rss_{D3}-------Rss_s} is the set of values of difference between the received signal strength and its threshold value.

CN = { } set of candidate networks to which the mobile node (MN) can make handoff.

P = set of priority values for j^{th} network where (j = 1 to K)

The RSS and the velocity of a mobile node (MN) is observed at the specified time interval and the decision is taken to select the candidate network as per the decision algorithm given below:

This algorithm find the number of candidate network (n).

Let us assume the mobile node (MN) is currently in network n_i.

Where

n = candidate network
K = All available network

Then

If $RSS_i < rss_{ti}$ then (where i is the current network Interface).

For all n_j where $j \neq i$

If ($Rss_j > rss_{tj}$ and $V_i < V_s$) then /(Rss of j^{th} network is greater than the threshold Rss of j^{th} network and the threshold velocity of j^{th} network is greater than the velocity of mobile node .than add them in candidate list)/

$CN = [CN \ U \ u(n_j)]$

$Rss_{Diff} = Rss_j - rss_{tj}$

2) Algorithm for assigning the priority :

After selecting the candidate network we have to assign the priorities to all the networks. In our algorithm the priority is based on $Rsss_{Diff}$. and traffic load on the network. If Rss_{Diff}. is high, then we assign high priority because higher the difference more better will be the RSS or it indicate that the mobile node is more nearer to the base station of that network. If a traffic on a network is high then we assign lower priority.

Algorithm for assigning the priority to all the network is as follows :

If
n = Candidate Network
K = Available Network
Then

For j = 1 to k do (j is the variable which is used to Assign position/priority to all Candidate network)

If j is not a candidate network then

$P_j = 0$ (if a network is not in a candidate Network list then assign 0 priority to them)

Elseif j is the only candidate network then

Pj = 1 (If there is only one network in the candidate list then its priority will be 1)

Elseif network is at i^{th} position in an ascending order sorted set of RSS_{Diff} traffic load on the network.

$P_j = i/K$

The network discovery module use the above algorithm to select the candidate network from the available network and then assign priority to them.

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3) Dynamic Decision (DD)

This module take a final decision of selecting a best candidate networks from a set of candidate networks decided earlier by network discovery (ND) module. This module calculate dynamic score " D_{SCORE}" for each network i as below:

$D_{SCORE(i)} = S(i) * P(i)$

Where

S(i) = Static score calculated by the network analysis module of ith network (WLAN)

P(i) = Priority decided by the network discovery module for the i^{th} network.

A candidate network which has highest value of "D_{SCORE}" is selected as the best interface for handoff.

V. Simulation

A application is written in VC++ to evaluate and analyze the proposed vertical handoff model for a heterogeneous network system where two cellular system GSM & CDMA and a WLAN form an overlay structure as shown in figure2.A mobile node (MN) with triple network interfaces can move in the cell boundaries of any network during simulation.

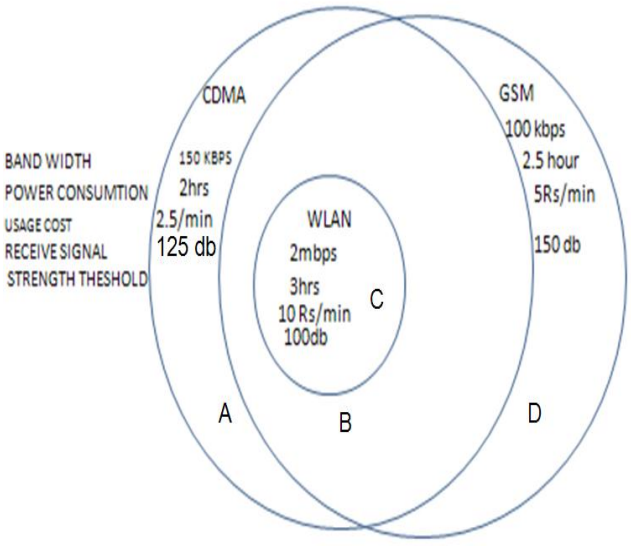

FIGURE -2 IMPLEMENTATION OF HANDOFF DECISION ALGORITHM

The mobile node (MN) can be in any one of region –A, B, C and D at a moment of time and can access the network as per below:

If the mobile node (MN) is in

Region A – It can access only CDMA network Interface.
Region B – It can access CDMA & GSMA network Interface.
Region C – It can access only WLAN network Interface.
Region D – It can access only GSM network Interface.

The simulation is carried out for all possible regions, At the start of simulation the mobile node (MN) can be in WLAN or in CDMA or in CDMA & GSM network based on the assumed parameters as mentioned in Figure 2.

The Simulations are performed for both Traditional Method i.e. standard decision model, Which does not use received signal strength and velocity in decision model and the proposed vertical handoff decision model. The proposed vertical handoff model can perform handoff to the "best interface " at the "best moment".

VI. Conclusion

In this paper ,We propose a vertical handoff model to perform vertical handoff to the best network interface at the best time moment. The proposed model make the vertical handoff decision based on the static factors (e.g. link cost, capacity ,power consumption, congestion on link) and dynamic factors(e.g. received signal strength, velocity, duration of a mobile node (MN) in a particular network). This model improve the whole system performance by reducing the unnecessary handoff and increases the user satisfaction by considering the user preferences in decision model. The result shows that the proposed vertical handoff decision model can perform vertical handoff to the " best interface " at the " best moment". This model is simple and applicable to any handoff implementation technique.

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