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OPTIMIZATION OF VERTICAL HANDOFF DECISION PROCESS FOR HETEROGENEOUS WIRELESS NETWORKS

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ABSTRACT

The most common method used for Vertical Handoff (VH) is the Strongest Signal First (SSF) method. In this technique, when there is a choice of multiple attachment points, the one that gives the Mobile Node (MN) the strongest signal is chosen. While it is simple and effective, the SSF method does not consider factors such as traffic load in the network, battery lifetime of the MNs and the cost of handoff. In this paper, we propose an optimized handoff decision algorithm that balances the load across all the attachment points, maximizes the collective battery life of the MNs and reduces the cost of handoff. We focus on the handoff between WLAN and Cellular Network.

Keywords: *WLAN, Cellular Network, Mobile Node, Vertical Handoff, Load balancing, Received Signal Strength (RSS), quality of service(QoS).*

1. INTRODUCTION

When the handoff is between sub-nets /cells of different wireless networks, the handoff is termed as Vertical Handoff (VH). In this paper, we focus on the handoff between WLAN and cellular network. There are two major architectures [1]-[3] for integrating the Cellular and WLAN network: tight Coupling Architecture and loose Coupling architecture. Here we use the tight coupling architecture. The advantage of using the tight coupling method is that, since the internet accesses the core of the cellular network, characteristics (such as security, quality of service) of the cellular network can be reused. Whereas in the loose coupling method, special Authentication, Authorization and Accounting (AAA) need to be provided [1].

In the traditional SSF method, when an attachment point experiences a signal with poor Received Signal Strength (RSS), it searches for another attachment point based on the strength of the signal it will provide the mobile node. It chooses the attachment point which gives it maximum RSS. But if a lot of MNs are attached to one attachment point due to high RSS, the power consumption will be more because of the congestion delay and the load will not be properly balanced across the attachment points leading to poor quality of service (QoS) after handover. In this paper, when there is a choice of multiple attachment points we choose the attachment points that will maximize the collective battery life of the MNs and will balance the load and reduce the cost of handoff. Our handoff decision method is based on analytical approach where we consider monetary cost, security, bandwidth and power consumption parameters before handoff execution. Our numerical results show that cost of handoff reduces compare to existing models.

2. SYSTEM MODEL

A. Network Architecture:

We consider a scenario as depicted in Fig.1. Each access network has a VH Decision Controller (VHDC) which contains the decision algorithm. The input to the VHDC is provided by Media Independent Handover Function (MIHF), IEEE 802.21 [6]. When the MN experiences degradation in RSS, it sends an 'event notification' to the MIHF layer. The MIHF layer then sends a 'command' to the lower layers asking them to search for an alternative attachment point. Once a suitable attachment point is found the MIHF of the MN communicates with the MIHF of the attachment point to initiate handoff (information service). This is the Link Layer Trigger [7], [8] provided to the VHDC by the MIHF.

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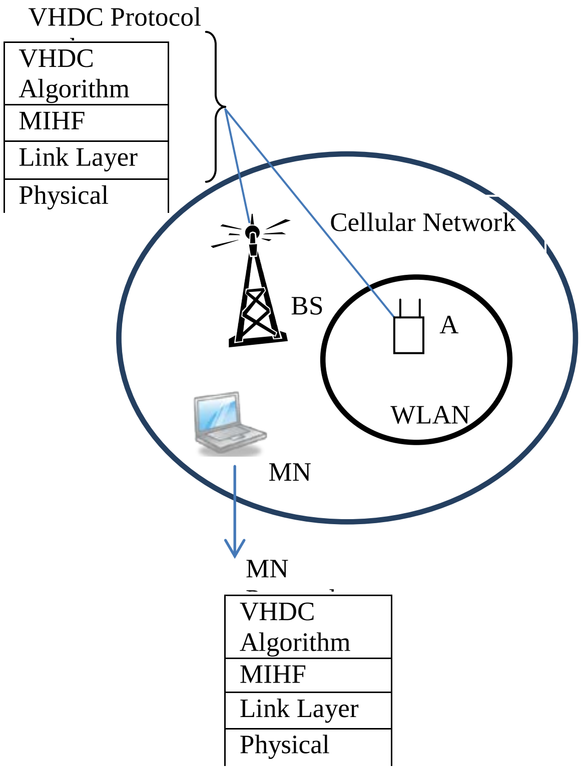


B. Vertical Handoff Decision Algorithm

Our optimized handoff decision is taken based on three parameters; battery life, traffic load and cost. Handover decision is taken considering one or combination of parameters. These three parameters are represented by α, β and γ, respectively. The consideration of each parameter in handoff decision is denoted by 1. For example, if battery life is considered in handoff decision it is denoted by $\alpha \equiv 1$ and if it is not considered it is denoted by $\alpha \equiv 0$.

Figure 2 shows the flow graph of our proposed VH decision algorithm. After the trigger from MIH layer VHDC needs to identify if the MN is in the service of an access point (AP) or a Base Station (BS). If the RSS has fallen below threshold while in service of an AP, then the MN can be handed-off to an AP or BS. If the MN was in the service of a BS, and the RSS from an AP is higher that threshold, then handoff is to an AP. At this juncture we incorporate an optional optimization technique for handoff decision. Depending upon the consideration of handoff decision parameters, there are following five options of handoff decisions.

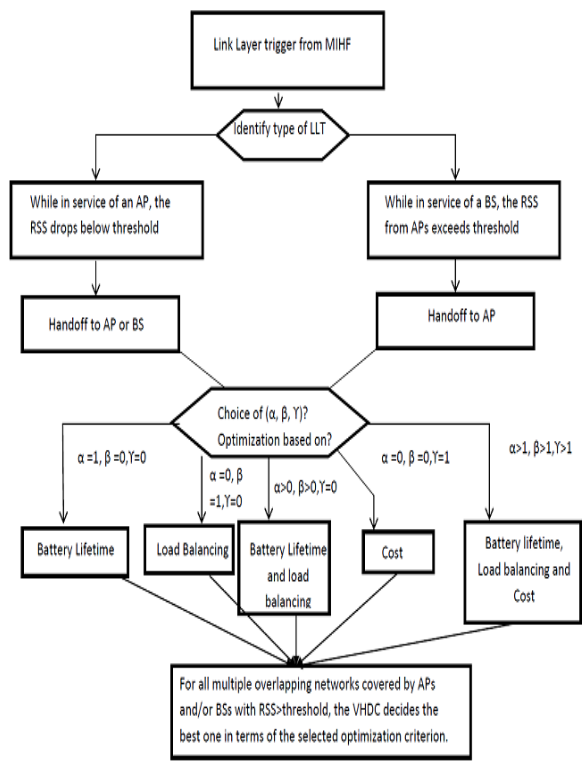
Case 1: $\alpha \equiv 1, \beta \equiv 0, \gamma \equiv 0$: Handoff decision is taken only when the MN has maximize battery lifetime of the MN.

Case 2: $\alpha \equiv 0, \beta \equiv 1, \gamma \equiv 0$: Traffic load: handoff decision is taken considering the traffic load in the new attachment point and to balance the traffic load across different attachment points.

Case 3: $\alpha \equiv 0, \beta \equiv 0, \gamma \equiv 0$: Decision is done depending on whether Battery lifetime and Load balancing conditions have been met:

Case 4: $\alpha \equiv 0, \beta \equiv 0, \gamma \equiv 1$: The handoff decision is made based on the cost such as Monetary cost, Security, Bandwidth, Power consumption

Case 5: $\alpha \equiv 1, \beta \equiv 1, \gamma \equiv 1$: Here handoff decision is made only when all the conditions are satisified i.e. Battery lifetime, Load balancing and Cost.



3. OPTIMIZATION MODELS

A. Based on Battery Lifetime

Let us consider a scenario with 'N' APs, 'M' BSs and 'K' mobile nodes. Load on any attachment point is a summation of the data rates of all the MNs accessing that attachment point. If l_{ij}

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represents the battery life of the mobile node 'i' at the attachment point 'j', then [7]:

$$l_{ij} = \frac{p_j}{p_{ij}} \; for 1 \le i \le N + M \qquad (1)$$

Where p_j is the available battery power at the MN and p_{ij} is the rate of consumption of power. Let $\{X = x_{ij}\}$ be an association matrix. The elements of this matrix have only two values: 0 or 1. $x_{ij} = 1$ if and only if the MN 'i' has a connection with the attachment point 'j'. Else x_{ij} has the value 0. The battery lifetime l_{tj} of MN 'j' for an association matrix $X = \{x_{ij}, l_{tj}(X)$ is [7].

$$l_{tj}(X) = \sum_{(1 \le i \le N+M)} l_{ij} . x_{ij} \qquad (2)$$

So the vertical Handoff Decision to maximize battery lifetime is given as [7]:

$$Max - L : Max \sum l_{tj}(X) \qquad (3)$$

Provided the load on each attachment point does not exceed the bandwidth of the respective attachment point.

B. Based on Load

The load effect on the base station or access point could be mathematically analyzed by the following model [7].

$$Opt - F : Min \sum_{1 \le i \le N+M} w(i) \left(\frac{\rho_i + \gamma_i(X)}{z_i} \right)^p \qquad (4)$$

Where, $w(i)$ represents the weight factor. Its value can range from 1 to 10, with the BS having a higher weight factor. This is in order to ensure that when there is a choice of handoff between an AP and a BS, the AP is preferred because of its low bandwidth cost and higher data rate. ρ_i is the load at the attachment point; which would be either the access point or the base station. z_i represents the maximum bandwidth provided by the access point and base station $\gamma_i(X)$ represent bandwidth requested by the mobile node.

C. Based on Cost

Based on the computational value of the following mathematical equation we need to select the access point or base station [8]:

$$C_i = \left(\frac{W_B \left(\frac{1}{B_i} \right)}{\max\left(\left(\frac{1}{B_1} \right) \dots \left(\frac{1}{B_n} \right) \right)} \right) + \left(\frac{W_M . M_i}{\max(M_1 \dots M_n)} \right) \qquad (5)$$
$$+ \left(\frac{W_S . \left(\frac{1}{S_i} \right)}{\max\left(\frac{1}{S_1} \dots \frac{1}{S_n} \right)} \right) + \left(\frac{W_P . P_i}{\max(P_1 \dots P_n)} \right)$$

$$Opt - Cost : Min(C_i) \qquad (6)$$

In equation (5) the first term indicates the available bandwidth of the channel, the second term indicates the monetary cost per minute, the third term indicates the security of the network and the fourth term represents power consumption level. By computing all these terms, if the value of C_i is low for a particular network then it would be chosen.

4. PROPOSED OPTIMIZATION TECHNIQUE

We propose a joint optimization for vertical handoff decision (VHD) with the consideration of battery life, traffic load and cost factor. Firstly, the for joint optimization of battery lifetime and load balancing and denoted by G [7]:

$$G(X, \alpha, \beta) = \alpha \, \Sigma l_{ij}(X) - \beta \sum_{1 \le i \le N+M} w(i) \left(\frac{\rho_i + \gamma_i(X)}{z_i} \right)^p \qquad (7)$$

From equation 7 we can say that if $\alpha \equiv 1, \beta \equiv 0$, then we consider only battery lifetime and if $\alpha \equiv 0, \beta \equiv 1$, then we consider only load and finally if $\alpha \equiv 1, \beta \equiv 1$, then we consider both battery lifetime and load.

The optimal value will be [1].

$$Opt - G : Max G(X, \propto, \beta) \qquad (8)$$

An optimization based on all three i.e. battery, load balancing and cost can be obtained by:

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$$C(\alpha,\beta,\Upsilon)=\alpha\ \Sigma l_{ij}(X)-\beta \sum_{1\le i\le N+M} w(i)\left(\frac{\rho_i+\gamma_i(X)}{z_i}\right)^p-[\Upsilon C_i] \quad (9)$$

$$Opt-H:MaxC(\alpha,\beta,\Upsilon) \quad (10)$$

From equation 10 we can say that if $\alpha\equiv 0,\beta\equiv 0,\gamma\equiv 1,$ we consider only cost and if $\alpha\equiv 1,\beta\equiv 1,\gamma\equiv 1,$ then we consider battery lifetime, load and cost.

Symbol	Definition	Value
M	No. of BSs	2
K	No. of MNs	20/80
p_j	Available power of MN	Initialized as 1000J
p_{ij}	Rate of consumption of power	Exponentially distributed with mean of 5mJ/s
w(i)	Weight	Any value from 1-10, higher value for BS
W_B	Weight of Bandwidth	0.5714
W_M	Weight for monetary cost	0.2857
W_S	Weight for security	0.1429
Z	Bandwidth	For AP- 2Mbps For BS- 20Mbps
ρ_i	Load at the attachment point	Number of on-going calls that particular attachment point
M_i	Monetary cost	Any value from 0-10 with 10 being the highest monetary cost
S_i	Security	Any value from 0-10
COV	Co-efficient of variation of energy	Standard deviation of load at AP/ Mean Load

5. NUMERICAL RESULTS

The simulations were carried out in MATLAB and we have created two scenarios and in both of them we have considered 6 APs and 2 BSs. Also, in first scenario we have considered 20 MNs and in the second scenario we have taken 80 MNs.

In figures 3, 4, 5,6 and 7 we consider the terms SSF as receiver signal strength, MAXL as battery lifetime, OPTF as load, OPTG as battery lifetime and load, OPT- cost as only cost, OPTH as battery lifetime, load and cost.

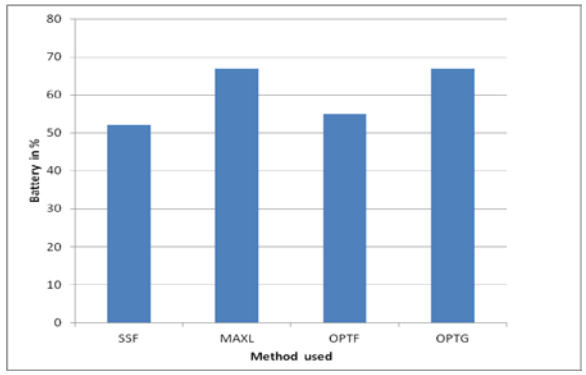

Fig.3. Comparison Of Battery Lifetime With 20 Mns

From Figure 3 and Figure 5, we see that in terms of optimal use age of battery, the MaxL technique performs the best. SSF method has the least remaining battery lifetime. In the SSF method when an MN needs to be handed-off, a suitable attachment point is chosen based on which gives it the strongest signal. It does not take into consideration the number of calls that attachment Point is already servicing. If there are many calls being serviced at that Attachment Point, then the time taken to complete the transfer of information is more and therefore the battery used is also more. Hence, the SSF method does not perform well in terms of optimal battery use age.

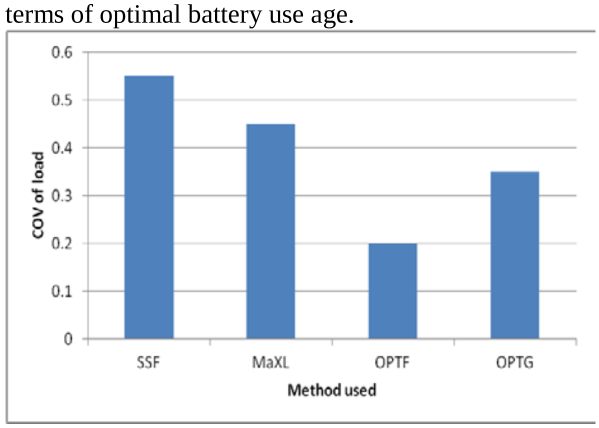

Fig.4. Distributedness of Load across Attachment points with 20 MNs

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The load is most evenly balanced across the attachment points in the OptF technique.SSF performs badly because it makes the handoff decision are based on the signal strength only. It does not consider load balancing.

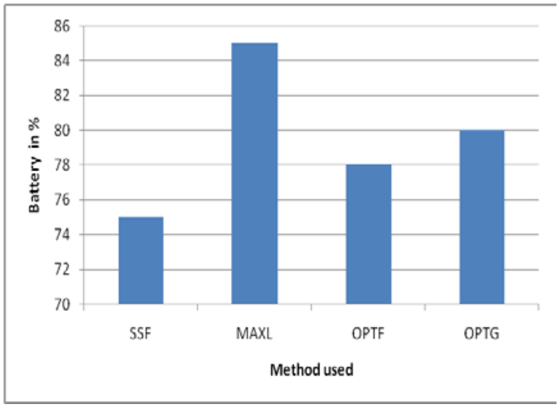

Fig.5 Comparison of battery lifetime with 80 MNs

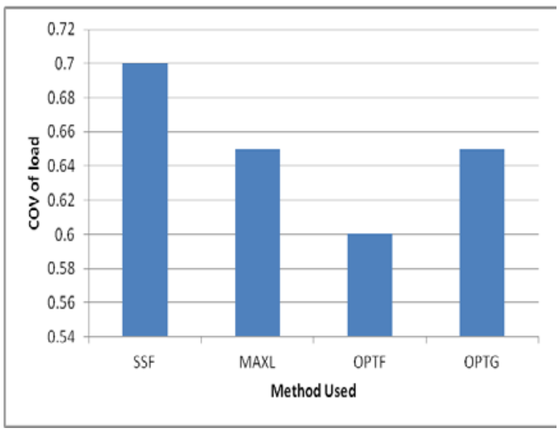

Fig.6. Distributedness of Load across Attachment points with 80 MNs

In the above fig.3 and fig.5 we see that SSF has the least remaining battery. Max-L has the highest remaining battery. The remaining battery of Opt-G is lesser that that of Max-L. This is because in Opt-G the handoff decision is made based on maximizing the battery life and balancing load across AP. Fig.4 and fig.6 show that Opt-F method ensures the best load balancing followed by Opt-g. SSF performs worst in terms of load balancing. On the y-axis of fig.4 and fig.6 we have Cov (Co-efficient of variation of load. This can be calculated as: standard deviation of the loads at the APs / mean load).

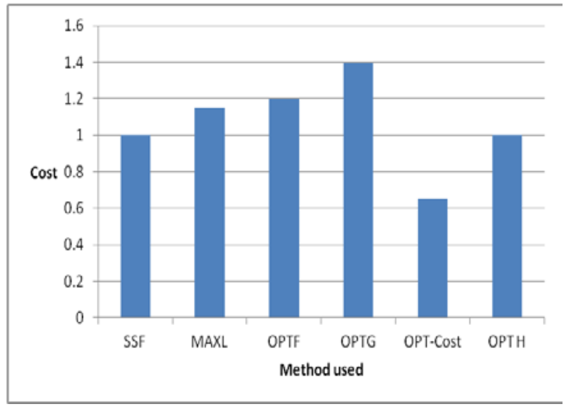

Fig.7. Cost of handoff with 80 MNs

In figure 7, we compare the cost of handoff of all the methods, Opt-Cost has the lowest cost. The joint optimization of battery, load and cost, Opt-H has a cost of handoff lower than the other methods but obviously not as low as Opt-Cost (since Opt-Cost makes handoff decisions based only on cost,whereas Opt-H considers other factors as well).

6. CONCLUSION

In this paper, we proposed a vertical handoff decision algorithm that maximizes the collective battery lifetime of all the MNs, balances the load equally across the attachment points and reduces the cost of handoff for infrastructure mode. We compared our method to the traditionally used Strongest Signal First (SSF) method. Our simulation was carried out in MATLAB and we have provided a detailed analysis of the results. We have concluded that out method performs much better in terms of remaining battery life of the MNs, load balancing across the attachment points and cost of handoff, that the SSF. Since, MIH 802.21 is an additional options for VH among different radio access technologies, proposed VHDC is an option for different access technology without altering their own handoff techniques.

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