A Novel Load Sensitive Algorithm for AP selection in 4G Networks

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Abstract **—With the advent of 3G cellular systems and the development of the same towards 4G, the need for efficiency in terms of signaling overhead between the actual mobile node at the lowest layer of the system architecture and the various other equipment providing services within the core network and without becomes critical. In 4G systems to suffice the needs of users with relatively low mobility requirements but yet providing a substantial amount of bandwidth in hot-spots it becomes essential to integrate WLAN 802.11 systems with currently existing UMTS GPRS systems which provide for wider mobility requirements. Efficiency at the lowest layer of the hierarchy is achieved by load balancing based connection protocol which takes into consideration the detection of advancement of the MN (Mobile Node) thus facilitating an optimal choice of AP (Access Point) for the MN to link up with, whenever it moves from one APs coverage area to another. In this paper we have provided an efficient load balancing based AP selection algorithm which considers the direction of advancement of the Mobile Node and hence is able to extract the optimal node for the User Equipment to link up with as it moves.**

Keywords: **Access Point Selection, Load Balancing, Advancement Direction, Mobile Node, 4G.**

I. INTRODUCTION

3G systems [5]-[9], which are the norm for today's leading service providers in the telecom industry is evolving into efficient 4G [6] integrated architectures [1] need to extract the very last bits of efficiency possible from the network algorithms [14] and architectures [16]-[17]. Referring to our previous research into development of an efficient MPLS enabled integration architecture for IEEE 802.11 and UMTS GPRS architectures [1], we develop a novel AP load sensitive algorithm for the optimal selection of an AP by the MN. This is critical in improving the performance characteristics of such systems, because incorrect or often suboptimal selection of APs by MNs can lead to rejection of binding requests and repeated unsuccessful attempts to bind with already overloaded APs. All this presents a severe retrograde to the efficiency and optimal network performance. The challenge is to explore the design of such an algorithm which not only selects the AP with respect to the current load that it is serving but also takes into account the mobility characteristics of the MN. The development and subsequent implementation of the proposed algorithm is essential to reducing the number of times the MN makes an "incorrect" choice. This algorithm provides the MN with the best AP, both in terms of load serviced as well as the direction of advancement of the MN. Such an algorithm will enable 4G systems to takes full advantage of IP based technologies to achieve much desired efficiency from the grassroot level.

II. ACCESS POINT SELECTION

The basic unit of WLAN network is a Basic Service Set (BSS) with one Access Point [16]-[17]. Several BSSs are connected to construct an Extended Service Set (ESS). We will persist with the term AP to maintain clarity in the ASSOCIATION procedure although the integration architecture clearly possesses AR's at the lowermost levels of the network structure. While the user that is associated with a BSS is moving, the handover procedure is initiated as follows:

1) The mobile terminal checks the Received Signal Strength (RSS) [16] of the periodically transmitted beacon signal from the currently associated AP.
2) If the RSS of beacon is found to be weaker than the threshold, the mobile terminal initiates the AP selection procedure.
3) In passive mode, the mobile terminal listens for the beacon signal from the neighbor APs, and in active mode, the mobile terminal transmits the probe request to the neighbor APs. The APs that receive the probe request send probe responses back to the mobile terminal.
4) The mobile terminal checks the RSS of beacon signals or probe responses from the neighbor APs, and selects the AP with the strongest signal strength and which satisfies it's selection algorithm which tries to predict the best suited AP according to the logical direction of advancement of the MN.
5) After choosing an AP, the mobile terminal associates to that AP.

6) After finishing the re-association of the mobile terminal, the new AP informs the old AP of the re-association using Inter-Access Point Protocol (IAPP) and the handover procedure is completed.

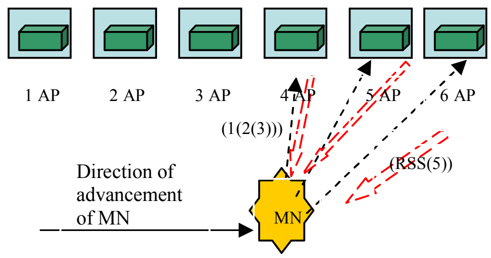

Fig.1 – MN selects AP's based on their RSS and optimality with respect to its direction of advancement.

III. SELECTION ALGORITHM

A <u>**MN Module**</u>

```
If ( current_beacon < threshold ) then {
   If ( ACTIVE_mode) then {
     Encapsulate_Advance_info(MN);
     Send_Probe( ) ;
     Wait( buffer_time);
     Receive ( Probe_response[ ] );
For
(iteration=0;iteration<num_of_APs;iteration++)
temporaryAP[iteration]=Select_above_threshold
(Probe_response[iteration] );
optimalAPselect=Select_optimal_AP
 ( temporaryAP[] );
 }
 Else Receive (RSS_beacon[ ] );
For
(iteration=0;iteration<num_of_APs;iteration++)
temporaryAP[iteration]=Select_above_threshold
(RSS_beacon[iteration] );
optimalAPselect=Select_optimal_AP
(temporaryAP[ ] );
}
Else Continue ( MN);
}
```

B <u>**AP Module**</u>

```
If (Receive ( AP_Probe[ ] )) != NULL then
{
Lookup_neighbor_table( tempstore[ ] );
Match_direction( tempstore [ ], AP_Probe[ ] );
optimalAPselect=Select_optimal_AP
(tempstore [ ], AP_Probe[ ] );
Encapsulate_optimalAP( RSS );
}
Else continue ( );
```

Current_beacon : current beacon strength
Threshold : threshold beacon strength
ACTIVE_mode : ACTIVE/PASSIVE mode
Buffer_time : Wait variable
Probe_response [ ]: Array for PROBE receival
temporaryAP [ ]: Array for AP's above threshold
RSS_beacon [ ]: Array for RSS beacons

IV. PERFORMANCE EVALUATION

The algorithm has been simulated on a generic 3G structure which consists of APs at the lowermost levels and the LEMAs [1] or SGSNs [6] in the middle layers above the wireless technology specific 3G-AR device. The MN has been simulated as an entity which attempts to traverse from one AP to the other in a particular direction. Random changes in direction of advancement have not been incorporated due to the fact that for a sample time of observation any particular MN will maintain its direction of motion with a due degree of assurance. As the MN traverses the lowest level AP line-up it tries to probe each AP entity to gather information about its load level as well as gather information about the "suggested" optimal AP data passed to the MN by the probed AP. This suggestion has been stored in the form of a simple array, which stores such optimal "suggested" AP information for each probed AP. There is one entry each for every AP with respect to the direction of traversal of the MN. The evaluation is depicted in Fig. 2 as shown below. We have analysed the performance of this algorithm on the basis of the number of "wrong" link-ups the MN incurs before it can successfully traverse the complete field of APs from the starting AP and get to the last AP. Wrong link ups can be defined as the selection of those APs which are in opposite direction to the motion of the MN and which therefore force the MN to again select another AP, in the desired direction and within the prescribed load level to link up with. The various series in the graph depicted below show comprehensively that our algorithm entails lesser number of wrong link-ups, than the scenario where the scheme is not implemented. The benefits of our proposed algorithm to dynamically select the most optimal AP for link-up using not only the load characteristics of the APs but also direction of advancement of the MN we can reap the benefits of incurring lesser wrong link ups.

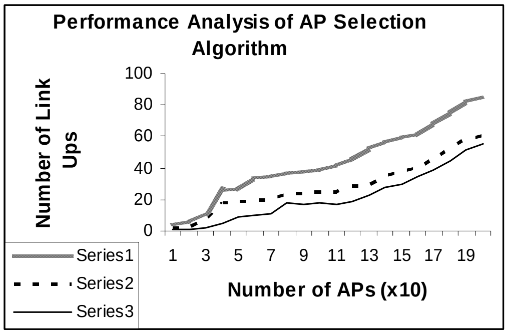

Fig. 2 Series 1 represents the total number of AP link ups needed for the MN to traverse the APs, while Series 2 represents the total number of wrong link-ups and finally Series 3 represents the number of reduced wrong Link-ups via the AP selection algorithm.

V. CONCLUSION

In this paper we have developed an efficient AP selection methodology which considers load at each of the AP's and its suitability with respect to the direction of advancement of the MN, leading to an efficient solution to load balancing considerations in such a network at the lowest level. This methodology will lead to significant savings in a dense MN environment exploiting tremendous scope to optimize AP selection on the basis of direction of advancement of the MN. This leads to lesser AP ASSOCIATE messages, lesser number of dropped frames which could not be handled by the AP because of heavy load, lesser number of frame collisions. This leads to a system that can optimally utilize the resources at its disposal by allowing the MN the best choice of AP in terms of both system load and direction of advancement.

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