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Dynamic Weight Assignment based Vertical Handoff Algorithm for Load Optimization

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Abstract

Objectives: Consolidating any two dissimilar networks leads to a formation of a heterogeneous wireless network. Vision to achieve distinct networks to get converged such that characterizing of the upcoming wireless networks becomes a reality. This in turn ushers in vertical handoff such that handoff among different technologies is efficient. And at the same time it is so smooth that naming it as seamless is justifiable. Pragmatic consideration of the network characteristics and the dynamics are very essential to choose one of the best available network handoff decisions. **Methods:** Stating conventionally, when a mobile client is roaming, a single criterion- for example, received signal strength is employed to realize the vertical handoff. But, single criterion consideration is not sufficient and taking into account of other parameters is needed for a proper handoff decision. The present paper puts forth a strong load balancing algorithm M-OPTF that is based on dynamic weight assignment technique for allocation of fresh calls and handoff calls. **Findings:** In the present scheme assignment of weight factor is done to attachment points basing on the distribution of load on them. In addition it contains a process for handoff decision that takes into account the velocity of mobile node to do triggering of handoff. The put forth M-OPTF algorithm is compared along with Remote Sensing Systems (RSS) and OPT-F algorithm in this paper. **Application/Improvements:** The simulation results confirm the fact that M-OPTF algorithm apart from balancing the network load it can effectively decrease congestion in network, reduce the number of handoffs that are unnecessary, and increases the battery life time, thus improve the overall performance of the system.

Keywords: Dynamic Weight Assignment, Load Balancing, Unnecessary Handoffs, Velocity; Vertical Handoff, Weight Factor

1. Introduction

In recent times, a real-time, with a good availability of instantaneous large-bandwidth, continuous support service and quality of service are important features required by a large variety of applications which utilize networks. Thus, it is necessary to provide the best combined use of resources that are possible so as to support connection among the heterogeneous networks that are available. In order to establish connection among different heterogeneous networks for better system performance and continuous availability, use of vertical handoff is one of the most important steps. So, to improve vertical handoff performance, one needs to develop vertical hand off algorithms for improved quality of service and better connection management. In Wi-Fi and Cellular networks overlapping scenarios, various such algorithms are implemented and compared to achieve optimum utilization of network resources under all the possible network conditions. While switching from one to another network, it is essential to maintain load balancing among various attachment points. Load balancing is a prime matter of concern to make use of available resources efficiently among single networks as well as different technologies in heterogeneous wireless networks. Therefore, handoff is one of the most important tasks in order to maintain the continuity during a call in progress. And its failure will cause an increase in the call dropping rate and also call blocking rate. The importance of dynamic resource utilization among heterogeneous wireless networks is on

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the increase day by day. Thus, load balancing between wireless networks is of prime importance. For the purpose of proper resource utilization, and extension of system capacity, as well as for providing the clients with improved quality service, load balancing is a significant step. Conventionally, load balancing is dependent on the system architecture and the load balancing algorithm. In this paper, efficient network architecture has been provided so that the load of a system can be properly balanced using dynamic weight factors. An extensive research has been performed on load balancing, mainly in the area of wired homogeneous networks. But load balancing in wireless networks is still the open the problem in the current research trend of the state of the art technologies. However, some of the following works is highlighted due to their significant impact in the research direction. These works are briefly discussed below. Remote Sensing Systems (RSS) based decision making[1] for vertical handoff is the simplest algorithm so far, but it is not a reliable option because of the fluctuation in RSS[2]. Moreover, the threshold of RSS is different for each and every heterogeneous network; so handoff based on RSS can lead to service interruption because of unnecessary handoff and non-uniformly balanced load[3-4]. A wide variety of methods are available for vertical handoff decision algorithm like RSS-based, fuzzy logic, context-aware, cost function, multi criteria, etc. In[5] RSS-based methods for handoff decision has been optimised by making use of RSS threshold and in[6] by combining RSS threshold with location and client's velocity. In various researches[7-11], it is indicated that load balancing is a needful step for improvising overall system performance, avoiding network congestion and increasing its capacity. A lot of studies have been conducted by various researchers on load balancing. In a two-phase load balancing technique effectively improves the utilization of network resources. In[12], load balancing techniques within access points are categorised as switching-load balancing, terminal master-load balancing, access-load balancing, network master-load balancing and so on. All these have their own pros and cons. An algorithm in which different types of calls are assigned to different load thresholds to achieve load balancing is introduced in literature[13] but, it is difficult to make accurate measurements for threshold setting. It is difficult to obtain a solution for the problem which is used in Genetic Algorithm[14] for optimal allocation of channels so that load balancing is maintained. A load control algorithm has been presented in[15]. Which periodically adjust the threshold among neighbouring networks according to the load condition, though it does not indicate how the clients are to be assigned in heterogeneous networks? Previously, a lot of algorithms have been used for performing vertical handoff. In RSS based algorithm, handoff decision has been made using a single criterion namely, RSS. In OPT-F algorithm load parameter is only being considered during handoff process. Our proposed M-OPTF algorithm considers the parameters like RSS, load, velocity of the mobile node, to scrutinize the performance of vertical handoff algorithm[16] A rational scenario using MATLAB has been developed to choose the feasible network for a Mobile Node (MN).The M-OPTF algorithm concentrates on distribution of the load equally among all the attachment points. It dynamically generates weight factors for each attachment points based on existing load distribution[17]. If load on particular attachment point is small then weight factor assigned to that attachment point will be more.

2. System Architecture

In this scenario two cellular and four Wi-Fi networks are considered. When an MN is voluntarily pushed from a heavily loaded cellular (or Wi-Fi) network to another lightly loaded Cellular (or Wi-Fi) network respectively, then it is called horizontal handoff. Whereas, if the mobile node is voluntarily pushed from a heavily loaded cellular (or Wi-Fi) network to another lightly loaded Wi-Fi (or Cellular) network respectively, then it is called a vertical handoff. Whenever handoff is required, first of all link layer is triggered by a mobile node. All the information such as RSS, velocity of mobile nodes and battery power is exchanged between link layer and Media Independent Handover Function (MIHF). MIHF of the mobile node and that of access point or base station exchange information as shown in Figure 1. MIHF is a protocol stack which is present in access point, base station as well as MNs. In order to exchange information between different networks such as traffic load, handoff call dropping rate, network capacity and so on, MIHF acts as a medium of communication. The proposed algorithm is implemented in vertical handoff decision controllers. Each access point and base station has its own VHDC. VHDC takes its input from MIHF layer via link layer controller and hence handoff decision is taken by VHDC for the coverage area lying in access point and base station.

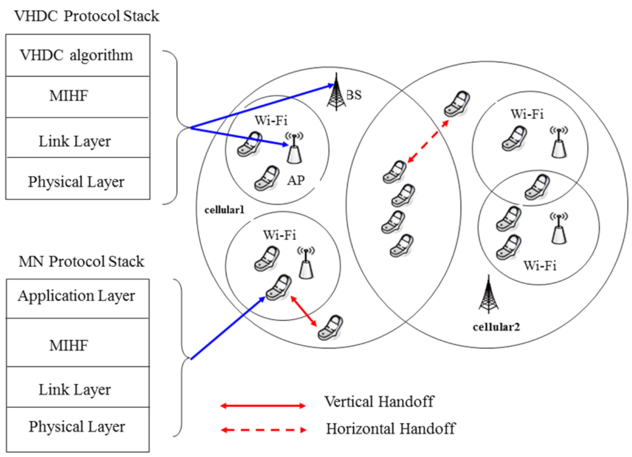


Figure 1. Wi-Fi and Cellular coexistence scenario

3. Handoff Triggering

Vertical or horizontal handoff is performed based on the handoff triggering. The handoff triggering decides whether handoff is required or not. In the existing method, handoff triggering is initiated based on RSS. In the proposed method handoff triggering is intiated not only based on RSS, but also on the velocity of the MN. By considering the velocity, the proposed M-OPTF algorithm minimizes unnecessary handoff. It is obvious that the Wireless Local Area Network (WLAN) coverage area is very small compared to the cellular area. Consider a situation an MN is moving through a cellular coverage area. Also imagine there are one or more WLAN APs in the neighborhood. If these can provide better RSS than the cellular BS, in the M-OPTF algorithm it is possible to accommodate requests from MN for VHO. If the MN moves at a high speed, the node's request for handoff into the WLAN AP can be declined. This is due to the fact that the MN will move out of the small WLAN coverage area very quickly. Otherwise, if the high speed MN's request for handoff to the WLAN AP is accepted, the control will be moved from BS to AP. Then within a short span of time, when the high speed MN moves from WLAN to cellular coverage area, again handoff is to be done to a BS. So, handoff is done twice. But in the proposed method, the handoff to the AP is skipped to a high speed MN. This reduction in number of handoffs for a high speed MN improves QoS. The proposed M-OPTFVHO algorithm for HWN (WLAN and cellular) is shown in Figure 2. The variables are assumed while determining the vertical handoff:

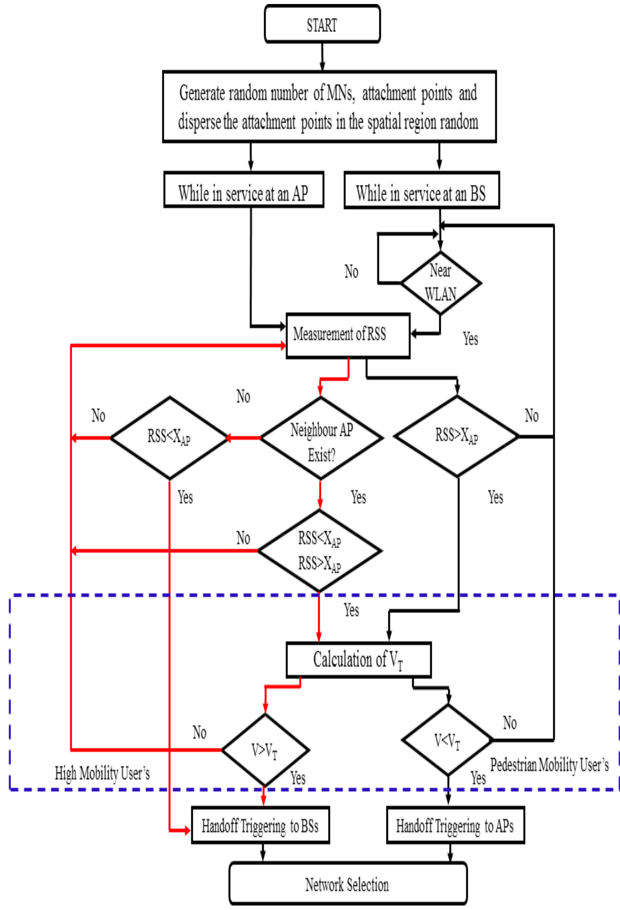


Figure 2. RSS and velocity criterion flowchart

1) X_{Ap}: Indicates handoff threshold value, while in WLAN service.
2) V_T: Velocity threshold, whether it is a high speed or a slow speed MN.

MN and AP/BS are randomly distributed in the spatial region which is shown in Figure 2. The two cases are discussed as follows:

Case 1: While an MN is in service at AP, it checks the status of the RSS continuously. If RSS at the MN is less than the given threshold level, it searches the neighbouring AP. If neighbouring AP is available, it checks the status of MN. When RSS is greater than the threshold level, it succeeds by checking the velocity of the MN. If the user velocity is greater than the threshold level, MN triggers the link layer (High mobility user's handoff triggering is done to cellular network). Else, it continuously measures the RSS, based on the status of MN's RSS as well as user velocity and checks whether the velocity is greater than the threshold level.

Case 2: While an MN is in service at BS, it checks the availability of the neighbouring AP. If neighbouring AP is available, it finds out whether the RSS of the MN is greater than the threshold level. When it is greater next it checks the user velocity; if the user velocity is less than the threshold level, MN triggers the link layer (pedestrian mobility client's handoff triggering is done to WLAN). Else, it continuously searches the nearby WLAN, whether the RSS of MN and user velocity are lesser than the threshold Level.

The flowchart for vertical handoff procedure using RSS and velocity criterion is given. In both cases, whenever handoff is needed, MN triggers the link layer. The link layer exchanges the information such as RSS, velocity of the MN and Battery power to MIHF. The MN of MIHF exchanges the information to the MIHF of AP/BS as shown in Figure 1. MIHF is a protocol stack, which is present in AP, BS and MN. MIHF is a common language which provides the message exchange between the different networks such as traffic load, handoff call dropping rate and network capacity. The proposed M-OPTF algorithm is implemented in VHDC. VHDCs are placed in the access networks (APs/BSs). The input given to VHDC is taken from MIHF layer via LLC and it provides the handoff decision function for coverage region of APs and BSs.

4. Network Selection Parameters

In the proposed M-OPTF algorithm, the mobile nodes are randomly distributed in the coverage area of base station and access points. Some of the nodes lie in the coverage area of base station alone or access point alone, while some lie in the overlapping region of both access point and base station. But the mobile node is connected to only one of these attachment points based on RSS. Load on each network (AP and BS) is measured as follows. For each access point $a_i \in A$ $(1 \le i \le N)$, the load on access point a_i is,

$$\tau_{\text{Wi-Fi}} = \sum e_{ij}\,, \text{for } 1 \le i \le N \quad (1)$$

$\mu_j \in V_a$

Where as the load on base station b_i *is*

$$\tau_{\text{Cellular}} = \sum e_{ij}{}^{b}\,, \text{for } N+1 \le i \le N+M \quad (2)$$

$\mu_j \in V_b$

Here, N is the number of access points, M is number of base stations, V_a is number of mobile nodes connected to access points, V_b is number of mobile nodes connected to base stations and e_{ij} is bandwidth. So far weight factor assigned in Wi-Fi and cellular system are fixed. Wi-Fi weight factor is higher than the cellular network because Wi-Fi bandwidth higher than the cellular systems. In this algorithm weight factor assigned dynamic manner depend upon the load of the network. In order to optimize the handoff decision, each metric weight of a candidate network should be adjusted to reflect this metric priority relative to the other attributes in different candidate networks. Thus, the weights should dynamically reflect the importance and relationships of the continuously changing ℓ_i under unpredictable wireless environments, and should magnify the dominant-difference among candidate networks. We modify the dynamic weights as follows. Suppose that the ℓ_i (Load in Aps/BSs) of W_a^{BW} and W_c^{BW} of the *n* candidate networks have been calculated and organized as,

$$W_a^{BW} = \lfloor l_1^{BW}, l_2^{BW} \ldots\ldots\, l_N^{BW} \rfloor \quad (3)$$

$$W_c^{BW} = \lfloor l_1^{BW}, l_2^{BW} \ldots\ldots\, l_{N+M}^{BW} \rfloor \quad (4)$$

Taking the ℓ_i of load of the *n* candidate networks for example, we define $\overline{W}_a^{BW}$ and σ_a^{BW} as follows:

$$\overline{W}_a^{BW} = \frac{1}{n}\sum_{i=1}^{n} l_i^{BW} \quad (5)$$

$$\sigma_a^{BW} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n} [(l_1 -]\overline{W}_a^{BW})^2} \quad (6)$$

$$\sigma_c^{BW} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n} [(l_1 -]\overline{W}_c^{BW})^2} \quad (7)$$

The key factors for bandwidth of Wi-Fi and cellular can be defined as below

$$\emptyset_a^{BW} = \exp(-\overline{W}_a^{BW} + \sigma_a^{BW}) \quad (8)$$

$$\emptyset_c^{BW} = \exp(-\overline{W}_c^{BW} + \sigma_c^{BW}) \quad (9)$$

$$\emptyset = \emptyset_a^{BW} + \emptyset_c^{BW} \quad (10)$$

Finally, the desired dynamic weights can be defined as

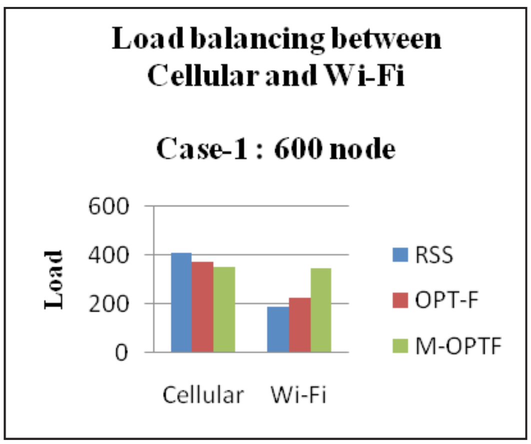
$$W_a^{BW} = \frac{\emptyset_a^{BW}}{\emptyset} \quad (11)$$

$$W_c^{BW} = \frac{\emptyset_c^{BW}}{\emptyset} \quad (12)$$

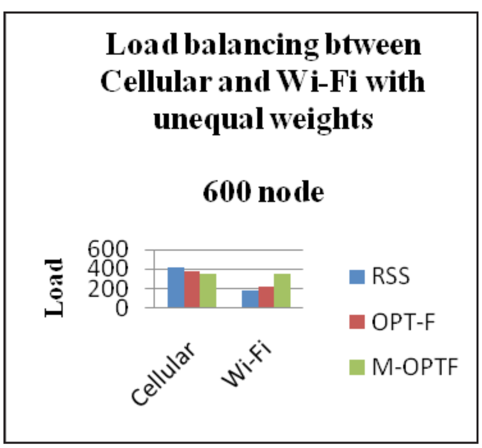
Based on these weight factors load is distributed.

5. Simulation Results

For the verification of the efficiency of the proposed algorithm, a heterogeneous network simulation platform is built using MATLAB. The bar graph shows distribution of load among cellular and Wi-Fi networks on implementing three different algorithms. The blue bar represents distribution of load by considering single parameter RSS. The red bar shows distribution of load by implementing another algorithm i.e. OPT-F which takes into account two parameters load and RSS. The green bar represents distribution of load by implementation of M-OPTF algorithm. It shows the best distribution of load among Wi-Fi and cellular as it is almost equally distributed since load is distributed based on dynamic weight factor as shown in Figure 3a and 4a. The graph in Figure 5a shows the covariance of load between Cellular and Wi-Fi network for three algorithms. The blue bar graph denotes very high value of covariance when load is balanced using a single

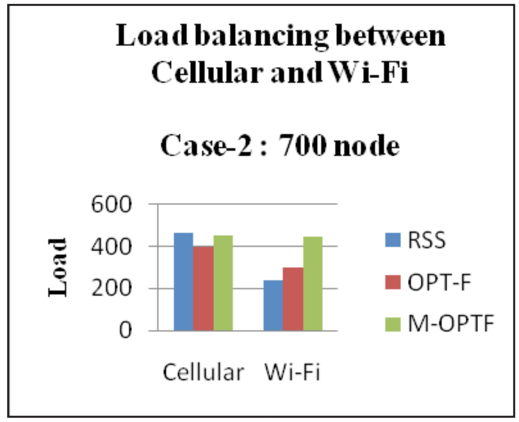


(a)

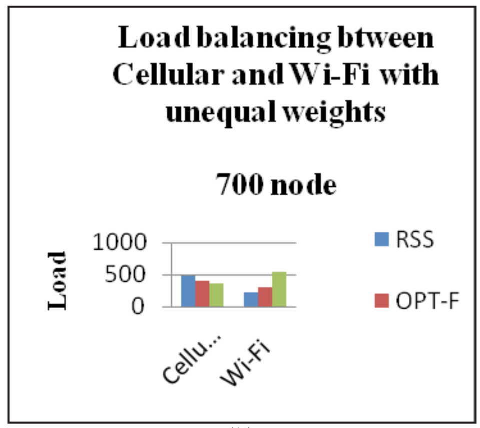


(b)

Figure 3a and 3b. Load balancing between cellular and Wi-Fi, case 1: 600 nodes

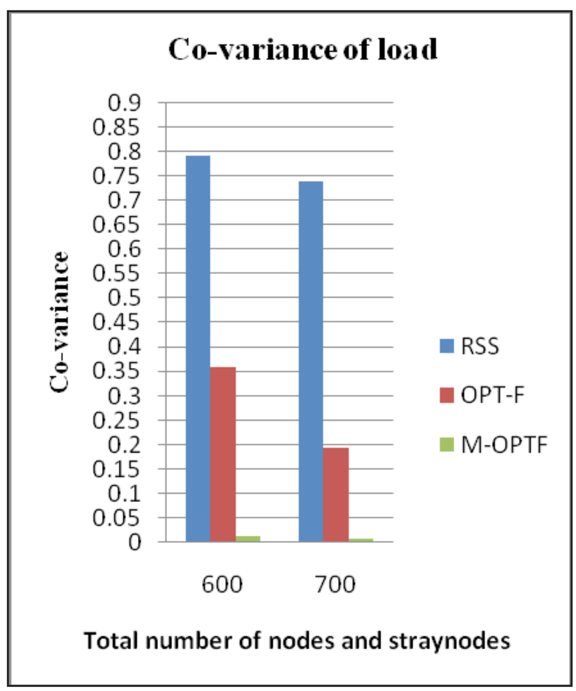


(a)

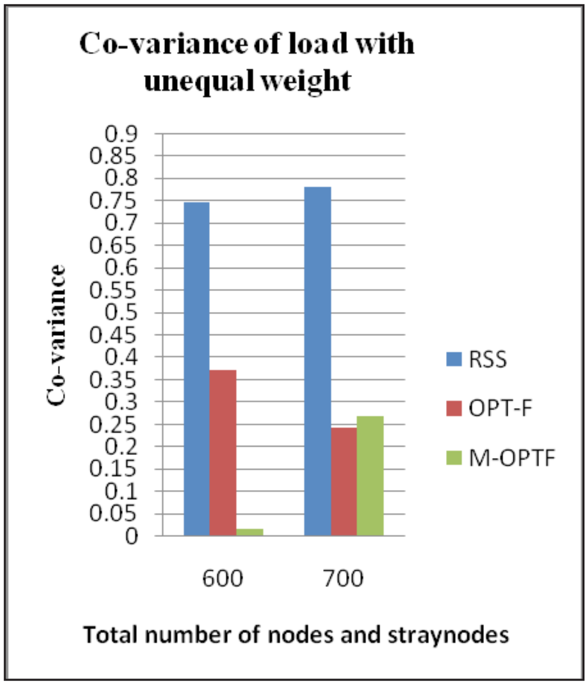


(b)

Figure 4a and 4b. Load balancing between cellular and Wi-Fi, case 2: 700 nodes



(a)



(b)

Figure 5a and 5b. Covariance of load

metric RSS. The red bar graph denotes slightly smaller covariance value than before, when another parameter load is taken into consideration along with the RSS. In both these cases, the covariance is high because load has not been uniformly balanced between the attachment points. The green bar graph depicts the covariance after the implementation of M-OPTF algorithm which uses dynamic weight factor for balancing load. The covariance is the least in this case because of the uniform distribution of load. In the Figure 3b, 4b and 5b depict the practical scenario where Wi-Fi has more bandwidth than cellular and thus Wi-Fi is more loaded than cellular in these graphs.

6. Conclusion

This paper presents an algorithm for load balancing in heterogeneous wireless networks. Co-variance of load determines how equally the load is distributed. If co-variance is small, then the load is more uniformly distributed between access points and base stations. In dynamic weight assignment algorithm, the stray nodes are distributed according to the previously existing load on access points and base stations. If load is more, weight factor assigned will be small and vice-versa.

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