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# OPTIMIZATION OF VERTICAL HANDOFF PERFORMANCE PARAMETERS IN HETEROGENEOUS WIRELESS NETWORKS

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## ABSTRACT

**We have a proposed a new method to select a network during vertical handoff to optimize different performance parameters such as number of handoff, throughput, power consumption etc. in heterogeneous wireless networks. In this paper we have used the multiple optimization problem(MOP) concept to represent multiple number of vertical handoff criteria which will select the best available network with optimized parameter values (such as latency of network should be minimum) in the heterogeneous wireless network. The formulated multiple objective functions is implemented using genetic algorithm. Then the problem is simulated using Matlab. The simulation result shows that the number of handoff and latency can be minimized where as throughput can be maximized, if we take optimized network parameter values during vertical handof**f.

***Keyword-*** **genetic algorithm, heterogeneous network, multiple objective problems, no of handoff, throughput optimization**

## 1. INTRODUCTION

In the last years, mobile communications have become pervasive to all activities of society. The number of mobile phones and wireless Internet users has increased significantly The current changing private and professional lifestyles has created a surging demand for communications on the move, reachability and wireless broadband. The 4G wireless system has the potential to provide high data transfer rates, effective user control, seamless mobility. Future Wireless systems will be characterized by their heterogeneity such as multiple access technologies provide access to internet content. A heterogeneous (or hybrid) network can be defined as a network which comprises of two or more different access network technologies (VANET, WLAN, UMTS, CDMA, MANET) to provide ubiquitous coverage. Indoor environment technologies 802.11, Bluetooth, HomeRF, and IrDA etc provide high data rates but cover smaller areas. On the contrary outdoor environment technologies GPRS, CDMA2000, Satellite etc. support low data rates ,but offer much wider area of coverage that enables ubiquitous connectivity. All the systems differ in terms of coverage, bandwidth, delay, cost etc. However, using multiple wireless network interfaces it is possible to avail the advantages of different types of network simultaneously. The varying wireless technologies are driving today's wireless networks to become heterogeneous and provide a variety of new applications (such as multimedia) that eases and smoothes the transition across multiple wireless network interfaces.

Many internetworking mechanisms have been proposed [1]-[4] to combine different wireless technologies. Two main architectures (a) Tightly coupled (b) Loosely-coupled have been proposed for describing internetworking of heterogeneous networks. However, roaming across the heterogeneous networks creates many challenges such as mobility management and vertical handoff, resource management, location management, providing QoS , security and pricing etc. In this kind of environment, mobility management is the essential issue that supports the roaming of users from one network to another. One of the mobility management component called as handoff management, controls the change of the mobile terminal's point of attachment during active communication [5].

Handoffs are extremely important in heterogeneous network because of the cellular architecture employed to maximize spectrum utilization. Handoff is the process of changing the channel (frequency, time slot, spreading code etc.) associated with the current connection while a call is in progress. Handoff management issues [6] include mobility scenarios, decision parameters, decision strategies and procedures. Mobility scenarios can be classified into horizontal (between different cells of the same networks) and vertical (between different types of network) .In homogeneous networks, horizontal handoffs are typically required when the serving access router becomes unavailable due to mobile terminal's movement. In heterogeneous networks, the need for vertical handoff s can be initiated for convenience rather than connectivity reasons. The decision may depend on various groups of parameters such as network-related, terminal related, user-related and service related. The network-related parameters are mainly defined as bandwidth, latency, RSS, SIR (Signal to inference ratio), cost, security etc. The terminal related parameters are velocity, battery power, location information etc. User related deals with user profile and preferences, service capacities, QoS etc. A number of vertical handoff decision strategies [4]such as (1)traditional(2) function-based (3)user-centric(4)Multiple attribute decision (5)Fuzzy logic-based(6) neural networks-based and context-aware have been proposed in the literature .The handover procedures can be characterized as hard or soft handoff .The handoff can be hard when the mobile terminal is connected to only one point of attachment at a time whereas the handoff can be soft when the mobile terminal is connected to two point of attachment.

The process of vertical handoff can be divided into three steps, namely system discovery, handoff decision and handoff execution. During the system discovery, mobile terminal equipped with multiple interfaces have to determine which networks can be used and what services are available in each network. During the handoff decision phase, the mobile device determines which network it should connect to. During the handoff execution phase, connections are needed to be re-routed from the existing network to the new network in a seamless manner .This requirement refers to the Always Best connected (ABC) concept, which includes the authentication ,authorization , as well as the transfer of user's context information. This paper presents the vertical handoff management and focuses mainly on the handoff decision problem. It is necessary to keep the decision phase in the global phase and to prove its contributions in the optimization of vertical handoff performance. For instance, the first choice can minimize the handoff latency, operation cost and avoid unnecessary handoffs. The second choice can satisfy network requirement such as maximizing network utilization. The third choice can satisfy user requirement such as providing active application with required degree of QoS. This process needs decision factors: decision criteria, policies, algorithms, control schemes. The decision criteria mentioned previously have to be evaluated and compared to detect and to trigger a vertical handoff. To handle [4] this problem many methodologies such as policy-enabled scheme, fuzzy logic and neural network concepts, advanced algorithms such as multiple attribute decision making, context-aware concept etc. have been explored.

The rest of the paper is organized as follows. We first describe the related works that has been done till date which helped us to propose the new approach. The next section describes the details of vertical handoff process and the heterogeneous wireless networking system model. At last the simulation results have been defined for the proposed approach, followed by the conclusion and future work.

## 2. RELATED WORK

The vertical handoff decision algorithms that are proposed in the current research literature can be divided into different categories. The first category is based on the traditional strategy of using the received signal strength (RSS) combined with other parameters. In [8], Ylianttila et al. show that the optimal value for the dwelling timer is dependent on the difference between the available data rates in both networks. Another category uses a cost function as a measurement of the benefit obtained by handing off to a particular access network. In [9], the authors propose a policy-enabled handoff across a heterogeneous network environment using a cost function defined by different parameters such as available bandwidth, power consumption, and service cost. The cost function is estimated for the available access networks and then used in the handoff decision of the mobile terminal (MT). Using a similar approach as in [8], a cost function –based vertical handoff decision algorithm for multi-services handoff was presented in [10]. The available network with the lowest cost function value becomes the handoff target. However, only the available bandwidth and the RSS of the available networks were considered in the handoff decision performance comparisons. The third category of handoff decision algorithm uses multiple criteria (attributes and/or objectives) for handover decision. An integrated network selection algorithm using two multiple attribute decision making (MADM) methods, analytical hierarchy process(AHP) and Grey relational analysis (GRA), is presented in [11] with a number of parameters. Multiplicative Exponent Weighting (MEW), Simple Additive Weighting (SAW), and Technique for Order Preference by Similarity to Ideal Solution (TOPOSIS) [12] algorithm allow a variety of attributes to be included for vertical handoff decision. Simulation results show that MEW, SAW aTOPSIS provide similar performance to all four traffic classes (conversational, streaming, interactive and background). GRA provides a slightly higher bandwidth and lower delay for interactive and background traffic classes. In [13], Nasser et al. propose a vertical handoff decision function that provides handoff decision when roaming across heterogeneous wireless networks.

The fourth category of vertical handoff decision algorithm uses computational intelligence techniques. In [14], an Artificial Neural Network (ANN) is used to control and manage handoffs across heterogeneous wireless networks. The proposed method is capable of distinguishing the best existing wireless network that matches predefined user preferences set on a mobile device when performing a vertical handoff. A fuzzy logic inference system has been proposed [15] to process a multi-criteria vertical handoff decision metrics for integration and interoperation of heterogeneous networks. In [16], two vertical handoff (VHO) decision making schemes has been proposed based on fuzzy logic and neural networks. In [17], a mobility management was proposed in a packet-oriented multisegment using Mobile IP and fuzzy logic concepts. Fuzzy logic systems and neural network classifiers are good candidates for pattern classifiers due to their non-linearity and generalization capabilities. The fifth category is based on the knowledge of the context information of the mobile terminal and the networks in order to take intelligent and better decisions [18]. In [19], the authors present a framework with an analytical context categorization and a detailed handover decision algorithm.

## 3. PERFORMANCE OPTIMIZATION OF VERTICAL HANDOVER DECISION

The VHD scheme presented in this paper consists of three VHD modules: Handoff Need (HN), Target Network Selection (TNS), and Handover Performance Parameter Estimation (HPPE). The handoff need module is used to predict the necessity of handoff. The necessity of handoff is predicted by using the handoff prediction algorithm which is based on received signal strength (RSS) concept. If the RSS of the MN in current network is less than the RSS of other existing networks then there will be a need for handoff. Then after knowing that there is a need for handoff then the next step is to decide the target network for handoff. In our research work this step is handled by the handoff target selection module using multiple objective optimization concepts that defines the main objective. Here the parameters of the networks can be represented by different criteria. The target network will be the network with minimum latency value, signal-to-noise ratio, power consumption and maximum throughput. Then HPPE module is used to optimize the throughput, packet loss, no of handoff and handoff failure probability of MN, across different APs or BSs during handoff which shows the performance of the proposed algorithm.

### 3.1 BASIC CONCEPTS OF MULTIPLE OBJECTIVE OPTIMIZATIONS

In single-objective optimization only one function is minimized or maximized [20]so it would be necessary to find a minimum or maximum whether local or global for that objective function. When we speak about multiple-objective function s, we wish to find the set of values that minimize or maximize each of these functions. The general multiple optimization problem(MOP) can be stated as follows…

Let S is a subset of $R^n$ be an n-dimensional space and $f_i(x)$ : $S \rightarrow R$ , i= 1,…., k,be k objective functions defined over S. Assuming $g_i(x) \leq 0$ j= 1,…., m be inequality constraints, the MO problem can be stated as finding a vector x * = ($x_1$*, $x_2$*,………$x_n$*) that satisfies the constraints and optimizes the functionf(x) = [ $f_1(x), f_2(x), \ldots f_k(x)]^T$ : $R^n \rightarrow R^k$

The objective functions may be in conflict, thus, in most cases it is impossible to obtain the global minimum at the same point for all the objectives. The goal of MO is to providea set of Pareto optimal solutions to the aforementioned problem.

Let u = ($u_1,\ldots,u_k$), and v= ($v_1, v_2\ldots,v_n$) be two vectors. Then u dominates v if and only if $u_i \leq v_i$ i= 1,…., k,, and $u_i < v_i$ for at least one component. This property is known as *Pareto dominance* and it is used to define the Pareto optimal points. Thus, a solution x of the MO problem is said to be *Pareto optimal* if and only if there does not exist another solution y, such that f(y) dominates f(x). The set of all Pareto optimal solutions of an MO problem is called *Pareto optimal set* and it is denoted as P* .The set PF*= { ( $f_1(x),\ldots,f_k(x)$) | x belongs to P*} is called Pareto front. A Pareto front PF* is called convex if and only if there exists w belongs PF* such that

$\lambda \|u\| + (1- \lambda) \|v\| \geq \|w\|$; for all u,v belongs to PF* and for all λ belongs to (0,1)

Respectively, it is called concave if and only if there exists w belongs to PF*, such that

$\lambda \|u\| + (1- \lambda) \|v\| \leq \|w\|$; for all u,v belongs to PF* and for all λ belongs to (0,1)

A Pareto Front can be convex, concave or partially convex and/or concave and/or discontinuous. The last three cases present the greatest difficulty for most MO techniques.

For the HTS module, the handoff decision problem can be solved by using multiple objective optimization concepts. For our problem we have used weighted sum method of MOP. According to weighted sum method of MOP,

$$F(x)= \sum_{m=1}^{M} w_m . f_m(x) \qquad w_m \in [0,1], \sum_{m=1}^{M} w_m = 1$$

The above equation is considered as the weighted sum scalarization of the MOP.

This MOP concept has been applied for solving our problem.

$$\text{Optimize } F(x)= \sum_{m=1}^{M} w_m . f_m(x) \quad w_m \in [0,1], \sum_{m=1}^{M} w_m = 1$$

$$= w1 * f_1(x) + w2 * f_2(x) + w3 * f3(x) + w4 * f4(x)$$

Where (1) $f_1(x)$ =Latency(x) is the latency function for any network which is calculated by using the heterogeneous network topology

(2)$f_2(x)$=Power(x) represents the power consumption function for the mobile node

(3) $f_3(x)$=S/N(x) represents the signal to noise ration function of MN for a particular service

(4)$f_4(x)$= throughput(x) is the throughput function

And w1, w2, w3,w4 are the weights of those functions respectively.

## 4. SIMULATION AND RESULT

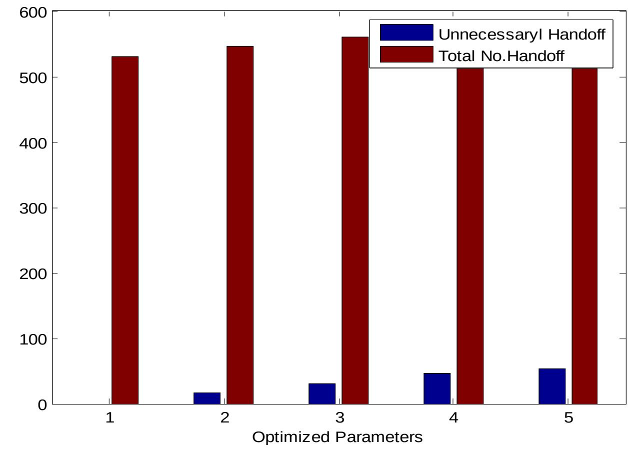
We have simulated our concept using genetic algorithm and implemented using MatLab. We assume that mobile device with multiple interface is moving in an heterogeneous network that is capable of accessing Bluetooth, wireless LAN, Wireless WAN (Wi-Fi) and GSM(Cellular Technology) networks. Let the mobile device is busy in downloading some audio and video files from the internet while moving in the environment. If the strength of the RSS varies at any given time then handoff necessity (HNE) module is called to decide whether handoff will occur or not. If it gives the value as handoff has to occur then handoff target selection (HTS) will be called to select the target network using the proposed algorithm from the list of available networks by taking the optimized parameter values of all the networks in the integrated heterogeneous environment.

As described previously, we have used the weighted sum method of multiple objective optimizations to measure the following performance parameters of handoff (a) no of handoff (b) probability of handoff failure(c) throughput (d) No of unnecessary handoff (e) Handoff latency. The network parameters are taken as network latency (communication latency), signal- to-noise ratio, power consumption and throughput. Using the algorithm defined in[21],the weight values of different objectives are calculated .Then objectives are ranked by grey correlation projection. The following table shows the no of handoff by considering multiple minimum and maximum objectives. The table1 shows that the number of handoff is decreasing by applying multiple objective optimizations. The fig1 shows the number of unnecessary handoffs and total number of handoffs that has occurred during the simulation period. Fig2 and Fig3 show that the throughput is maximized and the handoff latency is minimized respectively.

TABLE: 1

| Objective function | No. of Handoff | No. of unnecessary handoff |
|---|---|---|
| Minimize latency | 561 | 31 |
| Minimize S/N | 583 | 53 |
| Minimize power | 546 | 16 |
| Maximize throughput | 576 | 46 |
| Minimizing (latency, S/N, power using MOP) | **530** | 00 |

Fig:1



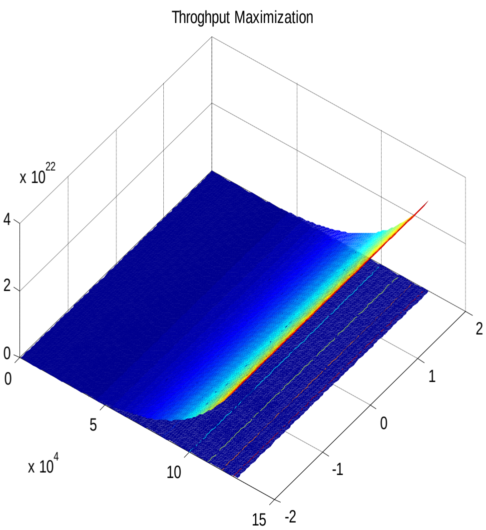




**Fig 2**

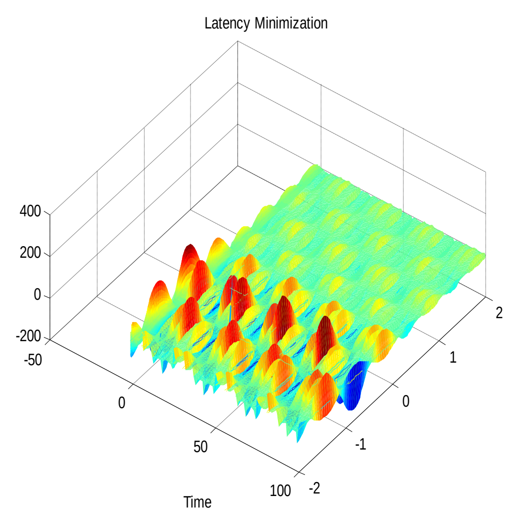



Fig3

## 5. CONCLUSION

In this paper we have presented a context-aware vertical handoff scheme for 4G heterogeneous wireless communication environment. It uses a wide range of context information about networks, users, user devices and user applications and provides adaptations to a variety of context changes, which are applicable to static and mobile users. The main importance of the research work presented in this paper is to develop a vertical handover decision mechanism for 4G heterogeneous wireless networks. The proposed handoff approach can handle the following optimization problems of vertical handoff in heterogeneous wireless network. (a) Handoff is done fast and its delay is as less as possible (b) Number of handoff is minimized, which avoids degradation in signal quality and additional loads of the network(c) Throughput during handoff is maximized (d) Handoff latency during handoff is minimized (e) Handoff procedure is reliable and successful (f) Handoff algorithm is simple and has less computational complexity etc.

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