Volume 1, No. 3, October 2010
Journal of Global Research in Computer Science
ISSN-2229-371X
RESEARCH PAPER
Available Online at www.jgrcs.info

AN OPTIMIZED VERTICAL HANDOFF DECISION STRATEGY USING GENETIC ALGORITHM IN HETEROGENEOUS WIRELESS NETWORKS

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Abstract: ***Next generation wireless network is envisioned as a convergence of different wireless access technologies that can be transformed into seamless communication environments through application of context-based handovers. Designing of error-free and fast-handoff support techniques in heterogeneous wireless environment is a challenging issue. To manage the ABC (Always best connected) requirement, various vertical handover decision strategies have been proposed in the literature using advanced tools and concepts. In this paper we have proposed a multi criteria vertical handoff decision algorithm which will select the best available network with optimized parameter value in heterogeneous wireless environment. The neural network and genetic algorithm tool has been used to implement and process and optimize the multi-criteria vertical handoff decision metrics.***

Keywords: ***vertical handoff, genetic algorithm, heterogeneous network, neural network, parameter optimization***

INTRODUCTION

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. The emergence and development of mobile devices continues to expand and reshape our living standards. In the recent years, advances in miniaturization, low-power circuit design, and development in radio access technologies and increase in user demand for high speed internet access are the main aspects leading to the deployment of a wide array of wireless and mobile networks. 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. Fourth generation wireless communication system is the promising solution for heterogeneous wireless networks. The 4G wireless systems have the potential to provide high data transfer rates, effective user control, and seamless mobility.

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 avoids 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.

RELATED WORKS

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 and TOPSIS 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 have been proposed based on fuzzy logic and neural networks. In [17], a mobility management was proposed in a packet-oriented multi-segment 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.

VERTICAL HANDOVER DECISION SYSTEM CONFIGURATION

The aim of our approach is to design an intelligent system that has the ability to select the best available wireless network by considering user preferences, device capabilities and wireless features for handling vertical handoff in heterogeneous wireless environment. Here, we consider that the mobile node is moving in an overlapping area covered by a group of wireless networks providing small and large coverage area and managed by different service providers. The mobile node may run a VOIP application and videoconference that requires an appropriate QoS level. Networks are divided into three categories: Home Network (HN), which is the network in which the mobile node has initiates its connection, the target networks (TNs) which are the networks to which mobile nodes intend to roam into, and the selected network (SN), which is the best network chosen by the mobile node using the intelligent scheme described in this paper.

A mobile node can exist at a given time in the coverage area of an UMTS alone. But due to mobility, it can move into the regions covered by more than one access networks, i.e. simultaneously within the coverage areas of, say, an UMTS BS and 802.11 AP. Multiple 802.11 WLAN coverage areas are usually contained within an UMTS coverage area. So, at any given time, the choice of an appropriate attachment point (BS or AP) for each MN needs to be made, and with vertical handoff capability the service continuity and QoS experience of the MN can be significantly enhanced.

Generally, the performance parameters of vertical handoff algorithms are (a) handover delay (b) number of handovers (c) handover failure probability (d) throughput. In our model, we have taken into consideration the following network parameters for vertical handoff decision function (i) bandwidth (B) (ii) latency (L) (iii) signal-to-noise ratio (SNR) (iv) throughput (TH) (v) cost(C) (vi) power consumption (P) and the network with minimum latency, cost, SNR and power consumption and maximum throughput will be selected, so that an appropriate QoS level can be maintained and the number of handoff can be minimized for all the networks.

This proposed technique consists of two parts. The first part defines a neural network approach to select a suitable access network once the handoff initiation algorithm indicates the need to handoff from the home network to a target network. The network selection decision process is formulated as a Multiple Attribute Decision Making (MADM) problem that deals with the evaluation of a set of alternative access networks using a multiple attribute access network selection (MANSF) defined on a set of attributes (parameters). The MANSF is an objective function that measures the efficiency in utilizing radio resources by handing off to a particular network. The MANSF is triggered when any of the following events occur: (a) a new service request is made(b) a user changes his/her preferences (c) the MN detects the availability of a new network (d) there is severe signal degradation or complete signal loss of the current radio link. The network quality Qi, which provides a measure of the appropriateness of certain network i is measured via the function:

$$Q_i = f\{Bi, 1/Li, 1/SNRi, THi, 1/Ci, 1/Pi\} \quad (1)$$

In order to allow for different circumstances, it is necessary to weigh each factor relative to the magnitude it endows upon for vertical handoff decision. Therefore, a different weight is introduced as follows:

$$Q\,i = f\{wb * Bi, wl*1/Li, wsn*1/SNi, wth*THi, wc*1/Ci, wp* 1/Pi\} \quad (2)$$

Where wb, wl, wsn wth, wc,wp are the weights for each network and device parameters respectively. The values of these weights are fractions between 0 and 1. The sum of all these weights are equal to 1.Each weight is proportional to the significance of a parameter to the vertical handoff decision. The larger the weight of a specific factor, the more important that factor is to the user and vice versa. The optimum wireless access network must satisfy:

Maximize Qi (p),

Where Qi(p) is MANSF calculated for each network i, and p is the input vector parameters. Due to the fact that each of the preferences chosen by the user has an associated unit that is different from the other (cost is measured in Rs, power consumption is measured in watt etc.), it is necessary to find a way for equation (2) to generate an optimized output using associated weights. The network selection algorithm has been implemented using Linear Vector Quantization (Mat lab 6 help) neural network model. The performance of the algorithm has been measured by using the number of handoff parameter for all networks. This approach can be considered as the non-optimized technique for vertical handoff decision.

The second part defines an approach to minimize the total number handoffs in the complete heterogeneous wireless network environment. The selection algorithm select that network for the handoff where the bandwidth, power consumption, signal-to noise ratio, handoff latency, operation cost is minimum and throughput is maximum. Basically the problem has been considered as an optimization problem that can be represented as

Minimize ∑ Xi,

Where Xi, is the number of handoff evaluated for the network i subject to the constraint as the bandwidth, power consumption, signal-to noise ratio, handoff latency, operation cost is minimum and throughput is maximum. This problem has been implemented using genetic algorithm and simulated using genetic algorithm pattern search tool box (Mat lab 6).

SIMULATION

In this section, we provide the evaluation parameters used to analyze the performance of the proposed schemes. In our work we consider that mobile nodes are moving uniformly in an area covered by a set of networks managed by six network service providers (NSPi, i=1..6). The simulation scenario consists of the following access networks GSM, CDMA, WiMax, for macro cell, WiFi for micro cell, Bluetooth and LAN for pico cell. A mobile device is busy in downloading some audio and video files from the internet while moving in the environment. Then, the first proposed algorithm will select a target network from the list of available networks by taking the non-optimized parameter values of all the networks in the integrated heterogeneous environment. As defined previously, the scheme is simulated using a neural network approach.

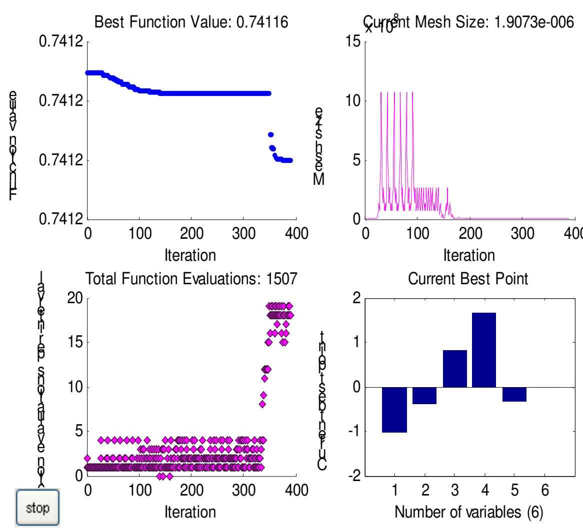

Figure-1

Data used in this paper was customized in a way to suit the purpose of this method. Bandwidth values are taken in the ranges [14…10000] k bits/s, latency values are provided by the networks is in the range of[.3..600] ms, cost values are in the range of [227..2700] Rs, SN ratio values are in the range-12.5 100], power consumption values are in the range [2..340] db and throughput values are in the range[22..144000] Kbps .We assume that the user is running a VoIP application, which needs a stable amount of latency and consumption of power. There were 120 samples each containing six features of the wireless networks and a seventh feature representing the type of network. The simulation has been carried out using about 120 samples. The simulation result that the total number of handoff is 88 independent of percentage of training data and testing data without optimizing the network parameters.

In the second scheme we have taken the optimized value of different parameters so as to minimize the total number of handoff for all the networks .As described previously, we have simulated the scheme using genetic algorithm (psearchtool of Matlab 6). The simulation result shows that the number of handoff is less if all the parameters are optimized. The problem is represented as a minimization problem with the constraints such as that network will be selected where the bandwidth requirement, power consumption, handoff latency, signal to noise ratio and cost is minimum and the throughput is maximum. The figure 1(current best point graph) shows the total number of handoff is less (about 50) in comparison to non-optimized parameter values. The positive value shows the number of good handoff and the negative values shows the number of bad handoff. The best-function value and the mesh size graph shows that the function value is decreasing means the number of handoff is decreasing if the optimize parameter values are taken during handoff decision.

CONCLUSION AND FUTURE WORK

4G in its evolutionary and revolutionary context do not allow an exact vision of the future. However, if past evolutionary developments are an indication of the future, there is a need to promote technological adaptability and interoperability for the next generation of wireless communications. This paper presents the design and performance issues for achieving an adaptable vertical handoff in heterogeneous 4G environment. Traditional handoff protocols are not sufficient to deal with the goal of seamless mobility with context-aware services. In this paper we have presented a context-aware vertical handoff scheme for 4G heterogeneous wireless communication environments. 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 proposed handoff approach can meet the following requirements of 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) Handoff procedure is reliable and successful (d) Handoff algorithm is simple and has less computational complexity etc. This handoff scheme can be extended further to optimize the QoS for different types of multimedia applications in heterogeneous wireless environment.

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