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Particle swarm optimization based network selection in heterogeneous wireless environment

Kiran Ahuja [a,*], Brahmjit Singh [b], Rajesh Khanna [c]

[a] Department of Electronics and Communication Engineering, DAV Institute of Engineering & Technology, Jalandhar, Punjab, India
[b] Department of Electronics and Communication Engineering, National Institute of Technology, Kurukshetra, Haryana, India
[c] Electronics and Communication Engineering Department, Thapar University, Patiala, Punjab, India

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ABSTRACT

Deployment of heterogeneous wireless networks is spreading throughout the world as users want to be connected anytime, anywhere, and anyhow. Meanwhile, users are increasingly interested in multimedia applications such as audio, video streaming and Voice over IP (VoIP), which require strict Quality of Service (QoS) support. Provisioning of Always Best Connected (ABC) network with such constraints is a challenging task. Considering the availability of various access technologies, it is difficult for a network operator to find reliable criteria to select the best network that ensures user satisfaction while reducing multiple network selection. Designing an efficient Network selection algorithm, in this type of environment, is an important research problem. In this paper, we propose a novel network selection algorithm utilizing signal strength, available bit rate, signal to noise ratio, achievable throughput, bit error rate and outage probability metrics as criteria for network selection. The selection metrics are combined with PSO for relative dynamic weight optimization. The proposed algorithm is implemented in a typical heterogeneous environment of EDGE (2.5G) and UMTS (3G). Switching rate of the user between available networks has been used as the performance metric. Moreover, a utility function is used to maintain desired QoS during transition between networks, which is measured in terms of the throughput. It is shown here that PSO based approach yields optimal network selection in heterogeneous wireless environment.

1. Introduction

The next-generation wireless networks consist of various mobile and wireless technologies. Due to complementary characteristics of different wireless networks, it is necessary to combine them to provide ubiquitous wireless access for users. The integration of heterogeneous wireless networks (HWNs) requires the design of intelligent network selection algorithm to ensure seamless communication, and provide high QoS for different multimedia applications [1].

A heterogeneous wireless network is composed of two or more wireless access technologies. Each access technology involved in HWN has its own characteristics in terms of coverage, QoS support, and operational costs. Users with multi-interface terminals are able to initiate connectivity through the access technology that best suits their attributes and the requirements of their applications. The main advantage of HWN lies in its ability that users can maintain their sessions when moving between different networks. This enables users to continuously select the most appropriate network during their communication. For network operators, HWN paves the way to higher profitability through more capable networks where complementary advantages of individual technologies are combined [2]. For example, EDGE network supports upto 384 Kbps. Over a wide geographical area while UMTS cellular networks can provide upto 2 Mbps in a smaller coverage.

In this paper, we focus on the selection of always best connected network in heterogeneous environment while maintaining QoS for multimedia services. Heterogeneous environment may consist of number of overlay wireless technologies. Proposed network selection model is represented in Fig. 1.

Initially monitor the networks present in heterogeneous environment of multimode mobile station (MS). Received signal strength (RSS) is used to sense the presence of wireless networks. If the MS detects a single wireless network (WN_1) then it is automatically connected to it. But when the MS senses more than one wireless network (such as WN_1,. . . . . .,WN_n) at the same time then the problem of network selection comes into the picture for best QoS. In the proposed model, first observe the physical layer metrics (such as averaged RSS, outage probability, available bit rate (ABR), signal to noise ratio (SNR), bit error rate (BER) and achievable throughput) of available networks in heterogeneous environment

* Corresponding author.
E-mail addresses: askahuja2002@yahoo.co.in (K. Ahuja), brahmjit.s@gmail.com (B. Singh), rkhanna@thapar.edu (R. Khanna).

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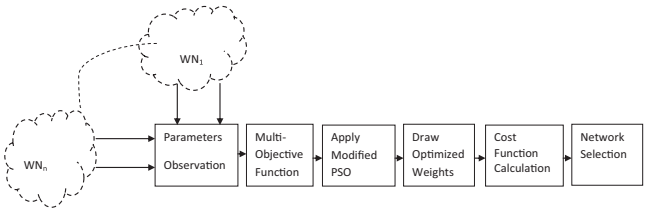

Fig. 1. Proposed network selection model in wireless heterogeneous environment.

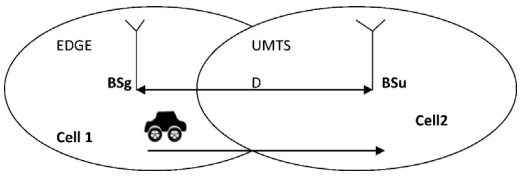

Fig. 2. Heterogeneous wireless network model.

to perform a network selection. Then calculate the multi-objective function NSDF (Network Selection Decision Function) based on observed physical layer metrics. The relative weights of each network selection metric are dynamic to several available wireless networks. Dynamic weights relative to selection metrics are optimized by using modified PSO (particle swarm optimization). Cost function is calculated based on observed physical layer metrics and relative optimized weights. The network having greater cost function value is selected as the Optimum network (ON) in the given heterogeneous environment while maintaining QoS for multimedia services such as audio streaming, geographical mapping etc.

The rest of the paper is organized as follows: Section 2 explains the work related to network selection algorithm on heterogeneous radio access technology, Section 3 describes the system model and Section 4 represents implementation of the proposed network selection algorithm. Performance evaluation of proposed algorithm is discussed in Section 5. Finally, conclusions are drawn in Section 4.

2. Related work

Many network selection algorithms have been proposed in literature. Artemis and Koutsorodi et al. focused on terminal-initiated and terminal-controlled access network selection in heterogeneous networks. Network status, resource availability, user preferences and service requirements determined the optimal local interface and attachment point [3]. Giupponi et al. used the fuzzy neural mechanism for the selection of best RAT among UMTS, GERAN and WLAN [4]. Khan et al. considered a user-centric network selection approach where negotiation between users and network operators was carried out using multi attribute auctioning mechanism. To reduce frequency of handovers, fuzzy logic approach was used in auction mechanism [5]. The authors in [6] utilized past knowledge of the service performance of available wireless networks to make a decision for network selection on given time intervals. They used PSO, fuzzy logic controllers, as well as genetic algorithm for optimization of decision making based on multi-criteria inputs. Porjazoski and Popovski presented an algorithm for radio access technology selection in heterogeneous wireless networks based on service type, user mobility and network load [7]. Its performance was evaluated using two-dimensional markov chain. Yang and Tseng proposed a scheme using a self-developed attribute rating method WRMA (Weighted Rating of Multiple Attributes) and a MADM (Multiple Attribute Decision Making) theory–TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) for network selection in heterogeneous wireless networks [8].

Kunarak and Suleesathira presented policies in the merit function to select an optimal target network [9]. Dwell time calculation has been proposed depending on the user speed and moving pattern as a selection metric. It outperformed in reducing the number of vertical handoffs and grade of service while increasing the average utilization per call of WLAN/WiMAX networks. A fuzzy logic technique combined with GRA classification method for efficient network selection was proposed in [10]. Alkhawlani and Abdulqader developed Radio Network Selection (RNS) solution by using combined effect of parallel fuzzy logic control and multi-criteria decision making (MCDM) system to achieve scalable, flexible and adaptable selection solution [11]. Yee et al. introduced load distribution model to facilitate better network selection using PSO. The network resource was optimized with an objective to distribute the system load according to the various conditions of the heterogeneous networks and to achieve minimum system cost [12]. Optimizing the selection process is an important issue of research, which leads to reduction of network signaling and mobile device power loss and on the other hand improves network Quality of Service (QoS) and Grade of Service (GoS).

The main focus of this paper is to achieve better QoS while selecting ABC network, using a novel network selection algorithm based on NSDF (Network Selection Decision Function). NSDF utilizes dynamic optimized weights to select ABC in heterogeneous environment of cellular networks. Dynamic weights of the parameters used in the cost function for network selection are optimized using modified PSO algorithm.

3. System model

In this section, we introduce network model of proposed network selection algorithm. Heterogeneous environment may consist of number of different wireless networks. For simplicity, without loss of generality, we consider a heterogeneous wireless network consisting of EDGE and UMTS cellular networks as shown in Fig. 2. It is assumed that a user is traveling at a constant speed in a straight line and MS may move from the cell which is served by base station 'BS_g (EDGE)', toward another with 'BS_u (UMTS)' at constant speed along a straight line and vice versa. Where, 'D' is the distance between the two base stations. MS samples the pilot signal strength at regular distance intervals as

$$d = kd_s \tag{1}$$

where d_s is the sampling distance (d_s = 1 m) and k, an integer with $k \in [0, D/d_s]$ [13]. Both the base stations are assumed to be located and operating from the center of the respective cells with equal transmitting power.

Selection metrics of cellular networks in heterogeneous environment are discussed as follows. RSS at MS affected by three components, i.e., path loss attenuation with respect to distance, shadow fading and fast fading. Path loss is the deterministic component of received signal strength, which can be evaluated by propagation path loss models [14,15]. The pilot signal strength received by MS from BS_g and BS_u respectively can be expressed in dBm as:

$$S_i(k) = K_1 - 10\gamma_g \log\ 10(kd_s) + \xi_g \tag{2}$$

$$S_i(k) = K_1 - 10\gamma_u \log\ 10(D - kd_s) + \xi_u \tag{3}$$

where, K_1 is a path loss parameter and γ_g and γ_u are the path loss exponents for EDGE and UMTS cell environments, respectively. i = 1 & 2 for EDGE and UMTS cell respectively. Shadowing is caused due to the obstruction of the line of sight path between transmitter and receiver by buildings, hills, trees and foliage, where the transmitted signal power is blocked and hence severely attenuated by the