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Network selection based on available link bandwidth in multi-access networks

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Abstract
One of the important aspects of seamless communication for ubiquitous computing is the dynamic selection of the best access network for a multimodal device in a heterogeneous wireless environment. In this paper, we consider available bandwidth as a dynamic parameter to select the network in heterogeneous environments. A bootstrap approximation based technique is firstly utilized to estimate the available bandwidth and compare it with hidden Markov model based estimation to check its accuracy. It is then used for the selection of the best suitable network in the heterogeneous environment consisting of 2G and 3G standards based wireless networks. The proposed algorithm is implemented in temporal and spatial domains to check its robustness. The numerical results show that the proposed algorithm gives improved performance in terms of estimation error (less than 15%), overhead (varies from 0.45% to 72.91%) and reliability (approx. 99%)as compared to the existing algorithm.
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Introduction

The wireless technologies have made a tremendous progress in the last decade, and provide a ubiquitous computing and communication environment for diversified real-world applications. In order to realize the concept of an 'Always Best Connected' (ABC) network, the next generation wireless networks should select the best available network that fulfills the quality of service requirements of the user. Available link bandwidth is one of the basic parameters to support a given service/application and hence ensures the quality of service required by the user as it moves from one access network to another.

The existing deployment of wireless technologies contains both 2G and 3G standards. Network selection in such a heterogeneous environment is an important research problem. The 2G standard (GSM-Global System for Mobile Communication) and 3G standard (HSDPA-High Speed Downlink

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Packet Access) wireless technologies typically provide data access rates that vary from 9.6 Kbps for 2G to 2 Mbps for 3G [1]. These rates are generally adequate for services employing a low to medium bandwidth e.g. voice communications, text messaging, instant messaging, electronic mail with no or relatively small attachments etc. Both 2G and 3G are milestones in mobile technology and represent two different phases. 3G mobile networks have a new set of communication protocols due to the rapid increase in data services and development in hardware and software, providing many new features for mobile users such as internet, mobile TV, video calls, video conferencing, mobile gaming whereas in case of 2G no such features are presented [2]. 2G is mostly used for voice transfer whereas 3G allows data transfer in addition to transmission of voice.

3G is much more secure technology than 2G, with clear voice and less disturbances. As the commercial companies compete with each other to increase their market potential, they retain 2G customers and attract new 3G customers in such a way that the customers can move seamlessly from one cell to another cell covered by different networks without knowing the underlying technology [3]. Service continuity in heterogeneous wireless access technologies requires preserving continuous services while moving through these technologies. Appropriate selection of the network in heterogeneous environment is one of the main keys.

There are a number of bandwidth estimation methods based on probing techniques in [4-13]. An ideal probing tool was provided with accurate estimation of available bandwidth prior to sending data packets [4]. In the PATHON model, there is no requirement to probe knowledge and management control over the network to provide an end to end measurement of available bandwidth. In order to reduce the measurement time, it considers less traffic [5]. The utilization of the network connection is measured by using the Tri Packets Method defined in probing technique [6]. The Packet Pair Probing Technique is used by wireless networks for bandwidth estimation while considering the capacity and the cross traffic variation of wireless links [7]. The Probe Gap Model was designed for both one hop and multi hop paths, under the case of path persistent cross traffic. Further by adjusting the input-probing rate, the Bandwidth Adaptive Method was introduced [8].

An active probing tool defined in [9] is based on the concept of self-induced congestion, which runs inside a real-time operating system and applies de-noising techniques to improve the measurement process. The Path Quick Method has been designed for rapid end to end available bandwidth estimation. In this method quick estimation was achieved by using a probing packet train [10]. Another available bandwidth estimation scheme was designed in which bandwidth availability was expressed in terms of a service curve. In this technique, estimation was based on a sequence of probing packets [11]. A probabilistic methodology has been designed to estimate available bandwidth under a non-busy assumption, namely the distribution of the output probe gap [12]. A one-way delay jitter based scheme has been developed for available bandwidth estimation that quantifies the captured traffic ratio and identifies the relationship between probing rate and available bandwidth [13]. Above discussed techniques introduce additional traffic to the network, increase overhead, and reduce reliability and due to these reasons, the estimation process becomes slow.

An Available Bandwidth Measurement Method for Video Streaming was defined in [14], in which differences of packet sending time and feedback receiving time were considered for estimation. Available bandwidth under burst arrivals of discrete cross traffic packets was estimated by queuing the theoretic foundation approach of a single-hop packet-train [15]. In the Minimal Backlogging Method, the available bandwidth of a queuing system was estimated; in this probing packets were sent to the queuing system by the nominal backlogging method [16]. Reliable available bandwidth estimation method distinguishes various queuing regions which resolve the false estimations [17]. The lightweight probing method estimated available bandwidth using a queuing analysis approach in which investigation on Squared Coefficient of Variation (SCV) of the inter-departure process was made with a periodic probing stream [18]. The Queuing Model described the mechanism for available bandwidth estimation using the output packet-pair dispersions [19].

One-way Delay Model was used to estimate available bandwidth in which proportional share of link capacity concept improved the measurement latency and accuracy [20]. The proposed algorithm in [21] selected the network on the basis of available bandwidth estimation. It estimated the available link bandwidth on the basis of average of current sample only. Analysis revealed that the proposed method effectively choose the suitable network for multimedia services by negotiating among available networks (i.e. WiMAX and 3G). Available link bandwidth was estimated using the Bootstrap Approximation Method for Network Selection in Heterogeneous Environment of 2G and 3G Networks in [22]. The performance of the proposed Network Selection Algorithm was estimated in both temporal and spatial domains in terms of estimation time and file size metrics to check its robustness. The proposed algorithm performed well in terms of accuracy and estimation time.

Although available bandwidth estimation methods have been proposed by different authors, the network scenarios and metrics used in the evaluations are limited and their analysis about the applicability of the tools in real network applications is inattentive. An additional issue is that these evaluations do not include the amount of experiments needed to provide statistically valid conclusions. In this paper, we propose an algorithm for network selection in a heterogeneous environment of 2G and 3G based on dynamic parameter (i.e. the available link bandwidth estimated by the Bootstrap Approximation Method). Bootstrapping allows gathering many alternative versions of the single statistic that would ordinarily be calculated from one sample. So it is able to provide accurate and more reliable available link bandwidth estimation in comparison to existing techniques for network selection in wireless heterogeneous environments.

The rest of the paper is organized in this manner. Section 2 describes the network selection algorithm under consideration. Experimental setup is discussed in Section 3. Also, it further describes the performance metrics used for network selection. Numerical results of the performance metrics are discussed in Section 4. Finally, a brief conclusion is given in Section 5.

Proposed network selection algorithm

A novel network selection scheme is proposed in order to always select the best connected network in a given heterogeneous environment. The flow graph in Fig.1 represents the

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