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A MIH-based approach for best network selection in heterogeneous wireless networks

Nouri Omheni[a], Faouzi Zarai[a], Mohammad S. Obaidat[b,*], Ikram Smaoui[a], Lotfi Kamoun[a]

[a] LETI Laboratory, University of Sfax, Tunisia
[b] Computer Science and Software Engineering Department, Monmouth University, West Long Branch, NJ 07764, USA

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ABSTRACT

In the next generation wireless networks, different technologies belonging to one or more operators should be integrated to form a heterogeneous environment based on an IP core network infrastructure. This ensures user mobility and service continuity by maintaining connections when switching between various technologies and it introduces new resources and possibilities for applications. In this context, an automatic interface selection based on instantaneous and practical constraints and user preferences (Quality of Service (QoS) parameters, available resources, security, power consumption, etc.) is therefore required. The different network selection and handover schemes proposed in the literature can be classified into three approaches according to who is responsible for making the handover decision: the terminal, the network or by a cooperation between both of them. However, these approaches keep presenting some drawbacks; namely the problem of resources management and network load balancing whenever the selection is controlled by the mobile terminal (MT) and the problem of scalability and unknown operator's management policy whenever the selection is rather controlled by the network.

In this article, first we propose a MIH based approach for handover initiation and preparation for heterogeneous wireless network. The proposed framework is based on the principals of IEEE 802.21 for context information gathering and optimized handover decision making. Second, we propose a new architecture and new network selection scheme that explicitly take into account the current resource usage and the user preferences. Furthermore, our solution ensures the selection of the most suitable network for each flow while taking into consideration its expectations in terms of QoS. A feasibility study of implementing a new architecture on a single MT is evaluated by using typical scenarios and using various algorithms. Thanks to the introduced function entities and modules in the proposed architecture, network utilization balancing and user and application expectations, which are successfully assured without operator intervention. Performance analysis shows that the proposed algorithm best meets the common quality requirements.

1. Introduction

The wireless network landscape is changing gradually from homogeneous to heterogeneous and future generation networks. In a homogeneous environment, network selection is considered as handover initiation stage. It decides if the handover will occur or not, and over which cell to redirect calls. Traditionally, it represents the need for horizontal handover to happen when the signal strength of the serving base station go down below a certain threshold value. In a heterogeneous environment, mobile terminals equipped with multiple interfaces must be able to select the most suitable access link among the available alternatives including GPRS, WCDMA/HSPA, LTE, WiMAX, and WLAN. Moreover, this kind of architecture is expected to support a number of applications and services with different QoS requirements to be provisioned to terminals and with different degrees of multi-mode capabilities to access the available networks (Nguyen-Vuong et al., 2008; Perez-Romero et al., 2007). Each mobile station and radio access network is characterized by the specific air interface technology, cell size, multiple access scheme, coverage, mobility type, among others (Weiss and Jondral, 2004).

The spreading of these wireless networks has encouraged the emergency of many applications such as Voice over IP (VoIP), video on demand, and web applications that take advantages of the mobility. However, a single technology can hardly satisfy all the applications expectations (required delay, jitter, bandwidth, bit error rate, security level, etc.). Therefore, the integration of different wireless technologies in a heterogeneous environment has offered

* Corresponding author.
E-mail address: obaidat@monmouth.edu (M.S. Obaidat).

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best opportunity for applications to be well delivered. However, in several situations, mobile terminals tend to be associated with networks guaranteeing the best performance to stay "Always Best Connected" which leads to overload the most attractive technology while keeping the others technologies underutilized. In such environment, the handover process becomes more complicated compared to the homogeneous one.

Hence, in order to overcome this problem and to benefit from technology diversity, an automatic interface selection based on instantaneous and practical constraints and user preferences as well as operator and network resources management constraints has become an inevitable trend.

The following metrics should be taken into consideration in the conception of selection mechanisms as selection criteria: Service type, network conditions, mobile terminal conditions, system's performance and user preferences. The combination of these parameters may increase the decision time and complexity of the algorithm. Then, smart technique can be developed to assess the efficiency of new decision mechanisms, balanced against user satisfaction and network effectiveness.

In reality, several factors such as the user, the terminal, and application affect the best network selection decision (Bari and Leung, 2007a; Smaoui et al., 2009). Moreover, the networks heterogeneity with different characteristics and mobility management policies constitutes a technical constraint that makes the selection decision more complex.

Access selection mechanisms can be under user control (Suciu et al., 2004a), by the network (Lee and Sriram, 2007) or in cooperative way taken by both the user and network (Qingyang and Jamalipour, 2005). In a user-centric approach, the selection algorithm is executed in the terminal and the access selection is under user control. In a network-centric approach, the algorithm is executed in some management and control entities in the network and based on the cooperation of attached user in obeying the decision made by the controller. In the cooperative approach, both user and network exchange information about the status of all entities for better decision making.

The MT Selection decision is a much solicited alternative due to the fact that the selected network is the best one that satisfies the selection criteria from the MT's point of view without operator intervention that aims at fulfilling its own needs. However, if we aim to ensure load balancing between the different networks, the MT should have a global vision about the network resources management which it is generally not possible due to operators' security concerns that inhibit the transmission of such operational information. In the second approach, which is based on network or operator decision making, the problem of network resources management is resolved based on the availability of network information such as network current load, operator policies, network conditions and capacities. On the other hand, we will be faced with the problem of operator's profit (Lassoued et al., 2008a) that tends always to select the most beneficial network from the point view of monetary cost or resources control by applying his proper policy independent of the user or applications expectations.

However, the network decision making needs the knowledge of each MT context such as the MT's battery status and the terminal memory capacity to decide the most adequate network for each mobile terminal which leads to have excessive overhead exchanges in the network. In the cooperative strategy, MT and networks tend to cooperate to select the best network satisfying user and applications requirements and resolve the limits of previous approaches. However, this approach still presents some implementation complexity and scalability concerns.

One of the protocols proposing vertical handover is the published IEEE standard 802.21 Media Independent Handover (MIH) (IEEE 802.21, 2008). The aim of this standard is to make link layer intelligence and other associated information accessible to upper layers in order to achieve the handover mechanism between different access technologies, while keeping session continuity (Omheni et al., 2013). MIH framework has been proposed to provide a common interface for managing events and control messages switched between handover decision module and different access technologies (IEEE 802.21, 2008).

In this article, first, we propose an MIH based approach for Handover initiation and preparation for heterogeneous wireless network. The proposed framework is based on the concepts of IEEE 802.21 for context information gathering and optimized handover decision making. Second, we present a network selection architecture and scheme that provide a resource-efficient mobility management that aims at selecting the most suitable network interface for each application. Our proposed architecture intends to resolve the limitations of previous schemes by satisfying user preferences while guaranteeing the best network resources management. We focus on the case of an operator having several access network technologies and we propose an architecture that is able to share the load among the different available technologies in order to satisfy as much as possible applications requirements and user expectations. Then, we evaluate the feasibility of our approach by studying mobile terminals behaviors with various multi criteria decision making algorithms.

This article is organized as follows. Section 2 describes and criticizes some related works. In Section 3, we present our MIH based approach for Handover initiation and preparation. In Section 4, we describe the details of our proposed network selection architecture. The selection scheme is presented in Section 5. In Section 6, we develop various simulations that highlight the contribution proposed in the previous sections. Finally, Section 7 concludes the work and proposes future work.

2. Related works

In the literature survey various network selection approaches have been discussed. A general classification of these approaches can be as follows: (1) traditional, (2) function-based, (3) user-centric, (4) fuzzy logic and neural networks, (5) multiple attributes decision making and (6) context-aware strategies (Bhuvaneswari and George Dharma Prakash Raj, 2012).

Traditional handover decision algorithms are based on the received signal strength (RSS) or on other parameters like hysteresis parameters (Pahlavan et al., 2000).

An optimized cost function is proposed in (Sun et al., 2008) to select the best available radio access technology in the decision making step and decide the criteria under which handover should be achieved. The selection phase is formulated as a constrained Markov decision process. Their aims were to maximize the expected total reward of a connection subject to the expected total access cost constraint. In their model, a benefit function is applied to assess the connection quality, and a penalty function is employed to model the signaling incurred and call dropping. The parameters considered in their selection approach are the connection duration, the available bandwidth and delay of the candidate networks, MT's velocity and location information, signaling load incurred on the network, network access cost, user's preference, and user's monetary budget for the selection stage.

Similar to this approach, an optimal network selection scheme for heterogeneous wireless networks is proposed in (Si et al., 2010) based on a multimedia application layer QoS and network access price. The integrated network is formulated as a restless bandit system in order to simply select the lowest index network. The selection policy is fully distributed and can be applied for both