Policy Based Access Management and Handover Control in Heterogeneous Wireless Networks

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Abstract

The next generation of mobile networks is expected to utilise multiple radio access technologies, seamlessly integrated to form a heterogeneous wireless network. On the arrival of call request, the network operator must assign an access network to the user. A call request can be due to a new call initiated within a cell, an intra-system or inter-system handover attempt. Selecting the most optimal network from those available and controlling network access is an important consideration for overall network stability and QoS provisioning. This work proposes a policy based management system to control network access in a heterogeneous wireless network. A call admission control policy admits a new user based on the current load and service mix in each available network. We also present an adaptive handover capacity reservation scheme to maximise resource usage while limiting the drop call rate and number of unnecessary inter-system handover attempts as users move between cells within the same network.

Introduction

Future 3G and 4G mobile networks will consist of multiple wireless access technologies such as WCDMA, EDGE and IEEE802.11b seamlessly integrated to form a heterogeneous access network environment [1]. Each network access technology provides different levels of coverage and quality of service (QoS) as well as cost to the end user. It is envisaged in such wireless networks that multi-modal terminals will seamlessly and dynamically access the different technologies to support the varying QoS and network connectivity constraints. Supporting this seamless mobility is seen as one of the key issues in resource management for heterogeneous wireless networks [2]. In this paper we will present a policy based call admission control scheme using capacity surfaces for in-cell call initiation, intra-system and inter-system handover requests. This paper extends the work presented in [3] by the development of an adaptive capacity reservation scheme for intra-system handover so as to maintain connectivity as users roam between cells within the same network and to avoid unnecessary inter-system handovers due to user mobility. Too much intra-system reserved capacity is inefficient as new call and inter-system handover requests are rejected even though sufficient capacity exists, while not employing enough reserved capacity results in excessive inter-system handover attempts and should be avoided due to the inherent high signalling load associated with the implementation of such handovers. Adaptive intra-system handover capacity reservation will dynamically adjust the reserved capacity in each capacity surface based on the expected number of intra-system handover requests.

Although work has been done on intra-system handover capacity reservation in homogeneous wireless networks [4], its application within a call admission control strategy in heterogeneous networks still remains to be investigated. In such networks, the performance of handover reservation becomes more critical to overall network stability and QoS provisioning as excessive inter-system handovers are initiated if insufficient intra-system reserved capacity exists.

Network Access using Policy Based Management

The proposed policy system architecture for network access management is shown in Figure 1. Policy system architectures tend to focus on the relationship between the points where the outcome of a policy is enforced, i.e. the Policy Enforcement Point (PEP) and the point where the decision on whether a policy decision is satisfied is taken, i.e. the Policy Decision Point (PDP) [5]. The PDP for network access control is implemented on a server within the network, where information such as network coverage, mobility support and current load are available, e.g. a base station controller in EDGE, radio network controller in UMTS or gateway router in WLAN. The data required by the access management policy engine is maintained in a policy repository. The policy repository makes available these policy parameters to the PDP in the decision making process. The network policy engine is responsible for selecting an access network on the arrival of a new call, intra-system or inter-system handover request. These access control decisions are made in the PDP, which contains the network selector. The network selectors function is to assign an access network for the requested connection. The policy in the network selector is to choose the access network that is currently least loaded for the particular type of service request, i.e. voice, www, video streaming. Using this policy, the load is balanced between the available access networks and avoids one network becoming excessively loaded. The network selector determines the residual capacity for each service type via network capacity surfaces stored in the policy repository. The capacity surfaces for each network were obtained via simulations in which the service mix was gradually increased to the point where the QoS offered to the end user degraded below acceptable levels. The surfaces show the trade off between the different service types. The access decision from the PDP is sent to the PEP, which informs the requested mobile whether its connection request is granted and to which network it should connect. Due to knowledge of network capacity, it is expected that this network selection policy will provide a greater level of

QoS to all users than simply allocating any network to a requesting user. It is envisaged that the proposed policy based access scheme will be implemented as part of a policy management system in UMTS [6].

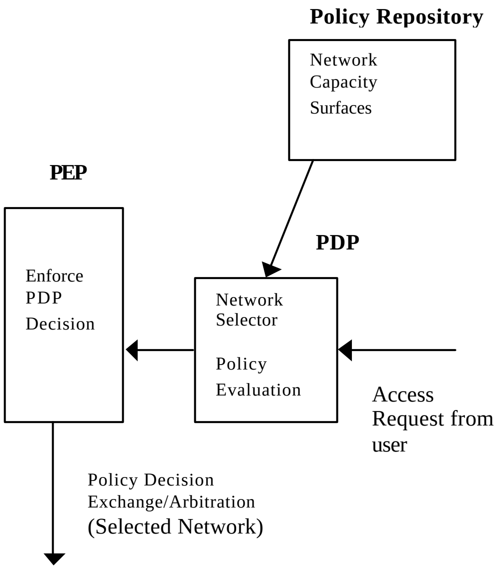

Figure 1. Policy Based Access Management

Adaptive Intra-System Handover Capacity Reservation

Intra-system handover requests are initiated as active mobile terminals move between cells within the same network. At time t we define the handover state vector, $h_{ij}(t)$ to be the number of active calls of each class l moving from cell i to cell j. In order to have a low call-dropping rate and minimal inter-system handover due to user mobility, reserved capacity is required in every cell throughout each network. Employing fixed capacity reservation is inefficient when the handover state in a cell is below the reserved capacity. This excess capacity should be utilised for new call arrivals and inter-system handover requests, thus enabling network operators to maximise revenue generation.

We therefore proposed dynamic handover capacity reservation throughout each network and use the capacity surfaces developed in previous work [3] to control handover reservation. Depending on cell location, time of day and user mobility between cells, the handover state over time follows a specific pattern. This information along with user location context, such as user direction and speed can be used to predict the handover state in each cell and thus enable capacity reservation via a second surface residing under the surface used in policy based network access. By having adaptive handover capacity reservation, the amount of capacity allocated to handover traffic can be controlled by capacity surfaces and enough resources reserved to handle the peak handover state as predicted for the next prediction interval.

The proposed scheme is assessed in terms of call drop rates and the extent of unnecessary vertical handovers due to insufficient capacity reservation.

Simulation Model

The proposed policy based access management and handover capacity reservation scheme are evaluated via a computer simulation model of a heterogeneous access network. We consider three access technologies, namely, (E)GPRS, UMTS and IEEE 802.11b WLAN. Multi modal terminals are positioned non-uniformly throughout the heterogeneous network. Three classes of service are considered, voice, web and video streaming, as these are expected to be among the most commonly used service types in future mobile networks. We have modified the random way-point model [7] to enable users to roam throughout the simulation area. The concept of attraction points presented in [8] is used to create a more deterministic movement of users than that achieved with the basic random way-point model. Over a 24-hour period, users are attracted to different zones such as business, suburban and residential, each of which are defined over the simulation area.

Conclusion

This paper presents a policy based access management scheme for heterogeneous wireless networks. The access management system uses capacity surfaces to assess the residual capacity available in each network and determine the best network to carry the requesting service. The final paper will present results showing the load balancing and QoS performance of the proposed access management system. The final paper will also present an adaptive capacity reservation scheme that predicts using previous handover state data and user location context the capacity required for future handover calls. Results from this scheme show maximum resource utilisation as just enough capacity is reserved to carry handover sessions.

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