QoS-aware path selection for multi-homed mobile terminals in heterogeneous wireless networks

Shin-Hun Kang and Jae-Hyun Kim
School of Electrical and Computer Engineering
Ajou University, Suwon, Korea
{cnonyk, jkim}@ajou.ac.kr

Abstract—In the heterogeneous wireless networks, the optimal network selection problem is one of the key issues. QoS aware path selection scheme is proposed in this paper, which estimates required bandwidth ratio based on the QoS requirements of target service and the SINR of each path. The proposed scheme can select the optimal path which can satisfy the QoS requirements among many heterogeneous wireless networks that change dynamically. The proposed scheme can also support multiple path selection as well as single path selection.

I. INTRODUCTION

Next generation wireless networks will integrate different networks such as WMANs, WLANs, and WPANs into a heterogeneous wireless network. And advanced multi-mode mobile terminals enable the users to achieve seamless handover between the heterogeneous wireless networks. It is very important to select an optimal access network among many available networks because each network has different advantages and disadvantages in terms of coverage area, data rate, bandwidth, cost, and so on.

A number of network selection schemes are proposed recently. A compensatory multiple attribute decision making (MADM) algorithm has been proposed in [1]. And a cost function based scheme has been presented in [2]. And an interface selection scheme based on bandwidth estimation has been proposed in [3]. But those works didn’t consider the case that a mobile terminal connects to two or more networks simultaneously. In that case, the mobile terminal has to determine whether it will connect to a single network or multiple networks simultaneously. If it is determined that mobile terminal will connect to multiple networks, mobile terminal has to determine whether it will achieve diversity gain or multiplexing gain. These aspects were not considered in the existing network selection schemes. Moreover, QoS requirements of target service and the effects of received signal strength were not considered. Therefore, in this paper, we propose a QoS-aware path selection scheme for multi-homed mobile terminals in heterogeneous wireless networks.

II. REQUIRED BANDWIDTH CONSIDERING QoS REQUIREMENTS

A. Effective Data Rate

We defined effective data rate as the data rate required to satisfy the QoS requirements of target service. Different application services correspond to different QoS requirements, such as delay bound, data rate, packet loss ratio bound, etc. Effective data rate is dependent on not only data rate, but also delay bound, packet loss ratio. For instance, shorter delay bound requires higher data rate and lower packet loss ratio bound requires higher data rate.

Effective data rate of path \( i \) can be obtained as

\[
ER_i = g \times s_i \times (1 - L)
\]

where \( g \) is the required data rate considering delay bound, peak data rate, mean data rate, and burst size. \( s_i \) is the number of transmission required to send a packet successfully, and \( L \) is the packet loss ratio bound.

Because the CBR voice applications always transmit packets at the peak rate, \( g \) can be calculated as

\[
g = R_{\text{peak}}
\]

where \( R_{\text{peak}} \) is the peak data rate.

Since the VBR voice applications transmit packets only during talk-spurt duration, \( g \) can be calculated as

\[
g = \lambda R_{\text{peak}} / (\lambda + \alpha)
\]

where \( \lambda \) is the talk-spurt duration and \( \alpha \) is the silence duration.

Since video streaming applications can be modeled as a dual bucket model, \( g \) can be obtained as

\[
g = R_{\text{peak}} \left( 1 + D \left( R_{\text{peak}} - R_{\text{mean}} \right) B^{-1} \right)
\]

where \( D \) is the delay bound, \( R_{\text{mean}} \) is the mean data rate, and \( B \) is the bucket size which can be calculated as

\[
B = \sigma \left( 1 - R_{\text{mean}} / R_{\text{peak}} \right)
\]

where \( \sigma \) is the maximum burst size.

Since other applications usually requires mean data rate, \( g \) of other applications can be calculated as

\[
g = R_{\text{mean}}
\]

\( s_i \) is obtained as

\[
s_i \left( 1 - p_{x,i}^{1/1} \right) / \left( 1 - p_{x,i} \right)
\]

This work was partly supported by the IT R&D program of MKE/IITA [2008-F015-02, Research on Ubiquitous Mobility Management Methods for Higher Service Availability] and the IT R&D program of MKE/IITA [2009-F-043-01, Development of user-centric terminal-controlled seamless mobility technology].
where $p_{ij}$ is the probability of packet loss determined by SINR of path $i$, and $l$ is the maximum number of retransmissions.

B. Spectral Efficiency

Since each path has different SINR, appropriate MCS level is different and result in different spectral efficiency. High SINR enables mobile terminal to use high MCS level, which requires small resources. So it is more efficient to select a path whose spectral efficiency is higher than others. Spectral efficiency of each MCS level and required SINR is listed in table I [4]-[6].

C. Required Bandwidth Ratio

Required bandwidth is simply calculated by dividing effective data rate by spectral efficiency. Since the total bandwidths of each network are different, required bandwidth ratio is defined as the ratio of the required bandwidth to the total bandwidth of the path.

D. Multiple Path Case

When the mobile terminal connects to two networks simultaneously to achieve diversity gain, mobile terminal will receive same packets from two different paths. Thus the probability of packet loss will be reduced as

$$p_e = p_{e, path1} \times p_{e, path2}$$

When the purpose is multiplexing gain, mobile terminal will receive some packets from one path, and the other packets from the other path. Therefore, the data rate will be split into two as follows

$$R_{peak} = R_{peak, path1} + R_{peak, path2}$$

$$R_{mean} = R_{mean, path1} + R_{mean, path2}$$

Other calculations are the same as the single path case.

## III. QoS-Aware Path Selection

Proposed path selection procedures are as follows. First, the attributes for use in path selection are gathered.

- CB: monetary cost to transfer a byte
- CA: radius of coverage area
- RBR: required bandwidth ratio
- N_RAT: the number of RAT to connect

And users are divided into three groups by user preference.

- Gold: users want highest-level QoS independent of cost
- Silver: users want to balance between QoS and cost
- Bronze: users think that cost is more important than QoS

Second, the values of each attributes are normalized. Third, weighting factors are determined according to the relative importance. Table II shows weighting factors obtained by analytic hierarchy process (AHP) [7]. And then, Euclidean distances from the weighted values of each path to the best and worst values are calculated. Finally, the path which is closest to the best value and farthest from the worst value will be selected using technique for order preference by similarity to ideal solution (TOPSIS) [7].

### IV. Conclusions

In this paper, we proposed the QoS aware path selection scheme based on estimation of required bandwidth ratio. Required bandwidth ratio can be used in other MADM-based network selection algorithms such as SAW, MEW, GRA, ELECTRE. QoS requirements and SINR can be reflected in network selection by employing the required bandwidth ratio as one of attributes. The proposed scheme can also support selecting multiple paths simultaneously. Performance evaluation and verification are remained as future work.

### REFERENCES


