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Interface Selection Schemes Aimed to Effective Transmission in Multi-network

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Abstract

This study proposes a network interface-based path selection scheme to guarantee the level of quality service required in the end-to-end (E2E) path under multi-network environments. The proposed schemes include a network QoS path-finding method and interface selection scheme for the purpose of finding paths under multi-network environments which consist of cell network and ad-hoc network. The advantage of the proposed schemes is to find multiple paths during the search for end-to-end paths and provide the paths which meet the required level of quality among the discovered paths. According to performance evaluation, it was confirmed that stable services are provided to the flows in the multi-network.

Introduction

The recent development of mobile communication and hardware manufacturing technologies, multi-network environment in which users can access to diverse wired and wireless networks (ex: WWAN, WLAN, WPAN, etc.) anytime and anywhere has been realized. In this study, a multi-network environment model shown in Figure 3 was assumed. In a multi-network, an E2E path can exist in each network interface. Here, the multi-paths refer to a cell interface-based path in the IEEE 802.16e-based WiMAX network and WiFi-based ad-hoc path in the IEEE 802.11 WiFi-based ad-hoc network. Among them, WiFi-based path is generally able to provide wider E2E bandwidth, compared to the cell-based path. This study focused on a path selection scheme which maximizes the bandwidth. For this, the followings were analyzed: how to measure bandwidth available on the E2E path for multi-interface nodes and QoS-based network interface selection algorithm. Figure 1 shows a network model assumed in this study. In terms of the construction of a network, it is limited to WiMAX Base Station (BS) coverage. Therefore, the ad-hoc network consists of the nodes in the WiMAX BS coverage. For a routing protocol available on an ad-hoc network, AODC protocol is chosen. In terms of WiFi MAC technology, IEEE 802.11 DCF is adopted. First of all, a network model in Figure 2 has two technical issues needed to develop the QoS-based network interface selection scheme. First, it is a matter of if a path actually exists in the ad-hoc network. Second, it is about a QoS-satisfying efficient path selection scheme when several E2E paths exist in that network. Therefore, this study proposes a method to construct Local Connectivity Set (LCS) to handle the first issue and several E2E path-based bandwidth measurement method and network interface selection scheme to cover the second issue.

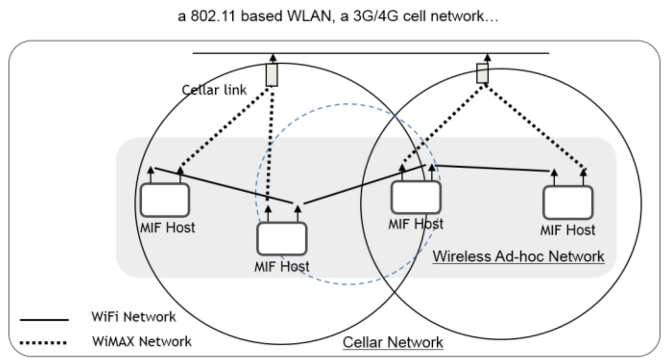

Figure 1. Multi-Network Model

This paper is structured as follows: In chapter 2, the proposed schemes are described. In chapter 3, performance evaluation is stated. In chapter 4, conclusion is given.

Proposed schemes

A. Construction of Local Connectivity Set

LCS is a set of information which judges if a path exists in the ad-hoc network. In other words, the nodes in the LCS are neighbor nodes which enable path-finding. Therefore, they can be regarded as the ones in which self and E2E paths can be set. The LCS construction method is as follows: As diagramed in Figure 2, LCS consists of the nodes from a 3-hop neighborhood. They get information on neighbor nodes through the AODV Hello message. First, nodes build a set of their 1-hop neighbor nodes and deliver the information on the 1-hop neighbor node set to neighbor nodes through the Hello message. Then, the neighbor nodes which received their Hello message may regard the information on a set of 1-hop neighbor nodes as those in a 2-hop neighborhood. Here, whether or not the 2-hop neighbor node information exists in their 1-hop neighbor node set is examined, and then information is constructed within their 2-hop neighbor node information table. A 3-hop neighbor node table is constructed as mentioned above.

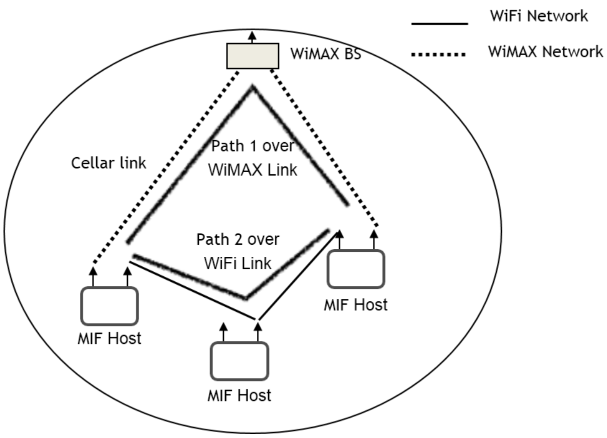

Figure 2. Network Model Assumed

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B. How to find the QoS-satisfying E2E path

The E2E path-finding scheme is conducted in each interface-connected WiMAX network and ad-hoc network. In the WiMAX network, first, a path is searched as stated in the Equation (1) below: This method is very easy and simple.

$$B_{available\_WiMAX} = \left(\frac{B_{req}}{RTT} \right) \tag{1}$$

With the Bandwidth Request (BREQ), a probe request message is created. Then, it is delivered up to the destination node to measure RTT after getting the probe response message. Then, an available bandwidth value (Bavailable_WiMAX) is measured.

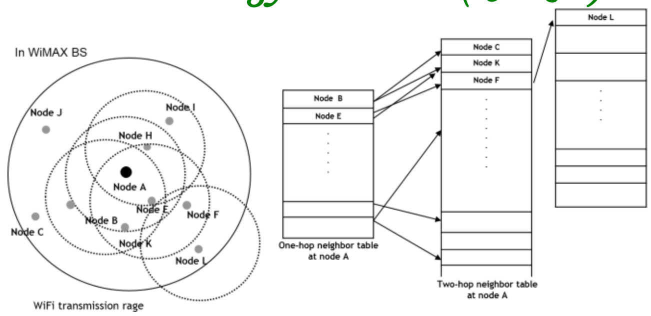

Figure 3. Example of LCS Construction

A path-finding scheme in the ad-hoc network is stated in the code below: This code is created through an AODV RREQ message. To reduce unnecessary signaling messages, in addition, this study proposes a call-handing function at the same time. This method uses the LCS information mentioned above as well. In terms of paths in the had-hoc network, the available bandwidth value is differently set as shown in Equation (2) at E2E path setting because of inter-node interference. For QoS-satisfying path-finding, therefore, this study proposes the Equation (2)-applied path-finding scheme.

$$f(x) = \begin{cases} \min\_chanel\_bandwidth, & h = 1 \\ \dfrac{\min\_chanel\_bandwidth}{2}, & h = 2 \\ \dfrac{\min\_chanel\_bandwidth}{3}, & h = 3 \\ \dfrac{\min\_chanel\_bandwidth}{4}, & h \geq 4 \end{cases} \tag{2}$$

```
E2E path discovery(Breq,destinationIP,CurrentHopCount)
{
Switch (CurrentHopCount)
{
  Case: CurrentHopCount == 0 // source node
  {
    if (destination IP is in the one-hop table)
                                              //end-to-end
      hop number is 1-hop
        if (Bavaliable,i > Breq)
          broadcast RREQ with CurrentHopCount+1
        else
          discard RREQ
    elseif (destination IP is in the two-hop table)
                        //end-to-end hop number is 2-hop
      if (Bavaliable,i > 2Breq)
        broadcast RREQ with CurrentHopCount + 1
      else
        discard RREQ
    else if
      if (Bavaliable,i > 3Breq)
        broadcast RREQ with CurrentHopCount + 1
      else
        discard RREQ
  }
```

```
  Case: CurrentHopCount == 1
                              //a node is an intermediate node
  {
    if (this node is a estination IP)
                             // end-to-end hop number is 1-hop
      if (Bavaliable,i > Breq)
        transmit RREP to a source node
      else
        discard RREQ
    elseif (destination IP is in the one-hop table)
                             // end-to-end hop number is 1-hop
      if (Bavaliable,i > 2Breq)
        broadcast RREQ with CurrentHopCount + 1
      else
        discard RREQ
    elseif //end-to-end hop number is more than 2-hop
      if (Bavaliable,i > 3Breq)
        broadcast RREQ with CurrentHopCount + 1
      else
        discard RREQ
  }
  Case:CurrentHopCount == 2
                             // a node is an intermediate node
  {
    if (this node is a destination IP)
                             // end-to-end hop number is 2-hop
      if (Bavaliable,i > 2Breq)
        transmit RREP to a source node
      else
        discard RREQ
    else if //end-to-end hop number is more than 2-hop
      if (Bavaliable,i > 3Breq)
        broadcast RREQ with CurrentHopCount + 1
      else
        discard RREQ
  }
  Case: CurrentHopCount == 3
                              // a node is an destination node
  {
    if (Bavaliable,i > 2Breq)
      transmit RREP to a source node
    else
      discard RREQ
  }
}
}
```

C. Network interface selection scheme

A network interface selection scheme is carried out in two stages. First, a multi-interface node decides if path-finding is possible in an ad-hoc network through the LCS table. Unless a destination node exists in the LCS table, a WiMAX interface is selected as a default regardless of if QoS is supported. Then, data are transmitted. If a destination node is found in the LCS table, on the contrary, QoS-satisfying E2E path discovery procedure is initiated. If a QoS-satisfying path is found during the path-finding in the ad-hoc network, the node selects a WiFi interface. If QoS-satisfying path is undetected, a WiMAX interface is selected after deciding if the QoS is satisfied through the WiMAX interface.

Performance evaluation

For performance assessment on the proposed scheme, an experimental network was constructed as shown in Figure 4. A flow was created in the experimental network as stated in Table 1, and an experiment was conducted in two different networks: The Regional Information Sharing System (RISS) network and non-RISS network.

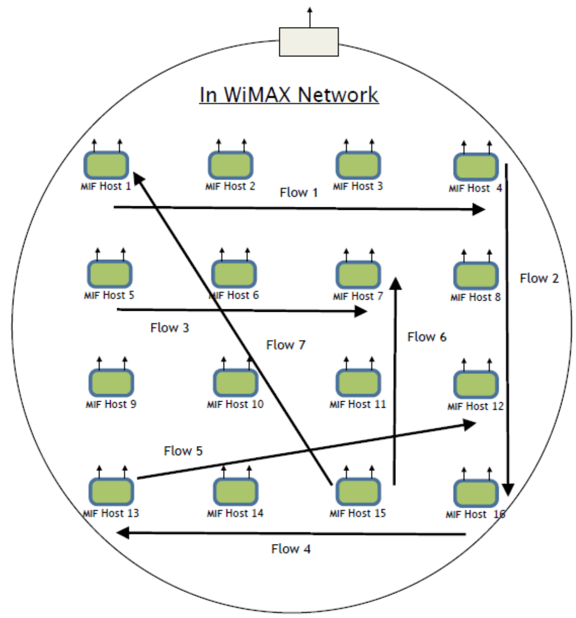

Figure 2. Experimental environment

[Table 1] . Experimental result

Flow ID	Source ID–Destination ID	Transmission Rate	In only WiMAX (non-RISS)		In multi-network (RISS)		
			Average E2E Throughput (Mbps/s)	Service Quality	Average E2E Throughput (Mbps/s)	Selected Interface	Service Quality
1	1 – 4	0.2 Mbps	0.17 Mbps	poor	0.19Mbps	WiFi	Good
2	4 – 16	0.1 Mbps	0.09 Mbps	medium	0.98Mbps	WiFi	Good
3	5 - 7	0.2 Mbps	0.18 Mbps	medium	0.2Mbps	WiFi	Good
4	16 - 13	0.2 Mbps	0.16 Mbps	poor	0.2Mbps	WiFi	Good
5	13- 12	0.1 Mbps	0.07 Mbps	poor	0.1Mbps	WiMAX	Good
6	15- 7	0.1 Mbps	0.08 Mbps	poor	0.1Mbps	WiFi	Good
7	15 - 1	0.2 Mbps	0.15 Mbps	poor	0.19Mbps	WiMAX	Good

For experimental environment, Network Simulator (NS)-2 was used. The experiment results are described in Table 1. During the experiment, service quality was assessed using

Equation (3). In a non-RISS network, first, the quality of service was poor in all flows except two. In a RISS network, on the other hand, high-quality service was found in all flows because a WiFi interface which provided the band-width in which all flows but the two were available was chosen.

$$S = \sum_{i=1}^{x} \frac{\frac{A_i - L_i}{A_i}}{x} \times 100 \quad (3)$$

Conclusion

Recently, multi-network access services are provided through multi-interface terminals in multi-network environments. Under these circumstances, E2E multi-paths could be available among these multi-interface mobile devices. As a result, there has been a rising need for a new method to provide the required quality of service. Therefore, this study proposed high-quality path-finding and network selecting schemes in multi-paths among multi-interface mobile terminals. In addition, it was confirmed that the proposed schemes provide the best services for multi-interface mobile terminals in multi-network environments through experiments.

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