A Profile-Based Network Selection with MIH Information Service

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ABSTRACT

This work provides a user profile based network selection algorithm with the assistance of the IEEE 802.21 MIH (Media Independent Handover) information service. In this research, a user profile system is designed to records the user's QoS requirements. The MIH information service provides network information such as MAC address and channel information for network selection. Besides, a rule-based network selection algorithm is proposed to integrate the user profiles and the information service to select a suitable access network. The proposed network selection algorithm is evaluated in a WiFi VoIP service environment by computer simulations. The simulation result shows that the proposed scheme performance better than the traditional RSS (Received Signal Strength) selection mechanism.

1: INTRODUCTIONS

The vision of the fourth generation network is to integrate different access technologies for ubiquitous access services. In order to access networks with different access technologies such as WLAN, GSM, GPRS, and UMTS, mobile nodes should be equipped with multiple interfaces. Therefore, when a mobile node is moving away from the access point, it can switch to a cellular system such as UMTS to keep its existing connections. However, if there does exist another WLAN access point, the mobile node might make a horizontal handoff to the new access point. Thus, a mobile node must make an intelligent decision in access network selection. The concept of "Always Best Connected", or ABC[1] has been proposed in order to make a person always choose the best available access networks at any point in time. However, ABC generates great complexity and a number of requirements, not only for the technical solutions, but also in terms of business relationships between operators and service providers. Therefore, a simple approach is needed to promote the concept of "ABC."

Many studies have been published on network selection [2]- [6]. In [2][3][4], many factors are considered to make a network selection, including RSS (Received Signal Strength), preferred access network type, monetary cost of services, QoS requirements of applications, etc. In [3][4][5], a cost-function based mechanism is used to represent the importance of considered parameters by different weights. The difficulty in the cost-function based mechanism is how to determine the weights for each parameter. A poor set of weights may make mobile device choose a wrong network. Instead of using cost functions to select networks, a rule-based mechanism is proposed in [6]. First, the RSS value is used to estimate access probability and then a formula for computing residual bandwidth is used to estimate if a new network can provide required bandwidth. However, they didn't consider delay for real-time services at current phase. The above researches do not describe how to obtain network information for their proposed solutions. It is clear that a mobile node can not know the QoS information of those access networks that the mobile node never connects to. Thus, how can an MT obtain sufficient information for network selection is an interesting issue.

This paper proposed a network selection algorithm that integrates a rule-based network selection mechanism with a user defined access profile. Besides, an information service is built on MIH (Media Independent Handover) [7] to collect the information for network selection. The benefit of using MIH information service is to collect historical information for mobile nodes, along with the assistance of pinging correspondent nodes to acquire the end to end delay. Consequently, the mobile nodes are able to compare the QoS parameters between different access networks to choose a preferred network based on the user profiles. In addition, the proposed network selection algorithm uses a priority-based rule which first eliminates intolerable networks and then chooses networks with better QoS parameters. By using of MIH information service, the mobile nodes can acquire network information without connecting to new access points, thus extra monetary cost and unnecessary testing are avoided. Finally, the proposed approach is evaluated in a WiFi VoIP service environment by NS2.

The rest of the paper is organized as follows. Section 2 introduces MIH system. Section 3 presents our network selection algorithm and the information services based on MIH. Section 4 describes a case study with our approach and the simulation result. Finally, section 5 concludes the paper and discusses future works.

2 MIH System

This paper was sponsored in part by "Aim for the Top University Plan" of Yuan Ze University and Ministry of Education, Taiwan, R.O.C., and the National Science Council, Taiwan, R.O.C. under Contract No. NSC-95-2213-E-155-005.

MIH (Media Independent Handover) is a proposed project by IEEE to optimize handoffs between heterogeneous 802 systems and cellular systems. MIH defines a MIH middleware architecture and a cross layer communication protocol, as shown in Fig. 1. MIH provides three services, media independent event service, media independent command service, and media independent information service. In MIH, local or remote layer 2 interfaces deliver events and triggers to upper layers. Events defined include Link_Up, Link_Down, Link_Parameters_Change, Link Going_Down, Link_Event_Rollback, etc. Layer 3 and above communication protocols issue commands to MIH middleware to control layer 2 and below. The information service of 802.21 affords network information as MAC address, security information and channel information. Each of layers exploits the information to decide handoff policy. Through the mechanism, the handoff between heterogeneous networks can be optimized.

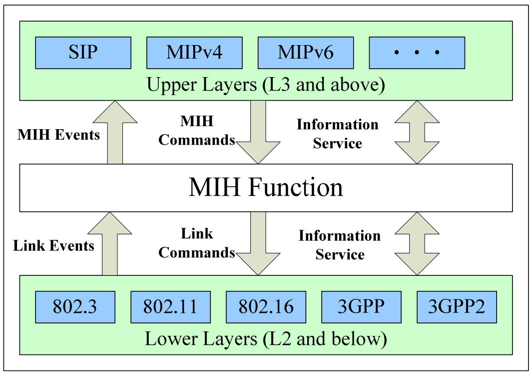

Fig. 1 Architecture of IEEE MIH

Network decision system uses the network information to decide whether the access network should be changed or not. The application layer registers itself to MIH function with a RSS threshold for a WLAN interface. The MIH function will then monitor the RSS value received from the WLAN interface. When the RSS crosses the registered threshold, the MIH function will use the event services to inform the application. Then the application can make some decisions such as a vertical handoff from WLAN to 3G by using the command services. At the same time, the decision module can also use the information services to get the network information for making the decision.

Fig. 2 (a) illustrates the MIH architecture in a mobile node. In mobile nodes, the most important component is "decision module". From a user perspective, a decision module registers some events to MIH. One of the common events is to define a threshold RSS value. In addition, when an application is executed, it should register with the decision module its application types (e.g. VoIP or FTP, etc.). Once the RSS value of current active interface is lower than the defined threshold, the MIH Function will inform the decision module for further processing. The decision module checks the user profiles according to the application type and chooses an appropriate access network to maintain the quality of connections. The MIH architecture of an access point (Fig. 2 (b)) is similar to the mobile node except that it maintains an information database.

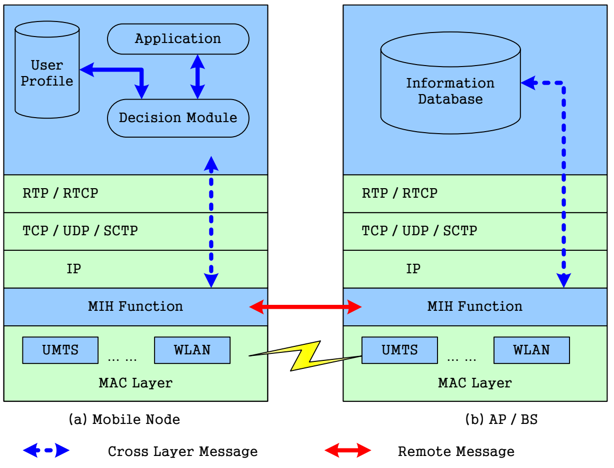

Fig. 2 System architecture of MIH MN and AP.

3 User Profile-Based Network Selection

To make a good network selection is an important issue in a heterogeneous wireless network environment. A good network selection here means that it suits users' preferences, such as power consumption, monetary cost and QoS requirement for applications. This section introduces a User Profile-Based Network Selection (UP-Based NS) by using MIH Information Services.

3.1 Network Selection Procedure

Bandwidth constraint and power constraint are both important for mobile device. Comparing with WLAN and cellular system, WLAN is usually free and support much larger bandwidth than that of cellular systems. Therefore, we always check if there exists an available WLAN during communication. On the other hand, the performance of power consumption in cellular systems is much better than in WLAN, such that we would prefer to make mobile nodes standby in cellular system.

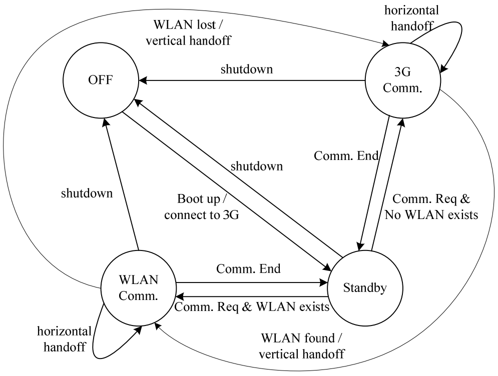

Fig. 3 State transition of mobile nodes

Figure 2 shows the state transition of mobile nodes. When a mobile node boots up, it should try to connect to a cellular system, e.g. UMTS, and stay at a standby mode for power saving. Once receiving a communication request, it can now scan for a WLAN if the user prefers to use a WLAN. If a WLAN does exist, the mobile node will then switch to the WLAN. However, if the mobile node can not find any available WLAN, it keeps using the cellular system for communications. During the communication with a cellular system, the mobile node tries to scan for available WLAN periodically if the user prefers to use a WLAN. Once a WLAN is found, the mobile node makes a vertical handoff to the WLAN for communication. During communication, a mobile node may travel around; the mobile node will do handoff as needed, either horizontal or vertical, depending on the network environment.

3.2 User Profile

A user defines its preference of access network type through a user profile. Based on the user profile, the decision module chooses an access network available to the best interest of users. Figure 4 shows the prototype of a user profile and Fig. 5 illustrates of its usage.

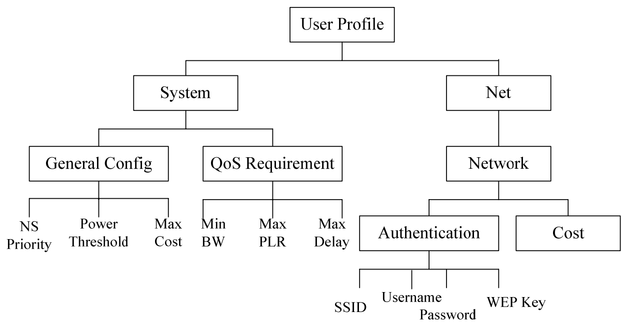

Fig. 4 Architecture of user profiles

In Fig. 4, a user profile is divided into two parts, system and net. The former includes general configuration and QoS requirements of a user. There are three parameters in the general configuration, network selection priority, power threshold and maximum cost. Network selection priority defines the attribute priority, such as cost, bandwidth and power consumption, in selecting an access network. If a user doesn't care about monetary cost, he can put cost in a lower priority. The maximum cost defines the monetary cost per minute that the user would prefer to pay. The setting of power threshold which represents the residual power in percentage is provided to avoid using some interface which consumes large energy.

QoS requirements include minimum bandwidth, maximum frame error rate and maximum delay. Only an access network satisfies the QoS requirement can be selected. For different type of applications, a different "QoS Requirement" should be provided. The "net" provides information of an access network. For example, for a specified SSID in WLAN, a user might need to enter WEP key or username along with password when he/she accesses the network. In order to automate the handoff process, information about networks such as username and password are also configured to speed up the handoff process.

Figure 5 shows an example of the prototype of a user's profile. In the example, the user prefers to choose a network with defined quality of services. For QoS requirements, take voice for example, the chosen network should provide at least 64 kbps of bandwidth, at most 10e-2 of the frame error rate and a maximum delay of 300 ms. After choosing a satisfied network, battery capacity will then be checked and finally the monetary cost of the selected network should also satisfy user's preferences. The type of "default" is used when a used application type is not defined. As shown in Fig. 5, the user is only willing to pay NT $0.2 per minute; as a result, no UMTS access network should be selected because it costs NT $4.2/$6.6 per minute for voice/video services.

```
<UserProfile>
  <System>
    <GeneralConfig>
      <NSPriority> QoS, Power, Cost </NSPriority>
      <PowerThreshold type="WLAN"> 30% </PowerThreshold>
      <PowerThreshold type="UMTS"> 15% </PowerThreshold>
      <MaxCost> 0.2 </MaxCost>
    </GeneralConfig>
    <QosRequirement type="default">
      <MinBW> 120 kbps </MinBW>
      <MaxFER>  10e-2   </MaxFER>
      <MaxDelay>  ∞ ms</MaxDelay>
    </QosRequirement>
    <QosRequirement type="Voice">
      <MinBW>  64 kbps </MinBW>
      <MaxFER>  10e-2   </MaxFER>
      <MaxDelay> 300 ms</MaxDelay>
    </QosRequirement>
  </System>
  <Net>
    <Network type="WLAN">
      <Authentication>
        <SSID> CISCO </SSID>
        <Username> username </Username>
        <Password> password </Password>
        <WepKey> wepkey </WepKey>
      </Authentication>
      <Cost> 0 </Cost>
    </Network>
    <Network type="UMTS">
      <Cost type="Voice"> 4.2 </Cost>
      <Cost type="Video"> 6.6 </Cost>
    </Network>
  </Net>
</UserProfile>
```

Fig. 5 A scenario of user profiles

3.3 Network Selection Design

In this section, the detailed design of network selection is described including the format of information table recorded in the information servers and the detailed message flows between mobile nodes and access points. After getting sufficient information for network selections, a strategy for selecting an appropriate access points is depicted.

3.3.1 Information Server

An information server plays an important role in helping a mobile node to choose an access network. Table 1 shows the format of an information table where SSID and MAC are the basic information of an access point. Figure 6 illustrates the concept of neighbors in Table 1 where the neighbors for AP1 include those access points that are accessible by AP1's client nodes. The neighbor information can help a mobile node to be aware of potential access points that it may switch to in the future.

The mode in Table 1 indicates the types of access points (for WLAN, it could be A/B/G) and cellular systems (UMTS/GPRS/PHS, etc.), which can give a hint about its available data rate. The larger the number of mobile nodes associated with an access point, the worse

Table 1 Information table in AP1

SSID	MAC Address	Neighbors	Mode	Connection number	FER	Reject	Update Time
AP1	00:90:4B:13:CA:13	AP2、AP3	G	12	3.28e-3	No	1151400625
AP2	00:14:7C:AE:6C:42	None	G	20	5.21e-2	Yes	1151400845
AP3	00:0E:35:9A:6F:5E	None	B	3	1.4e-4	No	1151400227
BS1		BS2	UMTS	5	1.16e-3	No	1151400931

the communication quality can be offered by the access point. Therefore, the indication of connection number is also recorded in the table. FER is short for Frame Error Rate which indicates the probability of error for the access point. Finally, the update time shows the last time when the information was updated and the reject field will be set when access points have served a quite number of mobile nodes.

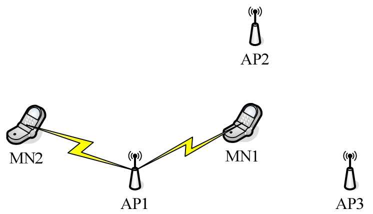

Fig. 6 The definition of neighbors

3.3.2 Message Flows between MN and IS

Fig. 7 shows the detail message flows. First, MN should register to its MIH function with a defined RSS threshold (e.g. -84dB) for triggering a network selection event. When MN moves away from its serving access points (AP1) and the RSS value is decreasing below the defined threshold, MN first scans for available access points and passes the information along with the address of CN to AP1 for network selection assistance (the message with solid line). When AP1 receives a request, it forwards the request to those access points and asks them to ping the CN (the message with dashed line). Then, these access points (e.g. AP2, AP3 and BS in this example) will ping the CN for the delay that MN would encounter if it uses them as its serving access points (the message with dotted line). Once these access points receive the ping result, they send the result along with their information table back to AP1. Finally, AP1 forwards the information to MN.

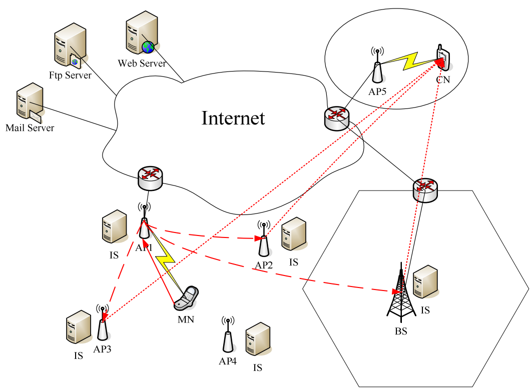

Fig. 7 Message flows for MN requesting info.

3.3.3 Network Selection Algorithm

According to the user profile, different application types may select different access points because of QoS constraint. To suit the users' preferences, the user profiles are used to indicate the QoS requirements for different service types. When an application is executed, it should inform the decision module what type of application it belongs. Therefore, with the information of the application type and the configured user profiles, the decision module can try to select an appropriate access network for the user. The steps for UP-Based NS schemes are described as follows:

Step 1. The application registers to the decision module to select an appropriate access network for the user. According to different service types, a relative rule-based checkup is generated from the user profiles.

Step 2. The decision module registers itself with a defined RSS threshold to MIH. When the RSS decreases below the RSS threshold, the MIH function informs the decision module such that the network selection procedure is invoked. After a short period of time, MN acquires the network information through its serving access point.

Step 3. Unsatisfied networks and some networks that set the reject field are eliminated.

Step 4. The remained networks are basically satisfied for the mobile node. For real-time services (such as voice/video conferences), the principle to choose a network follows the order of RSS, delay and FER. The quality of RSS value affects transmitting data rate, FER and the connectivity such that it's important to be considered first. Delay is also an important QoS factor for real-time services, so it's in the next priority. The last considered QoS factor is FER because it is relative to RSS and it has less influence with the retransmission mechanism. For best effort services (such as FTP), the consideration order is RSS, bandwidth, delay and FER because they need good connectivity and transmission rate.

4 Case Study: WiFi VoIP

This section describes a case study for VoIP in the environment of WLAN. To show how it works, we have made several comparisons between UP-Based NS and RSS-based network selection in different scenarios.

4.1 WiFi VoIP User Profile

We focus on the VoIP services in WLAN environment. To simplify the simulation, the power consumption and cost for accessing the networks are ignored. Thus, in the GeneralConfig, only QoS is set in NSPriority and PowerThreshold for WLAN is 0%. The QoS requirements for voice are at least 64 kbps of bandwidth, at most 10^{-e2} of the frame error rate and a maximum delay of 300 ms.

4.2 Simulation Environment

As shown in Fig. 8, there are several access points in an area to support a number of mobile nodes to connect with. To make sure the system work, it's assumed that all information servers (set on access points) can communicate with each other, and the simulation environment is based on 802.11e. Except the last mile, all other links are wired including correspondent nodes.

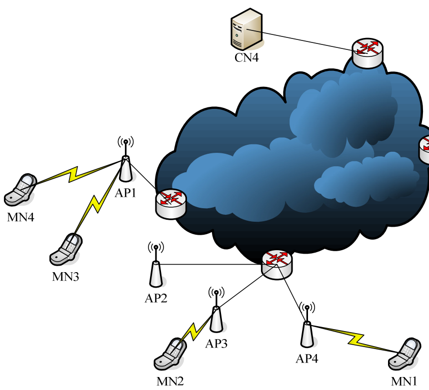

Fig. 8 Simulation environment

The mobile nodes are moving during the simulation. However, the handoff decision such as handoff timing and ping-pong effect avoidance are not in the scope. To simplify the simulation, for the former, there are two RSS thresholds, $threshold_{trigger}$ and $threshold_{handoff}$, are used where $threshold_{trigger}$ must be greater than $threshold_{handoff}$. $Threshold_{trigger}$ is used to make an active scan for neighbor access points and $threshold_{handoff}$ is used to trigger the network selection procedure. For the later, a simple strategy of dwell time [8] was used in the simulation. It's also observed that when the network selection was finished, a wrong handoff decision might be made. This is caused when existing association was affected and a network selection procedure was invoked. However, after a short period of time, the existing association is likely to be good again.

In order not to make a handoff in this situation, after selecting a network, one more comparison of RSS between current access point (RSS_{cur}) and a selected access point (RSS_{sel}) is made. The used method is shown in Fig. 9. When the mobile node was set in ping-pong mode, it means the mobile node is very likely in the overlapped area of two or more access points. To reduce the number of handoff, it's forced to associate with the access point with higher RSS. After the timer is expired, the mobile node is again free to choose other access points.

```
# original RSS becomes good
# handoff is made if RSS_sel – RSS_cur is greater than 4
if RSS_cur > RSS_ping-pong
  if RSS_sel – RSS_cur < 4
    keep original association
  else
    handoff to selected AP
# original RSS is still bad
# 1. set in ping-pong mode
# 2. handoff to the better AP
else
  set in ping-pong mode
  dwell time is used
  if RSS_sel < RSS_ping-pong
    keep original association
  else if RSS_sel – RSS_cur > 4
    handoff to selected AP
```

Fig. 9 Handoff decision used in simulation

Table 2 General parameter settings

Parameter	Value
$RSS_{ping\text{-}pong}$	-80
$threshold_{trigger}$	-76
$threshold_{handoff}$	-84
dwell timer	20 seconds
simulation time	600 seconds
WLAN settings	
WLAN environment	802.11e EDCA
propagation model	Shadowing Model
bandwidth	11Mb
MAC retry limit	7 times
frequency	2.472e9 Hz
transmission power	15 dBm
communication range	50 meters
VoIP settings	
packet size	20 byte
data rate	8k

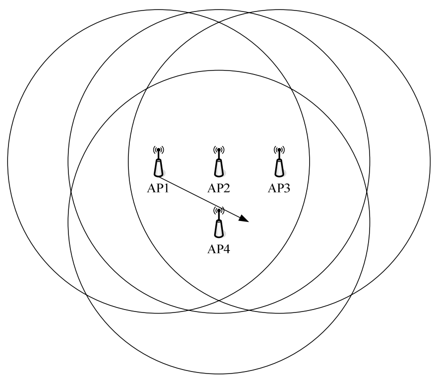

Fig. 10 Simulation scenario 1

The scenario of the simulation is shown in Fig. 10. Table 2 shows the general parameters in the simulation. The purpose of the simulation is to show how the proposed mechanism works. Four access points and 30 mobile nodes are deployed. The delay between all access points and point of attachment of Internet is set to 50 ms. There are also 30 correspondent nodes communicating with mobile nodes. The distances of (AP1, AP2), (AP2, AP3) and (AP2, AP4) are 20 meters. Mobile nodes are positioned near AP1 initially and they connect with AP1 and AP2 separately. During the simulation, they are moving along the arrow line with speed 1 m/s.

When there are lots of mobile nodes connecting to the same access point, they affect each other. The wireless channel is a shared medium. For real time services, if packets can't be sent for several retries, packets are dropped. In our observation, the number of mobile nodes is suggested to be fewer than 20 such that all mobile nodes can get acceptable communication quality. Therefore, the connection number in information table is set with a limitation of 20. That is, if a mobile node has received the information with 'Reject' field set, it should give up connecting with that access point.

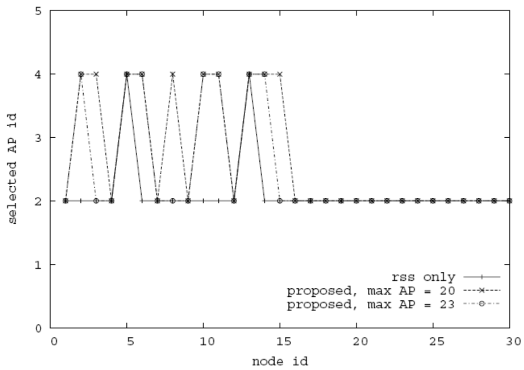

Fig. 11 Selected AP in simulation 1 (node = 30)

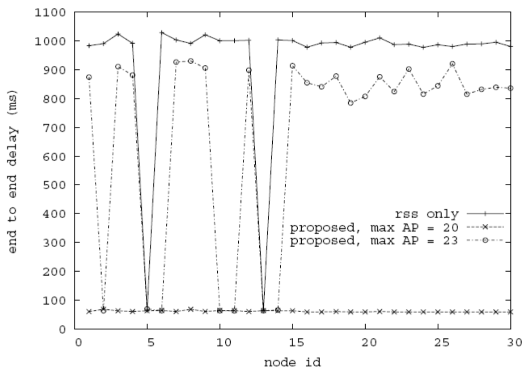

Fig. 12 End to end delay in simulation 1 (node = 30)

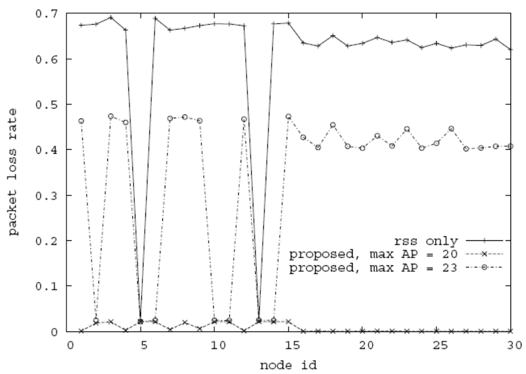

Fig. 13 Packet loss rate in simulation 1 (node = 30)

Fig. 11 shows the simulation result of selected access points. There are 28 nodes connecting to access AP2 in the mechanism of RSS only. As shown in Fig. 12 and Fig. 13, almost all mobile nodes get very bad end to end delay and packet loss rate with RSS only mechanism. Instead, with the assistance of information servers, there are at most 20 mobile nodes connected to AP2 while others are forced to connect with AP4 when *max_ap* is set to 20. This results in a good performance for all mobile nodes shown in Fig. 12 and Fig. 13. However, when *max_ap* is set to 23, mobile nodes connected to AP4 get expected communication quality but those connected to AP2 don't. This is because too many mobile nodes are contending for the channel.

5 Conclusion and Future Work

In this paper, we propose a network selection system by exploiting user profiles and information service based on MIH. A rule-based scheme is applied to help a user to select a good access network specified in the user profile. A simple simulation has been conducted to illustrate the feasibility of our system. The result shows that even with a simple information service the proposed scheme can perform much better than traditional scheme with RSS only. With the information such as connection numbers, delay (pinged by access points), the mobile nodes are able to compare these information with required communication quality. The results also show that the priority of QoS factors can indeed help to eliminate intolerable networks during the network selection process.

The information service offered in this paper is still very primitive. In the future, we will add more QoS parameters to the design of information table. In particular, we will extend the service to mesh wireless network.

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