AKTET
Journal of Institute Alb-Shkenca
Revistë Shkencore e Institutit Alb-Shkenca

ISSN 2073-2244
www.alb-shkenca.org


# WIRELESS MESHED ACCESS NETWORK

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**AKTET IV, 3: 443 - 448, 2011**

**SUMMARY**
In this paper wireless meshed access network topologies in regard to the requirements of Internet providers to deliver the same real-time broadband services to mobile users as to wired Internet users are discussed. In order to thoroughly investigate the idea of the wireless meshed access network topologies a new signaling protocol for QoS provisioning to mobile users for partially-meshed access network is proposed and evaluated. In addition, the impact of the proposed protocol on traffic distribution over the links of the access network is analyzed. Simulation results, in terms of RSVP signalling delay and the maximum allowed delay for QoS provisioning, show that the proposed protocol leads to improvements for meshed access networks in comparison to similar existing protocols. Furthermore performance analyses show that meshed access network topologies, combined with an appropriate protocol, are very convenient for controlling the distribution of traffic over the links of the access network.
**Key words:** Meshed networks, Protocols, QoS, Mobile Hosts, Traffic distribution

## 1. INTRODUCTION

During the last fifteen years we have seen a rapid growth of the two main communication technologies Internet and mobile communications. A further growth of these technologies is continuing, particularly towards real-time multimedia and non-multimedia service provisioning. Furthermore, trends are clearly indicating the integration of mobile communications and Internet technologies. Now mobile users are interested to get the same services on mobile terminals as on fixed terminals. These services require both QoS (Quality of Service) and mobility support. Since existing Internet QoS mechanisms do not consider mobile environments and on the other hand, Mobile IP does not provide QoS, several new solutions addressing QoS provision to mobile users have been proposed [5], [2]. However, none of them considers meshed access network architectures. Hence, in this paper the wireless meshed access networks topologies are discussed. In order to thoroughly investigate the proposed concept of the wireless meshed access network a new signaling protocol for QoS provisioning to mobile users for partially-meshed access network is proposed and evaluated. Furthermore, the suitability of the meshed access network topologies for controlling the distribution of traffic load over the links of the access network is investigated.

In the next section, the proposed protocol is explained. In Section 3 the simulation environment is given. Performance evaluation is presented in Section 4. Conclusions of the paper are given in the last section.

## 2. PROTOCOL DESRIPTION

The proposed protocol is based on an existing Mobile IP and RSVP interworking scheme known as flow transparency (FT) protocol [2] and can be considered as it's complimentary for meshed access network topologies. The basic idea of this proposal is to use the previous access router(s) as a nearest common router (NCR) for the old and the new added flow paths. Two new RSVP [1] messages: PathState_discovery and PathState reply, to optimise the use of already reserved resources, are added. As far as MIPv6 [3] is concerned, for address mismatch avoidance, the proposal given in [2] is adopted. Due to space limit it is considered only the case when mobile host (MH) is a receiver in a wireless access network, whereas the correspondent host (CH) is a sender in the fixed access network.

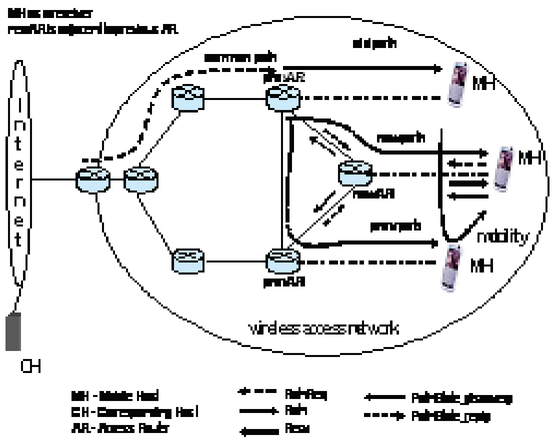



**Figure 1:** Proposed protocol, handover procedure

When the mobile host acts only as a receiver the mobility information, which contains the home address and the CoA (care of address) of the MH, is carried in the PathReq message. When the access RSVP router receives the PathReq message from MH, it checks first if it is the DNCR (Downlink NCR), by comparing the MH's home address with the existing one in the path state information. The following two cases may be considered:

1. If the new access router is not a DNCR, then the router sends a PathState_discovery message, containing the flow address, to all adjacent routers. All routers that receive this message with reply with the PathState_reply message for the indicated flow, which besides other needed information contains a one-bit flag to indicate whether the router has already a related *path-state*.

1.a. If two or more adjacent routers have a *path-state*, than the access router selects the next hop router, based on the routing table, and forwards the PathReq message (Figure 1). Upon receiving the PathReq message, the selected router will respond with a Path message towards the MH's new CoA and will also send a PathTear message to the old MH's CoA to trigger the release of the old reserved resources. After receiving the Path message the MH sends Resv message to reserve resources along the new path.

1.b. If none of the adjacent routers has a *path-state* then the access router selects the next hop router, and sends the PathReq message to that router. The selected router will forward the PathReq message to the next hop router. Each next hop router will check for being a DNCR. If it is, it will reply with a Path message towards MH CoA, if it is not, it will forward the PathReq message to the next hop router.

2. If the new access router is a DNCR, then the protocol procedures are the same as in the existing protocol [2].

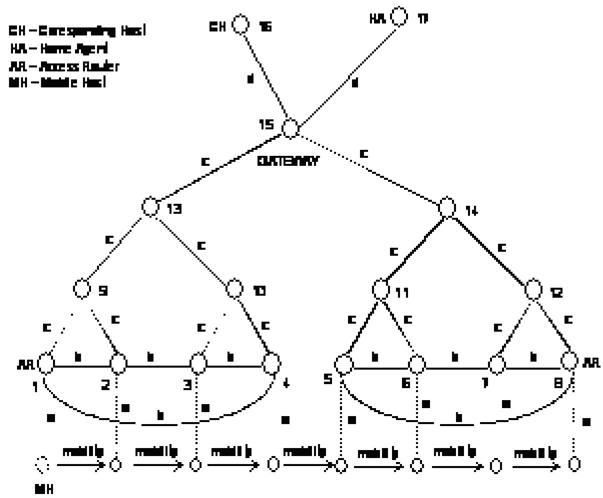
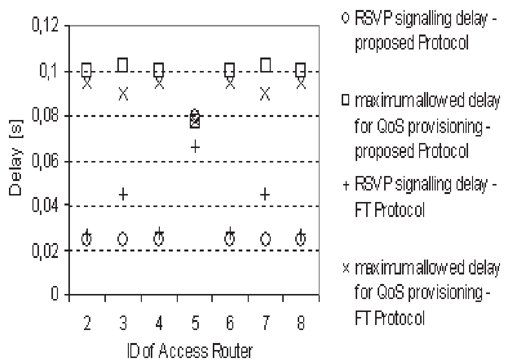



**Figure 2:** Network Topology 1

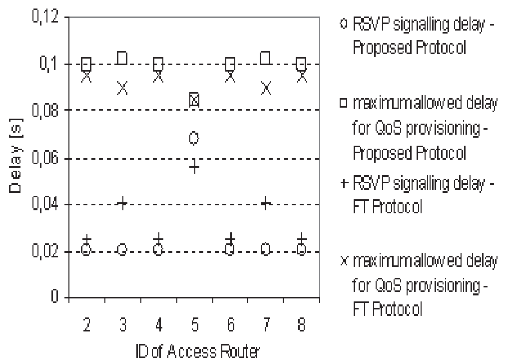
## 3. SIMULATION ENVIRONMENT

The basic topology of the simulated network Topology 1 (Figure 2) is hierarchical with the lowest level being meshed. Nodes **1** to **8** are access routers and I assume that each router is responsible for one wireless subnetwork. Nodes

**9** to **14** are intermediate routers in the access network, whereas node **15** is the gateway to the core network. In the core network only the CH and the home agent (HA) are shown. Links **a** are used to connect mobile nodes to access routers and they are assigned a constant delay of 0.05ms and a constant capacity of 2 Mb/s. Links between the access routers are denoted with **b** and they have a delay of 0.1ms. All other links in the access network, denoted with **c**, have a delay of 1ms. To the links **d**, in the core network, a delay of 20 ms is assigned. It is assumed that the MH is moving in the pattern 1-2-3-4-5-6-7-8, (which is typical for the case when a MH moves along a corridor or a highway), and handover occurs every 10 seconds




a) Access network congestion in Topology 1




b) Core network congestion in Topology 1

**Figure 3:** Proposed and FT Protocol, Topology 1

By assigning different capacities to the links, I have simulated two network congestion scenarios. In scenario 1, the access network is assumed to be congested, by assigning a capacity of 2 Mb/s to the links in the access network and 10 Mb/s to the links in the core network. In the second scenario, congestion is assumed in the core network by assigning a capacity of 2 Mb/s to the links **d** and a capacity of 10 Mb/s to the links **b** and c.

Two types of traffic were simulated: the real-time traffic transmitted from the CH to the MH and background traffic. Traffic from the CH to the MH is a 500 kb/s Poisson with constant packet size 500 bytes. Therefore, a bandwidth of 500 kbit/s is reserved from the CH to MH. The background traffic consists of 8x64 kb/s streams transmitted from the CH to the access routers. This traffic is also Poisson with a constant packet size.

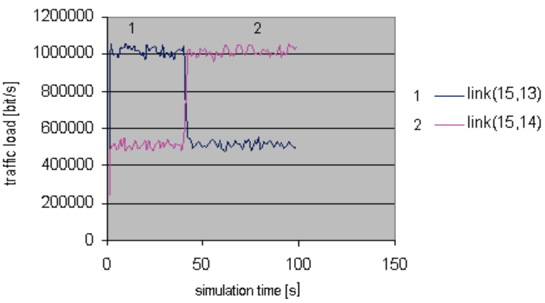
In order to demonstrate some of the features of the proposed protocol, I have also simulated two existing similar protocols [2] and [5].

## 4. PERFORMANCE ANALYSES

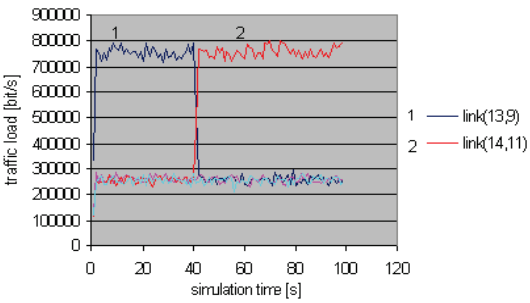
The RSVP signalling delay and the maximum allowed delay for QoS provisioning have been taken as performance metrics for the simulated protocols. The RSVP signalling delay is defined as the amount of time elapsed since a MH acquires a new CoA until resources in the new added path are reserved. The maximum allowed delay for QoS provisioning is defined as the time from the instant when the BU (binding update) is sent to the CH until the first packet with the new CoA arrives at the NCR.

As the proposed protocol highly outperforms [4] the conventional protocol, I will concentrate only in comparing the proposed protocol to the FT protocol. The simulation results (Figure 3), show that for all congestion scenarios the proposed protocol results in lower RSVP delays except during the handover from subnetwork 4 to subnetwork 5. This can be explained due to the fact that in this case the NCR is node **15** (gateway) and the *path-state* discovery procedure applied in proposed protocol (PathState_req and PathState-reply messages) results in longer delays. From the plots it can be seen that the minimum allowed delay for QoS provisioning is longer (better performance) in the case of the proposed protocol, because the NCR is located closer to the MN than in the case of FT protocol.

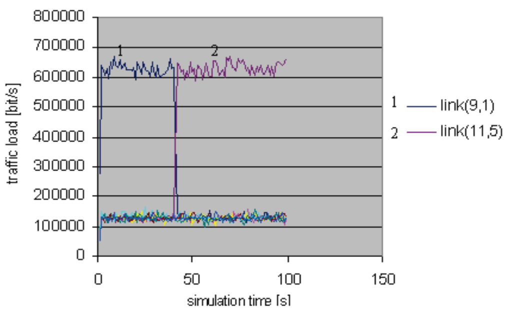
In order to show some additional features of the proposed protocol and of the meshed access network topologies, I have farther investigated the traffic distribution over the links of the access network for two different access network topologies.




a) Traffic load on links between gateway and routers on the third level




b) Traffic load on links between routers of the second and third level




c) Traffic load on links between access routers and routers on second le

**Figure 4:** Traffic load distribution in Topology 1

Figure 4 shows the traffic distribution on different links of the Topology 1, assuming background traffic load of 8x(2x64 kbit/s) and 500 kbit/s real-time traffic load from CH to MH. Initially MH is located in the subnetwork 1, and then it moves along the subnetworks 1-2-3-4-5-6-7-8, at time intervals of 10s. Curves on the upper part of the figures 4a, 4b, and 4c, show the total traffic, whereas curves on the bottom show the background traffic. As it can be seen from the Figure 4 traffic always flows along the reserved path 15-13-9-1, as long the MH moves within the subnetworks on the left of the Figure 2 with access routers meshed. When MH moves from subnetwork 4 to subnetwork 5 (at time instant of 40 s), then traffic flows along the reserved path 15-14-11-5, as long as MH moves within the subnetworks on the right side of the Figure 2. For example total traffic load on the link between nodes 9 and 1 is 500 kbit/s+128 kbit/s=628 kbit/s. The 500 kbit/s due to traffic from CH to MH and 128 kbit/s is the background traffic destined to access router 1.

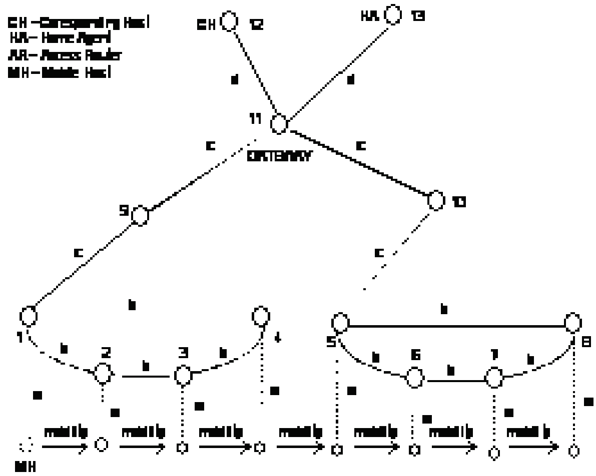
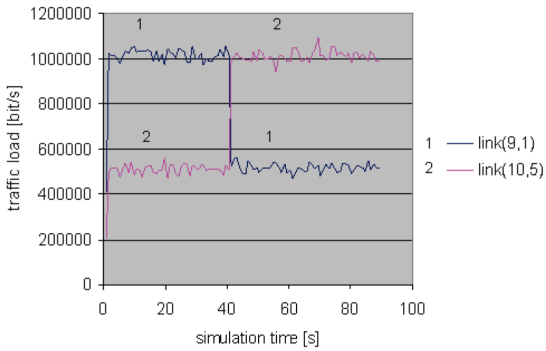
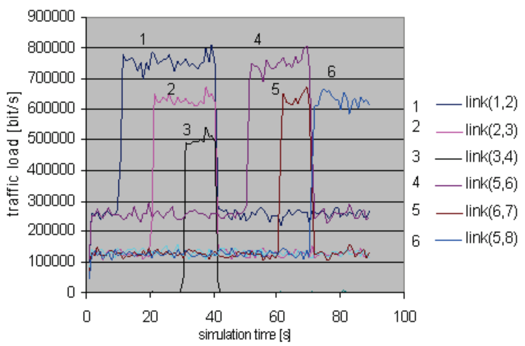


**Figure 5:** Network Topology 2

Along all other links flows only background traffic. This shows the specific characteristic of the proposed protocol that traffic load on the links that connect initial access router of the MH to NCR and other routers on the network hierarchy until to the gateway remains constant as long as MH moves between access routers that form a meshed access network. This feature gives the possibility to control the distribution of the traffic load on the access network, which is important for network planning and dimensioning.




a) Traffic load on links between routers of the second level and access routers




b) Traffic load on links between access routers

**Figure 6:** Traffic distribution for Topology 2

In its most complex form, a meshed access network could work like a peer-to-peer network, where access routers both send their own traffic and forward traffic on for other access routers. In its simplest form, shown in Figure 5 (Topology 2), access routers are connected in a ring. In the WLAN environment, for example, instead of moving traffic from a MH to a wireless Access Point (AP) to a wired network, such a mesh network moves traffic from AP to AP, depending on availability, and then eventually onto a wired network, and vice versa. In the given example, the MH is initially located in subnetwork 1, and then moves along subnetworks 1-2-3-4-5-6-7-8 after staying 10s in each of them.

Assuming a traffic load of 8x(2x64 kbit/s)+500 kbit/s=1524 kbit/s, Figure 6 shows the traffic load distribution on the different links of the access network of Topology 2. Analyzing the plot in Figure 6, one may observe that the total traffic load on the link between access routers 1 and 2 is 500 kbit/s+(2x128 kbit/s)=756 kbit/s. The 500 kbit/s is the real-time traffic transmitted from CH to MH, whereas 2x128 kbit/s is the background traffic destined to access routers 2 and 3. Because the background traffic destined to access router 4 is transmitted via direct link between access routers 1 and 4, the traffic load on the link between access routers 3 and 4 is loaded only with real-time traffic transmitted from CH to MH. Therefore, the most loaded link, as it is expected, is the link between access routers 1 and 2, since it has to carry the traffic transmitted from CH to MH and the background traffic destined to access routers 2 and 3. When MH moves within the subnetworks on the right part of Topology 2, the most loaded link is the one between access routers 5 and 6.

## 5. CONCLUSION

In this paper the wireless meshed access networks topologies are discussed. In order to thoroughly investigate the proposed concept of the wireless meshed access network a new signaling protocol for QoS provisioning to mobile users for partially-meshed access network is proposed and evaluated. The proposed protocol is based on an existing flow transparency Mobile IP and RSVP interworking scheme and can be considered as it's complimentary for meshed access network topologies. The basic idea of the proposal is to use previous access router(s) as a NCR for the old and the new added flow paths.

The simulation results, in terms of RSVP signalling delay and the maximum allowed delay for QoS provisioning, show that the proposed protocol leads to improvements for meshed access networks in comparison to existing protocols. Furthermore performance analyses show that meshed access network topologies, combined with an appropriate protocol, are very convenient for controlling the distribution of traffic over the links of the access network.

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