51. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

PROCEEDINGS

11-15 September 2006

FACULTY OF ELECTRICAL ENGINEERING AND INFORMATION SCIENCE

INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING - DEVICES AND SYSTEMS, MATERIALS AND TECHNOLOGIES FOR THE FUTURE

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=12391

TECHNISCHE UNIVERSITÄT
ILMENAU

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Andrea Schneider Fakultät für Elektrotechnik und Informationstechnik Susanne Jakob Dipl.-Ing. Helge Drumm
Redaktionsschluss:	07. Juli 2006

Technische Realisierung (CD-Rom-Ausgabe):
Institut für Medientechnik an der TU Ilmenau
Dipl.-Ing. Christian Weigel
Dipl.-Ing. Marco Albrecht
Dipl.-Ing. Helge Drumm

Technische Realisierung (Online-Ausgabe):
Universitätsbibliothek Ilmenau
ilmedia
Postfach 10 05 65
98684 Ilmenau

Verlag: isle
Verlag ISLE, Betriebsstätte des ISLE e.V.
Werner-von-Siemens-Str. 16
98693 Ilrnenau

ISBN (Druckausgabe): 3-938843-15-2
ISBN (CD-Rom-Ausgabe): 3-938843-16-0

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=12391

51st Internationales Wissenschaftliches Kolloquium
Technische Universität Ilmenau
September 11 – 15, 2006

R. Böringer, A. Mitschele-Thiel

Integrated-MPLS: An Applicability Statement

ABSTRACT

All-IP networks gain more and more importance even in the area of mobile communications. The next generation of mobile telecommunication networks will be based on technologies known from the IP world. Of special research interest are protocols for mobile access networks, because of the high requirements in this area. Due to the fact that the original IP-protocol family was not designed to support mobility and quality of service (QoS), there is a need to develop new protocols and mechanisms which overcome this drawback. In this paper we analyze Integrated-MPLS (I-MPLS) which integrates QoS and micro-mobility into one single protocol. The protocol specification let some room for improvements and extensions especially with respect to the applicability in real scenarios. In the following three important issues will be identified and solution therefor will be outlined.

INTRODUCTION

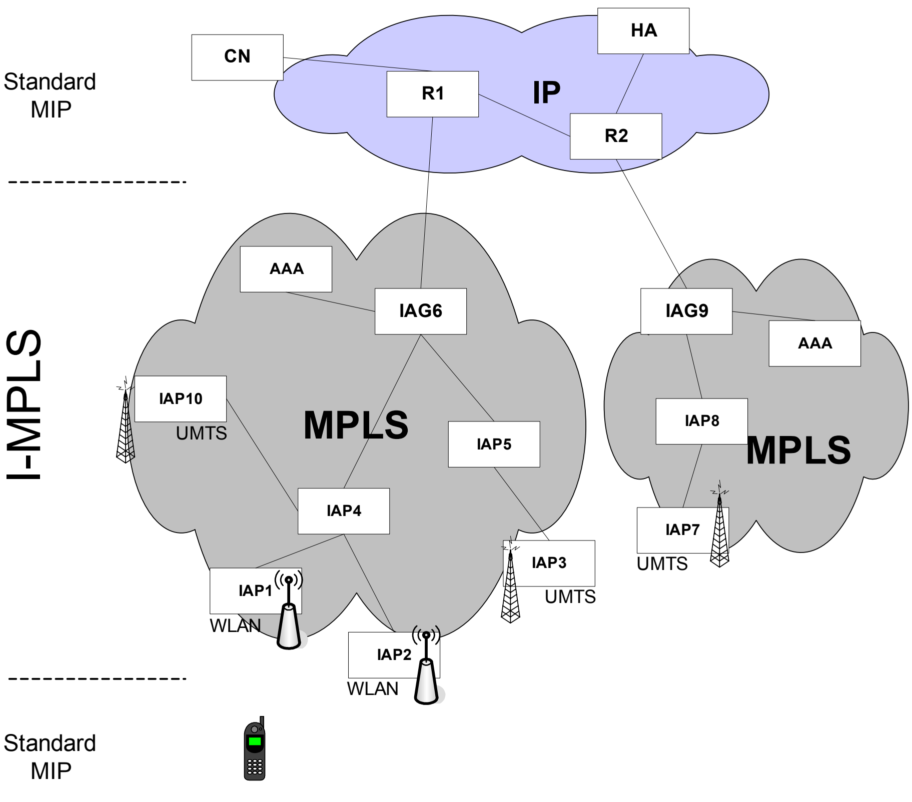

Figure 1 – Integrates-MPLS (I-MPLS)

In today's research and development activities we see a strong trend to use protocols and mechanisms of the IP world in the world of classical mobile telcommunication networks. Mobile operators expect a reduction of CAPEX and OPEX on the one hand. On the other hand they hope that it opens their networks for new services increasing the revenue. However, the classical IP world is not prepared for the high requirements of mobile telecommunication systems yet. In the future both, access networks and backbones have to support mobility, QoS, security and should be highly reliable as well [1]. For each of these tasks there exist several solutions. The challenge is to use these approaches together in one network and in an optimal fashion. Integrated-MPLS (I-MPLS) [2] as depicted in Figure 1 has been designed to provide micro-mobility and QoS support in one protocol. I-MPLS is derived from regular Multi-Protocol Label Switching (MPLS). MPLS uses short labels of a fixed length to accelerate the forwarding process. Due to the facts that these labels can be used to bind a flow to a specific path and that labels can be stacked, MPLS provides the capabilities for powerful traffic engineering. To provide mobility in IP-based networks Mobile IP (MIP) is the classical protocol which is used. The idea of I-MPLS is to encapsulate the MIP messages into a special RSVP-TE object carried by regular RSVP-TE messages. RSVP-TE (Ressource reservation ptorocoll – traffic extensions) [3] is one of the label distribution protocols of MPLS. The encapsulation allows I-MPLS to be fully transparent to mobile nodes and to their home domains as well. Thus, no changes are needed to these elements. Therefore an access point has to support both Mobile IP and I-MPLS including RSVP-TE as its signalling protocol. Such devices are called Integrated Access Points (IAP). I-MPLS supports fast handoffs like other IP-based micro mobility protocols as Hierachical MIP, MIP Regional Registration, Cellular IP or HAWAII. In contrast to these protocols I-MPLS provides support for QoS, traffic engineering and fast protection additionally.

QoS INTERFACE

As specified in I-MPLS there is no special QoS signaling between mobile nodes and IAPs. I-MPLS only adds an explicit QoS signaling procedure by means of RSVP-TE in the wired part of the network. A QoS interface is needed to translate the QoS requirements form the mechanisms of the wired part to the mechanisms of the wireless part and the other way around. Such a QoS interface than allows QoS guaranties along the whole path including the wireless link as depicted in Figure 2. The challenge arrises from the fact that the QoS mechanisms on the wireless link are mostly based on Layer 2 procedures and are radio technology specific whereby higher layer mechanisms are responsible for QoS in the wired part of

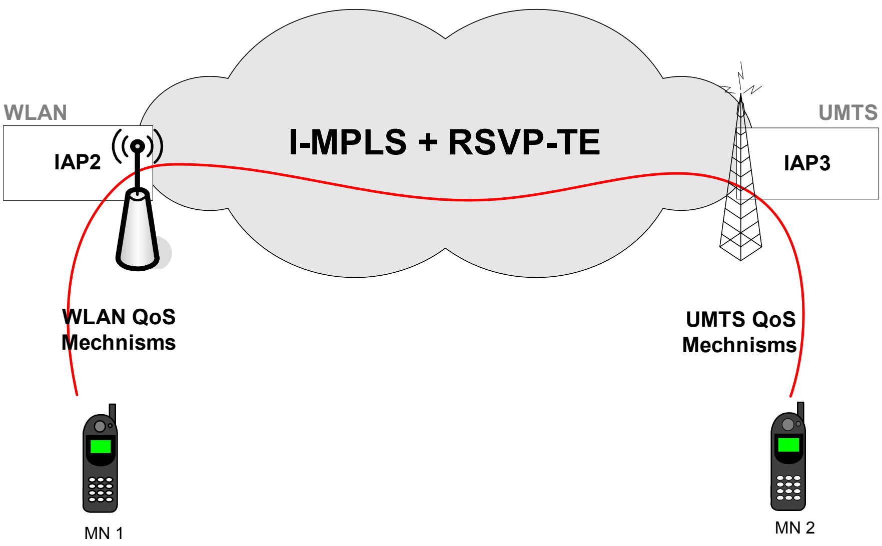

Figure 2 – QoS Mapping between different Technologies

the network. In [4] detailed QoS parameter mappings and signaling procedures between an RSVP-based network, UMTS and WLAN have been described. However, the proposed solution only works for WLANs supporting the IEEE 802.11e standard. Thus, there is a need for additional mechanisms supporting WLAN as radio technology even in the case the mobile nodes do not support IEEE 802.11e. The proposed solution in [5] was designed to support soft QoS without the need to extend the mobile devices or the protocols between mobiles and access points. An access points controls the data rate on its radio interfaces by utilizing a special QoS manager. This QoS manager periodically computes the availables data rate on the wireless link out of ARS (Adaptive Multi Rate) rates choosen by the mobile devices and the number of these devices which are assoziated with this access point. An extended Anomaly Model [6] is used to compute the data rates. This data rate estimation is used in stead of real measurements. An access point periodically compares the already reseved data rates for assoziated mobiles with the current data rate estimation. If the sum of the reserved data rate exceeds the avialable data rate the acess point releases one QoS connections after another until it is able to fulfill the requirements of the remaining QoS sessions again. If a RSVP request reaches an access point it only answeres with a positiv messages if the sum of all QoS session including the new one is lower than the estimated data rate on the radio link. For QoS signalling RSVP-TE is used which allows a seamless integration of such a QoS interfaces into I-MPLS-based networks.

PAGING

Most of the time a mobile node is in idle mode, meaning it actually does not need any resources. Due to the use of MIP as mobility protocol and the fact that MIP does not distinguish between idle and active modes of mobile nodes, also I-MPLS leggs of this feature. In I-MPLS if a mobile moves into the coverage area of an IAP it sends a MIP Registration Request message which always results in a resource reservation due to the RSVP-TE encapsulation. To avoid this, paging functionality can be integrated. Therfore, special paging areas have to be defined grouping several IAPs as it is shown in Figure 3. A paging area is identified by a paging area ID (PAID). By means of the PAID broadcasted by the Layer 2 procedures a mobile node is able to recognize the paging area of each access points it hears. Now a mobile node only undertakes a registration procedure if it enters a new paging area. This reduces the signalling load of the network. In I-MPLS this means additionally that also the ressource consuption with respect to the reserved data rates is dramatically reduced. However, the cost for the reduced signaling due to less MIP registrations is the circumstance that the network has to locate the mobile node within a paging area first before data can be transfered. The location is determined by using classical paging meaning a location request is sent to all IAPs in a paging area.

This implies that we have to optimize the paging area size to balance the saving due to lesser registration procedures and the expense resulting from the paging procedure.

This can be easily computed and is addressed in a couple of publications. Another still open issue is the optimal number and locations of the paging initiators. If only one paging initiator for all paging areas is used then this one has to maintain states for all mobiles and paging areas. Additionally, the mean path length between the paging initiator and the IAPs within the paging areas is quite long. This increases the paging cost. The other possibility is to place one paging initiator within each paging area by selecting one IAP to be the paging initiator. In this case a lot of paging initiators have to be maintained but the number of states one paging initiator is responsible for is much lower. Depending on the exact location the signalling load on small links can be quite high. This should be avaoided because of the limited capacities of those links which can directly be translated into higher expense. Again the complexity increases if dynamic paging areas are used. Dynamic paging areas adapt themselves or will be adapted to the current network situation. Algorithms for finding and maintaining dynamic paging areas are decribed in several publication. However, the issues of optimizing the paging procedure and thus the number and location of paging initiators was neglected.

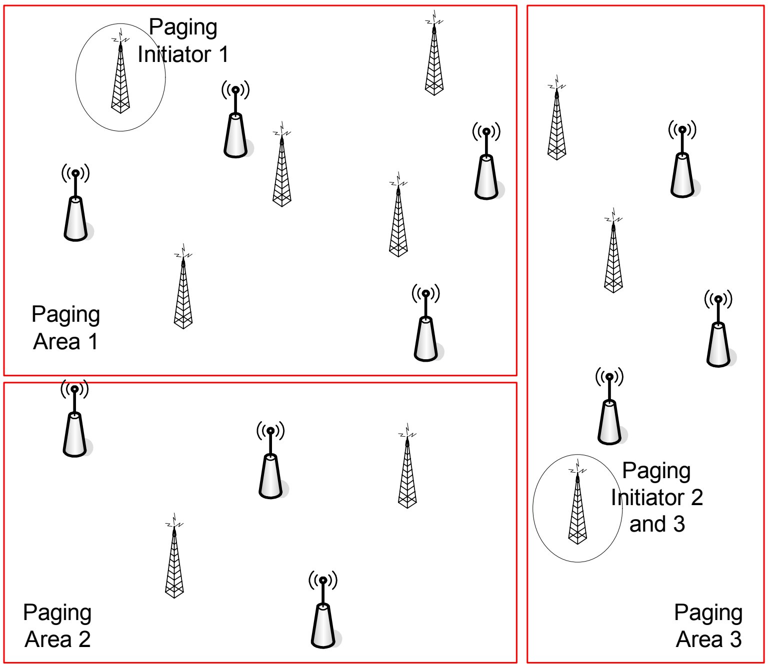

Figure 3 – Paging Areas and Paging Initiators

TOPOLOGY DISCOVERY

The hierarchical mobility approach of I-MPLS causes a tree-like logical structure as it has been shown in Figure 1. Figure 4 depicts that between one IAP and another there may exist several regular MPLS nodes. This means that an IAP has to know the address of the next higher IAP or IAG (Integrated-Access Gateway), respectively. Currently the I-MPLS specification does not comment on this issue. It is assumed that this information is available on each IAP. However, I-MPLS provides the possibility to change the logical topology dynamically. This is used to optimize the network concerning the desired handover latency, maximum delay of the user traffic and the operational expense on the IAPs. The optimization process by means of an mixed-integer programming algorithm is described in [7]. The network has to adapt itself to the current situation to reach optimal results. Therefore, the new logical topology has to be detected automatically. A automatic and periodicall detection process also prevents for misconfigurations and allows an autonomous reaction of the network to failures. A topology discovery mechanism can be integrated in I-MPLS by utilizing and adapting the HELLO procedures and messages of RSVP-TE. Actually, HELLO messages are used to detect if a neighbor is still available or not. In this messages a special IAP detection object can be integrated. The IAP detection object includes a initiator identifier, the number of hops to the gateway and a timestamp for synchronization purposes. Gateways in networks are always the initiators of the detection process. Always only one of the gateways is active and all others are passive and behave more or less like regular IAPs. The coordination who the active gateway is, is done by using the time stamps in the HELLO messages.

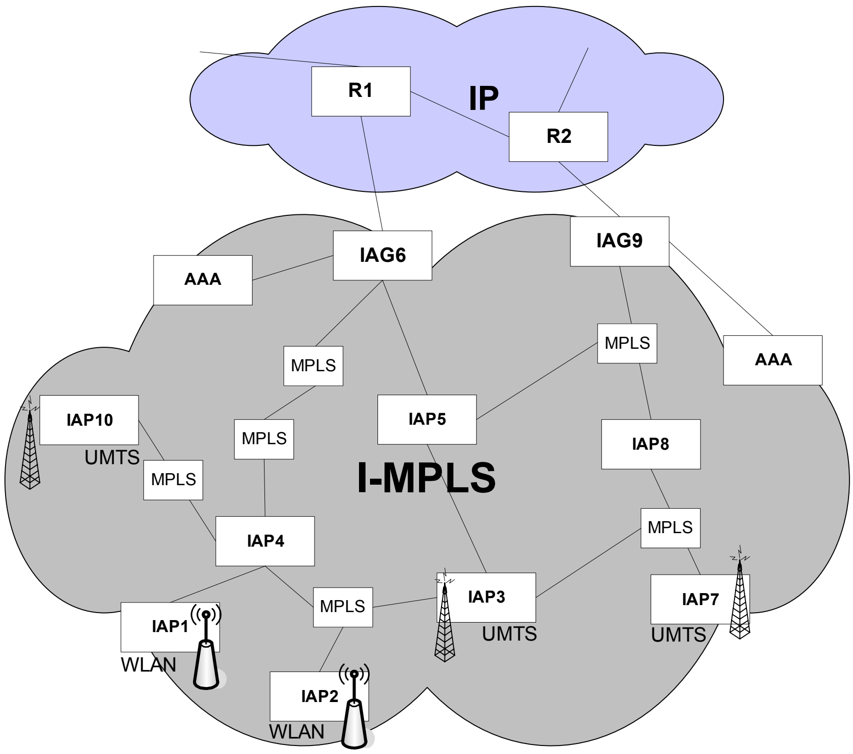

Figure 4 – An I-MPLS Network including regular MPLS nodes

Every IAP only stores the address of the next higher IAP or the gateway address respectively. This IAP is used as destination for all upstream session futher on. Such a topology detection mechanism has to be designed to be applicable even when regular MPLS/RSVP nodes are part of the network. The regular MPLS/RSVP-TE node may not support the extended HELLO procedures. They only broadcast the unknown IAP detection object to all of its neighbors. Therefor, to prevent selfrepreducing loops, a TTL has to be assigned which is as high as the longest non-IAP chain long is. A TTL which is to short may lead to a separation of subnetworks behind long non-IAP chains. After a timeout one IAP of a separate subnetwork would initiate a new topology detection phase. The IAP will increase the TTL by one until it receives a response from at least one gateway.

CONCLUSION

The applicability of I-MPLS was discussed on three different issues, namly a QoS interface, paging and an automatic topology discover process. For each of these issues a sultions was decribed too. A QoS interface can translate between the Layer 2 mechanims of the radio link and the higher layer QoS solutions of the wired part of the network. No extra protocol is necessary. QoS signaling can be easily integratesd in the signalling protocoll of I-MPLS. The high ressource consumption and the high signalling load due to the assumption that a mobile node is always active can be easily reduced by integrating paging in I-MPLS. To be able to profit from the high flexibility of I-MPLS meaning an adaptation of the network to the actual network conditions an automatic IAP discovery meachanism is needed. Even if I-MPLS is already powerful a lot of issues have to be solved which are mostly related to the applicability of I-MPLS in real network scenarios.

References:

[1] R. Böringer, A. Mitschele-Thiel, M. Bauer, M. Söllner, “MPLS/RSVP-TE-based Future UMTS Radio Access Network”. 2nd International Working Conference on Performance Modelling and Evaluation of Heterogeneous Networks (HET-NETs'04), Ilkley, U.K., July, 2004.

[2] R. Böringer, A. Saeed, A. Diab, A. Mitschele-Thiel, M. Schneider, “I-MPLS: A Transparent Micro-Mobility-enabled MPLS Framework”. 11th European Wireless 2005, Cyprus, 2005.

[3] D. O. Awduche, L. Berger, D. Gan, T. Li, V. Srinivasan, G. Swallow, “Extension to RSVP for LSP tunnels”. IETF RFC 3209, December 2001.

[4] R. Böringer, A. Mitschele-Thiel, G. Scharfe, "QoS in I-MPLS-based Heterogeneous Networks". 8th International Conference on Advanced Communication Technology (ICACT), Korea, Feb 20-22, 2006.

[5] R. Böringer, A. Mitschele-Thiel, M. Winkler, "Using an Extended Anomaly Model to Provide RSVP-based QOS in Wireless-LANs", The 17th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC'06), Helsinki (Finland), 2006.

[6] M. Heusse, F. Rousseau, G. Berger-Sabbatel, A. Duda, “Performance Anomaly of 802.11b“, Proceedings of IEEE INFOCOM, San Francisco, USA, Apr 2003.

[7] F. Liers, R. Böringer, A. Mitschele-Thiel, "Optimal Placement of Anchor Points within large Telecommunication Networks". 4th International Conference on Wired/Wireless Internet Communications WWIC 2006, Bern, Switzerland, 2006.

Authors:

Dipl.-Ing. René Böringer
Prof. Dr.-Ing. habil. Andreas Mitschele-Thiel
Technische Universität Ilmenau, Gustav-Kirchhoff-Str. 1
98693, Ilmenau
Phone: +49 36 77-69 12 26
E-mail: {rene.boeringer | mitsch}@tu-ilmenau.de