Mobile Multimedia Communication — Systems and Networks

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organized by

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Wireless and mobile communication are becoming increasingly important for various application areas going far beyond pure telephony. Just to name a few trends: body area networks, sensor-based networks and multihop ad hoc networks are of great interest leading to new infrastructures and propelling new applications in the context of ubiquitous computing. Furthermore, it is obvious that multimedia data need also to be transported through wireless networks or through a wireless access. Moreover, multimedia data will be exchanged during mobility and, thus, require proper networking support, for example, regarding continuous delivery and the like.

Mobile communication asks for both, proper network solutions including protocols and mechanisms as well as good systems including issues related to power management and hardware/software co-design. This Dagstuhl seminar on mobile multimedia communication has brought together researches from both groups (systems and networks) to stimulate interdisciplinary discussions.

This report gives an overview of the presentations given during the seminar and reflects the current research in both systems and networks for mobile multimedia communication. Although the majority of topics was related to networking issues (e.g., active networking, Quality of Service, protocol header compression), issues considering systems were also discussed, for example timing analysis of mobile communication systems.

Contents

1 Cellular IP

András G. Valkó; Ericsson Research - Andrew T. Campbell, Javier Gomez, Sanghyo Kim; Columbia University, New York

The development of small affordable notebook computers and palmtop devices creates the demand for ubiquitous wireless Internet access. Solutions to provide wireless IP access are studied in the concept of 3rd generation cellular networks (e.g., UMTS) and in the mobile routing working group of the IETF, separately. Both approaches have their drawbacks, however. While 3rd generation cellular systems represent a reliable and efficient mobility support that provides good handoff quality, it does not provide the simplicity and flexibility of IP based solutions. Mobile IP is a simple scalable solution, which does not, however, provide the handoff quality expected in cellular systems. Cellular IP represents a "third way" combining the advantages of these two approaches. It is a simple and scalable cellular wireless access protocol that uses cellular telephony concepts to provide fast seamless handoffs. In the presentation, we provide an introduction to the cellular IP protocol and present some early performance figures based on measurements in an experimental testbed.

2 Software Timing Analysis of Mobile Communication Systems

Fabian Wolf, Technical University Braunschweig, Germany

Accurate software timing estimation for telecommunication systems is impossible by pure simulation due to incomplete input data sets to the system under investigation. Intervals for software timing are needed to be able to meet hard real-time constraints. As parts of the input data sets are known, some control structures of the software implementation can be predicted, so simulation or prototyping based measurement for these parts of the software under investigation is possible to improve the tightness of the intervals. Control structures with unpredictable input data have to be modeled as worst case. This input data classification is straight forward for telecommunication systems as packet header parts are often predictable while the payload is not.
Results of the segments of the classified control structures under investigation are integrated and the overall interval for software timing and power consumption is calculated.

3 Header Compression in Mobile Environments

Mikael Degermark, Stephen Pink, Lars-Åke Larzon, Björn Nordgren; Luleå University, Sweden

The goal of this ongoing work is to enable IP Telephony end-to-end to and from mobile units using cellular technology. A severe obstacle for this to happen is the large headers. Voice packets will contain 20–80 ms worth of sound samples, an RTP header (12 octets), a UDP header (8 octets), and an IPv4 (20 octets) or IPv6 (40 octets) header. With 30 ms frames and a 6.3 kbit/s voice codec, the header overhead (not counting link-layer framing) is 167% for IPv4 and 250% for IPv6.
The large headers affect performance badly for wireless links not only because they consume bandwidth and add delay, but also because the large headers increase the probability that a packet will be damaged over the wireless link.
Header compression techniques can reduce the combined header to around 4 octets, but current schemes like CRTP increase the sensitivity to loss of compressed headers. However, by combining CRTP header compression with UDP Lite and clever versions of the "twice" algorithm, we show that the packet loss rate can be reduced by an order of magnitude.
By paying small costs in terms of processing power and memory usage, it is thus possible to lower the bandwidth demands, lower the transmission delay and reduce the packet loss rate over the wireless link.

4 UDP Lite

Stephen Pink; Luleå University, Sweden

UDP is an unreliable datagram protocol for use over IP which multiplexes packets from the network interface to the new process. In IPv4, there is also an optional checksum of the headers and user data. A user may chose not to use the checksum. This can benefit some multimedia applications which are tolerant to bit errors, but not to the loss of whole packets. In IPv6, the UDP checksum is no longer optional because the IP header checksum has been eliminated. This means that some multimedia applications can loose whole packets because of single bit errors of which they are tolerant.
We propose a new variant of UDP, which we call UDP-Lite which substitutes for the UDP-length field (which is redundant on the IP length) a checksum coverage field which represents the amount of UDP user data covered by the checksum.

Then, UDP-Lite can checksum just the header, the header + data, or the header and part of the data (e.g., the RTP header). UDP-Lite, then, is more flexible than UDP, more tolerant for multimedia but can be made as strict as UDP classic.

5 Efficient Active Ad-hoc Networking

Christian Tschudin, Uppsala University, Sweden

We present a packet format that can be used for unifying active networking, high speed forwarding and classic networking protocols. The "simple active packet format" has a single 64 bit field, the SAPF selector. Selectors identify protocols or flows, most of the selector values are assigned at run time using active packets. Although the SAPF layer is incomplete and active packets are slow, together they result in a fast AND flexible network architecture. We implemented SAPF for the Linux kernel and will use it for wireless ad-hoc networking, relying on the SAPF module for the forwarding and on active packets to fill the forwarding tables and to implement a variety of active routing protocols.

6 Transparent QoS Support by Transport Level Aware Link Level Mechanisms

Georg Carle, GMD FOKUS, Berlin; Frank Fitzek, Adam Wolisz, Technical University Berlin, Germany

It is a challenging task to provide IP services with QoS support in heterogeneous networks involving wired and wireless sections. The goal of this work is to enhance link-level error control by transport-layer information in order to meet transport layer reliability and delay requirements. We propose a CDMA MAC protocol that employs "Simultaneous MAC Packet Transmission" (SMPT) to recover errors at the wireless link. The capability of SMPT to use one or several wireless channels allows to reduce the probability of lost or late transport layer data units. We propose that the wireless host adjusts the MAC layer transmission window using estimations of the transport layer delay budget. We also propose to control the number of channels used by SMPT based on transport layer timing requirements.

7 QoS Agents for Diffserv Domains

Olov Schelén, Joakim Norrgård, Stephen Pink et al.; Luleå University of Technology, Sweden

We have designed a bandwidth broker architecture for service provisioning in differentiated services networks. The architecture provides services for reserving virtual leased lines (VLL) between endpoints or subnets. VLLs can be reserved immediately or in advance and the resources can be used by a defined subset of traffic between the points.
In this talk, I presented a prototype implementation of a bandwidth broker. The broker has a web interface for making QoS requests and it performs path-sensitive admission control in its domain. The broker sets up traffic conditioners in boundary routers to control traffic volumes.
I described the admission control algorithms and data-structures together with performance measurements. I also described how reservation state can be aggregated when brokers interact to setup VLLs over multiple domains.
More info: http://www.cdt.luth.se/~olov/publications

8 The DeepMap Projects and its Mobile Communication Infrastructure

Stefan Fischer, International University in Germany

DeepMap is a major project initiated by the European Media Lab in Heidelberg. About 10 German and an American University, as well as a number of research institutes and industrial partners are participating. The overall goal is to do research in a number of technologies that are considered key technologies in the coming decade, such as natural language processing, visualization, or mobile communication. As an implementation framework, the project partners cooperatively build a virtual tourist guide of Heidelberg, where all investigated technologies are integrated. The tourist guide provides a natural language interface and a head-mounted display to provide information. The system supports video, sound, 3D maps, animations etc.
The talk presented the DeepMap project vision and gave an overview of the included sub-projects. It then concentrated on the mobile communication part and outlined the virtual tourist guide's communication infrastructure. The goal is to first implement a running platform that in the second step can be used (a) in

the prototype, and (b) for further research. The platform includes GPS for user location, GSM or UMTS as low-bandwidth, and wireless ATM as high-bandwidth wireless networks. It is intended to use Mobile IP for mobility support as well as a Middleware platform enhanced by QoS support.
More information is available from EMLs web site at http://www.eml.org/ or from the International University at http://www.i-u.de/staff/fischer or directly from the author at stefan.fischer@i-u.de.

9 UTRAN Internet Access

Karl Jonas, NEC Europe Ltd.

Different architectures for support of mobile terminals have been developed in the telecom-world and in the Internet. The telecom-networks use a centralized approach with a highly controlled flow of information and signalling. This results in a very complex, expensive, controllable and reliable network. The Internet-approach is much more distributed, providing a best-effort service with simple communication protocols and cheap technology. Both approaches are converging. The Internet introduces/discusses improved and differentiated service quality. The Telcos recognize the advantages of the simple Internet Protocol (IP), integrating it in the next generation mobile telephone network (UMTS). We suggest a much more tightly integrated architecture, that does not only use IP as a forwarding mechanism in the UMTS core network, but also integrates and benefits from several other Internet-technologies, in particular mobility support by Mobile-IP.

10 Mobile-Awareness in Collaborative Learning Environments

O. Drobnik, J. Berghoff, M. Matthes; Dept. of Computer Science, J.W. Goethe-Univ., Frankfurt/Main, Germany

Mobility is becoming an increasingly important subject for computer-supported cooperation. Mobile-awareness grows to a major topic for CSCW-Systems in mobile environments. We consider several classes of awareness for CSCW-systems in

the context of mobility: group-awareness, session-awareness, member-awareness. A general system architecture is proposed based on Mobile-IP to support the distribution of awareness information.
The integration of mobile-awareness concepts into our collaborative learning environment is investigated. Our collaborative learning environment is a kind of knowledge modeling system: the members of a group collaborate to develop a common view of research topics. The prototype is a planned to run on an experimental mobile environment based on a WaveLAN radio network.

11 On Scheduling for Data Broadcasting Systems

D.N. Serpanos, A. Traganitis, D. Tripatis; Dept. of Computer Science, Univ. of Crete, Greece

Broadcasting systems provide an attractive, scalable solution to deliver multimedia applications to a large population with heterogeneous terminals, ranging from high-performance ones to wireless and mobile.
We consider a model where transmitted information is composed of objects and we compare two different broadcasting technologies: object-based and cell-based. In object-based transmission, all object data are transmitted consecutively, while in cell-based transmission, the cells of different objects are transmitted interleaved. We prove that object-based transmission provides improved delay characteristics than cell-based, interleaved transmission.
Furthermore, we consider a model where objects are composed of equal-sized items and where objects can have common items. We introduce a scheduling algorithm for items, which provides low average reception delay of objects. The results are improved relatively to state of-the-art algorithms, which schedule objects without accounting for common items.

12 Group Communication with Mobile Participants

M. Zitterbart, TU Braunschweig, Germany

Group communication is becoming increasingly important, e.g., to support multimedia applications such as tele-collaboration. The active multicast approach (AMnet) is supposed to provide a proper platform that is capable of individually supporting group participants with different requirements. QoS filtering (e.g., MPEG-1 filter) in active multicast nodes enables the provisioning of video flows with different QoS to different receiver groups. For example, a mobile user would receive a video stream with less data volume. This is transparent to the sender. Moreover, dedicated error control can be provided to these receivers.
AMnet is based on active networking. It supports HW/SW integration with respect to loadable service modules. An RSVP-based prototype is available. A more advanced system with proper signaling and resource management is currently under development.

13 INSIGNIA

Seoung-Bum Lee, Andrew T. Campbell; COMET Group, EE Department, Columbia University, New York, USA

INSIGNIA (stands for in-band signaling support for QoS in mobile ad hoc networks) is a new in-band signaling system for support of QoS in mobile ad hoc networks. The term, "in-band" sets to the fact that control information is carried in the IP packet header. We argue that the in-band approach is more suitable than out-of-band signaling approaches because the in-band nature allows INSIGNIA to be more responsive to the network dynamics. Moreover, out-of-band signaling often fails to reach the target mobile nodes when the connection is lost. To deal with the management of resources, INSIGNIA uses a "soft-state" approach which guarantees the release of unutilized reservations and soft-states on the old path/route.
INSIGNIA performs fast reservation, restoration and adaptation according to the network dynamics and resource availability. INSIGNIA also uses a new soft-state estimation scheme that effectively manages and releases resources on the new and old route.
Simulation results show the impacts and benefits of INSIGNIA in various environments (mobility, QoS, delay ...). Moreover, the effects of false restoration and resource lockup are presented.

14 Wireless ATM

Elmar Dorner, Institute of Telematics, University of Karlsruhe, Germany

This talk presents an overview of my work done in the area of wireless ATM.
In 1996, the ATM Forum has, driven by user request, founded two new working groups. Both deal with the support of ATM for wireless endsystems. The first one concentrates on the physical layer and the introduction of radio as a transfer medium for ATM. The second one looks into the mobility support for mobile endsystems. The first standard for a wireless ATM system was scheduled for October 1998, but at the time of writing there has no standard shown up.
A major feature of the ATM network technology is the ability to integrate different types of services and offer QoS support. So the aim a of wireless ATM extension should be to offer these QoS support, with respect to the different medium, as close as possible.
Our work includes different parts of such an architecture, each with the aim to provide additional support for the QoS adherence in the wireless network.
We developed a medium access control protocol that provides the different service classes as known in ATM. With this, it is possible to share the available bandwidth in a fair manner according to the requested QoS.
For the mobility management, we introduced a mobility parameter on a per connection basis. With this, we can harmonize the information from mobility profiles and gathered in zone managers. This allows us to build a mobility aware call admission control. Together with our handover protocol, it is possible to offer a far-sighted and active resource management for the radio cells.

15 Issues of Differentiated Services in Mobile Environments

Jörg Diederich, Institute of Operating Systems and Computer Networks, Technical University Braunschweig, Germany

The Differentiated Services approach provide means to support quality of service (QoS) in IP-based networks. In mobile environments, congestion cannot be avoided due to frequent changing routes. To deal with congestion, two solutions are presented: Long-term congestion can be handled with admission control and application adaptivity. In case of short-term congestion, priorities can be used to

provide different levels of QoS. These priorities can be realized by using Differentiated Services. As this work is in a very early stage, the presentation is more about work intended to do in the future rather than about results.
More info about this may be found in the future at:
http://www.ibr.cs.tu-bs.de/~dieder

16 Analysis and Evaluation of a New Feedback Error Control Scheme for Block-Based Video Communication in Packet Switched Wireless Networks

Jens Meggers, Lehrstuhl fr Informatik 4, RWTH Aachen, Germany

The presentation describes feedback schemes suitable for recovering from errors that occur at video stream receiver applications in the case of packet losses. A new error recovery scheme is introduced that has substantial performance benefits compared to already existing ones. The new scheme has lower bandwidth demands and allows for better overall video reception quality. We evaluated the different approaches analytically and by means of a prototype implementation in order to verify practical and theoretical achievements. Measurements from our prototype implementation confirm the results derived from our analytical model.

17 Connecting Mobile Hosts to the Internet

Andreas Fieger, Technical University of Braunschweig, Germany

The goal of this work is to provide an efficient and fast Internet connection for mobile hosts that bridge the last hop link relying on wireless transmission technologies. The special focus is on transport protocols within such a scenario. Due to the significantly different transmission characteristics of wired and wireless physical layer technologies, it must be questioned if it is an appropriate approach to operate TCP end-to-end over such a heterogeneous path. The main disadvantage of this approach is that transmission errors, that frequently occur at the wireless channel, trigger TCP's congestion avoidance mechanisms. One way to

overcome this deficit is to split the originally end-to-end operating transport connection into two connections, the first one operating over the wired sub-path, the second one operating over the wireless channel. The main benefit of this approach is that transport layer mechanisms, that are optimized for the transmission characteristics of the wireless channel, can be applied without loosing interoperability to TCP/IP based hosts within the Internet. Interconnection of the two transport layer connections is realized within the so-called transport gateway that is located close to the mobile station. To preserve short round trip times for the transport connection over the wireless channel, the transport gateway has to be migrated to a host that is closer to the current whereabout of the mobile station. Special mechanisms to reduce transport layer interruption time during the migration of the transport gateway are required. Furthermore, adequate support within the network layer (e.g., Mobile IP) is needed to guarantee that data packets are routed to the transport gateway and do not pass it.

18 Programmable Handoff Control

Gen Ito, Andrew T. Campbell; COMET Group, Columbia University, New York

In this talk, we argue that programmability of handoff control architectures can be brought to bare in order to respond to the specific needs of users, service providers and QoS.
Programmability can provide a foundation for the composition of access networks using fundamental software building blocks that realize handoff control, data link layer access, quality of service adaptation, and location management. By accelerating the programmability of mobile networks, network designers can innovate by dynamically architecting their networks, supporting a variety of service, equipment and environment factors. While the problem of programming quality of service adaptation in wireless networks has been addressed in the past as part of the mobiware testbed demonstrated at NOSSDAV 98, the issue of supporting programmable handoff control has not been considered. This presentation overviews an issue and outlines the design, implementation and performance evaluation of a programmable handoff control architecture.

19 Adaptive QoS over Wireless Networks

Javier Gomez, Andrew Campbell; Department of Electrical Engineering Columbia University, New York

We describe a framework for controlled-QoS in the presence of severe impairments at the wireless link. The model includes a predictor, compensator and adaptor which operate with the supervision of an arbitrator.
Channel prediction allows mobile hosts to defer transmission when the channel is in a fade. A compensator compensates mobile hosts which deferred transmission in the past. The compensator uses Weighted Round Robin with enhanced compensation capabilities.
Finally, an adaptor performs selective dropping when the buffer is about to overflow. Analytical and simulation results are presented showing the validity of our approach.

20 Multi-Language Modelling of Communication Systems

Kai Richter, Technical University of Braunschweig, Germany

Many state-of-the-art communication applications consist of a combination of reactive and transformative functions. Often, several languages with fundamentally different underlying models of computation are used in the design of an individual system. The languages are selected because of their particular suitability for certain applications and optimizations or because they have become generally accepted as a standard within an application field. For a sound design process and improved design space exploration across language borders, the different input models should be mapped to a common internal representation. We present the SPI model that integrates the aspects of several models of computation and is targeted to scheduling and allocation. The representation is extended to account for environment and constraint modeling.

21 Extending Cellular Systems using Mobile IP and IP Telephony

Håkan Mitts, Nokia Telecommunications

The trend today towards providing an integrated (tele) communication infrastructure largely based on IP is also impacting cellular systems. In Nokia, we have been looking at enhancing GSM access by replacing some of the GSM protocols with IP-based ones. In this work, we have used IP telephony (H.323) to provide some of the GSM access features for mobility management and call set-up. In addition, some enhancements to H.323 have been added. This has allowed us to add (nearly) standard based intermediate switching in the access allowing, e.g., corporation to do local switching in an economic way for GSM. In addition, using WLAN and mobile IP, we have been able to demonstrate dual stack (GSM/WLAN) access to high speed data. With this infra in place, GSM voice access can be also moved to WLAN using IP telephony.

22 Network Connection Sharing among Collaborative Users in a Wireless Ad-Hoc Network

Maria Papadopouli, Henning Schulzrinne; Computer Science Dept., Columbia University, New York, USA

In this talk, we present an overview of an architecture that enables resource sharing among users that wish to facilitate a common need or cooperate in order to increase their QoS, their data availability and possibly have financial benefits. The resources we consider are network connections to the WAN or the content of the user's local cache. We focus on the network connection sharing in the second half of the talk. Dual homed hosts that can simultaneously participate in a wireless LAN with other members of the collaborative group and also have access over the global network via a wireless WAN connection, share their wireless WAN connection with other hosts in the group by acting temporarily as gateways for them.
We present different scenarios that involve scalable (layered) multimedia data (streaming data) and we illustrate the advantages and motivations for this network connection sharing.
Specifically, we show.

- redundancy of common data (for collaborative applications as teleconfer-

encing, news on demand)

- utilization of idle connections
- increase of the QoS
- increase in the data availability
- gains through a bandwidth reusing or "co-op" mechanism (e.g. financial, e-cash, "rewards")

We discuss the main components of the system namely gateway announcement, discovery, gateway traffic monitoring and selection among the available gateways. In the end, we present a summary of simulation results to quantify the system performance and the load balancing characteristics among the gateways.
More information can be found at:
http://www.cs.columbia.edu/~maria