Rethinking Wireless Internet with Smart Media

Theo Kanter[1], Gerald Q. Maguire Jr.[2], Mark T. Smith[3]

[1] theo@it.kth.se, Ericsson Radio Systems AB, SE-16480, Stockholm, Sweden

[2] maguire@it.kth.se, Teleinformatics, Royal Institute of Technology, SE-164 40, Stockholm, Sweden

[3] msmith@hpl.hp.com, Hewlett- Packard Research Laboratories, Palo Alto, California, USA

***Abstract*—Third-generation mobile networks (3G) will support the end-to-end delivery of IP to wireless end-devices. The cost of this infrastructure and the moderate data-rates that can be expected have lead to proposals for a mixed 3G and wireless LAN (WLAN) approach. WLAN delivers much higher data-rates, currently up to 11 Mbps (IEEE 802.11b). Field trials with public WLAN extensions to Gigabit Ethernet networks show outdoor coverage of several hundred meters. Our previous work demonstrated smart delivery of multimedia involving agents running in the mobile, the access point, and the content provider. This allowed us to dynamically adapt both the application and network behavior (to each other) in order to meet the criteria for specific applications. In this paper, we extend this approach by adding service knowledge meta-data to the multimedia content (creating so-called Smart Media) to take advantage of the fact that for non real-time media content, which needs ample bandwidth to deliver, there does not need to be a coupling between transfer rate and playout rate. This approach enables the agent to further free resources for the delivery of streaming media to mobile users. In light of this approach, we propose novel network topologies with WLAN access using Smart Media Packets, for which we examine the minimal requirements for delivering the services.**

***Index terms*— smart, wireless, mobile, media**

I. Introduction

Third-generation mobile networks (3G) are planned to deliver end-to-end IP connectivity to mobile end-devices. Using IP-links over 3G access networks we will be able to deliver multimedia services, ranging from messaging and streaming, to interactive media. Studies have shown that data-rates will be moderate, and considering the high cost of deploying a 3G infrastructure, proposals have been made to combine 3G networks with so-called ‘hot-spots’ with wireless LAN access. Wireless LAN (WLAN) currently supports data rates up to 11 Mbps (IEEE 802.11b). In a recent field trial we extended a Gigabit Ethernet network with IEEE 802.11b WLAN access points, we measured outdoor coverage to several hundred meters at these data rates. It is possible to adapt the mode in which some applications operate based on where there are resources available, hence with relaxed requirements, we can often defer transfers until when (or where) communication conditions are more favorable. Therefore an operator might optimize delivery in the access network by exploiting traffic patterns to/from access points in order to transfer data as background traffic to connection-oriented applications. In a previous project we built a prototype for smart delivery of multimedia involving agents running in the mobile, the access point and the content provider [3]. The inherent asynchronous properties of some media allowed us to dynamically adapt the application and network behavior to each other in order to meet the criteria of specific applications. With this approach, we demonstrated that we could free additional network resources for new applications.

II. Problem Statement

We have been examining how we can extend our earlier work to build a Wireless Internet. Assuming that we can relax the requirements on the infrastructure even further: what are the optimal strategies from a cost/performance point of view in order to deliver the new services that are enabled by establishing IP-links between mobile devices and/or access points? Clearly, some services are not interactive and do not require end-to-end connectivity, other services are neither interactive nor real-time. In addition, we should further investigate possible means for applications (the agents) or *the content itself* to be clever about delivering the content.

III. Smart Media

In [1,2] we describe a service architecture, which allows applications to follow users, learning and adapting to the user’s communication context. A key feature of this service architecture is an eXtensible Service Protocol (XSP) that relies on meta-data describing the service capabilities and behavior of entities, such as mobile-devices, resources, or (potentially intelligent) virtual objects.

Similarly, we can add meta-data to content that is exchanged between such entities. Such an approach is taken in for instance MPEG7 where XML-formatted meta-data is used to scale and/or shape the play-out of media clips on terminals ranging from desktops with fixed Internet access to handheld devices with a low bit rate wireless access (e.g. GPRS). Even more importantly, adding meta-data to content enables agents in the service architecture network to adapt their behavior (to each other) in order to meet the criteria for specific applications. Our previous work demonstrated this smart delivery of multimedia utilizing agents running in the mobile, the access point, and the content provider [3].

We can extend this approach by creating Smart Media Packets by dividing the content into manageable chunks (the size of which is decided upon by the access network agent), to which user context and application related data is attached to the chunks as headers. This is tunneled on the application level by the agents, and reassembled at the other end. At each crossroads (places where we transfer from one network to another) there is an agent, which works as an application level router driven by the content of application & context header. Thus, agents running in routers can inspect the additional meta-data additional which is much like the additional information which has been used to be able to recognize a the start of video image frame - thus routers know that either they should pass the whole image frame or they if they don't have resources then they can eliminate all of the packets - since delivering only part of the image frame is not useful.

IV. Scenarios

Fig. 1 shows a network overview of possible scenarios, with a low bitrate GPRS macrocell for wide area coverage, which is complemented by high bitrate WLAN hotspots. An interesting feature is a mobile WLAN island (e.g., a taxi belong to a large fleet, equipped with a WLAN and storage capacity, to act as a mobile distribution point/proxy) that can be used by mobile users.

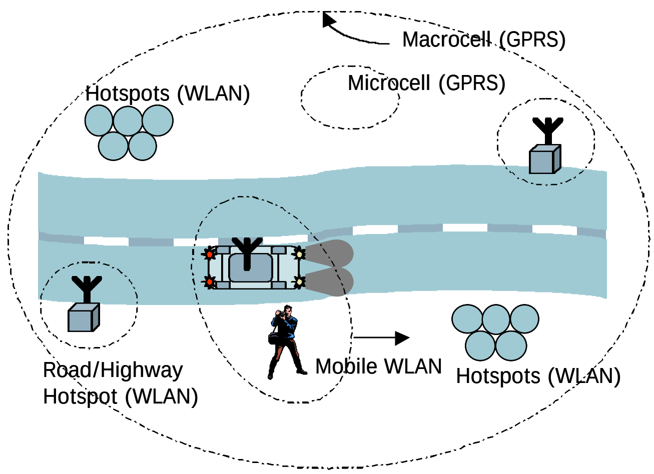

Fig. 1 Network Overview

The user's agents can apply their knowledge of the *user's communication* to select an appropriate distribution strategy – for example dividing a movie in smaller chunks and multicasting out these to available potential access agents. As person P passes through different access areas, he/she collects and sorts the chunks in the correct order in his/her end-device and is then able to play out the movie. Users can log bandwidth conditions and locations, and exchange this knowledge with access agents in order to plan transfers of content [7,8], such as MP3 clips, voice chat, or interactive voice.

The user's agent may also adapt to the user's *situation*, by sending non-linear media, e.g. keywords or key frames for later selection of whole sequences by the recipient [5]. In addition, when we record everything the user hears or sees, we can look for familiar patterns and relate these to a communication contexts and use these as cues for further optimization of communication behavior [6]. Even more importantly we can look for particular user situations, for new applications, such as augmented memory or mixed-reality presence. E.g., filtering out key frames a 3D model of the area that we have visited can be synthesized in which our actions are mapped on a virtual robot. Visitors, visiting the area equipped with a location aware mobile device, or virtual visitors connecting to the 3D model will be able to converse with our synthesized and logged alter-ego.

Furthermore, as our agent has recorded not only our perceptory data, but also our behavior, assisted by an active context memory [1], it is able to mimic us and in the future might act on our behalf even if we are not present.

V. Network Requirements

In this section we present data for WLAN access point density for common types of content transfer, starting with a detailed spreadsheet regarding MP3 play-out in a handheld device (assuming continuous user movement in one direction):

Antenna density to sustain MP3 playout						
Variable, constant	Unit					
Playout buffer	Mb	4	8	16	32	64
Playout rate MP3	kbps	16	16	16	16	16
Gross bandwidth	Mbps	11	11	11	11	11
Coverage diameter	m	200	200	200	200	200
Walking speed	m/s	1	1	1	1	1
Max distance 10/AP	m	450	700	1200	2200	4200
Max distance 100/AP	m	450	700	1200	1575	1575
Antenna density to sustain H.263 playout						
Playout rate H.263	kbps	20	20	20	20	20
Max distance 10/AP	m	400	600	1000	1800	3400
Max distance 100/AP	m	400	600	1000	1300	1300

Clearly, we can support a significant number of simultaneous users with high-quality audio (MP3) with large distances between antennas. The antenna density is largely proportional to the memory size in the device, leveling off beyond 16 Mb with as many as 100 users per access point to 1575 meters between access points. H.263 video with a relatively low-bitrate is slightly more demanding in bandwidth, but there is no dramatic decrease in the maximum distance between antennas. Handovers to GPRS can provide additional download of content to compensate via low-bitrate background traffic in the order of 10-20 kbps [3], resulting in even lower densities. In addition, if we could anonymously connect to vehicles belonging to a fleet of mobile WLAN-enabled caching servers in urban areas to deliver the content, then a five megabyte MP3 file divided into fifty 100K smart media chunks, can be forwarded to and between moving vehicles. At urban speeds, and an average of 3 hops, this file will be reassembled in its entirety at the recipients end in approximately half an hour. No routing mechanism is required, only a time-to-live attribute for the smart-media chunks, a garbage collection mechanism, and large disks.

For near-isochronous communication, such as wireless voice chat using a G723.1 speech coder, the bandwidth offered by GPRS background traffic in GSM systems is sufficient to deliver this low-bitrate voice,. However, the latency budget is used up by latency incurred in the GPRS air interface, which is in the order of 500 msec and time to set up per-packet packet paths, alternatively set up permanent ones and waste resources. Clearly, application awareness in the access network agent, enables us to optimize this behavior and minimize latency. On the other hand, wireless LAN is able to do fast handoffs, enabling us either use road/highway neighborhood hotspots as wireless extensions to fixed Gigabit networks.

VI. CONCLUSIONS

We have presented an approach to use application-aware meta-data to deliver services to mobile users, using mobile agents that use this data to negotiate the behavior of the applications or the resources. This approach enables a rich set of novel services. Furthermore, our approach enables us to rethink the requirements for a Wireless Internet.

Given the high transmission rate to low average playout rate ratio, this means that we should be dealing with delivery of objects which can be labeled - rather than blindly dealing with delivering synchronous bits. This also means that what the communication system is really trying to do is object multiplexing and not frame multiplexing - since the meaningful delivery is object and not frames. It further implies that the bursty nature of computer based communication can be exploited rather than viewed as an impediment to constant bit rate delivery of bits.

Our conclusions are that for asynchronous multimedia, instantaneous high-bitrate access enables a mobile to receive and transmit a large amount of data during the time when they pass through a hot-spot, hence this high bitrate is more important than total coverage. Smart Media support modeled as application-aware agents in the end-devices and network, with the additional information regarding content along with the user's context or communication are able to greatly reduce our requirements on the infrastructure, in terms of coverage. Our approach enables us to tailor the infrastructure to better user needs. In addition, [2] enables operators and service providers to data-mine the agents for such information, know how the services can operate, and build the infrastructure accordingly.

VII. FUTURE WORK

We are setting up a project to extend our prototype network that is based on IEEE 802.11b wireless LAN extensions to a Gigabit Ethernet in various locations of Stockholm with the mechanisms that were presented in this paper, in order to be able to further test. In this network we will provide SIP naming and localization for mobile agents, that will enable negotiation of communication as presented in this paper using XSP [2], resulting in the creation of personal, location- and network independent multimedia telepresence.

VIII. REFERENCES

1 T. Kanter, “Adaptive Personal Mobile Communication”, Licentiate Thesis, Teleinformatics, Royal Institute of Technology, March 2000.

2 T. Kanter, “An Extensible Service Protocol for Adaptive Personal Mobile Communication”, Submitted to the International Workshop on Smart Appliances and Wearable Computing (ISWAWC), April 2001.

3 T. Kanter, P. Lindtorp, C. Olrog, G. Maguire, "Smart Delivery of Multimedia Content for Wireless Applications", Proceeding of the 2nd International Workshop on Mobile and Wireless Communications Networks (MWCN'2000), May 2000.

4 L-E. Jonsson, M. Degermark, H. Hannu, K. Svanbro, “RObust Checksum-based header COmpression” (ROCCO), IETF Network Working Group Draft, September 1999.

5 Ignacio Más Ivars, "Universal Multimedia Access in MPEG-7", M.Sc. Thesis, Teleinformatics, Royal Institute of Technology, October. 1999

6 Joseph Mitola III, "Cognitive Radio: An Integrated Agent Architecture for Software Defined Radio, Doctoral Dissertation, Teleinformatics, Royal Institute of Technology, May 2000.

7 G. Liu, The Effectiveness of a Full-Mobility Architecture for Wireless Mobile Computing and Personal Communications, Doctoral Dissertation, Teleinformatics, Royal Institute of Technology (KTH), 1996.

8 D. Goodman, J. Borras, N. Mandayam, R.D. Yates, "INFOSTATIONS : A New System Model for Data and Messaging Services", Proceedings of IEEE VTC'97, vol. 2, pp. 969-973, May 1997.