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Broadcast/Multicast Services in Multi-Access Architectures

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***Abstract* — Mobile multimedia services exhibit challenging requirements in terms of asymmetry, interactivity, real-time, and multicast communication. A single access system can hardly ever serve all the different user needs, but a combined and co-ordinated system can. DRiVE has developed an architecture for a co-ordinated hybrid system providing multi-access connectivity [5]. OverDRiVE extends the architecture for provision of mobile broadcast/multicast services in a hierarchical network topology with different access technologies and mobility of entire networks [6]. The system supports efficiently mobile multicast services for large user groups by UMTS enhancements, multi-radio multicast mobility (including broadcast DVB-T networks) and a group management solution. This paper describes the OverDRiVE conclusions for providing mobile multicast services by hybrid systems.**

***Index Terms* — mobile broadcast, multi-access, interactive TV, MBMS, DVB-H.**

INTRODUCTION

Traditionally, broadcast systems provide users only with a unidirectional point-to-multipoint link, which is a limitation for interactive multimedia services. The broadcast operators and content providers get no feedback from the user and E2E interactive broadcast applications are not possible.

On the other hand, today's cellular systems have been optimized for mobile communication with only limited capabilities for simultaneous media delivery to large user groups. The mobile operators need broadcast capabilities for their emerging group messaging and mobile TV services.

Besides radio and television digital broadcasting systems like DVB-T are capable to support data push services, providing simultaneous access to real-time information as well as virtual interactivity between the end user and a cache in the user terminal. However, a return channel is required for real end-to-end interactive services and on-line charging of pay services. Hence the DVB-Project has concluded in their studies on the convergence of broadcasting and telecom platforms that the cooperation of broadcast and cellular systems gives additional benefit [1]. Recently DVB-H (H= Handheld [13]) has been proposed as extension of DVB to enable digital broadcast reception for mobile and battery powered devices.

Complementary 3GPP is currently standardizing Multimedia Broadcast and Multicast Services (MBMS) [2]. The overall ambition is to provide an efficient point-to-multipoint bearer in the core network and on the radio interface. MBMS offers a Multicast

and a broadcast mode. 3GPP MBMS will be standardized in 2004.

With the combination of broadcast and communication systems several services could be enabled, such as traffic information systems, sport clip distribution (e.g. subscription to football goal service) and mobile interactive TV (voting, gambling, betting on results, etc.).

The IST project DRiVE [3] has developed an architecture for a co-ordinated hybrid system providing multi-access connectivity. OverDRiVE [4] extended the architecture for provision of mobile multicast services in a hierarchical network topology with different access technologies combining the strength of cellular and broadcast systems. This paper describes the OverDRiVE conclusions for providing mobile multicast services by hybrid systems.

Scenario

In the context of this contribution, a multi-access system is considered. Multi-access is the capability to connect a terminal to several network attachment points of different technologies simultaneously for either obtaining access to the same application services or enabling a set of services by access combination. In addition each access system may provide further different application services. There can be simultaneous connections to different access systems, or connections to only one access system at a time. In a multi-access scenario

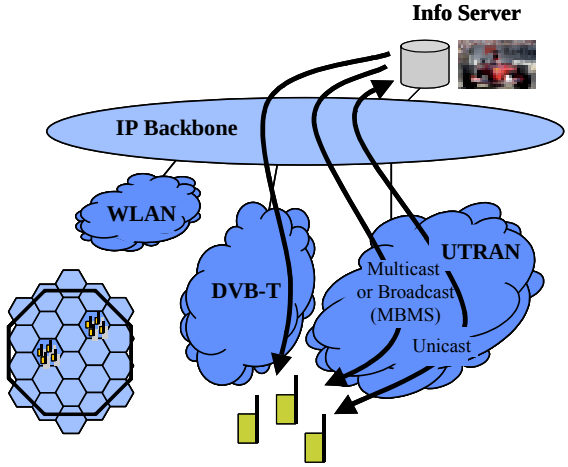

Fig. 1. OverDRiVE Scenario: The user experiences always-best connectivity for unicast and multicast services provided by a hybrid hierarchical network

the user could select the best access system to carry his multimedia traffic. The network could assist the user in this selection process, or alternatively it could select the best access system for the user. It is assumed, that at least one access system provides continuous connectivity to services in the infrastructure.

Multicast traffic is routed via different access systems based on the decision of a group and session management. The decision is dependent on the number of multicast-group members in a particular coverage area of a cell. If more members can be clustered in a larger cell, the group management triggers the shift of the users into the larger cell. An example is the replacing of several small WLAN cells by larger UMTS/DVB cells or the rerouting of traffic for large local groups from UMTS to DVB-T networks. On the other hand cellular networks can provide out of broadcast area services. The algorithms also depend on the terminal capabilities. Some terminals may be able to handle higher quality data streams than others. It seems to be natural to group the clients by their capabilities.

Besides the group and session management, complex problems of inter-system/vertical handover raise since there are some differences in the system characteristics, such as propagation loss behaviour, cell size and mobility pattern between cell layers. Additional challenges are also dictated when the handover occurs for an individual user or an entire sub-group of members within a multicast group. This will involve the identification of required functionality, appropriate handover initiation criteria, algorithm and control mechanism.

For an overview of mobile multicast techniques see [7].

Requirements

Many new mobile media services, such as sports clips distribution, mobile TV, and anytime anywhere city news call for an efficient support of large user groups. This requires the development of spectrum and network efficient mobile multicast techniques to be achieved by UMTS enhancements and a mobility solution for IP multicast flows in hybrid networks. Several objectives regarding multicast services in hybrid radio network

have been identified as following:

- Using mobile multicast group management to select the best multicast transmission path
- Enable Inter-system mobility for mobile Multicast users
- Enabling media delivery over lossy unidirectional channels
- Enabling multi-hop multicast forwarding to user groups, for example, in trains.

Architecture

An IPv6 based architecture enables interworking of cellular and broadcast networks and WLAN hotspots (figure 2). The backbone is access system independent, providing inter-system mobility and AAA services for roaming. Technically, the backbone is a pure IPv6 network.

To allow simultaneous delivery of multimedia services to large mobile user groups OverDRiVE investigated UTRAN enhancements for Multimedia Broadcast and Multicast Services (MBMS), proposing the introduction of OFDM and suggesting to switch from multiple dedicated channels to common radio resource (e.g. FACH) for about 7 (or more) simultaneous users of a multicast group in a cell, due to power control.

The different access systems possess different cell sizes resulting in a hierarchical coverage. Depending on the number of multicast-group members in a particular coverage area of a cell the group management selects the most appropriate access system or hierarchy level to route the multicast traffic. The moving network is formed within a vehicle as an IP-subnet. The size of a moving network may vary, from a few user nodes in a passenger car to several hundred in a train.

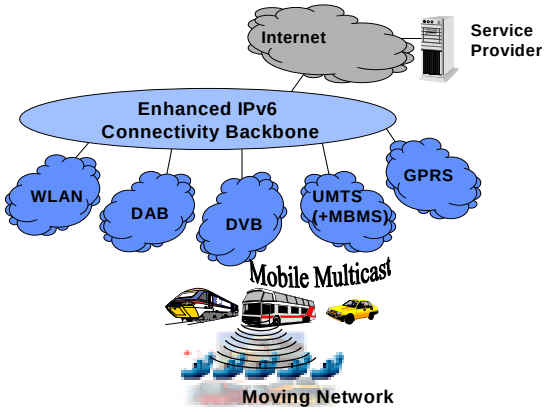

Fig. 2. OverDRiVE Architecture

Group Management

The multicast traffic is distributed over a hybrid hierarchical network. To make efficient use of the resources a group management is introduced that

- Decides whether point-to-point (ptp) or point-to many (ptm) transmission schemes are used for UTRAN, because ptm transmission reduce the cell capacity.
- Selects the most appropriate hierarchy level for the required coverage area.
- Groups according to terminal capabilities.

The group management has been implemented in a testbed and demonstrated for messaging and streaming services [16].

Seamless Mobility for Multicast Users

Two different approaches have been identified to support delivery of multicast traffic to mobile receivers, namely bi-directional tunneling (BT) and remote subscription (RS) [8]. BT hides the mobility of a mobile node from the multicast delivery tree and avoids frequent multicast tree reconstruction. However BT breaks the inherent multicast nature of radio bearers. In the RS approach at every handoff the mobile host should subscribe again to each active multicast session, at the new access point, resulting in temporary service interruption. On the other hand, it always keeps the optimal multicast nature of the connection. Based on these considerations we decided to use the RS method as the starting point of our research. We had to extend the RS method with a mobility triggered tree reconstruction mechanism and with a new module to achieve seamless handover support.

To enhance RS and to achieve seamless mobility for IPv6 multicast flows the project suggests to set-up a tunnel between the old and the new access point (AP) till the multicast tree has been reconstructed. The

mobile node monitors the link qualities of the neighbouring APs. If it detects an AP with better link quality, it informs the old AP to set-up a tunnel to the new AP. All multicast sessions that are received by the mobile host and are not supported yet at the new AP are temporarily forwarded over this tunnel. This mechanism has been implemented and validated in a prototype testbed [16].

Media Delivery over Unidirectional Channels

OverDRiVE supports several flexible multicast transmission technologies, depending on the type of multicast services to be provided. This includes real-time services such as audio and video streaming over IP, as well as datacast services requiring reliable delivery. Requirements of continuous and discontinuous multicast services have also been taken into account. We also introduced a hybrid multicast delivery scheme called Buffered Multicast, combining a multicast delivery scheme in the core with a unicast delivery scheme in the access network. The advantage of Buffered Multicast is its support of reliable delivery of multicast traffic onto an access network, without the introduction of network overhead in the specific case where the access network does not provide any support for IP multicast. [12] Additionally, value added services can be introduced, since at each access network the multicast content is locally buffered. Thus separate chunks of streaming content can be later re-sent on a on-demand basis (e.g. replay of important phases of a sport event). The local buffer potentially can be used to provide a cost-effective reliable multicast service.

To take full advantage of the point to multipoint capabilities of unidirectional channels (DVB-T [10], UMTS MBMS) the BTFTP (Broadcast Trivial File Transfer Protocol, [11]) unidirectional file transfer protocol was implemented and successfully tested. Both fixed and mobile reception were possible, involving the use of a DVB/UMTS equipped car. The DVB-T channel specially was used to effectively carry updated news (in HTML format), as well as IP streaming and traditional audio/video programs. The adopted solution scales well to simultaneously send in push mode updated contents to large number of customers, and the use of a FEC (forward error correction) scheme considerably improves the reception.

Moving Networks

Through the advancements in coordination and capacity of access networks the usage of these access systems for connecting not only single mobile hosts but complete moving networks to the Internet becomes very feasible. Examples of such networks are naturally vehicles (cars, trains, coaches, ships) that can provide in-vehicular communication infrastructure to allow built-in and mobile devices to communicate among themselves and with corresponding nodes in the Internet.

To provide mobile multicast services to moving networks a remote subscription at the Mobile Router (MR) with “MLD-based Multicast Forwarding” [9] inside the moving network has been selected.

This approach is well-suited for vehicular environment, because it is easy to implement, deploy and manage [14]. Especially, there is no need for a multicast routing protocol inside the moving network, MLD is sufficient. It preserves the multicast nature of the traffic all along the routing path and allows optimal routing, even with nested moving networks (e.g. a PAN-equipped user roaming into a vehicle), thus optimizing network and radio resources. It is also fully compatible with the seamless mobile multicast mechanisms presented above. Finally, per-flow handovers are possible for mobile routers capable of connecting to

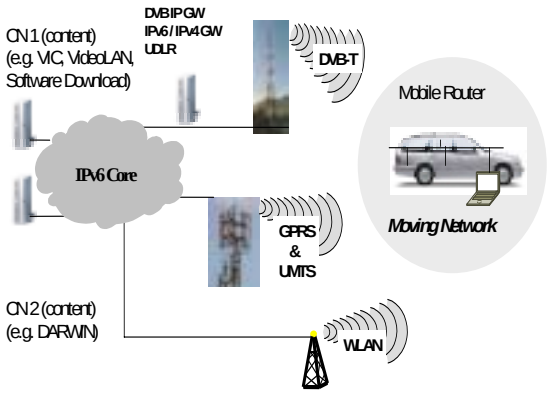

Fig. 3. OverDRiVE’s Multicast Multi-access Demonstrator [16]

heterogeneous access systems.

This solution has been implemented in a testbed using the LIVSIX open source IPv6 stack [15]. The demonstrator showed streaming over the access alternatives UMTS, GPRS, WLAN and DVB-T to the LIVSIX based mobile router in a car, to which the terminals can connect over WLAN or Bluetooth as second radio hop (fig. 3) [16].

Conclusion

Users demand for cost efficient provision of mobile multimedia services. OverDRiVE addresses resource efficiency by combining multiple access system in a co-ordinated hybrid system providing multi-access connectivity.

To support efficiently mobile multicast services for large user groups OverDRiVE employs UMTS enhancements (i.e. MBMS) and hybrid networks providing a coverage hierarchy (i.e. DVB-T, GPRS/UMTS and WLAN). The suggested UMTS enhancements increase the spectrum efficiency for mobile multicast services in cellular systems. The group management selects the most appropriate access system. The demonstrations proved seamless mobility for IP multicast services in a hybrid hierarchical network. The file delivery over lossy unidirectional links has been significantly improved by FEC. The results are currently being disseminated in the 3GPP MBMS and DVB-H standardization.

The presented integrated approach for resource sharing achieves a significant improvement for delivering uni- and multicast services in the targeted usage scenarios in terms of service quality, efficiency and cost.

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Paolo Casagranda graduated in Electronic Engineering from the Politecnico of Turin (1997), then he took a Master Degree (1998) in Networking and Multimedia at COREP, Turin, with a thesis on the Two Layer Data Carousel DVB profile.

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Thorsten Lohmar received his diploma degree in electrical engineering from the University of Aachen (RWTH) in 1997. Beginning of 1998, he joined Ericsson Research in Germany and was working on various topics in the areas mobile communication systems such as Quality of Service, Hybrid networking and integrating WLAN into cellular environments. Currently, he is primarily focusing on mobile multicast and broadcast services and actively contributes to MBMS standardization in 3GPP.

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Ralf Tönjes read communication engineering at the University of Hannover and biomedical engineering at the University of Strathclyde in Glasgow. He graduated with a Dipl.-Ing. degree in 1989 and a Master degree (MPhil) in 1990, respectively. In 1998 he received his PhD in electrical engineering from the University of Hannover. Between 1990 and 1998 he worked as a research engineer and teaching assistant at the Institute for Communication Engineering and Information Processing of the University Hannover. Since 1998 he is with Ericsson Research. He has been the responsible project manager for the IST projects DRiVE and OverDRiVE. He is an author and co-author of more than fourty scientific publications. His current research interests include wireless communication networks, moving networks and mobile broadcast.