Wireless Internet Architecture and Testbed for WINE GLASS

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Abstract: *One of the most challenging issues in the area of mobile communication is the deployment of IP-based wireless multimedia networks in public and business environments. The public branch may involve public mobile networks, like UMTS as 3G system, while the business branch introduces local radio access networks by means of W-LANs. Conventional mobile networks realise mobile specific functionality, e.g. mobility management or authentication and accounting, by implementing appropriate mechanisms in specific switching nodes (e.g. SGSN in GPRS). In order to exploit the full potential of IP networking solutions a replacement of these mechanisms by IP-based solutions might be appropriate. In addition current and innovative future services in mobile environments require at least soft-guaranteed, differentiated QoS. Therefore the WINE GLASS project investigates and implements enhanced IP-based techniques supporting mobility and QoS in a wireless Internet architecture. As a means to verify the applicability of the implemented solutions, location-aware services deploying both IP-mobility and QoS mechanisms will be implemented and demonstrated.*

I. Introduction

The increasing demand for innovative and flexible services using various media types in mobile environments is the key argument for adapting mobile communication systems to optimally support these most commonly packet-oriented services. The purpose of this paper is to present and explain the WINE GLASS approach of optimising a communication network with public and business wireless access networks for packet-oriented services. Three main aspects are covered by our approach: 1) Deployment of a packet-switching infrastructure to achieve connectivity between different access networks; 2) Enhancements of the public access network for packet transport; and 3) Utilisation of an adapted service platform to support innovative location-aware services. The problems that have to be solved within this context include among others: How to provide mobile specific mechanisms such as mobility management or appropriate authentication that solely base on packet-switching technology? Are existing approaches to the well-known problem of providing QoS in fixed packet-switching networks also applicable in mobile environments? Can the radio efficiency of wireless access networks be improved with respect to packet-oriented traffic? Which mechanisms do support a flexible creation and implementation of location-aware services?

The presentation of our approach to find answers to these questions is organised as follows: First the general architecture of WINE GLASS is described giving an overview of the investigated scenario. In section III. the deployed access networks and especially the emulation approach of the 3G access are presented. Section IV. deals with the aspects of the interconnecting IP infrastructure, while section V. examines the service platform enabling flexible creation of location-aware services. Finally the paper is concluded by a summarising description of the initial testbed and the expected results.

II. General Architecture

As one of the main objectives of WINE GLASS is to deploy the full potential of packet-switched networking as far as possible, the investigated architecture bases apart from the access networks solely on IP infrastructures. The scenario consists of two administrative domains potentially representing two

different operators connected by the public Internet. Each one of the administrative domains includes its own IP-based infrastructures either physically or virtually which are connected to different access networks, namely 3G UTRAN and a WLAN. Since one commonly accepted scenario assigns all fixed and mobile terminals a unique IP address and the usage of private address spaces potentially does not scale well IPv6 is deployed to overcome the scarceness of addresses.
With respect to the requirements to future mobile communication systems like UMTS the intra-domain infrastructures abstaining from any access specific network nodes like SGSN in UMTS R99 need to provide all required functionality regarding location management and authentication for mobile users and at least statistical QoS guarantees for non best-effort applications. Figure 1 presents an overview of the general architecture already depicting entities involved in the mechanisms for QoS provision (QoS Policy Server), mobility management (Home Agent (HA)), authentication (AAA-server) and service support (application server). Details on these entities will be provided by the forthcoming sections. In addition to architectural issues Figure 1 also shows different types of handovers between access networks and administrative domains that will be considered by the mobility management approach.

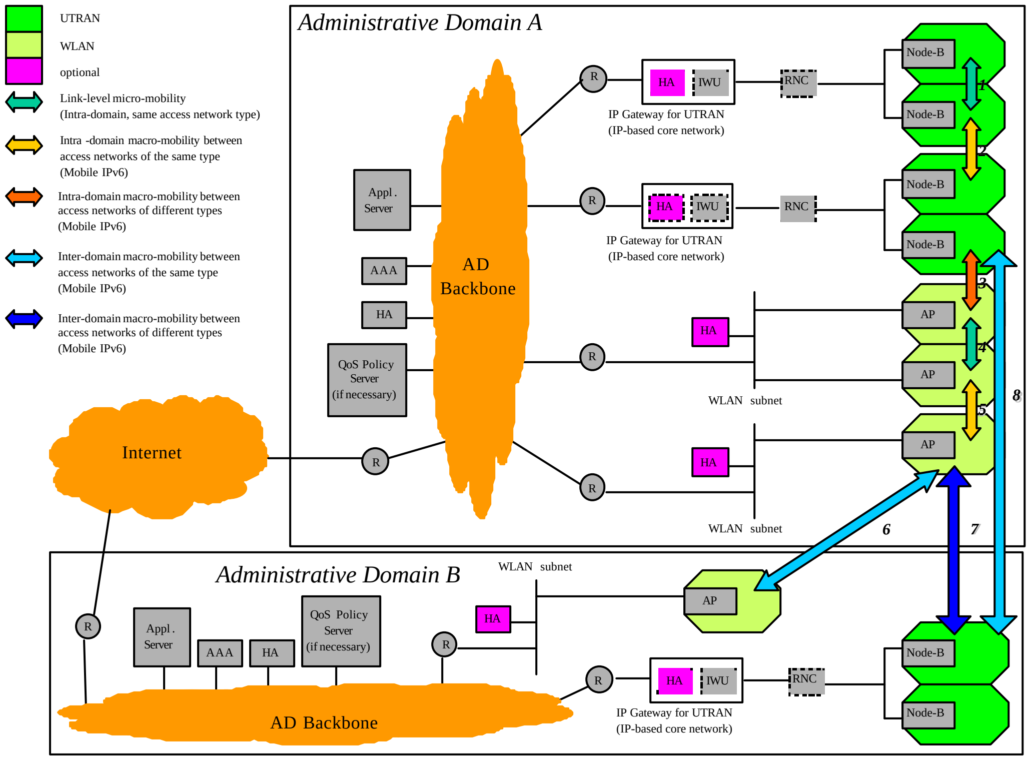

Figure 1 : WINE GLASS General Architecture

III. Access Networks

A conventional W-LAN access system will represent the business environment while due to the unavailability of UMTS equipment for the public 3G access an emulation approach of the UTRAN has been chosen. Central element of the emulation approach is the Real Time Emulator (RTE), which bases on an implementation used in ACTS-RAINBOW (see [1] for details). The objective of the RTE is to behave as a system from the viewpoint of the external entities that interact with it, in a given set of testing scenarios.
In particular, the UTRAN-RTE is based on the 3GPP UTRAN (FDD Mode) Architecture. The main focus of this emulator deals with packet transport capabilities of the UMTS Access Part; as well as with the interface between the UTRAN and the IP based 3G CN, that is, the Iu-ps interface.
According to the structure of the UTRAN radio interface protocol architecture, four main blocks must be taken into account to emulate the radio interface of the UTRAN:

- The Radio Channel Emulator devoted to provide the main transport capabilities of the physical layer. The development of this emulator will be based on a Hidden Markov Chain methodology.
- The MAC/RLC Emulator devoted to provide a reliable radio link in the air interface. The development of this emulator will be based in a SDT methodology.
- The Radio Resource Management Emulator acts as the controller and the manager of the available radio resources. In this block appropriate schedulers will be allocated in order to maximise the data throughput and to guarantee the QoS of the different user services.
- Packet Data Convergence Protocol performs the header compression and decompression of IP data streams at the transmitting and receiving entity, respectively. This layer also transfer of user data from the NAS (Non Access Stratum) and forwards it to the RLC layer and vice versa; as well as it multiplexes the different Radio Bearers onto the same RLC entity. The PDCP layer as well as the RLC provide data transport for the different traffic classes in transparent, unacknowledged and acknowledged mode. With respect to the QoS requirements of the services to be demonstrated in WINEGLASS, which are namely interactive services, background services and streaming, the acknowledged mode and the unacknowledged mode will be implemented.

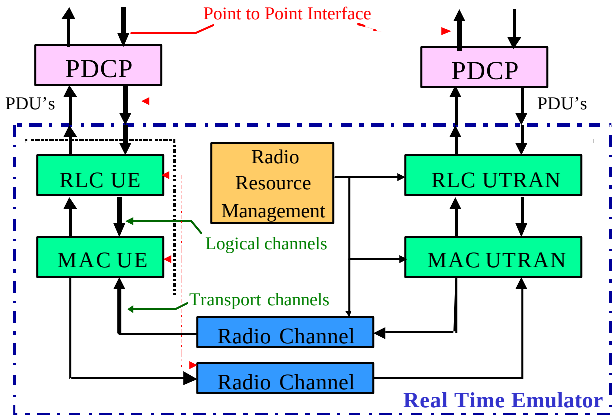

Figure 2 : RTE Overview

IV. IPv6 Infrastructure

The IPv6 network infrastructure consists of conventional IP routers connected by Ethernet or serial X.21 links. The separation into different administrative domains can be done either physically or by establishing Virtual Private Networks (VPNs). Regular routing protocols may run between the routers. The remainder of this section deals with IPv6-based mobility management, call control signalling and QoS management in separate subsections.

Mobility and Location Management

A Mobile-IPv6 based mechanism can theoretically be used to handle macro-mobility, i.e. mobility between administrative domains or access networks, and micro-mobility, i.e. mobility within one access network. The well-known limitations of Mobile-IP in handling fast handoff and the lack of other IP-based viable technology does not encourage to tackle micro-mobility at the IP level in WINE GLASS. Moreover, the deployed access networks already have their own support to handle mobility between access points; these access mechanisms are reliable and adapted to fast handoff. In the public context (UTRAN) of the WINE GLASS architecture, an handoff between different RNCs (SRNS Relocation), is considered as macro-mobility and will be handled with Mobile-IPv6.
Consequently the cases in which a mobile node moves in the same IP subnet with the same access router are handled by these networks (this includes movements 1 and 4 in Figure 1). We concentrate on movements that involve a change in the access router both in cases of horizontal handoffs (i.e. handoff between technologies of the same type, that means between two WLAN or UTRAN access points, as the movements 2 and 5 respectively in Figure 1) and of vertical handoffs (i.e.: handoff

between different technologies, which means between WLAN and UTRAN and vice versa as movement 3 in Figure 1). These horizontal and vertical handover scenarios will be considered both within the same administrative domain and between two different domains.

Mobile-IPv6 as it is now is not sufficient to satisfy all the requirements of the WINE GLASS architecture. One major issue to be overcome is the integration of Mobile-IPv6 and AAA to support inter-domain mobility including appropriate authentication. Related to this aspect the lack of the FA in MIPv6 raises several issues. In fact architectures proposed for IPv4 AAA, imply a single AAA server while AAA clients are positioned on FAs. In particular an important topic that deserves attention is where to place authorisation enforcement functionality in an Mobile-IPv6 framework and how to physically achieve authorisation enforcement. The solutions that can be foreseen imply that AAA functionality lays on particular IPv6 routers or reside on ad-hoc servers. Beside this, other critical issues refer to the determination of authorisation lifetime renewal together with address and key lifetime. In addition, in order to improve scalability and reliability, multiple AAA servers could be deployed within the same administrative domain. Apart from AAA-integration the utilisation of a Mobile-IP procedure for extra-UTRAN mobility management needs further attention. In Mobile IP handover procedures are mobile initiated, while from an operator point of view, the handoff procedure in public UMTS networks should be network-driven especially when Quality of Service and Policy rules have to be considered.

UTRAN IWF and NAS-Signalling

The WINE GLASS architecture abstains from the deployment of network nodes specific to access network functionality, such as SGSN or GGSN in UMTS R99 networks. The obvious benefit is the deployment of conventional and thus simpler routing or switching nodes in the core network. But this benefit comes at the expense of missing termination points for Non Access Stratum (NAS) signalling. An IWU (InterWorking Unit) is introduced in the WINE GLASS architecture to solve this problem. One IWU is associated to each RNC (can be co-located) so that interworking of the UTRAN access with the IP backbone can be achieved. Each RNC/IWU corresponds to a different IPv6 subnet and 1) relays IP datagrams from User Equipment (UE) attached to the RNC to the CN; 2) is involved in the AAA process for the UTRAN admission decision and 3) maps end-to-end QoS requirements to UTRAN QoS metrics.
As a consequence of the missing termination point NAS signalling as specified in UMTS R99 must be replaced by appropriate mechanisms. Apart from mobility management call control signalling for Circuit-Switched services and signalling to support packet services has to be provided. The support for packet services within UMTS refers to the activation, maintenance and deactivation of PDP contexts. Since all services including circuit-switched type service base on a packet-switching transport service (IP), terminals inherently activate something like “packet support” comparable to the GPRS PDP context during the attach-procedure to the network.
Regarding circuit-switched call control the removal of the CS-domain in WINE GLASS makes these procedures of the UMTS R99 Layer 3 signalling obsolete. As circuit-switched services will be realised using packet-switching transport, still call or session control at least in an end-to-end fashion is required. Voice over IP services are probably the most commonly known services that fall into the category of circuit-switched type services and therefore already existing call control solutions for fixed network Voice over IP services shall be re-used. There are mainly two well defined solutions: 1) The ITU H.323 series and 2) IETF’s Session Initiation Protocol (SIP). Due to the lightweight approach of SIP WINE GLASS will deploy SIP initially at least for end-to-end session and call control signalling, although the same functionality might also be provided by an H.323 solution. Figure 3 shows the testbed implementation of IWU and RTE on both terminal and CN side. As explained above, UMTS R99 NAS signalling is replaced by other mechanisms, but still mapping to RANAP procedures or more generally transport of NAS SDUs must be provided. Therefore the IWU provides one SAP for user and control plane NAS SDUs respectively. Initially NAS Direct transfer and Paging signalling will bypass the RTE, since the objective is to optimise for user-plane packet traffic. It is worth to mention that some sort of RANAP protocol is emulated in order to perform SRNS relocation. Due to

the relocation procedure two RNCs are emulated inside the same software block which is connected to two IWUs, such that the CN will see two access networks with different IP subnets.

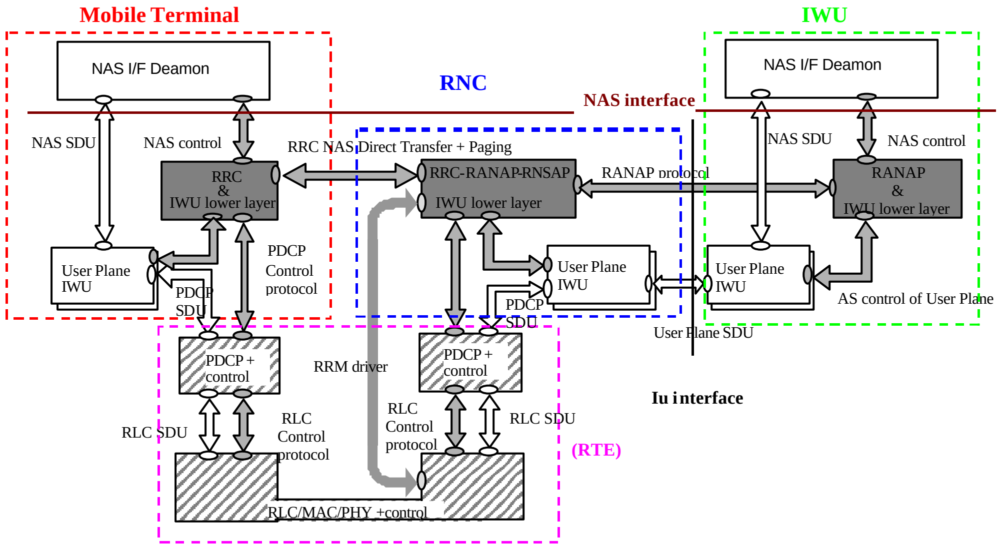

Figure 3 : Flows inside RTE and IWU

Concept for Adapted Service Support

The unpredictable varying nature of traffic to be carried by the WINE GLASS network makes appropriate support of different media types inevitable. Therefore at least the four QoS classes proposed for UMTS, namely conversational, streaming, interactive and background class will be supported. Apart from optimisations carried out on the radio stack (PDCP) also enhancements of the backbone network are required. In past decade many concepts for QoS support have been investigated. In case of the WINE GLASS architecture slightly different requirements compared to conventional fixed networks have to be taken into account. 1) Most importantly the backbone is not allowed to reject any new flow which has been previously accepted by the access networks. 2) For UTRAN access the backbone has precise a-priori knowledge of the characteristics of incoming traffic flows carried over dedicated radio channels. 3) For all access networks a bound on the incoming traffic is given by the maximum radio capacity.
The first requirement seems to make admission control in the backbone obsolete, but admission control algorithms can be used for QoS-routing in order to efficiently use network resources. We therefore follow the concept of MPLS for traffic engineering investigating the impact of these algorithms on path pre-computations. The latter two requirements can potentially simplify the task of network dimensioning, but traffic variations over short time scales as imposed by the mobile environment might lead to inefficient resource usage. Appropriate mechanisms to cope with deviations from the traffic specification due to source and radio channel variations will be studied.

V. Service Platform supporting Location Awareness

Today's creation and provision of new services that are not based on any WWW-technology requires time-consuming negotiations with network/service-providers and sometimes even more time consuming adaptations of the service-supporting platform. To allow flexible service creation and to decrease the "time-to-market" with respect to location-aware services a network should provide at least two mechanisms: 1) A procedure to be invoked by any user to retrieve its own position and 2) a procedure to broadcast unsolicited information within a well-defined geographic area. The WINE GLASS network provides all users/terminals with these procedures in a standardised way, but it should be noted that the availability of location information is assumed, i.e. no positioning methods will be investigated.

Let us assume that any network provider will only provide these two procedures for service support. The essential criteria for flexible and dynamic creation of services is how to offer new services to mobile customers and accordingly how to withdraw the offered services. A lookup service based on JINI technology is one viable solution to this problem, where service providers can register services to be offered and customers can search for services currently provided. By using JAVA/JINI it is inherently assured that customers can use offered services independently of their terminal equipment.

Generally the lookup service can be provided in a centralised manner, e.g. a central instance maintained by a single network/service provider provides this lookup service reachable under a well known address. Any instance (service provider or even single users) deciding to offer a service implemented in Java can register at this central lookup service and release an afore registered service. Alternatively, in absence of a central lookup service a user willing to provide a service in his adjacent area can spontaneously decide to establish a lookup service and to broadcast the according address to this area. This might involve an election procedure to select one out of several synchronously established lookups as well as a synchronisation procedure to align registry entries in multiple lookup services. There are certain application areas for both approaches: The centralised lookup also allows involvement of other centralised databases, e.g. customer profiles, and thus allows customisation of all services offered by a network. But in case of spontaneous services that shall be handled independently of service provider and location solely relying on a transport network, e.g. spontaneous chat during traffic queueing, the ad-hoc approach is the only feasible solution.

VI. Expected Results and Outlook

The envisaged demonstration testbed is capable to interconnect different wireless access networks that provide connectivity for mobile users. Different types of mobility can be demonstrated in order to verify the applicability of the Mobile-IPv6 based approach as solution for mobility management between different access networks taking into account AAA-constraints as well as QoS requirements. By means of the demonstration testbed on the one hand mobility performance as perceived by the user, e.g. interruption time of continuous sessions, and on the other hand end-to-end QoS potentially influenced by packet loss due to handover can be shown. Apart from QoS influenced by handover the grade of service provided by the adapted UTRAN packet radio transmission can be assessed by appropriate measurements which should result in an increase of radio efficiency and a decrease of the tail probability of the probability density function of UTRAN packet delay. The enhanced QoS mechanisms as deployed in the backbone for MPLS based traffic engineering should result in traffic load per link dimensioned according to required grade of service per flow aggregation, in appropriate routing of traffic paths and in a decrease of the call drop/rejection rate per traffic class. Significant differences to simple load balancing can be expected. The implemented testbed shall furthermore serve as transport platform for the investigated service platform and thus as a means to create and test innovative location-aware services. As key component of this platform the feasibility of the JINI-based lookup service will be proven.
In summary the technical issues covered by the WINE GLASS general architecture and implemented in the testbed include the most important packet-oriented mechanisms required for mobile communication in the near future. But there are also some issues beyond the scope of the project. Most importantly the support of real-time applications with hard QoS requirements needs further investigations. Furthermore, there is room for optimisation of signalling for mobility management QoS management and call control, where combinations or enhancements of Mobile-IPv6, SIP and RSVP can be discussed. And finally the service platform can only serve as basic enabler for future location-aware services. The creativity of each single customer can hopefully result in various services offered dynamically in any network.

References

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