DRiVE-ing to the Internet: Dynamic Radio for IP Services in Vehicular Environments

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Abstract

The European Union funded DRiVE project (Dynamic Radio for IP Services in Vehicular Environments) aims at enabling spectrum-efficient high-quality wireless IP communication in a heterogeneous multi-radio environment to deliver in-vehicle multimedia services. Key issues are spectrum efficiency and dynamic spectrum allocation within different radio networks, the IPv6 based network infrastructure with inter-working of cellular and broadcast radio networks, as well as adaptive services for the vehicular environment with a high degree of mobility. The paper gives a general overview of the DRiVE project and focuses on the network architecture for IP over multi-radio access networks and traffic control aspects within the emerging "DRiVE" network.

1. Introduction

The increasing demand for high-end multimedia services especially in the vehicular environment, driven by the car traffic density and the increasing amount of time spent within the vehicle, the cellular penetration and the growing adaptation to new technologies and data services represent challenging issues for mobile communication. Mobile multimedia services require high bandwidth, asymmetric, interactive, adaptive and location dependent communication facing the problems of cost efficiency and spectrum availability and the merge of distinct technologies for communication and broadcast services. The citizens' expectation for cost efficient provisioning of existing and emerging mobile multimedia services for information, education, training, and entertainment contrasts with the reality of scarce radio resources. This discrepancy is obvious for the delivery of high-quality services to highly mobile environments with cars, buses, and trains.

Within the European Union's 5th Framework IST (Information Society Technologies) Program a consortium of 15 leading companies from the telecom, media, automotive industry and R&D organizations have started a joint effort on spectrum-efficient high-quality wireless IP. The project called DRiVE (Dynamic Radio for IP Services in Vehicular Environments) is scheduled within a timeframe of two years, having started on 1st of April 2000.

The DRiVE project is coordinated by Ericsson and has BBC, Bertelsmann, Bosch, Daimler Chrysler, Nokia, Tecsi, Teracom, VCON and Vodafone together with leading European academic institutes as partners (also see [6]). It addresses the convergence of cellular and broadcast technologies to enable spectrum efficient high-quality wireless IP with the objective of delivering in-vehicle multimedia services. To achieve this objective the project investigates the co-operation of broadcast technologies like DVB-T and DAB (Digital Video Broadcast Terrestrial, Digital Audio Broadcast) and cellular systems like GSM, GPRS, and UMTS (Global System for Mobile Communication, General Packet Radio Service, Universal Mobile Telecommunication System) in a common frequency range with dynamic spectrum allocation. The work is in-line with the activities of international organizations like the UMTS forum [14] and the DVB project [7] addressing future system options.

The convergence of wireless/cellular networks and IP as basis for a broad range of communication services is the most challenging issue in the area of mobile communication. Mobility support for mobile nodes in IP networks is addressed by the Internet Engineering Task Force (IETF) working group "mobileip", proposing an extension to IPv4 (Mobile IP, cf. [13]) or an advanced mobility support within IPv6 (cf. [11]). These approaches address the so-called macro mobility within IP networks, i.e. a mobility between different IP networks. Each time the link layer connectivity is changed from one IP subnetwork to a different IP subnetwork, Mobile IP reconfigures the communication between a mobile node and other hosts using some specific IP network elements. To enhance IP mobility support for mobile nodes frequently changing their network connection within a larger area of an IP network (e.g. large local area network LAN or metropolitan area network MAN including several IP subnetworks and several wireless access points), the concept of Cellular IP was introduced (cf. [3], [4], [15]). Cellular IP provides handoff support for frequently moving hosts, thus supporting micro mobility within a larger IP network of the same administrational domain.

A homogeneous scenario of providing IP communication with mobility support over Bluetooth radio has been addressed in [1] or [2]. The DRiVE project broadens the scope of mobility issues by introducing an IP architecture operating across different radio access networks in a cooperative manner (e.g. asymmetrical data transmission using different radio links on upstream and downstream communication path).

The structure of the paper is as follows: Section 2 presents a general overview of the DRiVE project, its goals and the project structure in terms of workpackages. Section 3 has a focus on IP-related issues to realize the ideas of the DRiVE project. Section 4 depicts the registration and radio access system selection with an example. Section 5 concludes the paper and outlines future work.

2. DRiVE project overview

2.1. Project goals

The overall objective of the DRiVE project (Dynamic Radio for IP Services in Vehicular Environments) is to enable spectrum-efficient high-quality wireless IP in a heterogeneous multi-radio environment to deliver in-vehicle multimedia services enabling universally available access to information and support for education and entertainment.

To achieve these objectives the DRIVE project addresses the convergence of cellular and broadcast networks to lay the foundation for innovative IP-based multimedia services. Therefore, DRiVE addresses two key issues:

1. Inter-working of different radio systems (GSM, GPRS, UMTS, DAB, DVB-T) in a common frequency range with dynamic spectrum allocation.
2. Co-operation between network elements and applications in an adaptive manner.

These challenging objectives require research and development in the following areas:

- **Dynamic radio networks** (to increase the total spectrum efficiency and reach)
- **IP-infrastructure** (to ensure optimized inter-working of cellular and broadcast networks)
- **Ad-hoc configuration of services** for vehicular environments (to ease the creation of, deployment of, and access to personalized mobile services by a variety of radio networks)

Dynamic Radio for the provision of re-configurable systems: A major challenge with the provision of new mobile multimedia services is finding sufficient harmonized spectrum. In contrast to this harmonized vision, there is spectrum available at different frequencies depending on the region. The change from analogue to digital TV in many European countries within the next years will further contribute to this situation. Therefore, DRiVE focuses on methods for dynamic spectrum co-ordination. This requires methods for automatic spectrum selection, techniques for adaptation of sender and receiver to different frequencies, and investigations to assure the coexistence (with regard to interference and sensitivity) of different radio technologies. In a scenario of time and location dependent availability of spectrum one alternative to organize the dynamic spectrum allocation is to define a (logical) Common Co-ordination Channel (CCC). The vision is that any operator could work with any radio system on any band such providing re-configurable radio systems. The co-existence investigation will support regulators in defining fair spectrum sharing rules in Europe.

IP-infrastructure for the provision of high-end mobile multimedia: Scarce radio resources demand a spectrum-efficient implementation of mobile multimedia services. The selection and combination of different existing radio technologies (GSM, GPRS, UMTS, DAB, DVB-T) will depend on the number of users (uni-, multi-, broadcast), the required bandwidth for up- and down-link, security aspects, and type of application. The DRiVE project will develop an IP based mobile infrastructure that

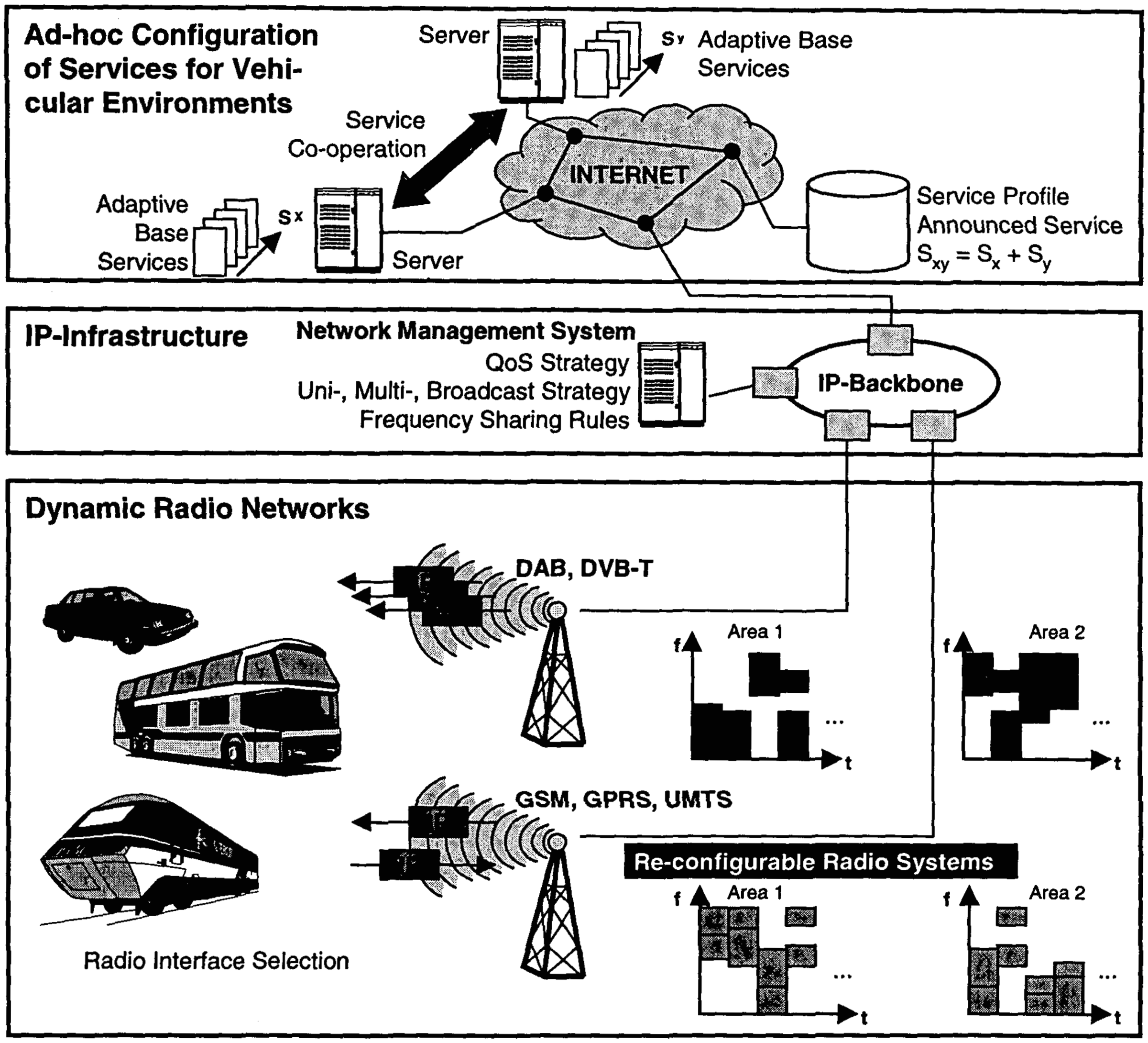


Figure 1: Overall architecture for multimedia service provision in a dynamic multi-radio environment

ensures optimized inter-working of cellular and broadcast networks on the IP level. The IP infrastructure will support profiles of different future mobile multimedia services, especially asymmetric communication for up- and downlink, uni-, multi-, broadcast, and interactive real time services (e.g. audio and video streaming). The different classes of the multimedia services will be managed according to a suitable quality of service model.

Ad-hoc service in vehicular environments: DRiVE tackles the provision of high-end mobile multimedia services over limited and varying radio resources by network elements and applications that co-operate in an adaptive manner. This requires scalable applications that can be distributed and downloaded to different physical entities to actively support the requested service. Furthermore, to make use of service co-operation and available multimedia conversion services, e.g. text-to-speech filters, a standardized interface is mandatory. The project will design and implement value-added services that will make use of standardized co-operation of base services. This will ease the rapid introduction and ad-hoc provisioning of new value added services from a set of base services by the content provider. The mobile user wishing to access a certain service will not have to care about the physical location or configuration of this service.

Figure 1 represents the three main building blocks addressed within the DRiVE project. Furthermore, it also identifies the areas addressed by the three workpackages of the project (WP1: Dynamic Radio Aspects; WP2: IP-

Infrastructure and Protocols; WP3: Services, Implementation and Trials).

2.2. State of the art and DRiVE advances

At present, strategies for handling interference between different radio systems typically assume a fixed allocation of frequency bands to operators and/or services, with sufficient guard band (Minimum Frequency Separation) between neighboring spectra, and a set of rules for spectrum usage (Frequency Sharing Rules) in cases where a common spectrum is used.

These strategies have some shortcomings, especially with respect to spectrum efficiency:

- Almost all radio systems face time-dependent load characteristics: A bandwidth reservation as close to the expected maximum load as possible will result in unused spectrum for long periods of time.
- Spectrum efficiency can be increased by choosing the optimum transmission technology for a given load scenario. As an example: Transmission via a DAB broadcast link should be preferred in a scenario where many mobile users are requesting the same data. Several point-to-point UMTS links would considerably waste bandwidth.
- Fixed allocated guard bands may be used by intelligent systems which, at least to some extent, are able to detect or predict interference (depending on the service).
- Existing systems cannot exchange information about their respective spectrum usage.

In the DRiVE project, concepts for a communication system with dynamic spectrum allocation will be developed and tested. Different radio bearers will dynamically share a common spectrum, allowing for reallocation of bandwidth according to a strategy based on factors such as load characteristics, interference condition, or provider policy decisions. In order to facilitate fair and efficient sharing of the available spectrum, DRiVE will examine the benefits of a Common Co-ordination Channel, which will serve as a means of co-ordination between different technologies. As a result, different service bearers will be provided with a dynamic, spatially and temporally flexible allocation of radio resources.

One of the main motivations for the development of IP version 6 (IPv6, [5]) was to restore the ability to provide a globally unique address to each device on the Internet and to permit the increasingly hierarchical addressing necessary as the Internet grows. IPv6 significantly increases the address space by increasing the address size from 32 bit in IPv4 to 128 bit. IPv6 also includes functionality to better support quality of service, IP mobility and multicast. However, many of the advantages of IPv6 have been made available also in IPv4 by means of protocol extensions.

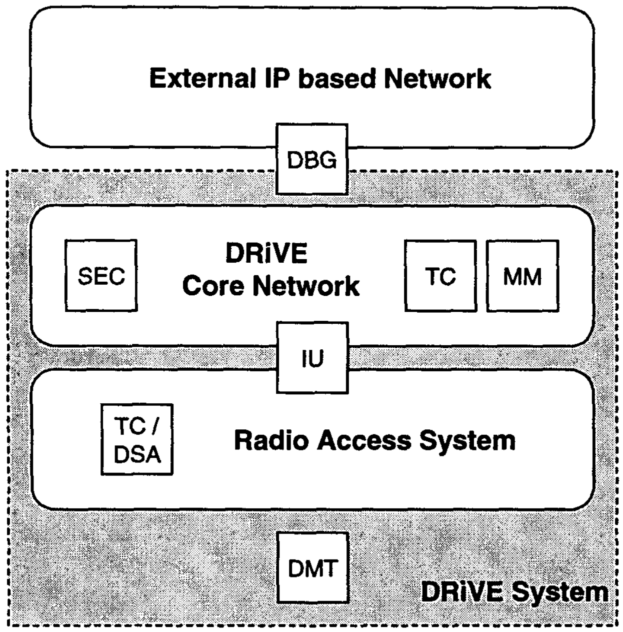
Within the DRiVE project, we study the role and behavior of IPv6 in a multi-radio environment. More specifically: We study which of the advanced features of IPv6 DRiVE can make use of and which features are missing. Since the migration from IPv4 to IPv6 will – if ever – happen on a rough path not completely known today, DRiVE has to ensure that the proposed IP based solution can also be applied to IPv4, i.e., a fallback solution must always be provided.

The envisioned dynamic multi-radio environment requires extensions of the addressing schemes and routing protocols used in the fixed Internet. IP packets have to be transmitted from and to vehicles, which are extremely mobile. The dynamic nature of this network is a major challenge to the routing itself and also on the update of the routing tables (from an IP perspective, changes in the spectrum allocation may result in start or end of sub-networks).

DRiVE will also specify a multi-radio traffic control unit which is aware of the currently available radio access networks and hence needs to interwork with the dynamic spectrum allocation. Also the integration of such a multi-radio traffic control unit into the network management platform situated in the network and in the vehicle needs to be specified. The proposed advanced multi-radio environment would not be acceptable in the marketplace without proper integration into the network management of operators.

The multimedia services of future mobile telecommunication and broadcast systems play a critical role in facilitating new and innovative mobility-aware services. The approach to ease the development of mobility-aware services has been to develop a middleware that hides the complexity of heterogeneous networks and operating systems from the service [12].

A user profile will support personalized services across different terminal platforms and different network technologies. The project will develop a set of "standardized" application programming interfaces (APIs), and promote them in the context of standardization activities, such as the MExE initiative (MExE – Mobile Station Application Execution Environment, [8], [9]). Moreover the project will provide QoS/cost-adaptive multimedia services that are optimized for vehicular environments and can be provided through a wide variety of radio systems. DRiVE focuses in particular on the creation of infotainment services for this kind of environments, while it looks to integrate innovative telematics services in its scenario rather than developing their own ones.



DBG	DRiVE Border Gateway
MM	Mobility Management
SEC	Security / Subscriber Management
IU	Interface Unit
DSA	Dynamic Spectrum Allocation
DMT	DRiVE Mobile Terminal
TC	Traffic Control

Figure 2: DRiVE functional network architecture

3. DRiVE IP infrastructure and protocols

The main goal of the workpackage WP2 (IP-infrastructure and protocols) of the DRiVE project is to design and specify the IP-based infrastructure for the transport protocols and services. The area of work includes issues of addressing, mobility and network management. Quality of service is also included.

The following subsections focus on first proposals for the IP-based network architecture and its functional elements and traffic control functions to determine the specific radio access network (in a multi-radio environment) to route IP traffic to and from mobile nodes considering Quality of Service requirements.

3.1. DRiVE network architecture

A basic approach in the DRiVE project is to reuse existing protocols concentrating on IETF activities. Thus, IPv6 and its associated protocols play a key role in the DRiVE network architecture. IPv6 offers several advantages compared to its predecessor, having a "cleaner" protocol design, integrated mobility support, security support and advantages in addressing.

Figure 2 presents an overview of some of the DRiVE system functions and their location within the DRiVE system reflecting the current state in the network architecture discussion. The network architecture comprises two major parts, the DRiVE core network part and the access system part. The term Radio Access System (RAS) refers to all network infrastructure native to a specific Radio access technology supported in DRiVE (GSM, GPRS, UMTS, DAB, DVB-T, WLAN). A RAS typically comprises a radio-link independent network (e.g. UMTS core network) with several radio technology dependent Radio Access Networks (RANs) attached.

The main task of the DRiVE core network is to provide DRiVE Mobile Terminals (DMT, mobile nodes in DRiVE terminology) a network infrastructure for accessing services which may be either located in external IP based networks, e.g. the Internet, or in the core network itself. In the latter case, bandwidth challenging real-time services hosted in the in the core network will benefit of the deployment of QoS techniques within the core network.

Within the core network, major parts of the Mobility Management (MM), Security/Subscriber Management (SEC) and Traffic Control (TC) system functions are hosted.

3.2. DRiVE core network

As a possible realization for MM in DRiVE, Mobile IPv6 is discussed. Using Mobile IPv6, the MM system function comprises a Home Agent service entity (HA_SE) implementing the functionality of a Mobile IPv6 Home Agent. However, for the need of DRiVE, plain Mobile IP may not be sufficient, as DRiVE will support the option of having different dataflows towards a DMT to be routed via different RASs. In addition to that, MM should support optimizations for seamless handover of a DMT between different RASs (inter-RAS handover). For RAS with no mobility support (e.g. DAB or DVB-T), the MM system function should guarantee efficient handover within the RAS (intra-RAS handover).

These enhancements, as well as part of Traffic Control functionality are considered to be located in the Service Support Node system entity (SSN_SE) (see section 3.4 for detailed information on Traffic Control). A SSN_SE is responsible for handling micro-mobility of DMTs connected to different RAS in roughly the same geographical region. Providing information about available RAS at the current position of a DMT and their properties the SSN_SE assists a DMT during the process of selecting the appropriate RAS for network access.

Authentication, Authorization and Accounting of DRiVE subscribers is a significant issue for the commercial deployment of the DRiVE system. As part of the security system function (SEC), authentication server system entities (AUTH_SE) are deployed in the core network for storing subscriber information and providing this information to other DRiVE system entities. In this early stage in the project, authentication and authorization will be considered only.

DRiVE Border gateways (DBG) connect the DRiVE core network to external (possibly IPv4 only) IP based networks (e.g. the Internet). As a DMT is not required to implement IPv4, the DBG will provide means for communication with external IPv4 only hosts.

3.3. Radio access systems

DRiVE address a large set of different RAS technologies which do not necessarily have to provide interfaces to IP based networks. Each access system should have access to the DRiVE core network by an Interface Unit (IU), providing a common level of abstraction of the individual RAS properties. As (possibly last) DRiVE aware IP router it has to exchange IP datagrams between the DRiVE core network and a DMT connected to a possibly IP unaware access system. Several IUs for the same type of access systems maintained by different operators are possible. Major parts of IU functionality are RAS specific. The objective of DRiVE is to support GSM/GPRS, UMTS, DAB and DVB-T as possible access systems and to specify IUs for each of them.

The DSA system function is in charge of distributing a given set of available radio resources (radio channels) to a set of radio transceivers of different access systems. Compared to fixed radio resource allocation, DSA should increase efficient usage of radio spectrum available to DRiVE. With DSA, radio channels can be assigned on-demand to radio access systems. Though DSA is the second major focus of the DRiVE project, many issues regarding interworking of TC and DSA nodes in DRiVE are still under discussion. In order to reduce complexity in the beginning of the project, traffic control and dynamic spectrum allocation are considered independently.

3.4. Traffic control within the DRiVE network

The DRiVE system comprises of various access systems that have different capabilities in terms of, for example, available bandwidth and coverage. Thus each access system is suitable to support a set of different services. A system may face some problems, such as degraded QoS, when it tries to support a service other than one of those it is able to satisfactorily provide.

The DRiVE system enables the integration of different access systems to support a broad mix of services. Based on the radio condition and the type of service, the DRiVE system is able to select the most appropriate platform to support user traffic. Thus, the overall spectrum efficiency can be increased.

Traffic Control is a key system functionality within the DRiVE system. It is responsible for coordinating the traffic distribution process and selecting the access system that can provide the requested service in the most efficient way.

The Traffic Control function has the following input:

- Terminal related information (such as terminal capabilities, location, and signal reception quality)
- User preferences (preferred access system, cost preferences)
- Traffic parameters (QoS requirements)
- Status of the network (load, available capacity)

Since most of this information (except network status) is available at the mobile node, it seems natural to let the mobile node select the access system which provides the service. However, it shall be ensured that the network status and interest is also taken into account in the traffic distribution process. One potential proposal to address this problem is sketched in Figure 3.

Using this approach, Traffic Control is decomposed into RAN Selection (RS), which is located in the mobile node, and functions in the network that assists the RS decision.

The RAN Selection function is responsible of selecting the RAN to be used. Key criteria for RAN selection is to satisfy the QoS requirement of the application. Other factors, e.g. cost of service, also need to be taken into account during RAN selection. The RS takes place at the start of a session and when a change in the network status or radio conditions occurs.

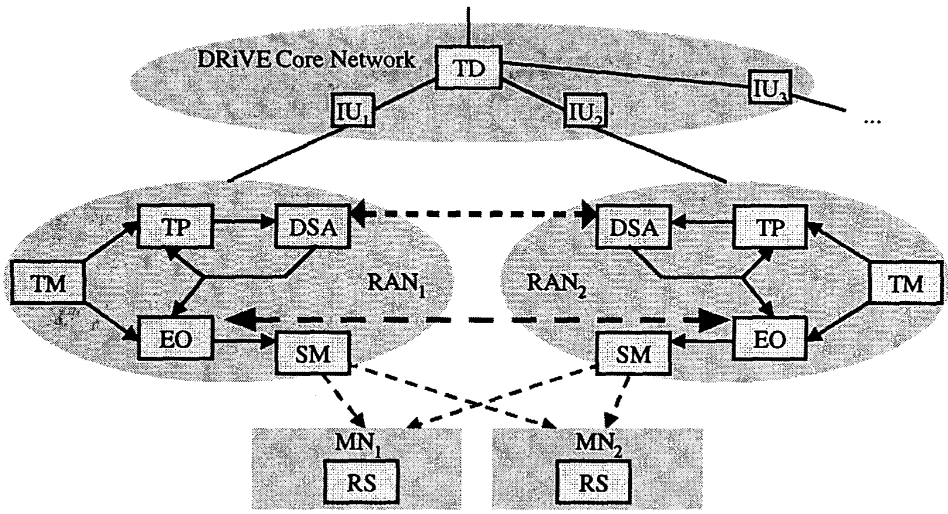


Figure 3: Functional Architecture for Traffic Control

The functions on the network side include Service Manager (SM), Efficiency Optimization unit (EO), Traffic Measurer (TM) and Traffic Predictor (TP).

The SM function is interfacing with the RS: it makes service offers based on the input received from EO. Service offers specify which services are actually supported in which quality and what is the cost associated with them. The major task of the SM is to map network status and efficiency to supported QoS parameter or costs for each service thus influencing the final RS decision.

The MN, i.e. the RS, decides which RAN (radio access network) should be used to route the user traffic. In addition the network, i.e. the EO (Efficiency Optimization) can influence the traffic load distribution between different RANs or cells. The EO evaluates the traffic load measured by TM in each cell and the information about available spectrum for each transceiver coming from DSA nodes.

TP provides traffic prediction for DSA based on a history constructed from the measured load received from the Traffic Measurer (TM). Using this information DSA tries to adapt to the needs of predicted traffic by requesting or releasing spectrum.

Three alternative methods exist to implement the RS decision on traffic routing. In the first alternative, the MN reacts to the RS decision by updating its mobility binding with Corresponding Nodes (CNs). All the datagrams originated from the same CN are routed via the selected access system or cell. However, the disadvantage is that datagrams of different sessions from the same CN can not be routed via different networks, even if those sessions may have different QoS requirements.

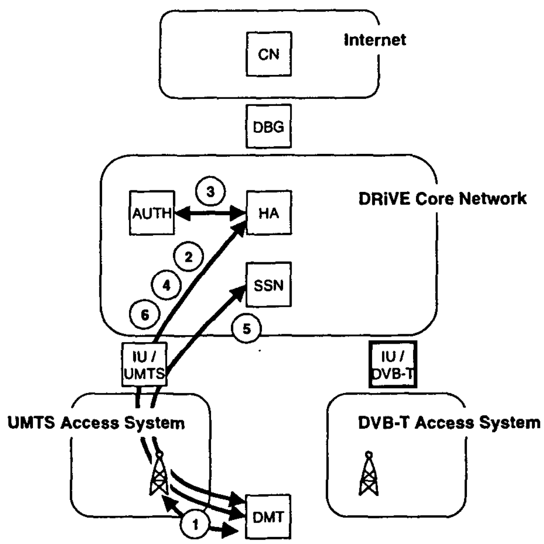
In the second alternative, the MN implements the RS decision by updating its mobility binding with the Home Agent (HA). All the traffic from HA will be routed via the selected access system. However, because HA only supports one primary care-of address, all the traffic from HA will be routed via one access network only.

In the last alternative, the MN requests a Traffic Distribution (TD) unit to route its traffic flows. MN registers its care-of address associated with TD into HA (or a CN) as its primary care-of address. All traffic from HA (or the above CN) towards the MN is routed via TD. MN requests RS to send its traffic distribution rules to TD. TD routes traffic to MN via different access networks according the rule defined by RS.

A MN may use any combination of the alternatives to distribute its traffic. For example, an MN may update its mobility binding with some CN nodes directly. At the same time, the MN can use the TD to distribute all the traffic flows coming from its HA.

4. Registration and RAS selection interaction example

To demonstrate radio access system selection in DRiVE, Figure 4 shows the interaction between the proposed system entities during the initial registration procedure of a DMT to the DRiVE system. This scenario assumes MM handled by Mobile IPv6. A DMT, equipped with UMTS and DVB-T radio technology connects to an UMTS network (1) and registers its current care-of-address in the UMTS access system at its HA_SE (2). For authentication and authorization of the DMT's request the HA_SE will be assisted by subscriber information obtained by its associated AUTH_SE (3). At this time, common network access for the DTM using its home address via the UMTS access system is possible.



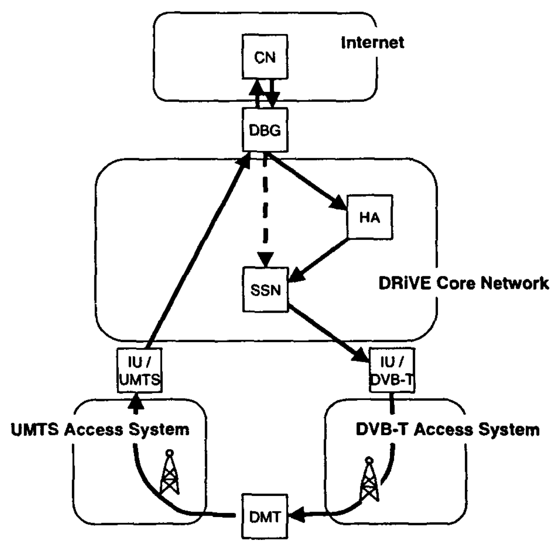


Figure 4 (left): Initial message exchange for requesting a broadband downlink connection

Figure 5 (right): Asymmetric data flow with narrow uplink and broadband downlink connection

Running a bandwidth consuming service, the DMT may regard its current downlink connection as not sufficient and requests a broadband downlink offered by a different access system. Based on location information, (e.g. cell information obtained from its currently connected RAS), the DMT requests the address of a nearby SSN_SE in charge for the RANs in the DMT's current geographical area (4).

Detailed information on available RAS (e.g. QoS properties, costs, current load) are available at the SSN_SE. Given that information, the TC system function on the DMT can select the RAS best suited for its needs. Having selected a RAS, the SSN_SE can be either instructed to forward all downstream traffic through the selected RAS or just a dedicated set of dataflows (5). After that, the DMT registers one of the SSN_SE's addresses as care-of-address for itself at its HA_SE to permit the SSN_SE to intercept DMT's downlink traffic (6). Any existing IPv6 binding cache mappings at correspondent nodes (CN) must be updated accordingly.

In the example given in Figure 5, the DMT has chosen an available DVB-T broadcast access system as a broadband downlink channel at its SSN_SE. Uplink communication towards a CN in an external network is still routed through the UMTS Access System. In case of support for binding caches at the CN, packets from the CN will be routed directly to the DMT's SSN_SE. Otherwise, packets will be intercepted by the HA_SE and tunneled to the SSN_SE.

5. Conclusions and further work

In this paper we presented a general overview of the goals and the challenges that are addressed within the DRiVE project. A detailed view on key issues concerning the IP infrastructure was discussed in the context of the general DRiVE network architecture. The challenge of providing IP services for mobile users over different radio access systems requires careful definition and positioning of key network elements within the overall architecture. The positioning depends on factors such as, signaling complexity and path length, network scalability, and operator scenario. The presented architecture follows the "Internet approach" and moves the TC complexity, i.e. the RS functionality, to the MN and leaves only the TD entity in the DRiVE core network. The RS selects the appropriate access system taking into account the users preferences, QoS requirements, the accessible RANs, and the costs. The TD routes the traffic through the selected RAN.

The presented approach assumes that the RAN operators own the spectrum. Each RAN possesses a DSA entity that negotiates with other RANs about spectrum. The DSA can be supported by the traffic measurements and traffic predictions. The operators employ a EO functionality to optimize the spectrum usage. The EO exploits the traffic measurements to increase the traffic load per used spectrum and encourages MN to move to other cells or RANs to increase the overall spectral efficiency.

The interworking of different radio systems imposes high demands on mobility with roaming and handoff between different RANs. In the presented work macro mobility is ensured by mobile IP and micro mobility by the RAN specific mobility management, e.g. cellular IP.

The ongoing work on the IPv6 based infrastructure includes the specification of mobility management and addressing multiple radio access networks as well as Quality of Service and network management issues. Furthermore ongoing work analyzes how the overall spectral efficiency can be improved by layered interworking and a better support for asymmetric communication services, especially in UMTS. Following approaches for asymmetric communication support are distinguished: Protocol optimization, multiplexing of multiple carriers in downlink (we assume that the downlink must provide higher throughput than the uplink), and additional RAN for downlink [10]. Further work within the project will address the issues of dynamic spectrum allocation DSA within the radio networks and the multimedia service configuration for vehicular environments (both not covered in detail within this paper).

The presented approach of a multi-radio infrastructure for optimized interworking of cellular and broadcast networks in a common frequency range with DSA opens new possibilities for wireless network operators: Operators can allocate spectrum for each service access network according to local and temporal needs. Users on the move are provided with the benefit of accessing enhanced IP based mobile services at anytime and wherever they are in a cost efficient way. Mobile devices will be able to select the optimal radio access for in-vehicle communication or broadcasting networks depending on time and location.

The presented concepts are discussed with cellular and broadcast operators, inside and outside of the DRiVE consortium. Cellular operators and especially UMTS operators will gain in that spectrum for mobile multimedia communication services can be allocated more dynamically. Thereby it is ensured that the success story of mobile communication is not stopped by a lack of suitable harmonized spectrum. In addition to that, in a co-operation with broadcast systems the mobile return channel can put additional load on the uplink of cellular networks, which is less loaded than the downlink in most asymmetric services Thereby revenues for cellular operators are increased. Broadcast operators will exploit the DRiVE concepts to offer interactive services. These interactive services are recognized as the value-added service for broadcast networks that will ensure profitability on the long run, especially if mobility is also taken into account in the broadcast system. The synergies of broadcast and new telecom industry will pave the way for future mobile multimedia systems.

The DRiVE project will demonstrate its key concepts and perform user trials to validate its concepts and technological advances.

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