ScaleNet – Converged Networks of the Future

ScaleNet – Konvergente Netze der Zukunft

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Summary This article provides an overview of ongoing research within the framework ScaleNet[1]. Considering IP as the basis transport scheme, the wireless and the wireline world have just started to move towards each other. ScaleNet is pushing this development by evolving a new system concept and by developing technologies[2] for Fixed & Mobile Convergence. ▸▸▸ **Zusammenfassung** Der folgende Beitrag präsentiert die aktuellen Arbeiten des Forschungsprojektes ScaleNet[1]. Der Einsatz von IP als gemeinsame Transportplattform sowohl für schnurlose als auch für drahtgebundene Kommunikation führt zu einer immer stärkeren Annäherung beider Welten. ScaleNet treibt diese Entwicklung voran und liefert ein neues Systemkonzept[2] für die Konvergenz von Festnetz und Mobilfunk.

KEYWORDS C.2 [Computer-Communication Networks] Fixed & Mobile Convergence, System Architecture, Ubiquitous Mobility, Overarching Network Functions

1 Introduction

The convergence of fixed and mobile networks is again a hot topic. The first discussion around Fixed & Mobile Convergence (FMC) in the late 1990s encountered technical, commercial and regulatory problems, which limited the availability of products. Nevertheless, many trials and a lot of press hype took place in the past. However, today's playing field looks quite different: We see massive use of IP for all types of communication, wide deployment of both mobile and fixed broadband networks, flat rates for data and voice services, and advances in terminal technology. Therefore major players in the market started to think about FMC solutions. Mobile operators have launched home offerings, trying to replace fixed phones and fixed Internet access. Wireline operators are offering converged services based on dual-mode terminals that can attach to both WLAN and cellular networks.

All these efforts are just a first step towards FMC for which the ScaleNet framework has been initiated in Germany [1]. Within ScaleNet, academia and industry jointly work from mid 2006 until autumn 2008 on the scaleable and converged multi-access operator's network from tomorrow, focusing on 2010 onwards.

ScaleNet is addressing both service and network convergence. The multi-play of services in ScaleNet embraces voice and video telephony, Mobile TV, massively multiplayer online gaming and Internet access.

[1] ScaleNet is partly sponsored by the German Ministry for Education and Research (Bundesministerium für Bildung und Forschung, BMBF) within the framework 'Network of Tomorrow'.

[2] This paper summarizes research undertaken by the ScaleNet consortium with complementary contributions from the different partners: Alcatel SEL AG, Deutsche Telekom AG, Ericsson GmbH, Fraunhofer Institut für Nachrichtentechnik Heinrich-Hertz-Institut, Lucent Technologies, QUALCOMM CDMA Technologies GmbH, Siemens AG, and Universität Karlsruhe, Institut für Telematik, together with a plurality of subscontractors.

Network convergence is seen as the migration of heterogeneous physical and logical network elements of fixed and mobile networks into one single (IP based) infrastructure.

Also other projects address network convergence, e. g., the IST projects Ambient Networks and Daidalos. The Ambient Networks project addresses amongst others the dynamic composition of networks owned by different operators, whereas the goal of the Daidalos project is a seamless, pervasive access to content and services via heterogeneous networks that support user preferences and context. Multi-access networks have also been addressed within the BMBF frameworks IPonAir (focus on hierarchical multi-access management), and COMCAR (focus on cooperation of broadcast and multicast network). In comparison with these projects, ScaleNet develops a Fixed & Mobile converged network architecture focusing on broadband access, aggregation and overarching network functions, meeting the requirements of both ETSI TISPAN NGN and 3GPP LTE-SAE.

The paper is structured as follows: Section 2 introduces the underlying ScaleNet architecture. Our view on FMC together with an architecture discussion is presented in Section 3. Support of ubiquitous mobility is addressed in Section 4 and Section 5 introduces overarching network functions.

2 High-Level ScaleNet Architecture

According to the goals of ScaleNet, a new integrated system architecture will be specified bringing together the wireless and the wireline world. Within this scope, two approaches for multi-access integration are of particular interest: One being 3GPP SAE and one being ETSI NGN (the later is in the following referred to as 'Unified Access Network Architecture'). Both offer specific multi-access integration solutions[3] for which ScaleNet currently considers none of them superior to the other. In fact, convergence of both approaches, SAE and NGN, is envisioned. Fig. 1 presents a high level overview picture of the ScaleNet architecture.

Enabled by ubiquitous mobility, users may move arbitrarily while being offered broadband network access at guaranteed Quality of Service (QoS). Last mile access is not restricted to any particular technique, neither in the wireless nor in the wireline domain. A particular characteristic of the ScaleNet architecture is inclusion of converged access and metro networks (also called Aggregation Networks)

[3] A detailed discussion and comparison of the two approaches is out of scope of this paper.

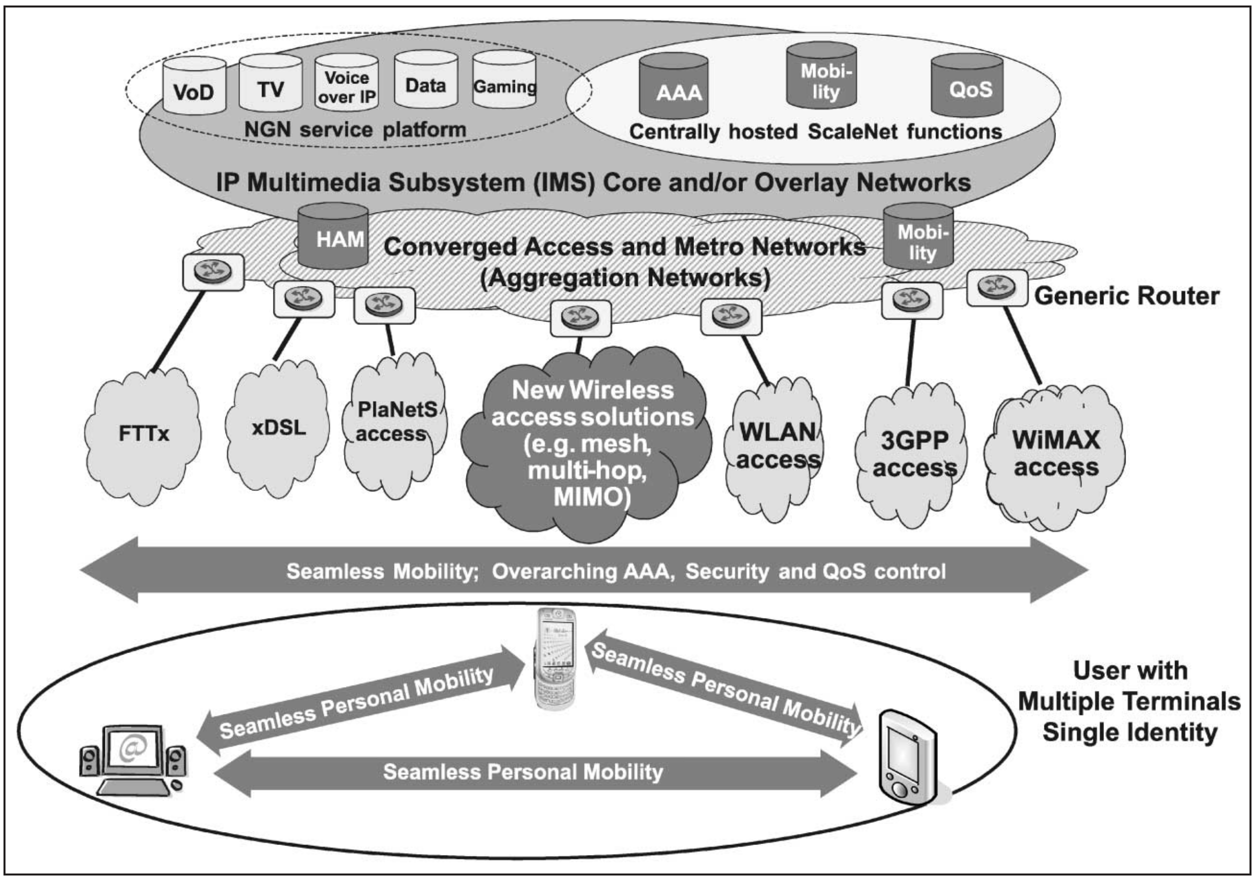

Figure 1 High Level ScaleNet Architecture.

that serve as connector between system specific last mile technologies and the IP Multimedia Subsystem core and overlay networks. Particular functions and entities herein (to be introduced in detail later on) care for unified IP-based transport of traffic. Different services are hosted on top, offered via an NGN service platform. For the delivery, the IP Multimedia Subsystem (IMS) will form the base in the ScaleNet context. It will be complemented by overlay networks that provide additional enhanced services. For the control plane, centrally hosted ScaleNet functions are foreseen to end up with an overarching system concept.

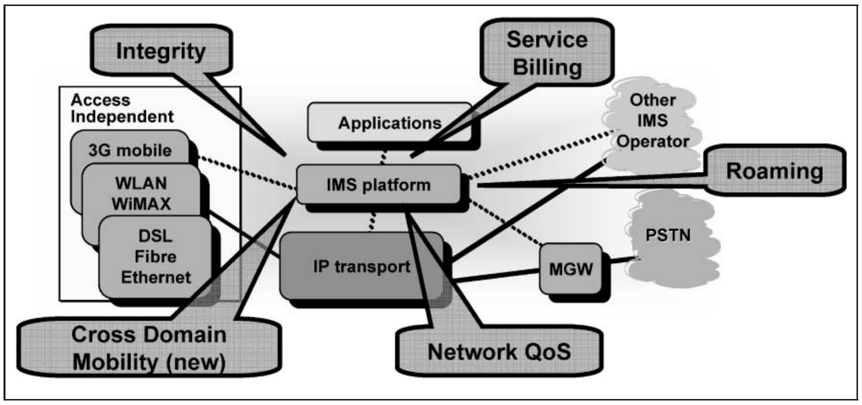

Figure 2 IP Multimedia Subsystem (3GPP/IMS).

3 Fixed & Mobile Convergence

The above-described system architecture integrates a plurality of access networks. Some of today's access networks (GSM, GPRS, UMTS, xDSL, HFC, …) provide individual end-user services like voice and messaging, others provide only IP connectivity. These legacy networks do not fulfil the requirement for user-centric broadband requests, however their existences have to be taken into account. In addition, service providers need to offer platform dedicated solutions, making the overall simultaneous introduction of multiple services expensive and risky. FMC as facilitated by ScaleNet allows for homogeneous delivery of service and network features via aggregation networks, independently of the access network, the network technology or the end-user terminal.

The present section copes with architecture questions being important for FMC within ScaleNet. The two considered standardization approaches (SAE, NGN) are shortly introduced. A complementing view on Multi-Stage Access Networks closes this architecture discussion.

3.1 IMS/TISPAN

3GPP/IMS defines a standardized multimedia architecture which provides the basic platform to introduce service and network convergence. Fig. 2 shows the overview concept of the FMC architecture distinguishing three planes: IP transport, IMS platform and Application plane.

IP transport provides the pure IP based packet transfer for QoS-managed services as well as for best-effort services. The IMS platform provides the control plane being responsible for, e. g., session establishment, roaming, security, QoS and billing. Network convergence on the control plane is given due to the access network independent design. The application plane allows the introduction of services commonly accessible across all access networks. Services only need to be developed once and are introduced via well defined reference points, e.g., within the home network of the user. Different end user devices are supported thanks to dedicated media adaptation.

Within the TISPAN (Telecommunication and Internet converged Services and Protocols for Advanced Networking) access network as shown in Fig. 3, NASS (Network Attachment Subsystem) is responsible for authentication, authorization and access management and RACS (Resource and Admission Control Subsystem) for QoS resource reservation, admission control and policy enforcement. The RACS assumes that police enforcement RCEF (Resource Control Enforcement Function) shall assure that the associated user traffic remains in accordance with the policy decision. A-RACF (Access Resource and Admission Control Function) is always located in the access network and supports the resource reservation methods,

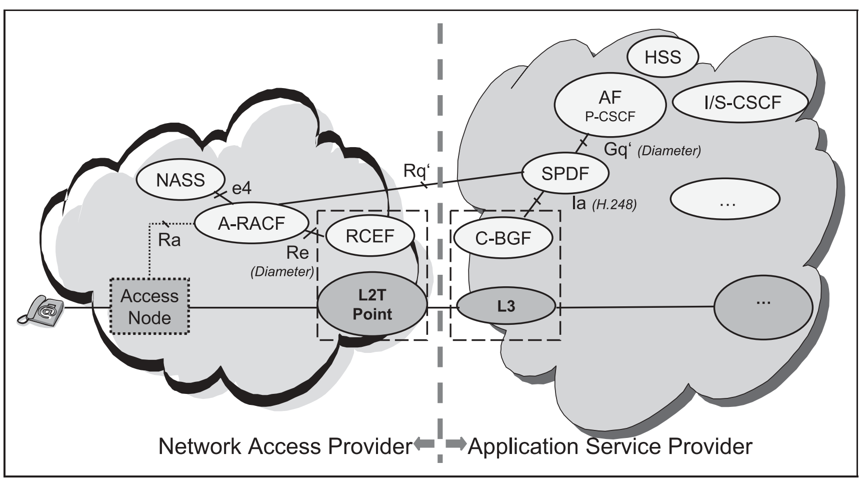

Figure 3 Reference Points in the TISPAN access network.

admission control and final policy decisions employed by the operator.

Different independent application service providers can request for QoS and resources using the Rq′ reference point, see Fig. 3.

3.2 System Architecture Evolution

An architecture that is of particular interest within ScaleNet is the one of 3GPP LTE/SAE (Long Term Evolution/System Architecture Evolution). Within this framework, the introduction of a new air interface and the evolution of the system architecture are discussed inside 3GPP. The logical high-level architecture is shown in Fig. 4. It is envisaged to support seamless terminal mobility between 3GPP access technologies (GSM, UTRA, EU-TRA) and towards non-3GPP access systems like WLAN (outside 3G operator control) via the 3GPP packet core/evolved packet core network. Moreover, enhancements on the Rx interface from the Policy and Charging Rules Function (PCRF) towards IMS are envisaged which is indicated by the '+' in the figure. The Rx+ combines the former Rx and Gq interfaces.

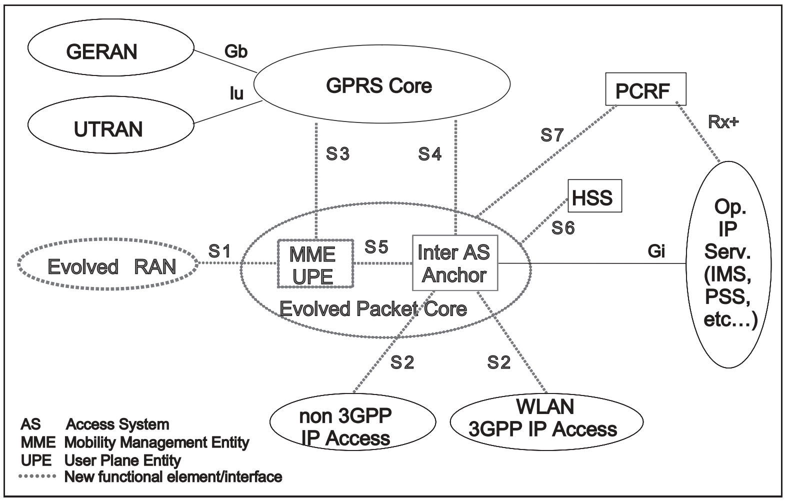

Figure 4 Logical high level architecture for the evolved system.

3.3 Unified Access Network Architecture

The second architecture to be considered by ScaleNet is inspired by ETSI NGN and goes beyond the 3G scenario. It integrates all available access technologies within a single, fully converged access network domain, see Fig. 5. Wireline and wireless access nodes are connected via a jointly managed, IP-based transport network with traffic-engineered routers or enhanced (Ethernet) switches. In a further stage, new elements like the 'Unified Router' (UR), a specific realization of the Generic Router in Fig. 1, will combine both technologies in just one single node with advanced packet routing and forwarding functionality. With this approach, every link – either wireline or wireless – will be equivalently treated as an IP hop

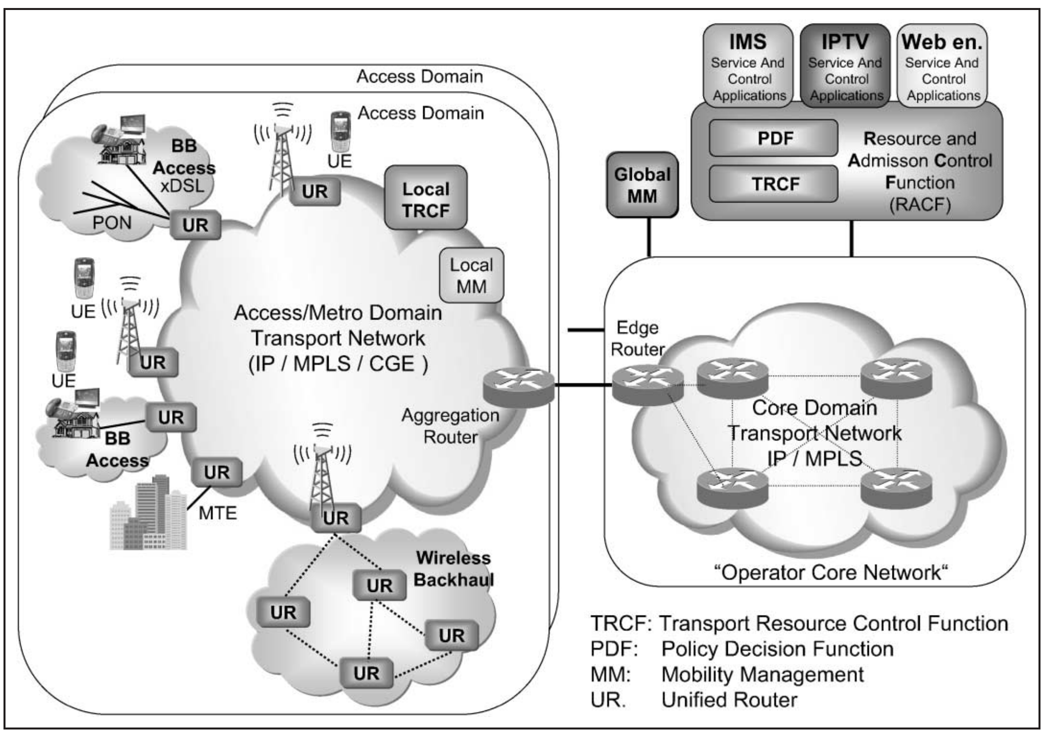

Figure 5 Unified Access Network Architecture.

associated with a generic link metric. This leads to a unified resource and mobility management. The selection of the optimum connection to be used is part of a routing algorithm that takes multiple paths within the converged access network domain into account. This can of course include QoS policy requirements set by the overall IMS service control function, but also micromobility (i. e., intra access network mobility), when handled by advanced routing protocols able to cope with the dynamic metrics of wireless links.

Previous projects like 'IPonAir' [2] already have indicated that the approach to integrate most UMTS Radio Access Network functions on one single platform is technically feasible. Nowadays, the Base Station Router [3] is the pre-stage device of the proposed UR and it is still able to support legacy handsets (UMTS Rel-99, UMTS Rel-5 etc.) with full QoS and mobility management.

Regarding terminals, it is expected that a ScaleNet enabled terminal will have different network interfaces available. Such terminals are studied in a complementing research project 'MxMobile' [4].

3.4 Multi-Stage Access Networks

Wireless radio access systems become increasingly important for fast Internet access. Besides cellular networks, more and more hot spots are installed as public Local Area Network (LAN) while mobile operators are addressing home extensions by wireless Digital Subscriber Line (DSL) solutions. This trend is accompanied by a continuously increasing bandwidth demand. Already in 2005, it was shown that radio access systems are able to support more than one Gigabit per second over the air [20]. But with increasing data rate, the supplied area of a radio cell decreases, which in turn necessitates an increase in the number of base stations. As each base station has to be connected to the backbone network, a strong demand for efficient and high data rate backhaul means arises. Due to high bandwidth requirements of accumulated transport traffic, fiber is commonly regarded as the most favourable medium. However, fiber deployment is not expected to achieve exhaustive coverage even on the long run.

On the other hand, demand for high bandwidth increases also in wired access systems. Here, the state-of-the-art access technology is DSL that suffers from similar coverage limitations for increasing data rates.

It is obvious that there is a gap between user demands and the existing technical and economic solutions. As fiber connections will not be broadly available in short- and mid-terms, an intelligent combination and concatenation of the wireless and wireline access and backhaul systems is required to overcome the individual reach limitations of these technologies in order to

- satisfy end users bandwidth demands,
- connect broadband RANs systems to the backbone,
- achieve full coverage with minimal transmit power,
- achieve full indoor and outdoor coverage, and
- enable fast and easy deployment based on the combination of wired and wireless forwarding systems.

The Multi-Stage Access Network working group within the Project ScaleNet aims for an optimum network architecture using multi-hop and mesh connections as shown in Fig. 6. Multi-hop and mesh net-

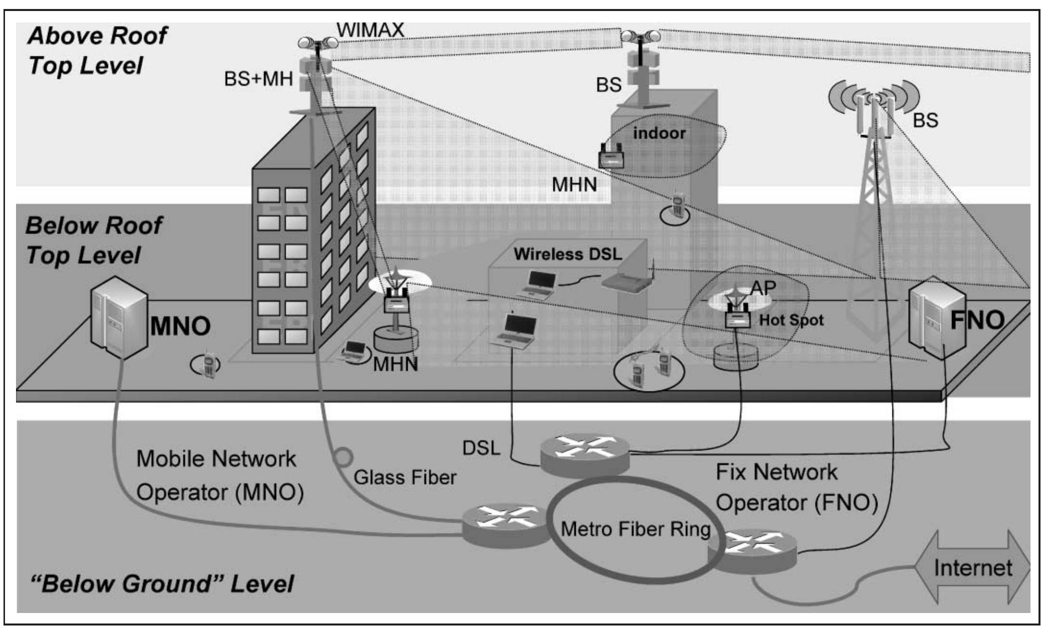

Figure 6 Multi-Stage Access Network within ScaleNet.

works have the potential to enhance the range, availability and capacity of broadband access networks cost-effectively. Furthermore, the working group will analyze which additional MAC or IP based mechanisms are needed to combine the stages of, e. g., multi-hop applied above and below roof top or relaying over more wireless hops and in which way radio systems equipped with multiple antennas can contribute to fill this gap.

4 Ubiquitous Mobility

Support of ubiquitous mobility across converged heterogeneous access systems is one of the most important functions of a future ScaleNet. Wireless access networks play the leading part for ubiquitous mobility because of their original mobile nature. In addition, they are essential to provide network connectivity for mobile end users on the move. Within this scope, mobility support is one of the most challenging requirements as there is no absolute guarantee for availability of wireless networks. Further, interoperability between different access systems has to be ensured to grant customers smooth and seamless service continuity.

4.1 Terminal Mobility

When talking about mobility, implicit considerations often relate to terminal mobility. Further types of mobility will be addressed in the next section, too.

Seamless IP Mobility Numerous real-time services offered recently by network operators and service providers like audio and video telephony, Mobile TV, etc. have completely changed requirements on Handover (HO) performance aiming at provisioning of seamless terminal mobility. The real-time property of these services results in considerably high impact of available network resources, packet loss and delay during HO on the service performance. Hence, establishment of seamless terminal mobility in ScaleNet is not limited to reduction of typical HO delay caused by rerouting of incoming data packets to be sent via the new network attachment point. Parameters of multimedia sessions must be adapted to the achievable level of QoS in order to exploit available network resources with the best possible service quality for end users.

How to decide whether and when to conduct a HO and to which network is an important question for scenarios with overlapping heterogeneous access networks. For policy-based mobility management, the decision algorithm is specified by policy rules considering user preferences, application QoS requirements, mobile terminal characteristics and available access networks. In ScaleNet, there are UE-centric decision features in the form of POLIMAND (Policy Based Mobile IP Handoff Decision) [5], and the network-centric decision features in the form of NAMM (Network Assisted Mobility Management) [6]. One ongoing work in ScaleNet is to use a policy-based Meta Control (MC) function to coordinate the decision making among several mobility decision engines, be they on the user equipments, in the radio access networks or in the core networks, aiming to achieve a reasonable and dynamic compromise between user autonomy and network control.

Vertical Handover ScaleNet is meant to support many different last mile technologies. This implies the disposition to switch the currently used (air) interface in order to maintain an active service. Vertical Handover (VHO) allows the end user to move freely between heterogeneous access networks whereby the previously mentioned seamlessness is a big challenge.

VHO becomes a special challenge in ScaleNet while providing real-time services for mobile customers. Data streams of real-time traffic are not self-adaptive to varying round trip packet delays and available network resources since UDP/RTP protocols that are generally used to transmit real-time data through the network, do not dispose of right mechanisms to accommodate data streams to the varying link conditions. Hence, VHO may end up in reduction of perceived QoS in case the new access network offers lower bandwidth or has larger transmission delays. It is hence to ensure that the network dynamically adapts to changes in order to prevent customer discontent caused by 'freezing' real-time streams. The followed approach is adaptation of the application, or its components, or the networking environment, or a combination of these. ScaleNet addresses this issue by means of the already discussed UE-centric POLIMAND and the network-centric NAMM.

In any case it is preferable to perform context-aware and proactive networking control. Such POLIMAND and NAMM may anticipate upcoming VHO decisions based on respective input information, also referred to as trigger. The probably best known trigger in today's (wireless) networks is indication of deteriorating link quality where signal strength is the base for (V)HO decision. Signal strength is used as handover trigger in well-known Mobile IP solutions, as well as in most link layer mobility approaches, e. g., mobility support in IEEE 802.11. Hence, a wireline-wireless VHO becomes a big challenge since the disconnection from wireline network is discrete and cannot be predicted that way.

Location based Mobility Besides physical measurements, location information is another valuable piece of context information (trigger) that is to be exploited to support system control in general, and terminal mobility in particular. Accordingly, ScaleNet applies location data for network management and mobility management in FMC networks. Knowing a terminal's current position and being able to anticipate its future whereabouts allows for the required proactive management. Expected benefits are given in terms of, e. g., decreased handover latency and increased Grade of Service.

Work conducted in ScaleNet comprises a two-step procedure. First, according to the spirit of converged networks, hybrid positioning techniques are evaluated to derive accurate location information. Then, dedicated means for further processing are derived including entities for (distributed) information storage or location proxies for fast and anonymous information requests. Location information subsequently needs to be explored and evaluated to derive subscriber's whereabouts in order to enable new services. Valuable trigger input can then be generated to be consumed by POLIMAND and NAMM. Further input can be derived to support heterogeneous access management (see Section 5.1 on Heterogeneous Access Management) as well as overarching mobility management.

4.2 Personal and Session Mobility

While Terminal Mobility as addressed in the previous section is related to physical movement of a mobile terminal, Personal Mobility [7; 8] focuses on the handover of a session across different user devices and different platforms. Session Mobility [8] comprises both mobility features.

One main focus of Personal Mobility is the usage of several end-user terminals either one after the other (serial) or in a parallel way. Transferring a session between these terminals that may be located in different networks is supported, but Personal Mobility does not cover terminals that are moving across network borders (Terminal Mobility). Accessing subscribed services at different terminals is possible due to personal identifiers.

Fig. 7 presents an exemplary Personal Mobility scenario, where a user who holds a session with UAS (User Agent Server) changes from a mobile terminal (UAC-A) to a fixed terminal (UAC-B). Another more complex scenario is to split up the session and to see the video stream on a high resolution screen device (laptop) and to hear the audio stream on a mobile phone. The latter scenario describes the parallel use of several terminals.

Session Mobility, see Fig. 8, is an umbrella term which includes Terminal and Personal Mobility. It is the ability of the mobile user to maintain active sessions while changing between terminal devices

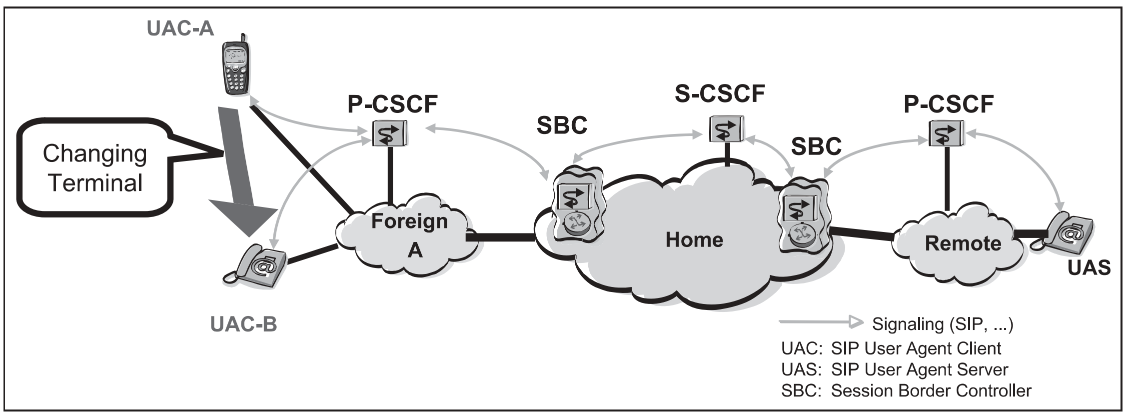

Figure 7 Personal Mobility.

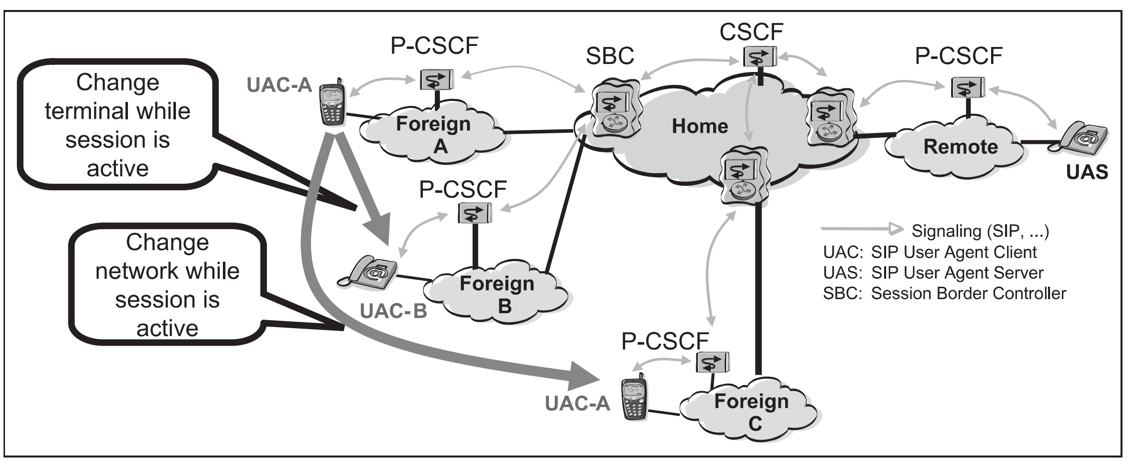

Figure 8 Session Mobility.

and moving across various access and core networks.

Within ScaleNet, dedicated means to support both, Personal and Session Mobility will be explored. One candidate approach to enable mobility across network boundaries is SIP (Session Initiation Protocol) based mobility which is characterized as application layer mobility. SIP based mobility hence shows the most attractive advantage due to mobility support independent of the underlying access network technology. This is fully in line with the requirements from the FMC perspective.

5 Overarching Network Functions

An integrated FMC approach according to ScaleNet needs to provide an overarching view. Real integration entails more potentials than just the accumulation of features from each single system. The following section picks out some of the overarching topics being served in the wide scope of ScaleNet.

5.1 Heterogeneous Access Management

The Heterogeneous Access Management (HAM) is one of the main ScaleNet control functions, which is needed for the IP optimised integration of heterogeneous access systems. The HAM hides the heterogeneity of the different access systems towards the mobile terminals as well as towards the network elements of the metro and core network domain. The Heterogeneous Access Management introduces Multi-Radio Resource Management (MRRM) in the terminal and access network controllers, which adapts to the underlying legacy radio access network functions. Moreover, the MRRM in a HAM server, interfacing with the above-mentioned MRRM components, provides two main services:

- **Neighbour-Cell Information Provisioning**: This service gives individual information about a terminal's possible *neighbour cells* to optimise the terminal's scanning for promising cells. For this, the HAM server maintains a neighbour data base, which contains static information like cell coordinates but also dynamic information like the current load situation for a service-aware optimisation of the neighbour cell list.
- **Access Selection**: The HAM server carries out an *access selection* to materialise the 'always best connection' vision. The access selection can be based on the QoS requirements of the service, user profile, terminal capabilities and status, policies, and resource availability in the different access systems.

In order to provide these two services, some auxiliary functions are needed

- **Capabilities Exchange**: The HAM server informs the network elements about its presence and its capabilities.
- **Cell/Access Registration**: Cells must register themselves with the HAM server to keep the neighbour data base up to date.
- **Update Cell Information**: Cells must report the current cell status to HAM server, e. g., update the cell load values, so that HAM server's access decisions and neighbour cell lists are based on the actual situation of the system.

The HAM functionality is closely related to the mobility management as it provides access selection decisions which trigger inter-access system handovers. It must be designed to interwork with existing and future mobility management mechanisms. Moreover, through an interface towards the session control, optimised service adaptation is supported. Heterogeneous Access Management can be implemented in a variety of architectures including centralised and distributed 3GPP based solutions as well as unified router approaches.

5.2 Overlay Networks

One of the goals of ScaleNet is to allow the rapid introduction of new services in a flexible and cost-saving way. Besides IMS based solutions, another promising approach to address these issues in ScaleNet is to use overlay networks. These are logical networks above the network layer that utilize their own routing mechanisms and addressing schemes independently of the network layer.

In ScaleNet, the typical applications for overlay networks will include: terminal mobility support [9], distributed storage services [10; 11], or the provisioning of group communication services [12; 13] that are not present on the network layer. Network applications like Massively Multiplayer Online Gaming (MMOG) traditionally use a client/server architecture. One major disadvantage of such an approach is the fact that all communication between two players is forwarded through the central server, thus making it a potential bottleneck. By using application layer multicast services, such an architecture can be replaced by a decentralized peer-to-peer approach, which will significantly reduce the operating costs and makes the system more scalable.

Although the use of overlay networks in the Internet has been widely studied in the last couple of years, the heterogeneous access networks and a high degree of terminal mobility, which are typical for ScaleNet, require further studies on how the existing overlay protocols will behave in a ScaleNet scenario. Most of the modern overlay networks used today (e. g., for file-sharing) are peer-to-peer systems, where only end-systems are part of the overlay. In ScaleNet however, there are additional dedicated overlay devices in the access and core networks. In our work, we analyze in which ways these devices can be used to optimize the overlay network. In order to make efficient use of these devices, we also have to adapt the overlay topology to the topology of the underlying network layer [14]. As the end-systems move between different access networks and thus change the topology of the underlay network, this adaptation process has to be triggered using cross-layer information from the HAM. In addition to the reduction of network traffic such a topology adaptation also leads to lower latencies between two arbitrary end-systems when communicating through the overlay network. This is especially important for real-time applications like video conferencing or the already mentioned MMOG.

Today, most applications that use overlay networks implement their own overlay network protocol. To minimize the costs of developing new applications in ScaleNet, the implementation of the overlay network has to be strictly separated from the applications. For this reason, in ScaleNet there is a generic interface between the applications and the overlay network, which enables us to reuse the same overlay network by different applications.

5.3 Quality-of-Service

In order to support use cases like 'Triple Play' (the possibility to share and play guaranteed quality voice and video with data) and 'Broadband everywhere' (provisioning of broadband services right to the border of the access networks) QoS support by the network is essential. For instance high volume downloads should not adversely affect high quality broadband voice/video connections. Authentication, Authorization, and Accounting (AAA) functions must be considered in the context of QoS provisioning, too, because otherwise every user may simply request services with highest QoS leading to no effective service quality distinction.

Providing an overarching QoS and AAA functionality for such a network is a challenging task, because we need to develop new mechanisms for handling the different technologies in terms of admission control, resource reservation and mobility. The IP-based abstraction helps hiding the underlying technology diversity. Moreover, there are obviously interactions between IP-layer QoS, QoS provided by the Heterogeneous Access Management at link layer level, and QoS requirements at the application level. Main functions of an overarching QoS control are admission control and management of resources. In order to provide QoS on demand, an appropriate signalling is required to request resources for QoS-based communication services.

One objective is to achieve a high state of integration of QoS and AAA in order to provide secure and seamless QoS-based communication even for mobile users. We also aim towards achieving robustness of the control mechanisms against failures and Denial-of-Service (DoS) attacks towards the control plane. Further goals are to provide a suitable functionality for different types of networks in order to support QoS guarantees end-to-end as well as charging in a secure and reliable manner, which justifies a tight coupling between QoS and AAA.

For QoS signalling and admission control, we currently concentrate mainly on two approaches, namely an IMS-based and an NSIS[4]-based solution for AAA and QoS control. For achieving FMC we consider anticipated handovers and authentication tokens for enabling the opportunity to keep the QoS, AAA credentials and respectively the session of a user unchanged during handovers. We investigate different possibilities for a tight coupling between the Diameter QoS [15] and QoS NSLP [16] applications to achieve a flexible, reliable and secure ScaleNet.

5.4 Charging and Accounting Services

The economic success of a network operator in the future does not only depend on his ability to provide attractive services to his customers in a heterogeneous environment but also on the capability to efficiently and correctly charge these customers.

For future scenarios it is important that mobile operators are able to swiftly and efficiently deploy new services, bundle existing services to new product offers that address their customers' needs, allow for an extended cost transparency for instance by means of a service-dependent advice of charge as well as change the employed charging and tariff models to gain a competitive advantage over their competitors.

All these aspects have to be supported by the charging system. To be both, scalable and efficient as it is aspired by the ScaleNet project, the charging system should be service-oriented, highly configurable based on policies, allow for an easy and secure interaction between different operators and providers as well as be convergent regarding online and offline charging functionality. The convergence feature must be introduced in a way that the additional requirements regarding real-timeliness that come along with online charging do not outweigh the gains by combining the two charging mechanisms.

Since certain aspects of the classical charging process are in nature not specific to the charging task, the charging approach that is further developed and refined in the ScaleNet project [17; 18] splits the classical charging architecture into two parts, one that takes care of the charging-specific areas, like rating and credit control and one that serves as a generic accounting infrastructure which is highly configurable and therefore can be used for different tasks beside charging such as intrusion detection. This accounting infrastructure comprising all network elements with accounting capabilities provides its accounting service via well-defined interfaces and employs protocols like

[4] NSIS = Next Steps In Signalling.

NSIS (Next Steps In Signalling) [19] for carrying the configuration information to the measurement points on the network elements thereby attaining a synchronisation of the accounting processes in the network.

6 Summary and Outlook

Future fixed and mobile networks that are being standardized in ETSI TISPAN and 3GPP LTE will have many common features. Both will be all-IP based and support broadband multimedia services. Both need new network functions to support mobility, QoS, security, AAAC and others. But fixed and mobile networks are also inherently different. The ScaleNet project has taken up the challenge to converge the future fixed and mobile networks to exploit the advantages of both, which nowadays is known as Fixed & Mobile Convergence.

The present paper provides a high-level view on ongoing research activities within ScaleNet, focussing on the scaleable and converged network of the multi-access operator of tomorrow.

Starting from a high-level architecture, related work with respect to FMC has been discussed. In this scope, particular interest is put on existing specifications from 3GPP SAE and ETSI NGN. However, instead of adopting one of these approaches, ScaleNet aims to propose its own concepts, including the vision of a converged architecture with Multi-Stage Access Networks. Besides architecture issues, ubiquitous mobility is a key feature of the future converged networks. Seamless vertical handover is one means to be applied, location based context information another to support Terminal Mobility. Moreover, Personal and Session Mobility based on SIP are considered as well. Since real integration entails more potentials than just the accumulation of features from single systems, overarching network functions have also been investigated in ScaleNet. Exemplary presentations on Heterogeneous Access Management, Overlay Networks, Quality of Service as well as Charging and Accounting Services are major overarching topics that are addressed within ScaleNet.

There are still a couple of other interesting fields to be explored including NGN services and broadband everywhere in ScaleNet. At the end of the project in 2008, development of a new system concept will be completed together with a prototypical implementation of an integrated demonstrator.

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