Trends in Multi Service Access

(Invited)

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The paper describes the evolution of the multi service offer in broadband access networks and the technical challenges to deliver the services in a cost effective way. It highlights some results and on-going research work in the European MUSE project on multi service access architectures and high bandwidth first mile solutions.

1. Introduction

The objective of the present paper is to discuss the trends in multi service access networks based on results and on-going work of MUSE (MUlti Service access Everywhere). MUSE is a large integrated research project of the European IST (Information Society and Technology) programme on broadband access that covers future access network architectures, access nodes, first mile solutions, residential gateways, and their end-to-end integration in lab trials (cf. Figure 1) [1][2]. The consortium gathers almost all major European vendors and operators, as well as some important research institutes in this field. A survey of the activities and achievements of the project hence provides a fairly good overview of the state-of-the-art and evolutions in broadband access. The paper thereby reflects on the motivation for chosen directions and on future challenges.

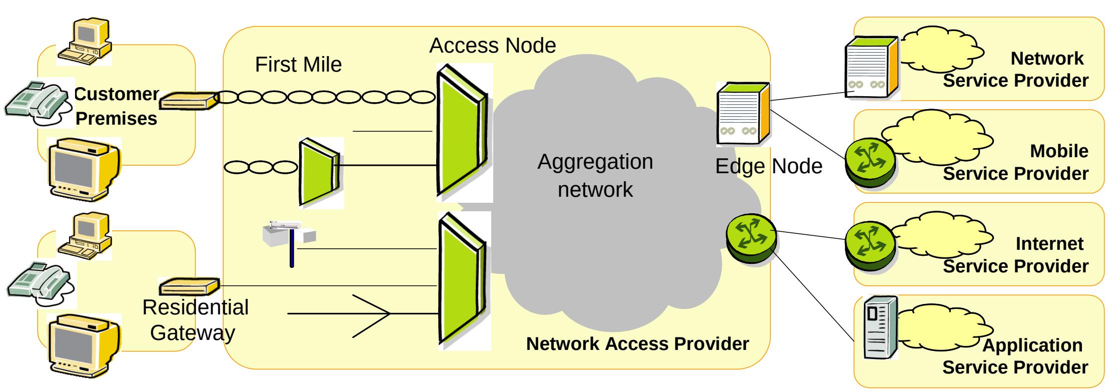

Figure 1: Multi Service Access Architecture.

2. From triple play to multi play

Today, a large part of the broadband subscribers in Europe is connected via an ATM (Asynchronous Transfer Mode) based ADSL (Asymmetric DSL) or DOCSIS based Cable modem. The offered bandwidth is a few Mbit/s for high speed Internet access services via a PC (Personal Computer).

With the erosion of the flat subscription fees for high speed Internet access, providers aim to offer new revenue generating services over the broadband infrastructure. Providers recently started with the deployment of a so-called triple play service offer, which delivers video, voice, and data over the same access technology. The business case for triple play is motivated by customer retention in a competitive environment, a price discount for the combined service package, and savings in capital and operational expenses due to the use of a single multi service access infrastructure for all services.

While the current triple play business model is a mere sum of the services, future triple play deployments will more and more exploit the combination of the three basic constituents to create new value added services. Instantiations for the combination of video and data are e.g. televoting and Internet access via a TV (TeleVision) terminal. Voice and data enable e.g. conference calls with a shared white board. Video and voice allow not only for videophone, but also for sharing experiences about a TV programme via a voice channel in overlay. A true triple play service simultaneously exploits all three constituents. AmigoTV is an example of a community TV solution developed in the IST MediaNet project [3]. It allows a group of people (e.g. friends, family) for sharing their experiences during a TV programme via emoticons, data, voice, and webcam images that are mixed in the video image with the regular TV programme.

The next wave of new services is expected to come from FMC (Fixed Mobile Convergence). The term FMC covers a wide range of services including nomadic services, session continuity, and continuous mobility. FMC is studied in various research projects (e.g. IST Ambient Networks [4]). MUSE is focussing on solutions and enhancements of the fixed access network to allow for FMC services. A first use case investigated by MUSE addresses nomadic services, such as nomadic pay TV and remote access to a server located in the network at home. A second use case of MUSE focuses on session continuity when a user moves his terminal from a WLAN (Wireless Local Area Network) at home to a UMTS (Universal Mobile Telecommunication System) or WiMax network during a video conference call. As a long-term variant of this use case, MUSE also investigates how to turn a WLAN at home into a public hot spot and how to support session continuity when hopping between such hot spots.

The research of the first phase of MUSE, which started in January 2004 and ended in February 2006, resulted in a multi service access architecture suited for triple play services at a low cost. The main challenge for the second phase, which started in January 2006 and runs until December 2007, is to prepare the network for the described trends of convergence of BB access and Multimedia services and for the convergence with mobile services (cf. Figure 2).

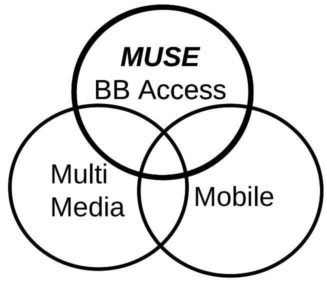

Figure 2: Convergence of broadband access, multimedia, and mobile technologies.

3. Trends in multi service access architecture

3.1 Evolution to Ethernet in the access

A trend observed at the start of MUSE was the emergence of Ethernet technologies in the access and edge network. Although ATM (Asynchronous Transfer Mode) was a well-suited technology for multi service networks, Ethernet promised to become a lower cost alternative. This was due to the efficient multiplexing capabilities of Metro Ethernet, an attractive price setting of optical Ethernet interfaces, the efficient reuse of know-how and components from the large LAN (Local Area Network) market, and the general acceptance of Ethernet in private networks allowing for easy interworking. In legacy networks, operators started to use Ethernet technologies in the aggregation network to upgrade the bandwidth capacity for video services, while carrying Ethernet over ATM on the installed ADSL (Asynchronous Digital Subscriber Line) based first mile. For new installations in the first mile, Ethernet became the choice for the link layer on high bandwidth solutions, such as VDSL2 (Very high bitrate DSL) and Optical access. The challenge for MUSE was to provide secure and scalable multi service capabilities in such an Ethernet based access network [2][5].

Solutions to shortcomings of Ethernet when used in an access network needed to be elaborated in MUSE. Ethernet was designed for a LAN with trusted users that belong to a same organisation. Ethernet does not enable for the authentication of users. Although the IEEE802.1P specification describes the use of priority bits, Ethernet does not provide guarantees for QoS (Quality of Service). The shared nature of Ethernet and the possibility to spoof Ethernet MAC (Medium Access Control) addresses represent unacceptable security threats when used in a public access network. Filters are needed in the access nodes to ensure address uniqueness. Intelligence is needed to prevent broadcasting of confidential data to other subscribers or competing service providers. Such broadcast messages are e.g. transmitted during the autoconfiguration with certain control protocols (e.g. PPPoE (Point-to-Point protocol over Ethernet, ARP (Address Resolution Protocol), or DHCP (Dynamic Host Configuration Protocol)).

3.2 Flexible support of different business models

MUSE had to consider different possible business models in the network architectural studies. Multiple providers will on one hand compete, but on the other hand join complementary expertises in alliances to offer the most attractive service package to the end-users. In addition to the roles of the network access provider, network service provider, and application service provider (which were already known from DSLF (Digitial Subscriber Line Forum) documents [6]), MUSE explicitly defined the new business roles of a packager and connectivity provider. The former packages the services from different providers as a single entity to the end-user, whilst the latter is responsible for the connection and QoS across networks owned by different providers. An actual player can combine one or more of these roles. A network access provider can offer IP connectivity services or applications directly to the end user (so called "IP retail model" and "application retail model") or offer his services to another provider (so called "wholesale model").

Each possible business model imposes specific requirements on the network architecture. MUSE described a reference architecture with the interfaces between the different possible players at data plane, control plane, and management plane. The business models influence the way that IP addresses are assigned. A dedicated activity describes the network and service management model for a multi-provider environment. An important challenge is also the configuration and management of services in a residential gateway by different entities.

3.3 Forwarding models for packet based access networks

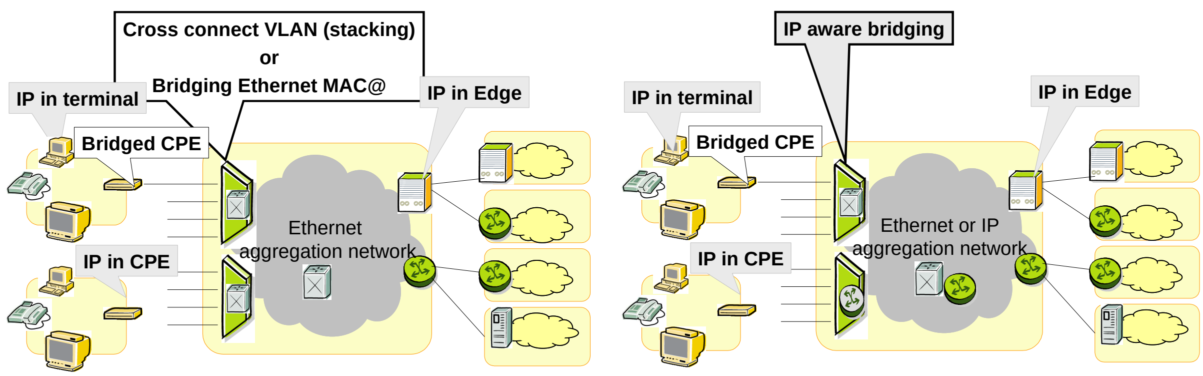

Figure 3: Model 1 - L2 forwarding (left) and Model 2 -L3 forwarding (right).

MUSE defined two forwarding models for the access network architecture to provide secure connectivity. Model 1 is based on L2 (Layer 2) Ethernet forwarding and Model 2 on L3 IP (Internet Protocol) forwarding (cf. Figure 3). In the Ethernet forwarding model, the access node is an (enhanced) Ethernet switch. The Ethernet forwarding can be done based on an Ethernet MAC (Medium Access Control) address, also called “intelligent bridging” or on a VLAN (Virtual LAN) per subscriber line, also called “cross-connect”. The “cross-connect” approach with VLANs is often proposed as solution for secure user segregation. VLAN stacking can be used to overcome to some extend the scalability limitation. As an alternative for L2 forwarding, MUSE demonstrated that intelligent bridging with Ethernet MAC addresses is possible in a secure and much more scalable fashion. This solutions was evaluated in lab trials at TNO and ACREO [7].

In the second model based on IP forwarding, the IP awareness and layer 3 functions are brought closer to the end-user by having access or aggregation nodes acting as layer 3 forwarders or routers in the aggregation network. These nodes completely terminate the layer 2 between the user side and the network side ports while the packets are forwarded between the ports based on the IP address. The IP forwarding model is an entirely new access architecture, which offers advantages with respect to the Ethernet model in terms of security, scalability, and QoS support [8][9]. This solution was on display at BB Europe [8] and is currently evaluated in the labs of T-Systems and Telefonica I+D [11]. An even more advanced approach is to move to a full router. Local peer-peer traffic can then be routed at the access node, which is more bandwidth efficient than via an edge node. The IP awareness in the access node allows for conventional IP based accounting tools to control the peer-peer traffic. Research was also dedicated to opportunities for IPv6 (IP version 6) in an access network, its coexistence with IPv4, and impacts on autoconfiguration [10].

3.4 QoS management in the access and aggregation network

Adequate QoS control is key in a multi service access network. Approaches that rely on an end-to-end QoS signalling per individual flow or connection have not been commercially successful because of their complexity (e.g. ATM, Intserv (Integrated Services)). Priority setting of traffic (e.g. Diffserv (Differentiated Services)) is acceptable in an over-dimensioned core network, but provides insufficient guarantees in the access and aggregation network. MUSE therefore elaborated a resource management architecture that simplifies the QoS control. It is based on pre-provisioned resources in the access network that are controlled by a NRC (Network Resource Controller) and is described in more detail in [12].

3.5 Autoconfiguration and authentication

MUSE studied auto-connectivity methods and per user authentication for the defined multi service architecture [5]. In addition to the conventional PPP (Point-to-Point Protocol) approach, alternative auto-connectivity methods and per user authentication were elaborated, based on DHCP (Dynamic Host Configuration Protocol) and IEEE802.1x. The use of non-PPP autoconfiguration enables the simultaneous support of sessions with different QoS requirements for one subscriber. It also relaxes the processing requirements for PPP on the dataplane by bringing the autoconfiguration protocols to the control plane. MUSE developed a single step approach in which the IP address is assigned simultaneously with the authentication, thereby simplifying the accounting, traceability, and troubleshooting.

3.6 Evolution to higher layer service enablers in the access

One can observe a trend of increasing higher layer awareness in the access nodes. The original ATM based DSLAM (DSL Access Multiplexer) provides a basic cross connect function. In order to support the described Ethernet forwarding architecture (model 1), an increased intelligence and session awareness were embedded in the access node. Layer 3 capabilities were introduced in the access node to support the IP forwarding architecture (model 2). With the continuously decreasing cost of processors and memory, an extrapolation towards even higher layer awareness in the access node becomes feasible.

The current research in MUSE investigates the possibilities of higher layer multi media service enablers in the access platform to provide value added services to the end user and the provider [13]. This can be the distribution of security functions, SBC (Session Border Controller) functions, capabilities to support QoE (Quality of Experience) monitoring, and features to improve the service performance. MUSE already demonstrated two examples of such embedded service enablers in a lab trial of the first phase: a TCP (Transport Control Protocol) accelerator and Time Shifted TV proxy were integrated in an access node [8].

3.7 Evolution to Fixed Mobile Convergence

Another on-going research track in MUSE is the preparation of a multi service access network for Fixed Mobile Convergence [14]. The challenges are to provide nomadic access to services from different locations or session continuity when moving a terminal from a home network to a public wireless network (cf. use cases in section 2). The business models of section 3.2 have to be extended with a mobile service provider and the notion of roaming. Nomadic services and session continuity entail new requirements for the authentication methods. In addition to the authentication per line, as done in today's access networks, authentication per user, per terminal, or per service is required. The policy frameworks for QoS of a fixed and a mobile network need to be aligned. Approaches to support mobility at the network layer (using Mobile IP) or at the application layer (using SIP (Session Initiation Protocol) are being studied and mapped on the access architecture.

4. Trends in the first Mile

Although technologies for high bandwidth transmission over various types of first mile media have been around for many years [15], MUSE maintains some research at the physical layer to explore longer-term innovations that may further reduce the investment or deployment cost [16]. This also includes a critical review of known concepts with respect to new architectural insights or the availability of new state-of-the-art components. MUSE studied solutions to get more bandwidth and quality out of the “copper resource” used by DSL. Considering the audience of the present conference, mainly some results and future activities on optical access are highlighted here.

4.1 Evolution of PON and PTP access solutions

While PON (Passive Optical Network) solutions have reached technical maturity in other IST projects [17], the research by MUSE on optical access focused on reducing the footprint of PTP (Point-To-Point) fibre architectures and a review of more advanced FTTx (Fibre To The x) architectures. A first approach was based on compact dual bi-directional transceivers that allow for a PTP optical access node with a density comparable to a conventional DSLAM [18]. A second approach reduced the size of the access node by an asymmetric PTP-PON approach [19].

Future research on optical access focuses on XL PON (eXtra Large PON). The target system features a reach of 100 km, a split of 512 optical network terminations, a shared downstream bitrate of 10 Gbit/s, and upstream of 2.5 Gbit/s. By using XL PON, the access nodes at local exchanges can be simplified to an optical splitting stage and an optical amplifier. The consolidation of network functions in a more centralized architecture promises operational cost savings. A SuperPON architecture was already investigated in earlier European research [20]. The lower cost of optical amplifiers and WDM components, as well as the improved performance of standard ITU-T GPON [17] suggest that the concept of a long reach high splitting PON should be revisited. MUSE has aligned its co-operation with the PIEMAN project for this research area [21].

4.2 Hybrid Fibre Radio and Hybrid Fibre DSL

MUSE also prototyped a new WIMAX over fibre solution [22]. As a specific innovation, the research addressed the transmission over MMF (Multi Mode Fibre).

It promises a possible low cost implementation for a short range access network with a transparent connection to a wireless home network. For distributing the microwave signals in a cost effective way, the so-called Optical Frequency Multiplying technique demonstrated long reaches (in the order of 2 km) by deploying the higher-order transmission lobes of MMF. Alternatively, SMF (Single Mode Fibre) is used in the feeder link followed by short MMF star links to the antenna sites (e.g. for fixed wireless access).

The same principle of transmission of analogue radio signals over fibre was investigated for a new DSL over fibre solution [23]. Analogue signals of different VDSL subscriber lines are up-converted to a specific subcarrier frequency at the cabinet. The different subcarriers are then multiplexed and transparently converted to an analogue signal that is carried over an optical feeder. The approach is potentially lower cost than the conventional solution with a digital baseband feeder due to a smaller cabinet size and lower power consumption. A point-to-point feeder to a cabinet was demonstrated in MUSE phase I. The present research focuses on applying the concept to a point-to-multipoint feeder with a passive start.

4.3 Coarse Wavelength Division Multiplexing in the Access

Lower cost CWDM (Coarse Wavelength Division Multiplexing) technology was evaluated in a ring architecture. The configuration flexibility and ways to provide redundancy in such networks were studied. An integrated lab trial was realised which combines VDSL over fibre, hybrid fibre radio, and digital base band over the same optical fibre using CWDM. It demonstrates how CWDM can feed cabinets with different drop technologies, as well as fibre to the premises [24].

5. Summary

The current offer of triple play services in broadband access will evolve to a multi play offer. The three constituents of triple play, being voice, data, and video, will be combined in various ways to create more added value. The experience of the users will be further enhanced with nomadic services and mobility capabilities to truly achieve multi service access everywhere.

This evolution entails important challenges for a broadband access network. Ethernet has emerged as a low cost access technology. Recent research by the MUSE project provided solutions to achieve secure connectivity, guaranteed QoS, and methods for authentication in an Ethernet based multi service access network. Special attention was paid to allow for a flexible implementation of open business models with different types of providers. The solutions were prototyped and successfully evaluated in integrated lab trials. In order to achieve low cost, interoperable solutions, MUSE is currently promoting its results in DSL Forum, ETSI, and Home Gateway Initiative. Future research is focused on enhancing the intelligence of the access platform by higher layer service enablers and preparing the access architecture for fixed mobile convergence.

In anticipation of a continuously growing demand for bandwidth, novel first mile solutions are being investigated that allow for low capital and operational expenses.

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