MUSE
MUlti-Service access Everywhere

Vitor Ribeiro[1], José Miguel Santos[1], Teresa Almeida[1], Kare Gustafsson [2]
Jeroen Wellen[3], Jeanne De Jaegher[4], François Fredricx[4], Peter Vetter[4]

[1] Portugal Telecom Inovação S.A., Rua Eng. Ferreira Pinto Basto,
3810-106 Aveiro, Portugal

[2] Ericsson AB, Torshamnsgatan 23,
164 80, Stockholm, Sweden

[3] Lucent Technologies Nederland BV, Larenseweg 50,
NL-1221 CN, Hilversum, Netherlands

[4] Alcatel Research&Innovation, Francis Wellesplein 1,
2018, Antwerpen, Belgium

Keywords. Broadband; Multi-service; Access; Access Nodes; First Mile; Home Gateways; QoS; Auto-configuration; OAM; CPE; xDSL; FTTx; IPv6; Ethernet; ATM; Techno-economic; Service enablers; Inter-working; Trials.

Abstract. MUSE is an integrated project of the 6th framework European research program.

The overall objective of MUSE is research and development on a future low cost, full service access and edge network, which enables the ubiquitous delivery of broadband services to every European citizen.
MUSE project integrates studies in the following areas:
- Access and edge network architectures and techno-economical studies;
- Access and edge platforms;
- First mile solutions (xDSL and optical access);
- Inter-working of the access network with home gateway and local networks;
- Lab trials.

The concepts of MUSE will be validated for three end-to-end deployment scenarios:
- Migration scenario featuring a hybrid access network of ATM and packet (Ethernet, IP) network elements and CPE with embedded service awareness and application enablers;
- Non-legacy scenario showing access nodes, various first mile solutions, and CPE that are optimised for native Ethernet and IPv6 throughout the home and access network;
- FTTx scenarios integrating new concepts for access technologies - VDSL, optical access, and feeders for wireless services, and service-aware CPE.

The expected impact and results are:
- Consensus about the future access and edge network by major operators and

Ribeiro V., Miguel Santos J., Almeida T., Gustafsson K., Wellen J., De Jaegher J., Fredricx F. and Vetter P. (2004).
MUSE - MUlti Service access Everywhere.
In *Proceedings of the 1st International Workshop on Shaping the Broadband Society*, pages 3-11
DOI: 10.5220/0001403100030011

vendors in Europe.
- Pre-standardisation work and joint position in standardisation bodies;
- Proof of concept demonstrators and lab trials by operators.

1 Integrated project organization

In order to reach the overall objectives of MUSE in an effective and manageable way, the integrated project has been organised in four ***subprojects (SP)*** (cf. Fig. 1. Integrated project organization). Subproject A will define the access and edge network architecture. It will drive the technical directions of the other activities in MUSE and ensure the overall coherence. Furthermore it will host the techno-economic evaluation of the various solutions and finally prepare standardisation inputs. The other subprojects B to D consist of a subset of partners who are co-operating on solutions for a specific deployment scenario, as further outlined below. Towards the end of the project, the access networks of the subprojects will be interconnected to validate their end-to-end interoperability.

Each subproject B to D consists of four ***work-packages (WP)***, which are organised per technical area: Access Platforms, First Mile Solutions, CP Gateways and Private Networks, and Lab Trials. The subproject organisation ensures the end-to-end integration of the prototypes from the different WP.

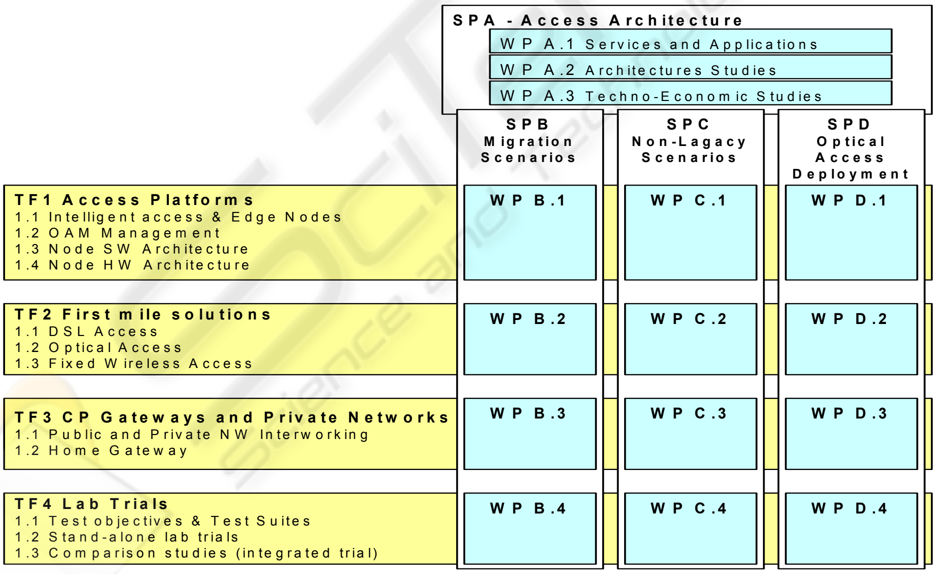

Fig. 1. Integrated project organization.

In order to ensure communication and consensus in the specific technical areas across the subprojects, four ***task forces (TF)*** have been defined. The respective work-packages of each subproject can contribute to a task force. The task forces outputs are common contributions to standardisation, position papers, and comparisons of different approaches or possible common specifications, so as to ensure global interoperability, when considering end-to-end solutions.

2 SPA - Access Architectures

The objective of SP A is to create a common vision of the access network architecture, enabling multi-service broadband access everywhere and for everyone. For achieving this objective, the research work that will be carried out in the Access Architectures subproject focuses on three main activities: WP A1 services and applications, WP A2 network architecture and WP A3 techno-economical studies.

During the whole project, SP A is responsible for the technical management of the integrated project, ensuring that studies and realisations in other subprojects are in accordance with the access architecture vision.

All major operators and vendors of MUSE participate in SP A activity.

3 SPB - Migration Scenarios

The focus of this Sub Project is to tackle migration scenarios for the introduction of multi-services. Migration means that the existing public network situation has to be taken into account. For that reason, and to facilitate multiple services introduction by multiple providers, gradual technical changes are applied in the network. The work also takes the results of the migration studies carried out in SP A into account as guidance for the activities.

More specifically at layer 2, the migration from ATM to Ethernet will be addressed, in the light of the need to leverage both technologies in an evolving access infrastructure and maximise exploitation of existing investments. The current installed base of broadband access heavily relies on ADSL, using ATM in access and aggregation networks, and in ongoing mass deployments aimed at providing ubiquitous broadband service. On the other hand Ethernet is being introduced in the aggregation network (EMAN) and is the pervasive protocol used in private networks. Clearly the interaction of ATM with Ethernet has to be thoroughly addressed in order to support the requirements of the multimedia and emerging peer-to-peer services (including end-to-end QoS).

Another migration track is the introduction of layer 3 awareness closer to the end users, e.g. in the DSLAM. These layer 3 (IP) functionalities can be driven by cost reasons and service reasons. More specifically, inserting service enabling functions operating at layer 3 and above expands the capabilities of the access nodes in terms of security, accounting, etc.

The considerable installed share of ADSL as first mile broadband technology must be taken into account for migration scenarios. Here SP B will evaluate technical improvements and the transition towards other DSL flavours (ADSL2, ADSL2+, VDSL).

On the user's side, the protocols (stacks and message flows) in the Home Gateway (both at public network side and at LAN side) have to be addressed in order to guarantee the delivery of the multiple services to the end-user and a proper interaction between user terminals and public network (e.g. for auto-configuration, the migration from PPP to DHCP must be addressed).

Currently all IP functionalities use IPv4. The evolution to IPv6 raises several opportunities and issues, and in this subproject the assumption is taken of a gradual introduction of IPv6 (in the first place in the residential networks and their residential gateways). Obviously a seamless coexistence with the installed IPv4 base in the access and aggregation public network is then required [1].

4 SPC - Non-Legacy Scenarios

The focus of SP C is twofold. Firstly, SP C targets a highly scalable platform solution based on a large (typically 100.000 users) single Ethernet switching domain with enough QoS to handle quality voice as well as advanced multi-media applications. This will be based on related work in, e.g., DSLForum [2] and IEEE 802.3ah [3]. In contrast to SP B "Migration Scenarios", SP C will not take into consideration a previously installed ATM base in the access part of the network – hereby the name "Non-legacy scenarios". Instead, subproject C will use Ethernet as the single communication technology in order for operators, providers and other parties of the business chain to provide more and more services at lower cost and in this way become more competitive. This is indeed a challenge and such a system has not been demonstrated before. Similar to ATM VC, SP C introduces service bindings, but in this case within the framework of mass-produced Ethernet technology with variable length packets size. Since user generated Ethernet packets do not have to be converted into and from fixed cells, they only have to be transported to the right place according to the "switch where you can, route where you must" paradigm to keep the costs for services as low as possible. In order to make this solution widely applicable, different first mile technologies have to be explored within this framework, e.g., Ethernet over DSL (using the already considerable installed copper pair technology) and Ethernet point-to-point fibre access. Looking to the customer side, the access network will be terminated by means of a home gateway. An IP phone will also be brought into the project for evaluation.

Secondly, IPv6 optimised solutions for the same type of network will be explored. Given the new IPv6 functionality, e.g., L2-addressing, auto-configuration and larger addressing space, the problem space for a public deployed broadband access network can probably be simplified to a large extent. This has implications on both the hardware and software architectures. These activities will be carefully coordinated with related work in, e.g., 6INIT [4] and the IPv6 task force [5]. Use of IPv6 allows de-centralised routing in access and edge nodes, a feature that has large technical and economical implications. On the technical side, de-centralised routing networks offer more throughput and less latency and are less vulnerable to core node failures. On the economical side, it allows network operators to offer added value through routing service. The implications of such a scenario on network nodes, services, applications, business models etc. will be studied in close co-operation with SP A.

Both approaches will work in parallel and together to see how different exacting problems related to the open multi-service environment can be solved. Focus questions will be how to meet the challenging QoS requirements, the required VPN functionality, auto-configuration, standardised open outer interfaces and OAM solutions that enable end-to-end QoS, full automation of customer interaction, network management and requirements on system and service management in edge nodes and CPEs.

The subproject also has at its disposal several sites to perform early and continuous trials both in the labs but also in the field with live customers. SP C will use these to test early prototypes coming both from inside and outside of MUSE in order to guide the further work.

5 SPD - Optical Access Deployment

Subproject D will address the challenges imposed by the deployment of fibre optic access in Europe. This sub project will focus on the migration of current infrastructures to high-speed fibre-based access facilities, including migration through VDSL, and on the interaction with multi-service gateways at the customer. Based on the studies in Subproject A and further detailed discussions within the different taskforces, a further elaboration on the specification and design of last mile technologies and customer terminals will be performed.

Although current access infrastructures are being upgraded to provide broadband services, the deployment of FTTH is still considered disruptive from an economic point of view. The most important reason is the huge investment needed to roll out the last portion of fibre to connect residential and small business users, and the de-investment of existing copper-based last-mile networks. Another reason is that current networks, cable, DSL and PSTN, deliver dedicated services and their associated QoS and operation characteristics. Current edge and access nodes have become a patchwork of functions for different last-mile services. On the other side, the market for end-user routers and gateways is booming, without facilities and support for communication and other QoS sensitive services. Subproject D will provide solutions for deploying optical access by determining techno-economic, operational and also practical issues that obstruct introduction. Based on this, a set of tools will be developed which, for the architectural part of it will be fed back to subproject A. Furthermore, novel enabling technologies will be developed resulting in lab demonstrations.

6 Task Forces

In addition to the in-depth research and prototyping work in subprojects B-D, consensus related activities across the subprojects will be conducted in four task forces. The outputs of the task forces are common contributions to standardisation, position papers, or comparisons of different approaches.

6.1 TF1 - Access Platforms

TF1 will pursue consensus on the proposed solutions for an open multi-service access platform at a node level. The following areas of common interest have been identified within the task force:

- End-to-end Quality of Service (QoS);
- Definition of NSM/OAM functionality in the multi-service access network;
- Identify possible advantages of IPv6 for the access and edge network

One of the major results from TF1 activities will be a description of concept, implementation and functionality of a European telecom access platform.

6.2 TF2 – First Mile Solutions

The main function of the First Mile solutions is to distribute and aggregate traffic associated with all types of services between Access Multiplexers and the users. Since installation and maintenance of access infrastructures will take much, if not most, of the network investments it is vital to keep the costs of new fibre and fixed wireless technologies low, while the economic lifetime of existing copper infrastructures should be extended as much as possible.

In the area of DSL access, the purpose will be to align the technological enhancements studied in the different subprojects, in particular Architecture and Migration issues: network management of quasi-autonomous DSL systems, best practices for OAM, loop-qualification, ADSL to VDSL upgrading, spectral management, and the coordination of standardisation efforts.

In the area of optical access, the purpose will be to compare architectural options addressed in subprojects C and D, as well as in former FP5 projects, and to generate recommendations on low-cost fibre deployment

6.3 TF3 – CP Gateways and Private Networks

The Gateway is a strategic component being the bridge between CP/Home/Private Networks and Public Networks. While Private Networks have to take PC and LAN technologies as a given, Public Network functionality will be enhanced in MUSE, encompassing mainly QoS/ VPN support and auto-configuration. It enables new applications and plug-and-play operation to the subscriber. Figure 2 shows the Gateway reference architecture, consisting of a Private Network part and a Public Network compliant part, both separated by a reference point. Public and Private Network functionalities may be concentrated in one physical box, but could be distributed over distinct devices in the Private Network.

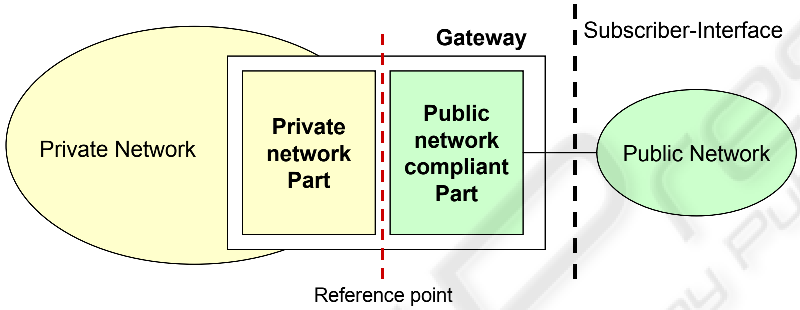

Fig. 2. Gateway reference architecture

In current networks the subscriber interfaces for broadband service are operator specific. TF3 will improve this situation by defining a common subscriber interface based on the network architecture of SP A.

6.4 TF4 – Lab trials and Demos

<u>Test objectives and test suites:</u>
The purpose of this task force is to define the test objectives and a test suite that will be used as a basis for the different subprojects B, C and D. It should be well defined what to test, how to test it and how to quantify the associated "performance".

<u>Comparison studies of trials:</u>
These activities focus on comparing different concepts, in an objectively comparable way, including those resulting from different sub-projects.
The comparison studies generate essential information to operators on the direction of migrating their networks.

<u>Integrated interoperability demo:</u>
A last activity of this task force is the co-ordination of full service, end-to-end, lab trials that integrate the set-ups realised in the different subprojects B, C and D (see Figure 3). Objective is to show the interoperability of the network functions in the respective platforms of subprojects B, C and D.

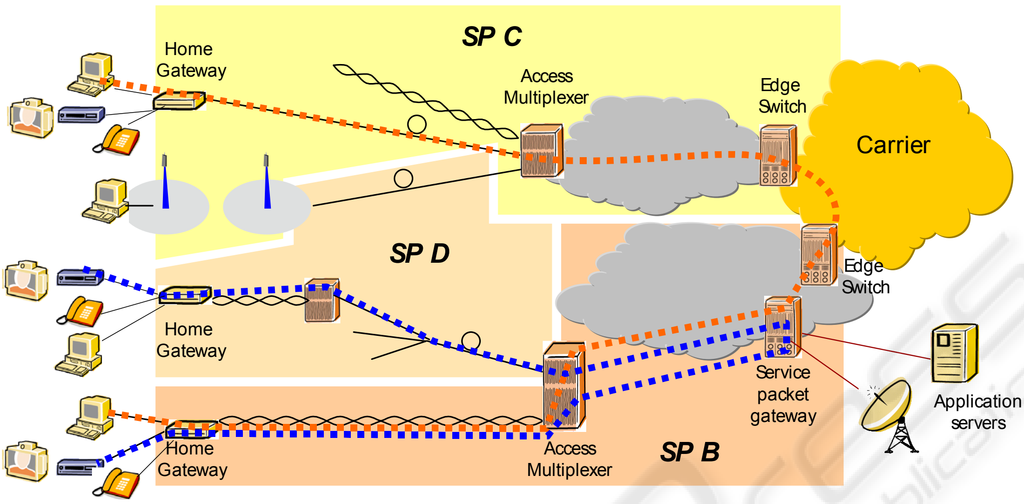

Fig. 3. Top level view of integrated trial

7 MUSE Partners

The following entities are participating in the MUSE Integrated Project:

Alcatel, Ericsson, Lucent Technologies, Siemens, Thomson Multimedia, Infineon Technologies, STMicroelectronics, BT, France Telecom R&D, Portugal Telecom Inovação, TNO Telecom, Telefónica Investigación y Desarrollo, TeliaSonera, Telecom Italia, T-Systems Nova, The Broadband Society of Aarhus, Fundacion Robotiker, Interuniversitair Micro-Elektronica Centrum (IMEC), Institut National de Recherche en Informatique et Automatique (INRIA), Budapest University of Technology and Economics, Institute of Communication and Computer Systems of the National Technical University of Athens (ICCS/NTUA), Lund University, Acreo, Universidad Carlos III de Madrid, Fraunhofer Institute for Telecommunications – Heinrich Herz Institute, Technische Universiteit Eindhoven, and University of Essex.

8 Conclusions

The MUSE project is a wide and ambitious European consortium that aims to provide expertise and guidelines to the networking community for supporting a generalised and ubiquitous offer of Broadband services.

In that pursuit, MUSE achieved bringing together both academic and competitive industrial and network operator partners, specialised in a wide variety of technologies for the edge and access network, working in order to reach consensus and compatible solutions for Multi service access everywhere.

Effort will also be directed to proof the viability of the solutions through trials, and important techno-economic analysis.

This common effort is accompanied by the necessary pre-standardisation work in order to permit a generalised adoption of the developed solutions by several networking players and allow inter-working. One important objective is to show the interoperability of the network functions in the respective platforms of subprojects B, C and D.

As a conclusion, although ambitious, and in spite of its complexity, MUSE is a pragmatic project, whose success will be based on the explained strategy.

References

1. Waddington, D.G.; Fangzhe Chang, “Realizing the transition to IPv6”, IEEE Communications Magazine, Volume: 40 Issue: 6, Jun 2002, Page(s): 138 –147
2. DSL Forum (http://www.dslforum.org/)
3. IEEE 802.3ah (EFM) - www.ieee802.org/3/efm
4. IPv6 INternet IniTiative (http://www.6init.org)
5. IPv6 Task Force (http://www.ipv6tf.org/ and http://www.ec.ipv6tf.org/in/i-index.php)