Demonstration Of TVoIP Services In A Multimedia Broadband Enabled Access Network

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Abstract

This paper gives an overview of the TVoIP (Television over Internet Protocol) services demonstrated in the MUSE (Multi Service Access Everywhere) subproject B lab trial which addresses a future Multimedia Broadband Enabled Access Architecture. The overall set-up including the prototype network elements and the use cases are described. Additionally an outlook to the planned tests is given and finally first test results are discussed.

Introduction

The main objectives of the IST project MUSE [1] – funded within the 6th Framework Program – is the research and development of a low-cost, full-service access and edge network, which enables the ubiquitous delivery of broadband services to every European citizen. The project deals with analyzing and defining architecture, developing of architecture compliant prototypes (i.e. Access Node, Residential Gateway, Application Server) and integration of prototype equipment to demonstrate the multi-service and multi-edge architecture.

Phase II of MUSE has paid special attention to the multimedia broadband applications. Within SPB (Sub-project B) a lab set-up was generated, which combines new and improved prototype equipment, like a TVoIP Gateway, an Access Node with integrated Service Plane and a Residential Gateway, with existing general public & home network elements (edge router, aggregation switch, TV set, phones, PCs etc.). The challenge was the integration of all these elements together.

The major improvements are increasing intelligence in the access platform, which will help the access provider to create added value for the offered services, a wider feature set within the Application Server and Residential Gateway as well as the use of VDSL2 (Very high bitrate Digital Subscriber Line) in the first mile to expand this bottleneck and prepare it for delivering high definition video and TV content.

As for the Phase I demonstrator the operator lab set-up is divided in two different set-ups at different locations with different main focus. One part is realized in Berlin at T-Systems lab with main focus on TV and video services as well as monitoring services and the other part is realized in Huesca at Telefónica lab with main focus on SIP (Session Initiation Protocol) services.

Overall set-up and prototype equipment

The T-Systems set-up – as shown on Figure 1 – is prepared for a various number of possible use cases.

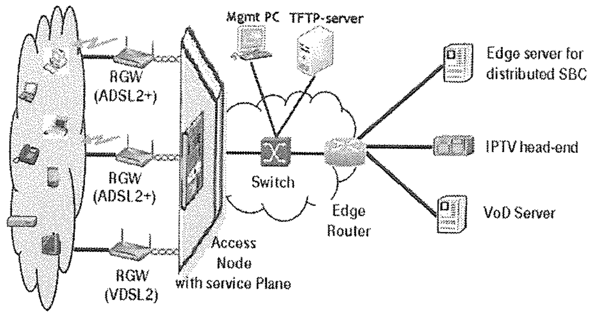

Figure 1: T-Systems lab set-up

This paper is limited to the TVoIP use cases and because of this only the involved prototype equipment will be explained more detailed.

The TVoIP part of the MUSE Sub-project B phase II System offers the possibility to have one platform providing all relevant video transmission and processing methods and a smooth migration to full packet based video transmission. An improved version of the TVoIP head-end acts as the heart of all TV related use cases. It is composed of a Maestream video server and a TVoIP gateway prototype. In this release multiple video compression standards and Transport Stream sources from multiple physical networks (ASI, ATM (Asynchronous Transfer Mode), GigE (Gigabit Ethernet)) are supported. Furthermore a transrating function is supported to transmit video/IPTV streams with adapted rates. In disturbed network environments a high video quality can be achieved by using enhanced FEC (Forward Error Correction) algorithm compliant to Pro-MPEG (Moving Picture Experts Group) Forum. To demonstrate and test this feature a modified STB (Set Top Box), which support this FEC feature as well, is provided. The main features for this lab trial are:

- IPTV (Internet Protocol Television) with support of MPEG2 and MPEG4
- IPTV with support of Standard Definition (SD) and High Definition (HD)
- Transrating of MPEG2/4 content
- Support of enhanced FEC algorithm

The heart of the Access Network is an Access Multiplexer enhanced with the Service Plane middleware that introduces a new plane on top of the existing data and

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control plane [9]. Such plane allows the development of new services and offers an API (Application Programming Interface) between the commercial Access Multiplexer and these new services. An efficient management allows starting, stopping and upgrading easily the services. To provide the additional hardware resources required by the Service Plane and the operating services an additional board – SEPIA (Service Enabling Platform for Intelligent Access) – is plugged into a Line Termination slot of the Access Multiplexer. One example for such new services is the ANTMA (Access Network TCP Monitoring Algorithm) service. With this new service the operator is able to transparently monitor TCP (Transmission Control Protocol) connections [7]. It measures the packet loss, RTT (Round Trip Time) and jitter between the access node and the end-device by looking at the TCP data and acknowledgement packets that pass the access node. Another service monitors RTP / RTCP (Real Time Protocol / Real Time Control Protocol) connections [8]. This service observes the RTP header and RTCP sender / receiver reports and is able to monitor the QoS parameters separately between the TVoIP gateway and the Access Multiplexer and between the Access Multiplexer and the end-device. These network statistics can help to reduce costs and time for analyzing and troubleshooting processes. It gives a better knowledge about the network and provides the possibility to monitor and manage the QoS (Quality of Service) of multimedia services, which is essential. Furthermore the Access Multiplexer is equipped with a VDSL2 board to deliver services at higher speeds, for example high definition video and TV content.

The last important prototype is the (RGW) Residential Gateway. This RGW is composed of a new, more powerful hardware and software with additional interfaces and functionalities – compared to the Phase I version. The new RGW version is enhanced with a VDSL2 NT and supports Ethernet QoS and IP acceleration for the routed mode. This combination can be used to demonstrate bit rate consuming use cases, such as support of multiple HDTV (High Definition TV) broadcast streams per home at the same time (watching and recording).

TVoIP use cases

The next paragraphs describe six use cases which are realized with the TVoIP set-up depicted in figure 2.

The first use case – **HDTV multicast** – offers one user the possibility to watch and/or record multiple (typically 3) HDTV streams at the same time. Two different Multicast streams can be shown on different TV sets, whereby one TV set is simulated by a mobile PC with a HD ready videosoftclient running on it. The 3rd one can be recorded via a PVR (Personal Video Recorder) function on a local hard disc provided by the STB or the mobile PC. The mobile PC is connected to the RGW as well. The streams are typically encoded in H.264 format at 10 Mbps and the zapping can be realized by means of IGMP (Internet Group Management Protocol) signaling. For this use case an Access Multiplexer with support of VDSL2 lines is essentially needed. Furthermore a RGW with support of IGMP snooping, IGMP proxy and a software IP acceleration framework is needed.

The second use case – **Multiple video compression standard processing** – demonstrates IPTV using different codecs (MPEG-2/4) and different resolutions (SD / HD). Only one platform is thus needed for all relevant transport stream processing and transmission methods.

To enhance such a platform a third use case is implemented – **MPEG-2/4 real time transrating**. This transrating is a remultiplexing feature and enables the service provider to receive national or regional TV channels from studios or broadcast centers via different networks (satellite, ATM or Ethernet) at high rates and send it to the customers at adapted rates. The transrated signal can be sent over different physical networks. This use case can be combined with the FEC use case, which will be described later on.

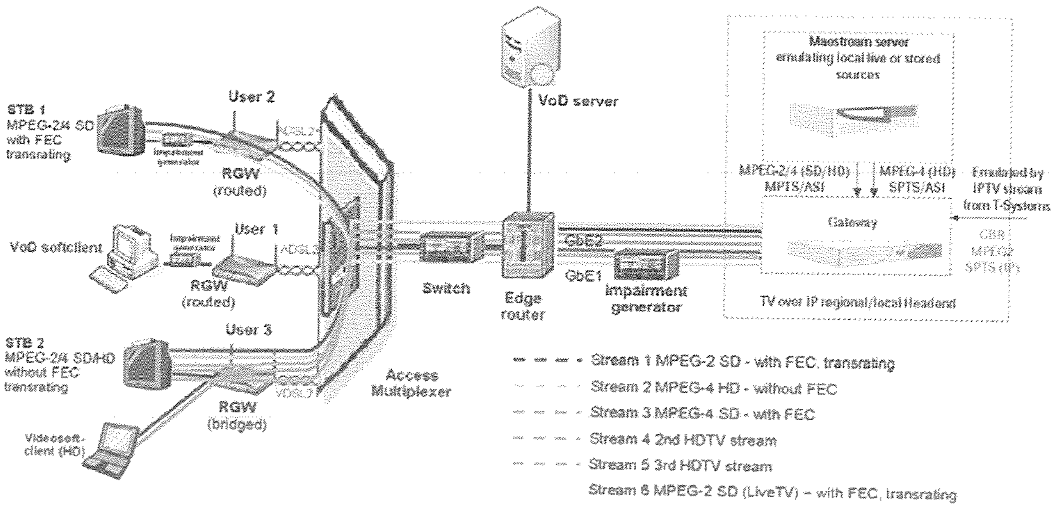

Figure 2: Set-up for TVoIP and VoD testing

In a fourth use case the **simultaneous handling of multiple transport stream sources** is demonstrated. For this purpose two sources are connected to the gateway part of the head-end – one live TV source delivered by a regional broadcast centre and one stored content source (Maestream server). This gives the service provider the opportunity to forward live events coming from a national or international broadcast station as well as insert local TV channels. The content from multiple sources can be delivered over multiple physical networks (ASI, ATM and GigE) and used to generate dedicated TV channel bundles for the customers. The support of different source signals offers the possibility for a smooth migration towards full packet based video transmission workflows.

The fifth use case – **enhanced Pro-MPEG FEC** – demonstrates the advantage of increased quality through improved recovering of possible errors. To make this important feature visible a TV multicast stream over the MUSE network is generated. This stream can be disturbed (loss, latency, jitter etc) by an inserted impairment generator. The TV stream is displayed once over a STB with FEC processing and once over a STB without FEC capabilities. So it is possible to compare the corrupted and the recovered stream directly in terms of quality and additional latency. The FEC process is compliant to the Pro-MPEG Forum Code of Practice #3 release 2. It carries FEC on different RTP ports than video, so STB without FEC can decode the video by ignoring FEC frames. The recovering using the mentioned FEC algorithm works for MPEG2 or MPEG4, SD or HD from Ethernet without inducing any modifications on video stream.

The sixth and last use case is the **TCP and RTP/RTCP monitoring** [5, 6, 7, 8, 9]. For this use case the MUSE TVoIP head-end is used to generate the video service and the RTCP Sender Reports associated to each streamed RTP TV Channel. The monitoring feature is implemented as a service running on the service plane in the Access Multiplexer and works with other TCP or RTP/RTCP sources as well. The client receives the video service and generates the RTCP Receiver Reports for RTP services. This demonstrator collects network information like packet loss and delay between access node and clients. For multimedia services like IPTV or VoD (Video on Demand) it is essential to have the possibility of monitoring QoS because it helps locating the impairment source and prevents service or network provider increasing troubleshooting costs when a problem occurs.

This use cases monitors two protocols: TCP and RTP/RTCP. In one sub-case the video is streamed from a Video-on-Demand server via a TCP connection. In another sub-case two users subscribe to the same TV channel, which is streamed over RTP. In both sub-cases a first impairment generator is installed between the video source and the edge router and a second one is installed in the home network. The SEPIA board within the Access Multiplexer transparently monitors these connections and measures or rather calculates network parameters (packet loss and RTT), provides network statistics and reports them. One of the two TV users has no impairment generator in its home network, so a difference in video quality on both clients can be observed for the RTP service. This difference correlates with the reported network statistics at the Access Multiplexer.

Planned tests and analyses

The main focus beside features & functionalities testing – especially concerning the TV and video use cases – is on QoS testing.

To evaluate the QoS for a particular service it is necessary to carry out some generic tests of network behavior. These tests are measurements of standard network parameters like throughput, packet loss, jitter and latency as well as considerations of overall network QoS handling. The first part is realized by using a traffic generator / analyzer, which is connected at the server and the client side of the network under test. An IP flow was generated and the already mentioned parameters were measured – according to the specific RFCs (Request For Comments). To evaluate the general QoS handling of the network under test the same test set-up was used, but now two flows are generated – one high priority and one low priority flow. During this test the traffic load of each flow will be increased from 10% to 100% of the link capacity by 10% steps.

The video quality of the former described video use cases was verified according to the MUSE Test Methods [4]. Following this the visual quality can be determined by using the free software tool VQM (Video Quality Metric – www.its.bldrdoc.gov). To avoid influences which are out of MUSE (i.e. influences by encoder / decoder or by display systems) the visual quality will be measured between the outgoing interface of the TVoIP head-end and the incoming interface of the TV set. For using VQM some format conversions are necessary, which could impact the test results. To assess the overall video quality it is needed to have a quality statement for the audio signal as well. The audio quality can be detected according to different methods (e.g. PEAQ (Perceptual Evaluation of Audio Quality)). The combined audio-visual quality can be predicted accurately from stand-alone audio and video quality models. The form of the predictive model is content dependent. According to MUSE Test Methods [4] it is proposed to use the mapping for high-motion sequences. A further important aspect for quality evaluation of audiovisual services is the synchronization between audio and video signal. An equation to determine a MOS (Mean Opinion Score) value for this aspect is given by MUSE. Roughly speaking there is a good quality of synchronization if the delay of the video signal is below 70ms or the delay of the audio signal is below 150ms. The QoS tests described above are applied to the following scenarios:

- IPTV with MPEG-2 SD
- IPTV with MPEG-4 HD
- Home network receives 3 HDTV streams
- IPTV with MPEG2/4 transrating without FEC
- IPTV with MPEG2/4 transrating with FEC
- VoD with wireline access (Ethernet)
- VoD with wireless access (WLAN)

One further important quality parameter for TV services is the zapping time. It has a major impact to the overall experience of watching TV. To evaluate the zapping behavior of the system two different aspects are considered. First the overall zapping time from pressing the channel change button on remote control until the channel starts on TV. For a better statistical probability this test should be repeated at least ten times. The second determined zapping parameter is the join-and-leave latency. This represents the time between sending a join packet and the first packet of the requested stream arriving or between sending a leave packet and the last packet of the old stream coming in.

Beside the QoS the treatment of multicast traffic within the network is essential for a successful providing of TV services. To evaluate this following tests have been realized:

- IP multicast reception
- NAT (Network Address Translation)/ Firewall traversal
- IGMP snooping
- IGMP version mix
- IPv4 multicast benchmarking test according to RFC 3918 "Methodology for IP Multicast Benchmarking"

Additional to the major block of QoS and the multicast related tests some feature and functionality tests, like start & stop the monitoring services on the service plane or a correlation of monitored statistics, injected impairments and visual distortion have been realized.

Test results

The described demonstrator allows for many test options that will only be partly evaluated in the framework of IST MUSE. Following listed and explained test cases make no claim to be complete.

A first successful pre-integration of the demonstrator equipment took place in the Alcatel-Lucent lab of Antwerp and afterwards the complete testbed were shipped, integrated and tested in T-Systems lab of Berlin.

First functional test after integration which covered subscribing a channel and displays it on a TV screen was successful. The ability to transmit multicast traffic over the network to provide IPTV services as well as the successful treatment of IGMP mechanisms for channel changing (zapping) has been confirmed. All these mechanisms work properly in switched and routed home network environments (tested with and without NAT).

In order to validate the possibilities of multicast transport within the MUSE network some generic network parameters (throughput, latency and latency distribution) were analyzed. In the test set-up a measurement tool was configured as multicast source and client and connected to both sides of the network under test. For ADSL2+ a multicast downstream throughput of 11.6 Mbps with an average latency of 4.1ms was determined. In case of using VDSL2 line the multicast downstream throughput increased up to 50 Mbps and the latency decreased to 2ms. The latency values are related to normal load conditions (up to 90% of maximum throughput). These results illustrate the large potential of VDSL2 in the context of providing HDTV content.

An important parameter for a good quality of experience in the context of IPTV services is the zapping time. Two different aspects were considered during the tests (see chapter before "Planned tests and analyses"). The average overall zapping time (measured with stopwatch) is between 2 and 3 seconds, whereby the combination of VDSL2 and STB without FEC capabilities has a slightly better performance. The channel change tests result in different behavior of the two STBs used in demonstrator set-up. Packet loss between TVoIP head-end and STB (FEC switched off) lead to higher zapping times and considerable fluctuations, furthermore an increasing impact on experienced zapping time was observed in connection with transrating on low bit rate channels. That means that a change from any channel towards channel 1, which is transrated from 2.3 Mbps to 1.7 Mbps, needs more than the usual 2 or 3 seconds. This behavior was stronger observed in Home network 2 (ADSL2+ and STB with FEC capabilities). On the other hand measurements of join latency were carried out. The average results are shown in the following table:

	join latency
home network 2 (ADSL2+ based)	48.43 ms
home network 3 (VDSL2 based)	10.22 ms

Table 1: join & leave latency

Additional functional tests to the monitoring services were successful. The reported packet loss correlates with the injected impairments and with the visual distortion.

The FEC algorithm was tested with two different kinds of packet loss: 1.) bursty packet loss (5s no loss followed by 1s loss) and 2.) random packet loss. The 1s packet loss burst can not be complete recovered by the FEC algorithm – still interrupts in the video flow, but the FEC algorithm is able to correct up to 5% random packet loss. In the current configuration of FEC on the TVoIP gateway, the recovering capacity is 10 consecutive packets loss each 100 packets, and the impairment node induces a bursty loss of 285 packets each 1425 packets.

For transrating a bandwidth decreasing by 30% was successful tested on MPEG2 SD streams with and without FEC, but on low bit rate streams (MPEG2 SD stream with average consumed bandwidth of around 2.3 Mbps) the video quality is not sufficient anymore (block effect). A reducing of transrating (e.g. 20% or 10%) leads to a better result.

Conclusions

The paper presents the TV, video and monitoring part of the MUSE II SPB lab trial. This demonstrator acts as proof of concept for the MUSE defined Access Network architecture and the depicted set-up as well as the described prototype equipment show the feasibility of delivering multimedia broadband services to the customer. Within the SPB lab trial the main focus is on the migration capabilities. Two examples for added value through migration possibilities are for example the migration from ADSL2+ towards VDSL2 for delivering multiple HD streams to the user (possibility to create more revenues for service providers) and the Access Multiplexer migration towards more intelligence through introducing an additional service plane and establishing network statistics monitoring services. This leads to a better service availability and decreasing of operational costs. The different described and analyzed use cases show the evolution of a centralized TVoIP head-end towards a distributed platform for all relevant transport stream processing and transmission methods. Furthermore the smooth migration towards a full packet based environment for all TV & video services has been considered.

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