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Executive Summaries for work packages WP5-WP8

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Abstract:
The scope of the P2P-Next project is to develop an open source platform based on open standards and future proof iterative integration for the next generation of interactive television. WP5-WP8 enable the creation of (user generated) content, provide innovative audio/video technology and user interfaces, develop an integrated consumer electronics device for the NextShare platform, and realise the Living Lab Trials as a large scale public test-infrastructure facilitating experimentation of the system architecture. This executive summary gives the results achieved in WP5-WP8, including standardisation activities, during the entire project in a nutshell.

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Executive Summary

The scope of the P2P-Next project is to develop an open source platform based on open standards and future proof iterative integration for the next generation of interactive television. WP5-WP8 enable the creation of (user generated) content, provide innovative audio/video technology and user interfaces, develop an integrated consumer electronics device for the NextShare platform, and realise the Living Lab Trials as a large scale public test-infrastructure facilitating experimentation with the system architecture.

P2P-Next promises to provide efficient and low-cost delivery of professional and user created content.

WP5 has provided reference content, developed systems through which this can be ingested into the P2P-Next environment, provided a standard for metadata and a framework for related interactivity, and provided systems for content to be searched for by users and displayed.

WP6 has provided contribution to the project mainly on two aspects:

- PC prototyping, called NextSharePC providing the P2P-Next PC implementation taking care of the usability, ease of use, stability and passing through the Living Lab qualification tests.
- WP6 research path, providing new technologies integrated into laboratory prototypes. Being focused more on innovation and new technologies perspectives rather than ease of use or testability, the research path provided to the project the leading edge technologies such as Scalable Video Coding (SVC) to support recovering from network losses, Low Density Parity Check and Forward Error Correction (LDPC-FEC) to detect and reconstruct lost packets, Zoomable User Interface (ZUI) to define a new way to browse and indexing for Multi Media content, and finally Adaptive Play-out to adapt player speed to the network bit rate fluctuations.

WP7 has delivered what we consider to be a feature complete prototype with its final **M52 firmware v2.1.1**. It incorporates complete integration with the Living Lab content delivery platform, spanning content discovery and social networking aspects, as well as incorporating feedback from end-users concerning usability and stability under normal operating conditions.

WP8 has deployed and tested the NextShare platform in both lab-based and real-world user environments. Various WP8 partners have also implemented their own web portal that utilises NextSharePC for content distribution. The results from these user trials have been utilised in the development of a number of ancillary services including a second screen application called NextShareMobile, and a quality-of-experience framework for evaluating NextShareTV. This period also saw the integration of Libswift into the living lab services.

In order to standardize the developed technology natural contacts were established with the following standardisation bodies: DVB (Digital Video Broadcasting) CM-IPTV as

well as DVB TM-IPI (IP infrastructure), ETSI TC MCD (Media Content Delivery), IETF (Internet Engineering Task Force) and MPEG (Moving Picture Expert Group) as well as to BitTorrent.org (for Open Source efforts, contributing to and extending de facto standards in the Internet Community).

The following P2P-Next developments were brought to standardisation: Metadata for discovery, search and selection of appropriate content in a peer-to-peer network and related APIs, The Next-Share core, the main software and protocol development in the project, providing peer-to-peer functionality for PC and CE networked environments.

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1 Executive Summary of WP5: "User Generated / Professional Content and Metadata

WP5 has provided reference content, developed systems through which this can be ingested into the P2P-Next environment, provided a standard for metadata and a framework for related interactivity, and provided systems for content to be searched for by users and displayed.

1.1 Production of interactive editorial and promotional content

The aim of this work was to develop reference content to be ingested into the P2P-system. It focused on editorial as well as promotional content, and required media planning support.

As part of this work different partners pursued relationships with content providers in their localities in an attempt to secure new content that would encourage potential trialists to use the system more extensively.

In the area of technical and user trials partners made available various audio-visual contents for P2P-Next demos and WP8 Living Labs. This included editorial on demand and live contents from BBC, JSI/RTV and UPB. Additional contents were made available via relationships with third-party content providers.

1.2 Content packaging ingest and adaptation

The aim of this work package was to address all content packaging, ingesting, and adaptation issues including to define a solution for how to package content items before they are ingested and to create a tool to manage processes associated with preparing a content item for ingest.

Content packaging provides a solution to packetize the content, the metadata and possibly additional metadata for the content items. To ensure backwards compatibility to older Bittorrent clients, the top-level description of every content item is a torrent file. In addition to the usual torrent attributes, the file contains the core metadata and possibly references to optional metadata or other data related to the content item. The additional data referenced can be provided by either the peer-to-peer system or alternatively by servers.

Content ingestion tools were created to ingest professional content as well as user-generated content into the NextShare system. Two ingest mechanisms were provided for the two alternative approaches utilized by BBC and JSI.

The content adaptation solution provides a codec-agnostic adaptation framework for scalable video content. This adaptation solution is developed jointly with WP4 and WP6 with WP5 focusing on the piece-picking algorithm which provides a mechanism to download the pieces of the highest possible quality while still ensuring that the pieces are downloaded in time for playback.

1.3 Rich metadata and signposts

The aim of this work was to create both content- and context-related, rich, standardized metadata. This is a key asset to enable television to move from the classical channel model towards an on-demand personalised experience.

The P2P-Next Rich Metadata specification provides a minimum set of attributes which are necessary to describe a content item in the NextShare system. Additionally, several types of optional metadata documents, like payment or advertising metadata, are specified.

To ensure compatibility with as many applications and existing metadata collections as possible, the attributes of the core and optional specifications of the P2P-Next Rich Metadata specification are mapped to three state-of-the-art metadata standards: TV-Anytime, MPEG-7, and URIPlay. Additionally, the Channel Metadata extensions provide a solution to describe the programming guide of a TV channel like BBC 1.

The Kendra Signpost specification provides a solution for content providers to ingest their content catalogue metadata via an associated public-facing web portal. The Kendra Signpost implementation enables the translation of content metadata from various providers to various schemes, including those compatible to the P2P-Next Rich Metadata specification, thus providing a convenient way for content providers, including recording labels and video distributors, to ingest all their content in a NextShare compatible way. The Kendra Signpost Search module also enables advanced semantic search of content ingested via the portal and provides a compact and extensible format for encoding and distributing search queries and content playlists.

The Content Collections specification describes how content can be announced to interested parties utilizing Atom feeds. The specification describes the discovery feeds, which provide an overview of the available live programs and on-demand collections of a single content provider, and the content feeds, which provide more details for specific content collections.

1.4 Lightweight interactivity for rich multimedia content

The aim of this work was to investigate, experiment, and implement a lightweight solution for interactivity (called LIMO) that must be generic and support basic interactivity such as events, actions, and links.

Initial research explored the potential ways to provide interactivity alongside video with lower barriers to entry than existing technologies, culminating in a plan to develop a system using a combination of the emerging HTML5 standard and JavaScript.

The team then developed demonstrations of how subtitles, chapters and further information panels could be added to video on demand using a combination of HTML5, JavaScript and JSON developed specifically for the project.

Two further prototypes built on the existing LIMO event types to demonstrate additional interactive features in the related areas of quizzing and polling.

In the final year of the project a further review of the state of the art led to a realisation

that a significant problem which needs solving, both for the P2P-Next project and others providing interactivity alongside video, is that of synchronising a live audio/video stream played within a browser to the timed metadata (eg LIMO events) streamed alongside it.

The output of this work has been a modified browser fully supporting the HTML5 audio and video elements. This involved development to bring current browser versions in line with the latest iteration of the HTML5 specification. Implementing the HTML5 media element startOffsetTime attribute showed that live synchronisation becomes possible, which validates the emerging HTML5 spec and opens up new possibilities for enriching live media with all kinds of related interactive events.

1.5 Presentation and usability

The aim of this presentation work was to design a number of user interfaces to support a range of different content providers and end users.

VTT built a portal integrating configurable feeds with search capabilities which was integrated with the ingest tools and decentralised search. The portal is a website for registered users to search, view and create P2P-Next content based on Drupal, a free and open source content management system (CMS) written in PHP and distributed under the GNU General Public License.

In the heart of the portal there are two custom content types created with CCK (Content Construction Kit): the “Channel” and the “Programme” content types. Both are based on the same underlying data structure called “Node”. They inherit all node attributes, for example: type, title, body, uid, status, created, changed, etc. and add their own attributes, like: programme id, programme thumbnail, duration, torrent file, etc.

While most of portal custom functionality is programmed in p2pnext custom modules, there are a huge number of contributed modules utilized to put bits and pieces together. Here are the most important ones: Views, CCK, Feeds & SimplePie Core, Token, Pathauto, FileField, ImageCache, ImageField, Date, Voting API & Fivestar and jQuery UI.

1.6 Content Search & Discovery

The aim of this search work was to investigate the different options for content discovery including fully decentralised search and discovery and to develop reference platforms.

Research defined the state-of-the-art in content discovery. From the literature we found that researchers still focus on the “functional aspect” of search and not on non-functional aspects such as security, spam and adversarial P2P information retrieval. In other words, researchers mainly ignore the challenge of building a trusted search service out of donated, untrusted, and unreliable resources. The conclusion was that “trustworthy search” presented a clear research opportunity for P2P-Next.

Reputation systems were seen as a candidate solution to address the challenge of whom to download from in an adversarial distributed system. Within this work we analyzed and improve a renowned reputation system – EigenTrust – which helps users download

authentic files and avoid inauthentic ones. We then proposed an attack resistant version of the current reputation system in NextShare – Bartercast – which helps in rewarding users who have contributed their resources.

1.7 Dissemination

For the WP5.2 task T5.2.1 covering content packaging a paper has been published that describes the content packaging mechanism:

- Christian Timmerer, Michael Eberhard, Michael Grafl, Keith Mitchell, Sam Dutton, Hermann Hellwagner, A Metadata Model for Peer-to-Peer Media Distribution, In Proceedings of the Workshop on Interoperable Social Multimedia Applications (WISMA 2010), CEUR Workshop Proceedings (CEUR-WS.org), Aachen, Germany, pp. N/A, 2010.

For the WP5.2 task T5.2.3 covering content adaptation there were several papers published:

- Michael Eberhard, Tibor Szkaliczki, Hermann Hellwagner, Laszlo Szobonya, Christian Timmerer, Knapsack Problem-based Piece-Picking Algorithms for Layered Content in Peer-to-Peer Networks, In Proceedings of the 2010 ACM Workshop on Advanced Video Streaming Techniques for Peer-to-Peer Networks and Social Networking (ACM Multimedia 2010), ACM, New York, NY, USA, pp. 71-76, 2010.

- Michael Eberhard, Hermann Hellwagner, Christian Timmerer, Tibor Szkaliczki, Laszlo Szobonya, An evaluation of piece-picking algorithms for layered content in Bittorrent-based peer-to-peer systems, In Proceedings of the 2011 IEEE International Conference on Multimedia and Expo (ICME 2011), IEEE, Los Alamitos, CA, USA, pp. 1-6, 2011.

- Michael Eberhard, Riccardo Petrocco, Hermann Hellwagner, Christian Timmerer, Comparison of Piece-Picking Algorithms for Layered Video Content in Peer-to-Peer Networks, In Proceedings of the Consumer Communication & Networking Conference 2012 (CCNC 2012), IEEE, Los Alamitos, CA, U.S.A., pp. 1-5, 2012.

For WP5.3 the rich metadata extensions used in P2P-Next have been standardized in MPEG. This activity has been documented in D9.8 (https://trac.p2p-next.org/raw-attachment/wiki/P2P-Next/WP9/P2P-Next-D9.8-Standardisationreport-v10.pdf, Section 2.1).

For WP5.4 the LIMO prototypes have been published online and as a result picked up by the HTML5 community as examples of work which pushes the boundaries of interactive video on the internet. Web video specialist Silvia Pfeiffer blogged about LIMO at http://blog.gingertech.net/2009/08/19/jumping-to-time-offsets-in-videos, while developer Remy Sharp used it as an example in presentations such as http://www.slideshare.net/remy.sharp/html5-friends and his book Introducing HTML5 http://www.amazon.co.uk/gp/product/0321687299.

The R&DTV demo led to email discussions with Silvia Pfeiffer in her role as invited expert on various W3C video-related working groups which has had a positive impact on the further development of the HTML5 standard with regards to video.

The BBC was contacted by Opera who are keen to see the startOffsetTime issue resolved and have asked the BBC to contribute further to discussion with WHATWG.

There has since been communication with WHATWG regarding standardisation of the HTML5 video track element that would make integrating LIMO with HTML5 more straightforward and potentially lead to a more universal platform for which other creation tools would already be available.

The BBC published its Firefox and FFmpeg patches on Github
https://github.com/bbcrd/HTML5-MediaElement-startOffsetTime

and contributed comments to the Firefox bug tracker
https://bugzilla.mozilla.org/show_bug.cgi?id=498253

1.8 Exploitation Plan for the Results

For WP5.2 there are no specific plans for the exploitation part of content packaging or content adaptation parts on their own but both are integrated in to the NextShare core for which the overall exploitation plan is described elsewhere

For WP5.3 Kendra is taking the Signpost code and concepts and extending them for the SARACEN FP7 EU project.

For WP5.4 the BBC was contacted by Opera who are keen to see the startOffsetTime issue resolved and have asked the BBC to contribute further to discussion with WHATWG.

For WP5.5 project partner DACC Systems AB is building commercial FairShare MediaWorld content delivery system in Sweden based on portal development of P2P-Next project which is described with the following objective:

The FairShare MediaWorld CDN (Content Distribution Network) system enables anyone to distribute digital content to any other user of the Internet at a very low cost. Distribution can be both private and professional and a number of different business models are available. An integrated Payment System handles all necessary payment functions including micro payments for all relevant business models. All usage of the FairShare MediaWorld is Self-Service through the FairShare MediaWorld Portal and the provided functionality. All distribution resources within FairShare MediaWorld are owned or controlled by the Users. (see http://thefsmw.com).

Additionally, in an internal development project (not funded by the P2P-Next project) VTT has developed a content management and delivery platform for internal use and for demonstration purposes based on technologies developed in the P2P-Next project.

The system called VTTube is used for live p2p-broadcasts in VTT-intranet from workshops, seminars and training events using a PC with two live video cameras: one camera for the presenter and one for the presentation. The employees of VTT can watch live broadcasts using their workstations and chat and post comments during the events. After the live event the videos will be available as VoD files in the system. The system is easy to set-up and use so that almost anybody at VTT is able to schedule and start live broadcast in the intranet using one or two video cameras connected to a PC. Also a lot of different VoD files from various research projects have been uploaded to the

content management system.

VTT is negotiating with several national and locally operating television and media companies in Finland about commercial internet-television solutions based mostly on the results of P2P-Next project.

At VTT the VTTube system will be used as a demonstration platform for potential customers and potential users of P2P-Next technologies. In addition also other IPR and results from other research projects like recommendation engine and semantic search technologies have been integrated to the VTTube system.

2 Executive Summary of WP6 “PC Integration and Prototypes”

The WP6 work package provided an implementation of the P2P-Next technology called NextSharePC running on a standard PC architecture. It consists of a collection of integrated SW libraries and applications enabling any PC user to exploit the advantages provided by the participation to a P2P-Next community through the P2P technologies and features developed within the project. The WP6 also carried out integrated prototypes of the most promising leading edge technologies applicable to the P2P Multi Media world. This made the overall project future proof and open for further improvements. The provided technologies range over latest generation Scalable Video Codecs, LDPC-FEC transmission error detection and corrections, Digital Fountains data distribution, player speed self adaptivity and Zoomable User Interface providing a new way to browse and index for Multi Media contents.

2.1 WP 6.1 - Latest generation video codec (H.264/SVC)

WP6.1 package was in charge of delivering and integrating a latest generation video codec to get maximum efficiency at low bitrates, to compensate for unpredictable network throughput and to adapt to the capabilities of the receiver. Scalable Video Coding was the selected technology which was optimized, tuned and integrated within the P2P-Next project having in mind the peculiarity of the application, also taking into account the P2P protocol piece size, the most common network congestion events and the requirement of a less perceivable quality degradation.

At the time project started the most suitable SVC implementation to start from was the JSVM 9.1 (Joint Scalable Video Model, the SVC reference software model provided by the Joint Video Team standardization committee). It has been heavily optimized, mainly on the decoder side, in order to achieve real time performance at the required video resolution. At the encoder side specific algorithms such as Constant Bit Rate (CBR) and Motion Estimation (ME) have been added in order to optimize the bit stream generator and accommodate a whole Group Of Pictures (GOP) in a P2P piece. During the second project year the newer version of decoder JSVM-9.15 was released which consequently was integrated into the P2P-Next prototype.

During Q2-2010 an Error Concealment algorithm also was integrated into the JSVM9.15 decoder VLC plugin, making the decoder error resilient up to a certain bit error rate and providing the upscaling capability in order to seamlessly recover from loss of spatial layers.

In the meanwhile the OpenSVC group delivered an open source implementation of SVC decoder. According to the benchmarking and comparison done it was concluded that this latest OpenSVC implementation performed much better than the old JSVM, so it was decided to move the SVC prototype to a better performing OpenSVC. This move implied the repeated integration of the Error Concealment algorithm. In order to support the decision to move from the JSVM reference model, already optimized, to the OpenSVC implementation, a benchmarking activity was carried out on both decoders. The figures below show a comparison of JSVM versus OpenSVC decoder over different PC CPUs. For a more comprehensive performance overview a full benchmarking report is available on P2P-Next wiki at https://trac.p2p-next.org/wiki/Benchmarking .

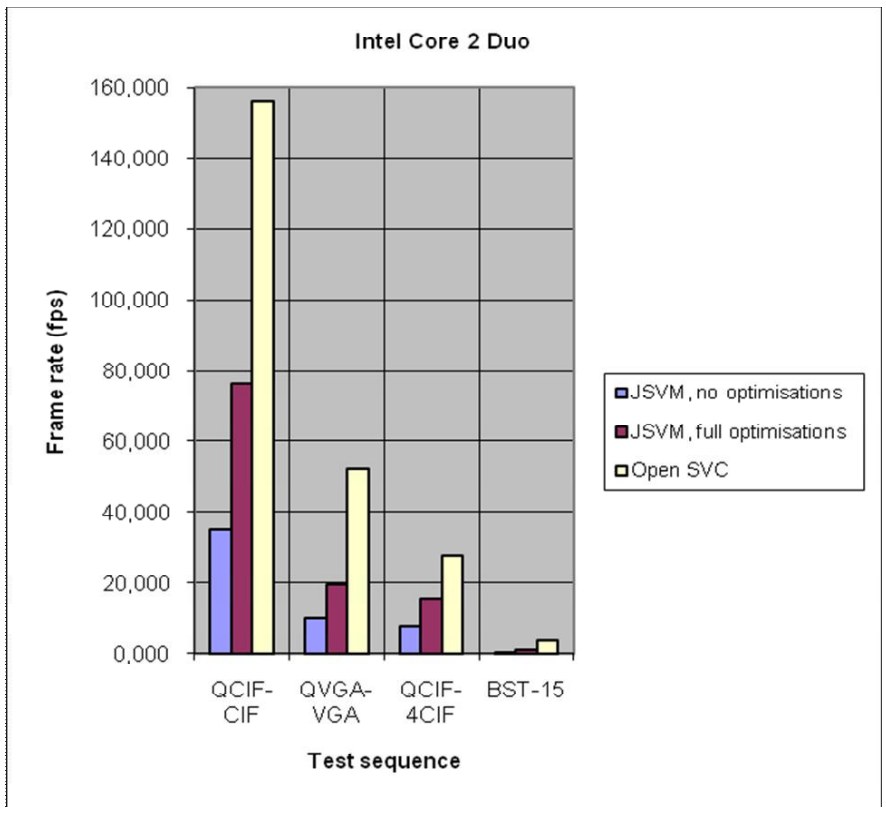


Figure 1. JSVM vs OpenSVC performances on iCore2

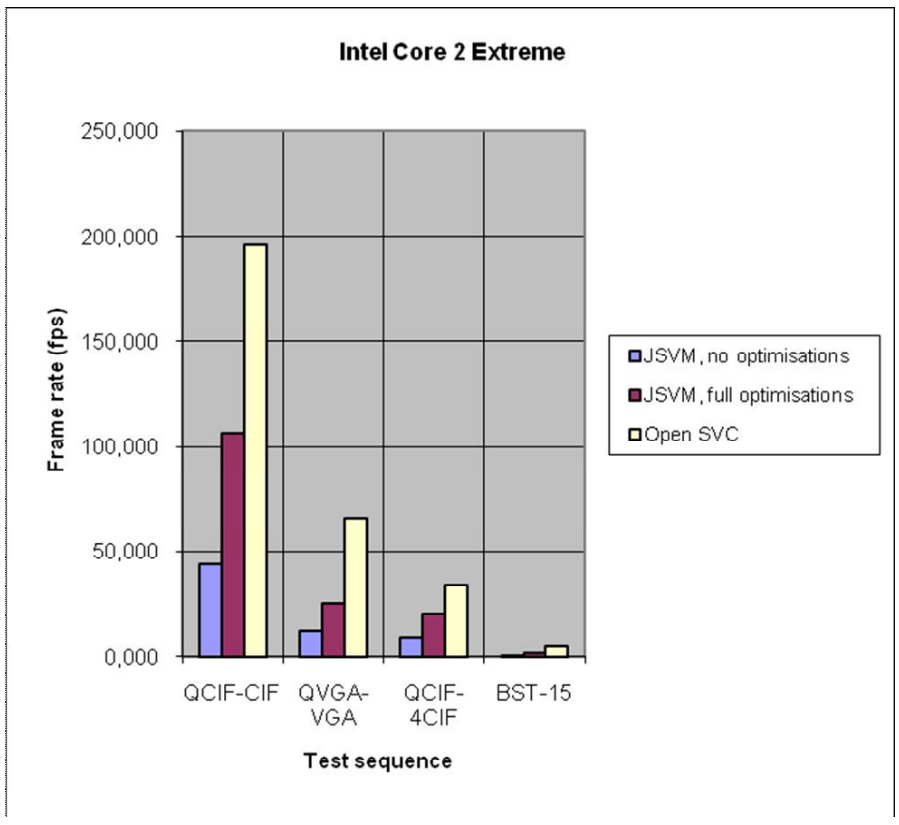


Figure 2. JSVM vs OpenSVC performances on iCore2Extreme

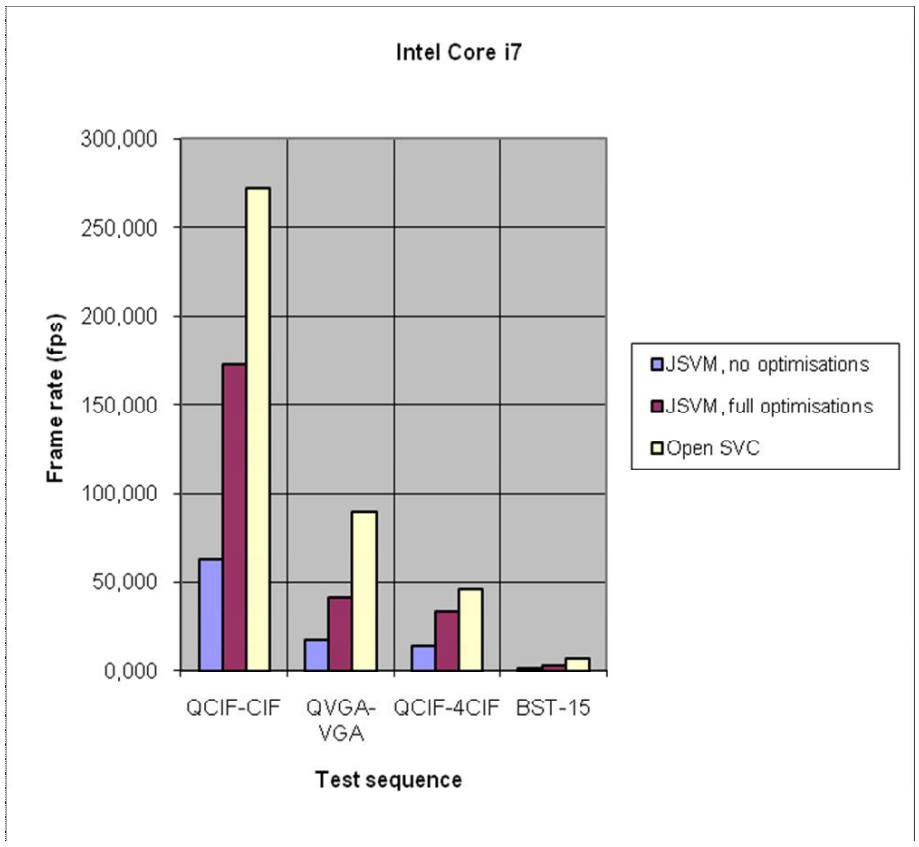


Figure 3: JSVM vs OpenSVC performances on iCoreI7

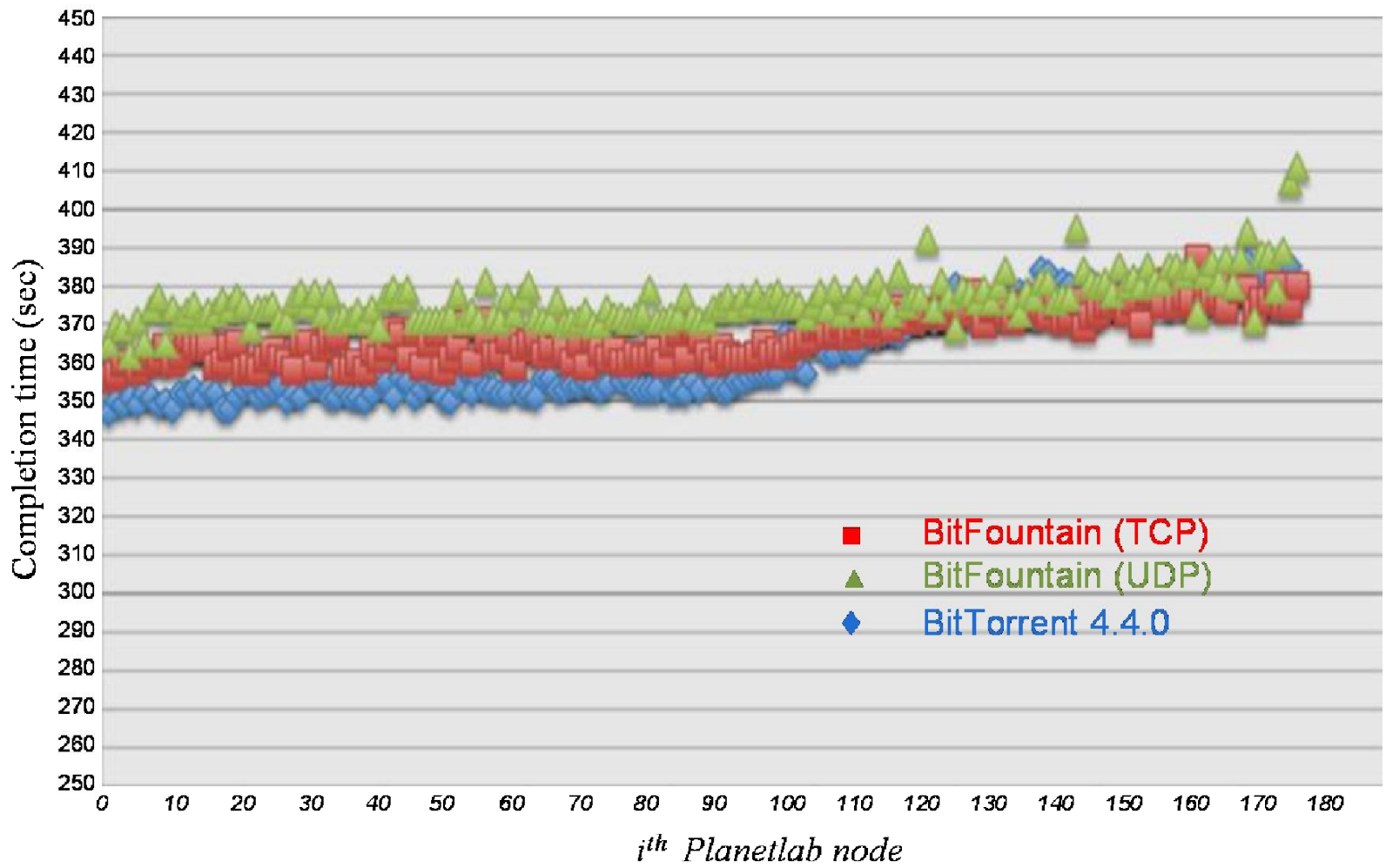
2.2 WP6.2 - LDPC digital fountains for application-layer FEC

WP6.2 was in charge of delivering technology for application-layer Forward Error Correction (FEC) digital fountains. The main objective of FEC codes is to compensate for transmission errors over unreliable networks. The digital fountains are a class of FEC codes that provide the user with the capability of recovering all source data. For the system to work it is necessary to simply receive enough encoded data (slightly more than the transmitted) independent of the reception order.

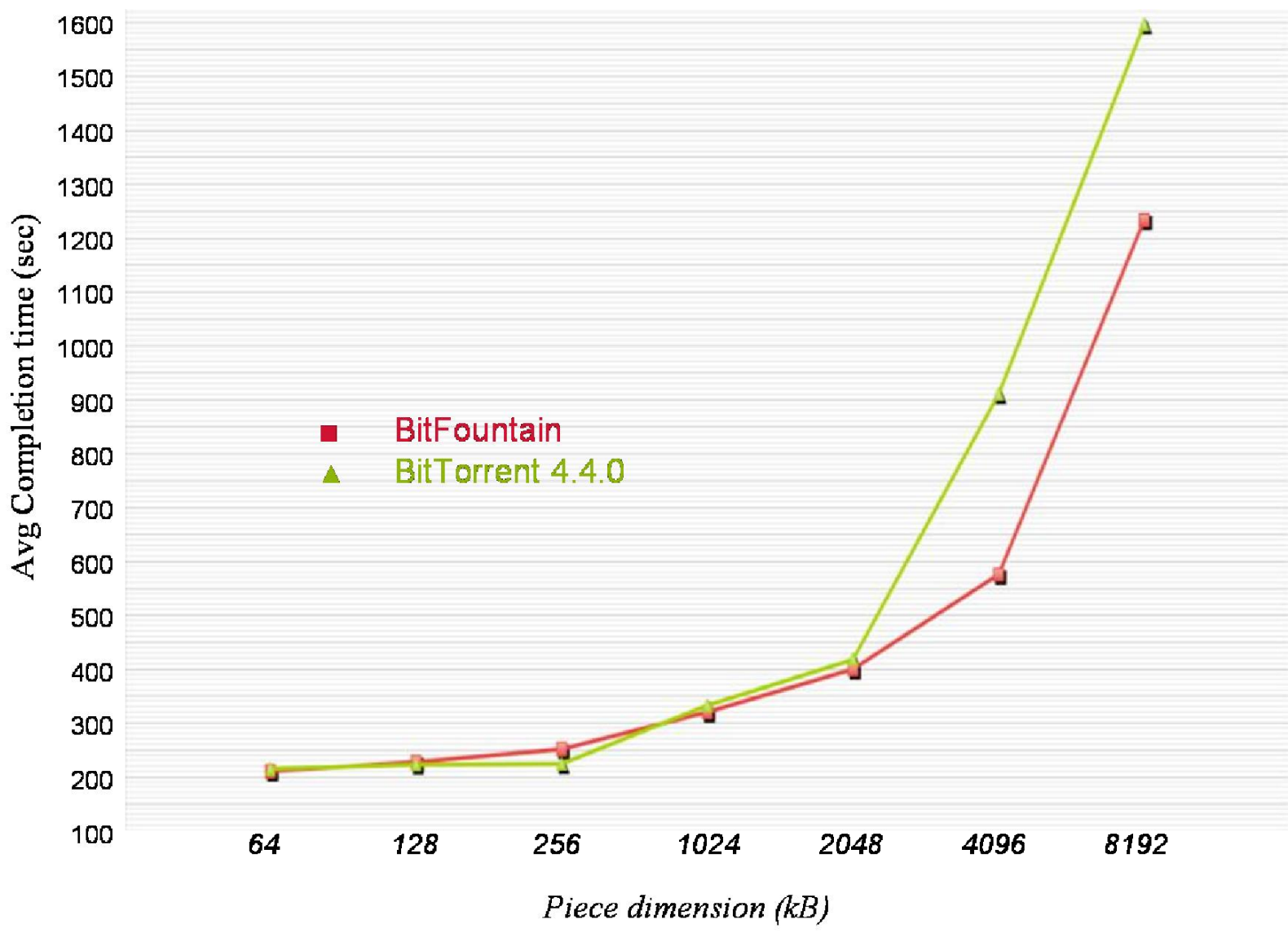
Within a P2P network paradigm the digital fountains can also be used to improve the efficiency of piece retrieval from different peers. The deliverable D6.2.3 improved the previous deliverables D6.2.1 and D6.2.2 implementing the adaptive decoding by message passing and the Gaussian inversion algorithm, while the final deliverable D6.2.4 provides a modified BitTorrent client supporting Digital Fountain for UDP network protocols. Deliverable D6.2.4 also provided an extensive benchmarking over the PlanetLab open network in order to better identify pros and cons of the Digital Fountains distribution technique over a real P2P network of participating peers and versus the traditional BitTorrent based clients.

Several experiments were carried out over the PlanetLab network using different BitTorrent clients properly adapted in order to understand and measure the benefit of this technology.

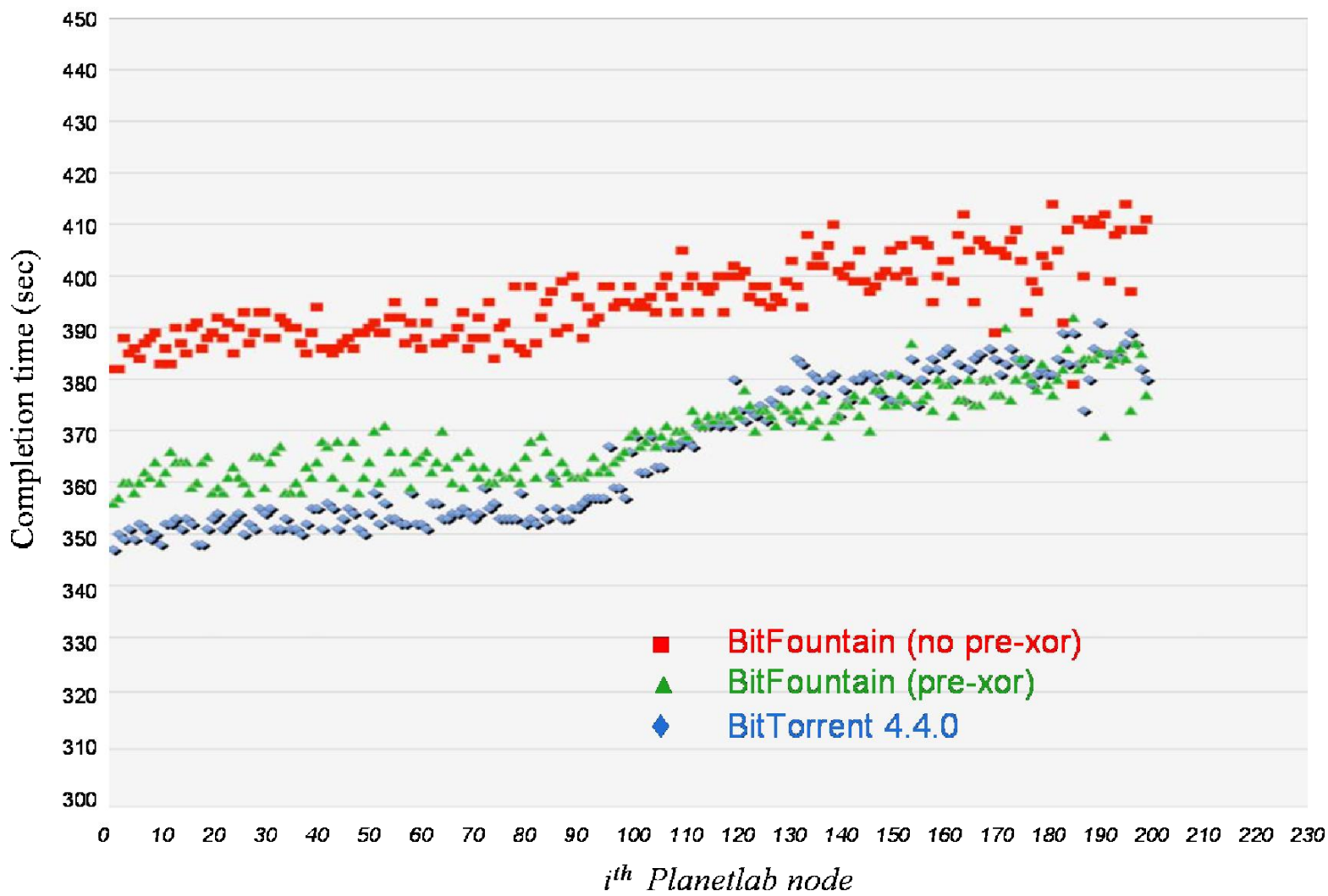
As we expected more encouraging results from our first comparison between BitTorrent (BT) and BitFountain (BF), we moved one step back, to more distinctly identify the effects of digital fountains within a mesh-based peer-to-peer streaming context. For this reason, we ran a new set of tests with a BF client based on TCP (as BT). The below figure shows that even rolling back to the original transport layer, the completion time difference between the two clients remained negligible.



At this point we decided to verify the effect of varying the piece size on the two protocols. The figure below shows that increasing the piece size, from a value of 2^{16} bytes to a value of 2^{22} bytes increases the completion time.



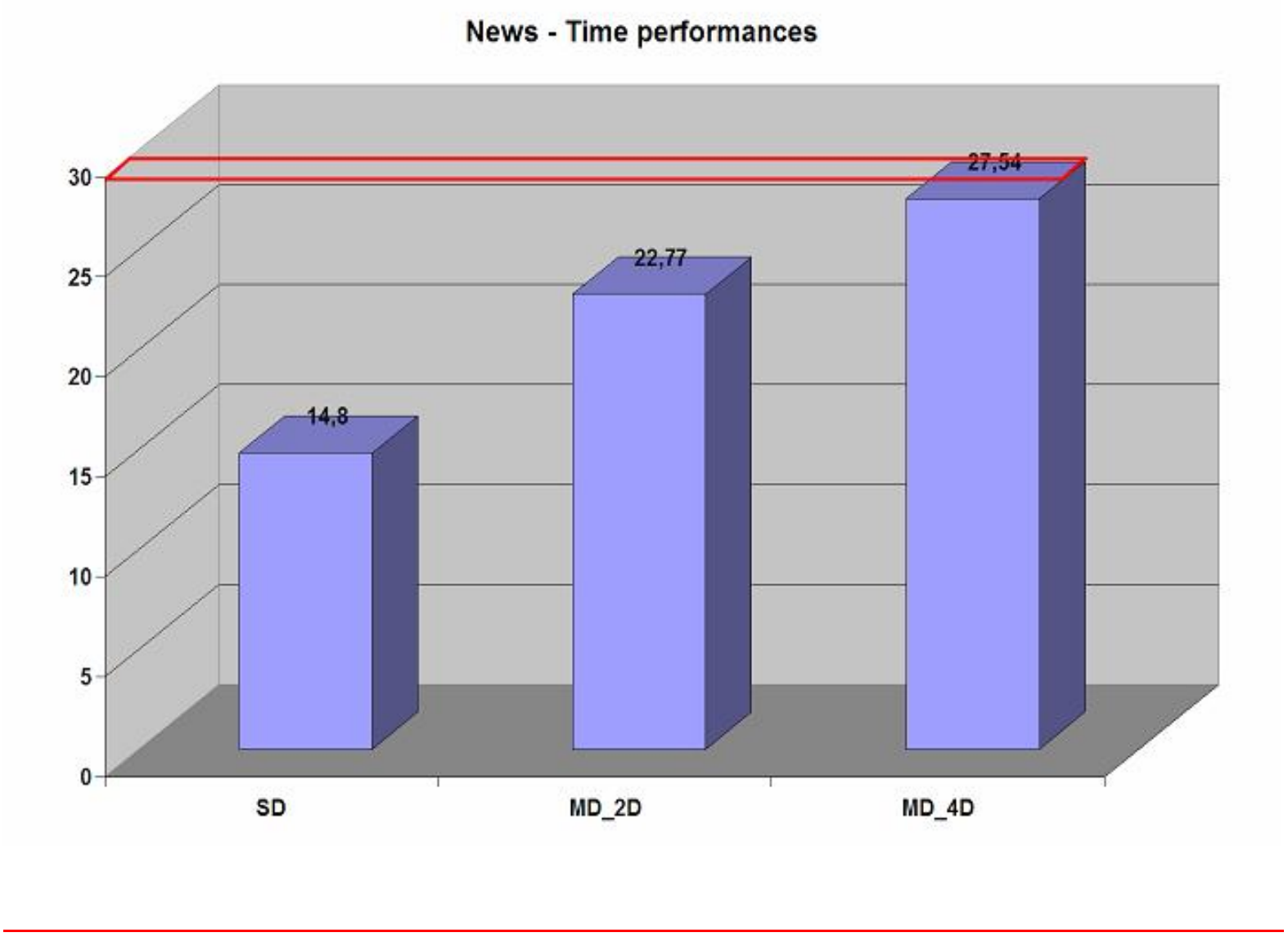
The results shown in the figure below, in particular aim at highlighting the importance of the coding and decoding delay within each node and showing the effects of randomly retrieving coded blocks compared to utilizing the BT protocol. We test three clients: BT, BF and a BF client where all the coding and decoding operations are pre-computed. Interestingly, a comparison between the completion times of the two BF clients indicates that about 30 seconds are wasted in the coding and decoding process. Moreover, as lower completion times typically correspond to better SETUP, END-TO-END and PLAYBACK continuity values, a first analysis of the below figure indicates that as it is, BF (pre-xor) peers achieve more or less the same performance of their BT counterparts (assuming coding and decoding delays negligible). A more attentive inspection, however, shows that the completion time of BT clients steeply increases between peers 100 and 130, while our BF client never changes its completion time growth rate.



2.3 WP6.3 - Multiple Description Video Coding (H.264/MDC)

WP6.3 has delivered tools for the Multiple Description Coding real-time receiver. MDC is a coding technique addressing recovery of network losses. The basic idea is to fragment the original sequence into “n” independent sub-streams referred as descriptions (differently from SVC where each layer is depending on the previous one) and let the peer recover all or part of the description and reconstruct, also through proper techniques to compensate the losses, the original content. WP6.3 has delivered both the pre-processing tools to obtain a parameterized number of independent sub-streams and the post-processing tools (integrated with an H.264 decoder) to reconstruct the original content given the possibly incomplete retrieved information. The figure below illustrates an example of the possible performance with the current implementation of the MD receiver scheme compared to a standard single description receiver on a AMD Dual-Core processor desktop PC. It can be easily seen that complexity of the MD scheme increases with the number of descriptions; the scheme

can run up to 4 descriptions in real time for the News sequence.



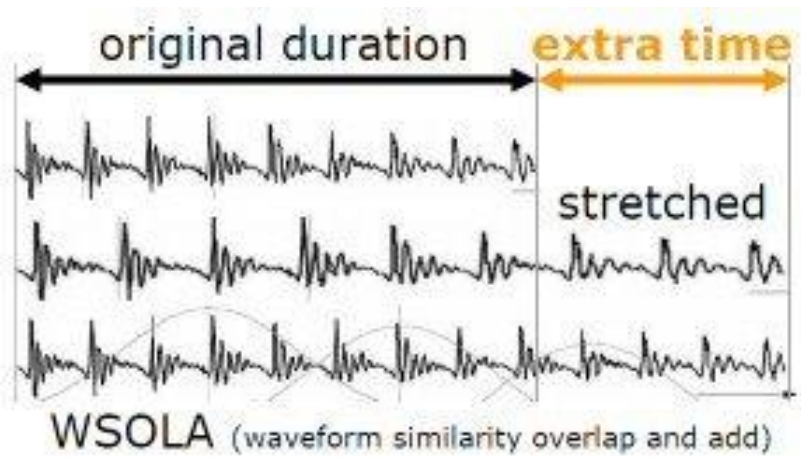
Time performances for News sequence (30 fps) with 1, 2 and 4 descriptions

2.4 WP6.4 - Audio and Video Adaptive Play-out

Adaptive play-out is the ability to make the play-out last longer or shorter. This is also known as or time stretching. or time stretching. It can serve several purposes, for instance buffer management and loss concealment.

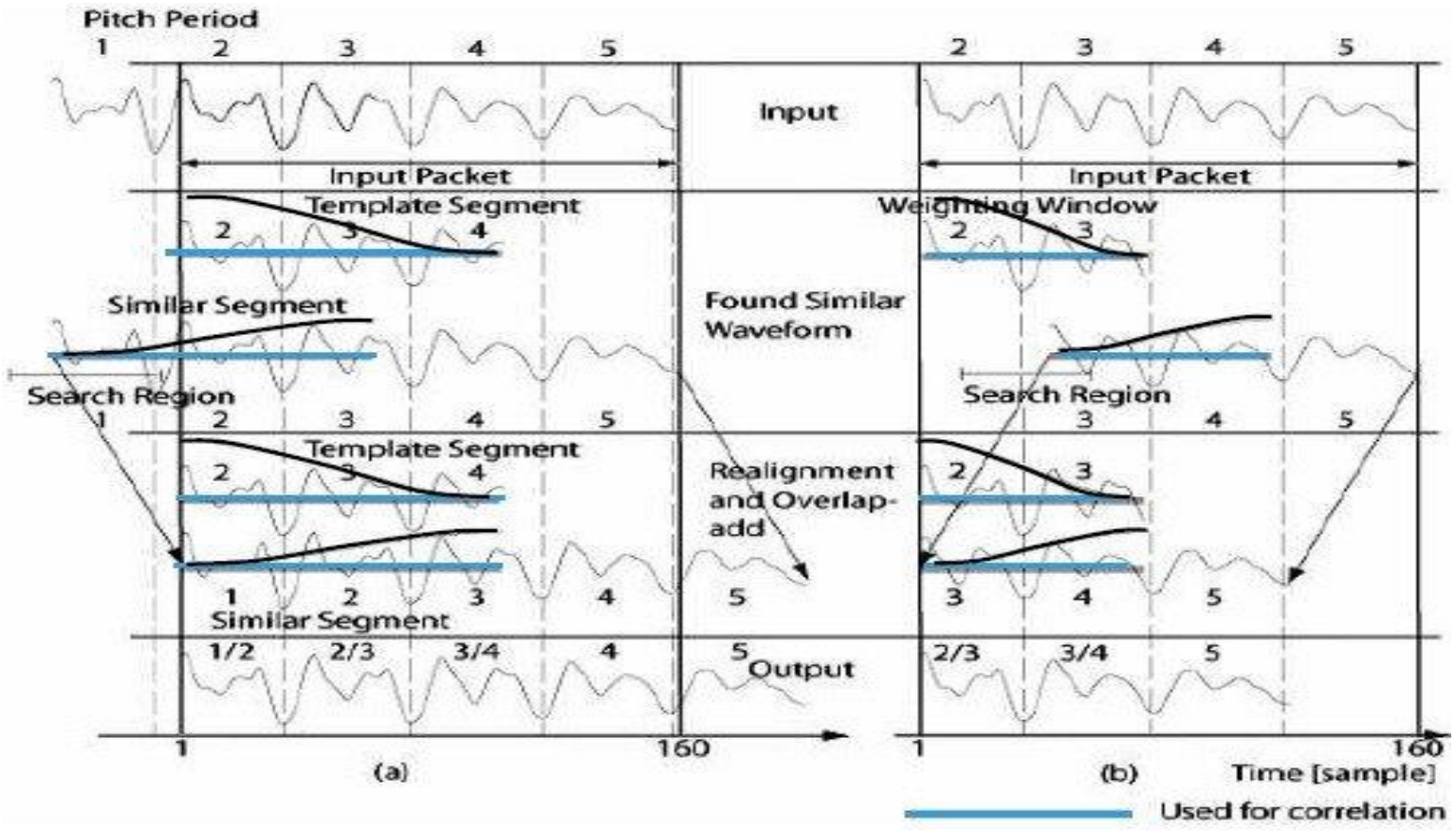
There are several techniques to do time-scale modification in the frequency or in the sample domain. If you simply stretch audio the pitch changes noticeably. Instead typical waveforms periods are cut-copied-pasted. One of the most advanced techniques to achieve that is WSOLA (Waveform Similarity OverLap and Add).

Following figure compares the approach of WSOLA and cut-copied-pasted.



In this work package WSOLA algorithm has been implemented. Then buffer management and loss concealment use cases have been addressed.

WSOLA approach is depicted in figure below

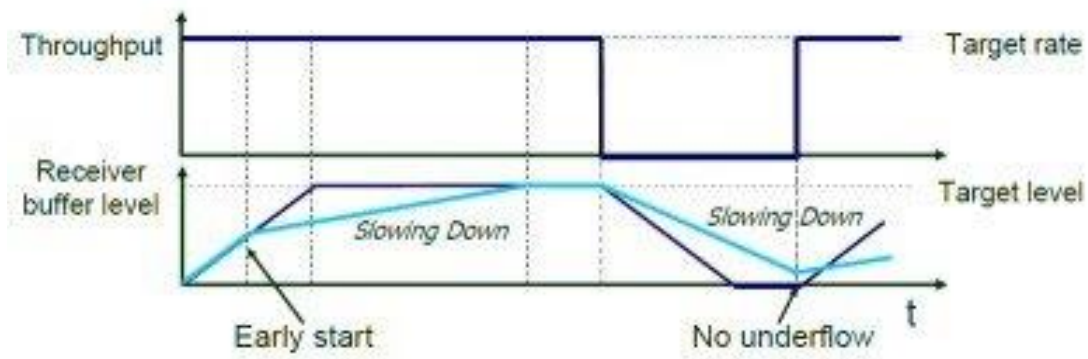


In this example the algorithm takes a segment known as template and searches back/forth for a best match. When it is found, the best-match is mixed with the template. Finally a longer/shorter segment is created by taking the mix and the rest of the segment from the best-match to the end of the packet.

It can serve several purposes as mentioned and briefly described below:

- Buffer management
- Loss concealment

1. Adaptive playout can be used to avoid buffer underflows/overflows by lengthening/shortening audio packets. Also, the pre-roll period can be shortened: the playout can start earlier, by slowing-down the buffer level will continue to increase, until an optimal level is reached as shown in figure below.



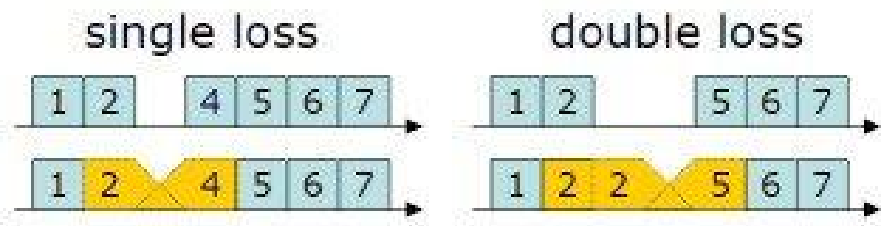
An adaptive control logic will decide the stretching factor based on network statistics (inter-arrival delays), buffer fullness and loss pattern.

The adaptation can depend upon packet contents. As an example unvoiced/noise segments can be stretched by a large amount; voiced/tonal segments are characterized by a trade-off between quality and stretching: transients can not be stretched.

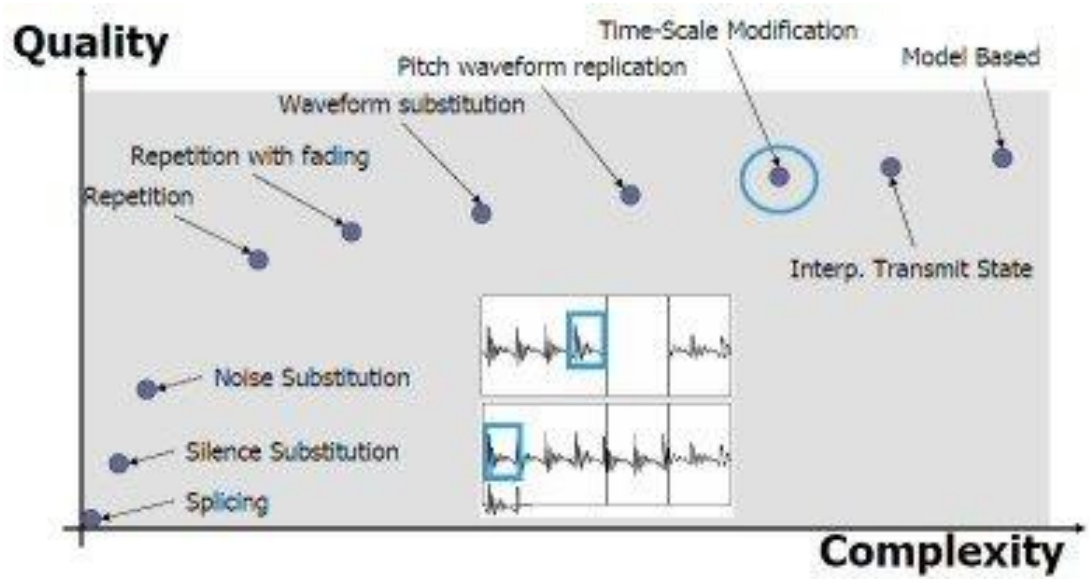
The adaptation can be time varying: lengthening can be done at the beginning of talk-spurts and shortening can be done at the end. This is known as **Virtual Buffering** as there will no buffer (hence no delay) except during talk-spurts.

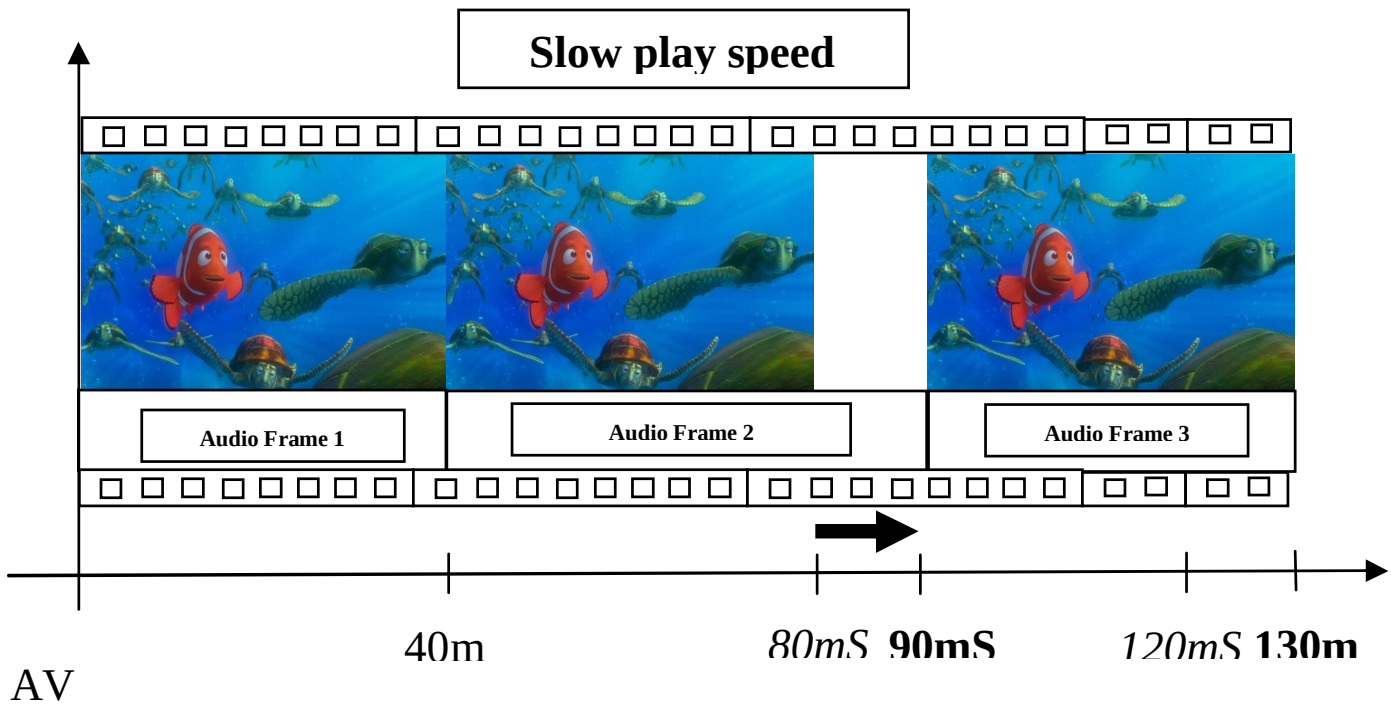
2. Loss concealment is done by stretching neighboring segments to literally fill the gap. The more the packets stretched, the less the stretching factor to be used and higher the quality.

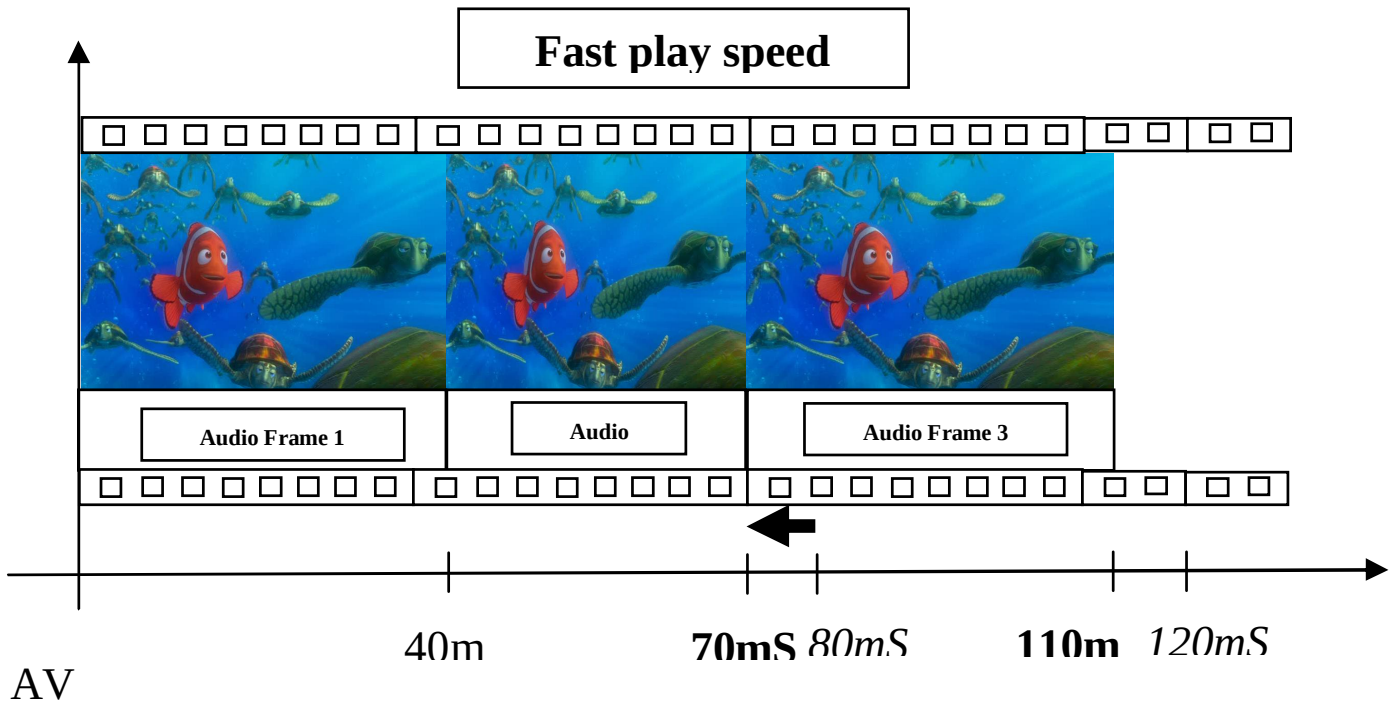
Actually packets will be stretched a little bit more than needed in order to be able to mix the overlap region and avoid discontinuities as shown in figure below.



The quality of the concealment will be very high with respect to other methods as shown in figure below.







2.5 WP6.5 - Integration of components

WP6.5 mainly addressed the second target of WP6: creation of a PC platform application integrating WP4 + WP5 + WP6 contributions to deliver a multi-OS application called NextSharePC to WP8 for the Living Lab trials. Given the different set of requirements involved with the prototyping of integrated WP6 technology and with the user-centric approach of the Living Lab trials, it was decided to create two parallel streams of integration, the first mainly addressing, through targeted technical tests, feasibility and technical effectiveness of innovative WP6 technology. User-friendliness and multi-platform support was considered with lower priority with respect to feasibility and performance. The second stream was oriented to progressive enrichment of NextSharePC to be deployed into the WP8 Living Lab and subject to WP8 acceptance criteria. Enrichment of NextSharePC came from WP6 prototypes (the first stream), from WP4 and WP5 technology (e.g. LIMO).

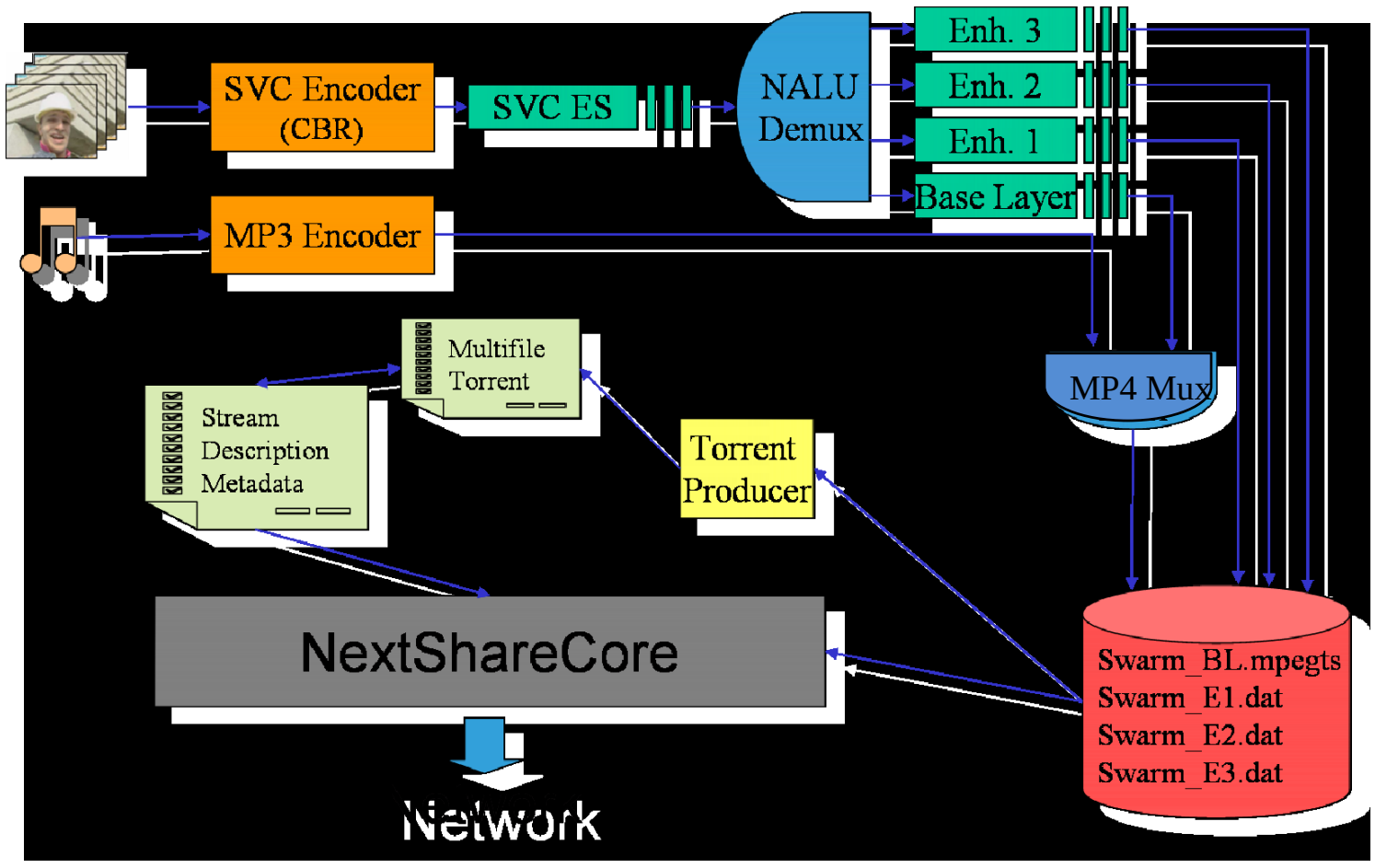
2.5.1 Integration of SVC lab prototype

The prototype integrating the Scalable Video Codec (aka SVC) basically was splitted into two applications:

- The first, named "producer side", providing the non real time SVC encoding, packetizing stream and metadata preparation.
- The second, named "consumer side", providing the P2P-Next client SVC enhanced, capable to download decode and render the SVC content coming from the P2P-Next swarm,

So, finally, the SVC demo prototype includes:

<u>On the producer side:</u>

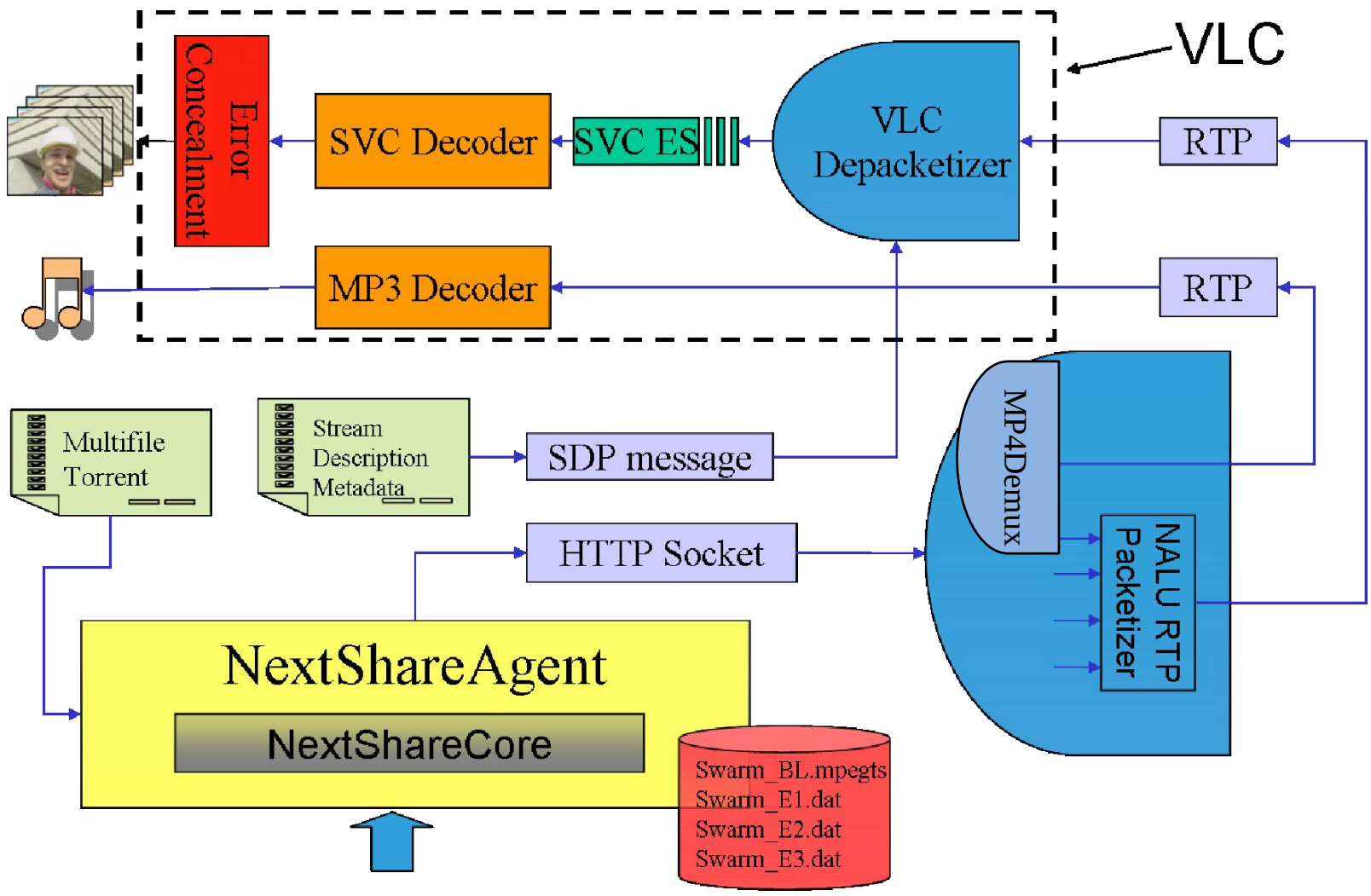


<u>Individual</u> blocks from above schema described in logical flow of data:

- **RAW data:** PCM audio file and YUV video frames, representing the original media content, stored on the Hard Disk. They can be transcoded from an original encoded sequence using VLC to create intermediate YUV frames. In this case PCM samples are not needed, VLC can eventually transcode from the original audio format to MP3 if needed.
- **SVC encoder:** this has been provided by WP6.1. It includes a Constant BitRate algorithm which permits to keep the bitrate of each layer's contribution almost constant. It creates an SVC compliant elementary stream on the HDD.

- **SVC NALU demux**: the aim of this block, also called **SVC Splitter**, is to demultiplex the contribution of each scalability layer and create one file per layer as described in 2.2.1.1
- **MP4 Muxer:** The *.dat* files created by previous block and related to enhancement layers can be delivered "as is" by NextShare. On the other hand, the base layer (also containing all the stream control information) must be synchronized with the audio content and then delivered inside an MP4 stream. The created *.mp4* file should then be playable by any H.264 enabled device/PC supporting mp4 container format.
- **Metadata creation:** This part includes the torrent file creation and scalability related metadata. The torrent file and the rich metadata description containing the scalability related metadata were linked to each other as defined within WP5.2. The rich metadata description provides information about the properties of each layer (i.e., the resolution, frame-rate and bit-rate) and these information can be used for the piece-picking process. The rich metadata description is created automatically based on the header information of the SVC stream.
- **Scalability enabled NextShare^{Core}:** this part was under the responsibility of WP4 and WP5.2. At each NextShare client that consumes an SVC stream, the pieces of the different layers are downloaded based on the priority (deadline), the sensitivity (layer), the availability in the network (rarest-first), the network conditions (bandwidth estimation), and the usage environment (context-related metadata). Piece-picking algorithms which consider these priorities have been developed in WP5 and have been integrated into the NextShare core.

On the consumer side:



Individual blocks from above schema described in logical flow of data:

- **Scalability enabled NextShare^{Core} with Agent:** It retrieves the different layers following the mechanism described in section 18. The agent then streams the recovered data to an HTTP socket
- **SVC streamer:** This block takes the stream from the HTTP socket, demuxes the SVC base layer and audio layer from the MP4 container, streaming the latter on an RTP socket and inserting the proper time stamps into RTP packets. The video base layer is then multiplexed with the the contributions of the enhancement layers (whenever available), rebuilding a sequence of "access units". Each access unit contains all available layers' contributions for a certain video frame. Access units are then mapped into RTP packets and sent to the video RTP socket, according with current related IETF draft specification 75.
- **SDP message:** The properties of the SVC stream that are available in the rich metadata description (from WP5) are provided to the VLC utilizing the Session Description Protocol (SDP). This information is subsequently used to configure the SVC de-packetizer.
- **SVC RTP De-packetizer with VLC support:** VideoLan client retrieve synchronized audio and video packets from the two different RTP audio/video sockets. Audio is reproduced using already available plug-ins/libraries while SVC packets must pass across a VLC plugin developed by STM (SVC de-packetizer), which opens the RTP packets and feeds the SVC decoder with the payload, also providing the time stamps to the video rendering plug-ins. The de-packetizer must be provided with the the stream properties(number of max layers, type of scalability, etc.), such information coming through VLC thanks to the SDP message.
- **SVC decoder:** This is the optimized SVC decoder delivered within WP6.1 context The decoder gets initialized with the highest SVC layer information (resolution ,quality,bit rate), theoretically provided by the stream. Within the current delivery the decoder was moved from the optimized JSVM9.15 to the better performing OpenSVC.
- **Error concealment:** this block, developed by VTT, is logically part of the decoder, where it was integrated. It provides error robustness to the decoder and conceals the errors mainly with the upscaling algorithm. Within the SVC integration context it is used to upscale/conceal the missing enhancement layers by upscaling the pictures to the highest resolution/quality.

2.5.2 Integration of NextSharePC platform

NextShare^{PC} latest V6 version consists of two plugins for video playback in a Web browser, called the *SwarmPlugin* and the *SwarmPlayer v.2*.3 Allowing playback directly in a browser makes it easier for content providers to integrate peer-to-peer based video delivery into their existing Web based distribution mechanisms (e.g. portals). The SwarmPlugin is a browser plugin that uses the VideoLAN Client (VLC) for video playback. The SwarmPlayer, as described below adds the tribe:// peer-to-peer transport protocol to a HTML5-capable browser which then handles playback in native HTML.

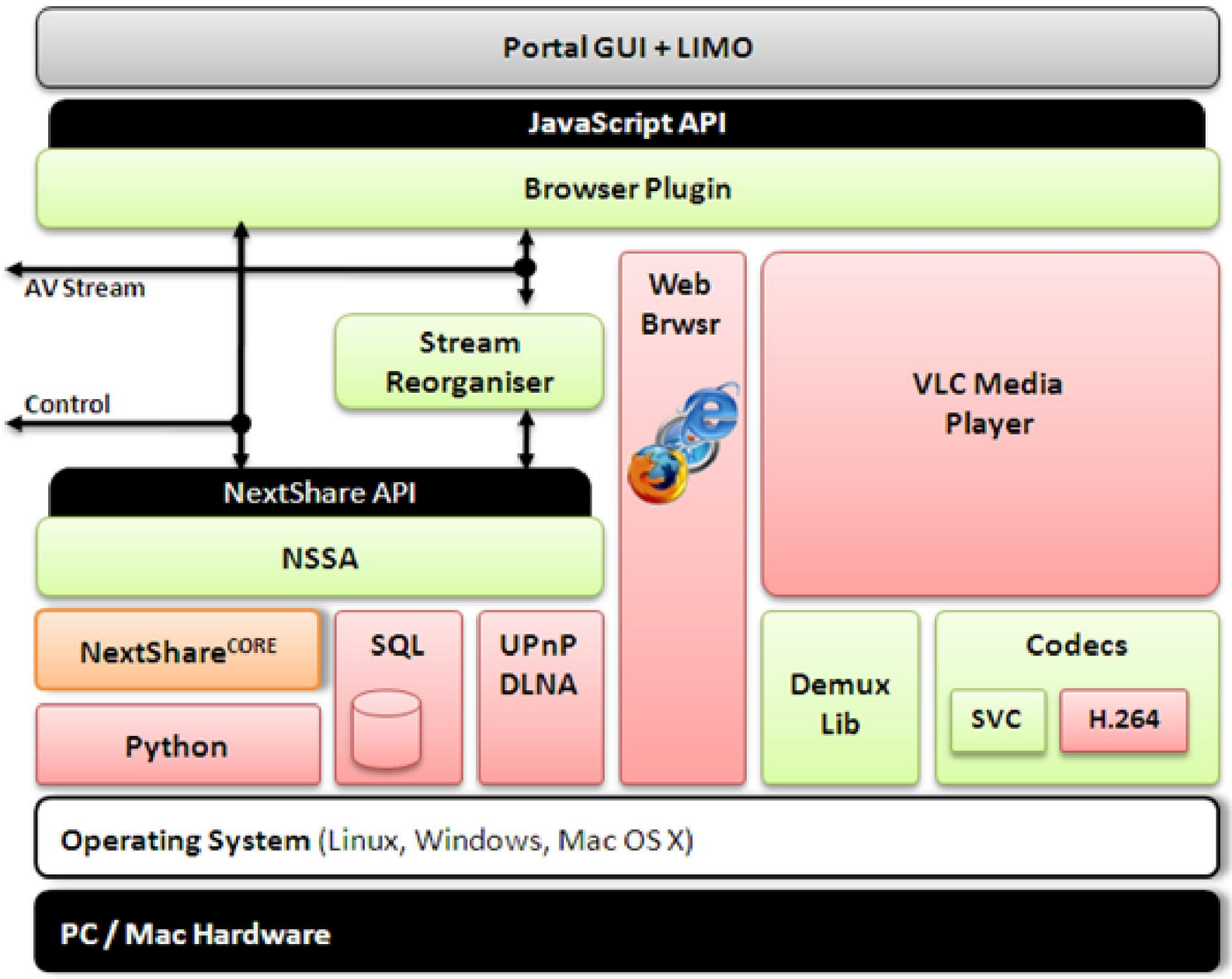


Figure 6.5: NextShare^{PC} architecture

The NextShare^{PC} application which implements the core of P2P-Next protocol consist of two parts:

- A back-end server called NextShare Agent (NSSA), which embeds the P2P core engine NextShare^{Core}
- A front-end part in charge of providing the user interface and content playback functionalities.

The NextShareCore usually called "background process" is the key component for the deep browser integration, and it acts in a non-intrusive way adapting the bandwidth donation to the actual network utilization. While on the other side the front-end web application (LIMO and/or web page) running on top of the browser VLC plug-in, is responsible of visualizing content and interacting with the final user.

During the project lifecycle an important exploitation of the NextShare^{PC} was its adoption by the Wikimedia Foundation to distribute Multi Media content. To support this exploitation a new variant of NextShare^{PC} was developed. The Mozilla Firefox web browser, with the appropriate plugin installed, currently is able to understand URLs that start with tribe://... in addition to traditional http://...

Thanks to its full HTML5 integration and compatibility the SwarmPlayer is specifically intended to be used with the new HTML5 media elements <video> and <audio>

which allow direct rendering of video and audio in a standardized way (cf. <img> for images.), and which are used also by WP5's LIMO.

2.6 Zoomable User Interface

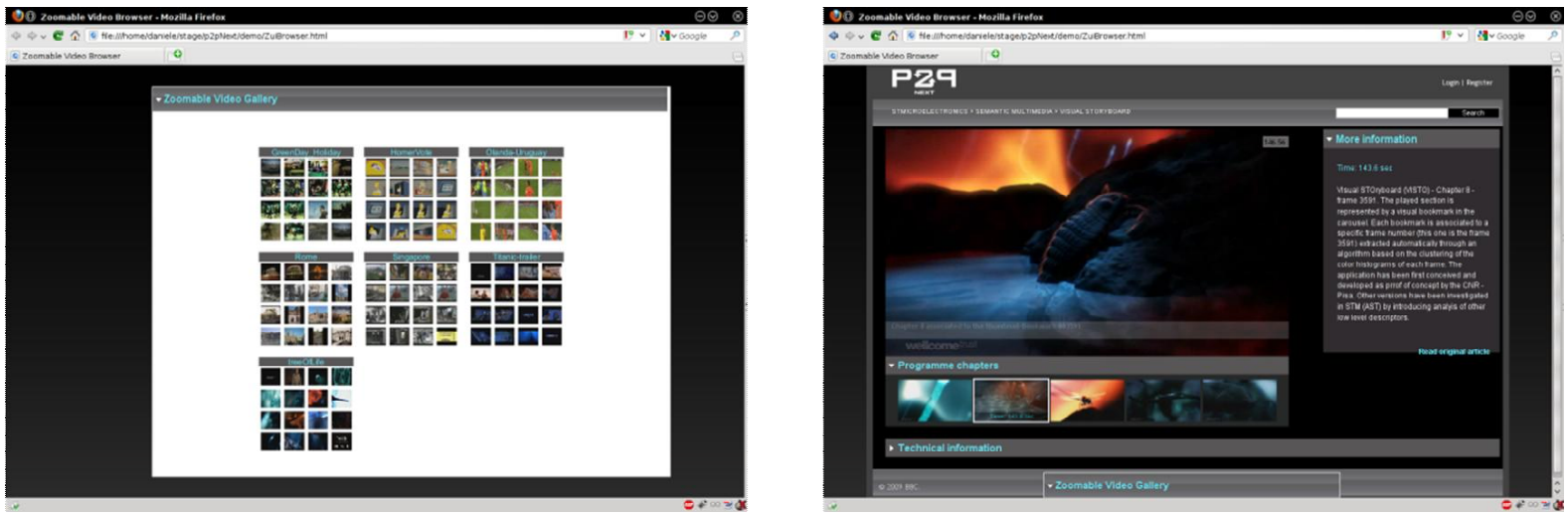
Workpackage WP6.6 has developed an innovative GUI, called Zoomable User Interface (ZUI), which permits to browse properly organized media contents zooming into a desktop area. ZUI can be exploited to provide an alternative and effective view of a file system, to realize a mosaic of video channels, a hierarchical program guide and zoomable micro-navigation system (chapters in video sequences). More precisely within P2P-Next it was decided to integrate the ZUI as a possible NextShare interface, thus providing an alternative to the main (and more complete in terms of features) web-technology based NextSharePC GUI. The FileMage[1] Zoomable User Interface (ZUI) has been extended to allow the **integration in a web page** and the visualization of **video storyboards**.

The provided demo application demonstrates how the ZUI can run inside a web browser (eg. Firefox or Chrome), being used for browsing a video collection. The demo consists of 2 modules:

- ***browsing module***: a web page embedding the ZUI as an applet for displaying a collection of video storyboards.
- ***playout module***: the BCC Limo demo page, a web page displaying a video and its chapters, plus a short description.

The demo is built with standard web technologies: Html (and in particular the last Html5 features for the video playout), Css and Javascript.

The **web page integration** has been made possible thanks to the creation of an **Applet version** of the FileMage ZUI. Figure 13 illustrates on the left the storyboard ZUI panel and on the right the ZUI running a video sequence in the BBC LIMO web page from within the Firefox browser.



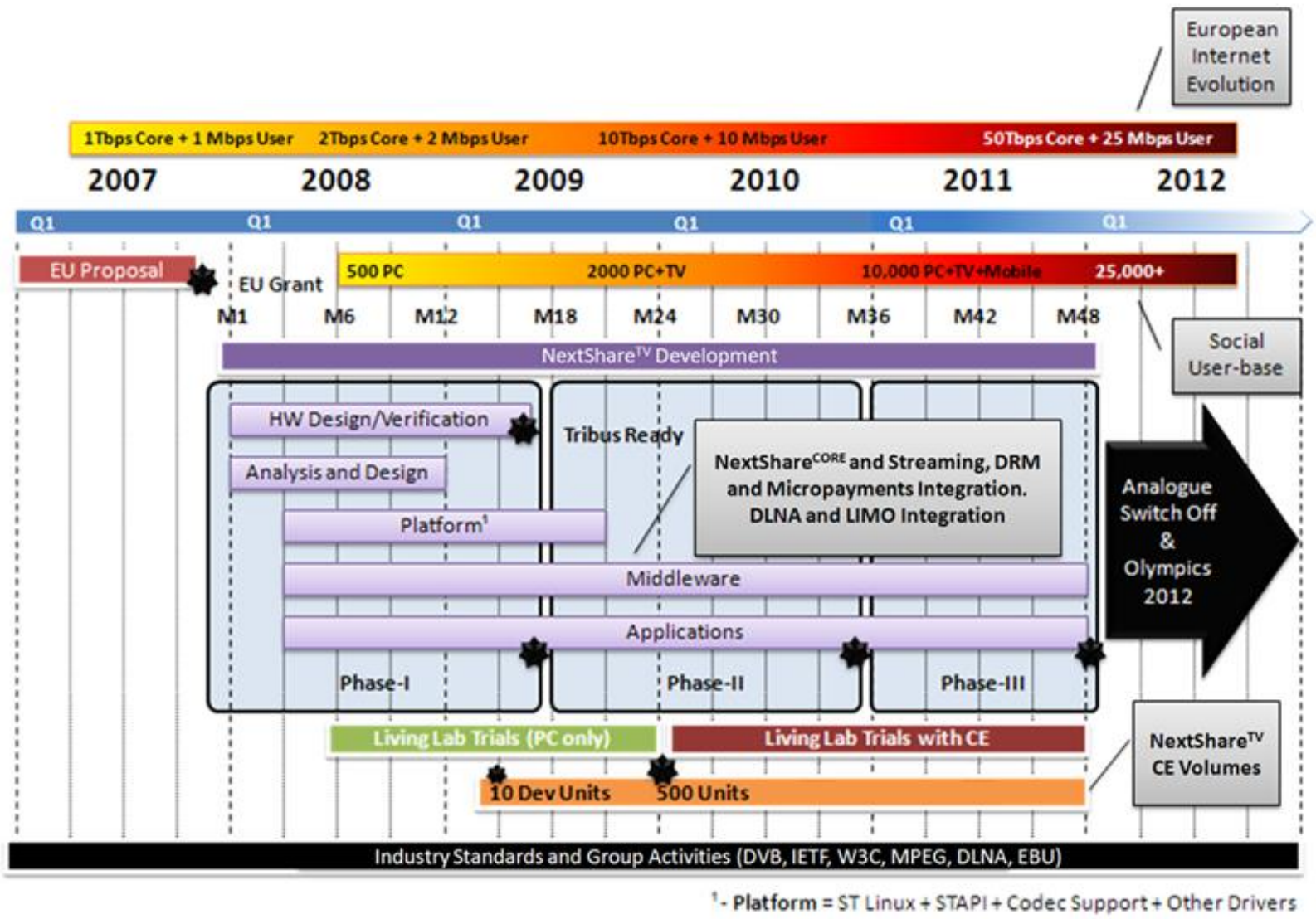
The ZUI running in Firefox

1 FileMage is a Zoomable User Interface application and is based on the Spellbook library, both developed at STMicroelectronics; Spellbook relies on the Piccolo2D open source framework (www.piccolo2d.org)

3 Executive Summary of WP 7 “CE Integrations and Prototypes”

The scope of work package WP7 was to develop a consumer device and user applications to aid the discovery, enjoyment, publication, and proliferation of a broad universe of legitimate digital media.

- All the aforementioned digital media shall be delivered via a next generation P2P media delivery network called NextShare;
- Users of the device shall be able to engage with a social network that shall amplify their abilities to discovery, enjoy, enhance and share digital media;
- Users of the device shall be able to purchase a broad spectrum of content from niche or local programming, through semi-professional, to premium[1];
- The consumer device shall be able to interoperate with other networked peripherals such as mass storage, camera, hand held, and home PC devices residing on the premises home network



The following table reports upon the achievement of the core objectives of WP7 in accordance with Annex-I of the project - using traffic light conventions:

Objective	M52 Status
Obj1 - Development of a consumer electronics device that gives consumers direct access to the P2P-next medium without requiring a PC for intermediation purposes	
Obj2 - Applications to enable self-provisioning and effective boot-strapping of a new consumer into the P2P-next community via NextShareTV and their remote control	
Obj3 - Applications to enable access to the content and services of the P2P-next medium but via a simplified user interface accessible via a remote control (continuous integration and utilisation of the core NextShare capabilities and APIs)	
Obj4 - Applications that showcase the possibilities that arise when P2P-next content and services are partnered with a traditional linear TV experience, and more specifically how the traditional EPG experience can be enhanced by the presence of social network derived metadata, and richer TV-Anytime structured metadata, as associated with on-demand content source material.	
Obj5 - Investigation into the requirement for adaptive user interfaces according to preference and/or experience-level of the consumer	
Obj6 - Support for multiple family members profiles and preferences, respecting their varying usage contexts, within a typical family home	
Obj7 - Manufacture of between 500 and 2000 in staged releases to the Living Laboratory2	
Obj8 - Online updates to CE firmware and consideration of how viable a continuous modular update capability would be for CE devices – in line with philosophy of continuous software updates advocated by the NextSharePC community	
Obj9 - Logging of usage of the P2P-next medium (content and services)	

We have managed to define a set of NextShare^{CORE} configuration parameters and algorithm patches that offer a stable and consistent services for both 576p and 720p content types – for both Live and VoD use cases. In addition, we have completed integration of the new *swift* protocol and proven that the low-power NextShare^{TV}

[2] A total 300 units were delivered to ULANC in the reporting period due to budgetary constraints reported and justified in the M24 report and subsequent 2010 review meeting.

device we have developed is capable of playing back Full-HD resolution content using this new protocol.

In addition we have create both a QA framework and remote testing framework that enable repeatable and thorough inspection and analysis of both the BitTorrent based NextShare protocol and *swift* protocols.

3.1 Overview of Work

M18 corresponded to the completion of **Phase-I** of WP7 activities. Phase-I aimed to create a baseline proof-of-concept platform that showed that NextShare on a CE device, of the lost-cost profile of NextShare^{TV}, is both possible and effective from a users point of view. It demonstrated that it was possible for users to provision themselves onto the P2P medium and begin to consume both Live TV and on-demand content in both SD and HD H.264 format with the Phase-I NextShare^{TV} prototype.

The **M24** deliverable represented a refinement of the **M18** release and included the following features and capabilities:

- Improvements in overall GUI performance through the replacement of the Trolltech Qt GUI framework with a custom built framework running on top of DirectFB;
- Evaluation and integration of optimised alternatives to the Python NextShare core software, specifically based on the Open Source libtorrent code-base;
- Facilitation of HD streaming to the STB at a bitrate of 2-3 Mbps and at a resolution of 720p24 – including production of a tool to allow remote configuration and management of test-swarms for the purpose of integration testing and public demonstrations.
- Addressing of subtle timing and buffering issues effecting the real-time decoding of HD streams, that arrive in a “bursty” manner from the optimised P2P middleware based on libtorrent;
- Integration of hardware acceleration of authentication processing utilising companion chip firmware developed by ST Microelectronics;
- Support for execution of NextShareTV entirely from a USB stick, without recourse to a built-in SATA HDD, and the associated provisioning, security considerations and maintenance of this device;
- Incremental improvements in the look-n-feel of the NextShareTV applications, based on initial feedback from project partners and the industrial community;
- Refactoring of the end-user applications code to increase maintainability and flexibility, along with the removal of Qt framework dependencies;
- Integration with the provisioning processes of the Living Lab trials;
- Implementation of operational statistics generation within the NextShareTV platform and its reporting back to the back-end services operated by other project partners;

- Implementation of an EPG based on WP5 metadata sources formatted as Atom feeds, which serve as the basis for extensions that utilise enhancement metadata/intelligence generated via the overlay or services provider: e.g. recommendations, related materials, presence-based information (behaviour of friends within a users social network);
- Initial architectural studies that outline the integration of NextShareTV with the WP5 Next-ad-server infrastructure and micro payments services planned beyond M24.
- Finalisation of Quick Start Guide and outer packaging in preparation for mass production and shipping.

The **M36** deliverable represented the completion of **Phase-II** of WP7s work plan and the completion of subcontractor activities in relation to the hardware.

M36 further refined the capabilities of the **M24** release/deliverable as follows:

- GUI enhancements and usability refinements driven from partner and trialist feedback;
- Preparation of a number of v1.x.y releases of NextShareTV for integration intooperational environment, and deployment to trialists;
- Support for enhanced metadata (feed-of-feeds);
- Preliminary libswift integration and testing;
- First stage of DLNA integration and utilisation for photo slide shows; Will form the basis for sharing of UGC (user-generated content) and mobile phone (iPhone and Android) mash-up between M36-M48;
- In-depth performance evaluation and analysis of Python M32 NextShare core release;
- Passive social extensions via integration with Facebook and Twitter (in particular addition of social metadata in the form of public tweets about the programme currently being consumed);
- Active social extensions and shared experience TV (watch-this-with-me);
- Manufacturing and shipment of 300 units of NextShareTV to project partners sites throughout Europe for usability testing;
- Support for remotely scripted testing of populations of NextShareTV devices as part of the WP8 integration work;
- Improvements to NextShareTV statistics collection and feedback on status via Technical Info dialog, along with refactoring to allow for improved stability and performance testing;
- Significant testing of piece sharing in test-bed of 16 x STB;
- Migration to M32 NextShare core software delivered by WP4.

The **M52** deliverable transformed the **M36** into what we considered a feature complete

prototype. It completed integration with the Living Lab content delivery platform spanning content discovery and social networking aspects, as well as incorporating feedback from end-users concerning usability and stability under normal operating conditions.

M52 further refined the capabilities of the **M36** release as follows:

- DLNA-based device discovery and browsing;
- Enhanced support for multi-device UX and remote control - incl. integration and testing with both Android and iOS based smart phones and tablet devices;
- User feedback submission on QoE (aka BLUE button interaction);
- Search and discovery user experience allowing free text searching of title and synopsis of content on NextShareTV network;
- Extensions for automated control of NextShare^{TV} for quality assurance purposes;
- Playback of collections from USB;
- Sharing of USB collections using UPnP / DLNA;
- Enhancement of DLNA / UPnP sub-system features:
    - Integration with Internet Gateway Devices - simplifying user setup
    - Client pop-up notifications
    - Integration of comment and ratings
    - DLNA now always enabled for all users
- Performance optimisations, in particular how seeding of large numbers of assets are managed (along with resuming of partial downloads);
- Improvements to the reporting of lost, stalled, dropped pieces during the operation of streaming - to allow for correlation with QoE feedback reported through the BLUE button interaction of trialists;
- Intensive testing and profiling of caching and seeding functionality;
- Migration to M40.1 release of NSC from WP4 - incorporating fixes for sharing in small swarm configurations;
- Integration and testing of distributed keyword search (although this was later disabled due to intrinsic performance overheads of running overlay functionality and its effect on streaming operation of STB - in particular SQLite query overheads associated with massive volumes of collected torrent/tstream files);
- Significant work to implement improvement to usability and UX based on feedback from Living Lab trialists;
- Multitude of improvements to the application's presentation and operation for a smoother experience including a new Main Menu structure for Browse and Search;

- Developments in parsing and using ULANC feeds for providing extra functionality for catchup VoD;
- Tweeting developments: user can specify a personal hashtag in their tweets and retrieved Tweets can be parsed for SocNET links with associated media played directly;
- QA system feedback messages;
- Optimization and testing of NSC for release to second round of LivingLab trialists;
- Preparation and optimization of NSC for IBC and NEM multi-peer demo including the preparation and testing of a demo swarm spanning a number of STBs spread across partner sites in Europe;
- Enhanced Geo-IP tagged swarm peer summaries (and the introduction of a diagnostic mode GUI, allowing users of NextShare^{TV} to see real-time levels of UL/DL to other STBs);
- SSH access to STBs supported for enhanced debugging;
- Workarounds were implemented to avoid audio breakup after a VoD seek;
- Support for playback of libswift-based VoD streams via the UPnP remote playback mechanism;
- Publication of content e.g. home movies directly via NextShareTV, without being intermediated by a high-performance PC – direct sharing of this content with friends via P2P.

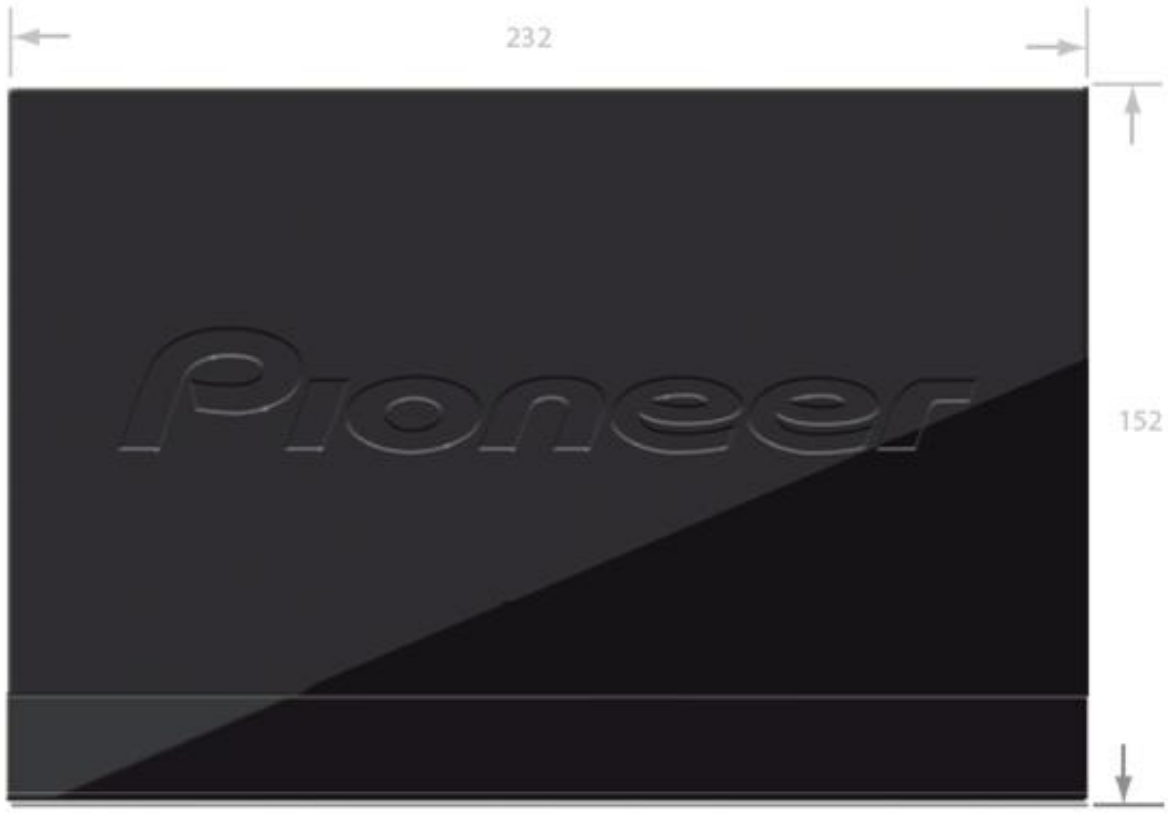
3.2 WP7.1 Tribus Hardware Platform and Remote Control

WP7 has manufactured and shipped 300 units of NextShareTV to ULANC and project partners sites throughout Europe for usability testing and local Living Lab integration.

3.2.1 N-Tronix Ltd Hardware Development

The electrical and mechanical design of NextShareTV was completed by M24, and a series of debugging pilot boards were manufactured and tested, culminating in the successfully mass production and distribution of 300 units to Living Lab trialists across the partner sites.

In the end the following simple chassis concept was selected by the consortium:



The following remote control design was selected:

Equinox E-Designs completed the PCB and schematics design for NextShare^{TV} by M6; in addition their high-speed DDR2 simulations of the board design completed successfully. The figures below show photo-realistic renderings of both the front and rear panels of the M18 NextShare^{TV} device:

Due to SATA support being removed from the underlying system-on-chip, a PATA-SATA stem board was developed to bridge the PATA HDD of the chip to the SATA HDD terminal for M18. As of M24 the PATA-SATA workaround was however removed, due to the restoration of SATA support to the Cut 3.0 silicon by ST Microelectronics.

Between M18-M24, the following activities were undertaken by N-Tronix Ltd (formerly Equinox E-Designs) on behalf of WP7 in their capacity as sub-contractor:

- EMC testing and CE marking processes where completed successfully (certificate of conformity included on following page for reference.
- Technology licensing has been completed, in particular:
    - MPEG-LA licensing for MP3 and H.264
    - Budget Pack WEEE registration underway
- Mass production test process, jig creation and test software was completed in cooperation with Marsh Consulting Ltd:

At the time of writing all 300 devices have been manufactured and supplied to Living Lab trialists.

A total of 275 NextShareTV devices were obtained from the 300 produced, representing a 10% failure rate. The remaining 25 boards exhibited various fault conditions that would need to be debugged before they can ever be deployed. It is not

possible to give a time-scale for how long it will take to inspect and debug the remaining 25 boards – hence they are considered beyond economical repair.

3.3 Marsh Consulting Platform Development

During **M0-M18** a number of platform readiness issues had to be contended with, which ultimately impacted the middleware and applications layers:

- Stabilisation and performance optimisation of Trolltech's Qt user interface framework on the ST Micro blitter chip integrated into their 7xxx series system on chips (SoCs)
- Integration of the data persistence engine
- Handling of video playback - in particular Matroska container support
- Control of HDMI output interface during initial setup of the Tribus STB
- General stability and performance optimisation work
- Network configuration and sensing work
- Supporting PDD with the Live CD release preparations
- Working in cooperation with PDD staff to create object wrappers around key platform functionalities mentioned above

During the 6 months from **M18-M24**, Marsh Consulting contributed the following platform and middleware integration results:

- Supporting refactoring of the Pioneer GUI framework and removal of Trolltech Qt in terms of the integration of the middleware with the directfb layer and underlying ST graphics/framebuffer drivers.
- Integration and testing of the Cryptographic Coprocessor OpenSSL engine supplied by ST Micro Electronics (AST) into NextShareTV. Subsequent benchmarking of the crypto engine to provide some performance figures for the set top box using SHA1 for various block sizes.
- Addition of support for USB mass storage devices to enable NextShareTV to run on a STi7200 cut 2 processor which has a non-functional SATA interface.
- Boot Application extensions to support both mass storage devices connected via either USB or SATA. USB devices take precedence over SATA devices to enable NextShareTV to be installed and run from a memory stick for demonstration and privacy purposes.
- Working with ST Micro Electronics to determine why the audio driver crashed when used. Eventually it was determined that the audio driver was not ported to support 32 bit addressing. A workaround was implemented by moving the A/V memory buffers used by the audio driver into the lower 128MiB of system memory.

- Working with Milton of PDD to integration the libtorrent streaming client solution with NextShareTV middleware and H.264 decoding platform.
- Preparation and support for the WP7 demonstrations of NextShareTV at IBC and NEM.
- Provision of a test mode to be used for automated testing of the NextShareTV units during mass production in cooperation with N-Tronix.
- Integration of the M16.3 (tp6) python code release using Python 2.5.4 for NextShareTV due to the poor reliability of the libtorrent solution on the set top box. Multiple user support added by restarting the tp6 python client in a different folder when a user logs out and a new user logs in. Extensive analysis and optimization of the tp6 release to minimise delays when starting a live stream.
- Support for DVI monitors added to allow cheaper monitors to be used with NextShareTV, support for which was not provided by the underlying ST drivers.
- Cooperation with N-Tronix to diagnose problems with the trial manufacture of the revision B PCBs using Sti7200 cut 3 processors.

During the 12 months from **M24-M36**, Marsh Consulting completed the following activities:

- Assisting PDD with the optimization of NextShare Core Live Streaming;
- Testing of Software Update Server with regard to NextShareTV firmware download and installation;
- Implementation of remote access to the STB file system using a Web Browser (for local testing purposes);
- Change to Internet Connection Detection on RESNET within LivingLab;
- New Technical Info Dialog support (interfaces to hardware and platform status including CPU core temperature, CPU statistics, network configuration etc.);
- Evaluation / Debug of Rev D STB Hardware from Ntronix;
- Testing/debugging of RevE samples based on 7200AWC SoC;
- Testing/debugging of RevE samples based on 7200ZWC SoC;
- User feedback [flashing LEDs on front panel] during a software update;
- JSON parsing integration;
- Volume and Parental control;
- Remote Testing requirements, architecture & design participation;
- Debugging non-deterministic NSTV crashes [ODT of DDR termination being disabled];
- Support for additional MCE-RC6 and Konig remote controls;
- Software Update 1.1.1.5694 to patch U-Boot for ODT fix;
- Software Baseline for Mass Production 1.1.2.5791;

- Remote Testing Implementation and Testing;
- SSL added to SocNET APIs;
- Assistance with the initial evaluation of swift;
- Runtime collation of CPU and Python process performance metrics for diagnostics;
- HDMI audio issue with some high end TVs;
- Faster Software Updates using an 'Update Now' facility;
- DLNA Media Server Discovery and Enumeration.

During the period **M36-M52**, Marsh Consulting Ltd continued to assist PDD with platform, driver and associated middleware integration spanning:

- Supporting release management for NextShareTV firmware;
- EIT processing extraction for accurate VoD recordings segmentation;
- Middleware integration assistance for:
  - Centralised search
  - UPnP basic remote control
  - User distortion feedback
- Adding low-level platform support for:
  - AoD & VoD seek forwards / backwards
- Platform / driver fixes for:
  - Breakup of multicast streams
  - Problem with web cache routing
- DLNA platform integration assistance.

The DLNA sub-system developed during M24-M36, was extended to allow for real-time configuration and control of the NSTV devices by our QA framework – specifically:

- Debugging levels
- Levels of logging
- Caching thresholds
- Upload / download rates
- Remotely instigated playback of artibrary torrent/tstream content
- Last, but not least, full access to the remote control functionality

3.4 WP7.2 CE Integration and Demonstrator Development

3.4.1 Applications / Demonstrator Development

The following list summarises the features we support in the latest **M52 firmware v2.1.1** and its applications:

- *Initial Setup* from a virgin installation, including configuration of screen settings, Internet connectivity (manually or via DHCP), and choice of Living Lab location;
- Support for navigating the main features of NextShare^{TV} via a *Main Menu* (as a basic user) and/or the *Navigation Bar* (in the case of an advanced user);
- Selection and consumption of professional content feeds provided by the BBC and ULANC based on *dynamically updated Atom-based feeds* formatted in accordance with the rich-metadata specifications of WP5;
- Ability to organise content items into user defined collections made accessible via a consumption oriented and simple (8-80 yrs old compatible) *Favourites* bar;
- Access to channel specific metadata, representing an EPG-like experience of presently showing, future and catch-up VoD programming via the *Feed Navigator*;
- Access to programme specific metadata through the *Info Bar* and the additional integration of these views with the EPG/Feed Navigator;
- *Creation of new users* and association of personal information with them including a choice of avatar, specification of their email address and security settings such as a *personal PIN* code;
- Adjustment of *System Settings* and *User Settings* that influence the way that the end-user experiences the NextShare^{TV} device and/or the services it connects to;
- Support for *Passive Social* behaviours such as viewing tweets related to content being watched or explored via the EPG, viewing live tweets of trending topics, reading social comments and/or ratings of programmes served within the Living Lab;
- Support for *Active Social* behaviours such posting comments to SocNET, the social network of NextShare^{TV}, or to other public social networks such as Twitter and Facebook;
- *Shared Experience TV:* the ability to establish friendships with other NextShareTV users and the sending of a live-link to what is currently being viewed via the NextShare system;
- Discovery of other networked devices such as iPhones and Android tablets via *DLNA/UPnP*, together with the exploration and viewing of content stored on these devices or USB sticks plugged in directly;
- Ability to fully control NextShareTV and undertake complex behaviours such as content search and commenting on content or chatting with other users via

both *Android and iOS based smart-phones and/or tablets*;

- Completion of various *Seeking* and *Pause/Resume* behaviours within VoD assets;
- Viewing of *Peer Connectivity Information*, such as the peers the STB is connected to and the UL/DL rates during playback of any asset;
- Management of a list of background downloads that are yet to be watched – the *"Watch List"* - for those times where Internet access is not reliable enough for real-time streaming;
- Viewing of a *Historical Log* of content views, posts to social platforms, remote test invocations, along with their status; and
- Ability to consult *Technical Information* about the status of the NextShare^{TV} device including the firmware version, Living Lab software update server status, network configuration, amount of data sharing occurring, and finally if and when any future remote test will execute.

3.4.2 Firmware Releases

Iterative development work completed in WP7 resulted in the following consolidated firmware release schedule:

Ver.	**Features**
0.1.1	Selection of initial STB settings such as language, display type, aspect ratio which is intended to be an essential preliminary step that must be completed before users can access to main functionality. Initial look-and-feel.
0.1.2	Completion of the Network Setup screens allowing manual or dynamic (DHCP) configuration of IP parameters with associated error checking of data entry. This release was intended to provide the foundation from which integration of the Tribler code base and functionality would proceed.
0.2.1	Introduction of a main menu and navigation bar that locates the user at all times and allows ad-hoc navigation within the application. Support for system reset. Selection of language choice for application. Virtual remote for informational purposes only.
0.3.1	Release for internal demonstration at the BBC in London allowing for live streaming over the internet, local VoD and local live streaming. This release also had the capability to automatically detect and download updates to the NextShare^{TV} software from update servers on the internet.
0.4.1	The NextShare^{TV} applications re-skinned for a consistent look and feel, also a favourites menu added with some sample media collections with some (BBC1, BBC News 24 and Dutch TV) streams selectable. A fully working interactive

	Virtual Remote control application was also provided to enable users to see the current remote control design and use this to navigate the NextShareTV menus.
0.5.1	Audio decoding, featured media ingest including multicast services, context sensitive help and context menu support.
0.6.1	Application support for text entry in the comment field of the context menu for media. Support for full software keyboard, SMS and predictive text entry.
0.7.1	New features to be found with this release are: base operating system now updated to Fedora 9, NextShare^{TV} now supports the concept of multiple users. Each user has distinct settings for Personal Details, Security and Application preferences. A special Admin user has been elected the default user. Only Admin can create/delete/modify other users. Parental control in the form of an Admin PIN and rating limits now apply.
0.7.2	Resolves some of the known issues from the 0.7.1 release: 'Oops' video sequence playback when a user is logged out, rework of SMS text entry, rework of Soft Keyboard text entry and addition of user preference for the default text entry mode
0.8.1	A basic framework for event reporting to the central Living Lab trial server has been implemented. Currently this gathers system status information every 15 minutes and logs this in a text based XML format to the console.
0.9.1 **(M18)**	Final release of NextShare^{TV} prior to M18 deliverable and represents a stable version of all functionality on the Cut 2.0 silicon-based pilot boards. A basic *Info Bar* has been added and is available when media playback is in progress and the INFO button on the remote control is pressed (F6 on the keyboard). The Info Bar provides the user with the following information: • Event name, Source name, Event rating, Event progress, Elapsed time
0.12.1 **(M24)**	Initial release of NextShare^{TV} prior to M24 deliverable and the first official trialists. Integration with content discovery feeds, presentation of the Feed Navigator/EPG, ability to create users, access Live and VoD streams, together with instrumentation that reports runtime statistics to the Living Lab trial statistics gathering systems.
1.0.0	Live streaming via a stable production-quality release
1.0.1	Bug fix release.
1.1.0	Technical Info dialog along with massively improved support for asynchronous feed processing.

1.1.1	MediaURI handling updates and migration to M24.2 core. Firmware update for U-Boot and STLinux kernel
1.1.2	Official mass production release including minor fixes for mass production testing
1.2.0	Social networking integration including the ability to bind either a Twitter or Facebook account or both to the NextShareTV device, along with the ability to post a NSPC-compatible short URL reference in the form http://nsh.me/abc, to NextShare content being consumed. Additionally support for community commenting and rating via SocNET.
1.2.1	Bug fixes for the social network integration functionality introduced in 1.2.0.
1.3.0	Moved to NSC M32 with improved support for VoD, and some tuning of NextShare core parameters to reduce stream start-up times. Ability to add and remove SocNET registered friends.
1.3.1	Final release of NextShare^{TV} prior to M36 deliverable incorporating user feedback and preliminary DLNA and mobile-mashup support.
1.3.1.6573	Bugfix release. DLNA mobile mashup.
1.3.1.6583	Re-Baseline of 1.3.1.
1.3.2.6656	Multicast stall bugfix.
1.3.2.6675	Multicast stall + webcache + vod speed up bugfixes.
1.4.1.6802	VoD Services. UPnP Remote. User Feedback.
1.5.1.7087	Search Integration.
1.5.2.7103	Bug fix release for live video stalling.
1.6.1.7126	Proper fix for live video stalling.
1.6.2.7364	Fix for 3 way linking.
1.7.1.7387	UI updates. UPnP extensions. IGD integration.

1.8.0.7578	IBC/NEM 2011 demo extensions. Limited to specific STBs.
1.8.0.7773	Final IBC demo. Limited to specific STBs.
2.0.0.7895	Release for 2nd round of Living Lab trials.
2.0.1.7912	Baseline release of 2.0 for 2nd round of Living Lab trials.
2.0.2.8004	Minor UX updates and torrent parameter checks.
2.1.0.8186	Background downloads, updated remote testing.
2.1.1.8297	Fix for overi cache peerid handling.
2.2.0.8381	Background downloads, UGC, swift integration
2.2.1.8445	General bug fixes, swift IETF demo

3.4.3 Local Integration Test and Performance Analysis

In the period M36-M52, WP7 created a QA framework that is an extensible test automation system. Although currently only targeted at NextShareTV it is designed to be reusable. Its aim within the P2P-Next project is to evaluate the performance of the set-top box and NextShare Core as well as providing insight into any problems found, to stress the system, and to give the ability to perform system-level functional testing.

To date the system has generally been used to evaluate performance on an isolated lab network where all parameters of the environment can be controlled. In this way it is possible to create swarms sharing either live or on-demand content entirely under our control and use this repeatability to perform investigations and evaluations as required.

The QA framework is comprised of a number of separate components, each possibly with multiple distributed instances. Interaction between components is via a central database and file store. Users interact with the QA framework via a plug-in to the project management system (Trac), allowing remote control and monitor capabilities using a simple web interface, e.g.:

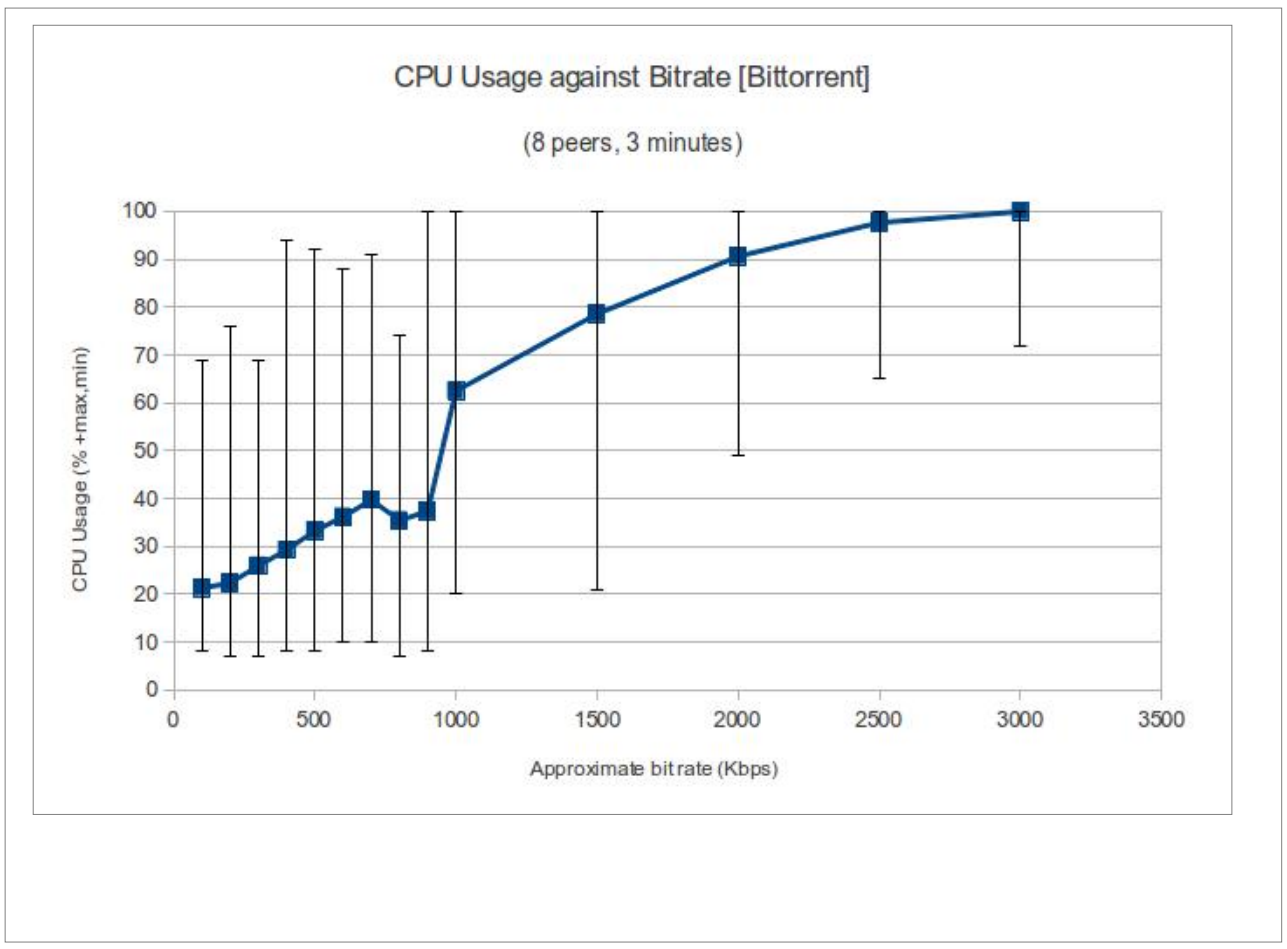
3.4.4 Remote Testing

The Remote Testing facility has been used extensively by ULANC. This capability complements the QA framework in that it supports distributed test devices rather than being limited to a lab-based network of devices. The combination of the two systems has enabled PDD and the Living Lab to gain a high-level of confidence about the deployment of NextShare to our low-power devices and the our choices concerning the configuration of NextShare Live and VoD services.

3.5 Conclusions

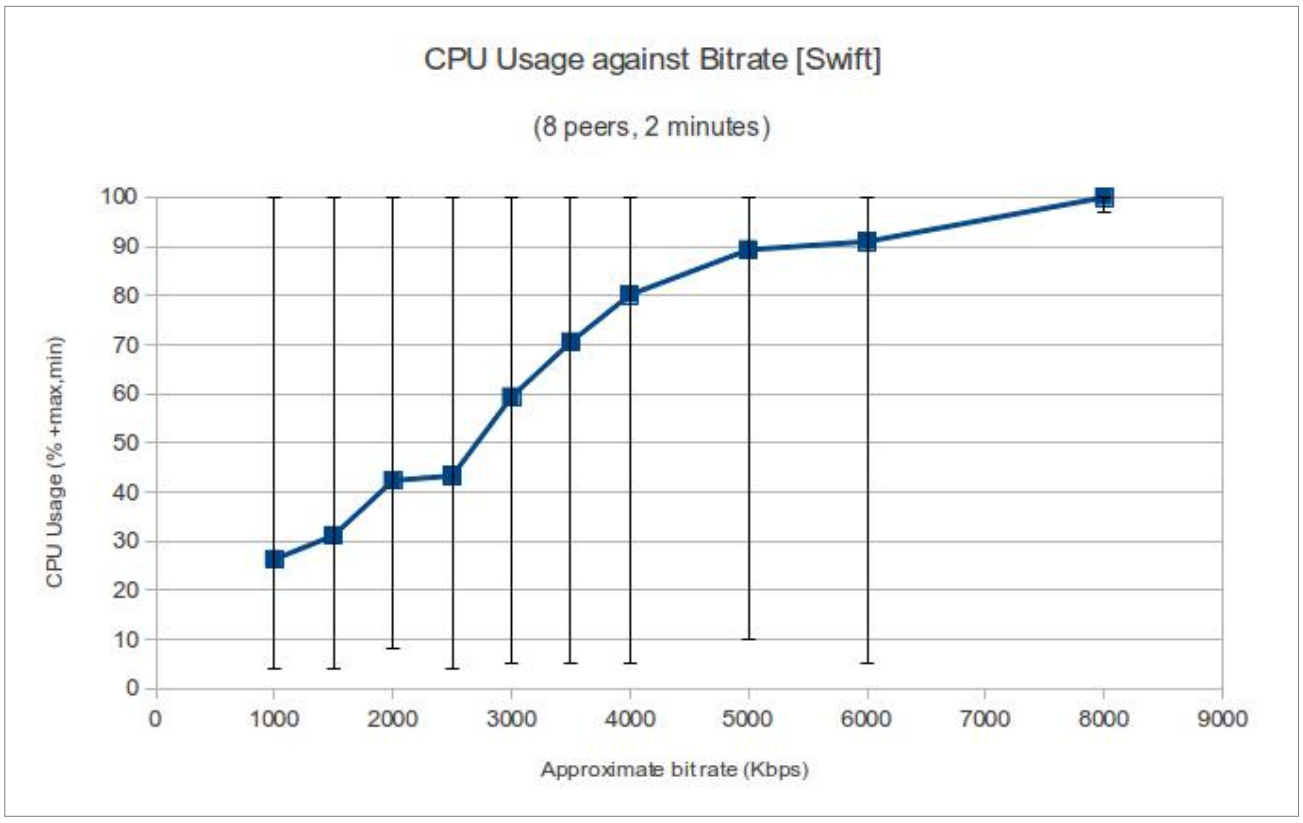
P2P content distribution is a viable technology for wide-ranging deployment on low-cost CE devices, at least from a technical standpoint. NextShare^{TV} supports both Live and VoD services at bit-rates up to around 3.5Mbps, offering internet-quality 720p video, with start-up delays in the region on 4-8 seconds, and random seeking within 2-3 seconds.

In order to avoid exceeding available CPU resources, NextShare^{TV} only shares pieces of content with up to 8 other peer devices at any given time. With 8 peer connections, and an appropriate choice of piece size for a given asset, NextShare^{TV} is able to support both SD 576i and HD 720p services; as long as the total bit-rate demanded by the audio, video and data components of the service do not exceed 3.0-3.5Mbps.



A significant factor effecting the CPU and memory requirements of NextShare is its implementation in Python; a dynamic, interpreted and automatically garbage collected language. Under normal usage, the Python process that runs the NextShare^{Glue} sub-system within NextShare^{TV} consumes over 50+MiB of DRAM, although we have found that it can work with only 10MiB of available DRAM.

In comparison, you can see below the relationship between service bitrate and CPU utilisation for *swift* – a natively implemented and UDP-based data transport developed within P2P-Next. The high er bitrates supported enable swift to support full HD resolution services.



3.5.1 Baseline Configuration of NextShare^{CORE}

The NSC settings described in this section are common to all invocations and uses of NSC by the NextShareTV devices. These settings define a safe-zone or ceiling within which other content-specific settings can adapt to fulfil various service requirements:

Max Upload Speed	512 KiB/s (approx. 4Mbps)
Max Download Speed	512 KiB/s (approx. 4Mbps)
Max Initiated Connections	8
Max Total Connections	8
Max Uploading Connections	4
Piece Size	Content or service specific
Sub-piece (slice) Size	32KiB
DL from Source Probability (dlprob)	0.75
Max Asset Size	7 GiB
Unchoke Bias	480

3.5.2 Service Profiles

All video services are assumed to be (trans/en)coded in H.264 format and then multiplexed with audio and other related streams into an MPEG2TS container. For an

incoming DVB service for example the following VLC (Video LAN Client) command-line would create a service eligible for ingest and delivery via the NextShare platform.

```
vlc --daemon dvb://frequency=506000000 \
    :sout-transcode-venc=x264 \
    :sout-x264-profile=main \
    :sout-x264-level=4.1 \
    :sout-x264-cabac=0 \
    :sout-x264-keyint=18 \
    :sout-x264-ref=3 \
    :sout-x264-interlaced \
    :sout-x264-bitrate=2048 \
    :sout-x264-ratetol=5.0 \
    :sout-x264-vbv-maxrate=2048 \
    :sout-x264-vbv-bufsize=512 \
    :sout-transcode-vcodec=h264 \
    :sout-transcode-vfilter=canvas{width=720,height=576,aspect=16:9} \
    :sout-transcode-audio-sync \
    :sout-transcode-acodec=mp2a \
    :sout-transcode-ab=128 \
    :sout-transcode-channels=2 \
    --sout \
    "#transcode{}:duplicate{ \
 dst=std{ \
 access=http, \
 mux=ts, \
 dst=:65000 \
 }}"
```

Key-frame interval, or the distance in frames between consecutive i-frame in this case, is 18 inline with DTG guidelines for terrestrial DTV services to ensure reasonable service presentation latencies.

NextShareTV implements and imposes a generalised policy for piece size calculations, which must be adhered to by content providers who specifically target our device:

- Piece size must be one of the following values [64KiB, 256KiB, 512KiB, 1MiB]

For VoD assets the following additional constraints apply:

- If asset size < 1.5GiB then piece size = 256KiB

- If asset size < 3.0GiB then piece size = 512KiB

- If asset size > 3GiB then piece size = 1MiB

3.5.3 Standard-Definition 576p (Live)

The NSC service settings required to support delivery of 576p according to the specification above are as follows:

Bitrate	256KiB/s video + 16KiB audio
Piece-size	64KiB
Slice-size	32 KiB

3.5.4 High-Definition 720p (Live)

For 720p services we converged upon the following settings as appropriate for carriage via NextShare to NextShareTV devices:

Bitrate	384KiB/s video + 16KiB audio
Piece-size	128KiB
Slice-size	32 KiB

3.5.5 High-Definition 1080i (VoD)

Due to CPU limitations we deemed it necessary to utilise the second-generation of NextShare protocol (libswift) for 1080i high-definition VoD services. Specifically the following operating parameters were chosen based on laboratory evaluations

Max Combined UL/DL Rate	1556 KiB/s (approx 12Mbps)
Actual DL Speed	120% of average asset bit rate - min of 384KiB/s
Actual UL Speed	(1556 - DL rate)
Max Total Connections	20
Chunk Size	8KiB [also supports 1KiB, 2KiB and 4KiB]

4 Executive Summary of WP 8 “Living Lab Trials”

WP8 has deployed and tested the NextShare platform in both lab-based and real-world user environments. Multiple Living Lab sites have been constructed and maintained. Several waves of user trials were promoted for the purpose of research and real-life evaluation of state-of-the-art technologies. Comprehensive data analysis models were developed to investigate the Living Lab trial from multiple perspectives. The results and recommendations within this work package have been fed back to other partners in order to further refine the general P2P-Next architectural specifications, as well as the reference implementations NextSharePC and NextShareTV. The results from user trials have also been utilised in the development of a number of ancillary services including a second screen application called NextShareMobile, and a quality-of-experience framework for evaluating NextShareTV. The next generation of P2P technology, libswift (swift), has also seen deployment and evaluation.

Regarding dissemination of results from WP8, there have been several papers published and submitted in conferences and journals such as the ACM Multimedia and IEEE Transactions on Multimedia. The WP8 partners have also represented the P2P-Next project at a number of events such as the NEM Summit 2011.

4.1 NextShareTV and NextSharePC Deployment

ULANC has deployed and conducted extensive testing of the NextShare^{TV} set-top boxes (STBs). Although there have been on-going tests (e.g., of those STBs deployed in households in the village of Wray), the bulk of the testing has occurred over two phases. The first phased occurred during the period of April 2011 to June 2011, and the second phase occurred between October 2011 and March 2012. Figure 4.2 shows the number of unique NextShare^{TV} devices per day and month over the two phased periods, and illustrates the success of the second phase. Usage of the NextShare^{TV} STBs peaked in December 2011, with 73 unique users on a single day.

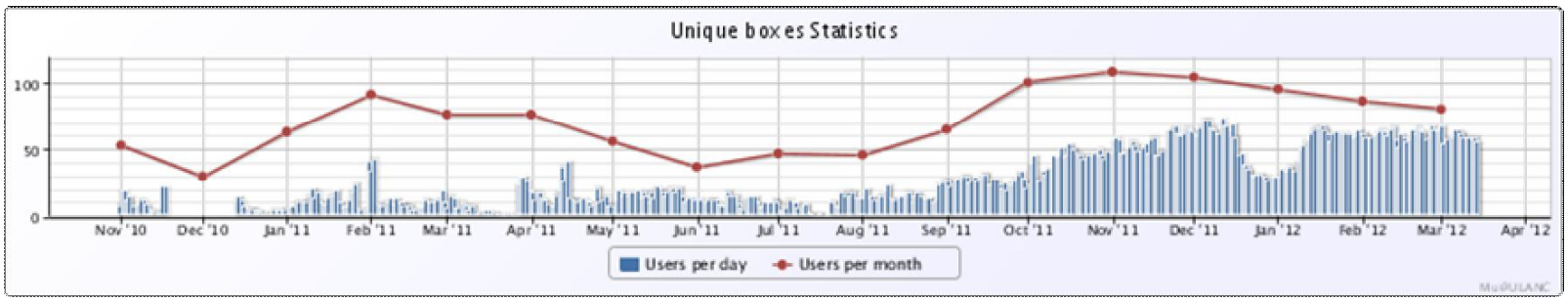


Figure 4.2: Unique NextShareTV Users

Various WP8 partners have introduced their own web portal with NextShare^{PC} (HTML5 and/or VLC-based) integration. **Error! Reference source not found.** shows ULANC’s final iteration of its IPTV web portal, which is used to provide both live and video-on-demand content via the NextShare^{PC} (VLC) plugin. **Error! Reference source not found.** shows the growing number of unique users of this service per day and month over the two phases. In the month of March 2012, usage peaked at 755 unique users for the month, and 370 unique users on a single day.

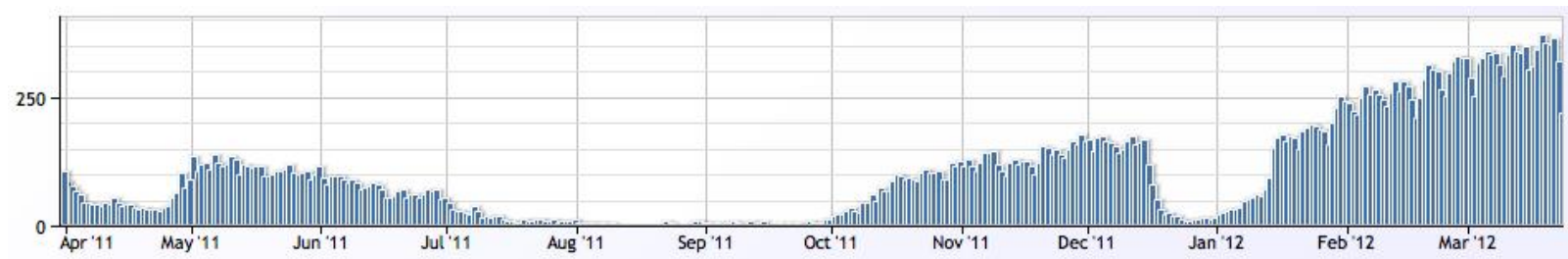


Figure 4.3: Unique NextSharePC Users per day

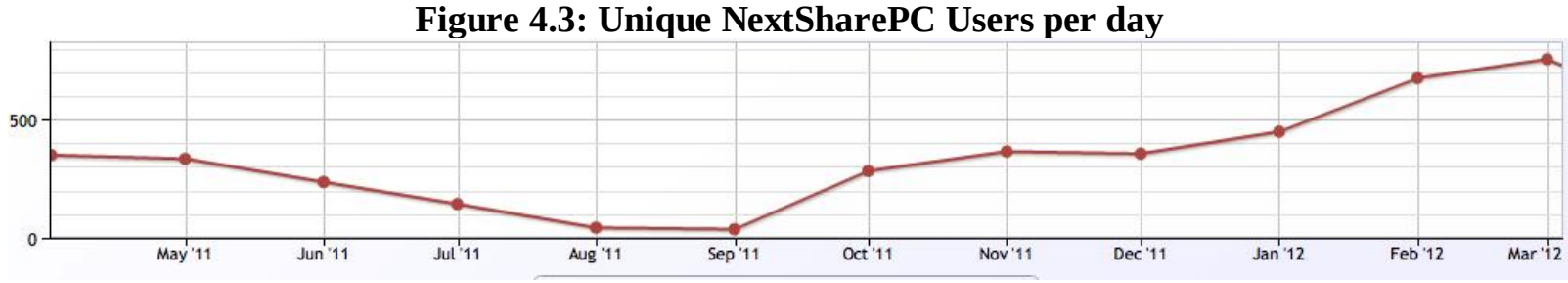


Figure 4.4: Unique NextSharePC Users per month

Figure 4.5: ULANC's Web Portal with NextSharePC Integration

During ULANC's final iteration, the video-on-demand service underwent an architectural transition. This transition included the splitting of the recording, seeding and tracking processes across multiple hosts, and expanding the number of seeded assets from 4000 to 10000 (with a capacity of 16000). The work on this transition of VoD asset management has greatly strengthened their VoD service, bringing in more user requests than ever before. Figure 4.6 shows our daily usage statistics of the most recent university term. The live service remains its popularity with a few distinct peaks marking the popular live sports and music events. The daily requests for VoD items exhibit a steady growth reaching over 600 on a single day, which covers over 75% of all on-demand requests. The figure also suggests that the "sit-forward" on-demand experience and "lean-back" live experience are believed to be able to co-exist in a converged TV service targeting different viewing preferences.

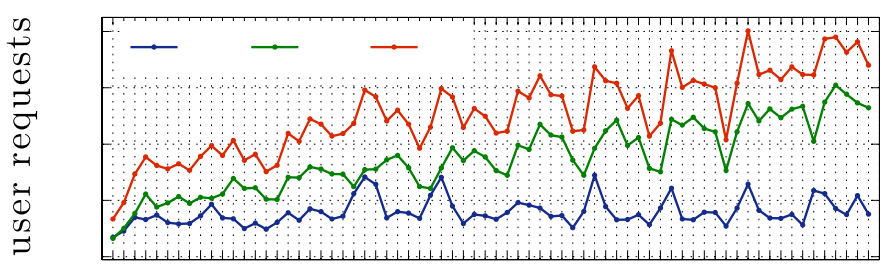
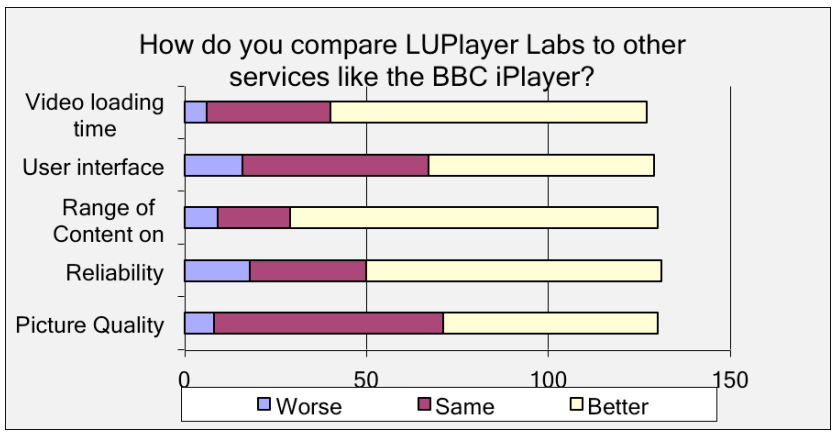


Figure 4.7: ULANC's Web Portal with NextSharePC Integration

In March 2012, visitors to ULANC's web portal were requested to complete a questionnaire, for which 113 responses were received. **Figure 4.8** shows a stacked bar chart of how these users compare the LUPlayer service with commercial alternatives, across five metrics: picture quality, reliability, range of content, user interface, and video loading time. LUPlayer performed strongly across all metrics, with only a small percentage of users perceiving it to be worse for each. It is particularly noticeable how strongly the LUPlayer faired for comparable loading time, despite its P2P-based content delivery. When asked how important the Living Lab IPTV service is to their everyday life, 89.3% of the users in ULANC indicated that the service is *very important* to them while 10.7% claimed the service as *important* (**Figure 4.8**).

Through the questionnaire, ULANC have also received many positive comments such as "I personally think the service is perfect how it is. I watch a lot of TV and having a full range of freeview channels available to me... I really hope the service continues next year…" and "It's cool as it is!". There are also suggestions such as "adding *people who watch this also watched* feature" and "facebook, twitter or other social network link ups.". Some users also requested to have recordings of University lecture available. The questionnaire strongly highlights the active user involvement in the WP8 ULANC Living Lab services, and the trend of social TV in the population of young adults.



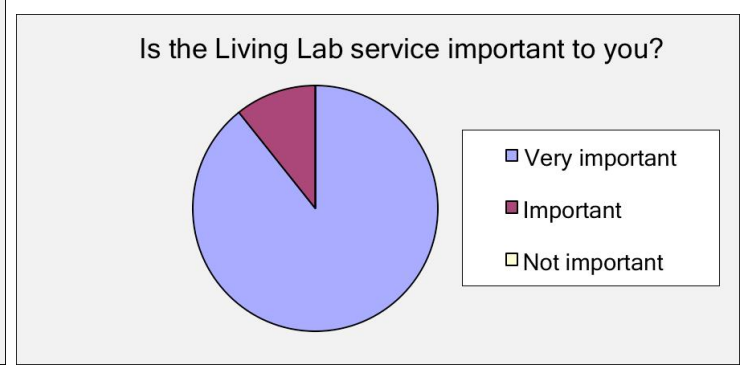


Figure 4.8: Questionnaire Results Comparing ULANC's Web Portal to Commercial Alternatives

Work has also been carried out to leverage the large collection of data in the centralised statistical service hosted by ULANC (**Error! Reference source not found.**). The focus of this work has predominantly been on social informatics, and how this can be integrated into the NextShare codebase for intelligent asset removal of video-on-demand assets. There have also been extended analyses on the performance of the P2P NextShareCore, on both NextShareTV and NextSharePC platform, in terms of loading time, peer number and sharing ratio.

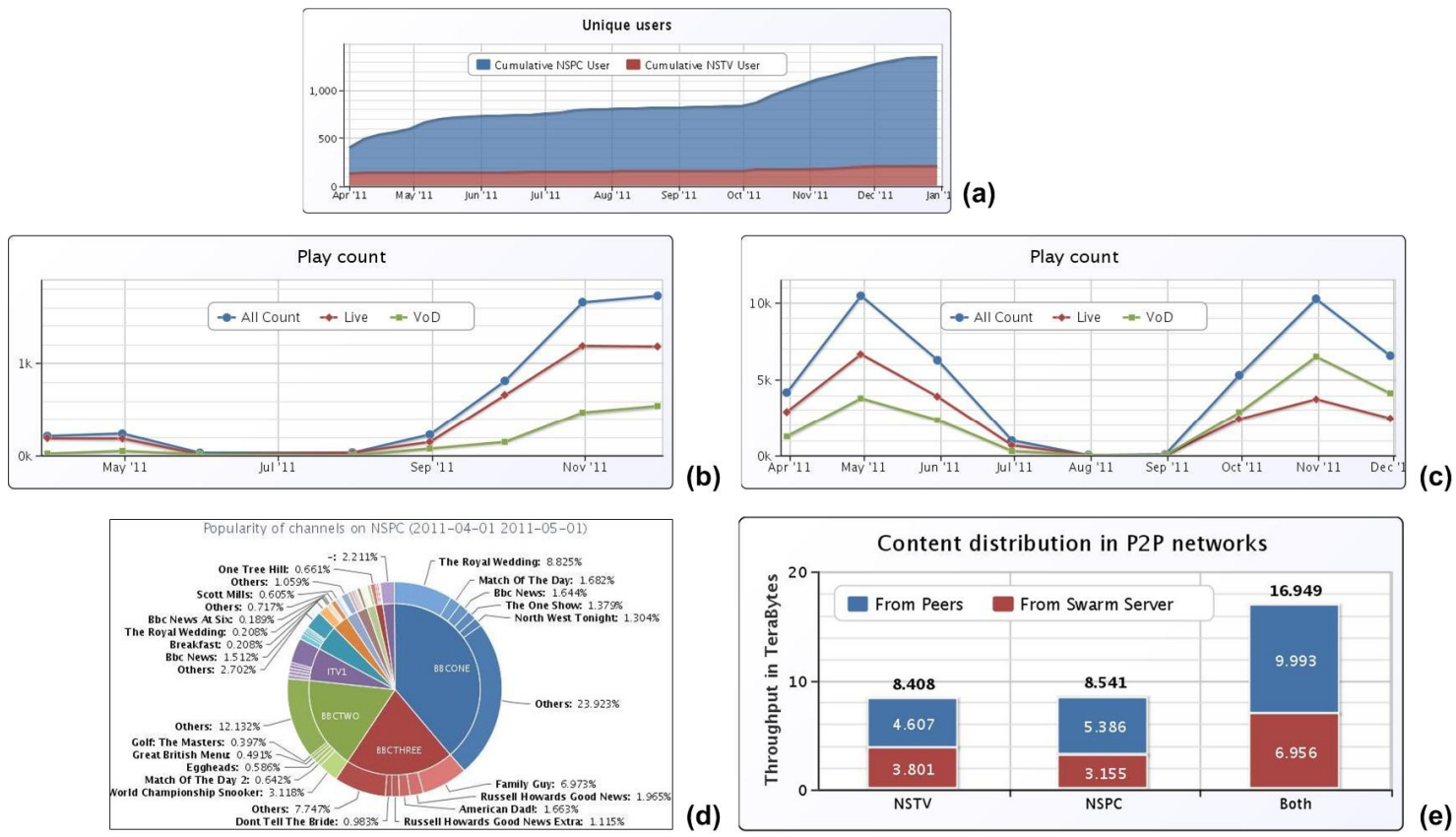


Figure 4.9: Statistical Analysis of Service Usage

There has also been ongoing work in WP8 to compare the NextShare platform against commercial alternatives (e.g., Octoshape).

4.2 The Shift Towards a Peer-Assisted Architecture (M40)

In order to run large scale tests on the NextShare platform, ULANC has implemented the M40 codebase for their services, which enables a peer-assited architecture. The infrastructure used to deploy the full peer-assist architecture consisted of a virtualised seed which handled the ingest, plus two supplementary physical caching servers supplied by Oversi.

During the integration various performance issues were noticed with the caching servers. This included incompatibilities between the libtorrent implementation on the caching servers and the NextShare^{TV} STBs. The STBs were unable to successfully receive any requested data from the caching servers, which manifested in playback issues. ULANC worked closely with PDD and Oversi to diagnose and test this issue in order to bring it to a resolution.

Utilising the caching servers, the peer-assist architecture was introduced for testing on specific production channels for live television. These tests occurred during a four week period between the 2nd March and the 30th March 2012.

Each WP8 partner has had to deploy some form of infrastructure to support their activities. ULANC is the largest in this regard, and currently supports 15 live BBC TV and radio channels, and around 10,000 video-on-demand assets (with a capacity of 16,000) over the NextShare platform.

4.3 NextShare Mobile

User feedback obtained from the initial Living Lab deployment of the NextShare^{TV} service suggested that many users were dissatisfied with the basic functionalities offered by the infrared remote control that was provided for interacting with the set-top box. This feedback was the predominant motivation for ULANC developing an integrated second screen application called NextShare^{Mobile}. NextShare^{Mobile} runs on Apple iOS devices (iPhone/iPod touch/iPad) and connects to the NextShare^{TV} set-top box through the Universal Plug and Play (UPnP) interface provided by PDD.

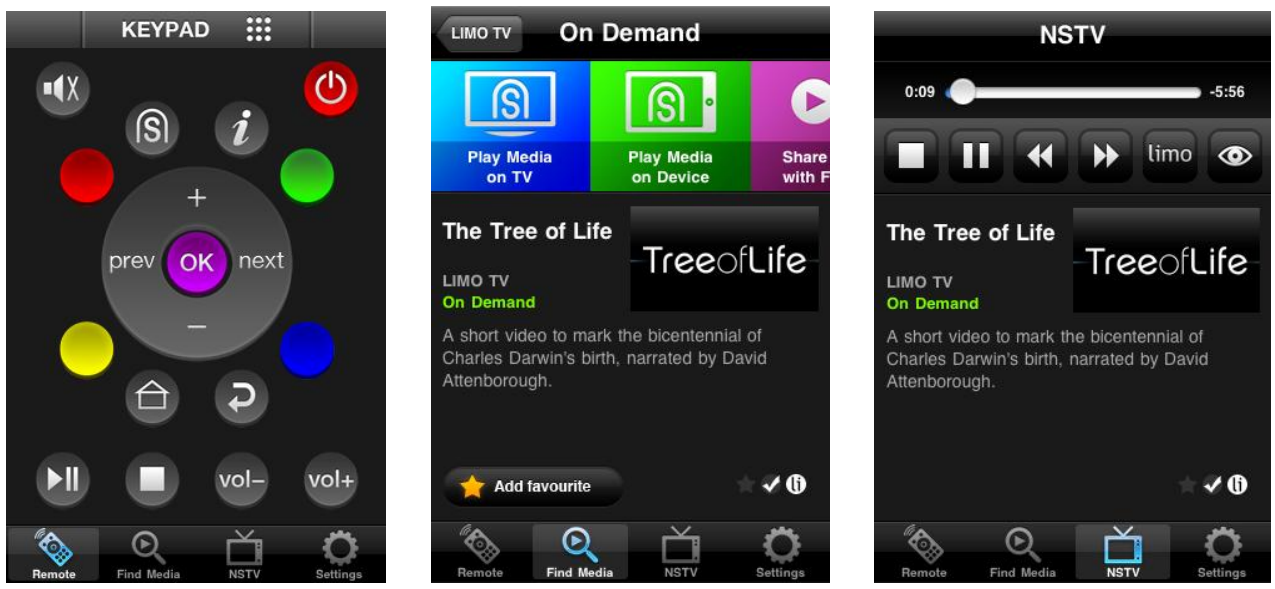


Figure 4.10: NextShareMobile Interfaces

NextShare^{Mobile} supports and exceeds the full range of functionality of a conventional infrared remote control, through virtual keypads, rich content discovery with customisable EPG styles, keypad search within the application, and the granular management of playback sessions. Utilising the Living Lab services, users are also able to view video-on-demand content directly through the NextShare^{Mobile} application. Once content has been identified through the feeds, NextShare^{Mobile} can make an automated transcoding request to convert content into a format suited to mobile devices, which is streamed directly to the device over HTTP. Furthermore, NextShare^{Mobile} implements LIMO (Lightweight Interactive Media Objects), a framework for timed metadata that was developed as part of the P2P-Next project. The LIMO framework can be used to build interactive applications that are associated with specific media content (e.g., captioning), or to attach arbitrary descriptive metadata relating to periods of time within the content (e.g., lists of characters). In the context of NextShare^{Mobile}, it is used to provide chapter navigation, quizzing, and subtitling of primary screen content.

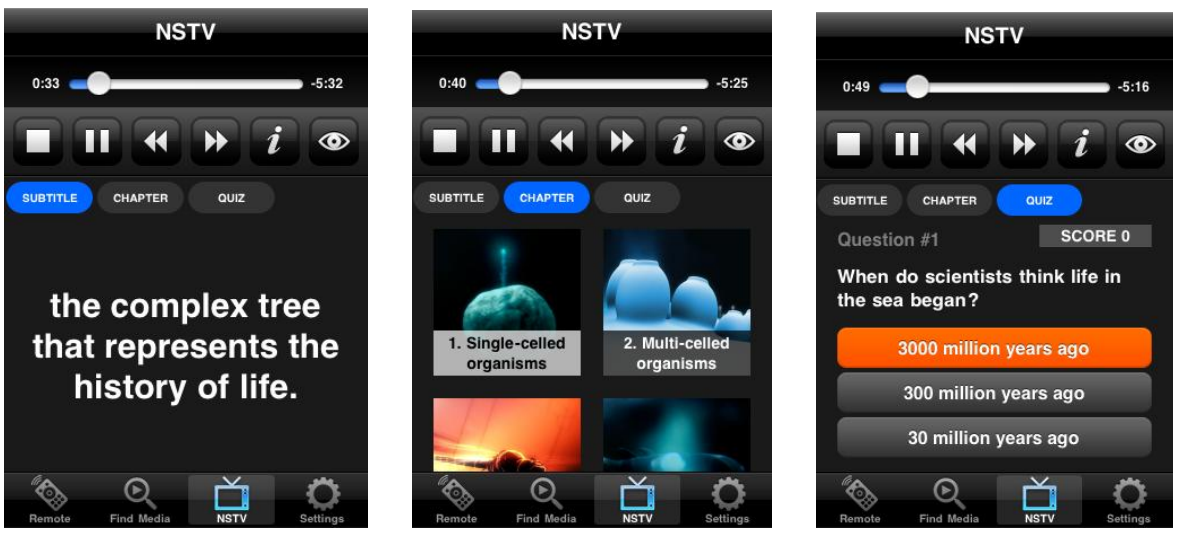


Figure 4.11 NextShareMobile LIMO Support: Subtitles, Chapters, Quiz

ULANC deployed five NextShare^{Mobile} devices into households in the village of Wray as part of a six-month ethnographic study. One of the challenges encountered in testing IP-capable multimedia consumption devices in a real world deployment (such as NextShare^{TV}), is that these devices are not typically physical located near sources of IP connectivity. Where this source exists, it is often in a place of work (e.g., office spaces), and the challenge becomes spreading this to the multitude of spaces of consumption. In order to address this issue, ULANC was required to install a multitude of network devices into households including wireless routers, switches, and HomePlugs for power line connectivity. NextShare^{Mobile} has also undergone a series of lab-based user experiments to compare its usability to traditional remote controls.

4.4 Quality-of-Experience

ULANC introduced a multimodal quality evaluation framework that is specifically designed and implemented for the assessment of video streaming services in its LivingLab (P2P-based IPTV systems). Figure 1 gives the framework for the evaluation system. The framework interacts with five key elements of a video distribution system including source content, audio-visual encoder (transcoder), distribution network, end system and end user. Multimodal assessment of service quality is conducted by the collaboration of measurement, analysis and diagnosis modules, which are realised by groups of functional components.

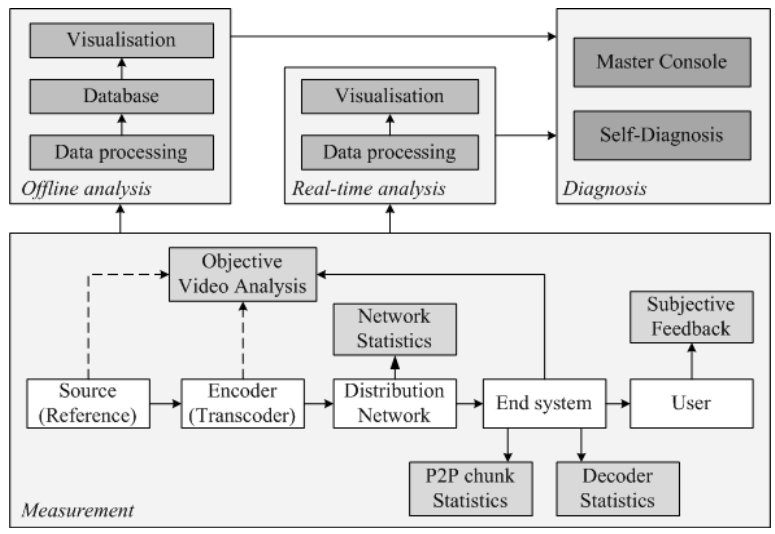


Figure 4.12: The Multimodal QoE Evaluation Framework

Relevant service metrics from all key elements of the distribution system are extracted and summarised by the measurement module before data analysis and visualisation of the analysis module are initiated. The diagnosis module coordinates analysis results for different measurement functions to enable comprehensive evaluation for service diagnosis. Functional modules and blocks can be selectively activated according to specific test plans and strategies.

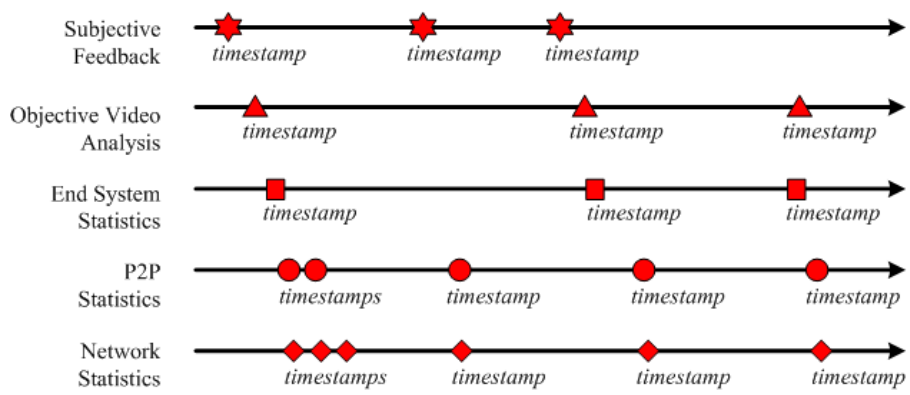


Figure 4.13: Multimodal Evaluation Associated by Timestamp Information

Using the time-stamp information that is associated with all evaluation processes, we are able to correlate pre-defined events that are detected in different layers. For instance, one can investigate how some packet losses are repaired by retransmission mechanisms of the P2P overlay, while others reach the video decoder and are eventually perceived by human users as visual distortions. The same set up can also be used to benchmark the performance and robustness of different designs on P2P piece discovery and distribution.

In order to realise a comprehensive evaluation of video distribution services, multiple different functional components have been designed to capture service statistics with respect to transmission, distribution, video codec and human perception. Overall, the measurement module is comprised of subjective feedback, objective video analysis, system statistics, P2P statistics, and network statistics.

The subjective feedback function provides a simple and interactive interface for viewers to notify perceived audio-visual distortions and to answer questionnaires regarding the overall service quality. The objective video analysis function captures decoded video signals from output of set-top box and analyses video quality using multiple no reference video processing models. System, P2P and network statistics functions report metrics reflect service status regarding video decoding, P2P piece distribution and packet-based networks respectively.

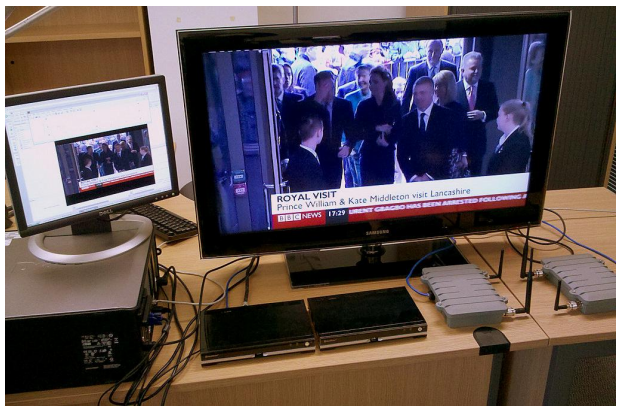


Figure 4.14: An Ongoing In-Service Quality Evaluation

On top of each measurement component, an analysis module is realised to conduct data mining (e.g., pattern recognition and time-series analysis) on large-scale raw measurement data and to interpret results for investigators using visualisation tools. Depending on the nature of underlying measurement, an offline analysis or/and a real-time analysis can be enabled. For the offline analysis, raw measurement results (usually in a format based on XML) are processed (e.g. parsed and concentrated) before registered into a statistics database. The database exposes interfaces for front-end applications (e.g., a dynamic PHP programme) to effectively retrieve, obtain and

visualise the archived measurement results. Using offline analysis, different evaluations can be applied repeatedly to any specified section of the entire archive reflecting specific measurement purposes.

Unlike the offline analysis, the real-time analysis models are implemented to actively pull data from measurement elements without intermediate procedures. Using real-time analysis, one can specify measurement strategies that are not feasible by offline analysis. For example, a direct connection to a set-top box can be established to request comprehensive live statistics of decoding process several times per second.

4.5 Multiple Screen Interaction

Norut has focused on multiple screens and interaction with users in living lab experiments (i.e., where more than one screen is synchronized with a set of content). A demonstrator was made to present information about the journey of the Norwegian Coastal Express (Hurtigruten) cruise liner using multi-screen synchronization (called Media State Vectors or MSVs), based on ideas from LIMO (Figure 4.15).

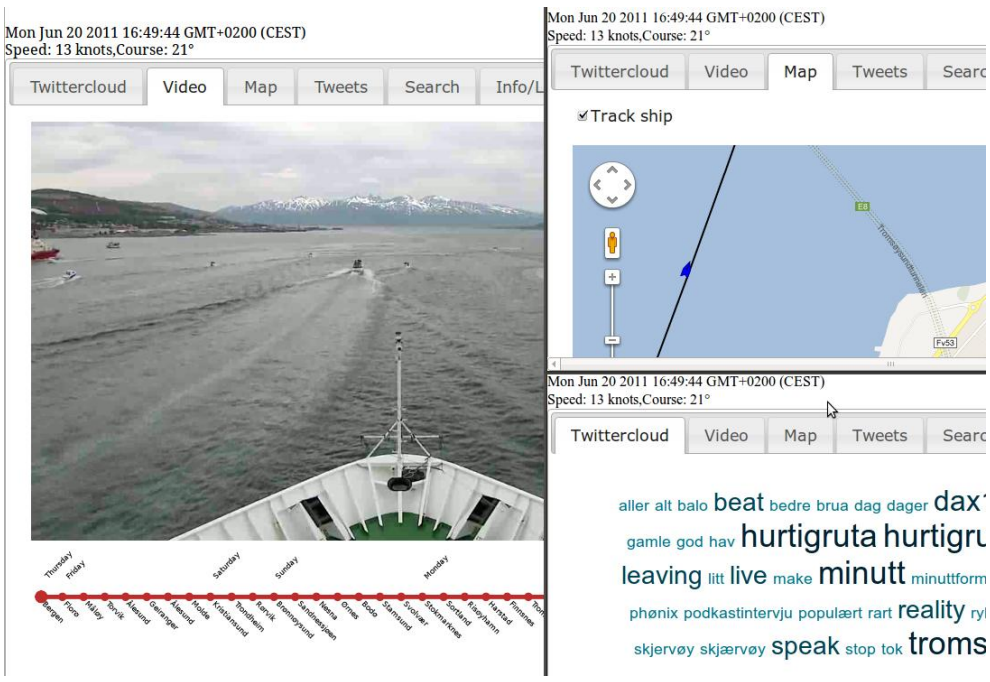


Figure 4.15: Three Screens Showing the Video, Map and TweetCloud.

MSV was also tested at the Insomnia music festival, where a particular focus was placed on user participation and community documentation.

4.6 Libswift

ULANC created a production swift-based VoD service in their Living Lab, which provided a 3-day catch-up window of BBC HD content, in addition to hosting the content discovery feeds for all IETF swift work, and a swift seed for all “testing” content in both standard and high definition. There were initial stalling and video sync issues with HD playback over swift on the NextShare^{TV} set-top box, and ULANC

liaised with Marsh Consulting to diagnose and resolve the issue. The ULANC swift service was then deployed to 10 users in preparation for the IETF presentation.

A PC-based swift client was also integrated into UPB's web portal (P2P-Tube), and both subjective and objective evaluations were performed.

The QA framework developed by PDD has also been used to perform a comparative analysis of NextShare and swift.

4.7 Dissemination of Results

There have been several papers that have been published which disseminate the results produced by WP8, including:

- Mu Mu, Andreas Mauthe, Gareth Tyson, Eduardo Cerqueira, "Statistical Analysis of Ordinal User Opinion Scores", IEEE Consumer Communications and Networking Conference (CCNC'12), 2012
- Mu Mu, Johnathan Ishmael, Keith Mitchell, Nicholas Race, "Multimodal QoE Evaluation in P2P-based IPTV Systems", ACM Multimedia (MM'11), 2011
- Mu Mu, Piotr Romaniak, Andreas Mauthe, Mikolaj Leszczuk, Lucjan Janowski, Eduardo Cerqueira, "Framework for the Integrated Video Quality Assessment", Springer Journal of Multimedia Tools and Applications (MTAP). DOI 10.1007/s11042-011-0946-3, 2011
- Christian Timmerer, Michael Eberhard, Michael Grafl, Keith Mitchell, Sam Dutton, Hermann Hellwagner, A Metadata Model for Peer-to-Peer Media Distribution, In Proceedings of the Workshop on Interoperable Social Multimedia Applications (WISMA 2010), CEUR Workshop Proceedings (CEUR-WS.org), Aachen, Germany, pp. N/A, 2010.

Significant activity has also been placed into preparing and submitting academic papers to the following outlets, which are still under review:

- A reference paper on Media State Vectors (multi-device synchronization for shared media experieneces). This was was submitted to IEEE Transactions by Norut.
- A journal paper on the QoE framework for evaluating P2P systems, by ULANC. This was was submitted to IEEE Transactions by ULANC.
- A conference paper on NextShareMobile, and it's usability in comparison to traditional infrared remote controls. This paper was submitted to Ubicomp by ULANC.
- ULANC has also been invited to write a book chapter by TMA on their QoE work.

The WP8 partners have also represented the P2P-Next project at a number of events:

- The NEM Summit 2011, which was attended by VTT, ULANC, and Pioneer. Demonstrations of NextShareTV and NextShareMobile were provided, as well as raising the general awareness of the P2P-Next project.

- The Peer-to-Peer (P2P) Techniques for Media Delivery Workshop at De Montfort University, Leicester, UK, which was attended by ULANC. A presentation of ULANC's Living Lab work, along with demonstrations of both swift and the NextShare platform (TV, PC and Mobile) were provided.
- A workshop hosted by the Framework for Innovation and Research in MediaCityUK (FIRM) project, which was attended by ULANC. A presentation and demonstration of ULANC's Living Lab work was provided.
- The B4RN event in Wray, which was attended by ULANC. The visit consisted of a demonstration of the NextShareTV and NextShareMobile devices, along with a press interview about the ULANC's Living Lab work in the village of Wray.

ULANC has hosted visits from Swisscom and the Chinese Ministry of Industry and Information Technology. The purpose was to highlight the full scope of the work conducted at ULANC’s Living Lab, the outputs of the P2P-Next project, and also to generate opportunities for future collaboration around this work.

A series of pre-commecial tests of the NextShare PC plugin and a payment system from DACC have been and continue to be performed. This work is being carried out by DACC, Mid Sweden University, Acreo (A Swedish research organization), and a local network operator called Servanet.

5 Standardisation Activities from P2P-Next

The main responsible partners for standardisation activities were EBU, IRT, TUD, PDD, STM and UNIKLU.

Based on the partners' regular activities natural contacts were established with the following standardisation bodies: DVB (Digital Video Broadcasting) CM-IPTV as well as DVB TM-IPI (IP infrastructure), ETSI TC MCD (Media Content Delivery), IETF (Internet Engineering Task Force) and MPEG (Moving Picture Expert Group) as well as to Open Source efforts and BitTorrent.org (contributing to and extending de facto standards in the Internet Community). Other potentially relevant bodies were actively monitored and informed about the P2P-Next developments: OIPF (Open IPTV Forum), DLNA (Digital Living Network Alliance), DCIA (Distributing Computing Industry Alliance), W3C (World Wide Web Consortium) and HbbTV (Hybrid Broadcast Broadband TV).

The following P2P-Next developments were brought to standardisation[3]:

- *Metadata for discovery, search and selection* of appropriate content in a peer-to-peer network and related APIs:
    - successful standardisation efforts were undertaken in MPEG-M (MPEG Extensible Middleware, formerly MPEG-AIT (Advanced IPTV Terminal)).
- *NextShare core, the main software and protocol development* in the project, providing peer-to-peer functionality for PC and CE networked environments:
    - LibSwift was published as an experimental internet draft by IETF
    - successful contributions to the LEDBAT standard setting effort (BitTorrent.org, IETF)
    - the P2P-Next proposal on the usage of Merkle hashes was accepted by BitTorrent.org
    - the P2P-Next proposal for peer discovery using PEX is in the process of being standardised (BitTorrent.org)
    - contribution of P2P-Next (Swarmplayer) to the Open Source ecosystem

Efforts to standardise towards the *service application level* (broadcast services, media formats & interoperability, home network interoperability, …) *and according APIs* were taken by the project as well but unfortunately could not be finalised as the respective standardisation bodies (DVB, ETSI, OIPF, DLNA, DCIA) currently do not have peer-to-peer in their focus.

[3] A detailed overview of the P2P-Next standardisation results can be found in D9.8

Additionally, after the finalisation of D9.8 (July 2011) the P2P-Next peer protocol proposal based on Swift has been selected by IETF PPSP (P2P Streaming Protocol) to become an IETF Internet Draft. The P2P-Next input “The Generic Multiparty Transport Protocol (swift)” *draft-grishchenko-ppsp-swift-03.txt* in the meantime has progressed to “Peer-to-Peer Streaming Peer Protocol (PPSPP)” *draft-ietf-ppsp-peer-protocol-01.txt* and is currently under active discussion in IETF PPSP.

6 Conclusions on WP5-WP8

The P2P-Next project was carried out in 52 months starting in January 2008. Each WP represents an integrated part of the project. The four last technical work packages (WP5-WP8) have delivered the following main inputs to the final goal:

- Content streaming process developed according to professional content providers' requirements for live and on-line content ingest
- A basic toolbox was developed to enable ingest of VoD content
- Rich metadata specifications for advertising, scalability and payment
- Design of a lightweight system for interaction called LIMO
- A configurable portal for discovery and playback of content distributed via Next-Share
- A PC prototype called Next-Share PC providing the P2P-Next implementation on PC level
- A scalable video codex (akaSVC) supporting recovering from network losses
- A low density parity check and forward error correction (akaLDPC-FEC) to detect and reconstruct lost packets
- A zoom-able user interface (akaZUI) to define a new way to browse andindex for multimedia content
- An adaptive Play-out to adapt player speed to the network bit rate fluctuations
- A complete prototype for CE integration of the living lab content platform
- A total 300 units of Next-Share TV were delivered to ULANC for the reporting period
- The Tribus Hardware Platform and Remote Control system consisted of the N-Tronix Ltd hardware and the Marsh Consulting Platform
- Both performance and remote testing of the system has been carried out
- Living lab tests of the Next-Share TV have been carried out on a series of test beds around Europe
- The living lab home page www.livinglab.eu was the portal for all testing activities supported by the NextShare Support Centre (NSSC) – http://nextshare.lancs.ac.uk/
- Standardisation of the most important P2P solutions developed, including metadata for discovery, search and selection of appropriate content, The Next-Share core, software and protocol for PC and CE networked environments.

The work packages have fulfilled all their goals specified in the original plan and delivered the corresponding reports, hence contributing to the final goals of the P2P-Next project. The final conclusions of the project are given in the Final report (D9.4).