Helsinki Metropolia University of Applied Sciences
Degree Programme in Information Technology

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Television Playout Development Towards Flexible IT-based Solutions

Master of Engineering Thesis
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Helsinki Metropolia University of Applied Sciences **Abstract**

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The purpose of this study was to update television playout system. An Estonian television and radio network operator Levira playout centre needed expansion in infrastructure to be able to accommodate larger channel count. Renewals of media asset management and automation systems were also required to handle requirements of the larger channel count and to automate processes.

Television playout systems and solutions are going through big changes. These changes reflect partially new developments in the whole broadcasting industry and the way people use video, as well as changes and development in other areas of technology, especially in IT. These changes do not come without challenges with new workflows and ways of operating. These projects were to be done not only for current needs but also to be ready for the coming years. This was taken into consideration on system design and planning as well as on choosing the partners for the projects.

As a result of this study, an up to date playout centre was designed with flexible IT based solutions that are easy to update and customize for varying needs of different television channels. Playout centre has room to grow and it is ready for requirements of future without need for major changes in the system.

Keywords	playout, television, MAM, automation, multi-platform, multi-channel

Metropolia Ammattikorkeakoulu **Tiivistelmä**

Tekijä Otsikko Sivumäärä Aika	Lauri Virkki Television lähetysjärjestelmän kehittäminen kohti joustavia IT-pohjaisia ratkaisuja 76 sivua 31.8.2011
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Työn tavoitteena oli television lähetyskeskuksen järjestelmän päivittäminen. Virolaisen television ja radion lähetysverkkotoimija Leviran lähetyskeskus tarvitsi laajennuksen olemassa olevaan järjestelmään, jotta se pystyisi lähettämään suuremman määrän kanavia. Myös lähetyskeskuksen medianhallinta- ja automaatiojärjestelmät täytyi päivittää tämän suuremman kanavamäärän tukemiseksi ja työnkulun tehostamiseksi.

Television lähetysjärjestelmät ja ratkaisut käyvät läpi isoja muutoksia. Nämä muutokset heijastuvat osin koko televisiotoiminnan muutoksesta ja siitä, miten katsojat ylipäätään käyttävät videota ja osin informaatioteknologian (IT) kehityksestä. Se on selvää, että muutokset tuovat uusia haasteita, edellyttävät täysin uudenlaisten työnkulkujen ja ajatusmallien omaksumista. Molemmat projektit toteutettiin ottaen huomioon tämän hetken tarpeet tiedostopohjaisen työnkulun ja kasvavan kanavamäärän tuoman kapasiteettivaatimusten suhteen sekä ennen kaikkea lähivuosien mahdolliset vaatimukset muuttuvien jakelukanavien osalta. Systeemin suunnittelu ja yhteistyökumppaneiden valinta painotettiin sen mukaisesti.

Toteutettuna lopputuloksena on television lähetyskeskusjärjestelmä, joka pohjautuu helposti päivitettäviin ja eri televisiokanavien vaihteleviin tarpeisiin mukautuviin IT-laitteistoihin. Järjestelmällä on tilaa kasvaa sekä kehittyä tulevaisuuteen ilman välitöntä tarvetta merkittäviin systeemitason muutoksiin.

Hakusanat	lähetyskeskus, televisio, medianhallinta, automaatio, monialusta, monikanava

Contents

Abbreviations and terms

Acquisition	The process of acquiring content that is used to produce a TV program.
Asset	Something that has any value. Content, for example a television program that has value for its owner.
Automation	Making a controlling of for example playout process more automatic. Eliminating manual deicision-making steps in a process.
Broadcasting	Sending television or radio signal to viewers.
Essence	The actual media, video, audio and any data that is part of the main content.
Hub-and-spoke	Model where main operations are centralized (hub) and additional and supporting operations are handled in remote sites (spoke).
Loudness	The perceptual strength of sound pressure. How loud audio sounds.
Master control	Main control room where decision and control of what is sent out for broadcasting is made.
Material eXchange Format (MXF)	A lot used file wrapper standard developed for use as file interchange format between different software/equipment.

Media Asset Management (MAM)	
	A system to control and handle media asset workflow in facility like television station.
Metadata	Data about data. Information about the actual essence or information how the essence should be processed.
Multi-channel	More than one channel. For example television operator who is broadcasting several channels has multi-channel playout centre.
Multi-platform	Broadcasting for more than one transmission path. Typical example is television channel that is available on both TV and Internet.
OPeration EXpence (OPEX)	
	Cost of running a business operation.
Playout	A process of making sure all required material, audio, video and additional data like subtitles are sent for transmission of a television channel.
Quality Control (QC)	A process of controlling that material is in correct format and does not include any errors.
Subtitle	Textual version of dialog in television program typically displayed in lower part of the screen.

1. Introduction

Publishing has been around for a long time and it has evolved in many ways. Although, the era of electronic media is quite a short period it is the fastest changing field in this industry and is re-defining the long history of publishing.

Television (TV) started as a completely new form of publishing in 1929 when BBC started regular transmissions. [1] Test broadcasts had been done even before that but before TV the only way to publish moving picture was in movie theatres or other shows in film. This was not a very efficient or fast way of publishing but it still exists as entertainment. Compared to print, which has been the strongest publishing method especially for news, TV has all the new aspects of a life cycle. Before a program is filmed and edited, there has to be production. Depending on program this can be done by one man with a camera to a huge production with tens of people working behind the camera or cameras to prepare the half an hour live evening news broadcast for us to watch at home. Also, TV broadcasting is in one way very different from traditional print media; it is a continuous process that nowadays, in most cases, never stops.

There have been big changes in TV production and broadcasting during its history. What started as film based operation first moved to open reel tape deck and then to videocassette. Videocassette changed to digital form while digital file based post-processing and video servers appeared. Currently there is a big change happening where besides moving to high-definition (HD) the whole production workflow is becoming file based.

In this thesis I will research and discuss the effect of these current changes on one small but very important part of the TV broadcasting, the playout. As an application case, I will use Levira playout centre project in Estonia.

2. Television playout

2.1 History

Besides test and research projects, the first public introduction of TV in Finland was in 1950 when American General Electric and their distributor in Finland, Anglo Nordic, organized demos in Stockmann department store. The goal was to push interest for televising Helsinki Olympic games in 1952. The first public TV broadcast in Finland took place in 24th of May 1955 from University of Technology’s TV studio. The broadcaster was a TV-club that later became TES-TV. Finnish broadcasting company (YLE) started test broadcasts in 13th of August 1957. At first it was TES-TV broadcasting on Wednesdays and Sundays and YLE broadcasting on Tuesdays, Thursdays and Saturdays. YLE changed from test broadcasts to regular broadcasting in 1st of January 1958. [1]

Cable TV in Finland started in 1975. It was at first a heavy operation with lots of own program production in mix with purchased content just like any TV broadcaster. Satellite downlinking channels for distribution by cable started only about ten years after launching of cable TV in Finland in 1982. [1;2] Distributing channels is nowadays the chosen operation mode for cable companies instead of producing own content. In mid 1980s a third TV-channel was introduced when commercial operations, previously broadcasted as part of YLE channels were separated to one channel later known as MTV3. [1]

At first all TV operations were live or from film. Even recording was done on 16 or 35 mm film. Magnetic recording was developed late 1950s and first open reel 2” video recorders at YLE were in operation in 1960. Archive recordings of broadcast were still done on 16 mm film as it was cheaper than tape at the time. [1] Playout master control operation was reading the log, finding the media, loading film or tape, rolling media and making the air switching. All promos were live – or pre-recorded. No editing was done. [3] On non-live productions film was the most popular medium used. Also, subtitling was done with text filmed on 16 mm film and played out on top of actual video film. Process and equipment for subtitling were created in-house at YLE [1]

Changes in technology brought big investments as moving to color TV forced to change pretty much all equipment used except film cameras that could simply be loaded with color film instead of black and white. Decision to move to phase alternate line (PAL) color TV in YLE was made in January 1968. [1] Videotapes developed into half the size – 1” – tape and then to videocassette. The advent of the videocassette (as opposed to the open reels of the 2-inch machines) opened the way to a new generation cart machines. A tape cassette does not have to be manually laced. It can be easily moved by robotic arm from storage to the tape deck. [4] This automated lots of playout operations but not without startup problems. In some cases operators had problems understanding that a robot could pick up the right tape only if information (later know as metadata) was fed into system.

Hewlett-Packard and Grass Valley both developed video disk stores that could be used on air. The way was now clear to play spots to air from disk rather than tape. [4] The first video server in Finland was at MTV3 for playout of commercials. [1] Until the end of the twentieth century the television workflow comprised a number of digital islands, linked by medium of videotape. The introduction of video server changed the operation of master control. From being a tape-handling exercise, it became a file-management issue. [4]

For a long time playout was mainly a single channel operation. A TV station with broadcasting license was taking care of their own playout. Nowadays this has become rare as we are talking of multichannel playout. Multichannel playout can mean a terrestrial station with a couple of channels all the way up to a cable operator with hundreds of channels. [5] Television playout has gone through several big development steps throughout its relatively short history.

2.2 Centralization and automation

There are different ways to streamline playout operations towards more cost effective and competitive operation. For large broadcasters one way to operate playout is hub-and-spoke model where most of the operations are centralized and some are done on spoke sites. [3] For example ingest and QC can be done on hub and only localization for ads and news tickers on spoke sites playing through the main broadcasted signal. Spoke sites can even be controlled from hub thus reducing manning costs. [6] Spoke sites can also be quipped with full standalone automation and media management systems including local ingest for improved resilience. [7] Possible combinations on hub-and-spoke model are numerous but the key point is utilizing centralized operation one way or another. In many cases the reason is simply to lower operational and investment costs on spoke sites. A frequently used model that is close to hub-and-spoke model is the way local advertisement is spliced in on transmission at head end multiplexes without de-coding the signal back to baseband and utilizing playout equipment.

For smaller broadcasters who have no benefit of hub-and-spoke kind of centralization, automation is the way to go. The first generation of broadcast automation cued up and played tapes to air. The second generation adapted to play out from video servers and added features like satellite recording. As ad and program distribution become solely file-based, the old cost associated one with moving tapes no longer existed. [6] Also, the whole ingest process can be more efficient or even completely automated.

Today, broadcasters who are still working with traditional isolated systems have become exceptions. Integrated channel management has replaced their existing systems, which were often developed in house. [8] In a traditional automation system a different piece of equipment is required for each process. [9] Video is played from tape or server, graphics are created with separate CG or logo generator and all equipment are controlled with playout automation software, which is essentially third party device controller. In this model there is often a vision mixer as master control switcher to select on air signal. This model is suitable for low channel count systems at best. [5] The basic infrastructure of digital media is moving from dedicated devices designed specifically for broadcast operations to commodity information technology hardware running specialist software. [10]

Combo model automation has video server with built-in automation with additional third party equipment attached to system. Hybrid system has automation built-in with all other needed features needed to handle a complete broadcast channel operation. [5] An existing video server/player with a simple clip player, which is not considered a true channel in a box and is really only useful for simple, jukebox-type playout. By adding simple enhanced graphics functionality, this approach moves closer to the channel in a box concept. [11] Software-generated graphics with shared video assets simplify the job of the centrally managed automation system, resulting in improved operational efficiency. [12] Even a channel in a box systems can have third party equipment attached if needed or wanted.

It is up to requirements of the channel/broadcaster which automation model best suits. Currently traditional models can mostly be seen on public broadcaster systems where there are not many channels and they want operations to be kept in house. Public broadcasters also tend to have the burden of long history of operation and deep-rooted operational models. Hybrid systems are best suited for large playout centers as they are most flexible on changing needs of the customer base and covering all sorts of different channel types. Hybrid system can also be the best solution for channels with lots of live content.

The move away from multiple device control to a single integrated playout device will be critical in controlling power consumption and simplifying the basic automation processes for broadcasting. [10] Broadcasters and other media companies can now ride the same technology wave that the Internet rides – Service-Oriented Architecture (SOA) and extensible Markup Language (XML). [13] Both are used especially on automation as well as media management processes. For multichannel playout, the operator-to-channel ratio will have a big impact on operating expense (OPEX) and a suitable choice of automation system can ease the job of the master control operator in managing many channels. [6] The challenge lies in automating processes to achieve efficient and cost-effective workflows. [14]

2.2 Workflow and operation aspects

2.2.1 Ingest

Tape is still a dominant media for acquisition, but its days are numbered. File-based workflows that begin with acquisition and continue through distribution are becoming the norm. [15] Tapeless operation cuts down manual operations and handling costs like shipping tapes around. [6] Tapes also have other problems. Not only do videotapes deteriorate over time, but the equipment required to play them back is becoming obsolete and in some cases, hard to find. [16] Now that even cameras use solid stage medium instead of tape and save directly to file, we are at the verge of truly tapeless world.

Files are often transferred over file transfer protocol (FTP) or other suitable connection for larger data transfers. A critical thing is security of transferring files. Digital cinema has especially emphasized this point. Also in house security is important for multichannel playout centers when handling files on storage system as same playout centre might even handle material for directly competing channels.

At ingest, besides verifying video features such as resolution and color information, capture related issues such as tape-induced block errors, blurriness in motion, background audio noise may also need to be detected. [14] Same quality control (QC) issues apply for fully file based ingest as well. Files need to be checked somehow. In most cases QC process is fully automated or at least semi-automated so that operator intervention is required only when QC system checking files detects error. Files must comply set rules for workflow of the playout station. If for example audio tracks were in wrong order or missing, it would be a disaster to find it out only when playout server is playing the file out for TV broadcast.

Ingest state can also include editing of the material. Trimming of clip in and out points as well as adding additional language tracks can be done on all up-to-date playout systems but sometimes there is a need for a bit more detailed editing of material before playout. One example can be creating promos of movies or TV series that are played on the channel later on. Material used on promos is of the actual movie – just edited to short form suited for promo clip. The latest development is automating creating promos as well by simply playing part of the content when needed – such as graphics template including a list of following programs.

2.2.2 Media asset management

Media asset management (MAM) system is always more or less tailored system that cannot be provided as out of the box solution. This is because all broadcasters have their own needs and existing systems to integrate MAM solution to. [17] An option is to build a system from a selection of manufacturers' file-based products – each chosen to suit your application. These products must be integrated to support efficient workflows. [18] Integration is the key word on MAM systems. Without MAM matching the needed workflow, it only makes things more complicated even if it would provide useful functions like searching the material.

Today's broadcast facilities typically comprise many different IT systems from scheduling and traffic through to content management and ingest, archive management, playout automation and content delivery. [19] Systems need to have the ability to function seamlessly together, automating steps based on rules and business logic rather than just presenting data for manual decision-making. [20] To avoid bottlenecks of direct communication between software clients and data servers as well as to tie different manufacturer systems together there often are separate application servers. Software clients communicate with application server that in turn pools required resources from the data server. Sometimes there is middleware that takes care of integrating end product or third party products to needed basic services of application server. [4] Lot of the file moving steps are automated as far as possible to avoid tying valuable staff resources on simple processes like moving files from one folder to another.

Within the media industry, workflow-oriented systems design is critical to organizations' successful shift toward cost-effective multiplatform content distribution. If an organization's workflow has been hard-wired to perform only a single job, then substantive changes to its business model, and in turn, to the organization's operations can potentially mean that the entirely new system must be deployed. [21] An important aspect of achieving efficiency is to ensure tight integration between different parts of the system. [18] As the volume, complexity and size of digital assets increase, file transfer and management workflows are being redesigned to save time and reduce costs. [22]

When talking of MAM systems there often is reference to essence. Essence is the actual media, video, audio and any data that is rendered as graphics that is the main part of content. In addition to essence content includes additional information, often in form of metadata, which adds for example user rights information on content. If content has value, it is called an asset [4]

When archive systems grow and get more complicated a thoroughly thought set of rules becomes utmost important. What needs to be archived and what does not? How long the archived material should be archived for – sometimes the answer is forever. And if forever, what is the plan to migrate archive to future formats as technology will change during time? [23] Hierarchical storage management (HSM) system is most common way to control tape (or optical) archives. HSM application sits between media management and storage or acts as service for storage network management. [4] Even archived material must be accessible on MAM. Otherwise there is no use to archive anything. With good integration to MAM system, archived material can be utilized in a way the archive is of real value for the broadcaster.

2.2.3 Playout

In master control, the program material is played to air according to a playlist (schedule) from the traffic department. The playout automation system processes the day's schedule. This queries the media management, and all the wanted files are moved and duplicated to the air servers. The operator can be warned of any missing material and take suitable action. At the scheduled time, the server is cued and played to air. [4]

Rather than simply loading a playlist and walking away, engineers need the ability to intervene at appropriate times to avert errors and to trigger events manually, as required. [24] The Master control operation is nowadays as much controlling and monitoring things happening on computer screen as it is watching picture on video screen. [3] The video screen is still very important as that us visual cue on what is really playing out to on air – and especially to show that video is really playing out in the first place. Transmission chain from playout centre to home can be so complicated and travel through so many pieces of equipment that there is no way one could monitor the whole chain in playout master control. And very often the transmission part is taken care by some completely other company.

In today's master control the video screens are large monitors run by multiviewer system. One screen can have tens of pictures to cover all steps where video is needed to be monitored on playout process, like live input feeds, server previews, server program outputs and the most important, on air – the last monitoring point out of playout centre showing what is actually playing out to air. Multiviewer systems provide a possibility for all kinds of automated problem monitoring to help operator. They can be set to display alert for example video freeze, video black levels, audio missing, audio levels, and so on. There are also system tools to check audio sync throughout the equipment chain – or even through transmission chain. The latest tool is a sort of fingerprinting on video that allows all equipment supporting it to analyze if everything on signal is as it should be and to display alert for operator if something is wrong.

The main thing dictating master control operation besides the automation type used is the channel played out. A film channel without commercials does not require much attention at all as it is mostly long duration movies so there is not much happening assuming files are problem free at stage of playout. Commercial music channel would be the opposite example with very short duration clips and lots of important commercials. And yet another completely different example would be sports channel with live broadcast possibly with need of live commentating – sometimes on several languages. In this example there would be need for audio mixing and control.

One aspect of playout is compliancy recording. Broadcasters must record all output in case of complaints or a rights issues. [25] On commercial channels compliance recordings can also be used for verifying billing of commercials. Typically compliance recording is done as low resolution as it is not for quality monitoring. However, all elements of broadcast such as subtitles must be included. Servers taking care of compliance recording are set to keep the files for required time and then delete to make room for continuing recordings. Compliance recording is often done at playout centre, as that is where playout for the channel is controlled.

2.3 Multi-platform playout

Multi-platform can mean, in wider respect, almost any broadcasting network where the same program is transmitted as it is or as edited, and optimized for streaming or downloading for different end use applications with or without contact request of the user. [26] In print media change towards multi-platform publishing has been happening for a while now with digital look-a-like or edited versions of magazines available through the Internet. This same development and even utilization of the same source material as print media for TV is only natural step. After all, in many cases the owner of a TV channel is media house that owns some print media as well.

Content transcode needed for different platforms is often well-defined and automatic process. Bigger challenge is how to repurpose content for different screen sizes and uses. Watching a clip from a computer screen at the office is a completely different experience than watching it from a phone screen on a rush hour tram. [27] What makes things more complicated is the different nature of mobile devices. Where computer a screen always has 72 pixels per inch, an Apple iPhone and Nokia E7 can have completely different resolution even if the screen size would be the same. Because of this, content must be rendered into even more variations not only for type of use, TV, computer or mobile, but also for type of end device.

Besides mobile devices one hot topic on broadcasting during last years has been three-dimensional video (3D). It puts even more demand on how material must be handled throughout the whole workflow as 3D is basically two videos that need to be transmitted together completely on sync – one for left eye, one for right eye. [10] Not to mention possible simultaneous broadcast for non-3D version of the same content.

With the consumer now being able to choose how, where and when to view media, content is king. The true key lies in producing and acquiring content that viewers want. A key feature of the digital media asset management system is its ability to manage different formats and versions of the same video master. [28]This puts great demand on asset management to be able to track the rights for the material throughout the whole workflow and life of the asset. One big challenge has been that Hollywood studios do not see mobile devices or computers to have same level of security as set-top-boxes used for regular TV viewing. And therefore licensing for same premium content as for TV has been a challenge. [29] According the IABM Broadcast Survey (September 2010) Internet is seen both as a threat and as a possibility for traditional broadcasters. [30]

3. Technologies

3.1 Broadcast video and audio

3.1.1 Digital video

All information human can sense, see and hear, is analog. At early stages of television all video was analog as well. Primary storage medium was videotape, which is a magnetic medium that was reproduced with mechanical videotape recorder. [31] With development of technology all data processing and storage has become digital. This applies to video as well even though origin in most cases and reproducing for end-user, human, is still analog.

In digital domain the most simple way to present data is in binary form – zeros and ones. One great advantage of binary data is that it is extremely robust – less prone for misinterpretation. Binary data can be presented (and transmitted) as an electrical signal of low and high voltage. Low voltage would mean zero and high one as shown in figure 1. Even if the signal would be significantly distorted the signal state can be determined by investigating the level in comparison to threshold that is set between the two ideal levels. Voltage higher than threshold would be one and voltage below the threshold would be zero. [32]

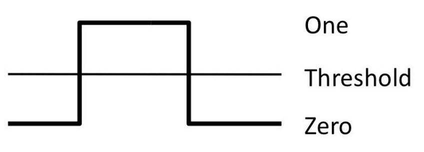


Figure 1. Binary electrical signal

Zero or one is the smallest value in digital world called bit. One bit, zero or one, does not provide much information alone but when combined into group of for example eight bits it can already have 256 different values. With 10-bits, which is 2^{10}; there would be 1024 possibilities. [33] More bits are more information – longer word length, which means faster processing of data.

Sampling rate for digital video is based on two factors. First, sampling had to occur frequently enough to accurately reproduce the analog signal. Second, the process had to be simple enough to integrate with the existing analog video. Main synchronizing signal for analog video is subcarriers frequency and that fulfilled both demands. However, sampling that equals subcarrier frequency itself is not enough. According the Nyquist theorem the sampling frequency must be more than twice the highest analog frequency in the signal. To avoid aliasing effect caused by this multiple subcarrier frequencies were used. [31]

In digital domain, each pixel in picture contains three numbers. One is representing luminance and other two the color difference. Eye is not equally sensitive to all colors. That is why most important is luminance signal and color difference can be half or even one quarter the luminance bandwidth. As color difference signal needs less bandwidth it means lower data rate. It also affects image quality. [32] International broadcast standard for this digital encoding ratio is 4:2:2. [33] There are some systems that use 4:2:0 or 4:1:1 encoding ratio but these are not used on high-end solutions. Also, 4:4:4 is used in some cases but that takes close to double the bandwidth of 4:2:2 so it is not too practical in broadcasting. Sometimes there is even a fourth sampling frequency added for key signal or alpha channel.

Digital video signals are normally transmitted as digital stream of binary bits referred to serial digital. The quantity of data in digital stream dictates the quality or detail of the image. The larger the amount of data, the greater the amount of bandwidth required to transmit the data. Digital data stream begins as bits, which are grouped into elements called frames. Groups of frames are organized into packets. Groups of packets are organized into segments. [31] In broadcast systems the most used digital video interface between equipment is serial digital interface (SDI).

SDI is video interface standard family created by Society of Motion Picture and Television Engineers (SMPTE). [34] There are different standards for different signals. Most relevant for today’s broadcast video are SMPTE 259M for SD-SDI, SMPTE

292M for HD-SDI and SMPTE 424M for 3G-SDI. Each of these standards supports needed amount of data to be transmitted for each signal type. SD-SDI runs at variety of bitrates depending on television standard – 480i or 576i. Bitrates for SD-SDI are 270 Mbit/s and 360 Mbit/s. The latter is used for wide screen signals. The standard includes other bitrates as well but these are considered obsolete. HD-SDI only runs in one bit rate, 1,485 Gbit/s, although it is possible to reduce this by 0,1% for locking to 59,94Hz equipment. [35] HD-SDI can be 720p or 1080i. 3G-SDI is 2,970 Gbit/s and that can also be reduced by 0,1%. Lots of equipment like routers are practically SD/HD agnostic, which makes system design lot easier. [36]

In addition to video information, digital stream in SDI can include ancillary data that is none-video-data within the signal. This data is carried in horizontal and vertical blanking period that would otherwise be just digital black. The most used ancillary data is audio. SDI signal can carry up to eight AES/EBU audio multiplexes, which is 16 audio channels. Other data that can be included is error detection and handling and timecode. [37]

SDI is most commonly transferred over 75 Ohm coaxial cable terminated with Bayonet Neill-Concelman (BNC) connectors. Typically SDI is used to connect video between devices. Distance covered for each type depends on cable characteristics – mainly cable core thickness. As an example Belden 1505A has maximum distance of 94 meters where as thicker Belden 1694A has 122 meters on 1,5 Gb/s SMPTE 292M HDTV signal as listed on Belden catalog. [38] Another thing that highly affects distance covered is receiver circuit on equipment the cable is connected to.

BNC (Bayonet Neill-Concelman – the name comes from connector type and names of two inventors. However, it sometimes is referred as Baby Neill-Concelman connector, the Baby N connector, the British Naval connector, or the Bayonet Nut connector [39;40]) connector is general radio frequency (RF) connector that is available in 50 Ohm and 75 Ohm. It has become a standard video connector that is used in all broadcast equipment. Only in equipment like large routers that have huge number of connectors that need to be fitted in small area there are other connectors used.

Nowadays when talking of HD-SDI or even 3G-SDI installations there are more things that need to be taken into consideration on installations. Video installations have become more like RF-installation as frequencies inside cable increase. Factors like stepping on cable during installation or bending cable too tights cause reflections on cable that increase return loss. [41] Higher frequencies in HD-SDI compared to SD-SDI mean that effects of shortcomings in installation practices are more serious. [35] Long cable runs for HD-SDI and especially 3G-SDI are not practical to do with coax cable as maximum distances are somewhere between 50 and 80 meters. Optical fiber connections are used instead. [37]

3.1.2 Reference video

Reference video or synchronizing signal (sync) is an analog video signal generated by sync generator. Sync generator is the heart of the system as in order to all equipment to see video exactly the same way and the same time frame as generated they have to be synced. Originally the sync signal was completely separate to actual video. For practical reasons it was combined to signal to form a single electrical waveform called composite video, which carries both synchronizing signal and brightness signal. [32] This composite signal contains both horizontal and vertical synchronizing pulses. Horizontal pulses appear at beginning of each line in video and vertical during every vertical interval. With these it is ensured that every piece of equipment is operating line-by-line, frame-by-frame basis. [31] Today's digital systems use only syncing part of the analog composite signal as all video content is transferred on separate digital connection.

Higher line density of high definition (HD) signal and therefore increased number of sync pulses would cause disturbance on actual video signal because of not so precise locking point on black burst sync signal. Therefore a separate tri-level sync was created. Instead of two levels in black burst there are three levels in sync where levels of same amount below and above blanking level counter effect each other and therefore prevent problems caused by bi-level, or back burst, sync signal. [31;42] It is up to each piece of equipment whether it actually requires tri-level sync or if it can use black burst just as well. However, no SD equipment can use tri-level but they require black burst. Difference between black burst and tri-level signal can be seen in figure 2.

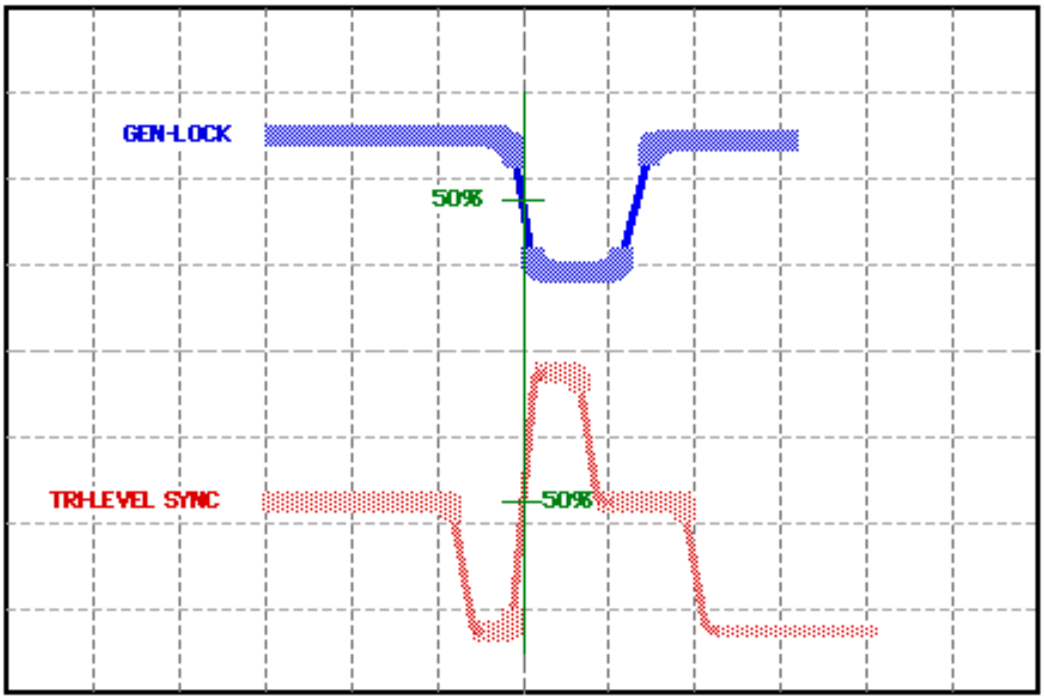


Figure 2. Black burst and tri-level sync signals [43]

On a system where you have only simple chain of equipment like camera directly connected to a monitor there is not much need for separate syncing. But in a larger system where video goes through number of equipment and especially where you switch between different video, syncing becomes important. Without syncing signals would roll, jump, flicker or tear. In other words there would be major disruption or breakup especially when switching between signals. [33]

3.1.3 Audio processing

Audio, just like video, is always analog for the end user, the human being. It is made audible by speakers or headphones that turn audio signal into sound waves. This chapter focuses on audio processing and handling from television playout system point of view – some aspects that mainly concern audio production are discarded.

Audio can be transmitted as analog or digital signal. On broadcast systems audio is more often in digital AES/EBU format. The name AES/EBU comes from two organizations behind the audio standard standardized as IEC 958 [32], Audio Engineering Society and European Broadcasting Union. AES/EBU was developed into 100 Ohm version using XLR connectors to allow usage of existing analog audio cabling as well as 75 Ohm version using coax cabling to allow longer cable runs. [32] AES/EBU audio can be embedded into SDI signal as well which rules out the need for separate audio cabling on video systems.

In the 1980's Dolby Labs developed multichannel surround audio solutions where audio is divided to more than two speakers used for stereo audio to gain more realistic listening experience. Most consumer equipment supports Dolby Digital, also called as AC-3 audio. Dolby Digital is 5.1 channel audio where there are five full channels – front left, right and center, and rear left and right. The sixth channel is a subwoofer for low frequency bass. [31] Dolby Digital is used on production and on consumer equipment especially together with HD video but for broadcast workflow the format used is often Dolby E. Dolby E is a professional digital audio coding technology that is optimized for the distribution of surround and multichannel audio through digital two-channel postproduction and broadcasting infrastructures. Dolby E enables the distribution of up to eight channels of audio via any stereo (AES/EBU) channel or via a recording onto two audio tracks of conventional digital videotapes, video servers, communication links, switchers, and routers. [44] Dolby E can be transmitted as SDI embedded audio but all equipment on signal path must be able to pass it through as it is and not to handle and process the data as if it was AES/EBU audio, as it is not.

Over decades, audio professionals in the production and broadcast industries have attempted to control audio so their audiences hear programs that are both intelligible and easy on the ear. [45] This states well the challenge of audio level and loudness control. Traditionally audio has been monitored by ear, simply listening. However, there are so many factors affecting how audio really sounds starting from speaker to acoustics to surrounding noise that in the end the effect might be completely different. Audio also has lots of nuances that escape traditional level meters that are offered in various types.

BBC developed the peak program meter to assist in level control in the 1930's. This meter has been standardized by EBU. After that there has been automatic gain and level controllers to make sure broadcasted audio is as should be. But broadcasters and especially advertisers began to utilize these automatic tools by adjusting audio to certain sound quality, which ends up sounding much louder without exceeding regulatory limits. [46] This effect can be often heard in today's TV broadcast where commercials between movies sound much louder than the movie. Or by surfing between channels as there can be huge difference on audio between channels.

One method to adjust audio loudness in channels broadcasting Dolby Digital audio is using dialog normalization, or dialnorm. Dialnorm works by setting the Dolby Digital receiver dialog level to match pre-determined loudness level of each program. [46] Dialnorm information is stored as metadata on Dolby Digital stream where home decoder then reads it and adjusts accordingly. However, this can cause problems if it is not used correctly or it is left as default instead of adjusting it according to the program. [47]

Loudness measurement and on-the-fly level control is one option commonly used by today's playout centers. This means ignoring possible dialnorm metadata. [47] The International Telecommunication Union's Radio communication sector (ITU-R) has published algorithm recommended to be used on estimating loudness levels. Relying on that alone would provide problems as audio level would vary wildly. [45] Instead there are processors like Jünger Audio Level Magic that can analyze audio live for both level and loudness and adjusts it according pre-set rules. [48] These rules must be considered channel by channel as for example reaction time must be completely different for a channel playing out music videos compared to channel showing movies. Audio control is based on processing done on transient processor and automatic gain control. [49;50] This process can be seen in figures 3, 4 and 5. Ideally there would be both short-term dynamic control as well as average level control applied to all broadcasts. [45]

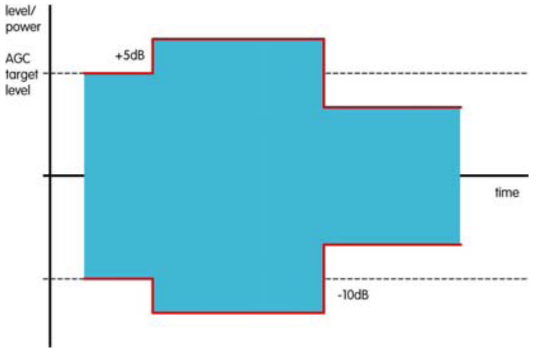


Figure 3. Input level change [49]

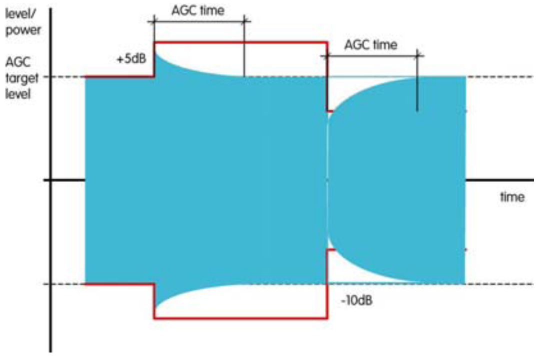


Figure 4. Effect of automatic gain control (AGC) [49]

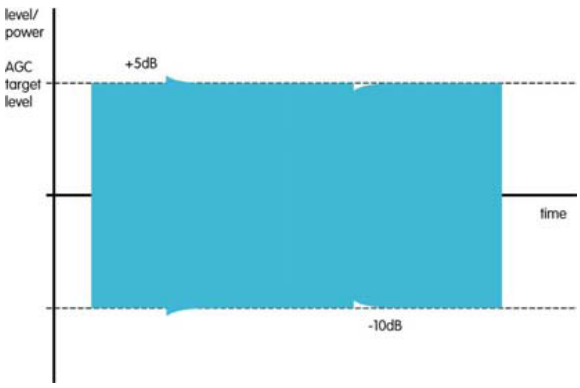


Figure 5. Effect of transient processing together with automatic gain control (AGC) [49]

Audio loudness differences have become so big issue where viewers have reacted loudly that besides developing automated control tools there are new types of measurement devices developed as well. In US there is even legislation in process to set technical guidelines on loudness on broadcast. [51] Developing better loudness control is a work in progress.

3.2 Video systems related IT technology

3.2.1 Video compression and file formats

Compression is the process of reducing data in a digital signal by eliminating redundant information. This process reduces the amount of bandwidth required to transmit the data and the amount of storage space required to store it. [31] The most important point is that what is thrown away is hopefully something we do not miss. For instance, we do not see detail as well in presence of motion, so we can eliminate that redundant information. [52]

Compression can be lossless or lossy depending on whether some data is lost on the process or not. Reducing data can be done by registering the differences within a frame (intraframe) and between frames (interframe) rather than storing all the information from each frame. [31] One factor dictating the amount of compression to use is required bit rate. Transmission systems might set up strict limitations on maximum bit rate that can be used. The same limitation can be set by decoder on end use device. For example DVD standard says maximum bit rate is 9,8Mb/s for all content and going above that might choke decoder on DVD player. On systems where video is played out as baseband the bit rate must be set on quality and resource basis. The quality must be good enough for the purpose and size of the storage must fulfill needed requirements.

In a way compression is as old as television broadcast as interlacing is a form of compression, a primitive way to reduce required transmission bandwidth. [32] Today's broadcasting is in most cases based on MPEG-2 compression, a standard created by motion picture experts group (MPEG) and adopted already in 1996. MPEG-2 is not only compression system but also a description of the transport stream that carries the content. [52]

MPEG compression utilizes a combination of two different compression schemes, spatial and temporal. Spatial compression reduces amount of data in each frame and temporal compression compares the changes between images over time and stores the data that represents only the changes. [31] Spatial compression uses same methods as

Joint Photographic Experts Group (JPEG) compression on still images. Frames compressed with JPEG are called I-frames where I stands for intra picture. I frames act as reference for temporal compression. [32] Frames between I frames are called P and B frames. P frames only include data that has changed from previous I frame where as B frames look both backwards and forwards to compare pixel blocks. [31] I frames grouped with P and B frames prior to next I frame are called group of pictures (GOP). GOP can include only I and P frames or all three; I, P and B frames. [32]

MPEG-2 is more complex than the original MPEG-1 but essentially it is an improved version of the MPEG-1. [31] Though using MPEG-2 can produce great results, the technology is much older than the standard adopted 15 years ago. The MPEG-4 standard, particularly Part 10 (also known as Advanced Video Coding (AVC) and H.264 for the ITU standard number) offers all that MPEG-2 does, plus many additional tools that can further improve the coding efficiency and reduce bit rates for equivalent quality. [52]

MPEG-4 part 10 still uses discrete cosine transform (DCT) compression, but allows variable block sizes, multiple reference frames for motion prediction, and the ability to code single blocks as intra (I) or predictive (P) data. Other significant developments after MPEG-2 were loaded into the standard, such as increased precision in motion prediction (one-quarter picture element, or PEL), more effective entry coding using content-adaptive binary arithmetic coding (CABAC) and content-adaptive variable-length coding (CAVLC). [52]

File based workflow forces system designers and manufacturers to deal with huge, growing range of individual codecs used by different systems and areas of production, preparation and distribution that make up any broadcast workflow. [53] Depending on hardware and software solutions used there can be limitations what file formats are supported on the workflow. Best-case scenario is that ingested file format can remain unchanged throughout the whole workflow. The worst-case scenario is that files must be trans-coded several times during the workflow. For all broadcasters - regardless of network infrastructure, compression solution and application specifics – the goal is to deliver maximum quality given bandwidth and cost limitations with sole purpose of maximizing revenue. [54]

3.2.3 Metadata and wrappers

Metadata is one half of the content, the other being essence, the actual content itself. Metadata can be structural or descriptive. Structural metadata gives information that may be necessary to process of the content like format, compression, and number of audio tracks used. Descriptive metadata provides other useful information about the content like program title, length or copyright holder. Descriptive metadata is what an often-used explanation says: data about data. [55;56]

The media management and automation market has a history of closed and proprietary systems. During last few years this has begun to change. [57] There have been a number of attempts at creating metadata frameworks such as DMS-1, Dubling Core, SMEF and most recently BXF. [18] Challenge on standardizing metadata is that not all processes need same metadata. Attempted metadata standards are for proposals that can be applied to a wide range of content types in many different industries. [4] Different phases on media workflow have different needs on asset management. Showing all metadata for everyone can even slow down productivity with too much information. [58] Identifying the essential metadata and ensuring that this is carried through the system along with the clip material, is a key to the success of integrated workflows. [18]

Sometimes metadata is controlled by separate metadata server that points to the actual essence stored in a separate storage system. Use of metadata server is called asymmetric pooling. Symmetric pooling is where instead of a metadata server there is an inline appliance between host bus adaptors and storage devices on network attached storage (SAN) system. [4] Storage systems will be discussed in more detail in the following chapter.

A self-contained file includes both the essence and the metadata, so there is a single entity to be transferred from one location to another. A reference file is made up of the media files themselves, plus a wrapper file that contains metadata and pointers to media.

[53] Using a wrapper allows the media and all of the metadata to be delivered in a unified stricture. [55] Examples of wrappers are AVI, QuickTime and MXF. MXF wrapper structure can be seen in figure 6.

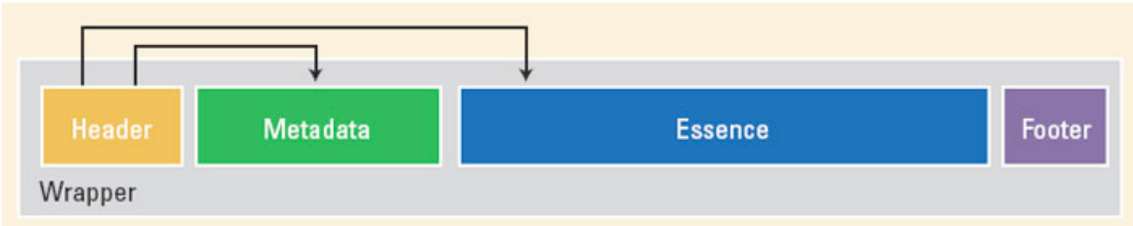


Figure 6. The MXF wrapper structure [56]

MXF development started when new file interchange format was needed for file-based workflows. Especially need to include metadata was important factor. As different users have different needs, MXF has several operational patterns that support different levels of complexity. [59] Problem with MXF is that its development took so long that even though many manufacturers wanted to adopt it, there was no set way. This ended up in a situation where everyone has their own flavors, all called MXF, but not really compatible with each other. Now situation has cleared and standardized but still challenge is that different operational patters are not cross compatible because of fundamentally different way of handling the essence. Currently two most commonly used operational patterns (OP) are OP-Atom and OP 1a. OP-Atom is SMPTE standard 377M and it can have essence as separate tracks. OP-Atom has become popular format on file based cameras and non-linear editing. OP 1a is SMPTE standard 378M and it has single file package containing all essence. [59]

MXF development has not stopped but is work in progress. New toolkits under development are MXF AS02 and MXF AS03. AS02 is developed as mastering tool for needs of production and AS03 as delivery format.

3.2.4 Disk drives and storage systems

File storage can be divided into subcategories. Online files are stored onboard server hard drives for immediate access and playout. Nearline files are stored on a network attached storage where they can be accesses by management systems and transferred for online workflow. Offline files are stored on a tape media or an external drive but not directly on the system. Sometimes offline is also archive but archive can also be fourth subcategory when archive medium is stored off-site. [22] Systems containing all these parts require good management of the assets with MAM or archive management software. [56] Typically all but archive storage systems are based on hard drives.

Hard drive is basically number of platters mounted on a spindle. Platter rotate on high speed, 5000 rpm to 15000 pm depending on hard drive type. Platters carry magnetic coating where read/write head on moving arm writes data or reads data on magnetic tracks. This mechanical construction is linked to external interface by disc controller. [4]

In addition to hard drives base on magnetic disk spindles there are solid-state drives (SSD) that have flash based memory chips for data storage. SSD drives do not contain any moving parts. Typically flash memory has been used in memory sticks and memory cards used for example in digital cameras. But now that memory size has grown SSD has become an option for computer hard drive as well. SSD drives have same interfaces as their magnetic disk versions. What makes flash based drives especially potential for future is their lower annual failure rate (AFR) compared to traditional hard drives. [60]

External interfaces of hard drives have developed over years. Advanced technology attachment (ATA) that was originally developed by IBM was long used for internal connections inside computer for hard drives as well as disk drives. ATA is a parallel interface and it became limit for drive performance and started to be replaced by serial ATA (SATA). Throughput of ATA was 133 MB per second where as SATA started at 150 MB per second and is architected to go up to 600 MB per second. However, the limit of SATA drives is 7200 rpm maximum spin speed. [61] Besides being used as internal interface of choice on computers, SATA is used a lot on large disk arrays.

Small computer system interface (SCSI) is actually a group of standards for storage interface architecture so SCSI does not limit on disk drives. Since its introduction SCSI has been considered as the prime choice for drives. It supports high spin speeds – up to

15000 rpm. SCSI is parallel interface that supports up to 15 devices on single bus. There are several SCSI interfaces where oldest ones like SCSI-1 are only 8 bit with maximum 5 MB per second where are latest ones are 16 bit like Ultra 640 with 640 MB per second. There is a next generation SCSI called serial attached SCSI (SAS), which, like the name points out, is a serial connection instead of parallel SCSI. SAS has higher throughput up to 12 Gb per second. SCSI and SAS are used where high performance is needed like disk arrays for video editing workstations. [4;61]

Fiber channel (FC) is full-duplex serial connection that can use copper conductors or optical fiber. It supports data rates form 133Mb/s up to 4 Gb/p over distances as long as 10 kilometer (over fiber). Disks are physically the same as SCSI, only the interface is a fiber channel instead of SCSI. Fiber channel can be connected in several different ways as opposed to SCSI, which is point-to-point or daisy-chain only. A fiber channel can be point-to-point, arbitrated loop or fabric with FC switch. [4;61]

Last commonly used interface is IEEE-1394 also know as FireWire. This is only used to directly connect disk drives and other equipment like video cameras to computers. There are several versions of FireWire connector and current maximum data rate is 800Gb/s. FireWire supports strings of equipment and hubs to connect device networks up to 63 devices. [4]

Magnetic disks as such can be volatile and data can be lost in case of drive failure. Another limitation can be that performance of single drive alone is not enough. To outcome these limitation there is redundant array of independent (or sometimes inexpensive) disks (RAID). Arrays consist of multiple disks organized as a large high-performance logical disk. Depending on requirements disk arrays can be configured on different RAID levels. [4;31]

RAID-0 is also called just bunch of disks (JBOD). RAID-0 is actually not true RAID – it is number of disks striped for higher data throughput. There is no redundancy – if one disk fails, all data is lost. JBOD is typically used on disk arrays for video editing workstations where high data throughput is needed. RAID-1 is mirrored. This is true redundancy – the entire array is mirrored or duplicated. The downside is that double amount of disks is needed. RAID-1 is often used on system drives on important servers. Higher RAID levels use parity data stored across array making it possible to rebuild a drive in case it has failed. In video applications typically used RAID levels are 5 and 6. On RAID-5 parity data is block interleaved across all drives. It protects against failure of any drive on array. RAID-6 is similar to RAID-5 but it uses stronger error-correcting code. RAID-6 is used on larger arrays where risk of multiple drive failure grows. Another level worth mentioning is RAID-10 that has RAID-1 arrays striped for performance. RAID-10 is good in performance and protection but inefficient on disk use. [4;31]

There are different kinds of storage systems. The most straight forward one is direct attached storage – a disk or array connected directly to host computer. It can be internal inside a computer chassis or external like a FireWire disk standing next to a computer. Direct attached storage cannot easily be shared between the computers. [61]

Network attached storage (NAS) allows storage to be placed anywhere on the network. [61] It shows as remote file server to any attached clients on a file system level. In the most simple form it can be a box with Ethernet connection attached to network. As NAS does not include too much configuration, expanding storage capacity is relatively easy. In larger systems NAS might operate as file server and have storage-attached network (SAN) connected to it. [4;62]

SAN architecture allows cluster of network-attached hosts to share the storage subsystem as a pool. Most common SAN connection is over fiber channel where a server has fiber channel link connected to fiber channel switch. Switch has a storage connected to it. The same switch can have other servers connected with fiber channel links that are all sharing the same storage. On SAN, fiber channel provides high enough speed interconnection fabric for storage arrays. SAN often uses TCP/IP communication between host computers and shared storage controllers. This IP traffic is usually carried over additional LAN instead of dedicated SAN. SAN solution is harder to manage than NAS. [4;62;63]

Tape is a traditional data storage medium on mass storages. It was the primary media used before magnetic disks were developed and as it has been around for long time, it is time proven technology. Several generations of different tape formats have been developed and currently the format in use is linear tape open (LTO). LTO was originally developed from ground up to avoid being constrained by legacy formats. It is open specification created by HP, IBM and Seagate. The latest version is LTO-5 that can store up to 1,5 TB of data. LTO-tapes have linear tape file system (LTFS) on tape, which allows them to be used on any LTO-system. LTO-tapes are not dependent on storage system or any higher-level software running the file system. Television broadcasters use robotic tape libraries that can contain hundreds of data tapes in robot. In addition, there is a slot to feed tapes off shelf to robot. This gives unlimited archive capacity. Tape robots are usually part of NAS or run as separate archive system. [4]

There are also robots developed for optical media like DVD or Blu-ray instead of tapes. These are often limited to write only type of disks, which makes archive maintenance even harder than with data tapes. On positive note, optical media is often cheap and multiplying disks for backup is not significant cost.

Most storage systems on TV-stations are combination of both disk-based storage and tape-based storage. Disk storage is used for daily operations and everything that requires immediate respond from storage like video clips to be played out that are stored on disk system in a playout server. Tape is a trustworthy medium for archive storage. Storage systems can be and often are distributed and divided into smaller nodes like internal storage of ingest server where files are moved to NAS only once ingest process has finished. The biggest concern is always failure that causes loss of assets regardless if storage is in house or outsourced in cloud. The traditional method of having videotape library meant that even if one tape stopped working all the rest did not where as problem on disk array can put everything on halt. [64;65;66]

3.2.5 Network

On a video system network can mean different things. On traditional video systems network has been only video and audio connected between equipment. When the system has grown large enough, patch panel has been added to allow easier changes on connections. When the system has grown even more a router has been added. With equipment becoming more like computers, and workflows becoming file based, IP network has become at least as important as video network. [36]

Today systems are often hybrids of video (and audio) network and Ethernet network. Modern network technology, like gigabit Ethernet, can easily cope with requirements for video material, but careful design of the switching architecture will be required to optimize the performance for the lowest cost. [4] The performance of Ethernet is usually specified in terms of the bit rate at which cabling runs. However, this rate is academic because it is not available at all times. In a real network, bit rate is lost by the need to send headers and error-correction codes and by loss of time due to interframe spaces and collision handling. As the demand goes up, the number of collisions increases and throughput goes down. [32]

Institute of Electrical and Electronic Engineers (IEEE) standardizes Ethernet network on standard number 802.3 and it’s supplements. The IEEE standards are organized according to the Open Systems Interconnection (OSI) reference model. The Ethernet standard concerns itself with elements described in layer 2 and layer 1, which include the data link layer of the OSI model and below. [67] OSI layer model can be seen in figure 7.

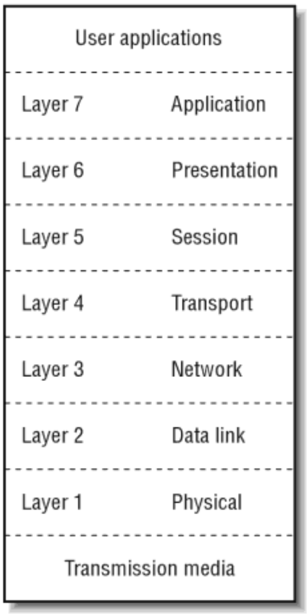


Figure 7. The seven layer OSI model [67]

High-level network protocols have their own system of addresses such as Internet protocol (IP) used on Internet. The IP based networking software in a given computer is aware of the 32-bit IP address assigned to that computer and can also read the 48-bit Ethernet address of its network interface. TCP/IP networks use address resolution protocol (ARP) to discover Ethernet addresses of other computers in the network. [67]

Depending whether the data going to a device on a local area network (LAN) or out to the Internet or a wide area network (WAN), IP addressing works differently. Over a LAN, machine address control (MAC) is used but if data travels out over a WAN, then IP addressing is primarily used. [68] IP addressing schemes for devices must be carefully planned so that here are no conflicts and that there are enough addresses reserved for future expansions. Static IP addresses are necessary. [36]

IP technology is uniquely suited for handling different error types. Reed-Solomon and row-column forward error correction (FEC) handle minor bit errors and occasional lost packets. In transmission systems with even higher error rates, packet doubling and automatic packet resending replace lost data. [69] Network success or failure is totally dependent on the proper load management ad programming of the core IP router. [15] If only one network is used it should be divided into virtual local area networks (VLAN) to distinguish critical traffic and non-critical traffic. If separate networks are used there is often a requirement for cross access between networks and that must be provided over a gateway. Either way, careful network design is a must to avoid bottlenecks caused by high bandwidth requirement of moving large video files for example to playout servers.

Both video and IP network data rates are increasing with 3G-SDI and 10gig Ethernet networks. Because of this more focus on cabling is required. New Cat 7 or Cat 6a that support 10GigE connections cannot be manually terminated but must be purchased as ready made instead. [70] It also applies to some optical cabling, which is more and more used with 3G-SDI because of difficulties on coax installations that might not be cost effective to terminate in house.

3.2.6 Video server

Video server was originally developed as a temporary store for short effect streams. As it matured it became possible to use server to play out television commercials to air. [4] Before only video tape recorders (VTR) were used for this purpose, but playing out short commercials for hundreds of times is not best suited for tape media. Media servers are now standard equipment for television broadcasters. As the cost per channel of broadcast-quality servers has come down and file based workflows have become essential to efficient, high-quality production, these station workhorses are being used in innovative ways beyond their original scope as VTR replacements. [22]

With development of computer technology, servers matured to level they are now commonly used on all playout. Playout delivery is a real-time process taking place every frame and every second, minute, and hour around the clock. [11] Video server must meet requirements for real time operations which is different compared to just any file server. Also, when comparing video server to VTR the difference that has enabled today’s file based workflows and automation is the network connection that enables communication and file transfers between other parts on system.

Modern processor paired with the right software that can divide tasks across the different cores correctly, enables the software approach to eclipse the typical performance profile of custom hardware. While hardware interface is still required to receive and output baseband video, it is significantly simpler and less restrictive than interface that requires onboard codec or set of codecs. [12] General operational idea of video server can be seen in figure 8.

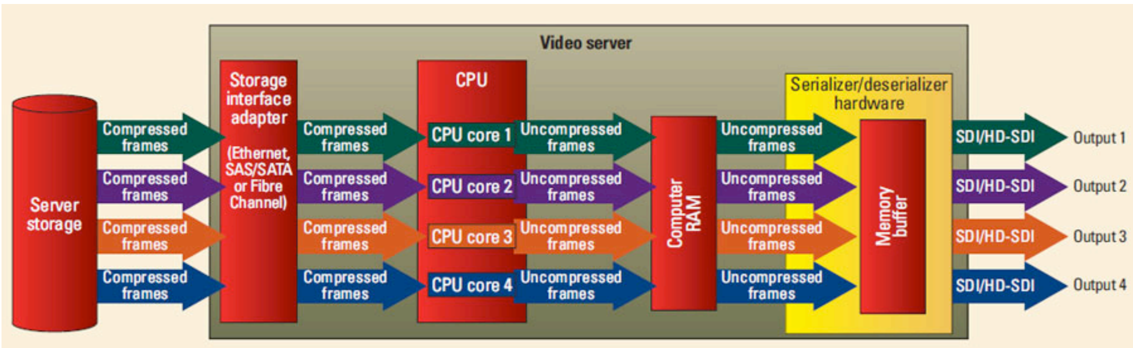


Figure 8. Multichannel software based playout server [12]

Besides hardware, playout server needs software to play out the files. Usually this is in form of playlist. Playlist consists of video clips, still images, sound effects and tickers. Besides basic elements playout software can include transitions between clips. In most cases playlists are crated by scheduling. Scheduling can consists playlist for days or even weeks in advance. [71]

Satellite feeds, which have traditionally been decoded to baseband and then re-encoded at a server record port, can now be recorded directly on to the video server via asynchronous serial interface (ASI) or IP. [12] This development reduces need of additional conversion to baseband video before server. It applies to the playout part as well. Depending the need playout can also be done without decoding into baseband video at all. Instead of output being video on SDI it is compressed video stream on IP. This is something that is not new for streaming for web only but time being it has not been widely adapted to TV playout.

4. Playout centre project – Levira playout centre in Tallinn

4.1 Project phases and history

Levira playout centre has been growing steadily in infrastructure as well as on number of channels played out. In this thesis I will focus on last part of expansion that included expanding infrastructure for maximum channel count of 30 channels as well as completely renewing the media asset management (MAM) solution. Even though these two steps happened partially simultaneously, they were handled as separate projects. Mediatrade as systems integrator managed both projects.

Mediatrade is a reseller and systems' integrator for digital media production, delivery and management equipment. The main market area for Mediatrade is Finland and Estonia, but they also sell to other parts of Scandinavia and the Baltic countries as appropriate. The company is based in Helsinki, Finland. [72] Mediatrade has been a key partner and system integrator for Estonian company Levira ever since they expanded to playout market in August 2007.

Levira is the only TV and largest radio broadcast network operator in Estonia. Levira is owned by Estonian state (51%) and French telecom and broadcasting company TDF Group (49%). Because of small home market, Levira started to develop services for international customers. Levira's fastest developing field of activities is audio-visual and multimedia services, providing technical multimedia services for customers all around the world. Levira's state-of-the-art fully automated play-out centre is playing out channels for local market as well as for Scandinavia and African countries. [73] Levira premises with the playout centre are located in Tallinn Teletorn – a Soviet built TV-tower reaching 314 meters heigh and being the tallest building in Estonia [74].

The role of system integrator is not only to sell and install equipment but also to make sure all parts of infrastructure are such that fit into the required workflow. The definition of systems integration by Internet dictionary is: "A discipline that combines processes and procedures from systems engineering, systems management, and product development for the purpose of developing large-scale complex systems. These complex systems involve hardware and software and may be based on existing or legacy systems coupled with new requirements to add significant added functionality." [75] Value added reseller is term sometimes used on simpler cases instead of systems integrator.

First phase of the Levira playout centre was built in 2007 for the launch of their playout services. This was a system for maximum of four channels that was built in temporary equipment room made out of office room. Control room was built to office room next to equipment room. Challenge on first phase was extremely tight schedule with only 60 days from order to commercial launch of the first channels.

Second phase was when completely new infrastructure was built with capacity to play out up to 12 channels in late 2008. For this system there was 24 server slots for playout and a separate ingest system with three server slots cabled for dual channel ingest servers. Archive capacity was expanded as well. This new infra was built to new proper equipment room at basement of Levira premises. New control rooms were also built to ground level floor to accommodate growing channel count. Material ingest was built to a separate room that was possible to use for layout control.

When this thesis was written, the company's aim was to expand channel count to total of 30 channels by adding infrastructure for 18 new channels as well as completely renew the MAM solution. Infrastructure expansion was built in summer 2010 and MAM project later in 2010. These would be third phase of the infrastructure and second phase of the MAM as there was no major change on MAM system on second infrastructure phase.

4.2 Infrastructure

4.2.1 Concept and layout

All main video connections on the Levira system are serial digital interface (SDI). The reason for this is quite simple – SDI is the most used signal type in broadcast and professional video world. In case of Levira playout centre there are a couple of real benefits of using SDI. First, it supports both HD and SD as long as the cable used is of type that supports HD signal. Cabling can be the same for all uses. Second, it supports embedded audio. As Levira is doing playout only – meaning they do not currently do editing of the video material at all – it is most practical to have audio with the video at all times instead of handling the two separately. This also significantly simplifies cabling, as there is no need for separate audio cabling. For video cabling it makes no difference what resolution the video is or how many audio channels there are. The only exception for the SDI video is reference signals, which are required for syncing purposes. Reference is analog video but it can still use the same type cabling as SDI.

The concept for the video infrastructure was created for the first phase and has remained the same throughout the growing of the playout centre. The first point is that any server on playout side can be used for any purpose. This means there are no dedicated main playout servers and backup servers but any server can be either one. This also helps on expanding the system, as server slots can be pre-cabled. Servers and needed distribution amplifiers (DA) are only purchased when needed. This also helps to reduce the initial cost of the system as some equipment is only purchased as needed basis.

To ensure that all parts of the system can be used for any channel all used equipment is HD. As virtually all HD capable products also support SD signals there is no need to separate and keep track which is SD and which is HD. The only place where this causes some problem is reference signals that are used to sync all equipment. I will discuss this separately.

For phase three infrastructure there was a need to change clue products supplier. Phase three is built with Miranda products. However, same concepts are utilized on previous parts of the system. Miranda Densité series has all the same or similar needed modules as Snell Vistek range that was used on earlier. With Miranda there was the benefit of smaller rack footprint because of smaller frame – two rack units instead of three. And more card slots per frame – 20 instead of 14. For phase three infrastructure there are total of six Miranda frames in a system where four have SDI DAs for server and channel needs, one has Frame synchronizers, and one has analog video DAs for reference signals. These module frames are distributed in racks so that the need for long cable runs between racks is minimized.

Rack layout as a whole was re-designed for phase three. One important factor was a goal to minimize cable runs between racks. The other are the possibility to utilize rack space more efficiently with modular audio processing and more centralized compliancy recording. Phase three part of the system is fitted in five racks with some equipment on old racks. One limitation on rack space use is high power need of the Supermicro servers that are used for playout. There are in maximum nine servers plus one Miranda frame in one rack. Rack power intake must not exceed what is possible to feed in. Each rack on phase three has two three-phase power input feeds. These are distributed to equipment in racks as evenly as possible so that all equipment having more than one power supply would have input from separate feeds. Distributing between two separate power inputs also gives additional redundancy in case of problems on power distribution of the building. Rack layout can be seen in appendix 1.

4.2.2 Playout servers

All video signals for playout servers are cabled through video router. Where video is also required for monitoring a DA is used to split the signal. A concept for video cabling for each server on the system can be seen in figure 9. Preview video output is only connected to monitoring. As preview is not needed anywhere else but monitoring it is not connected to router at all. Program output has DA as it is needed both on monitoring as well as on router.

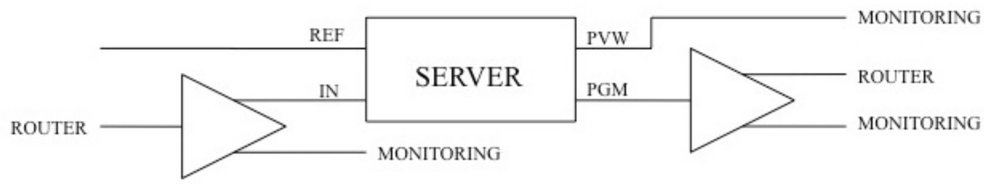


Figure 9. Playout server video connection concept

Input is used only on channels that have live programs or need to record input for near live programs. Input signal has a DA before server as server input is also needed on monitoring. Input video feed comes from outside of the playout centre from various sources like satellite. Input feed is converted to SDI at receiving end and inputted to playout system through frame synchronizer. Frame synchronizer ensures that video is running on the same sync as the rest of the system. From frame synchronizer the video is taken into router where it can be routed to any playout server. The same signal can be used for more than one server/channel. During live program, input feed plays through the playout server where additional elements like graphics can be inserted to video, if needed. As not all channels have live inputs, there are no frame synchronizers for every channel in the system.

4.2.3 Channel output

Channel outputs are connected from a router. This way any server can be used to play out any channel by selecting wanted server to each channel output. After the router there is audio processing. Automated audio processing is used to keep audio level within wanted range throughout volume and loudness changes between for example a movie and commercials. Older part of the system uses Jünger Audio b46 audio processors that are each separate one rack unit boxes. Phase three part of the system was built with modular Jünger audio C8000 solution where one frame can have maximum of 16 C8486 cards each providing the same function as one b46 with four or eight channel audio processing. This is more cost efficient and especially it saves rack space. One modular frame is three rack units in size and there are two frames on the system. After audio processing there is a DA, as output signal is needed in several places. The first output from DA is the main output to multiplexer (MUX) or other transmission equipment used for the channel. The second output is for monitoring. The third is back to router. And the fourth is for compliancy recorder. Channel concept can be seen in figure 10.

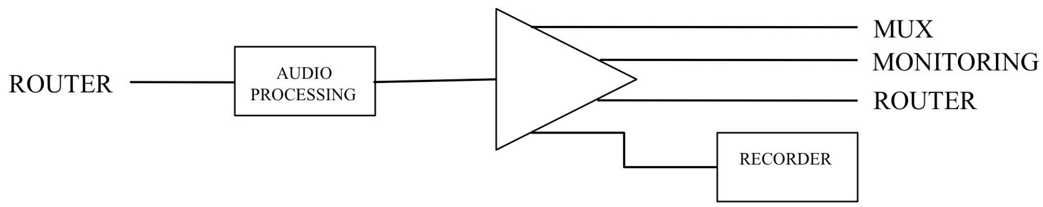


Figure 10. Channel output video connection concept

The concepts described above are repeated on the system to get into wanted channel and server counts. For the third phase of the infra, ten inputs with frame synchronizers, 18 channel outputs and 27 server slots were added in the system. This adds the total number of possible channels into 30. Number of servers in relation to output channels comes from redundancy requirement. In this system redundancy has always been N+1 type. This means that for N number of servers playing out channels there is one backup server. [76] Levira system server count is designed for 2+1 redundancy. In the end, the redundancy used depends on each customer they have. Some want 1+1 redundancy where there is backup server for every server playing out a channel. On the other hand, some do not want redundancy at all. It is a matter of cost of service for channel customer.

4.2.4 Video router

All discussed parts of the system connect to router. Router is the heart of the video system. In Levira system there are altogether three video routers and one RS-data router. Phase one had 32x32 Snell Halo router and 32x32 Snell Freeway data router. Data router is used for device control (RS-422) to allow ingest servers to control VTRs. In the second phase Halo was dedicated to ingest and new 64x64 Snell Sirius router was installed for playout needs. In the third phase second 64x64 Snell Sirius was installed. All video routers are independent but have some video lines to tie them into same system. Data router is slave to ingest router as they have the same equipment connected. This way no separate control is needed for the data router.

Because all critical video signals go through routers there are patch panels on all inputs and outputs of the router. This is to ensure that video signal can be manually patched past the router in case of equipment failure. In case of failure like this, switching servers must be done manually via patch panel. If additional problems like playout server failure arise, reacting and correcting problem takes more time but it is still possible. Making changes via patch panel always means breaking video connection so there will be a black picture out of playout. However, a router is such a critical part of the system that without patch panels router failure would mean loosing output of all channels connected through that router until router failure would be fixed. Because Levira system has more than one router there is more redundancy as not all channels and servers are affected in case of problems. The downside of having several routers is limitations on router control. There are tie-lines between routers to allow routing video from one router to another. The number of available outputs and inputs on routers limit the number of tie-lines that can be used to connect routers.

The router control system is designed so that all control rooms upstairs have an X-Y type panel and smaller pushbutton type panels depending on the need. Smaller panels are configured so that one panel is used to select sources for monitoring and separate panels are used for selecting servers for channel outputs. The latter are so called master panels as they are normally used to select which server is playing out to air. Router control panels connect via RS-422 line that can be chained from one panel to another. There are only two ports for panels on the router and because of this as well as to keep cabling between control rooms and equipment room simpler, all panels for phase three router are on the same cable chain. One limitation of panels connecting directly to router is that all routers need to have separate panel chains and sources connected to one router. They can only be controlled from panel connected to that same router. Router panel connection concept can be seen in figure 11.

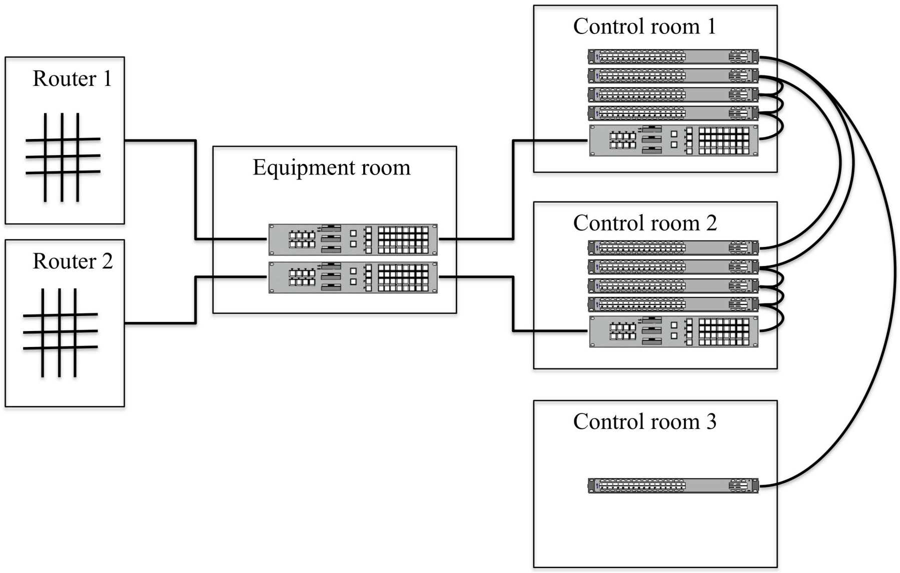


Figure 11. Router panel connection concept

4.2.5 Sync

Levira playout system has two sync generators and a failover switch between the two to keep sync signal up and running in case of equipment failure. Unfortunately it was impossible to add channels on failover switch for phase three as earlier parts of the system were up and running playing out channels during the installation. Because of this phase three system simply has black burst and Tri-level sync output from the second and newer master sync generator.

Sync signals are split to servers and frame synchronizers as well as a router with analog video DAs. The challenge with sync distribution it that it is up to the equipment what sync they need. And to make things more complicated this changes depending if the equipment is used for SD or HD. Miranda frame synchronizers can use either black burst or tri-level. But only in HD – if used for SD, the sync must also be SD.

Playout servers always need sync matching the format they are playing out. As it is not known what channels and formats playout servers will be when taken into use, system design is more of guesswork. As HD is becoming more popular, Levira system was designed so that there are more free outputs from sync DAs as tri-level. This way servers that are cabled to black burst can be changed to tri-level if needed. Manual change is required to plug the cable in to the right DA.

In addition to video sync all playout servers are also synced with net time. This allows servers to run in correct time in relation to playout schedules. Also, this allows switching between servers without time mismatch of the schedule playing out.

4.2.6 KVM system

All servers on the system are connected on a keyboard-video-mouse (KVM) system. This allows users on control rooms to access any server of the system on any of the user stations. KVM system was expanded with phase three. A new larger 16x64 switch was installed on the new system and the old switch was cabled to it so that all user stations connect to the new switch. Also, user station ports on old KVM switch connect to server ports on the new switch. This way the old switch is a slave to the new master switch and all servers on old switch can be accessed from any user station. Ingest has a separate small KVM system. It is the same series as playout KVM but of different brand so there is no official support to connect it to newer systems. Because ingest is separate operation, there is no harm to have it on a separate KVM. KVM switch connections can be seen on figure 12. Equipment room also has a KVM access point. This is located in a rack on old part of the system.

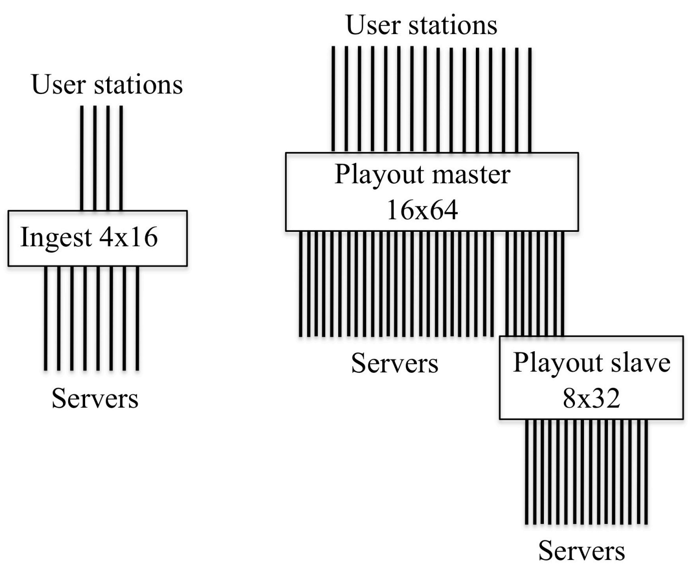


Figure 12. KVM switch connections

4.2.7 Ingest

Ingest system is a separate system. It has own routers, KVM system of its own and a separate control room. On first phase ingest servers were part of the playout system and they were used as backup servers when these were not used for ingest. On phase three ingest consists of two Amberfin servers. The system has a slot for third ingest server pre-cabled. Ingest control room has five VTRs that have also device control connection to ingest servers via RS-router. VTRs are installed on a rack in ingest control room to allow easier tape handling. Besides tape based ingest, some material comes in as files. Ingest workflow will be described in more detail in following chapters.

4.2.8 Ethernet

Ethernet network was changed quite a bit during the third phase installation. There were two main reasons for this. The first one is the addition of two new switches to system and possible data flow bottlenecks caused by this. The second one is changes on MAM system. There are now five gigabit Ethernet switches on the playout system. Topology was changed to star-configuration so that there is a new heart switch that has all MAM related servers connected. Four other switches have playout servers as well as other servers and equipment. These switches are linked to the heart switch. As most file traffic is from MAM system, especially from nearline storage to playout servers, the playout servers are distributed as evenly on the four switches as possible. Also, physical placement on racks affect on which switch each server is connected. Data traffic on other than the playout servers is mainly control data, which is not a lot of data. There is also one smaller switch for multiviewer control that is linked on one of the four switches to allow multiviewer configuration via one of the servers. Multiviewer system requires its own network for internal control. Having separate small switch for this makes sure no bandwidth is taken away from more important use. There is also a seventh switch for storage configuration needs. This is completely separate and it is not connected to main network at all. Main network switch interconnections can be seen in figure 13.

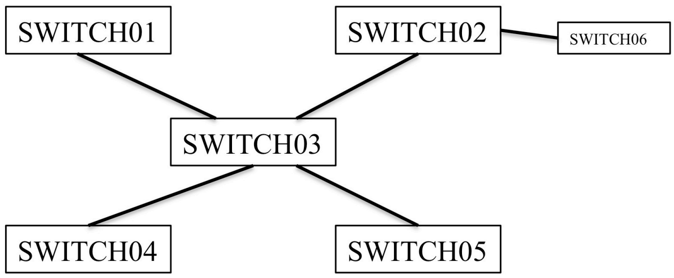


Figure 13. Ethernet network switch connections

4.2.9 Monitoring

There are two main things to monitor on a playout system: video and audio. Video monitoring is done via multiviewer system. Levira system had a Miranda Kaleido multiviewer from phase two and that was expanded to second frame interconnected to first one on phase three. Kaleido is a modular system that has dual output cards with DVI and audio output as well as 16 video input cards. Besides physical input, input cards can have software options for embedded audio monitoring, Dolby E audio monitoring, and subtitle monitoring. Kaleido frames are in a rack installed on phase two where some more room was made to fit the second frame for phase three. Outputs are extended with DVI and HDMI over fiber extenders to LCD screens in control rooms. For these extenders there is a fiber trunk line connection from the rack of equipment room to a wall box in an office room upstairs. From there the fiber connections are extended to wall boxes in each control room.

Audio monitoring is done with TSL audio devices with separate volume control in control rooms. Two main control rooms have a 5.1-speaker system and the third one only has a stereo system. TSL boxes support both SDI embedded audio as well as AES or analog audio. On Levira system there are both SDI and AES connected. SDI comes from router and one AES from multiviewer system. AES input on TSL only supports stereo audio where as SDI can have multichannel audio or Dolby E embedded. The reason for having both is the ease of use of the multiviewer audio as operator can select which audio to listen to by clicking a picture on multiviewer screen. Multiviewer also has level meters on screen to show audio level of each video. SDI audio for monitoring must be selected on router control panel.

In addition to monitoring on control rooms there is small monitoring unit in equipment room that has both a small screen for video and speakers for audio. This has X-Y type router control panels for both playout system routers next to it to select what to monitor. This is to check signals in equipment rooms so that there is no need to run between floors simply to see which video is where.

4.2.10 Installation

Installation for phase three infrastructure was done in two steps. First there was pre-installation in Helsinki and second, the actual installation in Tallinn. The schedule was tight as the order came in quite late. There was only three months from day of order to deadline of some new channels. The problem with this tight schedule was to fit the final system design and order of equipment to same time frame. There are always some changes on equipment during final system design but because of tight schedule, equipment were forced to be ordered immediately after order based on preliminary design done for quotation. In this case there were not many problems because of this as a system concept was known and tested during earlier phases.

Pre-installation was done in a separate space in the same building as Mediatrade office is. Racks were lined on a floor to simulate final installation at Levira equipment room and a frame was built to lift racks from floor level to allow cabling from under the racks. Lot of pre-installation work also goes into modifying racks. Equipment mounting rails in the racks must be put to right distance from front and back of the rack. Power distribution has to be installed. Because Levira has been using the same type of Rittal rack for all parts of the system, a lot of it has been tested and done before. For power distribution Rittal PSM-system was used as that allows an easy way of dividing between two three phase power inputs throughout the rack. All frames for DAs and other modular equipment were also installed to racks. Modular equipment frames were ordered with back panels in place to allow cabling to be done ready and connected. All cables were tested once terminated to be sure there are no non-functional cables in the system.

Video cabling between the racks was done to length during pre-installation so that the depth of the installation floor at Levira equipment room was taken into count and some extra length was added to be on the safe side. There were some long delays in pre-cabling because router delivery took a lot longer than estimated. Also, as cabling was done to length, no router cabling could be done before the router was installed to rack.

All Cat cabling for Ethernet and KVM was to be done on site as it was decided to go on cable trays above the racks. For cat-cables we used pre-made cables with measured minimum lengths. For some parts this meant some extra cable that had to be lost in rack because no cable with correct length was available.

After pre-installation racks were shipped to Levira. Once racks were in place, pulling pre-made video cable bundles in place was relatively easy. For video cabling there was still a lot of terminating to be done on cables for multiviewer as well as few other cables between racks that could not be done during pre-installation because of uncertain cable lengths. Multiviewer end of these cables could not be done beforehand as multiviewer is on rack that was already installed in previous phase and in use at Levira. These cables were prepared with enough length to reach this rack and left un-terminated.

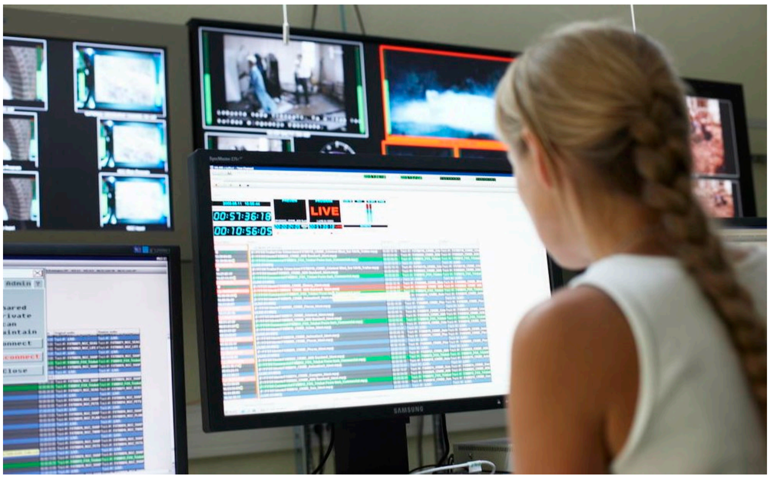
Levira took care of installing equipment in place for upstairs control rooms. Mediatrade did terminating and testing on these cables. It was the same equipment as there had been in the control room before so there was nothing that caused any problems.

Because of delays in pre-installation the project was running late. The deadline was the launch of two new channels so we had a backup plan to get these channels on-air in case of delays. Once the system was up and running it was immediately taken into use for these channels that were playing out from temporary solution.

4.3 Playout

4.3.1 Operation

In Levira one or more operators do master control in separate control rooms where one room controls several channels. The control room has a number of large screens where operators see the videos for all channels and servers. For operators to see and access playlist and settings on playout servers they have a number of LCD screens with mouse and keyboard that are connected to KVM system. There they can select which server to connect to in any of the user stations. Control room operation can be seen in picture 1.



Picture 1. Master control room operation [Levira Ltd]

Video monitoring is done via multiviewer system connected to screens on control room. All channel outputs as well as needed signals from each server – input, preview and program – are cabled to multiviewer. Layout of the multiviewer for each screen can be changed and configured freely. In theory each operator could have their own setup but in practice Levira control rooms have fixed setups that all operators use.

To select which server is playing out each channel, the control room has one or more router control panels. With these panels operators can switch between servers playing out to channels simply by pushing button on the panel. Similarly, operators have separate router panels to control audio monitoring. Monitoring panels are separate panels to master control panels to avoid human errors of mistakenly changing channel output.

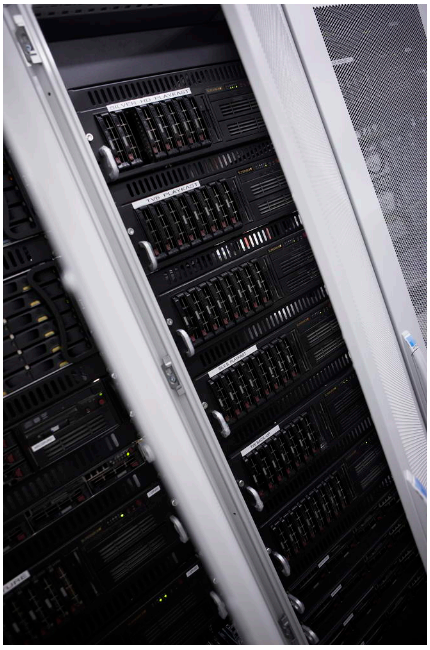
To monitor audio there are speakers connected to audio monitoring in each control room. On Levira system they have two options for audio monitoring – they can use multiviewer that supports stereo audio only on current setup. They can also use SDI embedded audio via video connection, which supports multichannel audio including DolbyE. Speaker setup is 5.1 in the main control rooms.

4.3.2 Playout server solution

The requirement for Levira playout from the startup was best suited for channel-in-a-box –type of playout solution. As stated in procurement: "Play-out will be fully automated and it includes whole process, from ingesting to play-out, including graphics, subtitling and others." Requirement for multiple file types is clearly stated in procurement. Low power consumption of server-based solution was the key during the first phase as equipment room was set up in an old office room. The first channel Levira launched was HD so that had to be ready from the very first phase – not just some promise for the future. The selected playout solution was OASYS. Their solution is software, named Player, with recommended setup installed on Supermicro server loaded with Matrox X.mio video card.

OASYS commissions automated playout solutions for news, film, music and entertainment channels and transmission centers throughout the world. OASYS is based in England but has a development subsidiary in Croatia. [77] Mediatrade has worked with OASYS as system integrator for several years before Levira project. OASYS is specialized in IT-based playout workflows but are open to work out a best-suited solution for each customer needs.

Server hardware requirements depend on the intended use. As different channels have different content there are different hardware requirements to cover needed processing power for the channel. HD has the hardest requirements on hardware. An other factor is how much graphics will be used. Simply playing through live input and inserting a few clips in between on a playlist does not require a lot from the hardware. The current recommended hardware setups are for HD three rack unit Supermicro server with two 2,0 GHz Nehalem prcessors, 12 GB of memory, 8 disk RAID for video, Matrox X-mio2 12/8000 video card and Windows 7 operating system. For SD system it is two rack unit Supermicro server with same parts as HD server except with four disk RAID and 12/6000 version of X.mio video card. For simple channels, the recommended setup is one rack unit server with same parts as SD server except for video cards that is Matrox DSX SD 300. Playout servers installed in a rack can be seen in picture 2.



Picture 2. Playout servers in racks [Levira Ltd]

Matrox X.mio video card has become de-facto standard video card that is used on most of the available broadcast video server solutions. Matrox as manufacturer has products for I/O devices like display adapters and video cards, h.264 encoding engines, converters and developer products. X.mio falls into the developer products category as it is targeted for original equipment manufacturer (OEM) use where it does not have its own software but runs as a device for software like, in this case, OASYS Player.

Matrox has branded their developer products under DSX product range. X.mio is the high-end video I/O card. There are two versions of it – older X.mio for PCI-x bus and newer X.mio2 for PCI-e bus. Both generations are available on single or dual channel version and firmware for SD or HD. Levira has playout servers using single channel version of both X.mio and X.mio2. All new servers are with X.mio2. Levira has some servers for simple ad-insertion use for SD channels that use lower cost Matrox DSX video cards.

Besides hardware Matrox has DSX software developer kit (SDK) that is modeled on a COM-based asynchronous architecture. It provides a common application programming interface (API) across the entire DSX family of hardware components. [78] This allows software developers to write integration and to utilize features on Matrox cards. Programming language for Matrox DSK is C++. Features controlled through SDK are codecs for audio and video, graphics overlay, and audio and video effects like transitions. OASYS has graphic features in their software and Matrox is used for graphics only on HD because of performance reasons. Otherwise Matrox is only video I/O for OASYS software. Matrox shares SDK through their entire product line – the code can be used across Matrox line with features build in the card limiting the use.

OASYS supports other hardware setups for both server and video card as long as minimum requirements are fulfilled but for Levira system it has made no sense going out of tested and recommended setups. Earlier Mediatrade supplied Levira all servers from OASYS. For phase three Levira is sourcing servers from a Supermicro dealer called Network Tomorrow in Estonia. This enables them for faster support in case of server part failures like hard drive dying that happens every now and then.

4.3.3 Software

OASYS has a family of software to meet all playout workflow needs. During first phase OASYS software was used for all other functions but archive. During phase three this thesis focuses on, OASYS software is only used for playout. This software is called Player. Player alone includes all features needed to run a simple TV-channel. Player is hardware independent software that can run even on relatively simple PC as long as minimum requirements are fulfilled. However, there are specified recommended hardware setups as discussed in previous chapter. Player license is controlled by USB dongle.

Each playout server has relevant schedule as playlist loaded on Player software. From this playlist the operator checks if there are any clips missing from the playout server, and modifies settings if there are any clip specific settings that need to be done. Also, there are lots of channel specific settings that are set up when the server is taken into use. Schedule can consist of lot more than list of clips to be played. All graphic overlays and subtitles can also be included in imported schedule. Or they can be created and added on Player by the operator. Player can also control external devices like VTR or router. Router control is something that us used at Levira for some of the channels. What is used and needed is completely dependent on the channels played out.

Playlist can run as fully automated based on what was scheduled. Or it can have features that are controlled manually – for example start of commercials during a live event can be set to require manual startup from operator. A backup server can be set up to load the same playlist and content as the main server backup is following. Because of net time syncing, the backup server can run on exactly same schedule and sync as main playout servers. As Levira is a playout centre that is playing out several channels everything is automated and scheduled beforehand. No operator actions are needed for normal playout.

Some channels have needed new features on Player software to fulfill requirements. For phase three there have been two major developments. The first one is possibility to play out both HD and SD at the same time. This is used for Estonian music channel. The second one is variable delay time shift feature for localization of a Russian channel with different commercial break lengths depending on location. This is important advantage of OASYS as they are flexible and fast to develop new features depending on customer needs.

4.4 Media asset management and automation

4.4.1 Background and setup

On a first phase of Levira system, the workflow was quite simple – schedules were manually created in Player that connected to nearline disk array for files. Ingest of material from tapes was done through OASYS Maker. Archiving was managed by Xendata middleware on Qualstar tape library. This worked for a small number of channels. But when the number of channels increased the amount of data ingested and handled increased and semi-manual system was no longer suitable on workflow or customer requirements on reliability.

Nearline storage capacity was already increased with another disk array when the system was moved to proper equipment room during infrastructure phase two. Ingest was also changed from OASYS solution to Amberfin iCR because Amberfin can do quality control (QC) and repurposing besides ingest. iCR is running on same hardware as OASYS solutions so there was no need to do any major re-cabling even though the software solution was changed. A Snell IQ series modular frame was added for QC purposes as iCR uses Snell processing on video QC.

With Amberfin ingest there were some changes on file formats. Earlier HD files were AVI with wav audio and for SD files were MPG. Now all ingest is MXF. But there are also quicktime (mov) files that come in to the system as files. OASYS Player can play out multiple file formats.

With channel number growing and data flow increasing with it there was need to re-new Levira playout centre workflow completely. The partners chosen for this process besides OASYS and Amberfin were SGL and IBIS. The project started very slowly at first as the order came in several months after quotations had been placed. Companies involved were already tied in another projects and required development work lagged.

Hardware setup was changed so that the archive server which has nearline storage disk arrays attached is no longer serving any other purpose but NAS server. Still the data flow requirement was so high that a second Ethernet card had to be added to avoid this bottleneck. Archive server connects to disk arrays on fiber channel through fiber switch. Ibis iFind run on separate server, as does SGL FlashNet. Both of these servers are generic HP servers with purpose recommended parts. FlashNet server is connected to tape robot with fiber. In addition, there is an OASYS QC server, which is the same model of Supermicro that is used for Player. All these servers are connected to the same network switch – switch number three – which is the hearts switch of the system network. MAM and storage system setup can be seen in the connection diagram in appendix 2.

Levira also has some need for repurposing of material for their customers. This is covered with the same proxy-files created for system needs or with Amberfin iCR. Repurposing needs have been so small that this has not been taken into consideration in practice. Ingest workstations are in full use on ingest and repurposing would load them too much. There is a slot for third ingest workstation in the system that can be taken into use when ingest or repurpose needs grow.

4.4.2 Workflows

Final playout centre operation consists of several independent workflows. Flow diagrams of workflows can be seen in appendix 3. Workflow guideline is as described by Levira in the beginning of the project. There are some changes that came from need of Levira customers or because of development process.

Material comes in to Levira playout centre on tapes and as files over network. If it is a file, the name is changed to match Levira naming convention and the file is manually moved to OASYS QC and proxy generation. If it is a tape, user inserts it into a VTR at ingest control room, switches video and RS routers to correct Amberfin iCR server and starts capture. Filename is set for correct naming convention and iCR does QC for the captured material. If captured file passes the QC, it is manually moved to OASYS QC process for proxy generation. Once OASYS QC accepts the file it automatically moves them to iFind watch folder. Now users can add metadata to ingested files.

Metadata is inserted on iFind once the material has been ingested and QC'd. The name of the clip is inserted in correct convention already in ingest process regardless if it is file or tape workflow. Metadata fields specified in Levira workflow are: ID, Filenames (separate fields for different files), Tape/FTP/HDD details, Program name, Episode number, Segment number, Channel name, Aspect ratio, Program type, Timecode information (in, out, duration), Ingestion special time, and Other.

Archiving is done manually in sense that the process needs to be initiated and clips selected for archiving by operator. In practice archiving means moving video files from nearline storage to data tapes on tape robot. Proxy files and other assets like metadata are kept on nearline. This way possible re-scheduling for playout can be done without a new ingest process. The downside of this is at the moment that nearline gets a huge number of small files that will not be needed. There is work going to fix this by organizing nearline into folders based on customer/channel.

Scheduling is done by manually creating schedules on OASYS. There are people working at Levira playout centre for this purpose only. A limitation of this process is that OASYS Player only allows two days worth of playlist to be created. Levira has investigated on long term scheduling solution but as of today, it has not been feasible to take that step. An other challenge when scheduling with Player is that it must see all material on storage in order for it to be scheduled. Because of this the workflow has OASYS QC process where final check is done for ingested material and a proxy file is created. With a proxy file, material can be scheduled even if it was archived away from nearline storage. Playout workflow can be seen in appendix 3.

5. Discussion

Television broadcasting as a whole is going through several changes at the moment. First of all there is the move to file based workflows and HD. Also, there is the move from linear broadcast to multi-platform delivery. All these changes affect playout directly or un-directly as well.

Move to HD is not really that big of a deal for any other but the home viewer. For old playout systems it can mean renewing the entire system if older SD only capable equipment and cabling is used. Relatively new systems like Levira playout centre, HD has been there since day one. The only real difference is that file sizes are larger, which affects on storage needs. Also, on mixed SD and HD operation there can be more file formats that need to be handled throughout the whole workflow.

File based production and workflows are huge changes in video production in general. People working in the industry need to learn a whole new mindset on how things are done. Move to a file based workflow should not be done just to save money, but rather to improve overall workflow, efficiency and add distribution options. Properly designed, such a solution can save money while delivering more and richer content, which is something stations can monetize. [79]

Playout part of the broadcast chain has been file based for a while now – but not as a workflow. Workflow wise it has been moving tapes between each stage of workflow. Changes on whole chain of processes that lead to playout bring out all new challenges with a move to file based workflows. Media management and file compatibility become the utmost importance. Yet the whole chain from camera to viewer is rarely file based. With all other broadcast methods except the Internet, material will still today most likely be played out to baseband before compressing it again for the actual transmission. Development of playout will also move towards better support of IP based transmission. This can be simply playing MPEG-2 transport stream directly to IP in addition to baseband video. From a system point of view it would only mean separate Ethernet connection for the on-air network connection.

It is clear that TV will spread into more delivery platforms besides the traditional linear broadcast over terrestrial, cable or satellite. This can already be seen in web-TV services most of the larger broadcasters have up and running in Finland. They provide at least some of the content they are broadcasting over the Internet as well. This is on both live streaming, and especially as on demand web-TV service. One form of multi-platform service is also the IPTV packages teleoperators are offering. They have channels available as linear broadcast over IP and also have additional services like personal video recorder (PVR) with automatically recorded content, possibility to watch TV on computer besides set top box, and on demand movie services. This is actually an area where traditional TV broadcasters have new competition from teleoperators. Then there is the mobile TV - linear or on demand, but in a mobile device.

Especially the move over various methods of TV over data networks – whether as linear broadcast or on demand based – is a rapidly growing trend. One very big matter setting the future for that path is who pays for the network bandwidth. There are legislative changes happening to guarantee all houses a broadband connection but when data traffic keeps continuing there will be bottlenecks somewhere. Whether that is a last mile, which is usually on cost of the end user, or trunk lines connecting cities, or even lines between continents. All new services based on IP traffic will increase bandwidth requirements on data networks. In a way reflection of this has been seen on mobile data. There have been data usage limitations set by some operators to decrease use of mobile data, as network development can not cope with the growing demand. [80] Which brings the question again, who will pay for the growing need of bandwidth in the end.

At Levira playout centre all equipment is HD capable, whether used for HD or SD. They have gone through complete renewing of MAM and automation workflows. When asked, Mr Indrek Lepp, the Director of Division of Multimedia Services at Levira points more efficiency especially on scheduling and otherwise as a thing for more development on the current system. According to Mr Lepp, other areas of development are better digital content management (DCM), fiber distribution networks to Baltic and Scandinavian TV networks and entry level cost-effective systems. Of these, more efficient workflows and DCM systems are in line with current trend towards the file based multi-platform playout systems. Lower cost entry-level playout is difficult to realize in a system built to fulfill high standards. However, for this there is already a partial solution from OASYS in form of a lower cost playout server. System level parts cannot really be downscaled unless a separate low-cost system is built with cheaper parts and less redundancy.

The biggest challenges on projects described on this thesis were related to tight schedule. Still, it did not bring any major problems as such. On infrastructure side installation was done systematically and was completed as fast as possible once the equipment was in and ready for installation. One challenge on system level is documentation. Currently cabling between control rooms and equipment room is taken care by Levira so there is in a way a mix of different installations done by different companies. A lot of this is not properly documented, at least not to a single documentation. This can bring challenges in future, especially if there are staff changes so that the undocumented knowledge on cabling disappears.

MAM project lasted quite a long time and included more development work done by solution providers. Integration work was required between manufacturers but that did not cause major problems, as it was anticipated. A challenge was that it had to be well managed to avoid dead ends on communication and to keep progressing in the project.

As a strong point on growing fast on basic playout services Mr Lepp lists quality at competitive price: The best does not have to be expensive. Other strong points of Levira playout system he lists are: neutrality in the light of business as well as technology, state-of-the-art facilities with full HD and SD support, flexibility and responsiveness, experienced and multilingual professional team, short launch terms and high service reliability, as well as proved high customer satisfaction. There are things that could not be achieved without a good working relationship with systems integrator and equipment manufacturers, especially OASYS, who develop the system towards the way customer needs and general trends are leading. Mark Errington, CEO of OASYS describes Levira as customer: “For OASYS, the Levira playout centre development has been a critical part of becoming recognized as a high quality solutions provider, which is responsive with development and support, and has truly elevated the company from niche single channel playout software, to multi-channel, multi-function playout solutions.” Development of Levira playout centre will continue as their operations grow and as they get new customers with different requirements.

6. Conclusions

Levira playout centre is today a leading multichannel playout centre utilizing IT based playout solution and workflow. They started with correct direction from day one as a clean site without the burden of old equipment. Now as they have been in operation for several years and grown significantly and fast, last with the project described on this thesis, it has been well proven that the system concept for infrastructure works. Also, their system as a whole is well suited and ready for what seems to be the future of playout systems. With the help of key partner like OASYS on playout with true channel-in-a-box-solution, they manage to fit in any requirements their customers present. MAM solution is now up to date and can be developed for possible changes or new requirements on workflow.

The best proof of a successful project and co-operation between everyone involved is the fact that Levira playout centre is and has been up and running with new systems and it keeps growing. It is safe to say Levira playout centre is well equipped for the current development as well as for the future.

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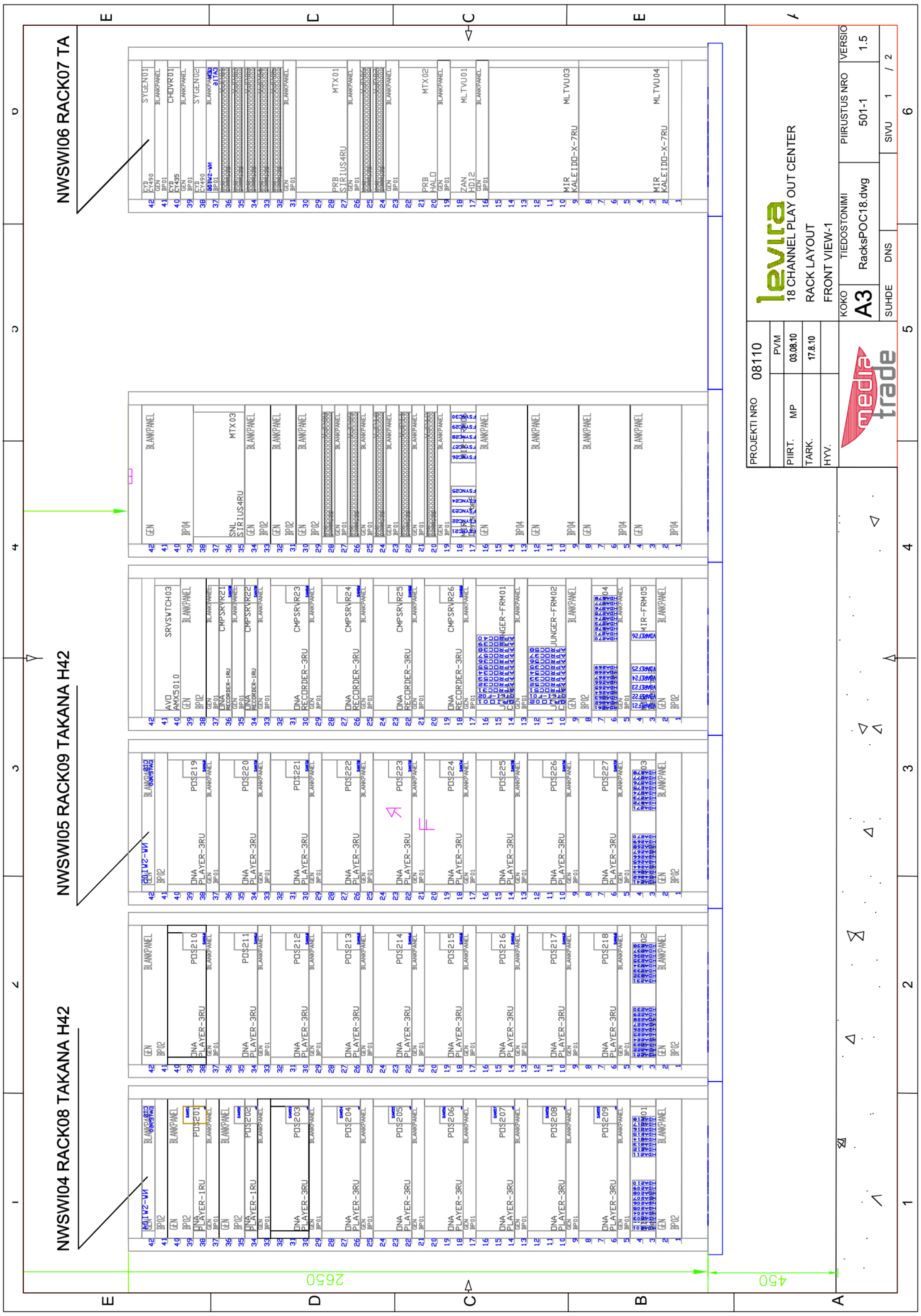
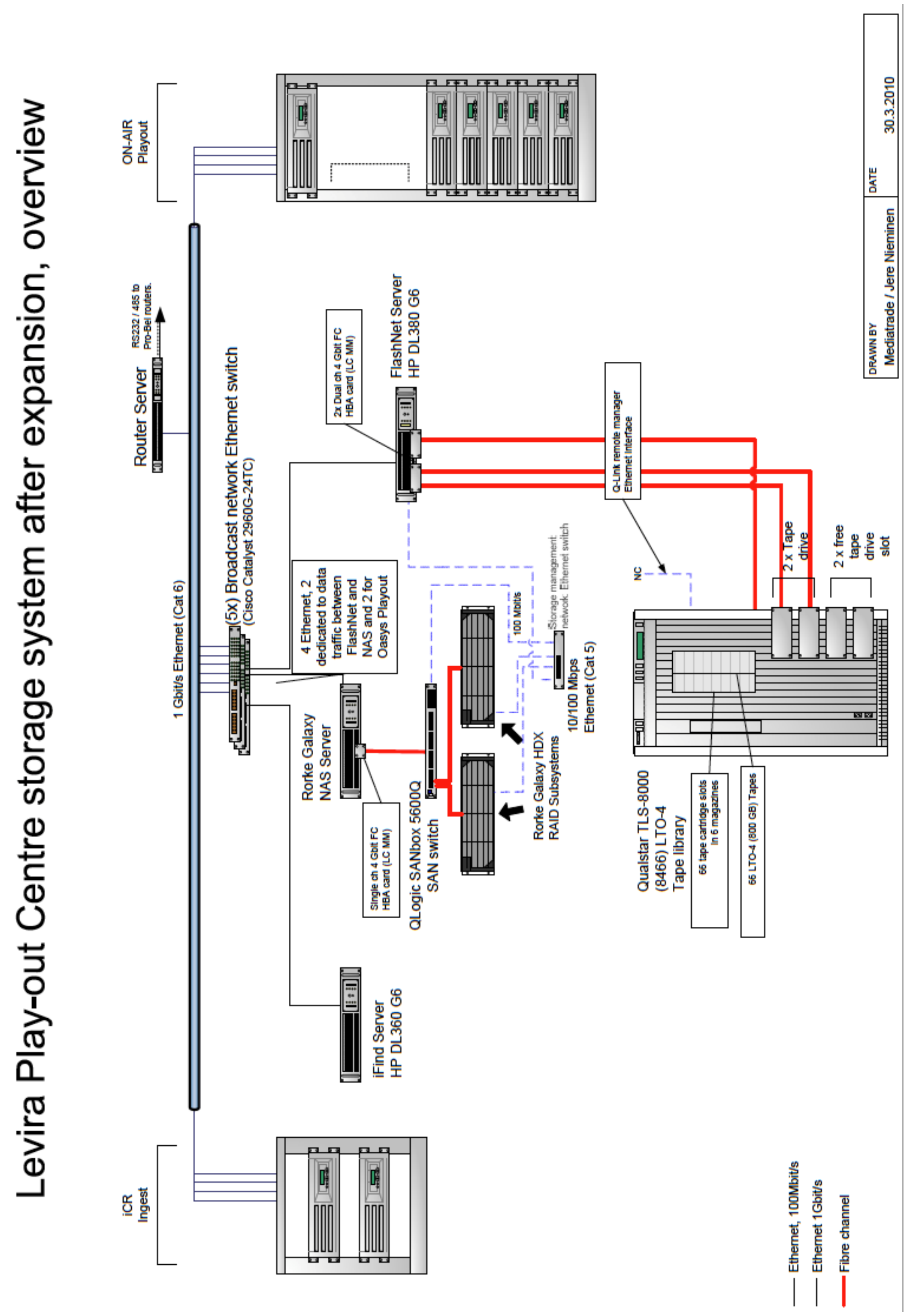
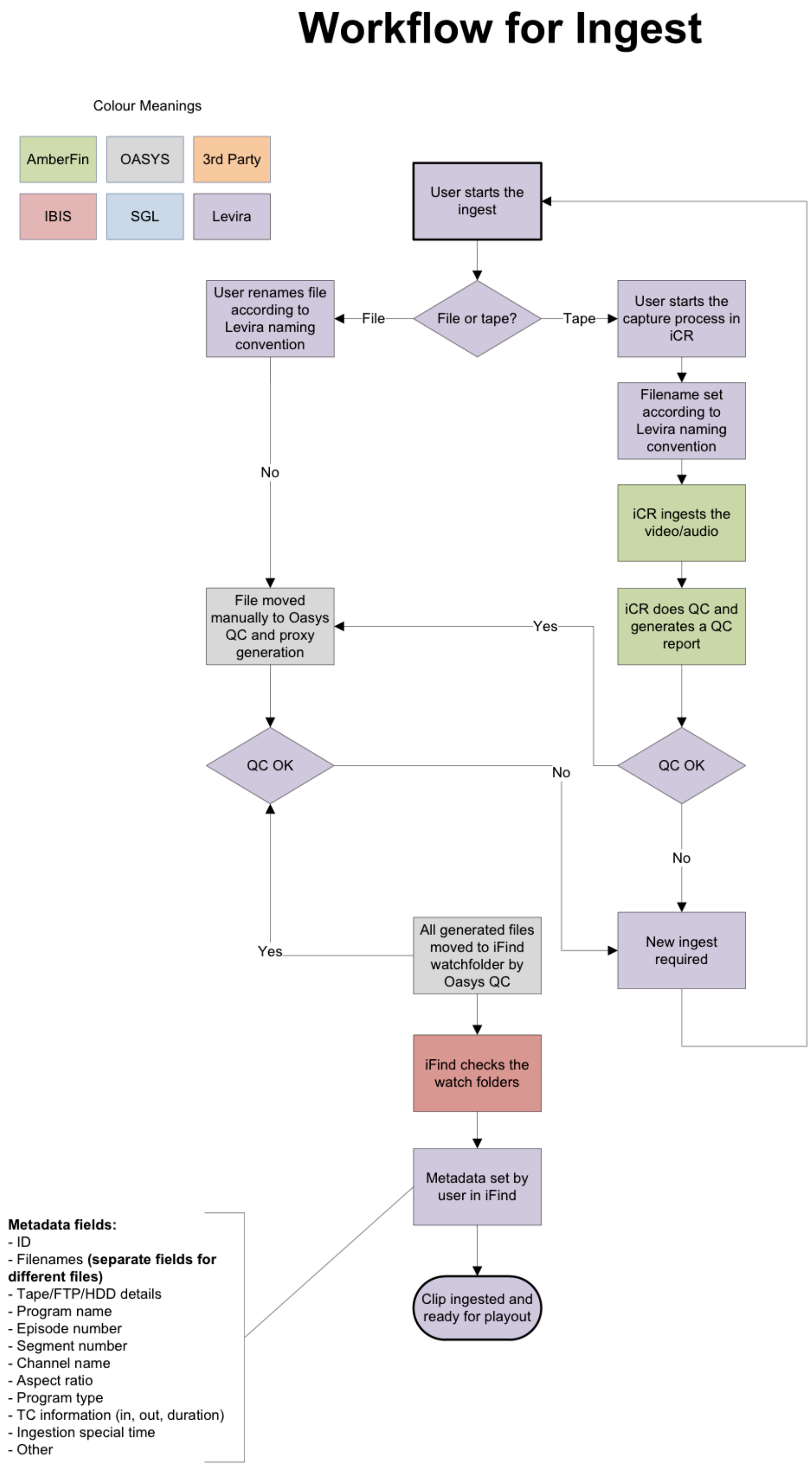
Appendix 1. Rack layout [Pimiä M. Mediatrade Oy 2010]



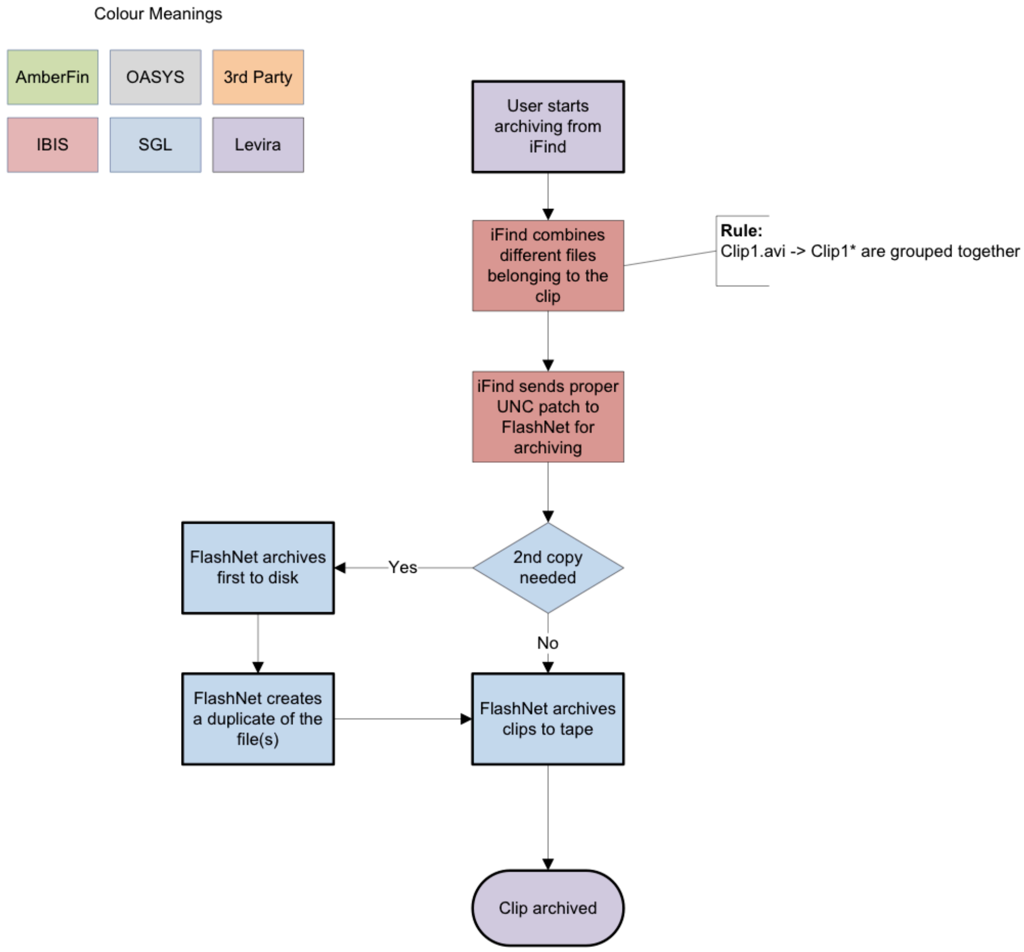
Appendix 2. MAM and storage system connection diagram. [Nieminen J. Mediatrade Oy 2011]



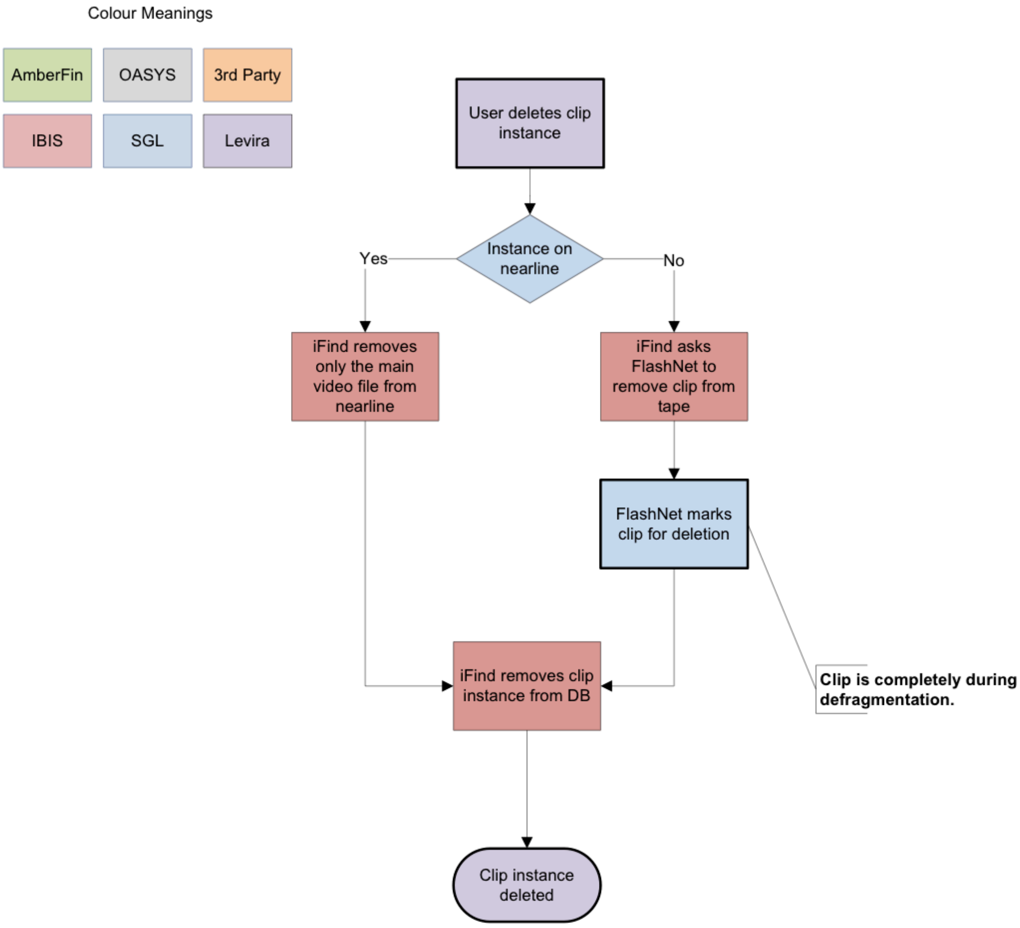
Appendix 3. Workflow diagrams [Nieminen J. Mediatrade Oy 2011]



Workflow for Archiving



Workflow for Deletion



Workflow for Scheduling and Playout