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Feasibility Study: Electronic Media Laboratory According to Industry Standard

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YAMK-insinöörityön tavoitteena oli selvittää Metropolian mediatekniikan laboratorion vastaavuus teollisessa elektronisen median tuotannossa noudatettaviin standardeihin. Laboratorion koulutusympäristönä tulee noudattaa paitsi mediatekniikan opetussuunnitelmassa audio-visuaaliselle tekniikalle oppimiselle asetettuja vaatimuksia, myös niitä prosesseja, käytäntöjä ja teknologioita joita ammattimainen elektroninen tuotanto ja julkaiseminen Suomessa toteuttaa. Oppimisympäristönä toimivan laboratorion kehittämiselle ja varustamiselle on ymmärrettävästi teknisiä, taloudellisia ja hallinnallisia rajoituksia, jotka estävät sen saavuttamasta teollista tasoa. Näiden rajojen ja kehittyneemmän teollisen mallin eroja tutkittiin. Tutkimusmenetelmäksi valittiin saavutettavuustutkimus *(eng. feasebility study)*, joka menetelmänä soveltuu teknologian, taloudellisen tai hallinnollisen kehittämiseen analysointiin. Tutkimuksella pyrittiin määrittelemään saavutettavissa olevan laboratoriomallin toiminnallinen validointi ja toteutettavuuden osoitus (*engl.proof of concept*).

Laboratorion audiovisuaalista tuotantoa ja sitä seuraavaa elektronista sekä digitaalista julkaisemista varten luotiin sulautettu malli. Mallissa huomioitiin televisioympäristössä meneillään oleva muutos, jossa perinteinen radiotaajuuslähettäminen on saanut vaihtoehdoksi IP- verkoilla suoritettavan jakelun. Videon editointi jälkituotantona analysointiin nykytilassa ja vertailtiin sitä täydellisen verkkoeditoinnin malleihin, jotka voivat myös toteuttaa pilviteknologioita hajautetussa tuotannollisessa yhteistyössä. Näin medialaboratorion mallinnuksessa huomioitiin toimialan ajan trendit ja tulevaisuuden näkymät. Tämä tutkimusaineisto hankittiin kirjallisten lähteiden lisäksi, alan messuilta ja konferensseista, maahantuojilta ja edustajilta sekä tuotanto- ja yleisradioyhtiöiltä.

Elektronisen median julkaisemista simuloitiin laboratorioympäristössä niin, että kaikki mahdolliset vastaanottotekniikat oli otettu huomioon. Julkaiseminen räätälöitiin myös soveltuvaksi eri päätelaitteille. Julkaisemisessa huomionarvoisiksi asioiksi nousivat audiovisuaalisen sisällön jälkiprosessointiin, paketointiin ja lähettämiseen liittyvät tekniset laadunhallinnan aspektit, esimerkiksi eri videonpakkausalgoritmien soveltuvuus videosisällön jakelussa, julkaisemisen automatisoinnin mahdollistaminen ja eri julkaisualustojen tutkiminen ja määrittely Lopputuloksena saatiin aikaan soveltuvuusanalyysi ja mallinnus, jossa määriteltiin elektronisen julkaisemisen teknisen opetuksen pullonkaulat teolliseen vastaavuuteen nähden. Suurimmaksi kompastuskiveksi voidaan mainita jakelujärjestelmän operoinnin hankaluus sekä verkotetun editointijärjestelmän määrittelyn haasteellisuus.

Keywords	elektroninen media, audiovisuaalinen tuotanto, soveltuvuustutkimus, verkkoeditointi

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The goal of this Master's thesis was to find out the Metropolia media technology laboratory’s correlation to industrial electronic media production standards and environments. The laboratory environment for education and training should be following not only media technology curriculum, but also the requirements set for learning audio-visual technology, including the processes, technologies and practices involved in professional electronic production and publishing in Finland. Since the role of the laboratory is to perform as an effective learning environment, there are some understandable restrictions in technology and development, in financial and in management section that prevent it from reaching the industrial level. These limitations and differences between this environment and more sophisticated industrial model were studied in this thesis.

Feasibility study, which is suitable for analyzing the technology, financial and administrative development all together, was selected as the research method. The study was intended to determine the achievable laboratory model of functional validation and also to demonstrate the proof of concept.

Audiovisual production in the laboratory and the subsequent electronic digital publishing was created as an embedded model. The model takes into account the ongoing changes in the television environment and the traditional radio frequency transmission, which is now competing with other alternatives such as IP network distribution. Video editing as post production was analyzed in its current state and compared to a complete network-based-editing NAS and SAN model, which can also be implemented in cloud technologies for decentralized co-operation. This way the model was following the industry trends and future prospects. Research material was collected and acquired from written sources, industry fairs and conferences, resellers and agents as well as production companies and broadcasters.

Practical implementation of electronic media publishing was simulated in the laboratory environment so that all the possible reception technologies were covered. Publishing was customized for compatibility with various devices. Noteworthy aspects in this publishing process were the post-processing, packetizing and distribution related quality management aspects their definition and management issues were also discussed in this thesis.
The end result was a feasibility analysis and model, which defines the electronic publishing technology teaching bottlenecks regarding the equivalence of the technologies in laboratory environment.

Keywords	Electronic media, audio-visual production, feasibility study, net-editing

Contents

Abbreviations/Acronyms

AAC	Advanced audio codec
AVC	Advanced video codec
BYOD	Bring-your-own-device
CIFS	Common Internet File System
CNN	Cable News Network
CPU	Central processing unit
DRM	Digital Rights Management
DSL	Digital Subscriber Line
DSLR	Digital-single-lens-reflex
DV	Digital Video
DVB	Digital Video Broadcasting
DVB-C	Digital Video Broadcasting - Cable
DVB-S	Digital Video Broadcasting - satellite
DVB-T	Digital Video Broadcasting - Terrestrial
ES	Elementary stream
FEC	Forward error correction
FPS	Frames per second
FTP	File Transfer Protocol
GB	Giga byte
GOP	Group of pictures
HbbTV	Hybrid broadband television
HD	High definition
HEVC	High efficiency video encoding
HLS	HTTP live streaming
HTTP	Hyper Text Trasnmitting Protocol
IaaS	Infrastructure as a service

IGMP	Internet Group Management Protocol
iOS	Apple operating system
IP	Internet Protocol
IPTV	Internet protocol television
ISO/IEC	International organization for standardization/International electro technical commission
IT	Information Technology
ITU-T	International Telecommunication Union standardization sector
JCT-VC	Joint Collaborative Team on Video Coding
KEM	Keller-Elektro-Mechanic
LAN	Local Area Network
LCD	Liquid-Crystal Display
LED	Light-Emitting Diode
LTO	Linear Tape-Open
MAM	Media Asset Management
Mbps	Mega-bits-per-second
MDS	Metadata Server
MHP	Multimedia Home Platform
MHz	Mega-herz
MOV	Quictime video format
MPEG-2	Moving Picture Experts Group standard for video encoding
MPEG-DASH	MPEG Dynamic and Adaptive Streaming over HTTP
MSE	Media Streaming Engine
MUX	Multiplex
MXF	Material Exchange Format
NAS	Network Area Storage
NFS	Network File System
NRK	Norwegian Broadcasting Corporation

NTSC	National Television System Committee
OFDM	Orthogonal Frequency Division Multiplexing
OS	Operating System
OTT	Over-the-top
P2P	Peer-to-peer
PAL	Phase Alternate Line
PAM	Project Asset Management
PAR	Pixel Aspect Ratio
PES	Packetized Elementary Stream
PSI	Program Specific Information
QAM	Quadrature Amplitude Modulation
QoE	Quality of Experience
QPSK	Quadrature Phase Shift Keying
RTMP	Real Time Messaging Protocol
RTP	Real-time Transmission Protocol
RTSP	Real-time Streaming Protocol
SAN	Storage Area Network
SD	Standard Definition
SNR	Signal to noise ratio
SR	Symbol rate
STB	Set-top-box
TCP/IP	Transmission Control Protocol / Internet Protocol
TS	Transport stream
TV	Television
UDP	User Datagram Protocol
UHD	Ultra High Definition
UI	User Interface
VCEG	Video Coding Experts Group

VFS	Virtual File System
VHS	Video Home System
VOD	Video-on-demand
VOIP	Voice over Internet Protocol
XML	Extensible Markup Language
YLE	Finnish National Broadcasting Company

1 Introduction

High-speed Internet connections and the fact that a large number of consumers have access to this fast broadband have enabled a variety of new IP-based services to penetrate the markets. Nowadays radio-frequency reception has received some noteworthy competitors from services that are offered from telecommunication operators as well as online services. Keeping up with the current and continuous change in the various technologies has scattered the field to the point where today's trends are already history tomorrow. If the technology and publishing fields are affected by fast development so is the market aimed for consumers. Consumers themselves must be aware of the latest trends and technologies in order to know what type of services they want to buy or what type of electronic appliances they need for these services. This is of course true in business world and the competition between brands has never been more aggressive.

In this thesis I will discuss the on-going changes in the broadcasting technology field and the new forms of electronic media publishing in the form of a feasibility study. As an example case I will use the Media Laboratory's electronic media-publishing environment and how it reflects the existing industry standards and current trends. In the conclusions a development plan will be introduced of how the laboratory should be developed further.

2 Method of research

There are three qualitative research methods applied in this study:

- general feasibility analysis
- case study methodology
- proof of concepts analysis

2.1. Feasibility study

In order to find out if a development project is feasible and relevant is the main goal in this thesis work. It can be seen as a valid goal for a development work of a laboratory to make it into the same standard as the responding real industry and business. Because the resources are evidently restricted, the potentials should be analyzed in a pre-study, which means that options are charted for the future to conduct the development. Figure 1 shows the focus of the research: from state-of-the-art to industry standard.

The reasons are then to:

- give focus and outline for the development
- narrow alternatives
- identify opportunities through investigation
- identify reasons not-to-proceed
- provide quality information for decision making
- supply documentation
- help to attract equity investment [1, 2]

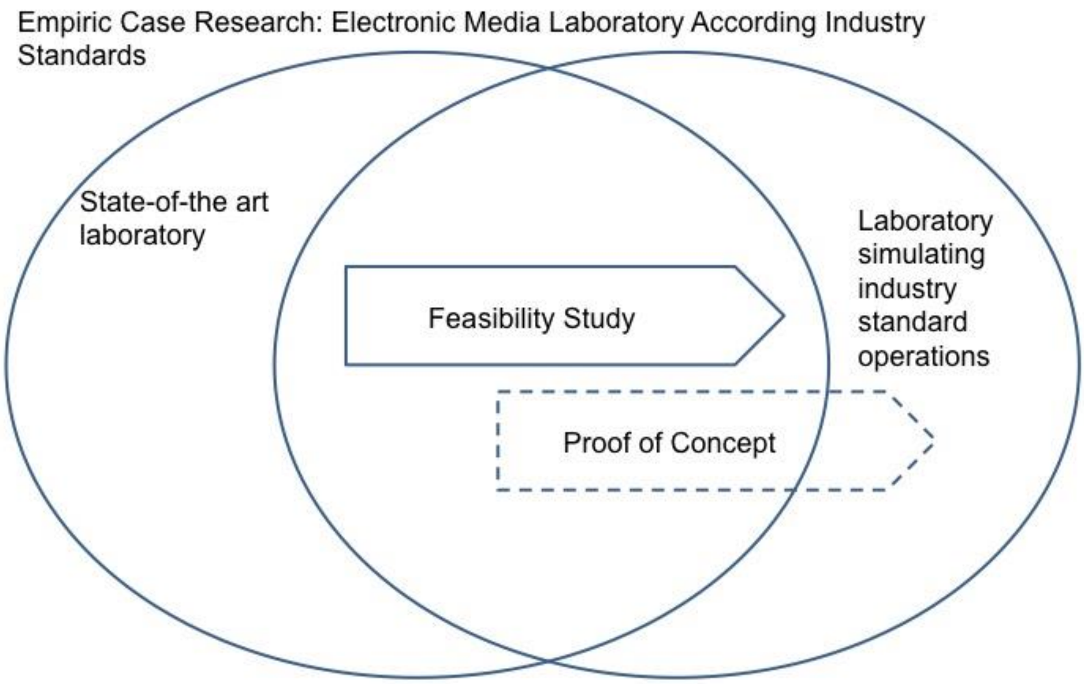

Figure 1. How feasibility study enables laboratory development to simulate industrial electronic media publishing

2.2 Case study

In case study the research item can be a social organization or process. Also it can be an action or an operation of a person, group or community.

A study can be based on single -case empiric research material or multi-case empiric material. A case study tends to analyze and compare models in real life context. The aim is to give an example of a typical case by utilization of multi-perspectival analyses. The focus and arrangement is then to compare the laboratory with real industry and business, to collect the necessary information from interviews, excursions and industry visits. [3, 4]

2.3 Proof of concept

Proof of concept as a research method concentrates in theoretical aspects in proofing that a set of requirements have been answered or that a theoretical basis is solid enough for a prototype or model.
The operative validation of prospective developed laboratory is this observatory angle of view. It is to see how the development process can be realized and will it have parallel features with industry. [5]

3 Electronic Media

Electronic media is one of the three types of mass media:

- Print media
- Digital media
- Electronic media

Electronic publishing is referred to as publishing of written content electronically e.g. e-books, articles and magazines online. In this thesis *Electronic Media Publishing* refers to electronic audio-visual media also known by its more common expression: *broadcasting*.

Electronic media on the other hand refers to audio-visual content that is published by utilizing various communication channels; radio frequency modulation and the many different means of Internet publishing.

Since the publishing industry is going through changes, it is obvious that publishing companies must come up with new ways to make revenue. Therefore, many broadcasters have already started to offer their content online as on-demand services or live streaming whilst viewers have more choice to select what services they want to consume [6].

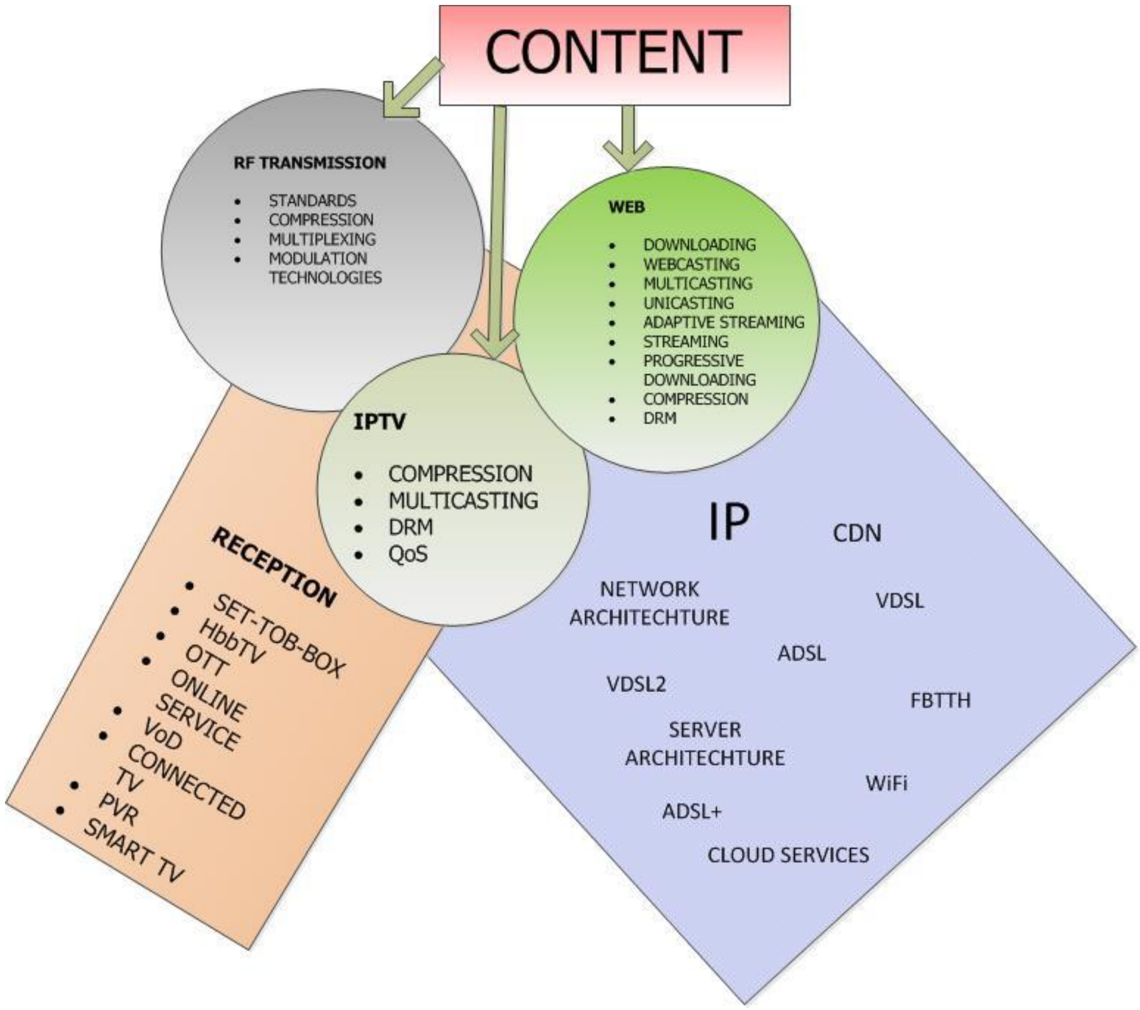

Figure 1. Illustrates how electronic publishing includes many different technologies

Many mass media companies that have earlier focused only on their core business are now facing a challenge: how to survive in everyday evolving market. Times have been rough for many companies, which has led to dismissal of staff and even bankruptcy. Electronic publishing has gotten its place in mass media and the figures show that the media consumption is growing every year: average Finn watches traditional television for 183 minutes per day which is 10 minutes more than in previous year [6]. Internet television has also become more popular as it is measured by how many start-ups are registered on a service e.g. YLE Areena and MTV3 Katsomo. Figure 2. Illustrates the changes in web video play launches on a monthly basis [7]:

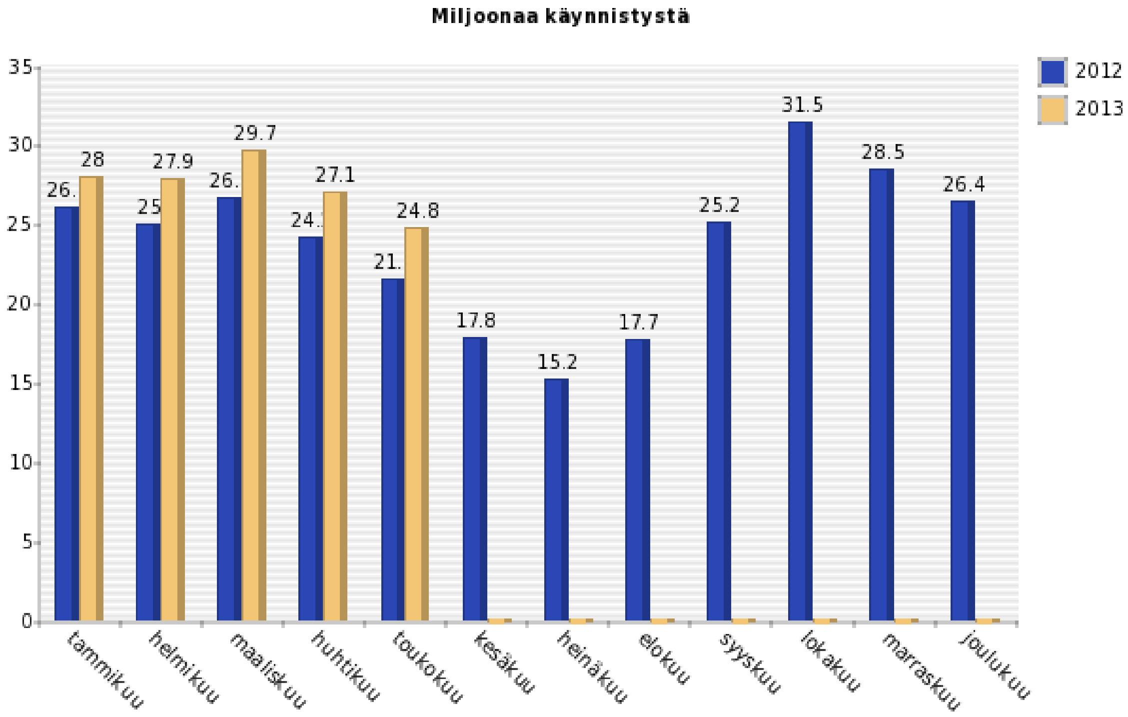

Figure 2. Web video play launches on a monthly basis. Numbers indicate millions of videos launched [8].

Postproduction is no longer separate from the other underlying systems. Agile systems can contain support for the entire workflow where content transmission, metadata addition and publishing can be done effectively as one continuous process. This is why the specification of the agile systems has to be defined thoroughly with all the necessary components included. The architecture of an agile system are defined from storage to Media management, and from systems supporting project collaboration to cross media publishing.

4 Electronic media production as ”end-to-end” process

Electronic media publishing is a process that requires a fundamental idea of the entire workflow from content production to publishing and archiving. All the different phases require different technologies that are part of the publishing process. Illustration 3 shows the workflow from capture to archive.

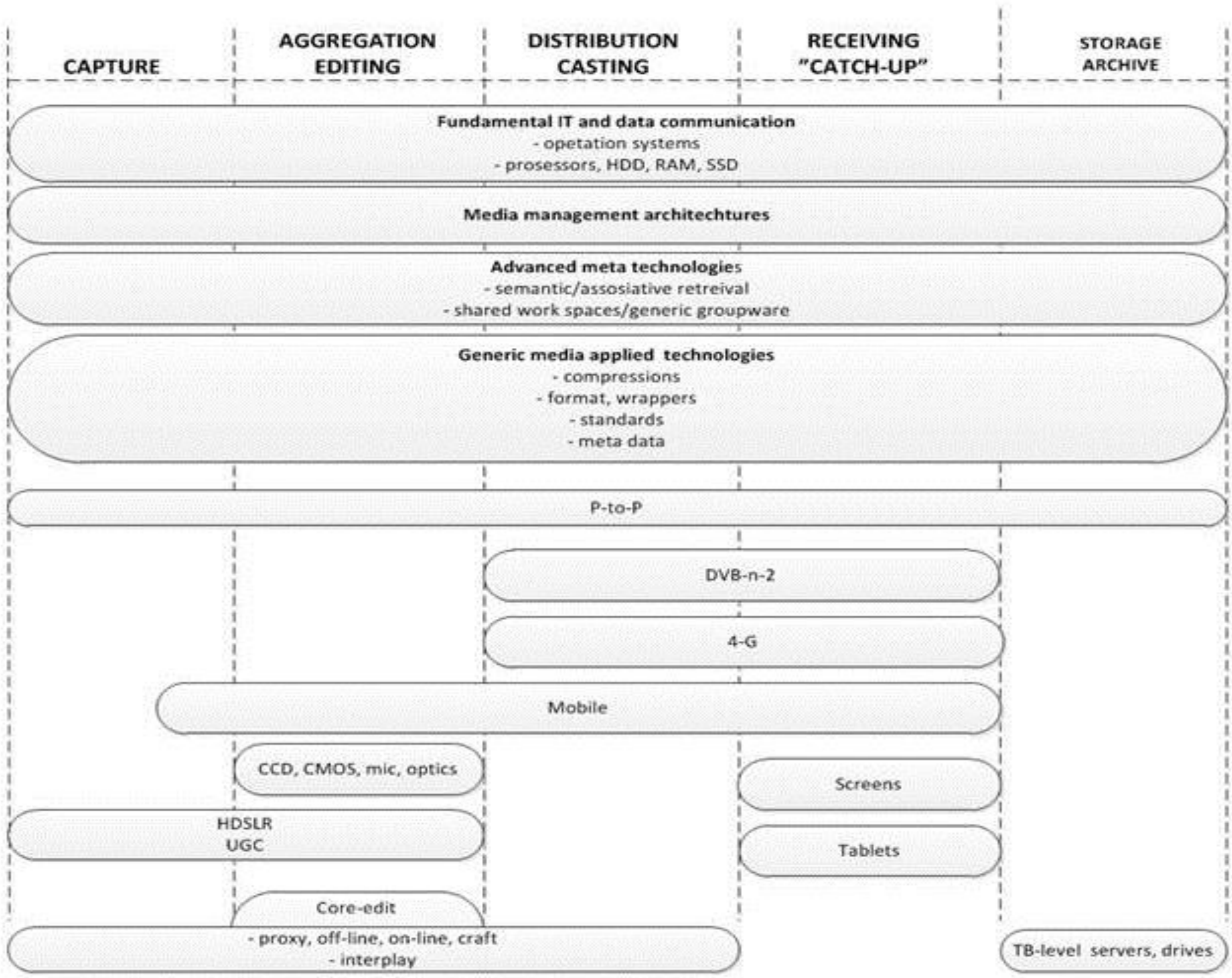

Figure 3. Illustration of fundamental end-to-end process in electronic media publishing. [9]

4.1 Development history of digital postproduction

Moving pictures have been around for over 200 years. First attempts being just single images drawn from a photograph like the zoopraxiscope in 1870's or actual motion picture from film projection in kinetoscope twenty years later. The invention of film in late 1880's meant also the starting point of film as industry when things such as close-ups and acting started to become popular in the filmmaking.
[9,10]

First actual editing as a process started after the invention of celluloid film. At the beginning of 1900's the tools used in editing were very ascetic, a pair of scissors and some glue. The problem was that actually no viewing device which the editor could utilize for monitoring while cutting the filmstrips existed. [12]

Help arrived a couple of decades later when Iwan Serrurier invented Moviola. Moviola, a device which purpose was to bring film watching to domestic market, was adopted by the industry and quickly became the standard device in every editing room.[13]

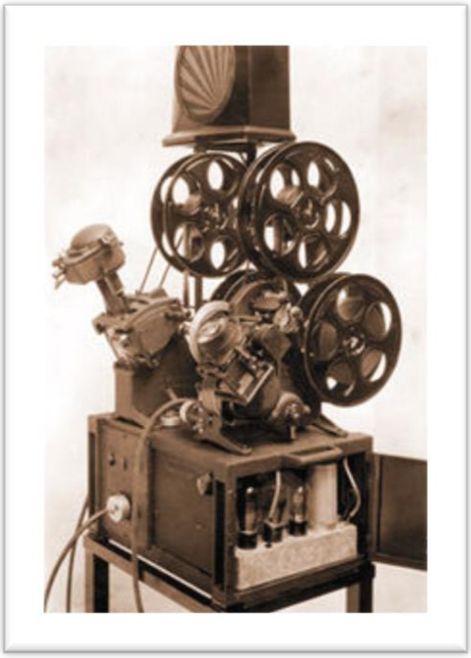

Figure 3. A Moviola [14]

First flatbed editors were developed a decade later. They became very popular and soon replaced the Moviola. Two device manufacturers were heading the way with their flatbed editing environments: Steenbeck and Keller-Elektro-Mechanic (KEM).

Figure 4. Steenbeck flatbed editor system [14]

Usually flatbed editors supported multiple reels, one for the motion picture and from one to three for audio. The system also contained an interlock mode where the synced picture and audio could be forwarded and rewind simultaneously in sync.
World’s first non-linear editor was the CMX 600. It had two monitors, one of previewing the original film material, and one playing the edited version. The system could only handle 30 minutes of black-and-white material and was very large in size. [12]

4.1.1 Linear to non-linear editing environment

Linear editing involved handling of film material. Film was cut and glued together again with a tape. This method was of course destructive since the film was physically changed when cut and glued to another strip. The editing process usually involved many stages when also a paper edit was made to prevent unnecessary cuts on the actual film. Preserving and making copies of the film became impractical and time consuming. The evolution of filmmaking technologies led to new and more portable technologies also available to consumers too: videotapes and camcorders.

Videotapes enabled copying sections from one tape to another without the need to physically touch the actual tape inside the casing. Camcorders, aimed at the consumer market, made it possible for anyone to become a filmmaker or a documentary maker.
Digital tapes pushed through and made postproduction approaches change again. Now the material was already in digital format but needed to be transferred from the tape to the computer. This non-linear and non-destructive editing enabled the material to be handled any way the editor would like, change the scene order, shorten clips and add effects. Everything could be accomplished by dedicated editing software. [15]
Today most cameras support tapeless production where the camera captures images and audio as files to a memory card or the cameras internal memory slot. This method of course supports file-like transfer from camera to the editing station without the need for any capturing or digitizing processes. Today almost all recorded video content is in digital form, although there are still those who think that film is the only real format for video recording; they refuse to acknowledge any other technologies.

4.2 Changes in electronic media postproduction

Below is a table where the different phases in electronic media postproduction are covered. Supremacies explain the positive impact the technology had to the industry and uncertainties explain the issues that were solved in the next phase of development. [12, 15]

Development level	**Supremacies**	**Uncertainties**
1. Tape-to-tape	Video material was ready for editing. No film development was needed.	Destructive one take at a time
2.Eletronic video (VHS, U-matic) to digital edit	- Sequence based editing was enabled and not only one take at a time - timeline based - non-linear / nondestructive	Digitizing analogue material
3.Digital tape (DV)	- video quality much better than in analogue tapes - enabled High Definition (HD) recordings	Compression in capture device which cause quality issues when transferred for editing - might be recaptured and prepared for edit-

		ing
4.Tapeless recording	- recorded material immediately ready for editing also in non-linear editing possible - metadata added - no footage capturing - no analogue-to-digital conversion	- capturing and editing doesn't integrate in same system - editing is independent process that doesn't benefit from metadata - transcoding is necessary to enable compatibility in editing - new files are created from sequences which produce more data
5. Capture and editing is integrated in the same system also enabling rough editing	- editing environment fully compatible - metadata utilized in editing - partial ingest enabled doesn't increase the amount of data	- planning and script writing are separate
6.Script-record-edit-integration	- script included in ingest - metadata utilization	- new systems are comprehensive but lack user experience
7. Cooperative shared work flow	- enables collaborative workflow - centralized data storage that can be cloud based - platform independent	- expensive with some compatibility issues
8. Bring Your Own Device	- flexible - facility independent	- security issues

File formats and compression technologies have evolved since the beginning days of digital postproduction. This has enabled additional data to be added in the files. This *metadata* is present today in all productions and cameras from consumer to professional market support this additional information.

4.3 Metadata

Recorded video and audio information contains additional data. This metadata is generated by the camera and by the user with dedicated software. Some camera manufacturers support metadata insertion via the cameras software or via memory card transfer. Metadata can contain not only camera manufacturers data but also anything from date and time to a detailed descriptions and user information. Metadata can also contain vital information about how different files should behave in certain environments. For example, some file formats contain video and audio data in separate files and when put together in editing software the metadata handles the syncing. These file formats include for example Material Exchange Format (MXF) that is platform independent and does not define which compression should be utilized. [16, 17]

Metadata can be utilized for many purposes e.g. for organizing and combining data, data identification, version control, rights management data, description of content, device generated metadata, user tracking and authentication. [18]

Metadata types include: descriptive metadata, structural metadata and administrative metadata. In this thesis work concentration is put on the administrative metadata since it is mainly utilized in Media Asset management systems. Administrative metadata collects the following information:

- When was data created
- How was data created
- Who created the data
- Data acquisition – how the data can be accessed
- Data file type and versioning
- Who can access the data

  [18]

5 Post Production as a Core of Quality Management

Electronic media publishing is fragmented, depending on representation of the physical size and the mode of application, up to dozens of different quality levels. In recording and distribution lies the richness of diversity, but between these two, inside the production chain exists the core of quality management: post-processing. Post-processing defines crucially the maximum advantage taken from the produced media content utilization as well as the functionality of the publishing.

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5.1 Variations in screen sizes

Before when editing was film-based and linear, the end result was to be put on a similar film roll where the assets were earlier taken from. Quality was not an issue since the materials were coming from a film roll, the same material as where the end result was going to end up. When technology enabled non-linear editing and computerization of post processing facilities and publishing became digital, the issue concerning quality and quality monitoring became obvious. The quality of the end result was to be taken into consideration while production was going on.

In post-production the way editing was made could also determine which device, for example, the video was intended to be shown. On a smaller screen small details could not be seen and for web publishing the compression had to be taken into account. Some filmmakers also like to create their productions in stereoscopic 3D, which of course means the use of capable production equipment such as cameras and later on in the post processing also effects. [15]

5.2 Collaborative workflow in postproduction

Fast Internet has enabled a new way of postproduction. Instead of being tied to a certain dedicated editing workstation, now postproduction can be done anywhere if the broadband connection is available and the speed is adequate. The scenario for this is to store the data in a centralized storage system and then either via file sharing, streaming technology or low quality proxies to share the editing process among the production team. In this collaborative postproduction different people in different locations can process the same assets. In this thesis three different possible technology implementations are explained:

1. File sharing from shared network storage
2. Proxies
3. Streaming from a centralized network storage with dedicated servers

5.2.1 System Integration in distributed collaborative production

The storage architecture and the supporting technologies enable true project collaboration and shared network editing. To make collaborative workflow possible, more detailed reviewing of the background technologies is required.

File Sharing

File sharing is the simplest form of distributed editing. Members of a production team can all have access to video files located on a local server. Problems occur when the file sizes grow larger and new versions of the editing project needs to be saved on the server. Usually this type of file sharing is suitable for collaborative editing in a Local Area Network (LAN), for smaller files and easy versioning of projects. If project access is needed outside a LAN without an adequate connection speed, editing can become time consuming when the files have to be transmitted between workstations and back to the server. Figure 6 Illustrates server-based file sharing which files all the computers have access to. Server shows just like a simple hard-drive on the computers recourses and files can be saved directly to the server from all the computers that have access to that shared drive. [19]

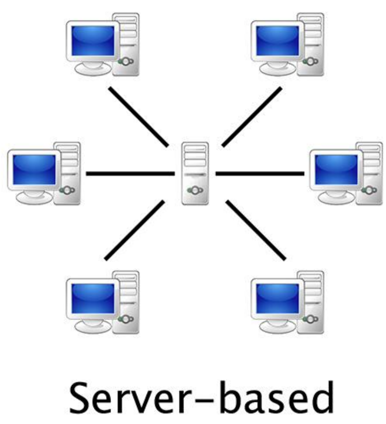

Figure 5. Server-based file sharing [21]

Peer-to-peer (P2P) utilizes the network clients for file distribution. This means that each user that is connected to the network can be a potential client and can share files from his or her own computer and download files from other clients. This type of file sharing is nowadays associated with illegal activities and piratism although the technology itself is efficient and excludes the need for server connections every time a file sharing is necessary. Figure 6 illustrates the how the P2P file sharing is different from a regular server-based sharing. In order for P2P technology to work client software must be running on each client computer. [20]

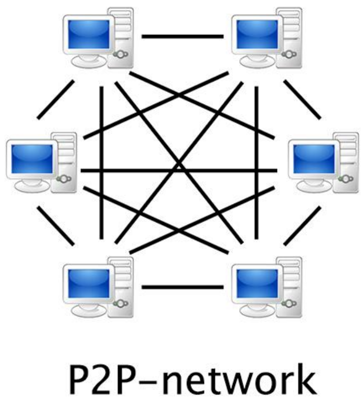

Figure 6. P2P file sharing [21]

Proxy generation

Next option is to do postproduction by utilizing a lighter compressed video reference files also known as *proxy* files. These files are generated either during recording by the recording device, mainly camera or camera attached device or a specialized recorder, or in the server side by Media Asset Management (MAM) server. These lighter versions of the actual video files are then utilized in editing and effects software and are later on replaced by the actual footage by utilization of time code reference. Therefore there's no need for file transmission between systems and workstations. Figure 3 illustrates Axlevideo's approach to proxies via their MAM system. [22]

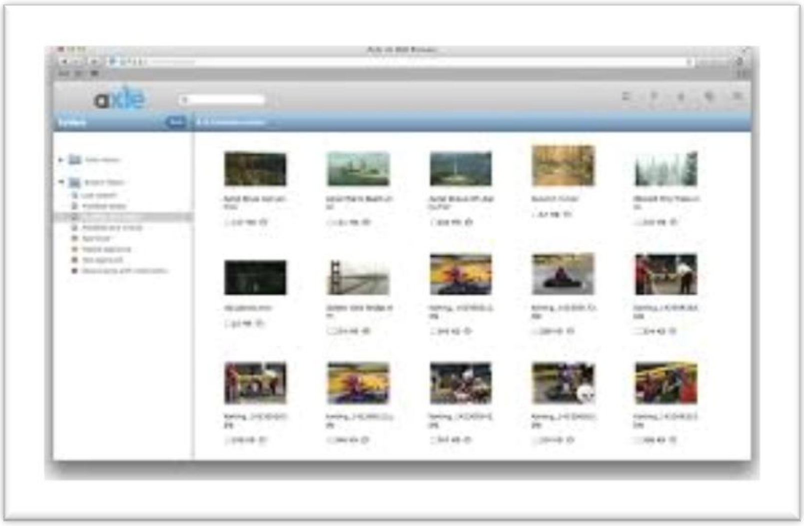

Figure 5. Axle Media Asset Management system view to proxies [22]

Streaming servers

Some newer technologies have introduced a new way of how to work with larger video projects. Instead of setting requirements for the editing workstation capabilities, the actual processing is done on the server side. This streaming technology already exists in distribution and publishing and now it is being harnessed for postproduction purposes.

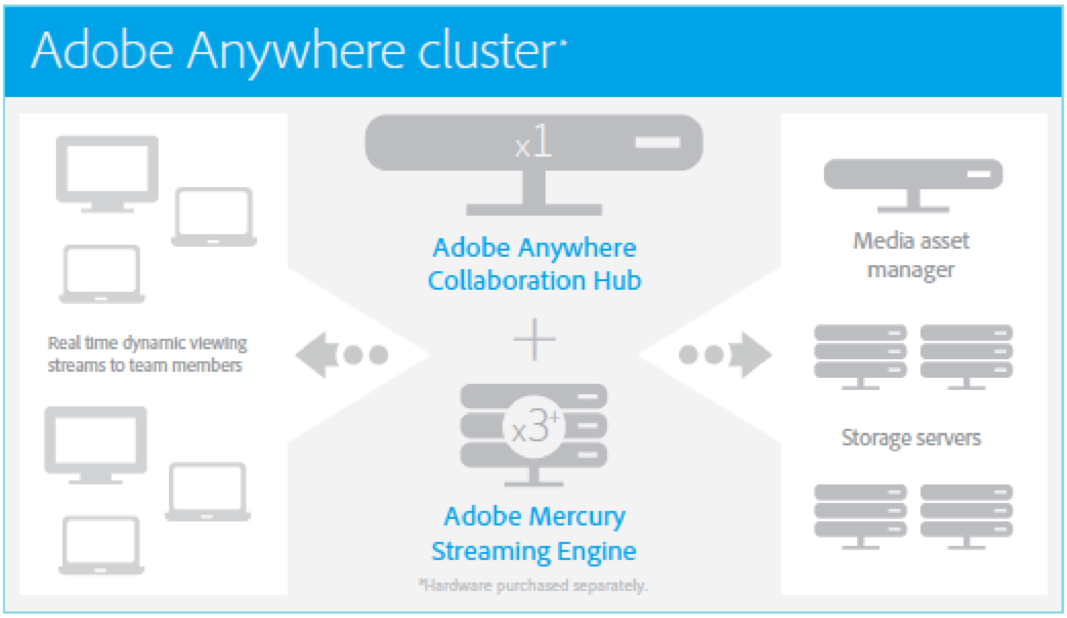

Figure 6. Adobes Anywhere with Mercury Streaming servers [23]

Adobe Anywhere system utilizes Mercury Streaming engines, which are dedicated servers that are in charge of streaming the content to the client computers while the actual data is stored in storage servers. Minimum amount of MSEs is three but the amount is scalable to larger amounts depending on the amount of simultaneous users on the system. Storage systems can be either Storage Area Networks (SAN) or Network Area Storage (NAS) based as long as the connection between the storage and the streaming engines are adequate. The streams are generated adaptively so if the network bandwidth suddenly drops, the stream is automatically changed to a version with a smaller bitrate. Adobe has also published an application where the clips inside a project utilizing Anywhere can be viewed on a tablet device. [23]

Metadata Server (MDS)

While recording, video audio and additional data is added to the files. This is one of the main reasons why the utilization of containers as file formats has become more popular among device manufacturers. This embedded metadata is stored together with the actual data files. Metadata can also be stored separately in a dedicated server and sometimes high-end server systems and contain several servers. This multiple server architecture is referred to as server cluster. Metadata server’s job is to provide and manage metadata requests by other servers when the clients access their files.
[24]

5.2.2 Storage Technology system specification

Video material in a distributed collaborative editing environment is stored in a centralized storage that can be either a Storage Area Network (SAN) or a Network Attached Storage (NAS) based system. Difference between these two systems is the physical networking of the servers and the various communication protocols they support.

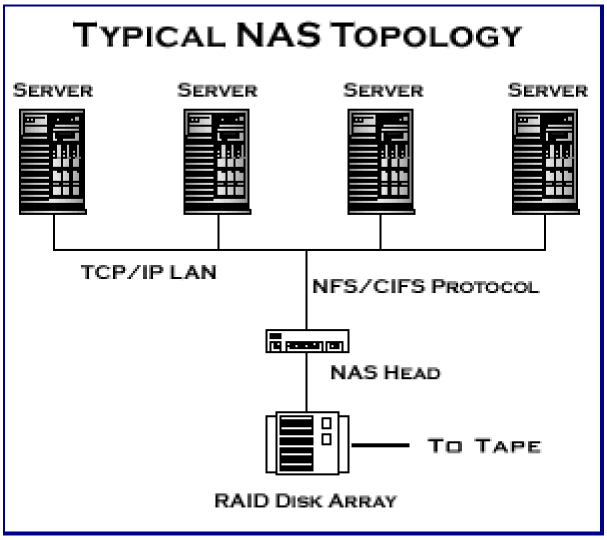

Figure 7. Network Attached Storage architecture [25]

With NAS systems the communication between the storage, the client and the archive systems is handled by Transmission Control Protocol / Internet Protocol (TCP/IP)protocol inside a Local Area Network (LAN). This requires a high bandwidth broadband connection between the different components in the system. Connection protocols such as Ethernet or Gigabit Ethernet are adequate to cover the bandwidth requirement. In this scenario the Metadata Server (MDS) can be added to handle the user traffic and to keep track with the file sharing and user management. To suit different Operating System (OS) platforms NAS systems file sharing operates via application protocols. One application protocol is the Network File System (NFS), developed in the 1980's by Sun Microsystems. This protocol enables multiple client access via Virtual File System (VFS) to the files on the storage like it was locally installed on a client computer. [25, 26, 27]

File sharing in larger scale is handled by Common Internet File System (CIFS) protocol. This protocol provides an OS independent technology for file sharing over TCP/IP protocol. This means that there is no extra software needed for storage access from the client side. This same protocol is also commonly utilized in network printer access. [28]

Utilization of browsers as windows to the backend systems has become very popular. Many system providers utilize Hyper Text Transfer Protocol (HTTP) as their interface to the server.

One of the file transfer methods with HTTP is the File Transfer Protocol (FTP), which requires a client to enable server access. FTP can be active or passive. In passive state FTP waits for the connection requests from the client side. This connection usually requires user authentication and specialized software for the connection establishment. In active state the server establishes the connection and data transfer is started automatically. For example software updates can utilize active FTP, so that the updating is occurring on the background. [30]

Storage Area Network (SAN) systems are attached to clients via Fiber Channel. Since the actual data transfer is in a separate network even very large amounts of data can be transmitted to the storage without affecting the communications network, typically Local Area Network (LAN). Control and monitoring of storage system is still done via traditional network architecture with its supporting protocols such as TCP/IP. [25]

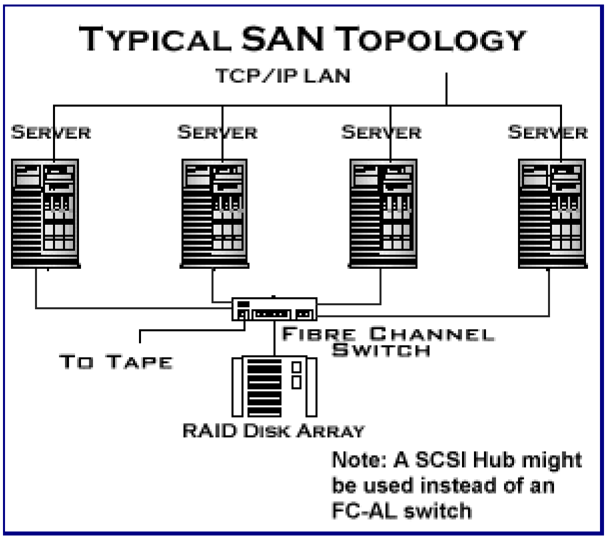

Figure 8. Storage Attached Network architecture [25]

Which topology is selected is determined by a set of factors:

- how long distance is between the clients and the server
- how much payload is put on the connections by means of data file sizes as well as amount of simultaneous users
- Switchers can become bottlenecks

Restrictions in the system architecture are caused by limitations in cable lengths. Although fiber channel can be long-distance, even kilometers, the price of the cable can

be ten times more expensive than with copper cable of same length. Also the handling of fiber, cable installations and splicing, requires skills and knowledge that only specialists in fiber optics can possess.
With copper cables, distance is measured in meters. Longer than that can cause packet loss and with video content it is shown as distinguished loss in quality. [34]

In media laboratory different scenarios are evaluated, which options would be most beneficial in utilizing existing SAN system and implementing new Media Asset Management tools to postproduction. Figure 7 illustrates how Aurora Galaxy SAN system could be utilized with HyperFS MDS and Strawberry project management tools. [32]

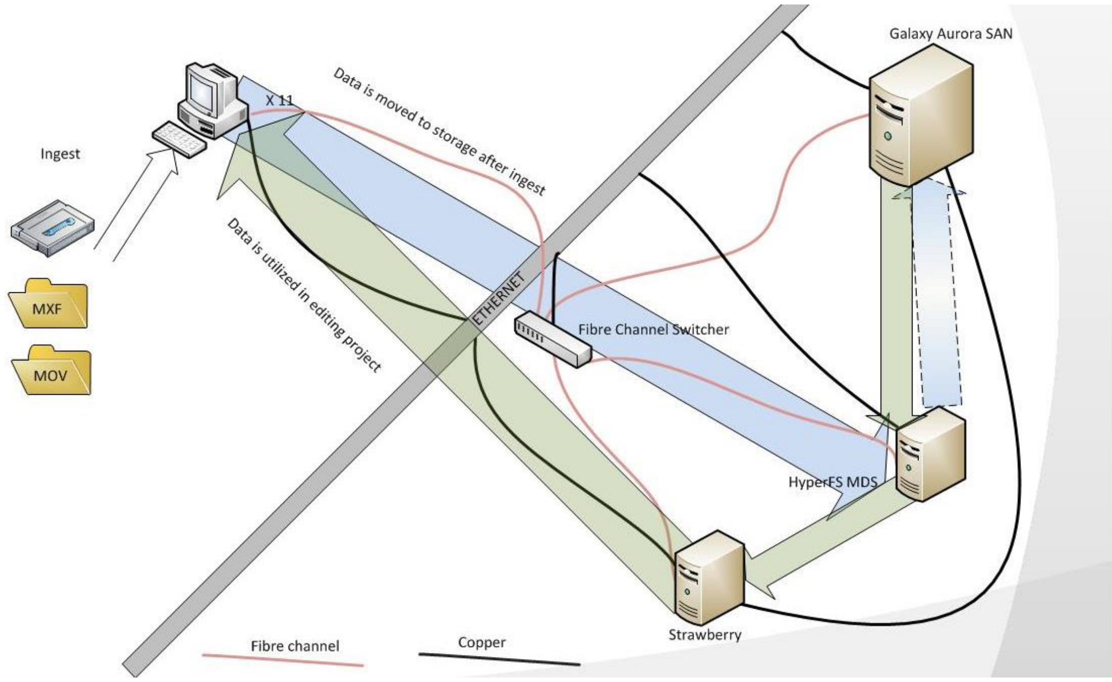

Figure 9. Media Laboratory distributed editing option

Media ingest is done via fiber channel to storage. HyperFS system is in charge of file sharing and user authentication but not file locking. In a shared environment this can become a big issue since there are several users accessing the same files.

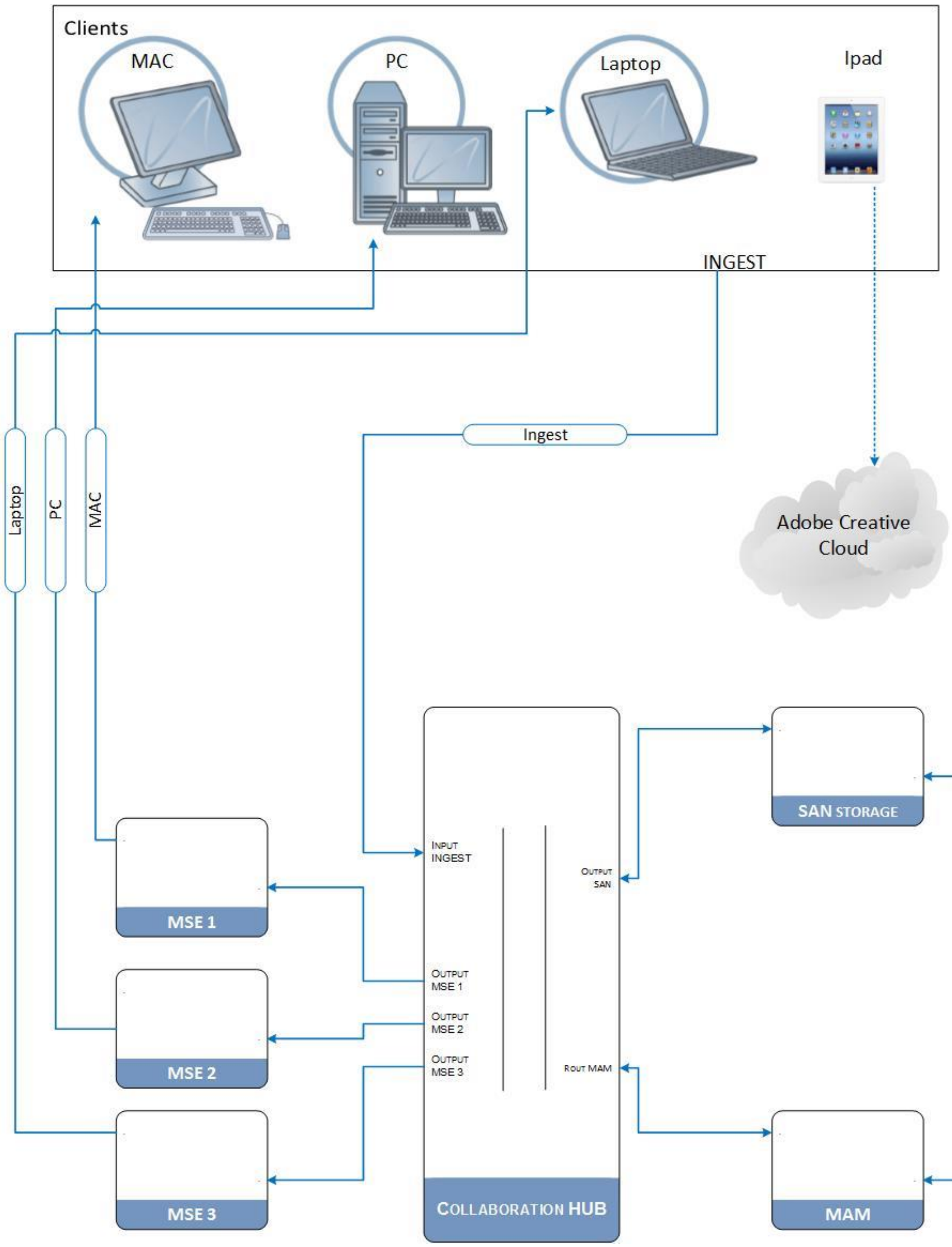

Figure 10. Adobe Anywhere system architecture

With Adobe anywhere the system architecture would look a bit different. Also the data access to existing projects could be possible anywhere where there is a network available. This system would enable BYOD and would not be tied to a certain physical location. Adobe Creative Cloud enables application download from cloud and when signed in a user can also view project timelines on iPad. [23]

5.2.2 Cloud-based services

In this thesis two different Cloud service scenarios are considered:

- A Cloud created by organisation, industry or company and utilized by authorised users, monitored by an administrative party. The existence of this cloud is obvious and can be localized. This cloud is referred to as “known cloud”.
- A cloud provided by a third-party and utilization is authorised to anybody with user credentials and authorized access. Location of this cloud is not known. This cloud is referred to as “online cloud”.

Online cloud video editing

If setting up a cloud editing inside an organisation is impossible, there do exist online clouds that are concentrated on offering video editing services. These services are intended for consumers and, therefore are not suitable for professional usage with large amounts of data.

Wevideo is online, cloud-based video editing service that has its own editing tools, publishing portal and collaboration tools for video editors. First the video is transferred to a computer and then via Wevideo portal clips can be uploaded in the cloud, edited, shared and published. Wevideo provides simple tools for video editing and for bigger projects extra cloud storage can be purchased for a monthly charge. After subscribing 5 GB storage comes for free with a watermark. Other options come with extra features and additional user licenses.
[35]

Sony has launched its own media cloud service the Sony Ci. The idea is the same as with the Wevideo but it contains a portal called Toolbox for collaboration, project creation and file sharing. It also includes RoughCut, a tool for editing and source combining and tools for reviewing the video and audio files as well as other tools for project collaboration. [36]

Kaltura offers open-source video platform that contains video editors, video players, content management system and collaborative tools for project working, all online. Their philosophy is to offer all the necessary tools for hosting, streaming and media management and media publishing in their platform the Kaltura Community. They offer 10 GB storage for free but charge for larger storage requirements with a monthly fee. [37]

Youtube has its own version of cloud editing. With a Youtube credentials the users can edit their uploaded videos before publishing them in the Youtube portal. The interface is very simple and does not offer many professional options for the editing. [38]

Storage-based cloud video editing

A known cloud can offer organisations and industries a solution that can have many benefits:

- Editing stations do not need massive hard-drive setups
- Editing is not tied to a certain workstation
- Assets can be accessed anywhere
- Enables *Bring-Your-Own-Device* (BYOD) type of approach in the organisation

There are of course some issues that can become obstacles with system architecture design:

- Price of a storage with all the necessary components
- Administration of users, data and projects
- Support in case of malfunction or problem
- Workflow that all the parties will respect

Setting up these systems require participation of system integrator, system designer and in some cases the information technology department in charge of the organisation's IT solutions. Constructing such a system is not possible by one operator only but requires expertise from hardware and software vendors and system integration specialists.

Comparison of Storage Architectures

To define the system architecture suitable for multiuser environment with every-day changing utilization scenarios, a comparison of existing systems was made to determine the technology approaches most appropriate.

The platform independent University model

Utilization of the laboratory's existing SAN system by adding components and MAM technology is one of the most important things under development in the laboratory. To benchmark the existing systems and their suitability to media laboratory some excursions and university visits needed to be made. One of the visits was in the Konrad Wolf Film and Television University in Potsdam Germany, where one of the comparisons was made. Since their goal was to build a system that was completely editing platform independent but robust and flexible and suited for the data amounts used in all the projects annually, was the approach similar yet different from the laboratory environment. Figure 11 illustrates their system architecture.

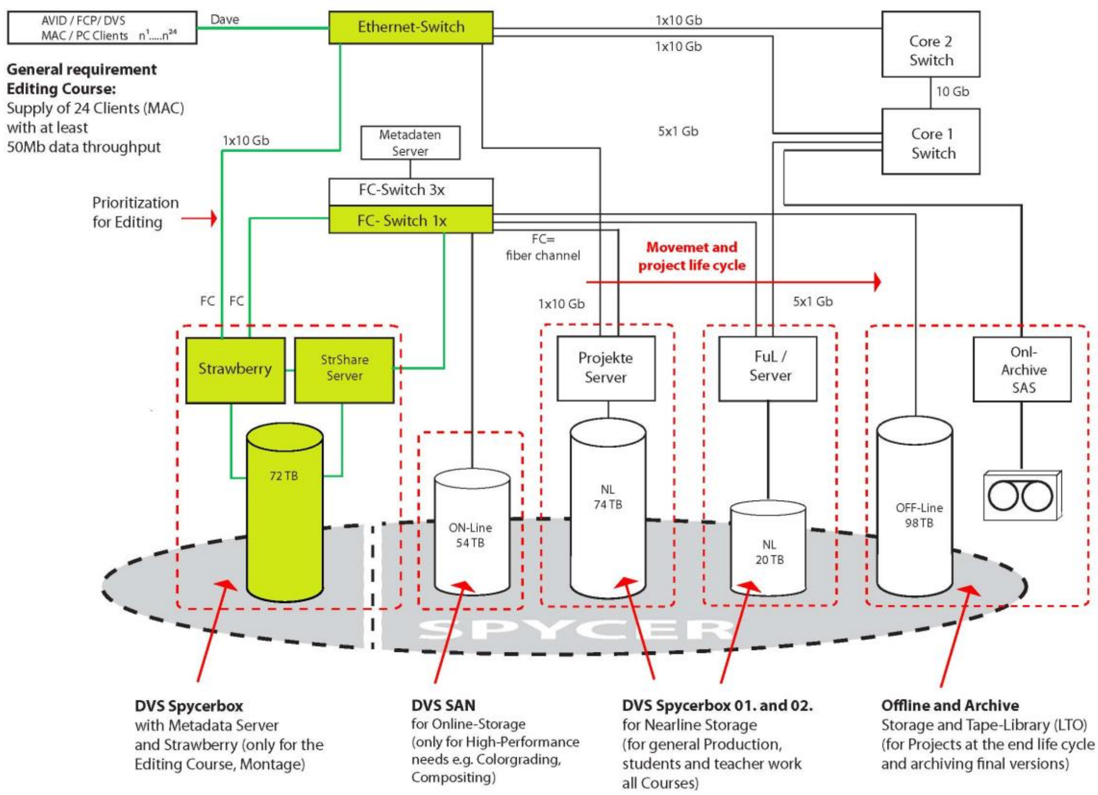

Figure 11. The HFF University storage model [39]

Their postproduction storage utilization is divided into sections. First section is utilizing Strawberry Project Asset Management (PAM) system after material ingests to create user access and project management related data. This section is for the editing course where the students are guided to use the different tools provided by Strawberry. After editing the material is moved to another storage for more post processing e.g. colour grading. After post processing and publishing the selected materials and are moved to archive, which can be server storage or Linear Tape-Open (LTO) magnetic tapes, for longer-term storage.

The Broadcaster model

In the industry large-scale storage architectures are compulsory due to huge amounts of data that is being generated every day. The system is somewhat complex but the basic idea is the same as in the HFF University model, after ingest data is pushed to different systems depending on the status and process of the data. Figure 12 is an illustration of a broadcaster's storage system infrastructure. This model implements end-to-end approach from production to storage and from distribution to archiving.

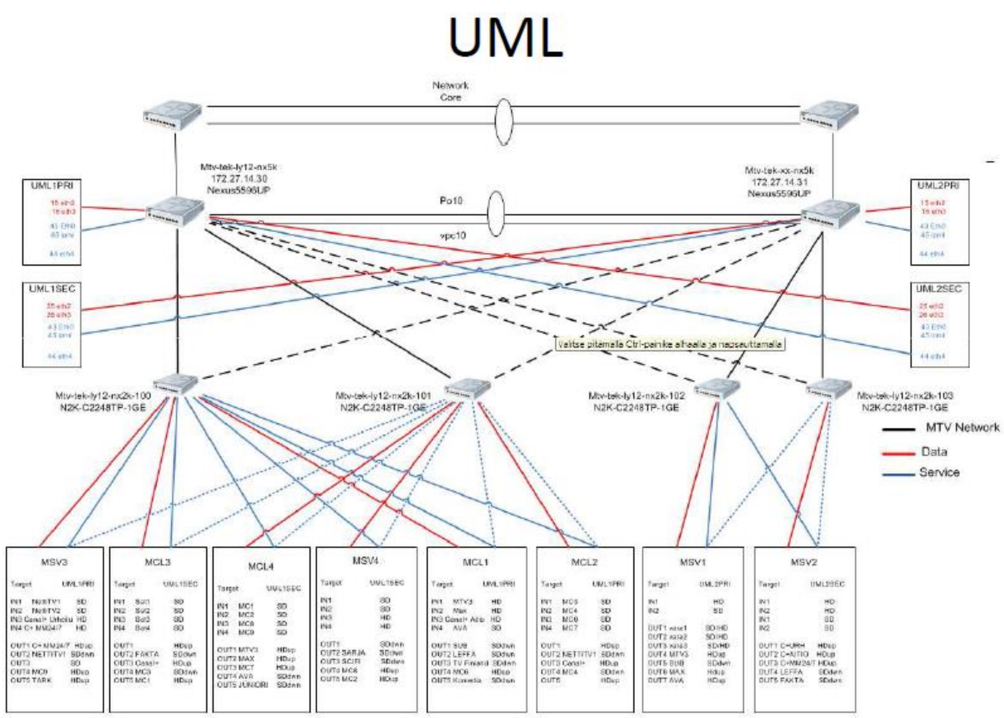

Figure 12. The Broadcaster storage model [40]

The process of how the materials are handled varies from the university model. This is because there are definite deadlines that are followed. Also because it is a commercial company the Digital Rights Management (DRM) issues are taken into account in the system. Figure 13. Illustrates the process and workflow of content in a commercial TV channel.

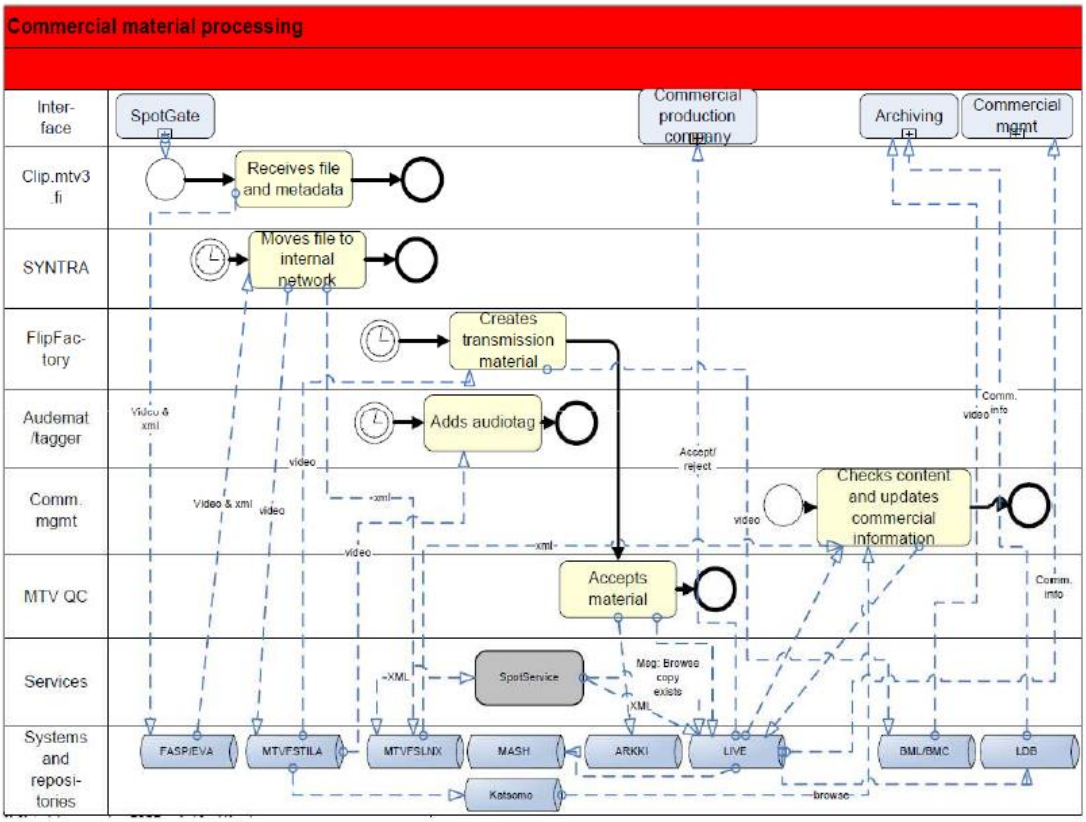

Figure 13. The Broadcaster material processing workflow [40]

6 Publishing and distribution

6.1 Postproduction compatibility to distribution and publishing

New development in broadband technologies such as video compression methods and wireless data transmission has enabled the development in distribution signal transmission technologies too. When frame sizes continue to get bigger, some new means for compression must be development in order for these bigger and sharper video frames to be stored and transmitted.

6.2 Frame sizes and frame rates

Each second (s) of video contains still frames that are rapidly displayed one after the other to create motion. How many still images are displayed per second is referred to as *frame rate (fps)*. Frame rate varies depending on the adopted television standard: Phase Alternate Line (PAL) utilized in Europe or National Television System Committee (NTSC) utilized in North America and some South American countries. PAL standard has a frame rate of 25 frames per second (fps) and NTSC 29.97 fps.
Frame sizes also differ between the two standards. PAL system for standard definition (SD) has 720 x 576 pixels and NTSC 720 x 480 pixels. The amount of pixels per frame remains whilst the aspect ratio of the image can change varying from 4:3 to 16:9. This is due to *Pixel Aspect Ratio* (PAR). Table 1 lists video frame sizes, aspect ratios and PARs for each frame size.

High definition video frames can be either 1280 x 720 pixels or 1920 x 1080 pixels for both standards. In PAL system the frame rate can be either 25 fps or 50 fps. For NTSC the frame rate can vary 29.97 fps or 59.97 fps. [41] Although the history of these two standards defines their development being fully tied on the electricity frequencies, today's televisions can display content with either 25 fps or 50fps. [42]

Frame size	Frame aspect ratio	PAR	Frame
720 x 576	4:3	1.066	PAL SD
720 x 576	16:9	1.422	PAL Wide
1280 x 720	16:9	1	HD
960 x 720	16:9	1.33	anamorphic HD

1440 x 1080	16:9	1.33	anamorphic HD
1920 x 1080	16:9	1	Full HD
2048 x 1080	16.9	1	2K
4096 x 2048	16:9	1	4K

Table 1. Video frame sizes their aspect ratios and PARs.

Pixel Aspect Ratio (PAR) defines the aspect ratio of a single pixel on a frame. PAR can be calculated by *display aspect ratio / video frame width x height.*
So for example in PAL Widescreen the PAR is calculated by:

$$\text{PAR} = \frac{16/9}{720\ x\ 576} = 1.422$$

Anamorphic frames are wider but during capturing they are squeezed to smaller frame size. When the frame is displayed on a screen, the pixels are stretched to fit the aspect ratio of the screen. [42]

Bit rate

Bit rate determines how much bandwidth does the content need for transmission. Bit rate is expressed by *bps*, which stands for *bits per second*. Bit rate is calculated by

Number of samples per second x number of bits per sample

Since television systems contain frames the calculations for the bit rate is:

Frame width x frame height x frame rate x bits per sample (colour)

For European PAL system the bit rate for one second (s) of video is calculated with 8 bits per sample:

720 x 576 x 25 x 8 = 82944000 bps --> 82,944 Mbps

For high definition video, in this case progressive 1080p:

1920 x 1080 x 50 x 8 = 829, 44 Mbps

Without compression the file sizes and the required bandwidth to transmit a full movie would be extremely large so looking at these numbers makes it obvious why compression is needed in video signal transmission. [43]

6.3 Signal Compression

Before any signal can be transmitted, the content and the carrier must be compressed. Compression methods depend on how large is the video bit rate and how much compression is required for the transmission. Standard Definition (SD) video and High Definition (HD) video might need different compression and codec algorithms due to variety in frame sizes and colour depths. The final compression scheme is selected according to where the transmission is aimed at e.g. if signal is distributed for TV reception or for a mobile phone.

Video compression

Chroma subsampling

Compression occurs already in the recording device before any post processing is done. Many cameras utilize the fact that human eye is more sensitive to changes in brightness (Y) than in colour (Cb and Cr). If the colour values are discarded the image is black and white. If the brightness values are discarded, there is nothing to be seen on the image. To compress the video frame, some pixel areas on the frame are utilizing the same chrominance data instead of all having their own. This method of signal compression is referred to as Chrominance subsampling or colour subsampling. There are a few ways how chrominance subsampling is utilized:

4:4:4

In this scenario there is actually no compression applied. Each pixel still has all the luminance and chrominance data. This quality is utilized in some professional cameras in film industry. [44]

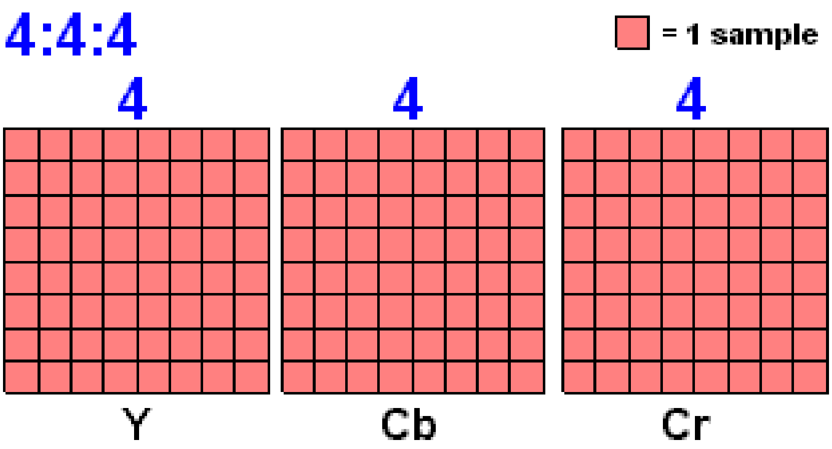

Figure 14. Chrominance subsampling 4:4:4 scenario [44]

4:2:2

In this scenario all the luminance data is preserved but every other pixel shares the same chrominance sample. This is used in many prosumer cameras and codecs such as DVCPro HD from Panasonic.

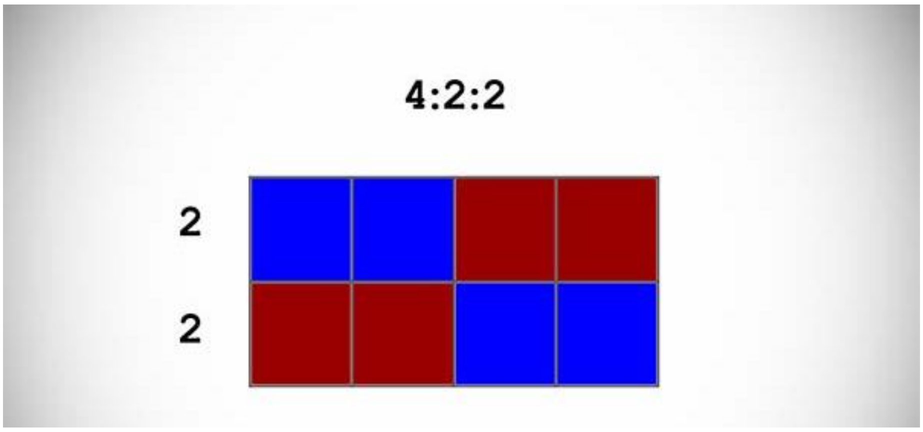

Figure 15. Chrominance subsampling 4:2:2 scenario [45]

4:2:0

This subsampling preserves again the luminance data but some chrominance data is lost. Every other pixel is sharing the same chrominance data as well as forcing the bottom pixels to do so as well. This scenario is utilized in many codecs and compression standards as well as in some Digital-single-lens-reflex (DSLR) cameras. This compression can sometimes be seen with the naked eye especially in the fine edges of an object in a video frame.

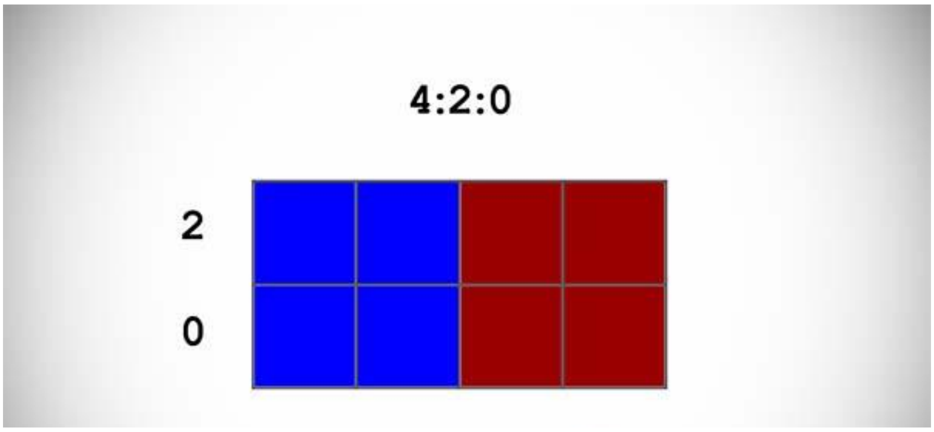

Figure 16. Chrominance subsampling 4:2:0 scenario [45]

Codec

Codecs are needed in compression. They determine how the audio-visual data is compressed for transmission and storage and decompressed for viewing. That is where the name codec is generated – to *code* and then *decode* the video. Codecs are necessary and depending on the algorithm used, the compression can be done effectively with barely any visible quality issues. New algorithms are developed to offer affective compression for Ultra High Definition (UHD) video. [48]

Container

Container holds inside video and audio files and metadata. Audio and video are compressed by using a elected codec and are then wrapped inside a container format. For example Quicktime has its container format .MOV that can contain video file encoded with H.264 and audio encoded with Advanced Audio Codec (AAC) and additional metadata. [48]

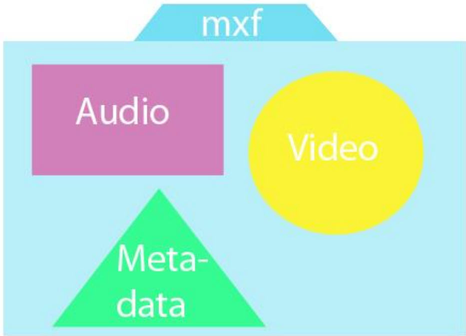

Figure 17. Media Exchange Format container content

MPEG-2

Standardised in the mid 1990’s MPEG-2 is still one of the most used compression standards today. It is one of the corner stones of digital television technology and is still utilized in transmission techniques in Digital Video Broadcasting (DVB). MPEG-2 specifies the utilization of the compression by its profiles and levels. Profiles determine the actual compression algorithm where the various levels can be selected. Levels define in detail the possible compression parameters from bitrate to frame size.

MPEG-2 profiles include:

- Simple profile
- Main Profile
- SNR Profile
- 4:2:2 Profile
- SP Profile
- High Profile

The MPEG-2 video compression is based on analysis and differences between a set of frames. A Group of Pictures (GOP) contains the vital pictures that eventually produce the actual compression [50].
These pictures include:

- Intra frame (I-frame)
- Predicted frame (P-frame)
- Bidirectional frame (B-frame)

I-frames contain all the information that a single frame has in a video file. The I-frame is encoded as it is, and no real compression is applied to it. P-frames are compressed according to previous I-frame or P-frame. B-frames are created by analysing previous frames and following frames. A GOP can have any combination of these frames, but the first frame has to be an I-frame. Illustration 16 describes the how a GOP is constructed. The more there are I-frames in the GOP, the bigger the file size will be. Sometimes fast movements and many changes in the video can cause the GOP to contain many I-frames. [46]

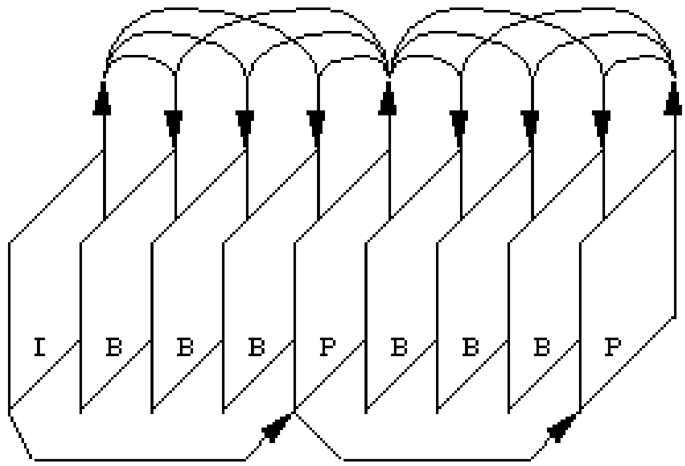

Illustration 18. describes the contents of a GOP [51]

In digital television systems the transmission is carried out by MPEG-2 Elementary Streams (ES) that contain one single program data, video and audio. These elementary streams are transmitted as Packetized Elementary Streams (PES) and added inside an MPEG-2 transcoded Transport Stream (TS). Inside TS can be many PESs containing programmes for an entire channel. TS is responsible for carrying the information to the receiving end. [46]

MPEG-4

Standardized in late 1990's, MPEG-4 was developed to continue the saga of MPEG-2 by providing more flexible and transmission friendlier concept of how to compress, deliver, publish and protect audio-visual content. Different profiles and levels define the purpose and the parameters utilized in the compression. The most common part of MPEG-4 is the H.264 (MPEG-4 part 10), which defines the compression algorithm for *Advanced Video Codec* (AVC) [41].

H.264 has seven profiles:

- Baseline Profile
- Main Profile
- Extended Profile
- High Profile
- High 10 Profile
- High 4:2:2 Profile
- High 4:4:4 Predictive Profile

Each profile contains a set off levels that define the maximum frame size and bitrate for the profile. Baseline profile is used in devices with lower processing power e.g. mobile phones. Main profile is utilized in media storage technologies and High profile in broadcasting and Blu-ray and the other High profiles are for professional applications e.g. cameras etc [41].

Compression is based on temporal redundancies, changes between macro blocks in analysed frames. The basic idea is the same as in MPEG-2, analysis of P and B frames in comparison to Intra frames. All the information does not have to be transmitted again from frame to frame so the P and B frames only contain the macro blocks that have changes in them by utilizing motion compensation. In motion compensation vector data, that indicates the changes between the original frame macro blocks and the P or B frame macro blocks are transmitted. If there are no changes occurring, no data is transmitted. This is why H.264 is very flexible compression algorithm and supports low bitrate encoding without necessarily any visual indication for compression. [41]

High Efficiency Video Encoding

High-resolution video is becoming popular in content production. Ultra High Definition (UHD) formats, such as 4K and 8K have been demonstrated in various trade shows and many camera manufacturers have already taken the next step forward and started the production of UHD capable cameras. For example Blackmagic has already brought out their 4K-production camera and Sony has brought out FDR-AX1 also capable for 4K productions. Prices of these two camera examples vary but transmission to higher resolutions in video leads to larger file sizes and new scenarios for compression must follow this development. For this demand ITU-T Video Coding Experts Group (VCEG) and ISO/IEC Moving Picture Experts Group (MPEG) formed Joint Collaborative Team on Video Coding (JCT-VC) to develop a new standard for video compression. As a result High Efficiency Video Encoding (HEVC) was developed. [51]

6.4 Digital Television - Second generation

Ever since the birth of Digital Video Broadcasting project (DVB) in 1990's it has been standardizing and pushing forward new technologies and development projects that would eventually benefit not only broadcasters but also device manufacturers and consumers. Satellite and cable technologies were leading the way of digitalization and eventually terrestrial systems were also digitized. [52]

Finland was one of first countries that switched to digital television broadcasting. Ever since 2004 when Finnish regulators decided to switch analogue broadcasting to digital within the following three years, the technologies have continued to evolve. Today while second generation of standards have been developed and implemented it has become obvious that consumers want more choice and flexibility for content selection regardless of the reception modes. [53]

Digital Video Broadcasting – Satellite

There are over 1000 satellites orbiting the earth at this moment from which most is for navigation, communication and other for commercial usage [54]. Since the very first satellite broadcast in the 1960's it has become one of the most important ways to communicate between continents and transmit TV channels to viewers anywhere in the world and especially for news gathering. [55]
Some satellites are positioned approximately 36000km from the earth's surface. This position is selected carefully because it is only at that altitude where the earth's gravitational forces won't be pulling the satellite down. At this particular altitude the satellite can orbit the earth at exactly the same speed as the earth is turning; once a day. [46]
First digital satellite transmission were launched in 1994 and now almost 20 years later the newer version of standard has already been published and brought into use in many stations across the world. This action was necessary especially now when there are over 100 Million receivers around the world. [46, 54]

Satellite transmission utilizes Quadrature Phase Shift Keying (QPSK) modulation mode where the digital information is carried by the modulated carrier wave in four phase angles. Each phase can obtain one pair of bits 00, 01, 10 or 11 and is represented by

45°, 135°, 225° or 315° phase angles. Adding more phase angles in the modulation scheme can increase the amount of information. 8PSK has 8 different phase angles for each 3-bit combination and 16PSK can have up to 16 different phase angles per 4-bit combinations. [46]

Satellite EIRP (dBW)	51		53.7	
System	**DVB-S**	**DVB-S2**	**DVB-S**	**DVB-S2**
Modulation & Coding	QPSK 2/3	QPSK 3/4	QPSK 7/8	8PSK 2/3
Symbol Rate (Mbaud)	27.5 (α = 0.35)	30.9 (α = 0.2)	27.5 (α = 0.35)	29.7 (α = 0.25)
C/N (in 27.5MHz) (dB)	5.1	5.1	7.8	7.8
Useful Bitrate (Mbit/s)	**33.8**	**46 (gain = 36%)**	**44.4**	**58.8 (gain = 32%)**
Number of SDTV Programmes	7 MPEG-2 15 AVC	10 MPEG-2 21 AVC	10 MPEG-2 20 AVC	13 MPEG-2 26 AVC
Number of HDTV Programmes	1-2 MPEG-2 3-4 AVC	2 MPEG-2 5 AVC	2 MPEG-2 5 AVC	3 MPEG-2 6 AVC

Table 19. Illustrates the differences between the old standard and the new S2 standard. [52]

Digital Video Broadcasting – Cable

Digital Video Broadcasting for Cable distribution (DVB-C) was published in 1994. Almost 20 years later utilization of its newer version DVB-C2 has been successfully pushed forward. In Finland distribution of Cable television is the responsibility of operators. Table 3. Illustrates the amount of cable and IPTV reception households in Finland between the years 2011 to 2013. This statistics is collected by Finnish Communication Regulatory Authority [46, 56]

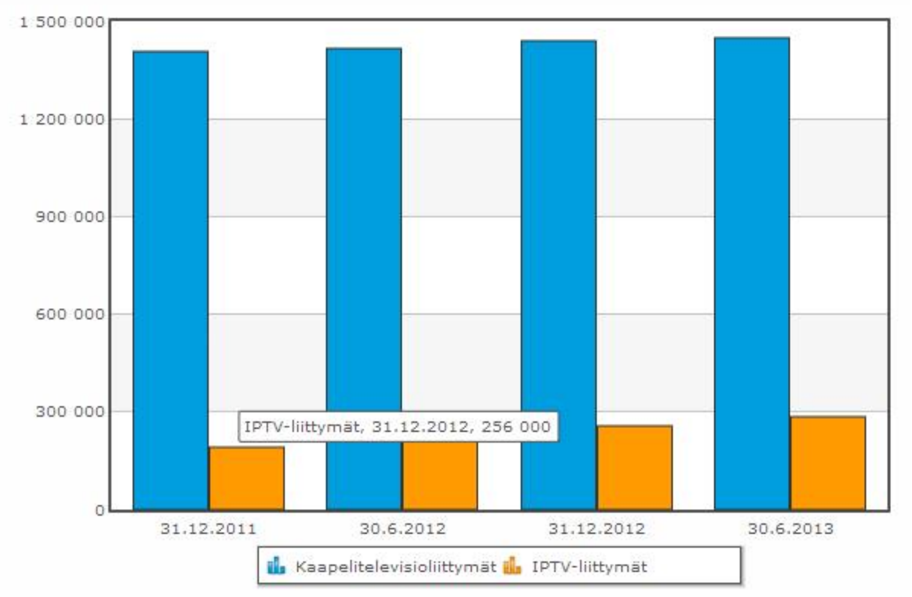

Table 20. Increased amount of cable and IPTV reception households in Finland illustrated in this graph. [56]

Cable transmission utilizes Quadrature Amplitude Modulation (QAM) scheme. In QAM the transmitted signal is modulated in the amplitude of the carrier wave. This modulation scheme can be utilized both in analogue and in digital modulation. The signals are 90° out of phase to each other and are called the sine wave and the cosine wave. These two signals are mixed together for transmission and then separated again in the receiving end for data separation. There are several QAM schemes utilized in digital television communication systems: 16QAM, 32QAM, 64QAM, 128QAM and 256QAM. These numbers refer to the number of signal possibilities. [46, 60]

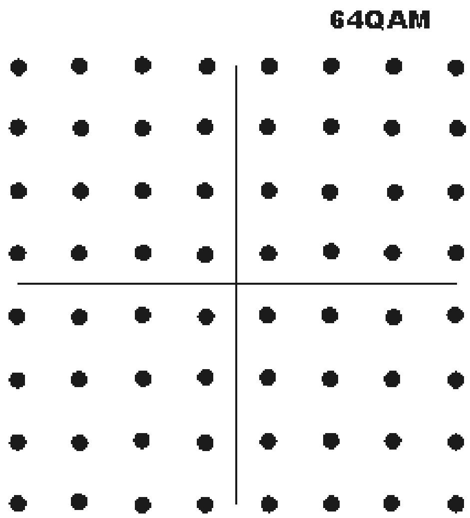

Figure 21. The 64QAM scheme [60]

DVB-C2, the second generation standard, offers more modulation schemes for higher bitrates and enables the utilization of multiple Transport Streams (TS). [60]

Both in DVB-S and in DVB-C the data rate is announced as Symbols per second (SR). The symbol rate can be calculated by

$$SR = \frac{\mathrm{DR}}{bps\ x\ FEC} \times \frac{\mathrm{nbytes\ per\ packet}}{ndatabytes}$$

How many bits per symbol is defined by the modulations scheme in power of 2 so e.g. 64QAM is 2^6=64 so the number bits per symbol is 6.

Reed-Solomon error correction is utilized as Forward Error Correction (FEC) scheme. [62]

Digital Video Broadcasting – Terrestrial

Terrestrial Digital Television reaches 99.99% of all Finnish households. Coverage is almost whole Finland like the Figure 6 Illustrates.

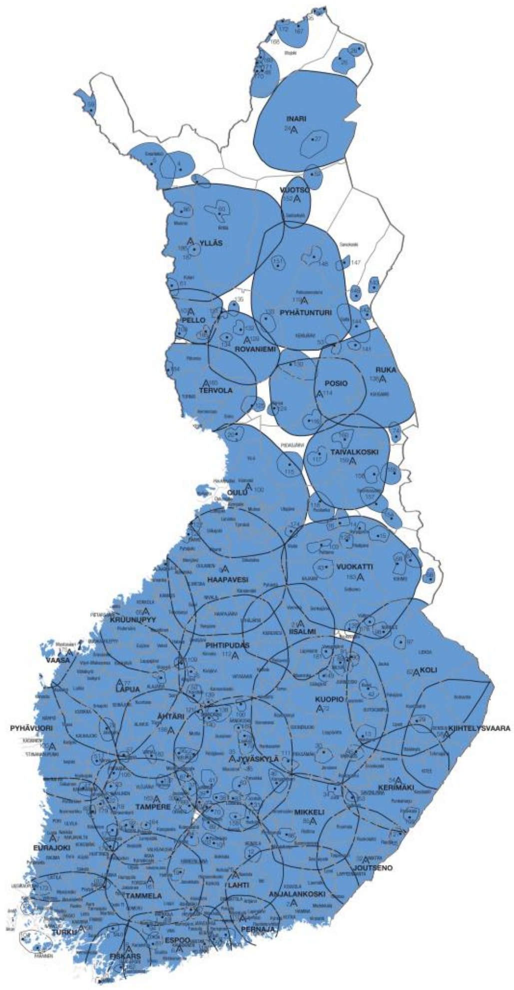

Figure 22. DVB-T coverage in Finland. [63]

Second standard (T2) was first published in 2009 and it had to fulfill some specifications set by the previous standard. First of all the utilization of the existing reception antennas and transmission links should be enabled in the new standard as well as the modulation schemes of OFDM (Orthogonal frequency division multiplexing).

Transmitting Digital Television in the existing infrastructure is still utilizing MPEG2 transmission technologies as specified in the DVB standard. Each elementary stream containing either video or audio stream is first packetized and then multiplexed into a transport stream (TS) carrier wave. A multiplex can contain several packetized elementary streams (PES) so the receiver must be able to re-compose a program from these elements (video, audio and data) so some additional information is needed. Therefore each transport multiplex (MUX) has to have Program Specific Information (PSI) added to it containing metadata in a set of tables. [46]

6.5 Transmission over Internet

Transmitting data over a network requires that all the receivers are uniquely identified. Each network-attached computer has its own Internet Protocol (IP) address that allows it to communicate with other computers in the network. When data is transmitted over an IP network it is divided into a sequence of packets. Figure 1.0 illustrates how an IP packet is formatted. Packets must be encapsulated before transmission by the transmitting device. During the encapsulation additional data is added to ensure that the transmission can be done and certain predefined protocols are being followed.

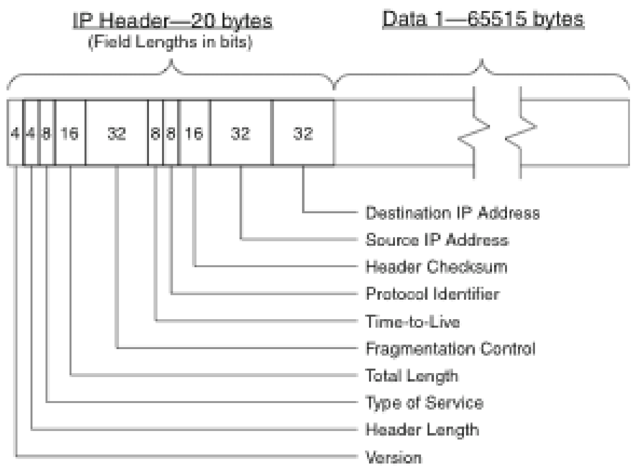

Figure 23. Format of an IP packet [64]

Internet video

Today video compression techniques, formats and quality issues are interesting to professionals only while regular users keep sharing, publishing and distributing video content online. Online video portals like YouTube enable fast ways to both access videos online as well as publishing them. Ever since fast broadband connections became available for user's online video content became a possibility too. Containing mainly video clips, today online video services such as YouTube receive 100 hours of video content every minute and over 4 billion hours of video content is watched every month by users online. [65] This is just the tip of the Iceberg because according to Cisco Visual networking Index: Forecast and Methodology 2012 – 2017 the amount of video content will increase so that video traffic is to become the biggest data traffic consumer and increase to 69% of all IP traffic. This is because the video content is becoming the most consumed online media content in 2017. There will be so much audio-visual media online that every second one million minutes of video will be uploaded, downloaded, streamed, started and watched in 2017. [66]

Internet Television

In addition to traditional television channels many broadcasters offer Internet television (Internet TV) on the side. Internet TV offers TV shows and movies as Video-On-Demand (VOD) services via their online portals. Sometimes the TV show is added as archive but sometimes the show might be available online only a limited amount of time. In Finland the most popular Internet TV is YLE Areena that offers both TV and Radio shows live online and as VOD's after they have been broadcasted on their traditional channels. [67]

Webcasting

Distributing live events or on-demand content online is sometimes referred to as webcasting. If webcast is done simultaneously while content is distributed over broadcasting networks it is referred to as simulcasting. Opera performances are distributed by webcasts online to websites or to other audiences in other parts of the world e.g. Metropolitan Opera live streams that can be viewed online [68]. Sometimes some content is only available via webcasting e.g. some online TV shows and TV series spinoffs [69].

Internet Protocol Television

Traditional television distribution via broadband network is referred to as Internet Protocol television (IPTV). IPTV reception requires specialized devices, usually an STB to be connected to the network and then to the TV. IPTV service is usually also based on subscription and while offering the traditional way of TV watching there's also additional technologies available such as Video-on-demand (VOD) and start-over-TV. Each TV channel is distributed via the network as multicast streams and each VOD when requested by the user is distributed as unicast. So the basic IPTV platform behaviour resembles traditional radio frequency broadcasts but with advantages by the transmission that is handled by a set of IP architectures instead of carrier frequencies travelling on air. This delivery method requires that the receiving end has bandwidth enough for the reception usually this means that Digital Subscriber Line (DSL) or fibre technologies must be used. [20, 64]

IPTV-architecture

The system architecture can be constructed in many ways and there are a few approaches to the technology. Some IPTV service providers have built their system by delivering all the free and pay channels over IP as well as the services they are offering to their customers. The heart of the system is then the Headend that is responsible of capturing, processing and delivering the TV channel information further. The signal coming to the headend can be both digital and analogue. In case of analogue signal dedicated equipment is needed for processing the signal before it can be delivered further in the system. Regardless of whether the signal captured buy the headend is analogue or digital some processing is anyway needed. The signals must be transcoded to match the IPTV system delivery specification. Figure 24 illustrates the location of a headend in IPTV infrastructure. There are currently two different video transcoding technologies utilized in IPTV systems: MPEG-2 and H.264 (MPEG-4 Advanced Video Codec). The transcoding profile must match the decoding profile utilized in the receiving end by the IPTV STB. Some service providers have chosen another approach by delivering only pay-tv channels and VOD services over IP and utilizing existing antenna or cable transmission for regular free channels. Therefore the STBs handling these types of services must have parallel technologies running inside from IPTV to a DVB tuner. [20, 70, 71, 72]

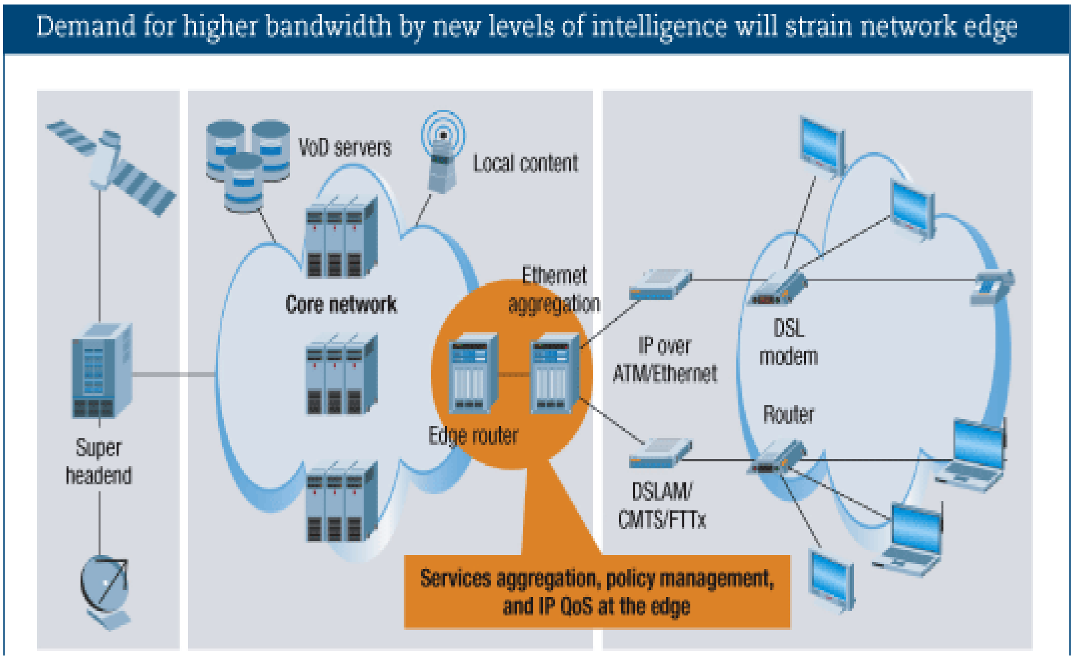

Figure 24. IPTV Headend system [70]

Digital Rights Management (DRM)

The content that is available via a subscription or purchase need to be encrypted. The encryption data is added to the content and without the adequate decryption it cannot be viewed. For real-time broadcasts, e.g. pay-tv channels, the encryption data is added before it is delivered from the headend system. The decryption of the signal is handled by the receiver after the licensing has been checked from the DRM Server. The same procedure is carried out in case of a VOD. [20]

Streaming Technologies and protocols

Video and audio can be delivered over IP in various different methods. Files can be added to a device or a server for download or progressive download or videos can be viewed live whilst they are being transmitted. This live playback is referred to as streaming.

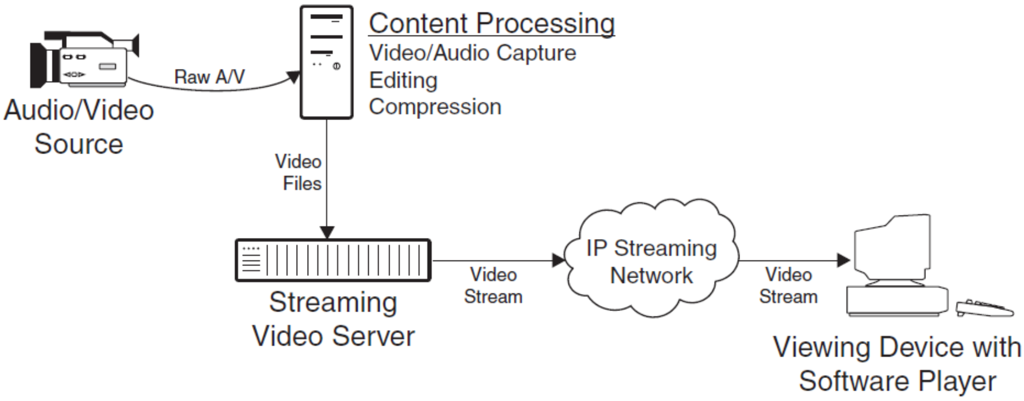

Figure 25. A typical streaming technology [64]

Streaming technology utilizes the same basic concept of delivering video and audio data over a network by first dividing it into a sequence of packets. The data rate of the transmission must match the data rate on the video. At the receiving end all the packets that arrive are played back by software. [64]

User Datagram Protocol (UDP) simply explained enables fast data transmission between applications on a network. Due to its flexibility UDP can start transmitting data without the need to establish a connection between the sending and receiving devices. This can cause some errors hence there's no mechanism defined in the protocol for error handling or data retransmission. UDP is used in video and audio transmission over a network. [64]

Transmission Control Protocol (TCP) unlike UDP, TCP protocol's main focus is on creating a connection between applications. This means that before any data can be transmitted a connection between the sender and the receiver must be established. TCP has error correction mechanisms where each packet is identified and if the receiver doesn't get all the data packets assigned for transmission these packets must be resend again from the transmitting end. Only disadvantage is that when transmitting video and audio all the packets must arrive on time and therefore resending missing or corrupt data again is not necessarily the best solution especially when transmitting video and audio. [64]

Real-time Transmission Protocol (RTP) was originally developed for videoconferencing but is commonly used for transmitting multimedia content over a network. Since RTP is built upon the UDP protocol it is mainly concentrating on delivering the packets on time to the receiving end instead of putting effort on error prevention or correction. Therefore RTP protocol is commonly used in Voice-over-IP (VOIP) as well as other real-time audio and video applications over a network. [20]

Real-time Streaming Protocol (RTSP) performs as a controller for real-time data delivered by other protocols over a network such as UDP and TCP. RTSP doesn't interfere to the delivery protocol but offers controls for video and audio data that is being streamed over a network. In a way it performs as a remote control enabling the user to skip certain parts of the content, stop playback and start from the beginning if necessary. This is possible due to time stamping that is added on the packetized content. [20]

Real Time Messaging Protocol (RTMP)

Developed for data streaming between Flash Media Server and client software e.g. Flash Player, this protocol is capable of both on-demand streaming as well as live streaming. The stream is divided into a sequence of segments that are transmitted to the client. One established RTMP connection would remain in a connected state, until the session is being terminated. Although the trafficking between the server and the clients can be reliable and stable there are other drawbacks to RTMP:

- no HTML5 support, the stream can’t be embedded via the HTML5 <video> element
- Port 1935, RTMP streams utilize this port and sometimes data access can be restrained by a firewall
- It is a *True streaming protocol, which* means that the video bitrate has to be smaller than the available bandwidth all the time while streaming. If bandwidth suddenly drops the video will stop playing instantly [73]

Besides streaming technologies many service providers decide to utilize other means of video delivery. Most commonly known services like YouTube and Vimeo both are utilizing a method of progressive downloading which in simplified words means delivering video content as small chunks of data that the client playback device downloads.

When each chunk is downloaded it can be played back. This continues until the entire file is downloaded to the disk or browser's cache memory. Usually the client can start viewing the content while it is still being downloaded progressively as the name progressive downloading states. With slow bandwidth connections progressive downloading can be tedious process where the first seconds are played back and then stopped to wait for more to be downloaded. [74]

Adaptive Streaming

Fast broadband connections have made it possible to watch high quality videos online, high quality meaning video quality varying from Standard Definition to High Definition. Services such as Netflix and Viaplay are offering new ways of media consumption. Because the only issue between these type of service providers and satisfied consumers is the various types of broadband connections available to consumers today. There are still some users out there that manage with a connection lesser than 2 Mbps where service like Viaplay requires minimum speed of 3 Mbps in order for the service to function. Lighter mobile version can work with 1, 5 Mbps speed on various mobile devices. [75]

Because of these various connections speeds and yet the amount of potential paying customers, technologies that can adapt to these varying conditions has been developed. This technology is referred to as *adaptive streaming* where the quality of the video stream adapts according to available bandwidth and the playback devices currently available central processing unit (CPU) power. In this technology the basic idea of progressive downloading is utilized. [80]
Most common adaptive streaming method is Hypertext Transfer Protocol (HTTP) Live Streaming from Apple, Dynamic Streaming from Adobe, Microsoft Smooth Streaming and still being in standardization process the MPEG Dynamic and Adaptive Streaming over HTTP (MPEG- DASH) [76, 77, 78, 79].

HTTP Live Streaming

Unlike in the broadcasting world, where the same content is delivered to many recipients at once, live streaming is accessed by browsing to a special website via a desktop computer or other device e.g. tablet or smart phone. Opening the on-going stream or in other words joining the live session usually requires presence of a dedicated server architecture that controls the content distribution to clients. In HTTP live streaming (HLS) introduced by Apple, dedicated servers can be any type of webservers or servers that are dedicated for video distribution e.g. Adobe Flash Streaming Server. The bit rate is adjusted accordingly to adapt in case of sudden change in bandwidth. [76]

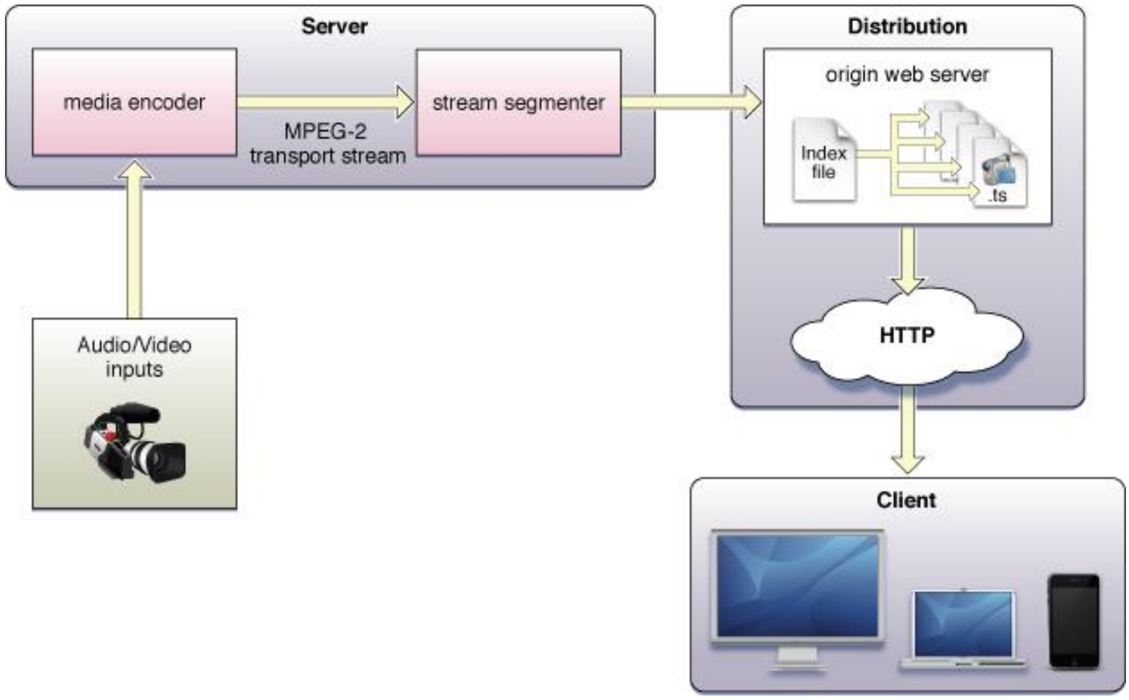

Figure 26. Basic architecture of an HTTP stream [76]

Basic architecture of an HTTP stream is illustrated in figure 7. The different components of an HTTP stream are the server components handling the content preparations e.g. the encoding and multiplexing as well as content segmentation, which means that the content is divided into a sequence of smaller chunks of data. Before segmentation the video and audio file is encapsulated into an MPEG-2 Transport Stream (TS). The segmentation is handled by specific software that divides the MPEG-2 TS to a small segments and an index file where all the segments are listed. The index file helps the reassembling of all the small segments at the client end. The distribution component handles the requests for the content coming from the client side, in other words when a user wants to join a live session a clicks to open a website, a request is sent to the web server responsible of the distribution and then delivers the requested content to the client side. Because of the nature of HTTP stream consisting of small chunks the client side must reassemble the all the small data segments so that the content can be viewed via a software player as one seamless flow of data. [76]

Smooth Streaming

Aimed for 2008 Olympic VOD delivery Microsoft has developed its own way of delivering adaptive streaming. The technology known as *Smooth streaming* is familiar from adaptive streaming where the quality of content is selected according to bandwidth and playback conditions. Content being divided to segments of 2s of video and then distributed to the client side that then assembles the 2s segments to become seamlessly playing video and audio. If a problem occurs e.g. one segment is not distributed or played back the next segment will be distributed with a lower bit rate. This means that the content is encoded with several different bit rate settings and then in case of changes in distribution conditions the quality is changed on the fly if necessary. [77]

MPEG Dynamic and Adaptive Streaming over HTTP

Standardization of MPEG Dynamic and Adaptive Streaming over HTTP (MPEG-DASH) is still in progress but the technology field is expecting it to be the answer to the big question of how to deliver video content to users who are utilizing different technologies on various platforms and with variety of broadband connections.

The idea is to combine the different existing adaptive streaming technologies as one uniform standard. Because of variety in reception platforms, devices and connection speeds, many service providers has encountered issues where the same content must be encoded and delivered in many formats so that Quality of Experience (QoE) is answered for all the current users. This is usually very expensive and requires support for selected formats as well as storage space and capacity from the backend systems that store and distribute the content. [78]

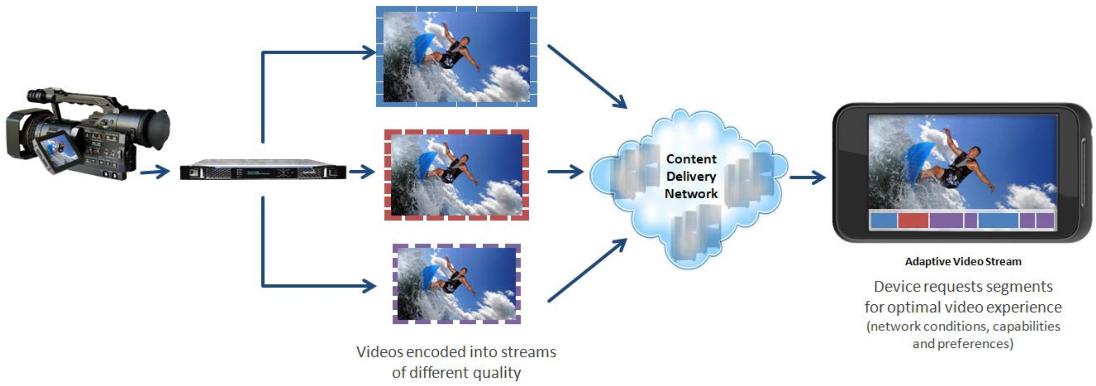

Figure 27. Illustrates the architecture of MPEG-DASH streaming HTTP Dynamic Streaming [78]

Adobe has developed its own way for offering adaptive streaming for Flash Streaming Server users. Adobe Flash Player 10.1 has support for HTTP Dynamic streaming that utilizes the same data fragmentation idea as the other HTTP based adaptive streaming technologies.

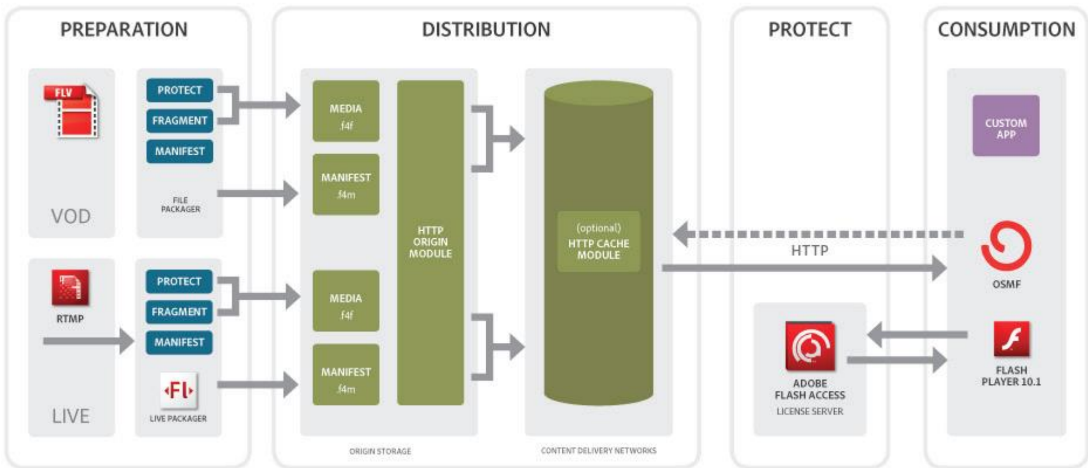

Figure 28. The architecture of HTTP Dynamic Streaming [79]

Live streaming via Flash Media Server to iOS devices require that the streams are first published to the Live Packager service that divides the streams to fragments and delivers them to Flash and iOS clients utilizing the HTTP protocol. Dynamic HTTP streaming utilizes technologies that are known methods of delivering video content over IP: progressive downloading and streaming. [79]

Unicasting and multicasting

Multicasting means delivery of data packets to multiple receivers at the same time. The needed bandwidth for transmission is kept optimal and therefore the network is not overloaded. This is accomplished by the routers and specialized protocols. When packets are being distributed over a network their specialized multicast IP addresses differentiate them from other IP packets and tell the routers to send them forward to their destinations. Multicasting utilizes a special set of addresses that identify the whole multicasting group usually between 239.0.0.0 to 239.255.255.255. [81]

Internet Group Management Protocol

Internet Group Management Protocol (IGMP) manages IPTV multicasting traffic in a network. When a user opens a multicast stream, a message is sent to the router that this client wants to join a multicasting group. Traffic is managed by delivering the stream to a provided multicasting address. At the same time the data packets are multiplied by the hosts to ensure that all the clients that have requested to join a group get their packets delivered. [82, 83]

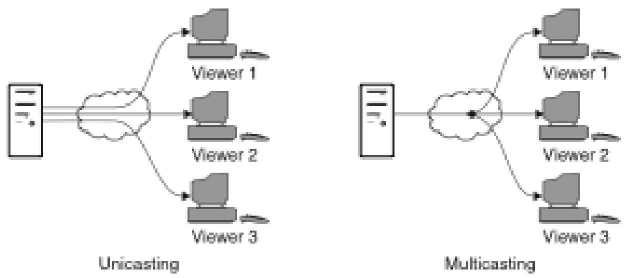

Figure 29. Unicasting and multicasting [64]

In unicasting each packet is sent from the source to the receiving end which means that every time the packets are requested by users the source must create a new set of packets for each user. This can cause a network overload especially if the requested packets contain a video stream.

Reception methods of Electronic Media

Finland was among the first European countries to switch to digital transmission. Analogue broadcasting transmission was shut down in September 2007. Analogue and digital transmission had been available parallel since 2000 to ensure the consumers enough time to adjust to this change. This meant that consumers had to buy new TV's or additional devices, mainly set-top-boxes to receive digital broadcasts thus most televisions were at that time still utilizing analogue technology. Finland was at that time still broadcasting in standard definition (SD) although first test transmissions for high definition (HD) broadcasts were already planned due to release of transmission bandwidth. Even after the total switch off in 2007 new technologies are being developed to eventually replace the old DVB with some major enhancements. [53]

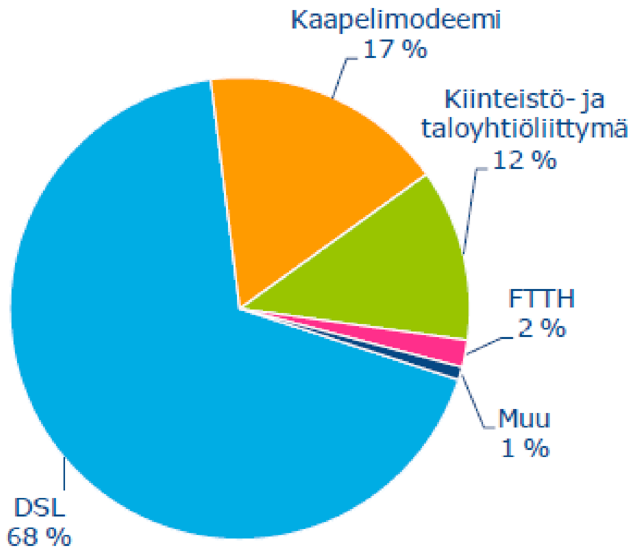

Figure 30. Broadband reception technology divisions in Finland [84]

According to Finnish Communications Regulatory Authority's market research most broadband reception technologies rely on DSL that enable fast Internet connections via copper or fibre network. Figure 11 shows how the different technologies are divided in Finland.

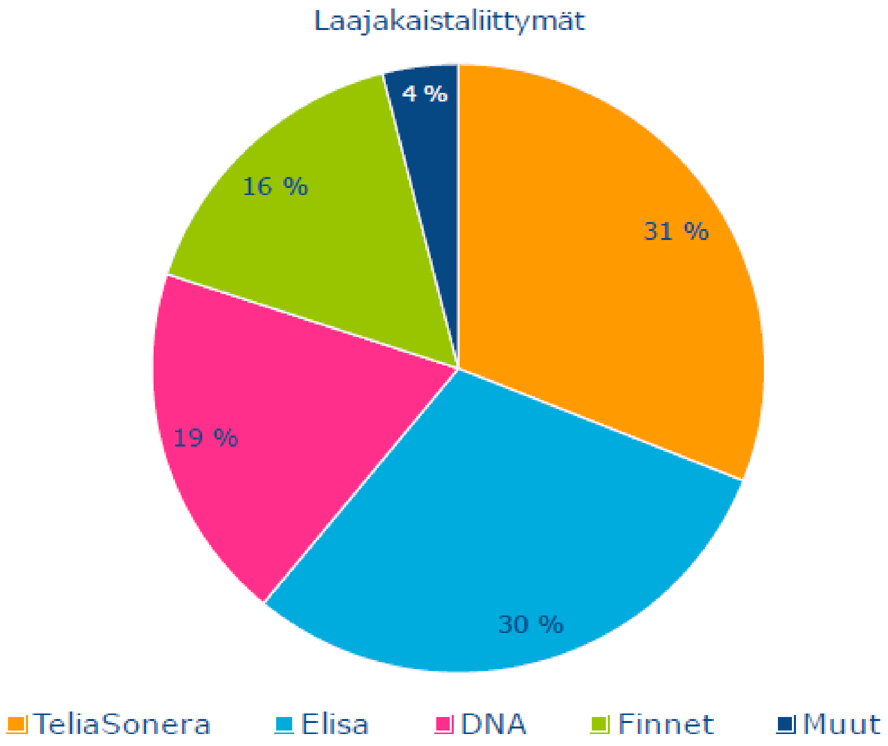

Figure 31. Broadband consumer shares in Finland [84]

Thanks to expanding fibre network as well as consumer awareness and available new technologies – broadband reception speeds have been increasing. Today one third of all the households that have a broadband connection have average data rate varying between 10 Mbps to 25 Mbps. This means that these broadband connections are fast enough for IPTV reception. So far only about 10 % of all the broadband connected households can have data rates up to 100 Mbps, which the result of everyday expanding fibre networks. This number of households has been increasing with every year. Figure 32 shows the situation between all the available bandwidths in Finland. [85]

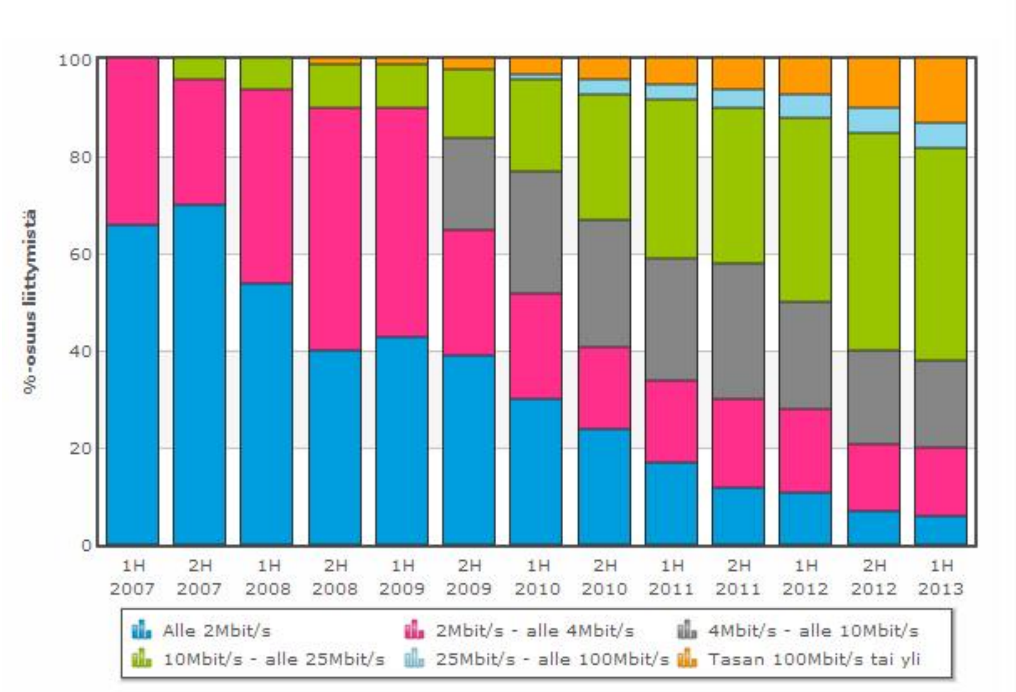

Table 32. Broadband reception speeds comparison between 2007 to June 2013 [85]

Today most bought televisions are already HD capable although actual HD broadcasts are only offered in parallel with the main channels. At the moment the actual HD channels are offered only by the pay TV channels e.g. C More.

The scenery of IP based video content delivery is going through a confusing phase. There are over a hundred different platforms available for end users to make the choice on which technology is most suited for their needs. Some value the variety of available programs, some the timing and recording options or if the platform is giving suggestions based on the viewer's last selections. Then there are catch-up TV, social TV, second screen etc. The main idea of these technologies is to enable a straightforward connection to the Internet. This online connection is referred to as Connected TV which can be more confusing hence there are a variety of other devices enabling Internet connection such as game consoles and Blu-ray players [86]:

Worldwide Installed Base: Connected Television
Units, Millions

	2012	2016	CAGR
Smart TV (1)	83.2	406.9	37.4%
Internet-enabled Standalone Blu-ray players (2)	18.9	82.2	34.1%
Consumer Connected STBs (3)	12.7	24.9	14.4%
Internet-enabled Games Consoles (4)	85.8	141.8	10.6%
Internet-enabled Pay-TV STBs (Hybrid STBs) (5)	26.2	126.2	37.0%
TOTAL	**226.8**	**782.0**	28.1%

Table 34. Premonitions on sales on connected devices [86]

World is preparing for IP takeover and Finland is slowly following these technology trends. Within the first half of 2012, 117000 sets of Light-Emitting Diode (LED) televisions, 67000 liquid-crystal displays (LCD) and 70000 set-top-boxes were sold in Finland. Sales of LED TVs are increased by 75% compared to the year before while the number of LCD's sold decreased by 46%. Prices of LED and LCD TV sets have been decreasing attracting consumers to buy more modern entertainment electronics. [86]

Most smart TV's allow the use of services such as Netflix via their user interface (UI) and users can themselves determine which applications they are interested in by adding them to their smart TV UI. There are also Blu-ray players that contain applications such as Netflix as well as other type of STB's included with browsers and live streaming capabilities.

6.6 Hybrid Broadband Television

Television isn't just a pre-scheduled passive piece of furniture anymore. Many expectations and predictions are focused on the development of television hence the technologies becoming more inexpensive and platforms enable new services to raise from simple ideas. One of these simple ideas is inherited from the beginning of 2000 when interactivity was considered important and worth investigating. Many try-outs were given but slowly it became clear that Multimedia Home Platform (MHP) wasn't the technology that would eventually conquer the world. World had to wait for another decade before Hybrid broadband television (HbbTV) came on the market. Main idea in HbbTV technology is to bring together various forms of digital television reception and the benefits of a broadband connection. Just recently receiving specification HbbTV consortiums main idea is "to create a standard for hybrid entertainment services" globally. [87]

Digita being the first in Finland to offer HbbTV content delivery to terrestrial clients by utilizing an application that can add content from the Internet to be added to any TV-channel and that can later on be modified to add content to a specific TV-program. This of course means that the TV must have the HbbTV option as built-in as well as an Internet connection. First channels to offer content to HbbTV's are MTV3 and YLE. [88]

6.7 Walled gardens

Some technology providers prefer to keep their customers closer. Walled gardens are used to create an environment where the users can have access to products and services via the technology provider's fairway. Apple is one good example where all the applications, content and services can be accessed only by their own software. Usually Walled gardens demand for an account and after signup the user can get the applications they want and start utilizing services they want. Amazon is also utilizing this kind of approach with the Kindle. [89, 90]

6.8 Over-the-top

Fast Internet is a requirement for the end user's IPTV reception. Minimum bandwidth is 8Mbps that usually is enough for video and audio stream to be delivered via TCPIP network utilizing various transmission protocols, from peer-to-peer to multicasting. Over-the-top (OTT) services offer access to video content without defining the means of delivery. Many different companies with a variety of approaches provide Hibox-like user interface for content access. [91]

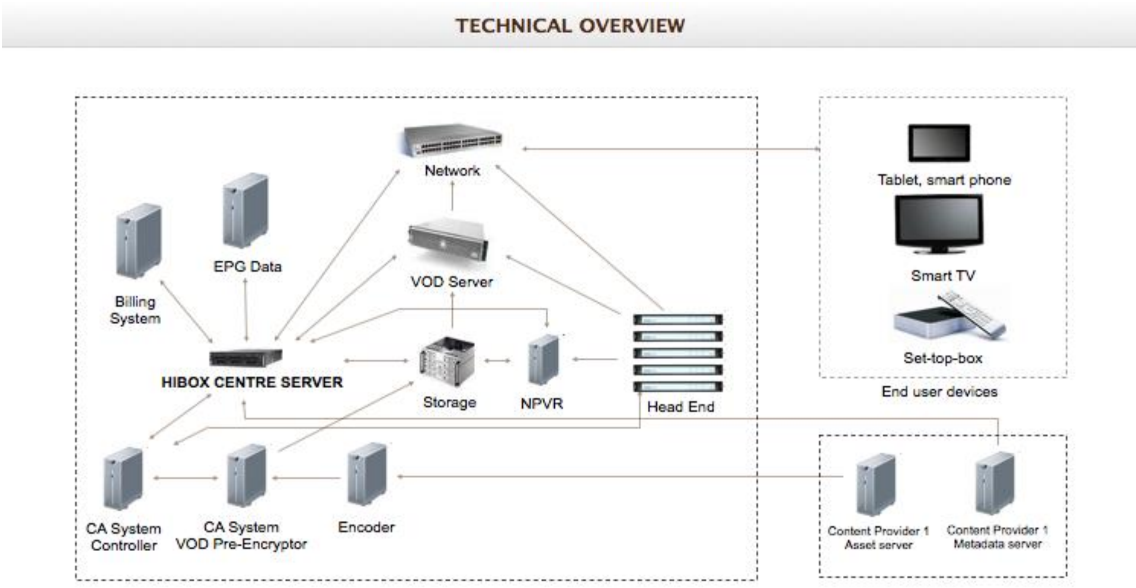

Figure 35. illustrates Hibox solution in OTT [91]

OTT services require a broadband connection that the user can buy from any service provider available in the area. The content is offered via a user interface (UI) that can contain basic services and applications in addition to the OTT services e.g. channel access and Video-on-demand (VOD) services.

6.9 Media Laboratory as state-of-the-art

It is necessary to follow the current trends of electronic publishing also in the university laboratory. Radio frequency modulation is already implemented so the next step was to build IPTV delivery network in a smaller scale and test the transcoding, multicasting and reception technologies. These steps were taken one at a time to slowly build up the cross media publishing environment. Image 36 illustrates how the different technologies are implemented in the laboratory premises and studio facilities. So far the supported technologies are:

- DVB-C modulation (64QAM)
- IPTV multicast inside the University LAN
- HTTP Streaming
- Flash Dynamic Streaming
- Recording the video feed and delivering it by VOD

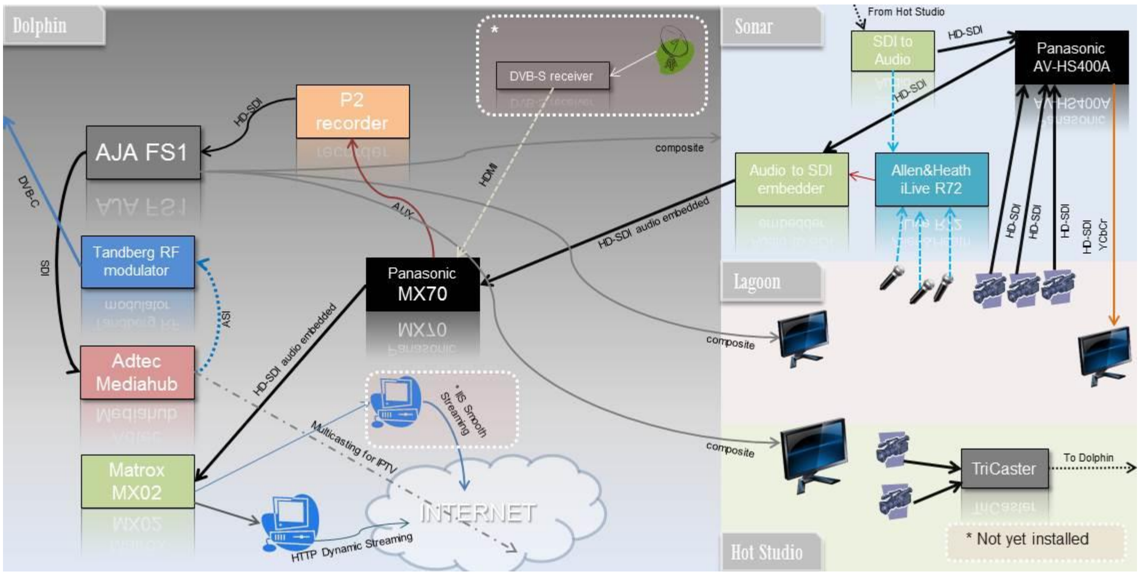

Image 36. Electronic publishing in media laboratory

Mostly the setting the transcoding and delivery parameters and settings are done manually since there isn’t any automated system that would take care of that like in the industry examples.

Radio Frequency Modulation

Frequency bandwidth is regulated and monitored by officials and the signal transmission on radio frequencies requires a license. Therefore it was most convenient to build a campus-wide cable network where all the content can be modulated according to DVB-C standard by utilizing a dedicated Quadrature Amplitude Modulation for signal distribution and to create our own campus-area channel on available frequency. Since all the commercial channels distributed in the campus-wide antenna network are distributed according to DVB-T standard the only one thing to do was to check that the frequency for our DVB-C distribution wasn’t reserved by any commercial broadcaster. Therefore the frequency was selected to 458 MHz.

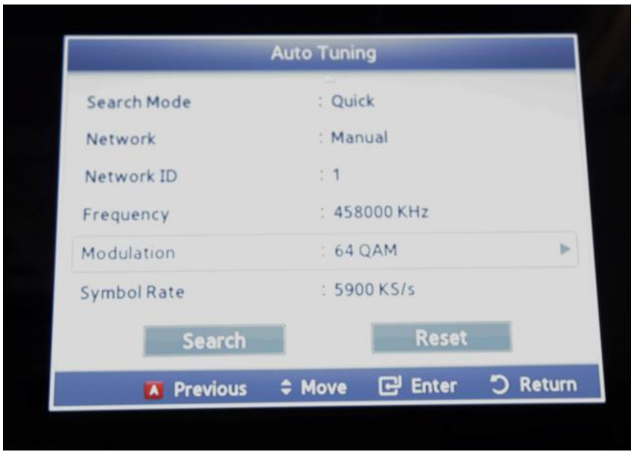

Figure 37. Metropolia DVB-C channel statistics

IPTV in laboratory

Delivering signal across campuses has been a challenge and still is. Radio frequency modulation is out of the question due to infrastructure therefore the only way to deliver signal across is to deliver it via IP network. Next big issue was the variety of reception devices with closed middleware but for testing the IPTV reception a developer solution was needed. The signal needed to be transcoded before it was delivered via IP-network. Transcoding is handled by Adtec Mediahub that is generating H.264 video to a provided multicasting address inside University LAN. Reception of the multicast can be accomplished by a software player e.g. VLC media player or an IPTV Set-Top-box. To simulate consumer IPTV reception an STB was purchased. Amino STB for developers offered a solution of IPTV reception with configurable channel list and other functions. Since this STB model is built for developers, it enables an OTT middleware to be added on it. At this point this technology is not yet covered and the research is still continued. In the future a OTT model will be constructed with a branded UI and services.

Streaming in laboratory

Setting up a stream is done manually. In case of a live stream the signal is directed from the central source to the capture card that is connected to the streaming software. In the software server address and transcoding parameters are added. Since the University already has a Flash Streaming Server running, most of the streams are directed through it. Decoding and viewing require a plugin. This has become an issue since there are a number of devices that don't support Flash e.g. Apple devices that don't have support for Flash. Therefore another approach was needed. The stream is re-packetized to HTTP stream that utilizes Web technologies and is applicable to iOS devices too. This is accomplished by a live packager application that in installed on the server side. It chops the stream into segments and rewrites them into f4f files. If the stream is created with a few different bitrate profiles for adaptive streaming purposes, a manifest file must be created to the live event folder in the server. The manifest file is written in an Extensible Markup Language (XML):

```
<manifest xmlns="http://ns.adobe.com/f4m/1.0">
   <dvrInfo beginOffset="30" endOffset="60"></dvrInfo>
   <media streamId="test1" bitrate="1000">
   </media>
   <media streamId="test2" bitrate="2000">
   </media>
   <media streamId="test3" bitrate="3000">
   </media>
</manifest>
```

Example of Maifest.xml [95]

The different stream bitrate profiles are named "streamId" with an Id name "test1" and then the assigned a defined bitrate.

Laboratory as a learning environment

The role of the laboratory is not only to implement and test the latest and upcoming technology trends, but to also perform as an inspiring learning environment for students. The Finnish Ministry of education and Culture defines the role of Universities of applied sciences and their responsibilities to educate professionals for the every-day evolving labor market. This statement is binding and sets the goals on how the media laboratory should be seen and how it should be developed further. [94]

As educational environment the laboratory should contain technologies that simulate the industry. This way the student can have an access to the technologies utilized in their future working environment and that truly supports their path to media technology professionals with the current information and knowledge valued by the industry. This is one of the reasons why keys-to-and services are not necessary the best solution hence the technology should be somehow shown and the students should get a comprehensive understanding on how the underlying systems are constructed and maintained.

Pedagogically the laboratory environment is utilizing the idea of learning by doing by problem-based learning and activating instruction. In case of laboratory as a learning environment it is necessary to allow the students to try different technologies and devices by giving them tasks. This applies also to networked editing environment as well as the different electronic media publishing technologies that are placed in the laboratory premises. Since students are young adults it is necessary to think about the role of the teacher. Instead of performing as an authority, teacher can become an enabler by giving assignments and challenges and helping the students if necessary incase the obstacles become too hard to overcome. Since the environment supports learning by doing, it is important that students can achieve learning experiences by doing, by trial and error and by experimentation. [95, 96]

7 Summary and discussion

After visiting national and international industry equivalents as well as other universities it is proven that the media laboratory still needs some improvements in the production systems but is supporting the electronic media publishing technologies available in industrial level today. Staying on top requires still some technologies that need to be implemented and that need to become part of laboratory electronic media publishing and testing environment. The laboratory is in small scale on-top of what is going on at this point in cross-media publishing trends, where “create once - publish many times” type of thinking is followed by the industry. This task is very demanding since the technologies are changing and developing and some are disappearing. The collaborative editing environment is still in development since it is not yet proven which technology is fundamentally best solution for educational multiuser environment such as media laboratory. Electronic media publishing is following the industry in centralized signal processing and delivery technologies. This includes radio frequency modulation for cable network, various streaming technologies and online publishing schemes as well as IPTV delivery and reception. Everything can be generated from one centralized source. Some technologies still remain are not yet implemented. Based on feasibility study and research a small-scale development plan was drawn

Media laboratory development plan:

Technology	Industry penetration	Utilization in media laboratory	Implementation status	Estimated time of arrival
DVB-C2	Yes	Simulate industry by modulating a radio frequency channel	Second generation standard not yet implemented in modulation	2014 -2016
DVB-S	Yes	Reception technology	Not yet implemented	2014
DVB-T2	Yes	Reception technology	Implemented by receivers	2013
IIS Smooth	Yes	Video transmis-	Implementation	2014

Streaming		sion technology, compression and streaming	started with setup of a server	
MPEG-DASH	No	Not yet	Supporting technologies are mapped	2014 - 2016
IPTV	Yes	Implemented	Done	2012
HTTP Dynamic Streaming	Yes	Implemented	Done	2012
OTT	Yes	Not yet implemented	Receiver technology and middleware are being researched	2014
Net-edit and collaborative workflow support	Yes	Partially. Storage system exists but the collaboration and file sharing system is being specified.	Research is still ongoing.	2014
HbbTV	Yes	Reception is implemented	This technology will not be supported in the laboratory due to the technology architecture and complexity of technology	2013
HTML-5 streaming	Yes	Research is ongoing	Implementation is in process	2014

Some important aspects of the process of this research arose that were concerning the technology implementation phase:

- support from information administration inside the organisation is crucial
- system administration responsibility (users, system, data etc.)

- Is the system integrator also the system consolidator and understand the role of the system inside the customer organisation's infrastructure

Figure 38 Shows how the integrator-centralized service provider model, where the integrator is also a consolidator between the customer and the other instances are needed for project accomplishment.

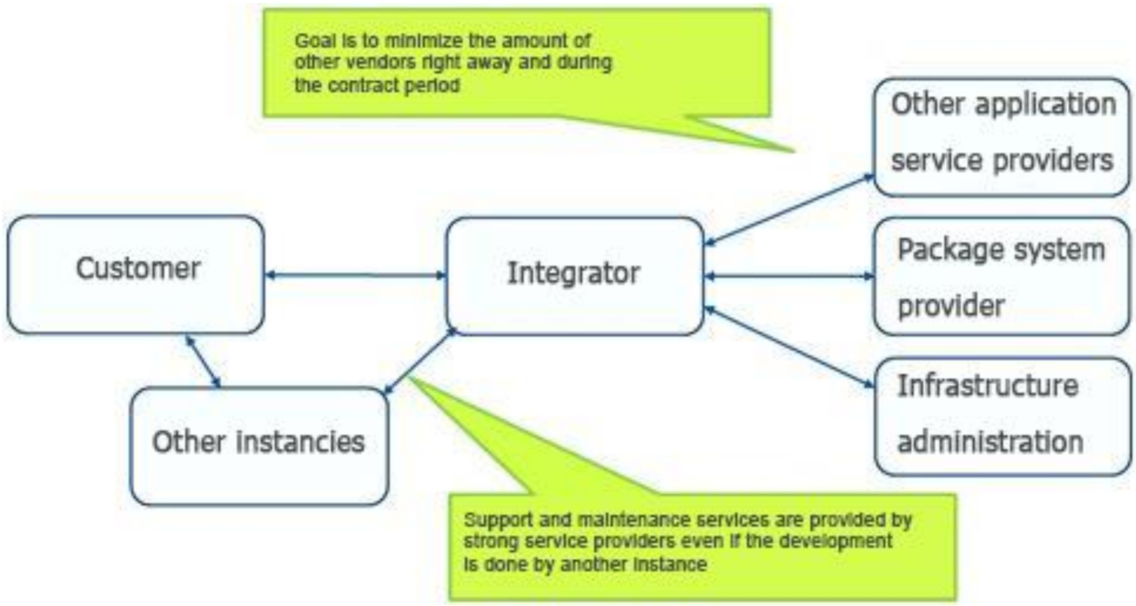

Figure 38. Integrator-based service provider model [97]

In media technology, it is crucial that in the production and distribution generic IT and telecom is being utilized. Construction of a comprehensive system for production and publication the key is in system integration, but the research shows that the integration is not always consolidated unless the system integrator knows the customer operations and needs adequately. The proliferation of cloud services makes it more problematic and the fact that the integrated service is dependent on the infrastructure.

8 Conclusions

Media production can be widely understood as a chain of different phases: production, postproduction, publishing, storage and archiving. Simulating this chain in educational laboratory environment can be accomplished to a large extent, but not completely. In this production chain, post processing culminates to media asset management in the organization; so far reaching the industrial level has become too big of a challenge.
In Media laboratory, as it is seen as a pedagogical learning environment, it is not possible to achieve the consolidate state of an integrated production system, because it is known that there are some failed examples in other European universities.
Production phase is not an issue, although the range of alternative equipment is wider than ever merging flexibly to home electronic devices. Although the distribution is manifold containing the linear IP-distribution, the education, experimentation and testing environment is constructed in media laboratory premises.

Decentralized collaborative working environment is the next stage in post-production

Professional media production takes place in an organization and is communal. Only integrated production and publishing system would make this learning environment equivalent to publishing business and industry. Because so far there is only one example that can correspond to this system (Potsdam) and they have adopted a fairly calm drama film production routine, there is no encouragement from universal bench marking to purchase services from inexperienced system integrators for a manifold electronic media production system that would eventually carry-out a routine-like news productions. The procurement should achieve a consolidated level, where users and the intended use of the system can be optimally stated. In addition to that the acquiring organizations own IT administration and existing infrastructure compatibility is still too ambitious challenge.

The Future

Since in the future media production will be carried out in cloud-based platforms, it is necessary to follow these trends and technologies. There are only two known broadcasters that are carrying out or planning to carry out a transition to a decentralized collaborative working environment in a cloud-based infrastructure (IaaS): Cable News Network (CNN) and Norwegian Broadcasting Corporation (NRK). National Broadcasting Company in Finland (YLE) is known to make preparations for a transition systematically. Since in video production the same software family is covering different phases in this technology, it is a necessity to follow their development and evolution in the market. It is also a necessity to follow how the local Finnish system integrators are developing before any decisions or acquisitions can be made. Because the Broadcasting industry must maintain a production and publishing system that is required to be fully functioning, it must have a continuing research and development support available. In this sense an academic institution has to settle for a system that has been only technically integrated, with expediency for the use and taking into account the users of the system.

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