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Building a Low-Cost Streaming System

Streaming and Camera Operating System for Live Internet Productions

Helsinki Metropolia University of Applied Sciences

Bachelor of Engineering

Media Engineering

Thesis

14 May 2015

Helsinki Metropolia University of Applied Sciences

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Title	Building a Low-Cost Streaming System
Number of Pages	78 pages
Date	14 May 2015
Degree	Bachelor of Engineering
Degree Programme	Media Engineering
Instructor	Kauko Ojanen, Senior Lecturer

This thesis describes a research and development project for a working live streaming system for a small society. The goal was to develop a software based live streaming system and to find out the best possibilities to expand the system into wider scale live productions for the future purposes. The goal was to build a working and cost-efficient set up with a low budget.

The streaming system was built based on four different software and simple cameras. A server computer was installed to keep and send the material as video-on-demand server and streaming server. The streaming software was installed to on a laptop computer that enabled the multi-camera directing, video mixing and streaming from one device. The website was built to offer streaming for multiple different devices and offer video-on-demand and live stream possibilities.

The project was successful and reached the set goal. The streaming server is managing the data well, and the website visitors are able to see the streams live or later.

The end result of the project, the live streaming system, is cost-efficient and simple. It supports good quality streaming with small equipment, but is easily enlarged for future purposes.

Keywords	live streaming, multi-camera production, bandwidth, on-demand streaming, protocols, codecs

Tekijä Otsikko Sivumäärä Aika	Ida-Maria Tunturipuro Suorien internetlähetysten kamera- ja lähetysjärjestelmä 78 sivua 14. toukokuuta 2015
Tutkinto	Bachelor of Engineering
Koulutusohjelma	Media Engineering
Ohjaaja	Lehtori Kauko Ojanen

Insinöörityönä tehtiin tutkimus ja toteutus järjestelmästä, jonka avulla voidaan toteuttaa suoria televisiolähetyksiä internetin välityksellä. Työ suunniteltiin kokouksiaan internetin välityksellä jakavalle yhdistykselle, ja työn tavoitteena oli toteuttaa tietokoneohjelmistoihin perustuva suoratoistojärjestelmä suoria televisiolähetyksiä varten. Tavoitteena oli suunnitella ja toteuttaa järjestelmä, joka on toimiva ja mahdollisimman kustannustehokas.

Median suoratoistojärjestelmä rakennettiin neljää tietokoneohjelmistoa hyödyntäen. Projektia varten rakennettiin palvelintietokone, jonka tehtävänä oli toimia videoiden arkistointitietokoneena ja suoratoistopalvelimena. Suoratoistoa varten asennettiin erillinen tietokone, joka mahdollistaa monikameraohjaamisen, leikkaamisen ja materiaalin lähettämisen eteenpäin internetin välityksellä.

Projekti oli onnistunut ja asetettu tavoite saavutettiin. Lopputuloksena oli toimiva lähetysjärjestelmä ja kotisivut, joista katsoja pystyy seuraamaan suoria internetlähetyksiä ja näkemään vanhoja nauhoitteita videoarkistosta.

Keywords	lähetysjärjestelmä, internet-video, monikameratuotanto,

Contents

1 Introduction

Live streaming can be used in many different styles and on many professional levels. It is a technical method to send data over the Internet. A working streaming system is taking into account many aspects of different areas. This thesis introduces the basic options for a streaming system from streaming protocols all the way to different camera and system set-ups.

Video can be streamed over the Internet with multiple different camera set-ups and recording styles. The method that is most used by the professionals is multi-camera technology. Multi-camera technology is the production style that is used when multiple cameras are used in one production. Multi-camera technology is nowadays most commonly used recording method for bigger live streaming purposes.

The purpose of the final year project that this thesis describes is to find and build a cost-efficient streaming system. This thesis project focused on the technology behind the streaming process and the project was based on different streaming and video software. The hardware was left out because the goal was to find the most cost-efficient options for the live streaming system. For better understanding of the methods behind the streaming, the most common streaming servers and used protocols and codecs were studied. At the end of the project, the live streaming system was tested and ideas for future system extensions are introduced in the thesis.

2 Streaming Technologies

2.1 Streaming Technology

Streaming technology is a technology that allows video, audio and other multimedia to be sent over the Internet. Streaming is sending multimedia data so that the end user can start processing the data before it is completely received. (McGath, 2013) Streaming technology can be live streaming or video-on-demand streaming. Streaming is the technology that is behind the real-time video chats in Skype, online broadcasting and the playbacks of Youtube videos to give a few examples.

Unicasting

A typical way to broadcast an Internet presentation is that the content is sent from one person to another with a one-to-one connection. This is called unicasting. Unicast is using IP delivery methods like the Transmission Control Protocol (TCP) and the User Datagram Protocol (UDP). (McGath, 2013) TCP and UDP are session-based protocols. When a media player client is connecting to a media server using unicast, it creates a direct relationship between the client and the server. Each individual relationship with the server takes up additional bandwidth (McGath, 2013) As an example, there is a company that wants to stream a presentation to its entire staff. The company has 100 workers on the main campus, 100 working on the second campus and 50 on the third campus.

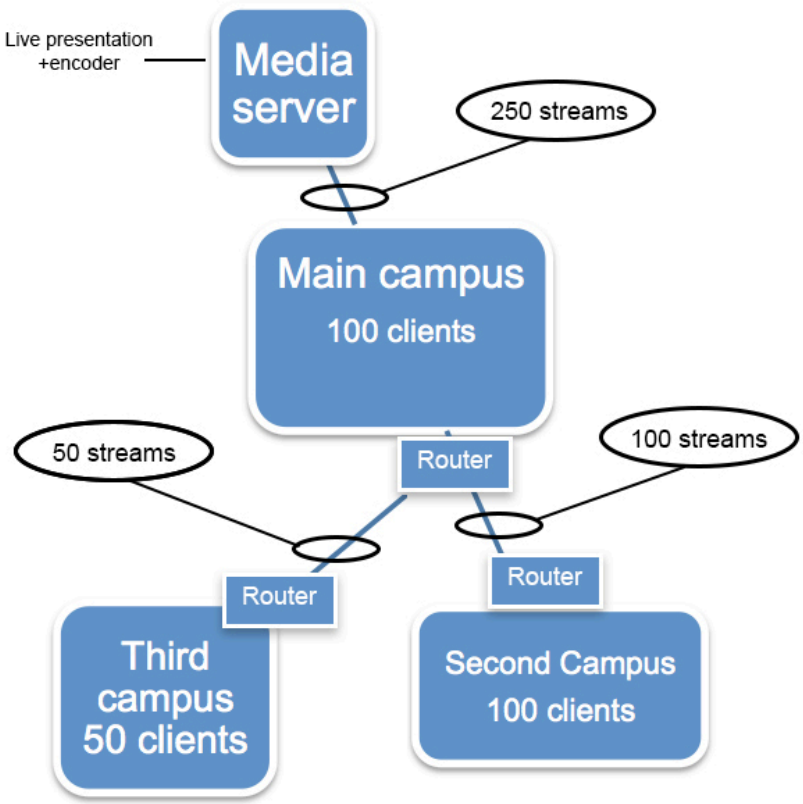


Figure 1. Unicasting figure, modified from (Austerberry, 2005 p.21).

Like the figure 1 shows, the media server needs to send 100+100+50=250 individual streams in order for everyone to be able to attach to it and see the presentation. If all the 250 clients are playing a stream of 1 Megabit per second (Mbps) streams, the total amount is 250 Mbits. If only 100 clients are playing the stream, the amount of bandwidth needed is 100 Mbps.

Multicasting

When multiple viewers are allowed to simultaneously connect to one stream or source, the method is called multicasting. Multicast method uses one-to-many connection. (Austerberry, 2008)

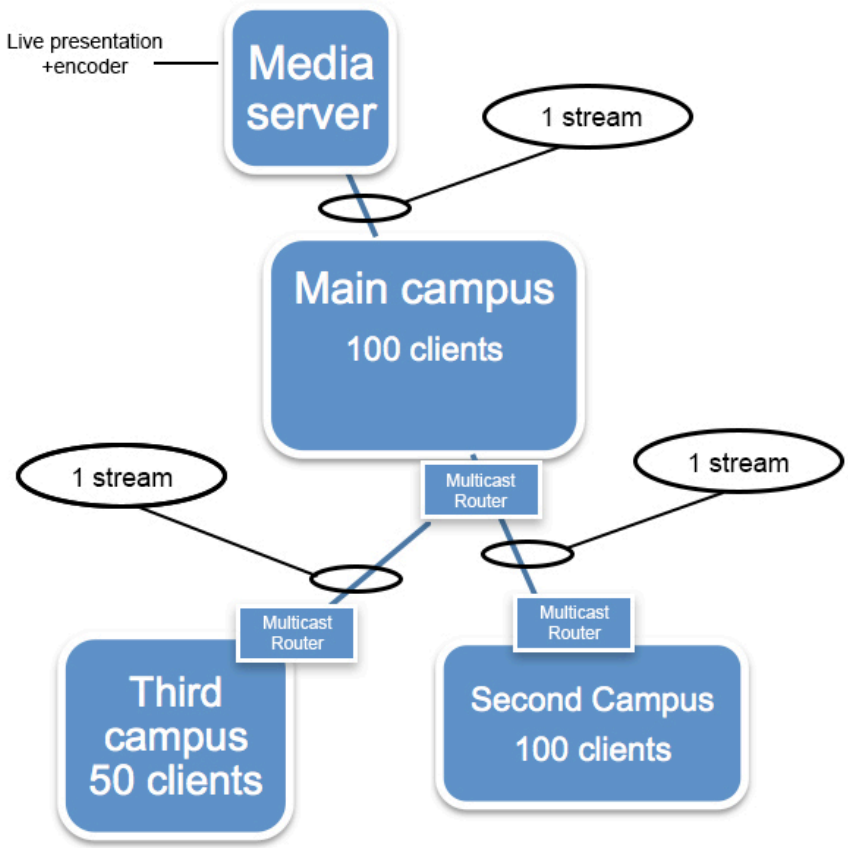


Figure 2. Multicasting figure, modified from (Austerberry, 2005 p.23).

Figure 2 shows the same example company that has a staff of 250 people on three campuses. This time the company is using multicasting for sending a presentation. A single stream is served to the Internet as multicast, so that all the viewers can attach to the same stream. The server has no knowledge of where the stream is going, unlike normal TCP client-server handshaking interactions of an Internet connection where the client and server have a direct relationship. The multicast source, server, relies on the multicast routers to forward the stream to all client subnets that have clients listening. Viewers can attach to the same stream at different points during the live stream. Because the multicast source is sending one signal per multicast station, the load on the server is the same even if there is only one client or if there are 100 clients. (Ze'evi, 2012)

Streaming technology has developed fast during the last couple of decades. The technology had its first successful experiments almost hundred years ago as the following quotation points out.

> The earliest reference to what we might recognize as ‘streaming media’ was a patent awarded to George O Squier in 1922 for the efficient transmission of information by signals over wires. At the time, broadcast radio was just starting up, and required expensive and somewhat temperamental equipment to transmit and receive. Squier recognised the need to simplify broadcasting, and created a company called Wired Radio that used this invention to pipe background music to shops and businesses. Later he decided to ape the Kodak brand name by renaming the company Muzak. This was the first successful attempt to multicast media (that is, transmit one signal over a cable to several receivers simultaneously). (Bucknall, 2012)

2.2 Live Streaming

Delivering multimedia content live over the Internet from a provider to the end user is called live streaming. Live streaming content can be a video stream, audio material and graphics. Internet TVs are the best example of a live stream. It is widely used technology when something is wanted to be seen in the Internet at the same time it is happening. For example filming a football game and sending it over the Internet at the same time is called live streaming.

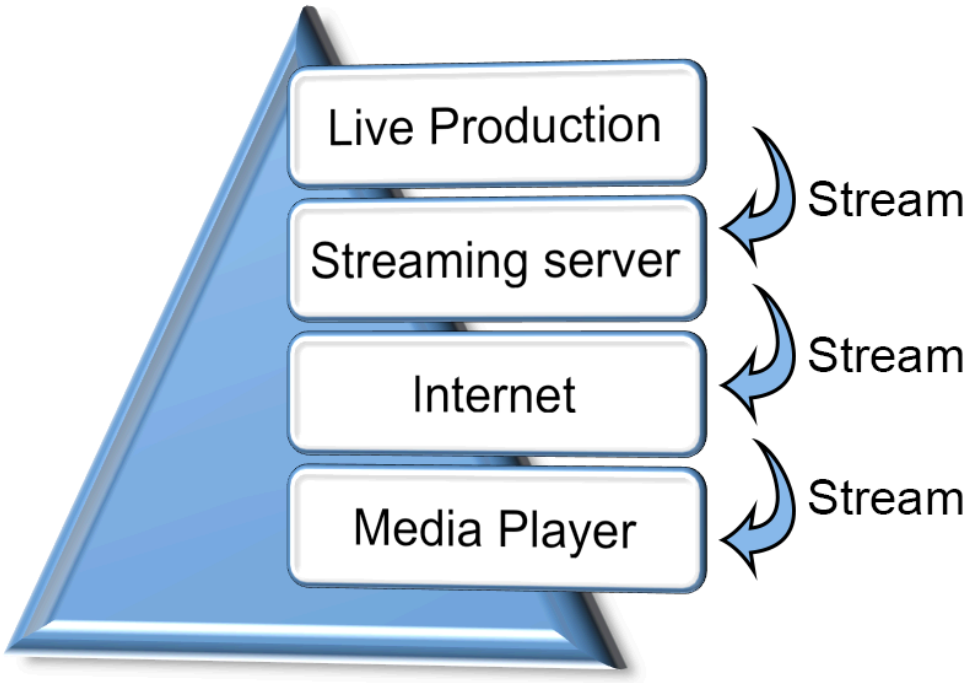


Figure 3. Live streaming

Figure 3 explains how the stream moves in the live streaming technology. When a live event is recorded, the production material is sent to the streaming server. The streaming server is sending the stream to the Internet from where the end users media player is requesting it. Live streaming is a term for the action that happens, when user is requesting a certain stream and it will be offered to that one specific user at the time the user wants.

World's first live streaming event was on September 5th 1995. ESPN Sports Zone streamed a live radio broadcast of a baseball game that was held between the Seattle Mariners and the New York Yankees. This was done with a technology that was developed by a company named Progressive Networks (nowadays known as RealNetworks) and the game reached thousands of subscribers. (Zambelli, The Guardian, 2013)

The streaming technology has developed really much since 1995 and nowadays almost anyone can stream almost when ever and where ever, thanks to the smartphones. To sum up the basic meaning of live streaming, this could be a headline: "When something is delivered live over the Internet, it is called live streaming. "

2.3 On-Demand Video Streaming

Video on Demand (VOD) is a system that allows a viewer to watch video or audio content whenever they want to. Video does not necessarily need to be watched at a specific broadcasting time.

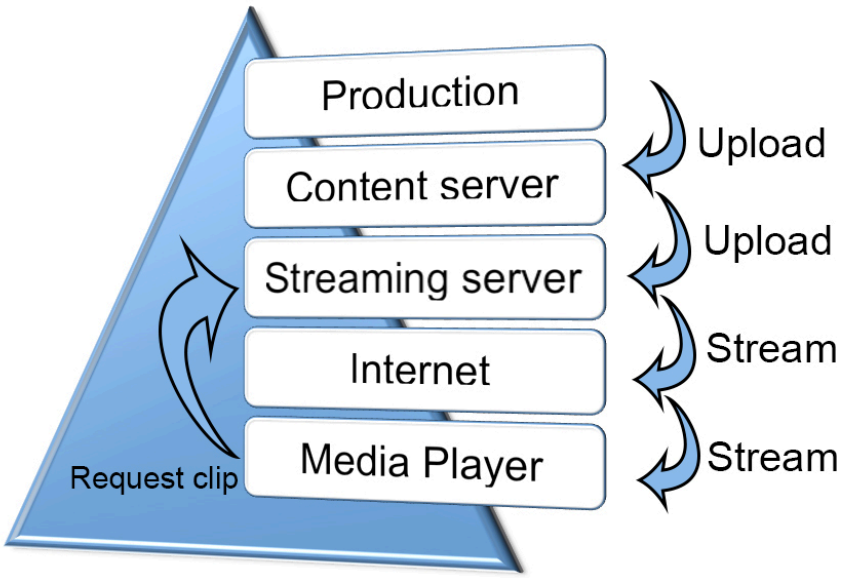


Figure 4. Video on demand streaming

Figure 4 explains how Video on demand technology works. Video on demand means uploading production material onto a server. When a user's media player is requesting for certain material, the streaming server starts to respond by sending the video stream from the content server to the Internet for that specific media player.

A typical example of on-demand streaming is YouTube or NetFlix. When video on demand is used, the users' viewing experience is more enjoyable than with the older video on the web system where the whole video is downloaded from a website. It takes a long time to download all the material, and often the user does not even want to watch all the videos on a page. VOD request the stream of the certain video clip that the user chosen and streams the video with the time and style the user wants to see it.

2.4 Devices

One of the requirements for live streaming nowadays is that it should be supporting different devices and multiple different platforms. The problem is that the devices all have their own operating systems and limitations, so that webpages and players need to be designed to work with different kind of platforms.

Developers are working with this issue all the time and already now there are systems that are covering multiple platforms. Unfortunately, the world of mobile and tablet man-

ufacturing is full of competition. This is causing the development of totally different kinds of operating systems that do not support each other. This means that the developers need to do extra work with designing working applications and players for all different platforms.

2.4.1 Computer Browsers

Most of the Internet users are still using computers. Computers can be said to be the main target on most of the cases in web development. However the more development there is, the more different devices there are on the market.

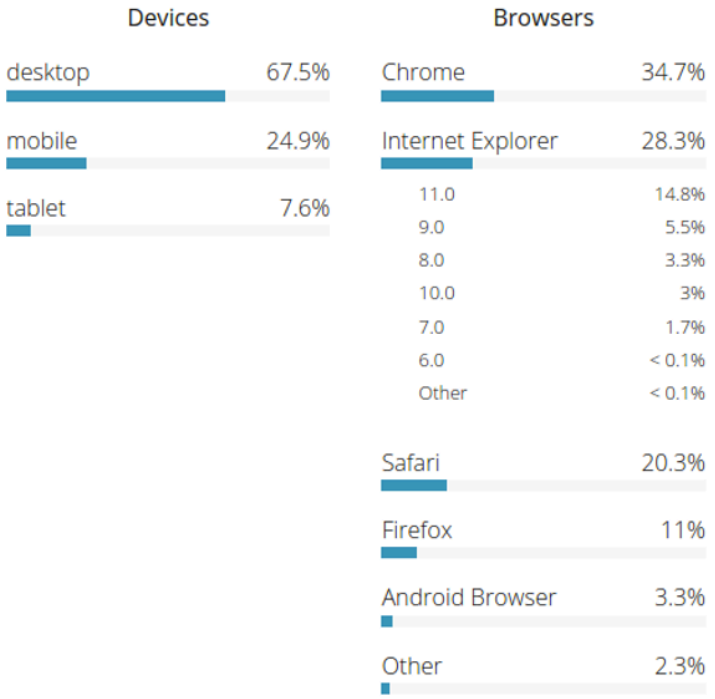


Figure 5. Most popular browsers in the United States 2015 (Vaughan-Nichols, 2015) .

Figure 5 shows that 67.5% of the Internet visits are done from the desktops and the most popular browser has been Google Chrome. The second was Internet Explorer, and the third was Apple's Safari.

When a web developer is designing a website and deciding which media players are being used, it is really important to be aware of the browsers that are "the most important ones", so that most viewers would stay happy and bugs are minimal. There are really big differences on browser supports and the technology behind each of them is allowing different kind of things to work with them.

2.4.2 Mobiles and Tablets

As mentioned earlier, mobiles and tables are becoming more and more popular when it comes to Internet use. The screen sizes and functionalities (touch screen) are pushing developer to stretch in designing to get satisfying results.

Already now developers are using styling, so that the browser tells to the website if the user is viewing it from a desktop, a mobile or a tablet. The websites are created to adapt themselves to fit the screen better. This is quite a familiar thing on basic webpages, but adding videos to a website is already more difficult.

The players are unique in all the devices and some supports for example Flash Player and others do not. Mobiles and tables are becoming more and more popular and maybe one day they will be mostly used platforms. The technology is developing and so are the designs and techniques.

3 Multi-Camera Production

3.1 Basics of Multi-Camera Technique

Multi-camera production is a method for video production where multiple cameras are recording simultaneously. Multi-camera production is the most used recording technique in TV broadcasting nowadays. It is recording with multiple cameras, which makes watching richer and more interesting. The multi-camera technique is used for example in talk shows, concerts and sports events. The production crew is collaboration between many professionals in their own fields. To be able to get the best possible result, the production crew must work perfectly together. Multi-camera production has been said to be a cheap and fast recording method, because it does not need necessarily any post-production. That is why it is the recommended technique for most of the live streaming productions and nowadays streaming programs, such as Telestream's Wirecast, support multi-camera directing.

3.2 Multi-Camera Production vs. Single Camera Production

The multi-camera technique cannot be compared to the single camera technique without taking into account quite many aspects. The main rule is that the single camera technique is used when recording movie kind of videos (Kuosmanen, 2012). Single camera technique takes a lot of time, since the action needs to be recorded multiple times, so that the action will be recorded from different angles. That is why the single camera technique needs post-production where the shots are cut into the storyline. The only case where a single camera can be used in live streaming purposes is when the picture is the same during the whole show and during a live interview where different angles of views are not necessarily needed. When a director is able to use multiple cameras, video can be cut live together and there will be multiple angles of views and more time to react to new actions with other cameras. The multi-camera technique uses a video mixer where the cutting is done live. The post-production part is not in such a big role as in single camera production. When the multi-camera technique is used for live streaming purposes, there will be no post-production, and everything will be done at the same time with broadcasting.

When comparing the budget that is needed for multi and single camera productions, the multi-camera production is in most of the cases a more cost-efficient option. Even

though the production crew is bigger, the video mixing and live cutting makes it faster, and the less time the post-production takes, the cheaper it gets. When recording with one camera, to be able to get the same result as with multiple cameras, the action needs to be repeated multiple times and that takes much more time and all the cutting and editing will be done in postproduction. (Keränen, 2000 p.4.)

3.3 The History of Multi-Camera Production

The history of multi-camera production is almost as long as the history of the television. The very first television broadcasts were based on live shows that were mostly done by using multiple cameras. In one of the very first television programs, in “The Queen's Messenger” that was published in the year 1928, three different cameras were used. (Queen’s Messenger.) In the early days of the television all the live broadcasts were cut with the help of an “electrical cutting table”. All this editing was done in the real time with the live show. (Pirilä, 2005 p.57.)

Finland's first “outside studio” broadcast was shown in January 1957. That was the day when TES-TV television showed the ballet called Swan Lake. After this Finland's television recordings took a big step forward. The National Radio and Television Corporation YLE (Yleisradio) bought their first production truck that allowed them to record and send broadcasts outside the studio. After this it has been possible to show more live broadcasts in television such as sports events. (Pirilä, 2005 p.58.)

3.4 Production Crew

The size of the multi-camera production crew can vary from a couple of persons to more than twenty people. Usually the production crew is formed of many professionals of their own fields such as: producer, director, set designer, makeup artist, talent/guest, audio engineer, video engineer, videotape engineer/operator, camera operator, assistant director, production assistant and director of photography (Kuosmanen, 2012).

The main authority in multi-camera production is the producer. The producer is the person that has all the strings in his/her hands. He/She has the highest responsibility for the things done and the work of the producer is mostly about administration and organizing. He/She normally is the person that keeps in contact with the show guests and

key persons of the production team. Without the producer there cannot be a production (Kuosmanen, 2012).

The role of the director is really important in multi-camera production (Kuosmanen, 2012). Even though the producer is taking all the responsibility, the director is the one who is taking care of everything in the shooting location and during the production. The director is the person who is directing the work of the cameramen and the rest of the production crew. The multi-camera production director has almost the same kind of role as a movie director has with movies. Only difference there is that multi-camera director is directing cameramen instead of focusing only on the actors. The director's opinion is being honored in every situation and there is no room for solo-artists. (Pirilä 2005, 18.) Multi-camera director's orders needs to be listened to in every situation. They should be taken as the "words of God". The director's main focus is to get the cameras to work in a way that when they are cut with the video mixer in a certain order, the end result is a professional looking, versatile video production.

The assistant director's job is to be the right hand of the director. Basically it means being the person watching the clock, setting up the clock and making sure that the director knows what is happening during the show and when. Usually the assistant director is also pushing the recording button and is working as a secretary during the broadcast.

The studio director is the voice of the director in the studio (Kuosmanen, 2012). He/She has all the time an intercom connection to the control room. The intercom is a system that handles all the other communication between control room and the studio and allows the studio team to hear the director and talk with him/her. The studio director is the person telling the show guests when things are happening and when the show is starting and so on.

The audio engineer is the one responsible for all the audio recording and mixing (Pirilä 2005). He/She is setting up all the microphones and making sure the audio sounds good in the broadcast.

To make sure the picture of the TV production looks good and that the picture of all the cameras are similar, the crew needs to have a person to take care of that, and that person is called director of photography. His/Hers responsibility is to operate the Cam-

era Control Unit (CCU) and check the levels of the lights together with the light man (Helenius, 2006).

In a multi-camera production crew every cameraman takes care of his/her own camera. When working as a cameraman, technical knowledge and an artistic eye are both needed, and to be good a cameraman, should be strong in both areas. There can be a situation where the director gives free hands to the cameramen, when the cameramen can forget the instructions in the camera list. The real talent is tested in spontaneous situation, and they are a chance to show some creativity. To be able to be a talented multi-camera cameraman, a person has to be aware of the basic rules and techniques of the shooting and the command language that the director is using. During the production, the cameramen are doing what the director is asking them to do.

Some members of the crew that have really important role in the production, but that are not always present during the actual recording, are for example the set designer, writer, light man and makeup artist. The set designer is the person that is setting up the studio and the light man is the one taking care of the lighting of the studio set (Helenius, 2006). The make up artist is the one that checks that the guest and the talents of the show look good. They check that they have enough makeup, so that the skin is not shining and that the clothes look good. (Kuosmanen, 2012).

Every single person that is working in a multi-camera production crew needs to have team spirit, because the productions are most of all teamwork. No one can be the star of the show and everyone needs to work together to be able to get the best possible result.

3.5 Camera Control Unit

Nowadays one really popular technical system in multi-camera production is triax cameras. A triax camera system is using triaxial cables that are going from cameras to the CCU (Camera Control Unit). In the old times when doing camera controlling, the director of photography needed to check all the camera options manually from the camera.

Figure 6. Camera control unit for three cameras.

The Camera Control Unit is allowing the camera controls to be checked from the CCU monitor, all cameras the same time. All of the camera's picture details, such as iris, color balance and saturation etc. can be checked and changed from the CCU (see figure 6). The job of director of photography is to check that all the camera images look the same, and for this the help of the CCU is really big.

As already mentioned, a triaxial cable is the one that is sending camera control information from the camera to the CCU and back. This is one of the main things the cable does, but it is made to transfer also other information.

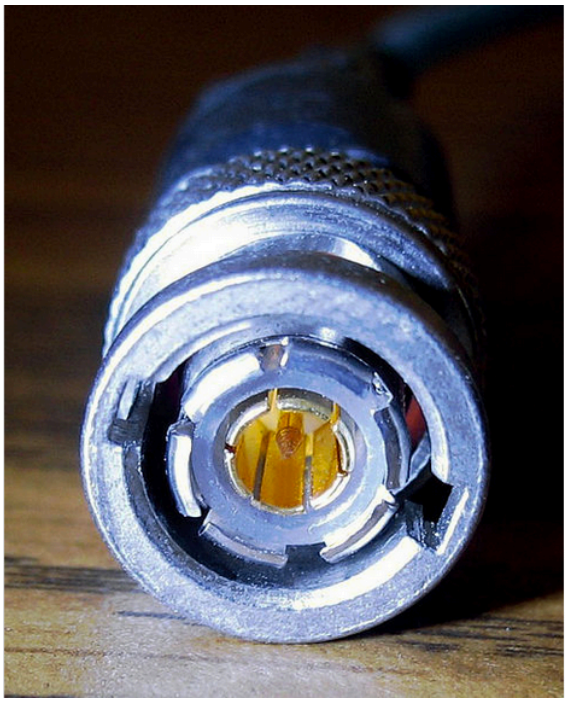


Figure 7. A triaxial cable is making many things easier in multi-camera production.

The triaxial cable (see figure 7) is sending video and audio information from the camera to the control unit, which allows the director to see the information also on his/her screen. The information is taken through CCU all the way to recording computer and video mixer.

There is more traffic from the CCU to the camera than the other way around. Of course the main information is the camera control information, but the triaxial cable is also bringing the return video to the camera. Return video is the video that is recorded on that moment. This means that the cameraman is able to see from his/her own screen the picture that is recorded from another camera. This allows the cameraman to be aware of what kind of pictures the other team members are recording and that helps them to decide what kind of picture the director is possibly asking them to record next. The triaxial cable is also really helpful, because the camera can get its power through it. There is no need for extra power cables or batteries, because the power is coming through the triaxial cable (Kuosmanen, 2012).

Also tally information is coming inside the triax cable. Tally is the name for the red light in the camera that is turned on when that specific camera is recording (Kuosmanen, 2012). This is helping the cameraman to know when his/her camera is live and also telling the presenter which camera to look at.

One really important detail in multi-camera production is that the camera operators need to be able to hear the director's voice so that they are able to record the way they are asked. Sometimes the camera operators need to inform the director during the recording (Kuosmanen, 2012). For this purpose a phone system called intercom has been invented. When the intercom is used, the camera operators are wearing headphones through which they can hear the director talking in the control room. The camera operators can also speak to the director through a microphone. This intercom system is also going through the triaxial cable (Kuosmanen, 2012).

3.6 Steps in the Production

There are three stages in multi-camera production. To get the best possible final result, it is important to make sure that all of these steps have been planned and done in the best possible way. The production is built of three different producing stages, pre-production, broadcast and post-production (Kuosmanen, 2012).

Pre-production is the part of the production cycle where all the planning and decision making is done. All the decisions about the coming production are done in the pre-production. It could be something like a "meeting" of the coming multi-camera production, where the producer is creating the production and all its content and steps.

In the pre-production meeting, it is a good idea to check the character and style of the new production (Kuosmanen, 2012). Meeting will decide what kind of video is going to be filmed and what kinds of angles of views are used. The director chairs the kick-off meeting and there he or she is telling what to do, so that the recording style is similar with all the cameras and so that everyone knows what to do when the time comes.

Another important thing to be thought through early enough is the budget. It is important to know what can be done in the studio and with the stage set. It is really important to know what kind of equipment is taken with the group to the shooting location (Helenius, 2006).

In the pre-production meeting, the director normally makes camera lists for every camera. That includes instructions for the cameraman telling what kind of picture sizes are to be shot in a certain point of the broadcast. (Pirilä, 2005, p.90-91.)

Broadcasting is the most important stage of multi-camera production. That is the stage where the actual work is done. When the red light turns to the “On the air” mode, every member of the production crew should know what is going to happen and what their own part is.

Post-production is the part of the production where the possible editing is done. Then the video gets its final form (Kuosmanen, 2012). The ditor tests that everything works and looks good. Normally multi-camera productions are cut in the same time when recording, so post-production is not always needed and that is saving a lot of money (Helenius 2006).

3.7 Shooting Techniques

3.7.1 Shooting

As multi-camera shooting is done with more than one camera, the technique is used differently compared to single camera productions. The difference is that the instructions of the recordings are written in the camera lists, or the director is giving the instructions to the cameramen with the help of an intercom.

3.7.2 Protective Line

Protective line is one of the main rules in multi-camera shooting. It is also called the 180-degree rule.

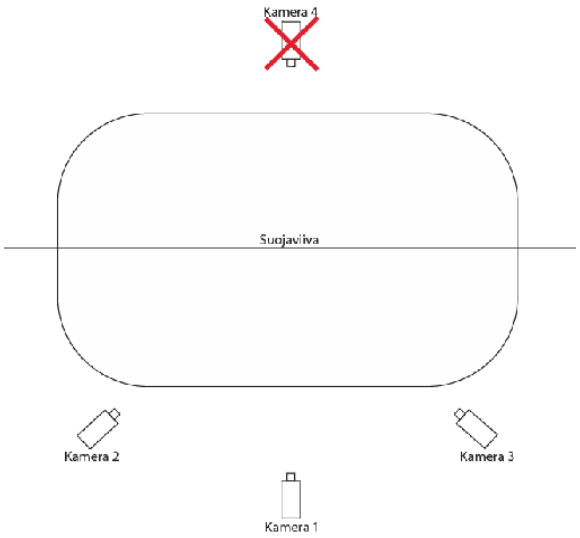


Figure 8. Camera 4 is breaking the protective line. (Salonen, 2009).

Protective line means that all of the cameras should be on the same side of the line (See figure 8) (Keränen, 2000, p.21). This makes watching easier and gives a possibility for the audience to understand the place and situation better. However, like in all art, breaking the rules has become an artistic style. Nowadays it is very often seen that concerts are being filmed also from the “wrong side” of the protective line, and the view from the artists’ side is showed. The only case where the 180 degree rule gives a permission to break the line is a situation when, the camera is moving. When the camera is moving while shooting, it shows the whole view to the audience and it is easier to watch.

3.7.3 Angles of View

Camera angles

By changing the angles of views a movie gets different feelings and becomes more interesting. Different angles give a rhythm to the video and excitement to the situations where lighting and items shot are staying the same (Helenius, 2006).

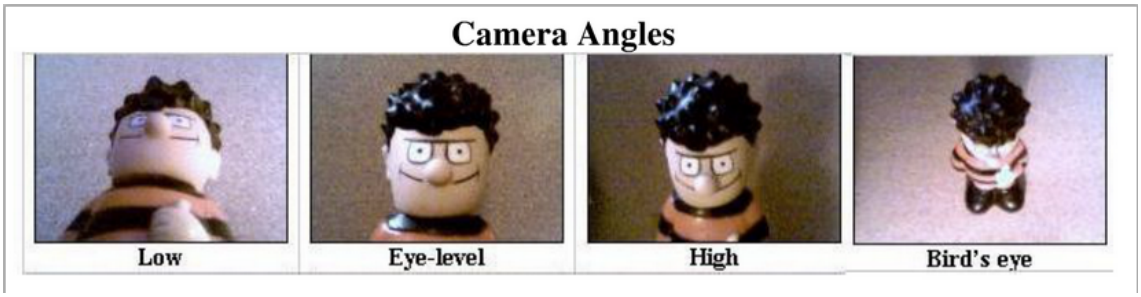


Figure 9. Different angles of views (Lyle)

The most common way to shoot is to get the picture from the height of the human eye. Other angles and sizes of views can show the difference in the shooting area or get some things more specifically shown to the screen. If the picture is taken from the top when the camera pointed a little down the person in the picture to looks small and miserable. Picture taken from low angle, so that the camera is pointing up, the person looks royal and tremendous. (See figure 9).

3.7.4 Picture Size

Planning a shootable picture size is really important. There are times when the director wants direct a talk show production, so that pictures are cut to the opposite pictures (Keränen, 2000). Opposite picture means, that the two people in the scene are having the same size of picture, but the persons is located to the other side of the picture.

Figure 10. Picture sizes (Lyle)

Basic shot sizes and their short names are having shortened names to make the communication language easier during the production. Here are the basic picture sizes. (See figure 10):

- XLS: Extreme Long Shot (body is far away)
- LS: Long Shot aka WS: Wide Shot (full body shot)
- MLS: Medium Long Shot (thighs and up shot)
- MS: Medium Shot (waist and up)
- MCU: Medium Close-Up Shot (elbows and up)
- CU: Close-Up (shoulders and up)
- BCU: Big Close-Up (chin and up)
- XCU: Extreme Close-Up (mouth to eyebrows)

  (Lyle)

Cutting to the really different picture size means that director cuts from the wide view to close up (see figure 10). The rule for cutting to the next camera is that the next picture

size has to be measured so that it is not too similar to the previous one, if the item or person in the shots is the same. The rule of thumb is to change from first picture size to at least two sizes bigger or smaller to avoid mistakes. For example a really common way is to cut from a medium long shot to medium close up shot.

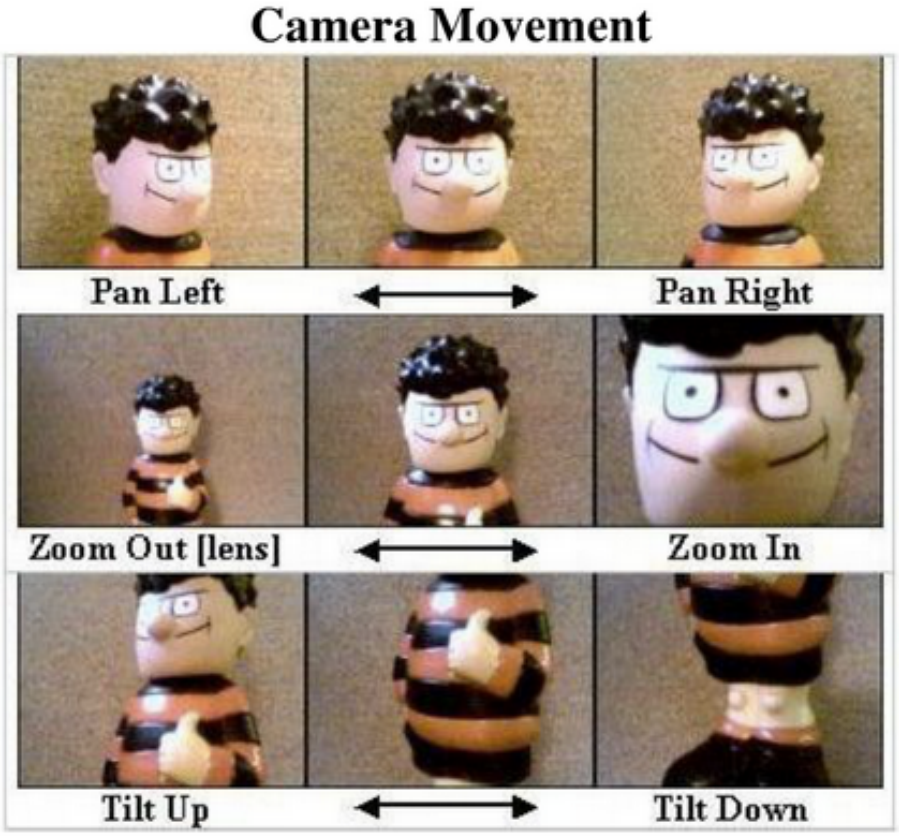


Figure 11. Picture movements. (Lyle)

Moving picture gives its own challenges to designing good picture sizes (Pirilä, 2005, 67.). In multi-camera production the situations are normally happening and changing fast which forces the decisions to be done really fast. That is working only if the cameraman knows the good picture sizes and how to make the shot. In many situations the director gives instructions verbally about the picture size wanted. In these fast situations the director usually uses the short names of each picture size. (See figure10.) The basic movements of camera are tilting, where the camera is moving in a horizontal way. Panning is the name of the movement that goes vertically, for example from right to left. Zooming is maybe one of the most well known movements, which is changing the size of the item in the picture or distance. (See figure 11.)

4 Live Streaming Servers

4.1 Apple Media Server

Apple is one of the leading hardware and software company and is best known for it's own Mac Book computers and iPhone smartphones. Apple is providing its own application also for streaming. Apple's streaming server is a practical tool if user is interested in streaming the content from a computer's movie or picture libraries to the smartphone. The application is called Air Media Center (Dynamic, 2014). With Apple's own words "Air Media Center is a multi-platform mobile media center that lets you effortlessly stream your media collection from your computer to your mobile device. " (Dynamic, 2014) Air Media Center is offering opportunity to stream without worrying about codecs, file conversions and it automatically transcodes the media to match the capabilities of the smartphone operating system. Air Media Center 1.0.19 supports the following file formats: AVI, DIVX, XVID, MKV/Matroska, MP4,M4V, MOV/QuickTime, MPG, MPEG-1 systems, MPEG-2 PS, MPEG-2 TS, MPEG-2 EyeTV, MPEG-4, ASF, WMV, WMA, WAV, MP3, 3GP, OGG, FLV and WTV/DVR-MS. (Dynamic, 2014)

4.2 Wowza Media Server

"Wowza Media Server is high-performance, extensible, and fully interactive media streaming software platform that provides live and on-demand streaming, chat, and remote recording capabilities to a wide variety of media player technologies." (Wowza.) Wowza Media Server is giving an opportunity to stream to several different media players such as Adobe Flash Player; Microsoft Silverlight player; Apple iPhone, iPad, and iPod touch and Apple QuickTime player (version 10 or later); AndroidTM smartphones and tablets; and IPTV/OTT set-top boxes.

Wowza Streaming Engine supports Apple HLS for iPhone/iPad and other compatible devices; MPEG-DASH for DASH-AVC/264-compatible players; Silverlight Smooth Streaming; RTSP/RTP for Android, QuickTime, and other 3GPP mobile devices; MPEG-TS for set-top boxes; and Adobe HDS and several variants of RTMP for applications using Flash Player (versions 7, 8, 9, 10 and 11).

Wowza Media server has five editions: Trial, Monthly, Daily, Perpetual and Developer.

The trial edition provides full, unrestricted functionality of the server and AddOns, but is has limited time for use. The monthly edition is giving client an access to all basic functionality. The starting price is $65 and the pricing changes after more instances are added. Perpetual license is a lifetime license for one-time payment and offers unlimited connections for one server. Developer license is free license for testing and developing available for 180-days. (Wowza)

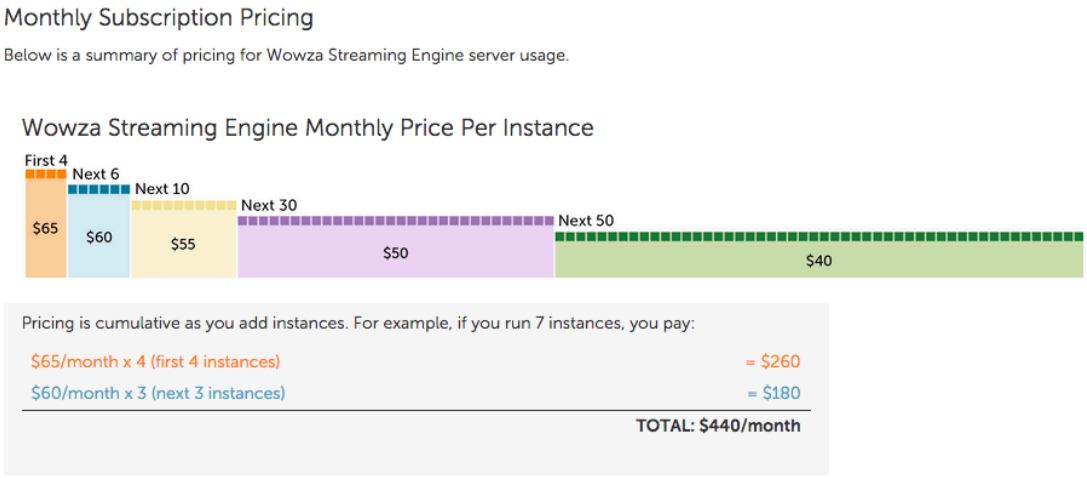


Figure 12. Wowza streaming engine monthly price per instance (Wowza)

As seen in figure 12, Wowza's pricing is set according to the number of instances used. An instance is a single copy of the Wowza Streaming Engine server software running on a single physical or virtual computer. When the Wowza Streaming Engine is installed for the first time, one instance started.

Wowza has a new way of offering live-streaming service. The service is called Wowza streaming cloud. As they advertize themselves "Wowza Streaming Cloud is cost-effective, with no-commitment, pay-as-you-go pricing for video delivery to anyone, anywhere." (Wowza.) The main feature and difference to the Wowza streaming engine is that it works in the cloud and saves the streaming material also inside the cloud. It is not a physical server, on a media engine, but a lighter version that is easily configured over the web and the price is based on the amount of use. (Wowza.)

4.3 Microsoft IIS Server

Microsoft Internet Information Server is a group of Internet servers that can be installed with Microsoft's Windows NT and Windows 2000 server operating systems. Microsoft ISS server includes a web or hypertext transfer protocol server and a file transfer protocol server. It is developed my Microsoft and the focus is to bring all web-server features into one platform, where separate streaming server is no longer needed.

> A typical company that buys IIS can create pages for Web sites using Microsoft's Front Page product (with its WYSIWYG user interface). Web developers can use Microsoft's Active Server Page (ASP) technology, which means that applications − including ActiveX controls - can be imbedded in Web pages that modify the content sent back to users. Developers can also write programs that filter requests and get the correct Web pages for different users by using Microsoft's Internet Server Application Program Interface (ISAPI) interface. ASPs and ISAPI programs run more efficiently than common gateway interface (CGI) and server-side include (SSI) programs, two current technologies. (Dodge;Lehto;& Weiner, 2008)

Microsoft IIS services have smooth streaming extension that dynamically detects local bandwidth and CPU conditions. It adjusts the video quality of a media file that the player receives. This allows consumers to experience high definition streaming quality. Smooth streaming extension supports also live streaming and video on demand streaming. Microsoft ISS Server is downloadable from Microsoft.com and it has a free trial version.

5 Streaming Protocols and Codecs

5.1 Protocols

According to the dictionary, a protocol is “a set of rules or procedures for transmitting data between electronic devices, such as computers. In order for computers to exchange information, there must be a known agreement as to how the information will be structured and how each side will send and receive it. Without a protocol, a transmitting computer, for example, could be sending its data in 8-bit packets while the receiving computer might expect the data in 16-bit packets. Protocols are established by international or industry wide organizations. (Britannica, 2014)

OSI Model			
	Data unit	Layer	Function
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation, encryption and decryption, convert machine dependent data to machine independent data
		5. Session	Interhost communication, managing sessions between applications
	Segments	4. Transport	End-to-end connections, reliability and flow control
Media layers	Packet/Datagram	3. Network	Path determination and logical addressing
	Frame	2. Data link	Physical addressing
	Bit	1. Physical	Media, signal and binary transmission

Figure 13. OSI model. (Ozer, 2012.)

ISO, International Organization for Standardization, created the Open Systems Interconnection (OSI) model to define seven layers for communication functions. Figure 13 shows how the OSI model is divided into two bigger layers, called media and host layer. Inside the two layers are seven more detailed layers: physical, data link, network, transport, session, presentation and application layer. As seen in the figure 13 (Ozer, 2012), every layer has its own function. Streaming is involving multiple different layers. Lower level layers (physical, data link and network layer) are working separately and other layers are involved with streaming protocols. The transport layer is responsible for sending data from one end to the other. The session layer organizes streaming activity into ongoing units like movies or broadcasts. The presentation layer manages the bridge between information as seen by the application and information as sent over the

network and the highest is the application layer where application talks to the network. (McGath, 2013)

> Support for the right streaming protocol does not necessarily mean that software will play a particular stream. You need software that supports both the appropriate streaming protocol and the appropriate encoding. (McGath, 2013)

5.1.1 RTP-family: TCP/UDP

The Real Time Transport Protocol, RTP, has been used for streaming purposes for a really long time. RTP is a transport protocol that is built on the User Datagram Protocol (UDP). The Real Time Transport Protocol is specifically designed for real-time transfers, such as live streaming and it is part of the transport layer. The Real Time Control Protocol (RTCP) is closely associated with RTP, but operates at the session layer. The main function of RTCP is "to provide feedback on the quality of the data distribution" (McGath, 2013)

> The Real Time Streaming Protocol (RTSP) is an application-level streaming protocol that can use multiple protocols in the transport layer to transmit its packets, including the Universal Datagram Protocol (UDP) and Transmission Control Protocol (TCP). (Ozer, 2012.)

Both TCP and UDP are protocols that are used for sending packets, bits of data over the Internet. They both are built on top of the Internet protocol. That means that when a packet is sent via TCP or UDP, it is sent to an IP address. (Hoffman, 2014)

Most of the Internet activity is happening by using the TCP transport protocol. (McGath, 2013) TCP stands for Transmission Control Protocol and it is the core protocol of the Internet Protocol (IP) suite. The term TCP/IP refers TCP over IP. TCP provides reliable and error-checked delivery of a stream between applications running on hosts communicating over an IP network. TCP is expecting a successful handshake before starting to send the data. When opening a webpage, a computer sends TCP packets to the web server's address. It asks the server to send the page to the computer and the webserver responds by sending a stream of TCP packets, which the web browser stitches together to for the webpage and to display it on the screen. When clicking something on the page, the browser starts sending TCP packets to the server and the

server sends the TCP packets back. TCP is not just one-way communication, but it is expecting an acknowledgement from the other end that the packet has been received. TCP is numbering each packet to guarantee that the receiver receives the packets. The receiver sends a message to the sender that tells it has received the packet. If a correct response is not received, the sender will resend the packet to make sure the receiver will receive it. The TCP protocol is also checking packets in case of errors. That is why TCP is all about reliability and it is ensuring no data is lost or corrupted. (Hoffman, 2014) TCP is operating at the transport layer, which is the middle layer in the OSI model (see figure 7). Transport layer is taking the responsibility for maintaining reliable end-to-end communications across the network. Also UDP is operating at the transport layer. The Internet Protocol is working at the network layer that is just below the transport layer.

UDP is a lightweight protocol when comparing to TCP. TCP and UDP are functioning partly in a similar way to each other, but UDP does not include two-way communication like TCP. TCP is adding a sequence number to each transmitted packet and the opposite host acknowledges those. The acknowledgement number is sent back from the opposite host to inform that the transmitted data was received successfully. UDP does not have this function that makes it faster, but not that trustworthy way to transfer packets. UDP will keep delivering information rather than putting extra effort into re-sending lost packets that TCP does. The sender does not expect to get any feedback if the receiver gets the packet. It just continues sending packets. UDP is used when broadcasting live streams for example. If a user is watching a stream and the Internet connection is lost for a few seconds, the UDP protocol ensures that the video only freezes for a moment and continues to play without the missing data. (Hoffman, 2014) It is good to notice that some firewalls might block UDP because they are made only for TCP communications. (McGath, 2013) UDP URLs are not supported in all the browsers, so a browser may need a plug-in to be able to receive the RTP/UDP stream. Standalone media players such as Windows Media Player and QuickTime Player can use RTP. iOS and Android devices do not have their own RTP-compatible players, but they need third-party applications to receive the stream. (McGath, 2013)

5.1.2 RTMP

RTMP stands for Real Time Messaging Protocol. It is a proprietary protocol and it is most commonly used by Flash, but some other software have implemented it as well.

RTMP operates applications through a session layer and it is normally used over TCP, but this is not necessary. (McGath, 2013) Apple's own operating system iOS does not support Flash or RTMP, so the only way to get RTMP streams to co-work with Apple products is to use a third-party code or a Flash plugin. (Adobe, 2015) Flash is the format that is most commonly used with RTMP; other formats also work with RTMP. (McGath, 2013)

The Real Time Messaging Protocol is primarily serving high-speed transmission of video, data and audio between Flash player and a server. RTMP helps to avoid latency and is delivering video streams smoothly. RTMP is splitting the data into fragments and makes them interleaved and multiplexed over a single connection. This is saving bandwidth. The interleaving and multiplexing of data is done at the packet level. The result is that RTMP encapsulates MP3 or AAC audio and FLV1 video multimedia streams.

As said earlier, RTMP is most commonly used by Flash. RTMP enables Flash player to make contact with the Flash media server and an RTMP connection is established. An RTMP connection is said to begin with a similar "handshake" as a TCP connection. The Flash player requests a specific stream and when the media server receives the request, it is sent to Flash SWF directly over the RTMP connection. The same stream can be sent to as many clients as request it and the bandwidth is allowing the stream to be spread. Bandwidth determines how many simultaneous streams can be sent. Capacity can be improved by chaining media servers together. (Čandrlić, 2014)

RTMP can be used behind the firewall where it is blocked when RTMP is tunnelled through HTTP (RTMPT). Other versions are RTMPE, which works with lightweight encryption, RTMPTE with tunnelling and lightweight encryption and RTMPS when encrypted over SSL. (McGath, 2013)

5.1.3 Apple HTTP Live Streaming

HTTP Live Streaming (HLS) is a streaming protocol that is developed by Apple. It is offering a way to send out audio and video over HTTP from a webserver for playback on iOS devices, such as iPhone, iPad, Apple TV and computers running Mac OS X. (Apple Inc, 2014.) HTTP Live Streaming supports adaptive bitrates.

Adaptive bitrate streaming dynamically monitors a computer's central processing unit (CPU) and memory capacity. Based on those values the adaptive bitrate streaming makes corresponding adjustments to the quality of the video. The process encodes the stream at varying bit rates and then segments the different bit rate streams into smaller parts. On a segment is normally 2-10 seconds long. The multimedia player can switch between the different bitrate segments and find the segment that is best based on the computer's bandwidth. (edchelp, 2014)

Figure 14 Adaptive bitrate. (Greggory, 2014.)

Figure 14 shows how the picture quality changes when the video is streamed using different Internet connections and devices. The better the Internet speed is, the better the quality of the video is. The first 10 seconds of the video the quality is 240p, which is quite poor. The reason is that it is streamed to a cell phone that does not have a good Internet connection. When the Internet connection is set up to be 4G, the picture quality is better. That is seen in 10-30 seconds. In 30 seconds, the Internet is working through powerful Wi-Fi, so the picture quality can be changed to 720p, which is already really good quality. These results can be reached in city areas, with a good Internet connection. When the player changes the video quality automatically, the video and audio are viewable all the time and the watching interruptions are minimal.

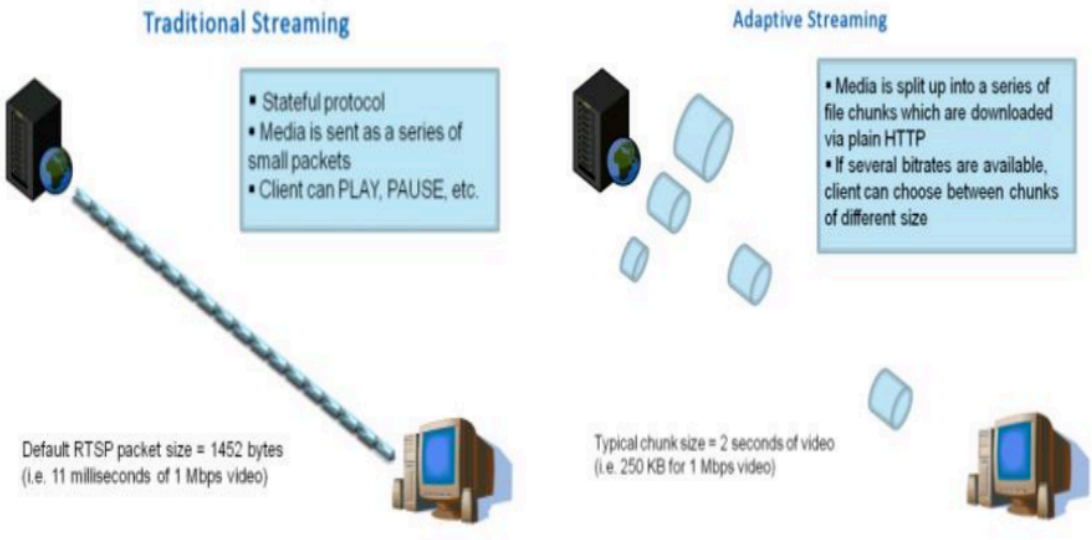


Figure 15. The difference between the traditional and adaptive streaming (Chave, 2012)

Figure 15 shows the main difference between the traditional and adaptive streaming. Traditional streaming is sending the data as a series of small packets. The adaptive streaming splits the media into a series of files chunks and those are downloadable via HTTP. “Adaptive bitrate allows the client to choose between different sizes of chunks.” (Chave, 2012). “Adaptive streaming is valuable for many reasons including low web-based infrastructure costs, firewall compatibility and bit rate switching” (Salo, 2011).

HLS can distribute both live and on-demand files and it allows the receiver to adapt the bit rate of the media with the current network speed which helps to prevent the play-back from being interrupted, enabling the best quality. (Pantos, 2014.) HTTP Live Streaming also provides for media encryption and user authentication over HTTPS, allowing publishers to protect their work. (Apple, iOS Developer Library, 2014.)

HLS works by breaking down video assets or streams into several small MPEG2-TS files of varying bit rates and set duration using a stream or file segmenter. The MPEG2-TS files are called “chucks” and they are usually 5 to 10 seconds long. The files are loaded onto an HTTP server together with a text-based manifest file with a .m3u8 extension that directs the player to additional manifest files for each of the en-coded streams. (Ozer, 2011.)

Companies like Adobe, Microsoft, RealNetworks and Wowza support HTTP Live streaming in multiple streaming servers. Even though HLS is based on iOS, the popu-

larity of Apple devices has led to the point where developers have increased the player side support for Android. (Ozer, Streaming Media, 2011)

5.1.4 Adobe HTTP Dynamic Streaming

HTTP Dynamic Streaming (HDS) is a streaming protocol provided by Adobe. HDS enables on-demand and live adaptive bitrate video delivery over HTTP connections. In the same way as RTMP, HDS operates with Flash, so it is mostly used for desktop environment.

Dynamic streaming allows users to deliver streaming video by dynamically switching among different streams with differing playback quality and size. This enables users to get the best possible experience in terms of their bandwidth and computer's hardware support. Dynamic streaming makes the streaming process smooth and seamless. Dynamic streaming automatically up- or downscales the quality of the stream to make the viewing experience smooth and buffering minimal. (Hassoun, 2010)

5.1.5 Microsoft Smooth Streaming MMS

Microsoft Smooth Streaming MMS is a streaming protocol designed by Microsoft. ISS Smooth streaming uses the MPEG-4 Part 14 (ISO/IEC 14496-12) file format as its storage and transport format. Smooth Streaming is part of Silverlight architecture and was developed in October 2008. Smooth streaming was demonstrated when Microsoft's media team created the on-demand and live streaming content fot the Beijing Olymics 2008. Smooth Streaming is acting like most of the adaptive streaming systems. The media content is segmented and those small chunks are delivered over the HTTP. (Salo).

> Specifically, the Smooth Streaming specification defines each chunk/GOP as an MPEG-4 Movie Fragment and stores it within a contiguous MP4 file for easy random access. One MP4 file is expected for each bit rate. When a client requests a specific source time segment from the IIS Web server, the server dynamically finds the appropriate Movie Fragment box within the contiguous MP4 file and sends it over the wire as a standalone file, thus ensuring full cacheability downstream.

> In other words, with Smooth Streaming, file chunks are created virtually upon client request, but the actual video is stored on disk as a single full-length file per encoded bit rate. This offers tremendous file-management benefits. (Zambelli , Microsoft corporation, 2009)

5.1.6 MPEG-DASH

MPEG DASH is the MPEG standardization of Dynamic Adaptive Streaming over HTTP. DASH is described by the ISO/IEC 23009-1 document. MPEG-DASH can be thought as an amalgamation of Apple HLS, Microsoft Smooth Streaming and Adobe HDS protocols. (Salo, 2012)

The basic functioning of DASH is really close to the other adaptive streaming protocols. The available stream content is sent to the player in a manifest file, which in DASH is called the Media Presentation Description (MDP) packet in XML format. The MPD file is comparable to the HLS m3u8 file, the smooth streaming manifest file or a HDS f4m file. When the manifest file is delivered, content is downloaded to clients over HTTP. The content is sent as a sequence of video files that are played back contiguously. MPEG-DASH offers live and on-demand content delivery, time-shift services and targeted ad insertion. (Salo, 2012)

Comparing different protocols

The basic functions of the protocols are quite similar, but there are differences in some of the functions.

Table 1 Comparison of streaming protocols based on (encoding.com, 2013)

	3GPP/MPEG-DASH	**Apple HTTP Live Streaming**	**Microsoft smooth streaming**	**Adobe HTTP Dynamic Flash Streaming**
Type	Open, standards-based	Single-vendor controlled	Single-vendor controlled	Single-vendor controlled
Source video codecs	H.264	H.264	H.264, VC-1	H.264, VP6
Source Audio codecs	AAC	AAC, MP3	AAC, WMA	AAC, MP3
Package/segment format	MP4 fragments + MPEG-2 TS	MPEG-2 TS	MP4 fragments	MP4 fragments
File storage on server	Contiguous or individual per segment	Individual file per segment (pre iOS 5.0)	Contiguous	Contiguous
Audio/video/text packaging	Multiplexed or separate segments for audio video	Multiplexed in 1 segment (pro iOS 5.0)	Multiplexed in 1 segment	Multiplexed in 1 segment
Segmentation and delivery	Multiple vendors. Standard HTTP or Streaming server	Multiple vendors. Standard HTTP or Streaming server	MS IIS	Adobe interactive Server
Playback	3GPP-Rel 9 or MPEG clients	Apple iOS, QR X	Silverlight	Flash, Air
Protection	Flexible	AES-128 encryption	PlayReady	Flash Access
Typical segment duration	Flexible	10 sec	2-4 sec	2-4 sec
Adaptation control	Client	Client	Client	Client

Table 1 shows some of the important details with streaming protocols and compares the basic features of MPEG-DASH, APPLE HTTP Live streaming, Microsoft Smooth Streaming and Adobe HTTP Dynamic streaming. Table 1 shows that the biggest differences between the protocols are with playback and protection. MPEG-DASH uses 3GPP-REL 9 or MPEG clients for playback. Apple's HTTP Live streaming is counting on Apple's own iOS players. Microsoft supports Silverlight for playback and Adobe

HTTP Dynamic streaming supports Flash and Air player. The protection is making the difference between the protocols, so that the MPEG-DASH protection is flexible. HTTP Dynamic streaming is handling the protections so that only Flash has an access to the stream. Smooth streaming is using Microsoft's own content protection tool PlayReady, which includes encryption, output protection and Digital Rights Management (DRM). As the table 1 shows, the segment duration varies between the protocols. MPEG-DASH is the only one that has flexible segment duration. Smooth streaming and dynamic streaming have 2-4 seconds and the longest time is with Apple HTTP live streaming that has segment duration time of about 10 seconds.

5.2 Codecs

William dictionary sums the meaning of a codec like this:

> A set of equipment that encodes an analogue speech or video signal into digital form for transmission purposes and at the receiving end decodes the digital signal into a form close to its original. (Collins, 2015.).

Codecs are compression technologies with two components; an encoder to compress files and decoder to decompress.

A codec can be lossless or lossy. Lossless codes reproduce exactly the same file, as the origina; lossless codecs will loose some of the information during the process. Lossless codecs are not working so well with video streaming since they cannot compress video to data rates low enough for streaming. (Ozer, 2011.) (Morrison, 2014.)

5.2.1 H.264

H.264 is a popular video codec standard that is nowadays one of the most commonly used video compression formats. The very first ready version of H.264 was completed in 2003. It is also known as AVC that stands for Advanced Video Coding; MPEG-4 Part 10. H.264 is a video codec that can reach high quality video in relatively low bitrates. A codec that is based on the H.264 standard compresses a digital video file in a way that it is only using half of the space MPEG-2 does and is reaching the same quality video. H.264 is offering the same HD quality but taking only half of the space the old codecs such as MPEG2, MPEG4, DivX and XviD take.

> “It was jointly developed by the Video Coding Experts Group (VCEG) of the ITU-T and the Moving Picture Experts Group (MPEG) of ISO/IEC. It uses state-of-the-art coding tools and provides enhanced coding efficiency for a wide range of applications, including video telephony, video conferencing, TV, storage (DVD and/or hard disk based, especially high-definition DVD), streaming video, digital video authoring, digital cinema, and many others” (Sullivan, 2004)

H.264 was maintained by two different organizations, which are together known as Joint Video Team (JVT). MPEG-4 Part 10 is an ISO/IEC standard that was developed in co-operation with ITU which is strongly involved in broadcasting television standards. ITU is designating the standard H.264, the MPEG-4 Part 10 video is sometimes referred to as either AVC of H.264. They both are valid.

H.264 is well known to be one of the encoding standards for Blu-ray discs. H.264 is also used when streaming Internet sources. The most well known sources are streaming videos from Vimeo, YouTube and the iTunes store. Adobe Flash Player and Microsoft Silverlight are also using H.264. Also various HDTV broadcasts, cable and satellite are working with H.264.

H.264 is normally used for lossy compression. H.264 also makes it possible to create lossless encoding, but that is not as common because normally the amount of loss when using lossy compression is imperceptible and the file size difference is very large between lossless and lossy. (Sullivan, 2004.)

5.2.2 H.265

H.265 is a developed version of H.264 and it was finalized in spring 2013, which makes it the latest generation video compression standard. High Efficiency Video Coding (HEVC) and ISO/IEC 23008-2 MPEG-H Part 2 are also know as H.265, because the standard was developed together the ISO/IEC Moving Picture Experts Group (MPEG) and ITU-T Video Coding Experts Group (VCEG) through their Joint Collaborative Team on Video Coding (JCT-VC). (Morrison, 2014)

H.265 provides superior video quality and up to twice the data compression as the previous standard H.264/MPEG-4 AVC. H.265 can support 8K Ultra High Definition video, with a picture size up to 8192×4320 pixels. (Morrison, 2014)

5.2.3 VP8

VP8 is an open source video compression format supported by a consortium of technology companies. ON2 Technologies, who released VP8 in September 2008, originally developed it. Google started a new media project called “WebM” in May 2010. The project was dedicated to developing a high-quality media format that is free to be used by everyone. This project included a new open source video compression format, VP 8. (Bankoski, 2010.)

VP8 has always had the focus of being a compression format for Internet videos, and that is why there are several things that make it a strong protocol for Internet use. VP8 has low bandwidth requirements and that is why it was “designed to operate mainly in a quality range from ‘watchable video’ (~30dB in the PSNR metric) to ‘visually lossless’ (~45dB)” as an article called “Technical overview of VP8, an open source video codec for the web” explains. (Bankoski, 2010.) VP8 has several technical innovations, such as hybrid transform action with adaptive quantization. VP8 uses 4x4 block-based discrete cosine transform action for all luma and chroma residual signals. VP8 is a block-based codec, which means that to encode a video frame it divides the frame into smaller segments, which are called macroblocks. Within every single macroblock, the encoder can predict redundant motion and color information based on previously processed blocks. To get more efficient compression, the redundant data can be subtracted from the block.

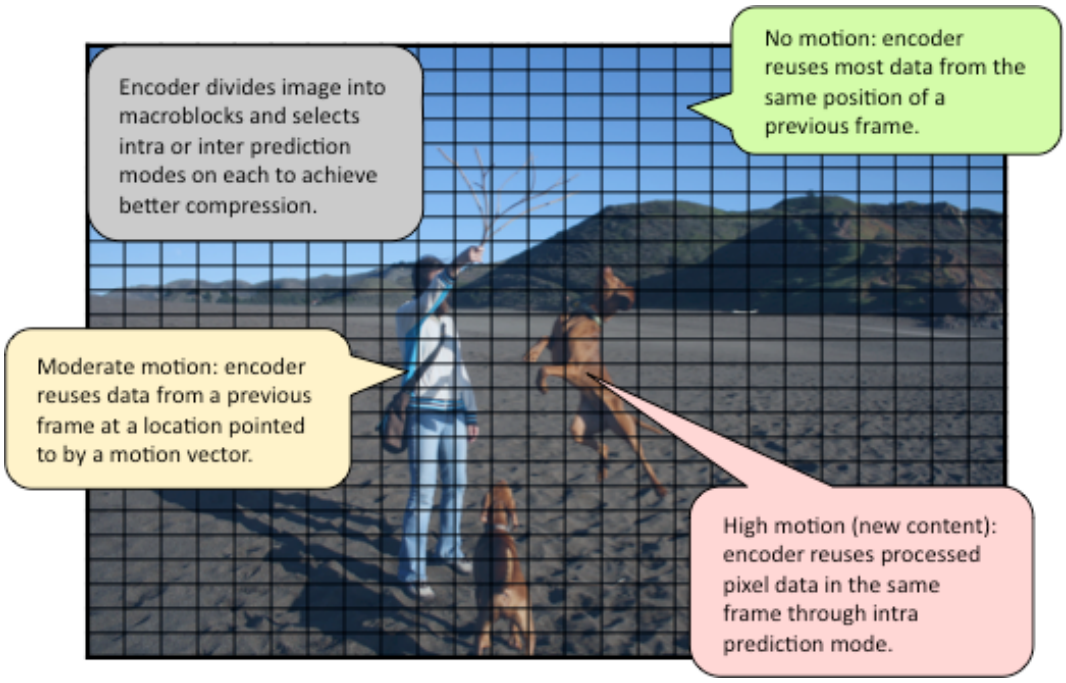


Figure 16. Basic functions of VP8. (Xu, 2010.)

Figure 16 explains how VP8 works. First the encoder divides the image into macroblocks, which are shown as rectangles. The VP8 encoder is using two classes of prediction. Intra-prediction is a method where the data within a single video frame is used and inter-prediction uses data from previously encoded frames. When video has a macroblock that has no motion, as in the figure 16 in which the sky stays the same, the encoder reuses most of the data from the same position of a previous frame. If a macroblock notices moderate motion, as in figure 16 in the place where the man stands, the encoder reuses the information from the previous frame at the location pointed to by a motion vector. When the video frame has fast movement, like in figure 16 where the dog is jumping, the encoder reuses processed pixel data in the same frame through intra-prediction mode. (Xu, 2010.)

5.2.4 VP9

VP9 is an open source and royalty free video codec that was developed by Google as a successor to VP8. Google integrated VP9 support into the Chrome browser and Youtube. The VP9 video format is also supported in Mozilla Firefox and Opera in the HTML5 video tag and the VLC player version 2.1.2. VP9 has many improvements compared to VP8. One of the main things that make VP9 the codec for the future is that it supports 8K content. (Kelly, 2014)

6 Streaming and Broadcasting Programs

6.1 Streaming Softwares

Streaming can be done with the help of different streaming softwares. Next chapers are telling more about five of them. These softwares were picked, because they cover different operating systems and they are softwares that support video mixing without separate hardware.

6.2 Telestream Wirecast

Telestream's Wirecast is a tool for live streaming a video production. Wirecast gives an opportunity to create, stream and record video for the web. Telestream Wirecast is working with both Windows and Mac operating systems and allows a user to create live stream or on-demand content for the web.

Wirecast is a tool that includes all the basic video mixing and recording tools needed, but without hardware. It is a program that has controls for video switching and audio controlling inside the screen. Telestream's Wirecast allows the user create professional looking real-time multi-camera streams and recordings.

Telestream has published (2015) the newest version of the software, Wirecast 6. It allows the user to create even a wider scale production.

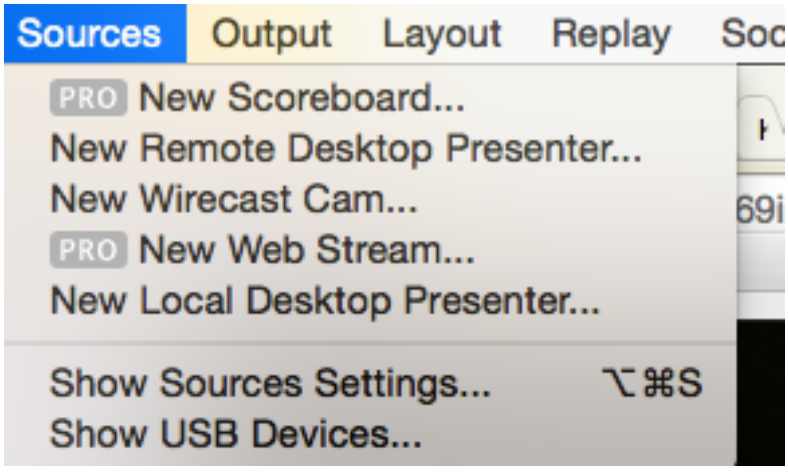


Figure 17. Screenshot of Wirecast source options. Screenshot. (Wirecast)

As seen in figure 17, Wirecast allows the user to capture the content in many different ways. Wirecast supports USB, Thunderbolt, SD/HD SDI and HDMI cameras. Wirecast allows the user also to stream via wireless cameras with an IP camera system or through Wirecast Cam that is software to use other devices such as smartphones as production cameras. Wirecast supports multiple different capture cards from Blackmagic design, Matrox and Epiphan. Telestream Wirecast has a professional version that allows capturing from RTMP stream and other web streams.

On their website Telestream lists multiple actions that can be done with Wirecast, such as live compositing with multiple layers, live switching, titles, lower thirds, transitions, chroma key, picture-in-picture, mix audio, audio delay, replay (Pro), create playlists, Twitter feeds, animated 3D titles with NewBlue titler pro live for Wirecast ($299), live scoreboards (Pro), integration with Sportzcast live, scoreboards (Pro) and 3D virtual sets (Pro)

The content can be streamed to a private channel or to live streaming services, such as YouTube, Ustream, Wowza and Akamai. The encoding is done with x264, H.264, Flash, ProRes, MJPEG, WMV and RTMP streaming protocol, RTP for multi- and unicast and MMS (Windows) can be used with Wirecast.

	Wirecast Studio $495	Wirecast Pro $995
Capture your sources	Buy Buy	Buy Buy
Unlimited number of input sources: Cameras, capture cards,Desktop Presenter, NEW! Twitter feed, Live U portable backpack	✓	✓
NEW! Wirecast Cam iOS 8 app – FREE Download the app and use any iPhone (4S or newer) or iPad on your Wifi network as an ingest source into Wirecast.		
Added input sources: Teradek Cube, IP Cameras, Web streams (RTMP, MMS, HTTP), NEW! custom scoreboard graphics		✓
NEW! NewBlue Titler Pro Live Option – $299 Animated 3D titles for Wirecast	Buy Buy	
Firewire HDV Option – $99 Input support for HDV cameras	Buy Buy	✓
Produce your show		
Powerful production tools: Lower thirds, transitions, NEW! playlists, chroma key & more	✓	✓
Added Pro-level production tools: Live scoreboards, NEW! replay, virtual sets, advanced audio controls		✓
Stream it live		
Encode to multiple formats for streaming and recording: Flash & MainConcept (H.264 & x264), WMV, ProRes, MJPEG	✓	✓
Add a delay to your stream: Delay your streamed broadcasts to add a buffer between your live stream and broadcast	✓	✓
Stream to multiple destinations: Streaming servers, streaming platforms & CDNs, record to disk, Broadcast to external monitors	✓	✓
Virtual Camera and Microphone output: Wirecast video and audio output can be picked up as a source in other devices or software.	✓	✓
Program feed output to Blackmagic Design: Take your Wirecast feed out directly to Blackmagic Design Intensity or DeckLink capture cards.		✓
Premium Support	$99/year	$199/year
Priority response, telephone support, Remote Access services	Add Premium Support	Add Premium Support

Figure 18. Wirecast studio and Wirecast Pro comparison. (Telestream, 2015.)

The difference between Wirecast Studio and Pro versions (see figure 18) is that the Pro version allows more input sources, such as IP cameras, RTMP and HTML web streams. The pro-version transmits the wirecast feed directly to Blackmagic design intensity or DeckLink capture Cards. Pro version has replay option, live scoreboards and better audio control system.

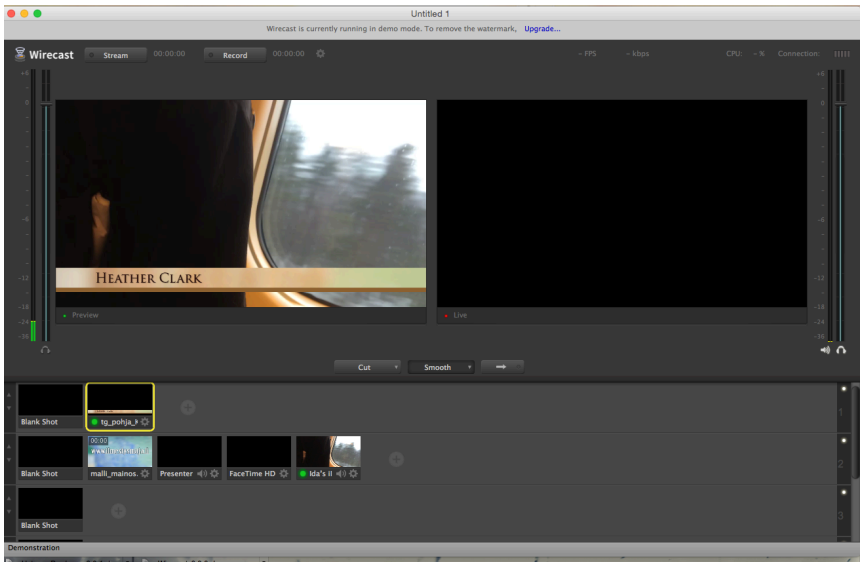


Figure 19. Screenshot of Wirecast layout. Screenshot. (Wirecast)

The software looks clean and informative (see figure 19). The layout can be modified based on the users' needs. The basic look includes a preview picture, a program picture, video mixing buttons, cut/smooth, simple audio analyzing tools and added content shared to multiple layers.

The software uses layers in the same way as any photo editing software. Videos, name tags, audio and other content can be added to separate layers so that they are shown in the video in a specific order. Some are on the back and others like nametags are added on top of everything. This gives a possibility to handle the shots and content in a faster and organized way.

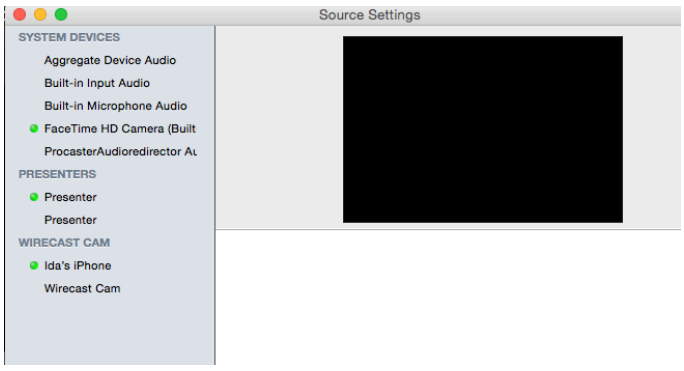


Figure 20. Screenshot of Wirecast source settings. Screenshot. (Wirecast.)

Wirecast can use multiple input sources (see figure 20) and they are easy to add to the software. The different types of input sources can be used in one video production

without problems. Wirecast supports multiple input sources, such as USB cameras, IP cameras and desktop presenter. They all can be added to the video production with one click.

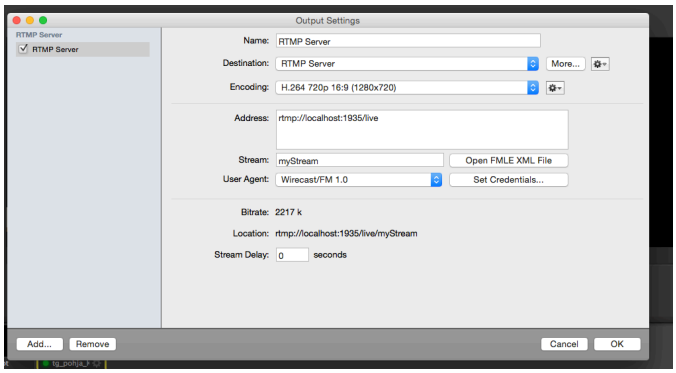


Figure 21. Screenshot of Wirecast output settings. Screenshot. (Wirecast.)

As seen in figure 21, Wirecast lets the user to configurate the output settings based on the user's need. The destination can be a RTMP server, or one of the automatically given ones such as Bamboozer, Akamai or YouTube as an example. Multiple different encoding options are given based on the streaming server that has been chosen. In the example in the figure 21, where the streaming destination is RTMP server, the encoding is set to be H.264 720p 16:9. Other H.264 based encoding presets are also supported.

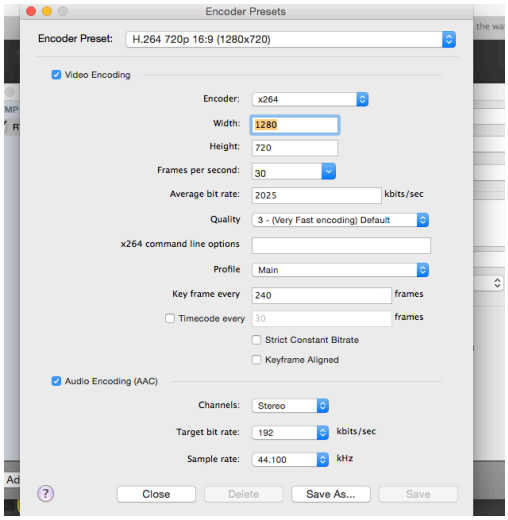


Figure 22. Screenshot of Wirecast encoder presets. Screenshot. (Wirecast.)

If needed, the video and audio encoding can be modified even more in detail under encoder preset (see figure 22).

Wirecast is diverse streaming software, that allows streaming to multiple different streaming providers. It is easy to use and can be used for videomixing.

6.3 Ustream Producer

Ustream is a streaming server service where people can add their own video stream and it can be viewed all over the world. UStream.TV is a stream service that allows users to stream a video for the web through the Ustream stream service website by using separate streaming software. Ustream producer is Ustream's own software that allows a user to add multiple cameras to their production and to create a ready content to be streamed to Ustream.TV. The Ustream software streams HD live broadcasts without advertizing. Broadcasts can be recorded and archived to the server for a certain amount of time depending on the contract. The Ustream stream can be viewed from multiple different devices and the stream can be easily embedded as an HTML5 player to any website.

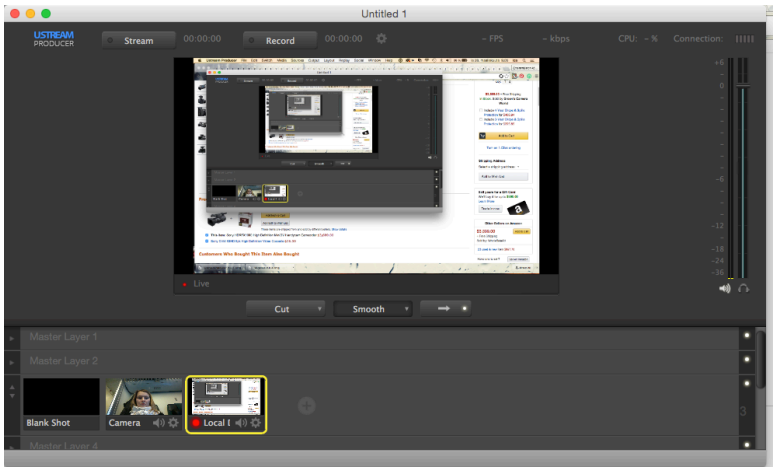


Figure 23. Screenshot of Ustream layout. Screenshot. (Ustream)

The Ustream producer has a similar look (see figure23) and tools as Telestream Wirecast with some exceptions. It is simpler and does not include preview audio monitoring and only one layer is available on the basic version. The only output option is to stream to Ustream.TV, so this software can be used only when streaming through Ustream servers. (Ustream)

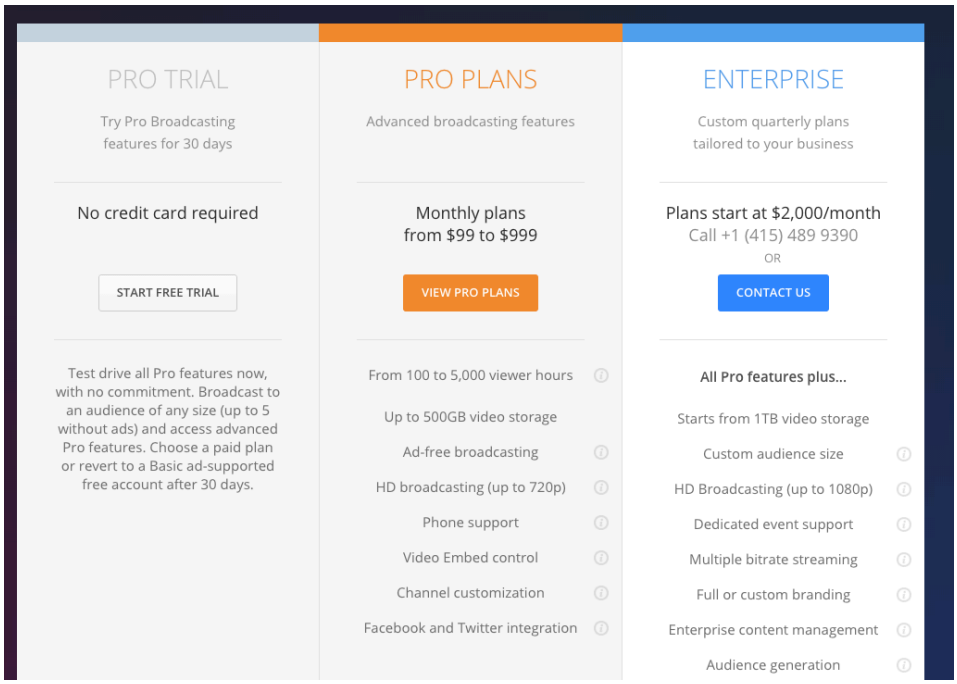
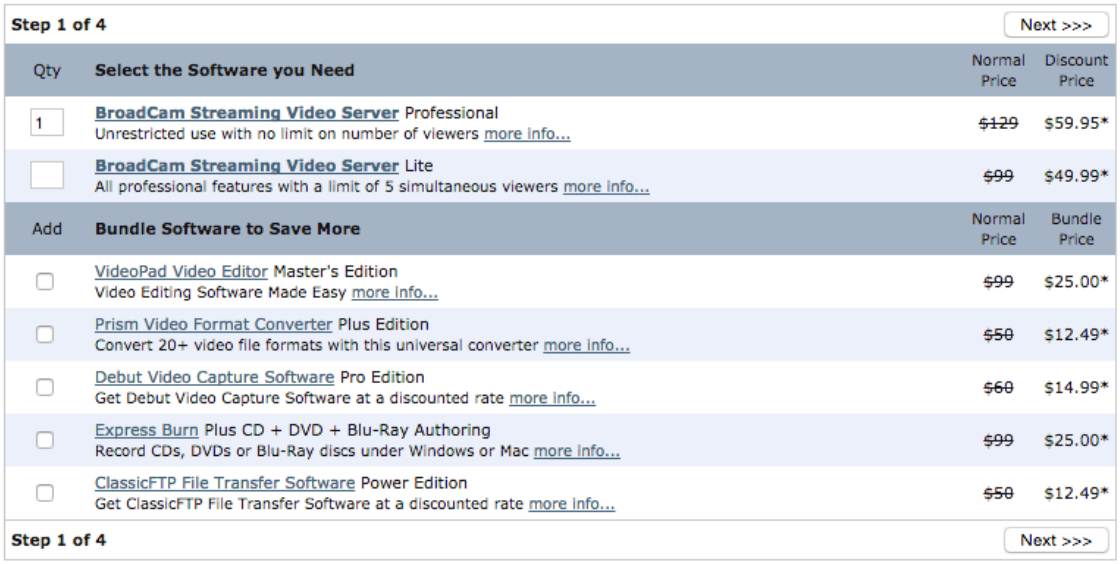


Figure 24. Screenshot of Ustream plans. Screenshot. (Ustream)

The Ustream producer has three categories that can be used (see figure 24). Trial is free and can be tested for 30 days. Pro Plans are for regular users and the price varies depending on the amount of watchers and the streaming time. With less use the price is 99 dollars per month, and the price it can grow to 999 dollars per month. Enterprise is a plan that is tailor made for companies. It offers for example HD broadcasting and has 1TB video storage. The price starts from 2000 dollars per month.

6.4 BroadCam Video Streaming Software

BroadCam is only available to Windows operating systems. The software allows a user to stream video content from the computer and host any number of pre-recorded videos. Input sources that can be used with BroadCam are network IP cameras or webcams.



Step 1 of 4 — Next >>>

Qty	Select the Software you Need	Normal Price	Discount Price
1	**BroadCam Streaming Video Server** Professional Unrestricted use with no limit on number of viewers more info...	~~$129~~	$59.95*
	BroadCam Streaming Video Server Lite All professional features with a limit of 5 simultaneous viewers more info...	~~$99~~	$49.99*
Add	**Bundle Software to Save More**	**Normal Price**	**Bundle Price**
	VideoPad Video Editor Master's Edition Video Editing Software Made Easy more info...	~~$99~~	$25.00*
	Prism Video Format Converter Plus Edition Convert 20+ video file formats with this universal converter more info...	~~$50~~	$12.49*
	Debut Video Capture Software Pro Edition Get Debut Video Capture Software at a discounted rate more info...	~~$60~~	$14.99*
	Express Burn Plus CD + DVD + Blu-Ray Authoring Record CDs, DVDs or Blu-Ray discs under Windows or Mac more info...	~~$99~~	$25.00*
	ClassicFTP File Transfer Software Power Edition Get ClassicFTP File Transfer Software at a discounted rate more info...	~~$50~~	$12.49*

Step 1 of 4 — Next >>>

Figure 25. Screenshot of Broadcam software prices (NCH Software, 2014.)

BroadCam can be bought with two different kinds of versions (see figure 25), Broad-Cam Streaming Video Server Lite or BroadCam Streaming Video Server professional. Lite has limited the amount of viewers that can watch simultaneously so that only five people can watch at the same time. The professional version does not limit the amount of viewers.

BroadCam is offering a free version for its customers if the customer is adding a link to the BroadCam website http://www.nchsoftware.com/broadcam/ next to the video stream.

6.5 Livestream

Livestream is a website to broadcast and watch live events. The Livestream team says that their mission is “To democratize live video broadcasting and provide the tools to bring every event live online” (Livestream, 2014). The Livestream corporation was founded 2007 and has developed so that they have 40, 000, 000 viewers to watch livestream events on their website every month.

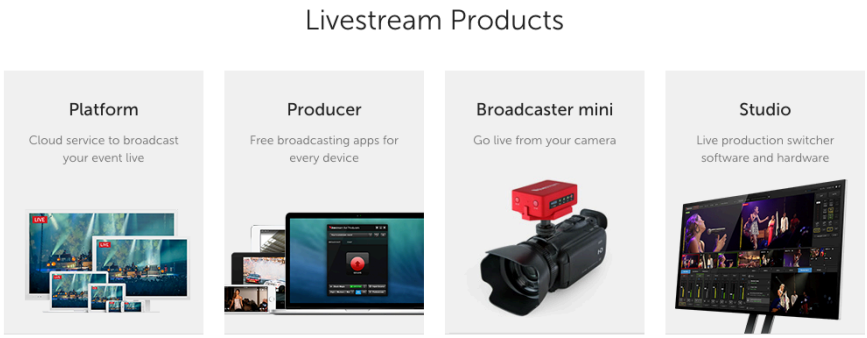


Figure 26. Screenshot of Livestream products. Screenshot. (Livestream)

Figure 26 shows the livestream products. Livestream offers four stages or deals for streaming producers. The Livestream platform is a cloud service for broadcasting. The platform has password protection and possibility to control where the content is shown. With the platform, it is possible to record the stream files in the cloud and have access to audience information analytics.

The Livestream producer offers broadcasting applications to multiple devices. Livestream Boadcaster Mini is a small device that can be attached to a camera to livestream straight from the camera. Livestream studio is live production switcher software and hardware.

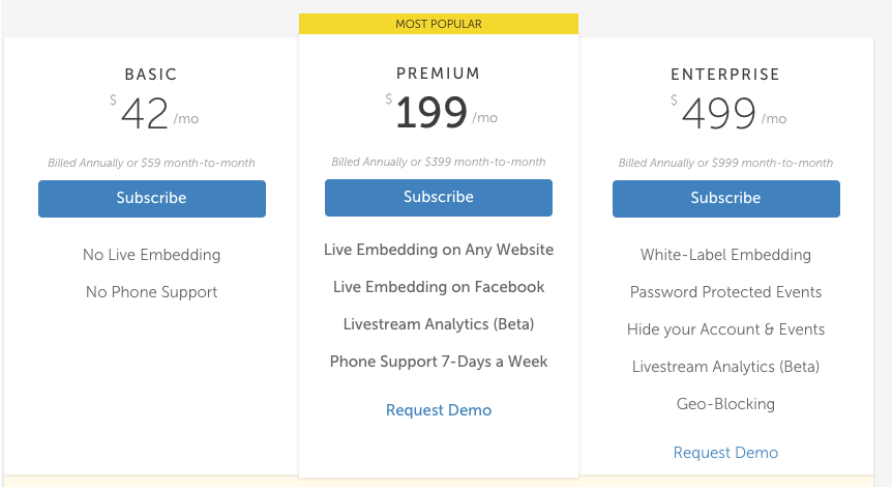


Figure 27: Screenshot of Livestream's most popular deals. Screenshot. (Livestream)

Livestream can be bought as three different deals (see figure 27). The basic deal cost $42 per month and has no live embedding possibility or phone support. The premium deal is $199 per month and includes live embedding on websites or Facebook. The

enterprise deal is for people and organizations needing password protection for streaming events. Enterprise deal costs $499 every month.

7 Players and Embedding

7.1 HTML5

HTML is markuplanguage that is developed by World Wide Wb Consortium. The HTML4 was standardized in 1997 and after long season of developing W3C published the newest revision of the HTML standard called HTML5 in October 2014.

HTML5 is an HTML standard that includes support for embedding multimedia, such as video and audio and dynamic graphics. Multimedia can be embedded to the page with the <video> tag. HTML5 allows the developer to add video to the page in the same way they are used to adding pictures.

HTML5 allows video to be embedded to the page without using a third party video player, such as Flash Player, Silverlight or Quicktime.

Element					
<video>	4.0	9.0	3.5	4.0	10.5

Figure 28. HTML5 browser support (W3Schools)

Figure 28 shows which versions of the browsers support <video> tag. These versions started to support HMTL5 video: Chrome version 4.0, Internet Explorer version 9.0 Firefox version 3.5, Safari version 4.0 and Opera version 10.5.

HTML Video - Browser Support

Currently, there are 3 supported video formats for the <video> element: MP4, WebM, and Ogg:

Browser	MP4	WebM	Ogg
Internet Explorer	YES	NO	NO
Chrome	YES	YES	YES
Firefox	YES	YES	YES
Safari	YES	NO	NO
Opera	YES (from Opera 25)	YES	YES

Figure 29. HTML Video Browser support (W3Schools)

HTML5 is widely working with different browsers and platforms (see figure 29). It is one of the methods that have excellent support for mobile phones. HTML5 is not only letting the developer to embed a video to the web, but it is also supporting audio and video streaming. There is a discussion going on about the safety of HTML5 and videos, because it is easier to steal content from the HTML5 player than it is to copy from a Flash player. It is a problem that hopefully will be taken care of in the near future.

Because iOS devices are not supporting Flash players, one way to reach the users of iOS devices is to use HTML5 players, since that is supported with iPad and other iOS based devices. (Dreier, 2010)

Embedding a video file with HTML5 is surprisingly simple. Listing 1 provides of how W3School is teaching how to use HTML5 with videos (W3Schools).

```
<video width="320" height="240" controls>
  <source src="movie.mp4" type="video/mp4">
  <source src="movie.ogg" type="video/ogg">
  Your browser does not support the video tag.
</video>
```

Listing 1. HTML5 embedding code. (W3Schools)

The result is a video that has a control bar and that is embedded on a webpage. HTML5 allows the developer to design the player. HTML5 has multiple different attributes to change for example the player color and controls, such as autoplay, preload, poster and loop. Because the <video> element is just another HTML element it can be styled like other HTML elements. HTML5 allows the developer to add borders, set opacity, apply a filter and do 3D transform actions on the video. As an example, a video can be turned into a black and white vide by applying grayscale(100%) filter to the video element. (LePage, 2010)

Here is an example of how to write HTML5 code when doing Cupertino streaming.

```
<Html>
            <head>
            <title> Cupertino streaming </title>
            <head>
<body>
            <video controls
src=http://[address]:1935/live/myStream/playlist.m3u8>
            </video>
</body>
</html>
```

Listing 2. HTML5 and Cupertino streaming. (W3Schools).

7.2 Flash player

Adobe Flash player was created by Macromedia, but it is developed and distributed by Adobe Systems Inc. It is used to execute rich Internet applications, view and stream video, audio and multimedia on a computer or another supported device.

Flash player runs SWF files and supports several data formats such as XML, JSON, AMF and SWF. Adobe Flash player supports many other multimedia formats, such as mp3, FLV, PNG; JPEG, GIF and RTMP.

7.3 Video.js

Video.js is an open source HTML5 and Flash player that supports video playback on desktops and mobile devices. Video.js is a project that was started in mid-2010, and the player is now used on over 100,000 websites. It is a CSS and JavaScript library that is made to help developers to build and work with HTML5 video. Another name for Video.js is HTML5 video player. Video.js helps to control skin built in HTML/CSS. Video.js fixes cross-browser inconsistencies and adds features like full screen and subtitles. It manages the fallback to Flash or other technology when HTML5 is not supported. Video.js provides coherent JavaScript API for interacting with the video. (Brightcove Inc.)

Video.js can be downloaded and hosted on the developer's own servers, or the free CDN hosted version can also be used.

```
<link href="//vjs.zencdn.net/4.12/video-js.css" rel="stylesheet">
<script src="//vjs.zencdn.net/4.12/video.js"></script>
```

Listing 3 Example code to embed video.js to the website (Brightcove.)

Listing 3 is an example of the code for embedding video.js player to the website. The videojs.com website has a link where the files can be downloaded. When using the CDN as a hosting server, this (listing 3) code needs to be added to the code.

If hosting everything in own server systems, this is the code pasted on the HTML.

```
<link href="//example.com/path/to/video-js.css" rel="stylesheet">
<script src="//example.com/path/to/video.js"></script>
<script>
  videojs.options.flash.swf = "http://example.com/path/to/video-
js.swf"
</script>
```

Listing 4. Video.js code. (Brightcove)

To add videos to the website, the videos should be in three different formats to cover all the devices; mp4, webm and ogg.

```
<video id="example_video_1" class="video-js vjs-default-skin"
  controls preload="auto" width="640" height="264"
  poster="http://your-website.com/video1.png"
  data-setup='{"example_option":true}'>
 <source src="http://your-website.com/video1.mp4" type='video/mp4' />
 <source src="http://your-website.com/video1.webm" type='video/webm' />
 <source src="http://your-website.com/video.ogv" type='video/ogg' />
</video>
```

Listing 5. Video.js source code to add different formats. (Brightcove)

7.4 JW Player

JW Player is an HTML5 and Flash video player that is a full-featured player with on-the-fly mode selection. It is offered being used for totally free and it has all the main player functionality, such as playlists, skinning and scripting. JW Player is supported on

the most popular desktop browsers and mobile devices. All HTML5 and Flash features are supported on Chrome, Firefox, Internet Explorer 9, Safari and Opera. In the mobile world, JW Player supports iOS devices and Android devices in HTML5. The mobile version always offers videos on full screen mode and JW Player uses a video controlling system that is provided by the devices so that they are optimized for the touch.

When there are some devices that do not support either Flash or HTML5, JW Player uses Download Fallbacks, which means that the player generates a formatted link with the video's poster image and a play button on top of it. By clicking the link, the video starts playing on the device's build-in media player.

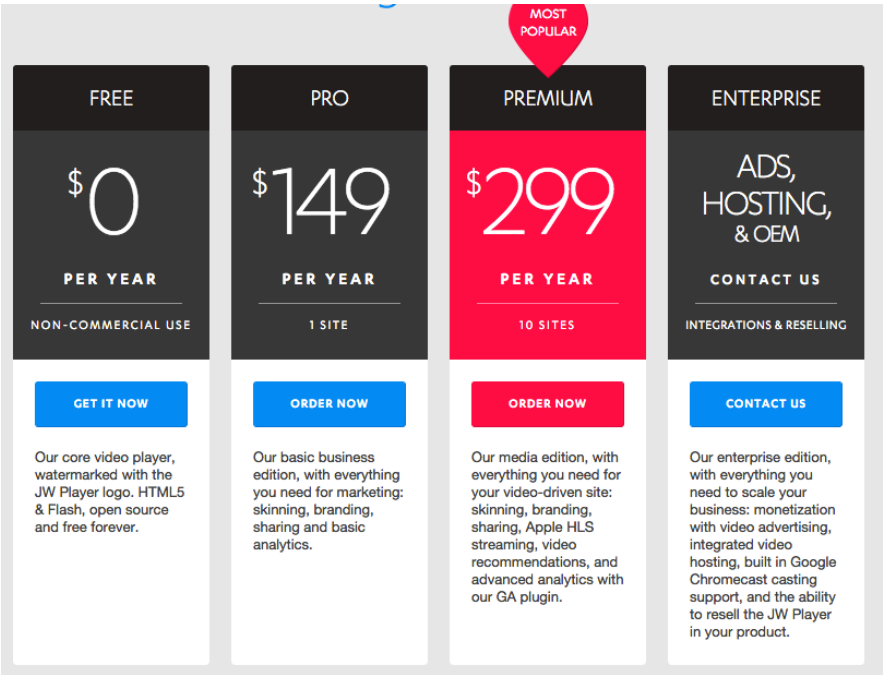
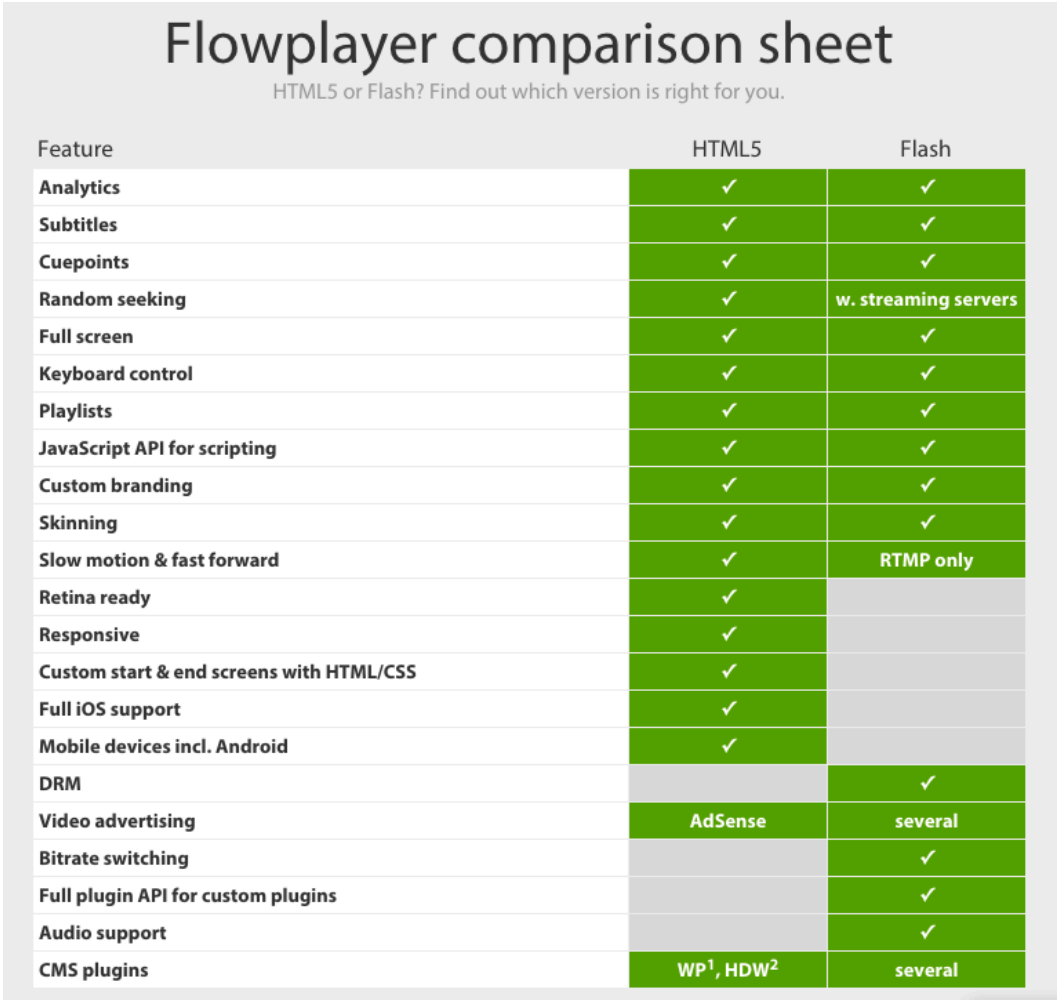


Figure 30. JW Player's four different versions. (JWPlayer)

JW Player can be bought in four different categories (see figure 30). The free version is offered for non-commercial use and has JW Player's logo on it. The pro version costs $149 per year and can be used for one site. It is a basic business edition that has all the marketing, skinning, branding, sharing and basic analytics options. JW Player's most popular version is the premium version that costs $299 per year. It allows the player to be used on ten different websites and has the same possibilities than the pro version, but also some extra. The premium version supports Apple HLS streaming and video recommendations, for example.

7.5 FlowPlayer

FlowPlayer has two video players, one that works with HTML5 and another one with Flash. FlowPlayer is advertising itself as a minimalistic player that is the smallest player in the market (JavaScript 38kB, Flash 7kB, CSS 24kB and jQuery 95kB).



Flowplayer comparison sheet

HTML5 or Flash? Find out which version is right for you.

Feature	HTML5	Flash
Analytics	✓	✓
Subtitles	✓	✓
Cuepoints	✓	✓
Random seeking	✓	w. streaming servers
Full screen	✓	✓
Keyboard control	✓	✓
Playlists	✓	✓
JavaScript API for scripting	✓	✓
Custom branding	✓	✓
Skinning	✓	✓
Slow motion & fast forward	✓	RTMP only
Retina ready	✓	
Responsive	✓	
Custom start & end screens with HTML/CSS	✓	
Full iOS support	✓	
Mobile devices incl. Android	✓	
DRM		✓
Video advertising	AdSense	several
Bitrate switching		✓
Full plugin API for custom plugins		✓
Audio support		✓
CMS plugins	WP[1], HDW[2]	several

Figure 31. FlowPlayer comparison. (Piirainen)

Because FlowPlayer is offering HTML5 and Flash video players (see figure 31), it is well supported on most of the devices. It has a fluid layout and lets the developer to create custom start and end screens. FlowPlayer also has a set of other functions such as Google Analytics, cuepoints, native fullscreen option, keyboard shortcuts, subtitles in CSS, a slow motions option and random seeking. It allows creating playlists and the quality can be retina ready.

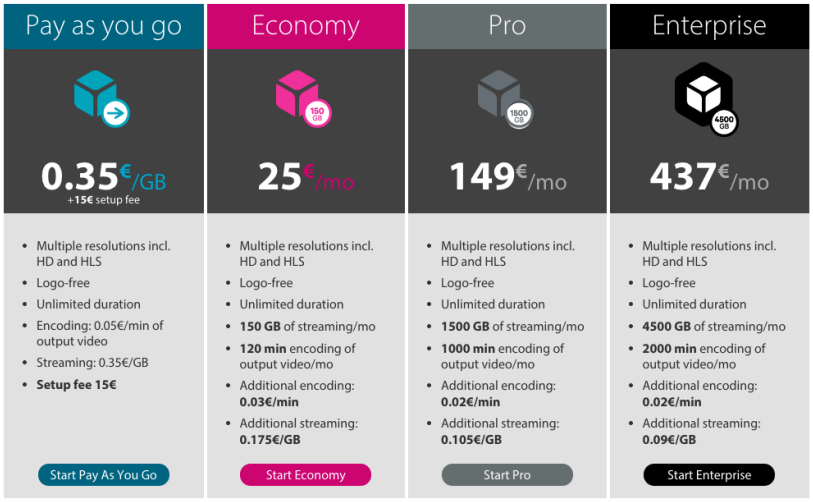


Figure 32. Screenshot of Flowplayer deals. Screenshot. (FlowPlayer)

FlowPlayer offers four different deals (Piirainen) (see figure 32). It is offered also as a free version, but that offers only an unlimited number of videos with maximum duration of four minutes, 5 Gb of streaming per month, and it has the FlowPlayer logo on the bottom corner of the player. The first thing to do is to decide how much streaming is done in a month. The economy deal offers 150 Gb of streaming per month and 120 minutes of encoding of output video every month. The pro version offers 1500 GB of streaming and 1000 minutes of encoding of output video. Additional streaming costs €0.105 per GB. The enterprise version is much bigger and also offers much more streaming (4500 GB pre month) and other possibilities. Flowplayer can also be bought as “pay as you go” plan, where it is paid (after paying the setup fee) only for the amount used. (Piirainen.)

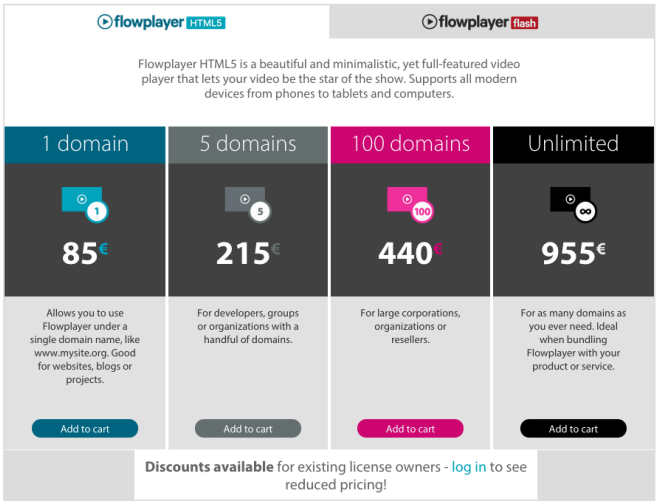


Figure 33. Screenshot of Flowplayer prices (Flowplayer)

The next thing to decide is how many domains are being used. Prices start from one domain for €85 until an unlimited amount of domains for €955 (see figure 33).

8 Quality of Services

8.1 Bandwidth

Bandwidth is one of the factors affecting how well the stream is sent forward to the client and how the client is going to enjoy the stream. Bandwidth is the amount of data that can be carried from a point to another in one second of time. The synonym for bandwidth is data transfer rate, which explains the meaning maybe more clearly. Network bandwidth is a measurement that is expressed in bits per second (bps). There are many websites that are calculating the network speed and bandwidth from the current Internet connections, for example speedtest.com. The website searches for the closest server and sends the ping there to measure latency and transfers testdata to measure the download and upload speed of the connection. When checking the bandwidth for streaming purposes, the upload speed is the one that matters for the one sending the stream forward.

Different applications and actions require different amount of bandwidth. According to Margaret Rouse's article, "An instant messaging conversation might take less than 1,000 bits per second (bps); a voice over IP (VoIP) conversation requires 56 kilobits per second (Kbps) to sound smooth and clear. Standard definition video (480p) works at 1 megabit per second (Mbps), but HD video (720p) wants around 4 Mbps, and HDX (1080p), more than 7 Mbps." (Rouse, 2014)

When defining the bitrate that is needed, it is wise to leave about 25% of the upstream unused. When the upload speed is for example 2Mbps, the stream bitrate should be around 1500Kbps. This leaves room for the occasional burst of data from the codec.

It is important to notice that the upload speed can change during the day, depending on the amount of the users online at the same time. The best and most accurate results are achieved when the tests are done around the same time of the day when the streaming is going to be done. Before deciding what the bitrate (Piirainen, -) going to be, it is good to remember that if the bitrate is set to be A, the viewers will need a download speed of approximately A + 500Kbps to get an enjoyable streaming experience. Here are some example bitrates that should give out a nice looking stream.

25 Frames per second, 480p (resolution 720*480): bitrate 750-1000Kbps
25 Frames per second, 720p (resolution 1280*720): bitrate 1500-3000Kbps
25 Frames per second, 1080p (resolution 1920*1080): bitrate 3000-5000Kbps

Bandwidth is a really important detail to take into account the get good-looking stream, but it is not the only factor that affects to the quality of the stream. Things like packet loss, latency and jitter are important details, and if they are not working properly they might give out an effect that looks like one is not having enough bandwidth. (Rouse, 2014)

The right amount of bandwidth can be calculated.
Example situation: 60minutes long program, 1000 viewers with 1500kbps bitrate.
The amount of bandwidth needed:
1500kbps*1000 = 1,500,000 kbps = 1 500 Mbps = 1,5 Gbps
1,500,000 kbps / 8 = 187 500 KBps

The amount of total data transfer for 60 minutes:
187 500 KBps*3600s= 675,000,000 kB
675,000,000 kB = 643,73 GB

Typical way of streaming service to charge the client is to charge not only for the bandwidth the live stream is taking, but also for the amount of data transfer. So the amount of viewers is affecting really much for the payments also.

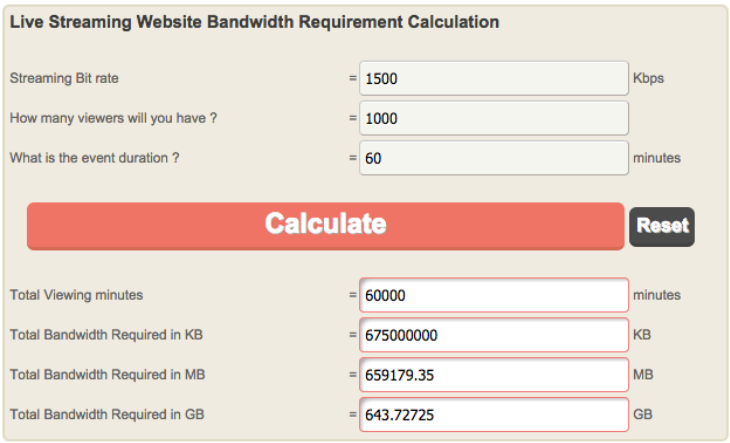


Figure 34. Bandwidth Calculator (EasyCalculation) .

Figure 34 intoroduces a typical banwidth calculator where the user can add the bit rate that is used and how long is the event. Based on those and the amount of viewers, the calculator tells the approximate amount of data transfer the live event is taking. This specific calculator misleads the user by naming the amount of data transfer as total bandwidth needed. But for average user, this is close enough, even though the word is not accurate.

8.2 CPU

CPU stands for central processing unit that is the most important element of a computer system in terms on computing power. The CPU is the part of a computer where most of the calculations are done. It is the heart and the brains of the computer.
For streaming purposes, the streaming computer is recommended to have at least a quad core processor to get good quality stream. Streaming is really much dependent on the CPU, so the graphic cards are not having that much impact. It is wiser to put some extra on the quality of the CPU, than to buy an expensive Graphics Processing Unit GPU. (R1CH, 2011)

8.3 Resolution

The resolution should be set so that it matches with the original source, or it is scaled down. If the video that is captured is 720p, the stream should be 720p, or if it needs to be scaled down, the quality can be set at 480p. The resolution of the video should never be scaled up for streaming. If the original video is captured at 720p and it is streamed at 1080p, there will be no gain in quality, but the stream is using more bandwidth than the video needs.

Here is an example list from google website about resolutions and what the recommended bitrates for each quality stages are.

1080p

- Resolution 1920x1080
- Video bitrates 3000-6000 Kbps, recommended 4500 Kbps

720p

- Resolution 1280x720
- Video bitrates 1500-4000 Kbps, recommended 2500 Kbps

480p

- Resolution 845x480
- Video bitrates 500-2000 Kbps, recommended 1000 Kbps

360p

- Resolution 640x360
- Video bitrates 400-1000 Kbps, recommended 750 Kbps

240p

- Resolution 426x240
- Video bitrates 300-700 Kbps, recommended 400 Kbps

(Google, 2015)

9 Creating a Live Streaming System with Wirecast and Wowza Server

9.1 Setting up the Streaming System

Project client is a small society that wants to live stream their meeting to their members around Finland. The society wants to get a streaming system that is cost-efficient, not using streaming providers and watchable from different devices. Because the main focus on the streaming is to stream music and players, there needs to be multiple cameras. The quality of the cameras should be at least SD, but preferably HD.

This example system is based on Telestream's Wirecast, Wowza Streaming services and JW Player. This setup is easily scalable in the future if needed, which was one of the requirements for the project.

Wirecast was chosen, because it is a more cost-efficient choice compared to an actual video mixer or other streaming softwares. Wirecast allows streaming to own RTMP server. Wirecast is a graphic player, video mixer and steaming program in the same packet. Wirecast supports multiple input sources, which means that multiple different kinds of cameras can be used. It receives the multimedia content and sends it to the streaming server, in this case Wowza Streming Engine. Wowza receives the RTMP-stream from the Wirecast and sends it to JWPlayer that plays the stream to HTML5 players, which work with multiple different devices. To get the stream to work with iOS devices, the stream should be sent as HSL stream.

First setup:
MacBook Pro (15-inch, Mid 2012), Processor: 2,3 GHz Intel Core i7, Memory: 16 GB 1600 MHz DDR3
DELL Power Edge 900
3x HD web-cameras
2x iPhone4s smartphones with Wirecast Cam Application
1x Panasonic HC-V770K camcorder
1x Matrox Mojito MAX's for HDMI and SDI signal
Telestream's Wirecast
Wowza Media Engine
JW Player on a website

Everything started by installing a Windows server 2008 operating system to DELL Power Edge 900 server. This computer was installed to handle the video archive and work as a streaming server. After downloading Wowza Media Engine on the computer it was set to work with standalone mode. This means that the server is working and functioning all the time, so that the video on demand is working properly at all times.

In order to be able to send the stream over the Internet from own server, one way to handle that was to give the server computer its own static IP. This was bought from Internet providers. In the Windows server, the static IP address can be configured under Control Panel from Local Area Connection Properties. On the properties tab, the IP address, the default gateway and subnet masks can be configured.

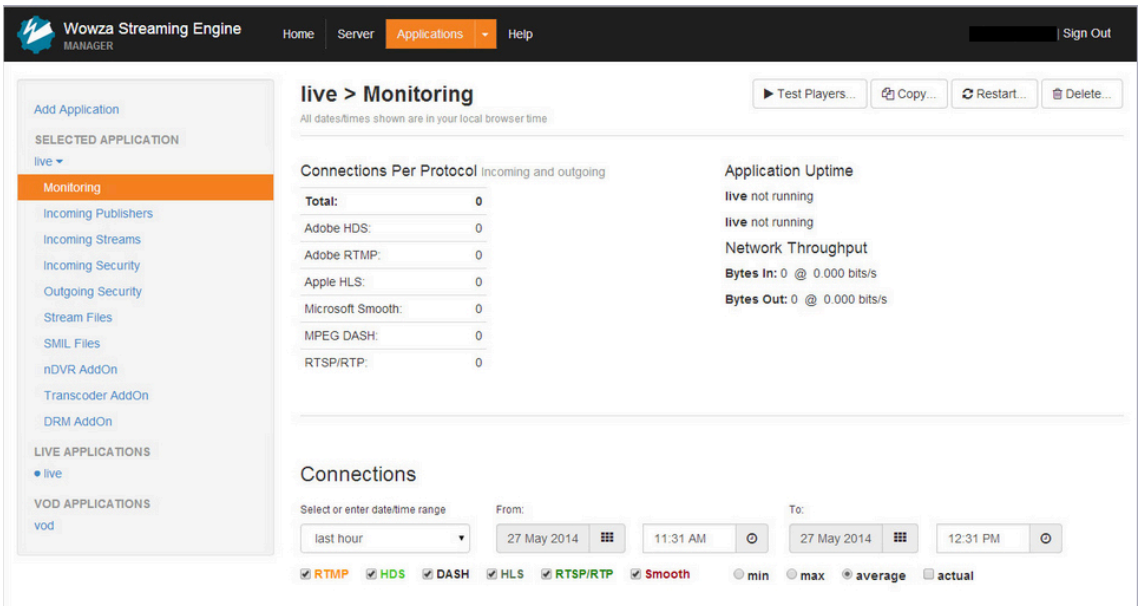


Figure 35. Screenshot of Wowza Streaming Engine manager. Screenshot (Wowza)

The Wowza Streaming manager (figure 35) gives the developer a possibility to analyze lot of data, from computer CPU to viewer's analytics. The figure 35 shows the application page, where incoming and outgoing streams can be controlled. Wowza has test players, which are great tools to see how the stream is shown with different devices and platforms. By clicking the Test Players button on the right top corner, Wowza offers the direct addresses to different streams. In this case, the goal is to stream to HTML5 player JW Player. That is why the web address under iOS devices the HSL stream is the one that is copy-pasted later to the JW Player.

After downloading Telestream's Wirecast, it is opened and the source settings are set up. Webcameras are plugged into the computer's USB port. A panasonic camera is plugged into Matrox Mojito MAX's HDMI port, which is Matrox's capture device. Matrox has Telestream support, so the video stream should be working without problems. Audio can be taken from the mixer through a Panasonic camera line input connections.

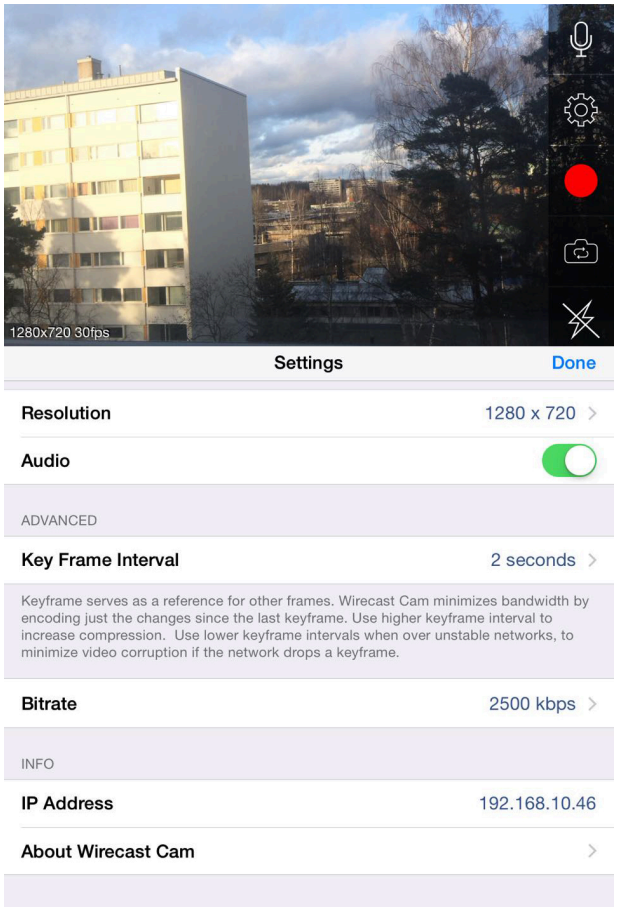


Figure 36. Screenshot of the Wirecast Cam settings, from mobile screen. Screenshot. (Wirecast Cam Application)

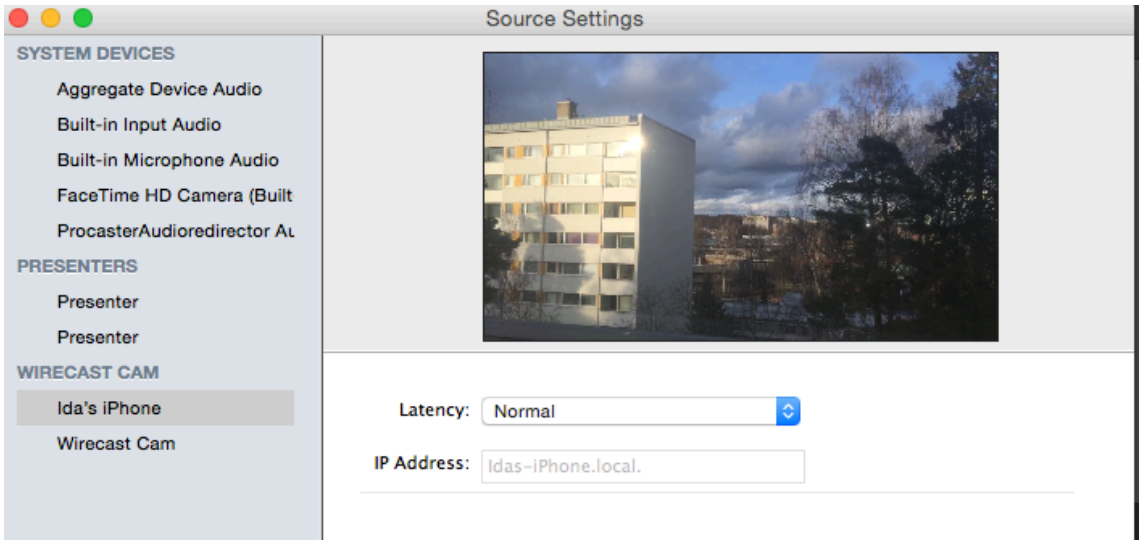


Figure 37. Screenshot of Wirecast's source setting, when adding new Wirecast Cam from iPhone. Screenshot. (Wirecast)

Wirecast has new feature called Wirecast Cam (see figure 37). It allows mobiles and tablets to be used as video sources. Application called Wirecast Cam was downloaded to the devices. In the screenshot shows the wirecast cameras (see figure 37). The application was installed to iPhone4S that had a name Ida's iPhone which can be found from the source list. The settings were configured to match the streaming setting from Wirecast (see figure 36) After making sure the streaming computer and the devices are using the same network, devices are ready for streaming. The devices were found in sources settings (see figure 37) by clicking New Wirecast Cam. After connecting, the Wirecast should show the video the device is shooting.

Figure 38. Wirecast's inputs during live streaming.

After plugging in all the cameras, there should be multiple videos added to the layers as in the example figure 38. Wirecast works like Photoshop, so the nametags are supposed to be on top of the main video layer. That is why they are added to the first or second layer. The top layer should also include introduction video and credit clips. Then the directing is done just like in normal multi-camera production.

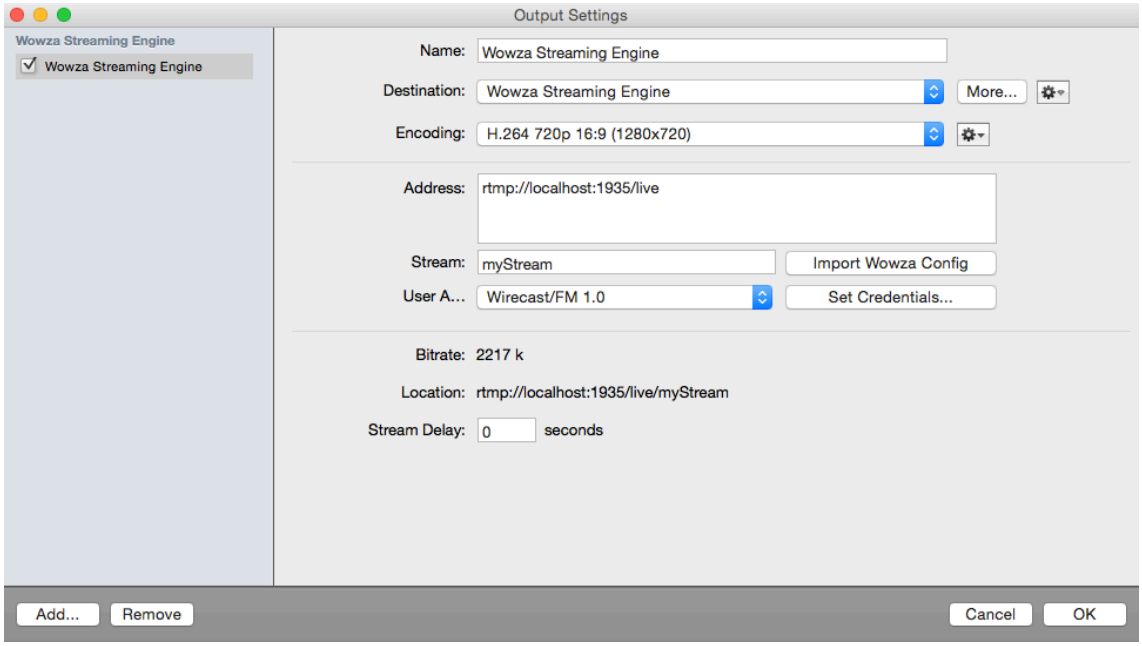


Figure 39. Screenshot of the streaming output settings. Screenshot (Wirecast)

Before the streaming was ready to start, the streaming output settings were checked. (see figure 39) Wirecast has already a basic setup for the Wowza Streaming Engine. The encoding was set to be H.264 720p and the video size is 1280x720. The address were the server IP address or DNS name instead of the local host (see figure 39).

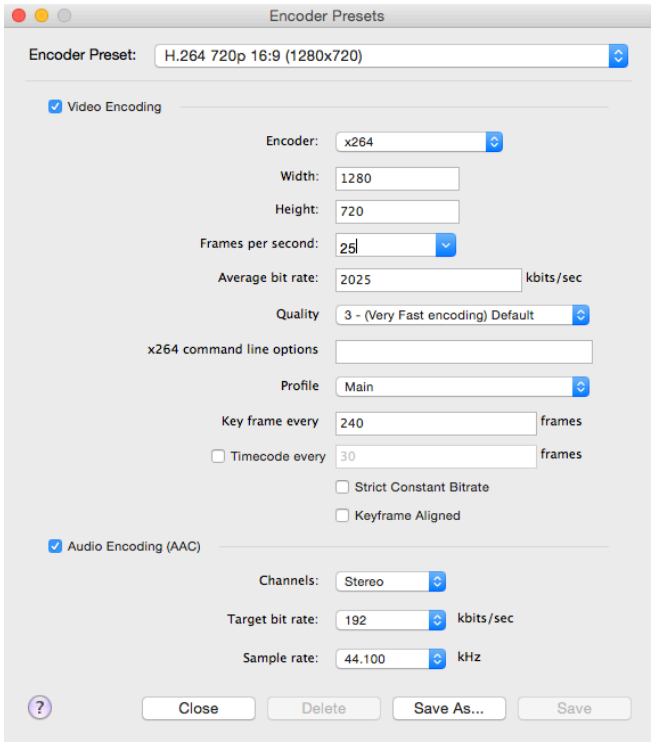


Figure 40 Screenshot of the encoder options. Screenshot (Wirecast).

Wirecast offers even more detailed encoder options, where the user can change things like the quality, frames per second and bitrate. These settings (see figure 40) are good for average streaming with average Internet connection.

When all the settings are ready and the Wowza server is on and running, the “stream” button is clicked. Then the stream quality can be checked with Wowza’s test players.

The next part was to download and embed the media player to the website. The player that was chosen is JW Player, because it has the widest support for multiple devices. JW Player is downloaded from the JWplayer.com and placed into the website folder.

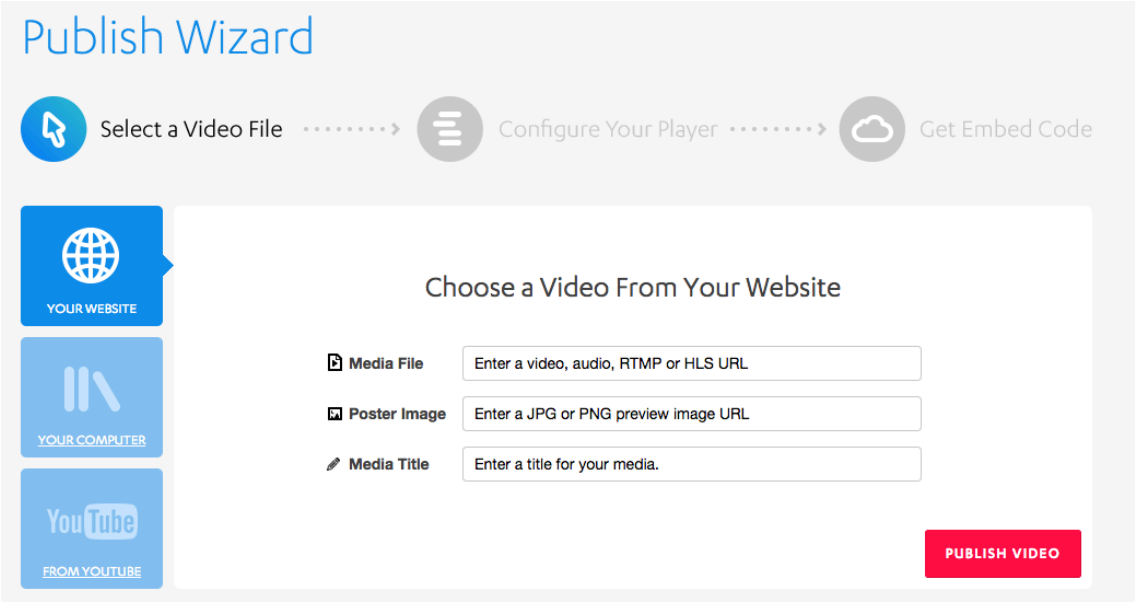


Figure 41. Screenshot of JW Player options. Screenshot. (JWPlayer)

JW Player was created with the help of a publishing wizard that can be found on the website (see figure 41). It was working in a way that the address of the stream, in this case the address given by Wowza for iOS devices was pasted on the “media file” frame. This was found after clicking the “Test Players” on Wowza Streaming manager‘s applications page. The poster image was added to the same page as well as the title. The next step was to configure the player, set the dimensions and choose if the primary state is HTML5 or Flash. In this case HTML5 is the one that is wanted. HTML6 was chosen, because it works better than Flash in iOS devices. The final step is to get the code that needs to be embedded to the website.

The code looks like this

```
<script src="https://jwpsrv.com/library/g97pnuRKEeS3HQp+lcGdIw.js">
</script>
```

Listing 6. The script code. (JWPlayer)

The listing 6 code was inserted inside the <head> tags of the HTML page.

The rest of the code was pasted inside the <body> tags, where the player is embedded.

```
<div id='playerdGnUSr9F'></div> <script ty-pe='text/javascript'>
jwplayer('playerdGnUSr9F').setup({playlist:
'http://content.jwplatform.com/feed/dGnUSr9F.rss',width: '100%',
aspectratio: '16:9'     });
</script>
```

Listing 7. Code for embedding the player to the website. (JWPlayer.com)

After pasting this code to the HTML page, there was a working stream that is viewable from multiple platforms.

9.2 Graphics

A live streaming production typically has several different graphics that are added to the video stream. These are for example an introduction video that is played before the actual show starts. In the end, there is normally an end-credits-video, where the production crew's names are listed. Both of these are part of the pre-production process, and the videos are made ready before the show starts.

Figure 42. Example Nametag from the live stream test

Everyone that has ever watched a TV show, a talk show or even a sports game knows that the names of the people starring in the program are shown also in the screen in so called nametags (see figure 42). A nametag comes to the picture, when a person is presented and introduced to the viewers. These nametags are normally picture files that have a name written on them. Typical nametag-formats are .png and .tga. Nowadays also short-video nametags are popular. The difference to the picture nametags is that the nametags have some movement inside them. For example the nametag could come from outside of the screen or the text could fade away. These files can be for example in the .mp4 format and the resolution and quality should be the same as the stream they are added into.

9.3 Audio requirements

In a streaming production, the audio is more important than the actual picture. That is because in most cases the audio is the one having the main information. That is why the audio requirements are important to take into account.

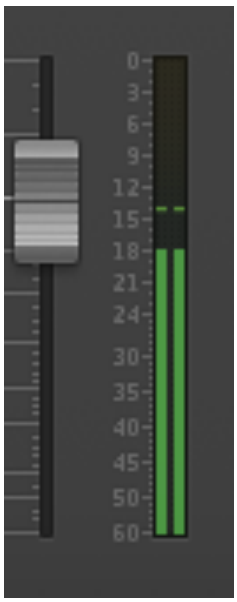


Figure 43. Audio meter

The average audio level in TV or streaming production is between -14dB (decibel) and -12dB. The peaks should never go above -10dB. Really general instructions for audio mixing are given below.

- Voice over, interview or presented audio is mixed between -14dB and -12dB.

- Sound effects between -20dB and -14dB
- Music is mixed to -12dB, when there is no voice over at the same time with the music and to around -19dB when there is some other audio at the same time.

To make sure there are no audio peaks, it is really common to use a limiter. A limiter can be set to the maximum sound level, when it is made sure the audio stays under control and there will be no peaks. As mentioned earlier, the normal limiter lever is around -10dB and it can normally be set from the mixer. In typical video production the audio is also compressed which means that the dynamic range between the loudest and quietest parts are lessened. Compressor boosts the quiet sounds and attenuates the louder signals.

9.4 Quality requirements

To reach the wanted quality, some setting should be taken into account and fixed.
Most of the streaming softwares use H.264 codec, especially when streaming RTMP. Normally the frame rate is set to be 25 frames per second. The higher the frame rate value is, the more frames the codec needs to process and that makes the stream smoother. (R1HC.)

Typical way of thinking is that the better the resolution is, the better quality the stream is. Unfortunately that is not necessarily always true. Most of the viewers will not have CPU and Internet connection that would support a high quality 1080p (1920x1080) stream with a suitable frame rate. The recommendation is to set the resolution lower (to 720p for example) and add a consistent frame rate. This will give an end-result that will propably work better with most of the users than the video where the resolution is set as high as possible. (R1HC.) The bit rate can be set based on the video that is streamed. If the video is mostly having still part and is for example a person talking to the camera, where the persons head is the only part that created movement into the picture. This kind of videos work better even with lower bitrate.

To ensure the clients to receive good quality stream, the stream provider should make sure, that there are enough bandwidth for all the users to see the stream.

9.5 Video/Camera requirements

Live streaming can be done on many different levels. The easiest way is just to plug in one web camera and stream with that. When the end result has to look more professional, the camera types can be chosen from many options. There is an example list below that describes how the camera set can grow and become a more professional set up step by step. The example case is to film conference with one head speaker and audience. Three cameras are used, because normally that is the minimum number of cameras that can create a versatile enough end result.

Two cameras are pointing at the speaker, one with a medium close-up shot and the other with long shot. The third camera is showing the wide angel where also the audience is shown.

1st set up

- Three high definition web cameras
- Laptop computer with 3 USB ports and a streaming program
- Cameras are without camera operators and showing the same picture all the time.
- A simple set up, where only an audio engineer and director are needed.

2nd set up

- Three HDMI connected Full HD cameras, for example Canon VIXIA HF R500 Full HD Camcorder or Three HD-SDI cameras, for example Sony PMW-EX1 cameras. The cameras set up can have SDI and HDMI cameras and as many as the director wants, max 4 four HDMI and four SDI cameras.
- A laptop with the ATEM Television studio device (or other capture card), that has four HDMI inputs and four SDI camera inputs
- Intercom or other communication system
- SDI and HDMI cables allow the audio recording inside the camera and without extra cable it can be taken to the program sound. The audio can also be recorded with mixer that it sending the signal to the capture card.
- Cameras can have camera operators that can move the camera the director wants. There will be more movement in the directing and the main camera can

follow the speaker if he/she is moving. Camera movement and changes of the sizes make a more professional look. More movement can be made with the help of different camera stands or dollies.

3rd set up

- Three Triaxial studio cameras, for example Sony HSC300R Multiformat cameras
- Digital Triax Camera Control Unit, video mixer, recorder, and intercom system.
- Studio camera set up needs more equipment, but makes more things easier and possible to be done.
- Cameras can have camera operators that can move the camera the way they are wanted. There will be more movement in the directing and the main camera can follow the speaker if he/she is moving. Camera movement and changes of the sizes make a more professional look. More movement can be made with different camera stands or dollies. The camera lenses can be changed. This allows even wider shots, and shooting from a really long distance. The camera controlling is more stable when focus and zoom are operated from external knobs. The camera can be set up on a crane or pump stand to create more professional camera movements.

Depending on the need, the camera set up can be made bigger or smaller. Professional systems are making some things easier and faster to control, but with professional people a good quality can be achieved also with smaller set up. (Kuosmanen, 2012)

9.6 Camera Colors

One big issue what will be faced when mixing different camera types together is the video's colors. Different cameras are build with different technique and that is why they are not producing the colors, contrasts and other picture elements similar way. Cameras may have different resolutions that cannot be manually changed. These details are causing the pictures to look different compared to each other. The more professional cameras are, the better color and picture controlling systems they have. Professional cameras have color configuration settings, where the director of photography can manually set up the color from white and black end and set up many other functions such as saturation and skin details.

When collecting camera set up with smaller budget, the best tip is to try to find similar type of cameras. Three similar web cameras give more even end result, than the production where professional studio cameras are mixed with smartphone cameras.

Average viewers will not notice the quality difference that easy as they will notice the difference with color and picture differences between the cameras.

9.7 Lighting Requirements

To be able to get good-looking recorded material, the lighting is in a big role. One of the only situations where the lighting is not needed is when the material is recorded outside where is enough natural light. In studio settings, the lighting is really important part of the production set. Lighting is used not only to show the faces of the talent, but also to light the studio environment and props.

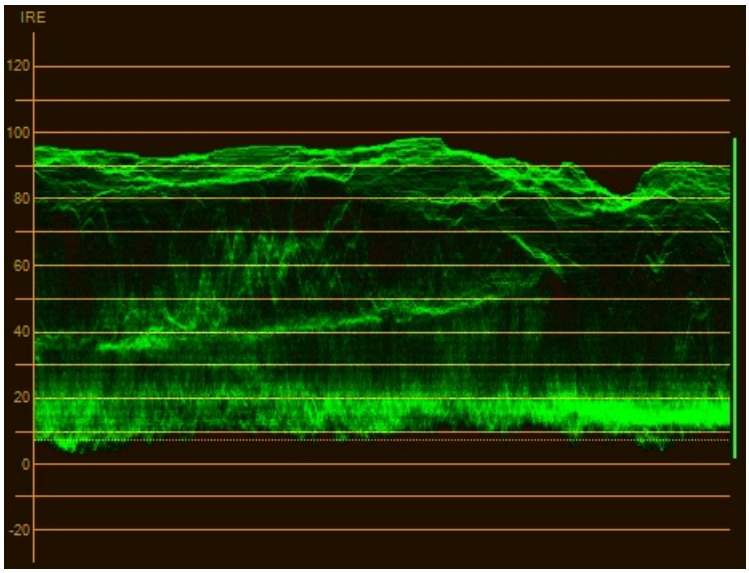


Figure 44. Waveform. (Cpc, 2012).

In the studio recordings, the lighting is set on the right level with the help of waveform display (see figure 44). In TV productions, the human face should be set to the 68% (Kolkka, 2013). This ensures that the face is not too dark and is not too bright. Both, too dark and too bright picture, are causing the video recording to look unprofessional. Also the person should brighter than the background.

Most used lighting systems are led panels and studio light heads. Company called ARRI makes one of the most used studiolights. Those lightheads can be pointed specifically to a certain point and really professionally light the object or person in the studio. Led panels are getting more popular, because they do not produce heat like normal studiolight do. Led panels can be bought in different sizes and normally they have switches for lights temperature and dimmer.

Typical studio lighting set up is called three-point lighting. This means that the object or a person has three lights that are pointing towards it from front. One light is set the middle and other two lights from angle of 30° from both sides. To avoid the object to be “clued” into the background, there should be one light coming from the backside. To set up the levels of each light, they need to be added to a dimmer. When the lights are set up correctly there should not be any shadows in the face and the level in the the waveform 68%. (Kolkka, 2013.)

10 Conclusion

Live Steaming is a technology that is used for sending data over the Internet. It has become a really popular method and it is widely used also among non-professionals. There are multiple different streaming server providers available and the software are giving more and more opportunities to do live streaming and even multi-camera directing without hardware.

The streaming system that this thesis deals with was built on top of Wowza Media Engine. It is a one good option for companies and societies to start their own live streaming service with their own server computer. The Wowza streaming server is supporting multiple other providers including Telestream's Wirecast, which is software for streaming and video recording. Because of the good support between the companies, the combination with Wirecast, Wowza and embedded JW Player is working well together and the system is trustworthy and gives a good starting point for future enlargements. Telestream's wirecast supports multiple camera inputs and multi-camera directing.

In general, streaming systems can vary depending on the needs of the clients. The project that this thesis has discussed gives a great starting point and leaves room to choose camera operating systems depending on the client's needs and quality standards. When there is a multi-camera crew, that is able to reach the technical standards and good stage set up with good lights, the end result is very nice looking and sounding live streaming and video recording material. And this all can be done with this cost-efficient streaming system.

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