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Business Models for Future Networked 3D Services

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Problem Description

The use of 3D technology has seen widespread increase during the last decade and in this thesis I will look at 3D technology and related business models. What kind of services can be enhanced with 3D technology, and how can actors in the market for 3D technology make business. In particular the following studies will be done:

- A background study of 3D technologies
- An overview over services utilizing 3D technology successfully
- Analyzing the business potential for 3D technology using Osterwalder business model ontology

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Assignment given: 23. January, 2011.
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Abstract

3-Dimensional (3D) technology has seen an increasingly widespread use over the last years, although the concept of 3D has been around for many years. Large studio movies being released in 3D and the development of 3DTVs and 3D games are the major reasons for its increasing popularity. The purpose of this thesis is to specify future collaboration space services based on the use of autostereoscopic 3D technology and propose possible business models. The collaboration spaces are geographically separated and let participants collaborate in a near-natural way through the use of autostereoscopic 3D technology. The business model analysis use the framework of Alexander Osterwalder's business model ontology. Different business aspects are studied in detail, including identification of products, customers and partners. A thorough financial analysis of the services are conducted and the basis for the estimates of the revenue and cost items are found in today's market prices. The results show that the services have a market viability even for small-scale environments.

Preface

This thesis is submitted to the Norwegian University of Science and Technology (NTNU) as a completion of the five-year program Master of Science in Communication Technology at the Department of Telematics (ITEM). The work presented has been supervised by associate professor Harald Øverby.

I would like to thank Harald for providing feedback and invaluable guidance on my work through meetings and discussion, it has been most helpful. Professor Leif Arne Rønningen at ITEM has helped by providing me with material to complete this thesis. I would also like to thank my father for patiently commenting and discussing the work with me.

At last, I am very grateful to both of my parents who have been a major support throughout my studies.

Marianne Bøhler

Trondheim, June 27th, 2011

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Acronyms

3D 3-Dimensional

3DTV 3-Dimensional Television

2D 2-Dimensional

HDTV High-Definition Television

FPR Film-type Patterned Retarder

LED Light Emitting Diode

LCD Liquid Crystal Display

VRD Virtual Retinal Display

HD High-Definition

CGI Computer-Generated Imagery

AVC Advanced Video Coding

DCT Discrete Cosine Transform

MVC Multiview Video Coding

DCI Digital Cinema Initiative

HDMI High Definition Multimedia Interface

RTP Real-time Transport Protocol

UDP User Datagram Protocol

IP Internet Protocol

DCCP Datagram Congestion Control Protocol

ICT Information and Communications Technology

CBC Customer Buying Cycle

DMP Distributed Multimedia Plays

IPSec Internet Protocol Security

MHS Multimedia Home Space

DSL Digital Subscriber Line

FTTH Fiber To The Home

MSC Message Sequence Chart

ISP Internet Service Provider

SLA Service Level Agreement

IRR Internal Rate of Return

Chapter 1

Introduction

This chapter introduces the background and context for the thesis, it describes the scope, problem definition and also the limitations of the thesis. An outline of the thesis is given in the last section.

3-Dimensional (3D) technology has seen an increasingly widespread use over the last years, although the concept of 3D has been around for many years already. Large studio movies being released in 3D, the development of 3DTVs and 3D games are the major reasons for its increasing popularity. In later years technologies that lets the viewer perceive 3D without the use of special eyewear have been developed. Autostereoscopic displays are one such technology which have been utilized today in a hand-held game console. For industry actors that want to make business it is interesting to see what kind of services can be enhanced with the use of new 3D technology, and how this can be realized.

1.1 Scope

Collaboration space services are services that can be enhanced and become near-natural with new 3D technologies such as autosterescopy. The scope of this thesis are proposing possible business models for such future networked 3D services. Alexander Osterwalder's business model ontology will be the framework used in proposing a business model. The different business aspects will be studied in detail including identification of products, customers and partners. A thorough financial analysis of the services will be conducted. In order to do so many estimates has to be made for the cost of future technology. To fully understand the possibilities and constraints with this future service, background studies on 3D technologies will be performed. The background study includes the technologies used for display, production and distribution of 3D. An overview of currently successful utilizations of 3D technologies will also be included.

1.2 Problem Definition

The work in this thesis is based on studying the following:

- Specify a future networked service utilizing 3D technology.
- Analyze the business potential for the future networked 3D service using Osterwalder's business model ontology.

1.3 Limitation of Scope

When talking about 3D technologies in this thesis it is limited to stereoscopic 3D[1]. This is technology that displays different images to each eye of the viewer, and in some cases different images if the viewer moves his/hers head. This means that 3D modeling and other technologies that present the 3D surface of objects on a 2D display using computer graphics technologies are out of scope for this thesis.

1.4 Related Work

Work that is related to the future 3D service that is specified is the work of Rønningen et al. in [34]. The work of Rønningen includes the concept of Distributed Multimedia Plays (DMP) which is a three layer architecture that aims to

[1]By the term ”stereoscopic” is meant that the human eyes see a scene from two slightly different angles. For simplicity the word ”stereoscopic” is later generally omitted.

provide "near-natural virtual networked stereoscopic multiview video and multi-channel sound collaboration between players and servers".

Work that relates to the business model aspect of this thesis follows the framework of fellow students Line Rød-Knudsen and Christer-Andre Larsen on business modeling of Smart House Technologies (SHT) [30] and Online Gaming Services (OGS) [20] respectively.

1.5 Outline

The thesis is structured in the following way:

- **Chapter 2** presents background on technologies for displaying 3D. Explanation of the human depth perception is also included.
- The 3D content has to be produced and distributed before it can reach a display technology. **Chapter 3** describes the different technologies that are used today for this purpose.
- **Chapter 4** gives an overview of the services that utilize 3D technology successfully today.
- The methodology used for analyzing the business potential for a 3D service presented in later chapters are Osterwalder's business model ontology. **Chapter 5** provides a summary of this methodology.
- **Chapter 6** presents virtual collaboration systems and a case study on a possible future collaboration system based on 3D technology.
- **Chapter 7** use Osterwalder's methodology to analyze the business potential of the future collaboration system presented in Chapter 6.
- **Chapter 8** discusses the results of the analysis done in Chapter 7.
- A conclusion of the findings in this thesis and suggestions for further work are found in **Chapter 9**.
- **Appendix A** contains a paper based on this thesis that is intended to be submitted for the International Conference on MultiMedia Modeling in Klagenfurt, Austria in 2012.

Chapter 2

3D Display Technologies

3D technology has seen an increasingly widespread use over the last years, even though the concept of 3D has been around for many years already. 3D technology can be traced back to the mid 1800's when the stereoscope was invented. This device shows two slightly different images for the left and right eye. The first public 3D movie, "The Power of Love", was displayed in a theatre in Los Angeles in 1922 and in the 1930's the first 3D color movie was produced. After this there was little use of the technology until the 1950's. The 1950's are described as the "golden era" of 3D with a number of 3D movies being produced. Each decade after this saw a revival of 3D as a result of a technical advance. During the 2000's many big studio movies were released in 3D and some so successful that it prompted a great interest in 3D movies again. The latest revival of 3D have although been slightly different from the earlier ones in the sense that great efforts have been put into the development of 3DTV. There is a combination of factors that has driven it forward such as the availability of large, affordable flat TV screens for households that are capable of displaying 3D content. In the near future it is expected that most full High-Definition TV (HDTV) displays for sale will be 3D capable. 3D content will also be easily available directly to the home via Blu-ray disks and high speed Internet [38].

This chapter describes the 3D display technologies known today and summarizes in the last section advantages and disadvantages with some of them. To understand how the 3D display technology works a description of the human visual system and depth perception is also in order.

2.1 Human Depth Perception

The human visual system make use of several depth cues to determine the relative depths in a scene. Some of these are 2D cues which can be seen in an ordinary picture or on a regular 2D display. These 2D depth cues are depicted in Figure 2.1 and described below [17]:

- **Occlusion:** occlusion of objects suggest their depth ordering. The trees in the background of Figure 2.1 occlude each other and hereby suggest their depth ordering.
- **Linear perspective:** objects of same size at different distances to the eyes projects images of different size onto the retina. As an example will two parallel lines appear to be closer together the further away from the eyes they get.
- **Light and shade:** how the light reflects from objects tell something of their depth relationships, shadows is especially important in this respect.
- **Relative size:** an object with a smaller retinal image appears to be further away than the same object with a larger retinal image. The sheep in Figure 2.1 are known objects with almost the same sizes, a much smaller sheep will then suggest their depth ordering.
- **Texture gradient:** in textures with constant size objects, such as footprints in the snow in Figure 2.1, their texture detail will vary in size with distance.
- **Aerial perspective:** when light travels longer distances it scatters and colors loose their saturation. Sharp edges of objects are diffused and color hue is shifted towards blue.

We see from Figure 2.1 that there are many cues in our visual system that suggests depth of objects in an image. It is important to have in mind that the 2D cues are a major contributor to the perception of depth to the human visual system. The four cues that we recognize as 3D cues however, are explained below [6][17]:

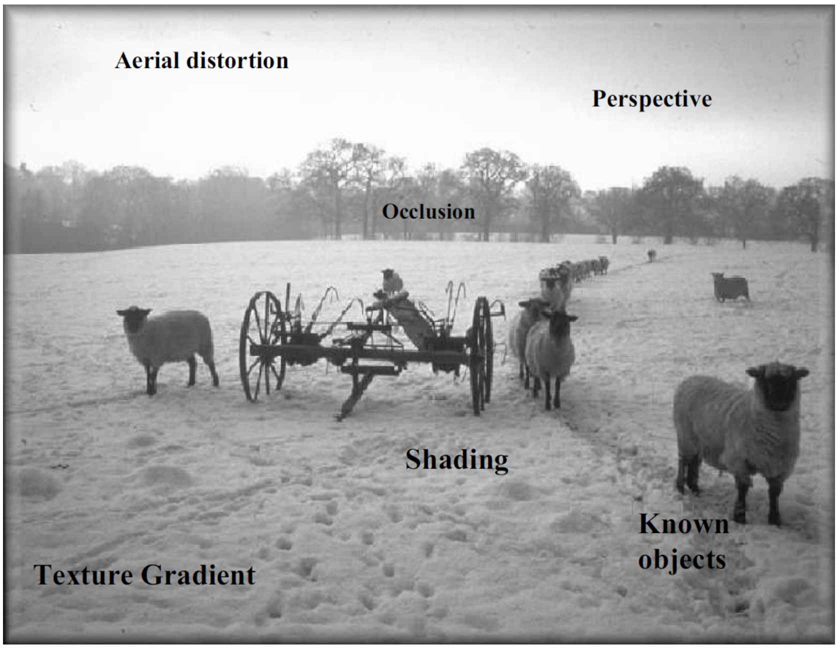

Figure 2.1: 2D depth cues [17].

- **Stereo parallax:** seeing a different image with each eye.
- **Movement parallax:** seeing different images when moving the head.
- **Accommodation:** when the eyes' lenses focus on the object of interest.
- **Convergence:** when both eyes converge on the object of interest.

The above mentioned cues are what make us perceive real depth, and are the ones utilized by 3D technology. Figure 2.2 explains how stereo parallax is used to create depth on a 3D display. It depicts how the images for each eye must be shown on the screen in order for the object to appear as if it is in front of or behind the screen. If the object is placed in the plane of the screen, the left and right images are coinciding (zero parallax). If the object is placed behind the screen (positive parallax) the image for the left eye is placed to the left of the image for the right eye. In the case of the object being placed in front of the screen (negative parallax) the figure shows that the image for the left eye is placed on the right side of the image for the right eye. With an object placed at infinity, the eyes will look along parallel lines with the same distance as the interocular distance (D) (they will not converge). Recalling the other 3D cues mentioned above, Figure 2.2 does not take into account accommodation or convergence. In

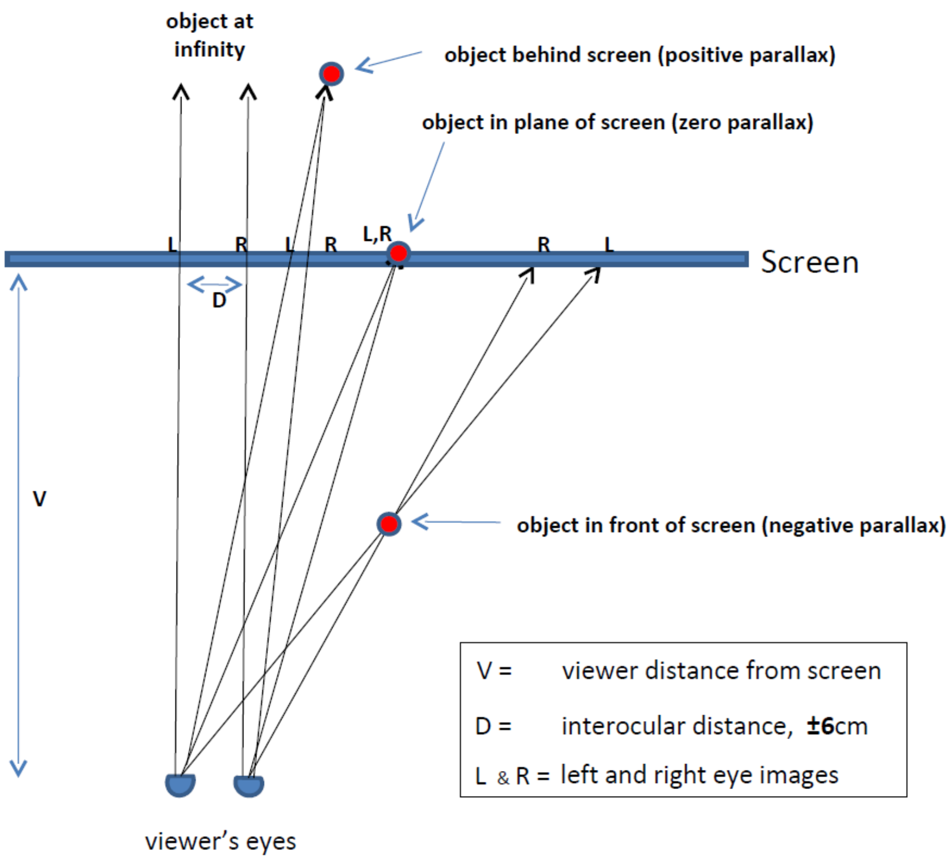

Figure 2.2: The use of stereo parallax depth cue in a 3D display [57].

the real world the accommodation and convergence of the eyes are always at the same point. This is also the case when the object is placed in the plane of the screen and we have zero parallax. There is however a difference between the accommodation and convergence when there is positive or negative parallax. The accommodation of the eyes will always be at the plane of the screen because this is where image itself is shown and where the eyes' lenses will focus. The convergence of the eyes will however be at the red dots in the figure. Therefore at positive parallax the eyes will converge at a point behind the screen, whereas at negative parallax the eyes converge at a point in front of the screen. Since the human eye is used to accommodate and converge at the same point this conflict feels very unnatural and can cause discomfort. Because of this is it important not to exaggerate the negative and positive parallax. Some viewers, it is said from 2% to 12% of the population, are not able to perceive any 3D effects at all. This is called stereo-blindness and is caused by medical disorders that prevent the eyes focusing correctly or by loss of vision in one eye.[4].

Having in mind the depth cues of the human visual system, the 3D display technologies that utilize these cues are described below.

2.2 Stereoscopy

Stereoscopy is a technique that creates an illusion of depth to the viewer with the help of special eyewear. It is done by displaying two different 2D images (one for left/one for right eye) to the viewer. The two images are of the same objects from slightly different projections. The visual stimuli from each eye are then combined in our brain and we will achieve the perception of depth. To present a different image to each eye of the viewer several methods with different types of eyewear are used and described below:

2.2.1 Anaglyph (Color Filter) Glasses

The earliest version of 3D was achieved using anaglyphs. An anaglyph image is made up of two differently colored images, one for each eye. Thus when viewing these images with glasses having corresponding color filters as the colors in the images, each eye will see its appropriate image and the viewer will perceive depth. The filter used for watching anaglyph images are usually red/green, red/blue or red/cyan color filters which are all non-overlapping color spectra. An example of an anaglyph image is shown in Figure 2.3. By wearing similar glasses as in this figure and watching the same image the left eye with the red filter will only see the red colors in the picture and the right eye with the blue filter will only see the blue colors. The two slightly different images will be combined in the brain and the viewer will get the perception of depth.

The advantages of this technology are that the glasses are cheap and the images are easy to create. There is no need for a special display to display the images or animations, for example will a regular TV monitor work fine. This was the start of 3D technology as we know it, but today it is rarely used due to the poor general picture quality and poor color reproduction [6].

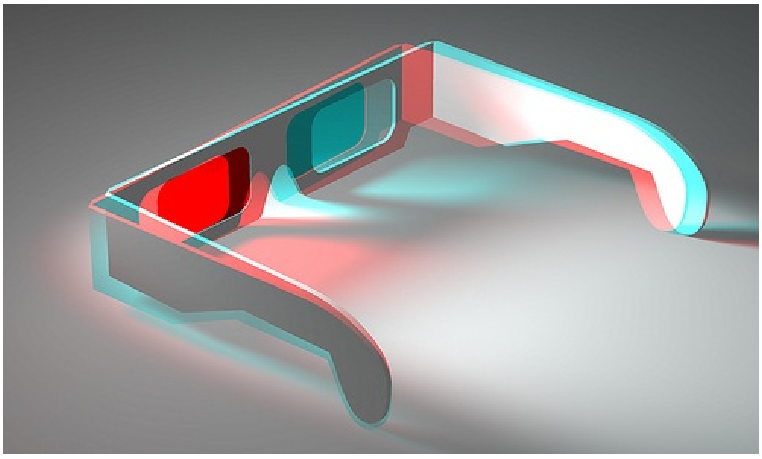

Figure 2.3: Anaglyph image of anaglyphfiltered glasses [1].

2.2.2 Polarization Filter Glasses

Polarization filter glasses are based on the fact that light is an electromagnetic wave, where electric and magnetic fields are vectors that have directions [25]. To present a stereoscopic motion picture on a screen using polarization the two images with slightly different projections are superposed onto the screen through differently polarized filters. The viewer wears same type of polarized glasses that makes left eye see one image and the right eye see the other image. The images are combined in the brain such that the viewer will perceive depth. Linearly or circular polarization are the two methods normally used today. Without going into further detail of the different polarization types there is a main difference that can be experienced by the viewer. Using linearly polarized filters tilting of the head can make the left and right images mix (called cross-talking) and makes prolonged use of this method uncomfortable. With circular polarization tilting of the head will maintain the left/right separation of the images [55]. Figure 2.4 illustrates light passing through linearly polarized polarizers. Linear polarized 3D glasses use vertical polarization on one lens and horizontal polarization on the other. When unpolarized light hits the vertical polarizer it will block all light except the vertical vector component. Putting a horizontal polarizer behind the vertical polarizer as shown in the figure will block all light.

The advantages of this technology over anaglyph images are that it produces full color images and good stereo effect. They are more expensive than anaglyph glasses, but still cheap compared to active shutter glasses (described next). The

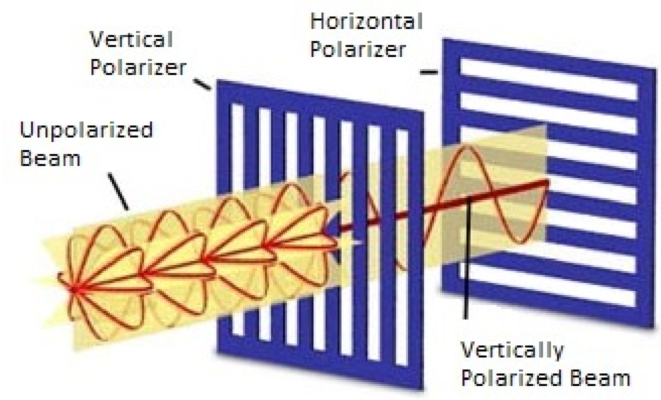

Figure 2.4: Light passing through linearly polarized polarizers [15].

disadvantages of this method are that the equipment for displaying is expensive. It requires two projectors mounted in a rack, a special projection screen and polarization filters for the projectors. The entire setup must be rigid and stable and the alignment of the projectors is demanding and critical for good results. This technology is used in 3D cinemas today and has had much success. A new 3DTV display technology was introduced in 2011, called Film-type Patterned Retarder (FPR), that uses polarization. It uses Light Emitting Diode/Liquid Crystal Display (LED/LCD) panel technology and shows different left and right images to each eye with the use of circular polarization [2]. This technology is said to have many advantages over the active shutter glass type 3DTVs described below. However, one disadvantage is that the vertical resolution will be reduced since both images are displayed at the same time.

2.2.3 Active Shutter Glasses

This method is based on time-multiplexed display of left and right images to the appropriate eye. In the liquid crystal method, which is the most common method, each eye of the glasses contains a liquid crystal layer which has the property of turning dark when voltage is applied and being transparent otherwise. Therefore the two images are not displayed simultaneously to both eyes as with polarization, but shown alternately by switching very fast between the two pictures. The display switches pictures typically 120-200 times per second (120-200Hz) and the glasses has electronically remote controlled shutters that is synchronized with the display [25]. This means that the shutter glasses blocks out the left eye letting the right eye see its intended image, then the right eye is blocked out and the left eye sees the left image. If the display switch pictures 200 times per second each eye will see 100 images each second and not notice that one of the eyes is blocked at all times. This is the most commonly used technology in 3DTVs today.

The main advantages of this method is that compared to anaglyph glasses it produces full color images and therefore maintains a good overall picture quality and stereo effect. The disadvantages of the method are that the glasses are expensive compared to the other passive glasses and it requires a display that can switch fast between the left and right eye images. To avoid flickering in the picture it requires minimum a 100Hz display, which means 50Hz for each eye. A practical disadvantage for users is that different manufacturers have chosen different solutions. This means that glasses from one manufacturer can not be used to successfully watch 3D on displays from another manufacturer (no industrial standardization). The glasses can also be quite bulky and difficult to wear for people using ordinary spectacles.

2.3 Autostereoscopy

Autostereoscopic displays allows the viewer to see 3D without the need for special eyewear. Figure 2.5 illustrates the multiview autostereoscopic display principle, where the stereo parallax and movement parallax cues are combined to achieve 3D without special eyewear. Illustration (a) in the figure illustrates how a person sees the real world. The viewer sees different images with each eye and also when he moves his head both horizontally and vertically. Looking at the world the viewer can potentially see an infinite number of different images. Illustration (b) in the figure shows the same viewing space as in (a), but here it is divided into a finite number of images in horizontal slots. This means that for each slot the viewer will only see one image of the scene, however a different image for each eye (stereo parallax). When the viewer moves his head to the next slot he will see a slightly different image (movement parallax). The images jump to a slightly different angle of the scene as the viewer moves between slots, he will not perceive smooth transfer as in illustration (a). These slots will thus provide the viewer with stereo parallax and some horizontal movement parallax cues. Since we have a finite number of slots in illustration (b) we can replace this scene with an autostereoscopic display as shown in illustration (c). Cameras have to capture images for each slot, and these are later shown in their respective slots in the autostereoscopic display.

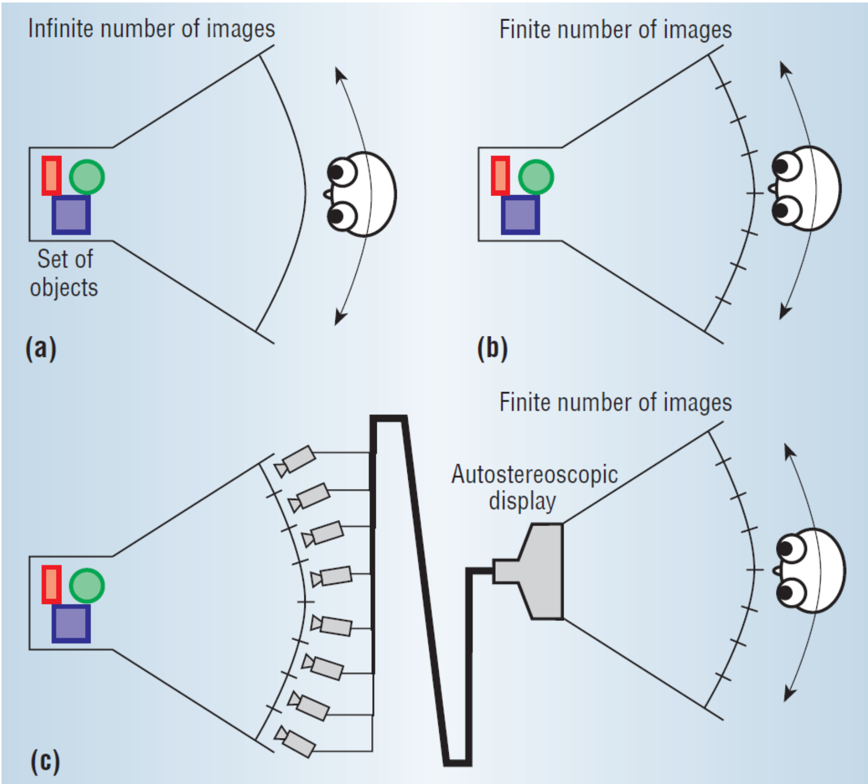

Figure 2.5: Multiview stereoscopic display principle [6].

The different technologies used to enable each eye to see different images without the use of eyewear are either parallax barrier or lenticular lenslets, illustrated in Figure 2.6.

Lenticular lens: Illustration (a) in Figure 2.6 shows an array of cylindrical lenslets placed in front of the pixel raster. The light from adjacent pixel columns are directed into different viewing slots when the viewer is placed at the ideal viewing distance. At this distance each of the viewer's eyes will see light from only every second pixel column. This means that one of the two visible images consists of every second column of pixels and the other image consists of the other columns [6]. One of the images is shown to the left eye and the other is shown to the right eye and hereby the viewer achieves the stereo parallax cue. The lenslets are like tiny stripes and are barely visible, but the texture of the lenticular can be felt by fingers due to the cylindrical lenses [25].

Parallax barrier: Illustration (b) in Figure 2.6 shows a barrier mask that is placed in front of the pixel raster so that each eye sees light from every second pixel column. In this way each eye sees a different image [6]. The barrier mask is like a fence with opaque and transparent strips placed a certain distance from the display surface. The geometry is adjusted so that the barrier blocks every second pixel for one eye and then the other pixels for the other eye [25].

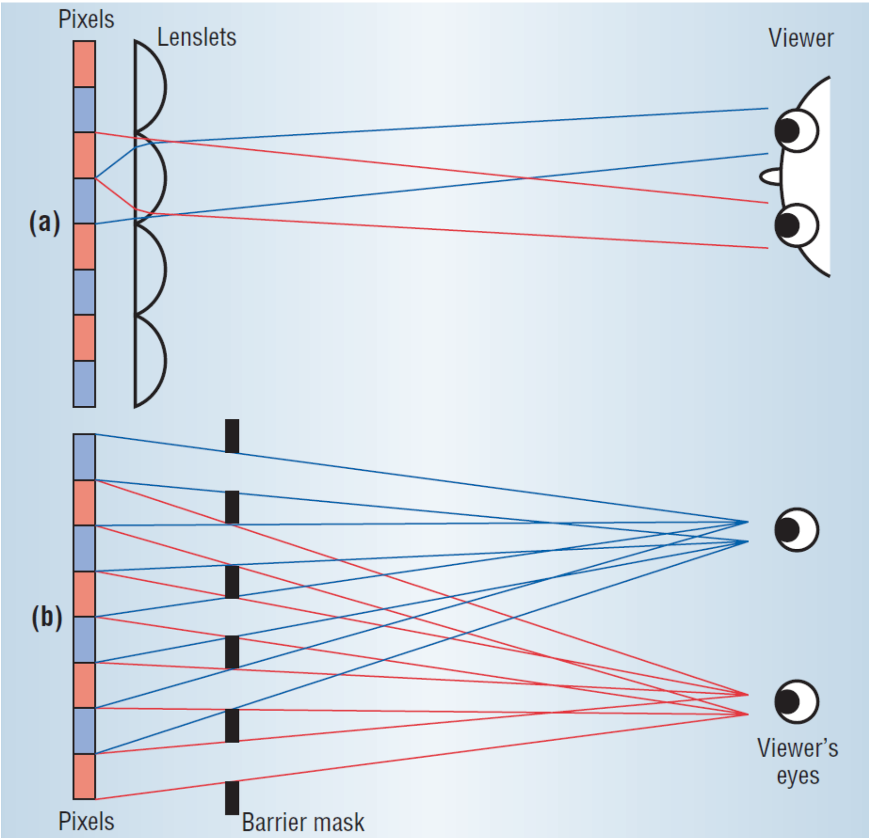

Figure 2.6: Multiview stereoscopic display principle [6].

Both of these technologies let the viewer see two different images without the use of special eyewear. However both suffer from the problem that there are only "sweet spots" in which the viewer can see the intended image. This means that there is only a specific range of positions where the viewer's eyes receive the proper separation of right and left images. Outside of these sweet spots there is no perception of 3D [25]. There are mainly three categories of autostereoscopic displays that use the above explained technologies and they will be described next [6]:

2.3.1 Two-view Displays

Two-view displays divide the horizontal resolution of the underlying display into two sets. Half of the pixels make up the the image for the right eye and the second half make up the image for the left eye. The pixels for each image are arranged so that every second are for left image and vice versa for the right image. The two displayed images are visible in multiple sweet spots. In these positions the viewer will see a stereoscopic image. There is however a 50% chance that the viewer will be in a spot where he will see a incorrect image [6]. It is important that the viewer remains fairly still in the same position and does not move much. Because of these limitations other autostereoscopic solutions has been developed that increase the number of spots where the viewer can see the correct image.

2.3.2 Head-tracked Displays

Head tracked displays are a two-view display that always knows the position of the viewer's head. This method only works for a single viewer at a time. Knowing the position of the viewer's head the display can accommodate and show the appropriate left and right images even when the viewer moves his head. The difficulty with this technology is the head-tracking. The user should not be required to wear special equipment, but the head-tracking technology is now sufficiently robust such that this is not a major problem. Another problem is physically moving the viewing zones. There are technologies where either the projectors are moved, the entire display is rotated or the light source is moved to accommodate the viewing zones accordingly to the viewer's head. Figure 2.7 shows two different methods for head tracking. Illustration (a) show how the viewing zones are swapped as the viewer moves his head, while illustration (b) shows only two viewing zones that is controlled in space by the display. It is important for these systems to be both rapid and robust. There are also methods that do not require mechanical movement, like using a liquid crystal display to form the parallax barriers in front of the original display [6].

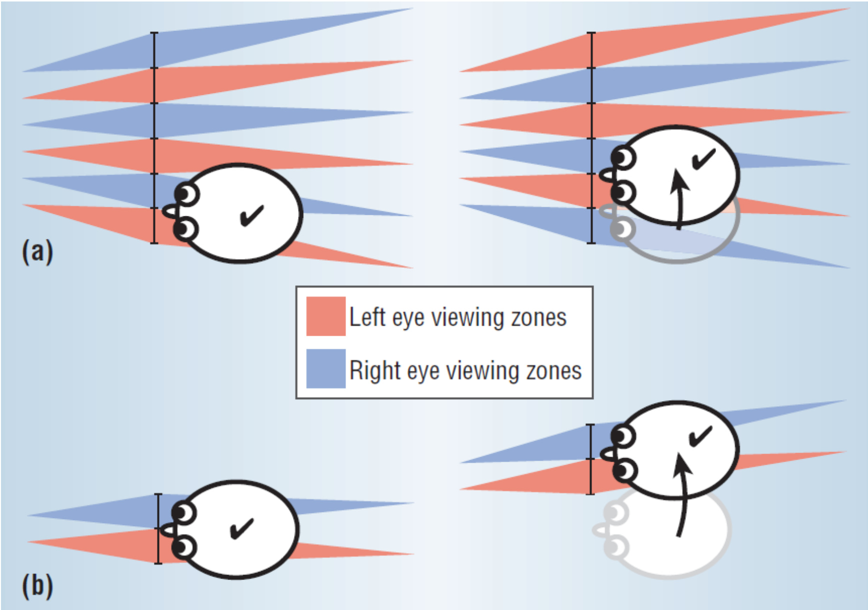

Figure 2.7: Different methods for two-view head-tracked displays [6].

2.3.3 Multiview Displays

Multiview displays is the extension of two-view displays to typically five or nine views (there exists devices with up to 50 or more views) [25]. This type of display lets multiple viewers watch 3D at the same time from different angles. The video capture is similar to stereoscopic recording, but cameras are needed, each shooting from slightly different positions. Each camera corresponds to a view in the multiview design. As a consequence of multiple views each scene will be displayed at slightly different angles and the viewer will perceive horizontal movement parallax in addition to stereo parallax. The advantage of multiview over the other systems is that the viewer or viewers has a larger area where they can perceive a correct 3D image. The disadvantages of a multiview display is the difficulty of building a good display with many views since with more views the resolution of each images decreases. There is also a problem of generating all the views simultaneously since all of the views are displayed at all times, independent of anyone watching that particular view [25].

2.4 Integral Imaging

Integral imaging can be seen as an extension of lenticular multiview autostereoscopic displays. The difference is that the lenticular sheet is no longer a cylindrical lens array, but an array of very small size spherical lenses. This array is called a microlens array and with this the viewer achieve both vertical and horizontal movement parallax and stereo parallax. The capture side of integral imaging consists of a 2D array of cameras [25]. There are needed as many cameras as there are lenses in the microlens array to produce an integral image. To achieve this in practice the same type of microlens array is used to capture the images as is used for displaying. As shown in Figure 2.8 the object of interest is captured by an array of microlenses. [22]. They generate a collection of 2D elemental images (one elemental image for each microlens) onto a matrix image sensor (depicted as "pickup device" in the top illustration). The elemental images are imaged by the corresponding microlenses onto the reference image plane (bottom illustration in

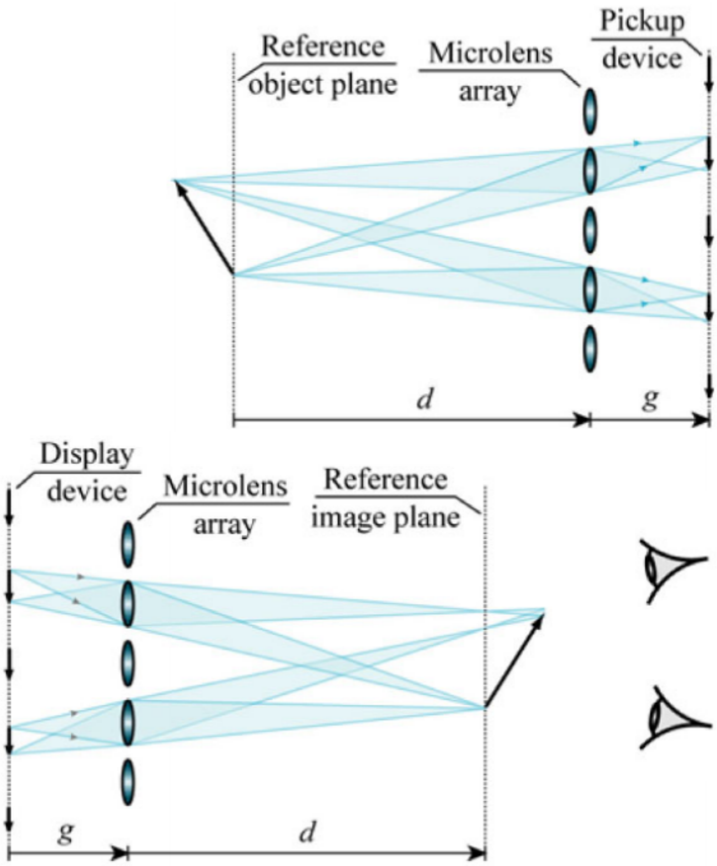

Figure 2.8: Integral imaging[22].

Figure 2.8). The 3D scene is reconstructed in the image space by the intersection of ray bundles emitted from each of the microlenses

2.5 Holography

Holography is a technique that allows the information from the light (such as intensity and directional information) reflected from an object to be recorded and later on reconstructed. The holographic recording itself is not an image, but an interference pattern that is obtained by having the information carrying light interfere with a reference beam. Interference requires coherent light which is used in lasers [25]. Coherent light is in phase which means that the waves travel "in step" and in the same direction. Figure 2.9 depicts how holographic recording is done on a photographic plate (this was the first technology used). The laser (coherent light) beam is split in two by a beamsplitter. One beam, called the reference beam stays undisturbed and strikes the photographic plate. The other beam from the splitter called the illumination beam strikes the object, and the light reflected from the object (called object beam) then strikes the photographic plate. The differences in phase and amplitude between the object beam and the reference beam causes the two waves to interfere and generates an interference pattern to be recorded on the photographic plate [42]. Figure 2.10 illustrates how the holographic reconstruction phase is performed. The photographic plate is illuminated with a reconstruction beam, which is the same as the reference beam or the original beam from the laser. This beam will be scattered by the interference pattern on the developed photographic plate. A viewer looking into this scattered light will see a virtual image of the original object [42]. Remembering the depth cues described early in this chapter, holography is one technology that fulfills all of these cues. Recent published information from Massachusetts Institute of Technology (MIT) indicate that research into holographic capture and display technologies have advanced significantly [9].

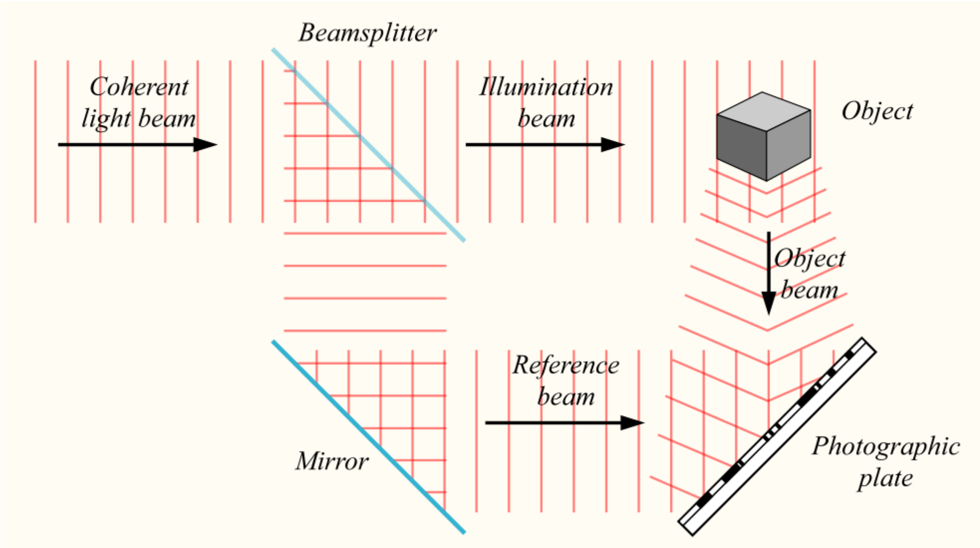

Figure 2.9: Holographic recording process [48].

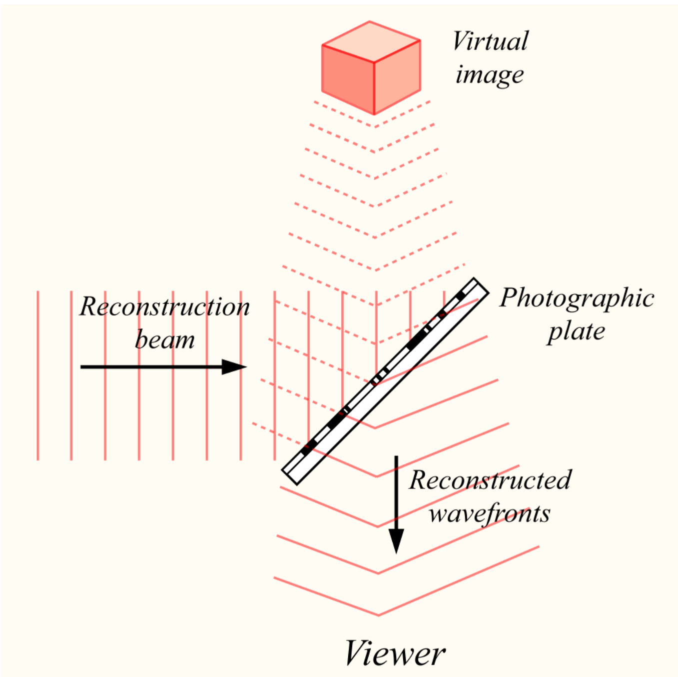

Figure 2.10: Holographic reconstruction process[48].

2.6 Volumetric 3D Displays

Volumetric 3D displays use a mechanical volume sweeping device that has display elements. The device is moved, usually in a cyclic manner, with a sweeping motion. The display elements are electronically excited to achieve appropriate brightness and color to the different positions at different instants of time at the passing of the sweeping device. If the volume is refreshed frequently enough e.g. 20 volumes per second (20 rounds per second for the sweeping device) the viewer will see a 3D image [14]. Volumetric devices provide stereo parallax and both vertical and horizontal movement parallax. The disadvantages of this technology is the mechanical constraints, and the limitation of what that can be displayed (usually just one object, not a scene). Due to the fast sweeping motion required these type of devices can be bulky and quite noisy [25].

2.7 Virtual Retinal Displays

A Virtual Retinal Display (VRD) is "glasses" the viewer wears that scan the light via an optical projection onto to the retina of the eyes. Viewers will see what looks like an ordinary display floating in front of their eyes. The diagram in Figure 2.11 shows how a VRD works. A light (photon) source generates coherent light beams that allow the system to draw a diffraction limited spot on the retina. The light beam is then intensity modulated to match the intensity of the image being rendered [41]. The beam is further scanned to place each pixel at the proper position on the retina. At last the optical beam is projected into the eye. The drive electronics synchronize the scanners and intensity modulator with the video source such that a stable image is formed. The advantages of VRDs is that the viewer can get stereo images in high resolution projected right onto the eye which gives a large viewing angle. This creates a natural 3D environment. VRDs can have many applications areas such as in medicine, manufacturing and communications, but to this date many challenges remain before the technology reach its full potential [41].

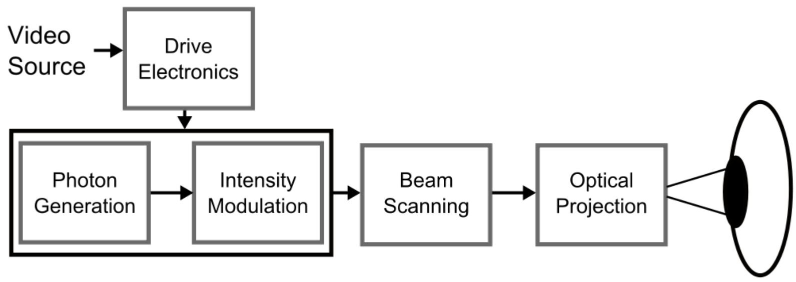

Figure 2.11: How a virtual retinal display works [41].

2.8 Properties of the Technologies

Having described the 3D technologies that we have today, a brief summary and assessment of these technologies follows. The ultimate goal of 3D technologies is to record the physical light distribution that we see in the real world and recreate this in the most natural possible way in a perceived 3D space. Some of the technologies do this in a better way than others, but there is often the issue of cost and how far the technology is developed. Stereoscopy is the simplest and oldest technique, but it is far from recreating the the physical light in a 3D space. This technique simply uses different technologies to show slightly different images to the left and right eye (stereo parallax). Here we have no movement parallax, and the focus of eye will always be in the plane of the screen while the eyes converge on an object placed virtually in front or behind the screen (which can cause discomfort). This and other irregularities such as mismatch in camera parameters can create unnatural viewing experiences [25]. However, due to the relative simplicity in both recording and displaying and improvement of the technology over the last years this (stereoscopic 3D) is the technology mostly used when talking about 3D today.

Autostereoscopic displays with multiple views let the viewer achieve some horizontal movement parallax in addition to stereo parallax without the use of eyewear. These are the main advantages of this technology while the problem of accommodation and convergence of the eyes still exist. The resolution of an autostereoscopic display is also a problem since that for each view it has to show two images on the same screen at the same time. This means that for each extra view the resolution of the images is reduced accordingly [25]. In the recording process there is needed as many cameras as there are views to achieve the movement parallax. Today the cost of large autostereocopic displays are high.

The advantage of integral imaging is that it has added the vertical movement parallax, but the practical problems with this technology are severe both in recording and displaying. The problems are the same as for autostereoscopy, but with integral imaging there are many more views (both in vertical and horizontal direction) and it is needed many more recording devices and much higher resolution in the display. An integral imaging based TV system would for practical reasons be impossible to carry out [25]. The holographic technology is the one nearest to recreate the physical light distribution in a 3D space and recent advances in this technology may come to fruition in the near to mid-term future.

The next chapter will describe the technologies behind production and distribution of 3D content.

Chapter 3

Production and Distribution of 3D Content

The previous chapter described the technologies for displaying 3D content. This chapter describes the technologies of production and distribution of 3D content that can be viewed on 3DTVs utilizing polarization or shutter glasses technology, two-view autostereoscopic displays and digital cinemas. For these technologies to have any value to viewers it is crucial that the content is interesting and that the 3D productions are good. This means that stereo effects must be carefully managed and not exaggerated in order for the viewer not to feel discomfort. Figure 3.1 gives a view of what this chapter is about. The different technologies involved in producing, compressing and distributing 3D content that are mentioned in this figure will be described in further detail throughout this chapter.

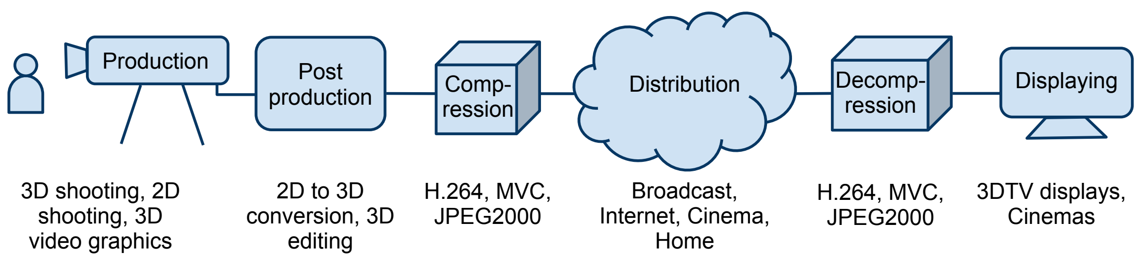

Figure 3.1: 3D content from production to display.

3.1 Producing 3D Content

There are essentially three different methods of producing 3D content. The first is to record the objects and scenes with a two-camera solution, the second is to convert existing 2D video into 3D video. The last method is to produce 3D content with a modeling software also known as 3D video graphics.

3.1.1 Two-camera Production

A common way of producing 3D content today is to use two cameras or two lenses together in one camera. This simulates the human way of looking at a scene, the two cameras being our two eyes. However, the interocular distance as mentioned in Figure 2.2, is approximately 6 cm (for "normal view"). In practice it can be difficult to place two high quality cameras this close. Large studio cameras therefore use mirror rigs to be able to shoot from the right distance apart. Smaller cameras such as the mini cameras depicted left in Figure 3.2 have small lenses that are narrow enough to be placed in side-by-side rigs [38]. Twin lens cameras as depicted to the right in the figure are available as a handy alternative to the mirror and side-by-side rigs. One must be careful with zooming under stereoscopic filming as this could destroy the 3D effects. There are some camera rigs can continuously change the distance between the cameras (the interoculary distance) to match the perspective of the lenses. When doing this they achieve 3D effects of objects placed further away. This however, requires extremely high precision and all adjustments are normally done by fast computing processing systems.

Figure 3.2: Two-camera systems for stereoscopic filming [38][39].

3.1.2 Conversion of 2D to 3D Content

This method use conventional 2D content and converts it into 3D content. This is a complex task and it requires a great deal of fast signal processing. A straight forward way to create stereoscopic 3D is by the cut-and-paste technique. The original image is used for the left eye and a new image is generated for the right eye. This generation is done by shifting local regions in the original image horizontally by cutting and pasting. Finding the local regions to shift can be done by object segmentation techniques which can be very effective if the objects in the scene are well segregated. Often this is not the case and other techniques have to be used. Tam et al. [37] highlights depth maps as a possible solution to extract depth information from a 2D image. There are as many ways to generate depth maps as there are 2D cues (described in Chapter 2.1). A main problem is how to extract the information and form a depth map, and later on extend this to image sequences to make 3D out of a 2D video. The goal is to avoid user interaction as far as possible especially for built in systems in 3DTVs that are supposed to create 3D content out of any 2D content on-the-fly. Today there are success stories of conversion from 2D to 3D. The movie "Alice in Wonderland" was originally shot in 2D and later converted to 3D by a high end system together with experts. However, there are many conflicting opinions of whether conversion of 2D to 3D is a good way of creating 3D content and if it should be used at all [40].

3.1.3 3D Video Graphics

The last method consists of creating 3D content by using 3D computer graphics also known as Computer-Generated Imagery (CGI). The software is used for creating an entirely virtual world with scenes and objects. Once the objects and scenes are created in software it is easy to generate the two slightly different images needed for stereoscopic video. Recent accessibility of CGI software and increased computer speeds has allowed for the individual artist to produce 3D content from home computers. An example of professionally successful use of CGI is the movie "Toy Story 3", released in 2010.

3.1.4 Discussion

Considering the costs of the different production methods, a single-camera 2D production with conversion to 3D at a later stage is a less costly alternative. However this method can produce various results if done"on-the-fly". When doing a regular 2D production of e.g. sporting events multiple cameras in different positions are used. Producing such events in 3D would mean doubling of cameras which is expensive. Experience also shows that when shooting 3D the cameras should be placed in different positions than for regular 2D production to achieve the best 3D effects. This means that the producers should have different crews for 3D and 2D production or that the quality of one production will be at the expense of the other (e.g. shooting with the 3D set-up and use the left eye images for the 2D production) [38]. Editing 3D content are straight forward as long as the cameras are set up properly. If the depth needs to be adjusted in post processing, this can be a time consuming process. The industry have experienced that whenever making 3D content it is necessary to have one person responsible for the stereoscopic result, called a stereographer. The role of a stereographer is to ensure the proper use of depth in every shot and between cuts, making sure that there are no nausea-inducing elements [8].

Summing up this section we see that the time and costs of producing good 3D content is considerably higher than producing 2D content. The audience of 3D must be willing to pay extra to see 3D content so that the production will not become a loosing project for producers. For large studio movies the audience have shown that they are willing to pay an extra 3-5 to see the movies in 3D. Up until now there have not been much 3D content produced solely for broadcasting to home having 3DTV displays. There has to be a willingness from the audience to pay extra to watch 3D before broadcasters can start these expensive productions.

3.2 Compression and Decompression

After producing video, either it is 2D or 3D, it has to be compressed for reasons of cost of storage and capacity in distribution. The raw video stream of a HD signal is 1.04 Gbit/sec and for stereoscopic video it normally doubles today. For compression of 2D video the standard used today is the H.264/AVC

(Advanced Video Coding) which is a DCT (Discrete Cosine Transform) block-oriented motion-compensation based compression. The H.264 standard has many applications and is used in Internet streaming, broadcast and in Blu-ray [47]. The latest amendment to this standard is the Multiview Video Coding (MVC) which allows encoding 3D video and multi-view 3D video [31]. The video stream for each eye or each view in 3D video and multi-view 3D video are very similar. It is therefore a high level of redundancy that can make the compression of these successful. The redundancy between the different views in combination with temporal redundancy is exploited when predicting the next frame and this is the key in the MVC encoding scheme. Using MVC outperforms independent coding of multiple video streams, but the gain depends on the content. The MVC technique is today used for encoding stereoscopic Blu-ray releases [31]. Another compression technique, that is set as standard for cinemas, is the JPEG2000 standard which is based on wavelet transforms.

3.3 Distributing 3D Content

Dissemination of 3D content has evolved from distributing 3D films to cinemas theatres to digital distribution: to 3DTVs in homes, via Blu-ray disks and to digital cinemas.

3.3.1 Cinema

Distributing 3D content to cinemas is done in the same way as for digital 2D movies. The Digital Cinema Initiative (DCI) have established a standard for overall system requirements and specifications. The actual distribution of data must be done in a secure environment and the content owner's encryption is required not to be removed during transport. It is required that all of the data of the original files are present at completion and that there are no corruption of data. Shipping of content can happen by physical media or transmission by satellite, fiber or copper. Cinemas are less dependent upon bandwidth or storage requirements than e.g. a broadcaster. Therefore, the bit rate is dependent on the desired image quality[5]. The large file size of the content is therefore usually not a problem for cinemas distribution. This is why we can experience high quality

3D content in cinemas.

3.3.2 Home

Viewing 3D content in the home involves media such as Blu-ray disks or content from game consoles. Receiving 3D content from broadcasters are explained later. Blu-ray disks have become a popular medium in recent years, and it is well suited for 3D content. The disks have large storage capacity that satisfy the demands of storing a 3D movie with full resolution for both the left and right eye images. The later versions of High Definition Multimedia Interface (HDMI)(version 1.4 an up), allows for communicating high quality 3D signals between different types of 3D capable equipment. These types of equipment include set top boxes, game consoles or different types of Blu-ray players and the 3DTV [16].

3.3.3 Broadcast

Transmitting 3D content from a broadcaster to the home is today done by using the same transmission systems as for conventional HDTV. The standards authorities are not planning on raising the bandwidth specifically for 3D, and there are neither any new compression standards specifically for 3D. This causes an issue since there for 3D is basically twice as much information that has to be transmitted. There are three different ways of solving this problem and they are depicted in Figure 3.3. The first one is the side-by-side method which reduces the resolution in the horizontal direction by 50% and put the left and right eye images next to each other. The second method is the top and bottom method which reduces the resolution in the vertical direction by 50% and put the images on top of one another. The frame sequential method is the third method depicted and it sends full resolution images for the left and right eye after one another. This means that only half of the images are for the left eye and half for the right eye, and it can hereby produce flickering. This method is not used in broadcast, but can be used in other types of 3D equipment where it is possible to increase the frame rate and hereby reduce flickering. For broadcast transmission the side-by-side or top and bottom technique are used. The resolution is reduced to half of the original quality for each image when using these techniques, but the perceived quality is not necessarily this bad. The brain has an unique way of making up for some of the ”lost” resolution when combining the two images [35].

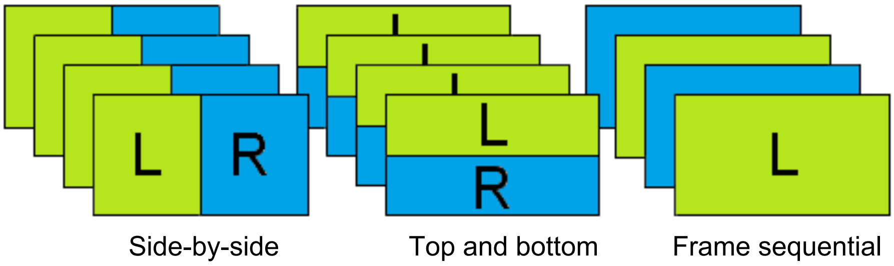

Figure 3.3: Transmission of 3D signals.

3.3.4 Internet

Many services are provided over the Internet today and there has been an increasing trend for delivering video as well. Delivering 3D content over the Internet is therefore a natural choice. The different protocols and the layering offer flexibility of design and therefore optimization for the specific needs of 3D content. The most widely used protocol for streaming of video today is RTP/UDP/IP (Real-time Transport Protocol/User Datagram Protocol/Internet Protocol). A problem with this is that is does not have congestion control and this becomes a problem when transmitting large amounts of data. Instead of UDP a possible alternative is DCCP (Datagram Congestion Control Protocol) [25].

Chapter 4

Utilization of 3D Technologies Today

In recent years 3D technology have received much attention. The latest revival of 3D was due to the improvement in technology for displaying 3D and some successful big studio movies that were released in 3D in the early 2000's. The development of 3DTVs and in the later years the availability of them has made 3D a common technology. This chapter will look at some successful applications of 3D technology.

4.1 3D Cinema

There has been initiatives for creating movies in 3D in the movie industry several times over the last 75 years. Poor picture quality and varying quality of content have made the audience loose interest in earlier years but with the introduction of digital cinema in the 2000's the quality of picture became much better. Cinemas is a place where a viewer can get the most out of 3D. This is because it is a dark room with a large screen and few other disturbing elements. Together with surround sound the 3D effects comes to its best and the viewer will experience the "wow"- effect that 3D is all about. When creating 3D movies much time is spent in post production making sure that 3D effects and overall quality is good. Compared to live events shown in 3D such as sports where there is no time for editing, the quality of 3D is normally far better in cinemas.

An example of a very successful movie in 3D is ”Avatar”. The use of 3D graphics together with real scenes make the 3D effects of this movie especially good and is the largest factor for the great success of in this movie. ”Avatar” had spectacularly high production costs and one reason for this is the use of advanced 3D technology. However, looking at the first weeks of screening it turned out to be worthwhile. In the U.S. the theatres with 3D screens accounted for 71% of the movie's gross despite representing only 60% of all theatres, while in Europe 25% of the screens were 3D and they accounted for 51% of the ticket sales [3]. This shows that 3D in cinemas can be very successful. It costs a bit more to watch the 3D versions of a movie but the audience today seems to be willing to pay the little extra.

4.2 3DTV and Blu-ray

The TV display industry developing 3D displays in order to sustain revenues were spurred on by 3D successes in cinemas. And by 2010 there were many 3D-ready TV displays available from different manufacturers [45]. The first 3D movies that were released on Blu-ray was in 2010 and to this date there are less than 50 movies titles available, but there are many planned releases [51]. In 2010 there were also launched multiple 3D channels, mainly from pay-TV producers [45]. Public broadcasters have yet to start producing 3D content, mainly because of the extra cost.

4.3 3D Games

Some of todays gaming consoles are 3D-capable and have available games that can be displayed on a 3DTV. Sony's game console PlayStation 3 was from 2009 able to do this, and today there are multiple game titles available. PlayStation 3 is also a Blu-ray player [54]. Microsoft's Xbox 360 has entered a partnership with 3DTV producer LG to make 3D gaming a reality on their consoles as well [7]. As of June 2011 they do not have many game titles available, but considering the development in this area it will not take long time before there will be. The game consoles mentioned can be connected to your 3DTV while the Nintendo 3DS on the other hand is a portable one-player game console. The Nintendo 3DS stand out a one of few commercial to have autostereoscopic screens. These screens lets the player perceive 3D without glasses. It was launched February 2011 [52]. The different game consoles are shown in Figure 4.1.

Figure 4.1: 3D capable game consoles[54][56][52].

Chapter 5

Osterwalder's Business Model Ontology

The goal of this thesis is to describe a possible business model for a future service utilizing 3D technology. In order to do this in a structural manner Alexander Osterwalder's business model ontology is chosen as framework. Osterwalder defines business models in the following way: "A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money." In other words a business model describes what a company offers, to whom it is offered and how it accomplishes this. This chapter provides a summary of Osterwalder's business model ontology. The summary will not cover every detail of the ontology, but include the elements that I see necessary for describing the business model of the future service.

This chapter is built around the four main areas (or pillars) that Osterwalder has described as the essential business model issues of a company. These main areas are again broken down into a set of nine interrelated building blocks, or simply called business model elements. The nine business model elements are the core of the ontology whereas the four main sections are a rough categorization [26]. The nine elements can be decomposed into sub-elements that have attributes. Figure 5.1 gives an overview of the business model ontology and how the nine elements relate to each other. In the figure the yellow boxes indicate elements (except "Actor" and "Profit") and the grey boxes related sub-elements. I follow the notation of Osterwalder where elements and sub-elements are in capital letters (e.g. VALUE PROPOSITION) and attributes are in capital and italic letters (e.g. *PRICE LEVEL*) [26]. Attributes of elements and sub-elements are shown in tables.

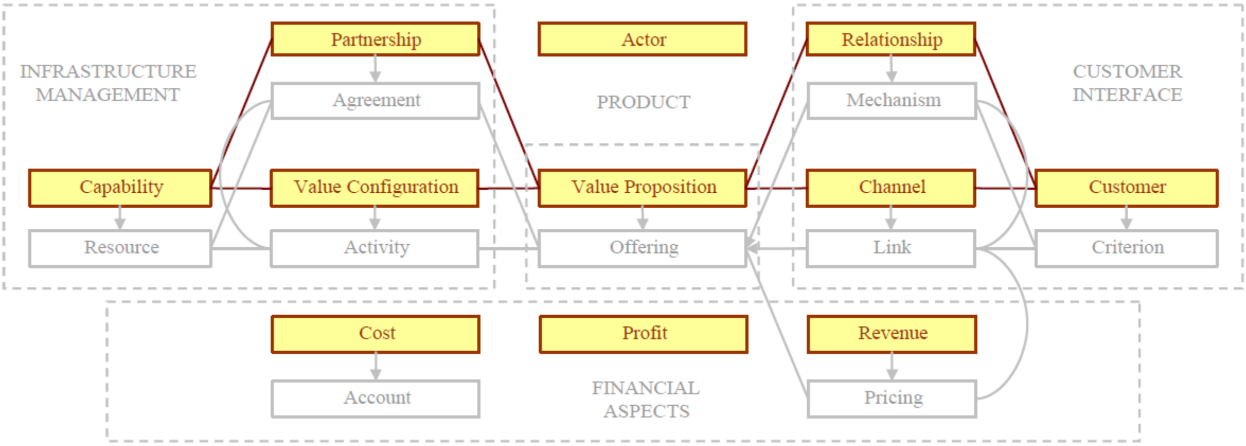

Figure 5.1: The business model ontology [26].

5.1 Product

Osterwalder's definition of PRODUCT is: "PRODUCT covers all aspects of what a company offers its customers. This comprises not only the company bundles of products and services but the manner in which it differentiates itself from its competitors". Looking at Figure 5.1, PRODUCT is composed of one of the nine elements, namely VALUE PROPOSITION, which can be decomposed into OFFERING(s).

5.1.1 Value Proposition Element

Osterwalder defines the VALUE PROPOSITION element as an overall view of one of the company's bundles of products and services that together represent value for the TARGET CUSTOMER(s). It describes the way a company differentiates itself from its competitors and why customers would choose to buy from this company and not another one. The VALUE PROPOSITION is based on one or several CAPABILITY(ies) (described later) and can be decomposed into a set of elementary OFFERING(s).

OFFERING

An elementary OFFERING describes a part of a company's bundle of products and services. It can illustrate a specific product, service, or product or service feature. It also outlines its assumed value to the customer. An OFFERING is characterized by its attributes *REASONING*, *LIFE CYCLE*, *VALUE LEVEL* and *PRICE LEVEL*. A set of OFFERING(s) with their attributes together represent a VALUE PROPOSITION.

REASONING: The reasoning on why the company thinks its VALUE PROPOSITION or OFFERING could be valuable to the customer. Value is normally created through the different types described in Table 5.1.

REASONING	
Attribute type	***Description***
{Use}	The actual use of a product or service (e.g. driving a car)
{Risk}	The reduction of a customer's risk (e.g. insurance)
{Effort}	Making customer's life easier through reduction of efforts (e.g. home delivery of groceries)

Table 5.1: The different types of *REASONING*.

VALUE LEVEL: Measuring the value level of a company's OFFERING allows the company to compare itself with its competitors. Osterwalder introduce a qualitative scale that relates to the value offered by competitors. The scale is described in Table 5.2.

VALUE LEVEL	
Attribute type	***Description***
{Me-too}	The value of the bundle of products and services the company offers its customers does not differentiate itself from the competitor's. Differentiation can take place through lower price, which is captured in *PRICE LEVEL*.
{Innovative imitation}	Company imitates existing VALUE PROPOSITION, but improves value by adding innovative elements.
{Excellence}	Value is pushed to its extremes.
{Innovation}	The company introduces a completely new product or service or a revolutionary combination of products and services.

Table 5.2: The different *VALUE LEVELs*.

PRICE LEVEL: This attribute compares the VALUE PROPOSITION's price level with the competitors price level. The scale is described in Table 5.3.

PRICE LEVEL	
Attribute type	***Description***
{Free}	Some companies can offer a VALUE PROPOSITION for free because their business model is based on other sources of income (e.g. free newspapers earn money on ads and classifies ads).
{Economy}	Low-end of price scale where a company can offer a price more attractive than the competitor's. To be able to do this the company has to streamline other elements in its business model.
{Market}	Pricing at market means little price variation from the rest of the market. Market price is still attractive if special features or attributes VALUE PROPOSITION means additional value.
{High-end}	Upper-boundary of the price scale, these prices are usually found in luxury goods, but also for new and innovative VALUE PROPOSITIONs.

Table 5.3: The scale of *PRICE LEVELs*.

LIFE CYCLE: The goal of the *LIFE CYCLE* attribute is to capture at which one of the five stages of the value *LIFE CYCLE* an OFFERING creates value. The five stages are described in Table 5.4.

LIFE CYCLE	
Attribute type	***Description***
{Value creation}	Based on agile manufacturing and mass customization and with the help of Information and Communications Technology (ICT), the customers can become important part of this process.
{Value purchase}	Value can be created during the purchase phase by facilitating the customer's buying experience and making it as smooth as possible.
{Value use}	The value that comes from the actual consumption and use of products and services. Value is maximized when the VALUE PROPOSITION's attributes match the needs of the customer.
{Value renewal}	It can be useful to renew value after or during consumption (e.g. an empty phone card). It can also be interesting to create additional value by adding new features to an existing value proposition.
{Value transfer}	The customer has the possibility to transfer value when the VALUE PROPOSITION has lost its value to the customer (e.g. sell used books on Amazon).

Table 5.4: The five stages of *LIFE CYCLE*.

5.2 Customer Interface

The CUSTOMER INTERFACE covers all customer related aspects. By Osterwalder's definition this pillar describes how and to whom the company delivers its VALUE PROPOSITION (the company's bundle of products and services). The CUSTOMER INTERFACE is composed of three of the nine elements, namely TARGET CUSTOMER, DISTRIBUTION CHANNEL and RELATIONSHIP, described in the next sections.

5.2.1 Target Customer Element

When selecting a company's TARGET CUSTOMER, segmentation is important. Effective segmentation enables a company to use the investment resources on customers that are most likely to be interested in the VALUE PROPOSITION. The TARGET CUSTOMER definition will also help a company define through which channels it effectively wants to reach its clients. TARGET CUSTOMER can be decomposed into sub-elements called CRITERION(s) which defines the customers characteristics. However, I will not use this low-level of details when describing the future service's business model and will not describe CRITERION any further.

5.2.2 Distribution Channel Element

The DISTRIBUTION CHANNEL(s) are the connection between a company's VALUE PROPOSITIONs and TARGET CUSTOMERs. A DISTRIBUTION CHANNEL allows a company to deliver value to its customers either directly, e.g. through a sales force or website, or indirectly through intermediaries such as resellers. Its main purpose is to make the right quantities of products or services available at the right place, at the right time to the right people.

LINK

The DISTRIBUTION CHANNEL element gives an aggregated view of how a company reaches its customers, and this can be decomposed into channel LINKs.

Osterwalder describes a channel LINK as a part of a company's DISTRIBUTION CHANNEL that illustrates specific marketing tasks. Channel LINKs also have the potential to create value and contribute to a company's VALUE PROPOSITION therefore the LINK element can inherit the characteristics and attributes of the OFFERING element. The details of this will not be further discussed in this summary since I do not intend to use it in my description of the future service. If the LINK element is not an OFFERING it will have an attribute called *CUSTOMER BUYING CYCLE* (*CBC*) described below.

CUSTOMER BUYING CYCLE (CBC): A DISTRIBUTION CHANNEL should be studied over the customer's entire buying circle. Osterwalder introduces an attribute that has the goal to identify which one of the functions of the CBC a channel LINK fulfills. Figure 5.2 shows the CBC and a summary of its four phases. The CBC reflects all possible contact points between a supplier and a customer.

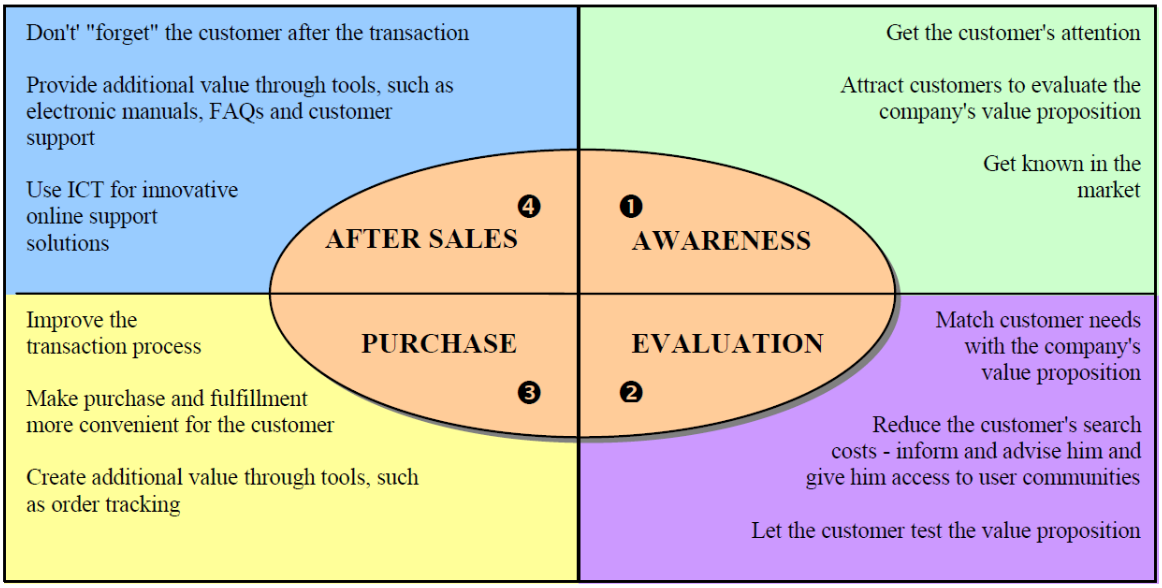

Figure 5.2: The customer buying cycle [26].

5.2.3 Relationship Element

The RELATIONSHIP element concerns the relationships a company builds with its customers. All interactions between a company and its customer's affect the strength of their relationship, but as these interactions come at a given cost a company must define what kind of customers they want to build a relationship with. Osterwalder definition is: "The RELATIONSHIP element describes the relationship a company establishes with a TARGET CUSTOMER SEGMENT. A RELATIONSHIP is based on *CUSTOMER EQUITY* and can be decomposed into several RELATIONSHIP MECHANISMs". Osterwalder use the attribute *CUSTOMER EQUITY* to classify relationships according to their customer equity goals, described in Table 5.5. I will not use the low-level abstraction of MECHANISMs in my description of the future service, hence is this not further described here.

CUSTOMER EQUITY	
Attribute type	***Description***
{Acquisition}	Companies must acquire customers to do business. Customer acquisition is a very expensive affair, and the relationship developed during acquisition phase strongly influences retention and add-on selling. It is important the customer acquisition is carefully managed and evaluated.
{Retention}	The goal of customer retention is to leverage customer acquisition investments. Customer acquisition is normally more expensive than retention and it is therefore important to find ways to extend the relationship between a company and its customers.
{Add-on selling}	This activity is associated with selling additional products and services to current customers. The products can, but do not necessarily have to be related to each other.

Table 5.5: The different *CUSTOMER EQUITY* goals.

5.3 Infrastructure Management

The INFRASTRUCTURE MANAGEMENT pillar is about how a company creates value. According to Osterwalder it describes what abilities are necessary to provide the VALUE PROPOSITION(s) and maintain the CUSTOMER INTERFACE. Looking back at Figure 5.1 the pillar is comprised of the VALUE CONFIGURATION, the in-house CAPABILITY(ies) and the company's PARTNERSHIP network which are all described in the sections below.

5.3.1 Capability Element

The CAPABILITIES of a company is described as the repeatable pattern of actions in the use of assets to create, produce and/or offer products and services to the market. A company has to use a set of CAPABILITIES to provide the VALUE PROPOSITION. ICT has made it possible for a company to outsource CAPABILITIES that does not belong to their core competencies. Thus, the CAPABILITY(ies) are based on a set of sub-elements called RESOURCEs from the company itself or its PARTNER(s). A PARTNER is also called ACTOR in Ostwerwalder's ontology. A PARTNER is an outside organization in which the company has entered a PARTNERSHIP with.

RESOURCE

A company needs RESOURCEs to create value and they are the source of the CAPABILTIES that are needed to provide a VALUE PROPOSITION. The attribute *RESOURCE TYPE* are a classification of the RESOURCEs that a company use, described in Table 5.6.

RESOURCE TYPE	
Attribute type	***Description***
{Tangible}	Plants, equipment and cash reserves.
{Intangible}	Patents, copyrights, reputation, brands and trade secrets.
{Human}	The people the company needs in order to create value with tangible and intangible resources.

Table 5.6: The classification of RESOURCEs.

5.3.2 Value Configuration Element

The main purpose of a company is the creation of value that customers are willing to pay for, and this value is an outcome of inside and outside activities and processes. The VALUE CONFIGURATION shows all ACTIVITYies and the links among them to create value. Osterwalder distinguish between three basic value types in the attribute *CONFIGURATION TYPE*, described in Table 5.7.

CONFIGURATION TYPE	
Attribute type	***Description***
{Value chain}	The activities a company does to deliver low-cost or differentiated products.
{Value shop}	The activities a company does to find out what the customer wants, how to deliver it, then finding out if the customer is satisfied.
{Value network}	A value network is created by linking customers together. The company provides a networking service.

Table 5.7: The three basic *CONFIGURATION TYPES*.

ACTIVITY

The ACTIVITIES are what a company performs in order to create and market value and generate profit. Returning to Figure 5.1 an ACTIVITY is executed by an ACTOR (which can be the company or a partner), they relate to RESOURCES and they are linked in a VALUE CONFIGURATION. An activity has two attributes described below:

ACTIVITY LEVEL**:** This attribute is described in Table 5.8.

ACTIVITY LEVEL	
Attribute type	***Description***
{Primary activity}	These activities are involved in the creation of the value proposition and its marketing and delivery.
{Support activity}	These activities are the underlying activities that allow the primary activities to take place (e.g. infrastructure, human resource management)

Table 5.8: The *ACTIVITY LEVELs*.

ACTIVITY NATURE**:** This attribute describes which type of primary activities that takes place. It depends on the attribute of the VALUE CONFIGURATION element, *CONFIGURATION TYPE*. There are three different *CONFIGURATION TYPEs* that all have different primary activities.

Value chain: The five primary activities of a value chain is depicted in Figure 5.3. Inbound and outbound is the logistic activities, whereas operations are the activities associated with transforming inputs into final product. The value chain create value by transforming inputs into more refined outputs, and more value is created at each step.

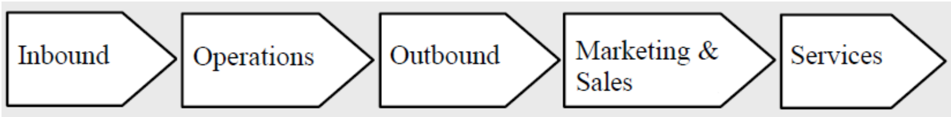

Figure 5.3: The five primary activities of a value chain [26].

Value shop: The five primary activities for a value shop is depicted in Figure 5.4. A value shop creates value by solving unique problems for customers. The value is created in a circle that starts by understanding a problem and finding different solutions. Choice is choosing amongst different solutions and at last controlling and evaluating if the initial problem is solved, then possibly start over again.

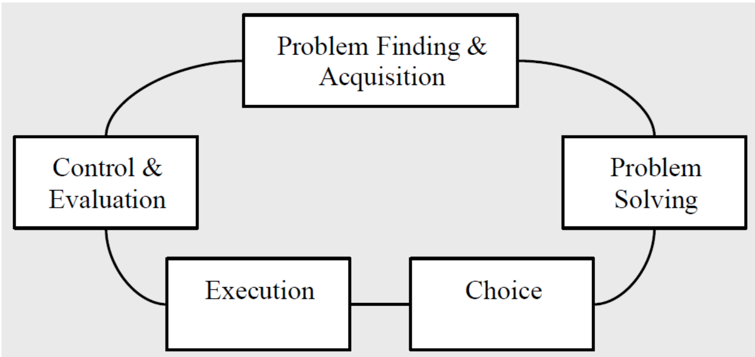

Figure 5.4: The five primary activities of a value shop [26].

Value network: There are three primary activities for a value network depicted in Figure 5.5. The network promotion is the activities associated with inviting customer to join the network, and selection of customer that are allowed to join. The service provisioning is the activities associated with establishing, maintaining and terminating links between customer and also billing of the service they receive. The network infrastructure is the activities associated with maintaining and running the infrastructure.

5.3.3 Partnership Element

Osterwalders definition of this element is as follows: "A PARTNERSHIP is a voluntarily initiated cooperative agreement formed between two or more independent companies in order to carry out a project or specific activity jointly by

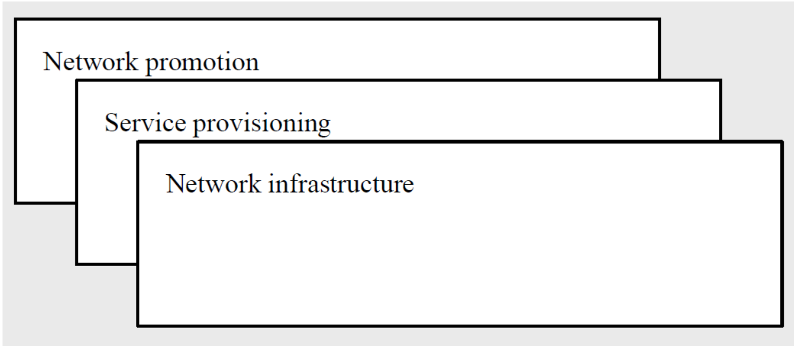

Figure 5.5: The three primary activities for a value network [26].

coordinating the necessary CAPABILITIES, RESOURCES and ACTIVITIES." A PARTNERSHIP is a set of AGREEMENTs that aims at explaining the motivation, function and conditions of an arrangement that has been done between business partners. I will not go into further details of AGREEMENTs as it will not be used when analyzing the business model of the future service.

5.4 Financial Aspects

FINANCIAL ASPECTS is the last pillar of the business model framework. All the other pillars described in this chapter influence the FINANCIAL ASPECTS. The REVENUE MODEL and COST STRUCTURE elements determine the company's logic for making profit or loss and therefore its ability to survive its competitors.

5.4.1 Revenue Model Element

The REVENUE MODEL element measures the ability of the company to make the value offered to the customer into revenue. The REVENUE MODEL can be decomposed into the sub-element REVENUE STREAM AND PRICING.

REVENUE STREAM AND PRICING

This element describes the incoming revenue stream of the company. A company can have many revenue streams and each of them can have one or several different pricing mechanisms. This element is characterized by its attributes which are described below:

STREAM TYPE: "The stream type describes the type of economic activity with which a company generates a revenue stream" [26]. The different *STREAM TYPEs* are described in Table 5.9.

STREAM TYPE	
Attribute type	***Description***
{Selling}	The activity of giving away some aspects of a ownership of a good or service in exchange for money.
{Lending}	The activity of giving something away for a period, and expecting to get it back when the period is through.
{Licensing}	The activity of giving someone official permission to do or have something (e.g. patent holder can give another company permission to use it in exchange for money).
{Transaction cut}	The activity of organizing, facilitating or performing a business activity between two or several organizations where goods are exchanged for money. A transaction cut or commission is paid to the party that has helped doing this.
{Advertising}	The activity of telling about something publicly and through media to influence the choices of customers.

Table 5.9: The different *STREAM TYPEs*.

PERCENTAGE: This attribute is the measure of how much a certain revenue stream has contributed to the total REVENUE MODEL.

PRICING METHOD: The different categories of pricing mechanisms are described in Table 5.10.

PRICING METHOD	
Attribute type	***Description***
{Fixed pricing}	Prices that do not differentiate in function of customer characteristics, by volume or real-time market conditions. Mechanisms are pay-per-use, subscription and menu pricing.
{Differentiated pricing}	Prices that are based on either customer or product characteristics and that are volume dependent.
{Market pricing}	This is prices based on real-time market conditions.

Table 5.10: The different *PRICING METHODs*.

5.4.2 Cost Structure Element

This is the last of the nine elements and it measures all the costs a company has to consider in order to create, market and deliver value to its customers. The COST element is a set of ACCOUNTs that each define the specific type of expenditures. Each ACCOUNT has the attributes *SUM* that measure the monetary value of an ACCOUNT and *PERCENTAGE* that measure how much a specific ACCOUNT contributes to the total cost.

Chapter 6

Virtual Collaboration Systems

Virtual collaborations involves two or more people that are working together or communicating without the physical face to face interaction. Early virtual collaboration systems are regular telephones and audio conferencing systems. And today video conferencing and telepresence systems are common. Video conferencing and video telephony became very popular in the 2000's with free services like Skype. State-of-the-art systems such as the telepresence system from Tandberg (now Cisco) requires its own room with specialized (2D) technology and design (at both sides of the communication) to give the feeling that both you and the communicating party is in the same room, having a meeting at the same table. These, and other similar systems are very expensive and meant for business purposes only. There is currently a European project called *3DPresence* that attempt to create "a 3D videoconferencing system that will tackle the problem of transmitting the feeling of presence in real-time to multiple remote locations in a transparent and natural way" [29]. This project will try to create a near-natural way of communication over the Internet which also is the goal of the work of professor Rønningen et al. [34] at the Norwegian University of Science and Technology. I will use some of the thoughts from Rønningen's work together with state-of-the-art technology to design of a future virtual collaboration service. The next section takes an overall look at the architecture and the possible use of future collaboration services such as the ones described in Rønningen's work.

6.1 Futuristic Virtual Collaboration System

The work of Rønningen includes the concept of Distributed Multimedia Plays (DMP) which is a three layer architecture that aims to provide ”near-natural virtual networked stereoscopic multiview video and multi-channel sound collaboration between players and servers” [33]. To construct such an environment an array of autostereoscopic 3D displays on all surfaces of a collaboration space with cameras embedded is a possible solution. The ultimate goal of DMP is to ensure that the maximum end-to-end delay is around 10-20 ms during collaborations and that the images keep a high-definition (HD) resolution. With current standards this is not possible and as Rønningen states in [33]: ”it is not the intention to speculate whether the market wants the services or not, cost aspects are not focused at all, and some technologies needed do not yet exist (and we do not know if they will exist in fifteen years or so).” However the DMP architecture is a proposal towards the realization of the vision of near-natural collaboration spaces.

There are three basic parts of the DMP system, namely the the concepts of *near-natural scene quality*, *SceneProfiles* and *Quality Shaping* that Rønningen et al. describes [34]. The *near-natural scene quality* means that a user should not perceive any large difference between seeing a person in the real world and seeing him in a virtual scene. The *SceneProfiles* provides standardized descriptions of how to shoot and present space, scenes and objects in a virtual collaboration space. The *SceneProfiles* are negotiated between the users before the service is set up. The traffic generated from a near-natural scene will be up to 10^3-10^4 times higher than what we are used to from video conferencing systems today. Hence *Quality Shaping* is what enables a graceful degradation of quality when the network is overloaded or components fail. A main importance in the DMP system is that scenes are divided into sub-scenes and objects are divided into sub-objects, which makes the multimedia packets independent.*Quality Shaping* can then make controlled dropping of sub-objects from selected packets and scale the resolution/composition thereafter. The design goal of the DMP system is to simplify existing collaborative systems and upper the quality by reducing the number of protocols and architectural layers [34].

The three layers of the DMP architecture seen from the user's perspective is depicted in Figure 6.1 and consists of: the *Linksical layer* which is the link/physical

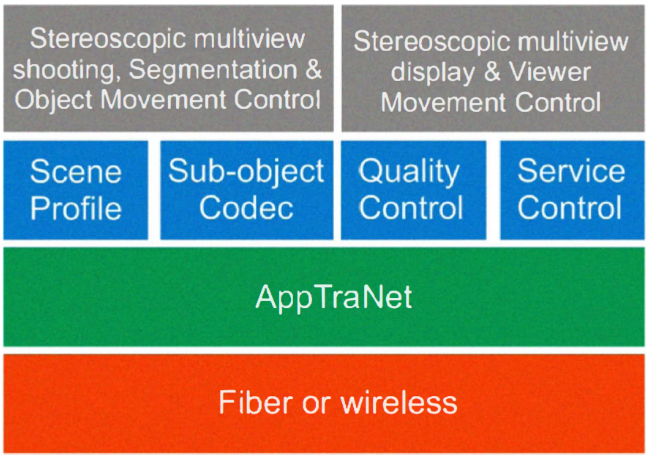

Figure 6.1: The three-layer DMP architecture from user's perspective [33].

layer combined ("Fiber or wireless" in the figure), the *AppTraNet layer* which is a protocol with a combined header for the application, transport and network protocol (built around IPv6 and IPSec) and at last the application layer which consist of the six functions depicted on top of the figure. The work of Rønningen et al. presents a vision of how people can collaborate in the future in a near-natural way with an ultimate goal of minimal end-to-end delay, and they propose this architecture as a possible solution. There are several ways of solving the different issues of how to communicate in a near-natural way, and some of todays research have already come far.

The areas of application for a virtual collaboration system could be many. By having collaboration spaces in many different locations people can communicate in a near-natural way with other people (located far away) without having to travel. If the maximum end-to-end delay requirements of 10-20 ms in [34] is met, one could use such spaces in musical collaborations (rehearsals, song lessons, musical theatre education) or in services offering people to experience concerts, opera and theatre in a near-natural way without being at the specific location. Such systems could also be interesting from a business perspective for reducing the cost and inconvenience of traveling, as it is a much more natural way of communicating than state-of-the-art collaboration systems. It may also be interesting for researchers working in different countries to have an opportunity to do research together and carry out conferences, and holding lectures. These system can be used as Multimedia Home Space (MHS), as described in [33]. It can be any room in the house, a specialized room built for near-natural virtual collaborations, or it can be the living room or kitchen where the walls are covered with autostereoscopic screens. Having such a room in a home opens for more services offered to the users. It can still be used for near-natural communication with other parties but it could also offer gaming services, streaming of concerts, movies or other big events or it can be used as a TV. There are many possibilities for offering services to these kinds of systems. Today, it is mainly the cost and the limitations in current technology that set restrictions to the imagination of what such future services could look like. The future service that is specified in the next section are somewhat more realistic than some of the services suggested here. Still the specification is based on the assumption that technology will develop and the costs decrease as it is not feasible to carry out with todays technology.

6.2 Case Study: "The Virtual Conference Room"

The system and accompanying services that is presented here use some of the thoughts from the DMP architecture together with technology that are available or under research today. This is a system that will offer near-natural collaboration services to the public. It is to be implemented in a room the size of one of the smaller theatres in a cinema and would make up a collaboration space for up to 50 people. "The virtual conference room" (from now on referred to as the

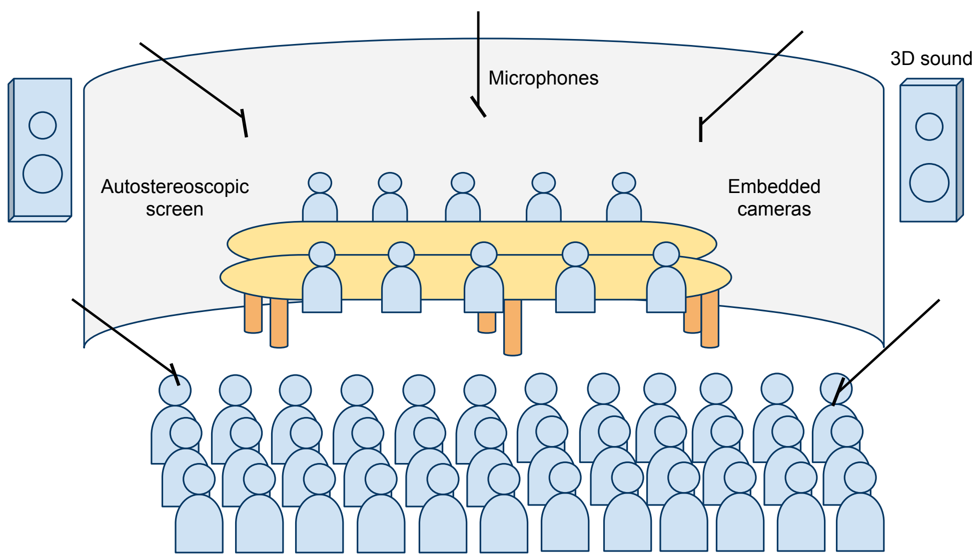

Figure 6.2: The virtual conference room.

collaboration space) will have a large autostereoscopic screen with multiple views, embedded cameras and 3D sound as shown in Figure 6.2. It is important that the system is the same (standardized) in all collaboration spaces and that the surroundings in the room are very similar to each other to achieve the perception for the people communicating that they are in fact in the same room. Figure 6.2 shows both people sitting at a table having a meeting and also people further back as they would sit if watching a lecture or a presentation. This is just an illustration of the different applications of the collaboration system, the two groups would not be there at the same time. Typical services that could be offered to customers are:

- A near-natural collaboration service for meetings, conferences and seminars.
- An auditorium for live near-natural lectures.
- Live streaming or playback of e.g. concerts and theatre.

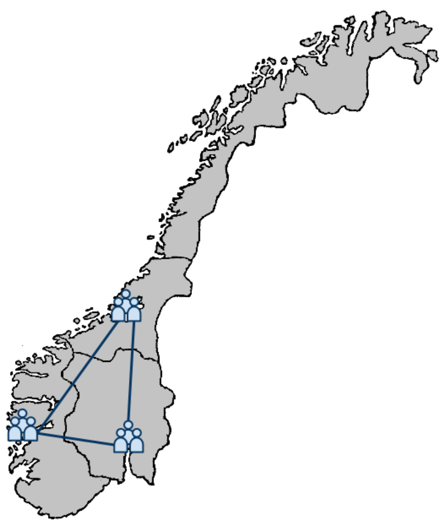

Figure 6.3: Placement of collaboration spaces.

Collaboration spaces will, to start with, be implemented in the large and dispersed cities in Norway as depicted in Figure 6.3. If the services prove to be successful they will be implemented in other cities and in other countries as well.This introduction to the system give an idea of what the main functionalities are. The rest of this chapter will provide a more detailed description of the system.

6.2.1 Functional Requirements

A functional requirement defines a function of a software system or a service. Functional requirements could be technical details, data manipulation, processing and other specific functionalities that define *what* a system is supposed to accomplish [46]. The system in this context refers to the service that are offered to customers and that is handled by administrators and operators. The functional requirements tell what the users, administrators and operators can expect from the system, described in Table 6.1.

Functional Requirements	
Requirement	***Description***
Handle users	The system should handle different users with different permissions. Typically one administrator with exclusive permissions and other personnel with limited permissions.
Report system status	Report status of the network connection between other selected collaborating spaces and if the services are functioning as intended, give alert if unusual occurrences.
Report equipment status	Report status of system equipment (e.g. cameras, microphones), give alert if they are not functioning properly.
Storage	Storage of recorded video and audio from own collaboration space or of received multimedia streams from other collaboration spaces. Storage of multimedia received (e.g. concerts, theatre) for later display to the public.
Other collaborations	Generate list of all collaboration spaces possible to connect to and their availability.
Multiple collaborations	It should be possible to connect to and collaborate with one or multiple other collaboration spaces.
Near-natural collaboration	People collaborating can expect near-natural representation of presence e.g. eye contact and sound.
Configuration	Administrators shall have the possibility to configure equipment and servers in a collaboration space.
Send/receive	The system should be able to send and receive large amounts data (detailed description in Section 6.2.3).

Table 6.1: The functional requirements of the system.

6.2.2 Non-Functional Requirements

A non-functional requirement is a requirement that describes qualities and constraints in a system [53]. The non-functional requirements of the system is described in Table 6.2 and in the text below:

	Non-Functional Requirements
Requirement	*Description*
Usability	The system should be easy to use for trained personnel. Users paying for the services are not expected to need any knowledge of the system.
Delay	The maximum end-to-end delay $\leq$ 350 ms.
Video Quality	Near-natural video quality.
Audio Quality	Near-natural audio quality.
Varying Quality	Quality is allowed to vary with time due to technical differences in collaboration spaces and the network connection, but with a maximum quality variation guarantee.
Security	Integrity, authentication and encryption of content should be provided.
Maintainability	The system should be easy to maintain.

Table 6.2: The non-functional requirements of the system.

Usability The system should be easy to use for personnel operating the system on a daily basis. This means setting up the connection between spaces, negotiating the configuration and monitoring that everything is working as intended during a collaboration.

Delay The maximum end-to-end delay should be no more than 350 ms. If the delay is more than this over a longer period of time the people collaborating will be having trouble communicating in a natural way.

Audio & Video Quality People using the collaboration space can expect near-natural representation of other collaboration spaces in both sound and image.

Varying Quality As different collaboration spaces will be physically different and the equipment and set-up of equipment is not exactly the same, one should expect that the quality of the near-natural representation of sound and image may vary. Also the quality of audio and video may vary depending on the network connection. However, the users can expect no more than a maximum variation of the quality.

Security The users can expect integrity, authentication and encryption of the content that is sent between collaboration spaces. The security for the payload of the packets can be ensured by Internet Protocol Security (IPsec). IPsec is an end-to-end security scheme and can ensure integrity, authentication and encryption of the payload [50]. It is also important that the system at the location of the collaboration space is secured by username and password, to avoid unwanted intrusion. Access control is important to avoid that people without knowledge to the system make changes and alter configurations.

Maintainability The system should be easy to maintain on a daily basis. Examples of such maintenance are checking that all equipment is functioning correctly and that the network connection is good prior to a collaboration setup. More advanced configurations and corrections require more expertise within the system, and this is something that the system experts or manufacturers of equipment may be required to perform. Examples of such are changing of cameras or microphones and configuration.

6.2.3 Detailed Description of the System

This system is meant to be placed in a medium sized room with capacity of up to 50 people. The system is composed of a large slightly curved autostereoscopic screen with dimensions of approximately 3×10 meters, and at least 12 horizontal views. A larger screen requires more views. 12 views is sufficient for a meeting of up to 10 persons and for conferences or lectures of up to 50 persons if they are sitting as in a movie theatre (behind each other). All chairs have to be carefully placed inside one of the views of the autostereoscopic screen. The resolution in autostereoscopic displays today is a problem when adding multiple views, so an assumption that has to be made is that the spatial resolution will become much higher in a few years. The image for each eye should have at least as good resolution as todays good HD displays, which means that the resolution of the screen has to be twice as high, for each view and this multiplied by the amount of views. This means that the screen described above need a resolution that is 24 times better than todays HD displays to meet the requirements of a near-natural video quality. This is not inconceivable in some years as there is already developed an 85-inch LCD display with 16 times as higher resolution than todays HD displays [32]. Embedded into the screen are multiple double micro-cameras for recording at a natural viewing angle. A double camera is needed for each view. It is extremely important that these cameras are focusing at exactly the right angle and that the lenses are placed the right distance apart. Failing to do so could cause irregularities between the views in the autostereoscopic screen at the receiving end, and exaggerated stereo effects which can cause discomfort with the viewers. The sound will be recorded with arrays of microphones and each collaborative space will have arrays of loudspeakers to recreate the sound of another space in a near-natural way. The design of the collaboration space in general will ideally be similar in each space; use the same type of furniture, colors and have same type of lighting.

The next sections will describe in detail the workings of the system end-to-end. Estimates for the data rates are shown and the assumptions made for the requirements of future technology is highlighted.

Compression and Distribution

A stream of high quality HD video is captured from each of the cameras embedded in the autostereoscopic screen. In compliance with the requirements there has to be an array of microphones capturing sound for each person in the meeting, in addition to microphones capturing the overall sound. Together this constitutes a large data stream that needs to be handled efficiently. An estimate for the amount of raw data must be processed is described in Table 6.3.

Raw HD video:	1.04 Gbit/sec[1] $\times$ 2 (stereo) $\times$ 12 (views) $\approx$	24.88 Gbit/sec
Raw audio:	512 kbit/sec[2] $\times$ 15 (microphones) $\approx$	7.68 Mbit/sec
SUM:		24.89 Gbit/sec

Table 6.3: Raw data rate from audio and video.

The raw data that comes from all the cameras and microphones needs to be processed together in an efficient way, and synchronization of all these sources is extremely important. From todays viewpoint the most reasonable way of doing this would be by encoders and decoders (combined known as codecs). Each collaboration room needs an encoder and decoder that compress and decompress the data, while keeping a high level of quality in the multimedia streams. There are codecs known today that can do this efficiently and with minimal latency for a single 3D video stream [36]. It is reasonable to believe that in a few years there will exists systems that can handle multiple 3D video streams. The different signals needs to be synchronized and labeled so they will reach the proper destination (correct view in the screen or correct loudspeaker) and I expect a future codec

[1] 1920 pixels horizontally $\times$ 1080 pixels vertically $\times$ 10 bit/pixel $\times$ 2 (color) $\times$ 25 frames/sec.
[2] For speech sufficient sampling rate is 32 kHz $\times$ 16 bit quantization.

to be able to handle these tasks. To estimate the compression rate and the data rate that are to be transmitted I use current state-of-the-art codecs, which use the JPEG 2000 compression standard mentioned in Chapter 3.2. Stephansen et al. [18] state that the codec can reduce the bit rate from a signal of 1.485 Gbit/sec to bit rate between 50 and 200 Mbit/sec with total latency of 120 ms. This is a reduction in bit rates to only 3.3%-13.2% of the original value. Using these compression rates as a basis I assume that the raw data from the recordings in a collaboration space can be compressed to approximately 10% of its original value. The compressed data will then have a rate of approximately 2.5 Gbit/sec.

Each collaboration space will have a dedicated server handling the data streams and the connection between collaboration spaces. The software running on these servers does distributing and routing of the data streams, and report status of system and network. Control packets for synchronization of sources, configuring packets and headers will add an approximately 20% extra data to the data stream. This means that the data rate that are to be transmitted is 3 Gbit/sec. The same amount of data rate is received from the other collboration space, which means 3 Gbit/sec upstream and 3 Gbit/sec downstream at all times during a collaboration.

Transmission

In order to meet the requirements of a maximum delay of 350 ms, the network connection has to be reviewed. The compression and decompression of the multimedia will be the largest source for delay which leaves little time for transferring the multimedia from end to end. The propagation delay is the time it takes for the signal to travel from the sender and receiver. With fiber the propagation delay is the speed of light and it is a physical limitation that will be present under all circumstances. However, this delay is small compared to the other delays and between cities in Norway this would account for 1-2 ms of the overall delay. A possible bottleneck is the access network. For these data rates all types of Digital Subscriber Line technology (DSL, often summarized as xDSL when speaking of the family of technologies) will not suffice in throughput. For this purpose we have to assume that each collaboration space has Fiber To The Home (FTTH) which means that optical fiber is extended from a central hub all the way to the subscriber. The core network in Norway and especially between big nodes that are found in the largest cities consist mainly of optical fiber. As an example of todays capacity, the three links between Trondheim and Oslo combined has a capacity on average of 23 Gbit/sec [43]. If we assume that the collaboration spaces have optical fibers connecting them from end-to-end, todays Internet could not successfully handle the amount of data that these kinds of collaborations need. It is required more intelligent equipment in nodes, switches and routers and/or more bandwidth in both core and access network. Looking at how far the research has gotten today, this is not infeasible in the near future. Scientists have succeeded in encoding data at a rate of 26 Tbit/sec, transmitting it over a distance of 50 km and decoding it successfully. Also, research now concentrates on developing systems for transmission lines in the range of 400 Gbit/sec to 1 Tbit/sec [27].

The system has to be able to handle some loss due to congestion and network failures. This loss may lead to a degradation in quality of multimedia, which is acceptable up to a certain point.

Receive and Display

The server at the receiving end ensures that the data stream is delivered to the decoder in the same manner as it was sent from the encoder. The decoder decompress the individual video and audio streams and send it to the appropriate receiving device. It is extremely important that each video stream and each audio stream is synchronized. If, for example the left and right eye video streams are not synchronized, it will be intolerable for a viewer to look at.

6.2.4 Example Use of the System

How the system works end-to-end is best explained by an example of a typical application of "the virtual conference room". 10 people in Trondheim and 10 people in Oslo want to have a meeting and they will use "the virtual conference room"'s meeting service. The collaboration spaces in both cities are reserved in advance by those responsible for the meeting via an online booking website or by telephone. The time is scheduled, and each collaboration space have trained personnel setting up the communication and checking that everything is working as it should prior to the meeting. The people having the meeting arrive at the scheduled time in each collaboration space and start the meeting immediately.

There are no human interaction in the system while the meeting lasts. The sequence of events and the interaction between the different components in the system are best explained by the help of a Message Sequence Chart (MSC) in Figure 6.4. The sequence of events start when a user (typically the operating personnel) want to connect to another collaboration space. The server exchange negotiating parameters and sets up the connection with the server in the other collaboration space. When the other server responds OK, the streaming of multimedia starts. In a real setting the streaming of multimedia starts from both collaboration spaces at the same time, but for simplicity's sake only from one end is depicted here. The sequence from capturing the multimedia in one end and until it is displayed at the other end is understood by looking at the figure, other details are found in previous sections. The time it takes from the multimedia is captured until it is displayed should be less than 350 ms.

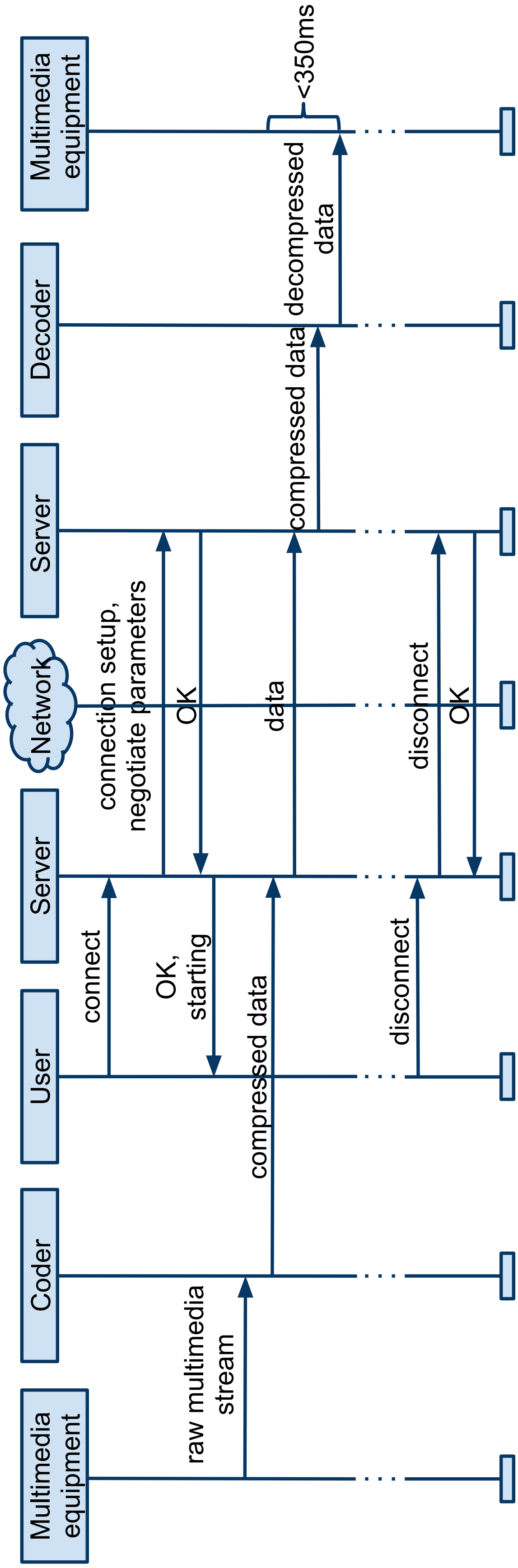

Figure 6.4: MSC of the communication between two collaboration spaces.

6.2.5 Issues with the System

Most of the issues with this system are mentioned earlier in the text, but this section is used to summarize some of the problems. The technology that exists today does not suffice for these kinds of collaborations but there is reason to believe that the required technology will be available in 5-15 years. The issues with the system that are not fulfilled or that are difficult with todays technology are listed in Table 6.4

Issues with the system	
Issue	***Description***
Display resolution	The resolution of the autostereoscopic screen need very high resolution to be able to show HD video to each eye and each view.
3D effects	3D effects have been known to cause discomfort with some viewers. It is important that the lenses are adjusted the right distance apart and in accordance with other cameras in different views. The users have to be carefully seated "inside" a view to achieve the correct 3D effects.
Codecs	Efficient codecs that can handle multiple multimedia streams and keep them synchronized is a very important part of the system. They need to compress the streams efficiently while keeping high quality of content and produce minimal latency.
Transmission	The network and network components need to handle at least 3 Gbit/sec upstream and 3 Gbit/sec downstream efficiently and with minimal delay.
Assembly	The system needs to be carefully assembled by experts. It is not a plug-and-play system.
Software	Software system to handle these kinds of collaborations does not exist today. It is assumed that specialized software have to be developed for the purpose of this system.
Management and operation	It is assumed that each collaboration space needs one trained person to operate the system on a daily basis. More advanced configuration or repair has to be done by system experts.
Cost	The cost of state-of-the-art technology today is high and it needs to be considerably improved.

Table 6.4: Issues with the system

Chapter 7

Business Model for "The Virtual Conference Room"

This chapter intends to give a detailed description of a possible business model for the "the virtual conference room". Osterwalder's business model ontology is used as framework for this description. The framework is described in detail in Chapter 5, and the reader is referred to this chapter if anything is unclear. Here, the terms from Osterwalder will be used without further explanation.

The structure of the business of "the virtual conference room" can be composed in many different ways. This depends on the actors; which of the actors compose the core business and which ones are partners. The different actors that has to be involved in order to develop, set up and run "the virtual conference room" are explained in Table 7.1. The different ways of structuring the business of "the virtual conference room" is presented below. One structure will be chosen and used throughout this chapter.

Service provider alone: One way to structure the business is by making the service provider the core of the business and all other actors to be partners. The service provider pays other actors a fixed price to set up collaboration spaces, develop software, provide rooms and Internet for "the virtual conference room". They keep a website, manage marketing and handle all customer related tasks. The service provider takes all the risk of setting up the system and in return get all revenue from customers.

ACTORS	
Actor	***Description***
Hardware suppliers	The producers of the hardware technology needed in each collaboration space. They are the producers of autostereoscopic screens, microphones, loudspeakers, cameras, codecs, servers and all the other technical equipment that are needed for a collaboration space. They also include the producers of all furnitures and fixtures needed so that all collaboration spaces are similar. This actor includes the installation contractors as well, since they often have a close connection to the producers.
Software developer	They develop the software that handles the communication between collaboration spaces.
Service provider	This actor offers the services of "the virtual conference room to customers. They handle marketing, booking of collaboration spaces and all other contact with customers.
Room suppliers	They lease the rooms in different cities that are needed to set up a collaboration space. They could typically be conference centers or cinemas in or near large cities.
Internet provider	This actor offer high bandwidth Internet connection to the collaboration spaces.
Content provider	They provide the content to be screened in the screening service of the collaboration space. Such content could be theatre and concerts. They are the companies that record and produce content.

Table 7.1: The actors of "the virtual conference room".

Service provider and room suppliers: A second possible way to structure the business is by having the service provider and the room suppliers being the main actors. The service providers offer the entire system and the set-up of the collaboration space to the room suppliers. The room suppliers pays the service provider a fixed price for doing this, in addition to handle booking, marketing and all customer related tasks. The room suppliers gets all the revenue from customers. They are the ones taking the investment risk. All other actors are partners.

Service provider and software developer: Having the service provider and software developer form the core of the business means that the operation and management of the system and customers related tasks are tightly coupled. These two take the risk of setting up the service together and get all revenue from customers. All other actors are partners.

Having the service provider and the software developer form the core is the most natural way of structuring the business, from my point of view. This because the software system behind "the virtual collaboration room" is specialized and has to be custom made, it is not an "off-the-shelf" product. It is reasonable to believe that the entrepreneurs behind the "the virtual conference room" are the ones that have the idea for the software system and are able to develop parts of it. In addition, maintenance and upgrade of the software system will be needed and installation of the software in every collaboration space must be done. And this is a reason why the software developers should be a part of the business and handle these tasks. From now on I will refer to these two as *the company*. The structure of the company is shown in 7.1 and the details of the business model will be explained throughout this chapter.

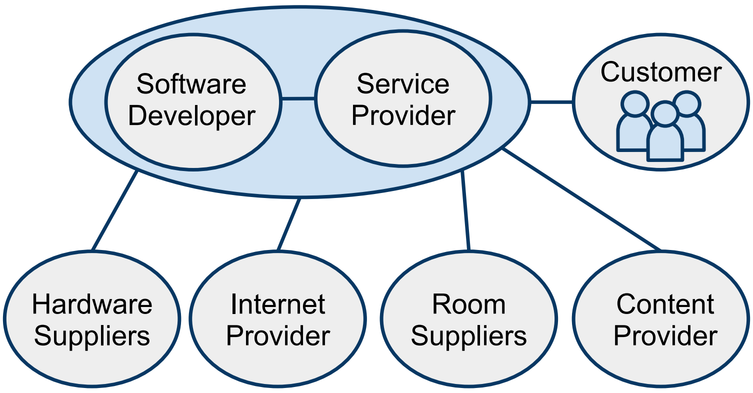

Figure 7.1: The structure of the company for "the virtual conference room".

7.1 Product

According to Osterwalder the product pillar covers all aspect of what a company offers its customer, and it is composed of value propositions. A value proposition is one of the company's bundle of services that is offered to the customer. This company has one value proposition which is that they offer a near-natural way of communicating with people located in other cities, or to experience special events through the use of autostereoscopic 3D. The value proposition is based on three offerings that are described in Table 7.2, 7.3 and 7.4.

OFFERING 1: Meeting service	
Attribute	***Description***
Description	This service offers a near-natural way to communicate for people located in different cities. It is meant for a maximum of 10 people in each collaboration space. They will be sitting at a table right in front of the screen communicating directly with the other collaboration space.
Reasoning	{use}{effort}: It is valuable to the customers through use, because they can communicate in a near-natural way. It reduces the effort of traveling in order to have a meeting.
Value Level	{innovative imitation}: The system imitates already existing system such as Tandberg's telepresence system, but it is innovative in offering a near-natural experience with 3D viewing and by being publicly available.
Price Level	{economy}: A competitor for this system is telepresence systems such as the ones Tandberg produce. Telepresence systems today are meant for businesses and their private use, and they are very expensive. Another "competitor" to these services are traveling in order to have a meeting. The purpose of this service is to offer a cheaper, easier and greener alternative than that of the competitors, hence the price level is set to economy.
Life Cycle	{value use}: Value is created through the use of the service.

Table 7.2: Offering 1 of the value proposition - a meeting service.

OFFERING 2: Conference, seminar or lecture service	
Attribute	***Description***
Description	This service is similar to the last service, but the arrangement is a bit different since it is meant for up to 50 people. It will be used in a typical conference setting where most of the people are sitting down to listen to one or more holding presentations. Not everyone are communicating at the same time.
Reasoning	{use}{effort}: The reasonings is the same as the previous. The service is valuable through use, and it is a reduction of the effort of traveling.
Value Level	{innovative imitation}: There are not any similar services today where this many people that can join in on a virtual collaboration. Still, it is an extension of the previous offering, therefore this value level is chosen.
Price Level	{economy}: The price level is set to economy, though there are not any similar services present today. There has to be a economic advantage for the customer to use this service compared to traveling.
Life Cycle	{value use}: Value is created through the use of the service.

Table 7.3: Offering 2 of the value proposition - a conference service.

OFFERING 3: Screening service	
Attribute	***Description***
Description	This service gives customers the possibility to experience a near-natural representation of an event that is happening or that has happened, by streaming or playback. Such events could be concerts, theatre or musicals. This is a one way communication.
Reasoning	{use}{effort}: The reasoning is the same as the previous ones, the service is valuable to customers through use and through the reduction on effort in traveling a longer distance to experience the same events.
Value Level	{innovative imitation}: This service contain innovative elements as opposed to watching the event on your own TV. The service is not fundamentally new hence this value level.
Price Level	{economy}: The service will be cheaper than paying for a ticket to see e.g. a musical or concert live, but more expensive than seeing it on TV. Since this service is closer to imitating the experience of seeing an event live, economy is the chosen value level.
Life Cycle	{value use}: Value is created through the use of the service.

Table 7.4: Offering 3 of the value proposition - a screening service.

7.2 Customer Interface

The customer interface describes all customer related aspects; who are the target customers and how the company interacts with them.

7.2.1 Target Customers

The company has a set of target customers which are found in Table 7.5.

TARGET CUSTOMERS	
Type	***Description***
Businesses	They include people that are pressed for time. Time is money, and they want to save the extra time used in traveling. They may want to have a green profile.
Researchers and universities	They need an inexpensive and time-saving alternative to communicate with other researchers and research institutions. They want to hold or see lectures without having to travel. They may also be environmentally conscious.
Culture interested public	Everyone that are interested in theatre, musicals and concerts. They want to see events that is happening in other cities without paying too much.

Table 7.5: The target customers of ”the virtual conference room”.

7.2.2 Distribution Channel

The distribution channel is the connection between the customers and the value proposition. It can be decomposed into links that describe specific marketing tasks. A link has an attribute called the customer buying cycle (CBC) that identifies which functions of the buying cycle the link fulfills. The channel links in which this company meet the target customers are described in Table 7.6.

7.2.3 Relationship

This element concerns the relationship that the company builds with its target customers. There is always a cost involved in acquiring customers, so the company needs a strategy for which customers they want to attract and how they will keep them. Three customer groups are identified for the company. There are different marketing tasks that is performed to reach each of them. Therefore will the relationship the company build with each of the customer groups be described separately and classified according to the customer equity goals. There are no additional products or services that the company offers except from the three services mentioned. Add-on selling for each customer group then means informing acquired customers of all the services that the company offer even though they are not the target customers for the other services.

Business Customers

{Acquisition}: The acquisition of these customers are done by visiting potential customer, sending out brochures, inviting to demos or trial and exposure at fairs. Selecting possible customers to invite to free trials of demos must be done carefully since it is an expensive marketing task.
{Retention}: When customers are acquired the goal is to keep them to leverage the investments of the acquisition. As mentioned, customers may be offered to reserve hours in every week or month at their convenience through special deals.
{Add-on selling}: Advertising of the screening service to existing business customers. They can choose to subscribe to a newsletter that informs of what is screened in each collaboration room.

DISTRIBUTION CHANNEL		
Link	***Description***	***CBC***
Company's website	This is the official website for the company. Here the system is presented and it lists all the cities where it is available. Customers can book "the virtual conference room" for meetings or conferences and pay. It has a schedule for when special events are screened in the different collaboration spaces and customers can buy tickets. This link is targeted at all customer groups.	{purchase}
Exhibitions	Holding exhibitions at e.g. industrial fairs to get in contact with potential customers. Large industries with dispersed offices are target customers.	{awareness}
Free trial	Invite target customers to a free trial of the service. The typical target would be large industries with dispersed offices, but could also be universities and researchers that have much communication with other research institutions.	{evaluation}
Demo	Invite key persons in businesses or universities to a joint demo of the system.	{evaluation}
Ads on websites	Carefully choose websites to advertise for the service. To reach businesses the company could consider serious newspaper sites. To reach universities and researchers a science newspaper could be relevant. In order to meet the customers that would want to see theatre and concerts the company could post ads on specific theatre's websites or ticket office websites.	{awareness}
Posters	Put up posters for specific events that are screened in the collaboration space. To attract the target customers the company would put them up in theatres, concerts halls and cinemas.	{awareness}
Brochures	Make brochures that present the system and send this out to target customers.	{awareness}
Visit customers	Arrange meetings with target customer to present the system, invite them to free trial or demo of the system and present special deals.	{evaluation}
Special deals	Potentially large customers can be offered special deals such as reservation of specified hours of the month or week at fixed prices.	{after sales} or {evaluation}

Table 7.6: The company's marketing tasks (links).

Researchers and Universities

{Acquisition}: Sending out brochures and inviting to a joint demo of the system is the most reasonable way to reach these customers. Ads on certain targeted websites or getting reviewed by a scientific magazine is also possible way to reach

these customers.
{Retention}: Keeping a relationship with these customers can be difficult because they may not have the need to communicate as often as businesses. However, keeping them updated on the availability of spaces and offer special deals if there are much availability is possible.
{Add-on selling}: As with businesses, current customers can choose to subscribe to a newsletter about screening events.

Culture Interested Public

{Acquisition}: Acquiring these customers is done through ads and poster on suitable websites and locations.
{Retention}: Having current customers subscribe to a newsletter that is sent out whenever there are screening events, is a possible way of keeping a relationship with these customers.
{Add-on selling}: Advertising about the meeting and conference services to these customers as well.

7.3 Infrastructure Management

This section is about how the company creates value. The company rely on many abilities to provide the value proposition and to maintain its customers, these are described in the next sections.

7.3.1 Capability

The capabilities of the company describes the repeatable pattern of actions and use of assets in order to offer the services to the market. A set of capabilities are used to provide the value proposition, and they rely on resources from the company itself or their partners to create value, see Table 7.7.

CAPABILITIES		
Resource	***Description***	***Type***
Hardware	The hardware needed to set up collaboration spaces are bought from partners. Hardware includes autostereoscopic displays, cameras, servers, furniture etc.	{tangible}
Software	The software needed for the communication between collaboration spaces is developed in-house.	{tangible}
System developer/experts	The software need to be developed and carefully installed and updated. These are employed by the company itself.	{human}
Installation contractor	Hardware and equipment has to be carefully installed. These are hired from the suppliers of the hardware to install it.	{human}
Internet connection	Internet connection and high bandwidth are a crucial resource for the collaboration services to work. It is provided by partners.	{tangible}
Content	Content for the screening service is provided by the company's partners.	{tangible}
Rooms	The company rents rooms on a long term basis to set up collaboration spaces. These rooms are provided by their partners.	{tangible}
Administration	Marketing, customer related tasks and resource management are done by these people that are employed by the company.	{human}
Operators	Each collaboration space needs an operator to operate the system on a daily basis. These are employed by the company.	{human}

Table 7.7: The capabilities of the company.

7.3.2 Value Configuration

The value that the customers pay for are an outcome of outside and inside activities. The value configuration shows all activities that are needed to create value. Before identifying the activities a proper identification of the value configuration of the company is in order. We distinguish between value chain, value shop and value network which is explained in detail in Chapter 5.3.2. The first phase of establishing this company requires buying equipment from different producers and setting it up to form a collaboration space. This imitates the activities of a *value chain* which means transforming inputs into a final product. This product, however, is not sold on the market "as is", but used for offering services to customers through a *value network*. It is here that the main activities of the company is performed. It is the main activities of the company, not its partners, that will be described. An activity is what a company performs to create value, and it is related to resources. A detailed description of the different activities of the value network are found in Table 7.8. Explanation of the activity level attribute and the primary activities of a value network is also found in Chapter 5.3.2.

ACTIVITIES		
Activity	***Description***	***Level***
Marketing	Part of {network promotion}: the different marketing tasks that the company performs in order to acquire and maintain customers.	{primary}
Manage website	Part of {service provisioning}: managing the company's website where the customers can book and pay for services.	{support}
Manage and update software	Part of {network infrastructure}: managing and updating the software that handles the communication between collaboration spaces.	{support}
Maintenance of hardware	Part of {network infrastructure}: maintaining and replacing equipment whenever it is needed.	{support}
Operate the system	Part of {service provisioning}: Operating the system on a daily basis includes setting up and tearing down the connection between collaboration spaces.	{primary}
Administrative tasks	Part of {network infrastructure}: management of human and other resources and call support. Contact with partners and outsourcing of certain activities to them.	{support}

Table 7.8: The main activities of the company.

7.3.3 Partnership

A partnership is an agreement formed between two or more companies. It is done in order to jointly coordinate the capabilities and resources to carry out an activity. This company needs several partnerships, described below:

Hardware suppliers: The company has to make agreements with different manufacturers of hardware to be able to build a collaboration space. These are the manufacturers of autostereoscopic screens, cameras, furniture etc.

Room suppliers: To set up a collaboration space it is essential to chose a place that is centrally located in relation to the customers. Conference centers or cinemas are usually centered in cities and are perfect for the collaboration spaces. Renting such room on a day-to-day basis is expensive so the company has to make a special agreement to get affordable annual rents. If this is not possible the company must consider to renting rooms in other types of accommodations.

Internet Service Providers (ISPs): The collaboration system generates large amounts of data that need to be sent back and forth between the collaboration spaces in real-time. The company need special service level agreements (SLA) with different ISPs in order to get high speed Internet access and reserve the bandwidth necessary.

Content provider: Whenever "the virtual conference room" are used for screening of special events such as theatre or concerts, the company has to buy content from a firm that records and produces these events.

7.4 Financial Aspects

All the above mentioned aspects of the business model influence the finances of the company. Estimates for setting up and running "the virtual conference room" are done in this section in order to see if this could be a successful business case. For the revenue model today's price level is used in pricing the different future services. For the cost structure I will, as mentioned earlier, assume that the newest technology in the future will have the same prices as state-of-the-art technology today.

7.4.1 Revenue Model

The revenue model is decomposed into the element *revenue stream and pricing* which has several attributes. The company generates revenue through offering different services to the customers by lending out collaboration spaces. The three different services all have the same *stream type*, namely {lending} and the pricing method for the services are {differentiated pricing}. For each of the three services that "the virtual conference room" will offer, the pricing will be slightly different. For the services of "the virtual conference room" to be attractive to target customers, the cost must be less than that of traveling. Below is suggested pricing mechanisms for each of the services and an estimate for the price level. All the prices are without value added tax (VAT).

Meeting service This service is meant to be both a time and cost saving option for customers. Hence, the cost of using this service has to be lower than airplane tickets and the cost of spending office hours traveling. There should be a fixed price for each person using "the virtual conference room" and a minimum rate for each hours use. A reasonable price would be 350 NOK per person, per hour. This is done under the assumption that a normal meeting lasts 1-2 hours. The minimum rate should be large enough to avoid deficiency in keeping the system running. The earning model of pay-per-person is selected, even though the system has fixed costs of keeping the system running. This is because I assume that businesses are willing to pay for each person that is present at a meeting as they would if they had to pay for transport to another city. Minimum hourly rate ensures there is no loss. Making special agreements with large customers such as weekly or monthly reservations of collaboration spaces for a fixed price is a strategy that should be used to ensure some income.

Conference service With this service, not everyone are expected to communicate on the same level as they would with the meeting service. Some might be there just to listen in and the price for this service should be a bit lower. The price for each person should be 200 NOK, with a minimum hourly rate. To be able to use this service instead of the meeting service they have to be at least 11 persons.

Screening service To estimate what these tickets should cost we can compare it to the price of regular tickets to theatre and concerts. In order for this to be a service that is profitable, or that at least does not turn into a loss we have to assume that the content that are to be screened can be obtained at reasonable prices. This means it has to be a production made not solely for this purpose, because the costs of producing 3D content can become quite high (described in Chapter 3.1.4). The events may need to be screened multiple times before being profitable, which means that there will not be too many live streamed events (in that case the ticket prices has to higher). For this to be an attractive service the price of one ticket should be 250-500 NOK, depending on the content screened.

7.4.2 Cost Structure

The cost structure element measures all the different costs the company has to take into account to create revenue streams. It can be decomposed into accounts that each define the specific type of expenditures. Below are the different accounts and estimates of their value.

Equipment for the collaboration spaces: The equipment for the collaboration spaces have to be bought from the company's different partners. This is a one-time expense for each collaboration space. We have to assume that some or all of the equipment is depreciated after a given time and a 5 year lifetime is a reasonable estimate. Instead of saying that all equipment has zero value after 5 years the company will have an annual expense for maintenance and replacement of equipment that is 20% of the value of the original equipment (see next account). When calculating the price for the equipment, state-of-the-art technology that is readily available today is used as a measure. As mentioned in the previous chapter, some of the technology required does not exist today, but it is assumed that it will be in a few years of time, and that it has the same price as the newest and best technology today. See Table 7.9 for details of the costs for one collaboration space. The total sum for this account is 5 495 000 NOK for each collaboration space and it is a one-time expense.

Maintenance and replacement of equipment: As mentioned earlier, instead of depreciating the equipment over 5 year and buy everything new, this account is created as a annual expense for the company. Each year the company will use 20% of the original value of the equipment to fix or buy new equipment. The total sum of this account is 1 099 000 NOK and it is a annual expense for each collaboration space.

Develop software: The software needed for the communication between collaboration spaces has to be developed solely for the purpose of "the virtual conference room". It would be natural if the entrepreneurs of "the virtual conference room" were the ones responsible for this and that they had an idea of how the software should work in order to help in its development. I reckon that it would take five software developers one year to create the software needed for the system (they also develop the website for the company). The salary for a software developer will be 500 000 NOK, and the

EQUIPMENT COSTS FOR ONE ROOM

Equipment	***Description***	***Total Cost***
Autostereoscopic displays	$11 \times 6 = 66$ 42" autostereoscopic displays put together constitute a display as large as the one in the requirements in previous chapter. One such screen costs 60 000 NOK today.	3 960 000 NOK
Cameras	A room needs small, but high quality cameras for at least each view of the display (15 set of cameras) and two for each view. Hence, 30 such small cameras are needed in each room. They cost about 25 000 NOK according to list prices.	750 000 NOK
Microphones	The room need many microphones to reproduce the sound naturally in the other end. I reckon the room would need 30 microphones which costs 2 000 NOK each [21].	60 000 NOK
Sound system	A good sound system is important especially for the screening service and multiple loudspeakers are needed. I reckon the total cost of this will be 150 000 NOK [21].	150 000 NOK
Codecs	Some codecs today can handle 3D signals with minimum latency. This system needs codecs that can handle 15 3D signals efficiently and with minimum latency. This does not exist today, but it is assumed that future codecs can handle this and have the same price as todays state-of-the-art technology which is 220 000 NOK for encoder and 130 000 NOK for decoder [11].	350 000 NOK
Server/PC	Each room needs one high performing PC, approximate price 25 000 NOK [28]	25 000 NOK
Furniture	Chairs, tables, lighting, whiteboards and everything that a meeting of conference room need is included in this post [19][13]. The cost of installing is included in the installation account.	200 000 NOK
TOTAL SUM:		5 495 000 NOK

Table 7.9: The cost of equipment for one room.

equipment needed for each developer to develop and test is about 50 000 NOK. With additional payroll tax and other social costs of keeping employees each salary of personnel will increase with 20% when calculating the overall costs of employees [44]. The total sum of this account is 3 250 000 NOK and it is a one-time expense.

Installation: The equipment bought from hardware suppliers needs to be installed properly. This include setting up the autostereoscopic screens, cameras, microphones, furnitures and sound system. Many adjustments have to be made for the best quality of sound and picture and this has to be done by professionals. The industry today usually estimates the installation costs to be 20% of the total equiment cost. Hence the total sum for this account will be 20% of 5 495 000 NOK, which is 1 099 000 NOK for each collaboration space.

Software maintenance and update: The people doing these tasks have to be system experts and it is likely that they have been involved in developing the software. They install the software in each collaboration space after the installation contractors have done their part and makes sure that everything is working as intended. They provide support in case the software system fails and do maintenance and improvements if needed. There will be permanently employed at least 4 persons to do these tasks. Their salary is 500 000 NOK a year. With the additional cost of 20% of keeping employees the total sum for this account is 2 400 000 NOK annually.

Leasing of rooms: The leasing of rooms for the collaboration spaces are done on a year-to-year basis. A week leasing of a conference room costs about 28 000 NOK according to [12]. This is too much according to the price "the virtual conference room" has set as reasonable prices for their customers. Considering that special agreements can be made with conference center or cinemas the price that is set should be reasonable. If no conference center or cinemas will house the collaboration spaces for this estimated price, then the alternative would be to rent independent rooms in the same area for lower prices. This account is estimated to be 400 000 NOK annually for each room.

Main office: The company needs a main office for the administration. It is not crucial that this office is situated in a city center, but it should be close to a city. In Oslo's outskirts office accommodations costs about 1 000 NOK/m^2 per year [23]. For 100 m^2 the cost would be 100 000 NOK per year in rent.

Set up main office: The main office and the people in the administration needs furniture, desktops or laptops and telephone. The sum of this account is 150 000 NOK and it is a one-time expence.

Administration: The people in the administration have the following tasks; phone support and booking for customers, marketing, economy and co-ordination of the company's resources. I reckon that to begin with 5 people are needed for these tasks. Their average salary is 400 000 NOK per year. With the additional cost of 20% of keeping employees the sum of this account is 2 400 000 NOK.

Marketing: This account is for all the marketing tasks the company performs. Advertisements and commercials will not be widely used because of the high costs and the small probability of reaching target customers. Inviting customers to demos or free trial of the system will cost the amount of keeping the rooms vacant. This account covers hiring a person to handle the marketing tasks and what the marketing tasks cost. It is very difficult to estimate the annual marketing budget, but to start with the company should not use more than 2 000 000 NOK per year.

High speed Internet access: Establishment cost to the ISPs for one collaboration space to get high speed Internet access will be 12 000 NOK and it is a one-time expense [10]. The annual cost for high speed Internet access for one collaboration space is estimated to be 200 000 NOK [10].

Content providers: The prices that broadcasters pay for content is variable. One hour of content costs from 40 000 NOK and up. Considering that there is only room for 50 people in the collaboration space and that prices of tickets should range from 250-500 NOK, one full-house evening of screening such content would leave the company with a big loss. A solution is to screen the same show multiple times until it creates a profit. The screening service has to be reviewed whether or not it should be something that the company offer to its customers. Considering that the company could get different agreements than a broadcaster and if it is possible to obtain content at reasonable prices this service should be included. I assume that the total sum for this account will be 600 000 NOK for all the collaboration spaces.

Competent personnel in each room: In each collaboration space the company needs one full-time employee and one half-time employee that is trained how to run the system on a daily basis and who can handle certain failures and report errors. These persons are payed by the company. The salary is 370 000 NOK for the full-time employee and 180 000 for the half-time employee. With the additional cost of 20% of keeping employees the sum of this account is 660 000 NOK for each collaboration space.

Tax: Together with all other businesses this company also needs to pay tax. The value added tax (VAT) will come on top of the prices that the customers pay and is taken out of this equation. The company must however pay a 25% tax on the annual revenue after the annual costs are subtracted.

7.4.3 Financial Analysis

This section intends to give an overview of the total costs of starting up this company and the annual costs and revenues of running "the virtual conference room". To do this the number of customers that will use the rooms and what types of services they will use are assumed. The first numbers will be based on the assumption that the services are fairly popular. Later the price and vacancy parameters will be changed to see how they affect the internal rate of return (IRR) and the profit of the company. The vacancy parameter tells something about the overall vacancy of the services. A 25% vacancy means that 1/4 of the capacity is unoccupied. It can also mean that there are 25% less customers present in each of the services.

Revenue and Cost with Three Rooms and 25% Vacancy

A reasonable way to start up will be to establish collaboration spaces in three different cities in Norway. The natural choice is to select the largest cities; Oslo, Bergen and Trondheim. The start-up or investment costs of the company are shown in Table 7.10. I reckon that half a year before the company can start making money people has to be employed, office accommodations has to be set

Develop software:	3 250 000 NOK
Equipment for 3 rooms:	16 485 000 NOK
Installation cost:	3 297 000 NOK
Internet establishment:	36 000 NOK
Set up main office:	150 000 NOK
Half of annual costs:	≈ 6 989 000 NOK
SUM:	30 207 000 NOK

Table 7.10: The investment costs of the company.

up and training of personnel has to be done. Hence, an additional start-up cost will be half of all the annual costs (minus the content acquisition). The time spent by experts installing the software system is not included as a separate item in the table since they are permanently employed by the company and receive annual salaries. After having set up the three collaboration spaces, the annual costs of running them are shown in Table 7.11 and a percentage distribution is shown in the pie chart in Figure 7.2. We see that the largest annual expense is maintaining and replacing equipment. It is reasonable that this is a large account since it prevents the company from having to change all equipment every five years. The other large expenses are salaries and marketing. The personnel needed in administration are the number of people needed at start-up when only three collaboration spaces are running. If the number of rooms should increase to say 10, more personnel is needed. The reason for this revenue/cost analysis is to see whether it is possible to start up this company and make profit during the first years. If this is possible then it is reasonable to expand to more collaboration spaces, but this will not be done here.

Maintenance/support software:	2 400 000 NOK
Maintenance/replacement equipment:	3 297 000 NOK
Leasing of rooms:	1 200 000 NOK
Main office:	100 000 NOK
Administration:	2 400 000 NOK
Marketing:	2 000 000 NOK
Internet access:	600 000 NOK
Content providers:	700 000 NOK
Operating personnel:	1 980 000 NOK
SUM:	14 677 000 NOK

Table 7.11: The annual costs of running three rooms.

The revenue streams of the company are more difficult to predict. Based on the assumption that the services are fairly popular a vacancy at each room of 25% is assumed. The rooms are available for collaborations from 09:00 to 19:00, 6

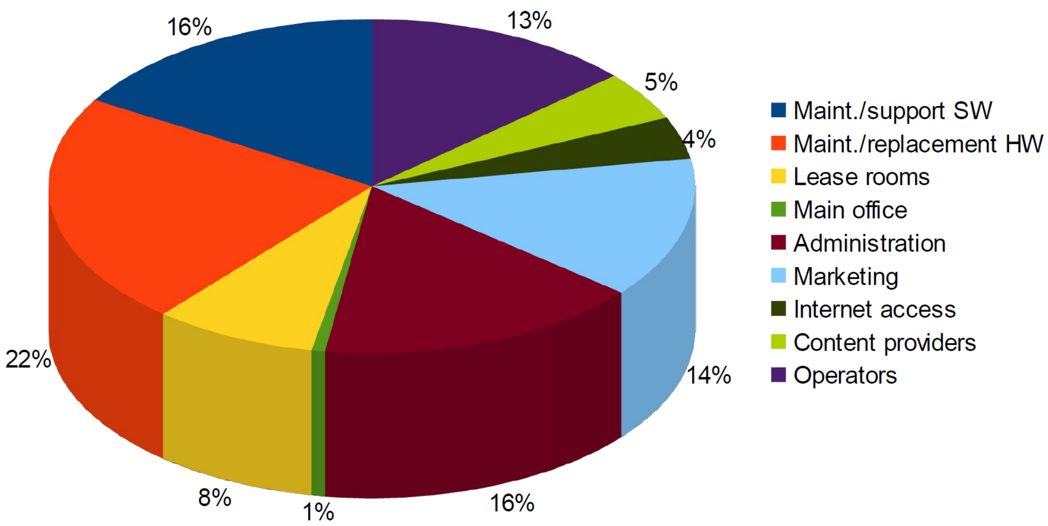

Figure 7.2: Percentage distribution of annual costs.

days of the week and if there are screenings of theatre or conserts this is done after 19:00. The holidays in Norway are subtracted which are 10 weekdays (100 hrs) at most. It is assumed that the meeting service will be more used than the conference setting; 70% of the occupied time is used for meetings which will have an average of 6 attendants and 30% of the occupied time are used for the conference service which will have an average of 30 attendants. Screening of theatre and concerts will be done once a week with the room filled to its capacity (50 people) and with average price 300 NOK per ticket. The annual revenue of running three collaboration spaces with these assupmtions are shown in Table 7.12. The percentage distribution of the revenue from the different services is

Hrs available/yr:	(10 hrs × 6 days × 52 weeks) - 100 hrs =	3020 hrs/yr
Hrs occupied/yr:	3020 hrs/yr - 755 hrs/yr (25%) =	2265 hrs/yr
Hrs meeting:	2265 hrs/yr × 70% =	1 585.5 hrs/yr
Hrs conference:	2265 hrs/yr × 30% =	679.50 hrs/yr
Meeting:	1 585.5 hrs × 6 ppl × 350 NOK × 3 rooms =	9 988 650 NOK
Conference:	679.50 hrs × 30 ppl × 200 NOK × 3 rooms =	12 231 000 NOK
Screening:	52 scr × 50 ppl × 300 NOK × 3 rooms =	1 755 000 NOK
SUM:		23 974 650 NOK

Table 7.12: The annual revenue of running three rooms.

shown in Figure 7.3. We see that the screening service has considerably lower revenue than the other services. In addition to this it has an own cost account, namely the cost of buying content. As mentioned in Chapter 3.1.4, producing 3D

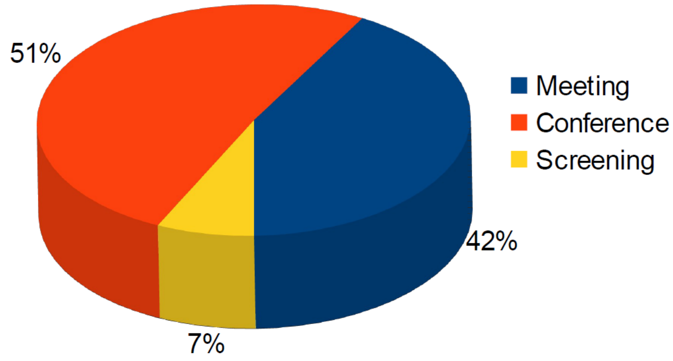

Figure 7.3: Percentage distribution of revenue.

content is costly. For this reason could it be difficult to acquire content which are attractive to customers while at the same time being inexpensive. It will have to be a matter of judgment for the company whether to offer the screening service, it will have to depend on the cost of 3D content.

The company needs to pay a 25% tax of the annual revenue after the costs are subtracted. The key figures of the company and the net annual revenue are shown in Table 7.13. The company has a net revenue of 6 973 238 NOK annually.

Investment costs:	30 207 000 NOK
Annual costs:	14 677 000 NOK
Annual revenue:	23 974 650 NOK
Revenue after costs:	9 297 650 NOK
25% tax:	2 324 413 NOK
Net revenue:	6 973 238 NOK

Table 7.13: The company's key figures.

For those interested in investing in this company it is useful to know the internal rate of return (IRR) which is a measure for the profitability of investments. To calculate the IRR we need to know the annual cash flows and for how long the cash flows will continue. The lifetime of the services that "the virtual conference room" provides are uncertain. Looking back, the different ways of communicating has changed dramatically over the last 10-20 years. And recent articles state that holographic 3D systems may not be far behind the autostereoscopic solutions in development. MIT have a team researching holographic capture and display technologies, and many of the challenges with this have already been overcome

[9]. Collaboration space system may also become more affordable so that it can be installed in the home as a Multimedia Home Space (MHS) or in offices. If this becomes widespread then the services of the "the virtual conference room" will become less attractive. This is possibilities of the future that brings the expected lifetime of the services down. Based on this the expected lifetime of "the virtual conference room" will be between 5-15 years depending on when new or more affordable technologies take over (10 years is chosen as average lifetime). This is used when calculating the IRR.

The general formula for calculating the IRR is:

$$NPV = \sum_{n=0}^{N} \frac{C_n}{(1+r)^n} = 0$$

NPV is the net present value which is the sum of all cash flows discounted back to its present value. Given the period (n), cash flows in the period (C_n) and the total number of periods, the IRR is given by r in the equation over. r is found by numerical or graphical methods [49].

The IRR can be compared to the interest rate for savings in the bank. Considering that this is a high risk project the IRR must be much higher than the savings interest rate from the bank in order for someone to invest in it. Before calculating the IRR we have to know the cash flows of the project. The initial negative cash flow have to be provided by investors. After this there are positive cash flows every year. It is not likely that the cash flows are the same each years, but for simplicity's sake it is assumed so here. Since the equipment is not depreciated in full after a fixed time, but constantly maintained and replaced there is no need for a large investment unless the company wants to expand.

The cash flow in year 0 is -30 207 000 NOK and for all other years it is assumed to be 6 973 238 NOK. The IRR as a function of years after start-up is shown in Figure 7.4. Looking at the graph we see that it takes five years before there is some return. Considering that this is a high risk project, investors will probably not consider investing until the IRR is between 15%-20%, which means that the lifetime should be at least 10 years.

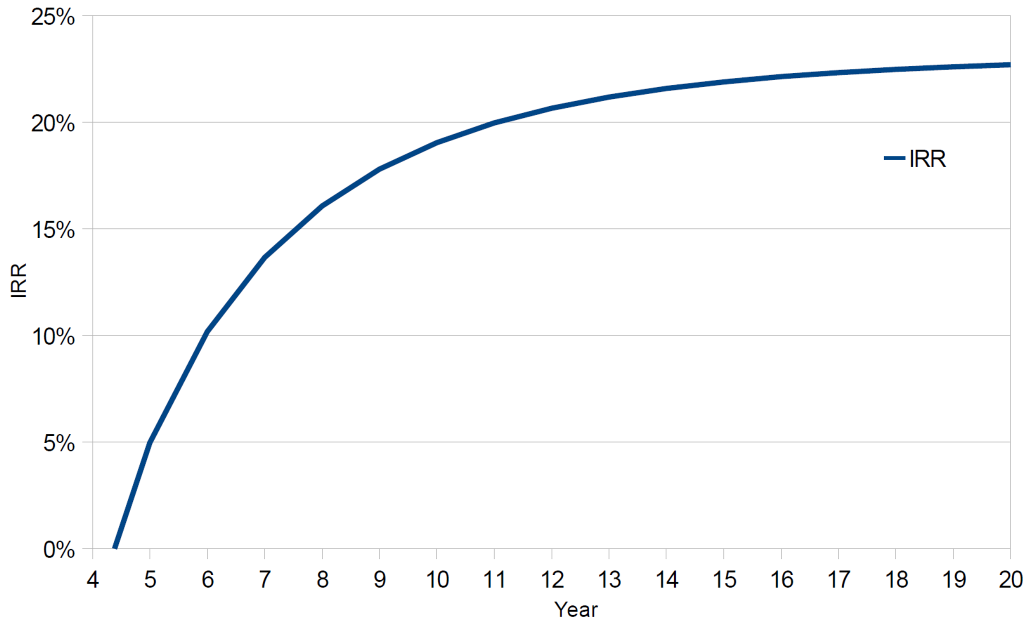

Figure 7.4: The IRR as a function of years after start-up.

Changing Variables

The numbers presented in Table 7.13 are based on estimates. One high uncertainty is the revenue streams. Without doing a complete market analysis it is difficult to predict how popular these services are going to be and what price to take. It is also difficult to predict whether there are other companies offering the same type of services or if traveling is an option that has become much more comfortable and easier by the time this idea is ready for the market.

In this section some of the uncertain variables are changed to see how it affects the revenue and profitability. The cost variables will not be changed. There are basically three variables that affects the profitability of this project; price of services, the lifetime of the project and the vacancy.

Changing Vacancy

First it will be shown how higher and lower vacancy will impact the revenue. All other parameters are the same as before. Figure 7.5 show the revenue relative to vacancy. This graph shows the annual revenue at different percentages of vacancy and according to annual costs. With 55% vacancy the company will have zero profit, and if the collaboration spaces are vacant more than this it will cost them more to run the business than they will earn.

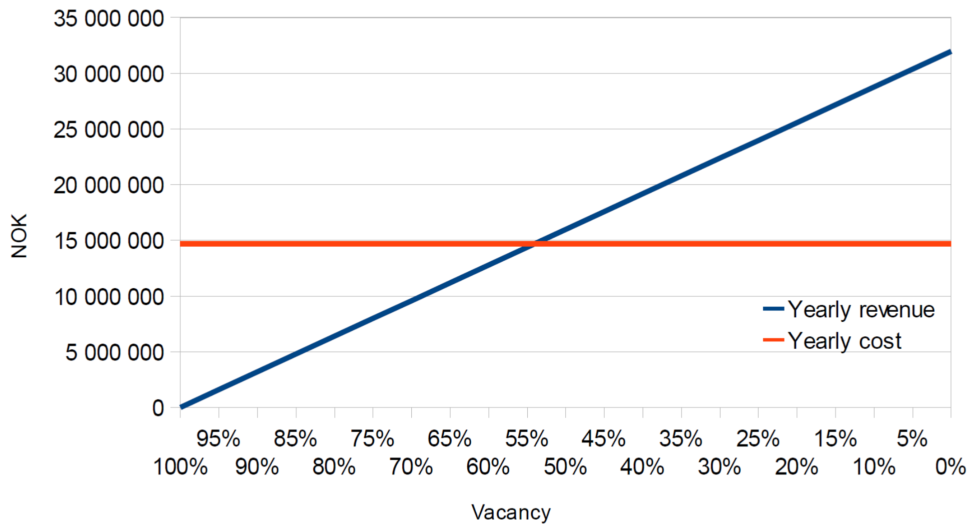

Figure 7.5: Revenue relative to vacancy.

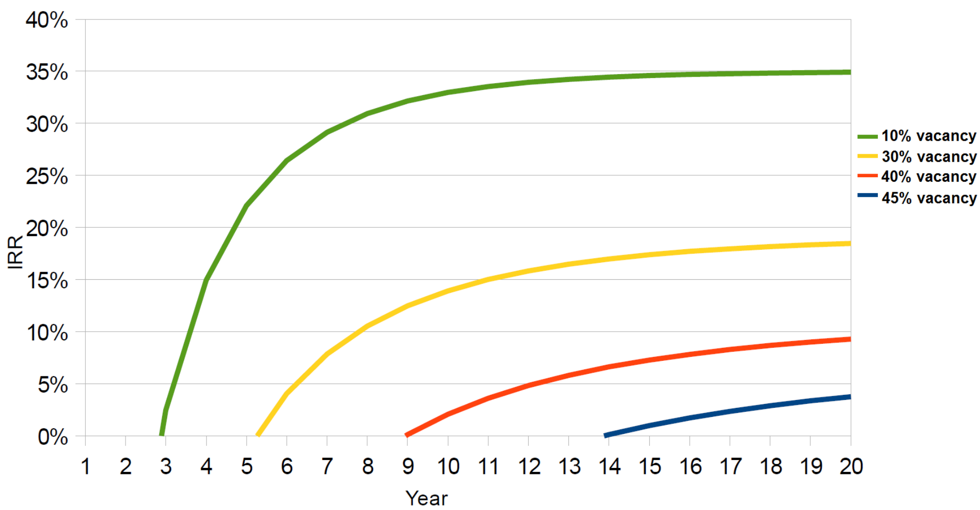

Figure 7.6: The internal rate of return at different vacancies.

For all vacancies higher or close to 55%, the IRR will be negative. In Figure 7.6 the IRR at different vacancies below 55% is depicted. This shows how high the vacancy can be for the project to still be profitable. At 10% vacancy the project will be profitable and give high returns after only 4 years. The IRR at 25% vacancy is depicted and discussed with Figure 7.4. With 30% vacancy the project should have a lifetime of at least 12 years before it gives high enough returns compared to the risk. If expecting lower vacancies than this, such as 40% and 45%, the IRR is very small for all years compared to the risk of investing in such a project. It is reasonable to say that 30% is the maxiumum vacancy the company expect and still be able to attract investors. 30% vacancy is not much vacancy, and there is little tolerance for a room to stay vacant for a week due to repairs. A possible remedy for this is to change the prices in order to generate more revenue. The company could lower the price if they knew that this would attract more customers or they could raise the prices if they could be sure to keep most customers. The maximum vacancy tolerance would then change. Changing the prices is described next.

Changing Price

The price for the meeting service is reasonable, and even cheap, if we reckon that an average meeting lasts for 1-2 hours. Using these services will be much cheaper than traveling. However, if the average meeting last for 6-7 hours then the cost savings of using this service will diminish compared to traveling. If we had known the demand for these kinds of services the price elasticity of demand would give a measure for how changes in price could change the quantity demanded. It is difficult to measure the demand and therefore difficult to set the right price. Table 7.14 show the low, medium and high prices for each service. The medium prices are the ones used up until now. The same assumptions for vacancy (25%) and

	Low	**Medium**	**High**
Meeting	250 NOK	350 NOK	450 NOK
Conference	150 NOK	200 NOK	250 NOK
Screening	200 NOK	300 NOK	400 NOK

Table 7.14: The different prices ranges for the services.

average amount of people using the services are used as before. Figure 7.7 shows how lowering and raising the prices affect the gross revenue. The gross revenue with low prices is 17 478 000 NOK and with high prices 30 471 300 NOK. These are high differences. In reality one would expect that the vacancy will be less with lower prices and a bit higher with higher prices. Considering the vacancy we have used previously (25%) there is not much tolarance before the profit turns into a loss when lowering the prices. It will probably be more reasonable to raise the prices a bit and allow for more vacancy. For businesses this will still be a cheap way of holding meetings compared to traveling.

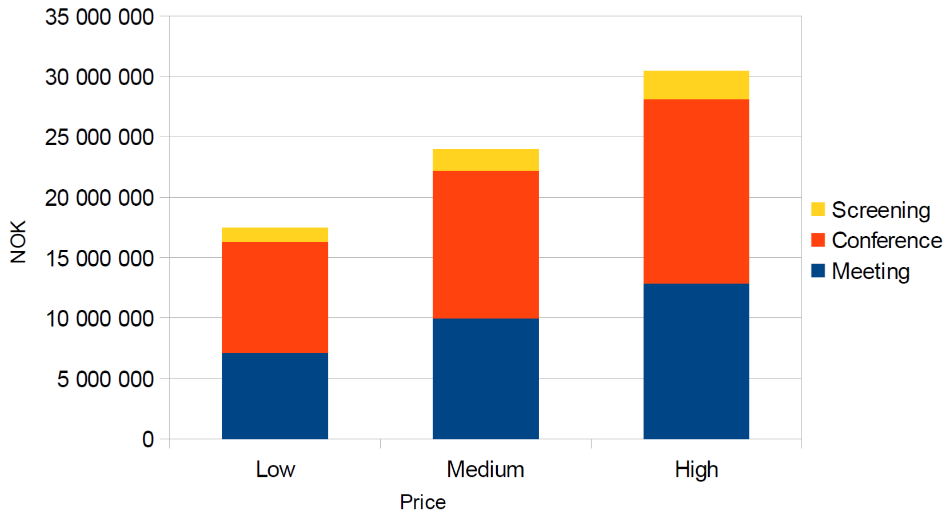

Figure 7.7: Revenue with low, medium (original) and higher prices.

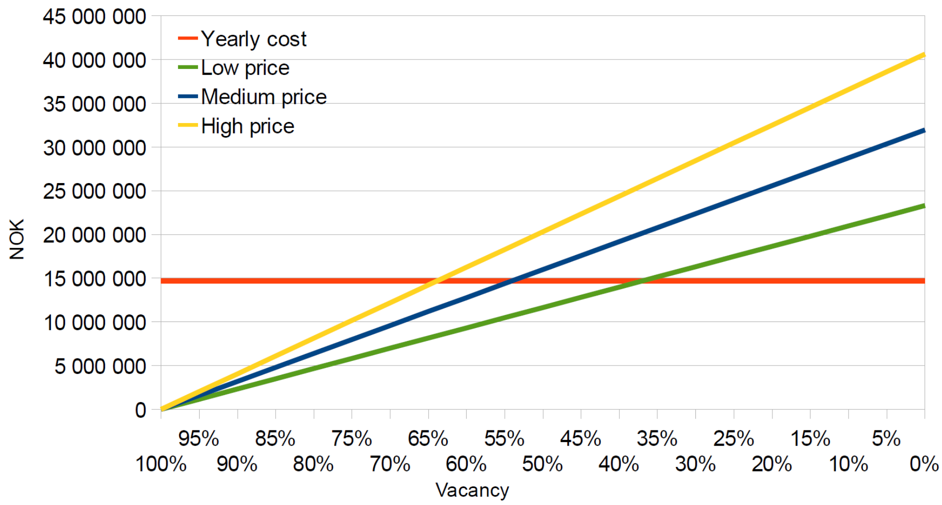

Figure 7.8: Revenue with different prices relative to vacancy.

In Figure 7.8 revenue with different prices is plotted as function of vacancy. We see that with higher prices the company can tolerate up to 65% vacancy before they start to loose money, and revenue is high for low vacancies. With lower price the company can have no lower vacancy than 35% before it will loose money. The IRR for each of the price levels is depicted in Figure 7.9. The calculations of IRR

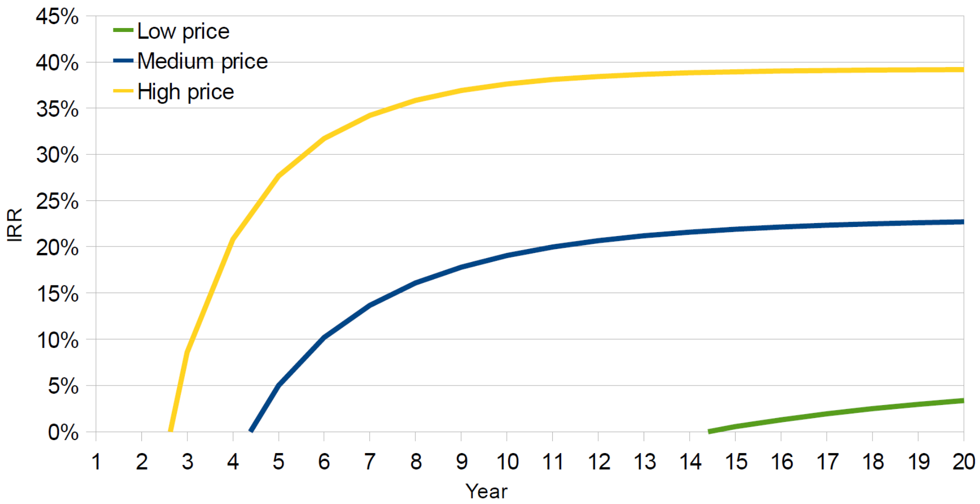

Figure 7.9: The internal rate of return at different price levels.

are done with the same assumption of vacancy of 25% (as earlier). We see from this figure that when lowering the prices there will be no relevant rate of return even after 20 years. Considering that the vacancy expected is 25% (which is low), the company could not set the prices at this level and expect that someone will be interested in investing. The blue line is the line depicted and discussed with Figure 7.4. With higher prices we see that after only 3-4 years the project has an high internal rate of return. With these higher prices the company could tolerate to have a higher vacancy. When addressing the business market the higher prices are still reasonable. Setting the price level to somewhere between medium and high prices would be reasonable for all target customers. The company could then tolerate a little more vacancy and the project would be more attractive for investors.

7.5 Summary

A summary of the business model for the company is done by using Osterwalder's business model ontology figure and filling in the most important key words, see Figure 7.10.

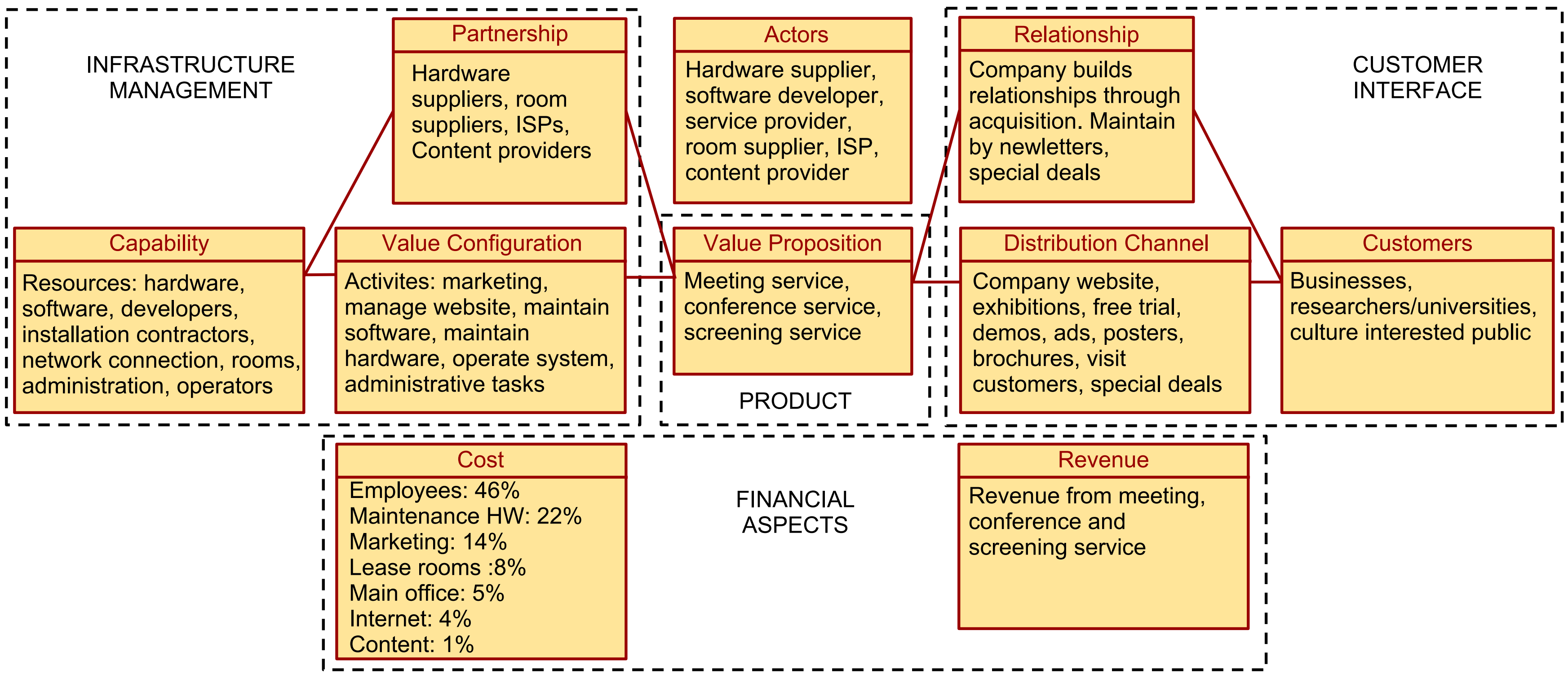

Figure 7.10: The business model of ”the virtual conference room”.

Chapter 8

Discussion

3D has seen an increasingly widespread use over the last years with 3D cinema, 3DTV and 3D games. 3D technology lets viewers experience more life-like and natural scenes than regular 2D technologies. Services that includes 3D technology is expected to increase over the years to come and the technologies will be further developed. Today most 3D technologies require special eyewear to separate the two slightly different images in order to achieve the 3D effect. Autostereoscopic screens however, use a special technology that separates the images for each eye and lets the viewer perceive 3D without special eyewear if he or she is located in the "sweet spots". The use of this technology in designing future near-natural collaboration services is a natural choice.

The future system that is specified in Chapter 6.2 is based on the autostereoscopic 3D technology. The services and the collaboration spaces are designed under the assumption that this and other technologies will develop over the next years. To begin with the autostereoscopic screens that exist today do not have the required resolution to obtain the wanted quality of picture. The other major constraint today include the processing and transmission of large amounts of multimedia content. Before the technologies to handle these challenges are available on the market at reasonable prices the services of "the virtual conference room" can not be realized. Current research have shown that the development of technology is going in the right direction but the question is when it will be available at reasonable prices.

Chapter 7 describes a detailed business model for a company that offers the services of ”the virtual conference room”. The last part of the chapter gives a view of the finances of realizing the services with todays prices as basis. There are high uncertainties involved with the assumptions made when describing both costs and revenue. Questions that arise are: will these services be interesting to customers in the future? If so, how much are they willing to pay? It is difficult to know the demand for these services without doing a market analysis. Therefore the basis for deciding the price for the services was to look at the expenses involved with traveling in order to arrange a meeting or conference. It is presented three price levels, which all are lower than the costs involved with traveling. In compliance with the fact that the effort of traveling also is reduced it is reason to believe that the services could be fairly popular. Assumptions for the number of customers in each service and the vacancy are made. All the expenditures are based on today costs such as salaries for employees, installation costs and high speed Internet access. The equipment costs are based on the prices for state-of-the-art technology available on the market today. Without knowing how the development and cost of technology will evolve this is the closest I get a reasonable estimate.

The assumptions and estimates for costs and revenues provide the basis for estimating whether this could be a profitable project. The key figures of the project with medium prices and 25% vacancy are shown in Table 7.13 on page 82. The investment costs are high and the costs involved with running the business year by year are mainly due to salaries. The annual net revenue, with medium prices, shows that it is a profitability possibility present. However, this is a high risk project and investors will expect a high internal rate of retur (IRR) on their investments.

The IRR is calculated for different vacancies and different prices. The IRR for different vacancies with medium prices are shown in Figure 7.6 on page 85. This shows that the maximum vacancy the company can allow is 30%. The IRR after 10 years is then approximately 15% and it is on the limit of being economically profitable. This means that there is little room for higher vacancy before the project is non-profitable. A possible way to get out of this is to increase the prices; the IRR for different prices are shown in Figure 7.9 on page 88. We see that low prices give a positive IRR first after 14 years. Consequently it would not be an alternative to lower the prices. Raising the prices gives a high IRR only after a few years. If the company can expect to keep most customers on raising the prices to somewhere between medium and high prices, this project could become profitable after a few years.

The lifetime for these kinds of services is uncertain. The different ways of communicating has changed dramatically over the last 10-20 years. Will these services will be a successful alternative to near-natural communication? And for how long until other technologies take over? As mentioned in Chapter 7, holographic 3D systems may not be far behind in development and this is a technology that gives even more life-like representations of scenes. This is news that could bring the expected lifetime of the services that ”the virtual conference room” offers down. A solution could be to change to this technology, but it would depend on the costs involved with introducing it. The lifetime of the collaboration space services based on the autostereoscopic technology could be between 5 and 15 years.

The system designed in Chapter 6.2 is based on a closed, decentralized solution where software are running on servers in each collaboration space. There is no possibility for others parties to connect to the system. A possible solution could be to have centralized servers that allows for multiple clients to connect and use the system. In the future it could be that several homes have a Multimedia Home Spaces (MHS) as described in Chapter 6.1. With a centralized, open solution the services of ”the virtual conference room” could be made available to the home through MHS’s. This could also open for new types of services and create more revenue. On the other hand, if MHS’s became more widespread the services of the ”the virtual conference room” could become less attractive since people could make use of this kind of service from their homes. This could however be countered by the fees charged to log on these services.

Over the last 75 years we have seen many periods where 3D technology has had revivals and then been ”forgotten” for some time again. The revivals are mainly caused by advancements in the technology and this latest revival is no exception. The question is: will it last this time? Some people are skeptical to 3D technology and claim that it only causes headaches and nausea. Others embrace the technology and think that this is the future media. As explained in Chapter 2.1, when viewing 3D the human eyes converge and accommodate at different points. This is an unnatural conflict as the eyes is used to converge and accommodate in the same point. This causes discomfort with many people and it is not recommended to watch 3D for many hours. Also, 2-12% of all viewers are unable to perceive any 3D effect at all. The 3D technology that has emerged over the last years has started to see widespread use and it is not likely that it will be "forgotten" as it has been earlier. We must, however, be aware of the sideeffects of 3D when deciding how and where to use the technology.

Chapter 9

Conclusion

This thesis presents a specification of future collaboration space services based on the autostereoscopic display technology. Many assumptions are made regarding the development of the technologies that the collaboration space services needs. This has to be done since the solutions of today are not good enough. Looking at how the relevant technologies has developed until now this should be reasonable assumptions.

The framework of Osterwalder's business model ontology is used to describe a possible business model in detail. Identification of products, customers and partners and other aspects of the business are done and a thorough financial analysis is conducted. The key figures of the business tell us that there are high investment costs involved with setting up the collaboration spaces and developing software. The annual costs involved with running the services are high, mostly due to salaries. The financial analysis shows that when expecting a vacancy of less than 30% and with medium to high range prices the collaboration space services has a market viability. This is for operation of only three collaboration spaces. The internal rate of return will be close to 20% after 10 years of operation with medium prices and 25% vacancy.

The finances of the business model are based on estimates. A high uncertainty is the revenue streams which are difficult to predict without analyzing the market regarding the demand for these kind of services. The costs of the technology needed is determined by the price for state-of-the-art technology. Today's technologies do not meet the requirements of the system but it is expected to be available in the medium term with the current rate of development.

The lifetime of this project is discussed and it is expected that to be around 10 years. By then it is reasonable to believe that new technologies have taken its place or the reduction of costs have made the collaboration space system common property. Changing to the new technologies or offering the services to the home could expand the lifetime. But this would mean extra investments and changes in the value propositions.

Because of the high uncertainties involved with this analysis some topics for further work are suggested in the next section.

9.1 Further Work

Forecasting the cost evolution of technology One of the high uncertainties in the cost structure of the business model presented are the price of technology. Instead of using todays prices, forecasting the cost evolution of the technologies used would present more accurate numbers. The work of Olsen and Stordahl presents an extended learning curve model that has the ability to predict cost evolution as a function of time [24]. This model can be used to achieve a more realistic analysis for the viability of the business.

Demand The demand for the services of "the virtual conference room" are unknown. Are the services interesting for customers? How much are customers willing to pay? What other alternatives exist compared to these services? These are questions that can be answered by future research.

Expansion of the business The financial analysis is done for start-up of the business with only three collaboration spaces. By assuming that the services are fairly popular further work would be to look at the possibility and profitability of establishing more collaborations spaces. This would mean more investments, but also greater revenue.

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Appendix A

A Business Case for Auto-stereoscopic 3D Collaboration Spaces

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Abstract. Auto-stereoscopic 3D technology has emerged as a promising enabler for near-realistic presentation of digital content. An application area for auto-stereoscopic 3D is collaboration spaces services (CSS), where geographical separated participants collaborate and consume real-time distributed multimedia content. However, a commercial deployment of CSS requires a thorough business analysis, including identification of CSS product offerings, customers and partners as well as an economic viability study of CSS. In this paper we present a business case for CSS. We show that CSS has potential market viability even for small-scale operations.

Keywords: 3D technology, business models, collaboration spaces

1 Introduction

Auto-stereoscopic 3D enables a complete 3D experience without the use of viewing glasses [1]. Displays providing auto-stereoscopic 3D have been available for the research community for some years, however, the cost of these displays have been about an order of magnitude larger compared to similar sized non-3D displays available to the general public. Recently, the cost of auto-stereoscopic displays have been dropping as new and innovative products start to utilize this technology, such as Nintendo 3DS [2] and 3D TV [3].

The Collaboration Spaces Service (CSS) [4] utilizes auto-stereoscopic 3D in order to create near-realistic experiences of geographical remote scenes. With CSS, users participate in creating and/or experiencing multimedia scenes by combining input from different geographical locations. Examples of applications supported by CSS include distributed music plays [4] and business meetings.

In order to enable a commercial deployment of CSS, there is a need to study different business aspects of CSS. Different strategic options available for business model design, and the choice of design will heavily influence the economic viability. In this paper we present a business case of CSS. We follow the Osterwalder ontology, and show how different business models are suitable for CSS. We also present an economic analysis of cost and revenue for CSS.

The rest of the paper is organized as follows: Section 2 gives an introduction to auto-stereoscopic 3D. Section 3 presents the Collaboration Spaces Service (CSS). The business model methodology is explained in Section 4. A business case for CSS is presented in section 5, followed by an economic analysis in section 6 and a conclusion in section 7.

2 Auto-stereoscopic 3D

Auto-stereoscopic displays allow the viewer to see 3D without the need for special eye-wear.
The technologies that enables the viewer to see different images include [1]:

- **Lenticular lenslets:** An array of cylindrical lenslets are placed in front of the pixel raster. The light from adjacent pixel columns are directed into different viewing slots when the viewer are placed at the ideal viewing distance. At this distance each of the viewer's eyes will see light from only every second pixel column. This means that one of the two visible images consists of every second column of pixels and the other image consists of the other columns.
- **Parallax barrier:** A barrier mask that is placed in front of the pixel raster such that each eye sees light from every second pixel column. The barrier mask is like a fence with opaque and transparent strips placed a certain distance from the display surface. The geometry is adjusted so that the barrier blocks every second pixel for one eye and then the other pixels for the other eye.

Both of these technologies suffer from the problem that there is only in "sweet spots" that the viewer can see the correct stereoscopic image. This means that there are a specific range of positions where the viewer's eyes receive the proper separation of right and left images. The three categorizations of auto-stereoscopic displays are [1]:

- **Two-view displays** divide the horizontal resolution of the underlying display into two sets. Half of the pixels make up the image for the right eye and the second half make up the image for the left eye. The correct vision of the two images are limited to a few “sweet spots” in front of the display.
- **Head tracked displays** are usually a two-view display that knows the position of the viewer's head. Knowing the position of the viewer's head the display can accommodate and show the appropriate left and right images when the viewer moves his head. A challenge with this technology is the head-tracking. The viewer should not be required to wear special equipment and another problem is physically moving the viewing zones.
- **Multi-view displays** is the extension of two-view displays to typically five or nine views. This type of display lets multiple viewers see the stereoscopic images at the same time from different angles. The viewer will perceive horizontal movement parallax in addition to stereo parallax. An advantage of multi-view over the other systems is that the viewers has a larger area where they can perceive the correct stereoscopic image. A disadvantages is the

difficulty of building a good display with many views, since the resolution of each image decreases as the views increase.

3 Collaboration Spaces Service

Virtual collaborations involves two or more people that are working together or communicating without the physical face-to-face interaction. Early virtual collaboration systems are regular telephones and audio conferencing systems, and today video conferencing and telepresence systems are common. Video conferencing and video telephony became very popular in the 2000's with free services like Skype. In [4] Rønningen introduces the Distributed Multimedia Plays concept (DMP) which is a three layer architecture that aims to provide “near-natural virtual networked stereoscopic multiview video and multi-channel sound collaboration between players and servers”. To construct such an environment an array of auto-stereoscopic 3D displays on all surfaces of a collaboration space with cameras embedded is a possible solution. The areas of application for a virtual collaboration system could be many. By having collaboration spaces in many different locations you can communicate in a near-natural way with people located far away without having to travel. Such systems could also be interesting from a business perspective for reducing the cost and inconvenience of travel, being that this is a much more natural way of communicating than state-of-the-art collaboration systems. These systems can also be used as Multimedia Home Space (MHS), as described in [4]. It can be any room in the house, a specialized room built for near-natural virtual collaborations, or it can be the living room or kitchen where the walls, the ceiling and the floor are covered with auto-stereoscopic screens.

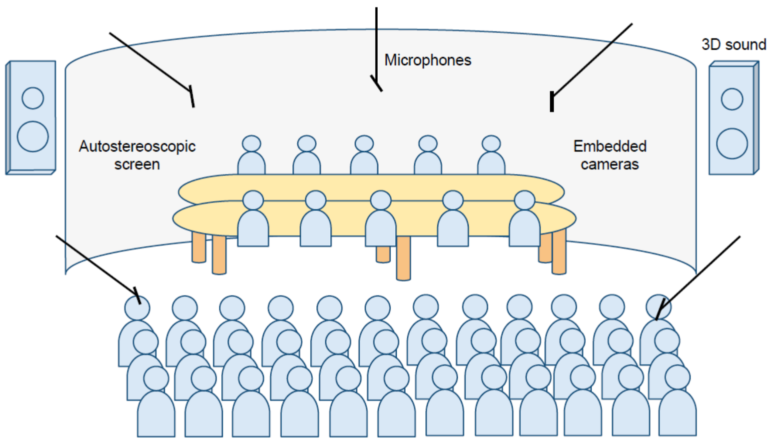

Fig. 1. Illustration of the CSS.

The system and accompanying services that are present here have used some of the thoughts from the DMP architecture together with looking at technology that are available or under research today. This is a system that will offer collaboration services to the public. It will be implemented in a room the size of one of the smaller theaters in a cinema and would make up a collaboration space for up to 50 people. "The virtual conference room" (from now on referred to as the collaboration space service) will have a large auto-stereoscopic screen with multiple views, embedded cameras and 3D sound as shown in Figure 1. It is important that the system is the same (standardized) in all collaboration spaces and that the surroundings in the room is very similar to each other to achieve the perception for the people communicating that they are in fact in the same room. Figure 1 shows both people sitting at a table having a meeting and also people further back as they would sit if watching a lecture or a presentation. This is just an illustration of the different applications of the collaboration system, the two groups would not be there at the same time. Typical services that could be offered to customers are:

- A near-natural collaboration service for meetings, conferences and seminars.
- An auditorium for live near-natural lectures.
- Live streaming or playback of e.g. concerts and theater.

3.1 Functional requirements

A functional requirement defines a function of a software system or a service. The functional requirements tell what the users, administrators and operators can expect from the system, described in Table 1.

Table 1. Functional requirements.

Requirement	Description
Handle users	The system should handle different users with different permissions. Typically one administrator with exclusive permissions and other personnel with limited permissions.
Report system status	Report status of the network connection between other selected collaborating spaces and if the services are functioning as intended, give alert if unusual occurrences.
Report equipment status	Report status of system equipment (e.g. cameras, microphones), give alert if they are not functioning properly.
Collaborations	Generate list of all collaboration spaces possible to connect to and their availability. It should be possible to connect to and collaborate with one or multiple other collaboration spaces. People collaborating can expect near-natural representation of presence e.g. eye contact and sound.
Storage	Storage of recorded video and audio from own collaboration space or of received multimedia streams from other collaboration spaces. Storage of multimedia received (e.g. concerts, theater) for later display to the public.
Send/receive	The system should be able to send and receive large amounts data

3.2 Non-functional requirements

A non-functional requirement is a requirement that describes qualities and constraints in a system [48]. The non-functional requirements for the service are seen in Table 2.

Table 2. Non-functional requirements.

Requirement	Description
Usability	The system should be easy to use for trained personnel. Users paying for the services are not expected to need any knowledge of the system.
Delay	The maximum end-to-end delay ≤ 350 ms.
Video quality	Near-natural video quality.
Audio quality	Near-natural audio quality.
Security	Integrity, authentication and encryption of content should be provided.
Maintainability	The system should be easy to maintain.

4 Business model methodology

In order to formalize and describe the business model, we use Osterwalder´s business model ontology [5]. A business model is a company´s money-earning logic. An overview of the model is depicted in Fig. 2.

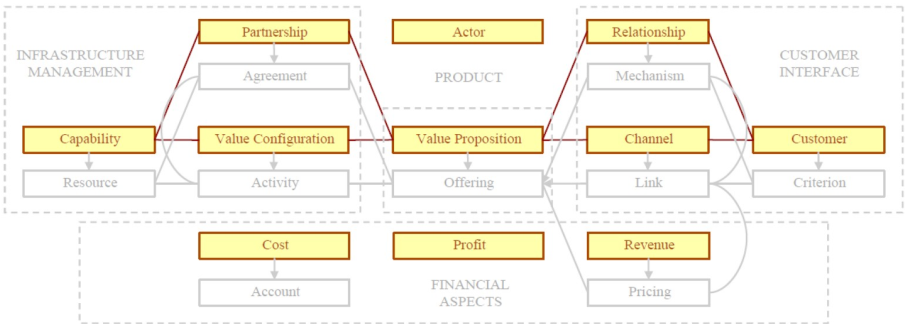

Fig. 2. An overview of Osterwalder´s business model ontology.

The model is divided into four main areas (which contains nine different elements) defined as follows:

- Product: Covers all aspects of what a company offers to its customers.
- Infrastructure management: How the company creates value.
- Customer interface: Customer related aspects.
- Financial aspects: Covers economic analysis of the company.

5 Business case for CSS

We outline different business model designs for CSS (section 5.1) and present a detailed business analysis of scenario 3 (section 5.2).

5.1 A Business Model scenarios of CSS

We identify the following actors needed for the CSS business scenario:

- **Hardware suppliers (HS):** the producers of hardware and equipment needed in each collaboration space.
- **Software developer (SD):** the developers of the software needed for the communication between collaboration spaces to function as intended.
- **Service provider (SP):** they offer the services of the system to the customers. They handle all customer related tasks.
- **Room suppliers (RS):** the ones that the lease rooms in different cities that are needed to set up a collaboration space.
- **Internet service provider (ISP):** they offer high bandwidth Internet connection to the collaboration spaces.
- **Content provider (CP):** they provide content that are to be screened by the screening service of the collaboration space.

We identify the following business design scenarios:

1. **Service provider alone:** One way to structure the business is by making the service provider the core of the business and all other actors partners. The service provider pays the other actors a fixed price to set up collaboration spaces, develop software, provide rooms and Internet for the collaboration spaces. They keep a website, manage marketing and handle all customer related tasks. The service provider takes all the risk of setting up the system and in return get all the revenue from the customers.
2. **Service provider and room suppliers:** A second possible way to structure the business is by having the service provider and the room suppliers being the main actors. The service providers offer the whole system and the set up of the collaboration space to the room suppliers. The service providers get a fixed price for doing this, and in addition handles booking, marketing and all customer related tasks. The room suppliers gets all the revenue from customers and are the ones taking all risk. All other actors are partners.
3. **Service provider and software developer:** Having the service provider and the software developer form the core of the business means that the operation and management of the software system and the customers related tasks are tightly coupled. They take the risk of setting up the service together and get the revenue from the customers. This is the business model that will be described in detail.

5.2 Business model analysis of scenario 3

Value proposition

The value proposition of the business is to offer a near-natural way of communicating with people located in other cities or experiencing special events in a near-natural way (theater, concerts). The value proposition is based on the three offering described in Table 3:

Table 3. Offerings of the value proposition.

Offering	Description	Attributes
Meeting service	This service offer a near-natural way of having a meeting between people located in different cities. It is meant for a maximum of 10 people in each collaboration space.	Reasoning: {use,effort}. Value level: {innovative imitation} Price level: {economy} Life cycle: {value use}
Conference, seminar or lecture service	The service is similar to previous one, but the arrangement is for up to 50 people. It will be used in a typical conference setting where most of the people are sitting down to listen while one or more hold presentations. Not everyone are communicating at the same time.	Reasoning: {use,effort}. Value level: {innovative imitation} Price level: {economy} Life cycle: {value use}
Screening service	This service gives customers the possibility to experience a near-natural representation of an event that is happening or that has happened, by streaming or playback.	Reasoning: {use,effort}. Value level: {innovative imitation} Price level: {economy} Life cycle: {value use}

Target customers

The target customers of the business are:

- **Businesses:** people that are pressed for time. They want to save the time used in traveling. They may want to have a ”green” profile
- **Researchers and universities:** they need an inexpensive and time-saving alternative to communicate with other researchers and research institutions. They want to hold or see lectures without having to travel.
- **Culture interested public**: everyone interested in theater, musicals and concerts. They want to see events that is happening in other cities without paying too much.

Distribution channel

The connection between customers and the value proposition is done through the distribution channel. The specific marketing tasks of the distribution channel are described in Table 4.

Table 4. Distribution channel

Link	Description	CBC
Company website	The official website for the business. The system is presented and it lists all the cities where it is available. Booking and payment can be done here.	{purchase}

Exhibitions	Exhibitions at e.g. industrial fairs to get in contact with potential customers such as large industries with dispersed offices.	{awareness}
Free trial	Invite target customers to free trials of the services.	{evaluation}
Demo	Invite potential customers to a joint demo of the system.	{evaluation}
Ads on websites	Carefully choosing websites to advertise for the services.	{awareness}
Posters	Put up posters for specific events that are screened in the collaboration space.	{awareness}
Brochures	Make brochures that present the system and send it to target customers.	{awareness}
Visit customers	Arrange meetings with target customer to present the system, invite them to free trial or demo of the system and present special deals.	{evaluation}
Special deals	Special deals can be offered such as reservation of specified hours of the month or week at fixed prices.	{after sales} or {evaluation}

Relationship

It is important that the business build relationships with their customers. The costs involved with acquiring customers can be leverage if the business build and maintain relationships with their customers. Most of the relationships involve offering the customers special deals if they agree to use the system on a regular basis. Also having the customers subscribe to newsletters that informs them of vacancy, special offers and screening events.

Capabilities

The capabilities of the company describes the repeatable pattern of actions and use of assets in order to offer the services to the market. The capabilities and resources of the business are described in Table 5.

Table 5. Capabilities

Resources	Description	Type
Hardware	The hardware and equipment needed to set up and maintain collaboration spaces are bought from partners.	{tangible}
Software	The software needed for the communication between collaboration spaces is developed in-house.	{tangible}
System developers/experts	The software needed for the communication between collaboration spaces is developed and maintained by these people.	{human}
Installation contractors	Hardware and equipment has to be carefully installed. These are hired from the hardware suppliers.	{human}
Internet connection	High bandwidth Internet connection is a crucial resource for the collaboration services to work. It is provided by partners.	{tangible}
Content	Content for the screening service is provided by the company’s partner.	{tangible}
Rooms	The company needs to rent rooms from partners on a long term basis to set up collaboration spaces.	{tangible}
Administration	Marketing, customer related tasks and resource	{human}

	management are done by the administration.	
Operators	Each collaboration space needs an operator to operate the system on a daily basis.	{human}

Value configuration
The value that customers pay for are an outcome of outside and inside activities. The activity nature of the business imitates that of a *value network.* The main activities of the business are described in Table 6.

Table 6. Activities

Activity	Description	Level
Marketing	Part of {network promotion}: the different marketing tasks that the company performs in order to acquire and maintain customers.	{primary}
Manage website	Part of {service provisioning}: managing the company's website where the customers can book and pay for the services.	{primary}
Manage/update software	Part of {network infrastructure}: managing and updating the software that handles the communication between collaboration spaces.	{support}
Maintenance hardware	Part of {network infrastructure}: maintaining and replacing equipment whenever it is needed.	{support}
Operate system	Part of {service provisioning}: operating the system on a daily basis includes setting up and tearing down the connection between collaboration spaces.	{primary}
Administrative tasks	Part of {network infrastructure}: management of human and tangible resources and call support. Contact with partners and outsourcing of certain activities.	{support}

Partnership
Partnership is an agreement formed between two or more companies to jointly coordinate the capabilities and resources to carry out an activity. This business need to establish partnerships with the following actors: hardware suppliers, room suppliers, Internet service providers (ISPs) and content providers.

6 Revenue and cost analysis of CSS

Revenue
Revenue is generated from the three services presented earlier. The services are priced per person, per hour and the prices presented are without VAT. It is presented three different price ranges; low, medium and high in Table 7.

- **Meeting service:** The cost of this service should be lower than the cost of traveling in order to have a meeting. It should be a minimum hourly rate.

- **Conference service:** The price per person should be lower for this type of service. It is arranged for more people and not everyone are active in the collaboration. Minimum hourly rate
- **Screening service:** The price of this service will depend on how much the content costs. Most 3D productions are expensive so the content will have to be screened more than once to avoid loss.

Table 7. Price for the services.

Service	Low	Medium	High
Meeting	45 USD	65 USD	85 USD
Conference	25 USD	35 USD	45 USD
Screening	35 USD	55 USD	75 USD

Some assumptions have to be made to estimate the revenue with the prices presented. The rooms are available from 09:00 to 19:00 6 days a week. Screenings are done after 19:00. Holidays are subtracted (100hrs). 70% of the time used for meeting, 30% for conference service. Meeting will have an average of 6 attendants and conference 30 attendants. Screenings will be done once a week with room filled to capacity (50 attendants). It is assumed that the service are fairly popular and that the overall vacancy is 25% (this means that ¼ of the capacity is unoccupied). The gross revenue of the service with different price ranges is presented in Fig. 3.

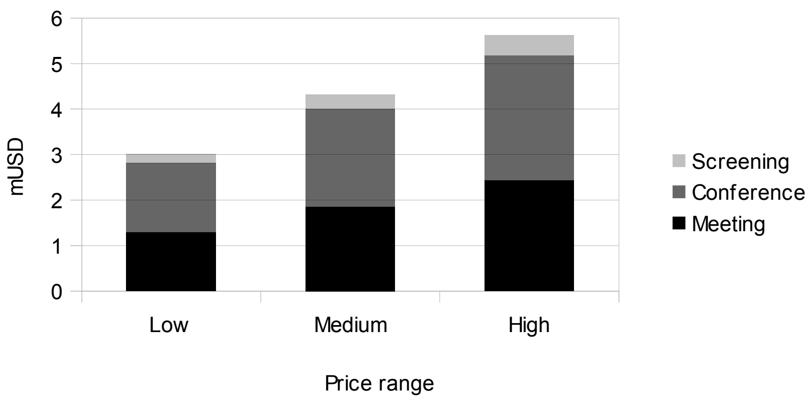

Fig. 3. Gross revenue of services with different price ranges.

Cost

The cost of hardware and equipment for one collaboration space is found in Table 8.

Table 8. Equipment costs for one CS.

Equipment	Description	Cost
Auto-stereoscopic displays	11 x 6 = 66 42" auto-stereoscopic displays put together constitute a large enough display.	707 kUSD
Cameras	Small, but high quality cameras is needed for at least each view of the display (15 set of cameras) and two for each view. Total: 30 small cameras.	134 kUSD
Microphones	The room needs many microphones to reproduce the sound naturally in the other end.	11 kUSD
Sound system	A good sound system is important especially for the screening service, multiple loudspeakers are needed.	27 kUSD
Codecs	The system needs codecs that can handle multiple 3D signals efficiently and with minimum latency. This does not exist today, but it is assumed that future codecs can handle this and cost the same as todays state-of-the-art codecs.	62 kUSD
Server/PC	Each room needs one high performing PC.	5 kUSD
Furniture	Chairs, tables, lighting, whiteboards and everything that a meeting of conference room need.	35 kUSD
	TOTAL COST:	**981 kUSD**

As a start-up the business will establish three collaboration spaces. The investment costs and annual costs of the business with these three collaboration spaces are described in Table 9.

Table 9. Costs

Expenditure	Description	Cost	Type
Hardware/ equipment for one CS	Equipment is bought from partners. The equipment is not depreciated but constantly maintained and replaced.	2 943 kUSD	One-time
Maintenance/ replacement of hardware/ equipment	20% of the total cost for the CSs is used for maintenance and replacement.	588.6 kUSD	Annual
Develop software	The software for the communication between collaboration spaces is developed in-house. Five software developers need one year to develop this. On top of salary is 20% in additional costs for employees. Equipment for development is included in this cost.	580 kUSD	One-time
Installation cost	The costs of installing hardware and equipment are 20% of the total cost of the equipment.	588.6 kUSD	One-time
Software maintenance and update	Update, support and install of software. It is needed four permanently employed system experts to do these tasks.	429 kUSD	Annual
Leasing rooms	Rooms for the CSs needs to be leased. They should all be centrally located.	215 kUSD	Annual
Main office	Lease office accommodations for the administration.	18 kUSD	Annual
Set up main	The administration needs furniture, desktop,	27 kUSD	One-

office	laptops etc.		time
Administration	The administration needs five people to complete their tasks.	428 kUSD	Annual
Marketing	The marketing tasks of the distribution channel.	357 kUSD	Annual
Internet access establishment	Establishment cost to ISPs for the CSs.	6 kUSD	One-time
Internet access	annual costs of high speed internet access for all CSs.	107 kUSD	Annual
Content for screening service	Content is expensive. The business can not afford using more than 125 000 USD annual on this. An alternative would be to shut down the service.	125 kUSD	Annual
Operating personnel	All CSs needs one full-time employed and one half-time employed to operate the system.	353 kUSD	Annual
Tax	The business has to pay 25% tax on revenue after annual costs are subtracted.		Annual

The total investment costs involved with setting up three collaboration spaces and developing the software needed for the system is shown in Table 10. It is assumed that people has to be hired and collaboration spaces need to be set up half a year before the business can start making money. The post "half of annual costs" is included in the investment costs and is half of annual costs except content for screenings. The annual costs of running three collaboration spaces are found in Table 11.

Table 10. Total investment costs of three CSs.

Develop software	580 kUSD
Equipment 3 CSs	2 943 kUSD
Installation cost 3 CSs	588.6 kUSD
Internet establishment	6 kUSD
Set up main office	27 kUSD
Half of annual costs	1 247.8 kUSD
SUM:	**5 392.4 kUSD**

Table 11. Annual costs of three CSs.

Maintenance/support SW	429 kUSD
Maintenance/replacement HW	588.6 kUSD
Lease rooms	215 kUSD
Main office	18 kUSD
Administration	428 kUSD
Marketing	357 kUSD
Internet access	107 kUSD
Content for screenings	125 kUSD
Operating personnel	353 kUSD
SUM:	**2 620.6 kUSD**

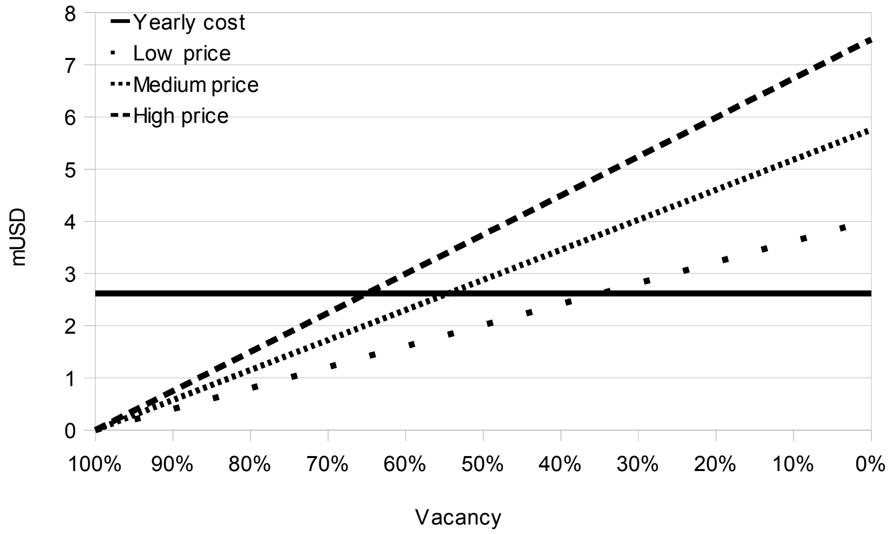

Fig. 4. Annual revenue with different prices relative to vacancy.

Fig. 4 shows the annual revenue for the different price ranges with respect to vacancy. It shows at which vacancies the business will experience negative earnings with the different prices. Using the high prices the business can tolerate 65% vacancy, for medium prices 55% vacancy and with low prices only 35% vacancy.

The net revenue with the different prices is the revenue after the annual costs are subtracted and tax of 25% is paid. The vacancy is assumed to be 25%, as earlier. The net revenue is shown in Table 12.

Table 12. Gross and net revenue for different prices.

	Gross revenue	Net revenue
Low prices	3 017.9 kUSD	298.0 kUSD
Medium prices	4 317.2 kUSD	1 272.5 kUSD
High prices	5 616.5 kUSD	2 247.0 kUSD

For those that want to invest in this business it is interesting to know the internal rate of return (IRR) which is a measure for the profitability of investments. Having the net cash flows of the different price ranges and the initial investment cost, the IRR is calculated for the different price ranges in Fig. 5. The lifetime of the business is important when finding the IRR. These types of services is expected to have a lifetime of approximately 10 years. We see that for the low prices the business has negative returns after 10 years. For medium and high prices the IRR is 20% and 40% respectively.

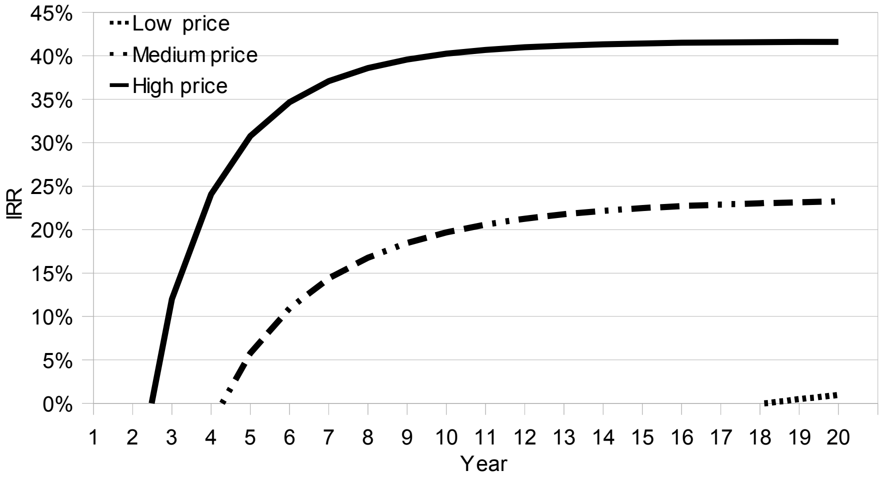

Fig. 5. The internal rate of return with different price levels.

7 Conclusion

This paper has presented a business case for CSS. We have used the Osterwalder ontology to model the CSS, and presented an economic analysis. The economic analysis shows that when expecting a vacancy of 25% and with medium range prices the CSS has a market viability. The internal rate of return will be close to 20% after 10 years of operation. This is for small-scale operations with only three collaboration spaces. The numbers that are presented are however estimates. A high uncertainty is the revenue streams which are difficult to predict without analyzing the market for the demand for these kind of services. The costs of the technology needed is determined by the price for state-of-the-art technology and based on the Norwegian market prices. Today's technology does not meet the requirements of the system but is expected to be available in the medium term with the current rate of development.

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