Next Generation Arena

— A Case Study of Nokia Corporation

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Laurea University of Applied Sciences **Abstract**
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The aim of this thesis was to create next generation arena experiences that would become possible in the next three to ten years with Nokia Corporation. The goal was to create realistic virtual event experience for people at home who may have physical or medical limitations to participate in live events. The base for this thesis was implemented in a five-day Design Sprint workshop, where the researching and prototype called 0.5 were implemented.

In the research process a survey and benchmarking were used. The targets of the benchmarking were Epic Games' game engine Unreal Engine 5, a German platform Noys VR that co-creates concerts natively to virtual reality, ABBA Voyage concerts and a Finnish virtual park Pikseli. With the results obtained by benchmarking, a relatively realistic experience for the current situation was obtained. A survey was used to map the opinions of potential future customers of the topic and what their expectations are about the topic.

As a result, a prototype was made of future virtual reality experience which is realistic. The prototype will bring the arena to your home by recreating the sound world and audience by replicating the events of the real arena to a virtual world. This includes audience movements, cheering, clapping and arena lighting. In addition to the current situation, future possibilities, and business opportunities to improve the concept even more are included. The purpose is to create new opportunities for remote participation in live events, rather than replace live events.

Keywords: virtual reality, arena events, benchmarking, design sprint, digital twin, tietojenkäsittely

1 Introduction

Virtual reality can be used to make different experiences possible remotely. Even though concerts are already being implemented in virtual reality, the feel of the audience and the venue are lacking. Different technologies to bring the whole experience as lifelike as possible into virtual reality in the near future were found. Utilizing virtual reality enables numerous possibilities and offers a capability to expand the concept to other events.

The aim of this thesis was to research new future virtual reality event solutions for Nokia Arena events. The assignment was to create next generation arena experiences and think of the possible business opportunities that would become available in the next three to ten years. The thesis is carried out in collaboration with Nokia Corporation and Laurea University of Applied Sciences in a Design Sprint workshop.

The goal was to find possible challenges from virtual events, which affect customer experiences and the user experience of virtual reality. Based on the findings the goal also was to create realistic virtual event experience for people at home who may have physical or medical limitations to participate in live events. Utilizing information gathered from customer understanding, a prototype concept is created that considers the current challenges in utilizing technology and the lack of lifelike experience. The knowledge base of the thesis is gathered from the client company and using survey and benchmarking as the research methods. The research methods and the knowledge base are further expressed in this report.

Virtual reality has vast future opportunities and is currently developing in a fast pace. When combining virtual reality with live entertainment events it brings up business to business and business to customer opportunities for Nokia. When bringing live events for larger audiences it can boost ticket sales and Nokia could sell the actual concept to other venues.

After the introduction, in the first chapter of this thesis, Nokia Corporation and Nokia Arena are introduced to the reader. The assignment will be properly presented in the second chapter. The third chapter is about Design Sprint itself and how the sprint was utilized throughout the project. Then the research methods are explained, and the fourth chapter also contains the data analysis of the survey and benchmarking. The purpose of the fifth chapter is to explain the virtual reality concept, and in the following chapter the prototype is introduced. The sixth chapter also contains explanations of the various techniques and technologies used behind planning the prototype. The seventh chapter is about the prospects of the concept, and the final conclusions of this project are also included in it.

2 Nokia Corporation

This thesis was assigned by Nokia, which is a Finnish multinational telecommunication, information technology and consumer electronics corporation. It was founded in 1865, and there are over 157 years of business behind it. (Nokia 2022.) Nokia operates in around 130 countries and has a total of 86 370 employees in 2021 (People and planet 2021, 7).

Nokia's net sales were 22,2 billion euros in 2021. It has 4000 patent families declared as essential to 5G. They have high sustainability standards, and they have a target to use 100% renewable electricity by 2025. (Nokia in 2021, 6.) Some of Nokia's sustainability highlights in 2021 were that they continued to drive down the energy consumption of their products and they were one of the world's most ethical companies in early 2022 (People and planet 2021, 9).

Nokia's purpose is to build critical networks with customers which connect people, machines, and devices to each other in real time. They want to respond to climate change through more efficient use and re-use of the world's resources. Nokia wants to make work, healthcare, markets, and education equally available to everyone and increase meaningful interaction with humans to promote development. (Nokia in 2021, 4.)

2.1 Nokia Arena

Nokia Arena is located in Tampere, Finland. It was opened on December 3rd, 2021. The owners of Nokia Arena are Finnish companies LähiTapiola, OP, Ilmarinen, SRV and the city of Tampere. Nokia Arena includes an international casino, Lapland hotel arena, versatile event spaces and many different restaurants. (Nokia Arena 2022a.)

Nokia Arena is a next-generation experience center which opens a new era in event experiences. The arena is 50 000 square meters large, and it can fit up to 15 000 event spectators. It is designed for sport events (mainly ice-hockey games), concerts, musicals, and theatre. It has 140 annual events and 1 million visitors a year. (Nokia Arena 2022a.)

Nokia Arena has ISO 20121 –certificate, which means that their operations are sustainable, and they take environmental and social responsibility into account. Gold level of international LEED environmental certificate was set as a design goal in the construction phase. LEED does not focus on just one aspect but looks at the whole, so important elements work together to achieve the best result. (Nokia Arena 2022b.)

2.2 Next Generation Arena Experience

The assignment was to create a next generation stadium experience and think of the possible business opportunities in arena context – whether they be realized on-site or remotely at home and would become possible in the next three to ten years (Nokia 2022).

The ideating started by mapping what the current limitations of live events are and how can they be improved in the future while giving more people the opportunity to attend the events at the same time. One week before the Design Sprint workshop a decision about the research question was made.

The research question was “How do we give people the possibility to realistically participate in the concert, even if they cannot get to the venue due to physical or medical limitations?”. The research question was used throughout the development task and the goal was to answer it in this thesis.

3 Design Sprint

Design Sprint is a five-day process developed by Jake Knapp, a designer at the technology company Google Ventures (Google Ventures 2019). With Design Sprints it is possible to solve large problems, test new ideas, get more done and faster (Knapp 2016, chapter 1, 6). The method is also cost-effective (Google Ventures 2019).

When doing a Design Sprint, it is important to focus on the surface and find answers to critical business questions before working further on the process. After this, it is easier to find out the underlying technologies and systems. (Knapp 2016, chapter 1, 28.)

On Monday, you map out the problem and choose an important place to focus on. On Tuesday, you sketch competing solutions. On Wednesday, you make difficult decisions and turn your ideas into testable hypotheses. On Thursday, you present a high-quality prototype. And on Friday you test it with real people. (Google Ventures 2019.)

Design Sprint as a thesis implementation method is an intensive five-day process where working takes place in a group. Each day has its own goal, what needs to be accomplished. The sprint workshop’s period schedule was based on the plan set by the course instructors, Jake Knapp's Design Sprint schedule was applied to the project.

The workshop week's schedule (Figure 1) started with concepting and ideating and continued the next day with designing and researching the concept. On Tuesday validating the concept was also done. The workshop continued on Wednesday with refining the concept and starting to build and design a prototype of the concept. Thursday consisted of finalizing the prototype and preparing a pitch for Nokia. The week ended with a pitch for Nokia and documenting the week.

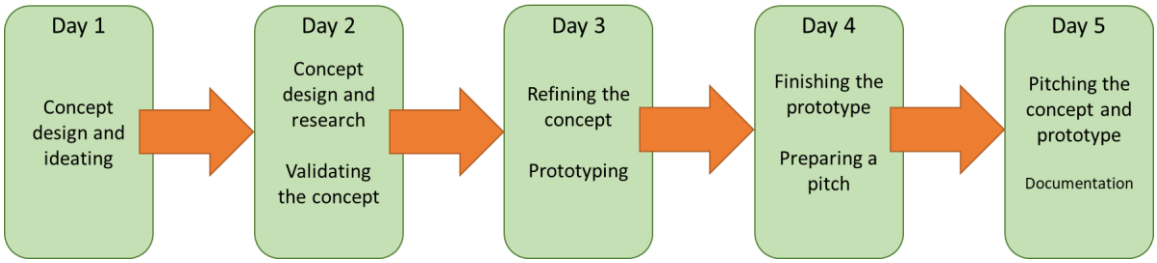

Figure 1: Design Sprint week schedule

The Design Sprint thesis is done in cooperation with the client company and its chosen sparring partners and course instructors. The thesis report and all other design sprint material are written together with the group. Design sprint is a fast-paced implementation method for the thesis, during which the student group and the client company, which in this case is Nokia, work in close interaction during the sprint week.

Work on the Design Sprint thesis started three weeks before the actual sprint workshop itself. Before the sprint, we familiarized ourselves with the client company, chose the topic, and developed a deeper understanding of the topic by collecting a knowledge base. During the sprint workshop, the group created a prototype and a pitch presentation, which were used to illustrate solutions for future arena experiences using virtual reality. The solutions were based on customer understanding, which was achieved through a survey and discussions with sparring partners of the client company, and current technologies were benchmarked.

At the end of the sprint, the group presented its results to the client company. We interacted closely with the client company and received validation for the concept from them during the sprint week. During the implementation of the design sprint thesis, the client company and the course instructors were contacted via Microsoft Teams calls and messages. Communication within the group took place through other channels. During the project, the group divided tasks and the work progressed as planned on schedule.

4 Research Methods and Development

To gain more information of the assignment, research of the topic was started. To gather relevant information on the topic, the current theoretical data needed to be explored to gain more information about the research question (Ojasalo, Moilanen & Ritalahti 2015, 25). The scope was limited to virtual reality arena events, mainly concerts. Survey and benchmarking were chosen as research methods to give qualitative and quantitative data.

4.1 Benchmarking

Benchmarking in general means a research method that is used in comparing companies' way of operating to another, preferably to a company with a higher performance. The main idea is to become aware of existing weaknesses and find better solutions. Benchmarking is a very commonly used method in today's business world since it can be very useful in different development and research projects. To get successful results from benchmarking, it is extremely important to be aware of its processes and types, so finding the best possible option becomes easier. (Laaksonen 2019.)

Benchmarking always requires lots of planning, collecting data, analyzing it, and then doing implementation for improvement plans. It is essential that the systematic process of benchmarking is followed to achieve the best possible results. In the book by Tim Stapenhurst "The Benchmarking Book: A How-to-Guide to Best Practice for Managers and Practitioners" (2009, 18) it is written that benchmarking usually consists of the following two aspects. First, comparing performance levels to ascertain the gap between the target company and the best, and to ascertain which organizations it is most likely to able to learn the most. Secondly, to study how the better or best performers achieve their excellent performances and then adapt and adopt their practices.

There are four main types of benchmarking: performance, internal, external, and practice. For example, performance benchmarking is the first type of benchmarking applied by institutions to identify issues in performance. This type of benchmarking uses quantitative research and data as key performance indicators. (Hanson 2022.)

4.2 Methods of Benchmarking

In Tim Stapenhurst's book "The Benchmarking Book: A How-to-Guide to Best Practice for Managers and Practitioners" (2009, 60-61) it is stated that there are various methods to benchmark, and not only one single method is always the correct one. When benchmarking, it is very important to find the most appropriate method to have the best possible benefit from it. A benchmarking study may adhere closely to one method, or it may follow a mixture of different methods.

Benchmarking Method	Features of the method
Public Domain benchmarking	Data is collected from public sources, for example consumer magazines or newspapers. The data is then analyzed and reported.
One-to-one benchmarking	By far the most written method in books, the original method of benchmarking. Studying the practices of the best existing organization, adapting their practices, and then improving their own based on the best possible option.
Review benchmarking	Several participants are visited to review certain activities at each of them and compare the findings. May consist entirely of data comparison, or of working practices, but is most likely including both.
Database benchmarking	Usually, an independent consultant builds up a database of performance levels from many organizations. Researchers then compare data from the database to other participants.
Trial benchmarking	Can be considered very similar to public domain benchmarking, but the main difference is that the benchmarking is carried out by the initiating organization.
Survey benchmarking	Fairly similar to trial benchmarking and public domain benchmarking. However, in a survey benchmarking the customer's point of view will be seen by carrying out a customer survey.
Business Excellence Models benchmarking	Consists of a set of interrelated criteria, that aims to capture all possible key factors of any successful organization. All excellence models work on similar principles, providing a mechanism for comparing the performance of organizations by scoring them against a standard.

Table 1: Methods of Benchmarking

As proposed by Stapenhurst, some of the different methods of benchmarking are public domain benchmarking, one-to-one benchmarking, review benchmarking, database benchmarking, trial benchmarking, survey benchmarking, business excellence models benchmarking. (Table 1.)

4.3 One-to-One Benchmarking as a Research Method

One-to-one benchmarking is not only the original benchmarking method, but also the most written method. It was originally developed in the 1970s and 1980s, and the concept behind it is very straight-forward. (Stapenhurst 2019.) Here is a common example of the method from the business world.

The first step is to find out which organization is the best, or at least amongst the best at performing the aspect your business is lacking. Then the organization is visited to ascertain their performance level and to learn from them. The third step is to study their practices, adapt from them, and even improve from that if it is necessary. Finally, the main goal is to adopt those new practices into your organization. (Stapenhurst 2019.)

It is not always possible to ascertain that the target organization is the best. With one-to-one benchmarking it is enough to know that the target has the following qualities: it is performing significantly better, and it is amongst the best in the area that is being benchmarked. To ensure these aspects, it is necessary to gather as much information and data as possible from a range of organizations. (Stapenhurst 2019.)

As this thesis is mainly about future possibilities, it was difficult to use this method with already existing techniques. The one-to-one method was the closest and the most adaptable of the different methods available. Regardless of the topic, utilizing the one-to-one method was successful in the research, especially when it comes to today's possibilities with the subject.

4.4 Benchmarking Virtual Reality

In the beginning of the research, benchmarking of a Finnish virtual reality park Pikseli was conducted for different virtual reality experiences. The main idea of the visit was to gather information about the current state of virtual reality. During the visit, different games and virtual experiences were tried to get the overall picture of the quality and realism of virtual reality. The visit helped realize how virtual reality is experienced today.

During the research a company Noys VR was found, a German platform which co-creates concerts natively in virtual reality instead of replicating an already existing concert in 360. Noys VR was founded in 2015 and its idea is based on the Oculus Touch controllers that allow the user to use different tools to interact with the environment. (Noys VR 2022.) Noys VR wants to offer the opportunity to hold concerts without issues like sold-out venues or too expensive travel due to long distances. It also wants to include the atmosphere of a live music concert, that video streaming for example cannot offer. These qualities were something that were desirable to achieve in the project.

The main idea was to find solutions for creating as realistic virtual reality arena experience as possible. The fact that most of this would happen in the future made benchmarking slightly difficult, but solutions to back up the idea were found. For example, techniques created with Unreal Engine were useful when building a real-life-looking venue.

Unreal Engine is the world's most advanced real-time 3D creation tool for photorealistic visuals and immersive experiences. Unreal Engine 5 has a redesigned Unreal Editor, which includes better performance, Quixel Bridge integration, an extended mesh creation and editing toolset, and improved path tracing among other next generation qualities. (Unreal Engine 2022a.) The research also showed that Unreal Engine 5 was used to create a virtual version of the upcoming Co-op Live music venue in the United Kingdom. This confirmed the vision and concluded that Unreal Engine 5 is the best possible option for creating a digital replica of the venue.

In addition to the virtual version of the arena, solutions for creating the artists on stage were needed. The research showed that it is possible to create digital replicas of the performer, and to back up this theory benchmarking of ABBA Voyage concert was done. ABBA Voyage is a virtual concert held in Queen Elizabeth Olympic Park, also known as ABBA Arena, in London. The concerts feature virtual avatars representing the band as they appeared in 1977. (ABBA Voyage 2022.)

Benchmarking Unreal Engine 5 and ABBA Voyage concerts helped to understand the realistic options for the idea with today’s technology. It proved that even with the current technology creating photorealistic surroundings is not impossible, and this was a great help in planning the prototype for this project.

4.5 Survey

Surveys are a common and important research method, which are used to collect and review large amounts of information on the topic being researched. They are an effective and a simple way of conducting research by producing numerical data that has statistically relevant information. They are also quick to create, which is why they can be used to collect information on a fast schedule. The survey can be done in many ways, for example electronically via e-mail, in writing sent with post, and face to face or through phone conversation. When using electronic or written methods, respondents fill the questionnaire by themselves, instead of the interviewee filling it in for the respondent in a face to face or a phone call survey. The downside of using surveys is that the data can be shallow and inaccurate. The respondents may not take the questionnaire seriously or not be aware enough of the subject (Ojasalo et. al 2015, 121). Surveys are mainly used to collect quantitative information because most of the answers can be expressed numerically. Although the surveys can also be used for qualitative research, by giving verbal questions in the questionnaires. (Vehkalahti 2014, 13.)

The interest about the topic from potential customers and the overall experiences and expectations of virtual reality needed to be found. Because of the Design Sprint method, the time was limited to collect information. Web survey was chosen, as it was easy and fast to create, and could collect a great amount of information in a short time. The questionnaire was created using Google forms, because of the ease of use. The questionnaire consisted of 13 questions, of which 12 were compulsory. 11 were multiple choice questions, and 2 were open questions. The questionnaire was kept clear and accessible, so the respondents would not have trouble answering the questions. The questionnaire collected 140 answers from all around Finland in a couple of days. Respondents' background information was collected with the first three questions, asking about their Age group, gender, and residential arena. As seen from the figure below (Figure 2), Of the 140 respondents 52 % (73) were 21-30 years old. 24 % (33) were 31-40 years old. 11 % (16) were 50 or over years old. 8 % (11) were 41-50 years old. And the smallest age group of the respondents was 16-20 years old, consisting of 5 % (7) of the respondents.

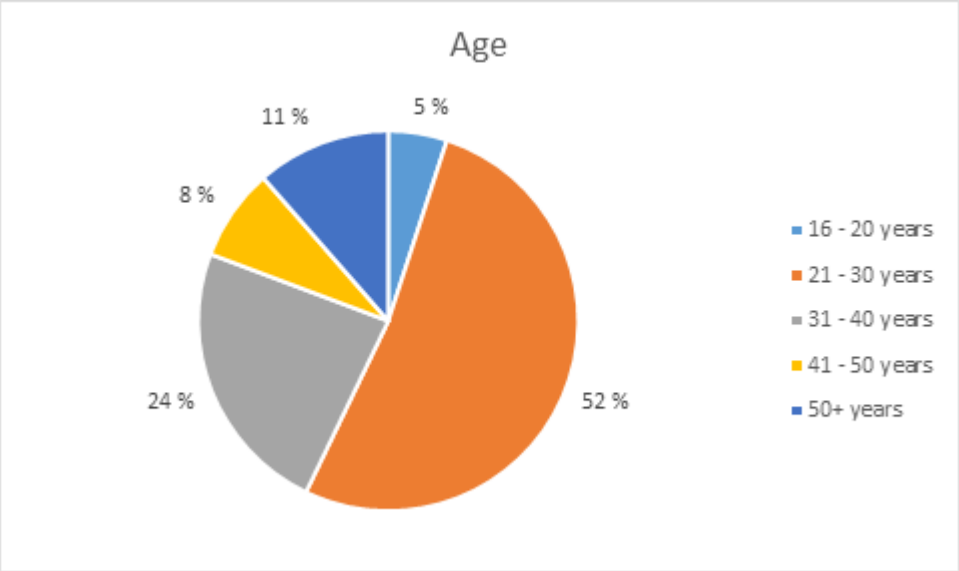

Figure 2: Ages of Respondents

Out of the 140 respondents, 59 % (83) were female, 40 % (56) were men and 1 % (1) were other. The figure below shows (Figure 3), that most of the respondents lived in Uusimaa, consisting of 79 % (111) of the answers. 11 % (16) answers were from Pirkanmaa. The rest of the answers were from all around Finland.

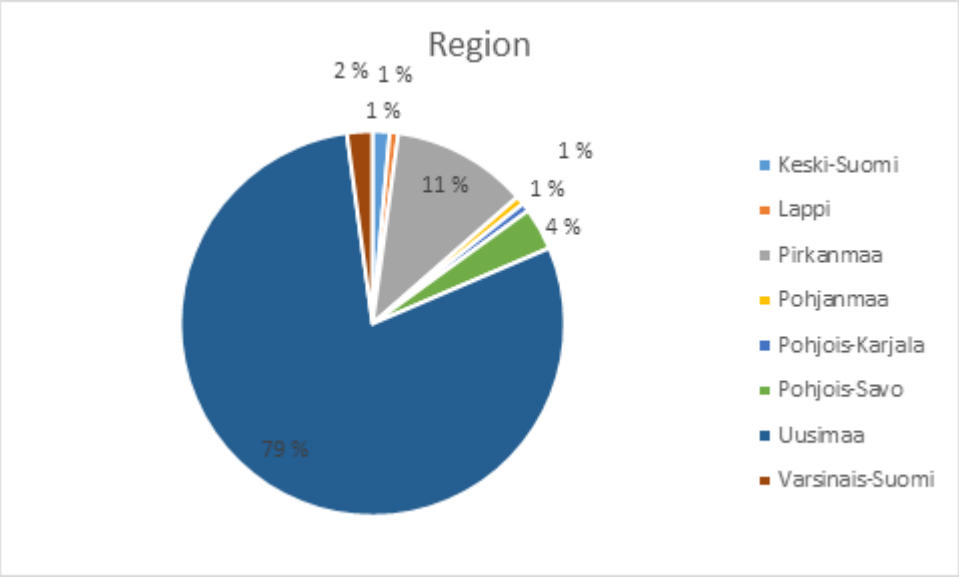

Figure 3: Region of Respondents

The next four questions mapped out what kind of events the respondents usually go for, and the number of times they usually attend the events per year. The results show that cultural events, concerts, plays et cetera, were the main attraction amongst respondents (89 %), and 41 % attend the arena events less than once or twice a year.

The final section of the questionnaire consisted of six questions on topics around virtual reality. As seen from the figure below (Figure 4), 57 % (80) had previous experience with virtual reality. 43 % (60) did not have any experience.

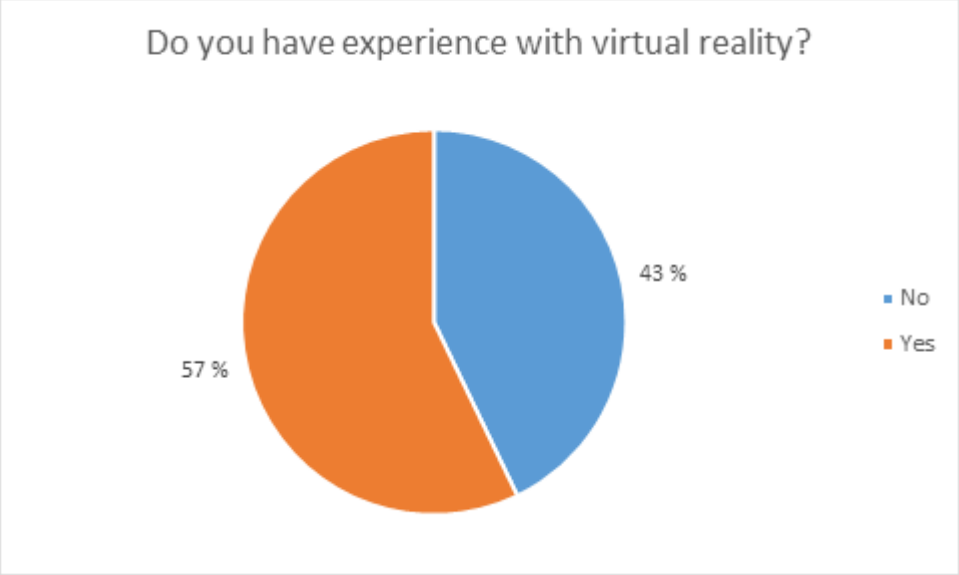

Figure 4: Respondents Experience with Virtual Reality

When asked about willingness to try virtual reality experiences in the future, the respondents were very willing to try it to out, as can be seen from the figure below (Figure 5). 91 % (128) responded yes, while only 9 % (12) responded no.

Figure 5: Respondents' Willingness to Try Virtual Reality

Question 10 received similar results to question nine, as can be seen from figure below (Figure 6), where majority of the answers were “Yes”. 90 % (126) of the respondents thought the possibility of virtual reality being more realistic in the future would get them interested, while only 10 % (14) answered “No”.

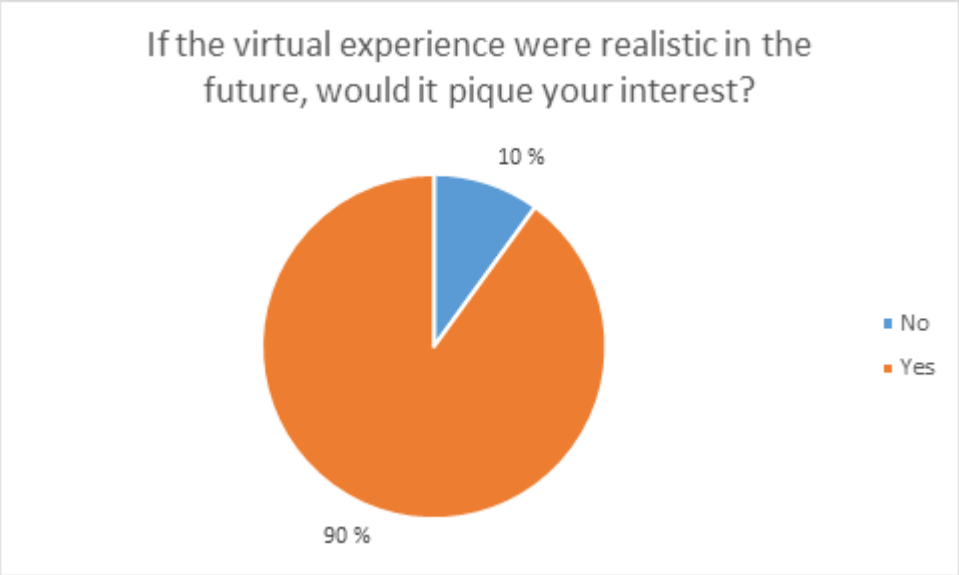

Figure 6: Respondents' Interest in Realistic Virtual Reality Experiences

In the last multiple option question, it was asked if respondents would be willing to buy tickets to virtual reality events, if the experience resembled the real event. The figure below (Figure 7) shows that 71 % (100) of the respondents would be willing to buy a ticket. 29 % (40) answered “no” to the question.

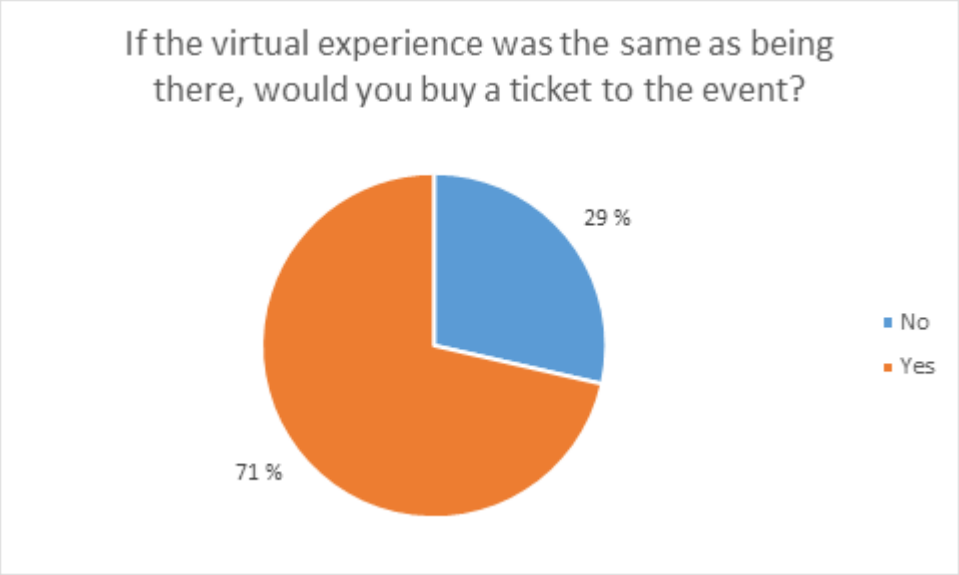

Figure 7: Respondents' Willingness to Buy Tickets to Future Virtual Reality Experiences

The two open questions were the last ones in the questionnaire. The first was compulsory, and it gave the respondents opportunity to talk about their expectations and preconceptions about virtual reality experiences. The last question was voluntary and gave respondents a chance to talk about their previous experiences with virtual reality if they wanted to. The last question was answered by 25 respondents.

4.6 Data Analysis

After doing the benchmarking and survey research analyzing the collected data was done more closely. Data analysis was mostly done by observing the collected data and choosing the most useful information. For analyzing the survey data, Microsoft Excel, was used which helped to concretize the results.

As stated before, the main idea behind benchmarking analysis is to help achieve goals through comparison with more successful operators. For this project it was essential to find the best possible options to achieve photorealistic virtual reality arena experience. Therefore, performance benchmarking was used, which is a quantitative research method.

Performance benchmarking is often the process of measuring and analyzing an organization's performance against other companies. When using strategic benchmarking, the idea is to compare the performance with the top performer on the market. It does not suggest quick changes but aims for long-term improvement. (Joshi 2022.) The idea was to find the best possible solutions for something that does not completely exist yet, so performance benchmarking in analyzing the targets was utilized.

The virtual reality that exists today for the larger audience is not quite the kind of quality this project needs. Solutions for more photorealistic options, where the end-user does not feel like being in a video game, when stepping into virtual reality were needed.

As mentioned before in the "Benchmarking Virtual Reality" chapter, solutions were found that help to create photorealistic surroundings for arena events. Based on the research, these techniques have already been used in creating digital replicas for arenas and artists. When analyzing the results showed that creating the desired virtual reality arena experience with today's technology may not be as challenging as we believed.

Doing benchmarking on different technologies and methods that already exist, pushed the project forward. It helped to realize that it does not require future technology to create a virtual reality arena experience, and by combining different technologies it can take less than ten years to have close to a real-life version of virtual reality.

The information and data from the survey was analyzed and observed to get an idea if the project was on the right track with the idea. While observing the data from the questionnaire, even though many of the respondents had no prior experience with virtual reality (Figure 4), they had great interest towards it (Figure 5). All age groups showed willingness to try virtual reality events in the future, if the technology was at a point where the experience would be lifelike (Figure 8). Although observing the data, it can be observed that most of the opposing answers came from the 21–30-year-olds (Figure 8).

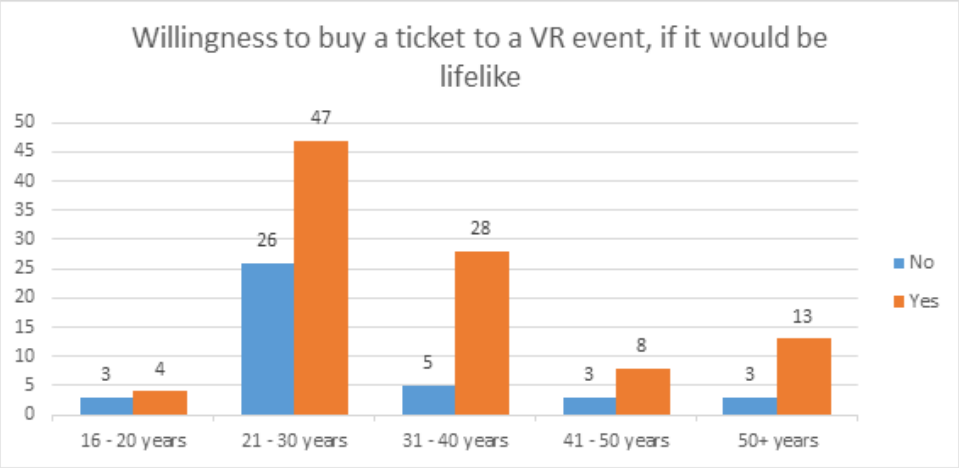

Figure 8: Willingness to buy a ticket to a VR event if it would be lifelike

Looking further into the answers from the 21–30-year-old age group, it was noticed that most of the respondents had previous experience with virtual reality, as can be seen from the figure below (Figure 9). Even though the majority of the answers were positive about the future of the virtual reality experience, it might be worth putting effort into the marketing for this specific age group, as they are the most skeptical about the topic based on the answers. Their knowledge of the state of current virtual reality technology might have a negative impact on their expectations for the future.

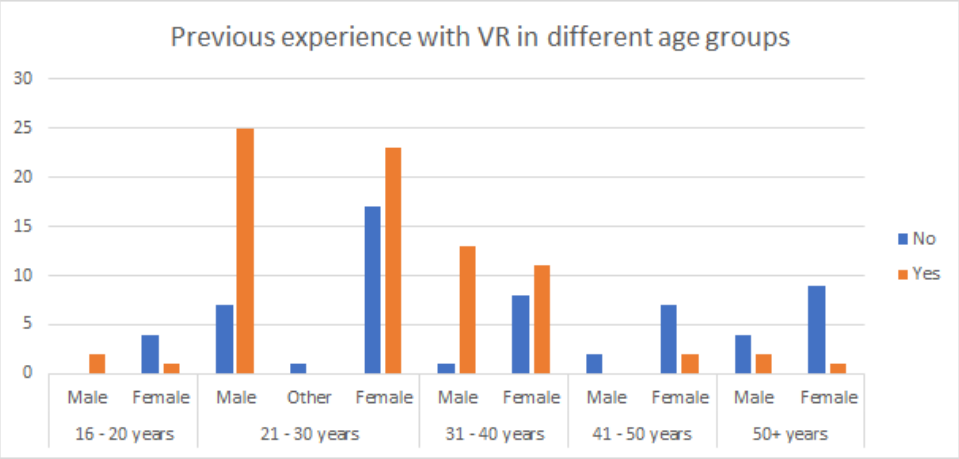

Figure 9: Previous experience with VR in different age groups and genders

For the open questions in the end of the questionnaire, the answers varied from enthusiastic to critical towards virtual reality itself. Responds with positive attitude towards virtual reality included “I look forward to the opportunities to try virtual reality being more accessible”, “I am looking forward to the opportunity to participate in events without traveling (due to the climate crisis, expectations are high so that traveling could be minimized).” which gave confidence that the concept is worth pursuing. Critical answers such as “The experience of community is not necessarily the same. If, for example, the concert itself felt authentic as a virtual one, the social aspect of the event would not necessarily be. If you could virtually meet other people and acquaintances, I could consider the virtual experience to feel authentic. The experience on site also includes preparation and leaving home, which is refreshing. I would certainly be very interested in a virtual concert, if it would be possible to bring artists who would otherwise never come to Finland to perform.”, “I don't think that, at least physically, you get the feeling that a live event creates. And that body reaction is important for yourself.” and “Virtual experiences should still develop a lot to make them almost realistic. Virtual experiences should also be significantly cheaper than physical on-site experiences.” strengthened thoughts about the quality of virtual reality services currently available. The answers varied widely, but mostly two topics emerged the most; The state of current virtual reality technology is not technically advanced enough, and respondents were hopeful for the future of virtual reality.

5 Virtual Reality Experience Concept

The goal was to find a solution to participate in events even when consumers are unable to attend the live events, because of distance from the location or medical and physical limitations. Even in a possible new pandemic situation there would be the possibility to still attend and keep the event going, because it is all virtual. It would also help to increase the number of viewers, because even if the arena's capacity is full, there is a possibility of attending the concert virtually. They could even record the events and sell it afterwards, so consumers can experience the event later.

The basic idea was to bring the arena event experience to the customer at home, via virtual reality by creating the whole experience as realistically as possible in the next three to ten years. The concept is a digital twin of the live arena experience in virtual reality, which requires a replication of the audience, lights, effects and sounds of the arena as they are at the arena.

The main benefit for the client company is the fact that the concept can be very widely expandable. The idea was to bring the realistic VR concert alive, but this technique is possible to use in a variety of sports games, musicals, theatre, and other large arena events. The business opportunities of the concept can be expansive, because it can be sold to other large stadiums as well. This is also something that could be a vital option for arena events especially in case of another pandemic in the future.

Sometimes the distance between the customer’s hometown and arena might be too long and that way attending the concert would become too expensive. There are also physical and medical issues that could prevent customers from attending the event. The event can be sold out in just a few seconds after the ticket sales opened, which is a very common issue especially with popular artists. The concept will provide a solution for all these problems and can open many opportunities to raise the ticket sales. This obviously will benefit the artists as well when they have the chance to sell VR tickets in addition to their live concert tickets.

6 Prototype

As per Nokia’s request, designing a prototype of the concept with the technologies currently existing was started. The main concept idea remained the same, as it was certain it is possible to recreate the arena environment in virtual reality at least in some manner. While researching video analyzing technologies, it was soon realized that the concept is not as far in the future as it was initially thought.

With the technologies existing today, a prototype with few caveats from the original concept can be achieved. Downsides consisted mostly about how the audience is rendered and how the graphics look. When researching the current technologies during the sprint workshop, a way to capture the audience in its entirety was needed, while keeping it efficient and still realistic as possible.

Research of game engines was needed to get a better picture of which engine would be most fit for the prototype. The game engine is a key part of graphics and how the actual performers can be brought to life in a virtual environment. Also lightning and soundscape is important when designing a virtual environment that is supposed to match the experience the customer would have, when attending a live event in an arena. This requires knowledge of lightboards and the protocols they use. When combining all the mentioned technologies it can be possible to replicate the event.

6.1 Game Engine

Even though the prototype concept is not a game, game engines can be used for a wide variety of use cases, including virtual reality, movies and television series. Unreal Engine has been used in massive Hollywood productions like The Mandalorian and Ford VS. Ferrari to create photorealistic special effects and surroundings. (Dev Community 2022a; Unreal Engine 2022.)

For the base of the prototype, a decision needed to be made which game engine to use for rendering the virtual environment. After researching the subject there were two major options available: Unreal Engine 5 and Unity. (Game Developer 2021.)

Ultimately Unreal Engine 5 was chosen as a proper candidate for the prototype, for its new features that allow its users to create an immersive, life like worlds and lightning. When using Nanite and Lumen, less processing power is required than with its predecessor and the virtual world can react in real time to light source changes. Nanite is a new feature introduced in Unreal Engine 5 that allows the engine to render high detail meshes using a virtualized micro polygon geometry system. Lumen is a fully dynamic lightning solution that allows artists to create more dynamic and realistic virtual scenery. (Unreal Engine 2022c.)

Unreal Engine has also been used in the past to create a digital replica of an under-construction arena Co-op Live music venue, United Kingdom’s only “music-first” arena (Unreal Engine 2022d; Co-op Live 2022). This also gave more confidence that Unreal Engine is the right choice for this project.

6.2 Arena

When the base of the prototype was set, a decision needed to be made how to replicate the arena itself. Nokia arena is a massive structure with a lot of functions including a hotel, casino, conference facilities, event facilities and restaurants. (Nokia Arena 2022c.)

As the idea is to make a digital twin of the arena (IBM 2022), a replicate of the arena needs to be created down to every last detail. Unreal Engine itself has modelling tools which can be used, or 3D modeling and animation software like Autodesk 3ds Max, Maya or even free software, for example Blender, can be used. 3D models from these can be imported as static meshes to Unreal Engine. (Unreal Engine 2022e; Autodesk 2022a; Autodesk 2022b; Blender 2022; Unreal Engine 2022f.)

A decision on which software the modeling artist uses, was left to them. While all the proposed software can do it all, from modeling to animation, they all have their strengths and shortcomings (Medium 2018a). Any software can be used for modeling that supports exporting files in FBX format (Unreal Engine 2022f). Many performers have their own stage, lightning, pyrotechnics et cetera. This requires the model to be tuned per artist to match the actual live show.

6.3 Performers

A key part of an entertainment event is obviously the performer. Since the project is mainly focusing on concerts, a concert will be used as the baseline setting for the prototype. To make a digital replica of a human, different paths can be chosen to achieve the goal. Either making a 3D model from scratch or making a 3D scan of the subject. For this project both are needed, since the assumption is that not all artists interested in virtual events are able or willing to provide 3D scans of themselves.

3D scans have been done in the past at least by artists ABBA and Lady Gaga (Abba Voyage 2022b; Human-Engine 2022). Lady Gaga had a 3D scan made of herself for a music video that required a digital replica of her (Paper 2020). ABBA is performing live using only digital replicas of themselves (Abba Voyage 2022b). The ABBA Voyage concerts have received positive reviews, which gives this project confidence that it is a viable concept (The Guardian 2022).

Replicating the performer itself in 3D is not enough and it is hard to impossible to predict what an artist does on stage at any given time. To make the performance appear on a virtual stage as it appears live at the arena, the artists' movements need to be tracked. With projects like AlphaPose that use video analyzing, object movement tracking and deep learning (Github 2022a). The wireframe of movements generated by AlphaPose can be used to animate 3D models in real time (Medium 2020). AlphaPose is not the only Human Pose tracking application, and similar results can be seen with other applications as well (V7 2022).

6.4 Audience

Replicating the audience is the most complicated part of this project, since tracking 15000 individuals is a task, that is not the main focus of this prototype. To accomplish an audience replica that matches the live audience at the arena requires tracking of movement, clapping, hand raising, jumping. Everything people do when they are attending an event. To accomplish a lifelike audience, a wide variety of techniques are used to track the movements and gestures of the audience as a mass rather than as individuals, to replicate the feeling of the real audience at the arena.

The use of computer vision, artificial intelligence and deep learning are needed to handle audience replication. For example, OpenCV can help with many of these needs. OpenCV is an open-source computer vision library which includes hundreds of computer vision algorithms which can be used, for example video analysis, object detection, stereo camera calibration and multiple-view geometry analysis. (OpenCV 2022.)

To get a view of the whole audience, a 360° camera (Scaramuzza 2022) or an array of downwards facing cameras placed on the roof of the arena can be used (Wilburn, Joshi, Vaish, Talvala, Antunez, Barth, Adams, Horowitz, Levoy 2005). Using a camera array could also enable a higher quality image of what happens on certain parts of the audience, which would make video analyzing easier. With this feed the movement of the audience can be analyzed at any given moment. Using prediction models and object tracking to detect the heads of the audience and track their movements (Zhang, Lin, Zheng, Tang, Fang, Yu 2019; Rodriguez, Laptev, Sivic, Audibert 2011; Science 2017).

With the data from the live audience, movement of the objects can be replicated in virtual reality by feeding the movement data to Unreal Engine and the 3D models of the replicated audience (Unreal Engine 2022g). While this prototype is not trying to replicate the individuals in the audience, this approach should be sufficient to replicate the general movement of larger masses in the audience. For example, if a larger crowd starts to run in circles or two sides of the audience decide to run towards each other (ABC News 2017).

There was also a need to find a way to know when people are cheering with their hands up and jumping. After researching the subject, two different ways to find out what gestures the audience is doing were found. Firstly, depth maps would be a viable way to detect certain gestures in the audience. Depth map is a representation of an image that contains the information of distance differences in the original image. The most conventional way to generate a depth map is to use a stereo camera and generate a depth map by tracking displacement point of two images you get from a stereo camera. OpenCV has a built-in algorithm to generate depth maps from stereo images (Medium 2018b; OpenCV 2022b). Depth maps can also be generated from single images using machine learning models like MiDaS (Github 2022b). Depth maps usually are black and white images in which the distance of object by color contrast can be seen. Brighter shades of white are closer to the camera and darker greys are further away, as seen in Figure 10. By calculating the changes in height using depth maps it can be predicted if the audience is jumping or raising its hands. For example, if the height of a mass changes frequently, it could mean jumping. If the height rises once and stays higher it can mean raising hands.

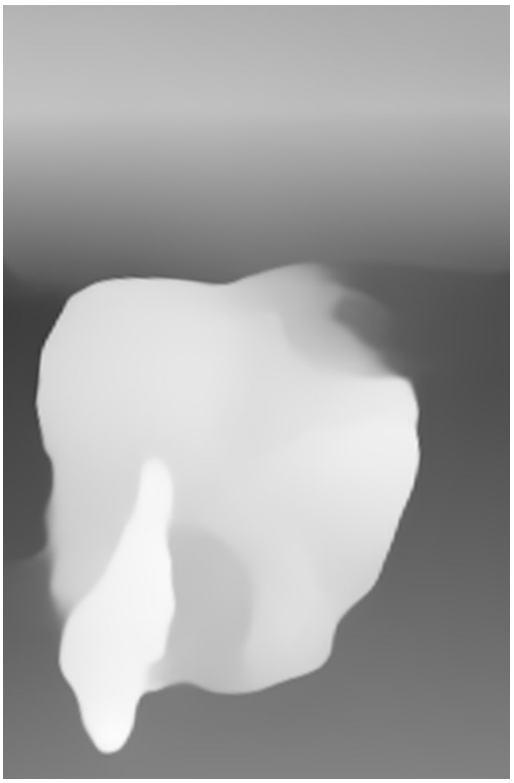

Figure 10: Depth map of a person standing with her hand raised up. Created with MiDaS using a single image

The second and perhaps a more viable option for gesture tracking is using artificial intelligence to recognize motion patterns and trends that represent, for example jumping and raising hands motions in larger crowds (RidgeRun 2022). Head tracking could also be used with motion tracking to recognize movement patterns in heads. The head recognitions algorithms are not perfect, but in the case of this prototype, it would not make a difference since a missing individual here and there would not matter when trying to replicate what the audience is doing as a mass (Sundararaman, De Almeida Braga, Marchand, Pettré 2021; University of Central Florida 2015). Recognizing patterns would trigger a cue to make certain parts of the replicated virtual reality audience to jump et cetera.

6.5 Sound

The sounds of the audience give a concert or any event more immersion and it is a key part in creating the atmosphere of an event. To replicate the sounds of the audience as they happen live, extensive microphone installations is required. Some arenas that hold sporting events, for example ice hockey, already have microphones installed midst the seats to capture the audience for television broadcasts. Wide variety of different microphones is required to capture all the ambience of a sporting event. (Shure 2022.)

When replicating a massive audience in virtual reality a large number of microphones need to be installed midst the audience to capture every part of the arena soundscape. When the user is moving around the arena, they should hear what the live audience is hearing at that location at the arena. Installing a microphone array throughout the arena will make it possible to capture the sounds and replicate them in Unreal Engine based on location (Learning about Electronics 2022; Unreal Engine 2022h).

Properly installed microphones that record the soundscape of the arena can be used to control the audience in virtual reality as well. Sound detection techniques can be used to detect clapping at certain areas. When the system detects clapping, it can work as a trigger for the replicated audience and make them clap as well (Github 2022c).

6.6 Lighting and Special Effects

Lighting and special effects, like pyrotechnics, give an event an important part of its visual look. Lights are used to create ambience and tie the experience together. Lighting is used to illuminate what you want the audience to look at. They are also used to evoke motions by incorporating them into the show. (AV Alliance 2022.)

Most lightboards use a protocol called Digital Multiplex (DMX), DMX is a protocol for lights just as MIDI is for sound. It is a unidirectional protocol, meaning the signal is one-way only from the controller to lights. DMX has 512 channels, which each contain a different instruction for a lighting fixture, may it be color, rotation, or any other function. DMX lightboards are the industry standard for controlling lights and it is used by small and large artists. (Sweetwater 2022.)

With Unreal Engine, replicating the lighting and special effects can be quite simple as it supports DMX protocol through a plugin. The DMX support was added specifically for the use case, in which it is needed for the prototype (Unreal Engine 2022i). It can be used to sync the lighting in virtual reality with the actual lighting at the venue and could also be used to control the actual lighting. The stage needs to be replicated per artist if they have a customized stage show. When everything is controlled with DMX, only matching configuration needs to be added to Unreal Engine (Dev Community 2022b).

7 Future Prospects and Conclusions

One of the greatest challenges during the ideation of the concept was making virtual reality realistic enough. Research showed that creating the environment, such as the crowd and the arena, is not the issue and even with today's technology it is possible to make it very photorealistic. We did not just want to make it look real, but to feel as real as possible as well. More research needs to be carried out to find possible solutions for this aspect.

One of the most interesting products in development are haptic feedback suits. For example, a company called Teslasuit has created developer kits of a suit that provides haptic feedback and captures motion and biometrics (Figure 11). The main idea behind the suit is based on a human-to-digital interface and is designed to monitor human behavior and improve performance. Teslasuit has a full body haptic feedback system that uses electro muscle stimulation (EMS) and transcutaneous electrical nerve stimulation (TENS). These are used to simulate a range of real-life feelings and sensations. Already back in 2019 with the utilization of the 5G network, Teslasuit haptic technology was used to transmit touch in rugby practice, despite the players were more than 100 miles apart. (Teslasuit 2022.)

Figure 11: Teslasuit tracks, records and monitors the movements and positioning of the user

The haptic feedback suit would bring the virtual experience to a whole new level of immersion, helping to feel the other members the of the audience walking through the arena, and even virtually take part in mosh pits and other activities happening during concerts. This would be the critical part of making virtual reality as realistic as it can be. More research should be carried out on the topic.

The main benefit for the client company is that this concept can be very widely expandable. The original idea was to bring the realistic virtual reality concert alive, but this technique is also possible to be used in a variety of different arena events. For example, sports games, musicals, theatre, and other arena events. We believe the business opportunities for this concept are great because it can be sold to other arenas as well. And not just nationwide, but in other countries as well. This concept is also something that could be a vital option for arena events especially in case of another pandemic in the future. Not to mention how widely this concept could be improved with the future techniques.

The benefits of the concept to the end user were also considered. For example, in some cases the distance between the customer's hometown and arena might be too long and attending the concert would become too expensive. There are also physical and medical issues that could prevent customers from attending the event. Or the event is sold out in just a few seconds after the ticket sales opened, which is a very common issue especially with popular artists. This virtual reality concept would bring the solution for all these problems and could open many opportunities to raise the ticket sales. This will then benefit the performing artists as well when they have the chance to sell virtual reality tickets in addition to their live concert tickets.

During the project we thought about logical options for bringing the virtual reality experience to the end user. Elisa Oyj, which is a Finnish telecommunications company, is already an existing partner with Nokia. Elisa could offer their cooperation by providing the virtual reality equipment, which could then be rented for customers who do not have equipment of their own. The ticket sales and equipment rental could both go through ticket sales and distribution companies, such as the Finnish ticket sales and distribution company Lippu.fi. The concept could this way be easily available from small group of friends to a larger number of people, such as after-work events or birthday parties.

The assignment was to create a next generation arena experience for Nokia Arena. The plan was to find out how realistic VR experiences could become in the future and would today's technology allow to create realistic arena experiences in virtual reality. We wanted to find solutions for creating a virtual reality experience that would give justice to live events by being a real-life alike replica of it. The goal was to create realistic virtual event experience for people at home who may have physical or medical limitations to participate in live events.

The Design Sprint workshop had a significant role in this thesis, since during the intensive period valuable feedback was received, we had the chance to develop the idea, and in the end of the workshop the image was clear of how to continue with the project. During the sprint workshop a survey and benchmarking research were conducted, which both provided important information in developing the idea. In the end of the week, concept and prototype was presented to Nokia. The presentation received positive feedback and the client company stated the idea had potential for further research and possible scalability exists.

In addition to technical details and research for the concept, business and marketing opportunities for the idea were thought. We believe virtual reality will have strong impact with the future arena events as it gives the chance to sell more tickets and even bring audience from across the globe. The survey also showed that there is a clear interest towards realistic VR experiences and people are curious about future possibilities when it comes to virtual reality. Virtual reality could someday have a strong foothold alongside live events.

This thesis project has taught us how to work on a relatively extensive project in quite tight schedule, had the chance to improve our teamwork skills, and learned how to do developing research with different methods. It was also very interesting to do this project with Nokia and hear their perspectives and opinions about our concept. In the end we believe after doing all the research and developing process for the concept, this has been an interesting and very instructive journey.

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Figures

Tables

Appendices

Appendix 1: Questionnaire

Virtual reality events of the future

With the help of this survey, we want to map experiences and thoughts about different virtual experiences of the future (5-10 years from now). The survey was created for the thesis and the background information needed for it. We do not collect personal data; we process the data anonymously. Thanks in advance for the answers!

1. Age
    - 16-20 years
    - 21-30 years
    - 31-40 years
    - 41-50 years
    - 50+ years

2. Gender
    - Male
    - Female
    - Other

3. Region
    - Uusimaa
    - Pirkanmaa
    - Varsinais-Suomi
    - Pohjois-Pohjanmaa
    - Keski-Suomi
    - Pohjois-Savo
    - Satakunta
    - Päijät-Häme
    - Etelä-Pohjanmaa
    - Lappi
    - Pohjanmaa
    - Kanta-Häme
    - Pohjois-Karjala
    - Kymenlaakso
    - Etelä-Savo
    - Etelä-Karjala
    - Kainuu
    - Keski-Pohjanmaa

4. What kind of arena events interest you?
    - Sports events
    - Cultural events (Concerts, plays, etc.)
    - I cannot say

5. Do you usually go to arena events...
    - … Alone?
    - … With another person?
    - … In a larger group?

6. How many times a year do you participate in arena events? For example, concerts or sport events.
    - 1-2 times a year
    - More often
    - Less often

7. Have you participated in events remotely in recent years? For example, to a concert or a sporting event.
    - Yes
    - No

8. Do you have experience with virtual reality?
    - Yes
    - No

9. Would you be willing to try the virtual experience again in the future?
    - Yes
    - No

10. If the virtual experience were realistic in the future, would it pique your interest?
    - Yes
    - No

11. If the virtual experience was the same as being there, would you buy a ticket to the event?
    - Yes
    - No

12. What expectations or prejudices do you have about virtual reality experiences?

13. If you have experiences with virtual reality, you can tell us about them below (optional).