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# Defining a Testing Platform for Smart TV Applications

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<p>The goal of the final year project was to study and describe the testing platforms for applications on Smart TVs. This included the whole process of testing of the functionalities of applications before actually releasing them to the public. Additionally, this project addressed the importance of testing during the development of an application.</p> <p>To reach the goal, two testing platforms were chosen which were Opera TV Store and Samsung TV Store. Two HTML5-based apps named Myapp and Tryapp were tested in Opera and Samsung TV Store respectively. The errors and bugs in these apps were determined during the process of testing.</p> <p>As a result of this thesis, issues during the development of an app can be detected and they can be fixed to ensure the functionality of the application. Thus, this thesis is useful for someone who is interested in developing an app for Smart TV. Moreover, this thesis can be helpful for students who want to publish their app in Opera TV Store and Samsung TV Store.</p>	
Keywords	Smart TV, apps, testing, interactivity

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## List of Abbreviations

IBM	International Business Machines
Coaxial RF	Coaxial Radio Frequency
LCD	Liquid Crystal Display
LED	Light-emitting Diode
NTSC	National Television System Committee
PAL	Phase Alternating Line

## 1 Introduction

Nowadays most of the technical devices have the provision of connection to the internet. In this situation nobody will be astonished of the fact that TVs can also be connected to the internet. The availability of numerous applications with an internet connection has made people's life easier, standard and smart which is why an internet-enabled TV is called Smart TV. In general, Smart TV is much more interactive than a normal TV and can be called an improved version of TV.

Also, it has become an integral part of human lives. Nobody in today's world is unaware of Smart TV applications because viewers have more options to choose as applications with different categories have provided a wide range of entertainment. In addition to this, the availability of making one's own application and publishing it in an application store has made users explore their own creation which means a user can be a developer as well. Even though there are plenty of applications available in Smart TV stores, users are allowed to create their own applications and publish them in Smart TV stores. This enables any user to be a developer and get revenue by selling his/her applications.

During the process of development of a Smart TV application, testing is very essential. Testing is done to determine the problems and errors occurring during and after the development. The errors occurred should be fixed before actually publishing the application in an application store. It assures the effective performance and quality of the application. So, to test a Smart TV application, a testing platform is needed. Thus, this thesis addresses testing platforms for Smart TV applications.

This project was executed as a Bachelor's final year project for Metropolia University of Applied Sciences. The thesis deals with the history of television and its increasing interactivity in the following years. Along with that the project consequently describes TV and its applications, giving information about technologies behind them. Finally, this thesis explores the possibility of testing the Smart TV applications before actually publishing them in a TV store. Overall, the thesis analyses the whole process of testing an application in two different testing platforms: Opera TV Store and Samsung TV Store.

## 2 Theoretical Background

### 2.1 Brief History of Television

Television is one of those technologies that have been on public demand since its invention. Almost every human being is aware of the existence of television. It is considered as one of the most popular media. It is delivered to almost every household. It provides entertainment and most importantly major happenings all around the world. It can be called a window to the world. It has made the world small by updating each and every individual of every corner of the world. The invention of television is the biggest achievement in the history of mankind.

#### 2.1.1 The Early Concept

The word “television” does not have a single inventor. The hard work of multiple scientists from all over the world has led to one of the greatest attainments in the history. The concept of television really started from the idea of transmitting pictures or objects onto a screen which was already known in the 1830’s. Scientists all over the world were working and experimenting on it. The theory of transmitting pictures to screen already existed but no one was able to put it into practice. After a series of experiments, finally in 1884, a rotating disk with a series of spiral holes was made. When a beam of light was passed through the holes, the light would transmit a line of image to the other side. When the disk was rotated, the entire picture was scanned combining the line of images in total. Unfortunately, this way of scanning pictures could not be experimented further because of lack of resources at that time. Later from 1923 till 1926, this idea was taken into account to test the first practical mechanical television system. [2.]

In 1926, the mission of transmitting moving pictures through the mechanical disk was successful and the first TV studio had been built. The first mechanical TV sets were sold to public. [1.] Even though it was a great success, the mechanical TV could not get much attention because of the poor picture quality. At that time, TV broadcasting could be done long distance but the poor resolution and fadedness of the pictures failed to make an impression in TV development. Thus, all the mechanical television systems were replaced by an electronic television system. [2.]

For the electronic television system, Cathode Ray Tube Technology (CRT) was used. Taking the idea of transmitting moving pictures onto screen, the cathode ray tube was developed in 1897. CRT is the vacuum tube that forms an image when an electron beam strikes on the surface. The vacuum tube is made up of glass and air is withdrawn to make it vacuum. The other end of the tube contains a flat screen coated with phosphor. The tube is heated and when the stream of electrons passes through the vacuum tube in high speed, it hits the phosphor screen which glows and forms an image. The CRT tube was used to produce television images in 1907. The use of the cathode ray tube for the electronic television system had a great potential but it was not taken into action until 1927. In 1927, a working model of electronic television was demonstrated. Thus, the birth of the world's first electronic television system happened through Cathode Ray Tube Technology. [2; 3.]

### 2.1.2 The Early Development

The early mechanical television was quite unsophisticated. The screen was the size of a dollar coin which means only one person could be seen at a time. This made it very tough for the actors because they had to take turns to be in front of the camera. Mechanical televisions were soon replaced by electronic televisions which were much bigger and better, solving the problem of smaller screen. The screens were 12 inch and 14 inch. However, the picture quality was still not so good. The color was black and white and actors had to use heavy makeup to be visible on the screen. In addition to this, cameras had some kind of problem with the color white so actors had to use black lipstick or green make-up and had to sit under hot lights just to look good in front of camera. [4; 5.]

The growth of TV development had just begun; World War II disrupted the rate of progress. Nevertheless, after World War II, the new era of commercial television began. By 1949, 44,000 households in the United States owned a television set. People could watch programs such as comedies, dramas, games and speeches. Cable television was introduced in 1948 in order to introduce the television in rural areas. The first remote control with a wire was also invented in 1956. Thus the evolution of television kept continuing. [4.]

In mid-1900s three color video encoding systems in television were developed which were NTSC, PAL and SECAM. NTSC which stands for National Television System committee was first released in the early 1960's in the USA. It contains 525 lines of resolution per frame at 30 frames per second with 60 Hz field frequency and with 4.2 MHz video bandwidth. Firstly, the NTSC system did not enable color transmission but when color was encoded in it, it became the first color TV broadcast system. Hence, it became the official analog video in the USA, Canada and other parts of America. Slowly, NTSC started getting popular in some other Asian countries as well. [6.]

Similarly, PAL stands for Phase Alternating Line which was developed in 1967 in Germany and the UK. It contains 625 lines of resolution per frame at 25 frames per second with 50 Hz field of frequency and 5.0 MHz video bandwidth. With the increment in video bandwidth, PAL came with the better color consistency and better picture quality. It slowly became popular in the UK, Germany, Spain and many other countries.

The third system SECAM stands for Sequential Color with Memory. It was developed in France in 1967. SECAM is almost the same as PAL but it transmits the color information differently compared to PAL and NTSC. Countries like France and Russia and many other countries from the Middle East and Eastern Europe started using the SECAM video format. As the years passed by, PAL became the most dominant among the three systems whereas SECAM was the second most popular. These three color encoded video standards were not compatible with each other but the conversion between them was possible. This development of television color video formats in the world took the television technology into another level of achievement. [6.]

Furthermore, the discovery of the video cassette recorder (VCR) in the 1980's created another landmark in the development of the features of TVs. Now, viewers could actually record their favorite shows or replay their programs so that they could watch them in their leisure time. Also, they could watch movies at home. Video games were also accessible. Direct-broadcast satellite television was introduced and the number of channels grew. Cable technologies were improved and they were much more sophisticated. There were numerous shows related to drama, comedy, education, news, and knowledge. Television was offered a wide range of entertainment. [4.]



Similarly, in 1984, CRT monitors were introduced by IBM. CRT monitors are the monitors based on Cathode Ray Tube Technology. First, CRT monitors came had 640 x 350 pixels with an enhanced colors graphics adaptor with 16 colors but they were very heavy and bulky. In the 1990's television screens were wider and bigger, being up to 40 inches. DVD players were also another improved technology compared to VCRs. They got a higher resolution and good picture quality. NTSC, PAL and SECAM DVD players used many signal connection ports like SCART, S-video, Coaxial RF, component video and composite video to get connection to TV. Thus, television became more portable with less weight. Along with that, there was nothing in the world that viewers were not able to watch. Television became a part of family and within a room, viewers got the feeling of a world tour. The increasing popularity of television led inventors innovate further and made television a daily usable media. [7.]

### 2.1.3 TV Screens

By 2000, Television sets got flatter screens like flat panel LCD, LED and plasma TV. LCD displays are one of the most popular displays. They occupy less space and are very lightweight. The most important thing is that they consume little power. Liquid crystals used in LCD do not emit light directly and they are manipulated to change the way of interacting with light. They are placed in the middle of two polarizers. They are twisted at 90 degrees with the surface. Crystals allow light to pass through the polarizer. But after applying a voltage to crystals, they block the light passing through the polarizer. The display controller is responsible for electric signals to the crystals and back light. The display controller plays its role by starting back light that passes through the first piece of the glass of crystal and also sends electric current to molecules of liquid crystal for aligning and allowing the changing level of light to pass through the second piece of glass which forms a picture on the screen with the black and white combination. In colored monitors, there are three liquid crystal cell with red, green and blue filters. After the light passes through, the filtered screen forms the color that appears in the monitor. Backlight consists of cathode and it is used according to the quality of monitors. Thus the technology behind LCD displays is formed. [8.]

The LED display system is the latest display system in the market. It consumes less power than LCD does and is slightly thinner than LCD. Their technology is quite similar to LCD display systems. The only difference in LED is that there is no backlight, which means the backlight in LCDs is replaced by diodes. LED monitors are LCD monitors with diodes. LED monitors are categorized into three types according to the arrangement of diodes in the monitors. Thus, diodes make the contrast and black level of LED screens better than LCD screens which proves that liquid crystals are unable to stop all backlight from a cathode and do not make black screen completely black in the monitor. [9.]

The plasma display system is another technology which consists of small pixel sized cells containing ionized gas. Each pixel has three fluorescent lamps, red, green and blue. Plasma is a gas with free flowing of electrons and ions. When electric current flows in plasma, gas atoms in the plasma are excited due to flow of charged particles and then they release the energy as photons of light. When the photons of light strike through the wall of three fluorescent lamps, the light is emitted and forms a desired picture on the screen. Plasma screens are for larger screens because the picture can be viewed from any angle. [10.]

## 2.2 History of TV Interactivity

Interactivity always means the ability of interacting with anything. While relating with the TV interactivity, the back and forth flow of information attracts users and makes users more enthusiastic, and curious about how the device responds after the action of a user. [11.] Undoubtedly, the interaction of TV has increased: people used to watch broadcasters' choices on television but now users can make their own choices.

### 2.2.1 User's Time on TV

Even though the interactivity of TV has increased, users are more attracted to the interactive features of mobile devices. The users switch on their mobile devices more often than their TV sets. [12.] This indicates that TV has not been as interactive as mobile devices.

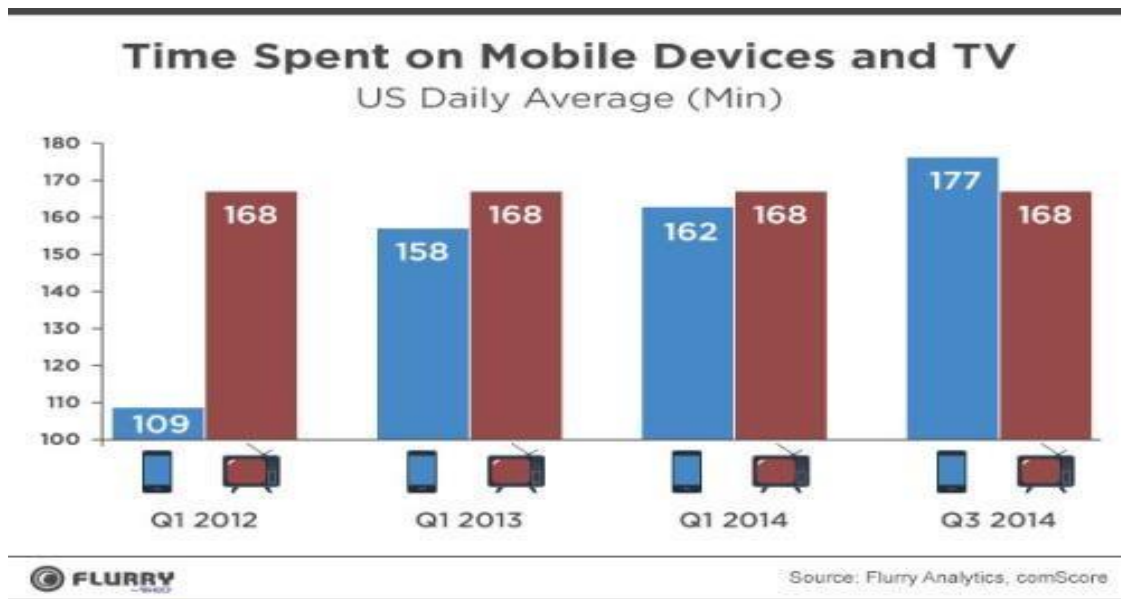


Figure 1: The time spent on mobile devices and TV. Reprinted from Simon (2014) [12].

As the graph indicates between 2012 and 2014, the time spent watching TV stayed constant whereas the time spent using mobile devices increased drastically. Despite the fact that the popularity of mobile devices is increasing day by day, the TV still exists. It is very fascinating to know that even though there are so many interactive technologies in the market, people have not stopped spending their time on TV. [12.]

Therefore, before users completely stop watching TV, the TV should be made as interactive as possible. To make the TV as interactive as possible, the TV should also be implemented with the interactive features like mobile devices are implemented. Hence, in order to fulfill what user wants and to attract them, televisions are being made more interactive so that users get satisfaction to the fullest level.

### 2.2.2 Multimedia Home Platform

In the early time of 2000s, the concept of connecting middleware to digital TV for interactive features was slowly arising. That made the world attracted to technology named Multimedia Home Platform. Multimedia Home Platform is often abbreviated as MHP. It is a middleware system that has numerous interactive TV applications which are designed to connect to digital TV in order to execute the interactivity. [13.]

MHP is developed by the DVB (Digital Video Broadcasting) project and it was first released in 2000 by ETSI (European Telecommunication Standards Institute). MHP-DVB functions through cable, fiber-optic and media. The idea is to combine the digital TV with World Wide Web and the internet. The result of it is the most interactive TV with various interactive Java-based applications. MHP uses the application model defined by Java TV. MHP applications can be written in Java or HTML. Java is by far the most common one. It is an open standardized middleware solution that uses Java API for many features like control of video and audio, communicating with remote servers, drawing objects on the screen, and accessing service information. The most common applications of MHP are interactive shows like online quizzes, online voting and text based information services like news reading. Games, T-commerce and banking are also the most preferred ones. [13.]

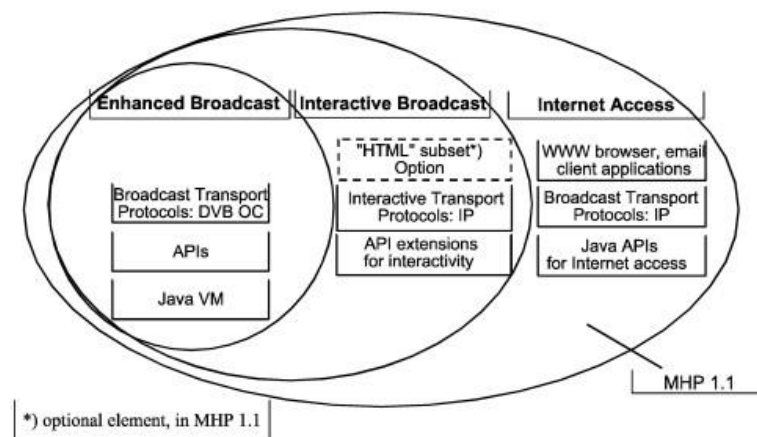


Figure 2: Different profiles of MHP. Reprinted from Jon (2006) [14].

The three services in MHP are illustrated in figure 2 and they are: enhanced broadcast, interactive broadcast and internet access. Enhanced broadcast broadcasts the applications that interact within a user but there is no communication between the receiver and the broadcaster. Interactive broadcast broadcasts the applications that give the possibility of communication between the receiver and the broadcaster. Online quizzes are an example of interactive broadcasts. Internet access contains applications that need the internet to use the applications. Online gaming is a good example. It uses Java API for the internet access.

As MHP is a DVB standard, it works in all DVB transmission technologies. If MHP is used within the DVB network, it is good. However, if it is out of the DVB network, it is not so good. Therefore, some of the DVB features were taken out and they were introduced

and named as GEM. GEM is the Globally Executable MHP. GEM can also be used by non-DVB systems which means GEM applications are easily portable to other middleware platforms. Later, in a few years of these multimedia home platform started to become extinct slowly when SET-TOP-BOXES (STB) were introduced in the market. STB displays the output when connected to a TV set and the output can be from an external source of signals such as video, audio, interactive video games, and internet web pages. The high use of STB left MHP behind in the market. MHP was abandoned by many manufactures and the further development was stopped. But GEM is still used in various huge companies like ATSC, ARIB, CABLELABS, and Blu-ray Disc Association. GEM is slowly evolving and it is becoming a platform for interactive TV applications. [13.]

### 2.2.3 The New Way of Interaction

The way of watching television has been changing over the last decades. Nowadays, people not only watch TV but they also use it for multiple purposes. TV experience used to be one-sided. The availability of programs according to the schedules would make people wait passively. The television was considered as a medium of spending time and relaxing with family and friends but now it is completely opposite of it. People do not want to wait passively in front of a regular flow of pictures. They want to watch their favorite programs whenever they like. They are obsessed with the boredom of just sitting and changing the channels using a remote control. Users are becoming more active as they want to broaden their mind and also save their time by doing multiple tasks. Instead of just sitting and watching, users prefer to use a second screen which is getting common day by day.

#### Second Screen

The second screen is any other second monitor used by television viewers while they are watching TV. Often, second screens are either Smartphones or tablets. There have been several speculations that most of the TV viewers use second screen to get rid of their boredom or to kill the time in the commercial breaks between their favorite shows. But that might not be true in all cases. The use of a second screen might depend on the necessity of certain information while using TV. For example, to connect more to a program in the normal TV, users might use second screen to follow the news and events of that specific program. Suppose, if a user could not understand a term or phrase in a movie, he/she can use a second screen to search for it and know

what the scene is about so that he/she will not miss any interesting facts. Also, users might want to check the schedules of a particular TV show. A second screen can be used in this case. Whether it is a TV show, or game or something else, second screen enables users to interact more with TV. [15.]

Not only while using normal TV, second screen can also be used while using Smart TV. For example, while playing quiz games, users might want to search for the answers and they can go for a second device. Likewise, it is impossible to use two different apps on the same screen so a second screen helps users to use another app while using a Smart TV app. Suppose a user cannot use Facebook and watch live videos on the same screen on TV. So, while watching a live broadcast on TV, users can use Facebook or check email on a second screen. Unlike in the 1990's, TV users nowadays do multiple tasks, and they just do not want to do only one task. So users are getting accustomed to the phenomenon of using a second screen, which has made the demand of Smart phones and tablets grow bigger and bigger.

### Control Devices

In order to attract users towards television, television has become interactive with the availability of internet connection. TV has transformed from passive into active experience. In the past decades, there used to be only one remote control to interact with TV but nowadays there are several controls to communicate with TV. The control devices discussed below are used while interacting with television.

- Remote Control

Remote control is the first native control of television. It has been used since the 1960s. Instead of using the television button, the remote control was introduced so that people could change the channels just by sitting on the couch. A remote control with wires was introduced in the beginning but nowadays wireless remote controls are found. Another new feature is that TVs does not have buttons anymore, and remote controls are used to interact with TV. TV functions according to the remote which enables the users to interact with TV. Almost every functions of TV can be controlled by the remote control for example on/off, changing channels, and changing the settings.

- Voice Control

Voice control lets users control the TV with their voice command. This control has already been introduced in Smart TVs recently. This availability in Smart TVs has made users interact with televisions without using a remote control. This control can be used for example for changing channels, turning the television on/off, changing volume, and opening apps. Thus, by just saying the name of the service, users can fully enjoy the new interaction of television. [16.]

Voice control in TV has not been utilized by users fully because it is not available in all languages and it is available only in a few locations. As it is a voice recognition feature, the pronunciation and dialects really influence the performance of the television. Besides all the inaccuracy of this feature, this feature of Smart TV is getting improved and hopefully every user will be able to enjoy it in the future.

- Motion or Gesture Control

Motion and gesture control is the sophisticated new control of Smart TV. This control has the ability to control TV by following the user's gestures. There are available lists of hand gestures according to the brand of Smart TVs and users can follow these gestures. These gestures can be zooming or rotating images. This motion control provides more fun and more interactivity to the users. [16.]

- Magic Motion Remote Control

Magic motion remote controls are similar to the wireless remote control but they contain a wheeler and a pointer that work as mouse. Magic Motion Remote controls are made for Smart TV for accessing the apps and browsing the web. A remote control with buttons is a little bit slow while moving the cursor and selecting the programs needed. Also, using apps with a remote control is very hard especially in text-based applications while sharing and commenting. Recently, speech control and gesture control have been added in magic motion remote controls for voice recognition and motion control. [17.]

- Wireless Mouse and Keyboard

TV can be connected to wireless mouse and keyboard so that users are able to use TV just like using a computer. The wireless mouse and keyboard enable users to use interactive apps and surf the internet effortlessly.



### 3. Smart TV

Smart TV was originally called “Connected TV”. In simple words, it is a TV that has the ability to connect to the internet either wirelessly or via an Ethernet cable. It has facilities of a normal computer but on a television screen. It contains thousands of applications which one can use it only when connected to the internet. It is like a feeling of using Smartphone applications on a much bigger screen in much more interactive way. It has got advanced computing ability which a normal TV does not. TV. Users have a lot more to do and watch than a regular available set of channels. People no longer have to wait or separate their time to watch programs when they are broadcast. They can easily surf the internet and also they can record programs within their TV. Viewers can play video files and music and watch family photos on high definition TV screen. Also, they no longer have to attach other video game devices to play games; in fact, they can find applications on the TV stores. Simply, TV with internet gives access to more quality programs on demand. Smart TV has proved to be a new generation of Television.

The first Smart TV related patent was built in 1994, and since then Smart TV has been developed and innovated further with more interactive features and brought into market in 2010. Today, it is the most dominant television. [18.] Smart TV runs a complete Operating system that provides a platform to develop application for developers. This Operating system has a software development kit (SDK) so that even viewers themselves can develop applications for it. This Operating system contains lot of applications. Users can choose any apps and install them directly in their television menu. Apps with different categories are found such as movies, games, social networking, education, weather, music, news, maps etc. Availability of numerous applications is the first benefit of Smart TV.

Furthermore, Web browsing is the second benefit that allows users to surf the internet and visit webpages, watch images and videos on a big high definition screen. Along with this, various functionalities of Smart TV has made users believe that it has computer-like features. Like computers, it also has peripheral inputs like USB, HDMI or DVI and memory card slots. Not only this but it also has PVR/DVR functionality which means that it is possible to record and list the shows without using other device. It contains pairing functionality like sharing media straight from a camera or phone. The ability to connect with Smart phones, game consoles, Blu-ray players and other digital



media players is also available in Smart TV. Control devices like gesture and voice control, face recognition and Smart touch pad control in Smart TV has made users' life easy. Likewise, picture quality is full HD 1080p which gives the sharp contrast and crisp quality that gives human eye relaxing capability like in cinemas. [18.]

### 3.1 Smart TV Applications

Apps found in the stores are the best assets of Smart TV. As TV is taken as a source of entertainment, most of the apps found in it also are related to the entertainment world. Numerous kinds of apps are implemented in a Smart TV Operating system where users can decide and install the apps they like. Some of the apps are unlimited whereas some are limited and users should pay to enjoy their more functionalities.

#### 3.1.1 Top Rated Apps

Applications with different categories are found in Smart TV store. The categories are Movies and TV shows, social networking, games, video, music, maps, online stores, sports and news.

Table 1. Some of the top rated TV applications found on every Smart TV. Data gathered from Chandra (2013) [19], Steve (2010) [20].

Categories	Applications	Uses
Movies and TV Shows	Netflix, Hulu Plus, HBO GO, Amazon Instant, ITVPLAYER, 4oD	Watching TV shows, movies, clips and documentaries
Social Networking	Facebook, Twitter, Skype	Messaging, posting videos, sharing, commenting and video calling
Games	Angry Birds, Blackjack	Playing games online and challenging friends

Video	YouTube	Commenting and sharing videos and channels
Music	Spotify, Pandora	Various music
Maps	Google Maps	Street views, maps
Store	eBay	Shopping and paying online
Sports	NBC Sport, BBCSPORT	Sports events and news
News	BBC News, CNBC, CNN	World-wide news

Table 1 indicates that there are numerous Smart TV applications. The demand of these applications is multiplied according to the functionalities found in them. In the movies and TV shows category, people like to use Netflix, Hulu Plus, HBO GO, Amazon Instant, ITVPLAYER, and 4oD because they stream thousands of TV shows, movie clips and documentaries. In social networking, Facebook and Twitter are the most liked text type apps whereas Skype is the best rated for video calls with friends and family. Nowadays, several important professional events like job interviews, office work presentations, and seminars are done in skype. [21.]

Moreover, Angry Birds and Blackjack are the most liked games for playing with friends online and challenging them. Similar to this, YouTube is the most rated app in the videos category simply because of streaming of thousands of videos and channels with the availability of commenting and sharing. It is a must have Smart TV app. In the music category, Spotify and Pandora are rated best for provision of varied music based on artists and genre. Likewise, Google Maps is the first-rated for street views and maps. eBay is known for shopping and paying online where the products are shipped to the buyer's destination. In the sports category, NBC sport and BBCSPORT are the most rated for sport news and events. Lastly, for worldwide news, apps like BBC News, CNBC and CNN are the top rated ones. [19; 20.]

### 3.1.2 Popular Apps

The rise of Smart TV depends on the rise of popularity of Smart TV apps. The apps are the assets of Smart TV. These assets have changed the viewer's way of using TVs in the living room. These assets are used by the users in daily basis. The users mainly prefer to use apps related to social networking, news feed and music. [22]

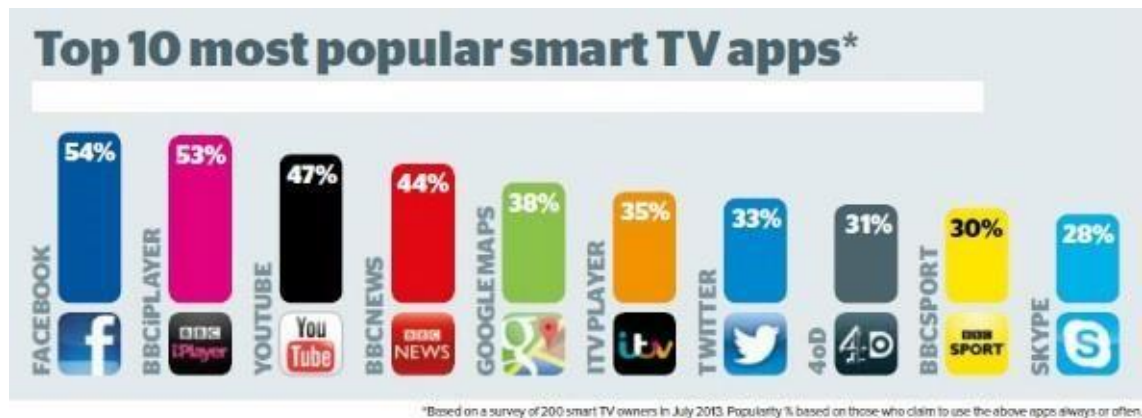


Figure 3: The most popular apps based on survey of 200 Smart TV owners. Modified from Andrew (2013) [22].

The figure above shows which apps are the most popular ones according to a survey of 200 Smart TV owners in July 2013. This research is based on users who often use the apps listed in figure 3. According to the survey respondents, Facebook is the most used app; 54% of 200 users use the Facebook app. Along with Facebook, BBCIPLAYER has taken the second position with 53%. Although YouTube is always the choice of Smart TV users, YouTube has become the third in this survey. YouTube is followed by BBCNEWS with 44%. After BBC news, Google maps has taken the fifth position with 38%. With few percentage down, ITV Player, Twitter and 4oD have 35%, 33% and 31% respectively. Finally Skype is the tenth popular app used by 28% users in Smart TV. [22.]

### 3.2 Technologies behind the Apps

The technologies which are used to develop the Smart TV apps are HTML5, CSS3 and JavaScript. HTML5 is known as Hypertext Markup language and it is the fifth and the latest version which is the most improved version with the most interesting new elements. It is used to specify the content and structure of web elements. CSS3 is the third version of Cascading Style Sheets and it is used for specifying the presentation of

web elements. Similarly, JavaScript is the standardized programming language that is used to specify the behavior of each web element.

In today's world, all web based environments are used through various devices like mobile phones, tablets, Smart TVs and these devices all support HTML5, CSS3 and JavaScript. This proves the demand of these three components in the market. They are the most essential technologies of the World Wide Web which is why all major browsers support them. They work together to make the most organized and logical code ever. Most importantly, they result in the best working environment with the most responsive design and unbelievable interactivity. They provide functionality which was not even considered a few years ago. They are the best technologies for developing Smart TV apps. After all, they implement all the functionalities required for a Smart TV app. [23, 17.]

HTML5 does the structuring of a page. Even without JavaScript it is possible to code pages by using HTML5 only but that will lack a lot of excitement and interactivity. JavaScript adds a compliment to the environment with making the pages jump. JavaScript can do many things from jumping pages to doing serious calculations. Like all programming languages, JavaScript handles coding techniques like loops, conditional branching and many more. Therefore, it is essential to have JavaScript in order to make a Smart TV app static. Likewise, CSS3 is the accessory that provides a polished look which makes the visuals pretty. The excellent use of CSS3 and JavaScript with HTML5 will wow the audiences with the result of proficient Smart TV app. [23, 37.]

### 3.3 Development of an App

Smart TV has been able to entertain and maintain people's life in various ways. Not only that but also the availability of making one's own app and publishing it in an app store has made users explore their own ability of enjoying their own creation. Although there are plenty of apps available in Smart TV stores, users are allowed to try to make their own apps and publish them into a Smart TV store. A user can be a developer, and being a developer, he/she can get benefit from apps by starting doing their own business from them. Thus, the developer cannot only enjoy their own app but they can also get revenue from it by selling his/her app in the TV store.

### 3.3.1 Design Specifications for Building an App

Developing an app for Smart TVs should be taken seriously and all the requirements should be fulfilled completely; otherwise, the developer might fail gaining the goal of his/her app. Some design requirements should be taken into account for building an app for all kinds of Smart TV stores and they are user distance, responsiveness, navigations and controls, simplicity, text, and privacy. [24; 25.]

- User Distance

The user interface of the TV is totally different while comparing to other devices like desktops, laptops, mobile devices and tablets. Therefore, the design created for other devices are not expected to work well on TV interface. [25.]

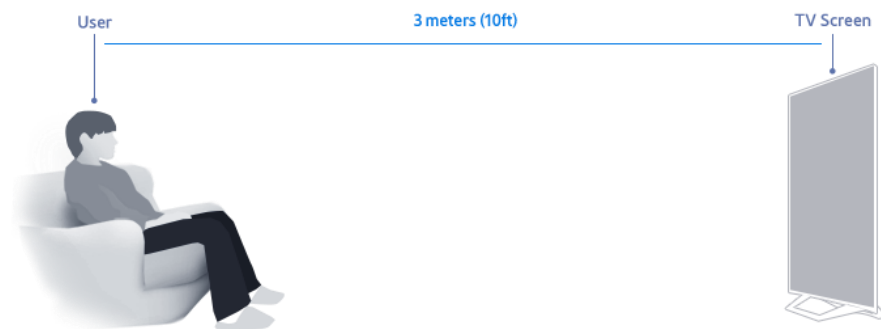


Figure 4: TV watching distance. Reprinted from Samsung (2014) [24].

It can be clearly seen from the figure 4 that the approximate distance from a user to TV is 3 meters. So the design of the application should be done in such a way that it is interactive even after using the app from 3 meters away. As the TV screen is bigger, there should be many considerations so that applications are usable on a bigger screen. All application elements should be made bigger than those elements used on computers and mobile devices. Text size and font should be made bigger and clear. Text spacing should be made bigger. There should be more empty space between the application elements. The highlight of the items selected should be pretty clear and visible so that the user does not need to spend time looking for them. The background color of the app should be made suitable for making the application design clear and observable. [24; 25.]

- Responsiveness

It can be said that TV remote controls are not that responsive. So the TV applications should respond in every detailed way. The reaction of the action done by the user should be very attractive and interesting. For example, use of sound and animation or showing the indication signs of process might attract more users. But the sound should not annoy the user, it should be used in a systematic and gentle way. And the animation should be used smoothly so that it would not ruin the mood of the users. Also, there should be a confirmation of where the application is going through while loading because the users should know where the application is heading towards. The application should respond to the users in a very subtle way so that users do not get confused and annoyed. [25.]

- Navigations and Controls

Using remote control is the most common way to interact with a TV. So, the interaction has to be able to work with remote control. The remote controller consists of four key navigations Right, Left, Up and Down. They actually should work properly while using an app.

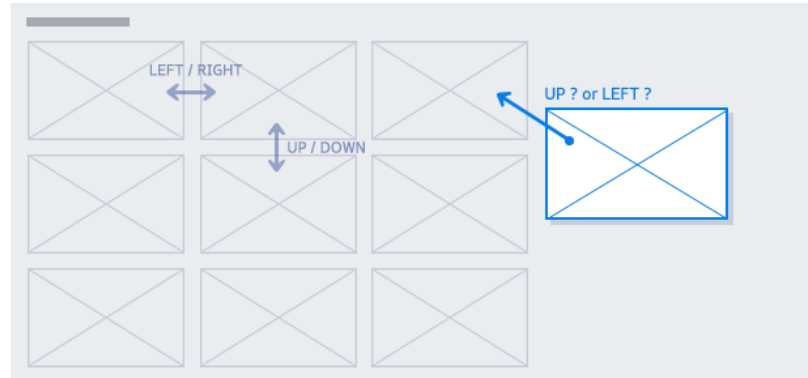


Figure 5: Confusion for diagonal navigation. Reprinted from Samsung (2014) [24].

In the figure above, the views are placed diagonally. The user might get confused what button to press to go diagonally. [24.]

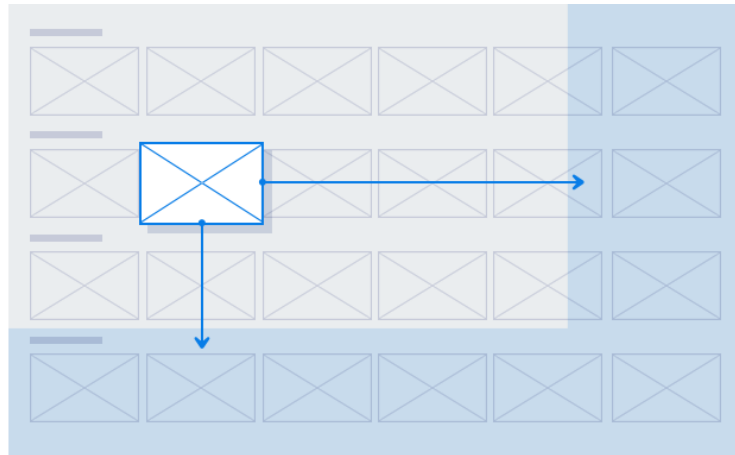


Figure 6: Flat-navigation. Reprinted from Samsung (2014) [24].

This figure is the best example for navigating between the categories and also choosing the content list. For example Up and Down will change the categories whereas left and right will change the content inside the selected category. [24.]

- Simplicity

No matter how the world is changing, users still love simple. Simplicity is the best policy. The application should be very simple to use, and the layouts should not be made complicated to confuse users. The users should understand the app immediately when they open the app so that there is no necessity to use a guide to use the app. This means that going through many levels of the app should be very easy and simple. Along with functions, the look of the app should also be simple because the use of too many colors will lead to the confusion of users while using the application. [24; 25.]

- Text

TVs are basically used by remote control and entering text with a remote control would be very hard. So, developers should avoid the text input. Even though the TV can be connected to a keyboard, every user might not own a keyboard. Therefore, the developers should consider the most common way of using the TV and develop their application in such a way that the more users do not encounter problems while enjoying the app. [25.]

- Privacy

TV is not just watched by a single person. TV is a social device that can be watched by more than one person at a time and it is not possible to hide things on a big screen. In this situation, a user might not want to give his/her personal information especially when it comes to credit card numbers or passwords. To solve this privacy problem, developers can allow users to create another version of an account that can be linked only to the TV application so that it is not an issue to share usual personal information. Along with that, developers should allow users to browse their history and also to clear it easily just to make sure there are no privacy problems. [25.]

### 3.4 Why Testing is Needed

Testing is the process of checking the developed application to ensure the application functions as well as it is supposed to. It is done to recognize the result of the application and fix the errors if it has any. This is done to determine the problems and errors that occurred in the application and fix them before actually releasing it to the public. This indicates that testing also saves time and money because time spent on solving and fixing errors is much more costly than the cost of testing. Thus, testing is the most important phase while developing any application. It helps to fix the bugs and issues during the development of a product. It assures the effective performance and quality of the application.

Furthermore, there are numerous Operating systems nowadays. In this case, a developer needs to be confirmed that his/her application should be able to work in every Operating systems. For this reason, testing should be done so that users using different Operating system can enjoy the application without any bugs and errors. That is the reason why the testing of the TV app is very essential before publishing it in the Smart TV store so that it will not crash which would result in complete waste of time and money.

In addition to this, user experience is the most important factor in any application. Applications are made for users. If they are not suitable for users, then the whole effort in developing an application is ruined. So, testing is very essential in the development of an application.



## 4 Testing Platforms

In order to test the TV applications, a testing platform is needed. This chapter describes two testing platforms to test. They are Opera TV Store and Samsung TV Store.

### 4.1 Opera TV Store

It is an HTML5-based platform that has numerous applications for TV. Users have the facilities of choosing the applications and adding them to their dashboard. Applications in the Opera TV store are presented as static thumbnail images. Once the applications are clicked, they appear in the full screen mode. In addition to this, developers can share and submit their apps in the Opera TV Store. Developers also can earn some revenue from their application and advertisements they publish in Opera TV store. It is available only on certain devices in the market. It is available in Sony Bravia TV's like 2012, 2013 and 2014 models. Also, it is available in Blu-ray Disc Players like the 2012, 2013, 2014 models of Sony Blu-ray Disc Players and in 2012, 2014, 2015 models of the Samsung Blu-ray disc players. Not only this, but Opera TV Store is also available in TiVo. [26.]

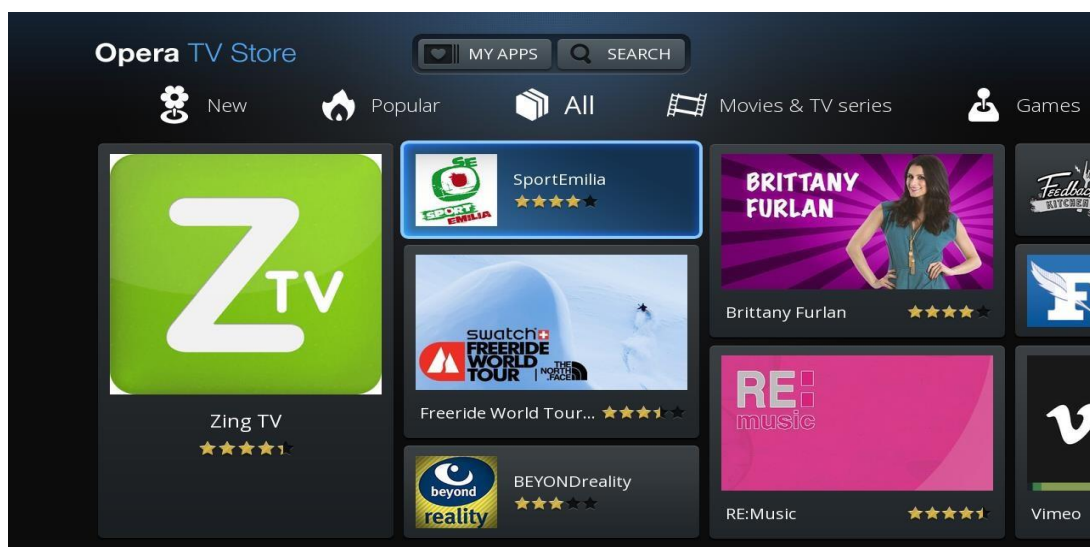


Figure 7: Dashboard of Opera TV Store from emulator. Screenshot.

Figure 7 shows that Opera TV Store contains apps of different popular categories like music, social networking, news and information, games etc. MY apps includes all the apps chosen by a user. New contains newly released apps whereas Popular contains

the most popular apps. Similarly other categories are Games, Movies & TV series, Internet TV, Music and News & Information. The architecture of Opera TV Store is such that the dashboard runs from the Opera TV portal servers and when the application is chosen, it appears as a full screen. At last when the application is finally opened, it runs from the other server that stores the actual application. Opera TV Store itself is not a host of the applications but it is a directory with the references to the actual URL of the applications.

Opera TV SDK is not available for download, instead users are allowed to experiment their application and submit it. As Opera TV Store is HTML5 based, the technologies used are HTML5, JavaScript and CSS3. In order to test the application in Opera TV Store, the application should be built with certain considerations so that the application functions properly in Opera TV Store. The app should not require scrolling. If the app contains a long list of items, then other mechanisms should be used to avoid the scrolling. JavaScript methods like alert (), prompt () and confirm () are not supported in Opera TV Store applications. Opera TV applications also does not support Adobe Flash or any other third party plugins. Multimedia plugins like audio and video should be implemented by using HTML5 elements such as <canvas> or <audio> and <video>. Although the remote control has exit and return button, if an app requires a back or exit button in its user interface, the window.close () method should be used to close the application. [27.]

#### 4.1.1 Testing

The components needed for testing are an Opera account, an application and a device. To test an app, a developer should have an Opera's developer's account so that information is private and saved in Opera. For saving an application on an Opera account, an HTML5-based application is needed. Likewise, to test that particular application, a real device is needed in which Opera TV Store is loaded.

Firstly, to test the app, it should be saved to the Opera TV submission portal. To save the app, a developer should be logged in first with Opera's developers' account. The submission portal contains a compulsory and strict form that needs to be filled. Most importantly, the URL of the application should be correct. Otherwise the application will not open in the Opera TV Store. When all the information is filled in, the app should

be saved but not submitted. The submit button directly submits the app into Opera TV Store whereas the save button will save the app in the submission portal. The reason behind this is to test the app before actually submitting it to the TV Store.

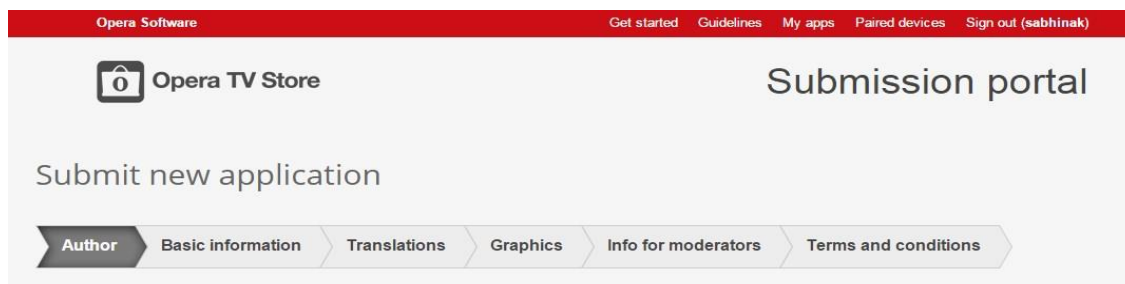


Figure 8. The process of submitting an application to the Opera Submission portal. Screenshot.

The figure above shows that Opera submission portal contains six different tabs. The author tab includes the information of the author such as name, address, email, webpage and a contact number. The second tab basic information contains the TV application name, URL, category of app, support email and application type. It also contains a list of video formats used in the app that have to be chosen by the developer. In addition to this, basic information category also includes information about the market which the developer should choose for the app to be available. Similarly, translations tab includes the language of the app, and the title and description of the app that appears in the Opera TV Store. The graphics tab contains various sizes of the icon and thumbnail of the app that developers have to provide for every type of screen. Information for the moderators tab includes a detailed description for moderators in which the functionality of the app should be described and it should only be in English. And finally the terms and conditions contain the whole agreement and all the criteria between the developer and Opera that have to be accepted by the developer.

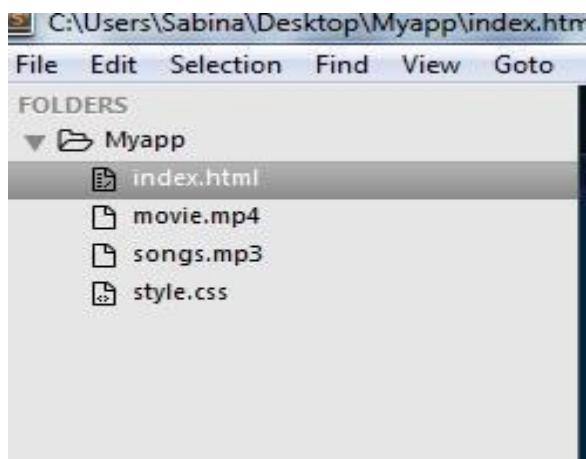


Figure 9. File structure of Myapp. Screenshot.

The figure above illustrates the file structure of Myapp. Myapp is an HTML5 based app that contains one video element and one audio element with their headings. It is kept in the lifestyle category. The purpose of using both multimedia elements was to figure out if both the audio and video element work properly. Another purpose was to find out whether the font size of the heading is big enough for every TV screen size. No styling was used, since the main focus for testing Myapp was its functionalities, not the look.

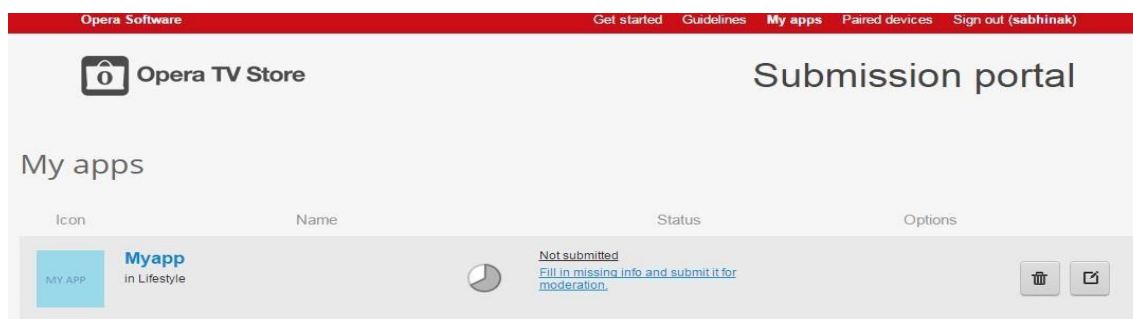


Figure 10. Myapp submitted in the Opera submission portal. Screenshot.

The figure above shows that Myapp was saved in the submission portal in the category of life style. The information about Myapp can be edited and also the saved app can be deleted from the submission portal. Once the app is saved in the submission portal, it should be paired with the device so that it can be opened in the Opera TV store. For this, the device ID for developers is needed and this is available in the Opera TV Store of the device. ID for developers is valid for only 15 minutes, but a new

one can be generated after 15 minutes is over. This ID should be entered in the submission portal paired device page and it sends a pairing request to the device. When the pairing request is accepted from the device, develop categories appears on the Opera TV Store and the testing application can be found in the develop section. In the develop section on the Opera TV Store, URLLoader can also be found. URLLoader is the loader that loads any application when given the URL of the application. But the advantage of testing the application by pairing to the submission portal rather than testing from the URLLoader is that it enables developers to check how the application behaves in the actual environment, what the icons look like, and what the description of the app looks like on the Opera TV Store.

The devices used in testing of Myapp are as follows:

- Opera TV Emulator version 3.4 and Virtual Oracle Box version 4.3.26
- Bluray Disc/DVD Player Sony BDP-S1200 connected with Samsung smart TV series 5

Opera TV Emulator is provided for free of cost by Opera Software and it can be downloaded from Opera's official webpage. It comes as a package with Oracle Virtual Box which means that the emulator runs in the virtual machine. It does not have the H.264 codec installed previously, but to view the media content, it should be installed when the emulator is running for the first time. The emulator can be used with a mouse and keyboard but it does not provide the same user experience as the remote control. So, to experience the use of a remote control, a web remote control can be accessed from the web interface, <http://localhost:5555>, and from any browser when the emulator is running.



Figure 11. The web remote to control the emulator. Screenshot.

The figure above shows that a web remote control was accessed from Opera browser with the URL, <http://localhost:5555>. The Opera TV emulator was used to open the Opera TV store and the navigation was done by using web remote control shown above. The idea of using a web remote control was just to get the real feel of a TV environment.

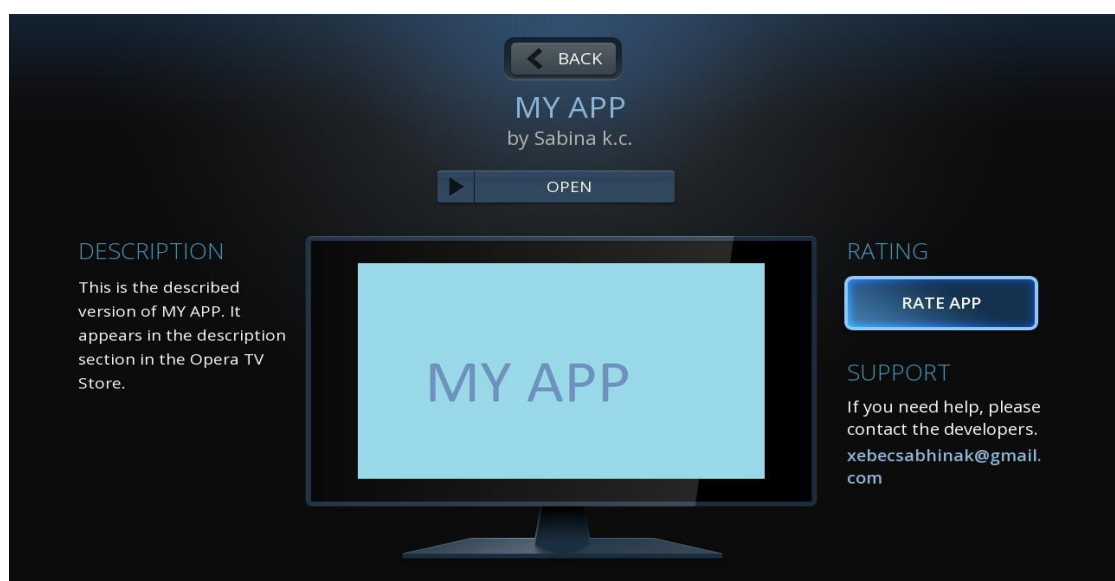


Figure 12. The look of Myapp with description and an icon in the Opera TV store in the emulator. Screenshot.

The figure above shows the screenshot of the first page of Myapp loaded in Opera TV emulator. The first look of the app shows that app can be rated and users can ask for support by emailing to the developer.

To ensure the functionality of an app, Myapp was also tested in an actual TV environment through the connection of Blu-ray Disc Player. The model of Blu-ray Disc Player was SONY BDP-S1200 which contains Opera TV Store. Blu-ray Disc/DVD Player consists of remote control, HDMI cable, Ethernet port, Coaxial Audio Digital Output and USB. It was connected with LED Samsung TV Series 5 with HDMI Cable. The internet was connected through the Ethernet port by an Ethernet cable. Navigation was done by the provided remote control of the DVD player. When the Opera TV Store is loaded, it is paired with the submission portal by getting ID for developers. Once it was paired, develop section appeared and MYAPP with its icon view was found. And Myapp was loaded. Hence, testing in Opera TV Store was completed.

#### 4.2 Samsung TV Store

Samsung TV Store is generally called SAMSUNG SMART HUB. It consists of all the applications which have, for example, the feature of surfing the web, downloading and installing, social networking, film and TV shows, music & videos, news and weather. The Samsung Smart Hub's applications are navigated by Left and Right keys of the remote whereas categories are navigated by the Up and Down key. Once the applications are clicked, they load directly to their home page.



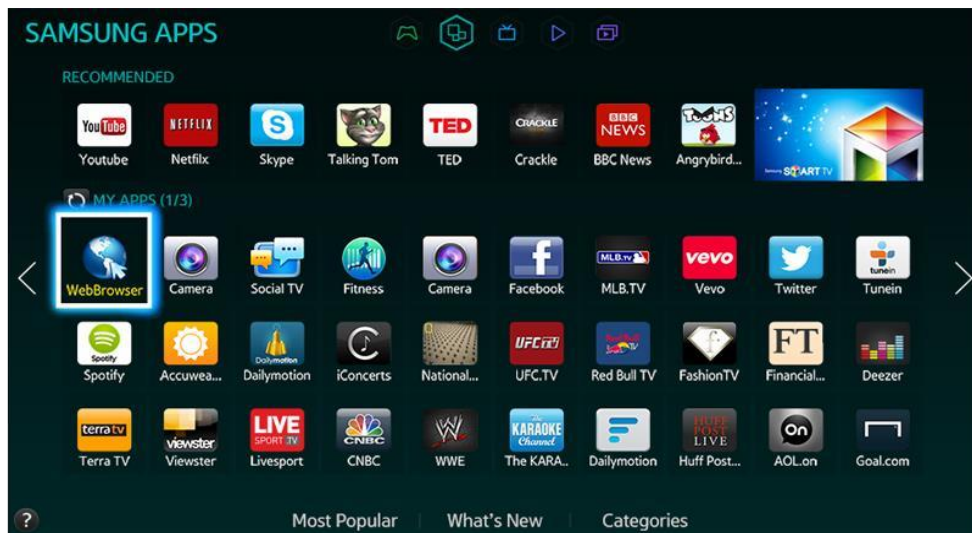


Figure 13. Samsung dashboard. Reprinted from Samsung (2014) [29].

Figure 13 shows that Samsung dashboard contains divisions like Recommended, My Apps, Most Popular, What's New and Categories. Recommended displays the apps that are recommended by Samsung to the users. My Apps contains the apps installed by the users whereas Most Popular contains the mostly used apps in Samsung TV Store. Correspondingly, What's new includes the newly released apps and Categories includes all the different categories found in TV store.

Samsung TV Store also provides a facility for developers to create their own applications and publish their apps. It provides Samsung smart SDK with simple platform APIs. It is an HTML5 and JavaScript based platform. And it supports three major resolutions: 960x540 pixels, 1280x720 pixels and 1920x1080 pixels [28]. Samsung Smart TV SDK is a development environment provided by Samsung Team in which developers can develop, run and test the applications. This package includes Smart TV Emulator, Eclipse, various plugins, readymade templates, debugger, Pretest tool, some installation guides.



#### 4.2.1 Testing

Testing in Samsung TV Store requires Samsung Account, Samsung Smart TV SDK, Apache server version 2.2.11 or any server, a device and most importantly an app. The Samsung Smart TV SDK version 5.1 and Java development kit (JDK) 8u40 are installed. A JavaScript project named Try is created in SDK. The name of the application is Try.

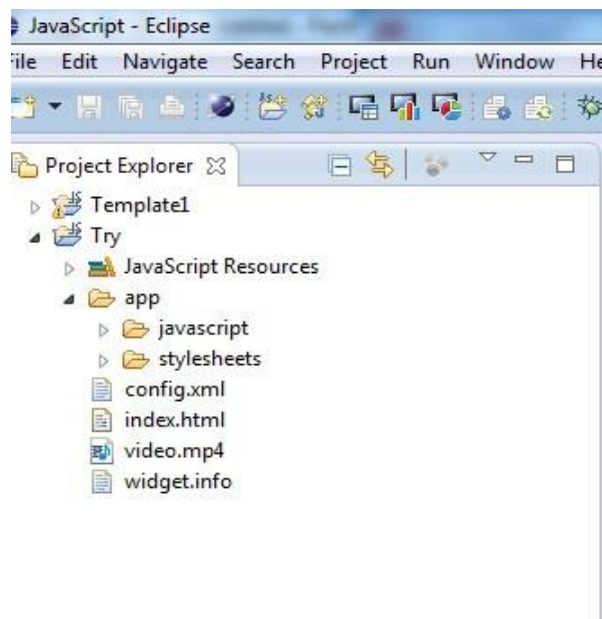


Figure 14. File structure of Try app in Eclipse. Screenshot.

The Try app shown in figure 14 contains one header, a paragraph and one video element. The devices used in testing the Try app are Samsung Smart TV Emulator version 5.1 and Samsung TV series 5 2013. In order to test, the emulator and TV should be configured.

- Configuring the Emulator

Firstly, the Samsung Smart TV SDK and Samsung Smart TV emulator are downloaded and installed together. The emulator needs a virtual machine to run through, so a virtual oracle box should also be downloaded and installed. When the Smart TV emulator is imported in the Virtual machine, the name of the emulator can be seen and that name should be given correctly into the system preferences of Smart TV

SDK. Similarly, the shared folders in the virtual machine manager of the emulator should be the same with the workspace of SDK inside the apps folder so that all the apps can be loaded. The workspace can be located anywhere as long as it is inside the folder named Apps, which will help the emulator to read the folder and load the apps without any disruption. Thus, any project that is created in the workspace can be run into Samsung TV emulator and it is possible to test its functionalities.

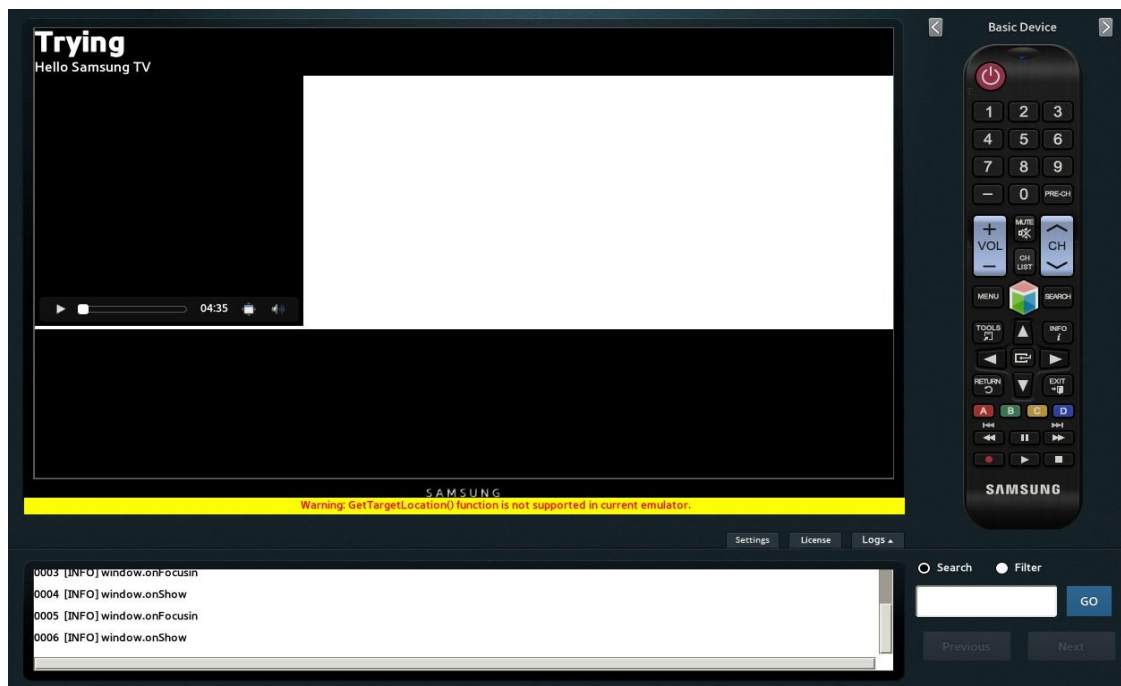


Figure 15. The Try app loaded in the emulator. Screenshot.

The figure above shows that the Try app was loaded in the Samsung Smart TV emulator. Virtual oracle Box version 4.3.26 was installed to run the emulator in Windows 7. Once the emulator was configured with Samsung TV SDK, the project was loaded in the emulator.

- Configuring the TV

To sync the app to TV, a server should be installed first. Developers are allowed to choose any server but the Apache server is the most recommended one. If the emulator is open, it should be closed first in order to configure SDK for TV. After this, in the preferences of SDK, the root folder of server should be changed to the server's directory folder where the documents can be accessed by a web server.

Once the app is ready, the config.xml file shown in figure no.14 should be edited by adding `<type>user</type>` between the `<widget>` and `</widget>` tags. This helps the TV to figure out that the application is a user application uploaded directly from PC to TV. Now, the app should be packaged in the server and this can be done by right clicking the app and selecting the packaging option. In the packaging option, the name and version of the app should be given and the region where the app is to be used should also be given. The last option "Update the packaged files on the server" should be selected and the title and description of the app should also be mentioned at the same time. The "Finnish" button can now be pressed and, following that a "Packaging done" message is displayed with the location of the packaged folder. The application is packaged to a zip file. If the location of the zipped folder is in the Web server then everything is perfectly fine. If not the zipped folder should be copied to the web server folder. Not only the packaged folder but another XML file name, i.e. widgetlist.xml should be copied to the Web server that contains the address of the zipped package application. This widgetlist.xml file helps the TV to find out where the zipped application is located on the server.

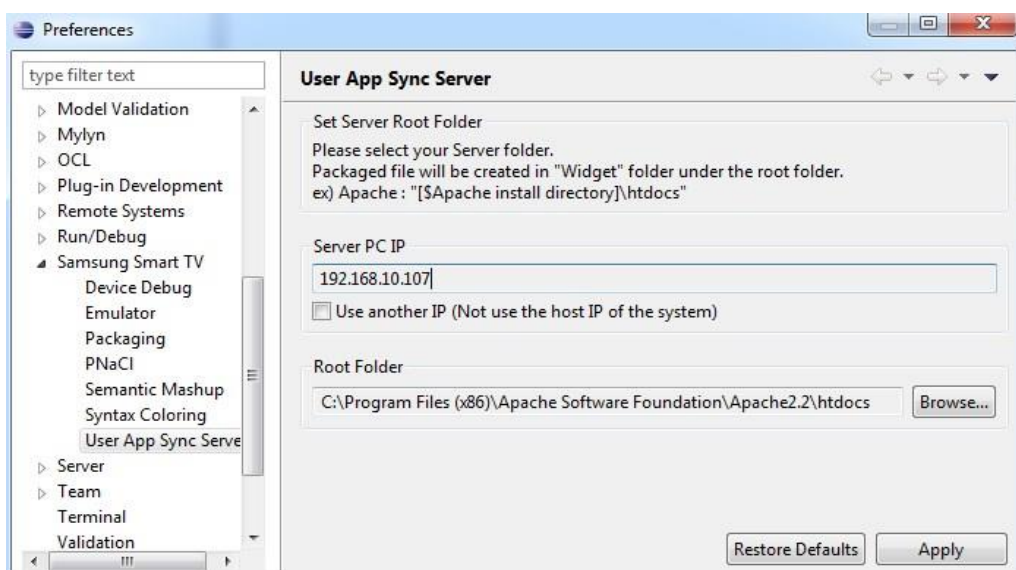


Figure 16. App Sync server by providing root folder and server PC IP. Screenshot.

Apache version 2.2 was downloaded and SDK preferences are configured with the Apache server by making the root folder in the Web server's folder named htdocs. The Try app was packaged named as Try with version 0.100 and Europe was selected as the region for the app to be used. The destination of the packaged Try app was different so, it was copied in the server inside the htdocs folder.

Finally, when the packaging of the application is finished, Samsung TV should be configured with an IP address of the server. For that, Smart TV should be connected to the internet first. Once the TV is connected to the internet, the user should log in his/her Samsung Smart TV developer's account in Samsung Smart Hub. As soon as the Samsung Smart TV developer's account is logged in, it should be logged out. Now, right after that, the user should log in putting the ID as "develop" and leaving the password blank. This will directly create a develop account and take the user into the develop section of the Apps. In the option tab of My apps, the IP address of the server should be typed where the application is packaged and it is followed by selecting of the User Application Synchronization option. While syncing, the TV searches for the widgetlist.xml file and gives the indication of installing new service with the name of the App. When the installation is finished, a new application appears in the My Apps category and hence the application can be loaded.



## Index of /

- [Try 0.100 Europe 20150422.zip](#)
- [widgetlist.xml](#)

Figure 17: Loading the server with its IP address in Google Chrome. Screenshot.

As the figure illustrates that the location [http://192.168.10.107/Try\\_0.100\\_Europe\\_20150422.zip](http://192.168.10.107/Try_0.100_Europe_20150422.zip) was linked in the widgetlist.xml file. The Figure 17 above shows that the server has both files now. The XML file was loaded through the server in the TV environment.

Correspondingly, Smart Hub was opened in Samsung Smart TV Series 5. After logging in and logging out of the developer's account, the ID "develop" was created and the account was logged in via the ID which led to the develop account. Right after that, the IP address of the server was set for the TV and User App synchronization option is chosen to sync with server. The TV searches for the server through the given IP address and finds widgetlist.xml and the Try app gets installed in Smart Hub.

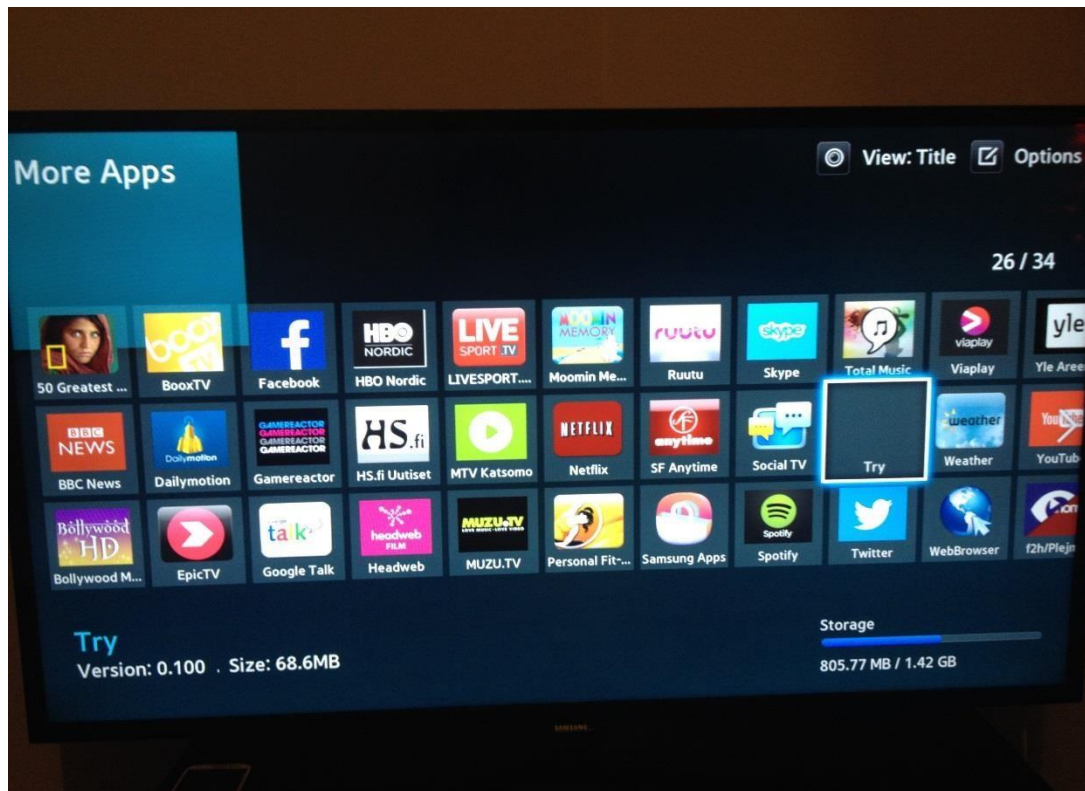


Figure 18: Installed Try app in Samsung TV Store. Screenshot.

Figure 18 above shows that the Try app was installed in Samsung TV Store in the category of More Apps. Thus, testing in Samsung Smart Hub was completed.

## 5 Results and Discussion

This project dealt with testing applications in two platforms named Samsung TV Store and Opera TV Store. The reason behind the usage of two testing platforms was to get familiar with two different kind of testing environments and to see how exactly the process of testing differs between the two platforms.

Samsung has the provision of an SDK package with all the installation guides needed. Along with SDK, an emulator and an eclipse were included. The project named the Try app was made in SDK's Eclipse workspace which had one header, paragraph and video element. After the simple HTML5 app named Try was completed, the configuration of the TV and emulator was a compulsory process in order to get connected to the TV and emulator. A Samsung account was needed only while configuring the TV. The Try app was installed in both the emulator and TV.

On the contrary, Opera TV Store has no SDK provided. Instead the Opera TV Emulator comes as a package with a virtual machine running through the Opera SDK. That means the Opera SDK is used only while using the emulator. It is not needed while connecting to the TV. Opera TV Store had no configuration process but an ID for developers was needed. For that purpose, the developer should already open an Opera account in the beginning of the testing process and should start saving the application in the submission portal. Consequently, the ID for developers was determined from both the TV and the emulator in order to get connected. Opera had no SDK so, the project named Myapp was made in Sublime Text. It contained one header, paragraph, video and audio element. It was opened in both the emulator and TV.

Even though the apps named Myapp and Try app were of same size, the font appeared smaller in Opera TV Store while comparing to Samsung TV Store. The video element did not work either in the Samsung TV emulator and Samsung TV. Instead the video worked both in the Opera TV and emulator. Though the video and audio did not work together at the same time in the Opera TV emulator which means multimedia content cannot be implemented in the same screen in the Opera TV emulator. Furthermore, the results of both emulators varied from time to time. It was very irregular



in a sense that it worked only a few times. That is why the emulators should not be trusted fully in the testing environment.

Testing in Samsung TV Store is much more complicated than in Opera TV Store. Testing in Opera by pairing the ID for developers was very a simple and quick process whereas in Samsung the configuration process was very time consuming. Samsung SDK with its long installation guides was very confusing to figure out in the beginning. However, once the TV and emulator are configured, testing for the second time will not be that time consuming.

Moreover, the technical problems which occurred during the testing in both TV platforms were similar. In Samsung TV Store, while synching with TV, the app got stuck and sometimes it failed for no reason. Likewise, the Samsung emulator got frozen and was restarted, again re-doing the process from the beginning. Similarly, in Opera TV Store, the Opera emulator also got stuck and force quit had to be done several times. Also, the ID for developers kept missing while pairing with the TV and emulator.

Developers who have limited time for testing can use Opera TV Store as a testing platform because it requires a very small amount of time. However, Opera TV Store cannot be found that easily. It is available only in a few Sony TV models and a few Samsung Blu-ray Disc Players. Thus, it will take an extra amount of money to buy a particular device because testing only in the emulator is a total risk. In comparison, Samsung TV can be easily found because it is much more common in our society than Opera TV Store. Typically, either a friend or a relative owns a Samsung TV which helps developers to test their application even if they do not own one. Thus, both of the platforms have their own advantages and disadvantages. Developers should evaluate their own conditions and choose which one is suitable for them. Hence, it can be concluded that both of the platforms are equally compatible to test Smart TV Apps.

## 6 Conclusion

The main goal of this project was to study platforms for testing Smart TV applications. The need for smart applications is very big in today's world. Every gadget that is used enables various interactive applications. These applications are taken as essential needs on a daily basis. In addition, people have gone beyond their capability and try to develop their own application for their own purpose. In this case, every application developed should be tested and fixed in order to get the expected functionalities. That is why the purpose of this project was to address the importance of testing in a developing environment.

In this project, when two similar developing apps were tested in two different testing platforms, the process of testing was different but the results happened to be quite similar. As a result of testing, unexpected errors and bugs were determined. The elements that were expected to work did not work well in the actual TV environment. This reflects that testing plays a major role in the development of an application. It allows developers to see how the application functions in an actual environment and enables them to fix problems before releasing the applications to the public. Two different apps used in this project were very simple HTML5 apps. If this project was carried out again in future, perhaps the apps could be very advanced so that the errors in them will be clearer which would help to compare both platforms in a detailed way.

As mentioned in chapter 6, it can be concluded that both platforms are equivalently appropriate to test a Smart TV application. In spite of this, my personal opinion is that Opera TV Store is the best testing platform for the developers. It was less time consuming. Every developer has a limited amount of time during the period of testing, so Opera would be the perfect option. Furthermore, it was very simple to pair Opera submission portal with the TV for testing, so the ones who do not have any experience of a testing environment can try it. Despite the fact that Opera TV Store is not easily accessible, one can buy Blu-ray disc players which are affordable and these disc players are completely applicable for other purposes as well.

The strength of this thesis is that it will help students interested in making applications for Samsung TV Store and Opera TV Store. In the future, more and more devices slowly will get connected to TV and the usage of applications will be more popular than ever. Many people will find a career in this field. Hence the chances of developing apps are



higher. Along with the development, testing environments are obviously needed to assure the quality of applications. Therefore, this project will provide developers help in evaluating which testing platform is suitable for them to test their app. Instead of surfing different tutorials on the internet, this thesis will guide them about the process of testing TV apps in Opera and Samsung TV Store. Furthermore, it will also be helpful for students interested in the history of television and the growing interactivity of televisions.

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