Paper

Digital Audio Broadcasting or Webcasting: A Network Quality Perspective

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Abstract—In recent years, many alternative technologies of delivering audio content have emerged, with different advantages and disadvantages. In this paper pros and cons of digital audio broadcasting and webcasting transmission techniques in a network quality perspective are described. A case study of user expectations with respect to currently available services is analyzed, and the perceived quality of real digital broadcasted and webcasted radio stations is examined.

Keywords—broadcast technology, mobile communications, quality of experience, quality of service, wireless communication.

1. Introduction

The current market condition in audio broadcasting and webcasting, also referred to as streaming, is characterized by the convergence of computer, telecommunication, and broadcasting technologies. It also relies on the divergence of different delivery and storage media, which use advanced digital signal processing techniques. The consumers are overwhelmed by new electronic gadgets, which appear each year on the market. They are astonished by new technical innovations that are being designed to change their life habits. The broadcasting sector is facing profound changes, particularly in a growing competition between the public and private sector, especially when it comes to providing high quality content.
With the development of storage media such as hard and flash drives, DVDs, or cloud-based online storage platforms, there is more demand for high quality broadcasted, streamed and downloaded material. Therefore, there is a growing demand for efficient ways of delivering high quality audio material at low bitrates, especially under bandwidth restrictions. Nevertheless, these standards and services sometimes fail to provide many users with the quality they expect in the digital era.

2. Broadcasting Services

The broadcasters are not all the same. They consist of public and private service broadcasters with a variety of national and regional stations. The conventional terrestrial radio transmission is faced with an increasingly strong competition from numerous streaming platforms and non-broadcast media, which use digital multimedia techniques to produce the optimum performance.

2.1. Terrestrial Broadcasting

The terrestrial broadcast delivery is the only free-to-air and cost-effective method for a truly mobile reception. However, in all developed markets, conventional analog and digital radio transmission is constrained by a lack of available spectrum. According to the European Broadcast Union (EBU) [1] the radio is:

- the vital cultural importance throughout Europe,
- consumed by a vast majority of Europeans every week,
- consumed at home, at work and on the move.

The frequency bands available for speech and sound broadcasting are becoming saturated. As a result, the reception quality is suffering more and more from mutual interference between transmissions. In many countries, there are very little or no prospects of additional radio services being provided by means of the existing analogue techniques [2].
Today, one of the main objectives of international broadcasters and content providers is to design and implement viable services, which are based on new universal digital delivery systems.

2.2. Webcasting

The Internet is an increasingly popular means of conveying audio, in particular music, to members of the general public. An audio streaming services are gaining more and more popularity. There are currently thousands of Internet radio stations offering audio streaming on-demand. Broadcasters are investing heavily in the Internet since nearly all of them have their own streaming website. This is also clearly visible in the number of available applications for popular mobile operating systems.
In some cases, the major drawback of streaming platforms is their relatively poor and insufficient sound quality. In order to listen to high quality audio one must purchase a premium account.

2.3. Defining Quality

When it comes to defining quality of a broadcasted or webcasted audio signal one question arises – how much infor-

mation could be lost or changed without seriously affecting the subjective quality of the material? Every lossy compression of audio content transmitted by the telecommunication channel causes degradation in quality. This degradation depends mainly on the transmission bitrate and coding algorithm [3].
The main factors that attract users to a particular service are:

- superior quality,
- stable reception, particularly in mobile environments,
- simple program selection tools,
- various services available at different data rates.

The quality of digital audio signals is defined by Quality of Service (QoS) parameters such as delay, frequency response, linear distortion, quantization noise, Signal-to-Noise Ratio (SNR), frequency bandwidth limitations. Whereas in Internet transmission, smaller or higher number of packets can be lost.
Subscribers expect their mobile devices provide high quality connectivity and performance at all time. Any interruption in data services is as critical as an interruption in voice. Depending on the service being used, subscribers have varying quality expectations for performance and usability. When subscribers consume content, their Quality of Experience (QoE) is not determined strictly by the speed achieved via wireless or wired technologies. They make subjective assessment based on a combination of factors as: speed, smoothness, latency. Service providers know, the better the experience, the longer and more frequently subscribers will consume content. Additional information may be found in [4].

3. Quality Perspective Survey

There are publications concerning popularity of different electronic media, including radio, television and the Internet [5]–[7]. They consist of scientific reports and analysis performed by public and private institutions, including universities. However, they analyze basic user activities and the impact of electronic media on society. These papers focus on, e.g. popular radio or TV channels, net browsing, e-commerce and shopping, as well as writing and receiving e-mails or using social media platforms. Most often, these studies were performed on a population of the so-called typical users, including students of humanities. The authors do not specify whether the surveyed population had a technical background or not. As we know, terms such as bandwidth, bitrate or spectrum may be an abstract concept for some of them.
Hence, authors have decided to carry out a survey on a group of 100 students of the Faculty of Electronics, Telecommunications and Informatics, Gdansk University of Technology. The research population resembles a group of young people between 18–25 years old, with a particular interest in new technologies. The study was conducted between the 13th and 24th of April 2015 in the form of a questionnaire. The questionnaire consisted of open and closed questions with single and multiple choices. The main aim was to determine what are their particular needs and expectations when it comes to delivering high quality audio content.

3.1. Mobile vs Stationary Devices

According to the study, almost three quarters of students prefer using mobile rather than stationary devices (Fig. 1). When it comes to listening to music or consuming other multimedia content, 39% of them uses a smartphone, whereas only 8% a tablet (Fig. 2).

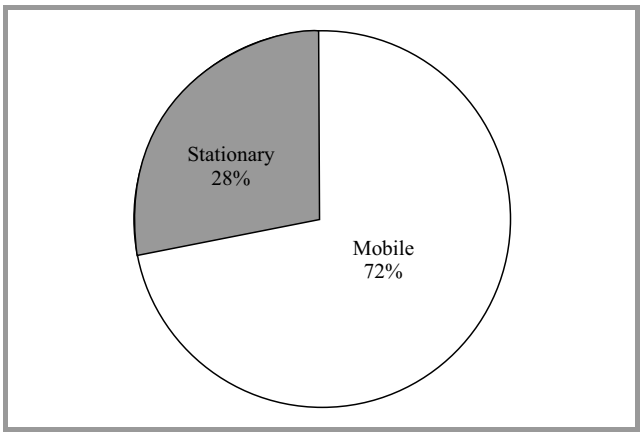

Fig. 1. Preferred type of consumer device.

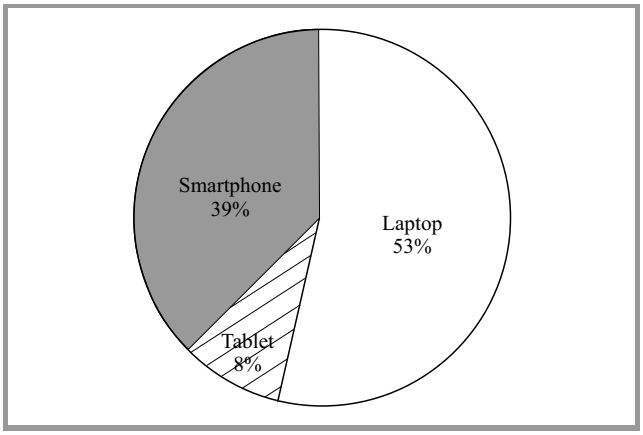

Fig. 2. Popularity of different kinds of mobile devices.

Surprisingly, considering the availability, size and weight of mobile devices such as smartphones and tablets, the laptop still remains the most popular device, with over 50%.

3.2. Streaming Platforms

The streaming platforms are very popular amongst students, 80% of the queried frequently use this type of service (Fig. 3), with over 90% of them being free services (Fig. 4).

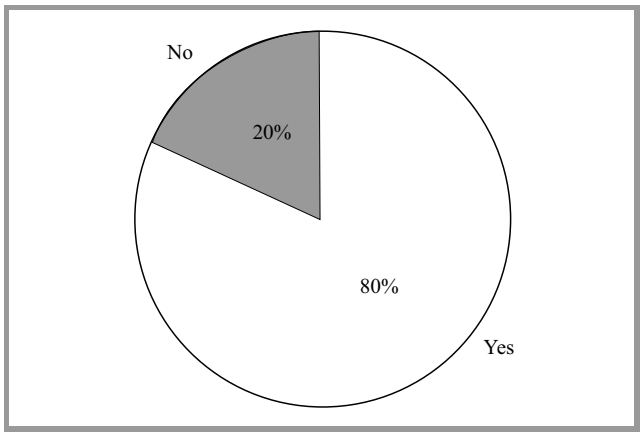

Fig. 3. Frequent use of streaming platforms.

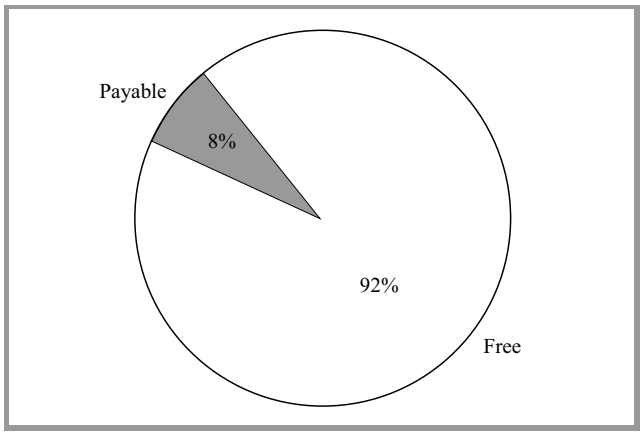

Fig. 4. Types of streaming platforms.

The most popular platforms are Spotify and Open.fm, with 23% and 22% shares respectively. Surprisingly, the majority, being 26%, listens to radio streamed live on the website of a particular radio stations. Streaming platforms such as Twitch.tv or TuneIn gained 9% and 4% respectively, whereas other received 16% (Fig. 5).

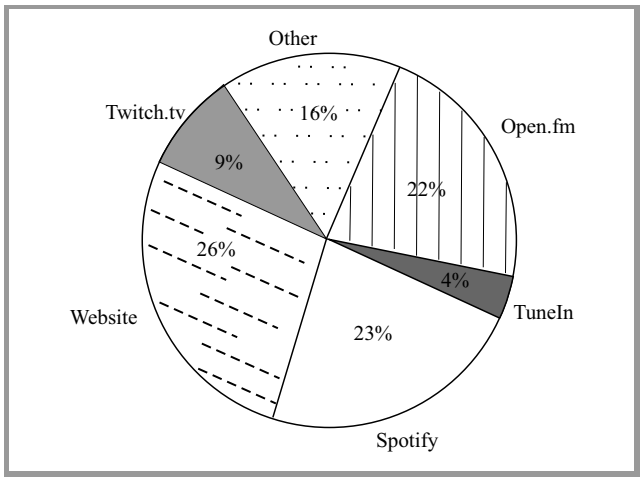

Fig. 5. Popularity of different streaming platforms.

In terms of energy and bandwidth efficiency, these results can be quite intriguing. Immediately, one question arises – is it really necessary to simulcast the same audio material terrestrially and online. The number of active streaming users has a significant impact on network load. As we know, a high number of simultaneous users can lead to higher delay. Furthermore, higher number of simultaneous users leads to less bandwidth allocated per capita. As a result, the user experience related with latency and limited bitrate of the audio stream may be disappointing. On the other hand, when users consume audio content using either analog or digital terrestrial radio transmission, they occupy the same share of bandwidth. The quality of the audio material is nearly the same for all, regardless of the number of active users.

The students responded that the main reason of using these type of services, instead of classical terrestrial radio transmission, is the availability and ease of use. According to them, Internet streaming provides an on-demand richer program offer and since they frequently use mobile devices, it is not any problem to choose a station from available programs. Another issue is, obviously, the lack of analogous or similar offer in terrestrial broadcasting. In their opinion, when it comes to streaming, commercial advertisements are less common.

3.3. Internet Connection

According to obtained data, over 70% of the surveyed group has a mobile data plan (Fig. 6). However, nearly 80% of them prefers fixed, either wired or wireless, over cellular connection (Fig. 7).

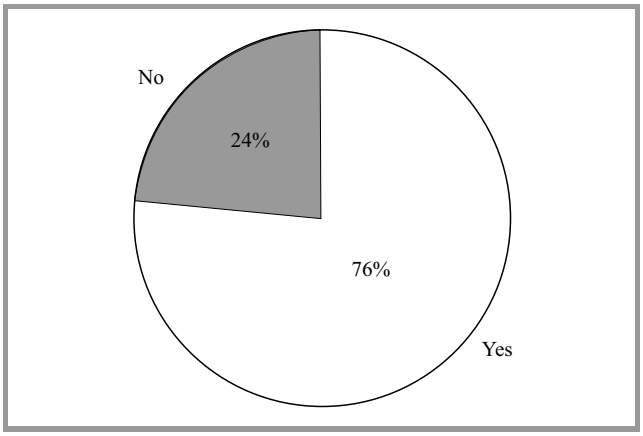

Fig. 6. Users with a mobile data plan.

But do we, as users, really have an option? If we carefully examine the situation in the developing countries, one can be easily noticed – the digital division. An individual that lives in the city center or close to it, has it all – a stable telecom infrastructure, even with Fiber To The Home (FFTH), and a high quality cellular coverage including Long Term Evolution (LTE). However, if a user lives in the suburbs or in a rural area, he or she seldom has any wired infrastructure. The only possible option is either satellite or cellular connectivity.

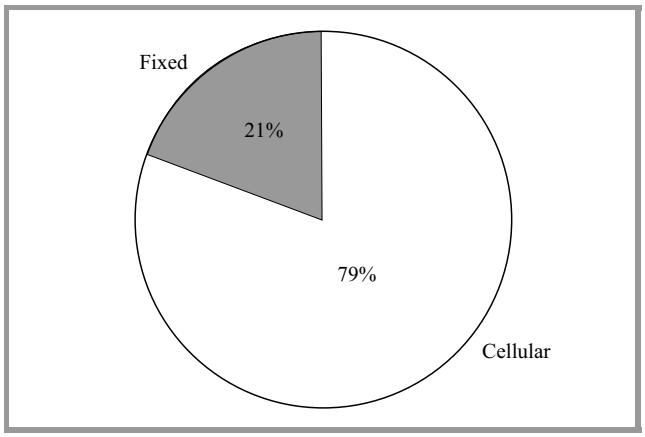

Fig. 7. Preferred type of Internet connection.

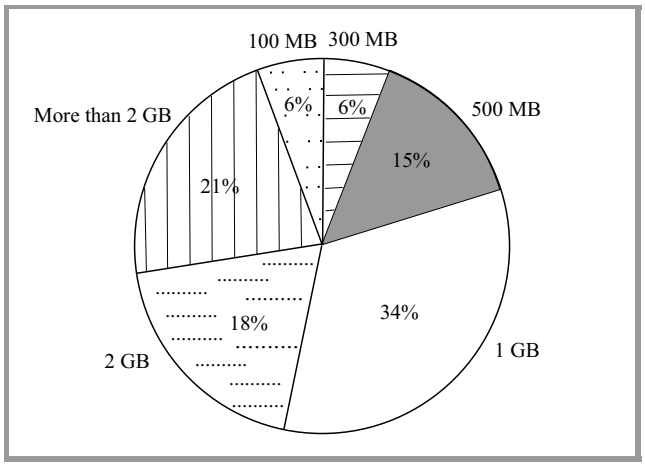

Fig. 8. Preferred type of Internet connection.

It is worth mentioning, that most of the surveyed students have a data limit of a couple of GB and higher (Fig. 8), which has a significant impact on network load.

3.4. Quality vs Network Load

Considering the most frequently chosen bitrate of audio content for either streaming or storing purposes, it is clearly visible that users prefer higher bitrates (Fig. 9). Among them, more than a half selects rates of 256 kb/s and higher, whereas less than 10% rates of 64 kb/s and less. Not surprisingly, users desire to have the best quality available, putting issues such as network load, stress of the mobile device or battery life aside.

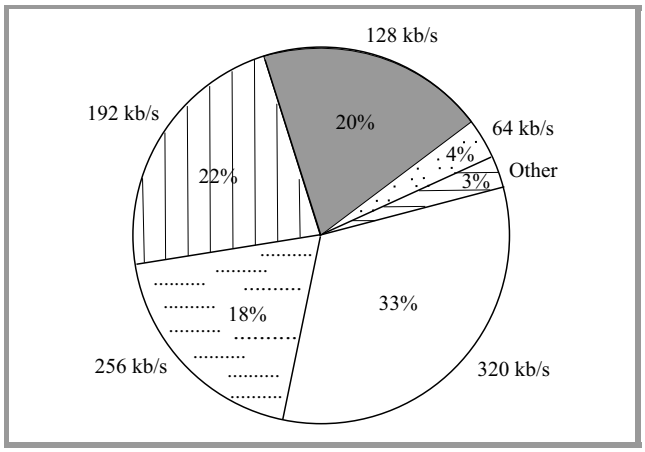

Fig. 9. Most frequently chosen bitrate.

Audio coding systems are used to reduce the amount of data required to represent an audio signal. There may be many reasons to do so, i.e. reduce storage requirements, transfer time or bandwidth requirements. However, there are applications where lower quality audio is acceptable, even unavoidable. The rapid development of the Internet, as a way of distributing audio material where data rates are limited, has led to a compromise in audio quality. Many delivery services, such as Internet streaming, digital satellite services or mobile multimedia applications, may operate at intermediate audio quality.

Considering the user's mobile data plans and selected bitrates, authors have prepared a chart describing how it can affect the network within a time interval (Fig. 10). Users with a data limit of 300 MB and lower can only affect the network under 10 hours per month, regardless of chosen bitrate. If we consider, that about three quarters of them have a mobile data plan of 1 GB and more, their activity will affect the network for tens of hours.

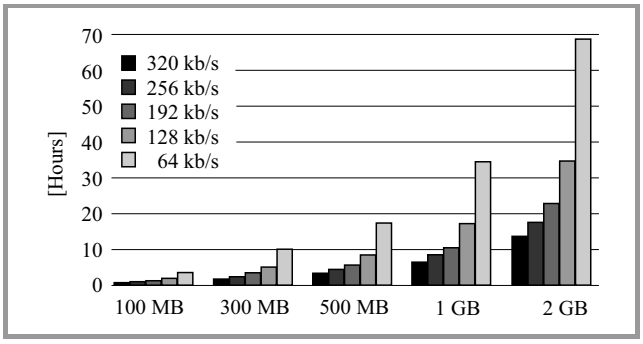

Fig. 10. Time period of user activity.

Nevertheless, mobile contracts, focused mainly on providing unlimited speech signal transmission, prove to be insufficient for the evaluation of long-term streaming of high quality audio content.

4. Perceived Audio Quality Study

The Digital Audio Broadcasting (DAB) [8] standard and its successor Digital Audio Broadcasting plus (DAB+) [9] are the most popular terrestrial broadcasting standards. There are publications concerning both subjective and objective quality assessments of speech and music signals, including [10]–[12]. However, they examine the quality of a predefined set of audio samples that had been processed using different codecs and bitrates. The authors did not encounter any publication on the assessment of an actual real-time live radio transmission.

Considering that the DAB+ platform has been launched in Gdańsk recently, a study was carried out concerning the

quality of the transmitted radio signal. Currently, 10 radio programs are available, with 5 of them being simulcasted in both analogue and digital terrestrial standards. The remaining 5 are new radio stations that are available only on the digital multiplex and online webcasting platforms. The profile and bitrate of new radio programs available on the digital multiplex and streaming platforms is shown in Table 1 and in Fig. 11. Each speech or audio signal was coded using the Advanced Audio Coding (AAC) algorithm.

Table 1
New radio programs available on the digital multiplex and streaming platforms in Gdańsk area

Profile	DAB+ bitrate [kb/s]	Streaming bitrate [kb/s]
Children	72	48
Information EN	64	48
Information PL	64	48
Pop music	96	48
Arts	128	48

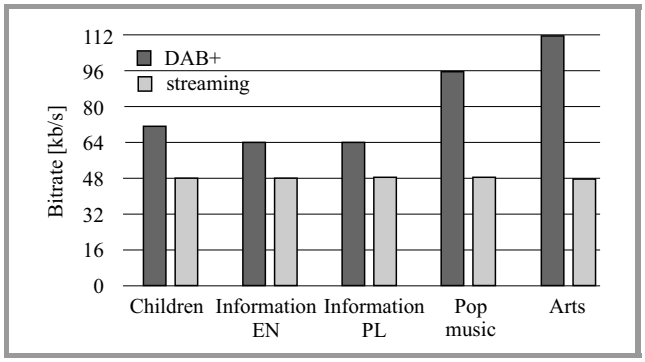

Fig. 11. New radio programs available on the digital multiplex and streaming platforms.

These 5 new stations are dedicated to different audiences. One of them for the youngest listeners, 2 for adults interested in current affairs, both in Polish and English. The remaining 2 are programs playing popular and classical music. It should be understood that the nature of the broadcast material might change in time with future changes in musical styles and preferences.

The study was performed between the 3rd and 21st of October 2015 on a group of 15 students according to recommendation [13], none of them had hearing disorders. Tests were carried out in turns, one participant after another, wearing headphones. Each participant was first instructed about the aim of the study, including the listening environment and equipment, and then asked to assess the quality of the transmitted radio signal.

The study consisted of two parts: Test 1 and Test 2. In Test 1 students were asked to rate the overall quality of each radio program transmitted terrestrially in Absolute Category Rating (ACR) scale, as shown in Fig. 12. In Test 2 they were asked to rate the impairments between "A" and "B", representing the same radio program transmitted terrestrial and online respectively in Degradation Category Rating (DCR) scale, as shown in Fig. 13. The confidence intervals were equal to 95%.

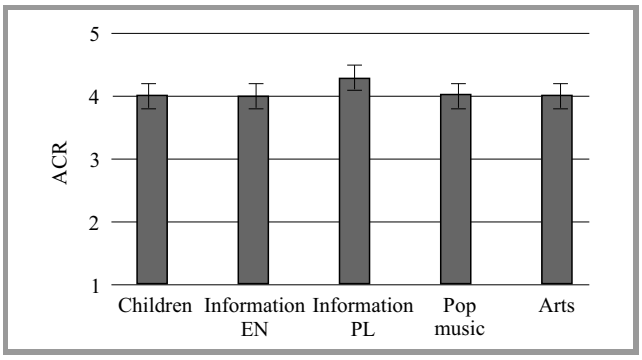

Fig. 12. Perceived audio quality of broadcasted radio programs.

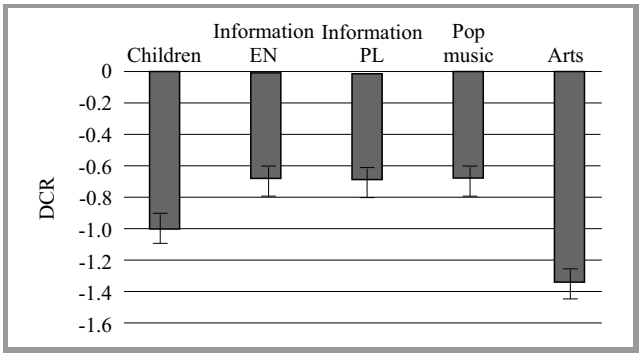

Fig. 13. Audio quality impairments between broadcasted and webcasted radio programs.

In both tests, the quality was assessed by the same group of subjects. Each individual had its own sheet of paper in order to write the score and comments. None of them was informed about the actual bitrate of the transmitted radio program.

According to reports from subjects in earlier listening tests, a fixed listening level was often perceived as annoying, being too low or too high for an individual. In order to overcome such possible problems, listeners were free to adjust the listening level before starting the experiment.

According to the listeners, the overall quality of terrestrial digital radio programs was ranked as good. This proves that the bitrate of each broadcasted radio stations was chosen properly. However, the streamed material was very limited in terms of bandwidth, with a clear cutoff of higher and lower frequencies. The voice of a radio presenter felt unnatural, whereas higher ratings were only observed in case of electronic music.

Quality assessment of speech and sound signals is a complex psychoacoustic phenomena related with human perception. It should be noted that each person interprets quality in a different way. The end perceived quality is sometimes less influenced by the consumer device than it is by the coding algorithm or chosen bitrate.

It can be noticed, that excellent audio quality, generally required from content providers, cannot always be achieved. This is caused either because of too low bitrates used, due to a narrowband transmission channel, or the type of audio material. If there is a serious constraint in terms of bandwidth, so that a broadcaster or webcaster is advised to use lower bitrates, it is often a better strategy to deliver a good stereo audio material than a poor or even bad multichannel audio signal.

One must keep in mind that in most cases, the bitrate of a free audio streaming service is limited. Better quality is reserved only for premium users who decide to switch to a payable service. Every broadcaster wishes to deliver near-studio-quality to the intended audience. Too high compression ratio may severely degrade the user experience. As a result, it will not meet the high expectations associated with new-generation digital broadcasting or webcasting services.

5. Conclusions

According to the study, the users prefer to consume audio content using mobile devices with a fixed Internet connection. However, providing high quality services is not always possible. Terrestrial broadcasting is facing many challenges and competition from webcasting services. It is very important that each service provider knows exactly the advantages and limitations related with different transmission techniques.

Broadcasting systems are capable of providing reliable digital services in real-time to all users located in a predefined covered zone. One of the main factors is clearly the cost of an infrastructure and transmission power required to cover a given area. Delivering high quality content to consumers is one of the most challenging tasks in the world of electronic media. Another crucial aspects is the efficient use of available bandwidth resources.

Broadcasters, telcos and content providers see the opportunity to offer more services, manufacturers look forward to selling larger quantities of devices and associated equipment, network operators are keen to build new telecom infrastructure. It is important to understand the pros and cons of different technologies and their commercial, economic, and operational implications. Broadcasters will always aim to use the best possible means to reach the user in the most effective way. Listeners will welcome every new technology that offers more features and higher audio quality. However, users do not mind about the technology used, they are only interested in the quality and the cost of a particular service.

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