An Investigation on LTE Broadcast

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Abstract
Broadcast and broadband communications have undoubtedly become a part of today's social life. Accessibility of content of interest to the audience at any place and at any time regardless of the type of content consumer device can have an effective contribution to the desire of the audience to use of the broadcast content. The HD and Ultra HD qualities, the desire for demand-driven applications, the interactive content usage and the diversity of broadcast content-usage devices have raised the challenge of both broadcast communications and broadband communications to meet the audience's future needs. This paper tries to explain approaches to overcome these challenges using the inherent capabilities of broadcast and broadband. Of course, the exact prediction of when this technology will come to full maturity is almost impossible.

Keywords: Broadcast, Broadband, Demand-driven systems, Interactive television.

1. Introduction

Audiences' expectations of television in future are greater than watching one-way programs. First, the audience needs demand-driven services that can deliver the interesting content to the audience at any place and any time regardless of the content consuming device. This device may be a flat screen TV in a room, a pathfinder device in a car or a mobile device such as a smartphone or tablet. In most European countries, the audience has accepted HD quality as the base quality in television broadcasting, and what is now expected is the Ultra HD and higher quality on new television devices and also on tablets and laptops. Desiring demand-driven systems, portable devices, and Ultra HD quality will impose a tough challenge to television and content delivery networks in the future.

Interactive use has many forms. In one form, the audience can choose the TV or multimedia content from a list that the system provides. In another form, the viewer will be allowed to view a content such as television series broadcasted in the past and has not followed. It can also provide new content that has been broadcasted in a demand-driven way only independently or in conjunction with a one-way system for the audience. Each of the new ways of video consumption, in addition to the use of YouTube content streaming, may discard traditional one-way TVs. When switching from one-way consumption into interactive and demand-driven consumption, an interactive model is expected. Although the exact prediction of when this technology will come to full maturity is almost impossible, but the availability of new and cheaper devices, and the more and more ability to deliver various content from diverse sources can disrupt TV/video productions, broadcast, and consumption patterns [1].

2. A Look at the Broadcast Domain

According to a report by the Ofcom Foundation, the conditions of European countries concerning the consumption of television content are very different [2]. This report shows how to use the digital TV platform in different countries. There is a huge difference concerning the access to the primary TV receiving devices that are fed by digital terrestrial stations. As shown in the diagram, Germany with 6% and Spain with 66% are, respectively, the smallest and largest consumers of digital terrestrial stations [3]. In England, Germany, Ireland and Poland, digital satellite platform is the most commonly used platform for television.

For the consumers of television content, whether they use digital satellites or digital terrestrial stations to receive their television content, none of these platforms adequately meets the growing needs for interactive and demand-driven TV pattern. Both the satellite and high-power high-tower (HPHT) digital TVs are basically designed on one-to-many architecture and offer limited freedom of action concerning feedback channels and timing control by the audience. This freedom of action becomes more limited particularly in the mobile and portable situation.

There are hybrid approaches that are being gradually developed in some countries. For example, the hybrid broadcast-broadband television (HbbTV) service is pushing away classical digital terrestrial television (DTT) in France as an optimal approach for connecting and accessing the broadband network.

Figure 1. HbbTV service on the French television.

Germany is an attractive case study for the challenges faced by the business sector. On January 16, 2013, the RTL group, one of two major commercial broadcasters in Germany, announced that it will stop the broadcast of four programs by digital terrestrial stations starting on January 1, 2015 [4]. RTL argued that with regard to commercial issues, classical terrestrial broadcast would not be any more economically viable [5].

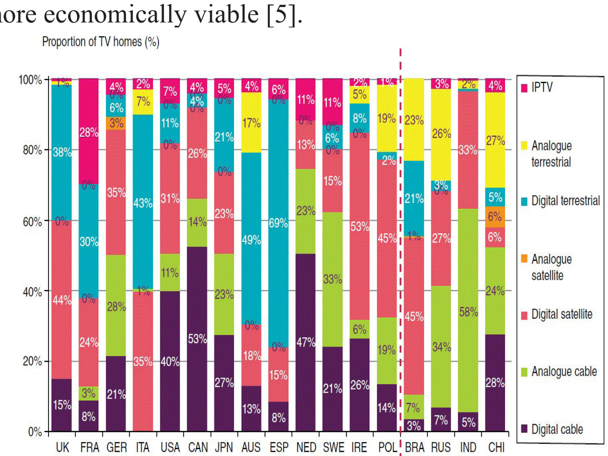

Figure 2. Using different TV platforms in different countries [2].

3. A Look at Broadband

Broadband is an important component of today's society, whose importance is increasing day by day. For example, 60% of the Swedish population has a broadband mobile network subscription, with an average consumption of 10 GB per month [6]. In recent years, broadband mobile network traffic has been doubled every year. According to the CISCO prediction, it is expected that the traffic growth trend will continue in the coming years. According to the outsourcing of this prediction, this concept means that the broadband network traffic will be doubled 30 times today in the next 5 years and it will increase by 1000 times today in the next 10 years. The explosive growth of traffic is a difficult challenge by itself, but it will create more problems in combination with other functions.

A report released by Cisco in June 2017 predicts that at the end of 2021, about 82% of the total global traffic will be related to video, so the important challenge for the broadband mobile network is servicing the huge volume of traffic for high-quality videos. Although the real growth is affected by the limitation of maximum download or upload volume, which is applied to many mobile users [7].

4. Comparing Broadband and Broadcast

Television and broadband mobile phone networks are very similar in terms of the challenges ahead. In addition, the pattern of television consumption suggests that future televisions and broadband mobile phone networks will be similar to each other in many respects in the years to come. Both services will inevitably provide HD and Ultra HD quality for the audience in dynamic and engaging ways. This issue requires an optimal approach for converging broadcast and broadband mobile network services.

In addition to technical challenges, the emphasis on the fact that providing services should be affordable by the audience is very important, so the cost of providing services is another very important challenge that needs to be addressed.

In summary, the broadcast advantages can be expressed as almost public access, support for any receiving mode such as fixed, portable and mobile, service quality assurance and predictability, optimized for one-way content delivery for a wider audience, cost independent of the number of concurrent viewers, the ability of users to access the entire network capacity and having no network congestion. In another direction, the broadcast disadvantages include the one-way nature of the network, the lack of a return channel, the lack of demand-driven services, the limited capacity of providing content and the lack of support for IP-driven networks.

In broadband, the two-way network provides interactivity. Optimization for the mobile network, support for most network services, the potential for unlimited content and service selection, increased and cheaper consumer content devices, support for IP-driven devices and network connectivity are among the advantages of the broadband network.

The lack of public access due to the existing capacity, limited coverage, the cost dependent on the concurrent users, and sharing the capacity among the users that creates the risk of congestion in the network are some of the disadvantages of broadband.

5. The Architecture of the Candidate Network for Converging Broadcast and Broadband

Traditionally, broadcast and broadband communication services have an independent and dedicated network structure. In the current state of technical readiness, the convergence in the delivery of media content occurs in applications and at the service level. An innovative radio access architecture needed for converging the mobile broadcast and broadband communications in the wireless/radio field needs to be developed.

Network convergence in the transmission layer causes the use of spectrum flexibility for one-way content and interactive broadcast in a multicast mode such as internet protocol television (IPTV) and unicast mode such as video on demand (VOD). The convergence approach has the following requirements.

• Terrestrial broadcast should be extended to a variety of devices connected to the network, such as smartphones and tablets for various uses, such as indoor use or mobile use.

• The bandwidth required for interactive and two-way capabilities in the TV broadcast should be provided.

• Flexibility should be created for meeting rapidly-changing customer demand.

• High spectral efficiency is required to achieve the highest desired emission specifications in the frequency band of 470 to 790 MHz.

• The low implementation cost for a cost effective setup should be taken into consideration.

In the following, we discuss the two types of potential architectures for broadcast-broadband convergence.

5.1. Cellular Broadcast in the TV Spectrum

This approach has a well-defined policy for future TV Broadcasting. It plans to operate the television content on cellular technology and on the UHF spectral range of 470 to 790 MHz. This means that the common terrestrial-based broadcasting built based on DVB-T/T2 will be completely abandoned by basic IP cellular systems such as LTE. One practical technique for this approach is the eMBMS approach on a single-frequency network (SFN) that has 3GPP LTE specifications.

The eMBMS multicast capabilities can be a good replacement for unicast for many types of live and non-live multimedia content. These techniques utilize the intrinsic broadcasting quality of the wireless networks to send all at once to multiple end-users, thereby optimizing the usable spectrum and reducing the cost per every bit of information. In addition, eMBMS can be dynamically changed and adjusted, resulting in eliminating the need for a dedicated spectrum.

In eMBMS, LTE carriers can be flexibly allocated to unicast and broadcast. This approach predicts that future receivers of the broadcast will be an LTE-A receiver that is embedded in today's customer video devices, such as what we call Set Up Box, smart TV and personal voice recorder [8].

Some mobile network providers claim that, given the advancements in cellular transfer technology and optimal combination with eMBMs, cellular broadcast can provide services of the same quality while occupying less frequency spectrum in comparison with DVB-T. Saving the frequency spectrum can be expected depending on the actual implementation and target applications.

Multiple configurations of cell broadcast can be provided. One of the choices is to broadcast all television programs on the SFN form by multiple cellular sites. Another choice is broadcasting just a few of the most popular programs, and the rest are broadcast through cellular unicast links.

The first choice has been tested in some California's cities [9]. In the tested samples, large potential capabilities were reported for improving the spectrum used in cases where coverage was limited to urban areas. The study claims that only 84 MHz of the spectrum is required to support current television services in urban areas using the latest LTE-eMS technology. This is very optimal compared to the 300 MHz bandwidth occupied by the current terrestrial broadcasting systems in the United States.

Although the conducted study has promising results, it is not clear that this conclusion will provide similar results in other countries according to DVB-T2 standard. In addition, there is no analysis of the economic impact in the scenario of this study.

A study was also carried out by The Royal Institute of Technology of Sweden (KTH) to investigate the feasibility of cellular broadcasting in the geographical area of Sweden [8]. Based on the findings of this study, there may not be so appropriate commercial benefit from using cell broadcasting to replace existing television services, especially in rural areas where cellular base stations have been deployed in a scattered way, but on the other hand, the research recommends the use of cellular broadcasting and acknowledges that cellular broadcasting will be beneficial in the near future, given the rapid change in the consumption pattern of television programs.

In summary, the works held on cellular broadcasting are not enough to make a definitive conclusion about the economic benefits, but cellular broadcasting in the television band can be beneficial in comparison with the classic DTT and its different configurations in many countries. Further more accurate research is needed to measure the performance of cellular broadcasting in different physical environments and in different application demands. The optimal design of cellular technologies, the development of cellular systems in accordance with the requirements of the broadcast and the collaboration with satellite broadcast for complementary coverage should be taken into consideration due to the expected improvements of satellite technology.

5.2. Hybrid Approach

Compared to the previous approach, which is quite clear to be a replacement for DVB-T by LTE-A over time, this approach proposes a new collaboration model between DVB-T and LTE-A to benefit from the synergy between them. In this hybrid network, there is an approach that can benefit from both the advantages of bandwidth saving and network cost limitation to maintain economic viability. Content sources can be shared among mobile network operators.

For example, the HbbTV2.0 service can allow a viewer to watch simultaneously the content of the broadcast as the main view and the broadband content as an alternative view. To implement content viewing services on multiple HbbTV2.0 screens, it introduces a mechanism for sharing the reference clock between the device and a buffering model for time alignment, which is needed for internal synchronization of devices. Internal synchronization of devices can be possible by the mechanism of clock sharing in applications running on any broadcast or broadband device [10].

The hybrid approach proposes an innovative concept for the coverage network with respect to broadcast and broadband convergence. This concept allows video content to be transmitted through the HPHT network or in the lower layers through LPLT [11]. The hybrid approach uses a creative idea that the LE signals are multiplexed within a DVB-T2 frame. The ability of signal multiplexing through DVB-T2 frames can be realized. The DVB-2 standard provides an additional frame for possible future improvements within itself, which is known as future extension frame (FEF). [12] The FEF also has the same ability to be transferred such as other DVB-T2 standard frames in the multiplexer.

The use of FEF is optional and has not yet been fully tested. When using the FEF, the transmission from DVB-T2 to LTE is switched, and eMBMS frames are used to deliver the broadcast content within the HPHT network.

Using this hybrid approach, DVB-T2 receiver needs only to decode the DVB-T2 content and pass it through the FEF. However, the LTE-A receiver should be able with some modifications to identify and decode the content transferred in the FEF. In this approach, the 470 to 790 MHz band can be dynamically allocated to deliver the broadcast or broadband content according to the needs and demands of the audience. The new mechanism for content delivery management and the dynamic allocation of the television spectrum between broadcast and broadband should be developed according to user demand and to one-way and interactive content delivery services.

One of the challenges is to provide more coverage area for the LTE eMBMS. To overcome this, larger cellular radii and integration of eMBMS in HPHT topologies are needed. Another issue is investigating the ability to identify and decode the LTE content embedded within the FEF in the HPHT network, which may have differences in the structure's architecture depending on the country and the used target.

In addition to the abovementioned issues, there are other improvements, including MPEG-H, which is the transfer of MPEG media content standardized by ISO and IEC as a new pattern for IP-based transfer of media content and is expected to replace MPEG-2 streaming. Although some broadcast-broadband systems have been developed for basic broadcast streaming systems, they need more intelligence to overcome the incompatibilities of the information formats and the synchronization mechanism between broadcast and broadband [13].

6. Conclusion

This paper discussed two candidate solutions for broadcast-broadband convergence, namely cellular broadcast and hybrid network architecture. In the future, the convergent architecture capabilities and content delivery methods should be further explored to identify in which conditions the broadcast-broadband convergence within the UHF TV band can be beneficial for different countries. Different countries have diverse geographic and demographic characteristics. Furthermore, due to different TV broadcasting and different consumption patterns, the benefits of broadcast-broadband convergence approaches should be evaluated at the level of a number of countries as a reference. The major criteria are development and deployment cost, spectrum efficiency in comparison with traditional DTT and the quality of television broadcast services. Social and economic impacts also need to be further investigated because it seems to have been neglected in the works that has been done so far. In addition, further study on the equipment technology should be held for finding out the potential of the approaches and proving the practical concept. The broadcast and broadband industry is facing many but similar challenges. Therefore, the biggest social benefit is obtained when the broadcast industry and the mobile industry collaborate with each other on the win-win basis to overcome these challenges. Specifically, the suggestion of protocol modification to unify the DVB-T2 and LTE eMBMS protocols, as well as the upgrade of LTE-A for a cost-effective executable broadcasting, will only be achieved when both broadcast and broadband industries are involved in that.

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