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# Towards Broadcasting Linear Content Over 5G Network

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**Abstract**

Today's society heavily relies on linear television systems featuring planned programs, which serve as a vital means of communication. The evolution of broadcasting linear content is notably driven by advancements in end users' devices. This transition has expanded it from a limited range of linear radio and TV channels to a comprehensive and distinctive array. This selection is accessible across diverse distribution network types. Among these networks, the prominence of the 5G network stands out as a notable platform for media and transmissions. Transmitting linear content over 5G networks involves efficiently delivering scheduled, real-time content to a large number of users simultaneously. This content encompasses live TV broadcasts, radio programs, and streaming events. While 5G networks offer significant advantages in capacity, speed, and latency, it's essential to consider specific factors when it comes to broadcasting linear content. Traditionally, cellular networks, designed for continuous service, have predominantly followed a unicast bidirectional communication paradigm for numerous years, providing a range of services to customers. This paper employs a research methodology to examine the future 3rd Generation Partnership Project (3GPP) 5G Multicast and Broadcast Services (MBS) standards, along with their constraints. Our approach includes a comprehensive literature review, technical specification analysis, and comparison of different broadcasting technologies within the 5G framework. By employing this research methodology, we gain a holistic understanding of the evolving landscape of broadcasting linear content over 5G networks. This contributes to the body of knowledge in this field and informs future advancements in broadcast technologies within the 5G ecosystem.

**Keywords:** Linear broadcasting,5G, 3GPP, MBS, multicast, broadcast

## Introduction

The rapid evolution of mobile communication technologies has paved the way for transformative advancements in content delivery and multimedia services. The introduction of 5G, the fifth generation of wireless technology, has brought forth new opportunities and capabilities for efficient and scalable distribution of multimedia content to a large audience. One of the key features of 5G that holds immense potential in this regard is Multicast Broadcast (MBB) services. In traditional unicast streaming, content is delivered individually to each user, resulting in duplicated transmission and increased network congestion as the number of users grows. However, with MBB, content is transmitted once and simultaneously received by multiple users within a designated broadcast area. This multicast transmission approach allows for more efficient use of network resources and enables the delivery of high-quality multimedia content to a large audience, all while maintaining low latency and optimal spectral efficiency. MBB services in 5G go beyond the capabilities of previous generations by leveraging the enhanced bandwidth, lower latency, and higher capacity offered by 5G networks. This opens up new possibilities for delivering a wide range of content, including live events, sports matches, breaking news, concerts, and other multimedia experiences that benefit from broad dissemination. The architectural components of MBB in 5G include the broadcast/multicast server responsible for generating and distributing the content, the multicast/broadcast area representing the geographical coverage for simultaneous content reception, and the multicast/broadcast gateway that facilitates the delivery of content from the core network to the access network. These components work in synergy to ensure efficient and reliable distribution of broadcast content. While MBB brings numerous benefits, it also presents challenges and considerations. Spectrum allocation and management, quality of service (QoS) and quality of experience (QoE) assurance, security, and content protection, as well as seamless integration with existing broadcasting technologies, are among the key areas of focus. Additionally, the emergence of edge computing, virtual reality (VR), Internet of Things (IoT), and artificial intelligence (AI) further presents opportunities for synergies with MBB, enabling personalized content recommendations, immersive experiences, and seamless integration with diverse applications and services. Looking beyond 5G, the evolution of MBB services continues to be a subject of research and standardization efforts. Next-generation broadcast technologies, hybrid models combining unicast and

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multicast transmission, content personalization, user interactivity, energy efficiency, and green broadcasting are some of the areas that researchers and industry stakeholders are exploring to further enhance the capabilities and effectiveness of MBB services.

In this paper, we employ three main methods that combine several approaches to comprehensively analyze the evolving landscape of broadcasting linear content over 5G networks. These methodologies are structured to ensure a thorough understanding of the subject matter.

A. Literature Review: This involves a thorough exploration and analysis of existing literature, research papers, articles, and relevant sources that discuss the topic of broadcasting linear content over 5G networks. The literature review helped to provide context, identify key concepts, and highlight existing research gaps and findings in this area.
B. Technical Specification Analysis: This method involves a detailed examination of technical specifications related to the 3GPP 5G MBS standards. We have delved into the technical documentation and standards set by 3GPP to understand the intricacies of the multicast and broadcast services within the 5G framework. This analysis helps in uncovering the specific functionalities, limitations, and potentials of these services.
C. Comparison of Broadcasting Technologies: This method involves comparing and contrasting various broadcasting technologies that operate within the 5G ecosystem. We have evaluated the strengths, weaknesses, advantages, and challenges posed by different broadcasting approaches within the context of 5G networks. This comparison shed light on the suitability of each technology for efficiently delivering linear content to a wide audience.

By combining these three methods—literature review, technical specification analysis, and technology comparison—the study aims to provide a comprehensive understanding of the potential, constraints, and implications of broadcasting linear content over 5G networks. This approach helps us to contribute valuable insights to the existing body of knowledge and aids in informing future advancements in broadcasting technologies within the 5G landscape.

The rest of the paper is structured as follows: Section 1 provides a brief description of existing digital broadcast technologies. Section 2 then introduces the details of 5G broadcast architecture and services. We also highlight some of the limitations of the existing architecture of the 5GS concerning support for MBS. Sections 3,4,5 provide 5G broadcast projects for several countries. Some recommendations in enhancement of the spreading of the 5G broadcast are given at the end.

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## 1. Digital Broadcast technologies

Digital broadcasting refers to the transmission of audio, video, and data content in a digital format. It involves the conversion of analog signals into digital form, which allows for more efficient and reliable transmission and reception of content. Digital broadcasting offers several advantages over analog broadcasting, including improved audio and video quality, enhanced transmission efficiency, and the ability to transmit more channels within the same frequency spectrum.

There are various standards and technologies used for digital broadcasting around the world.

**Digital Terrestrial Television (DTT):** DTT is the digital transmission of television signals over terrestrial networks. It typically uses the MPEG-2 or MPEG-4 compression standard and provides higher-quality video and audio compared to analog TV. DTT systems include DVB-T (Digital Video Broadcasting-Terrestrial), ATSC (Advanced Television Systems Committee), ISDB-T (Integrated Services Digital Broadcasting-Terrestrial), and others.
Internet Protocol Television (IPTV): IPTV is a digital broadcasting method that delivers television content over IP networks, such as the Internet or private networks. IPTV allows users to stream live TV channels, on-demand content, and interactive services on various devices, including smart TVs, computers, and set-top boxes.

**Direct-to-Home (DTH) Broadcasting:** DTH broadcasting involves the transmission of digital TV signals directly to home satellite dishes. Users receive the signals using satellite receivers and can access a wide range of TV channels and services.

**Streaming Services:** While not strictly broadcasting in the traditional sense, streaming services like Netflix, Amazon Prime Video, and Hulu utilize digital technologies to deliver on-demand video content over the internet. These services rely on adaptive streaming techniques to dynamically adjust the video quality based on the viewer's internet connection and device capabilities.

One of the prominent broadcast technologies is the use of multicast transmission over the mobile network. Multicast is a variation of broadcasting that involves the simultaneous delivery of content to multiple recipients who have expressed their interest in receiving it. The advantage of multicast is its efficiency in terms of bandwidth utilization. Instead of sending separate streams to each recipient, multicast allows for the replication of the data only at network junctions or routers when there is a branch point where multiple recipients are connected.

5G broadcast, also known as 5G multicast or 5G eMBMS (evolved Multimedia Broadcast Multicast Service), is a feature of the 5th generation (5G) mobile network that enables the efficient delivery of multimedia content

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to multiple users simultaneously. It allows for the broadcasting of popular or high-demand content, such as live video streams, or other data, to a large number of users in a specific area or across the network.

In the next section, we will give a short overview of the 5G architecture and the main elements of functionality.

## 2. Architecture of 5G Multicast Broadcast Services

The 3GPP technical specification TS 23.247 provides detailed information on the support for MBS within the 5G architecture. The specification outlines the key components and functions introduced in the 5G architecture to enable multicast broadcast services. The specification provides an overview of the major components in the 5GS architecture, including the new functions specifically designed to support MBS (Fig. 1) (3GPP TS 23.247, 2021). The network architecture of the 5G system has been improved to facilitate multicast and broadcast services. The objective of this design is to maximize the utilization of existing 5G system components whenever possible. Multicast involves delivering identical services and specific content simultaneously to a designated group of authorized UEs within the service coverage area. On the other hand, broadcast entails delivering the same service and content to all UEs within the service area. The choice between multicast and broadcast depends on the nature of the specific service being provided. The 5G MBS architecture is designed to efficiently deliver multicast content to a large number of users simultaneously. It comprises several key components that work together to facilitate the distribution of multimedia content over the 5G network.

The 5G MBS architecture operates as follows: The broadcast/multicast server generates the multicast content and sends it to the MBG. The MBG converts the content into the appropriate format for the access network and allocates the necessary network resources. The access network delivers the multicast content to the user devices within the multicast group. User devices receive and decode the content stream for playback.

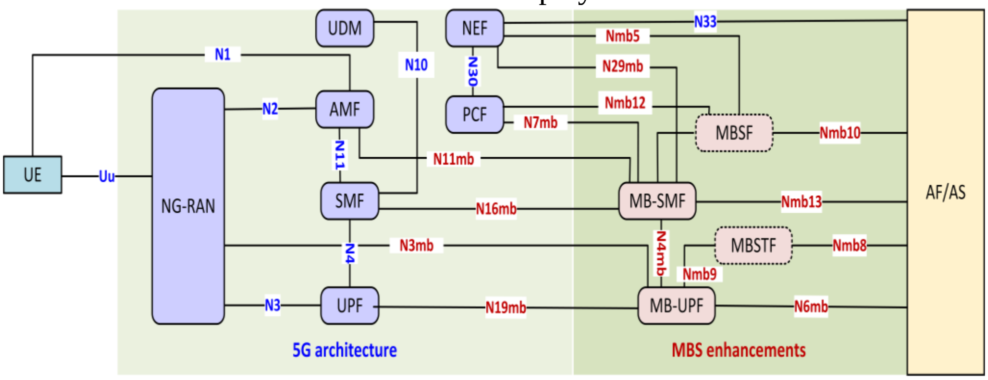


**Fig.1** 5G Broadcast Architecture

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*Content Provider:* The content provider is the entity responsible for generating or acquiring the multimedia content that will be distributed through the 5G multicast broadcast service.

*Broadcast/Multicast Server:* The broadcast server is responsible for preparing and transmitting the multicast/broadcast content over the 5G network. It receives the content from the content provider and packages it into multicast streams. The server manages the scheduling and distribution of the content to the appropriate multicast groups.

*5G Core Network:* The 5G core network provides the underlying infrastructure and functionality to support 5G multicast broadcast services. It includes several key components:

a) Multicast Broadcast Center (MBC): The MBC is responsible for managing and controlling the multicast and broadcast services. It handles the registration of users, the creation and management of multicast groups, and coordination with the broadcast server for content delivery.
b) Multicast Distribution System (MDS): The MDS is responsible for distributing the multicast streams from the broadcast server to the appropriate 5G base stations.
c) Service Gateway (SGW): The SGW acts as an interface between the 5G core network and the radio access network (RAN). It handles the routing of multicast traffic to the appropriate base stations.

*Radio Access Network (RAN): The* RAN is the part of the network that interfaces with user devices and provides wireless connectivity. In the context of 5G multicast broadcast services (3GPP TS 38.211, 2021), (3GPP TR 23.757, 2021), the RAN includes the following components:

a) 5G Base Stations (gNBs): The gNBs receive the multicast streams from the MDS and transmit them wirelessly to the user devices within their coverage areas.
b) Multicast/Broadcast Single Frequency Network (MBSFN): MBSFN is a specific feature in the RAN that enables the simultaneous transmission of multicast content on the same frequency resources to multiple base stations. Instead of sending the same data separately from each cell tower, which can lead to inefficiencies and interference, 5G MBSFN enables all the nearby base stations to transmit the same data in sync. This results in better coverage, reduced interference, and improved spectral efficiency for broadcasting or multicasting content (ETSI TS 103 720, 2020). It helps to improve efficiency and reduces interference for multicast transmission.

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*User Devices:* User devices, such as smartphones, tablets, or other 5G-enabled devices, receive the multicast/broadcast content from the base stations. The devices need to support the 5G multicast broadcast capabilities to receive and decode the multicast streams.

The architecture of 5G multicast broadcast services involves coordination between content providers, broadcast servers, the 5G core network, the RAN, and user devices to ensure efficient content delivery to multiple users simultaneously. While the architecture of 5G Multicast Broadcast Services offers many advantages, it also has some drawbacks and challenges: -content of synchronizations; scalability and coverage; quality of service variations, and resource wastage for non-interested users.

## 3. Multicast broadcast in Europe

Multicast broadcast services in Europe have gained significant attention and have been widely deployed by various broadcasters and network operators. The implementation and adoption of multicast broadcast in Europe have been driven by the need to efficiently deliver multimedia content, optimize network resources, and provide a seamless user experience.

**Digital Video Broadcasting (DVB):** Europe has widely adopted the Digital Video Broadcasting (DVB) standards, which include DVB-T (terrestrial), DVB-S (satellite), and DVB-C (cable) for television broadcast. These standards enable efficient multicast transmission of digital TV signals to a large number of viewers simultaneously. DVB-T2 has been introduced in several European countries, providing enhanced spectrum efficiency and higher-quality video delivery.

**Hybrid Broadcast Broadband TV (HbbTV):** HbbTV is an industry-standard that combines traditional broadcast TV with broadband internet connectivity, enabling interactive services and personalized content delivery. HbbTV utilizes multicast for efficient delivery of broadcast content while offering additional interactive features through unicast broadband connections. It has gained popularity across Europe, with many broadcasters providing HbbTV services to enhance the viewer experience. Some of the key features of HbbTV are Hybrid Broadcast, Broadband TV, Interactive Services, Red Button Functionality and Standardization (EBU TR 044, 2022). HbbTV has transformed the way viewers interact with television content, offering a seamless blend of traditional broadcast, and online interactivity. It provides broadcasters with new opportunities for content delivery and monetization while offering viewers a richer and more engaging television experience.

**4G LTE Broadcast (eMBMS):** Europe has been at the forefront of deploying and testing 4G LTE Broadcast, also known as evolved Multimedia Broadcast Multicast Service (eMBMS). Various European operators have conducted trials and commercial deployments of eMBMS technology. For

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example, Vodafone in Germany conducted trials of eMBMS for live TV streaming and multicast software updates. EE (now part of BT Group) in the UK also conducted trials and commercial deployments of eMBMS for live sports events and multimedia content delivery.

The project "Integration of Broadcast and Broadband in LTE/5G" (IMB5), funded by the Bavarian Research Foundation, focused on exploring the eMBMS LTE-broadcast mode and its potential improvements within two specific Single Frequency Network (SFN) field trial networks located in Erlangen and Munich, Germany( Heyn et al., 2016). The network diagram is shown in Fig.2. The project aimed to enhance the existing broadcasting feature for 4G/5G networks. For the User Equipment (UE) side of the trials, terminals provided by Qualcomm and Samsung were utilized. These terminals were based on commercial chipsets and were mainly used for conducting application layer tests. The purpose was to evaluate the performance and functionality of eMBMS LTE-broadcast using these industry-standard devices.

By conducting detailed field trials in the SFN networks and utilizing commercial chipsets in the UE terminals, the IMB5 project aimed to gain insights into the integration of broadcast and broadband technologies in LTE/5G networks, identify areas for improvement, and assess the feasibility of implementing eMBMS LTE-broadcast in practical deployment scenarios.

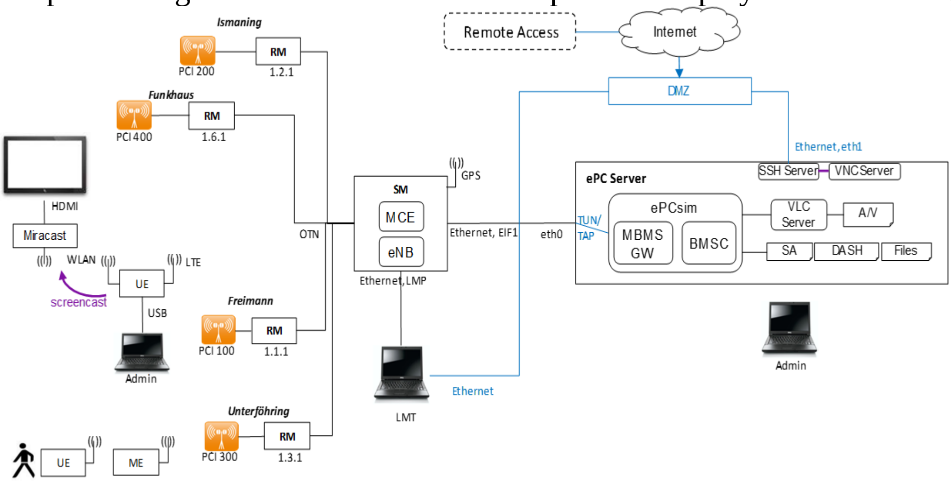


**Fig. 1** IMB5 block diagram

## 4. 5G Broadcast test projects

With the rollout of 5G networks, there is growing interest in leveraging multicast broadcast services for efficient content delivery. Several European countries and operators are actively exploring and researching 5G broadcast technology. Germany has been leading the way, with the Bavarian Research Foundation funding the 5G TODAY project, which aims to test and

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demonstrate the feasibility of 5G broadcast for delivering live TV content in the Munich region.

Several test projects have been launched in recent years, where they are the most prominent (Mi et al., 2020):

**A.** Cellnex, RTVE, Rohde & Schwarz, and Spinner team up to bring a new live mobile experience to smartphones, tablets, and a range of SIM-free devices throughout central Barcelona. The on-air signal will be transmitted on channel 56 with a 5MHz (750-755 MHz) bandwidth from the Cellnex Tower facilities in Collserola. Spinner, a global provider of filters for broadcast and mobile infrastructures, is participating in the proof of concept by providing a 5G Broadcast-based 5MHz filter for the transmitter. The content transmitted through the Broadcast/Multicast trial over 5G includes both live and delayed 4K transmissions. Live content includes the Radio 5 signal and Canal 24H.4K content is a promotional video that shows the high-quality image of the service. For network operators and content providers this experience will go to show that a whole new range of business models is now possible to deliver content or data to a large number of consumers without affecting the 5G mobile network.

**B.** The use of 5G Broadcast during the Eurovision Song Contest 2022 event showcased the potential of this technology for media distribution and audience engagement. By transmitting the signal live and in high quality from multiple sites in different European cities, it demonstrated the ability to reach a wide audience simultaneously. At the time, only a select group of users with 5G Broadcast-enabled smartphones in Paris, Stuttgart, Turin, and Vienna were able to receive these transmissions. Figure 1 illustrates the block diagram of the system used in this test, showcasing the relationship between various components. The video representation function is responsible for generating the video segments that are requested later by the eMBMS and the DASH servers. The functionality resembling eMBMS is implemented on a 5G NR radio interface. Additionally, for unicast communication, a direct connection is established between each user and the 5G base station (gNB) as required.

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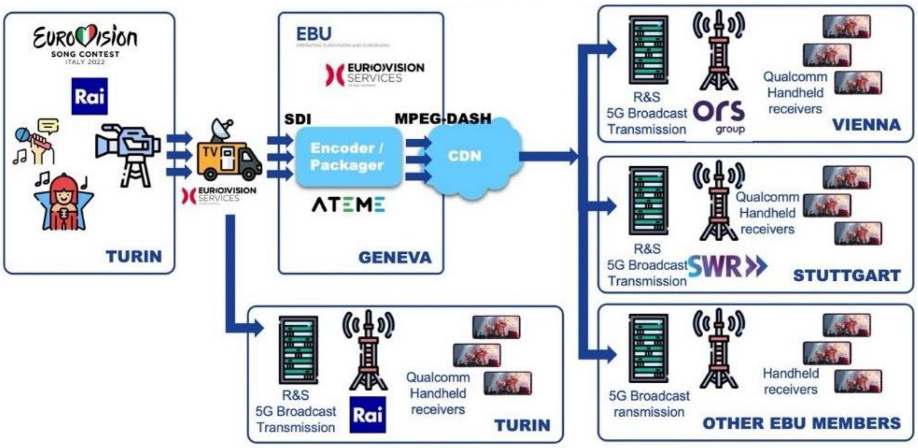


**Fig.2** Diagram of the setup for the trials involving the 4 sites (Säily et al., 2020)

**C.** 5G-XCast was a 5G-PPP Phase 2 project focused on developing point-to-multipoint (PTM) communication capabilities for 5G, primarily targeting the technical requirements of the Media & Entertainment (M&E) vertical. 5G-Xcast defined and assessed a conceptually novel and forward-looking 5G network architecture for large-scale immersive media delivery. The project focused on a holistic implementation of multicast and broadcast functionalities; a critical technology element in 5G systems and as a complement to unicast. 5G-Xcast harmonized media delivery among fixed, mobile, and terrestrial broadcast types of networks to provide an optimized and seamless media user experience.

**D.** In the UK, project ”5G RuralFirst”.Both technologies were used, Rel-12 eMBMS and LTE unicast and Rel-14/15 FeMBMS (Saily et al., 2020). The 5G Broadcast Radio trial comprised two parts; a public trial based on commercially available 4G equipment and the in-house development of a standalone ‘5G broadcast’ modem that implements the latest mobile broadcast features that weren’t available in commercial handsets.

**E.** Anotherproject was the ‘5G eMBMS Demo”in Finland (Yle et al., 2018). The main goal promoting broadcast-like services in the 5G network. Participants from media, press, ministerial, telco, EBU, etc. Multiple mobile devices receive broadcast-quality DASH streams via a 5G network in the 2.9 GHz band.

Many other projects tested in other European countries showed a coexistence with other broadcast transmission systems. Thus, in Spain, Italy, and Estonia regardless of the different types of equipment of the LTE and 5G systems. The broadcast had quite good results from the point of view of quality

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and coverage. To integrate the previous version of 5G need to develop a flexible, dynamic, and seamless switching between unicast and multicast or broadcast transmissions and the multiplexing of traffic under the same radio structures as the Garro et al. (2020) proposed. In some places with flat relief can be 5G-Xcast RAN where the new Radio Access Technology (RAT) supports dynamic adjustment of the Multicast/Broadcast geographical area based on e.g., the user distribution or service requirements (Jiménez-Soria et al., 2021).

On the application layer, it was shown that using LTE eMBMS, a flexible service mix of unicast MBB and broadcast linear TV could be delivered. For country-wide deployment of eMBMS SFN networks, physical layer waveform extensions such as an increased cyclic prefix of the currently standardized LTE signals were proposed ( Mi et al., 2020).

From a system architecture perspective, a receive-only mode enables free-to-air (FTA) reception with no need for an uplink or SIM card, thus enabling the reception of content without registration of legacy user equipment with a network. Another project result was the successful demonstration of the coexistence of LTE embus with spectrally adjacent existing broadcasting technologies DTT.

## 5. 5G Broadcast in the USA and the rest of the world

Multicast broadcast services in the USA have seen notable deployments and trials, primarily in the domain of mobile video delivery and public safety communications. One of the 5G broadcast demo examples was the U. S. Open Championship in June 2018, to used mmWave 5G cellular technology to stream 4K video for potential broadcast nationwide. AT&T provided the required spectrum to optimize the 5G performance; Ericsson provided the 5G network equipment, including radios, baseband, simulated network core, and 4K video encoder and decoder; Intel supplied the Intel® Mobile Trial Platform, working as the 5G modem or "phone. The network built for this test Fig-4 is Composition by: Compress video-convert raw UHD live broadcast camera quality video. Efficiently prepare and route the video to the 5G radio network, proving that 5G can effectively manage large volumes of data uploaded from multiple cameras. A key requirement of the trial was to upload large volumes at high speeds with extraordinarily little packet loss or degradation of quality from the transmission point to the production compound. Convert compressed data into broadcast-quality video at the on-site production compound and decode the UHD live video with no detectible loss in quality.

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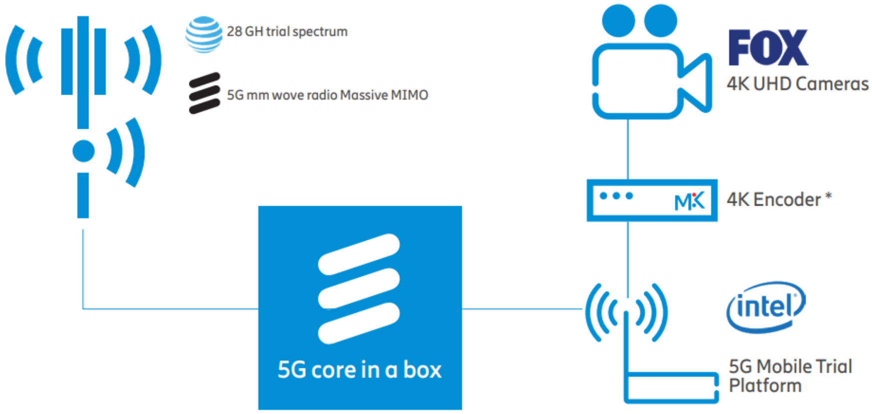


**Fig.4** 5G Broadcast Trial in U.S Open

South Korea has conducted several trials and pilots to explore the potential of 5G broadcasts. In 2018, the Korean Broadcasting System (KBS) and major telecom operators like SK Telecom, KT, and LG Uplus collaborated on a 5G broadcast trial during the PyeongChang Winter Olympics. This trial demonstrated the efficient delivery of live UHD (Ultra High Definition) content to multiple devices using 5G broadcast technology.

Ecosystem and Partnerships: South Korea's 5G broadcast initiatives involve collaboration between broadcasters, telecom operators, equipment manufacturers, and other industry stakeholders. Partnerships between broadcasters (such as KBS, SBS, MBC) and telecom operators (SK Telecom, KT, LG Uplus) have been established to evaluate and develop 5G broadcast services. Equipment manufacturers and technology providers contribute their expertise in developing 5G broadcast solutions.

China Telecom's "Hello 5G" project, launched in 2018, aimed to build a comprehensive 5G ecosystem that fosters innovation and enables the implementation of advanced applications. This ecosystem encompasses various domains, including artificial intelligence, drones, autonomous driving, precise positioning, and virtual reality (VR) in stadiums.

In April 2018, a significant milestone was achieved when the first flight of 5G drones was successfully demonstrated in Shenzhen. This demonstration highlighted the real-time transmission of 360-degree panoramic 4K HD video over a 5G network. This achievement highlighted the low latency and high bandwidth capabilities of 5G, which are crucial for applications such as drone operations.

Furthermore, in 2019, China Telecom conducted a real-time 4K live broadcast of the Spring Festival Evening in Shenzhen using 5G networks. Additionally, in Beijing, a VR-convergedmultimedia live broadcast was conducted over 5G, demonstrating the potential of 5G in enhancing multimedia experiences.

## 6. The future of 5G broadcast

The future of 5G broadcast holds exciting potential for delivering high-quality multimedia content, improving efficiency, and enabling new use cases. There are still some key aspects that could shape the future of 5G broadcast:

***Enhanced Mobile Multimedia***: 5G broadcast can significantly enhance mobile multimedia experiences by enabling high-quality video streaming, immersive virtual reality (VR), augmented reality (AR), and gaming services. With its higher capacity and lower latency, 5G can support the seamless delivery of immersive and bandwidth-intensive content to a large number of users simultaneously.

***Efficient Content Delivery:*** 5G broadcast can optimize content delivery by enabling one-to-many transmissions. Instead of unicasting the same content to multiple users, 5G broadcast allows for efficient distribution to multiple devices simultaneously, reducing network congestion and conserving resources.

***Cost and Spectrum Efficiency:*** Broadcasting content over 5G networks can offer cost and spectrum efficiency benefits. By leveraging broadcast technologies, operators can deliver popular content, such as live sports events or breaking news, to a wide audience without requiring individual unicasts. This can reduce network traffic and the associated costs while utilizing the available spectrum more efficiently.

***Public Warning Systems:*** 5G broadcasts can play a crucial role in public warning systems. It enables the simultaneous distribution of emergency alerts, disaster notifications, and safety-related information to a large number of users within a specific area. This can improve the effectiveness and timeliness of critical communications during emergencies.

***Internet of Things (IoT) Applications:*** 5G broadcast can support IoT applications that require efficient and scalable content distribution. For example, in smart cities, 5G broadcasts can be utilized to disseminate information to a large number of connected devices, such as traffic signals, streetlights, and sensors, enabling synchronized updates and real-time data sharing.

***Content Delivery to Vehicles:*** 5G broadcast can enhance in-car entertainment and information services by enabling the delivery of live content, including high-definition video, music, and real-time updates, directly to vehicles. This can provide a seamless and personalized entertainment experience for passengers, reducing the reliance on individual data connections.

The future of 5G broadcast will depend on the industry's adoption and standardization efforts. As technology evolves and market demands shape the landscape, further advancements, and refinements in 5G broadcast capabilities are expected, unlocking new possibilities for content delivery, user experiences, and innovative applications.

**Conclusion and recommendations**

This paper first gives a brief overview of 5G broadcast. It has the potential to revolutionize content delivery and enhance user experiences in several ways. 5G broadcast will depend on numerous factors, including industry collaboration, standardization efforts, regulatory considerations, and the market demand for such services. While the potential benefits are promising, the actual deployment and utilization of 5G broadcasts may vary across regions and operators. Several pilot projects around the world have demonstrated that 5G broadcast offers the possibility to radically transform broadcast transmission.

MBS is on an interesting journey of technical progress, standardization, and market deployments within the 5G ecosystem. The Future releases of 5G are expected to bring advancements in the areas mentioned, enabling new capabilities, and enhancing the overall MBS experience. This review also highlights the possibility of integration of existing digital broadcast technologies with 5G Broadcast. However, some recommendations derived from the literature and research papers (Jokela et al., 2020; Ahn et al., 2023; Silhavy et al., 2023; González et al., 2023), and the study of running projects and technical data can be noted:

- Broadcasters, content providers, and network operators should collaborate to explore and develop innovative 5G broadcasting solutions. Joint efforts can lead to the creation of compelling and immersive content experiences.
- Continued investment in 5G infrastructure is crucial to support the bandwidth and low latency requirements of broadcasting. Governments, regulators, and industry stakeholders should prioritize the development of robust 5G networks to ensure reliable and high-quality broadcasting services.
- Standardization bodies and industry organizations should work together to establish common standards for 5G broadcasting. This will enable interoperability, seamless content delivery, and consistent user experience across different networks and devices.
- Conducting research and experimentation with 5G broadcasting technologies is essential for exploring its full potential. Industry

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players should invest in research initiatives, pilot projects, and trials to uncover new use cases and best practices.

- As with any technology, ensuring user privacy and security is crucial. Industry stakeholders should prioritize the implementation of robust security measures and privacy frameworks to protect users' data and maintain trust in 5G broadcasting services.

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