Introduction to

5G Broadcast

Direct-to-mobile

A Future of Efficient and Accessible Content Delivery

By:

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Abstract

This paper explores the transformative potential of 5G Broadcast (5GB) technology, a new platform to deliver content directly to smartphones, CPE (customer premises equipment) or any other smart device with a 5G modem chip (5GB enabled). 5G Broadcast is a standalone technology that works independently of cellular services (i.e. without an eSIM/SIM card), WIFI, Bluetooth or satellite. Since broadcast is a one-way communication standard utilizing phones/devices set to 'receive-only' mode, unlike traditional internet downloads (unicast), 5G Broadcast utilizes a one-to-many approach, like TV and radio broadcasts ensuring efficient content delivery, freeing up valuable network resources and paving the way for exciting applications.

This paper provides an overview of 5G Broadcast technology, its applications, and its potential to add a new layer to content delivery. Additionally, it introduces the 5G Broadcast Collective, a non-profit association launched by XGN. The paper highlights the technical underpinnings of 5G Broadcast, including the role of FeMBMS (Further evolved Multimedia Broadcast Multicast Service) and the importance of 3GPP's standardized approach. Further it delves into the benefits 5GB offers, including:

- Emergency alerts and critical first responder solutions
- Data delivery services
- Data offloading opportunities for cellular carriers
- Support for diverse applications beyond entertainment, including location-based services.
- Improved traditional linear programming streams (television and radio)

Finally, the paper acknowledges the technology's current stage of development and highlights its promising future as a game-changer for efficient mobile content consumption.

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Introduction

In the landscape of telecommunications, 5G Broadcasting (5GB) stands as a transformative force, poised to elevate how we experience connectivity. This cutting-edge technology represents the fifth generation of wireless networks, promising unprecedented speed, reliability, and capacity.

5G Broadcast (5GB) is a super-efficient protocol for the mobile age and provides existing broadcasters with the game changing ability to deliver content direct-to-mobile (D2M). Instead of each phone requesting the same data stream individually (one-to-one approach i.e. unicast), 5G Broadcast sends a single, high-powered signal out to a broad area (one-to-many approach), just as TV and radio stations work. This one-to-many approach is the secret sauce. This means content gets sent out to a large audience all at once, making it efficient and freeing up valuable network resources for other uses. It ensures that everyone receives content, be it a live concert or sporting event, breaking news, etc. in crystal-clear quality, without straining the limited available bandwidth of traditional networks.

At its core, 5G Broadcasting harnesses the power of advanced networking architectures utilizing the latest software technology such as H.265 (and AV-1 in the near future) compression [8], to deliver lightning-fast data rates with minimal latency. This enables a myriad of applications, from critical first responder solutions to live event broadcasting and smart city infrastructure.

The benefits extend far beyond entertainment. 5GB enables you to receive life-saving emergency alerts, even if your phone is out of data or outside of cellular coverage ensuring critical information gets through, potentially saving lives. It can also be used for essential software updates, public transport updates, and emergency signage notices that are relevant to your location. As we embark on this era of unprecedented digital evolution, 5G Broadcasting stands as a beacon of progress, poised to revolutionize the way we engage with the world around us.

Throughout this paper, the term "Low-Power Television (LPTV)" refers specifically to LPTV stations operating in the United States. It's important to note that the maximum Effective Radiated Power (ERP) for UHF LPTV stations in the US is currently 15 kW. This contrasts with some European regulations, where stations with much lower power might be classified as full-power stations.

5G Broadcasting

3GPP has been supporting broadcast/multicast technology since the days of 3G, however the service did not achieve great success due to low media consumption using mobile devices at the time. Relevant work has been progressing from 3GPP's Release 9 through Release 16.

5G Broadcast is a global terrestrial broadcast standard that was completed in 2020 as part of the 3GPP Release 16 specifications. It added enhanced features to the initial enhanced TV (enTV) standard that was part of 3GPP Release 14. 5G Broadcast has been endorsed as a standalone terrestrial broadcast system via ETSI TS 103 720 technical specification and most recently by ITU-R where it is defined as a worldwide standard within ultra-high frequency (UHF) band. 5G Broadcast meets all broadcast requirements defined in 3GPP TR 38.913. This section explores the underlying technology, referencing the latest specifications from the 3rd Generation Partnership Project (3GPP).

Technical Specifications (3GPP Release 16)

The 3rd Generation Partnership Project (3GPP) is a consortium that defines the technical specifications for mobile communications technologies. When it comes to 5G Broadcast, 3GPP plays a crucial role in establishing the standards for its implementation; The single universal specifications for 5G Broadcasting ensures seamless operation and global compatibility. Here are some key aspects:

- **Evolution, not Revolution:** 3GPP didn't create a whole new system for 5G Broadcast. Instead, it builds upon existing technologies like Evolved Multimedia Broadcast Multicast Service (eMBMS) used in 4G networks. This approach leverages familiar ground while introducing enhancements for the 5G era, thus giving rise to FeMBMS.
- **Focus on Multicast and Broadcast Services:** 3GPP's vision for 5G Broadcast prioritizes delivering content efficiently to large audiences. This aligns with applications like live streaming, emergency alerts, and software updates, where a single transmission needs to reach many devices simultaneously.
- **Opening the Door for Diverse Applications:** 3GPP's focus isn't limited to traditional media like TV broadcasts. The specifications enable a wide range of applications, including public

safety alerts, targeted advertising, and content delivery networks (CDNs) that can leverage 5G Broadcast for efficient content distribution.

- **Spectrum Considerations:** 3GPP has approved the use of the Band 108 (470MHz-698MHz) and Band 107(612-652MHz) which aligns with existing UHF television frequencies used worldwide by broadcasters. In the US, broadcasters are restricted to Channels 14 through 36 which represents frequency range of 470-608MHz, a subset of Band 108.
- **Cyclic Prefix Extension**: To improve reception in challenging signal conditions, 5G Broadcasting signals leverage the Cyclic Prefix extension feature. This technique adds a redundant signal at the beginning of each data packet, allowing the receiver to compensate for signal delays and improve reception quality (details in 3GPP technical documentation).

5G Broadcasting technology offers a compelling solution for delivering content with exceptional efficiency and minimal network strain. Its ability to reach wider audience, reaching multiple types of devices, positions it as a game-changer in the mobile-driven future.

DTS (Digital Transmission Systems)

SFN (Single Frequency Network) in Broadcasting

An SFN, or Single Frequency Network, is a group of broadcast transmitters in a particular area that all transmit the same signal on the same frequency. This is beneficial for broadcasters since it provides improved coverage. By using multiple transmitters operating on the same frequency, SFNs fill in signal gaps and extend coverage to areas with challenging terrain or signal reception issues.

Potential drawbacks:

- **Potential for Interference:** If not properly designed and implemented, SFNs can create interference for other broadcasters using the same frequency in nearby areas. The FCC has strict regulations for SFN deployment to minimize this risk.
- **Coordination Challenges:** Operating an SFN requires careful coordination between all the transmitters to ensure they are synchronized and transmit the same signal with minimal delay.

In the USA, SFNs are categorized as DTS by the FCC. Here are a couple of potential reasons for this classification:

- **Technical Similarities:** SFNs are a type of DTS, using multiple transmitters to deliver a signal to a wider area. In an SFN, all transmitters broadcast the same exact signal simultaneously.
- **Regulatory Oversight:** The FCC wants to ensure that all broadcast operations comply with spectrum usage regulations and minimize interference with other broadcasters. Classifying SFNs as DTS allows the FCC to apply specific regulations and require broadcasters to demonstrate that their SFN design will not cause interference.

Overall, SFNs offer broadcasters a way to improve coverage and potentially reduce interference. The FCC classifies them as DTS since this classification helps ensure that SFNs are deployed responsibly and do not disrupt other broadcast operations.

Band 108 (Band 107 FOR EUROPE)

Band 108, as defined by 3GPP, refers to a specific range of radio frequencies on the electromagnetic spectrum, between 470 MHz and 698 MHz. 3GPP authorizes the use of Band 108 for the purpose of 5G Broadcasting.

The objective of defining Band 107(612-652MHz) is that it can fully reuse the RF components of B71, therefore requiring zero additional hardware on the devices. Thus, B107 is a potential 1st step in deployments in some markets (e.g. Europe).

Important to note:

- In US, broadcasters are restricted to the highest frequency of 608MHz.
- Each country has its own distinctive spectrum allocation. In the United States, broadcasters are designated a 6MHz bandwidth, whereas other nations exhibit a broad range for spectrum allocation.

FeMBMS (Further evolved MBMS)

At the heart of 5G Broadcasting lies FeMBMS (Further evolved Multimedia Broadcast Multicast Service). 3GPP has been supporting broadcast/multicast technology since the days of 3G (more specifically, UMTS (Universal Mobile Telecommunications Service). MBMS was devised to offer

both broadcast and multicast service over the 3G network. However, the service did not achieve great success due to low media consumption using mobile devices at the time.

With 4G Evolved Packet System (EPS), the MBMS system was enhanced to leverage the strengths of LTE, such as Orthogonal Frequency Division Multiplexing (OFDM) and the relevant work has been progressing from Release 9 through Release 16. To distinguish with the MBMS of UMTS, the enhanced MBMS leveraging 4G networks is called eMBMS (evolved MBMS) or FeMBMS (Further evolved MBMS) depending on the release (14 or later for the latter).

The architecture of eMBMS (and FeMBMS) different from MBMS in that there are more entities than BM-SC to support eMBMS, namely Multi-cell/multicast Coordination Entity (MCE) and MBMS Gateway (MBMS-GW). In Release 14, more features were introduced to enhance eMBMS and the eMBMS since Release 14 is usually referred to as FeMBMS in the industry. Furthermore, in FeMBMS, the architecture was enhanced to support the requirements of TV services to be carried over E-UTRAN.

Advantages of 5G Broadcasting

5G broadcasting holds immense promise for revolutionizing the way we consume and deliver media content. This groundbreaking technology offers several advantages that can significantly enhance the broadcasting experience for both broadcasters and viewers alike. It presents a unique opportunity for TV broadcasting stations to reach a wider audience and remain abreast of the ever-evolving technological landscape.

Universal Standard

Single Global Standard: Unlike other protocols that offer various options, 3GPP has established a single, unified standard for 5G Broadcast worldwide. This simplifies integration and ensures compatibility between broadcasters' equipment and hardware from different manufacturers.

Increasing revenue

- **Efficient Spectrum Utilization**: 5GB optimizes spectrum utilization through usage of modern compression techniques such as H.265 and H.266 which is currently not supported by traditional broadcasting. This enables broadcasters to deliver more content

over the same frequency bands, maximizing spectral efficiency i.e. since 5GB reduces the bandwidth requirements for the same stream, broadcasters can create many more subchannels within the same frequency bandwidth.

- **Monetization Opportunities:** This creates new monetization opportunities for broadcasters through targeted services while ensuring support for the coexistence of multiple services and applications.

Reaching New Viewers:

- **Mobile-First Audience:** Unlike other protocols, 5G Broadcasting can be received directly by any device with a 5G broadcast enabled modem chip, reaching a considerably wider audience. Traditional TV viewership is declining, especially among younger demographics who rely heavily on mobile devices. 5G Broadcasting allows broadcast stations to deliver content directly to smartphones and tablets, capturing this mobile-first audience.
- **Multi-Platform Delivery**: 5GB supports multi-platform delivery, allowing content to be seamlessly distributed across various devices and networks, including smartphones, tablets, smart TVs, and IoT devices. This enables viewers to access content anytime, anywhere, and on any device, ensuring a seamless and consistent viewing experience across platforms.
- **Improved Accessibility**: 5GB expands access to media content by reaching underserved or remote areas with limited infrastructure. Its robust coverage and penetration capabilities enable broadcasters to deliver content to a wider audience, including those in rural communities or areas with poor connectivity.

Leveraging Existing Assets:

- **Infrastructure Advantage:** TV stations already have established broadcast towers and transmission equipment. 5G Broadcasting utilizes the current infrastructure with the change of the modulator/exciter, minimizing the need for significant additional investments.
- **Spectrum Efficiency:** 5G Broadcasting utilizes the UHF spectrum currently used by TV broadcasters, making the transition smoother.

Cost-Effectiveness:

Lower Barrier to Entry: 5G Broadcasting offers a cost-effective way to reach mobile viewers since, in most cases, it requires only the modulator-exciter to be upgraded.

Competition:

Filling a Gap: While there are competing technologies for broadcasters, some TV stations might find 5G Broadcasting a more accessible option due to the smart phone compatibility and potentially lower upfront costs.

5G broadcasting represents a transformative leap forward in the broadcasting industry, offering unparalleled opportunities for broadcasters to deliver high-quality, immersive, and personalized content experiences to audiences worldwide. As this technology continues to evolve and mature, its impact on the media landscape is poised to be profound and far-reaching.

Current Advancements

XGN (XGen Network) has been the frontrunner in the field of 5G Broadcasting in the US. With strong belief in 5GB technology, we have been hard at work to demonstrate and prove its efficacy.

- On September 13, 2023, XGN launched WWOO, in partnership with Malachi Media, the world's first 24/7 5G Broadcasting station. Located in Boston Massachusetts and operating under experimental license from FCC (the broadcast regulating agency in USA), the proof of concept featured a streaming channel and demonstrated the delivery of emergency alerts to smartphones within ½ second. It also included a 5G Broadcast SDR receiver providing a pristine 1080p signal at 1400 kbps, using Ateme Encoder, to a 65-inch television.
- Sep 14th , XGN demonstrated Live 5G Broadcasting and Emergency Alerts Direct to Mobile.
- October 13th marked a huge milestone as XGN launched the world's first solution for 5G Broadcast to be received by the general public using a SDR (software defined radio).
- On November 2, 2023, XGN presented the first proof of concept to the FCC (Federal Communications Commission), the broadcast regulating authority in USA.
- At NAB Las Vegas 2024, XGN showcased modulator/exciter with receiver devices to demonstrate live 5G Broadcasting Direct to Mobile, utilizing an SDR (software defined ratio) based modulator/exciter, transmitting over UHF channel 28. Working on 3GPP's Release 16 it utilized the FeMBMS protocol and Band 108. On the receiver side XGN showcased smartphones and CPE (Customer Premises Equipment) enabled to receive 5GB signals on channel 28 in partnership with Qualcomm.

- With the intentions of propelling 5GB forward and accelerating its development and adoption XGN also launched 5G Broadcast Collective(5GBC), a non-profit association to assist broadcasters transition to 5GB. 5GBC handles the business and marketing end for everything related to 5G Broadcast while XGN provides solution oriented technical support for 5GB demonstrations worldwide. This non-profit provides a collaborative platform for broadcasters, vendors, and enthusiasts to band together to transform the world of broadcasting.
- Given the growing interest, most major transmitter manufacturers are working on developing solutions geared towards 5G Broadcasting.

Use-cases

Broadcast technology has historically served the public good by providing services ranging from delivery of Emergency alerts to news media and distance learning. 5G Broadcast carry forwards the lineage with a technologically advanced approach relevant to today's needs.

- **Emergency Alert System (EAS):**
    - **Emergency Alerts (EAS in USA):** 5G Broadcast offers a massive upgrade to the system by ensuring instantaneous alert delivery, within ½ a second to all users as compared to current 30 seconds, with markedly high accuracy. Also, 5GB will enable the alerts to be Geo-targeted for enhanced efficiency.
    - **Global EAS:** The biggest advantage of 5G Broadcast in the single global standard defined by 3GPP. The single standard presents a unique opportunity for all countries to utilize a standard emergency alert system, thus ensuring emergency alerts to be received by users even when travelling outside of their home country.
- **First responders:**
    - **Emergency Backup:** In an emergency scenario where cell services and internet go down, 5GB provides the backup channel of communication. Alleviating network congestion by offloading data/services to 5GB would ensure first responders receive crucial information for their effective actions.

  - **Emergency deployment:** In various situations like extreme weather emergency services have to be deployed in areas of either inadequate or compromised communication setup.

- **Data Delivery:** 5G Broadcasting presents a unique opportunity for Mobile Network Operators (MNOs) to address network congestion through content offloading, utilizing broadcasting infrastructure. By leveraging broadcast stations' infrastructure, MNOs can offload specific data streams, such as software updates, emergency alerts, or frequently accessed public information, to the 5G Broadcast network.

  - **Reduced Network Strain for MNOs:** Offloading specific data traffic to the 5G Broadcast network frees up valuable resources on MNOs' data networks. This can significantly improve network performance and user experience for subscribers accessing critical services or real-time content.
  - **Expanded Service Potential for Broadcasters:** Broadcasters can evolve from sole content providers to data service providers. This opens new revenue streams by offering their infrastructure for data transmission services.
  - **Enhanced Consumer Experience:** Consumers benefit from a more reliable and efficient mobile network experience due to reduced congestion on MNOs' data networks.

- **Traditional TV Broadcast:** 5GB allows the use of the latest encoding and compression standards such as H.265 (and H.266/AV1 in future) which reduces the bandwidth requirements for the transmission of the same stream, thus allowing much higher resolution content to be transmitted using much lower bandwidth. This enables traditional broadcasters to considerably increase the number of subchannels that they operate using the same frequency bandwidth.
- **Distance Learning/ Public good:** Beyond commercial applications, 5G Broadcast (5GB) offers significant potential for public benefit content delivery. Governments can leverage this technology to disseminate critical information during emergencies or for educational purposes. For instance, during the COVID-19 pandemic, the Indian government launched free educational channels broadcasting live and recorded classes for students at all levels.

5GB technology facilitates the deployment of significantly more such channels while maintaining efficient bandwidth utilization. Through the 5G Broadcast Collective (5GBC), stakeholders can collaborate on content creation and distribution strategies to maximize the impact of 5GB for public good.

- **Connected cities:** Every device today, from cars to doorbells, comes equipped with a silicon chip inside it. With advent of 5G Advance devices such as 5G CPE's providing a single box for universal connectivity will allow for connected cities, having miniature transmitters placed all over the city and providing high speed high reliance connectivity to vehicles and smart devices at the same time.

Challenges and Considerations

- **Early-Stage Technology:** 5G Broadcasting is still under development. While trials are ongoing, widespread adoption by both broadcasters and mobile device manufacturers is still in the future, the initial rollout being in the near future.
- **Device Compatibility:** Currently, not all smartphones have the necessary hardware to receive 5G broadcasts. Consumers need to wait for future phone models with updated software and chipsets, filtered to receive 5GB frequencies.
- **Content Strategy:** Stations will need to develop a compelling content strategy that caters to a mobile audience with shorter attention spans and a preference for on-demand content.
- **Regulation and Standards:** Regulatory frameworks and technical standards for 5G Broadcasting are still being finalized.

Opportunities

5G Broadcasting presents interesting investment opportunities, particularly in the U.S. for strategically purchasing LPTV stations. With 6 MHz of bandwidth, this is by far the least expensive beachfront spectrum available by multiples. This is an investment for the future and generally does not produce cash flow right now. However, if history is our lesson, this spectrum's value could increase multi-fold when widely deployed. XGN is working with investment groups to identify opportunities and assist in the operation and deployment of 5G Broadcast networks and solutions.

There are also opportunities in the development of both the hardware and software technologies plus solutions for 5G Broadcasting.

XGN works with clients worldwide to explore opportunities suited to the individual investor interests.

Conclusion

5G Broadcast stands at the precipice of a revolution in how we access information and consume content on the go. Its ability to deliver high-quality content efficiently, without data plans, opens doors for a multitude of possibilities. From seamless live streaming and emergency alerts to targeted advertising and niche programming, 5G Broadcast has the potential to reshape the mobile content landscape.

While 5G Broadcast technology is still in its early stages, the groundwork has been laid for its future success. Standardized approaches by organizations like 3GPP ensure global interoperability, and advancements in network infrastructure will further unlock its potential.

For U.S. Low-Power Television (LPTV) stations, 5G Broadcast presents a unique opportunity to transcend limitations and reach wider audiences. By leveraging this technology, LPTVs can become stronger voices within their communities, offering a platform for local content and fostering a sense of connection.

Looking ahead, 5G Broadcast holds immense promise for broadcasters, content creators, and viewers alike. As technology matures and infrastructure expands, we can expect a future where content is delivered efficiently, accessible to all, and tailored to individual needs. 5G Broadcast is not just a technological advancement; it's a step towards a more connected and informed experience for everyone.

Appendix

Abbreviations

1. 5GB: 5G Broadcasting
2. 5GBC: 5G Broadcasting Collective
3. FeMBMS/Fe-MBMS: Further evolved Multimedia Broadcast Multicast Services
4. eMBMS: Evolved Multimedia Broadcast Multicast Services
5. MBMS: Multimedia Broadcast Multicast Services
6. PBCH: Physical Broadcast Channel
7. PDCCH: Physical Downlink Control Channel
8. PDSCH: Physical Downlink Shared Channel
9. DTS: Distributed Transmission System
10. SFN: Singe Frequency Network
11. LPTV: Low Power Television (US UHF stations with a ERP of a maximum of 15kw)
12. UMTS: Universal Mobile Telecommunications Service
13. 5GC: 5G Core
14. 5GS: 5G System
15. E-UTRAN: Evolved UTRAN
16. UTRAN: UMTS Terrestrial Radio Access Network
17. EPS: Evolved Packet System
18. 3GPP: Third Generation Partnership Project [link]

Useful Links

1. 5G-MAG: https://www.5g-mag.com/
2. 3GPP Release 16: https://www.3gpp.org/specifications-technologies/releases/release-16
3. XGN Network: https://www.xgn.network/
4. 5G Broadcast Collective: https://5gbc.tv
5. Rules Governing the Use of Distributed Transmission System: https://docs.fcc.gov/public/attachments/DOC-362933A1.pdf
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