THE BROADCAST BRIDGE
Connecting IT to Broadcast

Mass Audience Broadcasting To Mobile With 5G Broadcast

Essential Guide

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Introduction

By Tony Orme, Editor at The Broadcast Bridge

Internet streaming has given us a hint of the future as it allows viewers to watch what they want, how they want, and when they want. Unfortunately, the limitations of internet delivery through its underlying technology often results in a poor quality of experience for the viewer, especially when watching large audience live events. However, a new type of technology, 5G-NR, is providing traditional broadcasting techniques to greatly improve the viewing experience even for high quality 4K and 8K services.

One of the challenges of internet streaming is that it doesn't scale well. And in the context of viewers watching live content, when a threshold of viewers is reached, the quality of experience degrades significantly for many of the viewers, not just those that has most recently joined. This is an unfortunate consequence of the HTTP/TCP/IP delivery mechanism that forms a fundamental component of internet delivery and changing it almost impossible.

Although solutions including CDN and server scaling exist and have gone a long way to help with the quality of experience, there will always be a natural limit based on the number of viewers, and when this is reached, the viewing experience will be compromised. Up until the adoption of live streaming over the internet, broadcasters never suffered from this problem, mainly because broadcasting from a transmitter serves all viewers within the RF pattern equally regardless of their number.

5G-NR consists of multiple services that solve specific applications. For example, mMTC (Massive Machine Type Communications) provides services to connect high volumes of devices together at relatively low datarates, as found with IoT (Internet of Things). But the mode broadcasters are most interested in is FeMBMS (Further Evolved Multimedia Broadcast Multicast Service), as it allows transmitters to send signals directly to all devices, similar to the traditional television broadcast method. Consequently, the quality of experience for the viewer is not influenced by the number of mobile viewing devices or smart TVs.

FeMBMS is a massive breakthrough for broadcasters as they do not need to rely on scalable internet delivery to deliver high quality 4K and 8K media to the viewers mobile devices or smart TVs. Media can be transmitted either encrypted or in the clear, thus opening the doors for Pay-TV and public broadcasting solutions. Furthermore, the commercial model can be based on a per-event type costing, or monthly and yearly subscriptions. This in part is due to the back-channel HTTP/TCP/IP link that is still available within the viewers device to facilitate internet connectivity and hence, multiple subscription models.

5G-NR provides the best of all worlds, a high datarate and low latency media broadcast method using FeMBMS, combined with HTTP/TCP/IP internet connectivity for lower peaky datarates typical of those found when downloading web pages to provide interactive information and subscription validation.

Tony Orme.

Television almost seems to have come a full circle as telcos, through initiatives such as 5G-NR with FeMBMS, are broadcasting to mobile devices and smart TVs similarly to traditional RF broadcasts. However, the potential for a greatly enhanced interactive viewing experience is massively improved due to all the extra features and modes 5G-NR has to offer. This will not only improve the viewers quality of experience, but also provide broadcasters with many more commercial opportunities to meet the needs of their audiences.

Tony Orme
Editor, The Broadcast Bridge

Mass Audience Broadcasting To Mobile With 5G Broadcast

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Viewers are making clear that they want to watch live events from their mobile devices as well as from the comfort of their own homes. Although internet streaming has given us a hint of what is achievable, its inability to scale to meet viewing demands is its Achilles' heel leaving viewers frustrated and in need of a better solution.

Internet streaming is fundamentally flawed when we try to scale. Every device requiring streamed media demands chunks of data from media servers resulting in a resource-heavy delivery system.

Adding a viewer's device to a streamed event makes a specific demand on the internet infrastructure, and when this reaches a certain tipping point, all users are affected and suffer a significant degradation in the quality of their signal and hence experience. 5G-NR solves these challenges to greatly improve the viewer experience and provide higher quality services such as 4K and 8K streaming. This in part is due to the broadcast capabilities that allows 5G-NR to send media directly to a mobile device regardless of the number of viewers watching the service.

Mobile data has traditionally used the unicast method of delivery. This works particularly well for web page type applications but is flawed when we consider large file downloads and media streaming. To work with the internet, traffic must be TCP/IP compliant, and when web pages are used, they must be HTTP/TCP/IP compliant. This is one of the fundamental challenges we have with streaming media and downloading large files over the internet. Although the TCP/IP provides guaranteed delivery for IP packets, it does so at the great expense of variable latency.

Latency has been gaining a lot of interest in recent years as broadcasters are seeing massive delays when streaming media over the internet, sometimes more than 60 seconds. The unicast restrictions that are manifested by TCP/IP, combined with the multitude of video and audio chunking buffers that are required, all contribute to the latency.

Broadcasters have historically not had to contend with this type of latency as there has always been sufficient RF bandwidth available for true one-to-many transmission over the airwaves. However, as the popularity of internet streaming continues to grow, new methods of delivering large volumes of content to viewers is required. To achieve this, the 3GPP consortium created the MBMS (Multimedia Broadcast Multicast Service), the eMBMS (Evolved MBMS) and then the FeMBMS (Further Evolved MBMS).

The MBMS system is a one-to-many efficient broadcasting feature that is an alternative to the unicast method of operation and was originally provisioned by the 3GPP consortium in release 5 back in 2015. Multiple international tests and technology demonstrations have taken place, but the fixed allocation of bandwidth that could be provided for both 3G and 4G meant its take-up was limited.

5G Overview

5G-NR is a combination of four technologies that are defined as: eMBB (Enhanced Mobile Broadband, mMTC (massive Machine Type Communications), URLLC (Ultra-Reliable Low-Latency), and eMBMS (Evolved Multimedia Broadcast and Multicast Services). 5G implementation is advancing as more parts of the specification are deployed to the network.

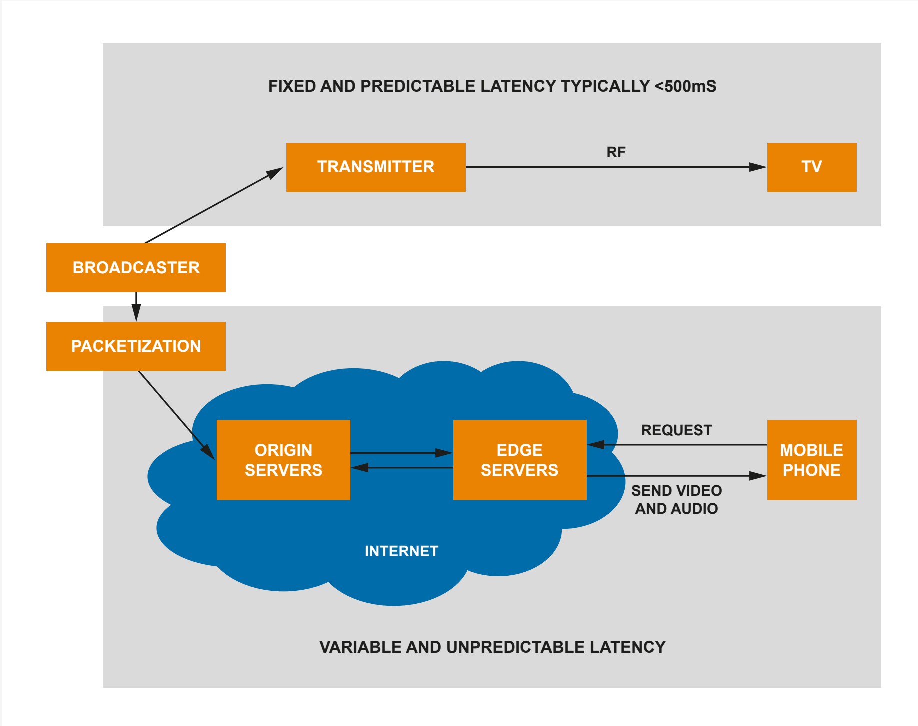

Figure 1 – traditional broadcasting workflows kept latency to below 500 milliseconds, mainly due to the one-to-many transmission that the uncontested RF allowed. However, delivery over the internet greatly increases latency and makes it unpredictable due to the influences of TCP/IP and video and audio chunking, and the effects this has on buffers.

eMBB is designed for high data rate applications and is seen as an advance on the 4G LTE mobile services, but with much higher bandwidth, data throughput, and reduced latency. The key objectives of eMBB are to provide a seamless user experience with greater coverage and faster data speeds, and it provides three main use cases: allow data access to a dense collection of users, provide data for highly mobile users, and deliver to users spread over wide areas.

Peak download datarate is 20Gbs with upload datarate of 10Gbps, and for 95% of the time, 100Mbps should be achieved. The data capacity of the network is 10,000 times that of 4G with coverage at approximately 10 Mbps/m2, and high-speed mobility is available with mobile devices moving up to 500Kmph.

As an example, in a sports stadium we would have tens of thousands of stationary supporters, but at the opposite extreme, in a train for example, there would be much fewer viewers watching events travelling very fast. The ultimate goal for eMBB is that users can get connected and stay connected as they move within the eMBB network.

Connectivity is improved so that users do not have to consistently hop from the network to private WiFi as is often the case with current 4G technology.

Trading Resource

mMTC caters for high volumes of connectivity as expected with IoT (Internet of Things) but a relatively low datarates. Device connection density is in the order of 1,000,000 devices per square kilometer, but with a low datarate in the order of 1 to 100Kbps. The device density is approximately ten times more than 4G. Long range is supported with long device battery life so that large numbers of IoT devices can be deployed that regularly transmit small amounts of data. The expectation is that the battery life of a 5G connected IoT device will be up to ten years.

URLLC is provisioned for mission critical applications where the short scheduling intervals of the packets will deliver latencies in the order of 62.5uS at the physical layer. It provides an air interface latency of less than 1ms and a 5ms end to end latency between the user equipment and 5G-NR the base station. Medium to low data rates of approximately 50 kbps to 10 Mbps are provisioned.

Although 5G-NR may have some analogies to 4G LTE, it's unfair to suggest 5G-NR is merely faster 4G as it provides more use cases than the LTE standard. The eMBB, mMTC, and URLLC all combine to provide a system that is future proof and will meet our needs for many decades to come. Other differences include the variable subcarrier spacing and use of bandwidth parts in the frequency allocation, both of which deliver higher data throughput with lower latency.

Two frequency ranges are currently defined for 5G – FR1 and FR2. FR1 covers the range below 6GHz, and FR2 has a range up to 60GHz, although some countries have the option of using UHF frequencies that are being released from broadcast television. The FR2 range makes provision for the millimeter wavelength spectrum to deliver the high data rates with ultra-low latency, however, this is at the cost of much reduced range of a few hundred meters and the inability to penetrate walls in buildings.

To achieve the lower latencies of less than 1mS, it's fair to say that we will need to use the higher FR2 millimeter frequency ranges. However, this does not preclude our ability to use URLCC at the lower FR1 frequencies. 5G is a completely managed and dynamic network that automatically allocates frequencies, bandwidth, and latency on demand, depending on the user demand.

Software Defined Networking

Network slicing is at the core of the 5G-NR network architecture and describes the ability of the operator to portion slices of the network based on the specific customer use case, thus moving away from the "one size fits all" of the preceding 2G, 3G, and 4G network solutions. In the same way that a nations transport system trades speed, cost, and convenience, allowing the user to choose the optimal transport method for their journey, the network slicing solution allows users to trade latency, bandwidth, and cost. Not only does this provide greater optimized user choice, but it also makes much more efficient use of the available network resource.

Multicast specifically provides a streaming method for broadcasting of scheduled content, such as sports events. The inherent reliance of the world wide web on HTTP/TCP/IP delivery makes multicasting almost impossible. However, with 5G-NR, multicasting can now be achieved. A subtle difference exists between broadcast and multicast, and that is broadcast will send the content to all users whether they want it or not, whereas multicast only makes the content available to subscribers of the service. 5G-NR and FeMBMS can facilitate both these methods. And in broadcast mode, this is analogous to traditional television broadcasting as a one-to-many delivery method is available.

FeMBMS also provides the full spectrum of HPHT (High Power High Tower) applications with down-link only. This Read-only Mode (ROM) allows broadcasters to send content via full signal bandwidth and make the channels available to every UE (User Equipment) without encryption or a SIM card. This lays open the potential for free-to-air services for public broadcasting especially in Europe with the division of the UHF 470-790 MHz spectrum range.

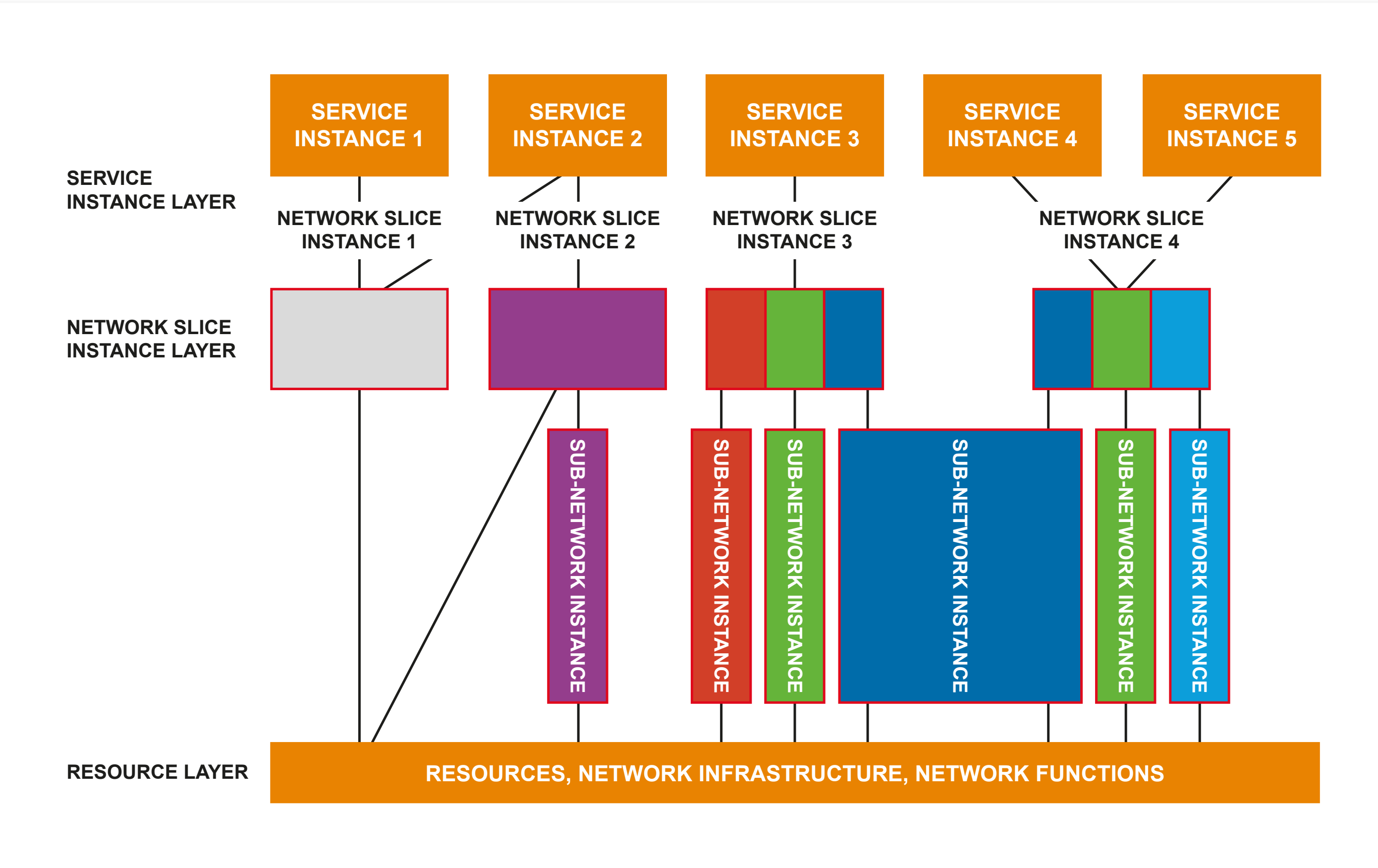

Figure 2 – Network slicing allows network operators to provide bandwidth and features on demand to make the allocation of resource both dynamic and scalable. FeMBMS allows a network operator to dynamically provision up to 100% of the network capacity to streaming services.

Digital Terrestrial Television (DTT) had exclusivity of this spectrum, but the division of the spectrum into two has provided dedicated scope for broadcast services using 5G-NR. The upper part 694-790 MHz is reserved for wireless broadband services, such as 5G, while the lower 470-694 MHz has been reserved for DTT.

Due to the design of the Single Frequency Networks (SFN), the HPHT transmitters can work alongside smaller Mobile Network Operator (MNSO) transmitters. And more elaborate networks can be provisioned using small cell structures to improve reception. Using the UHF frequencies also makes the design of the transmitters easier as the technology is established and better understood.

As FeMBMS works along other 5G-NR and unicast services, a whole plethora of on-line services are available with the broadcast media content. A simple antenna mounted to the home to improve 5G-NR reception will deliver a greatly enhanced viewing experience. The specification further supports a larger ISD (Inter-Site Distance) allowing for a larger reception area of up to 15km.

Dedicated or mixed FeMBMS carriers are available so that a mixture of unicast and broadcast services over a single carrier can be achieved. System information and synchronization signals are also possible for dedicated carriers.

FeMBMS networks can be aggregated into shared FeMBMS content distribution platforms. This means that the same content does not need to be broadcast at the same time over different networks, thus improving coverage and bandwidth efficiency.

To maintain backwards compatibility with existing and legacy systems, FeMBMS removes the need to transcode existing content. For example, an MPEG-2 Transport Stream over IP can be streamed over the FeMBMS network.

Making smart TVs and mobile device applications aware of the FeMBMS environment they are operating in will enhance the viewing experience the broadcaster is able to offer. Consequently, the xMB interface is available so that broadcasters can easily establish their TV services. This function effectively decouples the FeMBMS transport from the content and service layers allowing the broadcaster to create and terminate services and users without having to directly liaise with the network operator.

Security is always a major consideration for broadcasters as we move into the IP world and understanding where their content is going is incredibly important. When broadcasters used fixed point-to-point circuits to send their content to their telcos then security was relatively straight forward. However, when a high value media asset is streamed to a third-party supplier, the broadcaster needs to know where it is going. The xMB interface allows authentication of the broadcast/multicasting service provider through key encryption. This also extends to user authentication for pay-per-view services. Monitoring the status of the delivery is available using the xMB where statistics such as usage and QoE are provided.

Software defined networking through network slicing, combined with the peak datarates 5G-NR looks to provide, is delivering all the ingredients needed to make FeMBMS work efficiently and reliably. This will provide the low latency and high quality of service that today's viewers are demanding from all broadcasters and media providers. Viewers want to watch what they wany, how they want, and when they want. And 5G is certain to provide this.

The Sponsors Perspective

5G Broadcast – Finally A Solution To Mobile Television

By Mohamed Aziz Taga, PO & Head of Business Development, Rohde & Schwarz.

The idea of "content everywhere" is of course well established. Consumers like the idea that they can consume media – including video – on whichever device is to hand. Mobiles and tablets are seen as primary viewing devices today. More than 80% of internet traffic is video.

The problem is that, when users are out and about, mobiles and tablets depend upon cellular communication. This was conceived primarily for telephony, although of course there is increasing evolutionary development to be able to deliver data to mobile devices.

If you have been involved in any IP video implementations, you will be all too aware that data communication tends to focus on ensuring that the content gets through, rather than the deterministic approach video needs, where we demand a new picture every 50th of a second.

There is another layer of difficulty in cellular communication, which is that the capacity of the cell is fixed, so as more users want to connect at the same time, the bandwidth available to each individual is reduced. In streamed video this leads to a very obvious reduction in quality of experience. With consumers increasingly demanding 4K and high dynamic range Ultra HD, the situation can only get worse.

Inefficiency

Cellular communication is a one-to-one link. Obviously that is the case for a telephone call, but it is also the case when video is streamed. That is a natural consequence when each user is making an individual video on demand choice.

But when large numbers of people want to watch the same content at the same time – a major sporting event, for example – each is still relying on a one-to-one connection. That increases the data demand on the cell, which reduces the quality of experience for all.

Cellular technology continues to advance, to provide bigger bandwidth in the cell and therefore higher bitrates for more concurrent users. The counter to this capacity growth is that the cost of providing the service also grows and grows rapidly.

In a presentation at Mobile World Congress, Zhengmao Li, EVP at China Mobile, the world's largest cellular operator, told the audience that a 5G base station costs four times the price of a 4G/LTE base station, and to cover the same physical area 5G requires three times as many base stations. Add in the additional costs of the ground fibre network connecting all these base stations and you get an idea of the level of investment mobile network operators (MNOs) face in rolling out universal 5G coverage.

It is not just capex, either. The power consumption of a 5G base station is three times that of its LTE predecessor. Indeed, energy represents about 20% of the opex costs for MNOs.

5G Broadcast

All in all, it seems that expecting MNOs to build out comprehensive 5G networks, capable of delivering video to anyone anywhere, calls for very deep pockets, both in capex and opex. There is, of course, the environmental impact of the power consumption to consider too. And all this to provide variable quality of service in a rather inefficient manner.

The over-riding advantage of broadcast is that it is a one-to-as-many-as-will service. It does not matter if 10 people or 10 million are tuned to a broadcast, the operating cost and quality of experience is absolutely identical. The logical conclusion, then, is to broadcast content for reception on mobile devices.

Mobile broadcast has been tried in the past, with standards like DVB-H, but without significant success. Today it is available, in a practical and sophisticated way, with 5G Broadcast.

3GPP is the mobile industry's collaborative standards body, and in its definitions of 5G it includes FeMBMS: Further Enhanced Multi-Media Broadcast Multicast Service, but probably better known as 5G Broadcast.

In simple terms, this allows an overlay network to deliver a one-to-many video service. It is an overlay network, so it does not eat into the data capacity of the cell: rather it is broadcast very much the way that a terrestrial television service is broadcast.

The mobile device has to be equipped to receive 5G Broadcast, and leading chip provider Qualcomm already has silicon in production to provide this. It is unlikely to have a significant impact on the retail price of mobiles or tablets.

It does mean though, that you can receive 5G Broadcast without a SIM, although for dynamic subscription management you probably do need a data connection. With no need for a SIM the format is ideal for embedding into private or special purpose receivers: cars, for example.

Broadcasting the signal also eliminates the latencies inherent in one-to-one connections. Delays in today's cellular video on demand services can top 30 seconds: 5G Broadcast brings that down to one or two seconds, for a consistent viewer experience (including Ultra HD).

Applications

As well as the transmission of conventional television channels, there are many more applications where 5G Broadcast would add value for the consumer. An obvious example is at events, such as music festivals or major sporting events.

Local 5G Broadcast transmissions could provide the sort of rolling statistics, replays and insights that sports fans enjoy at home, making the stadium experience more engaging and entertaining. The gaps between bands at music festivals could be filled with interviews, backstage insights and other content. Many people enjoy the physical presence of being at major public events like royal weddings, even though in practice they cannot see much of what is happening: 5G Broadcast gives them the best of both worlds.

The same benefit of widespread reception without subscription makes it useful for public service announcements, from major incidents to missing children.

5G Broadcast also has applications in video on demand, too. Many people may choose to use a commute to catch up on favourite programmes, for example: rather than a lot of potentially unreliable one-to-one connections, machine learning algorithms could learn which content is widely watched and broadcast it to be stored in the consumer's device, ready for them to watch at the time of their choosing.

Vehicle applications are also potentially important. Information like realtime traffic information, mapping updates and changes to speed limits can be broadcast to suitably equipped cars, ensuring their on-board information and driver assist (or autonomous driving) systems are continually updated. 5G Broadcast could also be used to transmit software updates to ensure widespread immediate uptake.

Prospects

The 5G Broadcast concept helps mobile operators meet the ever-growing demand for video by moving it from the cellular network. For the consumer, this will guarantee a consistently high quality of experience.

The standards exist, the technology exists. As part of the Eurovision Song Concert in May 2022, a special mobile live stream version of the four-hour show was transmitted in four countries over 5G Broadcast, using transmitter electronics from Rohde & Schwarz to devices fitted with the Qualcomm chip. The demonstration was hailed as an enormous success.

In this article I have been able to give just an overview of the possibilities and practicalities. If you are interested, Rohde & Schwarz has published a comprehensive guide for network operators and content providers, which can be downloaded from rohde-schwarz.com or contact us for a printed version.

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