5G BROADCAST/ MULTICAST

Redefining the future of content delivery

5G Broadcast/Multicast | Booklet | written by Mohamed Aziz Taga | Version 01.00

A guide for network operators and content providers on how to use network resources more efficiently while creating new business opportunities and reaching wider audiences

ROHDE&SCHWARZ
Make ideas real

CONTENT

EXECUTIVE SUMMARY

5G clearly holds the promise of new and original technological and business opportunities. In fact, 5G is bringing new broadcast and multicast capabilities to the whole ecosystem, enabling new applications. Although live video distribution is very important, 5G broadcast/multicast does not necessarily mean mobile TV.

5G is not only capable of delivering media and entertainment to smartphones but can also provide smart vehicles with OTA updates, media and entertainment as well as map updates. Live event multicasting makes more sense when using this feature. 5G broadcast can transmit public safety multicasts, such as urgent weather and community information, and simplify the relationship between community members and public authorities.

Several other services could be optimized using multicast over 5G, including OTA multicast for centralized configuration and control, live commerce, and rural eLearning where no internet connection is available. In addition, 5G multicast enables venue casting to combine live experience with home comfort.

5G multicast is creating opportunities for broadcast network operators to make their infrastructure more dynamic and help them discover new distribution features. It also supports mobile network operators in offloading their heavy streaming and data loads to avoid infrastructure overprovisioning. As a result, they can serve consumers with higher quality of service while reducing CAPEX and OPEX.

Wider coverage and spectrum efficiency – Broadcasting/multicasting information via overlay networks is much more efficient than sending it hundreds of thousands of times to mobile network cells. Thanks to greater cell coverage, this improved flexibility will substantially reduce deployment and operation costs.

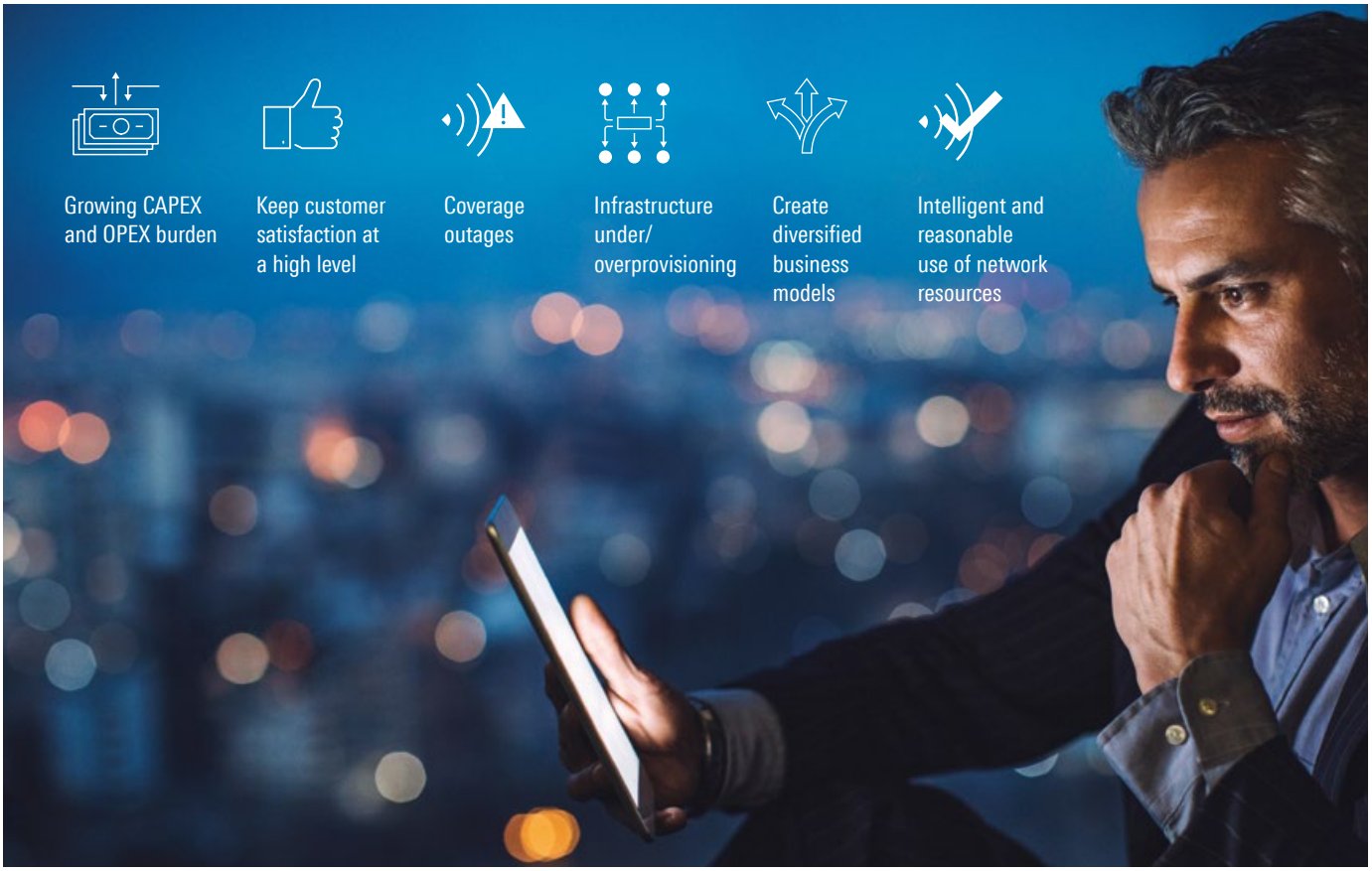
Better quality of service and higher quality of experience – Consumers expect higher quality with high definition (HD) and ultra high definition (UHD) resolutions as well as high dynamic range (HDR) for better picture quality. With the lower latency and higher flexibility that 5G multicast offers, the consumer experience can be improved with more real-time apps.

Section 1

NETWORK OPERATORS' TECHNICAL AND BUSINESS CHALLENGES

Network operators are classified into two distinct groups within this paper: mobile network operators (MNO) (also known as telecom service providers) providing mobile services, and broadcast network operators (BNO) involved in terrestrial TV and radio distribution.

It is quite clear that the mobile telecommunications era is here to stay. As part of our everyday lives, a world without mobile phones is difficult to imagine. The ease of communications has changed and is still changing the entire way we do things. Despite these good times, MNOs are still finding it tough to bring this "present day miracle" to their subscribers.



INABILITY TO COMBAT THE GROWING CAPEX AND OPEX BURDEN

Today, increases in data traffic and network complexity are leading to continuously growing operator CAPEX and OPEX. MNOs across the world are facing a new wave of network investment, ranging from 5G and low-power wide area networks to gigabit fiber. Yet the returns on this CAPEX remain uncertain with many 5G use cases still in their infancy. Moreover, the perception of broadband as a utility is threatening the premium pricing of fiber connectivity. Therefore, it is important for operators to develop new business models and cost structures in order to remain competitive and survive ongoing budget cuts. As operators grapple with an increasingly diverse network asset portfolio, making the right choices about infrastructure switch-off, spin-off and even sharing will become vital.

As a CAPEX burden example, during MWC 2019 Zhengmao Li, EVP at China Mobile, the world's largest mobile operator disclosed that a 5G base station costs four times the price of LTE and that 5G deployment would need three times the number of base stations for the same coverage as LTE due to higher frequencies[16]. Moreover, according to China Mobile's 2020 capital expenditure budget, each 5G base station costs an average of nearly CNY 400,000 (about USD 57,000 or EUR 53,000)[17]. We can imagine how much a nationwide 5G deployment would cost.

Moreover, CAPEX is not the only upcoming issue. The increased power consumption of next generation base stations may be one of the dirty little secrets of 5G. However, it may not be a secret much longer as operators roll out their initial networks.

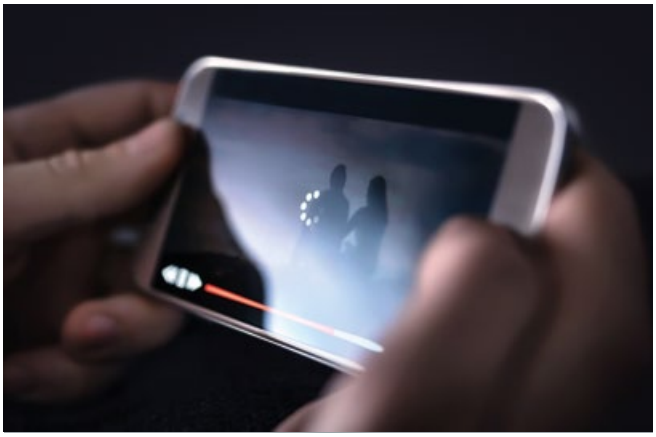
The power consumption of a 5G base station is three times that of its 4G LTE predecessor, according to Zhengmao Li, growing from 4 kW to 6 kW up to 12 kW to 16 kW. It is important to consider that power consumption is about 20 % of MNO OPEX.

KEEPING CUSTOMER SATISFACTION AT A HIGH LEVEL

In the face of increasing customer requirements related to new products and services combined with continuous growth in the subscriber base, it is a herculean task to keep customers satisfied at all times. Outstanding customer service, trouble-free network operation and flawless delivery of promised services are key competitive advantages for operators that drive customer satisfaction. Customers will stay satisfied with the latest applications and services at their fingertips in combination with network uptime. Especially when it comes to VoD and live streaming services, mobile users expect higher quality of service than is delivered today. They are not willing to accept standard definition anymore and do not have the patience to tolerate high network latency and longer buffering times. In short, customers want a continuously satisfactory experience to meet their changing tastes.

COVERAGE OUTAGES

Coverage outages represent a significant pain point for mobile network operators. While some large MNOs may have backup systems in place, the vast majority don't and are at continual risk of failure. Coverage outages can halt services and bring MNO operations to a standstill. Cellular network congestion is a major pain point:
Too many devices simultaneously accessing the same network and requesting high bandwidth services like video or live streaming cause a digital traffic jam. Network congestion is the leading cause of cellular coverage problems today. This pushes cellular networks to their limits and can lead to network equipment failures and inevitable network shutdown. In addition, due to design constraints, cellular networks are relatively small and costly. This limits the ability of MNOs to expand coverage nationwide due to factors such as rising CAPEX and OPEX but also the lack of frequencies that would allow implementation of greater coverage.



NETWORK INFRASTRUCTURE UNDER/ OVERPROVISIONING

Before cellular network deployment, MNOs perform network planning and dimensioning based on expected data traffic volume. The average data traffic volume includes the majority of mobile services to be used on a daily basis but does not consider peak traffic, such as live and linear services where more network resources are needed. In order to cover these peaks, operators still need to invest heavily in the network. Most of these investments could not be justified by a business case since they would involve preparing the cellular network for traffic peaks that only rarely occur. Therefore, MNOs are forced to choose between two evils: Overprovisioning the network to cover huge traffic peaks in order to satisfy all end users; or underprovisioning the network to reduce investment costs while tolerating poor QoE.

CREATE DIVERSIFIED BUSINESS MODELS

BNOs have strived for years with DVB-H and MediaFLO to expand and further diversity their traditional business models while reaching a larger audience with a greater number of devices. Unfortunately, they have not been successful. Nevertheless, BNOs are still hoping to achieve this goal with the help of new technologies like 5G.

INTELLIGENT AND REASONABLE USE OF NETWORK RESOURCES

BNOs have a huge asset related to the use of broadcast/multicast distribution models, i.e. spectrum efficiency. Public and private content is reaching millions of consumers simultaneously with huge coverage, timely synchronization and unprecedented video and audio quality. However, this jewel in their crown is wasted most of the time because the content is 24/7 on air, regardless of the presence of an audience, affecting energy efficiency and more.

In addition, the majority of terrestrial broadcast content is available in three other ways: satellite, cable and OTT. The use of terrestrial broadcast resources (infrastructure and frequencies) could be better managed and optimized while expanding free-to-air services, defining diversified business models and achieving advanced energy and spectrum efficiency. Deployment of broadcast/multicast over 5G applications in the UHF bands is definitely not a precondition. Technically speaking, other possibilities exist, such as the L band, which is also a good option for the technology. However, we should recall from physics that when using higher frequencies, we lose coverage and propagation models do not make sense anymore. Therefore, sub 1 GHz could be a better fit.

For ROM applications (regardless of output power: LP/MP or HP), Rohde&Schwarz recommends targeting all available ITU SDL bands for more flexibility and without any exceptions (see table below).

The remaining UHF bands are also suitable for such applications, i.e. 470 MHz to 694 MHz.

Band	Frequency (MHz)	Downlink (MHz)	Bandwidth (MHz)
29	700	717 to 728	3/5/10
32	1500 (L band)	1452 to 1496	5/10/15/20
67	700	738 to 758	5/10/15/20
69	2600	2570 to 2620	5
75	1500 (EU L band)	1432 to 1517	5/10/15/20
76	1500 (ext. EU L band)	1427 to 1432	5

Section 2

BROADCAST/MULTICAST AND UNICAST CONCEPTS

Unicast allows traffic, many streams of IP packets, to move across networks from a single transmitting point to another single receiving point. One-to-one bidirectional communications is the foundation of cellular networks, from GSM right up to the current LTE/4G and 5G technologies.

In broadcast mode, traffic flows from a single point to all possible endpoints that can be reached within the network. This is the easiest and most efficient way to ensure traffic reaches its destination. This distribution mode has been used for many years for free-to-air analog TV and radio distribution. Today it is mainly used in digital television and video/audio distribution networks.

Multicast enables traffic to exist between the boundaries of unicast (one-to-one) and broadcast (one-to-all). Literally, multicast is a "one source to many destinations" approach to traffic distribution. In other words, it only involves the destinations that openly choose to accept the data from a specific source and receive the traffic stream. For example, by purchasing a subscription, holders of vouchers/scrambling codes can decrypt the encrypted signal and discover the content.

For years, mobile cellular networks have been based primarily on a unicast communications model to provide various services to their end users. However, nowadays consumers enjoy watching a huge amount of premium content, including a large percentage of live media services.

Moreover, mobile user behavior and expectations are trending increasingly in the direction of higher quality of service, more features and better accessibility from the service providers. This puts network resources under pressure while pushing mobile networks to the limits of the unicast paradigm.

In this context, there are some critical questions: Is the unicast delivery mechanism sufficient alone to handle high congestion situations, or will additional broadcast/multicast delivery methods be needed?

This booklet provides an answer to this question and helps discover how to deliver high-quality, personalized live experiences to meet the growing demands of audiences.

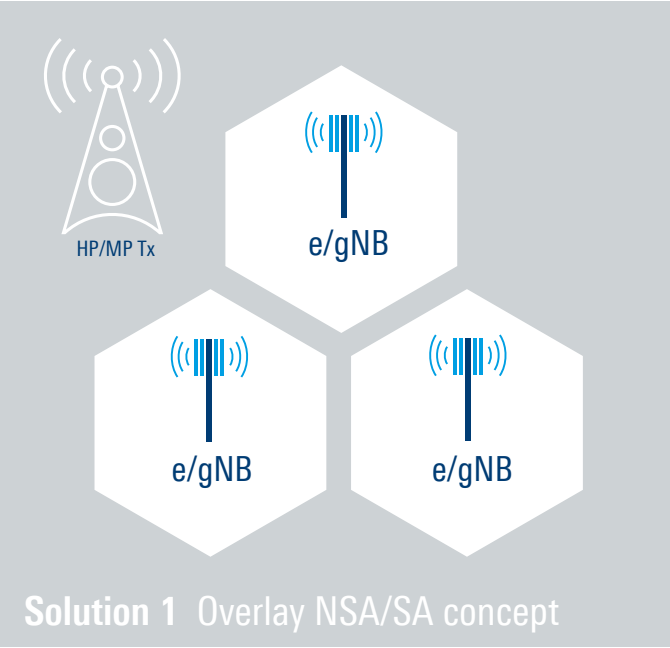
Section 3

ROHDE & SCHWARZ VISION – THE FUTURE OF MEDIA DELIVERY

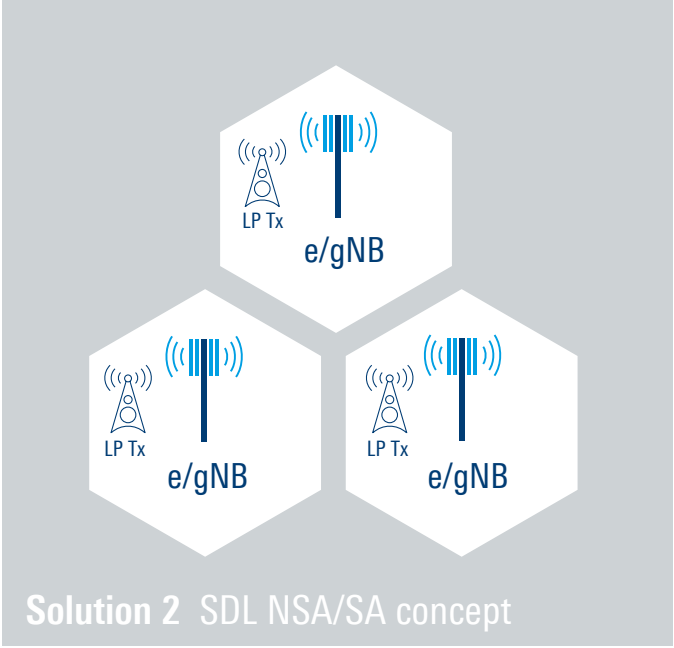
Rohde & Schwarz believes the one-to-many distribution approach is the right solution to address the technical and business challenges of network operators. 5G multicast allows MNOs to offload their premium content on the move, whether it is live/linear video/audio or even file based content, while reaching broader audiences and consistently delivering broadcast quality experiences according to individual tastes. For this to happen, they need a solution capable of handling a continuous flow of content while maintaining a congestion-free mobile network and avoiding infrastructure overprovisioning. This also significantly lowers the CAPEX and OPEX burdens.

Broadcast/multicast capabilities over 5G will enable several diversified business models for both MNOs and broadcasters while making BNO network resources more dynamic and smart.

Rohde & Schwarz strongly believes that providing a high-quality viewing experience, for 24/7 live linear services in particular, merits a purpose-built concept that takes reliability, scalability, sharing and cost into consideration.



Solution 1 Overlay NSA/SA concept



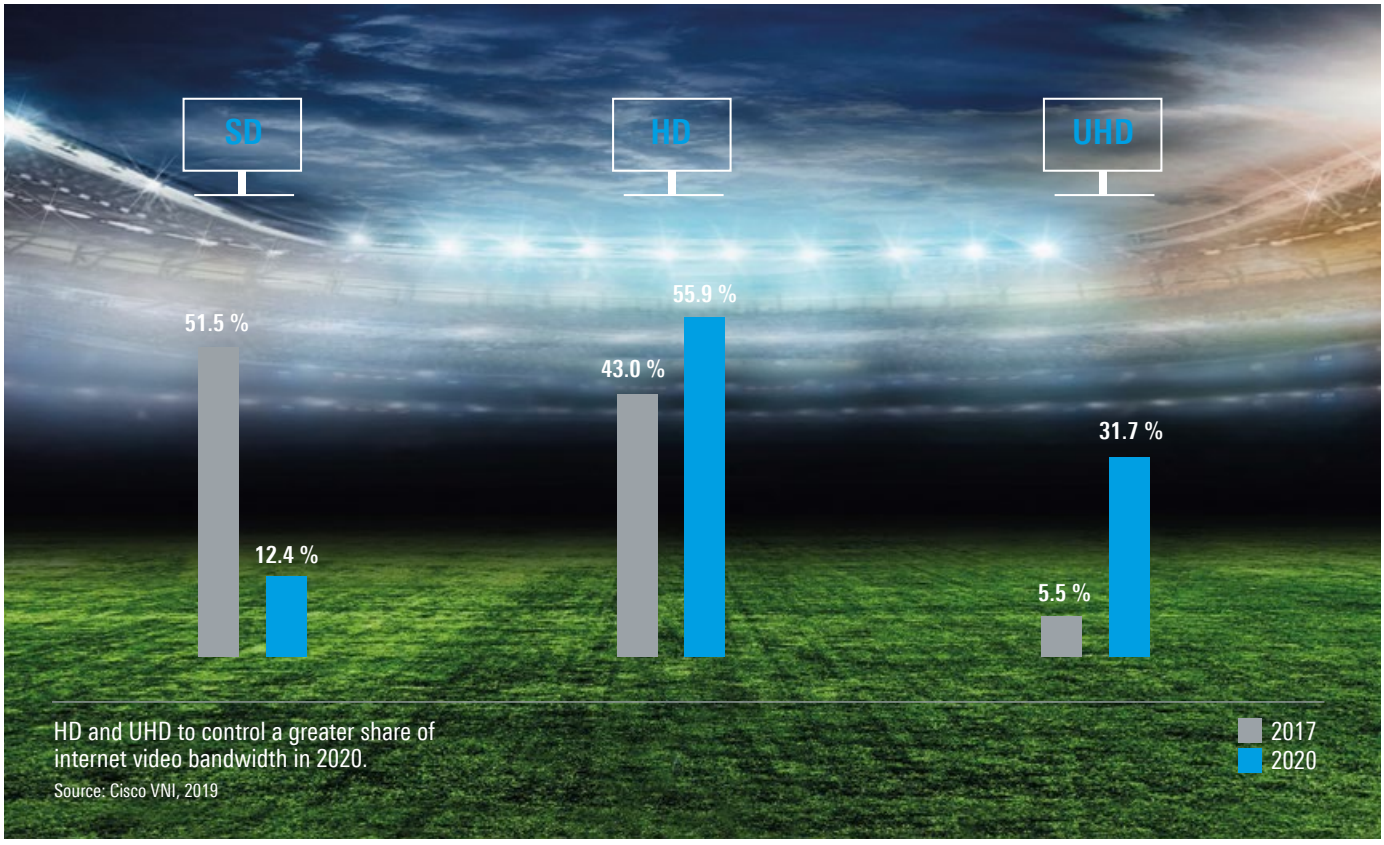
Solution 2 SDL NSA/SA concept

COMBINATION OF BROADCAST/MULTICAST APPROACH TOGETHER WITH UNICAST

Existing cellular networks with their bidirectional, unicast communications model have a major advantage since many business cases are built on this approach. However, some enhancements are needed.

Live/linear video/audio and file based content requested by many viewers should be distributed using the one-to-many model, as opposed to individual transmission, hundreds of thousands of times. However, this approach overwhelms network resources while delivering poor quality of sevice due to limited access network capacity.

A Rohde&Schwarz overlay network using SDL transmitters with 5 W to 100 kW output power (depending on network dimensioning) and a broadcast/multicast core network are connected to the existing 4G/5G core in order to handle data stream offloading. This approach relieves the cellular networks used for conventional mobile services. The concept can be deployed using a multiple-frequency network (MFN) such as a single-cell point-to-multipoint (SC-PTM) or single-frequency network (SFN).



HD and UHD to control a greater share of internet video bandwidth in 2020.

Source: Cisco VNI, 2019

QUALITY IS THE KEY

Because audience composition and behavior are difficult to predict, implementing live video streaming is never simple. Delivery of live video streams can be complicated due to limited capacity in the radio access network.

Live event viewers are as demanding as they are passionate. Engaging with content in a location with spotty unicast cellular service does nothing to dampen their expectation for a pristine viewing experience. Anything that comes between them and the action – slow startup time, very low video resolution, the dreaded spinning pinwheel – means lower engagement, higher churn, poor brand perception and a lower likelihood that they will return to the network in order to consume.

Consumers expect consistently high quality, performance and availability wherever, whenever and on whatever device they choose. However, it is now more challenging than ever to ensure an enjoyable, glitch-free viewing experience online – especially when streaming live. If audience turnout exceeds network capacity, users can be shut out of a live video streaming event, incapable of accessing content and left with a negative impression of the network operator or service provider. Even if your network is well-equipped to handle the demand, video performance can suffer as a result of network congestion, latency and packet loss, forcing your audience to disengage and pursue better video quality elsewhere. This can ultimately lead to the loss of your customer base.

Although the importance of quality has been a subject of discussion within the industry for several years, MNOs and content providers committed to long-term success must now adopt a more disciplined approach toward delivery and measurement – the stakes are too high to ignore the links between video quality, viewer expectations and business performance.

"MUST-HAVE" CAPABILITIES FOR A ONE-TO-MANY DISTRIBUTION MODEL

Rohde & Schwarz has identified seven "must-have" capabilities to deliver live events and popular content with broadcast-level quality.
Making this happen should be the top priority in the technology strategy of every mobile operator and event provider:

- Minimize delay experiences in current cellular networks ranging from 60 s/30 s down to only 1 or 2 seconds to provide broadcast-quality viewer experiences
- Ensure broadcast-level reliability so your service and content are always available for your viewers
- Enable premium content offloading from small cells into a supplemental downlink (SDL) while providing viewers with the best quality and minimizing unicast network use
- Ensure broadcast-level quality of service, making consumer experience a high priority
- Maximize audience reach through a modular architecture that allows multiple delivery channels to connect to a single origin
- Offer seamless, engaging viewing experiences by serving relevant, targeted ads at scale, to effectively monetize content
- Enable a variety of business verticals by using the same network resources, making investments future-proof

MULTICAST AS A SERVICE (MAAS) – BENEFIT FROM EXISTING RESOURCES

Rohde&Schwarz is proposing a completely new business model to MNOs, BNOs and content providers, revolutionizing the way premium content is distributed over the air to reach millions of people at the same time. Instead of acquiring new infrastructure and bidding hundreds of millions of dollars for 10 MHz or 20 MHz of bandwidth, MNOs can use what is "already there". In other words, broadcasting sites that are already built, network infrastructure that is installed and UHF frequencies that are well established for broadcast/multicast mode can be used as a service.

Why not exploit existing network and frequency resources and use them whenever you need to? Why should you overprovision your network infrastructure for occasional or sporadic traffic?

The answer is straightforward: Employ a multicast as a service (MaaS) approach and offload any type of content you would like in dynamic and intelligent ways. This booklet helps you better understand the technical and business benefits of this model and how it can be applied in realistic scenarios.

THE ROHDE&SCHWARZ FUTURE VISION MEETS CUSTOMER CHALLENGES

BNO

- Change in customer behavior
- Linear TV is losing popularity versus streaming services
- Smartphones/tablets are gaining importance
- No access to portable devices

MNO

- Exponential increase in mobile video consumption
- Live events are very important
- Consumers want premium content anytime/anywhere
- Quality of service is not ensured – poor user experience

Rohde&Schwarz vision: efficient media delivery – anywhere, anytime, to everybody

- Use of broadcast/multicast approach together with unicast → eMBB
- Deployment of overlay network with one-to-many concept
- Deployment of SDL mixed mode and/or dedicated mode in existing cellular sites
- Use of frequencies below 1 GHz (i.e. UHF, SDL, etc.)
- Enable multicast as a service (MaaS) and profit from existing resources
- Make broadcasting infrastructure more dynamic
- Avoid infrastructure overprovisioning while reducing CAPEX and OPEX

Section 4

5G BROADCAST/ MULTICAST TECHNOLOGY – ENHANCED ONE-TO-MANY DISTRIBUTION MODEL

The next quantum progression for technology supporting mobile communications networks, 5G, promises to provide new and radically different technological and business opportunities. In fact, 5G brings new broadcast and multicast capabilities to the whole ecosystem by giving network operators and broadcasters significant opportunities in several new business areas while offloading data capacity to create high spectral efficiency and reduced costs.

As a mobile network operator or media content provider in the mobile telco industry, this means a completely new range of business models are now possible for delivering content or data to very large numbers of consumers without affecting the cellular 5G mobile network. This new technology enables consumers to access high-quality media over a range of smartphones and SIM-less devices with greater coverage and lower latency.

3GPP Release 14 to 16 specifies the Further Enhanced Multimedia Broadcast Multicast Service (FeMBMS) as new broadcast/multicast enhancements for both dedicated and mixed modes. Using broadcast and/or multicast over 5G, mobile network operators can deliver premium content to mobile consumers while still attached to cellular networks with consistently high quality of service (QoS) and higher quality of experience (QoE) either via an overlay network or the SDL concept.

Free-to-air and/or encrypted ROM

In this new environment, we will see dedicated carriers with 100 % broadcast/multicast allocation in downlink mode. Services will be distributed in such a way that all kinds of devices can receive them, not only smartphones, but also smart cars and smart home appliances. No SIM card is necessary – consumers just need to be within the coverage zone in receive only mode (ROM).

Simplified architecture

In addition to MFN or SFN transmission mode in the access network, only a few infrastructure elements are needed in core networks in order to achieve lower latency and transparent transmission.

Wider coverage and improved spectrum efficiency

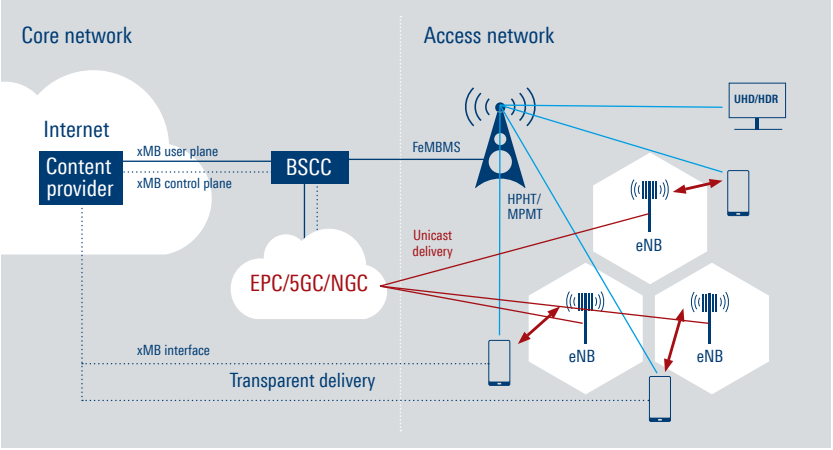
Broadcasting/multicasting data via high- or medium-power transmission in an overlay network or via cellular SDL low power is much more efficient than sending it hundreds of thousands of times to mobile network cells. In addition, the flexibility of the subcarrier spacing and cyclic prefix allows cell coverage ranging from 1 km to 100 km. This improved flexibility will substantially reduce deployment and operation costs.

Better quality of service and higher quality of experience

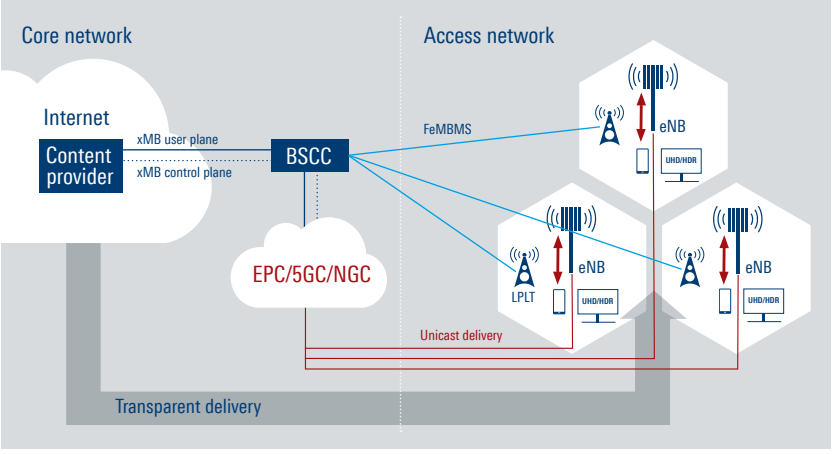
Consumers expect higher quality with the HD and UHD resolutions as well as high dynamic range (HDR) for better picture quality. Thanks to the lower latency and higher flexibility that 5G broadcast offers, consumers can enjoy an enhanced experience with more real-time focused apps.

ROHDE&SCHWARZ 5G BROADCAST/MULTICAST SOLUTION

FeMBMS : Overlay NSA/SA simplified architecture



FeMBMS : SDL NSA/SA simplified architecture



Rohde&Schwarz has developed a new, cost-effective end-to-end solution in line with the 3GPP standard. It aims to support network operators, delivering better quality services and promising higher quality of experience with reduced costs.

Rohde&Schwarz offers three solution models:

- Solution 1 – overlay NSA/SA for use in rural and suburban areas
- Solution 2 – SDL NSA/SA for use in dense urban areas
- Solution 3 – combined overlay and NSA/SA

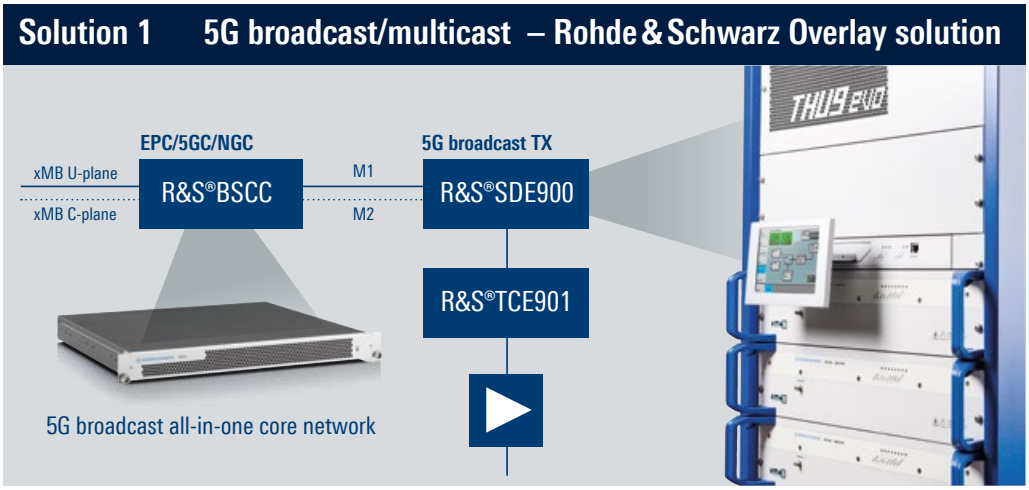
The 5G broadcast/multicast solution is composed of a multicast core network consisting of the R&S®BSCC broadcast service and control center and R&S®Tx9 transmitters in the access network.

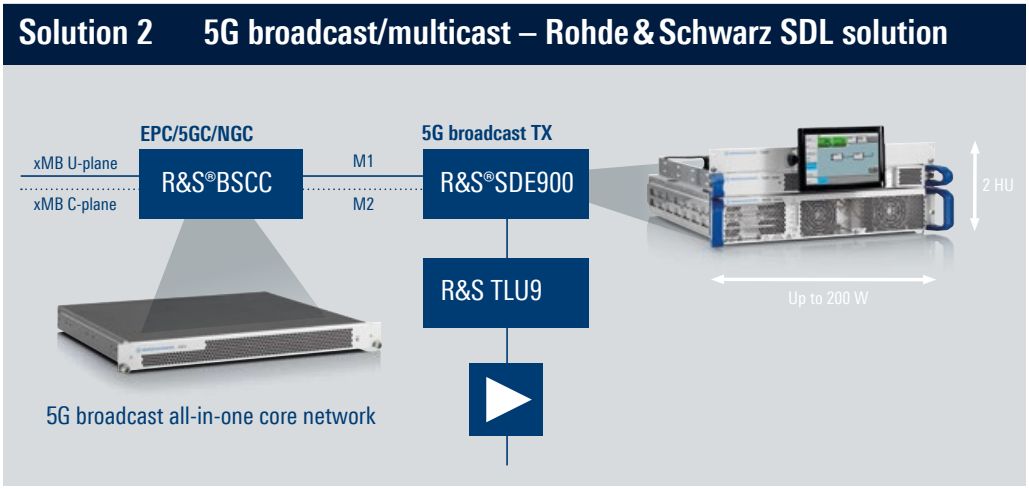
A more concrete way to enhance the existing cellular network could involve adopting Solution 1 for suburban areas and rural environments where line of sight is usually available. Here, an overlay network using HP/MP transmitters for greater coverage makes more sense in combination with either an existing non-standalone or standalone architecture.

However, in order to establish localized broadcast/multicast on a cellular level, Solution 2 would be more convenient in dense and/or urban areas while deploying add-on low-power transmitters (LP Tx) within existing cellular sites with minimal costs.

The low-power add-ons are purely software based and can be easily integrated into an existing cloud RAN (C-RAN) without additional hardware.

Furthermore, neither Solution 1 nor Solution 2 would prevent a network operator from choosing and deploying Solution 3. We can easily imagine a combination of Solutions 1 and 2 in order to achieve nationwide deployment of broadcast and multicast applications.





On the access network, the FeMBMS physical layer is implemented by the server based exciter solution, consisting of the R&S®SDE900 server unit and the R&S®TCE901 exciter. The R&S®SDE900 has a purely software defined approach that ideally prepares network operators for future signal processing requirements. Based on a high-performance server, it supports the FeMBMS physical layer as defined in 3GPP Release 14/16. The R&S®SDE900 is designed as a plug-in, rackmount module for the R&S®Tx9 generation of transmitters with different output power possibilities: high power, medium power and low power between 5 W and 100 kW. The software defined encoder generates the I/Q modulation data. The field-proven R&S®TCE901 exciter generates the COFDM waveform based on the I/Q data.

ROHDE&SCHWARZ BROADCAST SERVICE AND CONTROL CENTER (BSCC)

LIVE CASTING	PUBLIC SAFETY MULTICAST	VEHICLE CASTING	VENUE CASTING	OTA MULTICAST
eSPORTS	eLEARNING	LIVE COMMERCE	eAGRICULTURE	VIDEO ON DEMAND

Running as part of the core network, the software defined R&S®BSCC, including the broadcast multicast service center (BM SC), MBMS-GW and a centralized multi-cell/multicast coordination entity (MCE) is a new solution that enables the delivery of multimedia content over LTE/5G networks in broadcast mode. It encapsulates multimedia content into specific FeMBMS bearers to be delivered from the evolved packet core (EPC) down to the receiver. It allows network operators to roll out advanced FeMBMS services that mix potentially different types of media over networks with hybrid unicast/broadcast coverage.

R&S®BSCC is designed to support various streaming platforms, including MPEG-DASH, 3GP-DASH and HLS with FLUTE mechanisms. R&S®BSCC is fully ready to be virtualized and deployed within an existing cloud infrastructure to make it even more cost-efficient, flexible and easy to use.

To provide reliable indoor reception and avoid service interruptions, especially inside tunnels, underground and inside buildings, Rohde&Schwarz recommends either deployment of cost-effective gap fillers/repeaters or 5G Wi-Fi access points to convert the received 5G signal into an indoor Wi-Fi connection.

Section 5

BUSINESS POTENTIAL UNLEASHED BY BROADCAST/MULTICAST OVER 5G

5G broadcast is not restricted to mobile TV. It can deliver media and entertainment to smartphones and also reach smart vehicles with OTA updates, media and entertainment inside the car, and map updates.

Live event multicasting makes more sense when using this feature. 5G broadcast can transmit public safety multicasts, such as urgent weather and community information, simplifying the relationship between community members and public authorities.

Several other services could be optimized by using multicast over 5G, including OTA multicast for centralized configuration and control, live commerce, and rural eLearning where no internet connection is available or possible. In addition, 5G multicast enables venue casting where the consumer can combine live experience with home comfort.

5G broadcast/multicast allows many application segments to be efficiently implemented using 5G multicast either in downlink-only mode or in combination with the uplink channel, based on the same infrastructure.

LIVE CASTING

Nowadays, a variety of high-profile events worldwide are transmitted live and can reach millions of viewers on different types of devices, including smartphones, tablets, laptops, cars, public transit vehicles such as trains and buses, and even wearables like VR/AR glasses.

According to Akamai reports[8], peak live event-related traffic on the network grew from 21 Gbps in 2004 to more than 23 Tbps in 2018 – a 1000-fold increase. The 2018 World Cup was the most-streamed sporting event ever, by volume of data, on the Akamai platform.

In all, 2.7 times as much data was streamed in Russia than was streamed in Brazil in 2014 and 2.3 times as much as in Rio for the 2016 games – making it the most-streamed sporting tournament, by volume, on the Akamai platform to date. The number of minutes of footage streamed also vastly increased from Brazil to Russia. From start to finish, 29.3 billion minutes of football action were streamed from Russia, a 63 % increase over Brazil.

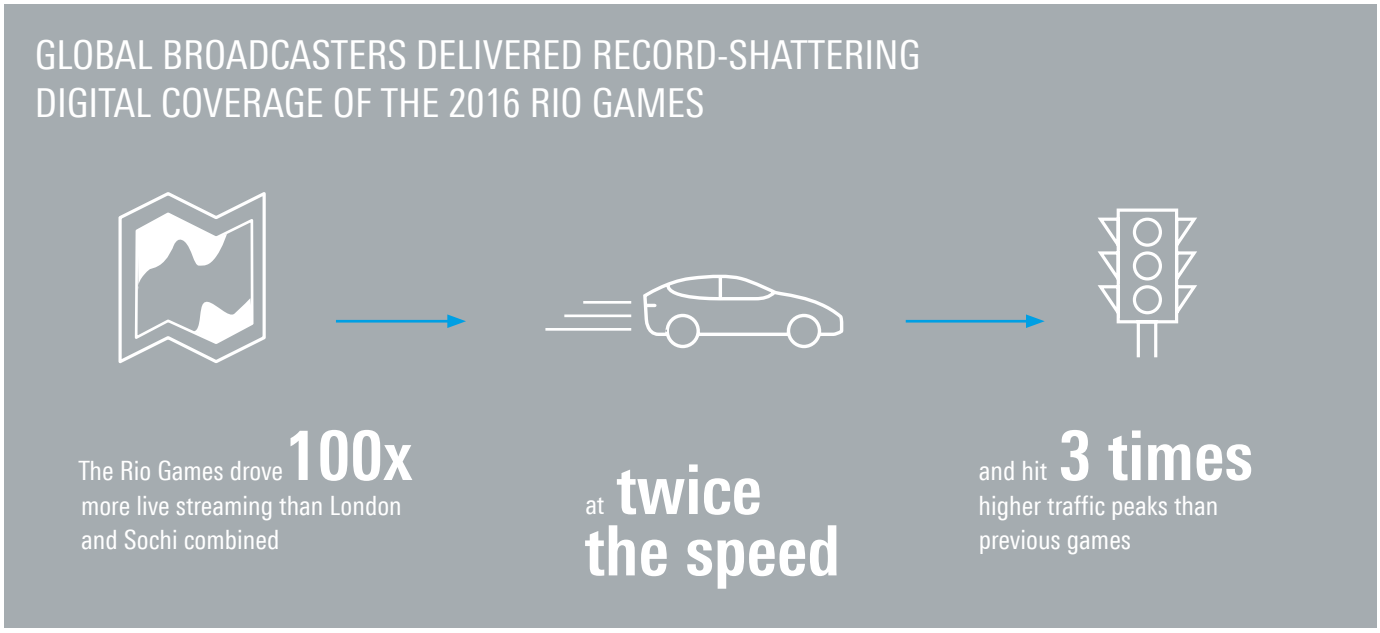
The Russian tournament drew unprecedented audiences for international football streaming, with the final match driving 7.9 million concurrent streams. The peak in the tournament was during the group stage, where two games (Mexico-Sweden and South Korea-Germany) took place at the same time and achieved 9.7 million concurrent streams.

Overall, peak bandwidth requirements for streaming the Russian games far exceeded the Brazil matches. In fact, 92 % of the games played in Russia topped out higher than the peak for the most-streamed match in Brazil. When the peak bandwidth numbers for every game of the tournaments are compared side by side, the average (median) peak in Russia was 10.54 Tbps, more than tripling the median peak in Brazil of 3.29 Tbps.

Famous events are not only related to football, but sports in general such as:

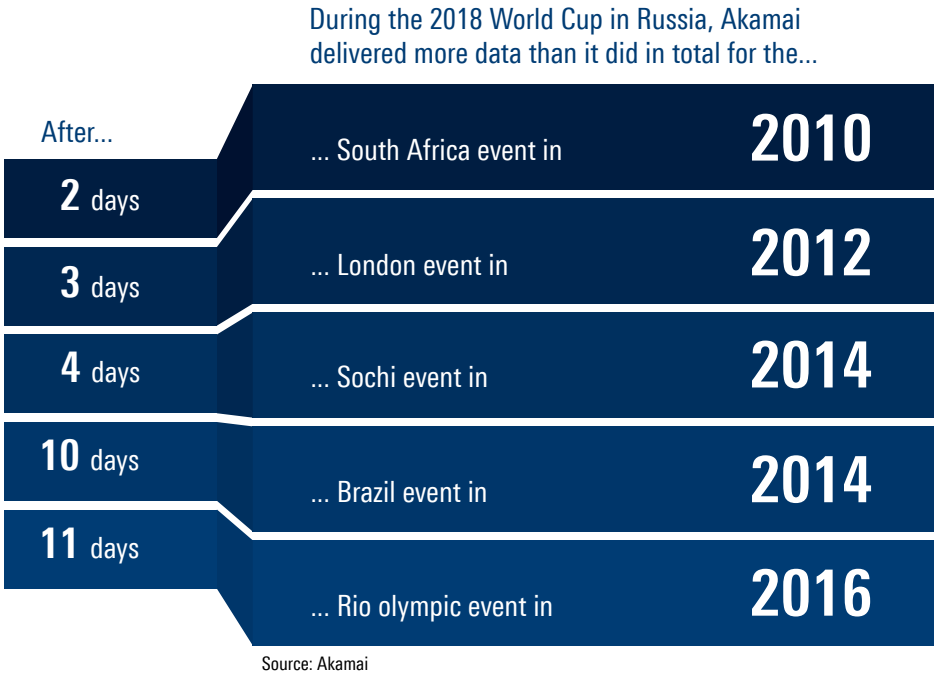
- American football, golf, hockey, cricket and rugby
- Football, basketball, handball, volleyball, baseball and tennis
- Formula 1/E, DTM&NASCAR, Olympic Games and more

Carnivals, festivals, royal weddings and political events are well suited to the one-to-many distribution model over 5G. The content itself is not only the driver, but the advertisements to be dynamically inserted are the second engine to make the business model successful.



Source: Akamai

HOW DOES THIS COMPARE TO OTHER EVENTS?



Source: Akamai

PUBLIC SAFETY MULTICAST

Ensuring public safety is one of the basic 5G broadcast tasks. A prime example is multimedia alert data with instructions, advice and additional information for users such as details on how to better react to the alert.

The digital structure of a message allows several types of alerts. For instance, in Amber alerts users are informed about a missing child in the area of the child's last known whereabouts. Apart from textual information, a picture of the child is also included in the message along with telephone numbers and URLs for the relevant authorities. Also, a map of the area could be distributed that includes information on the latest known whereabouts (e.g. route, play areas).

Multimedia data carries information that is otherwise difficult to squeeze into the limited amount of text an alert typically supports. This helps improve communications between communities and authorities.

Public safety also requires more efficient delivery of public announcements as well as emergency and warning alerts in case of threatening weather conditions or pandemic situations, for example.

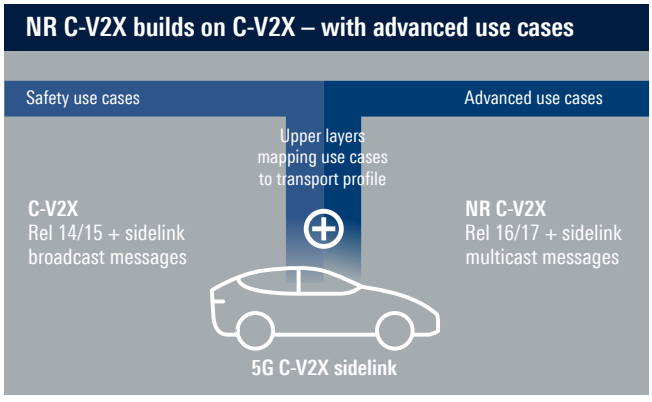
VEHICLE CASTING

Telecom operators with multicast support will enjoy great financial success in the automotive industries. In fact, vehicle-to-everything (V2X) is the standard definition for future vehicle communications protocols. With increased demand for autonomous driving vehicles, car makers like Tesla, BMW, Audi and many others need to rely on safe, reliable communications systems that can connect millions of their cars and devices.

Mobile operators, on the other hand, are rushing to accelerate the introduction of V2X communications in their upcoming 5G networks. However, many of these operators have overlooked one simple detail: multicast.

In today's 5G rush, many mobile operators failed to include LTE multicast in their growing networks and will soon struggle when millions of autonomous vehicles and internet of things (IOT) devices require frequent software upgrades or emergency alerts. Without Further Evolved Multimedia Broadcast Multicast Services (eMBMS), telecom operators will end up exhausting their 5G networks because they are not ready to exploit the power of multicasting.

Their revenue streams will radically decrease once half of their connected users are vehicles or machines. Not to mention that the automotive industries are already including multicast support in their V2X requests for proposals/offer (RFP/RFO).



Source: Qualcomm

Many MNOs like Telstra have recognized this trend and prepared their LTE and future 5G networks with a broadcast system. They will be among the first to compete for the V2X market share and will have a golden bargaining chip: multicast.

Many business verticals are addressed in this application segment. This includes software and firmware updates as well as media and entertainment inside the vehicle, such as audio and video streams, and even pre-loaded content that is requested on demand to avoid overloading the cellular network.

OTA real-time traffic is becoming an essential feature for implementation in cars, trucks and buses. As Qualcomm reported, V2X technology continues to evolve and the 3GPP Release 16/17 NR C V2X direct communications mode (or sidelink) specifications will support advanced use cases that could enhance autonomous driving, once again, without using the cellular network.

- Forward crash warning (FCW)
- Intersection movement assist (IMA)
- Blind spot warning/lane change warning (BSW/LCW)
- Optimal speed advisory (OPA)

According to Qualcomm, the NR C-V2X sidelink offers several enhancements in the form of higher throughput, lower latency, enhanced reliability and improved positioning – all of which are expected to enhance autonomous driving. In addition, the NR C-V2X sidelink also moves the default mode of operation from broadcast to reliable multicast communications. This is enabled by some fundamentally new innovations. These use case examples could be optimally implemented in a broadcast/multicast and unicast mixed mode where the downlink mode is implemented in multicast and an uplink feedback channel in unicast mode.

VENUE CASTING

The original idea involves creating a new level of fan experience in which audiences enhance the in-venue atmosphere with live home experience.

In fact, 5G multicast will enhance the fan experience inside stadiums and venues with many applications such as:

- Zoom-in possibilities
- Multi-angle viewing/streaming
- Repeat/slow motion features
- Additional camera angles
- Synchronized commentator options
- Personalized multi-game atmosphere
- Customized 1st person/3rd person view where fans can see and feel the movement of the player
- Fans will become part of in-field communications by listening to the discussion between referees, players and coaches with an original XR view.

Rohde&Schwarz predicts many business benefits by deploying this new level of fan experience. Based on a survey taking into account two major arenas in Germany (Allianz Arena in Munich and Signal Iduna Park in Dortmund), the fan experience can be enhanced via a ticket upgrade. This generates up to at least 12 % of additional ticket revenue per game – not taking into account the additional revenue through personalized ads on smartphones, tablets and even smart glasses.

This new business case creates additional benefits for MNOs including:

- Synchronized experience between all smartphones
- Seamless experience between game on the field and smartphones
- Combination of personalization and crowd experience/ atmosphere
- Excellent video quality – regardless of user numbers
- Highly scalable technical solution – regardless of concurrent user numbers

Telecom operators can target many different sports/organizations with their venue casting concept to generate additional revenue:

- Soccer/FIFA
- American football
- Basketball, baseball, handball
- Golf, rugby, cricket, tennis
- Formula 1/E, DTM, NASCAR
- Horse races (popular in UK and Middle East)
- Olympic Games

OTA MULTICAST

OTA multicast is a well-established business case, i.e. the concept of IoT. With 5G, over 10 000 smart, ready-to-connect devices are expected in the future per square kilometer.

This means more than 3 million smart devices in Munich, 7.8 million in New York and 15.7 million in London. These devices include smart home appliances and wearable products. Is such coverage really feasible based on cellular one-to-one connections?

With the data offloading concept, Rohde&Schwarz recommends using a one-to-many approach to multicast any data intended to reach multiple devices at the same time, such as software and firmware updates, remote bug patches and centrally managed configuration and control data.

eSPORTS

eSports is considered as one of the emerging business cases in the telco industry. The concept is simple: groups of people start gaming together and launch a broadcasting session in order to share their gaming atmosphere with many interested viewers. The eSports concept is creating a new wave of interest worldwide where events are staged with official tournaments and play-offs using several famous games like FIFA, DOTA2 and STARCRAFTII. Nowadays, even gaming consoles are including the option to start a broadcast session and share the gaming experience. Of course, dynamic ads could be inserted into any game.

eLEARNING

eLearning is no emerging use case but has been around for more than 10 years. Recently, the value of remote learning has risen again due to the pandemic where students and people cannot go to their classrooms for months or longer. Thus, the solution would be the internet. Sorry, wrong answer. All the fixed lines, wireless connections and mobile networks have been unable to reliably deliver the required service. The huge demand over mobile networks during the first week of the COVID-19 crisis when people were obliged to stay at home pushed regulators and MNOs to advise end users to use the network sparingly.

In contrast, 5G broadcast/multicast offers a way to reliably deliver virtual classrooms to students and pupils in situations where internet access is not practical – or in rural areas lacking fixed internet infrastructure and mobile network coverage.

LIVE COMMERCE

Live commerce, a new term used to describe the combination of streaming video and eCommerce, promises to revolutionize the retail industry and consumer shopping habits.

Just as online shopping transformed retail twenty years ago, live streaming promises to transform eCommerce today. Dubbed live commerce, this convergence of video and shopping helps improve engagement, close the gap between customer and product, drive sales, and – in cases where bidding is involved – increase the average sales price.

The trend dominates the Chinese market. Taobao – the world's largest eCommerce website empowers farmers, business owners and self-employed entrepreneurs with consumer-to-consumer live streaming. The Alibaba-owned platform lets users engage via live streaming features and a dedicated standalone app.

Hot on China's heels, South Korea also has a stake in the live-commerce game. LF Corp combines live streaming with real-time chat and one-click purchases to create seamless shopping experiences. This has resulted in a 30 % year-over-year increase since 2015.

Then there is TMON (formerly Ticket Monster), a Korean subsidiary of Groupon that commands product, grocery and travel verticals by bringing a wide range of shopping experiences to mobile devices.

Although late to the party, Amazon launched Amazon Live in 2019. Think Home Shopping Network goes digital, with the addition of icons fluttering on the screen each time a purchase is made. Models try on different outfits while hosts describe the material and fit, guest presenters demonstrate how to use different tools, and the top five toys are showcased for viewers.

But what if viewers could get one step closer? Immersive 3D experiences using virtual reality (VR) could accomplish just that, allowing buyers to study the clothing from every angle and experience the excitement of being in the crowd. Augmented reality (AR) also promises to push live commerce forward. Picture this: You can virtually visit a shopping mall where several brands are giving you the opportunity to try their clothes and goods without having to wait in long lines. The store's products can be broadcasted and as the choice is personalized, the uplink unicast channel is used.

But here is a question: Isn't live commerce just an exact replica of the in-store shopping experience? The answer is no. In a global economy where customer experience dictates which brands live or die, why not reach shoppers on their own terms?

eAGRICULTURE

eAgriculture is one of the new use cases that can raise awareness and interest by enhancing the relationship between farmers and agricultural authorities. Furthermore, it is possible to address the smart farming concept while creating new services using a broadcast/multicast design.

The eAgriculture business vertical has been addressed by the ITU since 2017. Several services have been defined for deployment mainly in Africa, but also in some regions of the US, Canada, Latin America and Europe. Many of these services can be addressed using broadcast and/or multicast over 5G.

In fact, information such as real-time market prices and updated farming techniques can easily reach thousands of farmers at the same time. In this way, a traditional farmer can manage to become a smart automated farmer, controlling many machines remotely, using a tablet.

eAgriculture supports farmers with disaster management and early warning systems in order to establish food safety, traceability and enhanced market access.

VoD

VIDEO ON DEMAND

Video on demand is becoming a daily routine. People are using streaming services anytime, anywhere on the go – especially when they are on the way to work or returning home. These streaming services vary in terms of quality. When viewers change locations rapidly from outdoor to indoor or travel by subway, video quality can vary from HD to SD and even pixelated frames. On top of this, latency due to buffering and jitter can create the world's greatest nightmare for viewers, drastically affecting mobile experience.

One idea to help overcome this situation is to allow content to be preloaded on smart devices when they are in idle mode or when they are not used overnight. In the morning viewers can easily find their favorite streaming series already preloaded and can watch them with higher quality with no buffering and no latency – and thus enjoy a better overall experience. Calculations by Rohde&Schwarz experts suggest that at least 35 % of current VoD traffic in mobile networks can be offloaded. With the consumed traffic offloaded, 5G cells can easily handle the remaining traffic.

ROHDE&SCHWARZ EXPERTS SUGGEST THAT 35 % OF CURRENT VoD TRAFFIC IN MOBILE NETWORKS CAN BE OFFLADED.

Section 6

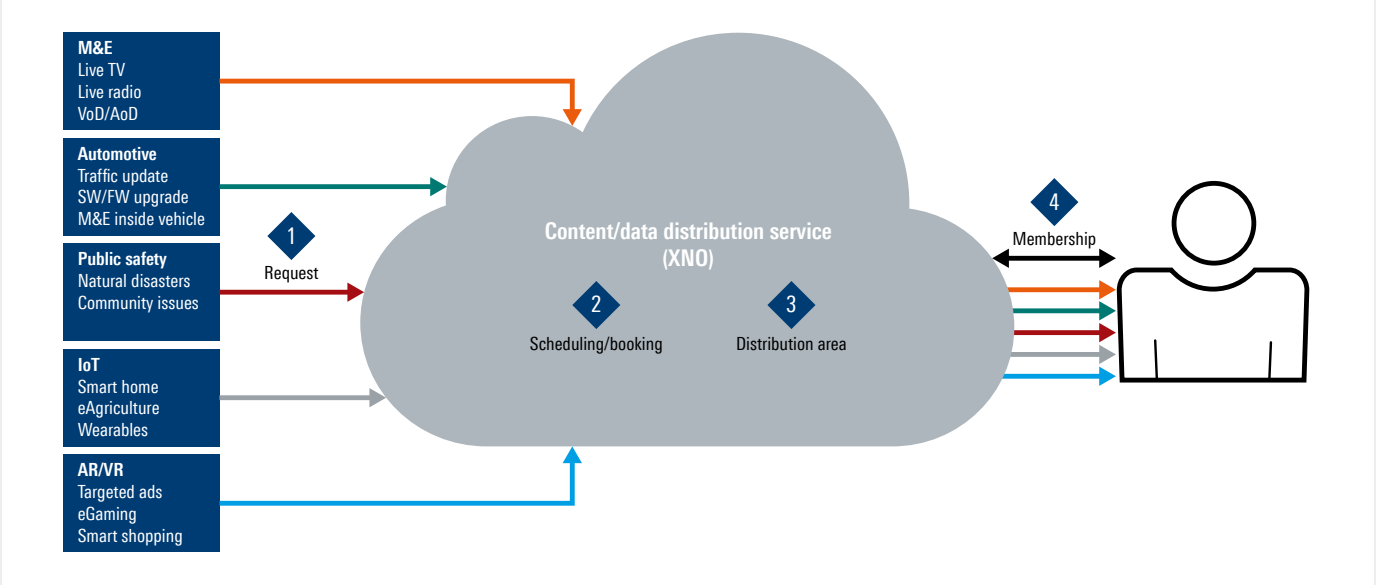
MULTICAST AS A SERVICE – A BOOKING SYSTEM ENABLING SEVERAL BUSINESS SCENARIOS

5G multicast creates opportunities for broadcast network operators to make their infrastructure more dynamic and allow them to discover new distribution features. Also, this technology helps mobile network operators to offload their heavy streaming and data loads so that they can avoid infrastructure over-provisioning. This allows them to serve their consumers with higher quality of service while reducing CAPEX and OPEX.

Multicast as a service is a business model designed by Rohde&Schwarz in order to optimize the delivery of one-to-many content and directly address the challenges faced by MNOs, BNOs and content providers. MaaS suggests four possible scenarios.

SCENARIO 1
DEDICATED BROADCAST/MULTICAST

In this scenario, MNOs and BNOs/XNOs host the content distribution service (i.e. the core and access networks operating in UHF or SDL bands). Their customers are content providers of different types depending on the application level: media and entertainment, automotive, public safety, OTA/IoT service providers, AR/VR service providers and more.

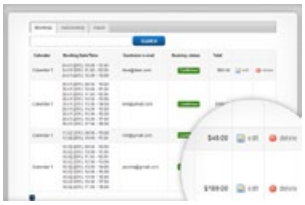


Content providers can easily use the MaaS model to reach millions of devices at the same time and with the same high quality and reliability. First, they create a business account for the service. Then, they can check the availability of date/time combinations in order to schedule their transmission and book a free slot. Finally, they can even choose the geographical distribution area depending on real-time coverage conditions.

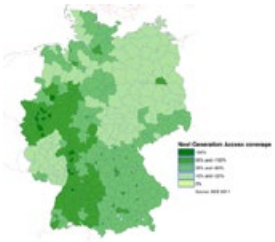
SCENARIO OPTION: B2B

Request → **Scheduling/booking** → **Distribution area** → **Payment**

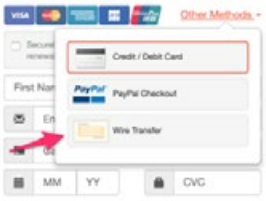
Create business account



Check availability
Choose date/time
Choose content quality/priority
Upload content



Choose what to distribute where



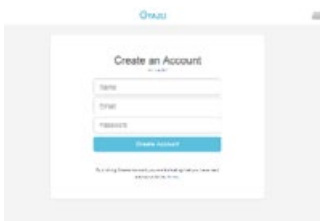
Choose payment method

In this scenario, viewers have a customer account where they can flexibly choose what kind of content they want to watch, whenever, wherever. The XNO can easily bundle several content types into one end-user application.

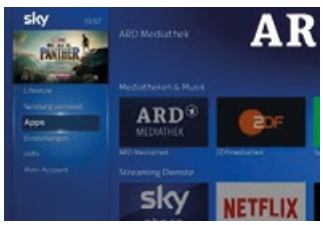
This can be charged based on the number of the devices used, providing an additional, effortless benefit for the MNO and/or BNO.

SCENARIO 1, STEP 4: B2C

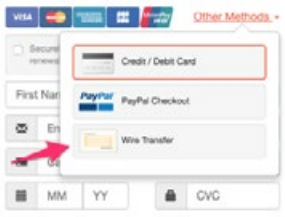
Membership → **Choose services** → **Payment**



Create customer account

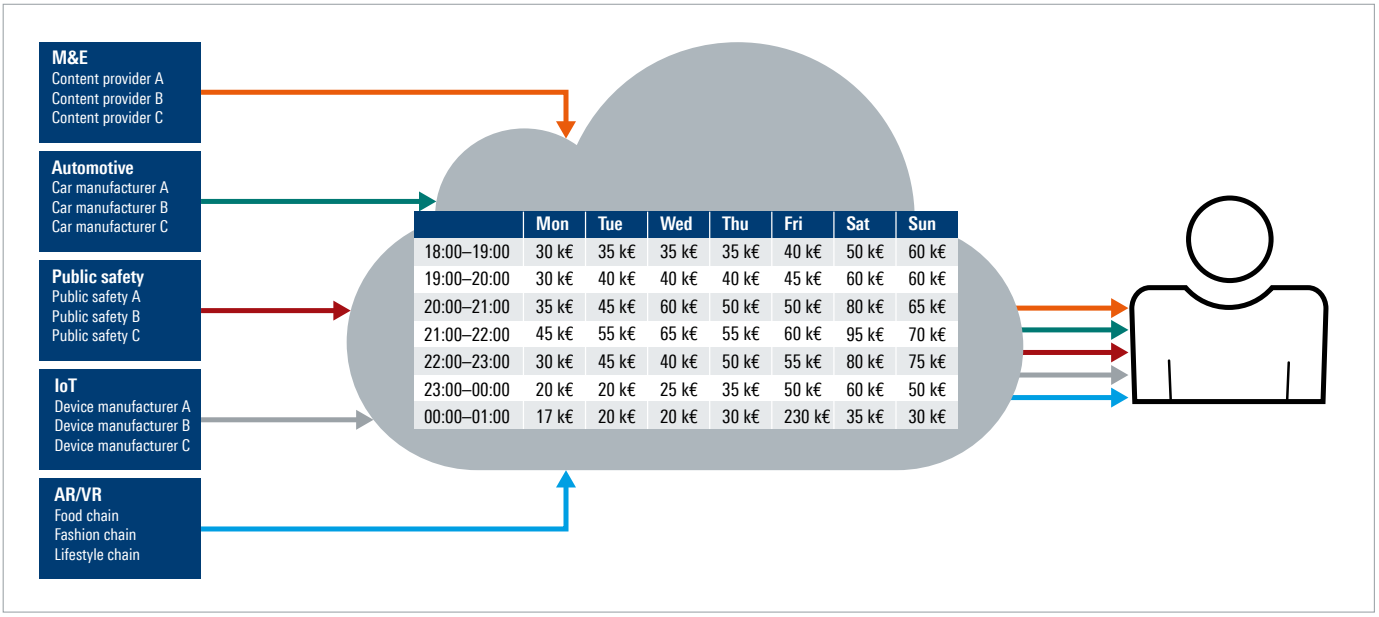


Select premium content

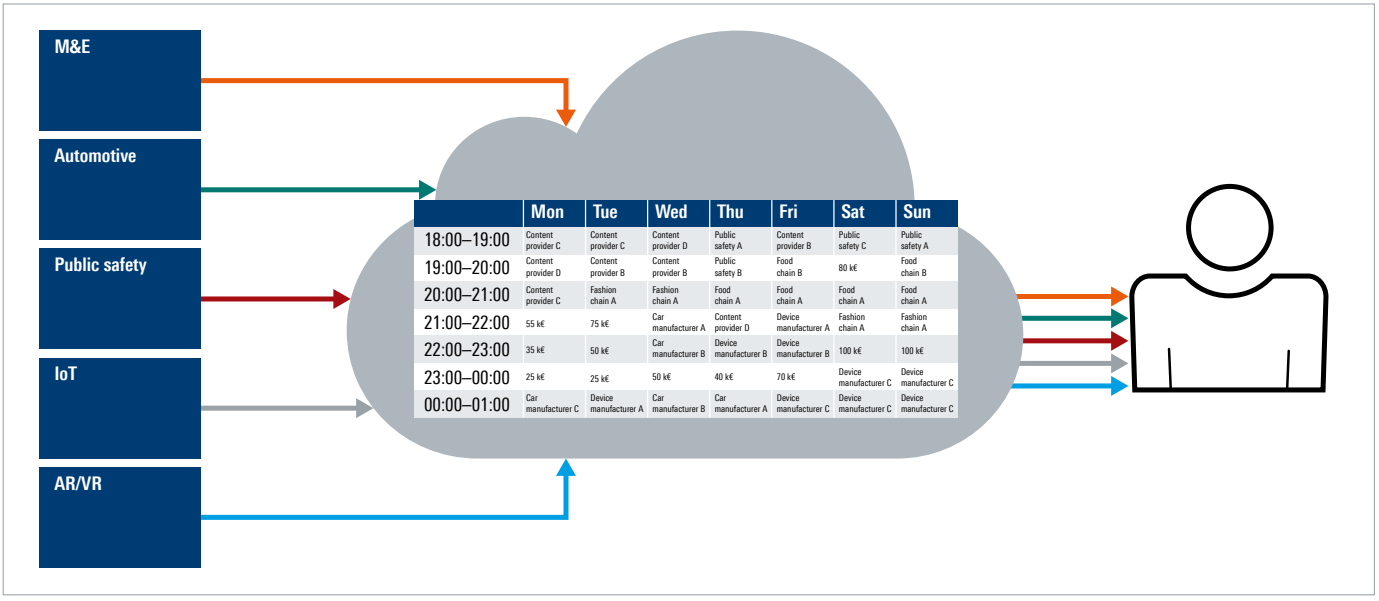


Pay just once

With 365 days per year and 24 hours per day, there is significant flexibility to allow different types of content/data to be smartly scheduled and optimally transmitted with the highest possible spectrum efficiency. Wider audiences can be reached with unparalleled quality of service. For example, the figure below shows a weekly calendar from 6 pm to 1 am with pricing per hour based on a maximum bit rate of 30 Mbit/s.



	Mon	Tue	Wed	Thu	Fri	Sat	Sun
18:00–19:00	30 k€	35 k€	35 k€	35 k€	40 k€	50 k€	60 k€
19:00–20:00	30 k€	40 k€	40 k€	40 k€	45 k€	60 k€	60 k€
20:00–21:00	35 k€	45 k€	60 k€	50 k€	50 k€	80 k€	65 k€
21:00–22:00	45 k€	55 k€	65 k€	55 k€	60 k€	95 k€	70 k€
22:00–23:00	30 k€	45 k€	40 k€	50 k€	55 k€	80 k€	75 k€
23:00–00:00	20 k€	20 k€	25 k€	35 k€	50 k€	60 k€	50 k€
00:00–01:00	17 k€	20 k€	20 k€	30 k€	230 k€	35 k€	30 k€



	Mon	Tue	Wed	Thu	Fri	Sat	Sun
18:00–19:00	Content provider C	Content provider C	Content provider D	Public safety A	Content provider B	Public safety C	Public safety A
19:00–20:00	Content provider D	Content provider B	Content provider B	Public safety B	Food chain B	80 k€	Food chain B
20:00–21:00	Content provider C	Fashion chain A	Fashion chain A	Food chain A	Food chain A	Food chain A	Food chain A
21:00–22:00	55 k€	75 k€	Car manufacturer A	Content provider D	Device manufacturer A	Fashion chain A	Fashion chain A
22:00–23:00	35 k€	50 k€	Car manufacturer B	Device manufacturer B	Device manufacturer B	100 k€	100 k€
23:00–00:00	25 k€	25 k€	50 k€	40 k€	70 k€	Device manufacturer C	Device manufacturer C
00:00–01:00	Car manufacturer C	Device manufacturer A	Car manufacturer B	Car manufacturer A	Device manufacturer C	Device manufacturer C	Device manufacturer C

This scenario can be considered as a market-driven booking system where prices dynamically vary depending on demand – just like booking a flight.

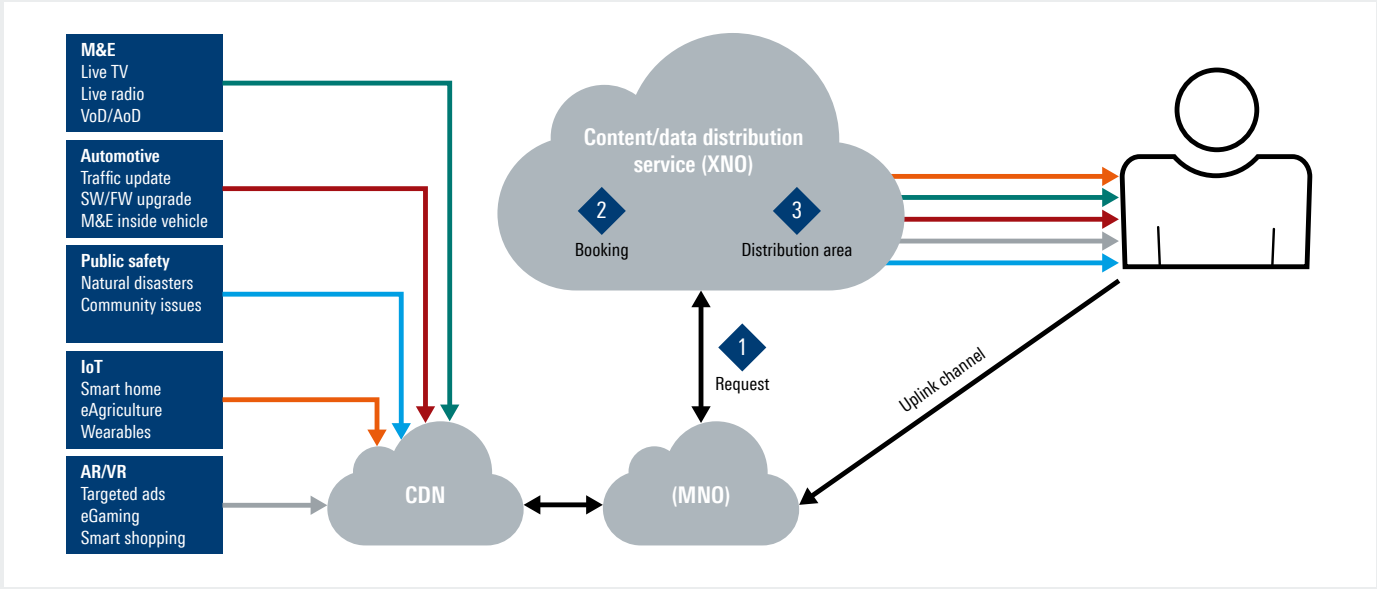
The price of non-booked slots can either increase or decrease. When there is no demand to book a slot and transmit content, the transmitters can be configured to shut down automatically in order to save power and increase energy efficiency. The theory is very simple: If you are not earning money, try to save costs.

Based on this example, we can see that M&E and advertisements related to content can be distributed during peak hours. Starting at 10 pm, software and map updates can be scheduled for transmission to vehicles via different bands. OTA updates can reach IoT devices such as home appliances and smart wearables. In addition, on-demand content (video and audio) can be easily preloaded to smart devices like smartphones, tablets and set-up boxes while they are in idle mode, thus freeing up the spectrum for daily 5G communications services.

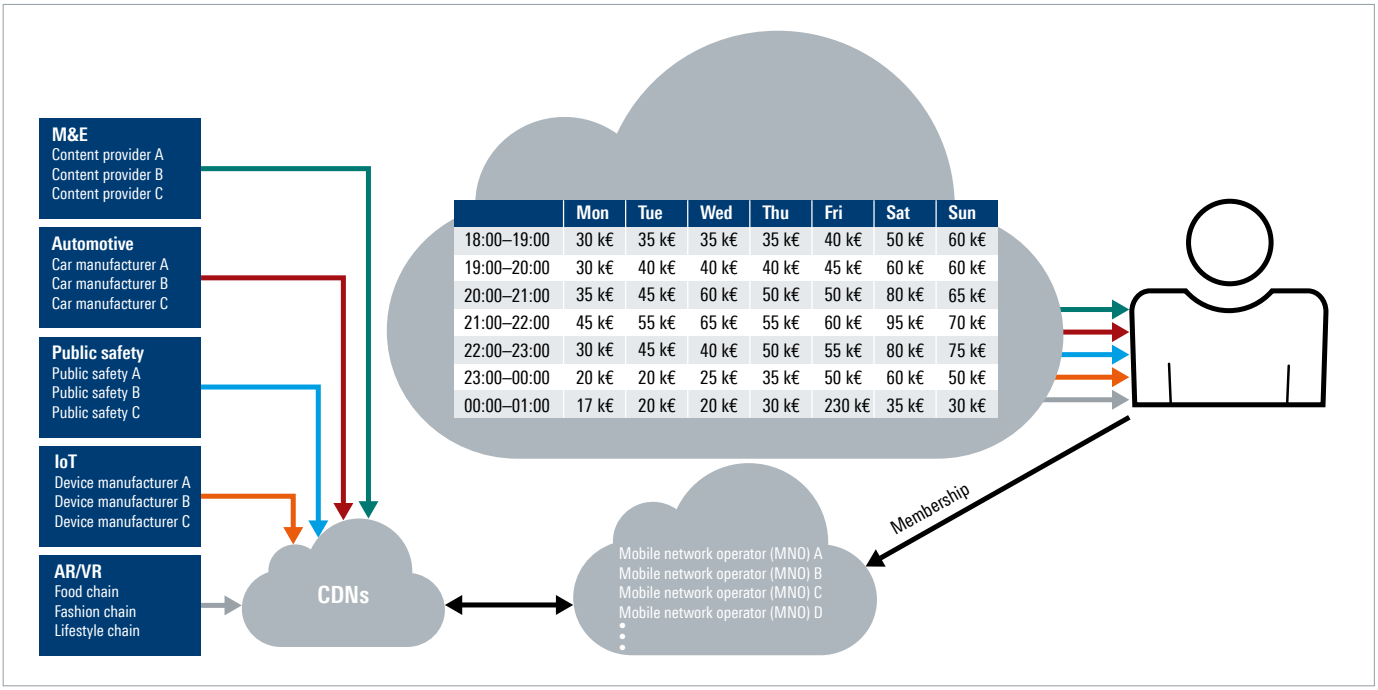
SCENARIO 2
MIXED BROADCAST/MULTICAST

Scenario 2 describes a business model where BNOs and MNOs are connected from a core network perspective. The main aim of this interconnection is to allow mobile operators to offload their data streams. Thus, they can achieve better spectrum efficiency and higher QoS for both offloaded and non-offloaded viewers, improving user experience.

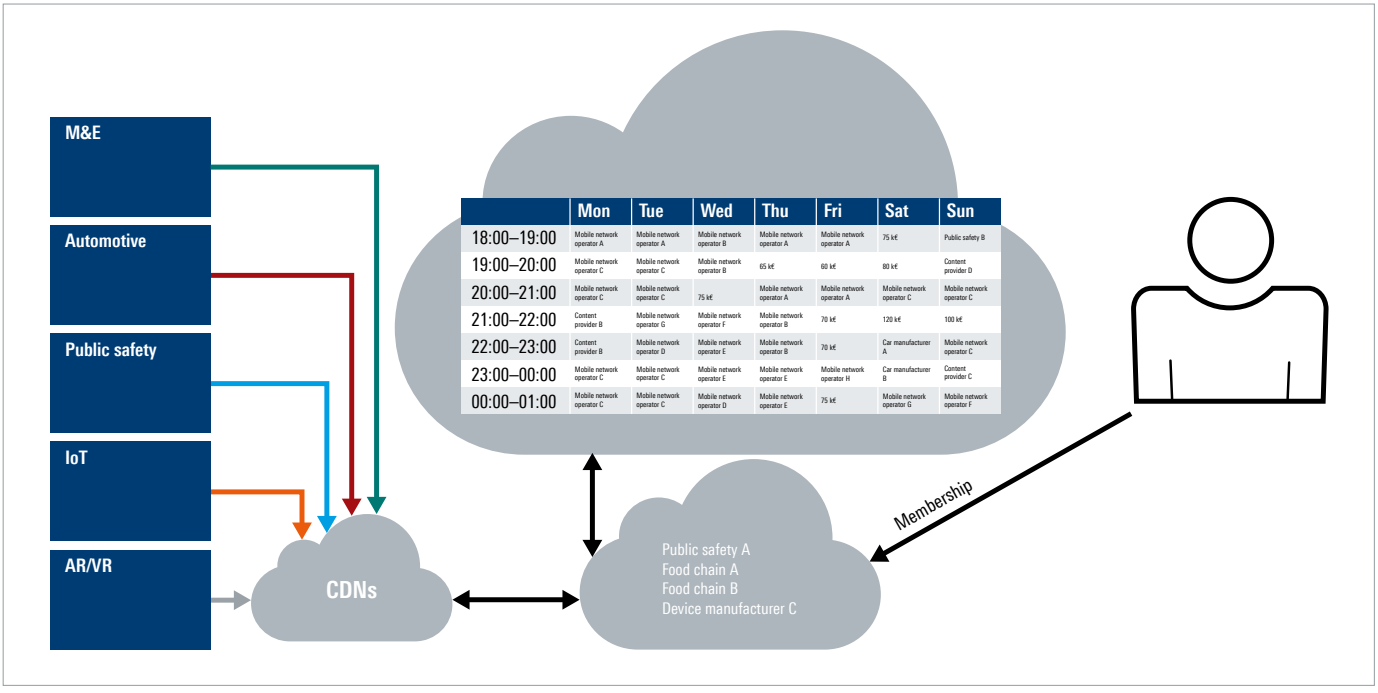
Mobile network operators can easily use the MaaS model to reach millions of devices at the same time and with the same high quality and reliability. First, they create a business account for the service. Then, they can check the availability of date/time combinations in order to schedule their transmission and book a free slot. Finally, the geographical distribution area can be chosen depending on real-time coverage conditions.



The pricing strategy defined in Scenario 1 is applied here as well: this scenario can be considered as a market-driven booking system where prices dynamically vary depending on demand – just like booking a flight.



	Mon	Tue	Wed	Thu	Fri	Sat	Sun
18:00–19:00	30 k€	35 k€	35 k€	35 k€	40 k€	50 k€	60 k€
19:00–20:00	30 k€	40 k€	40 k€	40 k€	45 k€	60 k€	60 k€
20:00–21:00	35 k€	45 k€	60 k€	50 k€	50 k€	80 k€	65 k€
21:00–22:00	45 k€	55 k€	65 k€	55 k€	60 k€	95 k€	70 k€
22:00–23:00	30 k€	45 k€	40 k€	50 k€	55 k€	80 k€	75 k€
23:00–00:00	20 k€	20 k€	25 k€	35 k€	50 k€	60 k€	50 k€
00:00–01:00	17 k€	20 k€	20 k€	30 k€	230 k€	35 k€	30 k€

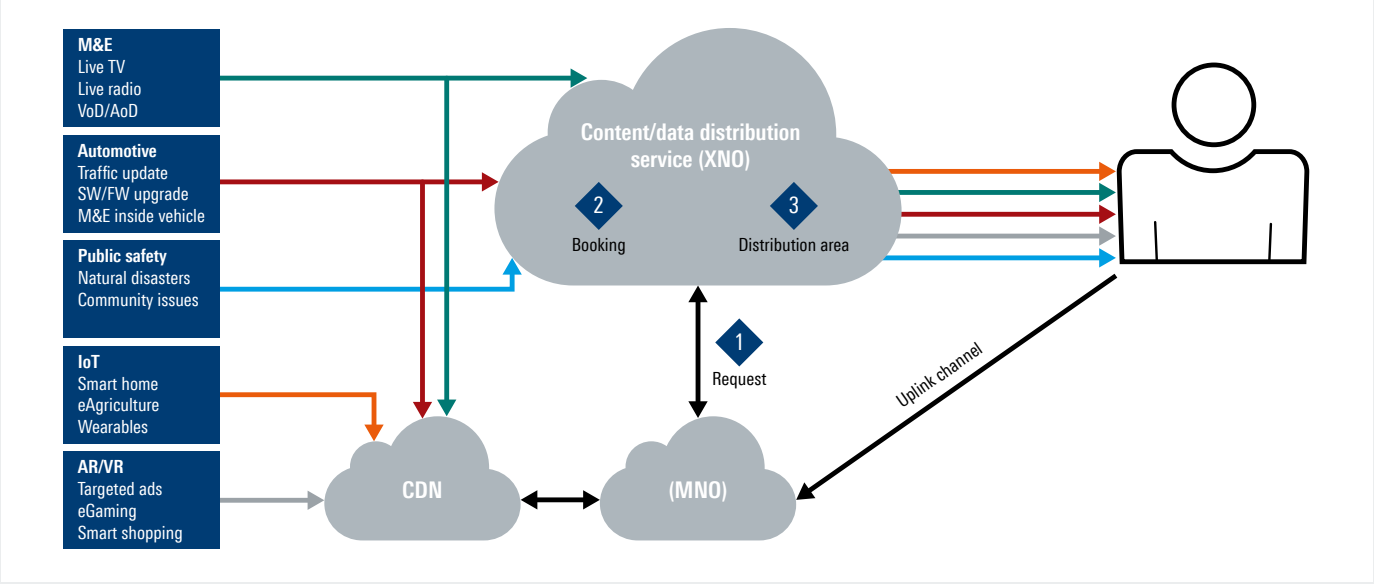


	Mon	Tue	Wed	Thu	Fri	Sat	Sun
18:00–19:00	Mobile network operator A	Mobile network operator A	Mobile network operator B	Mobile network operator A	Mobile network operator A	75 k€	Public safety B
19:00–20:00	Mobile network operator C	Mobile network operator C	Mobile network operator B	65 k€	60 k€	80 k€	Content provider D
20:00–21:00	Mobile network operator C	Mobile network operator C	75 k€	Mobile network operator A	Mobile network operator A	Mobile network operator C	Mobile network operator C
21:00–22:00	Content provider B	Mobile network operator G	Mobile network operator F	Mobile network operator B	70 k€	120 k€	100 k€
22:00–23:00	Content provider B	Mobile network operator D	Mobile network operator E	Mobile network operator B	70 k€	Car manufacturer A	Mobile network operator C
23:00–00:00	Mobile network operator C	Mobile network operator C	Mobile network operator E	Mobile network operator E	Mobile network operator H	Car manufacturer B	Content provider C
00:00–01:00	Mobile network operator C	Mobile network operator C	Mobile network operator D	Mobile network operator E	75 k€	Mobile network operator G	Mobile network operator F

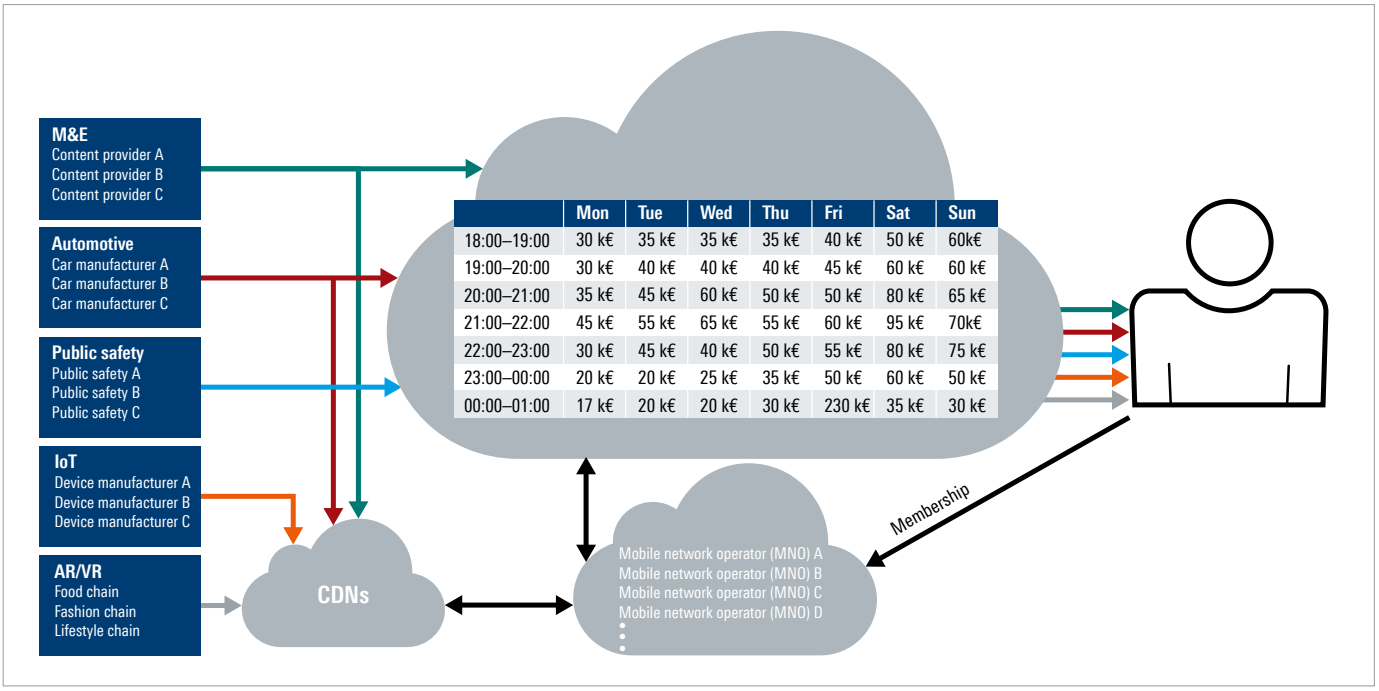
This scenario recommends using what is "already there" instead of acquiring new infrastructure and new frequencies. Broadcasting sites are already built, network infrastructure is installed and UHF frequencies are well established for broadcast/multicast mode in addition to the uplink channel already provided by mobile operators. It is just a new way to exploit existing network and frequency resources and use them whenever they are needed. This scenario supports MNOs by avoiding network infrastructure overprovisioning just for occasional or sporadic traffic.

SCENARIO 3
HYBRID BROADCAST/MULTICAST

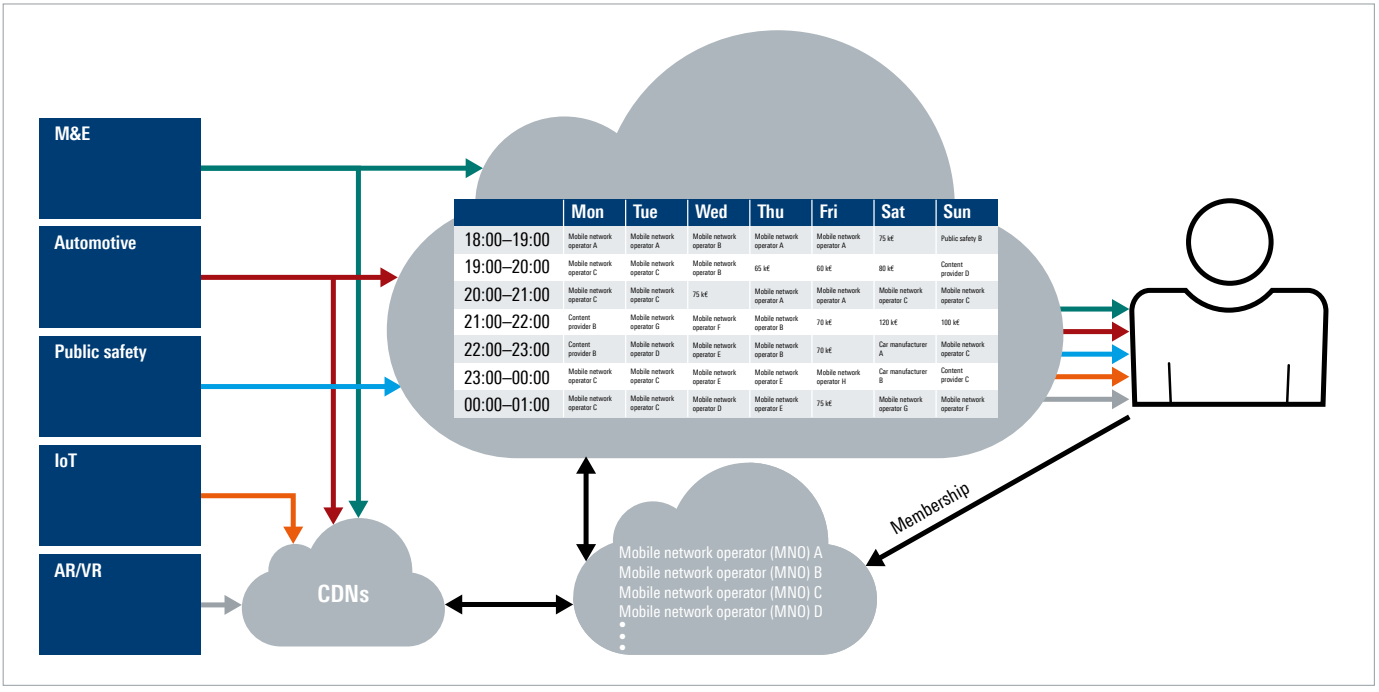
A hybrid broadcast/multicast environment is similar to Scenario 2. It allows mobile operators to offload their data streams to achieve greater spectrum efficiency and better QoS for both offloaded and non-offloaded viewers. The main difference is that this scenario gives content providers more flexibility to distribute their content directly and transparently via the booking system provided by the BNO. Greater cost efficiency can be achieved without having to go via a certain CDN.



The pricing strategy defined for the previous scenarios is applied here as well: this scenario can be considered as a marketdriven booking system where prices dynamically vary depending on demand – just like booking a flight.



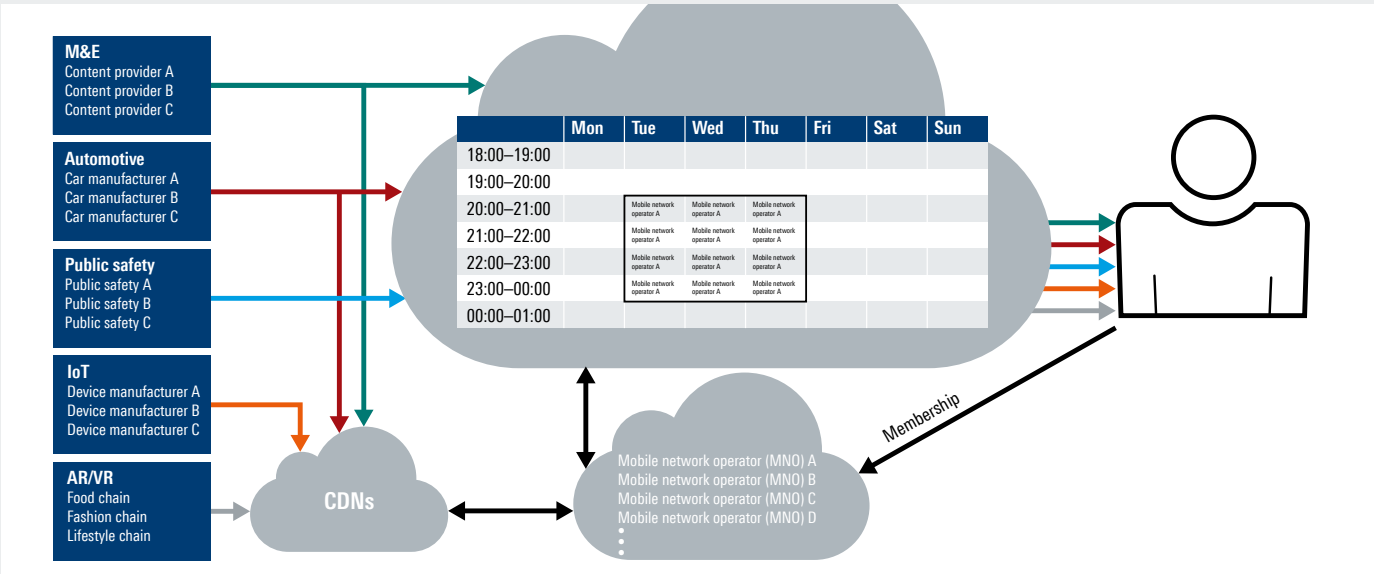
	Mon	Tue	Wed	Thu	Fri	Sat	Sun
18:00–19:00	30 k€	35 k€	35 k€	35 k€	40 k€	50 k€	60k€
19:00–20:00	30 k€	40 k€	40 k€	40 k€	45 k€	60 k€	60 k€
20:00–21:00	35 k€	45 k€	60 k€	50 k€	50 k€	80 k€	65 k€
21:00–22:00	45 k€	55 k€	65 k€	55 k€	60 k€	95 k€	70k€
22:00–23:00	30 k€	45 k€	40 k€	50 k€	55 k€	80 k€	75 k€
23:00–00:00	20 k€	20 k€	25 k€	35 k€	50 k€	60 k€	50 k€
00:00–01:00	17 k€	20 k€	20 k€	30 k€	230 k€	35 k€	30 k€



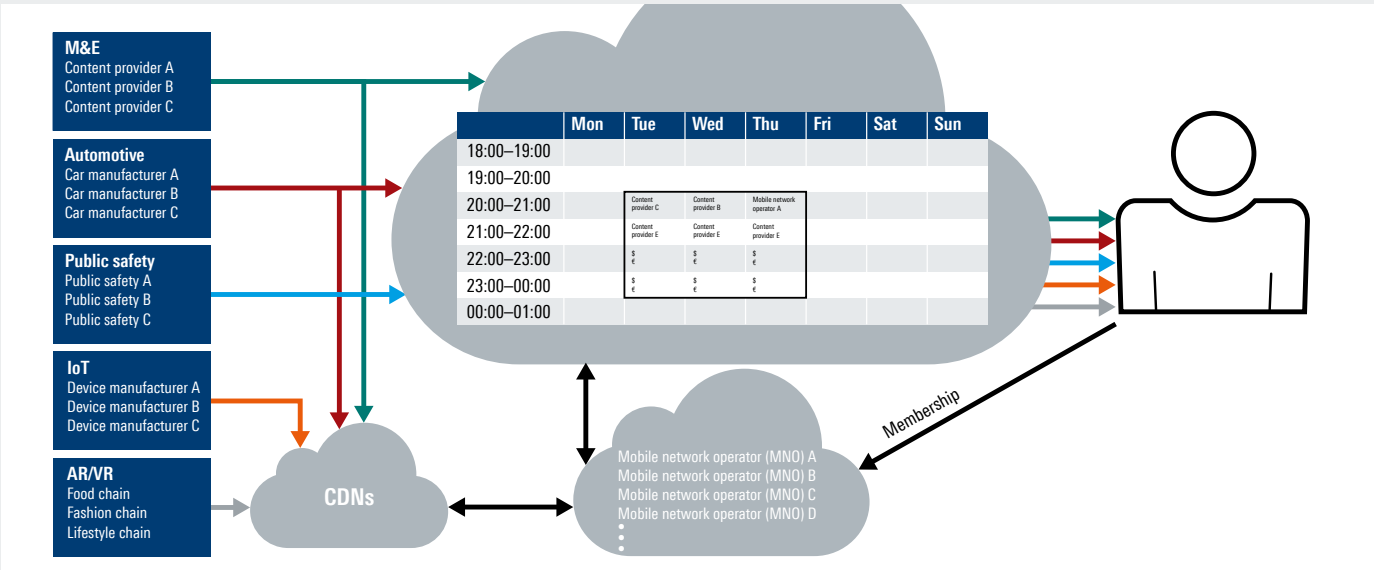
	Mon	Tue	Wed	Thu	Fri	Sat	Sun
18:00–19:00	Mobile network operator A	Mobile network operator A	Mobile network operator B	Mobile network operator A	Mobile network operator A	75 k€	Public safety B
19:00–20:00	Mobile network operator C	Mobile network operator C	Mobile network operator B	65 k€	60 k€	80 k€	Content provider D
20:00–21:00	Mobile network operator C	Mobile network operator C	75 k€	Mobile network operator A	Mobile network operator A	Mobile network operator C	Mobile network operator C
21:00–22:00	Content provider B	Mobile network operator G	Mobile network operator F	Mobile network operator B	70 k€	120 k€	100 k€
22:00–23:00	Content provider B	Mobile network operator D	Mobile network operator E	Mobile network operator B	70 k€	Car manufacturer A	Mobile network operator C
23:00–00:00	Mobile network operator C	Mobile network operator C	Mobile network operator E	Mobile network operator E	Mobile network operator H	Car manufacturer B	Content provider C
00:00–01:00	Mobile network operator C	Mobile network operator C	Mobile network operator D	Mobile network operator E	75 k€	Mobile network operator G	Mobile network operator F

Ultimately, both content providers and mobile operators are considered to be broadcast network customers and MaaS users.

SCENARIO 4
SHARED BROADCAST/MULTICAST



A shared broadcast/multicast business model can be best explained with an example: In order to cover Champions League and Europa League football matches with the best quality, the mobile network operator T-Mobile could use the MaaS model to exclusively book Thuesdays, Wednesdays and Thursdays from 8 pm to 11 pm in advance.



The MNO has an SLA with many Champions League and Europa League rights owners and content providers. The distribution costs are shared between the stakeholders, reducing the overall investment while reaching a huge number of devices with higher quality of service – without impacting the cellular 5G network. The booking and pricing strategy applied in previous scenarios are can also be applied to the shared broadcast/multicast business model.

Section 7

NETWORK OPERATORS – SPOIL YOUR CUSTOMERS WITH LOWER TCO

More than 70 mobile network operators carried out market research to better understand the relationship between 2018/2019 traffic revenue and mobile user data consumption.

So far, the strategy pursued by MNOs worldwide has been based on a "more for more" promise. This involves defining lower pricing per gigabyte and indirectly pushing users to consume more data volume. Mobile operators expected their aggregate revenue per user (ARPU) to grow and their data revenue to increase. Unfortunately, however, this has not been the case.

In fact, only 46 % of these operators have been able to convert this increase into ARPU growth. They are the ones able to monetize increasing mobile data usage. More than half of the mobile operators experienced a concrete loss by an average of 18 %.

This overall market trend can be explained by the many initiatives taken to improve mobile data monetization or customer loyalty – unlimited, zero-rating, rollover, speed tiers, video tiers, priority tiers, inclusive content, FMC, 100 % app based services. In fact, these are just a few examples with a limited data rate up to 512 kbit/s, therefore impacting the quality of service delivered to consumers.

ONLY 46 %

of network operators could convert increased data consumption

INTO REVENUE.

ONE-TO-MANY CONTENT – LIVE AND LINEAR CONTENT IS A GOOD EXAMPLE

Today, mobile network traffic comes in several different types, including file downloads, web browsing, live and on-demand audio, software updates, voice over LTE (VoLTE – soon to become voice over 5G) and video over LTE (ViLTE – soon to become video over 5G). In addition, video consumption constitutes over 70 % of overall mobile traffic. If we have a closer look, we can find many applications and services that can be distributed more efficiently and with higher QoS via a one-to-many model.

To make our study easy and understandable, we will only focus on one application: **live and linear content.** The aim of this study is to demonstrate how offloading this type of content will help MNOs to invest less and increase BNO revenues.

Based on a very conservative estimate, live and linear content **currently** constitutes **13 %** of overall video consumption (**~9 %** of overall mobile network traffic). By **2025**, mobile video consumption is expected to reach **80 %** of overall 5G mobile data traffic. Live and linear content in turn is expected to reach an average of at least **25 %** of overall video consumption five years from now. In other words, **20 %** of overall mobile network traffic.

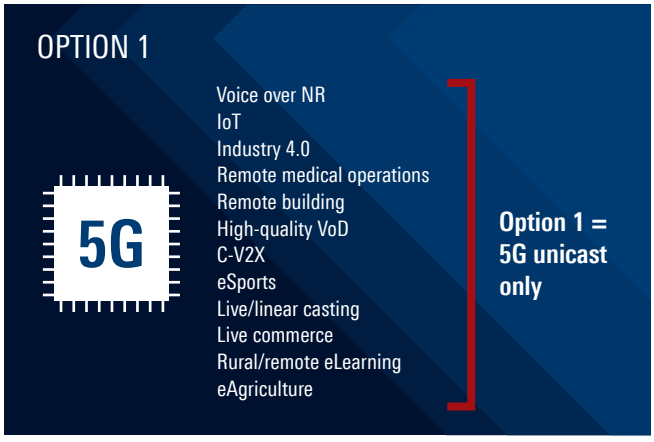
From an investment point of view, a worldwide average CAPEX of **EUR 300 million per year** is planned by an MNO in order to deploy and/or upgrade **200** radio access network sites yearly.

Again, based on a conservative estimate, mobile operators are expected to invest at least **50 %** on top of what they are already investing each year in order to meet the mandatory 5G specifications and try to cover the new type of mobile traffic. This is especially relevant for new use cases that do not necessarily constitute a concrete business case. Following the same logic, this means a worldwide average CAPEX of **EUR 450 million per year** will be required from an MNO to try to cover their needs.

Rohde&Schwarz suggests two different paths: Network operators can proceed with their current strategy of deployment of "**5G unicast only**" with cellular networks. Or, they could use a "**5G unicast+multicast**" approach where they can offload at least **20 %** of their mobile traffic load in broadcast/multicast mode while delivering unicast bidirectional traffic as usual (the goal of the second approach is to manage the current situation and save on future investments).

OPTION 1 – 5G UNICAST ONLY

In this case, mobile operators go ahead with their usual investment strategy under which worldwide average CAPEX is expected to reach **EUR 450 million per year**. Note that this figure only applies to the radio access network and does not take into account OPEX and additional sub 1 GHz frequencies.



OPTION 2 – 5G UNICAST + MULTICAST

The second path proposed by Rohde&Schwarz seeks to bring together all ecosystem players to achieve a win-win situation.

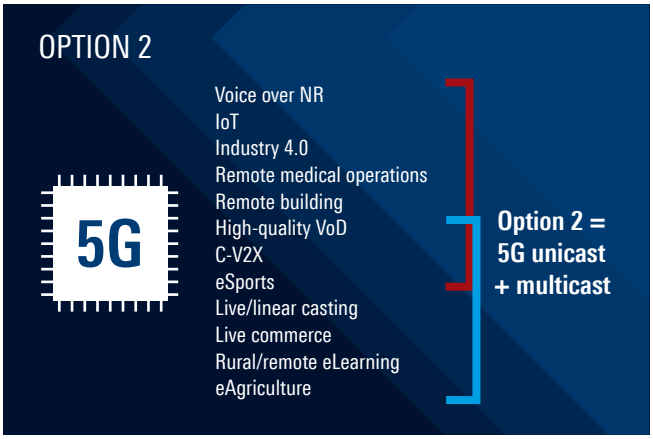
In this option, we considered that an MNO would generally require network resources in order to cover 3 hours of live and linear content per day annualy (365 days a year).

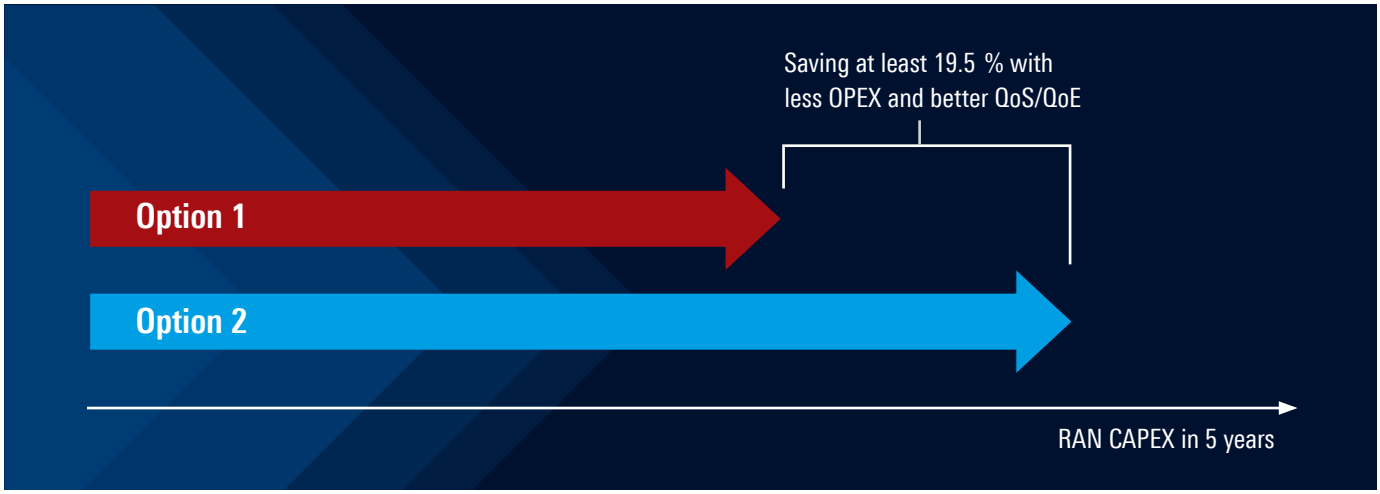
This case describes the broadcast network operator as a network infrastructure provider. This study considered a pricing example as follows: EUR 30 thousand per hour for 30 Mbits, i.e. EUR 1 thousand per hour for 1 Mbit. Ultimately, this means the mobile operator would need at most **EUR 33 million per year** in distribution costs if they bear the whole distribution costs on their own, just as described in Scenarios 2 and 4. Adding the unicast part, the total worldwide average CAPEX is expected to reach **EUR 393 million per year instead of EUR 450 million per year**. In other words, their future **CAPEX** is reduced by at least **14.5 %**.

Another alternative is to share the distribution costs with relevant content providers, as described in Scenario 4 (shared broadcast/multicast model). This automatically reduces the distribution costs of the mobile operator to at most **EUR 17 million per year**. Adding the unicast part, the total worldwide average CAPEX is expected to reach **EUR 377 million per year instead of EUR 450 million per year**. Thus, their future **CAPEX** is reduced by at least **19.5 %**.

In fact, in addition to dramatically reducing the CAPEX for live and linear content by between **14.5 % and 19.5 %, MNOs will not require any additional frequency-related investments and OPEX**, as they use existing infrastructure as a service, including operational costs.

This alternative is opening the door for content providers/owners to deliver higher quality of service to broader audiences using millions of devices with less cost – and even in many cases without any need for a CDN.





	BW (MHz)	Coverage	Max. bit rate	Bit rate/user	Latency	
* Current status **	MNO	70 % to 80 %	1 Gbps to 1.5 Gbps	5 Mbits to 12 Mbits	30 s to 60 s	4x4 MIMO
* Option 1 **	MNO	80 % to 90 %	3 Gbps to 5 Gbps	25 Mbits to 40 Mbits	3 s to 6 s	4x4 MIMO or more
Option 2 ***	MNO	95 % to 98 %	–	15 Mbits to 30 Mbits	1 s to 2 s	SISO

* Best case ** MCS is 256 QAM *** MCS is 64 QAM

NETWORK OPERATORS – UNICAST ONLY OR UNICAST + MULTICAST?

In order to reach these values, Rohde&Schwarz specialists took a close look at the data traffic volume, CAPEX and related revenues of more than 70 mobile network operators. In addition, data traffic volume for the world's 10 largest MNOs out of the 70 was analyzed. The conclusion is that it is worth exploring aspects related to network efficiency and high service quality while trying broadcast and multicast capabilities over 5G. Mobile network operators are recommended to choose the **"5G unicast+multicast"** option over **"5G unicast"**.

The analysis showed that BNOs are expected to increase their **CAPEX by 15 % to 20 %** during the **next 5 to 10 years** in order to upgrade their existing infrastructure. If we consider the same concept that a BNO would take over the load of mobile operators for **only 3 hours a day (365 days a year)**, BNOs could increase their revenue on average by **at least 14.7 % per year**.

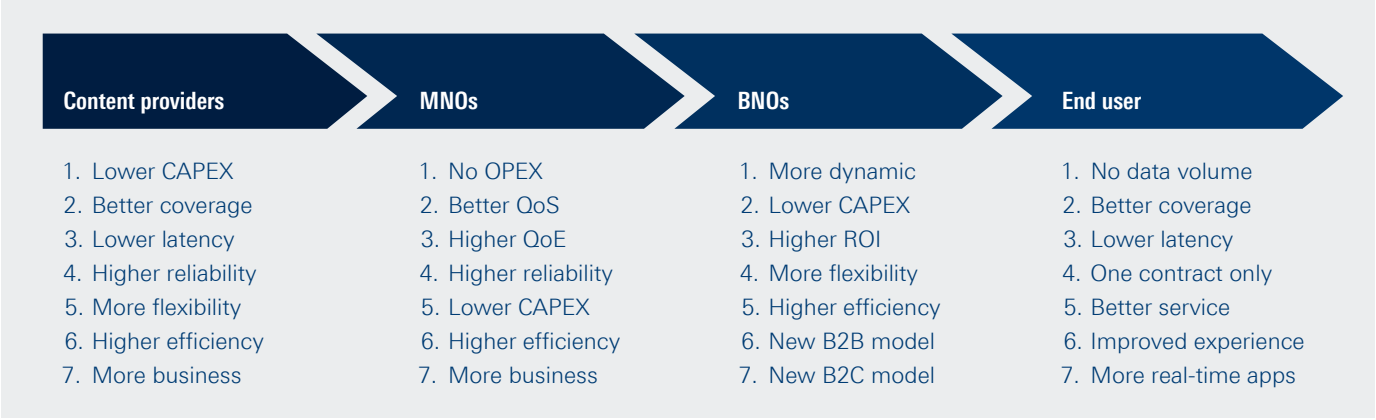
BNOs are currently are transmitting live and linear content 24/7, where only leasing the infrastructure for three hours would generate almost **15 % more revenue per year**. The question is what about the remaining 21 hours a day?

5G broadcast/multicast technology promises several applications in addition to live and linear content that – in combination with MaaS – will revolutionize the way OTA content reaches millions of devices in the most efficient way ever.

This analysis allowed us to gather more information in order to compare the current status with option 1 and option 2. We were able to demonstrate that implementing MaaS not only generates business benefits but also some key technical takeaways.

MAAS – BENEFITS FOR ECOSYSTEM PLAYERS

For mobile network operators, multicast as a service (MaaS) demonstrates business benefits where CAPEX is reduced by **at least 19.5 %**, including OPEX and without investing in new frequency bands. Several customer benefits are also evident such as outstanding quality of service and improved viewer experience, all of which lead to heightened customer loyalty.



KEY TAKEAWAYS – TELCO INDUSTRY WITNESSES

"A key lesson we've learned while working with our media customers is that although there is still a significant gap between streaming and TV, viewers demand an online experience that matches or exceeds that of broadcast." *Akamai*

"Operators would still need to invest heavily in the network. Most of these investments could not be justified by a business case since their only purpose is prepare for traffic peaks that rarely occur." *Major telco vendor*

"The challenges of providing a live streaming service that brings the TV experience to online audiences for live events and/or 24/7 live linear programming include: reducing live delay, attaining broadcast-level reliability, maximizing audience reach, etc." *Akamai*

"Mobile unicast cannot guarantee delivery similar to broadcast networks. Therefore, unicast MBB is not ideal for replacing broadcast networks." *Major telco vendor*

Section 8

CONCLUSIONS & PERSPECTIVES

The 5G broadcast/multicast concept helps mobile network operators handle congested and overloaded cellular networks. This is especially important when it comes to delivering critical live events and linear content which constitutes sizeable portion of video consumption in general and therefore leads to lower quality of service.

Rohde&Schwarz has been working extensively on new technical concepts and business models. Our goal is to develop new ways of ensuring efficient content delivery and better end-user quality of experience – along with diversified business strategies for mobile and broadcast operators to considerably reduce CAPEX and OPEX.

At the upcoming World Radio Conference (WRC23), the future use of the remaining UHF bands (470 MHz to 900 MHz) will be determined in Europe, Middle East and Africa, i.e. ITU Region 1 on the basis of the review in accordance with Resolution 235 (WRC-15). Mobile operators are looking at the spectrum with greater appetite while broadcasters will try to keep as much as possible of it.

There is a famous quote saying: "If you are not progressing, you are regressing."

The important question is: Who will take the lead in the UHF band? Mobile operators or broadcasters? Or maybe both? The Rohde&Schwarz vision as described in this booklet clearly prefers a win-win scenario over an "either/or" discussion.

Together with the 700 MHz, L band, 2.6 GHz (SDL bands) and sub 1 GHz band deployment possibilities, 5G broadcast/multicast technology is spoilt for choice. It is therefore no longer a question of "If" but rather a question of "When". We are confident that the market decision will be revealed soon.

LIST OF ACRONYMS

3GP-DASH	Progressive Download and Dynamic Adaptive Streaming over HTTP
3GPP	3rd Generation Partnership Project
5GC	5G Core Network
AoD	Audio on Demand
AR	Augmented Reality
ARPU	Aggregate Revenue per User
B2B	Business to Business
B2C	Business to Customer
BM-SC	Broadcast Multicast Service Center
BNO	Broadcast Network Operator
BSCC	Broadcast Service & Control Center
CAPEX	Capital Expenditures
CDN	Content Delivery Network
CN	Core Network
COFDM	Coded Orthogonal Frequency-Division Multiplexing
C-RAN	Centralized/Cloud based Radio Access Network
C-V2X	Cellular Vehicle to Everything
DL	Downlink
DVB	Digital Video Broadcast
DVB-H	Digital Video Broadcast-Handhelds
eMBB	Enhanced Mobile Broadband
eMBMS	Enhanced Multimedia Broadcast/ Multicast Service
eNB	Evolved Node B (LTE/4G base station)
EPC	Evolved Packet Core
FeMBMS	Further Enhanced Multimedia Broadcast/ Multicast Service
FLUTE	File Delivery over Unidirectional Transport
Gbps	Gigabit per second
gNB	New Generation Node B (5G base station)
GSM	Global System for Mobile Communications
HD	High Definition
HDR	High Dynamic Range
HLS	HTTP Live Streaming
HP Tx	High Power Transmitter
HPHT	High Power High Tower
IoT	Internet of Things
ITU	International Telecommunication Union
kW	Kilowatt
LP Tx	Low Power Transmitter
LPLT	Low Power Low Tower
LTE	Long Term Evolution
M&E	Media & Entertainment
MaaS	Multicast as a Service
MBB	Mobile Broadband
MBMS	Multimedia Broadcast/Multicast Service
MBMS-GW	Multimedia Broadcast/Multicast Service Gateway
MCE	Multi-cell/Multicast Coordination Entity
MediaFLO	Media Forward Link Only
MFN	Multiple-Frequency Network
MNO	Mobile Network Operator
MP Tx	Medium Power Transmitter
MPEG	Moving Picture Experts Group
MPEG-DASH	Moving Picture Experts Group-Dynamic Adaptive Streaming over HTTP
MPMT	Medium Power Medium Tower
MVNO	Mobile Virtual Network Operator
MWC	Mobile World Congress in Barcelona
NGC	New Generation Core Network
NR	New Radio
NSA	Non-Standalone Architecture
OPEX	Operational Expenditures
OTA	Over the Air
OTT	Over the Top
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
RFO	Request for Offer
RFP	Request for Proposals
ROI	Return on Investment
ROM	Receive-Only Mode
ROUTE	Real-Time Object Delivery over Unidirectional Transport
SA	Standalone Architecture
SC-PTM	Single-Cell Point-to-Multipoint
SD	Standard Definition
SDL	Supplementary Downlink
SFN	Single-Frequency Network
SLA	Service Level Agreement
SW/FW Update	Software/Firmware Update
Tbps	Terabit per second
Tx9	Transmitter Generation 9
UHD	Ultra-High Definition
UHF	Ultra-High Frequency
UL	Uplink
ViLTE	Video over LTE
VoD	Video on Demand
VoLTE	Voice over LTE
VR	Virtual Reality
Wi-Fi	Wireless Fidelity
XR	Cross Reality

Rohde&Schwarz
The Rohde&Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, monitoring and network testing. Founded more than 80 years ago, the independent company which is headquartered in Munich, Germany, has an extensive sales and service network with locations in more than 70 countries.

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