Broadcast and Multicast Communication Enablers for the Fifth-Generation of Wireless Systems

# Deliverable D6.9

# EuCNC and Global 5G Event 2019

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Disclaimer

Abstract

This document describes the demonstrators developed in the context of the EuCNC and Global 5G Event 2019. A total of six demonstrators are shown covering the main innovations and technical solutions carried out in 5G-Xcast for Media and Enternainment and Public Warning use cases. The EuCNC and Global 5G Event 2019 took place from the 17th to 21st June 2019 in Valencia, Spain.

Keywords

5G, demonstrators, EuCNC, media distribution, public warning, 5G-NR, MooD, mABR, multi-link, object-based broadcasting, eMBMS

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# 1 Introduction

The EuCNC and Global 5G Event 2019 (June 17th to 21st, Valencia, Spain) was the last opportunity for 5G-Xcast to show the achievements of the project in a public event. Therefore a total of six demonstrators where developed with the aim of showing the most representative use cases considered in 5G-Xcast and the technical enablers for multicast/broadcast operation in future 5G releases and networks.

The demonstrators, which are summarized in the next section, are the following:

- Forecast 5G: Object-based Broadcasting over multicast and unicast
- Content Distribution Framework in 5G Converged Networks
- Reliable Multicast Delivery in 5G Networks
- Efficiently delivering Public Warning messages with multimedia contents
- Hybrid Broadcast Services with Multi-Link
- Over-the-Air multicast over satellite or video caching and live content delivery

# 2 5G-Xcast Demonstrators present at EuCNC

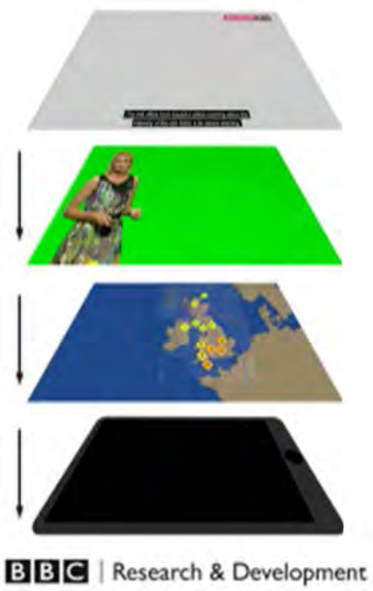
## 2.1 Forecaster 5G: Object-based Broadcasting over multicast and unicast

This demonstrator was developed by BBC R&D.

### 2.1.1 Objectives

To efficiently deliver high quality personalised media content to many users.

- Objective 1: deliver an enhanced audio/video media experience, in which the presentation of the content adapts to the user's environment, the user's preferences, the device's capabilities and includes personalisation. This is achieved by using an object-based approach, in which the media is delivered in multiple objects (e.g. the presenter video, the sign language video, and instructions for the weather map). These objects are then rendered optimally on the device.
- Objective 2: significantly reduce the resource cost of delivering high quality live media content to a large audience over IP by using multicast as opposed to conventional unicast. This is achieved using the Dynamic Adaptive Streaming over IP Multicast (DASM) system, developed by the BBC's R&D department.




### 2.1.2 Concept

The concept of the demonstrator is to show a hybrid of multicast and unicast objects being rendered seamlessly on the user's device. This is demonstrated by a weather forecasting app, see Figure 1. The traditional, non-object-based, weather forecast video is broken into a number of objects at production, which are streamed from the BBC in a pseudo-live manner. These objects include the presenter MPEG-DASH video, the sign language MPEG-DASH video, the subtitles, the audio, and the weather map (which is itself split into many image assets, the layout of which is controlled by events in the MPEG-DASH video streams). The UE then renders the objects depending upon several factors, including user preferences (for example choosing between the main presenter or a sign language presenter), device orientation (portrait or landscape), and unique personalisation to the user (in the form of icons for the location of the user's friends on the weather map).

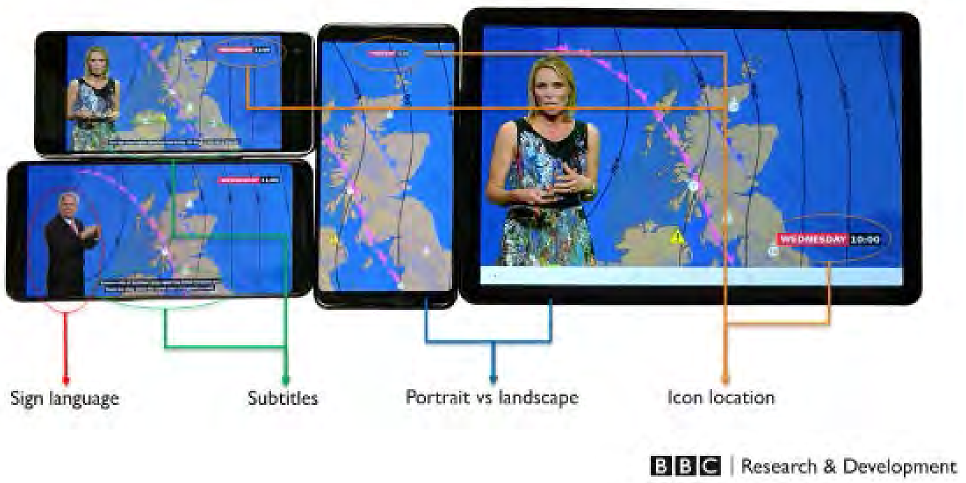



*Figure 1: Forecaster5G concept.*

### 2.1.3 Architecture

Multicast objects are delivered by the DASM system. We chose to multicast objects which are commonly used and/or bandwidth-heavy (for example the main video of the presenter, see Figure 2). The less commonly used and/or less bandwidth-expensive objects (for example the weather symbols and the personalisation images, again see Figure 2) are delivered over unicast HTTP. The demonstration videos and audio comprise a continuously looping pseudo-live stream of MPEG-DASH packaged media segments. The DASM Head-end system is located at the BBC and transmits the media objects as multicast HTTP resources. These are encapsulated in a GRE tunnel, which is delivered to the EuCNC venue. The GRE tunnel terminates on a DASM Client Proxy function, which resides at the EuCNC venue. The DASM Client Proxy decapsulates the multicast traffic and reconstructs the media objects from the received multicast streams. The DASM Client Proxy patches dropped multicast packets over unicast. The user devices (connected to the DASM Client Proxy over Wi-Fi) then consume the media via unicast HTTP. This architecture is illustrated in Figure 3.

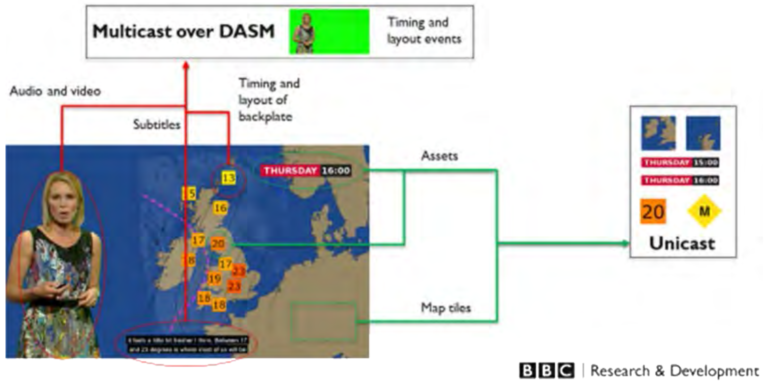



*Figure 2: Origin of the objects.*

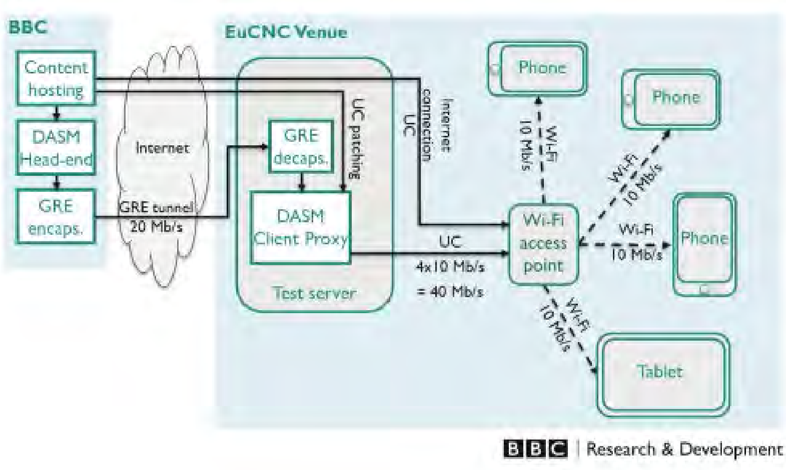



*Figure 3: EuCNC architecture.*

## 2.2 Content Distribution Framework in 5G Converged Networks

This demonstrator has been developed jointly by BT and Expway.

### 2.2.1 Objectives

This demonstrator showcases key features of the Content Distribution Framework developed in WP5. In particular the objectives were to show:

- The use of multicast/broadcast as an internal network optimisation, rather than as a service to be sold.
- The use of simple unicast interfaces with content service providers to simplify integration and facilitate adoption.
- How client applications do not require any modification to benefit from the use of multicast/broadcast.
- How the framework is applicable to both fixed and mobile networks.

### 2.2.2 Concept

The concept of this demonstrator was to realise implementations of the Content Distribution Framework on both fixed and mobile networks. We aimed to gain insight into the practical challenges of implementing the framework and testing the feasibility of various approaches. The resulting implementations allowed the benefits of the framework to be communicated in a visual and engaging way.

We chose to build two instances, one for the fixed network and one for the mobile. While they shared similar components, they had different requirements in terms of the network architecture. For example the fixed network features a home gateway which terminates a broadband connection and allows in-home devices to connect wirelessly over WiFi, while the mobile network included a cellular base station that provides a radio connection direct to the mobile UE.

We focused on using the BT Sport application, downloaded from the Google Play Store, as our exemplar application that remained unchanged. BT were able to provide test accounts and we were familiar with its operation and underlying media stream formats.

The demonstrator showed how the framework is able to steer unicast stream onto multicast/broadcast delivery as a function of the audience size. This was accomplished by using 3GPP Multicast Operation On Demand (MooD) and allowed video playback to continue uninterrupted during a delivery mechanism switching event.

### 2.2.3 Architecture

A high level architecture of the demonstrator is shown below…

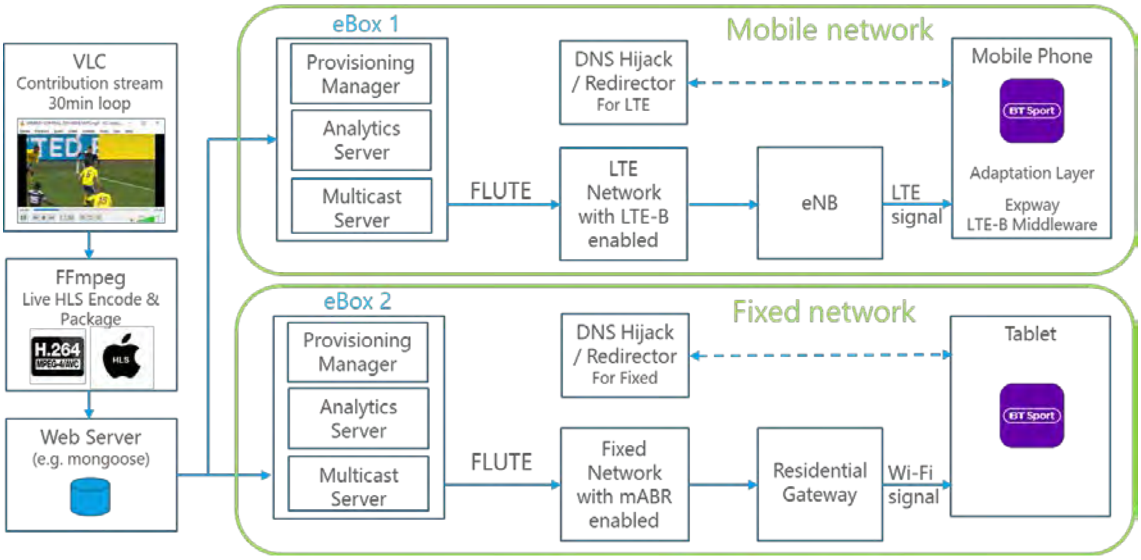



*Figure 4 Demonstrator architecture*

Local content was provided using VLC to playback a 30min football sequence on a loop. This was encoded and packaged by the FFMPEG open source multimedia suite, and made available to the framework though a webserver. We chose to generate content locally to avoid any issues around content rights, particularly as the original content streams are intended for the UK while the demonstrator was shown in Spain.

The eBox components in both implementations ingested the unicast content and prepared it for delivery over multicast. It also included an analytics server for monitoring the audience size. The provision manager provided a means for configuring and scheduling streams.

In the mobile case, an LTE network was provided using Amarisoft software coupled with a software defined radio unit programmed as an eNB. In the fixed case, the network was terminated with a WiFi enabled residential gateway.


*Figure 5 Mobile and fixed network implementations*

The BT Sport application was installed on Bittium mobile devices in the mobile case and tablets in the fixed case. Bittium mobile devices were used that they are MBMS enabled out of the box. In both cases, real time visual indication of the load on the network was provided. This was used to show how unicast delivery was used when one device was consuming content, but that broadcast delivery was used when two devices were consuming the same content. The switch between delivery modes was shown not to impact on the continuous video playout experienced by the end user.

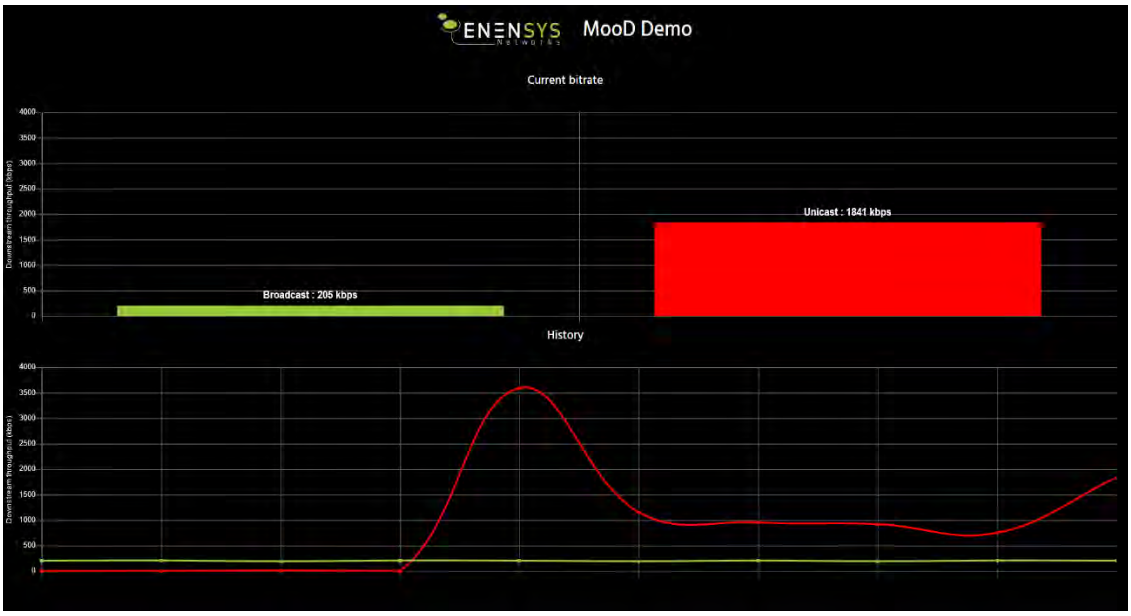



*Figure 6 Unicast delivery of a single live stream*

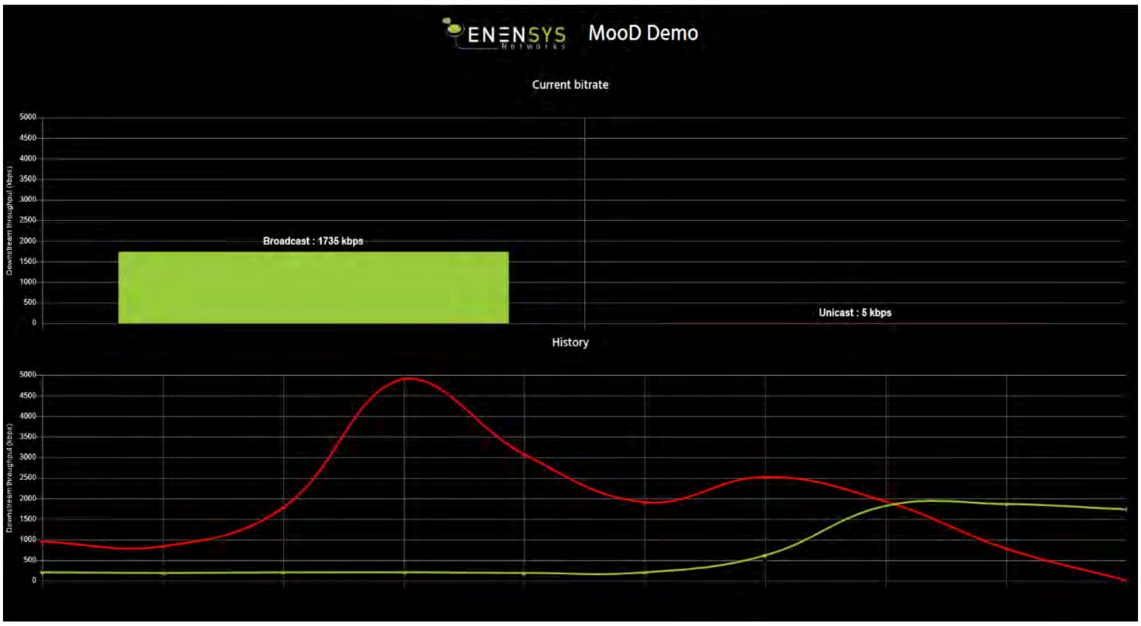



*Figure 7 Broadcast delivery to multiple devices*

## 2.3 Reliable Multicast Delivery in 5G networks

This demonstrator has been developed by Nomor Research in collaboration with Bundleslab, Broadpeak and British Telecom.

### 2.3.1 Objectives

The main objectives of this demonstrator are:

- To show the gains in and trade-offs among resource consumption, spectrum efficiency, service coverage, and QoE when multicast is introduced as a network optimization – against unicast delivery mode – for delivering popular DASH content, such as the Olympic games or weekly-aired TV shows, as well as
- To show the improvements in the observed trade-offs achieved by introducing multilink delivery.

### 2.3.2 Concept

The concept of the demonstrator is to analyse the reliable multicast delivery in 5G networks, using ATSC 3.0 service layer over Nomor Research's system-level simulator with 5G capabilities. It also highlights the effects of using application layer methods, such as DASH streaming and multilink delivery, on the efficiency and reliability of multicast delivery. Aforementioned KPIs are observed through the 5G simulator's GUI and BPK's QoE Analytics Server. The steps followed in this regard are as follows:

- The popular DASH content is first sent to the UEs in unicast delivery mode in the RAN (see Figure 8). High QoE is observed.
- The popular DASH content is then sent to the UEs in multicast delivery mode to provide network efficiency in terms of resource usage (see Figure 8).
    - o The live UE (represented by Android tablet in Figure 10) is initially located near the base station where it is covered by the MBMS service quite well.
        - Provided network efficiency and high QoE are observed.
    - o The live UE is moved to the cell edge, where its multicast signal reception is poor (see Figure 9).
        - High IP packet losses, failed playback on the tablet due to the packet losses and consequently low QoE for the UE are observed.
    - o Multilink traffic is enabled for restoring the reliability of the service delivery for UEs with bad channel conditions.
        - Compensated IP packet losses for the UEs with multilink initiated, restored playback on the tablet and consequently high QoE are observed.

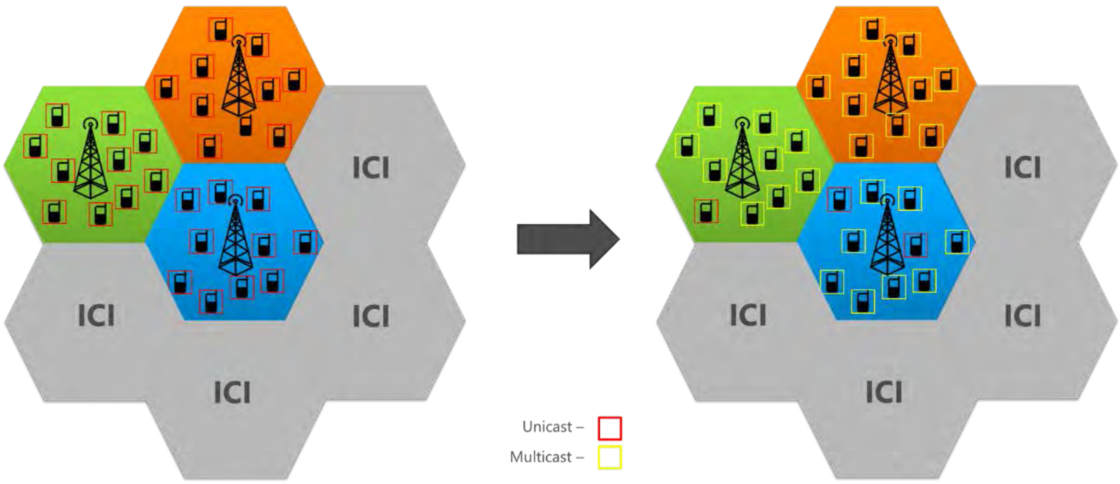



*Figure 8: The popular DASH content is sent via unicast vs. multicast mode*

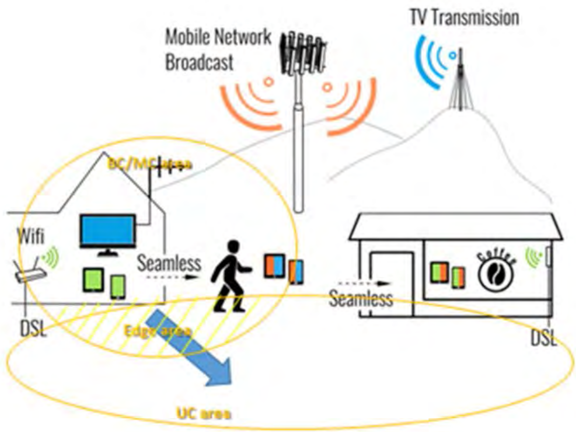



*Figure 9: The UE with poor multicast reception is provided with multilink-enhanced multicast delivery*

## 2.3.3 Architecture

The architectural framework of the demonstration is as shown in Figure 10. It consists of ATSC 3.0 service layer server and client, DASH streaming, 5G system level simulator, Multilink technology, network-related KPIs and QoE monitoring. All the components except the BPK QoE Analytics server which is reachable online were delivered to EUCNC venue for the demonstration.

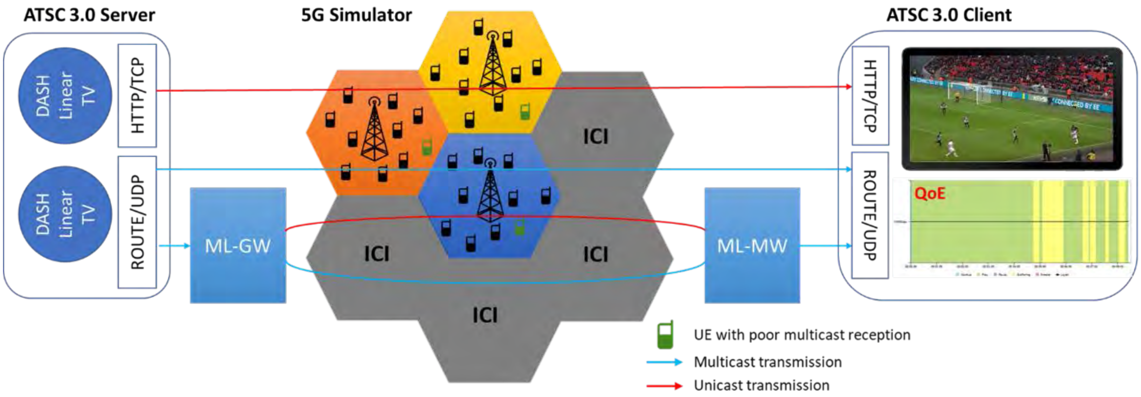



*Figure 10: Architectural framework of the demonstration*

Each demonstration scenario explained in 2.3.2 is initiated by pressing “Play” button on the Android tablet and consequently the setup components perform according to their described roles below:

- ***ATSC 3.0 Server:*** is the content and service provider, responsible for starting the service transmission. The content provided by BT is prepared according to the parameters in Table 1. It is served either upon request via HTTP/TCP or linear via ROUTE/UDP.
- ***5G simulator:*** emulates the cell environment with the parameters as provided in Table 1. It transmits the content either via unicast or multicast delivery mode. It acts as a forwarding entity for the captured media service and serves it to the Android tablet for consumption. Also, to better demonstrate the objectives, remaining UEs in the cells are emulated to receive the similar traffic generated by the simulator. Additionally, the simulator handles the multilink functionality

when enabled. This solution provided by BLB includes 1) Multilink GW, where the multicast stream packets are duplicated onto a newly-instantiated unicast session and 2) Multilink MW, where packets received from unicast and multicast are ordered and merged into one stream. It also provides real-time monitoring of network-related KPIs and QoE through its GUI.

- ***ATSC 3.0 receiver box PC:*** is configured as a forward proxy and hosts the ATSC 3.0 service layer software for HTTP/TCP or ROUTE/UDP reception.
- ***Android tablet:*** represents the UE through which the content playback is shown. For this purpose, it contains a media application that uses ExoPlayer, which is integrated with BPK's Smartlib QoE Library to collect QoE-related metrics, such as playback freezes, losses, initial playout delay, etc.
- ***QoE Analytics Server:*** provided by BPK, is a cloud-based server. It periodically fetches the metrics collected by Smartlib QoE Library and generates QoE reports.

*Table 1: Further information on some demonstration setup components.*

| **Subject** | **Information** | |
|---|---|---|
| *Stored content in ATSC 3.0 server* | - Wembley Cup Final 2018<br>- Codec: HEVC<br>- Unicast serving:<br>• 1Mbps@480p, 3Mbps@720p, 5Mbps@720p, 8Mbps@1080p, 12Mbps@1080p, 16 Mbps@1080p<br>- Multicast serving:<br>• 16Mbps@1080p<br>- ISOBMFF file format<br>- 1s DASH segmented | |
| *Simulation environment in 5G simulator* | Scenario | Urban |
| | Carrier frequency | 3.5GHz |
| | Total BS transmit power | 51dBm |
| | System bandwidth | 100MHz |
| | BS antenna configuration | [M, N, P] = [8, 4, 2] |
| | BS TXRU configuration | [Mp, Np, P] = [1, 4, 2] |
| | UE antenna / TXRU configuration | [M, N, P] = [1, 4, 2] |
| | UE mobility model | 3kmph, randomly uniform distr. |
| | BS noise figure | 5dB |
| | UE noise figure | 9dB |
| | BS ant. element gain | 5dBi |
| | BS ant. elevation – 3dB-BW | 65° |
| | Multicast MCS index | {2, 4} |
| | Multilink automatic switching threshold | Multicast $SINR_{eff}$(UE) < 10dB |

## 2.4 Efficiently Delivering Public Warning Messages with Multimedia Contents

This demonstrator has been developed by Fairspectrum, LiveU, Turku University of Applied Sciences, One2many and Universitat Politècnica de València.

### 2.4.1 Objectives

The main objectives of this demonstrator is to:

- Showcase various capabilities to deliver multimedia public warning efficiently.
- Include in the public warning message relevant information for people with hearing disabilities and illiterate, as well as additional context information.

The various capabilities showcased in the demonstrator to deliver multimedia public warning (PW) efficiently are:

- Dynamic spectrum allocation.
- Multilink channel bonding of a dynamic and static network.
- LTE broadcast (eMBMS).

### 2.4.2 Concept

The overall concept of the demonstrator is explained in several steps.

The starting point of the call flow is that the Public Warning System (PWS) has an alert to send to the UEs. The alert contains multimedia components. Using the Common Alerting Protocol specification, the multimedia component can be embedded together with the alert or provided as separate files which are referenced by the alert using URI.

1. Request dynamic LTE spectrum from spectrum management system

The PWS or related middleware or a manual method is used to request LTE spectrum from the spectrum management system

2. Push content to content server

The alert with its multimedia components is made available to a system (CDN or content server) that can be addressed by the UE. In the demonstrator the Google Cloud Platform (GCSP) was used. This step is listed as typically the PWS itself cannot be addressed by the public directly.

3. Perform unicast trigger over Wi-Fi or LTE

The PWS or related middleware or a manual method uses Google Firebase Cloud Messaging (GFCM) to trigger the PW App on the UE to fetch the alert. With the help of GFCM, this trigger can be received on either Wi-Fi or public LTE.

4. PW App on UE receives trigger from GFCM
5. The PW App request content from Wi-Fi or from eMBMS middleware in capable Ues. To determine the usage of Wi-Fi or eMBMS, the PW App checks the phone capabilities.
   a) Content fetched from content server, bonded LTE links by multilink to improve throughput
   b) Content fetched through eMBMS is using a broadcast which is a resource that is shared by multiple UE.
6. Display content. The user can select to play the multimedia content in the PW App.

### 2.4.3 Architecture

The demonstrated system contains a default network (Public LTE) and an additional network (LTE) to demonstrate the performance improvement of multilink and dynamic spectrum management, as shown in Figure 11. In this demonstration, a new spectrum resource is defined and created. The additional spectrum capacity is added to the default LTE capacity using multilink.

The trigger for the PWS alert is sent using the Public LTE to the UE. The UE will fetch the multimedia components using the bonded LTE connection by multilink. Further, eMBMS capable receivers receive the alert contents with multicast form the LTE broadcast signal created by spectrum management.

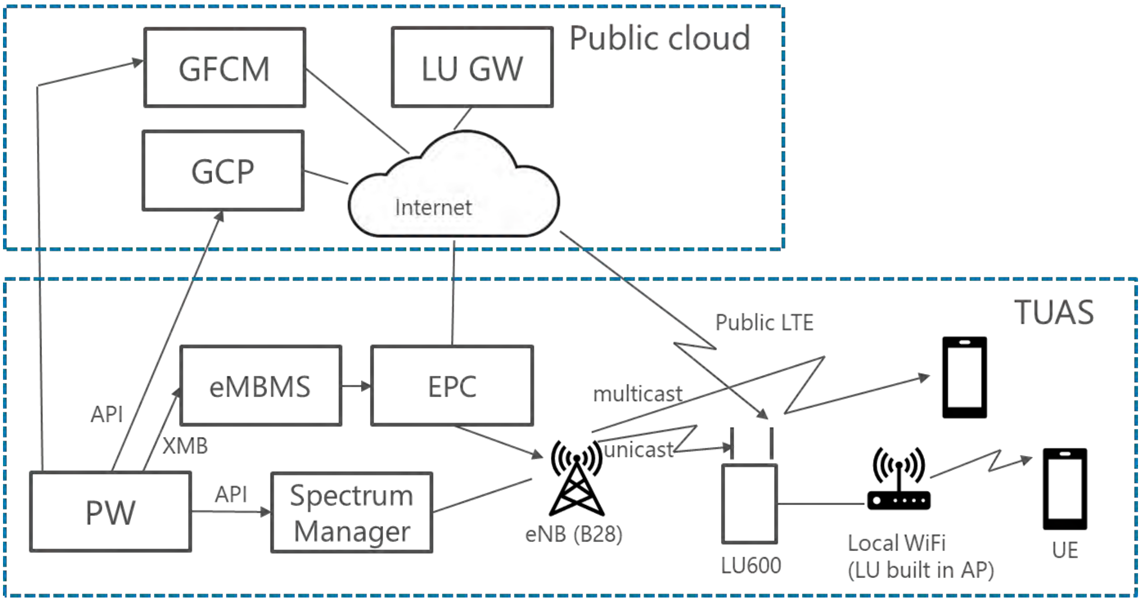



*Figure 11 Demonstrator architecture*

## 2.5 Hybrid Broadcast Services with Multi-Link

This demonstrator has been developed by Bundleslab and IRT with the support of LiveU and the EBU.

### 2.5.1 Objectives

The main objectives of the demonstrators are to:

- Improve reliability, bandwidth, mobility and traffic optimization by multi-link connectivity between different radio access technologies and networks.
- Create a virtual single broadband connection by the simultaneous use of multiple networks in a dynamic way.
- Improve user experience when moving from outdoor 4G/5G connectivity to indoor WiFi with a seamless viewing experience.
- Demonstrate Multi-Link protocol for enhanced broadcast delivery using on-demand video stream repair via unicast.

### 2.5.2 Concept

The overall concept of the demonstrator is explained in several steps:

- A mobile device (user equipment) is on the edge of the broadcast/multicast (BC/MC) area experiencing poor BC/MC service or a mobile user is going in and out of that BC/MC coverage area

- The content transmitted from the ML-GW (multi-link gateway, the server) down to the viewing device is split or duplicated over available links being them networks from different operators or even using different technologies. The ML-GW is able to dynamic balance traffic according to reception performance. The decision whether to split or to duplicate depends on the desirable gains in throughput, ancillary information and reliability, and a function of the link conditions.
- The content is reassembled at the viewing device (with eventual duplicates removed) as a coherent data stream ready for viewing. The content itself is not manipulated which means that the delivery is completely transparent to the content.

By means of multilink it is possible to show the possibility to achieve:

- Better reliability and availability of the service against fluctuation in bandwidth, latency or error rate and enabling a seamless transition between single-L2-link and multilink could be achieved in a reliable way due to the use of simultaneous multiple networks.
- Increased bandwidth with the possibility to deliver broadband content that would be impossible to deliver over a single link.
- Better mobility support with seamless transitions between coverage areas of different networks or technologies, with continuous QoS and QoE.

### 2.5.3 Architecture

The architecture of the demonstrator is based on the concepts developed in 5G-Xcast as shown in the following figure.

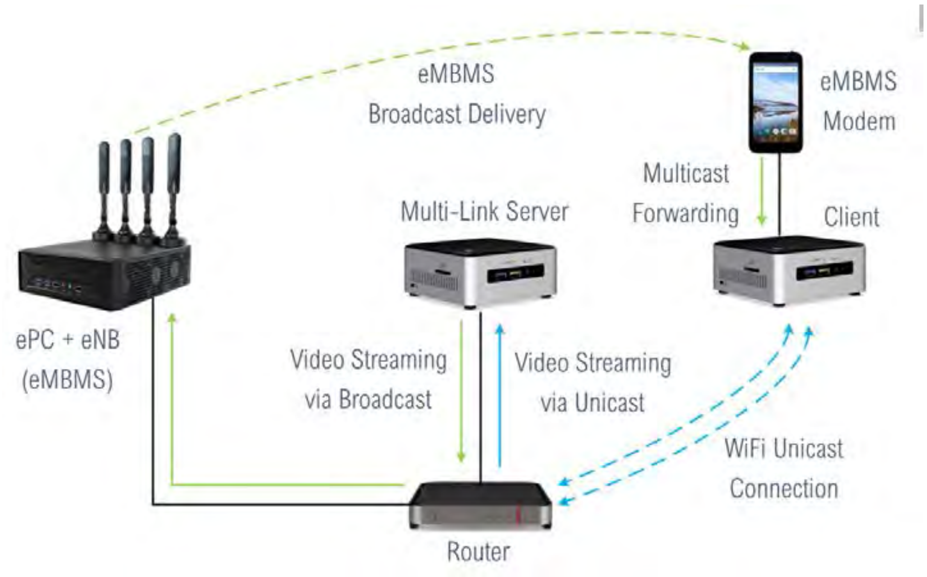



*Figure 12 Demonstrator architecture*

The Multi-Link server is able to reroute the data packets through the different available links. In this case, WiFi as the unicast connection and a multicast session over eMBMS. At the user end, the Multi-Link client performs the adequate data merger operation between the traffic delivered via multicast and unicast. In our case, the client is able to analize the multicast traffic from the eMBMS connection and evaluate packet losses. In such case, the corresponding data will be requested to the server and sent via the unicast link.

## 2.6 Over-the-Air Multicast over Satellite for Video Caching and Live Content Delivery

This demonstrator is a joint partnership between 5G-Xcast & SaT5G 5G-PPP projects involving Avanti's high throughput HYLAS 4 GEO satellite capacity, Broadpeak's MEC-enabled platform for Content Delivery Network, University of Surrey's 5G Innovation Centre test bed network and VT iDirect's 5G enabled satellite hub platform and satellite terminals.

### 2.6.1 Objectives

This demonstrator focuses on using satellite multicast capabilities to deliver live channels to a 5G Edge mobile network.

The main objectives of the demonstrator are:

- To improve video distribution efficiency using mABR over Satellite as contribution link
- To Minimize end-to-end latency using CMAF-CTE Dash over mABR link
- To Address all screens thanks to transparent use of local cache servers
- To Provide synchronized video delivery on any screen

### 2.6.2 Concept

The concept of this demonstrator is to showcase over-the-air satellite multicast technology for the delivery of live channels using a MEC platform for Content Delivery Network (CDN) integration with efficient edge content delivery. This Demonstrator highlights the benefits in terms of bandwidth efficiency and delivery cost of using a satellite-enabled link for provisioning live content in a 5G system.

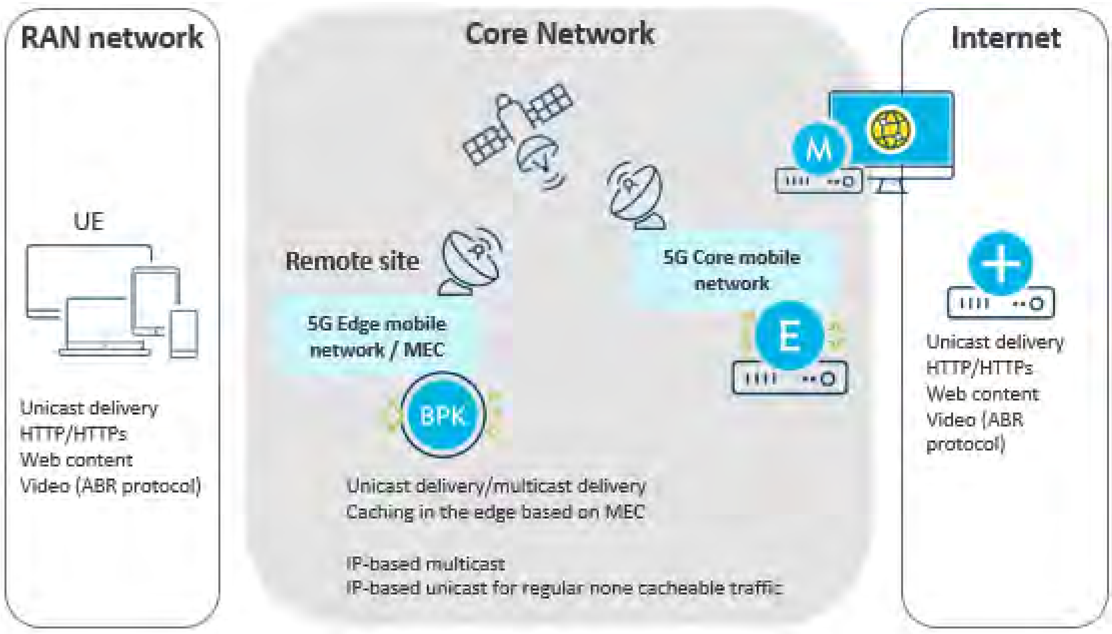



*Figure 13 Demonstrator concept*

### 2.6.3 Architecture

The following diagrams are logical representations of the architecture deployed for the demonstrator. These figures depict the data workflow from Broadpeak Content Server located at the University of Surrey (on the right hand side of the first figure) to the EuCNC event located in Valencia (on the left hand side of the second figure).

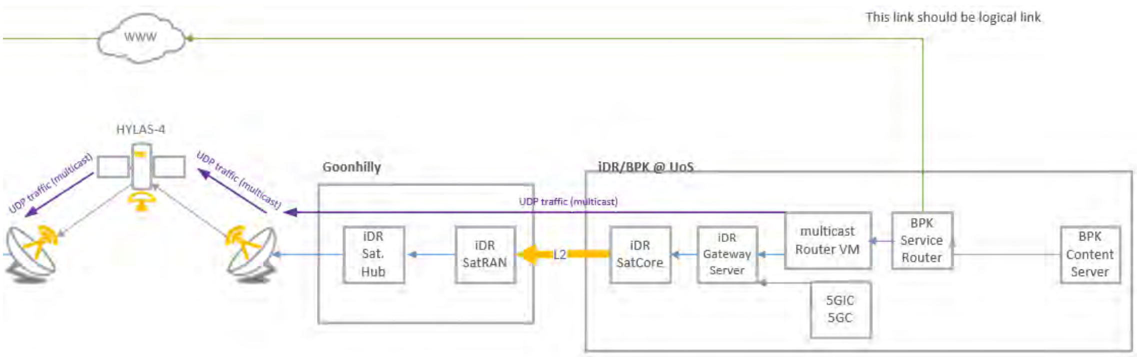



*Figure 14 Demonstrator Architecture – 5G Core Network*

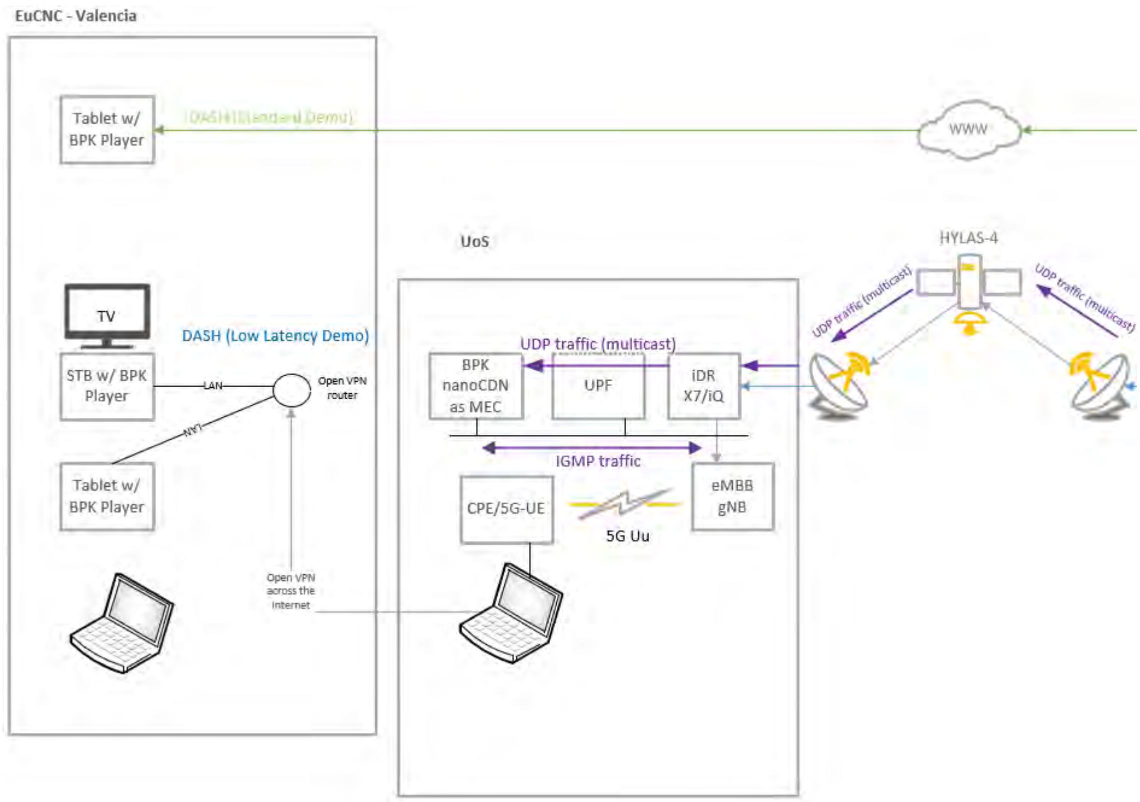



*Figure 15 Demonstrator Architecture – 5G RAN*

# 3 Event Report: EuCNC 2019 and Global 5G Event (Valencia, Spain, June 2019)

## 3.1 Booth overview and demo elements

The following pictures present the 5G-Xcast booth at the event with the 5 demonstrators. The 6th one, developed in cooperation with Sat-5G, was hosted by this project's booth.


*Figure 16 5G-Xcast booth overview*


Figure 17 Forecast 5G: Object-based Broadcasting over multicast and unicast

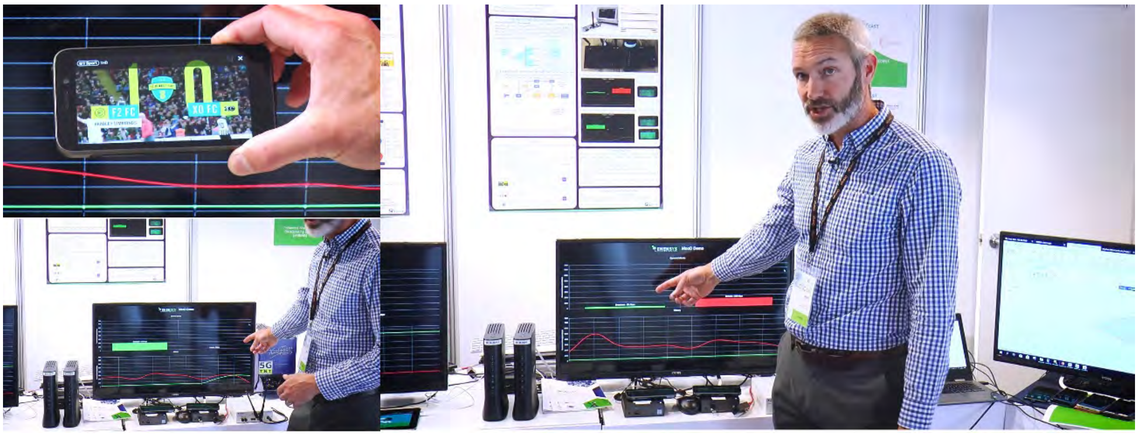


Figure 18 Content Distribution Framework in 5G Converged Networks

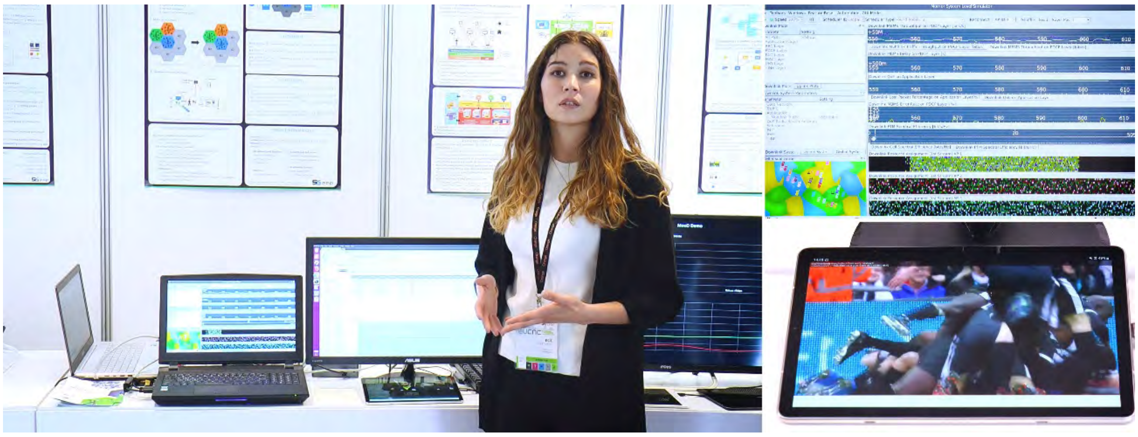


Figure 19 Reliable Multicast Delivery in 5G Networks

*Figure 20 Efficiently delivering Public Warning messages with multimedia contents*

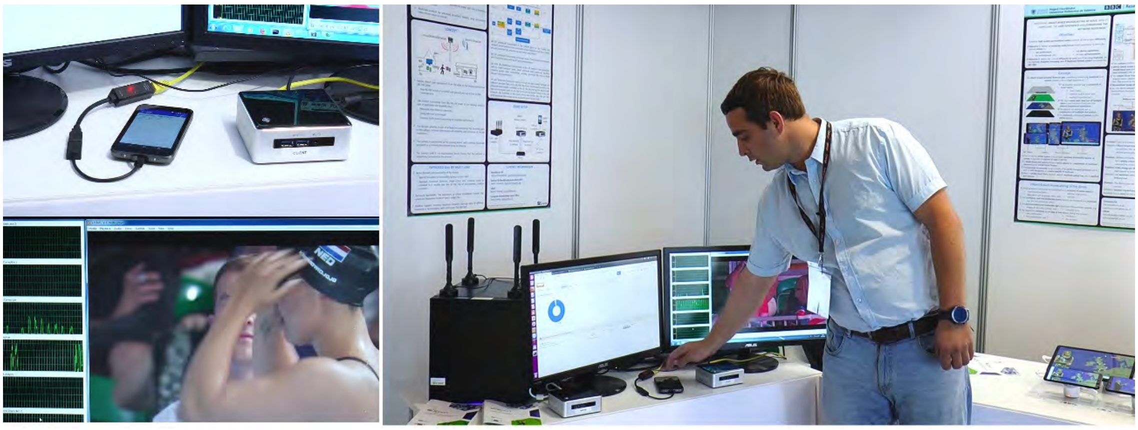


*Figure 21 Hybrid Broadcast Services with Multi-Link*

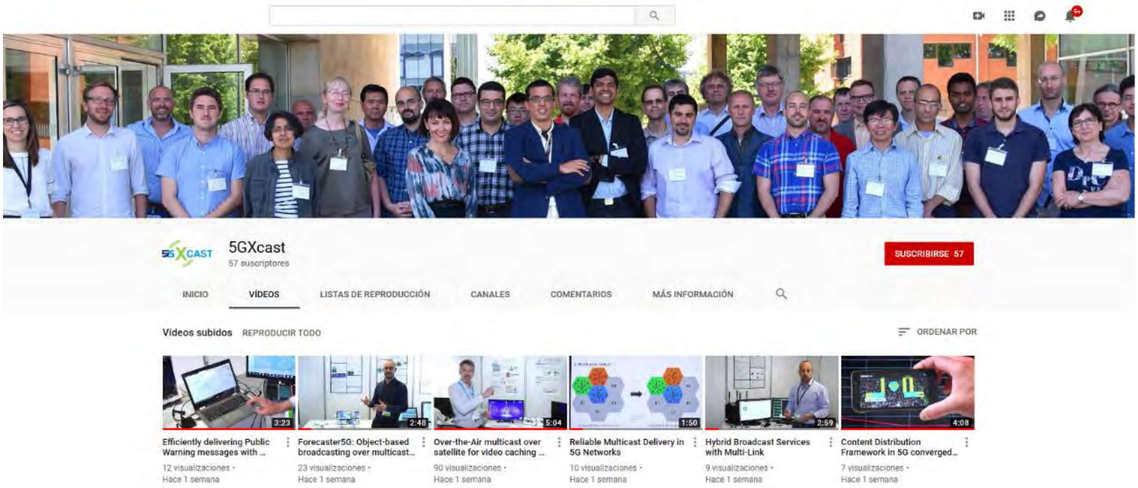

*Figure 22 Over-the-Air multicast over satellite for video caching and live content delivery*

## 3.2 Dissemination

A series of videos, posters, brochures were elaborated to support the description of each demonstrator.

### 3.2.1 Videos

Six videos are public available in Youtube explaining the most important features shown in each demonstrator.




The links to the videos are the following:

| | |
|---|---|
|   | https://www.youtube.com/watch?v=Y1b2eoXWvMI |
|   | https://www.youtube.com/watch?v=EfhAwHNK6e8 |
|   | https://www.youtube.com/watch?v=DvmDGPX1CgI |
|   | https://www.youtube.com/watch?v=uR7dc5rKxZ4 |

| | |
|---|---|
|  | https://www.youtube.com/watch?v=ouafFGDE_K4 |
|  | https://www.youtube.com/watch?v=LYbP6Nz_L9o |

### 3.2.2 Brochure

**"5G-XCAST WILL OPEN THE DOOR TO A NEW AGE OF IMMERSIVE MEDIA DELIVERY FOR EUROPE"**

## MAIN OBJECTIVES

**Point-to-multipoint capabilities**
To develop broadcast and multicast capabilities for the standalone 5G New Radio and 5G Core Network.

**Adaptable and converged network architecture**
Design a 5G converged network architecture combining fixed, mobile and terrestrial networks to dynamically and seamlessly switch between unicast, multicast and broadcast modes or use them in parallel.

**Innovative use cases demonstration**
Develop proof-of-concept prototypes at Radio Access Network (RAN), core and content distribution level and experimentally demonstrate key innovations deve-loped in the project for the media and public warning verticals.

## 5G-XCAST @ EUCNC

EUCNC 2019 June 18-21
European Conference on Networks and Communications | Valencia, Spain

**5G-XCAST - BOOTH 1**

- **DEMO 1** FORECASTER 5G: object-based broadcasting
- **DEMO 2** Converged, autonomous MooD in fixed/mobile networks
- **DEMO 3** Reliable multicast delivery in 5G networks
- **DEMO 4** Multimedia public warning
- **DEMO 5** Hybrid broadcast service with Multi-Link

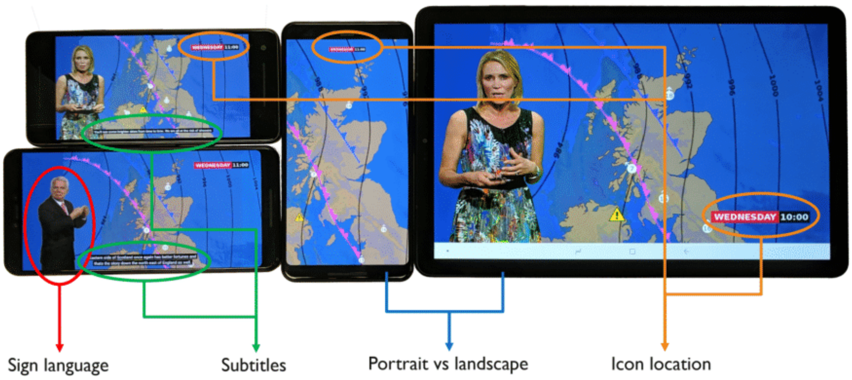
**5G-XCAST / SAT5G DEMO - BOOTH 12**

# FORECASTER 5G: Object-Based Broadcasting

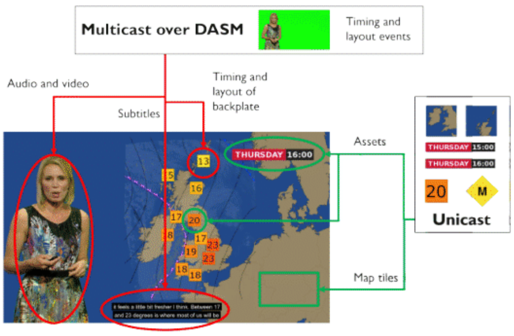
## OBJECTIVE

To efficiently deliver high quality personalised media content to many users, with the aim to:

- Deliver an enhanced object-based audio/video media experience, in which the presentation of the content adapts to the user's environment, the user's preferences, the device's capabilities and includes personalisation.
- Reduce the cost of delivering high quality live media content to a large audience over IP by using a hybrid of multicast and unicast, seamlessly combined on the device.



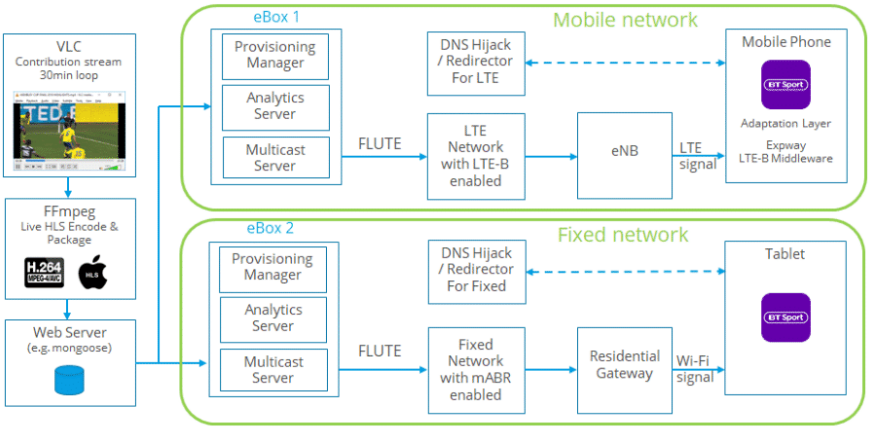

- The demonstration shows an object-based weather forecasting application. The weather forecast is composed of objects (e.g. MPEG-DASH video, the weather map/symbols etc.), which are delivered over the University of Surrey 5G core either using multicast (in a pseudo-live manner) or using unicast.
  - The multicast objects are delivered by the Dynamic Adaptive Streaming over IP Multicast (DASM) system, developed by BBC R&D.



# Converged, Autonomous MooD in Fixed/Mobile Networks

This demonstrator showcases key features of the content distribution framework. In particular, it will show:

- The use of multicast/broadcast as an internal network optimisation, rather than as a service to be sold.
- The use of simple unicast interfaces with content service providers to simplify integration and facilitate adoption.
- How client applications do not require any modification to benefit from the use of multicast/broadcast.
- How the framework is applicable to both fixed and mobile networks.

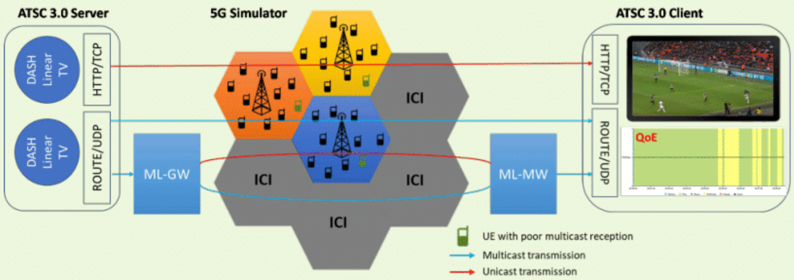



## BACKGROUND

- Content Distribution Framework is a network agnostic framework being applicable to both fixed and mobile networks, along with future 5G converged networks.
- It enables existing unmodified unicast delivered services to benefit from the scalability and user experiences of broadcast delivery (MooD).
- It allows seamless switching between unicast and multicast/broadcast content delivery as the BT Sport audience size changes.
- This PoC shows the framework employed using LTE-B and Multicast ABR.

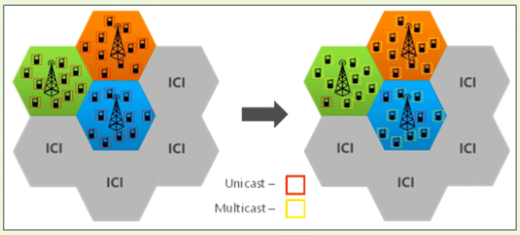
# Reliable Multicast Delivery in 5G Networks

- This demonstrator shows the gains in and trade-offs among resource consumption, spectrum efficiency, service coverage and QoE achieved by reliable multicast delivery for popular content distribution in 5G networks.
- The demonstration also highlights the effects of using application layer methods, such as DASH streaming and Multilink technology on the efficiency and reliability of multicast delivery.




- High quality multimedia content is transmitted by ATSC 3.0 server through 5G simulator that handles multilink functionality and acts as a forwarding entity for the ATSC 3.0 client via which the playback is shown.
- The improvements in terms of better RAN efficiency and user experience are visualized by the QoE Analytics Server and the 5G simulator.

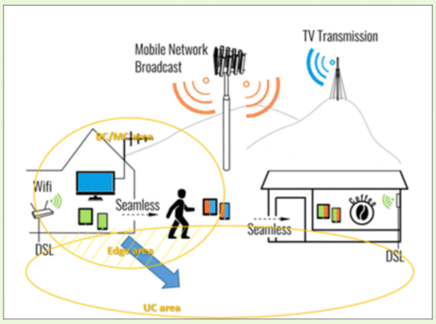
## UNICAST vs MULTICAST




Unicast delivery of all content

Multicast delivery of popular content

## MULTILINK ENHANCED MULTICAST



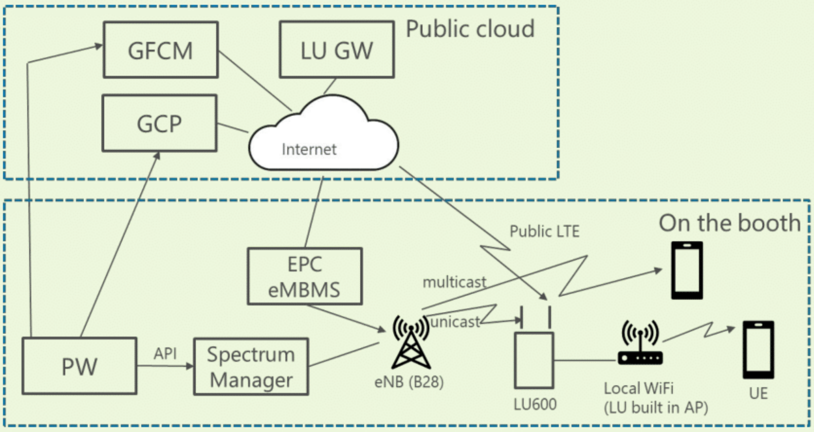

Multilink by means of multicast session packet duplication into unicast

## Multimedia Public Warning

**OBJECTIVE:**

The Multimedia Public Warning system demonstrates the delivery of multimedia-based alerts.

- Multimedia content provides more illustrative information for the users.
- On the network side, multimedia content poses load to the network, as the alert should be transmitted as quickly as possible to all users in the area.
- For this kind of service broadcast technology is a perfect match.
- As it is not expected that all the terminals are broadcast reception capable, also other means of delivering the alert are required.




Dynamic spectrum management, multi-link and broadcast technologies are integrated in a system to demonstrate delivery of public warning multimedia alerts to the user equipment.

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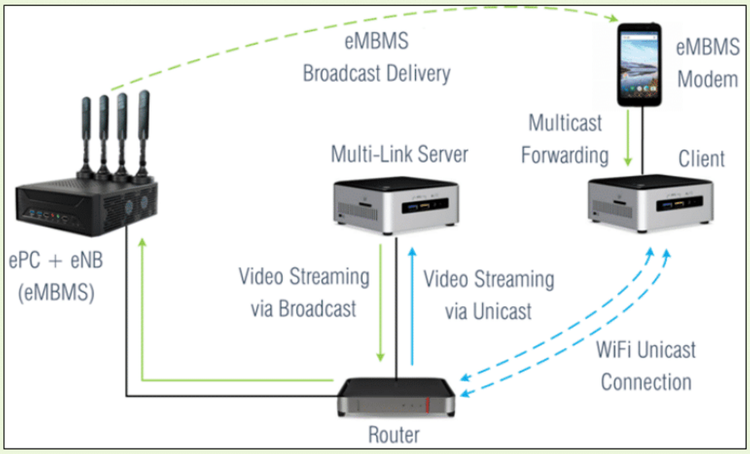
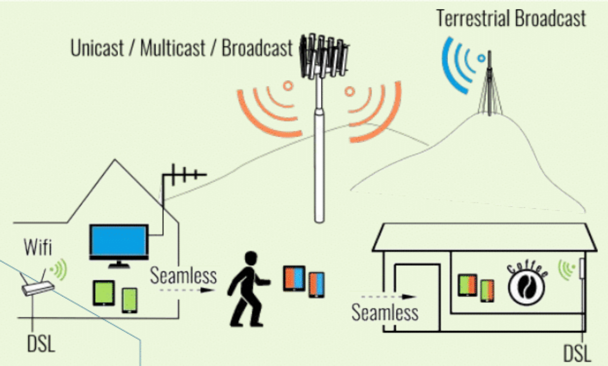
## Hybrid Broadcast Service with Multi-Link




- Improving reliability, bandwidth, mobility and traffic optimization by multi-link connectivity between different radio access technologies and networks.
- A virtual single broadband connection by the simultaneous use of multiple networks in a dynamic way.
- Moving from outdoor 4G/5G connectivity to indoor WiFi with a seamless viewing experience.
- Multi-Link protocol for enhanced broadcast delivery using on-demand video stream repair via unicast.



@5Gxcast 5g-xcast 5GXcast http://5g-xcast.eu

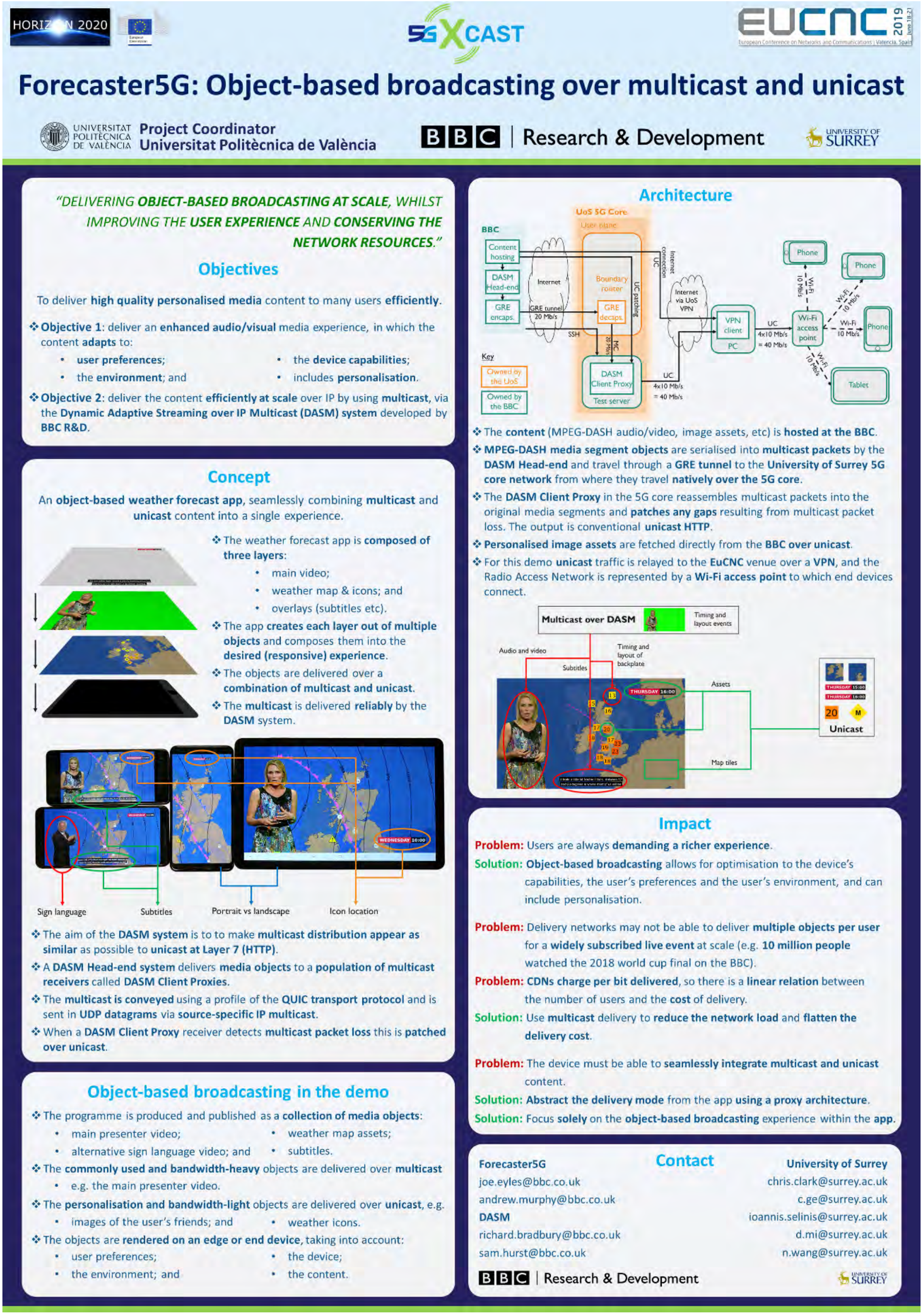
Project Coordinator:

Technical Managers:

Partners:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 761498.

### 3.2.3 Posters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EUCNC 2019
European Conference on Networks and Communications | Valencia, Spain
Forecaster5G: Object-based broadcasting over multicast and unicast
Universitat Politècnica de València
Project Coordinator
Universitat Politècnica de València
BBC | Research & Development
University of Surrey
"DELIVERING OBJECT-BASED BROADCASTING AT SCALE, WHILST IMPROVING THE USER EXPERIENCE AND CONSERVING THE NETWORK RESOURCES."
Objectives
To deliver high quality personalised media content to many users efficiently.
Objective 1: deliver an enhanced audio/visual media experience, in which the content adapts to:
• user preferences;
• the environment; and
• the device capabilities;
• includes personalisation.
Objective 2: deliver the content efficiently at scale over IP by using multicast, via the Dynamic Adaptive Streaming over IP Multicast (DASM) system developed by BBC R&D.
Concept
An object-based weather forecast app, seamlessly combining multicast and unicast content into a single experience.
The weather forecast app is composed of three layers:
• main video;
• weather map & icons; and
• overlays (subtitles etc).
The app creates each layer out of multiple objects and composes them into the desired (responsive) experience.
The objects are delivered over a combination of multicast and unicast.
The multicast is delivered reliably by the DASM system.
Sign language
Subtitles
Portrait vs landscape
Icon location
The aim of the DASM system is to to make multicast distribution appear as similar as possible to unicast at Layer 7 (HTTP).
A DASM Head-end system delivers media objects to a population of multicast receivers called DASM Client Proxies.
The multicast is conveyed using a profile of the QUIC transport protocol and is sent in UDP datagrams via source-specific IP multicast.
When a DASM Client Proxy receiver detects multicast packet loss this is patched over unicast.
Object-based broadcasting in the demo
The programme is produced and published as a collection of media objects:
• main presenter video;
• weather map assets;
• alternative sign language video; and
• subtitles.
The commonly used and bandwidth-heavy objects are delivered over multicast
• e.g. the main presenter video.
The personalisation and bandwidth-light objects are delivered over unicast, e.g.
• images of the user's friends; and
• weather icons.
The objects are rendered on an edge or end device, taking into account:
• user preferences;
• the device;
• the environment; and
• the content.
Architecture
UoS 5G Core
BBC
Content hosting
DASM Head-end
GRE encaps.
Internet
GRE tunnel 20 Mb/s
SSH
Boundary router
GRE decaps.
DASM Client Proxy
Test server
Internet via UoS VPN
VPN client
PC
Wi-Fi access point
Phone
Phone
Phone
Tablet
Key
Owned by the UoS
Owned by the BBC
The content (MPEG-DASH audio/video, image assets, etc) is hosted at the BBC.
MPEG-DASH media segment objects are serialised into multicast packets by the DASM Head-end and travel through a GRE tunnel to the University of Surrey 5G core network from where they travel natively over the 5G core.
The DASM Client Proxy in the 5G core reassembles multicast packets into the original media segments and patches any gaps resulting from multicast packet loss. The output is conventional unicast HTTP.
Personalised image assets are fetched directly from the BBC over unicast.
For this demo unicast traffic is relayed to the EuCNC venue over a VPN, and the Radio Access Network is represented by a Wi-Fi access point to which end devices connect.
Multicast over DASM
Timing and layout events
Audio and video
Timing and layout of backplate
Subtitles
Assets
Map tiles
Unicast
Impact
Problem: Users are always demanding a richer experience.
Solution: Object-based broadcasting allows for optimisation to the device's capabilities, the user's preferences and the user's environment, and can include personalisation.
Problem: Delivery networks may not be able to deliver multiple objects per user for a widely subscribed live event at scale (e.g. 10 million people watched the 2018 world cup final on the BBC).
Problem: CDNs charge per bit delivered, so there is a linear relation between the number of users and the cost of delivery.
Solution: Use multicast delivery to reduce the network load and flatten the delivery cost.
Problem: The device must be able to seamlessly integrate multicast and unicast content.
Solution: Abstract the delivery mode from the app using a proxy architecture.
Solution: Focus solely on the object-based broadcasting experience within the app.
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BBC | Research & Development
University of Surrey

HORIZON 2020

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European Conference on Networks and Communications | Valencia, Spain

# Converged Autonomous MooD in Fixed/Mobile Networks

BT EXPWAY

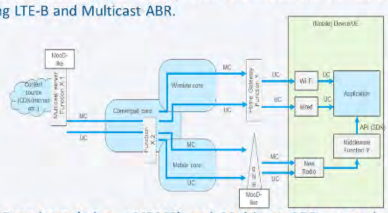
## OBJECTIVES

To show the **key features of the content distribution framework in 5G**:

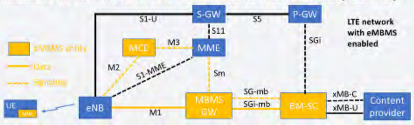
- Multicast/broadcast as an internal network optimisation
- Simple unicast interfaces with content service providers
- Without any modification to client applications
- Applicable to both fixed and mobile networks

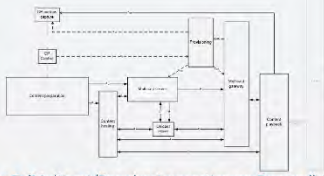
## BACKGROUND AND CONCEPT

- **Content Distribution Framework** is a network agnostic framework being applicable to both fixed and mobile networks, along with future 5G converged networks. The framework enables existing unmodified unicast delivered services to benefit from the scalability and user experiences of broadcast delivery (i.e. MooD). This PoC shows the framework employed using LTE-B and Multicast ABR.



- **LTE-Broadcast (a.k.a. eMBMS) and Multicast ABR** are technologies that allow to deliver media content in both efficient and scalable way to very large audiences in mobile and fixed broadband network, respectively.



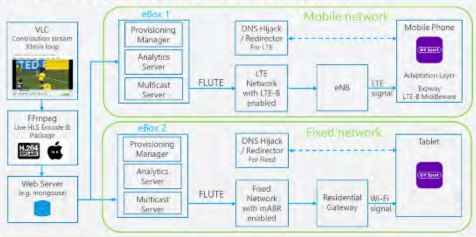



Multicast ABR simplified reference architecture

- **MooD** (Multicast/Broadcast operation on Demand) is an important feature that allows the system to seamlessly switch between unicast and multicast/broadcast content delivery according to the audience size.

## SETUP

- Sport content real-time encoded in HLS format and made available on a web server to simulate the CDN
- Mobile network with LTE-Broadcast support
- Fixed network having Multicast ABR enabled
- Same encapsulation protocol (e.g. FLUTE) for multicast traffic on both fixed and mobile networks
- DNS Hijack and redirector modules for fixed and mobile networks to redirect request to the emulated CDN
- Unmodified BT Sport App on tablets and smartphones

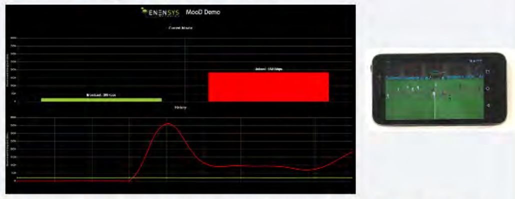



## IMPLEMENTATION

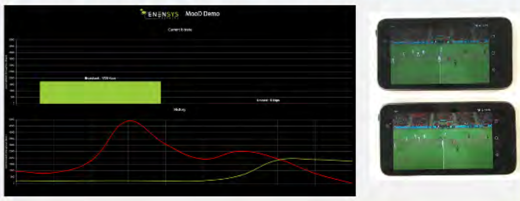
1. LTE-B created using Software Defined Radio (SDR) and Service Configuration

2. Multicast ABR created using Multicast Server, Multicast Gateway


3. Unicast delivery selected for one device




4. Multicast/Broadcast delivery selected as more devices consume content




## CONCLUSIONS

This PoC successfully demonstrates how broadcast/multicast can be used for internal network optimization of otherwise unicast delivered services. This approach has a number of benefits:

- Service roll out can be done region-by-region in response to local traffic volumes without requiring a full national rollout
- Can be applied to any existing unicast service without modification
- Applicable to both fixed and mobile networks along with 5G converged networks

Further work may follow to include reducing the amount of service specific configuration.

## CONTACT INFORMATION

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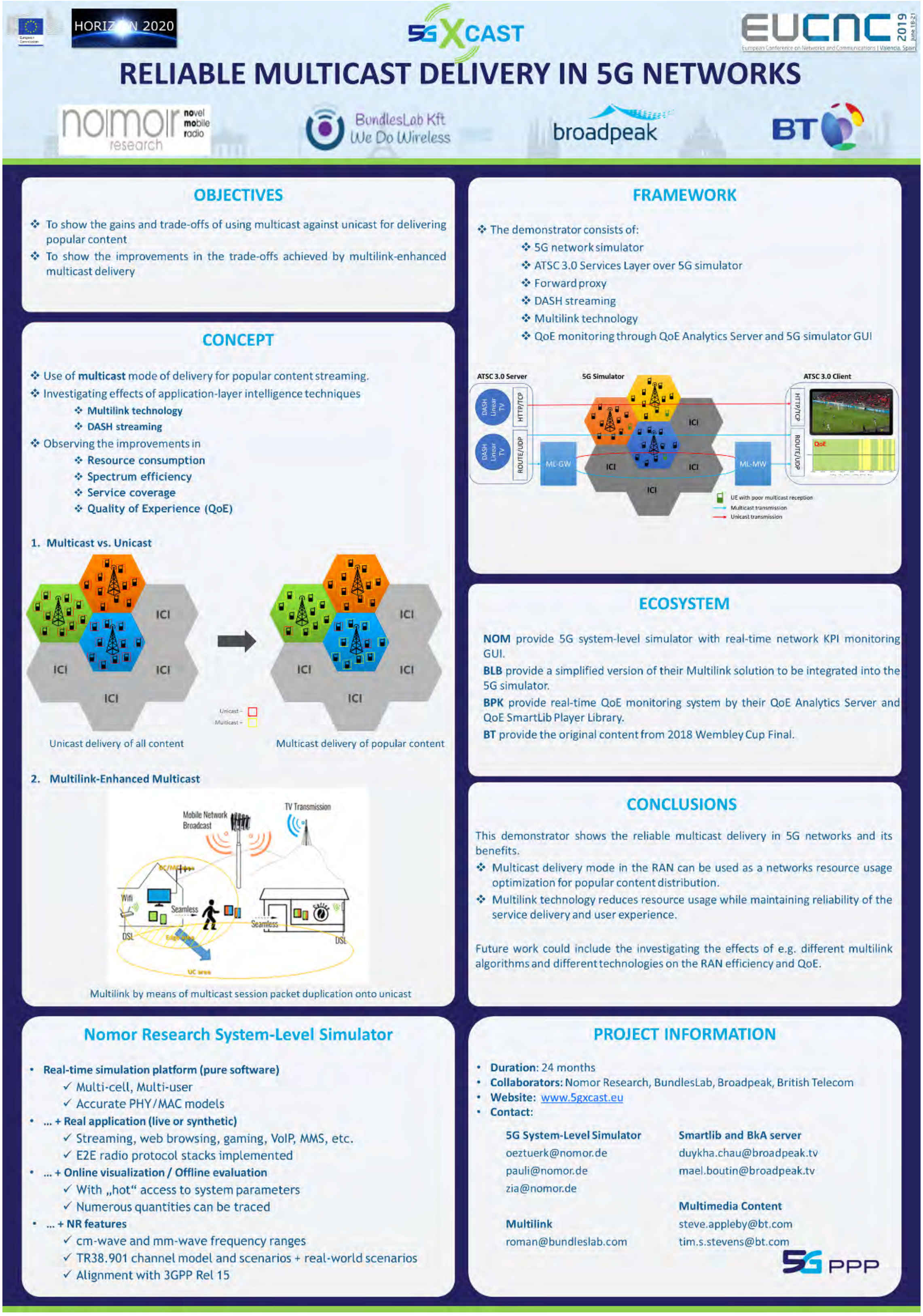
5G PPP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RELIABLE MULTICAST DELIVERY IN 5G NETWORKS
nomor research novel mobile radio
BundlesLab Kft We Do Wireless
broadpeak
BT
OBJECTIVES
To show the gains and trade-offs of using multicast against unicast for delivering popular content
To show the improvements in the trade-offs achieved by multilink-enhanced multicast delivery
CONCEPT
Use of multicast mode of delivery for popular content streaming.
Investigating effects of application-layer intelligence techniques
Multilink technology
DASH streaming
Observing the improvements in
Resource consumption
Spectrum efficiency
Service coverage
Quality of Experience (QoE)
1. Multicast vs. Unicast
ICI
Unicast delivery of all content
Multicast delivery of popular content
2. Multilink-Enhanced Multicast
Mobile Network Broadcast
TV Transmission
Wifi
Seamless
DSL
Multilink by means of multicast session packet duplication onto unicast
FRAMEWORK
The demonstrator consists of:
5G network simulator
ATSC 3.0 Services Layer over 5G simulator
Forward proxy
DASH streaming
Multilink technology
QoE monitoring through QoE Analytics Server and 5G simulator GUI
ATSC 3.0 Server
5G Simulator
ATSC 3.0 Client
HTTP/TCP
ROUTE/UDP
ML-GW
ML-MW
ICI
ECOSYSTEM
NOM provide 5G system-level simulator with real-time network KPI monitoring GUI.
BLB provide a simplified version of their Multilink solution to be integrated into the 5G simulator.
BPK provide real-time QoE monitoring system by their QoE Analytics Server and QoE SmartLib Player Library.
BT provide the original content from 2018 Wembley Cup Final.
CONCLUSIONS
This demonstrator shows the reliable multicast delivery in 5G networks and its benefits.
Multicast delivery mode in the RAN can be used as a networks resource usage optimization for popular content distribution.
Multilink technology reduces resource usage while maintaining reliability of the service delivery and user experience.
Future work could include the investigating the effects of e.g. different multilink algorithms and different technologies on the RAN efficiency and QoE.
Nomor Research System-Level Simulator
Real-time simulation platform (pure software)
✓ Multi-cell, Multi-user
✓ Accurate PHY/MAC models
... + Real application (live or synthetic)
✓ Streaming, web browsing, gaming, VoIP, MMS, etc.
✓ E2E radio protocol stacks implemented
... + Online visualization / Offline evaluation
✓ With „hot“ access to system parameters
✓ Numerous quantities can be traced
... + NR features
✓ cm-wave and mm-wave frequency ranges
✓ TR38.901 channel model and scenarios + real-world scenarios
✓ Alignment with 3GPP Rel 15
PROJECT INFORMATION
Duration: 24 months
Collaborators: Nomor Research, BundlesLab, Broadpeak, British Telecom
Website: www.5gxcast.eu
Contact:
5G System-Level Simulator
oeztuerk@nomor.de
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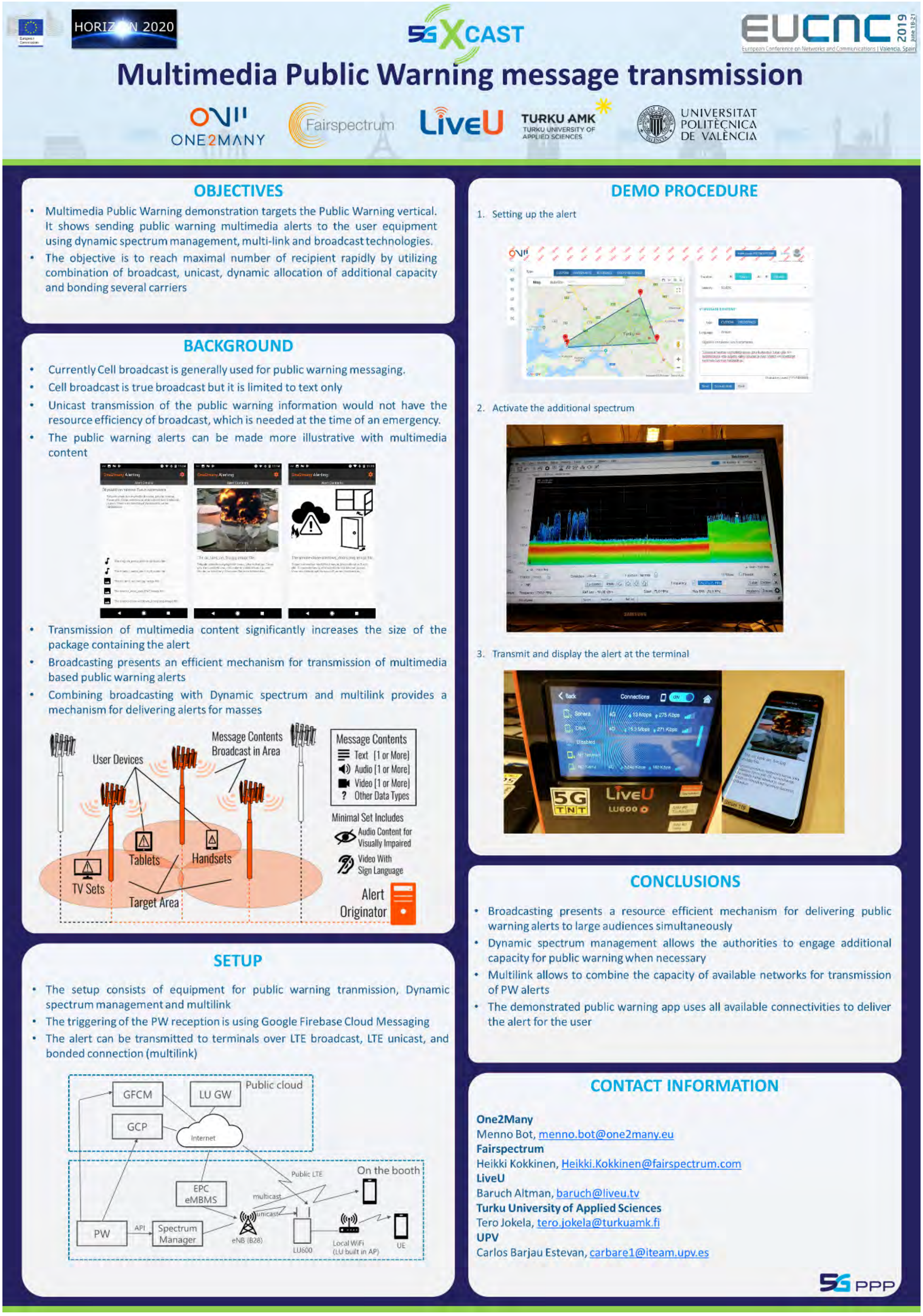
5G PPP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EUCNC 2019
Multimedia Public Warning message transmission
ONE2MANY
Fairspectrum
LiveU
TURKU AMK
TURKU UNIVERSITY OF APPLIED SCIENCES
UNIVERSITAT POLITÈCNICA DE VALÈNCIA
OBJECTIVES
Multimedia Public Warning demonstration targets the Public Warning vertical. It shows sending public warning multimedia alerts to the user equipment using dynamic spectrum management, multi-link and broadcast technologies.
The objective is to reach maximal number of recipient rapidly by utilizing combination of broadcast, unicast, dynamic allocation of additional capacity and bonding several carriers
BACKGROUND
Currently Cell broadcast is generally used for public warning messaging.
Cell broadcast is true broadcast but it is limited to text only
Unicast transmission of the public warning information would not have the resource efficiency of broadcast, which is needed at the time of an emergency.
The public warning alerts can be made more illustrative with multimedia content
Transmission of multimedia content significantly increases the size of the package containing the alert
Broadcasting presents an efficient mechanism for transmission of multimedia based public warning alerts
Combining broadcasting with Dynamic spectrum and multilink provides a mechanism for delivering alerts for masses
User Devices
Message Contents Broadcast in Area
Message Contents
Text [1 or More]
Audio [1 or More]
Video [1 or More]
Other Data Types
Minimal Set Includes
Audio Content for Visually Impaired
Video With Sign Language
Tablets
Handsets
TV Sets
Target Area
Alert Originator
SETUP
The setup consists of equipment for public warning transmission, Dynamic spectrum management and multilink
The triggering of the PW reception is using Google Firebase Cloud Messaging
The alert can be transmitted to terminals over LTE broadcast, LTE unicast, and bonded connection (multilink)
GFCM
LU GW
Public cloud
GCP
Internet
On the booth
Public LTE
EPC eMBMS
multicast
unicast
PW
API
Spectrum Manager
eNB (B28)
LU600
Local WiFi (LU built in AP)
UE
DEMO PROCEDURE
1. Setting up the alert
2. Activate the additional spectrum
3. Transmit and display the alert at the terminal
CONCLUSIONS
Broadcasting presents a resource efficient mechanism for delivering public warning alerts to large audiences simultaneously
Dynamic spectrum management allows the authorities to engage additional capacity for public warning when necessary
Multilink allows to combine the capacity of available networks for transmission of PW alerts
The demonstrated public warning app uses all available connectivities to deliver the alert for the user
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5G PPP

HORIZON 2020

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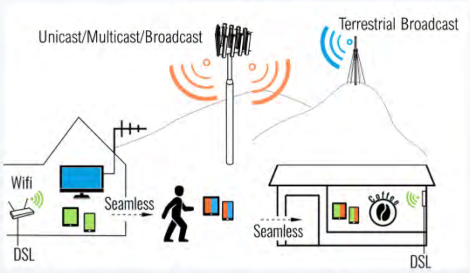
# Hybrid Broadcast Service with Multi-Link

BundlesLab Kft We Do Wireless · IRT · LiveU · EBU

## OBJECTIVES

- ✓ Improving reliability, bandwidth, mobility and traffic optimization by multi-link connectivity between different radio access technologies and networks.
- ✓ A virtual single broadband connection by the simultaneous use of multiple networks in a dynamic way.
- ✓ Moving from outdoor 4G/5G connectivity to indoor WiFi with a seamless viewing experience.
- ✓ Multi-Link protocol for enhanced broadcast delivery using on-demand video stream repair via unicast.

## CONCEPT

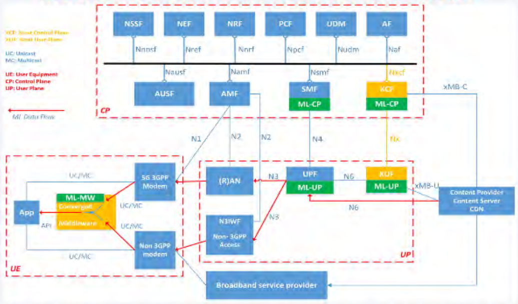



- ✓ Mobile device (user equipment) is on the edge of the broadcast/multicast (BC/MC) area.
  - Poor BC/MC service or a mobile user going in and out of that BC/MC coverage area
- ✓ The content transmitted from the ML-GW down to the viewing device is split or duplicated over available links:
  - Networks from different operators,
  - Using different technologies
  - Dynamic traffic balance according to reception performance.
- ✓ The decision whether to split or to duplicate depends on the desirable gains in throughput, ancillary information and reliability, and a function of the link conditions.
- ✓ The content is reassembled at the viewing device (with eventual duplicates removed) as a coherent data stream ready for viewing.
- ✓ The content itself is not manipulated which means that the delivery is completely transparent to the content.

## IMPROVED QoE BY MULTI-LINK

- ✓ Better Reliability and availability of the service
  - Against fluctuation in bandwidth, latency or error rate
  - Seamless transition between single-L2-link and multilink could be achieved in a reliable way due to the use of simultaneous multiple networks
- ✓ Increased bandwidth: The possibility to deliver broadband content that would be impossible to deliver over a single link.
- ✓ Mobility support: Seamless transition between coverage areas of different networks or technologies, with continuous QoS and QoE.

## MULTI-LINK FOR MEDIA DELIVERY IN 5G-Xcast



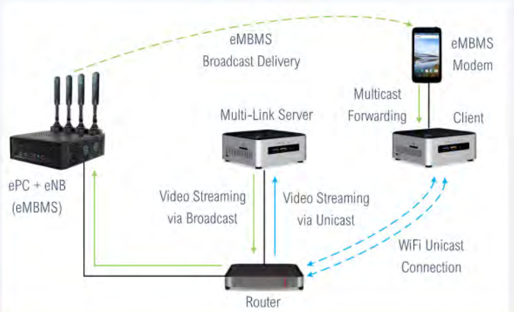

ML-CP: additional functionality in the control plane of the mobile core network, which performs the estimation of QoS parameters for data transfer via each available link, multilink session setup and release;

ML-UP: additional functionality in the user plane of the mobile core network, which performs data splitting, IP tunnel establishment;

ML-MW: ML middleware functionality in the UE between the Application and the lower transport levels, which performs data combining, signalling (channel quality data transmitting), caching, providing ML session setup request (QoS parameters).

ML-GW (Multilink Gateway) is able to reroute the data packets through the different available links, and a ML-MW (Multilink middleware) performs the adequate data merger operation at the UE. The ML-MW at the viewing user side communicates with the ML-GW which can be located either at the core network, the publisher, or the cloud. These two entities (ML-GW and ML-MW) exchange information about the performance of each link.

## DEMO SETUP

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