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

Deliverable D2.3
5G-Xcast outcome and future outlook

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Abstract

This deliverable has been prepared within Task T2.4 - Possible future work and longer-term use cases.

It provides an overview of the project results in terms of technical achievements and benefits. Views on possible areas for future work are also outlined based on the gaps that during the course of the project have been identified. Spectrum issues relevant to specific use cases are also taken into account.

Keywords

5G-Xcast, Media and Entertainment, PWS, IoT, Automotive, Spectrum

[1] PU = Public

Executive Summary

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List of Acronyms and Abbreviations

3GPP	3rd Generation Partnership Project
5G	5th Generation
Auto	Automotive
AV	Audio Vid
BC	Broadcast
CDN	Content Distribution Network
CN	Core Network
D	Deliverable
DVB	Digital Video Broadcast
EC	European Commission
eMBMS	enhanced MBMS
HD	High Definition
IoT	Internet of Things
KPI	Key Performance Indicators
M&E	Media & Entertainment
MBMS	Multimedia Broadcast Multicast Service
MC	Multicast
PoC	Proof of Concept
PTM	Point to Multipoint
PTP	Point To point
PW	Public Warning
PWS	Public Warning Services
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
RAT	Radio Access Technology
Rel	Release
ROM	Receive Only Mode
RRM	Radio Resource Management
TV	Television
UE	User
V2X	Vehicular to Everything
WP	Work Package

1 Introduction

This deliverable provides the final overview of the project results in terms of the project major technical achievements and benefits and identifies future work areas and new use cases as they emerged from the 5G-Xcast solutions, i.e. beyond those addressed in the project and enabled by the technical developments from the project.

The project's major technical achievements and benefits have been evaluated with particular reference to the use cases defined by the project and to the associated technical improvement potential of the 5G-Xcast RAN solutions.

Special attention has been paid to identify possible technology gaps that the project technical work was not able to fill by comparing the original use cases to the actual project's developments and eventually propose such gaps for possible future work and longer-term use cases.

As mentioned above, 5G-Xcast first focused on specifically probing project results in each WP in order to:

- Examine to what extent the initial use cases have been met by developments within the project;
- Identify other use cases that could be enabled through the technology researched within 5G-Xcast.

The results of such project probing and other relevant information concerning standards, trials and tests for future work and potential new business models are summarized in this document.

Finally, relevant spectrum aspects concerning specific 5G-Xcast use cases are also described.

2 5G-Xcast outcome

2.1 Overview on 5G-Xcast technical improvements and demonstrations

Six use cases and associated high-level requirements were defined in 5G-Xcast, within the WP2 work.

The complete description of such use cases and requirements is given in the Deliverable D2.1 [1].

The 5G-Xcast use cases targeted four different vertical markets, i.e. Media and Entertainment (M&E), Public Warning (PW), Automotive (Auto) and Internet of Things (IoT).

Three out of the six 5G-Xcast use cases are dedicated to the M&E vertical market, in particular: the hybrid broadcast service, the virtual/augmented reality broadcast, and the remote live production use cases.

The remaining use cases are dedicated to the PW, Auto, and IoT vertical, respectively, in particular, the multimedia public warning alert, the V2X broadcast service and for the massive software and firmware updates.

The use cases have been analysed in the different Work Packages (WPs) according to the specific perspective of each WP.

In particular, all six use cases have been studied by WP3 and WP4 in relation to their Radio Access Network (RAN) and the Core Network (CN) technical aspects, respectively.

In addition, building upon multicast and QoS network capabilities as studied in WP3 and WP4, the three M&E use cases have been further optimised by WP5 for what concerns the exploitation of a converged content distribution approach to make point to multipoint network technologies better suited to the requirements of network operators and third parties as well.

Finally, the hybrid broadcast service use case and the multimedia public warning alert use case have been tested at the Munich and Surrey test-beds and at the Turku test-bed, respectively [2], within the efforts of WP6.

In addition to addressing the use cases specifically defined within 5G-Xcast, analysis and technical solutions have also been developed to enable the 5G-Xcast solution to address terrestrial broadcast. Terrestrial broadcast was first addressed in LTE Advanced Pro 3GPP Release 14 in which the Multimedia Broadcast Multicast Service (MBMS) system was enhanced to operate in a dedicated mode for the delivery of linear broadcast services (i.e., radio and TV), fulfilling a wide set of requirements with input by the broadcast industry [3].

Deliverable D2.4 [4] was dedicated to this use case and details the 5G-Xcast design on air interface, RAN procedures, and workflow that enables terrestrial broadcast services based on different architectural alternatives. This work has gone significantly beyond the scope of current work within 3GPP Release 16 addressing LTE-based 5G Terrestrial Broadcast.

Whilst not including a return channel in itself, the terrestrial broadcast mode, could be combined with an independent unicast connection for interactivity in a similar way to HbbTV (Hybrid Broadcast Broadband TV) sets. This would then allow these developments to address requirements of the M&E 1, Hybrid broadcast service.

In order to provide a clear view of the technical solutions analysed in the different WPs, an overview of the main technical results for each WP is provided in the following.

WP3

In WP3, a holistic 5G-Xcast RAN solution has been provided to fulfil technical requirements of all six use cases across four verticals. The proposed solution includes an air interface design, a RAN architecture, radio access technology (RAT) protocols and radio resource management (RRM) algorithms and also contains two operation modes targeting different scenarios, i.e., mixed mode and terrestrial broadcast mode.

More specifically:

- The 5G-Xcast PTM air interface design has been introduced and evaluated against IMT-2020 requirements, as described in the Deliverable D3.2 [5] Section 3 and Section 5, respectively, verifying that the design fulfils use cases of M&E, PW and Auto verticals. Moreover, this design involves the physical layer development of both mixed mode and terrestrial broadcast mode, aiming at meeting the different scenarios of these use cases, e.g., with different network deployments.
- The 5G-Xcast RAN architecture design has been proposed and evaluated against 5G broadcast and multicast requirements defined in 3GPP specification 38.913, as described in the Deliverable D3.3 [6]. This design provides architectural solutions of the aforementioned two modes, for use cases of M&E, PW and IoT verticals, from logical architecture, RAN interfaces, RAN protocol architecture and procedures perspectives.
- The 5G-Xcast RAT protocols and RRM have been developed in order to address key challenges of RRM that apply to all six use cases in conventional PTM systems and are presented in the Deliverable D3.4 [7] and summarised in Section 8 and C.
- The selected solution approaches developed in D3.3 and D3.4 have been prototyped, shown in D3.5 [8], to demonstrate their effectiveness in addressing the challenges of meeting the related requirements with the conventional systems.

WP4

The WP4 technical improvements are based on two main alternatives, fully described in D4.1 [9]. These alternatives represent the baseline to develop the solutions for different verticals and applications.

Different verticals have been analysed and the main outcome can be summarised as follows:

- Terrestrial broadcast: a terrestrial broadcast system and workflow to enable terrestrial broadcast services based on different architectural alternatives have been developed and analysed, as described in the Deliverable D2.4 [4].
- Public Warning: a workflow to deliver multimedia public warning messages has been defined in the Deliverable D4.3, Section 8 [10]. In addition, an end-to-end solution for the delivery of a specific Public Warning service has been analysed

and developed based on the 5G-Xcast project technical solutions, as described in the Deliverable D2.5 [11] .

Mission Critical Communications: a 5G-Xcast solution for Mission Critical Communications has been developed, as described in the Deliverable D4.3, Section 12 [10].

WP5

In WP5, the PoC work [13] has focussed on an 'adaptation layer', which runs on the end device and hides the use of point to multipoint as much as possible from the player application. Importantly, this has allowed 5G-Xcast to show that a standard streaming application, designed only for unicast use, can benefit from multicast or broadcast without modification.

WP6

As mentioned above, the Munich, Surrey, and Turku test-beds have been first defined and deployed and then extensively used to test and demonstrate the hybrid broadcast service use case and the multimedia public warning alert. In addition, several demos have been performed in various international events.

2.2 Benefit analysis

The clause examines, for each of the use cases defined within the project, the beneficial impacts that deployment of the 5G-Xcast approach could bring vs. a 'do nothing' approach that maintains the status quo.

Use Case M&E 1 – Hybrid broadcast service

The requirements of this use case are rather demanding, and it may not be possible to satisfy them without a viable point-to-multipoint (PTM) solution, which is currently not available in 5G, i.e. outside 5G-Xcast.

In fact, while point-to-point (PTP) connectivity can in principle enable the hybrid broadcast use case, it does not scale well with the increasing number of concurrent users.

In particular for live events, networks would need to be dimensioned for peak demand, which is often difficult to anticipate, resulting in substantial investments. Otherwise, there is a risk of deteriorating quality of service and user experience. At the same time, outside times of peak demand, network resources would be underutilised.

On the other hand, 5G-Xcast makes this use case possible, resulting in the benefits originally anticipated and described in detail in the deliverable D2.1, clause 2.3.1 [1].

In fact, the 5G-Xcast framework enables a highly efficient way of using network resources while optimising the required investments and ensuring the highest possible QoE for the users. This brings substantial benefits not only to end users, but also to content and service providers, network operators and equipment vendors.

Furthermore, radio spectrum is used more efficiently and there are opportunities for innovative business models.

On top of the Broadcast (BC)/Multicast (MC) service, multi-link (unicast) allows for improved multi-network resource utilization (such as in converged networks), as well as higher quality content to viewers that enjoy dual network connectivity, and smoother transition QoE when moving between networks for such viewers.

Better user experience and viable business models will lead to a faster adoption of 5G.

Use Case M&E 2 – Virtual/augmented reality broadcast

Fully immersive virtual/augmented reality requires an extremely high throughput (e.g., 5 Gbit/s). If there are multiple viewers of the same content in the same area it would be challenging, if not impossible to serve them via PTP connectivity, for technical and commercial reasons.

The 5G-Xcast PTM solution makes this use case possible even on a large scale and this may enable new businesses to be created within M&E vertical, and possibly in other areas (e.g., professional applications, tourism).

Use Case M&E 3 – Remote live production

Remote live production requires a complex and expensive set-up. Furthermore, the conventional technical solutions may not have the desired flexibility and functionality.

In content production use cases, multiple users often require access the same feed at different locations. Many of these feeds are on uplink (e.g., from a camera or a microphone to the production facility). PTM solutions such as 5G-Xcast allow a significantly better use of the throughput capacity and, therefore, make 5G a more attractive technology option for this use case.

Use Case PW 1 – Multimedia public warning alert

PW today is based on cell broadcast technology which provides text-based warning messages that may contain links towards multimedia content (e.g., picture of the missing person). However, if many users download such content simultaneously then the network could become overloaded, leading to congestion. This makes it practically impossible to provide multimedia-content warning messages with the required availability and reliability.

With 5G-Xcast solutions multimedia content can be provided via broadcast or via multicast, which greatly improves the usefulness of warning messages. Not only because pictures of missing persons or maps with guidance to safety can be provided but also because audio and video files can be provided for visually- and hearing-impaired persons.

Use Case Auto 1 – V2X broadcast service

Vehicle to everything (V2X) communications have a plethora of applications related to multicast / broadcast delivery of common data to a multitude of vehicular users, including media and entertainment type of services, software updates and critical road transport information. The key requirements of low-latency and high-reliability, together with support for multicast / broadcast service delivery and high user density cannot be supported using currently available networks. Furthermore, there are requirements related to group communications (whereby messages are simultaneously sent to groups of users) and support for high mobility for such services, which cannot be satisfied efficiently using current solutions.

The terrestrial broadcast enhancements developed in 5G-Xcast enable a unified 5G framework for wide-area V2X applications and services for the delivery of common data to vehicular users, including support for high mobility. The mixed / transparent mode enhancements, in combination with unicast, enable high-reliability and low-latency service provisioning in compliance with the key requirements for such systems. The 5G-Xcast system also enables spectral efficiency improvements, as compared to the current state-of-the-art.

Use Case IoT 1 – Massive software and firmware updates

IoT is an essential part of the 5G system to enable Industry 4.0. While using a point-to-point delivery is extremely inefficient when a 5G system wants to deliver the same data such as software updates or group messages to millions of IoT devices, the 5G-Xcast PTM system represents an efficient and scalable solution for group message delivery and software updates to a large number of IoT devices over 5G networks. 5G-Xcast solutions also allow an optimised service layer based on a binary data format and message exchange that helps to improve the power consumption (i.e., ensure a longer battery life) for resource-constrained devices.

2.3 Spectrum aspects

The combination of spectrum bands and spectrum quality that the 5G-Xcast use cases require leads to various possible different options. In fact, the 5G-Xcast use cases belong to 5G vertical sectors (i.e., Media & Entertainment, Public Warning, Automotive, and Internet of Things) which greatly differ in terms of required coverage, bit rate, and quality of service.

Different spectrum options have been identified in the Deliverable D3.4 on a case by case basis according to the 5G-Xcast use cases' requirements, which could be considered for possible practical implementation, taking into account different possibly available frequency bands and spectrum usage conditions, i.e., either exclusive, shared or unlicensed.

From RAN point of view, analyses on spectrum utilisation for terrestrial broadcast deployment, and 5G-Xcast spectrum allocation plus spectrum sharing) have been provided in D3.2 [5], Section 3, and D3.4 [7], Section 4, respectively.

3 Future work and use cases

3.1 Future work for Media and Entertainment services

General survey

For the citizens of the European Community a permanent change in the use of media takes place. In addition to the classic distribution channels such as cable, satellite and terrestrial based broadcast the distribution through the internet has become increasingly important. Also, messenger services of powerful internet companies have experienced an increasing popularity. There is also a tendency for media consumption independent of time and space. Nevertheless, the linear consumption of media is still one of the biggest sources of revenue for the advertising industry. In the 5G-Xcast project new concepts in the combination of unicast, multicast, and broadcast (also via terrestrial networks) have been identified, how media content can be transmitted efficiently. The next step is to combine the different distribution channels with the different services in order to increase the quality of experience for the user. The goal from a user perspective must be to summarize the underlying technical transfer mechanisms and protocols used so far in a way that all desired services can be reached with just a single user interface. It should be noted that only a universal worldwide usable terminal that meets all these conditions should be developed. This ensures that a cost-effective and user-friendly end device terminal can be produced.

New air interface design

Currently the 5G-Xcast mixed mode air interface design reuses the New Radio Rel-15 air interface specification as much as possible to ensure the maximum compatibility with PTP. One possible future work could be to prototype a new 5G-Xcast air interface for a proof of concept in a way that the modification of the proposed mixed mode physical layer based will provide performance gains in PTM scenarios.

Further improvements for Receive Only Mode

At the moment, significant effort is going on in 3GPP and DVB to use PTM network capabilities. Specifically, most recent work on eMBMS has sought to support ROM (Receive Only Mode) so that 5G can deliver traditional TV services. So, the Receive Only Mode should be a part together with unicast and multicast delivery that allows a fully dynamic and self-optimising future distribution system.

3.2 Future work for PWS

PW content

PWS should support roaming. This means that if a person travels in any country that provides PWS with multimedia, this person should be able to receive PW messages with a similar experience as in the home country.

The multimedia content in a PW service may differ per country; for example, a video file may be present with content in sign language and the PW application on the UE should be able to display that if the user prefers to see that video rather than read the textual part. These differences in content may require standardization with respect to the type of files and also the number of files.

PW message trigger

The broadcast of a PW message needs to be notified to the PW application on the UE. In case this notification is done in the paging message (see Deliverable D3.3 [6]), the MBMS-notification in the paging message may contain the TMGI for the MBMS service that carries the PW message content, or the TMGI may have a standardized value that is specified by 3GPP as it is done for Receive-Only Mode Broadcast.

3.3 Future work for media services 5G network slicing

Concerning studies on 5G network slicing, the definition of a new media slice capable of supporting MC/BC out based on the 5G-Xcast system and service assumptions and requirements could be carried out.
In D3.3 [6], RAN slicing solution has been proposed from the RAN architecture design point of view, particularly in 5G-Xcast traffic differentiation, traffic throttling and the application of RAN slicing to the RAN multicast area. A future work on RAN slicing from air interface design perspective can be considered, where the interference among slices carrying different services could be investigated. In WP5 an overall vision and framework was introduced. A detailed architecture especially concerning the network slicing should be developed in the future. A simplification of the interface between the CDN and the network operator could also be advantageous. A first step towards this direction was already made by an input document on architectural alternatives to the 3GPP SA1 group.

3.4 Future work for automotive services

Autonomous Vehicles could benefit from BC/MC, for e.g., delivery of local/small area BC/MC of HD maps, video feeds from infrastructure cameras or other sensors etc. in junctions or similar areas. Developing localized edge ad-hoc or permanent BC/MC, or otherwise per the specific needs of AV use cases, could be an area for future work. To fully integrate the changes in the 3GPP Release 17 and onwards, possibly in the core and/or in the RAN more work needs to be done. For example, in RAN, more related KPIs can be identified for PTM V2X use cases, while the evaluation process for these potential KPIs may be different from that for PTP scenarios.

4 Conclusions

The 5G-Xcast project has created important foundations and concepts that can support the spread of 5G in the future.

In particular, the dissemination of content in different ways and in combination of complementary technologies were successfully demonstrated.

For the future, it can be expected that a paradigm shift will take place from a purely technical perspective to a service orientation.

The technical basics will increasingly be abstracted and will be visible to the user only as an application.

Another objective for future projects will be the focus on the end customer. The introduction of new services should take greater account of users' wishes.

Another finding from the 5G-Xcast project is the increasing complexity and diversification of terminals used in the 5G environment. Hence careful consideration on the impact of each service should be paid so that affordable devices suitable for masses would be produced in large numbers.

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