5G-MAG Reference Tools: Bringing 5G Media to Life

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WHO WE ARE
5G MAG

International non-for-profit cross-industry association
Global Internet, 5G-based access & APIs for media applications and services
Global Internet, 5G-based access & APIs for media applications and services
5G-MAG Reference Tools Development Programme

Community of Developers
Open community sponsored by 5G-MAG

Reference Implementations
for validation, testing, experimentation
WHAT WE DO
5G-MAG Reference Tools under development

- 5G Downlink Media Streaming (5GMSd)
- 5G Core Network components
- Multimedia delivery protocols
- MBMS & LTE-based 5G Broadcast
- Emergency Alerts over 5G Broadcast
- 5G Multicast Broadcast Services
- XR Media integration in 5G
- AI/ML Evaluation Framework
Some examples under development

5G Media Streaming network components developed so far:

- 5GMS Application Server
  - Wrapping OpenResty (Nginx)
- 5GMS Application Function
  - Built in the Open5GS framework.

5G Media Streaming Client components developed so far on Android:

- 5GMS-enabled Media Player
  - Wrapping ExoPlayer.
- Media Session Handler
  - Background service.
- 5GMS-Aware Application
  - App, optionally incorporating the Media Player component.
Some examples under development

Stationary reception
- rt-wui / VLC / dash.js / ...
- rt-mbms-mw
  (with rt-libflute)
- rt-mbms-modem
  (using srsRAN) SDR

Qualcomm QRD or CRD
- rt-mbms-mw-android
  QC MBMS MW
  Baseband (HW)
  with QC SW to enable ROM

Content Provider
- ffmpeg

Broadcast Core
- MBMS-GW (Sync)
- srsRAN mbms-gw
- M2 & S1 (ctrl)
- M1 (data)
- Modulator / eNodeB
- rt-mbms-tx
- digital I/Q data

Exciter
- SDR (BladeRF, Lime, Ettus, ...)

RTP MPEG-TS
or HLS/DASH
via rt-libflute

Amplifier + TX

xMB: ctrl & data

rt-mbms-mw
rt-mbms-modem
Some examples under development

XR & Immersive Media
3GPP Baseline Architecture for AR/MR (XR Baseline Client)
5G Media Streaming (5GMS) is a set of technical specifications defined in 3GPP with the aim to achieve better media streaming quality of experience by effective collaboration between content providers and mobile networks. Key features under development include:

- **Content Hosting**
  - CDN deployed both inside the mobile network.
  - Dynamic network QoS policy.
  - Automatically selecting the best representation switching during a streaming session.
  - Quality of Experience metrics reporting.
  - Supporting non-real-time performance evaluation.

The demo is using some of the 5G-MAG Reference Tools available in our GitHub, in particular the following:

- 5GMS Application Function
- 5GMS Application Server
- 5GMS Media Session Handler
- 5GMS Media Stream Handler
- 5GMS Application
- 5GMS Common Android Library
- 5G Service Consumers

- **Network Assistance**
  - Throughput estimation.
  - Bandwidth recommendation.
  - Enabling/Disabling QoS policy.
  - Consumption reporting.
  - Including exposure of CDN access logs.

Note that this demo is partially supported by third-party components (Open5G Core and Open5G 5gCore).

Get more details and join the Developer Community

deveoper.5g-mag.com
5G-MAG Reference Tools @ IBCShow 2023

**BRINGING 5G BROADCAST TO LIFE**
5G-MAG Demo powered by 5G-MAG Reference Tools

Visit us at Booth 10.D21 (EBU)  Demo setup by ORS Group and Bitstream
Contributions from Fraunhofer FOKUS, Qualcomm, TEAM-UP, ORS Group, and Bitstream

**TV AND RADIO SERVICES OVER OVER OTT & 5G BROADCAST**
LTE-based 5G Terrestrial Broadcast (3GPP REL-17)

LTE-based 5G Broadcast is a set of technical specifications defined in 3GPP to address requirements for broadcasting to mainstream mobile devices. This demonstrator presents the 5G-MAG Reference tools for 5G broadcast running on commercial research devices (CRDs). Key features under development include:

- End-to-end demo of 5G broadcast, including 5G broadcast core, transmitter and CRDs, for reception
- Seamless switching between 5G broadcast and broadband
- Uninterrupted video experience if the distribution path changes from 5G broadcast to broadband (ott→5G) and vice-versa
- Integration of broadcast and 5G broadcast functionalities in Android devices and applications
- Demonstration of emergency warning sent from 5G broadcast transmitter to CRDs.

The demo is using some of the 5G-MAG Reference Tools available in our GitHub, in particular the following:

- 5G Broadcast Transmitter for CRD
- MBMS Middleware for Android
- MBMS Middleware
- MBMS Modern
- FLUTE

Note that this demo is partially supported by third-party components (includes 5G broadcast core and Bitstream 5G Broadcast transmitter) which are not open-source but free to use for 5G-MAG members for tests and demos.

Get more details and join the Developer Community
developer.5g-mag.com
HOW TO PARTICIPATE
Contribute

GitHub

- All development is happening on Github
- Dedicated **project boards** for each new feature: https://github.com/orgs/5G-MAG/projects
- **Getting started guide** for each topic, e.g., 5G Downlink Media Streaming: https://github.com/5G-MAG/Getting-Started/wiki
- All information at https://github.com/5G-MAG

REQUESTS FOR FEEDBACK: https://github.com/5G-MAG/Requests-for-Feedback

5G-MAG maintains a GitHub repository open to the community to provide feedback on publications related to 5G-MAG’s areas of work. More information can be found at https://publications.5g-mag.com and the related 5G-MAG Workgroups.

For general information about 5G-MAG, send an e-mail. For 5G-MAG Reference Tools, follow the instructions here.
github.com/5G-MAG

*We accept code under the license terms contributors feel comfortable with (check each of the 30+ repos)*
Participate

Discussions around development of features and resolving issues. Dedicated channels for each project.

- [tinyurl.com/join5gmagslack](tinyurl.com/join5gmagslack)
- [5g-mag.com/community](5g-mag.com/community)
- [tinyurl.com/join5gmaggroup](tinyurl.com/join5gmaggroup)

**Calls**

- **Public Calls**
  - Last Friday of the month
  - 13:00 – 14:30 CEST

- **Internal Calls**
  - Fridays – every other week
  - 13:00 – 14:30 CEST

**Announcements** of upcoming meetings, new release candidates and new releases.

[5g-mag.com/community](5g-mag.com/community)
It’s...
5G MEDIA PRODUCTION
It’s... UPLINK VIDEO
It’s... STREAMING
It’s...

5G BROADCAST
It’s...

MULTICAST
It’s...

BEYOND 2D
It’s… XR
THANK YOU!
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In more details...

5G-MAG Reference Tools

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5G–MAG Reference Tools under development

- 5G Downlink Media Streaming (5GMSd)
- 5G Core Network components
- Multimedia delivery protocols
- MBMS & LTE-based 5G Broadcast
- Emergency Alerts over 5G Broadcast
- 5G Multicast Broadcast Services
- XR Media integration in 5G
- AI/ML Evaluation Framework
Implementing...
5G Media Streaming Architecture

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STREAMING OVER UNICAST 5G MEDIA STREAMING
5G DOWNLINK MEDIA STREAMING ARCHITECTURE (3GPP REL-17)
Available Resources

- GitHub Repositories:
  - 5GMSd Application Function (rt-5gms-application-function)
  - 5GMSd Application Server (rt-5gms-application-server)
  - 5GMSd Media Session Handler (rt-5gms-media-session-handler)
  - 5GMS Examples (rt-5gms-examples)
  - 5GMS Common Android Library (rt-5gms-common-android-library)
  - 5GMS Media Stream Handler (rt-5gms-media-stream-handler)
  - 5GMS-Aware Applications (rt-5gms-application)

- Find in our GitHub the following resources:
  https://github.com/5G-MAG/Getting-Started/wiki/5G-Downlink-Media-Streaming
  - Specifications and architecture
  - On-going projects
  - Using the tools
  - Related repositories
5G Media Streaming network components developed so far:

- 5GMS Application Server
  - Wrapping OpenResty (Nginx)
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5G Media Streaming Client components developed so far on Android:

- 5GMS–enabled Media Player
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- Media Session Handler
  - Background service.
- 5GMS–Aware Application
  - App, optionally incorporating the Media Player component.
## Under development: 5GMS Features (Update: January’24)

<table>
<thead>
<tr>
<th>5G Media Streaming feature</th>
<th>5GMS Application Function</th>
<th>5GMS Client</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Provisioning (M1)</td>
<td>Usage (M5)</td>
</tr>
<tr>
<td>Content hosting</td>
<td>Pull-based ✔️</td>
<td>Done ✔️</td>
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<tr>
<td>QoE metrics reporting</td>
<td>Pending release ✔️</td>
<td>Pending release ✔️</td>
</tr>
<tr>
<td>Consumption reporting</td>
<td>Done ✔️</td>
<td>Done ✔️</td>
</tr>
<tr>
<td>Network Assistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery boost</td>
<td>Not applicable</td>
<td>Done ✔️</td>
</tr>
<tr>
<td>Throughput estimation</td>
<td>Not applicable</td>
<td>To do</td>
</tr>
<tr>
<td>Dynamic Policies</td>
<td>Done ✔️</td>
<td>Done ✔️</td>
</tr>
</tbody>
</table>

**Not implemented and welcome…**

- 5GC with support for PCF
- 5GC with support for NEF
5G DOWNLINK MEDIA STREAMING ARCHITECTURE (3GPP REL-17)

**5G Downlink Media Streaming Client**
- rt-5gms-media-session-handler (5GMSd Media Session Handler)
  - 5G-MAG PLv1.0
- rt-5gms-application (5GMSd-Aware Applications)
  - Multiple
- rt-5gms-media-stream-handler (5GMSd Media Stream Handler)
  - 5G-MAG PLv1.0
  - ExoPlayer
- rt-5gms-common-android-library (5GMSd Common Android Library)
  - 5G-MAG PLv1.0

**5G Downlink Media Streaming Server Side**
- rt-5gms-application-function (5GMSd Application Function)
  - 5G-MAG PLv1.0
- Open5GS
- OPENAPI
- rt-5gc-service-consumers (Service consumer components)
  - 5G-MAG PLv1.0
- rt-5gms-application-server (5GMSd Application Server)
  - 5G-MAG PLv1.0
- rt-5gms-examples (5GMSd Examples)
  - 5G-MAG PLv1.0
  - NGINX
  - OPENRESTY

**Additional Components**
- DASH (CMAF)
- HLS (TS, CMAF)
- Media Service Layers
- Media Server (DVB)
- Code License

**Tools**
- 5G Core Network Auxiliary Functions
- 5G Media Streaming Architecture
- Auxiliary Functions

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5GMSd Application Function

- **Release v1.4.0** – 5GMS Application Function
  - Adds Consumption Reporting, Network Assistance, Dynamic Policies
  - Enhancements: ACME certificate management, Improved validation on API communications, Uplift all interfaces to comply with 3GPP TS 26.512 V17.7.0.
  - From previous releases...
    - Implementation of the interfaces at reference point M1 for: Provisioning Session (TS 26.512 clauses 4.3.2 & 7.2), Content Protocols Discovery (TS 26.512 clauses 4.3.4 & 7.5), Server Certificates (TS 26.512 clauses 4.3.6 & 7.3), Content Hosting Configuration (TS 26.512 clauses 4.3.3 & 7.6)

5GMSd Application Server

- **Release v1.2.2** – 5GMS Application Server
  - Adds Consumption Reporting
  - Feature: TS 26.512 v17.7.0 uplift
  - From previous releases...
    - Add Certificate handling for HTTPS distribution
    - Add M3 interface

5GMSd Media Session Handler

- **Release v1.1.0** – 5GMS Media Session Handler
  - 5GMS Consumption reporting: Add support to Media Session Handler
  - Dispatch information about locationReporting and accessReporting to the Media Stream
  - From previous releases...
    - Adds a MediaSessionHandlerMessengerService to establish a bidirectional messenger endpoint with the Media Stream Handler.

5GMSd Media Stream Handler

- **Release v1.1.0** – 5GMS Media Stream Handler
  - Initial support for 5GMS Consumption reporting
  - Add support for location reporting
  - From previous releases...
    - Adds an ExoPlayerAdapter that implements the M7 interface.
Release Highlights

5GMSd Application ([rt-5gms-application/releases](#))
- **Release v1.1.0 – 5GMS Application**
  - Request access to ACCESS_FINE_LOCATION to support location property when doing consumption reports
  - Request permission for getting GPSI for Consumption Reporting
- **From previous releases**:
  - Visualize the selected bitrate and the selected Representation as an overlay on top of the video
  - Move to Media3 for Exoplayer dependency
  - Adds a user interface to select between different M8 data/endpoints and to select the target stream to be played.
  - Allows for adding new M8 endpoints either via a local .json file or via a server endpoint.
  - Adds a network interface to fetch M8 information
  - **Exo-DVB-I Player**: The Exo DVB-I Player uses the Android ExoPlayer and the DVB-I Reference Client functionality to provide the capabilities to select and play back media content.

5GMS Common Android Library ([rt-5gms-common-android-library/releases](#))
- **Release v1.1.0 – 5GMS Common Android Library**
  - 5GMS Consumption reporting: Add support in common Android library
  - Multiple changes related to Consumption Reporting that add required model classes and new Util functions
  - Add new events to be dispatched to enable location reporting
  - Add logic to derive either domain name or the IP address from a request URL

5GMS Examples ([rt-5gms-examples/releases](#))
- **Release v1.0.0 – 5GMS Examples**
  - Adds a simple express.js server to mock functionality of the Application Function. The first route m8.js is used to return information about the available services and the available base URL to the Application Function. The 5GMSd Aware Application uses this route as M8 interface. The second route service-access-information.js provides the corresponding ServiceAccessInformation to the data that is returned via M8.
Projects:

5GMS Application Server for MVP#1

- Started with a single static Content Hosting Configuration file (JSON) following the syntax defined in TS 26.512 clause C.3.5.
  - Exposes a virtual host at reference point M4d.
- Changes to HTTP redirect handling by the 5GMS AS have been made recently.

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5GMS: Basic media stream handling (MVP#1)
Projects:

**5GMS Application Function for MVP#2**

- Started with a single static Content Hosting Configuration file (JSON) following the syntax defined in TS 26.512 clause C.3.5.
  - Exposes corresponding Service Access Information at M5d.
- No further development work planned on Application Function under MVP#2.
AS now configured by the AF and no longer accepts a static Content Hosting Configuration.
- Model: AS maintains a flat list of server certificates and a flat list of Content Hosting Configurations.

Initial implementation checked in to AS and AF repositories, including uplift of M3d API to track changes in M1d API as TS 26.512 V17.3.0.

No further work planned until Content Publishing Configuration for uplink media streaming is agreed (Release 18).
Projects:

5GMS: M1 provisioning

- Application Function now configured via the M1d API and longer accepts a static Content Hosting Configuration.

- Implemented first three APIs at M1d:
  - Provisioning Sessions API.
  - Server Certificates Provisioning API.
  - Content Hosting Provisioning API.

- Uplift to comply with TS 26.512 V17.3.0.

- (Fraunhofer FOKUS currently implementing the Metrics Provisioning API.)

- Next planned development by BBC:
  - Policy Templates Provisioning API.

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Projects:

5GMS: Network Assistance

- Aiming to support both delivery boost and throughput estimation (bit rate recomm.).
- Developed new service consumer libraries for communicating with the Binding Support Function (BSF) and Policy & Charging Function (PCF).
- Integration into 5GMS AF underway:
  - (No M1 provisioning: static configuration only 😊.)
  - Additional Service Access Information at M5 for use by the Media Session Handler.
  - Implement M5 Network Assistance API. (Uplift of 5GMS AF to recently published TS 26.512 V17.5.0 already complete.)
- Additional development of the Media Session Handler needed to invoke M5 APIs.

5GMS: Network Assistance and Dynamic Policies features

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Projects:
5GMS: Dynamic Policies

- Reuse service consumer libraries for communicating with the BSF and PCF.
- Development work in the 5GMS AF:
  - Implement M1 Policy Templates API.
  - Additional Service Access Information at M5 to support the Media Session Handler.
  - Implement M5 Dynamic Policies API.
- Corresponding changes to the Media Session Handler needed to invoke these at M5.
5GMS: QoE Metrics Collection & Reporting

- Metrics Measurement and Logging Client:
  - Performs the measurement and logging of QoE metrics in accordance with the Metrics Reporting Configuration part of provisioning data, supplied by the 5GMSd Application Provider to the 5GMSd AF, and forwarded by the 5GMSd AF to the Media Player via the Media Session Handler.

- Initial implementation of QoS metrics and consumption collection and reporting

- Aim to support multiple metric schemes. In particular:
  - For downlink media streaming, TS 26.247 clauses 10.6.1 and 10.6.2 specify the required MIME content type and metrics report format for the 3GPP urn:3GPP:ns:PSS:DASH:QM10 metrics reporting scheme

Projects:
5GMS: QoE Metrics Collection & Reporting

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Projects:

5GMS: Consumption Collection & Reporting

- Consumption Measurement & Logging Client:
  - Performs the measurement and logging of content consumption-related information in accordance with the Consumption Reporting Configuration part of provisioning data, supplied by the 5GMSd Application Provider to the 5GMSd AF, and forwarded by the 5GMSd AF to the Media Player via the Media Session Handler.

- Initial implementation of QoS metrics and consumption collection and reporting

- Aim to support multiple metric schemes. In particular:
  - For downlink media streaming, TS 26.247 clauses 10.6.1 and 10.6.2 specify the required MIME content type and metrics report format for the 3GPP urn:3GPP:ns:PSS:DASH:QM10 metrics reporting scheme.
Implementing...
5G Core Network components

developer.5g-mag.com
Available Resources

- GitHub Repositories:
  - 5G Core Service Consumers ([rt-5gc-service-consumers](https://github.com/rt-5gc-service-consumers))

- Find in our GitHub the following resources:
  - [https://github.com/5G-MAG/Getting-Started/wiki/5G-Core-Network](https://github.com/5G-MAG/Getting-Started/wiki/5G-Core-Network)
    - Specifications and architecture
    - On-going projects
    - Using the tools
    - Related repositories
5GC Service Consumers ([rt-5gc-service-consumers/releases](rt-5gc-service-consumers/releases))

- **Release v1.0.0 – 5GC Service Consumers**
  - This is the first release of the 5G Core Service Consumer libraries and tools. These are based upon the Open5GS 5G Core and can be used as an independent set of tools for testing or controlling 5G Core APIs or as libraries for adding API handling into your own Open5GS based AF implementations.
  - Initial commit of the Service Consumer libraries and tools
  - Service Consumer Libraries: Various bug fixes and improvements
Projects:
5GC: Service consumer libraries & test app

- The 5GMS AF needs to communicate with the 5G Core in order to manipulate network Quality of Service (QoS) for ongoing media streaming sessions.

- Solution: **reusable** service consumer libraries to invoke service operations on:
  - Binding Support Function (BSF).
  - Policy & Charging Function (PCF).

- Could also be exploited by future functions (MBSF, MBSTF, etc.)

- Also developing a command line PCF test application.
  - To test libraries against another 5G Core.

5GMS:
Network Assistance and Dynamic Policies features

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STREAMING OVER UNICAST 5G MEDIA STREAMING
5G DOWNLINK MEDIA STREAMING ARCHITECTURE (3GPP REL-17)

5G Core Network

5G NG-RAN (Radio Access Network)

5G Core and Radio Access Network

External Functions

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5G Media Streaming Architecture

5G Core Network

Content Provision & Management

Service Management & Control

Content Packager & Service Layer

Content Application Provider

CONTRIBUTION (INGEST)

DASH (CMAF)

HLS (TS, CMAF)

Media Service Layers

Video
Audio
TV
Radio
VoD
Podcast
Ads
Objects
Metadata
Accessibility
VR/AR/VR...
Projects:

5GC: Data Collection, Reporting & Event Exposure

- Exposure of UE Data to other Network Functions in the 5G System (e.g. NWDAF, third-party AFs,...).
- Implementation of a standalone Data Collection AF able to receive generic data reports from the UE and expose them as events to event consumers.
- Implementation in a shared library able to be integrated into the 5GMS AF.
- The project complements the client-side collection and reporting for QoE metrics and consumption.

5GMS: UE data collection, reporting and event exposure

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Implementing... Multimedia content delivery protocols
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Available Resources

- GitHub Repositories:
  - FLUTE Library for LTE-based 5G Broadcast / MBMS ([rt-libflute](https://github.com/5G-MAG/Getting-Started/wiki/Multimedia-content-delivery))
  - ROUTE integrated within MBMS Middleware ([rt-mbms-mw/tree/route-gpac](https://github.com/5G-MAG/Getting-Started/wiki/Multimedia-content-delivery))

- Find in our GitHub the following resources:
  - [Specifications and architecture](https://github.com/5G-MAG/Getting-Started/wiki/Multimedia-content-delivery)
  - [On-going projects](https://github.com/5G-MAG/Getting-Started/wiki/Multimedia-content-delivery)
  - [Using the tools](https://github.com/5G-MAG/Getting-Started/wiki/Multimedia-content-delivery)
  - [Related repositories](https://github.com/5G-MAG/Getting-Started/wiki/Multimedia-content-delivery)
Projects:

Support for FLUTE

- Implementation of FLUTE (File Delivery over Unidirectional Transport) library
  - IETF RFC 6726
  - With FEC Rapor10 support
**Implementation of ROUTE (Real-time Transport Object delivery over Unidirectional Transport) library to extract a DASH/HLS live filesystem from a ROUTE/IP session**

**What it implements at the server side:**
- ROUTE over multicast IP (UDP);
- Partial segments can be dispatched. Needed for low latency
- Not implemented: EXT_NOP/EXT_TIME, and optionally EXT_AUTH if used; Congestion; FEC (RAPTORQ as in RFC 6330)

**What it implements at the client side:**
- ROUTE over multicast IP (UDP);
- Skip repeated files;
- Low latency;
- Partially implemented: File repair simple option:
  - MPEG-2 TS: all lost ranges are adjusted to 188-bytes boundaries, and transformed into NULL TS packets.
  - ISOBMFF: all top-level boxes scanned, incomplete boxes are transformed in free boxes, except mdat.
- Not implemented: Reorder (with timeout); Choose service ID to bootstrap on for ATSC 3.0 mode; FLUTE (as documented in in RFC 3926 and TS 26.346); Congestion; FEC (RAPTORQ as in RFC 6330)
Implementing... MBMS & LTE-based 5G Broadcast

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TV AND RADIO SERVICES OVER 5G BROADCAST
LTE-BASED 5G TERRESTRIAL BROADCAST (3GPP REL-17)
TV AND RADIO SERVICES OVER OTT & 5G BROADCAST
LTE-BASED 5G TERRESTRIAL BROADCAST (3GPP REL-17)
Available Resources

- GitHub Repositories:
  - 5G Broadcast Transmitter (rt-mbms-tx)
  - Transmitter for QRDs and CRDs (rt-mbms-tx-for-qrc-crd)
  - MBMS Middleware (rt-mbms-mw)
  - MBMS Modem (rt-mbms-modem)
  - Web User Interface for Modem, MW & Application (rt-wui)
  - MBMS Examples (rt-mbms-examples)

- Find in our GitHub the following resources:
  - Specifications and architecture
  - On-going projects
  - Using the tools
  - Related repositories

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Under development

Stationary reception
Application
Middleware
Modem (HW)

Reception on mobile
Application
Middleware (Android)
Baseband (HW)

Content Provider

- xMB: ctrl & data
- BM-SC
- MBMS-GW (Sync)
- MME
- MCE
- M2 & S1 (ctrl)

Broadcast Core

- Modulator / eNodeB
- MI (data)
- digital I/Q data
- Exciter

Amplifier + TX

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Under development

Stationary reception
- \texttt{rt-wui} / VLC / dash.js / ...
- \texttt{rt-mbms-mw}
  (with \texttt{rt-libflute})
- \texttt{rt-mbms-modem}
  (using srsRAN) SDR

Qualcomm QRD or CRD
- \texttt{rt-mbms-mw-android}
  QC MBMS MW
  Baseband (HW)
  with QC SW to enable ROM

Content Provider

- ffmpeg
  - RTP MPEG-TS or HLS/DASH
  via \texttt{rt-libflute}

Broadcast Core

- \texttt{MBMS-GW (Sync)}
  - \texttt{srsRAN mbms-gw}
- \texttt{MBMS-GW (Sync)}
  - \texttt{M2 \& S1 (ctrl)}

Modulator / eNodeB

- \texttt{rt-mbms-tx}
  - digital I/Q data

Exciter

- SDR (BladeRF, Lime, Ettus, ...)
  - RF

Amplifier + TX

xMB: ctrl \& data
LTE-BASED 5G BROADCAST (3GPP REL-17)

**MBMS / LTE-based 5G Broadcast Client**

- **rt-imbms-mw** (MBMS Middleware)
  - 5G-MAG PLv1.0
- **rt-libflute** (FLUTE)
  - 5G-MAG PLv1.0
- **gpc-route branch** (ROUTE)
  - 5G-MAG PLv1.0

**MBMS / LTE-based 5G Broadcast RAN and Core**

- **rt-imbms-tx** (5G Broadcast Transmitter + basic MBMS gw)
  - AGPlv3.0
- **rt-imbms-tx-for-qrd-and-crd** (5G Broadcast Transmitter for QRD and CRD)
  - AGPlv3.0

**Protocols for multicast distribution**

- MBMS / LTE-based 5G Terrestrial Broadcast
- Protocols for multicast distribution

**Public release**

- Content Packager & Service Layer
- DASH (CMAF)
- HLS (TS, CMAF)
- Media Service Layers

**Pre-release (members-only)**

- Video
- Audio
- TV
- Radio
- VoD
- Podcast
- Ads
- Objects
- Metadata
- Accessibility
- VR/AR/XR
Release Highlights

LTE-based 5G Broadcast Transmitter (rt-mbms-tx/releases)
- Release v1.0.0 – LTE-based 5G Broadcast Transmitter
  - This is the first release of the LTE-based 5G Broadcast Transmitter. This implementation is based on the existing MBMS implementation in srsRAN_4G eNodeB, modified to include a feature set of 3GPP Rel-17 LTE-based 5G Terrestrial Broadcast. It also includes a basic MBMS gateway which creates a virtual network interface sgi_mb which receives IP multimedia traffic.

MBMS Modem (rt-mbms-modem/releases)
- Release v1.2.1 – MBMS Modem
  - Enables automatic gain control configuration for the SDR reader via the configuration file
- From previous releases...
  - Rebase to srsRAN. Important: This links to the fembms branch of srsRAN: https://github.com/5G-MAG/srsRAN/branches
  - Support for MIMO / dual RX streams from BladeRF

MBMS Middleware (rt-mbms-mw/releases)
- Release v0.10.0 – MBMS Middleware
  - Add support for seamless switching between broadcast and unicast delivery for HLS streams
  - Add support for three different service announcement formats as document
  - Add support for seamless switching demo via flute-ffmpeg watchfolder approach

Web User Interface (rt-wui/releases)
- Release v0.1.0 – Web User Interface
  - Add support for seamless switching between broadcast and unicast streams for HLS content
  - Update to dash.js 4.4.0
- From previous releases...
  - Provide DASH manifest url directly to application.js if available
  - Provide HLS manifest url directly to application.js if available

MBMS Examples (rt-mbms-examples/releases)
- Release v0.2 – MBMS Examples
  - Add support for seamless switching using the flute ffmpeg watchfolder approach
- From previous releases...
  - Adds an example implementation to demonstrate rt-mbms-mw usage without the rt-mbms-modem part.
Implemented so far…

- End-to-end support for LTE-based 5G Terrestrial Broadcast
  - Standalone 5G Broadcast transmitter and basic MBMS gateway (Release 14)
  - Standalone 5G Broadcast transmitter for QRDs and CRDs (Rel 9 with Receive-Only Mode capabilities)
  - MBMS Modem/Receiver (Release 17)
  - MBMS Middleware
  - Web User Interface for PHY layer and signaling parameters with integrated player

- Implementation of FLUTE and ROUTE libraries for the MBMS Modem
- Support of DASH, HLS and RTP playback over 5G Broadcast
- Support for seamless switching (only HLS) between unicast and broadcast

Not implemented and welcome…

- Uplift of 5G Broadcast transmitter to Release 18
- Seamless switching and Android middleware support for DASH
- Further development of MBMS gateway
- Development of BM-SC with xMB interface
Software-defined radio (SDR)-based modem with support of:
- Receive-only mode services within a mixed carrier (support of Rel-14 ROM)
- Receive-only mode services in a dedicated carrier (support of Rel-14, Rel-16 and Rel-17 features)

Dedicated 5G Broadcast SDR modem implements the following Rel-16 features:
- Increased CAS robustness
  - PBCH repetition
  - Semi-static CFI in MIB
  - New PDCCH format 4: 16 CCEs / 144 REGs
- New subcarrier spacings 0.37 kHz, 1.25 kHz and 2.5 kHz

Dedicated 5G Broadcast SDR modem implements the following Rel-17 features:
- Support for 6/7/8 MHz MBSFN subframes

Other improvements:
- Merged features from all branches (dual-rx, mixed mode, …) into development
- Took care of warnings: Now builds clean again with GCC 11.4 at -Wall -Wextra -Wpedantic -Werror
- Brought srsRAN_4G up to latest main branch revision from SRS
- Improved MIB decoding for dedicated cells, was getting confused by MBSFN symbols
- Speed up startup/synchronisation: SDR is only retuned if parameters have changed
- Fixed PDSCH resource allocation for 1.4MHz / 6 PRBs

Projects:
5G Broadcast SDR-based Modem
Work on two versions of transmitters oriented to:

- Receive-only mode services within a mixed carrier (support of Rel-14 ROM for CRD/QRDs)
- Receive-only mode services in a dedicated carrier (support of Rel-14, Rel-16 and Rel-17 features)
Web User Interface (rt-mbms-wui)

- Interfaces via RESTful API to rt-mbms-modem and rt-mbms-mw
- Useful for checking basic reception parameters
- Middleware file list and service announcement
- Contains HLS and DASH players
- New features added for visualization of advanced parameters
Seamless switching between broadcast and OTT/unicast content delivery

Enables flexible usage of bandwidth
- Broadcast on demand: services can be dynamically provisioned when the demand is there, otherwise viewers are on OTT / using CDN download
- Off-peak times are freed for e.g. content prepositioning / data services
- Any mix is possible, e.g.
  - 24/7 radio channels with robust coding and SCS 2.5kHz for high mobility
  - 4 TV channels at 1080p / 3 Mbps during the day, but only one at UHD / 12 Mbps for a sports game in the evening

Mobility scenarios between MBSFN areas: can carry same MBMS service
Implementing... Emergency Alerts over 5G Broadcast

developer.5g-mag.com
EMERGENCY ALERTS OVER 5G BROADCAST

LTE-BASED 5G BROADCAST EXTENDED WITH PUBLIC WARNING SYSTEMS

USER EQUIPMENT / DEVICES / APPLICATIONS

CONTENT PROVISION & MANAGEMENT

5G AND DATA NETWORK

USER EQUIPMENT / DEVICES / APPLICATIONS

- Content Provider App
- MBMS / LTE-based 5G Broadcast Receiver

CONTENT PROVISION & MANAGEMENT

- Cell Broadcast Entity (CBE)
- Public Warning Authority

MBMS LTE-based 5G Broadcast Radio Access Network

Access Stratum

MBMS LTE-based 5G Broadcast Core

- MME
- CBC

MBMS GATEWAY

MBMS/LTE-based 5G Broadcast

External Functions

Cell Broadcast Service

CLIENT-SERVER MODEL

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Available Resources

- GitHub Repositories:
  - 5G Broadcast Transmitter (*rt-mbms-tx*)
  - Transmitter for QRDs and CRDs (*rt-mbms-tx-for-qrc-crd*)
  - MBMS Middleware (*rt-mbms-mw*)
  - MBMS Modem (*rt-mbms-modem*)
  - Web User Interface for Modem, MW & Application (*rt-wui*)
  - MBMS Examples (*rt-mbms-examples*)

- Find in our GitHub the following resources:
    - Specifications and architecture
    - On-going projects
    - Using the tools
    - Related repositories
Under development: What is missing?

Under development...
- Initial support of SIB12 delivery over eNodeB

Not implemented and welcome...
- Development of MME with interface to CBC
- Development of CBC and interface to MME
- Development of CBE generating CAPv1.2 to CBC
- Mapping of CAPv1.2 to SIB12
Emergency Alerts over 5G Broadcast

- Implementation of Cell Broadcast Service functions
  - Cell Broadcast Entity (CBE)
  - Cell Broadcast Center (CBC)

- Implementation of interface CBE-CBC with Common Alerting Protocol v1.2 (CAP v1.2)

- Implementation of interface SBc between CBE and MME

Projects:

MBMS: Public Warning System

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Implementing...
5G Multicast-Broadcast Services (MBS)
developer.5g-mag.com
STREAMING OVER 5G MULTICAST–BROADCAST SERVICES

5G MULTICAST–BROADCAST USER SERVICES (3GPP REL-17)
Available Resources

- GitHub Repositories:
  - Under development

- Find in our GitHub the following resources:
  - [https://github.com/5G-MAG/Getting-Started/wiki/5G-Multicast-Broadcast-Services](https://github.com/5G-MAG/Getting-Started/wiki/5G-Multicast-Broadcast-Services)
    - Specifications and architecture
    - On-going projects
    - Using the tools
    - Related repositories
Under development: 5MBS Masterplan

- Start with Broadcast mode in RAN and 5G Core
  - MVP#0: only user plane – MB-UPF
  - MVP#0.1: user plane and control plane* – MB-UPF, MB-SMF* and AMF*

Why? Less complexity (MBS session management, implementation)

- Continue with Multicast mode in 5G Core (only shared subset with Broadcast)
Under development: What is missing?

**Under development...**
- Initial support of MB-UPF in 5GC

**Not implemented and welcome...**
- Support for MBS in gNodeB
- MBS User Services
- Linux-based Modem with MBS support
Initial implementation of **MB-UPF and basic multicast capabilities in the 5G Core**

Start with Broadcast mode in RAN and 5G Core
- MVP#0: only user plane – MB-UPF
- MVP#0.1: user plane and control plane* – MB-UPF, MB-SMF* and AMF*

**Why?** Less complexity (MBS session management, implementation)

Continue with Multicast mode in 5G Core (only shared subset with Broadcast)
Implementing...
XR Media integration in 5G

developer.5g-mag.com
Available Resources

- At the moment these GitHub Repositories are private:
  - XR Unity Player (rt.xr.unity-player)
  - XR Blender Exporter (rt.xr.blender-exporter)
  - Efficient glTF 3D import / export package for Unity (rt.xr.glTFast)
  - XR Content (rt.xr.content)
  - XR MAF Plugin (rt.xr.maf-plugin)
  - XR MAF Native (rt.xr.maf-native)

- Find in our GitHub the following resources:
  - Specifications and architecture
  - On-going projects
  - Using the tools
  - Related repositories

These repositories are currently under development and testing
- Early access for testing can be requested using the form available at
  - [www.5g-mag.com/early-access](http://www.5g-mag.com/early-access)
**Content Playback**
- Unity and Unreal Engine 5 are widely used for the creation of 3D experiences
- An open-source XR Player based on Unity Plugins is available (an XR Web Player is expected too)
- Player is able to load at runtime a 3D scene and render it to create an immersive experience
- Open-source will help developers to get started with standardized technologies and their integration into 5G-MAG

**Content Creation**
- Blender is an open-source and widely used 3D authoring tool with native support for glTF
- Extended Blender for authoring Metaverse 3D scenes
- Open-source project to close the loop on content creation/consumption
- Project in has recently been released through 5G-MAG
- Enables developers to create content and ship players that can consume it
Under development: XR Media Integration in 5G

- Next steps into integration with 5G
  - Enable QoS supported asset component streaming and download
  - Support both DASH and WebRTC
  - Interface with MSH to request QoS for multiple streams
  - Contributions are solicited
XR repos with ISO/IEC 23090-14 functionalities

- All issues related to the release of version 1.0.0 of the XR repositories dealing with functionalities defined in ISO/IEC 23090-14

- More information soon, please check: [www.5g-mag.com/tutorials](http://www.5g-mag.com/tutorials)

- Background information is available here:
Implementing...
AI/ML Evaluation Framework

developer.5g-mag.com
Available Resources

- At the moment these GitHub Repositories are private:
  - Evaluation Framework for AI/ML (rt-ai-ml-evaluation-framework)

- Find in our GitHub the following resources:
    - Specifications and architecture
    - On-going projects
    - Using the tools
    - Related repositories

These repositories are currently under development and testing
- Early access for testing can be requested using the form available at
  - www.5g-mag.com/early-access

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This project is the implementation of the AI/ML evaluation framework as defined in 3GPP SA4 TR 26.847.

The purpose is to establish an evaluation framework and use it for the evaluation of scenarios collected for the 3GPP FS_AI4Media study. This includes the collection of scenarios based on the use cases identified, and defining a scenario template for the description of scenarios for the evaluation.

The evaluation framework documents common testbed architectures and anchors, metrics (e.g. AI/ML task metrics, feasibility/performance metrics), and specific details (such as test configuration and constraints) for each scenario evaluation.
Extras for 5G-MAG members
developer.5g-mag.com
Currently 10 encoding recipes available, reach out if you’re looking for something else

Free cloud-based encoding service for experimentation in scope of 5G-MAG Reference Tools

Leveraging Dolby’s professional infrastructure (Hybrik)

Best effort and limited support for contributors (no SLA)

Free demo and testing licenses are made available by Dolby Laboratories to 5G-MAG members.

Please contact Kurt Krauss at Kurt.Krauss@dolby.com
5G Broadcast Modulator from Bitstem

- Supports FeMBMS (3GPP Release 14 up to 18) and eMBMS (Release 9/12 mixed mode for Android prototype handsets CRD/QRD)
- Channel bandwidths 3, 5, 6, 7, 8 and 10 MHz
- Subcarrier spacings ($\Delta f$) of 0.37, 1.25, 2.5, 7.5 and 15 kHz
- Supports ETWS/cell broadcast warning message distribution via SIB12
- RESTful API for configuration, control and status to allow for integration into an existing web interface or configuration system
- Data and control inputs through standardised M1, S1 and M2 interfaces, compatible with 3GPP-compliant 5G Broadcast cores
- Output of modulated I/Q data via Ethernet
- Supports demos and trials through direct ingress of traffic and local configuration, and can output I/Q data via USB directly to BladeRF SDRs
- Free demo and testing licenses are made available by Bitstem to 5G-MAG members.
  - Please contact Klaus Kühnhammer at klaus@bitstem.com
Nakolos: 5G Broadcast meets Broadband

- Nakolos, a joint-project by ORS Group and Bitstem GmbH develops products and solutions for content providers and broadcast network operators to utilize the combination of 5G Broadcast and Broadband.

- 5G Broadcast Core
  - FeMBMS, LTE-based terrestrial broadcast (3GPP Releases 14, 16, 17), eMBMS (Release 9/12 mixed mode for Android prototype handsets CRD/QRD)
  - Operable in 5G BC standalone or connected mode for broadcast-broadband solutions
  - Runs on-premise or in the cloud
  - Interoperability with different transmitter vendors and emergency warning systems by supporting 3GPP interfaces: xMB, M1, M2, M3, CAP
  - High availability through redundancy on-premise or in the cloud

- 5G Broadcast middleware
  - Standalone app for use-case tests
  - Easy integrable into existing apps for commercial use

- Hybrid connect
  - Broadband load monitoring
  - Dynamic provisioning of 5G Broadcast cores
  - Reports and insights

- Free demo and testing licenses for the 5G Broadcast core are made available to 5G-MAG members
  - Please contact Johann Mika at johann.mika@ors.at (More info at www.nakolos.com)
5G-MAG Reference Tools in use
developer.5g-mag.com
Conferences and Publications

PARTNER FOCUS

5G-MAG REFERENCE TOOLS DEVELOPING OPEN SOFTWARE TOOLS FOR 5G MEDIA
By Jordi J. Gimenez - 5G-MAG - PCMMag

Building a suite of open-source tools for 5G-based media services

A growing number of contributors are collaborating to develop an open-source ecosystem of tools to support 5G-based media services. One such initiative is the 5G-MAG Reference Tools project, which aims to develop a suite of open-source tools to support 5G-based media services. The tools are designed to enable developers to easily create and deploy applications that leverage the unique capabilities of 5G networks.

The 5G-MAG Reference Tools project is a collaborative effort that brings together experts from the telecommunications and media industries. The goal is to create a set of standards and specifications that will enable developers to build applications that are optimized for 5G networks.

The 5G-MAG Reference Tools project includes a range of tools, each designed to address a specific aspect of 5G-based media services. For example, there are tools to support 5G media streaming, 5G media broadcast, and 5G media recording. Each tool is designed to be easily integrated into existing media systems, and developers can use them to build applications that are optimized for 5G networks.

The 5G-MAG Reference Tools project is not only about developing tools; it is also about educating developers and other stakeholders about the potential of 5G-based media services. The project includes training sessions and workshops that are designed to help developers understand how to use the tools effectively.

The 5G-MAG Reference Tools project is a great example of how collaboration can lead to the development of innovative solutions. By bringing together experts from different industries, the project is able to create a suite of tools that are truly open-source and can be used by anyone to build applications that are optimized for 5G networks.

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Demos @ IBCShow 22

5G-MAG

Nakolos (ORS/Bitstem)

Fraunhofer FOKUS
FOKUS Media Web Symposium 2023
BBC R&D Open Day 2023
IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB) 2023

www.5g-mag.com/events
5G-MAG Reference Tools @ IBCShow 2023

BRINGING 5G MEDIA STREAMING TO LIFE
5G-MAG DEMO POWERED BY 5G-MAG REFERENCE TOOLS
VISIT US AT BOOTH 10.D21 (EBU)
CONTRIBUTIONS FROM Fraunhofer FOKUS, Qualcomm, Dolby and BBC R&D

STREAMING OVER UNICAST 5G MEDIA STREAMING
5G DOWNLINK MEDIA STREAMING ARCHITECTURE (3GPP REL-17)

5G Media Streaming (5GMS) is a set of technical specifications defined in 3GPP with the aim to achieve better media streaming. Quality of Experience (QoE) of 5G media streaming is achieved by using the 5G-MAG Reference Tools.

The demo is using some of the 5G-MAG Reference Tools available in our GitHub repository, in particular the following:
- 5GMS Application Function
- 5GMS Application Server
- 5GMS Media Session Handler
- 5GMS Media Stream Handler
- 5GMS Application
- 5GMS Common Android Library
- 5G Service Consumers

Network Assistance
- Throughput estimation
- Bit rate recommendation
- Temporary delivery buffer
- Consumption reporting
- Including exposure of CSN access logs.

Content Hosting
- CSN deployed inside or outside the mobile network
- Dynamic network QoS policy
- Automatically adapting representation switching during a streaming session
- Supporting on-the-fly performance adaptation

Quality of Experience metrics reporting
- Supporting on-the-fly performance adaptation

Note that this demo is partially supported by third-party components (e.g. Android and Open5G 5GC CORE).

Get more details and join the Developer Community
developer.5g-mag.com
5G Broadcast demo with pre-commercial devices

LTE-based 5G Broadcast is a set of technical specifications defined in 3GPP to address requirements for broadcasting to mainstream mobile devices. This demonstrator presents the 5G-MAG Reference Tools for 5G Broadcast running on commercial research devices (CRDs). Key features under development include:

- End-to-end demo of 5G broadcast including 5G broadcast core transmitter and CRDs for reception
- Seamless switching between 5G broadcast and broadband
- Uninterrupted video experience if the distribution path changes from 5G broadcast to broadband (5G-to-lte) and vice versa
- Integration of broadcast and 5G broadcast functionalities in Android devices and applications
- Demonstration of emergency warning sent from 5G broadcast transmitter to CRDs.

The demo is using some of the 5G-MAG Reference Tools available in our GitHub, in particular the following:

- 5G Broadcast Transmitter for CRD
- MBMS Middleware for Android
- MBMS Middleware
- MBMS Melder
- FLUTE

Note that this demo is partially supported by third-party components (includes 5G broadcast core and Bitstream 5G Broadcast Transmitter) which are not open-source but free to use for 5G-MAG members for tests and demos.

Get more details and join the Developer Community
developer.5g-mag.com
DEVELOPER XCHANGES
Developers present their implementations and progress with the 5G-MAG Reference Tools. Take a look at https://www.5g-mag.com/tutorials

5G-MAG PARTICIPATES IN OSMART WORKSHOPS
The OSMART (Open-Source Media Application Reference Tools) workshop is a regular exchange involving the development of open-source software for media applications with a series of status updates and roadmaps on relevant projects from relevant organizations. Find more information: https://www.5g-mag.com/osmart and join the community at https://github.com/osmart-community/
Stay tuned!

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