# Review OC5 experiment CDN-X-ALL

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FED4FIRE+ FEC6

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# vicomtech

## visual interaction & communication technologies

Vicomtech is an applied research centre specialized in Computer Graphics, Visual Computing and Multimedia technologies
Founded in 2001 and based at San Sebastián Technology Park

**ICTs and Digital Media**
Data Intelligence for Energy and Industrial Processes
Industry and Advanced Manufacturing
Intelligent Transport Systems and Engineering
eHealth and Biomedical Applications
Speech and Natural Language Technologies

# VICOMTECH & NITLAB

**CDN-X-ALL:** *CDN edge-cloud computing for efficient cache and reliable streaming aCROSS Aggregated unicast-multicast LinkS*

- **Experiment description (max. 4 slides)**
  - Concept and objectives
  - Background and motivation
  - Experiment set-up
- **Project results (max. 3 slides)**
  - Measurements
  - Lessons learned
- **Business impact (min. 4 slides)**
  - Impact on your business, .. how did Fed4FIRE helped you ?
  - Value perceived, .. why did you come to Fed4FIRE ?
- **Feedback (min. 4 slides)**
  - Used resources and tools
  - Added value of Fed4FIRE

# CDN-X-ALL EXPERIMENT: Concept

## Adaptive Streaming over HTTP
Media industry standard

- Wide display ecosystem
- Bandwidth optimisation
- Scalability & Better QoE
- Dynamic adaptation of media players
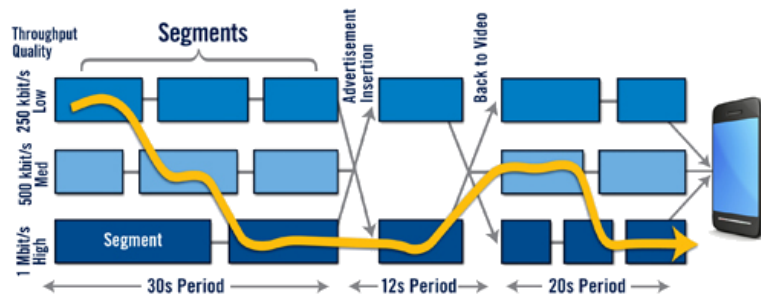
## *3GPP 4.5G/5G M&E*

- i.e Rel14. EnTV services over 3GPP

# CDN-X-ALL EXPERIMENT: Motivation

Edge Awareness Video delivery Analytics

3GPP eMBMS *"enhanced Multimedia Broadcast and Multicast System over LTE "*

- 3GPP Northbound interfaces:  MB2-C/U, xMB-C/U
- Transparent service mapping  1:1

5G ETSI standard on *Multi-access Edge Computing* allows deploying application services at the edge of the mobile network:

- Zero Latency
- Capillary
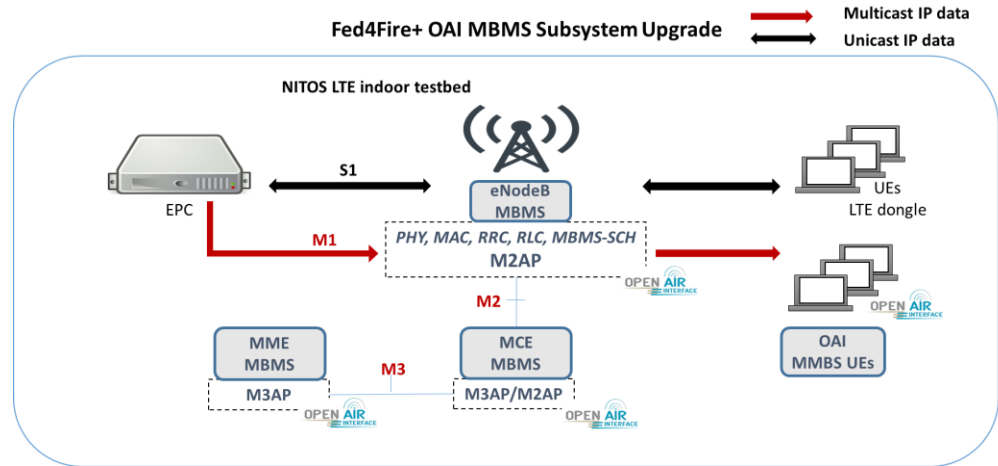- Distributed
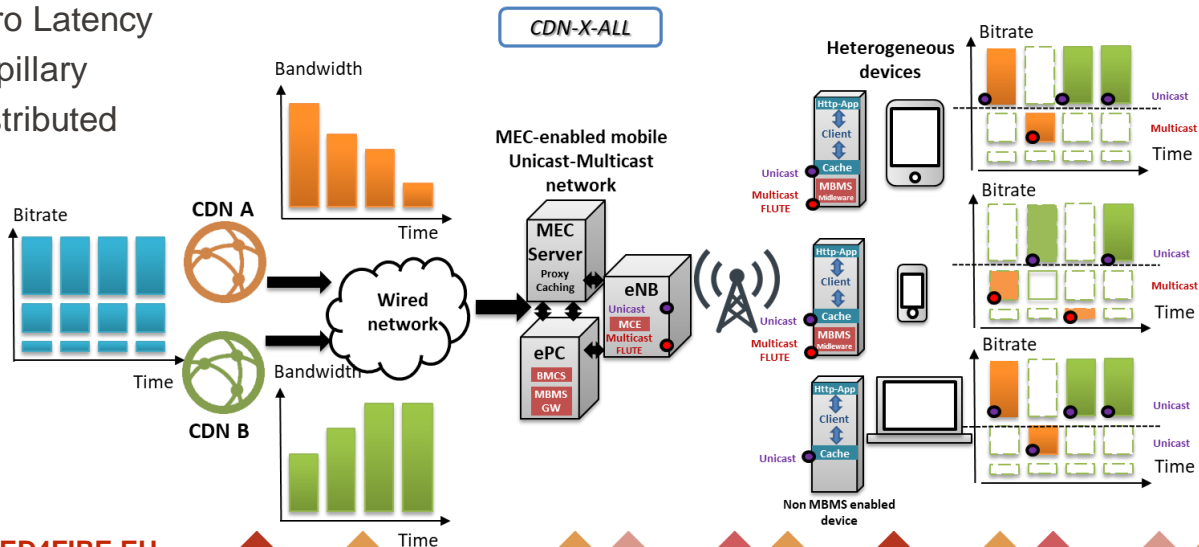
# CDN-X-ALL EXPERIMENT: Set-up (I)

**NITOS Testbed (Volos, Greece)**

- Custom **SDR** based 3GPP mixed UC/BC/MC environment (USRP nodes)
- Real UEs LTE dongles

**3GPP compliant** eMBMS LTE-A-Pro sub-system development

- Enhanced UE and eNB (MBMS)
- New Multicast Control Element (MCE)
- 3GPP TS 36.300 version 14.6.0
- E-UTRAN M2 Application Protocol (M2AP) 3GPP TS 36.443 version 14.0.1
- E-UTRAN M3 Application Protocol (M3AP) 3GPP TS 36.444 version 14.1.0
- PHY, MAC, RRC, RLC, PDCP, IP



Fed4Fire+ OAI MBMS Subsystem Upgrade

→ Multicast IP data
→ Unicast IP data

NITOS LTE indoor testbed

# CDN-X-ALL EXPERIMENT: Set-up (II)

*NITOS Testbed* **(Volos, Greece)**
- Indoor deployment that **feature LTE** in an RF-isolated environment
- Real UEs LTE dongles
- eNB+ePC OpenAirInterface (USRP nodes)
- DASH proxy parsing

*Vicomtech labs* **(San Sebatian, Spain**) with servers for media control and orchestration
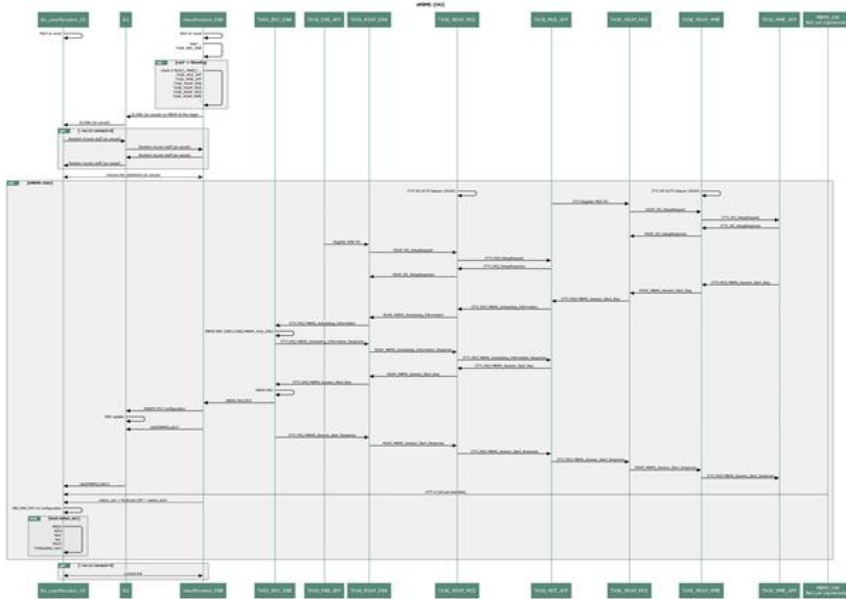- *Dataset* creation for ML model training
- *ML learning* for time series forecasting
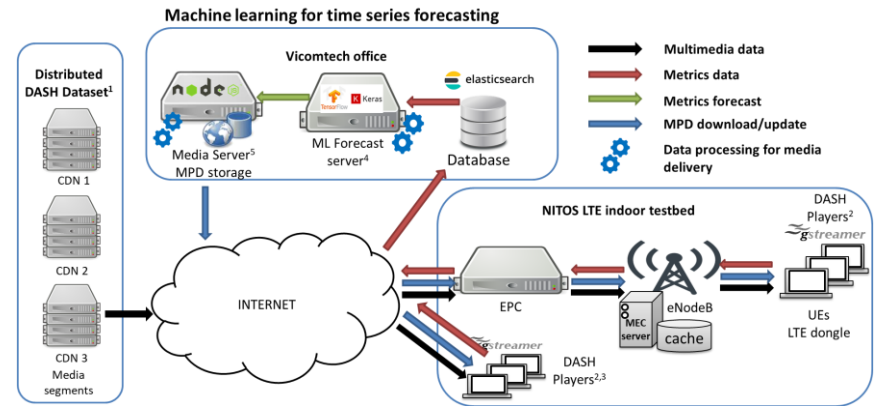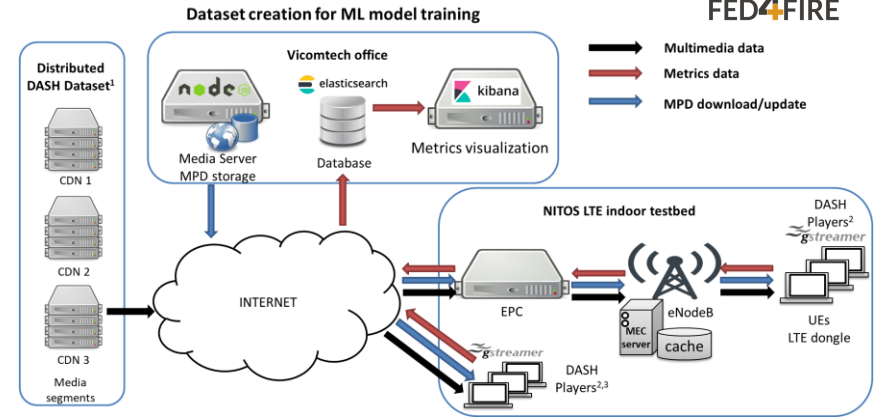
# CDN-X-ALL RESULTS (I)

**E2E eMBMS Sub-system Stack Implementation**



**Open Research Data**

Fed4Fire/CDN-X-ALL M3AP, M2AP reference points implementation pcap datatsets for the 3GPP MBMS profile

Morgade, Javier

Following datasets were generated at VICOMTECH (https://www.vicomtech.org) under project/experiment CDN-X-ALL: "CDN edge-cloud computing for efficient cache and reliable streaming aCROSS Aggregated unicast-multicast LinkS".

Project funded by Fed4FIRE+ OC5 (https://www.fed4fire.eu) under grant 732638.

The following data provide reference pcap captures that include relevant traces with standardized 3GPP interfaces for the 3GPP MBMS (Multimedia Broadcast Multicast Services) profile.



**eMBMS-Vicomtech Fed4fire fec6 cdn x all**

*This merge request includes procedures to enable an E2E mixed Unicast/Multicast(MBMS) OAI setup *Includes additional interfaces and impacts all layers (L1.L2.L3) on both eNB/UE sides *PHY.MAC.RRC.RLC.PDCP and Network interfaces have been implemented accordingly *M2AP 3GPP TS 36.443 interface: 1.MCE (Multicast Control Entity) entity developed (new dedicated task developed: TASK_MCE_APP) 2.eNB side M2 interface procedures (new dedicated task developed: TASK_M2AP_ENB) 3.MCE side M2 interface procedures (new dedicated task developed: TASK_M2AP_MCE) 4.ASN1 bindings for m2ap-14.0.0.asn1 implemented and tested 5.MCE config parameters *M3AP 3GPP TS 36.444 interface: 1.MME entity developed to handle M3 side (new dedicated task developed: TASK_MME_APP) (these procedures should be moved to OPENAIR-CN ... just implemented to easy the E-UTRAN MBMS stuff development) 2.MCE side M3 interface procedures (new dedicated task developed: TASK_M3AP_MCE) 3.MME side M3 interface procedures (new dedicated task developed: TASK_M2AP_MME) (these procedures should be moved to OPENAIR-CN ... just implemented to easy the E-UTRAN MBMS stuff development) 4.ASN1 bindings for m3ap-14.0.0.asn1 implemented and tested 5.MME config parameters
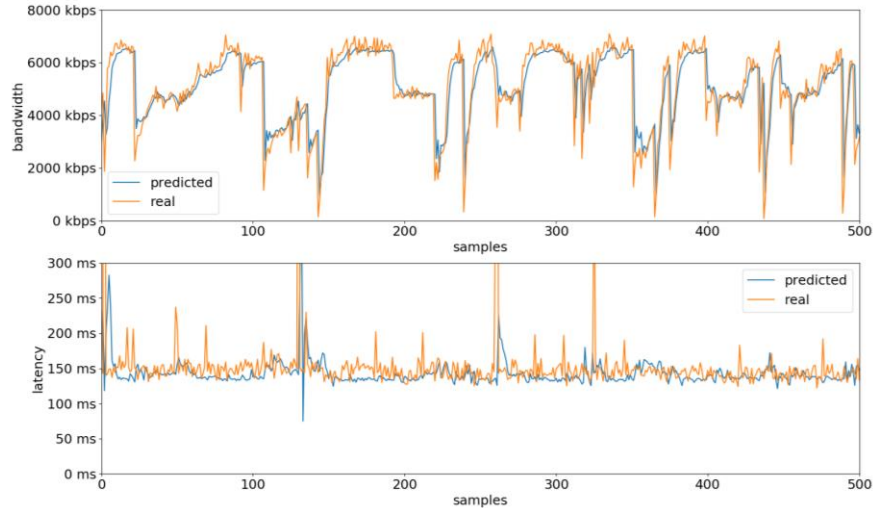
*ACKNOWLEDGEMENT: 1. This commit was developed at Vicomtech (https://www.vicomtech.org) under UE project CDN-X-ALL: "CDN edge-cloud computing for efficient cache and reliable streaming aCROSS Aggregated unicast-multicast LinkS" 2. Project funded by Fed4FIRE+ OC5 (https://www.fed4fire.eu) Signed-off-by: Javier Morgade javier.morgade@ieee.org

- *OAI branch "fed4fire_fec6_cdn-x-all"*
- https://trello.com/b/7kFj0kFp/oai-weekly-meetings
- *eNB/UE side:* PHY, MAC, RRC, RLC, PDCP, IP, M3AP, M2AP

- Vicomtech eMBMS implementation *delivered as Open Source* to OpenAirInterface5G SW Alliance **(+33973 src additions and +170 files)**
- 3GPP M3AP, M2AP *datasets published at Zenodo (*DOI: 10.5281/zenodo.3457936)

# CDN-X-ALL RESULTS (II)

**ML Forecast Engine**

**Open Research Data**



Fed4Fire/CDN-X-ALL network metrics dataset for time series analysis in Media content delivery for 4G/5G networks

Roberto Viola

The following dataset was generated at VICOMTECH (https://www.vicomtech.org) under project/experiment CDN-X-ALL: "CDN edge-cloud computing for efficient cache and reliable streaming aCROSS Aggregated unicast-multicast LinkS".

Project funded by Fed4FIRE+ OC5 (https://www.fed4fire.eu) under grant 732638.

The dataset provides network metrics captures across several days employing a GStreamer-based MPEG-DASH player running on an UE connected to a LTE network.

Nitos LTE/OpenAirInterface (OAI) testbed (https://nitlab.inf.uth.gr/NITlab/nitos/lte) was used to deploy the LTE network.

**CDN-like server/DASH Dataset -> Internet -> EPC/OAI -> eNodeB/OAI -> UE/DASH player**

The player downloads MPEG-DASH video files provided by Distributed DASH dataset (https://dash.itec.aau.at/distributed-dash-datset/), a dataset for CDN-like experiments, and captures the following data:

1. Date: date when the data is collected
2. Player: type of the player (in this case it is always "GStreamer")
3. Num: identifier of the player
4. URLVid: URL of the MPD file
5. Latency: latency experienced by the player
6. BW: bandwidth experienced by the player
7. Quality: chosen DASH video representation

zenodo

- **Time series Forecast ML model** tested and running at NITOS (BW, Latency, …)

- **Datasets containing network metrics collected** from GStreamer MPEG-DASH players (DOI: 10.5281/zenodo.3459164)

# CDN-X-ALL RESULTS (III): Lessons Learned

**5G SDN & SDR** technologies will **catalyse** agile network revolution **boosting service performance and will enable new use cases (O-RAN)**

**Realistic radio behaviour** on bootstrapping is often ignored on simulated experiments which can have a significant impact on the results

**Images** available are rather old; we decided to get the MBMS developments aligned with current OAI SoA

**Stability and performance** of USRP nodes performance could be improved (at least for LTE-UE operation) with dedicated **LTE-Band RF duplexers**

**Commercial Smartphones,** besides current LTE dongles, integrating commercial smartphones would enable extended features including the ability to test E2E MBMS with commercial UEs

**Continuous Integration methodology** to enable an open Fed4Fire+ CI for experimenters (we did it through OAI though)

**L2 Interconnection,** our experiment could be further evolved using FED4Fire Layer 2 inter-networking capabilities

**Experiment runtime (5 months)** has turned out to be a bit tight
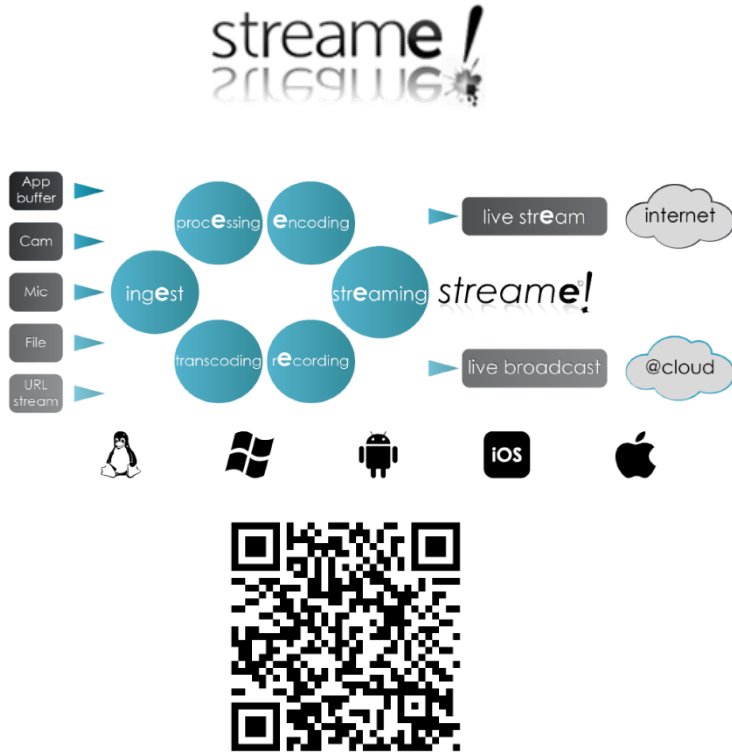
# IMPACT OF CDN-X-ALL

CDN-X-ALL impacts on different stakeholders:
- Video streaming technology providers for media services
- Telecom operators
- Broadcast operators
- CDN operators
- Wireless networks vendors
- Dense event performances
- 5G M&E

# IMPACT OF CDN-X-ALL: *streame!*



**Business Benefits:**

- Simplify streaming media delivery
- Boost prototyping
- Overcome multiple streams
- Synchronisation to provide richer experiences
- Deliver low latency streams

**Features:**

Streaming:
- RTP, RTSP, RTMP, HTTP, HLS, MPEG-DASH, WebRTC

Encoders:
- H.264 MP, HEVC/H265, AAC-LC/HC

Resolutions:
- 4K & UHD & HDR

Platforms:
- iMX HW support

HW Optimization:
- GPU coding

**Use Cases:**

- Second/Multi-screen apps
- Live media sharing
- Accurate timestamp based apps
- Synchronisation of multiple live stream
- Low latency
- Video calls
- Remote surveillance
- Factory supervisory control and data acquisition (SCADA) display
- Virtual desktop infrastructure (VDI)
- Cloud gaming for ultra-thin clients
- Efficient delivery
- Advanced advertising insertion
- Train / Bus entertainment systems

# IMPACT OF CDN-X-ALL: *streame!*



Source: 3GPP
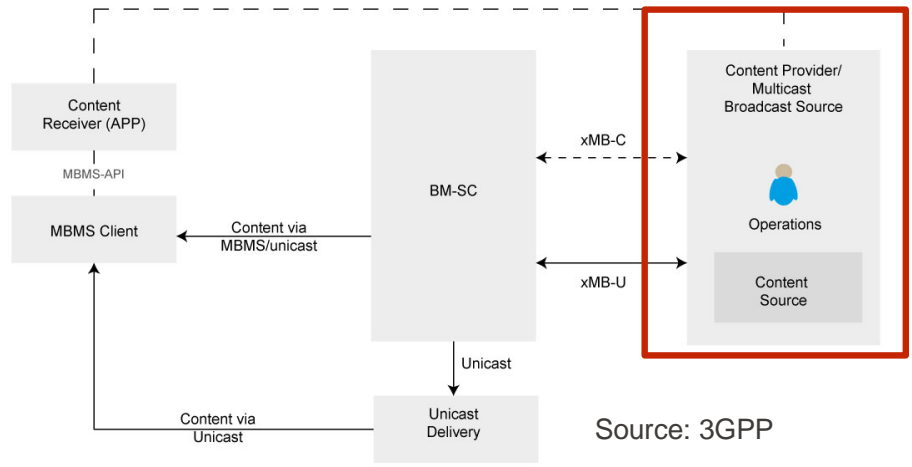
# IMPACT OF CDN-X-ALL : Scientific contribution

Presentation at OSA WS Fall (3-5 December 2019)

J. Morgade
**FeMBMS/eMBMS End-to-End Prototyping using OpenAirInterface5G**
OpenAirInterface Workshop Fall 2019 Beijing, 3-5 December 2019 Beijing China

MBMS contributions to be submitted to a Q1 Journal (by 1st December 2019)

J. Morgade et. al,
**Democratizing 5G Broadcast and Multicast: FeMBMS/eMBMS End-to-End Prototyping using OpenAirInterface5G**
IEEE Transactions on Broadcasting, Special Issue on Convergence of Broadcast and Broadband in the 5G Era

# FEEDBACK: Resources

Used Resources

- Nitos Testbed

- JFED reservation tool

Tools

- OMF experiment

- Image persistence

# FEEDBACK: Added Value

Base testbed features used:

- Book resources

- Detailed inventory

- Persistence of images

- Experiment orchestration and replay

- Results records

# FEEDBACK: Added Value

Specific testbed feature used:

- Real testbed where interferences, distances, modulation, constellation and muxing of LTE protocol comes into play

- Availavility of Linux-based computing resources for fast prototyping of massive headless media players

- Availavility of comercial LTE dongles helps to validate the development of custom 3GPP implementation

**WWW.FED4FIRE.EU**