

# 5G Broadcast

From Communications Theory to Mobile–Broadcast Convergence

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Why now

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76 %

of mobile data  
traffic is video

200 EB

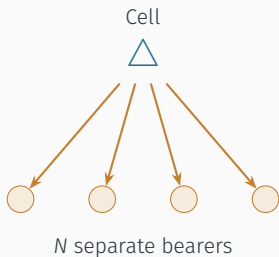
per month  
(Q4 2025)

43 %

of mobile traffic  
already on 5G

*Traffic grows roughly 2.4 times by 2031. Most of it is people watching the same thing.*

## One stream, a million times over



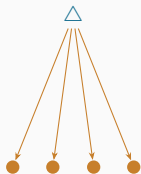
Unicast dedicates a separate bearer to every user. When millions request *identical* content in the same minute, one-to-one delivery makes load scale as  $\propto N$ .

The fix: send it *once*.

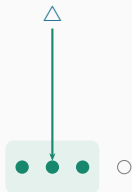
## The theory

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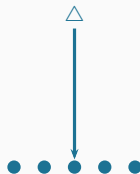
## Three ways to reach a crowd



Unicast (PTP)  
load  $\propto N$



Multicast (SC-PTM)  
one stream / group



Broadcast  
cost *indep.* of  $N$

*A broadcast costs the same whether ten or ten million users tune in, as long as they want the same content.*

## Every link has a ceiling

The Shannon–Hartley limit ties the maximum reliable rate to bandwidth and signal-to-interference-plus-noise ratio:

$$C = B \log_2(1 + \text{SINR})$$

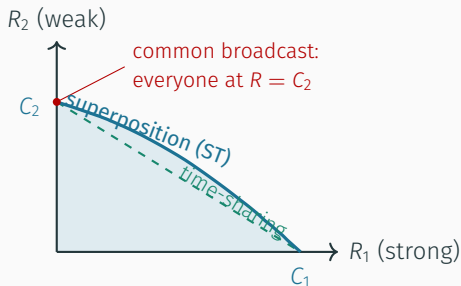
Unicast adapts modulation and coding *per user*. A broadcast stream must pick one configuration, sized for a guaranteed coverage target SINR  $\gamma_{\text{cov}}$  at cell edge:

$$R_{\text{bc}} \lesssim B \log_2(1 + \gamma_{\text{cov}}), \quad \Pr\{\text{SINR} < \gamma_{\text{cov}}\} \leq \epsilon.$$

- The rate is capped by the quality at the *target*  $\gamma_{\text{cov}}$  — the weakest channel you commit to serve, not the average or peak.
- Only a fraction  $\epsilon$  of locations may fall short — e.g.  $\epsilon = 5\%$  means 95% coverage. So lower  $\gamma_{\text{cov}}$  for more reach, raise it for more rate.

*Broadcast runs at one common rate, determined by the channel quality of its weakest receiver — so 5G Broadcast aims at better coverage for the worst spots, not higher peak speed.*

# The information-theoretic picture



Two-user broadcast channel:

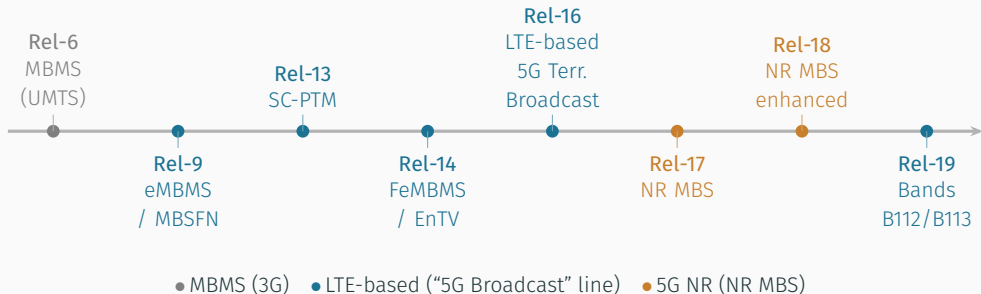
- **Simultaneous transmissions (ST)** reach the full rate region using superposition coding.
- **Time-sharing** (chord) is strictly smaller.
- **Common broadcast content:** one shared stream at the weak user's capacity  $C_2$ , which beats splitting into equal private streams.

*Broadcast trades per-user rate optimality for universal reach.*

## From MBMS to 5G Broadcast

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# Two decades of point-to-multipoint (one heritage, two families)



## "5G Broadcast" on LTE radio

- MBMS → eMBMS → FeMBMS → **LTE-based 5G Terrestrial Broadcast** (Rel-16); bands B112/B113 (Rel-19).

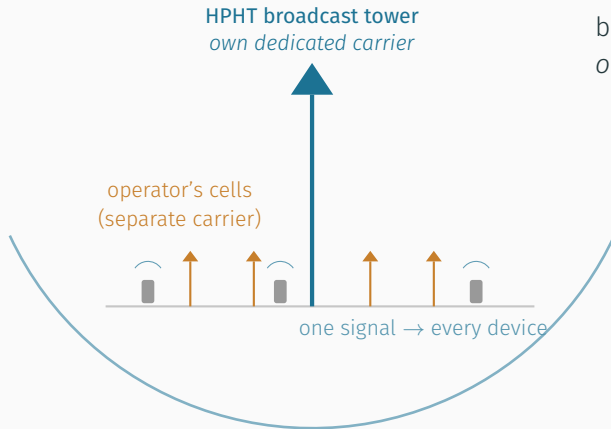
High-tower, receive-only, free-to-air terrestrial broadcast. Runs on the LTE air interface.

## MBS on 5G New Radio

- **NR MBS** (Rel-17) → NR MBS enhanced (Rel-18).

Multicast/broadcast built *inside* operators' 5G networks. Runs on the 5G New Radio.

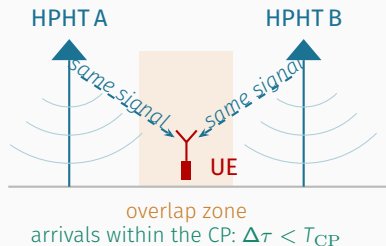
## “5G Broadcast” on LTE radio



A few high-power, high-tower (HPHT) sites blanket a wide area — one broadcast layer over the operator's small cells.

- Dedicated carrier: usually in dedicated broadcast spectrum (e.g. UHF) for broadcast.
- Receive-only: no SIM, no uplink, no subscription.
- Free-to-air: fed via the open xMB interface (vendor-neutral reference point, so any content provider can plug content into the broadcast network).

# Interference becomes signal in SFNs



In single frequency networks (SFNs), all HPHT towers send same time-synced OFDM signal on same frequency.

- In broadcast, the receiver's FFT combines arrivals within the same CP, so the copies add rather than collide.
- Cell-edge users, often weakest in unicast, can benefit most from SFN combining.

*SFN overlap can provide several dB of gain, often around 3–6 dB, in favourable geometries.*

## The cyclic prefix sets the range

In an SFN the CP must absorb the differential delay between sites ( $T_{CP} \gtrsim d/c$ ). A longer CP  $\Rightarrow$  wider SFN.

Mode	SCS	$T_{CP}$	$T_U$	SFN ISD
SC-PTM	15 kHz	4.7 $\mu$ s	66.7 $\mu$ s	1.4 km
MBSFN	15 kHz	16.7 $\mu$ s	66.7 $\mu$ s	5 km
MBSFN	7.5 kHz	33.3 $\mu$ s	133 $\mu$ s	10 km
<b>MBSFN (EnTV)</b>	<b>1.25 kHz</b>	<b>200 <math>\mu</math>s</b>	<b>800 <math>\mu</math>s</b>	<b>60 km</b>

*The 200  $\mu$ s EnTV cyclic prefix stretches SFN reach to ~60 km — exactly what high-tower networks need.*

**5G-Xcast** proposed a 5G-native architecture: broadcast as a RAN mode, not a parallel overlay.

- **CU/DU split** — gNB divides into Central + Distributed Units (Cloud-RAN).
- **RBMA** — a dynamic broadcast/multicast area that follows the users, not a fixed overlay.
- **RAN-SYNC** — RAN-level content synchronisation for SFN, no separate eMBMS entity.
- **Dynamic switching** — unicast  $\leftrightarrow$  broadcast per user group, on demand.

*Design goal is maximum commonality with unicast — broadcast as a configuration, rather than a second overlay network.*

## 5G three spectrum bands:

- Low (<1 GHz) — coverage.
- Mid (3.3–3.8 GHz) — balance.
- mmWave (24–40 GHz) — capacity.

5G Broadcast is downlink-only; it does not need uplink and fits unpaired broadcast spectrum.

## UHF 470–694 MHz:

- WRC-23: broadcasting kept as the only region-wide primary service in ITU Region 1.
- Secondary mobile allocation added by country footnote in parts of Region 1; WRC-31 will review the band again.
- Rel-17/18 added 6/7/8 MHz & downlink-only operation.
- Rel-19 standardises bands B112/B113 for commercial receivers.

## Convergence & outlook

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## Broadcasters gain

- Reach mobile devices directly
- Linear TV, radio & data
- Resilient emergency alerting

## Operators gain

- Offload popular live content
- Relief at peak demand
- Better experience in dense venues

*The technical core of convergence: dynamic switching between unicast and broadcast on one shared RAN.*

## Live events

Guaranteed quality independent of crowd size —  
*trialled at Paris 2024, Milano Cortina 2026.*

## Public safety

Resilient alerts to every device in an area — *EU  
cell-broadcast integration under study.*

## Automotive

FOTA updates & live map/traffic to whole fleets  
— *demonstrated by 5G-MAG & OEMs.*

## Linear TV & radio

UHD/HD to phones, no data-plan cost — *Rai's  
pre-commercial 24/7 service.*

- **Italy as the front-runner:** Rai / Rai Way run a pre-commercial service across five cities (Rome, Turin, Milan, Naples, Palermo), ~16 M people.
- **Olympic showcases:** Paris 2024 demonstrations; live trials during Milano Cortina 2026.
- **Germany:** Vantage Towers targeting commercial launch in 2026; Media Broadcast in 2027.
- **United States:** Rollout planned across 10 TV stations, >40 M people; commercial receivers expected in 2026.

## What lies ahead

- **Receivers:** First 5G Broadcast handsets & CPEs expected from 2026 onward, enabled by Rel-19 + Qualcomm chipsets.
- **Wider rollout:** Italy, Germany, the US moving trials → commercial in 2026–2027.
- **Production over 5G:** BBC, France Télévisions & Rai are pushing operators to expose open CAMARA QoD APIs — to make live contribution over public networks reliable (distinct from the broadcast downlink).
- **Towards 6G:** 3GPP Rel-20 studies are starting; broadcast is expected to be native to the 6G air interface.

Theory. Broadcast cost is independent of audience size.

Technology. Receive-only mode enables free-to-air, SIM-free access; the long cyclic prefix enables wide-area SFN coverage.

Convergence. One shared platform — the hurdles left are commercial, not physical.

Thank you — questions?