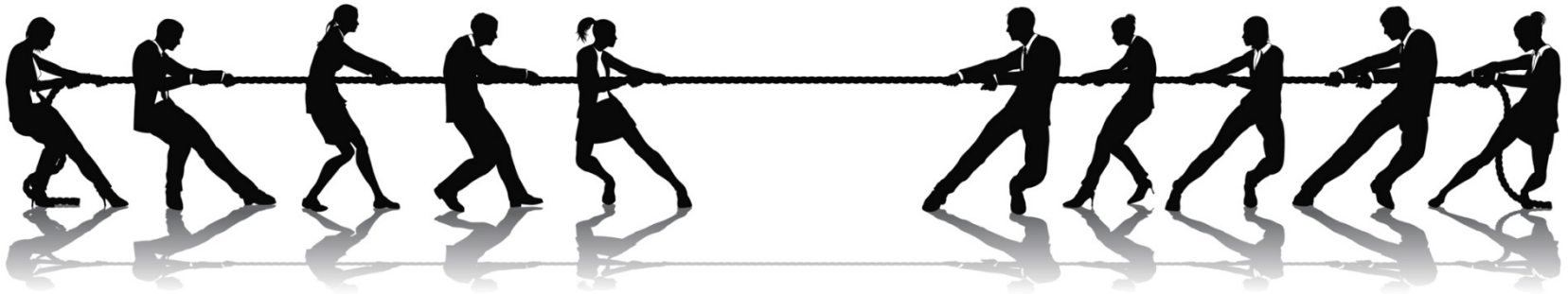
TERRESTRIAL BROADCAST VS. LTE-EMBMS: COMPETITION AND COOPERATION

Meeting of the IEEE BTS Chapter Montréal

2015-11-19



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The Competence in Digital Radio Systems

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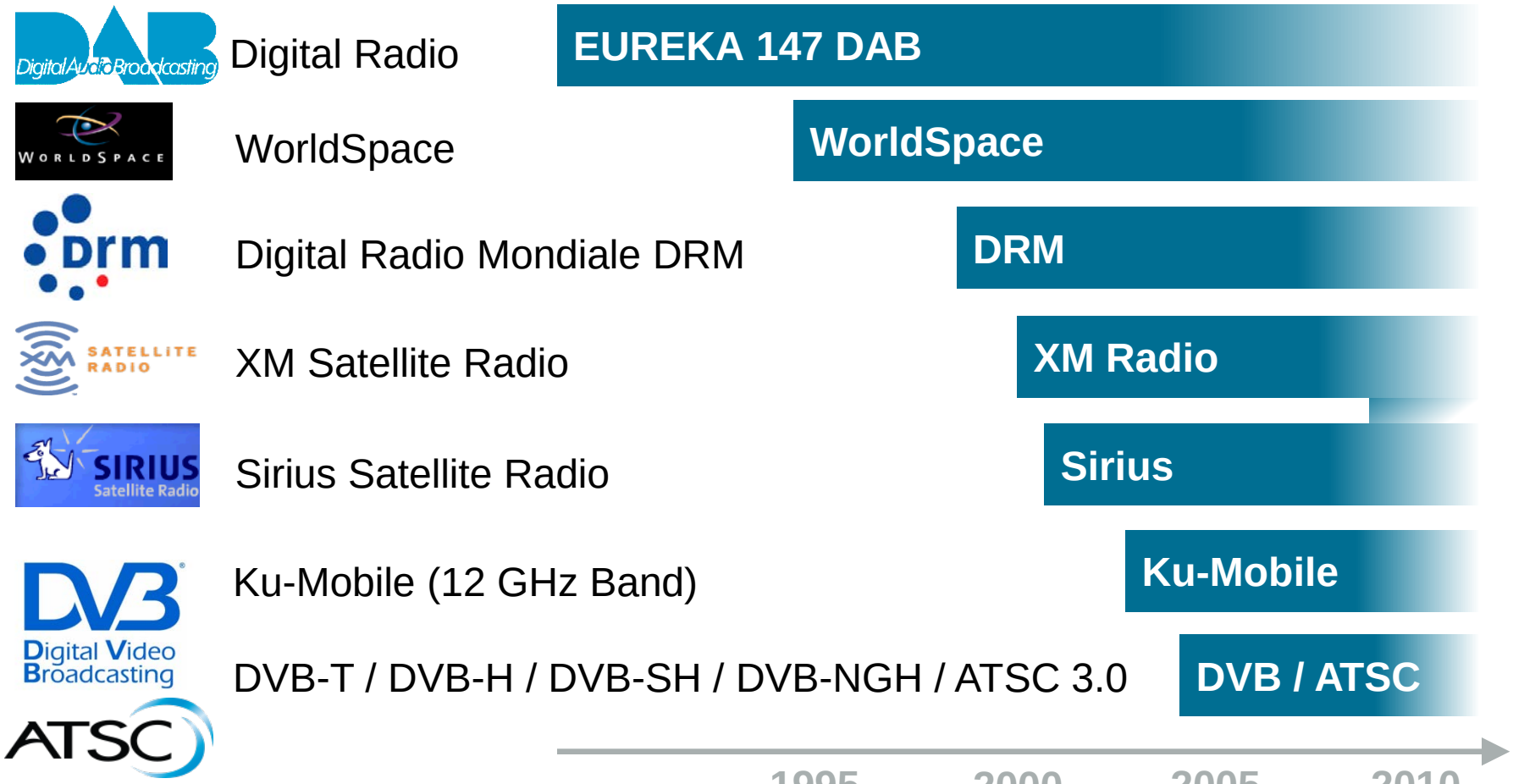

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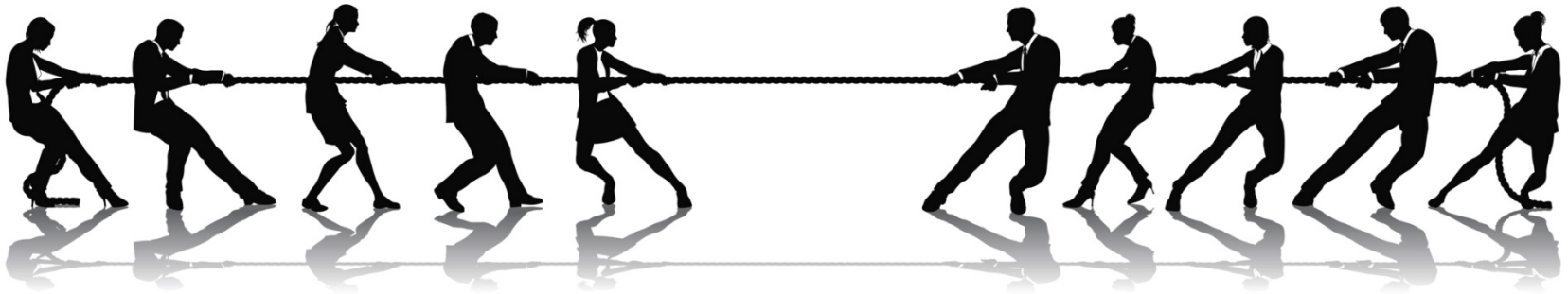
TERRESTRIAL BROADCAST VS. LTE-EMBMS: COMPETITION AND COOPERATION



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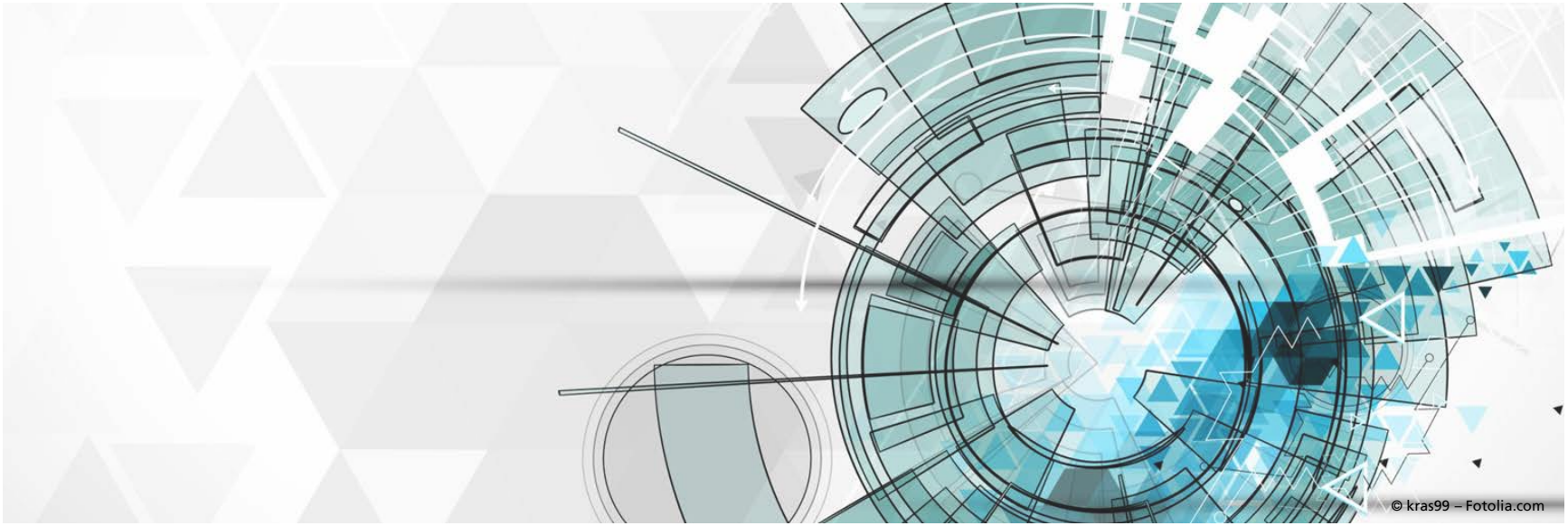
Terrestrial BC vs. eMBMS: Competition and Cooperation
Agenda

- Status Quo of terrestrial broadcast vs. cellular networks
- Future competition and cooperation scenarios
- Potential cooperation concepts (architectures and techniques)
- Conclusion and outlook



Terrestrial BC vs. eMBMS: Competition and Cooperation
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- Status Quo of terrestrial broadcast vs. cellular networks
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Status Quo
Focus of this Talk

- Focus here: Digital Terrestrial TV (DTT) broadcast
- NOT focus: **audio** broadcast (traditional radio)
  - Use case: very many, very cheap devices (either analog or digital)
  - Requirements: low data rates + relatively small spectrum
  - There is no real *competition* between audio broadcast and cellular communication
  - So there is little need to *cooperate*

➔ Very different from cellular communication

➔ Low pressure to release the spectrum

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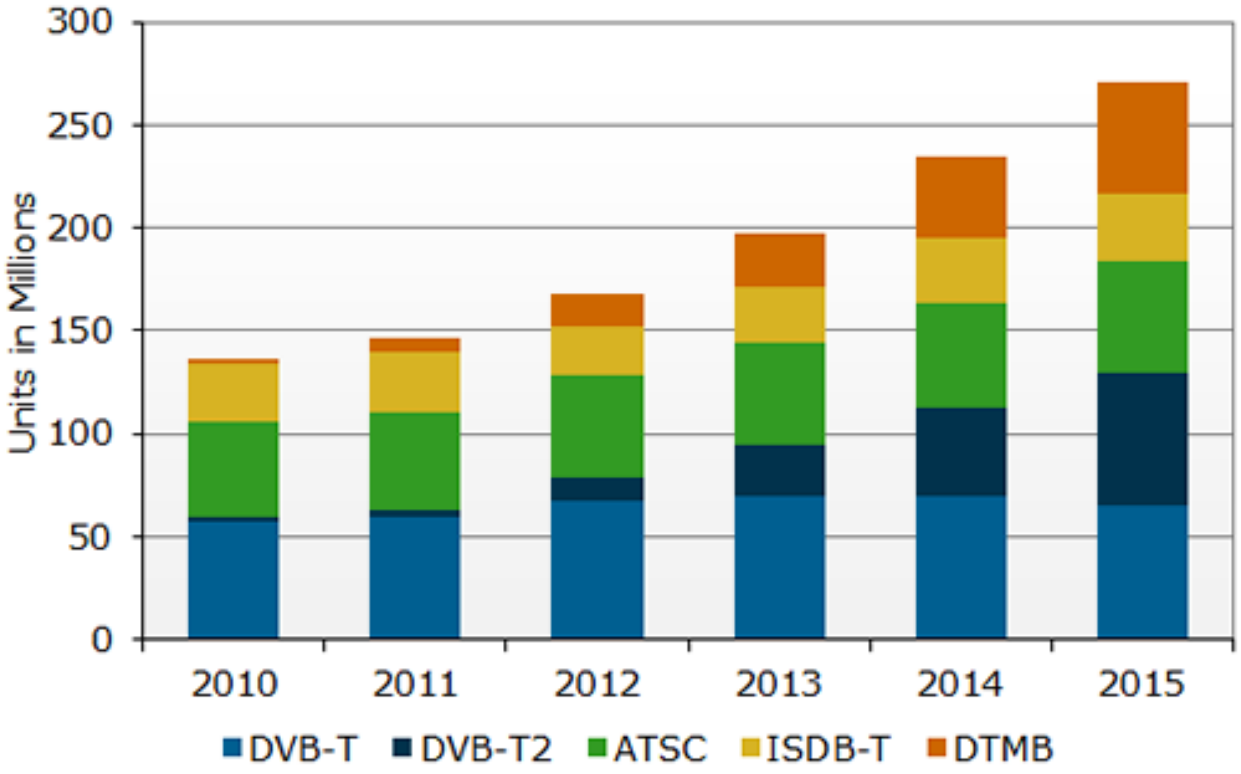
Status Quo
The Apparent Success Story of Digital Terrestrial TV

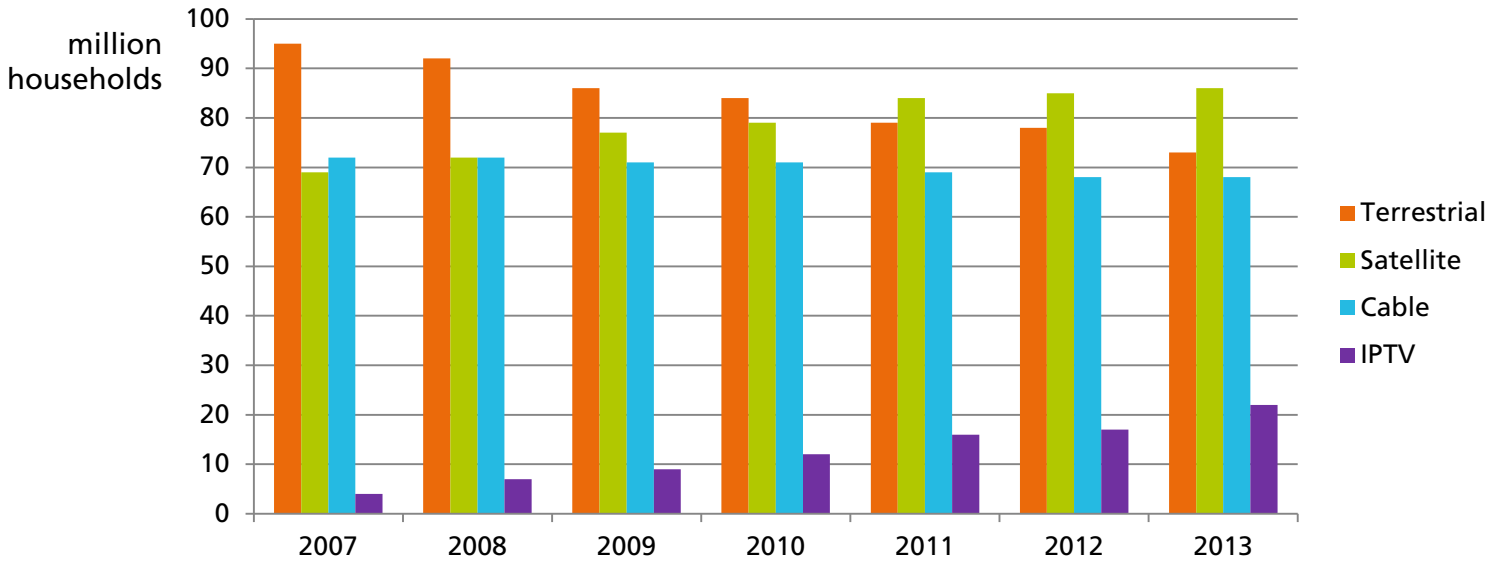
- Units shipped world-wide in each year (forecast from 2011):



Source: NPD DisplaySearch Quarterly TV Design and Features Report

Status Quo

Other Side of the Medal: Terrestrial TV is on the Retreat

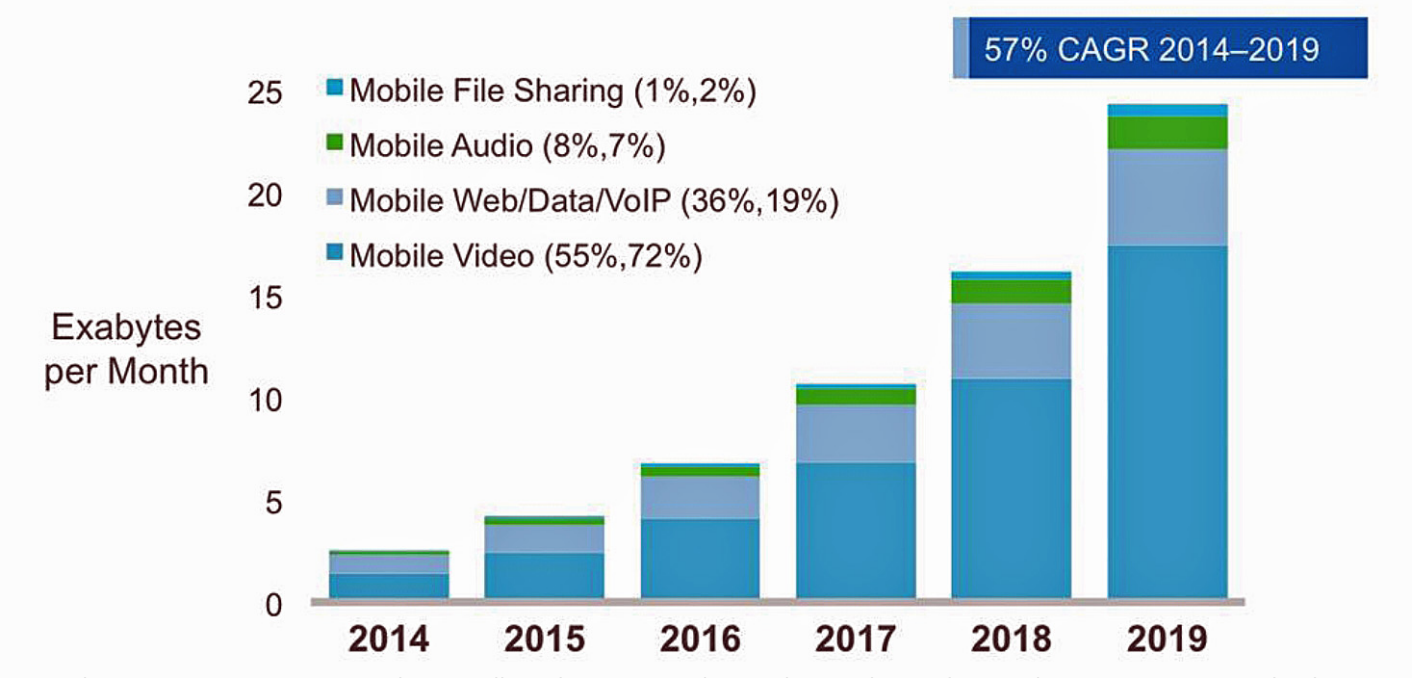


- TV reception (**analog** and **digital**) in Europe (23 countries)
- Reason:
  - Satellite and cable offer more channels and higher quality
  - IPTV is gaining ground

Sources: SES Satellite Monitors – www.ses.com/18028656 and www.ses.com/11613037

Status Quo
And Here Comes the Challenger…

- 1.2 billion smartphones shipped in 2014
- Mobile video traffic already exceeds 50% of the total traffic



Source: http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html

Status Quo
Broadcast Entering Mobile Devices

Earlier attempts to cooperate between the two worlds

- DVB-H, DVB-NGH, ATSC-M/H, MediaFLO
- ISDB-T 1seg, T-DMB

- Result: mostly no commercial success! Why?
  - Before the touchscreen era
  - Power consumption problem
  - Significant extra device cost
  - Operators sponsoring devices have no interest
  - **Not sufficient user demand to justify extra cost**

Source: https://commons.wikimedia.org/wiki/File:DMB_Korea.JPG

Status Quo
(Mobile) Communication Entering Broadcast Devices

- Smart TVs connect to the internet
  - for interactive services (HbbTV, ATSC 2.0)
  - for video streaming (VoD)
  - for video telephony (Skype)
  - for computer-like use (web surfing etc.)
  - for some clever things that you will see later

- Currently via Ethernet or Wi-Fi
- Soon with integrated LTE modems?
- E.g. in rural areas, where broadband connection is LTE anyway

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Status Quo
Broadcast as Part of LTE

LTE is making inroads into the broadcast segment:

- eMBMS (evolved Multicast Broadcast Multimedia Services) has been part of 3GPP standards for several years
- There is currently a lot of attention from cellular operators
- A number of pilot projects, test networks and even commercial services are in operation

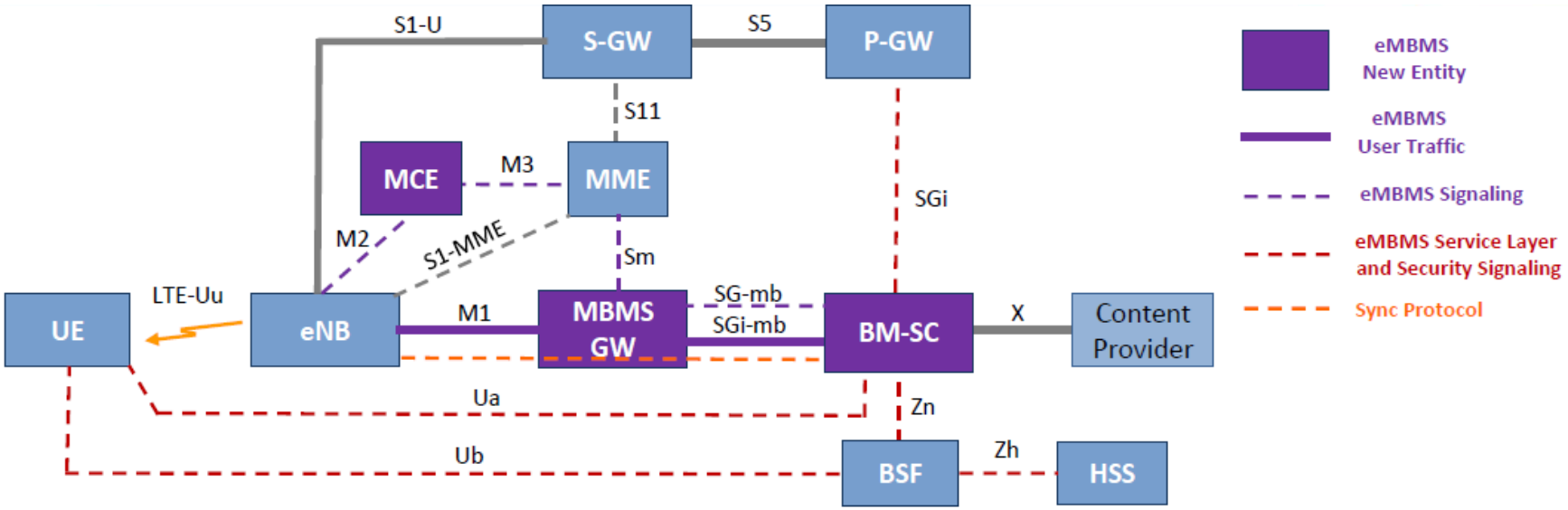
Source: GSA: LTE Broadcast (eMBMS) Update - March 2015

Status Quo
eMBMS Trials in Stadiums

Source: Ericsson, DVB World 2014

Status Quo
eMBMS System Design

- Integral part of LTE → uses same cellular network



Source: Qualcomm , LTE eMBMS Technology Overview, 2012

Status Quo
Strengths of LTE-eMBMS

- Shares same technology as LTE-Unicast
  - e.g. same capacity-achieving FEC code (turbo code)
- Supports Single Frequency Network (SFN) operation
- Extended cyclic prefix (guard interval) compared to LTE-Unicast: up to 33 µs (in theory)
- Can share the same carrier bandwidth quite flexibly with unicast services (but only up to 60% for eMBMS in current LTE releases)

DVB-T2:

very long LDPCCs

several 10 or 100 µs

However:

- Not optimum for covering larger areas (guard interval still too short)
- MIMO (Multiple-Input-Multiple-Output) disabled

Status Quo
Isn't eMBMS Just Another DTT System?

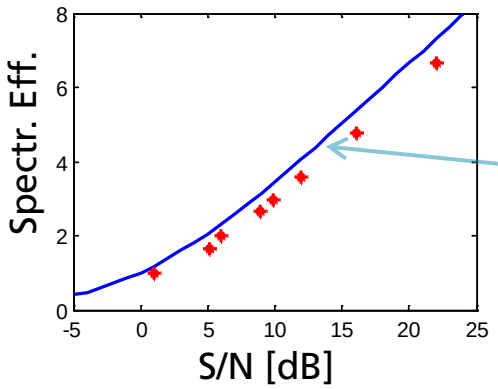
	Classical DTT	eMBMS
Operator	Broadcaster or broadcast network operator	Mobile network operator
Infrastructure	High-power high-tower transmitters (very large cells)	Base stations (macro to small cells)
Target devices	Large-screen stationary TVs, portable TVs	Handhelds (smartphones, tablets)
Service quality	Medium (SDTV/HDTV)	Medium (SDTV/HDTV)
Manufacturers (among others)	Samsung, Sony, LGE, Panasonic	Ericsson, Huawei, Qualcomm, Samsung

Status Quo

The Classical DTT Legacy: Very High Spectral Efficiencies

- Highly optimized Physical Layer design:
  - High constellation orders (up to 4096)
  - Long FEC code words and long time interleavers
  - Efficient signaling + pilot structures
  - Spectrally efficient Single Frequency Network (SFN) operation

DVB T2 ATSC 3.0



NUC gains	SNR Gain	Eff. Gain
64-QAM, R=7/15	0.5 dB	5%
64-QAM, R=10/15	0.5 dB	4%
256-QAM, R=9/15	0.9 dB	6%
256-QAM, R=11/15	0.7 dB	4%

Source: Uni Basque Country, UPV

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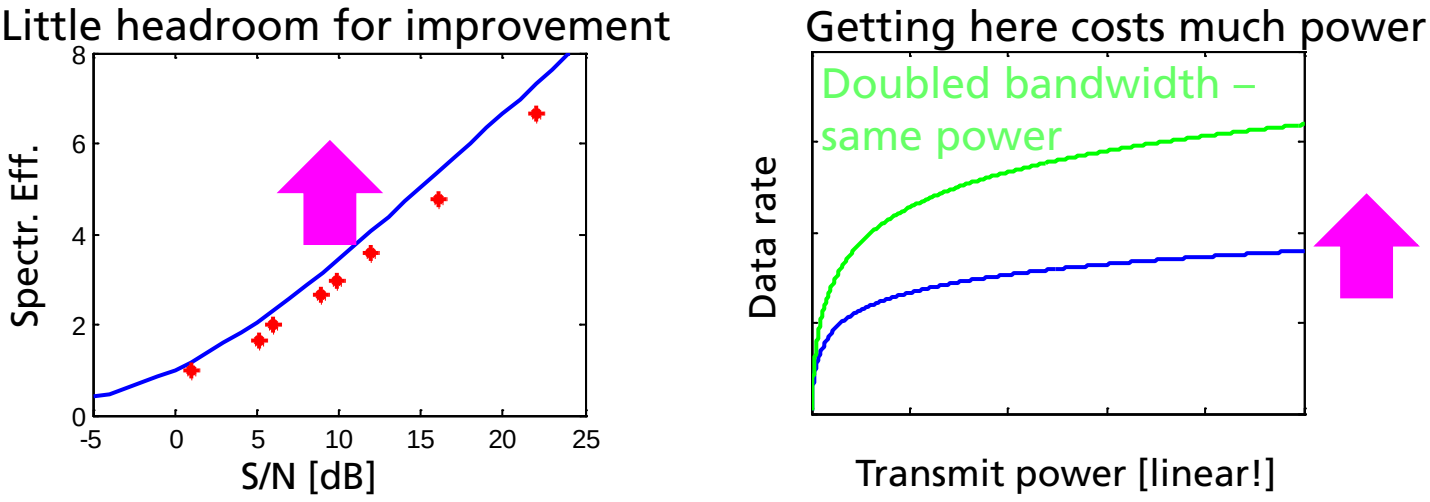
Status Quo
The Limits of Increasing Spectral Efficiencies



- Downside: More or less reached the Shannon limit for SISO transmission
- Moreover: The powerful MIMO concept can be exploited to a very limited extent:
  - High implementation cost both on Tx- and Rx-side
  - Limited gain (lacking a feedback channel) → only open-loop MIMO

Status Quo

Classical DTT and Cellular Video: Overlap in Usage Scenarios

Status Quo

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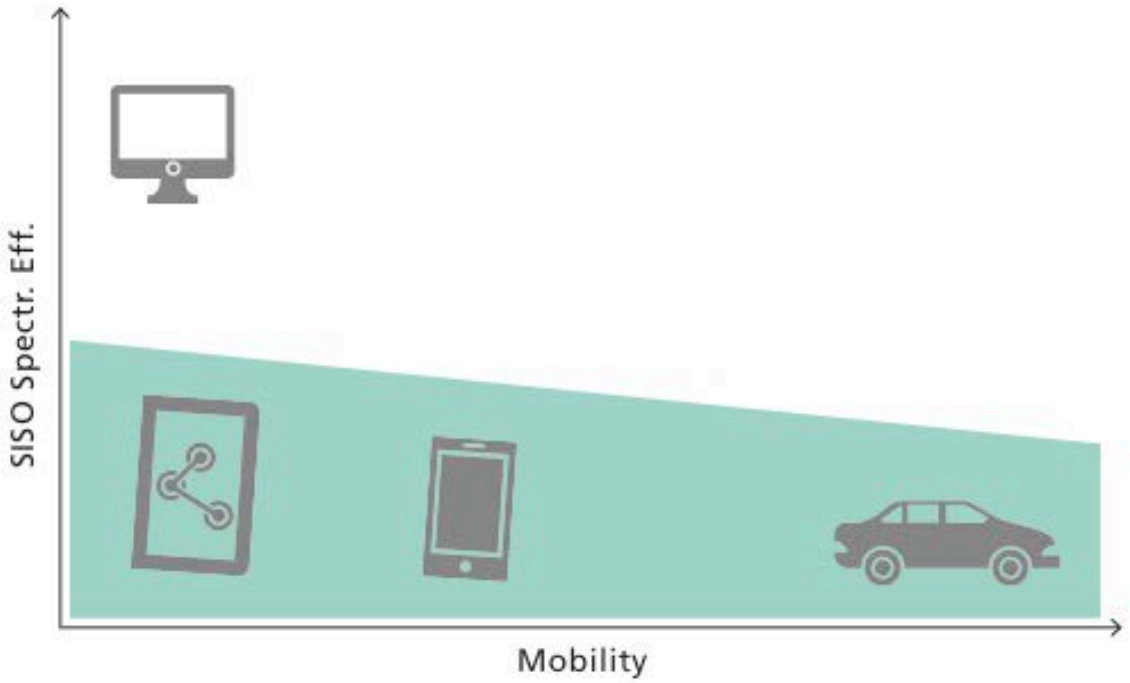

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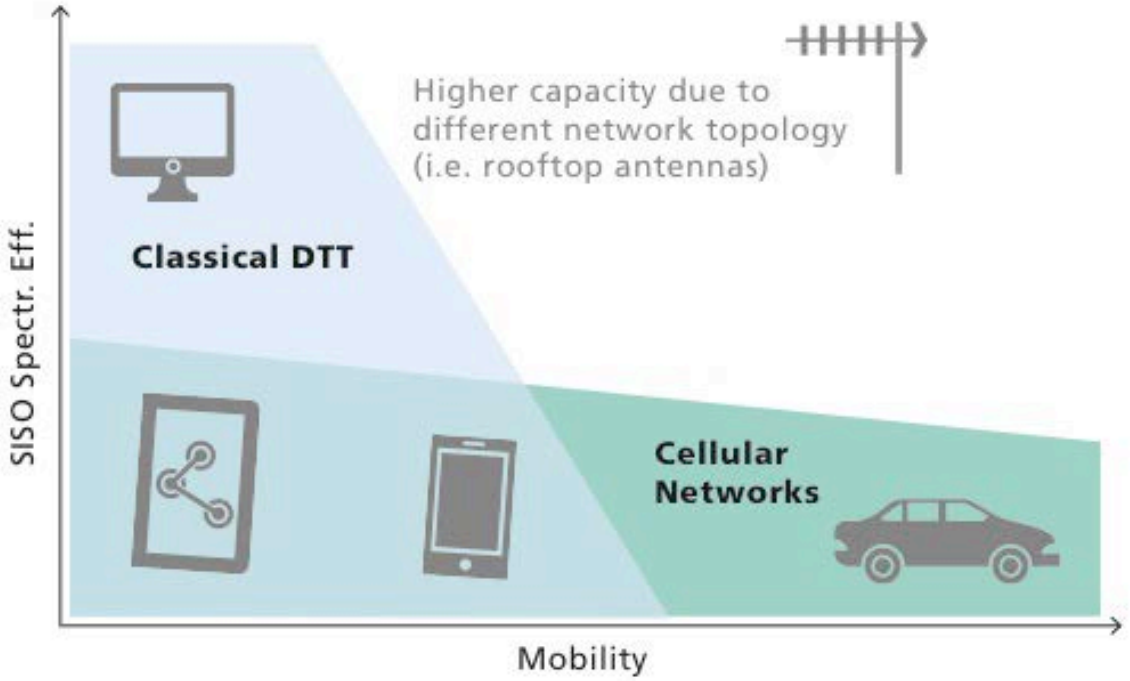

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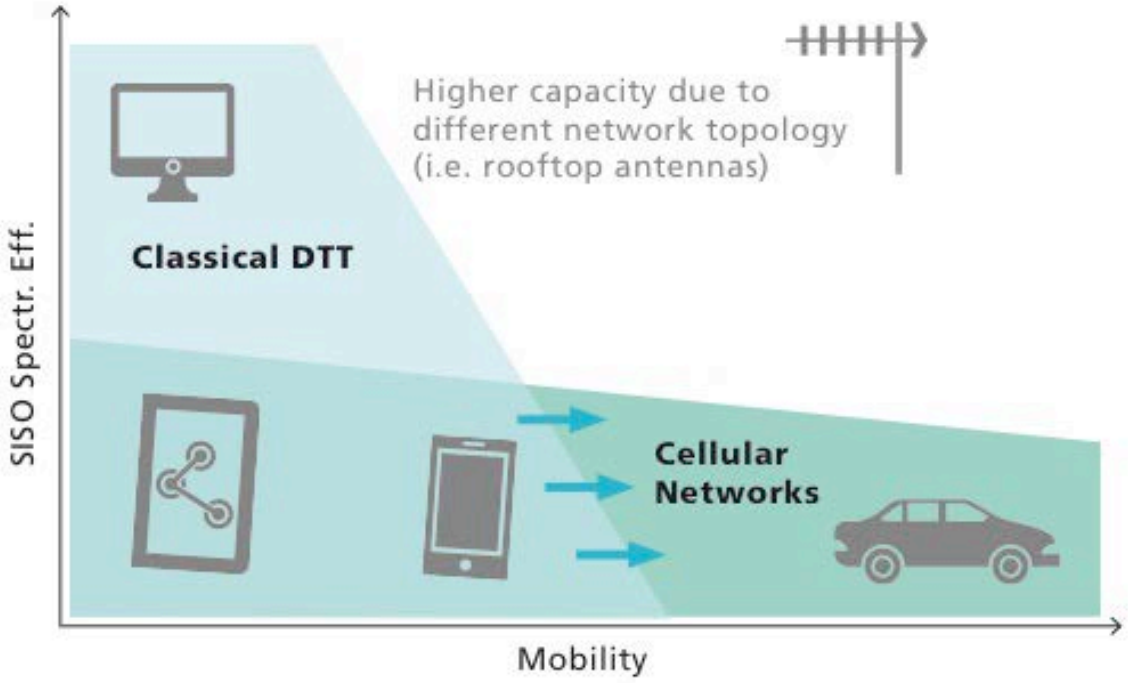
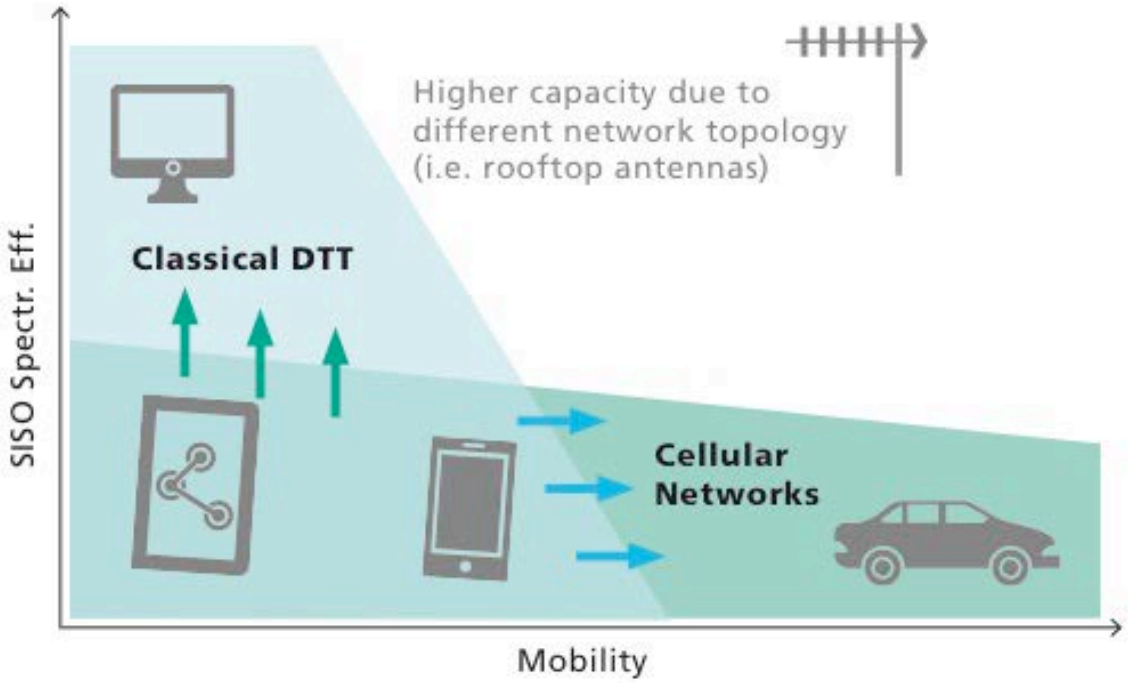


- Competition by support of mobile services in classical DTT standards

Status Quo

Classical DTT and Cellular Video: Overlap in Usage Scenarios



- Competition by support of mobile services in classical DTT standards
- (Increasing) competition by support of broadcast services in LTE

Status Quo
Data Rates and Bandwidths

- Video goes HDTV, 3D and even UHDTV - requiring higher data rates
- Spectral efficiency of DTT (e.g. DVB-T2, ATSC 3.0) plus source coding efficiency grows slower than required data rate and is already very close to the Shannon limit

SNR=17 dB	Video bitrate [Mbit/s]	Spectr. Eff. [bit/s/Hz]	Req. BW [MHz]
DVB-T with SDTV + MPEG-2	3.5	4	0.9
DVB-T2 with HDTV + H.264	9	5	1.8
ATSC 3.0 with UHDTV + H.265	15	5.3	2.8

- Additional bandwidth for DTT is not available either
- Quite the contrary: Mobile Network Operators exert pressure on regulators to reallocate further TV bands for “digital dividends”

Is Cellular Communications killing the classical Digital Terrestrial TV?

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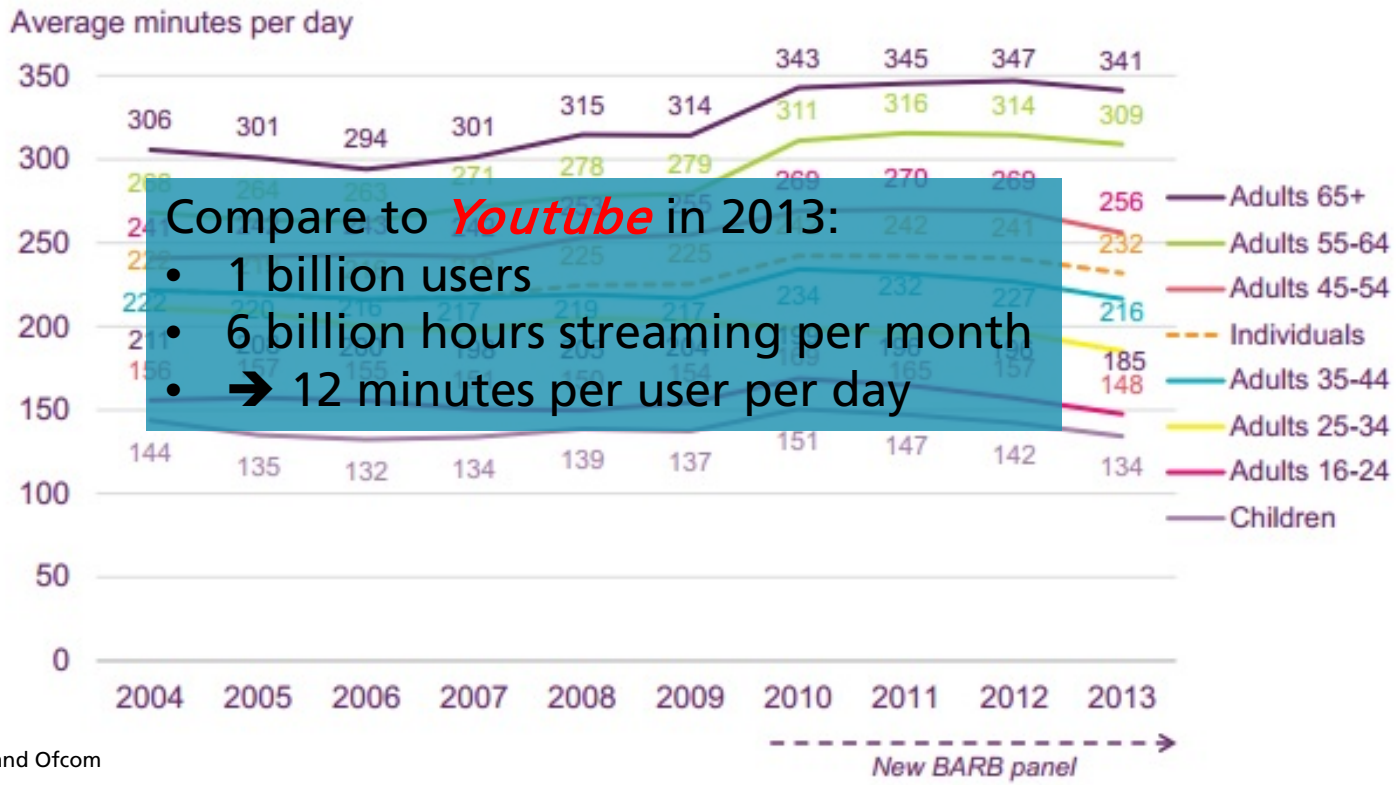
Status Quo - Excursus

Why Does Cellular Communication Dominate over DTT?

Too little TV usage is not the reason!!!

Figure 8: average minutes of daily TV viewing, all channels, by age, 2004-2013



Compare to *Youtube* in 2013:

- 1 billion users
- 6 billion hours streaming per month
- ➔ 12 minutes per user per day

Source: BARB and Ofcom

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Status Quo - Excursus
Explanation Attempts for Weak DTT Business Model

- DTT has alternatives: Satellite, Cable, IPTV
  - They have much higher capacities (better quality, more channels), and there is a move from DTT towards these
  - Cellular communications has no such alternatives
  - Moreover, LTE offers eMBMS as an alternative to classical DTT
- Consumer paying for the service, not for the carrier
- TV consumption is stagnating – cellular communications still is growing
- Other reason: TV infrastructure is much less costly than cellular infrastructure
- ➔ Cellular network operators need to charge significant subscription fees (>> fee for TV network operation) to re-finance

Is Cellular Communications killing the classical Digital Terrestrial TV?

Maybe – but maybe they can become friends instead…

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Future Scenarios
Which Way to Go for Classical DTT?

Scenario 1: Classical DTT ↑↑ CellCom	**Scenario 2:** Classical DTT → CellCom	**Scenario 3:** Classical DTT ← CellCom
Running in Parallel	Integrated	Eliminated

Use case-wise:

Scenario	Fixed TV	M/H TV
1A	Classical DTT	Classical DTT
1B	Classical DTT	eMBMS
2	Classical DTT → 3GPP Broadcast Profile	Classical DTT → 3GPP Broadcast Profile
3	None or eMBMS	eMBMS

Future Scenarios
Which Scenario Will Prevail?

All 3 scenarios at the same time –
It depends on the country!

- Winning scenario in a country depends on
  - DTT percentage
  - Dominant receive antenna: rooftop or indoor
  - Which DTT system is deployed (analog, 1st generation DTT = DVB-T, ATSC 1.0, ISDB-T, or 2nd generation = DVB-T2, ATSC 3.0)

Future Scenarios
Why do the Network Topologies Differ So Much?

- The Nürnberg DVB-T site broadcasts ≈ 70 Mbit/s within the ≈ 300 MHz TV spectrum
- In the same coverage area (≈ 6000 km²) within a similar bandwidth, the cellular networks transmit > 1300 Mbit/s unicast data on average over 24/7 (much more on peak times)
- Unicast needs much higher area spectral efficiency (bit/s/Hz/km²) than broadcast
- Can only be achieved by small cells
- In 5G, area spectr. eff. shall be increased by factor 1000 (up to 10 Mbit/s/m²)
- ➔ Ultra-dense networks
- Why do broadcast networks use large cells? ➔ **Cost!**

http://dvb-t.the-media-channel.com

Future Scenarios
Difference Between Rooftop and Handheld Reception

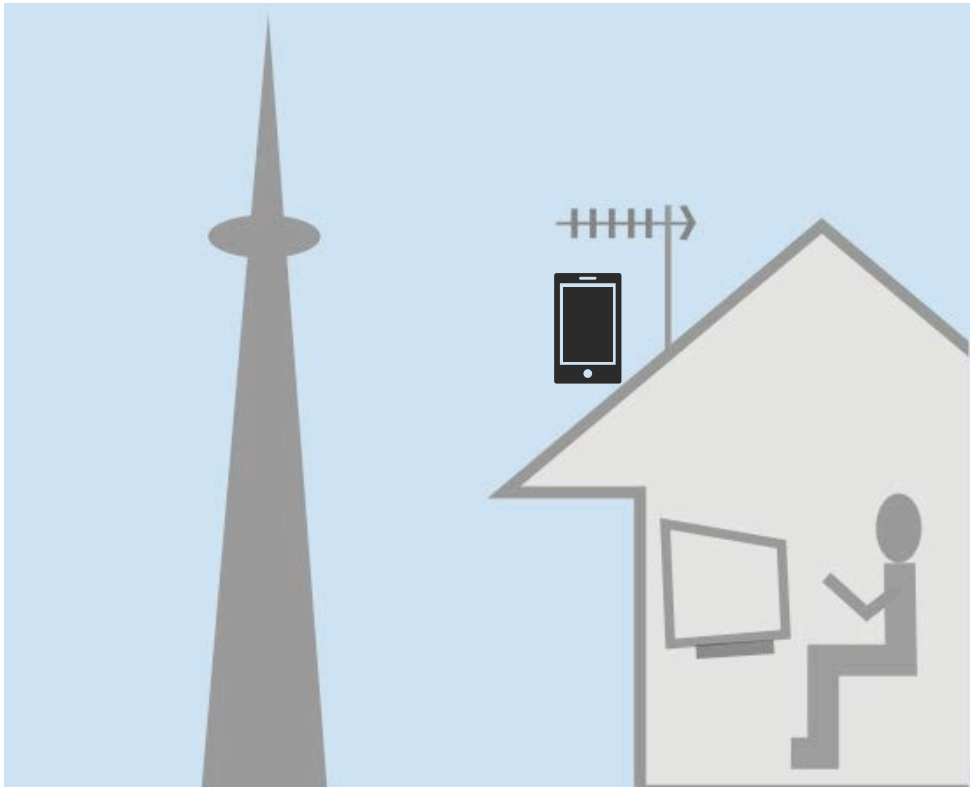
SNR_{HH} – SNR_{RT}:

N.Fig. + Impl. Loss +2 dB

Future Scenarios
Difference Between Rooftop and Handheld Reception

SNR_{HH} – SNR_{RT}:

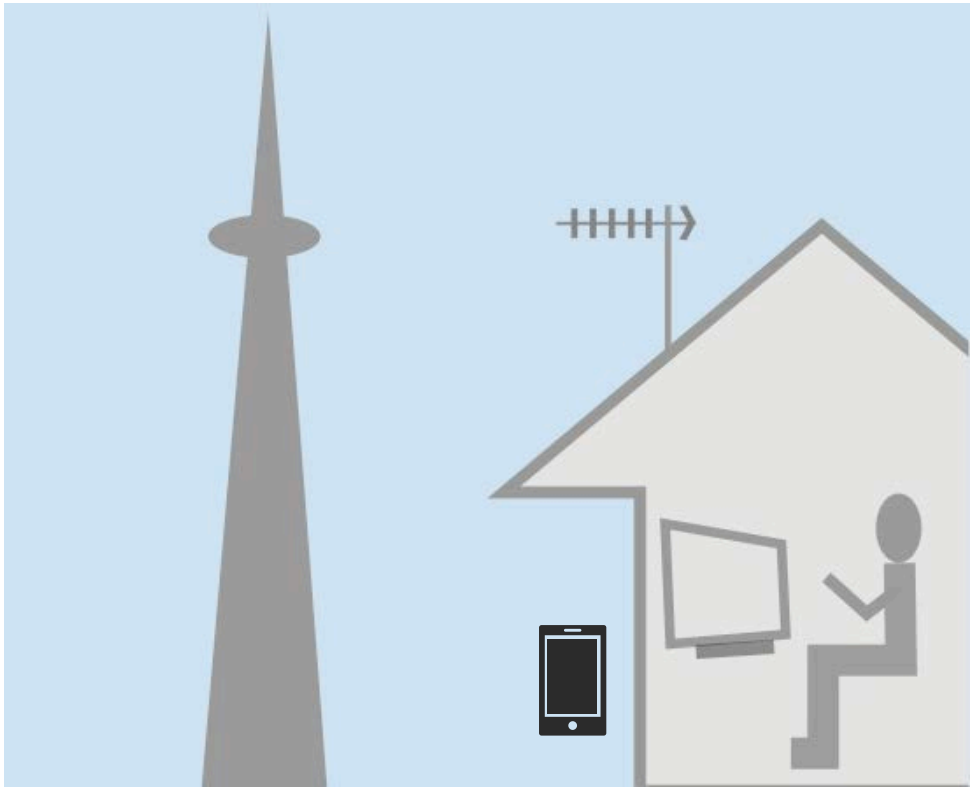
N.Fig. + Impl. Loss	+2 dB
Rx Antenna	-16 dB



Future Scenarios
Difference Between Rooftop and Handheld Reception

$SNR_{HH} - SNR_{RT}$:

N.Fig. + Impl. Loss	+2 dB
Rx Antenna	-16 dB
Height Loss	-20 dB



Future Scenarios
Difference Between Rooftop and Handheld Reception

SNR_{HH} – SNR_{RT}:

N.Fig. + Impl. Loss	+2 dB
Rx Antenna	-16 dB
Height Loss	-20 dB
Penetration Loss	-11 dB

Future Scenarios
Difference Between Rooftop and Handheld Reception

SNR_{HH} – SNR_{RT}:

N.Fig. + Impl. Loss	+2 dB
Rx Antenna	-16 dB
Height Loss	-20 dB
Penetration Loss	-11 dB
Add. Body Shadow	-4 dB

Future Scenarios
Difference Between Rooftop and Handheld Reception

- ➔ Simulcast of a dedicated rooftop signal plus a dedicated handheld signal nearly as spectrally efficient as only one very robust signal

$SNR_{HH} - SNR_{RT}$:	
N.Fig. + Impl. Loss	+2 dB
Rx Antenna	-16 dB
Height Loss	-20 dB
Penetration Loss	-11 dB
Add. Body Shadow	-4 dB
Total	**-49 dB**

Status Quo
Implications of SNR Difference

- Example:

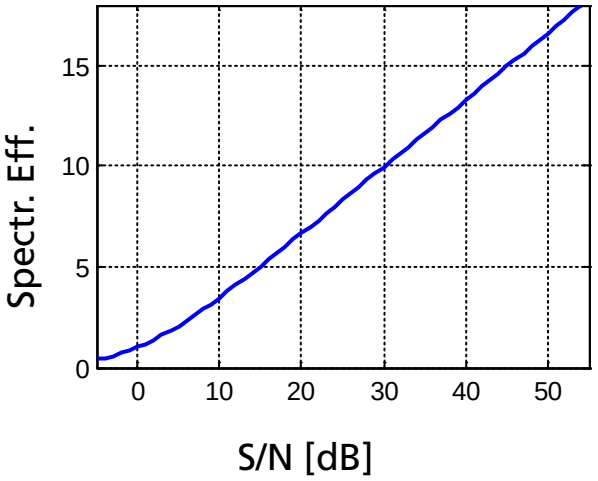
  SNR_{HH} = 0 dB

  ➔ SNR_{RT} = 49 dB

Shannon capacity:

➔ 1 bit/s/Hz

➔ 16.3 bit/s/Hz



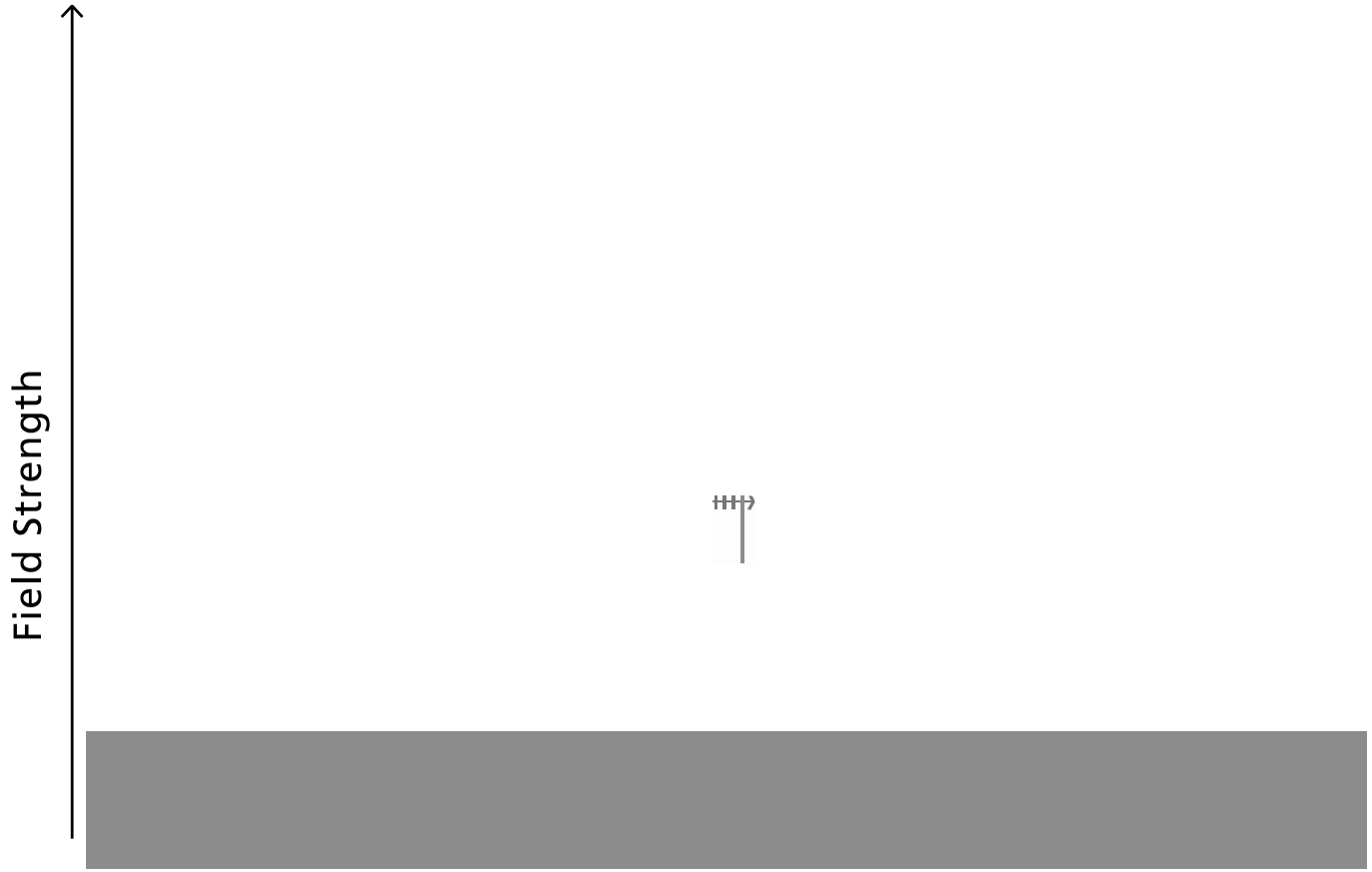
➔ One single very robust transmission @ 1 bit/s/Hz

➔ Simulcast of 2x same video quality @ 0.94 bit/s/Hz (total)

- Simulcast gives moreover the freedom to transmit (a) at higher quality to rooftop antennas and (b) using two different network infrastructures

Future Scenarios

Scenario 1A (Classical DTT for Fixed + M/H)



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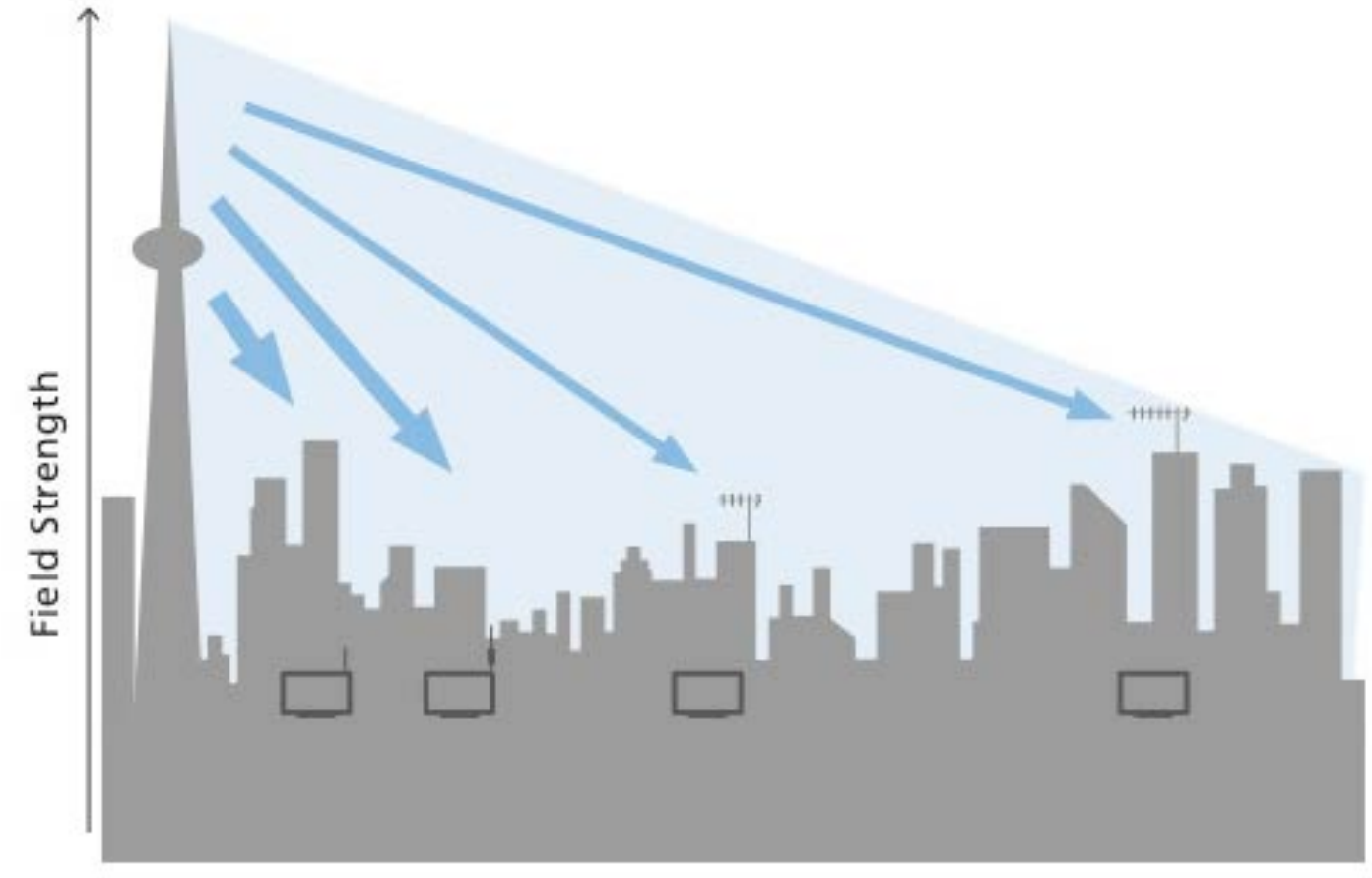

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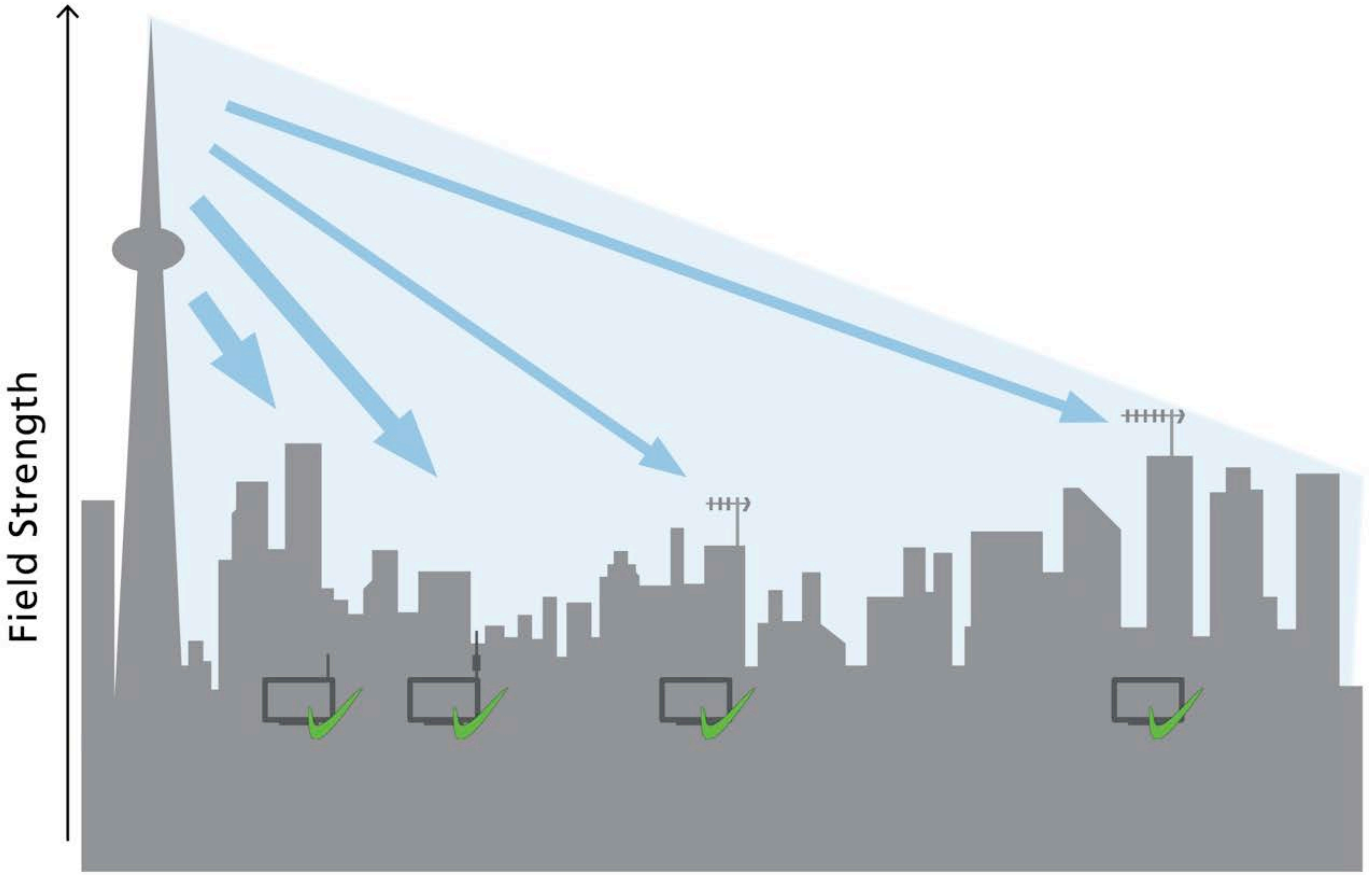

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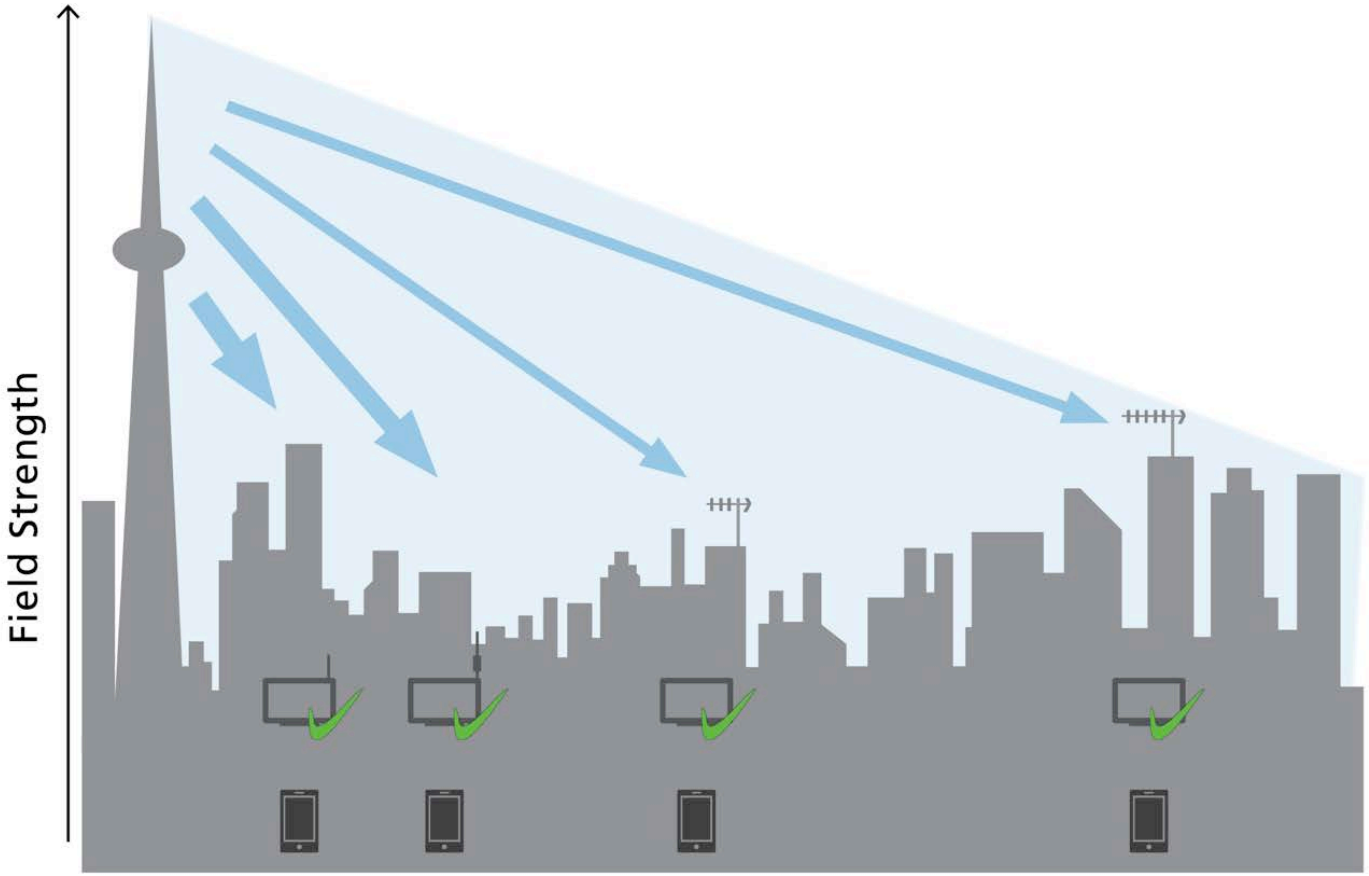

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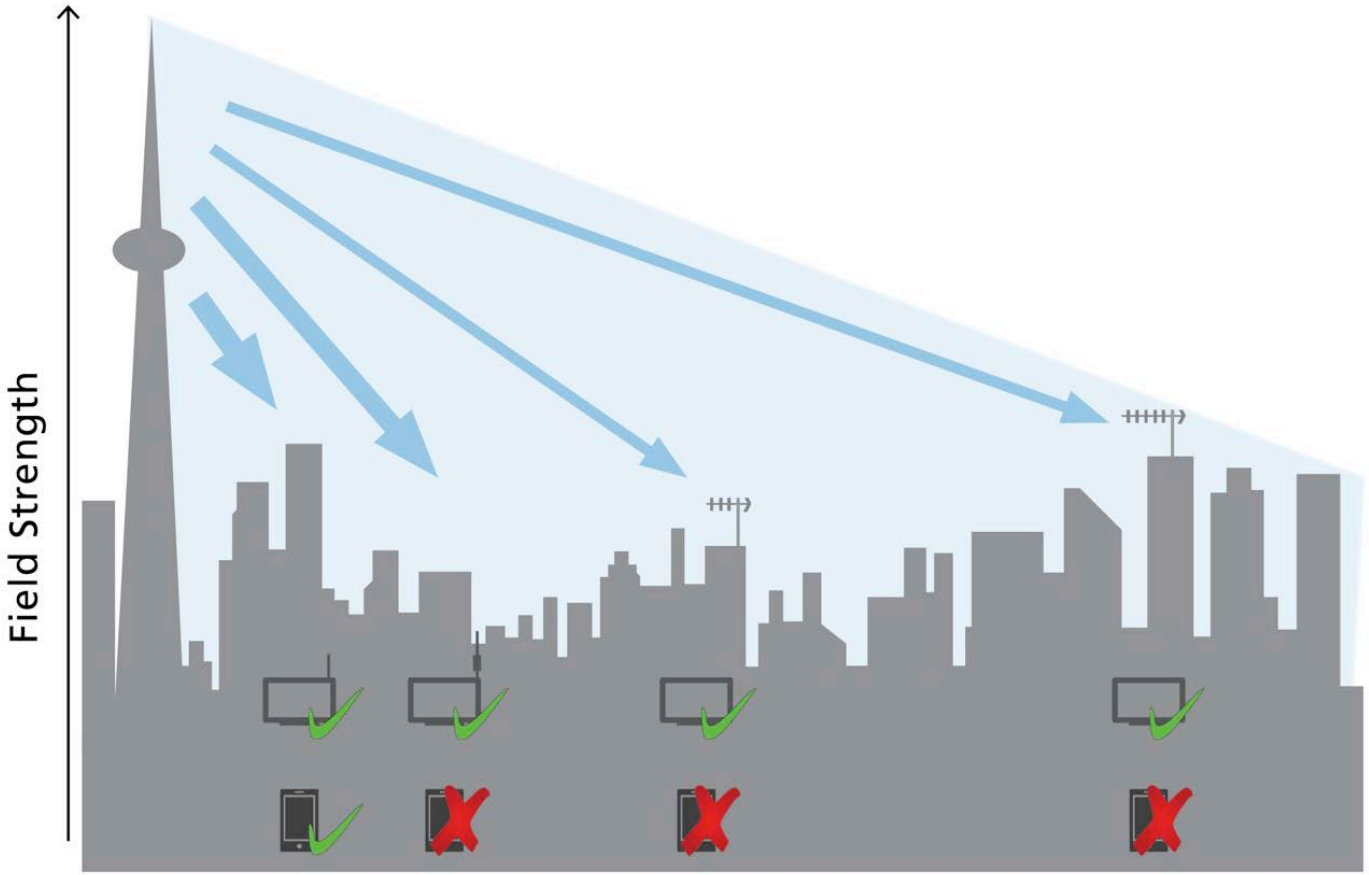
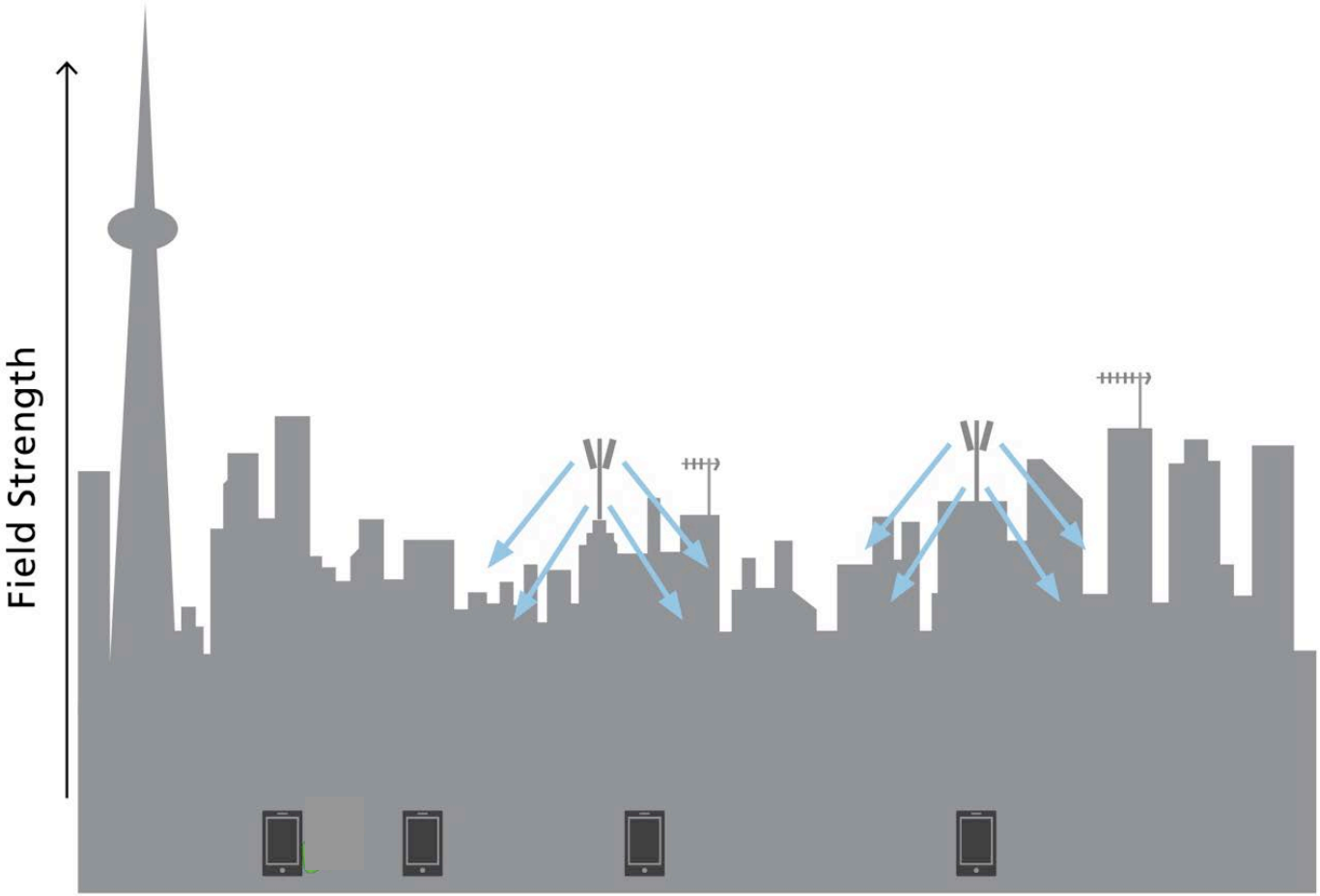


Future Scenarios

eMBMS instead of Classical DTT for Fixed + M/H



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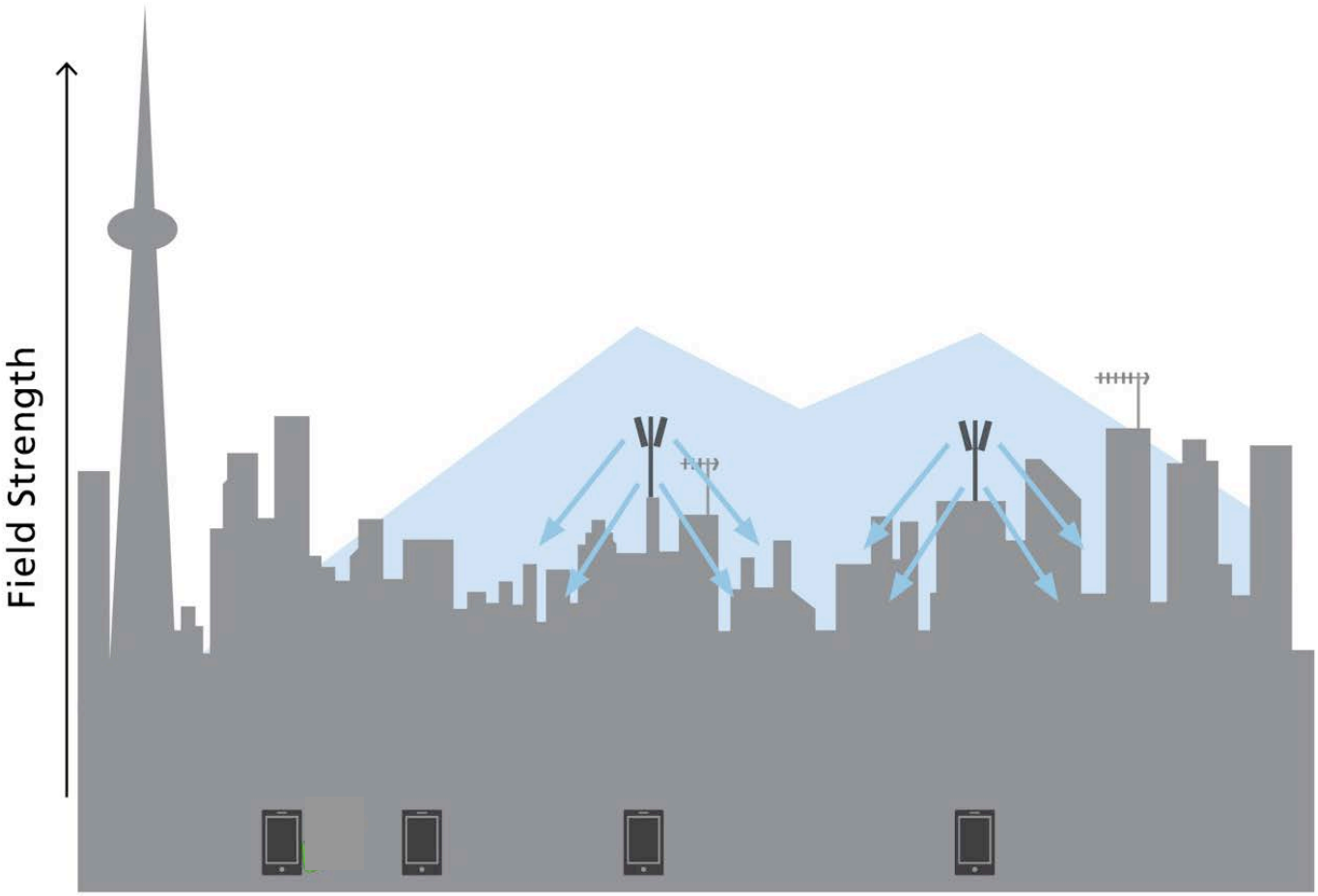
Future Scenarios

eMBMS instead of Classical DTT for Fixed + M/H



Future Scenarios

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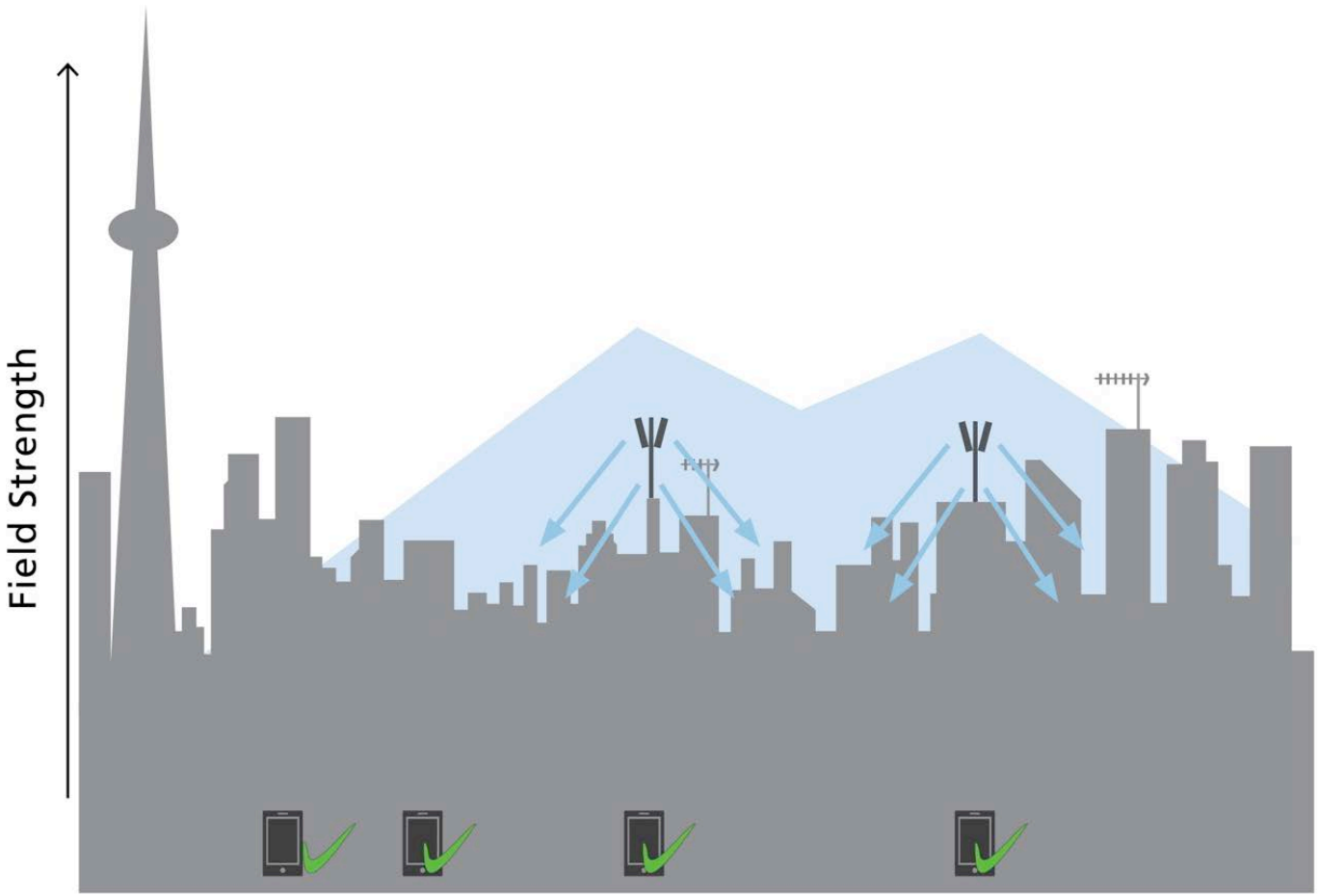


Future Scenarios
Scenario 1A (Classical DTT for Fixed + M/H)

- Observation: Broadcast exhibits a very non-uniform distribution of receive power over the coverage area
- For fixed TV, this can be partially compensated by rooftop antennas with higher or lower gains or even indoor antennas
- For handheld devices, no such compensation exists

- Cellular topology: much more even distribution of receive power

- Moreover, experience from DVB-H etc. shows that integration of classical DTT into cellular devices is unlikely

➔ <u>Scenario 1A</u> is not very likely

Future Scenarios

Scenario 1B: Classical DTT for Fixed, eMBMS for M/H

- For fixed reception, 2nd generation DTT standards (2G DTT) like DVB-T2 + ATSC 3.0 achieve very high spectral efficiencies
- Scenario 1B is good for countries that already have this scenario and where a switch-over (to e.g. Scenario 2) would not provide great benefit

➔ **Scenario 1B is very likely over at least 10-15 years in countries which have:**
- 2G DTT infrastructure (transmitters and rooftop antennas) already in place, and
- high DTT penetration

- Examples: Italy, UK
- After 15 years, the situation might be different

Future Scenarios
Scenario 2: 3GPP Broadcast Profile for Fixed (+ M/H)

- HPHT networks do have (cost) advantages for fixed reception
- Most countries have these in place for sufficient coverage → **keep them**
- Scenario 2 is useful for countries that benefit from a better waveform
  - Classical DTT has gained over many years profound expertise and devised suitable algorithms for HPHT networks
  - But the unicast features of cellular networks could prove very useful for an „improved DTT“ system
  - → Integrate this into cellular (i.e. 3GPP) standards
  - → Develop a new 3GPP Broadcast Profile

→Scenario 2 has good chances within the next 6-15 years in countries which have:
- not yet switched over to 2G DTT (or are about to), and
- a high terrestrial TV penetration

Future Scenarios

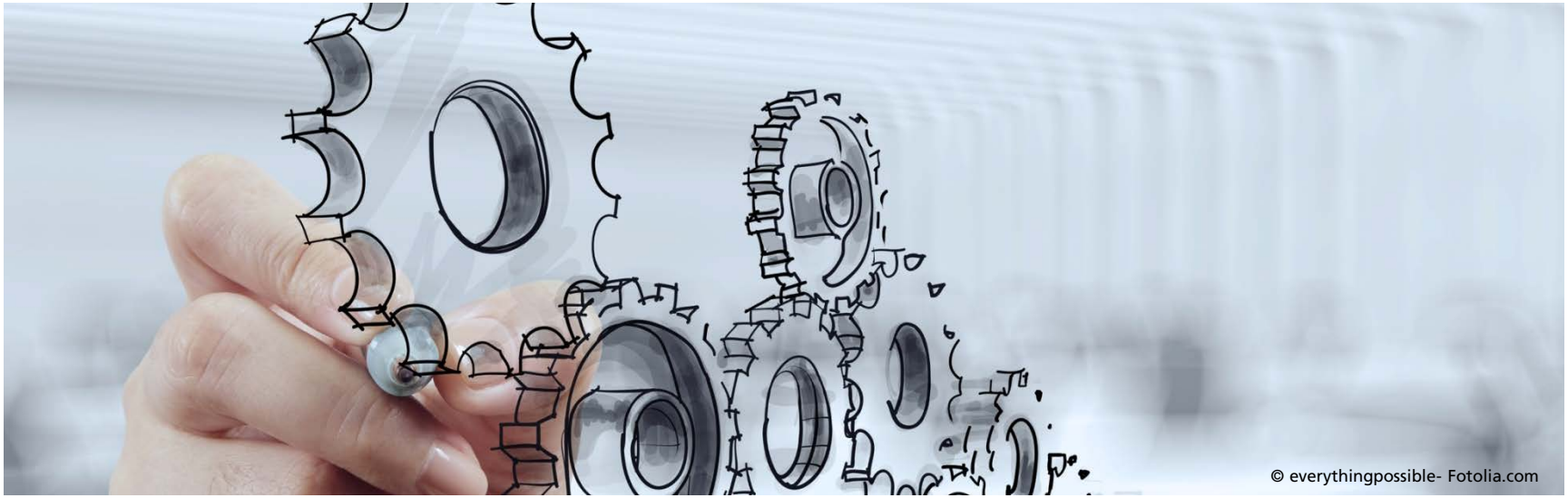
Scenario 3: No DTT (or only eMBMS)

<u>Scenario 3</u> is likely after the next 5-10 years for those countries, where DTT is fading away

- Replaced by satellite, cable and IPTV
- In these regions, the DTT spectrum might be refarmed and assigned to cellular networks („world region“-wide)
  - World Radio Conference 2015 just taking place now – Switzerland is in favour of refarming TV bands 470 – 790 MHz for cellular (see http://www.teltarif.de/paris-terror-rundfunk-abschalten-information/news/61815.html)
- In exchange, cellular operators might be forced to distribute some basic (public) TV services by (improved?) eMBMS
- However, this process takes some years
  - Technology (eMBMS) to be accepted by broadcasters
  - Has to be coupled with frequency license for mobile broadband
  - Modifications of media regulation
- Example: Switzerland, USA?

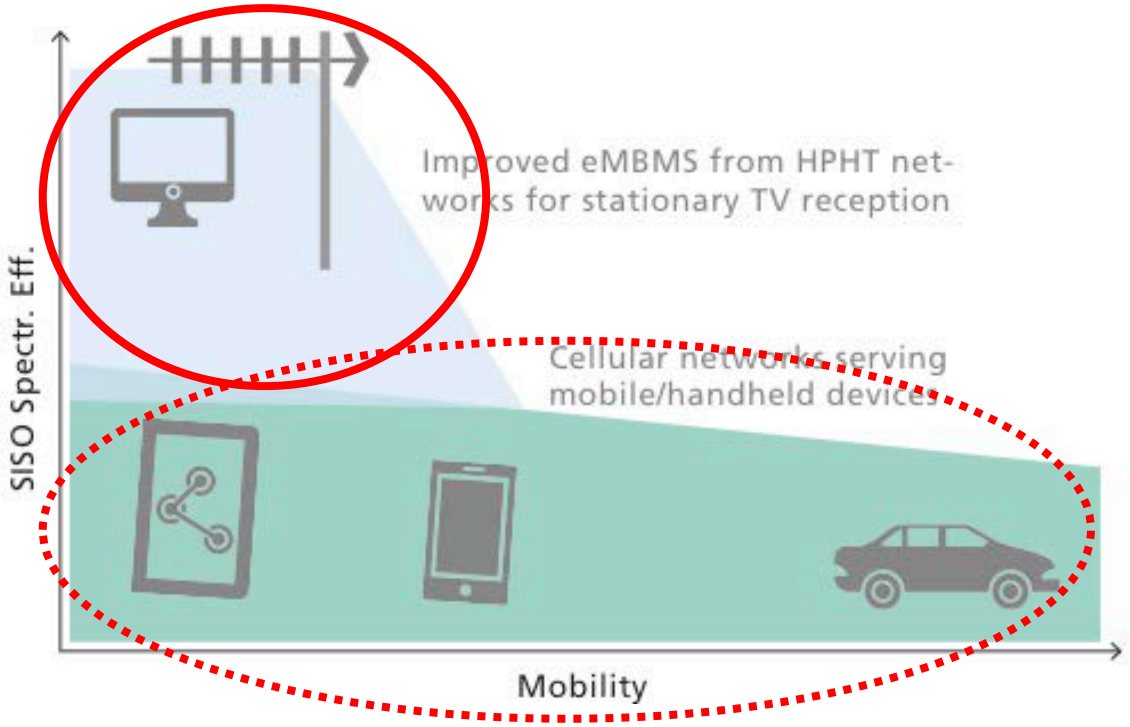
Terrestrial BC vs. eMBMS: Competition and Cooperation
Agenda

- Status Quo of terrestrial broadcast vs. cellular networks
- Future competition and cooperation scenarios
- Potential cooperation concepts (architectures and techniques)
- Conclusion and outlook



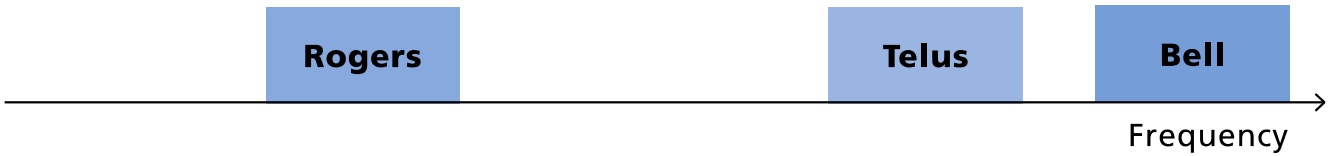
Cooperation Concepts

Our Focus: Scenario 2 (Mainly for Fixed Reception)



- HPHT serving higher definition content (rooftop or indoor antennas)
- Cellular networks covering mobile and handheld scenarios (in-/outdoor)

Cooperation Concepts
Spectrum of Scenario 2

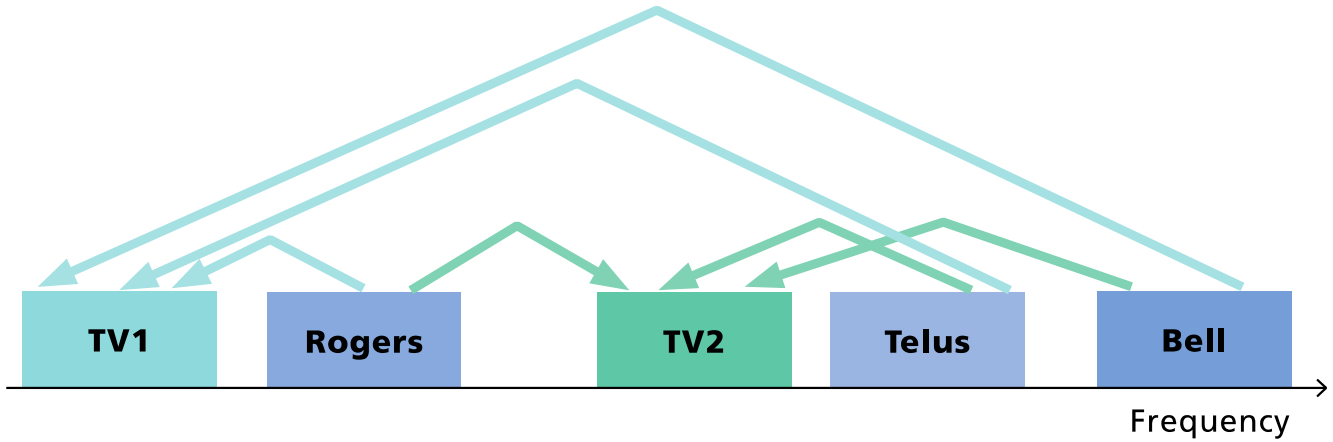


Cooperation Concepts
Spectrum of Scenario 2

- TV carriers are jointly used by all cellular operators
- Avoids duplicating the content

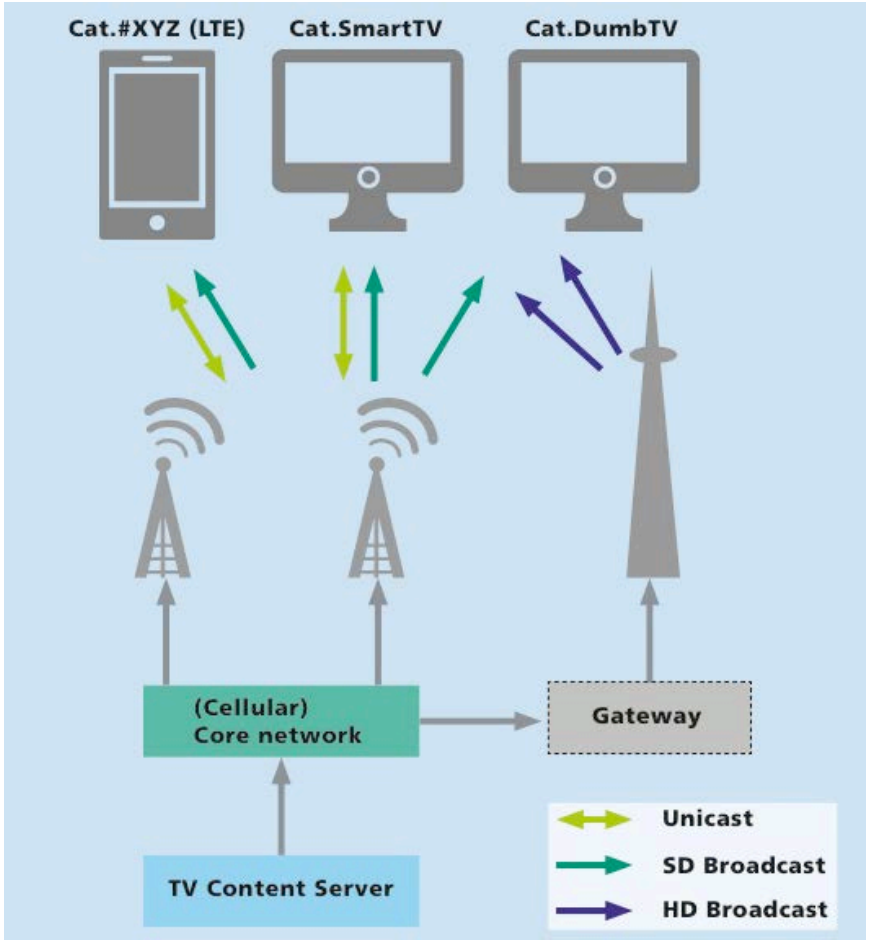
Cooperation Concepts
Spectrum of Scenario 2

- TV carrier does not belong to a single cellular operator
- Avoids duplicating the content
- Unicast carriers can link to TV carriers (enabling carrier aggregation)



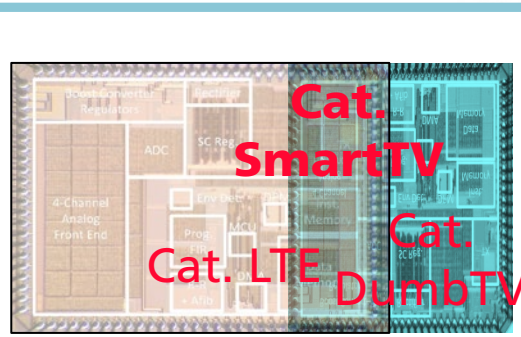
Cooperation Concepts
Scenario 2: Overview

- All devices can receive broadcast, but only „smart“ ones unicast
- Mobile/handheld devices only receive standard quality
- Fixed devices also receive standard quality, when reception of high quality content is too bad

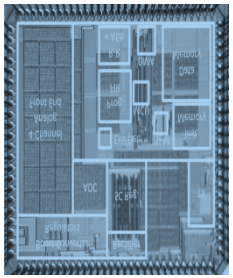


Cooperation Concepts
From eMBMS to a Stand-Alone Broadcast Profile

- Problem: LTE (and eMBMS) chips are quite expensive because of
  - high algorithmic complexity
  - high patent license fees
- ➔ Introduce an LTE (or 5G) **Broadcast Profile** with reduced functionality (cf. „Cat.0“ devices for IoT)
- Sheer broadcast profile has to be stand-alone to allow for cheaper chipsets (Cat. „DumbTV“):
  - lower complexity and less patent license fees



For comparison:
DVB-T2



Source: http://rlpvlsi.ece.virginia.edu/category/chip-gallery/chip-gallery

Cooperation Concepts
Benefits of the Broadcast Profile

- The similarity between Broadcast Profile and LTE allows for
  - lower-cost receiver chipsets
  - reception of SD content by eMBMS when no rooftop antenna is available
  - interactive services
  - secure pay-TV by using the LTE path
- Moreover, higher number of chips lowers the price!

Cooperation Concepts
How to Carve the LTE Broadcast Profile?

Exploit benefits of DTT

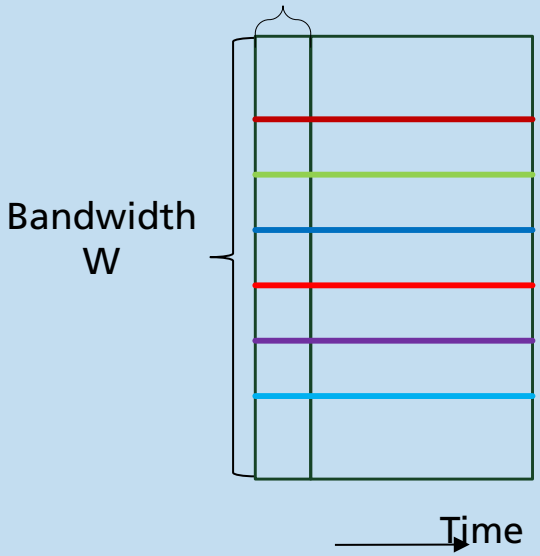
- Cat. DumbTV should be cheap, but need not be cheaper than DVB-T2
- In DVB-T2, the two dominant modules on the chip (causing highest chip cost) are
  - LDPC decoder (codeword up to 64 kbit long)
  - time de-interleaver (up to 2^{19} IQ samples storage)
- ➔ Broadcast Profile could contain similar modules

Avoid complexity of CellComm

- Cellular communication is optimized for unicast transmission and mobile operation (low latency, lower SNR, high pilot + signalling overhead)
- ➔ Broadcast Profile should re-use as much from LTE but recurve it to fit the fixed broadcast use case
  - e.g. relaxed latency requirements, reduced protocol stack

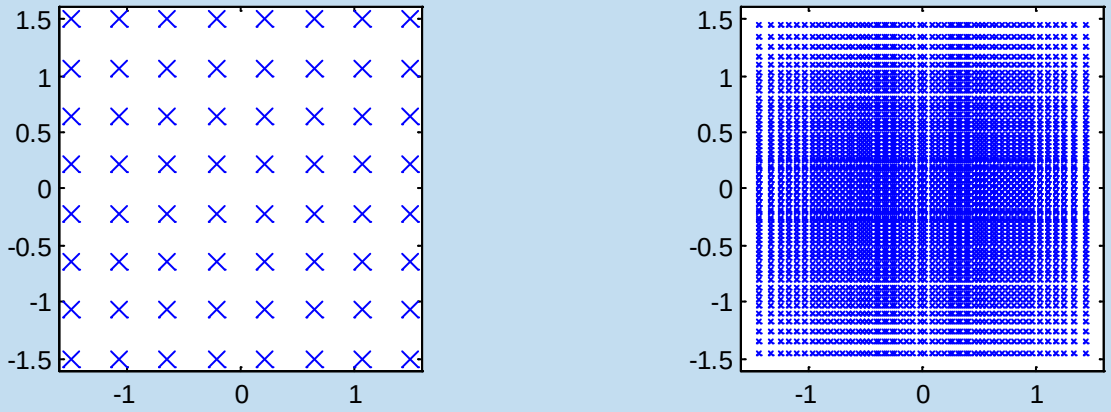
Cooperation Concepts
OFDM – FFT SIZE

- LTE: 2k FFT – short FFTs increase the sub-carrier separation and reduce chip complexity and cost
- DVB-T2: 32k FFT – long FFTs allow longer guard interval
  - ➔ very long channel impulse responses and large SFNs



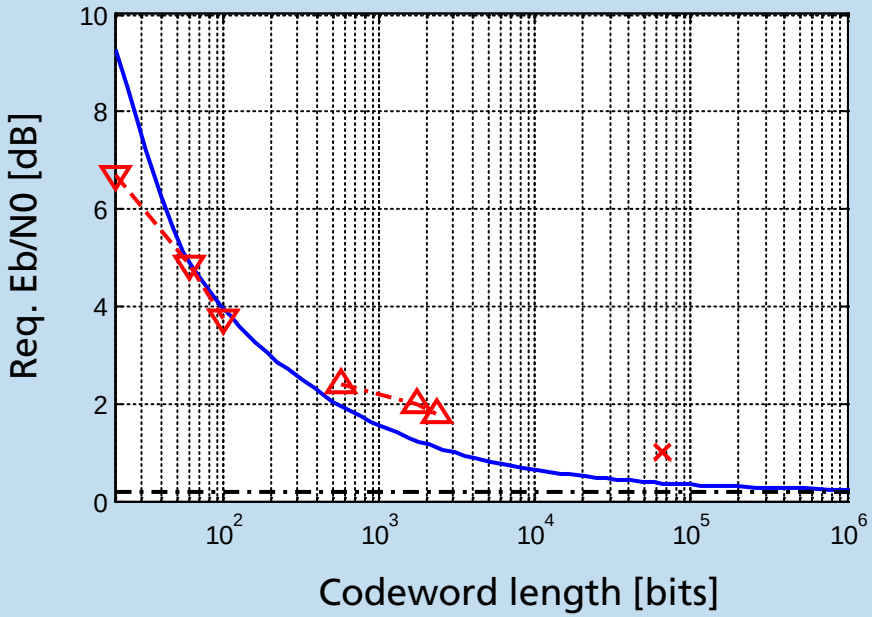
Cooperation Concepts
High-Order Constellations + Non-Uniform Constellations

- LTE: currently only max. 64-QAM, in future releases 256-QAM
- ATSC 3.0: High-order constellations: 256-QAM, 1k-QAM, up to 4k-QAM
- Non-Uniform Constellations (≈1 dB gain for ≥256-QAM)



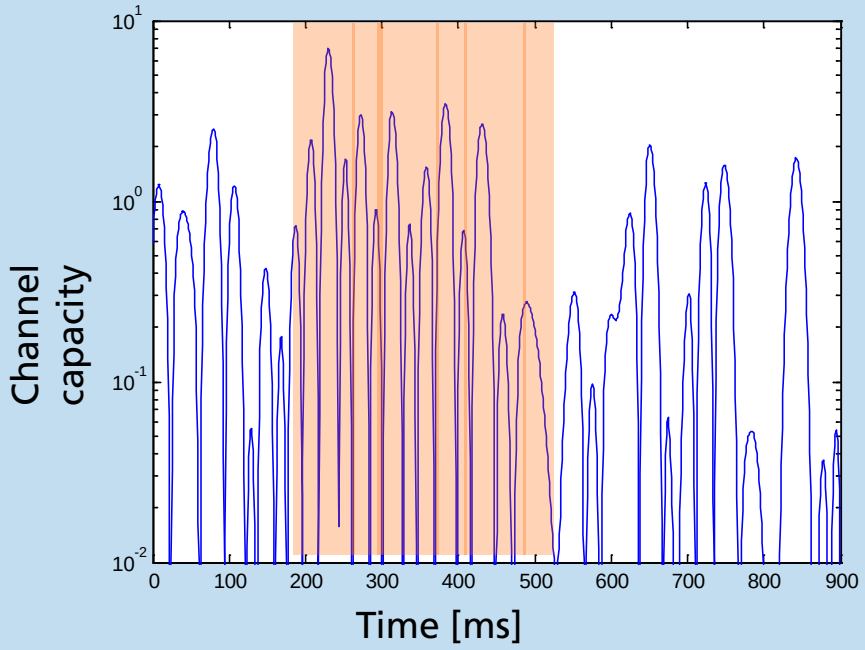
Cooperation Concepts
FEC Code – Longer Codewords

- LTE: Turbo Code, max. **info**word length: 6144 bits
- DVB-T2/ATSC 3.0: LDPC Code, max. **code**word length: 64800 bits
- → Broadcast Profile: use a Turbo Code, but with much longer infowords



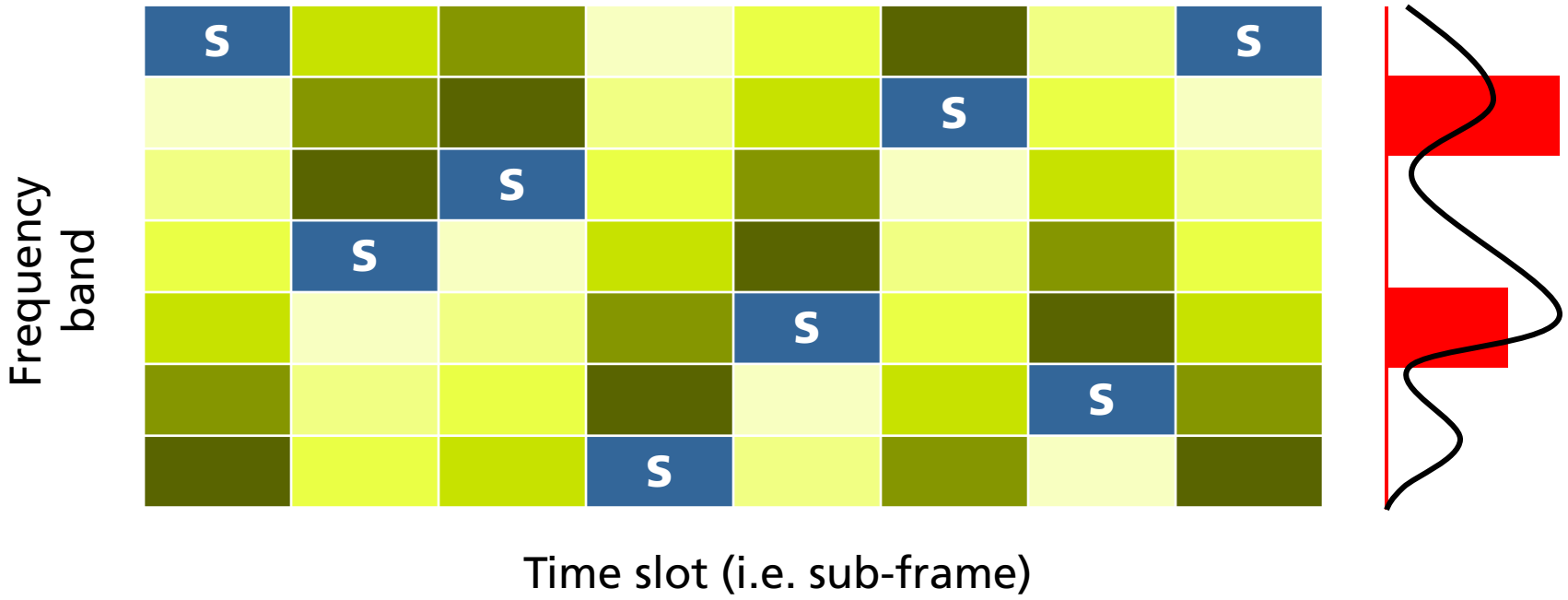
Cooperation Concepts
Longer Time Interleaving

- Useful, when no frequency diversity is available
- LTE: No time interleaving (apart from scheduling and Hybrid ARQ)
- DVB-T2: Time-interleaving over several 10 or 100 ms



Cooperation Concepts
Time-Freqency-Slicing

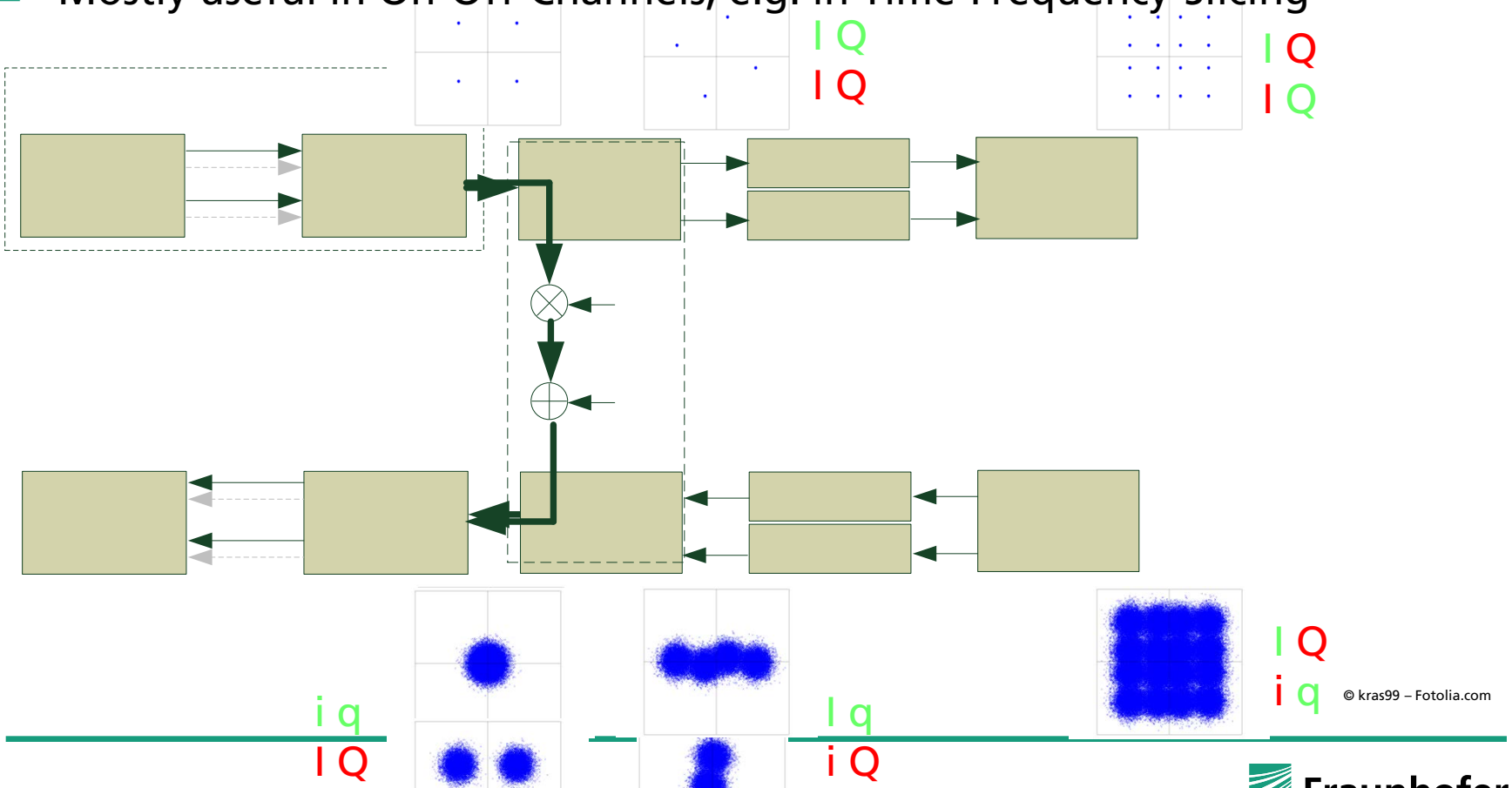
- Time-Frequency-Slicing (i.e. frequency hopping) for
  (a) combatting frequency-selective fading and
  (b) interference mitigation when reducing the frequency re-use factor



Cooperation Concepts
Signal Constellation Diversity

Breiling, Zöllner, Robert: "When do rotated constellations provide gains?", IEEE BMSB, 2014

- No feedback channel → employ **Signal Constellation Diversity** (Rotated Constellations) to increase signal robustness
- Mostly useful in On-Off-Channels, e.g. in Time-Frequency-Slicing



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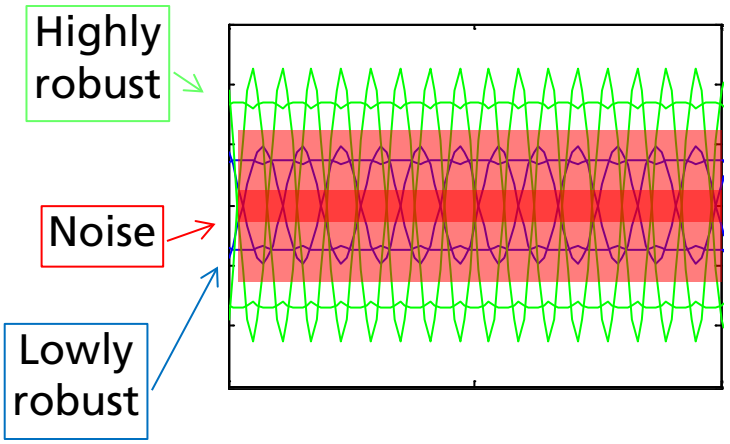
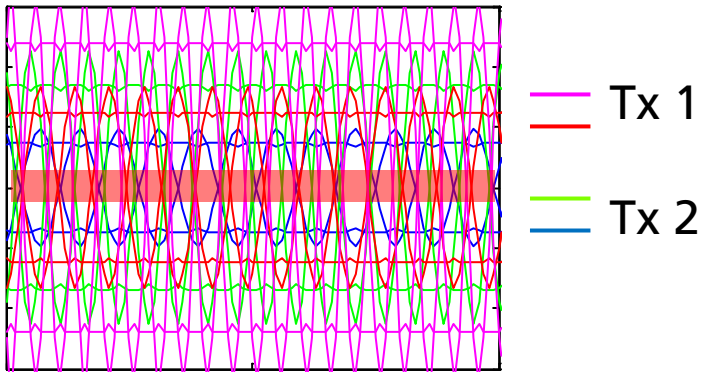
Cooperation Concepts
Rate Splitting – LDM/Cloud Transmission

- Idea by Yiyan Wu, Canadian CRC, Ottawa!
- Rate splitting approach for multiple access
- Layer Division Multiplexing (LDM – Cloud Transmission) for multiple robustness layers → similar to hierarchical modulation
- Principle can also be used to allow adjacent Tx interference when reducing the frequency re-use factor

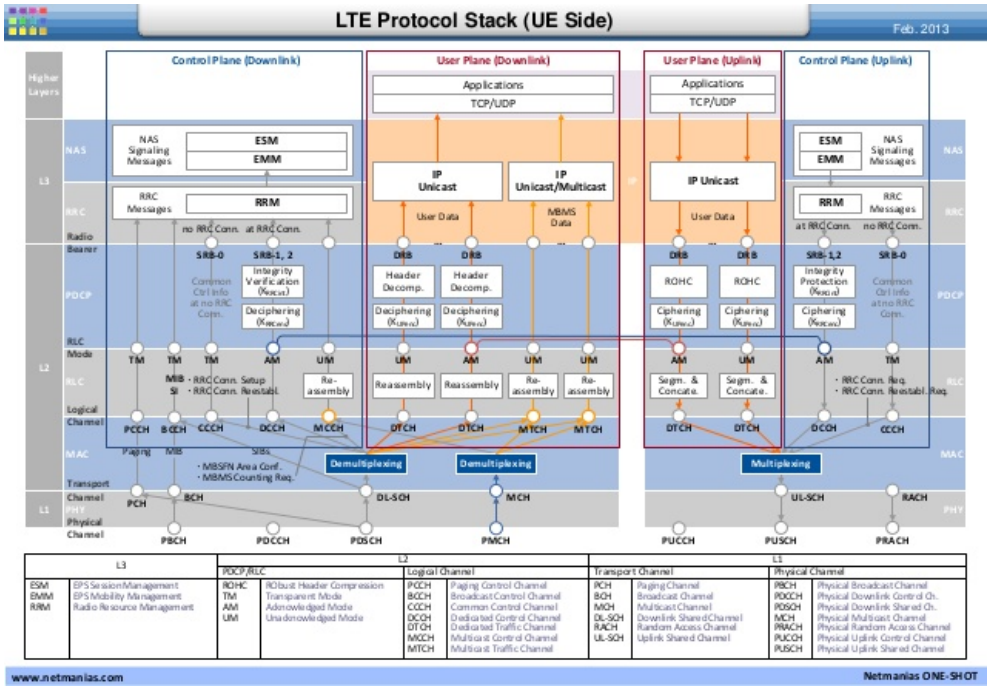




Cooperation Concepts

Some More Ingredients for the Broadcast Profile

- Fixed reception → lower pilot overhead suffices
- No (dynamic) bi-directional communication → lower signalling overhead



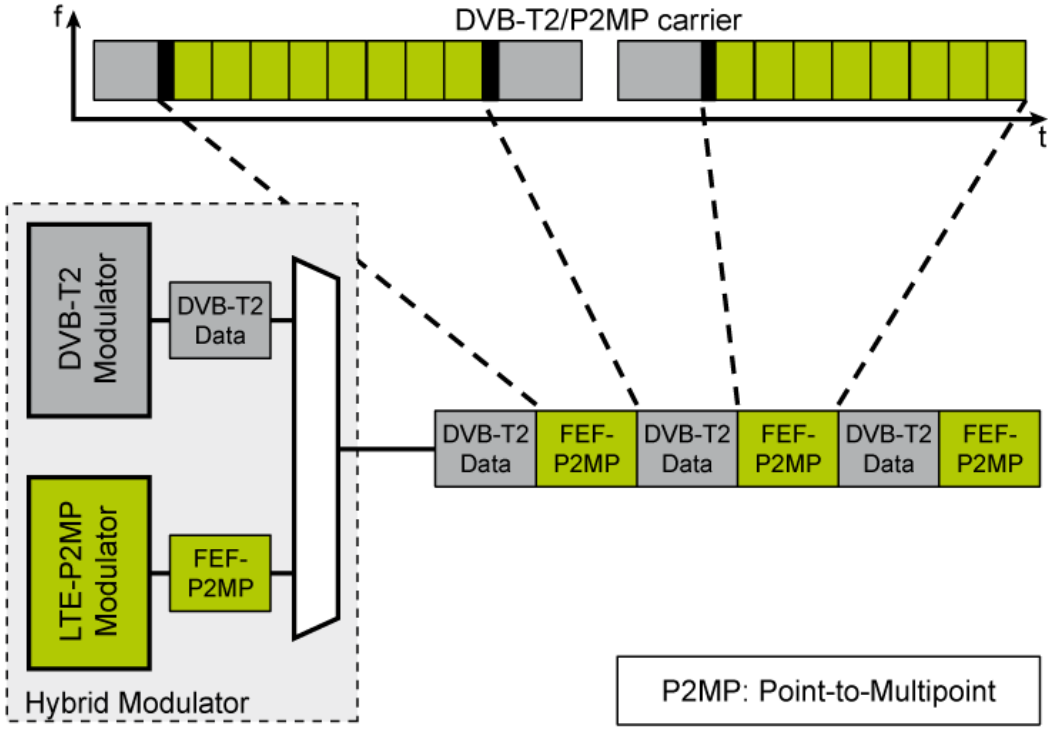
Source: www.netmanias.com

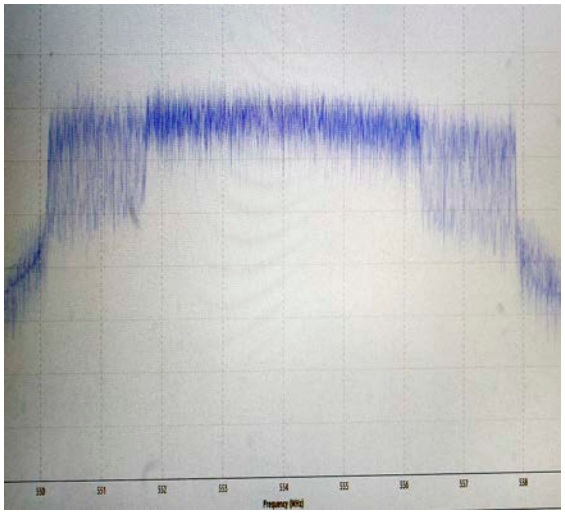
Fraunhofer IIS

Cooperation Concepts

Scenario Migration: Tower-Overlay-over-LTE-A+ (TOoL+)

- Idea of Prof. Reimers, IfN, TU Braunschweig/Germany
- The LTE-A+ signals are embedded in Future Extension Frames provided by DVB-T2 (and by ATSC 3.0)





Source: IfN, TU Braunschweig

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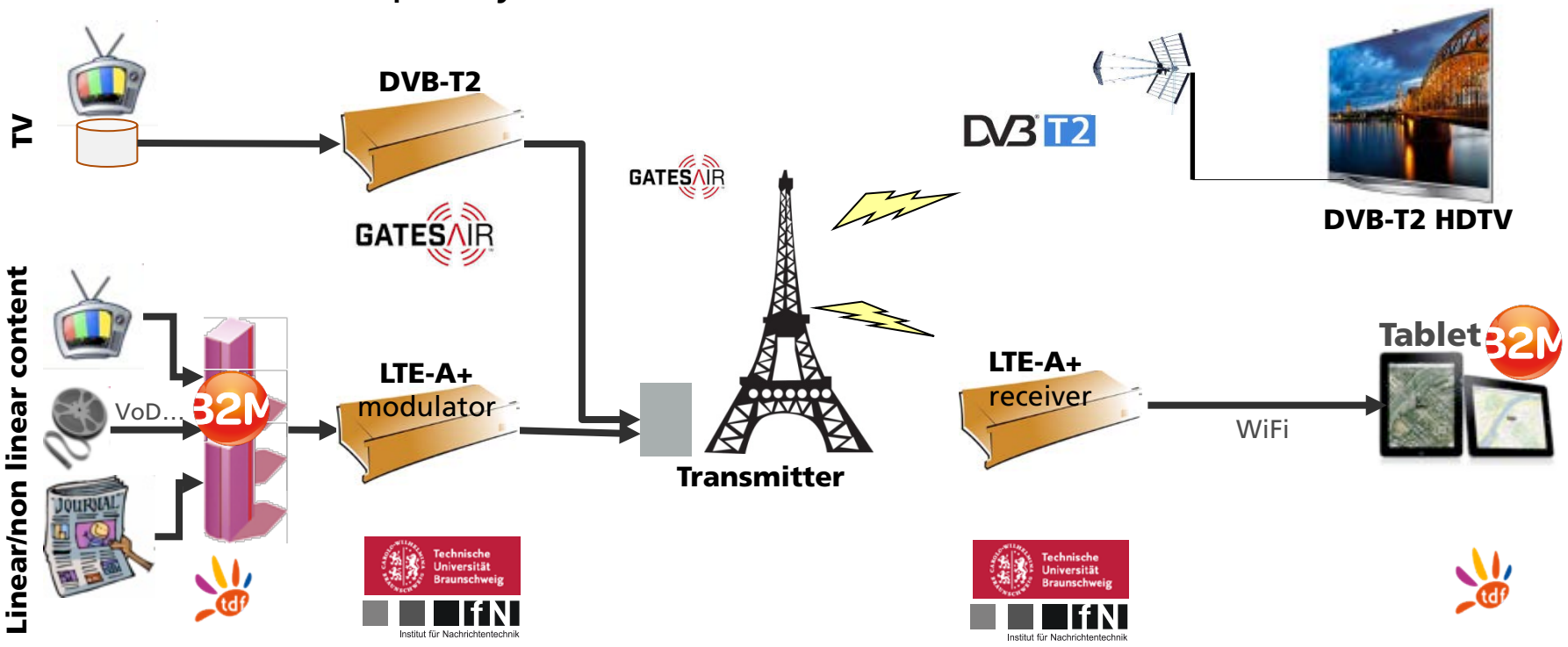
Cooperation Concepts
TOoL+ field trials

- In 2015: Paris, Aosta Valley in Italy and in Braunschweig/Germany
- Two independent DVB-T2 and LTE-A+ network components, sharing a broadcast frequency

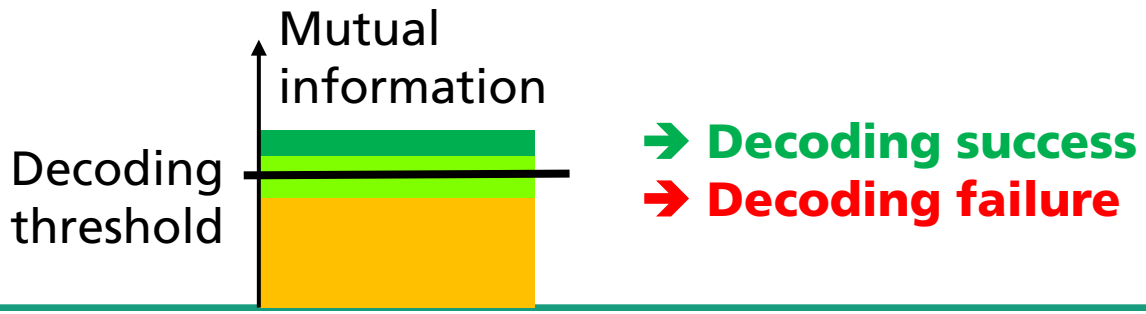


Source: Pierre Bretillon, TDF

Cooperation Concepts
Rendundancy on Demand (RoD)

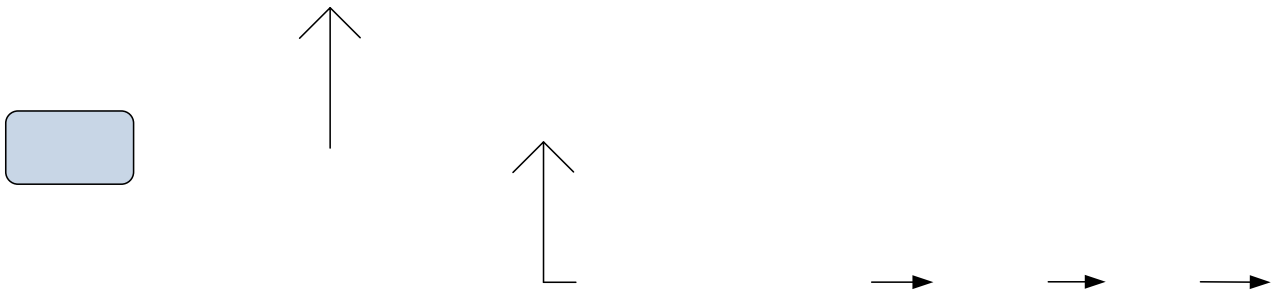
- Developed by TU Braunschweig and Sony – now investigated within DVB
- Idea: When a DTT receiver fails because of
  - time-variant fading
  - too low SNR in certain locations or at edge of coverage,

  the received signal is not 100% useless. Instead, it carries some information that just not suffices for decoding success.
- RoD receivers exploit cellular networks' unicast to request just the bit of required extra information (i.e. code bits)



Cooperation Concepts
Overview of the RoD System

Off the shelf
TV receiver

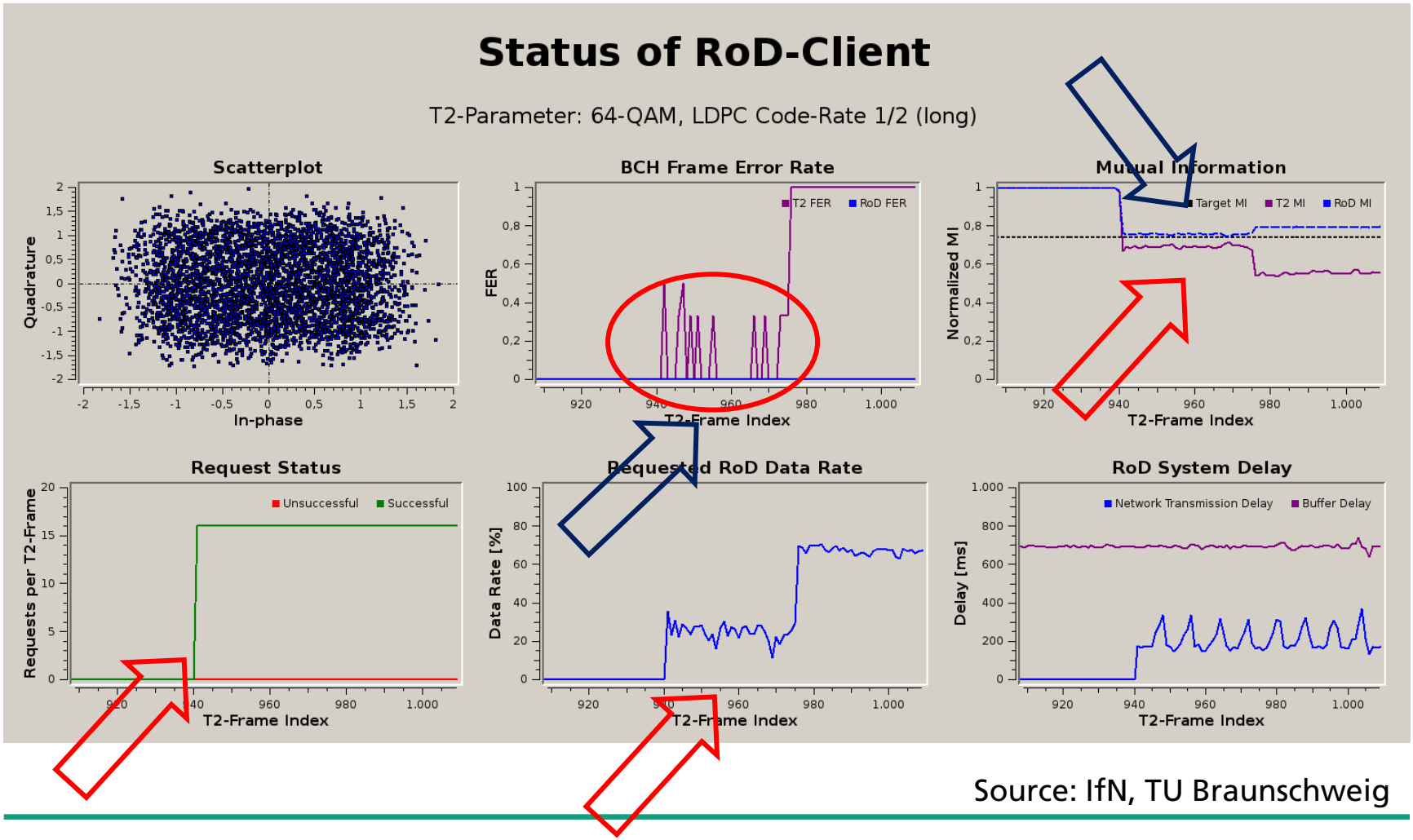


RoD
TV receiver

- RoD is backwards compatible (to DVB-T2, ATSC 3.0 …)
- Some buffering is required in the RoD receiver in order to compensate for the request cycle (for typically 200 ms)
- Only redundancy for the currently consumed service needs to be requested

Cooperation Concepts

Results of a (Vehicular) RoD Field Trial in Berlin



Source: IfN, TU Braunschweig

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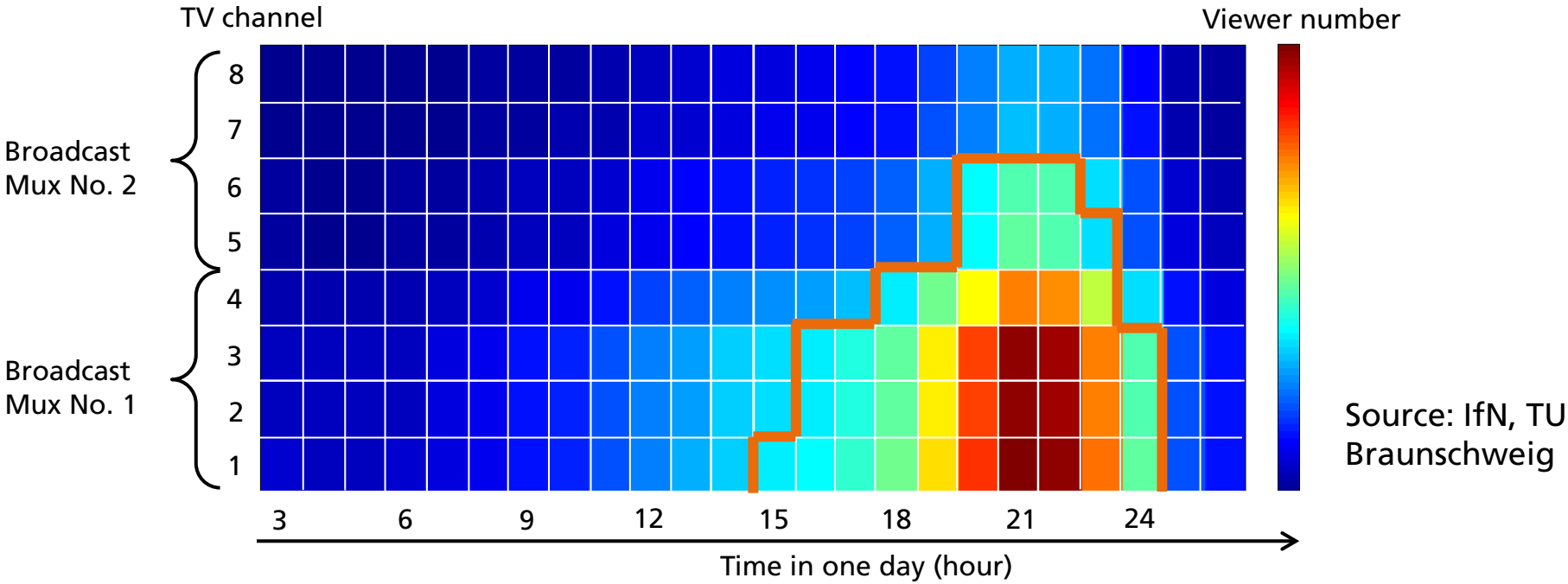
Cooperation Concepts
Dynamic Broadcast (Once Again From TU Braunschweig)

- Observation: Consumption of DTT services is very non-uniform over 24h
- But bandwidth is occupied 24/7



- Exploit this non-uniformity: use spectrum for DTT during peak time but for other unicast for off-peak time
- Off-peak time content: (unicast) TV services, prefetch cacheable content, …

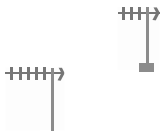
Cooperation Concepts
Overview of the Dynamic Broadcast System

Important:
The viewers will not notice any difference in comparison to traditional TV broadcast

- TU Braunschweig demonstrated the system live at IFA Berlin 2012

Cooperation Concepts
Distribution of TV Content

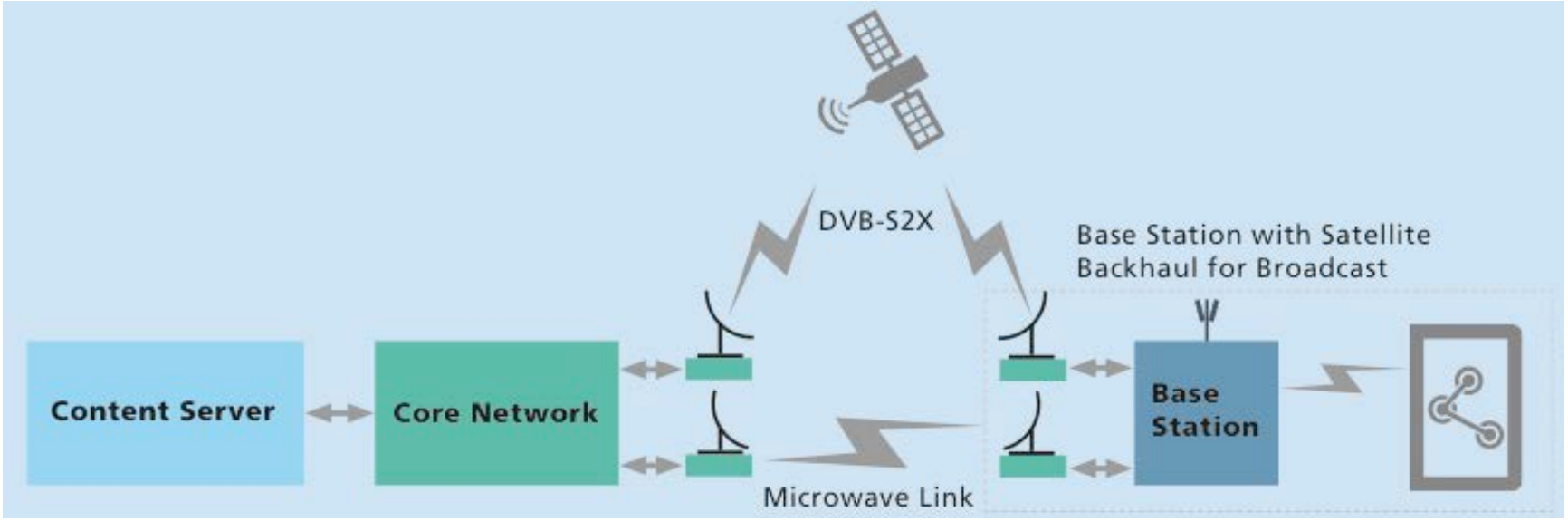
Terrestrial



- Scenario 2: Mobile/handheld are covered by (LTE) base stations
- But content is the same as for fixed TVs covered by HPHT
- ➔ Re-use these signals for the base stations and re-encode

Cooperation Concepts
Satellite Distribution of TV Content

- Especially for rural areas
- TV content very suitable for satellite backhauling
- Huge coverage area



- Format: suitable for also for satellite TV, or dedicated format for eMBMS?

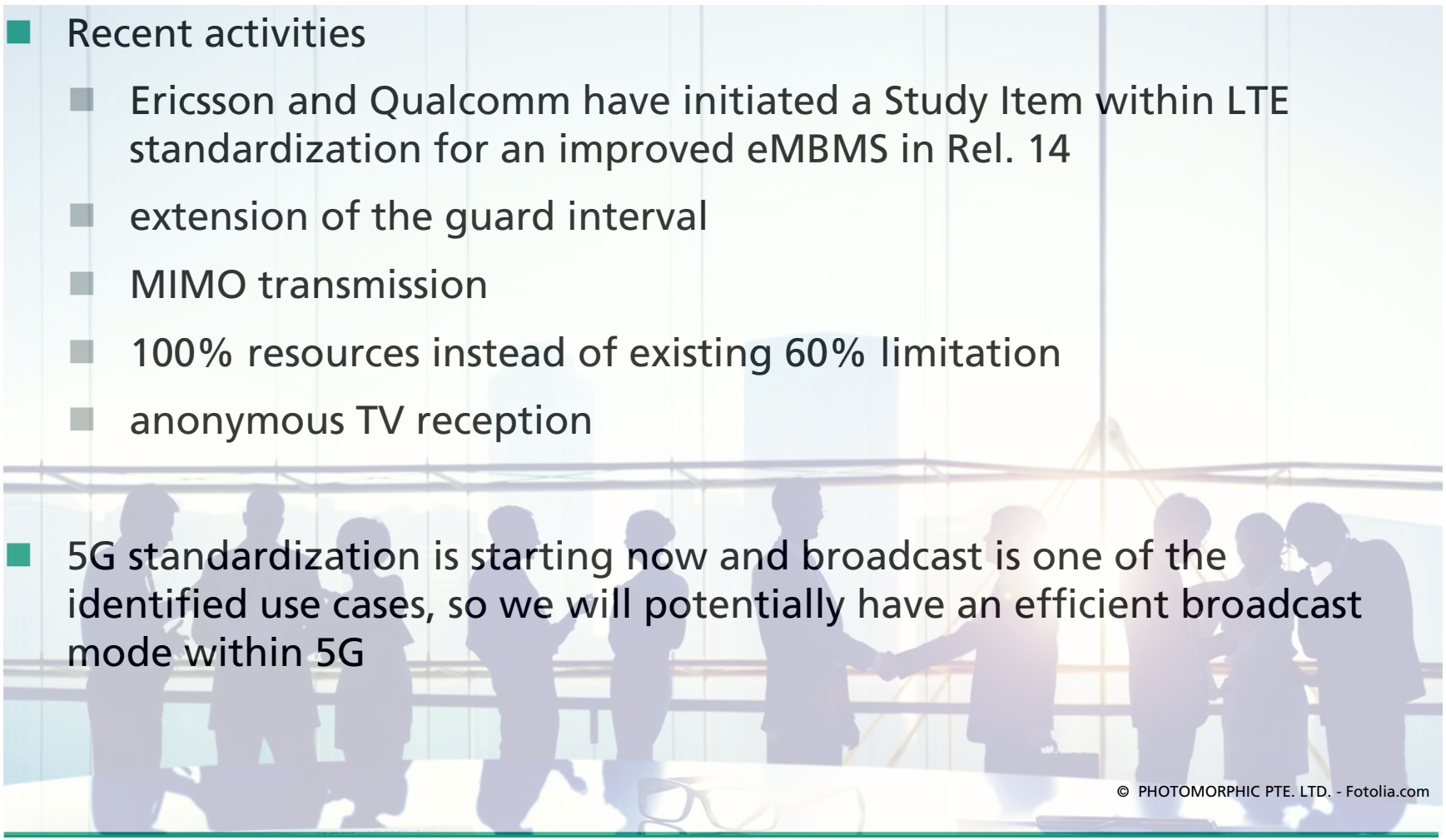
Cooperation Concepts
Cooperation Attempts in the Past

- Examples of cooperation efforts between mobile and broadcast worlds:
  - The Next Generation Handheld (NGH) ad-hoc group of DVB approached 3GPP (LTE) in 2011 to ask for a cooperation
    ➔ 3GPP showed little interest
  - Qualcomm and Ericsson proposed the use of LTE-eMBMS for the ATSC 3.0 standard
    ➔ ATSC showed little interest

Cooperation Concepts
Cooperation Attempts in the Present and Future

- Recent activities
  - Ericsson and Qualcomm have initiated a Study Item within LTE standardization for an improved eMBMS in Rel. 14
  - extension of the guard interval
  - MIMO transmission
  - 100% resources instead of existing 60% limitation
  - anonymous TV reception

- 5G standardization is starting now and broadcast is one of the identified use cases, so we will potentially have an efficient broadcast mode within 5G



Cooperation Concepts

Expected Winners and Losers in the DTT Business

Broadcasters	Cost-per-user expected to shrink	**+**
Broadcast network operators	Competition to cellular operators, but potential to run a HPHT network for the broadcast profile in parallel to the cellular unicast net-works	**-**
Transmitter manufacturers	Hard competition against the base station manufacturers (major change of technology)	**--**
Chipset manufacturers	Little chances against cellular chipset manufacturers	**--**
TV manufacturers	Device cost remains about the same (when no return link is needed) or falls (with return link + unicast)	**o/+**

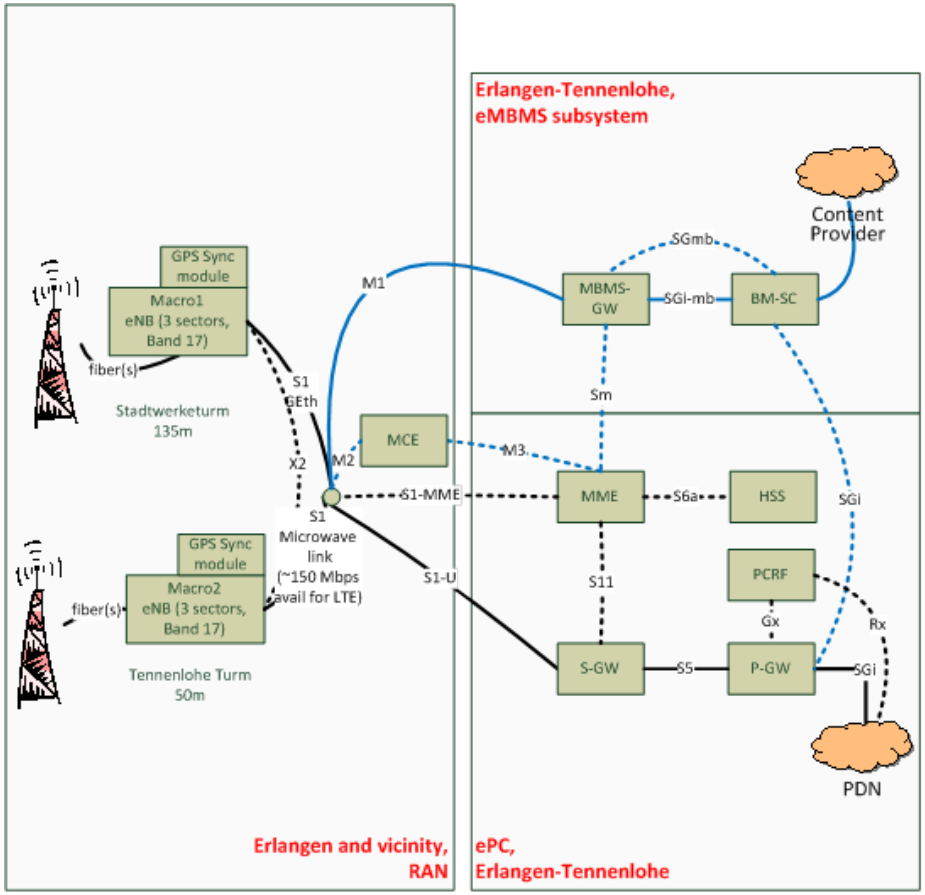
Cooperation Concepts
Fraunhofer LTE-A Testbed in Erlangen

A Kind of “HPHT“: Two base stations on High Towers

Distance between towers: 5.3 km
(larger than 16.7µs cyclic prefix)

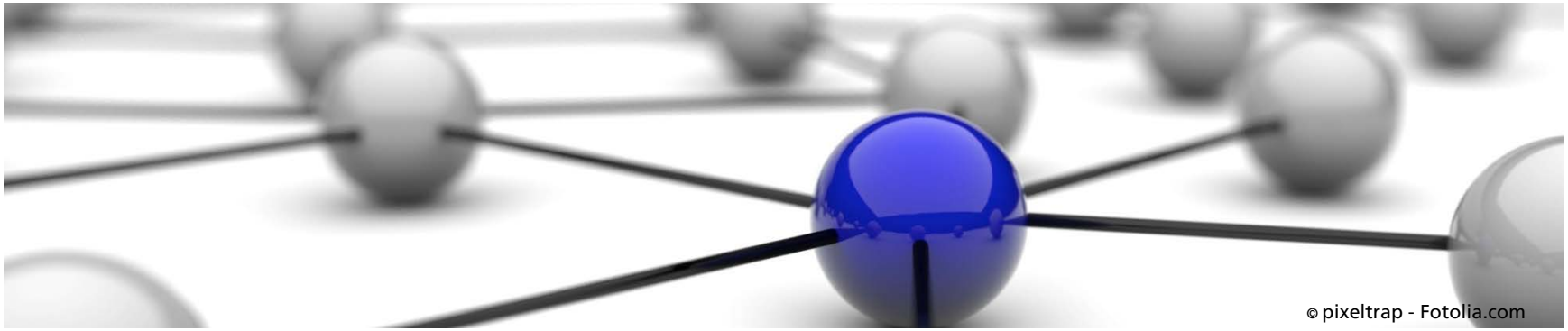
Cooperation Concepts
Fraunhofer LTE-A Testbed in Erlangen

- Using LTE bands 17 (700 MHz) and 2600 MHz
- Maybe extend to an HPHT site in Nürnberg later on (at approx. 15 km)
- Fraunhofer IIS is using this for trialling (conventional) eMBMS over HPHT network



Cooperation Concepts
Projects at Fraunhofer IIS in Erlangen

- DVB-NGH and ATSC 3.0 standardization
- IMB5: Trialling the Suitability of existing eMBMS for HPHT networks
- Software Def. Radio implementation of LTE+eMBMS (OpenAirInterface)
- Cosat, Satinet: Sat backhauling for LTE (incl. eMBMS) + media distribution
- 5G broadcast: all of this talk and more



Terrestrial BC vs. eMBMS: Competition and Cooperation
Conclusions

- Cellular communications raise data rates further
- Pressure for further digital dividends persists
- Cooperation between classical digital terrestrial TV and cellular communications is inevitable on the long term
- Digital terrestrial TV has assets that it should bring into the marriage
  - concepts (like scalability from Low Power-Low-Tower to High-Power High-Tower networks)
  - technologies (like time interleaving)
- Intense cooperation can generate a win-win-situation

Terrestrial BC vs. eMBMS: Competition and Cooperation
Outlook

- Fraunhofer IIS intends to initiate a 5G Broadcast project within the EU Research Framework Programme Horizon2020
- Possibly we will submit a broadcast proposal within 5G standardization

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Terrestrial BC vs. eMBMS: Competition and Cooperation

Contact

Thanks to Prof. Reimers (TU Braunschweig and Peter Siebert (DVB Office) for their inspirations!

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