Embracing heterogeneity in wireless networks

Thomas Sälzer, Huawei Technologies

IEEE Wireless Communications and Networking Conference (WCNC 2012)
Paris, April 3rd 2012

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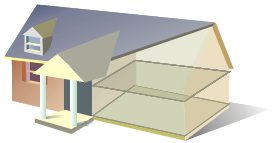
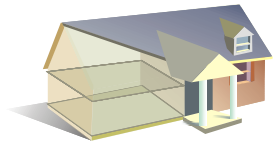
The way we communicate is changing

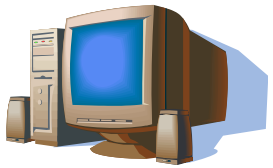



Call a location



Call a person

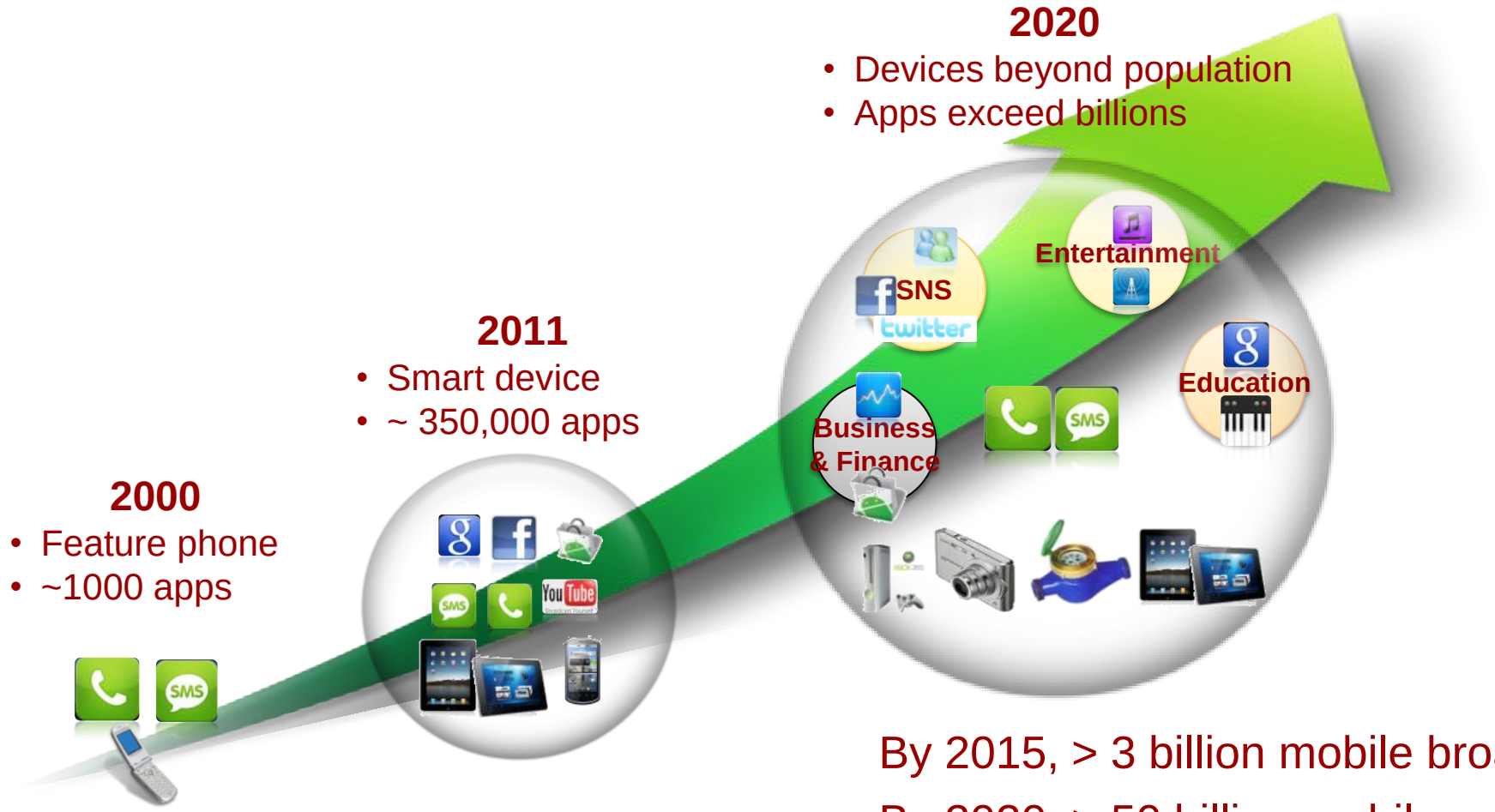




Connect to internet

The way we communicate is changing

Growth of traffic, service types and device park



By 2015, > 3 billion mobile broadband subscribers

By 2020, > 50 billion mobile connections (incl. M2M)

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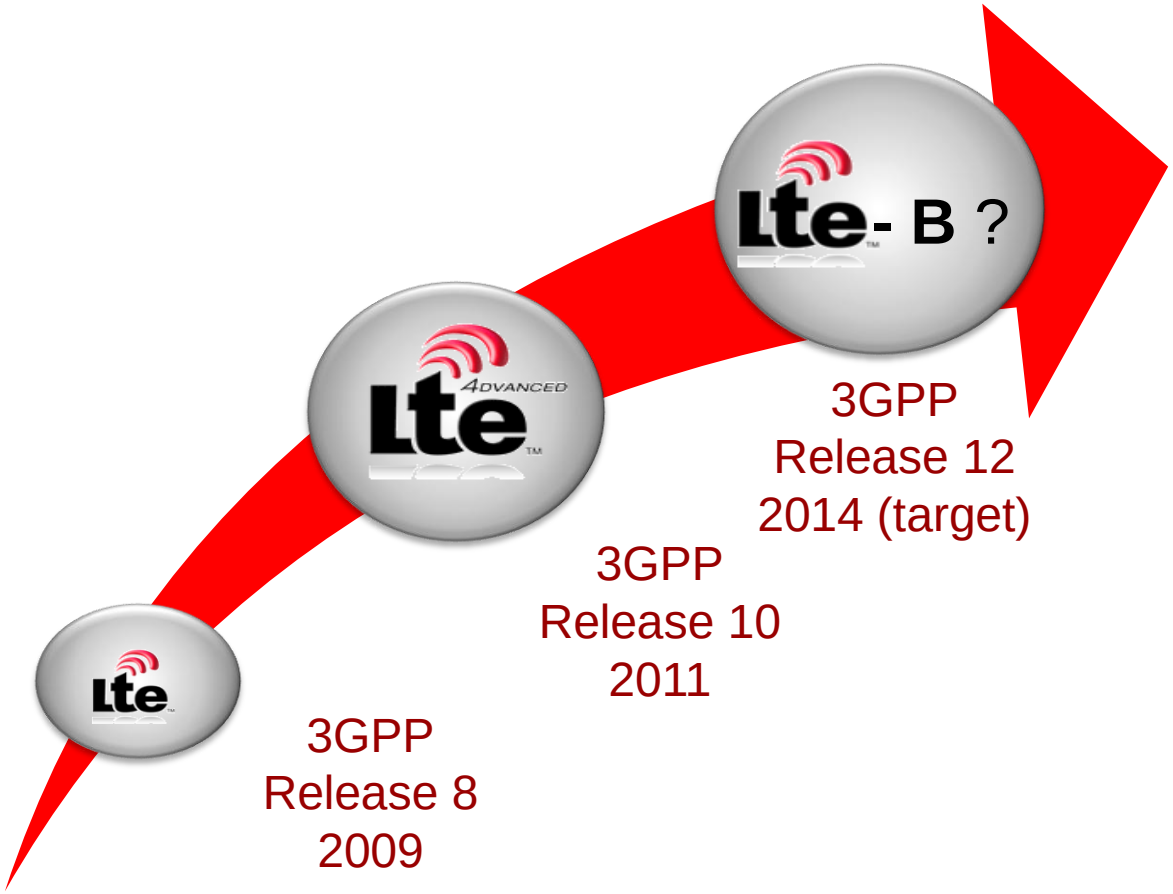
LTE – the fastest developing radio technology ever



3GPP
A GLOBAL INITIATIVE

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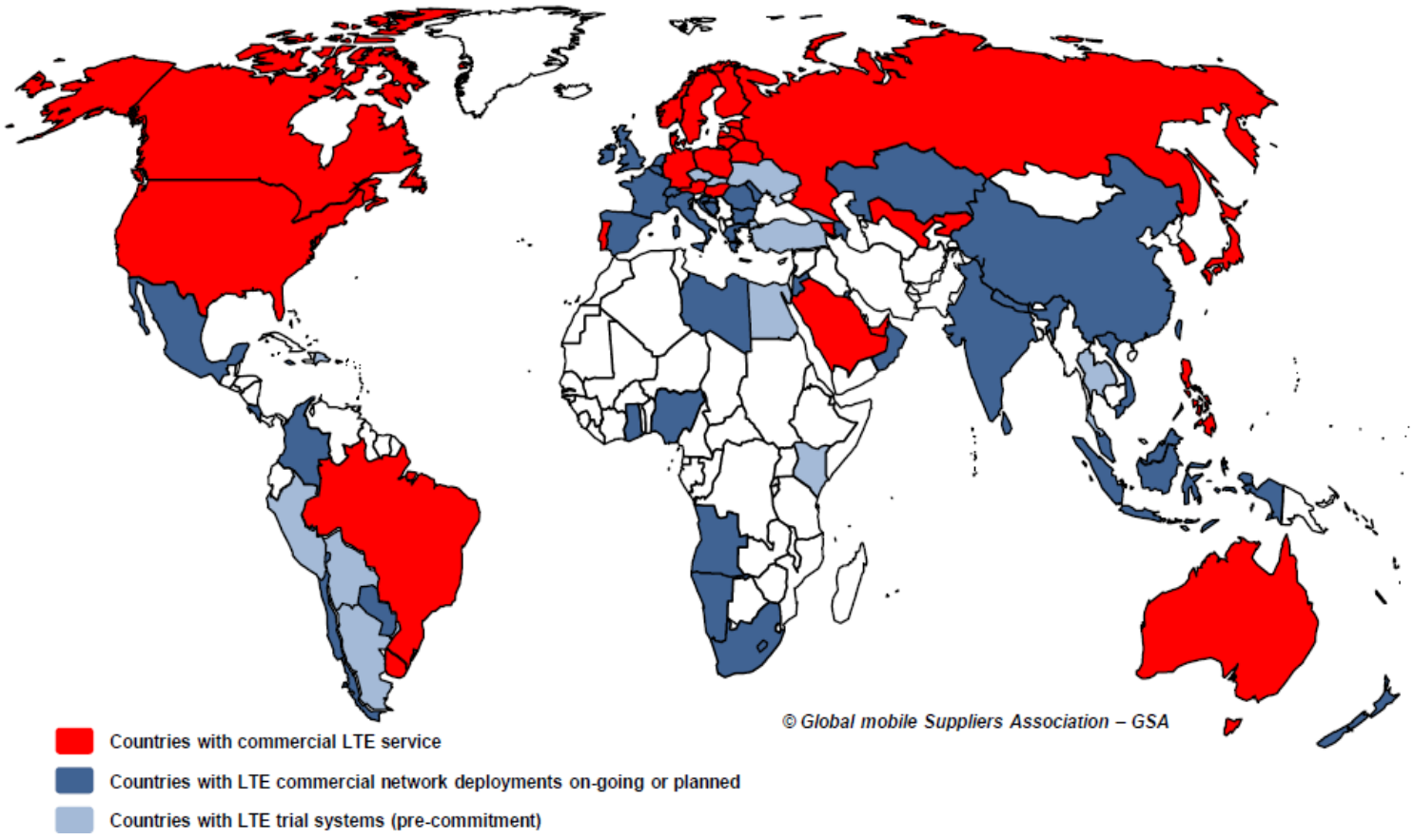
LTE – the fastest developing radio technology ever



- **301 operators are investing in LTE in 95 countries**
- 242 operator commitments in 81 countries
- 59 pre-commit. trials in 14 more countries
- **57 commercial networks in 32 countries**
- GSA forecasts 128 commercial LTE networks in 56 countries by end 2012

GSA

(source Global Supplier Association, March 14th 2012)

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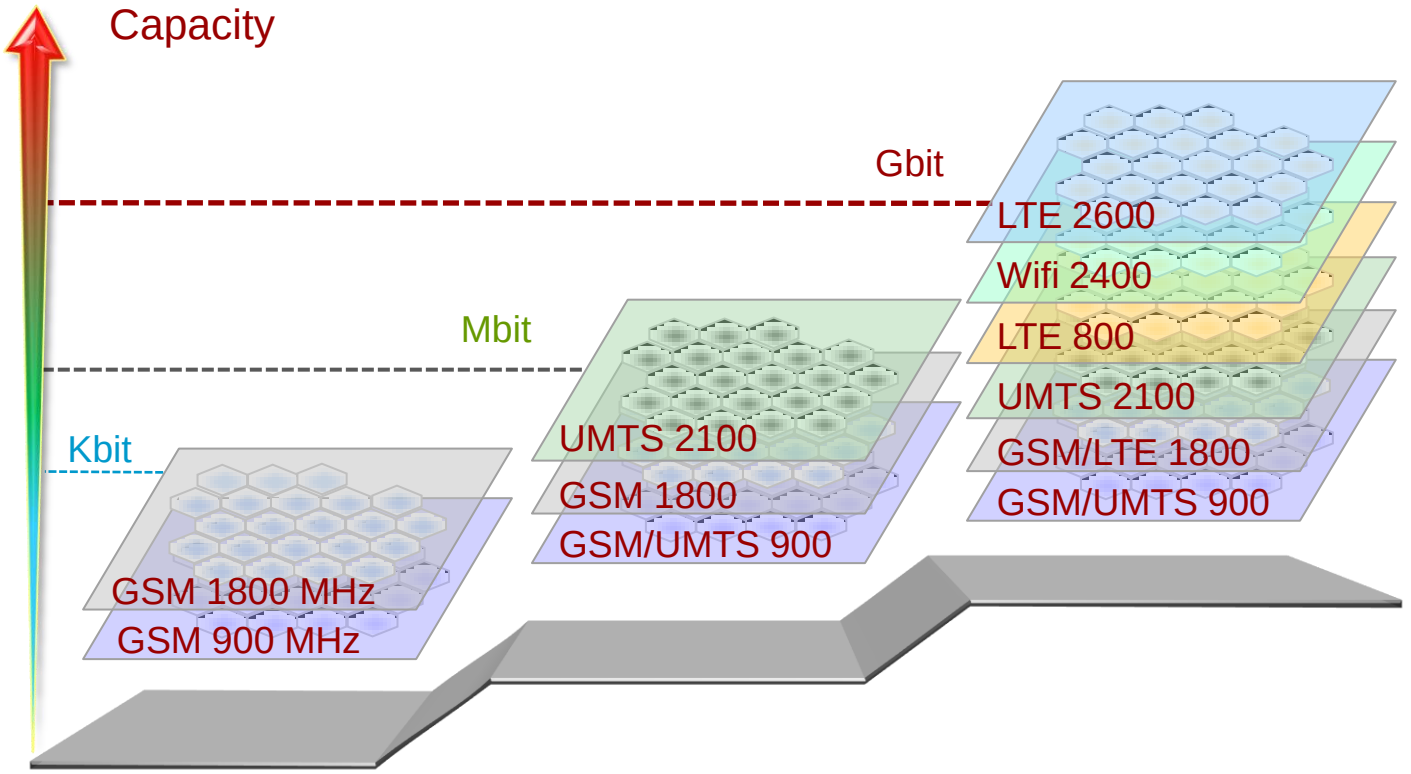
Capacity development requires multiple technologies



Multi-standard support and interoperation will be a reality for many years to come

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Multi-standard – not only an implementation issue

GSM UMTS LTE

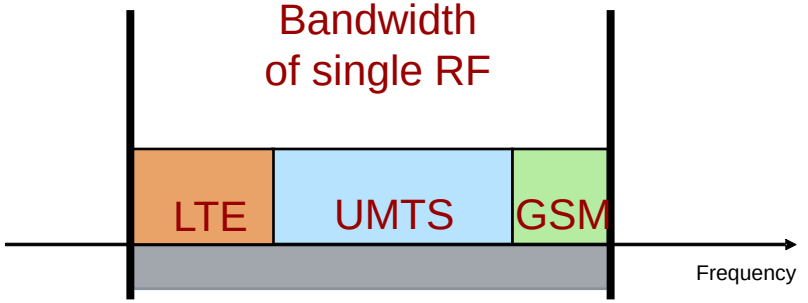
Traditional BTS Deployment

Single RAN Deployment (from 2008)

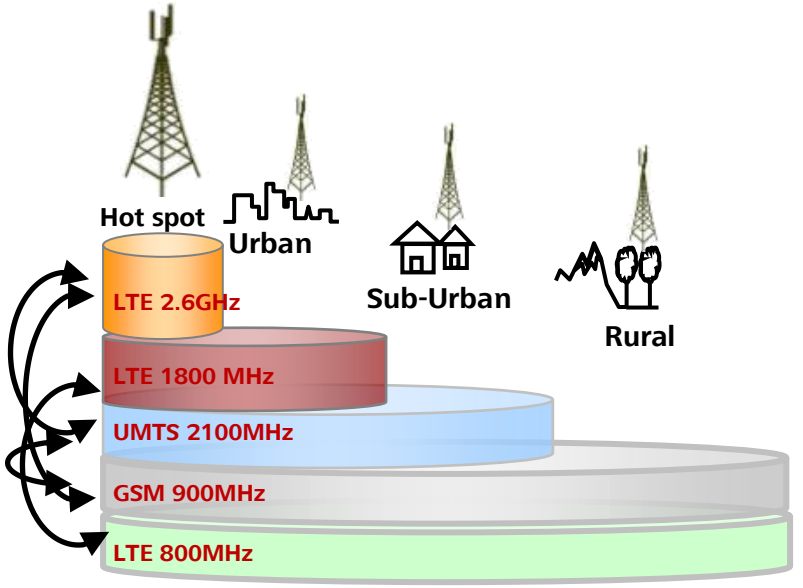
GSM / UMTS / LTE

Multi-standard – not only an implementation issue

- **RF requirements for multi-standard radio (MSR) equipment**
  - Common RF chains require specific design and coexistence requirements
  - 3GPP supports specific RF requirements for MSR from Rel-9 in contiguous spectrum and from Rel-10 in non-contiguous allocations



- **Interoperation of multiple radio technologies**
  - Radio resource management and inter-system handovers
  - Service continuity (in particular voice call continuity)
  - LTE supports inter-operation in particular with GSM, UMTS, HRPD, Wifi and WiMAX
  - Seamless roaming with Wifi is still a hot topic for mobile operators



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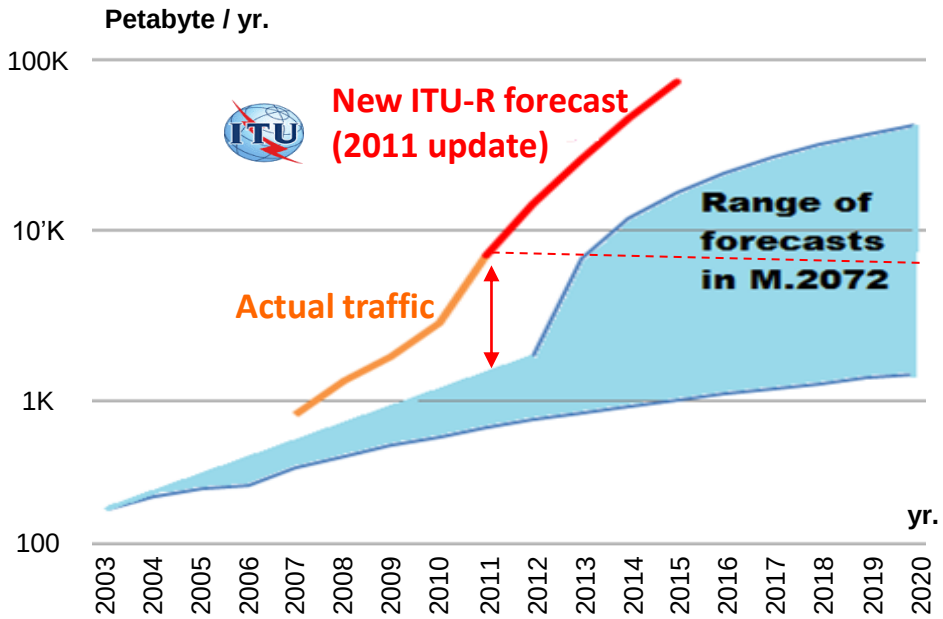
Spectrum

Throughput / Capacity increases linearly with available bandwidth



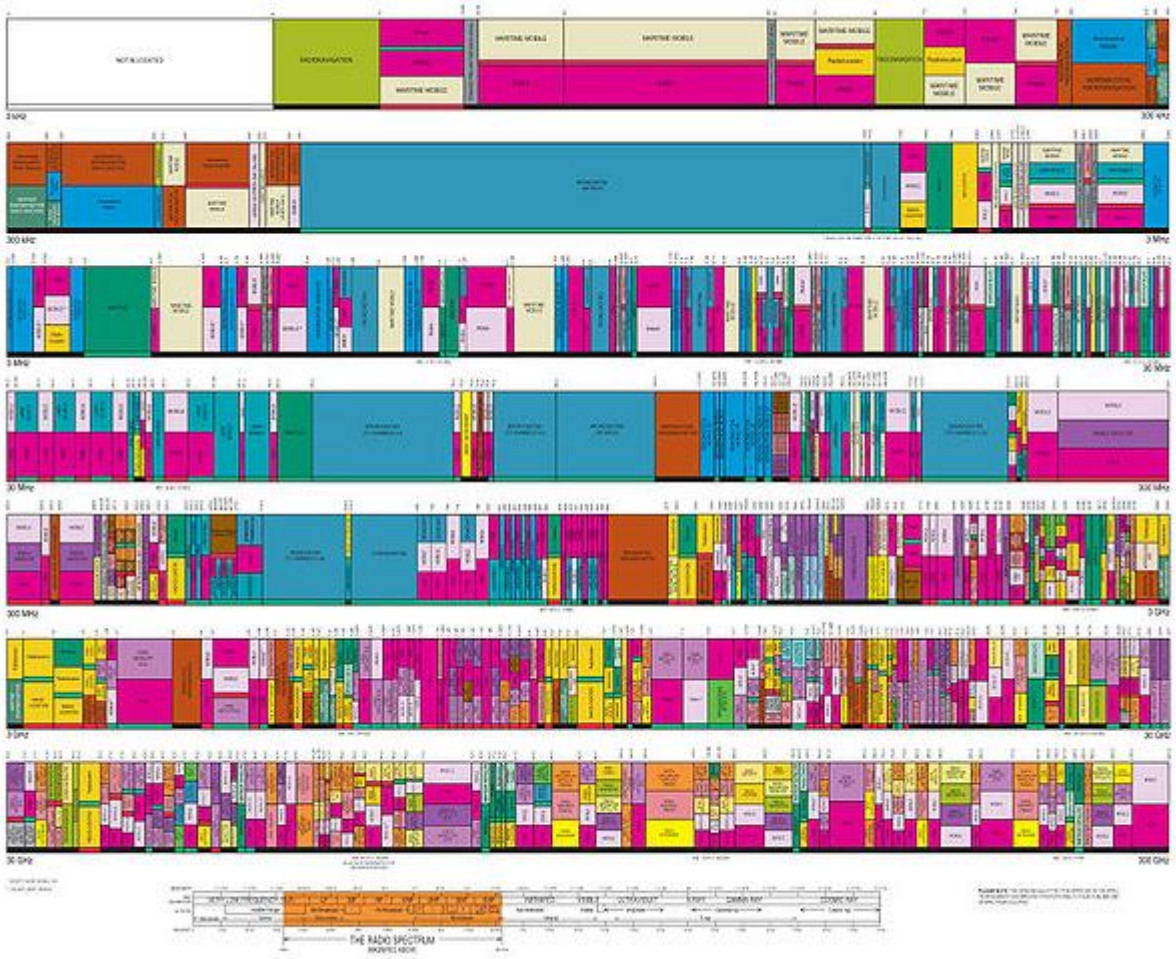


Illustration of US band plan, source NTIA

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Access to spectrum

- **Licensed spectrum**

  - Global IMT spectrum of 715 MHz currently available, plus <300 MHz on a regional basis
  - WRC'12 confirmed the intention to allocate more spectrum to IMT in the 700 MHz band (~90 MHz)
  - ITU-R forecasts a need of 1280 to 1720 MHz in the medium term for IMT (before 2020)
- **New spectrum opportunities**
  - European Comm.: 1200 MHz (incl. exist. 625 MHz) to be allocated to mobile broadband by 2015
  - FCC: Make 500 MHz of spectrum newly available for broadband within 10 years
  - Need to consider shared spectrum: Unlicensed spectrum, unlicensed secondary usage or Licensed Secondary Access (LSA) e.g. in TV white space,
- **New key features and technologies**
  - Spectrum aggregation
  - Sensing and Cognitive radio technologies for spectrum sharing
  - Offloading with fallback techniques to exclusive global bands, e.g. for mobility/roaming.

Current spectrum options for LTE

6 bandwidths available for LTE Rel-8 (1.4, 3, 5, 10, 15, 20 MHz)

Current spectrum options for LTE

X

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit	Downlink (DL) operating band BS transmit UE receive	Duplex Mode
	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	FDD
2	1850 MHz – 1910 MHz	1930 MHz – 1990 MHz	FDD
3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	FDD
4	1710 MHz – 1755 MHz	2110 MHz – 2155 MHz	FDD
5	824 MHz – 849 MHz	869 MHz – 894MHz	FDD
6[1]	830 MHz – 840 MHz	875 MHz – 885 MHz	FDD
7	2500 MHz – 2570 MHz	2620 MHz – 2690 MHz	FDD
8	880 MHz – 915 MHz	925 MHz – 960 MHz	FDD
9	1749.9 MHz – 1784.9 MHz	1844.9 MHz – 1879.9 MHz	FDD
10	1710 MHz – 1770 MHz	2110 MHz – 2170 MHz	FDD
11	1427.9 MHz – 1447.9 MHz	1475.9 MHz – 1495.9 MHz	FDD
12	699 MHz – 716 MHz	729 MHz – 746 MHz	FDD
13	777 MHz – 787 MHz	746 MHz – 756 MHz	FDD
14	788 MHz – 798 MHz	758 MHz – 768 MHz	FDD
15	Reserved	Reserved	FDD
16	Reserved	Reserved	FDD
17	704 MHz – 716 MHz	734 MHz – 746 MHz	FDD
18	815 MHz – 830 MHz	860 MHz – 875 MHz	FDD
19	830 MHz – 845 MHz	875 MHz – 890 MHz	FDD
20	832 MHz – 862 MHz	791 MHz – 821 MHz	FDD
21	1447.9 MHz – 1462.9 MHz	1495.9 MHz – 1510.9 MHz	FDD
22	3410 MHz – 3490 MHz	3510 MHz – 3590 MHz	FDD
23	2000 MHz – 2020 MHz	2180 MHz – 2200 MHz	FDD
24	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD
25	1850 MHz – 1915 MHz	1930 MHz – 1995 MHz	FDD
...			
33	1900 MHz – 1920 MHz	1900 MHz – 1920 MHz	TDD
34	2010 MHz – 2025 MHz	2010 MHz – 2025 MHz	TDD
35	1850 MHz – 1910 MHz	1850 MHz – 1910 MHz	TDD
36	1930 MHz – 1990 MHz	1930 MHz – 1990 MHz	TDD
37	1910 MHz – 1930 MHz	1910 MHz – 1930 MHz	TDD
38	2570 MHz – 2620 MHz	2570 MHz – 2620 MHz	TDD
39	1880 MHz – 1920 MHz	1880 MHz – 1920 MHz	TDD
40	2300 MHz – 2400 MHz	2300 MHz – 2400 MHz	TDD
41	2496 MHz 2690 MHz	2496 MHz 2690 MHz	TDD
42	3400 MHz – 3600 MHz	3400 MHz – 3600 MHz	TDD
43	3600 MHz – 3800 MHz	3600 MHz – 3800 MHz	TDD

Note 1: Band 6 is not applicable

6 bandwidths available for LTE Rel-8 (1.4, 3, 5, 10, 15, 20 MHz)

More than 35 bands currently specified for LTE in 3GPP (and more to come)

Terminal RF chain

Current spectrum options for LTE

X

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	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
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42	3400 MHz – 3600 MHz	3400 MHz – 3600 MHz	TDD
43	3600 MHz – 3800 MHz	3600 MHz – 3800 MHz	TDD

Note 1: Band 6 is not applicable

X

Inter-band combinations

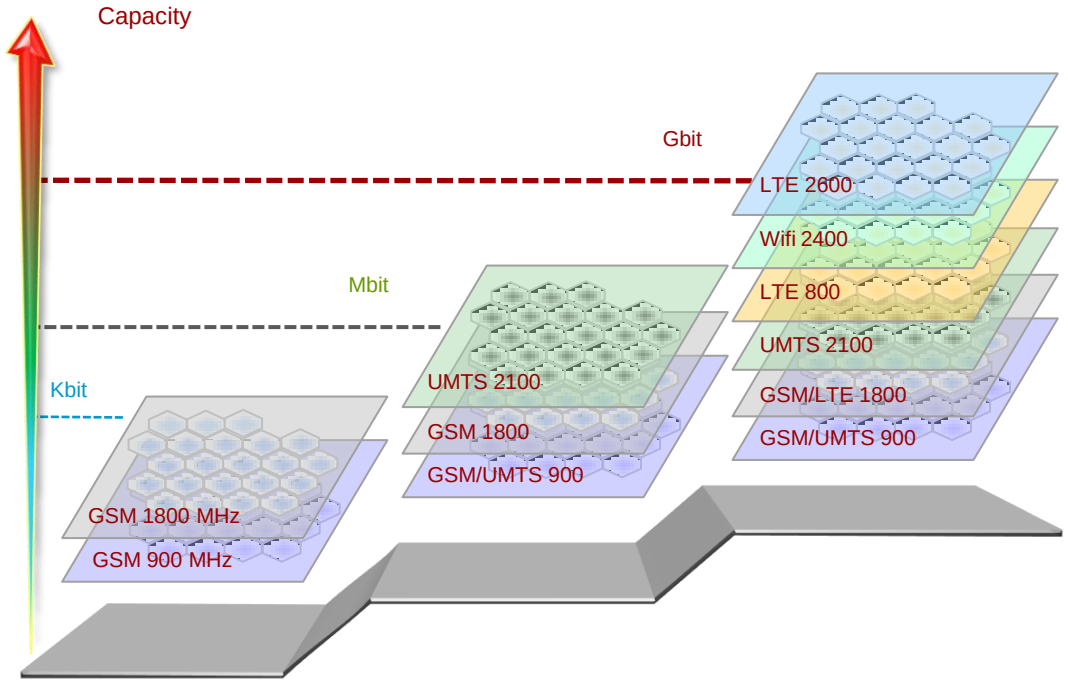
Inband contiguous or non-contiguous

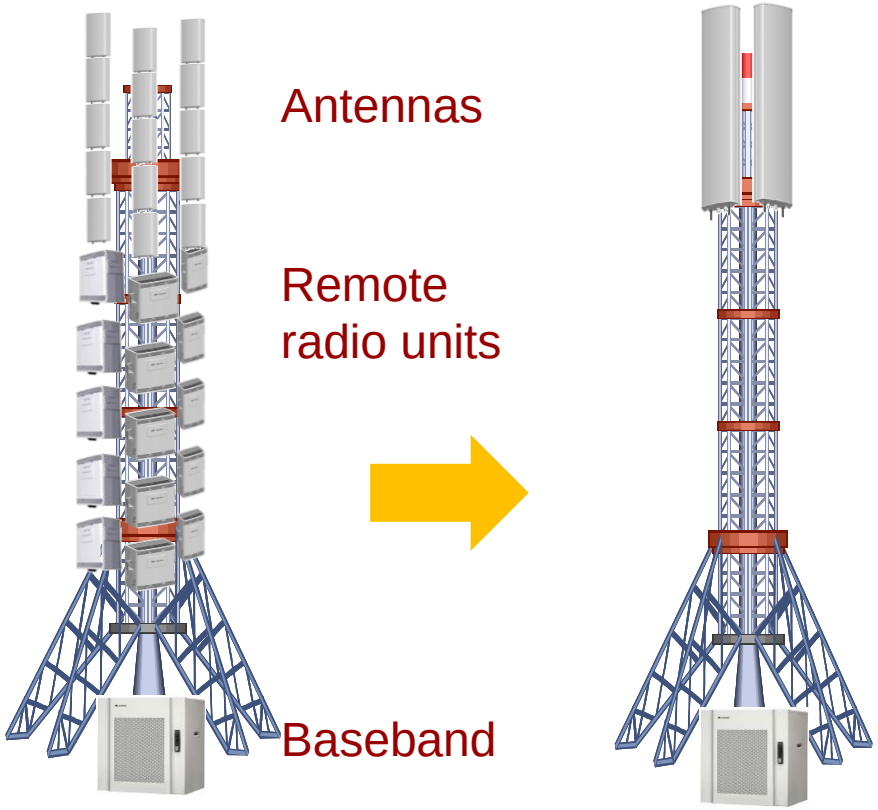
6 bandwidths available for LTE Rel-8 (1.4, 3, 5, 10, 15, 20 MHz)

More than 35 bands currently specified for LTE in 3GPP (and more to come)

LTE Rel-10 allows for Carrier Aggregation (up to 100 MHz)

Deployment challenge from spectrum and technology





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Multi-band Multi-standard Radio Unit (MB-MSR)

Present

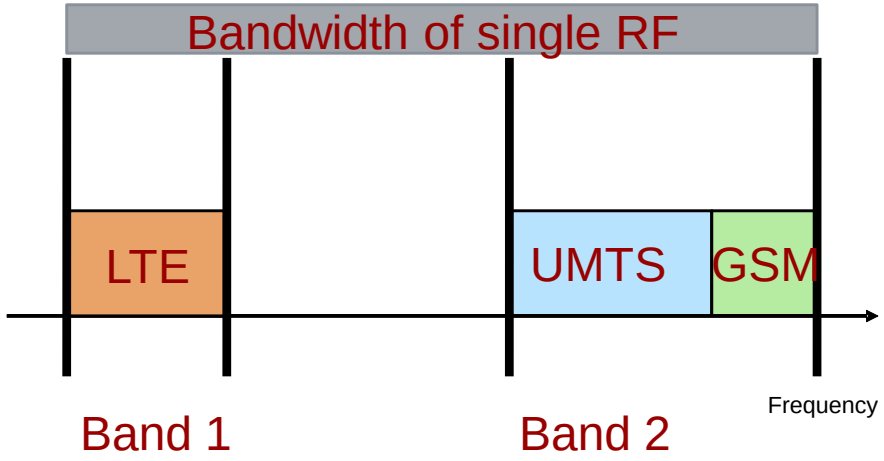
Single-band RF

3 boxes
(2 bands, 3 standards, multi-carrier, MIMO)

Future

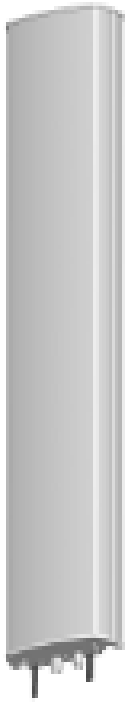
Dual-band RF

2 boxes
(2 bands, 3 standards, multi-carrier, MIMO)

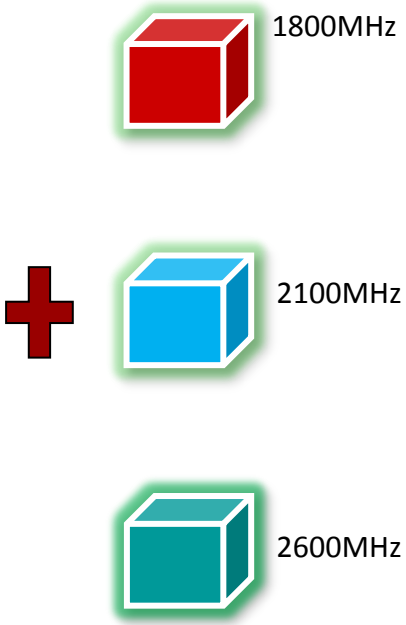


Active Antenna System (AAS)

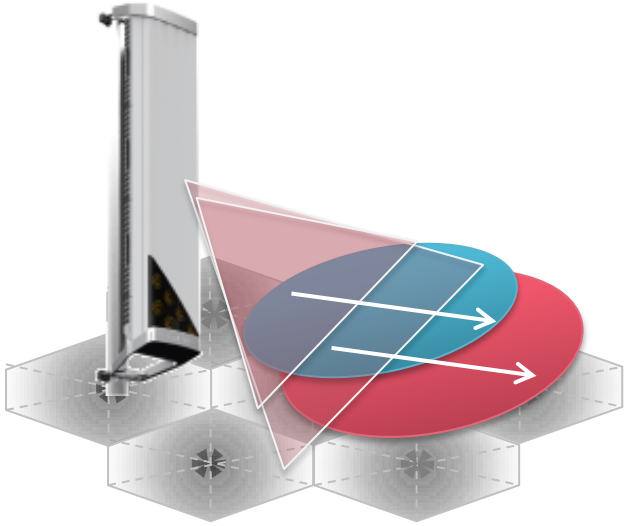
Antenna



RF Units

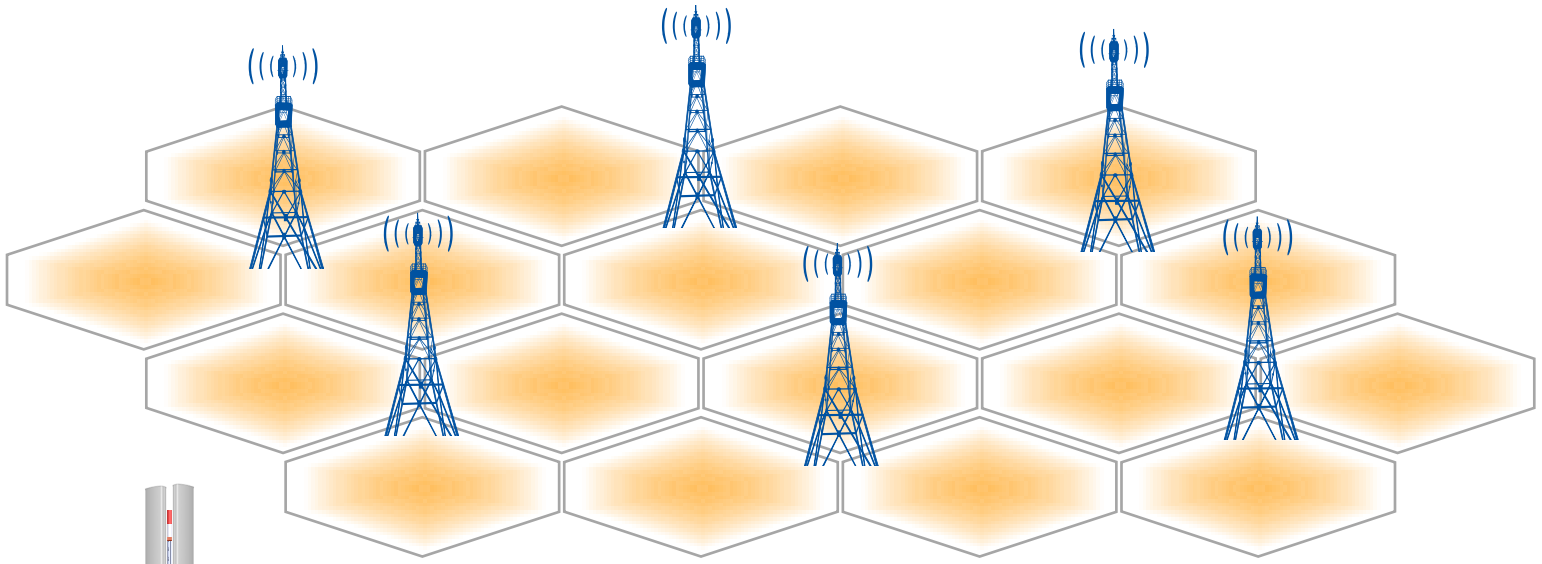


AAS



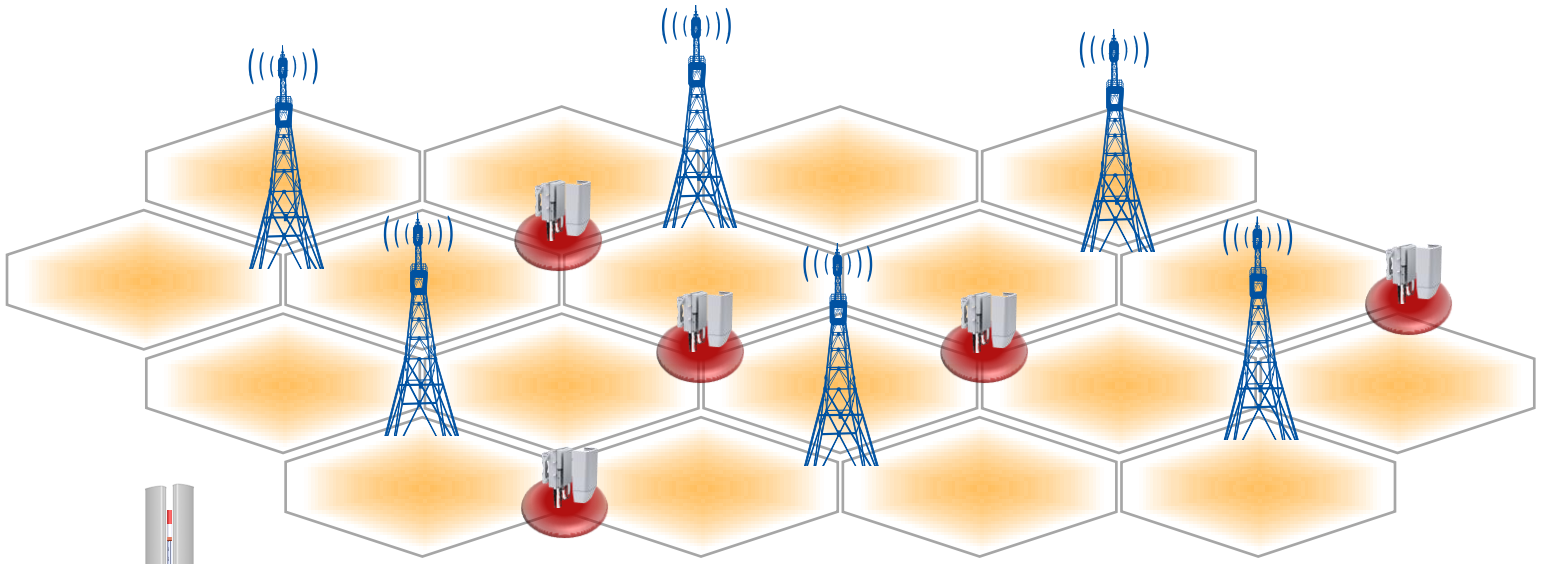
Enables user specific beamforming in Azimuth and Elevation (vertical cell split)

Network topology – getting closer to the traffic source



Macro-cell

Network topology – getting closer to the traffic source

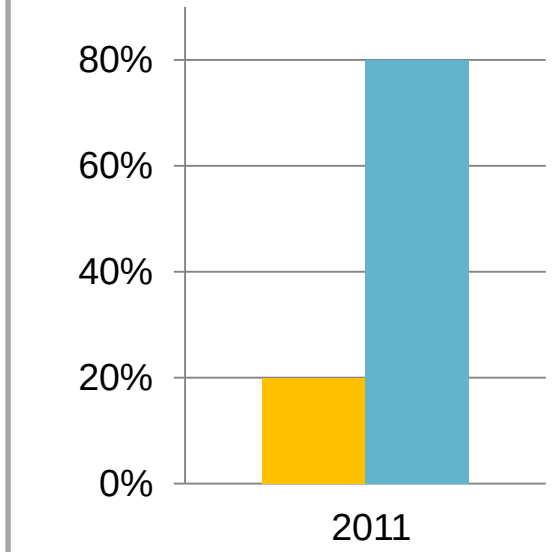


Macro-cell

Micro-cell

Field experience:

20% sites carry 80% traffic



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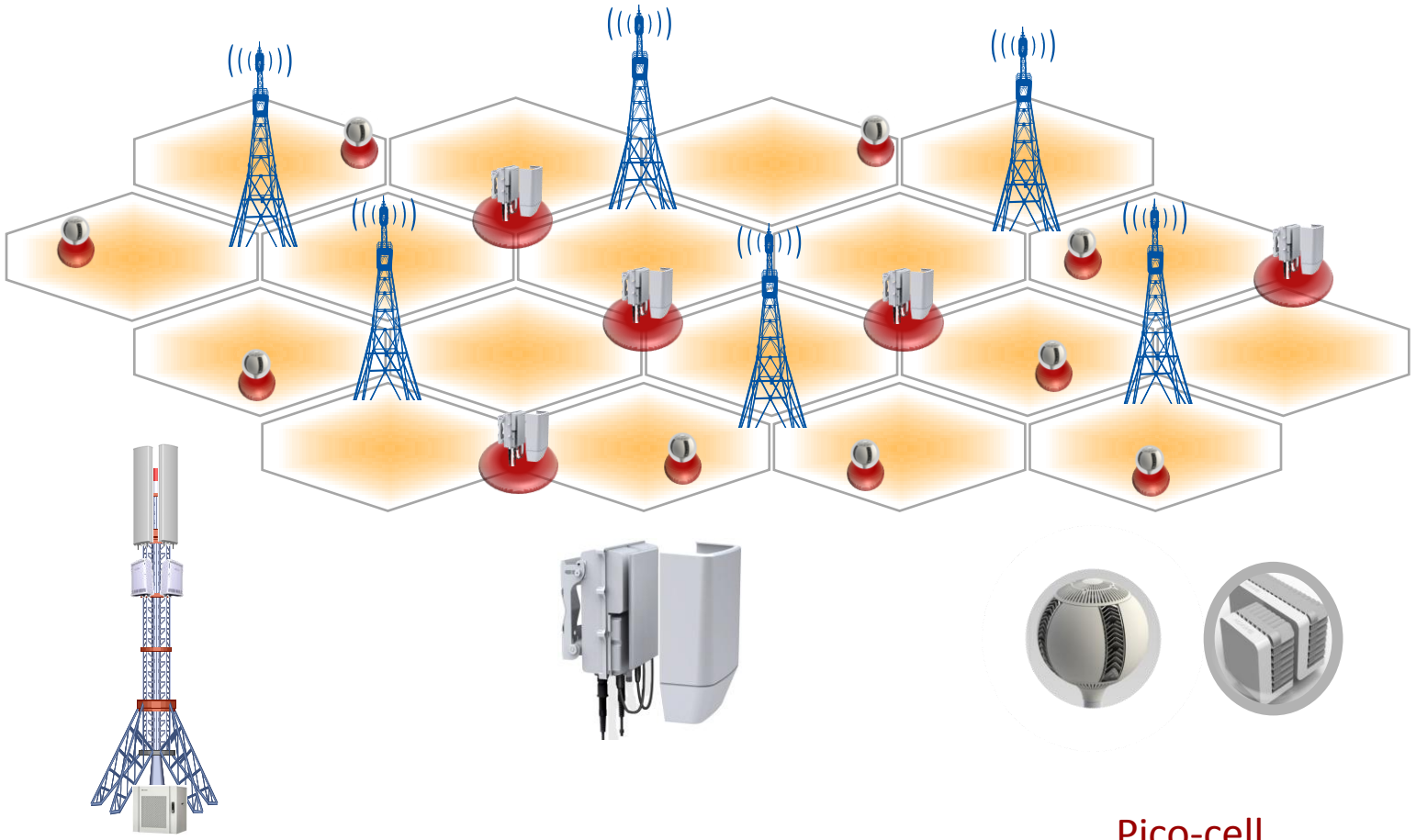
Network topology – getting closer to the traffic source



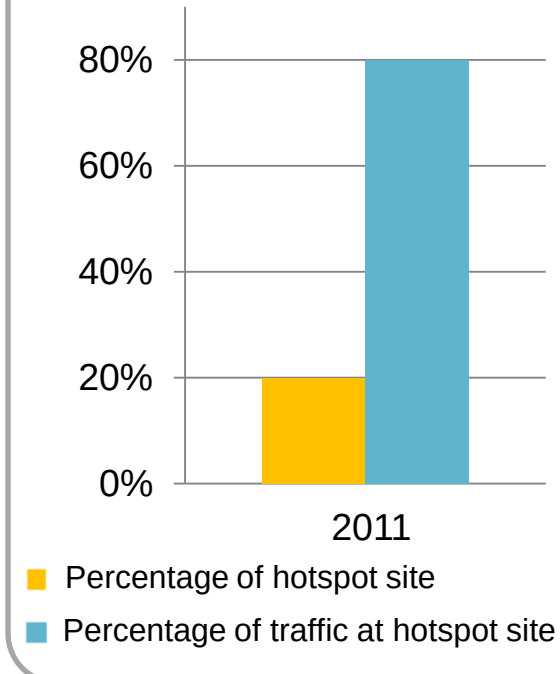
Macro-cell

Micro-cell

Pico-cell
(Atom-Cell)

Field experience:

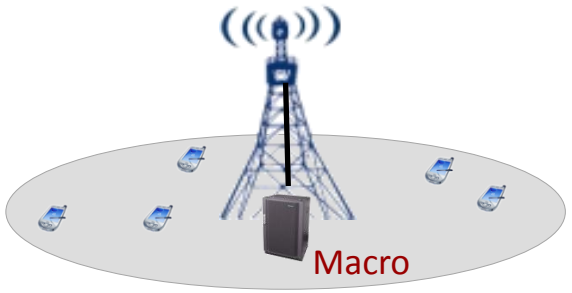
20% sites carry 80% traffic



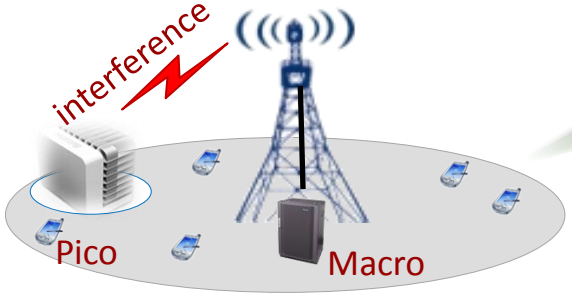
Evolution of heterogeneous network topology

Interference Management is crucial in co-channel deployments

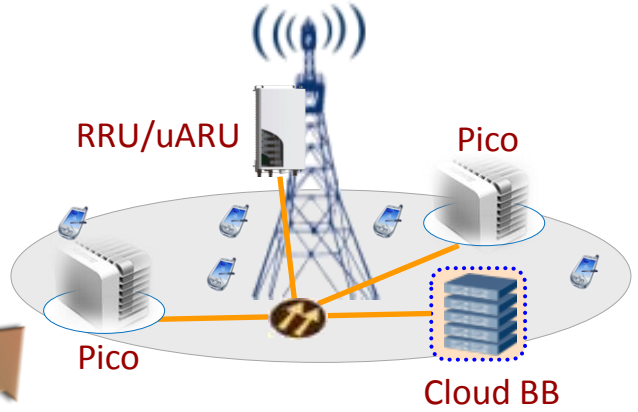
Standalone Macro
(baseline)



Non Interference Coordination:
Limited capacity gain



Well Coordinated :
Substantial capacity gain

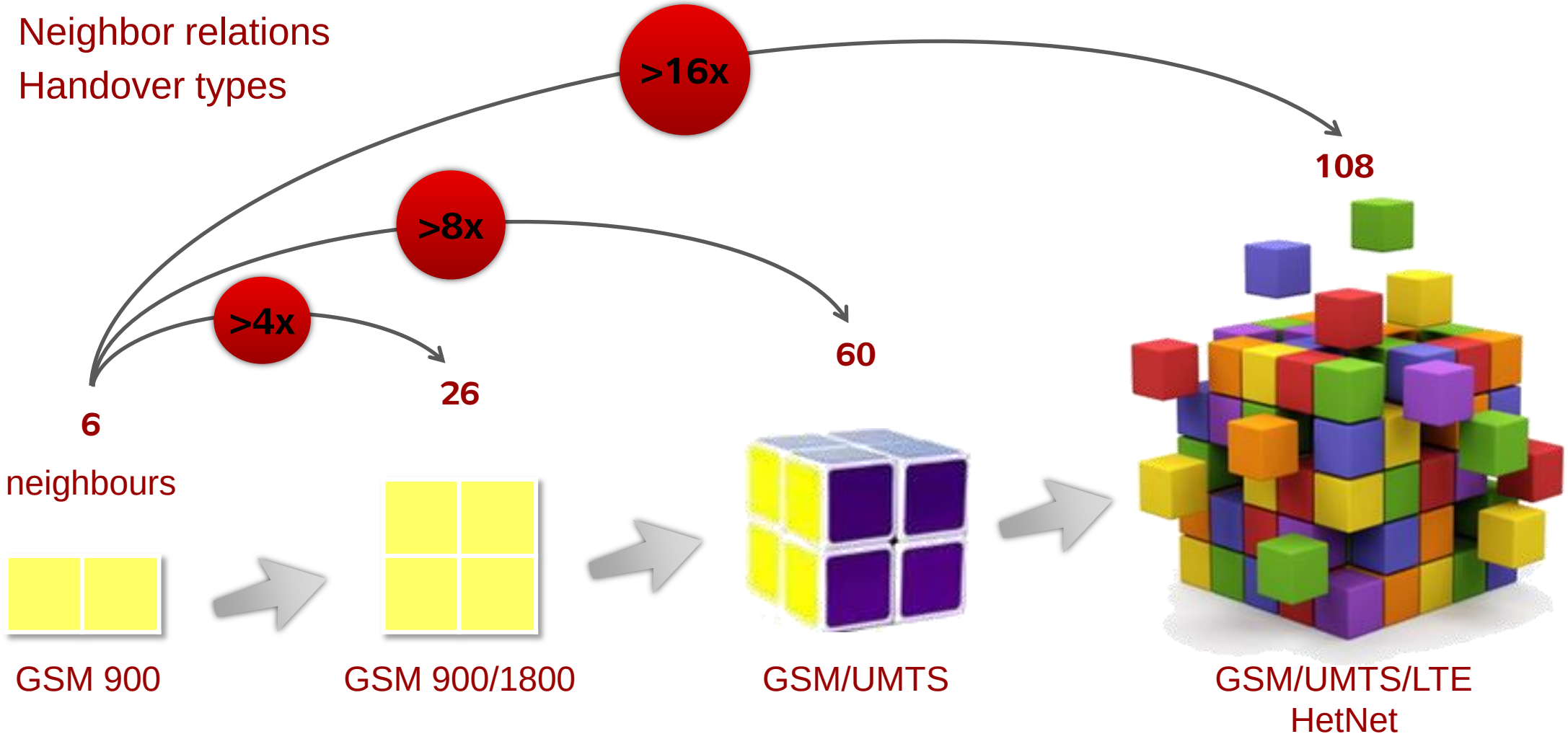


Key techniques

- Enhanced Inter-cell Interference Coord.
- Coordinated Multipoint Support (CoMP)
  DL (JP, CBF) , UL (IRC)
- Partially covered by
  3GPP Rel-10 and Rel-11 for LTE

Radio Resource Management Complexity Increase

- Neighbor relations
- Handover types



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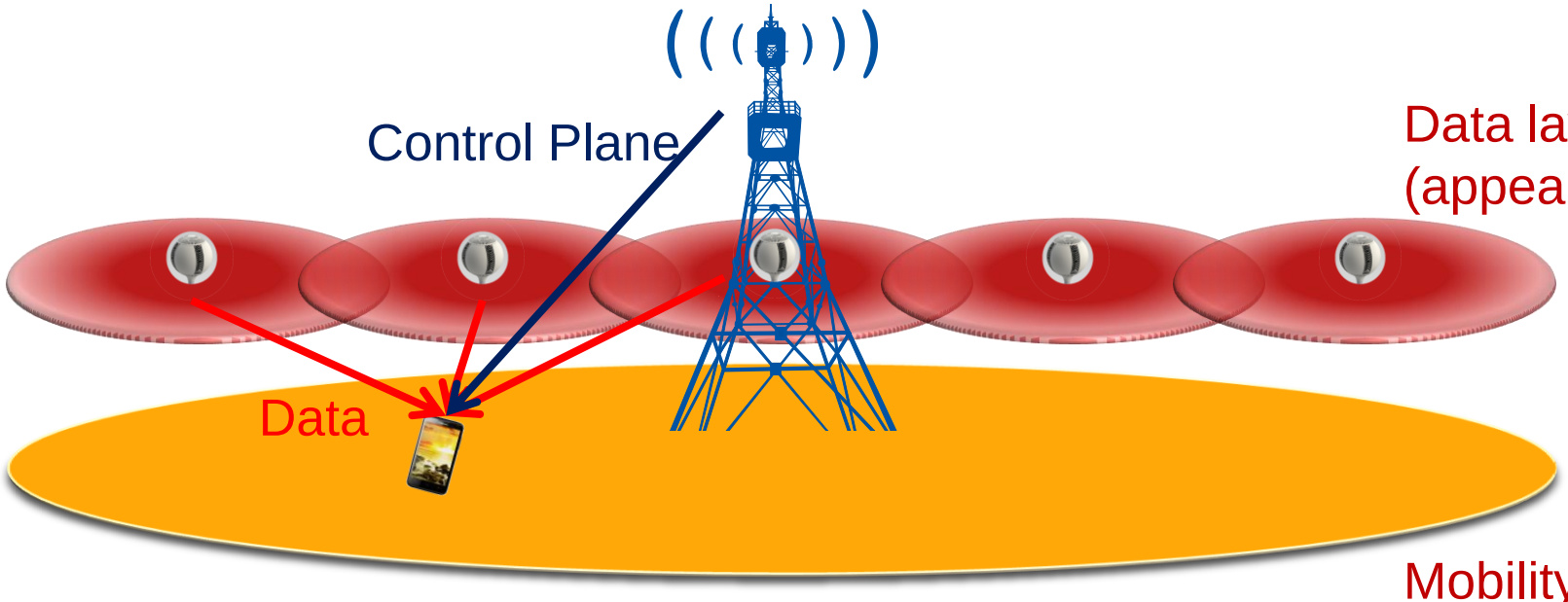
Towards a virtual cell concept



Data layer
(appears as a single cell)

Mobility layer
(transmitted from macro-cell only)

Terminal aggregates
data and mobility layers

Devices and Services

Smartphone

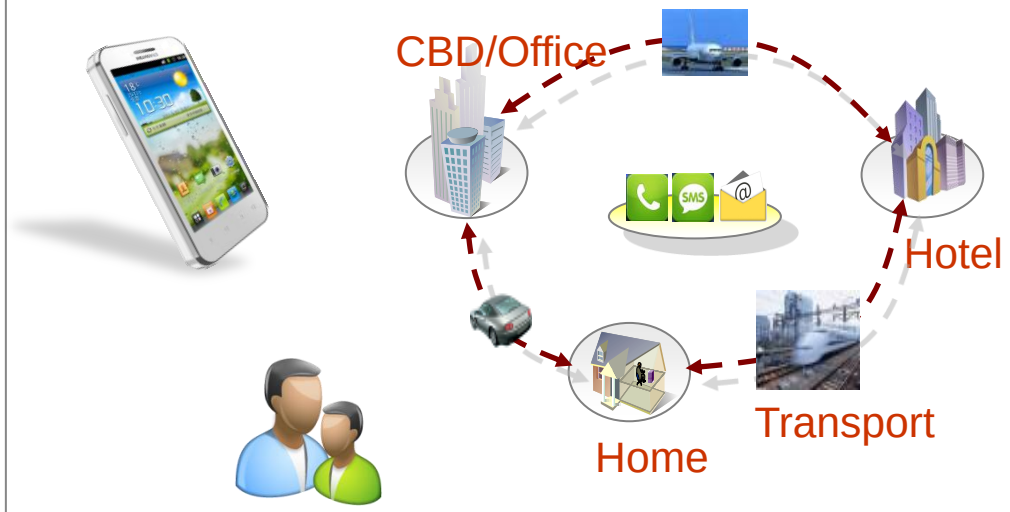
Tablet

Machine Type

Is it sufficient to dimension the pipe big enough ?

Smart phones – the «always on» challenge

Always On-line Anywhere



Using Various Applications Anytime

In UMTS, a single heartbeat message can generate more than 30 signaling exchanges between the smartphone and the network

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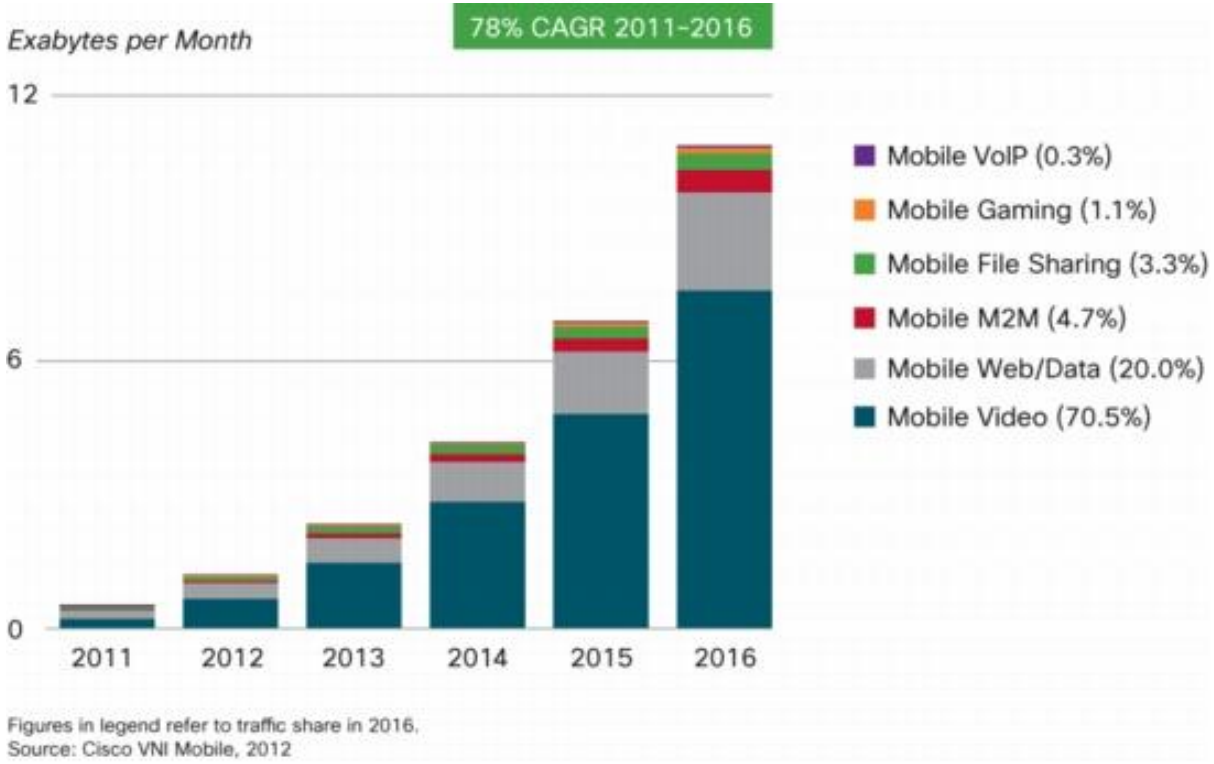
Video – the lion's share of mobile data

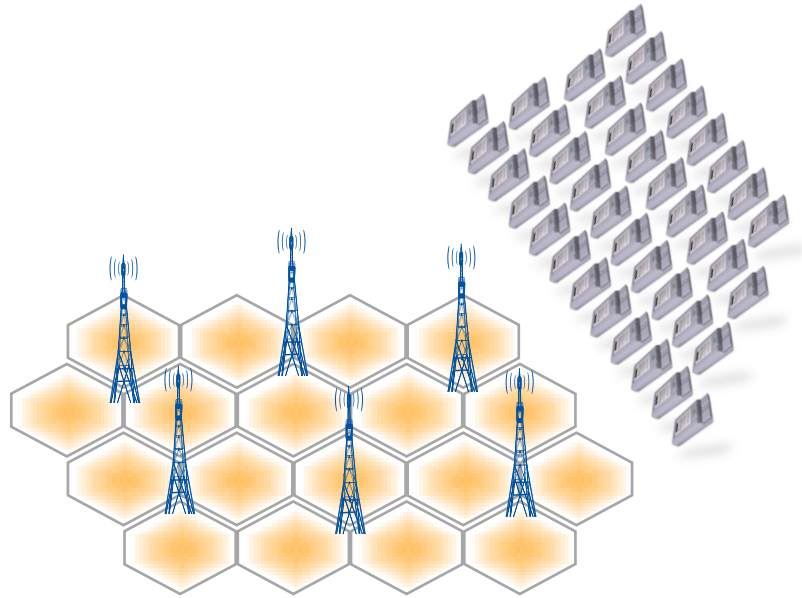


Figures in legend refer to traffic share in 2016.
Source: Cisco VNI Mobile, 2012

- **Transport alternatives**
  - Download
    - Long waiting time and local storage requirements
  - Broadcast mode
    - Dedicated mode/deployment, e.g. LTE MBSFN mode
    - Suitable for live events
  - Streaming
    - "Right on time"
    - High data rate and delay sensitive
- **Challenges for efficient streaming**
  - DASH – dynamic adaptive streaming over HTTP
  - An area for true cross-layer optimisation (radio <->application layer)

M2M – the fear of the locusts

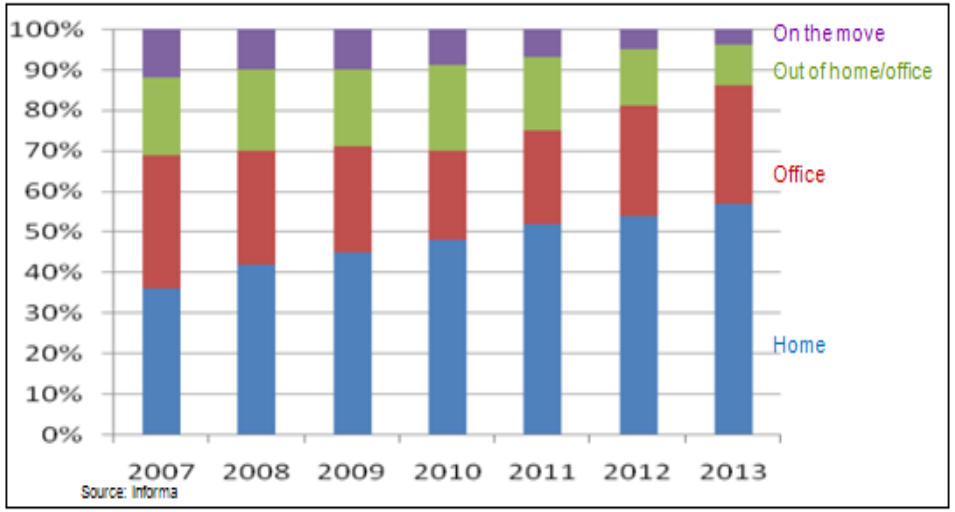
- **Devices outnumber subscribers by an order of magnitude**
  - Simultaneous access can lead to congestion
  - Roaming of M2M devices was seen as a potential thread
  - Overload control introduced in LTE Rel-10/Rel-11
  - Grouped signaling functions and priority handling are necessary



- **Cost challenge**
  - Main M2M use cases rely on low cost RF modules
  - Need to ensure coverage of low cost devices
  - Long renewal periods of M2M modules, e.g. in smart meters
  - Park of legacy modules increases and may delay network upgrades

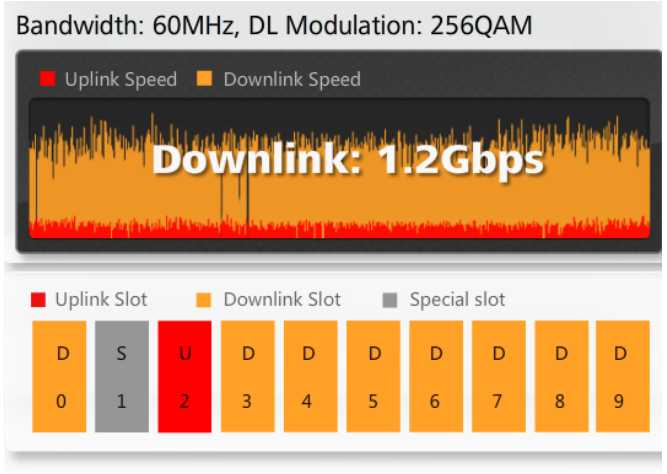
Hotspot and indoor – adapting to local traffic

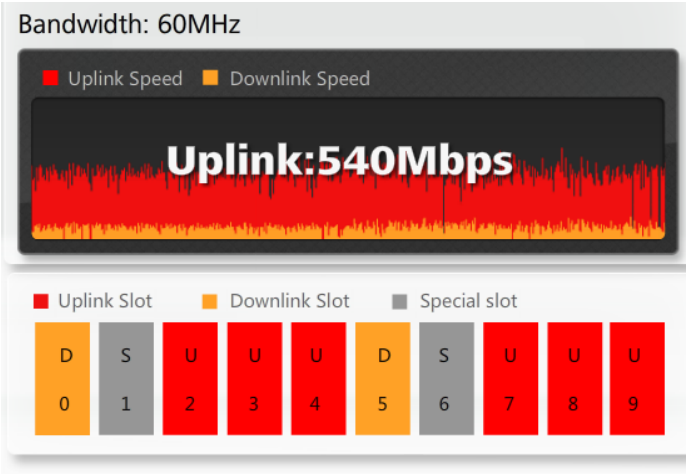
- **More than 80% of the traffic occurs indoor**



- **Characteristics of the scenario**
  - Intense traffic with highly asymmetric DL/UL ratio
  - High frequency bands, e.g. 3.5 GHz band
  - Low user mobility

- **Example of enhanced LTE TDD**
  - High peak rate
    (256 QAM and reduced overhead)
  - Flexible DL/UL ratio
    including extreme asymmetry
  - Guaranteed QoS and security





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Embracing heterogeneity by

- Enabling integration and interoperability of multiple radio technologies
- Solving the spectrum challenge with efficient sharing and RF integration
- New cell concepts for dense small cell deployments
- Making the radio access network smarter

A world community can exist only with world communication,

which means something more than extensive short-wave facilities scattered about the globe.

It means common understanding, a common tradition, common ideas, and common ideals.

Robert M. Hutchins (1899 – 1977)

Thank you

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