

# **TIES410 “Future Internet”**

## **Lecture Block II**

# Overview

- Spectrum issues & band allocations
- Multi-carrier and multi-band evolution
- Macro, micro, pico, femto
- Data offloading

# Meeting mobile data growth challenges

- Increase the spectral efficiency of existing channel
  - ◆ It is heavily associated with techniques, such as MIMO
  - ◆ However, it requires multiple antennas at both base station and a mobile
- Increase the size of communication channel
  - ◆ This is one of the most straightforward solutions
  - ◆ The associated challenge is that radio spectrum is very expensive and is not always contiguous
- Deploy more base stations
  - ◆ More base stations means less coverage holes and more places with a high signal strength
  - ◆ However, there still will be “cell edges”; network operation and maintenance also becomes cumbersome
- Offload mobile data to other access technologies

# Spectrum issues & band allocations

# Radio spectrum

- Each wireless technology needs a channel, which is physically a chunk of radio spectrum
- Radio spectrum can be “paired” or “non-paired”:
  - ◆ “Paired” or Frequency Division Duplexing (FDD)
    - ◆ It is used as a mainstream technology for GSM, WCDMA, HSPA+
    - ◆ Most LTE networks rely upon FDD
  - ◆ “Non-paired” or Time Division Duplexing (TDD)
    - ◆ It is used as a mainstream technology for IEEE 802.11/WiFi family and IEEE 802.16/WiMAX
    - ◆ LTE has a TDD variant called often as TD-LTE
    - ◆ WCDMA/HSPA also has a TDD variant
- Radio spectrum is handled and allocated by local regulators

# Ofcom unveils 4G spectrum winners

Source: Telegeography

20 Feb 2013

UK telecoms regulator Ofcom has revealed the names of those companies that successfully bid in the country's auction of fourth-generation spectrum. Following more than 50 rounds of bidding, five bidders have emerged with new frequencies, with all four of the country's existing mobile network operators laying claim to spectrum.

Vodafone (GBP790.761 million): 2×10MHz in the 800MHz band, 2×20MHz of 2.6GHz, 1×25MHz of 2.6GHz (unpaired)

EE (GBP588.876 million): 2×5MHz in the 800MHz band, 2×35MHz in the 2.6GHz band

Hutchison 3G UK (GBP225.000 million): 2×5MHz of 800MHz

O2 UK (GBP550.000 million): 2×10MHz of 800MHz

The BT (GBP186.476 million): 2×15MHz of 2.6GHz, 1×20MHz of 2.6GHz (unpaired) spectrum

# T-Mobile pays USD2.37bn for Verizon 700MHz licences

Source: Telegeography

7 Jan 2013

T-Mobile US has announced that its wholly-owned subsidiaries T-Mobile USA and T-Mobile License have signed agreements to purchase certain 700MHz A block spectrum licences from Verizon Wireless for USD2.365 billion in cash and the transfer of certain AWS and PCS spectrum licences, which have an aggregate estimated value of approximately USD950 million. Further, the two companies will also realign spectrum blocks in certain markets, primarily in northern California and the Atlanta area.

The transactions, when combined with T-Mobile's existing A block holdings in Boston, will result in the cellco holding low-band spectrum in nine of the top ten and 21 of the top 30 markets across the United States – including New York, Los Angeles, Dallas, Houston, Philadelphia, Atlanta, Washington DC and Detroit. T-Mobile anticipates rolling out services and compatible handsets on this A block spectrum as early as the fourth quarter of 2014.



# Orange returned 870MHz frequencies

Source: Telegeography

4 Feb 2013

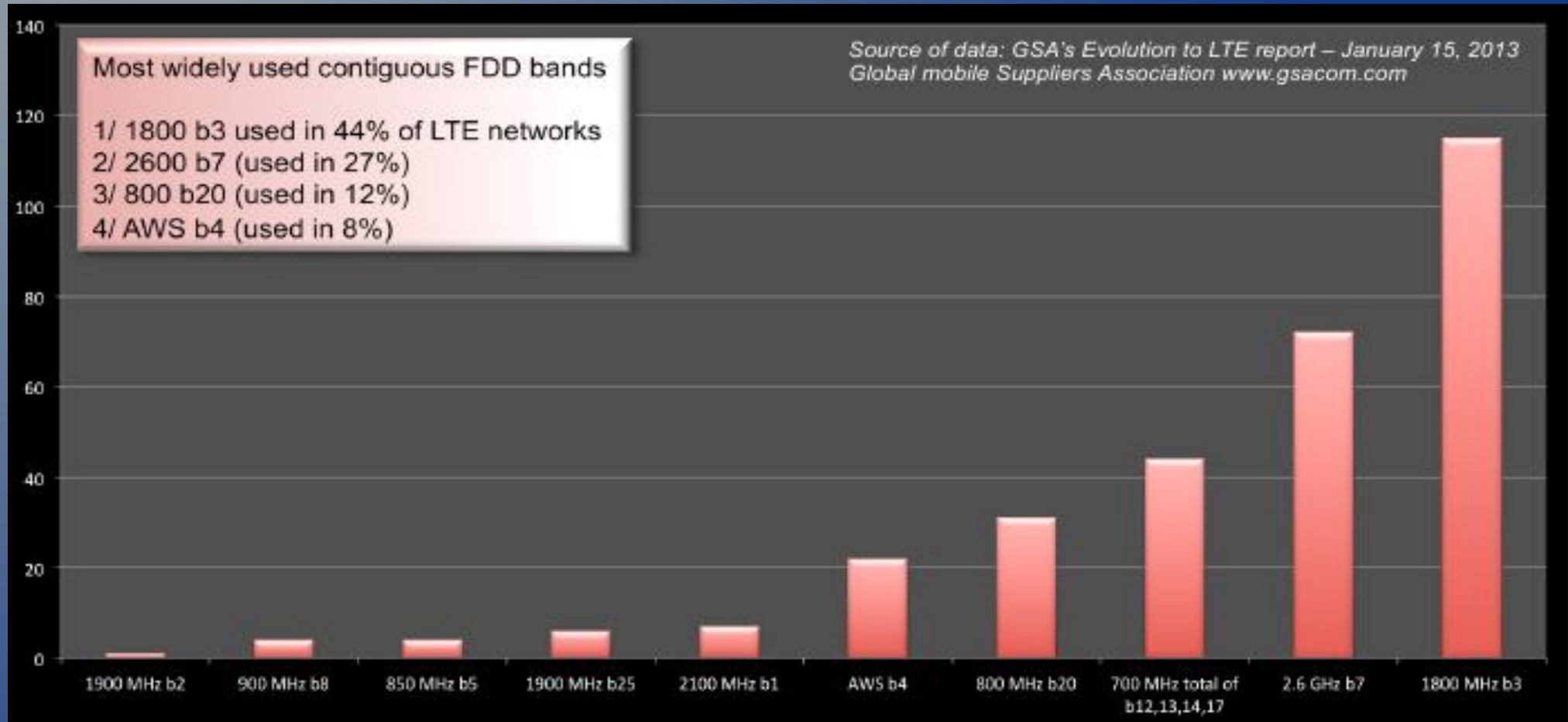
The Telecommunications Office of the Slovak Republic (TU SR) reports that Orange Slovakia has handed back mobile frequencies in the range 872MHz-876MHz, 917MHz-921MHz, which it acquired in 2008. The regulator says it can now potentially reallocate the spectrum, although Orange gave the reason for returning the frequencies as weak availability of terminal equipment in the 870MHz band.



# FDD vs. TDD

- Comparison between FDD and TDD might be somewhat academic
- In most cases an operator simply cannot choose freely
- In some countries local regulators offer either TDD or FDD
- Operator choice is governed quite often by what a regulator offers and/or what an operator already has, and what competitors do
  - ◆ Europe: predominantly FDD, but there are TDD trials as well
  - ◆ US: predominantly FDD, and there are also TDD trials
  - ◆ China: mostly TDD
- As of 2014, 235 LTE FDD networks, 15 LTE TDD networks, 13 LTE FDD&TDD networks

# LTE FDD and TDD bands



TDD bands of commercially deployed networks:

- 2.3 GHz (band 40)
- 2.6 GHz (band 38 and band 41)
- 3.5 GHz (band 48)

# TD-LTE trials launched in two new cities

Source: Telegeography

4 Feb 2013

China Mobile, the world's largest cellco by subscribers has activated trial 4G Time Division Long Term Evolution (TD-LTE) networks in two new cities, Hangzhou and Wenzhou, both in Zhejiang province, Tech in Asia reports citing state news agency Xinhua. The Hangzhou network comprises 2,400 base stations, covering 500 square kilometres and will serve around five million people. Subscribers in the city can take part in the trials by paying a CNY500 (USD79.4) deposit and choosing from a number of 4G packages, which are reportedly similar in price to its current 3G offerings. China Mobile will also showcase the platform by converting one city bus route into a '4G City Experience' by providing TD-LTE speeds via Wi-Fi.

# China Mobile and China Telecom look to sell 136m 4G devices in 2014

Source: Telegeography

24 Jan 2014

China Mobile and China Telecom are aiming to sell a combined total of 136 million 4G Time Division Long Term Evolution (TD-LTE) devices in 2014, DigiTimes quotes unnamed industry sources as saying. China Mobile, the world's largest wireless provider by subscribers is aiming to sell 100 million TD-LTE terminals, as well as 90-120 million devices compatible with its home-grown TD-SCDMA 3G platform.

Meanwhile CDMA operator China Telecom, the smallest of China's trio of cellcos, has set its sights on selling 36 million 4G devices in 2014, alongside 64 million 3G (CDMA2000) terminals. Telecom is currently in the process of procuring 300,000 TD-LTE MiFi routers, USB modems and CPE (customer premises equipment) devices, the sources claimed, saying that domestic vendors Huawei and ZTE were major bidders for the contract. In addition, China Telecom plans to launch entry-level TD-LTE smartphones priced at CNY1,000 (USD163.8) in the first half of 2014 as well as mid-range and high-end models in the second half. China's second-largest cellco, China Unicom, also has a concession for TD-LTE services, but intends to concentrate its attention on rival platform Frequency Division (FD)-LTE.

# Wireless channel size

- Depending on the wireless access technology design, the “size” of the wireless channel is either fixed or can be scaled
- WCDMA/HSPA
  - ◆ One carrier has a fixed size of 5MHz
  - ◆ There is however an ongoing SI to allow also 1.25 and 2.5MHz
- IEEE 802.16 WiMAX / LTE
  - ◆ The carrier size can take a number of fixed pre-defined values
  - ◆ IEEE 802.16 WiMAX: 1.25, 3.5, 5, 7, 8.75, 10, 14, 17.5, 28 MHz
  - ◆ LTE: 1.4, 3, 5, 10, 15, 20 MHz



# LTE-U

- Any versatile wireless access technology can adopt to a different band and/or bandwidth size
- Practically, nothing prevents from running LTE (or even HSPA) in the non-licensed spectrum
- LTE-U has become a hot discussion topic in 3GPP and in the whole industry
  - ◆ Allows for deploying LTE pico/femto cells in the unlicensed spectrum
  - ◆ Almost unlimited potential for data offloading
- Some potential drawbacks and uncertainties:
  - ◆ Co-existence with other technologies, such as WiFi and Bluetooth
  - ◆ Lack of network and interference control, and as a result risks of failed service, such as voice
  - ◆ Non-technical aspects, such as big WiFi vendors are now threatened by another technology competing with them in the same domain

# Key observations

- Every wireless access technology needs a “channel” to exchange data, which is a chunk of radio spectrum
- Regulators are in charge of allocation radio spectrum
- Depending on the technology and other factors, radio spectrum is allocated as FDD or TDD blocks
- Each block can vary in size depending on wireless technology capabilities and needs
- A possibility to combine different options results in segmentation of wireless market
- Deployment of LTE (and even HSPA) in unlicensed spectrum becomes a hot topic



# Multi-carrier and multi-band evolution

# General motivation

- Operators do not always have available spectrum in the same band
- Sometimes, the spectrum in the same band is not contiguous, i.e., it is scattered into several chunks
- It also often the case that operators intentionally go for spectrum in different bands
  - ◆ Low bands for coverage purposes
  - ◆ High bands for capacity
- The ultimate challenge is how to take full benefit of available spectrum

# HSPA and LTE bandwidth adaptation

- HSPA and LTE can adapt to available spectrum resources, but in slightly different ways
- HSPA:
  - ◆ The basic building block is 5MHz, a single carrier
  - ◆ Up to 8 carriers can be aggregated as per Rel-11
  - ◆ Carriers can reside in the same or different bands (two at most)
- LTE:
  - ◆ The basic building block is a carrier, which can vary from 1.4 to 20 MHz
  - ◆ There can be up to 5 carriers (total bandwidth of 100 MHz)

# Megacom upgrades to DC-HSPA+

Source: Telegeography

20 Jan 2014

Kyrgyz mobile operator Megacom upgraded around 20% of its base stations last year with Dual Carrier (DC)-HSPA+ technology, which enables maximum download speeds of up to 42Mbps. The cellco said that the majority of upgraded 3.5G base stations are located in the major cities of Bishkek, Osh and Jalal-Abad, where the demand data is particularly large. Coverage of Megacom's entire 3G network currently stands at around 50% of the country's populated territory and the company says it will continue to upgrade and expand the network during 2014.

Meanwhile, rival cellco Sky Mobile (operating under the Beeline brand) has installed 14 new GSM base stations in the provinces of Chui, Osh, Jalal-Abad, Naryn, Batken and Issyk-Kul to improve voice quality in the regions.

# Vimpelcom extends DC-HSPA+ network to St Petersburg

Source: Telegeography

7 Jan 2014

Russian mobile giant Vimpelcom, which operates under the Beeline brand name, has introduced Dual Carrier HSPA+ (DC-HSPA+) technology in the city of St Petersburg, providing customers with downlink speeds of up to 42Mbps. According to the cellco, 3G coverage in the city rose by 20% during 2013.

According to TeleGeography's GlobalComms Database, in January 2013 Vimpelcom revealed its intention to deploy DC-HSPA+ networks in seven of Russia's largest cities, in tandem with its ongoing LTE rollout. Moscow and the Moscow Oblast were the first regions to witness improved connectivity, in 1H13.

# Qualcomm First to Demonstrate LTE Advanced Carrier Aggregation

Source: 4G Americas

25 Feb 2013

Qualcomm Incorporated (NASDAQ: QCOM) today announced that its wholly-owned subsidiary, Qualcomm Technologies, Inc., in conjunction with Sierra Wireless and Ericsson, has successfully demonstrated LTE carrier aggregation and Category 4 data rates. LTE carrier aggregation is an important new technology that combines radio channels within and across bands to increase user data rates, reduce latency and enable LTE Category 4 downlink throughput speeds of up to 150Mbps for operators without 20MHz of continuous spectrum. The demonstration, powered by the third-generation Qualcomm Gobi 4G LTE MDM9225™ chipset — the first in the industry to support LTE carrier aggregation — Sierra Wireless' AirCard mobile hotspot and Ericsson network infrastructure will be displayed at the Qualcomm and Ericsson booths at Mobile World Congress in Barcelona.



# LTE carrier aggregation trends

- As per Rel-11, LTE can aggregate carriers only in two different bands
- In Rel-12, a possibility to aggregate carriers in three bands will be added (3DL/1UL)

◆ band2, band2, band13	1900/ 1900/ 700 MHz
◆ band2, band4, band13	1900/ 2100/ 700 MHz
◆ band2, band5, band30	1900/ 850/ 2300 MHz
◆ band2, band17/20, band30	1900/ 700/ 2300 MHz
◆ band4, band4, band13	2100/ 2100/ 2300 MHz
◆ band4, band5, band30	2100/ 850/ 2300 MHz
◆ band4, band17, band30	2100/ 700/ 2300 MHz
◆ band4, band29, band30	700/ 850/ 2300 MHz



# SKT and LG Uplus outline plans for deployment of 3band LTE-Advanced technology

Source: Telegeography

21 Jan 2014

South Korean mobile network operators SK Telecom (SKT) and LG Uplus have both separately revealed plans to deploy an upgraded 4G service later this year which they claim will offer speeds up to four times faster than possible with standard Long Term Evolution (LTE).

In a press release market leader SKT said it had successfully developed what it termed 'LTE-Advanced 3band Carrier Aggregation (CA)', which it said aggregates three bands – 20MHz + 10MHz + 10MHz – to support speeds of up to 300Mbps. With LTE-Advanced 3band CA expected to be commercialised by the end of 2014, SKT has said it plans to showcase the technology at MWC 2014, to be held in Barcelona next month. At the global exhibition, the cellco has confirmed it will demonstrate 450Mbps LTE-A by aggregating three component carriers (20MHz + 20MHz + 20MHz).

Meanwhile, GlobalPost reports that LG Uplus plans to roll out higher speeds via the combining of a 40MHz block of spectrum in the 2.6GHz band, a 20MHz block in the 800MHz band and a 20MHz block of 2100MHz frequencies. South Korea's smallest cellco by subscribers, LG Uplus was cited as saying of its plans: 'The 3band CA technology marks another progress from wider-bandwidth LTE-A service, and our demonstration proves our technology competitiveness ... The service will be available by the end of this year, with facilities and devices supporting the network under development.'

# Macro, micro, pico, femto Data offloading





# Macro, micro, pico, femto (big picture)

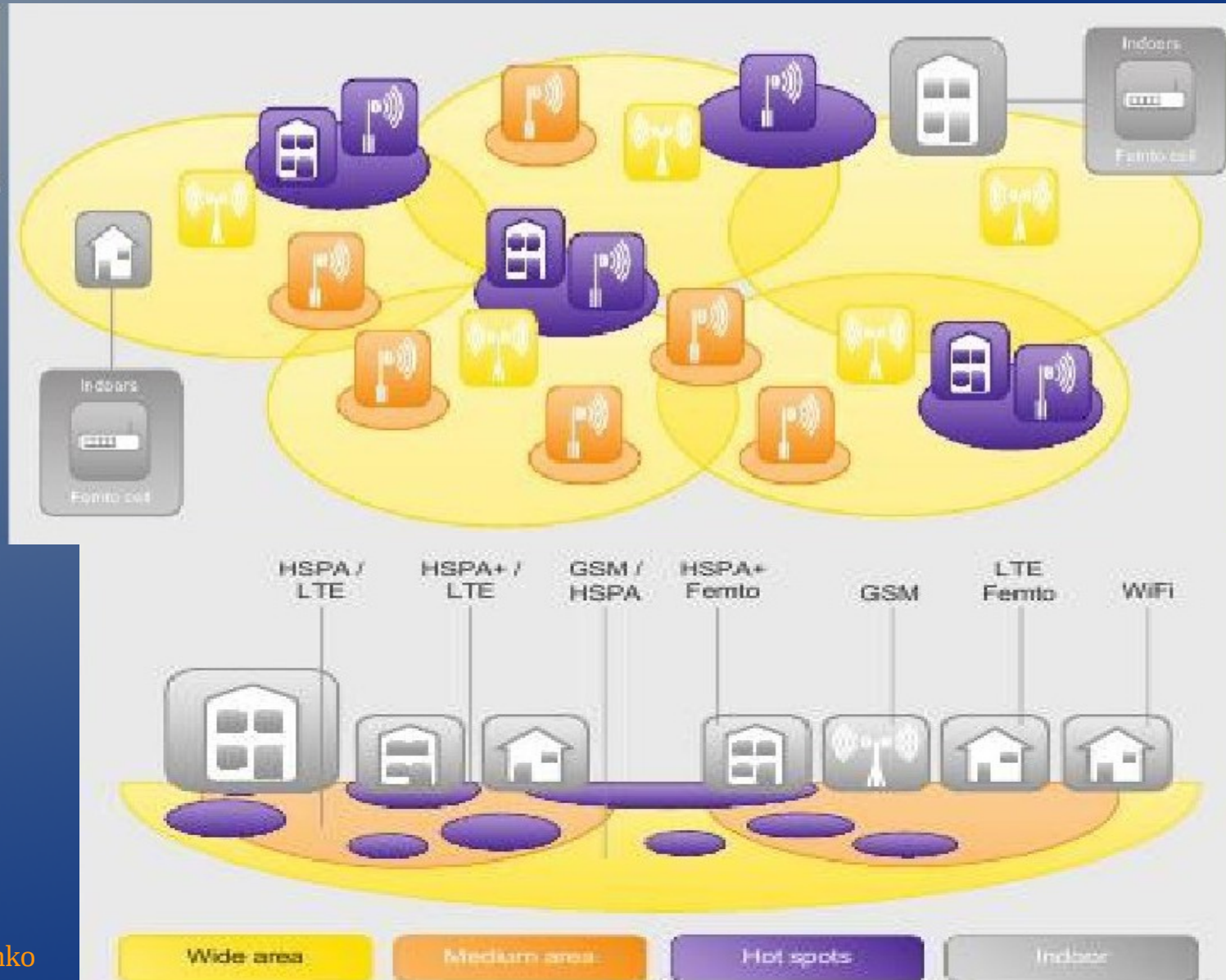


Source: 4G Americas



# Macro, micro, pico, femto

	Cell radius	Tx power
 Macro cell	> 300m	46 dBm
 Micro cell	100-300m	40 dBm
 Pico cell	< 200m	> 24 dBm
 Femto cell	10-25m	< 20 dBm



Source: NSN

# Deutsche Telekom teams up with Fon for blanket Wi-Fi network

Source: Telegeography

5 Mar 2013

Deutsche Telekom (DT) and global Wi-Fi provider Fon have unveiled a new partnership which will enable the Bonn-based operator to launch Germany's largest Wi-Fi network. With 'WLAN TO GO', users who share their home Wi-Fi with other users will gain access to around eight million FON hotspots across the world, free of charge, from the summer of 2013.

# Telefónica demonstrates seamless 4G-WiFi handover

Source: Telegeography

26 Feb 2013

While Wi-Fi is an excellent complement of a mobile network to efficiently increase network data capacity and indoor coverage in high density traffic areas, Telefónica believes that Wi-Fi's real value will come when it is fully integrated with 3rd Generation Partnership Project (3GPP) based mobile technologies. Telefónica's demo at the MWC showcases highly advanced network features enabling seamless handover between Wi-Fi and LTE and also implementing a set of network policies easing the discovery and selection of the network, regardless of the access technology and transparently to the customer. WiFi and LTE networks in seamless integration enabling communication uninterrupted service sessions during handovers across access technologies.