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EXPO : OCTOBER 3-4

INTEROP[®]

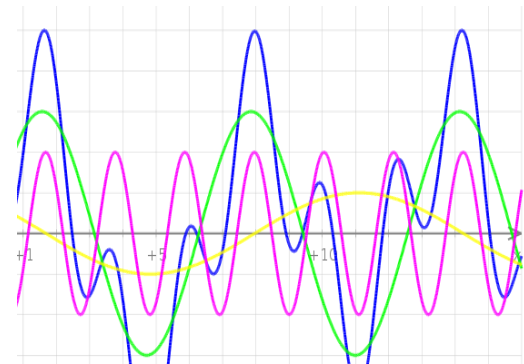
NEW YORK, NY
JAVITS CENTER

Wireless & Mobility

Everything You Need to Know About LTE

Fanny Mlinarsky
octoScope, Inc.

3-Oct-2012



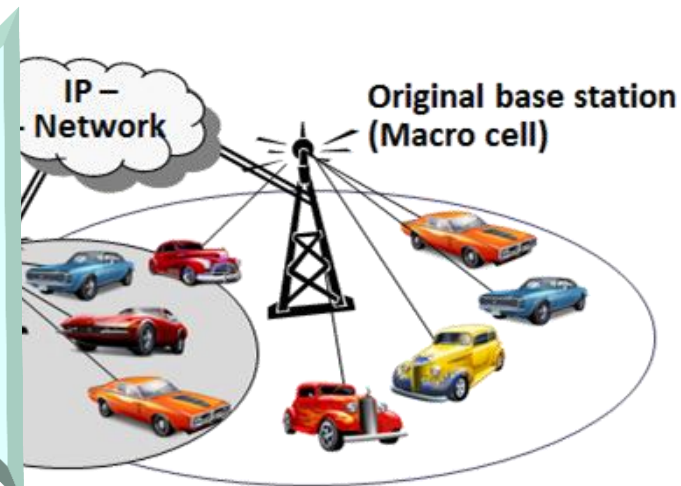
www.octoscope.com

Introductions - Fanny Mlinarsky

- President of octoScope
- Formerly with Azimuth Systems, Agilent, Teradyne
- Wireless industry CTO and entrepreneur



octoBox™ Wireless Testbed

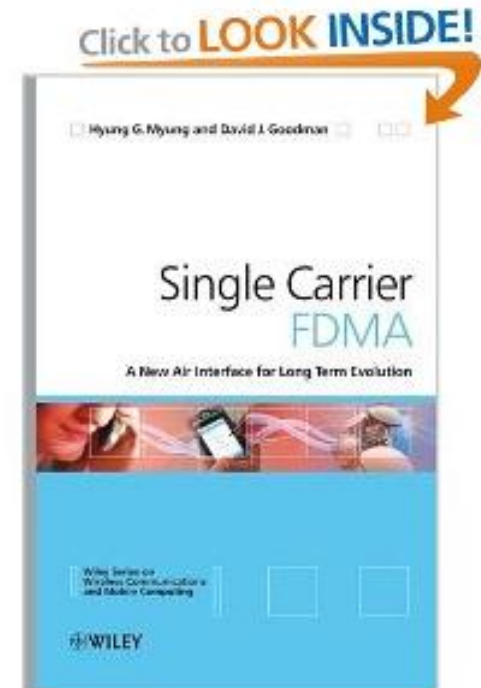


Test applications include:

- Range
- Roaming
- Mesh
- Connected vehicle
- Etc,

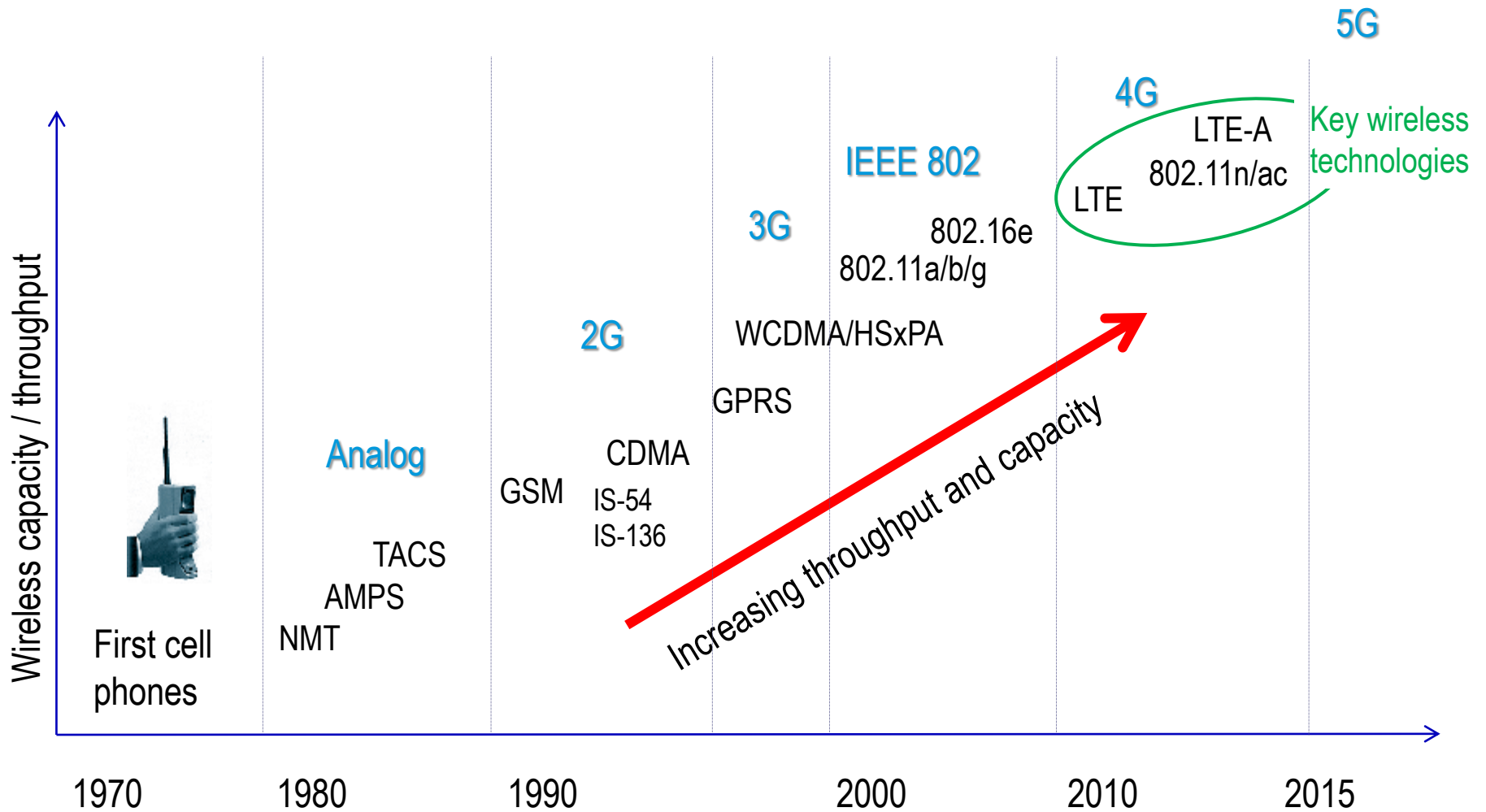
Introductions - Dr. Hyung Myung

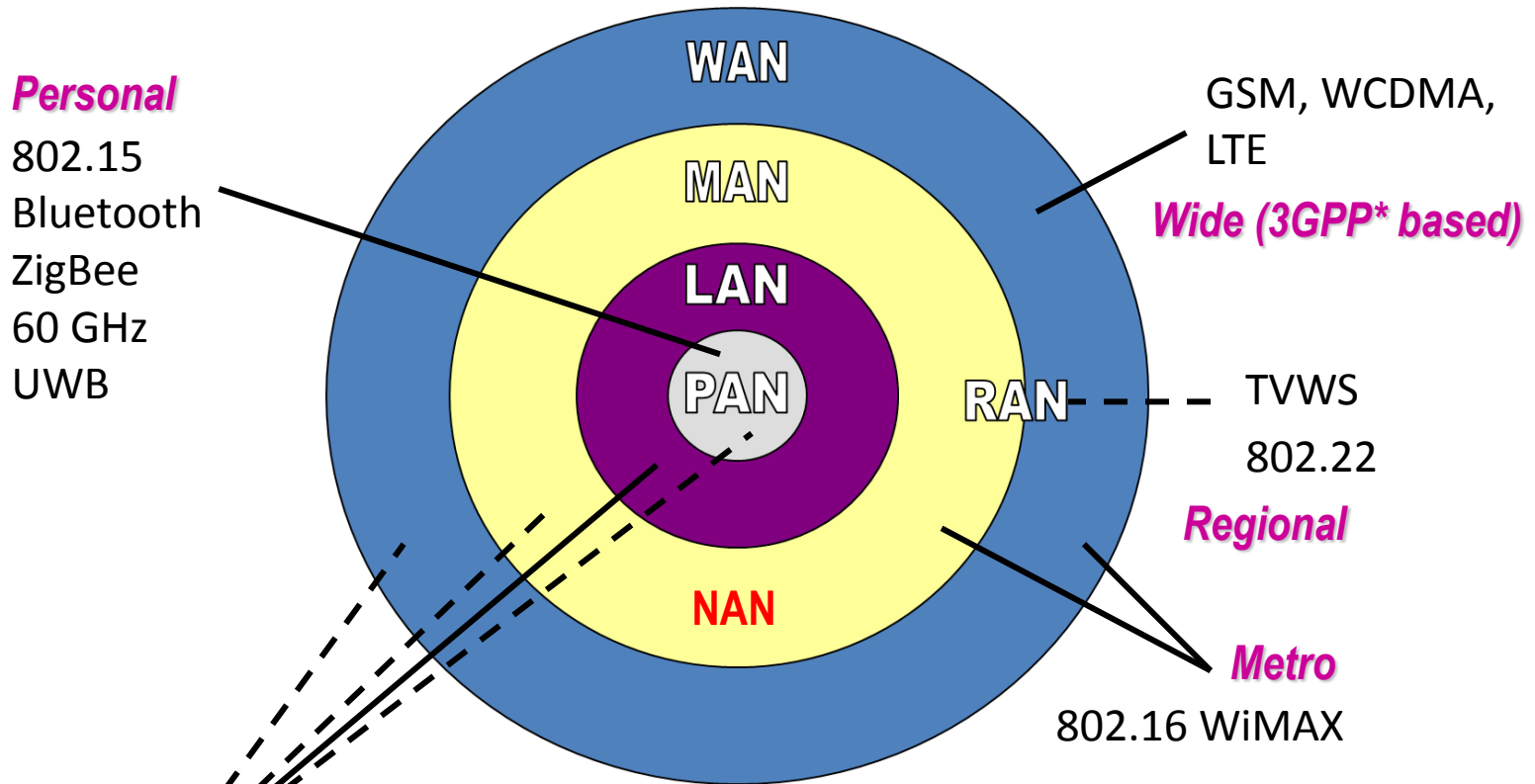
- Qualcomm Staff Engineer
- Previously with ArrayComm, Samsung Advanced Institute of Technology, InterDigital
- Republic of Korea Air Force; Department of Electronics Engineering at Republic of Korea Air Force Academy faculty member
- BS and MS degrees from Seoul National University, South Korea, MS degree from Santa Clara University, and PhD from Polytechnic Institute of NYU



“Single Carrier FDMA: A New Air Interface for Long Term Evolution”, (Wiley, 2008), by [Hyung G. Myung](#) and [David Goodman](#)

Evolution





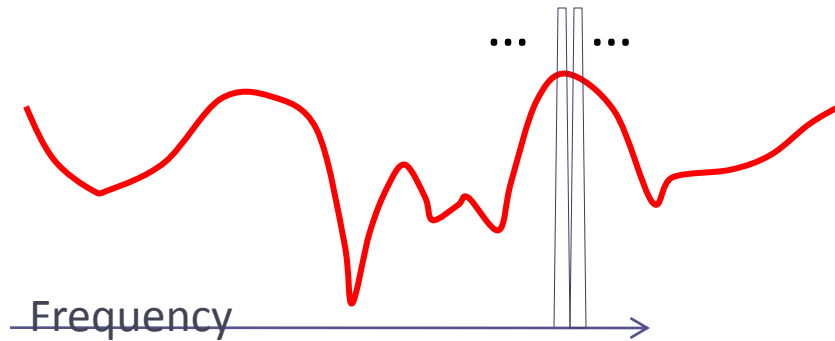
LAN = local area networking
 PAN = personal area networking
 MAN = metropolitan area networking
 WAN = wide area networking
 NAN = neighborhood area network
 RAN = regional area networking
 TVWS = television white spaces
 3GPP = 3rd generation partnership project

G	The G's	Peak Data Rate (Mbps)	
		Downlink	Uplink
1	Analog	19.2 kbps	
2	Digital – TDMA, CDMA	14.4 kbps	
3	Improved CDMA variants (WCDMA, CDMA2000)	144 kbps (1xRTT); 384 kbps (UMTS); 2.4 Mbps (EVDO)	
3.5	HSPA (today)	14 Mbps	2 Mbps
3.75	HSPA (Release 7) DL 64QAM or 2x2 MIMO; UL 16QAM	28 Mbps	11.5 Mbps
	HSPA (Release 8) DL 64QAM and 2x2 MIMO	42 Mbps	11.5 Mbps
3.9	WiMAX Release 1.0 TDD (2:1 UL/DL ratio), 10 MHz channel	40 Mbps	10 Mbps
	LTE, FDD 5 MHz UL/DL, 2 Layers DL	43.2 Mbps	21.6 Mbps
	LTE CAT-3	100 Mbps	50 Mbps
4	LTE-Advanced	1000 Mbps	500 Mbps

5G? 802.11ac – up to 6.9 Gbps

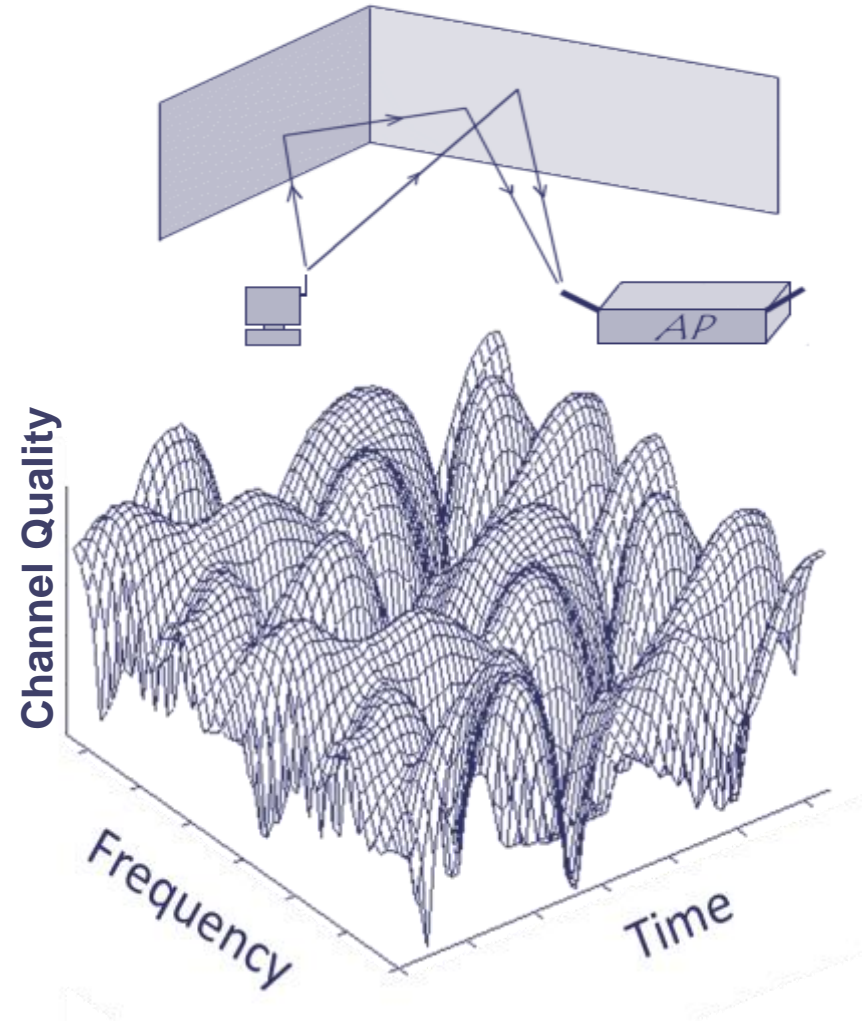
4G => OFDM

- Frequency and time variable wireless channel
- Multipath creates a sum of multiple versions of the TX signal at the RX

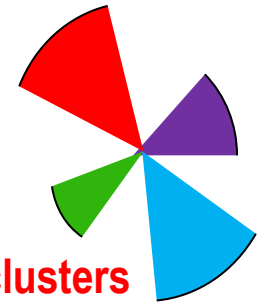


Frequency-variable channel appears flat over the narrow band of an OFDM subcarrier.

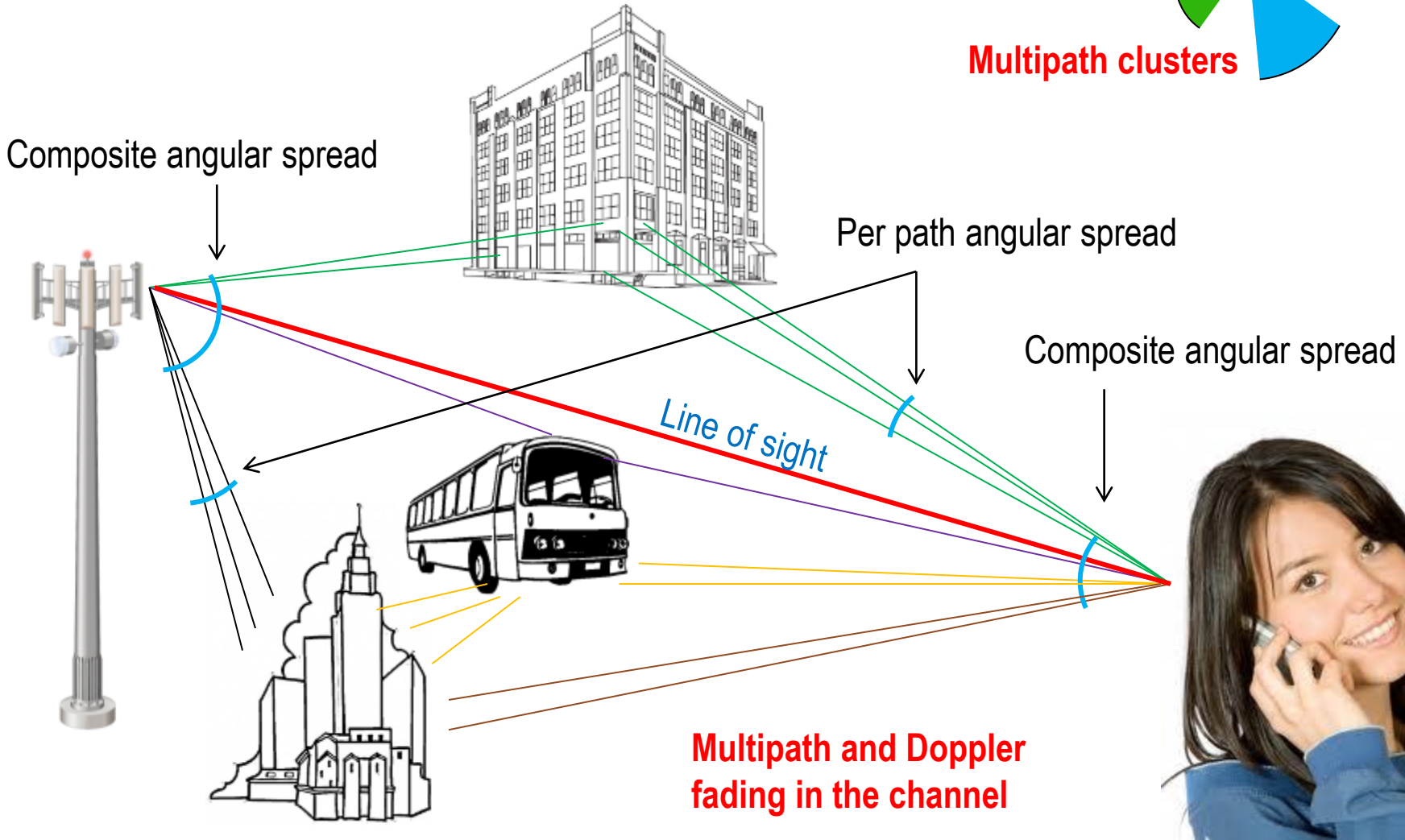
OFDM = orthogonal frequency division multiplexing



Wireless Channel



Multipath clusters



octoScope's LTE Throughput Measurements

DL/UL, Mbps



Samsung Galaxy 4G Tablet



LTE Vertical Markets

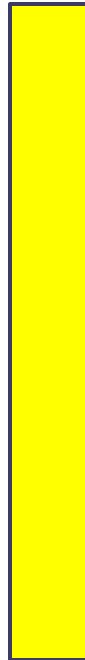
Cellular
Wireless broadband



Internet of things
M2M



Public Safety



Connected vehicle



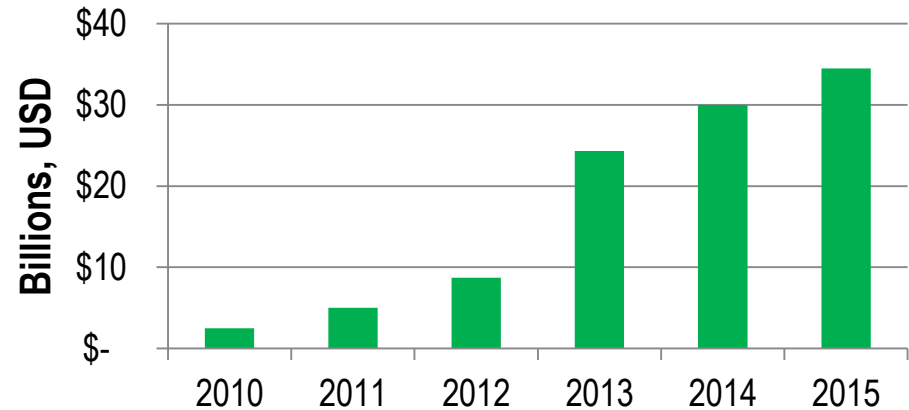
Smart grid



Wireless Broadband Market

- Spending on LTE infrastructure worldwide forecast:
 - Triple from \$8.7B this year to \$24.3 billion in 2013 (IHS iSuppli)
 - CAGR of 45% growth over the next 5 years ([Dell'Oro](#))
- Global mobile broadband traffic grew by 83% in the second half of 2011 with a CAGR of 234% during 2011 (Allot Communications)
 - Video streaming: 88% growth in 2H11; 42% all global bandwidth
 - VoIP and IM traffic grew by 114% in 2H11

Global capital spending by carriers on 4G LTE Infrastructure



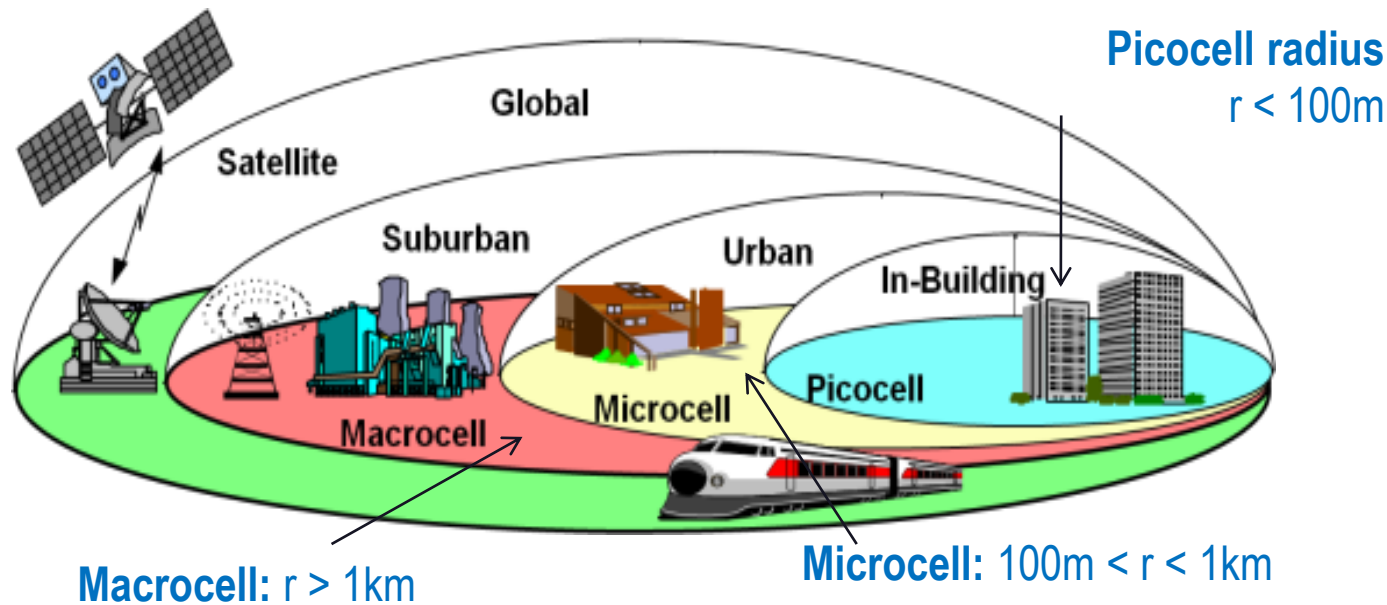
Source IHS iSuppli

In 2016 the number of connected devices will exceed the number of people on earth (7.3B)

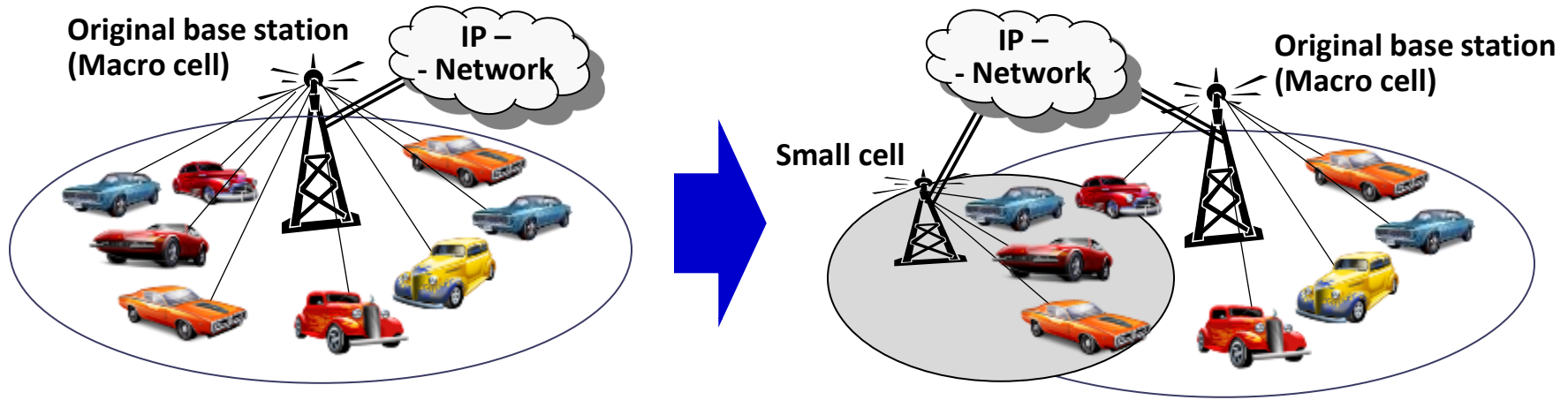
Source: United Nations

Small Cell Trend

- Pico base station shipments will begin to exceed macro base station shipments in 2016 ([Dell'Oro](#))
 - [Survey: 76% of industry insiders say small cells play a role in their networks](#)
 - [Small cells driving surge in microwave and millimeter-wave backhaul](#)
 - [Study: Small cell market to hit \\$2B by 2016, driven by capacity needs](#)



Implications of the Small Cell Architecture



- Issues with small cell architecture include
 - Increased instances of cell edge interference
 - Frequent handovers that may cause interruptions in transmission and dropped connections
- Need provisions for simpler automated installation

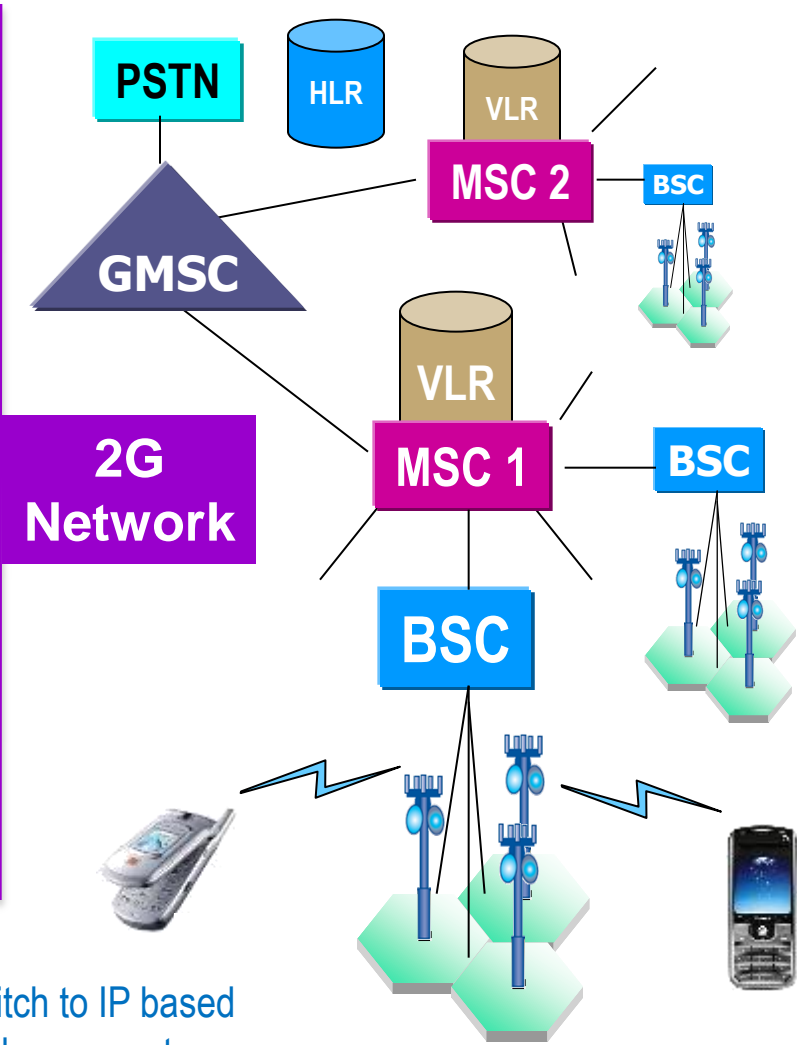
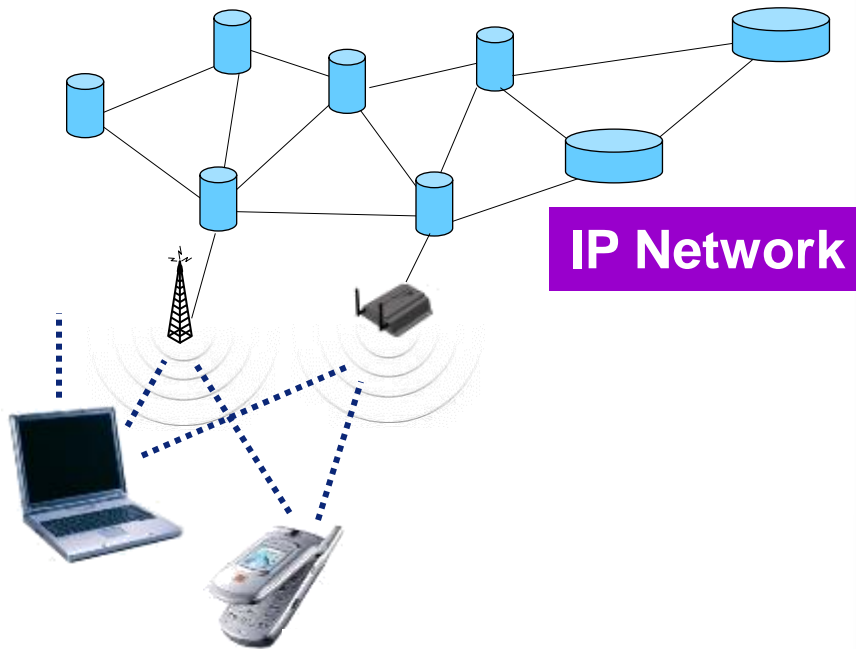
Microwave Backhauling

- For small base stations wireless backhaul is more cost-effective than fiber or copper cabling



Small 2G/3G/LTE
base stations
interconnected via
microwave links.

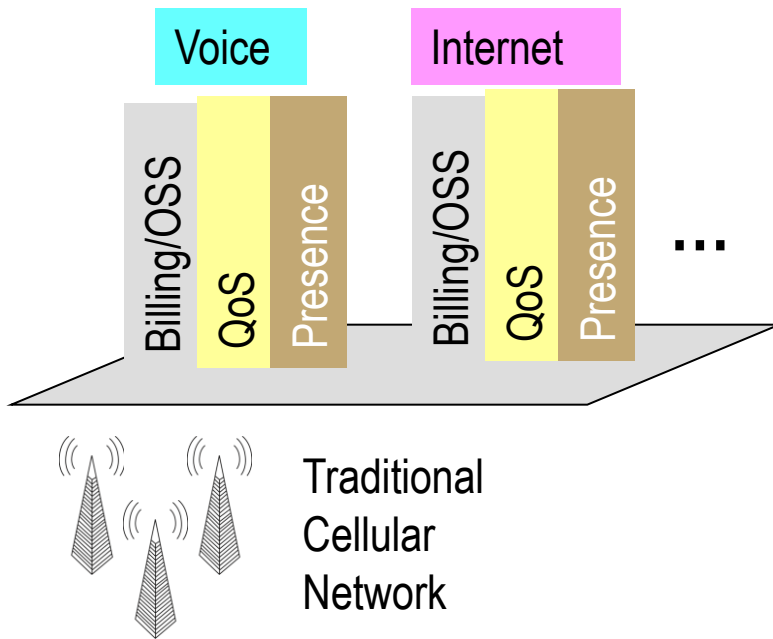
IP vs. 2G Network Architecture



GMSC = Gateway Mobile Switching Center
 PSTN = public switched telephone network
 BSC = base station controller
 MSC = mobile switching center
 VLR = visitor location register
 HLR = home location register

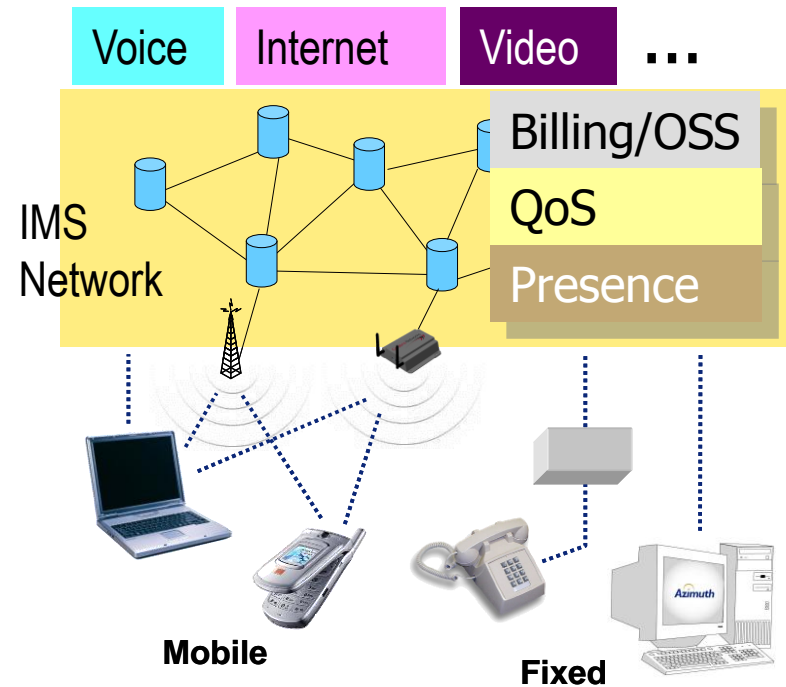
Migration requires a switch to IP based infrastructure that can also support isochronous voice services

Traditional “Stovepipe”



Stovepipe model – replicates functionality

IMS



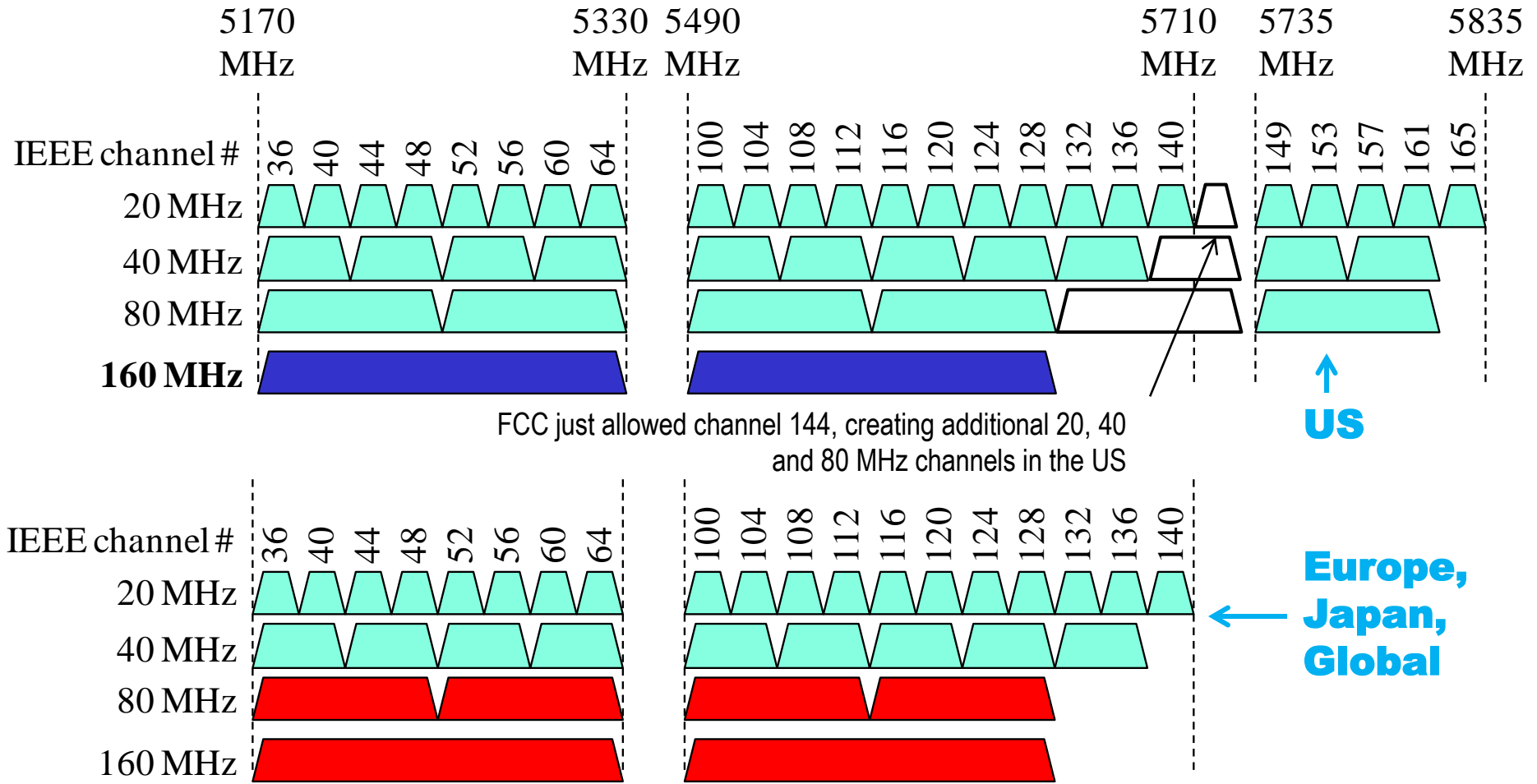
IMS – common layers facilitate adding services

Convergence of Wi-Fi and LTE

- Data
- Backhaul
- Indoors
- Outdoors
- Why Wi-Fi?
 - Abundance of free spectrum (500 MHz just in the 5 GHz band)
 - Huge capacity with “good enough” performance for data services



802.11 Channels in the 5GHz Band



IEEE 802.11 Emerging Specifications

<u>Standard</u>	<u>Overview</u>	<u>Specification</u>			<u>Standard completion (Target)</u>
		Transmission rate	Communication range	User velocity	
11ac	<i>High Throughput w/ wider channels</i>	Up to 6.9 Gbps			Dec/13
11ad	<i>High Throughput in 60 GHz band</i>	Up to 6.8 Gbps	10 m at 1 Gbps		Dec/12
11af	<i>Wi-Fi on TV White Space</i>	802.11n/ac rates scaled to channel	Up to 5 km		Dec/13
11ah	<i>Sub 1 GHz</i>	> 100 kbps	1 km		Mar/15
11ai	<i>Wi-Fi for mobile</i>	<i>Fast initialization (target 100 ms)</i>		Target: + 200 km/h	Mar/14

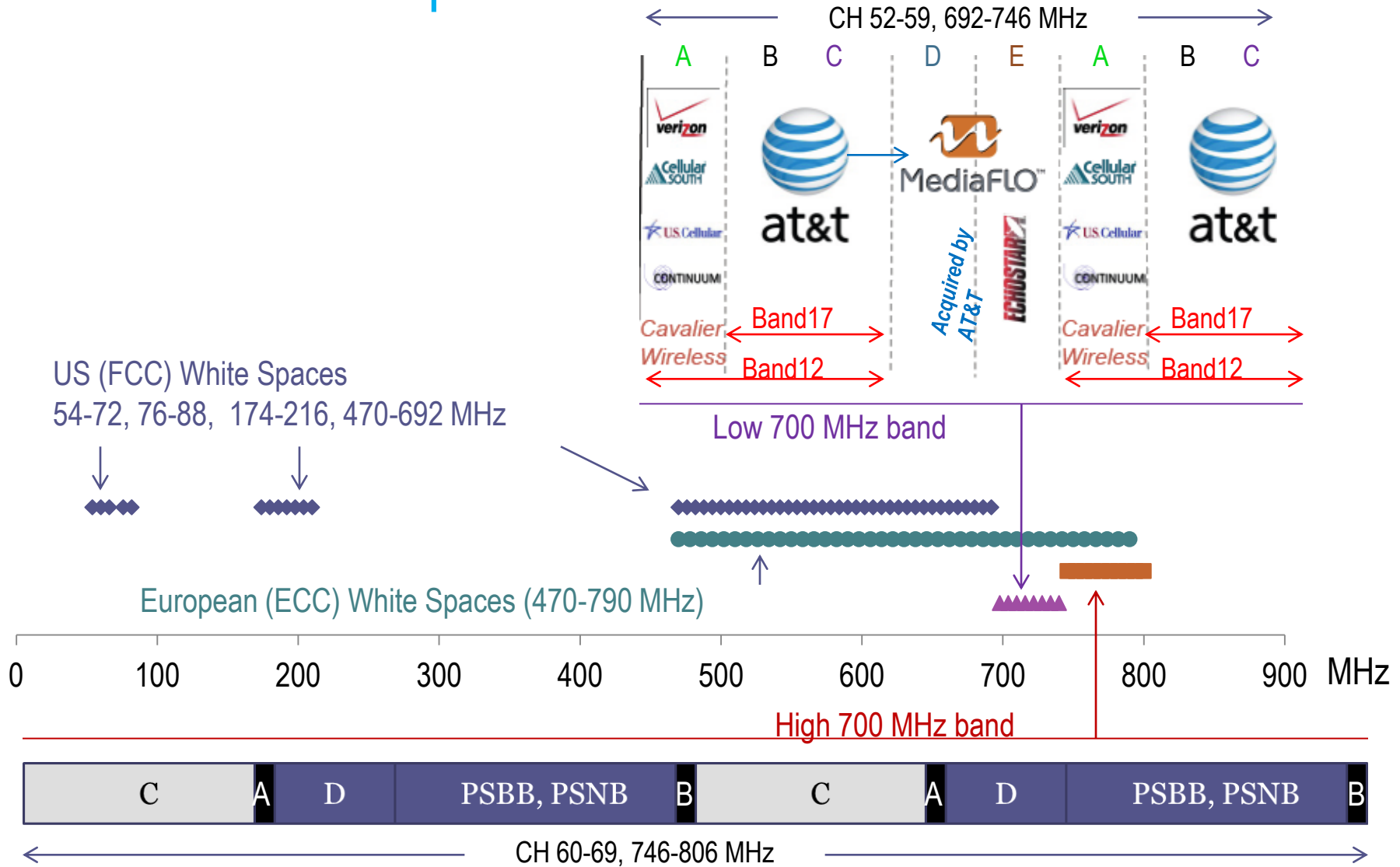
LTE-Advanced Emerging Technologies

Technologies /Solutions	Objectives
HetNet	Eliminate issues with Femto/Micro/Macro-cell converged network
SON	Self configuration of smaller eNBs
Carrier Aggregation	Implement wider LTE-advanced spectrum with limited spectrum resources. {Asymmetric (DL/UL) band for FDD is available.}
3G / 4G Handover	Enable 3G-4G hand-over (currently not available for LTE)
MIMO (Up to 8 X 8)	Higher data transmission for Downlink; beamforming for longer range or for multi-user MIMO
	Higher data transmission for Uplink or for multi-user MIMO
Relay	Higher data rate, expand coverage, improve cell-edge reception
CoMP	Helps manage band-edge eNB interference: inter-cell interference coordination (ICIC)

HetNet = Heterogeneous networks
 SON = self organizing networks
 CoMP = Coordinated multi-point transmission and reception

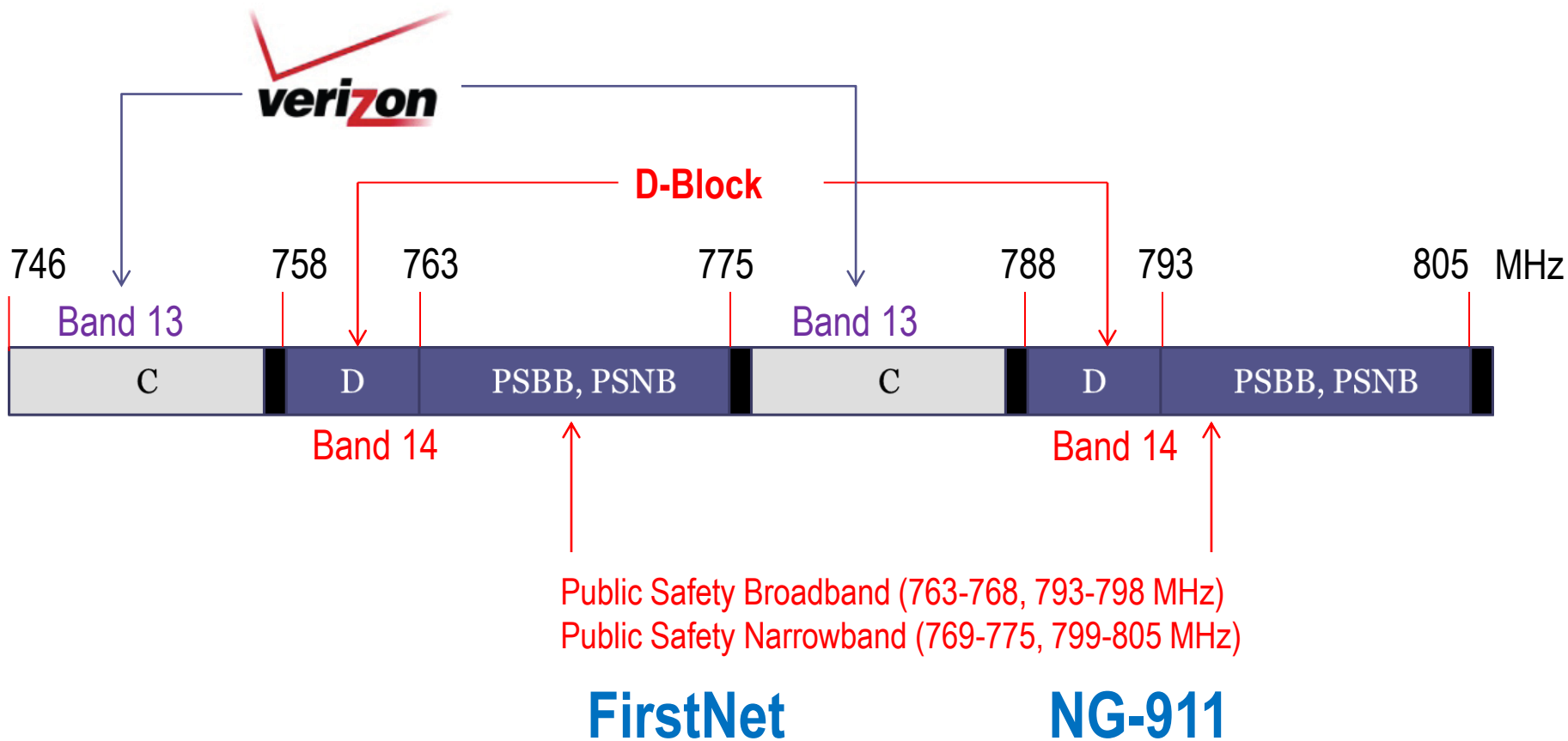
eNB = e Node B
 DL = downlink
 UL = uplink
 FDD = frequency division duplex
 MIMO = multiple input multiple output

UHF Spectrum



ECC = Electronic Communications Committee

High 700 MHz Band



NG = next generation

Summary

- LTE is here and works for data
- Unified universal technology serving verticals such as
 - Cellular / wireless broadband
 - Internet of things (M2M)
 - Public Safety
 - Connected vehicle
 - Smart grid
- Next steps:
 - IMS and VoLTE
 - Carrier to carrier roaming
 - 2G to 3G to 4G roaming

IMS = IP multimedia subsystem
VoLTE = voice over LTE

For More Information

- Visit www.octoscope.com
- [White papers](#), [webinars](#), [presentations](#), [articles](#) and [test reports](#) on a variety of wireless topics

Thank
You