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4G LTE: What it Means for Mobile Applications

Technology & Ecosystem Overview

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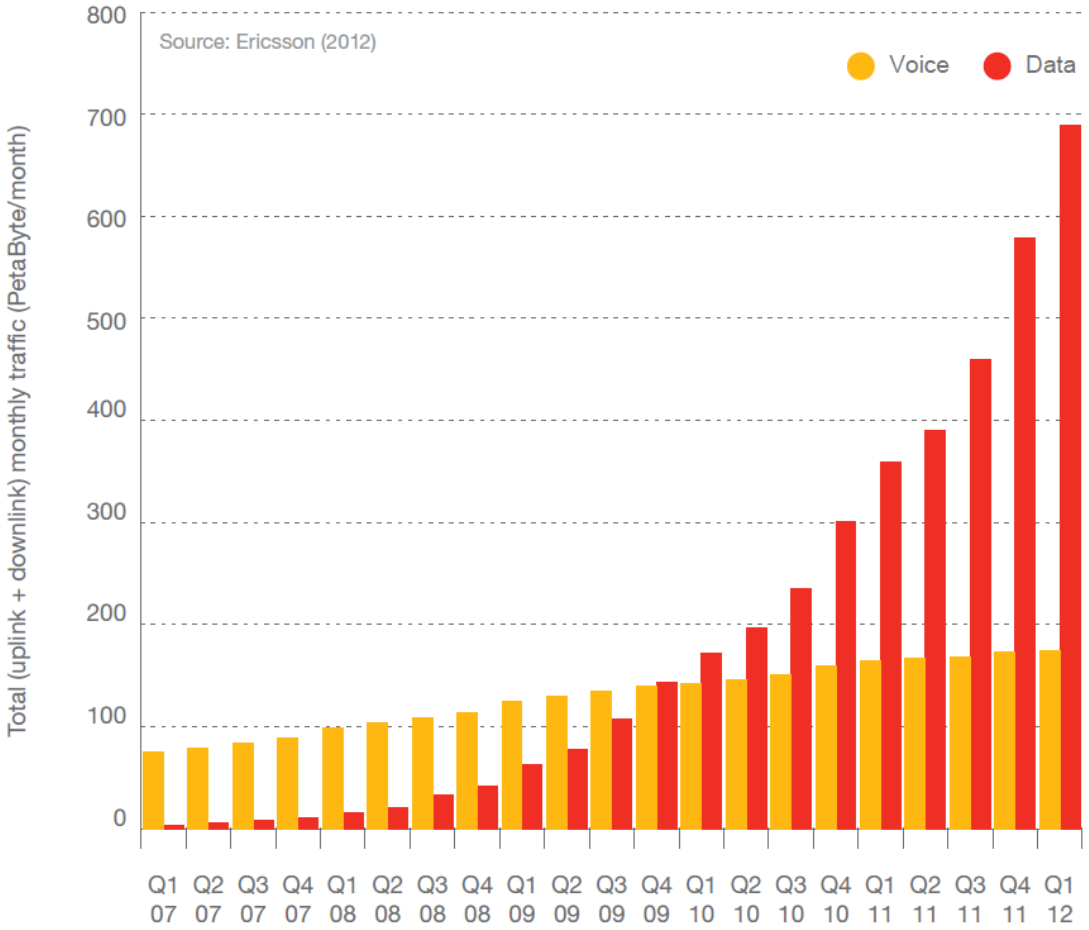
Agenda

- **Background & Drivers**
- Evolution
- LTE Enablers & Value Proposition
- State of Deployment
- Device Ecosystem
- LTE-enabled Applications

Global Total Traffic



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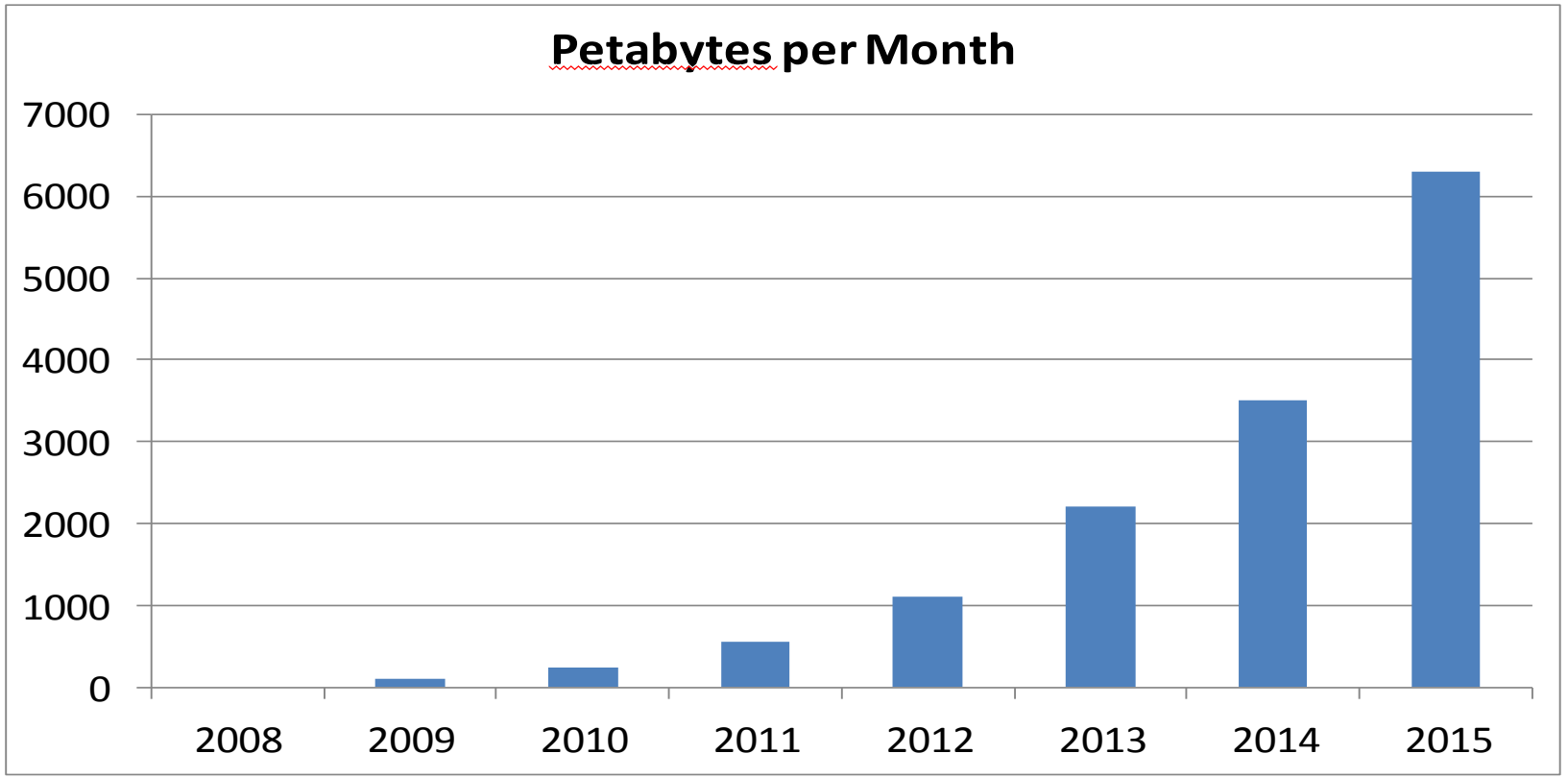
Growing Demand for Data



Source: Cisco Visual Networking Index

AT&T data traffic grew from just over 1 billion megabytes in the third quarter of 2007 to about 30.3 billion megabytes in the third quarter of 2010 - John Donovan CTO (2010).

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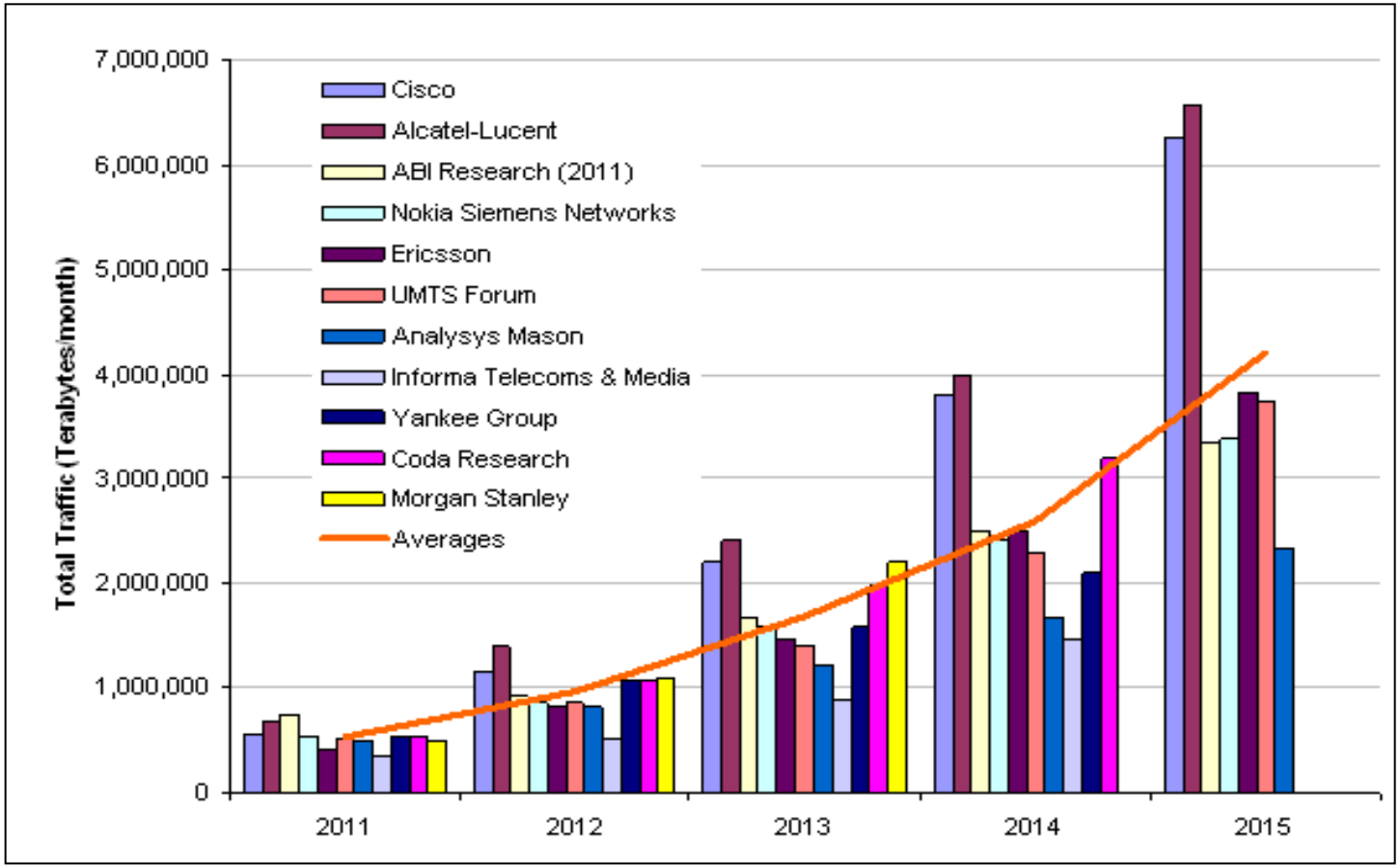
Mobile Data Global Traffic : Forecasts



Report ITU-R M.2243

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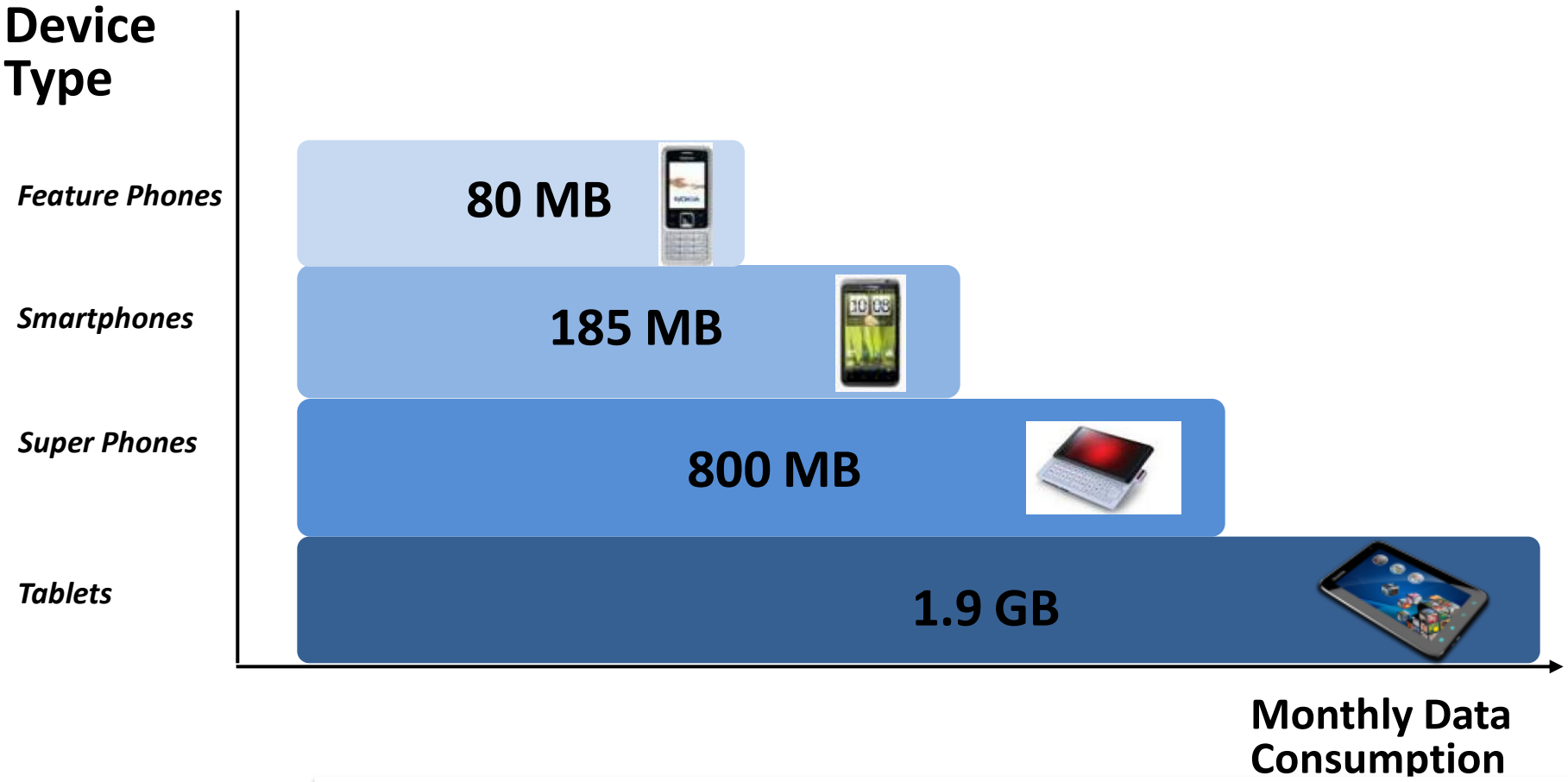
Bandwith Drivers - Devices



Bandwith-hungry devices and related applications are driving the increase in data consumption

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Bandwith Drivers - Applications

- **Proliferation of mobile apps via app online stores** - 10+ billion app downloads
- **Mobile Internet** - 10% internet traffic now mobile
- **Media-rich social networks** - 50%+ facebook time now mobile
- **Mobile Video download & upload** - 25% youtube traffic now mobile
- **Machine-to-machine** – strong growth of video applications

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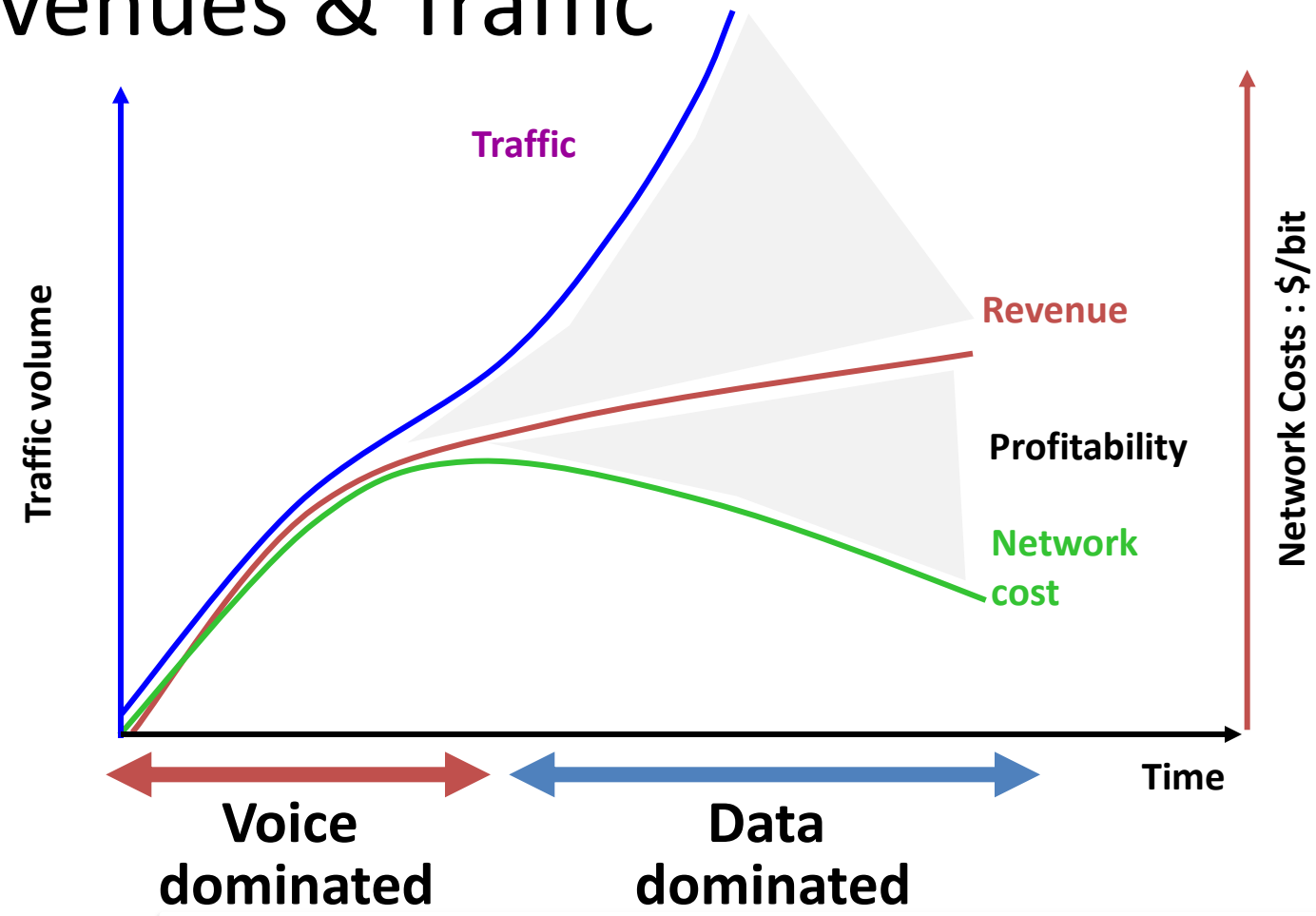
Cost Drivers: Decoupling of Data Revenues & Traffic



Network cost per bit needs to go down substantially to maintain profitability

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LTE : A Universal Wireless Standard

ADVANCED

Both 3GPP (GSM, GPRS, EDGE, UMTS, HSPA, HSPA+) and 3GPP2 (CDMA 1xRTT, EVDO) standards are evolving towards LTE which further evolves towards LTE-Advanced

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3GPP Standard Releases

Releases	Functional Freeze	Radio Features
Rel-99	March 2000	Basic 3.84 Mcps WCDMA (TDD and FDD), First deployable version of UMTS.
Rel-4	March 2001	Low chip rate TDD (1.28 Mcps), Multimedia messaging support, Initial step towards IP Core Network.
Rel-5	June 2002	HSDPA, IMS Phase-1, Full ability to use IP-based transport instead of ATM.
Rel-6	March 2005	HSUPA, WCDMA/WLAN internetworking, MBMS, IMS Phase-2, Initial VoIP capability.
Rel-7	December 2007	GPRS enhancements with evolved EDGE, HSPA+ (64-QAM DL, 16-QAM UL, MIMO), LTE & SAE basic study items.
Rel-8	December 2008	LTE (OFDMA based air interface), SAE (New IP core network), EDGE Evolution, Enhancements to HSPA+.
Rel-9	December 2009	HSPA and LTE enhancements including HSPA multi-carrier operation.
Rel-10	March 2011	LTE Advanced specifications to meet requirements of IMT-Advanced.

3GPP Release Comparison

	WCDMA (UMTS)	HSPA HSDPA / HSUPA	HSPA+	LTE	LTE Advanced (IMT Advanced)
Max downlink speed	384 kbps	14 Mbps	28 Mbps	300 Mbps	1 Gbps
Max uplink speed	128 kbps	5.7 Mbps	11 Mbps	75 Mbps	500 Mbps
Latency round trip time (UP)	150 ms	100 ms	50 ms (max)	~10 ms	less than 5 ms
3GPP releases	Rel 99/4	Rel 5 / 6	Rel 7	Rel 8	Rel 10
Approx years of initial roll out	2003 / 4	2005 / 6 HSDPA 2007 / 8 HSUPA	2008 / 9	2009 / 10	2013
Access methodology	CDMA	CDMA	CDMA	OFDMA / SC-FDMA	OFDMA / SC-FDMA

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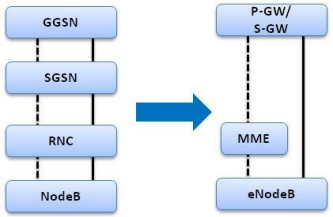
LTE Enablers

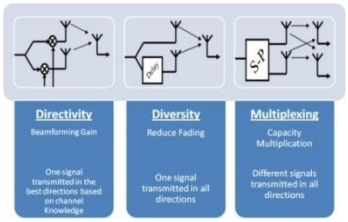
IP & FLAT

Architecture



MIMO

Multiple-Input Multiple-Output



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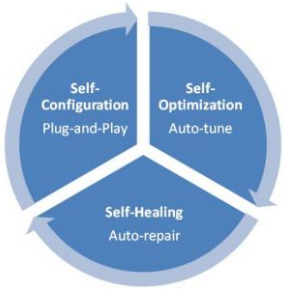
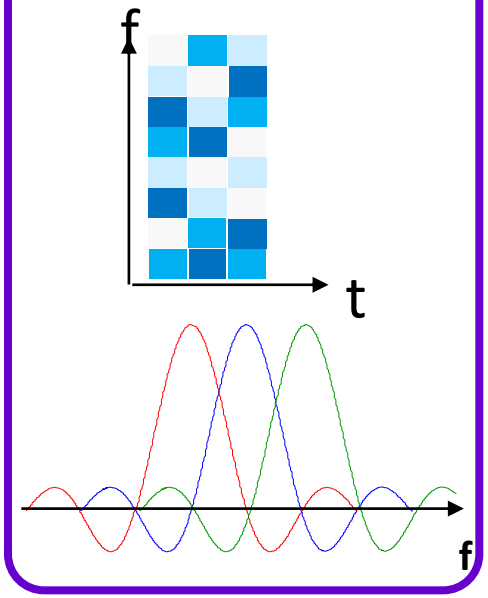
Self-Organized Networks



OFDMA

Frequency Division

Orthogonal subcarriers



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LTE Value Propostion

Costs per Bit Reduction

Reduced Latency

Increased System Capacity

Higher User Data Rate

Better Quality of Service

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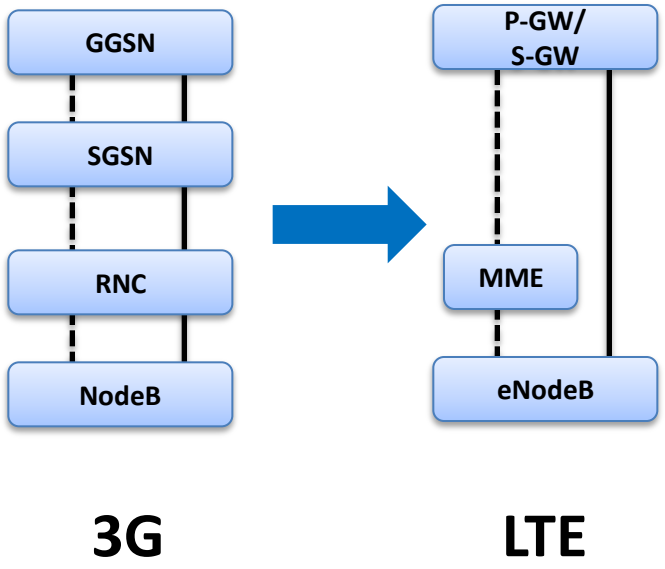
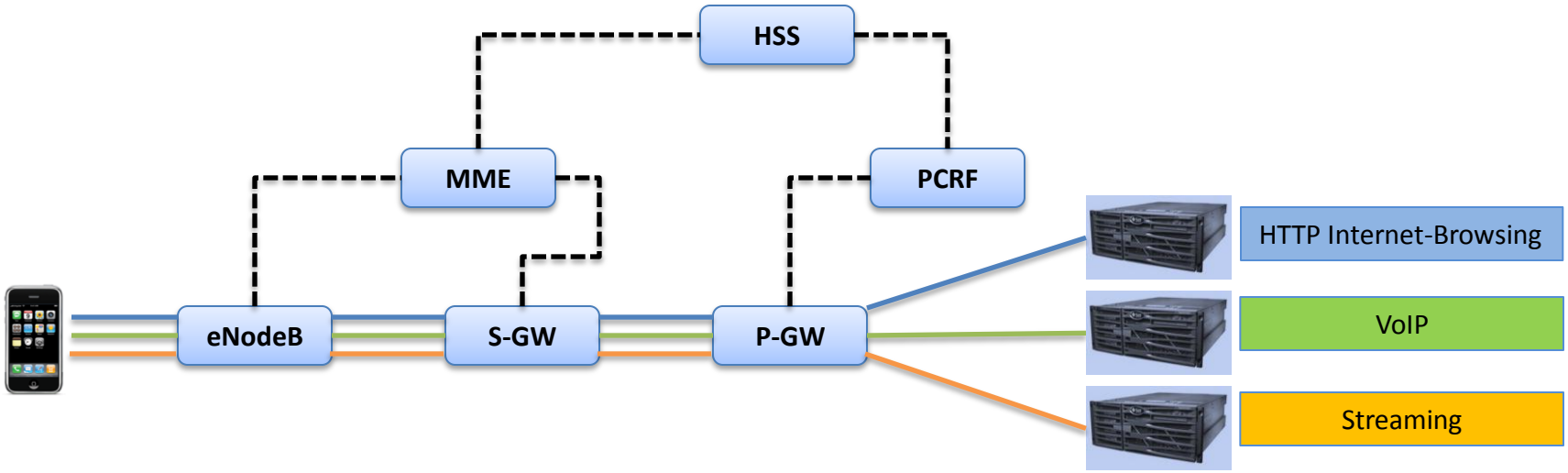
LTE Network Evolution

- An all-IP network
- Simplified and flatter network architecture
- Reduced number of nodes
- Low-latency network



QoS-aware Bearers



A UE can have several concurrent LTE bearers each with different QoS settings (priority, latency, packet loss)

LTE Standardized QCI Profiles

QCI	Resource Type	Priority	Packet Delay Budget	Packet Error Loss Rate	Example Services
1	GBR	2	100 ms	10^{-2}	Conversational Voice
2		4	150 ms	10^{-3}	Conversational Video (Live Streaming)
3		3	50 ms	10^{-3}	Real Time Gaming
4		5	300 ms	10^{-6}	Non-Conversational Video (Buffered Streaming)
5	Non-GBR	1	100 ms	10^{-6}	IMS Signalling
6		6	300 ms	10^{-6}	Video (Buffered Streaming) TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc).
7		7	100 ms	10^{-3}	Voice, Video (Live Streaming) Interactive Gaming
8		8	300 ms	10^{-6}	Video (Buffered Streaming) TCP-based (e.g., www, e-mail, chat, ftp,
9		9		10^{-6}	p2p file sharing, progressive video, etc).

Standardized QCI Characteristics *Source TS 23.203*

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LTE – Traffic & User-Experience Management

- Speed-based Pricing: maximum speed limit per end-user
- Unlimited Data Plan with speed dropping after exceeding a monthly data volume (e.g. 1 GB)
- Traffic shaping vs Net Neutrality

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1Gbps Throughput

- USB 2.0: max 480 Mbit/s (USB 3.0 4.6 Gbit/s)
  - Real writing speed is around: 50 Mbit/s
  - Real reading speed is around: 215 Mbit/s
- Typical hard drive: measured speed when copying file: 500 Mbit/s
- SATA: 3.0 Gbit/s (maximum transfer rate!)

Maximum vs Average Speed

- **Factors Impacting Maximum Speed:**
  - Size of Spectrum Band (1.4, 3, 5, 10, 15 and 20 MHz)
  - MIMO Configurations (1X1, 2X2, 4X4)
- **Factors Impacting Average Speed:**
  - Device categories/capabilities (5 categories)
  - Distance from cell center
  - Network Load (RF & transport)
  - Radio conditions

Average speed can typically be 10%-30% of maximum speed

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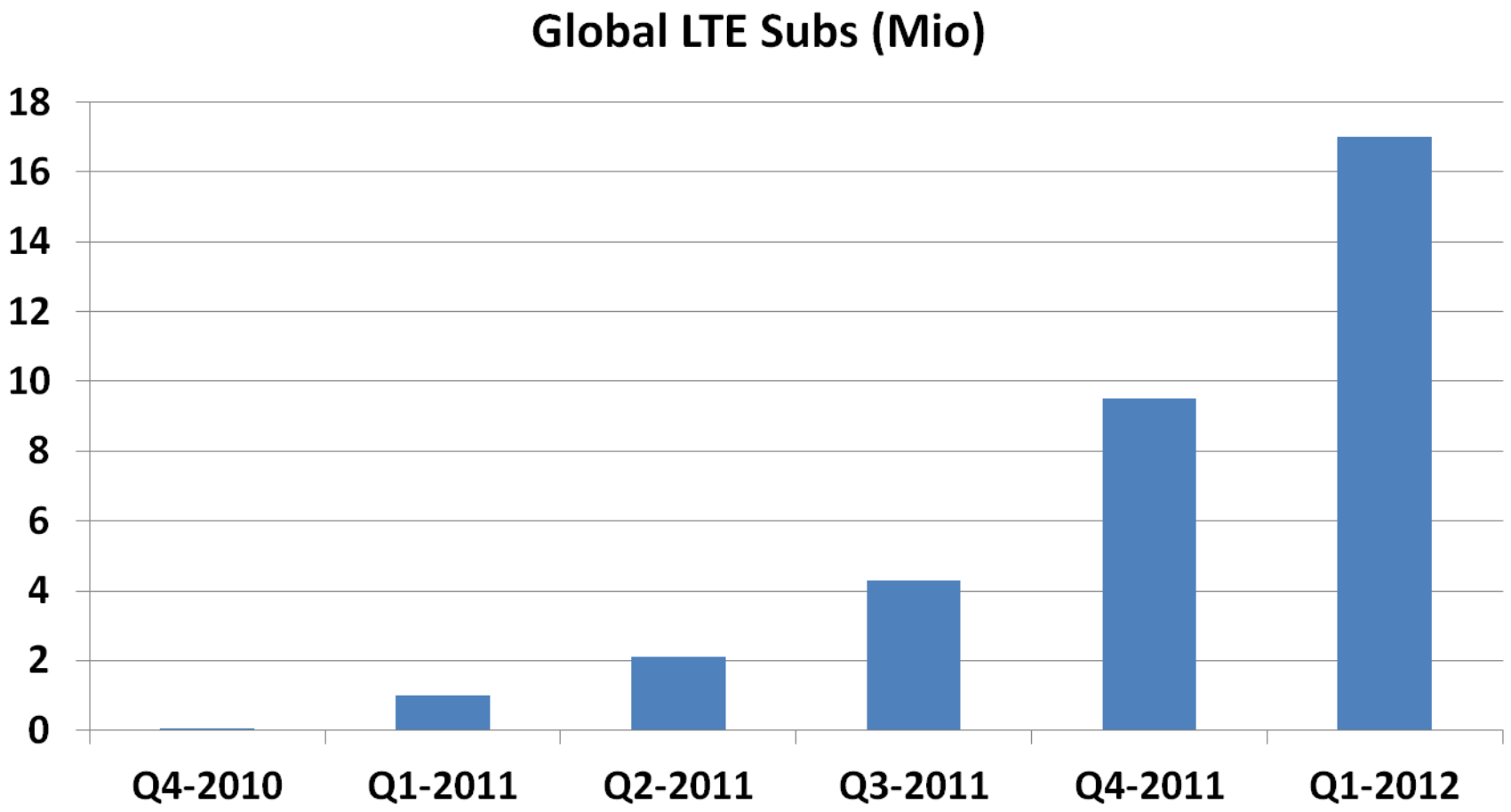
Global LTE Subs Q1-2012



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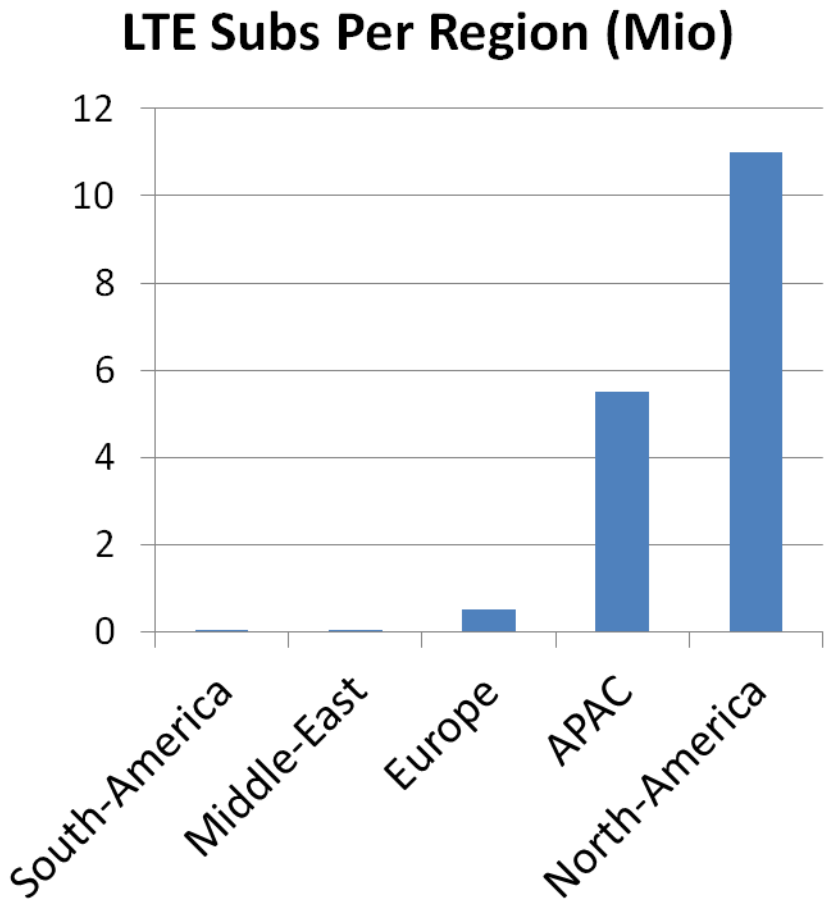
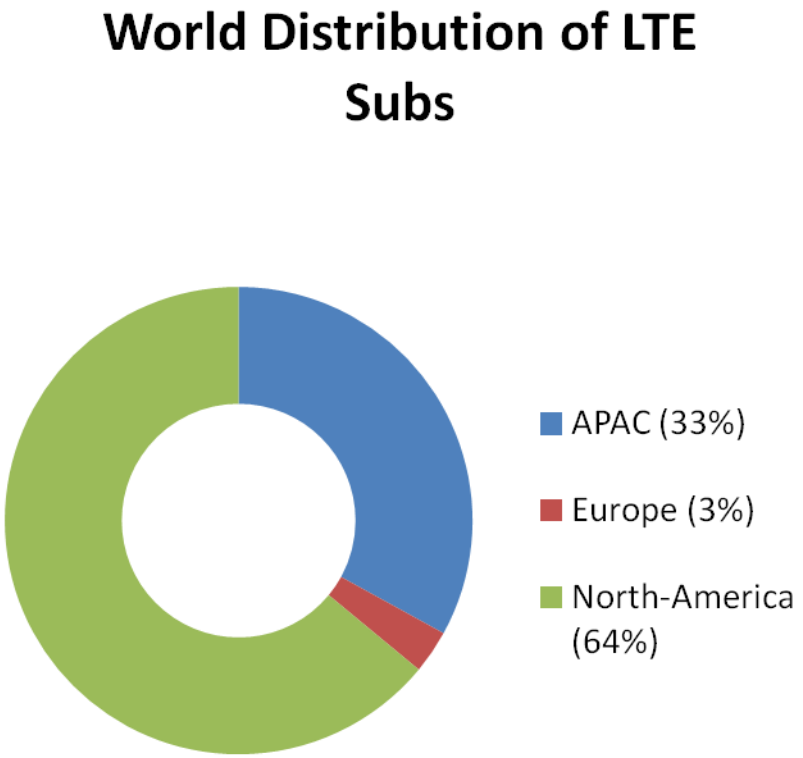
Global LTE Penetration Q1-2012





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GLOBAL LTE – AS OF JUNE 2012

- HSPA: 473 commercial networks in 180 countries
- HSPA+: 227 commercial networks in 109 countries
- LTE: 91 commercial networks in 47 countries
- LTE: 335 operator Commitments worldwide
- LTE: Over 130 commercial networks expected by year end 2012

LTE IN THE US – Q2 2012

Operator	Band	Coverage	Average Speed (*)
at&t	700 MHz	77 markets	10 times 3G
verizon	700 MHz AWS	400+ markets	5-12 Mbps (DL) 2-5 Mbps (UL)
Sprint	1900 MHz 800 MHz	50 markets	6-8 Mbps (DL)
T-Mobile	AWS	Planned for 2013	
metroPCS Unlimit Yourself.	AWS 1900 MHz	20 markets	2-6 Mbps (DL)
LEAP	AWS	Starting	3-15 times 3G

(*) as advertized on carrier's website

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LTE IN CANADA – Q2 2012

Operator	Band	Coverage	Average Speed (*)
ROGERS	AWS	60% population (EOY)	12-25 Mbps (DL)
Bell	AWS	46 cities	12-25 Mbps (DL)
TELUS	AWS	Similar	12-25 Mbps (DL)
SaskTel	AWS	Regina & Saskatoon	7-12 Mbps (DL)
MTS Allstream	AWS	Winnipeg & Brandon	-

(*) as advertized on carrier's website

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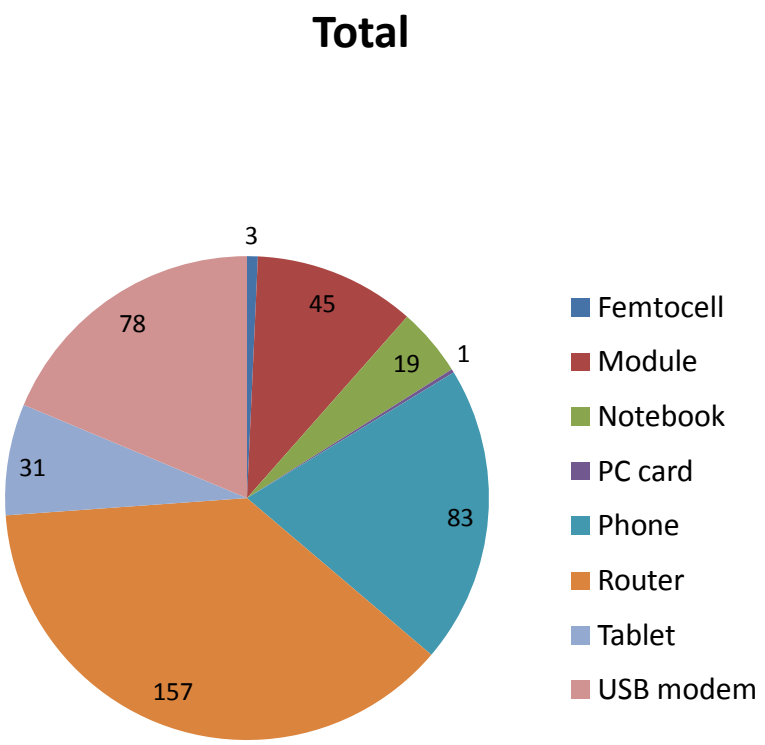
LTE Device Status – Q2-2012



BAND	FDD Device Count	TDD Device Count
700 MHz	193	
800 MHz	113	
1800 MHz	98	
2300 MHz		53
2600 MHz (Band 38)		59
2600 MHz (Band 41)		5
2600 MHz (Band 7)	123	
800/1800/2600	75	
AWS	78	

417 devices from 69 manufacturers

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The iPhone 5

- 2 GSM Versions
  - AT&T version: GSM, HSPA+, and LTE (AWS Band 4 & 700 MHz Band 12)
  - EU version
- 1 CDMA version (Verizon, Sprint, KDDI)
  - CDMA, GSM, HSPA+, and LTE
  - LTE bands
    - European 3G (Band 1)
    - 1800 MHz (Band 3)
    - North American Cellular (Band 5)
    - US 700 MHz Upper C block (Band 13)
    - Extended PCS band (Band 25)
- No support for 2,6 GHz (Band 7) nor 800 MHz (Band 20)

Some LTE Devices in Canada

Sony Xperia Ion

iPhone 5

Playbook

Motorola RAZR HD

Sierra Wireless AirCard 330U

Samsung Galaxy Notes

Samsung Galaxy SIII

LG Optimus

HTC One X

Nokia Lumia 900

Galaxy Samsung Tab 8.9

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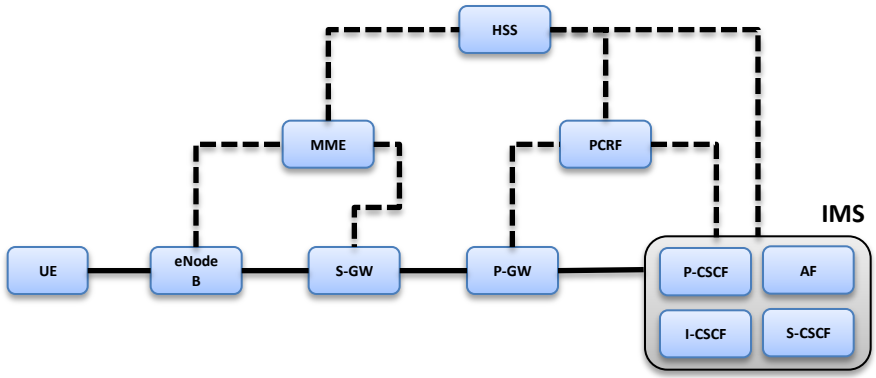
IMS-based Voice Over LTE

- Based on 3GPP TS 23.228 IMS supporting both legacy voice services and advanced multi-media services
- IMS is an SIP-based (Session Initiation Protocol) session and service control platform that enables delivery of multimedia applications across a broadband wireline or wireless network
- IMS was first introduced in the 3GPP Release 5
- Builds on IETF SIP technology (perceived Internet scaling and low cost)
- Split the access network from the service network permitting common service network across fixed, mobile and internet
- Multimedia in addition to voice; No need to standardized services only enablers



Deployment of IMS to support voice will foster development of advanced multi-media services hosted by carriers

Enhanced Mobile Video

- Higher video resolution
- Fewer visual artefacts as a result of lower compression
- Higher frame rate
- Shorter loading time to fill video buffer

Mobile Cloud Computing

- New Business Models
- Cloud increases capacity of mobile devices
- Requires LTE-like latency
- Cloud computing over tablets is powerful
- Personal & Business Clouds

Cloud Gaming

- Based on thin-client
- Game processing based in the cloud
- Requires LTE-like connection speed and ultra-low latency
- OnLive, Playcast Media

HTML 5 based Applications

- HTML 5 Web App should fix fragmented mobile application ecosystem
- Developers could focus on one set of tools
- Independent platform
- Less technology onboard phone (heavy processing is done in cloud)
- Cheap smartphone

Augmented Reality

- Adding information to real time picture from cameraphone
- Can be used for tourist info or video games

Connected Car

- 62.3 million global consumers will have Internet access in their cars by 2016, up from 970,000 at the end of 2009 - according to iSuppli Corp
- Mobile vs embedded devices
- Embedded cellular-to-Wi-Fi routers
- Entertainment (passenger-only); internet radio, music & video downloads
- Navigation: traffic camera video downloads, enhanced navigation systems

THANK YOU

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