

Beyond 4G

Introduction and LTE evolution

KIVI Telecom, Den Haag

Anne van Otterlo

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Main Mobile Technologies

ETSI/3GPP, all WAN

- GSM, since early 90-ies, Circuit Switched Data ~10kb/s, EDGE ~100kb/s
- WCDMA, since early 2000, UMTS ~1Mb/s, HSPA ~1-10Mb/s and evolving
- LTE/LTE-A, since ~2010, ~1-**100Mb/s** and evolving

IEEE

- WiFi or 802.11, LAN, since mid 90-ies (booming), 1-**100Mb/s** and evolving
- WiMax or 802.16, WAN, since early 2000 (fading), 1-**100Mb/s**

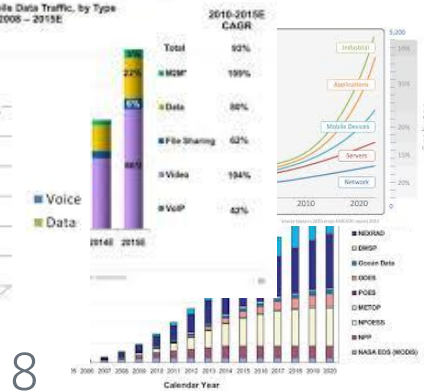
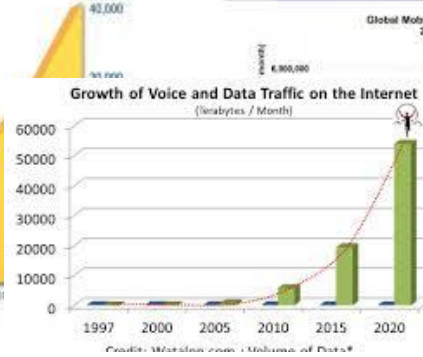
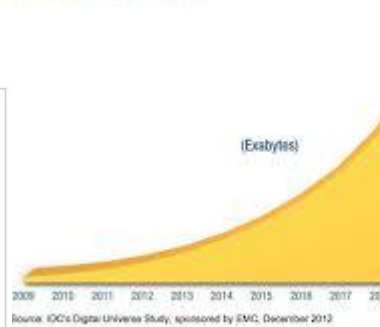
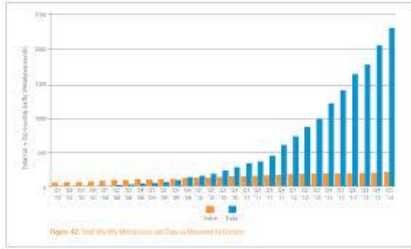
Other: Bluetooth, NFC, ...



Will data demand saturate?

The Digital Universe: 50-fold Growth from the Beginning of 2010 to the End of 2020

KP CB Global Mobile Data Traffic Should Grow 26x Over Next 5 Years

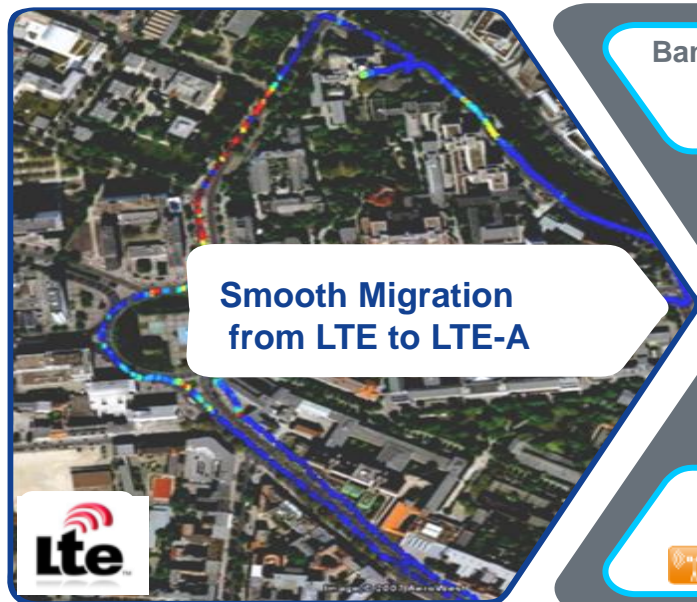


Cisco VNI study, world average 2GB/month/human by 2018
 → Cloud, Things & Video (79% of mobile traffic by 2018)

IP Traffic, 2013–2018							
	2013	2014	2015	2016	2017	2018	CAGR 2013–2018
By Type (Petabytes [PB] per Month)							
Fixed Internet	34,952	42,119	50,504	60,540	72,557	86,409	20%
Managed IP	14,736	17,774	20,898	23,738	26,361	29,305	15%
Mobile data	1,480	2,582	4,337	6,981	10,788	15,838	61%

Source: Cisco VNI study, June 2014

LTE-Advanced Key Ingredients or Toolbox of Features



More bandwidth

Bandwidth Extension / CA

100 MHz

More antennas



MIMO



Cooperative Systems



Cooperation

Relaying

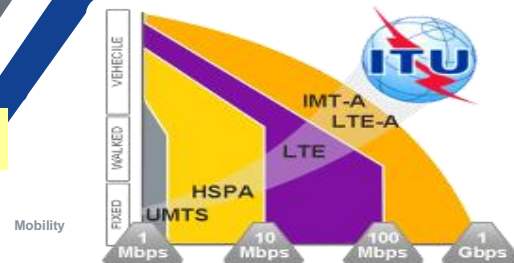


Heterogeneous Networks



More sites

Backward
compatible
to LTE



LTE: 3GPP Release 8, 9

LTE-A : 3GPP Release 10, 11, 12

Carrier Aggregation Market Introduction in Korea

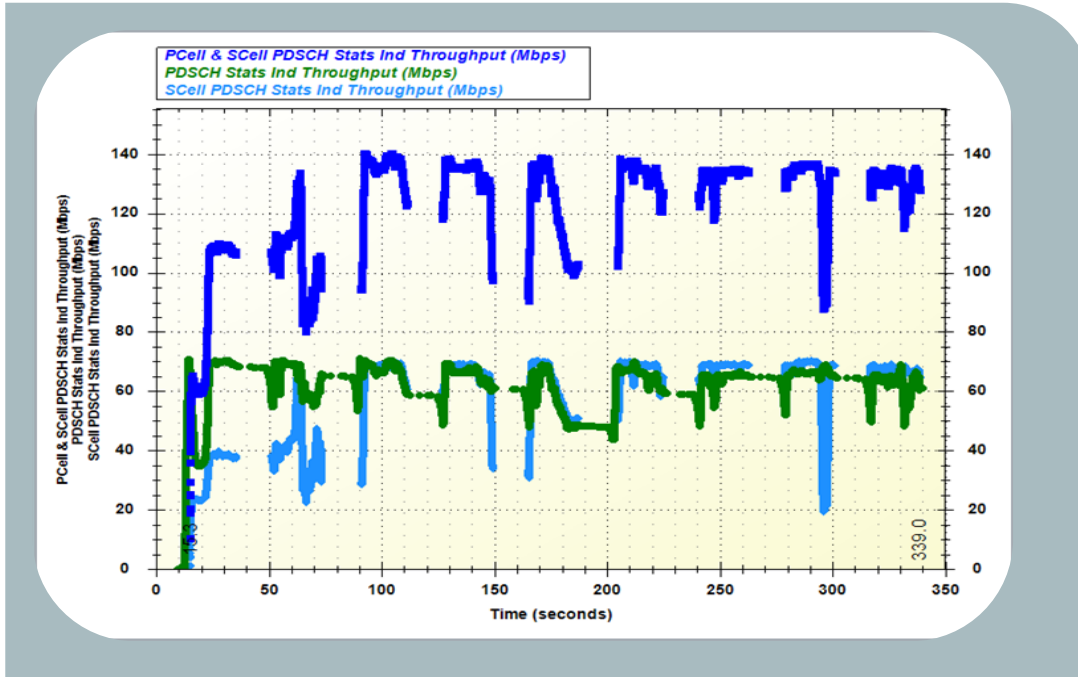
Since mid 2013

- Korea is the most advanced LTE market, LTE subs (23 Mio) passed 3G subs (22 Mio) in June 2013
- LTE-A Carrier Aggregation launched, and heavily promoted by the operators, few UEs (Samsung, LG) widely available
- CA data-rates can be frequently experienced in everyday use, ~40ms latency is the norm



Carrier Aggregation Drive Testing in Korea

10 + 10 MHz in live network 850 + 2100 MHz

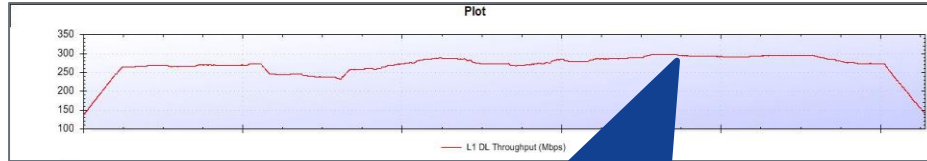


**Peak throughput
140 Mbps**

**Average throughput
59 Mbps**

**Primary and secondary
cell both at
70 Mbps**

Further examples: 20+20 MHz, LTE TD & FDD Carrier Aggregation, ...



Peak rate hitting 300 Mbps

Press Release, June 11th:

Nokia, SK Telecom achieve 3.78 Gbps throughput speed on converged TD and FD LTE spectrum

Nokia and SK Telecom have achieved a throughput speed of 3.78 Gbps on the converged TDD and FDD LTE spectrum. The trial used combined 10 spectrum frequencies allocated for both LTE variants for 200 MHz of bandwidth.

The throughput speed of 3.78 Gbps enables mobile broadband users to download a full-length 5 GB high-definition (HD) movie in 10 seconds.

elisa

BROADCOM.
Connecting everything®

nsn

Press Release
Espoo, Finland – February 11, 2014

Broadcom and NSN demonstrate Category 6 LTE-Advanced 300 Mbps on live commercial network from Elisa
Milestone delivers 2X the speed of the fastest LTE generally deployed today

Broadcom Corporation, Nokia Solutions and Networks (NSN) and Finnish operator Elisa today announced the first ever demonstration of LTE Advanced (LTE-A) carrier aggregation Category 6 (Cat 6) data rates of 300 Mbps on a live commercial network in the Nordic Countries. The achievement represents an important milestone for all three companies with the goal of delivering a superior mobile experience to consumers.

LTE Evolution: New Use Cases

New Application Areas

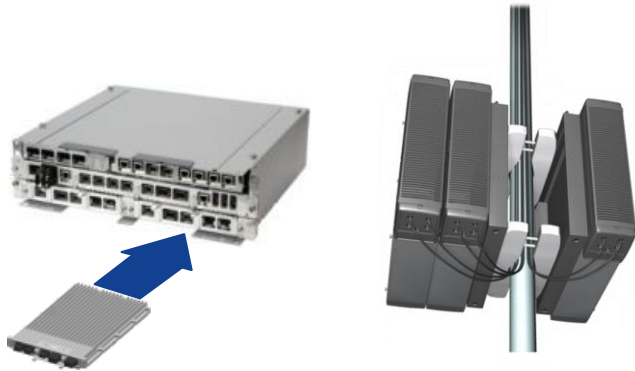
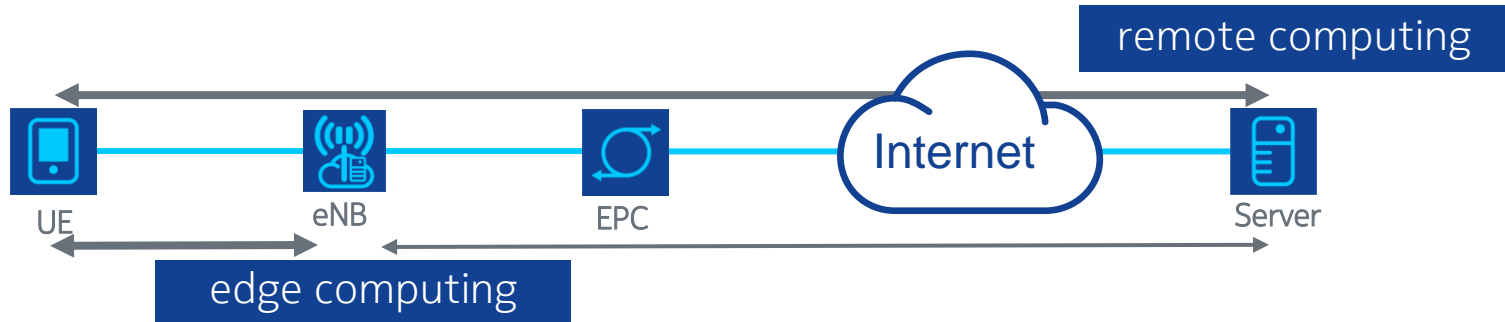
Internet of things	LTE-M = Machine-to-Machine
Proximity services	LTE-D = Device-to-Device
Replace terrestrial TV	LTE-B = Broadcast = eMBMS
Run public safety on your LTE	LTE for Public Safety
Move voice to IP in LTE network	LTE for Voice (VoLTE)
Connectivity for car entertainment	LTE for Connected Cars
Wi-Fi backhaul for airplanes	LTE for Airplane Connections

New Spectrum

500 MHz more spectrum at 5 GHz	LTE-U = Unlicensed Band
Sharing with incumbent user	Authorized shared access
LTE on 470 – 700 MHz	LTE on UHF Bands



Mobile Edge Computing



What is it:

- Computing & Applications
- Storage & Content
- Open platform (App factory) in the base station (eNodeB)

Use cases:

- Real time services
- Augmented Reality
- Caching and content
- ...

Benefits:

- Low Latency
- Intelligence
- Innovation
- Efficiency

Showcase: car-to-car and car-to-roadside communications

Mobile Edge Computing and LTE as basis for low latency reliable communication

20...50ms

delay between message generation by one car and message reception by other cars in the vicinity

0.5...1.5m

distance covered by other cars after message generation, e.g. a hard brake warning cars in the vicinity



Public technology showcase with



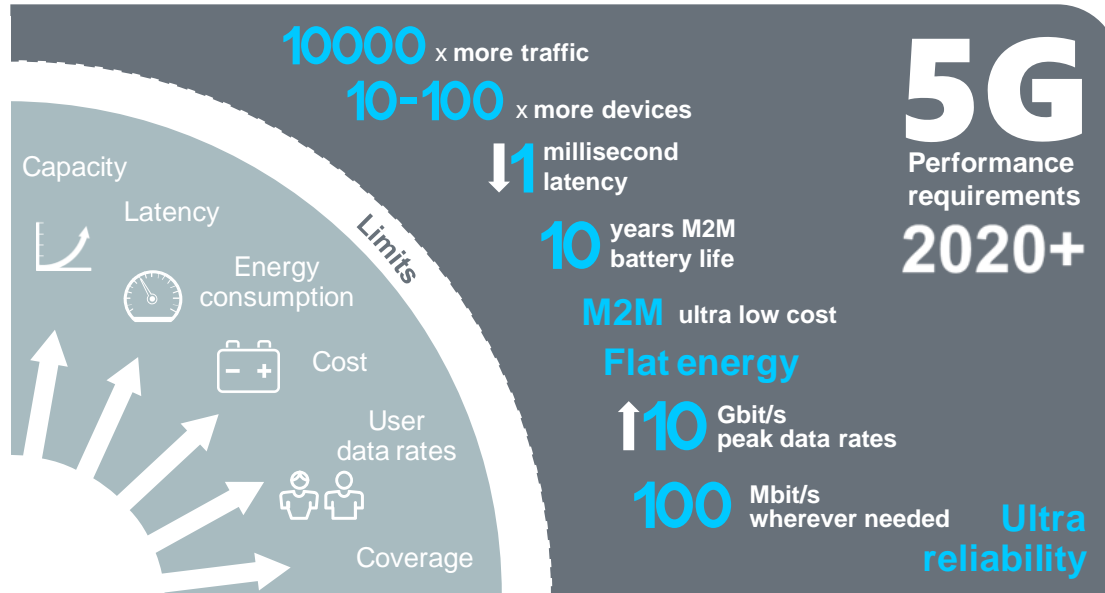
Notes

- This showcase was presented at ITS World Congress 2014 in Detroit, on the booth of HERE
- A T-Mobile US base station, equipped with RACS, was providing coverage at the event location
- Messages were generated by a simulator (hard brake, see picture) and real Honda cars driving on a nearby track

Public references

- [Nokia blog](#)
- [HERE blog](#)

Next: 5G



NOKIA