

5G

THE FUTURE OF MOBILE COMMUNICATIONS



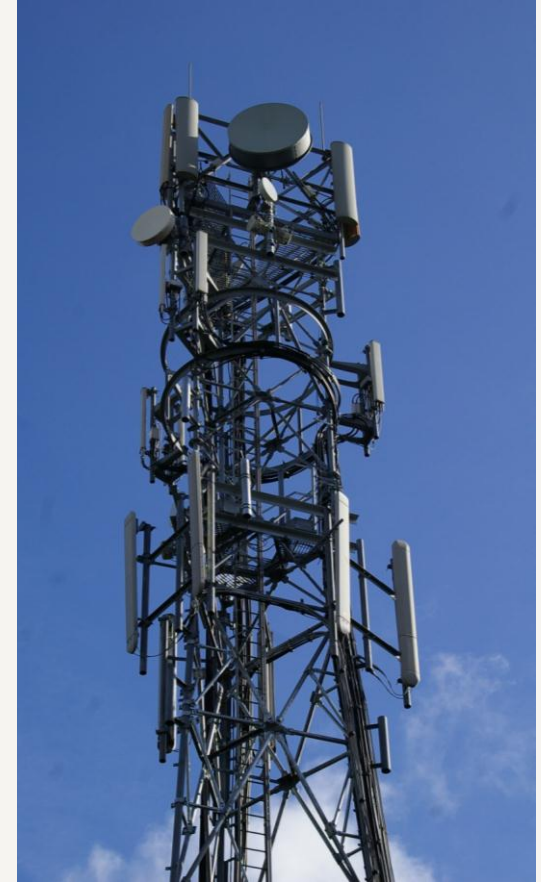
Martin Kingston
Principal Designer
RAN

Andy Sutton
Principal Network Architect
Network Strategy

03rd November 2015

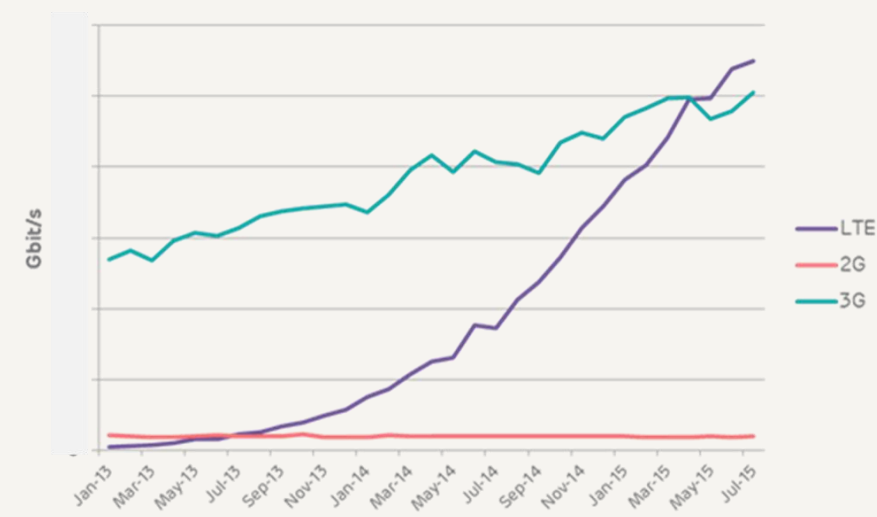
Agenda

- 4G traffic growth and the state of art in current mobile network technologies
- LTE-Advanced and Synchronisation
- What defines 5G? Key goals
- The key research areas for 5G
- Use cases of next-generation mobile networks
- Evolution path from today's networks to 5G
- 5G and Synchronisation
- The 5G timeline and radio frequency spectrum for 5G
- Summary

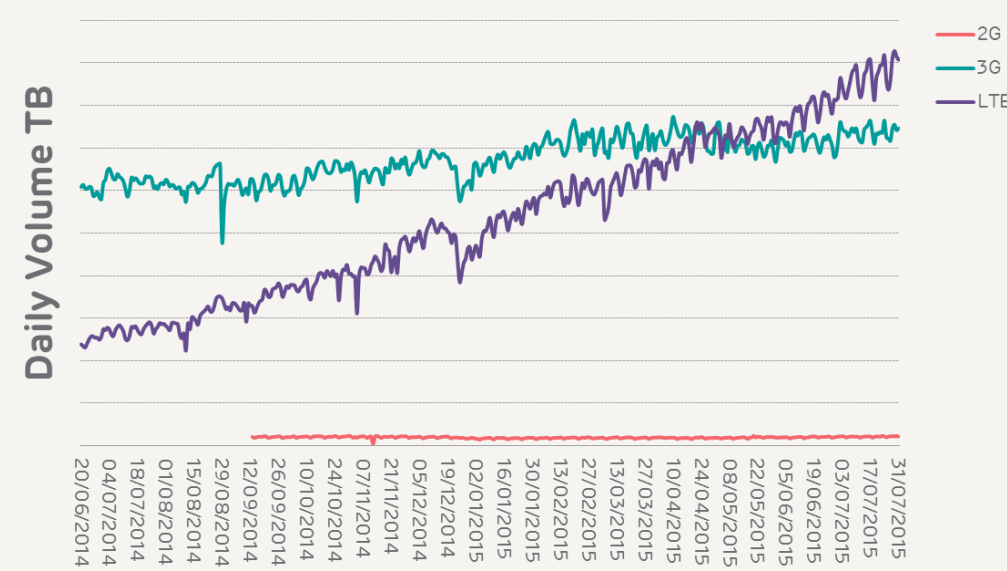


4G traffic growth, driven by adoption and video content...

Peak Throughput Per Layer



Volume Per Layer Per Day



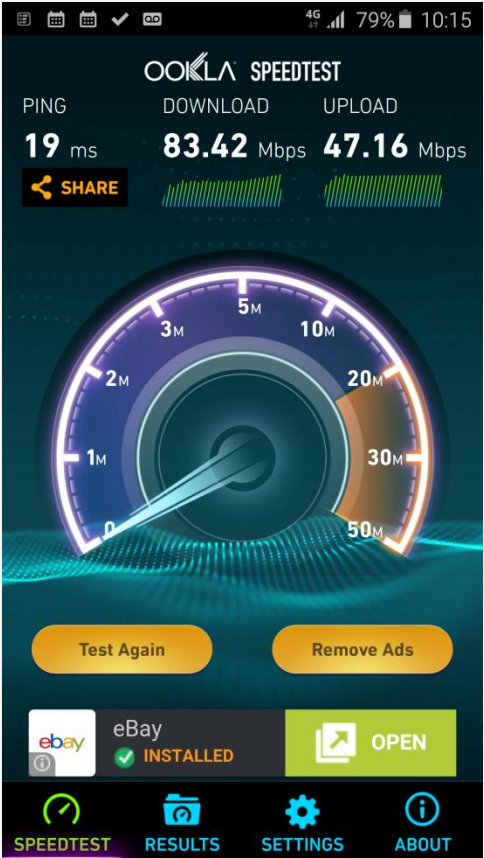
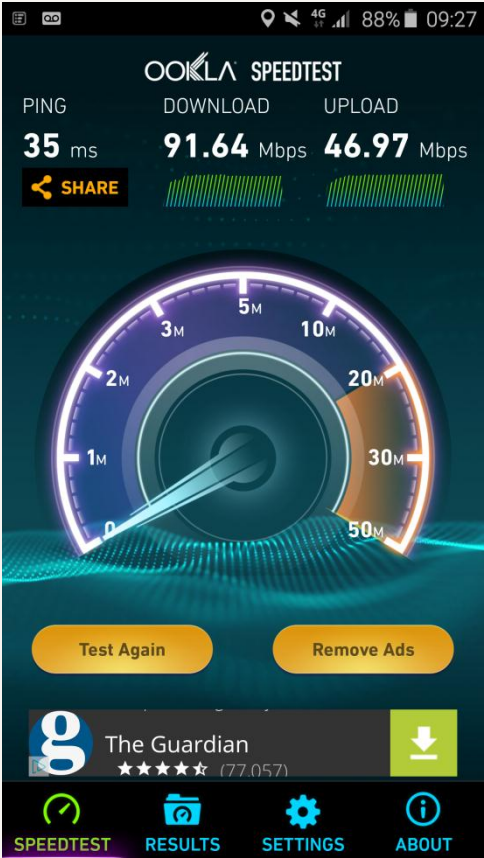
LTE-Advanced - the state of the art in 4G

1. High peak and average data rates in downlink and uplink
2. Low latency connectivity
3. High system capacity
4. Rural coverage



Recent live network speed-tests

Wembley, London, September 2015



LTE-Advanced Synchronisation

- The state of art in current mobile network technologies in the UK operates with the same level of synchronisation as used since the dawn of GSM!
 - Frequency 15ppb with G.823 traffic mask
- The first new requirement for 20 or so years will be phase synchronisation, supporting new services and increased capacity density in 2016.
 - eMBMS and eICIC
 - TDD on 2.3Ghz / 3.4GHz?
 - Phase +/- 1500nS



What defines 5G? Always Sufficient Rate to give users the perception of Infinite Capacity...

5G research goals

- Higher peak and average data rates in downlink and uplink

Peaks of 10Gbps, average of 1Gbps, minimum of 50Mbps

- Ultra-low latency

<1mS for certain services, <10mS as the norm

- Ultra reliable network

Wherever, whenever and whatever

- Energy efficiency

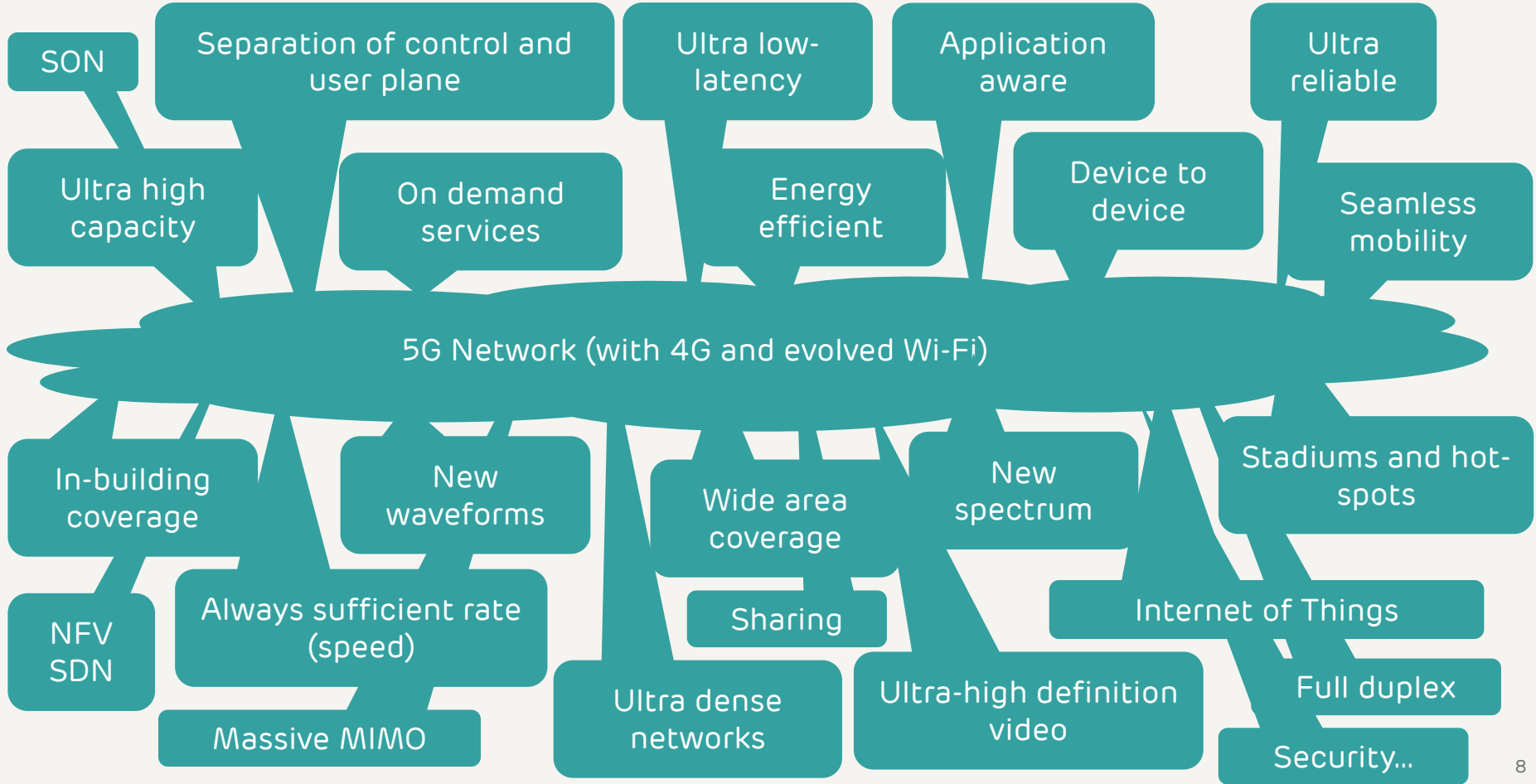
Doing much more with less

- Massive device connectivity

Internet of Things...











Key 5G research areas



5G use cases

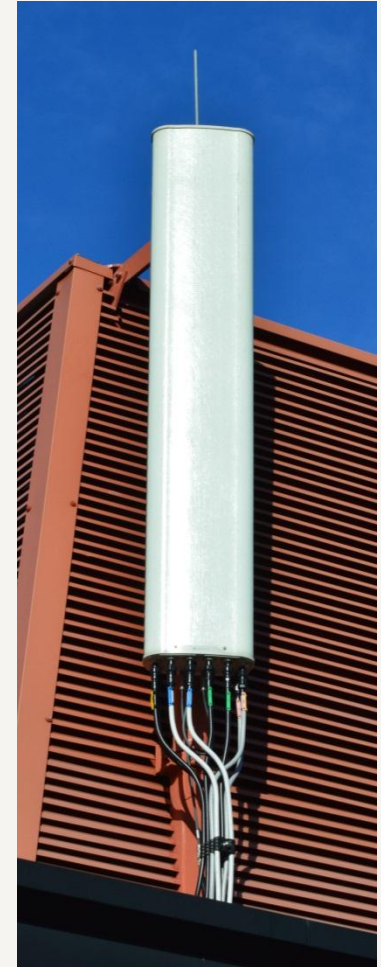


Broadband access in dense areas PERVASIVE VIDEO 	Broadband access everywhere 50+ MBPS EVERYWHERE 	Higher user mobility HIGH SPEED TRAIN 	Massive Internet of Things SENSOR NETWORKS 
Extreme real-time communications TACTILE INTERNET 	Lifeline communications NATURAL DISASTER 	Ultra-reliable communications E-HEALTH SERVICES 	Broadcast-like services BROADCAST SERVICES 

The evolution path from LTE-Advanced to 5G

LTE-Advanced features include:

- eMBMS
- Downlink Carrier Aggregation
- Uplink Carrier Aggregation
- Downlink MIMO (>R8)
- Uplink MIMO
- Heterogeneous Networks
- Relays
- Self Organising Networks (SON)
- UE Advanced Receivers
- Coordinated Multipoint Transmission and Reception
- But 5G may need a new waveform



LTE-Advanced Synchronisation, path to 5G

- Requirements for LTE-Advanced are well understood and aren't expected to change with further evolution
 - Frequency 15ppb with G.823 traffic mask
 - Phase +/- 1500nS
- New requirements from 5G will depend on whether new waveforms or other technologies are introduced for the air interface.
 - UF-OFDM / F-OFDM SCMA
 - Multicarrier schemes
 - CoMP
 - Massive MIMO, Full Duplex...



5G timeline

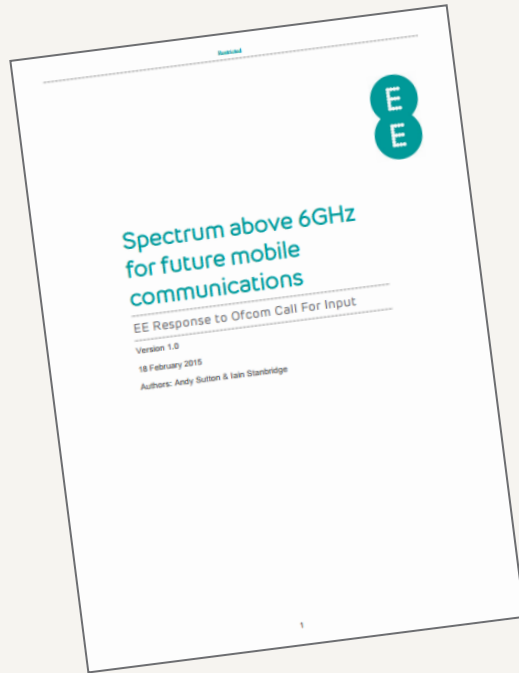
Key dates:

- WRC 2015
 - New spectrum bands <6GHz
- WRC 2019
 - New spectrum bands >6GHz
- ITU-R define IMT-2020
 - Technical performance requirements due in 2016
- 3GPP work-streams are on-going
 - Target Release 15 or Release 16
 - Late 2019/early 2020



Thoughts on future spectrum...

- 5G will start in <6GHz spectrum, typical cellular bands
- Then...



- Ofcom 2.3GHz / 3.4GHz 2016 auction:
<http://stakeholders.ofcom.org.uk/consultations/notice-2.3-3.4-ghz-spectrum/>
- Ofcom call for input on Spectrum above 6GHz for future mobile communications was published on 16/01/2015:
<http://stakeholders.ofcom.org.uk/consultations/above-6ghz/>
- 30 responses are available for review:
<http://stakeholders.ofcom.org.uk/consultations/above-6ghz/?showResponses=true>
- Ofcom published a summary document:
<http://stakeholders.ofcom.org.uk/consultations/above-6ghz/update-apr15/>

We're already helping the UK take the lead in 5G

- Platinum Founding Member of the 5G Innovations Centre at the University of Surrey
- Industrial advisory board member for EU Horizon 2020 TWEETHER project @ Lancaster University
- Researching UHD-TV and connected media applications and services with the University of Salford
- Supporting EU Horizon 2020 bids on behalf of UK academic organisations; financing leading edge research in the UK - providing on-going support and guidance
- Supporting UK Government's objective to ensure the UK is a major player in 5G networks and services research and development - knowledge economy
- Engagements with global partners to influence the development of the 5G eco-system



Summary

- 4G is the start of true mobile broadband
 - an IP based multi-media communications system
- Demand is huge, and will keep growing
- We will continue to evolve 4G to increase capacity, increase speeds and enhance the experience
- 5G is at the fundamental research stage, but will complement 4G networks
- 5G will support ultra dense networks with even higher peak and average data rates, with ultra low-latency to enable the tactile web and immersive real-time video
- From a speed perspective - 4G can take us to 1Gbps; 5G is everything beyond that...

Further information

- 5G - The Future of Mobile Communications - ITP Journal paper:
[https://www.academia.edu/11743695/5G - The Future of Mobile Communications](https://www.academia.edu/11743695/5G_-_The_Future_of_Mobile_Communications)
- Microwave and millimetre wave radio systems - ITP Journal paper:
https://www.academia.edu/13885538/Microwave_and_Millimetre_Wave_Radio_Systems
- Mobile network architecture - ITP Journal paper:
[https://www.academia.edu/13885065/Mobile_Network_Architecture_Evolution - 1G to 4G](https://www.academia.edu/13885065/Mobile_Network_Architecture_Evolution_-_1G_to_4G)
- The Evolution of Mobile Communications Networks - LTE-Advanced and 5G:
[https://www.academia.edu/10935998/The_Evolution_of_Mobile_Communications_Networks_4G_LTE-Advanced_and_5G - presentation](https://www.academia.edu/10935998/The_Evolution_of_Mobile_Communications_Networks_4G_LTE-Advanced_and_5G_-_presentation)
- Wembley stadium: <http://www.thinksmallcell.com/Enterprise/wembley-stadium-tour-deep-inside-ee-s-largest-das-deployment.html>
- EE - The road to 5G: <http://www.lightreading.com/mobile/4g-lte/ee-the-road-to-5g/v/d-id/712618>
- Rural not-spots: <http://www.newelectronics.co.uk/electronics-technology/mobile-phone-operators-are-turning-to-new-technology-to-solve-the-rural-not-spot-problem/83909/>

THANK YOU