Towards 5G – an operators perspective

Evolution or Revolution?

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BT Research & Innovation

WiMob Oct 2015

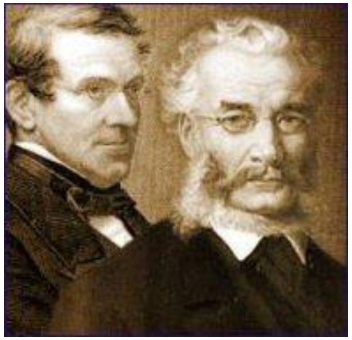
Towards 5G – an operators perspective

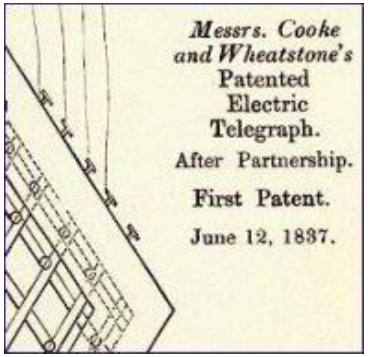
Evolution or Revolution?

Contents

BT has a long history of 'purposeful innovation'

With many world first achievements





World Firsts

1846: Telecommunications company: Electric Telegraph Company

1926: Two way transatlantic telephone conversation by radio

1943: Programmable computer: Colossus

1962: Telephone call via satellite

1968: Digital exchange

1980: Purpose-designed optical fibre submarine cable

1984: 140 Mbit/s commercial single mode optical fibre link

1989: Satellite telephone system: Skyphone

1999: GPRS live data call over a mobile network

2013: World's first G.fast trial

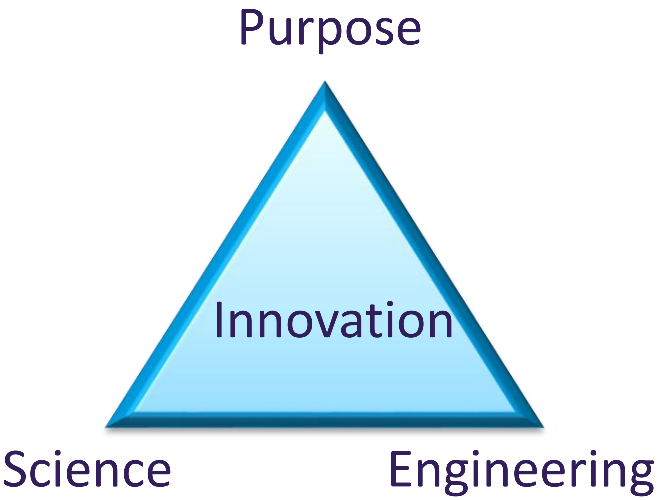
2014: 3 Tb/s optical fibre link in the core network

Adastral Park – 'a key UK engineering centre'

Using the power of communications to make a better world

Assist living

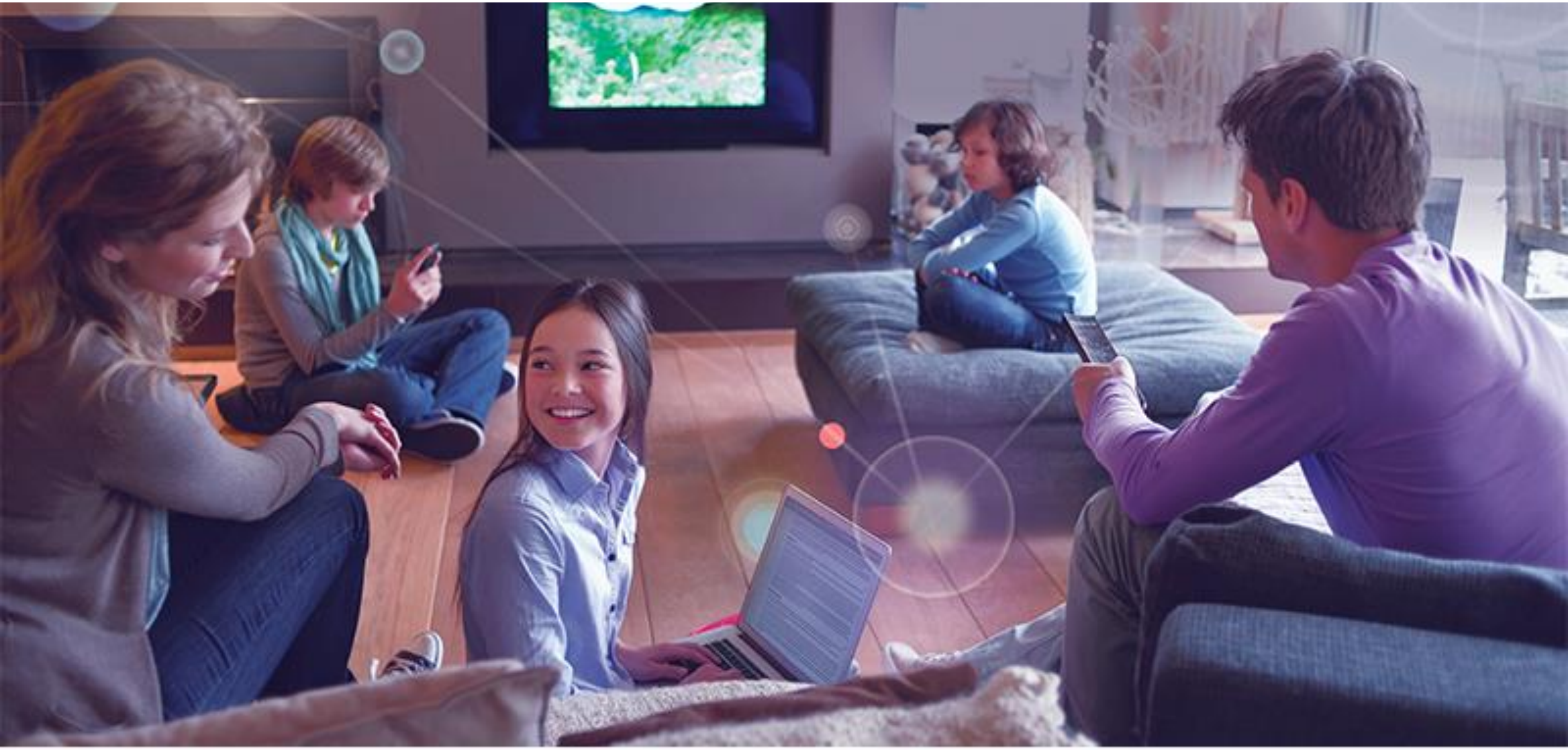
Always best connected



Ultra-Hi-Definition Entertainment

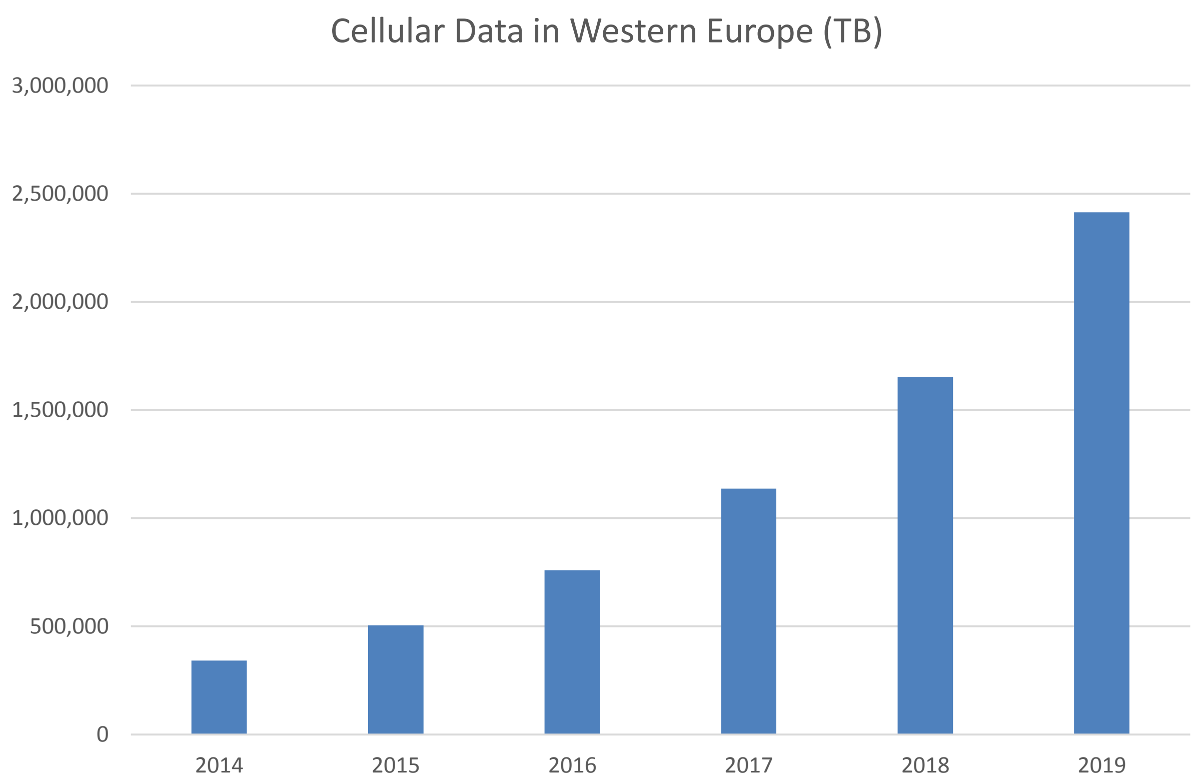
The Internet of Things

What is 5G?
Revolution or Evolution



Tomorrows citizens

Cellular Data Growth



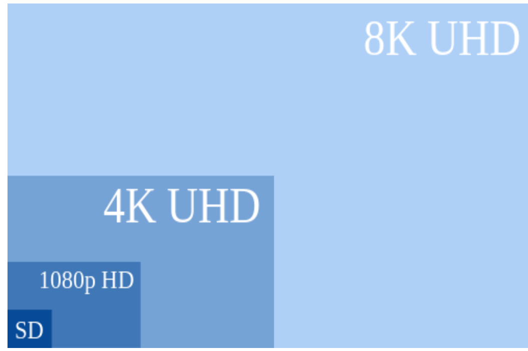
46% CAGR for Western Europe

Source: CISCO VNI Feb 2, 2015

The drivers for the next generation of mobile

Gaming

UHD Video



Mission Critical IoT

Interactive Services

Video

Internet of Things

The tactile internet

Massive
Machine to Machine

5G is in the research phase

1000x capacity

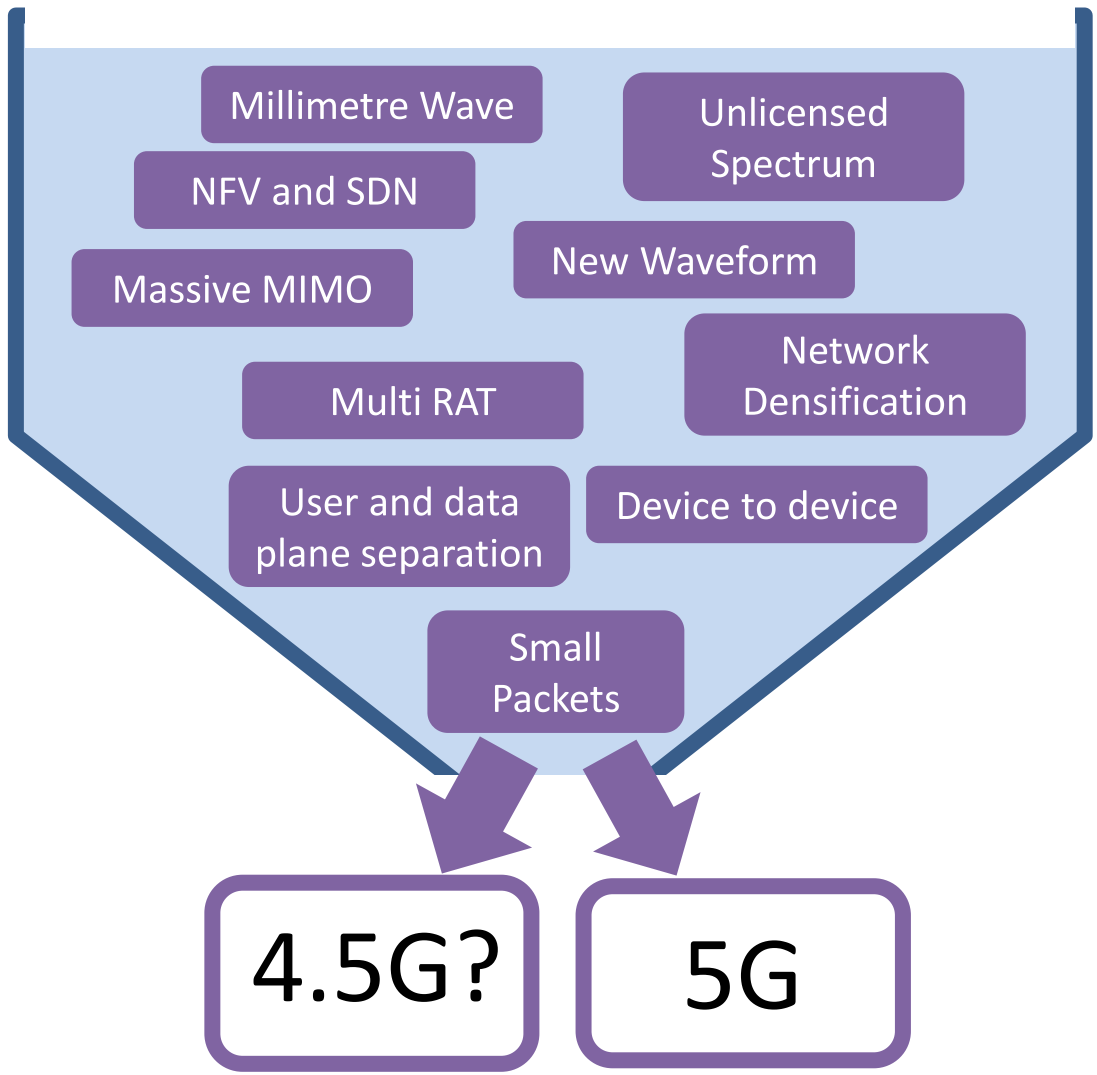
10Gbps Peak data rates

1Gbps Average data rates

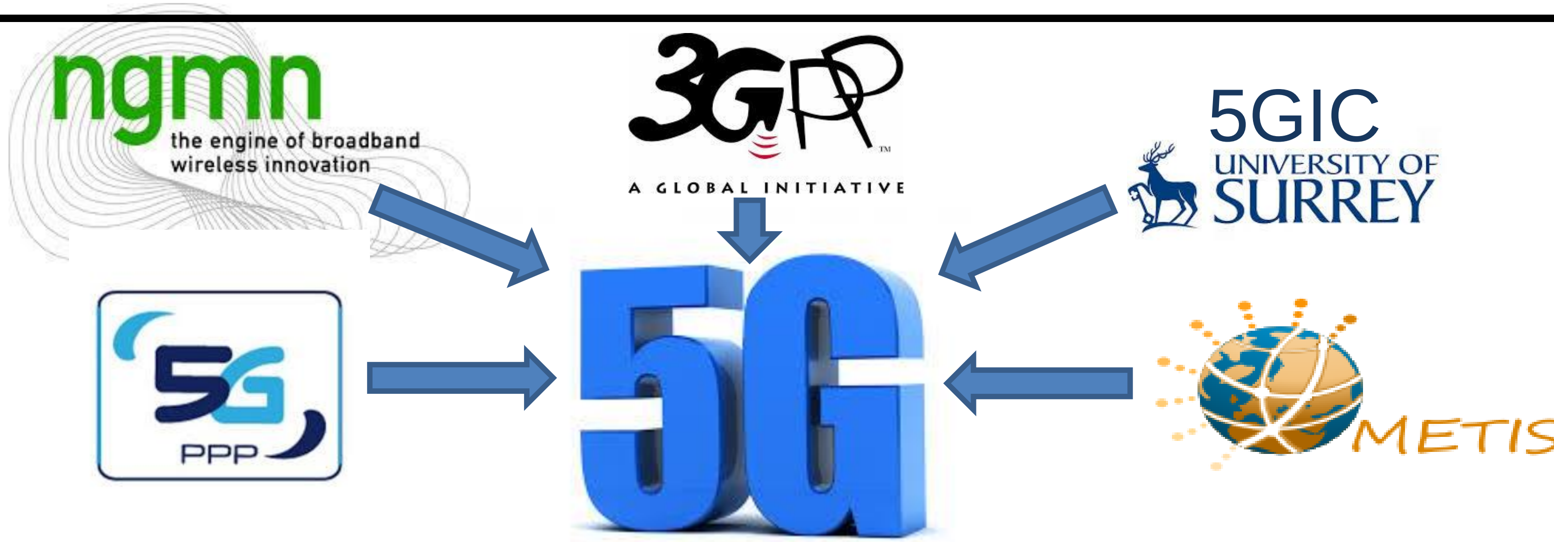
Sub 1ms latency

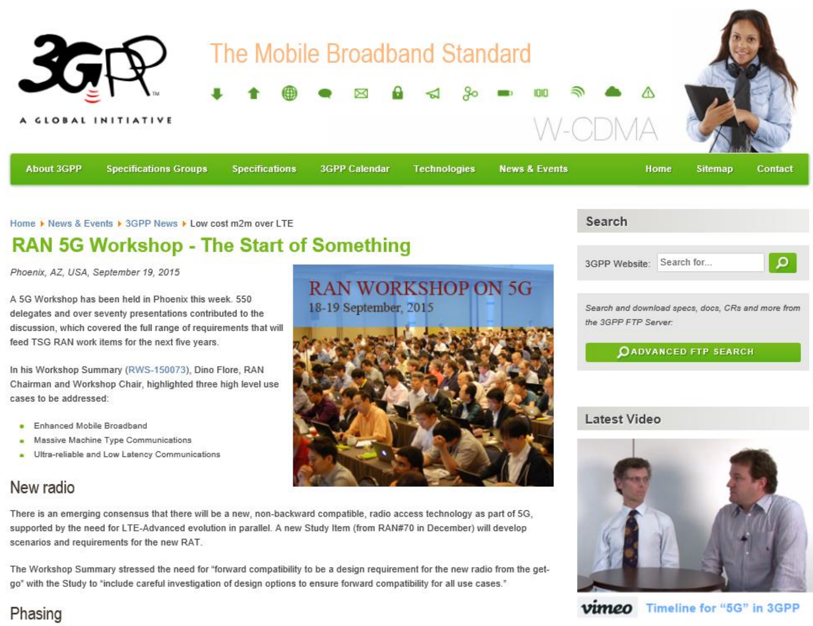
“Ultra reliable”

“Low energy”



Consensus is slowly forming on the future of 5G




3GPP
A GLOBAL INITIATIVE

The Mobile Broadband Standard

W-CDMA

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RAN 5G Workshop - The Start of Something

Phoenix, AZ, USA, September 19, 2015

RAN WORKSHOP ON 5G
18-19 September, 2015

A 5G Workshop has been held in Phoenix this week. 550 delegates and over seventy presentations contributed to the discussion, which covered the full range of requirements that will feed TSG RAN work items for the next five years.

In his Workshop Summary (RWS-150073), Dino Flore, RAN Chairman and Workshop Chair, highlighted three high level use cases to be addressed:

- Enhanced Mobile Broadband
- Massive Machine Type Communications
- Ultra-reliable and Low Latency Communications

New radio

There is an emerging consensus that there will be a new, non-backward compatible, radio access technology as part of 5G, supported by the need for LTE-Advanced evolution in parallel. A new Study Item (from RAN#70 in December) will develop scenarios and requirements for the new RAT.

The Workshop Summary stressed the need for "forward compatibility to be a design requirement for the new radio from the get-go" with the Study to "include careful investigation of design options to ensure forward compatibility for all use cases."

Phasing

Search

3GPP Website: Search for...

Search and download specs, docs, CRs and more from the 3GPP FTP Server:

ADVANCED FTP SEARCH

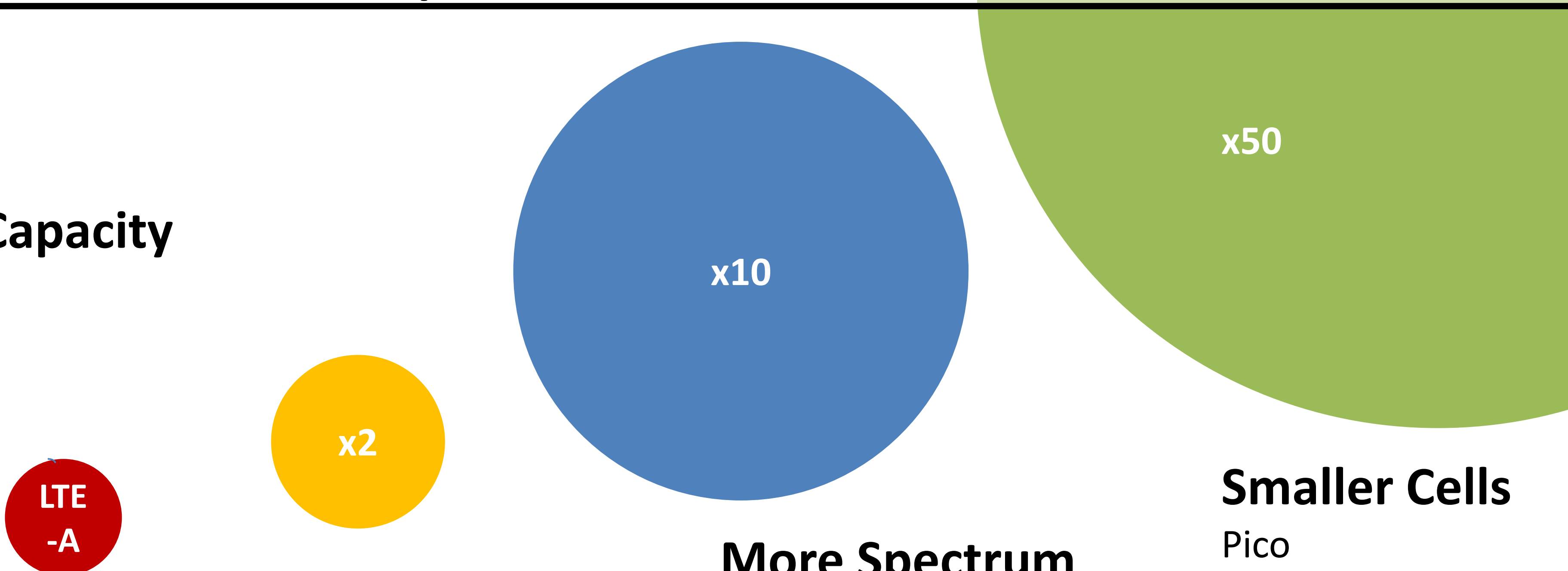
Latest Video

vimeo Timeline for "5G" in 3GPP

How will 5G achieve the capabilities?

Innovation is required in three dimensions:

Capacity



Smaller Cells

Pico

Femto

More Spectrum

mmWave

Unlicensed

Shared

Aggregating Channels

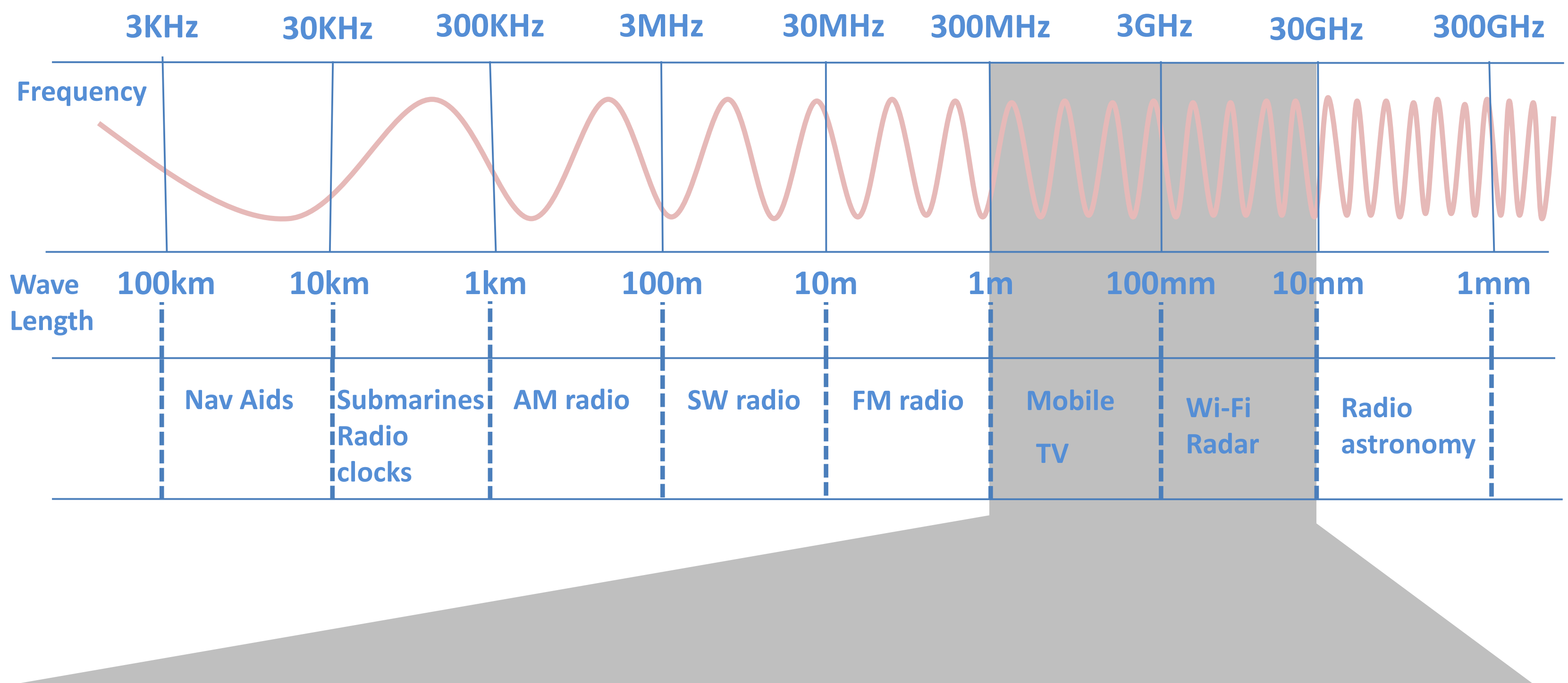
Spectrum efficiency

Information rate /Hz

MIMO / Beam forming

Small Packets

Where will more Spectrum come from?



Auctions:
2.3GHz
3.4GHz
700MHz

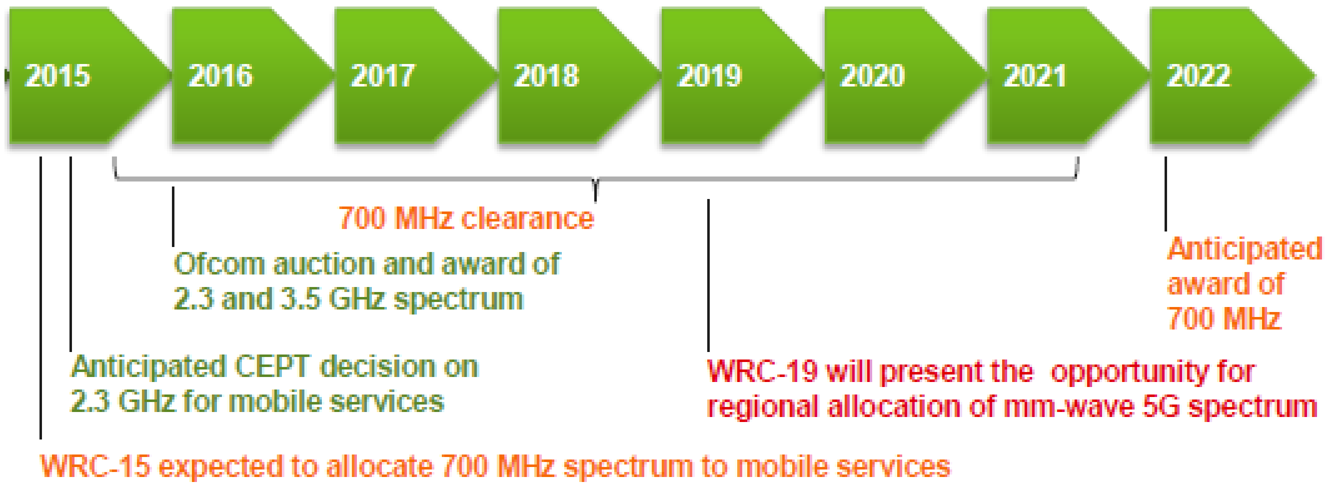
Spectrum Sharing:
TVWS

Unlicensed:
LTE-LAA
LWA
Wi-Fi

mmWave

Auctions

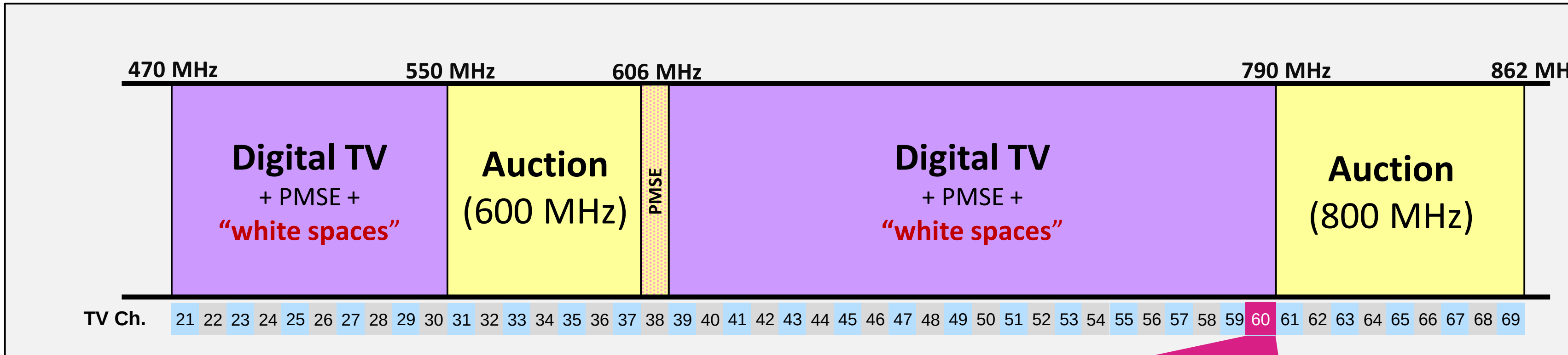
Regulators are releasing more spectrum for mobile broadband, sometimes it is not straight forward

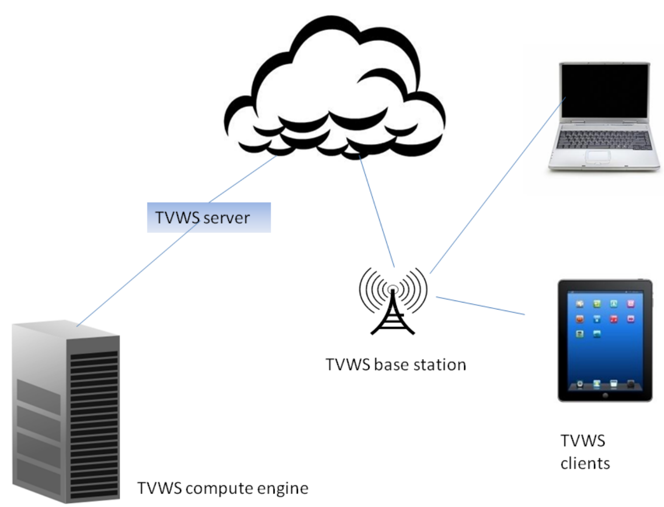


2.3GHz is very close to Wi-Fi working in the 2.4GHz band

Our research has concluded that a suitable separation needed between a 2.3GHz LTE UE and a Wi-Fi Access Point at 2.4GHz ranges up to 12m for the least resistant access points.

Spectrum Sharing: TV White Spaces

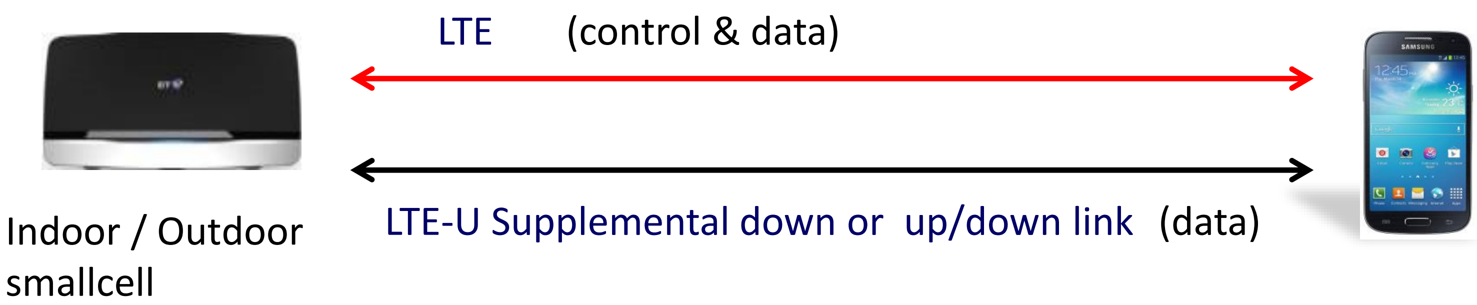




TV Ch. 60 example

LTE-U / LTE-LAA

Using unlicensed spectrum in conjunction with LTE



LTE-U will operate in one of two modes:

Supplemental Downlink: Additional downlink data capacity.

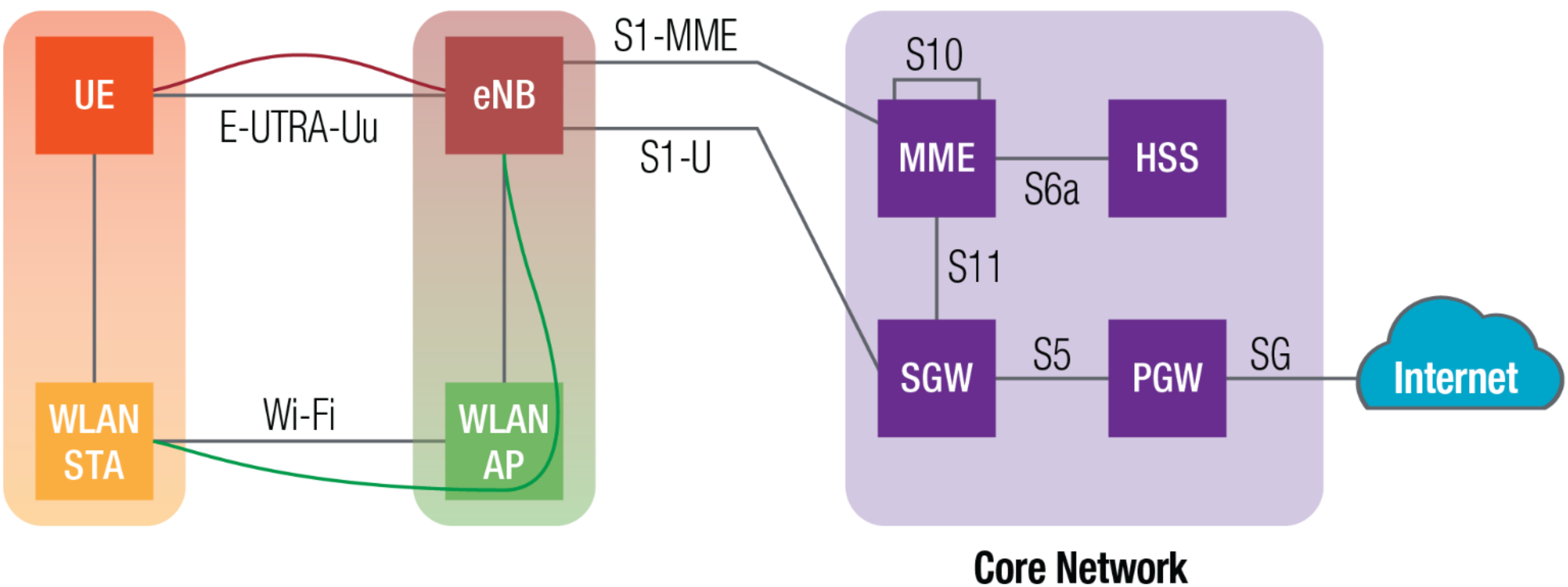
(1) Carrier Aggregation: Additional downlink and uplink data capacity

(3) Using 5GHz spectrum will give access to additional 20MHz channels

The key issue to resolve is co-existence between LTE & Wi-Fi

LWA – LTE Wi-Fi Aggregation
Combining LTE and Wi-Fi

A concept being carried forward into 5G

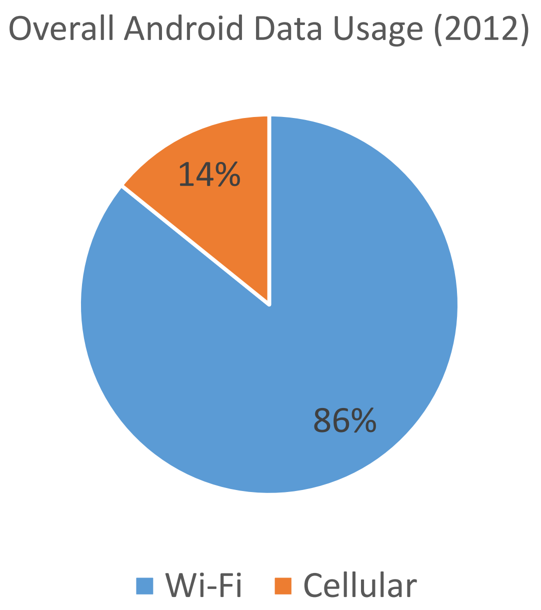


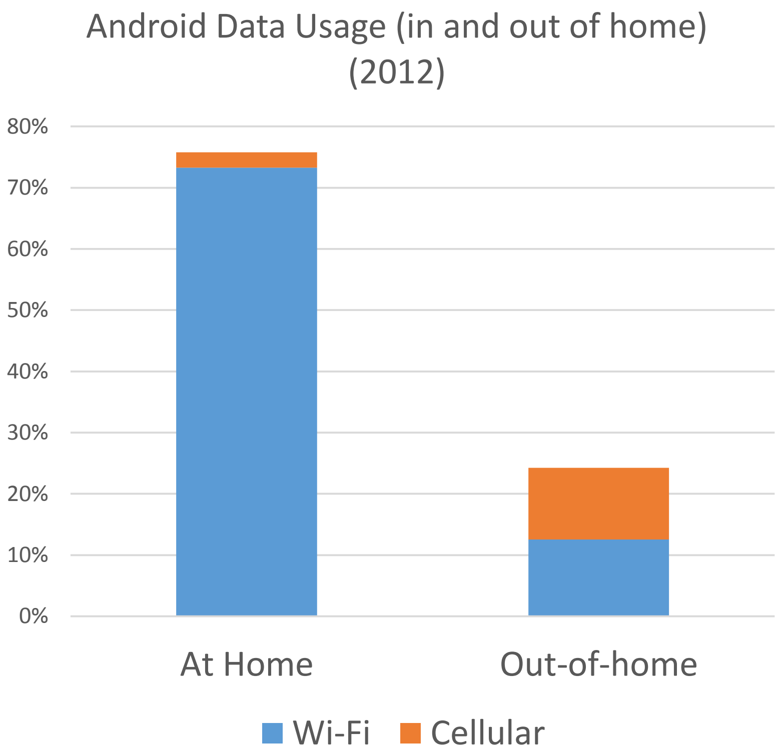
Source: Rukus

Where data carried today

Does using Wi-Fi bands increase capacity?

Wi-Fi is carrying >80% data traffic





Source: BT Wi-Fi Survey 2012 (~600 participants recruited by ICM)

mmWave

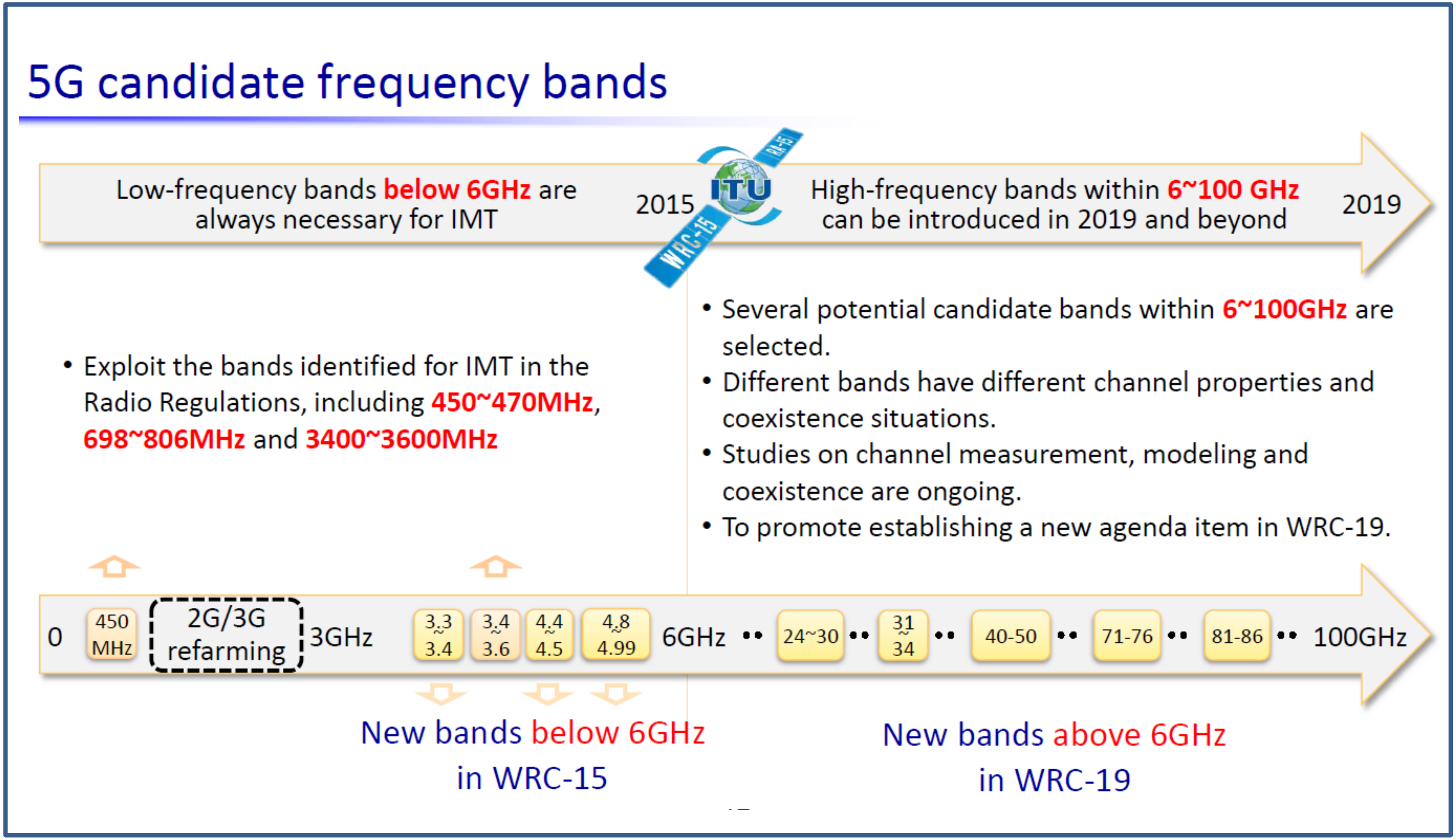
Research and development driven form vendors, notably Samsung and Huawei.

Samsung have build a proof of concept for a small cell ; 28GHz 500MHz bandwidth, beam forming

Harmonised spectrum probably not available before 2025

Source: 5GIC

Harmonised new bands above 6GHz unlikely before 2025



Source: China Mobile, 5G Huddle Copenhagen Oct 2015

Small cells
BT's Approach 'Inside-Out' rather than 'Outside-In'

BT focus: Urban and indoor capacity	**Mobile operator partner focus:** Outdoor and national coverage

50m Femtocells

100m Picocells

500m Microcells

1km

2km Macrocells

"a hub that includes Wi-Fi and a 4G cell; a combined router"



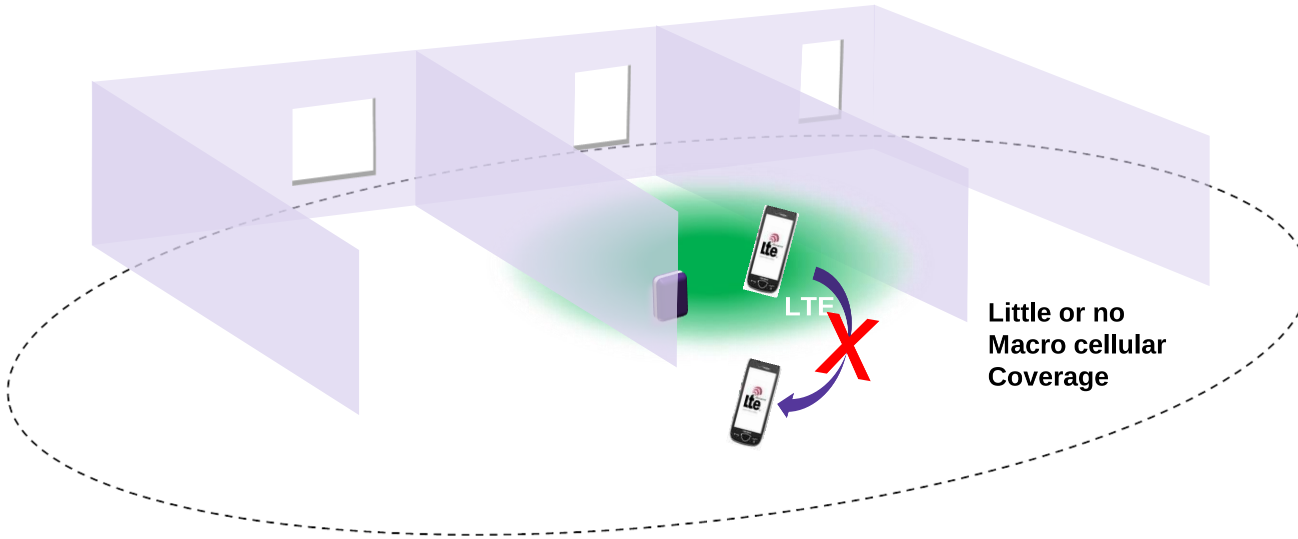

- Deploy small cells indoors for **capacity**
- Use MNO partner for **coverage**
- Integration of WiFi and LTE services
- Brings together the benefits of LTE and WiFi
- Open-mode system analogous to BT FON/BT WiFi
- 'Fixed meets mobile'

Inside / Out is a novel application of Femtocells

Historic Femtocell Application

– Coverage In-fill

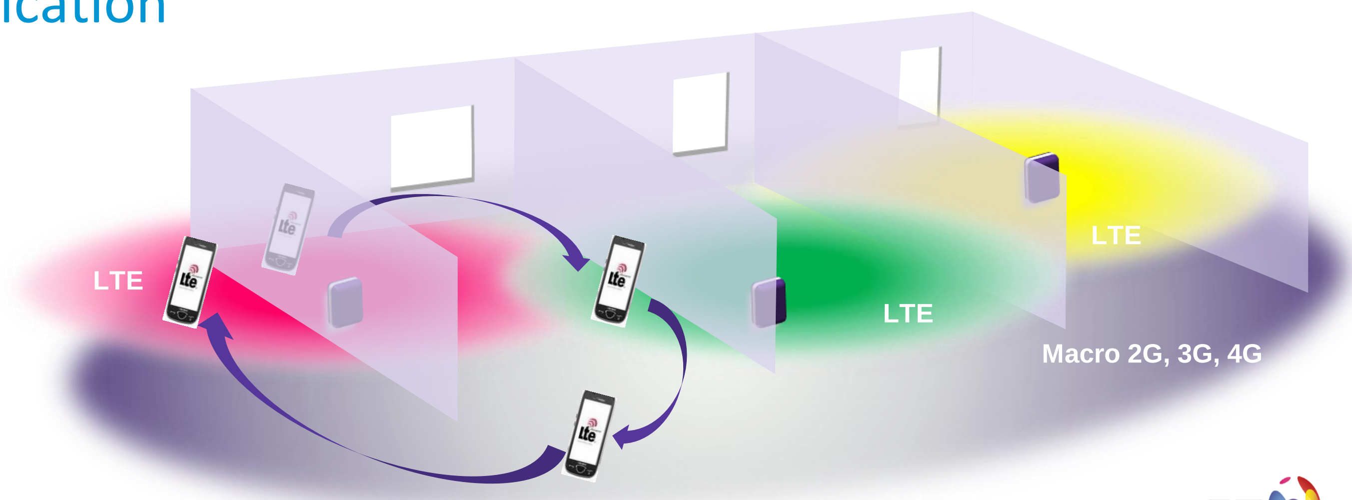
- Simple home appliance



BT Femtocell Application

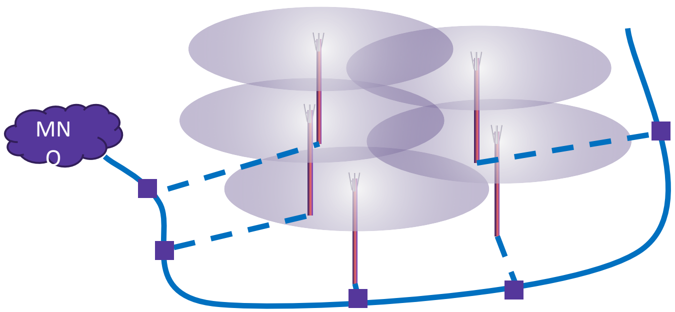
– Inside-out capacity

- Part of a contiguous network



Managing a dense Femto network requires a automation

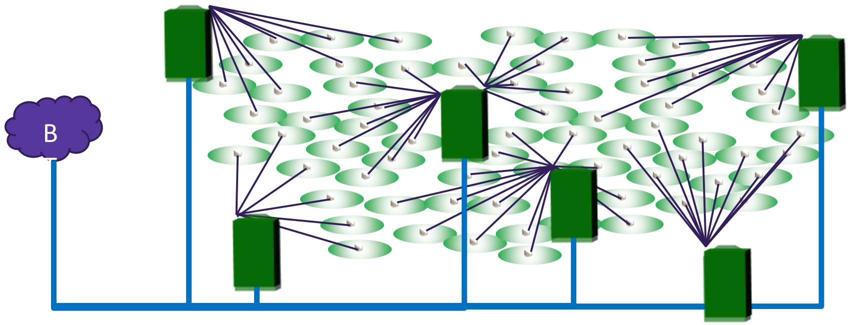
Macrocellular



~3 x 18,000 cells (3 sector sites)

Manual optimisation by large team of radio planners.

"Femtocellular"



~5,000,000 cells

Manual planning not possible due to scale. Alternative is an automated solution "a Self Organising Network, SON".

100x more cells

10x more cell boundary

SON is a range of automated functions which cover a number of capabilities:

- Self configuration
- Self Healing
- Mobility Management
- Interference Mitigation
- Energy Saving

SON Testing at the Building Research Establishment in Watford

September 2014 working with Qualcomm

Cluster 1, six cells

Victorian terrace
5 cells

Mansion
2 cells

Cluster 2, seven cells

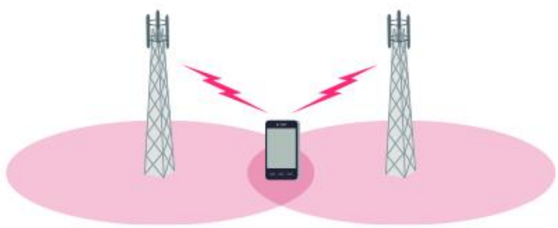
The Building Research Establishment has clusters of unoccupied residential buildings, built in typical UK materials and styles available for hire. This is ideal for early testing of dense femtocell deployments to establish the efficacy of SON techniques.

Examples of SON in action based on real test data

- Adjusting transmit power to improve network performance
- Resolving a user 'Ping-Pong' between femtocells

Testing Results	
Configuration	Auto-configuration of cell IDs and neighbour lists are essential because manual setting is untenable for a large dense deployment
Interference Mitigation	Automatic power management improves reliability and performance
Mobility optimisation	Frequent Handover (ping-pong) Mitigation can reduces unnecessary handovers by up to 15x

Emerging radio technology is driving the need for Cloud Radio Access Network (C-RAN)

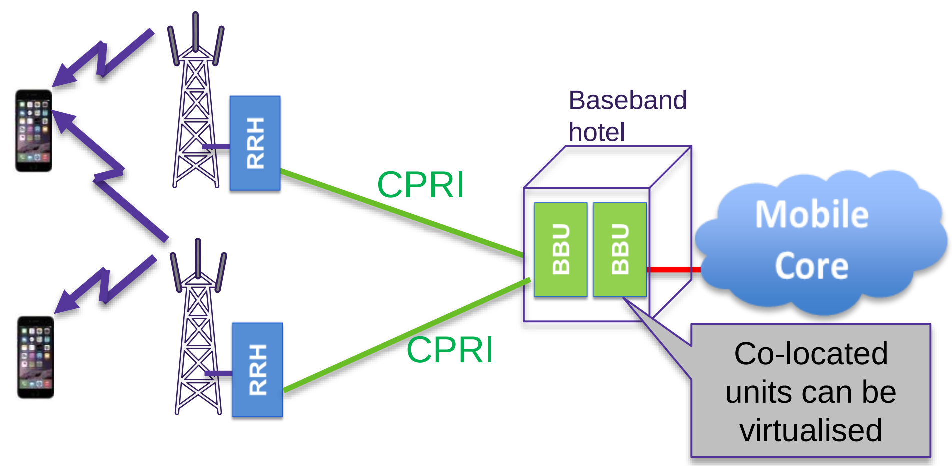


CoMP – Co-ordinated Multipoint

Device receives transmissions from multiple sites
Increases data rates available to uses at cell edge
Connectivity between sites must be high bandwidth, low latency
Air interface efficiency achieved at the cost of more capable backhaul

This is a drive to Cloud RAN

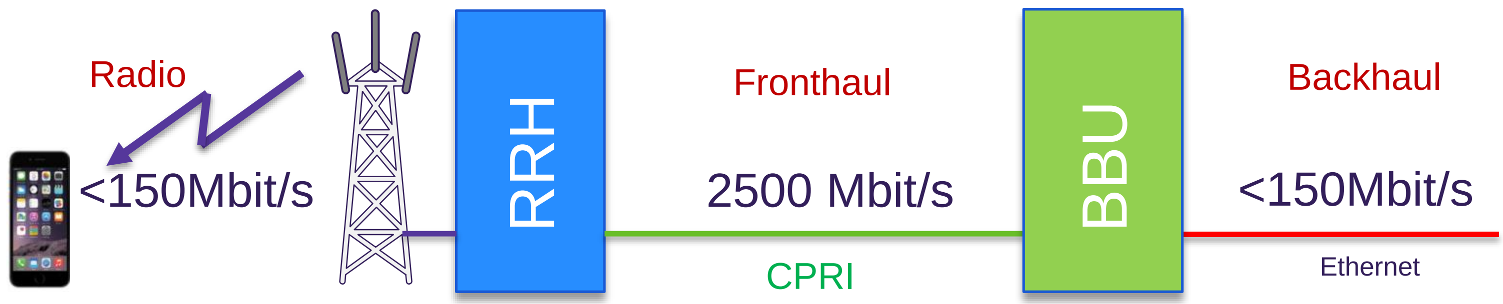
Split the base station electronics
Centralise the baseband units (BBU)
CPRI (Common Public Radio Interface) to the remote radio head (RRH)



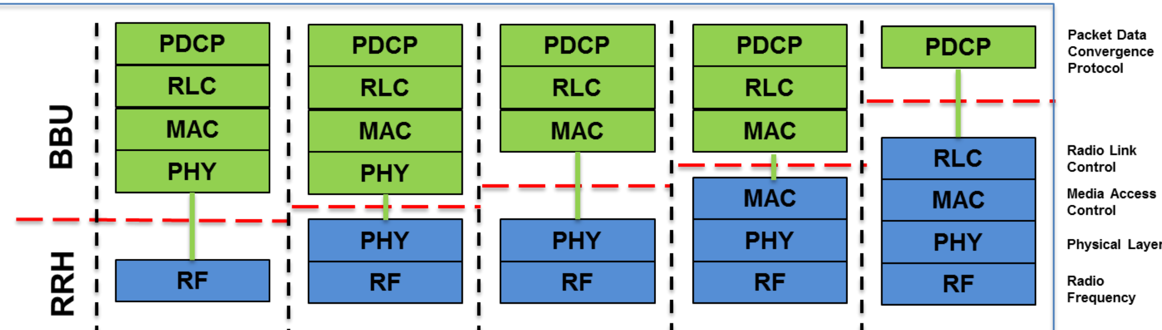
and Cloud RAN can also:

Reduce site footprint
Optimise equipment costs

Alternatives to CPRI



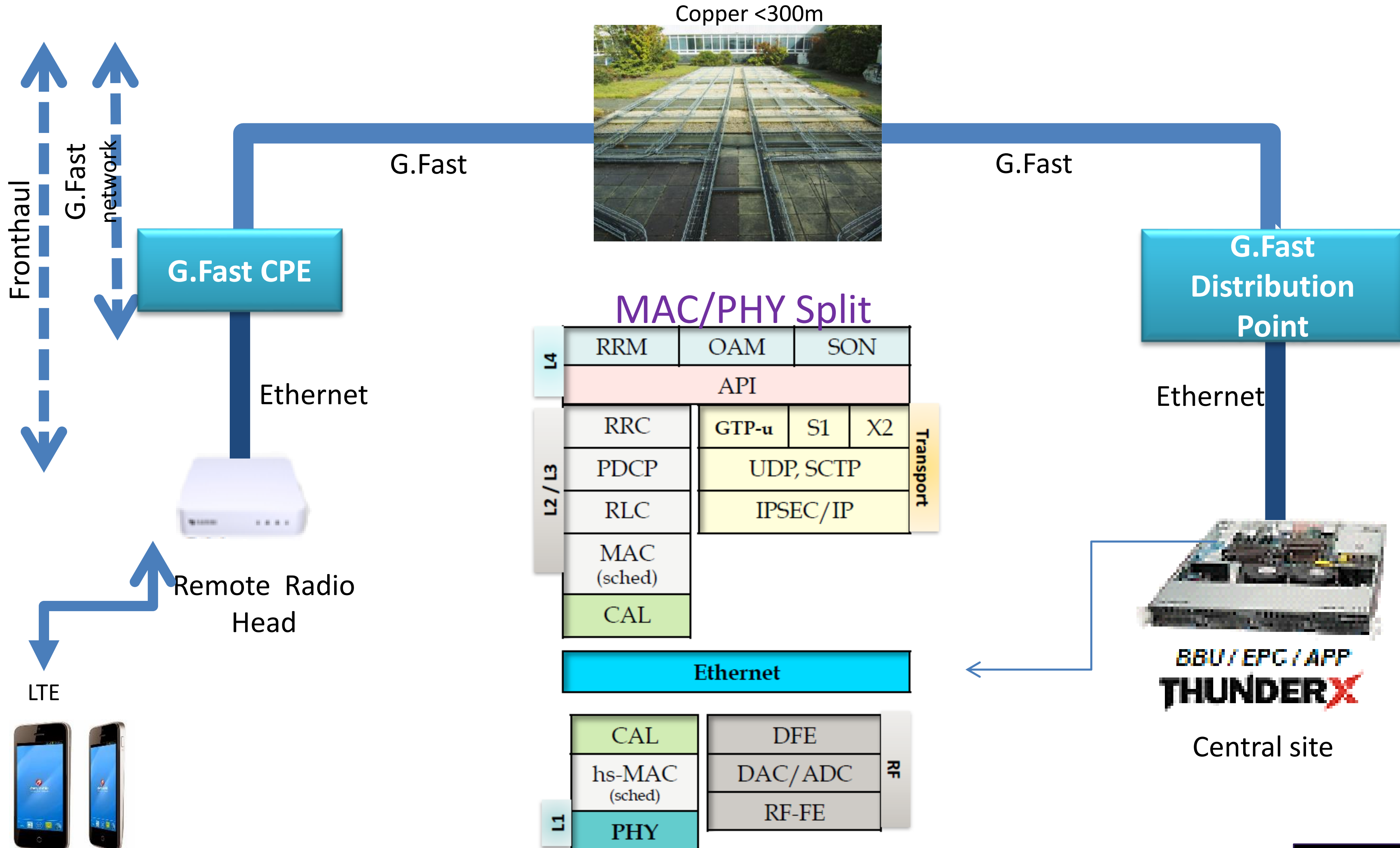
Base station functional split



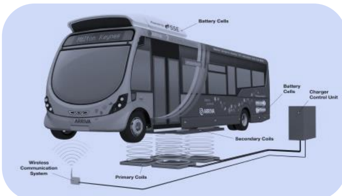
Function split impact

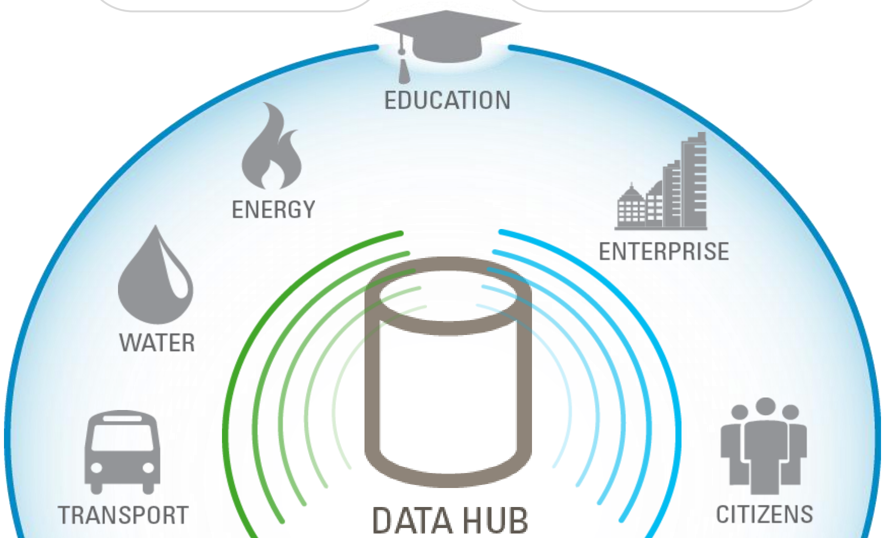
Connection	CPRI	Split PHY	MAC-PHY	Split MAC	PDCP-RLC
Data rate	2500Mbit/s	1075Mbit/s	152Mbit/s	151Mbit/s	151Mbit/s
Latency	<0.25ms	0.25-2ms	2ms	6ms	30ms
Impact on CoMP gain	0%	-5%	-15%	-25%	-55%
Technology	WDM-PON	WDM-PON	EAD, FTTP?	EAD, FTTP, G.fast?	EAD, FTTP, G.fast

Cloud RAN over G.fast



Smart Cities can improve the lives of millions



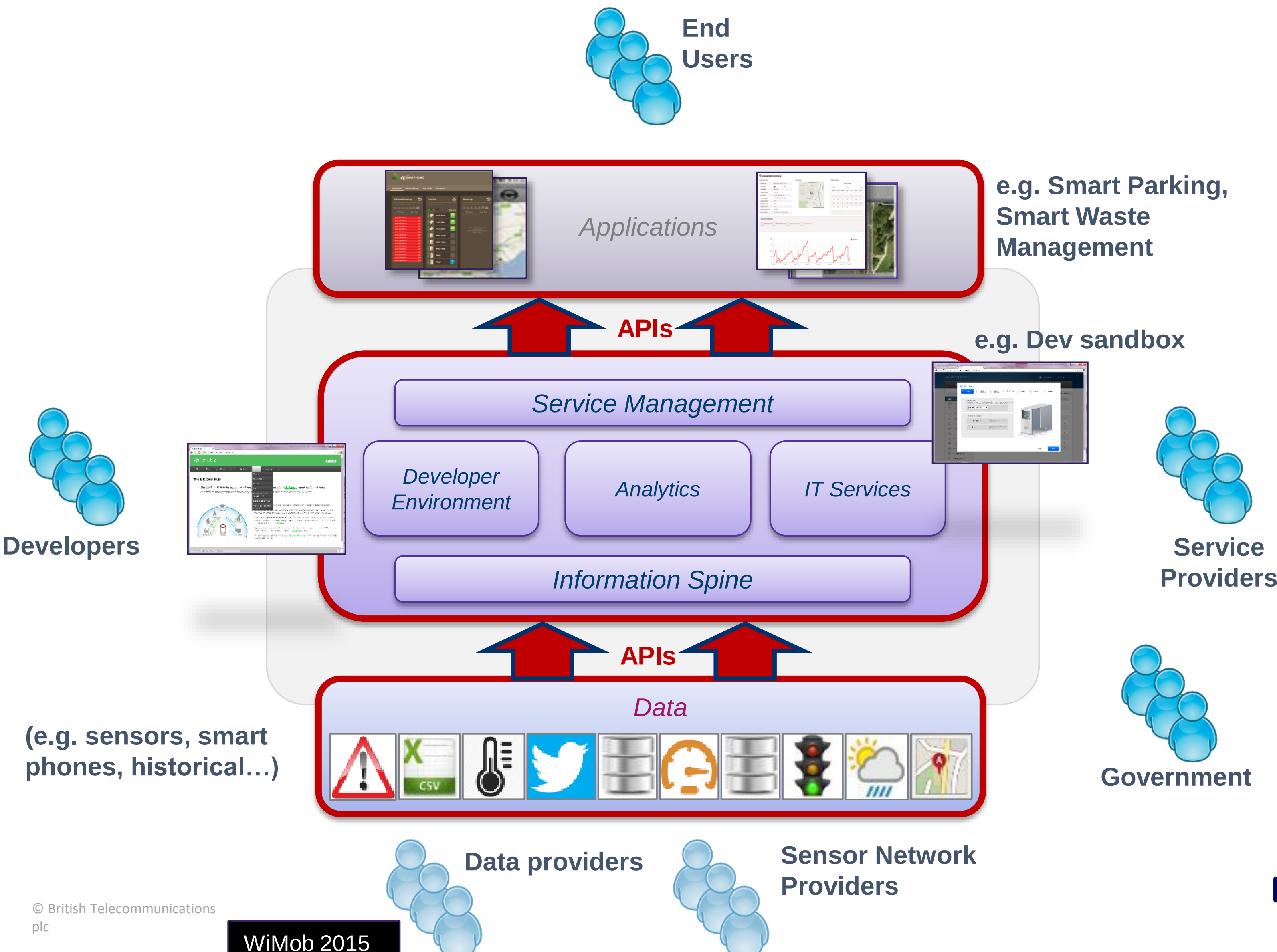


MK:SMART

- *Milton Keynes is the UK's fastest growing city, economy set to grow 67% by 2026*
- *City infrastructure under strain*
- *Target: enable growth of 20% with no net increase in water, energy, waste collection, and reduce congestion*
- *SME incubator of up to 90 SMEs, with projects in transport, energy, water, home, and education*

See www.mksmart.org, all rights reserved

The Information Exchange is at the heart of the Smart City

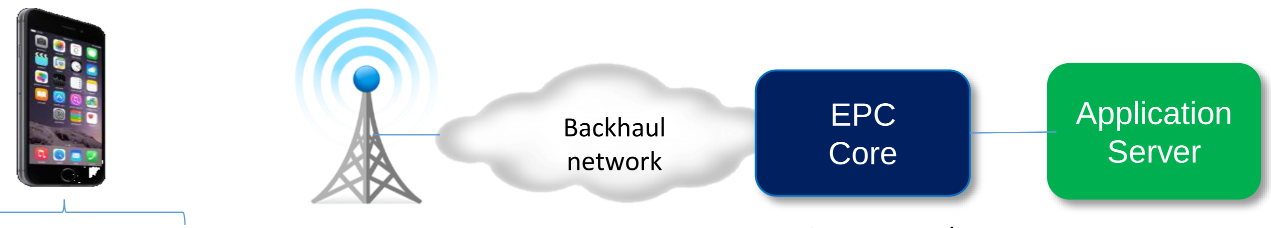


Current examples
From GiTex Dubai October 2015

LoRa network with launch plan 2016

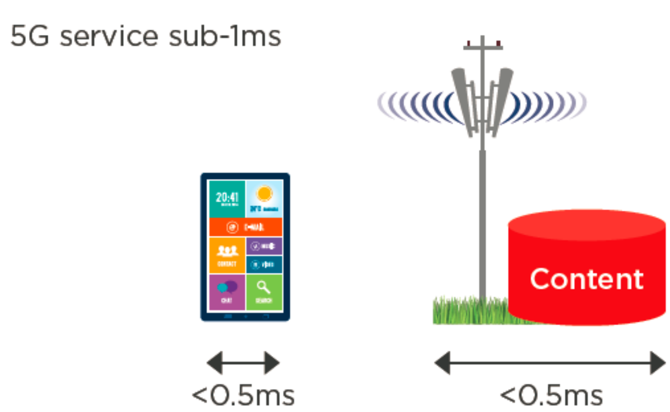
Robotic receptionist

Latency in 4G networks



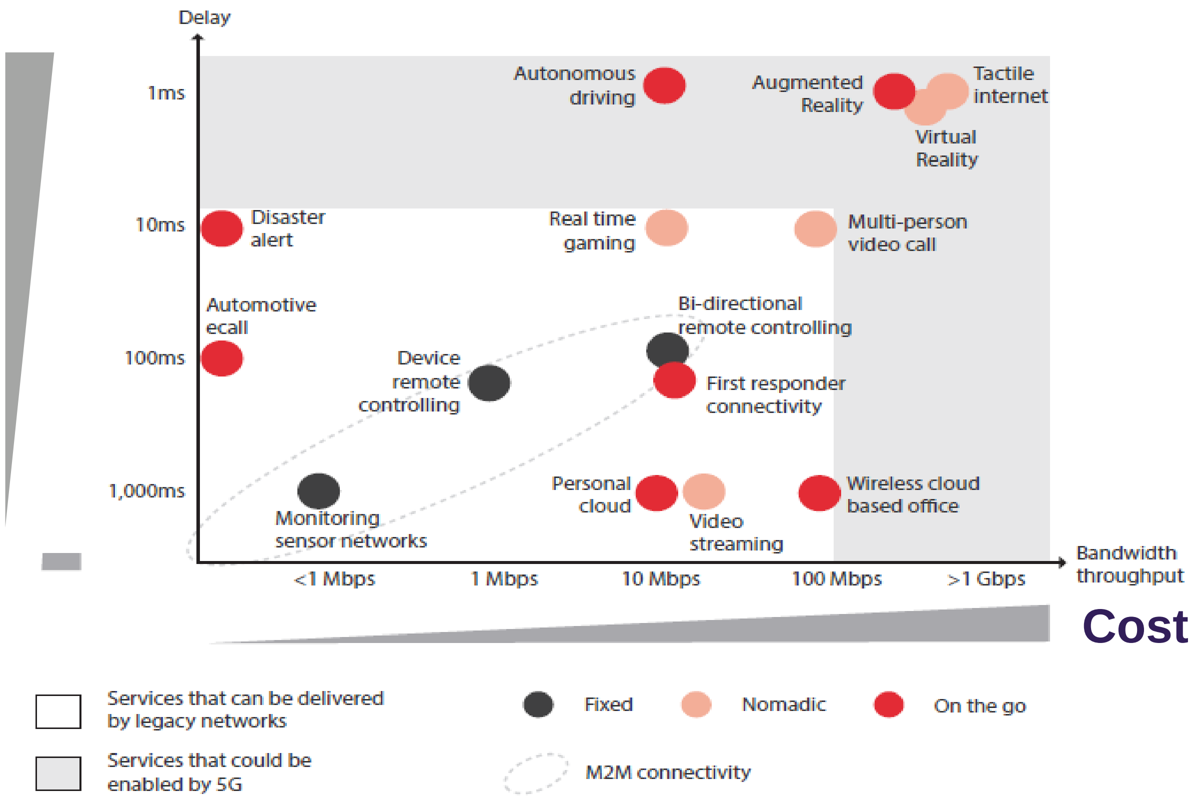
	Application Layer Processing	Device Radio Processing	eNB processing	Backhaul Transmission	Core Network processing	Application Server Processing	
Gaming application	5 msec					60 msec	Gaming server
Video decoding and rendering	40 msec					5 msec	CDN delivery
Network		4 msec	4 msec	4 msec	sub 1 msec		

GSMA suggest:
- Content needs to be within 1km of device
- Network sharing would be preferred
- New business models should be explored



Low Latency in 5G networks

Cost



Cost

Figure 1: Bandwidth and latency requirements of potential 5G use cases

Source: GSMA Intelligence

Maria Cuevas – BT TSO R&T

5G Core Network

needs to address future customer needs as well as optimal operational efficiency

Operator requirements

Optimisation

- Optimal traffic routing
- Simplified Operations
- Infrastructure reuse

Future requirements

5G Vision

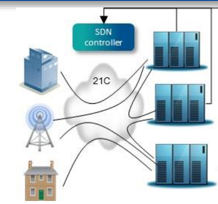
- Full convergence of fixed and mobile services (under debate)
- Extremely low latency
- Increased bandwidth
- High traffic density
- Massive capacity
- High mobility

Architecture and Technology

Network Function Virtualisation (NFV)

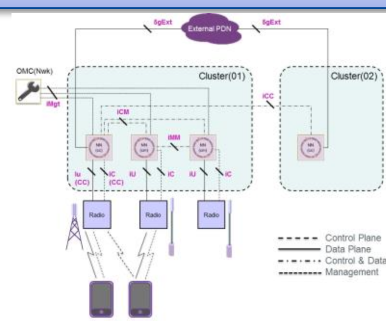
- Operational savings
- Infrastructure re-use
- Flexible scaling

Software-defined networks (SDN)



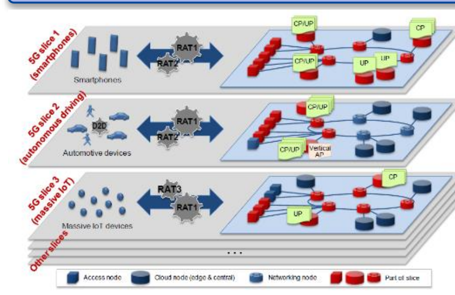
- Application-driven networking
- Network optimisation
- Flexible resource allocation (5G)

“Flat distributed cloud” (FDC) architecture



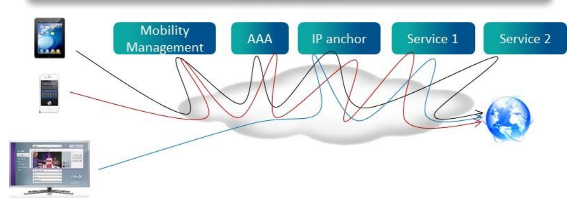
- Multi-Radio/Fixed Access Technology support
- Optimal functional distribution
- MEC (Mobile Edge Computing) proposal controversial

Network slicing



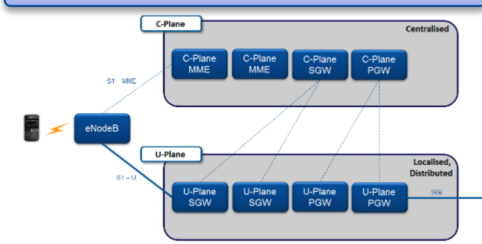
- Application-dependent “network slices”
- New business models

Flexible routing /dynamic resource allocation



- Pre-flow allocation of functional elements
- Optimal decomposition of functional architecture
- Full service flexibility

User/control plane separation



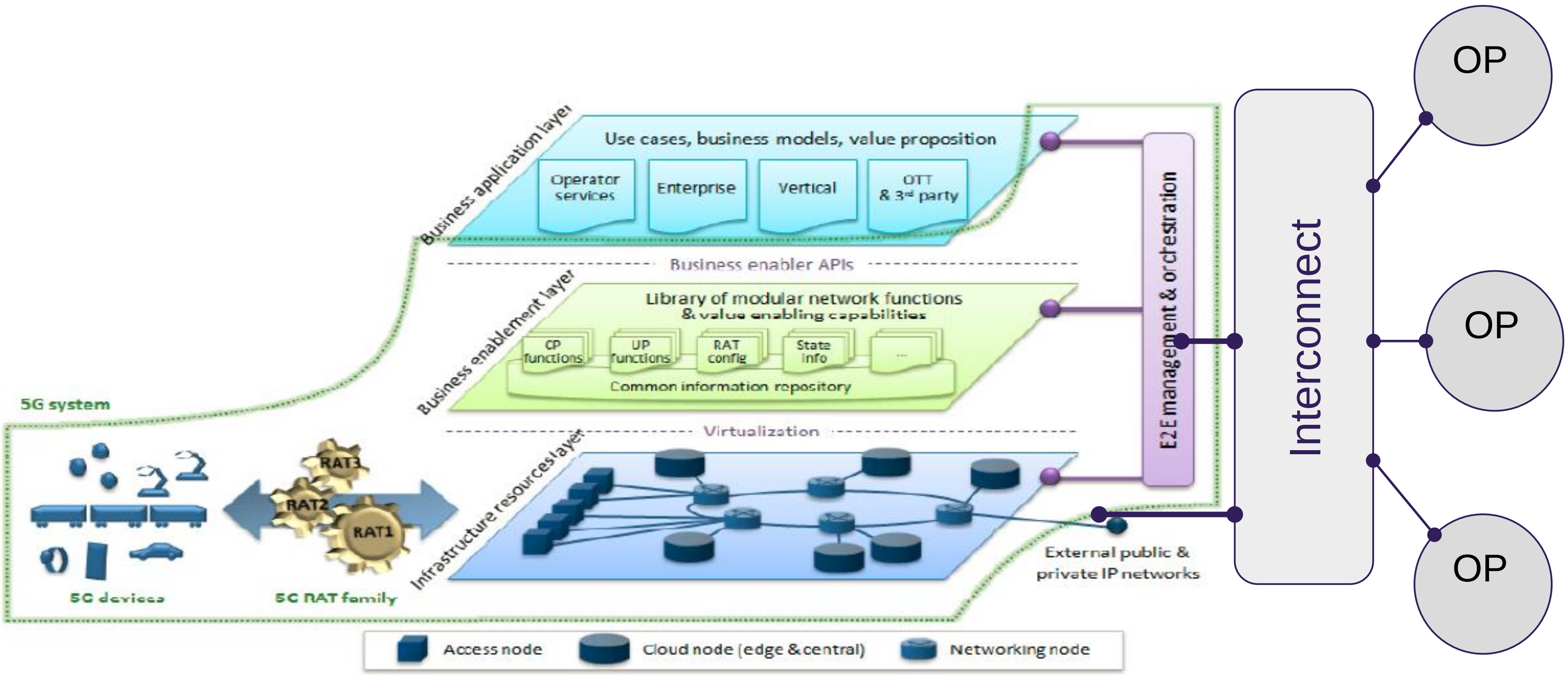
- Optimal network deployment
- QoE improvements

5G architecture to support new use cases

Today
Mobile Broadband
Telephony

Capabilities
Universal mobile Broadband
IoT
Low Latency

Verticals
Automotive
Sensor networks
Health
FMC



Source: NGMN white paper

Extra Material

LTE Enhancements – what's next?

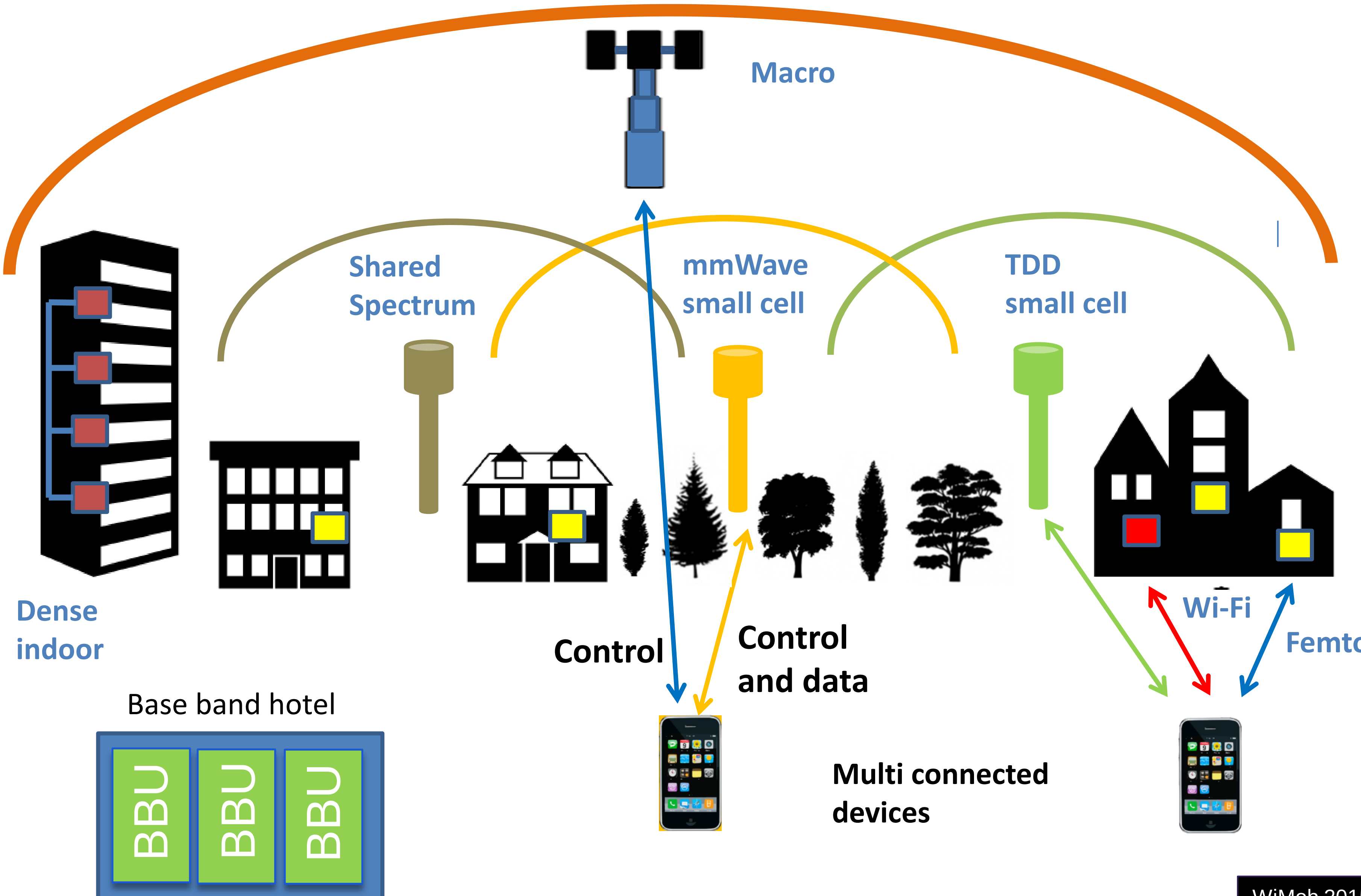
LTE Release 13: addressing the mobile broadband demand

- LTE Carrier Aggregation enhancements
  - Aggregate up to 32 Component Carriers
  - Useful in particular for LAA where large blocks of spectrum are available
- Elevation Beamforming / Full-Dimension MIMO
  - Support of two-dimensional antenna arrays to exploit the vertical dimension for beamforming and MIMO
  - Support of high-order MIMO systems with up to 16 antenna ports at the eNB
- Study on Low latency LTE*
  - Study of techniques that can significantly reduce the latency of the LTE air interface, including solutions for fast uplink access, shortening of the Time-Transmission Interval (TTI) and reduced processing time
  - The goal is to improve performance and user experience of existing services as well as to enable new delay critical services
- Study of downlink multi-user transmission using superposition coding*

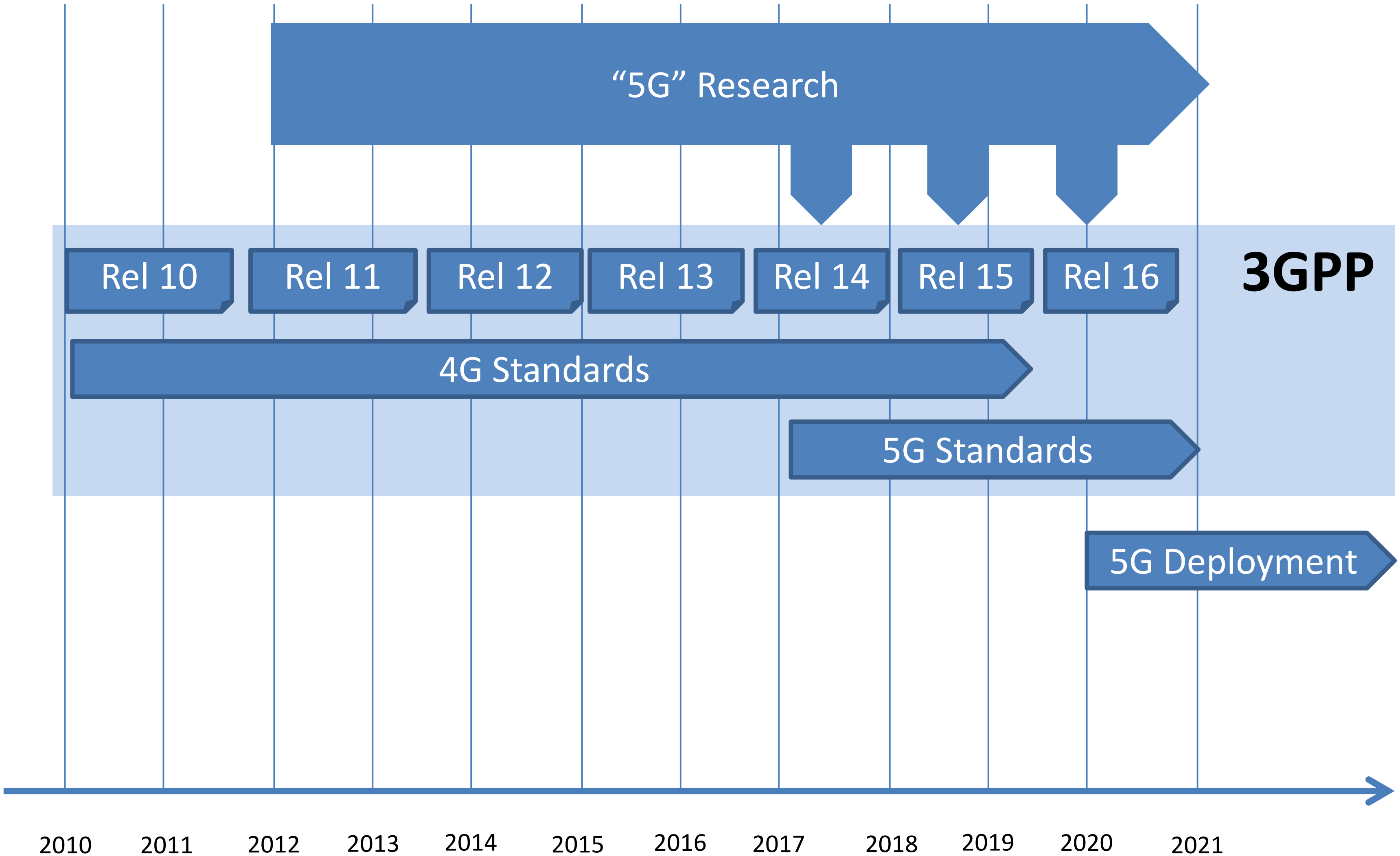
** Note: normative work (if any) for this item is targeted for Release 14*

Source: Dino Flore Chair 3GPP RAN

5G access network



What is the time line for 5G?



Conclusions

- 5G has the ambition and capability to become fundamental to the future digital economy
- There is much more work to do with added emphasis on extending the capabilities to support industry use cases
- Keeping costs low should be a key factor as 5G moves into standardisation

Questions?