ANNEX – 5G NETWORKS OVERVIEW

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Overview of 5G networks

1 5G is the next generation of mobile technology and is the successor to 4G Long Term Evolution (LTE) which is the current standard for wireless mobile communication. 5G offers new technical capabilities through its higher data rates, ultra-reliable and low latency (minimal time lag) communications, and massive machine-to-machine communications. Taken together these properties give 5G the potential to generate significant economic and social benefits across the digital economy[16].

2 5G is now available in over 100 UK towns and cities, including London, Edinburgh, Cardiff and Belfast. While 5G deployment today is primarily focused on providing additional network capacity in densely populated areas, in the longer term 5G will play a central role in the smart and connected cities and towns of the future. It has the potential to enable innovative services in manufacturing and logistics, transport and agriculture as well as enhancing the delivery of public services across healthcare and education.

3 Gigabit capable networks, such as full fibre, will underpin 5G services, providing higher speeds, reliability and resilience[17]. Dense fibre networks will be vital for 5G to deliver the high speed and high capacity backhaul capabilities that 5G networks will be built upon.

Mobile network architecture

4 The key components of **mobile networks** are as follows:

  a. Core Network – The core includes critical functionality, e.g. user authentication and call routing. The functions within the core network are increasingly moving to software-based architecture.

  b. Radio Access Network (RAN) – The RAN connects customer devices (e.g. handsets) and mobile phone masts using radio spectrum.

  c. Transport and Transmission – These functions aggregate traffic from the mast sites and carry it to the core network. The transmission network includes point-to-point optical transport – such as 'pipes' (the physical duct that contains copper and fibre cables),

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[16] *The impacts of mobile broadband and 5G, A literature review for DCMS,* Deloitte – June 2018

[17] Gigabit-capable means that the connection can handle speeds of 1,000 Megabits per second. Full fibre to the premises (FTTP) is optic fibre cable connected to premises and is the most reliable way of delivering gigabit-capable broadband speed.

microwave equipment and satellites – and the transport layer comprises a routing function that directs traffic.

d. Interconnect – Mobile operators connect to the wider internet via internet exchanges. These are network facilities operating within data centres, into which ISPs and digitally driven companies have high speed connectivity and connect to each other via switches and routers.

e. Operational and Business Support Management Systems – These are intelligent software that are critical for operating the network functions such as managing service provisioning, billing, customer services, and monitoring network performance. As with the core, these applications are increasingly being deployed as software-based, virtualised functions.

Figure 1[18]
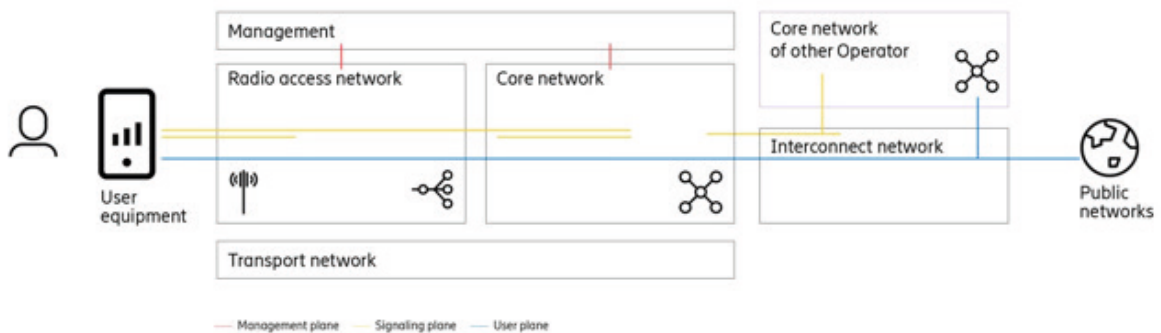
5 The architecture of a **fixed network** is similar to that of a mobile network. Connections between premises and local exchanges (or cabinets) in the fixed access network are equivalent to the wireless connection between handsets and mobile masts in the radio access network. All other elements of the fixed network are similar to mobile networks.

Elements of the supply market for RAN equipment

6 The RAN equipment market can be segmented by the generation of technology (2G, 3G, 4G and 5G), which determines the technical standards and systems used by the equipment. Generations can be identified by differences in functionality based on the various technical standards. For example, 2G systems support voice services and basic data transmission including Short Message Service (SMS) for text messaging. 4G systems utilise Long Term Evolution (LTE) technology, and are capable of providing higher data transmission speeds supporting enhanced data services such as video streaming.

7 5G systems will utilise a range of next generation technologies and be characterised by their ability to provide vastly increased capacity, at faster speeds and with lower latency.

8 The RAN equipment market can then be segmented further by cell size:

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18 Security in 5G RAN and Core deployments (White Paper), Ericsson – April 2020.

a. Macro cells – deployed on cell towers and building rooftops – can provide coverage up to tens of kilometres away from the cell site, whereas for small cells the coverage distance is up to two kilometres away. The range of a cell site is also dependent on the amount of data throughput the site has to carry. In high traffic areas the coverage will be reduced and therefore additional sites are required to meet demand.

b. Small cells will be a key part of 5G roll out in the longer term – located on lampposts, the sides of buildings, poles and also indoors, within businesses and public buildings. Small cells will support the 'densification' of networks and will enable the high capacity, high reliability and low latency properties of 5G, primarily in urban areas.

9 **The primary focus of this strategy is on the mobile RAN macro cell market** which is the larger mobile market segment[19] and where the significant majority of 5G infrastructure rollout will be concentrated in the short-medium term.

10 The macro cell market is also where consolidation is most pronounced and the risk of national dependency on a small number of suppliers is most pressing. On the other hand there is more scope for diversification amongst small cell suppliers where several smaller and emerging suppliers are present in the supply chain alongside the established global players[20]. These emerging small cell suppliers could play a role in helping to diversify the overall market but it should be noted that, while small cells are part of the overall network, the higher capacity, mobility and power requirements for macro cells means that most small cell suppliers are unlikely to be able to supply macro cell equipment at scale without significant investment and upscaling.

A changing RAN architecture

Open RAN

11 Open RAN is a new model of Radio Access Network (RAN) architecture using "open" and "interoperable" off-the-shelf hardware and software-defined components.

12 Open RAN concerns the setting of open standards for interfaces in the RAN. This will enable equipment from different vendors to be deployed with a "best-of-breed" approach in a multi-vendor network (i.e. operators choose the best vendor for a particular hardware or software component of the RAN to suit their particular requirements).

13 Open RAN standards are being developed by groups such as the ORAN Alliance and Telecom Infra Project, both with similar goals of bringing efficiency and cost reduction by virtualising the baseband functions over a white-box hardware and a software-defined technology, all based on open interfaces.

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[19] Macro cell core and RAN market shares accounted for over $32bn in 2018, whereas the market share for small cells accounted for $0.3bn in the same year – DNB markets, Telecom Equipment – 5G: on the threshold of a new cycle (October 2019)

[20] By 2026, as many as 30% of the installed base of outdoor small cell networks, and 71% of indoor enterprise systems, are likely to be operated by new entrants to the small cell segment – Small Cell Forum Market Status Report (July 2020)

14 As illustrated in Figure 2, under a traditional RAN architecture the radio unit (RU), which connects to the antenna, and the baseband unit (BBU), which connects the base-station to the wider network, are proprietary and linked via fibre by a proprietary common public radio interface (CPRI). Therefore the RU and BBU must be provided by a single vendor.

Figure 2
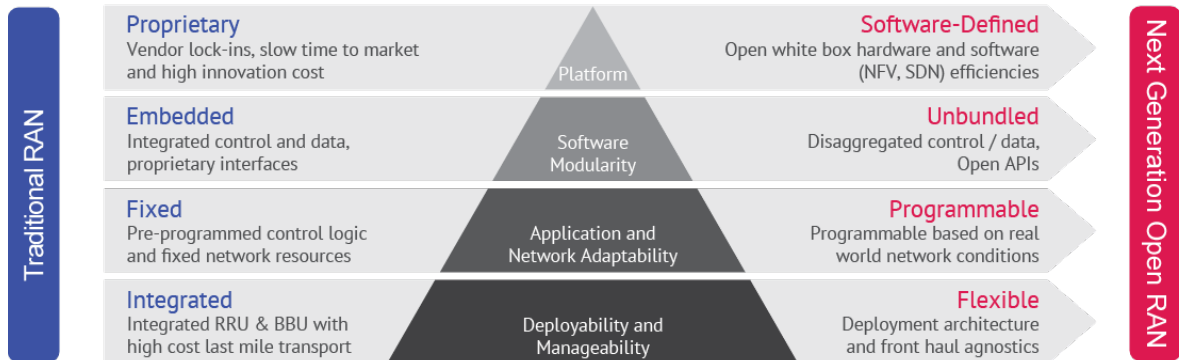
15 A baseband unit will typically host all the functional blocks in a radio processing chain from the top, addressing compression and ciphering all the way down to the Lower Physical layer which addresses beamforming and mapping the symbols that carry data into larger blocks for transmission. In between are key functions such as packet scheduling and modulation. Typically up to 30 of 'these' blocks comprise the chain. PDCP blocks typically sit in the CU but most blocks are in the DU. The point at which the DU is split from the Radio Unit (RU) is called the functional split. The 3GPP specifications for 4G and 5G networks describe several places for the functional split. Where the split occurs poses different deployment challenges in terms of co-location, latency requirements and connection bandwidth. Open RAN and the O- RAN Alliance have focussed on a '7.2x' split, which splits the Lower Physical layer between the DU and RU. Open RAN also introduces RAN Intelligent Controller (RIC) software, which facilitates the management of CU/DU functions.

Other approaches to interoperability

16 Open RAN is one of several technical methods the industry is progressing as it considers the opportunities brought about by increased interoperability. These solutions typically focus on enabling non-proprietary interaction between key components of the RAN. While these alternative solutions are not necessarily based on open interfaces, they have the potential to address barriers to diversification and enable operators to integrate equipment from new suppliers alongside legacy equipment from incumbent suppliers.

17 Today the interface between the current 4G Baseband Units and Remote Radio Units – the two key components of the RAN – is based on the **Common Public Radio Interface (CPRI)** protocol. This is an optional protocol meaning that suppliers will not necessarily make their interface available to others to enable interoperability. However, recent developments have led most of the major mobile RAN suppliers to establish an **'enhanced' Common Public Radio Interface (eCPRI)**. While the initial proposition of eCPRI is that of an open interface that makes it easier for operators to mix and match suppliers' equipment across the Baseband and Remote Radio Units, its implementation has yet to demonstrate a meaningful move toward interoperability. We are keen to see equipment

suppliers take further steps to open up this interface and remove a key barrier to interoperability and diversification.

18 This 'opening up' can then be taken a level further to enable interoperability within the Baseband Unit component of the RAN – between the centralised unit (CU) and the distributed unit (DU). The interface to enable interface between these two sub-components is known as the **F1 Interface.** Again ensuring these interfaces are standardised and open is central to delivering against the promise of interoperability.

Figure 3
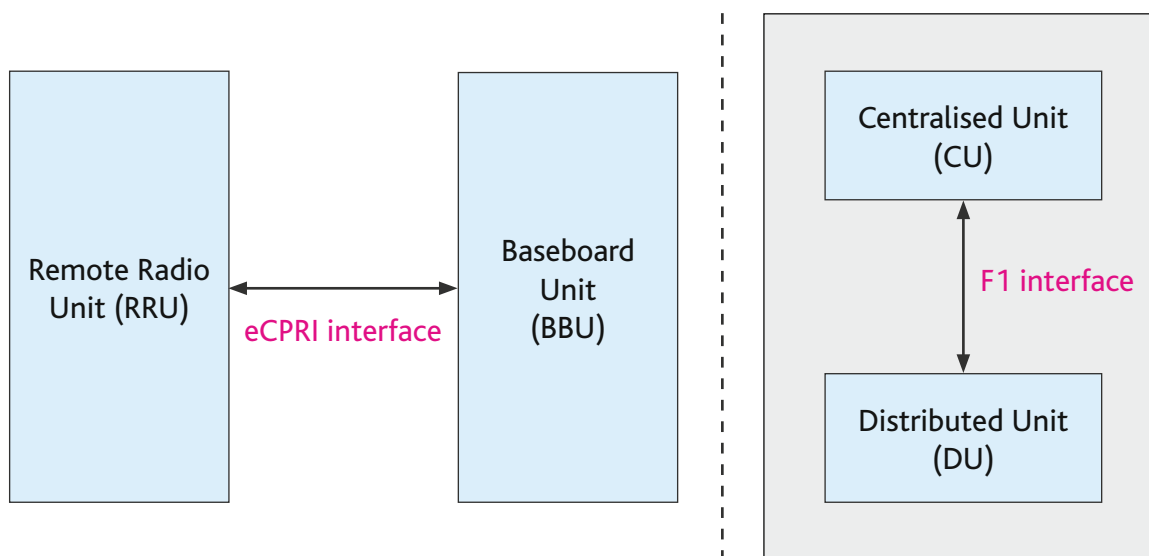
19 A further potential approach is the implementation of a **'5G overlay'**, utilising the X2 interface.[21] This enables a 5G equipment supplier to integrate its equipment into a network on top of another supplier's equipment, anchoring to its 4G equipment. While this deployment method is based on a standardised interface, it is an optional rather than a default. This means that the solution can only be effective where incumbent suppliers enable it and share and maintain the details of their implementation to enable others to interoperate.

20 It should be noted that the interfaces referenced here are not exhaustive and that there are further interfaces that are required to ensure the seamless operation of modern networks. A key set of further interfaces are 'management interfaces' – including business, service and network layers – that allows for the consistent management of various network functions and are critical when addressing network faults or issues as they arise.

21 All of these approaches require the cooperation of suppliers across the supply chain and so we are keen to see suppliers work together to open up these interfaces in order to facilitate genuine interoperability.

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[21] The X2 is an interface introduced by the LTE Radio Access Network. It connects neighboring eNodeBs across two suppliers in a peer to peer fashion to assist handover and to provide a means for rapid coordination of radio units.

22 A further challenge with encouraging these approaches to be adopted as the industry standard is exacting performance requirements in terms of reliability, ultra-low latency and extremely high data transmission rates. R&D to test and trial these interfaces is therefore essential in order to establish these approaches as default ways of working.

Standalone 5G solutions

23 'Standalone' (SA) architecture is an alternative deployment method, based on new 'greenfield' networks that may share transport, routing and switching with existing 4G networks. SA deployments are needed to deliver the full functionality of 5G, such as ultra-reliable, low-latency enterprise services.

24 As SA deployments are not as heavily based on existing networks, they represent a significant opportunity for new market entrants. This is because unlike previous generation networks, with 5G it is possible to integrate elements of different generations in different configurations; SA – using only one radio access technology (5G only) with a 5G core; and Non-Standalone (NSA) combining multiple radio access technologies (4G and 5G) based on a legacy (4G) core.

25 In a SA scenario, where the 5G radios can be deployed with a dedicated 5G core, network operators have the option to deploy and manage an 'independent' 5G network without needing to build the 5G network on top of a legacy network. This means that a new market entrant could be integrated into the network without any need to interoperate with existing equipment.