A NEW MOBILE GENERATION
RIDING THE 5G WAVE

Aaron White and David Coulling of Herbert Smith Freehills LLP look at 5G mobile technology and the challenges of deploying 5G mobile networks in the UK.

The next generation of mobile technology, 5G, has been on the horizon for a number of years. It is only now that momentum is building in the development of 5G that public excitement is growing around the possible services and applications that 5G technologies will support (*see box "The development of 5G"*).

5G is designed to provide greater capacity for wireless networks, more reliability and faster speeds, and will enable new services, such as massive internet of things. Some of the features that users can look forward to include 360-degree panoramic virtual reality video, unlimited cloud storage and instant access to applications without having to download or install them. Operators such as China Mobile are conducting proof-of-concept system field trials in 2017, and plan to move to large-scale pre-commercial 5G trials in 2018. The first wave of commercial 5G services and applications is expected to be launched by operators in South Korea, Japan, China, the US, Europe and the Middle East as early as 2020.

This article looks at:

- The types of services and applications that 5G technology is expected to deliver.
- Spectrum requirements for 5G.
- Some of the regulatory and commercial challenges in deploying 5G infrastructure in the UK.
- How new models for infrastructure ownership and collaboration will be required to deploy high-quality 5G infrastructure cost-effectively.
- Some of the different supporting legal structures for these new infrastructure models, their advantages and disadvantages, and practical considerations for the parties involved.

5G SERVICES AND APPLICATIONS

5G will build on the ongoing evolution of 4G technology and will deliver significant technological improvements in the form of enhanced mobile broadband, massive internet of things and fixed wireless access.

Enhanced mobile broadband

5G is expected to provide significantly enhanced mobile broadband, including in those areas where mobile broadband has traditionally struggled, such as at the boundary between cells, in high traffic areas such as stadiums and shopping centres, and on trains (*see box "Understanding mobile networks"*).

High speed, low latency, secure connectivity that is ubiquitous and highly reliable will offer a greatly improved mobile experience to citizens, and also provide a platform for new services and applications in markets such as virtual reality and augmented reality (*see box "Glossary"*).

Enhanced mobile broadband will also transform the way that information and content are created, shared and used; for example, by facilitating simultaneous streams over the same connection. There is also speculation that, with 5G, the roles of network and device will reverse so that some, or all, of the computer processing that usually occurs at device level will be performed by the network and, conversely, devices will become more like networking nodes.

Massive internet of things

5G will play a key role in supporting the massive rollout of intelligent internet of things nodes, and will drive the development of existing and new internet of things services and applications in vertical markets, including:

- Manufacturing, such as time-critical process control, non-time-critical factory automation and remote control.
- E-health, such as robotics, remote monitoring and smarter medication.
- Energy, such as advanced grid access, backhaul and backbone projects.
- Automotive, such as connected and autonomous vehicles, sharing a vehicle's point of view with remote devices, and the digitisation of transport and logistics.
- Media and entertainment, such as ultra high fidelity media, on-site live event experience, immersive and integrated media, and collaborative gaming.

On 1 April 2016, the 5G Infrastructure Public Private Partnership, which was initiated by the European Commission, industry manufacturers, telecommunications operators, service providers, SMEs and researchers, published a white paper on how 5G will empower vertical industries (*https://5g-ppp.eu/wp-content/uploads/2016/02/BROCHURE_5PPP_BAT2_PL.pdf*).

Fixed wireless access

5G mobile technology will also support the development of enhanced fixed wireless access services. Fixed wireless access is an established, cost-efficient method of providing broadband access using mobile technology without having to run fibre to every home, apartment building or business premises. The "last-mile" connection is provided by wireless technology to self-installed equipment in a customer's premises.

Until now, fixed wireless access using current mobile network technology was not able to provide performance, in terms of speed and latency, which was comparable to a fibre broadband connection. 5G mobile technology will enable fixed wireless access to deliver a level of service that is at least comparable to current broadband standards.

5G fixed wireless access has emerged, particularly in the US, as the likely first phase of commercial 5G services. Operators such as AT&T and Verizon Wireless are using 5G fixed wireless access as an opportunity to offer 5G services before the 5G standards are finalised by the 3GPP (the 3rd Generation Partnership Project). This will give those operators valuable insight into the characteristics of 5G technology for their pre-commercial trials and full commercial launches.

5G SPECTRUM

5G services and applications will require access to a range of different spectrum bands (both licensed and unlicensed) with different characteristics. In the UK, this will include spectrum at:

- Lower frequencies (700 MHz) to provide 5G coverage to wider areas.

The development of 5G

Mobile operators, equipment manufacturers and research bodies in North America, Europe and East Asia are leading the development of 5G.

The GSM Association (GSMA) is an international body which represents the interests of mobile operators globally. It is working with governments, its mobile operator members and industry sectors to help define the 5G technological requirements, identify appropriate spectrum frequencies and develop commercial business cases for 5G. In February 2017, the GSMA published a vision paper on the 5G era (*www.gsmaintelligence.com/research/?file=0efdd9e7b6eb1c4ad9aa5d4c0c971e62&download*).

National and international policy makers are also playing a key role in bringing 5G to life, with the European Union and the International Telecommunications Union looking to harmonise the spectrum needed to deploy 5G networks. The 3GPP, which brings together a number of telecommunications standard development organisations to define certain 3GPP technologies, is also leading the work around defining specifications for 5G technologies aimed at ensuring interoperability.

There is significant public pressure for the UK to be an early adopter of 5G and ensure that it becomes a global leader in digital connectivity. This goal is outlined in the government's 5G strategy for the UK, which was published in March 2017 (*www.gov.uk/government/uploads/system/uploads/attachment_data/file/597421/07.03.17_5G_strategy_-_for_publication.pdf*). To this end, in October 2017 the Department for Digital, Culture, Media and Sport launched a £25 million fund of matched-funds grants for testbeds and trials of 5G technology in the UK (*www.gov.uk/government/news/nationwide-competition-brings-5g-one-step-closer*).

In order to deploy 5G networks, UK operators will need to invest significant capital expenditure and operating expense. This comes at a time when operators' margins continue to be squeezed amid decreasing traditional revenue streams while they are still being required to invest significant amounts of capital in rolling out 4G networks to meet geographic coverage obligations and other contractual commitments. For example, UK operators are currently undertaking a £5 billion investment programme to extend coverage and capacity across the country. Operators will also need to identify new applications and services, and new markets (in particular around business-to-business and business-to-business-to-consumer propositions) which can be served by 5G and generate substantial new revenues. Innovative new business models will be critical if operators are to realise the full potential of their 5G investments.

- Higher frequencies with large bandwidths (3.4 to 3.8 GHz) to provide the necessary capacity to support a large number of connected devices and to enable higher speeds of data to flow between connected devices at the same time.

- Very high frequencies with very large bandwidths (24.25 to 27.5 GHz) to provide ultra-high capacity and very low latency networks and services.

With major operators seeking to launch commercial 5G services as early as possible, there is a risk of spectrum and technology for 5G being developed in a fragmented way across different countries. Operators, equipment vendors, policymakers and regulators will need to work closely together to avoid different proprietary 5G networks emerging, which may result in interoperability issues and stifle efforts to scale 5G cost-effectively.

Spectrum auction

As part of UK communications regulator Ofcom's programme of work around 5G spectrum, it is proceeding with the auction of spectrum in the 3.4GHz band (in addition to spectrum in the 2.3GHz band), which has been identified as usable for certain 5G services and applications from 2020.

The auction was originally planned to take place in the last quarter of 2017, but legal challenges by UK operators Three and BT in relation to the proposed spectrum caps mean that the auction will not be held until at least early in 2018. What is clear is that a fair and competitive auction is needed to allow the UK mobile telecommunications industry to evolve successfully towards 5G. Rebalancing spectrum holdings between the four main mobile network operators in the UK (O2, BT, Three and Vodafone), for example by imposing spectrum caps, should increase competition and in turn drive innovation and investment in 5G networks.

Spectrum sharing

In the UK, most, but not all, spectrum licences are tradable, which enables operators to share rights to use spectrum. Allowing spectrum to be shared means that it can be used in the most efficient way possible and it ultimately benefits citizens in terms of quality of service and the development of new and innovative mobile services.

Glossary

Backbone. The high-traffic and high-density connectivity portion of a communications network.

Backhaul. The network connectivity between a mobile network operator's radio base stations and local points of presence.

Bandwidth. In digital telecommunications systems, the rate at which information can be transferred (measured in bits per second (bit/s)).

Cell. The geographical area covered by a base station.

Content delivery networks. A system of distributed servers that deliver digital content to users based on their geographic location, the origin of the content and the content delivery server.

Frequency. The number of cycles or events per unit time, measured in hertz (Hz).

Internet of things. The network of physical objects that contain embedded technology to communicate and sense or interact with the external environment.

Latency. The time it takes for a source to send a packet of data to a receiver, measured in milliseconds.

Macrocells. Large land areas covered by a mobile network, with a cell range of between one and 30 kilometres in diameter.

Microcells. Small land areas covered by a mobile network, with a cell range of between 200 metres and two kilometres diameter.

Network densification. The deployment of small cells or macrocells to increase capacity in the radio access network.

Nodes. The point at which two or more branches of a network intersect or where the branch of a network terminates.

Points-of-presence. A node in a communication provider's network (such as an exchange or other operational building), generally used to serve customers in a particular location.

Small cells. Low-powered radio access nodes, with a range of up to a few hundred metres in diameter.

Spectrum. The frequency range of the electromagnetic spectrum that can be used for wireless communication.

In its "Update of 5G spectrum in the UK" report published in February 2017, Ofcom said that it will consider different aspects of spectrum sharing when identifying the most appropriate authorisation regime (*www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf*). This could indicate that Ofcom may be considering, for certain 5G spectrum licences, imposing conditions such as requirements to share the spectrum with other operators, anti-hoarding measures or even coverage obligations. A requirement to share 5G spectrum could be a way for Ofcom to ensure that mobile network operators with lower overall spectrum holdings gain access to the spectrum necessary to develop 5G services.

5G INFRASTRUCTURE DEPLOYMENT

While 5G will still require the use of macrocells, densification of the radio access network in

the form of mass small cells will be critical to support very high bandwidth, low latency and high reliability requirements for 5G services and applications, particularly at high and very high frequencies. The antennae for these small cells will be mounted at street level, typically on the external walls of existing buildings, lamp posts and other street furniture.

More dense 5G networks means that significantly more sites will be needed, and because of the challenges associated with securing such a large number of new sites, new models for infrastructure ownership and collaboration will be required (*see "New models for infrastructure ownership and collaboration" below*).

In order to achieve enhanced mobile broadband capabilities, network traffic will also need to be localised for specific services or applications; for example, through increased use in network infrastructure of local points-of-presence and content delivery networks that provide popular content to local users, reducing the impact on mobile backhaul and core network capacity.

Commercial challenges

There are a number of commercial challenges associated with deploying 5G infrastructure; in particular where mass small cell deployments will be required. Simply put, there are limited suitable new sites in the form of external walls of existing buildings, lamp posts, traffic lights and other street furniture to place the many hundreds of thousands (in London alone) of small antennae that will be required for 5G. Furthermore, when compared to other countries such as South Korea, the UK does not have the vast amounts of fibre in the ground that will be required to deliver 5G networks.

It is possible that the issue of availability of space could be exacerbated by a single operator or independent infrastructure provider seeking to gain exclusive access rights to use locations suitable for mass small cell deployments. In addition, new site lease arrangements will need to be put in place, for example, with local councils, and existing sites will need to be upgraded to allow for the deployment of 5G technology on those sites. This will potentially trigger a renegotiation or review of rental payments on many thousands of sites.

Mass small cell deployment will also carry with it significant mobile backhaul requirements. Each antenna (or group of antennae) will require a fibre link to backhaul traffic to the operator's existing mobile backhaul networks and other fixed telecommunications networks. This will require operators to work with local councils and other utility providers to rent space in their existing duct networks to deploy their own fibre, or alternatively to access fibre from third parties by way of managed or unmanaged backhaul or dark fibre products. In addition, these cells will need to be located in close proximity to supporting civil infrastructure, such as power and cooling facilities.

The overarching commercial challenge, given the significant capital expenditure and operational expense associated with deploying, operating and maintaining large numbers of small cells and associated supporting infrastructure for 5G, is how the industry will be able to deploy high-quality 5G infrastructure in a cost-effective manner.

Regulatory challenges

In addition to commercial challenges involved in 5G network deployments, there are the well-publicised regulatory issues associated with deploying mobile technology infrastructure. Local authority planning permissions, and other permits and approval requirements, are one of the major barriers to site acquisition and development. The Electronic Communications Code, which is set out in Schedule 1 to the Digital Economy Act 2017, will go some way to supporting efficient infrastructure development; in particular in relation to reforms around site rents, site sharing and upgrades, and dispute resolution (*www.practicallaw.com/w-008-3560*).

The mobile industry is also calling for a more supportive planning regime that facilitates faster processes to review new site applications and a more cost-effective mobile infrastructure rollout. Given the significant investment required to deliver 5G, it will be critical that the government provides a transparent and predictable pro-investment and pro-innovation regulatory framework, and reforms such as those described above will be critical if the UK is to evolve successfully to 5G.

NEW MODELS FOR 5G INFRASTRUCTURE OWNERSHIP AND COLLABORATION

The commercial challenges involved in deploying dense 5G networks, including securing suitable sites, the availability of the necessary backhaul links, upgrading transmission and core networks, and the availability of power supplies in the same location, may mean that multiple national or local 5G networks will not be technically, operationally or commercially feasible. Creative solutions on how best to build the collective 5G infrastructure will therefore need to be explored, while maintaining or enhancing competition between operators and other market players at the service layer. This will necessarily involve a broad range of stakeholders such as operators, infrastructure providers, financial investors, national government and local councils, businesses and communities.

Infrastructure sharing could alleviate some of the challenges associated with securing the large number of new sites and backhaul links required, by spreading the burden of securing those sites, as well as minimising the operational expense associated with deploying, operating and maintaining large numbers of small cells for each operator. For example, in certain locations (most likely initially to be densely populated urban areas), a single, shared small cell network that is designed, deployed and funded (for example, by an alliance or consortium of operators and infrastructure investors, or by an independent infrastructure provider) may represent a more efficient and cost-effective option.

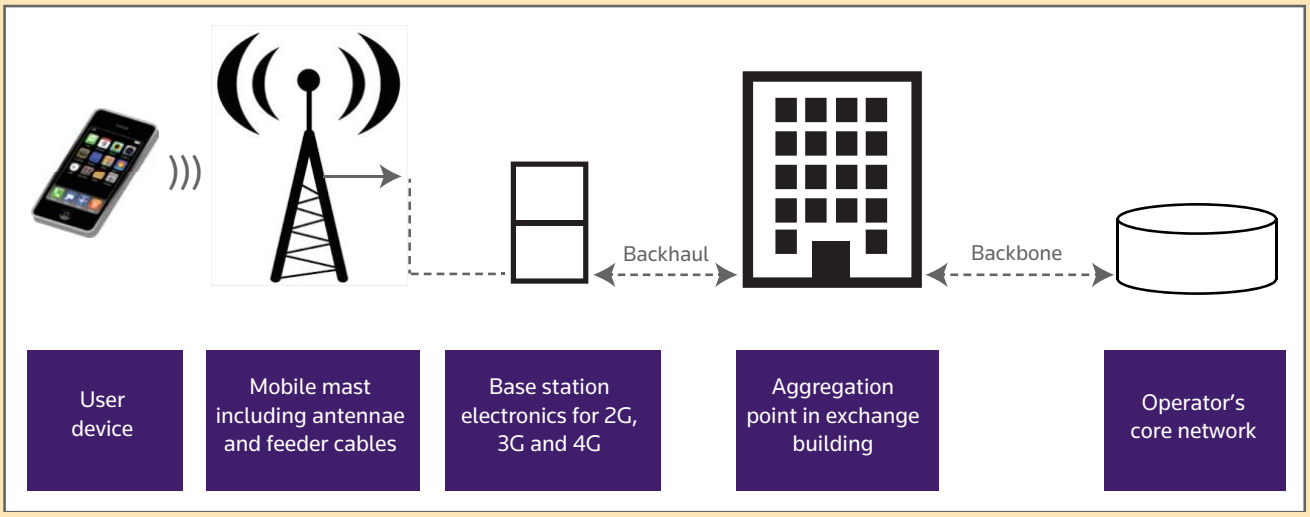
An alliance or consortium of this kind could, as a "neutral host", design, deploy and fund a single network of 5G small cells in specific locations. These small cells would be connected back to a nearby hub using fibre links, and from there to the operators' existing mobile backhaul and points of connection on their core networks. The operators would each be able to install their own equipment and provide 5G services over the shared infrastructure (sharing radio access network (RAN) equipment will not be possible initially with 5G and will depend on the development of this equipment by network vendors). An example of this in a 4G context was recently announced by Wireless Infrastructure Group and O2, which collaborated to launch new wireless infrastructure in Aberdeen (*www.wirelessinfrastructure.co.uk/city-of-aberdeen-paves-the-way-for-5g/*).

Other new collaboration models may include efficient techniques where access to infrastructure and backhaul is leased or assigned to users dynamically, based on different parameters such as usage and

Understanding mobile networks

Mobile networks operate in the following way:

- A mobile device has a built-in antenna which, using mobile spectrum, sends and receives signals to and from an antenna operated by a mobile network operator.
- The operator's antenna is located on infrastructure such as a mast, a rooftop, the side of a building or a street lamp.
- Near to the operator's antenna is the operator's base station equipment, which contains computing power and radio electronics. This base station is connected to the operator's antenna by a feeder cable.
- The base station sends the signal through a backhaul link (using transmission media such as managed fibre from a provider like BT) which is connected to an aggregation point.
- Here, the signal is broken out to connect to the operator's core network where security and billing are managed.
- The signal is then routed through the operator's core network to other operators' networks or to the internet.



location. Alternative network providers or "alt-nets" will also have an important role to play. Their networks, including for example wifi networks, will need to be integrated to provide the ubiquitous and high-speed, reliable and secure connectivity required in the 5G era. Policy and regulatory frameworks that support these new models will be needed.

5G STRUCTURING OPTIONS

There is a range of legal structuring options that could facilitate a collaboration or alliance for deploying 5G infrastructure, such as a purely contractual approach or a corporate entity approach. Other options not discussed in this article could include asset financing models, public "concession" agreements (for example, for rural and remote areas), managed service agreements and partnerships.

Purely contractual approach

The members of a collaboration or alliance may co-operate based purely on a contractual relationship. For example, they could enter into a collaboration, co-operation or framework agreement governing the design, deployment and funding of each localised 5G infrastructure project. This approach could be suited to the initial local 5G deployment projects, as it would allow for those projects to be rolled out incrementally, giving the members the information they need to establish whether they could work together under a more permanent and concrete arrangement.

This approach has the added benefit of being quick to establish, with few formal requirements, and it avoids the permanence of a corporate structure. However, unlike a corporate joint venture (JV), it does not easily accommodate new members, or the exit of existing members, and, if anything, will become more complex as a result. Liability issues, such as whether parties will incur liability for the acts of others (for example, breaches of network performance or availability levels), are more difficult to resolve and the members will have to rely on the liability provisions in the agreement. In addition, the sharing of costs incurred in connection with the deployment of 5G infrastructure will be more complex than in a corporate JV scenario, and a detailed cost-sharing and reimbursement model would have to be included in the agreement.

In addition, a purely contractual approach requires one of the alliance members to own the relevant assets used in the deployment, which can give rise to issues around a competitor having control over the assets used in the delivery of services to an operator's retail customers.

Corporate entity approach

One alternative to the contractual model is for the parties to co-operate through a separate corporate JV. The type of JV chosen will depend on the particular aims of the parties but, more often than not, it will take the form of a corporate entity such as a company limited by shares, although it can also take the form of a partnership. Some advantages of the corporate entity approach are that:

- It would be easier to operate where there are numerous members, especially once the 5G infrastructure project becomes operational.
- It may be easier to comply with requirements to operate on an arm's length basis or with information sharing restrictions put in place for tax or competition compliance reasons.
- The corporate JV may have limited liability status and the ability to raise finance, and will therefore be independent of the parties to the alliance.
- It would be easier to include new members to the alliance and to accommodate exits.

On the downside, however, establishing a corporate JV is likely to be more time-consuming and complex than the purely contractual approach. There are also often complexities relating to the parties' interests in, and contributions to, a JV of this kind.

Practical considerations

The choice of structure for the collaboration or alliance will be determined after considering the advantages and disadvantages of each structure, and a range of other issues such as what is actually being shared (for example, whether spectrum, sites, RAN equipment, transmission, design, build and operation, and financing are being shared), and whether it is an exclusive arrangement.

Once the structure has been established, the members will need to consider and agree on a number of practical issues, including:

- How the project is to be funded, both on its establishment and on an ongoing basis. The mechanics for valuing each contribution will need to be agreed, as will the resolution mechanism for any dispute as to contribution value.
- The assets and resources (such as network infrastructure or equipment, intellectual property or technology) that each party will provide and the terms on which they will be provided; for example, whether ownership of the assets will pass or they will be leased or licensed. The tax treatment for any transfer of assets will need to be taken into account. If assets are to be contributed, they will need to be valued. Adjustments will need to be made, if necessary, for any shortfall in the value of assets contributed or any disproportionate contribution.
- Regulatory and competition issues associated with entering into a JV (whether contractual or incorporated). Strategic alliances may raise concerns in terms of control and the potential for collusion, co-ordinated effects and information sharing. Merger clearances and ongoing monitoring may also be required. Any exclusivity arrangements entered into by the parties, including any non-compete or non-solicitation provisions, will also need to be reviewed for their compatibility with competition law.
- The governance arrangements for the day-to-day management and control of the project, such as: the composition of the board, various committees and sub-committees; management positions; the area in which to deploy the infrastructure; which sites to choose; how to design the sites; and who will be the key vendors for supplying, among other things, power, transmission and radio equipment. The mechanics for resolving any disputes between the members will also need to be considered.
- The liability regime under which the alliance will operate. Under a corporate JV, the company has limited liability, meaning that shareholders (that is, the alliance members) will usually be economically exposed for the company's debts and other liabilities only up to the value of their equity in the JV entity. A party to the alliance will want to carefully delineate its obligations and liabilities under the JV, including those in relation to: breach of licence conditions; compliance with applicable regulations such as the Construction Design and Management Regulations 2015 (*SI 2015/51*); and liability for any impact to the quality of service and customer experience. In the case of a purely contractual approach, the liability of the parties to each other will be controlled by the liability provisions of the agreement.

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- Appropriate exit and unwinding arrangements. In the case of 5G, it is possible that the life of the assets will endure beyond the term of the JV, so this will need to be dealt with along with issues such as: any debt funding or guarantees; existing arrangements entered into or otherwise agreed as a result of the alliance; ownership and use of networks and other assets, such as equipment, systems, property, intellectual property and data; contracts; and personnel. Furthermore, assistance and co-operation in relation to each party's deployment of its own network infrastructure and assets after the JV has ended will likely be required, as well as transitional active network sharing services while this deployment is taking place, procedures and timetables for unwinding any shared sites and infrastructure, and the separation of functions previously carried out by the JV vehicle.

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