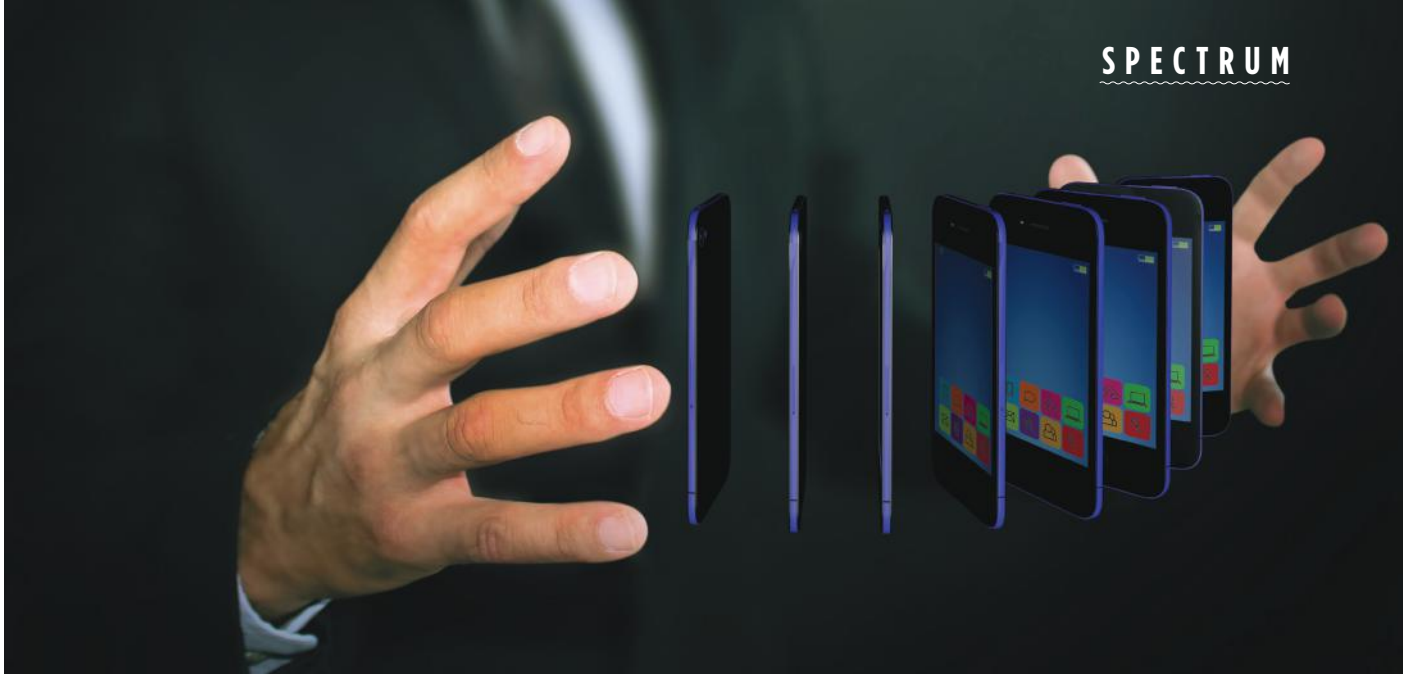

TAKING STOCK OF 5G

The hype about the next generation of mobile technology is likely to gather pace in the next few years, but currently there is a lot of scepticism about whether it qualifies as an integrated, great leap in progress, as **MARC BEISHON** finds in this round-up

Is 5G going to be the true next generation in mobile services, as 4G has undoubtably been, or is there a lot more nuance and evolution rather than revolution involved? Certainly there are sceptics now expressing warnings about the hype, and the way forward is, as always, likely to be guided by what investors are prepared to commit to in the cold light of day. And there are, to quote one analyst, a lot of 'known unknowns'. But all are agreed that 5G is not springing up in a vacuum, and there is a wide landscape of issues which are now in play and which are likely to shape reality as 5G services go live, possibly in under two years, if South Korean operators are able to deliver on a promise to have services running at the 2018 Winter Olympics.

BROUGHT TO (A TECHNICAL) BOOK

A new book, 5G Mobile and Wireless Communications Technology,[1] looks to have achieved its aim of covering this landscape, if only by sheer size – its 400 pages go to town in particular on the technical parameters of mobile networks and spectrum, while also setting the scene with the current state of play and the concepts and 'use cases' for 5G. It comprises contributed chapters from experts, mostly from mobile operators, equipment makers and academia, edited by a trio from Ericsson, Nokia Bell Labs and the Polytechnic University of Valencia, and a good deal of the material comes from an EU project, Mobile and wireless communication enablers for the 2020 information society (METIS), which concluded last year. There's a lot of 'skin in the game' here – have they achieved a balanced account?

It's a well-worked narrative now that 5G is needed to handle much higher data volumes, an explosion in machine to machine (M2M) communications, and associated factors such as low latency. Further, as the book notes, there should be a shift to mobile/wireless enabling a 'tipping point' for a more holistic economy, as many industrial and consumer sectors both build their own connectivity and interact in the knowledge society. But as the authors note, projections for 2020 have been revised down – mobile traffic down from 1,000 times higher to 250; the number of communicating machines down to 25 billion from 50 billion. These are still big numbers but it seems that as with the ongoing disputes about spectrum needed for mobile, reality is catching up with the hype.

In the introduction, there is a good set of basic information, such as a diagram of the requirements of what is termed IMT-2020 – that is, factors such as user data rate, latency, reliability, traffic capacity and connection density. It is noted that security is a key issue because mobile broadband will be increasingly used for internet access and cloud services. Global initiatives are listed – they include 5G-PPP (public-private partnership), the EU's successor to METIS; China's 5G promotion group; Korea's 5G forum; Japan's ARIB 2020 and Beyond Ad Hoc. And standardisation efforts are briefly covered.

A chapter on use cases – 14 in all – follows and includes autonomous vehicles, smart cities, media on-demand and smart energy grids. To cover these there are essentially three generic 5G services – extreme mobile broadband (high data rate and low latency); massive machine-type communication (for the billions of devices); and ultra-reliable machine-type communication (this is for industrial cases where very reliable low latency links are needed, for example). There is a good table on the needs of the use cases, such as what the values are for wireless communications serving a high-speed train. The technical needs of these are also covered and point to much of the rest of the book – they come

under four categories, namely a dynamic radio access network, lean system control plane, localised content and traffic flows, and a spectrum toolbox. We are not going to look in detail at these, and most of the book, as things get highly technical: there are no fewer than ten pages of acronyms...

An accessible chapter on spectrum notes: "Future regulation and technology development will have to navigate a complex landscape of spectrum availability... Multiple frequency bands, subject to different regulation, and including various forms of shared spectrum, are expected to be harnessed by wireless communication systems." The problem is that "many desirable spectrum bands are between 3 GHz and 100 GHz; however, these bands are in regions of the spectrum that are assigned to other services, such as radiolocation, fixed services (point-to-point links), active and passive earth exploration, and satellite communication. The region from 3 GHz to 30 GHz is heavily used by many of these services." New strategies for spectrum sharing are likely to be needed, but "exclusive licensed spectrum is essential for the success of 5G" (and for ultra-reliable machine-type communication).

This chapter adds: "The importance of spectrum valuation will be even more significant in 5G due to much higher bandwidth demand. Furthermore, it will be very difficult to assess the value of spectrum for 5G because of a much broader range of frequency bands to be exploited and more diverse ways of sharing and utilising spectrum to provide the expected quality of service and to secure investments."

UNKNOWNS OF 5G AND OTHER FACTORS

A joint meeting by the IIC and the Australian Communications and Media Authority (ACMA) in June saw a thorough briefing on 5G by Andrew Entwistle of New Street Research on the 'known unknowns' of 5G, especially aimed at investors.[2] He confirmed that while 4G will likely completely displace 2G and 3G and is a true generational shift, 5G will coexist with 4G for a long time, and "evolving and improving 4G will remain as the optimal solution for many locations and spectrum bands". Certainly 4G will remain dominant in sub-3 GHz bands, and many 5G features are only effective at higher frequencies.

One notable feature about 5G spectrum is that much more is expected to be allocated to it than now exists for current mobile – some 10 to 20 GHz – which means much wider channels that can deliver higher capacity and speeds. A problem with higher frequencies, though, is that they do not propagate as well as lower frequencies, so to get usable range and penetration, techniques such as 'beamforming' will be needed (and this is of course well covered in the 5G book, as is another technology, MIMO, or multiple-input multiple-output, already used in 4G. Beamforming is also used now in 5 GHz WiFi and other systems).

> **"It could be 2022 or 2023 before there are large scale deployments of 5G services."**

Apart from questions about range, Entwistle notes that high-frequency signals are not good at penetrating buildings, even with beamforming. This means that although indoor-to-indoor links with 5G will be good owing to a high level of reflected (multipath) signals, limits on outdoor-to-indoor links will be an important constraint, although the relative performance in different materials such as concrete and brick is not known.

And a third key unknown is timing – "It could be 2022 or 2023 before there are large scale deployments of well-functioning 5G services given the complexity involved and the many degrees of freedom that are expected in the standards. The timetable for 5G is far from clear at present."

One plausible deployment option is using 5G (or pre-5G) to serve rooftop antennas for wireline substitution. "Verizon is exploring this model with a view to 2017 deployment so the uncertainties

ROUNDING UP THE LATEST NEWS ANNOUNCEMENTS ON 5G

● Europe's leading telecoms operators have launched a 5G manifesto, in which they say they will launch 5G services across Europe by 2020 provided a regulatory environment exists that puts an increased emphasis on investment. In particular, "We must highlight the danger of restrictive net neutrality rules, in the context of 5G technologies, business applications and beyond... [and] a withdrawal of ex-ante regulation when appropriate is consistent with greater investment incentives for all players, in fibre among other 5G ready infrastructures". See bit.ly/29pk2QD

● The manifesto has been welcomed by the European Commission's Günther Oettinger, who says the Commission will produce a 5G action plan this autumn: "What is at stake with 5G is nothing less than Europe's global competitiveness."

● Meanwhile the US FCC has proposed rules that would open up almost 11 GHz of spectrum for flexible use wireless broadband – 3.85 GHz of licensed spectrum and 7 GHz of unlicensed spectrum. "If these rules are adopted, the US will be the first country in the world to open high-band spectrum for 5G," the FCC says. Specifically, the proposal will create a new upper microwave flexible use service in the 28 GHz, 37 GHz, and 39 GHz bands, and an unlicensed band at 64-71 GHz.

● Analyst firm Ovum estimates that 5G services will be available in more than 20 markets worldwide by the end of 2021, with services in all four major world regions. However, the vast majority of 5G subscriptions will be concentrated in the US, Japan, China, and South Korea, where major operators have revealed aggressive timelines for launching 5G services. The main use case for 5G by 2021 will be enhanced mobile broadband services.

● The University of Oulu's research unit, the Centre for Wireless Communications, in Finland, will develop 5G technologies for the 2018 Winter Olympics in Pyeongchang, South Korea.

about its range, capacity and economics could be clarified in the near future," reckons Entwistle, who remains sceptical for the time being. But the prospects for 5G to substitute for wired broadband without rooftop antennas look very weak because of the building penetration issue.

The potential market for 5G for delivering the internet to the rooftop, as an alternative to wired networks, does seem to be interesting given the potential savings in street infrastructure. But as Entwistle points out: "The technical ingredients for wireless point-to-point services already exist. There's been no need to wait for 5G. Our view is that any large wireless operator could have gone ahead with a rooftop broadband offer in a high spectrum band at any point in the past five years (and probably longer). Whatever factors have prevented wireless operators from offering point-to-point services as a substitute to wired broadband are probably still there in a 5G world."

Nevertheless there is activity on this front – Entwistle adds that Verizon's possible 'pre-5G' point-to-point home broadband services "would be a much more serious entry into the US home broadband market than its HomeFusion 4G fixed wireless proposition launched in 2012". Technically a point-to-point service is much easier to deliver than a mobile one as the beam does not have to track a moving end user or deal with rapidly changing link characteristics.

A rooftop proposition is complicated by factors such as whether a specific property can be serviced by a provider, challenges in installing antennas, and competition from wired services whose prices are now too low for a wireless substitution case to work.

BUT 5G WILL BE DISRUPTIVE

So where does 5G have a place? Serving many users at gigabit speeds outdoors and indoors, certainly, and it will give a major boost to fixed broadband services in areas with inadequate wired infrastructure. "Even if 'rooftop 5G' does not appear as a competitive substitute to wired broadband, we do expect that it will be very useful for any area without good wired infrastructure – remote and rural areas and also suburban and urban areas in many emerging markets," says Entwistle. "We would expect 5G fixed broadband to be very competitive with satellite broadband services for sites that are within a few kilometres of a cell tower."

And it will disrupt the traditional cellular model in at least three ways:

- Spectrum – huge quantities of high-frequency spectrum, spatial reuse of spectrum and new models for authorisation are likely to be disruptive
- Densification– wireless-only operators are already disadvantaged in small cell and WiFi deployment compared with integrated wireline players; 5G has the potential to accentuate this disadvantage if (as expected) it works best with smaller cell sizes
- Data bundles: paid vs free usage – wireless operators already struggle with the mix of paid cellular services and free WiFi usage. 5G makes this problem much worse, and could push most operators to offer unlimited usage bundles.

"We do not expect the current cellular business model to survive into the 5G era," comments Entwistle, and this holds true even if 5G turns out to be a damp squib. "We expect that 5G spectrum will be made available even where there is limited enthusiasm from operators, so the 'spectrum barrier to entry' will be lowered. Wireline operators, end users and others will add 5G connectivity in their homes, offices and public spaces. Device makers will include 5G in the leading smartphones and tablets. These developments will not be stopped by disappointing link performance, operator reluctance or a lack of real demand for gigabit speeds."

SPECTRUM PIPELINE

In notes about spectrum, he adds: "Our view is that the development of 5G services will be shaped by the mix of bands that are most readily available for 5G use. However we do not see any particular shortage of 5G spectrum in the pipeline, and we expect spectrum authorities to be energetic in bringing new bands into use, under pressure from governments that see 5G as hugely important in industrial policy terms." Issues affecting the spectrum 'pipeline' include:

> **We do not expect the current cellular business model to survive into the 5G era.**

- Exclusive licences or shared access – higher bands are well suited to shared access, particularly with 'cognitive' radios that are 'aware' of potential conflicts with other users
- Power limits – regulators have to decide which bands have which power limits. But traditionally expressed power limits on licensees aren't well matched to beamforming technologies such as 5G
- Directionality – 5G services are likely to be highly asymmetric, with far more traffic from the network to the user than from the user to the network.

Market forces are likely to be the main driver of international progress with spectrum allocations for 5G, rather than the formal processes of the ITU, a view supported by the lack of consensus on many 5G spectrum issues at the recent WRC-15 event. "FCC chairman Tom Wheeler encapsulated the aggressive 'realpolitik' approach we expect to see on 5G spectrum in a recent speech at a satellite industry event," says Entwistle. "After directly criticising satellite industry resistance to adjustments to 28 GHz authorisations ('Such intransigence was frustrating') he spelt out a tough line: 'I offer a bit of hard-earned experience: it is far more practical to get on the train than to be run over by it.'" Entwistle expects to see this appetite for progress in 5G spectrum at national level in many countries and regions, irrespective of formal international spectrum management.

INTERNET OF THINGS AND 5G

Entwistle raised some eyebrows when he put 5G applications in the internet of things (IoT) to one side. "IoT and its related themes receive the majority of attention in most industry and press coverage

of what 5G will become. However, in our view, telecoms investors should ignore the noise on this front because it is unlikely to translate into much value for operators and distracts attention from some of the more fundamental questions concerning 5G."

As he points out, progress in sectors such as automotive, energy and healthcare is only loosely related to '5G' in the sense of 5G as a set of future telecoms standards. There is a good set of IoT communications solutions that are nothing to do with 5G, including low power protocols such as LoRa, Sigfox and Weightless, and a range of 2G, 3G and 4G implementations tailored to IoT requirements. It is highly improbable that the 5G standards formation process will unify or simplify the existing plethora of IoT technologies. "At best 5G will form an umbrella for this diversity, with all progress being labelled as '5G' irrespective of the actual technologies in use," says Entwistle.

IoT will of course be important for various sectors and has many regulatory aspects but putting it into the mainstream telecoms value chain and also into the primary disruption caused by 5G are not so important. "IoT and vertical market solutions are interesting for equipment vendors, systems integrators, vertical market participant firms and end users, but much less so for network operators. Traffic volumes and revenue yields tend to be low and margins tend to be thin. IoT and vertical market solutions are not areas where telecoms operators have excelled to date and we see little evidence that this will change," comments Entwistle.

5G VISION IN PERSPECTIVE

Another view that the business case for 5G does not match its apparent technical promise comes from William Webb, CEO of Weightless SIG, an IoT standards group.[3] The technical logic that could serve apparently perfect connectivity is reasonably strong: "It recognises that different radio interfaces will be needed for different solutions such as broadband versus IoT. It builds on evolutions taking place within WiFi, IoT and vehicular communications. Finally, the implications of very low latency drive inexorably to millimetre wave deployments with their highly directive antennas and small cell sizes."

The problem, he says, is that there is no consumer money to pay for new services, and recent attempts to improve ARPUs with services such as picture messaging have not been fruitful, and much of the benefit has been captured by over the top (OTT) players such as Skype. Meanwhile IoT apps can already be served with existing systems. But with no new revenue, will 5G cut operators' costs, as 4G has? It seems not – "5G does not have any new air interface compared to 4G, nor does it promise much in the way of increased efficiency."

Further integration between networks – cellular and WiFi being the main ones – does not need a 5G standard, and millimetre wave cells are only useful in dense urban areas, but it is indoors where greater capacity is needed (and where WiFi rules). Essentially, current developments may just be badged 5G but are happening anyway.

ADVICE FOR REGULATORS

In advice for regulators, Webb says: "There are broadly two roles for regulators – management of radio spectrum and the rules that govern competition. Regulators should not focus on 5G spectrum, but should ensure that spectrum is available for each component. This involves delivering more spectrum for 4G solutions in bands such as 3.5 GHz and 700 MHz, delivering spectrum for IoT including enhanced unlicensed spectrum, and ensuring WiFi spectrum remains usable by controlling interference and helping optimise WiFi deployments in dense areas." For less certain applications such as millimetre wave it may be more sensible to enable sharing solutions until there is a business case for band clearance.

Regarding competition, regulators should have new models for operators to include companies that aggregate WiFi capacity, deliver IoT solutions, provide small-cell systems, and likely other approaches. "Mobile operators will need to adapt, possibly merge, and change network and spectrum sharing models, with the definitions of fixed or mobile becoming blurred. This implies loosening competition regulation now to send signals to spur business innovation."

> **This implies loosening competition regulation now to spur innovation.**

Webb also has advice for governments – they "typically want to encourage local industry to gain from selling new technologies, and ensure the early deployment of new wireless solutions to provide best-in-class services to their population". But it would not be best to aim for a 'leadership' position in 5G, he adds. "Rather than deploy 5G research centres, it is best to focus on elements such as leadership in connected cars, in IoT or in WiFi management. These do not require research activities but can benefit from directed government spending."

He gives the example of procuring a national IoT system like the smart energy meters underway in some countries, which "would spur local industry to deploy IoT solutions and develop applications and services that could subsequently be exported". Meanwhile at international level, he notes that the European Commission is keen to promote leadership in 5G but through large scale research funding. This is rarely effective, reckons Webb, as it is an approach followed for many years with the Framework and now the Horizon funding programmes, "but has not delivered a vibrant and successful European manufacturing industry, rather the converse". Instead, the Commission should seek to harmonise national strategies, "for example by encouraging a similar approach to IoT deployment across member states that would deliver economies of scale and make Europe of greater interest to global players. Fostering and funding standards bodies and forums is more appropriate than research entities."

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