guide

The path to true 5G and what it means for businesses

realwireless.
independent wireless experts

Real Wireless Limited
PO Box 2218
Pulborough
West Sussex
RH20 4XB UK

t +44 207 117 8514
f +44 808 280 0142
e info@real-wireless.com
w real-wireless.com
@real_wireless

Contents

Figures

Foreword

This is a guide for enterprise IT teams that want to understand what 'true' 5G might be able to bring to their businesses – and when. It also looks at the implications of network virtualisation and network slicing, key concepts often associated with 5G.

There are dozens of wireless technologies to choose from, and serving those technologies, hundreds more choices – for deployment, infrastructure, handsets, software, services, pricing and reach.

It's our job at Real Wireless to get granular with all this and provide independent advice so clients can adopt the right combination of technologies to bring the most benefit to their businesses.

When our enterprise clients are looking to improve their connectivity infrastructure – be that for a port, a hospital, a stadium, a transport terminal or in part of a city – they want to understand how major changes like 5G might impact their investment decisions.

The aim of this guide is to provide a realistic take on how we see the 5G roadmap evolving – what's happening today, what's likely to happen in the near future – and how significant shifts in network architecture like virtualisation and network slicing will affect services, costs and supply chain.

1. Path to true 5G

It has always been clear that the physical landscape associated with true 5G will look very different from what has come before it. This new world will be characterised by network architectures that describe a shift away from hardware dominated topologies, towards softwarisation and virtualisation. But we're not there yet.

Even ahead of the technical innovation, network function virtualisation is primarily about a *conceptual* shift in network design, away from specialised hardware – e.g., base stations – towards an environment in which functionality and services increasingly move into datacentres and edge cloud sites.

Delivering on the full, multi-service promise of 5G has always been contingent on the widespread adoption of such architectures, along with the creation of standalone 5G core networks. This is the move that facilitates techniques like network slicing, that in turn enable new service models and opportunities.

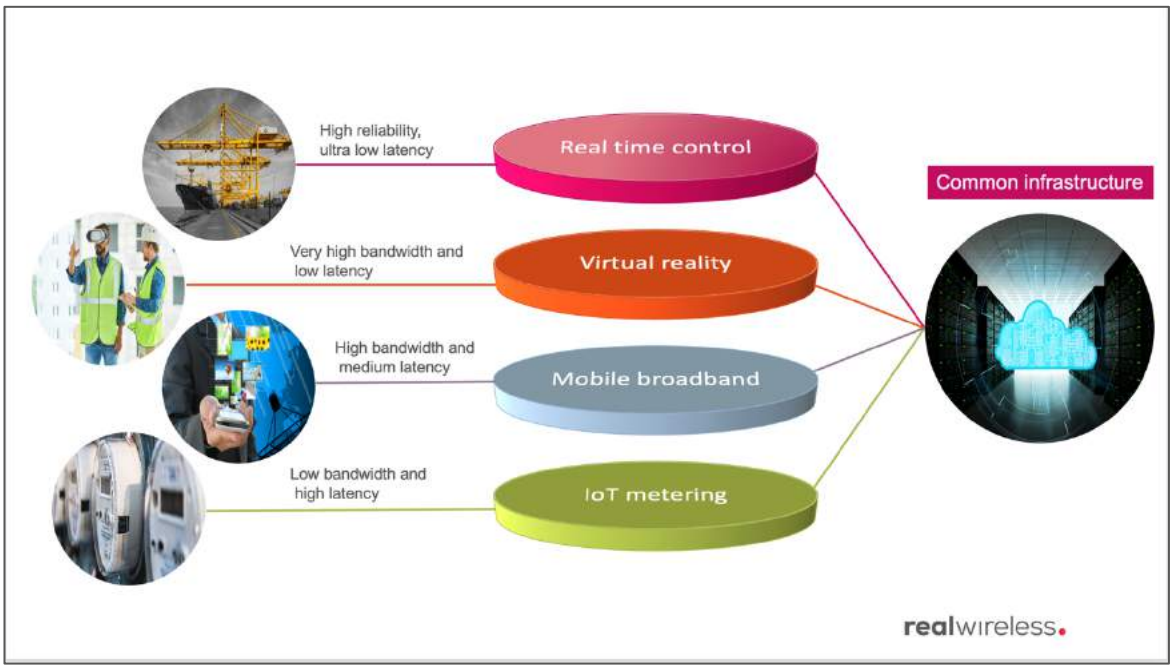

Figure 1-1 – Network slicing enables service providers to segment 'slices' for different users and use cases. Each slice is a discrete end-to-end network that can be configured to the requirements of its particular application.

Network slicing enables multiple logical networks to run on top of shared physical network infrastructure, supporting the more tailored, multi-service promise of 5G. This means that, for example, a low-demand activity like metering can be run on one network slice, while activities requiring real-time data transfer, like the operation of autonomous cranes in a port, can be run on another slice of the same network. While network slicing can be achieved without virtualisation, it can be implemented much more dynamically, flexibly and efficiently if applied to virtualised networks.

For service providers and their enterprise customers, this transforms the very fabric of what a network comprises and what it can offer, creating a virtual asset that encompasses not just networking capabilities but also compute and storage functions.

From an investment and deployment perspective, for most service providers this was always going to be an evolution rather than revolution, as they transition into 5G and consider how and when to migrate 2G/3G and 4G legacy services and devices. This is as it should be, not least because LTE (4G) remains a robust and flexible technology that still has a lot of life in it, while sunsetting 2G/3G will take time.

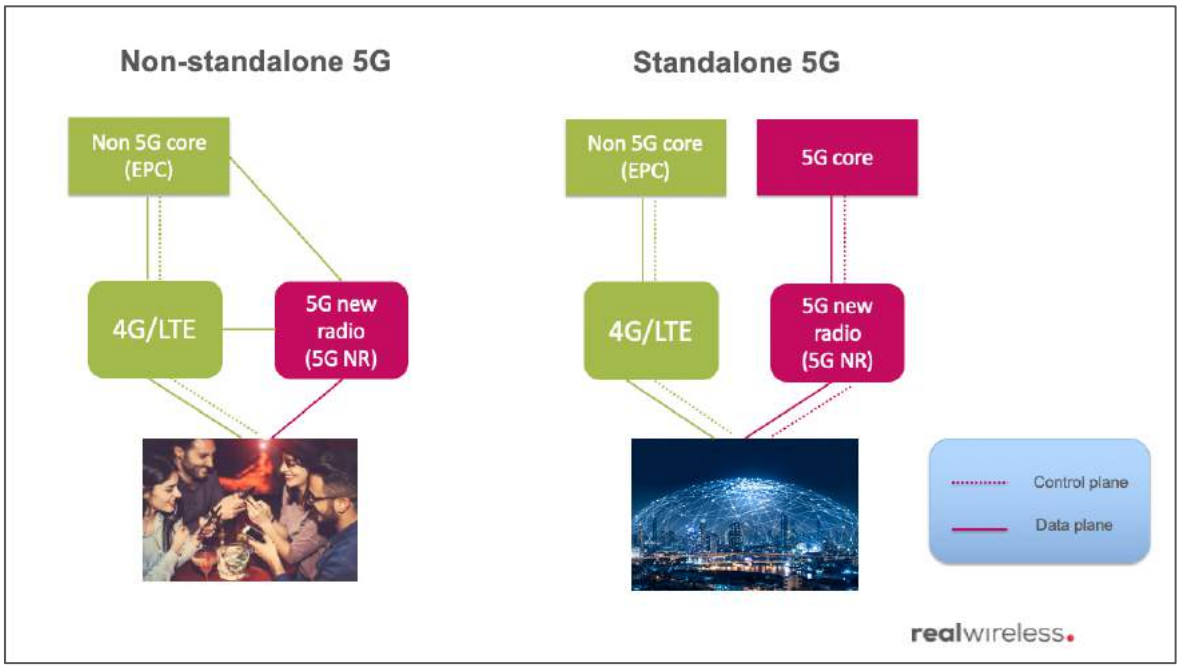

Figure 1-2 – Initial 5G new radio launches rely on existing 4G LTE infrastructure in non-standalone mode. Dynamic standalone 5G core networks with near-instant service implementation are still several years away.

Recent years have seen the usual claims from service providers to be first-to-market with the 5G New Radio (NR) technology. It is certainly true that, in most developed markets, the majority of tier one operators have now rolled out 5G technology in some shape or form. However, this has largely been about delivering additional carriers to existing 4G networks to improve capacity for consumer services. This means that while 5G NR is starting to be deployed, the realisation of its technical and commercial potential is still some years away.

The question we want to address here is how virtualisation plays its part in the roadmap to networks built around a 5G service-based architecture core that will enable the genuinely transformational service environment captured in that ubiquitous triad of enhanced mobile broadband, ultra-reliable low latency and industrial IoT.

What does that roadmap look like and what will be the role of virtualisation in the journey?

2. Virtualisation – a necessary good?

The short answer is that virtualisation is critical to the realisation of 5G. This is not just from an architectural perspective but also in the context of the 5G business case. In fact, the architectures of radio access networks (RANs) are continually evolving and *always* as a result of the combination of technical and economic drivers. Understanding the service-provider 5G roadmap and the role that virtualisation plays means thinking about the evolution from traditional distributed architectures (i.e., D-RAN) to more centralised, softwarised and potentially open architectures (via C-RAN, vRAN and OpenRAN).

The distributed or D-RAN approach to RAN architecture refers to deployments in which the antennas, radio frequency (RF) front end and base station (BTS) equipment are co-located on the same site.

In comparison with D-RAN, C-RAN or centralised RAN takes the disaggregation of the RAN to the next level. In simple terms, the initial stages of C-RAN see architectures in which network or base station functions are located offsite from the antenna and RF front-end equipment. This approach makes it possible to use the same processing and resources for multiple base stations. Instead of three sectors, you might control, say, six or ten sectors served from different tower sites from the same BBU – enhancing operational efficiencies and reducing capex.

And it's the C-RAN approach to network architectures that should bring us closer to the inevitable virtualisation of the RAN.

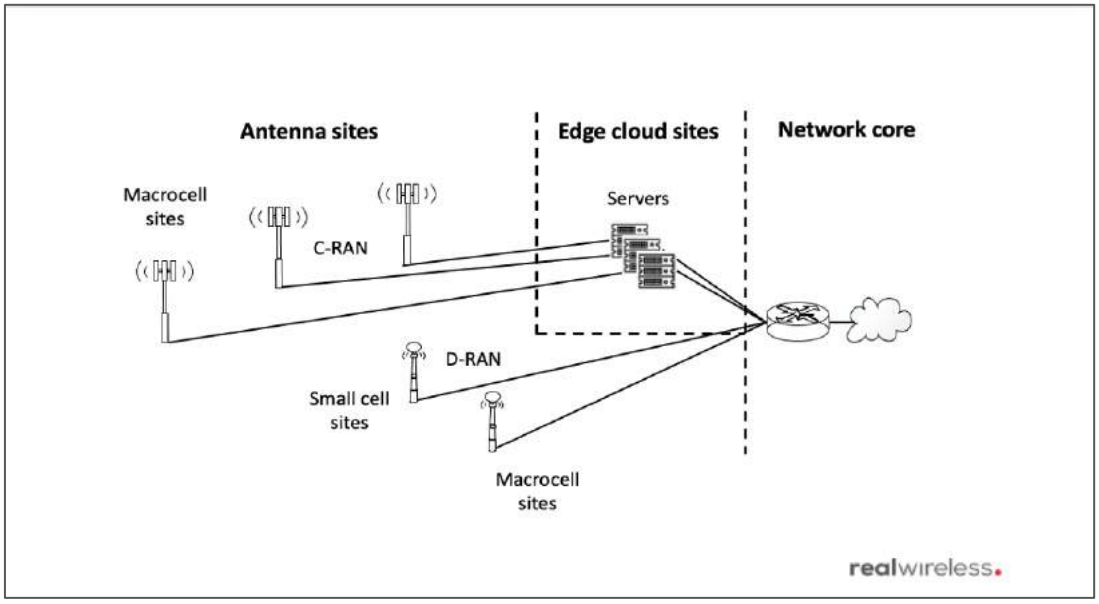

Figure 2-1 – The transition to virtualised networks was always going to be an evolution rather than revolution. It will include different types of RAN topologies, with varying degrees of functionality located at the antenna site and remotely.

A virtualised network can and should bring better cost efficiencies to the entire network, as we move away from site-based economics, to clusters of sites and the economics of networks as a whole. Important

enablers of benefits are a move to more general-purpose processors for traditionally bespoke hardware enabled functions, as well as bringing the immediacy of software driven approaches like continuous integration and delivery (CI/DI) into play. If implemented correctly, these approaches can improve reliability and flexibility and reduce costs when compared to a bespoke-base-station-at-cell-sites approach.

Such advantages, coupled with network slicing, will enable cost effective and more efficient implementation of bespoke and targeted services. For many service providers, this is especially important in the context of delivering the right sort of connectivity for industry IoT applications and Industry 4.0 in general – serving specialist requirements via existing infrastructure rather than scrabbling around trying to justify the very significant costs of bespoke deployments (and, in the process, almost certainly losing access to growth markets).

3. What about the downsides?

There are very few downsides to the *concept* of virtualisation. Most of the real-world challenges are associated with the fact that we're not reimagining network design with a blank sheet of paper.

Transitioning from the predominantly physical world of LTE to the more flexible virtualised environments of 5G is challenging and will certainly be staggered. Whilst there are some early cloud-based approaches to 4G/LTE, most service providers now focus on virtualisation and cloud native approaches as part of their 5G transition.

Another cultural challenge for mobile network operators (MNOs) is that virtualisation implies ceding control to systems and third parties in a way that makes many incumbents uncomfortable. For a start, the management and orchestration (MANO) of the many disparate elements of a virtualised network is already a bit of an issue. Indeed, given the range and diversity of resource demand implied by concepts like slicing, few service providers are convinced that today's proprietary MANO or even specialist service assurance products are up to delivering the right network resources to the right place at the right time. Indeed, dynamic end-to-end slicing offers no shortage of technical and commercial challenges related to more dynamic resource management, security and the ongoing convergence of the fixed and wireless domains.

At the same time, the dispersal and softwarisation of network elements to datacentres and edge sites means that the integrity of a growing volume of critical infrastructure is increasingly controlled by third parties.

The counter to this latter concern is that telecos simply need to join the rest of the 21st century and, in particular, their enterprise customers who have been putting trust in the big web scalers for years. For many, it's about taking a deep breath and bracing for the plunge into the unknown.

4. Who's in the vanguard?

The concept of network virtualisation was first mooted more than 20 years ago, having been matured in the computing and IT domain since the 1960s. Things have moved on a good deal since then. There's been a great deal of theoretical thinking, lab work, standardisation efforts and trials but, at the time of writing, commercial implementations remain thin on the ground.

For many, the poster child for the-shape-of-networks-to-come is Japanese operator Rakuten. As a green field operator, Rakuten has benefitted from that blank sheet referred to earlier, in the sense that it has not been constrained by the burden of legacy integration. This means Rakuten has been able to contemplate network design that places radio heads in the field, with the rest of its network virtualised.

Rakuten's approach certainly sets a stake in the ground but the detail around deployments is a little fuzzy. For example, the precise level of functionality delivered by Rakuten's radio units remains open to conjecture. Clearly the virtualisation of the lower layers of the protocol stack – where serious signal processing is required – is always going to be complex. It seems likely that for now lower layers of Rakuten's network remain in the radio head, with the higher-level functions fully virtualised.

In any event, Rakuten's investment in virtualisation remains a positive example of an operator taking the concept out of labs or trials and into a real, live network, albeit a network developed from scratch. It's already been recognised in two categories of Opensignal's Global Mobile Network Experience Awards 2021 and, while this is encouraging, as a case study it remains unrepresentative at a number of levels.

Elsewhere, we are also seeing frontrunners among the more conventional players. In the UK, Three virtualised its 4G core network with Nokia in 2020, while in the US Verizon has deployed a 5G standalone core network from Samsung. In general, though, it's once again a case of evolution over full-scale transformation, with a growing number of operators announcing the virtualisation of high-level core network functions. Nevertheless, this progress is, once again, encouraging, suggesting development filtering its way down the stack, virtualising layers as it goes.

While the large mobile operators tend to grab the headlines in this space, out of the limelight and on a smaller scale, alternative service providers like neutral hosts are pushing progress in different parts of the market. We are seeing an escalating trend in in-building and smart city solutions that employ virtualisation's "base station hotel" architecture, with distributed radio heads coming back to a centralised unit running the protocol stack in a more virtualised form. There are also examples apparent in localised network deployments using neutral host solutions – for example, the Wireless Infrastructure Group's C-RAN deployment in Aberdeen and the multi-party 5G-Create private network deployment in Liverpool using integrator Telet (see below).

However, beyond these early movers, proof of concept for slicing and the resolution of the challenges around the orchestration of these new networks and services remain largely in trials.

In terms of the orchestration and deployment of network slicing in the field, this is something Real Wireless has supported in Hamburg's 5G-MoNArch test bed.

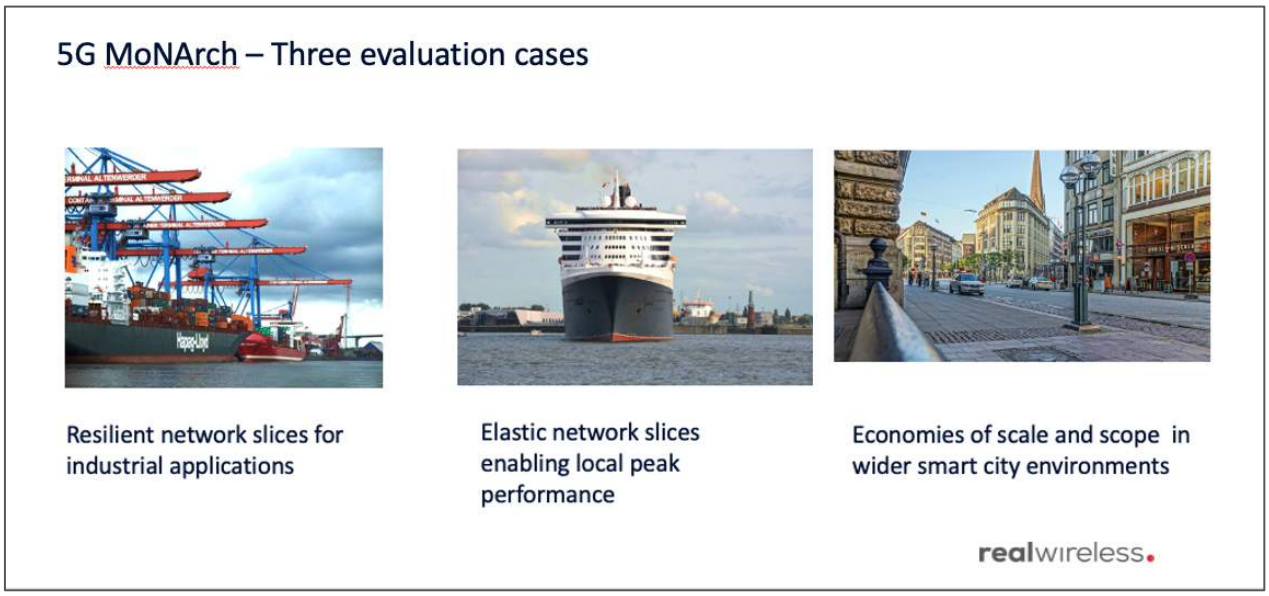

Figure 4-1 – As part of the 2-year EU Horizon 2020 5G-MoNArch project, Real Wireless assessed the operational value a 5G network could deliver to the users of Hamburg port

In this European Commission supported trial, Nokia used a Deutsche Telecom site in Hamburg to roll out bespoke slices and services for the Hamburg Port Authority. The slicing use case employed a graphical interface to dynamically call upon resources to add services to the network. The services were live within a matter of minutes and could be moved between data centres. While this was a test bed with limited range, the trial unequivocally demonstrated the technical feasibility of such an approach. Our conclusion was that if the scale could be ramped up and the characteristics of orchestration confirmed in the technical standards, then full commercial deployment should be possible. To find out more about the economics of 5G, read this summary of Real Wireless's report.

5. When will the vision become a commercial reality?

As far as enterprise engagement is concerned, 5G timelines should be all about managing expectations.

Dynamic 5G core networks with near-instant service implementation are still several years away – three to five years would be an optimistic estimate. The Hamburg case that Real Wireless supported and described above was unique, self-contained, at a comparatively small scale and had a great deal of resources thrown at it. Technological maturity for wide scale, large area implementation of such service delivery is still some way off. Virtualisation will continue as an iterative process, with flagship projects leading the way.

There are signs of progress all around showing the gradual emergence of the vision. EE's Emergency Services Network is an early example of slicing, the service provider ring-fencing hard slices of its existing 4G network for the exclusive use of the emergency services. In the enterprise space, Three in the UK has established a private network operating for the port of Felixstowe, integrating with their core network in London as a good example of adding an industrial user. These projects will continue to be joined by others

on a case-by-case basis, but as it stands, the options are not as flexible or dynamic as they will be in years to come.

The evolution away from bespoke approaches will take time and require solidification of the standards around orchestration.

In the meantime, the rollout of 5G standalone core networks will take the main focus over the next couple of years, and we are seeing the more pioneering networks already starting, with others to swiftly follow. Once those core networks are established, it unlocks the options of increased customisation within the network, likely starting with slicing on a reasonably static and limited basis. As the networks evolve, the standards become firmer and orchestration is established with virtualisation built in, then increased customisation and granularity of services will become more commonplace.

6. How virtualisation changes the supply chain

The new network architectures we have described can certainly improve and extend service delivery. It also extends the choice of service provider, with connectivity solutions that run on virtualised networking becoming accessible through system integrators and original equipment manufacturers (OEMs). However, virtualisation is disruptive and will only be pursued if it enables business strategy; service providers need to maintain and grow market share. Options are now available to reduce capex by separating network intelligence from the underlying hardware; even open sourcing the former and commoditising the latter.

It could be argued that in recent years, dominated by a small number of very large vendors and services providers, the communications industry has chosen to innovate within a relatively thin range. This tends to be the case with all successful technology sectors – the automotive industry is another obvious example – and only changes when growth stalls, customer demand changes or customers start to look elsewhere. That tipping point was reached some while back.

Virtualisation is a concept whose time has come because it addresses the requirements of the digital transformation of industry and enterprise. For the mobile sector, this offers a potential for growth into new or under-exploited markets. And it is already changing the connectivity ecosystem. This can be clearly seen in the private network space where smaller, specialist service providers *and* vendors are leveraging small cells to customise service offerings to specific end-user groups.

As we have seen, an important driver for both virtualisation and network slicing is the requirement for bespoke service delivery to meet specific enterprise demand.

It is unrealistic to expect even the largest of OEMs like Nokia and Ericsson to provide the best in class of varied and specialist network functions that the plethora of enterprise customers need and demand. Smaller vendors *can* do this and are already meeting such demand successfully with existing technologies. Looking ahead, there is clearly an opportunity for such businesses to partner with tier 1 suppliers to provide, for example, functionality to enhance reliability or security which can then become a feature of

wider area networks that MNOs can implement on a slicing basis. This will strengthen and differentiate service offerings, while extending and diversifying the supply ecosystem.

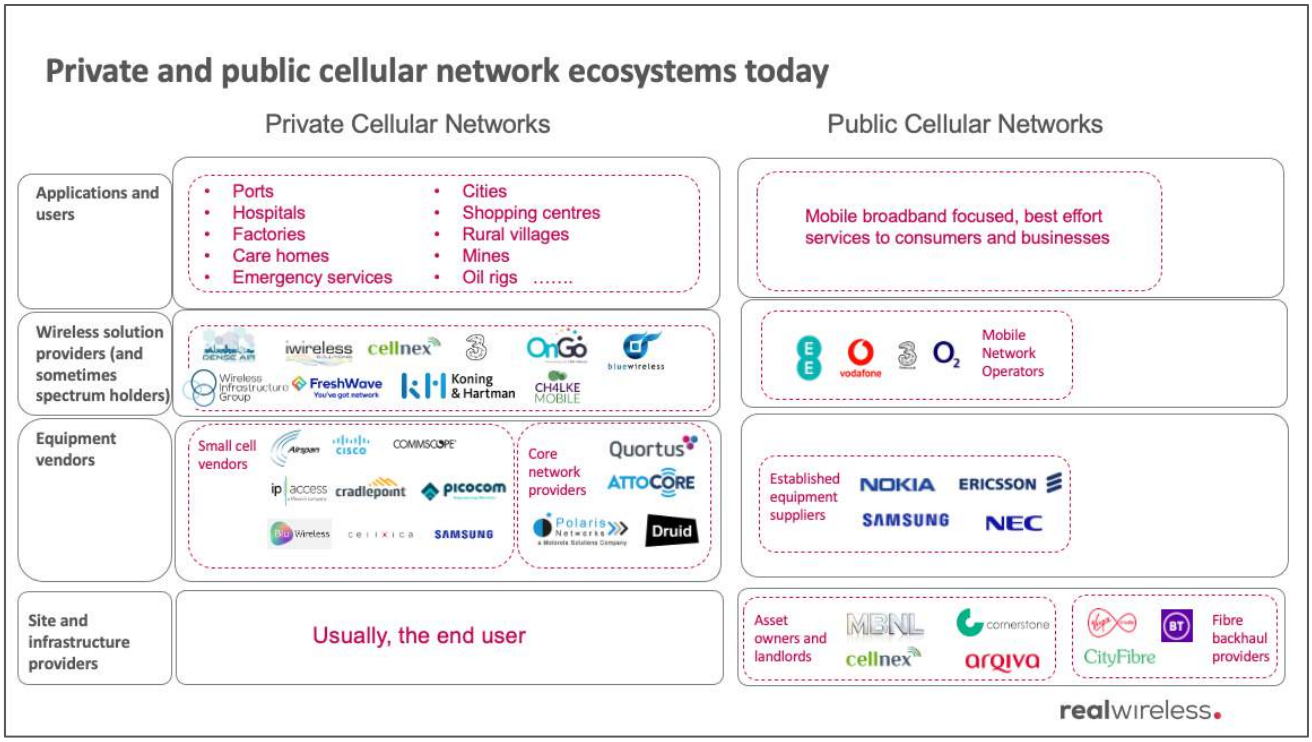

Figure 6-1 – Diversification of the cellular supply chain also carries with it the danger of fragmentation, which can only be addressed through the adoption of global standards with open, interoperable interfaces and application programming interfaces.

Standards bodies like O-RAN and Small Cell Forum assist the vendor and service provider ecosystem by facilitating the definition of open interfaces for the virtualised world. The opportunity is there for smaller vendors to enter the market and coexist with bigger players to deliver the functionality required for increasingly specialised demand. However, this requires operators to access more independent granularity in assurance to address the service level agreements (SLAs) that enterprises will expect and, while the required standardisation and enterprise-oriented thinking are in place at the theoretical level, the service assurance and orchestration required to manage all the added complexity remain a serious impediment.

With the emergence of private mobile networks and campus networks as an increasingly important commercial opportunity, OEMs and system integrators can and do offer solutions direct to enterprises. Those that have a capable IT infrastructure with edge and cloud capability can now connect in telco grade equipment and directly gain the benefits of a virtualised technology platform. This is a viable choice and can be done rather than operating business critical communications on the virtualised service delivery platform of an MNO. It's also starting to become a realistic choice.

Another challenge with such a diversified environment is governance – whose responsibility is it when there's a problem? New service delivery business models will come into play. One potential solution is the emergence of what might be described as uber service providers or 'thick' MVNOs (mobile virtual network

operators). This new breed of service provider would purchase a slice of capacity from multiple MNOs, taking end-to-end responsibility for assurance and orchestration, stitching a patchwork of resources together to implement customised functions with smaller vendors.

These structural changes and others are coming and are assisted by virtualisation, which has the potential to open up the ecosystem and drive changes across the entire telco sector.

7. Making it real

In a real-world setting, when we start to consider the commercialisation of service delivery via virtualised networks, we need to be sure that the structures, ecosystems and architectures to be evaluated can deliver across hybrid networks, especially in industrial contexts. Which is another way of saying that in the virtualised world there are many disparate factors in play and, certainly in this period of transition, both service providers and their customers will require expert support to ensure these new architectures are robust and cost-effective.

At Real Wireless, we have extensive experience at looking at the various options for rolling out new networks and deploying different solutions. Most recently we have worked with Liverpool City Council on its 5G Create project.

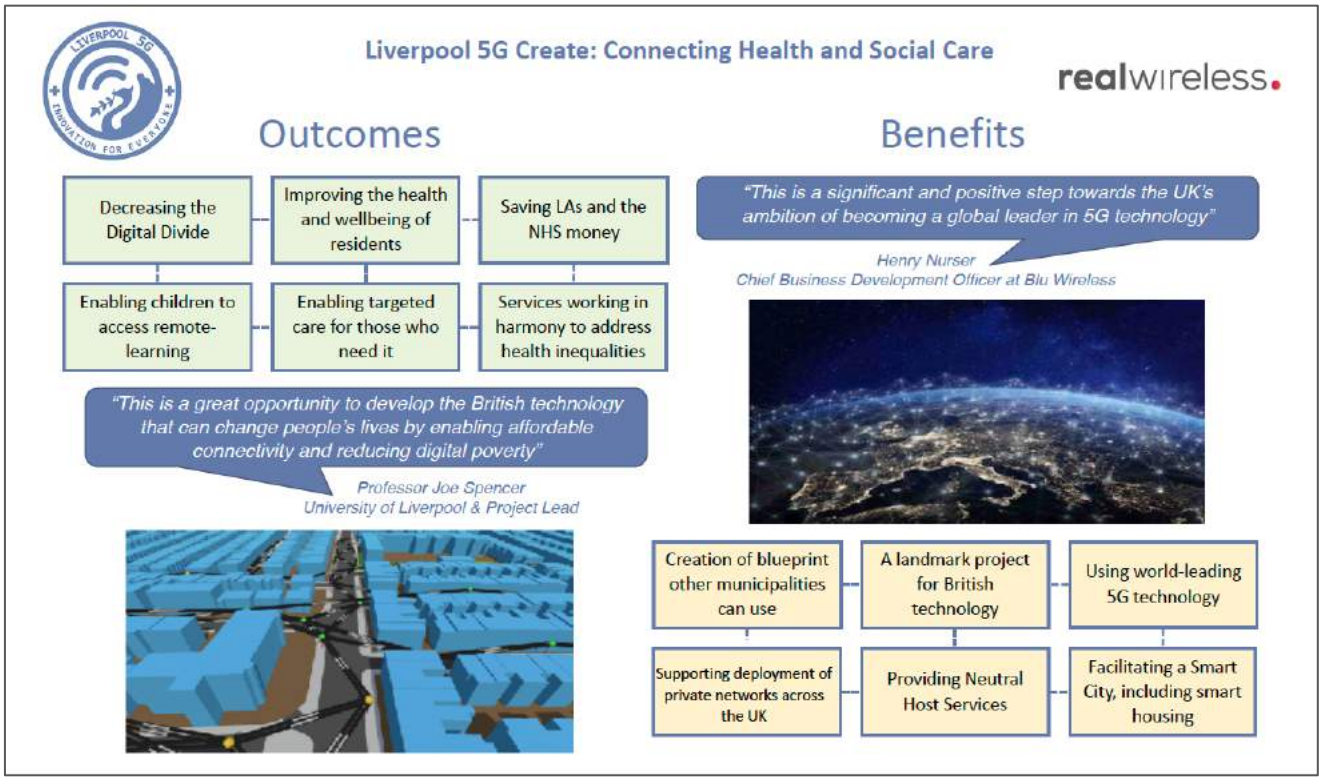

Figure 7-1 – Liverpool 5G Health and Social Care project aims to support vital health and social care technologies. It is part of a UK government programme to explore how 5G can boost business growth and maximise the productivity benefits of new technologies

Liverpool's Connecting Health and Social Care project aims to develop a private independent 5G network for health and social care services in selected areas of Liverpool. The network will reduce digital poverty for vulnerable people in need, providing safe, free and accessible connectivity to services including health, social care and education.

The technology needs to be able to deliver a broad range of services, including the support of a medical grade device to manage and monitor health conditions remotely, an app that teaches anxiety reduction techniques, a remote GP triaging service, wound care and management and sensor technology.

Along with the University of Liverpool, we are evaluating a number of different deployment models with a view to performing a cost-benefit analysis on the different options. Some of the scenarios in play include a private network deployed by the council themselves, and another using an MVNO to manage multiple slices from multiple MNOs.

The trial and assessment will run until March 2022 and will develop a blueprint for the use of private 5G networks in delivering public services. The blueprint will be disseminated across public bodies, leading to increased use of private networks for public services with reduced risk, based on the DCMS Testbed and Trials Programme.

We are currently undertaking a similar exercise for the European Commission's 5G TOURS project – looking at three different test beds, types of network deployment options and the associated costs and benefits of each. These are focused around providing services to the healthcare, tourism, airport and media and entertainment sectors and combine our more recent experience in private networks with the cost benefit analysis already done for sliced, virtualised wider area networks under 5G-NORMA and 5G-MoNArch.

It's worth noting that the adoption of these new network architectures is often likely to be accompanied by a multi-partner approach to service delivery. In the case of Liverpool 5G-Create, for example, the project's technical lead Andrew Miles describes the eco-system involved as follows: 'We're bringing together user services designed specifically for health and social care practitioners, new fibre infrastructure, the latest multi-gigabit mmWave mesh distribution technology from Blu Wireless, internet service providers Broadway Partners, a 5G small cell network from Telet Research and Liverpool's award winning healthcare cloud services provider AIMES.'

8. Conclusion

Virtualisation is already underway, although its full impact will not be felt for some years. It will have significant impact on the diversification of the connectivity ecosystem and the range of technologies employed in a network. This presents significant challenges around service assurance and orchestration that need to be urgently addressed.

Diversification also carries with it the danger of fragmentation, which can only be addressed through the adoption of global standards with open, interoperable interfaces and application programming interfaces. This is still some way off.

Finally, the governance of these complex hybrid networks may encourage the emergence of uber service providers or 'thick' MVNOs that look after operations and assurance on behalf of multiple operators. We would expect to see large system integrators taking a role in these scenarios. At the same time, some MNOs could evolve to become integrators in their own right – as is the case with Deutsche Telecom.

Not every MNO will want to deliver every industrial use case, and we are already seeing specialist system integrators moving in to own specific industrial uses. It seems likely that this will evolve so that such firms adopt the MVNO role.

We are currently living through a period of transition from the physical world to a virtualised environment that hold many challenges and a great deal of potential. Real Wireless looks forward to supporting its enterprise and mobile industry clients to make the most of the opportunities that lie ahead.

About Real Wireless

Real Wireless is the world's leading independent wireless advisory firm. Its network of experts includes engineers, physicists, economists, security advisors, business strategists and deployment specialists. Real Wireless clients benefit from a comprehensive portfolio of specialist and custom tools that analyse radio network performance, techno-economic impact and the business model implications of wireless systems. With this unmatched resource Real Wireless is able to advise the industry and all user groups, spanning businesses to governments, mobile operators, regulators and technology companies on every aspect of wireless technology.

Real Wireless has applied this unique range of technical and strategic expertise to some of the UK's biggest wireless infrastructure projects – from major stadium connectivity to shopping malls to transport systems – and has worked with operators, vendors and regulators on all forms of wireless connectivity. It has also advised governments and the European Union on the technical, social and economic implications of communications policy.

Real Wireless experts help clients to understand, select and deploy technology according to need; we deliver truly independent advice as we are not affiliated with any association, company or proprietary standard. That is why, with 5G on the horizon, Real Wireless is best placed to guide and advise businesses on the choices and opportunities next generation communications systems will bring.

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realwireless.
independent wireless experts

Real Wireless Limited
PO Box 2218
Pulborough
West Sussex
RH20 4XB UK

t +44 207 117 8514
f +44 808 280 0142
e info@real-wireless.com
w real-wireless.com
@real_wireless