techUK

WIRELESS WORLD RESEARCH FORUM

5G HUDDLE

Towards a global 5G vision

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2014

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Conference Report

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Day 1 - What Will 5G Be?

Opening Keynote Presentations - A Vision for 5G

Wireless World Research Forum Chairman **Nigel Jefferies**, setting the scene, said he hoped the conference would provide a good picture of where 5G developments are now. WWRF's job is to "look to the horizon," he said. It wants to consider, among other things, the need for additional spectrum and to identify some key technologies. Major trends include the move to cloud computing, increasingly virtualised networks and the Internet of Things (IoT).

It is clear so far that 5G isn't just about higher and higher bit rates, but about more efficient use of spectrum, reducing latency, and so forth, said Jefferies. Critical to 5G success will be the development of a single global standard.

At this stage, great effort is being put into research projects, Jefferies noted. Some trials are taking place, and the focus will move to standardisation after WRC-15, with product development sometime after 2020 and beyond. The European Commission has created the 5G Public Private Partnership (5GPPP) to drive collaboration, R&D and investment. There are, additionally, regional activities taking place in China, Korea, Japan, India and the U.S.

Moderator **Julian David**, techUK CEO, said his organisation is keen to take the opportunity for the UK to position itself as a partner of choice to all those in the world looking to move on 5G. Part of the job of techUK, which represents the high-tech industry "from chips to clicks," is to talk to stakeholders, particularly governments, about what is needed to secure our digital future, he said. A big piece of that is digital infrastructure and 5G. For techUK the 5G starting point is customer experience: 5G should be able to provide consistency across the coverage area and quality of suitable levels for the diverse range of applications.

Hamadoun I. Touré *(video address)*

"We are in for exciting times," as International Mobile Telecommunication (IMT) enables new trends in communications systems, ITU Secretary-General **Hamadoun I. Touré** said in a video address. "The exponential growth in data traffic means 5G will have to support a variety of applications and environments, offer more robust systems and higher levels of security, and make more efficient use of spectrum that will provide better energy savings at reduced costs."


Rt Hon David Willetts MP

The Rt Hon **David Willetts** MP, former Minister for Universities and Science, said he views 5G as a system which will make the IoT possible and allow more continuous communication than mobile phones. The IoT has caught the government's imagination because it offers an opportunity for the UK once more to be at the cutting edge of technological developments. Willetts said he wants the UK to be an early mover in 5G, playing a prominent role in standard-setting, R&D investment and data security, particularly cyber-security. Privacy and security issues were a concern in the Q&A. Privacy must be brought centre-stage, Willetts said in response to a question about whether the UK government should install a chief privacy officer. Everyone must be clear about whose data is being captured, he said. On the security side, small and mid-sized enterprises that may not have the resources to install effective security systems can turn to organisations such as the Open Data Institute and research centres for help, he said.

Audience members also wondered if the UK government may be too proactive in moving ahead, such as when it awarded contracts for smart metering before the technology was actually available.

In general, "it's good to be an early mover" despite the risk of getting the technology wrong, Willetts said. As for the UK leading the way in 5G standard-setting, Willetts noted some concern that the regulator, Ofcom, does not focus as much on its role. He recommended that if the UK wants to shape the discussion at the EU level and globally, it should engage with Germany, a potential ally on digital agenda issues.

Simon Towler, Deputy Director, Head of Telecommunications Policy, Department for Culture, Media and Sport, explained how the government is trying to put the UK at the forefront of 5G. The first challenge is to try to understand what 5G actually is, he said. Governments are "grappling with a set of fairly broad requirements" at this point. Two key trends are that everything is going to be connected by wireless technologies, and that higher data rates will be needed for richer services to ensure uniform experiences, Towler said. All this means that networks will have to be more extensive and have much more capacity. In addition to technological developments, there are also questions of how and when these technologies will be deployed, the level of investment needed to introduce them, and the timing of the investments. Increasing capacity requires some combination of more spectrum and more base station sites, and that is where governments come in, Towler said. 5G will need more spectrum and new approaches to spectrum management, but that is not the only answer, he said. The government must be more


Simon Towler

responsive to new developments and smarter about the spectrum available by promoting greater sharing of spectrum through techniques such as dynamic spectrum access. Spectrum must also be available for research, which will be a key enabler of 5G. This calls for a change of mindset in Government and industry and, where necessary, legislation.

Legislation, however, is only one lever in the hand of government, Towler noted. The UK has a proud history in the development of wireless technologies through the collaboration of academia and industry. The most powerful thing governments can do is bring people together, he said. Collaboration is the "key watchword" to enable 5G. A public-private approach to policy development is also required, he added.

Net neutrality and sponsored data raise "exceptionally difficult questions," not only in the U.S. but in Europe and the UK, Towler said in response to audience questions. The UK government's approach to net neutrality is to work with the Broadband Stakeholders' Group, techUK and others to encourage Internet service providers to explain their network management policies, rather than to be prescriptive, he said. The preferred approach is a voluntary industry code of practice. As to the observation that the amount spent on wireless network services in the UK is around 2 ½ times less than in the U.S., Towler said government is planning legislation aimed at taking as much of the cost as possible out of network-building and at making more sites available.

Rahim Tafazolli, Director of the Centre for Communications Systems Research and 5G Innovation Centre, University of Surrey, said 5G is about "always sufficient." 5G will "set a new paradigm of thinking," moving on from mobile systems based on 2G, he predicted.

Tafazolli expects 5G to be commercially available by 2020-2021, and it should be designed to work until 2030-2040. 5G should not be designed for specific systems and requirements.


Rahim Tafazolli and Julian David

In a projected future where the Internet is the platform that connects everything, communications networks become super-national critical infrastructure, said Tafazolli. 5G will also include all other national infrastructures, not just mobile broadband. The important thing is that massive amounts of data will not be needed because analytics discovers and communicates meaningful patterns in data that can then be translated into useful actions (actuation).

5G is about the user's quality of experience (QoE), and always providing a "sufficient rate to give the user the perception of infinite capacity," said Tafazolli. 5G must be at least 10 times faster than 4G because of latency issues, he said. Moreover, the user doesn't care how he receives the service as long as the price is right. Tafazolli urged the ITU not to set 5G for higher speeds. Rather, he said, the targets should be area spectral efficiency, energy efficiency, latencies and QoE.

Life in a 5G World - A shared vision for the next generation of wireless communication

This session, chaired by UK Spectrum Policy Forum Chair **Jim Norton**, looked at the potential services, applications and opportunities 5G and a future mobile and wireless communications system can deliver in 2020 and beyond. The Forum "tends to take a long view," which is why 5G is of such interest to it, he said.

5GPPP Chair **Werner Mohr** described the various ongoing 5G research initiatives in Europe and worldwide. A collaborative approach is necessary because 5G will require global standards, he said.

The best time to prepare consensus standards is before products and markets become competitive, he noted. 5G will be a combination of existing and evolving systems coupled with new, revolutionary technology.

There is a "tectonic shift" in who the final service client will be, said **Mischa Dohler**, King's College London Head of Centre for Telecommunications Research, Department of Informatics. The ecosystem will shift from today's business-to-consumer ecosystem to the business-to-business arena, he predicted. Future service opportunities will not only be with consumers but also with industry sectors such as oil and gas, construction and transportation, he predicted.

Barriers to entry for those servicing opportunities will be higher, but exit barriers will also be very high once a company establishes itself in the B2B market. Deregulation of core networks will be allowing B2B competition in a previously uncompetitive space, Dohler said.

One exciting idea for use of the 5G infrastructure is the notion of the "Tactile Internet." The idea is to push everything we've designed for humans and onto machines, said Dohler. 5G is pulling together technologies besides telecommunications to make the Tactile Internet a reality. We want a skill (action)-delivery network in place of today's content-delivery networks, he said.


Chih-Lin I

China Mobile, the world's largest mobile operator, has two 5G themes, said **Chih-Lin I**, Chief Scientist of Wireless Technologies, China Mobile Research Institute: "green" end-to-end efficiency and a "soft" move from the core network to the radio access network. Transitioning to the "5G Era" networks will involve rethinking energy and spectrum efficiency co-design; cells; signalling controls; antennas; infrastructure; and spectrum, she said.

Eduardo Esteves

5G is not just about high peak rates and frequency bands, said **Eduardo Esteves**, Qualcomm Technologies Inc. Vice-President for Product Management. Qualcomm views it as new services and devices that enable and connect new industries – such as smart cities, wearable devices and mission-critical applications – and empower new user experiences. The 5G era will be about making possible the scalability and adaptability to connect everything from 2020, he said.

Many questions remain about what infrastructure(s) 5G will run on, participants said during the Q&A session. China Mobile appears to assume it will be fibre, which might not work for the UK, said one audience member. Fibre will play a big role, but so will wireless backhaul, said Dr I. No single technology will solve all the problems, and they will have to be used in combination, said Mohr.

Dohler said the key question is who should own the fibre. Should Vodafone, for example, own it simply to service the edges? Could there be a backbone infrastructure that looks different from today's? The question should be who owns the customer, Norton said. This is important for fixed and mobile companies in the future, he said.

Another question was how to know when 5G has actually arrived. 4G was here when EE's marketing department said "We have 4G," and the same will be true for 5G, Dohler said. One audience member pointed out that multiple regulatory and standard-setting decisions will have to be taken, so it is unclear whether 5G will arrive all at once or over a period of time. There is an opportunity now to define a 5G system that is significantly better than 4G, said Esteves. There is no definition of what "Gs" are because they are simply marketing concepts, he said. He envisioned a scenario in which LTE continues to evolve and at some point someone deploys an LTE system and calls it "5G." The timeline will be when someone introduces something that is fundamentally different and that offers a system that enables new services, he said.

Day 2 - Creating the 5G Environment

Challenges and Opportunities


Jan Färjh

It's all about "one network, multiple industries," said **Jan Färjh**, Ericsson Vice President, Head of Standardization and Industry. A common network platform with dynamic and secure network "slices" allows spectrum frequencies to be used flexibly, avoids industry-specific spectrum allocation, and takes advantage of standardized network interfaces. However, 5G must balance complexity, cost, divergent nodes and relevance, he said in a keynote presentation. Defining a network too specifically could make it overly complex and too expensive to build.

5G will be disruptive in a positive way for many sectors, Färjh said during the Q&A. Many industries will take advantage of the network, which is how the 5G sector will expand its business, he said. Applications and services will be dealt with via solutions, using several air interfaces, he added.

The main 5G drivers are the mobile Internet and the IoT, said **Shaoli Kang**, System Engineer, China Academy of Telecommunication Technology. She described the 5G Vision of the IMT-2020 (5G) Promotion Group, the main body fostering 5G research in China: "Information a finger away, everything in touch." China's future IMT systems will require 1350-1810 MHz more spectrum by 2020, with spectrum demand beyond that still under study.

Technological and Network Evolution - Building a 5G Infrastructure

This panel, moderated by Arqiva Chief Technology Officer **Cameron Rejali**, examined how policymakers and industry can spur investment and innovation for 5G, and what spectrum, regulations and technology will be required for infrastructure.

The European Commission views 5G not only as "4G plus 1" but as a revolutionary way to use networks as building blocks for a networked society, **Thibaut Kleiner**, DG CONNECT Head of Unit, Network Technologies, said in a keynote presentation. The EU believes that 5G networks must have guaranteed minimum performance, he said.


Thibaut Kleiner

At EU level, the vision is that 5G will be an essential building block for the connected continent, not just a radio network, Kleiner said. The Commission believes that governments' role is to invest in research, such as via the 5GPPP, and deal with spectrum issues. They can


Peiying Zhu

also help build a global vision for the technology so it does not develop around different patterns.

Lee Hyeon Woo, Chairman of the Korean 5G Forum's Global Alliance Committee, noted that the number of mobile standards is getting smaller over time, as is the time gap between R&D and development of standards. That makes standards collaboration more important, he said.

From Huawei's perspective, 5G must expand services beyond mobile broadband to the vertical market such as the IoT and device-to-device communications, said Huawei Fellow **Peiying Zhu**.

The technology poses an unprecedented performance challenge because it must stretch in three dimensions—speed, links and latency. Re-architected 5G networks must include no-cell virtual radio access networks; be software-defined, simple and service-aware; and be able to monetize services, he said. There should be a standardized air interface framework for all applications.

Any 5G network must lower the net cost of service access for consumers, said Avanti Regulatory Affairs & Business Development Director **Kumar Singarajah**. 5G should make it possible to efficiently enable converged content and data delivery from multiple networks, including satellite, he said. He also said that current satellite systems are capable of supporting very high data rate services (> 100 Mbit/sec) to customers and that future satellite systems will support even higher data rates (> 1 Gbit/sec). The satellite sector will accordingly need full access to the existing ITU allocated spectrum to satellite services

The question is how mobile operators can retain their legacy networks and still have a more flexible, efficient, service-oriented system that maximises return on investment, said Telefonica UK Head of Network Strategy **Nektaria Efthymiou**. The industry needs a system that will converge all the activities they can perform on their 4G networks into consistent, seamless connectivity, she said.

It must have flexibility to develop new business models and support multiple technologies to optimise ROI. Changes in the physical infrastructure are also needed to enable networks to deploy 5G quickly and easily, she said. Social and economic structures are necessary to drive demand for 5G services.

Efthymiou, however, questioned whether 2020 is a realistic date for 5G rollout, saying the financial markets may penalise operators for deploying 5G before they have taken advantage of 4G. 5G must offer a uniform experience of Gbps speed and instantaneous response, but also low latency, said **Howard Benn**, Head of Standards and Industrial Affairs, Samsung Electronics Research Institute. It must also provide massive connectivity, and be green and

cost-effective, he said. Some technologies are "stepping toward addressing these problems" but revolutionary technologies may also be required.

One question is whether a specific band of spectrum will be needed for 5G. WRC-15 talks on WRC-19 have already begun, and Benn predicted that one area of discussion will be millimetre waves. There will also be developments in "less sexy" technologies needed for 5G, he said. The key is flexibility: 5G must work in different spectrum with different core networks.

LTE growth per user has not even reached 30% per year, one audience member noted during the Q&A. He questioned whether this is a transition or organic growth. People get used to using things, said Benn. The more they have access to data services, the more they will use them, he said. No one can predict what will happen in 15-20 years, said Efthymiou. Either design a system that works today and tomorrow or one that might need major changes, she said.

Asked whether there are collaborative research initiatives between the U.S. and the rest of the world, Kleiner said that in the U.S. the concept of 5G is "not at this stage accepted as such." The U.S. does not want to engage in discussions about 5G because it does not want to slow 4G deployment, an essential building block for 5G, he said. It's good that the rest of the world is developing a 5G vision now, he added.

One uncertainty is whether mobile operators are ready to invest in 5G. It may be too early to talk about that because operators are still trying to roll out 4G, said Kleiner. The EU vision is that 5G will not replace all current elements but will integrate with them. That will lead to intrinsic positives such as lower costs for integrating 5G networks, which will encourage investment by operators. In addition, the number of connected objects will provide another incentive for industry investment, he said.

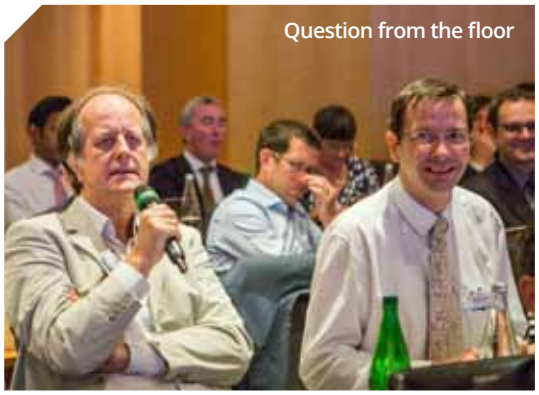
Lee recommended looking at the vertical market for 5G. Giving users higher speeds is important, but consumers probably are not willing to pay more, he said. The technology must allow more and more services and applications on the network so operators can recoup their investments and gain revenue. International standards will create economies of scale and reduce costs, said Efthymiou.


Philip Marnick

Standardisation and Regulatory Challenges - Working together to deliver a ubiquitous, high-performance 5G environment

This panel, chaired by **Martin Koyabe**, Head of Research & Consultancy Division, Commonwealth Telecommunications Organisation, looked at standardisation and regulatory challenges for the development of an infrastructure that will enable maximum global 5G deployment.

In his keynote address, Ofcom Group Director, Spectrum Policy Group **Philip Marnick** said that so far, mobile in every one of its generations has had a defined objective to fix.


Question from the floor

With analogue, it was how to have telephones without wires. There were national standards and defined frequencies to use, and most standards were defined in the local markets.

In the mid 80's, everything was going digital, Marnick said. Again, a number of different standards emerged. In some European countries, some people pushed for a phone that could be used at home and overseas, so GSM was born. Different standards evolved in the U.S. and elsewhere, leading to a battle over which of these standards was best, and to some being dropped. In the 1980's, there was a paper on "phones on the move," 1800 MHz spectrum was awarded and PCM became GSM. In the 90's, multi-media 3G emerged, but there was a fight between WCDMA and CDMA 2000. We then moved toward an Internet Protocol-based mobile standard, and one now called LTE has become a global standard. Now we're discussing yet another generation, and the question is what is the problem we're solving with 5G, he said. Many have confirmed that it's not just fast mobile, it's experience, applications and services.

We need another interface that delivers another set of standards, but we also need to build on what we have today, Marnick said. 2G to 3G was an evolution in concept, a revolution in networks. The question for 5G is whether we need a different group to develop standards. 5G is "about something new that is happening," not just mobile. Perhaps we need to pull together all the different parts of the wider technology sector of the industry, not just mobile, to make the standardisation happen, he said.

"Everything can be done via the Internet" and people will enjoy the benefits, said **Takehiro Nakamura**, NTT DOCOMO and Leader of the Association of Radio Industry and Businesses 2020 and Beyond Ad Hoc created to study 5G technology and use cases in Japan. Mobile data traffic has grown by 1.7 times in the past three years in Japan, and is expected to grow by 1000 times between 2020 and 2025. There must be a system for high capacity, he said. His group believes that 5G networks should consist of new radio access network technologies and Enhanced IMT-Advanced to satisfy those requirements not met solely by Enhanced IMT-Advanced.

ETSI Chief Technology Officer **Adrian Scrase** said his organisation is working over the next 12-18 months on building blocks on which the 5G system will be based. The timing discussion is where "I get an uneasy feeling," he said. 2020 seems to be an immoveable date, but is it realistic or is it being imposed on us? he asked. In the final months leading up to that date, standards bodies will go into a "panic" if we don't manage things correctly and will then have to correct all the errors made.

ETSI's role in 5G can be to take a good idea and build a community of interest, Scrase said. It can help develop good ideas, which can then be standardised. He suggested that a more streamlined standard-setting process might be useful. Additionally, standards bodies need to attract new sectors such as energy companies and vehicle manufacturers, he said. To do that they must be much more welcoming than they are now.

Asok Chatterjee, Executive Director, Standards, Telecommunications Standards Development Society, India (TSDSI), said India isn't held back by what might have happened in the past, giving it an advantage in 5G development. India launched the TSDSI in 2013.

Being a latecomer, "we have absolutely no intention of rocking the boat unnecessarily" and are making agreements with global standards bodies around the world, Chatterjee said. It is involving everyone in the areas on which it is working and plans to convene a group to get ideas from all segments of the ecosystem on the view from the Indian perspective. "Get used to the acronym TSDSI. Come work with us," he said.

Without a legacy to defend, TSDSI will be "totally open-minded." **Kent Rochford**, Co-director, National Institute of Standards and Technology/National Telecommunication and Information Administration Center for Advanced Communications, said spectrum is a key regulatory issue. The U.S. is currently freeing up spectrum for incumbent technologies, but higher frequencies haven't hit the main stage yet, he said. He predicted that the biggest discussion will be at WRC-18/19 on millimetre waves.

This year the FCC proposed a 3.5 GHz "innovation band" with three tiers—incumbent access, priority access and general authorised access, Rochford said. The proposal requires deployment of spectrum access systems to encourage new entrants as well as some spectrum-sharing, which is controversial. Spectrum-sharing standards will require a high degree of coordination, and must be robust and secure. This system might have some interesting proprietary elements.

Now is the time for operators to think about how they are going to make measurements for MIMO, Rochford said. Standards developers shouldn't pick just one or two technical goals and design the specification but must find the use cases first to inform the specifications more broadly from there.

However, atypical use cases sometimes push performance standards. Harmonisation will influence success for standards and regulation, not ad hoc solutions, he said.

Colin Langtry, Chief of the ITU Radiocommunications Study Groups Department, said the same process used to develop IMT-Advanced is likely to be used for development of 5G. That process is to establish requirements and then evaluate proposed systems against them. Successive World Radio Conferences have identified frequency bands for IMT, and WRC-15 will look at additional bands between 470 MHz and 6 GHz. Higher frequency bands may need to be considered in the future.

There is good consensus on where we are heading on 5G, Langtry said. The investigation of key elements of 5G is already well under way. No single new radio interface will do it all; multiple radio interfaces will be needed for quite some time.

In today's market there are few operators who have moved from 2G, let alone 3G, one audience member pointed out during the Q&A. He asked whether legacy issues must be removed from standards bodies or whether the shift to new mobile generations is market-driven. It's entirely market-driven, said Scrase. To some extent, developing nations can leap-frog to new technologies without having to deal with the legacy ones, he said.

Another issue related to the role of intellectual property rights in the standardisation process. The ITU has had many discussions about IPR, Langtry said, but progress has been relatively slow. There is a concurrent "thorny" debate in the EU and elsewhere, he noted. ETSI's experience with IPR politics is that it took the organisation five years to get the first version of a standard but it has now spent two years trying to make a small change to it, to no avail, said Scrase. He predicted that 5G will not make any fundamental changes to the IPR regime because the industry does not have the appetite for such changes.

Developing 5G Markets and Business Models

This panel, moderated by Analysys Mason Principal **Janette Stewart**, looked at what markets 5G will try to address in terms of coverage, capacity and speed, and what the routes to market might be.

GSMA Senior Director of Technology **Dan Warren** said we are going to end up needing a very large area of coverage if we're to do the IoT well. That implies spectrum bands low down in the frequency range, he said. On the other end, many step-changes in bandwidth are about "build it and they will come": Build something and an application will come along that adds value and generates revenue.

Some of what the 5G business model will look like is hard to perceive, Warren said. The common tenet is that new Gs come along about every 10 years or so. In 3G, everyone was promised mobile broadband, but what they got was fill-in voice coverage and a little bit of data. With 3.5G, data traffic exploded. With LTE, everything runs over IP, so the question before we get to 5G is "what is actually broken." 4G LTE is great, LTE Advanced will be even better. The only thing that's broken at the moment is coverage, which is an investment issue because of the need for base stations and backhaul.


Ramjee Prasad

The reason we don't have full coverage now is that the business model isn't there, Warren said. M2M is fundamentally important because the issue is coverage. The business model for a 5G network must be driven either by services we understand, such as health monitoring and connected cars, or, as we move to 2020, must justify itself before industry rushes into new investments and a new round of technology. We are talking about massive consolidation of existing technology, he said. Industry sustainability doesn't necessarily involve new investment in 5G.

Ramjee Prasad, Founding Chairman, Global ICT Standardisation Forum for India, said GISFI is playing a major role in taking India forward to 5G technology. It will help create markets, business models and technology. It has

developed "WISDOM," the wireless innovative system for dynamic operating megacommunications. It is also developing the concept of converging communication, navigation, sensing and services. It is working on the idea of human bond communication, which seeks to bind people together. Everyone has five senses - voice, vision, touch, smell and taste - but only sight and hearing are successful from a wireless perspective, Prasad said. After 2020 we will have communication of all five.

Finally, he added that GISFI is the first ICT standardisation organisation of India (commenced operations in 2009), and it has been playing a pivotal role in bringing India on to the standardisation world map.


Alistair Urie

To a fair degree, innovative services are about giving away things, in parallel to getting more revenue, said **Alistair Urie**, Alcatel-Lucent Architecture Strategy Director, Wireless CTO Office.

Providing Mobile Broadband access is "the bit operators give away after collecting the monthly access charge." The question is how to use 5G to help operators find new sources of revenue and what new tools will be put in place with 5G to help them.

The simple QCI table model of LTE is already broken with new values being defined for Push To Talk (PTT) services and 5G requirements for low latency and sufficient bitrate imply that further changes will be needed. Getting a flexible bearer approach, the ability for third parties to bring in policy about what's needed for their services, is important. We now have LTE and sell voice and services, but we need a better way of letting operators sell the great systems and capacities they have, of helping to make a better platform to market service capacity, he said.

The problem is to manage the massive user densities of stadiums and similar venues, and deal with user-generated content, a major source of uplink traffic, and a significant cost issue for operators.

Mission-critical services are also "a nice money-spinner" for operators if done right. Battery life will enable operators to sell new services to new types of devices. The key to battery life is signalling reduction, Urie said; the real issue to be addressed is how to reduce the cost of signalling.

Then there is the problem of supporting non-traditional devices. These six concerns will drive the definition of 5G networks and offer the opportunities, Urie said. 5G is the things operators will have to do on the radio and network to resolve those issues to drive revenues.

What comes before 5G – 4.5G, with carrier aggregation, working LTE-plus-Wi-Fi, and so on - is the starting point for 5G, Urie said. There are also some platform issues, but they won't be 5Grelated because they will be taken care of before 2020. 5G will be built over the end of the 4G evolution. One of the important things will be elimination of signalling for short packets, he said.

LTE is brilliant for scheduled traffic but not for unscheduled traffic, so 5G carriers will have to handle both

contention and scheduled traffic and signalling. 5G carriers will be deployed on both macrocell and small cell layers, he said. Because it will be done on top of 4.5G, with carrier aggregation and dual connectivity mechanisms already in place, from a business model standpoint it's no longer a standalone business case question but rather the marginal business case of adding 5G capabilities on top of an existing 4G investment, he said. He urged operators to start preparing for 5G by focusing ongoing investment on 4G LTE and to "stop investing in 3G!"

David Wood, Chair, London Futurists, discussed potential issues surrounding 5G and asked whether industry is ready for these disruptive changes. Newspapers and film rental companies, for example, failed to see new-trend "steamrollers" coming, he said. There are also trends that could disturb the evolution of 3G, 4G and 5G. Industry must be able to see the steamrollers coming, and have the agility and strength to turn them around for their advantage.

Wood laid out eight possible incoming steamrollers. One the potential backlash against technology due to the fear of lost privacy and security, as more and more people wear cameras on their bodies at all times which can identify individuals. Potentially even more disruptive is unemployment caused by new technologies that sparks societal anger and disenchantment with aspects of technology. There could also be technological disenchantment as people start to feel that they lack a fair share in society. Another possible problem is the IoT, which will see ubiquitous drones, with implications for wireless protocols.

Another prediction is the rise of collaborative communications with zero revenue, Wood said. More and more aspects of the economy will work collaboratively, along the lines of open source or Wikipedia, leaving no business model or revenue source. The implications here are "mindboggling," he said. Other trends are localism, with a backlash against travel due to concerns about climate change; hyper device-dependency, where people will feel "mad and mental" if their devices are cut off; and financial singularity, as digital money such as Bitcoins is increasingly used. Each of these scenarios has a 20-80 percent chance of happening within the next 10 years, Wood said.

If customer purchasing power is reduced, who will sustain operator's business models? Wood was asked. The fact that increasing numbers of people won't be able to find work will face every government in the world, said Wood. There will probably have to be income subsidies to avoid having people without money to buy goods, he said.

Asked how operators could charge for M2M services, Warren said they should do what suits their customers best. Another aspect of the M2M business model is that now, someone buys a chipset, installs it into the model, and sells to an integrator who then sells to operators, said Urie. But it is cheaper for integrators to use older technology, he said. If M2M creates great new features and there are 5G solutions, integrators must have reasons to use the latest technology or the business model will be in deep trouble, he said.

Bringing it all together

Summaries and conclusions


Nigel Jefferies

The 5G concept is "a lot clearer" now than a year ago, moderator **Nigel Jefferies** said in summing up. He noted several areas where there has been progress. These are: (1) The importance of having global standards, and whether their scope should be wider than the existing standards bodies can provide. (2) The voice of the regions, each with its own distinct vision of what 5G should be, but each believing that there should be bridges built to global standards. (3) The IoT is clearly growing in importance and should be strongly supported by 5G. (4) The importance of continuing the current rollout of 4G. (5) The need for more spectrum, spectrum assigned for 5G and spectrum-sharing. (6) The timing of 5G deployment must be realistic.

In the past nine months, the technical requirements for 5G are converging globally, said Tafazolli. What hasn't converged is agreement on the business case for 5G, he said. Most probably agree that 5G is more than just a mobile cellular generation system very different from earlier generations. Most speakers agreed that speed is not a differentiation between 5G and earlier Gs, but is for giving always-sufficient QoE to end-users, he said.

There is agreement that distinguishing features of 5G are flexibility, adaptability and simplicity of use by end-users and operators. In addition, many believe 5G should be able to aggregate different parts of the highly fragmented radio spectrum. It was also "rightly" mentioned that signalling architecture is the biggest problem because it was inherited from what was developed 30 years ago. A completely new architecture is likely needed, Tafazolli said.

Other areas of agreement are that the privacy and security of data have become very important, and that dynamic spectrum access could be an inherent aspect of 5G, said Tafazolli. Another key point was the huge reduction in the innovation cycle for new services, meaning that operators must learn lessons from the information technology industry. For all these reasons, we need "reasonable and sensible requirements" for 5G, he added.


Rahim Tafazolli

Satellite operators and broadcasters have a role to play in 5G, said Tafazolli. Digital terrestrial TV has content that is part of the content mobile networks provide, he said. Additionally, broadcasters have developed systems such as the BBC's iPlayer, which offer great opportunities for 5G. Satellite operators have built good backbone architecture, which could help reduce latency in some areas, he said.

Frank Fitzek, Principal Investigator, Communication and Storage, Dresden 5G Lab, urged the audience to view 5G holistically, as a full communication network and a cellular part. The most demanding aspect of 5G is the tactile network, he said. 5G needs massive throughput, reduction in latency, sensing, resilience, safety/security, fractal heterogeneity (heterogeneity of nodes) and energy saving.

To achieve that, 5G Lab is investigating four tracks: wireless network; silicon systems; mobile edge cloud (the personal cloud that follows users through the network wherever they are); and tactile Internet applications – that is, use cases people will want to pay for.

The next revolution, said Fitzek, is to have more flexible data packets than we have now. The next step is a code-centric network in which data is coded while it is transported and stored. Every node must be able to code because that makes data transfer very agile. Another necessary development is application program interfaces in the networks to enable businesses, he added. Network coding is the key technology for 5G, said Fitzek. It will enable the fusion of transport and storage in 5G.

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