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## WHY THE EU IS BETTING BIG ON

# 5G



Digital Agenda  
Europe



# research<sup>eu</sup>

## FOCUS MAGAZINE

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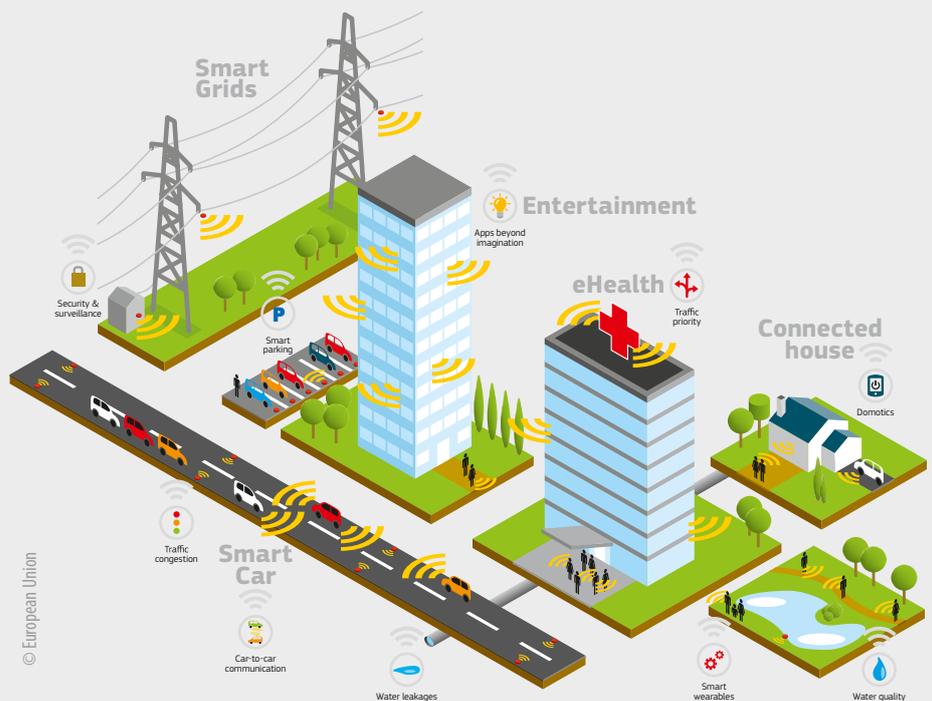
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# 5G



# WHY THE EU IS BETTING BIG ON 5G

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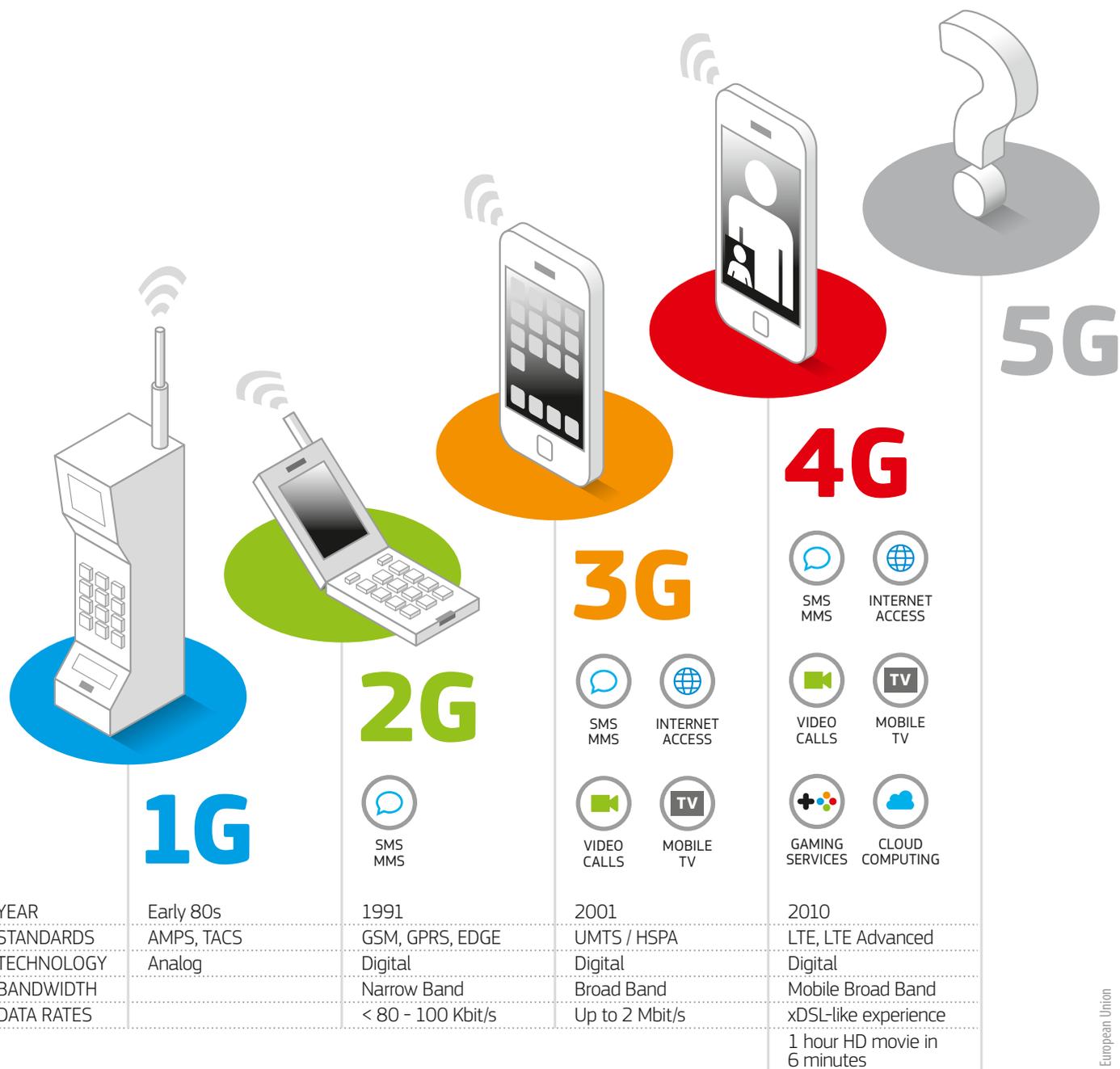
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WHY THE EU IS BETTING BIG ON 5G





GÜNTHER OETTINGER

## Objective 5G: the EU is reinventing 'connectivity' for the next decade!

*The next generation of wireless networks, the 'fifth generation' or 5G, will change the way we communicate, the way we do business, the way we do everything!*

*By the next decade, the digital economy should be a reality in all sectors of activity. As 'Connectivity' becomes more and more ubiquitous, more reliable and offers high speed and higher capacity, it will become the new 'lifeblood' of the digital economy and society.*

*The impact of 5G will extend well beyond telecommunications. It will induce a paradigm shift in a number of existing industries and trigger the emergence of new industries and ecosystems. Communications networks in the 5G era will also have more important societal roles than today: by connecting people, machines and things on a massive scale, it will facilitate the delivery of personalised healthcare and support an ageing society, it will help optimise transports and logistics, it will enhance access to culture and education for all, and it may virtually revolutionise public services.*

*We in Europe are already embarked on this trailblazing journey. In cooperation with industry, we launched the 5G Public-Private Partnership (5G PPP). The Commission has committed EUR 700 million of funding under the EU's Horizon 2020 research & innovation programme to accelerate the development of 5G. We are also establishing strategic cooperation agreements with key partners worldwide to achieve a common vision by end 2015 on what should be the main 5G functionalities and the global timetable to move from research to deployment.*

*To achieve all of this, the EU needs strategic investments in infrastructures and the development of innovative services. This is why EU support to research efforts will be complemented by support to private investments through the EUR 315 billion plan of President Juncker.*

*Building on Europe's strong track record in telecommunications technologies which dates back to the invention of the GSM standard, and with the massive efforts we have committed so far, we are confident that Europe has a unique opportunity to become a major player in the 5G era. This is essential because we believe that the communications infrastructure should become the most important of all infrastructures over the next decade, not only for the economy but for society as a whole.*

Günther Oettinger, Commissioner  
Digital Economy & Society



DEFINING THE NEXT GENERATION  
OF TELECOMMUNICATIONS

# WHY 5G IS SO IMPORTANT

With mobile traffic expected to grow by a factor of 1 000 by 2020, and the number of connected users to multiply 10 to 100-fold, the world clearly needs new communications infrastructure the like of which we have never seen before.

**B**ut 5G is more than just fast Internet for everyone — it will be the very backbone of the new digital economy. It will mean more and better jobs and will contribute to sustainable economic growth for decades to come. The transformative power of 5G in modernising cities, and industries such as transport, health and the utilities, make it crucial to our future development as a society.

5G is unique from its generational predecessors in that it will be truly user-centric. This will lead to the introduction of disruptive technologies redefining networks as we know them. New swathes of bandwidth have to be found to meet the massive demand that will be created by the new system. It will need a new approach to power-saving if we are to respect our commitment to the sustainability of the planet.

All this is why the EU has already committed to investing EUR 700 million in a 5G Public-Private Partnership for research, development and innovation in this field. It has already launched over 10 projects developing the technologies to place European industry ahead for the deployment of the future generation of optical and wireless communications by Horizon 2020. And we will be doing much more towards 5G in the years to come, as these pages illustrate.



*5G is more than just fast Internet for everyone — it will be the very backbone of the new digital economy.*



# WHAT IS 5G?

With each new generation of communications networks systems, from 1G to the more recently deployed 3G and 4G, connectivity becomes more prominent in our lives. These network technologies will further be extended by 5G, as the rapidly growing demand for digital products and services is vastly multiplying the amounts of data flowing through networks worldwide. This expansion is predicted to continue exponentially in the near future.

Mobile traffic is expected to grow by up to 1 000 times over the next decade, and this will have a tremendous impact on the underlying network infrastructure. There will be over 6 billion smartphone subscriptions by 2020, and over 90% of the population over six years old will have a mobile phone, according to Ericsson's latest Mobility Report.

'5G is expected to be commercially deployed in 2020 and the technology is predicted to have a faster uptake than 4G, just as 4G had a faster uptake than 3G,' the Ericsson report says. 'The difference here is that 5G will have to cater for thousands of new ways that mobile technology will be used.'

The immediate challenge of 5G networks will be to scale up to these traffic requirements and serve new kinds of elaborate machine-to-machine systems and applications, many of which are still to be developed. For that, communication networks require the new technological solutions which companies are now racing to provide.

Industry and academia experts from NetWorld2020, the European Technology Platform that laid the foundation of the 5G Public-Private Partnership, explain in a recent white paper that 5G will be 'providing a universal communication environment that enables to address wider societal challenges, such as transport, automotive, safety, employment, health, environment, energy, manufacturing and food production.' As such, 5G will be more than a new generation of network: it will deliver a business-critical infrastructure, fully integrated with the business value chain of 'vertical' usage segments and able to adapt to their specific requirements in real time.

So, think of cars, robots and drones, smart cities, whole ecosystems sprouting from the Internet of Things, with billions of machines talking to each other and their sensors relying on a steady stream of data delivered wirelessly. 5G means the seamless extension of services and coverage available anywhere, anytime, and this is where satellite technology comes in, too. All this will need global network interoperability for a mass market.



*Think of cars, robots and drones, smart cities, whole ecosystems sprouting from the Internet of Things, with billions of machines talking to each other and their sensors relying on a steady stream of data delivered wirelessly.*

The networks of today will have to go through significant evolution, if not revolution, since current infrastructure is too complex to continue to grow organically. There will have to be some degree of disruption to solve the issues of capacity needs, energy consumption, reliability and security that now face us.

Soon, just about everything will be wireless, be it over the last 100 metres or last 100 centimetres. And 5G will not only embrace individuals and communities of people, but also SMEs, public administrations, utilities and transport providers, and actors as distinct as the police and the creative industries. All their views will have to be taken into account as we travel together along the 5G journey. As new Digital Economy and Society Commissioner, Günther Oettinger, told the European Parliament: '5G is the future. We believe that it is the technology for the coming decades and we have to create the environment that is conducive to investment to attract private investors and investment.'



# 5G CAN ONLY WORK THROUGH STANDARDS

For 5G to become the Any Time, Any Where, Any Device technology network which users, businesses and engineers are dreaming about, it's got to be based on a global standard.

All the research projects being undertaken passionately across the globe in an attempt to power the 5G revolution lead in one direction: a single set of internationally agreed norms.

Whereas the standards for previous generations of mobile technology — 4G, 3G, 2G, going back to 1G in 1981 — have been based on competing, different technologies, the prospect of a single 5G standard today is very real. The challenge is to get closer to global interoperability and harmonised spectrum usage while including radical innovations compared to 4G, ensuring its upwards compatibility and building upon it, as prescribed by the current International Mobile Telecommunications-Advanced standard for DSL-like experience on the move.

The standardisation work will get going in 2015 as the global body concerned, the International Telecommunication Union, is expected to publish its 5G vision and set the 5G agenda for future ITU World Radio Conferences, drawing on sources from all over the world.

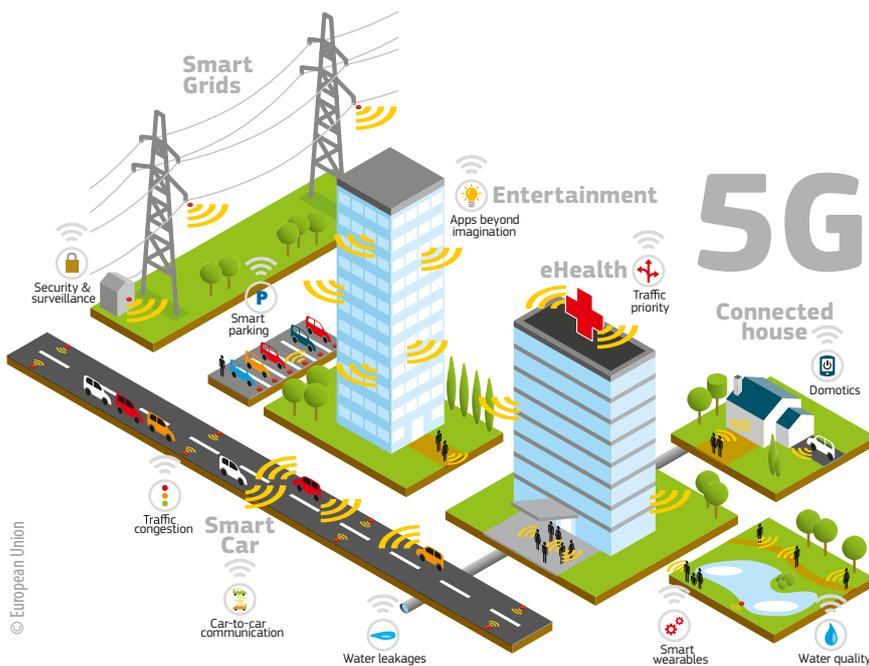
In 2016, the 3GPP, the global partnership between Standards Development Organisations

(SDOs) and other related bodies for the production of a complete set of globally applicable Technical Specifications in telecommunications should in principle start collecting information as to what requirements the standard should contain. Work on the product specifications should begin in 2018, complemented by discussions of the ITU World Radio Conference on additional spectrum allocations, so that the standard will be available in 2020 and early market deployment may start. This time frame is generally well accepted in Europe, though other regions may have slightly different views. The overall time frame will be defined in 2015 by the key SDOs. 'The standard needs to ensure a fair return on investment for all players — traditional and new — while stimulating innovation,' pointed out Mario Campolargo, Net Futures Director in the Commission's DG CONNECT.

Too much is riding on the process for it to fail. Involving all stakeholders in the standardisation work which is about to get underway is essential to producing 5G networks and devices that can be used by anyone, anywhere, for anything.

# 5G APPLICATIONS: SHAPING THE INTERNET OF THINGS

Whilst 5G promises major technical advances and better geographical coverage, its success will largely depend on its added value for consumers. Researchers are well aware of this, and will focus their efforts on various fields of applications including eHealth, smart grids, smart cars, connected homes, entertainment, and asset tracking, to name a few.



will improve and simplify EU citizens' lives.' Concretely, the 5G era will be that of the all-connected, where anything that can benefit from a connection will have one. Online services on-the-go, which were so far limited to our smartphones and are progressively introduced in wearable devices such as watches and glasses, will soon expand to dozens of devices per person.

## Smart everything

Over the past few years, we have seen smart cities, cars and homes progressively evolving from vague concepts to concrete solutions. What 5G offers is to set the stage for these new technologies, with enough capacity to welcome billions of connected devices and enough flexibility to adapt to each of these devices' needs, thereby optimising battery life. For this reason, 5G could be defined as a necessary evolution setting the stage for a mobile revolution.

A typical example is transport: Whilst some high-end cars can already connect to the Internet to provide the driver with real-time traffic information, 5G would add an additional layer of connectivity to the mix: your car will 'talk' to the other cars and to the infrastructure, so that you can obtain detailed information about traffic jams along the way and even get

If anything, 2014 was the year that saw our shiny new smartphones progressively being bundled with 4G technology, while cities across Europe were slowly building out their 4G networks. The full potential of 4G is still to be unleashed, which makes it difficult to picture what the next generation of connected devices and services will bring.

Whilst the question is still to be answered by the experts themselves, the European Commission provides us with some clues as to what EU citizens

can expect in 2020 and beyond. 5G applications should indeed revolve around the likes of connected homes (domotics), smart cars, telesurgery, entertainment, time-critical applications where instantaneous reaction is required.

These potential applications all go hand-in-hand with another concept: the Internet of Things, defined by the Commission as the 'inter-connection of everyday objects among themselves', in 'an ecosystem of smart applications and services which



first-hand images of road-blocking issues. This will help you make the best decision on whether or not to change your itinerary.

This support couldn't prevent you from wasting time and friends are coming to dinner? No problem. Your car and other smart devices will also talk to your house, and you can just tell your oven to preheat remotely. The possibilities are endless, and include luggage tracking to avoid bad surprises at landing, a fridge that automatically tells your smartphone when you ran out of milk, or even package delivery directly to your car wherever it is parked.

### Taking eHealth to the next level

Another key sector 5G engineers are expecting to boost is eHealth, which is

only starting to take off with around 60% of general practitioners using it in Europe. Telesurgery is one of the most exciting applications being evoked, thanks to a very low command-response time (1 ms is the target).

This new scope of possibilities is generally referred to as mHealth. mHealth is just one of the benefits of a digital society — helping patients, doctors and carers take control, wherever they are, from simple apps which help you stick to your exercise regime to monitoring tools for those on kidney dialysis.

### Leaving no one behind

One might think that these evolutions will only concern a small percentage of the population, but that would be ignoring the fundamental promise

of 5G. Not only will the new infrastructures allow for high-quality connections even in rural or remote areas, but crowded spaces will finally cease to be an arena where more people inexorably translates into lesser data transfer rates.

Watching a football game with 50 000 people around you? With 5G, you and all other spectators will be able to play and replay interesting phases of the game from different viewing angles and with high definition on your mobile phone or tablet, simultaneously without any sort of lag.

Experts promise that 5G networks will have space for over 7 trillion devices, which is 140 times more than the number of Internet-connected devices expected by 2020. A way to ensure the best services for all, without compromising on speed.

## AN INDUSTRY LOOK AT 5G BENEFITS



*'Our brand new motto is "Always in touch to connect to what is essential in your life". We think this perfectly reflects the ambitions of 5G and what it will bring to people living in the EU.'*

**Marie-Noëlle Jégo-Laveissière**, Executive Vice President of Innovation, Marketing and Technologies, Orange



*'We would like to have the flexibility to use this new platform without experiencing limitations. There will be no single or small set of killer applications, but rather a very flexible platform capable to adapt the needs of many different applications and users.'*

**Hossein Moiin**, CTO, Nokia



*'Many 5G application areas seem to be promising fields for the improvement of the Citizen's life, therefore generating Innovations with a real impact on the quality of life of the individuals and societies. These include smart cities applications, smart health, smart cars, fitness and sports with the combination of multiple sensors, or extra high definition mobile applications.'*

**Alcino Lavrador**, CEO, PT Inovação



*'With the introduction of 5G, EU citizens will be able to access amazingly fast, super real-time and reliable connections wherever they are. And they will be safer in doing so, thanks to enhanced security.'*

**Mustafa Ergen**, Chief Advisor, Türk Telecom

## DEFINING THE NEXT GENERATION OF TELECOMMUNICATIONS



*'We move from a world where non-availability and failures could be acceptable and where one could still live and work with poor internet access, to a world asking for a perception of infinite capacity anywhere. This is what I call 5G.'*

**Eric Béranger**, Head of Space Systems Programs, Airbus Defense and Space



*'NEC believes that 5G networks will drive a new era of innovation that will bring wide-ranging benefits to society in both mature markets and developing world. For example, by bringing ubiquitous access to areas of low population density, while minimising energy consumption, we'll be able to bring new mobile education services to areas with low levels of literacy to increase education levels.'*

**Naoki Iizuka**, CEO, NEC Europe



*'5G will drive the trend toward smart energy, factories and cities. We are working with our European partners on 5G applications making life in the city of tomorrow easier, greener and cheaper. Together with partners, we are researching ways of using 5G technology to provide self-driving cars with the connectivity required to navigate with full autonomy and ensure safety.'*

**Dr. Zhou Hong**, President, Huawei European Research Institute



## THE RACE IS ON...

Billions of euros are being invested in public and privately funded research in a race to prove the best 5G technologies before 2020.

A healthy mixture of competition and cooperation is fuelling the race between world regions to produce the next generation of wireless technologies. Large public-private partnerships and government-backed research projects are pushing technology far beyond its present limits in order to power the communications revolution and all-embracing Internet of Things.

The EU has set aside up to EUR 700 million in public funding to develop the next generation of ubiquitous 5G communication systems during its seven-year Horizon 2020 programme. For its part, the EU private sector has agreed an ambitious set of key performance indicators (KPIs) to leverage this public stake — seeking a five-fold return on investment — and will support the Commission in analysing the

effectiveness of the resulting research effort.

Other world regions are also investing billions of euros in major government-backed programmes and other academically-driven and private sector initiatives.

The International Mobile Telecommunications 2020 (IMT-2020) Promotion Group, in China, was formed with the Ministry of Science and Technology (MoST) and the National Development and Reform Commission (NDRC) to support 5G R&D, complemented by other dedicated traditional 'Mega' projects under the 863 Program.

The South Korean government, which signed a 5G research and standardisation cooperation agreement with

the EU in June 2014, is investing over EUR 1 billion in research to bring 5G to its population as quickly as possible through its '5G Forum'. Korea aims to trial its first 5G network at the Winter Olympics in Pyeongchang in 2018.

Japan, meanwhile, aims to test a first 5G network for the masses at the Tokyo Olympics in 2020. The private industry-led '2020 and Beyond' Ad Hoc Group is organising 5G development in Japan, under the umbrella of ARIB (the Association of Radio Industries and Businesses), and coordinating the country's contributions to ITU standards-setting.

In the US, the terminology '5G' has not been used so prominently, but there is also relevant academic research, for instance on mmwave applicability at University of New York and Berkeley.

AN R&amp;D PATH TO EU LEADERSHIP

# 5G — A STRATEGIC INVESTMENT FOR EUROPE

Investment is vital to ensuring that Europe plays a leading role in the development of 5G technology. It has been estimated that private companies will spend over EUR 234 billion in network infrastructure and technology over the coming decade, with competition to take 5G worldwide likely to be fierce. As this infrastructure is crucial for the entire economy; Europe must invest now if it is to secure its global competitiveness.

## An employment generator

Investment will help Europe's telecoms sector — crucial to economic growth and job creation — tap into the growth opportunities stemming from the convergence between IT and telecommunications.

The advent of 5G presents a unique opportunity, with timely and targeted investment ensuring that new high-tech jobs are created in Europe. Other regions such as China, Japan, Korea and the US have also recognised the strategic nature of this domain, and initiated significant research activities to define the networks of tomorrow and thus boost growth. This is a global competition in which Europe cannot be left behind.

## Creating new business opportunities

New 5G systems will open up new business opportunities in a wide range of domains, which should be exploited across Europe's regions. Broadband access to an interoperable and globally standardised communication network will help to overcome the digital divide in Europe between densely populated areas and rural areas, and help achieve economic development across all regions of the EU.

Investment will also help to support the development and commercialisation of new applications that 5G networks will make possible, from the anticipated growth in machines and sensors using the internet to communicate — a concept known as the Internet of Things (IoT) — to Ultra High Definition TV (UHDTV). Many industrial sectors are also interested in the possibility of using advanced 5G communication infrastructure to make processes and activities more efficient, competitive and secure.

SMEs are expected to provide a significant contribution to the development of these innovative 5G-based solutions. With the deployment of 5G infrastructure, most of the innovative applications are likely to come from the private sector's needs and developments. Therefore investments are needed to ensure that businesses are in a position to bring their new ideas to market. EU funding can play a crucial facilitating role here. Investing in 5G now will have a long-term impact on knowledge creation, help to develop a skilled workforce, make highly secure networks widely available and boost new web-based industries.

## THE INTERNET POTENTIAL IN FIGURES



# 5

The internet creates 5 jobs for every 2 lost.



# 33%

By 2016, mobile data will represent 33% of the total telecom services market, up from 22% in 2012.

# EU RESEARCH: FROM FP7 TO HORIZON 2020

EU-funded research plays a crucial role in managing the evolution of communication networks, defining new global standards and developing the technology and infrastructure to serve new and challenging demands. For 5G, investment under FP7 will be continued with a new 5G Infrastructure Public-Private Partnership (5G PPP) under the European Horizon 2020 framework.

European investment in 5G research will be amounting to EUR 700 million over seven years, while private contributions under the 5G PPP are expected to reach at least EUR 3.5 billion by 2020. A total of EUR 125 million has been made available in the first call for proposals, 'Advanced 5G Network Infrastructure for the Future Internet', which closed on 25 November 2014.

Funding for ICT-related topics can be found in all the core pillars as defined in Horizon 2020, from 'Excellence Science' and 'Industrial Leadership' to 'Societal Challenges', and investment in ICT is set to increase by about 25% compared to the Seventh Framework

Programme (FP7). This reflects the EU's recognition of the importance of the ICT sector, which currently represents 4.8% of the European economy and generates 25% of all business R&D expenditure. The use of ICT in society in general is pervasive: it is not only the ICT sector itself that will benefit from the increased funding, as essential EU policy objectives on health, ageing, climate, environment, energy, transport, public sector modernisation or security cannot be achieved without ICT innovation.

The 5G Infrastructure PPP has its roots in Horizon 2020's Industrial Leadership pillar, and will support EU competitiveness and economic growth by helping develop the fundamental framework of 5G technology. It will deliver the solutions, architectures, technologies and standards needed for the communication infrastructure of the coming decades.

## Staying ahead of the curve

Horizon 2020's 5G PPP aims to ensure that European industry drives the development of 5G standards and is able to develop and exploit at least 20% of global 5G standard-essential patents (SEP).

Horizon 2020's focus on the future of the internet builds on the past success of FP7-funded collaborative research

*Since FP7 started in 2007, a total of 207 research projects in network technologies have received about EUR 780 million in EU funding, the highest share of the ICT FP7 Thematic Priority.*



## 1.2%

Increased broadband penetration can create additional GDP growth of just over 1.2% in high-income economies.



## 968 000

In Germany between 2010 and 2020, broadband investments are expected to add EUR 170.9 billion to GDP, along with 968 000 jobs.

projects. Since FP7 started in 2007, a total of 207 projects have received about EUR 780 million in EU funding for research in network technologies, the highest share of the ICT FP7 Thematic Priority. The EU has also already invested some EUR 50 million in FP7 in projects specifically focusing on 5G and addressing emerging technologies.

These projects will bring very important initial contributions to the 5G PPP. They will be the cornerstone of the 5G architecture and will play a critical role in paving the way towards standardisation and the needed regulatory harmonisations — for example in terms of spectrum. 5G projects under FP7 and Horizon 2020 will enable Europe to take a lead in communication networks beyond 2020.

## INTERVIEW

# THREE QUESTIONS FOR MARIO CAMPOLARGO

## NET FUTURES DIRECTOR



MÁRIO CAMPOLARGO

### What is the main strength of Europeans in developing 5G?



Europe is at the cutting edge, as far as network technologies are concerned. The global leaders are largely headquartered in Europe and we are committed to 5G because it is a strategic area not only for our telecom industry but also for our Digital Single Market. We have the industrial base, the know-how and excellent research teams bringing together academia and industry, who have been pioneering 5G research already under FP7. We also launched the 5G Public Private Partnership (5G PPP) together with our industry partners and we have great expectations for the future. The first set of projects in the new Horizon 2020 programme will be announced early this year. Before that, EU players will already showcase first-class demos developed with the support of EU programme and will present our 5G vision in March at the World Mobile Congress 2015 in Barcelona.

### Things are moving fast with 5G development, and some global players from Asia aim to make the technology available as soon as 2018. Do you think Europe has a shot at taking the lead?



I would doubt that any region alone will be able to roll out 5G networks before 2020. If someone claims so, then it may not be 5G they are talking about! We know that South Korea plans to demonstrate advanced services (e.g. hologram TV and other challenging services) at the 2018 Olympic games. But this is not the same as deployment. And by the way, I have no doubts that European industry, including operators, will be involved and will follow closely the first large-scale 5G trials that are foreseen in South Korea and Japan between 2018 and 2020. The Next Generation Mobile Networks (NGMN) global association of operators is already very active in contributing to the 5G Vision.

### How are partnerships with the likes of South Korea and Japan helping the EU? What other help would Europe need?



We need strong global commitments to avoid competing standards, so that we have one global 5G. These partnerships are also essential to agree on a set of policies, like spectrum allocation. We are preparing joint actions with South Korea and Japan and we will explore future cooperation with China and the US. The next step for 2015 is to agree on a common global definition of the 5G technical parameters. Besides the international partners, we will also need strong alignment and support between the EU countries to successfully prepare the grounds for 5G deployment in Europe, as of 2020. 4G was invented in Europe, but today it is mostly deployed in Asia and America. I believe we can reverse that trend.

# COLLABORATIVE LEADERSHIP

With its 40% global market share in network technologies and EUR 700 million of funding under Horizon 2020, Europe stands a good chance of taking the lead in the 5G race. But this cannot be done without securing key alliances with other regions.

5G will emerge in a global market and a more complex ecosystem than previous generations of network technologies. Enabling super-fast transmission of voice, video and a complex range of communication data and services for more than 7 billion people and over 50 billion of connected devices is not an easy challenge. Integrating these technologies in a global network will require major efforts both in terms of research and standardisation.

**Strategic alliances with international partners will be necessary to steer technological development in the desired direction**

Whilst the industry intends to go for one global standard, governments need to provide support beyond financial aspects, also by making sure the right policy and regulation is in place before deployment. Besides a global commitment to avoid competing standards, global agreements on a set of crucial policies such as spectrum allocation are also needed.

Europe is in a strong position, having the competitive industrial base, the know-how and excellent research teams bringing together academia

and industry that are already pioneering 5G research. Regulators from EU countries have also started discussions on future spectrum requirements. Yet if we are to define common global standards in line with EU societal and business needs, this comes with another great challenge: organising strategic alliances between European players and international partners to steer joint technological development and large-scale trials. This needs to be done now.

In order to reach this objective, the European Commission recently called on stakeholders worldwide to reach a common, stable vision on the main functionalities of 5G, agree on the overall timetable and define the main technologies to be developed by the end of 2015. The first bold step was made in June 2014, when the EU engaged into an ambitious partnership and signed a joint declaration with South Korea.

The EU-South Korea 'Joint Declaration on Strategic Cooperation in Information Communications Technology (ICT) and 5G' foresees common work on the global definition of 5G research, the harmonisation of the radio spectrum to ensure interoperability, and the preparation of global standards for 5G. Concretely, this will see the parties fund joint research and development programmes in 2016 and 2017, work together towards global standards for 5G in the 3GPP and ITU standards-setting bodies, and cooperate on meeting the additional frequency spectrum requirements for the technology.

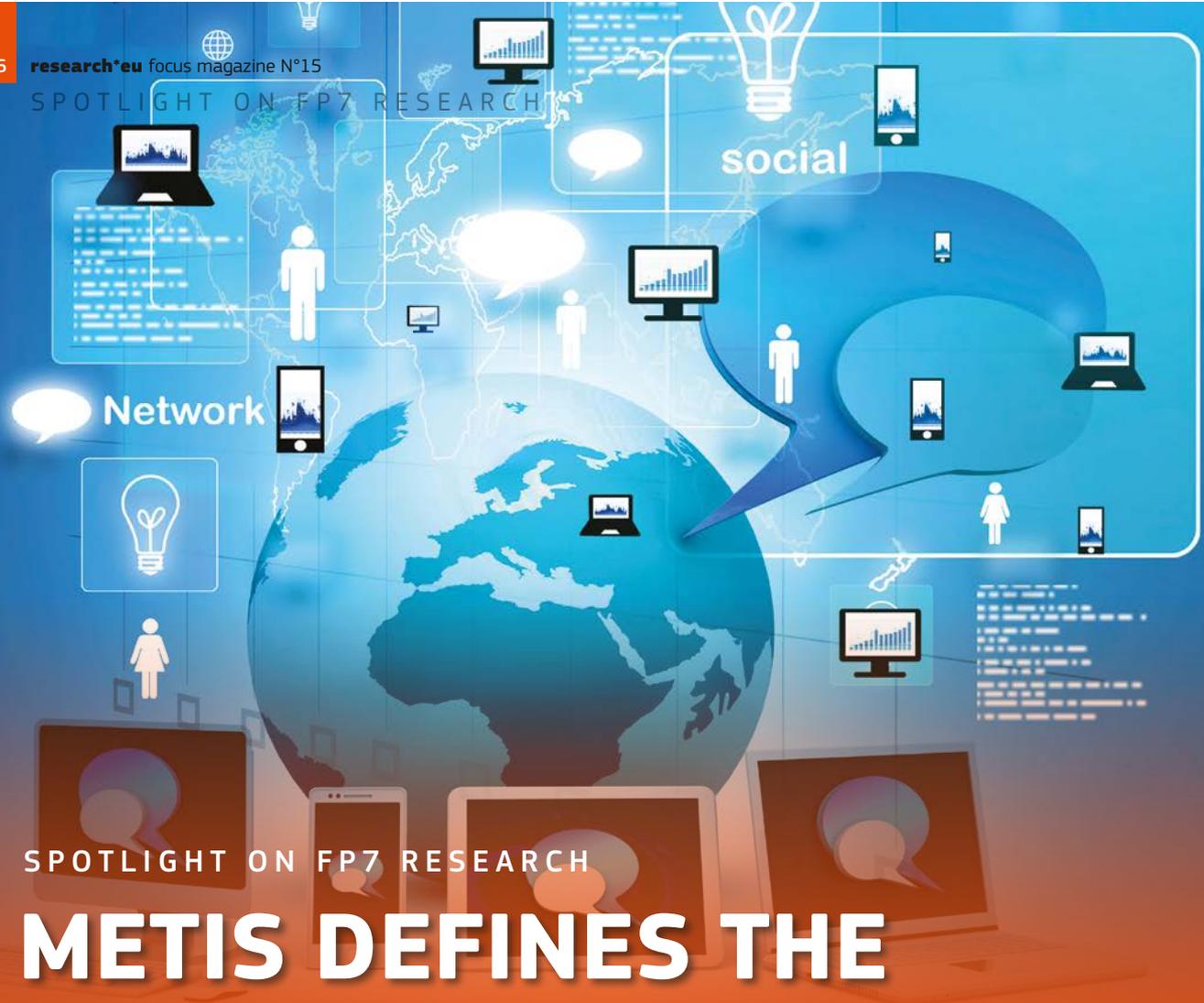


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Discussions will continue with China, Japan and the US, seeking to build further international partnerships which are all expected to stimulate investment by reducing individual risks and increasing economies of scale.

## Building on EU strengths

The EU rationale behind these partnerships is threefold. First, they can accelerate the pace of consensus-building worldwide, which means EU citizens can benefit from 5G benefits as early as possible. Secondly, they contribute to strengthening the European industry by supporting their views and developing their expertise, thereby giving rise to new champions and new ecosystems. Highly competitive EU sectors such as the automotive, broadcast and health services industries, along with disruptive and innovative startups, are already well placed to find early adopters of 5G technology worldwide. Finally, these partnerships are expected to help avoid issues related to fragmentation of approaches and standards between regions and protracted battles around intellectual property.



SPOTLIGHT ON FP7 RESEARCH

# METIS DEFINES THE FUTURE OF WIRELESS TECHNOLOGIES

As exciting as it sounds, 5G is still an abstract concept: 'I have no idea what 5G is,' said Nokia CTO Hossein Moiin at a recent news conference in Barcelona. If we are to benefit from 5G networks, services and applications in 2020, it is time for stakeholders to come up with a clear direction and definition. The EU-funded METIS project is trying to achieve just that.

**M**ETIS is the project that will be seen as the start of 5G,' explains METIS project coordinator Olav Queseth from Ericsson. 'It brings together the relevant players in the industry and academia to start building a consensus around what 5G is, and what the most important technologies to develop are.'

The project — which involves 29 partners from Europe and beyond including industry players Elektrobit, Ericsson, Huawei, Nokia, Orange, Deutsche Telekom, NTT Docomo, Telecom Italia, Telefonica and BMW as well as universities and research institutes — can be seen as an answer to three challenges our societies are about to face:

an avalanche of traffic, with an increase in worldwide use that is expected to result in 1000 times more data being exchanged; the explosion of the number of connected devices with the realisation of the Internet of Things; and an increased diversity of requirements coming from new use cases.

In a nutshell, METIS is about supporting evolution in our use of wireless technologies and making the transition as smooth as can be. 'I think the current technologies will continue to exist for a long time and they will evolve to support new use cases and applications. What is important is that some of these applications are easier to support or



would be better supported if we can develop new technologies that do not have to take into account limitations in the current designs,' Mr. Queseth says. For example, how can wireless infrastructures move towards higher frequencies, thereby achieving greater wireless broadband capacities and at the same time possibly simplify their implementation and reducing costs.

with, 'like for instance remote controlled vehicles or remote surgery.' The design and the test cases have been selected by the METIS team, based on five objectives: the future wireless network should be amazingly fast, have great service in a crowd, make sure that best experience follows you, provide super real-time and reliable connections, and achieve ubiquitous machine-to-machine communication.

### A scientific crystal ball

So what would the world look like with 5G enabled? 'People will continue to do what they do today,' Queseth explains. 'But at the same time we are seeing changes in our daily life that are driven by technology development, and these changes are quite large, from TV use patterns and access to education to the very way we organise our time. These changes take place one step at a time, and 5G is part of this evolution. Some changes will take place anyway, some may be boosted by 5G and some will never materialise. But it is almost impossible to know which is which.'

To overcome this difficulty, METIS' work is organised around what it calls a push-pull approach. On one hand, the team is developing new radio concepts to support future application needs. On the other hand, it builds on likely scenarios and observation of long-term trends to evaluate relevant use cases and derive the requirements 5G will need to meet.

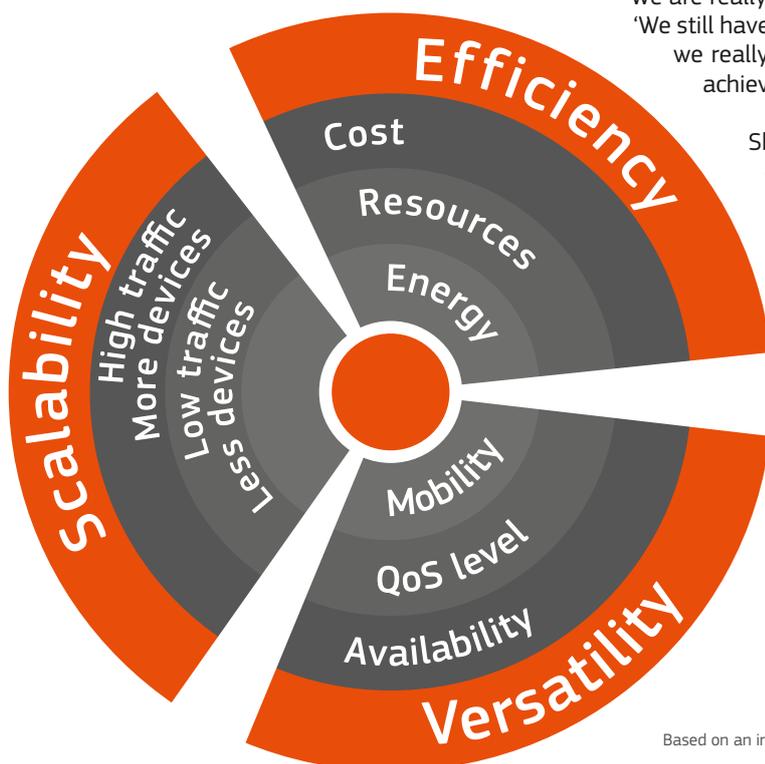
It is known, for instance, that the number of connected devices will increase exponentially over the years to come, and 5G will have to ensure very high reliability in situations where current technologies would be overrun. This also means that we will be more likely to use networks to perform tasks we currently wouldn't 'dare to trust the Internet

*It is known, for instance, that the number of connected devices will increase exponentially over the years to come, and 5G will have to ensure very high reliability in situations where current technologies would be overrun.*

### A cornerstone of 5G standardisation

METIS achievements so far include a future spectrum system concept, a technology roadmap, deliverables on network-level solutions and architecture, solutions for new radio access and a consolidated view on the most promising multi-node/multi-antenna transmission technologies. 'We are really happy with the results so far,' says Queseth. 'We still have some time to go and a few more things that we really want to do. But I'm quite hopeful that we'll achieve great results in the end.'

Should all objectives be met, the project will enable European lead on 5G and ensure an important contribution towards global consensus on how to define it.



Based on an infographic from the METIS website

## INTERVIEW

# THREE QUESTIONS FOR OLAV QUESETH

## COORDINATOR OF THE METIS PROJECT



OLAV QUESETH

### Why is it so important for Europe to lead the global consensus on 5G?

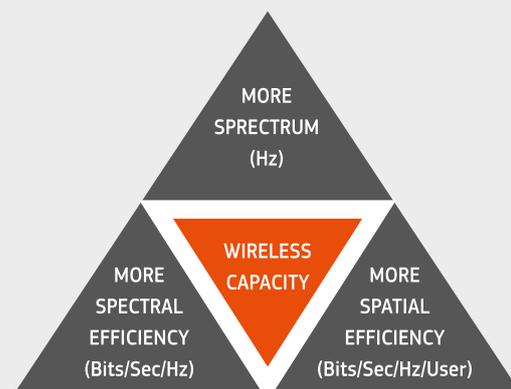
If Europe is the leader there is a larger chance that research and development is done in Europe, which would be leading to more jobs etc. This is also helpful for providing opportunities for developing new ideas and applications. Even though we live in an all-connected world where it is possible to get access to platforms etc. everywhere it is still so that a lot of new ideas are created when people can meet and talk to each other. If Europe leads, this means we also have the largest chances of coming up with new ideas.

### Growing infrastructure, such as an increased number of — and more powerful — antennas, can be both a technical and political challenge. How should 5G overcome these obstacles?

One of the things we are working on is how to enable smaller cells and thus use smaller, less powerful antennas. Smaller antennas with lower power use also means that the devices will be easier to place and hide. We are also working on technologies to allow more traffic from a single antenna site which should at least help overcome the problem of the growing need for more antenna sites.

### Another major challenge faced by devices manufacturers now is battery life. How can 5G be more powerful and less greedy at the same time?

There is not one solution to this, it is more a matter of constantly paying attention to power consumption. We need to make sure that everything that is not used is turned off. When things are used try to just use enough power to communicate. If a transmission can wait a bit it may be possible to bundle with something else later on saving a bit of power etc.



# THE ROAD TO UBIQUITOUS CONNECTIVITY

5G will see us enter a brave new world of pervasive service. As such, 5G is said to be not just another step along the mobile connectivity path but an entirely new way of managing connectivity. Hardly surprising then that entirely new innovations and approaches will be necessary to achieve it. Three EU-funded projects are exploring the questions, requirements and potential solutions thrown up by 5G ubiquitous connectivity.

## CROWD (CONNECTIVITY MANAGEMENT FOR ENERGY OPTIMISED WIRELESS DENSE NETWORK)

In an effort to move towards both improved both capacity and connectivity, the CROWD project is exploring how we can achieve more spatial diversity and energy-efficiency by deploying more base stations/access points and small cells.

The project develops a novel architecture which provides a network capacity increase approximately proportional to the user density increase, as well as wireless network energy consumption proportional to the volume of handled traffic. One of the key aims of deploying an increased number of small cells is to help offload the traffic of the cellular LTE network. But CROWD's focus is also to pave the way for the same type of mechanisms to be used in machine-to-machine communication as the Internet of Things emerges.

CROWD employs a Software-Defined Networking (SDN) approach, and the team develops protocols for radio network optimisation that can be used in the development of 5G.



*'We want all devices to be able to use all access points. What is essential here is that we guarantee continuity and quality for the user during the handover from one access point to another.'*

**Arianna Morelli,**  
CROWD project coordinator



## 5GNOW (5<sup>TH</sup> GENERATION NON-ORTHOGONAL WAVEFORMS FOR ASYNCHRONOUS SIGNALLING)

The 5GNOW project focuses on the wireless physical layer, aiming to develop solutions which offer a new kind of flexibility and robustness to different types of wireless networks in order to improve connectivity.

Specifically, the 5GNOW team, led by project coordinator Gerhard Wunder, has developed new concepts to serve as alternatives to LTE and LTE-Advanced strict synchronism and orthogonality when modulating the radio signals. Orthogonality — which means the ability to spatially separate the signals — and synchronisation were both appropriate for the LTE era, according to Mr Wunder. However, the future network with its huge range of devices and different demands will need to be designed, at least in parts, on very different design paradigms.

In terms of the air interface, the 5GNOW team has reduced the list of candidate solutions to only a handful of the most promising. The greater 5G community is now ready to pick up where the project leaves off. In the US, 4G America's white paper on 5G requirements and solutions references 5GNOW deliverables.



*'5G access will be highly asynchronous for specific services because of the fact that many devices, e.g. in Internet of Things types of applications, will not want to be connected all the time and do not operate to a common clock. 5GNOW has developed solutions to ideas on how such asynchronous operation can be more robust and scalable to the expected massive device numbers in a 5G network. However, many questions still remain: should we use new signals or use the same signals and cover them in one unified air interface?'*

**Gerhard Wunder**, 5GNOW, project coordinator



## DIWINE (DENSE COOPERATIVE WIRELESS CLOUD NETWORK)

'The DIWINE project is focused on solving the problem of wireless communications in complicated, dense, randomly defined networks using new ad hoc communication techniques. Project coordinator, Hrjehor Mark, talks about how DIWINE is contributing to the connectivity challenge.

**5G promises ubiquitous connectivity which inevitably presents a range of challenges. Which of these is DIWINE addressing?**

DIWINE has defined a range of 'key performance indicators' corresponding to the main goals of 5G: low latency, high throughput, energy efficiency, secrecy rates. Furthermore, DIWINE intends to introduce a completely new approach to wireless ad hoc networking, underpinned by a number of novel techniques, which is inherently much more efficient and introduces much less delay than the conventional one because it enables the devices in the network to cooperate more fully, rather than interfering with one another.

**What are the main achievements of DIWINE so far and how they will ultimately benefit connectivity for 5G?**

DIWINE has already established its new paradigm from a theoretical standpoint, showing how it can cope with networks with a high level of interference. A practical demonstrator of the technology is now also nearing completion. It will show how it is possible to reduce delay and increase throughput in dense relay networks which by their nature experience high levels of interference. This is achieved by 'exploiting' interference.

**DIWINE is conducting demonstration cases, including on smart metering networks. Are there lessons that could be applied in general to the Internet of Things?**

One important observation is that identifying and resolving practical issues like synchronisation and interference coordination are relevant to bring new ideas (such as physical layer and packet layer network coding) to market.

# SEEMINGLY INFINITE CAPACITY

The European Commission anticipates that by 2020 seven billion people will be connected through seven trillion devices. How to enable the instant connection of any device, at any time, anywhere on such scale will require an innovative new network architecture.

Three projects funded under the EU's Seventh Framework programme offer their take on finding solutions to the exponential demands that will be placed on network capacity under 5G.

## IJOIN — improved system efficiency

The IJOIN (Interworking and JOINT Design of an Open Access and Backhaul Network Architecture for Small Cells based on Cloud Networks) project has developed heterogeneous, flexible solutions to boost network capacity.

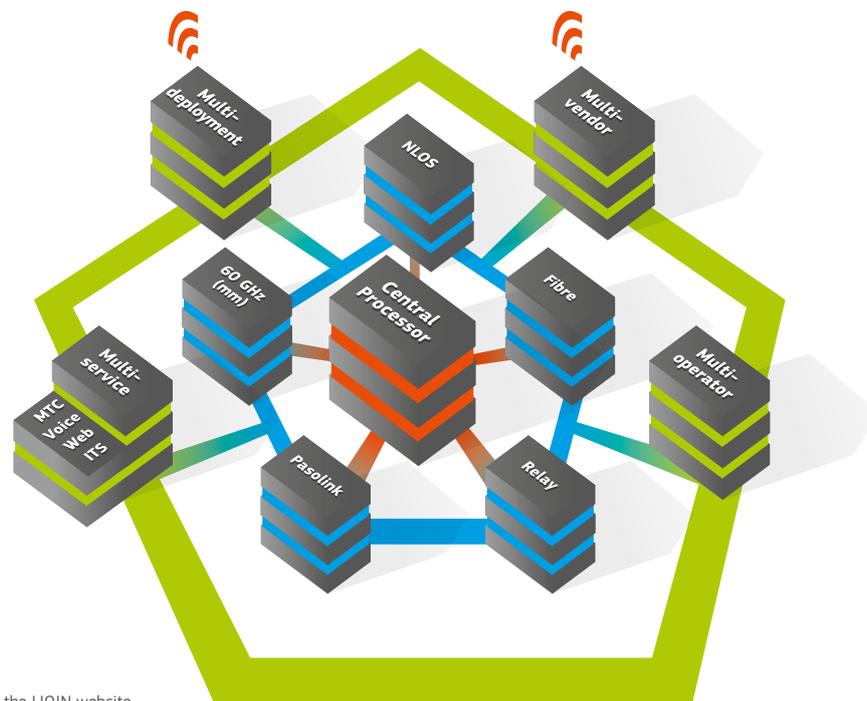
IJOIN explores a novel system architecture in which a major part of the mobile network intelligence is centralised and built on flexible, replaceable software. This allows for the optimisation of the mobile network operation, since only the software handling the intelligence and functionalities of the central nodes needs to be adapted or replaced, while using the same, low-cost hardware including in remote places. 'This means the best suitable algorithm can be used in every scenario,' explains project coordinator Dr Albert Banchs.

'Our target is to increase the system throughput within the same spectrum by a factor of 50-100 by enabling very high density deployments,' Dr Banchs says. The project is doing this through the introduction of novel algorithms that enable efficient frequency reuse, and by deploying intelligent coordination algorithms at the main data center.



*'The application of standardised cloud-platform technologies to radio access network technology is IJOIN's most innovative contribution. This eases the application of known data analytics technologies as the technological barrier between traditional radio access networks and IT domain is removed.'*

**Albert Banchs**, IJOIN project coordinator





## MIWAVES — opening up new spectrum bands

Millimetre-wave frequency bands can help to address the burden the predicted dramatic growth of mobile traffic places on the capacity of networks. The MIWAVES (Beyond 2020 — Heterogeneous Wireless Networks with Millimetre-Wave Small Cell Access and Backhauling) project aims at demonstrating the use of new spectrum bands, called millimetre-wave frequency bands, in future 5G mobile communication networks.

These new bands will enable wireless communications at a much higher data rate than today for a large number of users. Total bandwidth available today for mobile users does not exceed a few hundreds of MHz. Dr Laurent Dussopt, MIWAVES' project manager, explains. The project's goal is to enable the use of frequency bands in the millimetre-wave spectrum where much larger bandwidths are available. 'More specifically, we are targeting the 57 — 66 GHz band where up to 9 GHz of total bandwidth is available in Europe, which translates to more than 10 times currently available bandwidth,' says Dr Dussopt.

### How can MIWAVES benefit from smart analytics?



'Our vision is that the network will be able to identify if any mobile user can benefit from the 60 GHz service and automatically switch to this service if it is needed.'

**Laurent Dussopt**, MIWAVES project manager



The 60 GHz service described above will be available only in specific areas providing short- and medium-range wireless communications and will coexist with, and complement, the current long-range cellular network at low frequencies.

Network operators are facing limited capacity due to limited available spectrum resources or expensive spectrum resources. MIWAVES' research aims to open up new options for operators and to make sure their needs are addressed. Two network operators are involved in the project consortium.

## TROPIC — faster access, lower battery consumption

While small cell networking and cloud computing are typically seen as two distinct fields, the main goal of TROPIC is to bring them within a common framework. The project provides an innovative approach to speeding up access while ensuring energy efficiency.

Project coordinator Josep Vidal explains that the dense deployment of advanced small cells base stations can help to take cloud services closer to mobile users. The goal is to have simple, energy-efficient mobile devices that are able to run complex applications thanks to a virtual machine that is installed in advanced, small base stations with computing and storage capabilities.

While researching and developing highly technical solutions, the project keeps a firm eye on the needs of its end users. All developments are guided by sensible user scenarios and a mid- to long-term prediction of user requirements. 'Out of an array of interesting technologies at hand, we choose those more relevant and adapted to particular type of apps and radio scenarios,' says Dr Vidal.

### How will the research being carried out by TROPIC benefit all users?



'The project's goal is to benefit operators (with a potential new stream of revenues), small cell manufacturers (with new products), application developers (more demanding applications can be designed) and end users (with enhanced experience).'

**Josep Vidal**, TROPIC project coordinator



# INTRODUCING FLEXIBILITY TO 5G

One of the main technology areas for 5G is known as ‘virtualisation’, converting what was the work of costly and energy-sapping hardware components into software flexible enough to be deployed anywhere in the network. Network Functions Virtualisation (NFV) and Software-Defined Networking (SDN) are major steps in this direction and the EU has several ongoing research projects in this field. Here we look at four.



## MOBILE CLOUD NETWORK (MCN)

Cloud computing is a fundamental pillar of the future Internet but it is mainly based on large, fixed-location data centres at a time when users are becoming increasingly mobile, and they will be even more so by the time 5G will be deployed. The MCN project seeks to exploit the vast potential of cloud computing by taking it beyond data centres to the mobile end-user. By bundling mobile phone, computing and storage into one service, a new business actor will emerge: the mobile cloud provider. The MCN project is building the first-ever mobile network architecture to support cloud computing — using radio access networks, core network functionalities, and strategically located server clusters known as micro data centres. Soon it will be possible for some end-to-end mobile providers to operate without owning or operating any physical infrastructure.



*‘The European telco providers taking part are definitely gaining a strategic advantage from participating in MCN. This is far from abstract. Solutions are being tested and some are already being fed into the market to get a feel for what users will want.’*

**Uwe Riss**, MSAP in Switzerland, project coordinator

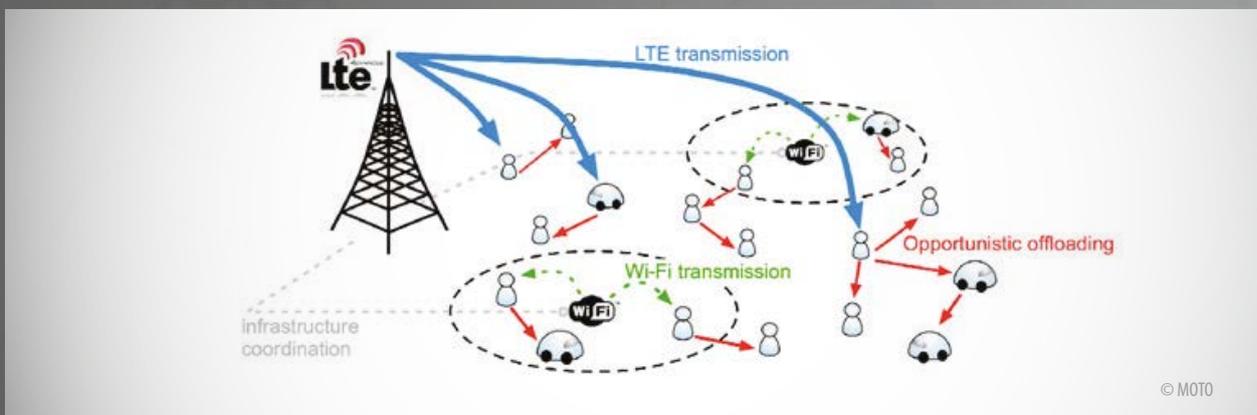




## MOBILE OPPORTUNISTIC TRAFFIC OFFLOADING (MOTO)

Mobile data has grown so fast over the last four years — 20-fold according to Cisco — that something has to be done to offload the traffic onto less critical infrastructure in order to avoid over-congested networks. The architecture designed must also be scalable upwards to accommodate the 5G revolution. The idea of the MOTO project is to develop offloading strategies to exploit the diversity of

wireless access technologies to switch traffic from one network to another before they become congested. Offloading, for example, from cellular to WiFi networks, or to 'multi-hop' ad hoc communications directly between user devices, will prevent networks from becoming overloaded as demand heats up. By differentiating between heavy and light users (20% of heavy users generate 80% of the traffic), MOTO puts the customer at the heart of the offloading strategies by providing operators with the flexibility to elaborate tiered pricing taking into account type of traffic (e.g. in relation to delay tolerance) and user consumption.



## NETWORK FUNCTIONS AS A SERVICE OVER VIRTUALISED INFRASTRUCTURES (T-NOVA)

Dr Anastasios Kourtis, of NCSR Demokritos Research Center in Greece, coordinates the T-NOVA project which is building a marketplace for software developers to offer virtualised functions replacing hardware components in networks. Below he explains his hopes for the platform.

### Which network functions can be virtualised?

Indeed, most network functions can be deployed as virtualised appliances. A software developer may have created, for example, a new intrusion detection algorithm and could sell it over the network operator's marketplace as part of a virtual security appliance. As another example, virtualised media transcoders could be deployed into the network to achieve better mobile video quality.

### In what way will the project boost European competitiveness?

We hope the platform will help small companies and start-ups get their network function prototypes into the marketplace as software modules as soon as they produce them. The introduction of the platform should avoid delays and the need of hardware prototyping. We should have a proof-of-concept demonstrator to show them by early 2016.



### How will your input into the standards process help you?



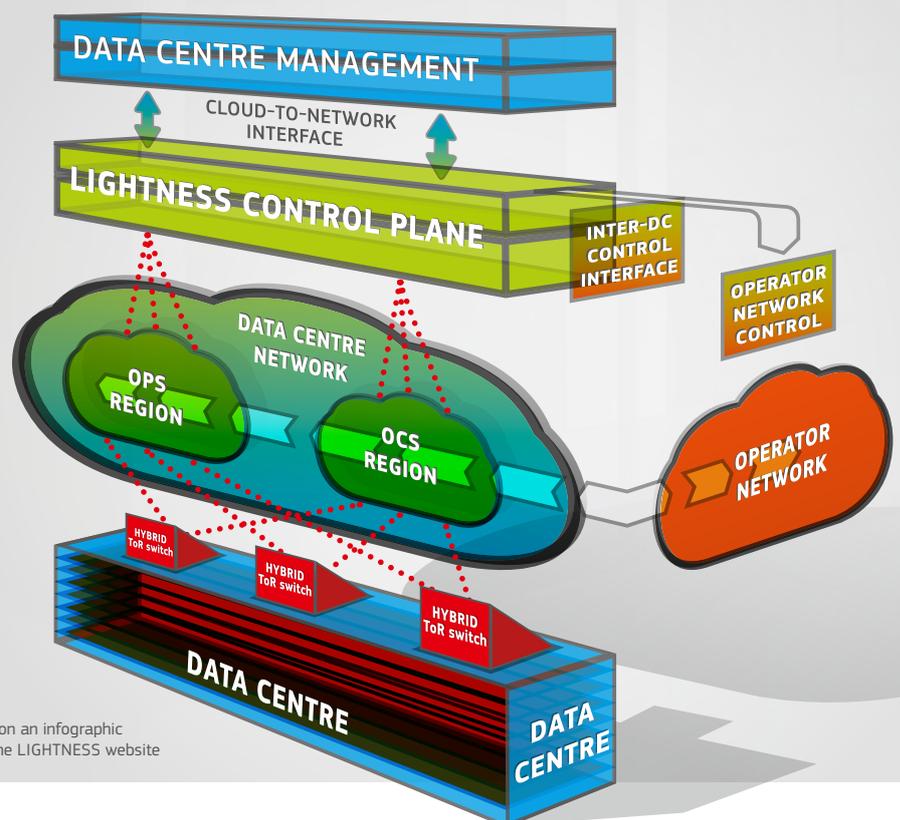
*We are trying to harmonise our architecture internationally. We maintain strong liaison with ETSI NFV ISG, which is the leading standardisation initiative in the field. We also have a good collaboration with AT&T in the US and NTT in Japan. So we hope that our marketplace will become a European success story further afield.*

**Dr Anastasios Kourtis**, NCSR Demokritos Research Center in Greece, project coordinator



## LOW LATENCY AND HIGH THROUGHPUT DYNAMIC NETWORK INFRASTRUCTURES FOR HIGH PERFORMANCE DATA CENTRE INTERCONNECTS (LIGHTNESS)

LIGHTNESS is an industry-driven project to strengthen European technology for connecting data centres together, anticipating the traffic that will grow between them. It is doing this by harnessing the improved power, speed and cost-efficiency of optical, over electrical, transmission. High-performance computing, cloud and server-side storage applications are already fuelling demand for high data throughput and fast response times. LIGHTNESS has developed an Optical Packet Switch (OPS) to provide nanosecond latency (response time) and a critical Top-of-Rack (ToR) network switch to reach data throughput at rates between 40 and 100Gb/s. Above all, the infrastructure must scale upwards for 5G in a way that current grouped Ethernet switches won't be able to. 'Scalability is really the key word of the project if we are to meet increased future demand,' said Matteo Biancani, of Interoute, the telecoms and cloud services provider leading the project.



Based on an infographic from the LIGHTNESS website



ALL FOR ONE: THE 5G PPP

# WHAT IS THE 5G PUBLIC PRIVATE PARTNERSHIP AND WHY IS IT IMPORTANT?

The 5G Infrastructure Public Private Partnership, or 5G PPP in short, was launched as a joint effort supported by the European Commission, telecommunication vendors and operators and the researcher community. It aims to develop the necessary, highly flexible infrastructure capable of meeting the ambitious requirements that the future internet will generate.

The 5G PPP is backed by a sizeable funding to foster a closer collaboration between industry players — current and new — and leading research institutes and universities, in order to develop first prototypes, explains the CEO of Alcatel Lucent, Marcus Weldon: 'Maximising the imagination and invention coming from such a research phase, before you then focus on the commercialisation phase, is very important. Otherwise you end up with what are essentially derivatives of today's technologies when what you want to do is develop a new space where you focus on capacity.'

The PPP needs to get started now with the development of this infrastructure to cater for the unprecedented demand that continuous growth and innovation will place on networks and performance characteristics.

## INNOVATIVE PARTNERSHIPS

The European Commission recognises the emerging paradigm change caused by the technology shift from traditional 'hardware-oriented' network management systems to more 'software-based' network management. It will require a drastically different set of skills and know-how,

the development of which takes time and money. Closer cooperation between the telecommunication and IT industries, that can then join forces with research communities in universities and R&D centres, will help Europe develop the advanced 5G infrastructure it needs.

Europe can make this vision happen through strategic investments in 5G technologies and related measures to focus and strengthen its knowledge in the new ICT fields — the 5G PPP will help spread that investment load and reduce business risks, offering the EU's ICT industry a competitive advantage in the global marketplace.

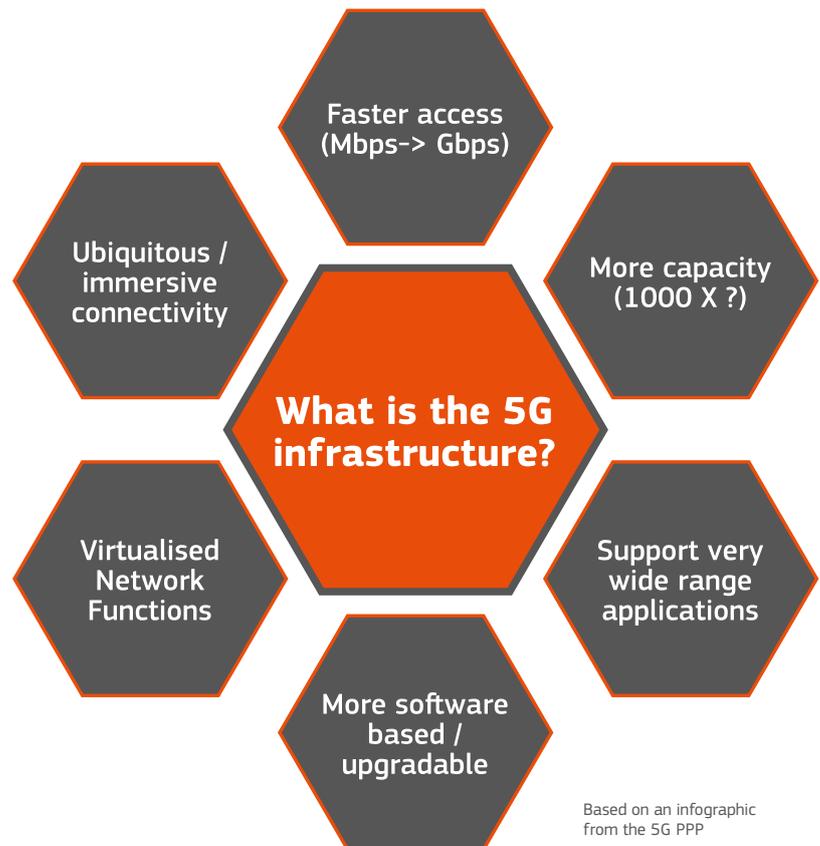


*'5G PPP can help get Europe back into a position of leadership, creating networks providing a self-sustaining business models in which vendors and operators can be successful and the users can have a great experience. That is what 5G should be about.'*

**Marcus Weldon**, CEO of Alcatel Lucent.

# UNITED TO MEET THE TECHNOLOGICAL CHALLENGES

The impact wireless connectivity will have on our daily lives in five years' time is as hard to predict today as it was five years ago. One thing we do know: we are looking at a revolution in ubiquitous ultra-broadband, not an evolution. A far higher proportion of the population is continually adopting new technological hardware that seeks real time information and an immersive experience. This means we now need to go beyond a 'client server' model in which network infrastructure is reduced to a pipe full of bits and bytes.



Eric Béranger, Head of Space Systems Programs at Airbus Defence and Space believes we are moving away from a world in which one can live and work even with occasional network non-availability and failure, to a world asking for a perception of infinite capacity anywhere — a world in which the public will demand 5G.

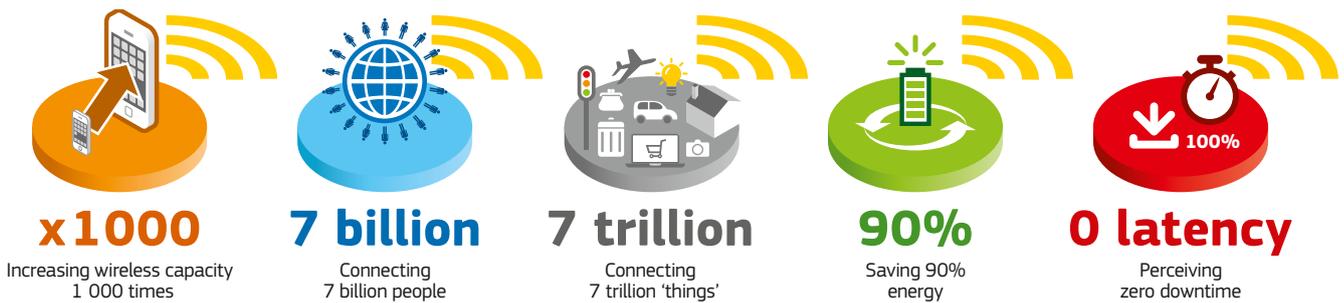
We can all observe a clear tendency in consumer expectations: digital services must be available everywhere, all the time, and must deliver more and faster capabilities and all this through any device,' Mr Béranger adds.



*'We can all observe a clear tendency in consumer expectations: digital services must be available everywhere, all the time, and must deliver more and faster capabilities and all this through any device.'*

**Eric Béranger**, Head of Space Systems Programs, Airbus Defense and Space





Dr. Zhou Hong, President of Huawei's European Research Institute, explains that 5G goes beyond being the next generation of mobile networks infrastructure. '5G is not just about smart phones, it will be the change engine to revolutionise the way we work and live, it will become the fabric for our everyday life.'

## 5G — aims and aspirations

The European Commission and the ICT industries are coming together to create future networks that will have 1 000 times greater capacity in comparison with 2010. Energy saving is one key target, particularly in relation to the radio access network: the goal is to reduce consumption by 90%.

Service creation and provision also need to be improved with average service creation times being reduced from 90 hours to 90 minutes and secure networks providing 'zero perceived' downtime. The number of users is set to grow exponentially, so dense deployments of links capable of connecting seven trillion devices belonging to seven billion people will be needed. Finally, more needs to be done to enable advanced, user-controlled privacy.

A new type of network architecture is needed to reach these key performance metrics. CEO of Alcatel Lucent, Mr Marcus Weldon explains, 'We have been building networks based on communications, voice, text emails and

messaging — focusing on coverage. Maximum capacity has come second.' This needs to change if we want to live our lives wirelessly and digitally. But all is not lost, 'One way forward would be to use existing 3 and 4G infrastructure, weaving solutions for capacity into existing networks and building on that.'



Some applications we know will become more and more central to our lives, for example: virtual reality offices requiring 1 to 10 Gb/s data rates; huge crowds at events such as football matches needing to access networks which can offer 9 GB/hour data volume; traffic efficiency and safety systems which require very low latency times; massive deployment of sensors and actuators which will have nearly 300 000 devices connected per access point with a battery life of one decade, and teleprotection in smart grid network with 99.999% reliability.

'Installing a 5G ecosystem pre-supposes access to an interface which supports a range of different traffic types from the high rate video down to the low rate of the 'Internet of Things' applications with a range of latency requirements,' Mr Béranger explains. In turn, those various traffic types will make use of a wide range of end-users devices which must all be interoperable.





## 5G PPP — WHO IS INVOLVED?

The European Commission feels the development of innovative solutions, the acceptance and standardisation of those solutions and their exploitation on global markets will be carried out more efficiently by the 5G PPP. They hope to bring on board:

- **Manufacturers in network, IT and microelectronics domains** who can research and develop solutions.
- **Communication service providers** who can identify their requirements and cooperate with manufacturers and the research community.
- **R&D centres and universities** who will provide concepts for innovative solutions.
- **SMEs** to provide specific, practical know-how.
- **Application developers** will share their requirements and challenges right from the conception of new networks.
- **International standardisation bodies and cooperation partners in other regions** can promote the global adoption of systems and solutions.
- **Regulatory bodies** to inform people of the barriers to adoption and deployment and mobilise investment.

## WHAT NEEDS TO BE IN PLACE FOR A HIGH-PERFORMANCE 5G NETWORK?

Establishing a 5G network able to meet the demands we can foresee today, and those that will be revealed in the coming years, is technologically challenging.

So how will this vision be achieved? We consider what the goals of the future network are, the hurdles that need to be overcome to achieve these, and we gain an insight into how this can be done from some key industry figures.

### Seemingly infinite capacity...

Providing 1 000 times higher wireless area capacity, in comparison with 2010, puts constraints on dimensions of the terrestrial networks. Huawei's Dr Zhou believes 5G's combination of unprecedented radio links and ultra-low latency is essential for the connection of many sectors. Meeting this requirement will require greater numbers of tower networks, in places augmented by satellite where there are low populations or limited infrastructure.

Mr Béranger, believes introducing satellite resources to network data distribution will help to off-load part of the traffic, optimising the infrastructure's ability to deliver. 'High speed broadband satellite systems are needed to extend the reliable delivery of 5G services to public transportations

including aircrafts, vessels as well as trains and buses,' he explains. SES's Chief Technical Officer Martin Halliwell agrees satellite's broadcast and multicast capabilities are very valuable for offloading the distribution of large amounts of content.

At Alcatel Lucent they believe boosting capacity requires a rethink on how we currently use the available radio spectrums. 'One of the fundamental principles of 5G, we believe, will be to have all radios on in your handset at once: wifi, Bluetooth, millimetre wave, LTE, Bluetooth radio – and all the frequency bands accessible,' says Mr Weldon.

Small cells are also being put forward as a possible way to provide seemingly infinite capacity. Wireless capacity spectrum is limited and it attenuates with distance. Alcatel Lucent believes 5G could use all the radio spectrum available, over the shortest possible distance leading to the best quality of reception. Previous macro networks, which site masts a kilometre away from the end user, will need to be re-designed. Small, low power cells, multi-band and flexibly managed, can be deployed in far greater numbers to be close to the end-user.

CEO of PT Inovação e Sistemas, Mr Alcino Lavrador agrees, explaining that smaller cells need more front- and backhaul and so will require a new radio interface and a more flexible spectrum. If this is put in place and small cells are widely deployed then it will radically change the way we interact with the network. A user immersed in a sea of radio spectrums would no longer be moving from cell to cell.



© geeunjin, Thinkstock

This could provide a seamless experience — there would no longer be points at which the user moved out of range or was handed over to another cell.

On the network side there is currently no coordination between wifi, cellular, LTE and 3G networks — the user switches between them. One of the big challenges facing 5G is the management of all those radio networks with a control plan that treats them as one continuous experience not as three, four or five different networks.

But deployment of small cells raises regulatory and commercial issues — would operators use the same unit or would they have to install their own? Where should they be deployed? Where can they be deployed in rural areas? How do you get permission to install inside a building, perhaps multiple times? How do you get permission to deploy on municipal infrastructure without painful application and planning processes?

'It is more of a political regulatory type-thing which has to be sorted out. Once we realise the world is going small, we need figure out how to optimise 'small' to maximise the speed of deployment and the rate at which we can get to 5G,' says Mr Weldon.

### ... without infinite energy consumption

Mari-Noëlle Jégo-Laveissière, Executive Vice President of Innovation, Marketing and Technologies at Orange, explains that electricity consumption and CO<sub>2</sub> emission are sharply increasing as customers ramp up their digital usage. '5G must address this issue if we want to keep our ecologic and economic bill at a reasonable level,' she says. 'Orange is willing to improve energy efficiency.' But how is that to be done?

Access sites (including backhaul) currently consume roughly 80% of the energy required for the operation of a cellular network. 'In order to save energy on the network side, an efficient sleep mode independent of the traffic load must be designed,' Ms Jégo-Laveissière says. Orange is interested in seeing how equipment can be activated and de-activated with a very small timeframe (a few tens of micro-seconds). Air interface design must allow user equipment and base stations to stay in sleep mode by limiting the transmission of reference and synchronisation signals.

'On top of that,' adds Ms Jégo-Laveissière, 'smart management and supply of energy must be enabled via energy metering inside all products, energy harvesting products, and so on.'

### Better security with no downtime

Thanks to the global coverage of satellites — on land, in the air, at sea — and the network's reliability and resilience, satellites can provide solutions to the challenges of security and uninterrupted service, maintains Mr Béranger. 'The reliability and availability ratios of satellite services are often higher than 99.9%. Their wide area coverage characteristics constitute the overlay network to enable resiliency and to support rapid network services,' he explains. Mr Halliwell adds, 'Caching content locally can allow for a "faster than light" call-up for the user.'

### Tighter privacy

The Chief Advisor at Turk Telekom Argela, Mustafa Ergen, says user-controlled privacy is an area that is being recognised as ever more important in software development. 'We started our Software Defined Networking in another context but it will evolve towards context-aware security and privacy especially for national networks,' he explained.

But some feel intelligent discussion should move on from debates on net-neutrality and privacy to what it makes sense to do from both a privacy and optimisation point of view. 'Privacy should be at the right level to protect the users' interests but also at the right level to allow maximum optimisation of the network for each user,' Mr Weldon feels.



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## PROBLEM-SOLVING EXTENDS BEYOND THE KEY AREAS OF RESEARCH

Standardisation and cost of ownership are also preoccupying the 5G PPP. Dr Zhou believes that the partnership will help here too. 'The 5G PPP will make it possible to achieve an early consensus on a number of key issues that will enable us to move forward,' he says. These include a common 5G vision, scenarios and use cases, spectrum utilisation, regulatory issues and pre-standardisation. It will also enable Europe to collaborate in order to reach early agreement on what needs to be tested and verified locally and through large-scale trials.

Ulf Ewaldsson, CTO of Ericsson, agrees, 'Pre-competitive research here plays an important role to bring a harmonised view amongst stakeholders on technologies for future generation of systems.'

According to Mr Halliwell, the main challenges are getting the different parties involved to collaborate effectively and work on the next generation of networks maximising the benefit of all existing technologies. 'This is the first time collaboration at this level is being put in place,' he explains. 'Primarily, this is not a technical problem, once the

commercial aspects of collaboration are agreed and satisfactory, the technical work follows.' Mr Weldon agrees, 'Once you get the cooperation and the collaboration in place, the technical solutions follow.'



*'Primarily, this is not a technical problem, once the commercial aspects of collaboration are agreed and satisfactory, the technical work follows.'*

**Martin Halliwell**, Chief Technical Officer at SES

Reducing the cost of service provision and running a network is essential to inspiring investment in innovative solutions. Streamlining standardisation through early collaboration and agreement will help bring down costs. 5G PPP will first be a place to build a shared vision among all European players about 5G goals, scope and system choices, believes Ms Jégo-Laveissière, 'It will also be a powerful brand to defend European industry role in the world. Achieving this will give a competitive advantage to the whole European economy.'

## THE INTERNET POTENTIAL IN FIGURES FINANCIAL SNAPSHOT

**In 2012:**



**2 646**

Global ICT market was worth EUR 2646 billion.



**1 630**

Global telecommunications market was worth EUR 1 630 billion.

## INTERVIEW

# THREE QUESTIONS FOR THIBAUT KLEINER

## NETWORK TECHNOLOGIES HEAD OF UNIT



THIBAUT KLEINER

### What are the biggest challenges and opportunities for 5G?

First we need to truly deliver 5G as a new digital infrastructure that is clearly better than 4G. Not as a marketing slogan. Then, the biggest challenge will be to design a global 5G network system that can deliver new services at affordable costs for a multiplicity of areas — from smart grid to connected cars, tele-medicine, and the Internet of Things. But this will require a 5G technology that is reliable, safe and secure, with network deployment and operating costs that are low enough. 5G promises much more polyvalent networks. With the softwarisation of network management, for example, we will expect much more creativity in communication services. Apps that directly play with the network to tailor it to the needs of users is what we can expect here. Some experts call it a 'plastic network'. This is a fantastic opportunity for innovation and for new generations of start-ups.

### Do you see spectrum as a major challenge for the success and early rollout of 5G? What can be done on the EU national and international level?

Yes, spectrum is and will remain a major challenge for the success and early rollout of 5G. We don't have enough spectrum in general and 5G is much about optimising the use of spectrum. But clearly, allocating more spectrum to 4G and later 5G would help and this is a global challenge. In light of the long decision cycles for spectrum allocation and assignment, it would be very timely for Europe to agree on a scenario already in 2015. This would help secure more spectrum bands at international (ITU) level for WRC-15 while preparing properly for WRC-19. An additional challenge will be to find a globally harmonised band for 5G roaming since all suitable spectrum is already in use in one or another part of the world.

### 4G has been available for a while now, but lots of regions are still relying only on 2G or 3G coverage. How can we ensure this doesn't happen with 5G?

This is a very pertinent question and I wish that Europe would today have reached a greater degree of deployment for 4G, compared to Japan, South Korea or the USA, for instance. At the moment we are gradually catching up with 4G deployments in Europe. We have positive signals from telecom operators that indicate that their 4G investments will reach EUR 2 billion or more per year over the next period. This could help achieve 80% of 4G coverage in Europe before the end of the decade. Countries like Sweden, Portugal and the Netherlands have already reached this 80% threshold and this is very encouraging.

In any case 3G and even 2G may still be in used in the future for specific usages, but I would expect a gradual phasing out. 5G will be a heterogeneous and ubiquitous network, meaning that it will use all available networking resources, from 2G to 4G to Wi-Fi and even device-to-device, and optimise users' quality of experience. An efficient 4G infrastructure will be needed to enable the future 5G deployment and the two infrastructures will complement each other for most of the next decade. 5G deployments are not foreseen before 2020 in the best case scenario and a lot of R&D is still needed to validate the technology and the concepts. We should therefore be able to prepare the deployment of 5G more thoroughly.

# CONNECTING THE DOTS

A game changer rather than a mere evolution of technology, 5G will be more than just 4G plus one. Likewise, the partnerships needed to get us there are more than the sum of their parts: building the right alliances will be the key to unlocking Europe's innovative potential.

The 5G PPP is driving this process by connecting industries, sectors, countries and regions.

'5G will be about enabling the transition toward the full digital economy,' explains Mari-Noëlle Jégo-Laveissière, Executive Vice President of Innovation, Marketing and Technologies at Orange. To incubate this transformation, the 5G PPP brings together a broad range of companies from the telecom and IT sectors including small firms, as well as a number of research institutes and organisations. This 'vertical' mobilisation is matched by the 'horizontal' alliance between the

public and the private sector which is the essence of the 5G PPP.

Bringing everyone around the same table is a prerequisite to achieving a common 5G vision. 'Global standards are essential to ensure global market and thereby also global coverage,' explains Ericsson CTO Ulf Ewaldsson. 'This can only be achieved using a global approach when it comes to both research and development, as well as standardisation.'

This view is shared by Dr Zhou Hong, President of Huawei's European Research Institute. 'It is vital that

public authorities develop effective policies, for instance with regard to spectrum, pre-standardisation and international collaboration,' he argues. 'The EU is taking the lead on developing this key technology, leveraging industry investments vital to drive technological progress, and maximising the benefits of the huge technological expertise available in Europe and elsewhere. It is fostering broad consensus and collaboration by involving all the key players in this process early on.'

# LEVERAGING EUROPE'S STRENGTHS

In this crucial start-up phase, public support for 5G can produce a decisive multiplier effect. Authorities from the local to the European level must pull their weight.

Europe's progress towards 5G is determined by a complex set of technological, regulatory and economic factors. Decision-makers have a key role to play in balancing these considerations and channelling efforts towards strategic areas.

'5G is targeting research and development of new communication networks, which should be based on global standards. Therefore, public research programmes and grants, in

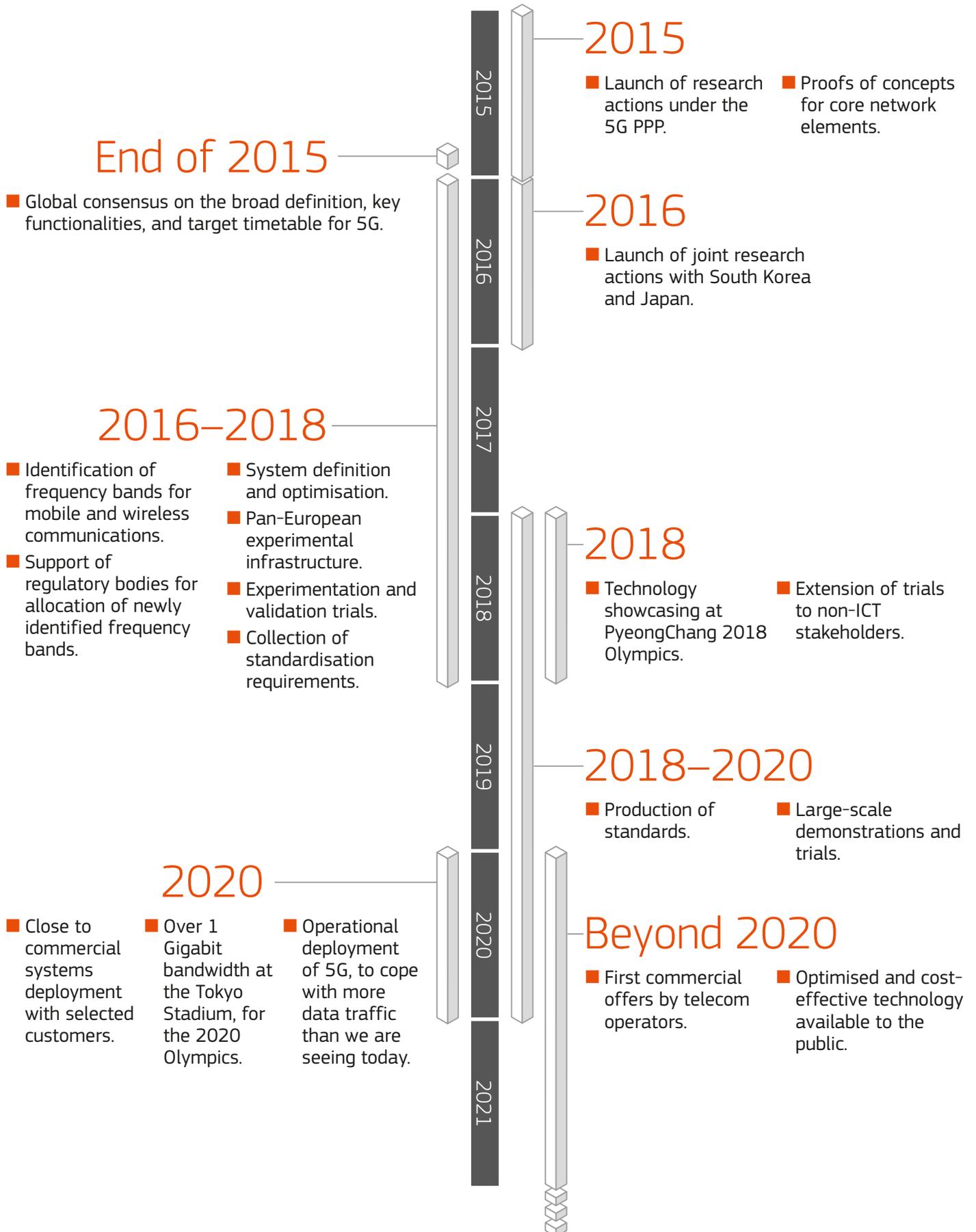
particular on EU level and — for certain technology developments — on national level, provide the environment for collaborative research even between competitors by avoiding legal issues with respect to competition law,' says Nokia's CTO Hossein Moiin.

By translating into industry investment, public funding triggers an important leverage effect. The 5G PPP plays a major role in this context: the

total public funding of EUR 700 million is expected to be matched by a similar amount of private investment.

As Türk Telekom Chief Advisor Mustafa Ergen explains, financial support and regulation fulfil complementary roles: 'Research grants are key to advance in two areas: wireless and software. Regulation will enable and accelerate global roaming and frequency allocations as well as interconnection policies and protect privacy rights.'

## TENTATIVE EUROPEAN TIMETABLE FOR 5G



The *research\*eu focus magazine* on 5G is produced by the Network Technologies Unit (E1) of the European Commission's DG CONNECT. This Unit supports research on wireless, optical and satellite communication technologies that, together, will help meet the demands of the future internet. The Internet of Things (IoT) is also a priority research area.

This magazine is a concrete response to calls by citizens for more openness and communication on science and technology developments. Through a community-focused approach, the magazine seeks to broaden understanding of the work of internet researchers, innovators and entrepreneurs.

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**More info:**

Network Technologies - Unit E1:

<http://ec.europa.eu/digital-agenda/en/network-technologies>

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**See also:**

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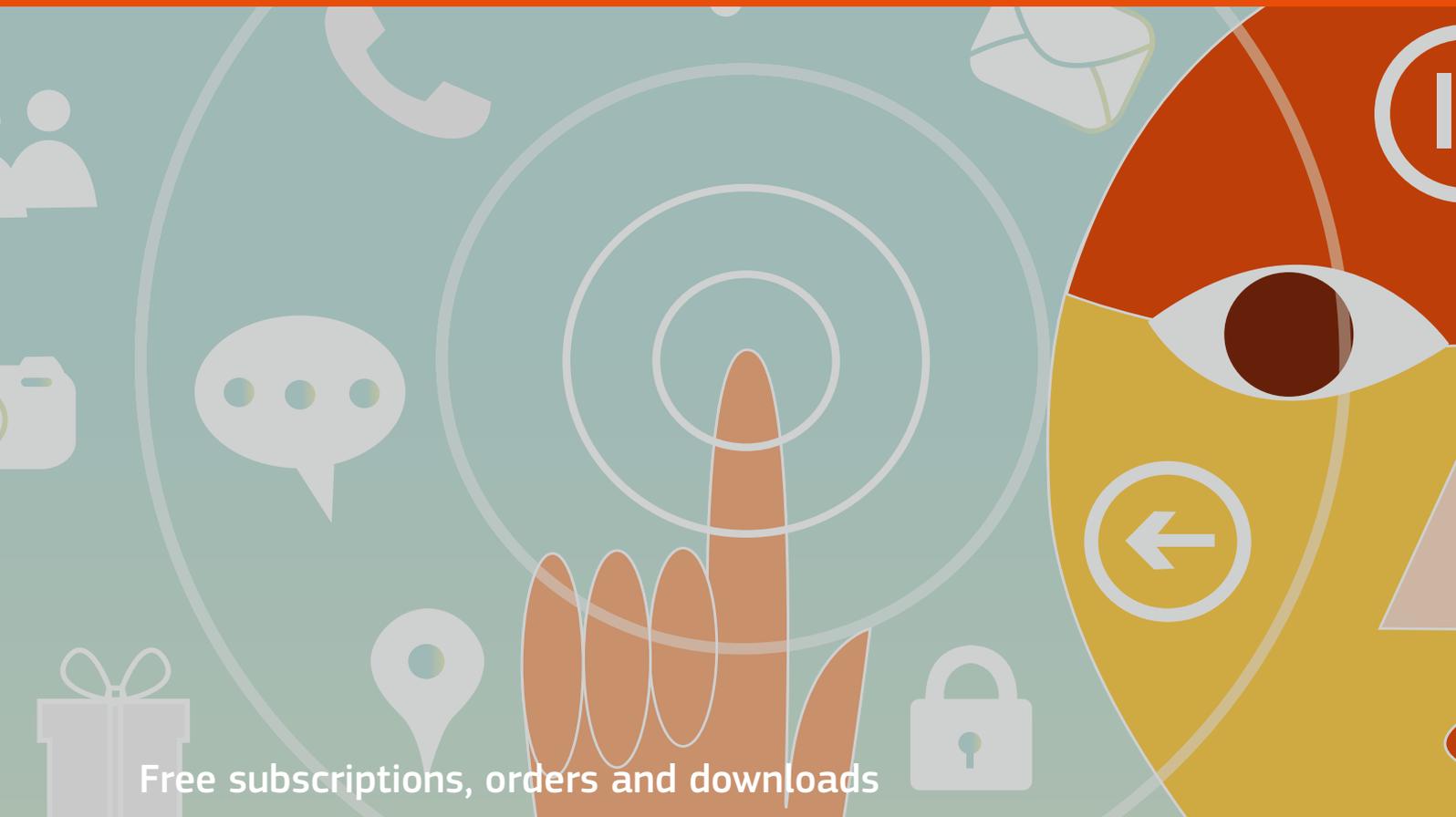
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5G Public Private Partnership: <http://5g-ppp.eu/>

NetWorld2020 European Technology Platform: <http://www.networld2020.org/>

**About DG CONNECT**

The Directorate-General helps harness information and communications technologies in order to create jobs and generate economic growth. It also aims to provide better goods and services for all, and to use the power of digital technologies to create a better world, now and for future generations.



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