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5G Technology

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ABSTRACT: What will 5G be like? What it cannot be is an incremental advance of 4G. The previous four generations of cellular technology have each been a major model shift that has broken backward compatibility.5G will need to be a paradigm shift that includes very high carrier frequencies with massive bandwidths, extreme base station and device densities, and unprecedented number of antennas. However, unlike the previous four generations, it will also be highly integrative. The aim of 5G is to provide ubiquitous connectivity for any kind of device and any kind of application that may benefit from being connected. To support this, the core network will also have to reach unprecedented levels of flexibility and intelligence, spectrum regulation will need to be rethought and improved, and energy and cost efficiencies will become even more critical considerations. This paper discusses all of these topics, identifying key challenges for future research and preliminary 5G standardisation activities, while providing a comprehensive overview of the current literature, and in particular of the papers appearing in this special issue.

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I. INTRODUCTION.

To enable connectivity for a wide range of new applications and use cases, the capabilities of 5G wireless access must extend far beyond previous generations of mobile communication. Examples of these capabilities include very high achievable data rates, very low latency, ultra- high reliability, and the possibility to handle extreme device densities, and will be realised by the continued development of LTE in combination with new radio-access technologies. Key technology components include extension to higher frequency bands, advanced multi-antenna transmission, lean design, user/control separation, flexible spectrum usage, complementary device-to-device communication, and backhaul/access integration. In contrast to earlier generations, 5G wireless access should not be seen as a specific radio access technology. Rather, it is an overall wireless-access solution addressing the demands and requirements of mobile communication beyond 2020.

The Next Generation Mobile Networks (NGMN) Alliance is a mobile telecommunications association of mobile operators, vendors, manufacturers and research institutes. It was founded by major mobile operators in 2006 as an open forum to evaluate candidate technologies to develop a common view of solutions for the next evolution of wireless networks.Its objective is to ensure the successful commercial launch of future mobile broadband networks through a roadmap for technology and friendly user trials. Its office is in Frankfurt, Germany. [1] The Next Generation Mobile Networks (NGMN) feel that 5G should be rolled out by 2020 to meet business and consumer demands. [1] In addition to simply providing faster speeds, they predict that 5G networks will also need to meet the needs of new use-cases such as the Internet of Things as well as broadcast-like services and lifeline communications in times of natural disaster. In order to meet these demands, 5G networks will need to adopt new technologies such as mesh networking, whereby devices communicate with each other directly rather than relying on network operators' base stations. This will increase the bandwidth available, lower power consumption, reduce infrastructure costs, improve spectral efficiency and increase the resilience of the network, but could also lead to higher latencies.[2] [3] [4]

II. 5G OVERALL WIRELESS-ACCESS SOLUTION CONSISTING OF LTE

LTE will continue to develop in a backwards-compatible way and will be an important part of the 5G wireless-access solution for frequency bands below 6GHz. Around 2020, there will be massive deployments of LTE providing services to an enormous number of devices in these bands. For operators with limited spectrum resources, the possibility to introduce 5G capabilities in a backwards-compatible way, thereby allowing legacy devices to continue to be served on the same carrier, is highly beneficial and, in some cases, even vital. In parallel, new radio-access technology (RAT) without backwards-compatibility requirements will emerge, at least initially targeting new spectrum for which backwards compatibility is not relevant. In the

longer-term perspective,the new non-backwards-compatible technology may also migrate into existing spectrum

Although the overall 5G wireless-access solution will consist of different components, including the evolution of LTE as well as new technology, the different components should be highly integrated with the possibility for tight interworking between them. This includes dual-connectivity between LTE operating on lower frequencies and new technology on higher frequencies. It should also include the possibility for user-plane aggregation, that is, joint delivery of data via both LTE and a new RAT.

III. REQUIREMENTS OF 5G AND ITS CAPABILITIES

In order to enable connectivity for a very wide range of applications with vastly different characteristics and requirements, the capabilities of 5G wireless access must extend far beyond those of previous generations of mobile communication.

Massive system capacity

Traffic demands for mobile-communication systems are predicted to increase dramatically [5] [6]. To support such traffic in an affordable way, 5G networks must be able to deliver data with much lower cost per bit compared with the networks of today. Furthermore, in order to be able to operate with the same or preferably even lower overall energy consumption compared with today, 5G must enable radically lower energy consumption per delivered bit. Another aspect of 5G system capacity is the capability to support a much larger number of devices compared with today.

Very high data rates everywhere

Every generation of mobile communication has been associated with higher data rates compared with the previous generation. In the past, much focus has been on the peak data rate that can be supported by a wireless-access technology under ideal conditions.

However, a much more imp ortant capability is the data rate that can actually be provided under real-life conditions in different scenarios.

> 5G should be able to provide data rates exceeding 10Gbps in specific scenarios such as indoor and dense out door environments.

> Data rates of several 100Mbps should be generally achievable in urban and suburban environments.

> Data rates of at least 10Mbps should be achievable essentially everywhere, including sparsely populated rural areas in both developed and developing countries.

Very low latency

Lower latency has been a key target for both 4G and the evolution of 3G, driven mainly by the continuous quest for higher achievable data rates. Due to properties of the internet protocols, lower latency over the wireless interface is critical to realize the higher data rates. 5G targets even higher data rates, and this in itself will drive a need for even lower latency. However, lower latency will also be driven by the support for new applications.Some of the envisioned 5G applications, such as traffic safety and control of critical infrastructure and industry processes, may require much lower latency compared with what is possible with the mobile communication systems of today. To support such latency-critical applications, 5G should allow for an application end-to-end latency of 1ms or less.

Ultra-high reliability and availability

In addition to very low latency, 5G should also enable connectivity with ultra-high reliability and ultra-high availability. For critical services, such as control of critical infrastructure and traffic safety, connectivity with certain characteristics, such as a specific maximum latency, should not only be ‘typically available.’ Rather, connectivity with the required characteristics has to be always available with essentially no deviation.

Very low device cost and energy consumption

The possibility for low cost and low energy consumption for mobile devices has been a key requirement since the early days of mobile communication. However, in order to enable the vision of billions of wirelessly connected sensors, actuators and similar devices, a further step hasto be taken in terms of device cost and energy consumption. It should be possible for such 5G devices to be available at very low cost and with a battery life of several years without recharging

High network energy performance

While device energy consumption has always been prioritized, high energy performance on the network side has more recently emerged as a KPI.

> High network energy performance is an important component in reducing operational cost, as well as a driverfor better dimensioned nodes, leading to lower total cost of ownership

> High network energy performance allows for off-grid network deployments relying on decently sized solar panels as power supply, thereby enabling wireless connectivity to even the most remote areas.

> High network energy performance is part of a general operator aim of providing wireless access in a sustainable and more resource- efficient way. The importance of these factors will increase further in the 5G era, and the possibility of very high network

energy performance will therefore be an important requirement in the design of 5G wireless access

Spectrum For 5g

In order to further extend traffic capacity and to enable the transmission bandwidths needed to support very high data rates, 5G will extend the range of frequencies used for mobile communication. This includes new spectrum below 6GHz, expected to be allocated for mobile communication at the World Radio Conference (WRC) 2015, as well as spectrum in higher frequency bands, expected to be on the agenda for WRC 2019. It is still unclear what spectrum in higher frequency bands will be made available for mobile communication, and the entire frequency range up to approximately 100GHz is considered at this stage. The lower part of this frequency range, below 30GHz, is preferred from the point of view of propagation properties. At the same time, very large amounts of spectrum and the possibility of very wide transmission bandwidths, in the order of 1GHz or even more, will only be available in frequency bands above 30GHz. Thus, spectrum relevant for 5G wireless access ranges from below 1GHz up to in the order of 100GHz.

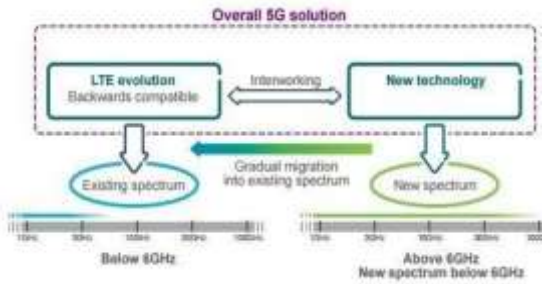

Fig1:Overall 5g Solution

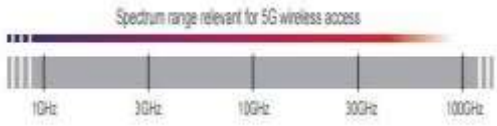

Fig2:Spectrum Range Relevant for 5G

It is important to understand that high frequencies, especially those above 10GHz, can only serve as a complement, providing additional system capacity and very wide transmission bandwidths for extreme data rates in dense deployments. Lower frequencies will remain the backbone for mobile-communication networks in the 5G era, providing ubiquitous wide-area connectivity.

IV. CONCLUSION

5G is the next step in the evolution of mobile communication and will be a key component of the Networked Society. To enable connectivity for a wide range of applications and use cases, the capabilities of 5G wireless access must extend far beyond those of previous generations. These capabilities include very high achievable data rates, very low latency and ultra-highreliability. Furthermore, 5G wireless access needs tosupport a massive increase in traffic in an affordable and sustainable way, implying a need for a dramatic reduction in the cost and energy consumption per delivered bit. 5G wireless access will be realized by the evolution of LTE for existing spectrum in combination with new RAT primarily targeting new spectrum. Key technology components of 5G wireless access include extension to higher frequency bands, advanced multi-antenna transmission, lean design, user/control separation, flexible spectrum usage, device-to- device communication, and backhaul/access integration.

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