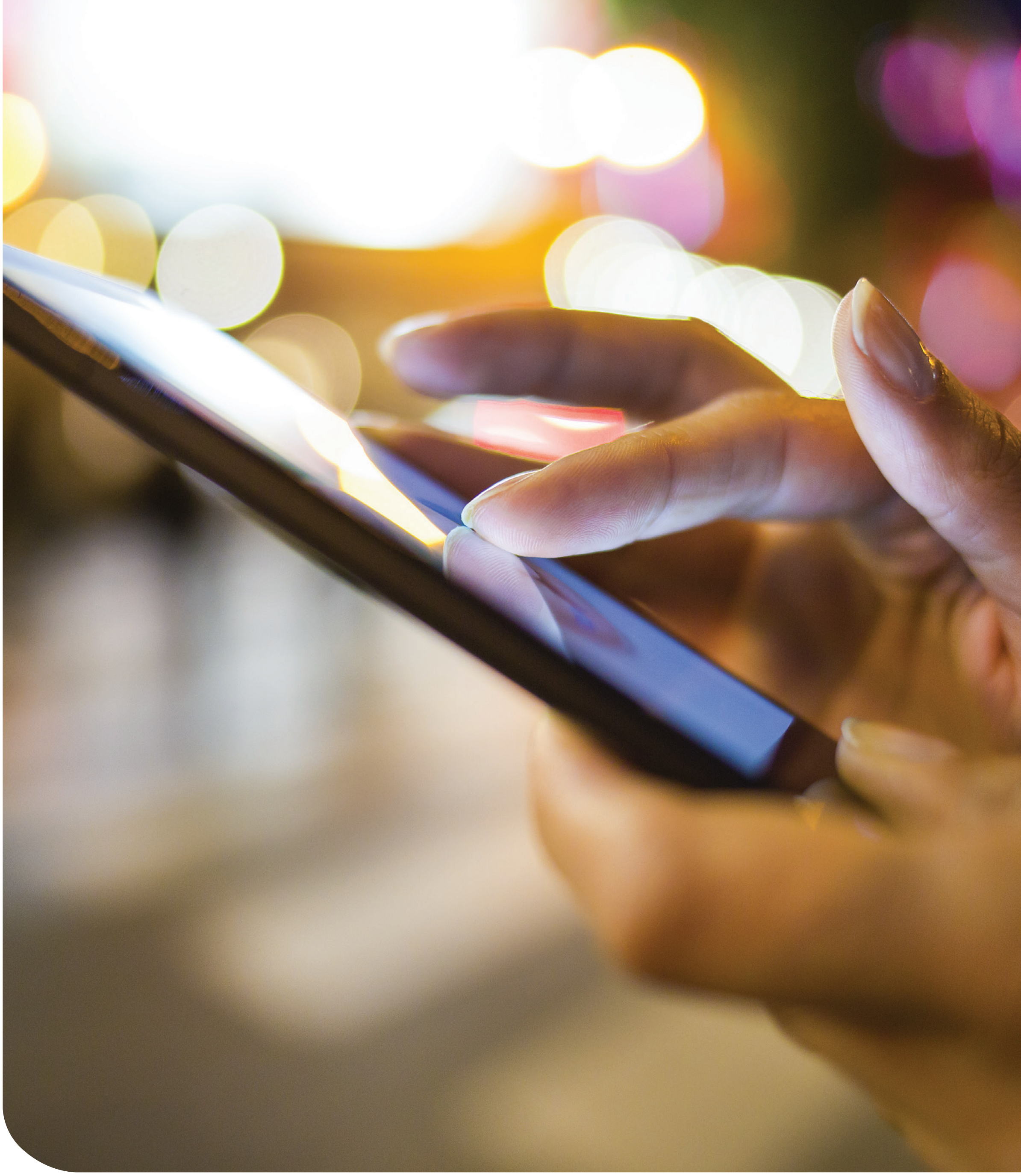

Ten **5G** Challenges for Engineers to Overcome

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As the cellular industry prepares for the move from 4G to 5G in a few years' time, here are ten key challenges that need to be tackled.

Though 4G has not been around for very long, already it is proving insufficient to deal with the diversified needs in terms of denser networks and increased capacity that factors such as the widespread use of smartphones and the emergence of the internet of things (IoT) are expected to bring. This is not the technology's fault; the smartphone revolution had not started when the 4G requirements and technologies were selected, and new applications/services are always evolving.

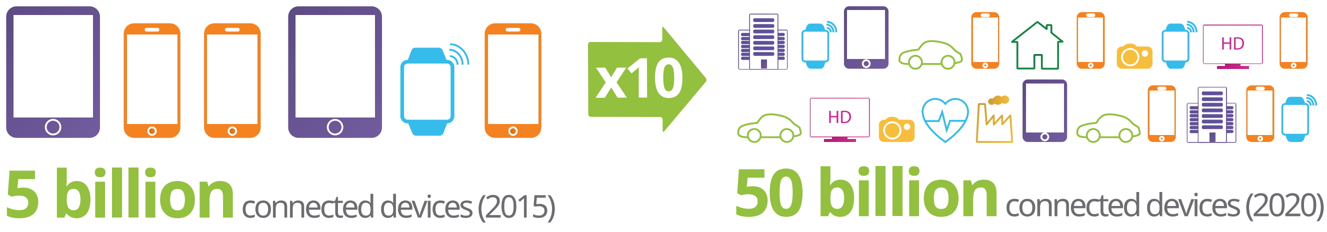
However, overcoming the current limitations of 4G is the principal goal of 5G, a concept that is both an evolution of wireless networks to meet future demands for data and a revolution in architecture to enable a cost conscious network that can be efficiently scaled. The technologies being proposed are also trying to look into the future and support what the networks and demand will look like in 2022 when 5G networks are expected to be deployed on a large scale.

To do this, there are several key challenges to be met in meeting the performance of these future networks using affordable technologies that are still in research and investigation. Here are ten of those challenges.

1- IoT and number of connections

The IoT is predicted to create a massive increase in the number of devices and connections across wireless networks. Some are predicting that billions of devices will be connected to the networks. Although many of these will only be sending and receiving relatively small amounts of data, they will create new demands in the total volume of data and managing the physical number of connections. In current 3GPP-based networks, there are control plane limits on the number of users that can be connected, and scheduling limits to numbers of users transmitting or receiving on specific network nodes, and this limit is unlikely to be sufficient to handle the growth of the IoT. Hence new scheduling and access control mechanisms will be required, as well as reducing the amount of control plane signaling for IoT users.

2 - Data volumes



The volume of data is a key driver for the development of 5G technologies. The amount of data being carried on mobile networks is growing at between 25 and 50 percent a year and this is expected to continue until 2030 at least, not just because of the applications that require higher data rates but also because of the increases in screen resolution and developments in 3D video. Also, LTE established that voice is now not a dedicated circuit switched service but an application also using packet data connectivity. So we see the challenge of data capacity in the end to end network needs to be increased, and this is not only the air interface but the whole access/core network. As new technology evolves then the bottleneck in the system may change, and so new data bottlenecks will need to be overcome.

2.5 exabytes per month (2015) → **x10** → **25** exabytes per month (2020)

1 exabyte = 1 billion billion bytes

3 - Increasing capacity without increasing cost

Users are consuming increasingly more data but are unwilling to pay many more times on their phone bills to cover a hundredfold increase in data. So the challenge is to increase the data capacity of the network without significantly increasing the operating cost. One technology being developed in 3GPP for LTE networks is to separate the distribution of control and user data planes to align to data requirements. A typical example would be to provide the control plane signaling to a wide area using a macro cell and then user plane data via small cells within the coverage of the macro cell. This enables a higher capacity of user plane data within the area without adding complexity. These methods of more efficiently using existing sites/spectrum/infra to increase capacity without adding significant extra cost will be a key challenge for 5G.

4 - Fast and flexible deployment architecture.

Speed of deployment of 3G and 4G was restricted by the speed at which suitable backhaul network capacity could be provided to each new site, and the capacity/flexibility of the backhaul. 5G will be challenged to further develop CRAN as another evolution in network design, complementing the user and control plane separation in the move towards more flexible cloud based networks. In this concept, some functions of the RAN are moved from the cell site back into a consolidated baseband cloud service. This provides a solution to support scaling and economy, leading to deployment flexibility and easier reconfiguration, because the core signaling and intelligence is held within the cloud and the only localized physical elements are the RF transceivers to provide RF connection to users.

5 - Real-time information for critical services

Emergency services, medical monitoring and other critical services require real-time data and a high level of reliability. Wireless networks are increasingly being used, for example, to provide remote patient monitoring and care as well as greater access to let medical staff provide remote support. Police, fire and ambulance services need high-reliability voice links without issues of call dropping and busy networks. Today, some of this is provided using dedicated networks, but these have limited data capacity (narrow bandwidth) and require high investment just to provide reasonable coverage. Future requirements are for high data rates and real-time interaction to allow the services to respond faster. So new network technologies and innovations are required for "ultra reliable" scenarios, where the ability to connect and operate in severely degraded or complete lack of infra-structure must be assured. This is based on using device to device direct communication, ad-hoc backhaul and networking, and flexible re-configuration of networks.

6 - Coping with augmented reality

As augmented reality becomes deployed on portable and personal devices, so the demand on network performance is dramatically increased. A key aspect is that the latency or delay must be very small to enable true interaction between the real and virtual environments. The human brain is very sensitive to time delays when processing visual data thus, unless the delay is small enough, true virtual reality services cannot be delivered. Each step in the link between device and server must be optimized for extreme low latency as well as the overall round trip time. New signal/routing architectures will also be required as the overall latency required cannot be achieved using traditional centralized server architectures. So it is expected that critical low latency services will need infra-structure and architecture to locate the service/server close to the user, to ensure latency between user and service is minimized.

7 - M2M and automotive

While there has been much talk about M2M and its role in the overall IoT, one sector that has been pushing forward in this area is automotive. There are automotive wireless connectivity applications already under development or in early trials and deployment. For example, in-vehicle infotainment is using the vehicle as a hub, and using cellular network as the backhaul. Tests are looking at using the vehicle as a base station or relay node within a network, due to its available battery power.

Intelligent transport systems are creating demand for vehicle-to-vehicle and vehicle-to-infrastructure communications, as well as linking the vehicle to other devices. And an ultimate goal that now looks within reach is fully autonomous driving, but this will require secure and reliable communications for a widespread public deployment (beyond current trials and deployment scenarios that still use driver intervention as a back-up mode).

5G networks should be able to support this, if the network can deliver the capacity/coverage/latency combination required by use of heterogeneous network technologies. The challenge to network architecture/concept/technology is to provide the flexibility to meet these requirements, but also with the high reliability/availability demands of autonomous driving.

8 - Device-to-device

Device-to-device communications have traditionally been outside the realm of cellular networks. These are direct links that do not relay information through the base station or over the network. Such walkie-talkie type devices have been available for a long time but with only narrow spectrum bandwidth and hence limited capacity to transmit data. Previous cellular networks have developed push-to-talk technology to deliver a similar user experience but for critical applications it cannot be guaranteed that the cellular network will have sufficient coverage. Hence, device-to-device communications allowing direct communications are being developed in LTE-A and the challenge is to have a more robust implementation in 5G where the network is designed and optimized to handle these types of communications.

9 - Air interface

One thing that is clear is that a new air interface will be needed. Current research even suggests that several types of air interface will coexist in the same network. From a theoretical perspective, this is ideal but from an operational and economical viewpoint, this would mean significant development costs and deployment effort. New air access schemes need to be developed for several new requirements, and also to improve current access schemes. OFDM used in LTE is limited due to interference, and low interference evolutions will be required to support denser frequency deployments. For wider bandwidth deployments in millimeter wave bands, then optimized waveforms suitable for 1GHz of transmission bandwidth will be required. As MIMO has been successfully deployed into 4G networks, it is expected that 5G will continue to support 5G and also expand further the MIMO capabilities using higher order MIMO and advanced beam-forming. In addition, the current static time/frequency resource allocation blocks must be revised, as more flexible methods of allocating and controlling resource allocations are required. This is driven by the wide diversity of devices expected to connect to 5G networks, with a wide range of resourcing/scheduling requirements.

10 - Network densification

It was seen as soon as 3G networks became congested, mobile operators realized they needed to add more cells and sectors to the system to increase capacity (rather than increase coverage). This has evolved to include many flavors of small cells that offer more connectivity options to the user in high capacity areas (e.g. WiFi access points, home basestations, indoor/shopping center femto cells). With 5G, the networks are likely to consist of several layers of connectivity from a wide area macro layer for lower data speed connectivity, through various other layers, to a localized layer for very high data speeds. Network deployment and coordination are major challenges here that need to be addressed as they increase exponentially with the number of network layers. This creates new challenges for field deployment and coverage optimization, for the access/core network Radio Resource Management (RRM) algorithm optimization, and for device mobility measurement/reporting capabilities.

Conclusion

As discussed, 5G networks will be principally designed for managing a greater diversity of data services, rather than simple browsing/streaming or social networking data capacity increases. Network densification is very suitable for increasing the capacity and data rate to meet future demands. It is likely that the high cost implications of developing an entirely new backhaul network will instead drive the industry to develop new technologies that can re-use and expand existing IP network technology and infrastructure in a more efficient way. To support these requirements, there are already research activities investigating specific technologies for use with 5G networks, with the aim of proposing solutions that will be included into 5G network specifications.

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Specifications are subject to change without notice.

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