Now is the time to prepare for 5G

White Paper

Making networks fit for 5G

The first commercial deployments of 5G networks are just a few years away, approaching fast. Communications Service Providers (CSPs) can gain a substantial competitive advantage by being the first to offer their customers exciting new services enabled by 5G.

In this paper we look at the steps CSPs can take now. Planning in 2017 to prepare for 5G is best focused on transforming network architecture, upgrading transport, adopting new spectrum and deploying new base station site solutions.

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1. Executive summary: preparing for 5G begins today

With the first commercial 5G networks expected to be brought to life around 2019-2020, communications service providers (CSPs) have a relatively short timescale of just two to three years to be ready. By starting now to prepare their networks, CSPs will give themselves the best chance of winning the competitive advantage of being early to market.

The key areas that will require attention include:

- Network architecture – the core network will become more distributed to provide low latency and the radio network will become more centralized for enhanced scalability
- Transport network - capacity will need to be upgraded to support faster data rates and higher capacities
- Spectrum – new bands will need to be used for 5G, both below 6 GHz and at millimeter waves
- Site solutions – it is likely that the practical deployment of 5G will use active antennas with beamforming. New types of cell sites and new deployment models will also be needed, including small cells.

Another aspect to consider is the deployment of new 5G-like services on 4.5G Pro/4.9G networks where possible. These are most likely to be in the areas of Internet of Things (IoT), public safety communications and automotive connectivity.

All these technologies and new services will be necessary to underpin a successful 5G launch and will take time to plan and implement, underscoring the need for 5G preparations to begin straight away.

2. A new network architecture with edge cloud

It is clear that a more distributed core network architecture than is used for today's networks will be a key part of 5G, which will involve cloud implementation. In addition, the radio network architecture will become more centralized. There are two major reasons for this - low latency performance to support new services and extreme scalability to meet rapidly changing demand.

This future network architecture is likely to use Multi-access Edge Computing (MEC) to cache content in an edge cloud and to provide content and processing to support local intranet and internet demands. While 5G technologies can minimize the radio latency, handling content close to the radio access point will also minimize transport latency for the lowest possible end-to-end latency.

This will require the delay-critical radio layers to be located close to the radio access site, while higher layer protocols can be located in the edge cloud. This also allows network capacity to be upgraded in the cloud without costly visits to the radio access site. Such upgrades will be needed, for example, when the CSP needs to connect a large number of IoT devices to the network.

Building this new network architecture will take time and Nokia advises CSPs to start now to consider the number of edge clouds and their locations that they will require.

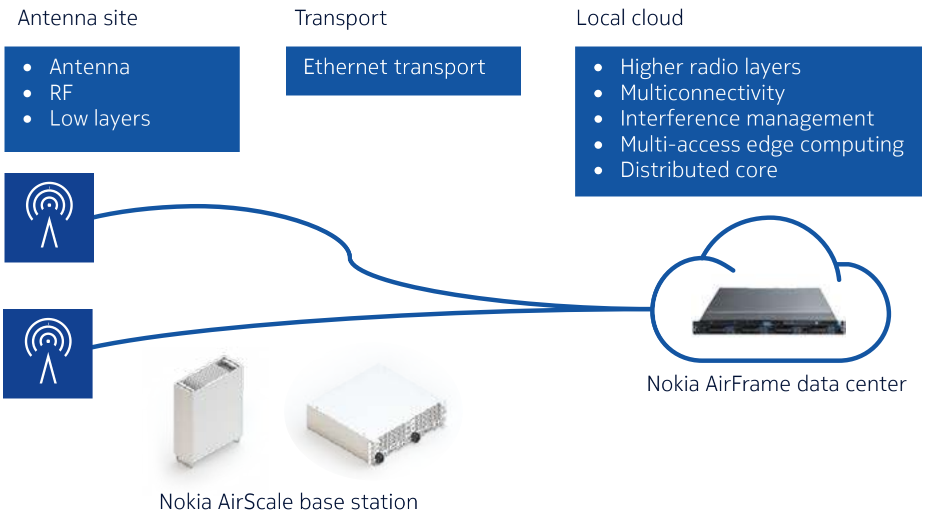

Figure 1: A more distributed network architecture with local cloud will be required for 5G

3. Transport network with high capacity

5G networks will provide high data rates and huge capacity by using more antennas and more cells, placing new demands on transport networks.

A conventional arrangement of centralizing radio processing and using Common Public Radio Interface (CPRI) interfaces would place severe bandwidth and latency requirements on the transport network. Therefore, 5G networks will be able to use other functionality splits to allow different transport capabilities with less demanding requirements.

If the transport network can provide low latency, then more functions can be located in the edge cloud. If the transport network has a higher latency, then more functions can be located at the antenna site. 5G networks will define two split points: one low layer split and one high layer split as shown in Figure 2. Both options have the low part of Layer 1 close to the radio, which minimizes considerably the transport requirements compared to CPRI.

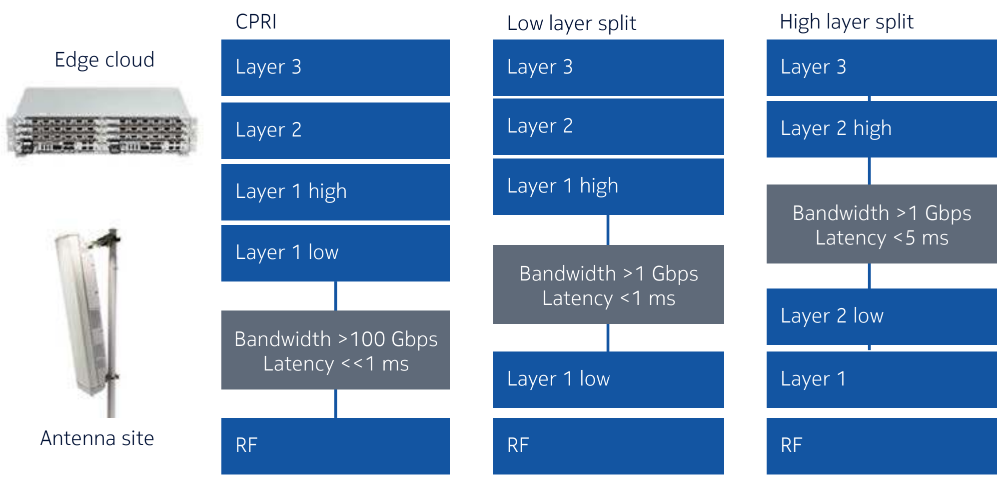

Figure 2: Radio network architecture split. Typical bandwidth and latency requirements for 3.5 GHz deployment with beamforming

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4. New and existing spectrum for capacity and coverage

5G will make use of existing FDD and TDD frequencies, as well as enabling the use of new licensed and unlicensed bands up to 90 GHz .

Millimeter wave bands above 20 GHz will be needed to deliver peak data rates of up to 20 Gbps and extreme local capacity. Meanwhile the sub-6 GHz bands will provide high data rates and low latency while reusing existing base station sites. Universal coverage to support critical services and indoor coverage will be achieved by the sub-1 GHz bands.

The mainstream spectrum options in the early phase of 5G will be 3.5/4.5 GHz, 28/39 GHz and 600/700 MHz followed by many other spectrum options. Spectrum acquisitions need to be planned well in advance to help a CSP access the relevant spectrum blocks it will need for deploying 5G.

Spectrum	5G spectrum per operator	Data rate
20-90 GHz	2000 MHz	20 Gbps
Below 6 GHz	200 MHz	2 Gbps
Below 1 GHz	20 MHz	0.2 Gbps

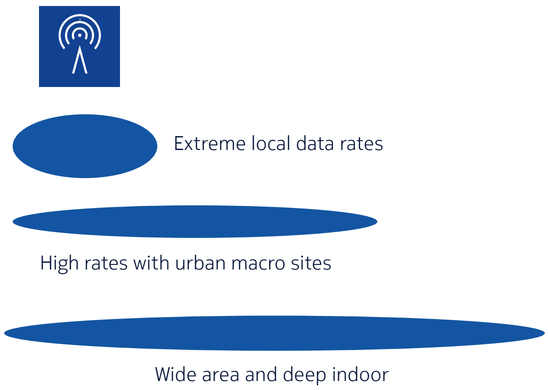

Figure 3: 5G enables CSPs to use all spectrum options

5. Active antennas lower costs and raise reliability

Beamforming with massive multiple input multiple output (MIMO) is an important technology that will help to enable 5G to live up to its promises. Massive MIMO is a proven technology that is already being used on LTE networks, for example, on the 2.6 GHz band to deliver higher data rates and more capacity.

Massive MIMO with 5G will provide even more benefits and becomes particularly important at higher frequency bands as shown in figure 4.

TD-LTE 2.6 GHz 64TRX	5G 3.5 GHz 64TRX	5G 28 GHz 16TRX
• Improves uplink coverage up to 8 dB • Increases cell capacity up to 5 fold • Upgradable to 5G	• Enhances 5G coverage to match LTE at 2 GHz • Increases spectral efficiency with massive MIMO • Enables compact site solution	• Designed for 5G fixed wireless use case • Leverages high bands for densified network deployments • Beamforming improves uplink and downlink signal quality

Figure 4: Nokia massive MIMO deployment options

Massive MIMO uses active antennas in which radio frequency (RF) units are integrated inside the antenna, unlike traditional separate passive antennas and RF units. Active antennas comprise a single integrated unit, making them easy to install and highly compact.

The simple installation, extreme reliability and low maintenance requirements of Nokia active antennas minimizes operational expenses (OPEX). The failure of one or even a few power amplifiers out of the 64 being used will lead to only a marginal loss of RF power. Digital algorithms are used to adjust the transmission weights to minimize the impact of failed units.

In a traditional RF head, a power amplifier failure would require the immediate scheduling of replacement work. An active antenna on the other hand would not need to be replaced because of a few faulty internal units. Even if several units fail, there is still no urgent need for maintenance work.

Figure 5: Example active antenna site solution with solar panels

6. Small cells for focused coverage and capacity

Already widely deployed, small cells will be an important component of 5G networks for delivering hotspot capacity and for improving local coverage.

Small cells can be deployed on sub-6 GHz frequencies, like 3.5 GHz, as well as on high frequencies where limited radio propagation creates a very small cell area. This means that conventional deployment strategies for macro cellular networks cannot be effectively applied to the roll out of small cells; new solutions are needed. Nokia offers a wide portfolio of small cell products (see Figure 6) which allows CSPs to take advantage of small cells today, providing essential experience to support their deployment as part of 5G networks.

Figure 6: The Nokia small cell portfolio for LTE networks

7. Preparing for novel services

5G will be a very capable set of technologies able to support many uses including massive machine communication and critical communication, as well as the more conventional mobile broadband. While traditional mobile broadband customer needs are well established, new applications will attract different customers, have different network requirements, support new devices and require new business models.

CSPs can start to prepare for the new opportunities by launching massive IoT and critical communication services on top of existing LTE, ready to be migrated to 5G in the future.

Narrowband IoT (NB-IoT) enables low cost and low power IoT using LTE. NB-IoT also substantially improves the link budget to achieve excellent coverage, even indoors.

One of the main uses for critical communication is public safety. Conventionally, this has been based on narrowband TETRA or P.25 systems that offer very limited data capability. LTE-based 4.5G networks can open up new possibilities for using data public safety application, such as real-time video. LTE networks offer features that prioritize public safety uses over other traffic. 5G networks will further improve these service capabilities to create new uses compared to 4.5G networks.

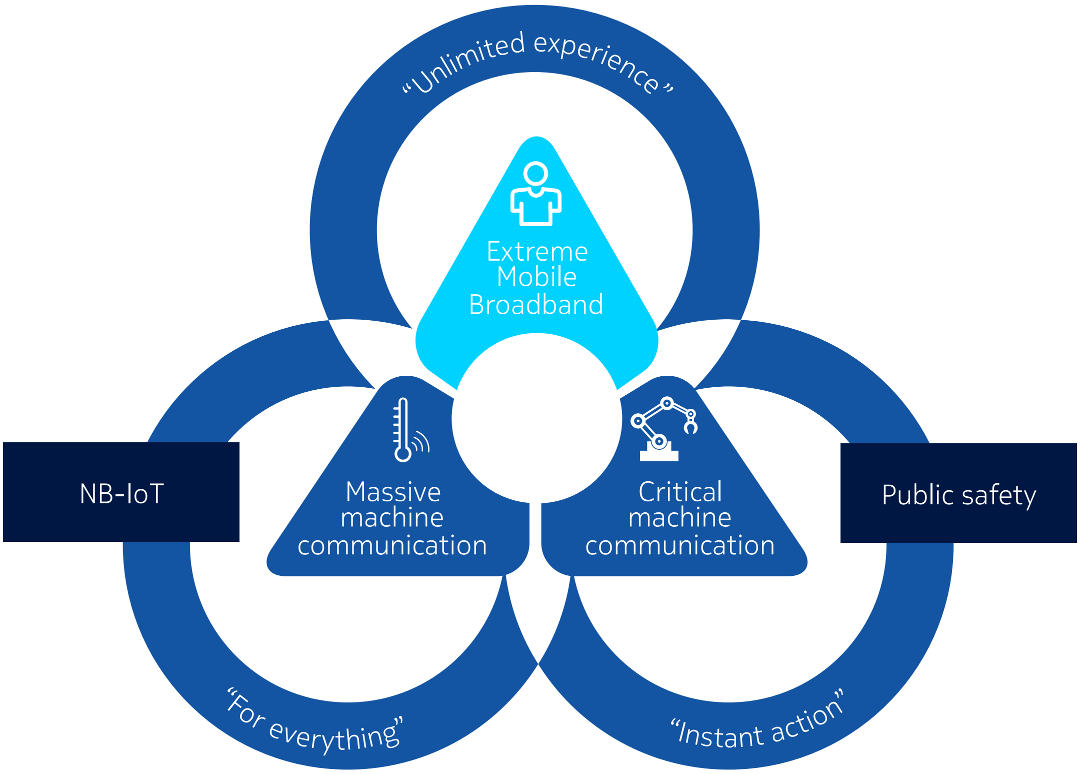

Figure 7: New services can be started on top of 4.5G/4.9G networks

8. Network slicing: creating a network instance for every use

5G networks will be able to support very diverse and extreme requirements for latency, throughput, capacity and availability. Supporting all these different uses cost effectively from one common infrastructure can be achieved with network slicing. The same network infrastructure can support, for example, smartphones, tablets, virtual reality connections, personal health devices, critical remote control and automotive connectivity.

CSPs can even begin to prepare for network slicing using their existing LTE networks. This can be achieved by implementing separate packet cores for mobile broadband and NB-IoT. The new packet core for NB-IoT can be implemented in the cloud including NB-IoT related optimization for control plane and small data transmissions. The solution is illustrated in Figure 8.

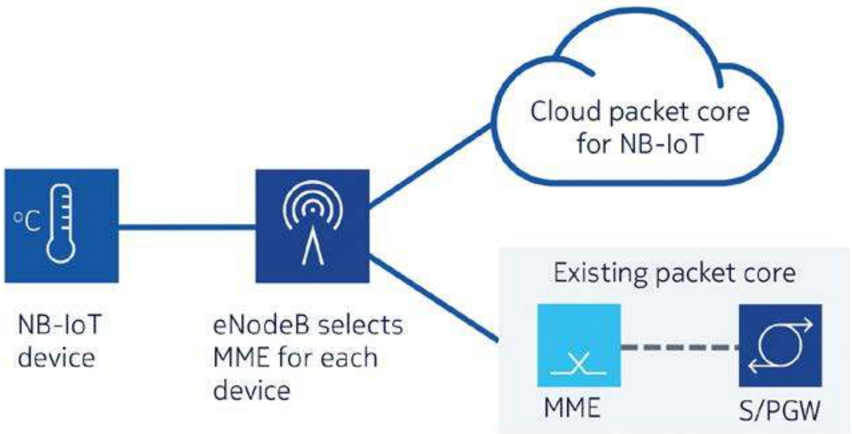

Figure 8: New packet core for NB-IoT in the cloud

9. Conclusions

The world is likely to see early commercial deployments of 5G networks before 2020, giving CSPs limited time to prepare for this new era in mobile communications.

Even though the full standardization of 5G has yet to be completed, there is a range of measures that CSPs can take in 2017 to begin their preparations using their existing LTE networks. These include transport network upgrades with edge cloud distributed architecture, planning for the acquisition of new spectrum, site solution planning for massive MIMO, small cell validations and commercializing new vertical services.

Starting preparations today will give CSPs the greatest chances of early success in what are expected to be fiercely competitive 5G markets.

Further reading

Nokia white paper: “5G Master Plan” https://pages.nokia.com/5g-master-plan.html

Nokia white paper: “5G for Mission Critical Communication” https://pages.nokia.com/GC200007.html

Nokia white paper: “Translating 5G use cases into viable business cases” https://resources.ext.nokia.com/asset/201152

Nokia white paper: “Dynamic end-to-end network slicing for 5G white paper” https://pages.nokia.com/GC200339.html

Nokia white paper: “5G System of Systems white paper” https://pages.nokia.com/GC200012.html

Abbreviations

CPRI	Common Public Radio Interface
IoT	Internet of Things
LTE	Long Term Evolution
NB-IoT	Narrowband IoT

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