WHITE PAPER



5G Network Slicing

A set of logical networks on top of a shared infrastructure







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he promise of 5G is to serve a wide range of use cases with three pillars: Mobile Broadband, Critical Communication, and Massive Internet of Things (IoT). The first release of 5G is clearly focusing on broadband communication to serve the needs of smartphone evolution to offer subscribers more throughput and a better reactivity of the network. The subsequent releases of 5G are now evolving to serve massive IoT, and critical communciation use cases.

Another trend in the industry is the virtualization of network resources. Instead of having one piece of hardware dedicated and optimized to one network function, the network functions could be offered on a commercial off-the-shelf (COTS) hardware or even cloud resources. This enables cost effective and flexible network deployment.

Combining the need to address specific use cases and leveraging network virtualization capabilities leads to the natural network slicing approach. Rather than having a single network serving different use cases, we have network slices that can operate in parallel for specific use cases: broadband, IoT, or critical communication. This leads to additional opportunities to allocate network resources to a specific entity; a private network as a slice dedicated to a factory, for example.

In this paper, we will go into more details on network slicing and then focus on the role of the SIM and its evolution in this area.



5G promise

he promise of 5G when 3GPP (the standardization body of the cellular world) started to work on it was to address use cases that may sound contradictory: Massive IoT, Mission Critical Control, and Enhanced Mobile Broadband. These objectives may seem incompatible as Massive IoT would require a solution (network and devices) that consumes very low power for devices running on battery in order to operate for more than 10 years, whereas Enhanced Mobile Broadband requires offering very high bandwidth.

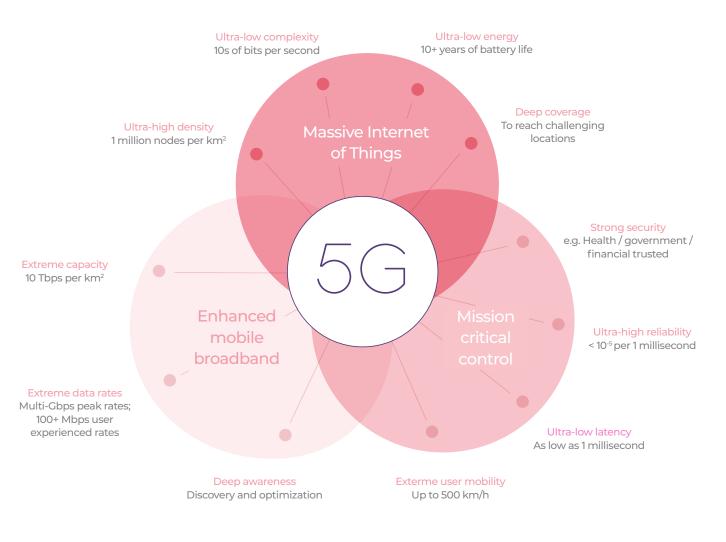


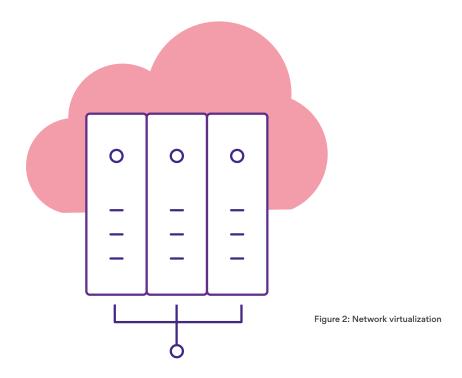
Figure 1: 3 5G pillars

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The first focus of 5G standardization and deployment was to be able to address one of the three pillars, the one that Mobile Network Operators are comfortable with and the most profitable segment at the time: Enhanced Mobile Broadband. This is fully inline with the mobile broadband evolution from 2G to 3G to 4G — offering more and more throughput and better reactivity to the network.

This leaves the other two pillars needing to be better addressed to fulfill the 5G promise: Massive IoT (ex. smart meters) and Mission Critical Control (ex. public safety networks). In addition to the 5G evolution to address Massive IoT and Mission Critical Control, there is another trend in the IT industry that is becoming a reality: network virtualization. In the past, a specific hardware was designed for a specific network function and linked to its dedicated software. Today, there is a need to virtualize these network functions with a software that can run on Commercial off-theshelf hardware or even in the cloud. This brings more cost efficiency, higher reliability, and more flexibility in the design of the network.



Conflicting network requirements and the trends towards network virtualization

naturally lead to the concept of network slicing and thus the implementation in 5G.

Network slicing

n the past, cellular networks were split into two networks types: the Circuit Switch (CS) network managing voice and SMS and the Packet Switch (PS) network dedicated to data. The rationale at the time was that voice cannot wait and data did not have the same constraints (jitter, delay...). This was the case with 3G networks. With 4G came the unification of the two worlds (voice and data) on data network with Voice over IMS over IP. Of course, this merge of networks has been transparent for the end user that is still able to make phone calls over IP and more data services.

In the current context, the two trends mentioned above (contradictory network requirements and network virtualization) have created new challenges. To cope with contradictory constraints, the network can be split again, but virtually, with slices dedicated to one use case.

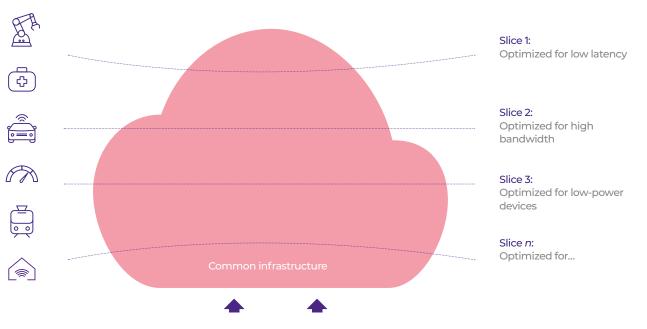


Figure 3: Network slicing

A common infrastructure can be virtually split to dedicate resources for a specific use case. A network slice can be seen as a *virtual* network that is dedicated to a certain type of service or application (e.g. automotive, IoT, or classic mobile broadband) with specific requirements: on functionality (e.g., priority, policy control), in performance (e.g., latency, mobility and data rates), for specific types of users (e.g. public Safety, corporate customers, roamers).

For instance, let us imagine a common infrastructure split into three virtual networks: one network slice could be dedicated to the Massive IoT use case — requiring support for a massive number of devices with low power consumption but with very limited throughput. This could be the case for smart meters, for example. Another network slice could be dedicated to critical communication — use case examples include monitoring factory robots or for firefighters. This network slice would have an extremely low latency service with very high reliability. While the final network slice could be dedicated to mobile broadband to serve smartphones requiring very high throughput.

This opens up additional possibilities for Mobile Network Operators to offer a slice of their network and allocate it to a specific factory. Essentially, this allows MNOs to offer network services to a company that operates a factory which requires dedicated network resources for its robots and equipment to ensure high reliability of its machines' connections.



Figure 4: Private Network Slice

SIM role

he SIM — whether in its traditional, embedded or integrated form — plays a key role in the evolution of network slicing. For the sake of brevity, when referring to the SIM throughout this paper, we are using the umbrella term to cover the SIM in its plastic Form Factor and soldered Form Factor as well as the reprogrammable SIM (eUICC) —where the Mobile Subscription can be changed, and the iUICC — where the SIM functionality is integrated within the baseband of the cellular device.

The basic functionality of the SIM is to authenticate the user subscription to the Mobile Network Operator's network but it can also do much more. It can pre-configure the device with preferred configurations loaded by the Mobile Operator into the SIM. This is the case for the network slicing configuration. The Mobile Operator can configure the SIM with rules to indicate which network slice the traffic of the device application will be directed to and to which a particular charging policy may apply. This is the URSP (UE Route Selection Policy).

The URSP is used by the connected devices to determine how to route applications traffic to the network slicing. This configuration (file) has been introduced with the 3GPP Release 16. 3GPP R16 is the second 5G release, after 3GPP R15 where 5G was first specified by this standard.



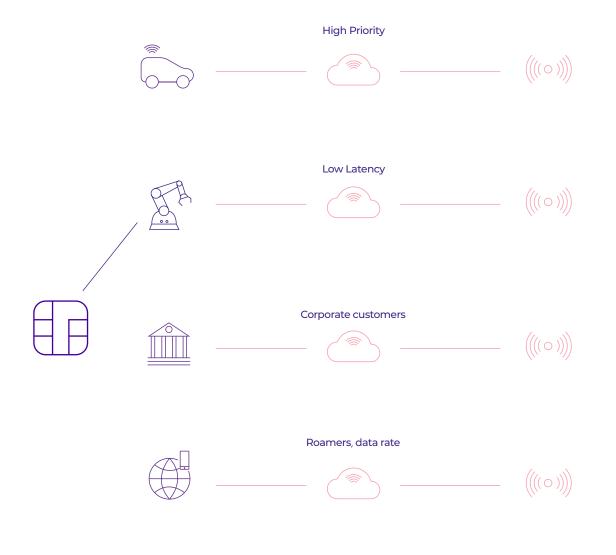


Figure 4: Directing the device application to the right slice

This URSP file with the SIM requires a specific memory format call BER-TLV. In simpler terms, that means that the Operating System (OS) of the SIM needs to support this specific way to manage memory in order to load the format required for this configuration file. The SIM and its evolution needs to support the right format of memory management for the Mobile Operator to be able to configure the appropriated routing of the User equipment for Policy and Charging control.

Conclusion

Network Slicing is a way for Mobile Network Operators to address specific use cases and potentially private network use cases. The SIM is playing a key role by hosting the device and application routing policy to one or the other slice. The Operating System of the SIM needs to be able to cope with a specific memory management format called BER-TLV. Mobile Network Operators shall then consider this feature in their SIM that has been introduced in 3GPP R16 to be able to cope with Network Slicing.

Abbreviations

3GPP	3 rd Generation Partnership Project
BER-TLV	Basic Encoding Rules - Type-Length-Value
CS	Circuit Switch
eUICC	embedded Universal Integrated Circuit Card
IMS	IP Multimedia Subsystem
IP	Internet Protocole
iUICC	integrated Universal Integrated Circuit Card
OS	Operating System
PS	Packet Switch
SIM	Subscriber Identity Module
URSP	User Equipment Route Selection Policy



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