An Introduction to Network Slicing

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1 Introduction

The purpose of this document is to provide an introduction to network slicing functionality, showing how it can be utilised by business customers to help digitise and mobilise their operations, to expand their current business, or to improve their current business processes.

We first define network slicing from the point of view of business customers. Subsequently, we discuss examples of characteristics and features offered by a network slice, giving business customers an initial idea how mobile network services can be customised through network slices to serve their individual requirements. We have provided a set of use cases to illustrate what network slicing can do for business customers.

Throughout this document we will make reference to business customers as the users of 5G services. Business customers are comprised of enterprises, specialised industries (often referred to as "verticals"), as well as individual consumers.

1.1 Abbreviations

Term	Description
5G	5th Generation Mobile Network
API	Application Programming Interface
APN	Access Point Name
AR	Augmented Reality
D2D	Device to Device
eMBB	Enhanced Mobile Broadband
E2E	End to End
GDP	Gross Domestic Product
IP	Internet Protocol
IoT	Internet of Things
NB-IoT	Narrow Band Internet of Things
QoS	Quality of Service
SLA	Service Level Agreement
SLR	Service Level Reporting
URLLC	Ultra Reliable Low Latency Communications
V2X	Vehicle to X (e.g. Vehicle, Infrastructure, Pedestrians)
VR	Virtual Reality

1.2 Network Slicing: The Concept

Communication technology has been a catalyst to the digitalisation of society, and a significant contributor to Gross Domestic Product (GDP) growth across the world. Looking into the future there is no reason to doubt that mobile communications will continue to develop, reaching segments of the industry such as automotive, manufacturing, logistics, energy, as well as sectors such as financial, healthcare and others that are not currently fully exploiting the potential of mobile services. The sub-optimal use of the mobile network is due to the diversity, and even conflicting, communications requirements of such businesses. One business customer, for example, may require ultra-reliable services, whereas other business customers may need ultra-high-bandwidth communication or extremely low latency. The 5G network needs to be designed to be able to offer a different mix of capabilities to meet all these diverse requirements at the same time.

From a functional point of view, the most logical approach is to build a set of dedicated networks each adapted to serve one type of business customer. These dedicated networks would permit the implementation of tailor-made functionality and network operation specific to the needs of each business customer, rather than a one-size-fits-all approach as witnessed in the current and previous mobile generations which would not be economically viable.

A much more efficient approach is to operate multiple dedicated networks on a common platform: this is effectively what "network slicing" allows. Network slicing is the embodiment of the concept of running multiple logical networks as virtually independent business operations on a common physical infrastructure in an efficient and economical way. This is a radical change of paradigm compared to current implementations. With network slicing the 5G network is able to adapt to the external environment rather than the other way around.

Just as digitisation has opened up the consumer market to a previously unimaginable array of experiences (most from outside the mobile ecosystem), we believe that slicing, and the adaption capabilities within, will be a similar catalyst for business customers, enabling them to facilitate their activities in ways we may struggle to even imagine today.

Note: it is fair to observe that a certain degree of customisation is available in 4G networks today through differentiation of Access Point Names, Multi-Operator Core Networks, Dedicated Core Networks. Due to the design decision of optimising 4G to provide an "always on" mobile broadband experience, however, the scope of the customisation is not as sophisticated as what could be achieved in 5G.

Network Slicing technology is maturing rapidly and several operators have already demonstrated slicing in their networks and across networks. With standards for slicing expected to be completed by 2020 we anticipate commercial deployments soon after this date.

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Defining a Network Slice

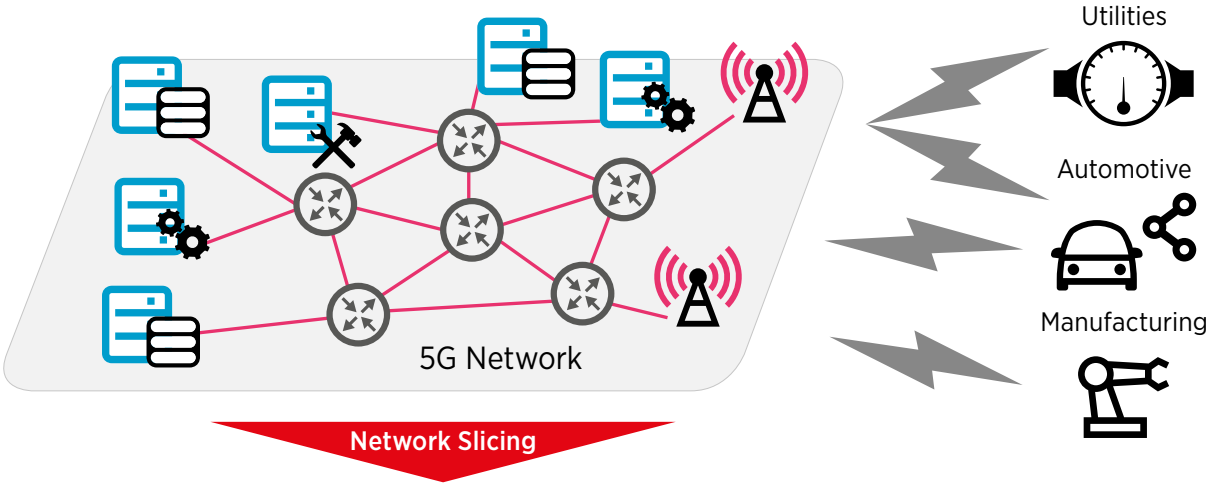
5G networks, in combination with network slicing, permit business customers to enjoy connectivity and data processing tailored to the specific business requirements that adhere to a Service Level Agreement (SLA) agreed with the mobile operator. The customisable network capabilities include data speed, quality, latency, reliability, security, and services.

From a mobile operator's point of view, a network slice is an independent end-to-end logical network that runs on a shared physical infrastructure, capable of providing a negotiated service quality. The technology enabling network slicing is transparent to business customers.

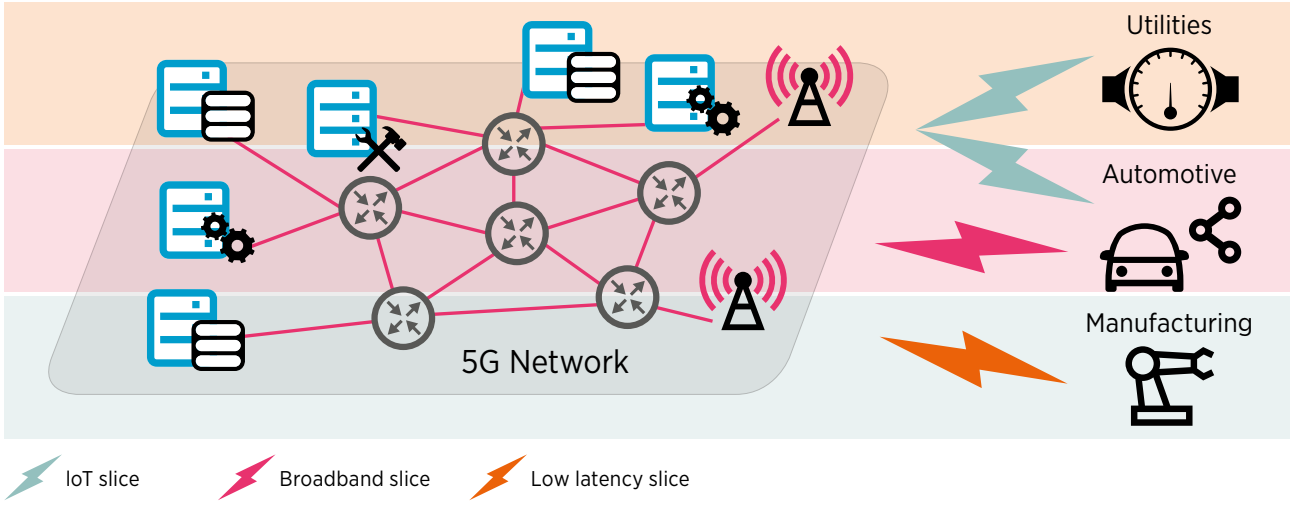
A network slice could span across multiple parts of the network (e.g. terminal, access network, core network and transport network) and could also be deployed across multiple operators. A network slice comprises dedicated and/or shared resources, e.g. in terms of processing power, storage, and bandwidth and has isolation from the other network slices.

Slice types could be defined from a functional or behavioural perspective. It is therefore anticipated that mobile network operators could deploy a single network slice type that satisfies the needs of multiple verticals, as well as multiple network slices of different types that are packaged as a single product targeted towards business customers (a business bundle) who have multiple and diverse requirements (for example a vehicle may need simultaneously a high bandwidth slice for infotainment and an ultra reliable slice for telemetry, assisted driving).

5G networks need to serve customers with very different needs



5G networks subdivided into virtual networks each optimised for one business case



Service Continuity

As the network slice is presented to the user as a normal mobile network, there is no impediment in providing a network slice type to devices that roam outside the home network thus delivering levels of service continuity required for a seamless experience.

From a technical perspective there are at least three ways to secure the availability of a suitable slice in an international roaming scenario:

- The visited network could provide to the international roaming user a network slice with equivalent functionality of the slice used in the home network. For example, the international roaming partners may agree to support a common set common set of standardised slices.
- The home network may export the blueprint of a custom network slice used by a user so that it can be instantiated and administered by the visited mobile network operator.
- The home network may extend the slice into the visited network, provided it has authorisation from the visited network to control the resources.

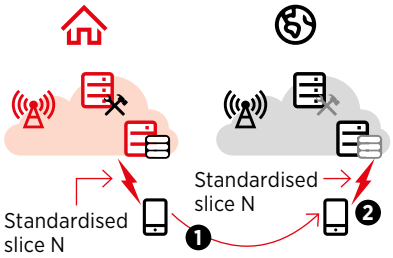
Creating a "Smart" Network

Todays operators are primarily concerned with carrying information from A to B. Limited scope is available for customising the characteristics of their network in order to be able, for example, to provide infrastructure to host third party applications/data embedded within the network or to allow third parties to integrate network functionality in the processes or systems' third parties which have already been deployed: network slicing is set to change this paradigm by unlocking new types of utilisation models, some of which are described below.

Hosting applications: Operators can have the capability of hosting applications (e.g. enterprise applications) as well as to collect relevant data within a network slice. Data collected in the slice together with external sources can be used by machine learning algorithms to predict future trends or to improve analytics, and more generally to improve the performance and efficiency of the enterprise application.

In this scenario, the operator will ensure that mission critical application data and processes on a network slice are completely isolated from other slices that run on the same infrastructure.

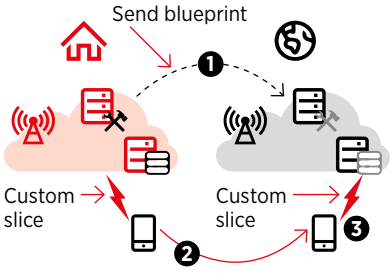
Examples of Instantiating a Network Slice for International Roaming



Standardised slice types

A globally agreed slice type allocated to the international roaming device is instantiated in the visited network

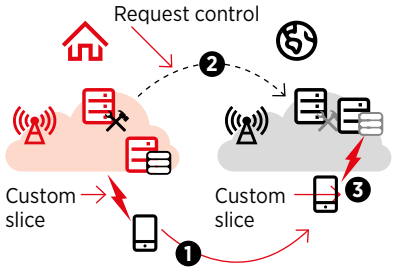
1. The device roams into a visited network
2. The visited network instantiates the same standardised slice



Network slicing blueprint export

The home operator provides the slice blueprint to the visited network who instantiates it for the roaming device

1. The home network exports the custom slice template
2. The device roams in a visited network
3. The visited network instantiates a slice identical to the one used at home



Virtual home slice

With permission from the visited operator the home operator takes control of the network resources in the visited network

1. The device roams to the visited network
2. The home network requests permission to control the visited network
3. The device uses the same slice as when at home

Capability exposure: Operators can offer a business customer the capability to manage their own services or slices (e.g. dimensioning, configuration) by means of Application Programming Interfaces (APIs) offered by the operators according to a contract or SLA. These APIs will also provide access to network-specific information allowing each business customer to derive insights, for instance, into the perceived service quality, current network condition or the environment.

Integration in existing business processes: Some business customers may already have a communication or computation infrastructure in operation, e.g. within an industrial area. If required, this infrastructure can be integrated into the network slice.

Potential Value Chain

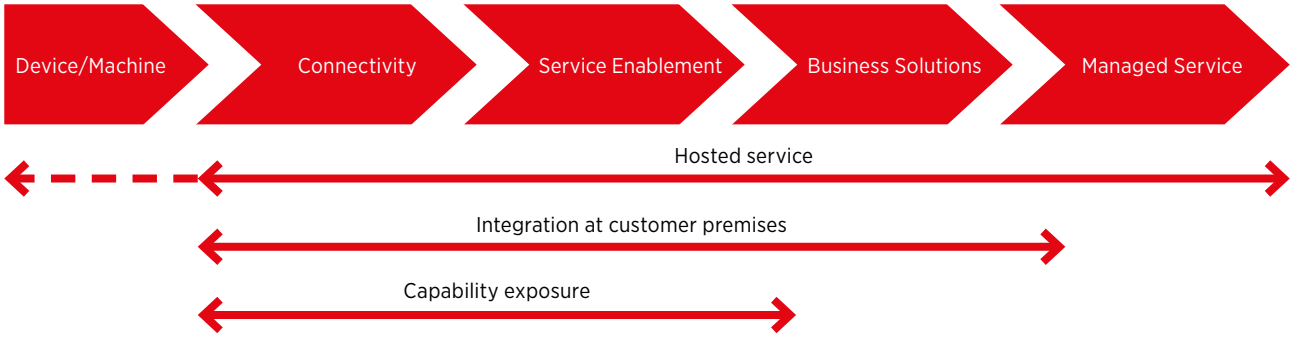


Illustration of the portion of the value chain addressable by operators depending on the business model adopted to serve the network slice to the customer.

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The Network Slicing Blueprint

The salient feature of network slicing is the ability to customise the capabilities and functionality that a mobile network offers to business customers. Such customised service can be logically separated into two components: Network Connection Service or Network Resources Service.

Network Connection Service

Network Connection Service describes the functionality offered to business customers at a connectivity level. The Network Connection Service comprises a set of technical attributes that determine the behaviour of the slice, as well as the topology and geographical spread of a slice. A non-exhaustive list of characteristics that a business customer may require an operator to provide includes:

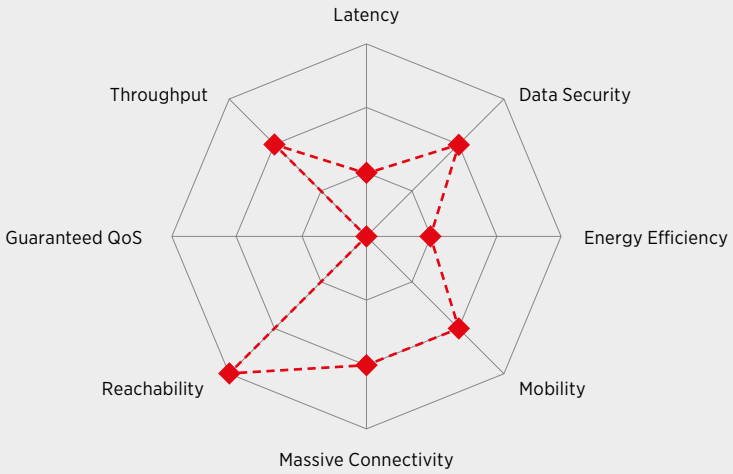
- **Near real-time latency** (end-to-end delay) for services with requirements on very low and stable latencies.
- **Stable and reliable** high upload and download speeds.
- **Guaranteed SLA:** the capability of a network slice to provide certain level of E2E assurance to the requested system functional and performance requirements with appropriate Service Level Reporting (SLR) method.
- **Coverage to ensure** seamless service experience across networks and country boundaries.
- **Connected device management** (of an agreed number), from only a few devices, up to extreme high density of devices/connections also including very specific Device to Device (D2D) connectivity and/or hardware requirements.
- **Seamless mobility** for uninterrupted service delivery and stable quality in scenarios with medium to high velocity (e.g. high-speed train, aviation), across heterogeneous (licensed and unlicensed – e.g. 5G and WiFi) networks that may also belong to multiple different service providers.
- **Energy efficiency** could be provided in the case where ultra-low energy utilisation is required (e.g. NB-IoT scenarios) on the network side, as well as on the device terminal side (e.g. very long battery life).
- **Data security** to satisfy security & privacy requirements beyond today's capabilities and also for extremely sensitive data transmission (e.g. National security, fraud/cyber crime sensitive).

Network Resource Service

Business customers may be granted access to the operator network resources for running proprietary applications. The operator will commit to provide a lifecycle management service, i.e., open lifecycle management capability to the business customer. Besides these network resource services, the network is able to offer additional platform services. The list below details non-exhaustive examples of technology elements which can be used to customise the platform services:

- **Big Data analytics** could be offered as a service to support the data management for orchestration of complex processes or ecosystems.
- **ID / Asset management** for secured, real-time, automated authentication of (and between) assets/devices/users including ID management as a service.
- **Platform security** as a service to provide various levels of security in order to satisfy data security & privacy requirements beyond today's capabilities. This might also include the storage of extremely sensitive data (e.g. National security, fraud/cybercrime sensitive).
- **Dynamic charging** of real-time interactions, based on adaptive customer/market demands.
- **Cloud computing**, that is ubiquitous access to operator's resources such as storage and computing power.
- **Edge computing** for distributed computing and data storage for services with low latency requirements to enable ultra-fast interactions/responsiveness.
- **Partner integration** for easy and instant integration of partners, new entities etc.
- **Positioning** as a service which is tailored to the requirements of the service, e.g. in terms of accuracy and frequency.
- **APIs** providing different control and management capabilities to a vertical, e.g. to adapt the geographical spread of a slice, as well as the provisioning of various types of information from different sources, e.g. perceived service quality, current network conditions, etc. could be provided via the API.

Network slicing customisation

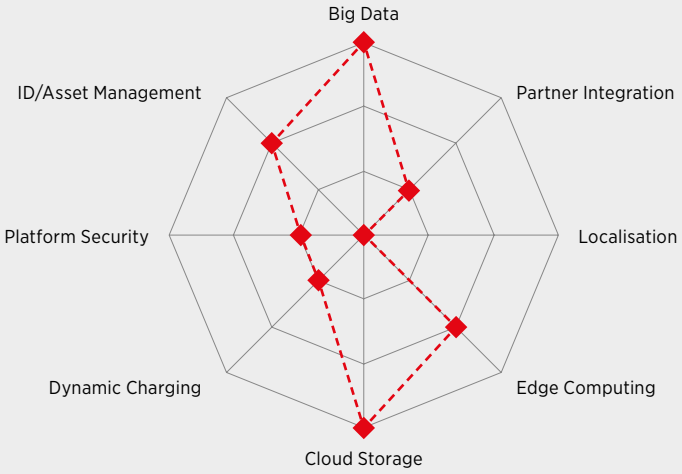


Network Capability

- Latency
- Data Security
- Energy Efficiency
- Mobility
- Massive Connectivity
- Reachability
- Guaranteed QoS
- Throughput

Network Services

- Big Data
- Partner Integration
- Localisation
- Edge Computing
- Cloud Storage
- Dynamic Charging
- Platform Security
- ID Management



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What can Network Slicing do for your Business?

When utilising network slicing, business customers have access to highly customised networks tailored to their specific requirements in a cost effective, timely and efficient way which can be governed by a service level agreement.

The following examples detail a few of the more diverse use cases to highlight the potential of network slicing.

Industry Sectors with high potential for the application of Network Slicing

- Consumer
- Government
- Automotive
- Utilities
- Logistic
- Media & Entertainment
- Industrial Internet
- Financial
- Health & Wellness
- Smart Cities

Example 1: Automotive slice(s)

A modern "connected" vehicle requires an extremely versatile network that can simultaneously deliver high throughput of in-car entertainment, ultra reliability and low latency (URLLC) for assisted/autonomous driving, data gathering and analysis from telemetry sensors, device to device communication and possibly more.

Continuity of service when moving between different operators networks (e.g. international roaming) is an important feature that needs to be provided.

These diverse requirements will be served by a business bundle.

Example 2: Industry automation

A factory may order an URLLC slice from the operator for industrial automation production, allowing the robots in the production line to be controlled and monitored. Control and monitor system developed by industrial manufacturers are recommended to be deployed in edge data centre (i.e., as an edge computing application) through an open interface provided by operators.

Example 3: Slice for the enterprise network

In the traditional network, security requirements of enterprises are usually fulfilled by establishing a private network, or by overlaying additional authentication methods at service level. By introducing network slicing, customised authentication can be implemented during the procedure of slice selection and access. The private network is no longer needed.

For example, a taxi company may require a network slice optimised to dispatch and manage the vehicles. The company can trace the vehicle location, and provide an uncongested route for the vehicle. The company can also dispatch and interact with their vehicles within one slice. With a specialised network slice, they can achieve effective scheduling and better security.

Example 4: Slice for massive IoT

The complexity of network management will be increased if diverse massive IoT terminals exist in the generic network. Operators can deploy different slices for different IoT users. These slices may have special charging and control functions, making network management easier, and deployment faster.

For example, a transport traffic management department may order a massive IoT network slice to monitor and manage the real-time status of their systems. With this slice, they can collect the real-time traffic situation through massive Machine Type Communications terminals. They can then analyse their information and publish it on their monitor screens to inform related users (e.g. with respect to traffic jams). With a specialised network slice, they can support numbers of info collectors, and they could also achieve higher efficiency with lower cost.

Example 5: AR/VR live broadcast

The news, sports or concerts could be broadcast live for users to enjoy through Augmented Reality (AR) or Virtual Reality (VR) technology. AR/VR live broadcast service requires the network with the following features:

- One-to-many downlink connections: This capability requires the network to enable special network functions. For example, in the 5G core network, it requires a multimedia broadcast services function. In the wireless access network, it requires a multi-cell coordinating function for broadcast/multicast transmissions. For the IP backhaul, it requires IP multicast deployment. These requirements are different within a typical network, e.g. for enhanced Mobile Broadband (eMBB).
- High Density Computing: VR/AR technology requires high density computing to deal with AR/VR video processing.
- QoS requirements: In order to guarantee the user experience, a typical VR/AR live broadcast program requires 1Gbps bandwidth and 10 ms ~ 40 ms latency.

The last two features are also required to support immersive video services.

Example 6: Service continuity across multiple networks

Many 5G use cases are based on the expectation of ubiquitous access and network services and will be realised without the need for complicated business engagement with many operators. This is especially significant in Europe and federated countries. For instance, for V2X use cases, vehicles frequently cross country boundaries and need to roam from one operator to another. In such a scenario, the same or similar slice support for V2X use case should be available in the visited operator domain.

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The Future for Network Slicing

This document has sought to outline how the features of Network Slicing allow for the creation of new business models and revenue streams.

Building on this, the GSMA intends to release companion documents covering the following items:

- Policy and Regulatory considerations.
- Study of business relationships between operators and verticals.
- An in-depth analysis of requirements of vertical industries and the definition of default network slice types that satisfy them.

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