Network Slicing to serve Vertical Industry Use Cases.

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24. VDE/ITG Fachtagung Mobilkommunikation
„5G für vertikale Industrien"

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DR. NICO BAYER.
WHO AM I?

Senior Project Manager @ Deutsche Telekom

- Technology Innovation

- Topics: 5G, network slicing, proof of concepts, testbed implementations, access bundling, Wi-Fi, energy efficiency, multihop networks, etc.

Chairman of the GSMA Network Slicing Taskforce (GSMA-NEST)

- The focus of GSMA-NEST is manifold:
  - Vertical industry engagement to discuss network slicing, use cases and requirements
  - Definition of the Generic Slice Template (GST) which a collection of attributes to characterize network slices
  - Identification and definition of a basic set of slices with industry accepted slice characteristics in order to satisfy early marked demand and to simplify global slice availability (roaming)

AGENDA

WHAT IS NETWORK SLICING?

OPERATORS NEED MORE RADICAL APPROACHES TO DELIVER CAPITAL EFFICIENCY AND NEW SOURCES OF REVENUE.

## Global Mobile Data Traffic Forecast by Region

47% CAGR 2016-2021

- Latin America (LATAM)
- Middle East and Africa (MEA)
- Central and Eastern Europe (CEE)
- Western Europe (WE)
- North America (NA)
- Asia Pacific (APAC)

Exabytes per Month

2021 breakdown: 6%, 15%, 10.7%, 8.6%, 13%, 46.7%

[Source: Cisco VNI Mobile, 2017]
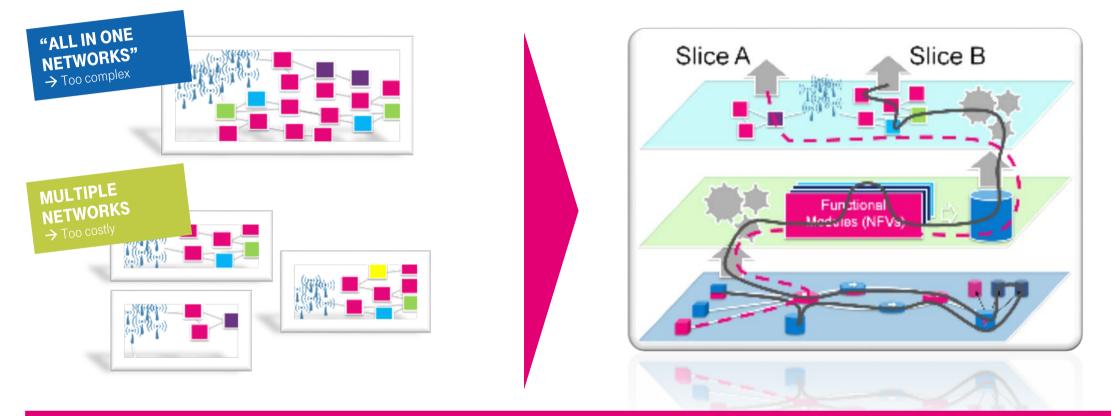
B2B is expected to be the source of incremental revenue but has demanding and diverse requirements.

Extreme Data Rates — up to 20 Gbit/s*

Extreme Capacity — 10 Tbit/s per km²

Energy Efficiency — 10 years of battery life

Ultra-high Reliability — up to 99,999 %

MASSIVE BROADBAND

5G

MASSIVE MACHINE COMMUNICATION

CRITICAL COMMUNICATION

Ultra-high Density — 1 million connections per km²

Ultra-low Latency — 1 - 10 ms

Precise Positioning — < 10 cm accuracy

User Mobility — up to 500 km/h user movement speed

More radical solutions to deliver against customer needs and to deliver a return for future investment are needed.

NETWORK SLICING PROMISES TO ADDRESS VERTICALS' BUSINESS NEEDS IN AN EFFICIENT AND FLEXIBLE WAY.

"ALL IN ONE NETWORKS" → Too complex

MULTIPLE NETWORKS → Too costly

Slice A   Slice B

Functional Modules (NFVs)

Network slicing: tailored virtual networks on a single physical infrastructure as a potential enabler for the B2B business.
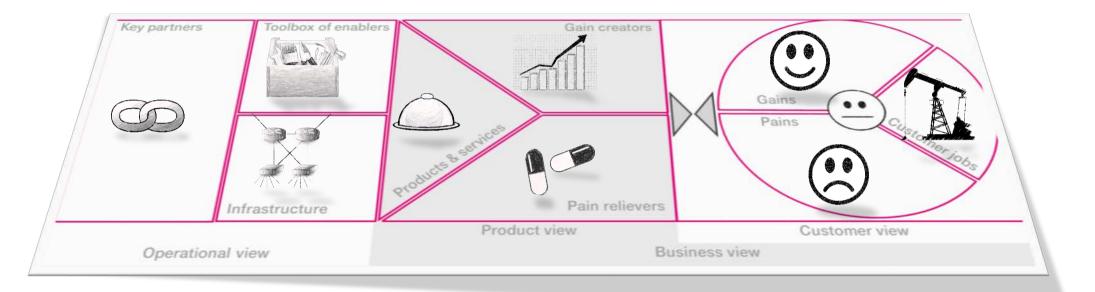
DIVERSE SLICES ON TOP OF A COMMON INFRASTRUCTURE.

5G slice 1 (smartphones)

Smartphones

RAT*1 / RAT2

CP*/UP* CP CP/UP UP UP

5G slice 2 (autonomous driving)

D2D

Automotive devices

RAT1 / RAT2

CP/UP CP/UP Vertical AP*

5G slice 3 (massive IoT)

Massive IoT devices

RAT3 / RAT1

CP UP

...

* CP = Control Plane, UP = User Plane, Vertical AP = Vertical Access Points, RAT = Radio Access Technology

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THE NETWORK SLICING CANVAS PROVIDES DIFFERENT VIEWS ON NETWORK SLICING.

The interpretation of the business model canvas by A. Osterwalder for network slicing.

Operation: Isolation of common physical resources in an automated and efficient way.

Business: Network slicing is about selling tailored networks with certain characteristics and quality guarantees (SLAs).

BUSINESS ASPECTS OF NETWORK SLICING.

CUSTOMER VIEW IS ABOUT THE USE CASES AND REQUIREMENTS OF THE VERTICAL INDUSTRY CUSTOMERS.

Customer view

Vertical Industries
Automotive
Logistics & Transportation
Industry 4.0
Health & wellness
Education
Utilities
Media & Entertainment
Financials
Smart Cities
Agriculture
...

VERTICAL INDUSTRIES

USE CASES

REQUIREMENTS

Operational requirements

Functional requirements

Performance requirements

A Network Slice Instance provides the network characteristics which are required by a Service Instance and contains several Network Slice Subnet Instances (NSSIs).

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USE CASES ARE MANIFOLD AN DIVERSE.

# EXAMPLE: REQUIREMENTS FOR INDUSTRY 4.0.
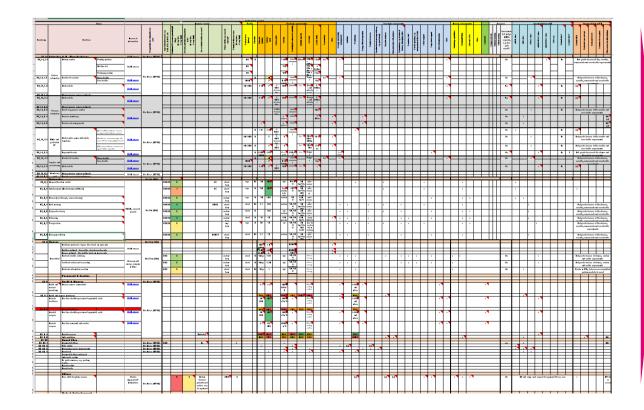
Source: 5G-ACIA whitepaper "5G for Connected Industries and Automation"*.

Use case (high level)		Availability	Cycle time	Typical payload size	# of devices	Typical service area
Motion control	Printing machine	>99.9999%	< 2 ms	20 bytes	>100	100 m x 100 m x 30 m
	Machine tool	>99.9999%	< 0.5 ms	50 bytes	~20	15 m x 15 m x 3 m
	Packaging machine	>99.9999%	< 1 ms	40 bytes	~50	10 m x 5 m x 3 m
Mobile robots	Cooperative motion control	>99.9999%	1 ms	40-250 bytes	100	< 1 km²
	Video-operated remote control	>99.9999%	10 – 100 ms	15 – 150 kbytes	100	< 1 km²
Mobile control panels with safety functions	Assembly robots or milling machines	>99.9999%	4-8 ms	40-250 bytes	4	10 m x 10 m
	Mobile cranes	>99.9999%	12 ms	40-250 bytes	2	40 m x 60 m
Process automation (process monitoring)		>99.99%	> 50 ms	Varies	10000 devices per km²	

Source: ZVEI

Source: https://www.5g-acia.org/fileadmin/5G-ACIA/Publikationen/Whitepaper_5G_for_Connected_Industries_and_Automation/WP_5G_for_Connected_Industries_and_Automation_Korrektur_Download.pdf
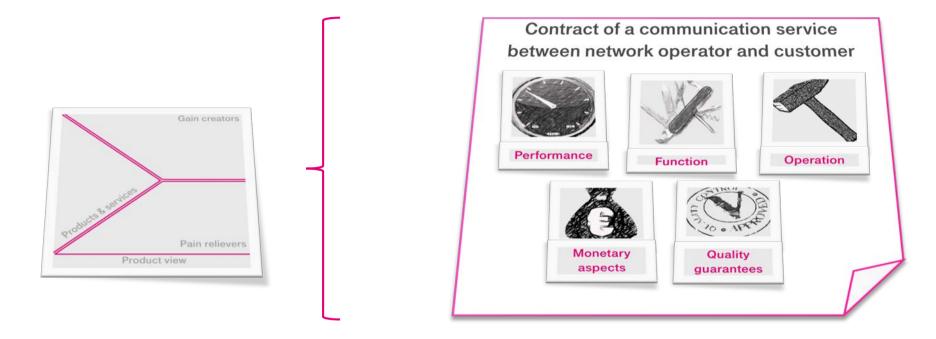
MORE DETAILS ON USE CASES AND REQUIREMENTS.

Network Slicing Use Cases Requirements

5G networks, in combination with Network Slicing, permit business customers to enjoy connectivity and data processing tailored to their specific business requirements. Mobile communications provided by smart networks will enhance the efficiency and productivity of business processes and create more opportunities for operators to address business to business segments.

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NETWORK SLICING TRANSFORMS THE BUSINESS FROM THE ONE SIZE FITS ALL PARADIGM TO CUSTOMIZED SERVICE OFFERINGS.

Contract of a communication service between network operator and customer

Performance | Function | Operation

Monetary aspects | Quality guarantees

Gain creators
Products & services
Pain relievers
Product view
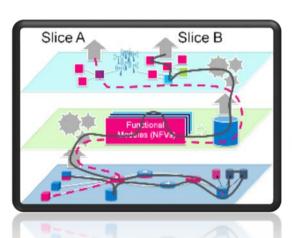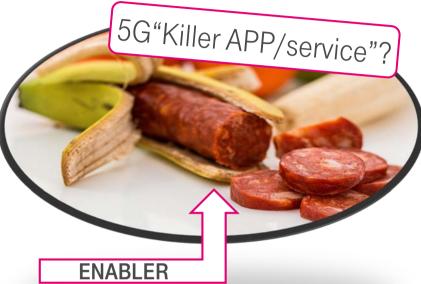
The value proposition of network slicing are tailored networks with certain characteristics and quality guarantees (SLAs).

BESIDES SERVING THE PULL MARKET NETWORKING SLICING SERVES THE EVEN MORE IMPORTANT PUSH MARKET.

5G"Killer APP/service"?

Dynamic Map Update | New AR Solutions | Campus Networks | Massive Video Uploads

Reliable Connectivity | Asset Tracking

NEED/DEMAND

Slice A | Slice B

Functional Modules (NFVs)

ENABLER

PULL: Deliver against the needs and requirements of vertical industries.
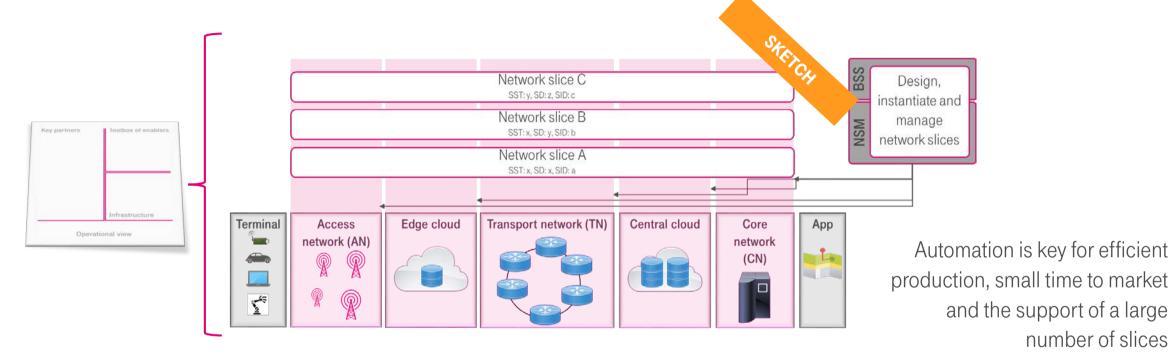
PUSH: Flexible infrastructure and solution which makes us prepared to efficiently deliver against the unexpected

Flexible infrastructure and solutions in order to serve the expected as well as the unexpected in a flexible and efficient way.
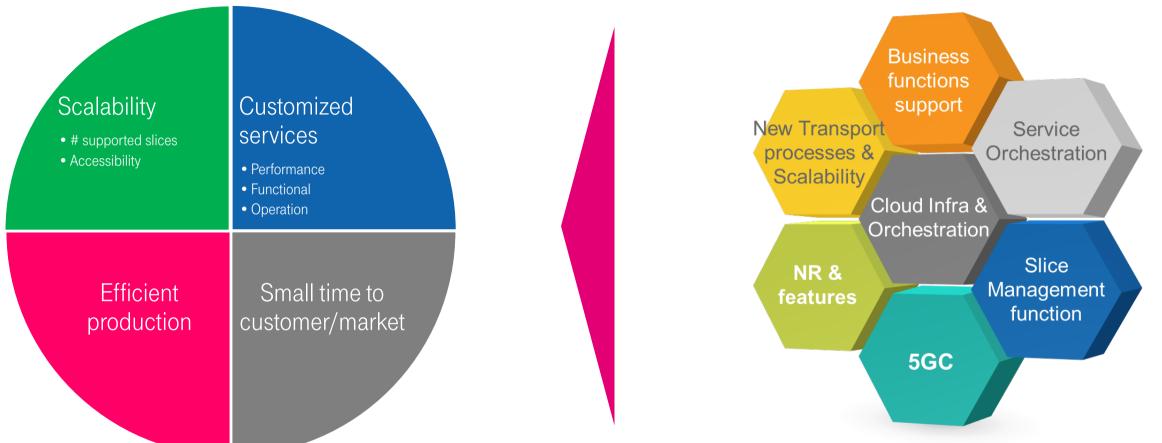
TECHNICAL ASPECTS OF NETWORK SLICING.

THE OPERATIONAL VIEW IS ABOUT HOW THE SLICE IS IMPLEMENTED AND IS TRANSPARENT TO THE SLICE CUSTOMER.

SKETCH

Key partners | **Toolbox of enablers**

Infrastructure

Operational view

Network slice C
SST: y, SD: z, SID: c

Network slice B
SST: x, SD: y, SID: b

Network slice A
SST: x, SD: x, SID: a

BSS

NSM

Design, instantiate and manage network slices

Terminal

Access network (AN)

Edge cloud

Transport network (TN)

Central cloud

Core network (CN)

App

Automation is key for efficient production, small time to market and the support of a large number of slices

Network slicing needs to consider the whole E2E chain and each network slice subnet needs to support network slicing - waiting for 3GPP Rel. 16+ is not enough.
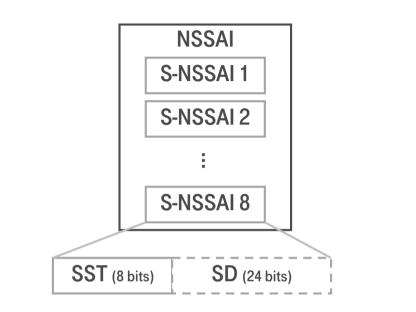
NETWORK SLICING – A HIGH LEVEL TECHNICAL DEFINITION.

Scalability
- # supported slices
- Accessibility

Customized services
- Performance
- Functional
- Operation

Efficient production

Small time to customer/market

Business functions support

Service Orchestration

New Transport processes & Scalability

Cloud Infra & Orchestration

NR & features

Slice Management function

5GC
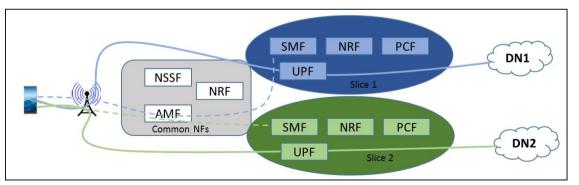
Network slicing: Provisioning of customized services in a scalable and efficient way with small time to customer/market.

IDENTIFICATION AND SELECTION OF NETWORK SLICES.
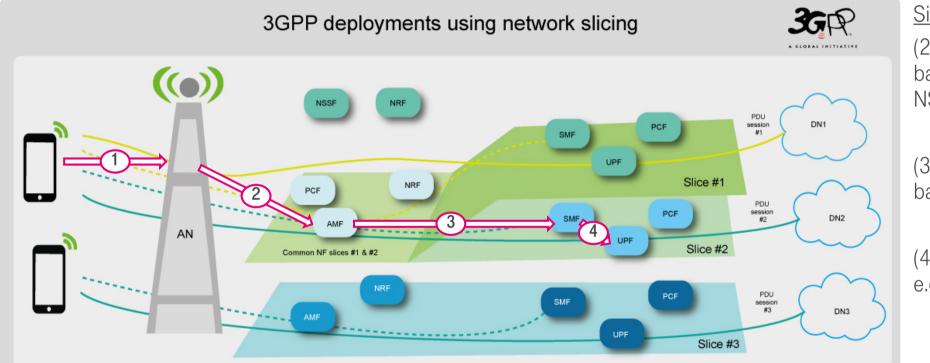
- Identification of a Network Slice is done via the Single Network Slice Selection Assistance Information (S-NSSAI).

- The NSSAI is a collection of S-NSSAIs.

- A single UE may be served by at most eight Network Slices at a time.

- The S-NSSAI signaled by the UE to the network, assists the network in selecting a particular Network Slice instance.

- An S-NSSAI is comprised of:
  - A Slice/Service type (SST), which refers to the expected Network Slice behavior in terms of features and services;
  - A Slice Differentiator (SD), which is an optional information that complements the Slice/Service type(s) to differentiate amongst multiple Network Slices of the same Slice/Service type.

- The S-NSSAI may be associated with a PLMN (e.g., PLMN ID) and have network-specific values or have standard values.

Source: 3GPP https://sdn.ieee.org/newsletter/december-2017/network-slicing-and-3gpp-service-and-systems-aspects-sa-standard

NETWORK SLICE SELECTION BASED ON NETWORK SLICE SELECTION ASSISTANCE INFORMATION (NSSAI).

3GPP deployments using network slicing

Source: 3GPP https://www.3gpp.org/news-events/1930-sys_architecture

Simplified process

(2) gNB selects the AMF based on requested NSSAI provided in (1).

(3) AMF selects SMF, e.g. based NSSAI provided in

(4) SMF selects the UPF, e.g. based on NSSAI

The AMF instance that is serving the UE is common to all the network slice instances that are serving the UE.

GLOBAL SLICE AVAILABILITY.

Scenario 1: Usage of standardized slice types.

1. HPLMN and VPLMN have a roaming agreement for standardized slice types.

2. The device roams into the visited network and requests access to a standardized slice type.

3. The visited network validates the request and assigns a standardised slice type (NEST) to the roaming device.
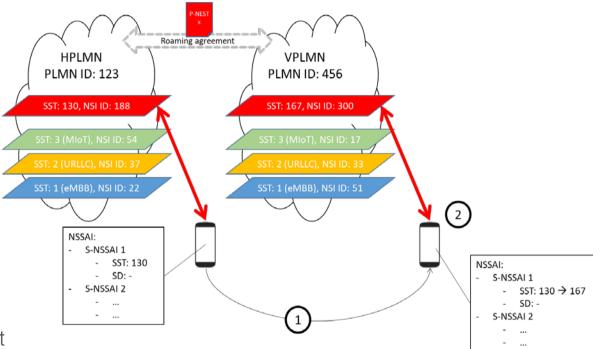
Requires revision of traditional roaming agreements in order to consider quality guarantees and service level agreements.

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GLOBAL SLICE AVAILABILITY.

Scenario 2: Network slice type export.

1. The HPLMN does have a roaming agreement with the VPLMN and the home operator provided the P-NEST of the network slice to the visited operator.

2. The visiting network operator instantiates the slice based on the P-NEST.

3. The device roams into the visited network and aim to connect to its individual slice.

4. Mapping of the Subscribed S-NSSAIs values to the S-NSSAI values used in the VPLMN.

5. Device will be connected to the network slice instance .

6. Depending on how long the instantiation might take, it might make sense to pre-instantiate the slice.

Requires revision of traditional roaming agreements in order to consider quality guarantees and service level agreements.

DTAG NETWORK SLICING TRIAL ACTIVITIES – CURRENT FOCUS ON CAMPUS NETWORKS.

DTAG NETWORK SLICING TRIAL ACTIVITIES.

CURRENT FOCUS ON CAMPUS NETWORKS.

EXAMPLE FOR A CAMPUS AREA.

Factory Floor

Warehouse

Office

Utilities

Outdoor Intralogistics

Security Infrastructure

PUBLIC NETWORK COVERAGE.

Public cellular coverage

LOCALLY ENHANCED CELLULAR COVERAGE.

Locally enhanced cellular coverage

Public cellular coverage
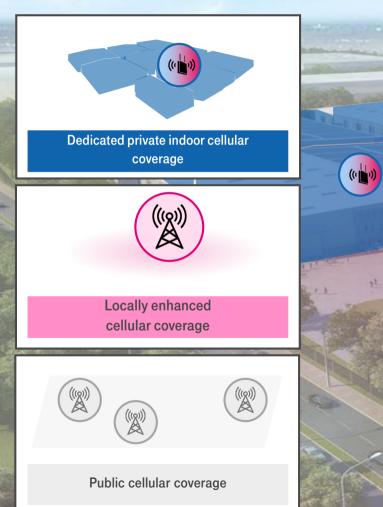
CAMPUS SOLUTION WITH PUBLIC AND PRIVATE LAYER.

Dedicated private indoor cellular coverage

Locally enhanced cellular coverage

Public cellular coverage
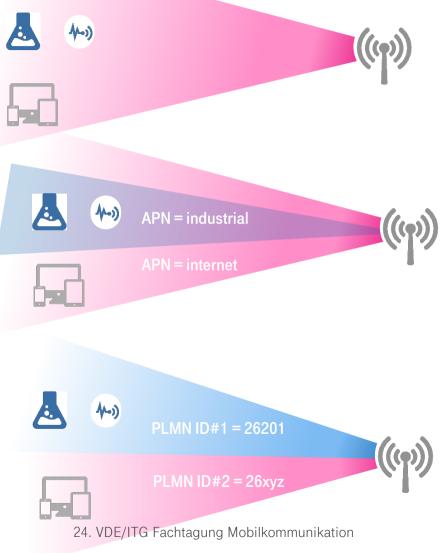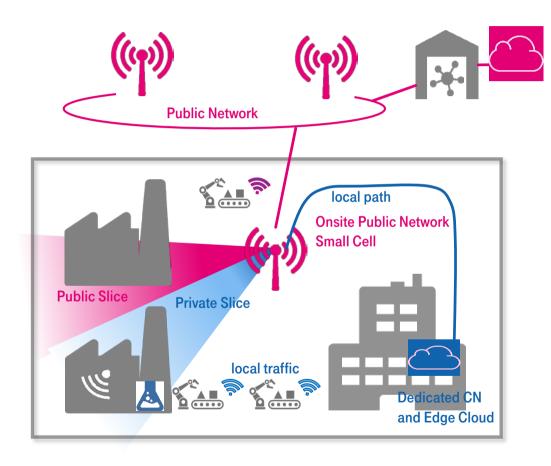
PROVIDE BOTH PUBLIC AND PRIVATE COVERAGE.
DUAL SLICE APPROACH.

- 1st step: Provide public coverage on Campus (as today, business model network-as-a-service)

- 2nd step: Use RAN to fulfil the demands for both public as private network

- Independent from RAN technology used (LTE, 5G NR), this can be seen as an early implementation of "5G network slicing"

- Basic solution based on APN/IP VPN (available today, business model network-as-a-service)

- Advanced solution based on separate PLMN ID

APN = industrial

APN = internet

PLMN ID#1 = 26201

PLMN ID#2 = 26xyz

DUAL SLICE ADVANCED SOLUTION.
## "DUAL SLICE" TO PROVIDE PUBLIC AND PRIVATE NETWORK.
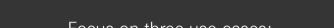
- Reuse of public infrastructure / cells to construct the 2nd layer – private slice

- Combined radio layer with guaranteed resources and dedicated PLMN ID

- Managed 2nd Core Network, to keep traffic local and achieve high customer autonomy

- Network-as-a-Service (NaaS) offering matching the customer demand and understanding of a private network

- Mid term: Customer self-admin, dashboard, ..

TRIAL WITH HAMBURG PORT AUTHORITY

Focus on three use cases:

- <u>Traffic light control</u>: Traffic lights which are connected through wireless connection; reliable and resilient; data integrity

- <u>Video streaming</u>: Support on-site workers through AR; use of VR in port planning

- <u>Sensor measurements</u>: Sensor measurements on barges which must be connect through wireless terminals

Blldquelle: Hafen Hamburg / Michael Lindner / Peter Glaubitt / Dietmar Hasenpusch

OSRAM CAMPUS TRIAL.
KICK-OFF @ MWC 2019.

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Campus Network opening
Live from OSRAM plant Schwabmünchen

OSRAM CAMPUS TRIAL.
DETAILS CAN BE FOUND IN THE FOLLOWING VIDEO.

https://www.telekom.com/ajax/de/564156?modId=&ratio=%5Blandscape_ratio16x9%5D

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DTAG & CENTER CONNECTED INDUSTRY.

Center Connected Industry (CCI)

- CCI aims to unite industry and technology companies in order to set up innovations particularly in the area of future logistics

- Joint projects are supposed to prototype industrial use cases in a demonstrational factory in Aachen at first

- Prototyping of end-to-end campus network solutions
    - Dual slice approach in the beginning and 5G in the later phases
    - Infrastructure available in August

- https://connectedindustry.net/

ERLEBEN, WAS VERBINDET.

CCI OPPORTUNITIES: USE CASE TRIAL & SHOWROOM.

Area for indoor use cases

Showroom & workshop area

Events & presentations

Free space for outdoor use cases

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SUMMARY & CONCLUSIONS.
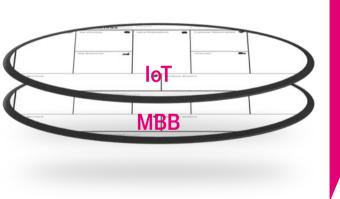
SUMMARY & CONCLUSIONS.

- Network slicing from a business point of view is about selling tailored networks with certain characteristics as well as quality guarantees and a major opportunity for operators to establish new types of business models

- Network slicing is an efficient and flexible way to offer tailored services based in virtual networks implemented on a single physical infrastructure

- Besides serving the B2B market networking slicing prepares us for the unexpected
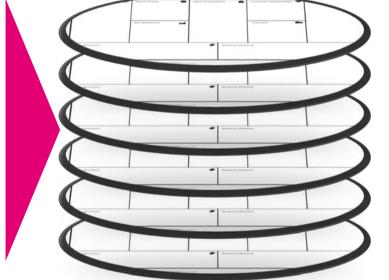
NETWORK SLICING REPRESENTS A MAJOR OPPORTUNITY FOR OPERATORS TO ESTABLISH NEW TYPES OF BUSINESS MODELS.

TODAY operators serve a few business models

TOMORROW operators flexibly serve a large number of business models

IoT

MBB

Each business model does have...

- ...key activities and key resources
- ...an eco-system with key partners
- ...a value proposition
- ...customers and relationships with them
- ...channels to reach out to the customers
- ...cost and revenue structure

Source: https://www.strategyzer.com

Operators have to understand the business transformation coming with the introduction of network slicing.

WOULD YOU LIKE TO KNOW MORE?

THANK YOU.