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5G Network Slicing - The Panacea for Realtime Network Reliability, Data, and Latency Challenges

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Programmable Realtime Networks
RealTime Communications (RTC)
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5G Network Slicing

- 5G Network Slicing Context
- 5G Wireless Platform
- Network Slicing Solution
- Network Slicing Provisioning
- Ultra Reliable Low Latency Offer

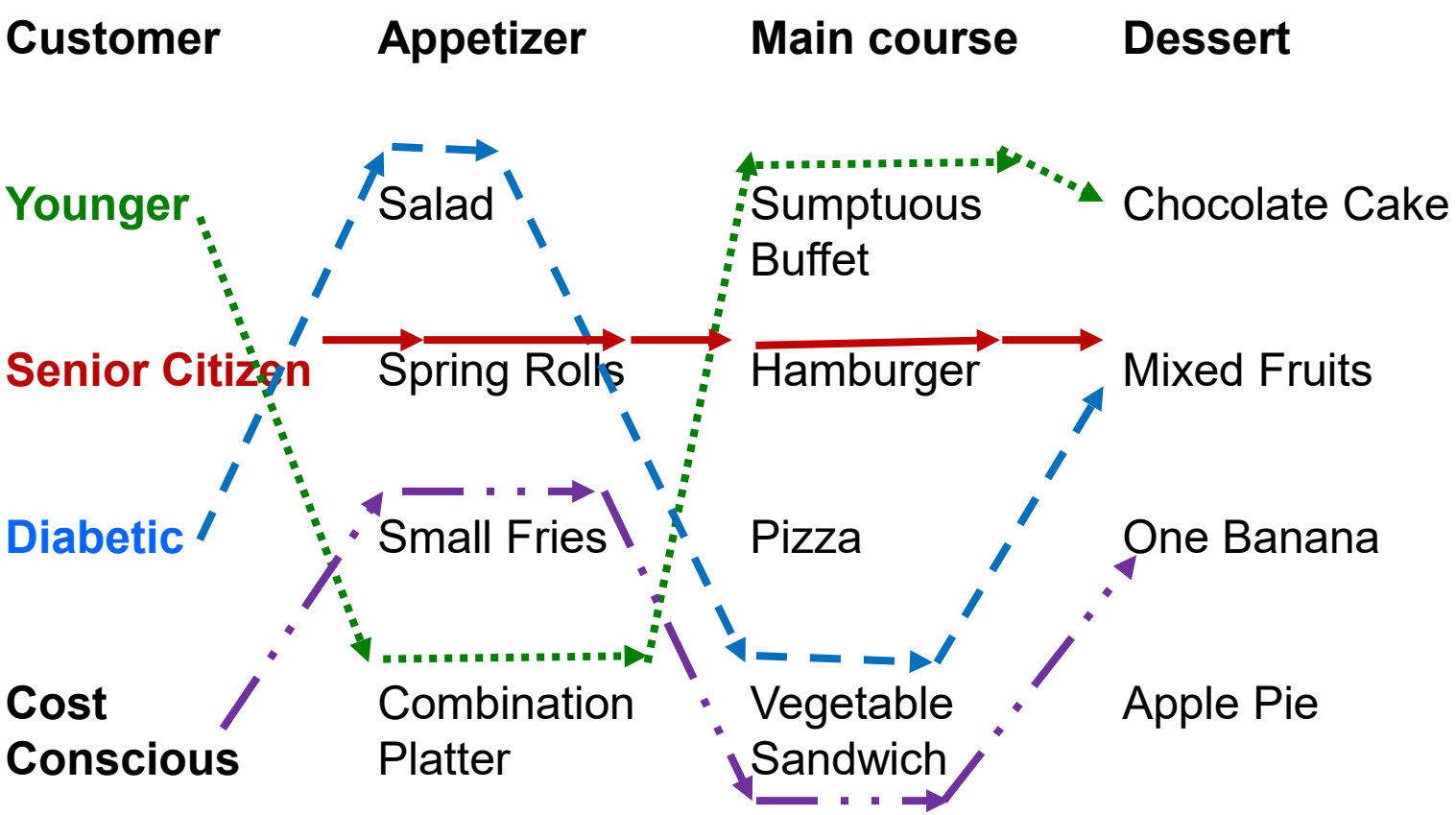
Network Slice

- Virtual, Independent End-to-end Networks within the Mobile Operator's Physical Network
  - Radio Access Network (RAN), Transport, Core, and Mobile Edge
- Different Requirements on Functionality
  - Priority, Charging, Policy Control, Security, and Mobility
- Differences in Performance Requirements
  - Latency, Mobility, Availability, Reliability and Data Rates

A service-oriented views.

Slicing – Restaurant Example

Typical Customer Requirements: Expense, Calories, Carbs, Sugar content



4G versus 5G Network Slicing

4G:

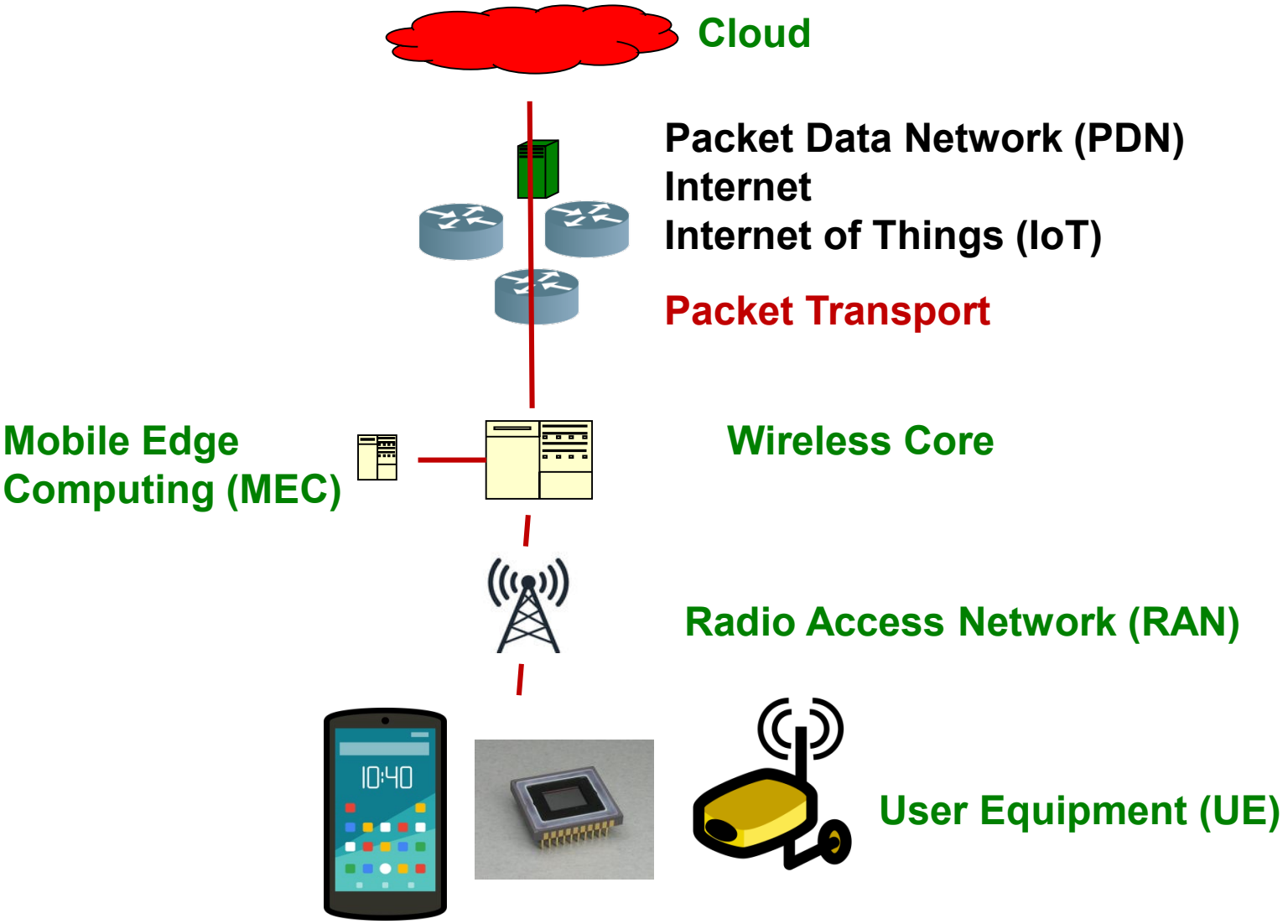
- Use Access Point Name (APN), Virtual Private Networking (VPN), and Fixed Networks
  - Limitations
    - Configurations had to be Hardcoded
    - Process Highly Manual and Cumbersome
    - Lack of Flexibility and Differentiation

5G:

- Service Flexibility and Ability to Deliver Services Faster
  - High Security, Isolation, and Applicable Characteristics
  - Efficient Usage and Management of the Network Resources
  - Differentiated Services at Scale

Flexible, programmable, with open interfaces

5G Architecture



Voice + Data + Video + Machine Type Communication (MTC)

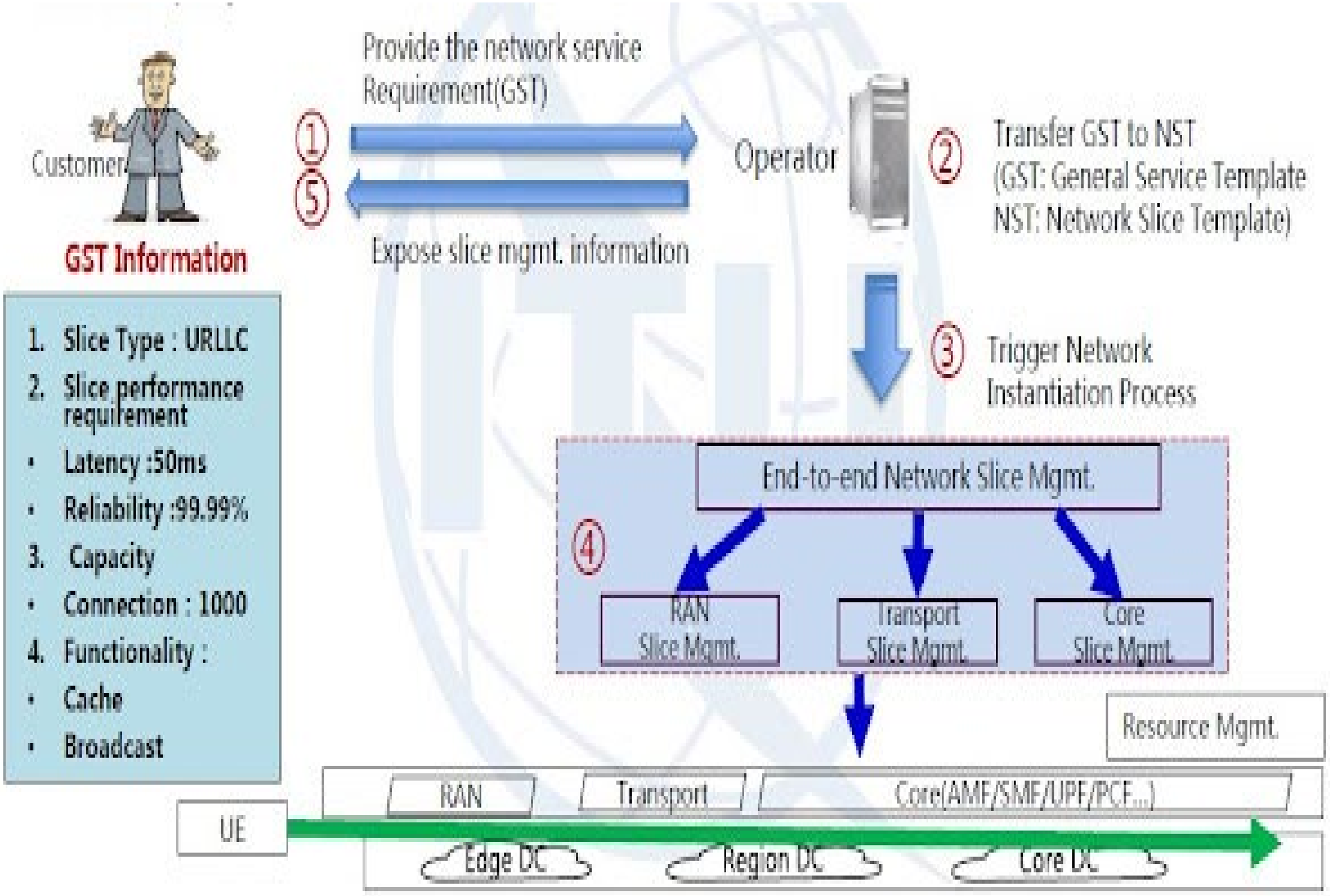
Forming of End-to-End Virtual Network

- Service/Application/Business Layer
  - High-level Descriptions of End-to-end Network Services and Interfaces for Creating New Services.
- Network Function Layer
  - Virtual and Real Network Functions to Run on the Infrastructure Resources
- Infrastructure/Resource Layer
  - A Reserve (Pool) of Resources
    - Computational, Storage, Network and Radio
- Management and Orchestration Entity
  - Responsible for the Implementation of Slices using
  - Control the Entire Life Cycle of Slices

Flexible, Dynamic, and Programmable 5G network Platform

- Network Function Virtualization (NFV)
  - Create and Modify Network Resources to Reflect the Service
  - High Network Efficiency through Optimum Resource Utilization.
- Software Defined Networking (SDN)
  - Introduce Dynamicity to the Transport Network
  - Programmatic Control of the Traffic Management Processes
- Cloud Based Architecture
  - Automated Network and Service Orchestration
  - Reduced Creation Time Scales for New and Innovative Services
- The Control Plane and User Plane Separation (CUPS)
  - Decentralization of the Data Forwarding Component
  - Packet Processing and Traffic Aggregation Performed in the Distributed Edge Clouds

5G Slice Provisioning Process



https://blog.3g4g.co.uk/2019/01/5g-slicing-templates.htm

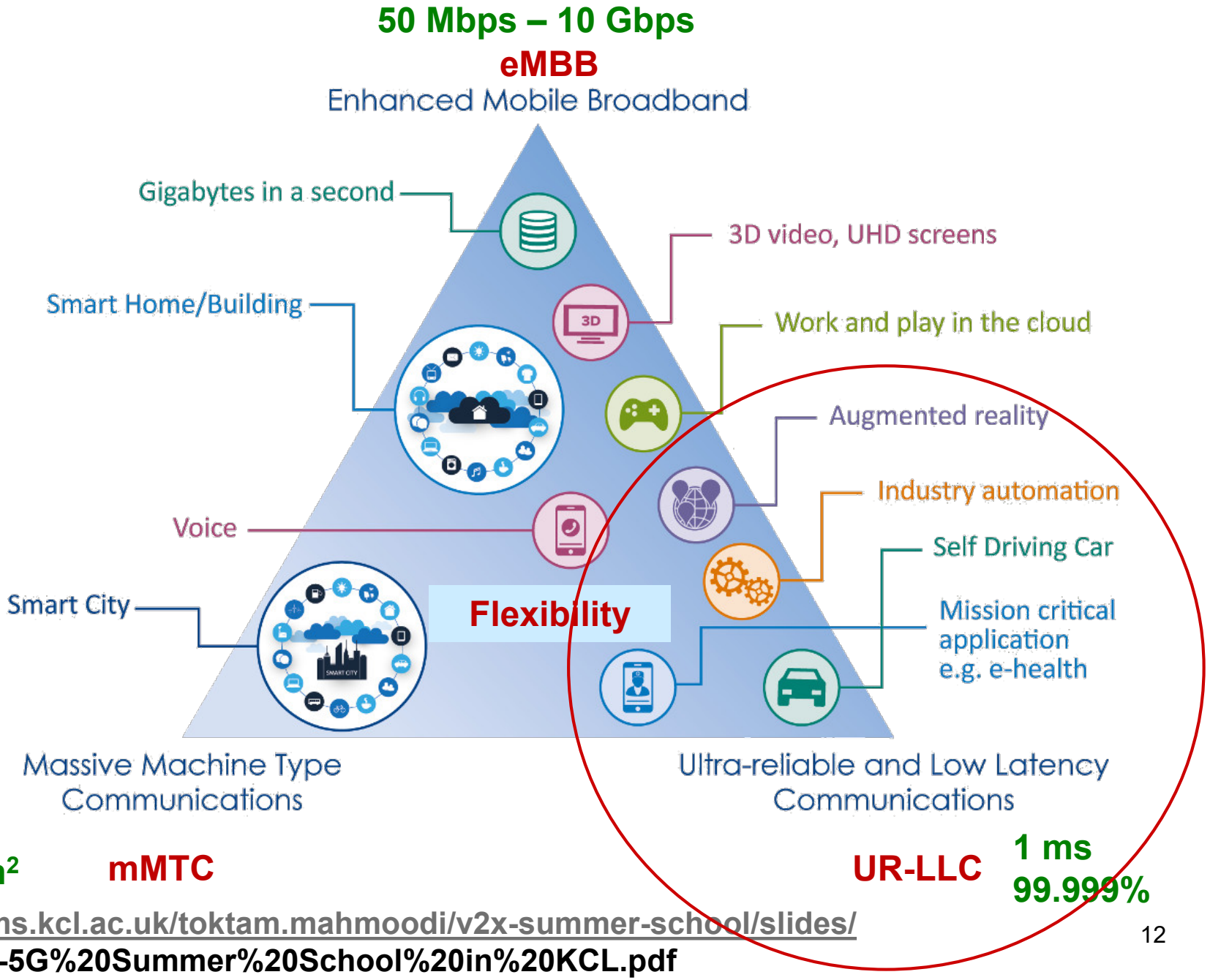
Key Entities Associated with a Network Slice

- Slice Specific Authentication and Authorization (NSSAA)
  - Augment Primary Authentication with Authenticated and Authorized by a AAA Server using Additional Credentials
- Network Slice Management Function (NSMF)
  - Perform Cross-Domain Network Slice Orchestration
  - Allow for the Instantiation and Configuration Of Network Slice Resources for each of the Use Case Types
- Single-Network Slice Selection Assistance (S-NSSAI)
- Unique Identification of a Network Slice
  - Slice Service Type (SST) and Slice Differentiator (SD)

Working of a Typical Network Slice Algorithm

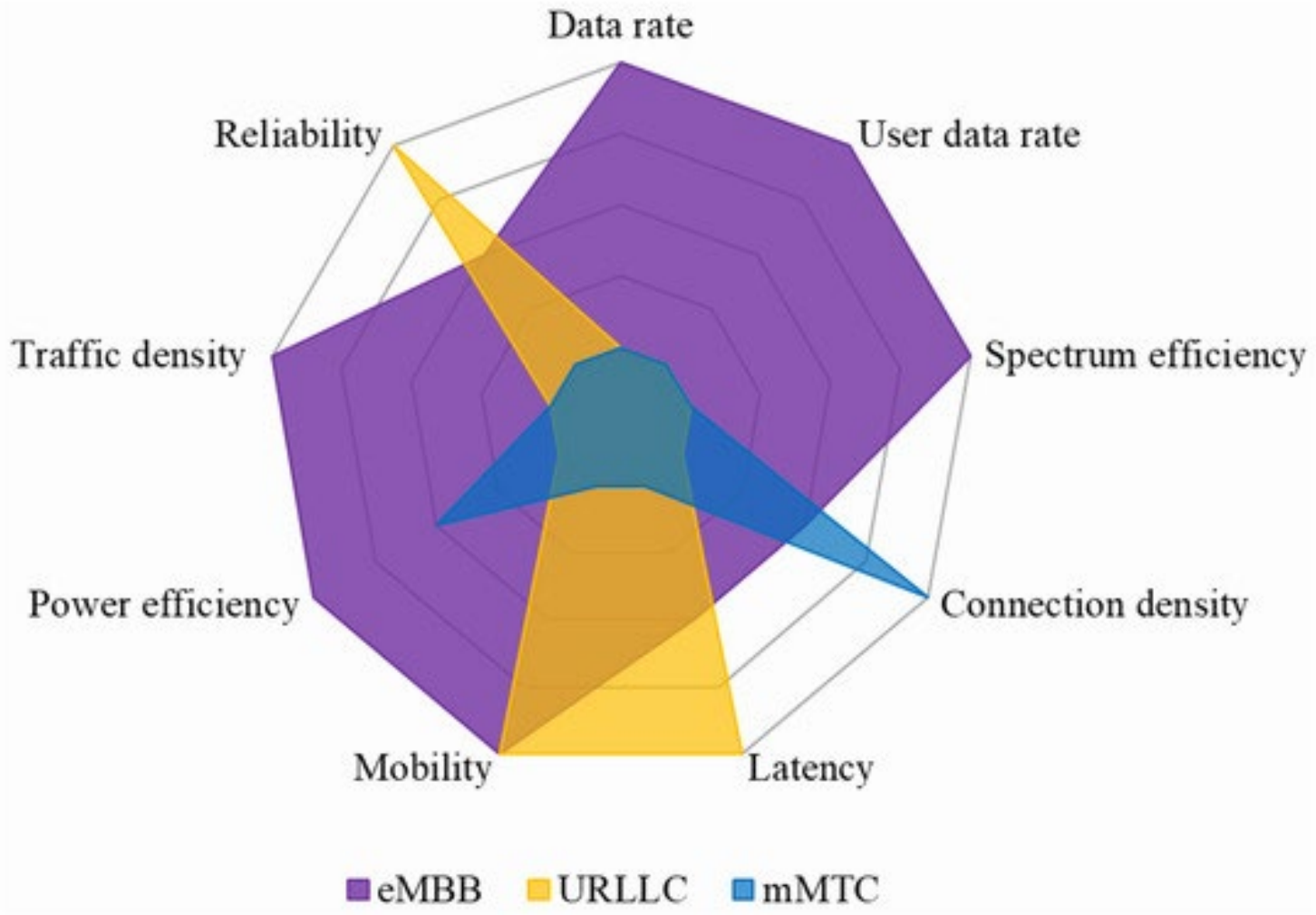
- The Slice Node Importance Is Ranked by considering the Node Resource and Topology Attributes
- The Slice Nodes are Provisioned according to the Ranking Results in the Slice Link Provisioning Stage
- A Shortest Path Algorithm Is Implemented to Obtain the Candidate Physical Paths for the Slice Link
- Strategy for Selecting a Candidate Physical Path to Increase the Slice Acceptance Ratio
  - Calculate the Path Factor Pf which is the Product of the Maximum Link Bandwidth Utilization of the Candidate Physical Path and its Hop-count
  - Choose the Candidate Physical Path with the Smallest Pf To Host The Slice Link

IoT Applications and 5G Offers



https://nms.kcl.ac.uk/toktam.mahmoodi/v2x-summer-school/slides/Day-2/EK-5G%20Summer%20School%20in%20KCL.pdf

5G Offer Characteristics



https://www.mdpi.com/2079-9292/11/14/2111

5QI QoS for UR-LLC Type Applications

5QI Value	Resource Type	Default Priority Level	Packet Delay Budget	Packet Error Rate	Default Max Data Burst Volume	Default Averag-ing Window	Example Services
82	Delay-critical GBR	19	10 ms	10^{-4}	255 Bytes	2000ms	Discrete Auto-mation

GBR: Guaranteed Bit Rate

Key Performance Indicator (KPI) for URLLC Offer

Core

Attribute		Value
Availability		99.999
Session and Service Continuity Support		1
Slice quality of service	3GPP 5QI	82
Supported device velocity		2

Application Specific

Attribute		Value
Data rate		Range up to 20 Gps
Spectral Efficiency		Upto 30 bps/Hertz
Density of connection		Upto 1M devices/km^2
Mobility		Upto 500 Km/hr.

Bounded latency, ultra-reliable data delivery and ultra-low latency

Summary

- Offer Differentiated Network Services with varying Network Performance Characteristics
- End-to-end Network Slice Orchestration and Operations Solution spanning RAN, Edge, Transport, and Core Network Domains
- URLLC Slice Required High Reliability and Low Latency
  - Autonomous Vehicle, E-health, Factory Automation
- Segment Attributes into Core and Application Specific Base
  - Core: Availability. Session And Service Continuity Support, Slice Quality Of Service (Qos), Supported Device Velocity
  - Application Specific: Data Rate, Spectral Efficiency, Density of Connection, Mobility

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Questions / Clarifications?