NOKIA

Cost saving by automation in 5G

József Varga

Agenda

- **5G – slicing, virtualization**
- A simple 5G core cost calculation
- Cost saving by automation in 5G – for 5G core network operator
- Cost saving by automation in 5G – 5G private network user examples

COVID-19 accelerates digital transformation

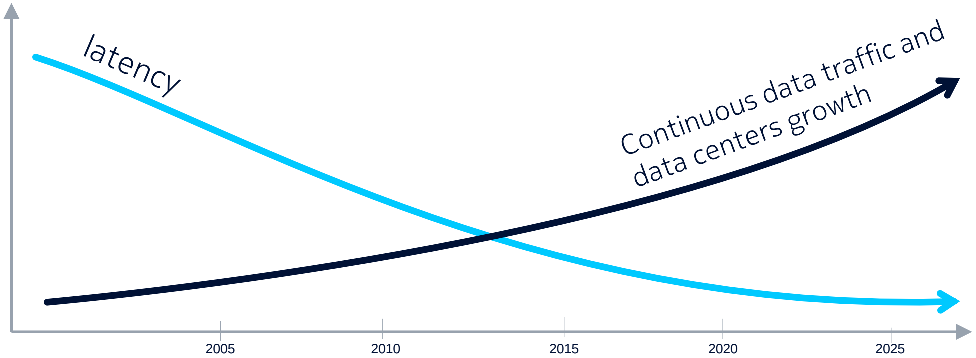
Social distancing-driven use cases

Remote working | telehealth | gaming | education | video conferencing

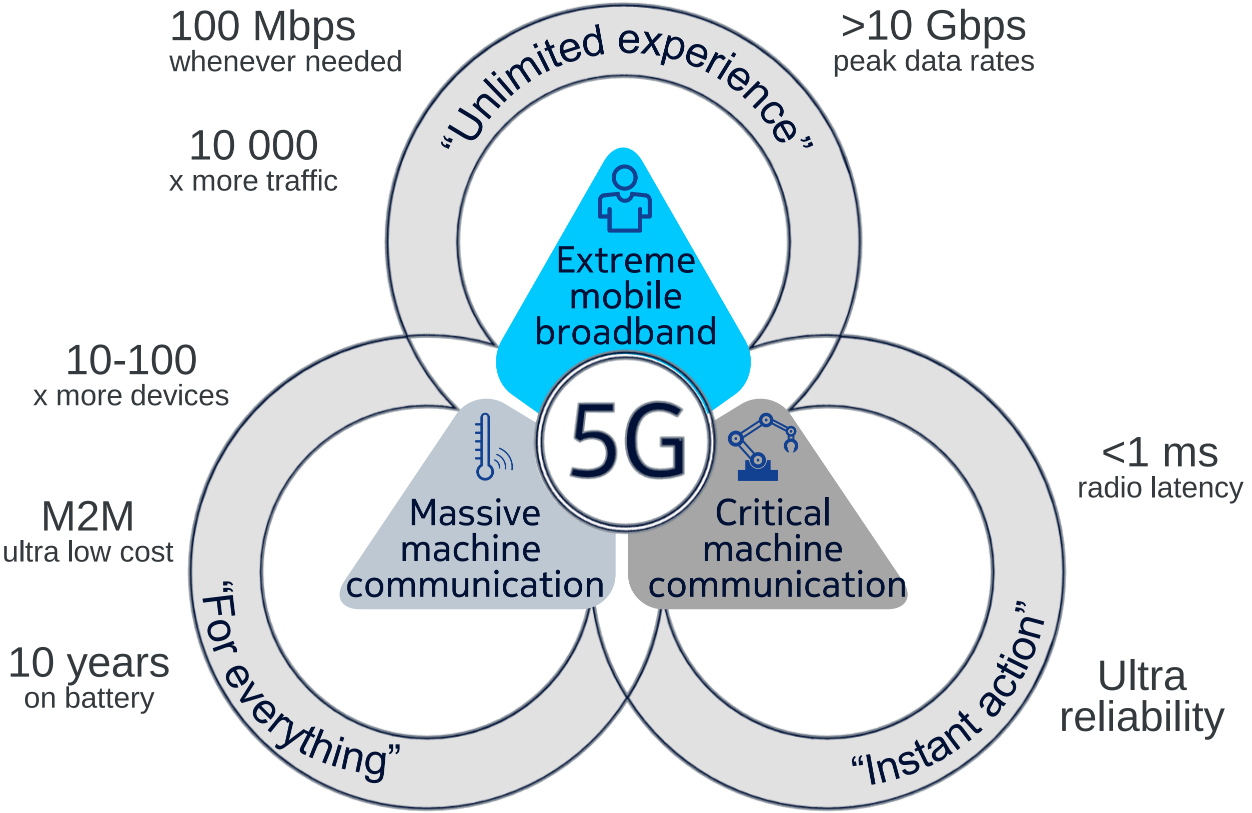
Network transformations

Virtualization | 5G | Edge computing

Additional capacity is needed



5G


100 Mbps
whenever needed
10 000
x more traffic
>10 Gbps
peak data rates
10-100
x more devices
M2M
ultra low cost
10 years
on battery
<1 ms
radio latency
Ultra
reliability
"Unlimited experience"
"For everything"
"Instant action"
Extreme mobile broadband
Massive machine communication
Critical machine communication
5G

5G standardization in 3GPP

Phase 2. 3GPP Rel'16/17. Enhance URLLC & eMBB

Phase 1. 3GPP Rel'15. New Radio. eMBB (& some URLLC)

Nov 2021

2019			2020				2021				2022			
Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

R15 Extreme mobile broadband

R16 Industrial IoT (URLLC)

R17 Wider ecosystem expansion

R18 5G Advanced

Release 15
- Mobile broadband
- Commercial 04/2019

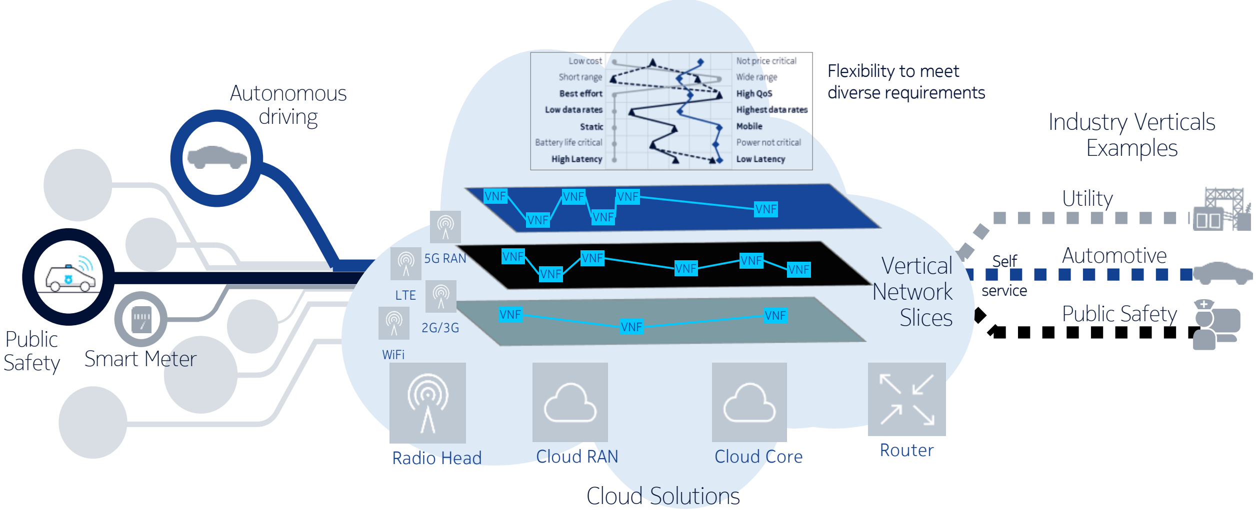
Release 16
- Industrial IoT (URLLC)
- Completed 12/2020

Release 17
- Wider ecosystem
- Completion mid-2022

Release 18
- 5G-Advanced
- Expected end-2023

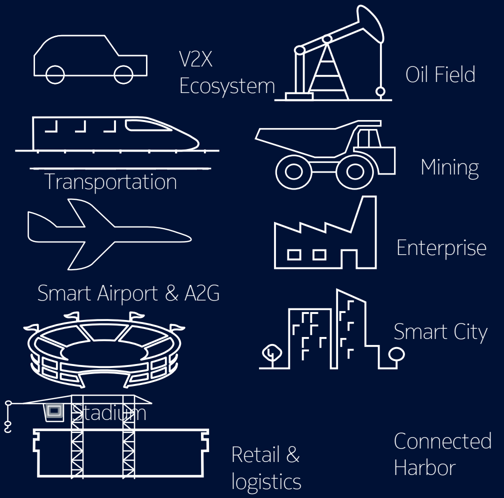
- 100 X peak rate
- 1000 X capacity
- latency down to 1ms

Versatile use cases



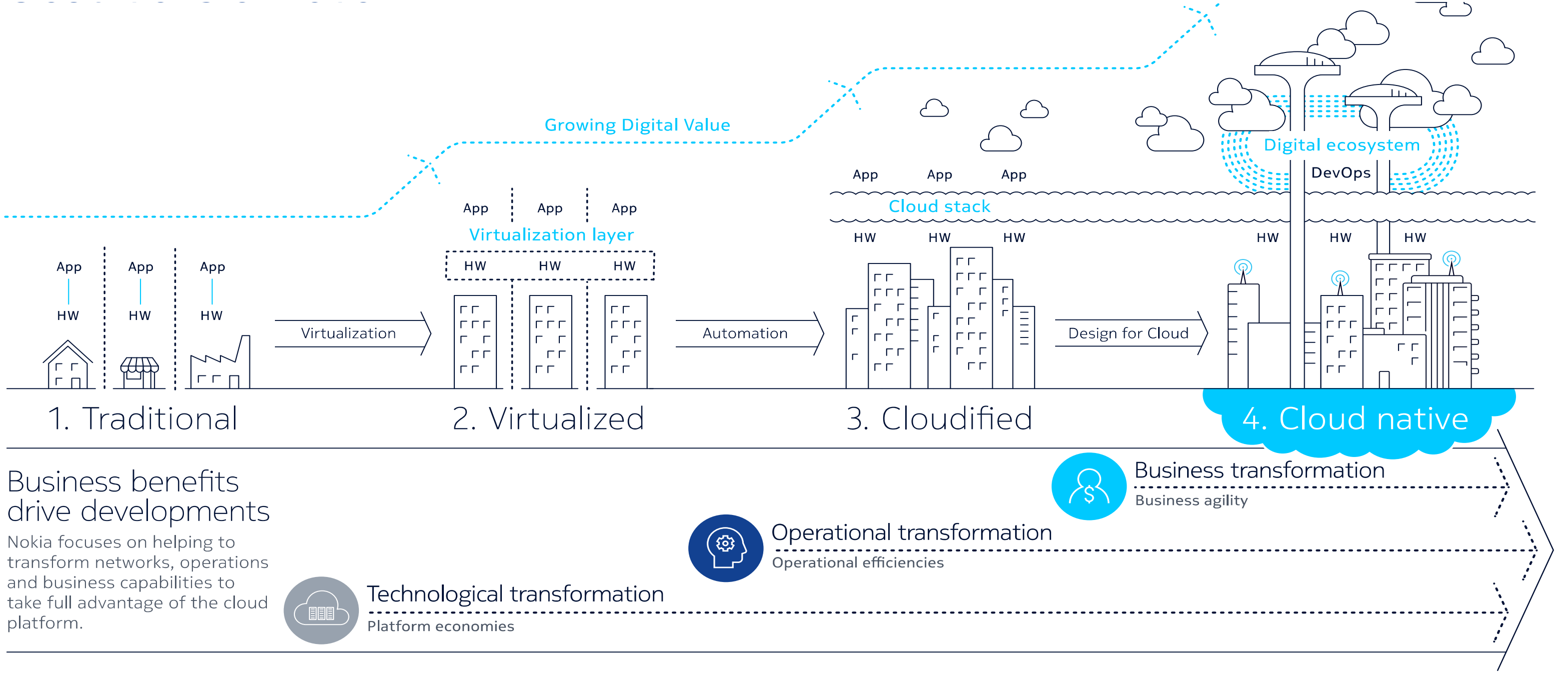
Network Slicing

Running multiple logical networks on a shared physical infrastructure in an optimized way

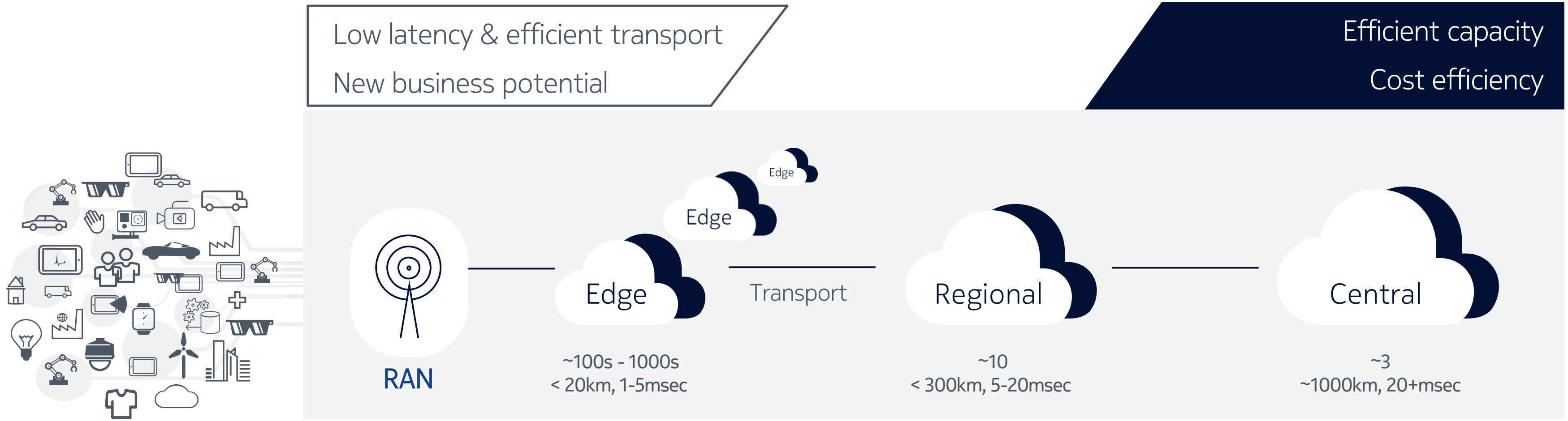


Cloud technology and application transformation continues

NFV marked Telco cloud beginnings, not the destination



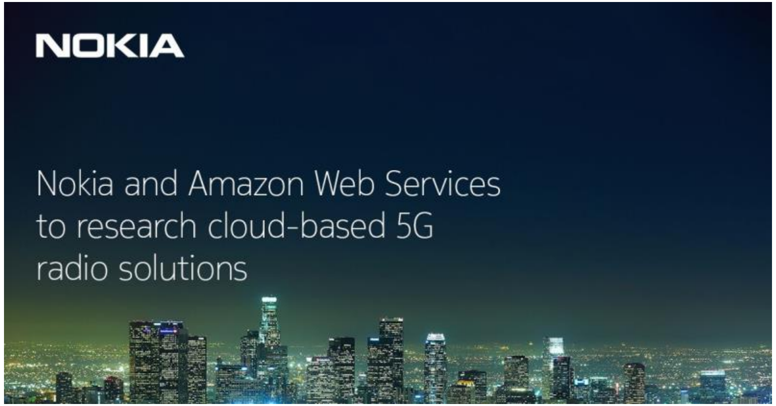
Distributed Cloud



- A.k.a.
  - On-prem cloud (up to 2 km)
  - Far Edge Cloud (2-30 km)
  - Metro Edge Cloud (30-500 km)
  - Core Cloud (500-1500 km)
  - Centralized Cloud (3000 km)

Infrastructure operational models

- Own? – the "usual"
- Lease? – e.g., AWS Outposts
- Use public cloud? – see the news
  - Nokia and AWS to enable cloud-based 5G radio solutions
  - Nokia partners with Microsoft on cloud solutions for enterprise
  - Nokia and Google Cloud partner to develop new, cloud-based 5G radio



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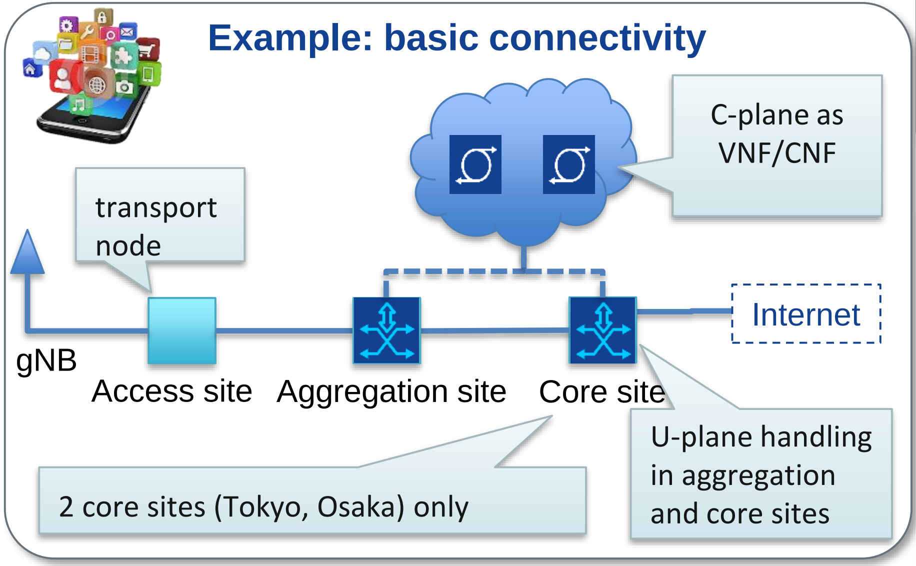
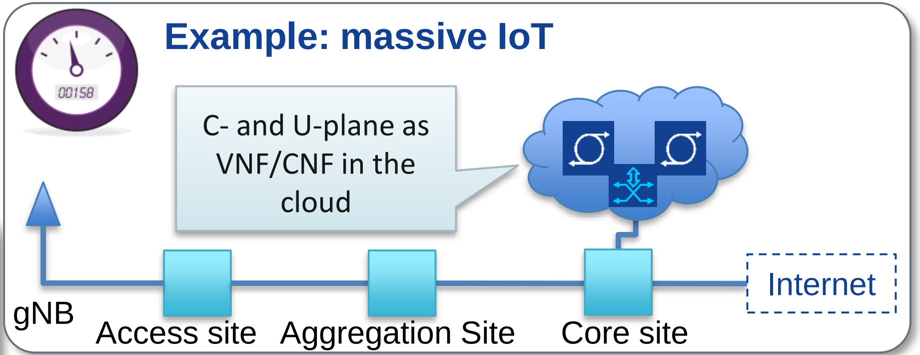
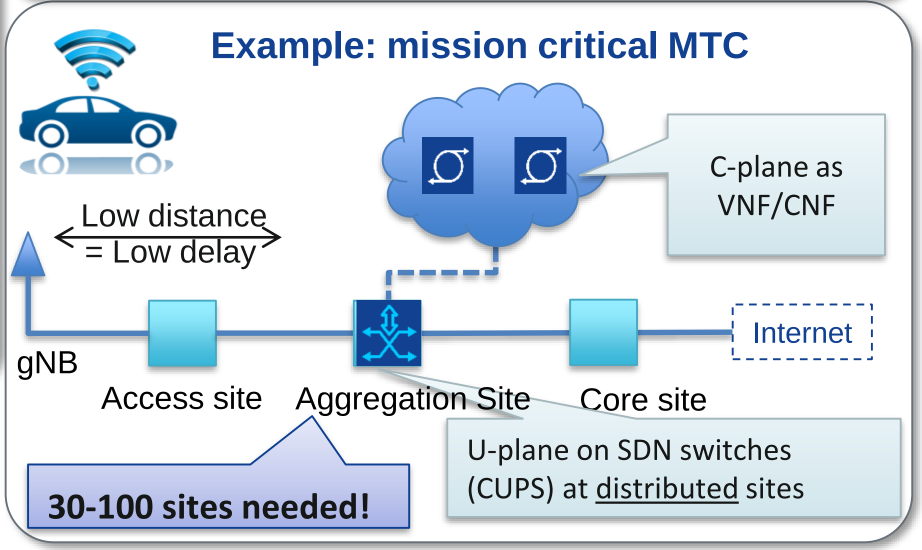
Example deployment







Cost function (base version)

Instead of the general form of TCO → a monthly TCO form is used

$$TCO = CAPEX + \int_t OPEX\, dt$$

$$\frac{TCO}{month} =$$

site construction

server, switch, software at site

site power consumption

$$\sum_{i \in all\ sites} \left(\frac{CAPEX(site_i)}{site_{depr}} + \sum_{NE_j \in site_i} \frac{CAPEX(NE_j(i))}{depr(NE_j)} + OPEX(site_i) + OPEX_{IT}(site_i) \right)$$

$$+ adm \left(\sum_{i \in all\ sites} \sum_{NE_j \in site_i} NE_j \right)$$

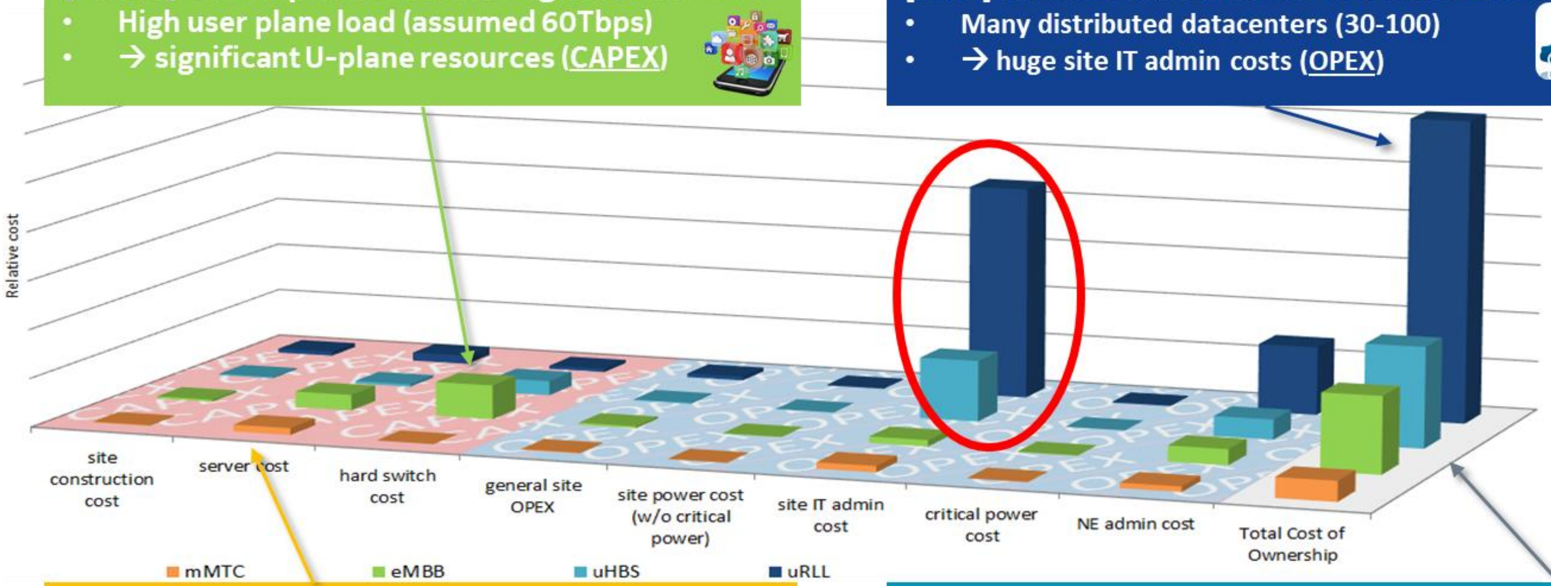
NE admin (centralized)

site IT admin

"Unwise" deployment – cost contribution of different core network slices

[eMBB] Smartphone traffic: significant TCO:
- High user plane load (assumed 60Tbps)
- → significant U-plane resources (CAPEX)

[uRLL] Mission critical MTC: dominates TCO
- Many distributed datacenters (30-100)
- → huge site IT admin costs (OPEX)



[mMTC] Massive IoT: lowest TCO
- 700 mio devices: low U-plane / high C-plane load

[uHBS] Ultra dense broadband: high TCO but …
- Resources needed only during events
- → optimization potential

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The "problem" with uRLLC requirements

- low latency → must be served close to edge → high number of "LL DCs"
- ultra-reliable → Tier 4 DC, 24/7 on-site IT support → min. 4 IT administrator / site

IT admin cost reduction	How	Problem
Partial coverage	Less site	No full V2X coverage
Additional services in LL DCs	Straightforward cost saving options, but not really applicable for LL DCs "far, far away" (those DCs still needed to serve V2X use cases country-wide)	
uRLL services in 3^{rd} party DCs		
Unattended LL DCs	less IT administrators, sharply reduced costs	Keeping ultra-reliability

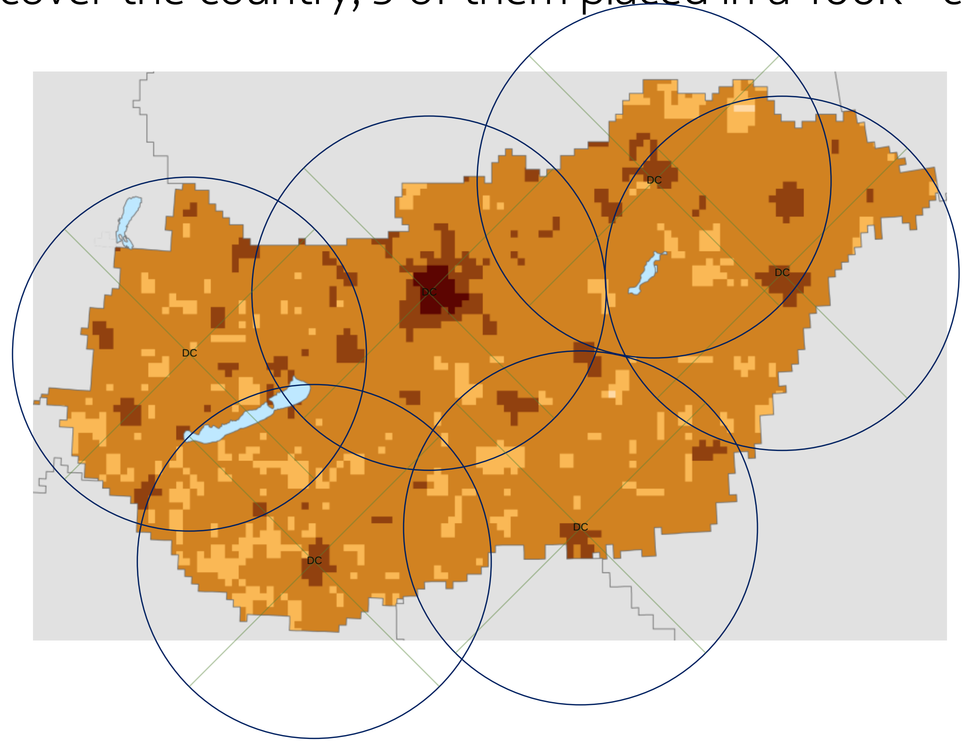
- Unattended LL DC is the generic solution, but reduced hardware availability must be compensated to reach our goal…

Assumptions for ultra low latency DCs

- Harsh and relaxed assumptions based on the 1+5 ms latency requirement:
  - From the 5ms core network delay budget assign 1ms or 2ms for the electrons/photons to travel in aggregation network (and assign 4ms or 3ms to apps and routers/switches to process data)
  - Assume 1:3 or 1:2 ratio for the geographical distance to cable length ratio
- Coverage area of LL DCs are estimated by circles, attempted to locate datacenters in cities whenever possible (At the end real life aggregation network topology must be considered)
- This results in 33km / 100km coverage radius for LL DCs
  - light travels 200km / ms in fiber
  - A to DC + DC to B legs mean 100km radius can be served by ULL DC (per allowed ms latency)
- Added 1.5ms aggregation network budget and 1:2.5 beeline cable length ratio as "average", resulting in a 60km coverage radius

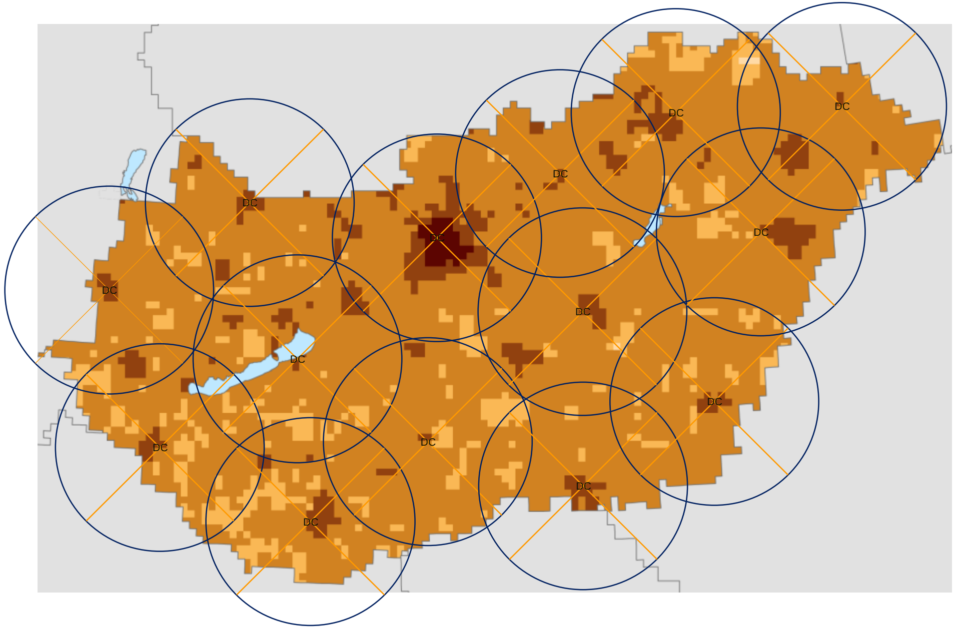
100km coverage radius

6 DC can cover the country, 5 of them placed in a 100K+ city



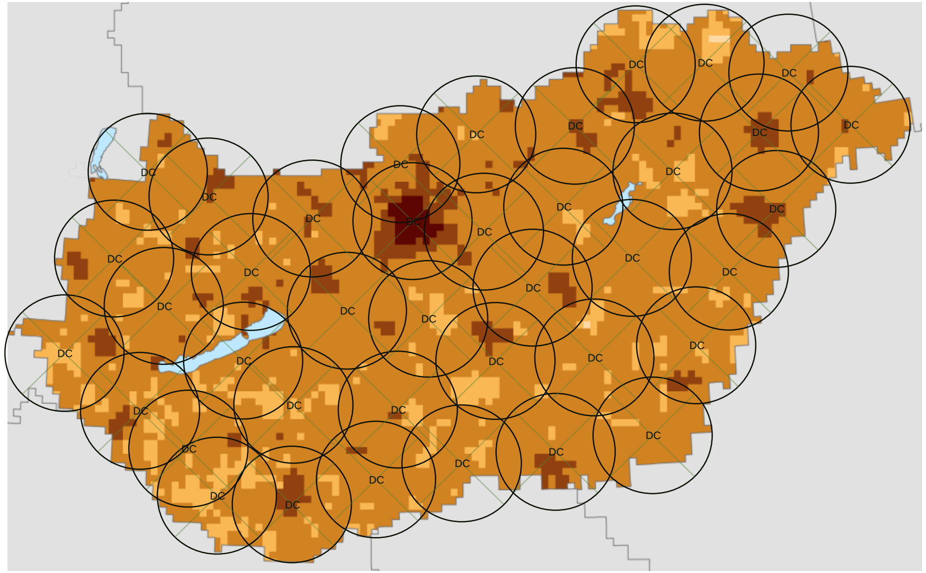
60km coverage radius

14 DC can cover the country, 6 of them placed in a 100K+ city



33km coverage radius

39 DC can cover the country, 7 of them placed in a 100K+ city



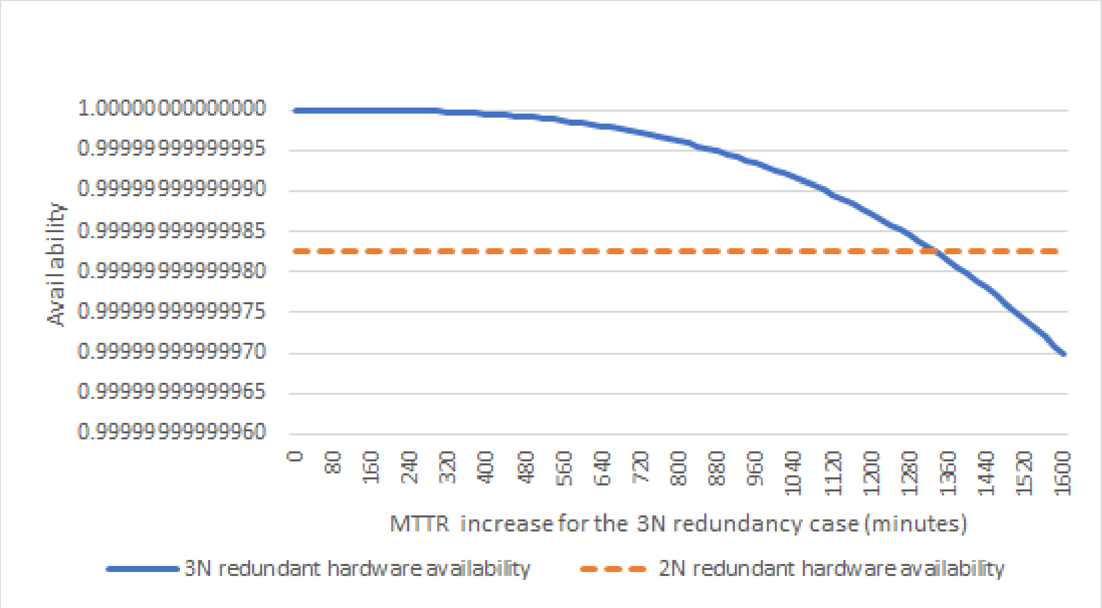
Service availability in a datacenter

Software availability	VNFs implementing uRLL service are up and running
Hardware availability	Necessary hardware capacities are available
DC availability	DC infrastructure available (e.g. has power)
Network availability	DC has connectivity towards the served users

A highly available machine is ultra-reliable if it has a high mean uptime.

Increase redundancy to compensate increased MTTR

compensated MTTR increase (minutes)			
MTTR (minutes)	***MTBF (hours)***		
	200,000	***300,000***	***400,000***
10	970	1110	1230
20	1540	1770	1950
30	2020	2310	2550
40	2440	2800	3090
60	3190	3660	4040
90	4180	4790	5280



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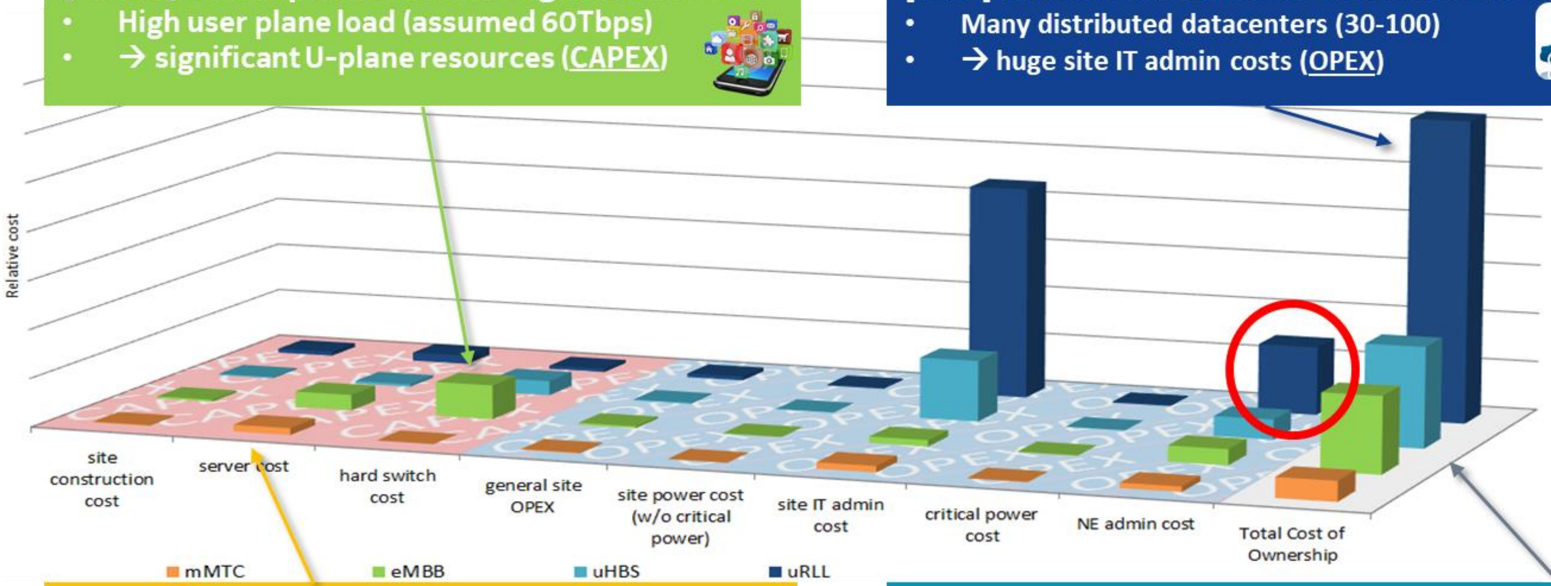

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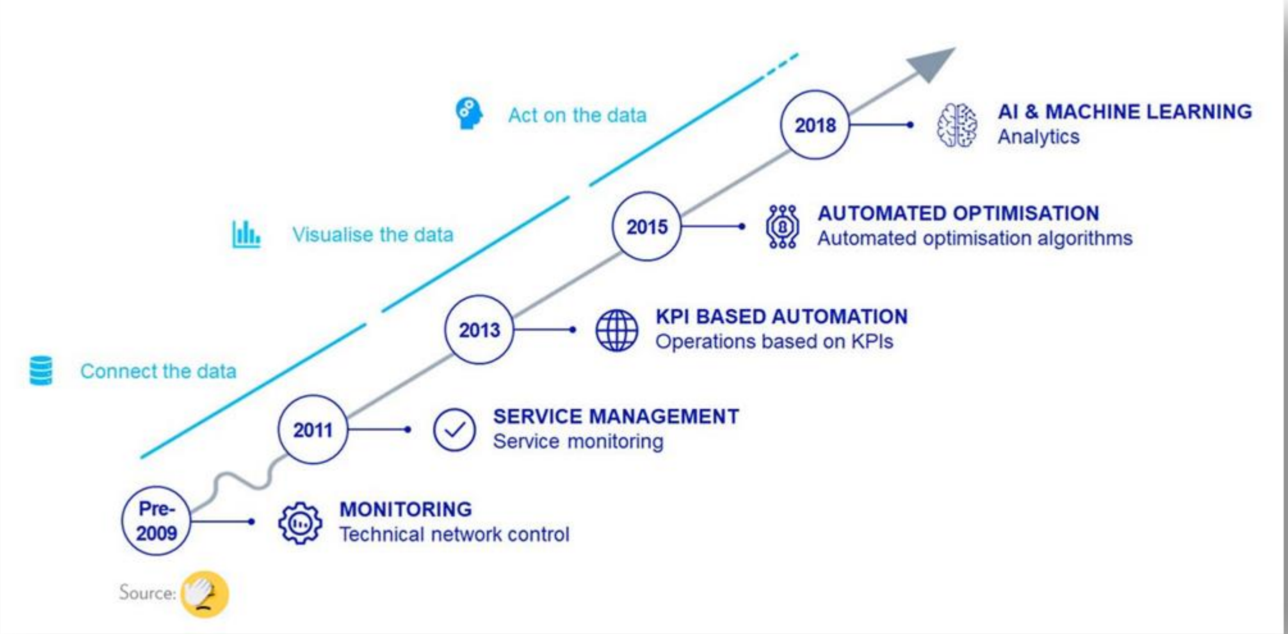
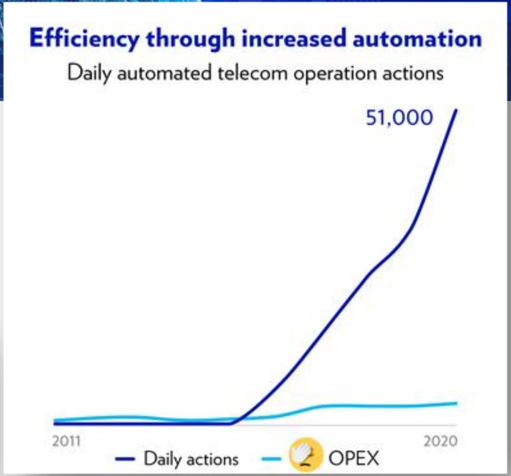
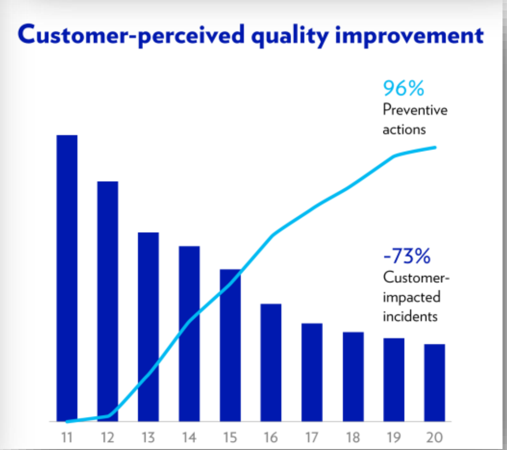
Automation was there in the pre-5G era as well

Customer view of automation evolution







Bell Labs

The importance of management and orchestration

If not automated…

No centralized view of resources

- Data centers (centralized and distributed) managed separately

Hardware rack management

- Each hardware rack is managed separately
- Monitoring resource utilization across all nodes simultaneously

HW configuration

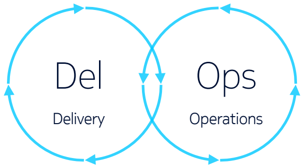
- Configurations and updates (firmware etc.) needs to be done one by one for each HW component

Hardware (under)utilization

- Some of the servers are underutilized or not used at all
- Energy efficiency monitor

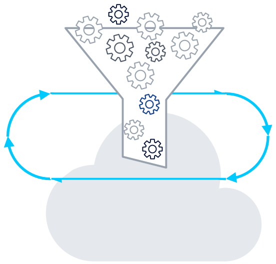
Core automation use cases

Core network updates



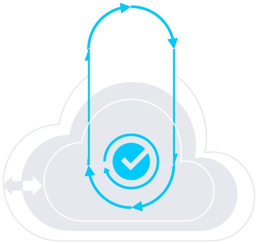
Meeting the diverse needs of CSPs

Core configuration and customization



Minimizing outages due to human errors

Core network optimization



Scaling microservices to dynamically adapt the NW

Network healing

Leveraging the massive redundancy in the cloud

Slice creation & validation

Auto-configuration and validation of slices

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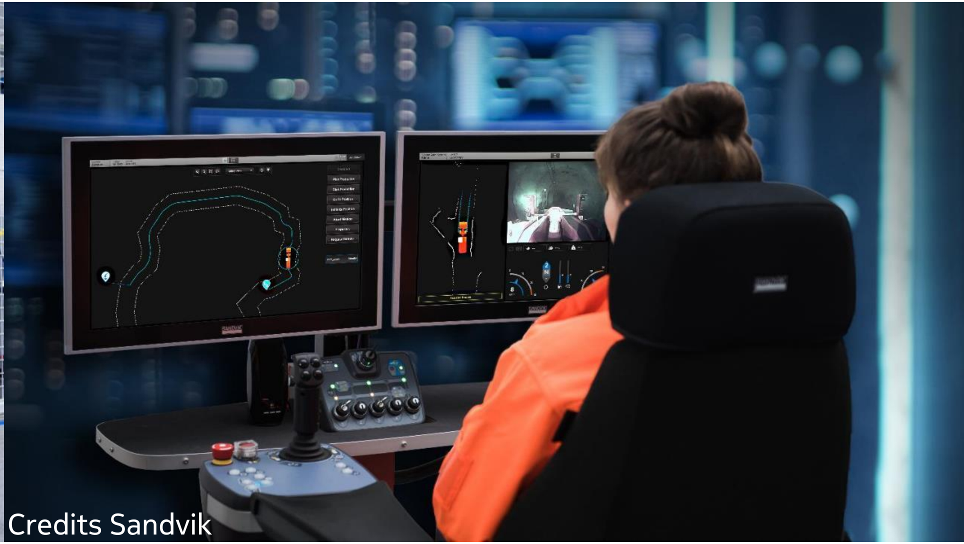
Private network examples – 1



Credits Sandvik

- Factory automation – Nokia Oulu factory
  - Sensor communication
  - Mobile robots: Telepresence, material transport
  - Indoor positioning
- Mining – Sandvik
  - Operation of autonomous loaders and trucks
  - Real-time monitoring of underground and outdoor premises to keep people and equipment safe

Private network examples – 2

- Wind parks – Sempra
  - 42 square mile wind park, real-time data streams, increased sensor use, fiber replacement
  - Remote worker connectivity for production & safety
  - Early warnings enable predictive maintenance - save up to 90% of turbine pitch assembly repair
- Port 4.0 – terminal operator, Port of Zeebrugge
  - Citymesh enabled a private 5G ready network to facilitate efficient execution of work orders by connecting vehicles, terminals and people

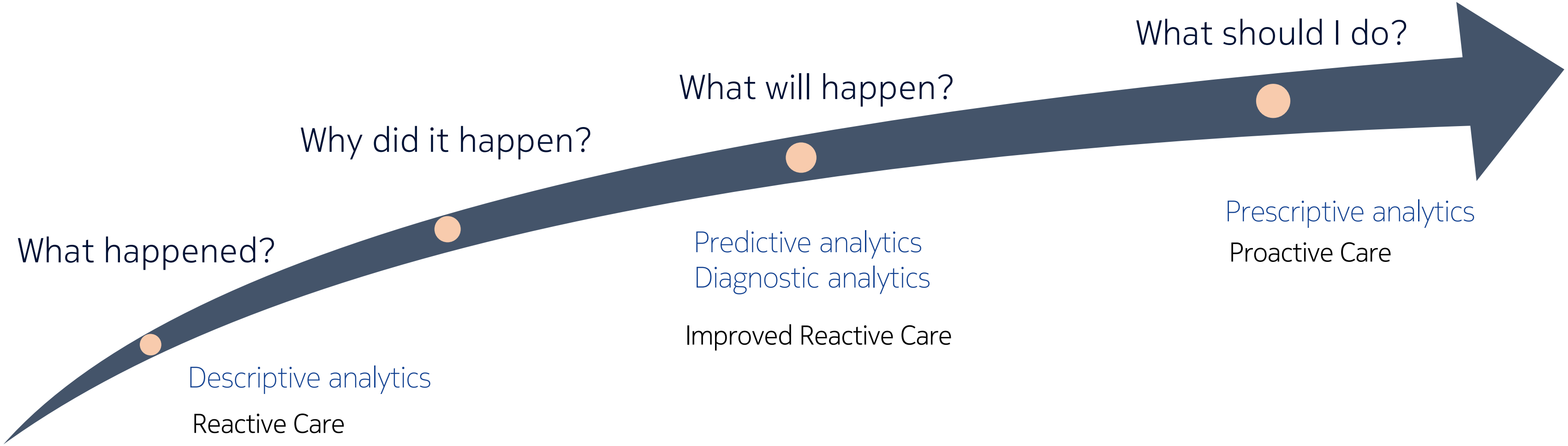
Private network examples – 1

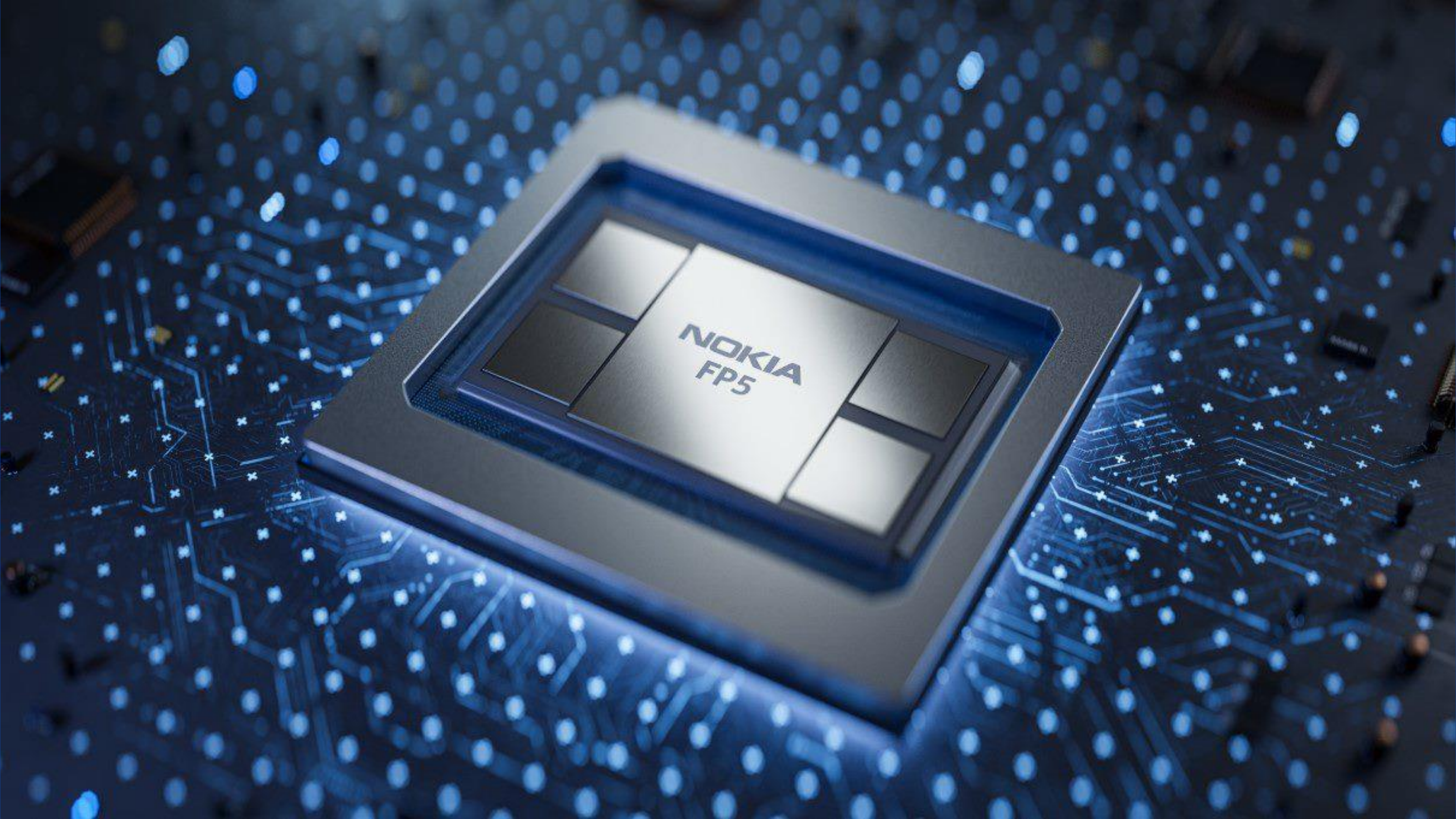
- Health care – Oulu University Hospital
  - High Accuracy Indoor Positioning (HAIP) deployment displays in real-time the location of assets
  - Automated guided vehicles (AGV) deliver medicines (less walk for pharmacy assistants by ~10 km/week)
- Water management – City of Sudbury (Ontario)
  - Connected locations not previously accessible for complete data analytics
  - Real-time visibility of water levels to assess the exact health of the system at any point in time

5G requires effective management of network slices and service deployment

References: Bell Labs Consulting studies

A shift from reactive to proactive analytics

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