



FLAGSHIP
UNIVERSITY
OF OULU

5G•6G

OpenRIT 6G

6G FLAGSHIP

Being a 5G test network operator, what it requires and what has been learned


Research Council
of Finland

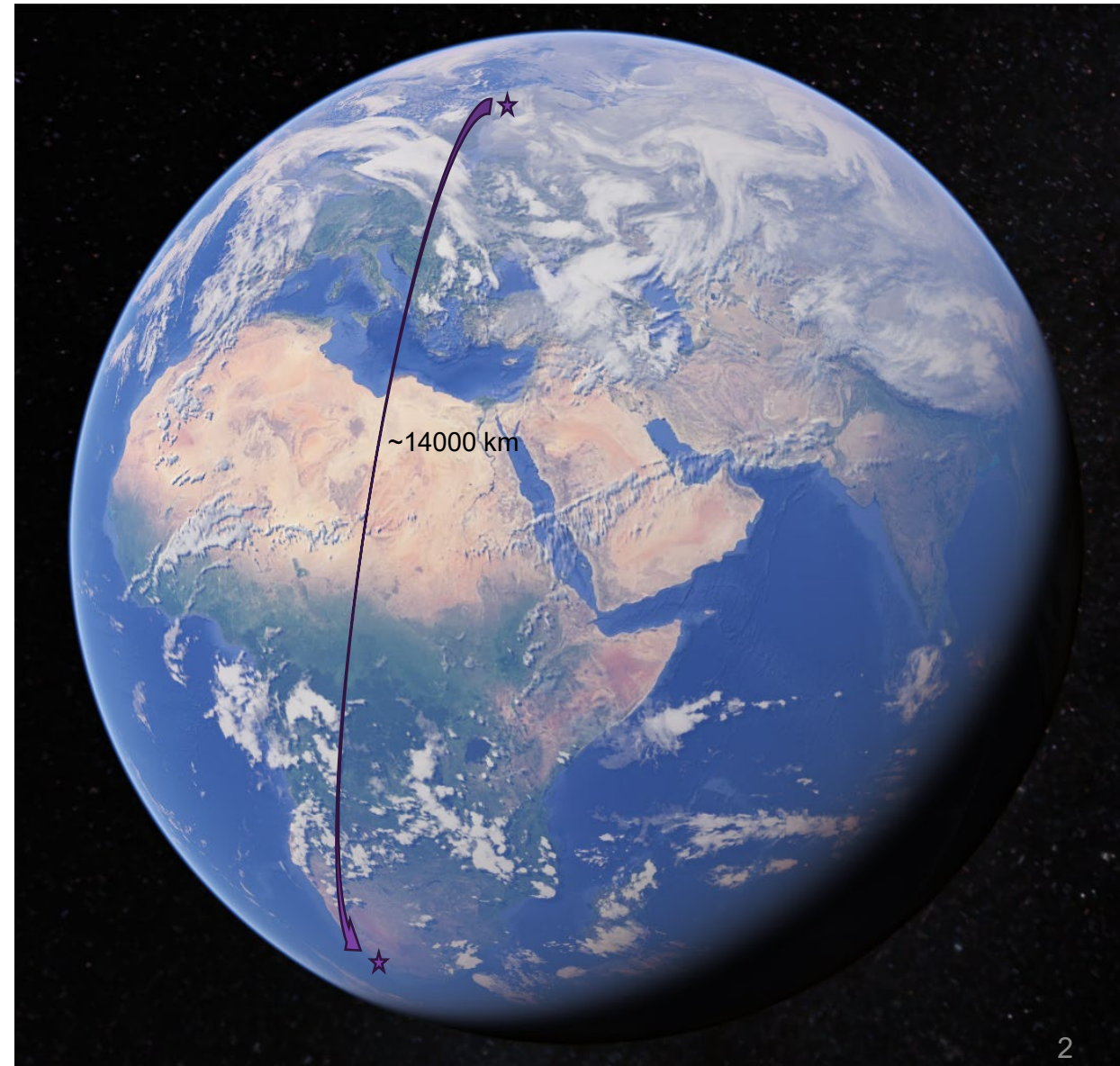

FLAGSHIP PROGRAMME

Matti Hämäläinen (Adjunct Professor, Dr.Sc.)

Olli Liinamaa (Test Network Lead)

Introduction of the speaker

- Dr. Matti Hämäläinen
 - Centre for Wireless Communications – Networks and Systems, University of Oulu
 - Adjunct Professor (Docent)
 - docenture on wireless body area networks
 - Research focus: UWB, WBAN, radio propagation and channel modeling, medical ICT
 - Representing 6GFlagship
 - the 1st global 6G research programme
 - partly funded by the Research Council of Finland for eight years



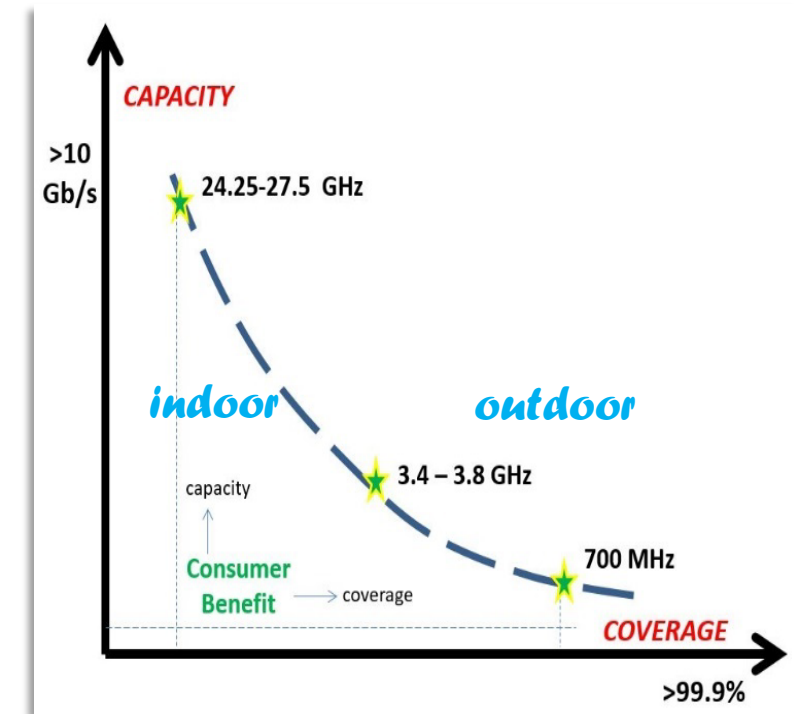
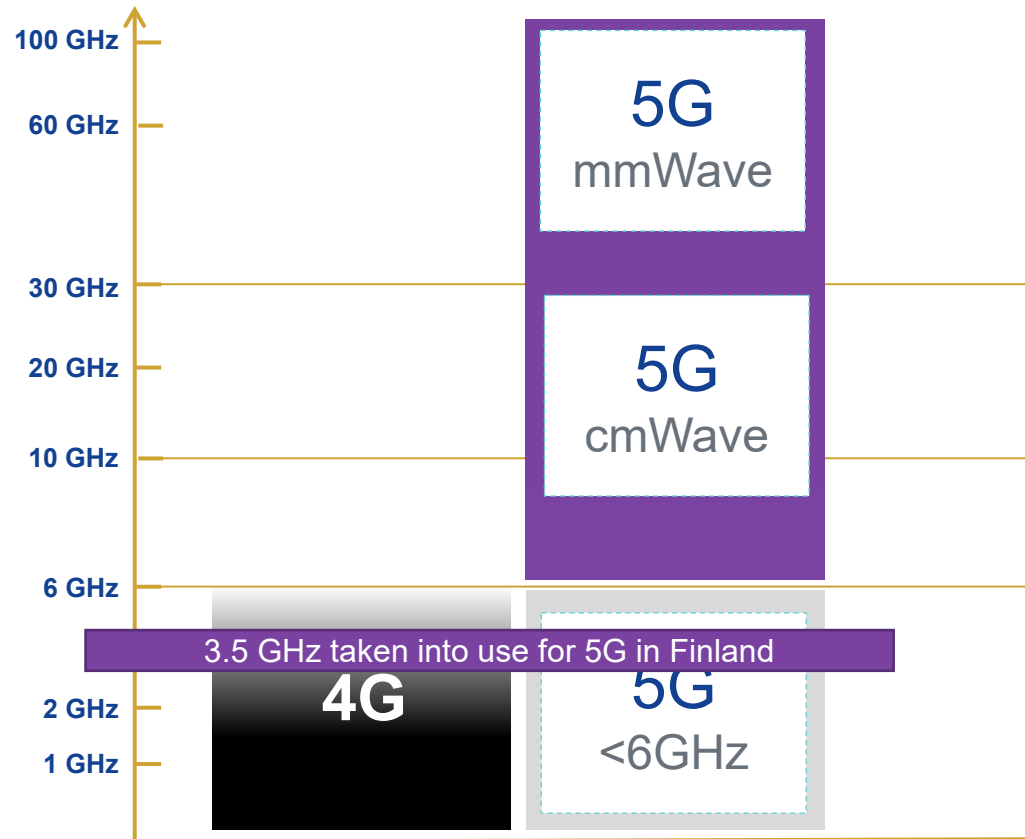
Goals of the talk



- Centre for Wireless Communications at the University of Oulu is a 5G test network operator
- In this talk, some topics from the test network development process will be highlighted

- Frequency spectrum is a limited resource
- Frequency regulation is done either in national level or in many cases, they are global
 - typically, licensed bands are provided for the communications service providers (CSP), i.e., telecom operators
 - unlicensed bands are also available, but their operation is also under regulation
 - WiFi, BLE, LoRaWAN, etc.
- Restrictions apply also for the certain frequency bands
 - dedicated frequency bands for different services
 - radio astronomy, military, navigation, etc.
- New technologies, applications and users utilizing different parts of the radio spectrum are increasing!
- The following discusses how to be an academic 5G test network operator.
 - How to become a cellular test network operator?
 - What is needed and some advice for the starters.

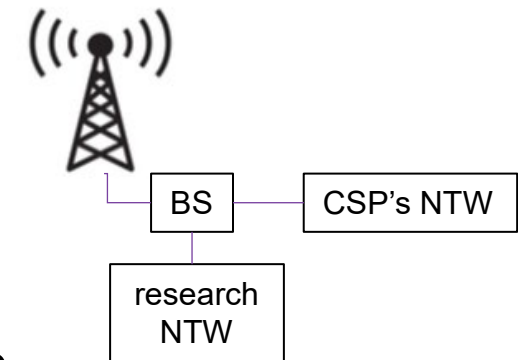
5G Standardization includes various frequency bands



Increasing coverage decreases capacity.
Trade off!

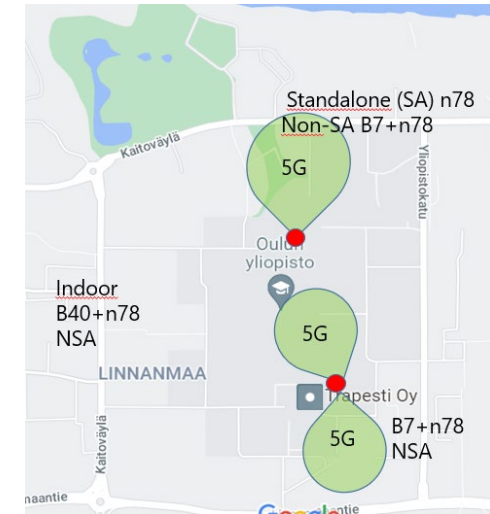
Starting point

- First, options for the academic player to be a test network operator:
 - partnering with the CSP
 - network assets partially dedicated for test network use, e.g., given for research purposes
 - a base station
 - a cell or partial frequency band, which is not used by the owner
 - operator builds and owns the network infrastructure
 - fastest way to proceed
 - build own network infrastructure
 - apply own local frequency band if applicable (loan/rent)
 - some part of the frequency band are loaned or rented from the license holder for non-commercial research use
 - partnering with a vendor
- In Finland, some frequency bands are authorized for R&D use in specific geographical areas
 - such a spot is available, e.g., at the Oulu University's Linnanmaa campus area



Next step – carefully consider in advance

- After the consensus with the CSP / authorities has been reached for spectrum allocation, the next steps ahead include
 - defining the targeted area and coverage
 - indoors or outdoors
 - beamforming
 - local area: few blocks in certain direction(s)?
 - wide area, longer distances?
 - defining the targeted service level
 - type of network structure: only research or general use network?
 - network availability, e.g., 24/7, including support
 - access and security management and control
 - network robustness
 - are there hardware (terminals, base stations, etc.) available, especially if targeting towards a new technology?
 - how to determine a network quality?
 - what are the key performance or value indicators (KPI/KVI)?
 - what is needed to reach the preset goals?
 - network evolution and maintenance
 - customer support



Defining the targeted coverage

- Licensing clauses give requirements and limitations for the operation
 - geographic coverage area
 - indoor/outdoor
 - transmission power, antenna heights, antenna directions, etc.
- where to install base station components and mount antennas?
 - accessory compartment, power supplies, cabling, battery backup
 - connection to core network, registers, etc.
- are we targeting to outdoor or indoor coverage or both?
 - impact on technology selection and assembly
- is the network based on one technology, or being heterogeneous?
 - bridging different technologies
- operator, even a test network operator, needs customers so the coverage area should be such that there is enough possible users for the offered services
- test networks do not include roaming to commercial networks
 - fully private networks



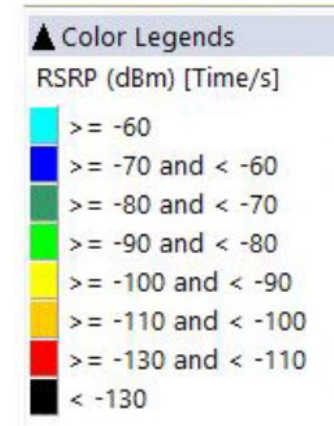
We need also ...

- To run own cellular test network, you need
 - user devices
 - phones need to be hacked to include new network ID to the white list of allowed networks
 - own SIM cards
 - to control network access
 - personnel to work with the network
 - different expertise are required
 - good implementation, research, maintenance and publication plans
 - money
 - building a test network with full functionalities requires lots of investments even working with a vendor support
 - CWC is collaborating with Nokia (infrastructure) and local CSPs
 - total costs depend on the size and provided services of the test network



Defining the targeted service level

- The service provider defines the services the network supports
 - **data** only
 - data and voice/messaging
- Who is the customer?
 - researchers and projects
 - technology and service developers
- What kinds of user equipment are available and ready to be used?
 - machine or human, or both to be served
 - what services we need to provide?
- Targeted performance requirements depend on several things, such as frequency, transmission power, antenna tilting, etc.
- Measurable KPIs are such as
 - coverage
 - data rates, throughput, BER
 - latency
 - edge/cloud services
 - capacity
 - number of users and traffic to be served



- After the network is ready, it needs to be further developed and maintained
 - new features and updates appear frequently
 - research and international standardization processes bring new requirements and use-cases
 - new research => new problems?
 - malfunctions of the devices need to be fixed
 - adjusting the operation in
 - network level
 - cell level
- Customer support
 - where to get user equipment?
 - how to deliver SIM cards?
 - what kind of databases are needed to support and maintain operations?
 - who helps the customer if problems appear?

collaboration with authorities, commercial CSPs



CWC's path



SLICES-RI: 15 countries
(<https://slices-ri.eu/>)

First open test network
(<https://services.5gtn.fi/>).

5G mmW trials in Olympics
with ETRI and Nokia

Operator grade
live 5G micro-
operator network

Selection to RCF
FIRI roadmap

Selection to ESFRI
FIRI roadmap

Scaling to
verticals

Ongoing 6G
experiments

6G Standardization
begins

2015

2018

2019

2020

2021

2023

2025

2026

5GTN

4G-LTE

5G PoC

5G NR

5G+

5G+

...

6G

6GTN



LTE small cell
@2.1 and 2.6 GHz



5G PoC/5G NR



5G Macros at 3.5GHz
For IoT - NB IoT/LTE-M

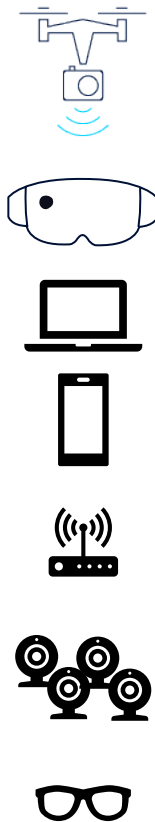


Indoor 5G
@3.5GHz

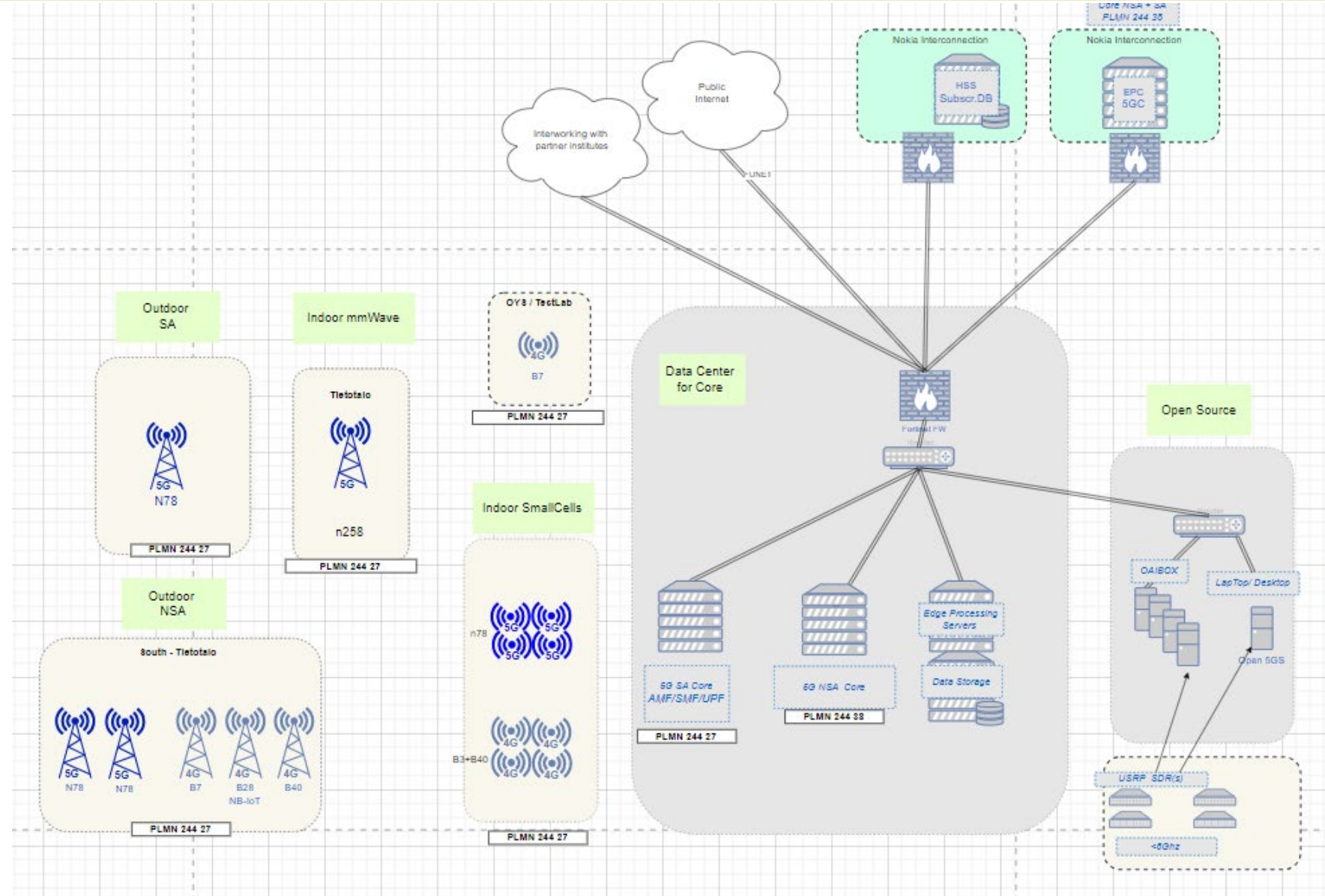


5G NR @24 GHz

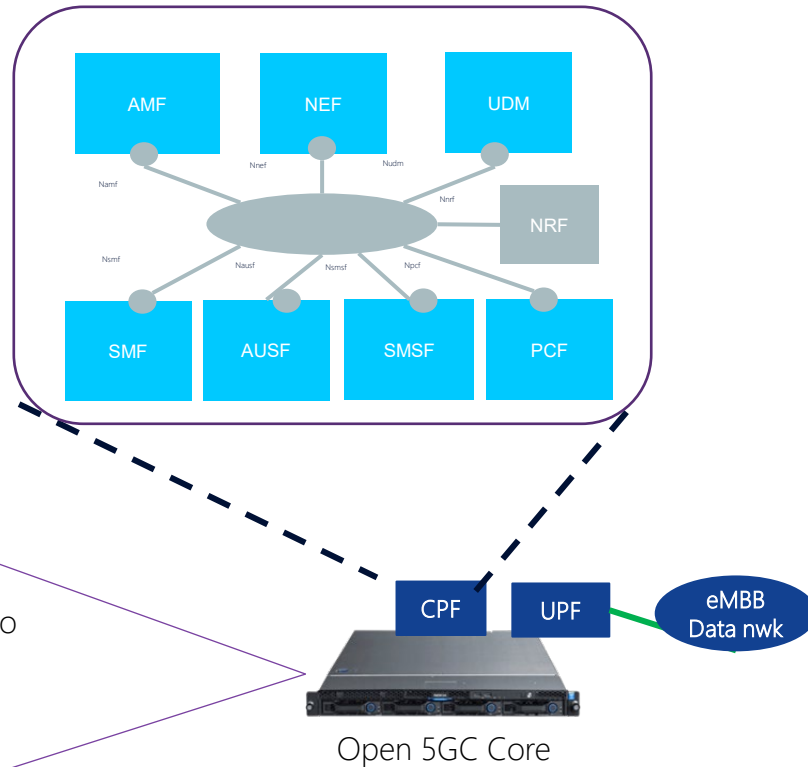
Architecture overview



Connected devices, different verticals



Open source vs. commercial 5G



- 5G experimentation following OAI progress
- Highly customizable solution for deploying academic 5G
- Flexibility of introducing standard interfaces and developing network functions based on open source assets

Commercial 5G radio

SW Based Radio

SW Based Radio

OAIBOX OpenSource 5G Solution

- AMF Access and Mobility management Function
- SMF Session Management Function
- AUSF Authentication Server Function
- SMSF SMS Function
- PCF Policy Control Function
- NEF Network Exposure Function
- UDM Unified Data Management function
- DSF Data Storage Function
- SDL Shared Data Layer
- NRF Network Repository Function
- UPF User Plane Function

Where we are now?



Where we are now?

- 5GTN main server room



Where we are now?

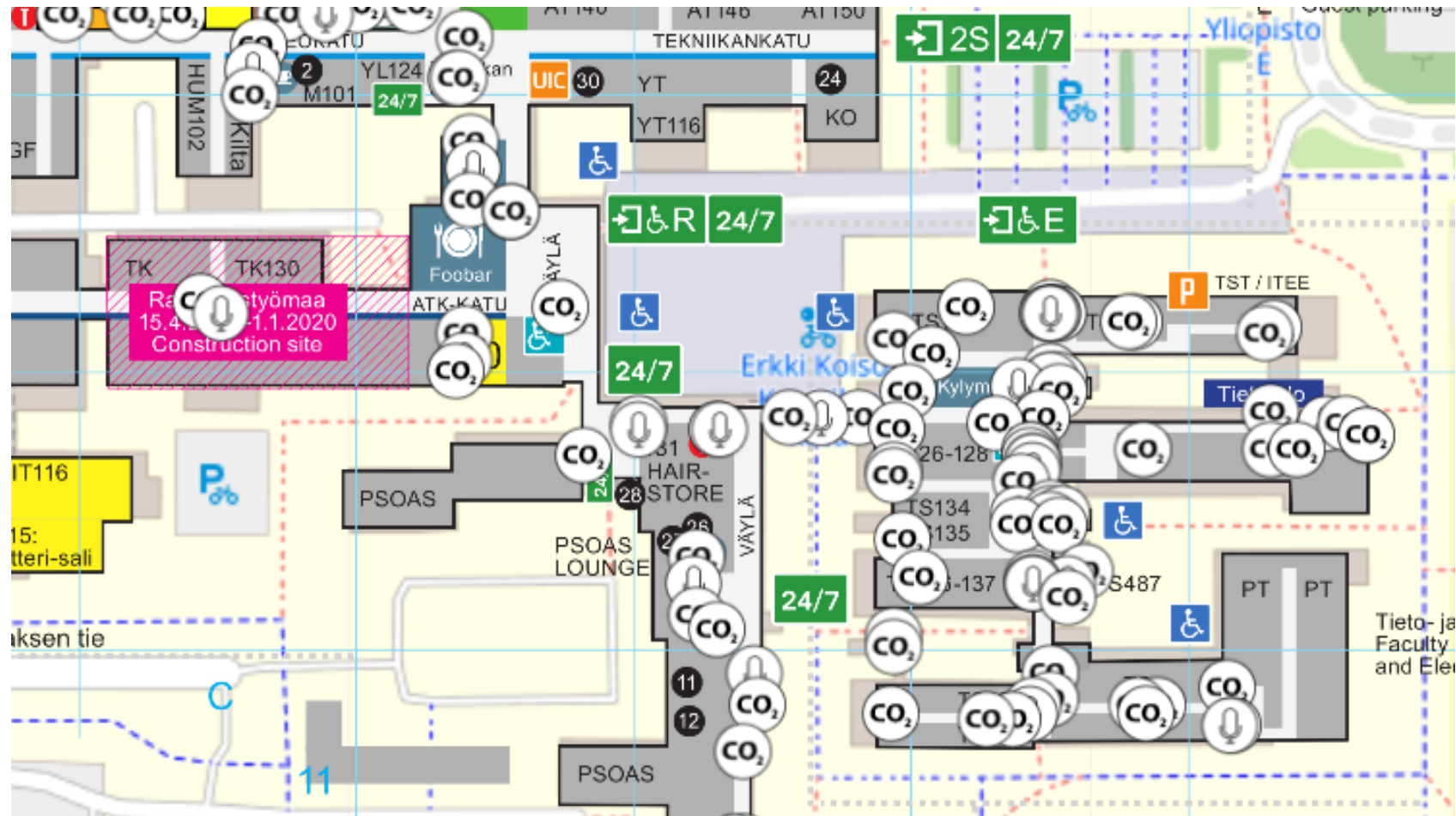
- indoors: 850 MHz and mmWave @ 24 GHz



Examples of use-cases

Indoor monitoring

- BLE
- LoRa
- NB-IoT
- WiFi



Real-time data available at
<https://smartcampus oulu.fi/manage/>



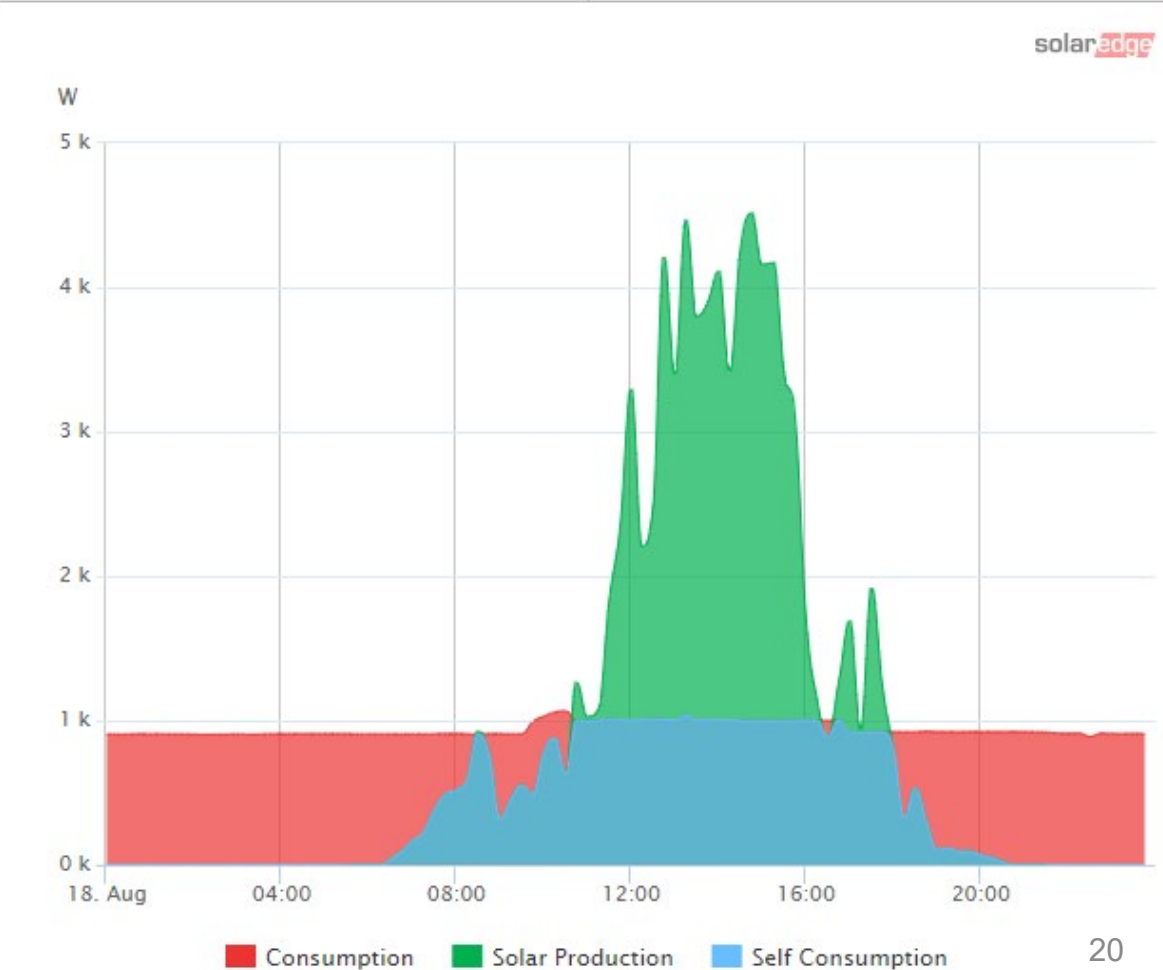
Energy monitoring

- 18 solar panels connected for research purpose
- Environmental data from panels collected with IoT sensors
- Energy forecast data from Finnish Meteorological Institute
- Real-time data access to energy production and 5G consumption



Power and Energy

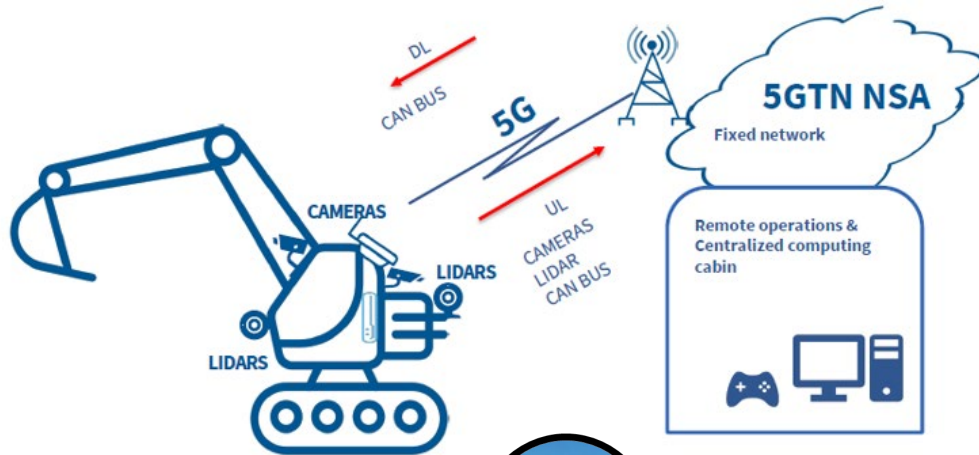
Day Week Month Billing Cycle Year
08/18/2022



Examples

Smart excavator

- Excavator connected via 5G TN
- Remote and autonomous operations



Test Car integration

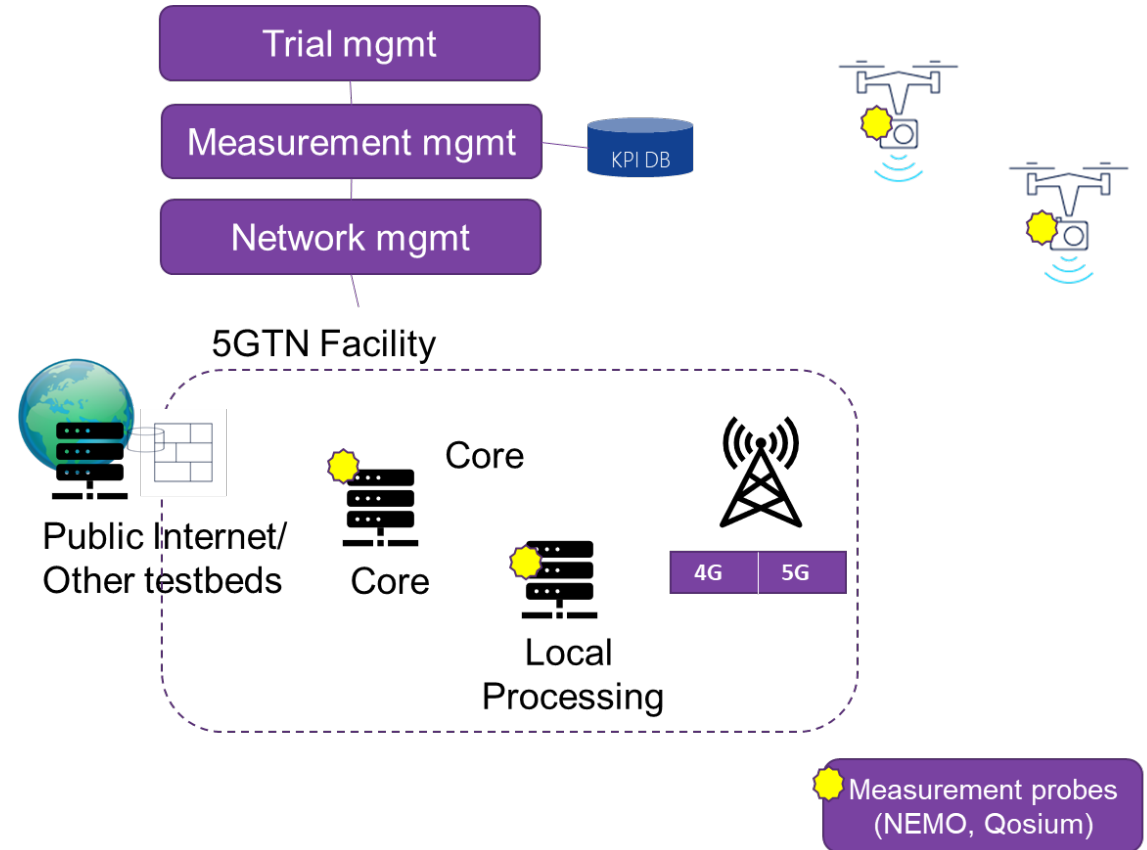


- Remote monitoring of vehicles data from CAN bus
- data send out via 5G link
- Software platform research and visions
- app from app store
 - new functionalities
- Vehicle as a robot

Examples

Drones

- Drones carrying 5G UE and measurement devices as payload
- Tools for
 - Measuring radio i/f characteristic and network QoE
 - Managing and controlling testing and storing measured KPI's



- Define the size of the targeted network as it has impact on
 - costs
 - complexity
 - workload
- Do collaboration with CSP and HW manufacturers
 - take only the mandatory network components under your own hands
 - think about the network scalability
 - maximize the collaboration with CSP
- Vertical researchers
 - think, where 5G (6G) will bring advantage for your studies
 - 5GTN is just an enabler for wireless data transmission
 - what happens next, is not a primary task of the test network operator
 - new services and end-users are needed to utilize data, which is provided via the test network

<https://www.6gworld.com/6gsymposium-spring-2024/>



Levi,
Finland

Thank you!

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