



5G Networks: 5G Ultra-Large Cell Technologies

Prof. Ari Pouttu

Prof. Matti Latva-aho

University of Oulu

Centre for Wireless Communications



Introduction

- **5G is said to revolutionize traditional mobile communication business ecosystem by connecting billions of devices and ultimately digitizing the entire society.**
- **This development is in the beginning based on dense small cell networks in specific high demand locations providing tailored end-to-end network slices for vertical sectors' specific needs.**
- **Policy makers have globally recognized the importance of widespread deployment and timely take-up of very high capacity networks as the key enabler for realizing the full benefits of digital transformation. At the same time underserved and unserved areas need to be considered giving rise to ultra-large cell designs in 5G.**
- **Prediction: Mobile communication business ecosystem will open up for sharing economy that brings together entities to share or exchange otherwise underutilized assets without high upfront investments.**



Spectrum



The near-term spectrum for 5G as proposed by industry: pioneering 5G bands

- The 5G Industry Association (and others) are proposing as pioneering 5G bands (at least in EU)
 - 700 MHz, wide area and indoor coverage
 - 3.4-3.8 GHz, suitable for urban areas
 - 24.25-27.5 GHz, useful for hot spots
- The 700 MHz band lends itself to large coverage but is the band sufficient for the services foreseen for 5G and for the current regulatory framework with licensing.
- Can remote areas be offered to micro-operators?
Local co-operatives? Municipalities?



Low Frequency Spectrum Solutions



The near-term spectrum for 5G as proposed by industry: pioneering 5G bands

- The 700 MHz band lends itself to large coverage but is the band sufficient for the services foreseen for 5G and for the current regulatory framework with licensing?
 - Split between operators
 - Bandwidth requirements
 - Range requirements
- Co-existence in other low frequency bands may be the solution



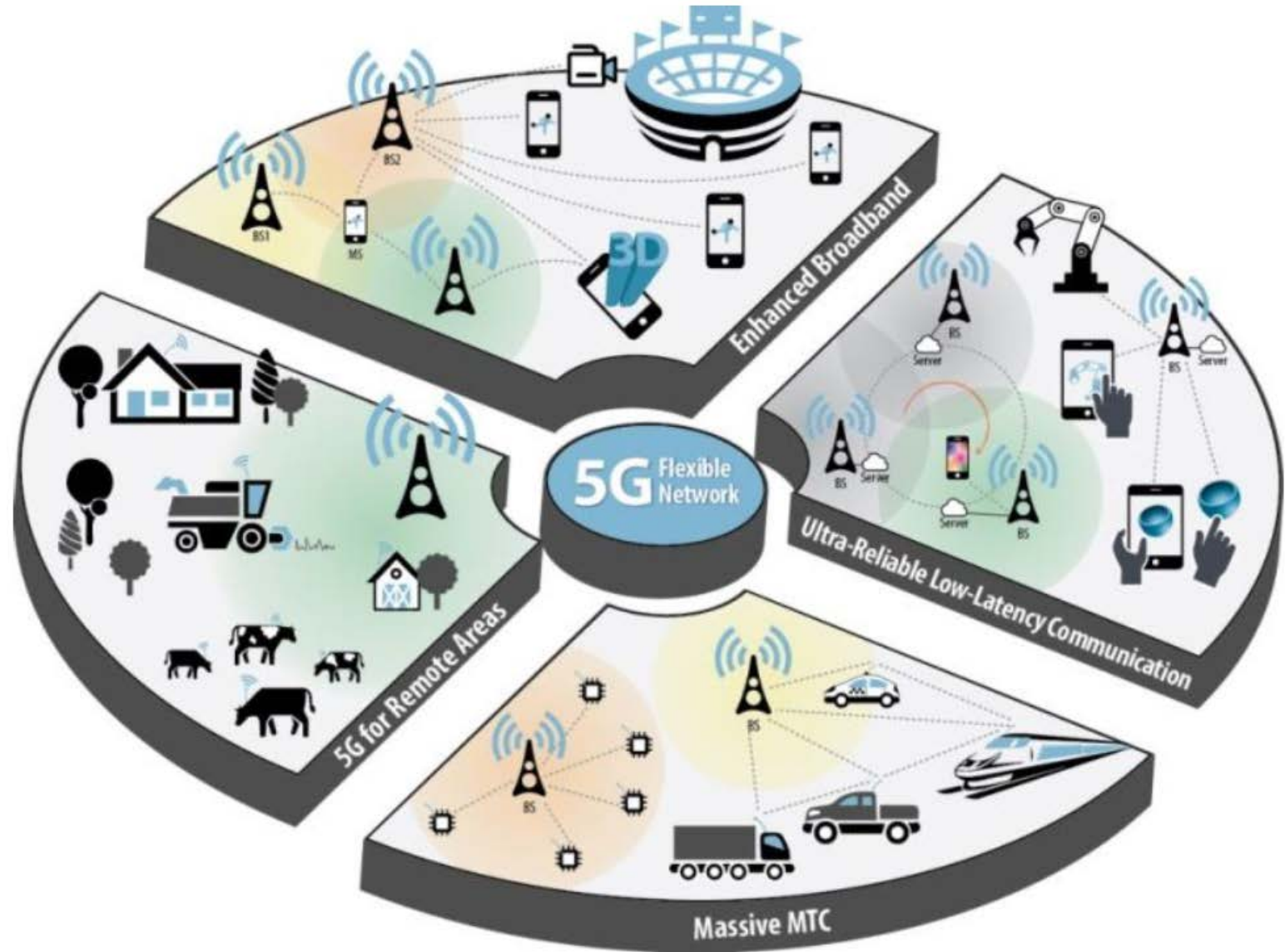
The 700 MHz Band and Co-existence on Other Parts of the Spectrum

- **Systemic challenges to be tackled**
 - **Achieving high spectrum efficiency at large distances;**
 - **Overcoming double dispersive channel using limited overhead;**
 - **Providing high throughput at the cell edge;**
 - **Achieving low operation costs and high energy efficiency;**
 - **Coexisting with other technologies and other secondary networks;**
 - **Providing flexible, dynamic and fragmented spectrum allocation;**
 - **Providing very low out-of-band emissions;**
 - **Establishing reliable long distance uplink from power-limited devices.**



A network slice towards 5G for Remote Areas

- Let's design a high capacity waveform and protocol stack for a new network slice offering 5G for remote or sparsely populated areas





The 700 MHz Band and Co-existence on Other Parts of the Spectrum

- **Solutions required include**
 - **advanced waveforms to increase spectrum efficiency and reduce out-of-band emissions**
 - **modern channel coding schemes**
 - **collaborative spectrum sensing to protect the incumbent spectrum users and to enhance the coexistence between secondary networks**
 - **new cognitive cycle for dynamic resource allocation**
 - **cooperative communication based on D2D and relays**
 - **MIMO aiming for diversity, multiplexing and/or beamforming to increase robustness and coverage combined with MIMO and antenna diversity (aggregation of fragmented new bands and waveforms)**



Satellite ?

One more network slice for 5G



Sat5G

❑ Overall objectives

- Contributing to the 5GPPP use case “**Broadband access everywhere**”, SaT5G will foster the implementation of solutions enabling the “plug and play” integration of satcom components into 5G networks.
- To this aim, SaT5G will **research and validate the key technology enablers through validation and demonstration in live 5G testbeds.**
- SaT5G impact is for the satellite industry to join the European initiative in the deployment of a competitive and ubiquitous 5G network globally.

❑ Schedule

- 30 months duration

❑ Consortium

- AVA project coordination, TAS technical coordination
- 16 partners (satellite/terrestrial operators, vendors, universities and research centres)

Use Cases & Research Pillars



Use Case 1: Edge delivery & offload for multimedia content and NFV software



RP VI: Caching and Multicast for Content/VNF distribution to the edge over satcom

Use Case 2: 5G Mobile backhaul



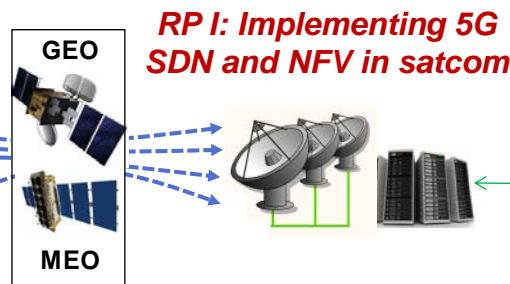
Use Case 3: 5G Fixed backhaul



Use Case 4: 5G Small cell backhaul

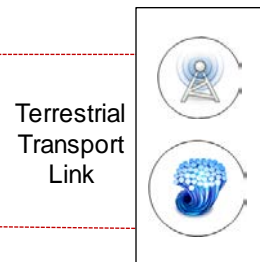


RP III: Multi Link and Heterogeneous transport

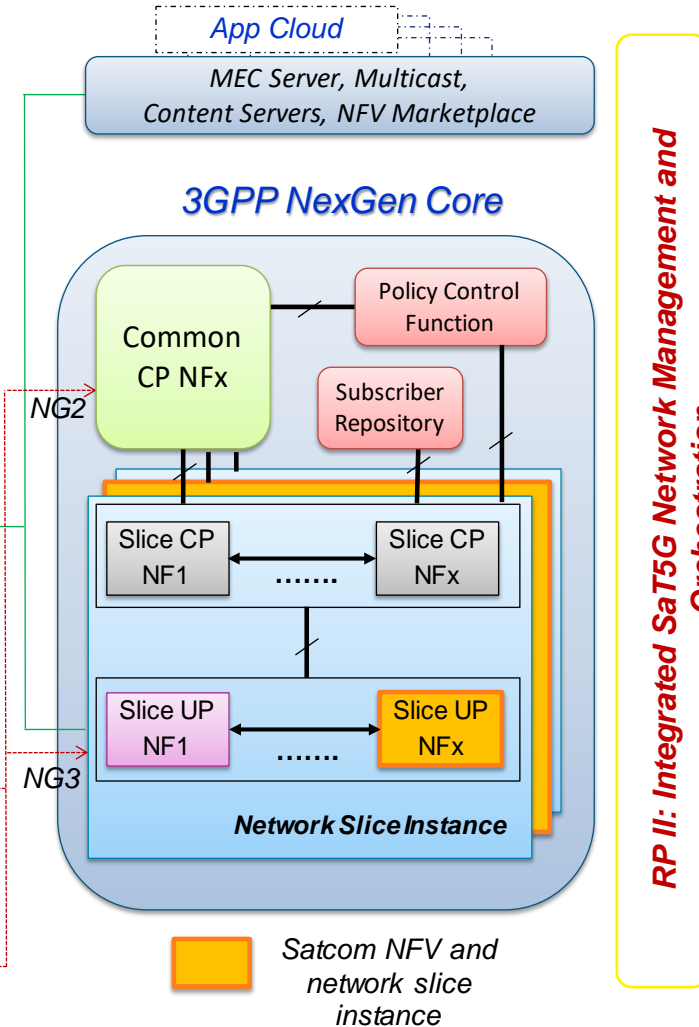


RP I: Implementing 5G SDN and NFV in satcom

RP IV: Common 5G-satcom Control Plane/User Plane Functions

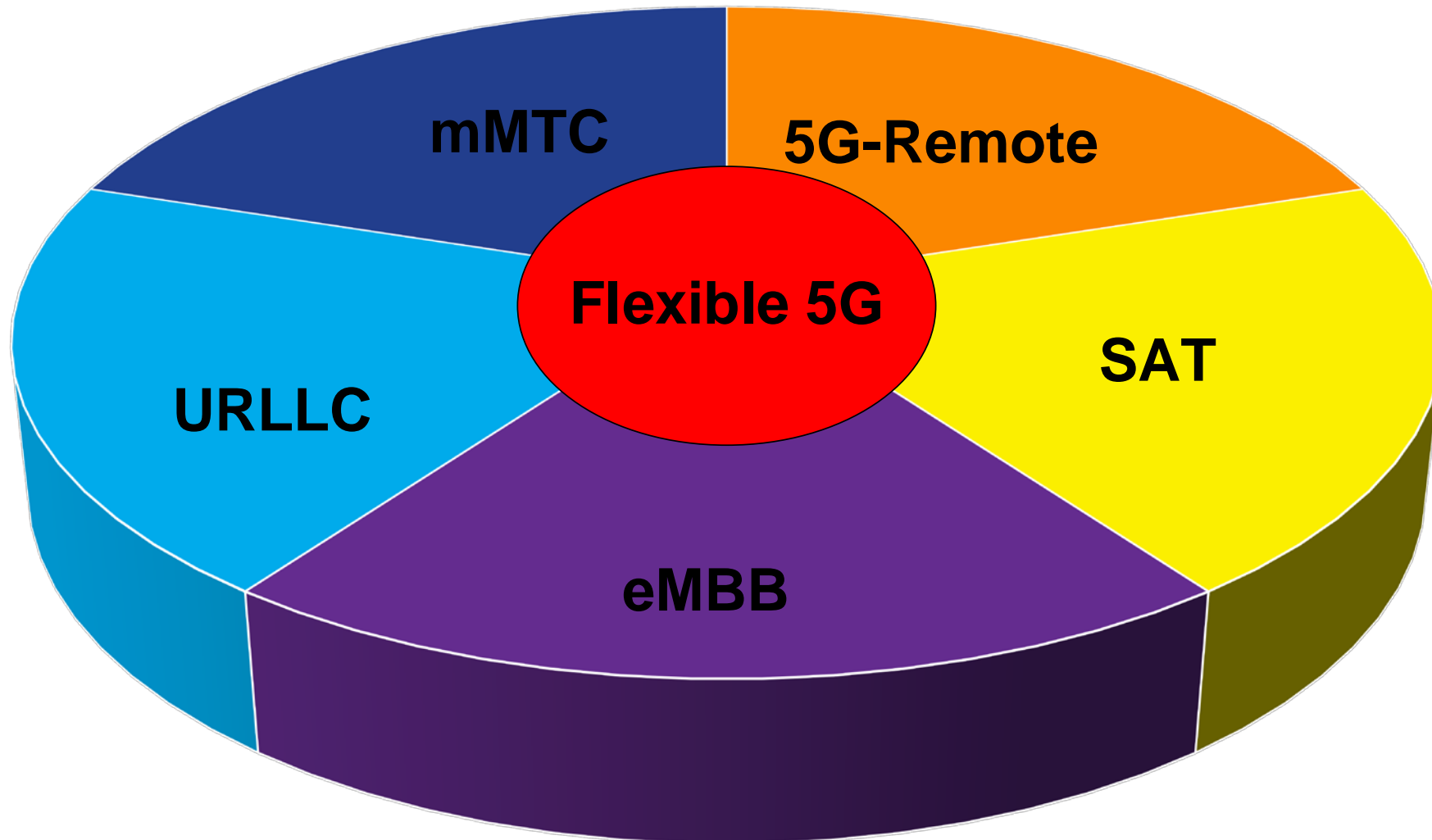


RP V: 5G Security extensions to satcom





One more network slice for 5G ?





Micro operators

or sharing economy?

Is there 5G spectrum – or just spectrum?

Micro operator concept to boost service delivery in 5G

- Growing digitalization requires that versatile location and case specific requirements with high traffic densities are met (particularly in indoors).
- uO5G challenges the traditional wireless connectivity MNO market dominance to speed up digitalization across verticals for service delivery.

➤ **Concept of micro operators (uO)**

Tekes

Challenge
Finland





Trends of change in mobile connectivity

From outdoor macro cell deployments

To indoor small cell networks

From exclusivity in spectrum access rights

To operation in shared spectrum bands

From sharing between an operator and an incumbent

To inter-operator spectrum sharing

From small number of dominant MNOs

To emergence of a large number of local network operators

From owning infrastructure

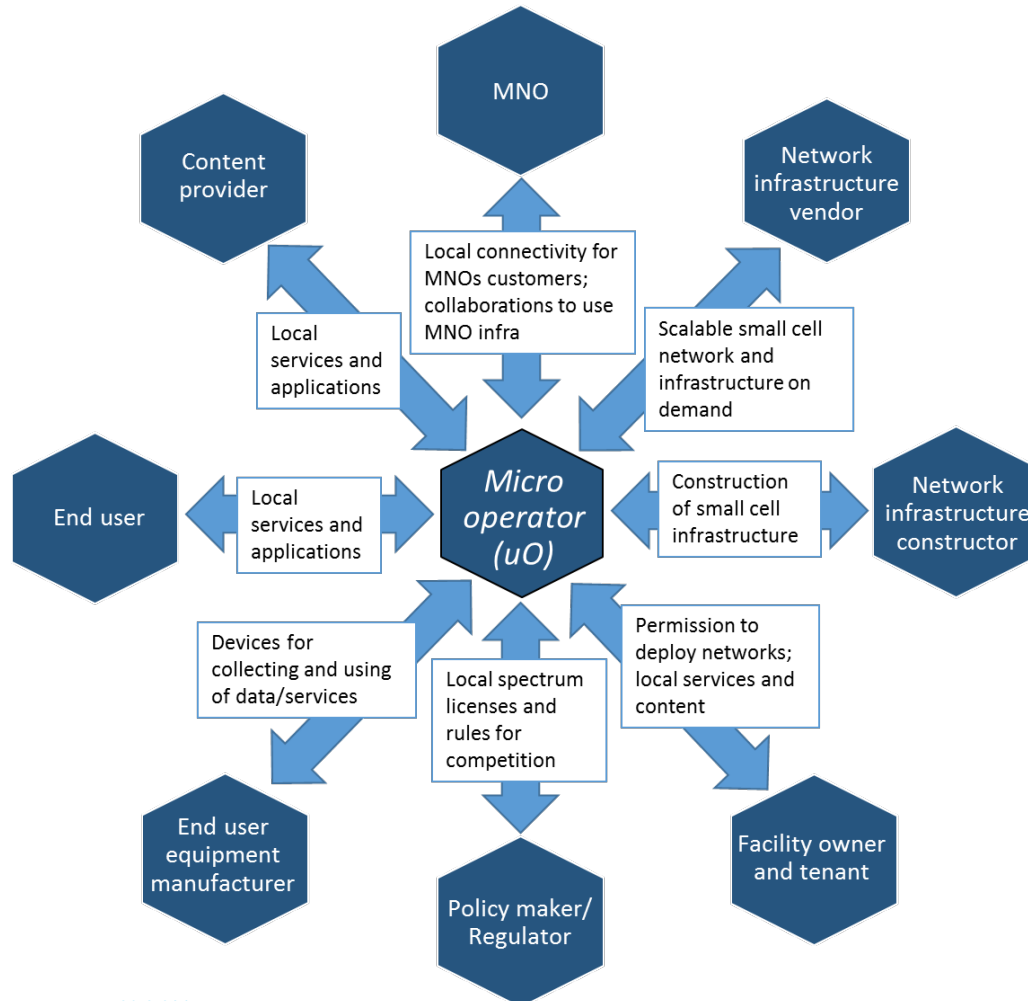
To leasing network slices on-demand

From a small number of nation-wide spectrum licenses

To a large number of local spectrum licenses



What is needed for uO?

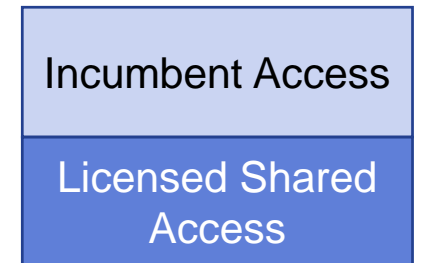
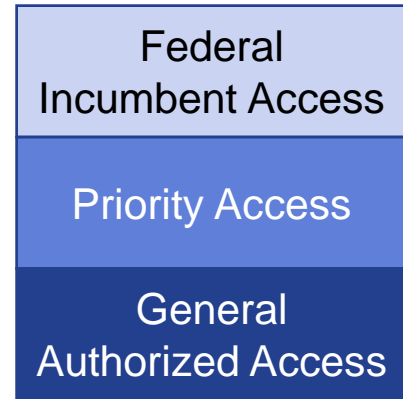


- Regulation that assigns local licenses for micro operators and makes building of indoor connectivity feasible
- Business models that are scalable across different verticals
- Technology for local small cell deployments and leasing the required infrastructure without high up-front investments



Regulatory developments globally enable local networks

- The US regulator FCC:n has introduced a three-tier model in 3.55-3.70 GHz that enables market entry for new players with local access rights
- In Europe the Licensed Shared Access (LSA) – concept in 2.3-2.4 GHz and 3.4-4.2 GHz bands enables local deployments of mobile communications while protecting incumbents
- Other regulatory developments towards the new sharing economy (use of big data, pricing, privacy, competition, roaming, building of indoor networks)
- Can remote areas be offered to micro-operators?
Local co-operatives? Municipalities?

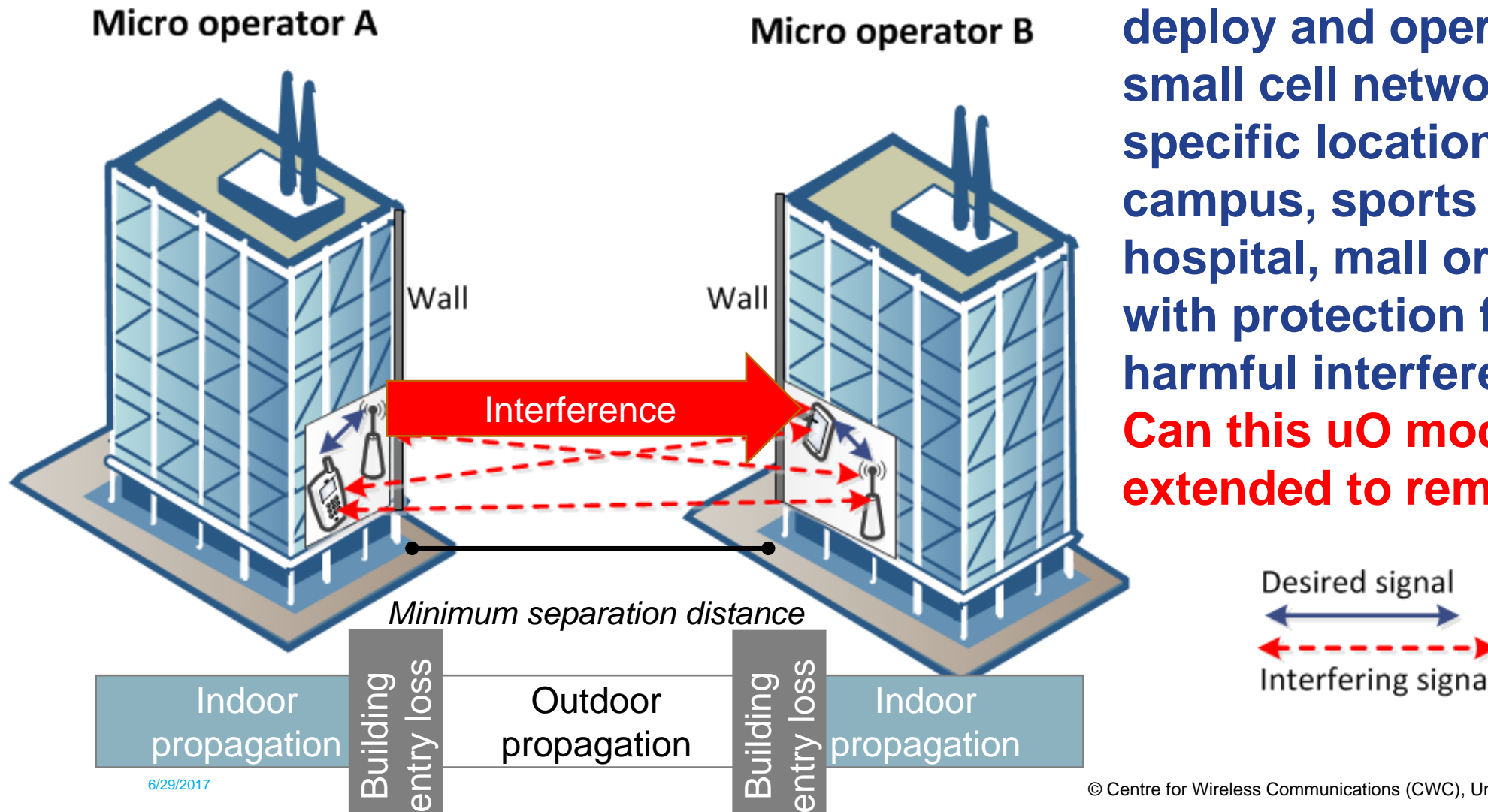




Micro license model

“Micro licensing” opens the market for new entrants to deploy and operate local small cell networks in a specific location such as campus, sports arena, hospital, mall or factory with protection from harmful interference.

Can this uO model be extended to remote areas?

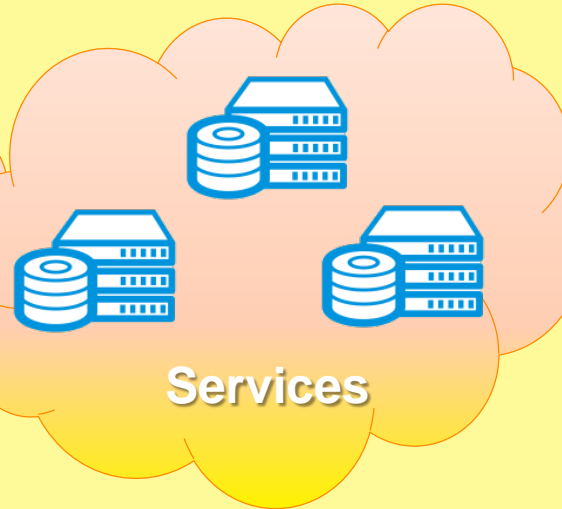
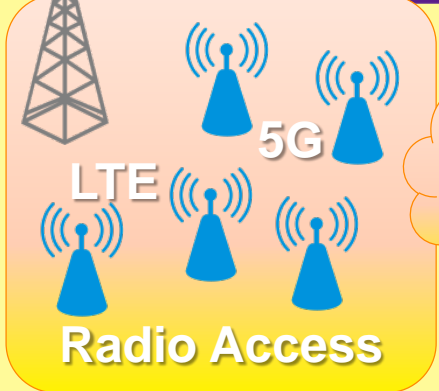




And I leave you with ...

WiFi and IoT networks
integrated

5G Test Network



5GTNF
Interconnections

Other 5G Test
Networks

From LTE
evolution to 5G
radio access

Mobile Edge
Computing to
bring services
close to users
access

Core network in
a cloud
environment

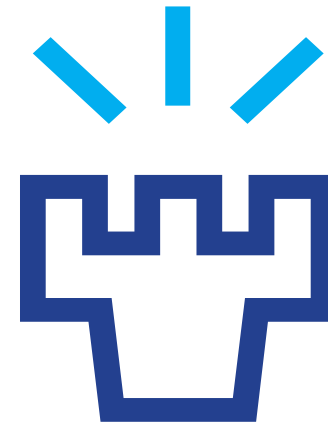
Cloud systems
for applications
available

Secure connection to
other 5G test sites in
Finland and worldwide



CENTRE FOR WIRELESS COMMUNICATIONS
University of Oulu

#cwcoulu #5GTN



**UNIVERSITY
OF OULU**

Contacts:

ari.pouttu@oulu.fi

marja.matinmikko@oulu.fi

matti.latva-aho@oulu.fi