Sustainable and Adaptive Ultra-High-Capacity Micro Base Stations

CHIST-ERA Project Seminar 2022

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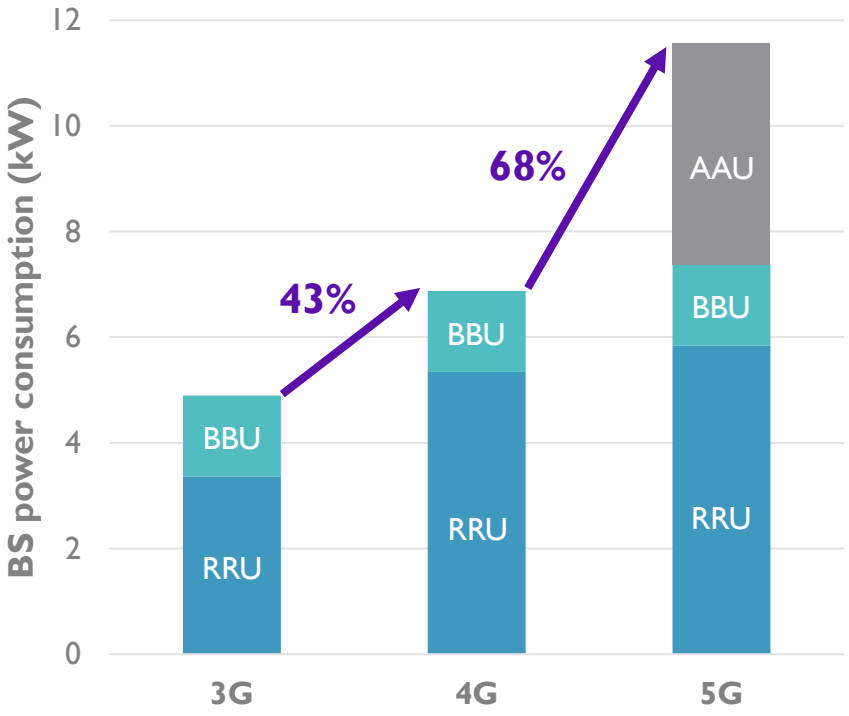
CHIST-ERA-20-SICT-003

5G is the most power hungry mobile technology ever!

Significant power consumption increase with each generation of mobile networks



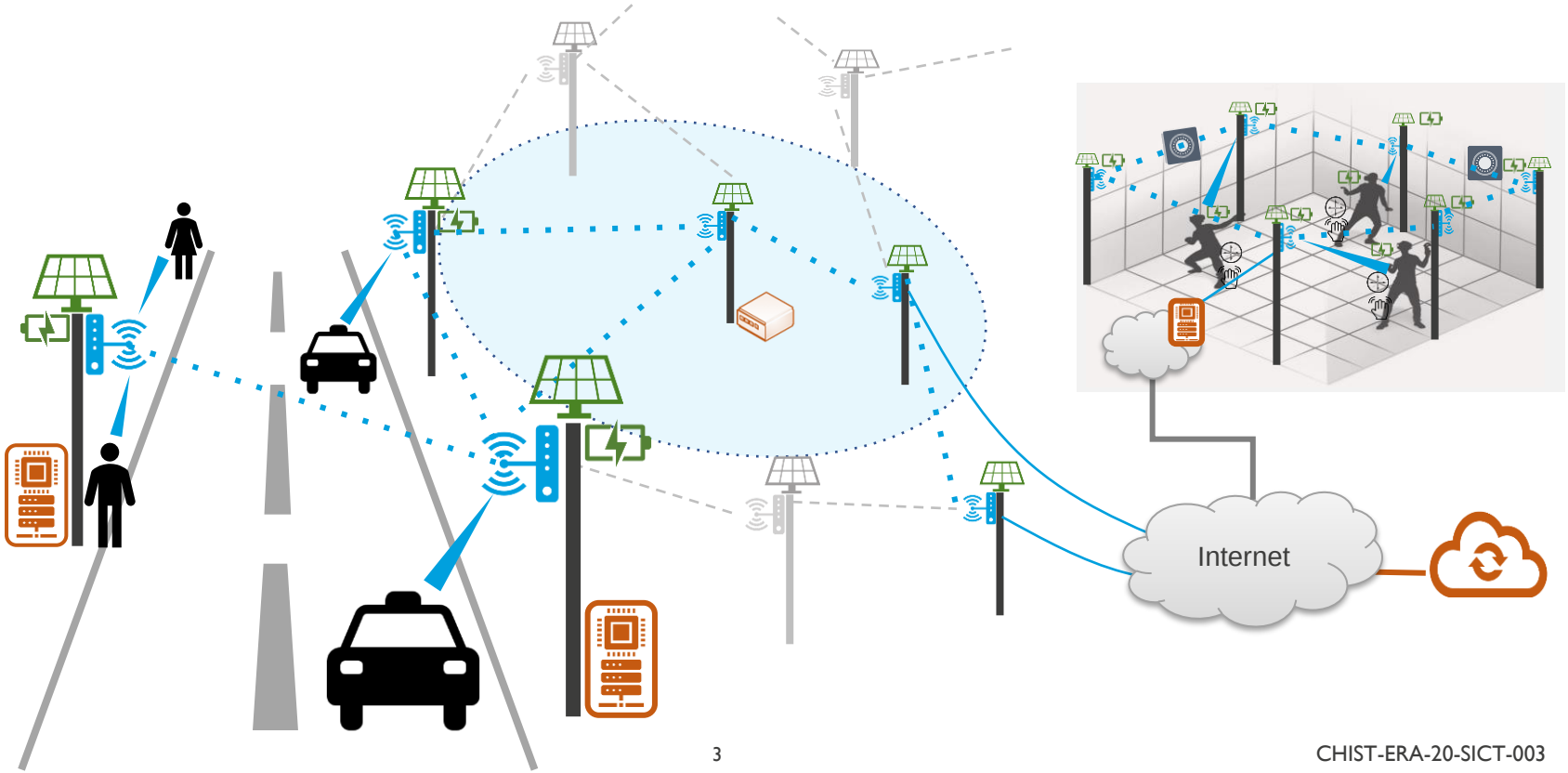
- 5G is most energy efficient per bit
- **BUT**, total power consumption per base station is **68% higher** in 5G than 4G
  - > 10kW with 5 frequency bands
  - > 20kW with 10 frequency bands
  - and base station densification...

SAMBAS goal: Sustainable beyond-5G mmWave network infrastructure, reducing reliance on non-renewable energy

Source: *D. Chen, et al., "5G Power: Creating a green grid that slashes costs, emissions & energy use," 2020.*

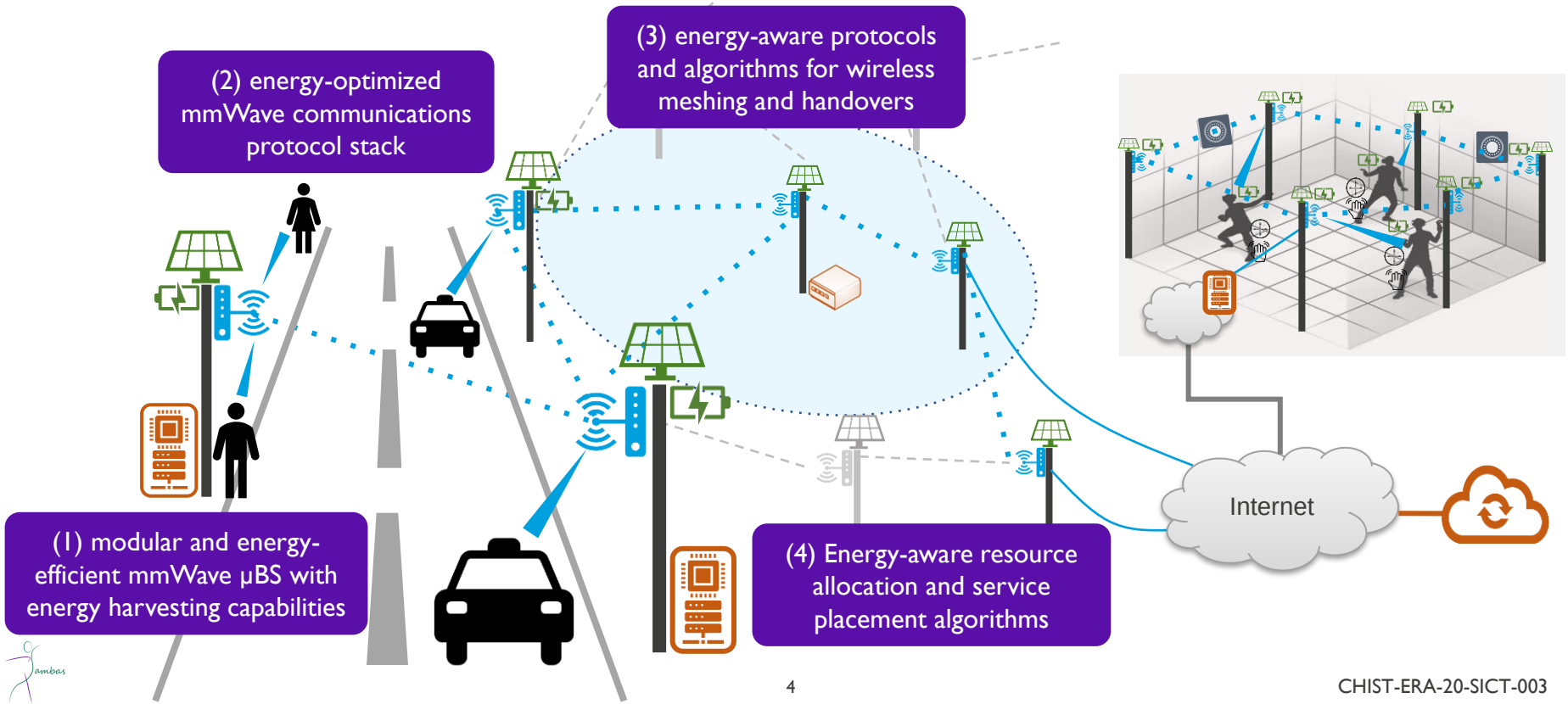
Project overview

Main concept: energy harvesting mmWave micro base station (μBS)

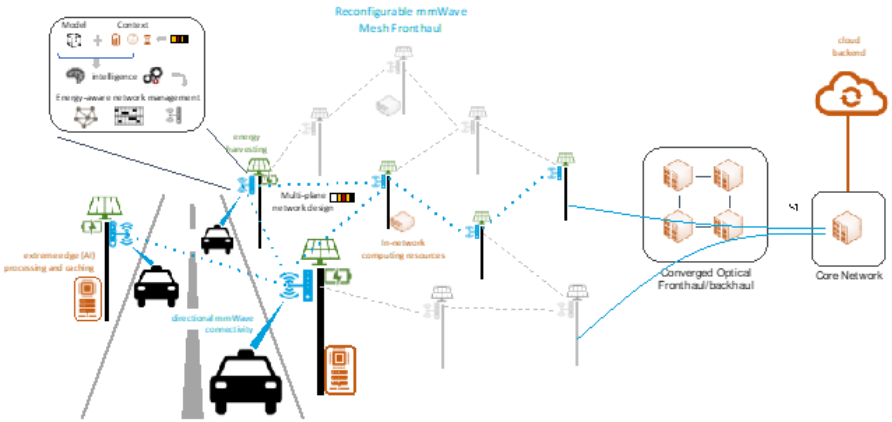


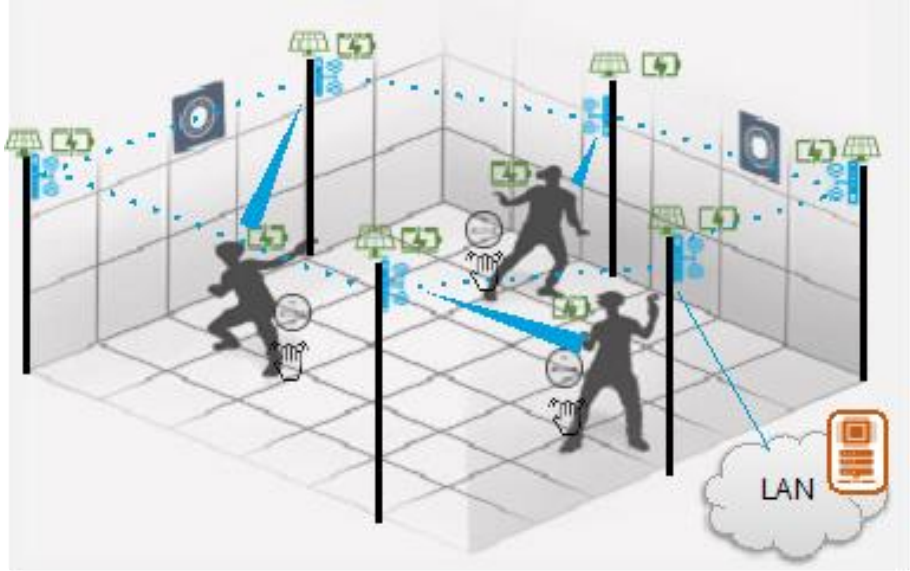
SAMBAS target innovations

End-to-end energy-aware joint resource and network optimization



The project will prototype 2 use cases





OUTDOOR Use case

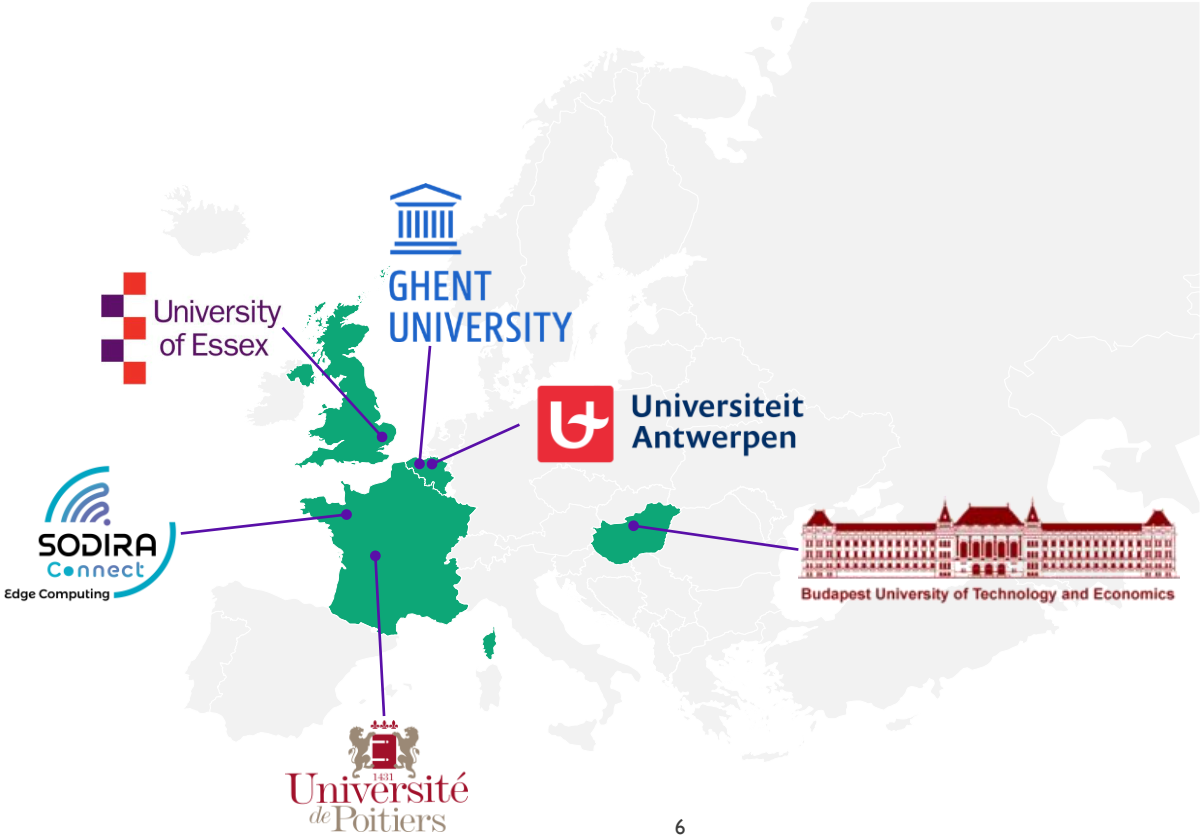
Vehicular communication in dense areas and autonomous driving

INDOOR Use case

Interactive virtual reality application

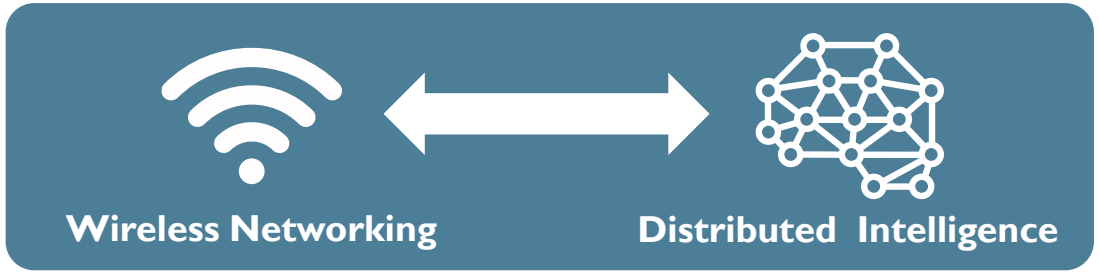
SAMBAS consortium

5 academic and 1 industry partner spread across 4 European countries

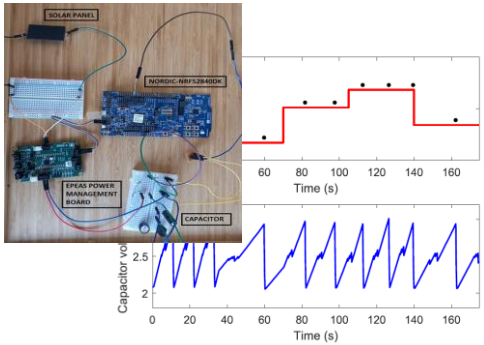


University of Antwerp

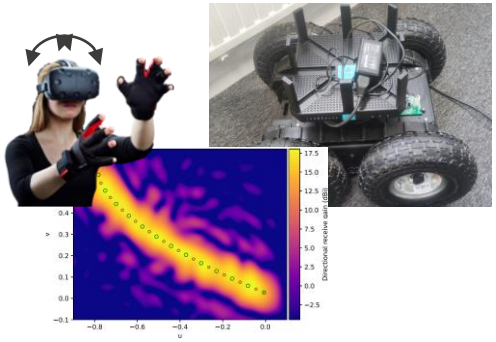
IDLab research group



Energy-aware networking

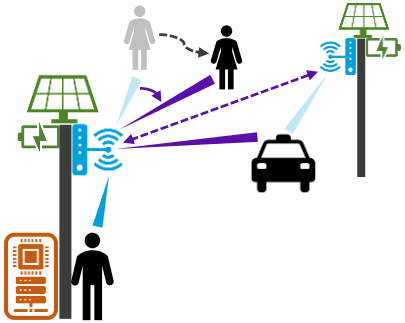


mmWave protocol design



SAMBAS contributions

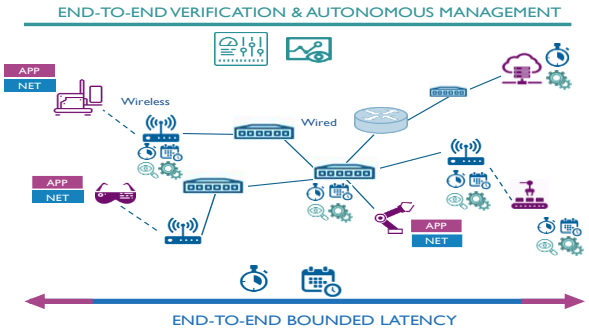
- Project coordination
- Energy lifecycle modelling for energy harvesting wireless devices
- Beamforming and channel access algorithms
- Energy-aware handover algorithms

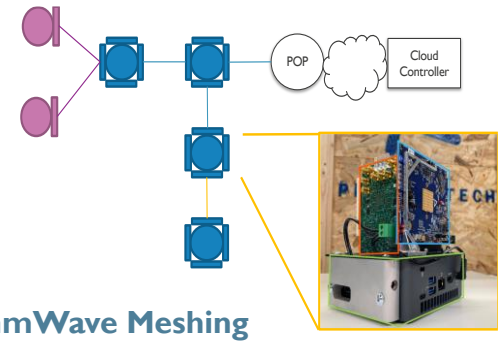


Ghent University

IDLab research group

Verifiable wireless-wired time-sensitive networking

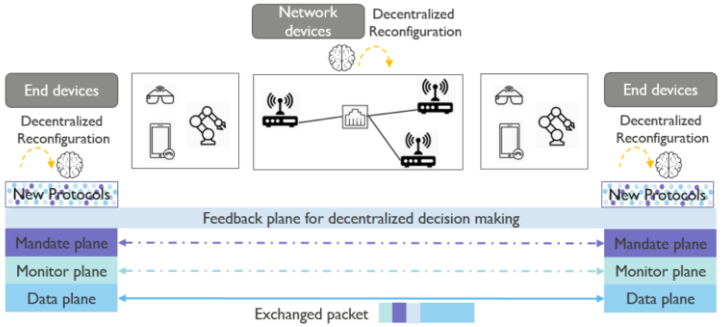




mmWave Meshing

SAMBAS contributions

- Novel decentralized network design for mmwave networks
- Context-aware network operation
- Energy-aware meshing and handover decisions
- Integration coordination

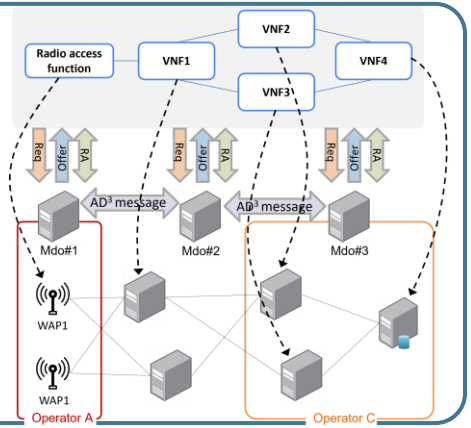


University of Poitiers

RUBIH, XLIM Lab

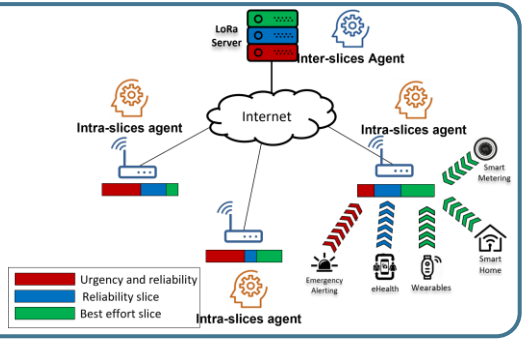
Virtualisation of cellular networks

- End-to-end virtualisation
  - Static/Dynamic VNF-FG embedding
  - Single domain
  - Muti-domains cooperative / non-cooperative



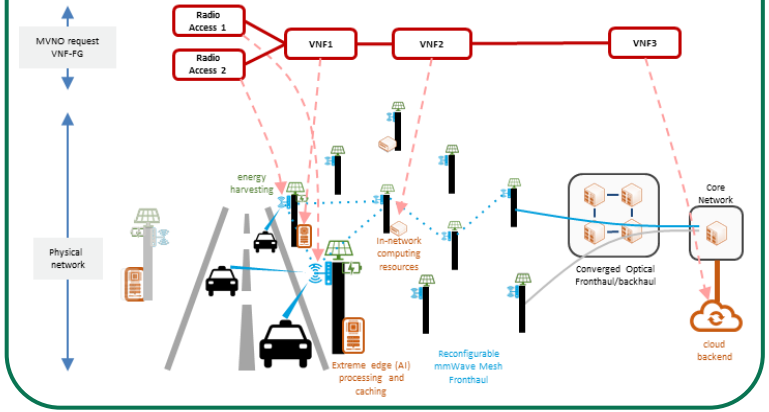
IoT network slicing

- IoT **QoS** differentiation
- **Radio** and **computing** resources allocation
- AI based solution for **large scale** IoT



SAMBAS contributions

- Energy-aware network virtualization and resource allocation
- Efficient and **energy aware** VNF-FG embedding approach
- VNF **migration** (Virtual Machines, Dockers) from one physical node to another one based on predictive approaches



Sodira Connect

Expertise and project contributions

SODIRA Connect is a French SME in the domain of Content delivery, IoT, Edge computing and virtualized functions for Mobile Edge Computing.

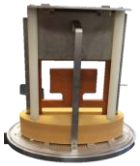
NAVICollect Solution

Complete IoT solution with Service Platform

NAVIGateway

NAVIManager

In 2021 SODIRA Connect acquired **ADVANTEN** specialized in the design and manufacturing of antennas and wireless connectivity solutions for mobile and fixed applications.



SAMBAS contributions

- Joint energy-focused mmWave radio and computing resource allocation
  - Containerisation of caching application
  - Integration in the overall framework
  - Study of algorithmics adapted to mm wave
- Dissemination : web site design and social network presence

University of Essex

6G mast with inbuilt wind turbine(s) **using bridge-based power sharing**:

- Multiple turbines
- Bridge based power sharing
- Three-phase bridge rectifier

Role in SAMBAS Project

- Technical Leader & WP2 leader
- Investigate 60-110 GHz (V-E-W bands) mmWave technologies
- Renewable microgeneration powering of μBS design

SAMBAS technologies being investigated by UEssex:

- High-capacity (multi-Gb/s) modulation schemes (e.g. COFDM)
- a converter designed to work with a permanent magnet (PM) generator, featuring:
    - low construction cost, high efficiency, high reliability, and simple design and control.
- μBS hardware and firmware integrated with the energy harvesting and storage.

Budapest University of Technology and Economics

BME Expertise related to SAMBAS:

- Network **optimization:** optical access and optical core for 5G
- **Exposure** and **orchestration** for Cloud-Native Stand-Alone 5G cellular mobile core
- Private **5G test-bed** with mmWave massive MIMO

BME Contribution to SAMBAS:

- mmWave 5G network optimisation to **reduce energy** requirement
- Radio Access and Core Network – **design and operation** strategies
- New **mmWave Path-Loss Model**s evaluated and proposed

- **Tradeoff** between **5** somewhat contradicting aspects:
  - **Energy** requirement
  - **Throughput**
  - **Delay** (RTT)
  - **Availability**
  - **Cost** (CAPEX+OPEX)
- **Optimisation** framework, measurements, simulations, prototyping

ambas