

Remote Area Networks

- The Last Frontier for Universal Access

Yaning Zou, Technische Universität Dresden, Germany

Luciano Leonel Mendes, Inatel, Brazil

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Motivations and Applications

Motivations for Remote Areas



- Connectivity gap in rural areas

- New markets for operators

- IoT in Remote Areas

- Road coverage



Connectivity in remote areas



- Last frontier for universal access.

- 3.9 billion people unconnected.

- High social impact:

- e-gov

- e-health

- remote education



New Market for Operators



- New customers.
- Micro-operators partnership.
- New services to be offered.



IoT in Remote Areas



- Smart Farm application

- Field information: soil, water, air.
- Remote activation: watering system.
- Cattle monitoring.
- Machinery control: platooning.



IoT in Remote Areas

RAN5E



Use of Drones for pesticide and fertilizer.

Road Coverage

RANGE

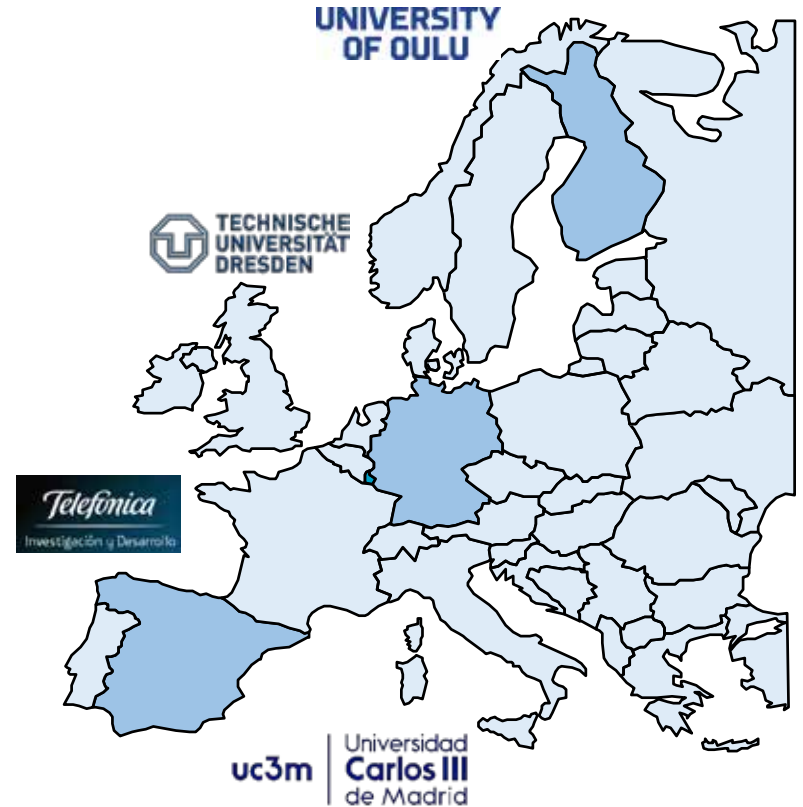
- Entertainment
- V2X connectivity
- Safety



5G-based Solution

- **Funded by ICT EU-BR JOINT CALL**
 - Call topic: 5G Networks
 - H2020-EUB-2017 on the EU side
 - 4ª Chamada Coordenada BR-UE em Tecnologias da Informação e Comunicação
- **Project duration: 30 months**
- **Starting date: 1st November 2017**
- **Budget:**
 - EU funding: EUR 999.906,25 BR funding: R\$ 3.248.121,34

5G-RANGE Consortium



5G-RANGE Goals



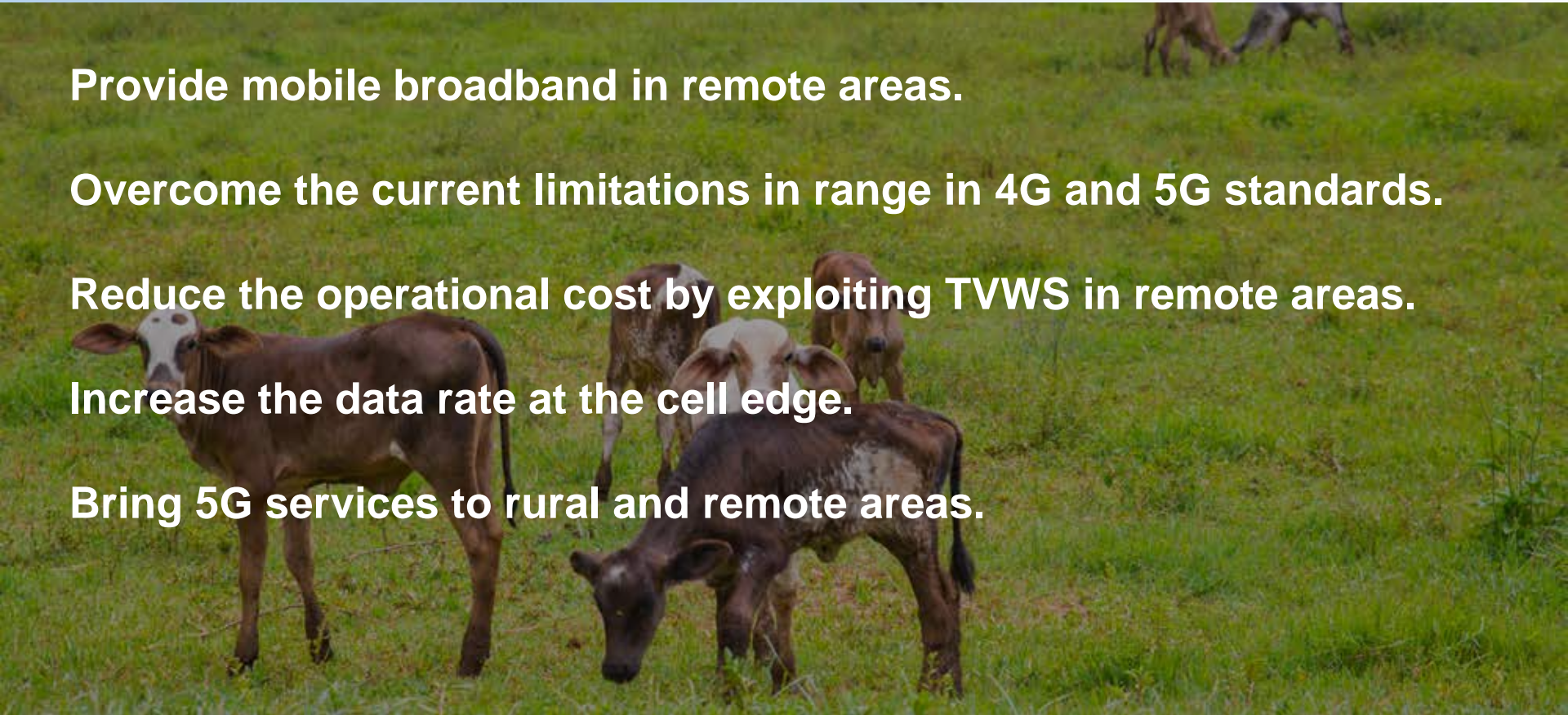
Provide mobile broadband in remote areas.

Overcome the current limitations in range in 4G and 5G standards.

Reduce the operational cost by exploiting TVWS in remote areas.

Increase the data rate at the cell edge.

Bring 5G services to rural and remote areas.



5G-RANGE Requirements



Cell radius: 50 km

Data rate: 100 Mbps

Mobility: 120 km/h

5G services: MBB & IoT



5G-RANGE Features



Robustness: MIMO diversity and Polar Codes

Smartness: Cognitive Radio & Dynamic Spectrum

Coexistence: Low Out-of-Band emissions

Flexibility: covers multiples scenarios

Evolution: Software Defined Radio approach



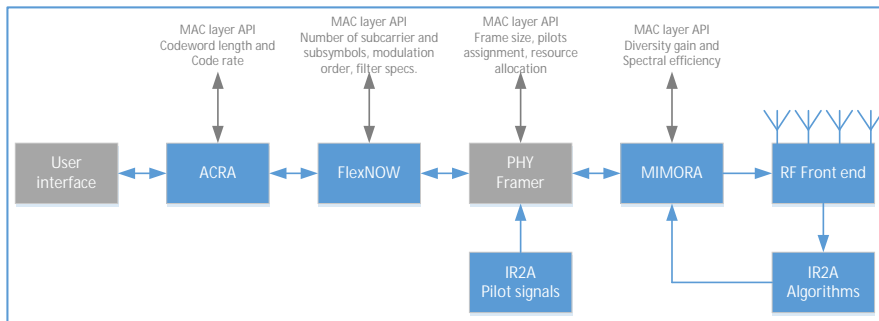
5G-RANGE Features



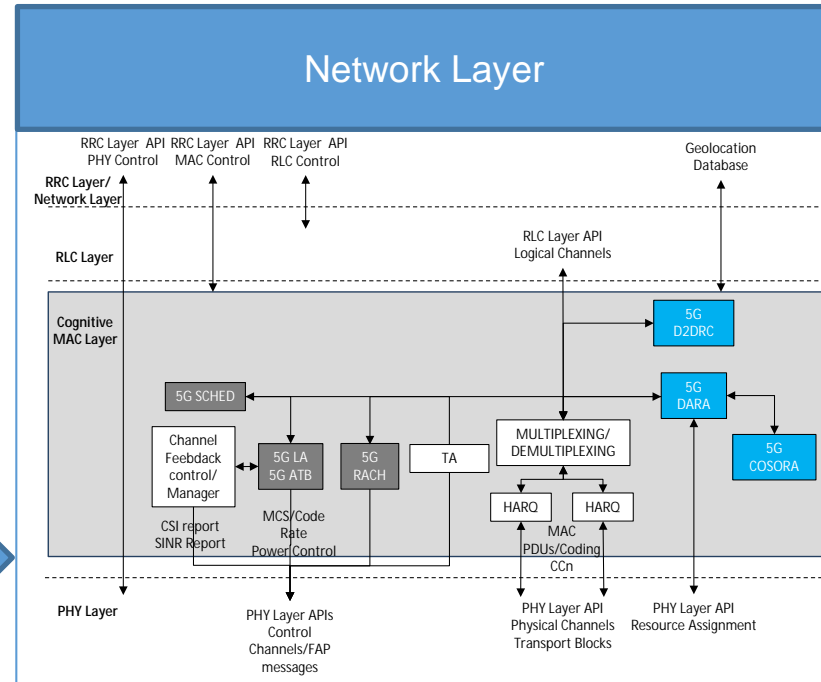
Exploit the advances proposed for 5G.

But tailored for the new scenario.

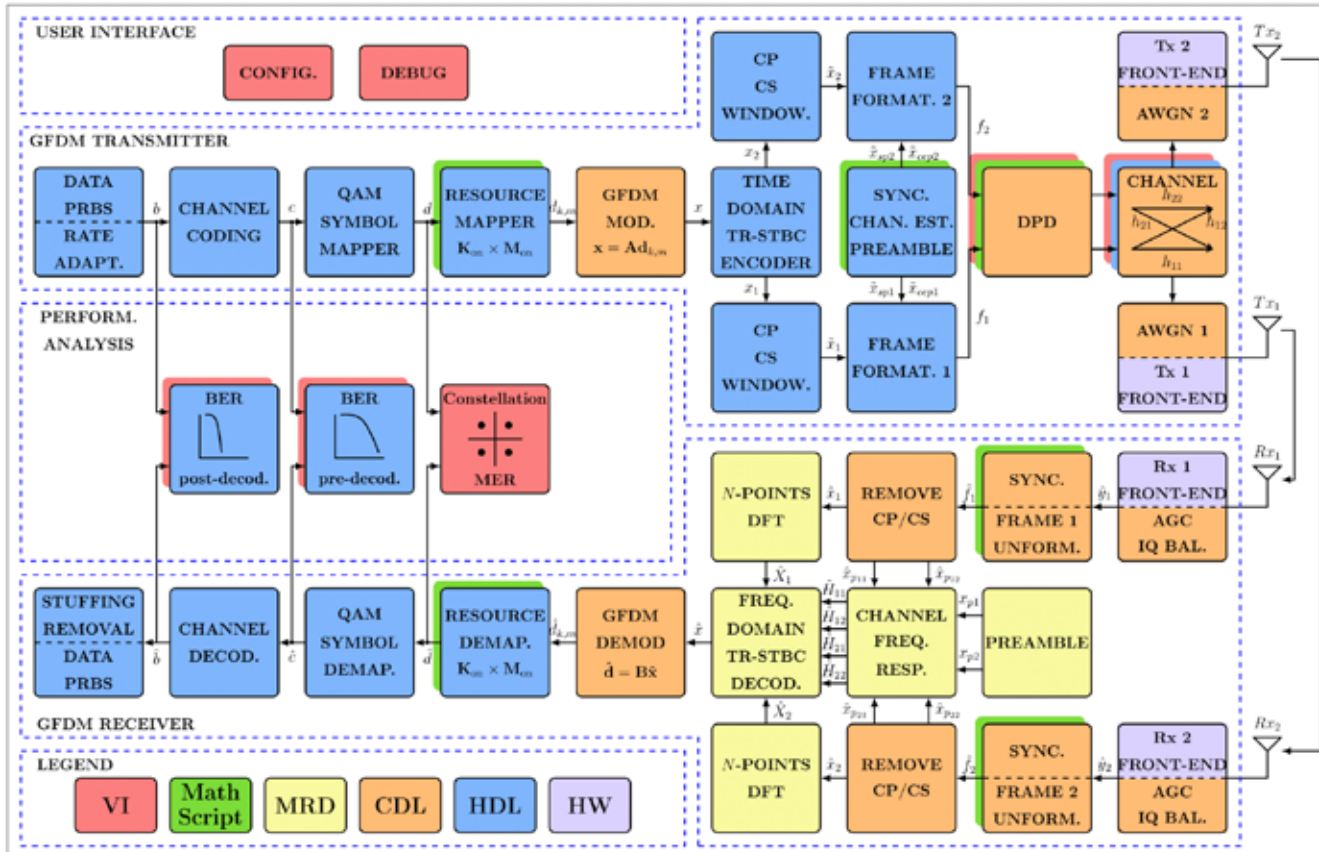
Flexible PHY



Cognitive MAC



5G-RANGE Features



Development of a Long-range Network based on SDR.

Combination of FPGA and CPU/GPU processing for higher throughput and flexibility.

Fast prototyping environments. Build RF front-end for sub 1GHz white space exploitation.

5G-RANGE Field Test



- System parameters:

- § MIMO: 2+2
- § TX1 power (EIRP): 50,5 dBm
- § TX2 power (EIRP): 48,5 dBm
- § Transmit antenna gain: 9 dBi
- § Receive antenna gain: 9 dBi
- § BW: 6 MHz or 12 MHz
- § Frequency: 700 MHz band



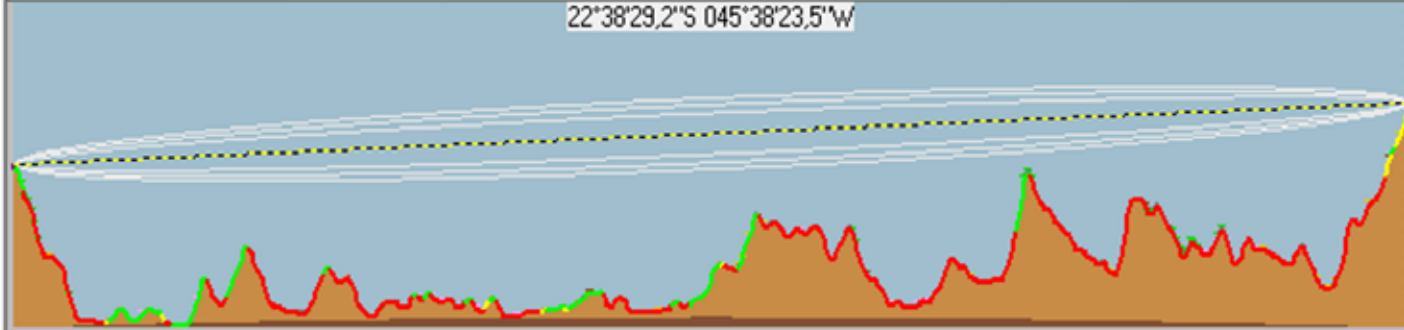
5G-RANGE Field Test



Estimated Data

Azimuth=168,05°	Elev. angle=-0,118°	Clearance at 0,13km	Worst Fresnel=2,5F1	Distance=50,60km
Free Space=123,8 dB	Obstruction=0,6 dB TR	Urban=0,0 dB	Forest=1,0 dB	Statistics=6,4 dB
PathLoss=131,9dB	E field=49,9dBμV/m	Rx level=-78,1dBm	Rx level=27,81μV	Rx Relative=1,9dB

22°38'29,2"S 045°38'23,5"W



Measured Data

Power	Ant 1	Ant 2
	-69.87 dBm	-64.9 dBm
Rate	22 Mbps	
BW	6 MHz	
Modulation	64 QAM	
Code rate	3/4	
MER	23.29 dB	
BER	≈ 0	
Distance	50.60 km	

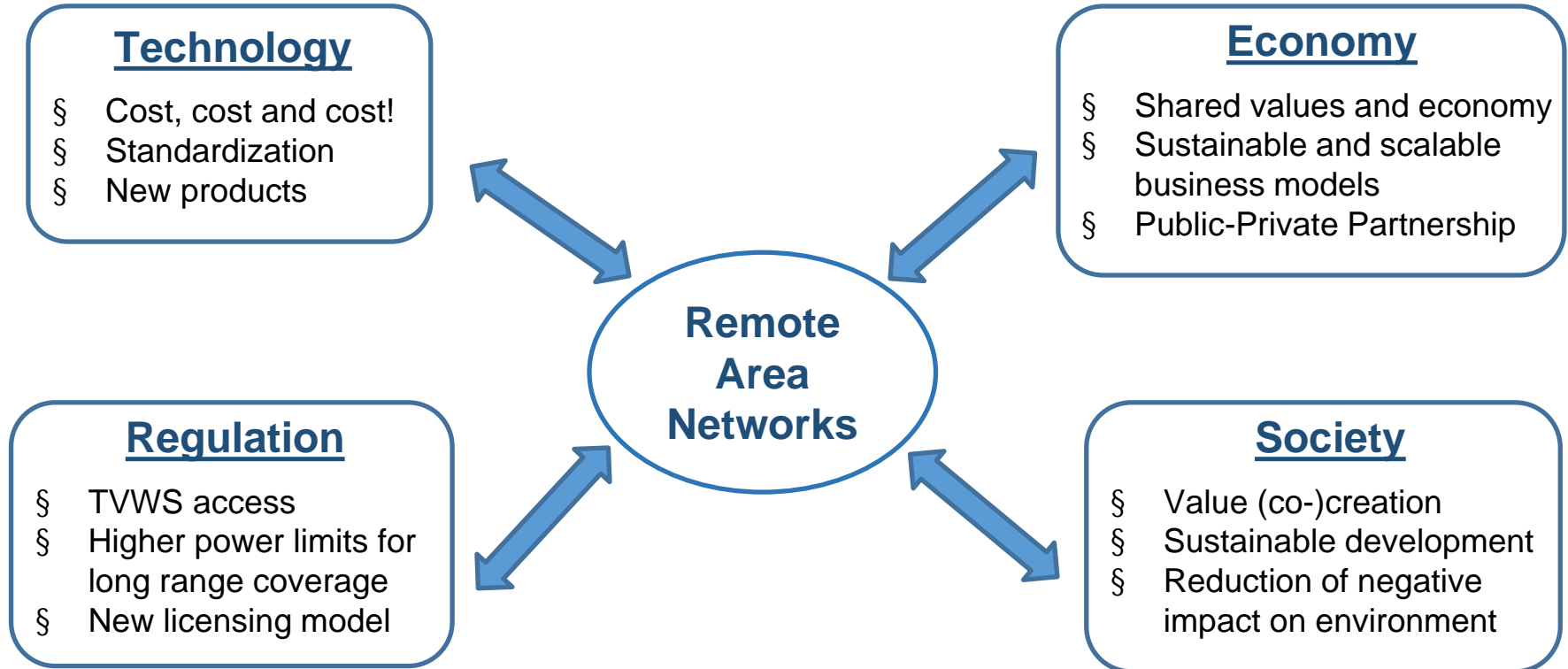
BW (MHz)	Modulation	Code rate	Bit Rate (Mbps)	BER < 10 ⁻⁶	SNR (dB)
6	64-QAM	3/4	22	yes	28.51
6	64-QAM	5/6	24	yes	29.98
6	256-QAM	5/6	32	yes	26.31
6	256-QAM	3/4	29	yes	29.18
12	64-QAM	5/6	48	yes	29.35
12	256-QAM	5/6	64	no	29.15
12	256-QAM	3/4	57	yes	27.33

Remote Area Networks in 2030 Framework

- **Broadband access data rate ~ 1Gbps**
 - Immersive experiences for e.g. entertainment, education, agriculture and health-care applications
 - Better coverage & mobility trade-off
- **Low latency especially while using satellite backhaul**
 - Mobile edge computing at local network
- **Connecting diverse ranges of devices**
 - Heterogeneous and flexible network topologies
 - Ultra-fast information processing/fusion

- **Reliable and resilient network for 24/7 operation**
 - Example: autonomous machinery for seeding and harvest
 - Always available and robust network
 - Reliable coverage
- **Shared infrastructures for the shared economy**
 - Multiple operators/applications using the shared infrastructure
 - Virtualization of infrastructures
 - Data handling, security and privacy!!!

Major Challenges and Opportunities



Connecting the Last Billions



Thanks for your attention!

yaning.zou@ifn.et.tu-dresden.de

luciano@inatel.br

<http://5g-range.eu/>