# Remote area Access Network for 5th GEneration

## Results

### Project Information

**5GRANGE**

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Coordinated by UNIVERSIDAD CARLOS III DE MADRID Spain

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<th>Start date</th>
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<td>1 November 2017</td>
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*Another small step: A new age of solar system exploration*

NO. 104, JULY 2021
Deliverables

Documents, reports (18)

Report describing the performance evaluation of the proposed solution
This report will present the performance evaluation of the proposed 5G-RANGE network using two different approaches. In the first one, the software-based system will be exploited to analyse the overall system performance under laboratorial and controlled channel conditions. In the second approach, the 5G-PoC BS and 5GPoC UE will be employed to measure the system performance assuming real channel conditions. The results obtained in both approaches will be compared with the requirements listed in WP2.

Spectrum Sensing to Complement Databases
Report describing spectrum sensing techniques and their performance for the 5G remote area.

Architecture conception for 5G for Remote Area network
Macro conception of the architecture assuming the integration of the 5G for Remote Areas with the other 5G application scenarios and a technical report describing the system platform and the definition of the API for data flow among the different layers.

Exploitation, communication, dissemination and standardization – Part I
This deliverable will provide the detailed report about Regulatory framework for mobile Internet service in remote areas (T7.1), Business modelling (T7.2), Standardization (T7.3) and Dissemination (T7.4).

Definition of Cognitive MAC Reference Architecture

Exploitation, communication, dissemination and standardization – Part III
This deliverable will provide the detailed report about Regulatory framework for mobile Internet service in remote areas (T7.1), Business modelling (T7.2), Standardization (T7.3) and Dissemination (T7.4).

Dynamic Spectrum Access and Resource Allocation
Report describing dynamic spectrum access and resource allocation for cognitive MAC layer.

Exploitation, communication, dissemination and standardization – Part II
This deliverable will provide the detailed report about Regulatory framework for mobile Internet service in remote areas (T7.1), Business modelling (T7.2), Standardization (T7.3) and Dissemination (T7.4).

**Report describing the prototype integration**
This deliverable will describe the integration of the real-time blocks that will culminate in the 5G-PoC BS and 5G-PoC UE. The Internet access in remote areas use-case will be targeted as the main application for the prototype system.

**Initial version of the Network-level Architecture and Procedures**
This report is an initial version of the network layer architecture resulting from the work developed in tasks T5.1 and T5.2. The final version will be provided by deliverable D5.2.

**Final report on Network-level mechanisms implementation**
This report will provide the information about the network level mechanism that have been implemented and promoted to the proof of concept integration in WP6.

**Report describing the 5G-Range operation for the remote area Internet access use-case**
This report will present the results obtained in the filed demonstration of the proposed network. The demonstration will target the remote area Internet access scenario and the developed prototypes will be used to provide the service in a remote location. Besides the measurements regarding system performance, the demonstration will also collect data about the quality of experience of the users.

**Cognitive MAC Layer Simulation Model Development and Evaluation**
This report will provide the final version of the Network-level architecture and network procedures developed in tasks T5.1 and T5.2 (T5.2 will still last some more months after this deliverable to be able to consider some feedback from the integration phase in WP6 and details from the implementation from T5.3 that in any case would be incorporated in deliverable D5.3).

**Application and requirements report**
Technical report describing the main application for broadband Internet access in rural areas and the corresponding requirements for the PHY and MAC layers, including the metrics for performance evaluation. Specifically, this deliverable will define the requirements for the innovative blocks proposed in this project: 5G-ACRA, 5G-FlexNOW, 5G-MIMORA, 5G-IR2A, 5G-COSORA, 5G-DARA and 5G-D2DRC.
Physical layer of the 5G-RANGE – Part II
Description: Technical report describing waveforms, corresponding inner transceiver designs and MIMO schemes for the 5G-RANGE. 5G-FlexNOW, 5G-MIMORA and 5G-IR2A blocks with the corresponding complete specification, will be part of this deliverable.

Report describing the software-based system integration
This deliverable will describe the integration of the several modules of the 5G-RANGE simulator, showing how each block will be combined and parametrized to fulfil the network requirements

Physical layer of the 5G-RANGE – Part I
Technical report describing 5G-RANGE channel models and channel coding/decoding schemes. This deliverable includes the 5G-ACRA block with the specifications and encoding/decoding algorithms definition

Publications

Peer reviewed articles (12)

Pilot- and CP-Aided Channel Estimation in MIMO Non-Orthogonal Multi-Carriers
Author(s): Shahab Ehsanfar, Maximilian Matthe, Marwa Chafii, Gerhard P. Fettweis
Published in: IEEE Transactions on Wireless Communications, Issue 18/1, 2019, Page(s) 650-664, ISSN 1536-1276
DOI: 10.1109/twc.2018.2883940

VENUE: Virtualized Environment for Multi-UAV Network Emulation
Author(s): Victor Sanchez-Aguero, Francisco Valera, Borja Nogales, Luis F. Gonzalez, Ivan Vidal
Published in: IEEE Access, Issue 7, 2019, Page(s) 154659-154671, ISSN 2169-3536
DOI: 10.1109/access.2019.2949119

Unified Low Complexity Radix-2 Architectures for Time and Frequency-domain GFDM Modem
Author(s): Nimr, Ahmad; Chafii, Marwa; Fettweis, Gerhard
Published in: IEEE Circuits and Systems Magazine, Issue 1, 2020, ISSN 1531-636X
DOI: 10.1109/mcas.2018.2872662
A Multi-Site NFV Testbed for Experimentation With SUAV-Based 5G Vertical Services

Author(s): Ivan Vidal, Borja Nogales, Francisco Valera, Luis F. Gonzalez, Victor Sanchez-Aguero, Eduardo Jacob, Cristina Cervello-Pastor
Published in: IEEE Access, Issue 8, 2020, Page(s) 111522-111535, ISSN 2169-3536
DOI: 10.1109/ACCESS.2020.3001985

5G Waveforms for IoT Applications

Author(s): Ivo Bizon Franco de Almeida, Luciano Leonel Mendes, Joel J. P. C. Rodrigues, Mauro A. A. da Cruz
Published in: IEEE Communications Surveys & Tutorials, Issue 21/3, 2019, Page(s) 2554-2567, ISSN 1553-877X
DOI: 10.1109/comst.2019.2910817

Automated Deployment of an Internet Protocol Telephony Service on Unmanned Aerial Vehicles Using Network Functions Virtualization

Author(s): Borja Nogales, Ivan Vidal, Victor Sanchez-Aguero, Francisco Valera, Luis F. Gonzalez, Arturo Azcorra
Published in: Journal of Visualized Experiments, Issue 153, 2019, ISSN 1940-087X
DOI: 10.3791/60425

Channel estimation for massive MIMO TDD systems assuming pilot contamination and flat fading

Author(s): Felipe A. P. de Figueiredo, Fabryccio A. C. M. Cardoso, Ingrid Moerman, Gustavo Fraidenraich
Published in: EURASIP Journal on Wireless Communications and Networking, Issue 2018/1, 2018, ISSN 1687-1499
DOI: 10.1186/s13638-018-1021-9

Enabling Multi-Mission Interoperable UAS Using Data-Centric Communications

Author(s): Ivan Vidal, Paolo Bellavista, Victor Sanchez-Aguero, Jaime Garcia-Reinoso, Francisco Valera, Borja Nogales, Arturo Azcorra
Published in: Sensors, Issue 18/10, 2018, Page(s) 3421, ISSN 1424-8220
DOI: 10.3390/s18103421

On UW-Based Transmission for MIMO Multi-Carriers With Spatial Multiplexing

Author(s): Shahab Ehsanfar, Marwa Chafii, Gerhard P. Fettweis
Published in: IEEE Transactions on Wireless Communications, Issue 19/9, 2020, Page(s) 5875-5890, ISSN 1536-1276
DOI: 10.1109/twc.2020.2997839

Energy-Aware Management in Multi-UAV Deployments: Modelling and Strategies

Author(s): Victor Sanchez-Aguero, Francisco Valera, Ivan Vidal, Christian Tipantuña, Xavier Hesselbach
Transport-Layer Limitations for NFV Orchestration in Resource-Constrained Aerial Networks

Author(s): Luis F. Gonzalez, Ivan Vidal, Francisco Valera, Borja Nogales, Victor Sanchez-Aguero, Diego R. Lopez
Published in: Sensors, Issue 19/23, 2019, Page(s) 5220, ISSN 1424-8220
DOI: 10.3390/s19235220

A CDL-Based Channel Model With Dual-Polarized Antennas for 5G MIMO Systems in Rural Remote Areas

Author(s): Alexandre Matos Pessoa, Bruno Sokal, Carlos F. M. E Silva, Tarcisio Ferreira Maciel, Andre L. F. De Almeida, Francisco Rodrigo Porto Cavalcanti
Published in: IEEE Access, Issue 8, 2020, Page(s) 163366-163379, ISSN 2169-3536
DOI: 10.1109/access.2020.3020538

Performance Evaluation of Windowing Based Energy Detector in Multipath and Multi-signal Scenarios

Author(s): Johanna Vartiainen, Heikki Karvonen, Marja Matinmikko-Blue, Luciano Mendes
Published in: Cognitive Radio-Oriented Wireless Networks - 14th EAI International Conference, CrownCom 2019, Poznan, Poland, June 11–12, 2019, Proceedings, Issue 291, 2019, Page(s) 59-72
DOI: 10.1007/978-3-030-25748-4_5

Performance Analysis of a 5G Transceiver Implementation for Remote Areas Scenarios

Author(s): Wheberth Dias, Danilo Gaspar, Luciano Mendes, Marwa Chafii, Maximilian Matthe, Peter Neuhaus, Gerhard Fettweis
Published in: 2018 European Conference on Networks and Communications (EuCNC), 2018, Page(s) 363-367
DOI: 10.1109/EuCNC.2018.8443268

5G-RANGE - Applications for the Future Long Range Network
Author(s): Luciano Mendes
Published in: 2018
5G-RANGE Remote area Access Network for 5th GEneration

**Author(s):** Luciano Mendes  
**Published in:** Global 5G Event, 2017

Contribuições para o Desenvolvimento do 5G no Brasil

**Author(s):** Luciano Mendes  
**Published in:** Workshop Telecomunicações - FIESP, 2018

REACH EUB-Day 2018 RJ e Recife - Brazil

**Author(s):** Cecilia Matsumura  
**Published in:** N/A, 2018

Artificial Intelligence for Scheduling Resource Blocks in LTE/5G Networks

**Author(s):** Marcos Caetano, Guilherme Branco, Gabriel Ferreira, Priscila Solis  
**Published in:** Workshop on Cloud Networks 2018, 2018

O acesso 5G em áreas remotas e rurais: uma proposta de solução e possíveis aplicações

**Author(s):** Moacyr Martucci  
**Published in:** SEMISH / CSBC 2018, 2018

Excellence in ICT Cooperation: Preliminary Results of Projects of the EU-BR 4th Coordinated Call and Future Directions

**Author(s):** Moacyr Martucci  
**Published in:** Cloudscape Brazil 2018, 2018

Projetos Colaborativos em IoT

**Author(s):** Priscila Solis  
**Published in:** 3o. Congresso Brasileiro e Latinoamericano em IoT, 2018

Connectividade e IoT para o Agronegócio (Connectivity and IoT for Agribusiness)

**Author(s):** Carlos Lorena, CPqD  
**Published in:** ForAGRI - Intelligent Agribusiness Forum, 2018

5G for Remote Areas: Challenges and Opportunities

**Author(s):** Ari Pouttu (UOULU)  
**Published in:** 6th Global 5G Event, 2018
NFV orchestration on intermittently available SUAV platforms: challenges and hurdles

**Author(s):** Luis Félix González Blázquez, Iván Vidal, Francisco Valera, Víctor Sánchez-Aguero, Borja Nogales and Diego R. López

**Published in:** IEEE INFOCOM Workshop: MiSARN 2019: Mission-Oriented Wireless Sensor, UAV and Robot Networking, 2019

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Linear GFDM: A Low Out-of-band Emission Configuration for 5G Air Interface

**Author(s):** Ivo Bizon Franco de Almeida, Luciano Leonel Mendes

**Published in:** 2018 IEEE 5G World Forum (5GWF), 2018, Page(s) 311-316

**DOI:** 10.1109/5gwf.2018.8516993

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Sparse Code Multiple Access applied in the Generalized Frequency Division Multiplexing

**Author(s):** Guilherme Pedro Aquino, Luciano Leonel Mendes

**Published in:** 2018 IEEE 5G World Forum (5GWF), 2018, Page(s) 49-54

**DOI:** 10.1109/5gwf.2018.8517096

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Experience - Implications of Roaming in Europe

**Author(s):** Anna Maria Mandalari, Marco Mellia, Gorry Fairhurst, Andra Lutu, Ana Custura, Ali Safari Khatouni, Özgüz Alay, Marcelo Bagnulo, Vaibhav Bajpai, Anna Brunstrom, Jörg Ott

**Published in:** Proceedings of the 24th Annual International Conference on Mobile Computing and Networking - MobiCom '18, 2018, Page(s) 179-189

**DOI:** 10.1145/3241539.3241577

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NFV orchestration on intermittently available SUAV platforms: challenges and hurdles

**Author(s):** Luis F. Gonzalez, Ivan Vidal, Francisco Valera, Victor Sanchez-Aguero, Borja Nogales, Diego R. Lopez

**Published in:** IEEE INFOCOM 2019 - IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS), 2019, Page(s) 301-306

**DOI:** 10.1109/infcomw.2019.8845040

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Other (15)

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5G-RANGE Remote area Access Network for 5th GEneration

**Author(s):** Luciano Mendes and Peter Neuhaus

**Published in:** EUCNC 2018, 2018
5G-RANGE Remote area Access Network for 5th GEneration

Author(s): Luciano Mendes et al
Published in: MOMAG 2018, 2018

5G-RANGE Project

Author(s): Peter Neuhaus (TUD)
Published in: N/A, 2017

Inatel testa com sucesso 5G em Santa Rita do Sapucaí

Author(s): Inatel
Published in: N/A, 2018

Presentation to Undergraduate students at POLI-USP

Author(s): Cecilia Matsumura
Published in: N/A, 2018

"Webinar #6 - INCOBRA sobre O Program Horizonte 2020 (Webinar INCOBRA on the Horizon 2020 Program)"

Author(s): Claudia Piovesan Macebo - CPqD, Gustavo Matta - Fiocruz, Gustavo Dalmarco - PUC - RS
Published in: INCOBA Webinars - Increasing International STI Cooperation between Brazil and the European Union, 2018

Missão Técnica Especialistas Brasileiros na Europa

Author(s): Cecilia Matsumura
Published in: Dialogo Setorial Brasil União Europeia em 5G e IoT, 2018

Workshop Brasil-Europa Pesquisa em Inovação em IoT FAPESP
Author(s): Cecilia Matsumura  
Published in: 2018

5G-RANGE: Remote Area Accessits Network for the 5th Generation  
Author(s): Jorge Seki, CPqD  
Published in: 2018

Projetos de Cooperação Técnica Internacional  
Author(s): Carlos F. M. e Silva (UFC)  
Published in: 1a Onda de Redes e Segurança da Informação, 2018

5G - Range Project Booth  
Author(s): Priscila Solís  
Published in: CSBC2018, 2018

5G for Remote Areas: Field Tests  
Author(s): Luciano Mendes (Inatel)  
Published in: 2018

Advanced Remote area Access Network for 5th GEneration  
Author(s): Luciano Mendes (Inatel) and Peter Neuhaus (TUD)  
Published in: IEEE 5G Summit Dresden 2018, 2018

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