RESOURCE ALLOCATION TECHNIQUES FOR SPECTRALLY EFFICIENT MASSIVE ACCESS

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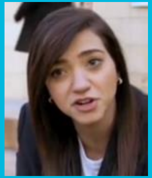

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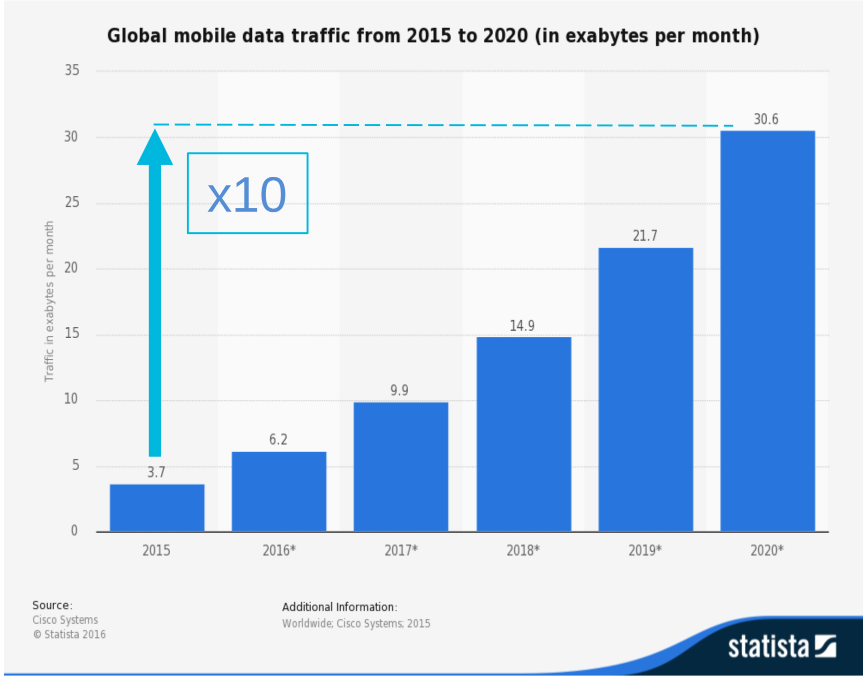
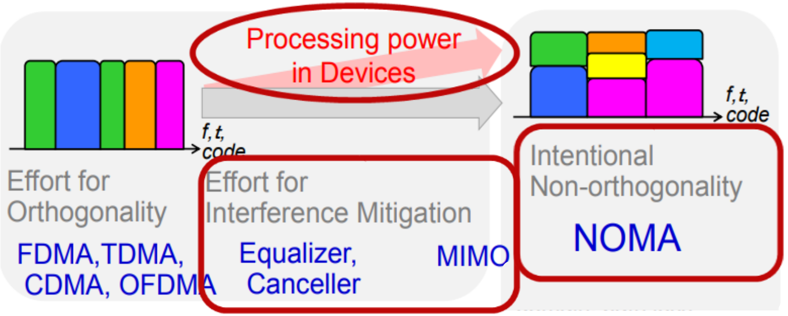


- Mobile traffic => 10x increase in 5 years
- Spectral resources scarce
- New techniques required to accommodate



- Promising Approach: Non-Orthogonal Multiple Access
- Several variants
  - Power-domain NOMA
  - Sparse code multiple access (SCMA)
  - Layer division multiplexing (LDM)

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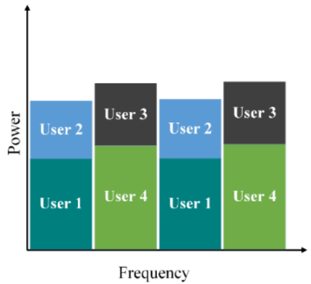
- PD-NOMA
  - Serve multiple users non-orthogonally on the same frequency resource
  - Different power values to users multiplexed on the same frequency band



- Definitions
  - $x_{k,s}$: signal relative to user *k* on subband *s*
  - $P_{k,s} = \mathbb{E}[|x_{k,s}|^2]$: power allocated to user *k* on subband *s*
- Downlink
  - Successive interference cancellation (SIC) performed at the receiver side
  - SIC performed in the increasing order of channel gains
  - Achieved rates:

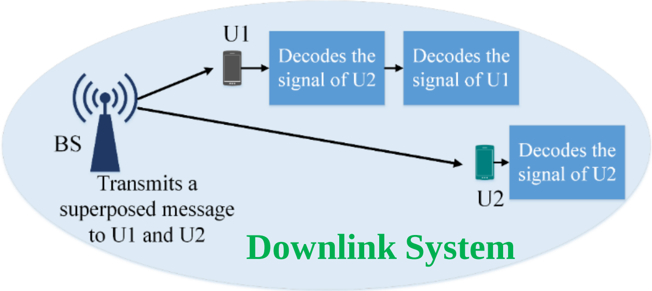
$$\begin{cases} R_{k_1,s} = B_c \log_2\left(1 + \frac{P_{k_1,s} h^2_{k_1,s}}{N_0 B_c}\right) \\ R_{k_2,s} = B_c \log_2\left(1 + \frac{P_{k_2,s} h^2_{k_2,s}}{P_{k_1,s} h^2_{k_2,s} + N_0 B_c}\right) \end{cases}$$

Channel gains

No interference

Bandwidth per subband

Inter-user interference

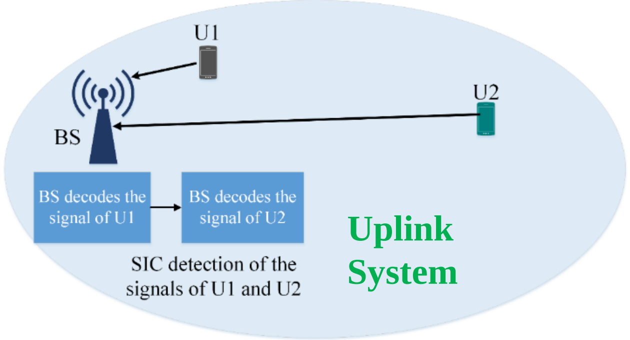


- Uplink
  - SIC detection at the level of the BS performed in the decreasing order of channel gains
  - Achieved rates:

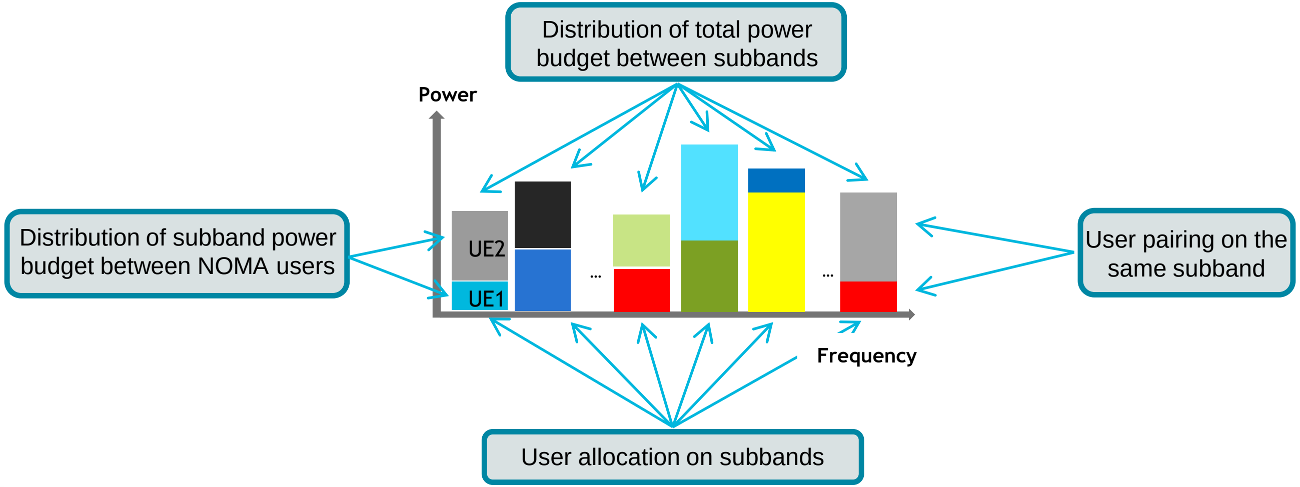
$$\begin{cases} R_{k_1,s} = B_c \log_2\left(1 + \frac{P_{k_1,s} h^2_{k_1,s}}{P_{k_2,s} h^2_{k_2,s} + N_0 B_c}\right) \\ R_{k_2,s} = B_c \log_2\left(1 + \frac{P_{k_2,s} h^2_{k_2,s}}{N_0 B_c}\right) \end{cases}$$

Inter-user interference

No interference



4 PhD theses, 1 postdoc and 3 Master theses



Colour = user allocation
Amplitude = power allocation

4 PhD theses, 1 postdoc and 3 Master theses

FANTASTIC 5G

FRANCE BREVETS

EU H2020 2015-2017

2015-2017

User allocation on subbands

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Colour = user allocation
Amplitude = power allocation

- Weigthed proportional fairness
- Flexible throughput vs fairness maximization metric
- Fairness maximization metric
- Waterfilling-based power allocation (MaxH-min D)
- Analysis of NOMA rate vs channel gain of paired users

- Mutual Successive Interference Cancellation (SIC)
- Mutual SIC for efficient Coordinated Multi-Point (CoMP) systems
- Drone placement strategies for complete interference cancellation in two-cell NOMA CoMP Systems

Allocation metrics

Interference management

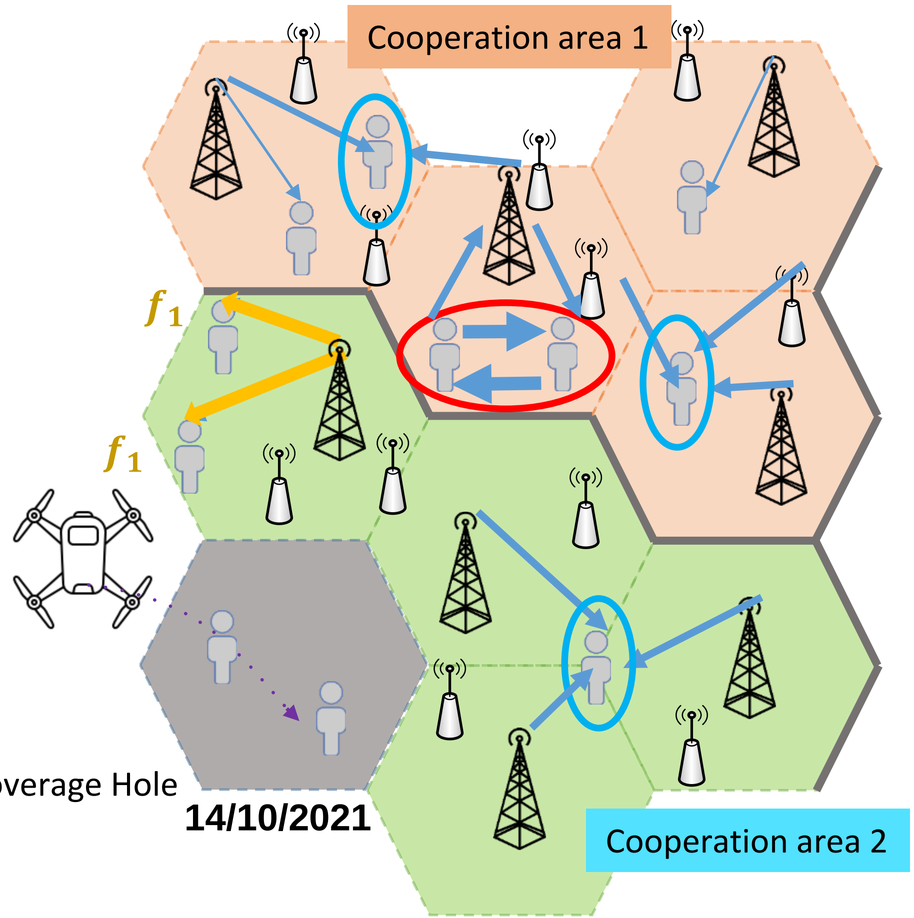
Deployment scenarios / Services

- Cognitive radio scenario with target user rates
- Support of broadcast services using NOMA with minimum impact on broadband
- Distributed Antenna Systems (DAS) with and without individual antenna-based power constraints
- Mixed traffic types using NOMA and DAS

HOLISTIC SOLUTION FOR SPECTRALLY EFFICIENT MASSIVE ACCESS

- Network architecture:
  - Distributed Antenna Systems **DAS**
    => short links, improve diversity, allocation
  - Device to Device **D2D**
    => offload infrastructure, interference
- Coordinated Multipoint **CoMP**
  => reduce interference, allocation
- Unmanned Arial Vehicles **UAV**
  => coverage extension, positioning, allocation
- Non-Orthogonal Multiple Access techniques **NOMA**
  => spectral efficiency, interference, allocation

Support of massive access
…with shared and limited resources



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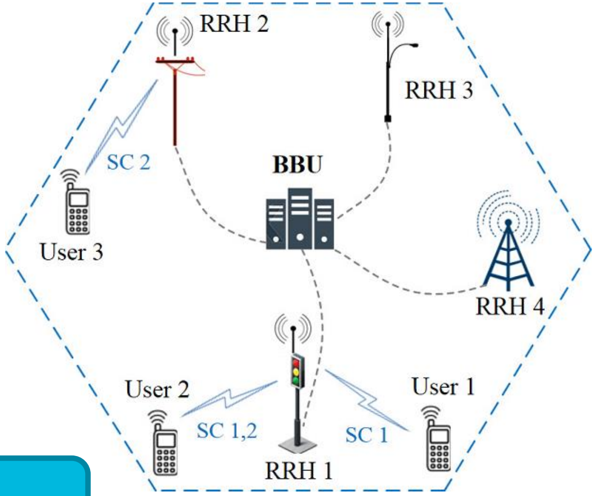
POWER MINIMIZATION IN DAS WITH NOMA

- System Model
  - Downlink system
  - *R* RRHs, *S* subbands
  - System bandwidth *B*
  - Maximum of 2 multiplexed users per subcarrier
  - *K* users per cell with rate requirements $R_{k,req}$
  - With(out) individually power constrained antennas

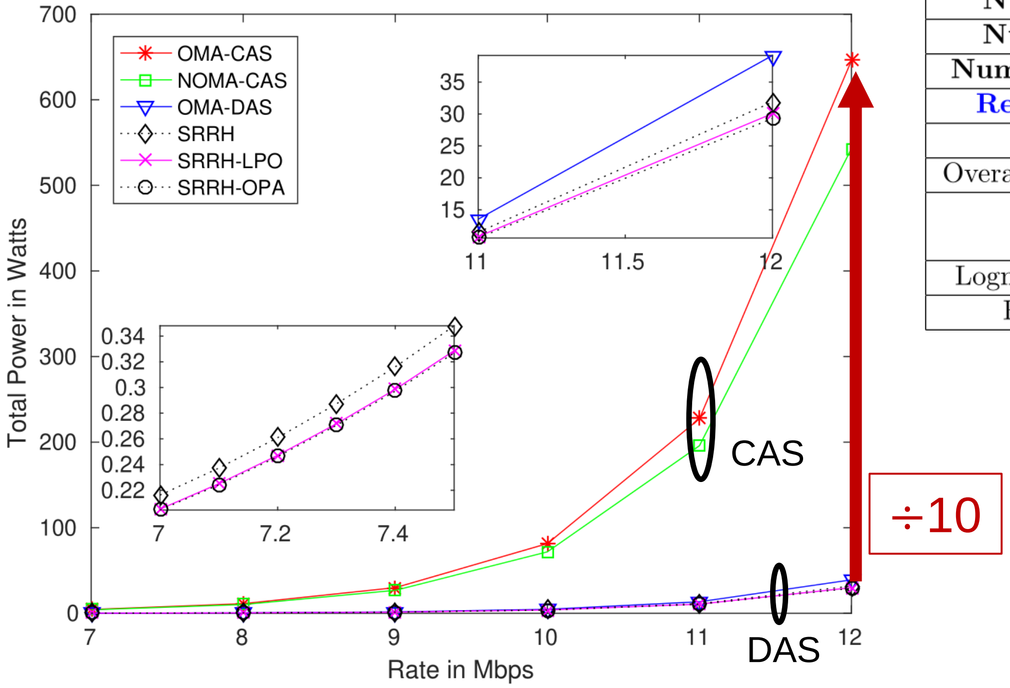


Study Items: joint user-antenna-subcarrier selection and power allocation

Solution: Method to mitigate interference at both NOMA users: mutual SIC

Centralized Antenna System (CAS) vs Distributed Antenna System (DAS)

Power as a function of the required rates



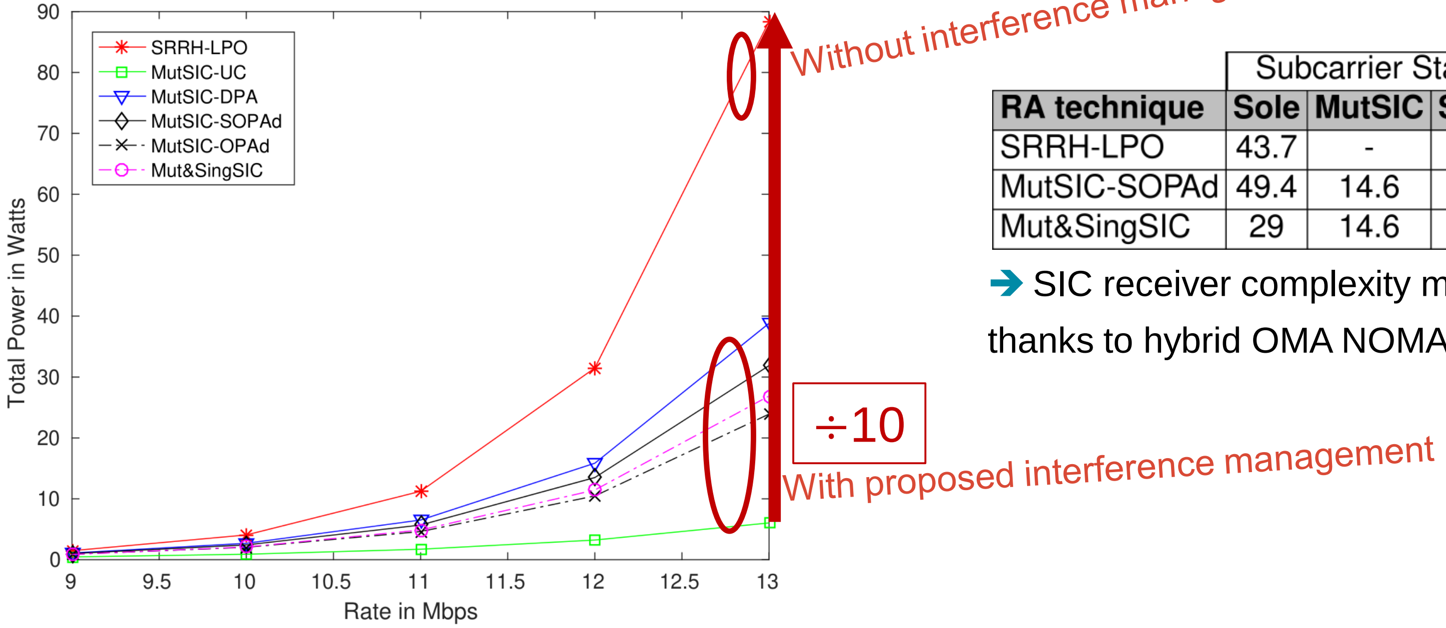
❑ Parameters

Number of antennas R	**4**
Number of subbands S	**64**
Number of users in the cell	**15**
Required rates per user	**7 Mbps to 13 Mbps**
Cell Radius R_d	500 m
Overall Transmission Bandwidth	10 MHz
Distance Dependent Path Loss	$128.1 + 37.6\log_{10}(d)$(dB), d in Km
Lognormal shadowing variance	8 dB
Receiver Noise Density	4.10^{-18} mW/Hz

SRRH	Single SIC FTPA
SRRH-LPO	Single SIC LPO
SRRH-OPA	Subcarrier-user-antenna assignment from SSRH-LPO with optimal power allocation from [1]

[1]: X. Li, C. Li, and Y. Jin, “Dynamic Resource Allocation for Transmit Power Minimization in OFDM-Based NOMA Systems,” IEEE Communications Letters, vol. 20, no. 12, pp. 2558–2561, Dec 2016.

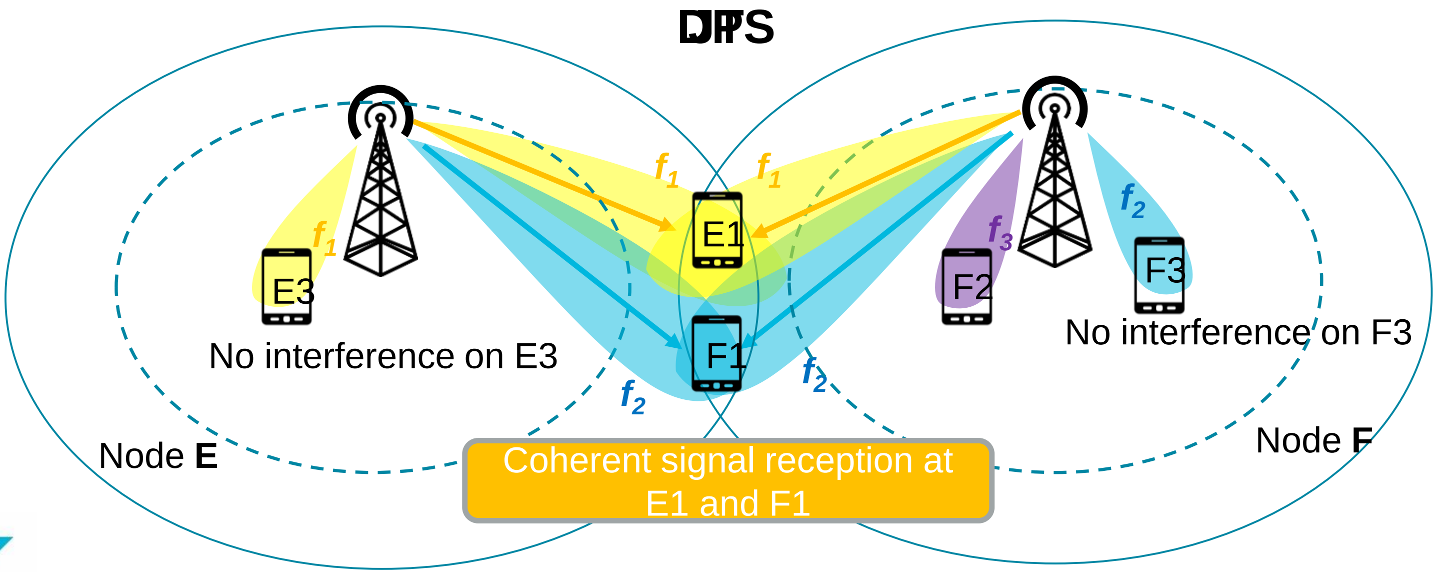
Power as a function of the required rates



	Subcarrier Statistics		
RA technique	**Sole**	**MutSIC**	**SingSIC**
SRRH-LPO	43.7	-	20.3
MutSIC-SOPAd	49.4	14.6	-
Mut&SingSIC	29	14.6	20.4

➔ SIC receiver complexity mitigated thanks to hybrid OMA NOMA system

- Enable cell coordination for improving cell-edge performance **without** restricting network resources
- CSI and data exchange: Dynamic Point Selection (DPS), Joint Transmission (JT)
- Extension of proposed interference management technique => complete interference cancellation



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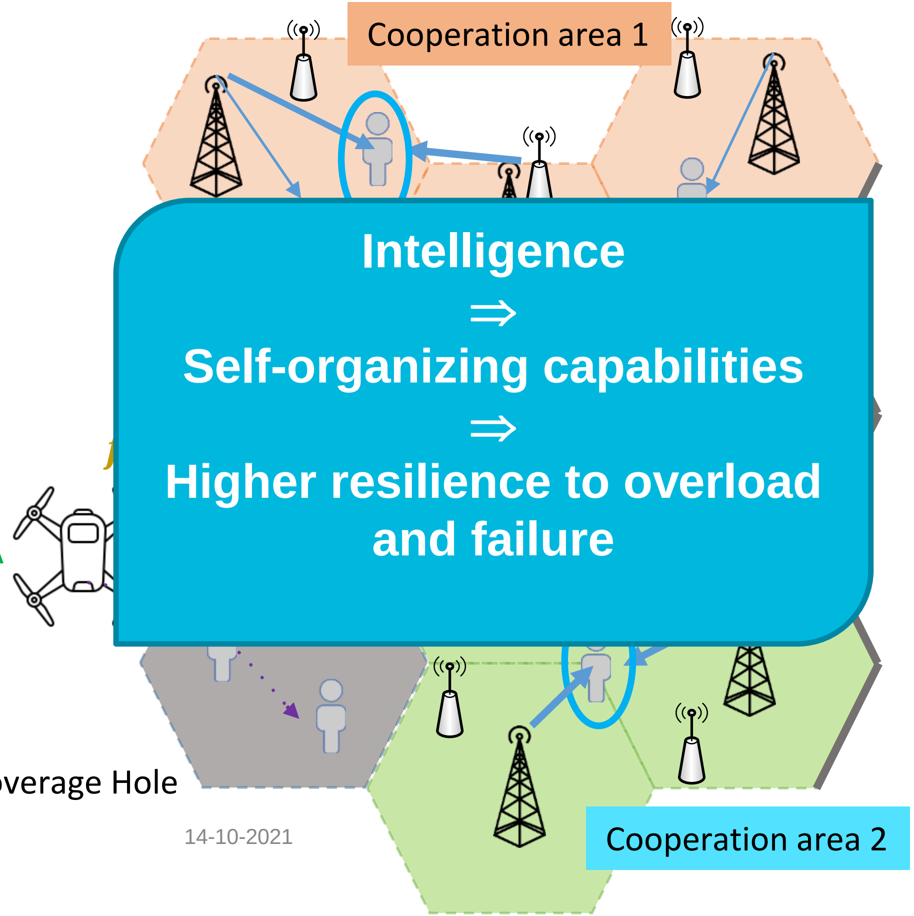

Intelligence

⇒

Self-organizing capabilities

⇒

Higher resilience to overload and failure

PUBLICATIONS
Journals

1. A. Kilzi, J. Farah, C. Abdel Nour, , C. Douillard. “Optimal Resource Allocation for Full-Duplex IoT Systems Underlaying Cellular Networks with Mutual SIC NOMA”, *IEEE Internet of Things J*., In press.
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4. A. Kilzi, J.oumana Farah, C. Abdel Nour, C. Douillard, “Mutual Successive Interference Cancellation Strategies in NOMA for Enhancing the Spectral Efficiency of CoMP Systems”, *IEEE Trans. Commun*., 2020, 68 (2), pp.1213 -1226.
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8. J. Farah, A. Kilzi, C. Abdel Nour, C. Douillard, “Power Minimization in Distributed Antenna Systems using Non-Orthogonal Multiple Access and Mutual Successive Interference Cancellation*”, IEEE Trans. Vehic. Tech*., 2018, 67 (12), pp.11873 - 11885.
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