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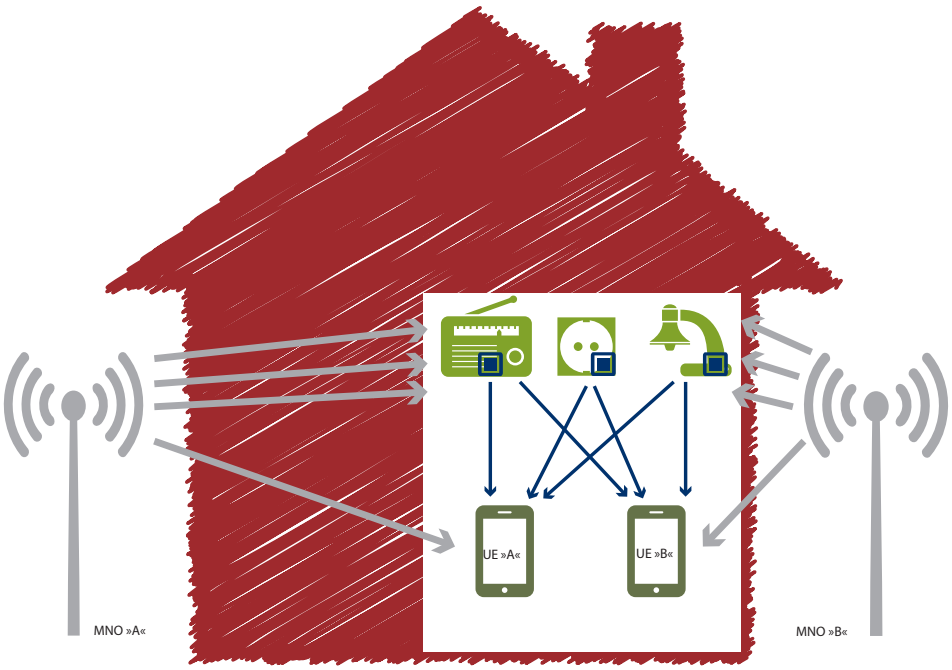
# UE-SIDE VIRTUAL MIMO USING MM-WAVE FOR 5G




**Shared UE-side Distributed Antenna System (SUDAS) for 2 UEs connected to 2 mobile networks, supported by 3 so-called SUDACS to increase the data rate.**

## Executive Summary

The ambitious data rate target of 10 Gbit/s for the 5G standard is elusive despite the use of advanced air interface technologies such as massive MIMO, two-tier networks with small cells, and mmWave links.
In order to approach this high target data rate for 5G user equipments (UEs) inside a building, we propose in in the full whitepaper (see link on other side) to use an infrastructure of many low-price relay nodes installed in fixed indoor locations. These relay nodes receive signals transmitted from a base station on a mobile band at ultra-high frequency (UHF) and forward them via mmWave links to the UE, and vice versa. We refer to this scattered infrastructure as a Shared UE-side Distributed Antenna System (SUDAS).
A SUDAS translates massive spatial multiplexing in a licensed mobile band into massive frequency multiplexing in an unlicensed mmWave band. This new concept is derived from Virtual MIMO schemes known from the literature, such that the mmWave band is used for relaying and the infrastructure can be shared between multiple UEs and multiple mobile network operators (MNOs).
In an internal research project, we have considered three different options for the out-of-band relay nodes in this innovative system: amplify-and-forward (AF) and compress-and-forward (CF) either based on IEEE 802.11ad (WiGig) or on a 5G-specific air interface dedicated to mmWave relaying.

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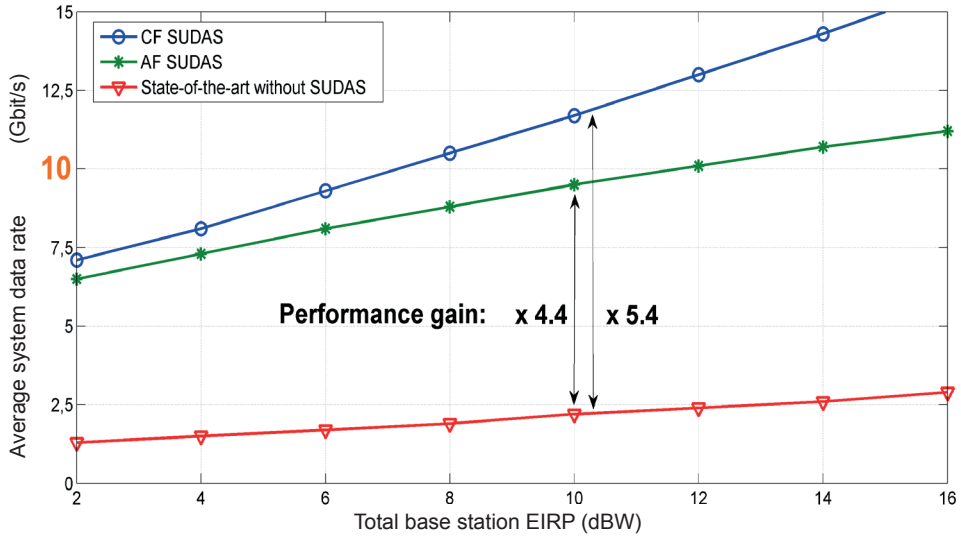
The full whitepaper can be downloaded from:

www.iis.fraunhofer.de/sudas

All three options have been analyzed with respect to various aspects for their use in a practical 5G system. Among others, the following points have been examined:

- Mechanisms for resource allocation considering the SUDAS-sharing between multiple UEs and MNOs.
- Realization of multi-user MIMO in such a setting.
- Potential usage scenarios.
- Consideration of the cost of the hardware implementations.
- Channel estimation and synchronization of the relayed signals.




**Simulated achievable data rates in downlink for two proposed schemes compared to state-of-the-art (LTE-like) link. Channel models: Winner+ outdoor-to-indoor and IEEE 802.11ad "living room". Distance to base station: 100m. System parameters are exposed in the full whitepaper.**

The above figure shows the results from system simulations using realistic models for the UHF and mmWave channels. As can be seen both SUDAS with AF and CF relaying realize an extraordinarily high gain in data rate compared to a system without SUDAS, and bringing 10 Gbit/s to homes and offices appears to become realistic.
The compelling results obtained from the analysis and simulations imply that the novel SUDAS-like infrastructure could be highly beneficial for 5G and should be seriously considered as part of it. Within 5G, an air interface profile dedicated to mmWave relay links should be specified. As of today, only the surface has been scratched of many practical aspects involving such a system. Therefore, we believe that the open issues that are named in the full whitepaper are very promising topics for 5G research projects.

## Advantages of SUDAS:

- Significantly higher data rates than massive MIMO
- Higher data rates and/or lower cost than small cells
- High degree of diversity and high robustness
- Transfer of 5G deployment cost from MNO to end user
- End user can install infrastructure parts according to his data rate needs
- No regulatory issues about using the mmWave band for 5G