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| **Department** | Electrical Engineering (ESAT) |
| **PhD defence** | 22 December 2022 |
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| **Funding** | FWO |
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# Distributed Signal Processing Algorithms for Sensor and Actuator Networks

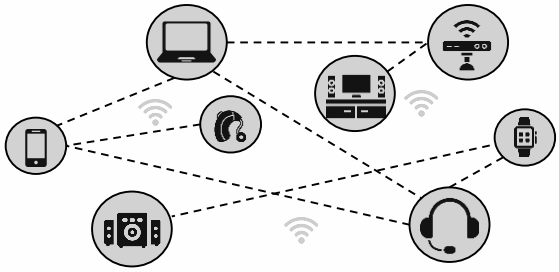
*Applied to Wireless Acoustic Sensor and Actuator Networks and Cell-free Massive MIMO Systems*

## Introduction / Objective

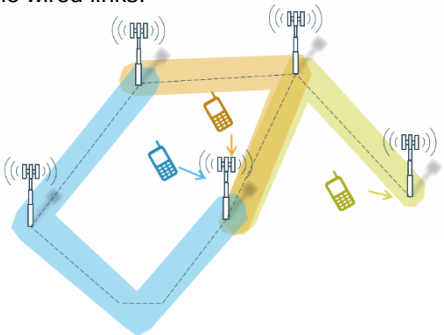
Technological progress in current analogue and digital devices together with the miniaturization of hardware have pushed sensing and actuating devices to new heights. These devices can be connected to form a so-called **sensor and actuator networks (SANs)** in order to cooperate with each other to improve their signal processing task, such as the estimation or creation of a certain signal of interest. Two specific classes of SANs are considered in this research work as shown in the figure below, the first one being **wireless acoustic sensor and actuator networks (WASANs)** and the second one are **cell-free massive MIMO (CFmMIMO) systems**, where the connections between the different devices are made using wireless and wired links respectively. This research work aims to develop signal processing algorithms that let the nodes of some particular SAN cooperate and share their local sensor signals and parameters to enhance their own performance, and this for a broad range of different signal processing tasks like speech enhancement, sound zoning, uplink and downlink data transmission and channel estimation.

## Research Methodology

As the energy budget of each node (often battery-powered) in a SAN has to be minimized, this research attempts to develop efficient **distributed signal processing algorithms**. Distributed processing using fused sensor signals and parameters provides an attractive alternative to centralized processing, since for the latter case all the uncompressed sensor signals and local parameters of the entire SAN have to be aggregated and processed in one place (e.g., in a fusion center). This would require a large communication bandwidth, consuming a lot of energy, and also a computationally strong fusion center, which then forms a single point-of-failure.

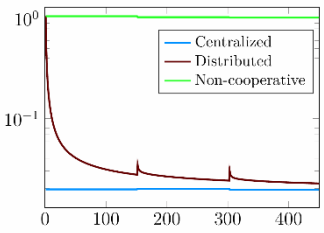


(**Top**) Example of a WASAN consisting of multiple different devices with both microphones and loudspeakers connected with wireless links.
(**Bottom**) Example of a user-centric CFmMIMO system were the signal for a user is only processed by the access points in a local user-centric subnetwork and the communications are organized using the available wired links.



## Results & Conclusions

The developed distributed algorithms




- significantly reduce the required communication bandwidth;
- simplify the required local computations or divide them between different nodes;
- are able to track changes in the environment and can deal with an increasing number of devices and sources.

All this results are obtained without sacrificing the estimation or creation performance compared to the centralized case and outperform the stand-alone solution significantly.

## Major publication


Van Rompaey, R., Moonen, M., “Distributed Adaptive Signal Estimation in Wireless Sensor Networks with Partial Prior Knowledge of the Desired Sources Steering Matrix”, *IEEE Transactions on Signal and Information Processing over Networks*, vol. 7, 2021, pp. 478-492.