Future millimeter wave networks set to deliver the best features of high and low frequencies

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Fig. 1. Angle of arrival (AoA) estimation at Low Frequency (2.45GHz). The set-up includes an antenna array of 4 elements. We use the algorithm MUSIC in order to estimate the AoA of the signal received. Credit: © IMDEA Networks Institute

Future high-speed communication networks based on millimeter-wave

(30-300GHz) technology will be more robust and efficient in delivering extremely high speed, high quality video, and multimedia content and services thanks to the results of a ground-breaking research project. The recently-concluded project was a collaboration between Huawei Technologies and IMDEA Networks Institute, the Madrid-based research body pioneering many technologies that are being deployed in the new 5G landscape.

Dr. Joerg Widmer, the Principal Investigator on the project and Research Director at IMDEA Networks, describes the challenge his group tackled. "A signal's path loss increases significantly with its frequency. So, High Frequency (HF) communications, like millimeter wave systems which offer the speed and capacity that 5G and 802.11ad-standard Wi-Fi networks require, demand directional antennas in order to overcome the resulting attenuation. This results in high signaling overheads, since both ends of the communication have to continuously update their antenna steering as nodes move and blockages interrupt the line-of-sight path. These problems are avoided in low frequency (LF) networks, with their rich multi-path environment and much lower attenuation rates."

"We've explored how to use low frequency bands to infer the channel characteristics of high frequency millimeter-wave bands and to support the network in terms of beam tracking, angle of arrival estimation, and location information. By studying this approach and other LF-HF channel correlations that may enable LF to assist HF, we've been able to develop techniques that improve performance in the millimeter-wave band and reduce the control overhead required to operate the network. We demonstrated that the mechanisms and algorithms we developed work not only in theory but also in real-world wireless networking environments during the experimental evaluation phase of the project."

Widmer is clear about the significance of the project. "To my

knowledge, this was the first time that these two systems have been studied together, in depth. Our team of experts achieved some really interesting results, developing techniques that will enable operators to improve their performance in the millimeter-wave band and thereby reduce the control overhead they require to operate their present and future networks. Our work has already resulted in two patent applications, with a third currently being evaluated for viability."

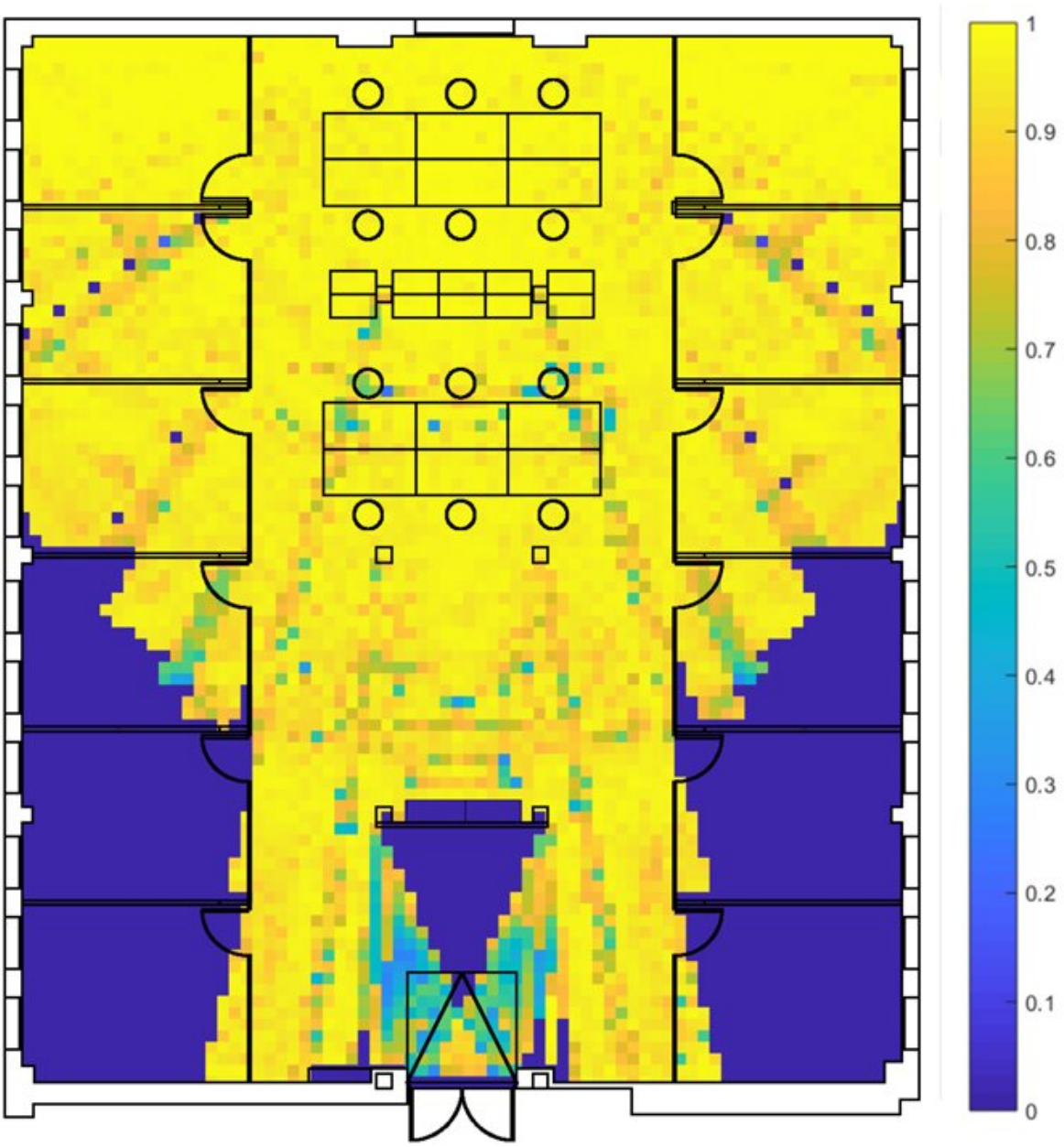
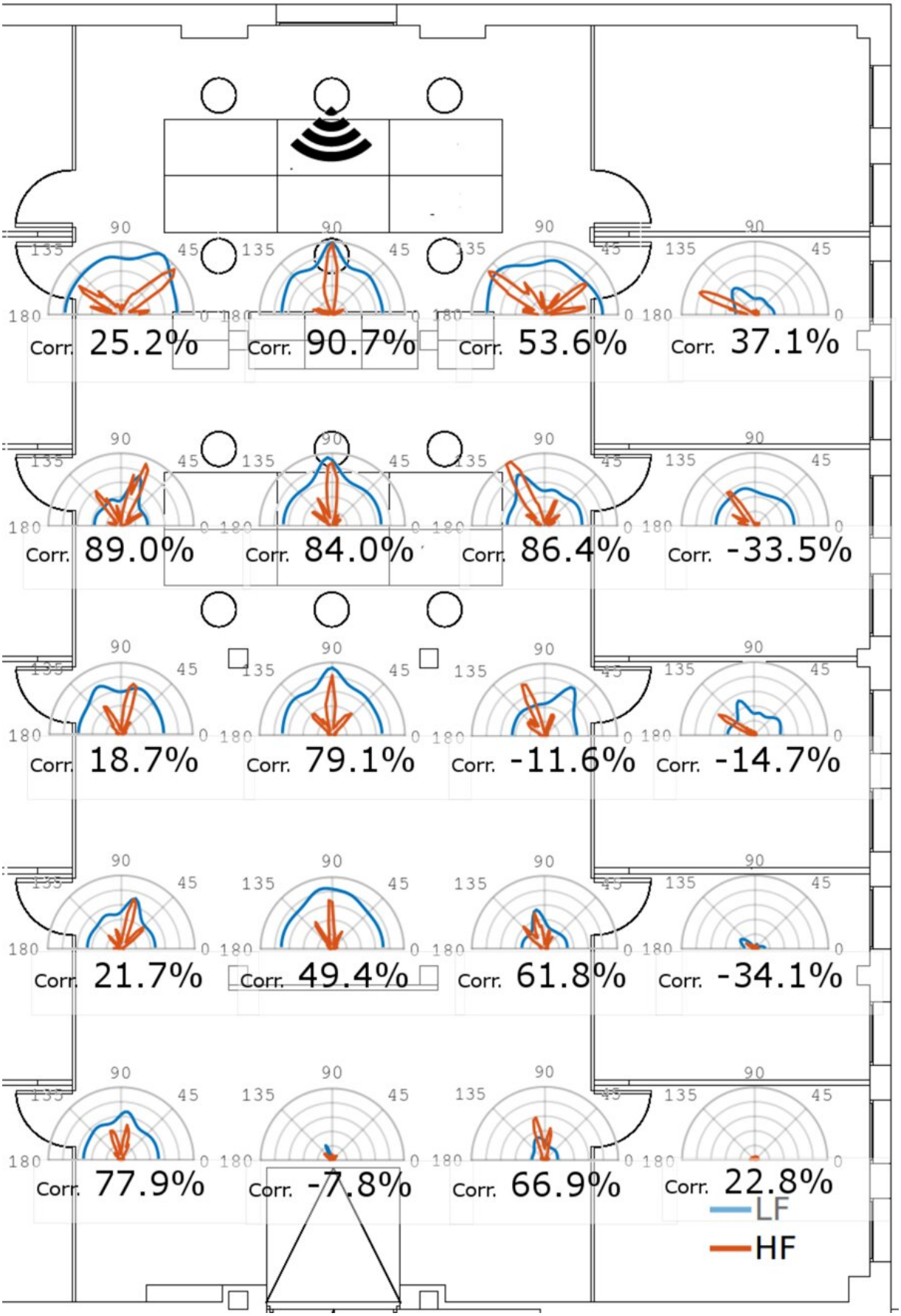


Fig. 2. Angle profile correlation depending on the number of antennas used (16 antennas in this figure). Credit: © IMDEA Networks Institute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LF
HF

Fig. 3. Angle profiles for LF and HF. The graph shows the intensity of signal received depending of the angle for each point. Also, it is included the correlation between the angle profiles at the two frequency bands under study. Credit: © IMDEA Networks Institute

"One of the most important challenges was to study the channel correlation that may enable LF to assist HF," continues Widmer. "We had to consider a lot of variables in this study, such as the scenarios, power, and delay of the signal, number of paths, and the number of antennas of each system. The IMDEA Networks team was comprised of researchers with backgrounds in math, programming languages, material physics, radio frequency propagation and communication standards. The application of this diversity of expert knowledge, with the wealth of technical resources at our disposal, all helped to ensure our success in achieving our goals for this project."

More information: Pablo Jimenez Mateo et al. A Comprehensive Study of Low Frequency and High Frequency Channel Correlation In: *International Conference on Computing, Networking and Communications (ICNC 2019),* 18-21 February 2019, Honolulu, Hawaii, USA.

Provided by IMDEA Networks Institute