

Energy and Spectrum Efficient Millimeter-Wave Reconfigurable Massive MIMO for 5G Systems and Beyond

Project Summary

Overview: To fulfill the ever-increasing demands for high-speed, large-capacity wireless services, millimeter-wave (mmWave) technology has emerged as a promising solution for next-generation of wireless networks. The mmWave systems operate in the frequency range of 30-100GHz, where the available bandwidth is wider than that of legacy wireless systems at microwave frequencies. However, the use of such high frequencies incurs severe signal attenuation and path loss, which is the dominant limiting factor for the coverage and robustness of mmWave communications. A natural solution to resolve this issue is to adopt massive multiple-input multiple-output (MIMO) in mmWave transceivers, where a large number of antenna (e.g. hundreds or more) are used at the base station. However, as the number of antenna elements increases, not only hardware costs and size increase drastically, but also the computational complexity of the antenna array processing techniques becomes prohibitively high. In addition, large size massive MIMO transceivers may not fit well into small-cell wireless networks. The objective of this research is to propose a new hardware architecture for mmWave massive MIMO systems that is significantly smaller in size and outperform the conventional massive MIMO in term of spectral and energy efficiency. This key technological innovation will become possible by using a new signal processing framework and by integrating reconfigurable antennas with controllable radiation pattern characteristics. Completing this invention will be an essential step toward unleashing the well-appreciated potential of mmWave and small-cell technologies, which will make available abundant spectrum opportunities for wireless connectivity in both cellular data services and Internet of Everything (IoE). The secondary objective of this project is to train students in the field of wireless communications and enhance their learning experiences, research skills and hardware design knowledge in cutting edge technologies.

Intellectual Merit: The project is expected to significantly advance the understanding in the mmWave massive MIMO and small-cell technologies which are expected to play a key role in fulfilling the future data capacity explosion and energy consumption escalation and potentially significant impacts to electrical engineering, computer and information science, antenna design, and the mathematical and physical sciences. Since the project exploits the advantages of signal processing, coding and antenna design to overcome technical barriers and establish a signal processing framework, the work is an open research area with many interesting and important problems to address. The proposed project may potentially have significant impact across electrical engineering, computer and information science, and mathematical and physical science domains, as well as across a broad range of commercial, homeland security, infrastructure, aviation, medical, transportation, and other fields that increasingly leverage and extend communication systems and their potential uses.

Broader Impacts: The research will provide a new wireless network architecture to meet the ever-increasing wireless traffic demand and to address the needs on network cost reduction and global environmental protection. The PI believes that this project will advance the state-of-the-art in designing robust and efficient wireless networks. Additionally, research and development in the wireless communication field is expected to create numerous new jobs in the United States as wireless equipment manufacturers and providers struggle to meet the ever-growing throughput demands on wireless links.

This project requires understanding of a number of subjects including digital communications, signal processing, and antenna theory. There are few occasions when such a large number of disciplines within engineering and computer science are applied to a single project. Due to the multidisciplinary nature of this work, it will present an ideal avenue to train students. Since CSUB is minority school, the PI is exceptionally positioned to broaden the participation from women and minority groups in research.