Internet of Things for Advanced Manufacturing

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Overview: Advanced manufacturing is an ecosystem where information, automation, computation, software, sensing, and networking converge with the manufacturing industry. At the heart of these emerging new relationships is the Internet of Things (IoT), which is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and network connectivity. Each thing is uniquely identifiable through its embedded computing system and is able to connect and exchange data with other things. It is estimated that the IoT will consist of about 30 billion objects and the market will reach $267B by 2020. **The goal of this project is to create an unprecedented IoT infrastructure through collaborative and multidisciplinary research to facilitate and enable advanced manufacturing in Kentucky**. As shown in Fig. 1[1], IoT has three major components: Things, Connections and Data. This project will address major challenges in all three areas by leveraging the recent advances in wireless connectivity, ultra-low cost communication devices, and big data.

Intellectual Merit: Proposed research activities include, but are not limited to:

1. **Wireless communications and networking**. In this research thrust, we propose to develop a low-cost wireless communication infrastructure to provide seamless wireless connection to every component in Kentucky's manufacturing ecosystem. Such a communication infrastructure will not only improve the manufacturing ecosystem efficiency, but it will also enable the visualization of the system operations and therefore simplify the system management. However, there is a number of challenges in developing such a wireless communication infrastructure, especially in the respects of communication reliability, security, and privacy. We will develop practical and fundamental solutions to address these challenges by taking advantage of the advances in signal processing and network protocols in the past decades, and unify the solutions to provide seamless, reliable, and secured wireless connection to every component in Kentucky's manufacturing ecosystem.
2. **Ultra-low-cost communication devices**. Ubiquitous communications that provide reliable connections for anything at anywhere will take center stage of future IoT. In such IoT networks, traditional wireless communication transceivers may impede their massive deployment due to their high cost and power consumption. As a result, ultra-low-cost transceivers have become an intriguing alternative to realize future IoT. In this research thrust, we will propose fundamentally new transceiver architectures (e.g., transceivers with one-bit ADC) to eliminate the upper-layer protocols and significantly reduce the power consumption and device cost.
3. **Big data and machine learning**. Future IoT network will generate real-time big data that needs to be managed, communicated, interpreted, aggregated, and analyzed. To this end, innovative big data processing, mining and optimization techniques will be developed and applied in order to support real-time decision-making capabilities. In this research thrust, significant efforts will be spent on distributed real-time big data graph embedding to enable machine learning based decision makings such as multi-label classification in advance manufacturing process and traffic prediction in intelligent transportation systems.

Broader Impacts: This project will advance the state-of-the-art of design, analysis and implementation of IoT infrastructure that covers a broad spectrum of STEM field. Results of this project will be integrated into course modules in STEM to enrich the curriculum and educate future professionals in wireless communications, signal processing, power electronics, sensors and data science. The project will also have direct impact on IoT industry as the outcomes will include a number of IPs for technology transfer and commercialization.

[1] https://www. machinemetrics.com/

Fig. 1. Major IoT components