

The Nano-Enabled Internet of Things Research Community

Current Members

MANTH

CNF

SENIC

NNF

KY-NNIN

NNCI Annual Meeting
October, 2020

What is the Nano-Enabled Internet of Things?

It is our conjecture that many devices and applications for the Internet of Things will be enabled by nanotechnology

- The IoT ‘things’ may in many cases comprise small-scale structures, sensors, and actuators (MEMS)
- The IoT ‘things’ may need to process, store, and collect data, requiring on-board electronics
- The IoT ‘things’ will need to communicate with the Internet, requiring communication protocols in multiple bands using multiple modalities
- We can exploit nanotechnology to create unusual ‘things’ – biodegradable, medical, robotic, ubiquitous sensing, ...



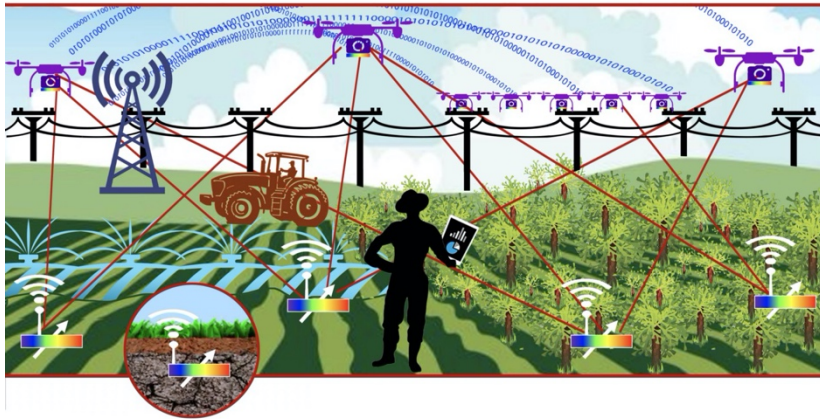
publicdomainvectors.org

The Nano-IoT Research Community Vision

- Our vision is that the ubiquitous sensing potential of the Nano-Enabled Internet of Things (**Nano-IoT**) will:
 - provide the input necessary for data mining/big data processing to understand complex system behavior
 - augment the interaction environment in future workplaces
 - be the transducers that can monitor living things from agriculture to medicine
 - catalyze the convergence of researchers from many intellectual backgrounds
 - ...
- **Nano-IoT** encompasses several of the themes of the NSF Ten Big Ideas, including: Future of Work, Growing Convergence Research, Understanding the Rules of Life, and Harnessing the Data Revolution.

Example 1: NSF ERC for the Internet of Things for Precision Agriculture (IoT4Ag)

Penn (lead), Purdue, University of California (Merced), University of Florida
Director: Prof. Cherie Kagan



Theme: **IoT4Ag** researchers will create miniature soil-based sensors and swarms of aerial and ground-based robots, find new ways to network them together in communication-constrained environments and develop high-level data science techniques that will allow data from different sensors in the field to be integrated with data from weather reports and commodity markets, synthesizing it into actionable information.

Thrust 1: Agricultural Sensor Systems (Eshani, Rowland)

Thrust 2: Communication and Energy Systems (Allen, Love)

Thrust 3: Decision and Response Systems (Buckmaster, Mangharam)

The convergence of plant science, distributed sensors, communications, data science, agricultural practices, and robotic surveillance/interrogation

Example 2: Underlying Technologies That Enable Nano-IoT

Energy-Efficient Information Technologies



Nebraska background in post CMOS electronics

Ongoing

PSPINS: Polarization and Spin Phenomena in Nanoferroic Structures



nCORE
Nanoelectronic Computing Research

Antiferromagnetic Magneto-electric Memory and Logic Center (AMML)

Past

Center for NanoFerroic Devices



Applied Physics Letters

PERSPECTIVE

scitation.org/journal

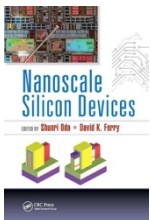
Magneto-electric antiferromagnetic spin-orbit logic devices ^{EP}

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Nano-IoT Research Community



Chapter: "Potential of Nonvolatile Magneto-electric Devices for Spintronic Applications" (2015)

Peter A. Dowben, Christian Binek, and Dmitri E. Nikonov

NNF brings in experience in IoT device design/fabrication/characterization/benchmarking

- Non-volatile memory
- Ultra low power dissipation
- scalability

Azad Naeemi
Andrew Marshall
Shaloo Rakheja

Proposed Structure of our Research Community

- Nano-IoT members will hold or participate in a yearly, day-long symposium that will rotate among the community sites.
 - The major goal of the symposium is to summarize, inform, and exchange the work of NNCI users
 - New ideas to be introduced through invited external speakers
- Each member of the Research Community will send at least one speaker from their site to the rotating symposium, with the twin goals of
 - presenting research from their site; and
 - bringing back the knowledge of research going on at other sites, disseminated through local symposia
- Community members will subsequently hold a seminar at their home site for home users where the information discussed at the symposium will be disseminated.

Proposed Structure of our Research Community

- The host site will report out to the NNCI Annual Meeting
 - High level research highlights
 - lessons learned that could continually improve the information dissemination within the communities.
- Possibility of creation of high-level 'nuggets' of topical interest for broader dissemination and outreach

Nano-IoT Research Community Plans

- Our original plan was to hold the first symposium in October of 2020
- We are currently targeting late spring of 2021 for a first Nano-IoT Research Community meeting
 - Day-long event
 - Invited Speakers
 - Presentation from each RC member site of Nano-IoT research highlights going on at their site
- Possibility to exploit lessons from virtual meetings to hold a hybrid meeting that could allow more members of sites to participate

Other Application Areas

- Smart Cities
 - Industry
 - State and local initiatives
 - Non-profits
- Autonomous driving
- Sports
- Medicine
- Synergy with other established manufacturing centers
 - Flextech; flexible electronics
 - ...