



IU BLOOMINGTON

# EMERGING AREAS OF RESEARCH

## Abstract Template -- Due June 30, 2017

Title of initiative to be proposed:

Towards Collective Intelligence from IoT Edge Devices to Cloud Data Centers

Name of lead PI, with title, department/school:

Martin Swany, Professor, Dept. of Intelligent Systems Engineering, School of Informatics and Computing

Key team member names and departments/schools (up to 10 names):

Judy Qiu (Associate Professor, ISE, SoIC), Minje Kim (Assistant Professor, ISE SoIC), Lei Jiang (Assistant Professor, ISE SoIC), Alexander Gummenik (Assistant Professor, ISE SoIC), Feng Guo (Assistant Professor, ISE SoIC), Lantao Liu (Assistant Professor, ISE SoIC), Greg Lewis (Assistant Professor, ISE SoIC)

Description of area to be proposed. What constitutes this area of research or creative activity as emerging?  
(Word limit=500)

Integration of Artificial Intelligence (AI), Internet-of-Things (IoT) and Cloud Computing (CC) is a promising emerging area that will profoundly change the approach to science and society with an impact on applications such as surveillance systems, autonomous driving and intelligent transportation, precision health and environments, etc. It turns big data into actions through an integrated system with new capabilities, richer experiences, and unprecedented economic opportunities. However, the diversity of the computing resources and the different application-specific needs across the networked devices raise challenges. For example, a state-of-the-art AI model (e.g. a deep neural network) often resides in the cloud, since CC supplies the required high-level intelligence by enabling access to a centralized pool of powerful computing resources and big data. However, the unpredictable network latency, expensive bandwidth, and privacy concerns hinder CC from meeting the stringent requirements of real-time applications. Therefore, sometimes the IoT edge devices could be better off running the intelligent tasks, while complex AI models are not affordable due to the limited resources. To this end, the initiative tackles the heterogeneity of the networked computing units and the way the AI applications are decomposed across them.

An Example Scenario:

A distributed ecosystem adaptively controls a variety of intelligent tasks by pushing some of them towards the IoT edge devices. On the edge side, various wearable sensors of varying levels of fidelity run a lightweight AI task to detect an event of interest in real time (e.g. an irregular heartbeat). This lower-end device fires up the communication channel only if an event is detected, reducing communication costs. Then, a mid-level AI engine, implemented in a larger device with more resources available (often called the fog), conducts an advanced activity such as predicting the context (e.g. the user is working out). Eventually, the comprehensive AI in the cloud analyzes big data collected from many users and makes a final decision (e.g. calling 911). Likewise, this initiative is to balance the load of the AI tasks across the wearables, coordinated robots, biomedical/environmental sensors and data centers, so that the whole infrastructure works as a collective intelligence.

The Team:

We see this emerging area of research in a holistic way. First, we fabricate smart sensors for various applications. Then, we invent extremely efficient computing architectures as a low-power brain of the IoT edge devices and robots. Our research on edge computing systematically balances the job loads in-between the edge and the cloud. The CC part innovates the parallelization technologies tailored for training and running the massive AI models. The glue of the project is our expertise in machine learning theories, specialized with the hardware-friendly binarized arithmetic. With the efficient machine learning techniques, we can add an additional flexibility to those AI engines so that they can be freely deployed not only in the cloud with its full functionality, but in the embedded systems in its resource-saving form. On top of this expertise of the team, examples above also point out the breadth of potential interest across IU.

Please submit to [earprogram@indiana.edu](mailto:earprogram@indiana.edu)