FY2016 Academic Alliance LDRD Call Supplemental Information Doc SAND2015-10150R
(for plus-ups to existing LDRDs, or for new projects ≤$100K/year)

Proposal No.: 16-0306 Supplementary
AA University Partner: Georgia Institute of Technology
Principal Investigator: Uzoma Onunkwo, 09336
Duration: 2 Years
Requested Funding:
FY16: $75K
FY17: $75K

1. Is this a plus-up to an existing LDRD? **No (plus-up to a New LDRD: 16-0306)**
   a) Existing LDRD Information:

   Project No: 16-0306

   Project Title: High Fidelity Simulations of Large-Scale Wireless Networks

   Principal Investigator: Uzoma Onunkwo (09336)

   Investment Area: Defense Systems and Assessments

   Current Funding (without requested plus-up)

   FY16: $300K

   FY17: $300K

   b) Provide a brief description of how the proposed collaborative R&D relates to the existing LDRD (~200 words)

   Our existing LDRD is a new start for FY16 that is projected to solve the problem that there are no acceptable scalable framework for doing large-scale (> 1000 nodes) wireless network simulation. Our LDRD project is not attempting to develop a new network simulator, but to develop an integrable scalable simulation framework for existing well-published simulators (such as ns-3) using our expertise in high performance computing and parallel algorithms. To demonstrate effectiveness and make a strong case for wide adoption of our potential accomplishments, the team has decided on working on an interface with the well-accepted ns-3 network simulator. It is in regards to ns-3, that Georgia Tech has a very strong expertise, especially Prof. George Riley's group. Prof. Riley has led many architectural development and protocol studies in ns-3. Ns-3, however, has not had any decent implementation for parallel discrete event simulations in the wireless network domain thereby making it impossible to use for cyber studies involving beyond a few tens to hundreds of wireless devices. It is this mutual need and respective expertise of the Sandia and Georgia Tech team that we intend to grow to yield a first known high fidelity wireless simulation of scale.

2. Tie to Academic Alliance Call:
   a) Provide a paragraph describing how this R&D bolsters the strategic nature of the relationship between Sandia and the University (~ 200 words).
   - *What is the anticipated benefit to the Academic Alliance Partner?*
   - *What is the anticipated benefit to Sandia?*

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Sandia National Laboratories

- *Describe the potential for future impact on mission, leadership in a new scientific field, new intellectual property or advanced technologies, transformational program implications, etc.*

Sandia has built a strong reputation in scalable network simulation and emulation for cyber security studies to protect our nation's critical information infrastructures. Georgia Tech has preeminent reputation in academia for excellence in scalable discrete event simulations, with strong emphasis on simulating cyber networks. Many of the experts in this field, such as Dr. Richard Fujimoto, Dr. George Riley, and Dr. Chris Carothers, have strong affiliations with Georgia Tech. The collaborative relationship that we intend to immediately pursue is in high fidelity simulations of practical large-scale wireless networks using ns-3 simulator via Dr. George Riley. This project will have mutual benefits in bolstering both institutions' expertise and reputation in the field of scalable simulation for cyber-security studies.

This project promises to address high fidelity simulations of large-scale wireless networks. This proposed collaboration is directly in line with Georgia Tech's goals for developing and expanding the *Communications Systems Center*, the *Georgia Tech Broadband Institute*, and *Georgia Tech Information Security Center* along with its yearly Emerging Cyber Threats Report. At Sandia, this work benefits the defense systems and assessment area with promise for large-scale assessment of cyber security needs and vulnerabilities of our nation's critical cyber infrastructures exposed to wireless communications.

b) What's next (~ 200 words):

- What follow-on or next steps will be necessary to achieve these impacts?
- What's the time frame for these next steps, and for the identified impacts?

The objectives of this joint effort are to advance the state-of-the-art in scalable wireless network simulation, to build a capability which is universally available to researchers in the area of cyber security, to jointly promote the reputations of both institutions, and to build a stronger bipartisan relationship between Sandia Laboratories and Georgia Tech.

Towards these objectives, we intend to execute the following next steps that will integrate our LDRD breakthroughs with the ns-3 simulator, backed by Georgia Tech. Our collaborations will address:

a) the use cases for cyber-security wireless networking studies using ns-3,
b) the architectural design and integration of our envisioned scalable simulation framework into the ns-3 simulator, and
c) the validation and verification of the jointly developed simulation capability.

The time frame for this collaboration effort is two years with the tasks highlighted in the table below.

Task	1H FY16	2H FY16	1H FY17	2H FY17
Kick Off Meeting/Plans	X			
Cyber Security Use Cases	X	X		
Algorithms & Code Implementation	X	X	X	X
Verification & Validations			X	X
Test and Evaluation			X	X
LDRD Reporting and Conference Publications				X

Our final vision also includes bolstering exceptional full-time hiring and faculty sabbaticals from Georgia Tech.

3. Provide a basic breakdown of the budget: If Sandia costs are covered by the existing project, enter "0".

The budget breakdown for this effort is highlighted in the below table.

Amounts	FY16	FY17	FY18
Funding to AA School:	$60K	$60K	0
Sandia Costs:	$15K	$15K	0
Total:	$75K	$75K	0

4. Who are the participating researchers at Sandia and at the AA school?

Dr. Uzoma Onunkwo (Sandia National Laboratories)
Dr. Robert Cole (Sandia National Laboratories)
Dr. George Riley (Georgia Institute of Technology)

Our principal investigator (Uzoma Onunkwo) is also a member of the Georgie Tech corporate recruiting team at Sandia National Laboratories and alum of the university. He intends to synergistically use our corporate recruiting missions to bolster stronger interactions with the Georgia Tech team, which include activities such as Tech Talk and informal meeting sessions with the faculties and directors.

Dr. Robert Cole has a previous working relationship with Dr. George Riley along with multiple technical publications.

5. Additional Information Regarding the Proposed Work: (Max 1 page).
Use up to one additional page to expand on the Proposed Work, e.g., more details regarding the technical approach and how it differs from prior work; the leading edge nature of the work; milestones, success measures, and outputs; and/or technical challenges and risks and how those will be managed. This information will be used by the reviewers to evaluate the technical merit of the work.

The new LDRD project is geared to address high fidelity simulations of large-scale wireless networks. The problem with network simulators (e.g., OPNET and ns-3) is that they are either poorly designed for scalable simulation of wireless networks or simply lack the ability to do so. This issue thus reduces virtually all studies involving wireless systems to a hundred or less simulated devices. However, the proliferation of numerous wireless systems, along with the expected booming growth in wireless networks with the proliferation of Internet of Things (IoT), makes simulative studies beyond hundreds of systems imperative for national cyber security purposes.

Our Sandia team has expertise ranging in the area of high performance computing, scalable efficient algorithm development and implementation, and cyber security simulations. Our project has identified ns-3 as the most promising discrete-event simulator to interface with our expected scalable simulation framework to address and demonstrate useful network studies. Ns-3 already provides excellent models of key pieces in network protocol studies; however, it lacks parallel implementations in the wireless regime.

The Georgia Tech team, led by Dr. George Riley, has played major role in the development of the current ns-3 simulator. This simulator is the most used (measured by technical publications in IEEE and ACM) tool in academic and government arenas. Dr. George Riley has years of experience in large-scale compute networks, distributed discrete-event simulations.

If successful, this project promises to deliver a first-time high-fidelity simulation of wireless networks. In the process, it will build a stronger academic alliance with Georgia Tech. This will subsequently enable many valid large-scale cyber security investigations and vulnerability assessment at Sandia. Given the wide adoption of ns-3, the success of our work could invariably lead to wide variety of network security studies and protocol developments that can be of great interest regarding our critical cyber infrastructures.

The success of this project will place Georgia Tech and Sandia National Laboratories among the premiere institutions for national scale cyber security analysis. This aligns with core mission areas related to cyber security and protection of critical infrastructures. In addition, Dr. George Riley's team along with other possible collaborators with him at the institution can grow Georgia Tech's capabilities with likely funding sources from National Science Foundation (NSF), which has funded his work in the past. Finally, our success should enable subsequent bipartisan relationships between Sandia National Laboratories and Georgia Tech in large-scale systems including high performance computing, cyber analytics, and machine learning.

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