The University of Queensland - IIT Delhi Academy of Research (UQIDAR) Joint PhD Project Proposal Template

1. Project details

Project title

Learning-based optimization strategies for sustainable IoT communications

Project ID

UQIDAR-00161

2. Supervision team

Please visit the IITD website www.iitd.ac.in and UQ website http://researchers.uq.edu.au/ to highlight potential collaborators that would be best suited for the proposed project. Complete where possible – advise if you'd like assistance establishing contacts.

	University of Queensland	**IIT Delhi**	**External/Industry (if applicable)**
Supervisor name and title	*Raja Jurdak, Honorary Professor, Senior Principal Research Scientist at CSIRO Australia*	*Swades De, Professor*	
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URL for more info	*http://jurdak.com/ https://scholar.google.com/citations?user=n8xYIkQAAAAJ&hl=en*	*web.iitd.ac.in/~swadesd https://scholar.google.co.in/citations?user=BfVMzzkAAAAJ&hl=en*	

3. Other supervisors

Please provide information about other associate supervisors below.

Full name and title(s): **Assoc Prof Marius Portmann**
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Full name and title(s): **Dr. Hemant Rath (Senior Scientist), Dr. Bighnaraj Panigrahi (Scientist), Dr. Samar Shailendra (Scientist)**
School/department/company details: TCS Research and Innovations
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2. Field Of Research (FOR) codes

Specify up to four four-digit FOR codes for your project – see **here** for more detail on FOR codes.

1 DIVISION 08 INFORMATION AND COMPUTING SCIENCES	3 DIVISION 10 TECHNOLOGY
2 DIVISION 09 ENGINEERING	4.

3. Keywords

Please choose up to 4 keywords for your project. E.g. Nanotechnology, data science, novel batteries, etc. Keywords will assist in classifying project and presenting projects to students on the applications portal.

1 Edge computing	3 Learning techniques
2 Sustainable IoT communications	4 Sparse signal processing

4. Discipline background of candidate

Please outline the preferred background of your student. E.g. Organic chemistry, physiology, topology, CFD, etc. This will assist in presenting projects to applicants on the apps portal.

1 Electrical Communication Engineering	3 Applied mathematics
2 Computer Engineering/Technology	4 Signal processing

5. Project description

In this project, we intend to develop the innovative data-driven techniques for application context aware smart computing and communication strategies at the edge nodes for 5th generation Internet of Things (5G IoT) and beyond communications. The use cases are important from both indoor as well as outdoor perspective, though the operating conditions, available resources, and objectives could be significantly different. Usually the smart devices/robots/sensors used in such use cases are of heterogeneous types and in large scale. Mobile communication and energy agents (e.g., unmanned aerial vehicles (UAVs)) are also deployed to undertake certain important tasks such as sensing, controlling, recharging, managing, remote diagnosing, etc. To perform the desired tasks by the appropriate smart device and/or mobile agents and at the right time requires coordination among the devices/ mobile agents and the central control system. For this, data collected by sensors and mobile agents are to be communicated either to a central system or to set of distributed agents or nodes depending upon the use case and the architecture. Primary objective of this project is to study context-aware, sustainable communication and networking issues in deployment of smart sensors and mobile agents and to provide optimal solutions in terms of algorithms, protocols, and deployable proof-of-concepts on application aware network platform.

6. Project deliverables/outcomes

Some of the-problem areas in the project are:

- Application context specific communication network protocol design for 5G IoT use cases. The contexts are expected to be stochastically dynamic. The specific cases of interest are: (i) smart city and industrial pollution map creation and localization and (ii) smart-grid/smart-metering applications.
- In all use cases, while performing the desired task, the energy, bandwidth, and storage requirements are critical to resource efficiency. To this end, an effective strategy would address the problem by “learning” from the individual time series of sensed data as well as from inter-sensor coordination, which could be at the node-level as well as at the network-level.
- Notwithstanding the efforts on energy efficiency, for uninterrupted network operation, a node with finite battery capacity needs to be recharged “online”. To this end, many industrial/ agricultural application scenarios would require dedicated wireless charging resource, where radio frequency (RF) energy transfer would be of interest. This is a crucial point from 5G prospective as alternate energy usage is a must item and through this it can be achieved to some extent. Mobile robots with terrestrial or aerial mobility will help while avoiding communication traffic flow related funnelling problem.
- Specific interest would be drone/UAV-assisted energy replenishment and data collection, where the basic channel models may need to be re-investigated. Channel models are crucial for network architecture and deployment.

In the project scope primary focus would be given to learning and processing intelligence at the edge. Beyond data-specific

features, effects of communication network constraints, e.g., congestion-induced delay and jitter, and wireless channel induced stochastic losses would be of interest in this project. Channel induced stochastic losses will be accounted as important factors from communication protocol and algorithm design and validation viewpoints. Context-specific network communication platforms will be developed, which can be adapted to satisfy various QoS requirements in 5G IoT use cases, namely remote connectivity, smart grid, and smart city. The two application domain specific broad classification of air-to-ground (AtG) communication studies would be: (i) urban/suburban, smart city type of sensing and automation applications, (ii) rural agricultural deployments for mechanized farming. For sustainable sensor node operation via on-demand wireless energy supply, RF energy transfer and our recently-proposed multihop RF energy routing technology will be refined by incorporating multi-antenna and beamforming technologies, which have not been explored before.

Deliverables:

a) Multiple new concepts (e.g., architecture, protocols, algorithms, proof-of-concepts, and embedded system implementations) will come out of the project, which can also be used as standalone components.
b) The various context-specific IoT data, e.g., localized pollution samples and smart meter data from the selected appliances, will be made available on public repository for further analysis and research.
c) The research outcomes will be presented as papers in reputed international conferences, journals, and magazines.
d) Intellectual property (IP) filings on some of the novel learning-based algorithms are expected.

7. Research impact themes

Highlight the research impact theme(s) this project will address. Feel free to nominate more than one. For more information, see http://www.uq.edu.au/research/impact

1. Healthy Ageing
2. Feeding the World
3. **Resilient Environment**✓
4. **Technology for Tomorrow** ✓
5. Transforming Societies

8. Type of student

This project is best suited for an:

i-student	✓
a-student	
i- or a-student	

Please note that:

- an i-student will be expected to spend year-1 at IIT-D, year-2 at UQ and the remaining time at IIT-D.
- an a-student will spend year-1 at UQ, year-2 at IIT-D and the remaining time at UQ.
- All students will be required to complete some amount of coursework in their first year.

9. Student capabilities and qualifications

Essential capabilities:

Strong mathematical background, strong background in Signals and Systems and in Probability and Stochastic Processes

Desirable capabilities:

Interest/capability of working on hardware systems (implementation/experimentation using SDR/USRP kits and embedded hardware systems) will be advantageous.

Expected qualifications (Courses, degrees, etc.):

The students are expected to have degrees in Electrical Communication/Computer Engineering or allied areas such as Applied Mathematics