Internship offers

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Project title: Self-Optimizing Fabric (SOF) for ENCQOR Network

What is our goal and what problem are we solving?

What makes 5G unique is that it is the first generation of networking that makes connectivity as transparent as air; this when complimented with high performance ubiquotius compute and machine intelligence gives rise to a landscape that vastly different than the current. 5G era systems are anticipated to highly interconnected compositions of heterogenous intelligent components. These systems will require new paradigm of plan, design and operations that allows the individual components to contribute to the collective (competeing or collaborating) goals while maintaining their individual targets, and that allows the invidual components to evolve along with the collective system while maintaining strict separation of concerns.

Key research objective of this project is to assess the **associated complexity**, explore novel techniques, e.g. new Machine Intelligence sciences to provide systems recommendations for new paradigms for plan, design and operations of 5G era systems. Five research questions are identified in this project:

1. How to overcome complexity associated with current 5G systems:
    a. facing limitations/boundaries of available resources;
    b. facing limitations of adaptability of legacy solutions (limited scalability/flexibility);
    c. facing limitations of available decision making entities (network slice orchestrators and SDN-controllers will not be enough) &
    d. facing lack of intelligent solutions.

2. How to tame ever increasing complexity resulting from multi-dimensional variance of beyond 5G applications like low-latency, massive scalability, extreme mobility, energy efficiency:
    a. necessity for novel design, planning and operations paradigms;
    b. Assessment of legacy ML/DL tools vs new intelligence sciences (e.g. emergence) for applicability to system optimization &
    c. necessity of novel tools to model and study the behavior of such highly complex systems.

3. How to efficiently plan, design and operate component based systems in which individual components are intelligent agents, powered by advanced Machine Intelligence techniques, and how to enable collaboration across multiple intelligent agents with competing and conflicting (often times, selfish) reward functions toward common collaborative goals?

4. What would be the limitations of the current 5G technologies, and how can we push the boundaries of these technologies given advances in theoretical research in continuous optimization, AI, control theory, and network science?

5. What are the optimal methods to implement, validate and verify beyond 5G systems, addressing some of the imminent optimization challenges, e.g. autonomous device swarms?

How do we solve it?

As part of its ENCQOR 5G partnership, Ciena is creating an international research ecosystem with industry and academia to assess demand-side implications of fully-connected intelligent fabrics of the future. The results of these studies will inform new paradigms for planning, design, and operation of 5G era intelligence systems. In addition to Ciena, the founding members of this ecosystem include ÉTS University, Mitacs, and the Platform Lab at Stanford University.

The ecosystem will determine how to create and utilize a Self-Optimizing Fabric (SOF) to address the complexity of distributing intelligence across disparate, interconnected systems while maintaining any necessary separation of operational tasks. An example application of this would be mobile esports, wherein multiple mixed reality applications, edge delivery platforms, and network interconnectivity work in unison towards the common goal of delivering an optimal gaming quality of experience with seamless continuity across multiple mediums.

Specifically, through this collaboration, SOF will transform the ENCQOR corridor for discovery and verification of real-world use-cases by bringing together 5G technologies with AI and cloud assets, all underpinned by an adaptive network. Results from the explorations will help inform how distributed intelligence systems of the future will be planned, designed, and deployed for rapid service delivery and operational efficiency.

International students are welcome to apply.

Requirements:

Working conditions

Candidates are required to work at Ciena facilities in Montréal at least 50% of time, and will be able to work at the ÉTS campus as well. A laptop will be provided. No work-permit is required.

Candidates will be funded according to the MITACS Accelerate program: work blocks in 4 months increments. Details of the program can be found at:
https://www.mitacs.ca/en/programs/accelerate

PhD students will work in 6 to 8 block increments.

Candidates will be supervised by a professor at ÉTS Montréal and an industrial researcher, and possibly a professor at Stanford University as well.

Candidates will be responsible for research dissertations, technical reports, and conference/journal articles based on outputs of hands-on discovery and verification in ETS and Ciena Labs. PhD students will be required to publish at least three articles detailing the outcome of his/her project.

Technical skills:

- Programming languages: Java, Python, Go, Scripting: required
- Linux OS: required
- Networking: Ethernet, IP: required
- Architectures: SDN, NFV: required
- Machine learning algorithms: Required
- Machine learning tools: TensorFlow, Scikit Learn, Keras.io
- Data Science, Artificial Intelligence: required
- Deep Learning: required
- Open Platforms: Openstack, Kubernetes: Basic knowledge
- 5G control plane, data plane and management plane: Basic knowledge
- 3GPP SON systems: Basic knowledge
- Self-Optimizing systems design, models and algorithms: Basic knowledge
- Autonomic systems design, models and algorithms: Basic knowledge
- Complex Adaptive System (CAS): Basic knowledge

This project will require a collaboration between the interns. This project requires **12 Ph.D's**. The goal of this project is to:

- Demand side research and requirements analysis for intelligence frameworks that will underpin the SOF.
- Evaluation and recommendations for novel techniques for effective implementation of the intelligence framework. This will include :
    - Investigation for a **state-of-the-art methods** for data collection, data pre-processing, model development, model deployment.
    - Work includes analysis and research for an AI framework suitable for SOF. The architecture studies will cover data collection, data modeling, tools and generic AI algorithms. The research studies should investigate four components: i) data collection, ii) data pre-processing, iii) model development, and iv) model deployment. Parallel data processing and scalable storage management methods should also be investigated in this framework.
    - The candidate will work with AI/ML platforms like TensorFlow and scikit-learn to develop predictive models. Research includes the investigation of AI models applied in different fields like telecom, complex adaptive systems, collaborative agents etc.. using approaches such as RNN, CNN, ANN, Ant Swam Optimization, and evolutional algorithms (e.g., genetic).
    - An analytical framework will be recommended by the results of the studies, in which the whole lifecycle of a complex application made of many smaller components will be monitored and optimized

- AI pipeline and machine learning flows for SOF elements

- Reseach, requirements anlysis and recommendations analysis for latency critical communications of interactive AI components. The goal of this work item is to create a framework including an abstraction layer and the communication protocols that constitute the interconnection layer of the collective and collaborative SOF multi-agent intelligence system.
- Hands-on discovery and verification with concrete software artificats in the research labs; to include but not limited to:
  - Model driven service enablement AI pipeline for 5G mobility stack
  - Information models & templates to enable self-optimizing multi-agent intelligence applications.
  - Modeling approachs to represent the information of the federation framework, and then design test scenarios for the federation (taking into account of new requirements of 5G applications.)
  - Traffic modelling and future traffic projections, use case analysis, software system requirements and recommendations, and KPI recommendations for AI driven multi-access edge systems

THANK YOU !

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Contactez-moi si vous avez des questions concernant les programmes Mitacs.

Contact me if you have any questions about Mitacs Programs.

Intern #1 (Ph.D) – P3.1: "Requirements analysis research & architecture definition for AI Framework"

The goal of this intern project is to define requirements analysis for an AI framework that will be embed AI capabilities into various SOF elements such as agents and managers.

In terms of research, the intern will investigate state-of-the-art methods for data collection, data pre-processing, model development, and model deployment.

In terms of implementation, the intern will implement core components of the proposed framework. These components will serve as building blocks to develop intelligence in SOF elements.

Intern #2 (Ph.D) – P3.2: "Software stack and implementation and AI algorithms for SOF framework"

The goal of this intern project is to develop algorithms and methods for data acquision, pre-processing, and modeling (with a focus on supervised and unsupervised learning models), as well as for knowledge discovery.

In terms of implementation, the intern will work with AI/ML platforms like TensorFlow and scikit-learn to develop the predictive models. The intern will also implement software modules for data pre-processing.

In terms of research, the intern will investigate optimization methods to tune up the learning models, analyze datasets to extract feature, and build methods for model deployment.

Intern #3 (Ph.D) – P3.3: "Software stack and implementation and AI algorithms for SOF framework"

This intern shares the same goal with PhD3.2, but focusing on reinforcement learning models for self-optimization and self-healing.

In terms of implementation, the intern will implement a framework for reinforcement learning used for real-time optimization of SOF elements.

In terms of research, the intern will design iterative algorithms for decision-making process, as well as optimization models for resource allocation and capability negotiation.

Intern #4 (Ph.D) – P3.4: "Collaborative AI: Multi agent intelligence system formation"

The goal of this intern project is to create a framework including an abstraction layer and the communication protocols that constitute the interconnection layer of the collective and collaborative SOF multi agent intelligence system.

In terms of implementation, the intern will develop software modules for dynamic discovery (both capability and semantics), dynamic capability negotiation (E-W & N-S), and self-assembly.

In terms of research, the intern will design methods for the interpretation of capabilities between SOF elements, algorithms for semantic discovery, and negotiation protocols.

Intern #5 (Ph.D) – P3.5: "Collaborative AI: multi agent intelligence federation "

The goal of this intern is to investigate efficient and optimized methods to federate elements SOF across multiple jurisdictions.

A key consideration of federation relates to systems that spread across multiple administration, especially those within different commercial organizations, and other low trust environments, such that there is limited or no visibility of the arrangement of the system in one administration from the other. There is little opportunity for any one administration to oversee the whole at an appropriate level of detail. In this case a distributed form of optimization will be necessary. It is assumed that this optimization will be carried out in under a regime of federated policy to ensure necessary consistency

In terms of implementation, the intern will develop software modules for control-loops at both low-level and high-level of the systems for the federation of SOF elements.

In terms of research, the intern will formulate the problem of federation across multiple jurisdictions, and develop optimization models. AI/ML will be developed to deal with the complexity of the federating process.

Intern #6 (Ph.D) – P3.6: "SOF AI Market place"

The goal of this intern is to perform end-to-end verification of multi agent intelligence framework for self-optimizing systems, and define information models & templates to enable self-optimizing multi-agent intelligence application.

In terms of implementation, the intern will carry out multiple test scenarios to verify the federation framework, and will also implement core information models and templates for multi-agent intelligence applications in general.

In terms of research, the intern will investigate modeling approach to represent the information of the federation framework, and then to design test scenarios for the federation taking into account of new requirements of 5G applications.

Intern #7 (Ph.D) – P4.1: "*Requirements analysis for intelligent device swarms and recommendations for new paradigm for design, plan, deploy and operate multi access system*"

The goal of this intern is to perform end-to-end verification of multi agent intelligence framework for self-optimizing systems, and define information models & templates to enable self-optimizing multi-agent intelligence application.

In terms of implementation, the intern will carry out multiple test scenarios to verify the federation framework, and will also implement core information models and templates for multi-agent intelligence applications in general.

In terms of research, the intern will investigate modeling approach to represent the information of the federation framework, and then to design test scenarios for the federation taking into account of new requirements of 5G applications.

Intern #8 (Ph.D) – P4.2: "*AI driven multi access edge software stack architecture Design, Implement, verify e2e software stack for multi access edge*"

The goal of this intern is to design an architecture and then implement software modules that enable a real MEADS use-case, with a focus on AI methods for control and prediction dealing with challenges identified by PhD4.1.

In terms of implementation, the intern will customize the generic AI framework defined in a related project to MEADS, and embed it into existing network management platforms and architectures.

In terms of research, the intern will investigate an optimized network management architecture for the MEADS application, develop data models for different elements of the application, and then propose a framework for optimizing service provisioning.

Intern #9 (Ph.D) – P4.3: "Multi-agent architecture for MEADS"

The goal of this intern is to implement AI algorithms for SOF agents in order to achieve MEADS use-case.

In terms of implementation, the intern will customize the generic AI framework defined in a related project to MEADS, and embed it into existing network management platforms and architectures.

In terms of research, the intern will investigate an optimized network management architecture for the MEADS application, develop data models for different elements of the application, and then propose a framework for optimizing service provisioning.

Intern #10 (Ph.D) – P4.4: "Multi-access optimization for MEADS"

The goal of this intern is to design and implement the Self Optimizing MEADS based on fundamental elements created by PhD4.2 and PhD4.3 interns.

In terms of implementation, the intern will customize the generic AI framework defined in a related project to MEADS, and embed it into existing network management platforms and architectures.

In terms of research, the intern will investigate an optimized network management architecture for the MEADS application, develop data models for different elements of the application, and then propose a framework for optimizing service provisioning.

Intern #11 (Ph.D) – P4.5: "AI-based MEADS communication"

The goal of this intern is to collaborate with PhD 4.4 in designing and implementing the Self Optimizing MEADS based on fundamental elements created by PhD4.2 and PhD4.3.

In terms of implementation, the intern will implement and verify SDIDA pattern for MEADS fabric, and then integrate the elements for end-to-end MEADS scope.

In terms of research, the intern will define optimization models for intra and inter-domain taking into account specific constraints of MEADS. QoS provisioning will be investigated, through mobile edge caching and mobile edge computing models. Finally, the intern will carry out realistic scenarios of MEADS.

Intern #12 (Ph.D) – P4.6: "AI-based MEADS communication"

The goal of this intern is to collaborate with PhD 4.4 in designing and implementing the Self Optimizing MEADS based on fundamental elements created by PhD4.2 and PhD4.3.

In terms of implementation, the intern will implement and verify SDIDA pattern for MEADS fabric, and then integrate the elements for end-to-end MEADS scope.

In terms of research, the intern will define optimization models for intra and inter-domain taking into account specific constraints of MEADS. QoS provisioning will be investigated, through mobile edge caching and mobile edge computing models. Finally, the intern will carry out realistic scenarios of MEADS.

International students are welcome to apply!!