Project Description

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Introduction

This proposal is a direct follow-up of an active project started in August 2019 by Dr. Clément Aubert, Assistant Professor in Computer Science, and John Natale, third-year student in Mathematics with a minor in Computer Science.

The project aims at using mathematical tools (set theory, category theory) to get a better understanding of the mechanisms of distributed computation. The core idea is to use mathematical equivalences to equate programs that are unessentially different. This is an active area of study, with a large community of researchers, at the cross-roads of Computer Science and Mathematics.

Our main goals, aside from the educational goals detailled below, are to produce a research document that will be shared with experts in the field through self-archiving on the arXiv.org repository, and a poster for the Symposium that will get re-used in other venues and will be self-archived as well. All the material produced will be released under Creative Commons licenses, to ease distribution and re-use by the community.

Significance to the Discipline

Configuration structures are a frequently-used mathematical model relying on set and category theories that was introduced in the 80's, but that lacks an un-ambigous and settled definition. The structure evolved over the time, and multiple definitions – apparently equivalent, but not proven to be equivalent – co-exist in the literature. As a result, multiple equivalences on concurent programs co-exist, and are used simultaneously in the literature, even if they carry different meanings and implications.

Settling once and for all the "right" definition, and proving what are the acceptable variations, will have several impacts:

- It will constitutes a key-reference in the field, allowing to find in one handy document a clear and argumented definition,
- It will allow to "iron out" the equivalences on programs, and lay the foundation of a clear, justified, rule to determine if two programs are "essentially the same",
- It will be a useful entry door to researchers in close communities, containing numerous references to fundamental research articles.

Mentoring

The main educational goal of the project is to **give to John the taste of a scholarly culture, and by doing so to stress the relevance and importance of undergraduate research**. It should be noted that John is a first-generation student, and as a consequence the first of his family to engage in research.

More precisely, our goals are to:

- Foster John's independence, to sharpen his capacities to solve problems by himself.
- Improve his self-efficacy, to believe in his capacities but also to identify when and how to ask for help.
- Encourage his curiosity, to drive his own intellectual journey.
- Leverage the CURS workshops to have a better understanding of the multiple facets of high-quality undergraduate research, and to benefit from a good professional development.
- Introduce to the administrative aspects of research[1] by e.g. searching for good-quality journals and venues to submit our work, or funds to sparkle other projects.
- Become confident with technologies (git, LaTeX, references managers, …) common in research.

John Natale's Roles

John Natale already made his debuts in research in Computer Science and Mathematics, and starts to have some familiarity with how to conduct research in those fields. For this project, his roles will include:

- Being the lead on the writing and editing of a document that summarizes our findings, as well as on the Symposium poster,
- Reading and understanding important (excerpts of) papers in the literature,
- Being able to re-formulate in his own term the research project we are following, to write a clear introduction to our document,
- Reporting regularly to Dr. Aubert, and articulate clearly what has been achieved, what needs to be done, and where help is needed.

Dr. Aubert's Roles

Dr. Aubert has mentored three research students, three teaching assistants, and one student through the African American Male Initiative at Augusta University since his arrival in Fall 2017. His duties will include:

- Providinig guidance and impromptu clarifications whenever needed, to develop John's skills and understanding, and to encourage interactions by letting him drive our discussions.
- Valuing John's skills and benefiting from his rigor and intuition to strengthen the project.
- Proposing short-terms goals that support and realize long-term plan and achievements.
- Giving to John as much independence and liberty as wished, in conjunction with a constantly available support, while respecting his individuality.
- Easing John into formulating his own hypothesis, testing them, and guiding the future progresses of the project.
- Helping John formulating the research problem in his own term, and encouraging him to present his understanding of the project in public venues.

[1] Something that already started, since John took an active part in the writing of this current proposal!

More generally, Dr. Aubert will always make sure that his expectations are clearly communicated and understood, and convey through regular meetings and email exchanges his intuitions, solutions, and suggestions to support the project's progress and our educational goals.

Timeline

We are applying for the second session, that spans from May 18 (week 1) to June 18 (week 5).

In the table below, *PDW* stands for "Professional Development Workshop".

Week	Program	CURS Event
-3	-	*Mentor Orientation Brunch*
1	Review of existing litterature, writing of first definitions (configuration structure, concurrent program)	*Kickoff and Student Orientation Breakfast, PDW*
2	Comparison between existing definitions, proof of (in)equivalence between them	*PDW*
3	Detail equivalences between programs induced by (variations on) configuration structures	*PDW*
4	Investigation of other sources of equivalences, reaching out to experts in the field	*PDW*
5	Wrap-up and document what is left to do, preparation of the poster	*PDW*
9	-	*Summer Scholars Symposium*

A regularly updated document and journal will help in completing those milestones, and will constitute a way of assessing of the progresses of the project as well as of the clarity of our understanding of the project's developments.

It should be stressed that Dr. Ioana Cristescu (Tarides, Paris) and Dr. Emmanuel Beffara (Aix-Marseille University, Marseille) already showed interest for that project, and should be able to review and comment on our findings on week 4. Their expertise in close fields will be an asset to open our project to new scientific directions and review the correctness of our findings.

Budget Justification

The only expenses are the color research poster for the Summer Symposium, the stipend for Dr. Aubert and the salary for John Natale. Our personal computers, Dr. Aubert's office, whiteboard and markers will be put to contribution to lead our theoretical research. Dr. Aubert already has access to most of the relevant journals and papers in the topic, and can access other references free of charge.

We may look for a laboratory, classroom or office for John to work, possibly sharing it with other students enrolled in the Summer Scholars Program, but that should be free of charge as well.