Attachment 1: Research Project Proposal

Section A: Overview of the Research Project Proposal

1. Academic level (Masters or PhD): Masters

2. Broad field of research: Engineering

3. Title of the research project: Hardware Acceleration for Computational Electromagnetics

4. Research project abstract:

Traditional acceleration strategies for computational electromagnetics (CEM) involve distributed computing methods (such as MPI) and shared memory programming paradigms (e.g. OpenMP). Additional improvements have also been established with graphic processing units (GPUs). The aim of this project is to implement a parallelised computational electromagnetics (CEM) solver, for well-known techniques, such as the Method-of-Moments (MoM), using hardware acceleration strategies. These acceleration techniques is focussed on applying devices such as FPGAs and GPUs to improve the memory and run-times associated with conventional solvers.

Section B: Supervisor's Details

1. (a) Supervisor's title and full name: Dr. Danie J. Ludick

(b) Name of the South African or SKA Partner Country university at which the primary supervisor is a permanent academic staff member: Stellenbosch University

(c) E-mail address and/or contact telephone number: dludick@sun.ac.za | 084 524 5994

(d) Supervision of postgraduate students:

Name of Student	Nationality	Date started Master's degree	Date completed / will complete degree	Title of thesis	Co-Supervisor
Tristan Steele	South African	January, 2016	December, 2017	Coupled Structural and Electromagnetic Analysis of a Radio Telescope	Prof. David Davidson, Dr. Martin Venter
Lydia de Lange	South African	January, 2018	December, 2019	Array failure detection using Machine Learning	
Ntombi Mtetho	South African	January, 2018	December, 2019	Developing a fully functional Aperture Synthesis Array Radio Telescope	

Section C: Full Research Project Proposal

1. Scientific merit:

Computational electromagnetic problems are becoming increasingly more complex, specifically in terms of the electrical size of the structures being analysed. Radio telescope antennas that form part of the SKA, e.g. parabolic dish reflectors, or large finite antenna arrays exhibit this complexity and the numerical analysis using CEM solvers can be costly in terms of memory and runtime. The goal of this research is to investigate the use of hardware accelereration strategies by using devices such as FPGAs or GPUs to accelerate various key parts of the algorithms, thereby enabling the analysis of larger CEM problems accurately and quickly.

2. Feasibility:

Stellenbosch University offers access to a state of the art High Performance Computing (HPC) facility, various commercial CEM codes such as FEKO, as well in-house solvers that can be used for this study. In addition, FPGA and GPU devices that can be applied to this work is readily available.

Initially, the student will work on gaining an understanding of fundamental computational electromagnetic (CEM) methods, such as the Method-of-Moments (MoM), which is offered during the first semester of the MEng as part of a comprehensive set of postgraduate courses. Other coursework include a revision of electromagnetics and antennas. A postgraduate course on High Performance Computing (HPC) is also planned for 2019.

In the first year, a detailed literature study and revision of current hardware acceleration approaches is expected. The student will also investigate conventional parallelisation strategies, such as that offered by MPI and OpenMPI to obtain a benchmark of existing approaches. A working CEM solver forms the main goal for this phase of the Meng.

The goal of the 2nd year is to master FPGA / GPU programming methods and to apply this to the CEM solver developed in year 1.

3. Relevance of the research proposed to the SARAO priority areas:

The skills that are acquired by the candidate will not only allow the student to become acquainted with CEM solving methods – something that is useful when simulating antenna structures in the context of the SKA - but also to FPGA and GPU programming, with focus on algorithm acceleration. This skill is transferable to other sectors, e.g. signal processing. This is relevant in the context of the SKA research objectives, as laid out in Annexure 1 of the

Application Guide (see Point 2: Real time Signal Processing instrumentation for Radio Astronomy, specifically using FPGA and GPU platforms).

4. Students with an interest in programming, electromagnetics as well as computing will be ideal for this project.

Section D: Signatures

1. Signature of primary supervisor and date of proposal submission:

Dr. Danie J. Ludick - 2018-08-31