# Parallel & High Performance Computing Education – A Botswana Perspective

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***Abstract*—**This paper presents the needs for Parallel and High Performance Computing education in Botswana. The application needs along with the Supporting National & Regional Policy are also presented. Personnel Needs Statement for HPC and the way the hardware was obtained are also provided. The need for skills in HPC and how to generate them from within are also detailed, followed by the current status of the HPC system in Botswana. Our capacity partners are also listed and the conclusion provides our experience in this arena.

**Keywords-**HPC, Needs Statement, Supporting National & Regional Policy, Personnel Needs Statement for HPC and HPC Botswana experience.

## I. INTRODUCTION

High Performance Computing (HPC) systems form important part of economic development in any country. Botswana is an African country, where HPC needs are felt in some critical areas. Such needs statement along with the Supporting National & Regional Policy are also presented. Personnel Needs Statement for HPC and the way the hardware was obtained are also provided. The need for skills in HPC and how to generate them from within are also detailed, followed by the current status of the HPC system in Botswana. Our capacity partners are also listed and the conclusion provides our experience in this arena.

### Application Needs Statement for HPC

Botswana is a large country with a small population distributed across small centers of life.

- Mining & Mineral Prospecting (Diamonds, in particular)
- Agricultural science
- Conservation & Animal eco-system (tourism is a big money spinner)
    - Bird eco-system (ornithology is the next money spinner – not yet exploited fully)
- Square Kilometer Array Antenna
    - Supporting platform – HPC ecosystems, Science Data Processor and Cyber-infrastructure
- Bioinformatics & Population Studies.
    - Human Heredity and Health in Africa – **H3 Africa**
- **Others:** Cybersecurity, Computational Chemistry, Fluid Dynamics, Computational Linguistics

### Supporting National & Regional Policies

- Botswana National S&T Policy of 1998
- Botswana National Research, Science & Technology Plan (2005)
- Revised National Policy on Research, Science, Technology and Innovation, 2011
- Botswana Space Science & Technology Strategy (Draft 2018)
- Botswana National Cyberinfrastructure Strategy (Desirable)
    - Supporting Compute and Data Infrastructure
- Botswana National Open Data Policy (Desirable) – Will Open up opportunities in
    - Open Government,
    - Research, Science, Technology & Innovation
    - Data for Development
- Regional SADC Cyberinfrastructure Framework (Approved By SADC RSTI and Education Ministers 2016)
- SADC Strategic Plan on STI 2015 – 2020
- SADC Infrastructure Vision 2027 & Digital SADC 2027

### Personnel Needs Statement for HPC

- Acquiring HPC hardware is relatively easy; Building human capacity is very much needed.
    - HPC , Data and Data science skills and research pipeline
- For a small country, Scientific and Engineering skills and specialist skills are aplenty.

- Formal education on HPC to the Scientific and Engineering community is needed – e.g., Roadshows, hands-on workshops & exposure, etc.
- Creating a (small) core experts in HPC and using them as evangelists for seeding HPC awareness throughout Botswana & SADC region.
- Solving Botswana & SADC specific HPC application problems.

**Acquiring Hardware from TACC.**

Hardware was acquired from TACC and process involved was arduous, to say the least.

**Skill Needs Statement on HPC**

- Architectural Issues.
- (simple) Parallel programming and Programming models issues.
- Algorithmic Paradigms. Underlying HPC Communication Models.
- Memory Hierarchy.
- Cache memory management issues, including data consistency management.
- Task Scheduling and Load Balancing.
- Debugging Parallel and HPC Programs.
- Cross-cutting topics
- Performance Metrics.
- Application Management.
- Benchmarking Issues.

**Current Status**

- HPC System is present and operational.
- Few members are fully trained.
- Application potentials not exploited.
- Flagship projects, collaborations and Industrial applications not taken off yet.
- Regular and formal HPC training available only in University of Botswana, Gaborone.


**Botswana HPC System**

- Elements of HPC infused in some advanced courses

**Capacity Partners**

Our capacity development partners include: TACC, Software Carpentry, SADC, International Centre for Theoretical Physics, H3 Africa, Centre for High Performance Computing and CODATA.

**Conclusions**

- HPC Education very much needed in Botswana and in the SADC region.
- Application potentials are aplenty.
- Creation of core experts is very much required – some expertise already there.
- More formal education on HPC and formal training are required.
- Creation of Graduate Diploma in HPC may be worth considering.
- Managed to conduct one HPC Workshop for Botswana & Tanzania at CHPC
- Industrial involvement is not there!

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