



# Towards Enhancing Computational Capabilities in Africa: The University of Benin HPC Initiative.



A seminar presentation by:  
Babatunde J. Odetayo

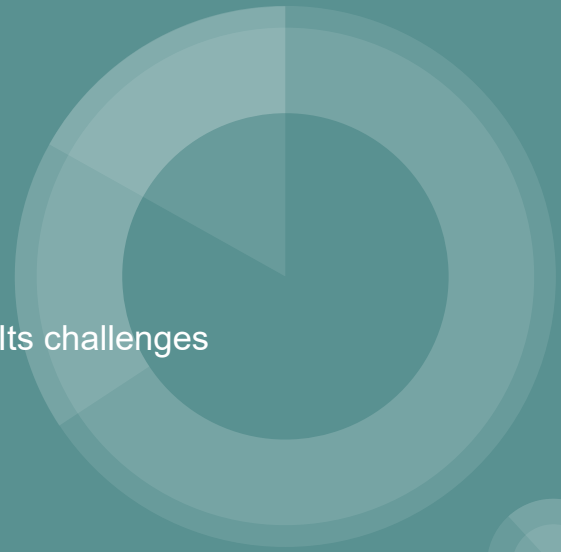
## A Personal Introduction:



- Msc in Computer Science from University of Benin, Nigeria
- Conducting my PhD research in Authentication model
- Has a working experience as a System Analyst and Lecturing in the last 10 years in the University.
- Major interest in Cybersecurity
- Joined CERN Collaboration June 2023.
- Working on the project : Development and Operation of CMS Online System Administration at CERN, Geneva.
- A Guide at CERN Science Gateway
- Facilitator of CERN/Uniben HPC initiatives

## Seminar Overview:

- The Background
- HPC and Its importance in modern research
- The Present state of Africa's computational capability and Its challenges
- The University of Benin's HPC initiative.
- The Recommendations.



# The Background

Findings from ASFAP & ACP2022 (Morocco) shows

- The region (Africa) faces a limited access to high-performance computing (HPC) resources.
- There is a lack of awareness regarding the important role of computing in various fields.
- This constraint significantly hampers the progress of scientific research and development across the region.
- Increasing computational resources is proposed to address the evolving demands of science and technology.
- Expanding HPC infrastructure will also strengthen the region's potential for scientific breakthroughs and innovation.



# High-Performance Computing (HPC)

**Mode:** ability to process data and perform complex calculations at high speeds.

**Concept:** divide a job into pieces that can be run on separate computers/cores and then the output is combined to form the solution.



HPC Cluster



Parallel Data Processing

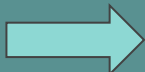
## Attributes:

- Consists of thousands of interconnected processors working together.
- Parallel processing techniques
- Perform quadrillions of calculations per second
- used in industries where rapid data analysis, modeling, and simulations are crucial for decision-making and innovation.

# Computing Evolution (CERN)

## Time to process 1 year of LHC Data

- 1st Gen.
- IBM 7099 series
- ~1960
- 13.2 billion years



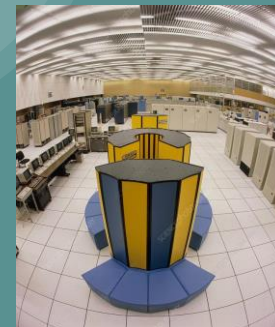
- 2nd Gen.
- CDC 7600 series
- ~1970
- 65 million years



- 4th Gen.
- HP-SHIFT
- ~1995
- 11,000 years



- 3rd Gen.
- CRAY X-MP/48
- ~1985
- 3.2 million years



- 5th Gen.
- IBM 1401
- ~2005
- 35 years



Future LHC Computing

## Common HPC in Africa (Top500)

- Centre for High Performance Computing (CHPC), in Cape Town, South Africa. It uses Lengau Cluster.
- University Mohammed VI Polytechnic (UM6P) Morocco: Home to the (ASCC), houses the Toubkal supercomputer.
- These are used to handle complex simulation and data-intensive tasks.
- Support a wide range of scientific and engineering applications, including climate modeling, materials science, and drug discovery.



## African HPC capabilities in world ranking

- The fastest supercomputer in Africa is Toubkal (UM6P - ASCC). It occupies 246th position in Top500 supercomputers in the world, Nov. 2023, 277th June 2024.
- Lengau in South Africa had its position in Top500 last in 2019.
- HPC in Egypt had its position in Top500 last in 2008.

A **supercomputer** has a high level of performance

- Processing Speed
- Number of jobs that can run concurrently
- Numbers of cores
- Capacity of the RAM
- measured in (FLOPS) instead of (MIPS)





# Top500 Supercomputers' ranking (June. 2024)

Rank	Name	No of Cores (CPU + GPU)	Rmax (PFlop/s)	Country
1	Frontier	8,699,904	1,206.00	USA
4	Fugaku	7,630,848	442.01	Japan
5	LUMI	2,752,704	379.70	Finland
6	Alps	1,305,600	270.00	Switzerland
...	...	...	...	...
277	Toubkal	~ 69,000	3.16	Morocco
...	...	...	...	...
500	HSUper	41,832	2.13	Germany



- FLOPS: a measure of a computer's ability to perform complex mathematical calculations involving decimal numbers with high precision. 1 petaflop = 1 quadrillion ( $10^{15}$ ) floating-point operations per second (flop/s).

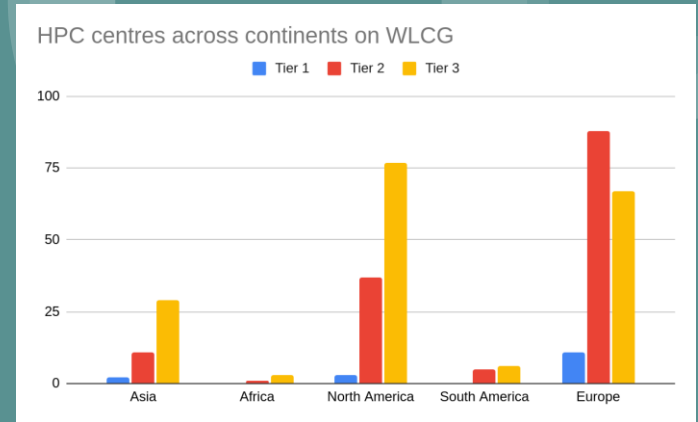
# Why HPC is important for Africa?

- plays a key role in driving quality research, innovation, education and economic growth.
- Aid to address our peculiar challenges in the region.
  - **Agriculture:** HPC allows for more precise, efficient, and sustainable agricultural practices, leading to better yields, reduced costs, and environmental conservation.
  - **Healthcare:** speed up the process of drug discovery, personalised medicine and disease modelling.
  - **Climate change:** aids to improve climate modelling and prediction. Renewable energy research etc



## Key Challenges to Maximizing HPC Potential in Africa

- Lack of authentic commitment from African governments toward advancing scientific and technological innovation.
- Significant costs associated with acquiring, operating, and maintaining HPC systems.
- Insufficient number of skilled computational scientists and engineers to support and drive HPC initiatives.
- Restricted access to high-quality data, limiting the effectiveness and application of HPC systems.



# The University of Benin's HPC Initiative.



- Joined CERN/CMS Collaboration in August 2022.
- had five students sent to CERN for summer students programme performed different projects in physics, mechanical and computer science fields
  - Finite Element Analysis: Modeling the removal platform for CMS cavern
  - Modification of the New Vacuum Tank Cage
  - Unified Unified Web-Page Management, Static Code Analysis and Deployment with GitLab-CI for the CMS Tier-0 Project
  - Investigation on the Structural Dynamics of the Decay Vessel For the SHiP Experiment
- Nigeria/CMS Virtual visit was held in October 2023. It includes participants from Ghana and Kenya.
- Technical collaboration with CERN commenced mid last year with Uniben PhD student on ground at CERN working on a project:
  - Development and operation of Online CMS System Administration.
  - This triggered the commencement of UNiben-Cern HPC Initiative.
  - HPC4N (Apparent Name)



# What is the HPC4N project?

High Performance Computing for Nigeria

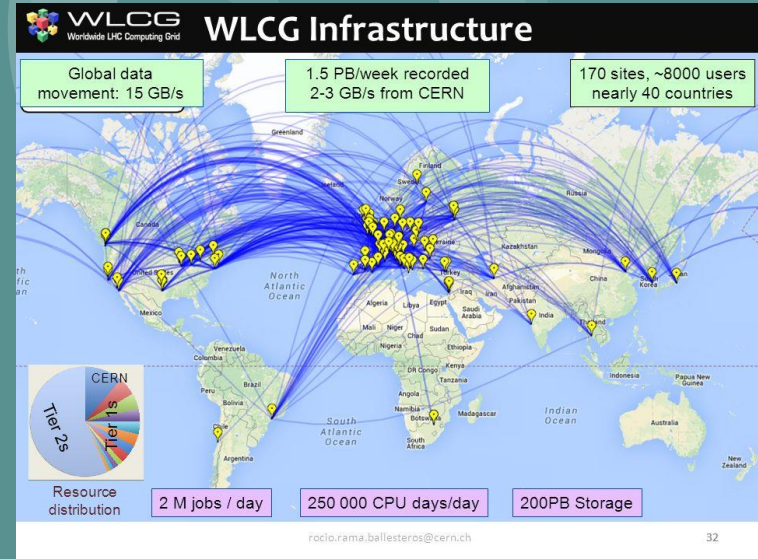
- What is the goal of HPC4N?
  - Enhance the computational capacity of Nigeria and Africa as whole by setting up an HPC dedicated to peaceful research
- What are Uniben & Partners' roles been?
  - Housing infrastructure
  - Power and Cooling systems
  - Safety systems
  - Good Bandwidth for data transfer rate
  - Other auxiliary networking devices
  - staffing
- What are CERN/CMS roles been?
  - Set up the project structure and governance
  - Donate repurpose servers
  - Train Nigerian experts at CERN.
  - May aid in setting up a dedicated fundraiser.
- What are the expected outcomes?
  - Become CMS Computing centre (20% capacity)
  - Provide free computing power to universities (80% capacity)



# Objectives of HPC4N project

High Performance Computing for Nigeria

- Objectives in Nigeria
  - Boost Computational infrastructure in Nigeria
  - Build up the research capabilities for the Nigerian university to retain talented students.
  - Enhance state-of-the-art technology transfer between CERN, its partners and Nigeria
  - Drives economic growth
- Objectives in Africa
  - Enhance the overall computing capacity of the region
  - Boost scientific collaboration and participation.
  - Drives economic growth and development in the region
- Objective in CERN
  - Expand CERN computing physic data analysis capabilities (WLCG).



# Expected Impacts of HPC4N project

High Performance Computing for Nigeria

## Computations on HPC4N

Different types of simulations and complex calculations will be running at high-speed on the HPC resources

## Science Discoveries

Through the utilization of the HPC4N facility, science discoveries will occur at a faster rate and bring Nigeria closer to other developed countries with regards to the tech-gap

## Boost R&D

The most common users of HPC resources are academic institutions, scientific researchers, and engineers who face certain technology limitation challenges.

## Students Internship

Unique opportunities are provided for university students to attain hands-on experience and technical expertise while they maintain the operation of the HPC4N. Retain our experts.



# Overall Benefits of HPC4N Project

High Performance Computing for Nigeria

Allow researchers, faculty and students to conduct world-class computational research in the form of various numerical modeling, simulation and numerical analysis in the following areas:

- Prototype climate modeling
- Global sea level forecasting
- Computational Neuroscience
- Genomics and System Biology
- Public Health Research and Diabetes Research
- Environmental monitoring
- The Data Center and Cloud Computing research
- Biology, Chemistry, Engineering, Physics and Psychology.
- Social sciences.



Enhance the conduct of Quality researches to meet peculiar needs of the region as highlighted in the SD goals:

- Agriculture
- Healthcare
- Climate Change



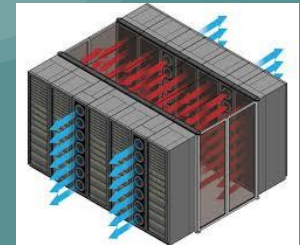


# The Needs and The Challenges of HPC4N Project

High Performance Computing for Nigeria

The project is at the infant stage and its success factors depend on:

- Funds availability (Overhead cost: ~ \$400k - \$500k)  
Setting up the centre with State-of-the-art equipment.
  - Uninterruptible Power System & Backup.
  - Cooling System
  - Safety System
  - Auxiliary Networking systems
- Good Data Transfer Rate (up to 10G)
- Full participation of Public and Private parastatals for sustainability.



# Recommendations on Enhancing HPC in Africa

High Performance Computing for Nigeria

1. Instead of providing financial aid or loans to African states, developed countries should directly invest in sustainable projects, such as the establishment of HPC (High-Performance Computing) centers within the region.
2. Greater and more meaningful collaboration from the region is essential for sustainable development in science and technology, as seen in global examples like CERN.



## References

- "TOP500 Supercomputer Sites". 13 November 2023. Archived from the original on 13 November 2023. Retrieved 28 January 2024. <https://www.top500.org>
- "TOP500 List - November 2023". November 2023. Archived from the original on 1 March 2024. Retrieved 24 April 2024. <https://www.top500.org>
- African Connect3. MARWAN: boosting connectivity in Morocco <https://africaconnect3.net/marwan-boosting-connectivity-in-morocco/>
- The African Strategy of Fundamental and Applied Physics. Report of the 2020–2024 Community Study on the Future of Fundamental and Applied Physics in Africa <https://www.overleaf.com/project/641cb576cbc10c4f851986ad>
- The Worldwide LHC Computing Grid (WLCG). <https://home.cern/science/computing/grid>

## Special Thanks

- VC, University of Benin, Prof. Lilian Imuetinyan, Prof. Musibau Bamikole, Martin Gastal, Emilo Meshi, Marc Dobson, CMS DAQ Team & CMS DAQSysAdmin.
- The African friends at CERN... Abdool, Chilufya, Diallo, Doomnull, Fatima, Hassnae, Mounia, Mohamed, Tyra, Salah-Eddine, Xola and the rest...
- Ketevi .. always smiling Boss, the organizers and all the participants of this seminar.



Thanks for listening



# Storage

