
# Next Generation I/O for the Exascale

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# I/O is the Exascale challenge

- Parallelism beyond 100 million threads demands a new approach to I/O
- Today's Petascale systems struggle with I/O
  - Inter-processor communication limits performance
  - Reading and writing data to parallel filesystems is a major bottleneck
- New technologies are needed
  - To improve inter-processor communication
  - To help us rethink data management and processing on capability systems

# Amdahl and the “well balanced” computer


- Any computer system’s performance is limited by its slowest component
- For example
  - Reading from disk is often the slowest operation
  - We can add more disks in parallel until the aggregate disk throughput just saturates the CPU
  - … but this isn’t how many modern systems are designed with on-node disks rare in large systems
- Amdahl tried to quantify the characteristics of a well balanced computer in three further laws

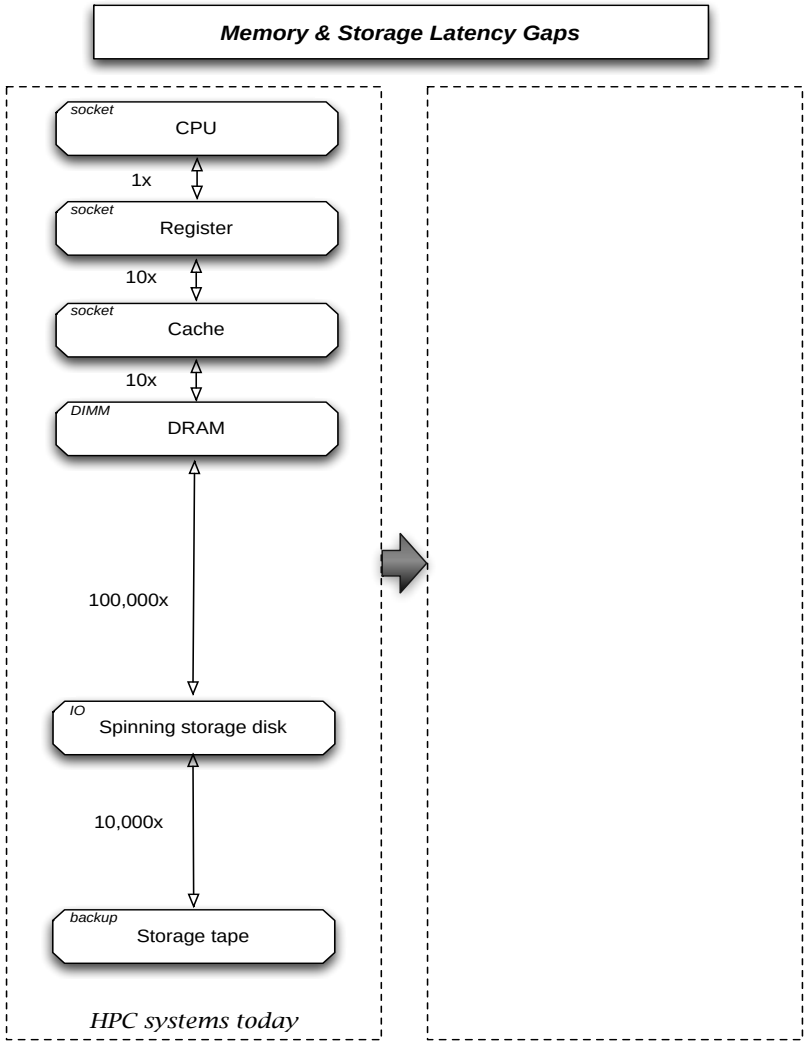
# Three laws of a well balanced computer

Amdahl himself called these 'observations'

- Law 1
  - One bit of sequential I/O per second per instruction per second
  - This is called the *Amdahl number*
- Law 2
  - Has a memory with a Mbyte / MIPS ratio close to 1
  - This is called the *Amdahl memory ratio*
- Law 3
  - Performs one I/O operation per 50,000 instructions
  - This is called the *Amdahl IOPS ratio*
- A well balanced system today has Laws 1 and 2 ≈ 1
- Today for most hard disk technology Law 3 ≈ 0.014
- Many HPC systems have Amdahl numbers ≈ $10^{-5}$

# A new hierarchy

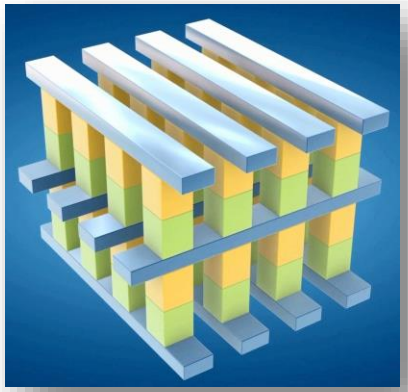
- Next generation NVRAM technologies will profoundly changing memory and storage hierarchies
- HPC systems and Data Intensive systems will merge - HPDA
- Profound changes are coming to ALL data centres
- … but in HPC we need to develop software – OS and application – to support their use



# Intel/Micron 3D XPoint Memory

## Features

- Transistorless
- Very fast compared to NAND flash
- Low power (no DRAM refresh)
- Non-volatile
- Very large
- … and close to the CPU



## NEXTGenIO objectives

- Develop new server architecture based on next gen Intel Xeon and 3D XPoint technologies
- Investigate how best to use it in HPC – develo; the software stack
- 3D XPoint is very versatile and will transform HPC

# NEXTGenIO project

## Project

- Research & Innovation Action
- 36 month duration
- €8.1 million
- Approx. 50% committed to hardware development
- Prototype system available from Month 27

## Partners

- EPCC
- INTEL
- FUJITSU
- BSC
- TUD
- ALLINEA
- ECMWF
- ARCTUR

# How will we use this?

- Main options
  - As memory – volatile or non-volatile
  - As a file system
  - As a combination of the above
- Different use models
  - Check pointing of applications
    - Resiliency
    - Power efficiency
  - High performance parallel data storage
    - During job execution
    - Within a workflow
  - Very large memory applications

# An example: ‘Hibernating’ an Exascale system


- A key Exascale challenge relates to electricity costs
- Early systems will require > 50Megawatts
- NV-DIMMs give us the opportunity to
  - ‘Barrier’ an entire system
  - Save all DRAM data to NV-DIMM
  - Power down during a peak period e.g. dinner time
  - Restart in a matter of seconds
- Easy to negotiate lower electricity pricing with this operational mode

# Final words

- NEXTGenIO will be the first project to develop solutions using the 3D XPoint technology
- Very exciting mix of hardware and software development
- Strong team of partners
- Making good progress
- First architectural designs completed
- This may be one of the most transformational projects any of us will ever work on