Scalable data-handling: Future perspectives for software and hardware

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ECMWF

ECMWF's HPC Targets

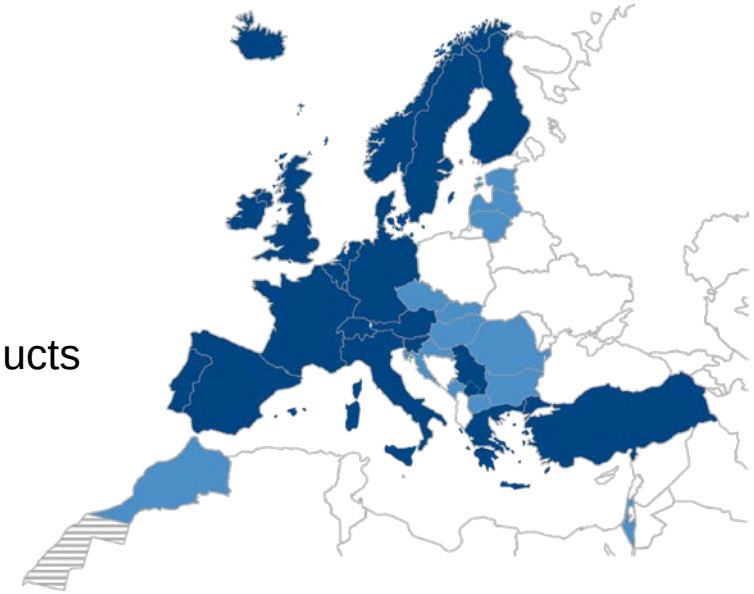
What do we do?

Operations – **Time Critical**

- Operational runs – 2 hours from satelite cut-off to deliver forecast products
- 10 day forecast twice per day, 00Z and 12Z
- Boundary Conditions 06Z and 18Z, monthly, seasonal, etc.

Research – **Non Time Critical**

- improving our models
- climate reanalysis, etc



HPC Facility Targets

- **Capability**, minimise the time to solution of Model runs
- **Capacity**, maximise the throughput of research jobs per day

Tension

Time Critical vs. **Non Time Critical**

Capacity vs. **Capability**

"A supercomputer is a device for turning ***compute-bound*** problems into ***I/O-bound*** problems."

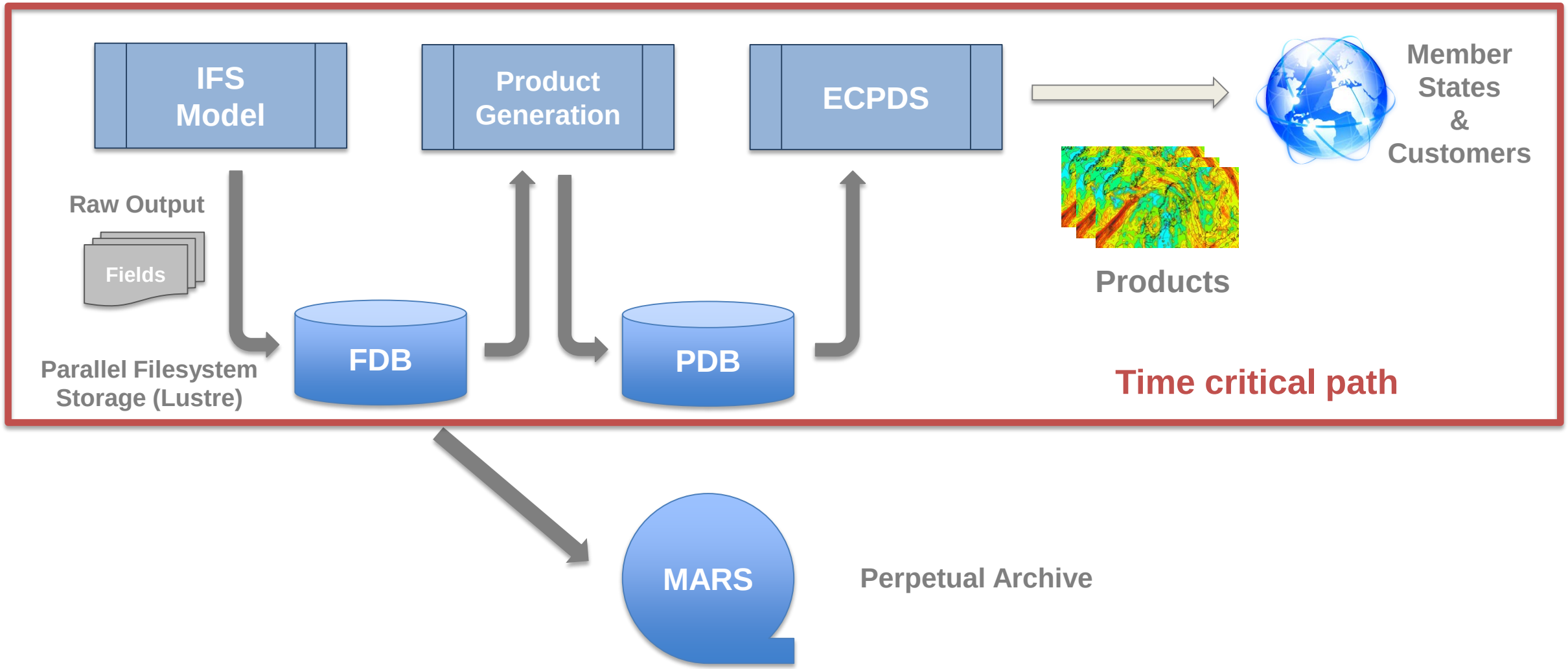
-- Kenneth E. Batcher, Prof. Emeritus, Kent State Univ.

IO Profile

- Daily IO profile includes peaks due to **time criticial** runs
- Peaks require an otherwise *oversized parallel storage* system
- **Objective**:
  - soften these peaks by optimizing application IO
  - co-design HPC system with vendors
  - maintain **capability** (reduce TCO)
  - increase **capacity** (more research runs)

Can we **reduce** the need for *oversized parallel storage* system?

ECMWF's Production Workflow



Estimated Growth in Model IO

2015

16km, 137 levels

Time critical

- 21 TB/day written
- 22 Million fields
- 85 Million products
- 11 TB/day send to customers

Non-time critical

- 100 TB/day archived
- 400 research experiments (tasks)
- 400,000 jobs / day

2020

Increase: 2 horizontal, 1 upper air

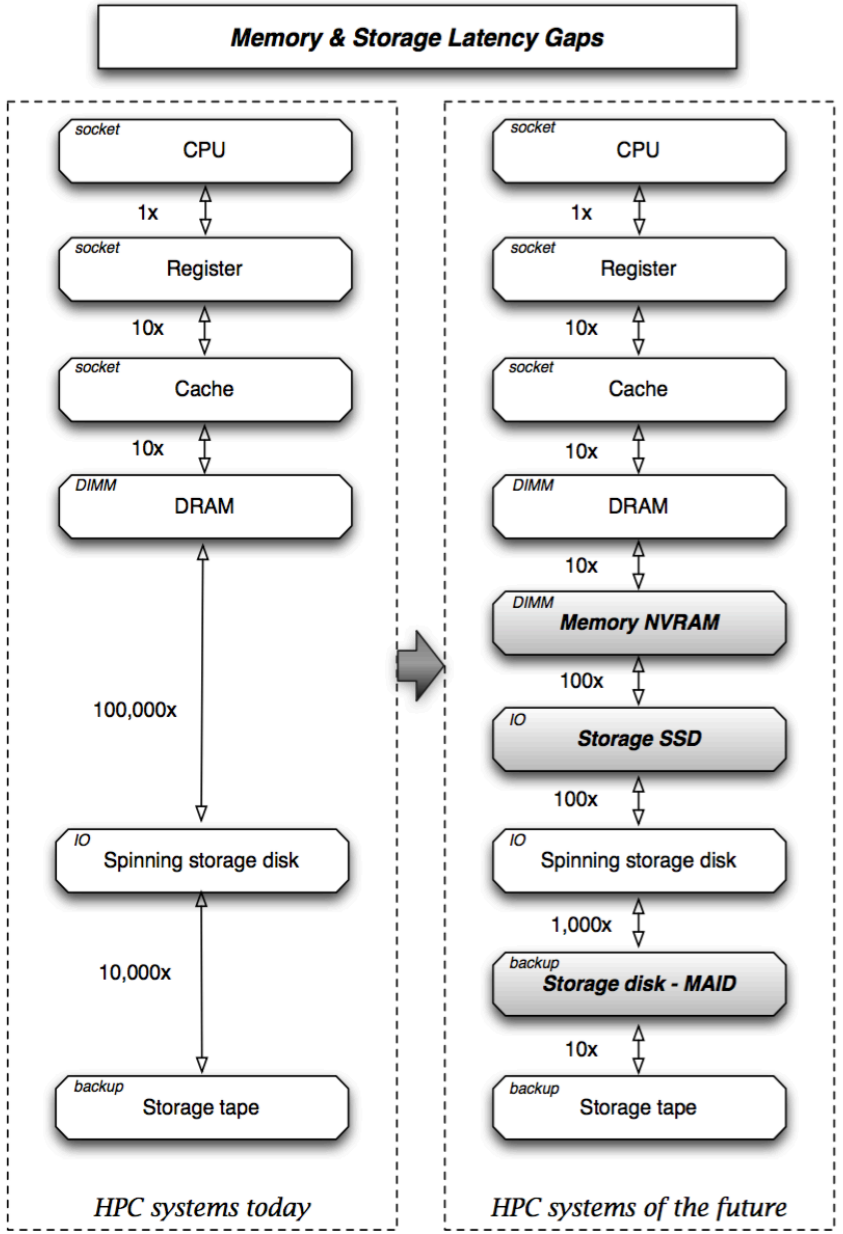
Time critical

- 128 TB/day written
- 90 Million fields
- (?) 450 Million products
- (?) 60 TB/day send to customers

Non-time critical

- 1 PB/day archived
- (?) 1000 research experiments (tasks)
- (?) 1,000,000 jobs / day

Feeling the Byte?



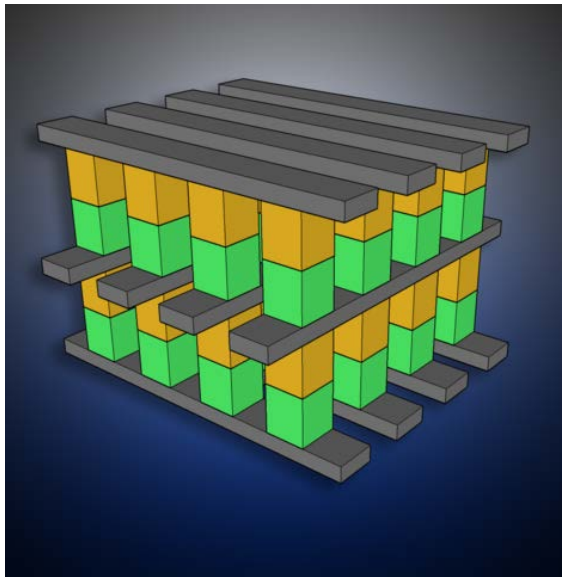
I/O Gap

NVRAM Intel 3D XPoint

Key characteristics:

- storage **density similar** to NAND flash memory
- **better durability**
- **speed and latency better** than NAND, though slower than DRAM
- priced between NAND and DRAM

Source: https://en.wikipedia.org/wiki/3D_XPoint



"3D XPoint" by Trolomite
Own work. Licensed under CC BY-SA 4.0

Challenges

- Likely **not on every node –** need **remote** access
- Different way to store data: **(Key , Value)**
- **Object store** (e.g. Intel DAOS)

I/O Paradigm Shift

How is ECMWF planning to use this technology?

- **large buffers** for **time critical** applications
  - similar to *burst buffers* but in application space
- **persistence** until archival, for **non time critical**
  - adding a new layer in the hierarchical storage system view

What is NextGenIO?

Integrated into ECMWF's Scalability Programme

Exploring new NVRAM technologies to minimise Exascale I/O bottlenecks

Partners

- EPCC (Proj. Leader)
- Intel
- Fujitsu
- T.U. Dresden
- Barcelona S.C.
- Allinea Software
- ARCTUR
- ECMWF

Project Aims

- Build an HPC prototype system with Intel 3D XPoint technology
- Develop tools and systemware to support application development
- Design scheduler startegies that take NVRAM into account
- Explore how to best use this technology in I/O servers

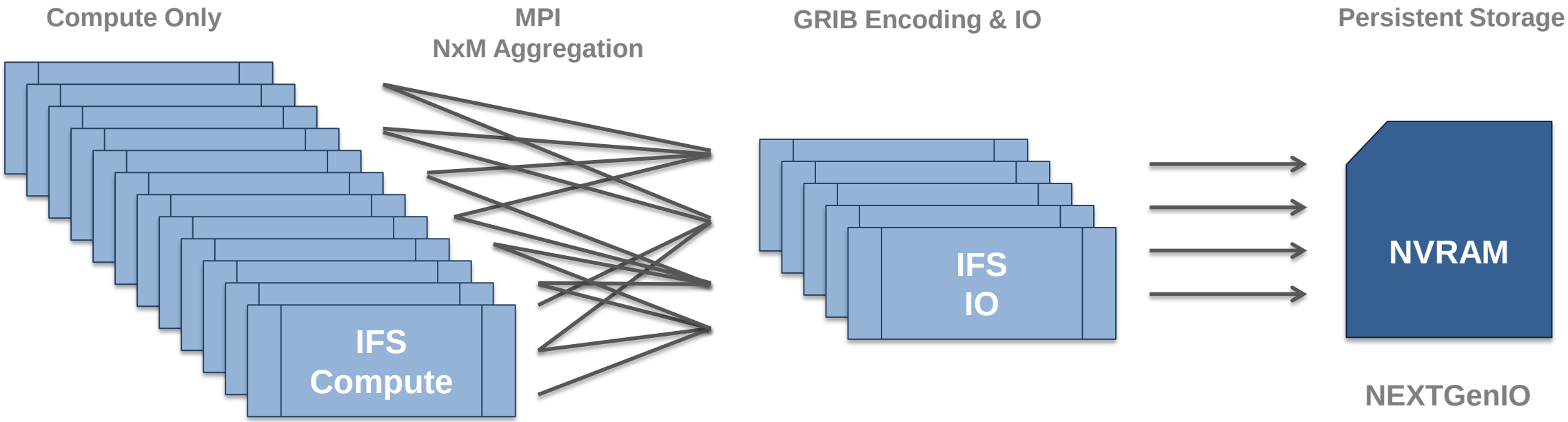
ECMWF Tasks

- Provide requirements and use cases
- Develop a I/O Workload Simulator
- Explore interation with I/O server layer in IFS
- Test and assess the system scalability

http://www.nextgenio.eu - EU funded H2020 project

IFS IO Server

- Based on MeteoFrance IO server for IFS
- Entered production in March 2016



What if some node fails?
Issues with **resilience** in **time critical path**

Summary

- Filesystem IO is a bottleneck to **time critical capability** computing
- Need to increase **capacity** with same **TCO** (run more experiments)
- **NVRAM** will bring a **Paradigm Shift** for I/O on HPC
- **NextGenIO** is a co-design project with Intel & Fujitsu
  - Adapting 3D Xpoint technology to HPC, in particular to NWP (IFS)
- Stream Model Output to Product Generation
  - **Minimize** filesystem IO in the **critical path**
  - **NVRAM** can be used as application controlled *burst buffers*

Message To Take Home

NVRAM will change the way we use and store data

What would you do differently,
if your disk access would be 10,000x faster?

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