



Storage evolution at CERN

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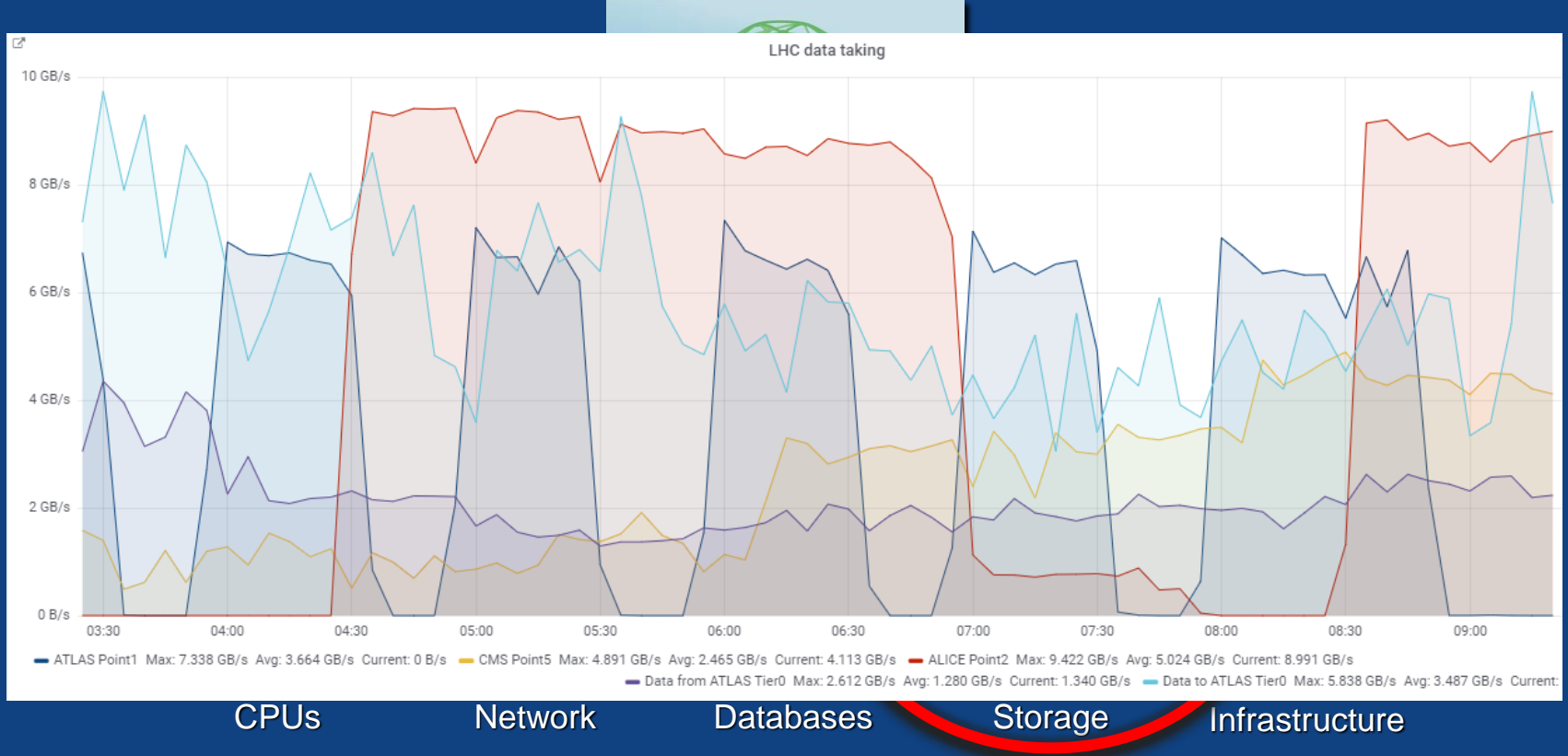


“Why” data management ?

- Data Management solves the following problems
 - Data reliability
 - Access control
 - Data distribution
 - Data archives, history, long term preservation
 - In general:
 - Empower the implementation of a workflow for data processing

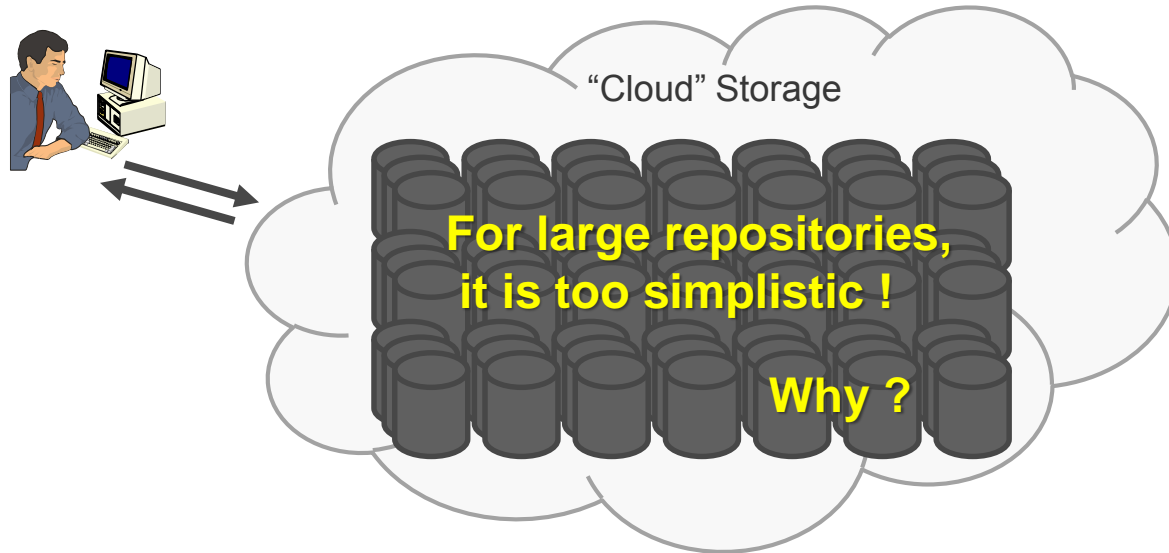
CERN Computing Infrastructure

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Can we make it simple ?

- A simple storage model: all data into the same container
 - Uniform, simple, **easy to manage**, **no need to move data**
 - Can provide sufficient level of performance and reliability

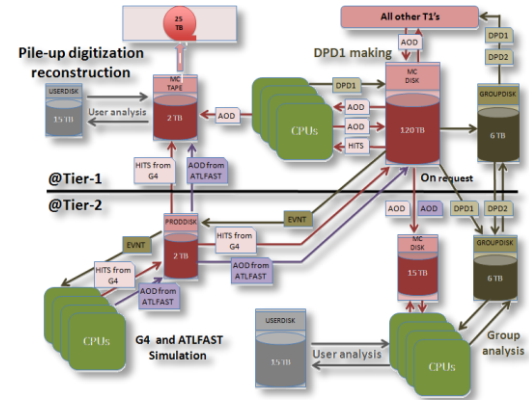
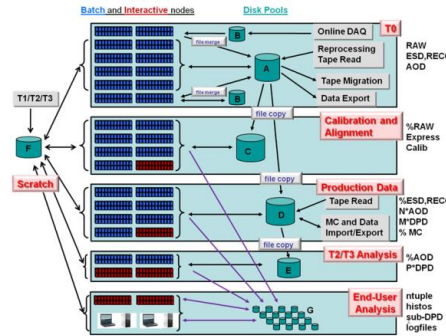
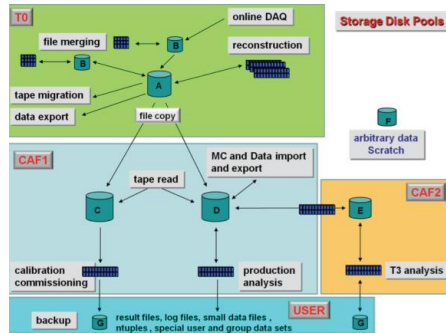


Why multiple pools and quality ?

- Derived data used for analysis and accessed by thousands of nodes
 - Need high performance, Low cost, **minimal reliability** (derived data can be recalculated)
- Raw data that need to be analyzed
 - Need high performance, High reliability, **can be expensive** (small sizes)
- Raw data that has been analyzed and archived
 - Must be low cost (huge volumes), High reliability (must be preserved), **performance not necessary**

So, ... what is data management ?

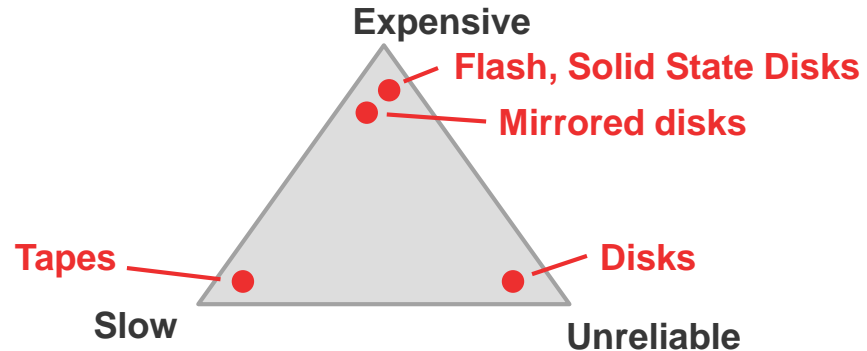
- Examples from LHC experiment data models



- Two building blocks to empower data processing
 - Data pools with different quality of services
 - Tools for data transfer between pools

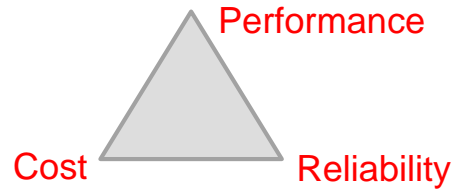
Data pools

- Different quality of services
 - Three parameters: (Performance, Reliability, Cost)
 - You can have two but not three

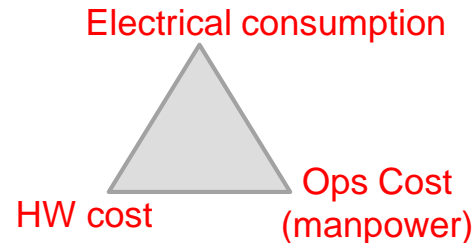
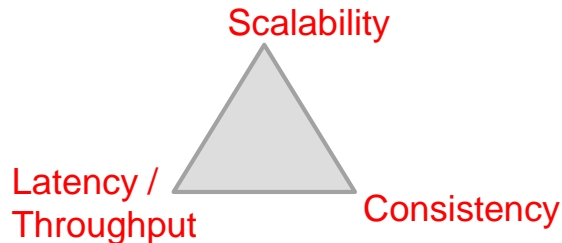


But the balance is not as simple

- Many ways to split (performance, reliability, cost)

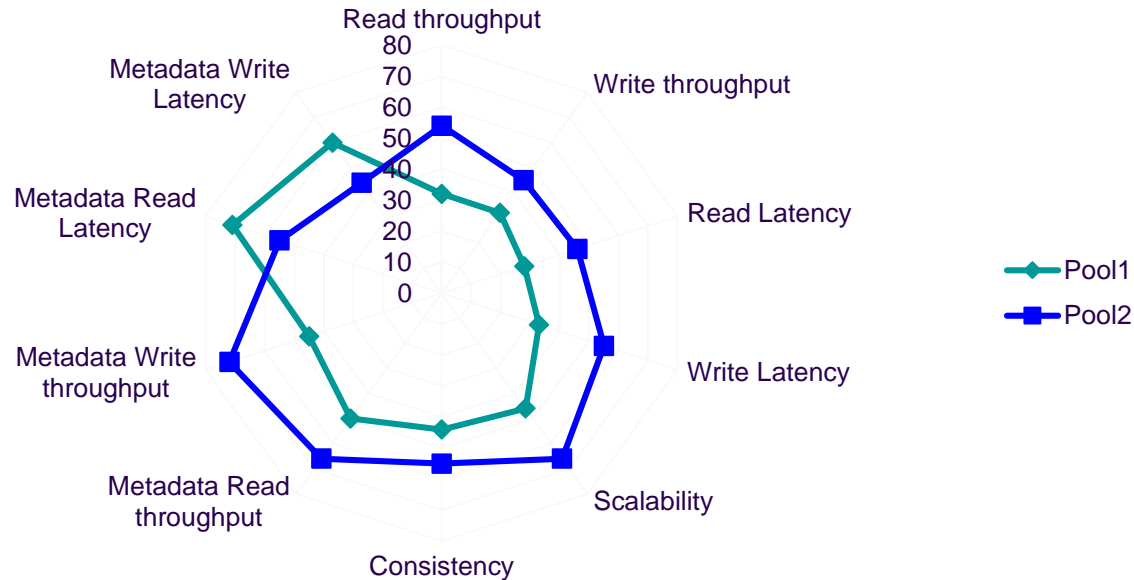


- Performance has many sub-parameters
- Cost has many sub-parameters
- Reliability has many sub-parameters



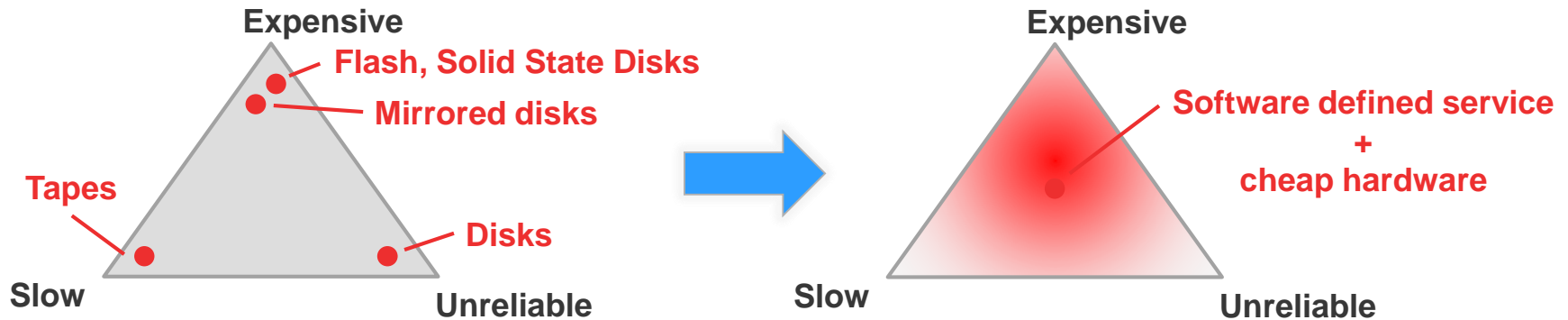
And reality is complicated

- Key requirements: Simple, Scalable, Consistent, Reliable, Available, Manageable, Flexible, Performing, Cheap, Secure.
- Aiming for “à la carte” services (storage pools) with on-demand “quality of service”



Where are we heading ?

- Software solutions + Cheap hardware



Present Strategy, Future Evolution

- Software
 - Software is the most strategic component
 - When you are 'big', using proprietary software is extremely risky
 - It is important that software has a fixed-cost only
- Hardware
 - If the "software" problem is correctly handled, the Hardware + Energy is where variable-costs are concentrated
- Manpower cost
 - Ensure that the 'marginal' cost is as small as possible, maximise automation
- With this approach ...
 - the cost of adding a PB of storage is limited to the cost of a PB of HW
 - the cost of operating an additional PB of storage is limited to the cost of the required energy and hardware amortisation

Software

- For the most strategic component, **shortcuts are possible** but risky
- Example of a heading-for-a-disaster strategy:
 1. Look for the best commercial software available ...
 2. Negotiate an outstanding discount, which includes unlimited usage for xx years ...
 - Easily done when you are a 'big' customer. You can even get it for free.
 3. Deploy rapidly, grow rapidly, ... for xx years.
 4. Pay back all your past savings (and more) at the end of the xx years when you will attempt to renegotiate the contract ...
- Does it make sense ? Yes, if you have implemented a clear and tested exit strategy from the beginning

Software strategy

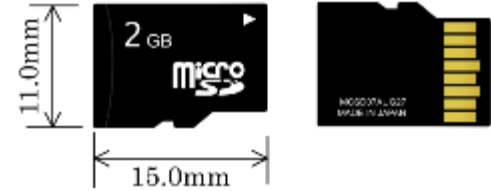
- Three safe scenarios for successful software strategy:
 - Use only commercial software that implements **well understood functionalities** on well **established standard interfaces**. There must be implementations from **multiple independent vendors** with **demonstrated interoperability**.
 - License cost should be fixed (volume and usage independent) and should not expire.
 - Must have the perpetual right to continue to use the 'old' software in case we would not need or accept or afford to buy renewed version of the software
 - Use Open Source software that has **no license cost associated**. Fund the necessary software development costs through **separated software maintenance or development contracts**.
 - Develop core software components ourselves. In open source.
- All three approaches are successfully being applied for the storage service strategy at CERN

Hardware

- In the year 2000, all CERN data (from the previous accelerator - LEP) were filling the datacentre (100 TB)
- Today, all this data can be stored in a drawer of my office
- Will I be able to store all current CERN data in my drawer in 10 years ?

Important digression

- a MicroSD card has a volume of $V_{SD} = 15 \times 11 \times 0.8 = 132 \text{ mm}^3$
 - Available with 512 GB or (soon) 1 TB size
- a 3.5" HDD is $V_{HDD} = 101 \times 146 \times 25.4 = 374'548.4 \text{ mm}^3$
- You can pack many microsd cards in the volume of one hard disk. What storage would you have ?
 - $V_{HDD} / V_{SD} = 2837$ cards. Capacity = 1.4 PB or (soon) 2.8 PB.
 - 100 PB would require 35 HDD, which fit in my drawer.
 - 100 PB can already fit my drawer **today** using microsd cards
- Will it be slow ? Unreliable ?
 - With striping and erasure encoding you can expect these new storage devices to be arbitrarily reliable (unbreakable) and arbitrarily fast: Always matching the performance of the external interface (Eg: SATA 6 GB/s)
- Media Cost ?
 - Today 250 - 350 K\$/PB using microsd. 20 - 30 K\$/PB using HDD. 5 - 10 K\$/PB using Tapes.
 - So the only question left is :
 - in 10 years, will flash memory match HDD cost ? Will it match tape cost ?
- Intrinsic advantage
 - No power consumption when idle
 - Significant higher performance and reliability



Strategy - Conclusion

- LHC next physics run is expected to deliver 10x today data rates and requires 10x data volumes.
- Must keep **fixed cost** for software.
 - No license cost proportional to data volumes, or number of nodes, or cores, or disk, or data transferred.
 - (this is why CERN has a Storage group)
- Maximise economy of scale on hardware
 - For storage, this means minimize the cost per PB
 - Many vendors are heavily investing in flash memory to deliver extremely fast storage product that outperform the existing ones at **higher cost (bad !)**
 - However, that there is a market for **low cost, high capacity**, flash storage
 - Reliability and performance can be obtained with software
 - Current strategy is to seek for the cheapest possible storage media.



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