POLITECNICO DI MILANO

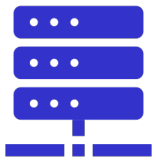
Computing Infrastructure





Storage

The topics of the course: what are we going to see today?



HW Infrastructures:

System-level: Computing Infrastructures and Data Center Architectures, Rack/Structure;

Node-level: Server (computation, HW accelerators), **Storage (Type, technology),** Networking (architecture and technology);

Building-level: Cooling systems, power supply, failure recovery

SW Infrastructures:

Virtualization: Process/System VM, Virtualization Mechanisms (Hypervisor, Para/Full virtualization)

Computing Architectures: Cloud Computing (types, characteristics), Edge/Fog Computing, X-as-a service

Methods:

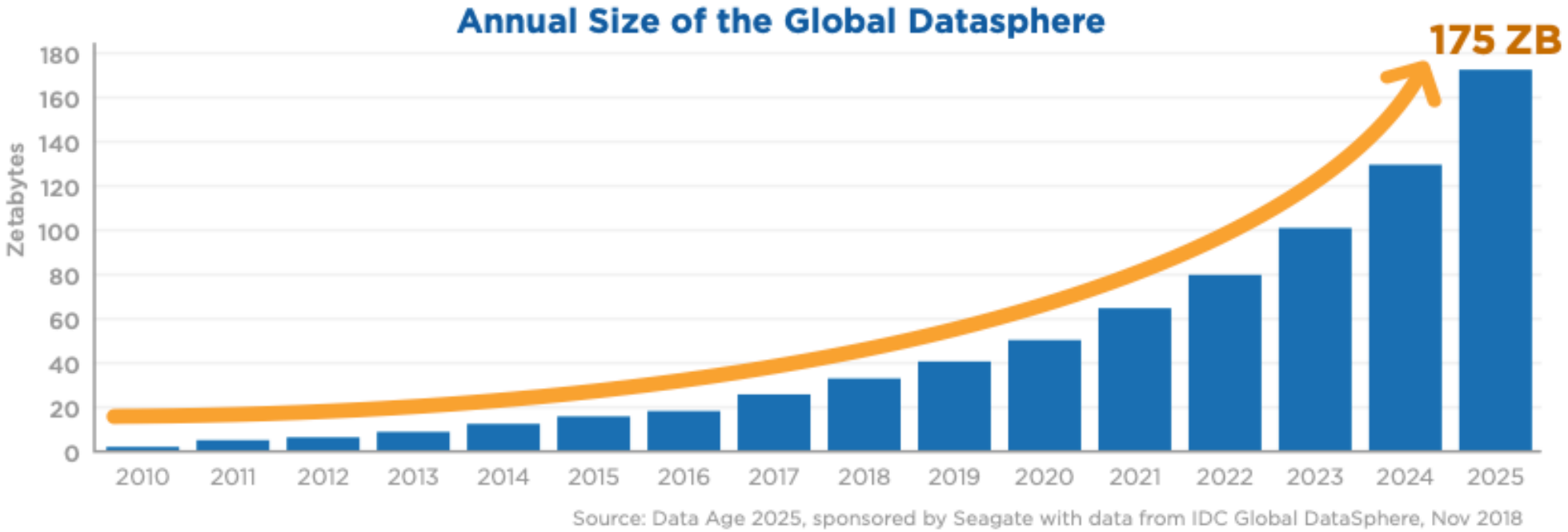
Reliability and availability of datacenters (definition, fundamental laws, RBDs)

Disk performance (Type, Performance, RAID)

Scalability and performance of datacenters (definitions, fundamental laws, queuing network theory)

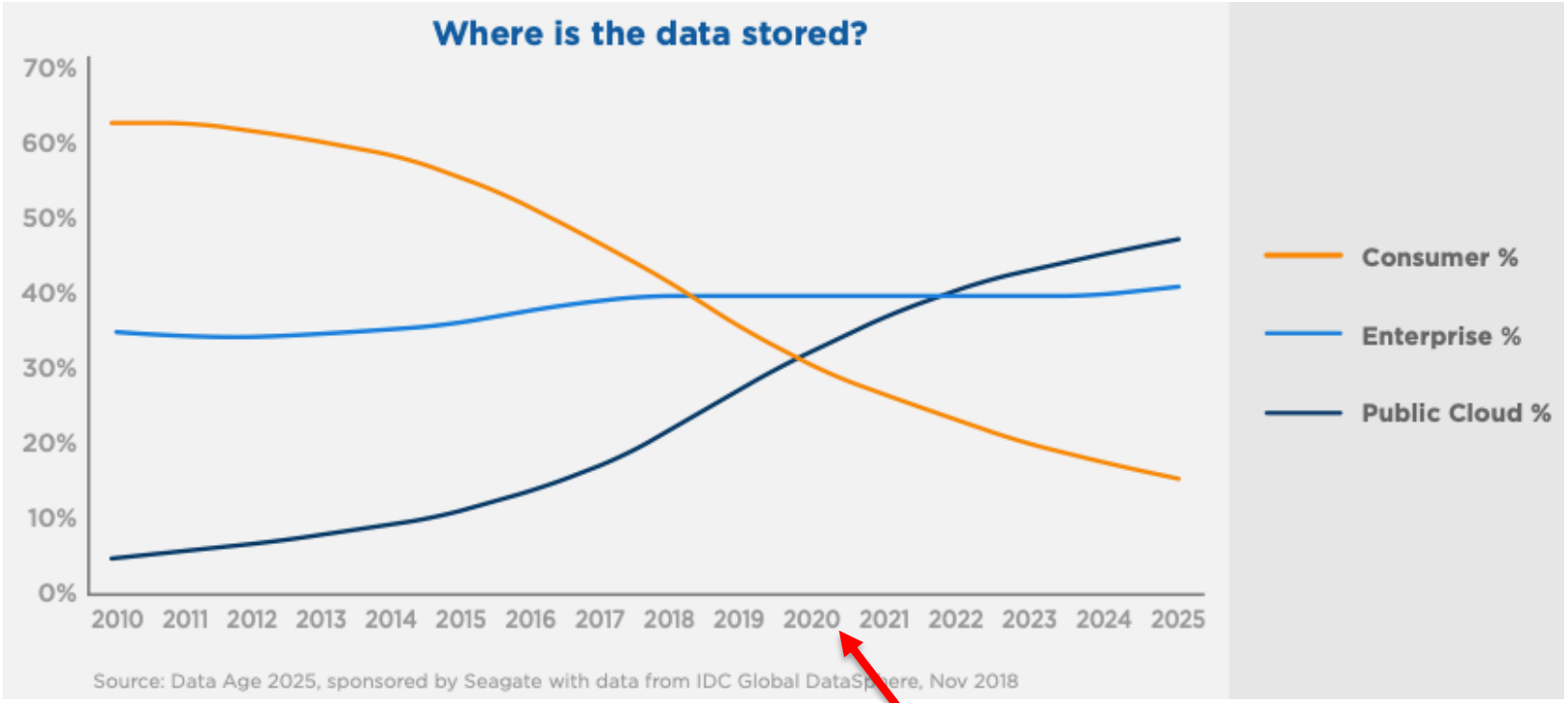
Some Trends…

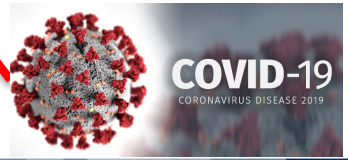
- Data-driven world
  - 80s-90s data was primarily generated by humans
  - Nowadays machines generate data at an unprecedented rate
    - Not only Media (image/video/audio/socialmedia) as big-data source
    - Sensors, surveillance cameras, digital medical imaging devices…
    - Industry4.0 and AI



Some More Trends…

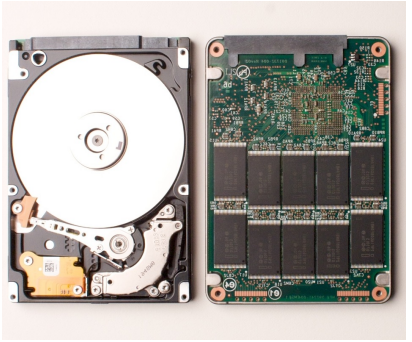
- The growt favors the centralized storage strategy
  - Limiting redundant data
  - Automatizing replication & backup
  - Reducing management costs

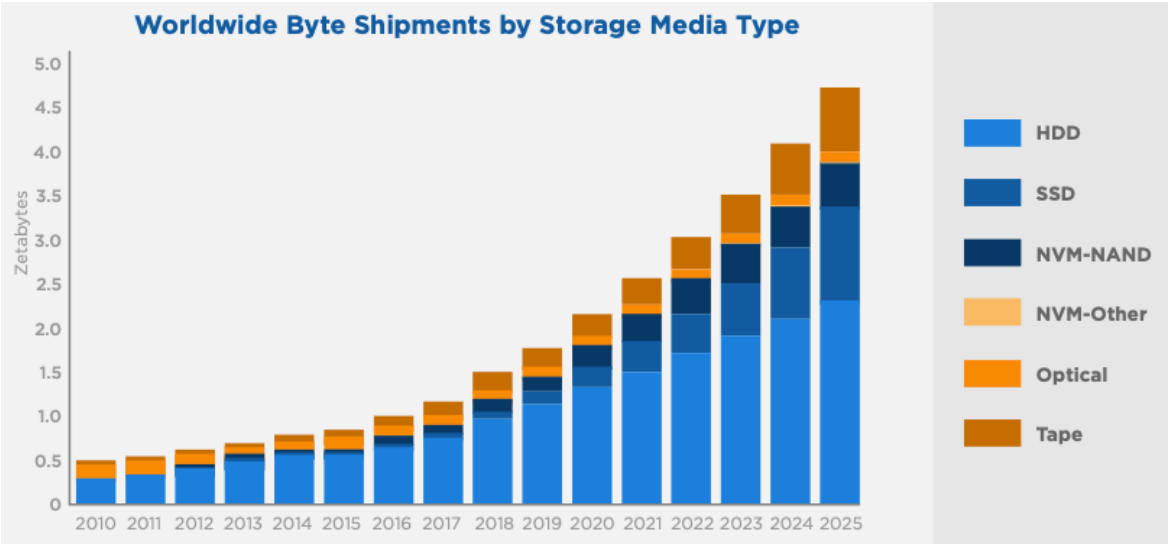




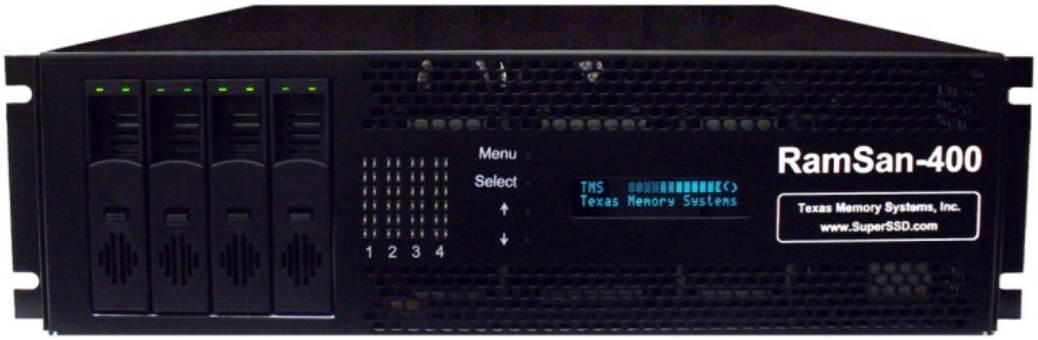
Storage Technologies

- Storage technology is dominated by HDDs
  - Magnetic disks with mechanical interactions
- «Recent» technology advancement brought SSDs
  - No mechanical or moving parts
  - Built out of transistors (NAND flash-based devices)
- NVMe - Non-Volatile Memory Express
  - Latest industry-standard to run PCIe SSDs
- Tapes … *will never die*





Hybrid solutions (HDD + SSD)



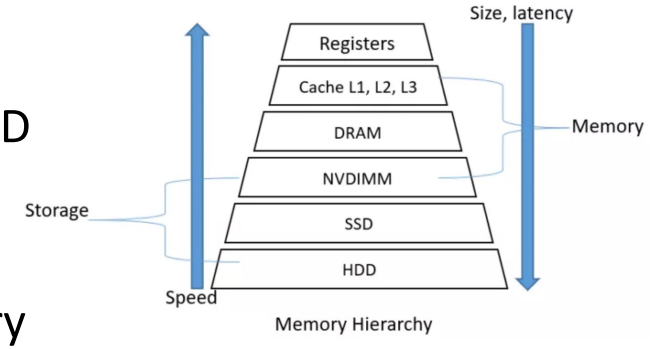
Some large storage servers use SSD as a cache for several HDD. Some mainboards of the latest generation have the same feature: the combine a small SSD with a large HDD to have a faster disk.

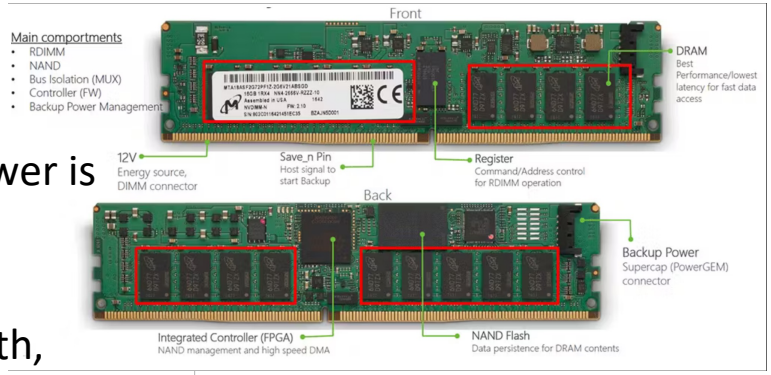
Some HDD manufacturers produce Solid State *Hybrid Disks* (SSHD) that combine a small SDD with a large HDD in a single unit.

Hybrid (MEMORY) solutions: NVDIMM

NVDIMM (Non-Volatile Dual In-line Memory Module)

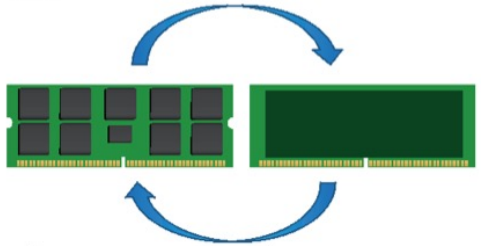
- Integrates DRAM with non-volatile memory, typically NAND flash, on a single module
- High performance while ensuring data persistence during power outages (onboard backup power source, e.g. battery or capacitor)
- Key features:
  - Data Persistence: NVDIMMs retain data even when power is lost, making them ideal for applications requiring high reliability and fast recovery times
  - Performance: They offer low latency and high bandwidth, similar to traditional DRAM, but with the added benefit of non-volatility
  - Byte-Addressable: NVDIMMs support direct CPU access, allowing for efficient data manipulation without needing traditional storage interfaces
  - Cost: more expensive than traditional DRAM due to the inclusion of non-volatile memory and backup power, but significant performance and reliability advantage





How It Works

If there is a power failure, the supercap module powers NVDIMM while it copies all data from the DDR-3 to on-module flash



When power is restored NVDIMM copies all data from flash to DDR-3 and normal operation resumes

Do you see anything strange here?