



3.1 Architecture and basics

Intro

Network Attached Storage (NAS)

FiberChannel SAN (FC-SAN)

Ethernet-based SAN (IP-SAN and FCoE-SAN)

3.2 RAID levels

RAID 0, RAID 1, RAID 5, RAID 6, RAID 10

3.3 Enterprise storage subsystems

Example Storage Appliance (NetApp)

Enterprise Storage Features

Software-Defined Storage (SDS)

NetApp Storage Systems

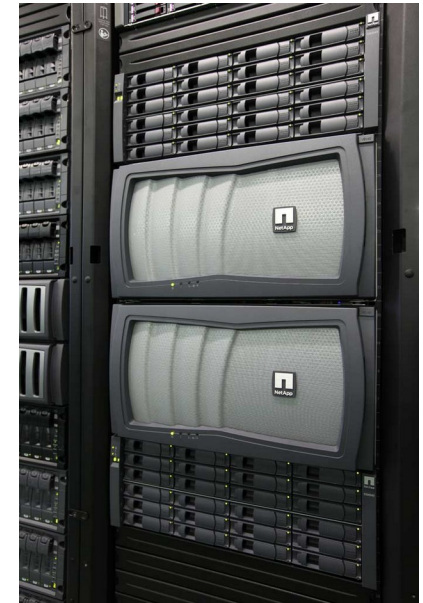
Hardware

- Multiple expansion drawers supported
- Hundreds of SATA/SAS/Flash drives
- Hundreds of TB up to PB raw capacity
- Up to 16/32x FC or FCoE ports
- Up to 8/16x Ethernet ports (10/25/100 Gbit/s)
- All components redundant and hot-swappable



Supported protocols

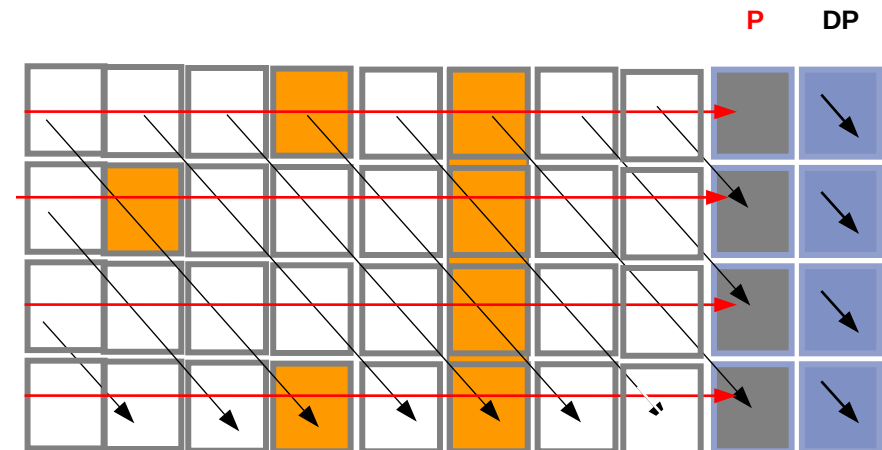
- NAS (CIFS and NFS), Object (S3)
- FC-SAN (FCP) and IP-SAN (iSCSI)

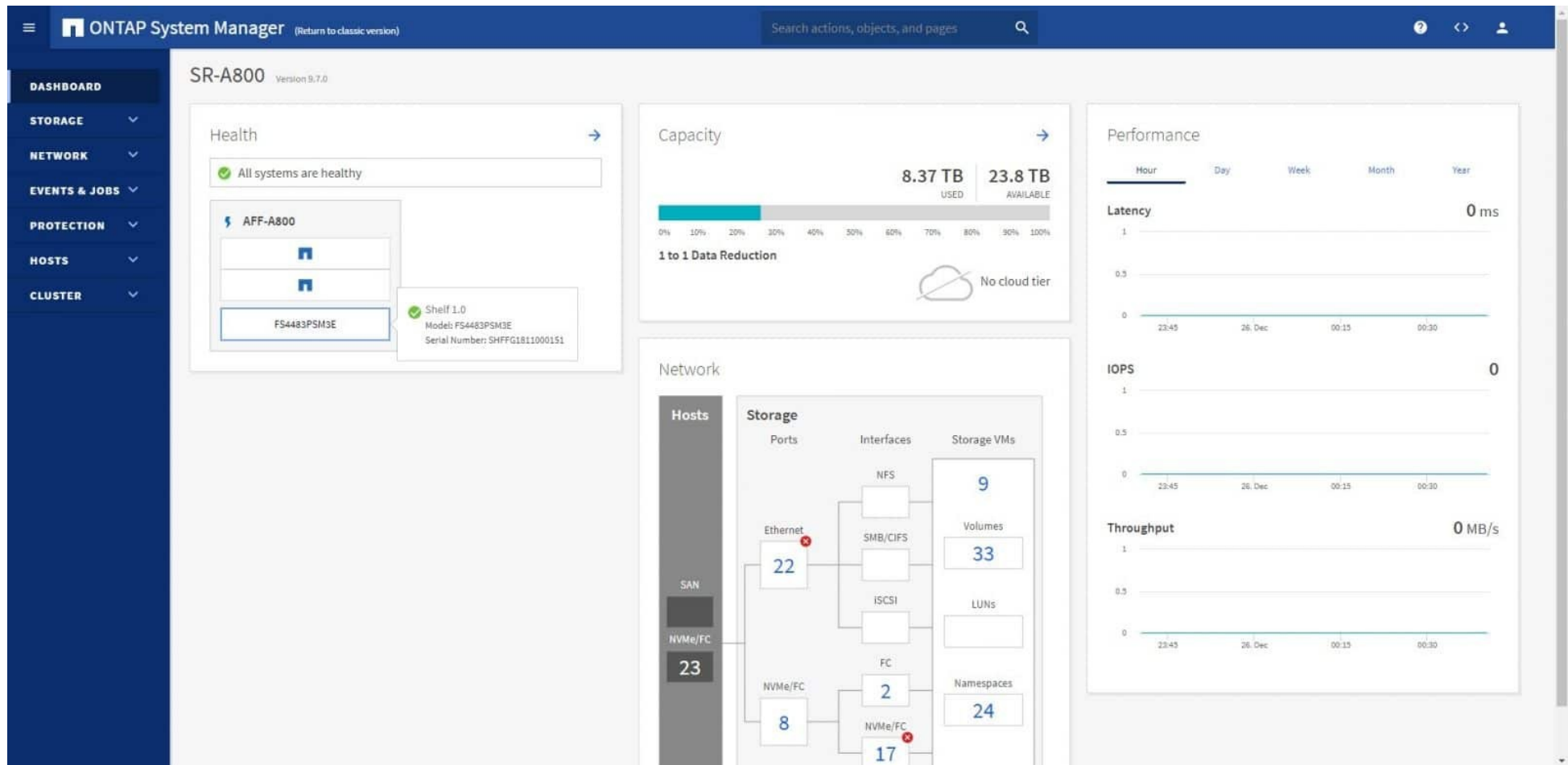


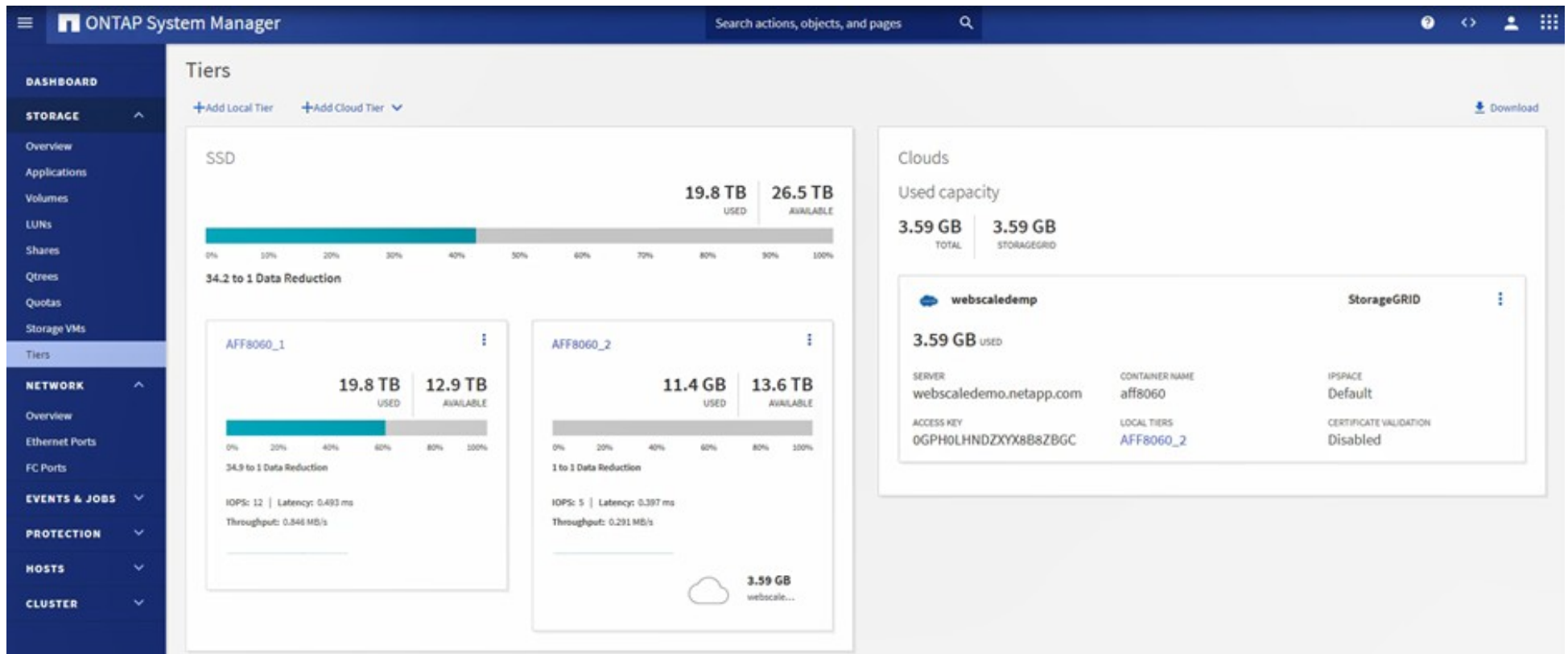
Operating systems

- NetApp: ONTAP
- RAID-DP (double parity, custom RAID 6)
- RAID-TEC (triple erasure coding)

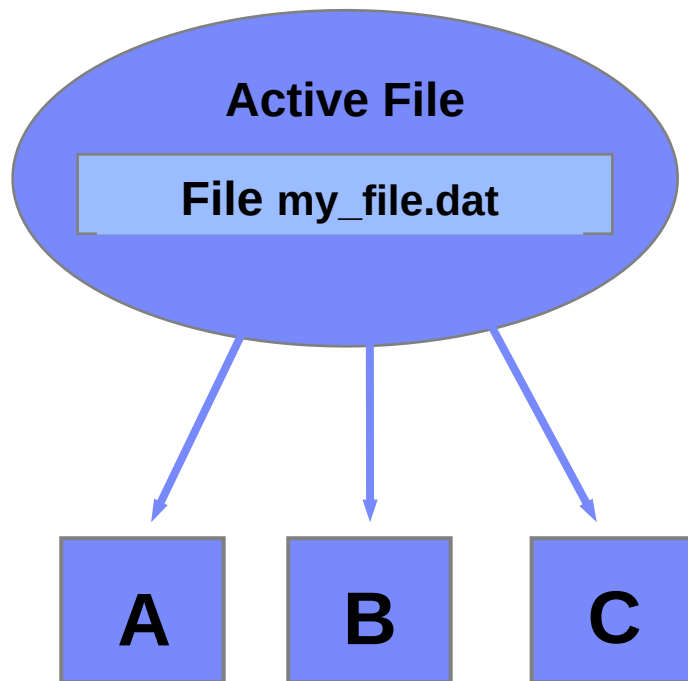
Thin provisioning	SnapMirror asynchronous replication
Compression	SyncMirror data protection
Compaction	Trusted Platform Module (TPM) support
Deduplication	MetroCluster IP
Snapshots	NVMe over FC Protocol
Encryption*	NVMe over TCP Protocol







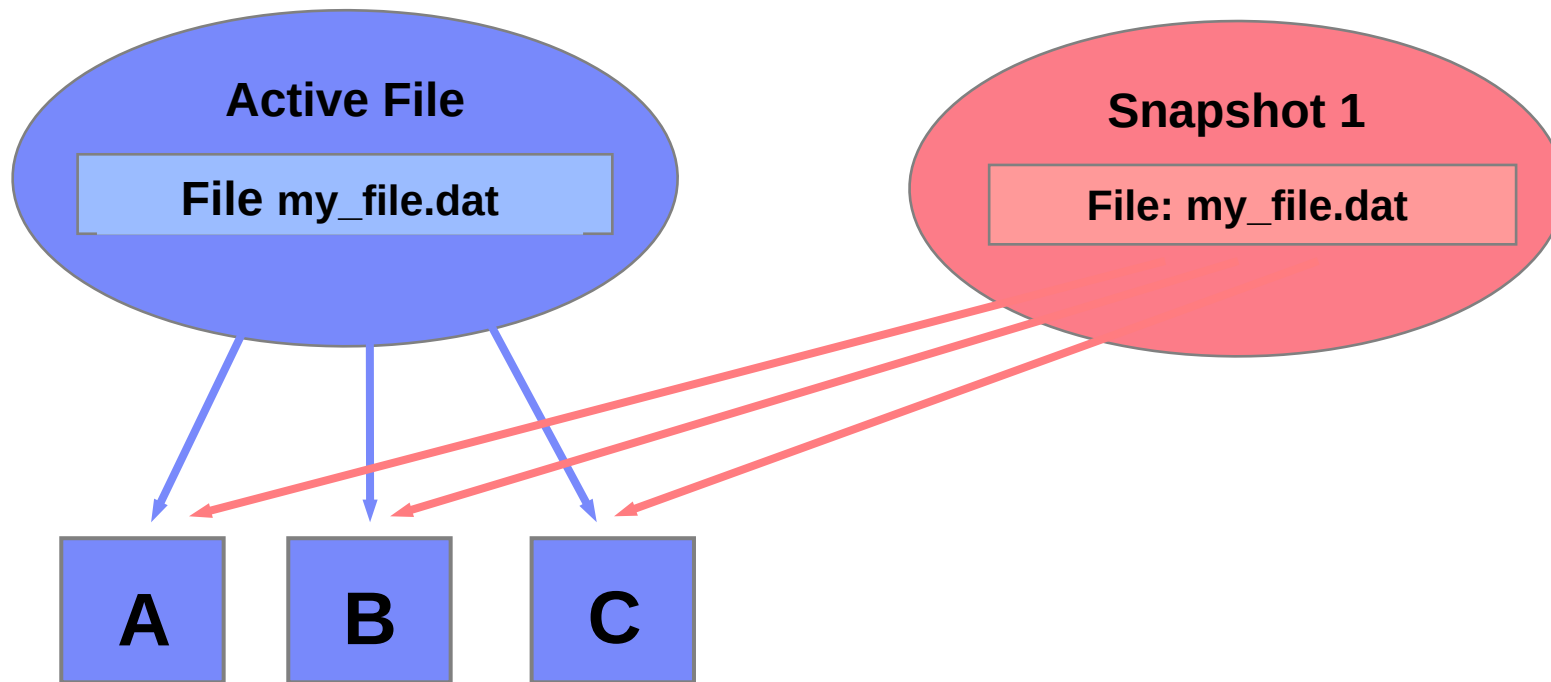
Example NetApp feature: backup with SnapShot (1)



■ Single file

- Physical blocks A, B and C comprise file my_file.dat

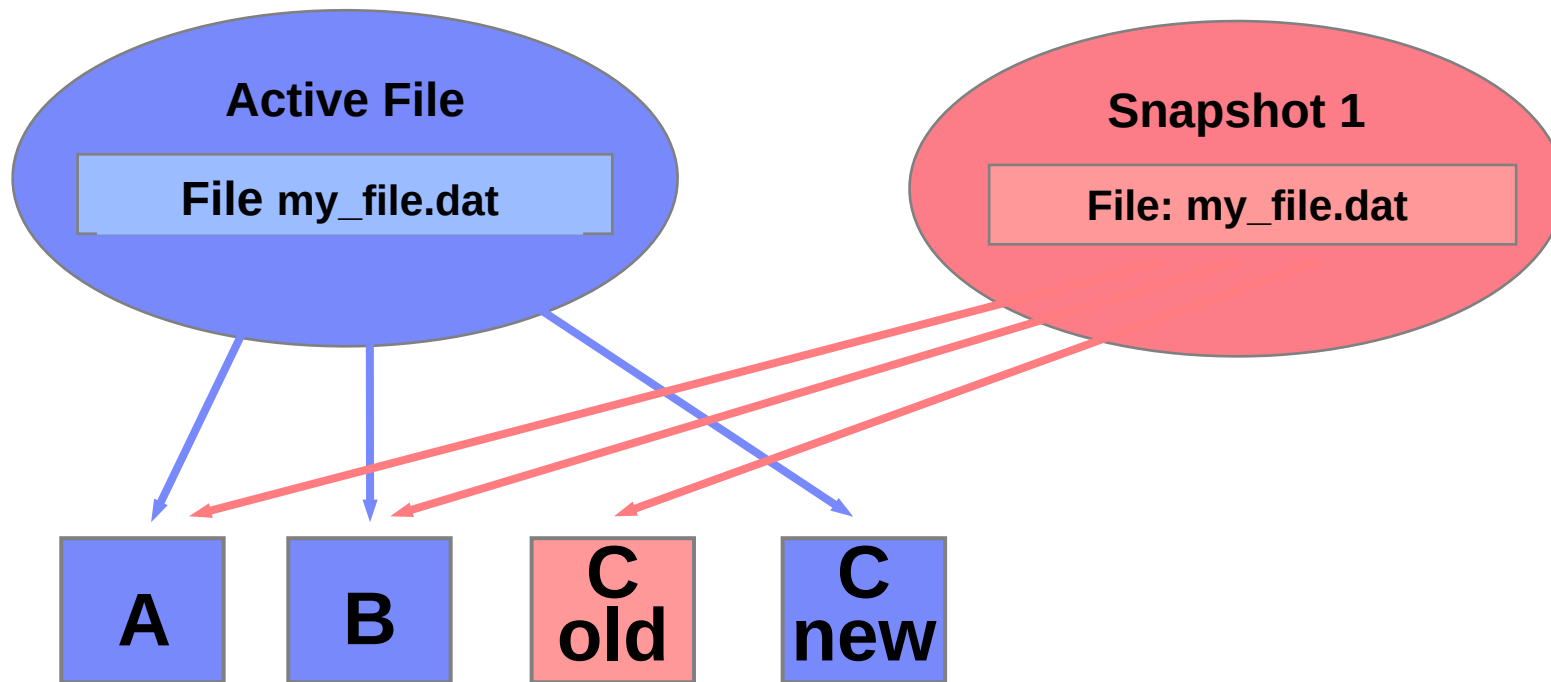
Example NetApp feature: backup with SnapShot (2)



■ First snapshot

- Comprised of physical blocks A, B und C
- Very fast creation time for a consistent copy (point-in-time copy)
- No physical copying of data blocks, only snapshot i-Nodes are created
- No additional disk storage required for data blocks, only small amount for metadata
- Snapshot can be immediately used for read-only operations (like backup)

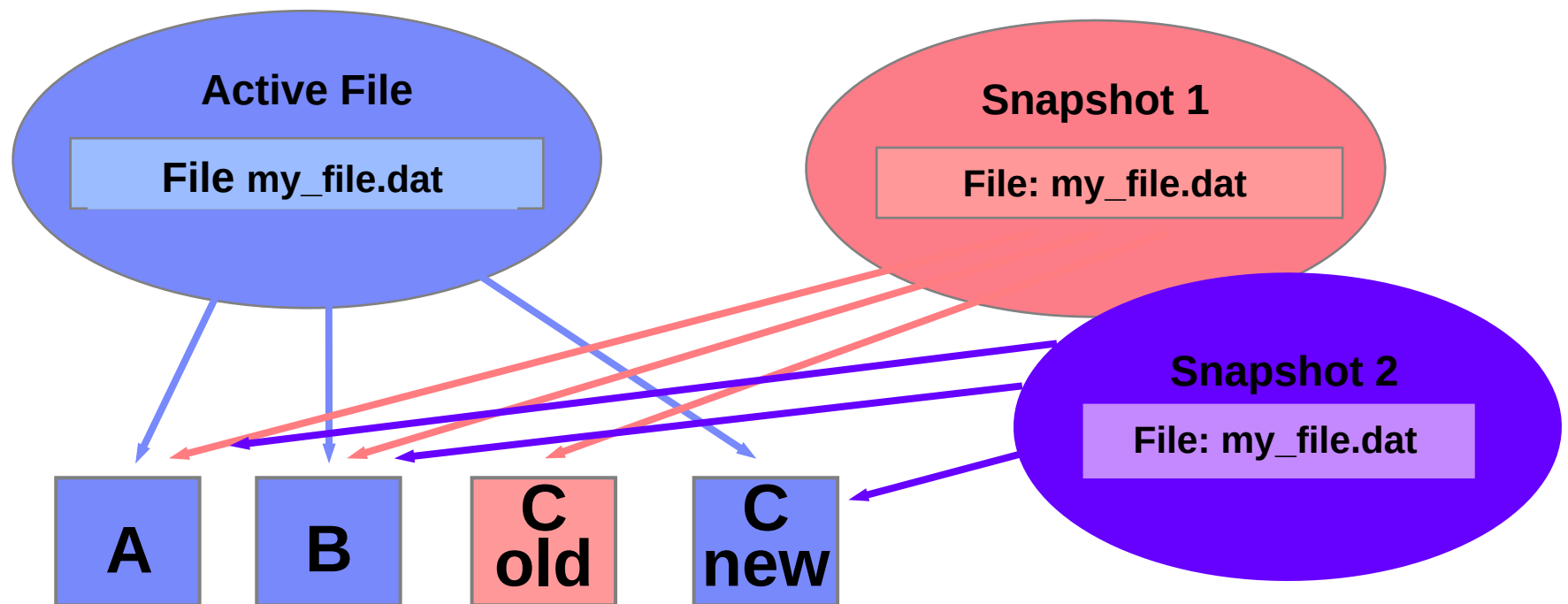
Example NetApp feature: backup with SnapShot (3)



■ Write operation to active file

- User modifies content of data block C
- New data block C created, original block C not modified
- Active file now: A, B and C new
- Snapshot 1: A, B and C old

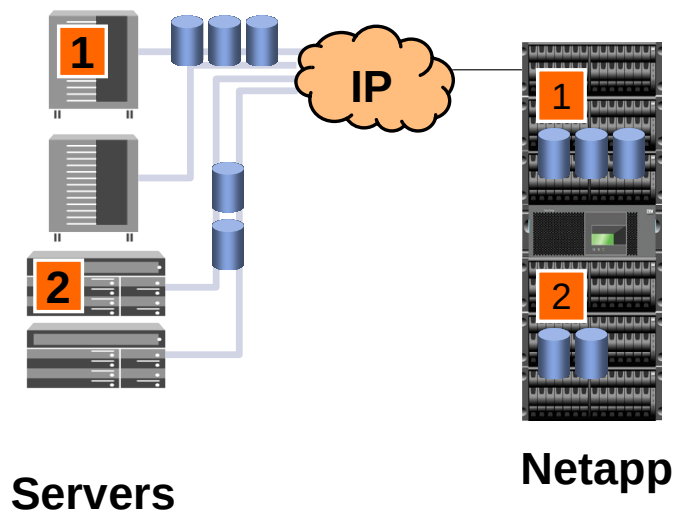
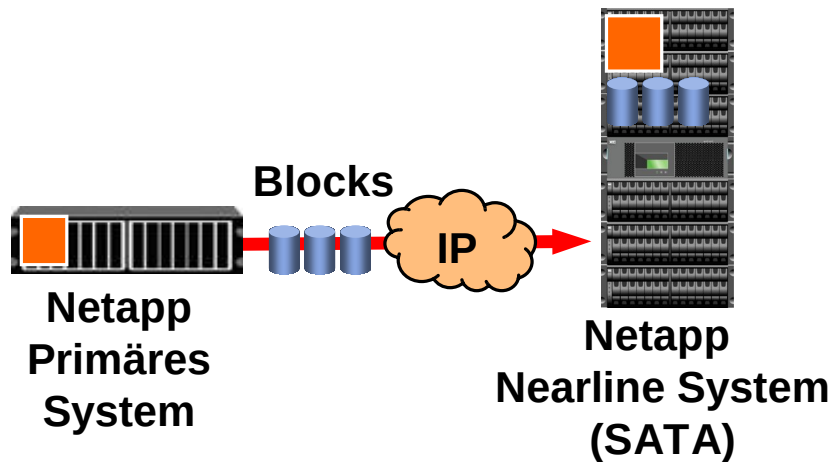
Example NetApp feature: backup with SnapShot (4)



■ Additional snapshots can be created

- Active file: A, B and C new
- Snapshot 1: A, B and C old
- Snapshot 2: A, B and C new

Example NetApp feature: SnapVault and Open Systems SnapVault



■ **SnapVault** is an online Disk-to-Disk backup and recovery solution:

- On a regular basis one Netapp transfers data snapshots to a backup Netapp system.

The backup Netapp can use cheap SATA disk drives with higher capacity.

No intervention from OS required.

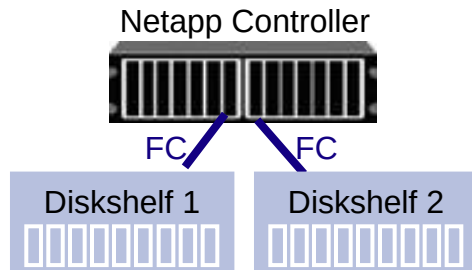
- Full volume copy of the primary NetApp system on initial backup, afterwards only changed blocks get transferred.

- WORM ready

■ **Open Systems SnapVault** software allows server to push their backups (file or block) onto NetApp systems and restore from there. This works also when using external SAN volumes as source.

- First backup is a full volume copy, after that only changed blocks get transferred.

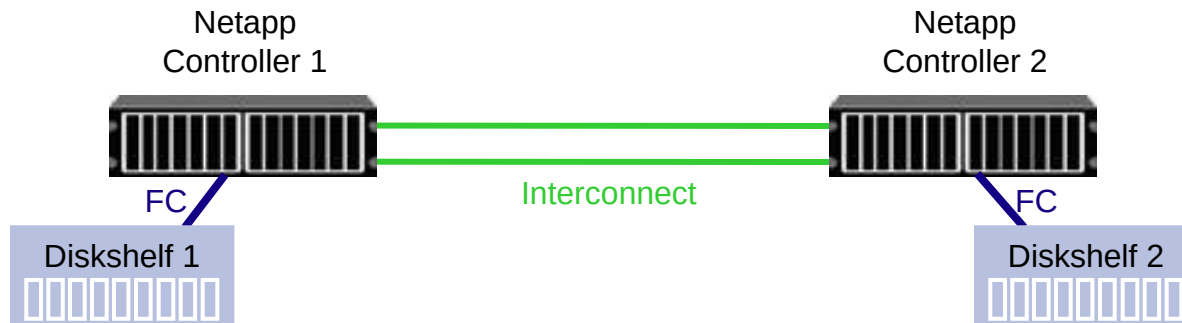
Example NetApp feature: SyncMirror



SyncMirror guarantees high availability:

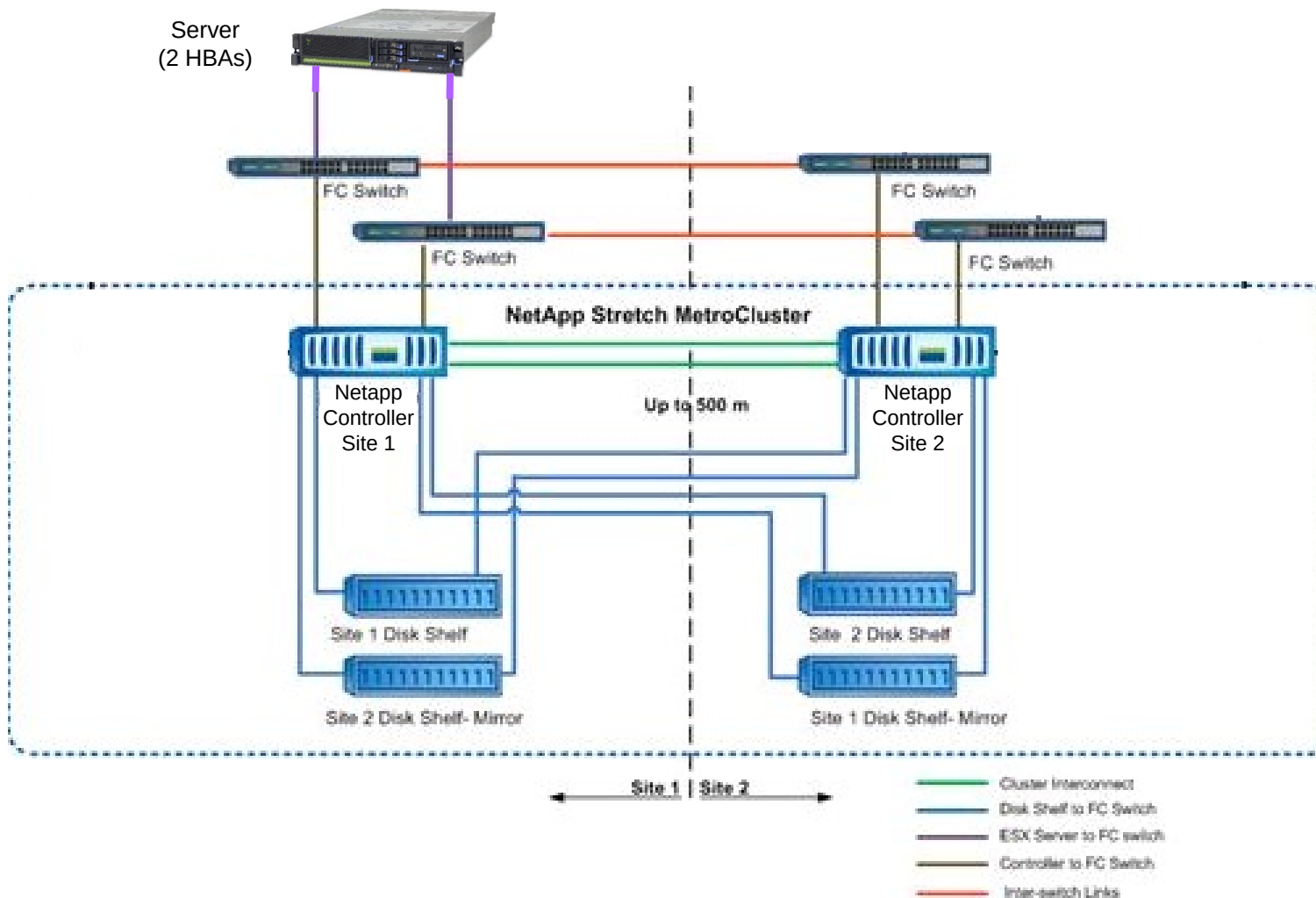
Synchronous mirroring across enclosures on one controller

Synchronous mirroring across enclosures on two different controller (very popular)



Example NetApp feature: Metrocluster

MetroCluster enhances SyncMirror to **synchronous mirroring** beyond a local data center (site 1 and site 2)



MetroCluster synchronously mirrors data in 2 sites:

- Compensates outage of one controller
- Compensates outage of one disk shelf

Features:

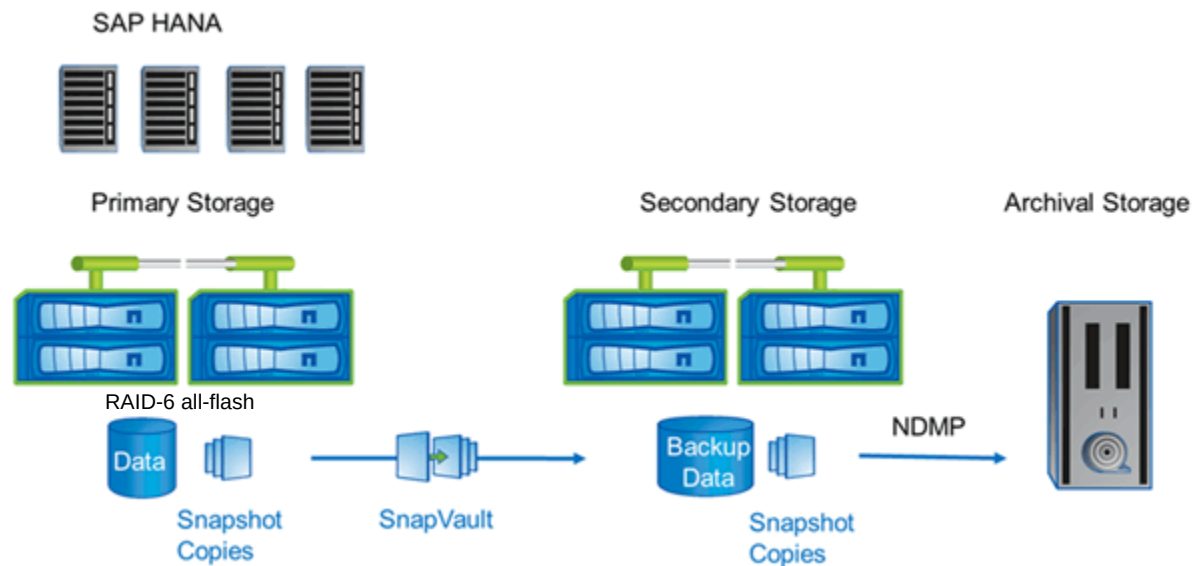
- Stretch Metro-Cluster**
up to 500m
- Fabric Metro-Cluster**
up to 100km

Example architectures for different use cases (1/2)

Example 1: critical company infrastructure, central SAP ERP database

Ultimate availability required, multiple layers of safety.

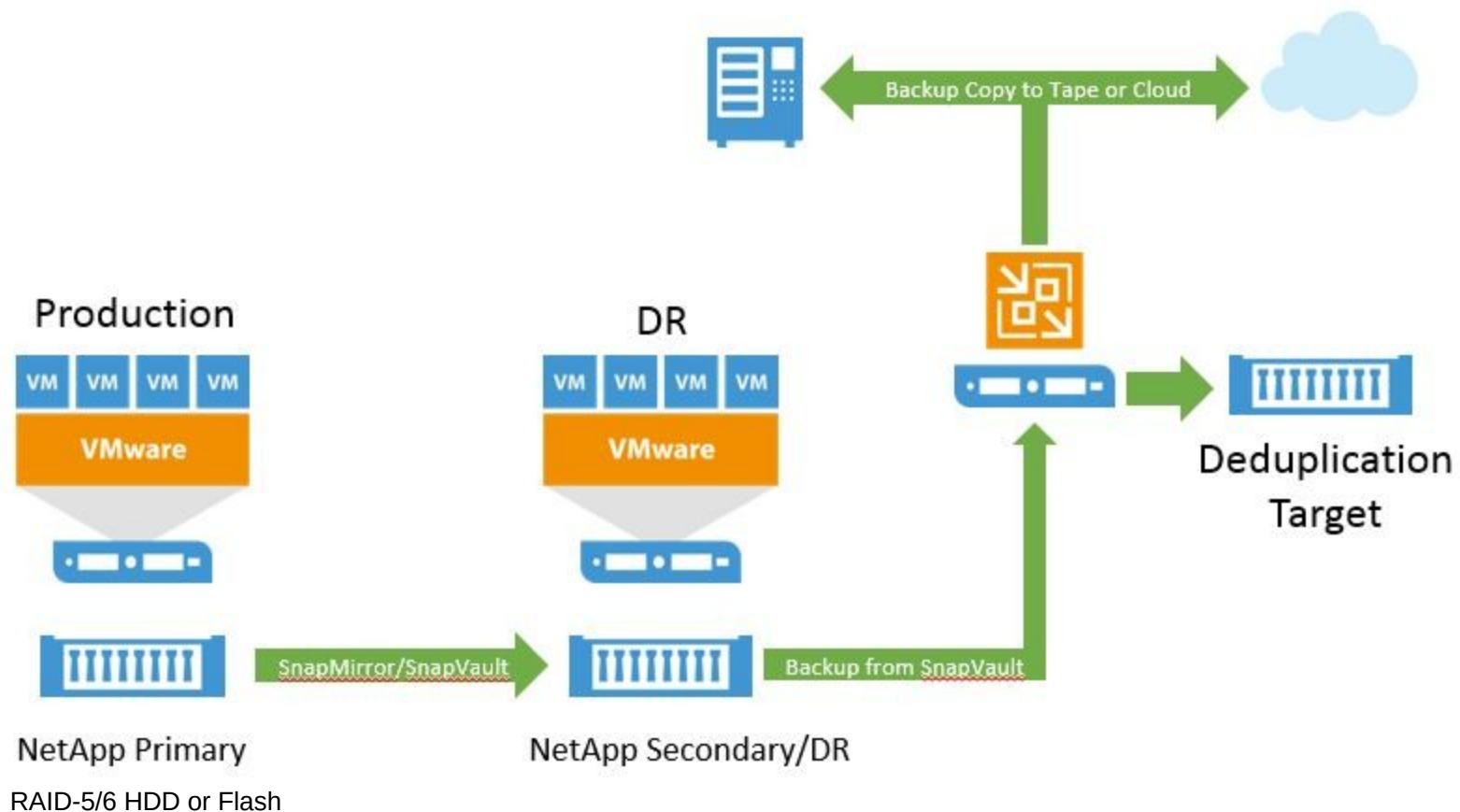
About 4x to 5x of actual storage capacity required to purchase.



Example architectures for different use cases (2/2)

Example 2: standard company applications, based on VMware

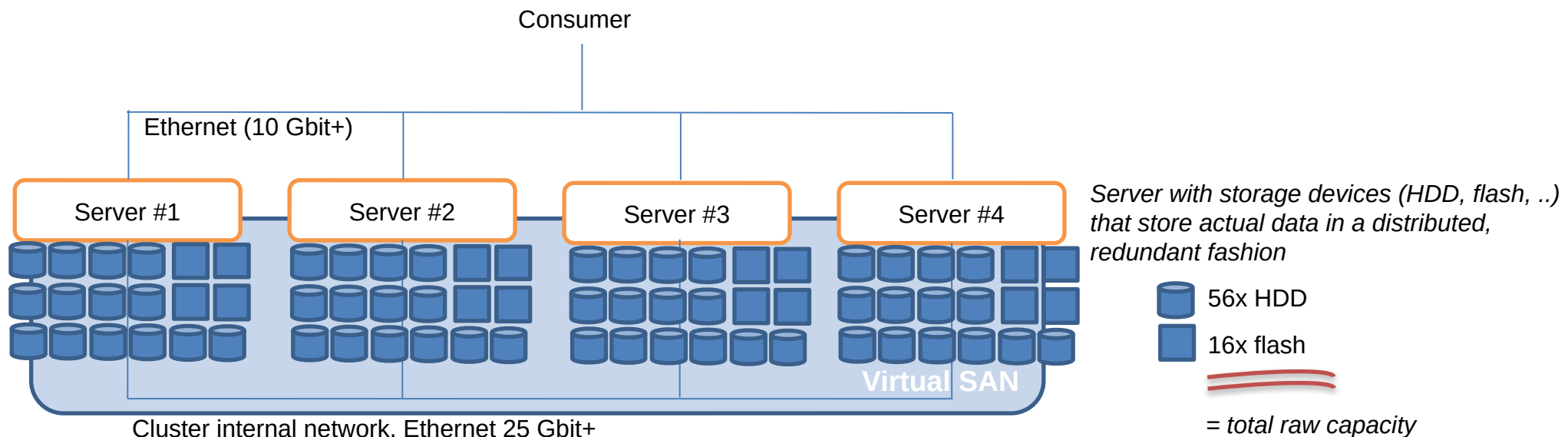
About 2x/3x of actual storage capacity required to purchase.



Software-Defined Storage (SDS)

Standard x86 server, with disk drive or flash storage.
Software turns multiple servers into a virtual storage with SAN-like features.

Examples: HDFS (Hadoop), Ceph, VMware vSAN, MS Storage Spaces Direct (S2D)

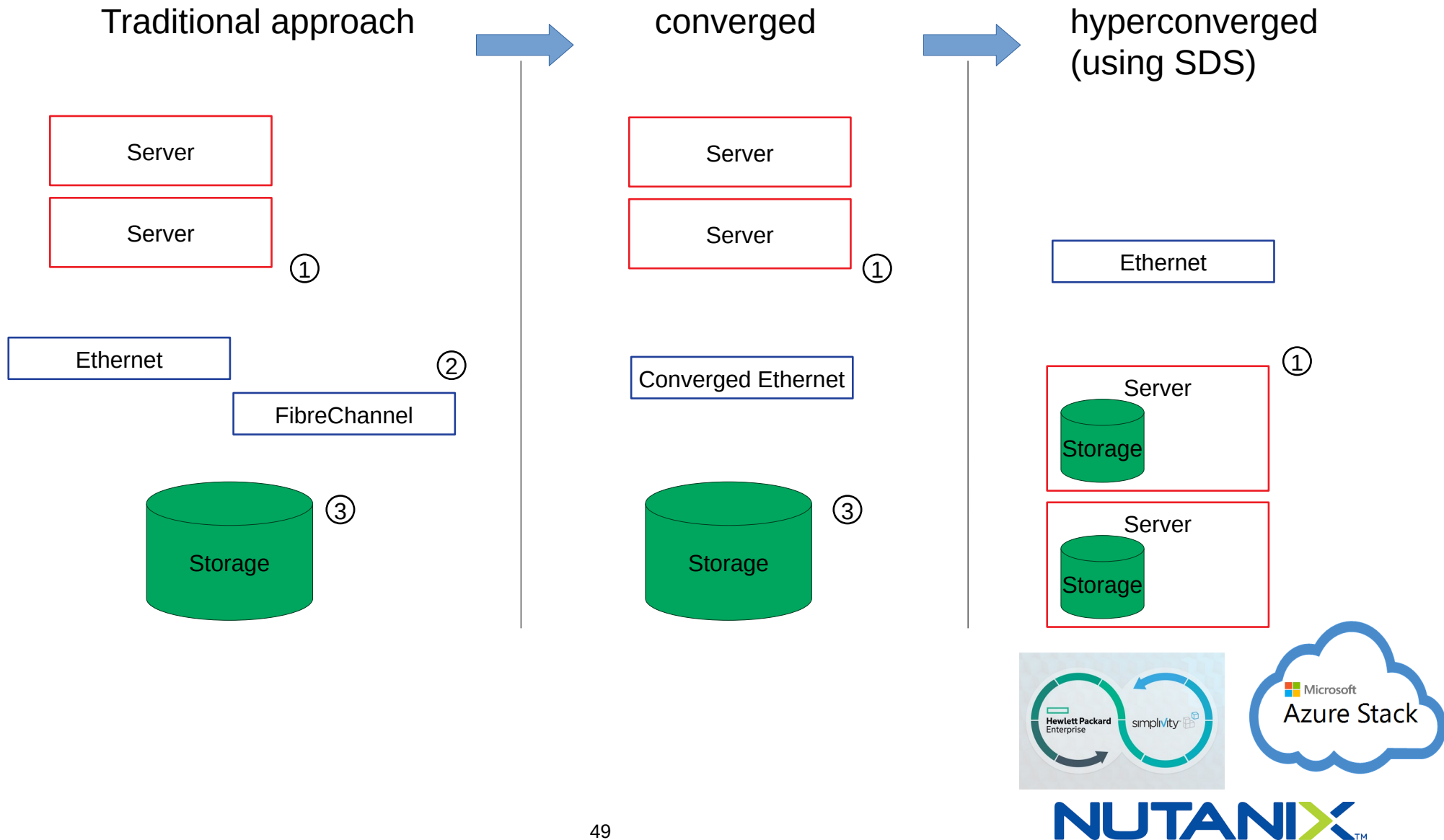


Usable capacity depends... examples:
3-way data replication: 1/3 of raw or 33%
Erasure coding: 4 data + 2 parity => 4/6 of raw or 66%

Latest architectural option:
hyperconvergence

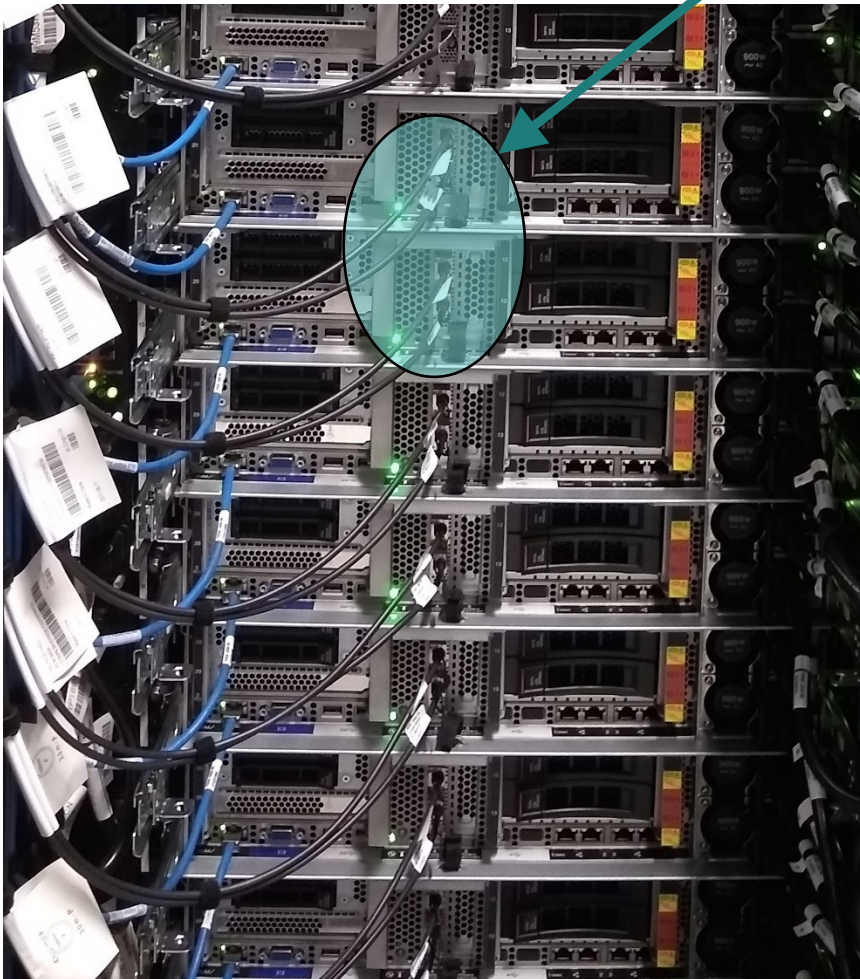
HCI – hyperconverged infrastructure

Current market trend



Example of a hyperconverged rack: MS Azure Stack

Server only have Ethernet ports



Rear

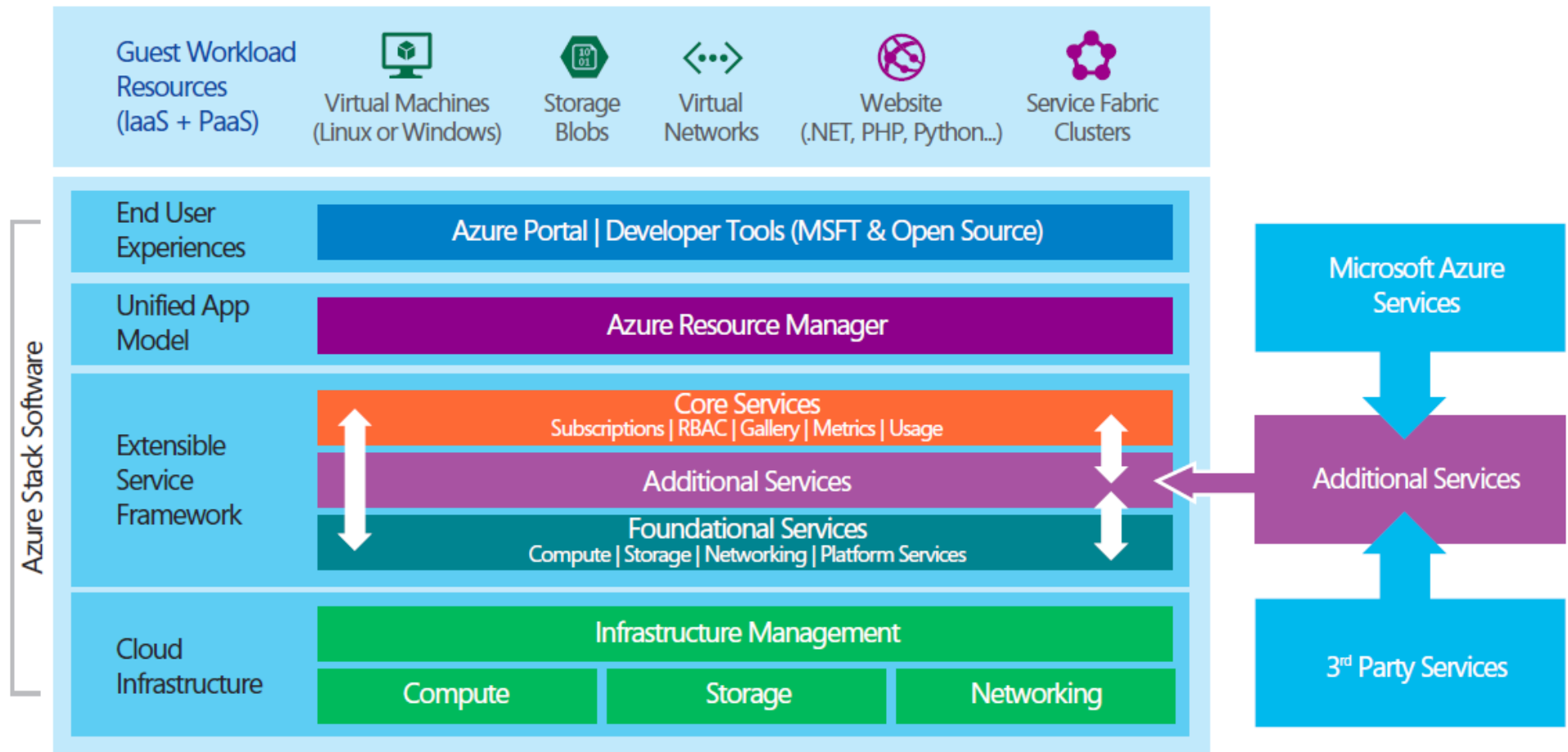
Front



Example of a hyperconverged cloud stack: MS Azure Stack

Azure Stack architecture summary

Together with Azure public cloud → **Microsoft Arc** (think: vCenter)



<https://azure.microsoft.com/en-us/products/azure-stack/hub/>

