CompSci 401: Cloud Computing

Storage Interfaces

Prof. Ítalo Cunha
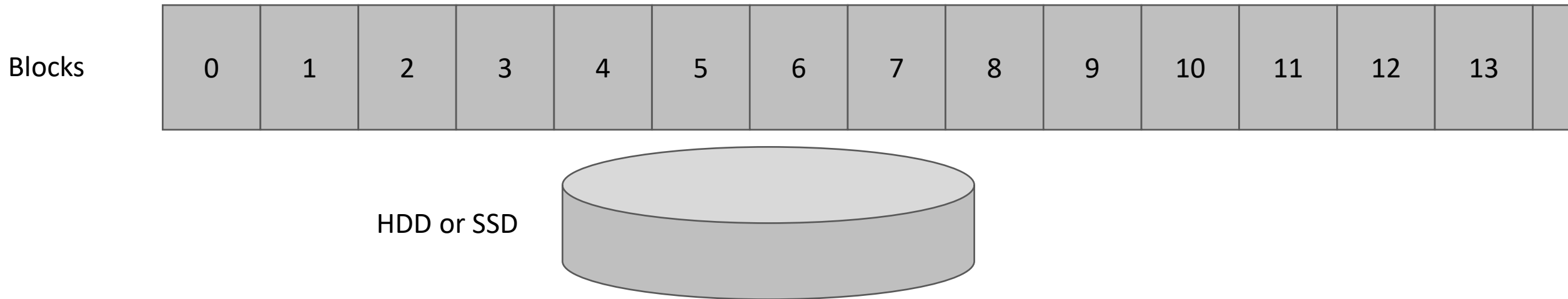
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The disk interface

- Hard disk drives (HDDs) and solid state drives (SSDs)
- Block-oriented interface
  - Blocks have a fixed size like 512 or 4096 bytes
  - Blocks are numbered
  - Writes and reads operate on whole blocks
    - Cannot read or write only part of a block
    - To change one byte in an existing block we read the entire block, and then write the whole block with the modified byte
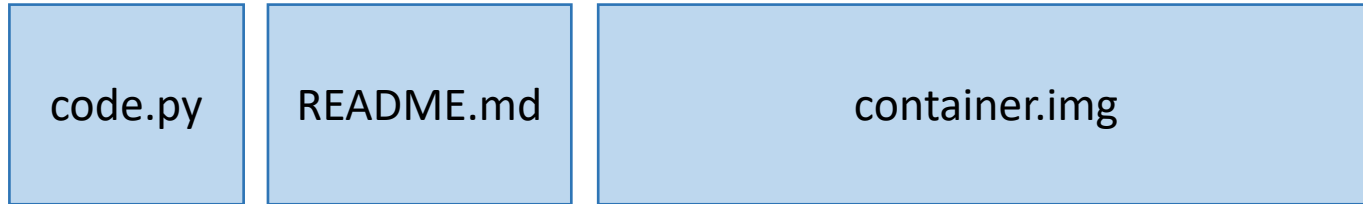
The file interface

- Operating system contain file systems
  - Windows: NTFS and FAT
  - MacOS: APFS, HFS+
  - Linux: ext4, reiserfs, XFS, btrfs, …
- File systems provide a higher-level interface do disk blocks
- File operations
  - Open/close
  - Read/write
  - Seek → Change the position in the file being read from or written to
  - Metadata → Directories, names, owner, access permissions, creation date
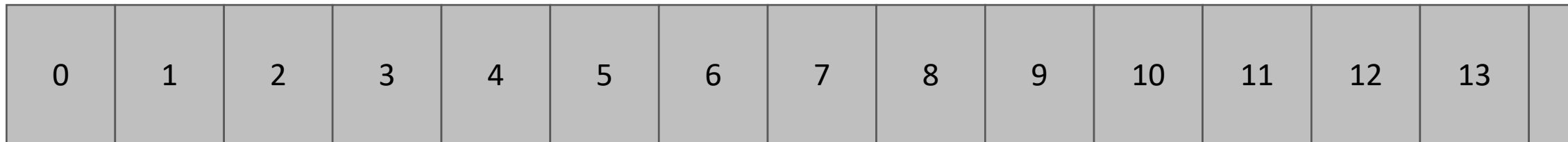
The disk and file interfaces

Blocks

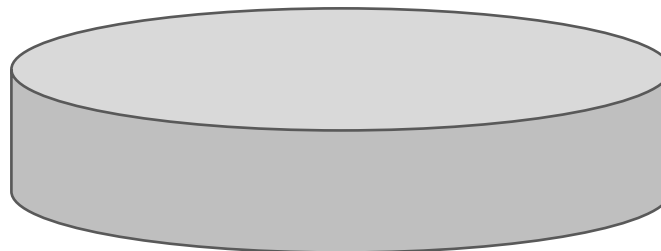| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |

HDD or SSD

The disk and file interfaces

Files
(logical)

| code.py | README.md | container.img |

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HDD or SSD

The disk and file interfaces

Files (logical)

code.py	README.md	container.img

Filesystem

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owner
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Remote Storage
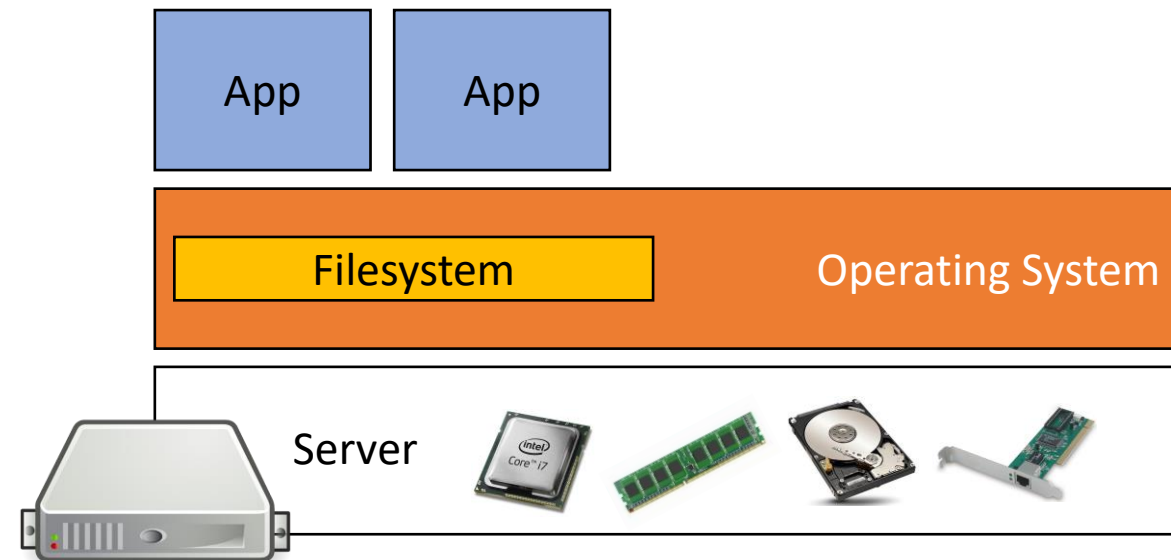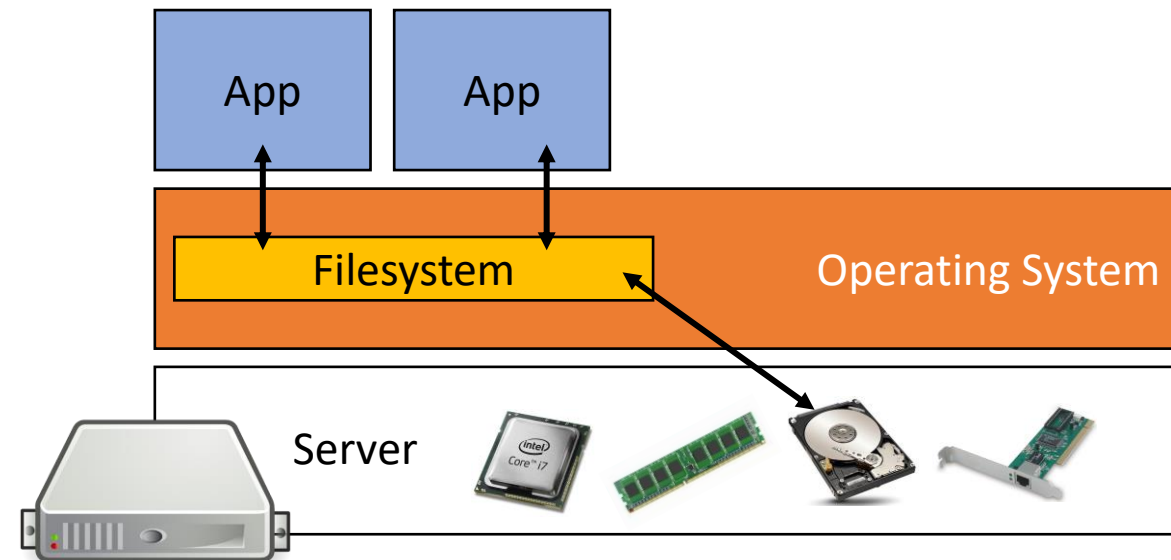
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Use of storage interfaces

- Server has resources, including storage

- Operating runs applications and mediates access to hardware

- Applications access storage through files

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- Server has resources, including storage

- Operating runs applications and mediates access to hardware

- Applications access storage through files in a filesystem
  - Applications use the filesystem's interface
 - Filesystem uses the disk block interface
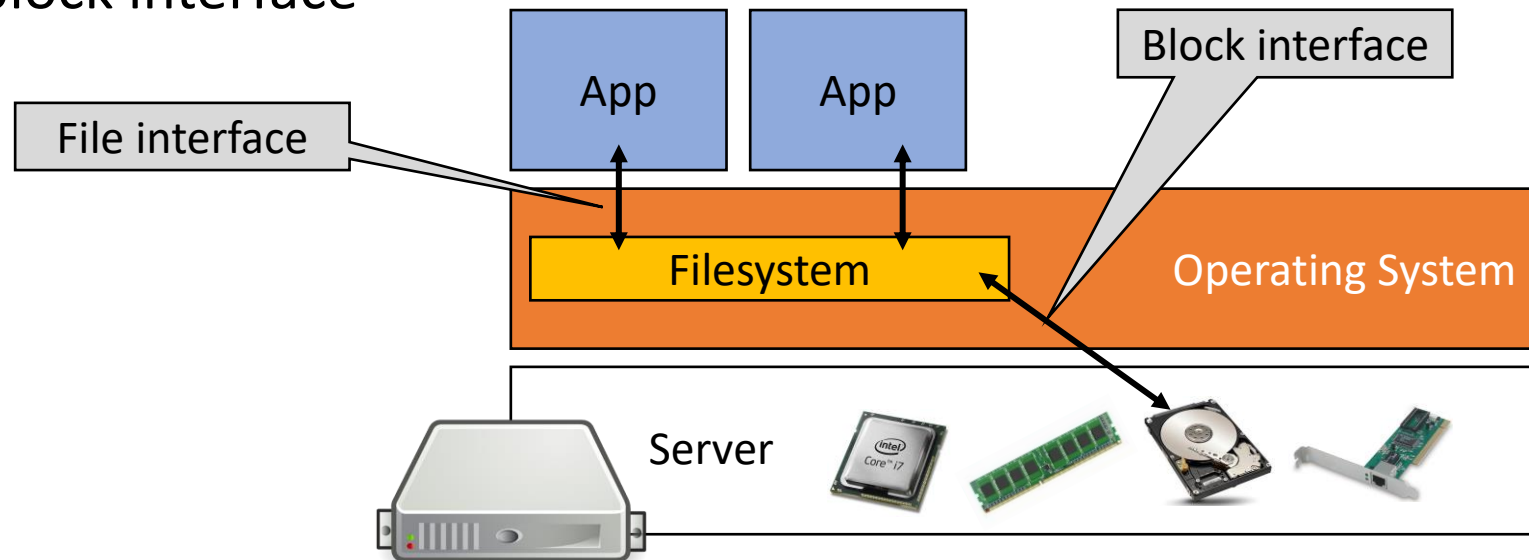
App

App

File interface

Block interface

Filesystem

Operating System

Server

Local and remote storage

- Storage can be local or remote
- Local storage is accessed through a bus (like PCI Express)
  - Also called directly attached storage
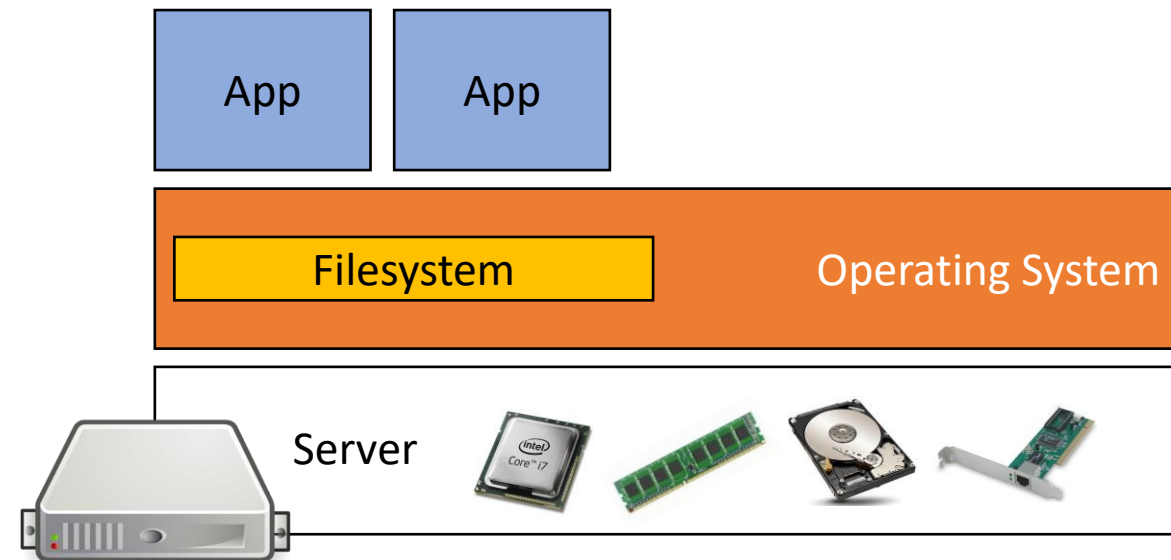
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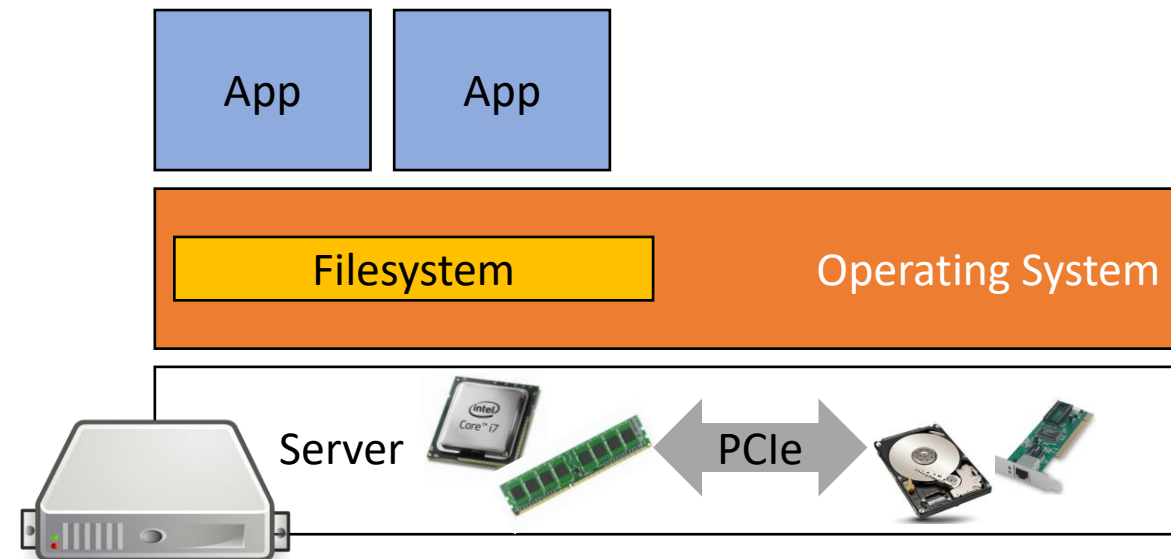
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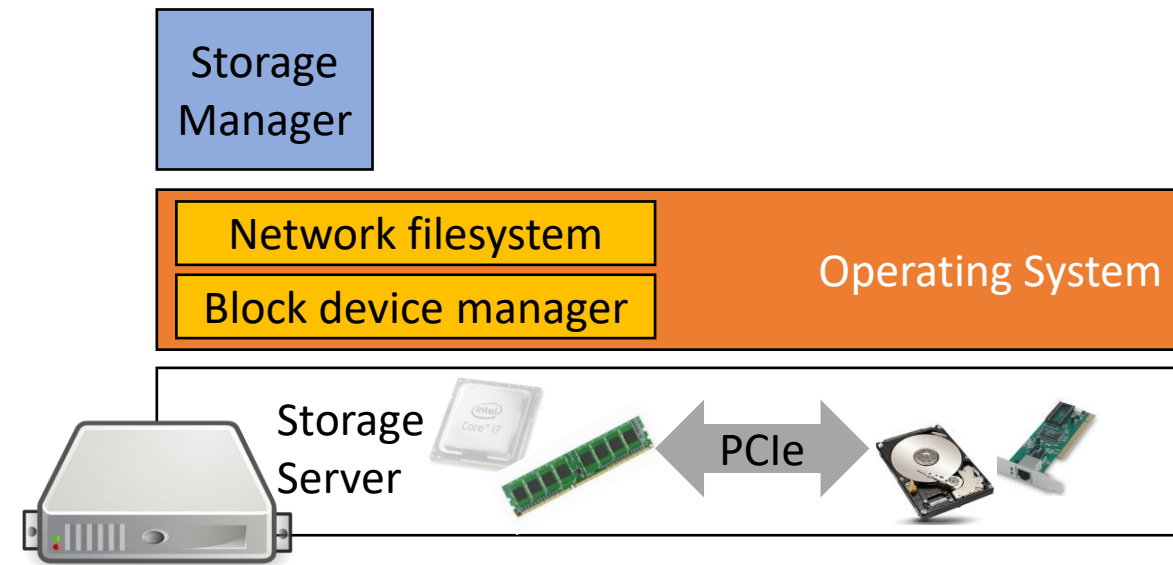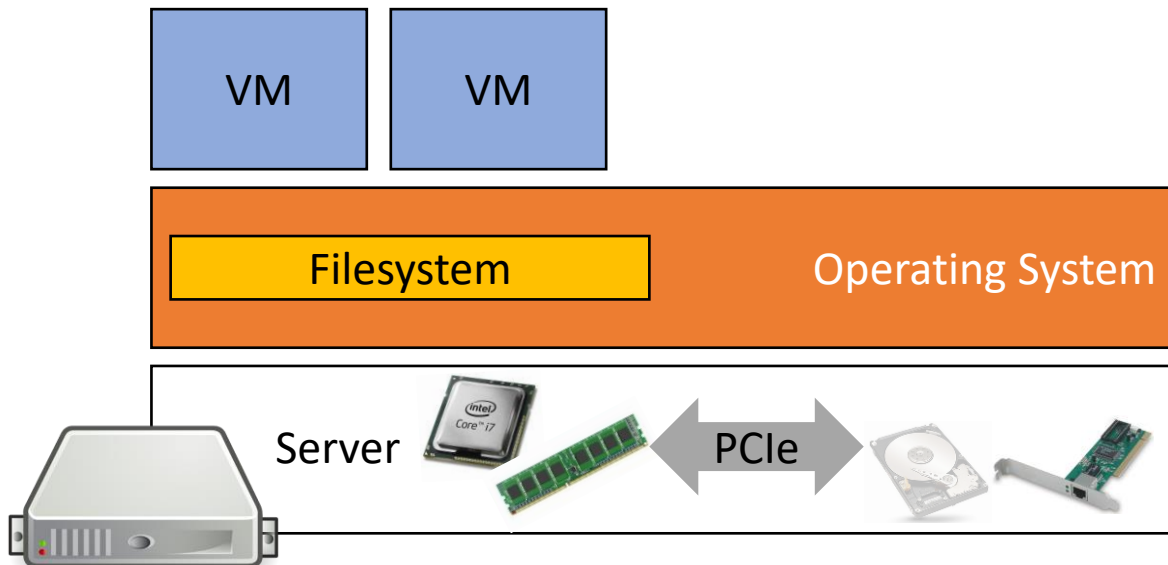
- Remote storage is storage accessed on another server

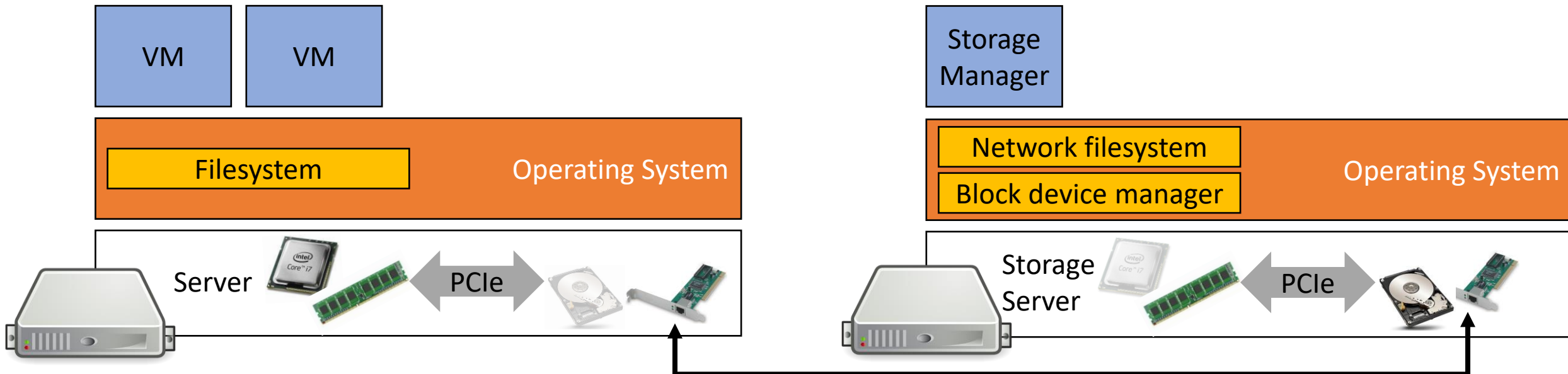# Local and remote storage

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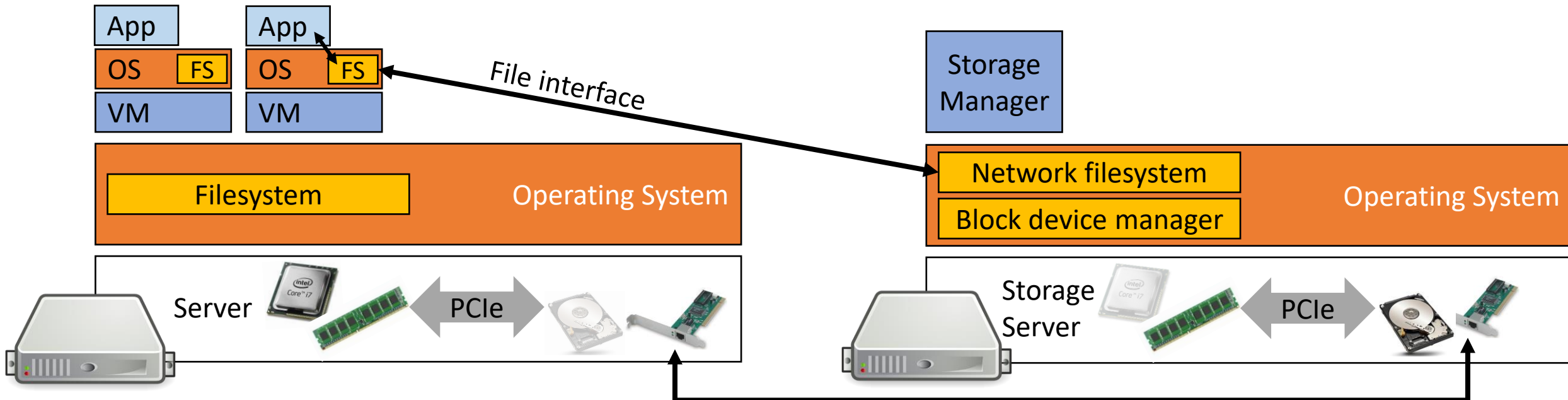# Remote storage interfaces

- Remote storage can be made available at the file or block interfaces

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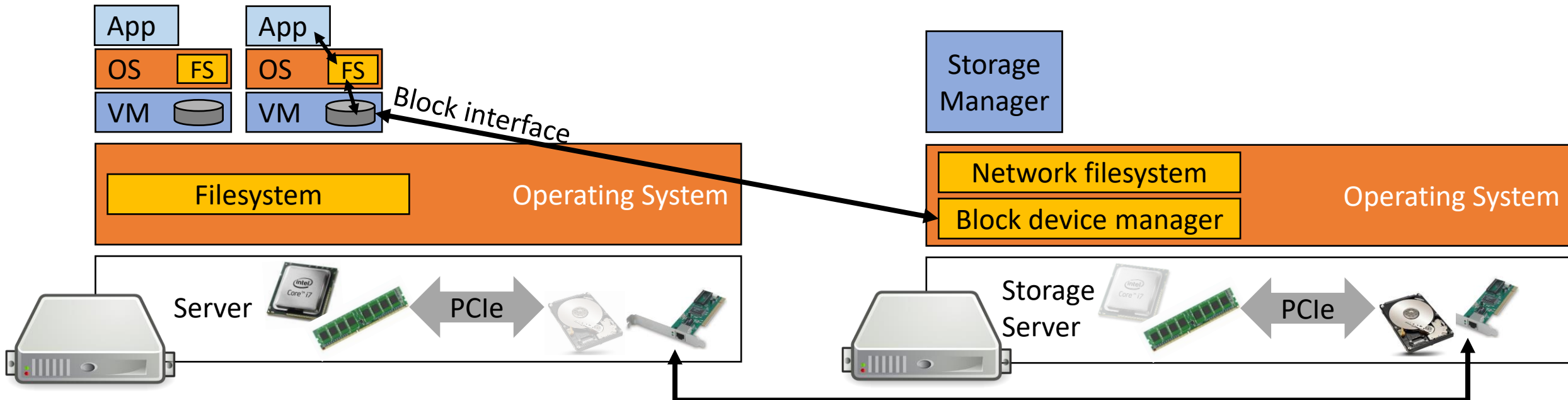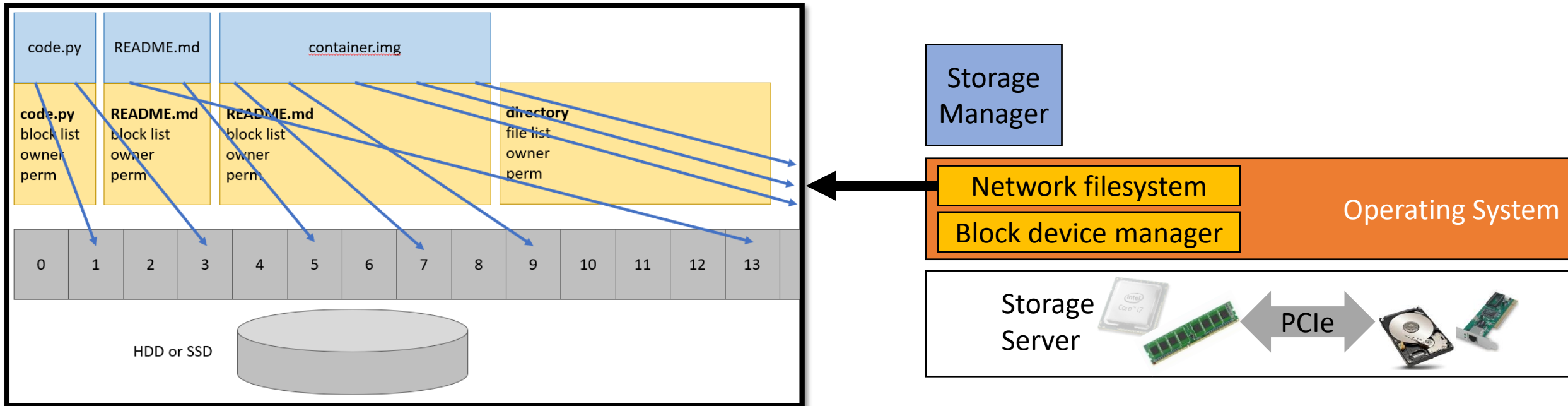
Remote storage implementation

Remote storage implementation

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HDD or SSD

Storage
Manager

Network filesystem

Block device manager

Operating System

Storage
Server

PCIe

Network protocol
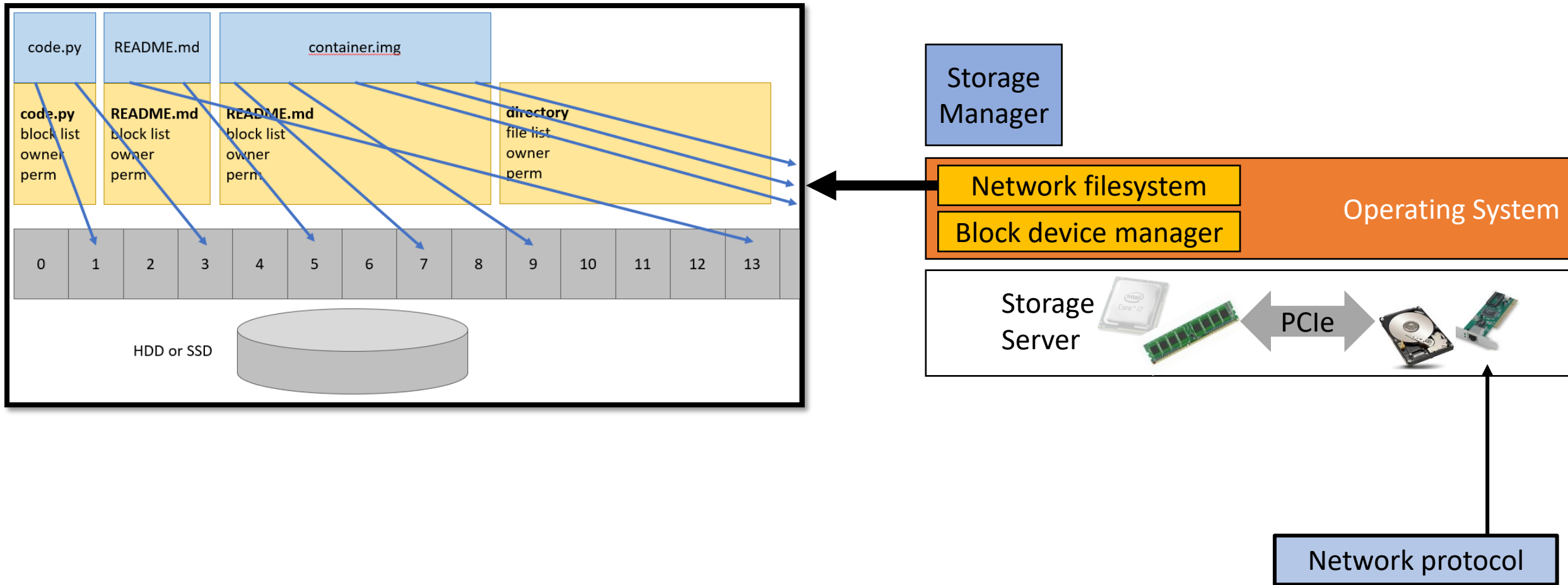
Remote block storage implementation

Virtual disks

Virtual disk 1		Virtual disk 2		Virtual disk 3		Virtual disk 4		Virtual disk 5	

Block mapping

Virtual block	Physical block	Virtual block	Physical block	Virtual block	Physical block	Virtual block	Physical block	Virtual block	Physical block
0	399	0	25	0	67712	0	5612	0	145673
1	321	1	71	1	418	1	67823	1	2457
2	…	2	…	2	…	2	…	2	…

Blocks

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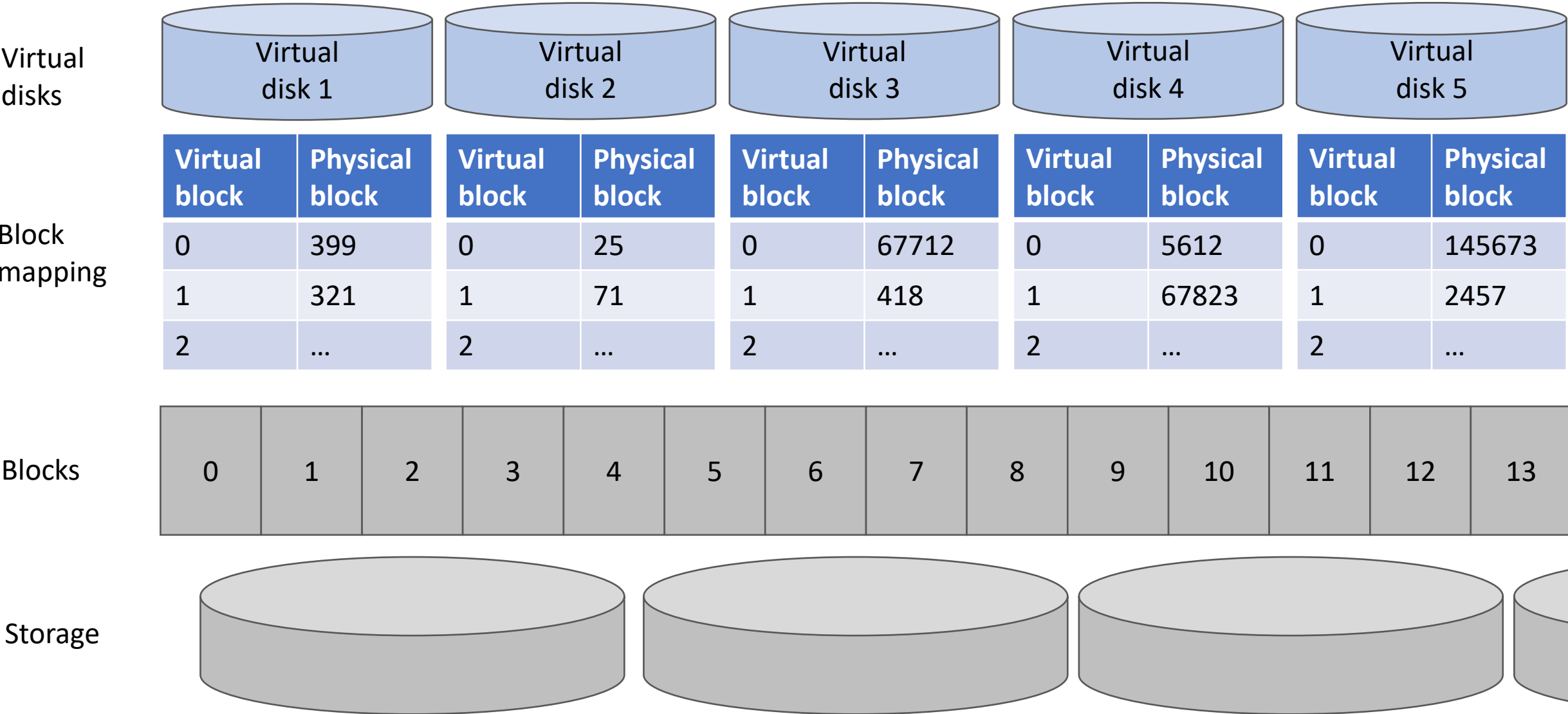
Storage

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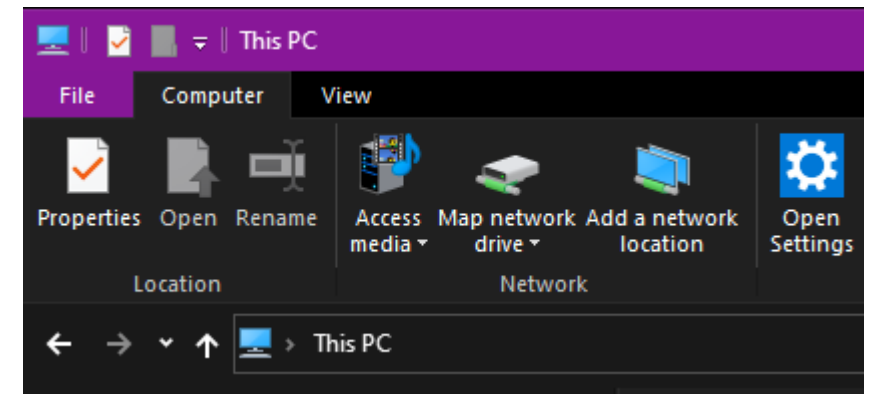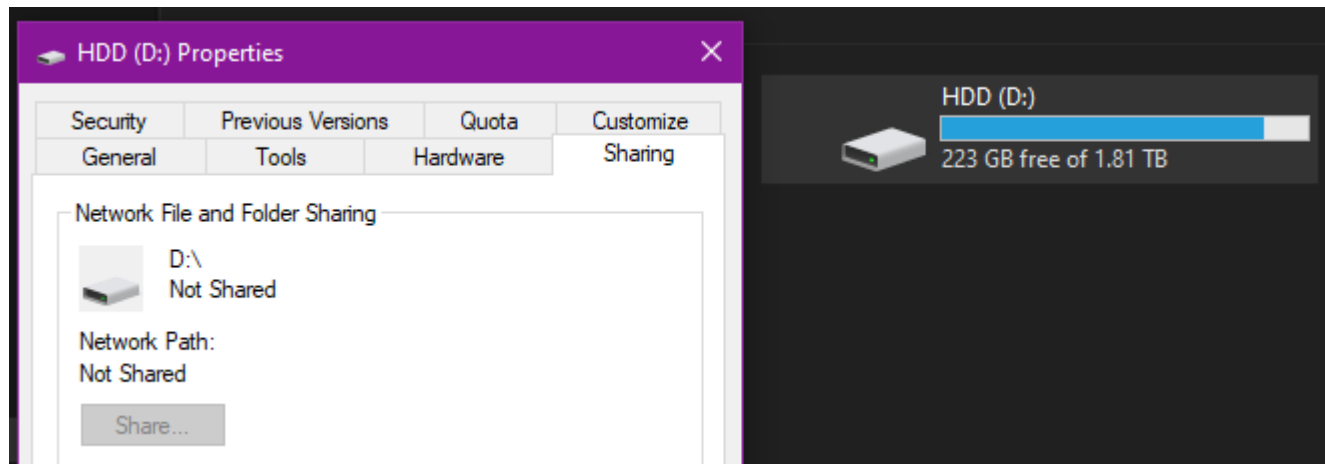# Network Attached Storage and Storage Area Networks

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Host-based NAS

- Operating systems have support for sharing disks over the network

Storage-centric servers

- Some servers are built to support dozens of disks
- NAS software will allow accesses to these disks

Dedicated NAS devices

- Custom-built devices

- Usually run a proprietary operating system and software stack

- Support for combining multiple NAS devices

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Storage Area Networks

- Pairs network attached storage with dedicated network infrastructure
  - Network dedicated to data access allows optimizations not suitable to general-purpose networks

Storage Area Networks

- Pairs network attached storage with dedicated network infrastructure
  - Network dedicated to data access allows optimizations not suitable to general-purpose networks
- However, current deployments use standard Ethernet for both application and storage traffic
  - Hyper-converged infrastructure

Comparison

Network Attached Storage

- File interface/network filesystem
- Filesystems are OS-specific
  - Limits cross-platform use
- Works well with any app
- Can be mounted anywhere
  - Including containers

Storage Area Network

- Block interface/virtual disk
- Works with any operating system
- More flexibility
- Not directly usable by apps
  - Including containers
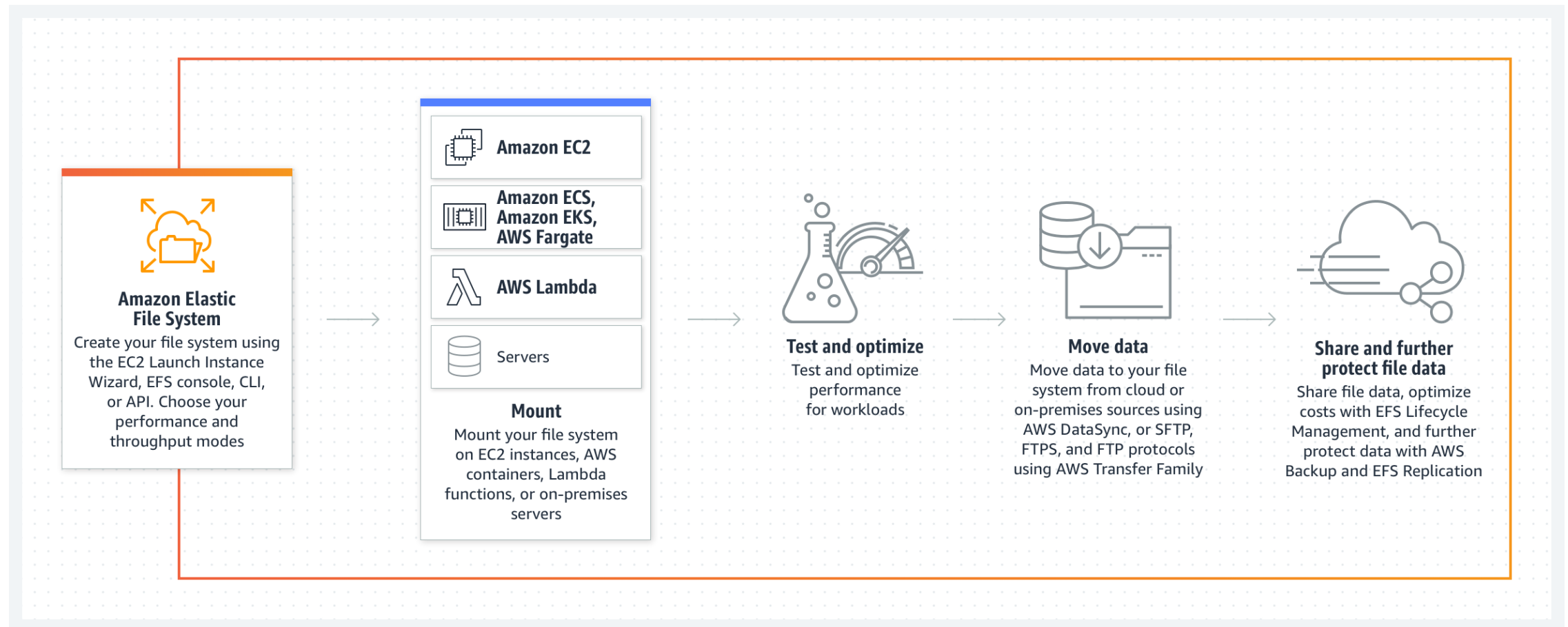- Hard to share data in virtual disks

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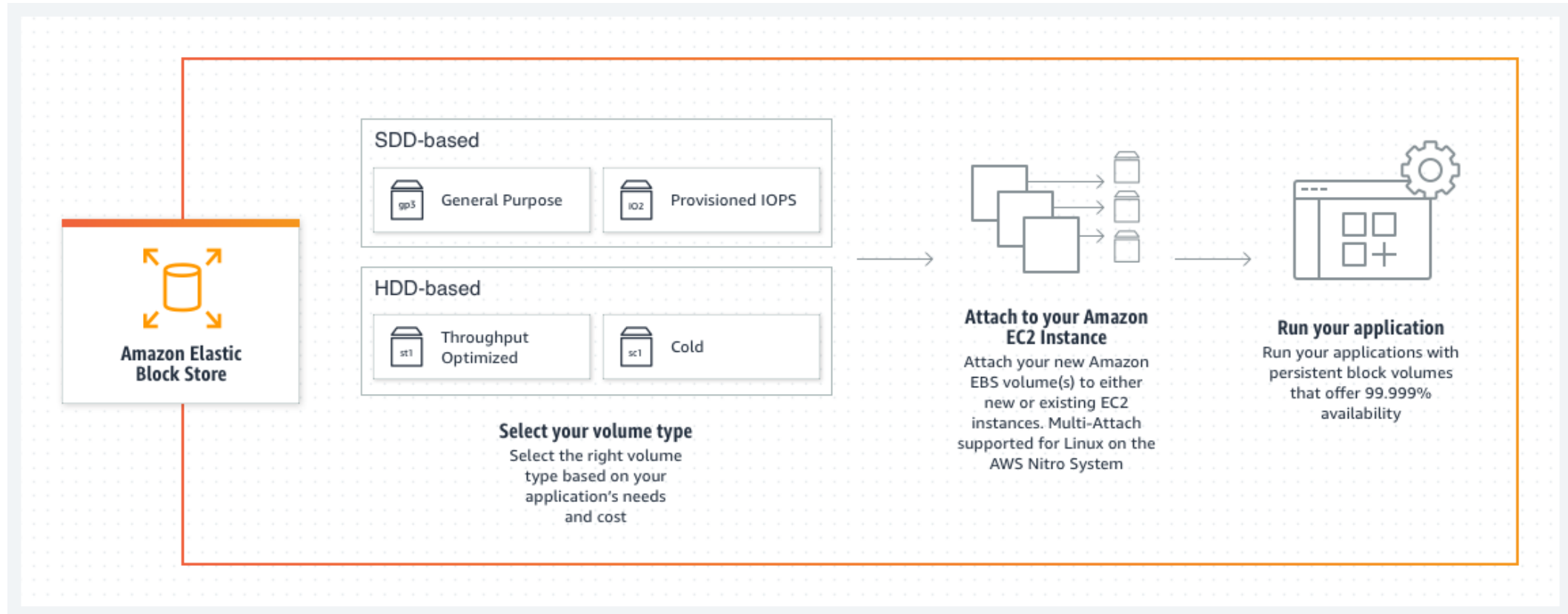# Cloud Storage Solutions

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Cloud providers have multiple interfaces

- File interface (Amazon Elastic File System)

Amazon Elastic File System
Create your file system using the EC2 Launch Instance Wizard, EFS console, CLI, or API. Choose your performance and throughput modes

Amazon EC2

Amazon ECS, Amazon EKS, AWS Fargate

AWS Lambda

Servers

Mount
Mount your file system on EC2 instances, AWS containers, Lambda functions, or on-premises servers

Test and optimize
Test and optimize performance for workloads

Move data
Move data to your file system from cloud or on-premises sources using AWS DataSync, or SFTP, FTPS, and FTP protocols using AWS Transfer Family

Share and further protect file data
Share file data, optimize costs with EFS Lifecycle Management, and further protect data with AWS Backup and EFS Replication
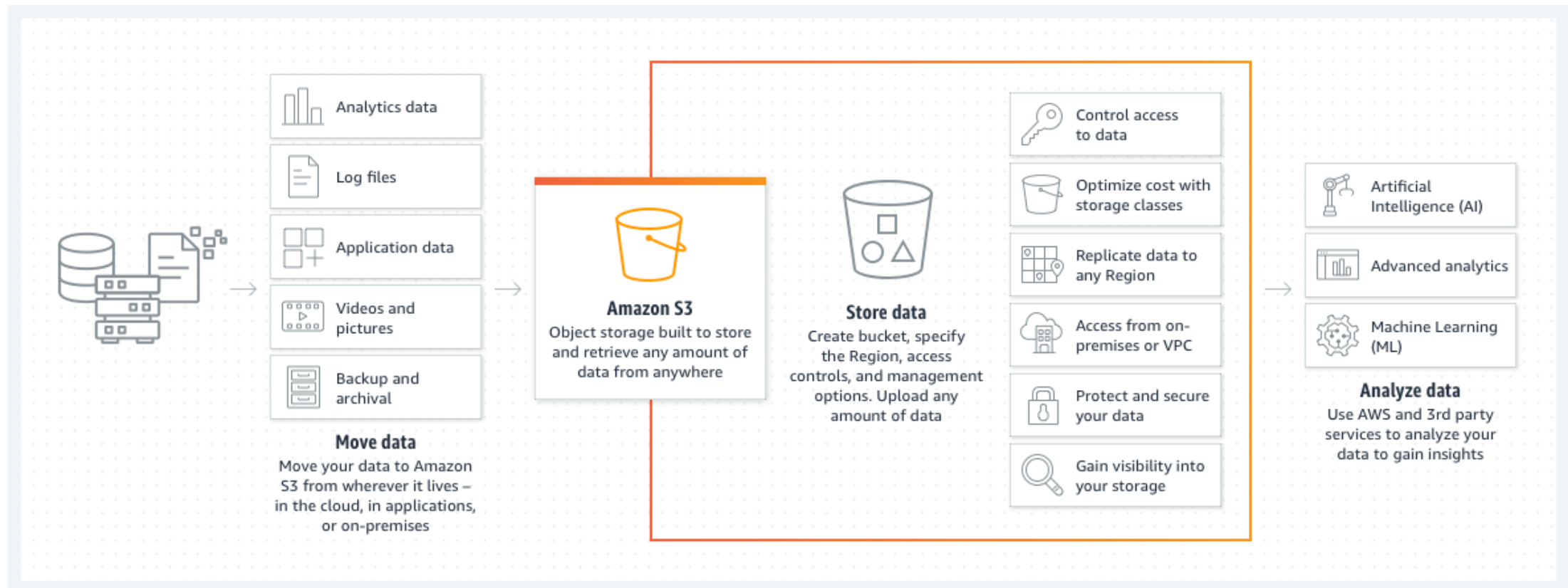
Cloud providers have multiple interfaces

- Block interface (Amazon Elastic Block Store)

Cloud providers have multiple interfaces

- Object interface (Amazon Simple Storage Service)

Object storage

- Arbitrary objects
  - Applications can decide what to store

- High scalability
  - Services can store arbitrary number of objects

- Universal accessibility
  - Objects can be accessed through multiple interfaces

- Independence from operating system
  - Interface defined by the object storage system