

# System Administration

## Week 02, Segment 3 Storage Virtualization

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<https://stevens.netmeister.org/615/>

## Storage Virtualization

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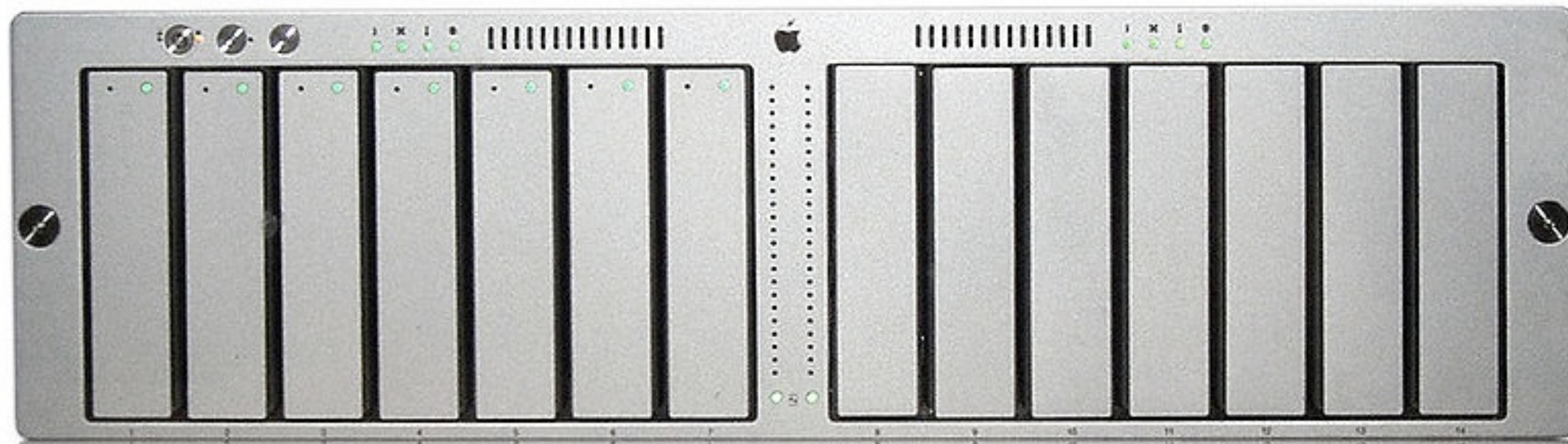
Separating physical and logical storage, physically backed by e.g., a disk array.

- Storage device-based: e.g., RAID
- Host-based: e.g., device mapper, logical volume management, ZFS

## Storage Virtualization: RAID

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- allow file systems to be larger than the physical size of a disk
- increase I/O performance when *striped*
- fault tolerant when *mirrored* or *plexed*



## Storage Virtualization: RAID

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**RAID 0** Striped array (block level), no parity or mirroring

**RAID 1** Mirrored array, no parity or striping

**RAID 2** Striped array (bit level) with dedicated parity

**RAID 3** Striped array (byte level) with dedicated parity

**RAID 4** Striped array (block level) with dedicated parity

**RAID 5** Striped array (block level) with distributed parity

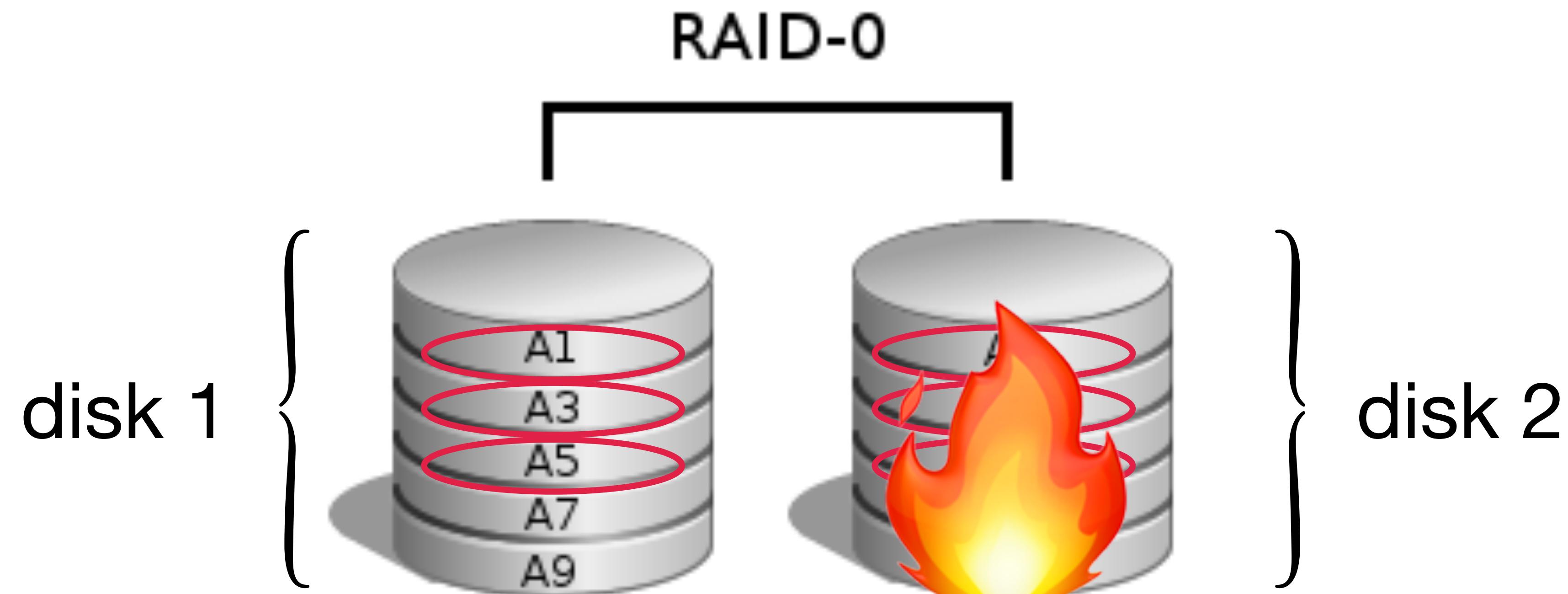
**RAID 6** Striped array (block level) with double distributed parity

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## Storage Virtualization: RAID

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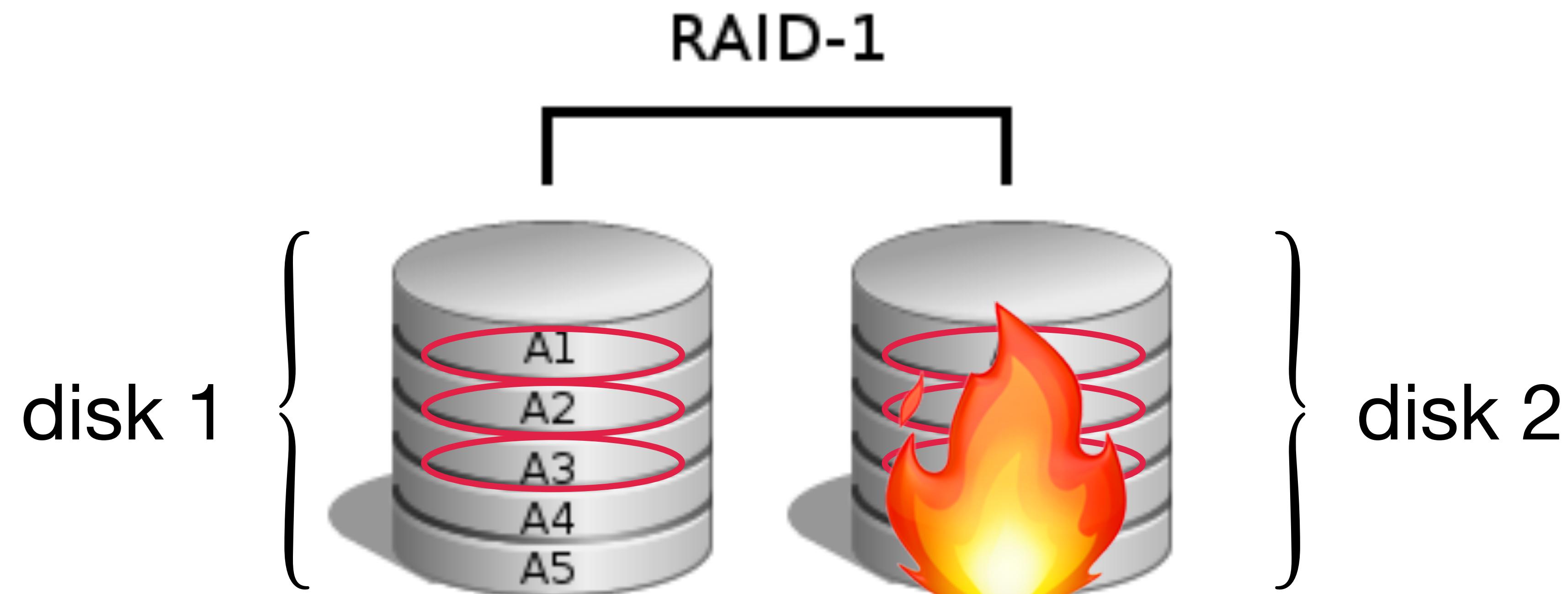
- RAID-0: block-level striping



## Storage Virtualization: RAID

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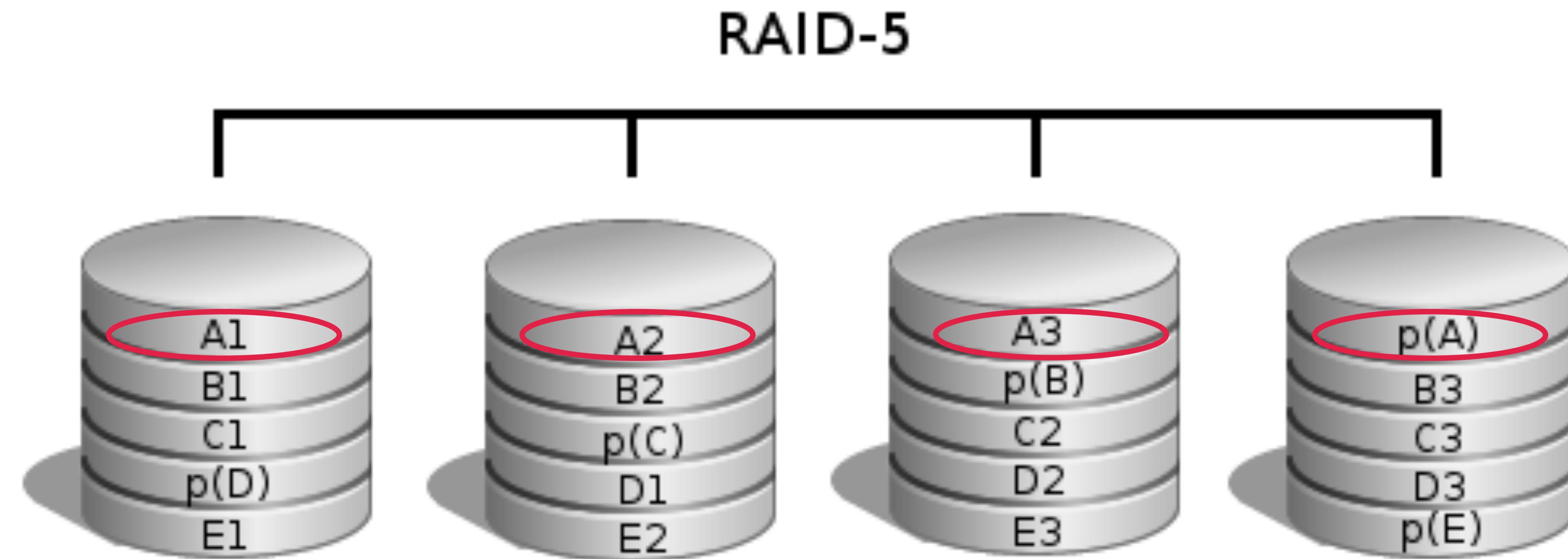
- RAID-1: mirroring



## Storage Virtualization: RAID

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- RAID-5: block-level striping with distributed parity



## Storage Virtualization: RAID

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**RAID 0+1** Mirrored array of stripes

**RAID 1+0** Striped array of mirrors

**RAID 5+0** Striped array of multiple RAID 5

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## Storage Virtualization: Logical Volume Management

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- divide physical storage units into *physical volumes* (PVs)
- pool physical volume groups into *logical volumes* (LVs)
- combine/create logical volumes to allow for
  - combining / concatenating individual disks (JBOD)
  - hot swapping
  - dynamically resizing file systems
  - adding RAID functionality across logical volumes
  - implicit backup via snapshots

```
[rainman$ dmesg | grep sda
[    1.241463] sd 0:0:0:0: [sda] 41943040 512-byte logical blocks: (21.5 GB/20.0
GiB)
[    1.242467] sd 0:0:0:0: [sda] Write Protect is off
[    1.242939] sd 0:0:0:0: [sda] Mode Sense: 00 3a 00 00
[    1.243503] sd 0:0:0:0: [sda] Write cache: enabled, read cache: enabled, does
n't support DPO or FUA
[    1.245729] sda: sda1 sda2 < sda5 >
[    1.246458] sd 0:0:0:0: [sda] Attached SCSI disk
[   6.195695] EXT4-fs (sda1): mounting ext2 file system using the ext4 subsyste
m
[   6.200759] EXT4-fs (sda1): mounted filesystem without journal. Opts: (null)
```

```
[rainman$ lsblk
```

NAME	MAJ:MIN	RM	SIZE	R0	TYPE	MOUNTPOINT
sda	8:0	0	20G	0	disk	
└─sda1	8:1	0	487M	0	part	/boot
└─sda2	8:2	0	1K	0	part	
└─sda5	8:5	0	19.5G	0	part	
└─nemo--vg-root	252:0	0	17.5G	0	lvm	/
└─nemo--vg-swap_1	252:1	0	2G	0	lvm	[SWAP]

```
[rainman$ swapon --show
```

NAME	TYPE	SIZE	USED	PRI0
/dev/dm-1	partition	2G	5.1M	-1

```
rainman$
```

```
rpool/ROOT/omnios-r151034m 908M 6.38G 860M legacy
root@ip-10-10-0-59:~# zfs create extra/space
root@ip-10-10-0-59:~# zfs set mountpoint=/mnt extra/space
root@ip-10-10-0-59:~# df -h /mnt
Filesystem          Size  Used  Available Capacity  Mounted on
extra/space        1.75G  24K    1.75G     1%      /mnt
root@ip-10-10-0-59:~# echo yay > /mnt/file
root@ip-10-10-0-59:~# ls -l /mnt
total 1
-rw-r--r--  1 root  root          4 Jan 31 16:17 file
root@ip-10-10-0-59:~# diskinfo
TYPE   DISK           VID   PID          SIZE    RMV  SSD
XEN    c1t0d0         Xen   Virtual disk  8.00 GiB no   no
XEN    c1t5d0         Xen   Virtual disk  1.00 GiB no   no
XEN    c1t6d0         Xen   Virtual disk  1.00 GiB no   no
XEN    c1t7d0         Xen   Virtual disk  1.00 GiB no   no
root@ip-10-10-0-59:~# df -h /mnt
Filesystem          Size  Used  Available Capacity  Mounted on
extra/space        1.75G  24.5K   1.75G     1%      /mnt
root@ip-10-10-0-59:~# zpool add extra c1t7d0
root@ip-10-10-0-59:~# df -h /mnt
Filesystem          Size  Used  Available Capacity  Mounted on
extra/space        2.69G  24.5K   2.69G     1%      /mnt
root@ip-10-10-0-59:~#
```

## Recommended Exercises

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Use ZFS to create mirrored, striped, and RAID-Z pools. Simulate hard drive failure by detaching a volume – how does each handle this scenario?

You saw how to add a new disk to a ZFS pool. Can you *remove* a disk? What if the filesystem usage is greater than the resulting pool would be?

Next time: Physical Disk Structure and Partitions

## Links

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File Systems and Storage Models:

<https://www.netmeister.org/book/04-file-systems.pdf>

Managing ZFS File Systems in Oracle Solaris 11.3:

[https://docs.oracle.com/cd/E53394\\_01/html/E54801/index.html](https://docs.oracle.com/cd/E53394_01/html/E54801/index.html)

RedHat LVM Administrator Guide:

[https://access.redhat.com/documentation/en-us/red\\_hat\\_enterprise\\_linux/6/html/logical\\_volume\\_manager\\_administration/index](https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/6/html/logical_volume_manager_administration/index)

A Linux user's guide to Logical Volume Management:

<https://opensource.com/business/16/9/linux-users-guide-lvm>

Wikipedia:

<https://en.wikipedia.org/wiki/RAID>

[https://en.wikipedia.org/wiki/Logical\\_Volume\\_Manager\\_\(Linux\)](https://en.wikipedia.org/wiki/Logical_Volume_Manager_(Linux))