# OSTEP Chapter 38

*ECE 3600, Fall 2022*

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## Table of Contents

# 1. RAIDs

| Disk 0 | Disk 1 | Disk 2 | Disk 3 |
|---|---|---|---|
| 0 | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 |

Figure 38.1: **RAID-0: Simple Striping**

N disks

disk = address % N

offset = address / N

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| Disk 0 | Disk 1 | Disk 2 | Disk 3 |
|---|---|---|---|
| 0 | 0 | 1 | 1 |
| 2 | 2 | 3 | 3 |
| 4 | 4 | 5 | 5 |
| 6 | 6 | 7 | 7 |

Figure 38.3: **Simple RAID-1: Mirroring**

disk1 = (address % (N/2)) * 2,  disk2 = disk1 + 1

offset = address / (N/2)

write to both disks,
read from even-numbered disk for even offsets,
read from odd-numbered disk for odd offsets.

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| Disk 0 | Disk 1 | Disk 2 | Disk 3 | Disk 4 |
|---|---|---|---|---|
| 0 | 1 | 2 | 3 | P0 |
| 4 | 5 | 6 | 7 | P1 |
| 8 | 9 | 10 | 11 | P2 |
| 12 | 13 | 14 | 15 | P3 |

Figure 38.4: **RAID-4 With Parity**

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| Disk 0 | Disk 1 | Disk 2 | Disk 3 | Disk 4 |
|---|---|---|---|---|
| 0 | 1 | 2 | 3 | P0 |
| 5 | 6 | 7 | P1 | 4 |
| 10 | 11 | P2 | 8 | 9 |
| 15 | P3 | 12 | 13 | 14 |
| P4 | 16 | 17 | 18 | 19 |

Figure 38.7: **RAID-5 With Rotated Parity**

## 2. Comparison

N disks

Each disk: B blocks, S MB/sec sequential, R MB/sec random, T sec latency

| | RAID-0 | RAID-1 | RAID-4 | RAID-5 |
|---|---|---|---|---|
| Capacity | $N \cdot B$ | $(N \cdot B)/2$ | $(N-1) \cdot B$ | $(N-1) \cdot B$ |
| Reliability | 0 | 1 (for sure)<br>$\frac{N}{2}$ (if lucky) | 1 | 1 |
| Throughput | | | | |
| Sequential Read | $N \cdot S$ | $(N/2) \cdot S$ | $(N-1) \cdot S$ | $(N-1) \cdot S$ |
| Sequential Write | $N \cdot S$ | $(N/2) \cdot S$ | $(N-1) \cdot S$ | $(N-1) \cdot S$ |
| Random Read | $N \cdot R$ | $N \cdot R$ | $(N-1) \cdot R$ | $N \cdot R$ |
| Random Write | $N \cdot R$ | $(N/2) \cdot R$ | $\frac{1}{2} \cdot R$ | $\frac{N}{4} R$ |
| Latency | | | | |
| Read | $T$ | $T$ | $T$ | $T$ |
| Write | $T$ | $T$ | $2T$ | $2T$ |

Figure 38.8: **RAID Capacity, Reliability, and Performance**

## 3. Exercises - RAID Level 0

Exercises from the book using raid.py:

```
numDisks 4
chunkSize 4k

$ python ./raid.py -n 4 -R 21 -L 0

LOGICAL READ from addr:17 size:4096
  Physical reads/writes?

LOGICAL READ from addr:8 size:4096
  Physical reads/writes?

LOGICAL READ from addr:10 size:4096
  Physical reads/writes?

LOGICAL READ from addr:16 size:4096
  Physical reads/writes?

$ python ./raid.py -n 4 -R 21 -L 0 -r

LOGICAL OPERATION is ?
  read  [disk 1, offset 4]

LOGICAL OPERATION is ?
  read  [disk 0, offset 2]

LOGICAL OPERATION is ?
  read  [disk 2, offset 2]

LOGICAL OPERATION is ?
  read  [disk 0, offset 4]
```

# 4. Exercises - RAID Level 1

```
$ python ./raid.py -n 4 -R 21 -L 1

LOGICAL READ from addr:17 size:4096
  Physical reads/writes?

LOGICAL READ from addr:8 size:4096
  Physical reads/writes?

LOGICAL READ from addr:10 size:4096
  Physical reads/writes?

LOGICAL READ from addr:16 size:4096
  Physical reads/writes?

$ python ./raid.py -n 4 -R 21 -L 1 -r

LOGICAL OPERATION is ?
  read  [disk 2, offset 8]

LOGICAL OPERATION is ?
  read  [disk 0, offset 4]

LOGICAL OPERATION is ?
  read  [disk 1, offset 5]

LOGICAL OPERATION is ?
  read  [disk 0, offset 8]
```