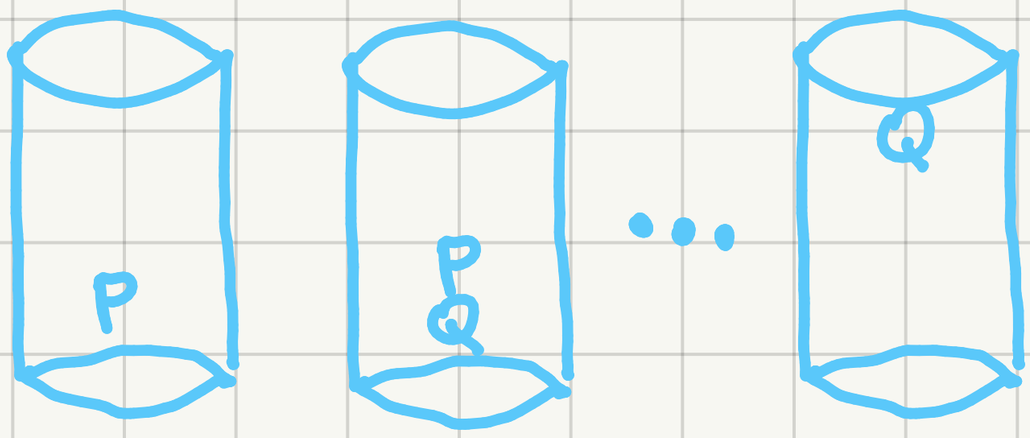
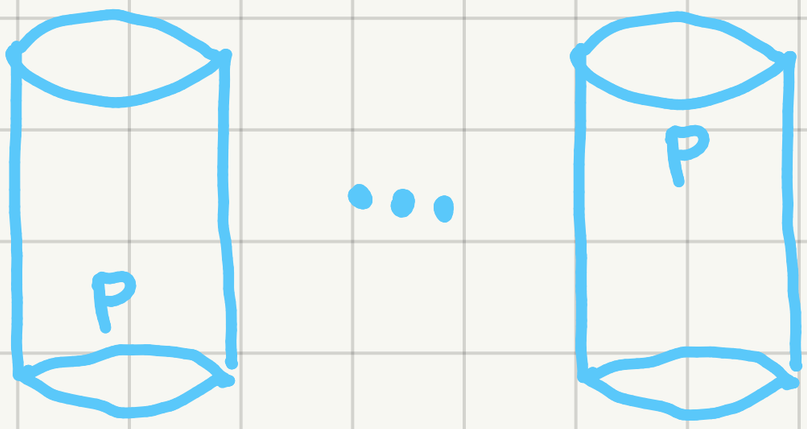
① RAID 6 N=10 I/O OPERATIONS?



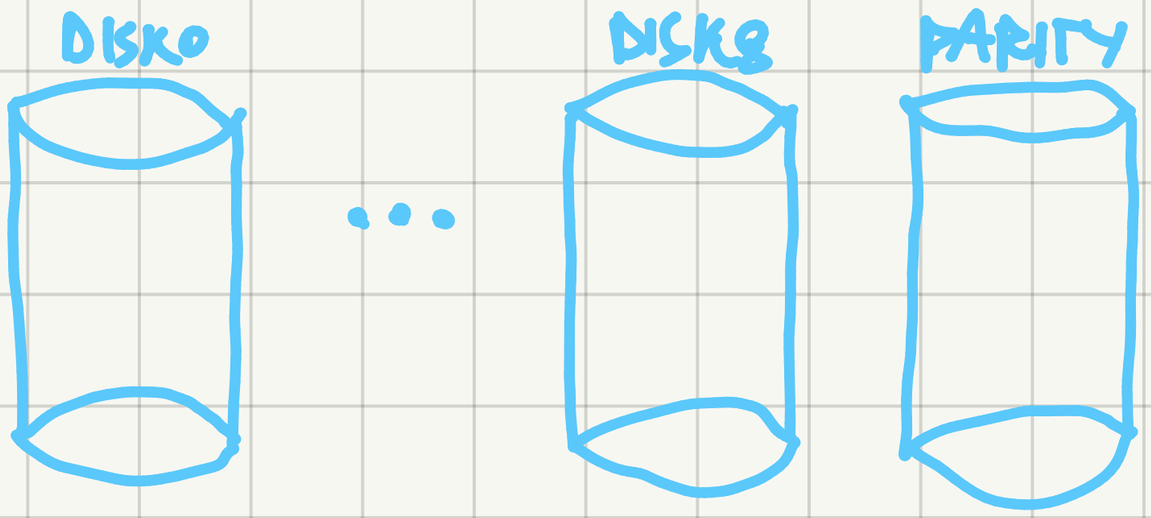
I/O OPERATIONS = 1 (READ OLD VALUE) +
2 (READ PARITIES P, Q) + 1 (WRITE NEW VALUE)
+ 2 (UPDATE PARITIES) = 6

② RAID 5 N=10 I/O OPERATIONS?



I/O OPERATIONS = 1 (READ OLD VALUE) +
1 (READ PARITY) + 1 (WRITE NEW VALUE) +
+1 (UPDATE PARITY) = 4

③ RAID 4 N=10 I/O OPERATIONS?



I/O OPERATIONS = 1 (READ OLD VALUE)
1 (READ PARITY) + 1 (WRITE NEW VALUE) +
+1 (UPDATE PARITY) = 4

④

RAID 0+1 N=6 MTTF(ONE DISK) = 600 DAYS MTTR(ONE DISK) = 5 DAYS MTTDL?

$$MTTDL = \frac{1}{P(FAIL\ 01)} = \frac{2MTTF^2}{N^2 MTTR} = 4000\ DAYS$$

⑤

RAID 6 N=7 MTTF(ONE DISK) = 600 DAYS MTTR(ONE DISK) = 5 DAYS MTTDL?

$$MTTDL = \frac{1}{P(FAIL\ 6)} = \frac{2MTTF^3}{N(N-1)(N-2)MTTR^2} = 82285\ DAYS$$

⑥

RAID 1+0 N=8 MTTF(ONE DISK)=800 DAYS MTTR=15 DAYS MTTDL?

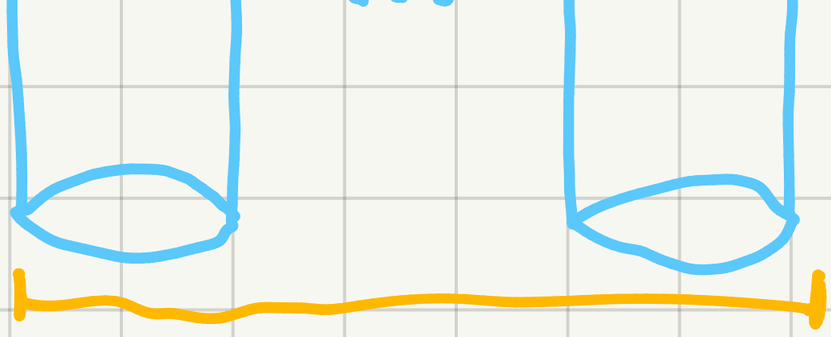
$$MTTDL = \frac{1}{P(FAIL\ 10)} = \frac{MTTF^2}{N \cdot MTTR} = 5333\ DAYS$$

⑦

RAID 5 N=7 MTTF(ONE DISK)=600 DAYS MTTR=5 DAYS MTTDL?

$$MTTDL = \frac{1}{P(FAIL\ 5)} = \frac{MTTF^2}{N(N-1)MTTR} = 1714\ DAYS$$

⑧ RAID 5 N=4 M=2TB SS=50MB/s RS=5MB/s RANDOM WRITE x?



I/O OPERATIONS RANDOM WRITE =
1 (READ OLD DATA) + 1 (READ OLD PARITY) +
+1 (UPDATE DATA) + 1 (UPDATE PARITY) = 4

$$X = N \cdot \frac{RS}{I/O\ OPERATIONS} = 5MB/s$$

⑨ RAID 4 N=4 M=2TB SS=50MB/s RS=5MB/s SEQUENTIAL WRITE x?

$$X = (N-1) \cdot SS = 150\ MB/s$$

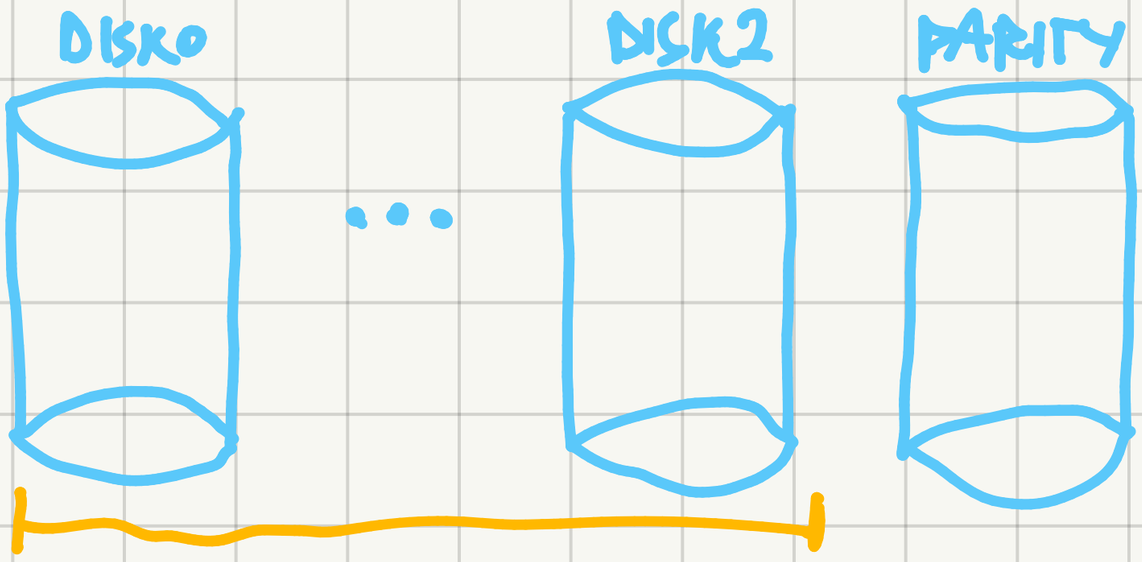
⑩

RAID 0+1 N=8 MTTF(ONE DISK)=400 DAYS MTTDL>12 YEARS $MTTR_{MAX}$?

$$MTTDL = \frac{1}{P(FAIL\ 01)} = \frac{2MTTF^2}{N^2 MTTR} > 12 \cdot 365 = 4380\ DAYS \qquad MTTR < \frac{2MTTF^2}{4380N^2}$$

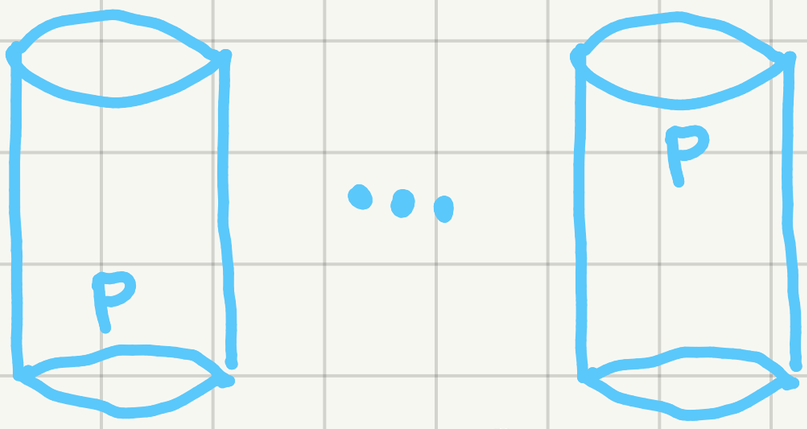
$$MTTR_{MAX} = 1,14\ DAYS$$

(11) RAID 4 N=4 M=2TB SS=50MB/s RS=5MB/s RANDOM READ X?



$X = (N-1) \cdot RS = 15\ MB/s$

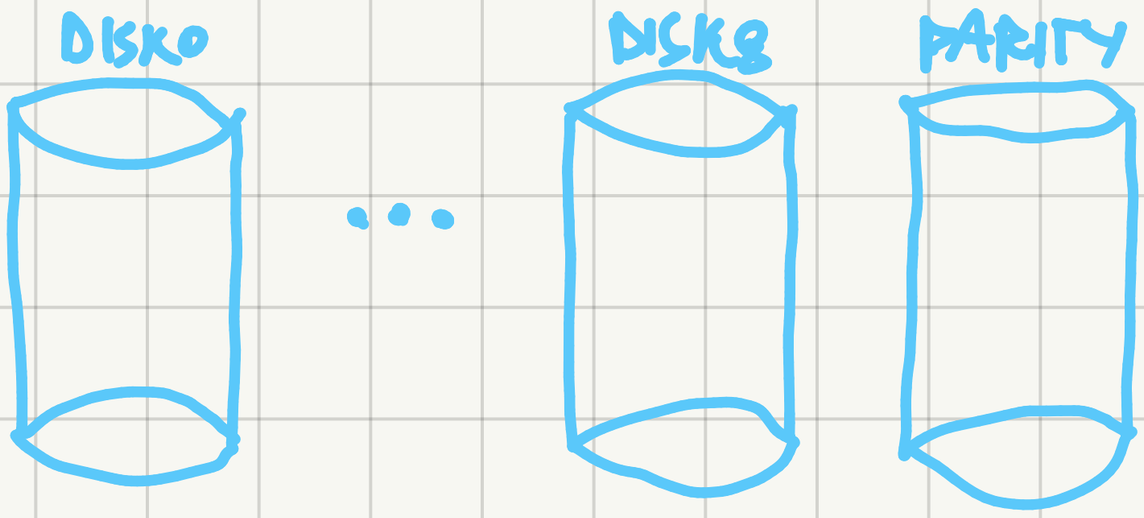
(12) RAID5 N=8 M=2TB SS=75MB/s RS=7,5MB/s RANDOM READ X?



I/O OPERATIONS RANDOM READ= 1 (READ DATA)

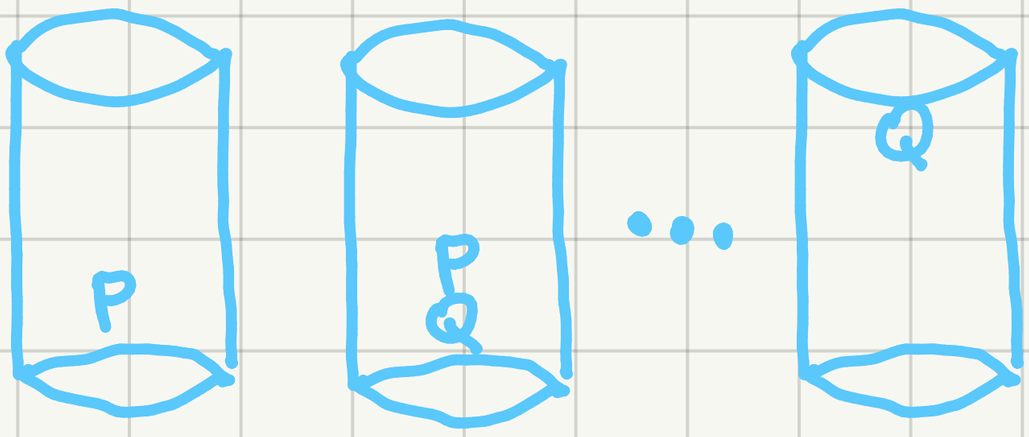
$$X = N \cdot \frac{RS}{\text{I/O OPERATIONS}} = 8 \cdot 7,5\ MB/s = 60\ MB/s$$

(13) RAID4 N=10 UPDATE I/O OPERATIONS?



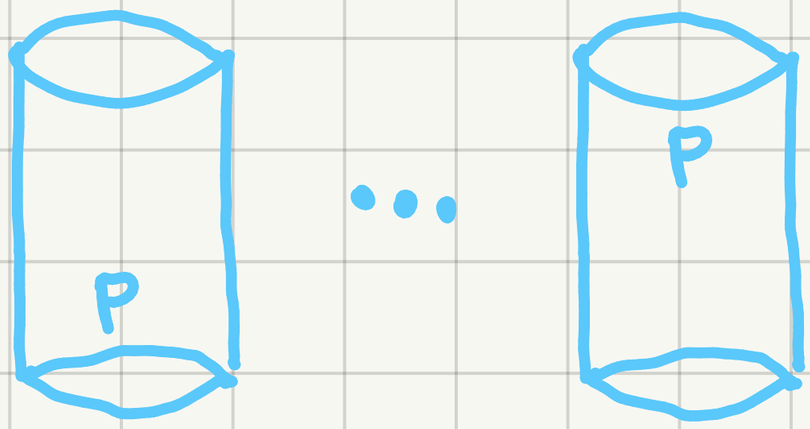
I/O OPERATIONS = 1 (READ OLD VALUE) + 1 (READ PARITY) + 1 (WRITE NEW VALUE) + +1 (UPDATE PARITY) = 4

(14) RAID6 N=10 UPDATE I/O OPERATIONS?



I/O OPERATIONS = 1 (READ OLD VALUE) + 2 (READ PARITIES P,Q) + 1 (WRITE NEW VALUE) + 2 (UPDATE PARITIES) = 6

15 RAID5 N=8 I/O OPERATIONS?



I/O OPERATIONS = 1 (READ OLD VALUE) + 1 (READ PARITY) + 1 (WRITE NEW VALUE) + 1 (UPDATE PARITY) = 4

16 RAID 5 MTTF=1200 DAYS MTTR=10 DAYS MTTDL=1825 DAYS N_{MAX}?

$$MTTDL > \frac{1}{P(FAIL\ 5)} = \frac{MTTF^2}{N(N-1)MTTR}$$

$$N(N-1) > \frac{MTTF^2}{MTTDL \cdot MTTR} = 78,90$$

$N^2 - N - 78,90 > 0 \quad N > 9,39 \quad N_{MAX} = 9$

17 RAID 0+1 N=8 MTTF=450DAYS MTTDL>2555 DAYS $MTTR_{MAX}$?

$$MTTDL = \frac{1}{P(FAIL\ 01)} = \frac{2MTTF^2}{N^2 MTTR} > 2555 \qquad MTTR < \frac{2MTTF^2}{N^2 \cdot 2555}$$

$MTTR_{MAX} = 3,4768$ DAYS

18 RAID 10 N=6 MTTF=425 DAYS MTTDL>4380 DAYS $MTTR_{MIN}$?

$$MTTDL = \frac{1}{P(FAIL\ 10)} = \frac{MTTF^2}{N \cdot MTTR} > 4380 \qquad MTTR_{MIN} = \frac{MTTF^2}{N \cdot 4380} = 6,8731 \text{ DAYS}$$

19 RAID 5 N=7 MTTF=415 DAYS MTTDL>5475 DAYS $MTTR_{MIN}$?

$$MTTDL = \frac{1}{P(FAIL\ 5)} = \frac{MTTF^2}{N(N-1)MTTR} > 5475 \qquad MTTR_{MIN} = \frac{MTTF^2}{N(N-1)MTTDL} = 0,75 \text{ DAYS}$$

20 RAID 5 N=8 MTTR ≥ 0,25 DAYS MTTDL ≥ 5475 DAYS $MTTF_{MIN}$?

$$MTTDL = \frac{1}{P(FAIL\ 5)} = \frac{MTTF^2}{N(N-1)MTTR} > 5475 \qquad MTTF_{MIN} = \sqrt{MTTDL \cdot N(N-1) \cdot MTTR}$$

$= 276,8$ DAYS

11 RAID 5 $MTTDL = 6,5y$ $N = 8$ $MTTF = 2y$ $MTTR$?

$$MTTDL = \frac{1}{P(FAIL\ 5)} = \frac{MTTF^2}{N(N-1)MTTR}$$

$$MTTR = \frac{MTTF^2}{N(N-1)MTTDL} = 0,011y$$