

POLITECNICO DI MILANO

COMPUTER INFRASTRUCTURE

CHEAT SHEET

*Authors:*  
FABC07



June 28, 2018

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# 1 Performance evaluation

## 1.1 General

1.  $\lambda_K = \frac{A_K}{T}$ ,  $\lambda := \text{arrival rate}$ ,  $A_K := \text{num of arrivals}$
2.  $X_K = \frac{C_K}{T}$ ,  $X_K := \text{throughput}$ ,  $C_K := \text{num of completions}$
3.  $U_K = \frac{B_K}{T}$ ,  $U_K := \text{utilization}$ ,  $B_K := \text{busy time}$
4.  $S_K = \frac{B_K}{C_K} = \frac{U_K T}{C_K}$ ,  $S_K := \text{service requirement per visit}$
5.  $N = \frac{W}{T}$ ,  $N := \text{customer population}$ ,  $W := \text{accumulated sys time}$
6.  $R_K = \frac{W}{C_K}$ ,  $R_K := \text{residence time}$
7.  $V_K = \frac{C_K}{C}$ ,  $v_K := \text{visits}$
8.  $D_K = V_K S_K = \frac{B_K}{C}$ ,  $D_K := \text{demand}$

## 1.2 Utilization Law

$$U_K = X_K S_K = X D_K$$

## 1.3 Little's Law

$$N = X R$$

## 1.4 Response Time Law

$$R = \frac{N}{X} - Z, \quad Z := \text{think time}$$

## 1.5 Forced Flow Law

$$X_K = V_K X$$

## 1.6 Performace Bounds (Closed Models)

1.  $D = \sum_{k=1}^K D_K$
2.  $D_{max} = \max_K D_K$
3.  $N^* = \frac{D+Z}{D_{max}}$

## 1.7 Throughput Bounds

### 1.7.1 Batch

$$\frac{1}{D} \leq X(N) \leq \min\left(\frac{N}{D}, \frac{1}{D_{max}}\right)$$

### 1.7.2 Terminal

$$\frac{N}{ND+Z} \leq X(N) \leq \min\left(\frac{N}{D+Z}, \frac{1}{D_{max}}\right)$$

### 1.7.3 Transaction

$$X(\lambda) \leq \frac{1}{D_{max}}$$

## 1.8 Response Time Bounds

### 1.8.1 Batch

$$\max(D, ND_{max}) \leq R(N) \leq ND$$

### 1.8.2 Terminal

$$\max(D, ND_{max} - Z) \leq R(N) \leq ND$$

### 1.8.3 Transaction

$$D \leq R(\lambda)$$

## 1.9 Performace Bounds (Open Models)

1.  $X(\lambda) \leq \frac{1}{D_{max}}$
2.  $\frac{D}{1-\lambda D_{avg}} \leq R(\lambda) \leq \frac{D}{1-\lambda D_{max}}$
3.  $\lambda_{sat} = \frac{1}{D_{max}}$

## 2 Virtualization

### 2.1 Virtual istration performance

$T_v = T_p(1+p_p o_p)$ ,  $T_v$  := time to run in virtual env,  $T_p$  := time to run in physical env,  $p_p$  := privileged instruction,  $o_p$  := overhead execution

## 3 Disks

### 3.1 Disks performance

1.  $T = (1-l)(N)(T_s+T_L)+T_T+T_c$ ,  $T$  := service time,  $T_s$  := seek time,  $T_L$  := latency time,  $T_C$  := controller time,  $T_T$  := transfer time,  $N$  := number of blocks,  $l$  := latency
2.  $T_T = \frac{S}{r_t}$ ,  $S$  := total file size,  $r_t$  = transfer rate
3.  $T_L = \frac{1}{RoundPerSecond}$

## 3.2 RAID

### 3.2.1 RAID 0

Striping only, no redundancy (the more disks, the more probability to lose data, the better performances)

$$MTTDL = \frac{MTTF}{n}$$

### 3.2.2 RAID 1

Mirroring, no striping (usually two disks)

$$MTTDL = \frac{MTTF^n}{2MTTR^{(n-1)}}$$

### 3.2.3 RAID 1+0

Striping first, second mirroring (at least 4 disk, even number)

$$MTTDL = \frac{MTTF^2}{nMTTR}$$

### 3.2.4 RAID 0+1

Mirroring first, second striping (at least 4 disk, even number)

$$MTTDL = \frac{2MTTF^2}{n^2MTTR}$$

### 3.2.5 RAID 5

block interland distributed parity (support one disk fails) (at least 3 disks)

$$MTTDL = \frac{MTTF^2}{n(n-1)MTTR}$$

$$P = \sum_{i=0}^{(n-1)} D_i$$

### 3.2.6 RAID 6

block interland distributed parity (support two disks fail) (at least 4 disks)

$$MTTDL = \frac{MTTF^3}{n(n-1)(n-2)MTTR^2}$$

$$P = \sum_{i=0}^{(n-1)} D_i$$

$$Q = \sum_{i=0}^{(n-1)} gD_i, \quad g \neq 1$$

## 3.3 Dependability exponential distribution

1.  $F(t) = 1 - e^{-\lambda t} = 1 - e^{-\frac{t}{MTTF}} := \text{unreliability}$
2.  $f(t) = \lambda e^{-\lambda t} = \frac{e^{-\frac{t}{MTTF}}}{MTTF} := \text{density function of fails}$
3.  $R(t) = e^{-\lambda t} = e^{-\frac{t}{MTTF}} := \text{reliability}$
4.  $MTTF = \mathbb{E}[\mathbb{X}] = \frac{1}{\lambda}$
5. if  $t \ll MTTF \Rightarrow F(t) \approx \frac{t}{MTTF}$

### 3.4 Not repairable failure

#### 3.4.1 Serial components

1.  $R(t) = \prod_{i=1}^n R_i(t)$
2.  $MTTF_{serie} = \frac{1}{\sum_{i=1}^n \frac{1}{MTTF_i}}$
3. if  $MTTF_1 = \dots = MTTF_n \Rightarrow MTTF_{serie} = \frac{MTTF}{n}$

#### 3.4.2 Parallel components

1.  $R(t) = 1 - \prod_{i=1}^n (1 - R_i(t))$
2.  $MTTF_{parallel} = \sum_{i=1}^n MTTF_i - \frac{1}{\sum_{i=1}^n \frac{1}{MTTF_i}} = \sum_{i=1}^n MTTF_i - MTTF_{serie}$
3. if  $MTTF_1 = \dots = MTTF_n \Rightarrow MTTF_{parallel} = MTTF(\sum_{i=1}^n \frac{1}{i})$

### 3.5 Repairable failure

1.  $MTBF := \text{mid time between failure} = MTTR + MTTF$
2.  $A := \text{Availability} = \frac{MTTF}{MTTR + MTTF} = \frac{MTTF}{MTBF}$

#### 3.5.1 Serial components

1.  $A = \prod_{i=1}^n A_i$
2.  $A_{serie} = \prod_{i=1}^n \frac{MTTF_i}{MTTF_i + MTTR_i}$
3.  $MTTF_{serie} = \frac{1}{\sum_{i=1}^n \frac{1}{MTTF_i}}$
4.  $MTTR_{serie} = \frac{(1 - A_{serie})MTTF_{serie}}{A_{serie}}$

#### 3.5.2 Parallel components

1.  $A = 1 - \prod_{i=1}^n (1 - A_i)$
2.  $A_{parallel} = 1 - \prod_{i=1}^n (1 - \frac{MTTF_i}{MTTF_i + MTTR_i})$
3.  $MTTF_{parallel} = \frac{A_{parallel}MTTR_{parallel}}{1 - A_{parallel}}$
4.  $MTTR_{parallel} = \frac{1}{\sum_{i=1}^n \frac{1}{MTTR_i}}$