Politecnico di Milano

Computer Infrastructure

Cheat Sheet

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Contents

1 Performance evaluation

1.1 General

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

1.2 Utilization Law

$U_K = X_K S_K = X D_K$

1.3 Little's Law

$N = XR$

1.4 Response Time Law

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

1.5 Forced Flaw 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 istruction performace

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

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

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)
$MTTDL = \frac{2MTTF^3}{n(n-1)(n-2)MTTR^2}$
$P = \sum_{i=0}^{(n-1)} D_i$
$Q = \sum_{i=0}^{(n-1)} gD_i,\ g \neq 1$

3.3 Dependability exponential distribution

1. $F(t) = 1 - e^{-\lambda t} = 1 - e^{-\frac{t}{MTTF}} := unreliability$
2. $f(t) = \lambda e^{-\lambda t} = \frac{e^{-\frac{t}{MTTF}}}{MTTF} := density\, function\, of\, fails$
3. $R(t) = e^{-\lambda t} = e^{-\frac{t}{MTTF}} := reliability$
4. $MTTF = \mathbb{E}\left[\mathbb{X}\right] = \frac{1}{\lambda}$
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 $MTTF_1 = \ldots = MTTF_n \ \Rightarrow \ MTTF_{serie} = \frac{MTTF}{n}$

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 $MTTF_1 = \ldots = MTTF_n \ \Rightarrow \ MTTF_{parallel} = MTTF(\sum_{i=1}^{n} \frac{1}{i})$

3.5 Repairable failure

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

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. $MTTR_{parallel} = \frac{1}{\sum_{i=1}^{n} \frac{1}{MTTR_i}}$