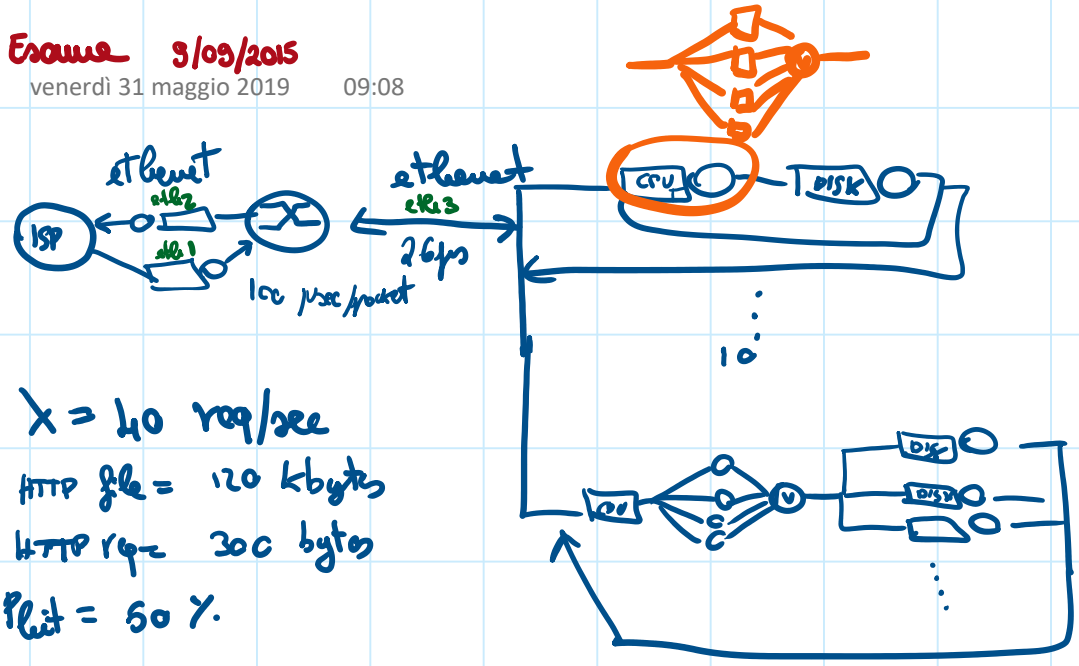
Esame 9/09/2015

venerdì 31 maggio 2019 09:08



$\lambda = 40$ req/sec

HTTP file = 120 kbytes

HTTP req = 300 bytes

$p_{hit} = 50\%$

$D_{core,hit} = 20$ msec $D_{core,miss} = 40$ msec

$D_{DS} = 25$ msec

Service time for 10kbytes = 10 msec

$D_{DISK} = \frac{100K}{10K} \cdot 1 \text{ msec} + 10 \text{ msec} = 20 \text{ msec}$

TCP
IP
ETH

Networking

$$Delta_1 = \frac{300 \cdot 10^3 + (3+1)(o_{TCP} + o_{IP} + o_{ETH})}{0.5 \cdot 10^6} = 1.064 \cdot 10^{-6}$$

$U_{eth1} = \lambda \cdot Delta_1 = 4.45 \cdot 10^{-5}$

$R_{eth1} = \frac{D}{1-U} = 1.064 \cdot 10^{-6}$

$Segments = \frac{120K}{1460} = 83$

$Delta_2 = \frac{(3+83)(o_{TCP} + o_{IP} + o_{ETH}) + 120K}{0.5 \cdot 10^6} = 2.48$

$U_{eth2} = \lambda \cdot Delta_2 = 9.96 \cdot 10^{-3}$

$R_{eth2} = \frac{D}{1-U} = 2.51 \cdot 10^{-4}$

$U_{router} = 0$

$D_{router} = ((83+3) + (4)) \cdot 100\,\mu sec = 9 \cdot 10^{-3}$

$R_{router} = D_{router}$

$D_{ISP} = ((300 \cdot 10^{-3}) + (4)(o_{TCP} + o_{ETH} + o_{IP}) + 120K + 85(o_{TCP})) \cdot 1.5 = 9.44 \cdot 10^{-3}$

$$D_{Delta3} = \frac{\left((300 \cdot 10^{-3}) + (a)(ov_{TCP} + ov_{ETH} + ov_{IO}) + 12eK + 85(ov_{TCP})\right) \cdot 1.5}{2 \cdot 10^{6}} = 5{,}4 \cdot 10^{-5}$$

$$U = \lambda \cdot D_{Delta3} = 3{,}76 \cdot 10^{-3}$$

$$R = \frac{D}{1-U} = 9{,}44 \cdot 10^{-3}$$

$$D_{CPU} = 20 \cdot 0.5 + 0.5 \cdot 40 = 30 \text{ min}$$

$$U_{CPU} = \frac{40}{\frac{60}{10 \cdot 4}} \cdot 30 \cdot 10^{-3} = 0.03$$

capacity node · 4 core

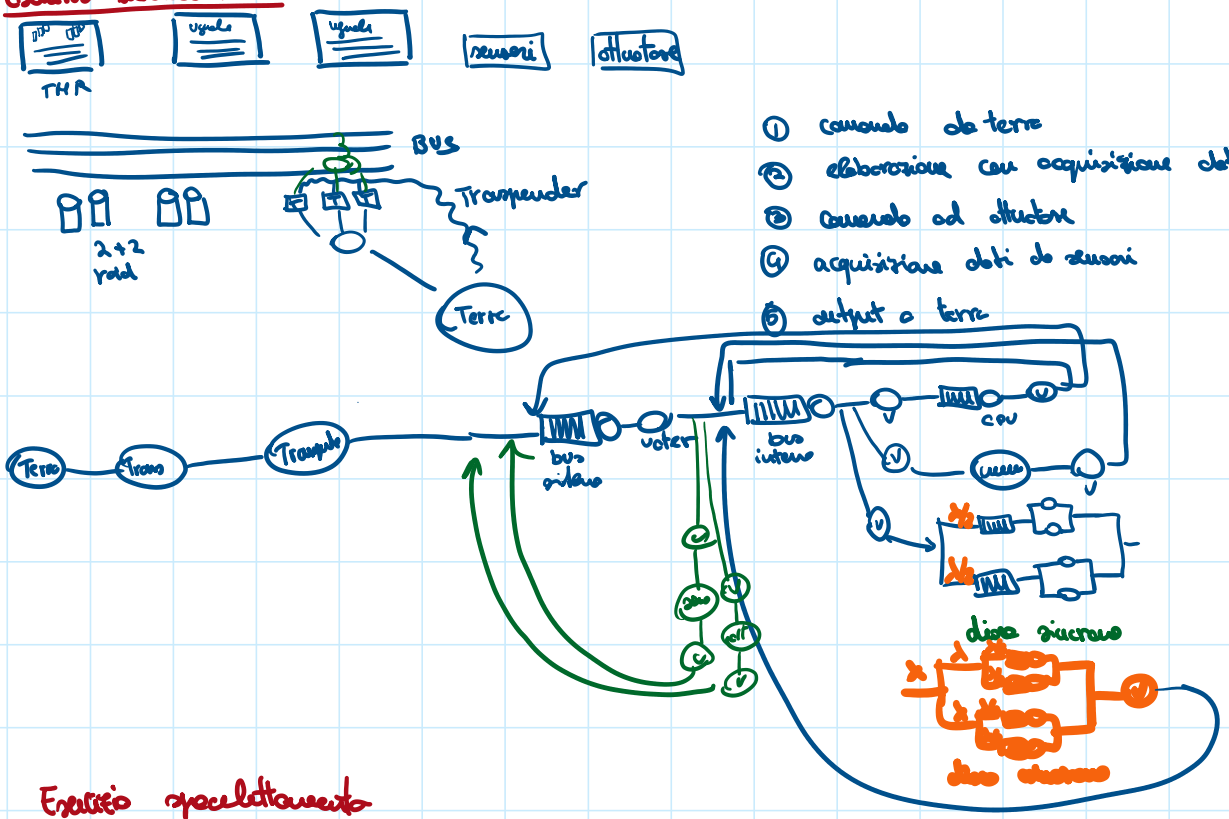
$$R_{CPU} = 0.03 \text{ sec}$$

$$D_{FS} = 0.5(25 + 20) = 22{,}5 \text{ min}$$

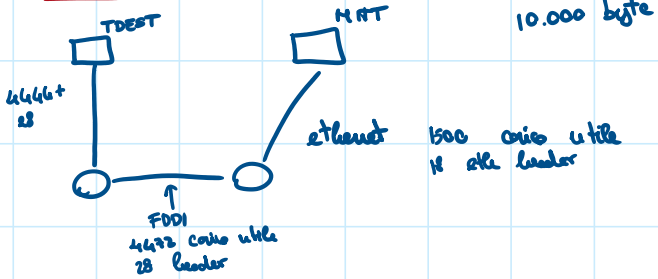
$$U_{FS} = \lambda \cdot D_{FS} = 0.9$$ bottleneck

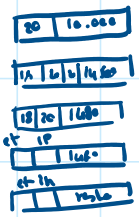
venerdì 31 maggio 2019 11:48

Esercizio modellazione



Esercizio speculativo





Esame 2006-07-03

sabato 1 giugno 2019 13:08

Segmento TCP = 10.000
header eth = 18 byte
bandwidth = 20 Kbyte/sec

Ipotizzo di non conoscere l'MTU

$\frac{10000}{65515} = 0.15 \Rightarrow 1$ segmenti TCP

$\frac{10000 + \#\text{segmenti} \cdot O_{TCP}}{65515} = 0.15 \Rightarrow 1$ datagramma

$\frac{1000 + \#\text{segmenti} \cdot O_{TCP} + \#\text{datagram} \cdot O_{IP}}{1500} = 6,69 \Rightarrow 7$ frame

Esame 20/2/2013

sabato 1 giugno 2019 13:28

$\lambda = 50$ requests/second

4 CPU working in parallel

Raid 1 disk (8+8)

ethernet = 100 Mbit/s

router delay = 100 μsec

router-ISP = 1 Gigabit/sec

file-req = 400 bytes

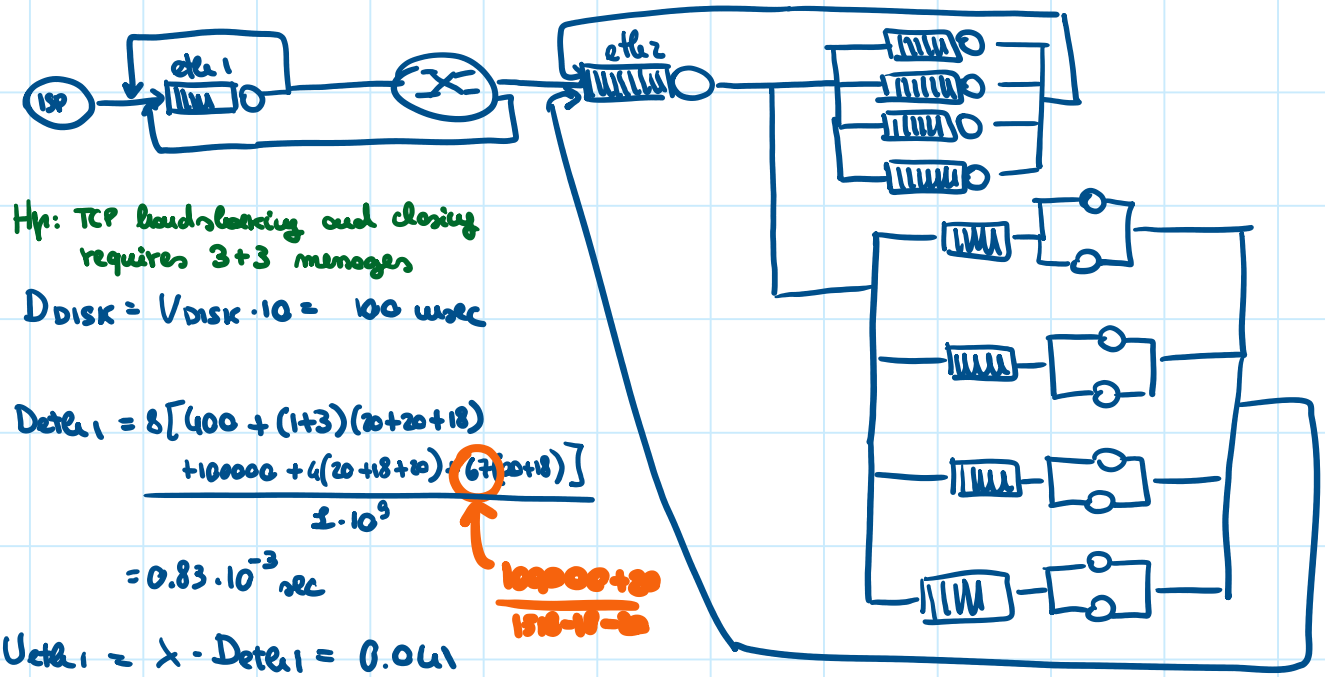
file = 100000 bytes

S_{CPU} = 20 sec × request

S_{disk} = 10000 bytes in 10 msec

R = ?

bottleneck?



Hp: TCP load balancing and closing requires 3+3 messages

$D_{DISK} = V_{DISK} \cdot 10 = 100$ msec

$$D_{eth1} = 8\left[400 + (1+3)(20+20+18) + 100000 + 4(20+18+20) + 67(20+18)\right] / 1 \cdot 10^9$$

$$= 0.83 \cdot 10^{-3} \text{ sec}$$

$U_{eth1} = \lambda \cdot D_{eth1} = 0.041$

$$R_{eth1} = \frac{D}{1-U} = \frac{0{,}83 \cdot 10^{-3}}{1 - 0.041} = 8{,}73 \cdot 10^{-4} \text{ sec}$$

$R_{Router} = D_{router} = \text{latency} \cdot (75) \approx 7.6 \cdot 10^{-6}$

Eth2: 2 volte la request + 1 volta il file

$$S_{ETH2,req} = \frac{8\left[(3+1)(20+20+18) + 400\right]}{100 \cdot 10^6} = 5{,}05 \cdot 10^{-5} \text{ sec}$$

$$S_{ETH,file} = \frac{8\left[(4)(20+20+18) + 67(20+18) + 100000\right]}{100 \cdot 10^6} = 8.3 \cdot 10^{-3}$$

$D_{eth2} = 2 \cdot 5{,}05 \cdot 10^{-5} \text{ sec} = 10{,}1 \cdot 10^{-5}$ sec

$D_{eth2,file} = 8{,}3 \cdot 10^{-3}$ sec

$D_{eth2} = 8{,}43 \cdot 10^{-5}$ sec

$U_{ETH2} = \lambda \cdot D_{ETH2} = 50 \cdot 8{,}43 \cdot 10^{-3} = 0.42$ sec

$R_{ETH2} = \frac{D}{1-U} = 0.014$ sec

$R_{ETH2} = \frac{D}{1-U} = 0.814$ ms

$U_{CPU} = \frac{\lambda}{4} \cdot D_{CPU} = \frac{30}{4} \cdot S_{CPU} = 0.25$

$R_{CPU} = \frac{0.025}{1-0.25} = 0,26$

$D_{coppia} = \frac{100}{2}$ msec $= 50$ msec

$U_{coppia} = \frac{\lambda}{4} \cdot D_{coppia} = 0,625 = U_{raid}$

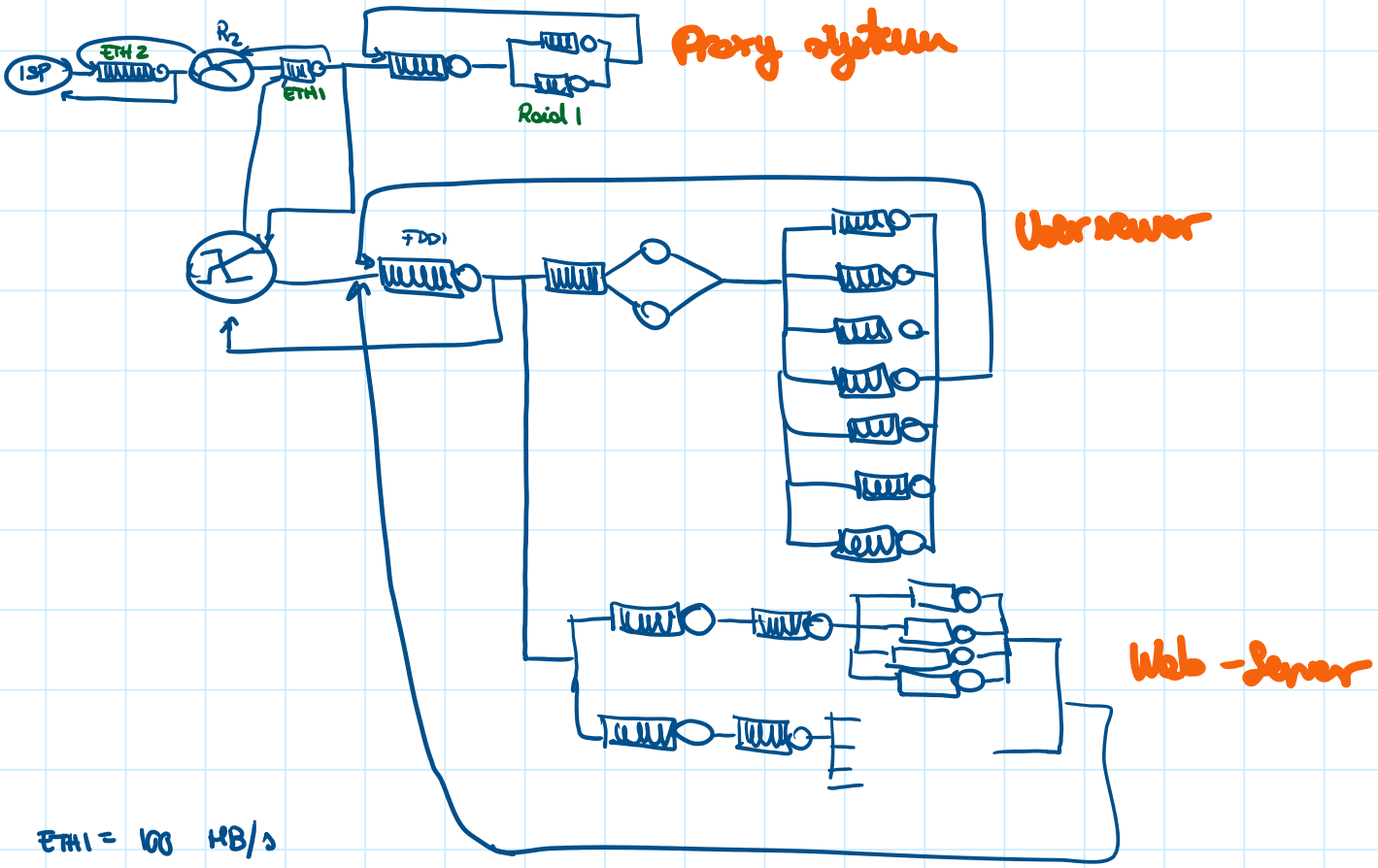
$R = \frac{D}{1-U} = 0.133$

$R_{sistema} = \sum R_i$

$Bottleneck = \underset{i \in I}{\text{argmax}}\{U_i\}$ || sottosistema con U più alto

24 Maggio 2012

sabato 1 giugno 2019 14:32



ETH1 = 100 MB/s

FDDI = 300 MB/s

routers delay = 1 ms

ETH2 = 16

Probabilità FS = 30%

Prob WS = 70%

Prob HIT cache = 50%

$F_{File-server}$ = 30 Kbytes

$F_{File\ WS}$ = 200 Kbytes

Request = 400 bytes

$S_{USER,CPU}$ = 30 msec

$S_{User,DISK}$ = 30 msec

$S_{web,CPU}$ = 50 msec

S_{web,FS_CPU} = 30 msec

$S_{web,DISK}$ = 400 msec

$S_{proxy,CPU_{HIT}}$ = 10 msec

$S_{proxy,CPU/D,min}$ = 20 msec

$$ETH2 = \frac{\{[(3+1)\,58 + 400 + [(2+3)\cdot 58 + 30000]\,0.3 + [(27\cdot 3)\cdot 58 + 200.000]\cdot 0.7\}\cdot 0.8}{1\cdot 10^8} = 1.24\cdot 10^{-3}\ sec$$

$U_{ETH_2} = \lambda \cdot D_{ETH_2} = 3.72\cdot 10^{-3}$

$R_{ETH2} = \frac{D_{ETH2}}{1-U} = 1.24\cdot 10^{-3}$ sec

$R_{router2} = delay \cdot \#requests = 1\cdot 10^{-3}\cdot (4 + 24\cdot 0.3 + 140\cdot 0.7) = 0.105$ sec

ETH1

$$D_{ETH1} = [4\cdot 58 + 400]\cdot 0.3 + [24\cdot 58 + 30000]\cdot 0.3 + P_{HIT}\cdot (4\cdot 58 + 400 + (140\cdot 58 + 200.000)) + 2P_{miss}(4\cdot 58 + 400 + 140\cdot 58 + 200.000)\Big/ 100\cdot 10^6 = 2{,}28\cdot 10^{-3}$$

$U_{ETH1} = \lambda \cdot D_{ETH1} = 6{,}84\cdot 10^{-3}$

$U_{ETH1} = \lambda \cdot D_{ETH1} = 6{,}84 \cdot 10^{-3}$

$R_{ETH1} = D_{ETH1} / (1 - U_{ETH1}) = 4.13 \cdot 10^{-3}$

FDDI

$D_{FDDI} = [4.68 + 400 + 24.68 + 30000] \cdot 0.3 + ([4.68 + 400 + 200000 + 140.68] \cdot 0.5) 0.7 = 1.65 \cdot 10^{-4}$

$U_{FDDI} = \lambda D_{FDDI} = 4.98 \cdot 10^{-4}$

$R_{FDDI} = \frac{D_{FDDI}}{1-U} = 1.66 \cdot 10^{-4}$ sec

Proxy

$D_{Proxy} = (10 \cdot P_{HIT} + 20 \cdot P_{MISS}) \cdot 0.7 \simeq 11 \cdot 10^{-3}$ sec

$U_{Proxy} = \lambda \cdot D_{Proxy} = 40 \cdot 10^{-3}$

$R_{Proxy} = 0.015$ sec

Filesystem

$D_{FS} = 60$ ms $\cdot 0.3$

$U_{FS} = \lambda \cdot D_{FS} = 0.054$

$R_{FS} = 0.063$ sec

WebServer

$D_{WebServer} = 50 + 30 + \frac{40}{4} = 80 \cdot 10^{-3}$ sec

$U_{WebServer} = 0.5 \cdot 0.7 \cdot \lambda \cdot D_{WebServer} = 0.067$

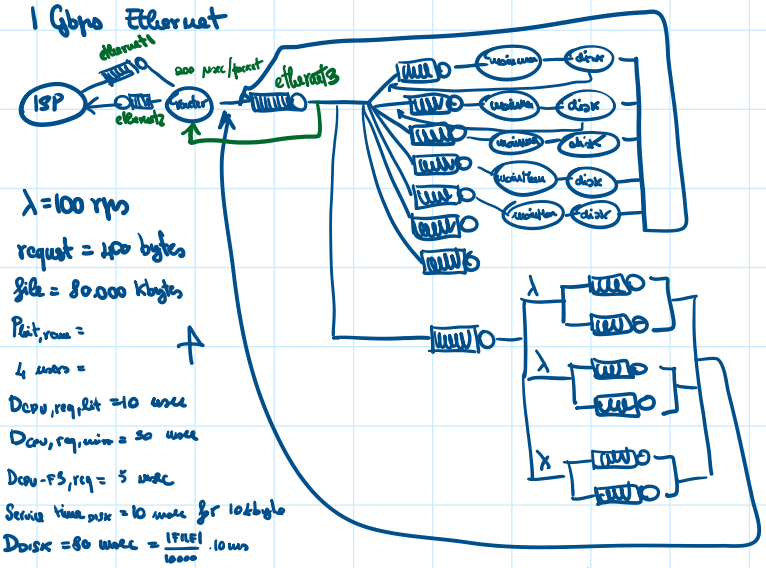
$R_{WebServer} = 0.094$ sec

$R_{TOT} = \sum_i \cdot R_i$

Esame

domenica 2 giugno 2019 16:04

1 Gbps Ethernet



$\lambda = 100$ rps

request = 400 bytes

file = 80.000 Kbytes

$P_{hit,ram}$ =

4 users =

$D_{CPU,req,hit} = 10$ msec

$D_{CPU,req,miss} = 30$ msec

$D_{CPU-FS,req} = 5$ msec

Service time disk = 10 msec for 10 Kbyte

$D_{DISK} = 80$ msec $= \frac{|FILE|}{10000} \cdot 10$ ms

Router

Drouter

ETH1

$D_{ETH1} = \frac{[(3+1)(58+20+8)+400]8}{1 \cdot 10^9} = 5 \cdot 10^{-6}$

$U_{ETH1} = \lambda \cdot D_{ETH1} =$

$R_{ETH1} = \frac{D_{ETH1}}{1-U} =$

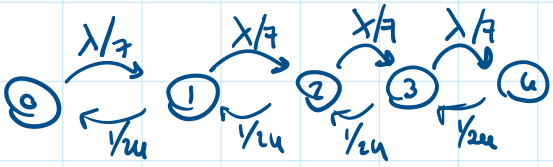
ETH2

$D_{ETH_2} = \frac{[5(38)+53(38)+80.000]}{1 \cdot 10^9} = 6{,}38 \cdot 10^{-6}$

devi tenere conto della prob di hit Ph

ETH3

$D_{ETH3} = \frac{0.3\,P_{hit}((3+1)(58)+1600+5 \cdot 38+53(38)+80.000) + 2P_{miss}((3+1)(38)+1600+5 \cdot 58+53(38)+80.000)}{1 \cdot 10^9} = 6{,}73 \cdot 10^{-4}$



CPU

$D_{CPU} = 10 \cdot 0.3 + 30 \cdot 0.7 = 24$

CPU-FS

$D_{CPU-FS} = 5$ ms

DISK

$D_{DISK} = 80$ msec $/2$

Available

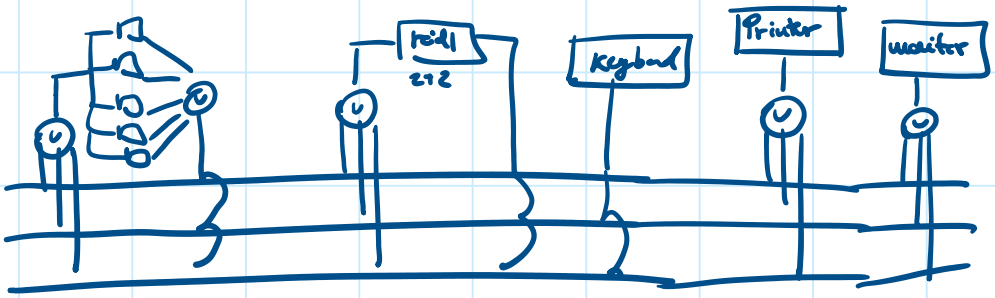
$A_{CPU} = 1 - (1 - A_{CPU})^2$

$A_{raid} = (1 - (1 - A_{DISK})^2)^4$

Esame 15-04-13

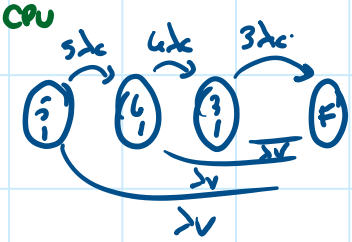
martedì 4 giugno 2019 13:59

Esercizio 1



Reliability

CPU



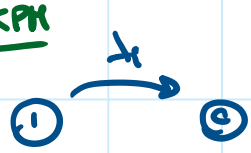
$$\dot{P}\binom{5}{1} = -P\binom{5}{1}(5\lambda c + \lambda v)$$

$$\dot{P}\binom{4}{1} = -P\binom{4}{1}(4\lambda c + \lambda v) + P\binom{5}{1}5\lambda c$$

$$\dot{P}\binom{3}{1} = -P\binom{3}{1}(3\lambda c + \lambda v) + P\binom{4}{1}4\lambda c$$

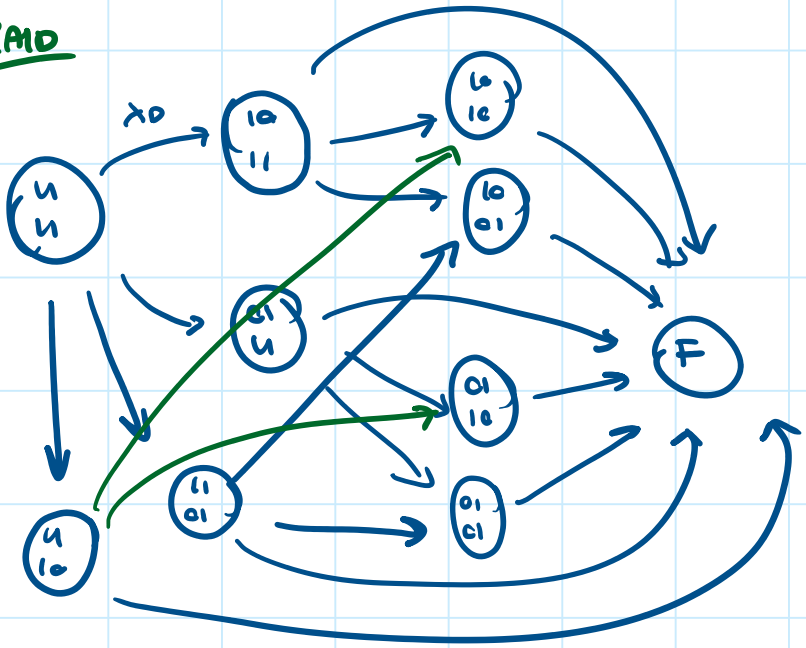
$$\dot{P}(F) = P\binom{3}{1}$$

KPH

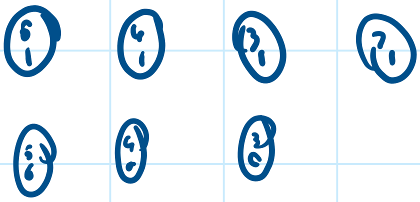


BUS+VOT

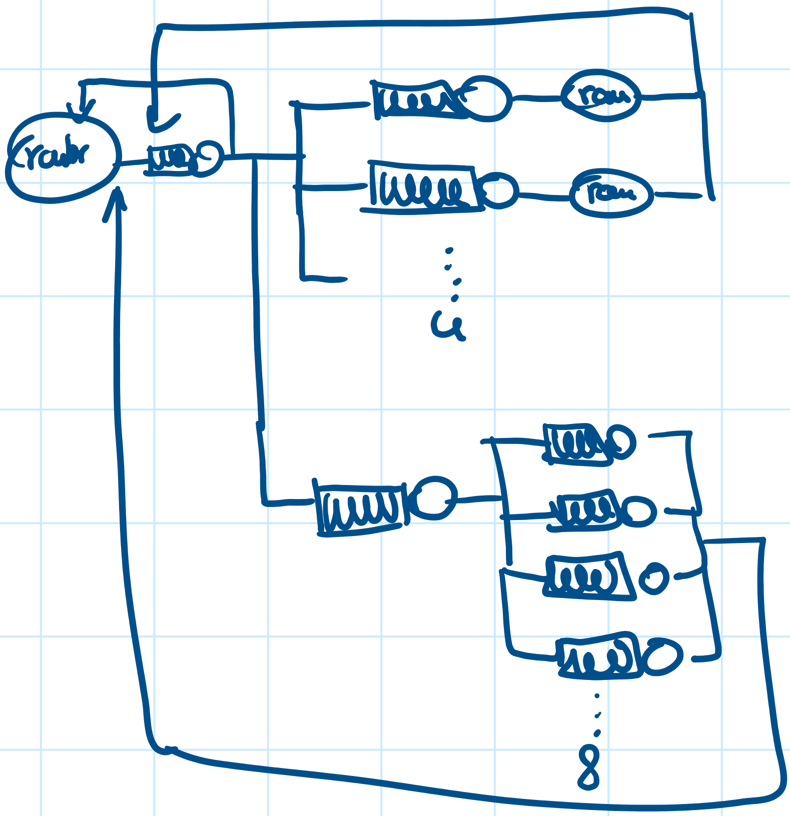
RAID



Availability



Esercizio 3



$\lambda = 100$ r/s

ETH = 2 GB/s

FILE = 100 kbytes

Request = 500 bytes

$D_{CPU,HIT} = 5$ us

$D_{CPU,MISS} = 10$ us

$D_{CPU-FS} = 10$ us

$D_{DISK} = 10$ ms

$D_{CPU} = 0.5 \cdot (5 \text{ us}) + 0.5(10) = 7.5$

$D_{DISK} = 0.5 \cdot 10 \text{ us} = 5$

$D_{CPU-server} = 0.5 \cdot 10 \text{ us} = 5$

$D_{max} = 7.5 \Rightarrow \lambda_s = 133$

$D_{ETH} = [(3 \overset{+3}{+} 1)(58) + 500 + 2(58) + 66(38) + 100.000]\,P_{hit}$
$+ 2P_{miss}((6) \cdot 58 + \text{quello dentro al } P_{hit}) \;/\; 2 \cdot 10^9$

$U_{server} = \frac{\lambda}{\ } \cdot 7.5 \cdot 10^{-3} = 0.18$

$U_{server} = \frac{\lambda}{\mu} \cdot 7.5 \cdot 10^{-3} = 0.18$

$U_{CPUs} = \lambda \cdot 5.6^{-3} = 0.5$

$U_{DISK} = \lambda / \beta \cdot 3 \cdot 10^{-3} = 0.06$

$R_i = \frac{D_i}{1 - U_i}$ $\uparrow throughput = \lambda \Rightarrow$ resta valida

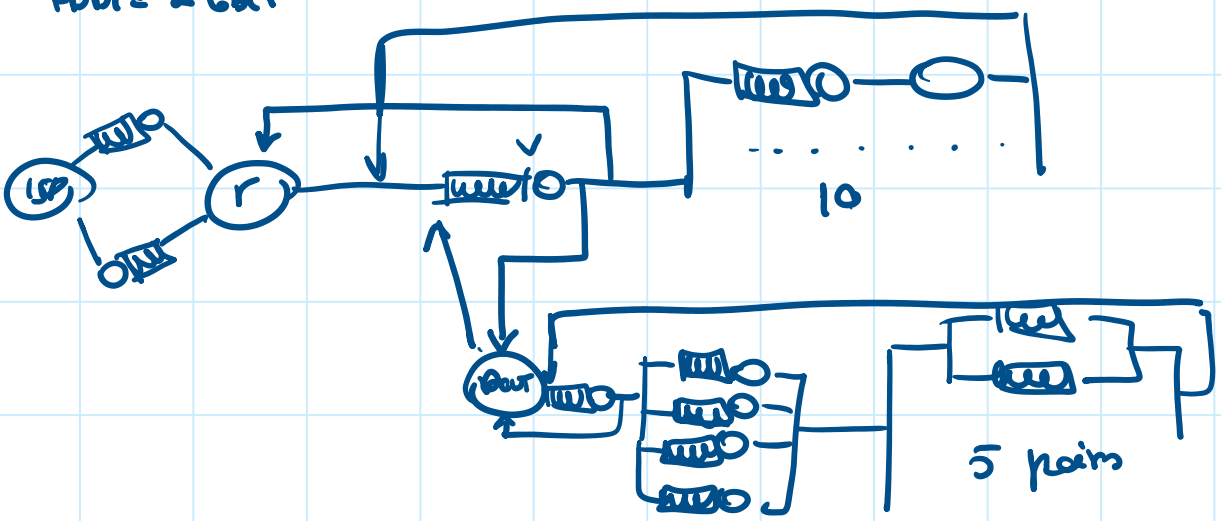
Esame 11/02/2016

martedì 4 giugno 2019 15:15

$\lambda = 300$ rps
Irequest = 600 bytes
ETH = 1 Gbit
FDDI = 2 Gbit

$D_{CPU,H} = 10$ ms
$D_{CPU,M} = 20$ ms
$D_{CPU,FS} = 10$ msec

|FILE| = 100 kbytes
$p_{HIT} = 50\%$



$$D_{DISK} = \frac{100.000}{10.000} \cdot \frac{1}{2} \cdot 10 = 50\,ms$$

$$D_{ELAB} = \frac{8[400 + 4 \cdot 38]}{256 \cdot 10^6} = 1{,}37 \cdot 10^{-3}\,sec$$

$$D_{ELAB,out} = \frac{\lceil 100.000 + 68\,(20 \cdot 18) + 3 \cdot 58 \rceil 8}{256 \cdot 10^6} = 3.21$$

$$R_{in} = \frac{D_{in}}{1 - U_{in}} \qquad U_{in} = \lambda \cdot D_{in}$$

Esame 22/03/2016

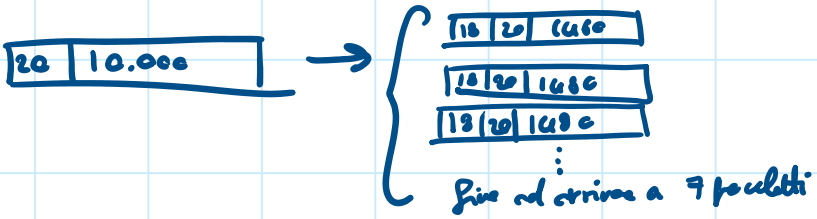
martedì 4 giugno 2019 16:09

Esercizio 2

10.000 byte to send

element = 18 header

$\frac{10.000 + 20}{1480} = 6,7$ 7 pacchetti



Alternative

Esame 22/5/2017

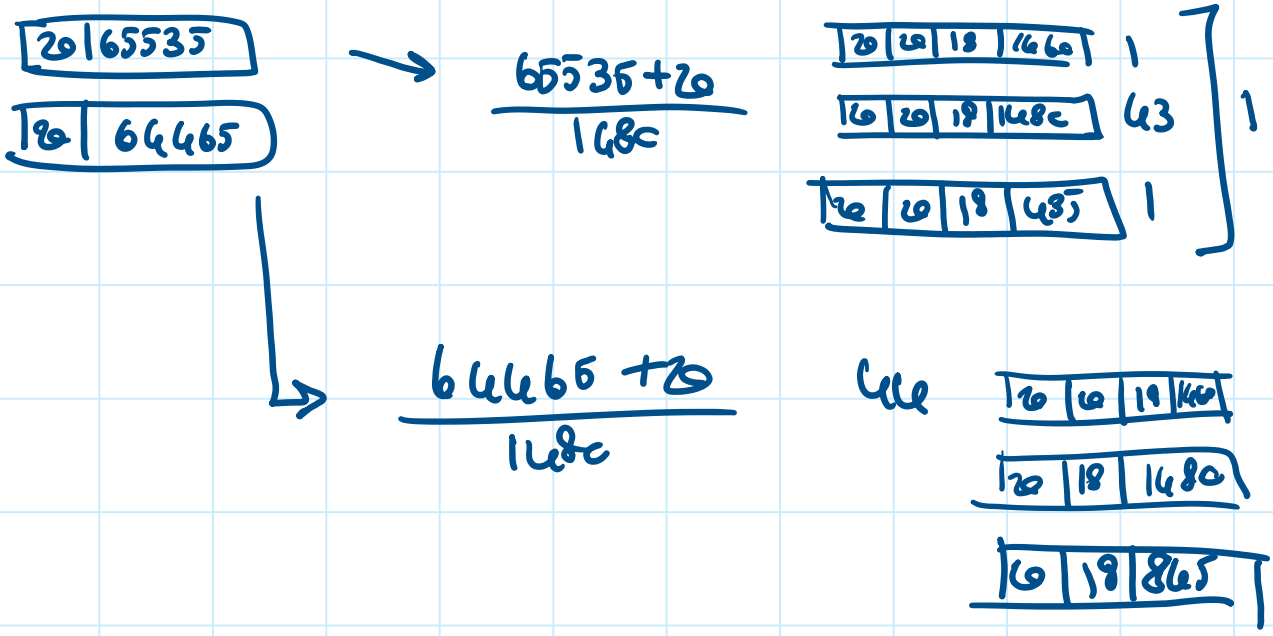
martedì 4 giugno 2019 17:50

Esercizio 2

TCP segment = 130.000

M. frammenti = $\frac{130.000}{65535} = 1.7 \cdot 2$

M. datagrammi = $\frac{130.000 + 2 \cdot 20}{1480} = 88$ pacchetti



$2(58) + 87(38) + 130.000$

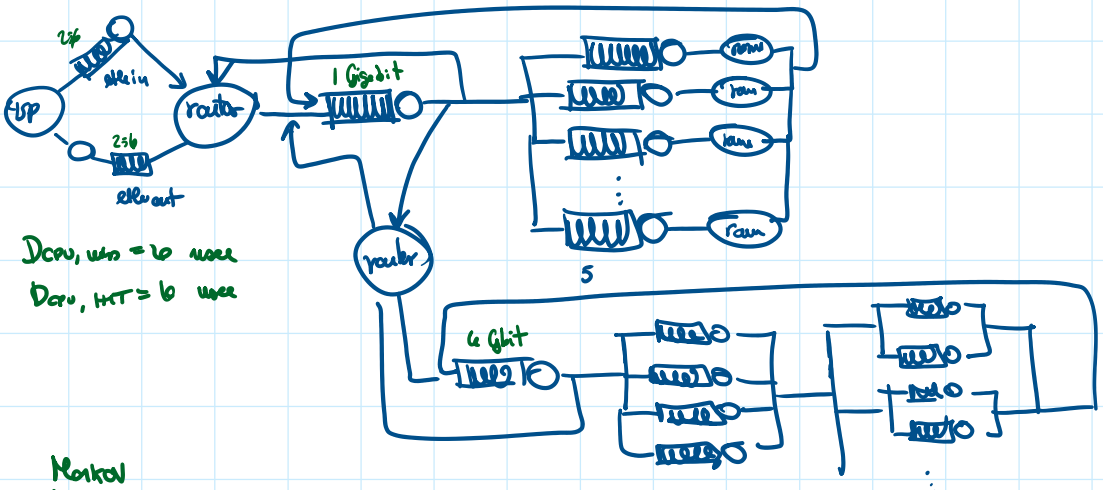
Esame 4/24/2015

martedì 4 giugno 2019 18:12

$\lambda = 100$ rps

|request| = 400 bytes

|file| = 200 kbyte



$D_{CPU,user} = 10$ msec

$D_{CPU,HTT} = 6$ msec

Markov

$D_{CPU} = 0.7 \cdot 10 + 0.3 \cdot 26 = 7 + 6 = 13$ msec (10 cpu bound)

$\mu = 1/13 \cdot 10^{-3} = 77$

$$\begin{cases} P_0 \lambda/5 = P_1 \mu \\ P_1 \lambda/5 = P_2 \mu \\ P_2 \lambda/5 = P_3 \mu \\ \sum_i P_i \end{cases}$$

$P_0 = 0{,}75$

$P_1 = 0{,}18$

$P_2 = 0{,}04$

$P_3 = 0{,}01$

Eth in

$D_{eth,in} = \frac{((3+1)58 + 400)}{256 \cdot 10^6} = 2{,}46 \cdot 10^{-6}$

$U_{eth,in} = \lambda \cdot 2{,}46 \cdot 10^{-6} = 7{,}46 \cdot 10^{-4}$

$R = \frac{D}{1-U}$

Eth out

$D = \frac{3 \cdot 58 + 4 \cdot 20 + (45 \cdot 3 + 3)(38) + 200000}{256 \cdot 10^6} = 8{,}02 \cdot 10^{-4}$

$U = \left(P_{last}((1-P_3) \cdot \lambda \cdot D) + P_{twice}((1-P_3)^2 \cdot \lambda \cdot D\right) = 0.078$

$R = \frac{D}{U-1}$

Router

$n = (1-P_3)(4 + (45 \cdot 3 + 3) + P_3(4) = 141$

$D = 1.4 \cdot 10^{-3}$

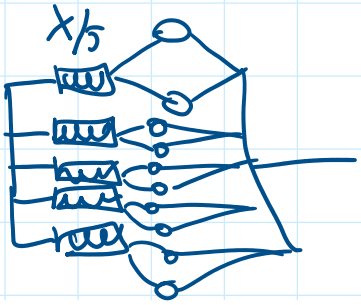
$R = D$

Eth out

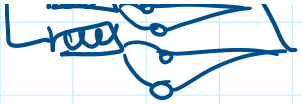
$D = \left[P_{last}(400 + (4 \cdot 38) + (1-P_3)(4 \cdot 20 + 4 \cdot 38 + (4 + (45 \cdot 3 + 3)38 + 200.000)) + 2P_{twice}\left((1-P_3)(400 \cdot 4 \cdot 38 + 45 \cdot 3 \cdot 38 + 4 \cdot 20 \cdot 4 \cdot 38) + P_3(400 \cdot 4 \cdot 38)\right)\right] \cdot 8$ / $1 \cdot 10^{-3}$

$U = \lambda \cdot D$

$R =$



Disk



$R =$

CPU

$D = (1-P_2)(P_{vis} \cdot 20ms + P_{ret} \cdot 10) =$

$U = \lambda \cdot D$

$R = D/(1-U)$

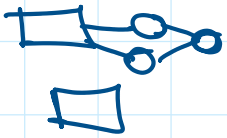
Disk

$D = \frac{20000}{2 \cdot (20000)} \cdot 10ms = 50\ ms$

$U = (P_{vis})(1-P_2)\, D \cdot \lambda = 1.5$

$R =$

Food



$$D = \frac{P_{vis}\left((1-P_2)(400 \cdot 4 \cdot 58 + 4 \cdot 20 + 3 \cdot 58 + (45 \cdot 3 + 3)38\right) \cdot 8}{4 \cdot 10^9}$$

$U = \lambda \cdot D$

$R = D/(1-U)$

1649040

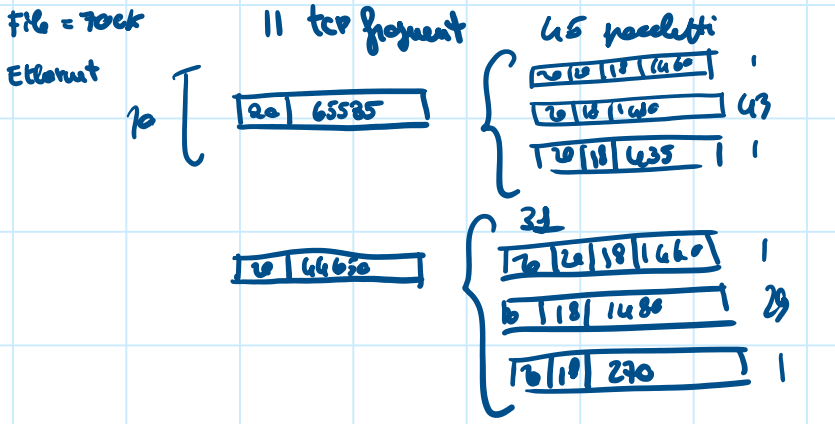
$D = 0.5 \cdot (40)$

$10 \cdot 20$

Esame 16/06/11

mercoledì 5 giugno 2019 10:19

Esercizio 2



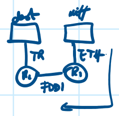
$$\frac{10(58 + 38 \cdot 44 + 65535) + (58 + 38(30) + 44650)}{20 \cdot 10^6}$$

Esame 03/07/2006

mercoledì 5 giugno 2019 10:34

Esercizio 2

200.000



200K = 4 TCP segments

|20|65535| ×4

|20|62140| ×1

{ |20|20|18|1460| 1
|20|18|1480| 43
|20|18|435| 1 }

→ { 42
|20|20|18|1460| 1
|20|18|1480| 40
|20|18|1480| 1 }

Su FDDI e TR sostituiamo ethernet header con 28

Invertiamo l'ordine

200.000 TCP fragment = 4 fragment

|20|65535| 3

|20|3335|

{ 15 pacchetti
|20|20|28|4432| 1
|20|28|4452| 13
|20|28|3227| 1 }

→ { |20|20|28|3335| }

Ethernet level

3 { |20|20|28|4432| → 4 pacchetti { |20|20|18|1460| 1
|20|18|1480| 2
|20|18|12| }

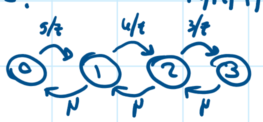
|20|28|4452| → { |20|18|1480| 3
|20|18|12| 1 }

|20|28|3227| } → 3 pacchetti { |20|18|1480| 2
|20|18|267| 1 }

20|20|10|3335| → 3 { |20|20|28|1460| · 1
|20|28|1480| 1
|20|28|455| }

Esercizio n.3

$\bar{R}$=? M/M/1/3/5



Service rate = 10 sec

$$\begin{cases} P(0)\,5/7 = P_1\mu \\ P(1)\,4/7 = P_2\mu \\ P(2)\,3/7 = P_3\mu \\ \sum_i P_i = 1 \end{cases}$$

P_0, P_1, P_2, P_3

$N = \sum_1^3 i \cdot P_i$

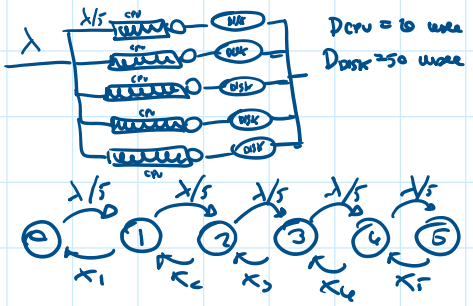
$X = \sum_1^3 N_i \cdot P_i$

$R = N/X$

Esercizio n.4

Esercizio 11.4

$\lambda = 25$ req/s cluster da 5 server



Caso u=1

$R_{CPU} = 20$ ms
$R_{DISK} = 50$ ms
$X_{TOT} = 1/\tau_C = 14.28$

$N_{CPU} = 0.28$
$N_{DISK} = 0.714$

Caso u=7

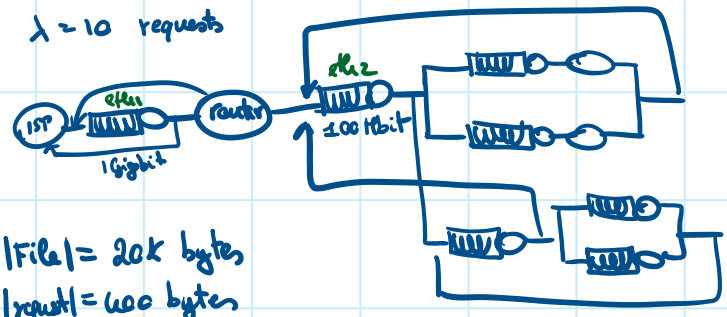
$R_{CPU} = 20(1 + 0.28) = 25.6$
$R_{DISK} = 50(1 + 0.7u) = 85$ ...
$X_{TOT} = 3/m = 18$
$N_{CPU} = 0.46$
$N_{DISK} = 1.53$

$$\begin{cases} P_0 \cdot \lambda/5 = P_1 X_1 \\ P_1 \cdot \lambda/5 = P_2 X_2 \\ P_2 \cdot \lambda/5 = P_3 X_3 \\ P_3 \cdot \lambda/5 = P_4 X_4 \\ P_4 \cdot \lambda/5 = P_5 X_5 \end{cases}$$

$$\overline{X} = A_{5\,\text{serv}}(P_1 \cdot X_1 + P_2 \cdot X_2 \cdots) + \binom{5}{1}(A)^4(1-A)(P_1 \cdot X_1 + P_2 \cdot X_2 \cdots) + \binom{5}{2}(A)^3(1-A)^2(P_1 \cdots)$$
$$+ \binom{5}{3}(A)^2(1-A)^3(P_1 \cdots) + \binom{5}{4}(A)(1-A)^4(P X_1 \cdots)$$

Esame 15/11/2012

mercoledì 5 giugno 2019 15:42



|File| = 20k bytes
|request| = 400 bytes
$D_{CPU,client}$ = 10 msec
$D_{CPU,S}$ = 20 msec
$D_{CPU,FS}$ = 10 msec
D_{Disk} = 20 msec

$P_{miss} = 0.5$
$P_{hit} = 0.5$
MTTF = 100.000 hours
MTTR = 1 hour

Delta =

$$Delta = \frac{8[4.58 + 400 + 6.58 + 13(38) + 20.000]}{1 \cdot 10^9} = 1.7 \cdot 10^{-4}$$

$U = 1.7 \cdot 10^{-3}$

$R = \frac{D}{1-U} = 1.7 \cdot 10^{-4}$

Router

m = 21 packets

$D = 20 \cdot delay = 2.1 \cdot 10^{-3}$

Delta2

$$6.58 + 1.5(2.58 + 400 + 2000 + 13.38)$$

$$Delta_2 = 8[P_{hit}(1.58 + 400 + 4 \cdot 58 + 13(38) + 2000) + 2P_{miss}(1.58 + 400 + 1.58 + 13(38) + 100 eq)] = 2.55 \cdot 10^{-3}$$

$U = 10 \cdot 2.55 \cdot 10^{-3} = 2.55 \cdot 10^{-2}$

$R = \frac{2.55 \cdot 10^{-3}}{1 - 2.55 \cdot 10^{-2}} = 2,61 \cdot 10^{-3}$

CPU

$D_{CPU} = 0.5 \cdot 10 + 0.5 \cdot 20 = 15$

$U = 10 \cdot 15 \cdot 10^{-3} = 75 \cdot 10^{-3}$

$R = \frac{15 \cdot 10^{-3}}{1 - 75 \cdot 10^{-3}} = 0,01$ sec

CPU - FS

$D = 0.5 \cdot 10$ ms $= 5 \cdot 10^{-3}$ ms

$U = 10 \cdot 5 \cdot 10^{-3} = 0.05$

$R = \frac{5 \cdot 10^{-3}}{1 - 0.05} = 5.26 \cdot 10^{-3}$

FS

$D_{Disk} = 0.5 \cdot 20$ msec $= 10 \cdot 10^{-3}$ msec

$U = 0.5 \cdot 10 \cdot 10 \cdot 10^{-3} = 0.05$

$R = \frac{D}{1-U} = 0.010$ sec

$V = 0.5 \cdot 10 \cdot 10 \cdot 16 =$

$R = \frac{D}{1-V} = 0.010$ sec