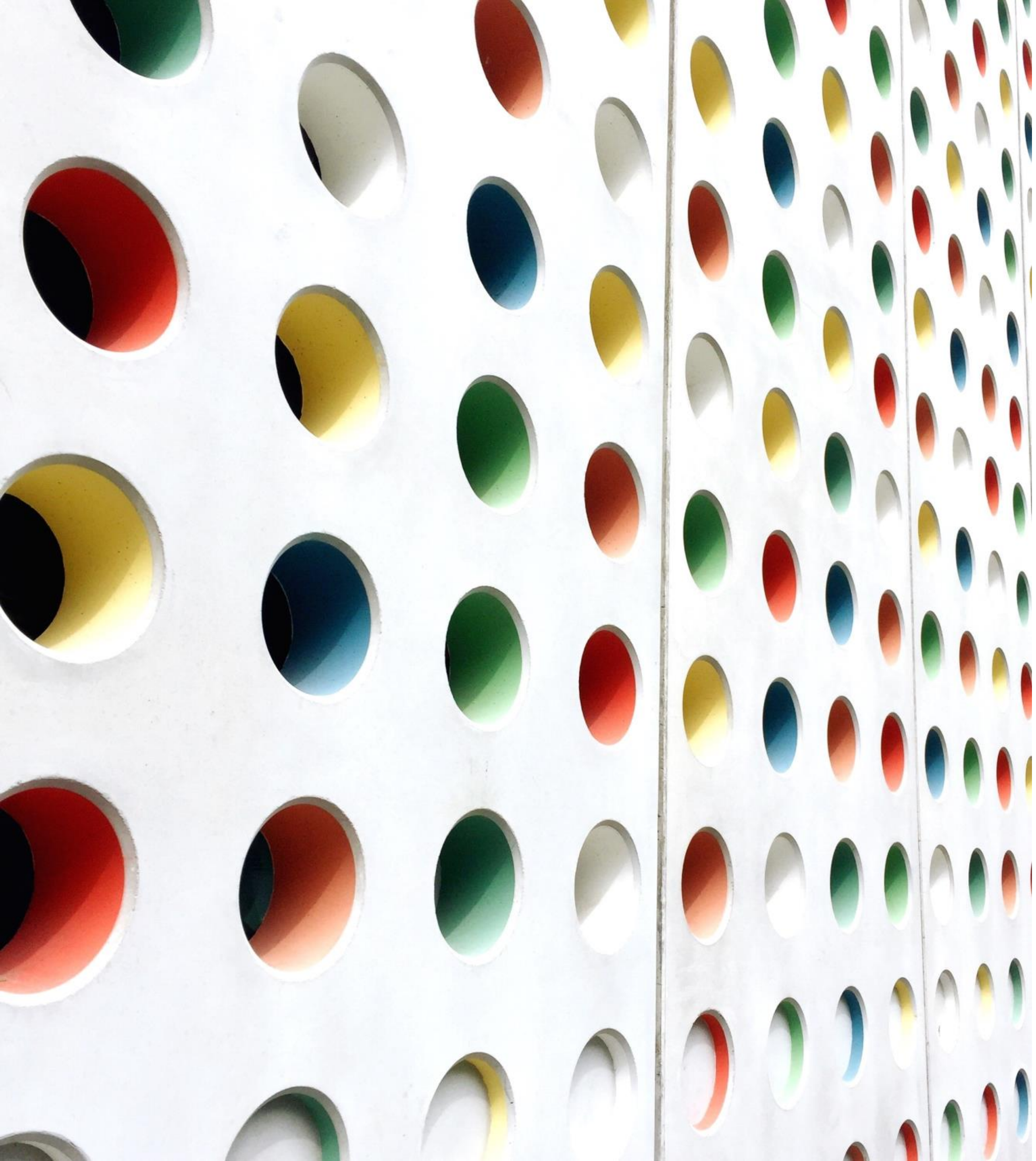

Availability from State Graph

M2 RSID SFS 2022

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Markov Chain: Calculate Availability

DRAW AND DETECT DOWNTIME STATES

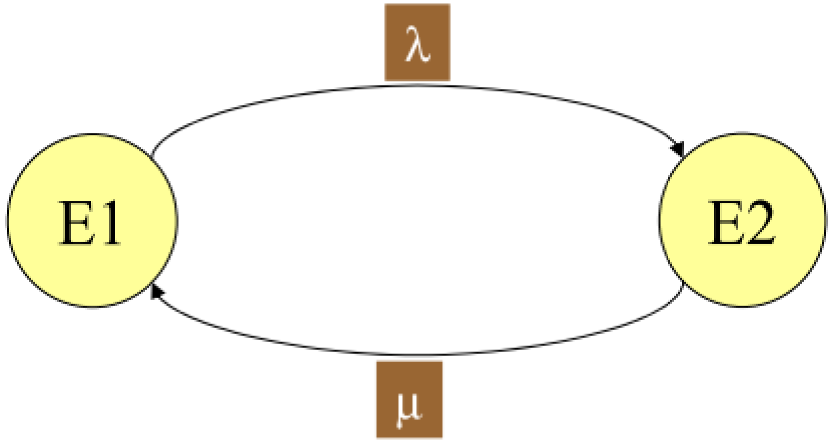
ESTABLISH THE TRANSITION MATRIX.

SOLVING A SYSTEM OF EQUATIONS .

Markov Chain: What Equations

Transition Matrix
P vector of probabilities to remain in states
Sum of P=1
Sum of P.M=0

Markov Chain: Example 1
Repairable Component



Transition Matrix M

$$M = \begin{pmatrix} -\lambda & \lambda \\ \mu & -\mu \end{pmatrix}$$

$$p.M = 0$$

$$p1 + p2 = 1$$

$$\Rightarrow$$

Solving the equations

$$p.M = 0$$

$$p1 + p2 = 1$$

$$\Rightarrow$$

$$P.M = \begin{pmatrix} -\lambda.p1 & \lambda.p1 \\ \mu.p2 & -\mu.p2 \end{pmatrix}$$

$$P1 + P2 = 1$$

$$\Rightarrow -\lambda.p1 + \mu.p2 = 0$$

$$\lambda.p1 - \mu.p2 = 0$$

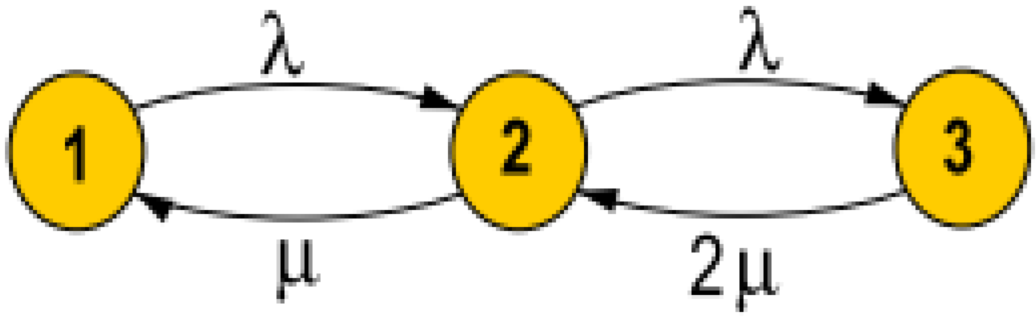
$$P1 + P2 = 1$$

Calculation of availability A=P2

$$\lambda P_1 = \mu P_2$$
$$P_1 + P_2 = 1$$

$$P_1 = \mu/(\lambda+\mu)$$
$$P_2 = \lambda/(\lambda+\mu)$$

2 identical repairable components in passive redundancies



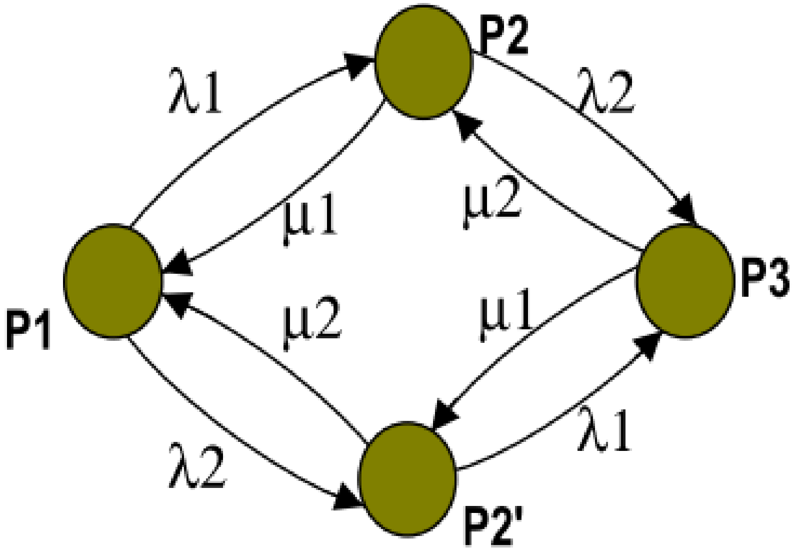
Hypothesis: switching and Sensing Organs are perfect ,

Sate 1 , 2: available

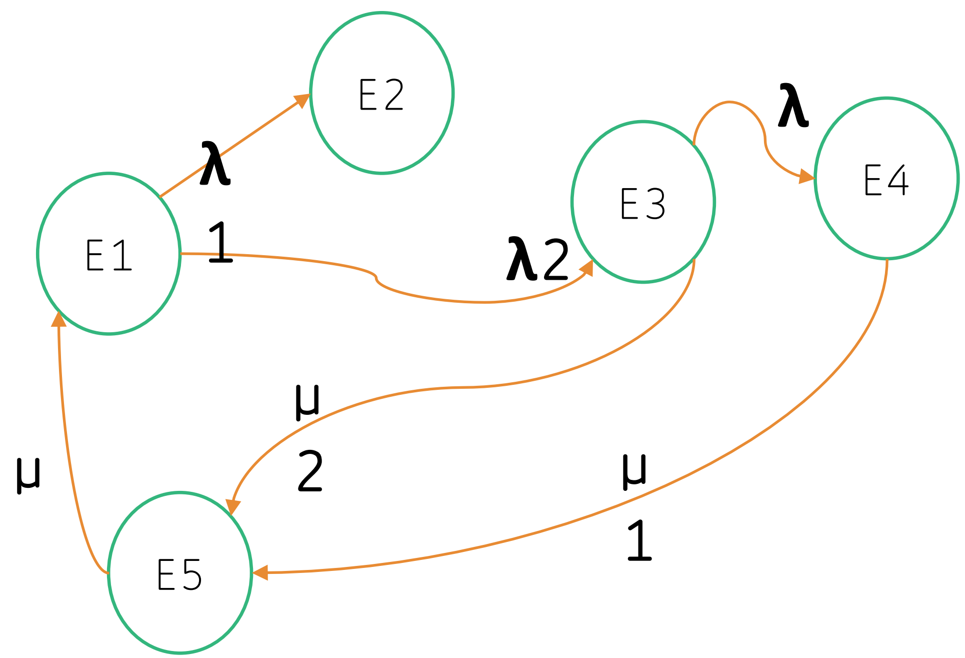
State 3 unavailable

A=1-P3

2 components repairable in active redundancies

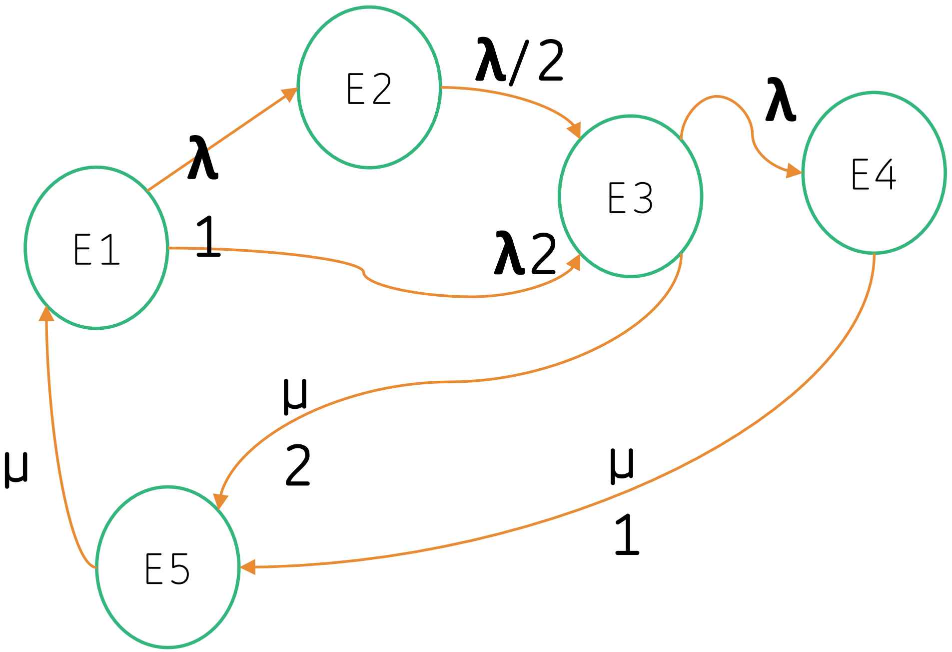


Availability Estimation example: E2 and E4 unavailable



Transition Matrix M

$$M=\begin{matrix} -\lambda 1-\lambda 2 & \lambda 1 & \lambda 2 & 0 & 0 \\ 0 & -\boldsymbol{\lambda}/2 & \boldsymbol{\lambda}/2 & 0 & 0 \\ 0 & 0 & -\lambda-\mu 2 & \lambda & \mu 2 \\ 0 & 0 & 0 & -\mu 1 & \mu 1 \\ \mu & 0 & 0 & 0 & -\mu \end{matrix}$$



Equations resolution

$$\begin{matrix} -\lambda1-\lambda2 & \lambda1 & \lambda2 & 0 & 0 \\ 0 & -\boldsymbol{\lambda}/2 & \boldsymbol{\lambda}/2 & 0 & 0 \\ 0 & 0 & -\lambda-\mu2 & \lambda & \mu2 \\ 0 & 0 & 0 & -\mu1 & \mu1 \\ \mu & 0 & 0 & 0 & -\mu \end{matrix}$$

$$p.M = 0$$

$$\sum P = 1$$

$$\Rightarrow$$

$(-\lambda1-\lambda2)P1 + \mu.P5 = 0$

$\lambda1, P1 - \frac{\lambda}{2} P2 = 0$

$\lambda2, P1 + \frac{\lambda}{2} P2 + (-\lambda-\mu2)P3 = 0$

$\lambda, P3 - \mu1.P4 = 0$

$\mu2.P3 + \mu1\ P4 - \mu.P5 = 0$

Availability evaluation A=P2+P4

$(-\lambda 1-\lambda 2)P1+\mu.P5=0$

$\lambda 1, P1-\frac{\lambda}{2}P2=0$

$\lambda 2, P1+\frac{\lambda}{2}P2+(-\lambda-\mu 2)P3=0$

$\lambda, P3-\mu 1.P4=0$

$\mu 2, P3+\mu 1\ P4-\mu.P5=0$

$\lambda 1=0,5/\lambda 2=0,2$

$\lambda=0,3$

$\mu 1=0,4$

$\mu 2=0,7$

$\mu=0,1$

$(-0,7)P1+0,1.P5=0$

$0,5\ P1-0,15\ P2=0$

$0,2\ P1+0,15\ P2-P3=0$

$0,3\ P3-0,4\ P4=0$

$0,7\ P3+0,4\ P4-0,1\ .P5=0$

$p1+p2+p3+p4+p5=1$