

Stochastic Reward Net (SRN)

- Introduced by Ciardo, Muppala and Trivedi [1989]
- Structural characteristics
 - Extensive Marking dependency allowed for firing rates and firing probabilities
 - Transition Priorities
 - Guards (Enabling functions) for Transitions
 - Variable cardinality arcs

1

Stochastic Reward Net (SRN)

- Stochastic characteristics
 - Allow definition of reward rates in terms of net level entities
 - Automatically generate the reward rates for the markings
 - Enables computation of required measures of interest

2

Example: Multiprocessor with failure

- Number of processors: n
- Single repair facility is shared by all processors
- A reconfiguration is needed after a covered fault
- A reboot is required after an uncovered fault

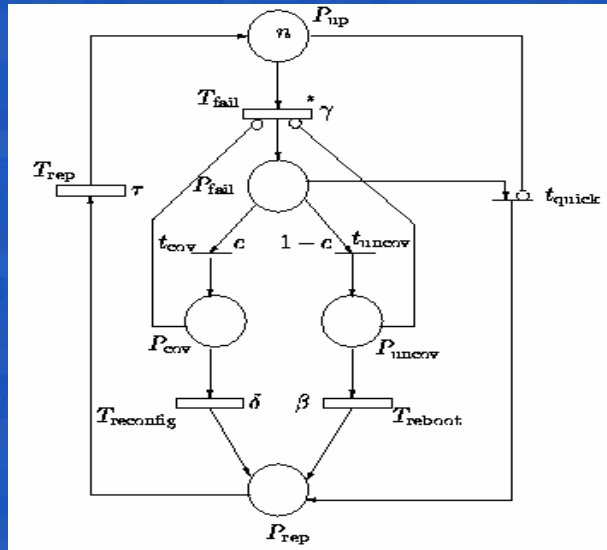
3

Assumptions:

- The failure rate of each processor is γ
- The repair times are exponentially distributed with mean $1/\tau$
- A processor fault is covered with probability c
- The reconfiguration times and the reboot times are exponentially distributed with parameter δ and β , respectively

4

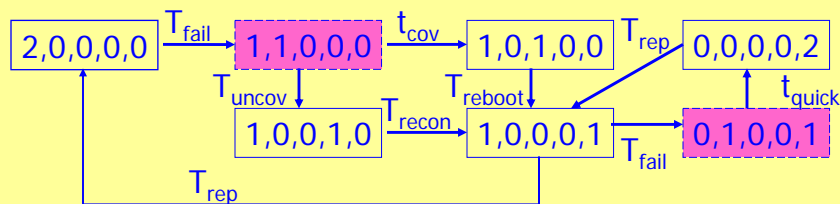
GSPN Model for Multiprocessor



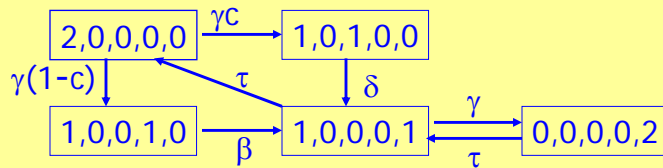
GSPN Model of a Multiprocessor

5

ERG for Multiprocessor Model (n=2)



Extended Reachability Graph for Multiprocessor model



Reduced ERG for Multiprocessor model

6

Example: Reward Rates for Multiprocessor Availability

- Reward rate at the net level for steady –state availability

$$r_i = \begin{cases} 1, & \#P_{up} \geq 1 \text{ and } (\#P_{cov} + \#P_{uncov}) = 0 \\ 0, & \text{otherwise} \end{cases}$$

- Reward rate at the CTMC level for steady-state availability (n=2)

$$r_i = \begin{cases} 1, & i = (2,0,0,0,0), (1,0,0,0,1) \\ 0, & \text{otherwise} \end{cases}$$

7

Analysis Procedure of SRN

Stochastic Reward Nets

Reachability Analysis

Extended Reachability Graphs

Eliminates vanishing markings

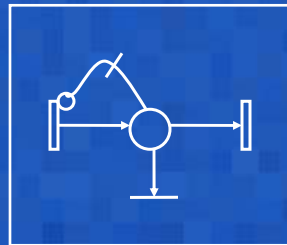
Markov Reward Model

Solve MRM (transient or steady-state)

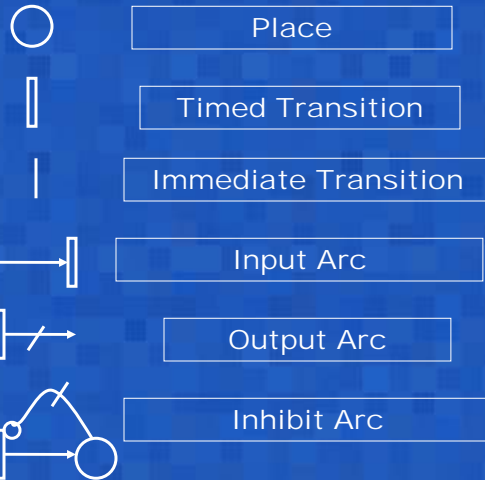
Measures of Interest

8

SRN Summary



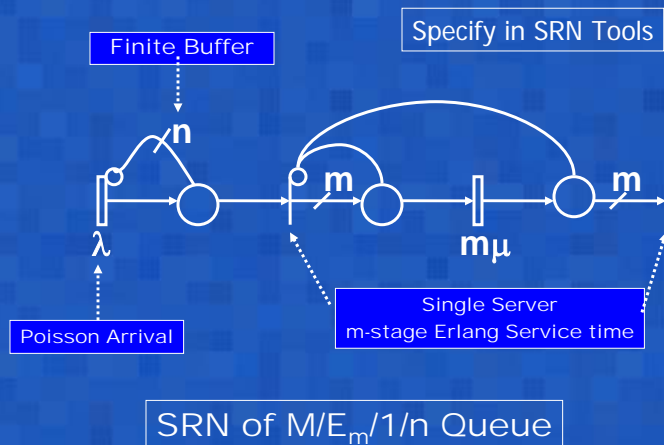
An SRN



9

SRN Analysis: Step-1

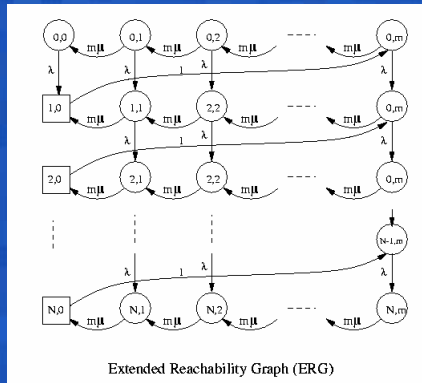
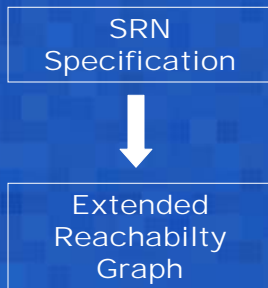
- Abstract the system -> SRN Model



10

SRN Analysis: Step-2

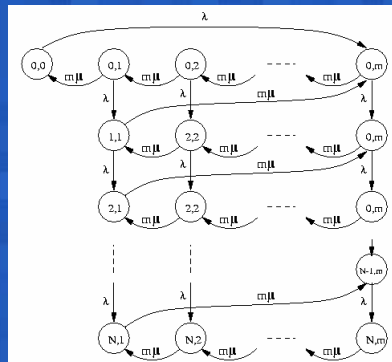
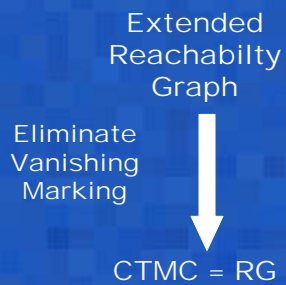
- Reachability Analysis: Automatically Generate ERG



□ Vanishing Marking ○ Tangible Marking

SRN Analysis: Step-3

- Reachability Analysis: Automatically Generate RG



□ ~~×~~ ○ ✓

12

SRN Analysis: Step-4

- Solve CTMC
 - Steady-state Analysis: A System of Linear Equations
 - Gauss-Seidel, SOR (Successive over-relaxation)
 - Power method, etc.
 - Transient Analysis: A coupled system of ODE
 - Classical ODE Methods
 - Randomization (or Uniformization), etc.

13

SRN Analysis: Step-5

- Compute measures of interest
 - Measures of interests: Blocking/Dropping Probability, Throughput, Utilization, Delay etc.
 - Measures can be defined as **reward functions** which specify reward rates on net-level entities.

Steps 1-5: The SPN Tool does it all!

14