Performance Modeling of Finite-Source Cognitive Radio Networks

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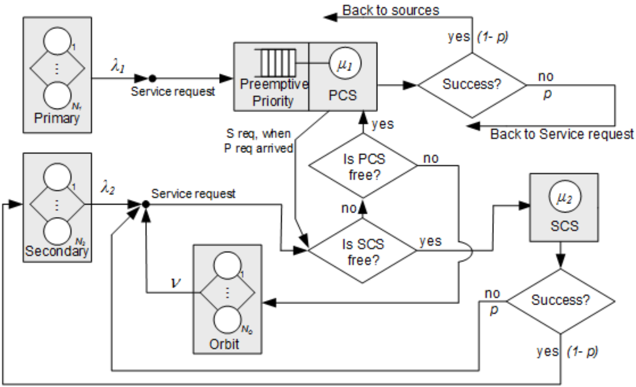
Outline

Finite-source retrial queueing system



Retrial queueing system

Mathematical model

- $k_1(t)$ is the number of high priority sources at time t,
- $k_2(t)$ is the number of low priority (normal) sources at time t,
- $q(t)$ denotes the number of high priority requests in the priority queue at time t,
- $o(t)$ is the number of requests in the orbit at time t.
- $y(t) = 0$ if there is no job in the PCS unit, $y(t) = 1$ if the PCS unit is busy with a job coming from the high priority class, $y(t) = 2$ when the PCS unit is servicing a job coming from the secondary class at time t
- $c(t) = 0$ when the SCS unit is idle and $c(t) = 1$, when the SCS is busy at time t.

The system state at time t can be described by the following continuous time Markov chain with finite state space

$$X(t) = (y(t), q(t); c(t), o(t))$$

Let us denote the steady-state distribution by

$$P(y, c, q, o) = \lim_{t \to \infty} P(y(t) = y, q(t) = q, c(t) = c, o(t) = o)$$

Performance measures

Once we have obtained these limiting probabilities the **main system performance measures** can be derived in the following way

- *Utilization of the primary server with respect to primary users*

$$U_{11} = \sum_{q=0}^{N_1-1} \sum_{c=0}^{1} \sum_{o=0}^{N_2-c} P(1,q,c,o)$$

- *Utilization of the primary server with respect to secondary users*

$$U_{12} = \sum_{q=0}^{N_1-1} \sum_{c=0}^{1} \sum_{o=0}^{N_2-c} P(2,q,c,o)$$

- *Utilization of the primary server*

$$U_1 = U_{11} + U_{12}$$

- *Utilization of the secondary server*

$$U_2 = \sum_{y=0}^{2} \sum_{q=0}^{N_1-1} \sum_{o=0}^{N_2-1} P(y, q, 1, o)$$

- *Average number of jobs in queue*

$$\overline{Q} = E(q(t)) = \sum_{y=0}^{2} \sum_{q=0}^{N_2-1} \sum_{c=0}^{1} \sum_{o=0}^{N_2-c} qP(y,q,c,o)$$

- *Average number of jobs in the orbit*

$$\overline{O} = E(o(t)) = \sum_{y=0}^{2} \sum_{q=0}^{N_2-1} \sum_{c=0}^{1} \sum_{o=0}^{N_2-c} oP(y,q,c,o)$$

- *Average number of jobs of primary users in the network*

$$\overline{M_1} = \overline{Q} + U_{11}$$

- *Average number of jobs of secondary users in the network*

$$\overline{M_2} = \overline{O} + U_{12} + U_2$$

- *Average number of jobs in the network*

$$\overline{M} = \overline{M_1} + \overline{M_2}$$

- *Average number of active primary users*

$$\overline{\Lambda_1} = N_1 - \overline{M_1}$$

- *Average number of active secondary users*

$$\overline{\Lambda_2} = N_2 - \overline{M_2}$$

- *Average generation rate of primary users*

$$\overline{\lambda_1} = \lambda_1 \overline{\Lambda_1}$$

- *Average generation rate of secondary users*

$$\overline{\lambda_2} = \lambda_2 \overline{\Lambda_2}$$

- *Mean response time of primary user's jobs*

$$\overline{T_1} = \frac{\overline{M_1}}{\overline{\overline{\lambda_1}}}$$

- *Mean response time of secondary user's jobs*

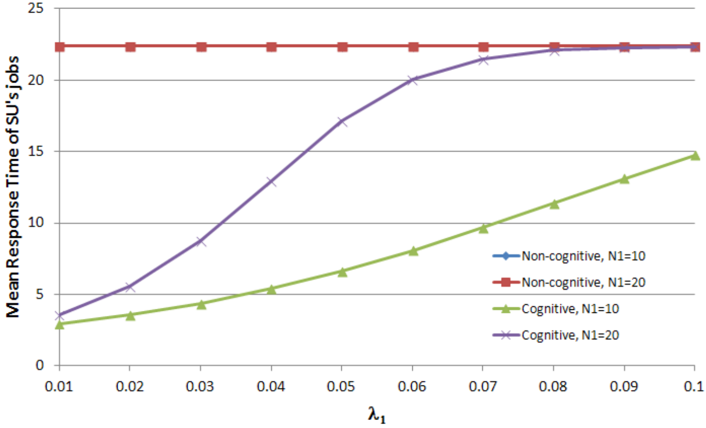
$$\overline{T_2} = \frac{\overline{M_2}}{\overline{\overline{\lambda_2}}}$$

Numerical examples by the help of MOSEL

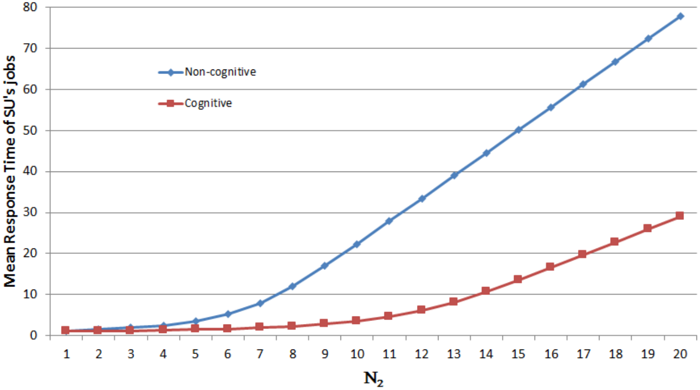
MOSEL (MOdeling, Specification and Evaluation Language) developed at the University of Erlangen, Germany, is used to formulate and solved the problem.

Input parameters

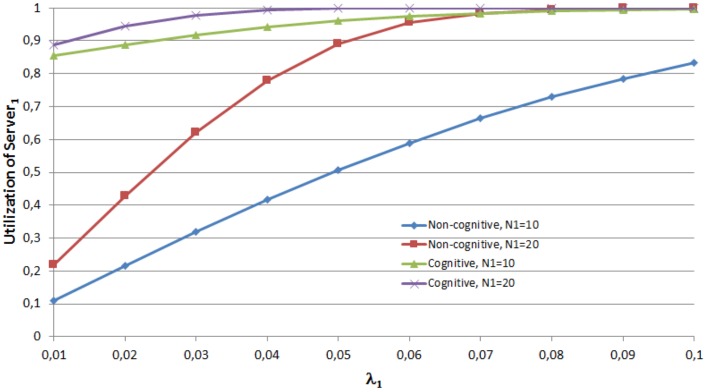
Case studies								
No.	N_1	N_2	λ_1	λ_2	μ_1	μ_2	ν	p
Fig. 2	$10, 20$	50	$x - axis$	0.03	1	1	20	0.1
Fig. 3	10	$x - axis$	0.02	0.03	1	1	20	0.1
Fig. 4	$10, 20$	50	$x - axis$	0.03	1	1	20	0.1
Fig. 5	10	$x - axis$	0.02	0.03	1	1	20	0.1
Fig. 6	10	$x - axis$	0.02	0.03	1	1	20	0.1
Fig. 7	10	$x - axis$	0.02	0.03	1	1	20	0.1
Fig. 8	10	$x - axis$	0.02	0.03	1	1	20	0.1



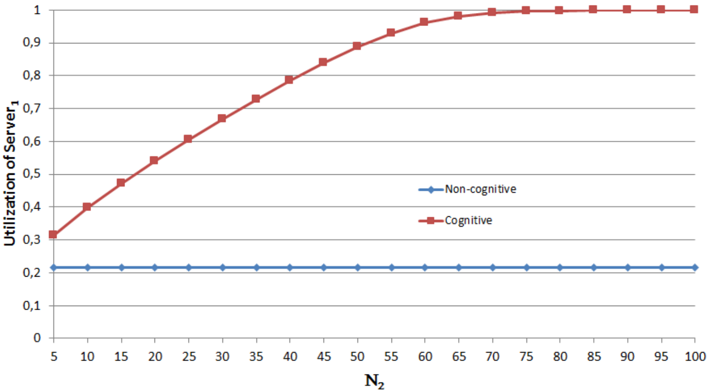
Mean Response Time of SU's jobs vs. λ_1



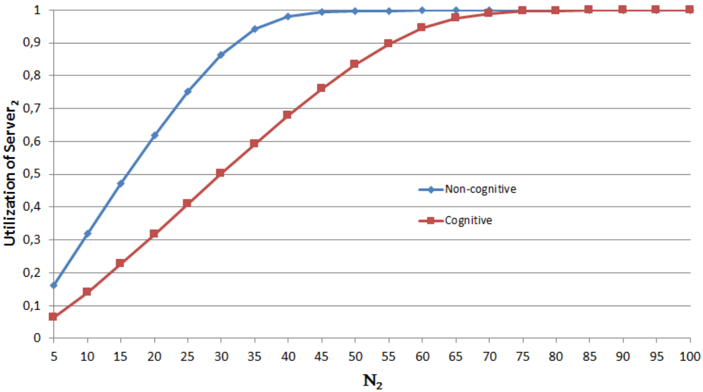
Mean Response Time of SU's jobs vs. N_2



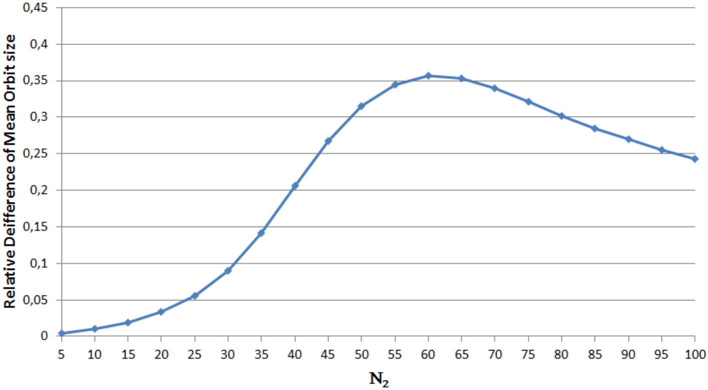
Utilization of PCS vs. λ_1



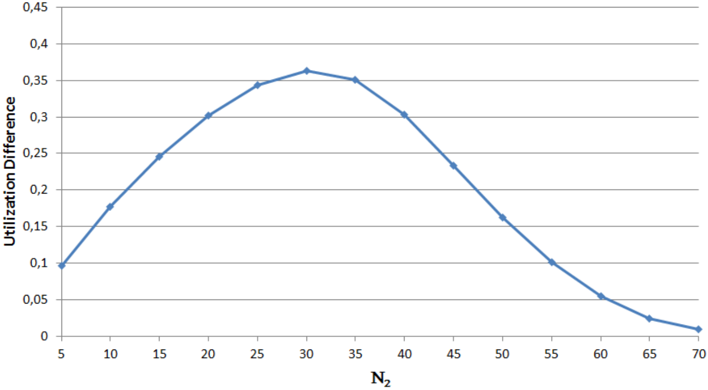
Utilization of PCS vs. N_2



Utilization of SCS vs. N_2



Relative Difference of Mean Orbit Size vs. N_2



Difference of utilization of SCS vs. N_2

Conclusions

1. Finite-source retrial queueing system with primary and secondary calls
2. Markovian model via MOSEL
3. Effect of some input parameters on performance measures in steady-state
4. Graphical illustrations, case studies

Bibliography

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Thank You

for Your

Attention