Secondary user behaviour in Cognitive Radio environment

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Outline

Introduction

Radio bands have often been overcrowded due to several wireless technologies working in the same bands

Measurement results in the uplink channel of the 850 *MHz* GSM band show that currently the duty cycle is less than 10% over a 24 hours

The goals of achieving an occupancy reduction of overcrowded unlicensed bands and an increase in utilization of the licensed bands can be obtained using Cognitive Radio (CR)

The migration to more recent technologies (3G/4G) has decreased occupancy level of band reserved to 2G technology, making it desirable to CR applications.

CR reference environment

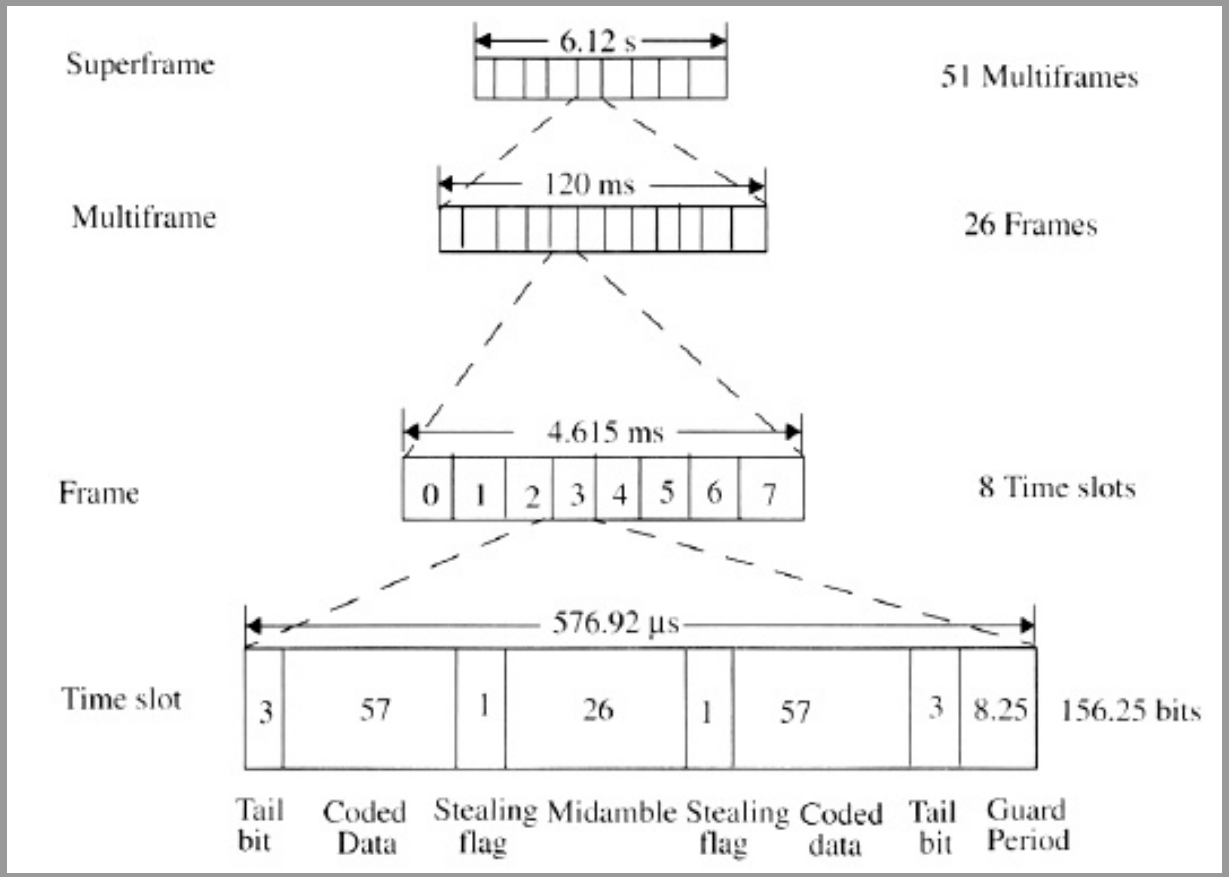
GSM uses a combination of Time-Division and Frequency-Division Multiple Access (TDMA/FDMA)

Each 200kHz channel is divided into eigth timeslots

GSM protocol uses slow freqeuncy hopping, power control and discontinuous transmission and reception to increase quality and to reduce battery consumption

A CR Secondary User (SU) can access unused channels at certain times (e.g. at night) or unused timeslots due to low traffic conditions or to discontinuous transmission.

GSM frame structure



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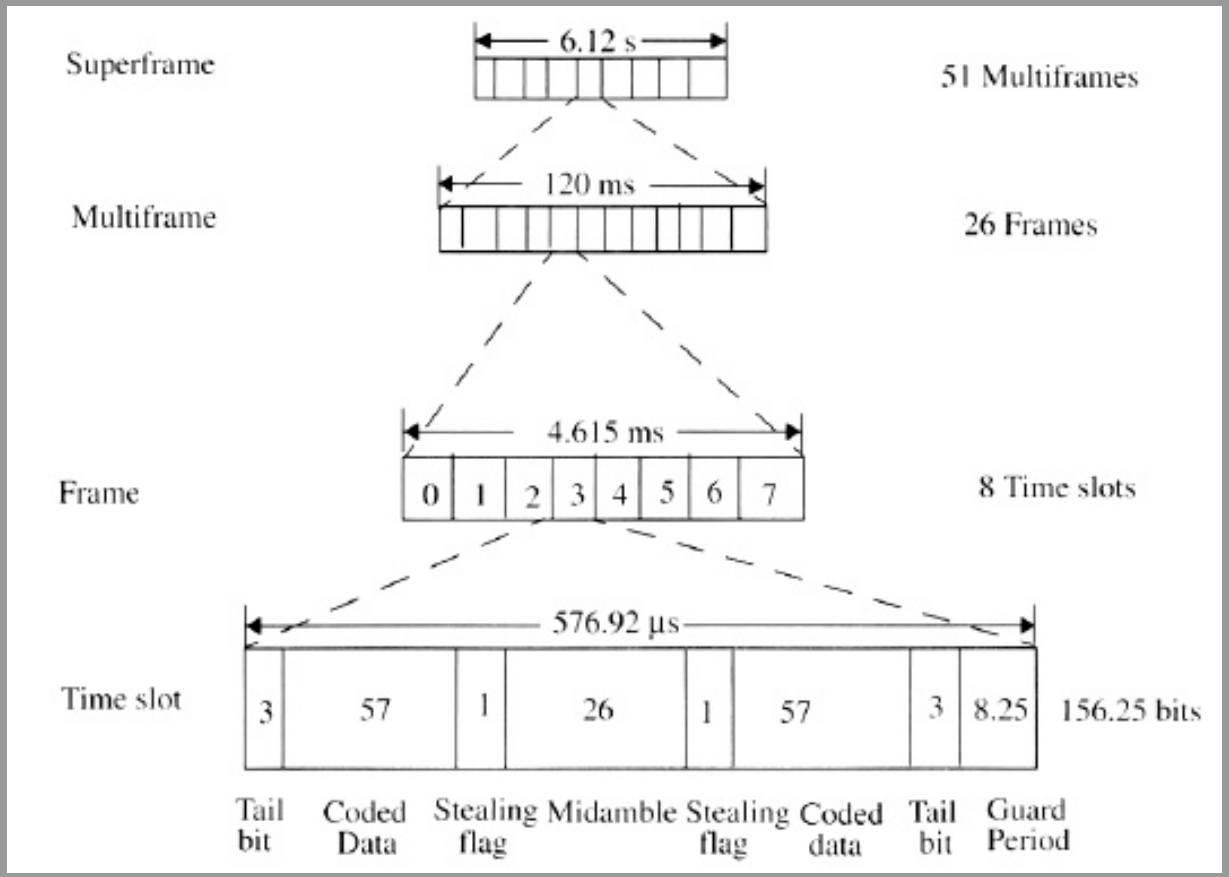

We propose totake into account synchronized SUs which are able to recognize the GSM time slot boundaries in order to reduce interference with PUs

Modelling user interactions

- We use a Non Markovian Stochastic Petri (NMSPN) net model with the aim to study interactions between PUs and SUs
- We make use of some Petri net extensions: enabling functions in particular
- The model is organized into two interacting NMSPNs
  - PU medium access do not depend by SUs
  - SU medium access depends by PU

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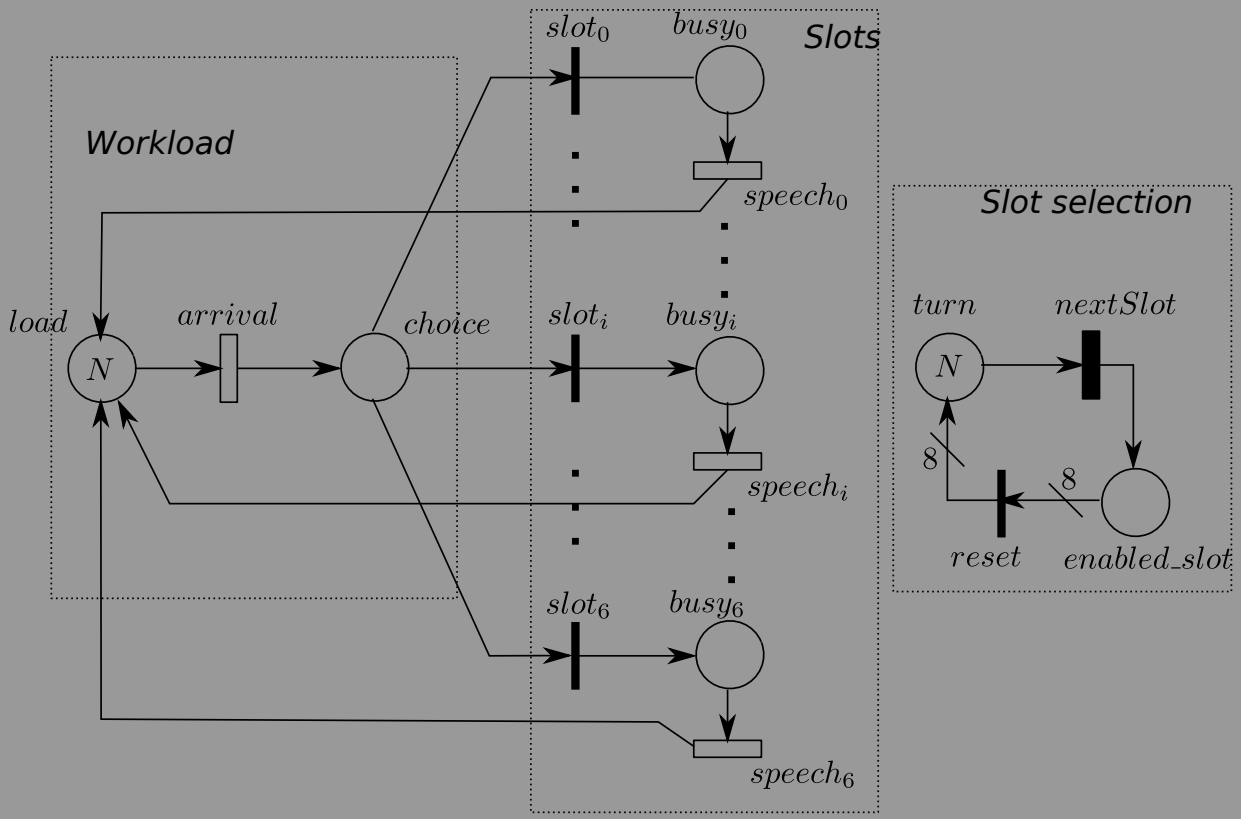
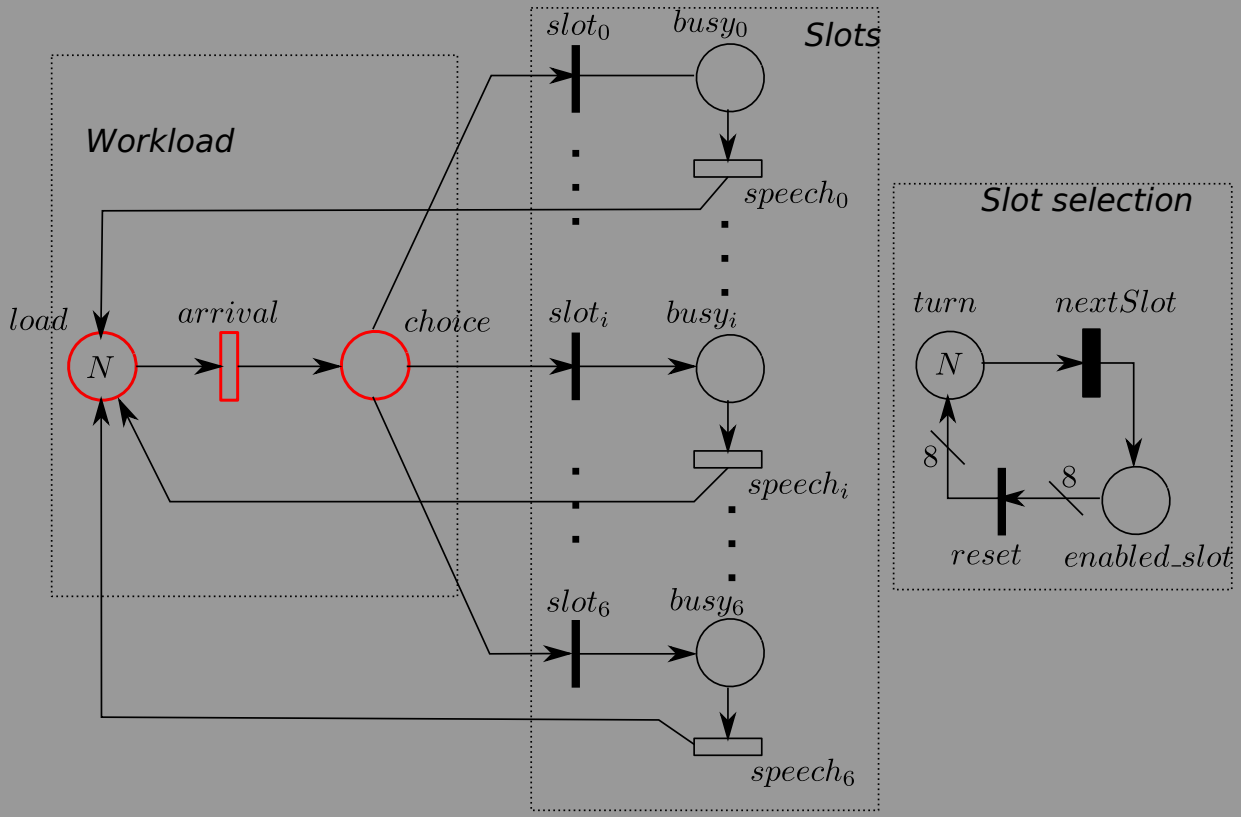
PU model



Transition	Enabling function
$slot_i$	$\#enabled\_slot == i$
$speech_i$	$\#enabled\_slot == i$

PU model



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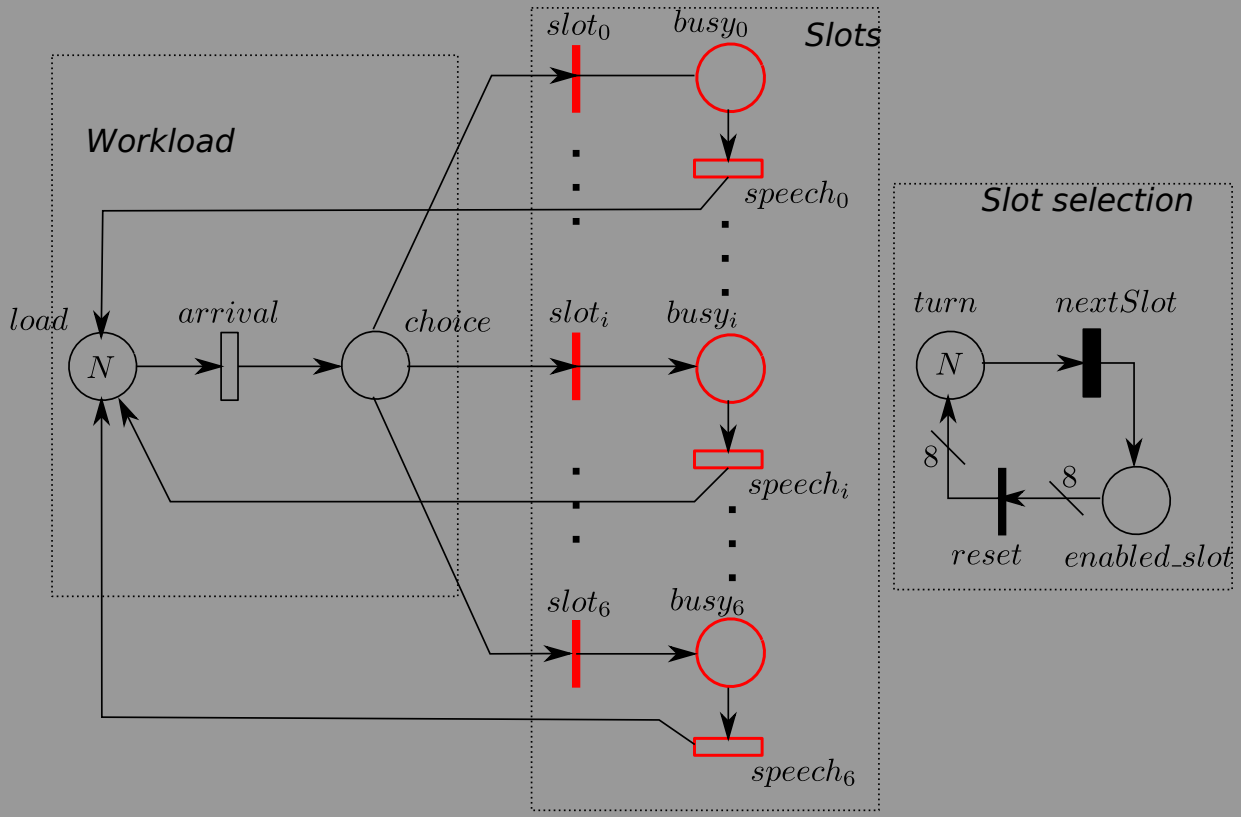

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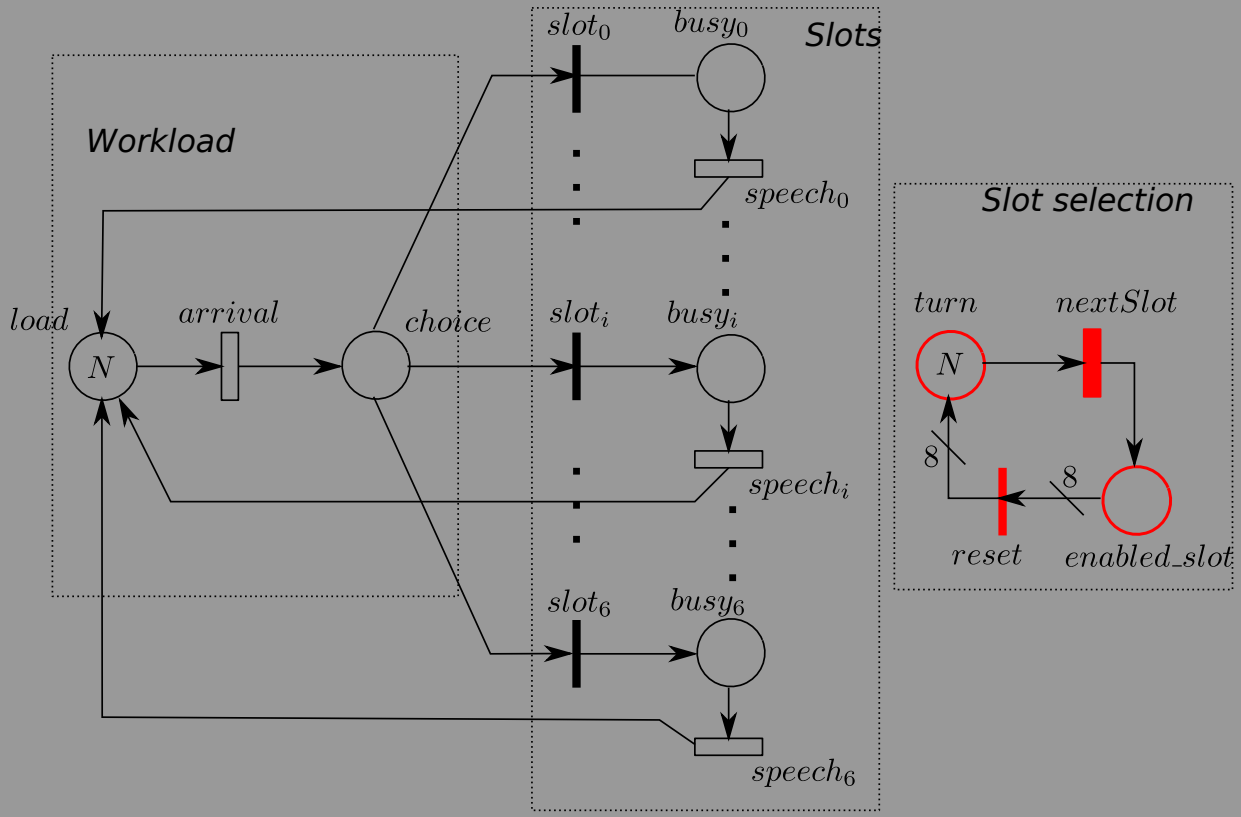

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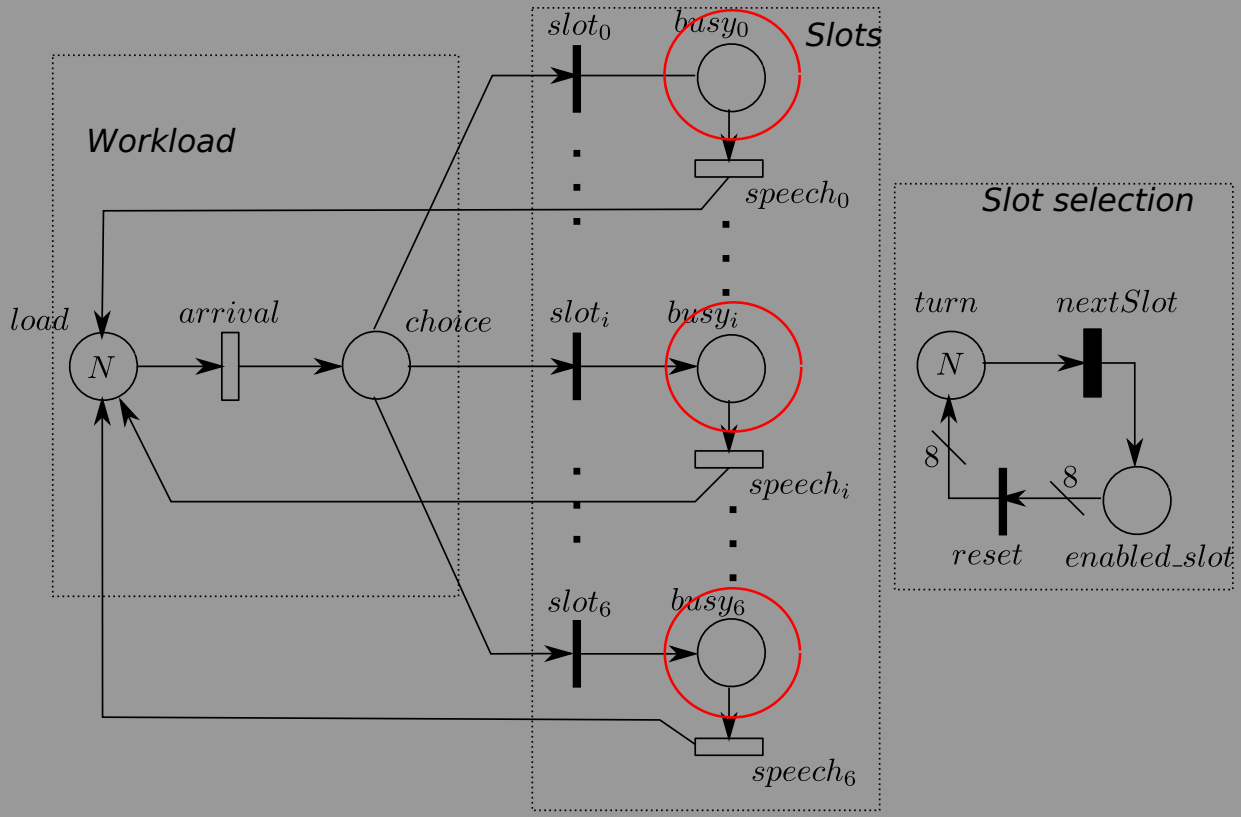


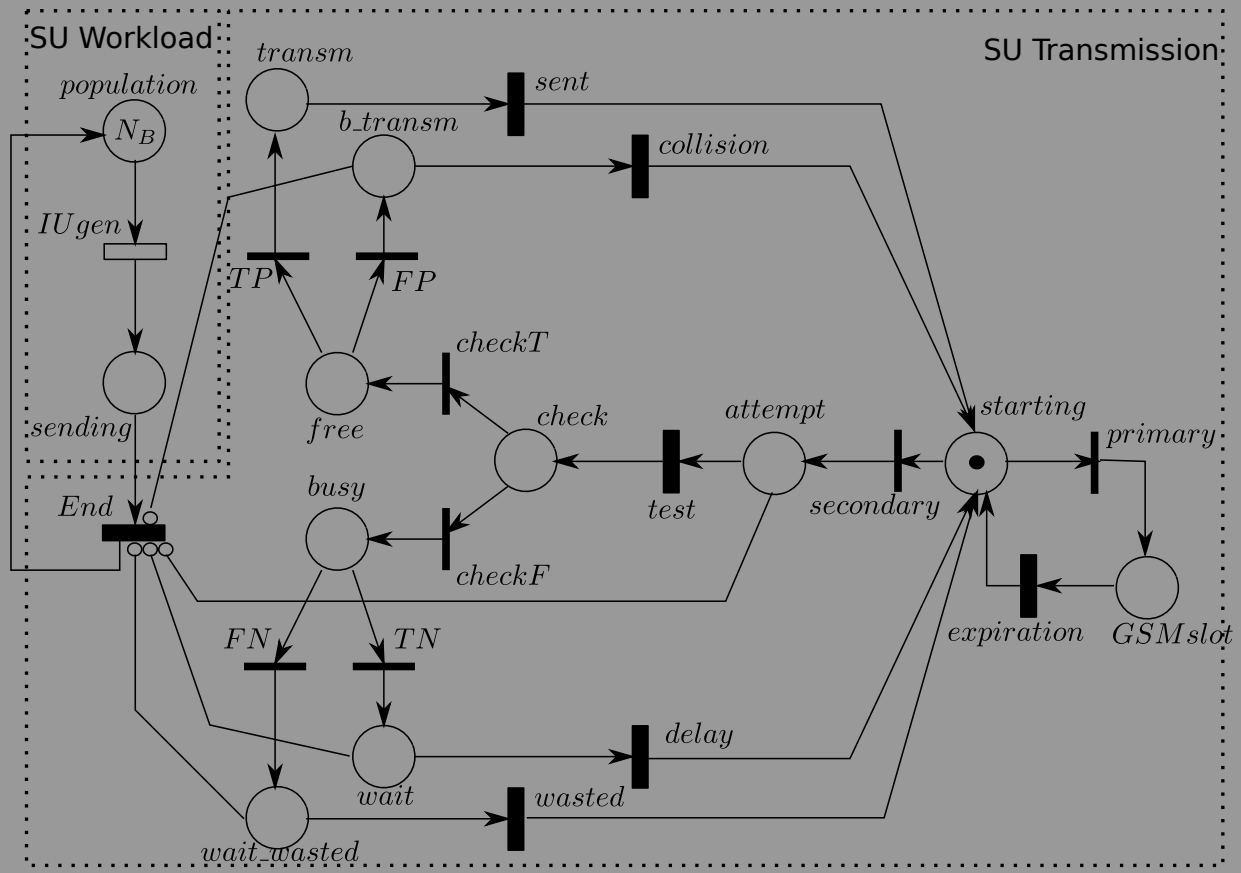
$$P_s^i = P\{\#busy_i == 0\},\ 0 \leq i \leq 6$$

Parameters

- Expected call holding time: 180 s
- Expected call arrival rate: from 6 $calls/hours$ to 60 $calls/hours$
- Base Transiver Station operating at 200 KHz

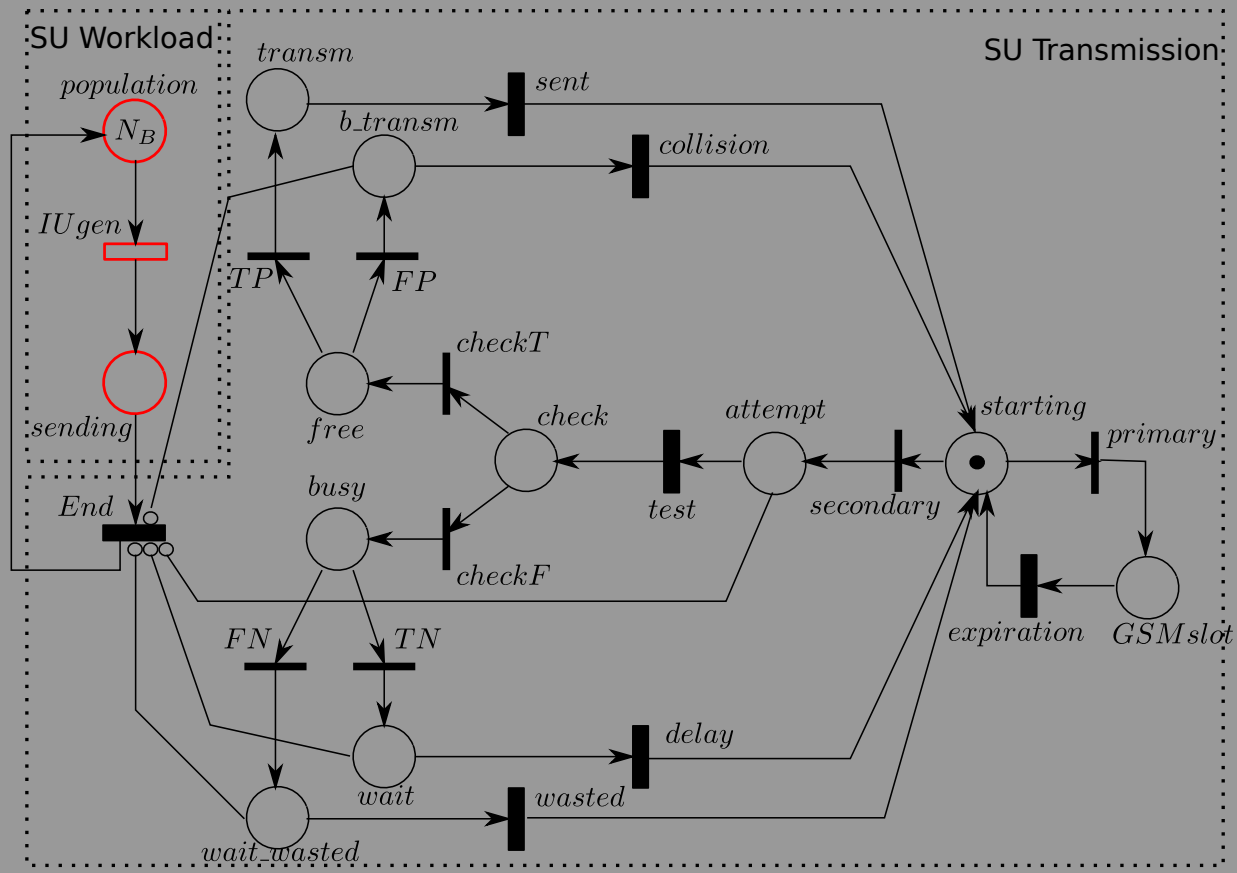
W_l (Erlang)	P_s
0.3	0.957
0.6	0.907
1.0	0.855
1.5	0.763
3.0	0.569

SU model



Transition	Enabling function
primary	$\#sending == 0$
secondary	$\#sending > 0$

SU model



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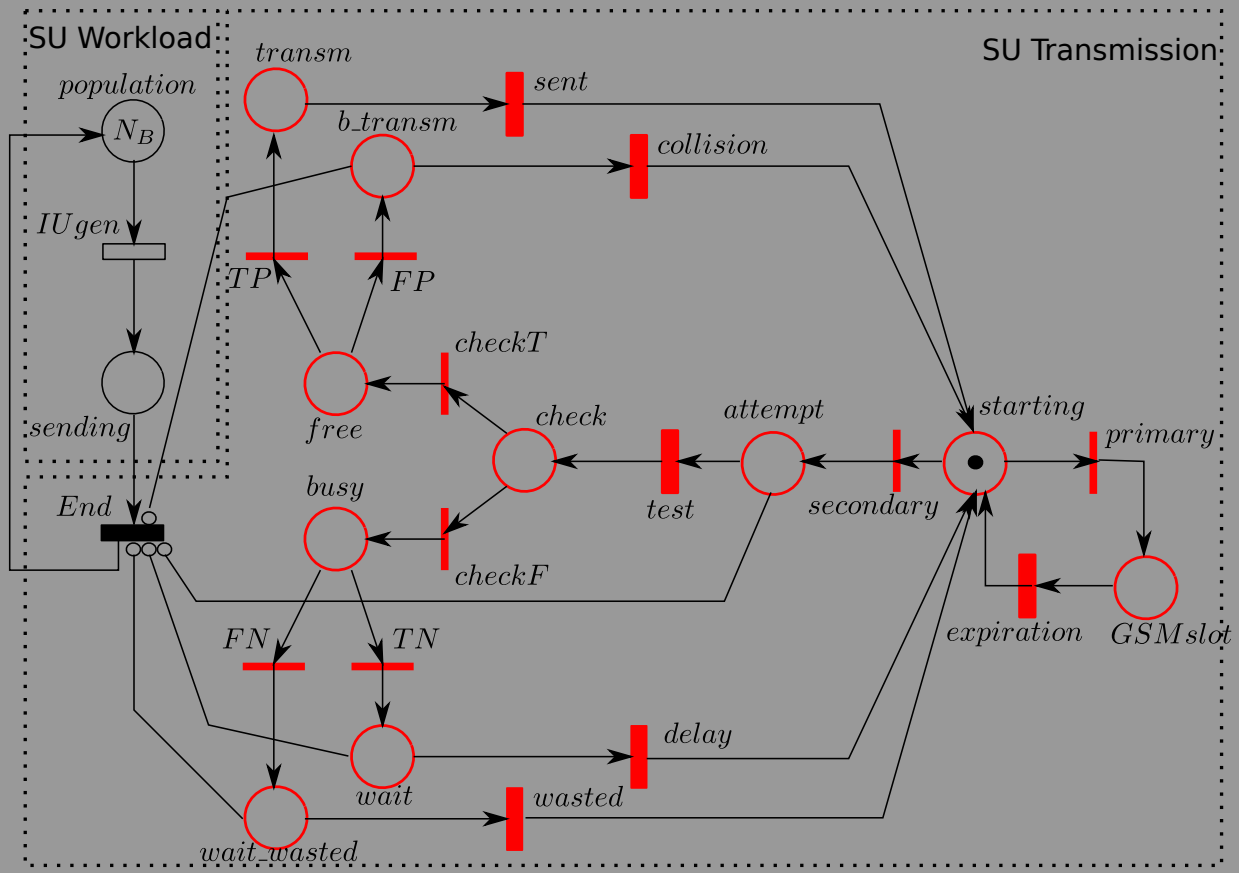

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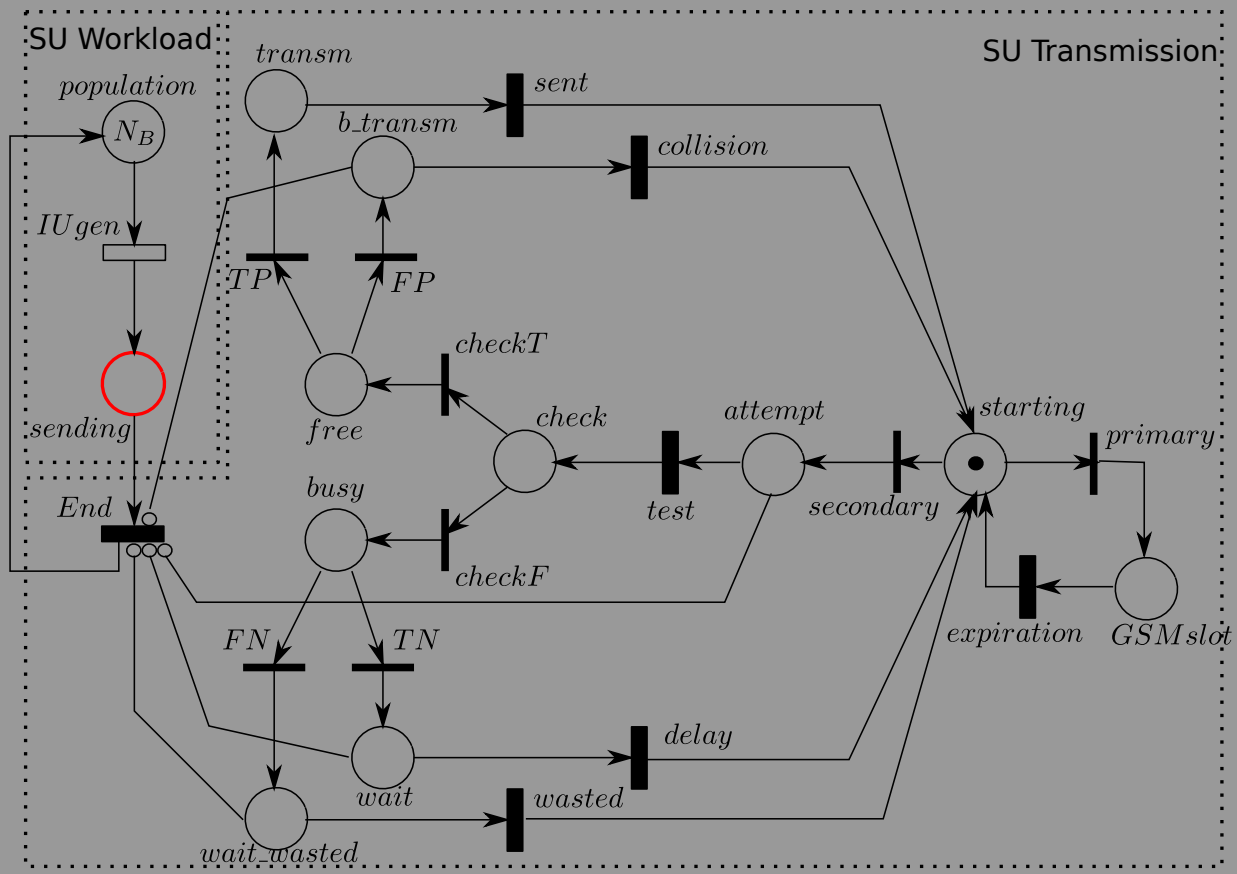
SU model



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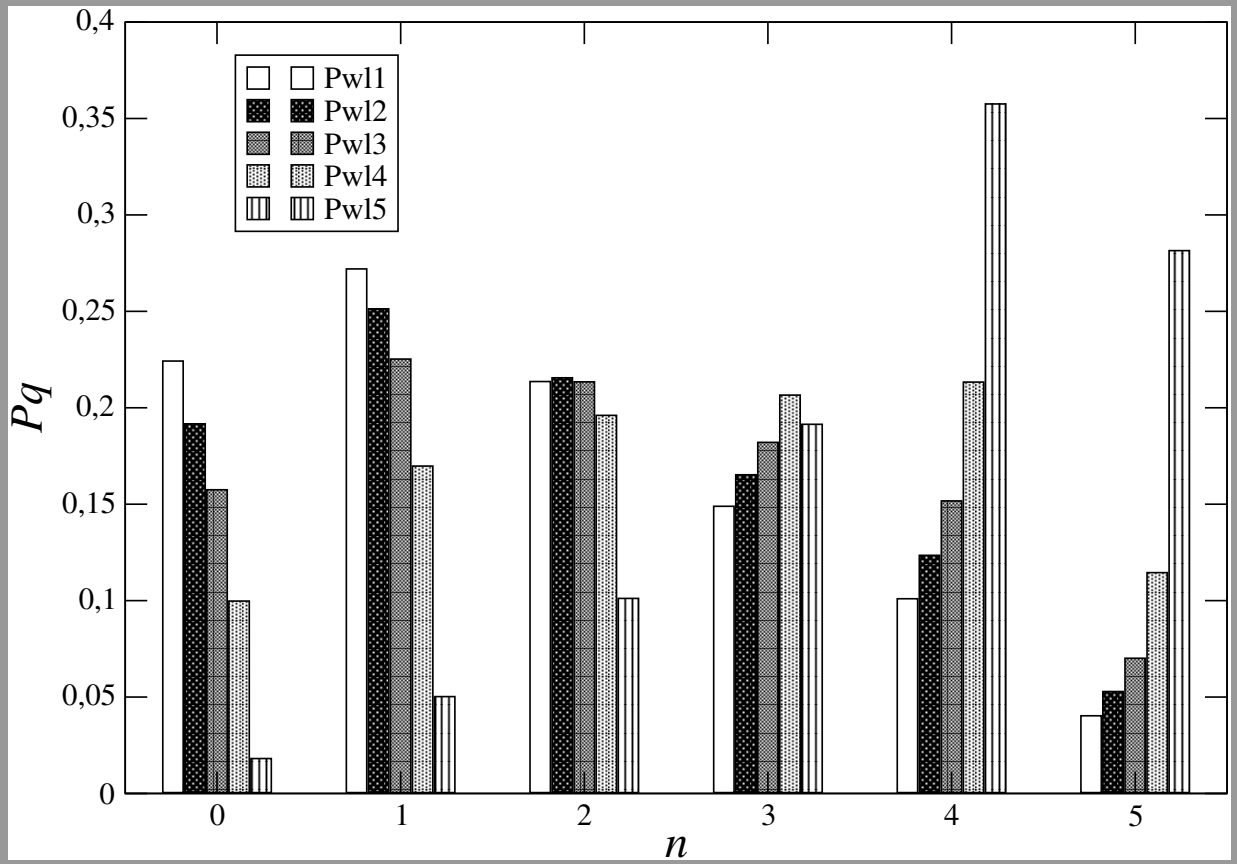
secondary	$\#sending > 0$

$$P_q(i) = P\{i \text{ IUs are in the system}\} = P\{\#sending == i\}$$

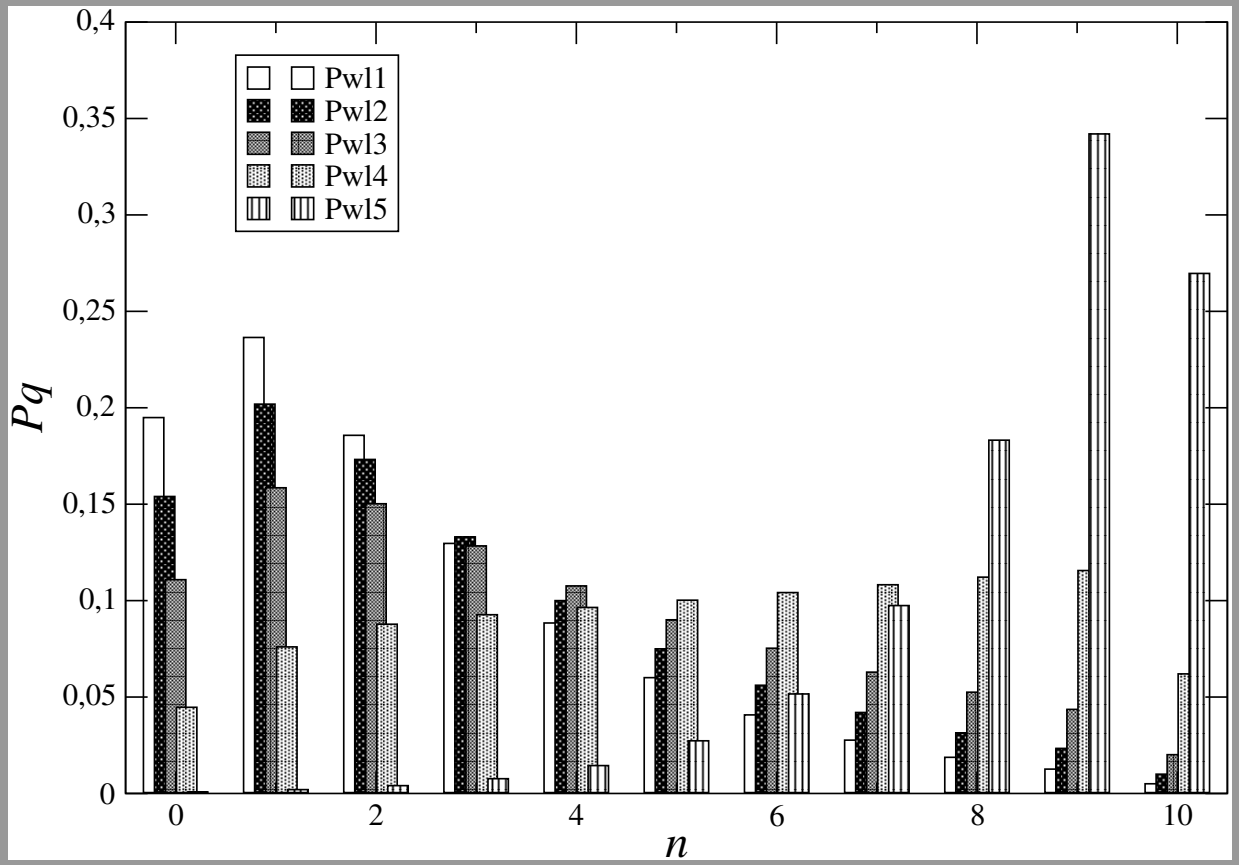
Parameters

- Population: $N_B = 1000$
- Information unit length: 8192 *bits*
- Generation rate: 0.06 IU/s
- Sensing algorithm time: 25% of a time slot

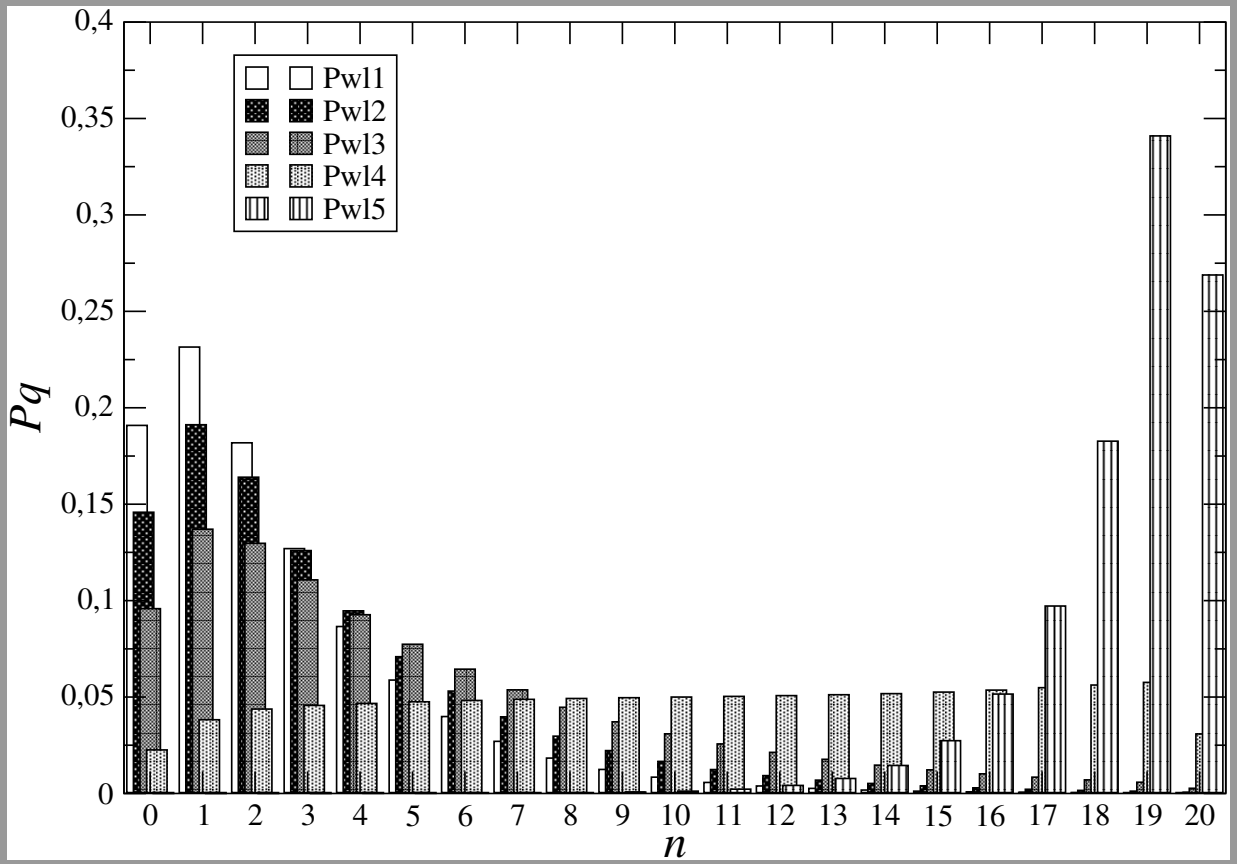
Results


0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
Pq
Pwl1
Pwl2
Pwl3
Pwl4
Pwl5
0
1
2
3
4
5
n

Results


0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
Pq
Pwl1
Pwl2
Pwl3
Pwl4
Pwl5
0
2
4
6
8
10
n

Results


Pwl1
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0,35
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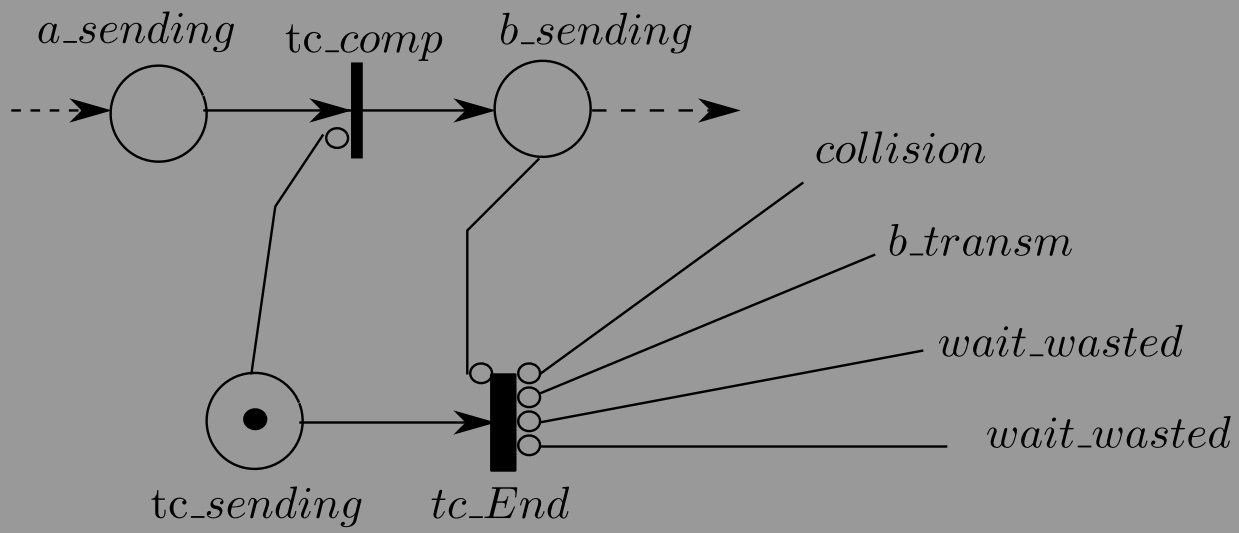
0,25
0,2
0,15
0,1
0,05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

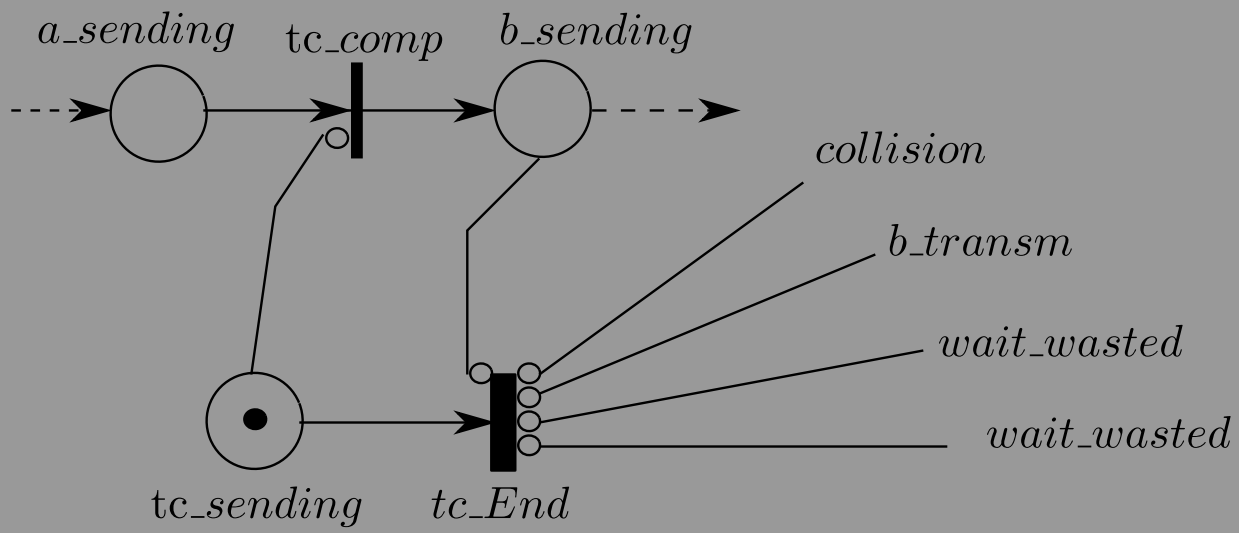
Conditioned response time distribution



$$F_i(t) = P\{\#tc\_sending == 0, t | M_i\}, \ \forall t > 0$$

$$F_r(t) = \sum_{i=0}^{N_B - 1} P_q(i) F_i(t)$$

Conditioned response time distribution



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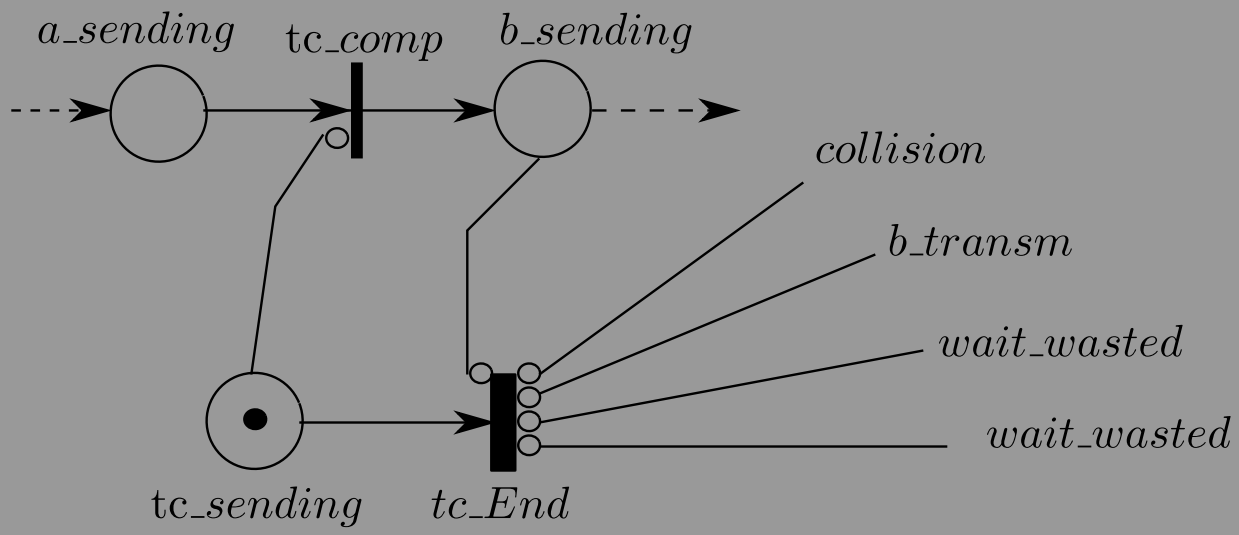

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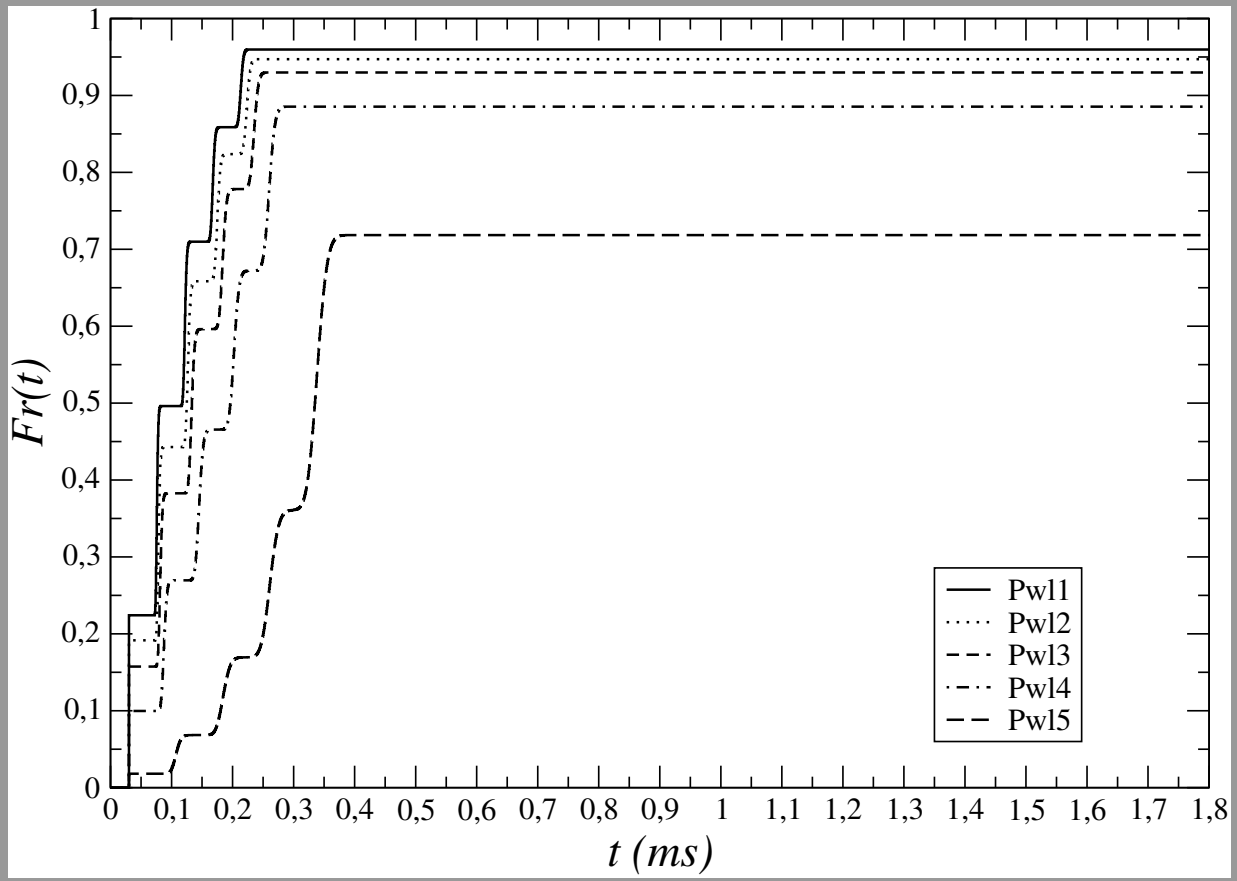
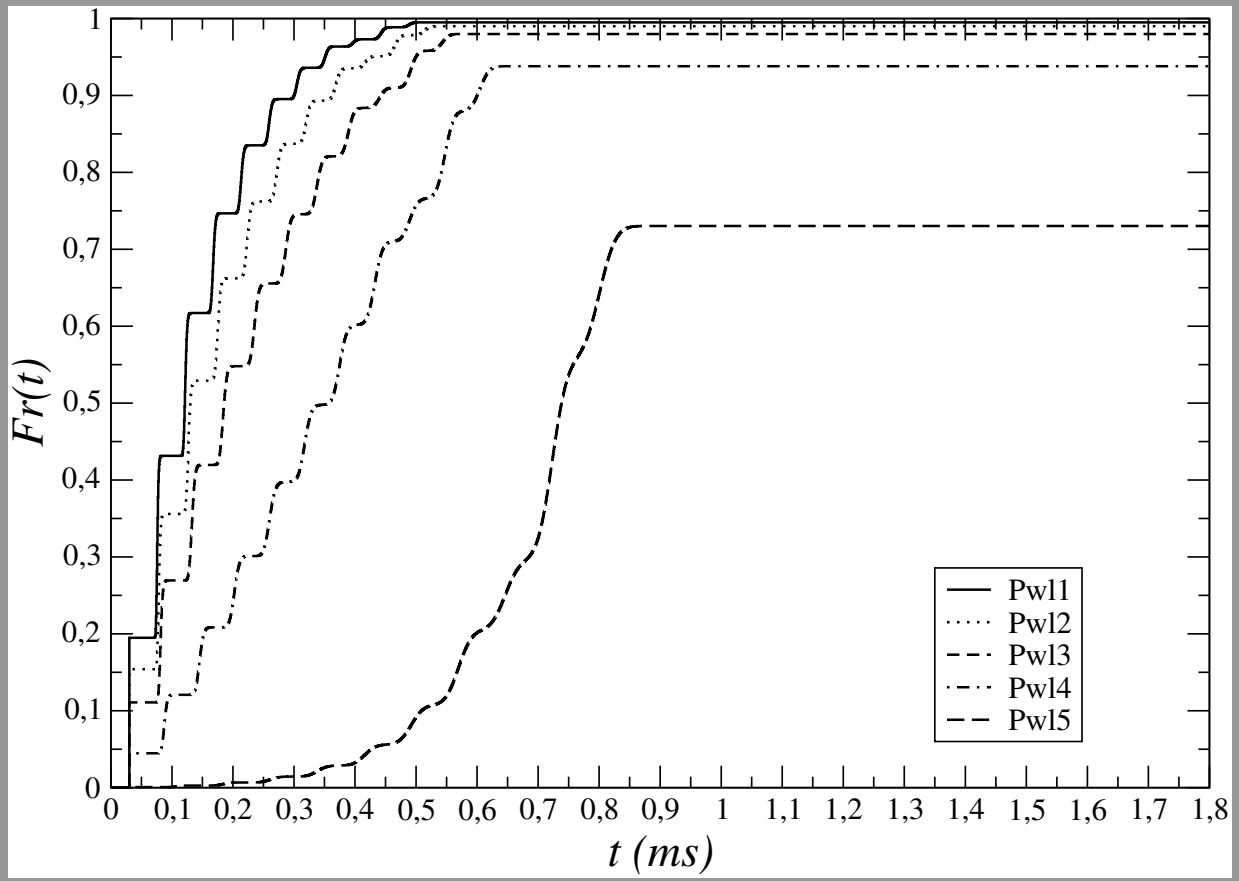

Fr(t)
t (ms)
Pwl1
Pwl2
Pwl3
Pwl4
Pwl5
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
1,1
1,2
1,3
1,4
1,5
1,6
1,7
1,8

Results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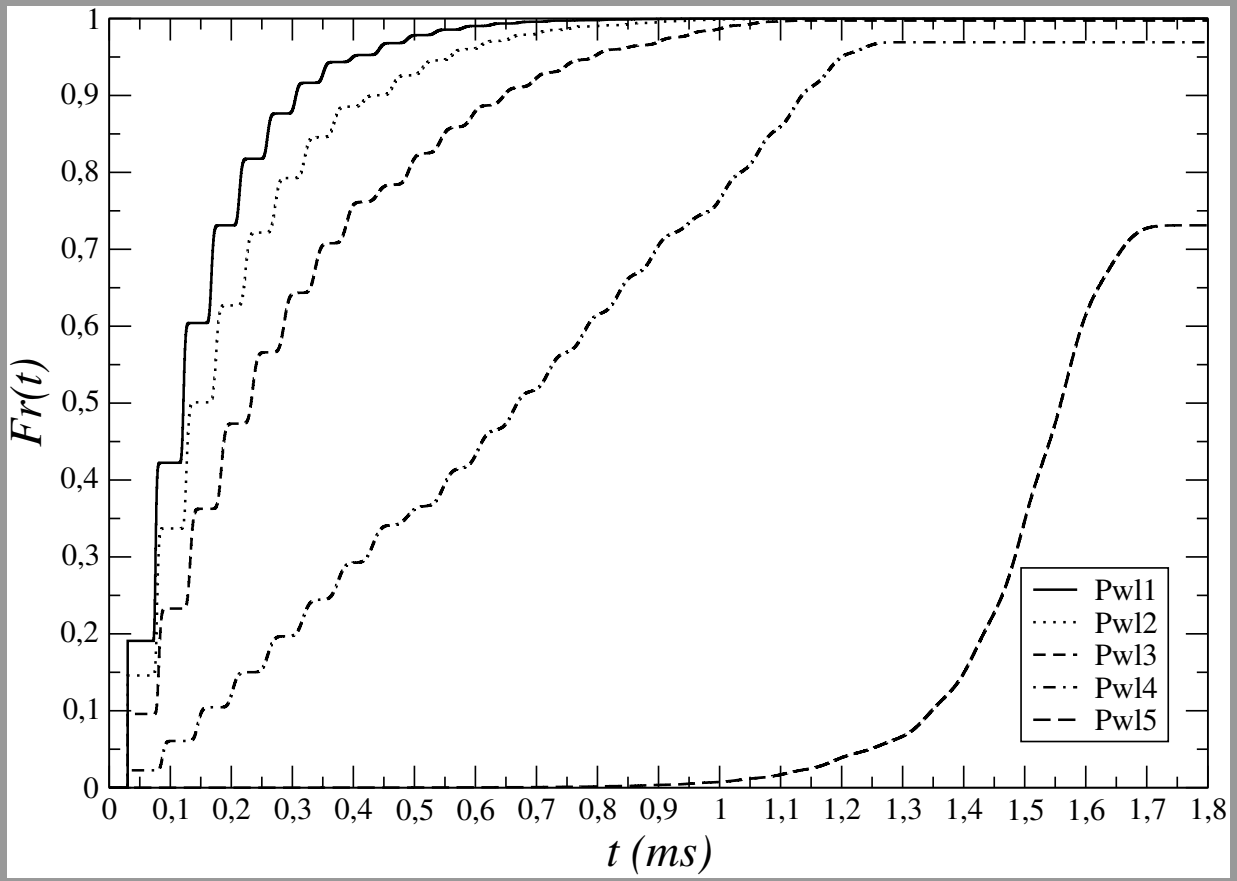
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0,7
0,8
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1,2
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1,4
1,5
1,6
1,7
1,8

Conclusions

A syncronized SU access to licensed band has been proposed and modelled

- different loads conditions of the licenced band
- interactions between SUs and PUs

Future work

- model validation
- more realistic SU workloads
- evaluation of the misclassification error in terms of requested sensing time and the portion of time slot

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Thank you ...