ΗΜΜΥ ΕΜΠ

6ο εξάμηνο

Συστήματα Αναμονής

Lab 3

Ήβη Χατζή

[redacted]

Προσομοίωση συστήματος M/M/1/10

(1)

Για λ=1:

Transition	Current state	Arrivals at current state	Next transition
1	0	0	arrival
2	1	0	arrival
3	2	0	departure
4	1	1	departure
5	0	1	arrival
6	1	1	arrival
7	2	0	departure
8	1	2	departure
9	0	2	arrival
10	1	2	departure
11	0	3	arrival
12	1	2	departure
13	0	4	arrival
14	1	2	departure
15	0	5	arrival
16	1	2	departure
17	0	6	arrival
18	1	2	departure
19	0	7	arrival
20	1	2	departure
21	0	8	arrival
22	1	2	arrival
23	2	0	departure
24	1	3	departure
25	0	9	arrival
26	1	3	departure
27	0	10	arrival
28	1	3	departure
29	0	11	arrival
30	1	3	arrival

Για λ=5:

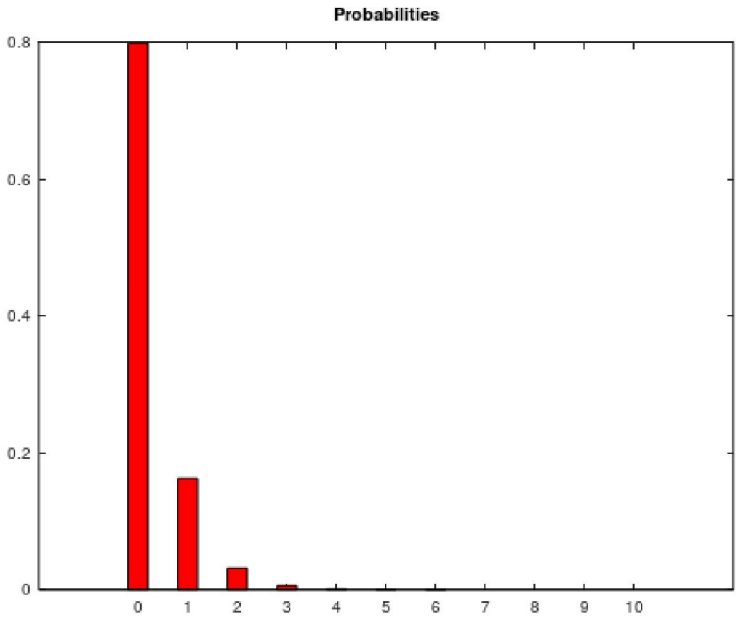
Transition	Current state	Arrivals at current state	Next transition
1	0	0	arrival
2	1	0	arrival
3	2	0	arrival
4	3	0	arrival
5	4	0	departure
6	3	1	departure
7	2	1	arrival
8	3	1	departure
9	2	2	arrival
10	3	1	departure
11	2	3	arrival
12	3	1	arrival
13	4	0	departure
14	3	2	departure
15	2	4	departure
16	1	1	departure
17	0	1	arrival
18	1	1	departure
19	0	2	arrival
20	1	1	departure
21	0	3	arrival
22	1	1	arrival
23	2	4	departure
24	1	2	departure
25	0	4	arrival
26	1	2	arrival
27	2	4	arrival
28	3	2	departure
29	2	5	arrival
30	3	2	arrival

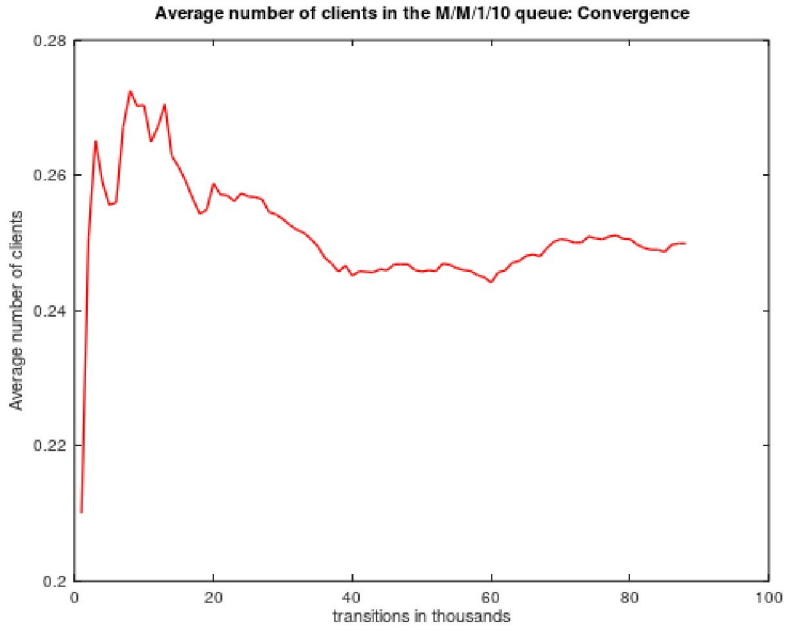
Για λ=10:

Transition	Current state	Arrivals at current state	Next transition
1	0	0	arrival
2	1	0	arrival
3	2	0	arrival
4	3	0	arrival
5	4	0	arrival
6	5	0	arrival
7	6	0	arrival
8	7	0	departure
9	6	1	departure
10	5	1	arrival
11	6	1	arrival
12	7	0	departure
13	6	2	arrival
14	7	0	departure
15	6	3	arrival
16	7	0	arrival
17	8	0	arrival
18	9	0	departure
19	8	1	arrival
20	9	0	arrival
21	10	0	arrival
22	10	1	arrival
23	10	2	arrival
24	10	3	arrival
25	10	4	arrival
26	10	5	arrival
27	10	6	departure
28	9	1	arrival
29	10	6	arrival
30	10	7	arrival

(2)

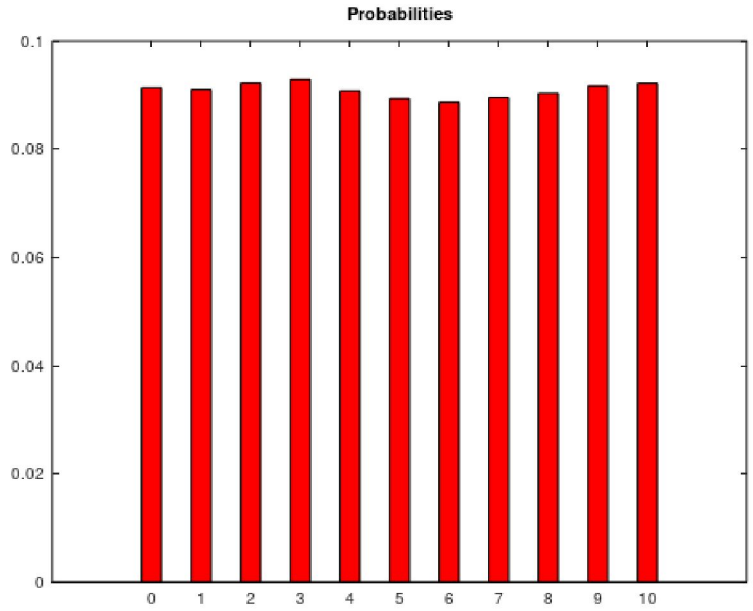
Για λ=1:

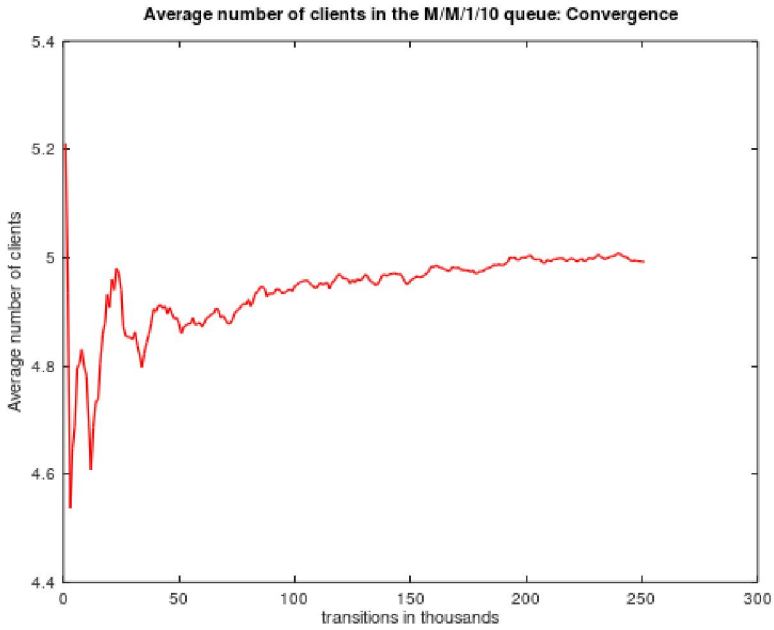





```
Average number of customers: 0.250437
Probability of rejecting a customer: 0
Average waiting time: 0.250437
```

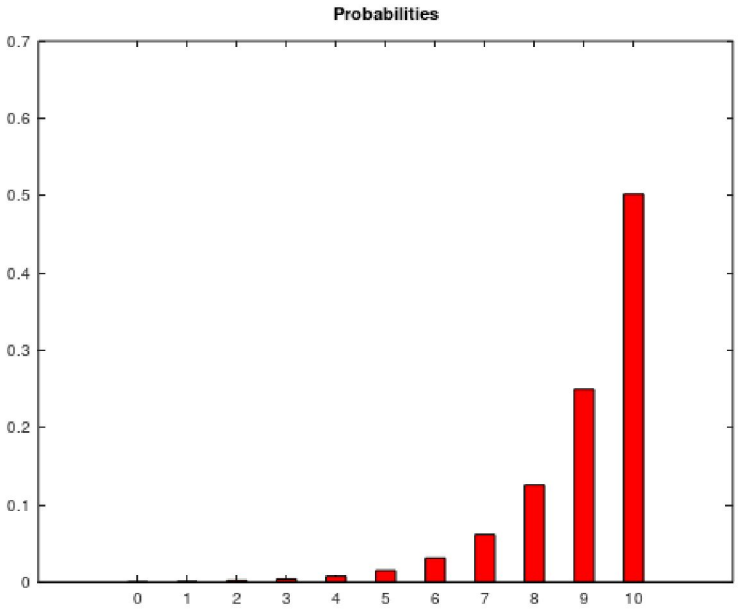
Για λ=5:

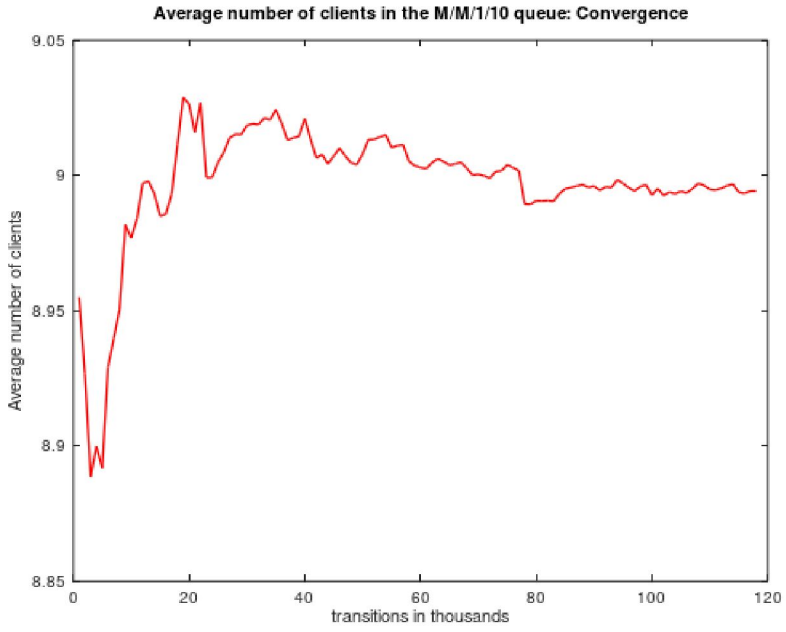





```
Average number of customers: 4.96927
Probability of rejecting a customer: 0.0899782
Average waiting time: 1.09212
```

Για λ=10:





Average number of customers: 8.98739

Probability of rejecting a customer: 0.494595

Average waiting time: 1.77825

(3) Όσο πιο κοντά στο 1 είναι ο λόγος λ/μ, τόσο περισσότερο αργεί να συγκλίνει η προσομοίωση. Τρέχοντας την προσομοίωση πολλές φορές, παρατηρούμε ότι για λ=1 ή 10 τις περισσότερες φορές συγκλίνει μετά από τουλάχιστον 50000 μεταβάσεις, οπότε μπορούμε να τις αγνοήσουμε. Για λ=5 όμως αργεί περισσότερο να συγκλίνει οπότε μπορούμε να αγνοήσουμε τις πρώτες 150000 μεταβάσεις.

(4) Το μ το χρησιμοποιούμε μόνο κατά τον υπολογισμό του threshold. Οπότε ορίζουμε πλέον το threshold μέσα στο while loop ως εξής:

```
threshold = lambda(n)/(lambda(n) + current_state+1);
```

Κώδικας

```
% M/M/1/10 simulation.

clc;
clear all;
close all;


rand("seed",10);
lambda = [1 5 10];
mu = 5;

for n=1:3
  threshold = lambda(n)/(lambda(n) + mu); % the threshold used to
calculate probabilities

  transitions = 0; % holds the transitions of the simulation in
transitions steps
  arrivals=zeros(1,11);
  total_arrivals = 0; % to measure the total number of arrivals
  current_state = 0;  % holds the current state of the system
  previous_mean_clients = 0; % will help in the convergence test
  index = 0;
  to_plot=zeros(1,1000);

  % for debugging
##  tracestate=zeros(1,30);
##  tracearrdep=zeros(1,30);
##  tracearrivals=zeros(1,30);

  while transitions >= 0
    %threshold = lambda(n)/(lambda(n) + current_state+1);
    transitions = transitions + 1; % one more transitions step
    % for debugging
##    if transitions<=30
##      tracestate(transitions)=current_state;
```

```
##      tracearrivals(transitions)=arrivals(current_state+1);
##    endif

    if mod(transitions,1000) == 0 % check for convergence every 1000
transitions steps
      index = index + 1;
      for i=1:1:length(arrivals)
          P(i) = arrivals(i)/total_arrivals; % calculate the
probability of every state in the system
      endfor

      mean_clients = 0; % calculate the mean number of clients in the
system
      for i=1:1:length(arrivals)
         mean_clients = mean_clients + (i-1).*P(i);
      endfor

      to_plot(index) = mean_clients;

      if abs(mean_clients - previous_mean_clients) < 0.00001 ||
transitions > 1000000 % convergence test
       break;
      endif

     previous_mean_clients = mean_clients;

   endif

   random_number = rand(1); % generate a random number (Uniform
distribution)
   if current_state == 0 || random_number < threshold % arrival
     % for debugging
##     if transitions<=30
##      tracearrdep(transitions)=1;
##     endif

     total_arrivals = total_arrivals + 1;
     arrivals(current_state + 1) = arrivals(current_state + 1) + 1; %
increase the number of arrivals in the current state

     if current_state<10
        current_state = current_state + 1;
     endif

   else % departure
     %for debugging
##     if transitions<=30
##      tracearrdep(transitions)=2;
##     endif

     if current_state != 0 % no departure from an empty system
        current_state = current_state - 1;
```

```
      endif
    endif
  endwhile

  printf('For lambda=%d\n',lambda(n));
  printf('Ergodic Probabilities\n');
  for i=1:1:length(arrivals)
   disp(P(i));
  endfor
  printf('\n');

  printf('Average number of customers: %d\n',mean_clients);
  printf('Probability of rejecting a customer: %d\n',P(11));
  throughput=lambda(n)*(1-P(11));
  printf('Average waiting time: %d\n\n',mean_clients/throughput);

##  printf('First 30 states');
##  disp(tracestate);
##  printf('\n');
##  printf('Arrivals at current state');
##  disp(tracearrivals);
##  printf('\n');
##  printf('Next is arrival(1) or departure(2)')
##  disp(tracearrdep);
##  printf('\n');

  figure(1);
  plot(to_plot(1:index),"r","linewidth",1.3);
  title("Average number of clients in the M/M/1/10 queue:
Convergence");
  xlabel("transitions in thousands");
  ylabel("Average number of clients");

  figure(2);
  bar(0:10,P,'r',0.4);
  title("Probabilities")
  %pause(2);
endfor
```