Technische Universität München
Informatik VIII
Netzarchitekturen und Netzdienste
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Tutorial – Discrete Event Simulation

Assignment 2, SS 2011

Submission **until Mon 6th of June 2011, 08:00 am** via e-mail to `klein@net.in.tum.de`
with subject: `DES Blatt 2,` *Surname_1st_group_member*, *Surname_2nd*, *Surname_3rd*

Up to three students may submit their exercise together.

Exercise 1 — Evaluation of waiting queues

Waiting queues can be used to describe / analyze the behavior of a system. In this exercise you will extend the simulator which you have implemented in the previous exercise such that it is able to collect the following statistics:

- Average customer waiting time
- Average processing time of a customer
- Average retention time of a customer
- Average number of packets in the queue
- Customer blocking probability
- Utilization of the system

a) Implement a class Customer which holds the arrival time, the service init time, and the service completion time of the current customer.

b) Implement classes DCounter and TD Counter which calculates the statistics mentioned above.

c) Implement a class RandVar which returns exponentially distributed random numbers with a given mean. Use the standard Java RNG with seed 100 for the customer arrival and seed 200 for the departure events. **Hint:** Exponential distributed random numbers X can be generated from uniform distributed random numbers $U \sim (0, 1)$ by using the following equation: $RVX = \frac{-ln(U)}{\lambda}$

Exercise 2 — Comparison of waiting queues

The performance of a system is usually influenced by the variance of the arrival process and the service process. In this exercise you will compare the performance of different systems depending on the variance of both processes and the maximum length of the waiting queue. Use a simulation duration of $T = 10\hat{}7$s and present the results in table. Which system would you prefer as a customer.

a) System A: M / M / 1 - ∞, Arrival rate = 9.5/s, Service rate = 10/s.
System B: M / M / 1 - 3, Arrival rate = 9.5/s, Service rate = 10/s.
System C: M / M / 1 - 10, Arrival rate = 9.5/s, Service rate = 10/s.

b) System D: D / D / 1 - ∞, Arrival rate = 9/s, Service rate = 10/s.
System E: M / D / 1 - ∞, Arrival rate = 9/s, Service rate = 10/s.

c) System F: D / M / 1 - ∞, Arrival rate = 9/s, Service rate = 10/s.
System G: M / D / 1 - ∞, Arrival rate = 9/s, Service rate = 10/s.

Hint: A modification of the simulation time is necessary in order to simulate a customer arrival rate of e.g. 10 customers per second. Use the following time transformation: 1 s real time corresponds 100 time units / ticks in the simulation. As a result, the customer arrival and service completion rates are decreased by a factor of 100.

Exercise 3 — Impact of distributions on the Medium Access Control (MAC) protocols

Non-uniform distributions provide a simple possibility to optimize the performance / efficiency of MAC protocols. The SIFT-MAC protocol applies a non-uniform distribution in order to minimize the collision probability. The medium access procedure of the protocol can be described as follows. A node that wants to transmit a packet senses the medium. If the medium is busy, it continuous to sense the medium until the medium becomes idle. A node starts its backoff procedure as soon as it detects an idle medium. Then the node waits a certain number of backoff slots according to a pre-defined distribution. Before it starts to transmit, it senses the medium again to verify that there is no ongoing transmission. *A collision only occurs if two or more nodes choose the same backoff slot duration, provided that no other competing node chooses a shorter backoff slot.* Figure 1 illustrates the medium access procedure of the protocol.

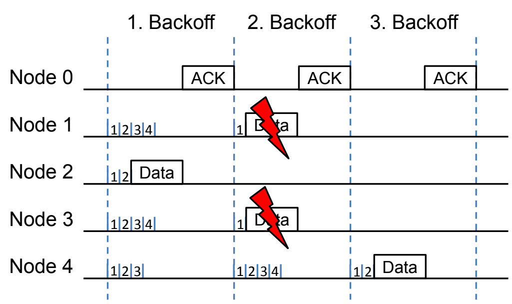

Abbildung 1: Sift - Medium Access

In the following, you will analyze a **SINGLE** backoff phase in which 4 nodes compete for the medium access. The nodes choose a backoff slot between 1 and 4 according to the distribution shown in Table 1.

Use the following variables for your calculation:

- $n =$ Maximum number of backoff slots
- $m =$ Number of competing nodes
- $k =$ Number of nodes which access the medium at the same time
  (Note that $k = 1$ represents a successful contention resolution)

Calculate the following probabilities for the distributions given in Table 1.

Tabelle 1: Distribution – Backoff Slot Selection

Distribution / Probability	Slot 1	Slot 2	Slot 3	Slot 4
Uniform	0.25	0.25	0.25	0.25
Sift	0.10	0.14	0.22	0.54

a) Calculate the probability that all nodes access the medium at the same time (k=4).
b) Calculate the probability that three nodes access the medium at the same time (k=3).
c) Calculate the probability that a single node gains access to the medium (k=1).