«»«»«»«»«» 57:022 Principles of Design II «»«»«»«»«»
Homework Assignments, Spring 1994
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«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«» HW #1 «»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»

1. The foreman of a casting section in a certain factory finds that on the average, 1 in every 8 castings made is defective.

a. If the section makes 12 castings a day, what is the probability that 2 of these will be defective?
b. What is the probability that 3 or more defective castings are made in one day?

2. A light bulb in an apartment entrance fails randomly, with an expected lifetime of 20 days, and is replaced immediately by the custodian. Assume that this bulb's lifetime has an *exponential* distribution.

a. What is the probability that a bulb lasts longer than its expected lifetime?
b. If the current bulb was inserted 10 days ago, what is the probability that its lifetime (since it was inserted) will exceed the expected lifetime of 20 days?
c. If you were to test 10 of these bulbs, what is the probability that more than half will exceed the expected lifetime?
d. If the custodian has 2 spare bulbs, what is the probability that these (including the one currently in use) will be sufficient for the next 60 days?

3. The probability that each car stops to pick up a hitchhiker is p=2%; different drivers, of course, make their decisions to stop or not independently of each other.

(a) Given that a hitchhiker has counted 30 cars passing him without stopping, what is the probability that he will be picked up by the 40th car or before?

Suppose that the cars arrive according to a Poisson process, at the average rate of 10 per minute. Then "success" for the hitchhiker occurs at time t provided that both an arrival occurs at t **and** that car stops to pick him up. Let T be the time (in seconds) that he finally gets a ride, when he begins his wait at time zero.

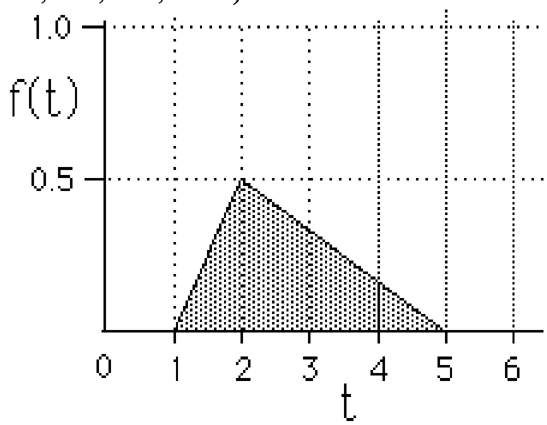
(b) What is the distribution of T? What are E(T) and Var(T)?
(c) Given that after 4 minutes (during which 35 cars have passed by) he is still there waiting for a ride, compute the expected value of T (his total waiting time, including the 4 minutes he has already waited).

«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«» HW #2 «»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»

1. (a.) Using the last four digits of your ID# as the "seed" for the "Midsquare" technique, generate a sequence of 5 pseudo-random numbers uniformly distributed in the interval [0,1].
(b.) Using the "Inverse Transformation" technique and the first 5 numbers generated in (a.), generate the interarrival times for 5 vehicles which form a Poisson process with arrival rate l=2/minute.
(c.) What is the expected number of arrivals during the first minute? What is the actual # of arrivals in your simulation? What is the probability that you would observe *exactly* this number of arrivals in this Poisson process?
(d.) Why cannot the Rejection Technique be used in (b)?

2. The Triangular distribution is often used to model a random variable for which the user can easily estimate the three parameters: a (the minimum possible value), b (the maximum possible value), and m (the most likely value). Suppose that we wish to generate 5 random numbers having the Triangular distribution to

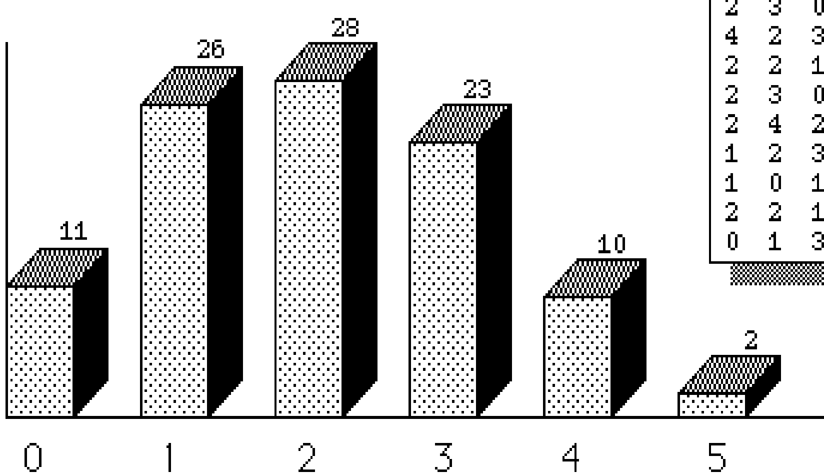
simulate a service time which is at least 1 minute but no more than 5 minutes, with 2 minutes being the most likely time. (That is, a=1, b=5, m=2.)



(a.) Using the five uniformly distributed random numbers generated in (1.), plus as many additional random numbers as are necessary, use the Rejection Technique to generate five random numbers with this Triangular distribution.
(b.) How many uniformly distributed random numbers were necessary for (a.)?
(c.) Could the Inverse Transformation Method have been used to generate these five random numbers with this Triangular distribution? If so, explain briefly how (but you needn't do it). If not, explain briefly why not.

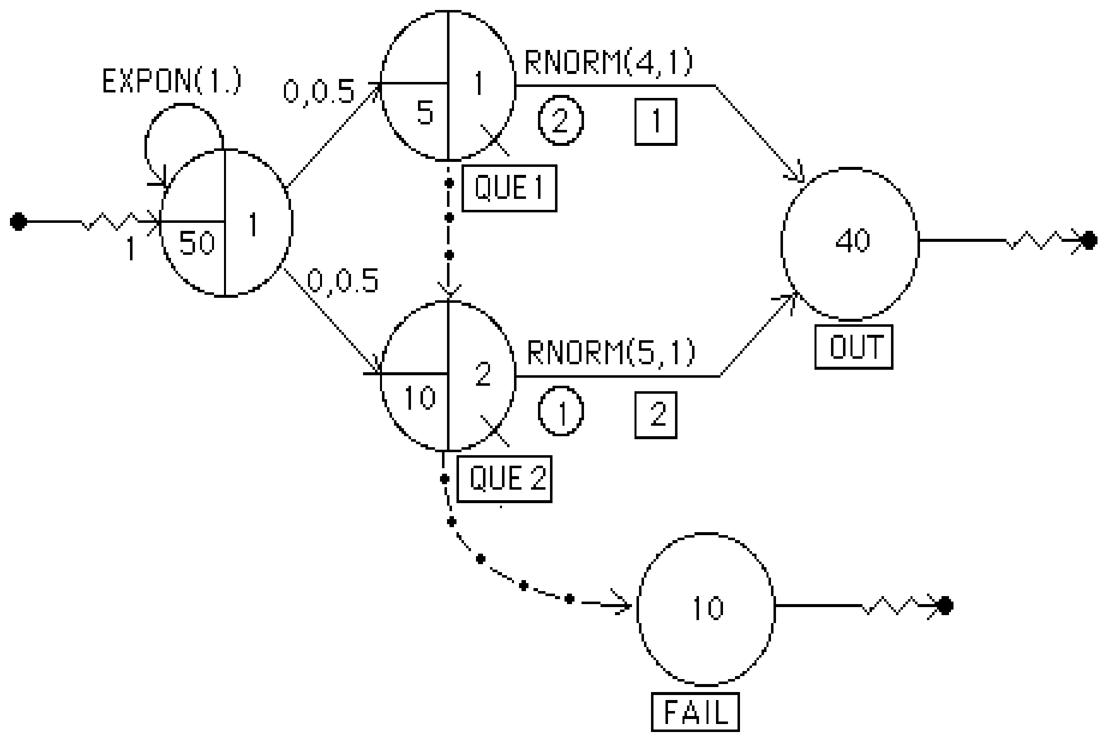
3. As part of a simulation, one hundred pseudo-random numbers were generated for the Poisson distribution with arrival rate 2/minute. These numbers are shown in the table below, with the histogram indicating the frequency of the values 0-5. Perform a Chi-Square Goodness-of-Fit test with alpha=5% to test whether the random number generator is in fact generating "random" numbers with the given arrival rate. (Note: the parameter is not being estimated from the data, and so there is no corresponding reduction in the degrees of freedom.)

5	2	1	0	2	2	3	0	4	3
2	3	0	1	2	4	3	2	1	0
4	2	3	2	1	2	2	3	2	1
2	2	1	1	3	4	3	1	3	1
2	3	0	3	1	3	5	3	4	3
2	4	2	1	0	1	2	0	1	1
1	2	3	2	3	1	4	3	1	2
1	0	1	2	1	3	2	3	0	3
2	2	1	4	2	2	2	1	1	3
0	1	3	1	2	0	4	3	4	1



«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«» HW #3 «»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»

1. Write the SLAM statements for the network model below (but don't run the model), and answer the questions:



a. What is the maximum number of entities in the system at any time?
b. What is the maximum number of entities which can wait in queue #1?
c. If an entity arrives at queue #1 and finds it full, what happens to the entity?
d. What is the maximum number of entities which will be created?
e. How many servers will serve the entities waiting in queue #1? in queue #2?
f. If an entity arrives at queue #2 and finds it full, what happens to the entity?
g. How many entities do you expect to arrive at queue #1?
h. Under what circumstances might the simulation terminate?

2. Draw the network model which corresponds to the SLAM statements below (but don't run the model), and answer the questions:

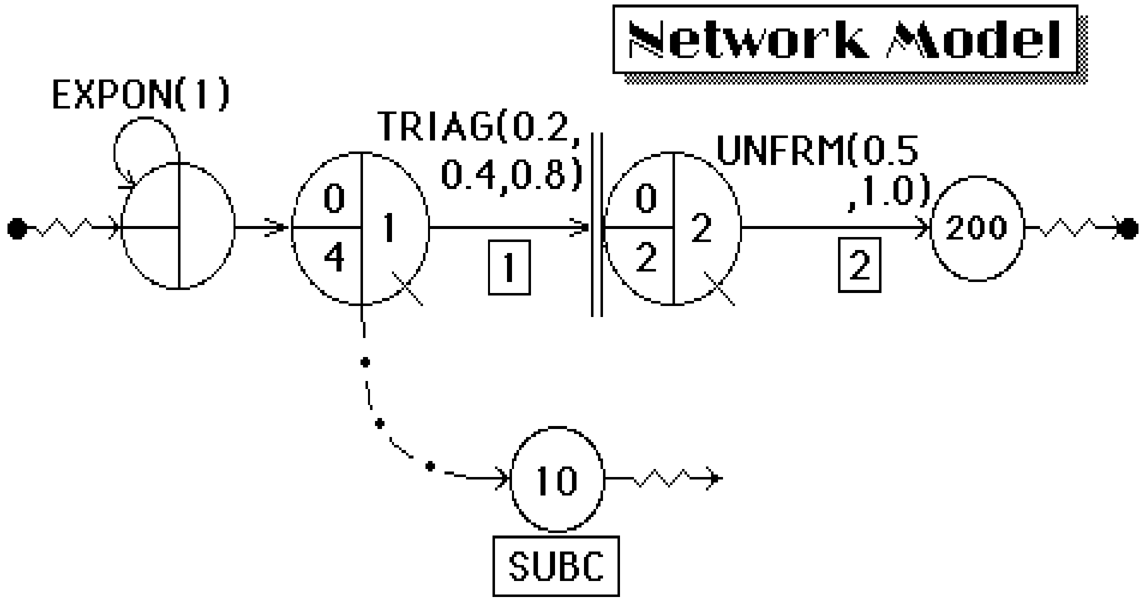
```
NETWORK;
          CREATE,EXPON(2.),,,50;
          ASSIGN,ATRIB(1)=1;
               ACTIVITY,,,QUE1;
          CREATE,EXPON(4.),,,50;
          ASSIGN,ATRIB(1)=2;
QUE1      QUEUE(1);
               ACTIVITY(2)/1,RNORM(5.,1.);
QUE2      QUEUE(2),,5,BLOCK;
               ACTIVITY(1)/2,RNORM(4.,1.);
          GOON,1;
               ACTIVITY,,ATRIB(1).EQ.1,QUE1;
               ACTIVITY,,ATRIB(1).EQ.2,DONE;
DONE      TERM,50;
          END;
```

a. What is the maximum number of entities which can wait in queue #1?
b. What is the maximum number of entities which can wait in queue #2?
c. If an entity arrives at queue #2 and finds it full, what happens to the entity?
d. What is the maximum number of entities which will be created?

e. How many servers will serve the entities waiting in queue #1? in queue #2?
f. Under what circumstances might the simulation terminate?

3. Run the SLAM simulation model for the maintenance shop example described in the class notes ("Blocking & Balking from QUEUE nodes") and answer the questions based upon the output. See:
- "Running SLAM" on the library fileserver
- the "slam" manual page on the Apollo (type "man slam" at the prompt)
- the SLAM control statement and network formats in the appendix of the class notes

(Note that the "time between creations" and the number of entities required to terminate the simulation in the class notes have been revised here.)




```
GEN,NAME,HOMEWORK 3,2/21/94;
LIM,2,,200;
INIT,,250;
NETWORK;
          CREATE,EXPON(1);
          QUEUE(1),0,4,BALK(SUBC);
              ACT/1,TRIAG(0.2,0.4,0.8);
          QUEUE(2),0,2,BLOCK;
              ACT/2,UNFRM(0.5,1.0);
         TERM,200;
SUBC      TERM,10;
         ENDNETWORK;
FIN;
```

You must create a text file (with extension .dat) containing the above SLAM statements, and then type "rslam" at the % prompt. You will then be prompted for the file name, which you should enter without the .dat extension.

a. What is the fraction of the machine repairs which are subcontracted?
b. At what (simulated) time does the simulation terminate?
c. What is the average number of machines in the maintenance shop (both waiting and being repaired)?
d. What fraction of the time is operation #1 "blocked", i.e., not busy but not able to begin the next machine because there is no waiting space in the waiting area for operation #2?
e. What fraction of the time is operation #2 busy?

«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«» HW #4 «»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»

1. A new device has been manufactured, and is to be marketed with a 90-day warranty. In order to determine its 90-day-reliability, a life test has been performed, in which 100 identical units of this device are operated, and the failure times (in days) of the first ten failures were recorded:

i	T[i]
1	14.42
2	69.96
3	89.46
4	133.14
5	135.98
6	186.27
7	226.78
8	229.14
9	233.68
10	235.63

The manufacturer wants to determine:

a.) the expected lifetime of the device

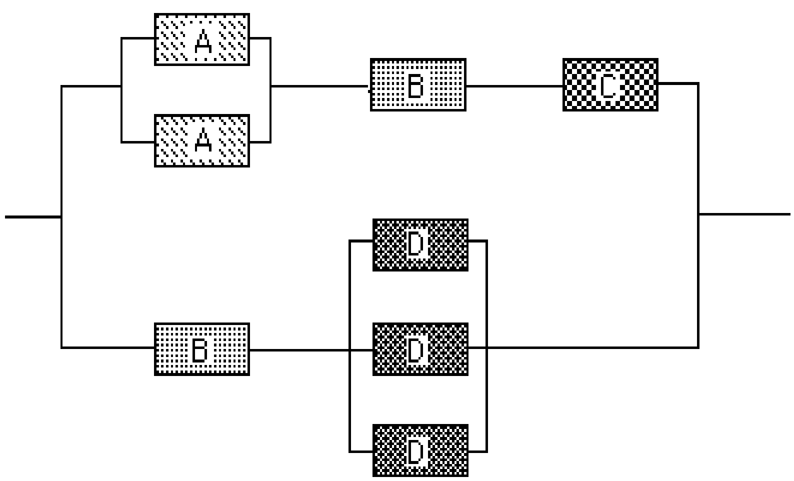
b.) the standard deviation of the lifetime

c.) the probability that the device will fail during the warranty period, i.e., its first 90 days of operation.

Using "Cricket Graph", enter T (the failure times) and R (the fraction surviving). Then, using the available transformations, define 2 new variables ln T and ln ln 1/R. Plot these 2 new variables and fit a line (using Cricket Graph's curve-fitting capability). Then, using the line which was fit, estimate the location parameter **u** and the shape parameter **k** for a Weibull probability model of the device lifetime. Use this probability model to estimate the desired quantities (a)-(c).

d.) a customer wants to design a system using this device, but requires 95% reliability for a designed lifetime of 3 years. This is to be achieved by installing several redundant units of this device (i.e., in parallel). How many total units of this device are required?

2. A system contains 4 types of devices, with the system reliability represented schematically by



It has been estimated that the lifetime probability distributions of the devices are as follows:

A: Gamma, with mean 900 days and standard deviation 250 days

B: Exponential, with mean 2500 days

C: Gamma, with mean 2000 days and standard deviation 400 days

D: Exponential, with mean 1000 days

a.) Find the ALPHA and BETA parameters for the two Gamma distributions. (Cf. page 109 of the SLAM text.)

b.) Compute the reliabity of each device for a designed system lifetime of 500 days:

Device	Reliability
A	________
B	________
C	________
D	________

c.) Using the reliabilities in (b), compute the system reliability:

Subsystem	Reliability
AA	________
AA+B+C	________
B+DDD	________
Total system:	________

d.) Now, draw a SLAM II network which will simulate this system, with the simulation terminating when the system fails.

e.) Simulate 1000 units of this system, i.e., request that SLAM run the simulation 1000 times by specifying NNRNS equal to 1000 in the GEN control statement. Also, specify that the variables are not to be re-initialized after every run by specifying NO for JJVAR in the INIT control statement. Include a COLCT node to collect statistics on the failure time, and prepare a histogram. The following control statements should work:

```
GEN,yourname,RELIABILITY,3/2/94,1000,,N,,N,Y/1000,72;
LIM,,,8;
INIT,,,NO;
NETWORK;
          (SLAM II network statements go here)
     END;
FIN;
```

f.) What is the mean lifetime of the simulated system?

g.) Compare your computation in (c) with the fraction of the 1000 systems which have survived 500 days in the simulation.

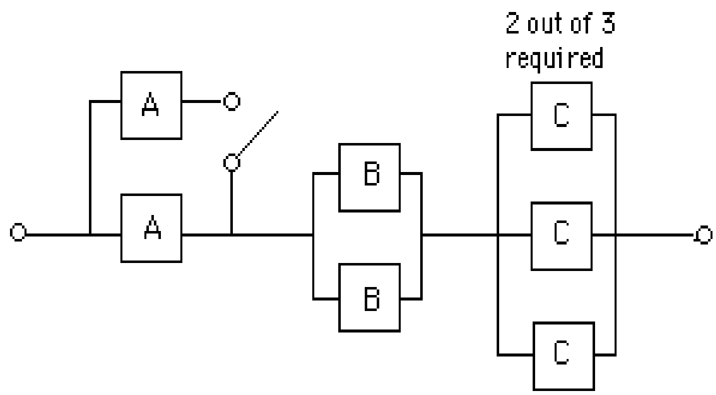
Note: In order to estimate the reliability of devices A & C, you may find it necessary to run SLAM to simulate each device for 500 days.

«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«» HW #5 «»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»

1. A bank currently has two tellers, each teller having his own queue. Customers arrive randomly at the rate of 1 per minute, and choose the shorter queue. The average service time by teller #1 is 45 seconds, with a standard deviation of 15 seconds, while for teller #2 the mean is 50 seconds with a standard deviation of 20 seconds. Assume that for each teller, the service time has a normal distribution, and that a customer cannot "jump" from one queue to the other, once he has selected a queue.

A new arrangement is being considered by the management, in which a single queue forms, and the customer at the head of the queue chooses the next available teller. (If both tellers are available when the customer arrives, assume that the choice of teller is random.) Simulate both systems (using SLAM II) for an 8-hour day, and compare the average time in the systems for the customers. (What, if any, is the % reduction in average time in the system if the new plan is implemented?)

2. A system has 3 types of components (A, B, & C) which are subject to failure. As shown below, the system requires at least one of components A and B, and at least two of component C. One of component A is in stand-by. When the first component A has failed, the second is to be switched on, and until then does not "age" or fail. Assume that the sensor/switch has 99% reliability.



The lifetime distributions of the three component types are:

Component A: Erlang, being the sum of five random variables, each having exponential distribution with mean 50 days.
Component B: Exponential, with expected lifetime 200 days.
Component C: Exponential, with expected lifetime 250 days.

a. Draw a SLAM network which can simulate the lifetime of this system.

b. Enter the network into the computer, and simulate the system 1000 times, collecting statistics on the time of system failure. Request that a histogram be printed. Specify about 15-20 cells, with HLOW and HWID parameters which will give you a "nice" histogram with the mean approximately in the center and with small tails.

Note: Be sure to specify on the GEN statement that you do NOT want intermediate results, and that the SUMMARY report is to be printed only after the 1000th run. Also specify on the INITIALIZE statement that the statistical arrays should not be cleared between runs.

c. What is the average lifetime of this system?

d. Suppose that the system is required to survive for a 100-day mission. What is the reliability of the system, i.e., the probability that the system survives 100 days?

e. Suppose you will offer a warranty on this system, such that 95% of the systems will survive past the length of the warranty. What should be the length of the warranty?

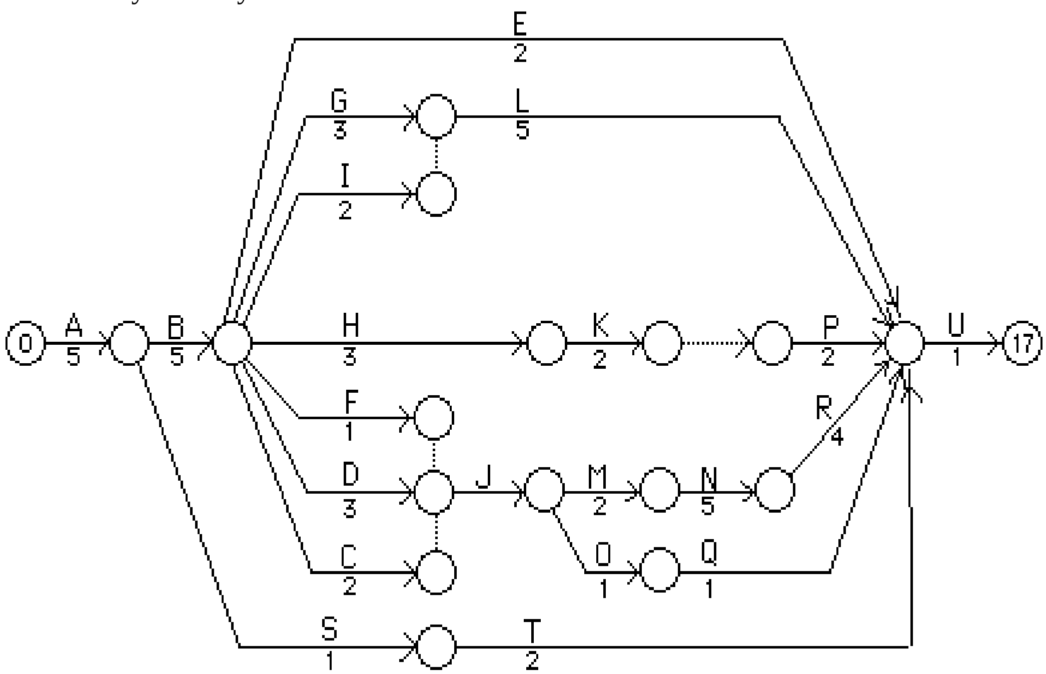
«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«» HW #6 «»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»

Project Scheduling. A building contractor is building a house. He has identified the component activities below, with their predecessors and durations as indicated:

ID	Description	Duration	Predecesors
A	Basement	5	-none-
B	Erect house frame	5	A
C	Rough electrical work	2	B
D	Rough plumbing	3	B
E	Roofing	2	B
F	Chimney	1	B
G	Siding	3	B
H	Hardwood floors	3	B
I	Windows & Doors	2	B
J	Wallboard	4	C, D, F
K	Trim wood	2	H, I, J
L	Paint exterior	5	G, I

M	Paint ceilings	2	J
N	Paint interior walls	5	K, M
O	Kitchen cabinets	1	J
P	Finished plumbing, heat	2	K, O
Q	Finished electrical	1	O
R	Finish floors	4	N
S	Fine grading of site	1	A
T	Landscape	2	S
U	Clean up site	1	E, L, P, Q, R, T

a. The building contractor has prepared the A-O-A Project Network shown below. There are, however, some "dummy" activities missing, and some "dummy" activities with no direction indicated. Draw the necessary "dummy" activities.



b. Label each of the nodes so that for each activity from node i to node j, i<j.

c. Compute the Early Time (ET) for each node (i.e., event):

Node	ET	LT
0	___	___
1	___	___
2	___	___
3	___	___
4	___	___
5	___	___
6	___	___
7	___	___
8	___	___
9	___	___
10	___	___
11	___	___
12	___	___
13	___	___
14	___	___

15	___	___
16	___	___
17	___	___

d. Compute, for each activity, the early start (ES) time, the early finish (EF) time, the late start (LS) time, and the late finish (LF) time, and the (total) float (TF).

ID	Description	Duration	ES	EF	LS	LF	TF
A	Basement	5	____	____	____	____	____
B	Erect house frame	5	____	____	____	____	____
C	Rough electrical work	2	____	____	____	____	____
D	Rough plumbing	3	____	____	____	____	____
E	Roofing	2	____	____	____	____	____
F	Chimney	1	____	____	____	____	____
G	Siding	3	____	____	____	____	____
H	Hardwood floors	3	____	____	____	____	____
I	Windows & Doors	2	____	____	____	____	____
J	Wallboard	4	____	____	____	____	____
K	Trim wood	2	____	____	____	____	____
L	Paint exterior	5	____	____	____	____	____
M	Paint ceilings	2	____	____	____	____	____
N	Paint interior walls	5	____	____	____	____	____
O	Kitchen cabinets	1	____	____	____	____	____
P	Finished plumbing, heat	2	____	____	____	____	____
Q	Finished electrical	1	____	____	____	____	____
R	Finish floors	4	____	____	____	____	____
S	Fine grading of site	1	____	____	____	____	____
T	Landscape	2	____	____	____	____	____
U	Clean up site	1	____	____	____	____	____

e. Circle the ID of each critical activity in the preceding table in (d), and indicate the critical path on the diagram in (a).

«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«» HW #7 «»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»

Project Scheduling, Part One

The Walker-Portland Company is currently in the process of planning to construct a new warehouse faciilty to reduce the company's inventory storage problems. Most of the work will be performed by the company's own construction division, but certain portions of the project, such as electrical and plumbing work, will be subcontracted.

Assume that you have been retained by the company as a consultant to aid in the planning and administrative control of the project. You called a meeting with the general foreman, estimator, and chief engineer, all from the company's construction division. Together, you have prepared time estimates for the various activities of the project. These include an optimistic, pessimistic, and most likely time for each activity, shown below. Assuming a beta distribution of activity durations, you then compute the mean and variance of each.

In addition, the estimator and foreman discussed in some detail how these activities should be sequenced, since the list in the table below does not necessarily indicate the order in which the work should be performed. During their discussion, you made the following notes:

- Corporate management approval must be obtained before any work or procurement of supplies can begin.
- Procurement of materials and subcontracting negotiations can begin as soon as approval is obtained.
- Grading can begin as soon as subcontracting negotiations are completed.

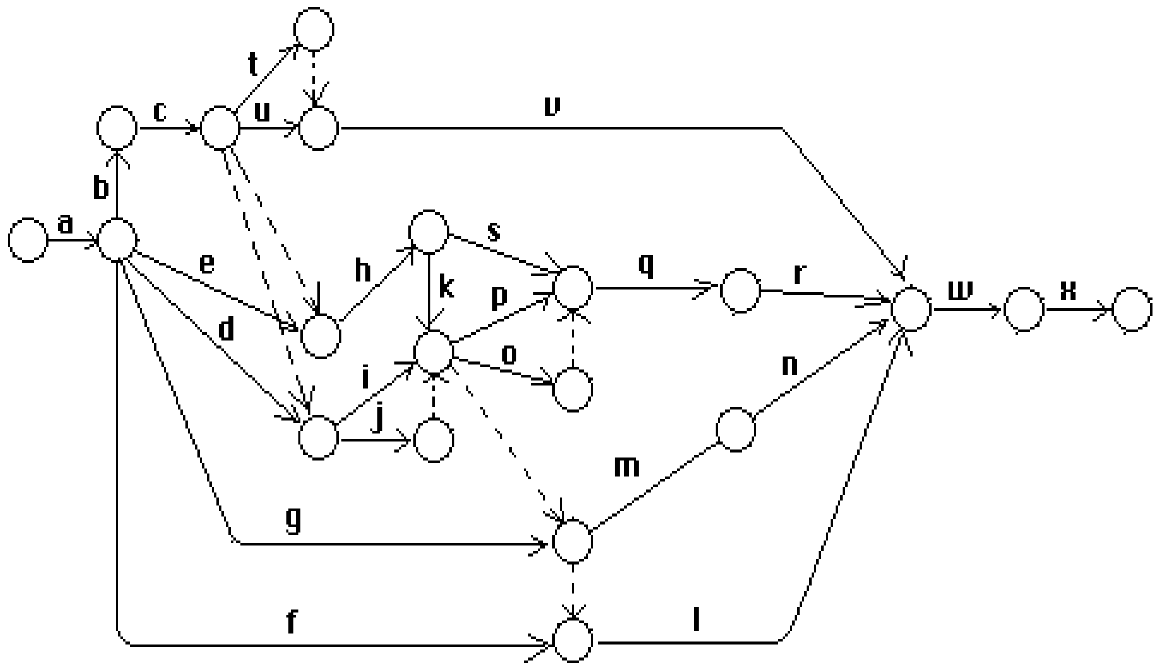
- Foundation can be poured following excavation and after concrete arrives.
- Building footings can be poured as soon as excavation work is completed.
- Framework must be erected in conjunction with (simultaneously) pouring of building footings.
- Floor slab can be poured at completion of foundation pouring. Extra time is allowed in estimates for safety reasons so that floor work does not interfere with framework construction.
- Exterior walls can be put up following completion of steel framework and arrival of supplies.
- Roof can be installed after steel framework is up. Roof slab pouring must precede roofing installation.
- Electrical and plumbing work can commence as soon as steel framework is up.
- Insulation and interior walls can be put up after electrical and plumbing work.
- Interior painting must await installation of interior walls.
- Work for sewer drain, driveway, and parking lot can begin as soon as building site is graded and excavated. Final backfilling and grading must await completion of these activities.
- Installation of fuel oil tank and heating system must be started after the foundation has been poured. It must be completed before the interior walls are put in.
- Cleanup is the final work before job acceptance.

Activity Code	Activity	Optimistic time	Most likely time	Pessimistic time	m	s^2
a	Obtain corporate mgmt. approval	2	5	8	5	1
b	Complete subcontractor negotiations	1	3	7	3.3	1
c	Grade building site & excavage for foundation	5	7	9	7	0.4
d	Procure structural steel for framework	10	15	20	15	2.8
e	Procure concrete for foundation	1	3	5	3	0.4
f	Procure exterior window & door frames	5	7	11	7.3	1
g	Procure supplies for exterior walls & roofing	1	3	5	3	0.4
h	Pour concrete for foundation	9	10	15	10.7	1
i	Pour building footings	4	5	10	____	____
j	Erect steel framework	8	11	14	11	1
k	Pour floor slab & lay concrete flooring	5	9	13	9	1.8
l	Erect exterior walls	21	24	27	24	1
m	Pour roof slab	9	12	15	12	1
n	Lay roofing	2	3	8	3.7	2
o	Electrical work--subcontracted	8	10	14	10.3	1
p	Plumbing--subcontracted	7	10	13	10	1
q	Install insulation & interior walls	10	15	20	15	2.8
r	Paint interior	3	5	9	5.3	1
s	Install fuel tank & heating system	8	10	16	10.7	1.7
t	Excavate & lay sewer drain	5	8	11	8	1
u	Driveway & parking lot--subcontracted	9	12	15	12	1
v	Backfill around building & grade	6	8	10	8	0.4
w	Clean up building and grounds	2	2	2	2	0
x	Obtain job acceptance	3	5	9	___	___

Time is in working days.

1. Verify that the A-O-A network below adequately represents the project. (There is no guarantee that I've not made an error! If so, make the correction(s) necessary.)
2. Number the nodes, so that if there is an arrow from node i to node j, then i<j.
3. Compute the expected duration and variance of activities (i) and (x).
4. Using the expected durations, apply the forward pass algorithm to compute, for each node i, ET(i), and the expected completion time of the project.
5. Apply the backward pass algorithm to compute, for each node i, LT(i).
6. Indicate on the network the critical path.

7. Find the variance of the completion time of the project.
8. Estimate the probability that the project can be completed in 80 working days (16 weeks).



Project Scheduling, Part Two

9. Draw a SLAM network to simulate the project. Assume a triangular distribution for activity durations. Include a COLCT node to collect statistics on the completion time and to prepare a histogram.
10. Simulate the project 1000 times. What is the average project completion time, in days? What is the standard deviation? Compare with the values found in Part One.
11. Using the histogram of project completion times, estimate the probability that the project will be completed within 80 working days. Compare to the value computed in Part One.

«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«» HW #8 «»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»

Instructions:

- *For each case below, draw a SLAM network model. Be sure to include nodes to collect the statistics requested.*
- *If your ID# is odd, enter the necessary SLAM statements, and run the simulation model for #1, and if even, for #2. Estimate the requested quantities. . Note that #1-2 are from HW #11 of 1993, but in that assignment the analysis was to be done using queueing theory, not simulation. You may be interested in comparing the theoretical results with the results of the simulation, however. (Cf. HW #11 Solutions.)*
- *All students should enter the SLAM statements and do the simulations for #5. (#3 and #4 require only the SLAM network.)*

1. Barges arrive at the La Crosse lock on the Mississippi River at an average rate of one every two hours. It requires an average of 30 minutes to move a barge through the lock.
Assuming that the time to move the barge through the lock has exponential distribution, it is desired to find:
   a. The average number of barges in the system, i.e., either using or waiting to use the lock.
   b. The average time spent by a barge at the lock.
   c. The fraction of the time that the lock is busy.
   d. The standard deviation of the time to move a barge through the lock.

If the time to move a barge through the lock has, not exponential, but normal distribution N(30,15), what are the revised values in (a), (b), and (c)?

2. In a particular manufacturing cell, one repairman has to maintain four machines. For the machines, the time between breakdowns is exponentially distributed with an average of 4 hours. On the average, it takes half an hour to fix a machine (exponentially distributed). An analyst wishes to answer the following questions:

a. What fraction of the time will the repairman be busy?
b. What is the average number of machines in need of repair (including those in the process of being repaired)?
c. What is the average time between a machine breakdown and that machine being restored to operating condition?

3. A system has two servers. Arrival of customers is a Poisson process, with average of 6/hour. Service times are normally distributed, with mean 20 minutes and standard deviation 10 minutes. If a customer arrives and finds both servers busy, there is a 75% probability that he departs without entering the queue. Estimate

a. The average number of customers in the system, i.e., either being served or waiting to be served.
b. The average time spent by a customer in the system.
c. The fraction of the time that each server is busy.
d. The standard deviation of the time spent by a customer in the system.

4. When the Old Capitol Mall parking ramp has two windows open at which departing parkers may pay, autos always choose the shorter queue and may not change queues once they have chosen. After paying the parking fee, the auto must wait for an opportunity to enter the street, which happens randomly, with an average wait time of 10 seconds. (Until the auto enters the street, the auto behind it cannot pull up to the window.) If autos leave the ramp at the rate of 4/minute and time at the window is uniformly distributed between 10 and 30 seconds, find:

a. The average length of the queues.
b. The average time spent by an auto in the queue.
c. The average total time spent by an auto between arriving at the queue and departing the ramp.
c. The fraction of the time that each cashier is busy.
d. The fraction of the time that a window is "blocked" from serving a waiting auto while the auto having just paid is waiting to enter the street.

5. A machine shop performs three types of jobs (A,B, and C) which require varying amounts of time for operations on three machines (drill, lathe, grinder) followed by an inspection:

			Time in minutes		
Job type	# of jobs	Operation	minimum	most likely	maximum
A	20	Lathe	10	20	45
		Grinder	5	10	20
		Inspection	10	20	35
B	30	Lathe	20	35	50
		Drill	10	20	30
		Grinder	10	20	40
		Inspection	15	25	45
C	50	Grinder	5	10	20
		Drill	10	15	30
		Inspection	5	10	15
		Drill	15	20	40
		Inspection	10	20	30

Assume that operation times have triangular distribution. The shop foreman has been asked for an estimate of the time required to complete these jobs. Assign arbitrarily a priority for the jobs on each machine (may differ according to machine) and simulate the shop in order to estimate:

a. the makespan, i.e., the total amount of time to complete all of the jobs.
b. the average time in the shop for each job type.

c. the utilization of each machine and the inspector.

Choose another assignment of priorities which you think might lower the makespan and repeat the simulation, estimating the same quantities.

«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«» HW #9 «»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»

Instructions:

- *For each case below, draw a SLAM network model. Be sure to include nodes to collect the statistics requested.*
- *If your ID# is odd, enter the necessary SLAM statements, and run the simulation model for #1, and if even, for #2. Estimate the requested quantities.*

1. Barges arrive at the La Crosse lock on the Mississippi River at an average rate of one every two hours (24 hours/day). However, the lock is in operation only between 8 am and 6 pm. It requires an average of 30 minutes to move a barge through the lock. (No barge begins its passage through the lock after 6 pm, but any barge which has begun its passage will complete it before the lock is shut down that evening.) We wish to simulate a week's operation of the lock. Assuming that the time to move the barge through the lock has a normal distribution, with standard deviation 10 minutes, it is desired to find:

   a. The average number of barges in the system, i.e., either using or waiting to use the lock.
   b. The average time spent by a barge at the lock.
   c. The fraction of the time that the lock is busy.
   d. The standard deviation of the time to move a barge through the lock.

2. In a particular manufacturing cell, one repairman has to maintain four machines. For the machines, the time between breakdowns is exponentially distributed with an average of 4 hours. The machines operate 24 hours/day. On the average, it takes half an hour to fix a machine (exponentially distributed). The repairman works an eight-hour shift, from 8 am until noon, takes a 1-hour break, and then works from 1-4 pm. An analyst wishes to answer the following questions:

   a. What fraction of the time will the repairman be busy?
   b. What is the average number of machines in need of repair (including those in the process of being repaired)?
   c. What is the average time between a machine breakdown and that machine being restored to operating condition?

3. During a certain busy period of the day, the Old Capitol Mall parking ramp has two windows open at which departing parkers may pay, autos always choose the shorter queue and may not change queues once they have chosen. Half of the parkers have the correct change, in which case the time required at the window has normal distribution with mean 10 seconds, standard deviation 5 seconds. The other half of the parkers spend an amount of time at the window having normal distribution with mean 30 seconds, standard deviation 10 seconds. After paying the parking fee, the auto must wait for an opportunity to enter the street, which happens randomly, with an average wait time of 10 seconds. (Until the auto enters the street, the auto behind it cannot pull up to the window.) If autos leave the ramp at the rate of 4/minute, find:

   a. The average length of the queues.
   b. The average time spent by an auto in the queue.
   c. The average total time spent by an auto between arriving at the queue and departing the ramp.
   c. The fraction of the time that each cashier is busy.
   d. The fraction of the time that a window is "blocked" from serving a waiting auto while the auto having just paid is waiting to enter the street.

4. At Osco Drug Store, there are three check-out lanes. Customers join the shorter waiting line, but may freely switch from one lane to the other in order to be served more quickly. (That is, there is never a case in which a clerk is available but customers are waiting in the queue for another clerk.) The store's policy is to add a check-out clerk if there are more than two customers waiting in each line. Customers arrive at the check-out lanes at the rate of 1/minute (forming a Poisson process), and the time required to check them out is

normally distributed with mean 60 seconds, and standard deviation 20 seconds. We wish to collect statistics to estimate:

a. The average number of clerks working at the check-out lanes.
b. The average number of customers waiting to be served.
c. The maximum number of customers waiting to be served.
d. The average total time spent by a customer at the check-out lanes (waiting plus being served.)

«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«» HW #10 «»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»«»

1. Draw the SLAM network which could be used to model the following system.
An airline ticket counter has two customer queues, one for regular customers, who are serviced by 4 agents, and one for frequent flyer membership customers, who are serviced by one agent. Approximately 2 out of every 10 customers have frequent flyer memberships. Customers arrive with an exponentially distributed interarrival time with mean two minutes. If an arriving frequent flyer membership customer observes that the regular customer queue has two or fewer people while the frequent flyer agent is busy, the customer will enter the regular customer queue. Service time of regular customers is normally distributed with a mean of 10 minutes and a standard deviation of 4 minutes. Service time of frequent flyer customers is also normally distributed but with a mean of seven minutes and a standard deviation of 2 minutes.

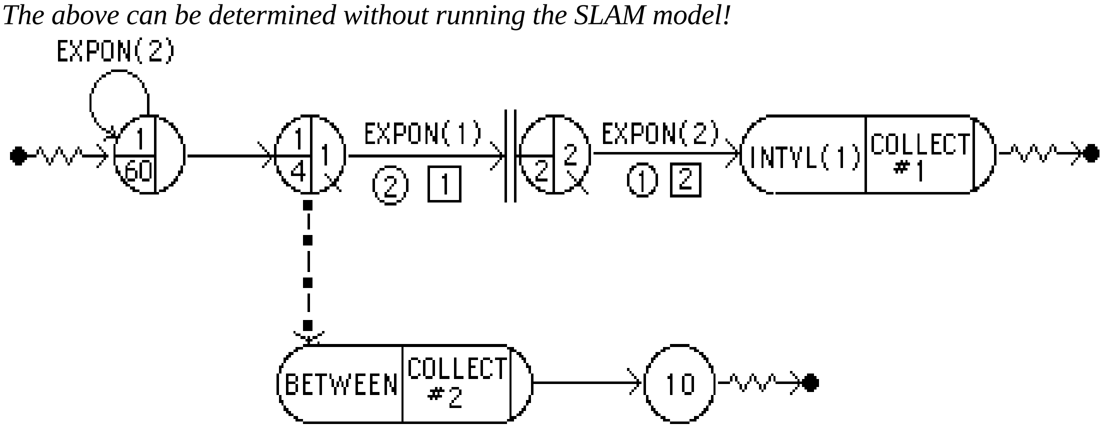
2. Arriving parts must be processed at two machine centers. Each machine center has limited storage space for waiting parts. Parts which arrive and cannot be stored at the first machine center are sent elsewhere for storage, to be processed at a later time. Consider the SLAM II network below and state the following values:

_______ a. The average time between arrivals.
_______ b. The total number of servers in the system.
_______ c. The number of entities in the system initially.
_______ d. The capacity of the first queue.

If all times were constants, equal to the mean of the probability distributions in the original network, state the following values:

________ e. The time at which the first part leaves the system.
________ f. The time at which the first part arriving at the system leaves the system.
________ g. The value of the mean reported by the first COLCT node.
________ h. The value of the mean reported by the second COLCT node.
________ i. The time at which the simulation terminates.

The above can be determined without running the SLAM model!



3. An experiment consists in tossing a coin until the first head shows up. One hundred repetitions of this experiment are performed. The frequency distribution of the number of trials required for the first head is as follows:

Number of trials:	1	2	3	4	5 or more
Frequency:	40	32	15	7	6

a. Assuming that the coin is fair, what are the expected frequencies?
b. Are the observed frequencies consistent with the assumption that the coin is fair? (Use a=0.05.)

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