Homework 1

DATA604 Simulation and Modeling

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February 2, 2016

1.1

Name several entities, attributes, activities, events, and state variables for the following systems.

(a) A cafeteria

Entities

- Serving Line
- Food Servers
- Tables

Attributes

- Number of Food Servers
- Number of seats per table
- Rate of serving for Food Servers
- Time range for eating the meal

Activities

- Waiting in line
- Being served by a Food Server
- Waiting for a table to eat
- Eating at a table

Events

- Arrival of new person in serving line to be served
- Person leaving serving line
- Person waiting for seat at table to eat
- Person finishing eating and leaving table

State Variables

- Number of people eating at tables
- Number of people waiting in line to be served

(b) A grocery store

Entities

- Checkout lanes

Attributes

- Max number of items allowed in checkout lane
- Rate of checkout for cashier

Activities

- Customer shopping in the grocery store
- Customer checking out (paying for goods)

Events

- Arrival of customer at grocery store
- Arrival of customer at checkout lane
- Customer completing checkout
- Customer departing store without purchasing anything

State Variables

- Number of customers in grocery store
- Number of customers in checkout lane lines

(c) A laundromat

Entities

- Washing machines
- Drying machines

Attributes

- Washing machine run time
- Drying machine run time
- Ratio of washing machine to drying machine capacity

Activities

- Washing clothes
- Drying clothes
- Loading washing machine
- Transfering from washing to drying machine
- Unloading from drying machine

Events

- Washing maching cycle starts
- Washing machine cycle stops
- Dryer cycle starts
- Dryer cycle stops

State Variables

- Number of busy washing machines
- Number of busy dryers

(d) A fast-food restaurant

Entities

- Cashiers
- Back-cooks (i.e. burger flippers)
- Fryers

Attributes

- Burgers per burger flipper
- Orders of frys per Fryer
- Cashier busy or not

Activities

- Cooking a burger
- Making french frys
- Cashier taking order, accepting payment

Events

- Order in
- Order ready for pickup
- French fries done cooking

State Variables

- Number of orders pending
- Number of burgers being cooked
- Orders of french frys cooked/ready for serving
- Number of bugers being ready for serving

(e) A hospital emergency room

Entities

- Doctors
- Beds
- Patients
- Admitting staff

Attributes

- Patients per Doctor

Activities

- Patient admitted
- Doctor take care of patient
- Patient discharged

Events

- Patient arrives
- Patient admitted
- Doctor discharges patient

State Variables

- Beds empty
- Patients awaiting addmission
- Paitents awaiting discharge

(f) A taxicab company with 10 taxis

Entities

- Taxis
- Dispatcher
- Customers

Attributes

- Taxi has customer
- Taxi enroute to customer
- Customer waiting for taxi

Activities

- Enroute to customer
- Transporting customer

Events

- Picking up custommer
- Dropping off customer

State Variables

- Taxis with customers
- Customers waiting for available taxi

(g) An automobile assembly line

Entities

- Parts
- Assembly machines
- Workers

Attributes

- Parts inventory
- Assembly machine rate of production
- Worker rate of production

Activities

- Machine assembling car
- Worker assembling car
- Staging parts for use by Machine or Worker

Events

- Car assembly started
- Car assembly completed
- Parts depleted
- Car assembly by machine X completed
- Car assembly by worker Y completed

State Variables

- Cars on assembly line
- Parts inventory level
- Workers out sick/vacation
- Machines broken down

2.1 Consider the following continuously operating job shop. Interarrival times of jobs are distributed as follows:

Time Between Arrivals (hours)	Probability
0	0.23
1	0.37
2	0.28
3	0.12

Processing times for jobs are normally distributed, with mean 50 minutes, and standard deviation 8 minutes. Construct a simulation table and perform a simulation for 10 new customers. Assume that, when the simulation starts, there is one job being processed (scheduled to be completed in 25 minutes) and there is one job with a 50-minute processing time in the queue.

```
existingJobs <- data.frame(customer=c(-2, -1),
                           interarrivalHrs=c(0,0),
                           interarrivalMins=c(0,0),
                           arrivalMins=c(0,0),
                           jobProcessingMins=c(25, 50))

newJobs <- data.frame(customer=seq(1, 10),
                      interarrivalHrs=sample(seq(0, 3),
                                             size=10,
                                             prob=c(.23, .37, .28, .12),
                                             replace=TRUE),
                      interarrivalMins=rep(NA, 10),
                      arrivalMins=rep(0, 10),
                      jobProcessingMins=rnorm(10, mean=50, sd=8))

newJobs$interarrivalMins <- newJobs$interarrivalHrs * 60
newJobs$arrivalMins <- cumsum(newJobs$interarrivalMins)

simTable <- rbind(existingJobs, newJobs)
simTable
```

```
##    customer interarrivalHrs interarrivalMins arrivalMins jobProcessingMins
## 1        -2               0                0           0          25.00000
## 2        -1               0                0           0          50.00000
## 3         1               3              180         180          44.57550
## 4         2               0                0         180          36.54425
## 5         3               1               60         240          44.80684
## 6         4               1               60         300          59.80041
## 7         5               2              120         420          73.62703
## 8         6               1               60         480          28.03371
## 9         7               1               60         540          49.21791
## 10        8               0                0         540          45.53814
## 11        9               2              120         660          60.17811
## 12       10               2              120         780          44.98210
```

(a) What was the average time in the queue for the 10 new jobs?

(b) What was the average processing time of the 10 new jobs? The average processing time is computed below:

```r
mean(newJobs$jobProcessingMins)
```

```
## [1] 48.7304
```

(c) What was the maximum time in the system for the 10 new jobs?