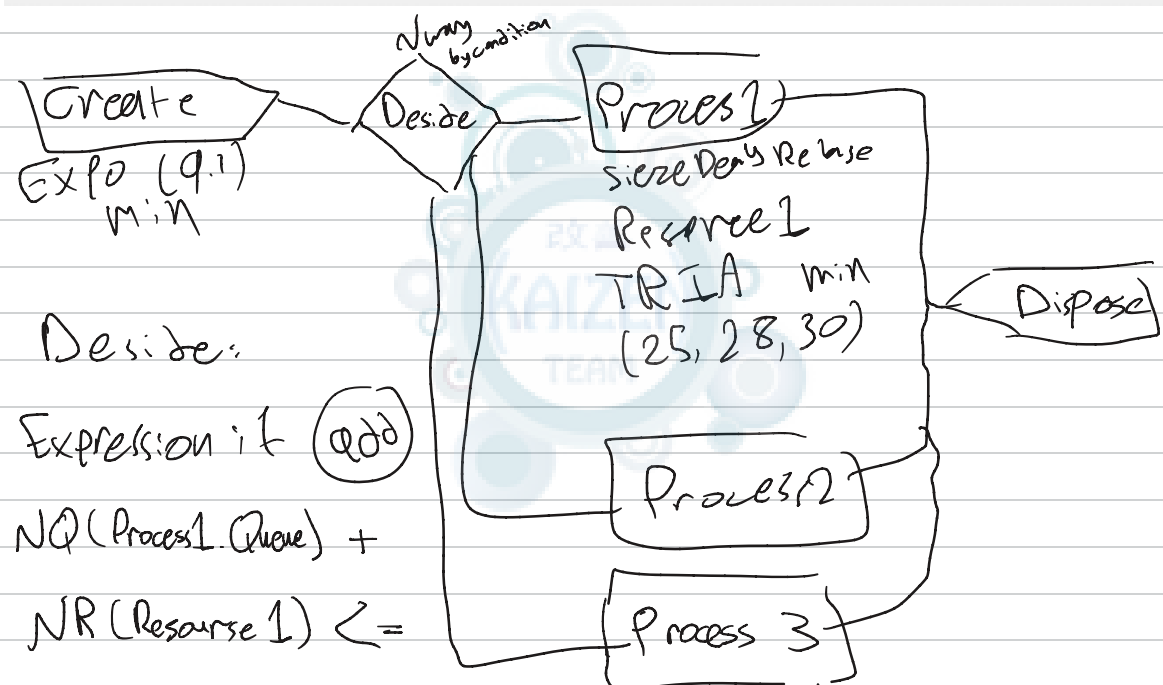


by Eng. Zena Qasem

4.0 a)(5 points) Trucks arrive with EXPO(9.1) interarrival times (all times are in minutes) to an unload area that has three docks; the first truck arrives at time 0. The unload times are TRIA(25, 28, 30), TRIA(23, 26, 28), and TRIA(22, 25, 27) for docks 1, 2, and 3, respectively. If there is an empty dock, the truck proceeds immediately to that dock. Assume zero travel times to all docks. If there is more than one empty dock, the truck places preference on the higher-numbered dock (3, 2, 1). If all the docks are busy, it chooses the dock with the minimum number of trucks waiting. If there is a tie, it places preference on the lowest numbered dock (1, 2, 3). Note that in "by Condition" Decide modules, the tests are done from top to bottom, and the first one resulting in a "true" sends the entity out through that corresponding exit point. Model using arena



Decide:

Expression if (add)

NQ(Process1.Queue) +

NR(Resourse 1) <=

NQ(Process2.Queue) + NR(Resourse 2) && <=

NQ(Process3.Queue) + NR(Resourse 3)

(add) Expression if

NQ(Process2.Queue) + NR(Resourse 2) <=

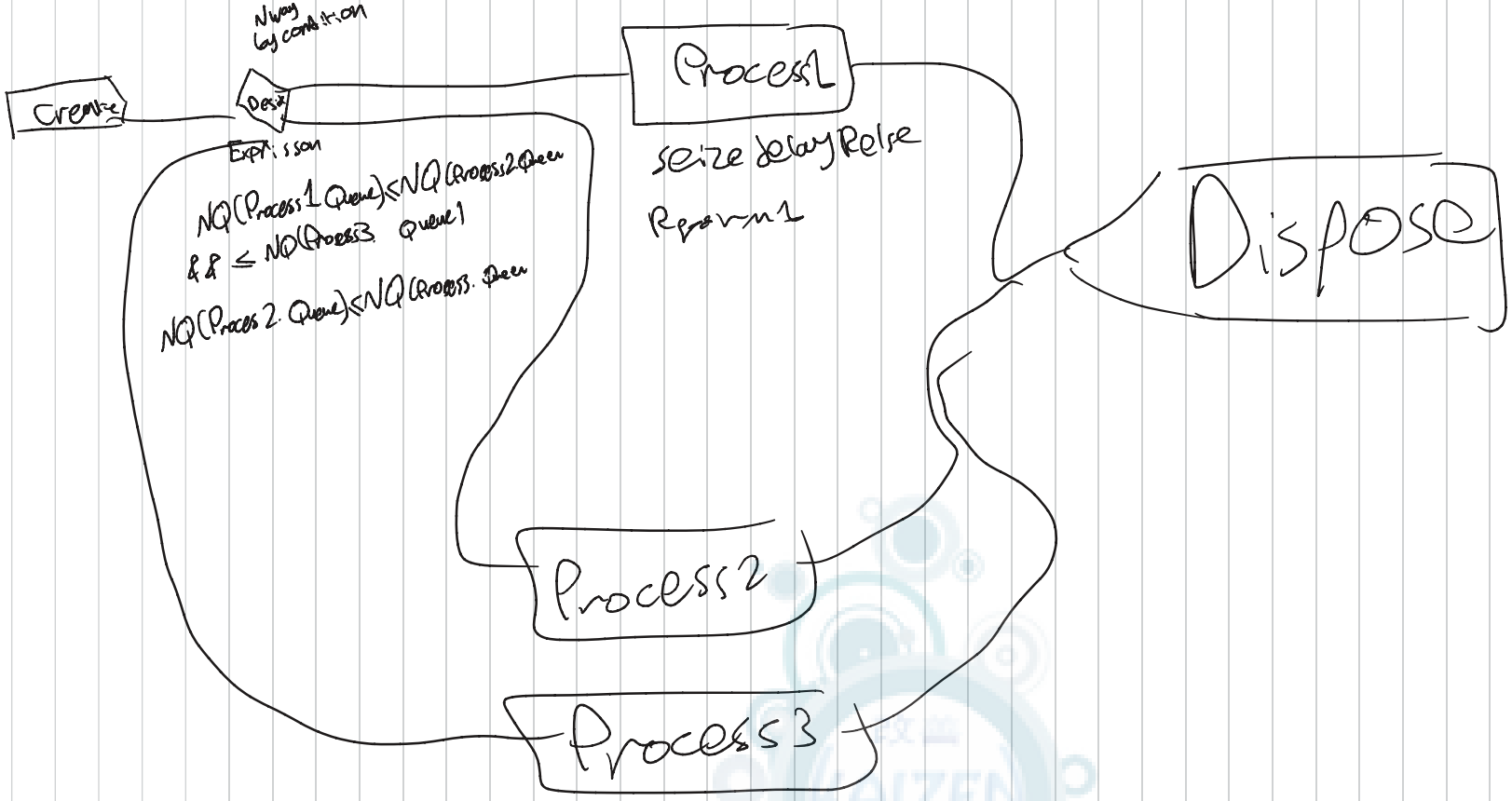
NQ(Process3.Queue) + NR(Resourse 3)

Quiz Simulation Prof M. Barghash IE SoE UoJ 28/10/2025

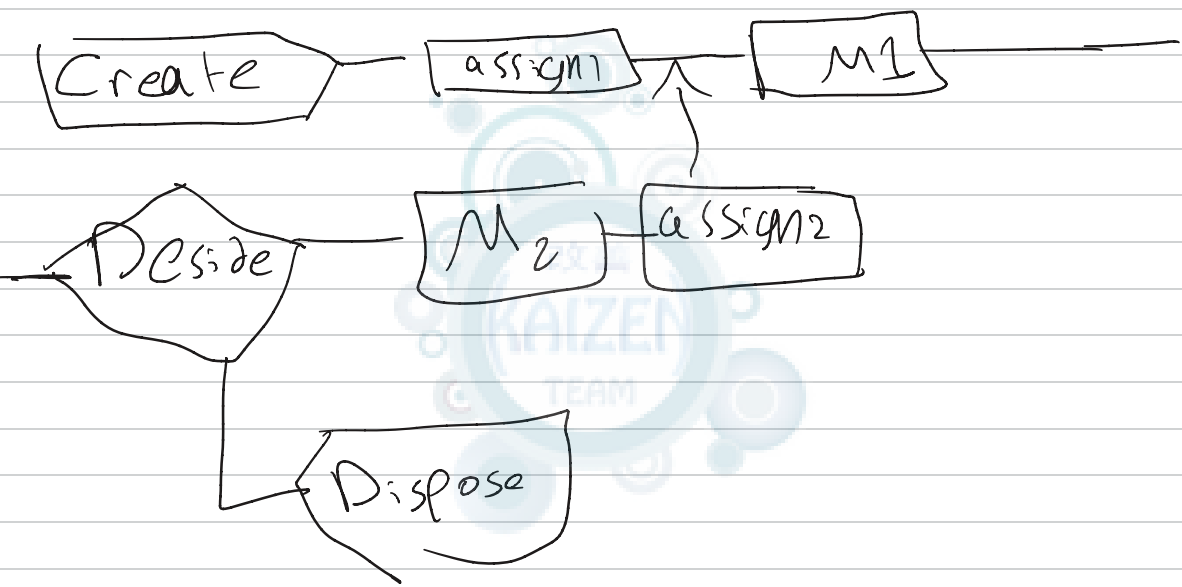
Name: ID:

Q1)Describe how to add obtain the simulation output as subcategories instead of mean and standard deviation

Q2) A grocery store has three checkout lanes (checkout 1, checkout 2, and checkout 3), each with a single checker. Shoppers arrive at the checkout area with interarrival times having an exponential distribution with mean 2.4 minutes. The shoppers enter the lane that has the fewest number of other shoppers already in the queue (not counting any shopper already in service at the checkouts). If there are ties for the shortest queue, the shopper will join the lowest-numbered checkout (that is, 1, 2, or 3). The checkout service time for all shoppers follows an exponential distribution with a mean of 6.35 minutes regardless of which checkout they choose. Create a simulation of this system and run it for a single replication of 48 hours (starting empty and idle, and with the fi rst shopper's arriving at time zero) to determine the average and maximum time from when the shopper arrives at the checkout area until they complete their checkout. Also observe the average and maximum of each of the three queue lengths, and the utilization of each of the three checkers. Add a plot to track the length of each queue on the same set of axes, color-coded, and animate your queues and resources. Put a text box in your model containing a table of your results, and comment briefl y on why they are consistent with both the queue-choice and tie-breaking rules.


N way
by condition
Create
Decide
Expression
NQ(Process1 Queue)≤NQ(Process2 Queue
&& ≤ NQ(Process3 Queue)
NQ(Process2 Queue)≤NQ(Process3 Queue
Process1
seize delay Relase
Return 1
Dispose
Process2
Process3

4.0 a) (5 points) Parts arrive at a two-machine system according to an exponential interarrival distribution with mean 20-minutes; the fi rst arrival is at time 0. Upon arrival, the parts are sent to Machine 1 and processed. The processing-time distribution is TRIA(4.5, 9.3, 11) minutes. The parts are then processed at Machine 2 with a processing-time distribution as TRIA(16.4, 19.1, 20.8) minutes. The parts from Machine 2 are directed back to Machine 1 to be processed a second time (same processing-time distribution as the first visit but an independent draw from it). The completed parts then exit the system. Model using arena



assign1 :

add attribute
name: Type
value 1

assign2 :
add attribute
name Type
value 2

Decide 1 :
2 way by condition
Expression
if attribute Type == 1

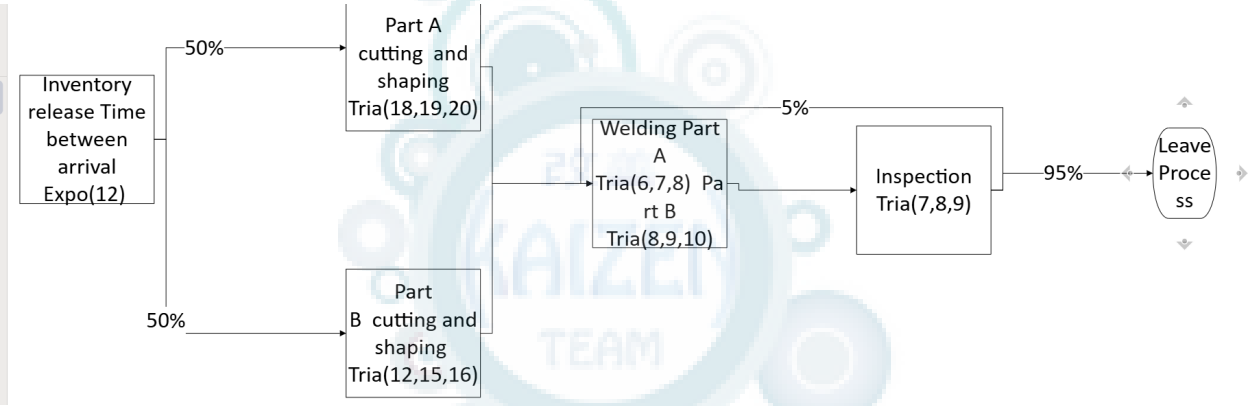
Quiz Simulation Prof M. Barghash IE SoE UoJ 28/10/2025

Name: ID:

Q1) (3 points)

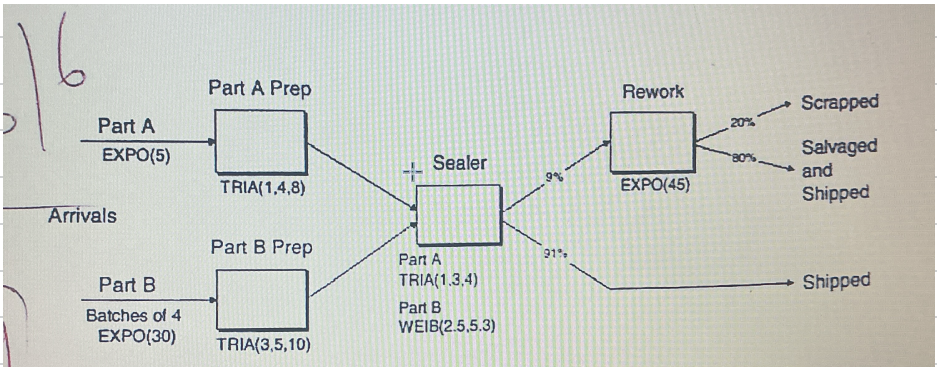
Describe the non-stationary arrivals, and how implement them in arena?

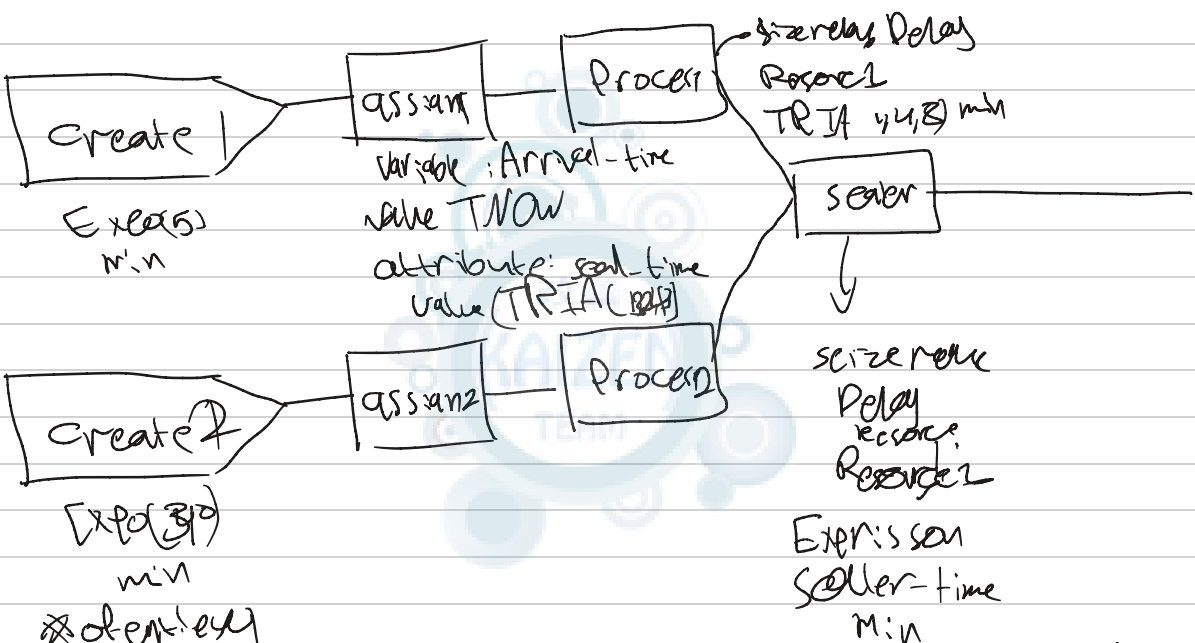
Q2)) a) show the arena simulation for the system shown in the following figure. Add statistical collection for the number of parts produced and the time in system

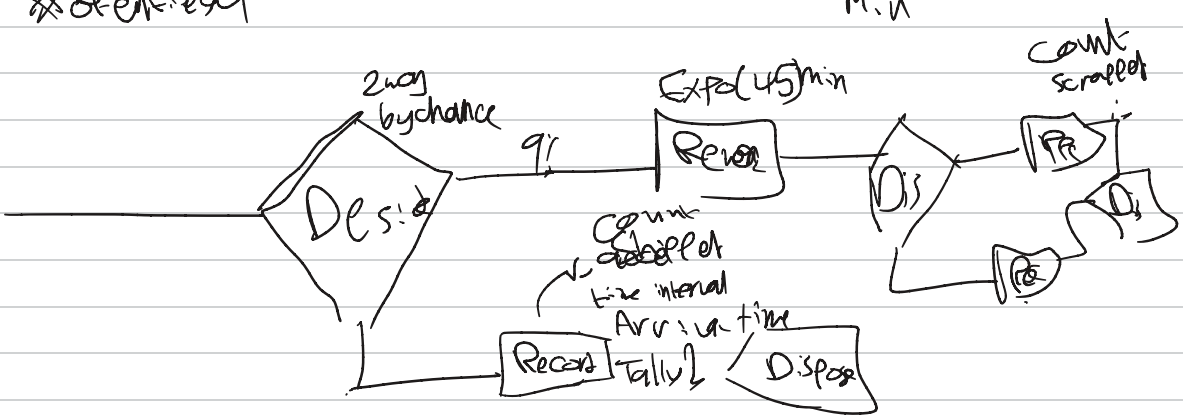


The process depicted in the flowchart represents a manufacturing workflow for producing parts, starting with an Inventory release. The Inventory release time between arrivals follows an exponential distribution with a mean of 12 minutes (Expo(12)), and it splits its output equally, with 50% feeding into Part A cutting and shaping and the other 50% into Part B cutting and shaping.

For Part A, the cutting and shaping stage takes a triangular distribution of time between 18, 19, and 20 minutes (Tria(18,19,20)) and feeds into the Welding Part A stage. The Welding Part A process follows a triangular distribution with parameters 6, 7, and 8 minutes for the Part A and 8, 9, and 10 minutes for the part B. both parts proceeds to the Inspection stage. The Inspection stage takes a triangular distribution of time between 7, 8, and 9 minutes (Tria(7,8,9)), and 95% of its output moves to be shipped while the rest (5%) go back to welding stage which takes tria(3,4,5) only.

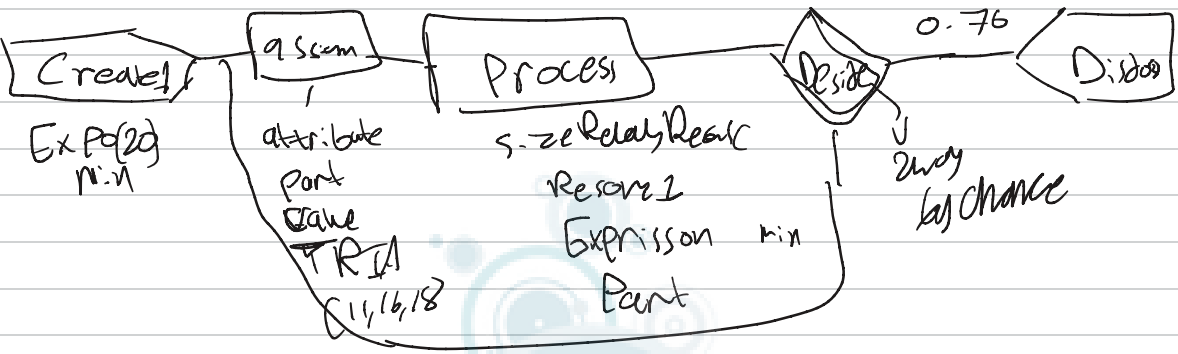

Part A Prep
Part A
EXPO(5)
TRIA(1,4,8)
Arrivals
Part B Prep
Part B
Batches of 4
EXPO(30)
TRIA(3,5,10)
Sealer
Part A
TRIA(1,3,4)
Part B
WEIB(2.5,5.3)
9%
91%
Rework
EXPO(45)
20%
80%
Scrapped
Salvaged and Shipped
Shipped


Create 1
Expo(5)
min
assign
Variable: Arrival-time
value TNOW
attribute: seal_time
value (TRIA(
Process
Sizerelay, Delay
Resource1
TRIA 4,4,8) min
sealer
Create 2
Expo(30)
min
assign2
Process
sizerelay
Delay
resource
Resource1
Expression
Seller-time
min

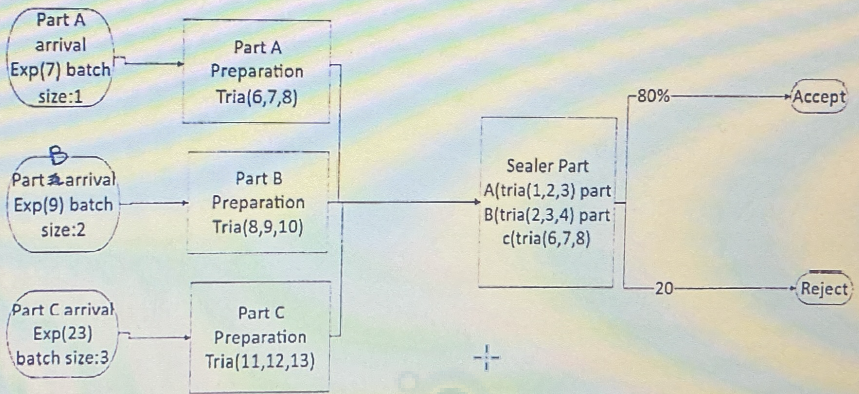

2way by chance
Decide
Expo(45)min
Rework
Dis
count scrapped
Count
time interval
Arrival time
Record
Dispose

Q5) Parts arrive at a single machine system according to an exponential interarrival distribution with mean 20 minutes; the first part arrives at time 0. Upon arrival, the parts are processed at a machine. The processing-time distribution is TRIA(11, 16, 18) minutes. The parts are inspected and for each part there is a 0.24 probability that it will need

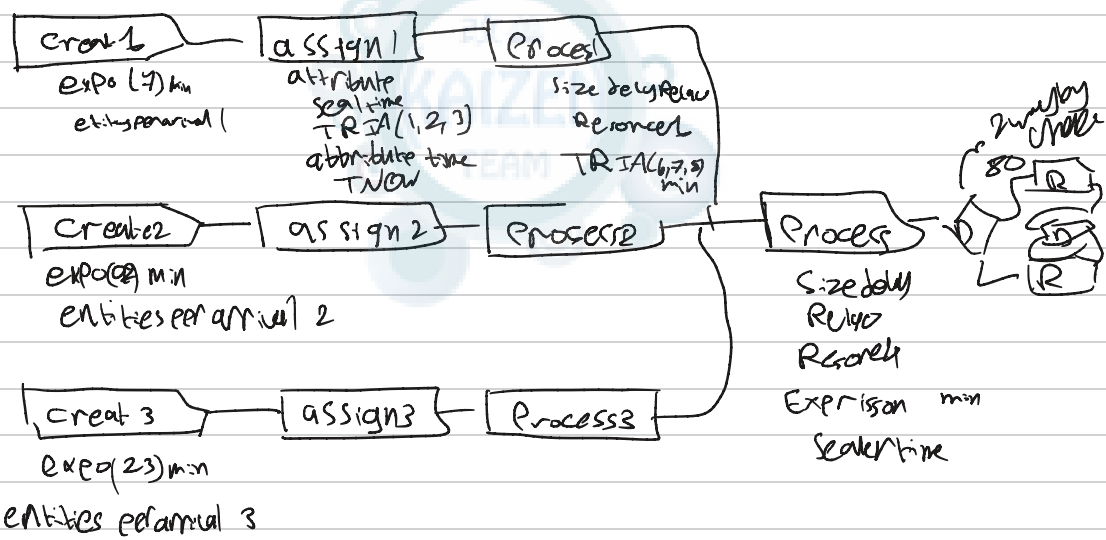
to be sent back to the same machine to be reprocessed (same processing-time distribution but a fresh draw from it, and all send-back decisions are independent of each other). There's no limit on how many times a given part might have to go through the machine for processing/reprocessing (6 points)



Q3) a) show the arena simulation for the system shown in the following figure. Add statistical collection for the number of parts produced and the time in system



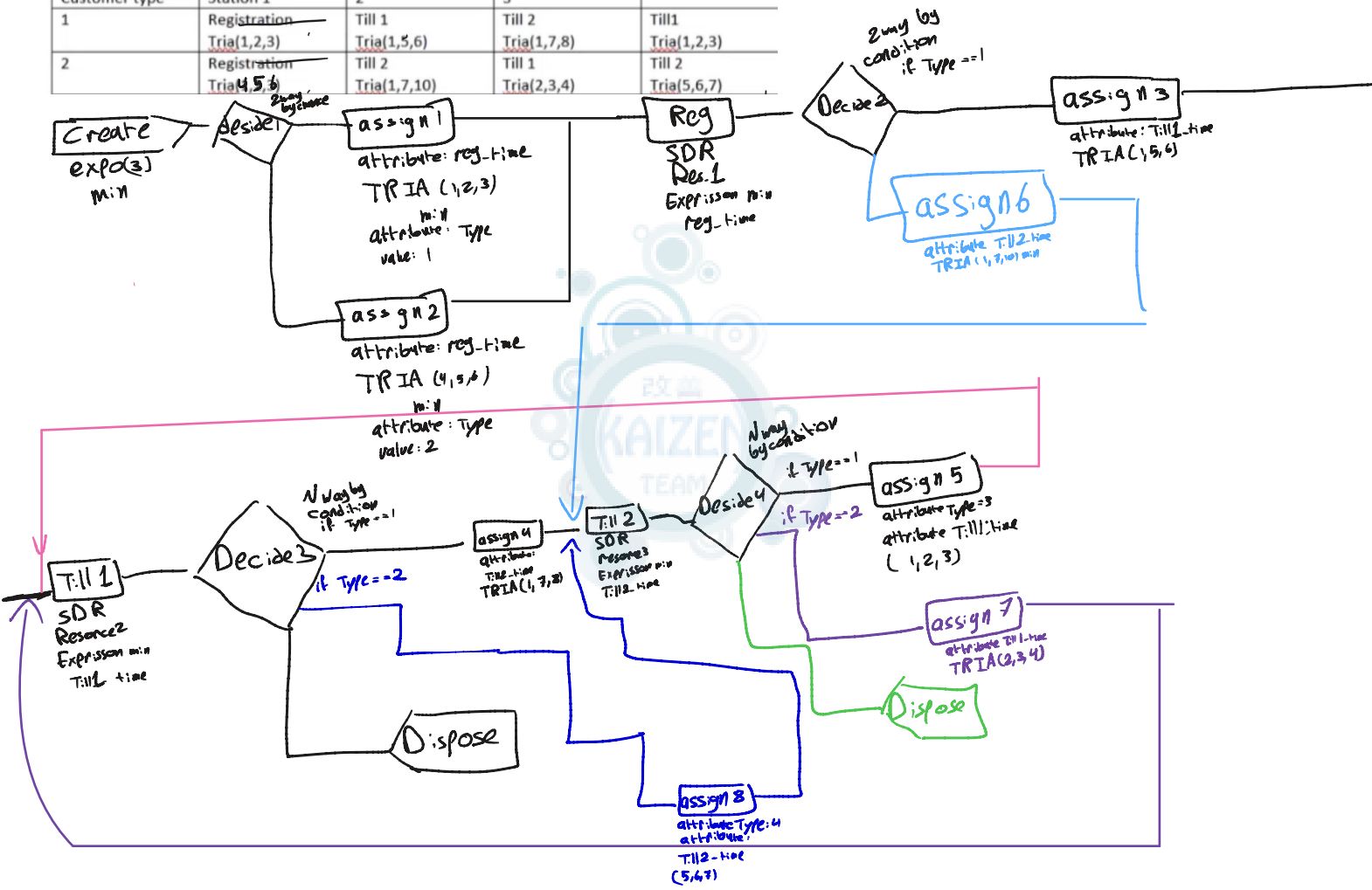
Three parts arrive a, b, c then they are prepared , the sealer time for each is shown in the figure. (6 points)



for Record 1 : Add counter
Parts accepted
Add time in bound
time
Tally 1

Q2) customers arrive to an establishment with an interarrival time of expo(3). There are four stations and two types of customers, the following table shows the sequence and operation time for each customer, model using arena

Customer type	Station 1	2	3	
1	Registration Tria(1,2,3)	Till 1 Tria(1,5,6)	Till 2 Tria(1,7,8)	Till1 Tria(1,2,3)
2	Registration Tria(4,5,6)	Till 2 Tria(1,7,10)	Till 1 Tria(2,3,4)	Till 2 Tria(5,6,7)



Q2) customers arrive to an establishment with an interarrival time of expo(3). There are four stations and two types of customers, the following table shows the sequence and operation time for each customer, model using arena

Customer type	Station 1	2	3	
1 40%	Registration Tria(1,2,3)	Till 1 Tria(1,5,6)	Till 2 Tria(1,7,8)	Accounting Tria(1,2,3)
2 60%	Registration ~~Tria(1,2,3)~~ (5,6,7)	~~Till 2~~ Tria(1,7,10)	~~Till 1~~ Tria(2,3,4)	Accounting Tria(5,6,7)

we will have 4 process 1- Reg

2- Till

3- Till 3

4- Acount

Process 1

Size Delay Relase

Resource: Reg-staff

Expression: Reg-time (min)

Process 2

Size Delay Relase

Resorce: Till 1

Expression: Till 1-Time (min)

Process 3

Seize Delay Relase

Resource: Till 2

min Expression

Till 2-Time

Process 4

Seize Daly Realse

Resource account

Expression min

account-Time

Data definition:

Attribute
Name

1 Reg_time

2 Till1-Time

3 Till2-Time

4 account-Time

assign1

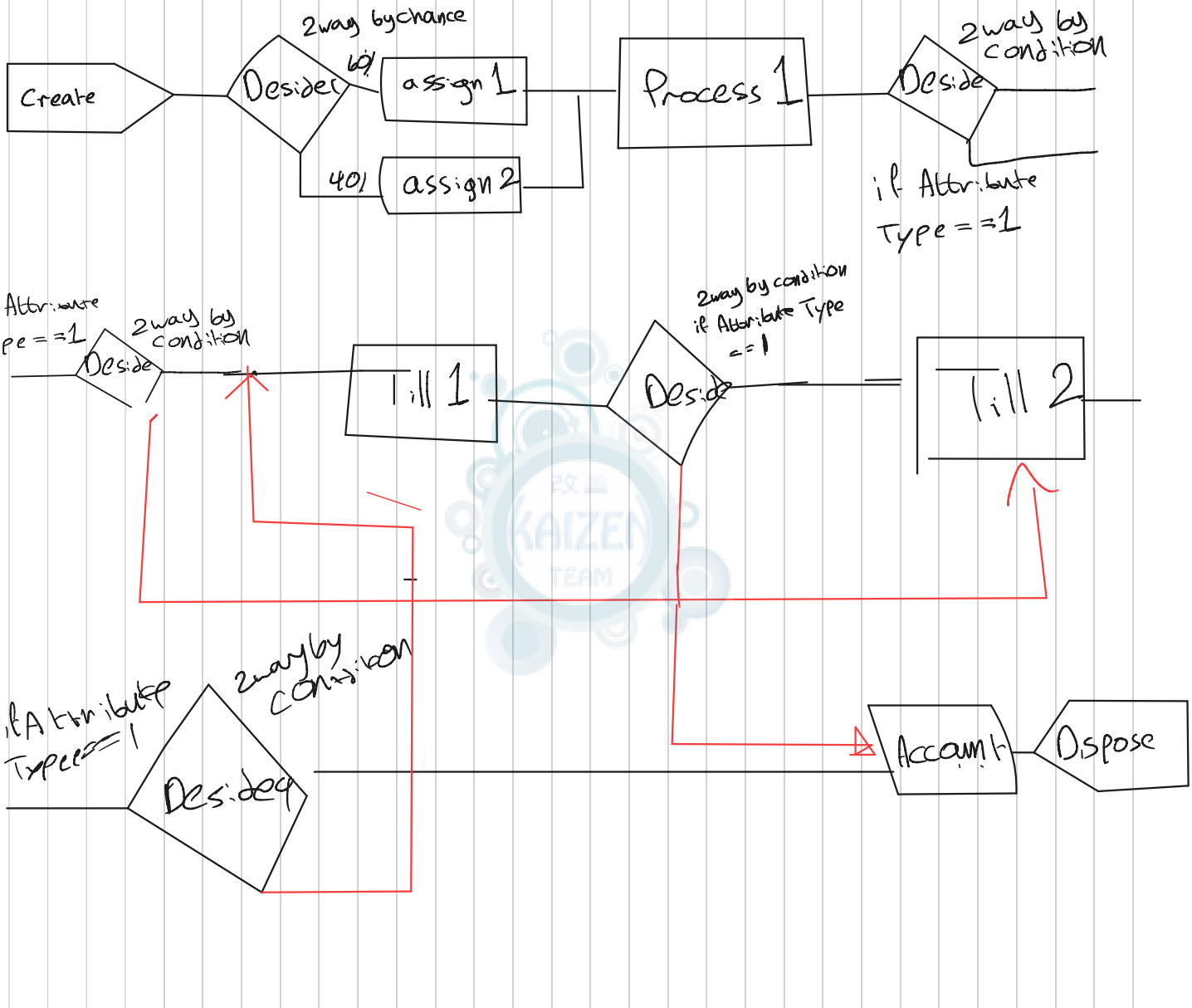
Attribute Type
value1
Attribute Reg-time
value: TRIA(1,2,3)
Attribute Till1-time
value TRIA( )
Atribute Till2-time
value TRIA( )
Attribute account_time
value TRIA( )

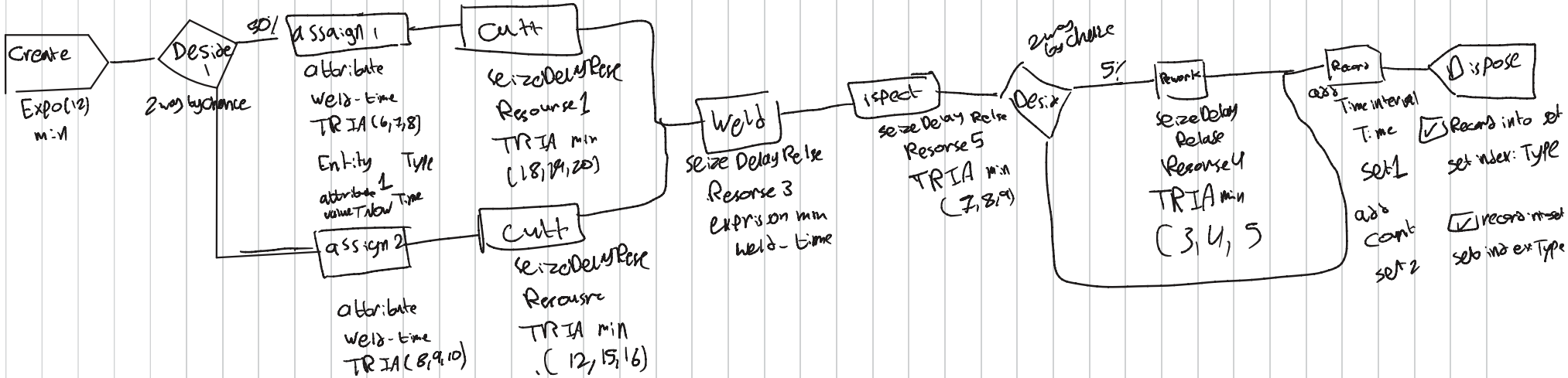
Entity Picture Picture.Green ball

assign2

Attribute Type
value 2
Attribute Reg-time
value: TRIA(5, 6, 7)
Attribute Till1-time
value TRIA( )
Atribute Till2-time
value TRIA( )
Attribute account_time
value TRIA( )

Entity Picture Picture.Blue Ball


2way bychance
60
40
Create
Decide
assign 1
assign 2
Process 1
Decide
2way by condition
if Attribute Type ==1
if Attribute Type ==1
Decide
2way by condition
Till 1
2way by condition if Attribute Type ==1
Decide
Till 2
if Attribute Type==1
Decide
2way by condition
Accumulate
Dispose



Data definition

set

Name	Type
set1	Tally
set2	counter

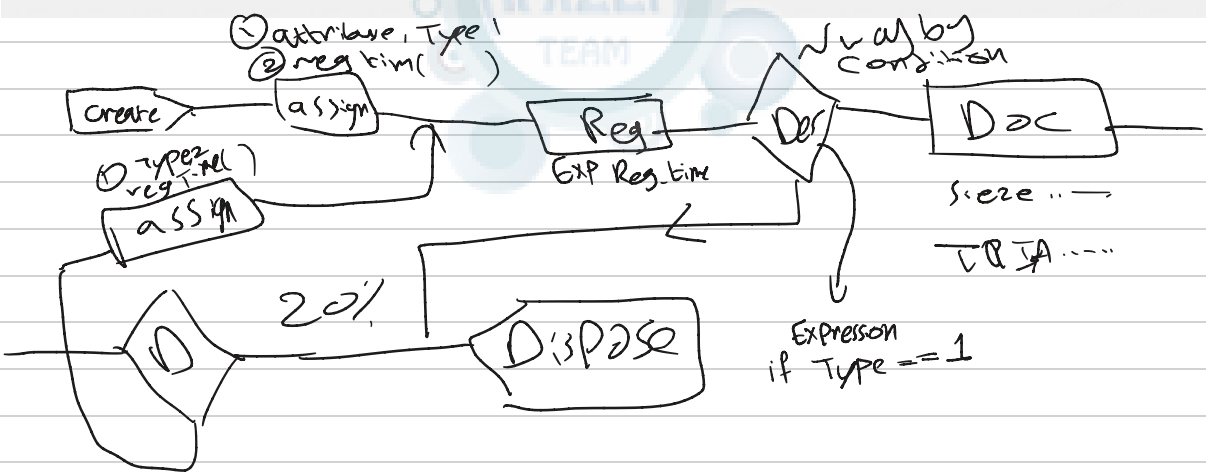
, remove
2 rows → Tally1 Tally2
2 rows
↓
counter1
counter2

Q5) Parts arrive at a single machine system according to an exponential interarrival distribution with mean 20 minutes; the fi rst part arrives at time 0. Upon arrival, the parts are processed at a machine. The processing-time distribution is TRIA(11, 16, 18) minutes. The parts are inspected and for each part there is a 0.24 probability that it will need

to be sent back to the same machine to be reprocessed (same processing-time distribution but a fresh draw from it, and all send-back decisions are independent of each other). There's no limit on how many times a given part might have to go through the machine for processing/reprocessing (6 points)

No need for assign/attribute

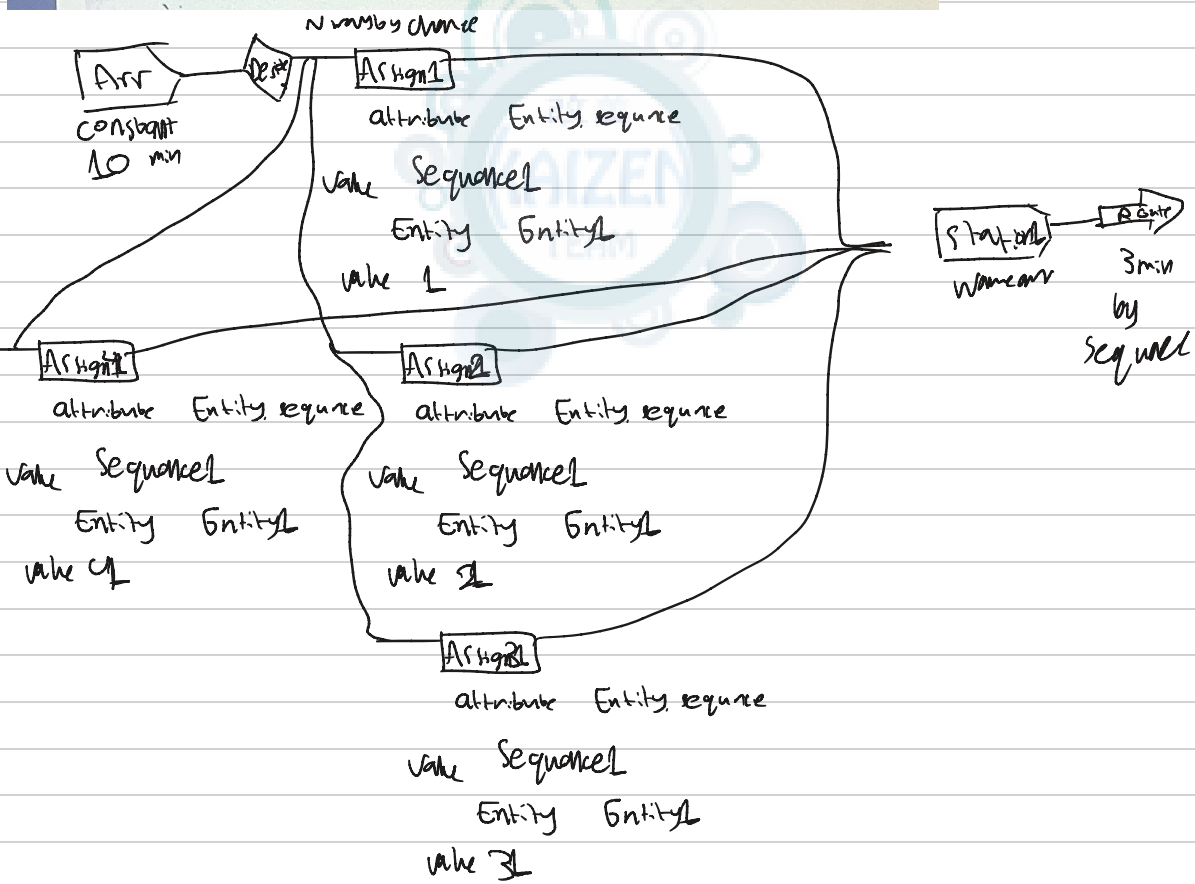
2.0 b) (5 points) An acute-care facility treats non-emergency patients (cuts, colds, etc.). Patientsmarrive according to an exponential interarrival-time distribution with a mean of 11 (all times are in minutes). Upon arrival they check in at a registration desk staffed by a single nurse. Registration times follow a triangular distribution with parameters 6, 10, and 19. Patients go to doctor take tria(5,7,10) then 80% of the patients leave, 20% of the patients go back to registriation to take new appointment take 2 tria(1,2,3) mins then leave

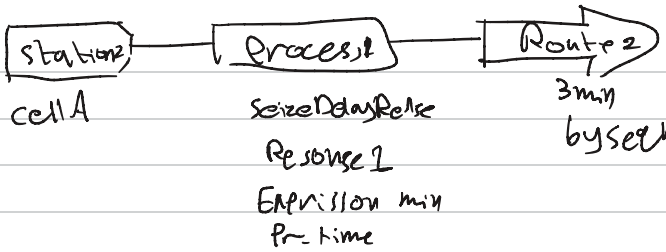


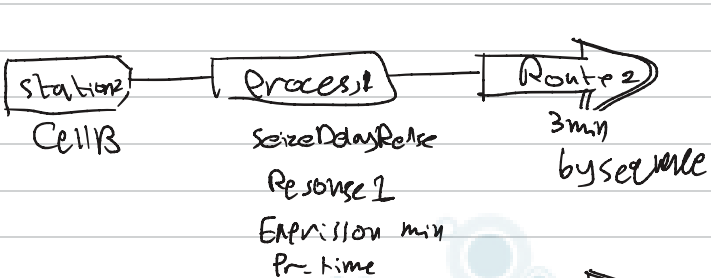
Q5) A part arrives every 10 minutes to a system having three workstations (A, B, and C), where each workstation has a single machine; the first part arrives at time 0. There are four part types, each with equal probability of arriving. The process plans for the four part types are given here. The entries for the process times are the parameters for a triangular distribution (in minutes).

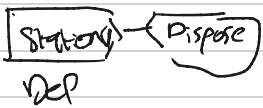
Part Type	Workstation/ Process Time	Workstation/ Process Time	Workstation/ Process Time
Part 1	A 5.5,9.5,13.5	C 8.5,14.1,19.7	
Part 2	A 8.9,13.5,18.1	B 9,15,21	C 4.3,8.5,12.7
Part 3	A 8.4,12.15.6	B 5.3,9.5,13.7	
Part 4	B 9.3,12.6,16.0	C 8.6,11.4,14.2	

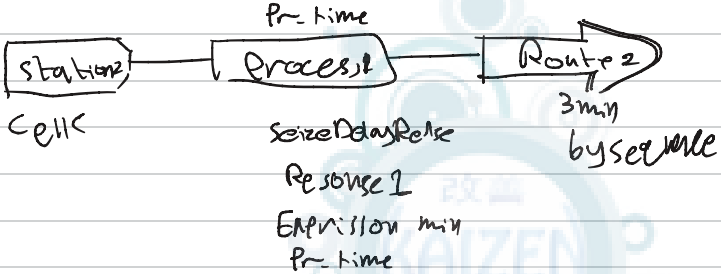
Assume that the transfer time between arrival and the first station, between all stations, and between the last station and the system exit is 3 minutes. Use the Sequence feature to direct the parts through the system and to assign the processing times at each station. Model using arena (7 points)











Data Definition:

Sequence add 4 sequencies

Sequence1

Station

A Attribute pr_time TRIA( )
B
Def

Q5) A part arrives every 10 minutes to a system having three workstations (A, B, and C), where each workstation has a single machine; the first part arrives at time 0. There are four part types, each with equal probability of arriving. The process plans for the four part types are given here. The entries for the process times are the parameters for a triangular distribution (in minutes).

Part Type	Workstation/ Process Time	Workstation/ Process Time	Workstation/ Process Time
Part 1	A 5,5,9,5,13,5	C 85,14,1,19,7	
Part 2	A 8,9,13,5,18,1	B 9,15,21	C 4,3,8,5,12,7
Part 3	A 8,4,12,15,6	B 5,3,9,5,13,7	
Part 4	B 9,3,12,6,16,0	C 8,6,11,4,14,2	

Assume that the transfer time between arrival and the first station, between all stations, and between the last station and the system exit is 3 minutes. Use the Sequence feature to direct the parts through the system and to assign the processing times at each station. Model using arena (7 points)

Data Definition:

sequance name : Rows

Station

sequance 1 — A Att Pr-time TRIA(5,5,9,5,13,5)

C Dep Att Pr-time TRIA(85,1,4)

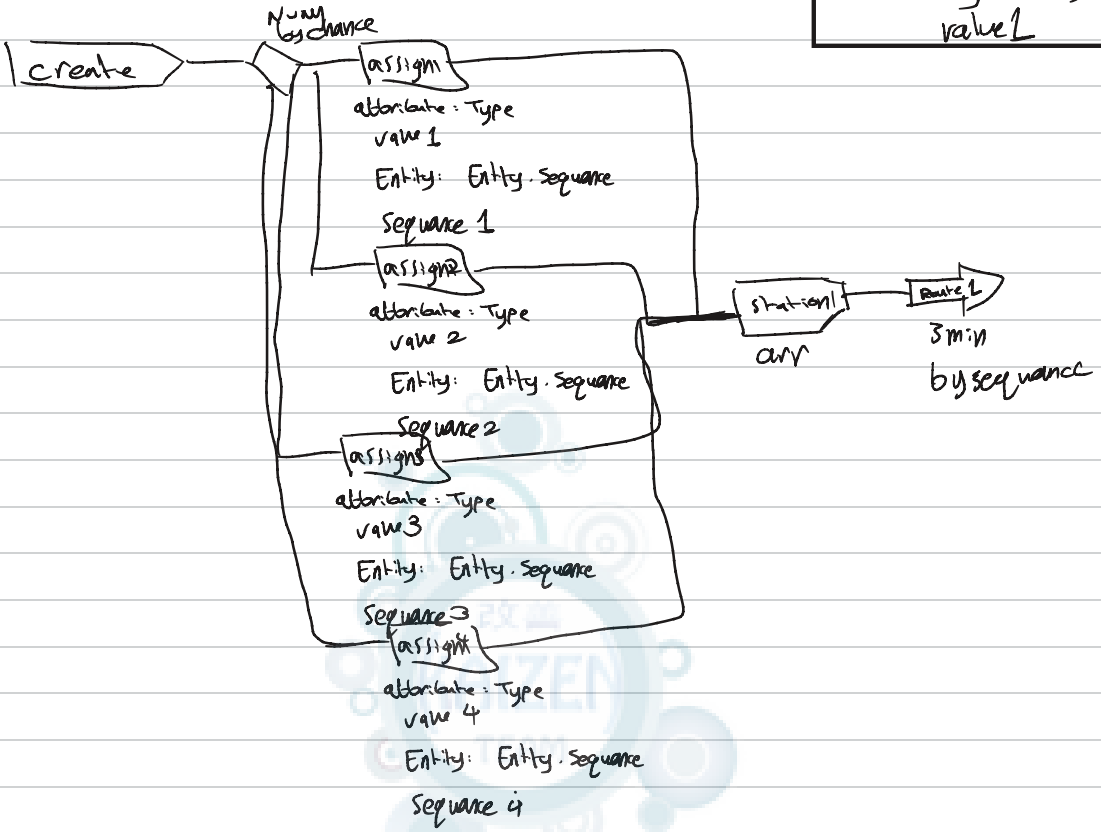
sequance 2 — A, B, C, Dep

sequance 3 — A, B, Dep

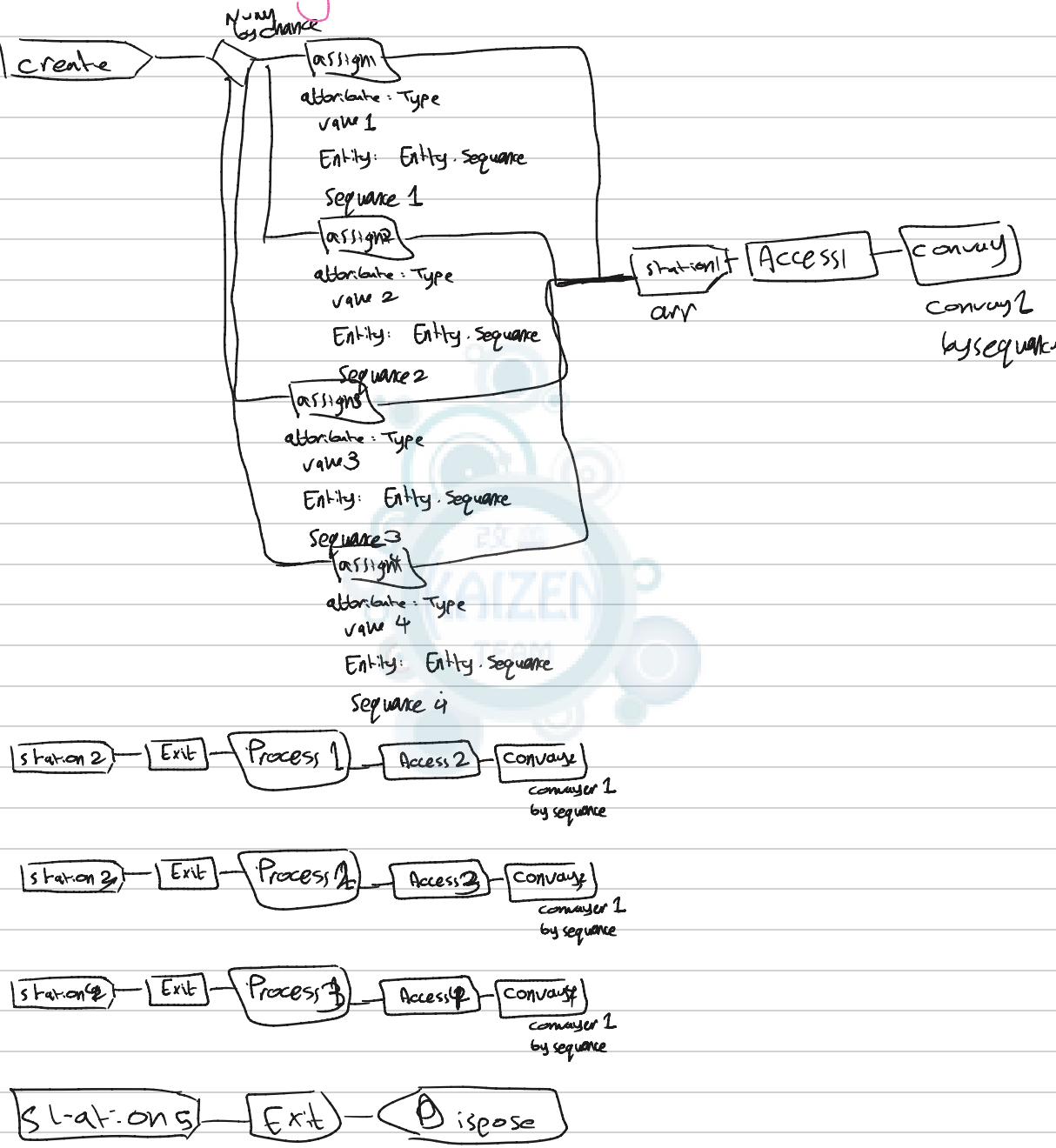
Sequance 4 — B, C, Dep

Route Model 8

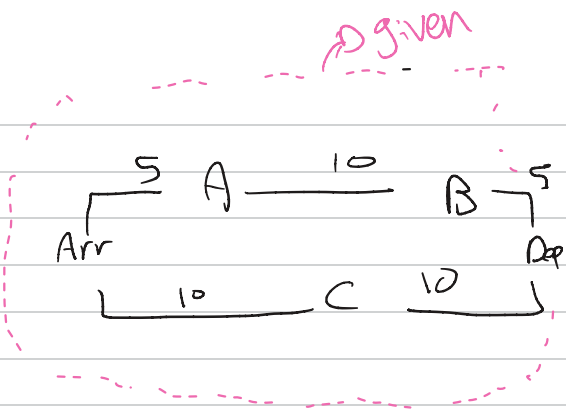
Note:
Use AttributeType
ex Entity: Entity1
value1



Conveyor model:



Material Handling



conveyor double click

segment double click

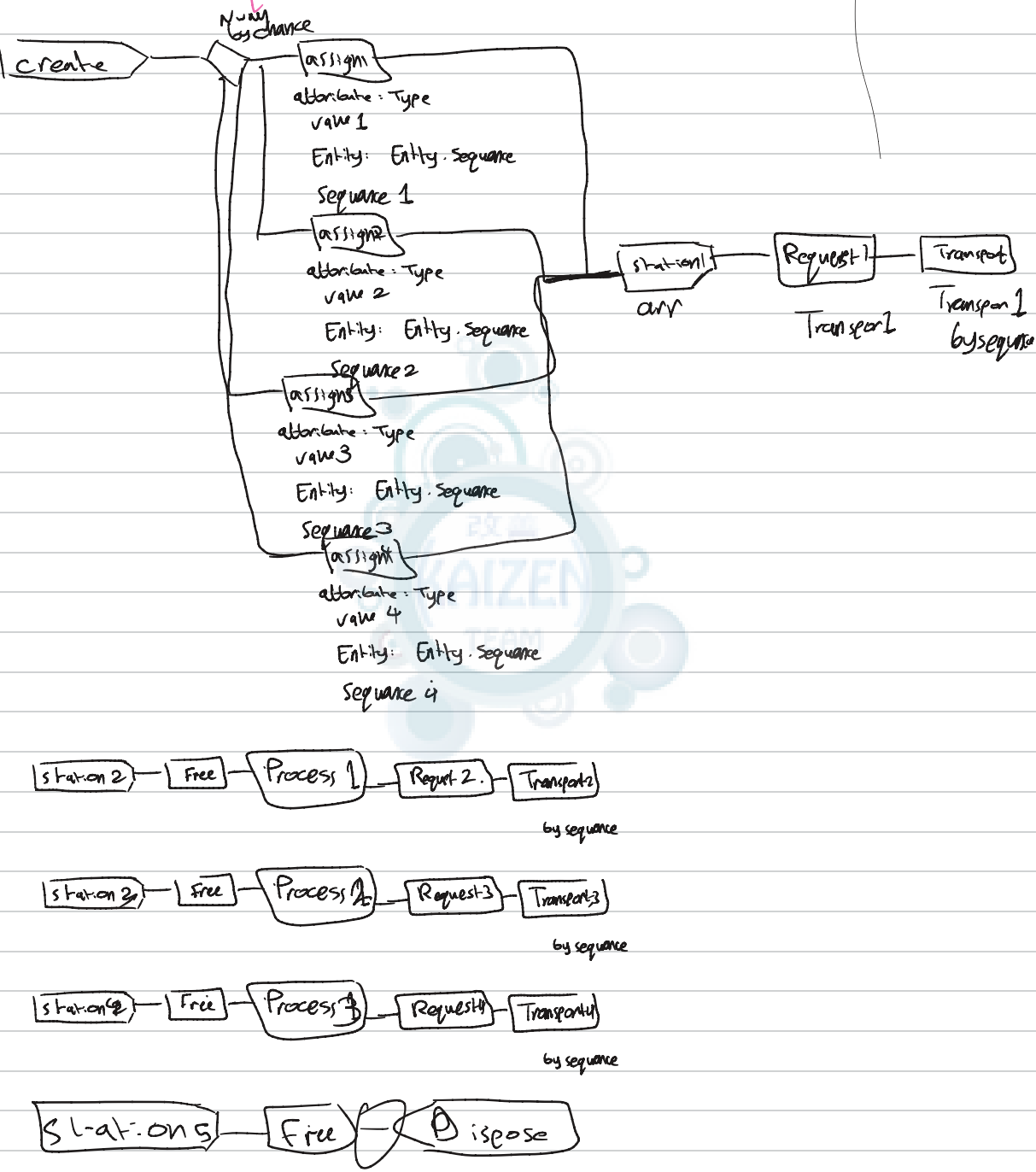
Beginning station

conveyer 1 arr



next station	length
A	5
B	10
Dep	5
C	10
Arr	10

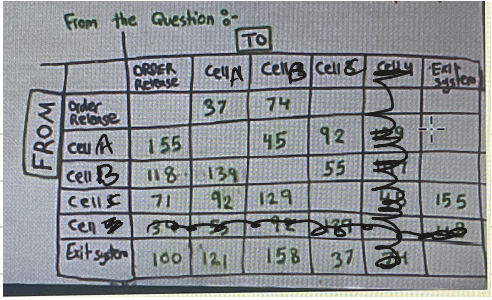
Transport Model 8



Material Handling

Transport double click

Distance double click



From the Question :-

TO

FROM	ORDER RELEASE	CELL A	CELL B	CELL C	CELL D	EXIT SYSTEM
Order Release		37	74			
Cell A	155		45	92		
Cell B	118	139		55		
Cell C	71	92	129			155
Cell D	~~130~~	~~55~~	~~92~~	~~285~~		~~155~~
Exit system	100	121	158	37		

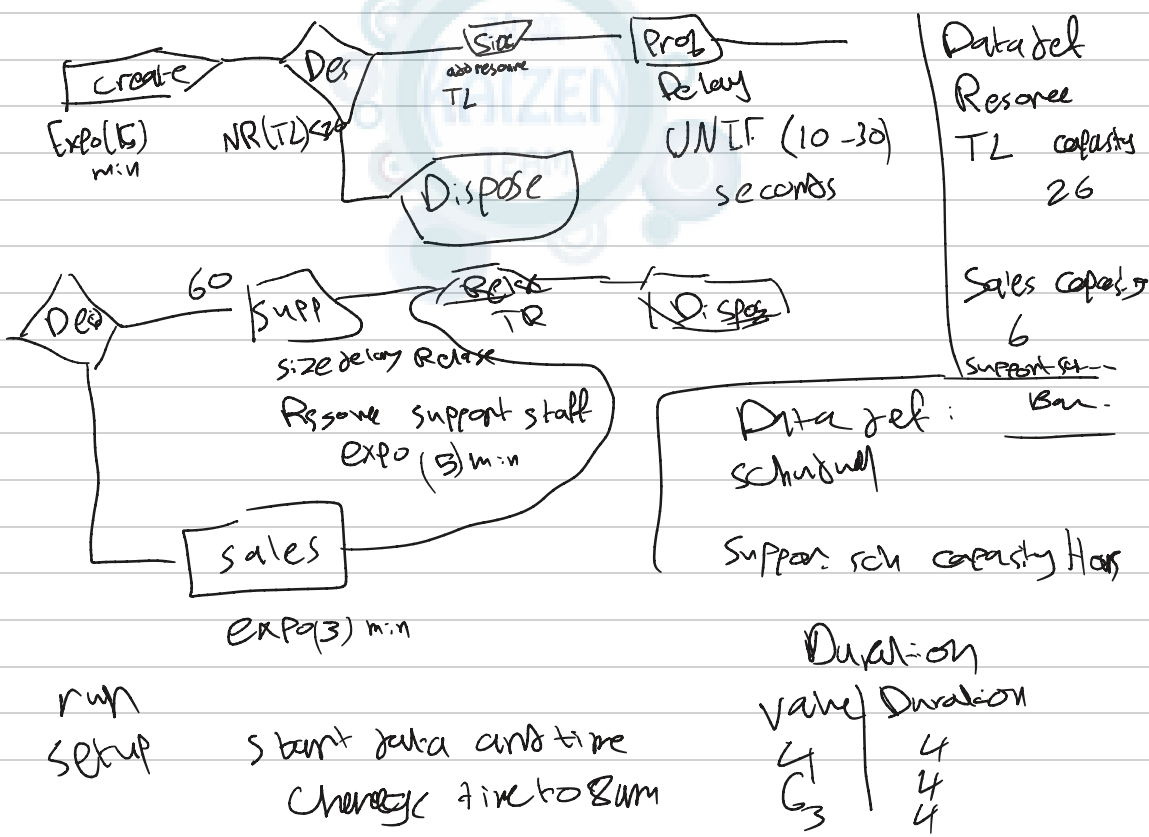
Beggiregstation	Endingstation	Distance
Arr	cell A	37
Arr	cell B	74
cell A	Arr	155
⋮	⋮	⋮
dep	cell C	37

(3)

Name: ID:

Q1) A call center has a **26 trunk line limit**, meaning it can handle up to 26 simultaneous calls (including those on hold, in the message, or with agents). Incoming calls arrive at an average rate of **15 calls per minute** following an exponential process. Each caller listens to an initial message with a duration uniformly distributed between **10 and 30 seconds**. After the message, callers select either **Support** (60% probability) or **Sales** (40% probability).

- **Support Department**: Has agents with varying schedules:
  - 8 AM–12 PM: 4 agents
  - 12 PM–4 PM: 6 agents
  - 4 PM–8 PM: 3 agents
  - Service time per call is exponentially distributed with a mean of **5 minutes**.
- **Sales Department**: Has **6 agents** available at all times. Service time per call is exponentially distributed with a mean of **3 minutes**.
- If all trunk lines are occupied, additional callers are blocked and leave the system.



4

A system with two operators ahmad a[illegible] said, one in the morning 8AM-5PM and one in the evening 3PM-12PM the arrival to the process is expo(5). Use resource sets to mode the process



Expo(5) min

Size Delay Release

~~Resource name : sch1~~

set set1

Run
setup

Start Date and Time

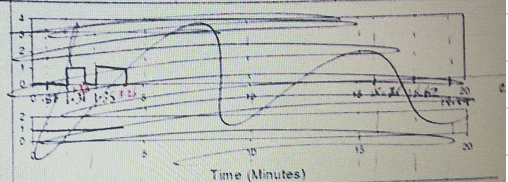
8am 28-Nov

Data set:
schedual

sch1 Capacity Hours Duration

value	Duration
1	9
1	9

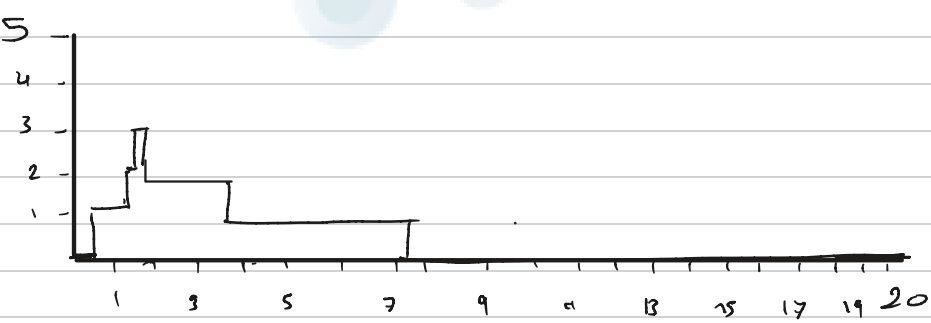
Number of completed waiting times in queue	Total of waiting times in queue	Area under $Q(t)$	Area under $B(t)$
$Q(t)$ graph			
$B(t)$ graph			



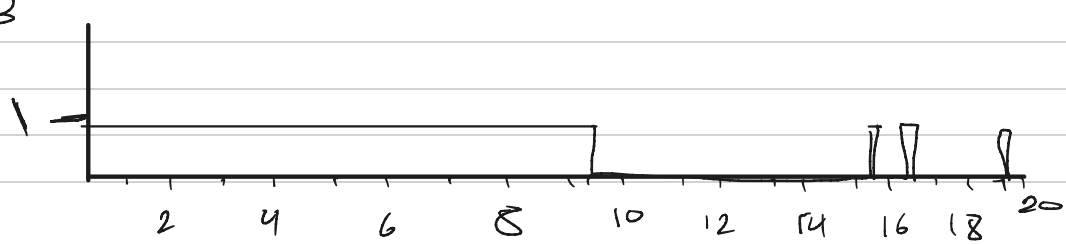
Interarrival times	~~0.87~~	~~0.44~~	~~0.04~~	~~11.91~~	~~0.86~~	~~2.87~~	6.14	4.09	0.31
Service times	~~1.38~~	~~1.85~~	~~3.90~~	~~3.53~~	~~0.11~~	~~0.05~~	0.30	1.28	12.29

Arr	Dep	T	Q
0	1.38	1.38	0
0.87	3.26	2.39	0.5
1.31	7.16	5.85	1.95
1.35	9.69	8.34	5.81
15.76	15.87	0.11	0
16.62	16.67	0.05	0
19.49	19.79	0.3	0
~~25.63~~	—	—	

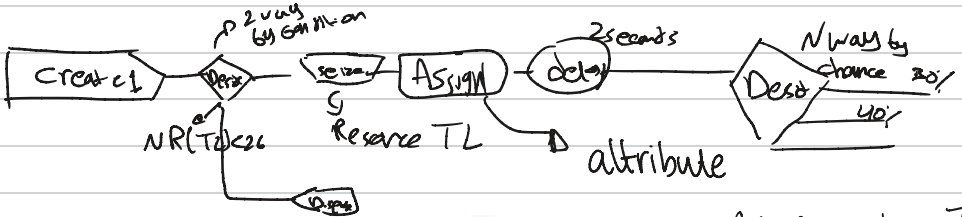
Q



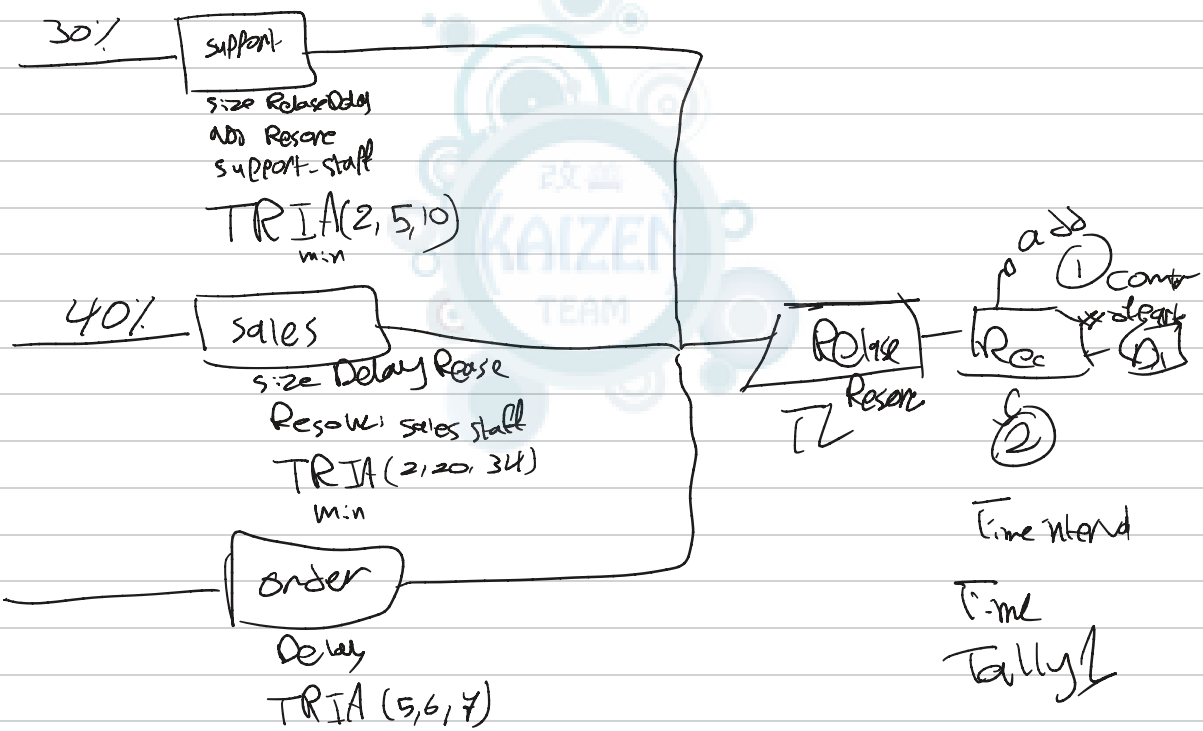
B



Q4) a) Show the Arena simulation for the following: a call center with 12 trunk lines if the customer finds all lines busy he will leave count the number of customers leaving this way. Customers getting in listen to automatic message for two seconds, then select one of three procedures, support (30%) two workers for 8 hr shift and 1 operator for the 8 hour evening shift it takes tria(2,5,10) minutes, sales (40%) talks with the one of fives sales staff in the morning shift only for tria(2,20, 34) minutes, and order status (40%) which is an automatic message for tria(5,6,7) minutes. Collect statistics about time in system and numbers served. (4 points)



time calle TNOW



Start 8am

Data def

sch1 capacity Hours

sch2 capsity Hours

2	8
1	8
5	8

Resource saves

support TL

Baseline sch sch1 sch2

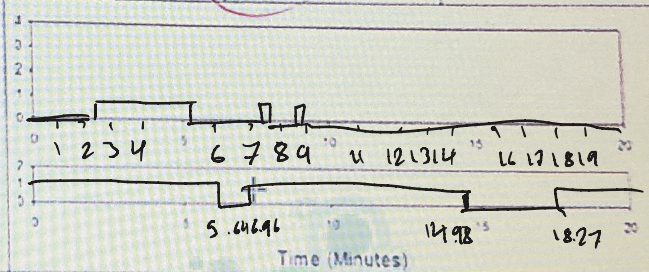
Fixed capsity 1,2

Q1) perform simulation by hand for the single machine single queue system with the following characteristics and draw the figures(4 points)

System	Clock	B(t)	Q(t)	Arrival times of custs. in queue	Event calendar
Number of completed waiting times in queue	Total of waiting times in queue		Area under Q(t)		Area under B(t)

Q(t) graph

B(t) graph



Interarrival times	2.67	4.29	0.33	1.26	9.72	2.32	3.05	5.15	4.93	7.45	9.34	7.91	4.66
Service times	5.49	0.15	0.85	0.54	6.63	2.26	10.3	5.59	0.44	1.34	1.73	1.72	15.4

Arr	Dep	T	Q
0	5.49	5.49	0
2.67	5.64	2.97	2.82
6.96	7.81	0.85	0
7.29	8.35	1.06	0.52
8.22	14.98	6.76	0.13
18.27	20.53X	—	
20.59X			

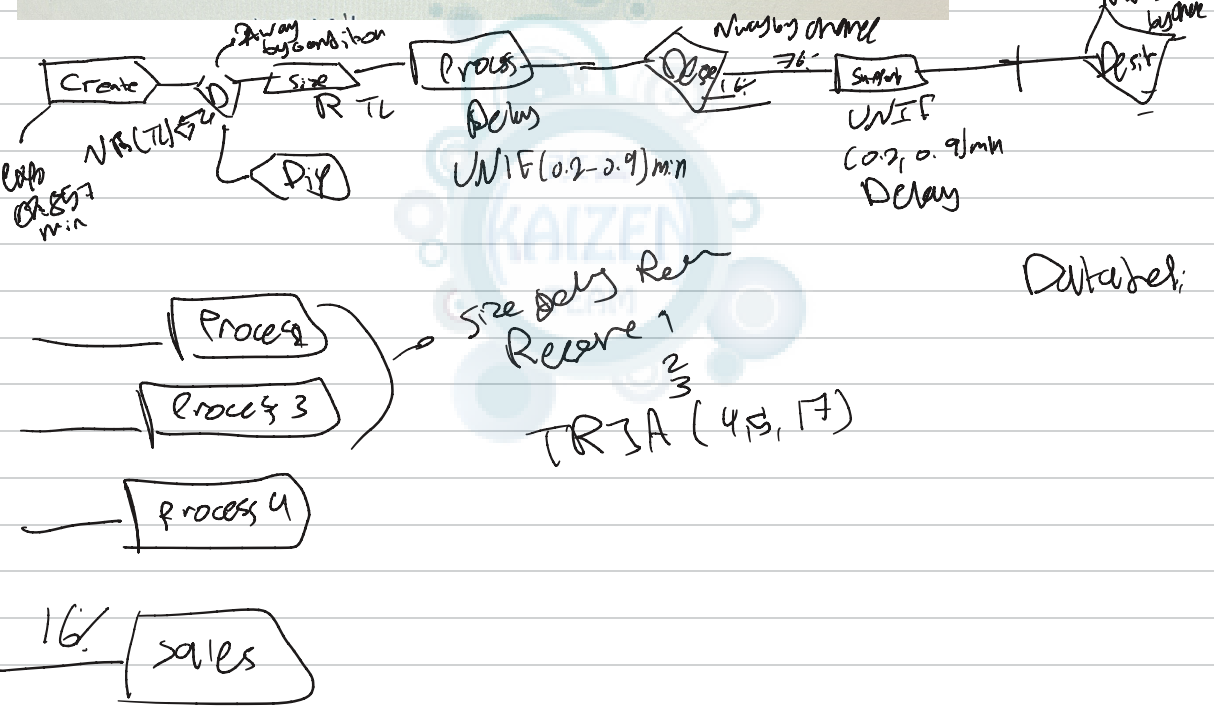
Q4) The call center handles customer calls through a central number with 4 trunk lines and operates from 8 am to 4 pm. Calls arrive every 0.857 minutes on average (exponentially distributed). If all lines are busy, callers are lost. Callers choose between technical support (76%), sales (16%), or order status (8%), after a brief recording (0.2–0.9 min).

Technical support calls (UNIF(0.2, 0.9) min to select product) are handled by 8 specialists: 2 for product 1, 3 for product 2, and 3 for product 3. If none are available, calls queue with music. Service time is TRIA(4, 5, 17) minutes.

Sales calls are handled by 4 salespeople, or queue with music if unavailable. Sales calls last TRIA(4, 15, 45) minutes.

It turns out that there are six salespeople with the staggered daily schedules summarized as (number of people @ time period in minutes): 1@60, 3@60, 4@90, 5@60, 6@60, 5@90, 6@90, 5@30, 3@60, and 2@60.

Order-status calls are system-handled (TRIA(2, 3, 4) min); 15% request human help and are routed to sales staff but with lower priority than regular sales calls. These follow-up calls also take TRIA(2, 3, 4) minutes. Calls are answered as long as they enter before 6 pm. Model using arena (7 points)



Symbol	meaning	Symbol	Meaning
	speed of run		station (to animate)
	fast forward run		connect
Number of Replications:	Number of times the simulation will run	Input Analyzer	Input Analyzer
	segment	Warm-up Period	Period where no statistical input is taken

b) Describe how to add an animation for the resource , and entity (2 points)

Animate → Resource — | Name: — | Pick a symbol | ok

Q3) a) show the arena simulation for the system shown in the following figure. Add statistical collection for the number of parts produced and the time in system

Q4) a) Show the Arena simulation for the following: a call center with 12 trunk lines if the customer finds all lines busy he will leave count the number of customers leaving this way. Customers getting in listen to automatic message for two seconds, then select one of three procedures, support (30%) two workers for 8 hr shift and 1 operator for the 8 hour evening shift it takes tria(2,5,10) minutes, sales (40%) talks with the one of fives sales staff in the morning shift only for tria(2,20, 34) minutes, and order status (40%) which is an automatic message for tria(5,6,7) minutes. Collect statistics about time in system and numbers served. (4 points)

b) for part a) describe how to add an animation for the number of people being served currently in the system (WIP) 2 points?

add WIP, after seize and befor the Exits

and then animate the variable

add only one WIP if there was only one entity

3.0 (5 points) model the call center with the following specs:

One phone number for customers to call in to 26 trunk lines, one needed for each call (incoming or outgoing, talking or on hold) Arriving call finding no free trunk lines gets busy signal, goes away Count number of such rejected calls Calls arrive with interarrivals ~ EXPO (0.857) min. First call arrives at time 0 Three incoming call types Initial recording to decide ~ UNIF (0.1, 0.6) min.

Tech support (76%), sales (16%), order status (8%) Tech-support calls For product type 1 (25%), 2 (34%), or 3 (41%) Needs qualified tech-support person Two for type 1, three for type 2, three for type Separate FIFO queues for each type Conversation time ~ TRIA (3, 6, 18) min. for all types Then leaves system Sales calls All the same Four sales staff, all the same One FIFO queue feeding all sales staff Conversation time ~ TRIA (4, 15, 45) Then leaves system

set دكالاكتور كلي لازلب بستاج

بس بحس لا

5.0 (5 points) The sequences are already defined as sequences 1 -4. Now there is a conveyor loop that goes from the arrival station to cell 1 cell2 depart then cell4 then cell3 then arrival distances is the same assume 5 units, model sing arena

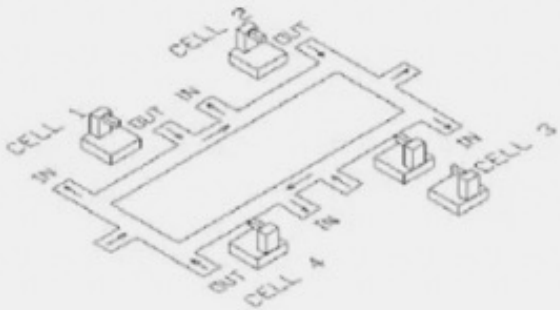


Figure 7-1. The Small Manufacturing System Layout

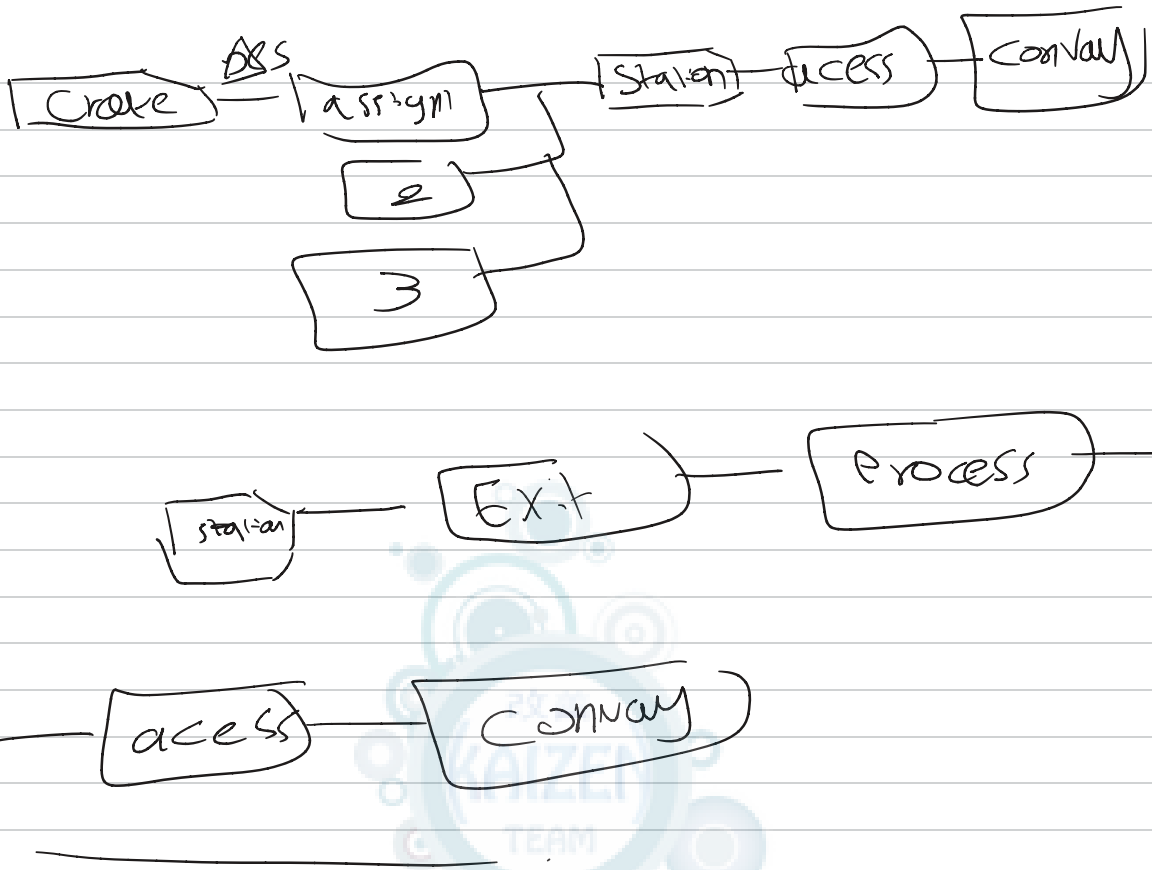
Table 7-1. Part Routings and Process Times

Part Type	Cell/Time	Cell/Time	Cell/Time	Cell/Time	Cell/Time
1	1 6, 8, 10	2 5, 8, 10	3 15, 20, 25	4 , 16	
2	1 11, 13, 15	2 4, 6, 8	4 15, 18, 21	- 6, 9, 12	3 27, 33, 39
3	2 7, 9, 11	1 7, 10, 13	3 18, 23, 28		

create ... Conveyor

model segments

sequence



if we have a Type of machine where one is faster than the other:

define variable(f) [0;8]

define the two response as M1 and M2 and place them in a set R3

M1 and M2 in the expression (Pr_time) of ( ) index from set

Transportation:

Free Transport Distance

Distances ويجوز Transport يجوز

Data dition من