



**National University**  
of computer and emerging sciences

## Final Project Report

Course: Simulation & Modelling

Semester Project

By

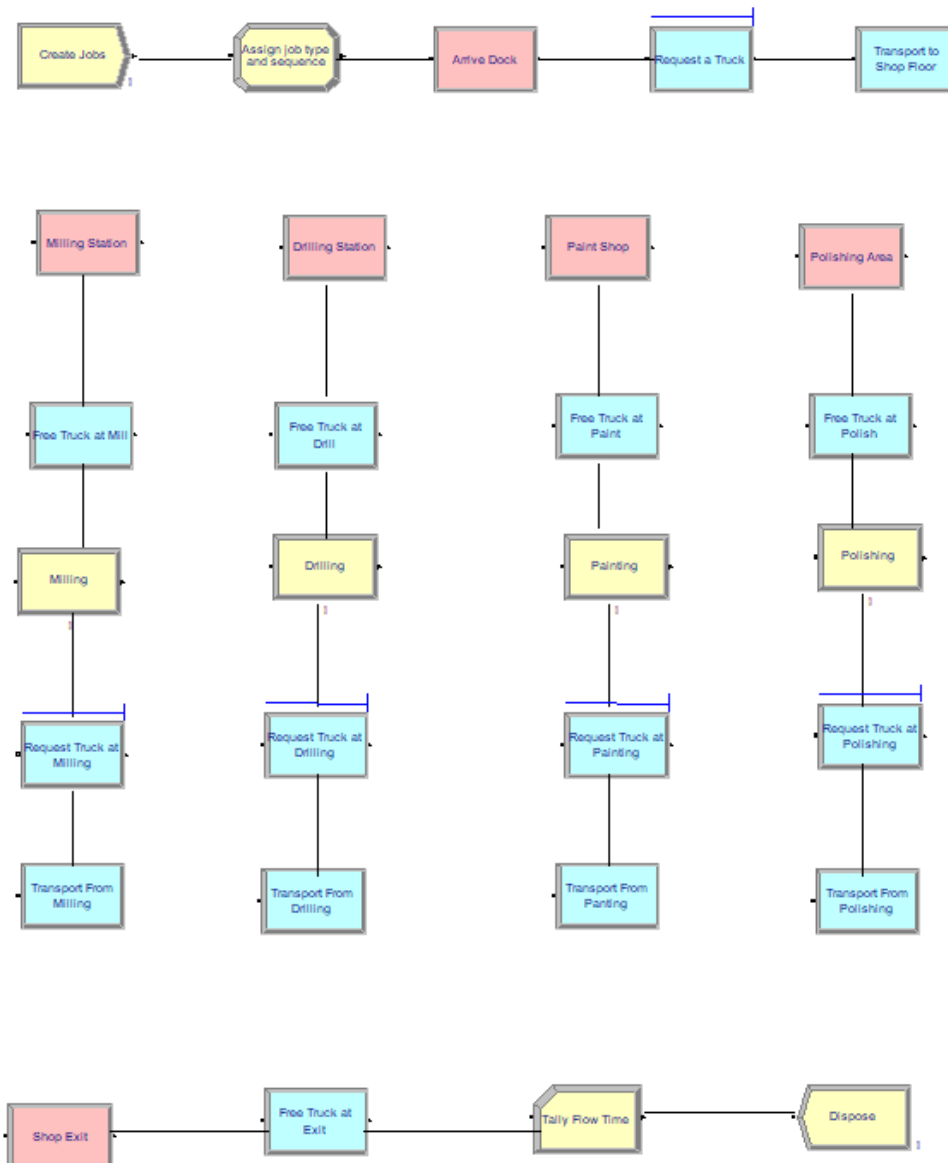
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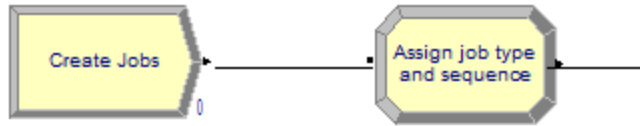
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Arena Model for the Gear Manufacturing Job Shop Problem



Gear entities are created in the Create module, called Create Jobs. The field labeled "Entities per Arrival" specifies that batches of 10 gear jobs arrive together, while the "Time Between Arrivals" section indicates that the time between batches is randomly distributed between 400 and 600 minutes. After arriving, each gear job is treated as an individual entity.

Name:		Entity Type:	
Create Jobs		Gear	
Time Between Arrivals			
Type:	Expression:	Units:	
Expression	UNIF(400,600)	Minutes	
Entities per Arrival:	Max Arrivals:	First Creation:	
10	Infinite	0.0	
OK		Cancel	Help

After an incoming gear entity arrives, it moves on to the Assign module, which is named Assign Job Type and Sequence. In this module, a gear entity is given a specific type by being randomly selected from a predetermined distribution. The resulting type code (either 1, 2, or 3) is then saved as the entity's Type attribute. Additionally, the module assigns the current simulation time (Tnow) to the entity's ArrTime attribute, which will be used later to calculate the entity's flow time.

**Assign** [?] [X]

Name:  
Assign job type and sequence

Assignments:

Attribute, Type, DISC(5,1,8,2,1,3)
Attribute, Arr Time, TNOW
Attribute, Entity, Sequence, Type
<End of list>

Add... Edit... Delete

OK Cancel Help

Sequence - Advanced Transfer		
	Name	Steps
1	G1	5 rows
2	G2	4 rows
3	G3	0 rows

Double-click here to add a new row.

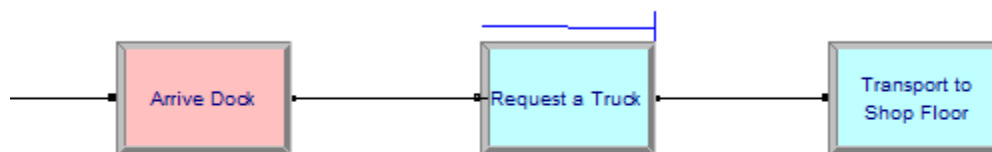
Steps				
	Station Name	Step Name	Next Step	Assignments
1	Drilling			1 rows
2	Painting			1 rows
3	Polishing			1 rows
4	Shop Exit			0 rows

Double-click here to add a new row.

Assignments			
	Assignment Type	Attribute Name	Value
1	Attribute	Drilling Time	18

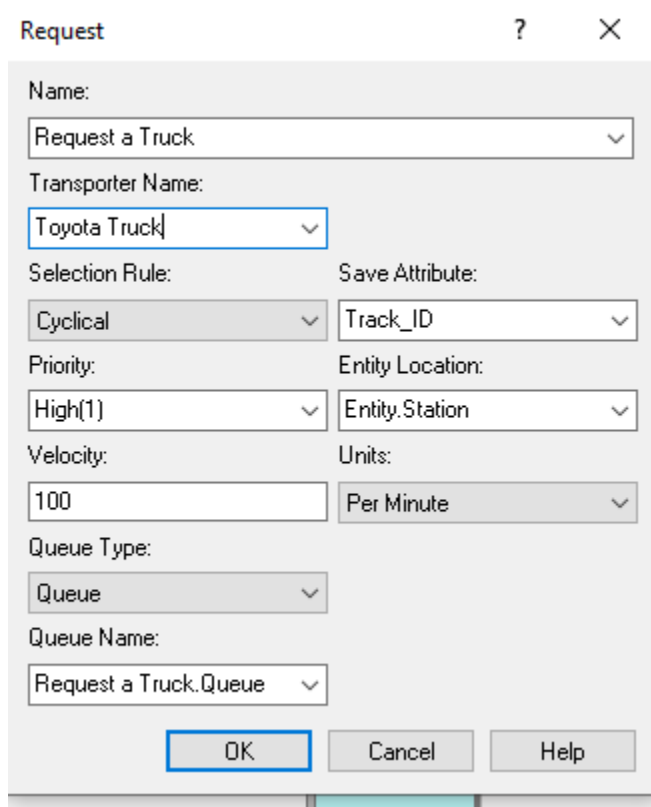
Double-click here to add a new row.

The Sequence module's dialog spreadsheet (located at the bottom of Figure), the Steps dialog spreadsheet (which is used to specify operations steps for G1 gears and is located in the middle of the figure), and the Steps Assignment spreadsheet (which is located at the top of the figure and is used to specify the amount of time for milling type G1 gears) are all displayed in the figure.



Since requesting transporters from multiple locations can create contention for resources, the Priority field allows the modeler to assign a priority to requests issued at multiple Request modules. In this case, a high priority is assigned to clear the arrival dock as quickly as possible.

The Entity Location field indicates the location of the requesting entity, and the Velocity field specifies the transporter's velocity, which is set to 100 feet per minute. Finally, gear entities requesting transportation at the same Request module are instructed to wait in the queue called a Truck.Queue until a transporter becomes available.



The image shows a 'Request' dialog box with the following fields and values:

- Name: Request a Truck
- Transporter Name: Toyota Truck
- Selection Rule: Cyclical
- Save Attribute: Track\_ID
- Priority: High(1)
- Entity Location: Entity.Station
- Velocity: 100
- Units: Per Minute
- Queue Type: Queue
- Queue Name: Request a Truck.Queue

The 'OK' button is highlighted.

Once a gear entity has taken hold of a truck, it proceeds to a module called "Transport to Shop Floor". In this module, there is a dialog box displayed in Figure . The fields "Transporter Name" and "Unit Number" indicate the type and ID of the selected transporter, which in this case is the truck whose ID is stored in the "Truck\_ID" attribute of the requesting gear entity. The destination for the gear entity and transporter is specified in the "Entity Destination Type" field as "By Sequence", meaning that the destination is determined by the gear entity's sequence number. Alternatively, the field can specify a station module name using the "Station" option or an attribute or expression. The gear entity and transporter move together at a velocity of 100 feet per minute, as specified in the "Velocity" field. Note that the velocity may vary depending on the type of trip, so an empty truck and a loaded one may move at different velocities.

Transport

Name:  
Transport to Shop Floor

Transporter Name: Toyota Truck Unit Number: Track\_ID

Entity Destination Type:  
By Sequence

Velocity: 100 Units: Per Hour

Guided Tran Destination Type:  
Entity Destination

OK Cancel Help

The paragraph describes how the distances between different facilities are specified, and it mentions two dialog spreadsheets. Next Figure shows the Distance module dialog spreadsheet on the left and a corresponding Stations dialog spreadsheet on the right. The Stations spreadsheet pops up when a button under the Stations column in the Distance spreadsheet is clicked.

```

graph TD
    Milling[Milling] -- 1 --> RequestTruck[Request Truck at Milling]
  
```

Distance - Advanced Transfer

	Name	Stations
1	Toyota Truck.Distance	0 rows

Double-click here to add a new row.

Stations

	Beginning Station	Ending Station	Distance
1	Arrive Dock	Milling Station	100
2	Arrive Dock	Drilling Station	100
3	Milling Station	Drilling Station	300
4	Milling Station	Paint Shop	400
5	Milling Station	Polishing Area	150
6	Paint Shop	Polishing Area	300
7	Drilling Station	Paint Shop	150
8	Drilling Station	Polishing Area	400
9	Paint Shop	Arrive Dock	250
10	Polishing Area	Arrive Dock	250
11	Polishing Area	Shop Exit	200
12	Shop Exit	Arrive Dock	550
13	Shop Exit	Drilling Station	500
14	Shop Exit	Milling Station	300
15	Shop Exit	Paint Shop	400
16	Shop Exit	Polishing Area	200

Double-click here to add a new row.

Free
?
×

Name:

Free Truck at Mill
▼

Transporter Name:

Toyota Truck
▼

Unit Number:

Track\_ID
▼

OK

Cancel

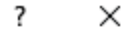
Help

Resource - Basic Process

	Name	Type	Capacity	Busy / Hour	Idle / Hour	Per Use	StateSet Name	Failures	Report Statistics
1	Milling Machine	Fixed Capacity	4	0.0	0.0	0.0		0 rows	<input checked="" type="checkbox"/>
2	Drilling Machine	Fixed Capacity	3	0.0	0.0	0.0		0 rows	<input checked="" type="checkbox"/>
3	Painting Section	Fixed Capacity	2	0.0	0.0	0.0		0 rows	<input checked="" type="checkbox"/>
4 ▶	Polishing Section	Fixed Capacity	1	0.0	0.0	0.0		0 rows	<input checked="" type="checkbox"/>

Double-click here to add a new row.

Process



Name:		Type:	
Milling		Standard	
Logic			
Action:		Priority:	
Seize Delay Release		Medium(2)	
Resources:			
Resource, Milling Machine, 1		Add...	
<End of list>		Edit...	
		Delete	
Delay Type:	Units:	Allocation:	
Expression	Minutes	Value Added	
Expression:			
Milling Time			
<input checked="" type="checkbox"/> Report Statistics			
OK		Cancel	Help



**Request** ? X

Name:  
Request Truck at Milling

Transporter Name:  
Toyota Truck

Selection Rule: Save Attribute:  
Smallest Distance Track\_ID

Priority: Entity Location:  
High(1) Entity.Station

Velocity: Units:  
100 Per Minute

Queue Type:  
Queue

Queue Name:  
Request Truck At Milling.Q

OK Cancel Help

**Record** ? X

Name:  
Tally Flow Time

Statistic Definitions:

Time Interval, Arr Time, Yes, Flow Time, Type
<End of list>

Add... Edit... Delete

OK Cancel Help

Set - Basic Process

Name	Type	Member Definition Method	Members
1 ▶ Flow Time	Tally	Manual List	3 rows

Double-click here to add a new row.

Members

	Tally Name
1	G1 Flow Time
2	G2 Flow Time
3	G3 Flow Time

Transporter - Advanced Transfer

Name	Number of Units	Type	Distance Set	Velocity	Units	Initial Position Status	When Freed	Report Statistics
1 ▶ Toyota Truck	2	Free Path	Toyota Truck.Distance	100	Per Minute	2 rows	Remain Where Freed	<input checked="" type="checkbox"/>

Double-click here to add a new row.

Statistic - Advanced Process

Name	Type	Tally Name	Tally Output File	Expression	Collection Period	Report Label	Output File
1 Toyota Truck Utilization	Time-Persistent	Tally 1		nt(toyota Truck)	Entire Replication	Toyota Truck Utilization	
2 ▶ G1 Flow Time	Tally	G1 Flow Time			Entire Replication	G1 Flow Time	
3 G2 Flow Time	Tally	G2 Flow Time			Entire Replication	G2 Flow Time	
4 G3 Flow Time	Tally	G3 Flow Time			Entire Replication	G3 Flow Time	

Double-click here to add a new row.

## SIMULATION

The simulation of the ARENA job shop model spanned over a year, during which various parameters such as Replication Length and Hours Per Day were defined in the Run Setup. The corresponding setup is displayed in Figure 3.20. The simulation allowed for the observation of entities (represented as gears) as they moved through different facilities, waited for processing, and transferred between machines. It is assumed that the plant operates 24 hours a day, with three shifts of eight hours each. Upon completion of the simulation, a report will be automatically generated. This report can be used to determine Gear flow times (by type), Gear delays at operation locations, Machine utilizations, and other relevant information.

Run Setup

Run Speed   Run Control   Reports   Project Parameters

Replication Parameters   Array Sizes   Arena Visual Designer

Number of Replications:  
1

Initialize Between Replications  
☒ Statistics   ☒ System

Start Date and Time:  
☐ Monday , 8 May 2023 9:47:04 pm

Warm-up Period:  
0.0

Time Units:  
Hours

Replication Length:  
365

Time Units:  
Days

Hours Per Day:  
24

Base Time Units:  
Minutes

Terminating Condition:

OK   Cancel   Apply   Help

RESULTS

## Key Performance Indicators

### System

Number Out

Average

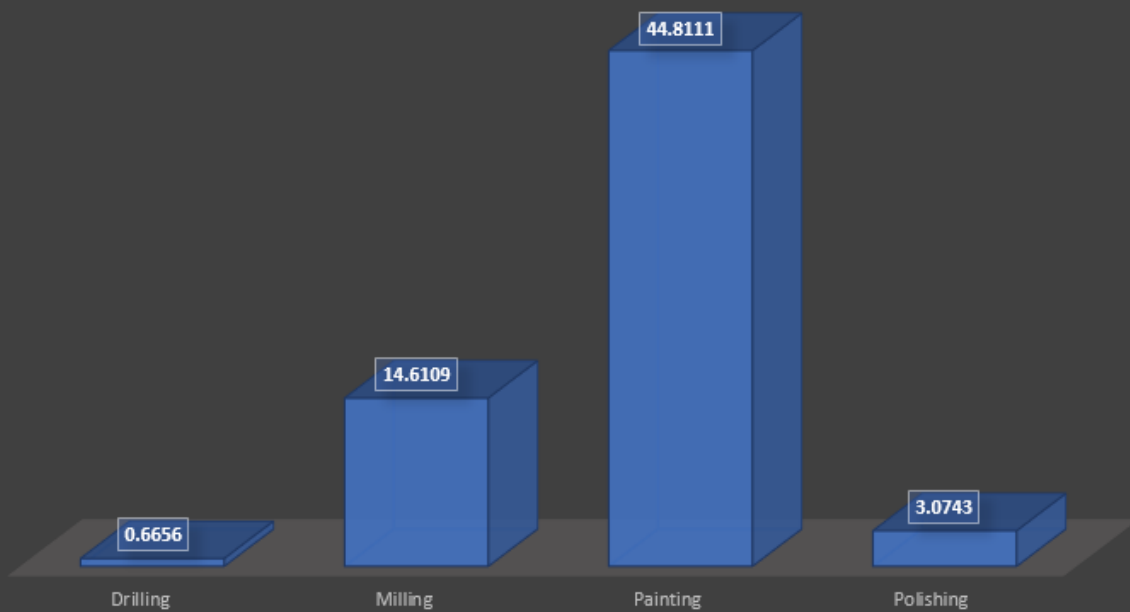
10,470

Wait Time Per Entity	Average	Half Width	Minimum Value	Maximum Value
Drilling	0.6656	0.058478552	0.00	16.0000
Milling	14.6109	0.283086009	0.00	62.0000
Painting	44.8111	0.502319726	0.00	156.50
Polishing	3.0743	0.087881937	0.00	15.0000

### Usage

Instantaneous Utilization	Average	Half Width	Minimum Value	Maximum Value
Drilling Machine	0.08984399	0.001432065	0.00	1.0000
Milling Machine	0.1248	0.001909548	0.00	1.0000
Painting Section	0.4480	0.004240685	0.00	1.0000
Polishing Section	0.2988	0.002281493	0.00	1.0000

## GEAR DELAY



# RESOURCE UTILIZATION

