Arab Academy for Science and Technology and martime transport

College of Computing and information technology

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Course: CS305- Modeling and Simulation

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Assignment 2

Create a python/simpy model for one of the following problems.

1. Consider a human resources (HR) application, configured as a two-tier client/server system, consisting of four client nodes and one server node, with traffic flows as shown in the schematic representation of Figure 14.5. This HR application supports a number of services (request types) related to the company employees, using a database server that maintains an HR database (HRDB) of employee-related information. Database transactions types have the attributes displayed in Table 14.1. Service requests belong to the following types:

  1. A request of type Add adds a new employee with all his/her information (name, address, phone, expertise, etc.) to the HRDB in a message size of 1024 bytes, and the system returns a confirmation message of size 256 bytes.

  2. A request of type Delete deletes an employee entry (with all the related information) from the HRDB. The system returns a confirmation message of size 512 bytes.

  3. A transaction of type Find finds the complete employee information in the HRDB, based on partial data (e.g., the name alone). The system returns a reply message of size 512 bytes.

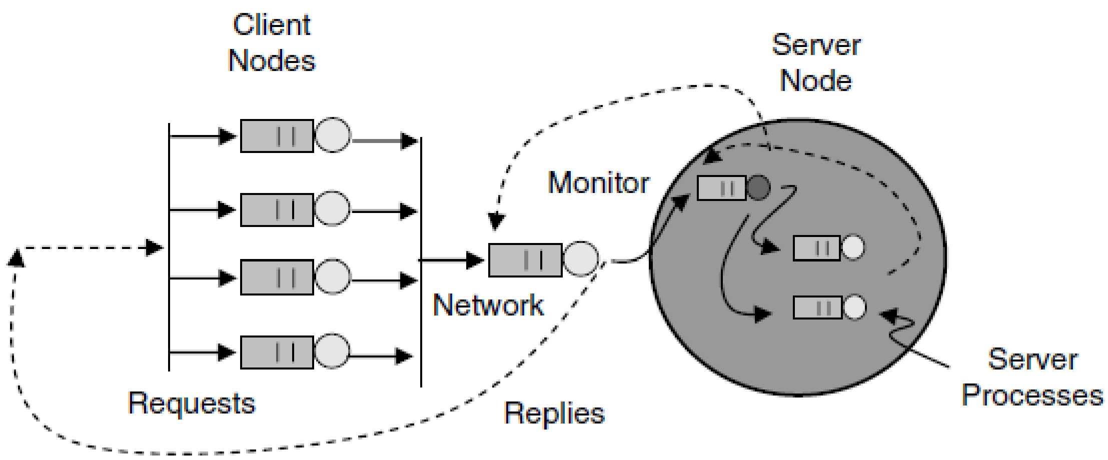

Figure 14.5 Schematic representation of the HR client/server system.

Table 1. Transaction attributes of the HR application

Request Type Number	Request Type Name	Service Requested	Request Size (bytes)	Reply Size (bytes)
1	Add	Add employee	1024	256
2	Delete	Delete employee	1024	512
3	Find	Find employee	256	512
4	Search	Search for employee	512	Disc({(0.2, 64), (0.3, 512), (0.3, 1024), (0.2, 2048)})

Table 2. Client-side service request profile

Client Node	Request Interarrival Distribution (messages/millisecond)	Request Type Distribution
1	Expo(1/30)	Disc({(0.2, 1), (0.15, 2), (0.4, 3), (0.25, 4)})
2	Expo(1/60)	Disc({(0.4, 1), (0.6, 2)})
3	Expo(1/120)	Disc({(0.6, 3), (0.4, 4)})
4	Expo(1/80)	Disc({(0.2, 1), (0.2, 2), (0.4, 3), (0.2, 4)})

A transaction of type Search searches the HRDB for all employees with common characteristics (e.g., same expertise, same department, etc.). The system returns a reply of random size; its (discrete) distribution is given in Table 1.

To characterize the traffic patterns in the system, we need to specify the arrival processes of all request types at each client node. Table 2 provides service request profiles. Note that the second column specifies the multiplexed request streams from each client node as Poisson processes with associated exponential interarrival time distributions. The type of any request in the corresponding multiplexed stream is specified by an associated discrete distribution in the third column.

The server node has a TP monitor that receives requests and routes them to the server process providing the requested service. There are two server processes, called sp1 and sp2; the former provides services of types Add and Delete, and the latter provides services of types Find and Search. The elapsed times for each service request type (including all CPU times and database-related times) are displayed in Table 3.

On service completion, replies to service requests are returned to the TP monitor, which in turn sends them back to their respective clients over the transmission network. The service time at the TP monitor is 1 millisecond per visit, while the BWC of the transmission network is 200 bytes/msec at 70% MTE.

Table 3. Elapsed times for service request types

Request Type	Request Type Name	Elapsed Time (milliseconds)
1	Add	10
2	Delete	8
3	Find	15
4	Search	Disc({(0.2, 10), (0.3, 25), (0.3, 32), (0.2, 45)})

a. Develop an model for the HR client/server system and simulate it for an 1-hour period.

b. Estimate the following statistics:

_ Server process utilizations

_ Transmission network utilization

_ Average pooled network delay

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2. Three-tier architecture in e-banking. The First New Brunswick Savings (FNBS) bank has introduced e-banking to its customers. The e-banking infrastructure consists of a cluster of two server nodes linked to each other via a TP monitor, which dynamically balances the workload of each server in the cluster. The processing time at the TP monitor is 0.05 seconds. The e-banking program offers a number of services to its customers, as follows: account identification (AI), view account summary (VS), view last 15 withdrawals (VW), view last 15 deposits (VD), and view interim account report (VR). The elapsed times of services are server-node dependent. These are given in following table along with request priorities.

Request Type	Request Priority	Elapsed Time on Server Node 1 (seconds)	Elapsed Time on Server Node 2 (seconds)
AI	1	Unif(4, 8)	Unif(12, 16)
VS	2	Unif(10, 18)	Unif(15, 27)
VW	3	Unif(12, 22)	Unif(12, 22)
VD	4	Unif(8, 15)	Unif(12, 16)
VR	5	Unif(15, 30)	Unif(22, 45)

Interarrival times of requests are iid exponentially distributed with a mean of 10 seconds. The probabilities of service request types arriving from any node are given in the next table.

Request Type	Probability of Request Type
AI	0.1
VS	0.15
VW	0.20
VD	0.20
VR	0.35

Once a service request is executed, a reply is sent back to the client. Request message sizes are fixed at 2048 bytes, whereas reply message sizes are iid Disc ({(0.3, 1024), (0.3, 2048), (0.4, 8096)}). Messages between client and server nodes are transported via a transmission network with a BWC of 2500 bytes per second and MTE of 70%. There are two server processes at each server node. The allocation of request types to server processes at each node is given in the following table.

Node/Server Process	Service Types
Node 1 / SP_1	AI, VS
Node 1 / SP_2	VW, VD, VR
Node 2 / SP_1	AI, VS, VW
Node 2 / SP_2	VD, VR

Server processes implement priority queueing disciplines with smaller priority values of requests given higher priority.

a. Develop a model for the FNBS bank's e-banking system and simulate it for an 8-hour period.

b. Estimate the following statistics:

_ Server process utilizations

_ Transmission network utilization

_ Average pooled network delay

_ Average response time for each service request type

_ Average delays at server process queues

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3. Consider a job shop producing three types of gears, G1, G2, and G3, for three different types of cars. The job shop is spread out geographically on the factory floor and its layout consists of the following locations:

_ An arrival dock

_ A milling workstation with four milling machines

_ A drilling workstation with three drilling machines

_ A paint shop with two spray booths

_ A polishing area with a single worker

_ A shop exit.

The distances among locations are given in Table 4.

Table 4. Distances among job shop locations

From Location	To Location	Distance (Feet)
arrival dock	milling workstation	100
arrival dock	drilling workstation	100
milling workstation	drilling workstation	300
milling workstation	paint shop	400
milling workstation	polishing area	150
paint shop	polishing area	300
drilling workstation	paint shop	150
drilling workstation	polishing area	400
paint shop	arrival dock	250
polishing area	arrival dock	250
polishing area	shop exit	200
shop exit	arrival dock	550
shop exit	drilling workstation	500
shop exit	milling workstation	300
shop exit	paint shop	400
shop exit	polishing area	200

Table 5. Operations plan for gears by type

Gear Type	Operations Sequence	Processing Time (minutes)
G1	milling	35
	drilling	20
	painting	55
	polishing	15
G2	milling	25
	painting	35
	polishing	15
G3	drilling	18
	painting	35
	polishing	15

Gear jobs arrive in batches of 10 units and their interarrival times are uniformly distributed between 400 and 600 minutes. Of arriving batches, 50% are of type G1, 30% are of type G2, and 20% are of type G3. A gear job arrives at the arrival dock and from there is dispatched to its specific (type-dependent) sequence of manufacturing operations. A sequence consists of a subset of milling, drilling, painting, and polishing operations. Table 5 displays the operations plan showing the sequence of operations and the associated processing times for each gear type. The layout of the job shop and operation sequences of gear types are depicted in Figure 13.47.

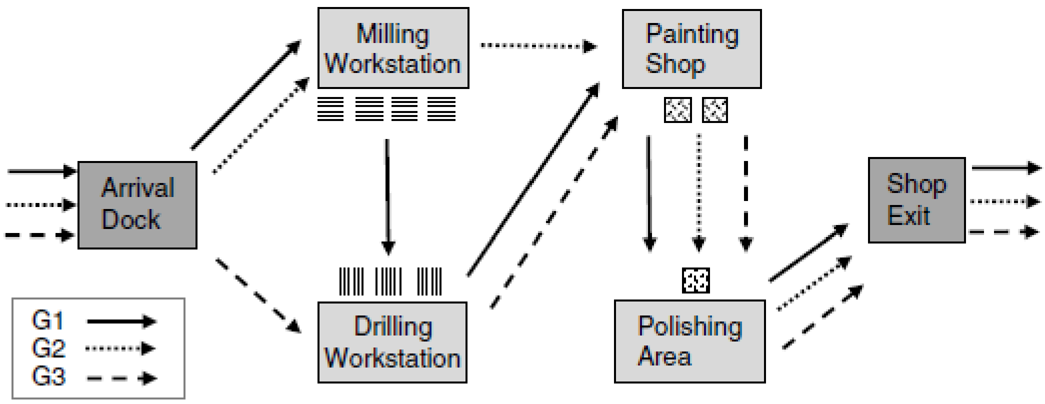

Figure 13.47 Layout of job shop and operation sequences by gear type.

Gears are transported among locations by two trucks running at a constant speed of 100 feet/minute. Each truck can carry only one gear at a time. When a job is complete at a location, the gear is placed into an output buffer, a transport request is made for a truck, and the gear waits for the truck to arrive. Once a gear is transported to the next location, it is placed in a FIFO input buffer. Finally, when the polishing operation is completed, the finished gear departs from the job shop via the shop exit.

a. Develop a model for the job shop and simulate it for an 8-hour period.

b. Estimate the following statistics:

_ Gear flow times (by type)

_ Gear delays at operations locations

_ Machine utilizations

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4. Consider a generic packaging line for some product, such as a pharmaceutical plant producing a packaged medicinal product, or a food processing plant producing packaged foods or beverages. The line consists of workstations that perform the processes of filling, capping, labeling, sealing, and carton packing. Individual product units will be referred to simply as units. We make the following assumptions:

1. The filling workstation always has material in front of it, so that it never starves.

2. The buffer space between workstations can hold at most five units.

3. A workstation gets blocked if there is no space in the immediate downstream buffer (manufacturing blocking).

4. The processing times for filling, capping, labeling, sealing, and carton packing are 6.5, 5, 8, 5, and 6 seconds, respectively.

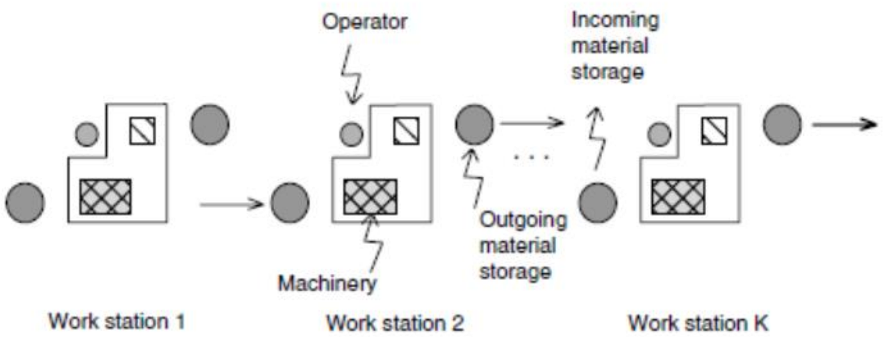

Figure 11.1 A generic production line.

a. Develop a model for the packaging line and simulate it for a 100,000 seconds period.

b. Estimate the following statistics:

_ Throughput

_ Average inventory levels in buffers

_ Downtime probabilities

_ Blocking probabilities at bottleneck workstations

_ Average system flow times (also called manufacturing lead times)