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   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

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- Bowersox, Donald J., Closs, David J., (1996), "Logistical Management." Tata McGraw, Hill, New Delhi.
- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio," Ohio State University.

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UNPUBLISHED DISSERTATIONS AND THESES

- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

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- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Political Weekly, Viewed on December 17, 2011 http://epw.in/user/viewabstract.jsp

ANALYSIS OF MOBILE AGENT BASED E-SUPPLY CHAIN MANAGEMENT SYSTEM USING QUEUING THEORY: A COMPARATIVE STUDY BETWEEN M/M/1 AND M/D/1 MODELS

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ABSTRACT
The product reaches at dispense of consumer through diverse segments. The amalgamation of all these phases is often being phrased as Supply Chain. Effective and Efficient utilization of these phases assists an organization to optimize the overall outlay of production activities. SCM utilizes technology to manage these supply chain in a methodical approach resulting in enhanced deployment of resources thereby improved operational efficiency and effectiveness. Advent of Internet technologies added a new aspect to SCM, by connecting the enormous network of supply chain through Internet, often being referred to as e-SCM. e-SCM initiated the notion of "anyone, anything, anywhere", which influences a product's time-to-market, price, quality, information exchange, delivery, amid other activities of SCM. In this manuscript, a Mobile Agent based Electronic Supply Chain Management (e-SCM) is being proposed. The anticipated model consists of a set of mobile agents functioning cooperatively to uphold supplying, manufacturing, inventory and distributing. Another imperative task performed in the manuscript is to uncover the relevancy of the proposed architecture using Queuing theory. The complete model is being tested on M/M/1 and M/D/1 Queuing models and the comparative study is being conducted based on four queuing parameters, namely, waiting time for customer request in the system, number of customers in the system at a time, time for each customer in the queue, and, total number of customers waiting. Finally, the associated simulations and numeral results are provided to appraise the queuing parameters.

KEYWORDS
Mobile Agents, e-SCM, Queuing Theory, M/M/1, M/D/1.

INTRODUCTION
With the intensification of markets, escalation in information technology, and the curbing life cycle of products, many IT applications have been employed to rationalize and optimize supply chains [1]. One of the most complicated but a vital issue in SCM is to perk up the competence of supply chains from the perspective of the complete supply chain, not individual companies. More explicitly, the configuration, optimization and minimizing the bullwhip effect [2] are considered critical issues for efficient supply chain management [3], [4]. Advent of Mobile Agents added additional prospects for the management of supply chain. As the complication and extent of supply chains amplify, companies are finding it thornier to assemble systems sustaining the dexterity of activities executed by the autonomous supply chain members. Agent-based Supply Chain Management system could endow with an elucidation to this quandary, as they present the prospects to assemble a large, multifaceted system out of relative simple, autonomous parts [5].

The attempt of this manuscript is twofold:

1. to blueprint a mobile agent based e-SCM, thereby, improving the synchronization within a supply chain and gratifying the organizational requirements, and
2. to evaluate the complete system using two different queuing models, M/M/1 and M/D/1 and then selects the preferable model.

The e-SCM model is developed using Mobile Agents because of its following characteristics [6]:

1. Intelligence: Mobile agents utilize techniques from the field of artificial intelligence, which empower Mobile Agents with intelligence and common sense. This feature helps the Mobile Agents based e-SCM with the decision making capabilities as supply chain consists of autonomous cooperating systems. Decision-making capabilities require multiparty negotiation and coordination.
2. Autonomy: Mobile Agents can self decide the sequence of actions to be performed to achieve the give task. This autonomy enables Mobile Agents to operate without requiring human involvement. This characteristic helps to manage the interactions between humans and humans and information systems.
3. Responsiveness: Mobile Agents perceive their environment (which may be the Internet, a collection of other agents, etc.) and respond in a timely fashion to changes that occur in it. At the same time, agents should not simply act in response to their environment; they should be able to exhibit opportunistic, goal- oriented behavior and take the initiative when appropriate.
4. Communicative Ability: Mobile agents provides user friendly interface so that the end user can easily interact with the agent. Agents are social entities and often communicate and collaborate with one another in order to complete their tasks. For example, the mobile agent can communicate with other mobile agents and act accordingly.
5. Adaptability: Mobile Agents learn about the user's behavior and adapt themselves to suit the user. A supply chain is adaptive and changes over time. New organizations might become involved and other might disappear.

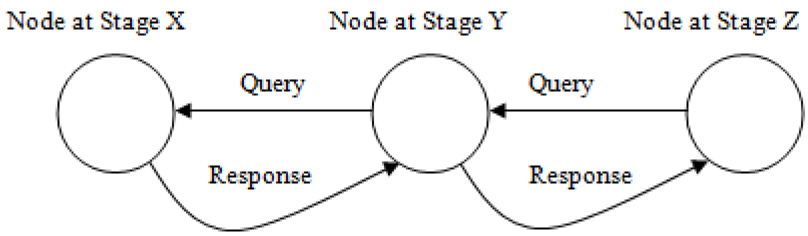
The proposed Mobile Agent based e-SCM architecture was tested systematically on M/M/1 and M/D/1 queuing models respectively. The vital divergence amid the two models is the methodology espoused for servicing of the requests. In M/M/1 queuing model, the service distribution varies with respect to the type of request, whereas, in M/D/1 queuing model, the service distribution relics constant irrespective of the type of requests. Preference between the models is being recommended in the conclusion component of the manuscript.

The manuscript is divided into following sections: Section 1 of the paper describes the proposed architecture for Mobile Agent based e-SCM. Section 2 elaborates the working steps of the proposed architecture. Section 3 mentions the complete working model using UML 2.0 diagrammatic technique, called, Sequence Diagram. Section 4 depicts the flowchart of the proposed system and elaborates the basic difference between M/M/1 and M/D/1 queuing model. Section 5 demonstrates the findings of four queuing parameters being worn in the design. Section 6 illustrates the result analysis and the relative study of the model among M/M/1 and M/D/1 queuing system. Section 7 concludes the paper.

ARCHITECTURE OF MOBILE AGENT BASED e-SCM
The proposed architecture is alienated into three stages, Z, Y and X correspondingly. At stage Z, there are two Mobile Agents *[BA_Z]* and *[SA_Z]*. BA_Z is the end-customer, who actually gives the order to the suppliers. The mobile agent for suppliers is represented by *[BA_Z]*. *[BA_Z]* amasses the information from inventory of *[SA_Z]*, and transfers the requests to Production Agent, *[PA]*. Upon getting the requests, *[PA]* frontwards the requests to Buyer Agent at Stage X, represented as *[BA_X]*, who process the requests and relocates it to Supplier Agent at Stage X [SA_X].

Figure 1 gives the complicated and multifarious analysis of e-SCM architecture. Each node specified in the architecture symbolizes supplier of some type. So, Seller Agent (S_A) at stage X will be able to sell to Buyer Agent (B_A) at stage Z. This case is valid for all the stages.
The simplified structure of Supply Chain as mentioned in Figure 1 is depicted in Figure 2, which is 1-node architecture of Supply Chain.

FIGURE 1: 1-NODE e-SUPPLY CHAIN ARCHITECTURE

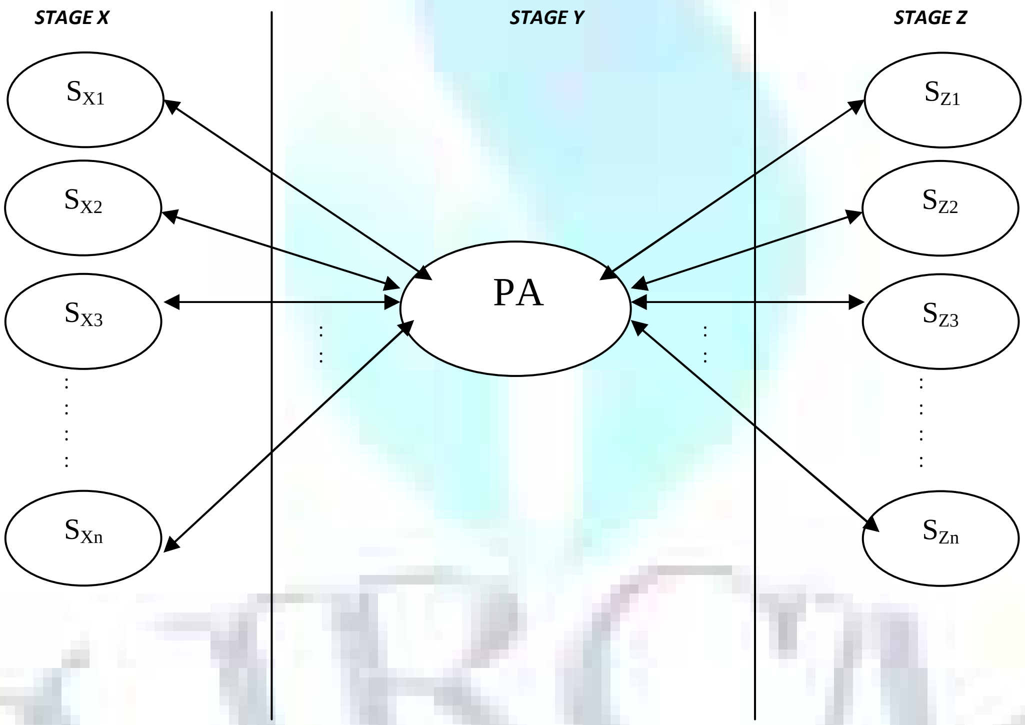


There are two important facts that have to be considered from Figure 7 and Figure 8 respectively.

Fact 1: Buyer Agent (B_A) initiates the process at Stage Z and Seller Agent (S_A) at Stage X completes the cycle.
Fact 2: It is assumed that:
Stage X is the stage of procuring raw materials.
Stage Y is the stage of production.
Stage Z is the stage wherein the end customer enquiries for the product.

These mobile agents are alienated into three phases as given in Figure 1. It is assumed that each node is represented by one mobile agent. It is also presumed that each stage X and Z has "n" number of suppliers and buyers, as illustrated in Figure 2.

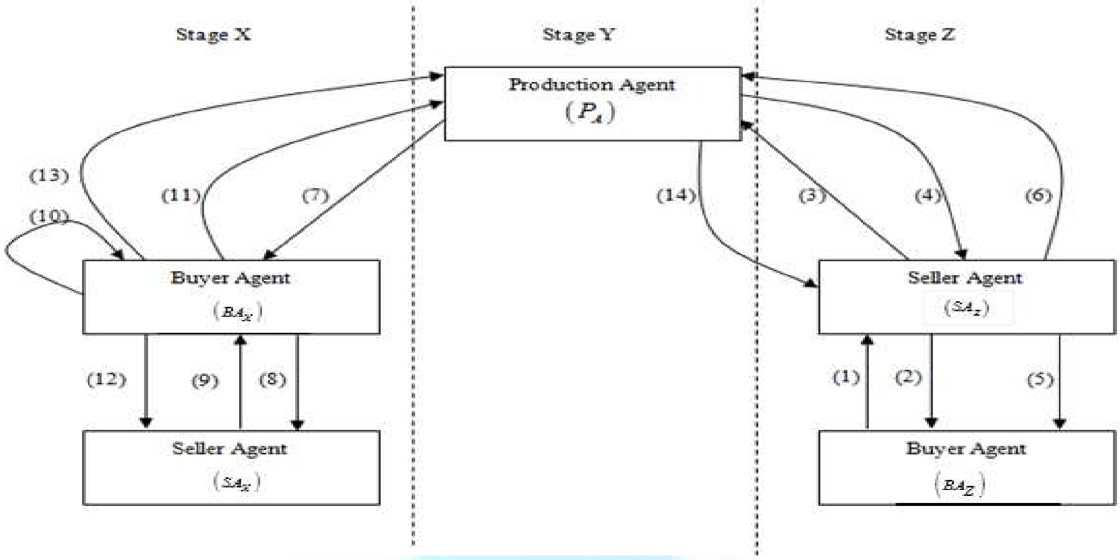
FIGURE 2: 3-NODE n-TIER SUPPLY CHAIN ARCHITECTURE



WORKING STEPS OF SUPPLY CHAIN USING MOBILE AGENT

The elaborated version of proposed architecture is given in Figure 3.

FIGURE 3: COMPLETE ARCHITECTURE OF IMPLEMENTATION OF MOBILE AGENTS BASED e-SCM



The working steps are as follows:

Step 1: The Buyer Agent at this stage $(Stage\ Z)$ is the end customer. Number of Buyer Agents can be mathematically represented as

$$BA_{Z[i]} = \{BA_{Z[1]}, BA_{Z[2]}, \ldots\ldots\ldots BA_{Z[n]}\}\ \forall i = 1\ldots\ldots n \quad (1)$$

The demand for each of these Buyer Agents (BA_X) are

$$D_{Z[i]} = \{D_{Z[1]}, D_{Z[2]}, \ldots\ldots\ldots, D_{Z[n]}\}$$

Maximum prices which a buyer can pay are

$$MP_{Z[i]} = \{MP_{Z[1]}, MP_{Z[2]}, \ldots\ldots\ldots, MP_{Z[n]}\}$$

Expected price from the seller can be denoted as

$$EP_{Z[i]} = \{EP_{Z[1]}, EP_{Z[2]}, \ldots\ldots\ldots, EP_{Z[n]}\}$$

Cost price for the buyers

$$CP_{Z[i]} = \{CP_{Z[1]}, CP_{Z[2]}, \ldots\ldots\ldots, CP_{Z[n]}\}$$

Step 2: Upon receiving the Buyer Agents $\left[BA_{Z[i]}\right]$, the number of Seller Agents are generated as

$$SA_{Z[i]} = \{SA_{Z[1]}, SA_{Z[2]}, \ldots\ldots\ldots, SA_{Z[n]}\} \quad (2)$$

Each of these agents has the following data

- Price that will be offered (OP_Z)
- Capacity (CAP_Z)
- Lead Time (TL_Z)
- Delivery Date (DD_Z)
- Cost of Product (CP_B)
- Weight of each customer W_{B_Z}

Each of the Seller Agent $\left[SA_{Z[i]}\right]$ then ranks all by the buyers by comparing expected price from each buyers with the maximum price.

Selection Criteria:

$$\left(MP_{Z[i]} > EP_{Z[i]}\right) \forall i = 1\ldots\ldots\ldots n \quad (3)$$

Rank Criteria:

$$Rank = DESC\left(MP_{Z[i]} - EP_{Z[i]}\right)\forall i = 1.........n \quad (4)$$

where, $DESC$, is the Descending Sorting.

Step 3: The Seller Agent $\left[SA_{Z[i]}\right]$ receives the orders to fulfill as per the demands from different buyers, but has the limitation of Capacity

Capacity Criteria:

$$CAP_Z >= Selected\ buyers\ from\ D_{Z[i]} = \{D_{Z1} + D_{Z2} + ... + D_{Zn}\} \quad (5)$$

The demands from the selected number of buyers are added and taken into consideration.

It must be noted that the Production Agent (P_A) does not have capacity to fulfill all the orders. So, P_A requests $[SA_Z]$ to rank them according to their weights.

Rank criteria of the Buyers by the Seller Agent $[SA_Z]$ is called Buyer Weights.

Step 4: The Buyer Weight $W_{B_{Z[i]}}$ is based on the two assumptions:

Assumption 1: If the Buyer has earlier bought the products from the seller, the weight are assigned as

$$W_{B_{Z[i]}} = W_{B_{Z[i]}} + 1 \quad (6)$$

When, Buyers buy for the first time, then

$$W_{B_{Z[1]}} = 0$$

Assumption 2: Apart from the weight, the total quantity is also a must, and is given by $TQ_{B_{Z[i]}}$.

If, $W_{B_{Z[i]}} = 0$, $TQ_{B_{Z[i]}} = 0$ (7)

$[SA_Z]$ will respond to P_A about $\{W_{B_{Z[i]}}, TQ_{B_{Z[i]}}\}$ of the Buyer.

Step 5: In this step, the seller acknowledges its decisions to all the buyers. The rejected buyers can make their submissions again depending on their demand requirements. If the seller agent $[SA_Z]$ gets an order with a better price from any of the rejected buyers, it has two options:

Option 1: It can prefer this customer, but due to capacity constraint it has to reject one or more of the already selected buyers. In such a case, the rejected buyer will list the seller in the defector list and its weight will go down.

$$W_{S_{Z[i]}} = W_{S_{Z[i]}} - 1\forall i = 1..n \quad (8)$$

Option 2: The second option for the seller is to reject t he profitable offer from the buyer and stick to its original generated buyer list and thereby avoiding the reduction of its weight in the selected buyers list.

Such a selection between any of the above-mentioned two options is called Negotiating Criteria and is given by Mathematical formula as stated

$$Negotiating\ Criteria = DESC\left[\left(CP_{B_1} - CP_{S_1}\right), ..., \left(CP_{B_n} - CP_{S_n}\right)\right] \quad (9)$$

It must be noted that the initial price from all the buyers will be the Current price of the Seller $\left(CP_{S_i}\right)$ only. It is only after rejection, the buyer may submit a new price by adding an additional amount to buy the product depending on their demand requirements.

$$CP_{B_i} = CP_{S_i} + x \quad (10)$$

where, x is the added amount to the product purchase, which is based on price being offered to the seller.

Step 6: The Seller Agent (SA_Z) now forwards all the accepted orders (as mentioned from Step 1- Step 5) along with the Delivery deadlines $\left(DD_{Z[i]}\right)\forall i = 1........n$ to the Production Agent P_A.

Step 7: The Production Agent (P_A) gets all the information as required from the Seller Agent (SA_Z). Now P_A starts communication from Buyer Agent (BA_X) of Stage X. From BA_X, P_A gets the information about holding cost (H_C) and Lead Time (T_L) to evaluate the following

Maximum Price of Buyers ➔ $\left[MP_{BA_{X[i]}}\right] >= Current\ price\ of\ Seller - H_C - PE_B$

$$= CP_{S_{X[i]}} - H_C - PE_B \quad (11)$$

Delivery Deadline

$$DD_{X[i]} >= T_L + DD_{Z[j]}\forall i = 1....n\ and\ j \in \{selected\ buyers\ at\ stage\ Z\} \quad (12)$$

Step 8: The Buyer Agent $\left[BA_{X[i]}\right]$ asks for the current price $\left(CP_{B_X}\right)$, capacities of the seller $\left(CAP_{B_X}\right)$ and Demand Deadlines of the item $\left(DD_{B_X}\right)$.

Step 9: The Seller Agent $\left[SA_{X[i]}\right]$ upon receiving this, sends current price $\left(CP_{B_X}\right)$, capacities of the seller $\left(CAP_{B_X}\right)$ and Demand Deadlines of the item $\left(DD_{B_X}\right)$ as response.

Step 10: The Buyer Agent $\left[BA_{X[i]}\right]$ then ranks all the sellers based on the condition (as given in Step 2).
Selection Criteria:

$$MP_{BA_{X[i]}} > EP_{BA_{X[i]}} \quad \forall i = 1....n \qquad (13)$$

Rank Criteria:

$$Rank = DESC\left(MP_{X(i)} - EP_{X(i)}\right)\forall i = 1.........n \qquad (14)$$

Step 11: The Buyer Agent $\left[BA_{X[i]}\right]$ then selects the preferred Sellers based on the comparison of their expected price with its maximum price.

Step 12: The Buyer Agent $\left[BA_{X[i]}\right]$ submit the offers to the Sellers. It must be noted that the offer is being made through rank criteria as described in Step 10. If the seller rejects the offer, Buyer Agent has two options:

Option 1: $\left[BA_{X[i]}\right]$ can submit the request to the next ranked seller. This is performed by scanning through the list generated by rank criteria.

Option 2: $\left[BA_{X[i]}\right]$ can again the offer to the same seller with the better price $\left(B_P\right)$ option.

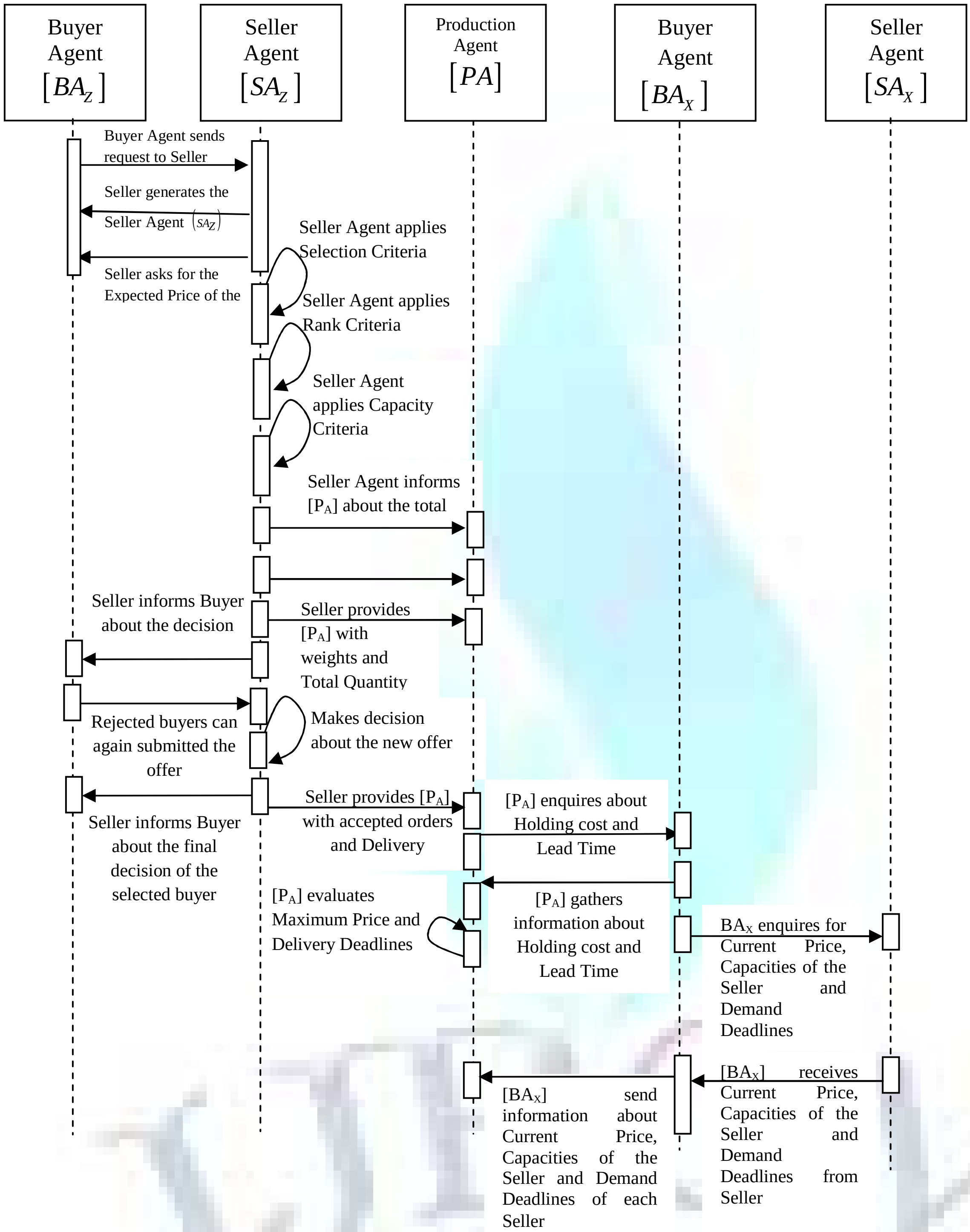
Step 13: Out of any of two options being selected from Step 12, the Buyer Agent $\left[BA_{X[i]}\right]$ informs the P_A and waits for the response to be received. After $\left[BA_{X[i]}\right]$ gets the response, it evaluates the $\left(DD_{B_X}\right)$. If $\left(DD_{B_X}\right)$ goes beyond the expected date, it will put the sellers in the defectors list and its weight goes down. The updated information is being informed to P_A. After this, $\left[BA_{X[i]}\right]$ activates the payment process.

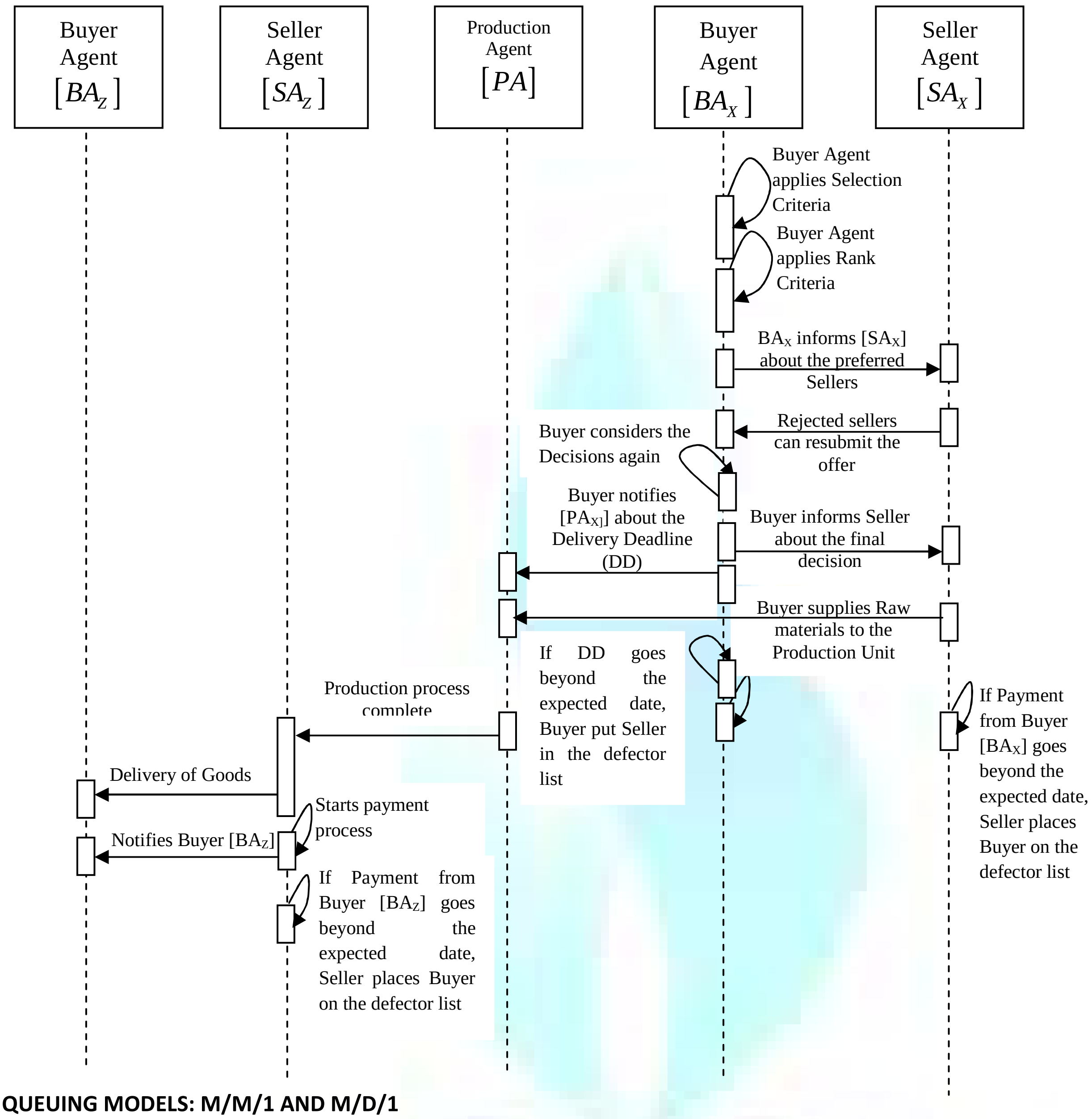
Step 14: The final step activates after the production is completed. P_A informs $\left[SB_{Z[i]}\right]$ to finally deliver the goods to the buyers and communicate the payment process to the Buyer. P_A also starts to monitor the payment from the buyer. If the buyer does not pay for the goods received on or before the Deadline, it puts the buyer in the defector list and its weight in both P_A and SA_z goes down.

BUSINESS PROCESS USING SEQUENCE DIAGRAM

Figure 4 elaborates the complete business process for execution of Supply Chain process using mobile agents. The Figure defines all the 14 steps used for execution of the complete design mechanism.

FIGURE 4: SEQUENCE DIAGRAM FOR THE PROPOSED MODEL





QUEUING MODELS: M/M/1 AND M/D/1

Queuing models have been established to be incredibly valuable in many practical applications in business such as, e.g., production systems, inventory systems and supply chain management. These applications apprehension in particular design problems, where we necessitate answering difficulties like:

1. Is the system competent to knob the requests?
2. What should be the layout of the system?
3. How do we have to divide work among several capacities?

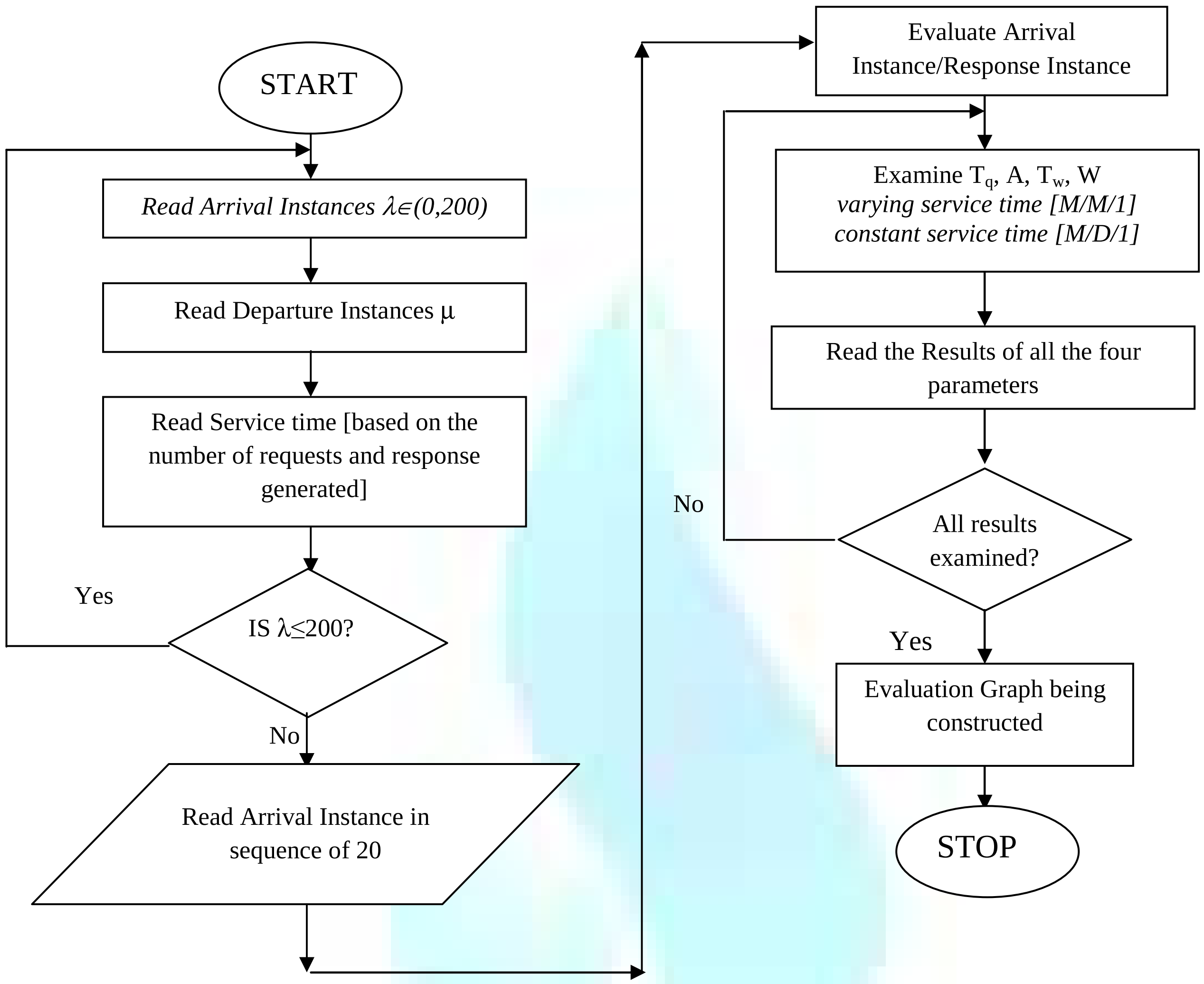
In countless applications the unpredictability in the arrival and service processes are critical to the performance of the system. Queuing models help us to appreciate and enumerate the effect of variability.

The projected architecture of performance of e-SCM via Mobile Agents was tested based on two different types of Queuing models, namely, M/M/1 and M/D/1. The basis for evaluating the system on queuing strictures is that in M/M/1 model, the service time amends with respect to the number of requests being expected by the model, whereas, in M/D/1 model, the service time vestiges stable irrespective of the requests being received by the system.

The software code was developed using Java 2.0 using Mobile Aglets code and executed considering the number of requests being acknowledged. The software program evaluated the queuing models based on four parameters, specifically,

1. *Average waiting time each request is in the system, T_q*
2. *Average of total number of requests in the system, Q*
3. *Average time each request waits in the queue, T_w*
4. *Average number of requests waiting, W*

4.1 FLOWCHART FOR IMPLEMENTATION OF RESULTS USING M/M/1 QUEUING MODEL



PERFORMANCE MEASURES

The evaluation of the architecture is being judged using four different parameters (discussed in Section 4). The comprehensive architecture is developed by evaluating the requests acknowledged at the rate of 20 requests and response being generated. The imperative point of concern here is that the response may include the set of requests still not processed from the previous sequence and is added in the next array of requests received by the system. This increases the service time for M/M/1 queuing model affecting the overall performance of the projected architecture. The service time is maintained at constant to numeral value 3.00 in M/D/1 queuing model and the result is being analyzed accordingly.

TABLE 1: AVERAGE WAITING TIME FOR EACH REQUEST IN THE SYSTEM

		M/M/1 Queuing Model		M/D/1 Queuing Model	
Number of requests arriving/sec	Number of responses generated/sec	Service Time/sec (Varying for M/M/1 model)	Average waiting time each request is in the system	Service Time/sec (Fixed for M/D/1 model)	Average waiting time each request is in the system
λ	μ	S	T_q	s	T_q
20	21	0.66	13.86	3.00	33
40	55	0.89	3.263333	3.00	7
60	77	0.99	4.484118	3.00	8.294118
80	91	1.12	9.265455	3.00	13.90909
100	129	2.07	9.207931	3.00	8.172414
120	151	3.29	16.02548	3.00	8.806452
140	169	4.11	23.95138	3.00	10.24138
160	179	5.05	47.57632	3.00	15.63158
180	211	5.23	35.59774	3.00	11.70968
200	246	6.13	32.78217	3.00	9.521739

TABLE 2: AVERAGE OF TOTAL NUMBER OF REQUESTS IN THE SYSTEM

		M/M/1 Queuing Model		M/D/1 Queuing Model	
Number of requests arriving/sec	Number of responses generated/sec	Service Time/sec (Varying for M/M/1 model)	Average of total number of requests in the system	Service Time/sec (Fixed for M/D/1 model)	Average of total number of requests in the system
λ	*μ*	*s*	*Q*	*s*	*Q*
20	21	0.66	20	3.00	10.52381
40	55	0.89	2.666667	3.00	1.969697
60	77	0.99	3.529412	3.00	2.375095
80	91	1.12	7.272727	3.00	4.196803
100	129	2.07	3.448276	3.00	2.336541
120	151	3.29	3.870968	3.00	2.538133
140	169	4.11	4.827586	3.00	2.999592
160	179	5.05	8.421053	3.00	4.763599
180	211	5.23	5.806452	3.00	3.476686
200	246	6.13	4.347826	3.00	2.767409

TABLE 3: AVERAGE TIME EACH REQUEST WAITS IN THE QUEUE

		M/M/1 Queuing Model		M/D/1 Queuing Model	
Number of requests arriving/sec	Number of responses generated/sec	Service Time/sec (Varying for M/M/1 model)	Average time each request waits in the queue	Service Time/sec (Fixed for M/D/1 model)	Average time each request waits in the queue
λ	*μ*	*s*	T_w	*s*	T_w
20	21	0.66	13.2	3.00	30
40	55	0.89	2.373333	3.00	4
60	77	0.99	3.494118	3.00	5.294118
80	91	1.12	8.145455	3.00	10.90909
100	129	2.07	7.137931	3.00	5.172414
120	151	3.29	12.73548	3.00	5.806452
140	169	4.11	19.84138	3.00	7.241379
160	179	5.05	42.52632	3.00	12.63158
180	211	5.23	30.36774	3.00	8.709677
200	246	6.13	26.65217	3.00	6.521739

TABLE 4: AVERAGE NUMBER OF REQUESTS WAITING

		M/M/1 Queuing Model		M/D/1 Queuing Model	
Number of requests arriving/sec	Number of responses generated/sec	Service Time/sec (Varying for M/M/1 model)	Average number of requests waiting	Service Time/sec (Fixed for M/D/1 model)	Average number of requests waiting
Λ	*μ*	*s*	*W*	*s*	*W*
20	21	0.66	19.04762	3.00	9.52381
40	55	0.89	1.939394	3.00	0.969697
60	77	0.99	2.750191	3.00	1.375095
80	91	1.12	6.393606	3.00	3.196803
100	129	2.07	2.673082	3.00	1.336541
120	151	3.29	3.076266	3.00	1.538133
140	169	4.11	3.999184	3.00	1.999592
160	179	5.05	7.527198	3.00	3.763599
180	211	5.23	4.953371	3.00	2.476686
200	246	6.13	3.534818	3.00	1.767409

RESULT ANALYSIS

The comparison between M/M/1 and M/D/1 queuing models is being conducted by using both simulation and queuing model based on four stated parameters and the study was undergone with the observation of minimum number of 200 customer requests at a time. Due to restricted time, the research had been conducted with minimum volume, this research can be extended with larger number of requests per unit time and more days of surveillance, it paves the way to give more precise results. The graph(s) in Figure 6 (a)-(d) is depicts the results obtained.

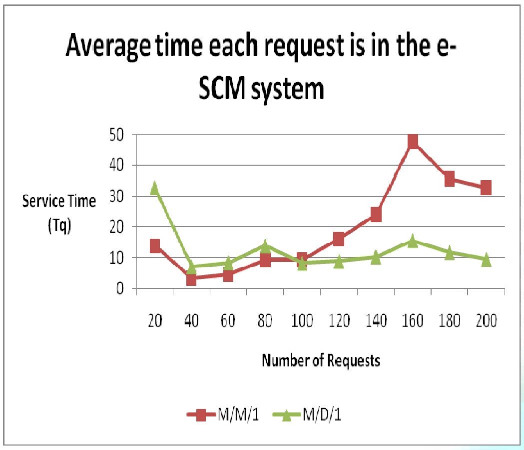


Figure 6(a): Evaluation of T_q

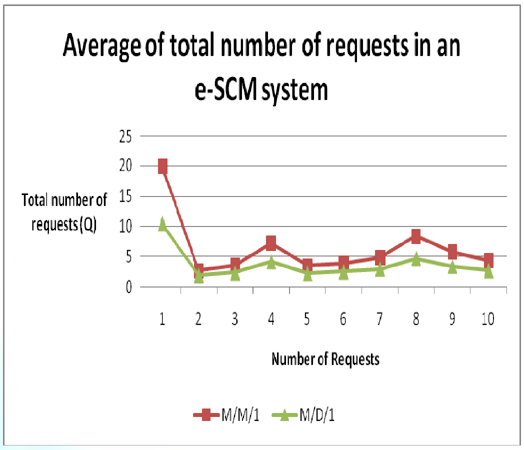


Figure 6(b): Evaluation of Q

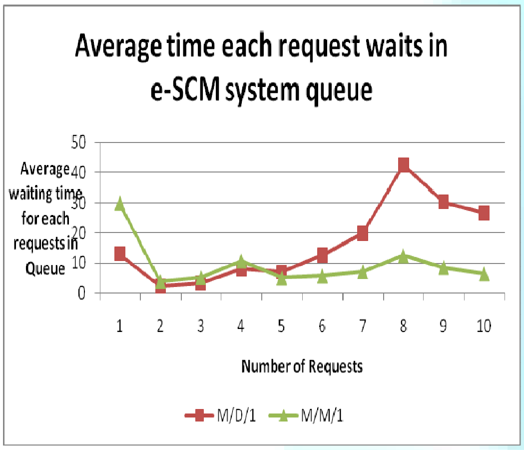


Figure 6(c): Evaluation of T_w

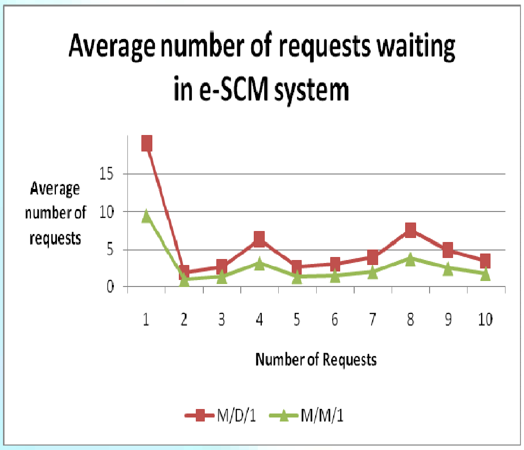


Figure 6(d): Evaluation of W

The analysis of the results gives the following result:

1. For lesser number of requests (in range of 20-60 requests) being acknowledged by the system, the suitable adopted model would be M/D/1, keeping the service time constant for dispensation the requests from BA_Z.
2. For larger number of requests (>60 requests) , the apposite adopted model would be M/M/1, varying the service time with respect to the requests being received by the scheme.

CONCLUSION

The paper is an attempt to integrate mobile agents and supply chain and evaluate the same by comparing the execution steps using M/M/1 and M/D/1 queuing model. In this work, first study on supply chain, SCM, software agent, mobile agent and mobile agent environment is performed. Then the conceptual model for supply chain using mobile agents is proposed. In this model, almost all the functionalities of supply chain are performed using five different mobile agents. Also, almost all activities of supply chain being performed intelligently and automatically by these agents. Further researches are expected to enhance the agent capability with a perfect knowledge base and enforce its security to protect the sensitive information. However, in all the study conducted earlier, the performance analysis of the complete system was missing. The mathematical analysis of the proposed e-SCM model using Mobile agents is an attempt in the direction and the study will be continued even further with larger number of requests being received and evaluated.

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