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Design of Flow Control Mechanism Model for Markovian Multi Stage Queueing Network

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Abstract: Stochastic simulation of multi stage queueing network is a powerful tool that provides some form of predictive modeling prior to design the large scale parallel computer curvation architecture. An interconnection network curvation, simulations can be performed using a wide variety of input parameters such as offered load, multicast traffic pattern, routing scheme or (internal) buffer configuration. The fixed inter stage connections between the adjacent stage exists with a number of switches at each stage that are effervescently set to establish the desired connection route the requests from the inputs to the outputs. In a multistage interconnection network that sharing the internal links by different paths across the network introduces extra contention. Various design parameters can be examined concerning network performance in terms of throughput and delay. Network traffic and resource scheduling is modeled by stochastic simulation. The simulations yield performance measures such as throughput, mean delay, delay time distributions or mean buffer queue lengths in individual network stages. Finally the concept of decomposition is used to replace the heterogeneous sub-network with flow equivalent devices. Based on the graphical representation it clearly displays the calculations of performance measures over the period of simulation in multistage queueing networks.

Key words: Queueing network · Stochastic Processes · Scheduling · Decomposition · Flow Equivalent Device

INTRODUCTION

Multi stage interconnection network plays a vital role in the parallel computing system. The communication subsystem links the processors and input/output controllers in a parallel processing subsystem and has an insightful impact on system capacity, performance analysis. Such interconnection networks can be constructed from single or multiple stages of switches. In the case of single stage network where the data may have to be passed through the switches quite a few times before reaching the final destination. On multistage network, one pass of multistage stages of switches is usually sufficient. The network characteristic functions are determined by the input units which are connected with the output units. Then showed how to characterize the distributed server system so as to construct a model to predict response times as well as estimate system capacity. According to the arrival pattern of the Poisson process entering customer goes to the first service station in its routing sequence of stage process.

At each service station, there is one machine with exponential distribution of processing time. The queueing network is assumed to be in the steady-state and the service rates are controllable. After completing the stage process of the individual parts, they are assembled to each other and after passing some other stage and assembly process, the final product leaves the system in its f inished form. All inter-station buffers are infinite. An implicit hypothesis in the literature is that transit time in buffers is null, i.e., a part which leaves a machine is supposed to be instantaneously available for the next machine. The time needed to cross the intersection buffers may be much greater than the service time and there is no reason to claim that its effect on the system will be negligible. Therefore, the transport times between

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the service stations are assumed to be independent random variables with exponential distributions. The time spent in a service station would be equal to the processing time, plus waiting in the queue in front of the service station. Therefore, the time spend by a finished product in the system would be equal to the length of the longest path of the queueing network whose curvation lengths are the transport times between the service stations. We can analytically obtain the distribution function of the stage lead time by computing the distribution function of the longest path in the queueing network.

The analytical methods above are considered the stage and assembly processing times as independent random variables and ignore their dependence on the arrival and service rates of jobs at various stages in the staging process. Therefore, the time spent waiting in queues in front of service stations should be considered in order to compute the stage lead time. The theory of stochastic processes has been used as a framework to analyze the performance of the actual computer system during the given time period. The following assumption is considered in the theory of stochastic processes such that the system is ergodic, stochastic equilibrium, stochastically independent jobs with an exponential distribution and job steps follows Markov chain. This paper presents the Markov analysis of queueing networks with several classes of customers. The decomposition principle improved approximation when the number of state changes within the subsystem.

Literature Survey: Optimal Control of Service Rates and Arrivals in Jackson Networks has developed and extended the research in the distribution function of the shortest path in networks of queues [1, 2]. An approximation to multistage stochastic optimization had analyzed in multi period batch plant scheduling under demand uncertainty and explained the multilayer multistage interconnection networks [3-7]. A Markovian Single Server with Upstream Job and Downstream Demand Arrival Stream had envisaged and analyzed the optimal throughput allocation in stochastic networks [8-10]. [11-13] has explained the performance analysis and clearly pictured the multi-objective routing within large scale facilities using buffer allocations in open finite queueing networks. [14] has introduced the fair end-to-end window based congestion control. [15-17] has designed a new algorithmic approach for the design of Markovian queueing network with multiple closed chainsand discusses the performance modeling in Multi-component online services.

Effervescent Multistage Aggregative Network: Each effervescent multistage assembly system can be modeled as an open queueing network, in which each service station settled in a node of the network represents a stage. The following assumptions are made:

According to a Poisson process the arrival rate of each job enters system is λ. Service discipline is based on FIFO. When a job, entered the system, it goes directly to a first stage station for service and it queues up if the jobs are being processed. After completion of processing at a stage station, it goes to another stage station to be processed in its routing sequence of stage process. The processing time at each service station is independent of preceding processing times. Processing times of stage and assembly process are exponentially distributed (including set up times on the service station).There are no interruptions due to breakdowns, maintenance, or other such cases. After completing the stage process of each class and it is assembled to some other class in an assembly station. Each job class part, statistically independent of the other. Each service station with only one incoming curvation indicates a stage station. Each service station with more than one incoming curvation indicates an assembly station. The product leaves the system in its finished form from the sink node of the queueing network. The queueing network is in the steady-state and its service rates are controllable. It is clear that the arrival process to the stage stations prior to an assembly station is the Poisson process with the rate of ë. Each assembly station has more than one arrival stream, but each assembly process can begin if and only if the stage process of all corresponding individual parts, which should be assembled to each other, has been finished. Therefore, it is reasonable to approximate the arrival process to an assembly station, for each set of individual parts available for the assembly process, as a Poisson process with the rate of λ.

The curvation lengths of the network indicate the transport times between the service stations, which are assumed to be independent random variables with exponential distributions. Consequently, the time spend by a finished product in the system or the stage lead time would be equal to the length of the longest path of the queueing network, in which the length of each node which contains a service station is equal to the time spent in this station.

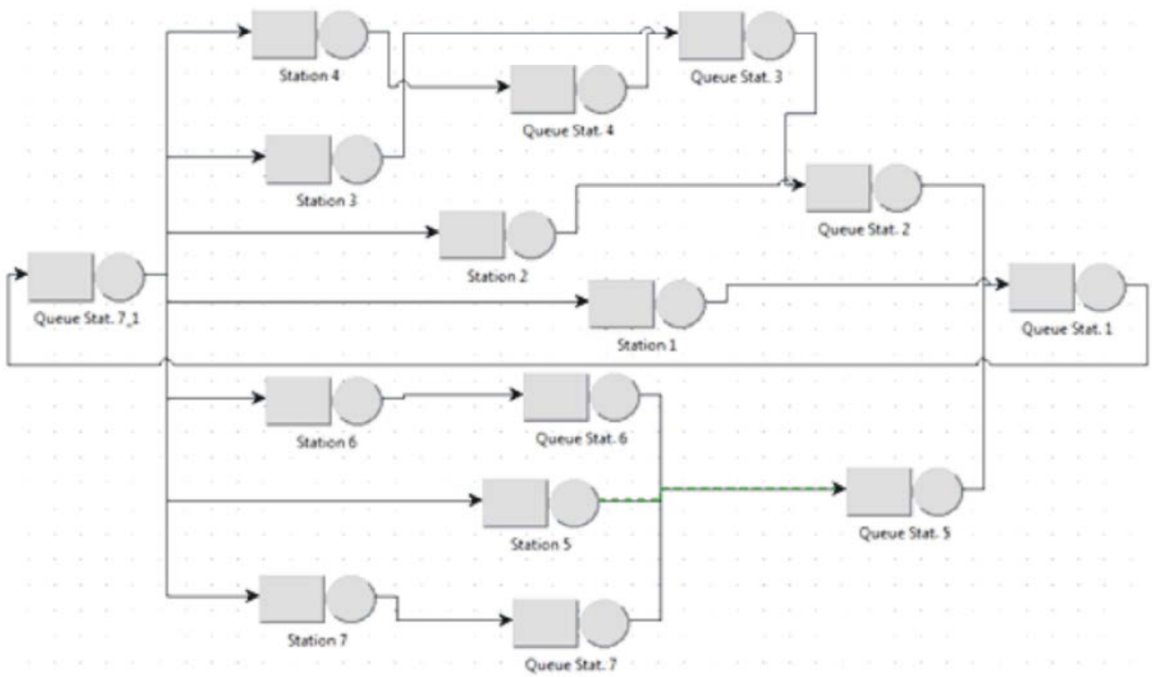


Fig. 1.1: Multistage Markovian Queueing System

Every two nodes of the queueing network associated with an effervescent multistage assembly system are connected by at most one directed path. The type of service rate control considered here is such that the exponentially distributed processing time, corresponding with the ith service station, increases from a given average rate μ_i, when only one server works, to an average rate of $\gamma_i\mu_i$, according to whenever servers are employed in this service station, in order to minimize the total operating costs of the system per period, minimize the average lead time and maximize the probability that the stage lead time does not exceed a certain threshold.

State Transition Balance: The assumption of job flow balance is deficient to compute the response time accurately. To represent the job distribution, define a state of the system, a vector $n=(n_1,n_2,n_3.....,n_K,)$; $n_i, > 0$ is the number of jobs at device i. In the following discussion $\underline{u}$, $\underline{v}$ and $\underline{w}$ denotes a distinct system states. If the system moves from state $\underline{u}$ to $\underline{v}$ state without passing through any observable state, a one step transition has arisen. Let Ψ ($\underline{u}$, $\underline{v}$) denotes the number of one step transitions observed from $\underline{u}$ to $\underline{v}$, $\Psi(\underline{u}, \underline{u}) = 0$ implies no state change.

The conversation of transition equations is:

$$\sum_{\underline{u}} \Psi(\underline{u}, \underline{v}) = \sum_{\underline{w}} \Psi(\underline{v}, \underline{w}) \text{, for all } \underline{v}$$

The state space balance equations is:

$$\sum_{\underline{u}} P(\underline{u})\Phi(\underline{u}, \underline{v}) = P(\underline{u}) \sum_{\underline{w}} \Phi(\underline{v}, \underline{w})$$

where, $\Phi(\underline{v}, \underline{w}) = \dfrac{\Psi(\underline{v}, \underline{w})}{T(\underline{v})}, T(\underline{v}) \neq 0$

And P ($\underline{v}$) = $\frac{T(\underline{v})}{T}$ is the time proportion for $\underline{v}$.

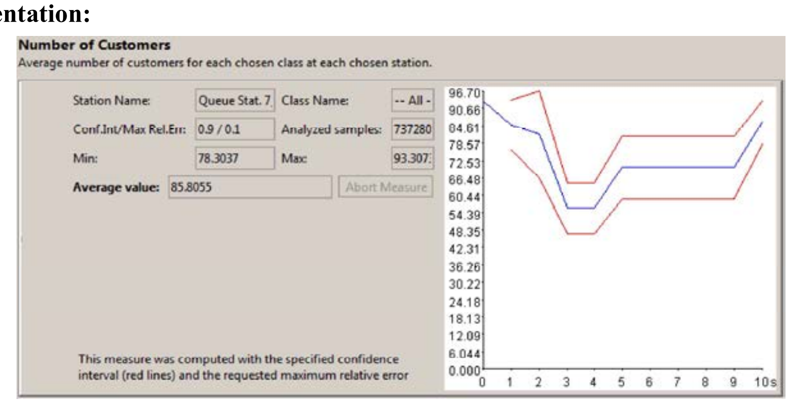
The routing frequencies are independent of the system's state. Routing homogeneity assumption denotes the job depend on the intrinsic demands of the job not on queue length. The stochastic counterpart of routing homogeneity is the job transitions follow an ergodic Markov chain. Interconnections between the input ports and output ports are employed by the control mechanism. Each node in the network is called a cross point and is a simple switch which has two states, open and closed. Using centralized control the network can satisfy all unicast and multicast connections. Multistage interconnection networks are constructed from the stages of interconnected crossbar switching elements of low degree. The crossbar switching component is appropriate for employing with distributed control within in the multistage interconnection network. An incident packet has prolonged by a tag which specifies the enforced destination. The selector of the input port examines this tag and inspects the state of the arbiter of the required output port and selectors can employ concurrently and asynchronously. Multicast connections are not supported by this design of crossbar network. This crossbar network may be used with either a self-routing or with a source routing control algorithm and may be referred to as a self-routing crossbar switch.

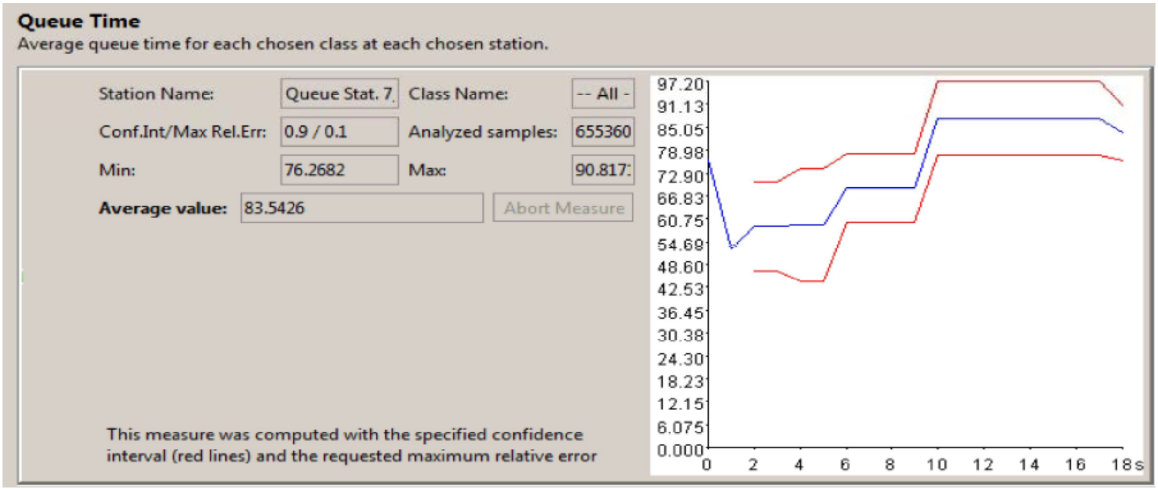
Control Mechanism: Interconnection networks may also be classified according to the control mechanism employed to effect connections between input ports and output ports. If the algorithm is centralized and implemented in a central processor, then the state of all existing connections and all connection requests may be consulted in order to make the necessary routing decisions. The use of a centralized control mechanism implies circuit switching where the holding time of a connection is much greater than the time required to establish connection. In fast packet switching applications the control mechanism must be distributed across the switch fabric and must be capable of operating without access to information regarding the entire state of the switch. Three classes of distributed routing algorithm are relevant to a regular network: source routing, self-routing and regular routing. Source routing requires a tag to be prefixed to the packet which specifies all of the routing decisions to be taken within the network, one field of the tag for each switch in the path. It thus removes the burden of route computation from within the switch fabric to the periphery. The self-routing and regular routing con-trol mechanisms are sometimes confused as both require a tag to be prefixed to the packet specifying the required destination output port number and both rely upon the regularity of the interconnection network. Self-routing applies to dynamic, multistage interconnection networks. It may be implemented such that each switching element within the path makes a simple routing decision based only upon the tag of the incoming packet independently of the position of the switching element within the interconnection network.

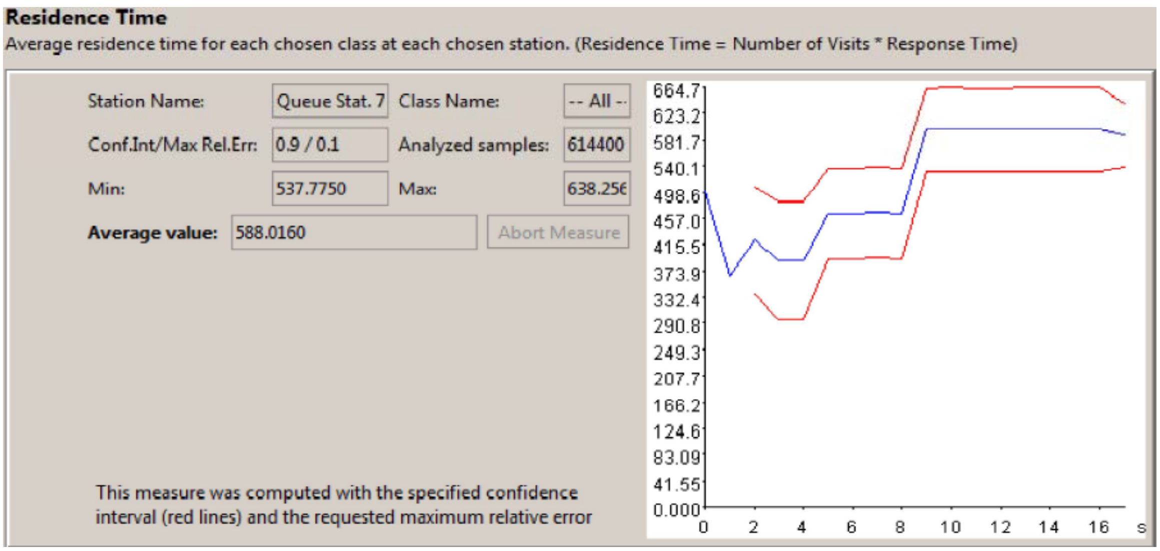
The regular routing mechanism applies to regular static networks in which each network node makes a routing decision based upon the packet tag and the position of the node within the network. This decision requires a certain amount of computation and thus involves some delay. The regular routing algorithm is thus best suited to conventional packet switching applications. The routing decision in a self-routing algorithm, however, requires no computation, does not involve the maintenance of routing tables within the switch fabric and may be executed by very simple hardware within a single bit time. It is therefore of considerable interest in fast packet switching application.

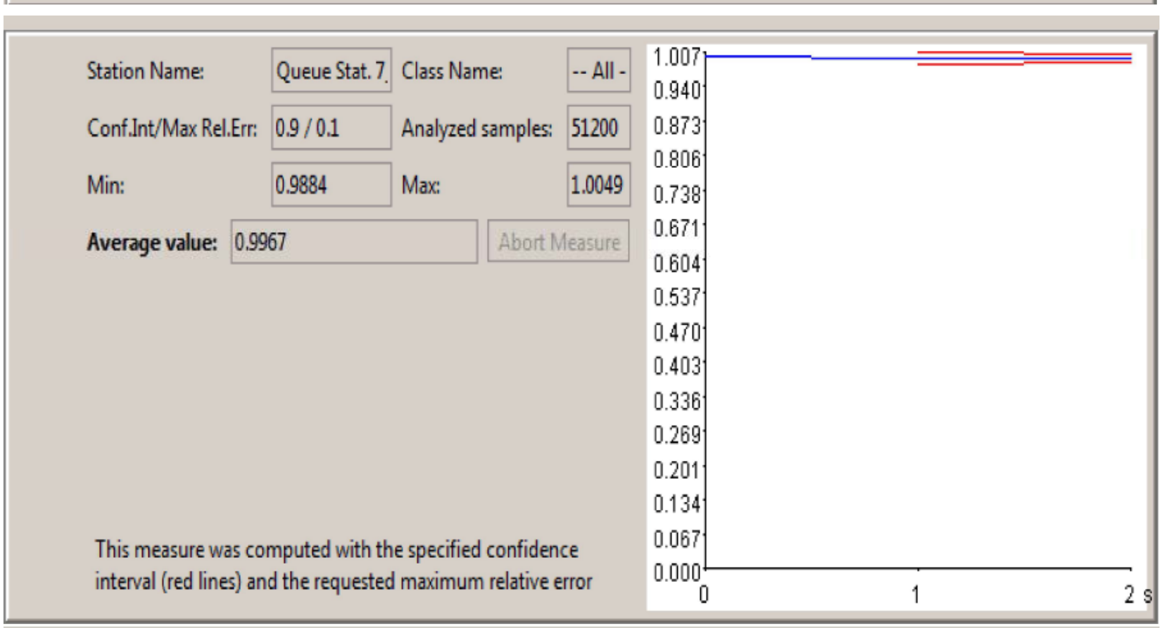
Decomposition: The principle of decomposition is applied to study the subsystem which is independently interacting with its environment. The subsystem is operated under a constant load of N jobs. After the completion of each job, the analyst adds another job to keep the load equal to N. A subsystem has to replace by an equivalent device, when the subsystems output rate is completely determined by its given load N. A sub-network of system whose devices and routing frequencies are homogeneous, which is decomposable from the system. Homogeneity avers exact decomposability for a device. Decomposability provides a better approximation when the number of state changes within the subsystem between interactions with the environment. The most important applications of decomposition have been for virtual memory systems, blocking and other behaviors could not be represented in the queuing network model.

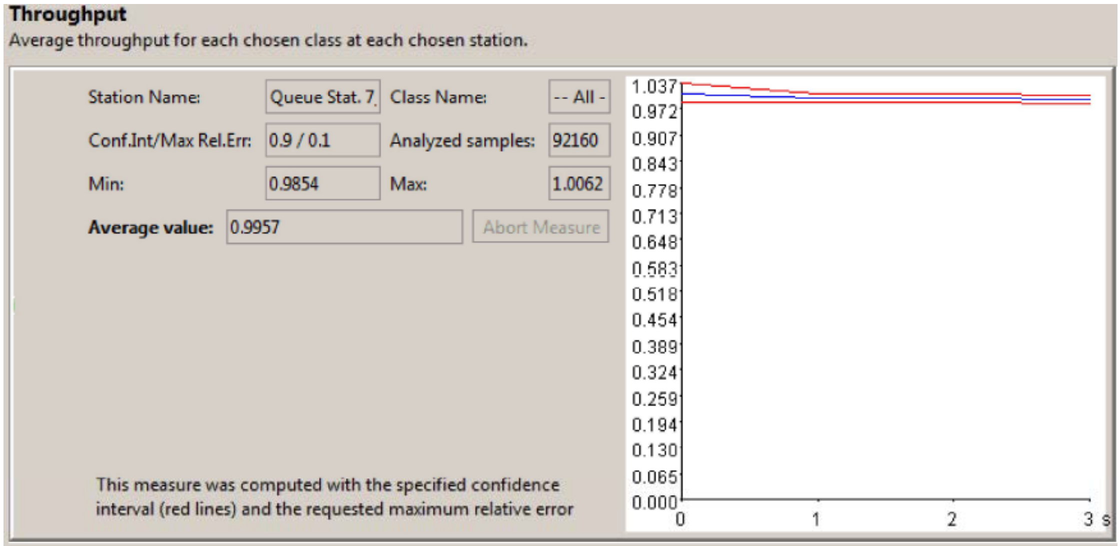
Graphical Representation:

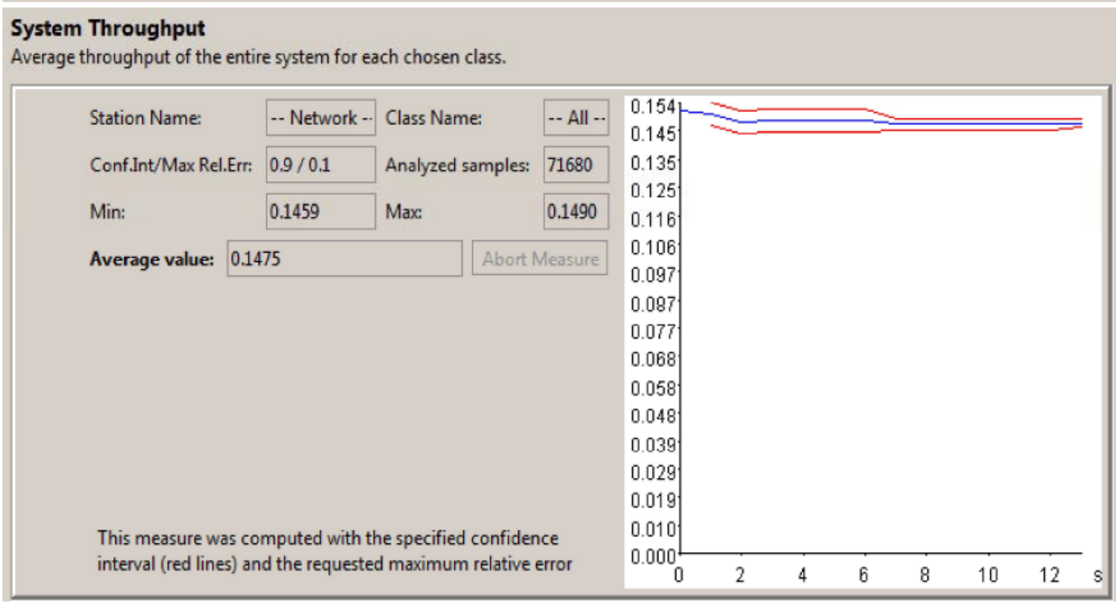



Queue Time
Average queue time for each chosen class at each chosen station.
Station Name:
Queue Stat. 7
Class Name:
-- All -
Conf.Int/Max Rel.Err:
0.9 / 0.1
Analyzed samples:
655360
Min:
76.2682
Max:
90.817
Average value:
83.5426
Abort Measure
This measure was computed with the specified confidence
interval (red lines) and the requested maximum relative error
97.20
91.13
85.05
78.98
72.90
66.83
60.75
54.68
48.60
42.53
36.45
30.38
24.30
18.23
12.15
6.075
0.000
0
2
4
6
8
10
12
14
16
18s


Residence Time
Average residence time for each chosen class at each chosen station. (Residence Time = Number of Visits * Response Time)
Station Name:
Queue Stat. 7
Class Name:
-- All --
Conf.Int/Max Rel.Err:
0.9 / 0.1
Analyzed samples:
614400
Min:
537.7750
Max:
638.256
Average value:
588.0160
Abort Measure
This measure was computed with the specified confidence
interval (red lines) and the requested maximum relative error
664.7
623.2
581.7
540.1
498.6
457.0
415.5
373.9
332.4
290.8
249.3
207.7
166.2
124.6
83.09
41.55
0.000
0
2
4
6
8
10
12
14
16
s


Station Name:
Queue Stat. 7
Class Name:
-- All -
Conf.Int/Max Rel.Err:
0.9 / 0.1
Analyzed samples:
51200
Min:
0.9884
Max:
1.0049
Average value:
0.9967
Abort Measure
This measure was computed with the specified confidence
interval (red lines) and the requested maximum relative error
1.007
0.940
0.873
0.806
0.738
0.671
0.604
0.537
0.470
0.403
0.336
0.269
0.201
0.134
0.067
0.000
0
1
2 s





CONCLUSION

This paper presents the tool for stochastic simulation of multistage interconnection networks. Transient network behavior can also be evaluated, especially when observing traffic that changes with time. The presented tool allows for evaluating various network configurations under different traffic conditions. Based on the above graphical representation it is found that the performance analysis to queueing network with several stages of customers. The number of jobs multiprogrammed in each job class is not fixed which depends on the amount of memory available for each workload. Simple crossbars can be simulated as well as multistage interconnection networks that are arranged in multiple layers. The other parameters like bandwidth and probability of acceptance also consider in analyzing the irregular networks. The decomposability principle allows studying a non homogeneous subsystem using stochastic analysis. In spite of its internal behavior a subsystem can be represented by a homogeneous device which interacts with its environment.

REFERENCES

1. Azaron, A. and S.M.T. Fatemi Ghomi, 2003. Optimal Control of Service Rates and Arrivals in Jackson Networks, European Journal of Operational Research, 147: 17-31.

2. Azaron, A. and M. Modarres, 2005. Distribution Function of the Shortest Path in Networks of Queues. OR Spectrum, 27: 123-144.
3. Balasubramanian, J. and I.E. Grossmann, 2003. Scheduling Optimization under uncertainty- An alternative approach, Computers and Chemical Engineering, 27: 469-490.
4. Balasubramanian, J. and I.E. Grossmann, 2004. Approximation to multistage stochastic optimization in multi period batch plant scheduling under demand uncertainty, Industrial and Engineering Chemistry Resecurvation, 43: 3695-3713.
5. Tutsch, Dietmar and Gunter Hommel, 2003. Multilayer multistage interconnection networks. In Proceedings of 2003 Design, Analysis and Simulation of Distributed Systems (DASD 2003); Orlando, SCS, pp: 155-162.
6. Tutsch Dietmar, Matthias Hendler and Gunter Hommel, 2001. Multicast performance of multistage interconnection networks with shared buffering. In Proceedings of the IEEE International Conference on Networking (ICN 2001); Colmar, pp: 478-487. IEEE, July 2001.
7. Elmaghraby, S.E., A.A. Ferreira and L.V. Tavares, 2000. Optimal Start Time Under Stochastic Activity Durations. International Journal of Production Economics, 64: 153-164.
8. Gold, H., 1998. A Markovian Single Server with Upstream Job and Downstream Demand Arrival Stream. Queueing Systems, 30: 435-455.
9. Gupta, P. and A.L. Stolyar, 2006.Optimal throughput allocation in general random access networks, Proceedings of 40^{th} Annual Conf. Inf. Sci. Systems, pp: 1254-1259.
10. Harrison, J.M., 2002. Stochastic networks and activity analysis, In Y. Suhov, editor, Analytic Methods in Applied Probability, In Memory of Fridrik Karpelevich, Providence, RI, American Mathematical Society.
11. Hemachandra, N. and S.K. Eedupuganti, 2003. Performance Analysis and Buffer Allocations in Some Open Assembly Systems. Computers and Operations Research, 30: 695-704.
12. Kerbache, L. and J.M. Smith, 2000. Multi-Objective Routing within Large Scale FacilitiesUsing Open Finite Queueing Networks, European Journal of Operational Research, 121: 105-123.
13. Mo, J. and J. Walrand, 2000. Fair end-to-end window based congestion control,IEEE/ACM Transactions on Networking, 8(5): 556-567.
14. Neely, M.J., E. Modiano and P. Lic, 2005. Fairness and Optimal Stochastic Control for Heterogeneous Networks, INFOCOM.
15. Siva Selvan, K. and C. Vijayalakshmi, 2010. Design and Analysis of a Queueing Model for Adaptive Control in Multi-tiered Web Technology, Recent Trends in Statistical Research Publication of Manonmaniam Sundaranar University, pp: 101-108.
16. Siva, Selvan K. and C. Vijayalakshmi, 2010. Algorithmic Approach For the Design of Markovian Queueing Network with Multiple Closed Chains, International Conference on TRENDZ information Sciences and Computing.Proceedings IEEExplore, Sathyabama University TISC.
17. Stewart, C. and K. Shen, 2005. Performance modeling and system management for Multi-component online services. In NSDI, pp: 71-84.