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Contents

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Focus

The Internet and communication technology has revolutionized the way people are connected with each other. Machine-to-Machine (M2M) communication is a new form of data communication that does not necessarily require human interaction or intervention in the communication process. It may involve a very large number of connected devices which vary from highly-mobile vehicles communicating in real time to immobile meter-reading appliances that send small amounts of data sporadically possibly distributed in a vast geographical area. It uses wire and wireless media including mobile networks and technologies. The objective is to enable the flow of data efficiently between machine-to-machine and machine-to-people. The new form of communication can be applied in several areas such as security and surveillance, traffic tracking and tracing, remote diagnostics and healthcare monitoring, automated manufacturing and control, facility management, and remote maintenance and control, to name a few. The paper, "Internet-Based Configuration of Machine-to-Machine Communication for Information Distribution" by Ogwueleka Francisca Nonyelum, proposes an Internet-based architecture for M2M communication and computation to enhance information dissemination in National Public Security Communication System (NPSCS) network in Nigeria. With this approach, a stolen car reports its location to the system in the nearest police station when the security system is triggered; a housebreak will be reported by an alarm system even if the phone lines are cut; a car reports that its airbags have been activated to an emergency center; a smoke detector device reports to the alarm system in the closest fire service station when there is an unusual smoke in the house even if the occupants of the house are not around; and other such processes. The paper presents a survey to determine if the proposed approach is suitable for public security network. The findings from the analysis show that the proposed architecture for M2M communication and computation is most suitable for deployment in a public security network which will allow machines to use Internet to talk to each other.

The overwhelming popularity of the Internet attracts the fraudsters who lure uninformed users, collect sensitive information through phishing websites and indulge in fraudulent activities. Phishing websites look similar to those of legitimate organizations, and ignorant users are easily exploited by the phishers. It is very difficult to provide a comprehensive catalog of technologies employed by phishers. Thus, the Internet has become another venue for criminal activities which are growing gradually despite several available measures to tackle the menace. The paper, "DHCP-Enabled LAN Prone to Phishing Attacks" by Swapan Purkait, presents a laboratory-based study to create a successful phishing attack on a DHCP-enabled LAN and proposes several countermeasures to address this security concern. The study uses popular websites such as Yahoo, Gmail, Facebook and Orkut to create phishing attacks and detects the attacks using well-known tools, browsers and antivirus software such as Netcraft, Mozilla WOT, Internet Explorer, Firefox and Norton. The analysis shows that all these anti-phishing tools failed to detect these simulated attacks. The study also proposes various measures that include creating access control list, MAC-based filtering, running script at client computer and counting the number of routing hops between the client computer and visiting website.

Multiplexers enable sending of two or more signals or streams of information on a transmission medium simultaneously. The advantage of multiplexers is that they enable carriers and end-users to take advantage of the economies of scale. In a statistical multiplexer, packets are assumed to be arriving at the multiplexer with the inter arrival times being Independent and Identically Distributed (IID). The service time is also IID. The inter arrival times are generated from the corresponding probability distribution. When a packet arrives to an empty or idle system, the packet is immediately served; otherwise, it is queued. In the paper, "Queue Behavior of Statistical Multiplexers" by Johnson Adegbenga Ajiboye, Yinusa Ademola Adediran and Mary Adebola Ajiboye, the queue behaviors in the multiplexer's buffer were examined. The results show that the average number of packets in the multiplexer queue increases in an exponential form with increase in utilization. At high utilization, there is a dramatic increase in the number of packets in the multiplexer queue which may lead to packet loss when there is no sufficient buffering. Comparison of the simulation and analytical results for the mean number of packets in an M/M/1 multiplexer queue reveals that results are within ±23% for offered load of up to 90%.

Software agents and multi-agent systems offer tremendous potential benefits for designing open distributed systems. In particular, mobile agents are very attractive due to the fact that they promise reduced network traffic and latency, disconnected operations, asynchronous interaction, adaptability and support for heterogeneous environments. The paper, "Mobile Agent-Based Event-Driven Wireless Sensor Network (MAEDWSN) in Ring Frame Machine" by G Sundari and P E Sankaranarayanan, describes a method in which a mobile agent communicates wirelessly with the sensor network to collect the yarn breakage data which would serve the mobile end-user. The objective is to reduce the energy consumption of the sensors and the end-to-end delay while collecting the data on yarn breakages for monitoring of production process. The simulated results have been compared with the well-known client-server approach and found to be satisfactory.

Finally, the paper, "Role of Service Level Agreements in SaaS Business Scenario" by Vikas Kumar and Prasann Pradhan, discusses the composition and requirements of the Service Level Agreements (SLAs) for the SaaS environment. It analyzes a number of major cloud services to outline the most focused components in the SLAs, which include the social media services, e-mail services as well as the commercial services. Since the number and type of the cloud services is increasing day-by-day, the SLAs are becoming more and more complex and challenging. The paper also discusses these challenges to the SLAs in the light of next generation services.

A C Ojha
Consulting Editor

Queue Behavior of Statistical Multiplexers

Johnson Adegbenga Ajiboye, Yinusa Ademola Adediran***
*and Mary Adebola Ajiboye****

In a statistical multiplexer, packets are assumed to be arriving at the multiplexer with the inter arrival times being Independent and Identically Distributed (IID). The service time is also IID. The inter arrival times are generated from the corresponding probability distribution. When a packet arrives to an empty or idle system, the packet is immediately served; otherwise, it is queued. In this paper, the queue behaviors in the multiplexer's buffer were examined. The results show that the average number of packets in the multiplexer queue increases in an exponential form with increase in utilization; and at high utilization, there is a dramatic increase in the number of packets in the multiplexer queue which may lead to packet loss when there is no sufficient buffering. Comparison of the simulation and analytical results for the mean number of packets in an M/M/1 Multiplexer Queue reveals that results are within ±23% for offered load of up to 90%.

Keywords: STDM, TDM, DSL, VoD, QoS, Queuing system, Multiplexing, Demultiplexing, Buffer

Introduction

The process of combining two or more communication paths into one is referred to as multiplexing (Regis and Donald, 2000; Stallings, 2004; and Ajiboye and Adediran, 2010). In multiplexing, system resources are shared among multiple users. Multiplexing is an acronym used in networking and it refers to sending two or more signals or streams of information on a transmission medium or carrier simultaneously. Multiplexer's behavior is similar to those of concentrators and contention devices. These devices enable multiple relatively low speed terminal devices to share a single high capacity circuit between two points in a network. The advantage of multiplexers is that they enable carriers and end-users to take advantage of the economies of scale (Horak, 2007). Conversely, demultiplexing is the reverse of multiplexing and refers to the phenomenon of separation of the multiplexed signals (Held, 2001).

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The synchronous time division multiplexing is grossly inefficient in terms of channel utilization (Stallings, 2004; and Ajiboye and Adediran, 2010). This is because most of the time slots in a frame are unused and are therefore wasted. According to Stalling (2004), in a situation where computer terminals are linked together using a shared computer port, even when all the terminals are working, in most cases, there is no data transfer at any particular terminal. Therefore, it means that the network will be on idle mode when there is no data transfer at any time instance.

According to Ajiboye and Adediran (2010), Statistical Time Division Multiplexing (STDM) is a system developed and being envisioned to overcome some inefficiencies of standard time division multiplexing, where time slices are still allocated to channels, even if they have no information to transmit. Hence, users are granted access to the channel only when there is a message to be transmitted. This is also known as Asynchronous Multiplexing system. It opportunistically takes advantage of the fact that terminals or devices are not all transmitting at the same time. The messages or signals to be transmitted are merged into a single queue and transmitted on a first-come-first-served basis. However, if the queue of a traffic stream is empty, the next traffic stream is served and no communication resource is wasted. STDM uses a variable time slot length and allows channels to vie for any free slot space. In most cases, the data rate of the output is less than the sum of the data rate of the input (Stallings, 2004). According to Wesley (1998), queuing analysis indicates that a moderate size buffer can achieve an allowable overflow probability and queuing delay.

In the design of Asynchronous Transfer Mode (ATM) networks, the concept of multiplexing integrated services traffic such as voice, data and video on a common channel to ensure efficient utilization of the transmission link capacity. Time slots are allotted asynchronously. Currently, the service classes defined by ATM Forum for these applications are Constant Bit Rate (CBR) and Variable Bit Rate (VBR). However, since most traffic sources are intrinsically variable bit-rate, it is generally accepted that using the VBR class will result in better information quality (Kunyan *et al.*, 1996).

Heyman *et al.* (1992) studied source modeling and performance issues using a long (30 min) sequence of real video teleconference data. It was discovered that traffic periodicity is able to cause different sources having identical statistical characteristics to experience differing cell-loss rates. For a single-stage multiplexer model, some of this source-periodicity effect can be mitigated by appropriate buffer scheduling.

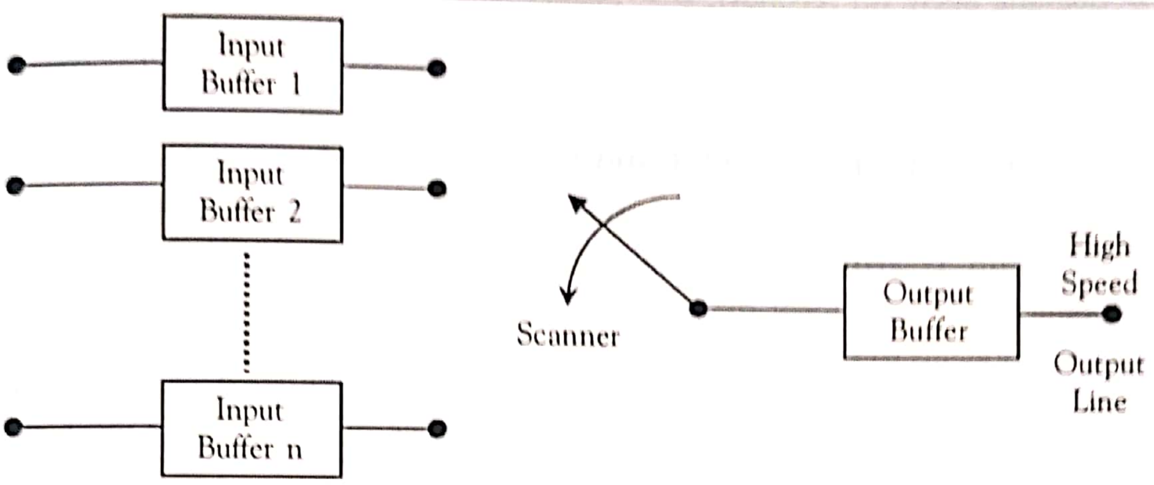
2. Objective of the Study

The purpose of this research is to study the behaviors of the multiplexer queue which is a temporary storage place for the packets. When a packet arrives at a busy multiplexer, it is queued and the packet waits for its turn to be served. Ajiboye and Adediran (2010) considered the performance of statistical multiplexer systems. This work examines critically the behavior of buffer under different system conditions.

3. Analysis of Statistical Multiplexers

A statistical multiplexer comprises the following: a buffer, coding/decoding circuit and switching circuit (where there are multiple lines). The behavior of the buffer can be analyzed by employing queuing models with finite waiting lines. Message arrivals can be approximated as a Poisson process. According to Stallings (2004), a statistical TDM system will generally use a synchronous protocol. Therefore, synchronous transmission is assumed for reliability and simplicity in data transmission. Figure 1 shows the schematic diagram of a statistical multiplexer.

Figure 1: Schematic Diagram of a Statistical Multiplexer



Source: Stallings (2004)

At each discrete clock, data are taken out synchronously from the buffer for transmission. When the buffer and server are empty (i.e., transmission facility is idle) at the beginning of a clock time, arriving data at the buffer during the period between clock times must wait to begin transmission at the beginning of the next clock time. In queuing theory terminology, the above system implies there is a gate between the server and waiting room which is open at fixed intervals.

3.1 Queuing Delays in Statistical Multiplexer Buffers

Queuing delay is the time it takes for an arriving packet to wait in a queue until it can be executed. When packets arrive in a server, they have to be processed and transmitted. If packets arrive faster then the server can process them (such as in a burst transmission), the server puts them in the queue (also called the buffer) until it can get around to transmit them. Queuing delay is proportional to buffer size. The longer the line of packets waiting to be transmitted, the longer the average waiting time is. However, this is much preferable to a short buffer, which would result in ignored ('dropped') packets, which in turn would result in much longer overall transmission times.

Queuing analysis reveals that STDM has a smaller average delay per packet than synchronous TDM and even FDM (Kancherla, 1989). The reason for the poor delay in the performance of TDM and FDM is that communication resources are wasted when allocated to a traffic stream with a momentarily empty queue, whereas other streams may have packets waiting in the queue. Packet switching introduces a variable delay due to the queue in each outgoing transmission link. This average delay is given by (Kancherla, 1989).

$$q = \frac{bn}{s(1-\rho)} \qquad \ldots(1)$$

where

q = queuing delay (in seconds), b = packet length, ρ = utilization of the channel, s = speed of the transmission channel (in bits per sec) and n = number of tandem (or series) links.

3.2 Statistical Multiplexing, DSL and ADSL Networks

The ADSL is a member of the DSL family of technologies. It was introduced by Bellcore in 1989 and is still undergoing rapid advances in development. It is a telecommunication protocol that can be used in a twisted pair line. ADSL requires dedicated modems to be put at both ends of the local line. Telephone companies were interested in Video on Demand (VoD) technology as an additional source of revenue. VoD would send video over the existing telephone lines for entertainment, an alternative to video rentals (Milanovic and Maglianella, 1998).

Huang *et al.* (2000) worked on statistical multiplexing in networks with adaptive transmission rates with focus on DSL broadband access networks where users have mixed data and multimedia traffic flows. They proposed a class of Alternate Maximization (AM) algorithms (AM-D and AM-M) which solve the statistical multiplexing problem for both delay insensitive data traffic and delay sensitive multimedia traffic respectively by jointly allocating bandwidth and buffer resources to users. The QoS requirements of the downstream and the upstream applications are dependent on these two parameters. In the downstream, the multiplexing link has a total buffer size shared by a set of users, with each user having several classes of applications. There is the need to optimize the achievable bandwidth rates of all DSL links as well as the buffer partition at the multiplexing link. However, in the upstream each user is having a fixed buffer space which is located at its individual link and there is no need to consider buffer allocation. The effective bandwidth of delay insensitive data traffic proposed in the AM-D algorithm is given by Huang *et al.* (2000) as:

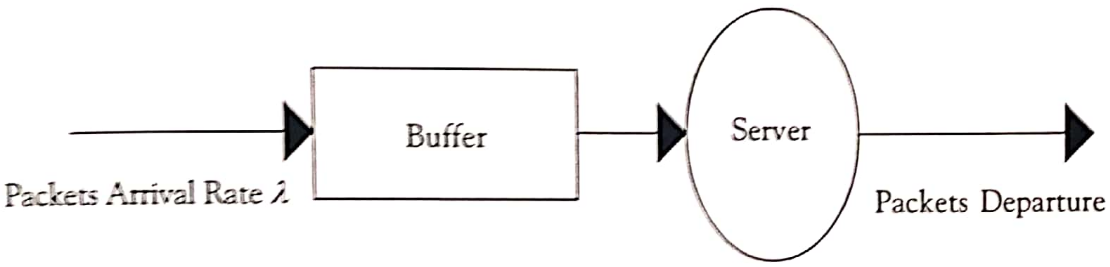
$$g(\delta) = \frac{1}{\delta}\int \left(e^{\delta x} - 1\right) \lambda dF(x) \qquad \ldots(2)$$

where $F(x)$ is the distribution of identically distributed random variables, δ is a spatial parameter and λ is packet arrival rate.

4. Statistical Multiplexer Queue Model

The multiplexer is modeled as M/M/1 and M/D/1 queue, as shown in Figure 2. Packet arrivals are modeled with a Poisson process with average rate λ per minute Poisson. The average service requirement of each request is link capacity μ. Link utilization ρ is the ratio of load to capacity when load is less than the capacity. The packets must wait in the queue until the single server is free. The amount of time required to serve the packets is random with average rate of μ packets per minute. In this model, a set of arrival times and service times are first generated for each packet and then the total time that each customer must wait on the basis of these times are computed. The times are generated using an exponential distribution.

Figure 2: Single Server Queuing System



The average size increases as ρ approaches 1. For $\rho < 0.5$ the average number of packets in the M/M/1 queue is less than 1. For $\rho = 0.8$, E[W] = 4. The buffer size for M/M/1 and M/D/1 queue is given by Stallings (2004).

$$E[W] = \begin{cases} \dfrac{\rho}{1-\rho}, & \textit{for M/M/1 queue} \\ \dfrac{\rho^2}{2(1-\rho)} + \rho, & \textit{for M/D/1 queue} \end{cases} \qquad \dots(3)$$

The ratio of the residence time (mean time a packet spends in the system) to the service time for each packet is given by Bunday (2000).

$$\frac{T_r}{T_s} = \begin{cases} \dfrac{1}{1-\rho}, & \textit{for M/M/1 queue} \\ \dfrac{(2-\rho)}{2(1-\rho)}, & \textit{for M/D/1 queue} \end{cases} \qquad \dots(4)$$

Queuing theory plays a key role in modeling and analyzing networks. It is used to determine the statistics of a queue from which desired performance metrics, such as queue length or loss probability, may be derived.

5. Multiplexer Simulation Using MATLAB

The multiplexer buffer is modeled and simulated as an M/M/1 queue using MATLAB. Each packet arrival at, or departure from, the multiplexer is represented by an event. When a new event happens (i.e., when a new packet arrives or when the multiplexer finishes serving a packet) the simulation code then decides, based on the state of the system, what the next event of the system will be (e.g., if a packet is served, and there are packets in the queue, then the next service starts). Note that to track the state one needs to keep track of both how many packets are in the queue and whether or not anyone is being served. The only time the state can change is either when the next packet arrives or when the multiplexer finishes serving a packet. In between these events, the state cannot change.

A variable, *nextarrival*, gives the time when the next packet arrives to the multiplexer while the variable *nextdeparture* gives the time when the packet currently served departs from the multiplexer. This value is assumed to be infinite when the queue is empty. The *nextarrival* and *nextdeparture* variables determine the next event that occurs. When the *nextarrival* variable is less than the *nextdeparture* variable then an arrival event is initiated.

For each packet arrival that occurs, the queue length is increased by one and the next arrival is scheduled. An exponential interarrival time was generated from random numbers by using the inverse transformation method to generate negative exponential random numbers. From an exponential distribution with parameter λ we can first generate a random number, *rand*, uniformly distributed in the interval [0, 1] using *rand* in MATLAB as shown in Equation (5) (Jaan, 2005).

$$e = \left(-\frac{1}{\lambda}\right) \ln\left(rand\right) \qquad \ldots(5)$$

If the packet that arrives is the only one, then it is immediately serviced and the random service time generated in Equation (6) determines how long the service takes (Jaan, 2005).

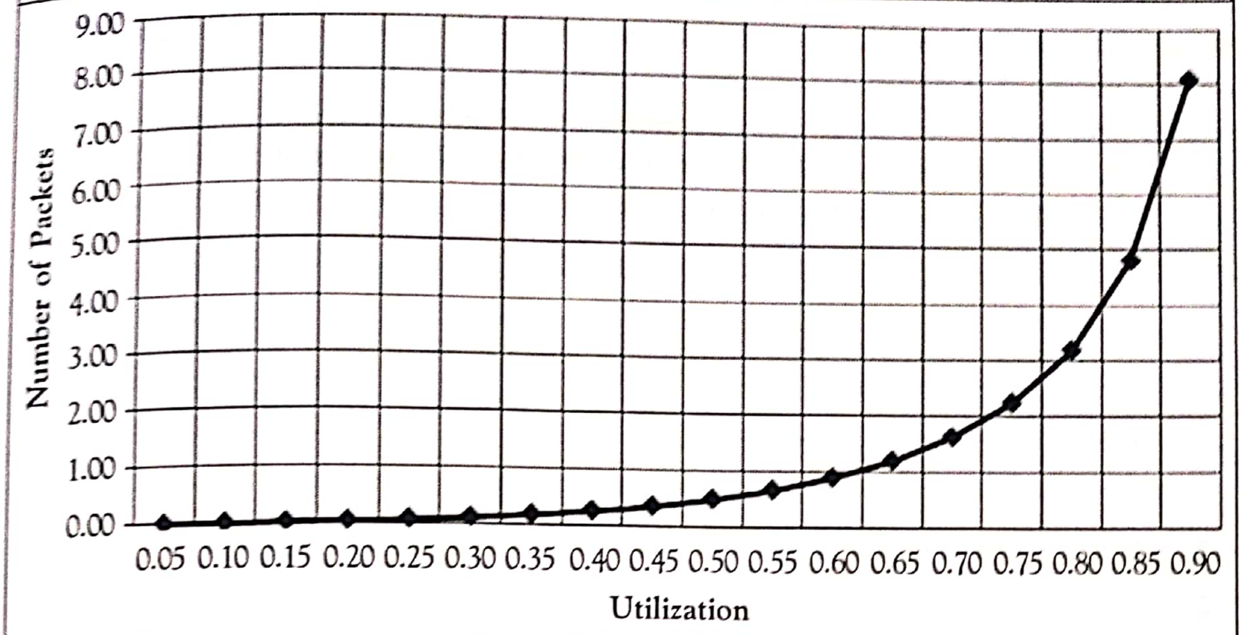
$$e = \left(-\frac{1}{\mu}\right) \ln\left(rand\right) \qquad \ldots(6)$$

For the departure, the current queue length is decreased by one. This either leaves the queue empty and the *nextdeparture* variable is set to infinity or brings in another packet into service and the *nextdeparture* variable is set to generate a service time for the packet. This is continuously repeated until the simulation time is exceeded.

5.1 M/M/1 Analytical and Simulated Queuing Model Results for Multiplexer Queue

The result of the analytical M/M/1 queuing model generated for 0-90% utilizations is shown in Figure 3, which reveals that the average number of packets in the multiplexer queue increases in an exponential form with increase in utilization. Also as expected,

Figure 3: Mean Number of Packets Versus Utilization in an M/M/1 Multiplexer Queue for Utilization Between 0 and 90%



when utilization approaches unity, there is a dramatic increase in the number of packets in the multiplexer queue and may lead to packet loss when there is no sufficient buffering.

Figure 4 gives the comparison between the simulated and analytical results for the M/M/1 multiplexer queue. Simulated values and analytical values are close at utilizations below 0.90. Figure 5 shows the percentage error between the analytical and simulated results. The simulation and analytical results for the M/M/1 case are within ±23% for offered load up to 90%.

5.2 M/M/1 and M/M/2 Analytical Queuing Model Results

Figure 6 shows the analytical results for the mean number of packets in queue for the M/M/1 and M/M/2 models when the multiplexer is viewed as a 1-server queue and also as a 2-server queue. The results show utilization can exceed numerical value of 1 only in an M/M/2 multiplexer queue. Up to a utilization of about 0.3, it is observed that the number of packets in the M/M/1 and M/M/2 is at a very close range, but above this utilization, the numerical values of the M/M/2 model are consistently lower than those of the M/M/1.

6. Discussion

Figure 3 is nonlinear graph. The most striking feature in this figure is that there is a sharp 'knee'. The implication is that there is a threshold operating point above which the delay and buffer requirements are very sensitive to the utilization but below which delay and buffer requirements change a little. The natural choice of utilization is then somewhere above, yet safely close to the threshold.

Figure 4 compares the mean number in queue versus utilization for the analytical and the simulated M/M/1 queue for utilizations below 90%. Figure 5 shows the percentage error between the analytical and simulated results. There is a very close range between the results, particularly at very low utilizations and with highest error of 23% observed at utilization of 0.65.

Figure 4: Comparison of Analytical and Simulated Mean Number of Packets in an M/M/1 Multiplexer Queue for Utilization Between 0 and 90%

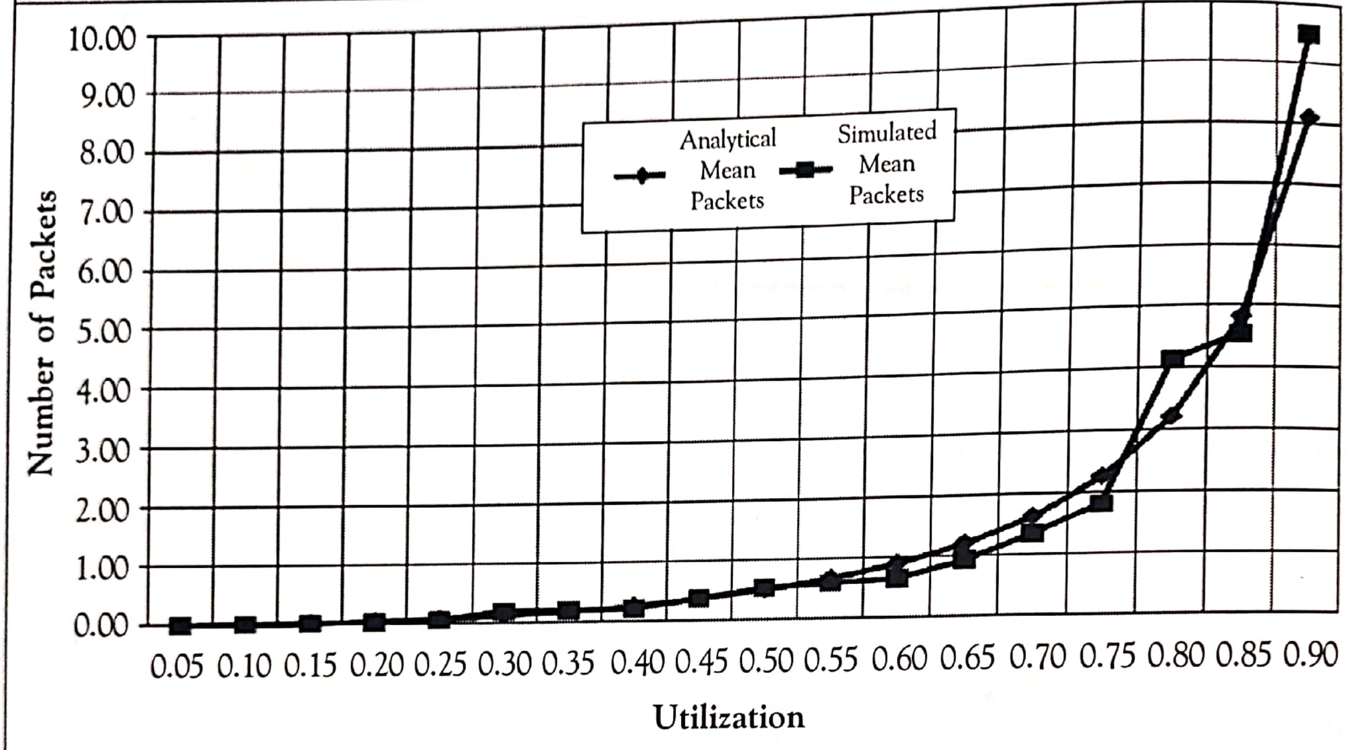


Figure 5: Percentage Error Between Analytical and Simulated Results for M/M/1 Queue Model

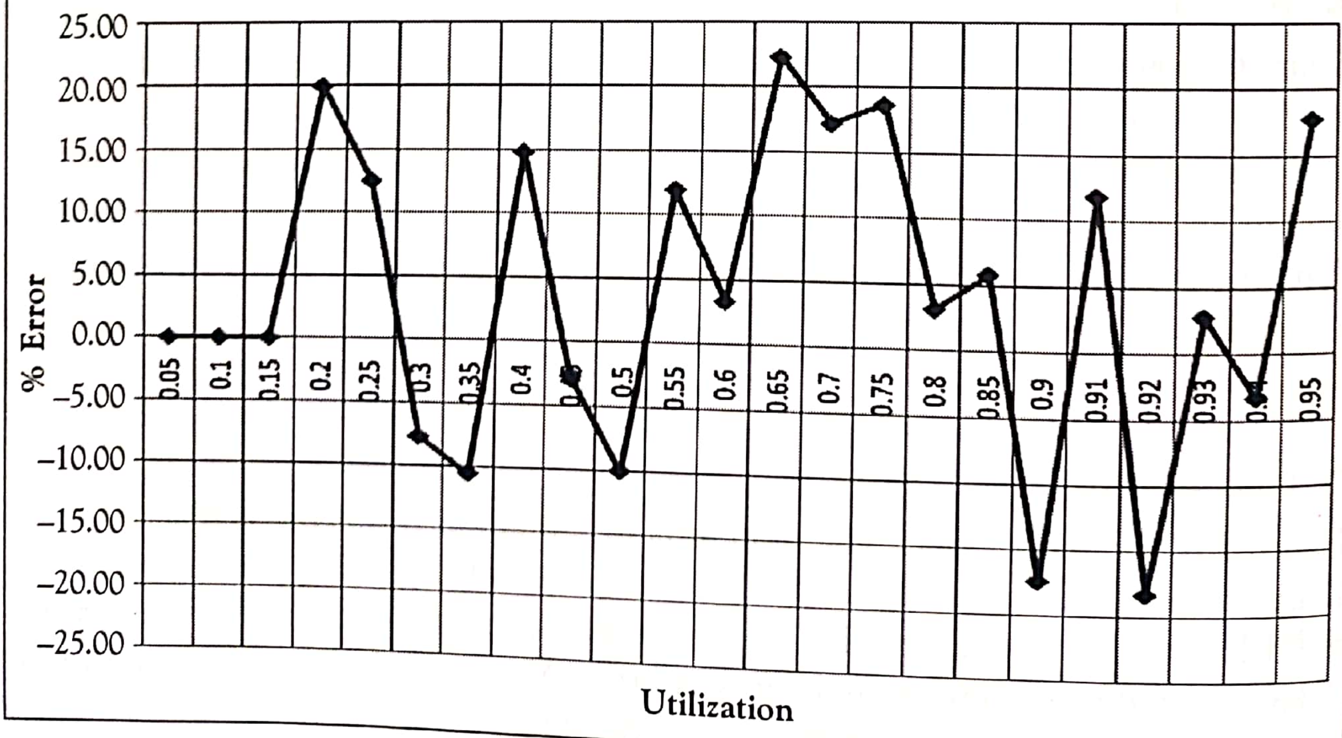
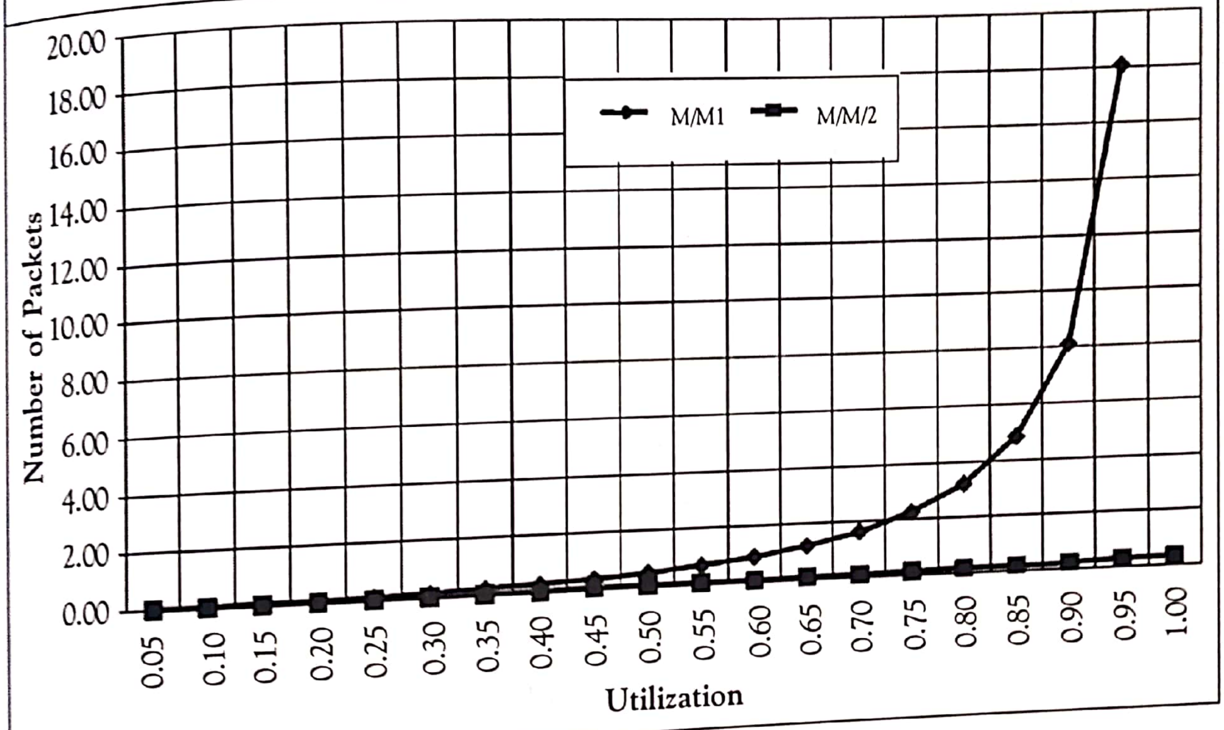


Figure 6 shows the graphs of the mean number of packets in queue versus utilization of the multiplexer under varying network conditions. The graph compares the mean number in queue versus utilization for a single server and 2-server queue. The single server reaches saturation when the utilization is very close to unity. As seen from the figure, the single server is nonlinear. When the capacity of the queue is infinite, then no packets are ever lost from the multiplexer; they are just delayed until they can be served. Under these circumstances, the packets' departure rate equals the arrival rate. As the arrival rate (this is the rate at which packets pass through the multiplexer) increases, the utilization increases, and with it, congestion occurs. Queues become very large near system saturation, growing without bound when utilization is unity. As the queue becomes longer, the waiting time increases and the multiplexer becomes saturated, working 100% of the time.

Figure 6: Mean Number of Packets in Queue Versus Utilization for M/M/1 and M/M/2 Analytical Queue Models



Conclusion

Analytical and simulation results of the behavior of the multiplexer buffer or 'waiting room' have been presented. Comparison was also done for the analytical results of the mean number of packets between the M/M/1 and M/M/2 queue. The results showed that the average number of packets in the multiplexer queue increases in an exponential form with increase in utilization; and, at high utilization there is a dramatic increase in the number of packets in the multiplexer queue, which may lead to packet loss when there is no sufficient buffering. Comparison of the simulation and analytical results for the mean number of packets in an M/M/1 Multiplexer Queue reveals that results are within ±23% for offered load up to 90%.

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