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A Catalog Use Study of the Library Online Catalog

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A CATALOG USE STUDY OF THE LIBRARY ONLINE CATALOG

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This independent study submitted by Randy Pederson in partial fulfillment of the requirements of Master of Public Administration from the University of North Dakota is hereby approved by the faculty advisor under whom the work has been done.

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Advisor

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INTRODUCTION

In the spring of 1989 the University of North Dakota Libraries began local automation with the installation of an integrated library automation system. The system's online public access catalog (OPAC) module allows library users to identify books on a computer terminal rather than with a card file. It was expected that these changes would have an impact upon how well library users would be served at the catalog. In the fall of 1988 a study was conducted of card catalog use to predict the minimum number of terminals necessary to satisfy current demand. An arrival rate of 0.35 users per minute and a service time of 5.77 minutes was observed.[1]

At present the Library is planning several enhancements it will make to the automated system which has since been named ODIN (Online Dakota Information Network). The Library has already introduced a new service which will allow ODIN to be used as a gateway to gain access to other library automated systems in Minnesota and South Dakota. Also, serial record holdings are being added to the library

[1] Randy Pederson, "Determining the Minimum Number of Public Online Terminals Needed for the Library Online Public Access Catalog," (Grand Forks, N.D.: University of North Dakota, 1988), 11-12, typewritten.

catalog on ODIN, and it is likely the printed serials list will then be discontinued in favor of using ODIN. Finally, databases in addition to the library catalog will be included in ODIN sometime during the spring of 1992. The databases will allow library users to search for periodical articles as well as books on ODIN.

The purpose of this study is two-fold. The results of the study completed in 1988 documented the demand for card catalog service. But demand for catalog service may be influenced by the vehicle used to provide the service. Studies have shown that service times are comparatively longer for online catalog users than for card catalog users, in some cases as much as 117 percent greater.[2] To accurately access the demand for online catalog service additional study was required. Secondly, demand for terminal access also will be influenced by an increase in the number of services offered. The future addition of new services available through ODIN will create increased demand to use the library terminals. In anticipation of the changes about to take place in ODIN the present study will provide a baseline from which to measure change. A queueing methodology is used to determine the present demand for service and how long it takes to satisfy the demand.

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[2] John E. Tolle, Nancy P. Sanders, and Neal K. Kaske, "Determining the Required Number of Online Catalog Terminals: A Research Study," Information Technology and Libraries 3 (September 1983): 263.

Probabilities of a library user finding an available terminal to service them are calculated as well as the probability of waiting in queue. The minimum number of terminals to service users are determined for three different probabilities of waiting for 1 to 5 minutes.

When an individual arrives at a service facility desiring to be served and finds that all servers are busy a queue develops. The length of the wait is dependent upon the number of people arriving to be served and the length of time it takes to service each individual.

The online public access catalog uses a computer terminal rather than a card file as a means of providing access to the library catalog. Library users can access every record in the library catalog from a single terminal. Since the card catalog used file drawers to store the library catalog there were many discrete access points capable of servicing many library users at one time. Rarely would more than one catalog users demand the same drawer.

Servicing a large number of catalog users with an online catalog requires that multiple terminals be available. But exactly how many terminals does the Library really need? To have too few terminals available would result in lengthy queues. Library users undoubtedly would become frustrated and irritated with the quality of the service being provided. They may forgo using the catalog. If too many terminals are available no one will ever have to wait to use a terminal. But it would likely be a waste of scarce resources. The rational choice is to buy just enough terminals to satisfy demand without causing lengthy queues to develop.

In discussing the catalog system a number of terms are used which are unique to the queueing methodology. Terms which are introduced in the text are defined here to reduce confusion for the reader. Some terms while common may be used in a different context in the queueing methodology.

DEFINITION OF TERMS

Arrival Rate. The rate at which individuals arrive at the catalog. Represented by the Greek letter λ.

Balking. Describes the individuals who desire service but elect not to join a queue.

Interarrival Time. The amount of time elapsed since the last individual arrived at the catalog for service.

Multiserver Queue. A type of queueing model where more than one server is available and assumes there is a common waiting line, servers are finite, and individuals in queue are served first in, first out (FIFO).

Queue. A line of people or objects waiting to be serviced.

Renege. When individuals who have joined a queue to receive service, but decide to exit the queue before being served.

Service Rate. The rate at which individuals are serviced at the catalog. Represented by the Greek letter μ.

Service Time. The amount of time it takes to service each catalog user.

Steady State. The system after the initial effects of starting up the system have worn off and the system has settled into it's typical pattern.

CHAPTER I

CATALOG USE STUDIES

Hundreds of catalog use studies have been conducted in academic libraries to determine how library users search the catalog, how often it is used, the identity of the users, and why they are using the catalog. For the purpose of this study the review of the literature was limited to those studies which focused on frequency of catalog use, the number of users, and the length of time the catalog was used. The studies reviewed below share a common purpose. Each library was going through a period of technological change, moving from a card file catalog to either a microform or online catalog. The librarians attempted to plan how they would service users with microfiche readers or computer terminals once the change was made.

Literature Review

Queueing methodology was first suggested as a means to analyze the problem of congestion at the card catalog by Bookstein.[1] A queueing model was constructed to analyze the merits of splitting the dictionary catalog into an

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[1] Abraham Bookstein, "Congestion at Card and Book Catalogs: A Queueing Theory Approach," <u>Library Quarterly</u> 42 (July 1972): 316-328.

author/title catalog and subject catalog thus creating additional discrete points of access. By providing more access points in the catalog the chances of any two users demanding the same drawer for service would be reduced. Another early use study of library catalogs was conducted by Lipetz in the early 1970's.[2] The purpose of the study was to provide information on how to best computerize the library catalog at Yale University. Lipetz was interested in the traffic volume at the card catalog and counted arrivals at the catalog for a period of one year. His findings indicated that peak times of usage occurred from 10am to 12pm, 1 to 4pm, and 7 to 9pm with the greatest volume of traffic occurring from Monday to Wednesday.[3]

Sage conducted a catalog use study at Iowa State University to determine if circulation and door-count statistics could be used to predict catalog use.[4] Random observations were made of the catalog during the peak hours of operation to determine the period of the day with the greatest arrival rate. Analysis of circulation and door-count data with observations at the catalog showed a low correlation. The peak time of arrival was determined to be

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[2] Ben-Ami Lipetz, "Catalog Use in a Large Research Library," Library Quarterly 42 (January 1972): 129-139.

[3] Ibid., 133.

[4] Charles Sage and others, "A Queueing Study of Public Catalog Use," College and Research Libraries 42 (July 1981): 317-325.

between 2:00 p.m. and 2:30 p.m.[5]

Drone collected data on the length of time library users spent at two different card catalogs at the University of Illinois Music Library. Her findings indicated that 75 percent of the users at the sound recording catalog, and 72.5 percent of the users at the book catalog, completed their searches in four minutes or less, while ninety percent of all searches at the sound recording catalog and at the book catalog were completed within 11 minutes and 9 minutes respectively.[6] The average time spent at searching all catalogs was 4.5 minutes.[7]

A computer simulation model was constructed by Force and Force to predict service times for each new user arriving at the online catalog.[8] First, arrival rates at the catalog were recorded for all hours the library was open for a sample period. A mean service time of 7.06 minutes was observed at the catalog.[9] Then, using a technique called the Monte Carlo method a probable service time was

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[5] Ibid., 320.

[6] Jeanette M. Drone, "A Use Study of the Card Catalogs in the University of Illinois Music Library," Library Resources and Technical Services 28 (July-September 1984): 256.

[7] Ibid., 257.

[8] Ronald Force and Jo Ellen Force, "Access to Alternative Catalogs: A Simulation Model," College and Research Libraries 40 (May 1979): 234-239.

[9] Ibid., 235.

generated for each new arrival. An optimal solution to the number of terminals was sought to maximize usage of the time available.

Knox and Miller simulated searches with an online catalog to come up with an average service time for each user while planning for an online catalog at Northwestern University.[10] Observations which they had made of actual searches performed by library users at the card catalog were simulated to arrive at an average service time of 6.6 minutes for each user.[11] The arrival of users at the catalog were recorded in intervals of five minutes. Data collection was limited to the predicted hours of heavy usage at the card catalog.

Borgman and Kaske used queuing theory for predicting the number of terminals needed for an online catalog at the Dallas Public Library.[12] Data was collected on the usage of the card catalog with the assumption that the level and patterns of usage would be identical. The number of people

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[10] A. Whitney Knox and Bruce A. Miller, "Predicting the Number of Public Computer Terminals Needed for an On-Line Catalog: A Queueing Theory Approach," Library Research 2 (Spring 1980-81): 95-100.

[11] Ibid., 98.

[12] Christine L. Borgman and Neal K. Kaske, "Determining the Number of Terminals Required for an On-Line Catalog through Queueing Analysis of Catalog Traffic Data," in Public Access to Library Automation, ed. by J. L. Divilbiss (Urbana-Champaign, Ill.: Graduate School of Library and Information Science, University of Illinois, 1981), 20-36.

arriving at the card catalog were recorded in fifteen minute intervals. The duration of individual search times for each user was also recorded to the nearest minute. Enough data was collected to give a representation of one day's activity, plus one Saturday. From this data the probability of finding a terminal idle, the average number of people waiting in line, and the average length of time spent waiting in line for a terminal to become idle were calculated.

In the early 1980's Tolle and others working for the Online Computer Library Center (OCLC) were trying to determine the required number of terminals for an online catalog at Ohio State University.[13] Reference questions, building occupancy, and arrival and departure times of library users at the card catalog and online catalog were recorded during times of heaviest usage over a period of one year. A large variation was found in the mean service time between card catalog and online catalog users. An average service time of 3.83 minutes was recorded for card catalog users, compared to an average service time of 8.34 minutes for online catalog users, over twice the service time for card catalog users.[14] With data in hand the traffic intensity was calculated and compared with a table of

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[13] Tolle, 261-265.

[14] Ibid., 263.

numbers which was constructed specifically for the catalog arrival rate experienced at Ohio State University. The purpose of the table was to determine the minimum number of terminals necessary when ninety percent of the users should wait no longer than one minute before finding a vacant terminal.

A recent catalog use study at North Carolina State University limited data collection to the peak time of the year in late October and early November.[15] The time of each new user arriving at the card catalog or terminals were counted with a computer. Service times were collected from transactions recorded by the online catalog by determining the lapse of time between logons and logoffs. A service time of 5.5 minutes was calculated.[16] Tables constructed by Taylor were used to determine the minimum number of terminals for a 99 percent probability of waiting one minute or less.

Taylor constructed sixteen tables showing the minimum number of terminals necessary when the arrival rate and service rate are known.[17] The tables were constructed with

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[15] Janet Gebbie and others, "Determining the Minimum Number of Terminals for an Online Catalog at a University Research Library," Journal of Library Administration 9 (Fall 1988): 49-56.

[16] Ibid., 53.

[17] Raymond G. Taylor, Jr. "Determining the Minimum Number of Online Terminals Needed to Meet Various Library Service Policies," Information Technology and Libraries 6 (September 1987): 197-204.

the idea that each library has a different tolerance towards how much time it will allow a user to wait before being served. Each table represents a given probability a user would have of waiting for a particular arrival rate and service rate. As a result, library administrators could compare the terminal requirements for various waiting times. The utility of the application of the queueing model for studying catalog use was extended to the library administrator. The library administrator would know exactly what improvement could be made in the level of service and exactly how much it would cost in terms of the number of terminals and costs related to there installation.

The further utility of the queueing methodology beyond simply determining a minimum number of terminals was demonstrated by Taylor.[18] A computer program was developed which provided the results to several basic queueing equations, the steady state probabilities of N users in the system and the probability of users waiting. These results were generated for a range of terminals to afford an opportunity to view how much service quality would deteriorate were some terminals to fail.

The installation of an online catalog can be one of the largest capital expenditure undertaken by a library. Taylor

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[18] Raymond G. Taylor, Jr. "Measures of Expected Online Catalog Performance for Public Access Terminals," Information Technology & Libraries 7 (March 1988): 24-29.

sought to show library administrators how to plan for an acceptable level of service at the least possible cost for terminals.[19] The increment of a single terminal could significantly improve the service a library could offer by reducing waiting for the user at a minimal cost.

The literature of queueing theory as applied to catalog use studies reveals the utility of this method of research. The use of an optimization model to study services in a public or non-profit agency is as effective as it is in the private sector. Service can be increased to an optimal level at the least possible cost. It also demonstrates an efficient use of resources to governing authority.

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[19] Raymond G. Taylor, Jr. "Incremental Costs of Library Service Policies for Online Catalog Access," Information Technology and Libraries 6 (December 1987): 305-309.

CHAPTER II

QUEUEING SYSTEMS

Queueing models are a technique from the field of operations research which are extremely useful in describing and explaining queues. Queues are something we experience frequently in every day life. We may experience queues at the supermarket, at the bank, or even the post office. The services provided by many organizations, be they public agencies or private businesses, sometimes necessitate those demanding service to wait in queue before receiving it.

Libraries also have many situations where queueing may take place. There are many service points in a library, each offering a different kind of service. One of them is the library catalog. An online catalog is a very likely situation where queueing might occur.

People have different tolerances for waiting. Many times when faced with the situation of waiting in line for service some people will balk at joining a queue, they will not enter the system for service. At other times people may join a queue and wait for a period of time but then renege and leave the queue before receiving service. A person may come back at another time to receive service or they forgo service completely.

Methodology

The layout of the catalog area is as follow. There are twelve terminals connected to the ODIN system all in one centralized location. Several of the terminals have printers attached making them more desirable to users. Approximately 20 feet away is a terminal situated near the Reserves counter. This terminal is most often used to locate reserve items, although it also may be used to identify books in the library collection. Six more public access terminals are located throughout the building. These terminals were not monitored during the study. The number of transactions completed at each of these decentralized terminals are considerably lower than the centralized terminals. Personal observation and also transaction logs would seem to indicate these terminals would be unlikely to experience queueing to any significant degree.

Data on the number of users arriving at the catalog and length of time it takes to service them are required to understand the queueing system at the public access catalog. The data then can be used in standard queueing formulas to provide information about the queue. The queuing model requires knowledge of the arrival rate, or the frequency which library users appear at the catalog for service and the service rate, or the length of time it takes to service each library user.

As suggested by Gebbie[1], Knox[2], Sage[3], and Tolle[4] data was only collected during the periods of heaviest usage at the catalog. It is logical to assume that if there are enough terminals to serve catalog users during times of heaviest usage they will be more than adequate to serve users at off-peak times as well. Historical data from the last year was available for the number of transactions completed each month by the online catalog. As evidenced by the transaction logs, October and November have been the months with the largest number of transactions on the online catalog. This was not exactly a startling revelation since data gathered from other library operations, i.e. reference statistics and building population counts as well as personal observation also indicate the months of October and November to be extremely busy. Data collection at other academic libraries conducting use studies reported similar times of heavy catalog use.[5]

Data collection was limited to the peak hours of usage rather than record every hour of the day. Online catalog transaction logs provided evidence of the times of the day

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[1] Gebbie, 52.

[2] Knox, 96.

[3] Sage, 317.

[4] Tolle, 261.

[5] Gebbie, 52.

over the past two years that were busiest. Several peak times during the day were identified when catalog use activity was apt to be greatest. The times identified were 10 a.m. to 12 p.m., 1 to 4 p.m., and 7 to 9 p.m. The hour from 2 p.m. to 3 p.m was identified as the time likely to have the most activity during the day. Data were gathered during each of the times of probable heavy catalog usage. Data on catalog use was collected during each day of the week except Saturday which was expected to have a low rate of use. In all, a total of 45 hours were sampled.

Data collectors were given a brief orientation on how to record time of arrival and the length of service time. During the first half hour of data collection, the progress of the data collector was monitored. Monitoring of the data collectors continued through out the sample and was adjusted when their appeared to be deviations from instructions.

Data Collection

An observer was stationed at a table in the catalog area from which all the terminals included in the study were in clear view. Data collectors were provided with a digital clock to note the exact time of arrival and departure. The time values observed were recorded on a data collection form (see appendix 1) designed for recording arrival, starting, and ending time values.

The time of arrival of each new user at the catalog was recorded by the data collector. The arrival time was also considered the start of service. The time of departure was recorded when a user left the catalog area. If the system was full, a separate start time was recorded.

Data collectors were given the following guidelines for recording departure time. Any time a user left the area a departure time was recorded. Were a user to leave the area but found to return to the system within a short period of time they were recorded as a new arrival. Any time a user exited the system, even for the shortest period of time, the vacated terminal would be immediately available to service the next user waiting in queue.

The data collector began recording time values at the beginning of the assigned hour. Library users who were present at the start of the hour when data collection began were included in the sample and the start time was recorded as missing. Time of departure was then noted. Catalog users who arrived within the time period of the sample but remained in the system after the sample was completed were recorded with an end time as missing. Whenever a catalog user arrived or departed without being detected by the data collector and subsequently noticed, the ending time was recorded as a missing variable.

CHAPTER III

DATA ANALYSIS

A multiserver queueing model was used to analyze the data. In a multiserver queue the following is assumed: a common waiting line, the number of servers available are finite, and when all the servers are busy, service is provided to those waiting in queue as first in, first out (FIFO). The model in fig. 1 describes a multiserver queueing system such as the one at the catalog.

```
Arrivals                        Servers

                                  S1
                                  S2
0000 ------------>---------->     S3
                                  .
                                  .
                                  Sn
```

Fig. 1. Multiserver Queueing Model

In each queueing system there are four basic questions we seek to find answers as represented in fig. 2. The expected number in the system ($\underline{L}$) refers to all those currently being served and all those waiting in line ($\underline{L}_q$) to receive service. The time in the system ($\underline{W}$) is the interval between entering the system for service and when the system is left. The waiting time in queue ($\underline{W}_q$) is the interval between entering the system and the start of service. With

Expected number in system	($\underline{L}$)
Expected number in queue	($\underline{L}_q$)
Expected time in system	($\underline{W}$)
Expected time in queue	($\underline{W}_q$)

Fig. 2. Basic Queueing Variables

this information the administrator can decide if the quality of the service is acceptable.

In the multiserver queueing model of the catalog area there are three independent variables which affect the number of people in the system and the amount of time spent in the system. The number of users entering the system per unit of time (arrival rate), the length of time it takes to service each user (service time), and the number of terminals (servers). The arrival rate and service time cannot be controlled in the catalog model. Each individual decides when they will arrive at the catalog. Likewise, each individual controls their own service time. However, the number of terminals available can be manipulated to improve service.

A mean interarrival time and a mean service time was calculated for all users at the catalog. The mean interarrival time was 1.9 minutes, meaning a new user arrived at the catalog every 1.9 minutes. Users arrived at the catalog at a rate of 0.53 per minute. The mean service time at the catalog was 7.68 minutes for a service rate of

0.13 users per minute.

Interarrival times and service times were evaluated for fitting a theoretical probability distribution model. If the observed categories could be fitted to a probability distribution showing the results were not due to chance the queueing formulas would then be applied. The frequency distributions for the observed interarrival time and service time were modeled in a pair of histograms (figs. 3-4). Frequencies of interarrival times were displayed in intervals one minute. The frequency of service times were represented as intervals of four minutes.

An exponential distribution of the frequencies was chosen to represent the data. Exponential distributions are most often used in queueing models because of their unique properties. Each individuals decision to arrive at the catalog is made independently of others, their decision to arrive at the catalog is made randomly. The probability of when the next user will arrive is not influenced by when the last user arrived. The lack of memory is an essential feature of the exponential distribution making it a good model of choice for interarrival times. Another reason for using an exponential distribution is that often service times are likely to be small. The exponential distribution is best used as a model for service times which are short.

The distribution of interarrival time and service time frequencies were tested for significance with the Chi-Square

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"Goodness of Fit" test to see if the results obtained were

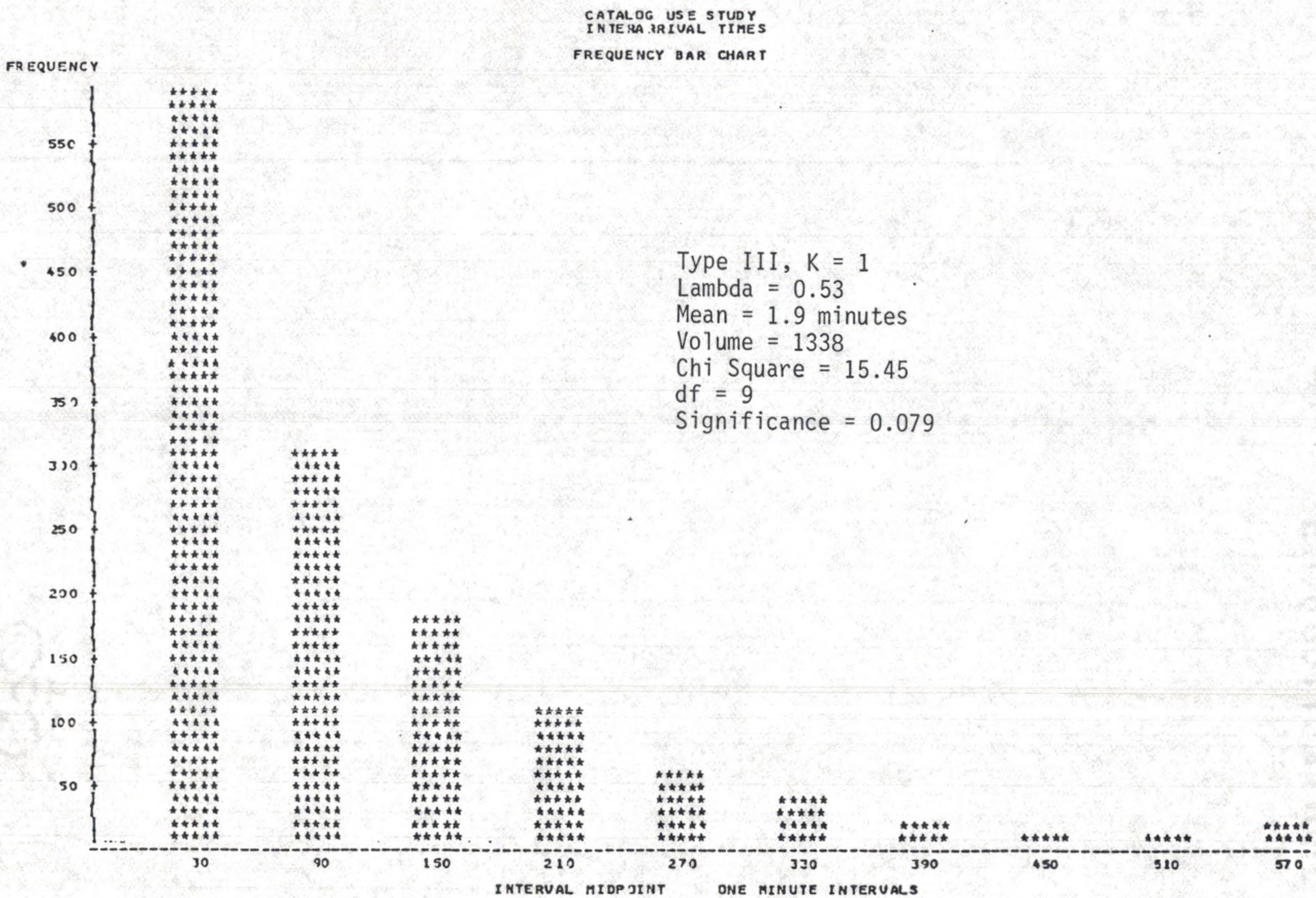

Fig. 3. Frequency distribution of interarrival times in sixty second intervals with a midpoint of 30 seconds.

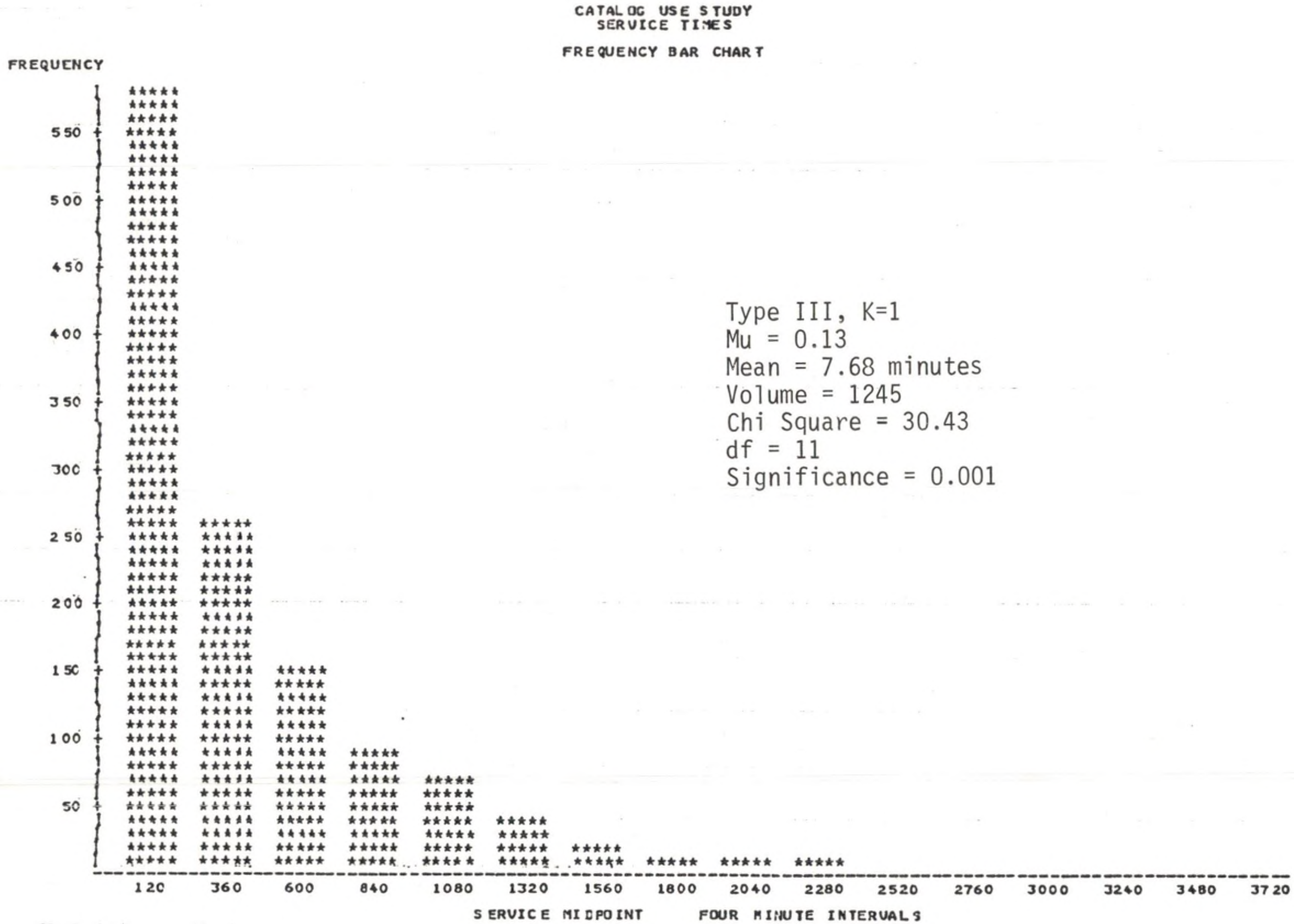

Fig. 4. Frequency distribution of service times in 240 second intervals (four minutes) with a midpoint of 120 seconds.

due to chance. The Chi-Square was calculated with the SPSS-X computer software. Observed values (O_1) were the frequency of each interval from the histogram for interarrival times and service times. The expected values (E_1) for the frequency interval were derived from the formula $e^{-t/x}$. In fig. 5 the details of how the expected proportion of each

1st cell	$(1 - e^{-1/x}) \times n$
2nd cell	$e^{-2/x} (1 - e^{-1/x}) \times n$
3rd cell	$e^{-3/x} (1 - e^{-1/x}) \times n$
	. . . .
nth cell	$e^{-t/x}$

Fig. 5. Expected Frequency Values

frequency interval was determined, where t = time interval, x = mean, and n = volume. The interarrival distribution was only significant at 0.079 level (fig. 3) using intervals of one minute, service time distribution was significant at 0.001 level (fig. 4) when categorized as intervals of four minutes.

The values of L, L_q, W, and W_q may now be found. These values refer to what is likely to occur after the system has achieved steady state, meaning the system has settled into it's typical pattern after start-up. In fig. 6 the requirement for steady state in a multiserver queueing system is given, where s is the number of servers. If $\lambda > \mu$ the queue would continue to grow after the system started up. In the multiserver queueing system at the catalog with

$$\lambda < s\mu$$

Fig. 6. Requirement for Steady State in a Multiserver Queueing System

13 servers $\lambda < s\mu$ since 0.53 < 13(0.13) or 0.53 < 1.69. The requirement for steady state is fulfilled. To find the values of L, L_q, W, and W_q we begin by finding probability that the system is empty using the equation in fig. 7. The probability that any number of people are in the system could be determined from this basic equation.

$$P_o = \frac{1}{\sum_{n=0}^{s-1} \frac{(\lambda/\mu)^n}{n!} + \frac{(\lambda/\mu)^s}{s!}\left(\frac{1}{1-(\lambda/s\mu)}\right)}$$

Fig. 7. Probability the System is Empty

The expected number of people in queue (L_q) can be derived from the formula in fig. 8 using the value of P_o derived from the formula in fig. 7.

$$L_q = P_o \frac{\lambda^{s+1}}{\mu^{s-1}(s-1)!\,(\mu s-\lambda)^2}$$

Fig. 8. Expected Number of People in Queue

Finally, the values of W_q, W, and W may be worked out with the formulas in fig. 9.

$$W_q = L_q/\lambda \qquad W = W_q + 1/\mu \qquad L = \lambda W$$

Fig.9. The queueing equations for expected number in queue (W_q), expected waiting time (W), and expected number in system (L) are given above.

Rather than calculate each of the values for L, L_q, W, and W_q with pencil and paper a computer program especially developed by Taylor for measuring catalog performance was used.[1] In Table 1-1 summary statistics for the arrival rate and service rate at the catalog which was generated by the program is displayed. The program also generates information on the steady state probabilities for the number of users in the system. It determines the probability of N users in the system, the probability that there are less

Table 1-1.--Cycle Identification and Summary Statistics

Usable Terminals = 13
Mean Arrival Rate, Users Per Minute = 0.53
Mean Service Rate, Users Served Per Minute = 0.13
Average Time Individual User Spends on Terminal = 7.69
Effective Service Rate, All Terminals Combined = 1.69

than or equal to N users in the system, and the probability that there are more than N users in the system. The probability of waiting in queue is also calculated for values of 1 to 5 minutes.

Table 2-1 shows the steady state probabilities for 0 to 21 users with 13 servers available. The steady state probabilities in table 2-1 can provide information on the probability of the number of users who are in the system. For example, from table 2-1 it can be determined that the

[1] Raymond G. Taylor, Measures of Expected Online Catalog Performance for Public Access Terminals. (Raleigh, N.C.: North Carolina State University, August 1987).

probability there are 11 users or less in the system is 99 percent P[X=<11]=0.999. We also can determine the probability that there will be more than 4 users in the system is 39 percent P[X>4]=0.386. Finally, table 2-1 can also tell us the probability that there will be exactly N users in the system, for example, the probability that there will be exactly 8 users in the system is 3 percent P[X=8]=0.032.

The steady state probability for users waiting in queue at the catalog with 13 usable terminals to service them are nil P[X>13]=0.000 as we see in Table 2-1. Since there is no probability of waiting in queue we can see in table 3-1 the

Table 2-1.--Steady State Probabilities for 13 Servers

Number (N)	P(X=N)	P(X=<N)	P(X>N)	
0	0.017	0.017	0.983	
1	0.069	0.085	0.914	
2	0.141	0.227	0.773	
3	0.192	0.419	0.581	
4	0.195	0.614	0.386	
5	0.159	0.773	0.227	
6	0.108	0.881	0.119	
7	0.063	0.944	0.056	
8	0.032	0.976	0.024	
9	0.015	0.991	0.009	
10	0.006	0.997	0.003	
11	0.002	0.999	0.001	
12	0.001	1.000	0.000	
13	0.000	1.000	0.000	Being Served
				*************
14	0.000	1.000	0.000	Waiting
15	0.000	1.000	0.000	
16	0.000	1.000	0.000	
17	0.000	1.000	0.000	
18	0.000	1.000	0.000	
19	0.000	1.000	0.000	
20	0.000	1.000	0.000	
21	0.000	1.000	0.000	

probability of waiting from 1 to 5 minutes in queue is also nil P[WT>1]=0.000. But on occasion terminals fail, they also become temporarily disabled because of user errors. When this happens the chance of user having to wait before being served increases. The steady state probabilities, waiting time, and summary statistics are given in the appendix for 8 to 12 servers. If five terminals go out of service and there are only eight usable terminals, the probability of waiting one minute or less increases to 4 percent as can be seen from table 3-6 in the appendix

Table 3-1.--Probability of Waiting Time in the Queue Exceeding T

T	P(WT>T)
1	0.000
2	0.000
3	0.000
4	0.000
5	0.000

Average Number in the System = 4.08
Average Number in Queue = 0.00
Average Time in System = 7.69
Average Time in Queue = 0.00

A purpose of this study was to determine the current demand for catalog service and the minimum requirement for terminals to meet this demand. Using the tables published by Taylor the minimum number of terminals for a given arrival rate and service rate can be determined.[2] In table

[2] Taylor, "Determining Policies," 198-203.

4 the minimum number of terminals to satisfy different probabilities of waiting from 1 to 5 minutes before finding an open terminal are given. Reading from this table it

Table 4-1.--Probabilities of Waiting and the Required Number of Terminals for a Service Rate of 0.13 and an Arrival Rate of 0.53

	99%	90%	80%
One Minute or less	11	9	8
Two Minutes or less	11	8	8
Three Minutes or less	10	8	7
Four Minutes or less	10	8	7
Five Minutes or less	10	8	6

can be determined that only eleven terminals are necessary to avoid having users wait more than one minute 99 percent of the time. Since there are already thirteen terminals the present number of terminals should be more than adequate to satisfy present demand.

CONCLUSION

As a result of the data analysis, it is obvious that library users are not experiencing any queueing at the library catalog. The data, which was collected during all peak times, was an average over all the periods observed. Some peak periods have a higher traffic intensity than others. It is possible a sudden, temporary increase in usage may occur and as a result a waiting line will develop. If several terminals become temporarily locked-up because of user error or because of a communication problem on the network, the likelihood of a user having to wait also increases. The addition of new services on ODIN is likely to increase the usage of terminals. The demand for these service may be so great that queueing will occur. Thus, sudden unexpected demand, terminal breakdowns, and additional uses for ODIN shall likely increase the possibility that queueing may occur in the future.

A catalog use study in 1988 found an arrival rate of 0.35 users per minute and an average service time of 5.77 minutes. In the current study an arrival rate of 0.53 users per minute and an average search time of 7.68 minutes was observed. Arrival rates at the catalog increased by 51 percent and service times by 33 percent over a three year period. The amount of increase noted might be partially explained by the differences between how the card catalog was used and how ODIN is used. When the library catalog went online the reserve collection list was added to the catalog. Students could find which materials their instructors had placed on reserve by using ODIN. This might partially explain an increase in the arrival rate, but not the service time. Reserve collection users should have a shorter service time since they are searching for a known item rather than for items on a topic. Another explanation may be that library users are inclined to use an online catalog more because they prefer it over a card catalog. It is also possible that users are experiencing longer search times because they expect to find what they need on ODIN and continue searching until they are satisfied with the results. Through interviews conducted at the Reference Desk, some library users admit they expect to find periodical articles on a topic using ODIN. The longer search times observed may be due to user expectations.

The increased arrival rate and average service time are greater than expected since catalog access has been decentralized. Besides the main catalog area, six other terminals are located in the building. Also, an ODIN session may be established by remote access through the campus computer network at any time, day or night, any day of the year. Considering the numerous ways which catalog users have available to access the catalog the increase in demand at the main catalog area is higher than expected. Were it possible to count the total number of ODIN users and service times the true demand for catalog service could be observed.

Several questions remain which were not within the scope of the present study, and will require further investigation. What will be the impact of future additional services and added databases on a library users ability to find an available ODIN terminal to service him? How will the enhancements affect the demand for catalog service. Laying aside the question about demand for terminal availability, how will the increased demands on the ODIN system affect the average response time on the network. If and when demand for using ODIN reaches a point where response times become unacceptable, an expense will be incurred to upgrade the computer system which will be much higher than the cost of additional terminals.

The present study sought to determine if the present number of terminals were adequate to meet the demand for catalog service. While terminal capacity was found to be quite satisfactory for the present it is not clear what impact future enhancements will have on the quality of service. Periodic monitoring of the catalog is necessary to keep the quality of the service high. Some additional studies might also be undertaken to plan for future innovations.

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APPENDIX 1

CATALOG USE

DATA COLLECTOR: ______________________

STARTING TIME: ______________ AM PM (circle one)

LOCATION: ______________________ AISLE #: ________ DATE: ____________

Terminal Number	SEX M/F	RACE W/B/O	HAIR COLOR	OVER 30 ?	CLASSES ?	UPPER BODY- shirt/sweater/jacket/ etc. (including color)	LOWER BODY- pants/skirt/shorts/ etc. (including color)	ARRIVAL TIME			STARTING TIME			ENDING TIME			
								HOUR	MIN	SEC	HOUR	MIN.	SEC.	HOUR	MIN.	SEC.	

APPENDIX 2

TABLE 1-2
CYCLE IDENTIFICATION AND SUMMARY STATISTICS

USEABLE TERMINALS = 12
MEAN ARRIVAL RATE, PATRONS PER MINUTE = .53
MEAN SERVICE RATE, PATRONS SERVED PER TERMINAL PER MINUTE = .13
AVERAGE TIME INDIVIDUAL PATRON SPENDS ON TERMINAL = 7.69 MINUTES
EFFECTICE SERVICE RATE, ALL TERMINALS COMBINED = 1.56
STEADY STATE PROBABILITIES PROVIDED FOR N FROM 0 TO 20
WAITING TIME PROBABILITIES PROVIDED FROM 1 TO 5 MINUTES

TABLE 2-2
STEADY STATE PROBABILITIES

NUMBER(N)	P(X=N)	P(X=<N)	P(X>N)	
0	0.017	0.017	0.983	
1	0.069	0.086	0.914	
2	0.141	0.227	0.773	
3	0.192	0.419	0.581	
4	0.195	0.614	0.386	
5	0.159	0.773	0.227	
6	0.108	0.881	0.119	
7	0.063	0.944	0.056	
8	0.032	0.976	0.024	
9	0.015	0.991	0.009	
10	0.006	0.997	0.003	
11	0.002	0.999	0.001	
12	0.001	1.000	0.000	BEING SERVED
				*******************
13	0.000	1.000	0.000	WAITING
14	0.000	1.000	0.000	
15	0.000	1.000	0.000	
16	0.000	1.000	0.000	
17	0.000	1.000	0.000	
18	0.000	1.000	0.000	
19	0.000	1.000	0.000	
20	0.000	1.000	0.000	

TABLE 3-2
PROBABILITY OF WAITING TIME IN THE QUEUE EXCEEDING T

T	P(WT>T)
1	0.000
2	0.000
3	0.000
4	0.000
5	0.000

AVERAGE NUMBER IN SYSTEM = 4.08
AVERAGE NUMBER IN QUEUE = 0.00
AVERAGE TIME IN SYSTEM = 7.69
AVERAGE TIME IN QUEUE = 0.00

****

TABLE 1-3
CYCLE IDENTIFICATION AND SUMMARY STATISTICS

USEABLE TERMINALS = 11
MEAN ARRIVAL RATE, PATRONS PER MINUTE = .53
MEAN SERVICE RATE, PATRONS SERVED PER TERMINAL PER MINUTE = .13
AVERAGE TIME INDIVIDUAL PATRON SPENDS ON TERMINAL = 7.69 MINUTES
EFFECTICE SERVICE RATE, ALL TERMINALS COMBINED = 1.43
STEADY STATE PROBABILITIES PROVIDED FOR N FROM 0 TO 19
WAITING TIME PROBABILITIES PROVIDED FROM 1 TO 5 MINUTES

TABLE 2-3
STEADY STATE PROBABILITIES

NUMBER(N)	P(X=N)	P(X=<N)	P(X>N)	
0	0.017	0.017	0.983	
1	0.069	0.086	0.914	
2	0.141	0.227	0.773	
3	0.191	0.418	0.582	
4	0.195	0.614	0.386	
5	0.159	0.773	0.227	
6	0.108	0.881	0.119	
7	0.063	0.944	0.056	
8	0.032	0.976	0.024	
9	0.015	0.991	0.009	
10	0.006	0.997	0.003	
11	0.002	0.999	0.001	BEING SERVED
				*******************
12	0.001	1.000	0.000	WAITING
13	0.000	1.000	0.000	
14	0.000	1.000	0.000	
15	0.000	1.000	0.000	
16	0.000	1.000	0.000	
17	0.000	1.000	0.000	
18	0.000	1.000	0.000	
19	0.000	1.000	0.000	

TABLE 3-3
PROBABILITY OF WAITING TIME IN THE QUEUE EXCEEDING T

T	P(WT>T)
1	0.001
2	0.001
3	0.000
4	0.000
5	0.000

AVERAGE NUMBER IN SYSTEM = 4.08
AVERAGE NUMBER IN QUEUE = 0.00
AVERAGE TIME IN SYSTEM = 7.70
AVERAGE TIME IN QUEUE = 0.00

****

TABLE 1-4
CYCLE IDENTIFICATION AND SUMMARY STATISTICS

USEABLE TERMINALS = 10
MEAN ARRIVAL RATE, PATRONS PER MINUTE = .53
MEAN SERVICE RATE, PATRONS SERVED PER TERMINAL PER MINUTE = .13
AVERAGE TIME INDIVIDUAL PATRON SPENDS ON TERMINAL = 7.69 MINUTES
EFFECTICE SERVICE RATE, ALL TERMINALS COMBINED = 1.3
STEADY STATE PROBABILITIES PROVIDED FOR N FROM 0 TO 18
WAITING TIME PROBABILITIES PROVIDED FROM 1 TO 5 MINUTES

TABLE 2-4
STEADY STATE PROBABILITIES

NUMBER(N)	P(X=N)	P(X=<N)	P(X>N)	
0	0.017	0.017	0.983	
1	0.069	0.086	0.914	
2	0.141	0.227	0.773	
3	0.191	0.418	0.582	
4	0.195	0.613	0.387	
5	0.159	0.772	0.228	
6	0.108	0.880	0.120	
7	0.063	0.943	0.057	
8	0.032	0.975	0.025	
9	0.015	0.990	0.010	
10	0.006	0.996	0.004	BEING SERVED
				******************
11	0.002	0.998	0.002	WAITING
12	0.001	0.999	0.001	
13	0.000	1.000	0.000	
14	0.000	1.000	0.000	
15	0.000	1.000	0.000	
16	0.000	1.000	0.000	
17	0.000	1.000	0.000	
18	0.000	1.000	0.000	

TABLE 3-4
PROBABILITY OF WAITING TIME IN THE QUEUE EXCEEDING T

T	P(WT>T)
1	0.005
2	0.002
3	0.001
4	0.000
5	0.000

AVERAGE NUMBER IN SYSTEM = 4.08
AVERAGE NUMBER IN QUEUE = 0.01
AVERAGE TIME IN SYSTEM = 7.71
AVERAGE TIME IN QUEUE = 0.01

****

TABLE 1-5
CYCLE IDENTIFICATION AND SUMMARY STATISTICS

USEABLE TERMINALS = 9
MEAN ARRIVAL RATE, PATRONS PER MINUTE = .53
MEAN SERVICE RATE, PATRONS SERVED PER TERMINAL PER MINUTE = .13
AVERAGE TIME INDIVIDUAL PATRON SPENDS ON TERMINAL = 7.69 MINUTES
EFFECTICE SERVICE RATE, ALL TERMINALS COMBINED = 1.17
STEADY STATE PROBABILITIES PROVIDED FOR N FROM 0 TO 17
WAITING TIME PROBABILITIES PROVIDED FROM 1 TO 5 MINUTES

TABLE 2-5
STEADY STATE PROBABILITIES

NUMBER(N)	P(X=N)	P(X=<N)	P(X>N)	
0	0.017	0.017	0.983	
1	0.069	0.086	0.914	
2	0.141	0.226	0.774	
3	0.191	0.417	0.583	
4	0.195	0.612	0.388	
5	0.159	0.771	0.229	
6	0.108	0.879	0.121	
7	0.063	0.941	0.059	
8	0.032	0.973	0.027	
9	0.015	0.988	0.012	BEING SERVED
				********************
10	0.007	0.995	0.005	WAITING
11	0.003	0.998	0.002	
12	0.001	0.999	0.001	
13	0.001	0.999	0.001	
14	0.000	1.000	0.000	
15	0.000	1.000	0.000	
16	0.000	1.000	0.000	
17	0.000	1.000	0.000	

TABLE 3-5
PROBABILITY OF WAITING TIME IN THE QUEUE EXCEEDING T

T	P(WT>T)
1	0.014
2	0.007
3	0.004
4	0.002
5	0.001

AVERAGE NUMBER IN SYSTEM = 4.10
AVERAGE NUMBER IN QUEUE = 0.02
AVERAGE TIME IN SYSTEM = 7.73
AVERAGE TIME IN QUEUE = 0.04

****

TABLE 1-6
CYCLE IDENTIFICATION AND SUMMARY STATISTICS

USEABLE TERMINALS = 8
MEAN ARRIVAL RATE, PATRONS PER MINUTE = .53
MEAN SERVICE RATE, PATRONS SERVED PER TERMINAL PER MINUTE = .13
AVERAGE TIME INDIVIDUAL PATRON SPENDS ON TERMINAL = 7.69 MINUTES
EFFECTICE SERVICE RATE, ALL TERMINALS COMBINED = 1.04
STEADY STATE PROBABILITIES PROVIDED FOR N FROM 0 TO 16
WAITING TIME PROBABILITIES PROVIDED FROM 1 TO 5 MINUTES

TABLE 2-6
STEADY STATE PROBABILITIES

NUMBER(N)	P(X=N)	P(X=<N)	P(X>N)	
0	0.017	0.017	0.983	
1	0.068	0.085	0.915	
2	0.140	0.225	0.775	
3	0.190	0.415	0.585	
4	0.193	0.608	0.392	
5	0.158	0.766	0.234	
6	0.107	0.873	0.127	
7	0.062	0.935	0.065	
8	0.032	0.967	0.033	BEING SERVED
				*******************
9	0.016	0.983	0.017	WAITING
10	0.008	0.991	0.009	
11	0.004	0.996	0.004	
12	0.002	0.998	0.002	
13	0.001	0.999	0.001	
14	0.001	0.999	0.001	
15	0.000	1.000	0.000	
16	0.000	1.000	0.000	

TABLE 3-6
PROBABILITY OF WAITING TIME IN THE QUEUE EXCEEDING T

T	P(WT>T)
1	0.039
2	0.023
3	0.014
4	0.008
5	0.005

AVERAGE NUMBER IN SYSTEM = 4.14
AVERAGE NUMBER IN QUEUE = 0.07
AVERAGE TIME IN SYSTEM = 7.82
AVERAGE TIME IN QUEUE = 0.13

****