La Trobe University Library

Client Services Committee

Bundoora Library Computer Workstation Usage

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Executive Summary

On-campus computer workstation usage has been identified as an important area of concern for our Library. To assist in meeting our Strategic Objectives in this area and deliver a service, which our clients will rate as noticeably, better than 2004, an extended computer workstation survey was carried out. This survey was conducted at the Bundoora campus library from Monday 12th September to Friday 23rd September 2005.

The objectives of this survey were to establish the duration of waiting times in queues at workstations and to determine the effect that the additional 24 workstations had on queuing duration, accessibility and Quality of Service.

The methods used to analyse the data collected were adapted from Erlang formulae used by Knox and Miller [7] and, where possible, the results were compared to the 2004 Seating Survey [4]

The main findings of this study showed that the amount of time client spent in queues waiting for access to workstation ranged from 2 to 16 minutes with an average of 11 minutes.

If 24 more terminals were made available, it is predicted that just 1 minute would be the longest queuing delay during the busiest periods that our clients will experience.

The major recommendations are follows:

- The benchmark for acceptable queuing durations needs to be established so that the optimal number of additional workstations can be acquired if necessary. Possible analytical methods of benchmarking should be investigated.

- The problem of where to house new workstations and positioning of queues needs to be investigated.

- Appropriate signage relating to location, number and type of workstations available in the library should be placed prominently to allow clients the possibility of investigating alternative workstation sites.

- Express workstation usage needs to be investigated as to efficiency and possible time limiting.

- Investigate the possibility of placing a workstation in some lockable carrels. This would mean some additional workstations could be suitably located on Level 3.

- Continue to investigate ways of improving wireless transmissions within the Library complex especially in the new group areas on Level one.

Client Service Committee

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1 Introduction

1.1 Purpose

The primary objective of this survey was to determine the time clients spend waiting to access computer workstations on all Levels in the Bundoora Library.

A secondary objective was to measure the effect that the recent addition of 24 computer workstations on Level One has had on the overall computer workstation usage. In particular, verification of an improvement in Quality of Service (QoS) over last year's level was expected.

A tertiary objective was introduced: to identify the relevant parameters of QoS that can be measured or derived and to devise an efficient manual data collection protocol, then document and share this experience, in accordance with our Client Service Charter [1] and Strategic Plan [2].

1.2 Background

1.2.1 The Survey

This survey is concerned with two key points of our Client Service Charter [1]. These are that the Library aims to:

1. Provide access to information services and resources that meet client information needs
2. Ensure information resources are available in a timely manner

Furthermore, as stated in the 2004 Annual Report [3], the Library recognizes the "need to provide high quality and reliable services while balancing increasingly complex service demands and rising costs of information resources within the budgetary framework." This includes "Monitoring the adequacy of study facilities".

During 2004, an on-campus Seating Usage Survey [4] revealed (among other things) that computer workstations have the highest occupancy rates and that the heaviest use of on-campus study facilities is from Monday to Wednesday.

In May 2004, a Rodski Customer Satisfaction Survey [5] identified the most important areas for improvement as:

1. The number of computers available, and
2. The adequacy of computer facilities and electronic equipment.

The 2004 Annual Report [3] also states that "Despite concerted efforts to upgrade these two areas following the 2002 survey results, there will again be a need to target improvements to such facilities in 2005".

Therefore, it was decided to conduct another Computer Workstation Survey for a two-week period from the Monday, 12th September to the Friday 23rd September 2005. The 2004 Survey was from the Monday 13th September to the Friday 24th September.

To permit comparison with the previous Seating Usage Survey [4], the data collected in this Survey (again during peak periods) included:-

1. The days and times of peak workstation usage and the numbers and locations of these workstations.

However, since there appeared to be an additional complexity to the task of predicting client usage of these resources, it was decided to measure additionally:-

2. The time taken to obtain access to a workstation during peak periods (i.*e. the time a client actually stands in a queue).*

3. The actual queue lengths (i.*e. the number of clients standing in each queue).*

4. The number of clients who left the queues prematurely (*we called these "Aborts")*.

5. The approximate timings of printer usage.

This additional data should lead to a better understanding of our clients' usage of these resources. This in turn, should lead to more accurate and timely predictions of future usage levels, and so, enable us to deliver optimised computer workstation facilities to our clients, proactively.

It is hoped that this would promote future Rodski Surveys to be performance indicators of Library excellence, as well as giving clients the important message that the Library is empowering them by valuing their survey responses.

1.2.2 The computer workstations and printers of this Survey

The Bundoora Campus of the Latrobe University has a three Level building with over 12,000 square metres of floor space as its Library. The main entry to the Library is on Level 2.

On each Level are a mix of facilities for our clients/students comprising:-
(a) single study seating and carrels (single study rooms)
(b) group study seating
(c) computer workstations connected via LAN to internet and to our Catalogue System
(d) AV computer workstations and AV viewing booths
(e) microform stations, as well as
(f) staff areas, amenities, toilets, etc.

Item (c) is of primary interest to this survey and a summary of existing computer workstations is shown in Table 1. The location and number of these workstations can be seen on the floor plans. *(These floor plans can be provided on request)*

Table 1: Queue and workstation numbers and configurations

Queue	Level	No. of Workstations	Stand/Sit	Print/No Print
1 (Catalogue)	2	21	Stand	No print
2	2	42	Sit	Print
3	2	36	Sit	Print
4 (Express)	2	6	Sit	Print
5 (1st Stairwell)	3	20	Sit	Print
6	1	24	Sit	Print
Total N°. of Workstations		149		

N.B. Computer workstations in training room 2b, Audiovisual, second stairwell (Level 3) and standing computers (Level 1) were not included in this survey, since these workstations were not included in the deliberations of the 2004 Survey.

Briefly, the workstations listed in Table 1 are personal computers (PCs), mostly with Samsung flat-panel monitors. These are networked via LAN to both our Library Catalogue system and the internet. Most of them also have the capacity to send documents to one of four HP LaserJet 8100 printers located on Level 2. These fast mono-laser printers are capable of 32 A4 pages per minute for a fee of 11 cents per page. Print jobs are spooled by a client from any "numbered" workstation, on any Level. These printers are clearly visible from the workstation queues on Level 2.

All workstations are located in groups along bench-tops/carrels that are clearly visible to clients who could be in a queue waiting for a vacancy.

The queue structure is semi-formal in that there is a rope strung between posts on one side of the computer workstation area. Clients coming to Level 2 from other levels can bypass the queues and go straight to any of the printers for de-spooling their print-jobs.

De-spooling involves a 6-step procedure after entering a "charge-card" into a card-reader at a dedicated printer-workstation. This procedure is referenced as "Instructions for Printing from Workstations" [6].

2 Methodology

2.1 General

A literature search was conducted on computer queuing using the search terms "retail queuing", "doctor's waiting room", "bank queuing", "queue and library", "waiting times" and "queue and computers". Numerous articles were found; however, only 3 articles were of relevance to this survey. These had been written approximately 25 years ago and the means of information collection, gathered by the libraries described in these articles, was entirely manual. Of the 3 papers, the one by A. W. Knox & B. A. Miller [7] had the most utility. In this paper, library staff acquired data by observing heavy usage periods. Student assistants also recorded the arrival and departure times of catalogue users. This enabled the calculation of the required number of computer terminals for their new "automated" catalogue system, using the Erlang Delay Formula.

2.2 Discussion of Methodology

As used by Knox and Miller [7], during a heavy-use hour the Erlang method for a single queue requires:

1. An arrival rate to the queue, e.g. x-clients per recording period
2. A departure rate from the workstations, e.g. y-clients per period
3. The number of workstations associated with that queue, e.g. 24

The period chosen in Knox and Miller [7] was 5 minutes. This is short enough to be convenient for their manual timings, yet many times longer than their benchmark or targeted maximum queuing duration (which was just a few seconds).

In this analysis, the actual clients' longest time spent in the queue was used. This is a more realistic measure than, for example, an hourly average, which could easily hide relevant peaks, or an arbitrary 5 minute interval, which could easily be a tolerable fluctuation.

Therefore, the 3 longest times spent in a particular queue were averaged and all the rates associated with these times were calculated. All rates were then normalised to the same unit, namely "clients per hour". The averaging at this stage was to reduce the effect of human error, which was detected in the manual data gathering of these counts/timings.

It was noted that no provision was made by Knox and Miller [7] for premature departures from their queue. This meant that special consideration was required for this parameter in the current survey. Additional factors raised by Knox and Miller [7] that are pertinent to the current survey are:

1. One or two Express terminals for quick searches, with restricted usage duration and standing access only, would improve service.
2. Alleviating lengthy on-line searches by the provision of off-line printouts with next day delivery.
3. Increase of usage of a new on-line service due to increased user demand in general.
4. "the calculated probability of waiting (0.028 in that study) and the average waiting time (2.64 seconds) required that all terminals be working. Realistically, this is unlikely to happen."

The Bundoora library has 6 Express workstations (supplied by Queue 4 on Level 2) out of a total of 149 computer workstations, or a ratio of 1 to 25, compared to a suggested minimum ratio of 1 to 7 by Knox and Miller [7]. Express queues are used in supermarkets, presumably with cost/benefit advantages. Observations of several supermarkets show them to use a ratio of about 1 to 7. This large

difference in our library's ratio strongly suggests that Express queue usage, in the Bundoora context, should be analysed more fully.

The Bundoora system of printer usage was not intended to reduce workstation usage. In fact, printer usage could be contributing to workstation usage because printer use does not force the termination of workstation usage. At the time of the data collection for this survey, the library had 4 printers, which could be used by clients from other library areas or queues, so that there is a "back-end" parameter of relevance to the departure rate from workstations on Level 2. This parameter is difficult to identify fully because clients can arrive at Level 2 from workstations on other Levels, bypass the queues on Level 2, and cause what could be "invisible" queues at the Level 2 workstations. In effect, some clients could be coerced to extend their stay at a Level 2 workstation when they see that the 4 printers are all in use.

“Printer usage page counts” were not available at the time of this survey. These figures could show if the printer usage was causing bottle-necks (i.e. “invisible" queues). These figures could also be obtained as daily costing figures of revenues received from clients via the charge-card readers, or from IT as prints per day. Reasonably accurate estimates of printing throughputs could be made, taking into account that charge-cards are also debited for photocopying and that a prints-per-day count would include set-up, maintenance and diagnostic prints.

One additional departure from the simplistic queuing model described by Knox and Miller [7], is that our library has more than 6 informal queues on 3 different Levels, with clients able to move from queue to queue relatively easily. One queue is for Express workstations and there is one queue to workstations from which no printing is possible. Furthermore, on Level 2, queue balancing can occur when clients can see that a nearby queue is shorter or shrinking faster. Lastly, there are instances of a group of clients occasionally using a single workstation.

For all of the above reasons, it was decided that an Erlang Formulae Testing Stage would be appropriate. If the testing failed, an alternative Queuing Theory approach would need to be found.

3 Data Collection.

3.1 The days and times of peak workstation usage.

In 2004, peak workstation usage times were established using the “Facilities Use Rate” methodology, as described by Van House [8]. This provided a simple-to-use method where 7 counts were conducted each weekday over a two-week period.

This method was used to determine the peak periods of workstation usage by recording queue length. It was established in 2004 that, by using 1-hour data collection intervals, the peak usage occurred between 11:30 am and 2:30 pm, especially early in the week. Thus, in 2005, complementary data was collected only at these four times, 11:30 am, 12:30 pm, 1:30 pm and 2:30 pm.

Library Attendants collected this data under the supervision of the Attendant Team Leader. As most Attendants have been involved in seating surveys before, it was not necessary to run formal training sessions.

3.2 Additional Measurements

After some consideration, it was decided to use a similar, manual gathering of data, as outlined in Knox and Miller [7], to establish the longest durations clients actually spend in a queue before gaining access to a computer workstation.

3.3 Data Types

A special Data Collection Form *(See Appendix 1)* was designed to enable trained staff to record the following information accurately and efficiently, at each of the six (6) queues.

3.3.1 The time taken to obtain access to a workstation during peak periods (i.e. *the time a client actually stands in a queue).*

The average queuing time of clients was established from data gathered at the same collection times as in the 2004 survey (i.e.11.30 am, 12.30 pm, 1.30 pm and 2.30 pm), every weekday for this survey.

The arrival time of the first client to join each of the six (6) queues on or soon after 11.30 am was recorded, as was that client's departure time from the queue (to access a workstation). These data were collected again at 12.30 pm, 1.30 pm and 2.30 pm and recorded on our Data Collection Form.

Subtraction of these times gave us the actual duration each client spent in a queue.

3.3.2 The actual queue lengths.

During the interval of a client arriving at and departing from a queue (i.e. the client's duration in the queue), the number of new arrivals to that queue were counted and recorded on the Data Collection Form.

3.3.3 The number of clients who left the queues prematurely.

At the same time that new arrivals were noted, the number of aborts were also counted and recorded on the Data Collection Form.

3.3.4 The average time that a client spends at a workstation.

Because these timings were unavailable from IT at the time of the survey, it was estimated that their manual collection would have doubled the time and staff required to conduct this survey. Although these values can be derived simply from the recorded "Time In Queue", "Number In Queue" and "Number Of Aborts", they will not be very accurate (See Appendix 2 - Calculation Step 5). The main reason for this is that, occasionally, one workstation was used by a group of clients.

It was decided, therefore, to estimate approximate workstation usage times from a "simulation" run of the Erlang Formulae at the Erlang Testing Stage of the Analysis. This involved "plugging" in various workstation usage rates (i.e. departure rate from each workstation as clients per hour) as well as the number of workstations for each queue into the Formulae and checking that the calculated queuing durations were in fact close to those that were measured. The workstation usage rates (that gave the measured queuing durations) would then used for Erlang predictions of queuing durations that could be expected for various numbers of workstations.

3.3.5 The approximate timings of printer usage.

These timings were recorded separately, independently to the Data Collection Form.
It was observed that, during a few busy periods, printer usage was constant but not what would appear to be very heavy.

Only on a few occasions was there more than one person at a printer. The printer usage appeared to be "efficient" in that, on average, only 20 seconds was required to select the file to print and the first page was printing within 10 seconds. It appeared that about 15 pages was an average print run per client. This took approximately 30 seconds to print.

This suggests that, if the printers are running faultlessly, there should not be a "bottle-neck" caused at the "back-end" of our queuing model. However, because clients were observed to return to their workstations after printing on most occasions, printing should be included as an optional workstation activity, along with email, internet use, library database searches, etc.

4 Analysis

4.1 Workstation Usage Comparisons

Table 2 shows daily averaged numbers at workstations and queues as a comparison between 2004 and 2005. The daily averaged numbers at workstations are actually the totalled client counts at all workstations surveyed, taken at the 4 sampling times on both Mondays, then both Tuesdays, etc. The two Monday totalled counts were then divided by two, to give a single average Monday count for 2004. The same calculations were done for all 2005 counts. The calculated number of clients at a workstation at any one time was worked out by dividing this average by the number of sampling periods and the number of workstations to give the number of clients per workstation per sampling period.
Similarly, the numbers in queues are actually the totalled client counts in all 6 queues taken at the 4 sampling times on both Mondays, then both Tuesdays, etc.

Table 2 – Summary of data

Average Number of Clients at all Workstations and all Queues Surveyed by Day and by Year						
Day-Year	**No. of work stations**	**No. at Work stations**	**Calculated No. at a workstation at any one time**	**No. in Queues**	**No. of Aborts**	**Time in Queues (mins)**
Monday-2005	149	622.5	1.04	62	37	111
Monday-2004	125	550	1.10	59.5	-	-
Tuesday-2005	149	638.5	1.07	63	22.5	101.5
Tuesday-2004	125	533	1.07	47.5	-	-
Wednesday-2005	149	614	1.03	26	18	57
Wednesday-2004	125	526	1.05	54.5	-	-
Thursday-2005	149	620	1.04	37	11	52
Thursday-2004	125	537.5	1.08	42	-	-
Friday-2005	149	589.5	0.99	8.5	3	13.5
Friday-2004	125	508.5	1.02	19.5	-	-
				No of workstations surveyed in 2005	149	
				No of workstations surveyed in 2004	125	
				No. of time periods for data collection	4	**on each day**

Data for number of aborts and time spent in queues were not collected in 2004

Since the number of clients in 2004 was only slightly lower than 2005 and Table 2 shows 2005 to have similar queue lengths to 2004 (even though 24 more workstations were available in 2005), the indication is that no improvement in the QoS occurred in 2005 due to that increase in the number of workstations.

Table 3 (following) shows the corresponding number of clients in all queues when the peak workstation occupancy was recorded.

Table 3 Peak Numbers at Workstations and queues

Peak Recorded Number of Clients at all Workstations for each Day of the Week				
Day-Year	**Time of Recording**	**No. of Clients at all Workstations**	**No. of Clients in all Queues**	**Total No. of Clients**
Monday-2005	12:30pm	167	28	195
Monday-2004	2:30pm	148	17	165
Tuesday-2005	11:30am	163	32	195
Tuesday-2004	1:30pm	147	13	160
Wednesday-2005	1:30pm	165	3	168
Wednesday-2004	11:30am	134	26	160
Thursday-2005	1:30pm	162	13	175
Thursday-2004	12:30pm	149	17	166
Friday-2005	12:30pm	159	9	168
Friday-2004	12:30pm	137	8	145

Table 3 confirms that QoS, as shown by the number of clients in queues during peak usage times, actually declined from 2004 to 2005, in spite of the extra 24 workstations

4.2 Queuing Analysis

Once the data was gathered and the peak usage times confirmed, the average of the highest three values of queuing durations as well as the queue lengths and numbers of unsatisfied departures (Aborts) were calculated for each of the 6 queues.
Although Aborts are a strong indicator of potential problems, it is expected that they would be reduced to a negligible size with an increase to the number of workstations.

The Abort Rate was not included, therefore, in the Arrival Rate of clients to the queues in this Erlang analysis. This was handled well by Library staff collecting the data, who did not count clients as Aborts" unless they actually were in the queue for a nominal time. Each queue was analysed independently, even though many aborts would have a load-balancing effect on other, less busy, queues.

Two formulae were used from Knox and Miller [7] for further calculation. The first formula is known as: - *Erlang delay formula.* This formula calculates the "probability of waiting for a workstation" from the "number of workstations" available, a "rate of arrival" to a queue and a "rate of departure" from the workstations, during a peak period.

The second formula calculates the "average waiting time" to be expected from the previously calculated "probability of waiting", "number of workstations", "rate of arrival" and "rate of departure" as used in the "delay" formula.

Assumptions made in using *Erlang delay formula as referred in Knox and Miller [7]:*

1. A single queue of clients forms for each area of Workstations with arrivals to each queue occurring randomly.
2. During peak periods, on average, the rate of departures from workstations is not reduced by "back-end" printing bottle-necks.
3. Neither clients leaving queues permanently nor those seeking a shorter queue during peak-usage periods would force a model change from Erlang.
4. The Abort Rate will reduce to nearly zero when the adequate number of workstations are provided, hence reducing the delays endured by our clients.

In both validating, then using the Erlang Formulae, a number of intermediate steps were calculated to permit easy checking. These intermediate steps may be referred to in the spreadsheet used to calculate results shown in this report.

5 Validating the Erlang Formulae Usage

The validating technique, involved calculating a Departure Rate from each Workstation for each queue (during a peak usage period)**.**

In summary, the calculated Departure Rate (Clients/hour) compared fairly well with the values required by the Erlang Formula to give the same Queue Waiting times for all 6 queues. The variances were largely due to the simplifying assumptions made in the calculations.

The steps involved in the calculations and the Erlang Tabulation can be seen in Appendix 2.

6 Using the Erlang Formulae

The Erlang Formulae produced plausible projections for queuing times when the total number of workstations at each queue were used.

Various numbers of workstations were tried in the formula to give a range of waiting times (approx 10 minutes, 5 mins and 1 min). Of course, a 1 minute waiting time in a queue would be a most acceptable delay to most clients. Realistically, reference Knox and Miller [7] states that estimates derived from Erlang Formulae must be treated as optimistic.

The current counts of workstations including the current queuing waiting times are also shown.

Table 4 Comparison of actual to predicted wait times

Queue No. {Current No. of Workstations}	No. of Work stations	Arrival Rate to Queue (clients/hr)	Abort Rate (clients/hr)	Departure Rate from Ea. Workstation (clients/hr)	Predicted Wait time in the queue (mins)
1 {21}	19	81.7	30	4.40	28.2
	20				6.3
	21				2.7
	23				0.7
2 {42}	42	28.0	11.7	0.63	15.7
	43				9.5
	44				6.0
	48				1.1
3 {36}	36	30.0	18.4	0.81	16.3
	37				9.2
	38				5.6
	42				0.9
4 {6}	6	3.9	0	0.94	10.3
	7				3.3
	8				1.1
5 {20}	20	10.0	15.0	0.48	8.0
	21				4.3
	23				1.3
6 {24}	24	10.2	15.3	0.39	15.7
	25				8.7
	26				5.0
	29				1.0

Key:	> 10 mins (approx)	= 10 mins (approx)	= 5 mins (approx)	= 1 min (approx)

The single colour across an entire row relates to the current situation. The other colours for a given row illustrate the effect of varying the number of workstations.

From the current number of 149 computer workstations, an increase of 24 to a total of 173 workstations is indicated in the above table as being able to reduce the amount of time spent by our clients in queues, to an average of approximately 1 minute queuing time. These formulae can be used to calculate an optimum number of workstations for whatever queuing duration is benchmarked as acceptable during peak-usage periods.

While looking at Table 4, the following comments should be considered:-

- Queue 1 currently has a longest Wait of 2.7 mins. It has the highest Abort Rate of 30 clients / hour. Excluding Aborts, it is easily the fastest Queue. Printing cannot be done from this queue's workstations. These workstations are used while STANDING only.
- Queue 2 currently has a longest Wait of 15.7 mins. It is one of the 3 busiest queues.
- Queue 3 currently has a longest Wait of 16.3 mins. It is the SLOWEST and LONGEST Queue with the largest number of Aborts.
- Queue 4 currently has a longest Wait of 10.3 mins. It is the SHORTEST Queue (but not the fastest) with no recorded Aborts. It is the Queue to the EXPRESS workstations yet they are used while SITTING, not standing.

- Queue 5 currently has a longest Wait of 8 mins. These Workstations have the second-longest duration of use by clients - 155 mins *(See Appendix 2)*.
- Queue 6 currently has a longest Wait of 15.7 mins. These Workstations have the longest duration of use by clients - 182 mins *(See Appendix 2).*

7 Observations

This survey has identified a number of factors:

1. Queuing durations as a negative performance indicator. Clients don't like waiting, so they "Abort" when the queue is too long or too slow.

2. Our clients can avoid a slow or long queue by going elsewhere.

3. Workstation usage durations are a positive performance indicator, as our clients appear to be satisfied with this service and tend to overstay.

4. Printer usage is a positive performance indicator when the printers are functioning properly (printer availability is an additional service which is obviously welcomed)

5. All workstations are overstayed (according to the 1-hour Library Policy limit), except those from Queue 1, which are standing-use only and do not permit printing.

6. Clients often use Queue 1 as a "toe-in-door" and observation-point from which they abort to the shortest queue.

7. Group-usage of workstations poses additional problems in data collection and queue analysis.

Ongoing surveys can be streamlined if not replaced entirely by automated data-gathering systems that could be built-in to the workstations network. Such automated data-gathering would greatly reduce the amount of data collection and training which would mean many staff hours saved.

It is also important to factor in the predictable changes/trends that are emerging due to dropping computer prices, availability of devices with utility for our clients, such as increasing lap-top usage, wireless technology becoming affordable, and portable and compact memory devices finding uses in academia.

A small step towards such Library Service excellence has been attempted with the careful application of a Queuing Theory technique which was found in a Literature search. Its applicability to our needs was tested and it appears to be reliable. The direct result of its successful use would be the ability to predict accurately, the queuing impost on our clients, given the number of available computer workstations. Of course, a prerequisite is the need to be aware of the relevant factors and assumptions that underpin the successful application of the technique.

8 Conclusions

The amount of time clients(on level 1) spent in queues waiting for access to workstation ranged from 2 to 16 minutes with an average of 11 minutes.

Comparison of the queuing data obtained in the current study with the 2004 data shows that although there was an increase in the number of workstations from the previous year, the actual number of clients at workstations and in queues dropped only marginally.

The key parameters to be collected for this kind of study are: Queuing Duration, Queue Lengths, Workstation Usage Duration, Printer Usage and Abort Rates. A template has been designed and a protocol written for recording raw data.

9 Recommendations

1. This survey has uncovered some interesting aspects of the Library's computer workstation usage. However, further analytical investigations would be worthwhile. Further study could be undertaken by students/staff interested in Queuing Theory to provide a more comprehensive modelling of Library's workstation usage. This should include analysis of the effect of Express workstations as well as printers.

2. The benchmark for acceptable queuing durations needs to be established so that the optimal number of additional workstations can be acquired if necessary. Possible analytical methods of benchmarking should be investigated.

3. If the Library was to acquire new workstations, there is the problem of where to house them. The survey has shown that Level 2 is the hub of the Library; however, space on this Level is at a premium. It would therefore be recommended, as first step, that an additional 5 workstations and one printer be housed on Level 1. This should reduce the waiting times during peak periods to just 1 minute according to the Erlang prediction and could stand as a solid test of the Erlang Formulae and the Methodology.

4. The functionality of some queues, especially Queue 6, which is awkwardly positioned near the entry door on Level 1, could be improved. Although Queue 3 is the longest and slowest, it does not warrant special treatment.

5. Appropriate signage relating to location, number and type of workstations available in the library should be placed prominently to allow clients the possibility of investigating alternative workstation sites.

6. Investigate a more formal queuing arrangement to reduce client discontent, as demonstrated by the recorded number of aborts from queues and to enable automatic queuing data collection, such as "take-a-number" or "swipe your card" methods.

7. If the 24 new workstations on Level 1 have suitable data logging capability, then perhaps this data could be extracted and used in future surveys. This data would save staff time by reducing manual data collections e.g. duration of workstation usage. If additional data about the detailed nature of clients' transactions on these workstations was available, this could enable the Library to deliver better QoS with more timely adjustment to their availability, in view of ever-changing client needs.

8. Enforcing a fixed period to the workstation usage such as the 1-hour per session limits as stated in the information page on computer facilities on our website [9] would have a negative impact on QoS. However, such constraints *should* be applied to our Express workstations serviced by Queue 4, which are used for 64 to 93 minutes per client on average. It would be prudent to establish the exact nature of Express workstation usage before assigning a rigid time-limit on their use.

9. Investigate the possibility of placing a workstation in some lockable carrels. This would mean some additional workstations could be suitably located on Level 3.

10. Continue to investigate ways of improving wireless transmissions within the Library complex especially in the new group areas on Level one.

10 Acknowledgments

I would like to thank Sue Porter for her literature search on computer queuing and all staff who diligently and enthusiastically collected data for this survey, as well as Helen Lynas for collating of some data.
A consultant did much of the mathematical analysis required for this survey. This was greatly appreciated.

11 References

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Appendix 1

La Trobe University Library
Bundoora Client Services Committee
Bundoora Computer Workstation Survey

DATA COLLECTION FORM 1.2

QUEUE No.	
Location:	Level -
Description:	No. of Workstations -

Nominal Time	***Arrival Time**	***Depart Time**	**Number in Queue	****Number of Aborts**
11:30am				
12:30pm				
1:30pm				
2:30pm				

Completed By:	
Date:	-9-2005

*Arrival and departure time of target.
**Queue length at departure time not including target
*** Count **all** patrons who leave the queue in this column (except targets)

Contingencies

- If target leaves queue prematurely then the next person who joins the queue becomes the target. Amend arrival time immediately.
- If there is no queue on arrival – record zero count.
- Count all patrons in the queue at the target's departure time.
- Count number of patrons who leave the queue (N.B. this count is recorded in separate column under "Number of aborts"). Count all patrons who leave the queue regardless of whether they are before or after the target.
- If target jumps the queue more than one place then restart with new target otherwise continue as normal.

Lea Beranek
September, 2005

Appendix 2

Calculations used for Validating the Erlang Formulae

Calculation Steps:

1. Average Arrival Rate to a queue (clients/hr) = Departure Rate from a queue (clients/hr) = 60 x (Average No. in Queue - 0.15xAverage No. of Aborts) / Average Time in Queue (minutes)

2. Abort Rate (clients / hour) = 60 x No. of Aborts / Time in Queue (minutes)

3. Arrival Rate to ea. workstation = Departure Rate from a queue / No. of workstations at each Queue

4. Departure Rate from each workstation = Arrival Rate to each workstation (clients / hour)

5. Derived Time (in minutes) each client spends at a workstation at each queue = 60 / Departure Rate (clients / hour) from each workstation at that queue

Table 5 Individual queue averages

AVERAGES CALCULATED FOR EACH QUEUE FROM RAW DATA								
Queue	Time in Queue (mins)	No. in Queue	No. of Aborts	STEP 1 Arrival Rate to Queue (clients/ hr)	STEP 2 Abort Rate (clients/ hr)	STEPS 3-4 Departure Rate from each work Station (clients/hr)	STEP 5 Derived Time at each work station (mins)	No. of workstations
1	2.7	3.8	1.3	81.7	30.0	3.89	15	21
2	15.7	6.8	3.0	24.4	11.7	0.58	103	42
3	16.3	8.2	5.0	27.2	18.4	0.76	79	36
4	10.3	0.7	0.0	3.9	0.0	0.65	93	6
5	8.0	1.3	2.0	7.8	15.0	0.39	155	20
6	15.7	2.7	4.0	7.9	15.3	0.33	182	24

For the same “Av. Time in Queue”, the “Derived Av. Time at a Workstation” (shown in Table 5 as STEP 5 - see above) is close to, yet consistently larger than the Erlang Formula requirement (shown below in Table 6 in the blue column). The explanation is that our Derived Av. Time is inflated due to occasional multi-client usage of single Workstations.

The comparison of Departure Rates from Workstations, as calculated in Table 5, with those produced by the Erlang Formula in Table 6, is even closer.

This allows the use of Erlang with the reduced Av. Time at a Workstation figures with some confidence.

Table 6 Validation of Erlang formulae

VALIDATION OF ERLANG FORMULAE					
Queue	No. of Work stations [s]	Av. Time Ea. Client Spends at a Workstation (mins) [from Erlang]	Av. Arrival Rate to Queue = Av. Departure Rate from Queue (clients/hr) [Ar]	Av. Departure Rate from Ea. Workstation (clients/hr) [Dr]	Av. Wait time in the queue 60 * [p] / [X] (mins)
1	21	14	81.7	4.40	2.7
2	42	95	24.4	0.63	15.7
3	36	74	27.2	0.81	16.3
4	6	64	3.9	0.94	10.3
5	20	124	7.8	0.48	8.0
6	24	155	7.9	0.39	15.7

Additional intermediate steps in the Erlang Formulae calculations can be seen in the associated Spreadsheet, which will be made available on request.