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A proposal for an ISDN Pilot Study

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A pilot study of ISDN, by deploying services to a few users who have readily identifiable bandwidth requirements, is proposed.

Executive Summary

The remote access service is critical to achieving the Lab's mission and provides a significant resource at a very advantageous cost/benefit ratio. However, the transition from character to graphics mode terminals and the increased dependence on file servers are precipitating a demand for much higher bandwidth than can be provided by the existing service which uses the traditional modem and phone line combination. In particular, certain key applications are not runnable from home because of slow terminal response and long data access times; and while improved bandwidth could be obtained by upgrading the existing (modem based) system *or* by using ISDN, only ISDN provides enough bandwidth to satisfy the demand.

While considerations of cost, availability and need made ISDN difficult to justify in the past, changing conditions now make it attractive. Specifically, it is *widely available*[1], there *is* a critical need for a certain set of users, and the ongoing costs are acceptable (about $48/month compared with $39/month for telephone + modem). Only the initial hardware costs detract from ISDN. These are about 2.5 times that of setting up a phone service and because of this, deployment should remain selective until the prices come down further.

We therefore propose that a pilot study of ISDN be conducted deploying it to a limited set of users who have well defined needs for higher bandwidth. The pilot should be conducted over a period of four months with the expectation of continuing indefinitely if it is successful. We propose to use BRI (Basic Rate ISDN) in both the user's home and the Computer Center and to use filtering bridges to extend LAN functionality to the user's

1. The PacBell program ISDN Anywhere makes at available to most urban subscribers.

home using Combinet filtering bridges[1]. The cost of setting up the pilot is estimated to be $753 for each user and $1253 for each computer center line. Initially, five users would be provided with ISDN and three lines would be installed in the computer center. The total estimated cost for the pilot is $8772 including estimated line charges. The ongoing charges, should the pilot be continued, would be $312/month. At the end of four months we propose to evaluate the performance/usefulness of ISDN and if appropriate, use the pilot as the starting point for further deployment.

Introduction

SLAC enjoys a significant benefit from the local off-site use of its computer facilities. That benefit is estimated to be equal to between twenty and thirty-five full time equivalents (FTE) at a cost of about one FTE[2]. Moreover, off-site access is essential for non-business hours troubleshooting, where key people can respond without delay to critical problems. Without the ability to respond through the network, it is doubtful that SLAC could continue to operate as efficiently and effectively as it does. Finally, many people are willing to make an additional contribution to the lab's mission by providing software development, documentation and a variety of computer dependent functions. Clearly, in the present climate of diminishing staff it would be prudent to encourage this additional contribution, regarding it as a resource which should be husbanded.

Of particular concern is the fact that many users find themselves using a graphics mode terminal on-site and a character mode terminal at home. In addition to forcing these users to remember two ways of doing everything, many functions are no longer able to be performed at home because of incompatibilities between character and graphics oriented application. For example, many programs organize mail files and folders incompatibly with other mailers. The result is that a graphics oriented mailer can organize files in such a way that a character mode mailer does not know how to access them. The result is that a user may be able to read e-mail at work but not at home, or vice versa. This is very annoying and discouraging: We should not be suprised to find that the amount of time people are willing to devote drops off as a function of their frustration level.

The existing arrangement, where character mode terminals communicate with the computers using telephone lines and modems, has worked satisfactorily until recently. However, some developments are now forcing us to reconsider how off-site access should be provided. In particular, increased reliance on graphics applications already mentioned and the increased access to data stored on file servers at SLAC by home users are creating a demand for higher bandwidth than is possible through standard phone lines. Moreover the VM phaseout will require replacing many application services that are currently effective in character mode, with ones that require higher speed graphical access. In addition the planned removal of the MICOM switch will require the replacement of its modem pool with more modern higher speed connections.

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1. These bridges implement dialback and authentication security features which will be tested and evaluated.

2. This estimate was arrived at by summing the total connect time to SLAC's modem lines for a single month. The modem pool includes lines connected to the MICOM switch and lines providing ARA (Appletalk Remote Access). It does not include the connect time of those who use telnet.

In planning for the future, we have identified two options, both of which will probably need be deployed to some extent. These are (1) to re-deploy the existing phone access as the MICOM is phased out, using newer technology to its maximum advantage while accepting the inferior performance; (2) to deploy ISDN, thus providing the increased bandwidth, particularly where applications require it.

We note that this is not the first time ISDN has been proposed. A previous proposal in June 1993 outlined the need for ISDN at that time. Since then many factors including availability, costs and applications have changed. Table 1. illustrates the change in costs since then.

Item	ISDN Single Line Service - 1993	ISDN Single Line Service - 1995
One Time Costs	$2890	$1600[a] ($1252)
Monthly Lease Costs	$54	$24
Monthly Use Costs	$37	$34

TABLE 1. Comparitive ISDN costs 1993 - 1995

a. This assumes that there is a computer center line for each domestic ISDN line because this assumption was used in the 1993 proposal. In this proposal we are able to recommend using fewer lines in the computer center because of the availability of hunt groups. At a ratio of three comp. cent. line to each five users, the cost would equal the parenthasized number.

We argue that an evaluation is timely beecause there is an immediate need to deploy ISDN on a limited scale. This need is being driven by applications which require bandwidth to function satisfactorily and particularly applies to the network management software used by SCS where the delivery of 24 hour coverage, is limited by the time it takes to start up the most critical network monitoring tool from off site. Other applications include the SLC and SLD control systems and many utilities such as mail, screen mode editors, news browsers, WWW and access to central file servers. Finally, the increased need for remote access to file servers from off-site and the exploding use of the World Wide Web, a tool which has been taken up lab wide, are adding to the demand.

In comparing the two technologies, (phone and ISDN), we note that both the bandwidth and the line availability problems could be partly addressed by deploying a new terminal server and higher speed modems. However this solution has a number of drawbacks. These are: (1) The maximum bandwidth attainable would be 28.8Kbps[1]. (2) This bandwidth is not high enough to support most X-terminals[2] (3) nor is it high enough to effectively support critical applications, (4) the MICOM switch would need to be upgraded (contrary to the VM phaseout plan) or replaced by a new terminal server (about $4000 for 20 lines). (5) it is not clear that we would continue to benefit from the additional pro-

1. Although 28.8Kbps is supported by the latest modems this speed is only available when the connection between the user and SLAC is of highest quality. More often, the modems negotiate a lower speed such as 19200Kbps or 12KBps.

2. (a) Network Computing Devices - Technical Note: “Network Loading and the NCD Network Display Station”, (b) F. Abar,C. O’Reilly, E. Wocklund, “Network Load of X Terminals”

ductivity we enjoy from offsite users because people get discouraged when using terminals that are too slow for their application or are simply unable to run the applications they need.

On the other hand, ISDN offers a throughput of up to 128Kbps compared to 28.8Kbps,, easily meeting the X-terminal bandwidth requirement. Secondly, it is available to most residential sites, i.e. most SLAC users, and finally, has monthly rental and usage charges comparable with POTS (Plain Old Telephone Service). Comparison of the monthly charges for ISDN and POTS shows that when either service is used for about 2 hrs. per day, the monthly cost ratio for POTS vs. ISDN is about $39 to $48 or 1: 1.4, even though the ratio of available bandwidth is better than one to four.

Presently, the start-up costs for ISDN are sill higher than for POTS because of the cost of end point equipment. However, when the cost of a terminal server, needed to support modems, is included, the setup cost ratio is still only $595 (ISDN)[1] vs. $250(POTS) for home and $1095 vs. $550 for the computer center. ISDN also offers the advantage that it can be deployed on a line by line basis, that is, without the necessity of deploying new terminal server equipment in groups of eight or sixteen lines needed to support higher speeds. Finally, the prices of ISDN equipment, having fallen substantially within the last year, are expected to continue to decrease as more providers enter the market.

Discussion

Demand Critical Applications

Certain critical applications at SLAC need higher bandwidth to function properly. In some cases the effect of slow response is to render then too frustrating to work with. In other cases they are unusable. These are listed below:

- The network management software is used by the SCS Network Group to monitor status and identify problems with SLAC's network. The software, which presents a network map highlighting problem areas, relies on a graphics terminal, and since the map is too big to fit on one screen it is broken into many pages representing different levels of detail or area. Network staff Connie Logg, David Millsom and Don Pelton rely on this map to diagnose problems 24 hours each day. However, when accessed using a terminal connected to a phone line, each page takes many minutes to draw. The normal (and necessary) pattern of use is to jump from page to page, redrawing each new page after a jump. This is the only way the utility can be used and it is so slow as to be unusable. In order to get quick access to at least one page, some people leave their terminals connected continuously, at a high cost.
- Analysis of physics data is now performed with interactive X-applications such as SLD's Midas and CERN's PAW. However, the response of these applications at home is so slow as to defeat the interactive nature of these applications.
- Tony Johnson is on call to deal with problems involving the SLD off-line batch system and MC farm as well as the on-line tape handling and status systems. In addition he is called on to regularly monitor the status of the SLD software from home. To do this requires a graphical user interface. Tony also develops X-windows based appli-

1. It shouldbe noted that traditionally, over the years, it has cost about $500/user to switch to the current highest speed modem.

cations such as physics analysis tools and WWW applications. Current modem speeds make both of these activities too painful to do using an X-terminal connected via a conventional phone line.

- Richard Dubois oversees the processing of the SLD data. The monitoring tools are all WWW or other X-application based. These include the scanning of event displays and the work also includes the further development of WWW tools to test for data integrity. Again, the slow speed of a conventional modem, particularly when used in conjunction with a Graphical User Interface, is simply too painful to use.

More generally, demand for higher bandwidth between home and SLAC has increased rapidly in the last few years. Traditionally, steadily increasing throughput rates, provided by the phone service and currently supplied by SLAC, ranging from 110bps (late 1960's) to 14400pbs (present) have been adequate to support most of the functions provided through character mode terminals. Higher speeds readily support character mode applications up to and including screen mode editors which frequently repaint the entire screen after changes have been made. 9600-14400bps is also adequate in many cases for character mode terminals which support an extended graphics mode. In this mode hosts use character escape sequences to activate extended graphics features in character mode terminals. Typically, many characters must be transmitted to construct a graph or diagram.

Unfortunately, character-mode graphics terminals suffer from a number of disadvantages. For example there is no standard defining how they are to interact with the computer, so that applications must be re-engineered for each new type or make of terminal to be supported. Secondly, they do not support a mouse. Lastly, they can only support multi-windowing in a very primitive way.

These problems have largely been solved by X-terminals. X-terminals provide a standardized interface to graphical applications on a server which provides window support and has the mouse support integrated into the server software and hardware. Because the terminals support windows, multitasking at the user level and multi-threaded applications can be readily supported. Finally, the raster nature of the windows provides the greatest possible flexibility to graphical applications allowing bitmapped graphics, including color and greyscale images and even desktop video.

Typical workstations now in use at SLAC routinely use the X-windows interface to interact with the user. Moreover, many applications originally implemented on character mode terminals have been ported to run on X-windows terminals. These application are in constant use at the lab.

One disadvantage of X-terminals is that the protocol overhead between server (the X-terminal) and the client (the application program) is much higher than that of character mode terminal because of the additional functionality. This does not cause a problem in the typical LAN environment in which the network link between server and client operates at 10Mbits/sec. However, this is obviously far greater than 14400bps throughput commonly supplied by SLAC and causes such a serious performance loss over dialup lines that many X-window applications become unusable. In other words, for users to get satisfactory performance out of X-window oriented applications at home a higher bandwidth is essential. Presently, this can only practically be provided using ISDN[1].

Availability

Until about a year ago, ISDN was available to a limited set of phone customers, the availability depending on the model of phone switch providing their service and the distance between the phone switch and the customer premises. Those who were not served by ISDN-capable equipment were forced to use more expensive options such as switched-56 and dedicated lines.Within the last year however, PacBell has introduced a program called ISDN Anywhere[1] in which they are attempting to make ISDN available to all customers subject only to the constraint that the customer's local loop be no more than 30000 ft. Even if the service is not available on the nearest switch it will be provided by back-hauling it from the nearest ISDN-capable switch. We thus have a good basis to expect that the majority of the SLAC community could get access to ISDN now, if needed, or all will be able to get it within the next year or so.

Cost

A second factor making ISDN more attractive is the change in cost of the service. The following table shows the cost of installing and operating ISDN in a residence and the central office (Computer Center) and compares this cost with POTS.

Item	**ISDN/ home**	**ISDN/ CompCen**	**POTS/ home**	**POTS/ CompCen**
Installation	**$158**	**$158**	**$100**	**$100**
End-point Equip	$595[a]	$1095[b]	$250[c]	$450[d]
Total Installation	$753	$1253	$350	$550
Monthly Rental	$24	$24	$15	$15
Usage (line) charges[e]	$24	$0	$24	$0
Avail band. Kb/sec	128Kbps[f]		28.8[g]	
Total Monthly	$48	$24	$39	$15

TABLE 2.

a. Using a Combinet EVERYWHERE 160 filtering bridge.

b. Using a Combinet EVERYWHERE 200 filtering bridge.

c. Using a USRobotics 28.8K modem.

d. Using a USRobotics 28.8K modem in conjunction with 1/20 of 20-line terminal multiplexor.

e. Based on 100 hours/month at $.01/minute, i.e. about 10hrs/week.

f. Based on 2 B channels.

g. Based (generously) on V.34 28.8Kbps modems which have only recently started to become available.

1. Some studies have shown that the sustained bandwidth required for an X-terminal session is about 50-80Kbps. This fits comfortably into the bandwidth envelope provided by ISDN.

1. (TM) Subject to distance and some other restrictions. A Pacific Bell representative to us that they might not deploy ISDN on small rural exchanges.

The table show that while the start-up costs for ISDN are about double, the monthly rental and line charges comparable. In fact, the ratio of ongoing charges of ISDN to POTS is 1.4:1 while the ratio of available bandwidth is 4:1.

In addition, these figures represent a worst case scenario: Firstly, they assume that there is a one-to-one correspondence between ISDN lines at home and ISDN lines in the computer center. In practice the number of ISDN lines in the computer center is expected to be about one third of the number of lines in the field. Secondly, the figures assume the use of BRI lines (2 x B channels + 1 D channel) in the computer center. In practice, if the number of users grows, PRI(Primary Rate ISDN=23 x B + 1 D) lines would be deployed at much lower cost. In fact, Pacific Bell has a submission before the California PUC to allow it to provide PRI ISDN for $400/month plus line charges. This would provide 11-23 simultaneous ISDN sessions and allow for dynamic and efficient allocation of bandwidth as demanded by each application.

Proposed ISDN Deployment

On the above grounds, we propose to conduct a pilot study of ISDN to investigate the suitability of the service for SLAC's future off-site needs. The aim of this study will be:

- To evaluate the ISDN service's ability to provide the bandwidth appropriate for meeting the demands of current applications,
- To determine the actual personal and financial cost of providing the service,
- To determine whether ISDN scales in such a way that it can be provided widely to SLAC off-site users

Configuration Options

A number of configuration options have been considered. These fall into two basic classes; (1) providing a point-point arrangement, essentially like a faster phone line, in which protocols such as Xremote, PPP and SLIP are used, and (2) providing an extension of a segment of SLAC's ethernet network into to home.

Each of these configurations has merits and deficiencies: for option (1) the configuration is generally cheaper to start-up because the cost of equipment is less than for option (2) but is much more messy to implement and would be likely to be trouble-prone, thus costing more to manage and support. Option (2), is simpler to implement, i.e. it is "cleaner" and would require less management, but costs are higher than option (1).

We recommend option (2) because we think that in the long term, if ISDN is successful, that it will scale better than option (1). In particular, it has the advantage that it provides an ethernet segment in the user's home which 'looks' to the software just like a segment at SLAC. This means the user's software can be implemented at SLAC and transparently turned on at home. This seems to be a sensible strategy for keeping the management costs down. Another reason for choosing the ethernet option is typically the interrupt load from a character oriented interface is higher than for an ethernet interface. This is because the cpu must be interrupted once per character or group of characters rather than being once per packet (containing a number of characters per packet).

Deployment

It is proposed to deploy ISDN to the five people listed in Table 3. The table gives the home location of each person along with the major application which will benefit from ISDN's bandwidth. Each person will be provided with a BRI (Basic Rate ISDN) line where each such line provides two B channels capable of running at 56-64Kbits/sec and one D channel which is capable of 16Kbits/sec. Each user will be supplied with a Combinet 160 ISDN BRI LAN Bridge which will provide one LAN (ethernet) connection to the user's terminal or workstation.

It is proposed to deploy three BRI lines in the computer center. These lines will be configured with Combinet 200 LAN Bridges. Each Combinet 200 supports packet filtering. This prevents unwanted ethernet packets from being transmitted over the ISDN circuit making it more likely that the circuit will be dropped through being idle. The bridges also support 'on-demand' call control which provides for the ISDN circuit to be kept active only while there is traffic actually flowing between SLAC and the user's home. This feature will help to keep the line charges down.

Two other features provided by the bridges are dialback security and BONDING (Bandwidth On Demand). Dialback security makes it possible to restrict connections to SLAC from previously specified offsite ISDN numbers by requiring the number to be called back from within SLAC after the connection is requested.

BONDING is a feature in which one B channel is initially activated when an ISDN call is established and the second only when the application demands more bandwidth than can be supplied by the first B channel.

TABLE 3. Proposed ISDN pilot users.

Who	Location	Application	Function
Connie Logg	Los Altos	Netview	Network diagnosis
Don Pelton	Palo Alto	Netview	Network diagnosis
David Millsom	Los Altos	Netview	Network diagnosis
Richard Dubois	Burlingame	SLD control	SLD troub.shoot
Tony Johnson	Menlo Park	SLD control	SLD troub.shoot
3x ISDN BRI	Menlo Park	ISDN serv	ISDN service lines

In conducting the study we (SCS) will be particularly interested in the following issues:

- The effectiveness of ISDN at supporting X-terminals: This includes seeing whether applications are responsive enough and whether the X-terminals are responsive enough (the window manager, for example) to be usable.

- Management issues: We wish to know how much effort is needed to manage ISDN at the computer center. This includes setting up the service at SLAC and configuring terminals and workstations for homes, the effort involved in trouble shooting and handling users questions.
- The performance of the equipment: This includes optimal parameters needed to keep line traffic and line costs to a minimum, the ability of the bridges to keep extraneous traffic to a minimum and the effective throughput attained once compression is taken into account.
- Usage monitoring; We wish to monitor usage in order to forecast the cost of deploying ISDN more widely to SLAC users.

In addition, we will be calling on the users in the study to report on their experience including but not limited to level of satisfaction with the service, whether it met their needs, what the main problems were, whether it could be improved and how. We would particularly like to gauge how much more they can get done using the higher throughput although we realize that this can be very subjective.

Final Recommendations

It is proposed to continue the evaluation of the service for about four months. At this point we will decide whether we think ISDN should play a permanent role at SLAC and if so, at what level and make a suitable recommendation. Also, at this time we hope to be able to make a more accurate forecast of the costs. If the service proves to be effective for those in the study, the services will be allowed to continue while the next phase is being developed. This next development will most likely consist of expanding the existing service or re-engineering it, particularly at the computer center end.

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