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Establishing a Data Communications Network: A Case Study

This paper is a description of the Lincoln Trail Libraries System (LTLS) Data Communications Network which was developed without the support of our computer system vendor by nontechnically oriented librarians. In order to explain some of the determining factors which resulted in the development of the Lincoln Trail automated circulation/online catalog system and the decision to develop our own telecommunications network without the support of the computer vendor, this paper will begin with a description of Lincoln Trail, its membership and a very brief overview of the history of the automation project.

Lincoln Trail is one of the eighteen library systems that serve libraries in the state of Illinois. It is a cooperative library agency which encompasses a nine-county region in east central Illinois. This region is 5,902.5 square miles in area and has a population of 439,108 people. The population density is 74 persons per square mile, compared to 205 per square mile statewide. Six of Lincoln Trail's nine counties have population densities below 48 persons per square mile. Its membership consists of forty-seven public libraries, five academic libraries, twenty-four school libraries and twenty-five special libraries. Of the forty-seven public library members, only 6 percent serve populations over 25,000. Thirty-nine public libraries (87 percent) are located in communities with under 10,000 residents, and 83 percent of the libraries are in communities with fewer than 5,000 residents. Thirty-four public libraries have an annual tax income under \$30,000. Due to the fact that the majority of the public, academic and school libraries are located in low population density areas, their property tax bases are limited. Property tax levies are the funding source for these libraries. The result is that these libraries' expenditures are geared toward traditional

library services and programs. Therefore, it has been the role of Lincoln Trail to support the establishment of innovative library services and to assist the libraries in maximizing their use of funds.

One of the primary responsibilities of any of the Illinois library systems is the processing of interlibrary loan requests both within their individual boundaries and between systems. In order to meet that responsibility, Lincoln Trail developed an in-house collection of books in order to fill the majority of interlibrary loan requests generated by member libraries. However, it would be impossible to maintain a large enough collection to fill all the requests from this collection. Therefore a union card catalog was established at the system headquarters. This union catalog was composed of card sets submitted by member libraries when they acquired new titles in their collections. All libraries were to notify system headquarters staff when titles were withdrawn from their collections. Interlibrary loan requests that could not be filled from the Lincoln Trail collection were then searched in the union card catalog and routed to the holding library. Lincoln Trail established a delivery system to route requests and interlibrary materials.

In 1976, a survey was conducted to determine the use of the Lincoln Trail collection and the completeness of the union catalog. This study showed that of the total collection, 65 percent had never been used, 19 percent had been used once, 8 percent had been used twice, and only 10 percent had been used more than twice. At the same time it was discovered that 20 percent of the interlibrary loan requests had not been filled within five weeks of submitting the request. A major problem in routing requests was the inability to determine circulation status. The study revealed that the system libraries were not keeping up with updating the union catalog. Lack of access to the union catalog by both the libraries and their patrons was also a hindrance.

Based on these results, it was decided to examine alternative methods for improving interlibrary loan service. In 1977, following a report submitted by a committee of the Lincoln Trail Board of Directors, it was decided to replace the union card catalog with an automated catalog/circulation system and to invite member libraries to input their holdings and use the computer to record and process their circulation transactions. Lincoln Trail would then have current accurate data about the libraries' collections and would be able to route requests for on-shelf items. Members would also be able to search the system for Lincoln Trail holdings. In response to Lincoln Trail's invitation to participate in the computer database, seven public libraries and one academic library agreed to enter their collections into the database and use the computer system for circulation. Excluding the collections of the University of Illinois and Eastern Illinois University,

these libraries represented 62 percent of the titles held in Lincoln Trail. The largest library has an annual circulation of 1 million items, an income over \$1 million, a collection of over 200,000 items, and a staff of twenty-four librarians. The smallest library has an annual circulation of 21,118 items, an annual income of \$15,258, a collection of 20,000 items, and a staff of one librarian. It was our intent to use this very diverse selection of eight libraries as a demonstration to the other system members that automation could be an efficient alternative to traditional circulation methods for any type or size library. In order to do that, it was necessary to ensure that the costs of automation be kept at as low a level as possible. This was particularly important because of the limited funds available to our members.

The three cost factors identified as having the greatest impact on participating libraries were equipment maintenance, retrospective conversion and data communications. The maintenance charges for the central site were divided among the online libraries based on their previous year's circulation. Lincoln Trail underwrote their share of the maintenance until they had completed their retrospective conversion. Each library would be responsible for their individual terminal maintenance. Lincoln Trail provided a subsidy to the libraries based on titles input which helped defray some of the retrospective conversion costs. During this initial phase it was assumed the computer vendor would provide the technical expertise to minimize communications costs.

Following the selection of the computer system, the project coordinator requested the assistance of the vendor in evaluating the equipment requirements for the eight libraries and received an estimate on the number of terminals needed by each library. The proposal stated that each terminal would require a separate telephone circuit and included a recommendation that Lincoln Trail contact the telephone company to get price quotes for line charges. While the central computer equipment was being installed, the project director called the local telephone company to obtain approximate costs for telephone lines to each of the eight libraries. The average cost was \$350-\$500 per month per library. It was felt that this would be unacceptable to the majority of the libraries and posed a serious threat to the success of the project. The telephone company offered the assistance of an Illinois Bell marketing representative. Following several meetings, the telephone company presented three possible telephone line configurations. These configurations were all based on multidrop lines with several libraries sharing a single long line circuit to which they would be connected with much shorter tail circuits. The costs were considerably less than the original price estimate for a single line for each terminal connected to the central computer. Using the information obtained from the telephone company, the project coordinator contacted the computer

vendor. The vendor responded that neither the hardware nor the software were capable of supporting multidrop communication. Since the Lincoln Trail staff had no previous experience with data communications or computers, the information provided by the vendor was accepted without questions. Only two libraries out of the eight had the financial resources to absorb the estimated telephone costs. Since the original purpose for the installation of the computer was the development of an online union catalog, the participation of only two libraries was totally insufficient.

At the point when it was felt there were no alternatives, we received the aid of our largest academic library, the University of Illinois. At the same time that Lincoln Trail was beginning its automation project, the University of Illinois was implementing the Library Computer System (LCS) at both the Urbana campus and the two Chicago campuses. It had already been decided to expand LCS to include other academic libraries in Illinois. They were faced with even greater telecommunications charges than Lincoln Trail since that computer system was to be based in Chicago and participating libraries were located throughout the state. Therefore, the Lincoln Trail computer coordinator contacted the University Computer Services offices and requested information on how the data communication network for LCS was being planned. In response, we received information about telephone service which could be ordered through the State of Illinois. The state had contracted with Illinois Bell for a data circuit service called TELPAK, a service which provided discounted line charges. Any telephone line less than ninety miles long was a flat \$90 per month. The furthest library was just under ninety miles from Lincoln Trail headquarters. It was decided to order all the telephone circuits with the exception of those located in Champaign and Urbana through TELPAK. The \$90 per month charge was within the budget limits acceptable to the libraries.

Terminal equipment was then ordered from the computer vendor. The terminals which were ordered were to be used for data entry. None of the eight libraries had been OCLC users and the funds for contracting with a retroconversion service were not available. This meant each library would be required to manually key in all the bibliographic data contained on their shelflist cards. Realizing that under the best of circumstances this would be time-consuming and labor-intensive, the initial equipment specifications were for terminals operating at a minimum of 1200 baud or 120 characters per second in order to provide sufficiently rapid response time. After placing the first equipment order, Lincoln Trail was informed that the main computer and modems were incapable of a rate faster than 30 characters per second. Not having any alternatives, the timetable for data entry was revised to allow more time. The telephone lines were ordered to support 300 baud, two-wire service.

Before the terminals were installed, the vendor notified Lincoln Trail of a new communications device which had been added to their product line—eight-channel multiplexers. The multiplexers would enable a library to operate a maximum of eight terminals using one telephone line, all at thirty characters per second. Although the purchase price and monthly maintenance charge were high, two libraries decided to purchase the multiplexers in order to decrease telephone line costs.

Following the installation of the terminals and multiplexers a series of events took place that were critical to the decision to discontinue relying on the computer vendor for data communications needs. Six months after the terminals were in place, an analysis was conducted to compare the actual rate of data entry with the rate that had been projected. Even after making allowances for the slower transmission speed, the actual rate was much too slow. This was accounted for in two ways—terminal failure and central processing unit (CPU) downtime. The CPU downtime was resolved by having a complete set of spare parts placed at Lincoln Trail. The terminal downtime was a more difficult problem. When a terminal failed, the unit was shipped to the computer vendor. Instead of the unit being replaced immediately with an equivalent terminal, the library had to wait for the original terminal to be repaired and returned. This process could take up to four weeks during which time data entry was curtailed or discontinued, depending on how many terminals were still in place. Although Lincoln Trail felt that this was an unacceptable situation, maintenance was being paid to the computer vendor and there was no known alternative method of repairing the equipment.

Shortly after the analysis was conducted, the multiplexers began to fail. Again, when the unit failed it had to be shipped back to the vendor for repair. This was a serious problem because without the multiplexer, none of the library's terminals were operable. The multiplexers were located in two of the largest libraries with many titles to input. The project coordinator requested a copy of the operating manual in an attempt to do some on-site troubleshooting. This was not successful because no one on staff was familiar with data communications protocols and the equipment had been modified, making the manual inaccurate.

Another factor which resulted in the decision to develop our own network was the formation of an Illinois consortium of higher education institutions. Its purpose was to negotiate discounted prices for all types of computer equipment and supplies. As an affiliate of the University of Illinois, Lincoln Trail was able to become a member of the consortium and we began to compare consortium prices with those charged by the vendor. The difference was significant.

Finally, the vendor announced that the computer hardware could be upgraded to support 120 characters per second transmission. This necessi-

tated the upgrade or replacement of terminals and multiplexers. It was decided to proceed with upgrading the central computer and to evaluate alternative sources for terminals and multiplexers.

By doing some cost comparisons it was determined that the terminals purchased from the computer vendor were five times the discounted price available through the consortia. Taking into account the purchase of a pair of modems, the consortium price was still 50 percent less. It was estimated that twelve months of vendor maintenance totaled the entire replacement price of a new terminal purchased through the consortium and that difference would become more dramatic over time, since the vendor's maintenance charges increased 10 percent annually. It was decided to discontinue purchasing simple keyboard display terminals from the vendor, discontinue vendor-supplied maintenance, and upgrade all the terminals transmission speeds. The libraries would pay Lincoln Trail a much reduced maintenance charge which would be used to purchase spare equipment. It was also decided to return the multiplexers for a credit on the central site maintenance and replace them with units that could be repaired locally.

As was stated previously, there was no one on staff with prior data communications experience. Therefore it was decided to purchase exactly the same type of terminal as that marketed by the vendor since it was known they interfaced with the computer. In addition, these terminals could be repaired locally at reasonable cost. Journal articles that reviewed and compared multiplexers were obtained and, based on these reviews and recommendations from the university's computer services office, it was decided to purchase units manufactured by a local company. These units were inexpensive and could be easily upgraded to accommodate more terminals without requiring total replacement of the multiplexers. The manufacturer was willing to perform on-site maintenance and provide replacement units if necessary.

The first step was to upgrade all the telephone lines to allow faster transmission rates. We then replaced all the terminals which could not operate at a faster speed. In order to upgrade the terminals that could operate at a faster speed, the modems were replaced. Although this was an expensive undertaking, money would be saved on maintenance charges and data entry rates increased.

It was at this stage that the first major problem was encountered. Prior to this, terminal equipment supplied by the computer vendor had been installed by their service personnel. The principles of installing terminals were understood by the staff, but not the actual method of installation. Since the computer and modems all required RS-232 connectors, this meant Lincoln Trail staff now had to know what wires on the data cable were soldered to what pins of the RS-232 connector. The pin assignments

varied with the terminal model. The vendor terminals had been modified so that they required nonstandard pin assignments. The terminals connected to the multiplexers required still another pin setting. The off-the-shelf terminals required a third arrangement. Since the principles of RS-232 were not understood, the logic for why some pins were used in certain settings was not understood. In a trial-and-error method, several terminals were installed. However, it was extremely time-consuming and frustrating for both the libraries waiting to have the terminals installed and the staff trying to install the equipment. If the equipment did not work at installation, the staff had no way of knowing if it was the terminal, the modem or the telephone line. Multiplexers caused even greater confusion. The problem was solved by the project coordinator who installed one terminal in each type of situation, trying different pin assignments until one worked. A chart was then made which outlined the color wire that needed to be soldered to each pin for different types of terminals. Although the wire colors have no real function in establishing the communications connection, it was a simple means for the staff members to remember how to install a terminal.

There is another kind of connection that needs to be made before the communications link is complete. The cable that carries the incoming and outgoing data between the modem and the telephone line needs to be properly attached to the telephone interface device. Each data circuit consists of four wires—two for incoming data and two for outgoing data. Typically, the telephone interface consists of a small box at which point the four wires terminate. Each wire is color coded and is wrapped around a screw in the interface box. Each screw has a symbol next to it which indicates the color wire from the modem's data cable that needs to be placed on top of the incoming telephone wire. Supposedly, if the person installing the terminal correctly matches up the colored wires the connection is made. This connection needs to be made at both the terminal site and the central computer. Unfortunately it was not that simple.

There are four different telephone companies in Lincoln Trail's nine-county area. Each of the four telephone companies uses a different type of termination box although the principles are the same for all four types. Two of these companies provide service to areas that are primarily rural and therefore have had very little experience installing data circuits. This resulted in servicemen from the telephone companies being unfamiliar with the proper installation of the termination box therefore making the color coding unreliable. This complicated the situation for the Lincoln Trail support staff responsible for installing the equipment and slowed down the installation process.

Rather than waste time trying to bring logic to an illogical situation, the project coordinator contacted the multiplexer manufacturer. The mul-

tplexer manufacturing representative recommended the purchase of a telephone handset with test leads in place of the standard cord. The leads could be held up to a pair of termination screws and if there was a tone from the computer it could be heard over the telephone. Then the LTLS staff member would then know what wires from the modem to connect to what terminating screws.

Based on this success, we began to rely less on guesswork and more on the advice of local vendors. Also, on recommendations from local business and representatives from the University of Illinois, we began to develop a supply of professional tools with which to install the equipment and troubleshoot equipment failure. We stopped soldering connections and bought a terminal installation kit which allowed the Lincoln Trail staff to perform the installation quickly and be assured of better connections. The soldering procedure had involved two staff members and frequently the connections were not solid. We began to buy data cable in 500-foot reels which was sold to the libraries on a per-foot basis when they had equipment to be installed. One library purchased a printing terminal which they wanted to have connected to the central computer. This required an entirely different pin configuration than any of the previous terminals. After contacting the vendor who sold us the terminal installation equipment, we leased a breakout box for an afternoon. The breakout box told us exactly what pins need to be connected and the terminal was operating in less than two hours. As the staff spent more time working with the equipment, they began to want more information about the basics of data communications. The multiplexer manufacturer sent a service representative to give a presentation on the basics of telephone service and troubleshooting telephone problems. In addition, two videocassettes which explained the basics of RS-232 and the operations of a breakout box were leased. Staff members were then able to read and understand the equipment manuals before installation and decide how they needed to be configured.

As we became more successful in installing and maintaining data communications equipment, the network became more sophisticated. We now have many different brands of video terminals and printing terminals in our libraries. The choice of terminal depends on the application and availability of local service. With the divestiture of AT&T we became concerned about the stability of TELPAK, and began recommending that all libraries with more than one terminal consider the purchase of a multiplexer. We now have multiplexers ranging in size from sixteen-port units to two-port units. The largest libraries recover the costs for the multiplexers in ten months while the two port units reach the break-even point in fifteen months. We are currently installing microcomputers in smaller member libraries. The microcomputers will be used to record

circulation transactions on a floppy disk which will be downloaded via a WATS line on a daily basis.

Telephone and equipment costs have dropped over the past two years. In 1981 telephone costs were \$1270 per month to support twenty-eight terminals. In 1984 telephone costs are \$1500 per month to support eighty terminals. With the exception of laser scanner terminals and lightpen terminals, all equipment is maintained locally. All malfunctioning equipment is replaced or repaired within twenty-four hours.

There are still two outstanding problems—i.e., dealing with local telephone companies and setting up a consistent procedure for each type of equipment in the field. Of the two, the telephone service has been the longest-lasting problem. As stated earlier, there are four telephone companies in our area. Because all of the service originates in Champaign, the telephone service is ordered through Illinois Bell. Until 1 January 1984, whenever there was a problem with a telephone circuit we had to call Illinois Bell. Then the Illinois Bell staff had to contact the local company where the library was located and work with their staff in correcting the problem. One telephone line was out of service for five days while Illinois Bell and the local company tried to determine the problem. Finally, an Illinois Bell representative traveled to the local company switching center and discovered the problem—the circuit had been disconnected. It was back in service five minutes after the problem was discovered. Of seven data circuits installed in 1983, five were installed incorrectly and required at least one return visit before the problem was resolved. Since January 1984, we have faced even more confusion. For some circuits we call Illinois Bell, for others we call AT&T. When we contact AT&T with a problem, they are sometimes slow about contacting the local telephone company to dispatch servicemen. The second largest library was without telephone service for three days because the local telephone company dispatched only one repairman where two are required to thoroughly test a line. When he could not find a problem the account was closed even though the problem was not resolved. It required three more calls before two servicemen were dispatched. Again, they found the problem in less than thirty minutes and the library could begin using the system immediately afterward. In response to this, we have been purchasing more sophisticated multiplexers and modems that have greater testing capability. With this equipment we can perform a number of tests at Lincoln Trail before calling the telephone company resulting in faster response from the telephone company.

Because there is such a wide range of equipment in the field, both local library staff members and Lincoln Trail staff members were experiencing trouble spotting problems simple enough to be repaired either at the library or at Lincoln Trail. In response to this, we are now completing a

checklist specifically for each brand of terminal and multiplexer used at Lincoln Trail. Each library will receive a copy of the checklists for the equipment which they own. These checklists outline steps they can perform to try to correct the problem. Lincoln Trail will have a different checklist consisting of steps to take after the library staff has tried to resolve the problem. It is hoped that this will be a simple, consistent method of determining causes for equipment failure, thereby enabling us to resolve the problem in a timely fashion.

Although the network has expanded over the past three years and member libraries have saved money on telecommunications, equipment and maintenance, we do not feel that we have the perfect solution. Over the next year we will be investigating more sophisticated methods of eliminating or reducing data communications charges. Some methods that are being considered include shared lines with other state or local agencies, more effective use of dial access for smaller libraries and cascading multiplexers. It is very likely that we will have to sacrifice some response time for lowered costs, but if TELPAK is discontinued this will be our only choice.

If someone were to ask me if the original decision to forego vendor support of our equipment and data communications needs was the correct decision, I would have to reply that it was very appropriate for us at that time. First, there was an operations staff responsible for maintaining and running the computer. It was a logical extension of their job descriptions to include equipment installation and maintenance. This meant it did not require hiring additional staff. Second, because member libraries are small and have limited funding, it was absolutely essential that costs be kept at a minimum. By taking advantage of price discounts from local vendors and state purchasing plans, we were able to ensure that libraries could afford to automate. By having equipment maintained and repaired locally, maintenance costs were kept at a minimum and equipment downtime eliminated. Because we were not limited to the vendor's product line, we were able to buy more flexible, powerful data communications equipment that was suitable to a wide range of libraries. Finally, although Lincoln Trail staff members did not have sophisticated technical backgrounds, we were able to locate people in the area who did have the knowledge we required. At that time the staff of the computer vendor did not have the skills we needed. A major disadvantage was the amount of time we spent obtaining the expertise to maintain the network. The end result has been a computer system that will be used by twenty-three libraries within the next year—almost 25 percent of our members. It has become a viable option for all types and sizes of libraries and has allowed all of them to consider automation in their future.