AUTOMATED STORAGE/RETRIEVAL AND RETURN/SORTING SYSTEMS

By Richard W. Boss

While librarians don't like to think of libraries as warehouses for books, there are a number of technologies developed for warehouses that can be used in libraries. Among these are automated storage/retrieval (AS/R) and return/sorting systems, collectively known in the warehousing industry as materials handling systems. When used in libraries, the former technology consists of computer-driven robotic retrieval of densely stacked storage bins, thus cutting down on the amount of space required to house a collection. The latter consists of book drops, conveyors and sorters that cut down on manual handling of books and other library materials being returned.

Both technologies are cost effective only in relatively large libraries. A basic AS/R system stores up to 1.2 million items, although most are initially loaded with fewer than 600,000 items. A basic return/sorting system is designed to accommodate an annual circulation of at least 250,000 items.

AUTOMATED STORAGE/RETRIEVAL SYSTEMS

Automated storage and retrieval systems (AS/Rs) are complex and expensive, typically costing millions of dollars. While more than a dozen companies manufacture AS/Rs, only one, H.K. Industry, is known to have targeted libraries. The description of the technology is, therefore, based on its product--one that has been installed by several libraries in North America, including the University of California at Northridge in 1991 and the University of Nevada at Las Vegas in 2000.

Items to be stored are assigned to and placed in a bin and each bin is assigned a location; the bins are then placed in an industrial rack assembly. A large assembly may be up to 40 feet high and 90 or more feet long. A computer-controlled mini-load crane (an electrically-driven forklift-like mechanism running on floor-mounted and overhead rails in aisles between racks) moves into and out of the rack assembly removing and replacing bins. When an item is requested, the bin location is sent to the mini-load crane, which retrieves the bin and carries it to the operator. The operator, guided by a visual display on a PC-based workstation, takes the item from the bin and places it on a conveyor or in a pneumatic tube for delivery to the service desk. Elapsed time for retrieval from the AS/R can be well over a minute; but, by taking advantage of the data maintained by the computer, high-demand items can be moved to the front of the rack assembly after they have been used and returned. In a library application, 40 retrievals per hour per operator is common, but it can be as high as 100 if everything which has circulated recently is in the nearest bins. Returning the item to storage follows the same procedure in reverse and requires a comparable amount of time.

[Contact: HK Systems, 2655 St. James Drive, New Berlin, WI 53151, Telephone 800-424-7365, fax 262-860-7014, Web: www.hksystems.com].

Benefits

There are several benefits to AS/R Technology, among them low storage space requirements, high patron success rates, good collection preservation, and low ongoing costs.

Storage Space Requirements

The major benefit of AS/R technology is a dramatic reduction in library materials storage space. Storage of 1.2 million books and book-equivalents requires only 8,000 square feet as compared with 120,000 square feet using conventional shelving. The "fullness" of the shelves can have a negative impact on use of materials in open stacks. At 85 percent full, it is increasing difficult to reshelve items and keep shelves in order. In contrast, there is no negative impact related to the "fullness" of an AS/R bin-even at 100 percent. Success Rate The "success rate" of patrons is increased when AS/R technology is used to store books and other library materials. The success rate is the percentage of materials sought which a patron is actually able to locate. It is the product of the "holdings rate" and the "availability rate." A library with extensive holdings may have 90 percent of what patrons seek in the catalog, but if only 50 percent of the catalog holdings can be found, the success rate is only 45 percent. On the other hand, a library with a holdings rate of 80 percent and an availability rate of 90 percent would make patrons 72 percent successful.

A major factor in achieving a high availability rate, and thus potentially a high success rate, is the availability of materials either on the shelves or identified in circulation records as outstanding to a known patron and subject to recall or reservation.

Any open access approach is subject to items being out of order as the result of reshelving by patrons, the intentional misplacement by patrons seeking to restrict access to all but themselves, or even theft. Since patrons do not have access to the AS/R and the system retrieves only the bin in which the inventory shows the item is to be housed, there is virtually no chance of losing track of an item.

Collection Preservation

A collection must be protected not only against theft, but also against heat, humidity, and seismic activity. Heat and humidity can be controlled by a properly adjusted HVAC system but any collection open to patrons must be controlled within a range comfortable for humans, 65-75 degrees and

40-60 percent humidity. Areas closed to patrons can have the temperature reduced to 50 or lower and the humidity to 30 percent, thus extending the life of the materials. Each degree below 65 adds at least a year to the life of printed materials.

The extent of seismic damage is very much dependent on the strength and flexibility of the shelving or other storage equipment. Bracing is necessary to limit lateral movement and crossbars to reduce the risk of the domino effect if one unit topples against another. Theoretically, AS/Rs are structurally better able to withstand seismic activity than conventional open stack shelving. The earthquake that struck the University of California at North Ridge demonstrated the ability of an AS/R to withstand extremely strong natural forces. The system sustained only minor damage, and no books were damaged. A considerable amount of conventional shelving collapsed and even that which withstood the quake spilled large numbers of books into the open aisles between ranges.

Low Ongoing Costs

The cost of maintaining 8,000 square feet of space with a ceiling height of 40 feet (HVAC and custodial) is approximately $64,000 per year. While custodial cost is low because the area is small and not open to the public, the great ceiling height and lower-than-average temperature and humidity in an AS/R require more HVAC cost per square foot than open access areas.

Maintenance of the equipment costs roughly $40,000 per year, plus an allowance of about $5,000 per year for computer replacement. In addition, an onsite technician is highly desirable. A technician will cost over $41,000 per year (including 23 percent for fringe benefits).

An AS/R will require at least one operator each hour a library is open. One should also assume that peak activity will be at least three times the average, therefore, requiring two or three operators during some hours. Assuming that the materials in the AS/R have been selected on the basis of low frequency of use, it is likely that no more than 100,000 circulations will occur each year--8 percent of the total number of items. In open stacks, the in-house use is 1.75 times the circulation. Using the same ratio-an assumption which would be valid only if patrons were encouraged to request any title believed to be relevant to their inquiry-there would be as many as 275,000 retrievals and 275,000 "rebinnings" in a year. It would take 13,750 hours of staff time to handle this workload. The actual number of hours would be somewhat higher because of peaks and valleys in the activity. If one assumes 16,000 hours, the cost for 8.0 FTE (full-time-equivalent) staff would be $160,000 per year--a figure that assumes an hourly cost of $10.00.

In contrast, the costs of maintaining 120,000 square feet of floor space (HVAC and custodial) is approximately $600,000 per year, however, the shelving itself will not require maintenance or repair for twenty or more years. Reshelving and shelf-reading will require a minimum 20,000 hours a year (10 FTE) (at a cost of $200,000 a year.

The total annual savings realized with an AS/R storing 1.2 million items is approximately $468,000 ($340,000 as against $808,000 per year).

Drawbacks

There are a number of drawbacks to AS/R technology, including high start-up cost, loss of "browsability," inappropriate selection, and inadequate prompting.

High Start-up Costs

Storage capacity for the 1.2 million volumes (books and book-equivalents) requires a system with six cranes aisles, six end-of-aisle workstations, 13,260 bins, and an electric track vehicle delivery system. The system is controlled by up to six PC-based workstations. Equipment cost is approximately $2,220,000-a figure that includes the ETV (electronic tracking vehicle), and a mechanical delivery system between the AS/R and a public service desk.

While there is considerable disagreement among architects about the cost of building a 40-foot high chamber with a floor-loading of 300 pounds per square foot, the median cost quoted by architects consulted is $200 per square foot. The total space needed to accommodate 1.2 million volumes is 8,000 square feet; thus, the building would cost $1,600,000.

The total capital cost for an AS/R is approximately $3.820,000.

If fewer than 1.2 million books need to be stored, the AS/R should be designed for 1.2 million capacity so that the system can be expanded with only the addition of crane aisles, bins, and end-of-aisle workstations. The cost for an AS/R that is configured for 40 percent of ultimate capacity would be approximately $3 million.

Entering records for AS/R stored material into the system will cost a minimum of $.10 per item, or $120,000 (using the 1.2 million figure). While all records are entered into a library's automated library system, AS/R also requires the entry of records and bin location information into the AS/R computer.

Despite the high start-up costs, AS/R is cost effective for large libraries because it is considerably less than providing for the same number of volumes on conventional shelving. The total space needed to accommodate 1.2 million volumes on conventional shelving is 120,000 square feet. Total start-up cost for conventional open stack shelving for 1.2 million volumes, including the building and the shelving all cost elements, would be approximately $21 million--a figure based on a construction and equipment cost of $175 per square foot.

Browsability

"Browsability" is the opportunity to browse the shelves to look not only for that which has already been identified, but for related materials. This serendipitous discovery factor is important to many patrons. On the other hand, many patrons would like to limit the retrieval time. They want to obtain a few titles quickly. Unless a library makes a good case for the use of AS/R, the decision to install it can be controversial.

The quality of bibliographic access is always an issue, but particularly so if patrons cannot examine materials on the shelves. Even a catalog that conforms to current cataloging code (Anglo-American Cataloging Code II) does not answer all questions a person searching the catalog may have. For example, one California State University at Northridge faculty member interviewed by the author was using materials written in Greek and the online patron access catalog was, in his opinion, not complete enough for him to determine if a book was the translation of a specific edition he was seeking. In an open access environment, he would go to the stacks to examine materials and browse, but in a restricted access environment the catalog must substitute both for known item look-up and for browsing in the stacks. He was unaware that there was no limit on the number of items he could request from the AS/R and that the staff had been instructed to make no comments about a request for a large number of items.

If the bibliographic records were to include links to the tables-of-contents of monographs, the need for browsing would be substantially reduced.

Inappropriate Selection

An obvious choice for an AS/R are materials which have not circulated for a long time, but equally suitable are materials not traditionally subject to browsing in open stacks such as bound volumes of journals. The greatest source of frustration for patrons is the storage of very popular materials in an AS/R. Rather than finding best sellers on special display racks or in the open stacks, patrons must submit a special request.

The return to the open shelves of materials which circulate two or more times in rapid succession from the AS/R has been an effective way of limiting patron frustration.

Inadequate Prompting

It is essential that there be well-designed prompt screens in the online patron access catalog to alert users to the fact that an item is readily available onsite in an AS/R, subject to request and retrieval in a matter of a few minutes. When the promps are inadequate and patrons go to the open shelves looking for materials, there can be a serious public relations problem.

Mechanical Failure

The AS/R's life expectancy is 20 years or more, although moving components will require regular servicing, and replacement of computer equipment should be anticipated at least three times during this lifespan period. Mechanical failure will occur, therefore, it is essential that library staff be able to handle most problems. Ideally, a library would have an AS/R technician on staff.

Materials that cannot be retrieved because of mechanical failure of retrieval equipment are worse than lost as patrons may blame the library staff for the failure.

98 percent reliability-the reliability level of AS/R systems-is high by most standards but, in a library open 100 hours per week, the loss of access two percent of the time could be two key hours during the week. Most of the downtime consists of jammed or misaligned bins; a problem staff can fix within minutes by merely giving the robot a different address past the problem point. That allows the technician time to schedule his/her work so that the most critical problems are addressed first.

RETURN/SORTING SYSTEMS

There are two vendors of return/sorting systems for libraries: Tech Logic in the United States and Codeco in Denmark. The latter has installations in Belgium, Denmark, Finland, France, Germany, Norway, the Netherlands, and Sweden. It has established a North American office in Canada. It first demonstrated its product line in the United States at the 2002 ALA Annual Meeting. While the components of the two systems are similar, the point at which materials are discharged and re-sensitized is different. Tech Logic performs these functions as part of the sorting process that follows the return; Codeco has incorporated these functions into the book drop.

Return/sorting systems are interfaced to an automated library system via TCP/IP under the SIP 1 or SIP 2 protocol. All types of security strips are accommodated, including electro- magnetic, RF, and RFID.

A return system can be utilized by a library that has an AS/R, but none is known to have done so.

Tech Logic

Tech Logic's return/sorting system moves books and other library materials from wall-mounted return drops via conveyors to machinery which squares the books and other library materials, scans the barcode labels to discharge them, resensitizes the security targets, and rotates and places them on the shelves of special carts ready to be reshelved. A "petit" system that is limited to a book return and conveyor has recently been introduced as an option.

The Greensboro Public Library of North Carolina was the first North American library to install a Tech Logic return/sorting system in late 1998. Subsequent customers include the public libraries of Boulder (CO), Carmel (CA), Council Bluffs (IA), Dakota County (MN), Eugene (OR), Hennepin County (MN), and Topeka (KS). The company has recently signed an agreement with the Seattle Public Library for a system that includes a 72-bin sorter for the main library, plus a 40-bin sorter for interagency movements of materials. The contract, which totals $5.7 million, also includes a migration to RFID for all 40 agencies.

[Contact: Tech Logic Corporation, 1616 Gervias Avenue, Maplewood, MN 55109-2128, Telephone 800-494-9330, fax 651-747-0493, Web: www.tech-logic.com].

Codeco

Codeco has offered return units without sorting capabilities for several years. It recently paired its MARK-4 return unit with a sorting unit designated the MARK-10. The MARK-4 accepts library materials into a vertical opening located beside a color monitor after the patron has inserted his/her card into a reader, scans the barcodes and discharges the materials, re-activates the security tags, and prints out a receipt. If a library wishes, the unit can operate without requiring the insertion of the patron card.

If a MARK-10 sorting unit is attached to a MARC-4, the books and other library materials are sorted into four to 37 storage bins by category. A library has the option of configuring a system with only two bins, in which case the returned items are sorted as to be reshelved and to be placed on the hold shelf. The two units can be at some distance from one another, even on separate floors.

[Contact: Codeco North America, 10230 125 Street NW, Edmonton, AB, Canada,T5N 1S9, telephone 888-809-0099, fax 780-455-7068, Web: www.codeco-library.com].

Benefits

The greatest benefit of return/sorting units is the reduction in ongoing operating costs as the result of a significant reduction in the handling of returned items by library staff. Staff do not have to empty book drops, move materials, check them in, resensitize them, or place then on carts or in bins for shelving. Anecdotal evidence suggests that the initial investment can be recovered in as few as four years.

Drawbacks

Relatively high start-up cost is the greatest drawback to return/sorting systems. Return/Sorting systems are relatively expensive, typically at least $70,000 for a basic return system and $250,000 or more for a return/sorting system depending on the size of the installation. A $250,000 return/sorting system would have no more than five bins, among which might be adult, children's, and A-V. It is a good idea to have a "reject" bin for items that the sorter cannot categorize. A 60-bin system would cost a minimum of $750,000.

Return systems are typically installed in libraries which have at least 250,000 circulations a year; return/sorting systems in libraries which have at least 750,000 circulations per year.

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