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Selecting Link Resolver and Knowledge Base Software: Implications of Interoperability

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Abstract

Link resolver software and their associated knowledge bases are essential technologies for modern academic libraries. However, because of the increasing number of possible integrations involving link resolver software and knowledge bases, a library's vendor relationships, product choices, and consortial arrangements may have the most dramatic effects on the user experience and back-end maintenance workloads. A project team at a large comprehensive university recently investigated link resolver products in an attempt to increase efficiency of back-end workflows while maintaining or improving the patron experience. The methodology used for product comparison may be useful for other libraries.[1]

Keywords: link resolvers, knowledge bases, criteria, evaluation, library systems, electronic resources, OpenURL

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Selecting Link Resolver and Knowledge Base Software:

Implications of Interoperability

The term "link resolver" refers to specialized software used to provide context-sensitive links among the panoply of systems that compose a modern library's electronic collections. Because libraries provide access to the full text of electronic books and articles through a variety of subscription and access options, the most important function of link resolver software is to provide users accurate links to full text throughout the library's electronic library collection. The software interacts with a "knowledge base" maintained by the library so users don't need to know anything about the library's business arrangements. Link resolver software can also generate links into systems such as the catalog, repositories, and bibliographic citation software. Ultimately, the software simply provides a common framework for sharing bibliographic metadata between systems.

The history of link resolver software began in the late 1990s at the University of Ghent, where Herbert Van de Sompel and colleagues developed "Special Effects" or SFX. Working with ExLibris, Van de Sompel also developed the OpenURL framework to provide "a standardized format for transporting bibliographic metadata about objects between information services (Van de Sompel & Beit-Arie, 2001). NISO standardized the OpenURL protocol in 2004 as ANSI/NISO Z39.88 and many vendors developed and released their own link resolver software. For readers who wish a fuller historical overview, a 2010 *Library Technology Reports* was devoted to link resolvers. Readers who are unfamiliar with the steps involved in link resolver link creation are directed to Kasprowski (2012), who provided an excellent description and diagram of how links are created.

At James Madison University (JMU), the library maintains three knowledge bases for over 198,000 journal holdings (this figure includes individual title subscriptions, titles in journal collection packages, and titles in aggregator databases). Serials Solutions' 360 Core serves as the library's primary journal knowledge base and public A-Z list while Serials Solutions' 360 Link is currently used as the library's link resolver. Collections are also maintained in OCLC's Worldshare Management Services for the library's Interlibrary Loan Direct Request service. Library-specific holdings are maintained by the JMU library while holdings for shared consortium collections are maintained by the Virtual Library of Virginia (VIVA). JMU also maintains a separate pseudo-knowledge-base in EBSCO to support the "Full-Text Online" checkbox. Separately, the library also uploads its journal holdings to EBSCO from Serials Solutions once per month.

Given that uploading holdings data to and from Serials Solutions' 360 Core and trouble-shooting Serials Solutions' 360 Link resolver across all providers is time-consuming, JMU sought to investigate efficiencies related to using an EBSCO or OCLC solution. EBSCO's Full-Text Finder had potential to integrate better with EBSCO Discovery Service and other subscribed EBSCO databases for an improved patron experience, while OCLC's link resolver is integrated with OCLC WorldShare Management Services, a service already maintained for ILL Direct Request Article Linking. Furthermore, both EBSCO and OCLC resolver products are complimentary with the library's current vendor subscriptions, meaning the library would realize significant annual savings were it to discontinue its subscription for Serials Solutions' suite of products. Another major vendor's link resolver product (Ex Libris's SFX) was not reviewed because it would add an entirely new vendor to the JMU portfolio, thus negating much hope of an efficiency gain for JMU.

In 2012, Marshall Breeding predicted a trend where libraries choose link resolver software based on their integration with discovery services or automation platforms. Based on an evaluation of link resolver software, this article provides more specific insights into this trend and discusses ways in which software may continue to challenge the potential of such integration.

Literature Review

This literature review first presents an analysis of how metadata standards, vendors' metadata quality, and link resolver software have developed over time to improve link resolver success. Second, technical evaluations of full-text linking are compared and contrasted, with an attempt to determine whether a common definition of link resolver success has been developed and to explore the extent to which link resolver success is improving over time. Finally, other types of product evaluations are analyzed to identify additionally important criteria for product evaluation.

Articles about Link Resolver Technologies and Standards

The success of link resolvers is dependent on 1) complete, consistent, accurate citation metadata, 2) accurate knowledge base holdings, and 3) accurate link syntax as generated by the software. Multiple parties may be responsible for deficiencies across the three areas.

Libraries have reported problems with the metadata used by link resolvers for years (Machovec & Stockton, 2004; Beall, 2005; Livingston, Sanford, & Bretthauer, 2006; Wakimoto, Walker, & Dabbour, 2006). These problems have affected the success of link resolvers: a 2007 survey with 118 respondents, mostly North American academic libraries, found that 72% "agreed or strongly agreed" that there was a significant problem with generating complete, accurate links (Culling, 2007, p. 33). Chandler, Wiley, and LeBlank (2011) researched the

question of why OpenURLs fail so frequently, and found problems were due to variation in

ISSNs, incorrect volume, issue, and page number information, and incorrect dates. In a grant-

funded study (Chandler, 2009) they built a system to analyze and score 800,000 OpenURLs from

the L'Année Philologique database, and were able to provide feedback to the vendor about

common types of errors for the database (Chandler et al., 2011).

Although problems remain, the field has progressed substantially. Work by groups like the

UKSG / NISO Knowledge Bases and Related Tools (KBART) working group has improved

metadata accuracy among content providers and streamlined metadata exchange processes to

minimize errors (National Information Standards Organization [NISO], 2016b). KBART, for

example, has outlined sixteen fields for content providers to provide additional information that

would improve knowledge bases (Anderson, 2014; Glasser, 2012; NISO, 2016b). More recently,

NISO IOTA (Improving OpenURLs Through Analytics) offered strategies to measure OpenURL

quality and decrease source URL errors (2016a), and NISO PIE-J (Presentation and

Identification of E-Journals) tackled the issue of how ISSN and journal title changes break links

for patrons (Glasser, 2012; NISO, 2016c). Because of these improvements, the research team at

JMU decided to check a sample of citations from the top-used sources in order to test full-text

linking success, but did not conduct an extensive empirical comparison of metadata quality

across vendors' knowledge bases.

Articles Reporting Technical Evaluation Results

While metadata quality is important, the logical rules for creating OpenURL links using that

metadata also play an important role in successful full-text linking. Because libraries do not have

access to vendors' software code, studies have conducted comparisons of how well vendors'

products make full-text links by using a "real-life" approach, selecting a sample of citations and

following the pathway from a database to the full text. This section reviews the methodologies,

definitions of success, and findings of several such studies. Table 1 provides a summary of link

resolver software tests for the reader's convenience. Because of the different methods and

definitions of success, the study results are not quantitatively comparable with one another.

Table 1. Summary of Link Resolver Software Tests

Study	Vendors	Document types	Number of source databases tested	Sample size (number of citations)	Success rate
Wakimoto, Walker, and Dabbour (2006)		Multiple, not specified.	8	266	78% (SFX)[1]
Jayaraman and Harker (2009)		Journal articles	7	380	89% (2006) 91% (2009)[2]
Trainor and Price (2010)		Journal articles, book chapters, books, dissertations, newspaper articles	7	351	93% (SFX at CUC) 70% (SFX at EK)[3]
Herrera (2011)	Serials Solutions, WebBridge	51 articles, 3 books, 7 dissertations	NA	380	48% (WebBridge) 89% (360 Link)[4]
Chisare, Fagan, Gaines, and Trocchia (2015)	EBSCO Full Text Finder, OCLC	Journal articles	7	117	82% (FTF) 83% (OCLC)[5]

1. Menu information was correct (either "no links to full text" or successful link to full text).
2. Complete article or page with link to full text article.
3. Menus that offer full text contain at least one link to full text
4. Direct links to full text.
Successful linking to full text (e.g., sometimes direct linking, sometimes through the menu)

Wakimoto and colleagues (2006) performed "likely keyword searches" in eight databases and clicked on the SFX button for the first thirty unique results, eliminating citations from the same journal or magazine, for a total sample of 266. Their criteria for software success was that the link resolver menu information was correct (either "no links to full text" or successful link to full text). Their definition of full-text linking success included situations where patrons had to do more searching on the target web site, a decision which later researchers critiqued. The authors noted that one out of every three links to full text required the user to search the target database to find the full text. They described the reasons for failure as mostly "the result of incorrectly generated OpenURLs from source databases, thus sending incorrect information to SFX" (p. 133), thus, not problems with the link resolver itself.

In another study of the SFX link resolver's accuracy, Cindi Trainor and Jason Price (2010) suggested expanding Wakimoto and colleagues' scope of "failed links" to include those where the user was forced to search or browse for full text, since users are often not willing or able to perform these steps to find full text. They proposed a better way to evaluate link resolver success would be "how many resolver menus that offer full text contain at least one link that leads directly to accessible full text?" (p. 60). When they applied this "alternative definition," the SFX resolvers in their study were successful approximately 80% of the time. Another interesting finding was the difference between two SFX resolvers at different institutions – CUC's SFX resolver outperformed EKU's SFX resolver at 76% to 64%.

Rather than advancing Trainor and Price's approach of expanding the scope of failed searches, Jayaraman and Harker (2009) returned to Wakimoto et al.'s definition of successful full-text article access as seeing the actual article or seeing a page with a link to the full-text article, including table-of-contents pages for issues. In a 2008 trial study, they found an 89%

success rate with EBSCO LinkSource in linking overall. This compared with a success rate of

58% with their previous link resolver software (LinkFinder Plus). In addition to the success rate

used by Wakimoto et al., Jayaraman and Harker used an "efficiency" rating exploring the

average number of clicks required. For LinkSource, they reported 1.46 mouse clicks per query,

whereas LinkFinder Plus had required just 1.05 clicks per query. Because success was more

important than efficiency, they opted for LinkSource. For a follow-up study, their methodology

began with generating a random sample of 4,000 citations, then using criteria such as whether

the citation was in an indexed source to narrow the sample to 380 citations. They chose seven

sources (e.g., PubMed, Google Scholar) from which to test links. If the source did not index the

journal for a given citation, the item was skipped. For each citation, testers recorded whether

they could access full text, and how many clicks it took to find out whether it was accessible.

The overall success rate was 91%; it varied across sources from 87.69% (PubMed, Ovid

MEDLINE, Gale HRC) to 96.92% (EBSCO Academic Search Premier). They provided a

detailed list of problems; in summary they seemed to reflect known problems with link resolver

software. For most of their examples, they were able to recommend working with one or more

vendors to improve the problem. Although this study's use of clicks per query was interesting,

the fact that the researchers did not continue to use this metric, and the small effect size (e.g.,

1.46 vs. 1.05 clicks per query) suggested not using that metric for the present study. The number

of clicks has also been shown to be a less important variable for user experience than progress

(Nielsen, 2008).

In addition to testing the success of full-text linking with Innovative Interfaces' WebBridge

and Serials Solutions' 360 Link, Herrera (2011) also attempted to correct issues by contacting

the vendor (or fixing the knowledge base, in the case of WebBridge), and conducting a follow-up

test. Herrera used Google Analytics to identify the OpenURLs for their initial sample based on popularity. The study found that only 48% of the articles they tested in WebBridge linked directly to the full text, while 89% of the articles they tested in 360 Link linked directly to full text. In the follow up test, after they had attempted to correct 37 resolver-related issues, there was still a 10% link-resolver failure rate with WebBridge, while the same issues in 360 Link were all resolved (p. 385).

The literature showed no consensus about whether success should be defined as immediate gratification (e.g., seeing a full text article after the first click) or expected to include cases where the user is required to perform follow-up actions, such as browsing a table of contents or performing follow-up searching on a vendor's web site. For this study, the team decided to use an inclusive definition of success, which will be described in the methodology.

Other Types of Product Evaluations

The literature also contains research evaluating link resolvers using methods other than OpenURL evaluations. The link resolver menu and its integration with results lists has received significant attention in the literature; libraries have investigated the user experience with different layouts, logical link presentations, text and labels, and the proliferation of available services that can be accessed from the menu or via links in results lists.

Researchers have shown the importance for link resolvers to link directly to full text rather than stopping on a menu screen. Imler and Eichelberger (2011) assessed undergraduates' use of SFX by having them view a results list and select and print full text for the five most relevant articles, and recording the students' research sessions. Only 24 (62%) of the 39 students successfully printed five articles. Of the 26 students who even clicked on the SFX button, six did not click on "Go" to get to the full article. Ponsford, Stephens, and Sewell (2011)'s usability tests

also supported using SFX's "direct linking" feature to skip the menu. Based on a review of two years of usage statistics, they also investigated the hypothesis that users seldom clicked on links other than those for full text, even when full text was not available. Overall the researchers concluded that users don't care much about the additional features on link resolver menus. However, the benchmarks for determining "how much users care" are unknown and seem to be set arbitrarily by researchers. In Trainor and Price's (2010) study, the researchers were pleased with the fact that the link resolver menu's Google Scholar link was used 6% of the time it was available, and that a "Distance Education Request" link was used 80 times within its first month (p. 12). Thus, findings are mixed as to whether additional menu links are useful, and the criteria used to determine usefulness are relative to the institution's services and goals. For this reason, the present study did not perform usability testing, but rather the team investigated the customizability and capabilities of the link resolver menu to support the potential for making changes in response to user experience study results or local needs for integrations. The "one-click" or direct linking feature was deemed important, as was the ability to add or remove links to desired services.

Other studies investigated the amount of work required to support the link resolver and/or knowledge base. An early study by Livingston, Sanford, and Bretthauer (2006) assessed the functionality and performance of resolvers through a literature review, surveys, and visits to other libraries. They found the amount of staff time spent to customize and maintain resolvers varied widely. For example, 89% of LinkFinder Plus users spent more than 40 hours on customization prior to and post rollout, and .34 FTE on maintenance, but only 6% of Article Linker users spent that much time on customization, and only .25 FTE on maintenance (p. 186). Although the groups' sample sizes were not equivalent, limiting analysis, the study still

illustrates how different products can influence the effort library staff must contribute. Johnson, Leonard, and Wiswell (2015) performed a functional evaluation of the back-end link setup and maintenance of Innovative Interfaces' Web Bridge and EBSCO LinkSource. WebBridge required much more care and feeding by design. The library's initial choice of WebBridge was predicated on consortial ERM arrangements, where schools shared a knowledge base. Upon separating their ERM from the consortium, the library chose LinkSource and noted a dramatic reduction in staff time spent on troubleshooting.

Related to the expenditure of staff time is the quality of the vendor's support. Breeding's (2012) product comparison, based on solicited and publicly available vendor information, described a wide variance in the number of vendor personnel devoted to the products (8 at OCLC, 12 at Serials Solutions, and 29 at Ex Libris and EBSCO). Yet, the number of personnel is only one factor; based on a written survey of libraries for the same study, Breeding found Serials Solutions received the highest satisfaction, responsiveness, and ease of administration scores from libraries despite their lower personnel numbers, although in general the differences between products on survey results was "subtle" (2012, p. 175). Vendor support can also change over time. Just three years after Breeding's study, Koury (2015) evaluated the customer service of Ex Libris for SFX and found their "Total Care" tier of support lacking. ExLibris's turnaround time for responses for incidents in a two month span was most often 6-7 days, with 14 of 80 requests receiving no response from the vendor. Only 10% of requests were responded to within two days. In addition to explaining the importance of link resolver vendor customer service, Koury describes how business relationship problems between third-party providers and resolver vendors (in this case, EBSCO and ExLibris) can hamper success. Koury's article urges libraries not to assume vendor support will be good, and to document response times and customer service

errors in order to be able to present clear patterns of poor service rather than coming across as a customer who is "cranky or difficult after a few anomalous incidents" (p. 153). The present study evaluated vendor support by their responsiveness as well as the representatives' knowledge of their products and relevant technical details.

Improvements in metadata standards, vendors' metadata quality, and link resolver software seem to have improved full-text linking over time and have expanded the suite of services for which libraries use knowledge base and link resolver software. Although establishing a baseline of full-text link success is important, vendors seem to be reaching a threshold of competence (Breeding, 2012), making other aspects of software selection such as customer support increasingly important. While a comparison of link resolver and knowledge base software will be inherently linked to a library's technology strategy (e.g., other system and product decisions), a common set of criteria for evaluation would make a useful addition to the profession.

Institutional Setting and Review Criteria

James Madison University is a public, comprehensive university in western Virginia's Shenandoah Valley (James Madison University, 2016). JMU has about 20,000 undergraduate and 1,800 graduate students, and its mission is "preparing students to be educated and enlightened citizens who lead productive and meaningful lives." At JMU, Libraries & Educational Technologies provides all library services to campus as well as classroom technology, instructional design, online learning, and digital assignments support.

The Link Resolver Evaluation Team at James Madison University was charged with reviewing competitor products to Serial Solutions. The library was generally satisfied with the performance of Serials Solutions 360 Link, but hoped to eliminate back-end redundancy and multiple knowledge bases. Although a competitor to Serials Solutions, SFX was not reviewed

because it would have added a vendor relationship to JMU's portfolio. JMU was also interested

in the opportunities of collaborative metadata management in OCLC, and potential integration of

EBSCO Full Text Finder and EBSCOnet.

The team envisioned its work as being split into two phases. First, evaluation of needed

product features and back-end administration capabilities would be conducted to determine

which products met the baseline requirements of Technical Services units. Since user satisfaction

with the current software was deemed acceptable, only if back-end advantages were found to

support a change in software would public services be involved. Because the team found back-

end administrative requirements were not met, the project concluded after the first phase.

Criteria

Although the most important function of link resolver software is generating links to full text,

the power of the OpenURL standard and the valuable information in the resolver's knowledge

base have been harnessed for many other applications, such as downloading title lists that

include both subjects and holdings, and running overlap analyses between collections. Appendix

A provides a framework of elements based on our study and those found in the literature that

should go into libraries' criteria checklists. This section provides information about the criteria

JMU chose for this project.

Back end functionality. Knowledge base management core functions, including the batch import and export of collections and databases using common standard(s) such as KBART. Also important were the facilities for importing holdings into the discovery tool and MARC record delivery (for importing journal records into the catalog). Collection maintenance considerations also included the ability to create and upload custom collections, such as JMU's print journal holdings. Knowledge base integrations with other library and consortial knowledge bases (e.g., EBSCONet, LOCKSS, GetItNow were also important.

Specific functions that had become part of JMU's existing e-resource workflows included the provision of a holdings report and the overlap analysis tool. Holdings reports, which include subject headings, are used for statistical gathering and collection evaluation as well as troubleshooting access and subscription issues. Overlap analysis is primarily used for collection development purposes. The library often runs overlap analyses between collections when it considers purchasing new journal packages, comparing those titles lists and holdings with those to which the library already subscribes. These two features—holdings reports with subject headings and overlap analysis—are available from JMU's current e-journal management system, which is Serials Solutions' 360 Core.

Link resolver technical testing. JMU's criteria related to link resolver technical testing were first, that the library's highest usage database sources (e.g., Google Scholar, EBSCO) had no issues with the link resolver, and that links from the resolver to JMU's top full-text targets met the library's expectations for accuracy and precision. Specific steps related to technical testing will be detailed below.

Menu differences. Because this project focused on the back-end functionality, the team tested three aspects of the link resolver menu. Generally, the team investigated the degree to which the interface was customizable and configurable. The team also checked for the existence of the "One-click" feature and tested link resolving to Interlibrary Loan.

Vendor-Specific criteria. Price and contract options were important to our selection decision, but as mentioned earlier, because JMU had existing contracts with OCLC and EBSCO that supported complimentary access to their resolvers, the only question here was whether the advantages of Serials Solutions software were worth the subscription. More unknown was the vendors' customer relations related to the software, including response times related to urgent needs and for enhancement requests, and whether the contacts seem to have sufficient technical expertise.

Aspects not evaluated. Although the team paid attention to the knowledge base interface user experience and the amount of staff time required to administrate the product(s), we did not formally evaluate these. The JMU team also did not evaluate resolver links to services other than Interlibrary Loan such as the library catalog or bibliographic citation management software. Finally, because we did not move to the public services involvement phase, the team did not evaluate the A-Z listing of journals beyond a cursory check to be sure it existed and met basic informational requirements.

Results

Because any "checklist of features" will quickly become dated, and others have noted the top tier of vendors develop these products very competitively (Breeding, 2012), this article does not provide an exhaustive description of features for each product, but highlights findings of specific interest.

Back-End Functionality

Neither OCLC nor EBSCO's products provided a centralized overlap analysis function, which allows libraries to compare title and holdings data across subscribed and unsubscribed collections, a feature that comes with the Serials Solutions product. The library routinely uses this function for assistance with collection development decisions and holdings maintenance, so this was a major drawback to both products.

The library already maintains its holdings in Worldshare (where the knowledge base for OCLC's Link Resolver product is managed) for the integration with the library's interlibrary loan services. Administrators can set specific license settings, lending permissions, and WorldCat holdings at collection levels in order to streamline ILL lending services. Administrators can also share collections (and share the management of those collections) with other institutions or members of a consortia, a feature the library currently makes use of in maintaining its holdings for its ILL department. Worldshare also makes MARC records available by collections, a very helpful service especially for importing batches of bibliographic data into the library's OPAC for large collection packages. In seeking ways to simplify workflows across multiple systems, the team found this capability in particular to be a promising tool. The team was also pleased to find the ease with which administrators can create and customize collections (including collections for print titles). EBSCO's product did not have these advantages.

Link Resolver Technical Testing

Each provider's interface has different OpenURL configuration possibilities. Some providers allow library administrators to specify multiple link resolvers so that more than one revolver option displays on the public interface. Other providers, require designating only one resolver at a time. Also, some providers are able to set up staging platforms or "trial accounts" in order to

test resolvers without interruption on the public platform. The team started its testing with this

last group of providers, given that it would be the least disruptive to users. The team then moved

to testing the other providers, announcing in advance to the library which provider platform

would be affected, in what way and at what times. To minimize disruption, testing took place in

the summer months and during the morning, which was the lowest usage part of the day.

The testing team identified multiple full-text journal articles across library-subscribed

collections (including both aggregator databases and journal collections). To do this, the team

first searched and verified access to full-text journal articles from journal providers' web sites.

The team then attempted to link to these articles from heavily-used databases (such as

EBSCOhost, Gale, ProQuest, Elsevier, and others), tracking whether the link resolver succeeded

or failed in providing the full-text content of the articles. To determine which databases were

heavily used, the team examined clickthrough reports from JMU's current link resolver, which

indicated the number of times a database was used, both as a source and a target. For each source

database, the team made certain to use the same set of articles with both link resolvers, as this

would more accurately reveal any major differences regarding the equality of their OpenURL

functionality and user experience.

Linking was judged "successful" as long as users ended up getting to the full-text content via

successful linking. Thus, this included links from the source database to the full-text content of

the article directly, to the article record from which the full-text content could be downloaded

(e.g., PDF), or links that were provided on the link resolver's menu. The testing team found that

both link resolvers shared a very similar success rate. EBSCO's Full Text Finder successfully

linked to full-text articles 82% of the time, while OCLC's Link Resolver was successful 83% of

the time. Problems tended to be related to specific articles, not to specific products. The team

found that successful linking for specific articles with one product correlated with successful

linking for the same articles with the other product. In cases where the linking failed, the issues

mostly stemmed from a problem specific to the target database or with the library subscription,

not with the resolvers' functionality. For instance, sometimes users were taken to an abstract

only or to a paywall page.

Menu Differences

While menu pages for both link resolvers provide article-level links to full-text content, the

testing team found the OCLC's menu display to be clearer, with a more responsive design (see

Figure 1).

Figure 1. OCLC Link Resolver menu.

In addition to the article-level links, OCLC's menu page included both journal-level and collection-level links, with subscription coverage dates. It also provided full citation information for the article and options to "Cite," "Request," and report access issues. While EBSCO's menu page included citation information, subscription coverage dates, and links to search the library's local catalog and Google Scholar, the team found the menu page denser, with links and text clustered together (see Figure 2).

Figure 2. EBSCO Full Text Finder Link Resolver Menu.
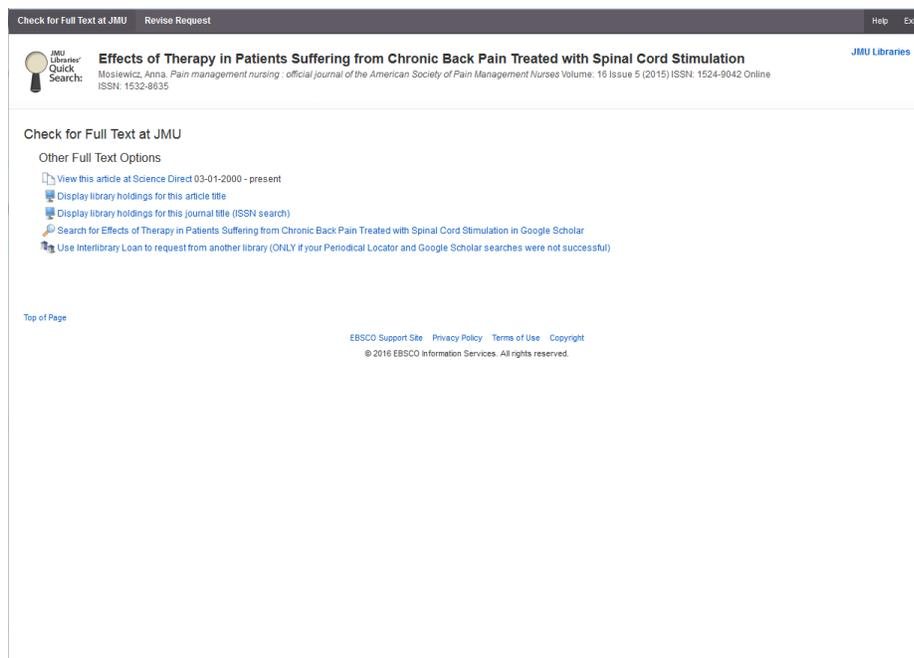
Neither EBSCO's nor OCLC's products allow libraries to customize the menu interfaces in ways currently available with the Serials Solutions product. For instance, the library cannot embed chat widgets or other tools in either product. All three link resolvers offered the "one-click" option, a feature which bypasses the link resolver menu page, taking users directly from the source database to the full-text article in the target database when available, with just one click. Yet, OCLC's product did not currently provide a way to link to the link resolver menu page should there be a problem with the target database or should the user wish to view all the OpenURL targets available, including other resources in which the full-text article is available.

Configuring Interlibrary Loan in OCLC's resolver was non-intuitive. Furthermore, communication issues with OCLC customer service (lack of follow-up, need for our contact to check with specialists) delayed resolution of this issue. However, once it was set up it worked as expected.

Vendor-Specific Criteria

As mentioned earlier, if JMU were able to use OCLC or EBSCO's link resolver, it would enjoy annual savings by being able to cancel our Serials Solutions subscription. The other aspect investigated was vendor customer relations, including response times related to urgent needs and for enhancement requests, and whether the contacts seem to have sufficient technical expertise. JMU engages with all three vendors' customer support departments regularly. The team felt both EBSCO and Serials Solutions provided good customer support in terms of timely and accurate answers to our questions. The team had some difficulty in understanding the different full-text linking options offered by EBSCO Full Text Finder because our experience with EBSCO Discovery's built-in full-text features, but development staff at EBSCO were able to clarify the situation. During this evaluation project, the team had trouble getting timely responses from OCLC to our questions. Emails required follow-ups to get responses, and sometimes the responder did not seem to know the product well enough to answer.

<center>**Discussion**</center>

Link Resolver Quality Improvements over Time

As discussed in the introduction, work by NISO and other groups has improved the ability to communicate about metadata standards and has improved the success of OpenURL linking in general. Although variant methodologies make it challenging to compare technical evaluation results over time, the fact that librarians began expanding the scope of "failed links" to include those where the user is forced to search or browse for full text suggests general improvement of link resolver-generated OpenURL links. That is, as *any* links to full text become generally successful, our expectations that they deliver the user *directly* to full text increase.

Variations between major vendors' products in terms of OpenURL quality itself may be less

critical than other aspects of the overall e-resources suite of software. Breeding (2012) who

compared four products suggested the major vendors' products themselves aren't all that

different in terms of basic linking features and OpenURL link quality. The linking tests in this

study supported this assertion, as problems found with links in one product were also found

when using the other product. Although the link resolver functionality is the most visible, if its

performance seems roughly equivalent across vendors, back-end workflow tools may be the

deciding factor in selection decisions. Modern academic libraries use their knowledge bases for

many purposes other than supporting the public link resolver. For JMU, the overlap analysis

function provided by Serials Solutions was a major factor supporting the additional expenditure

required to maintain our Serials Solutions subscription.

Several librarians have heralded the promise of library services platforms to streamline data

workflows, especially with respect to electronic resources (Breeding, 2012; van Ballegooie,

2014). Some of the major vendors' sales demonstrations promise single-knowledge base

solutions. Yet, many libraries are still maintaining multiple knowledge bases. Why is this? One

major factor still seems to be business competition. Koury (2015) described several ways in

which the failure of EBSCO and ExLibris to collaboratively improve metadata sharing had a

deleterious effect on link resolver performance at multiple libraries. Problems included faulty

linking, inaccurate "no full-text" messages in ExLibris's discovery interface even when EBSCO

full text was available, and the need for library staff to painstakingly test EBSCO access within

ExLibris. In addition to the technical problem-solving, the finger-pointing that can ensure among

competitors makes it difficult to diagnose or solve issues once found. Thankfully, a competing

trend to all-in-one, one-vendor solutions is emerging.

First, a major project to build an open source knowledge base, Global Open Knowledgebase (GOKb) released version 3 in 2015.[2] The project is Mellon-funded and uses the Open Refine platform. As of 2012, Breeding found such community-based efforts (including also CUFTS at Simon Fraser and Gold Rush at Colorado Alliance of Research Libraries) to fall in a lower tier of completeness, complexity, and cost, which may be useful to libraries of more modest means (2012, 176). Second, EBSCO and others announced their intention to build a fully open source integrated library system / library services platform at EBSCO Academic Users Group (Collins & Brooks, 2016). This system would use GoKB and other open approaches to create a modular, API-driven product. Given this trend, the question of whether a unified system or a decoupled approach will better serve libraries has emerged. Although aspects of multiple knowledge bases may seem redundant and inefficient, the decoupled approach allows some advantages. Having the data loaded into multiple platforms enables libraries to take advantage of the strengths and unique features of specific systems — in JMU's case, Serials Solutions provides the library with several tools for internal workflows, while Worldshare supports efficient and accurate ILL functionality. Furthermore, using multiple vendors' products reduces the ability for any one vendor to control the library's ability to serve patrons. If one system is down, not all library services are down, and the library can even make adjustments to provide alternative access. Our familiarity with import and export from multiple systems means the library is able to change solutions and doesn't feel beholden to one vendor.

Along with the literature review, this study offers suggestions for methodologies related to link resolver and knowledge base product evaluation. Defining criteria for evaluation is critical

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[2] Version 3 of the Global Open Knowledge Base
Released as Production. http://www.k-int.com/news

to ensure the many stakeholders of link resolvers and knowledge bases are included. We have offered a generic checklist template in the appendix, but each library will necessarily place different weight and different specific requirements on the various categories listed. Regarding any technical evaluations of OpenURL linking, it is important for studies to define success clearly. If libraries are unsure of how they wish to define success, using a previous study's definition would permit comparison. One of the limitations of this study was not choosing a scientific sample of citations; for a more empirical approach to identifying OpenURL sources to test, researchers could follow the approach of Herrera (2011), described earlier.

One of the critical aspects in JMU's decision was our evaluation of the vendor's customer support, and vendor support for software development. Breeding (2012) and Koury (2012) urged libraries not to assume vendor support will be good, and to document response times and customer service errors in order to be able to present clear patterns of poor service. JMU found that response times and customer service familiarity with link resolver and knowledge base products varied by vendor. Related to this is the importance of factoring staff time for maintenance. Livingston, Sanford, and Bretthauer (2006) found large differences between vendor products among their survey respondents reporting on the amount of staff time expended on maintenance activities. Eighty-nine percent of LinkFinder Plus users spent more than 40 hours on customization prior to and post rollout, and .34 FTE on maintenance, but only 6% of Article Linker users spent that much time on customization, and only .25 FTE on maintenance (p. 186). Johnson, Leonard, and Wiswell (2015) noted that after switching to Link Source, a dramatic reduction in staff time. Migrating from one vendor to another, or being migrated to new software by a current vendor, can add significant one-time costs to staff time.

Public services' librarians and end users were not included in this study because the library

was satisfied with users' current experience, but these stakeholders' perspectives would have

been critical if our research had pointed to a change. In the literature, overall success of link

resolvers is increasingly defined not just by OpenURL links' technical accuracy, but in the

overall user experience. The link resolver's menu options are of marginal interest compared with

intuitive, direct linking to full text. Users just want to get the full text; they don't want the other

menu options (Ponsford, Stephens, & Sewell, 2011). Designing the link resolver button itself, or

choosing the best wording for text links to full text, seems like an area still ripe for empirical

research (Imler & Eichelberger, 2011). Furthermore, users have more options today for finding

full text besides link resolver software. Dixon et al. (2010) found that Google Scholar was users'

favorite tool for finding articles given a citation. Google Scholar also enabled them to be the

most successful and the most efficient when compared with the library's journal portal and link

resolver find-an-article-by-citation form. Although Scholar can be configured to use an

institution's link resolver, it also provides many direct links to full text, both via open access

sites and commercial providers. According to a report from Elsevier specifying the referrer to

JMU-subscribed full text, while 44% of users get to JMU-subscribed Elsevier full text through

the link resolver, 26% come from Google or Google Scholar directly, and the balance came from

direct links (e.g., bookmarks) or other web sites (e.g., PubMed). Link resolvers are only one part

of the linking puzzle.

<div align="center">**Conclusion**</div>

Selecting link resolver and knowledge base software has become more complicated than ever

due to the increasing need for system interoperability. Libraries' expectations for clean metadata

that follows professional and industry standards have correspondingly increased. Software and

knowledge bases are used for many back-end processes and workflows as well as public link resolving functions. The development of library service platforms introduced the idea that an all-in-one system would be beneficial, but the diversity of libraries' requirements seem to support the need for multiple tools. Furthermore, the advance of open data sources like GoKB, and announcement of an open source library service platform by a major vendor (Collins & Brooks, 2016) suggests that a decoupled approach to electronic resource management will exist as a competing trend in the foreseeable future. When libraries compare link resolver and knowledge base solutions, creating a checklist of criteria can help an organization consider both strategic goals and pragmatic concerns in its decision. Identifying which stakeholders' requirements need to be considered and specifying those requirements will focus attention on key factors.

Appendix: Checklist of Criteria for Knowledge Base / Link Resolver Evaluation

Note: not all items in the checklist may apply to every library.

1. Knowledge base management

    a. Batch import / export collections and databases using common standard(s) such as

       KBART

        i. Import holdings into ILS

        ii. Import holdings into discovery tool to be sure journal records are included

            in discovery search

        iii. MARC Record Delivery

    b. Collection maintenance

        i. Create a Custom Package / Collection

        ii. Upload a "Selected Collection". Allows users to upload a collection edited

            offline. As just one example, institutions may have a journal collection in

            their institutional repository

        iii. Notes Field

        iv. Tokens: Some providers require a "token" to be included in the URL sent

            to them. Is there a place in the link resolver to input this token?

        v. Share Journal Collections with other libraries (e.g., upload a custom

            collection that other libraries can select, such as an institutional repository

            journal collection or consortially defined collection).

    c. Holdings Report

    d. Access points (A-Z list)

    e. Overlap analysis tool

      f. Knowledge base integrations with other library and consortial knowledge bases

         (e.g., EBSCONet, LOCKSS, Pubget)

      g. Activity History (tracks institutional activity)

2. Price and contract options

3. Knowledge base interface for staff: does it allow efficient completion of needed tasks?

   [Library should list tasks they expect to perform with knowledge base]

4. How much staff time will be required to administrate the product(s)?

5. Vendor's customer relations

      a. Can the vendor meet the library's expectations related to urgent needs? For

         enhancement requests?

      b. Does the vendor's customer relations team have sufficient technical expertise?

6. Source database integrations

      a. Google Scholar links into the resolver?

      b. The library makes a list of the top sources

      c. Links to the link resolver meet the library's expectations for accuracy and

         precision (whether the link produces article, journal, or title-level links).

7. Link Resolving to Full Text

      a. [The library makes a list of the top sources and targets.]

      b. Links to full-text meet the library's expectations for accuracy and precision

         (whether the link gets the user directly to full text, or to the publisher's web site,

         or a menu).

8. Link Resolving to Other Services

    a. [Library needs to list all the services, such as Interlibrary Loan, the library catalog, or bibliographic citation management software, for which the link resolver is seen as a critical pathway, and determine accuracy and precision of links.]

9. Link Resolver User Interface

    a. One-click feature (user clicks on the link resolver button and is taken directly to full text, without stopping on a menu)

    b. Customization [The library should determine the extent to which they wish to customize the menu interface]

    c. Web form for looking up specific article ("Find Article by Citation") (Dixon et al. 2010)

10. A-Z listing of journals

    a. For staff

    b. For end users

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