Reference Linking in a Hybrid Library Environment

Part 1: Frameworks for Linking

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Abstract

The creation of services linking related information entities is an area that is attracting an ever increasing interest in the ongoing development of the World Wide Web in general, and of research-related information systems in particular. Currently, both practice and theory point at linking services as being a major domain for innovation enabled by digital communication of content. Publishers, subscription agents, researchers and libraries are all looking into ways to create added value by linking related information entities, as such presenting the information within a broader context estimated to be relevant to the users of the information.

This is the first of two articles in *D-Lib Magazine* on this topic. This first part describes the current state-of-the-art and contrasts various approaches to the problem. It identifies static and dynamic linking solutions as well as open and closed linking frameworks. It also includes an extensive bibliography. The second part, SFX, a Generic Linking Solution describes a system that we have developed for linking in a hybrid working environment.

Linking

The creation of services linking related information entities is an area that is attracting an ever increasing interest in the ongoing development of the World Wide Web in general, and of research-related information systems in particular. Although most writings on electronic scientific communication have touted other benefits, such as the increase in communication speed, the possibility to exchange multimedia content and the absence of limitations on the length of research papers, currently both practice and theory point at linking services as being a major opportunity for improved communication of content. Publishers, subscription agents, researchers and libraries are all looking into ways to create

added-value by linking related information entities, as such presenting the information within a broader context estimated to be relevant to the users of the information.

One of the first people to recognize this potential was Gardner. He expressed the desire to implement a hypertext structure linking scientific articles as a long-term goal of the electronic archive conceived by King and Roderer in 1978 (King and Roderer 1978), which he introduced to the psychology community more than a decade later (Gardner 1990). Hitchcock (Hitchcock et al. 1997a) relates the necessity of links to the associative modus operandi of the human mind. It comes as no surprise that both Gardner and Hitchcock refer to the historic writings by Vannevar Bush, in which he introduces the associative indexing (hypertext) Memex concept (Bush 1945).

But theoretical justification for linking information has become quite superfluous, since many practical illustrations of its importance have become available. Hitchcock attributes the explosive success of the World Wide Web to its linking possibilities (Hitchcock et al. 1997a). In the area of scholarly information, linking solutions have been introduced and have quickly become popular with their users. Initiatives by the Institute of Physics Publishing and BiomedNet spring to mind, where journal articles and their citations are being linked with the corresponding primary and secondary data. Ovid's linking in its Biomedical collection, SilverPlatter's SilverLinker, Links between articles in HighWire Press, and ISI's Links in the Web of Science are other examples. The list of linking initiatives has grown rapidly, driven by expectations for a fully linked scholarly communication environment, created by these early linking-showcases.

Linking in library solutions

The necessity of linking

In the context of networked library services, the necessity to integrate secondary data, catalogues and primary information has been expressed quite some time ago (Evans et al. 1989; Van de Sompel 1991). More specifically, librarians have brought to the fore the need to link abstracting databases with library catalogues (Dempsey 1993; Dempsey 1995; Van de Sompel 1993); catalogues with primary information (Van de Sompel 1994); abstracting databases with full-text primary information (Arms 1993). These specific linking notions have evolved towards a concept of connecting all the available information, in order to come to a fully interlinked information environment (Van de Sompel 1997b). Lynch puts it this way (Lynch 1997):

Over time, the set of necessary linkages will expand to include not only A&I databases to primary content and serials holdings and serials holdings to primary content (or, more precisely, to navigational systems for cover-to-cover content of journals, including material not in the scope for the A&I databases), but also from (monographic) catalog bibliographic records to primary content (or to finding aids that assist in the navigation of large collections of primary content) and to secondary materials such as book reviews.

The omnipresence of the World Wide Web has raised users' expectations in this regard. When using a library solution, the expectations of a net-traveler are inspired by his hyperlinked Web-experiences. To such a user, it is not comprehensible that secondary sources, catalogues and primary sources, that are

logically related, are not functionally linked ([Van de Sompel 1997a](#)).

Once implemented, such library link services become popular with the target audience and turn out to be an important aspect of integrated library services. There are indications of a strong correlation between this satisfaction and the introduction of linked electronic services. Caswell has shown this regarding the link between A&I databases and library catalogues ([Caswell et al. 1995](#)). Users' reactions to the linking experiments in the [Open Journals project](#) -- where article citations and A&I databases have been linked -- were very positive overall ([Hitchcock et al. 1998b](#)). In a survey of library users at the [Los Alamos National Laboratory](#) 30 percent of the customers were 'delighted' and the majority of the remainder 'satisfied' with the highly linked library service ([Weislogel 1998](#)). And a public presentation of the link service described in [Part 2](#) of this paper -- held on the occasion of the conclusion of the Flemish Elektron project (a very modest e-Lib look-alike) in December 1998 -- led to very positive feedback from the audience, again emphasizing the desire of users to work in a fully linked environment.

The actual situation

Static and dynamic linking approaches

Linking mechanisms that are in use or are being developed in the scholarly information environment, can be categorized as static or dynamic, depending on the architectural set-up of the information collection:

- *Static linking:* Lately, most initiatives -- initiated by both commercial and non-commercial authorities -- have used a static linking concept. Links between information entities are computed in advance using batch processes and are held in a linking database. Typically, the processes use SICI-related information to detect relationships. Static links are used in initiatives like [IOP](#)'s HyperCite, [BioMednet](#)'s Bundled Links, [Ovid](#)'s Biomedical Collection and many other commercial linking frameworks as well as in advanced electronic library services like the [Los Alamos Library Without Walls](#) ([Knudson et al. 1997](#); [Luce 1998](#)) and [Tilburg](#)'s and [Bielefeld](#)'s environments.

  Records in such a database of static links describe relations between information entities that are available in the controlled environment. Static links are foolproof in the sense that following a pre-computed link will most certainly lead to the desired target. When considering solutions where bi-directional linking -- from now on called interlinking -- is the aim, building the linking solution requires the availability of all data that needs to be interlinked under the control of the authority creating the environment. Given the preliminary state of interoperability initiatives that might overcome this problem, the information collection must be centralized and self-supporting.

- *Dynamic linking:* Some interesting initiatives have started from a decentralized concept, where not all of the data that is required to build an interlinked information environment can be under the control of the authority creating the environment. As such, "a priori" computation of the links is not feasible, and linking must be done in a dynamic way, computing the links for an actual information entity "on the fly". Of special interest in this area is the work by the [Multimedia Research Group](#)

of the University of Southampton, who have extensively published very valuable information on their ongoing linking implementations and experiments ([Carr et al. 1995](#); [Hitchcock et al. 1997a](#); [Hitchcock et al. 1997b](#); [Hitchcock et al. 1998a](#); [Hitchcock et al. 1998b](#)).

Given the requirement to control the information collection, in order to be able to interlink the information, the centralized commercial solutions are restricted by the sphere of influence of the information provider. Therefore, the creation of a fully interlinked information environment -- that would result in a true one-stop shop -- would require either an information monopoly or extensive partnerships. Although some publishers call for subject-driven cross-publisher information shops ([Kierman 1998](#)) with [DOI](#) as an enabling instrument, some industry observers see little tradition in the cooperation required for success. Therefore, the realization of a true one-stop shop under commercial control might not be a reachable goal. But if it is, it will most probably not come from an information monopoly that would support a static linking approach, except in narrowly defined fields. Logical behavior by companies in the information industry would normally prevent a broad monopoly from developing. A dynamic approach seems to be more likely.

In the non-commercial arena, the systems that make up hybrid library environments can be under local control, as is typically the case with OPAC and some secondary data systems. Alternatively, systems may also be under technical control of an external authority, such as a database vendor, a subscription agent, a publisher, and another library. The non-commercial parties -- libraries and consortia -- are in a much better position to build integrated services, since they are not copyright owners. As such, they are neutral enough to potentially receive a green light from a wide variety of information vendors, to integrate and interlink their data-collections. Therefore, the future reality of hybrid library systems will most probably exclude linking solutions that require the local availability of all data or even important parts of it. Hence, also in hybrid library environments, linking tends toward a dynamic approach.

Closed and open linking frameworks

The frameworks that have been introduced so far feed links based on the collection that the provider of the links -- henceforth referred to as the authority -- has within its reach, and leave no room for adaptation to the environment where the links are consumed. The linking frameworks can be called "closed." The following considerations apply for the closed linking approaches:

- *Dictated linking:* the linking solutions basically start from a presumption that includes a dictate about the target of a link. Linking from a record in an abstracting database leads to the corresponding full-text, and linking from a citation in a paper leads to a bibliographic description in a predefined database.

- *Limited range of linking:* many of the linking solutions are limited to the sphere of influence of the authority, being its collection.

- *Linking bypasses the local environment:* links are being delivered from the authority directly to the end user. The local institution where the links are used has no means to act upon the link.

Such limitations cause serious problems. Most environments where links are consumed are hybrid libraries, made up of OPAC systems, abstracting databases, e-journals and e-editions as well as web-services. Some of the latter can hardly be classified using traditional library jargon. In this environment, a wide range of services -- that go beyond the initial aims or the possibilities of the authority -- can be delivered by creatively using the available information. The combination of an information unit that a user considers to be of interest and the entire collection that is accessible in the actual environment in which he operates can lead to the provision of a wide range of extended services for that information unit.

The authority can not anticipate the diversity of information that is available in the local environment. Thus, in order to deliver links that deal with the full richness of the information environment, the authority can not just autonomously define the target(s) of a link. Rather, linking should be seen as influenced by the environment where the link will be used. It should reflect a combination of the authorities' and the consuming institutions' intentions, ultimately even the users' goals.

Although these considerations apply to both commercial and non-commercial authorities, the hindrance resulting from closed linking frameworks is most significant with commercial services that follow a strategy of vertical integration that restrict the freedom to combine information from different vendors in the same environment. In a consortium environment some libraries rely on the hosting authority for all their library services, making the local environment the same as the authority's. As such, integration can fully be dealt with by the authority. But in some consortia, participating libraries may host some information locally that is not relevant to the entire consortium, but still want it to be integrated with the whole. The concrete examples below illustrate the problem. Most apply to commercial services:

- The consuming institution might not be willing to present a link leading to a pay-per-view service, out of principle or because it holds a local copy of the paper (Bide 1997; Hellman 1998).

- The consuming institution might want to present alternative or additional link targets within its accessible environment. For instance:

   - IOP's link from a citation in an IOP published paper, to the corresponding Inspec abstract is an important service. But, the Inspec database might be available in the local environment, and the consuming institution might prefer to redirect users to the local copy, because it is linked to a local document delivery service.

   - It has been predicted that it will take about 20 years until 90% of the references in journal articles will be to papers that are in electronic form (Bide 1997 cites Norman Paskin). Thus, a link-to-holdings from a citation in a paper is an important service that institutions might want to supply in addition to the link to the abstract intended by the authority.

   - When a user's attention is drawn by a citation included in a journal

paper or one found in an abstracting database, viewing the corresponding full-text might not be the only concern. The user might want to get an indication of the quality of the cited journal before deciding to read the full-text (Wang 1999). Or the user might want to look up the author's background as an alternative method of quality control. The citation might originate from a special issue on the user's actual research topic, and as such the whole table of contents of the cited issue might be relevant.

- ○ When the user has located a book in the OPAC, an abstract or book review might be welcome.

- ○ An authority might host only electronic secondary and primary data for a library consortium, while each of the institutions run their own Integrated Library Systems. In this case, the link-to-holdings facility depends on the local environment where it is being used.

The mainstream of the current linking approaches excludes the involvement of the consuming institution that is required to implement such services. The context of the environment in which the de-facto interlinked information is consumed is being ignored.

Design considerations

Given the increasingly distributed nature of the information collection at hand, a dynamic linking approach or at least some combination of static and dynamic linking might prove to be the most realistic path leading to a fully interlinked environment. The desire to act upon information units that are being provided by an authority calls for an open linking framework that is not in place. The alternative is to create extended services -- like the ones mentioned above -- using a dynamic linking approach. In the current closed linking context, this presents some important challenges:

- *grabbing a link-source item:* in order to be able to present locally defined links for a certain information unit (the link-source) originating from an authority, it is necessary to identify, capture and analyze the unit in the local environment first. When source systems are under local control, the required system enhancements can be dealt with internally, using ad-hoc techniques. When source systems are under external control, grabbing the link-source can become a very cumbersome task. Complex proxying and parsing solutions have been introduced to deal with this problem (Hitchcock et al. 1997a). Eventually, both situations should be handled via the same generic open linking framework. But in the absence of it, finding techniques to grab link-sources presents a major challenge in dynamic linking solutions.

- *Link verification:* inherent to dynamic linking approaches is the uncertainty regarding the success of a link that has been created on-the-fly. Depending on the protocol supported by the linked system, links can be verified before delivery or not.

- *Data-processing delay:* the dynamic approach to linking causes processing delays when servicing links. Lynch anticipated this problem for link verification in a distributed environment (Lynch 1997) and designers of the Open Journals Project (Hitchcock et al. 1997a) have confirmed the

problem in the operational context of citation linking. Later, delay in response times was mentioned as one of the few criticisms by users of the Open Journals test system (Hitchcock et al. 1998b). In hybrid library environments, the number of information units that are being transferred daily can be very high. For each of these units, delivery of extended services will introduce certain delays. Therefore, in the design of a linking solution, processing delay must be an important concern.

- *Locally hosted linking service:* the multitude of heterogeneous information systems that should be interlinked, calls for a linking service that can be shared amongst systems (Carr et al. 1995; Pearl 1989). Such a linking service provides a look up in a database where data items are interpreted as links. Since the consuming institution is in the unique position to know its complete interlinkable collection, it should host and (co)-feed the linking service. The early Ghent linking experiments confirmed the necessity for a linking service in an empirical manner. These experiments required link-specific enhancements to be made to each of the systems where links originated. It was anticipated that such an approach would soon lead to a maintenance overhead of system enhancements.

- *Link-to-services:* in order to be able to link into a system, it must provide a link-to-service, that can be addressed using a published link-to-syntax. For instance, most of the actual Integrated Library Systems provide a syntax for a link-to-holding facility. Linking into secondary services, such as A&I or citation databases, has not been dealt with so far, and it comes as no surprise that real linking services are rare in that area. PubMed's NCBI Citation Matcher is a very noteworthy exception. Some primary publishers and intermediates have made available genuine link-to-services, that can be used when jumping from A&I services or OPACs into their full-text collections:

  - Academic Press
    http://www.apnet.com/www/ideal/linkgide/links.htm
  - American Physical Society http://publish.aps.org/linkfaq.html
  - SwetsNet http://www.swets.nl/press/may982.html
  - Elsevier ScienceDirect
    http://www.sciencedirect.com/science/page/static/splash_pr9.html
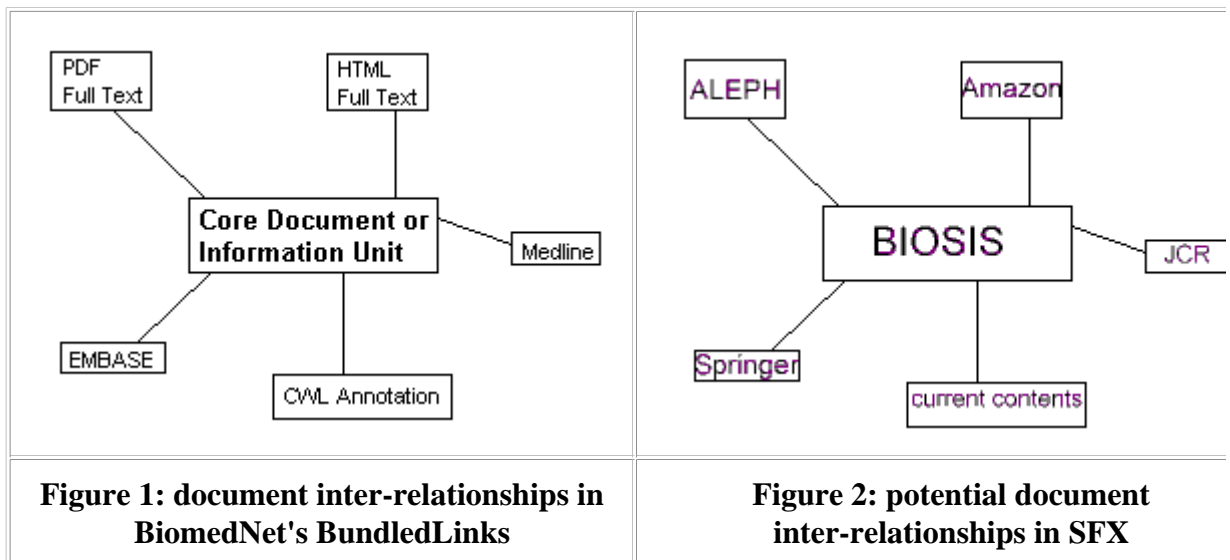 - UMI SiteBuilder http://www.umi.com/builder

But with many publishers that have online content, no such services are supported. Careful examination of their URL structures may lead to insights that can help when trying to link into their collections. Still, there is no overall uniformity in the approaches taken, and linking can become very complicated due to authentication issues, the level(s) of the links that can be created (journal level, publication year level, volume level, issue level, article level), the information required to create the links etc… Again, a generic framework, accepted by the scholarly publishing community would be most welcome. The SLinkS initiative (Hellman 1998) should be seen as a feasible proposal.

- *Licensing and consortia:* the presentation of links to end-users is dependent on licensing and subscription boundaries that apply within the collection. In a consortium environment, where different parties have access to different information sources via the same service, this can turn interlinking of the sources into a quite complex matter.

The feasibility of dynamic, open linking -- the SFX system

This paper has described the need for dynamic, open linking, but has not demonstrated that such systems are practical. Part 2 of this paper describes the SFX service for dynamic linking in a hybrid library. SFX presents a solution to interlink the available information entities in a hybrid library environment, without requiring "a priori" computation of links from the available data. The solution uses concepts drawn from the domain of linking services, without being one in the strict sense of the meaning.

In SFX, the notion of a database containing bundles of links in which each record represents an inter-relationship between documents -- as used in BiomedNet's BundledLinks (Hitchcock et al. 1997b) (Figure 1) -- is replaced by a concept of potential inter-relationships between documents, expressed at the level of the databases from which they originate (Figure 2). The "a priori" computation of links -- as done in self-supporting environments such as BiomedNet -- is replaced by the "a posteriori" conceptual verification of links via the SFX-base, without any further functional verification. This results in a level of verification that lies between no verification, which is achieved when adding links blindly, and on the on-the-fly verification of links for every link-source (if that would be possible). The former requires little computing overhead but offers poor service; the latter offers perfect service, but causes significant delays (Hitchcock et al. 1997a). The proposed design achieves a balance between the extremes, through the introduction of the SFX-base that exploits know-how about the actual hybrid library environment in order to reduce both the amount of potential dead links and the required computing time. The more the SFX-base is fine-tuned, the more the risk of dead links can be reduced. Spreading the total required processing time over different phases further reduces delays.

Figure 1: document inter-relationships in BiomedNet's BundledLinks	Figure 2: potential document inter-relationships in SFX

Interpreting the SFX solution as a searching aid or as a provider of extended services helps to justify the lack of complete verification that can be expected from true linking services. Moreover, such an interpretation can lead to the inclusion of other types of links in the Colli, such as:

- Links that redirect the actual search term to resources related to the one from which the link-source originates.

- Links that use other information from the link-source rather than

SICI-related ones.

The main goals of the SFX-experiment were:

- To justify the claim for an open linking framework that provides links as a combination of the information providers' and the hybrid libraries' aims. This has been achieved by illustrating the kind of extended services that might be delivered in such a context and has been approved by the enthusiastic reaction of the audience during the public presentation of the experimental SFX-service.

- To find an architecture allowing for the delivery of extended services. A possible architecture is described in Part 2 of this paper.

- To identify the main bottlenecks when turning an experimental version into a production system. Three areas have been identified:

  - *grabbing the link-source:* the proposed solution has introduced the notion of the SFX-identifier as a means of grabbing the link-source. It has been shown that ad-hoc solutions can be implemented for systems under local control. The Open Journals Project has shown the possibility of using proxying techniques. A generic solution would be welcome.

  - *Link-to-services:* extended service links can hardly be delivered into information resources that do not provide and support a link-to-service. Link-to-services exist for some primary collections but are rare for secondary databases. In order to be able to exploit the full richness of the hybrid library environment, each information resource should come with a link-to-service. Furthermore, if such link-to-services are conceived of as adhering to some generic framework -- such as the SLinkS framework proposed by Eric Hellman (Hellman 1998) -- the implementation of SFX-like software would become much more straightforward.

  - *Maintenance of the SFX-base:* it has been shown that fine-tuning of the SFX-base is crucial with respect to the quality of the extended services that can be provided. In the SFX-experiment, the design of the SFX-base was rough and it has been fed "manually". There is clearly a need for more fine-tuning of the design, and for automated procedures to feed the SFX-base.

A recommendation

Straightforward progress in all three areas is highly dependent on the cooperation of the information industry. Many established players might be reluctant towards such an idea (Hitchcock et al. 1998b) since it requires far-reaching openness of their services. Proprietary solutions are part of a traditional strategy aiming at the minimization of competition (Porter 1979), and a revival of that marketing concept can be found in many parts of the information industry, where the battle for the one stop shop market has exploded. Linking is considered to be a very important matter by major players in the information industry. Elsevier's Karen Hunter (Hunter 1998):

In 1996 I said: "One of the key roles a publisher should play in the future is

creating links -- adding value by integrating information letting people maneuver through the space and get a full range of information." Amen. My current motto is "the publisher with the best links wins". I don't lose sleep over this, but it's a mantra that I keep repeating to all who will listen. No publisher is an island, no information cannot be improved by enriching its context. (Pardon the double negative).

In due time, services of such importance will be subject to differential price setting. Wittingly or unwittingly outsourcing such new information services to commercial parties will lead to a dependency on their integrated solutions. Outsourcing of scholarly publishing to commercial publishers has led to a pricing spiral (Bennett 1998). Although the literature is abundant about the serials crisis, the problem should not be seen as restricted to the area of the journal literature. At the core of the problem lies the notion of total dependency. It comes as no surprise, to find recent evidence of a sudden price increase with a factor of 3.5 for a commercial database service, after acquisition by a main commercial player in the information industry (Case 1998). A similar situation may lay ahead for linking services, since closed linking frameworks in the hands of commercial parties will make the academic community completely dependent on those solutions, leaving no room for hybrid libraries to act in this domain. Hunter's quote not only stresses the importance of linking, it also calls for bridges between publishers, without mentioning libraries. This mirrors the observation that libraries are not involved in the DOI initiative (Scott 1998 ; International DOI Foundation 1999), although that might be due to their own lack of initiative.

This linking domain opens an opportunity for the subversive initiatives in the area of scholarly communication to become more widely accepted via an integration into library services. Kling and Covi have already brought to our attention that the marginal situation of e-journals (Harter and Kim 1996 ; Harter 1996) might be overcome by integrating those into the scholarly document system of libraries, indices and abstracting services (Kling and Covi 1995). As such, the adherence to an open framework for interlinking, that would enable libraries to deliver extended services for the alternative e-journals, might be part of the path leading to more general acceptance. A similar remark applies to the e-print servers, that turn out to be very successful in the intended user-community (Ginsparg 1994 ; Luzi 1998). Still, their integration into library services worldwide might be an impulse for a move from a successful subversive communication initiative to a wide-spread accepted publishing model.

Meanwhile, libraries should strive for an alteration of the linking frameworks into a direction that enables them to fully exploit the collection they access, acquire or build. The pursuit of the means that enable the creation of extended services, like the ones described here, should be high on the agenda of libraries worldwide. In the same manner as libraries are uniting in order to formulate guidelines for consortia deals (Turner and Yale University Library 1998), they should bring forward requirements for information systems that enable them to build and control extended services upon the information they license or acquire. At first sight, such services might look like just another bell or whistle for electronic library services. But as argued above, for once things are less innocent than they seem.

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