Semantic Technologies as Enabler for Distributed Adaptive Hyperlink Generation

Ruben Verborgh, Mathias Verhoeven, Erik Mannens, and Rik Van de Walle

Ghent University – iMinds – Multimedia Lab Gaston Crommenlaan 8 bus 201, 9050 Ghent, Belgium ruben.verborgh@ugent.be

Abstract. It is difficult for publishers to include the right links in documents, because they cannot predict all actions their users might want to perform. Existing adaptive navigation systems can generate relevant links, but doing this on a Web scale is non-trivial, especially if the targets are dynamic actions. As a result, adaptation often happens in a centralized way on a limited or closed document and action set. Distributed affordance is a technology to automatically generate links from any Web resource to matching actions from an open set of Web services, based on semantic annotations. In this paper, we indicate how this technology can be applied to adaptive navigation. We investigate how the generated links can be represented and how their relevance can be guaranteed. Based on that, we conclude that semantic technologies are an enabler to perform adaptive navigation to dynamic actions in a distributed way.

Keywords: adaptive navigation, adaptive hypermedia, Semantic Web

1 Introduction

The revolutionary concepts of hypertext have profoundly shaped the way we nowadays consume information, make decisions, and perform actions. Adding hyperlinks to documents transforms them into an affordance [7] through which users can select those actions [5]. However, this only helps users to the extent the actions they want to perform are afforded by the hyperlinks present in the document. On the Web, the world's largest hypertext system, publishers of documents are the ones who decide what hyperlinks their document contains, and thus what actions the user can perform through hypertext. Of course, it is impossible for a publisher to foresee *all* actions that *any* of its users would like to perform on a published resource. For instance, if the user wants to see the map of a certain place, but the publisher provides an address without the desired link, the user has to enter this address manually in a mapping application. We have previously called this *affordance coupling* [9]: pure hypertext-driven navigation on the Web would only work if the publisher could predict users' desired actions.

To solve the discrepancy between what publishers afford and what users need, we have previously developed an architecture for *distributed affordance* [9]. Based on semantic annotations extracted from documents, this approach enables 2 Ruben Verborgh, Mathias Verhoeven, Erik Mannens, and Rik Van de Walle

hypermedia clients to automatically create hyperlinks to actions that operate on the resources inside these documents. In contrast to most other approaches, we explicitly focus on *actions* that involve a document's resources *directly*, as opposed to finding contextually related documents. This paper explains how distributed affordance can serve as an adaptive hypermedia technique. In Section 3, we describe the architectural differences from other adaptive systems. Section 4 examines representation methods of the generated action links. In Section 5, we investigate how to determine what actions are relevant to the user.

2 Related Work

Brusilovsky gives a comprehensive overview of the aspects of adaptive navigation support [3], as well as various systems that existed at the time. He distinguishes five categories of adaptive navigation: *direct guidance*, *link ordering*, *link hiding*, *link annotation*, and *link generation*. The latter category consists of three kinds of approaches: *discovery of new links*, *similarity-based links*, and *dynamic recommendations*. The solution discussed in the present paper falls into the latter group, yet our generation strategy is *open-ended* on both sides of the link, whereas traditional adaptive navigation techniques mostly consider closed corpora. Furthermore, whereas adaptation techniques are traditionally characterized by a specific kind of knowledge representation [2], our technique decouples the information needed for adaptation from a specific representation format.

Dolog and Nejdl discuss the use of Semantic Web technologies for personalized link generation on the Web's open corpus [4]. The present paper differs in two aspects from the work they describe. First, they identify *ontologies* and *reasoning* as the corner stones of Semantic Web-based personalisation techniques. Our method is instead based on matching *Linked Data* [1] to *semantic service descriptions* [11]. Second, they focus on linking related pieces of *information*, whereas we are primarily interested in creating personalized *action* links. These links target dynamic information created from Web services, such as a link that connects any photo on the Web to its black-and-white version, which is then generated on-the-fly when the link is activated. In addition, we also target *world-changing* actions, such as sharing, ordering, purchasing, *etc.*

3 Architecture

Distributed affordance involves three parties that each supply a piece of information that allows links to be generated in a distributed way [9]:

- The information publisher adds semantic annotations to the document. Lightweight annotation mechanisms are sufficient, such as Open Graph or Schema.org, which are possibly already present for other purposes [10].
- The action provider offers semantically described Web services [11].
- The user indicates preferences for certain actions and providers, either implicitly or explicitly (see Section 5).



(b) distributed adaptive hyperlink generation

Fig. 1: Distributed adaptive navigation systems are highly scalable because adaptation happens at the client. This is enabled by semantic annotations in the original page that make it machine-interpretable.

These three pieces of information combined enable automated link generation in a distributed way, wherein the word "distributed" serves a double purpose. First, the affordance provided by the generated action links is distributed over multiple action providers, each of which can offer a specific action on the resource in the document. Second, adaptation does not need to happen at a centralized adapter, as is the case with most traditional adaptive systems [Fig. 1a]. Instead, because of the semantics in the document, adaptation can happen in a distributed way at the client [Fig. 1b], either through a browser extension or through a *shim* script that dynamically transcludes the generated links in the document [9].

The enabler of our distributed approach is machine-interpretable semantics, as it allows the on-the-fly combination of documents and services to create the actions the user needs. For instance, if the document indicates the page contains a postal address, the adapter will search for services that a act on a postal address and b have an outcome the user is interested in. Concretely, the user might be interested in viewing a map or adding this address to her personal address book. Semantic matching and subsequent instantiation of the address in the corresponding service descriptions [11] will result in direct links to both actions. Then, these actions have to be presented to the user, which is the topic of the next section.

4 Representation

Brusilovsky identified four categories of links [3]: contextual links that are embedded in parts of text or pictures, local non-contextual links¹ that reside on the page but are not intertwined with its content, index links on overview pages, and

¹ Here, "non-contextual" refers purely to link *placement* and not to relatedness, as generated links should at least be contextually related to the document's contents.

map links that represent a hyperspace or area thereof. Clearly, only the first two categories are relevant here, since the links we generate appear on content pages. This leaves us with two approaches: in-context action links near the resources on which they act, or action links in a separate menu.

In-context links When the document has been marked up with embedded semantic annotations, such as HTML5 microdata or RDFa, the actions generated based on those annotations can be placed close to them. Note, however, that linking from "hotspots" is often not desirable, as the links do not point to merely relevant documents, but to actions on the resources. For instance, it would be confusing if a link on an address directly inserted it into the user's address book. In contrast, a link labeled "add to address book" in the vicinity of the address indicates the intent more clearly. To suggest proper link placement, hypertext representations can indicate a placeholder where such links can be inserted [9]. However, this requires the publisher to be aware that adaptation might happen, which is why automated placement is more transparent.

Menu-based links Since we have no control over the page layout—as distributed affordance adaptation works on the full set of all Web pages—we might opt to insert in a separate menu instead. One option are contextual menus that appear when the cursor is hovered over resources that are part of the action. For instance, hovering over an address might reveal a pop-up menu with "map" and "address book" links. However, this approach will not work well for touch-based devices, which are increasingly gaining popularity. Therefore, we have experimented with a link sidebar that can be shown on demand. An alternate solution, not covered by Brusilovsky's categorization, is to show the action links in the browser window instead of the page itself, which is possible if distributed affordance is supported by the browser or through an extension. That way, the page renders as intended by the publisher, while still affording the user's preferred actions.

The benefit of in-context links is that they are close to information, and this proximity might allow the user to perform the action effortlessly. The drawback is that it can be hard to add them to existing pages in an aesthetically pleasing way—unless the publisher creates a designated affordance placeholder. The advantage of menu-based links is that they are non-obtrusive and offer more flexibility with regard to presentation and emphasis, at the cost of distance from the resources they act on.

5 Relevance

The other challenge in using distributed affordance for adaptive navigation is to find the actions that are relevant for a user. The difficulty lies in the fact that we support an open set of Web services, which, in combination with an open set of resources, result in an unlimited amount of possible actions. So far, the examples in this paper were rather simple, but we aim to support actions such as the following: Semantic Technologies as Enabler for Distributed Adaptive Hyperlink Generation 5

- Given a page with a book review, the user might want to buy the book through a preferred online bookstore, download it to her tablet, borrow it from a local library, or check if people in her social graph like it.
- When reading a page about a movie, the user can be interested to obtain tickets for a nearby movie theatre, to stream a digital copy to her portable media player, or to give it as a gift to someone else.

These examples indicate that complex matchmaking takes place. On the one hand, we need to determine the possible desired actions. Both examples show that there are actions tied to the *specific resource type* (books can be borrowed, movies can streamed) and actions tied to a *more general supertype* (books and movies can both be sent as a gift). On the other hand, the same action can be realized through different providers: there are several websites that allow to buy books and/or movies. With this in mind, we envision two possible strategies.

Explicit bookmarking Similar to the current practice of bookmarking, *i.e.*, saving the of a page in the browser for future use, actions can also be "bookmarked". We can imagine for instance, if a user visits an online bookstore, that she is offered to bookmark the "buy" action. Underneath the cover, this will add the corresponding Web service description to the user's collection. When the user then visits a document about a book, the description is then instantiated into a direct action link to buy that specific book. In that sense, the user is bookmarking *open-ended links*, the target of which becomes concrete at runtime.

Implicit modeling With bookmarking, the user is responsible for building an explicit model. However, it is far more convenient if the right actions can be suggested without an explicit selection process. Therefore, a user model can be constructed based on data mining [6]. Data sources of interest include previously visited sites of action providers (in combination with service discovery [11] on those sites) and the user's profile on social networking sites and interests from people in the user's social graph [8]. In case this data is missing or incomplete, the system might fall back on a "generic" user model that captures actions a typical user might perform on given resources.

Although implicit modeling is clearly more powerful, explicit bookmarking is more straightforward from an implementation perspective. In practice, both techniques can be combined: relying on an implicit model, but explicitly including bookmarks chosen by the user.

6 Conclusion

In this paper, we examined distributed affordance as an adaptive hypermedia technique. Our method differs from previous adaptive navigation systems, because our goal is to combine a) adaptation of the full Web corpus b) links to dynamic actions and c) fully distributed processing. Semantic technologies are a key enabler for the successful combination of these aspects, as they create the common understanding that eliminates the need for a centralized adaptation component

that must be aware of the full set of documents and actions. The important difference is where the knowledge is concentrated. In centralized systems, this knowledge resides mostly in the adaptation algorithm, whereas distributed affordance uses the knowledge provided by the semantics in the resource description and by the semantic service description.

Currently, we have implemented both the in-context and menu-based representation variants. In the near future, we will conduct user studies to see how both options are perceived and under what circumstances either one is most effective. As far as relevance is concerned, the implementation focuses on explicit bookmarking, but we plan to extend this to implicit user modeling as well.

We believe that distributed affordance can give a significant boost to serendipitous reuse of services, as it dynamically generates inbound links to them. Especially in mobile contexts, where invoking actions is more difficult because of limited controls, direct service action affordances could be a game changer. Demos and documentation are available online at http://distributedaffordance.org/.

References

6

- Bizer, C., Heath, T., Berners-Lee, T.: Linked Data The story so far. International Journal On Semantic Web and Information Systems 5(3), 1–22 (2009)
- 2. Brusilovsky, P.: Methods and techniques of adaptive hypermedia. User Modeling and User-Adapted Interaction 6(2–3), 87–129 (1996)
- Brusilovsky, P.: Adaptive navigation support. In: Brusilovsky, P., Kobsa, A., Nejdl, W. (eds.) The Adaptive Web, pp. 263–290. Springer-Verlag (2007)
- Dolog, P., Nejdl, W.: The adaptive Web. chap. Semantic Web technologies for the adaptive Web, pp. 697-719. Springer-Verlag, Berlin, Heidelberg (2007), http: //dl.acm.org/citation.cfm?id=1768197.1768224
- Fielding, R.T.: REST APIS must be hypertext-driven. Untangled Musings of Roy T. Fielding (Oct 2008), http://roy.gbiv.com/untangled/2008/rest-apis-mustbe-hypertext-driven
- 6. Frias-Martinez, E., Chen, S., Liu, X.: Survey of data mining approaches to user modeling for adaptive hypermedia. IEEE Transactions on Systems, Man, and Cybernetics 36(6), 734–749 (Nov 2006)
- 7. Gibson, J.J.: The theory of affordances. In: Shaw, R., Bransford, J. (eds.) Perceiving, Acting, and Knowing: Toward an Ecological Psychology. Lawrence Erlbaum (1977)
- Torre, I.: Adaptive systems in the era of the semantic and social web, a survey. User Modeling and User-Adapted Interaction 19(5), 433–486 (2009)
- Verborgh, R., Hausenblas, M., Steiner, T., Mannens, E., Van de Walle, R.: Distributed affordance: An open-world assumption for hypermedia. In: Proceedings of the Fourth International Workshop on RESTful Design (May 2013), http://distributedaffordance.org/publications/ws-rest2013.pdf
- Verborgh, R., Mannens, E., Van de Walle, R.: The rise of the Web for Agents. In: Proceedings of the First International Conference on Building and Exploring Web Based Environments. pp. 69-74 (Jan 2013), http://thinkmind.org/download. php?articleid=web_2013_3_30_40070
- Verborgh, R., Steiner, T., Van Deursen, D., De Roo, J., Van de Walle, R., Gabarró Vallés, J.: Capturing the functionality of Web services with functional descriptions. Multimedia Tools and Applications 64(2), 365-387 (May 2013), http://link.springer.com/article/10.1007%2Fs11042-012-1004-5