Multi-Layered Cross-Media Linking

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ABSTRACT

The integration of printed paper and digital information enables new forms of enhanced reading. We present digitally augmented paper as a specific application of our more general Integration Server (iServer) architecture for cross-media information management. Multi-layered linking is introduced as a way to manage the granularity of link anchors and an application making active use of multi-layered links is presented. Furthermore, we point out how the concept of supporting multiple layers in link management can be applied to other media such as, for example, XHTML in combination with the XML Linking Language (XLink).

Categories and Subject Descriptors

H.5.4 [**Hypertext/Hypermedia**]: Architectures

General Terms

Design

Keywords

Cross-Media Linking, Augmented Paper

1. INTRODUCTION

As part of the European project Paper^{++} [6], under the Disappearing Computer Programme (IST-2000-26130), we are investigating the augmentation of physical paper. Instead of replacing printed documents by digital technologies, we aim for integration of paper and digital media. The purpose is not only to provide links between printed and digital information, but also to support flexible ways of hypermedia browsing in terms of easily navigating between physical and digital information spaces.

2. MULTI-LAYERED LINKING

The way that we define link anchors and targets on digitally augmented paper is crucial in supporting multi-layered linking on paper. Instead of using unique identifiers (e.g. simple barcodes) as anchors, we introduce the concept of *active areas* to define link anchors as well as link targets. Various kinds of shapes such as rectangles, circles, polygons and also complex shapes composed out of a group of other shapes are supported to describe these active areas.

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Prior to discussing the benefits of multi-layered linking, we briefly outline the technology we use for spatial information encoding on paper documents. Every page is covered by a grid of invisible inductive barcodes providing information about the page number and the (x, y) coordinates within the page. Further, every document has a unique document identifier (unique barcode or RFID tag). A special reading device in the form of a pen is used to pick up this spatial information by swiping over arbitrary parts of a page. The Paper^{++} information server fetches the corresponding document and page objects based on the unique document ID and page number and checks for every shape associated with the page, if it contains the current (x, y) position. Details about the position detection and transformation process can be found in [5].

To achieve more flexibility in defining the granularity of link anchors, we introduce the idea of virtual page layers. Each active area (shape) is associated with a specific virtual page layer. There can be no overlapping areas within a single page layer but shapes on different layers may intersect. Furthermore, an explicit order is defined over the set of page layers. If a point (x, y) belongs to more than one shape located on different layers, the shape on the uppermost layer is always selected.

We now present an application that has been developed based on our information infrastructure for digitally augmented paper making active use of multi-layered link anchors. A city map of Zurich has been augmented with links on three different layers (background layer, region layer and detail layer) to provide supplementary tourist information (parts of the map are shown in figure 1).

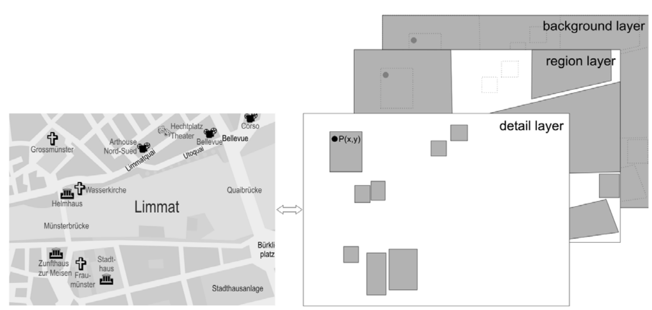

Figure 1: Virtual page layers

A single rectangular active area, covering the entire map and linking to some general information about Zurich, has been defined on the *background layer*. It provides some kind of "backup" link for the case where a user points to a map position for which no other active areas have been defined. The second layer, the *region layer*, contains links to information about larger regions of the city whereas the topmost layer, the *detail layer*, defines link anchors for information about specific buildings or places. The point $P(x, y)$ lies within three different active areas defined on each of the three layers but the system will only resolve the link bound to the shape on the topmost layer (detail layer) and therefore return the most specific information: that happens to be some data about the Grossmuenster cathedral.

In addition, specific layers may be activated and deactivated enabling us to generate context dependent results by binding a particular position on a page to different annotations depending on the current set of active layers. By defining links to semantically related concepts on the same layer (e.g. a restaurant layer, a cinema layer and a layer containing all the shopping facilities) we can dynamically customise our Zurich city map by activating or deactivating specific layers. Further, the layering can be used to provide some "zoom-in" functionality on images or tables of data as a result of repeated selection (similar to the concept of information filters described in [2]). To achieve such an zooming effect, the areas and layers have to be defined in such a way that repeated selection of the same page position causes the uppermost layers to be deactivated in turn, moving down to areas defined on lower layers.

Virtual page layers and the facility to support zooming provides a whole new set of interaction possibilities for paper interfaces, where digital media can be used to provide information about the current context. It is a concept that offers much flexibility, but will require significant investigation to establish guidelines for the use of layering in order to avoid users becoming lost in their navigation of these virtual layers placed over physical documents.

As stated earlier, digitally augmented paper is just one specific application of our general Integration Server (iServer) for cross-media information management. The *pages* and associated *shapes* are a media-specific implementation of the abstract *resource* and *selector* concepts defined by the iServer architecture. A *resource* is the most general type of data component and represents an entire information unit. Furthermore, the *selector* construct enables parts of a related resource to be addressed (similar to the reference objects described in the FOHM model [4]). A selector is associated with exactly one resource, whereas a resource can bind more than one selector.

The iServer architecture is designed as an extensible link management platform able to support any kind of new media types. We now discuss how multi-layered linking can be easily applied to HTML documents by providing media-specific resource and selector implementations. For the sake of simplicity, let us assume that our HTML documents conform to the W3Cs XHTML standard, i.e. they are valid XML documents (which simplifies the discussion but is not an absolute requirement to support HTML as a media type). The definition of a corresponding selector for XHTML documents is quite straightforward since we can build on work that has already been done in context of the XML Linking Language (XLink) [3], a new standard to link XML documents.

XLink uses the XML Pointer Language (XPointer) to address parts of an XML document. By using XPointers as XHTML selectors within the iServer framework, any part of an XHTML document becomes a potential link anchor or link target. Moreover, note that we gain additional features not available in the XLink language. We can define multi-layered links together with a well defined semantics for overlapping links. This becomes very useful in cases where we want to link from different levels of granularity. For example we may want to link not only a full paragraph of an HTML document, but also specific words within this paragraph. The layering concept will always be aware of the context in which the current selection has to be resolved. Furthermore, the iServer architecture is not limited to link within a single medium but enables cross-media linking between all supported media types. Therefore, parts of an HTML document can be linked to printed documents and vice versa.

It is a fact that most existing link services do not allow nested link anchors at all or, in the case that it is possible to define nested anchors, they lack the possibility to control the behaviour of nested links. *ThirdVoice* as well as Hyper-G's *Harmony* browser [1] do not provide any functionality to explicitly define the "priority" of overlapping links and therefore the user always has to choose manually from a list of available links.

3. CONCLUSIONS

We have presented multi-layered links on printed documents as a way to control and refine the granularity of link anchors and support new forms of user interaction such as a "zooming" functionality based on repeated selection of the "same" anchor. Furthermore, we have shown how layering can by applied to and extends the functionality of other media such as for example HTML in conjunction with XLinks.

4. REFERENCES

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