

# Suggestions for Visualising Physical Hyperlinks

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**Abstract.** Physical browsing is a tag-based and mobile device-centric interaction paradigm for ambient intelligence settings. It is a means of associating physical objects and their related digital information by creating physical hyperlinks. The tags, or physical hyperlinks from the user's point of view, have to be visualised to tell the user of the existence and location of the links, how they can be selected and what action they contain. Based on link visualisation in desktop WWW, we present the problem domain, some suggestions for visualising links in ambient intelligence settings, and example visualisation designs to illustrate our ideas.

## 1 Introduction

In physical browsing, the user can access information or services about an object by physically selecting the object itself, for example by touching or pointing to the object with a mobile terminal. The enabling technology for this is tags that contain the information – for example a Universal Resource Locator (URL) – related to the object to which it is attached, and mobile terminals equipped with tag readers. A tagged physical environment can be seen as analogous to a WWW page. It contains links to different services and the user can 'click' these links with a mobile terminal in the same way desktop WWW links can be selected with a mouse.

The first step in physical browsing is *physical selection*, a method for the user to tell the mobile terminal which tag it should read – that is, which physical object the user wants to access. We have defined three physical selection methods: pointing, touching and scanning [1] and implemented them on a PDA [2]. Touching means selecting the link by bringing the terminal very close to the link. Touching can be implemented for example with short-range Radio-Frequency Identifier (RFID) tags. Pointing is a directional long-range selection method, similar to a TV remote control. One way to implement pointable tags is to add a photosensitive sensor to a long-range (typically a few metres) RFID tag with a sensor interface<sup>1</sup> and a pointing beam into the mobile terminal. In scanning all tags within the reading range are read and presented to the user as a list from which the user can continue the selection using the

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<sup>1</sup> Long-range passive RFID tags with a sensor interface are not yet generally available, but they are being developed for example in European project MIMOSA, see <http://www.mimosa-fp6.com>.

graphical user interface (GUI) of the terminal. Scanning requires from the tags only that they are readable over a long range, and for example Bluetooth devices typically use scanning as the selection method.

Ballaghas *et al.* [3] have analysed the design space of mobile phone based interactions in ubiquitous computing. In their design space, physical selection is situated in the “selection” interaction task, and touching and pointing are in the “selection of object with direct pick device” interaction technique. Scanning does not directly map into the selection technique categories of Ballaghas *et al.*

After physical selection, an *action* follows. The action can be anything the terminal is capable of, for example loading a WWW page, making a phone call, setting a mobile phone to silent mode, turning on the lights of the room, or reading a temperature sensor. The action can be determined indirectly by mapping a tag identifier into some action, or the action can be stored directly in the tag. For example, Mifare1k<sup>2</sup> RFID tags can contain one kilobyte of information, which is enough to directly store URLs in the tag itself.

One research challenge in physical browsing and especially in the physical selection phase is the visualisation of the links in the physical environment. The main challenges are communicating to the user 1) the existence of a link, 2) the precise location of the link, 3) the supported selection methods, if the link does not support all selection methods, and 4) the action of the link. By visualising the link in the physical environment, we mean marking the technical device implementing the link somehow – for example in the case of a Radio-Frequency Identifier (RFID) tag it would mean adding some symbols to the RFID “sticker” itself.

To better illustrate the design challenge, let us consider a simple scenario: a movie poster augmented with several short-range RFID tags. The poster includes touchable links for 1) the movie’s WWW page, 2) downloading free movie trailer and theme song via Hypertext Transfer Protocol (HTTP), 3) ordering a chargeable theme (screensaver, background image and ring tone) via mobile phone messaging system, 4) a WWW link to the local movie theatre’s ticket buying service and 5) the phone number of the same service. As the poster is located on a bus stop, there are also other links in the environment. The bus stop sign itself is augmented with a pointable long-range tag that contains real-time information about the buses that are stopping in this location. All these services could of course be behind one WWW page, but physical browsing allows for more natural interaction than using a WWW service with a mobile phone. With all these services having a physical link of their own, the user interface is transferred from the small screen to the large poster and from menu selections to touching or pointing the desired links directly on the poster.

In the scenario, it is useful to indicate the presence of the links in the poster so that the user waiting for the bus will know there are some interactive services available. The technology of the poster tags limits their selection method to touching, so the precise locations need to be marked. The user should also have information about how the tags of the poster and the bus stop sign can be selected so that touch-range tags will not inadvertently be pointed. Finally, there is a difference between the ac-

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<sup>2</sup> See for example

<http://www.semiconductors.philips.com/products/identification/mifare/classic>

tions. Some of them contain free-of-charge information, some chargeable data and some (the ticket reservation call tag) communications between people.

Visualisation happens in several levels of physical browsing. In addition to the physical link, the information can be presented in the terminal. A useful aid in determining the action of the link would be ‘hovering’ in the same way it is possible in current desktop WWW browsers. In hovering, the user could select the link, but instead of immediately activating it, the terminal would query the tag for the action and display it to the user. It is also possible to display the link for confirmation after selection or create a separate page containing visualised virtual links after selecting the physical link in the object. However, in our physical browsing evaluations the users have preferred to open simple information links as effortlessly as possible without confirmations and intra-terminal operations. Our whole visualisation work intends to support this single most important case: the simple free-of-charge information content must open with a minimum of confirmations or menu selections. We see this as an essential requirement for natural interaction in ambient intelligence environments and therefore the links must be presented so that they support this.

There is no single correct solution to the visualisation chain, rather this work should be seen primarily as an analysis of the challenges, and as a suggestion for the physical presentation layer for the links. Our simple visualisation example at the end of the paper should be seen only as an example to illustrate our views and the challenges we have found, rather than as a real proposition for visualisations.

## 2 Physical Hyperlinks in Related Work

Riekkilä *et al.* [4] have built a system that allows requesting pervasive services into a mobile phone by touching RFID tags with a separate RFID reader connected to the phone. As a part of their work, they have designed visualisations for the tags. The basis of the symbols is a ‘general’ tag depicting a generic RFID tag. In addition to the general tag, they have added into the general tag special icons for example for printing, setting phone profile and placing a call. These special tags describe additional information related to the action of the tag. Riekkilä *et al.* report in their results that the users preferred the special tags because “the special tags present their meaning in a concrete way that they felt was logical, fast, and easy to use”. Users also felt the special tags were more secure because they could better predict the action. Because the system of Riekkilä *et al.* only supports selection by touching, they did not visualise the selection method in any way.

Want *et al.* describe several applications [5] in which they have used RFID tags as physical hyperlinks. One of them is Photo Cube, which has a picture of a person on each side. Embedded into the picture is a tag that contains a link to that person’s home page. In other applications, the link is embedded under a descriptive text and the user has to figure out the existence and action of the link by guessing from the appearance of the object, or by experimenting.

Kindberg *et al.* have built CoolTown [6], which is implemented with both active infrared tags and passive RFID tags. In CoolTown, the links are often scanned for automatically and displayed in the mobile terminal instead of the environment. They

have also created eSquirt, a protocol to transfer URIs between devices. The user has to point the mobile terminal towards the target device to send the link, meaning that the user has to know the presence and approximate location of the receiving “link”. Another directional IR-based system is GesturePen by Swindells *et al.* [7]. In their article, they have a picture of an object they have augmented with an infrared tag, which is visible only as a technical device, but without any other identification of its presence or function.

In visual tagging systems [8], the tags are inherently visible, and thus clearly communicate their presence to the user. However, the tags are all similar in appearance, and the action does not show in any way.

The current commercial physical links visualise their implementation technologies. These links are for example NFC<sup>3</sup> symbols, or logos of commercial Bluetooth<sup>4</sup> and infrared-based local service providers<sup>5</sup>, forcing the users to concentrate on the technology instead of the content.

### 3 Implications from Scenarios

We have designed several tag-based ambient intelligence scenarios [9] that utilise physical selection as one of their basic interaction patterns. From these scenarios, we have identified the following common classes of actions in addition to viewing simple information content:

- making a phone call or sending a message,
- downloading and installing an application,
- starting an application in the terminal,
- connecting an external wireless device to the terminal,
- user identification, for example mobile terminal as a key,
- setting the terminal state, for example to silent mode,
- controlling an external device, for example lights,
- reading a sensor attached to a tag, and
- reading tag contents for future use, for example for ‘drop’ operation, and ‘dropping’ saved tag contents to a target device.

In addition to the actions, some non-functional characteristics might be useful to visualise. Examples of these are the cost of the service, and whether the communication is local or external.

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<sup>3</sup> <http://www.nfc-forum.org>

<sup>4</sup> <http://www.bluetooth.com>

<sup>5</sup> See for example <http://www.bluecasting.com>, <http://www.kameleon-europe.com>,  
<http://www.wideray.com>

## 4 Lessons from Hyperlinks in Desktop WWW

### 4.1 Visualising Links

Hypertext Markup Language (HTML) [10] defines two components for each hyperlink: the Universal Resource Identifier (URI) [11], or address of the resource, and the visual presentation of the link. The presentation can be for example a fragment of text or an image. The usual way for presenting a textual link has been to use a different colour for the link and to underline it [12, 13]. Textual links are generally used in two ways: as navigational link lists, or as links inside regular text. For example, an almost standard navigational aid in current websites includes a navigation bar – a list of textual links – on the left side of the page. Nielsen and Tahir state [13] that in the navigation bars it is not strictly necessary to visualise the link by colours and underlining. The navigation bars have become so common that users are normally able to recognise them as link lists without any specific visualisation techniques. We expect the physical links to gain a similar status with time; that is, the users will learn the common places and uses for these links.

An image is another common presentation for a link. Image icons are used in the same way as in non-browser graphical user interfaces and in addition to them, any image can act as a link.

By default, most WWW browsers display the address of the link in the status field or as a tool tip while the cursor is hovering above the link. For the user, this is a useful indicator of the existence of the link and gives a hint about the action by displaying the URI or link title. We suggest hovering as a similar interaction technique for mobile terminals and tags.

### 4.2 Visualising Actions

With *action*, we mean the result of selecting a link, for example displaying a new WWW page or opening an email client to send mail to an address specified in the link. The resource identified by the URI is typically another WWW page. It may also be of different content type, for example an image or a PDF document. Displaying these resources is left to the WWW browser and it may display them itself or launch another application to display the resource. An example of a content type that typically is handled outside the web browser is `text/x-vCalendar`<sup>6</sup>, which is used to transmit calendar entries and is usually handled in a specific application. The main classes of actions available in desktop WWW are thus:

- Opening a new WWW page or another resource that the browser itself can handle, for example an image and
- Opening a new resource the WWW browser cannot handle on its own, such as a calendar entry, or a `mailto` link.

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<sup>6</sup> <http://www.imc.org/pdi>

Nielsen and Tahir have suggested in their guidelines that any link that opens a resource other than another web page should be designed so that it clearly tells the user what will happen [13]. This visualisation is very important when the link opens another program and takes the user away from the browser application. A classic example of bad link design is to link a person's name to his or her email address. When clicking the link, the user expects intuitively to see the person's WWW page, but is instead thrown into the email application. Instead, the link visualisation should indicate the action, for example by displaying the email address as link text instead, or using a commonly recognised email icon as the presentation. We see the visualisation of physical hyperlinks as a similar problem and that lessons learned from desktop web can and should be applied in physical environments as well. The action of the link should thus be included in the link visualisation.

### **4.3 Context of the Link**

In addition to the immediate link presentation, users interpret the existence and the properties of the link from other sources. WWW pages often follow regular patterns, like having in the upper left corner an image link that leads to the front page of the site [13]. Users have learned these through visiting several sites that behave in similar ways and many designers have learned to adhere to these unwritten standards.

This is possibly the most important lesson from desktop browsing. The physical objects typically already have some function and the users will expect the link to be related to that function. The object itself can thus be seen as one part of the link presentation, just as the whole page or context of the WWW link is part of its presentation. However, there are still questions regarding the physical hyperlink, for example whether a link in a door gives information about the status of the door or toggles the lock.

## **5 Visualising Physical Hyperlinks**

As stated earlier, the first two challenges for visualising physical hyperlinks consider the existence and location of the link. Any visual presentation in the same spot as the tag will tell the user that there is a link, and it will tell the user the exact location of the link. The next two challenges consider the selection method and the action. There are only a limited number of methods for selecting a link in a physical environment, even if new selection methods in addition to pointing, touching and scanning are needed and defined.

The number of actions is, however, large and not limited in any way. In desktop user interfaces, there are some conventions for commonly used icons, such as a floppy disk often representing the save function. However, for more uncommon actions the designers often design their own icons that may be difficult to understand for the users. Another option is to reduce the amount of visualisations by classifying the different actions into wider groups based on what the user expects from selecting the link. The most precise way to visualise the action is a specific icon for each possible action. The other extreme is a single icon that only communicates the presence of a

link. The aforementioned classification categories may be a reasonable compromise. On the other hand, for example setting the terminal state is such an abstract concept that it is hard to design a good icon for it. The more concrete icon for setting the terminal into silent mode is far easier and understandable to the user.

We have chosen not to visualise the implementation technology at all other than implicitly in the selection method. Optimally, the user should not be required to know whether a link can be read using RFID, Bluetooth or some other technology. For example, when the user touches a link, the terminal should use all the short-range technologies it can to read the contents of the tag. The current physical links work exactly opposite to this and concentrate on visualising the implementation technology.

## 5.1 Constructing Visualisations

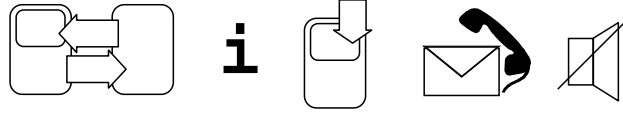
Some simple ways to design a visualisation for a link include using a *geometrical shape* for the whole visualisation, a *colour*, and a *shape for the actual content icon*. The actions are more variable than the selection methods and the icon content shape allows a large number of variations. Therefore, we suggest the content shape to be reserved for the action, as in desktop GUI icons.

This will leave for the selection methods the other visualisation techniques, for example the overall shape of the visualisation and the colour. The colour does not associate with any selection method but if for example presenting pointable tags as blue becomes a standard, the users will learn it. It may be possible to design overall shapes for the links so that they naturally map to the different selection methods. In addition to that, we presume that shape will also become a learned notion, if for example simple geometrical shapes like circles, triangles and squares are used around the action icon. Ideally, the link can be selected by touching, pointing and scanning, but the technical limitations of tags may exclude some methods. In the next subsection, we suggest an additive method as an example that can visualise different selection methods by combining selection symbols around the action icon.

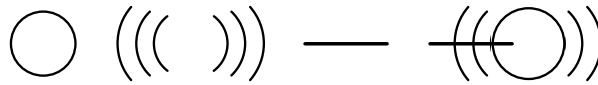
Textual links are also a possibility and they are unambiguous if the link text is chosen well. While it could be possible to use link text in physical hyperlinks too, it would cause some problems in practice. In desktop environments, it is easy to control the size of the link text, but links in small objects or links farther away from the user might become difficult to recognise.

## 5.2 Example Visualisations

In Figure 1, there are icons for visualising actions: connection/control, information retrieval, download/install, messaging and an icon for setting the terminal to silent mode. It should be noted that these are only examples to illustrate the concept of visualisation. For example, the ‘i’ icon is comprehensible only for people who live in cultures that associate ‘i’ with information.

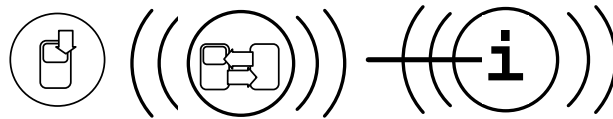


**Fig. 1.** Actions. From left to right: connecting, information, download, messaging and silent mode.



**Fig. 2.** Selection methods. From left to right: touch, scan, point and a tag supporting all three selection methods.

In Figure 2, there are additional additive visualisations for presenting the selection methods. The first one is for touchable (short-range) tags and the second with ‘radio waves’ is for tags that can be read by scanning (long-range). The third symbol is for pointing and in the last symbol, the three selection symbols are combined into one visualisation for a link that can be selected by any selection method.



**Fig. 3.** Actions and selection methods combined.

We show three combinations of actions and selection methods in Figure 3. The first visualisation represents a link that can be read by touching and that downloads or installs software to the terminal. The second one shows a link that can be selected by touching or scanning and that connects the terminal to another device. The third visualisation describes a link that contains a simple information page and can be selected using any selection method.

## 6 Conclusions

We have analysed how links can be selected in current desktop World Wide Web, and what actions are available both in web and in physical browsing systems. Based on these analyses we have presented suggestions for visualising links in ambient intelligence settings, and a few example visualisations. In addition to the link visualisation itself, the context and perceived affordances of the object will also give suggestions



for the action, for example, a link in a door is likely to open or lock it and not turn on the lights of the room.

We have implemented a preliminary version of the hovering concept as a part of a physical browsing application. Our future work on physical hyperlink visualisation will include further studying hovering and how to divide the visualisations between the physical tag and the graphical user interface of the mobile terminal.

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