One Way Interaction: interactivity over unidirectional links

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ABSTRACT

In this paper we describe a strategy to achieve limited interactivity in situations where part of the communication is restricted to one direction. We illustrate this strategy in a scenario in which a stationary presentation system generates adapted interactive graphical way descriptions for mobile users in the form of hypergraphics. These descriptions are shown on a mobile display unit with very limited computing capacity. For technical reasons the communication between the presentation system and the mobile display system is restricted to one direction (i.e. the broadcasting of information by the presentation system) and to a relatively low bandwidth. A limited form of interactivity of the generated graphical presentations can be achieved without sending back information from the mobile unit to the server. By anticipating all possible interactions with a generated hypergraphical presentation the necessary variations can be generated and broadcast. If the transmission of the different levels of this presentation tree follows a certain scheme, the available level of interactivity of a presentation increases over time (as its exploration consumes time), while a very fast availability of the first and most simplistic presentation can still be guaranteed. Furthermore, any delay that could be caused by communicating back and forth with the presentation system over the low bandwidth connection is avoided, since all the necessary presentation parts are cached on the display device after one broadcasting cycle.

KEYWORDS: Interaction, Presentation Systems, Hypergraphics, Resource Adaptiveness

Introduction

We describe a scenario in which a mobile user is guided through a building by means of adaptively generated hypergraphical way descriptions. The mobile user is equipped with a small display unit with limited computing capacity, such as the 3COM Palm III PDA. The hypergraphics are generated on a stationary presentation server for which we can – given the task at hand – assume sufficient computing capacity. The generated descriptions are broadcast via a system of infrared transceivers installed in every room and in certain locations along the hallways of the building. Each transceiver broadcasts a presentation that was specifically generated under the assumption, that the user is within the transceiver's range at the given time. The presentations are received by an infrared sensor built into the PDA and displayed on its screen. Since power consumption of the mobile unit must be kept low, infrared communication over these distances from the unit back to the stationary system is practically out of question. Nevertheless a certain amount of interactivity of the generated graphical descriptions is desirable. A user should at least be able to query details about information she sees on her display, i.e. the displayed text should be hypertext and graphics should be hypergraphics. In order to achieve complete interactivity without two way connectivity between the generation system and the display unit, the complete hyperpresentation has to be transmitted. Given the low communication bandwidth over the infrared channel, this involves too much data to allow for a fast display of the initial presentation, unless the presentation is split into small pieces in a useful way.

Structure of the presentations

One possibility to split a hyperpresentation into pieces is to distinguish between different interaction levels, which creates a tree structure with relatively small pieces of presentation at each node. Let's say the initially visible hyperpresentation before any interaction is at level 0 or at the root of this tree. If additional information exists for a certain element of the level 0 presentation, this additional information can be categorized as a level 1 presentation part. For a given level n hyperpresentation, there are usually several level $n + 1$ presentations, one for each selectable element. Each of the level $n + 1$ presentation parts contains just the amount of information that needs to be added in response to the corresponding interaction. In order to make this clearer, let's look at the following example (Fig. 1):

A user is guided through a building and enters a room or subpart of the hallway (defined by the area covered by a single infrared transceiver). The display unit should almost immediately show a very simple level 0 presentation, which should be easy to decode and which should involve only a small amount of data to be transmitted. In the case of way descrip-

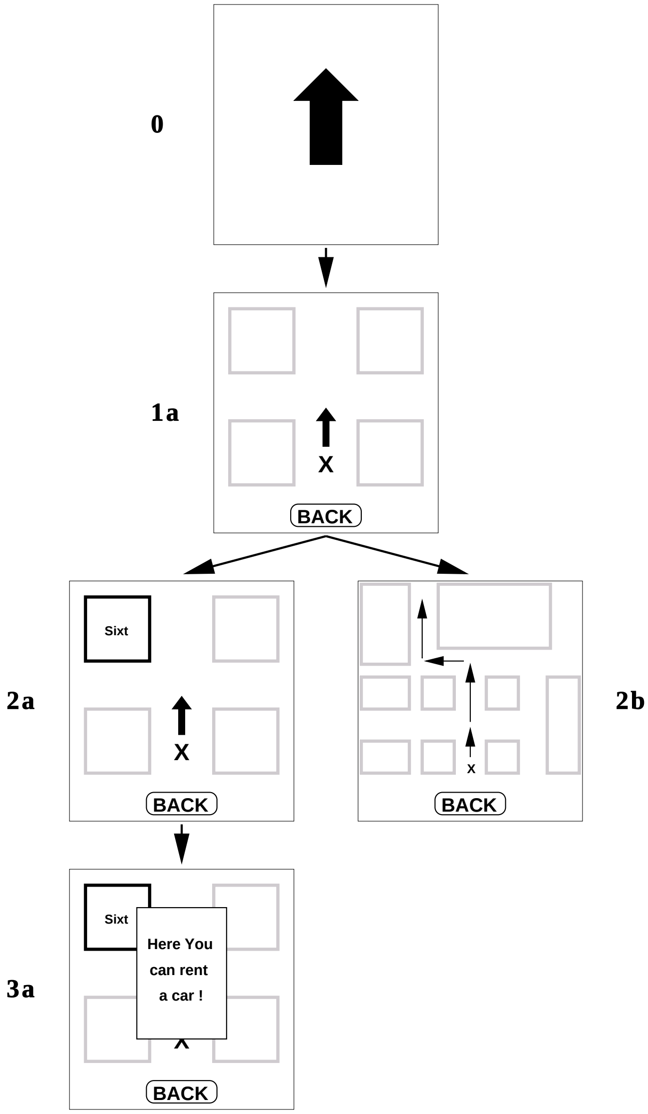

Figure 1: Structure of a simple hypergraphical presentation

tions, this could, for example, be an arrow pointing in the direction to be followed (assuming a current walking direction and that the PDA is held upright). If the user immediately proceeds to the next section, nothing but this simple arrow is ever displayed. If she decides to stay in the same area for some more time, this might be because the level 0 presentation didn't provide enough information to proceed. While the user stays in the same area, additional information is received by the PDA, so that a more detailed presentation can be displayed, either automatically or on request. If, for example, the user taps the initial arrow with the pen, a simple map sketch with the user's position and the intended walking direction can be displayed as the level 1 presentation, providing additional landmark and orientation information. In order to make this map interactive again, additional (level 2) information must be received, such as details about elements visible in the map. As soon as this information is available, the respective elements become selectable (see Fig. 1, transition from 1a to 2a). When they are selected by the user, the additional information can be displayed immediately (Fig. 1 part 3a).

Every part of the presentation that was received is cached inside the display unit, so that after one broadcasting cycle (all of the parts have at least been transmitted once) the complete version of the hyperpresentation is available. The user can then navigate back and forth through the presentation tree by tapping selectable elements or a **back** button. Transitions from one level of the hyperpresentation to another can either be a refinement of the information displayed (1a to 2a, 2a to 3a), a generalization providing more context (1a to 2b) or a qualitative change of the way in which information is presented (0 to 1a). The exact form and structure of the whole hyperpresentation is generated automatically, and the design decisions involved in this process are beyond the scope of this paper.

Broadcasting scheme

From the above example we can see that different presentation levels can be broadcast at different time intervals. Certainly the level 0 presentation must be available at least every one or two seconds, because we can't predict at which point in time a user enters the cycle of transmitted pages. For the level 1 presentation a longer interval between retransmissions can be allowed. A lower bound for this interval is provided by the estimated minimal time until the level 1 presentation can be requested (i.e. until the user has understood and interacted with the level 0 presentation). This also implies that the intervals between retransmissions can increase at least linearly with the level of a presentation part. From these constraints a sequence of presentation parts can be derived, which ensures a short delay for the initial presentation and mostly 'hides' delays for subsequent presentations 'behind' the time it takes the user to read and understand the presentation of the next higher level. For the simple example above, such a sequence would be:

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0, 1a, 0, 2a, 0, 1a, 0, 2b, 0, 1a, 0, 3a
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In this cycle of 12 transmissions, the level 0 presentation is transmitted in every other step. Transmission of the level 1 presentation part takes place in every fourth step, so that the average delay for the level 1 presentation is twice the one for the level 0 presentation. The remaining presentation parts of levels 2 and 3 are transmitted only once every 12 steps, which results in an average delay of 3 times the one for level 1.

Broadcasting schemes for more complex presentation trees tend to be very tricky to design in a deterministic way. One solution to this problem is to assign every presentation part in the tree a probability depending on its level and the number of parts within the whole presentation, and then on the basis of these probabilities randomly select the next part to be transmitted. In the above example one possible distribution of probabilities would then be:

presentation	probability
0	0.5
1a	0.25
2a	0.1
2b	0.1
3a	0.05

Presentation 0 is chosen in every step with a probability of 0.5, which means that it is transmitted statistically every other time. Presentation $1a$ is transmitted every fourth time again, so the average delay is twice the one for level 0, level 2 takes five times the time of level 0, and level 3 ten times. Such a distribution of probabilities can be computed for any given presentation tree according to certain constraints. If we allow for the delay to increase exponentially, we will get much lower delays for the first few levels at the cost of interactivity at deeper levels. If we constrain the increase in delay to be linear with a factor relatively close to 1, the distribution of probabilities will approach an equal distribution. In this case we would gain a relatively fast availability of deeper interaction levels at the cost of a relatively high delay for the initial presentation.

These constraints can be formulated according to the task and situation at hand, as well as depending on the overall amount of data to be transferred and the necessary interaction speed. Since the presentations in our scenario are generated automatically, a distribution can even be derived from the estimated relative importance of different parts of the presentation. This allows the broadcasting scheme to be adapted not only to the restrictions of technical resources, but also to the use of cognitive resources of a user.

Summary

We have presented a method to achieve a certain form of interactivity (hypertext / hypergraphics) over a one way connection. The method was illustrated with a scenario, in which a presentation system is connected to its mobile display unit over a one way infrared link. The generated hyperpresentations are split into small parts which are categorized by the level of interaction at which they are needed. By transmitting the different levels of the presentation at different time intervals, the available communication bandwidth can be used in such a way, that, no matter at what point in time the user establishes a connection, a fast availability of the first presentation level can be guaranteed, while other levels will appear with delays according to the estimated time at which they are needed. This broadcasting scheme provides a substantial gain in interactivity over well known schemes such as the one used to distribute, for example, video text. It is also independent of the application domain presented here and can be used for information presentation via arbitrary hypermedia.

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