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Kids as Data: Using Tangible Interaction in a Science Exhibit

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Abstract

This paper describes the design and implementation of a science exhibit aimed at giving children an understanding of the different factors that can affect the speed of a computer. The exhibit uses tangible interaction engaging visitors in a way that would not be possible using standard interaction techniques such as a keyboard and mouse. An informal evaluation of the initial prototype has indicated that the exhibit is successful at informing the users of the concepts being presented.

Keywords

Tangible interfaces, e-Learning, science exhibit

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

K3.m. Computers and Education: Miscellaneous.

Introduction

This paper describes the design and implementation of an exhibit for a local science centre. The purpose of the exhibit is to provide visitors to the centre a better understanding of an aspect of computing. Although the target audience for the exhibit is 10-12 years old, the exhibit must be accessible to the wide range of visitors to the centre who vary in age from pre-school to adult.

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ACM 1-59593-298-4/06/0004.

The exhibit uses tangible interaction to demonstrate the effect different computer components have on computer speed. Users of the exhibit are required to move data through the different components in order to display an image on the screen. Tangible interaction was chosen, as opposed to using a mouse and keyboard, for several reasons: it provides a certain novelty which may attract visitors to the exhibit; it requires the user to physically move through the exhibit to transfer the data reinforcing the effect of the different computer configurations; and it affords a simple and robust interaction with the user.

At the time of writing, the exhibit has been prototyped and informally evaluated. It is hoped that it will be installed in the centre early in 2006 enabling a more comprehensive evaluation of its effectiveness to be undertaken.

Related Work

Fitzmaurice *et al.* introduced the concept of graspable interfaces which used physical objects – or bricks – that were tightly coupled to virtual objects [1]. By manipulating the physical object, users were able to manipulate the virtual object in a tangible way. Similarly, Ullmer *et al.* used *phicons* [2] - or physical icons – to allow users to manipulate objects on a virtual desktop.

Ullmer *et al.* also suggested that phicons – in this case wooden blocks called *mediaBlocks* – could be used as references to online data allowing for the “containment, transport, and manipulation” of the data. Barrett & Maglio [3] suggested that floppy disks could be used as the physical tokens with the disks containing a reference to the data. This enabled the disks to appear

to have limitless capacity while still functioning in the usual way.

The WebStickers system [4] used barcodes attached to physical objects such as Post It notes to act as physical bookmarks for URLs associated with the barcodes. The bookmarks could then be shared by passing the note onto a friend or colleague.

The PegBlocks system [5] is an example of the use of tangible interaction in an educational setting. The system enabled kindergarten children to develop an understanding of some abstract physics principles through the manipulation of a set of wooden blocks containing protruding pegs. The system encouraged spontaneous collaboration as a change made in one block caused a reaction in a distant connected block.

Exhibit Design

The exhibit described in this paper is intended to help users understand an aspect of computing. Although an exhibit could be generated on a standard desktop computer it was decided to build the exhibit using a tangible interface with the visitors required to physically “move” the data to complete the task. It is hoped that this will prove both more memorable and more educational than simply clicking on a screen.

Several possibilities were considered regarding the aspect of computing to be demonstrated with the two most likely ideas being: the effect different computer components have on computer speed; and the transfer of packets using the TCP/IP protocol. The second idea was discounted as, to be effective, it would require groups of users to act as the packets which become unordered while crossing the network. While this is

entirely feasible it would not be accessible to individual visitors to the centre.

Once the concept to be demonstrated was finalized it was fairly straightforward to conceive of a sample task the users would have to complete: the rendering of an image onto a screen. Based on the current configuration of the exhibit the users are required to transfer image data between the different components of the computer in order to display the image.

The users are able to choose between four different configurations of computer, each of which vary in the quality of components used. Four components are varied: the processor and bus (which vary in speed); and the cache and memory (which vary in size). The computer modelled by the exhibit greatly simplifies the underlying concepts being demonstrated. For example, if the cache is sufficiently large then the data need only be fetched from there with no requirement to pre-fetch the data into the cache. The differences between the four configurations are summarized in Table 1. An alternative approach where the values for the four variables could be set using four sliders was considered but was discounted as it made it too easy to simply turn everything to the maximum value and get the fastest configuration without any understanding of the underlying principles.

Figure 1 gives an overview of how the different components fit together to create the exhibit. The various components are designed to be located across a wall with the distance between the disk and the other components maximised to indicate the expense of disk access. In the prototype implementation, the disk is

approximately 7 meters from the CPU, the memory is approximately 2 meters from the CPU and the cache is adjacent to the CPU.

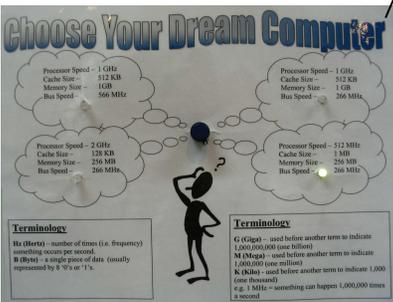
Configuration	Advantage	Disadvantage
1 - Fast CPU, small memory & cache, average bus.	Able to process data into an on screen image quickly.	Data must be fetched from disk 4 times.
2 - Large Memory, average bus, CPU and cache.	Data only needs to be fetched from memory.	Processor not very quick; 4 trips required to fetch data.
3 - Large memory, fast bus, average cache & CPU.	Only 2 trips required to fetch data.	Processor not very quick.
4 - Large cache, average memory & bus, slow CPU.	Data can be fetched directly from the cache.	Slow image processing. 4 trips required to fetch data.

Table 1. Summary of different computer configurations.

Once the user has selected the desired configuration the start button is pressed and a picture of the user is captured by the webcam. It is this image that will be transferred to the CPU for processing and subsequent display. Using a RFID tag the user must then transfer the data between the components of the computer to display the image. Data is transferred by “collecting” it from the first component – by swiping a RFID tag at the appropriate RFID reader – and “passing” it to the next - again, by swiping the appropriate reader. The component the user must swipe next is indicated by a light above the appropriate RFID reader.



The computer components (shown as solid boxes) are represented by RFID readers (above). A reader is lit if data is available for collection.



The users can select from one of four preset configurations. The currently selected configuration is lit.

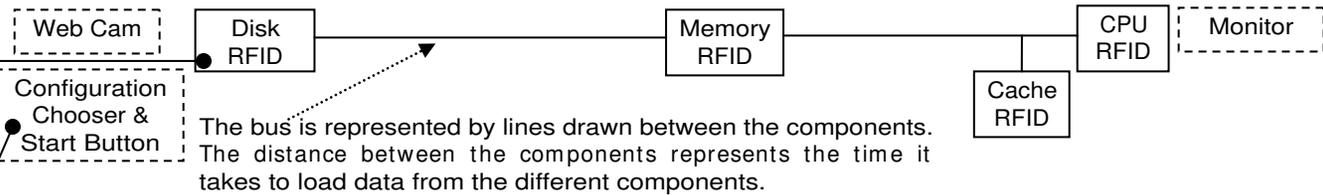


Figure 1. Schematic layout of the exhibit. The four main computer components – the disk, memory, cache and CPU – are RFID readers. The sliders and button allow the user to configure the computer and take the image to be transferred. The callouts show the current prototype implementations of a RFID component and configuration selector.

In configuration 1, for example, the data must first be fetched from the disk and subsequently passed to the memory and CPU for processing. The user therefore is required to swipe the disk, memory and CPU RFID readers as they light up. When the CPU receives the data its light flashes at a speed relative to its processing speed and the portion of the image represented by data transferred is drawn on the screen. Once the processing is complete the Disk RFID will light up again and the user must repeat the task four times until the image has been completely processed.

Figure 2 shows the display on the exhibit's monitor. Two images are currently displayed: a completed image and a partially processed image. The amount of the partially drawn image shown represents the amount of data transferred to the CPU and processed. This image is located to the right of the initial image with subsequent images spiralling around the first image until the screen is full and the initial image – if still visible – is replaced. Once an image has been fully processed a new computer configuration can be selected and the task can be repeated with a new image.



Figure 2. Screenshot showing earlier image fading and current image partially processed.

As part of the self maintenance of the exhibit the completed image in Figure 2 is starting to fade. Similarly, a partially processed image – if unchanged

for five minutes - starts to fade allowing a new configuration to be chosen.

Exhibit Implementation

The exhibit uses Phidgets [6] to provide a tangible interface for visitors. Four RFID readers connected to an USB hub represent the components of the computer. A rotation sensor is used to allow visitors to select the computer's configuration. The exhibit software is written in Java.

Discussion

A prototype of the exhibit has been demonstrated to a small number of potential users. Although this can in no way be considered a formal evaluation it did indicate that the exhibit at least partially fulfilled its purpose. Some of the users carefully considered the different computer configurations before selecting what they thought to be the optimal configuration whereas others were satisfied to see what effect changing the configuration would have without necessarily thinking about the underlying reasons. This would seem to confirm that the use of preset configurations - as opposed to the use of sliders for the different variables - is the correct approach as it requires either some thought or some experimentation to determine the best configuration.

It was also found that the layout of the exhibit should be adjusted from that shown in Figure 1. As it stands, the monitor which shows the images after processing is next to the CPU RFID which is at the far end of the exhibit from the start point. This makes sense from the point of view of the flow of the exhibit - the data is transferred through the exhibit to the CPU where it is processed and displayed – but it created the wrong

focal point when users approached the exhibit. Most users were initially attracted to the monitor despite the large “Start Here” sign at the opposite end of the exhibit. We hope to solve this by placing the monitor above the exhibit. This will also allow the exhibit to be presented as a super size computer with the monitor sitting on top as is the case with many computer setups. The elevation of the screen will also enable it to be seen from a greater distance making the exhibit more accessible to onlookers.

Some of the more technically aware users questioned the exhibit's accuracy. It is true that some details – such as the need to fetch data into the cache before it can be used – and tricks – such as different caching techniques that can help overcome limited cache size are omitted in the exhibit. It is felt, however, that these details would merely cloud the principles being presented and are not appropriate to the target age group. There is, however, some discussion of such techniques in the documentation that is presented in association with the exhibit.

Future Work

Once the exhibit is installed it is hoped that a more formal evaluation of the exhibit will be possible. This will determine whether the exhibit is effective at conveying the principles of how computer speed is affected by different components.

The use of RFID to allow visitors to the science centre to simulate the movement of data through a computer system has many future possibilities. One such possibility - the demonstration of TCP/IP to a group of users – was previously discussed. A further extension would be to create multi-site exhibits where visitors in

disparate locations are able to interact. This interaction may be active – i.e. one user responds to another user's actions - or passive – i.e. the users' actions combine but no explicit interaction is required.

Conclusions

This paper has presented the design and initial implementation of an exhibit designed to give users a better understanding of the effect different components have on computer speed. The exhibit uses tangible interaction to reinforce the differences by making the users physically move between the computer components to transfer the data. Although an initial demonstration of the exhibit indicated that users were at worst required to experiment with different computer configurations and at best analysed the configurations to determine the fastest it is only once the exhibit is installed into the Science Centre that the true value of the exhibit will be known. It may be that the users of the exhibit will view it as an interesting novelty and simply generate an image to be displayed without any thought to the speed of the process. If this is the case the concept behind the exhibit - the use of RFID technology to simulate the transfer of data - could be used to demonstrate other aspects of computing.

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