InfoPoint: A Device that Provides a Uniform User Interface to Allow Appliances to Work Together over a Network

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Abstract: This paper proposes a new hand-held device called 'InfoPoint' that allows appliances to work together over a network. We have applied the idea of 'drag-and-drop' operation as provided in the GUIs of PC and workstation desktop environment. InfoPoint provides a unified interface that gives different types of appliances 'drag-and-drop'-like behaviour for the transfer of data. Moreover, it can transfer data from/to non-appliances such as pieces of paper. As a result, InfoPoint allows appliances to work together, in the real-world environment, in terms of data transfer. A prototype of InfoPoint has been implemented and several experimental applications have been investigated. InfoPoint has shown its applicability in a variety of circumstances. We believe that the idea proposed in this paper will be a significant technology in the network of the future.

Keywords: Data transfer; Direct manipulation; Drag-and-drop; Hand-held device; Information appliances; Non-appliance; User interface

1. Introduction

Owing to recent improvements in digital and network technologies, network connection is extending beyond personal computers to embrace home appliances such as TVs, air conditioners and refrigerators. Such network-connected appliances are often called *information appliances* [1]. It is now reasonable to expect that all appliances will communicate with each other via wired/wireless networks in the near future.

When we use information appliances in such an environment, however, we will encounter various problems, especially concerning the user interface. Suppose that a user wants to print out an image stored in a digital camera as shown in Fig. 1. The digital camera is not usually capable of handling printers directly, even though both the digital camera and the printer are connected to a network. Thus the data must initially be transferred to a personal computer. The picture data are then printed out via the personal computer, and the results placed in two steps. The interface of a typical printer is designed only to handle data from computers.

In addition, in current network environments, the ID (e.g. host name, IP address) of the

Fig. 1. The interface of a typical printer.

appliance must be known before it is possible to transfer data. This is so regardless of the physical locations of appliances. For instance, even if there is a printer in front of a user, there is no way to print something out from it without information such as the name of the printer. The problem is that the design of interfaces does not allow the use of intuitive operation. An operation could, for example, correspond to the action of physically moving an object from the right-hand to the left-hand side of a desk.
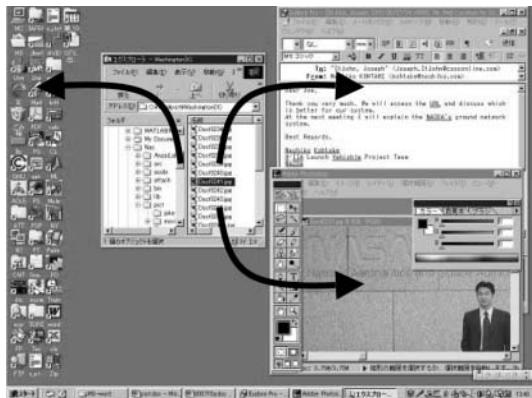
Fig. 2. 'Drag-and- drop' operations.

The way in which memory cards are now widely used is a partial example of the intuitive handling of data. For example, after taking photos with a digital camera and storing the image data in a memory card, the card can be inserted in a PC for data transfer, or in a projector for projection of the images on to a screen. To transfer data in this manner, a user does not need to know the name of each PC or projector, instead transferring data by physically moving the memory card.

In the example mentioned above, however, a network is not used to transfer the data, that is, this mode of use is off-line. It thus does not take advantage of the benefits of having various appliances 'on-line', which can provide more flexible and useful ways of handling data. Above all, we believe that in current network-connected environments, interfaces that keep the intuitiveness involved in the handling of physical objects in the real world are necessary to enable the efficient handling of data by users.

In contrast to these situations, the GUIs provided in desktop environments allow users to transfer data among applications by using a mouse. In the common 'drag-and-drop' style of operation, a user first 'points' to an object such as an icon on the screen by pressing a mouse button, 'drags' it to a desired location, and 'drops' it there by releasing the button. The user can, for example, transfer data from folder A to folder B by a drag-and-drop operation. Moreover, the single mouse operation can be used with different applications. As shown in Fig. 2, a user is able, according to the destination of the picture data, to attach it to an email message, to edit it in an editor, or to browse through it on a picture viewer. This style of operation is extremely convenient and is widely used in today's desktop applications.

Table 1 compares typical operations in the desktop environment and the real-world environment. In the desktop environment, a single operation, such as the drag-and-drop, can be used in various contexts. In the real-world environment, in contrast, the user must select the operation that is appropriate to the target appliance. The most common situation today is to have each interface in the real-world environment tethered to a single appliance. Although it may be possible to connect the appliance to a network, this is not designed to allow data processing among multiple and various appliances over a network. A user interface for the transfer of data among various appliances in a uniform way is required for the emerging network-connected environment.

In this paper, we report on our development of a device called InfoPoint that allows appli-

Table 1. Desktop vs. real-world

Desktop environment	Real-world environment
Moving a data file from folder A to folder B	*Printing out data from a digital camera on a printer*
1. Open folder A	1. Check a cable between a digital camera and PC
2. Point to a target data file	2. Check the image data in the digital camera
3. Drag the data file from folder A	3. Transfer the data to the PC
4. Drop the data file into folder B	4. Print out the data from the PC to a printer
Attaching a data file in folder A to an email message	*Recording a TV programme on a videotape in a VCR*
1. Open an email editor	1. Find the target TV programme in a newspaper
2. Point to a target data file	2. Check a videotape in a VCR
3. Drag the data file from folder A	3. Remember the TV programme information
4. Drop the data file into the email editor	4. Input the TV programme data to the VCR

Fig. 3. A conceptual example.

Fig. 5. Transferring data from a poster.

ances to work together over a network. InfoPoint is able to transfer data from one appliance to another by the operation of a uniform pointer in a similar way to drag-and-drop. The appliances have various interfaces, so a uniform pointer, in the same role as a mouse in the desktop environment, is indispensable in the handling of data transfer among appliances of different types. InfoPoint corresponds to the mouse, and enables the common handling of data among the appliances. A conceptual example of the use of the InfoPoint is shown in Fig. 3. With the same operation, a user is able to copy data from a desktop computer to a laptop computer, a PDA, or even a printer.

As shown in Fig. 4, it is possible to use InfoPoint to make a VCR automatically record a TV programme. The data on the TV programme is transferred to the VCR by a drag-and-drop operation, just like the dragging-and-dropping of picture data on the icon of a picture editor in a desktop environment's GUI.

Moreover, all of the data is stored on a network and can thus be transferred over the

network, so it is even possible to transfer data that is printed on paper and create new applications by attaching data on paper. For example, it would be possible to transfer a URL from a poster to a computer and then browse through the details stored under that URL (Fig. 5). InfoPoint enables appliances to work together in tasks that involve data transfer, letting all appliances handle data.

2. Realising Drag-and-Drop Operations in the Real-World Environment

The hand-held part of the InfoPoint system is shown in Fig. 6. The primitive operations required to apply a drag-and-drop style of operation under InfoPoint are shown in Table 2. This table shows each step of a drag-and-drop operation for the transfer of data on the desktop of a PC, and the corresponding steps by which


Fig. 4. Using InfoPoint to operate a VCR.
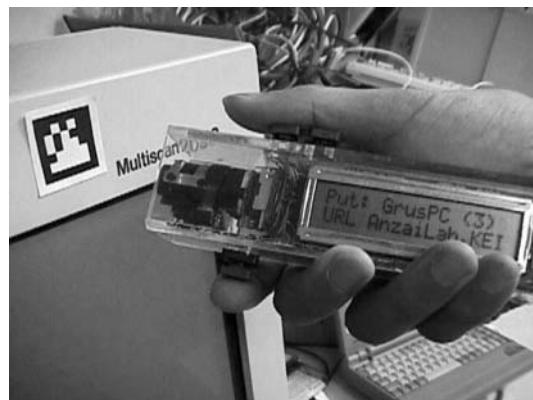
Fig. 6. The hand-held part of InfoPoint.

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Table 2. Realising drag-and-drop operation in the real-world environment

	Desktop	Real-world
Select Data	Point & Click	Digital Camera Point & Get Info Point
Move Data	Drag Visual Feedback	Visual Feedback
Select Destination	Drag	Point
Select Operation	Open, Send, Cut, Copy, Delete, Property Point & Click	Select
Do Operation	Drop	Put
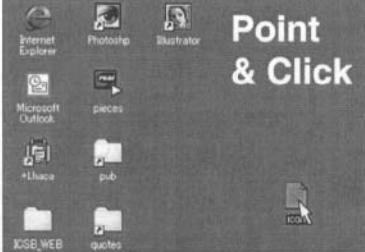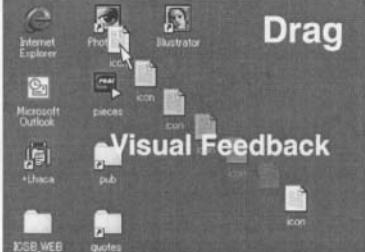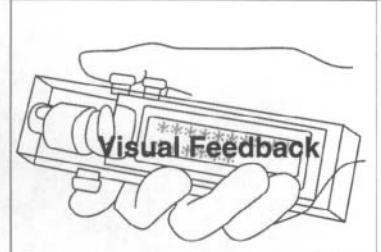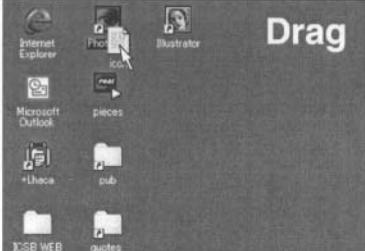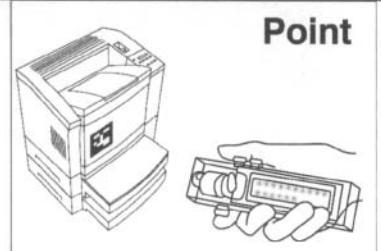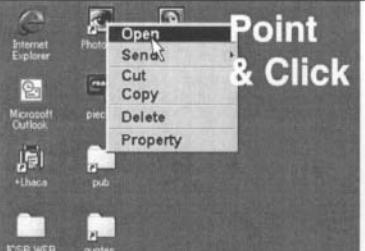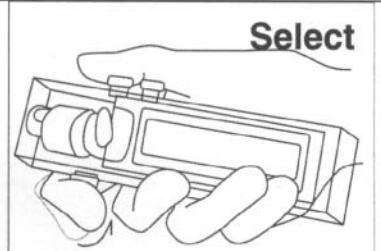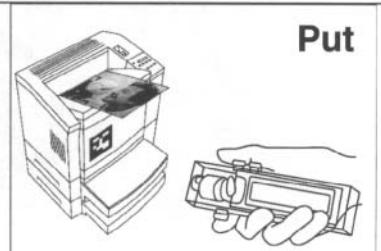
InfoPoint is applied to a similar data transfer in the real-world environment.

2.1. A uniform user interface for the transfer of data among multiple appliances

The icons of desktop environment are of various types: text-data icons, picture-data icons, application-software icons, and so forth. A user can transfer data among icons of various kinds by drag-and-drop operations. In the real-world environment, InfoPoint is designed for the transfer of data with a uniform user interface, between the following types of objects.

- **Active objects:** objects that can be directly controlled via the network (e.g. computers and information appliances) or via an object such as a computer that can be reached directly via the network (e.g. typical household appliances).
- **Passive objects:** objects that cannot be placed under network control (e.g. printed paper, posters, and business cards).

Even given the fact that a networking is becoming ubiquitous [2], we believe that working with paper and other printed text is quite an important idea, because we still use written text such as memorandums, instructions and prompts for the control of appliances, and so forth. The electronic features of InfoPoint are strongly augmented by its applicability to paper and to other physical artifacts.

2.2. Selection of the target object

Pointing at a target object to select it, the metaphor which is used in the selection of data such as icons by mouse operations in the desktop environment, is also appropriate for the real-world environment. InfoPoint, therefore, required a pointing function to identify objects as the targets of operations. Although technologies of various kinds for target identification are available, such as infrared (IR) beacons and radio frequency (RF) tags, we felt that the visual marker was the essential form for InfoPoint. A visual marker can be applied to a non-appliance of any kind including paper. A marked non-appliance becomes a target object for InfoPoint. Moreover, such markers are easily made by printers, and do not require additional equipment such as batteries. Each marker has its

unique ID and all possible targets can be individually located by applying visual markers that can be identified by InfoPoint. The actual transfer of data is implemented according to relationships between IDs. This allows InfoPoint to be used to drag data from non-appliances. For instance, we can drag a URL from a poster then browse through the data at that a URL by dropping the URL on our web browser.

2.3. Data storage on the network

In the desktop environment, a user is unable to drag a new set of data while still dragging another set of data. He must release the first set of dragged data or drop it on the target icon before dragging the new set of data. This is not a problem in the desktop environment, because the area of operation is usually limited to a single screen. It normally takes a few seconds, at most, to complete a drag-and-drop operation. However, the area of operation in the real-world environment is huge. There will be many kinds of data and many target objects that can exist anywhere. For example, one may want to drag a picture data from the office, and drop it onto the computer at home. Moreover, it may be necessary to drag other data on the way from the office to the home. To allow for such circumstances, InfoPoint must provide the illusion that a user can hold multiple sets of dragged data. When a user drags an object, he may want to see the kinds of objects that are being dragged, and the objects that have already been retained, i.e. those for which the completion of drag operations is pending. A small display would support the user in this by visual feedback.

It is expected that all appliances will soon be
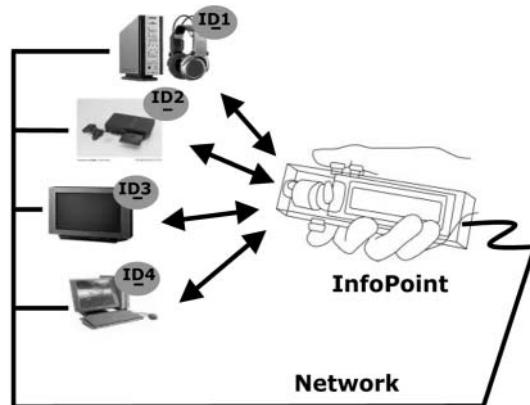
Fig. 7. Future highly networked environment.

connected to a network (Fig. 7). In such an environment, the data being dragged will not have to be stored in the memory of the InfoPoint device, because it will be possible to place it anywhere on a the network instead. The data will then be transferred to a target object. During dropping of the data, the movement of the data itself gives the user the illusion that the data is being transferred from the InfoPoint device to the target object.

2.4. Filtering of multiple data objects

There will be many target objects and they will be able to exist anywhere on a network. In such an environment, it will be necessary to filter the data to find the specific data that suits a given destination object. That is, the appropriate data will be automatically filtered from the set of dragged data. For example, when the InfoPoint device is pointing at a VCR, movie data will be suitable but music data will not. After the unsuitable data has been filtered out, the data that is suitable for dropping will be listed on the small display as visual feedback and the user will then select the required data. The drag-and-drop operation of InfoPoint thus includes a 'select'

operation. The familiar drag-and-drop operation of the desktop environment, augmented according to the above four technical points and applied to the real world is called the 'Get-and-Put' operation. The InfoPoint system applies an extension of the 'Pick-and-Drop' [3]. Although our system applies the style of operation 'pick' and 'drop' metaphors as its respective 'get' and 'put' operations, the purpose of the InfoPoint is not merely to operate computers but to also operate with appliances and other real-world objects in a unified manner.

3. System Architecture

The system architecture is described in this section. Figure 8 shows the overall InfoPoint system. Each user has his own wearable InfoPoint unit and the hand-held device for InfoPoint has been developed to be as small as possible so that a user can easily operate it with only one hand. All data IDs and object IDs of the system are in a shared database on the network. Each wearable unit has its own database, the InfoPoint Database, for storing the headers of data that InfoPoint has dealt with in the past. The
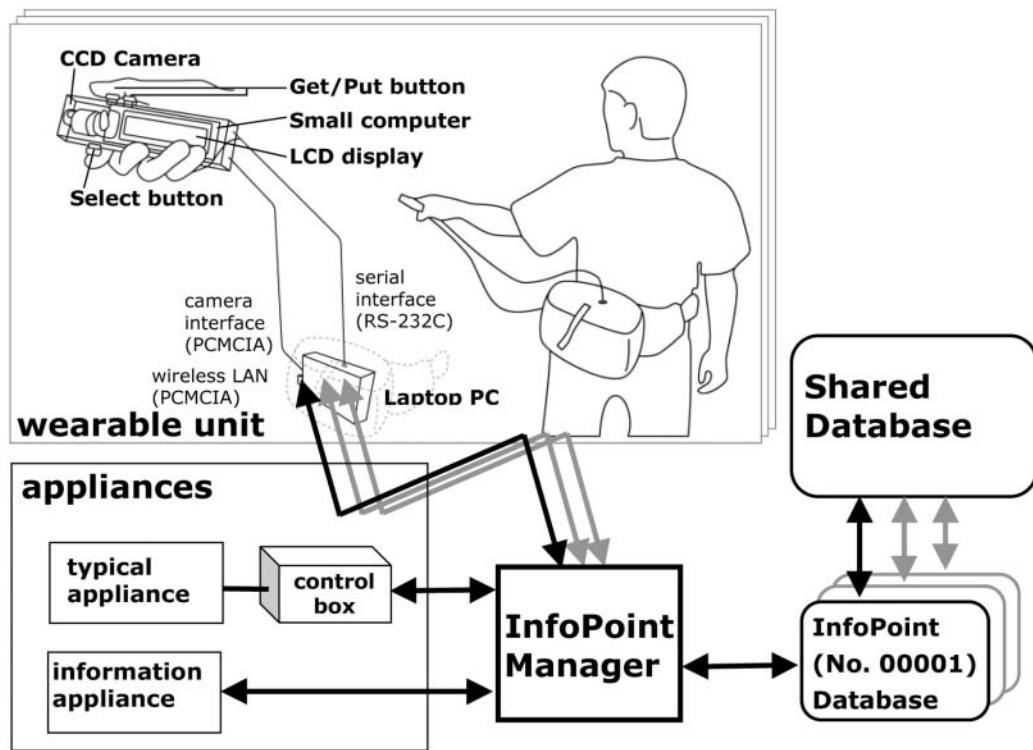
Fig. 8. Schematic diagram of the InfoPoint system.

InfoPoint Manager controls the flows of data between the wearable unit, the shared database and the appliances. All databases and the InfoPoint Manager are connected to a network via wired or wireless channels. When a user points the hand-held InfoPoint device at a visual marker, this pointing behaviour is recognised by the InfoPoint Manger, and the data that is suitable for getting or putting will immediately become visible on the small display. The following sections describe the details of each subsystem.

3.1. Real-world environment

To identify real-world objects as the targets of 'get-and-put' operation, printed 2D-matrix code is deployed in this prototype system as visual markers on network devices. The code is detected by a CCD camera in the hand-held InfoPoint device. A unique 2D-matrix code is applied to each target object.

3.2. Wearable unit

The hand-held part of InfoPoint (Fig. 9) consists of the following items: a CCD camera to detect the 2D-matrix codes; three input buttons to select, get, or put data; and a liquid crystal display. A small computer (PARALLAX BASIC Stamp II IC) in the hand-held InfoPoint device controls the I/O of signals and the image on the display. The computer is able to exchange data with a laptop PC (Mitsubishi AMiTY-CN). The device is small enough to allow unrestricted mobility. The laptop PC is carried on the user's waist. It recognises the 2D-matrix codes from the CCD camera's video images, and communicates with the InfoPoint Manager over a wireless-LAN connection.
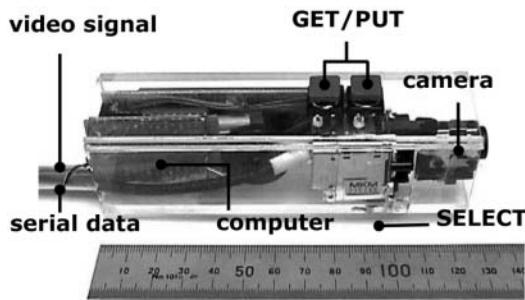

Fig. 9. Configuration of the hand-held device.

3.3. Data management

The shared database actually consists of two databases, as shown in Fig. 8 (lower right). One is the database of target objects (e.g. VCRs, computers, posters). The records of this database are composed of the ID numbers, names and kinds of objects. The other is the database of source data (e.g. URLs, text files, TV programme information). The records of this database are composed of the ID numbers, titles and kinds of data. A get operation involves the retrieval of data from the source database to the individual InfoPoint database. When a user points the InfoPoint device at a 2D-matrix code, the InfoPoint Manager contacts the InfoPoint Database and the Shared Database, and shows the possible operations, the names of the target objects, and the titles of the data on the small display. If a user then presses the get button, the InfoPoint Manager receives the get command via the laptop PC, then copies the record on the target object from the Shared Database to the user's InfoPoint Database. When, on the other hand, put is selected, the InfoPoint Manager transfers the source data from the Shared Database to the target object and deletes the corresponding data from the user's InfoPoint Database.

All code of this system is written in Java [4] except for the PBASIC used in the small computer of the hand-held InfoPoint device and is executed on IBM PCs. Many of the applications described in Section 4 were developed with a Java interface.

3.4. Appliances

Information appliances receive commands for operations directly from the InfoPoint Manager. However, conventional appliances that cannot be connected to a network are operated by a control box (Sony VboxII-CI11000s), which is operated via an IBM PC on the network (Fig. 8, lower left).

4. Potential Advantages of InfoPoint

We have implemented several applications for InfoPoint. We assume that this technology will become one of the functions of PDAs and that every user will have his own InfoPoint device.

Some of these applications are described in the following subsections.

4.1. Transferring data from computer to computer

A basic use of InfoPoint is in transferring data between computers. When a user wishes to transfer data between computers, he simply gets the data from one computer display and puts it onto the other computer. When pointed at the target object, the InfoPoint display gives three indications signs: the possible operations (get, put, or both), the name of the target object, and the titles of the source data that are available for the operations.

If more than two kinds of operations are available, their data titles will be shown. Pressing the 'select' button scrolls through the list of selections. This get-and-put operation is more direct than typical operations in the real-world environment, and InfoPoint creates the physical illusion that one is, for example, getting some data from the computer to one's right and putting it into the computer to one's left. Without InfoPoint, such a data transfer could not be completed without verbal support. For example, a typical conversation might be: 'What is the name of the machine from which you want to transfer data?' '*Moon_PC*.' 'Open the folder *Picture2001* on my disk C: and...'. In this example sequence, '*Moon_PC*' and '*Picture2001*' are symbolic concepts that become unnecessary information in the 'physical' transferring of data by InfoPoint.

Another application is at a meeting where a presenter is using a projector (Fig. 10). A participant is able to get the current presentation

Fig. 10. From a projector to a computer.

slide by physically pointing the hand-held InfoPoint device at the projector and pressing the get button. When he wants to get the entire set of slides for the presentation, he can press the select button to choose the 'Entire Slide' menu item from the small display and then press the get button to get the set. After that, if he wants a copy of any acquired slide, he can point the InfoPoint device at his computer and upload the slide by pressing the put button. In this case, the projector itself is not storing the data for the slides. The transfer of the slides occurs via the network, and the projector is used as a physical landmark in obtaining the data because there is a mental connection between the projector and the slides that are displaying.

4.2. Operating information appliances

The InfoPoint application allows a user to operate appliances. For example, when the InfoPoint device contains data on TV programmes and the user points it at a target VCR deck, the small display on the InfoPoint device shows the titles of TV programmes available to be selected for recording. After he has selected the data on a programme and put it into the VCR, the VCR receives the data and sets up for automatic videotape recording (Fig. 4). Similarly, to print out a picture from a digital camera, a user gets the data from the digital camera and puts it into a printer.

4.3. Getting data from paper

The InfoPoint application is able to get data from printed papers by recognising 2D-matrix codes. When a user points the InfoPoint device at a target, the display shows a list of titles of data objects associated with the identified paper. The user is then able to directly get the data from the target object by using the same kind of operation as is used with information appliances. The user in Fig. 5 gets the URL from the target poster and put it into the web browser. He can then browse through the detailed information related to the poster.

An image on TV can include an ID as a 2D-matrix code for transmission to the InfoPoint device. Instead of writing down a displayed URL, the user simply points the InfoPoint device at the TV screen. The InfoPoint system then identifies the 2D-matrix code. Figure 11 illustrates this process. When the user, while watching a TV

Fig. 11. Netsurfing.

Fig. 12. Attaching data to a business card.
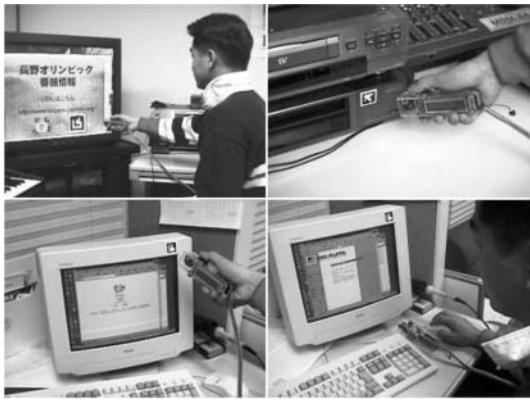
programme, finds interesting information displayed along with a 2D-matrix code, he gets the data from the TV screen (upper left). When he puts it into the appropriate field of the web browser display on a nearby computer (lower left), the corresponding page will appear on the screen. Browsing through the data on this page, he also finds data on a target TV programme and gets it from the web browser (lower right). Finally, he goes to the VCR deck, and puts this data into the VCR to make it record the TV programme (upper right). Netsurfing in the real world thus becomes available without changes to the existing broadcasting system or to TV sets.

4.4. Putting data to papers

InfoPoint is also able to put data on papers to augment their information. For example, it would be useful to be able to attach data to a business card (Fig. 12). A user could put his latest paper on his business card. He would then not have to bring a copy of his paper, and people who received his business card would be able to view the paper on a computer display. Another possible application is the attachment of presentation-slide data to a corresponding document. The user is able to get the slide data from the computer and put it onto the printed document. The user can then simply take this document to the conference, get the presentation file from the document, and put the file into the projector. The user then does not have to carry a computer, projector or floppy disk. Teachers can also use this system to announce information about homework. After a teacher has put data, including a title, for homework on a

bulletin board, students would be able to get it at any time by using InfoPoint.

5. Discussion

5.1. Comparison with other identifying technologies

We have employed pointing at 2D-matrix codes as the way of identifying target objects for this InfoPoint system because:

- it is an appropriate approach for the real-world environment;
- 2D-matrix codes are easy to produce by using a printer; and
- they can be attached to non-appliance objects such as paper.

This technology can therefore be used to augment electronic features while carrying the additional advantage of being applicable to paper.

Along with our current research as described in the preceding sections, we are trying to extend the capabilities of InfoPoint by improving the identifying technology. That is, in addition to InfoPoint's current capability of handling user input selected by pointing, ubiquitous sensors that are able to recognise the environment will communicate with InfoPoint so that the position of the InfoPoint device and its distance from the target appliances can be measured. InfoPoint will then provide information according to the situation. We call this identifying technology 'Proximity Identification'. The concept is illustrated in Fig. 13.

With this technology, we can provide a
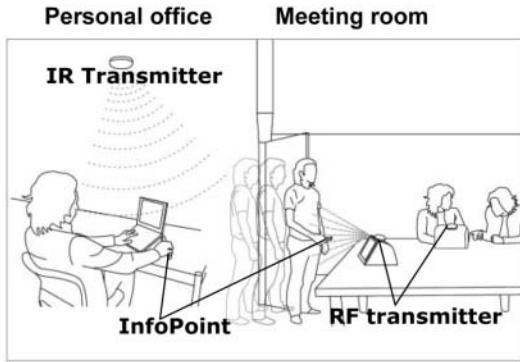
Fig. 13. Proximity identification.

service by which, for example, when a user gets to his office, any URLs that are related to his schedule are listed on the InfoPoint display. In another case, when he gets to a meeting room, files to do with the meeting are listed on the display.

Other identifying technologies have their relative advantages and disadvantages (e.g. infrared (IR) beacons [5–8] need batteries and RF tags [9] cannot be made by normal printers), and, on certain applications, provide a better service than the 2D-matrix code. The utility of InfoPoint can be extended by appropriately applying these other technologies. IR beacons, for example, periodically transmit an ID to the surrounding area. This beacon covers a room-sized area and is relatively robust in terms of orientation of sensors. In the case of RF networks, the emergence of new technologies based on short-ranges connectivity, e.g. Bluetooth [10], and the increasing number of devices equipped with network connections create a vast potential for exploring the possibilities of InfoPoint in the highly networked environment of the future. JINI [11] and HAVi [12] have been developed for the connection of home appliances and consumer electronic products. These recent developments represent the possibility of a new class of middleware for the building of distributed software applications that run from small portable devices and then locate and interact with network services, and will also contribute to the development of InfoPoint in the future.

5.2. ID management

In this prototype InfoPoint system, all data IDs and object IDs are temporary. However, to apply

get-and-put operation to all objects and data in the real-world environment, each must be assigned a unique ID, much like the International Standard Book Number (ISBN) [13] and Universal Product Code (UPC) [14] that are already in use in bookstores and supermarkets, respectively. The Shared Database presently handles an entire management and updating of the database that controls these IDs. However, the separate control of IDs and data is considered desirable. As with the Internet, the IDs, corresponding to URLs, should be administrated collectively and this data should be managed in several databases on a network. Applying this method to the InfoPoint system allows the free and prompt renewal of the data. For instance, data related to TV programmes would be managed in the database of a TV station in the same way as a web page related to the TV station. To sum up, one ID should be assigned to one set of data or to one object, and an ID data should be reached and transferred by the InfoPoint system via a network, thus enabling the conveyance of data as much as possible.

6. Related Work

A PDA is used as a controller for interactive TV in the PDA-ITV [15]. Although it uses two different displays for one task, the roles of PDA and TV are static: the PDA always acts as a controller for the TV alone. Neither seamless manipulation nor interactive data transfer between the PDA and ITV are possible. For example, a user can not drag data from the TV screen, to then drop it into the PDA.

The PaperLink [16] is a computer-augmented pen with a video camera that is capable of recognising the text of a printed document. Although PaperLink can drag data from a piece of paper and then drop it on another piece of paper, it does not support appliances in working together. The user cannot operate a computer and information on paper with a PaperLink pen.

MediaBlocks [17] are small tags used as physical containers for digital information. The user can virtually attach digital data to things by using these tags. This system assumes that every appliance has a tag reader/writer, and this makes it difficult to scale the environment. A user is unable to see the carried data until the tag is actually inserted into a tag reader/writer.

Finally, the Pick-and-Drop [3] system has a

direct manipulation technology that can be used to transfer data from computer to computer as well as within a single computer. Pick-and-Drop allows the user to 'pick up' data from a display and drop it onto another display as if he were manipulating a physical object. Our InfoPoint system is an extension of this system.

7. Conclusion

In this paper, we have introduced InfoPoint, a universal device that allows appliances to work together over a network in the real-world environment. The major advantage of InfoPoint is that it expands the operations of appliances without the complication of functions caused by using multiple controllers. Although InfoPoint cannot control appliances as can freely as conventional controllers, its universal data transfer augments the features of controllers. In the future, even when the conventional controller for a given target appliance is more capable than at present, the transfer of data between multiple appliances will be an imperative. We are also currently working on applying RF networks to the system, based on proximity identification. With this system, the user will be able to handle more flexible styles of data transfer in the real-world environment.

Acknowledgements

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