Design issues in distributed interaction supporting tools: mobile devices in an ATC Working Position

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ABSTRACT
In this paper we describe our exploration of some distributed-interaction prototypes designed for Air Traffic Control purposes. We think that this new form of interaction can play an important role in bringing closer together the user and the systems he is using. We believe that mobile devices, combined with new interaction styles, can be used as a lever to change the way user interfaces are designed. The Air Traffic Control application domain raises interesting issues in its transformation, which we have tried to address using personnal digital assistants. Our work focused particularly in an interaction shared between a fixed working position and a mobile one such as PDA. In this document, we want to show how we used previous studies on collaborative work and how we applied very simple but efficient design techniques to elaborate an experimental platform which explore different aspects and issues related to distributed interaction.

Keywords
Air Traffic Control, distributed interaction, mobile devices, prototyping , PDA, pick and drop

INTRODUCTION
Each time we have been showing an airport equipped laptop computer, we have felt that a new range of possibilities was offered to us in terms of mobility, naturally, but more also in our working methods. We believe that this feeling is illustrating the fact that we can use our computers in much more efficient way: we're allowed to show what we're doing to our colleagues, we can produce and share our information seamlessly. This raises the following assumption: as software developers, we are still stuck to a desktop centered interaction, and we often use two mice when there are two computers on our desk. This leads us to design technology-constrained artifacts when the new developments in the field of mobile technology should help us to think different.

Both the Newton and the Palm Pilot have made available a new way of handling and sharing personal data. However, the latest personal digital assistants still rely on the desktop metaphor conveyed by the PocketPC operating system. We believe we should take benefit from the coming out of this new design space to advocate a methodology that is not bound to old technology driven models.

We have based our work on recent studies to explore this design space. In the field of interaction styles and techniques, we tried to implement distributed interaction such as pick and drop as introduced in [4].

RELATED WORK AND LITERATURE

Distributed Interaction
The idea of an interaction which is not concentrated on only one system is not new. In 1998, Frederic Puleggi introduced the notion by illustrating it with the metaphor of the painter handling in one hand, a brush, and in the other one, a palette. The interaction of the painter with the whole system is distributed between the palette and the canvas. In this case, both, information and functionalities are separated on the palette and the brush. That's exactly what we mean by distributed interaction. This is a seamless interaction across several distinct physical devices. And this kind of interaction is particularly well supported by interactions styles like pick and drop [4] which extend possibilities of drag and drop to physical distinct systems. We think that distributed interaction is important to design systems which support cooperative work and more particularly in the case of heterogeneous systems composed of mobile and fixed working positions.

Direct Collaboration, Free Information
In [5], Stephane Sire has shown the benefits of direct collaboration when compared to computer protocols. Indeed, it seems to us important to give the user a kind of proximity, familiarity with his tool and some expression spaces for example for free annotation. We assume that this feeling of proximity is given to us by the use of mobile devices such as Personal Digital Assistants because we use them in a manner very similar to which we do normally with tools: we can carry them anywhere with us and handle them very simply. Michel Beaudoin-Lafon introduces such Instrumental Interaction in [1].

Design methods
Designing prototypes of novel interfaces in a specific domain like Air Traffic Control require to have at your disposal some appropriate design methods. Wendy Mackay described in [2]

developed such methods for generating ideas and supporting innovative approaches. These methods are notably based on Cognitive Walkthrough, brainstorming, video recording and the production of scenarios. We also involved controllers in the exploration and design process.

APPLICATION DOMAIN: ATC

A changing environment

The aging process of the hardware and the sheer augmentation of air traffic has led the air traffic controllers to be provided with new tools. One of the key issues in this change is the possible replacement of paper strips with electronic artifacts. It is true that a work method based on a per-flight representation of the situation might not be the best to solve conflicts between flights. However, the disappearance of the paper strips also means the disappearance of the tangible objects, as a tool for direct coordination between controllers, the disappearance of a surface for free annotation, as seen in figure 1, and the disappearance of all the memory tips linked to these annotations.

Figure 1: A paper strip

In [3], we can see the added value of graphical and ecological design to convey some of these good properties to an electronic strip environment. If we remove the strip, it will give place to new candidates to the objects of interaction, and the techniques we have learnt from our study can prove to be helpful to those new developments.

Control Working Position

The Control Working Position (CWP) is a set of tools to allow a couple of air traffic controllers to assess a situation and make decisions to smoothen the traffic and enforce both safety and capacity. The key features of this collaboration, communication, information and decision support tools are their dynamic, their complexity bound to the systems they are linked to, and the safety they must abide to.

As you can see in figure 2, the new CWP in French en route air traffic control are hosting many different tools: a graphical display of the radar situation, a tool to customize this display, a tool to enter commands to the flight plan management system, tools to call other positions, tools to talk to the pilots, tools to show meteo info for instance, tools to replay the latest messages exchanged on the phone or on the frequency, etc. However, almost each tool has been designed independently, and there is no shared interaction made possible. Furthermore, when other controllers come to give help in a critical situation, the input devices (mouse and touchpad) can not be shared between two people, whereas it was possible to take a strip, annotate it, and give it back to the tactical controller.

As in other situations, the tools have suffered from the same biases as the one we are using as developers: the technology has prevented the designer from anticipate what it could be possible to do ten years later. To avoid this phenomenon, we believe our study based on mobile devices and on distributed interaction can give hints to avoid this trap.

Figure 2: ODS control working position

Useful constraints

Although the domain of ATC and the CWP might seem tough to handle, it proves to be a very challenging and interesting case of study for a novel methodology. The users are not computer-literate, they are still in the process of changing their working methods, and the information they are handling now is made tangible through paper strips for instance. In this respect, we are very far from the computer scientist case and its single desktop concentrating all the functionalities.

A PARTICULAR MOBILE DEVICE: PDA

Why a PDA ?

Latest PDAs feature state of the art technology, ranging from touch screen color screen to multimedia abilities, high memory and computing power, high speed wireless networking, etc. These features make them a good choice to deliver interactive applications that do not require a good knowledge in computer science.

The particular interaction constraints of a PDA, because of the limited bandwidth associated to the screen size and lack of input devices, force the developer to use either natural writing recognition or gesture recognition. As the device itself can be used in many different environments, we must ensure that the GUI will be tolerant to task interruptions: this wipes out the building of modal interfaces.

Implementation

We have been using a couple of Ipaq, running the linux operating system and the X11 windowing system. Thus, we have been able to insert our prototypes into a CWP demonstrator, and to use the same programming techniques as on desktop applications.

In order to allow the mix of multiple instances of PDA-based applications and desktop applications, we built them upon a software bus, allowing a program to connect and disconnect without having to reconfigure the rest of the test bench. This software bus [1] is an event based system, allowing any application to subscribe to event patterns. The idea is to reproduce

[1] Ivy software bus home page http://www.tls.cena.fr/products/ivy

one of the most widespread graphical toolkit programming style. The GUI itself has been built upon the Zinc toolkit [2], on top of the tk toolkit. are the key to rapid prototyping.

FROM SCENARIOS TO AN EXPERIMENTAL PLATFORM

Scenarios

Trying to generate new ideas at the center of ATC, mobile computing and HCI can lead us to a trap: one often tries to reuse his know-how. In order to solve this problem, we used the Cognitive Walkthrough and video observing described in [2], in-situ observation to elaborate scenarios supporting some tasks performed by controllers such as finding informations about specific procedures or organizing coordination. The involvement of the users themselves in the design process is one of the keys to ensure we address their needs, however, the technologies used and the research area requires the mixing of different audiences during the cognitive walkthroughs. The result of this preliminary work is a list of ATC related scenarios involving the use of a PDA. Here is a sample of this list:

- A student is learning on a CWP with real traffic. The teacher controller can trigger the recording of a laps of traffic in order to replay it later on another position, for instance during the debriefing; he can use the PDA to take written or audio annotations related to the situation. He also can check if the learning objectives.
- The Control Center chief controller is in charge of the monitoring of what's happening in the control room. He also manages information about the upcoming traffic to trigger decombining of two sectors. The access to real time traffic prediction and informal workload hints makes him a good candidate to use a PDA as a tool to share information all across the control room.
- When a pair of controllers are replaced by a new team, these had to access the traffic context, either by observing a few minutes or asking questions, and much of the written information on the strips gave them history of the clearances given to the pilots. However, the disappearance of free information with the replacement by electronic strips prevents them from accessing this kind of information. A PDA can be a way to store history and context.
- The decombining is when an airspace volume is split in two, and the control, first made by one position, is done by two position. With paper strips, controllers could either take the strips away to the new position, or make the system reprint them there. With a PDA, the controller would come to the position, share the context, and take the strips group by group in a way that is observable both by the other controllers and by the system.
- When an unusual situation occurs during the life of a flight, the controller has to follow a checklist in order not to compromise its safety. Instead of searching this information in a filing case, he just has to browse a checklist on a PDA, which makes his action observable to the system.

We have identified different HMI functionalities out of these scenarios: navigation, CSCW, information transfer, etc. However, if we decided to sum them up in a fixed list, we would here again fall into the trap of intelligence, and reuse the interaction models we already know. The design of the prototypes themselves has been done in a multidisciplinary way, and they have been the bricks of the experimental platform. A graphics designer was implied in the design of one of the prototypes to find a graphical formulation to some needs such as suggesting gestures etc.

[2] Zinc toolkit http://www.openatc.org/zinc

Experimental Platform

The advantage of this kind of platform is to allow exploration and innovation. A single application attempting to address problems and issues of distributed interaction cannot be a good solution. The risk is to focus on one single aspect in depth, thus neglecting the range of possibilities offered by these scenarios.

Our experimental platform is the way to experiment the tasks described in the scenarios above. The programming techniques can be shared between many prototypes. This far, we have organized it around four prototypes implementing the following interaction styles: pick and drop, bimanual interaction, direct manipulation, gesture recognition. One of them runs on a desktop touch screen, and the others are currently remote displayed on our Ipaqs.

Prototypes

Figure 3: the Digibook prototype

The Digibook prototype, in figure 3, is addressing the issue of navigating in an information system on a PDA and presenting information such as aeronautical weather forecast or aeronautical procedures. We chose the metaphor of a notepad presenting sheets of information. The use of this electronic notepad obeys to very similar interactions than we have with a paper one. A notepad is simple to use, the functional model of its functioning is well-known, the way to interact with this device is similar to the way to use a paper notepad and the notepad maximize the space available to display information. To be coherent with the metaphor of notepad, we naturally chose adapted interactions: you can turn pages with a simple gesture and classify them by manipulating the sheets directly. This study on presentation of information raised some interesting issues: for example the limitations induced by the amount of information we can display on these small-screen devices and particularly when it is question of relatively complex informations like procedures or rules which, in ATC, can include maps and long structured text.

Figure 4: the DigIpaq prototype

DigIpaq illustrated in figure 4 is implementing pick and drop on an existent prototype developed at CENA of electronic stripping, based on DigiStrips [3]. You can literally take a strip from the working position and put it on your PDA for example for writing on it in a decombining situation. With this prototype, you can manipulate a complex information very transparently. This prototype shows important issues about how to manage the change of representation when we use direct interactions such as pick and drop. DigiPad, illus-

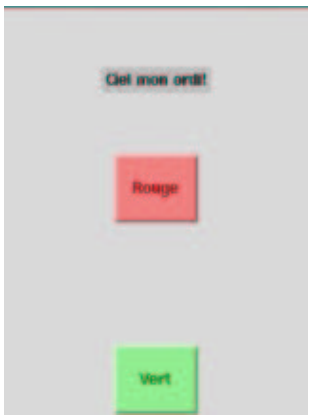

Figure 5: the very basic but efficient DigiPad

trated in figure 5, is one another prototype of the platform implementing multimanual interaction. With the PDA in one hand, you can color the strips on the fixed working position represented in the figure 6. This prototype is a good illustration of the possibilities of distributed interaction and it is very close to the metaphor of the painter we introduce before. Here, we only separate a functionality (the change of color) of the object on which this functionality applied (electronic strips). For the user it means that this is not modal contrary to classic applications.

DISCUSSION AND CONCLUSION

By using this approach, we raised many interesting issues, with regard to the interaction styles and techniques, the design process for novel interfaces. We have begun to show the limits and benefits of using a PDA as a support for direct collaboration, as each exchange involving an action on the PDA

Figure 6: the DigIpad working position

can be observed by a tier, and can convey information in the style adopted. The notion of personal computer should be revisited, as the information you bring with you and you can modify with a touch of your stylus is much closer than the one you have to access through a networked desktop computer.

However, we have not made any experiment to validate our claims. And the limits of the voice recognition, the writing recognition, the amount of information that you can display on a device fitting your palm might be the limit of the interaction bandwidth.

ACKNOWLEDGMENTS

We would like to thank Frédéric Puleggi for the work he did on the Newton, Stephane Chatty, Johnny Accot and Stephane Sire for their ideas and work, Véronique Picard and Daniel Etienne for their contribution.

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