Overview of Cross-Device User Interaction for *Littery Augmented Paper - LAP* - Environment

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ABSTRACT
Recently a tablet with LCD becomes thin, light, and inexpensive. In the near future, we will be able to have many tablets as the commonplace electrical appliances. We call it *"Littery Augmented Papers" - LAP – environment* because the tablet can be seen as the computer-augmented paper. We have designed a usable and effective cross-tablet user interaction for LAP environment, which consists of *(i) operations among tablets* and *(ii) tablet connection operations* and implemented the prototype system based on VNC-architecture.

Keywords
Pen-based user interface, tablet, cross-tablet user interaction, ubiquitous computing, LAP

BACKGROUND
In the near future, *"Littery Augmented Papers" - LAP – environment* will emerge, where tablets with LCD are ubiquitous. But it is doubtful that the current interaction scheme is suitable for LAP environment [1].

Our research has originated in two findings. The first finding is that the current information systems such as personal computers provide us with the quite limited information space. The current display device is far form the real paper. Current device has less than 1/16 information display power of the paper if it is estimated in the total number of pixels [1]. On the contrary it is widely known that the intelligent worker needs the wide information space in order to compare, analyze and evaluate the vast range of information simultaneously. Even if the display device reaches the real paper, we will use many tablets just as we spread many papers on desk.

The second finding is the absence of the suitable user interface. Actually there are many researches on the pen-based user interface. Most of them focused on the usable interface for the single display. A few research, such as *RVI-DESK [2]* and *"Pick and Drop"[3]* dealt with the multiple displays. However, they coped with the limited coverage of the usage of multiple displays such as the transfer of the data between the multiple tablets. They are not powerful enough for LAP environment.

USER REQUIMENTS
The followings are the summaries of the user requirement found in the paper-based mockup experiment.

(i) One tablet should display one type of information. Users tend to assign the tablet to the specific data when many tablets are available.

(ii) Data on the tablets should be easily "transferred", "copied" and "shared" among many tablets.

(iii) The transferred, copied and linked data includes the windows (i.e. view area) and icons as well as data.

(iv) Tablets should be easily connected and disconnected. The grouped tablets should behave as if they were one tablet..

"LAP" OPERATION
"LAP" operation consists of *(i) operations among tablets* and *(ii) tablet connection operations*

LAP Operations among Tablets

To display the data on the tablet, the system must know what data to display, which tablet to display and how to display the data. So we defined the basic structure of LAP operation as Operation between tables as shown in Fig.1 (a). That is, LAP operation between tablets consists of *"Start-operation"*, *"End-operation"* and *"Operation-type"* that correspond to what data to display, which tablet to display and how to display the data,.

Start-operation indicates what data to display. Since the displayed data is not simple, we call it "object". The object includes icons and windows as well as simple data. So users can move any of data, icons and window itself form one tablet to another. *Start-operation* is done by *"tap"* for the small target (e.g. icons) or *"drag"* for a big target (e.g. windows or data).

End-operation indicates which tablet to display. The operation must specify the display area of the tablet as well as which tablet to display. So *End-operation* is also done by *"tap"* for the small area or *"drag"* for a big area. The area

may be the part of one tablet, the whole area of one tablet, or the connected area of two or more tablets. Fig.1 (b) shows four types of End-operation (one tap and three drags).

Operation-type indicates how to display the data. In other words, it defines how to manage the displayed data. The user can transfer the data, icon and window to another tablet. The question is whether *"transfer"* means *"move"*, *"copy"*, or *"link"*. In case of *"move"*, the data, icon and window disappear in the original tablet and appear in the destination tablet. In case of *"copy"*, the data, icon and window are copied and appear in both the original tablet and the destination tablet. In case of *"link"*, they appear in both tablets but the data, icon and window are not copied but share the unique source. So if the user changes the status of one tablet, the other tablet is automatically changed because they share the same data source. *Operation-type* is specified by the pen's button between *Start-operation* and *End-operation*.

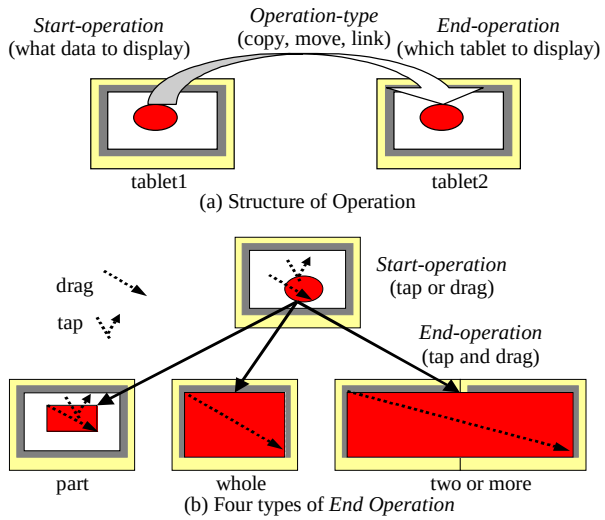

Figure 1: LAP Operations among Tablets

LAP Tablet Connection Operations

Although it is possible to connect the several tablets by dragging the several tablets sequentially at the *End-operation*, sometimes the users want to connect them explicitly.

Let's assume that tablet1 displays something on the whole information area and tablet2 is out of duty as shown Fig. 2. If the user draws two lines on both tablets as shown Fig.2 (a), then tablet1 and tablet2 adhere in order to match these lines. Or if the user drags the corner of the window to tablet2 as shown Fig.2 (b), then the tablets are connected and the window is expanded to the connected tablet.

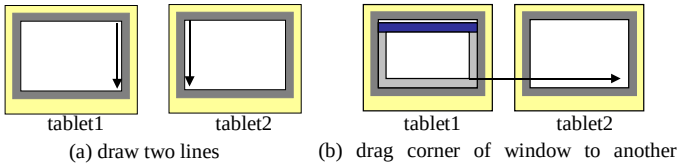

Figure 2: LAP Tablet Connection Operations

PROTOTYPE SYSTEM

To realize LAP environment without any modification on the current applications and the current operating systems, the system architecture was developed by VNC (Virtual Network Computing) [4] as shown in Fig.3.

The single LAP-Server has the huge invisible desktop and the user's application software run on the server. The multiple LAP-Clients display the specified portion of the desktop of the LAP-Server. The displayed data is transferred by VNC protocol.

Basically, the LAP-Client shares the display of the LAP-Server by the VNC architecture and the shared area is managed by LAP architecture.

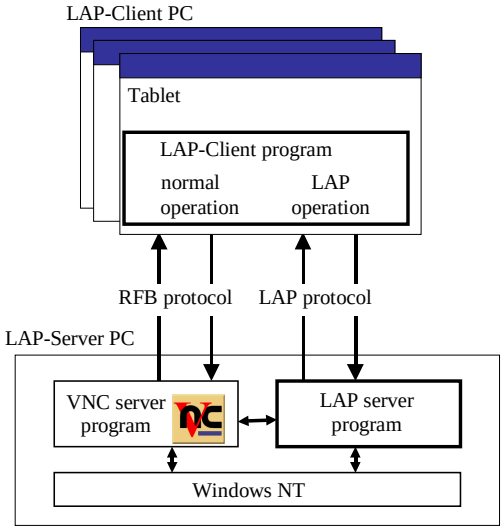

Figure 3: Prototype System based on VNC

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