

# Distribution Primitives for Distributed User Interfaces

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## ABSTRACT

This paper defines a catalog of distribution primitives for Distributed User Interfaces. These primitives are classified into four categories and represents operations that the developers and/or the users can executes to distribute the UI.

## Author Keywords

Distributed User Interfaces, Distribution Primitives.

## ACM Classification Keywords

C2.4. Distributed Systems. H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## General Terms

Design.

## INTRODUCTION

The DUI domain is still in evolution and there exist no toolkit allowing the creation of DUIs. In most pieces of work, there is almost *no genuine DUI*. There exists toolkits to create UI such as Java Swing or Microsoft Foundation Classes, but they do not support DUIs [4]. The UI elements simply remain in their initial context, while communicating with each other, but without redistribution. There is some distribution of UI elements, but it is mainly *predefined* and *opportunistic*: no configuration of the distribution at run-time. In Sj lund [1], the repartition of UI elements across the Smartphone and the TV is fixed. It is not possible to rearrange their distribution. Some works allow distribution at run-time. The UI elements subject to this redistribution are mainly *containers*, such as windows or dialog boxes. The problem is that the *granularity* of UI distributed elements is often *very high*; it is not possible to distribute any widget.

In addition, it is not *replicable*. When another platform comes in the context of use, it is hard to migrate on this platform parts that have already been transferred to other

platforms.

In Luyten[3], there are already attempts to model the distribution. The granularity is however limited to predefined tasks.

To sum up, we are looking for a way to support distribution at both design-time and run-time with very low and very high granularity and to support replicable distribution, while being compliant with the DUI goals. As in [5], this paper tends to help understanding and managing DUI.

## CATALOG OF DISTRIBUTION OPERATIONS

We propose a catalog of distribution operations and a toolkit based on this catalog.

## Toolkit

A toolkit has been developed upon the catalog. It creates application with UI separated in two-parts: the proxy and the rendering. A command line interface is provided to allow manual redistribution at run-time, see Fig. 1.

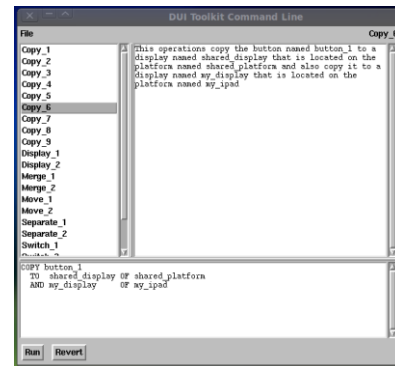


Figure 1. Command line interface provided by the toolkit

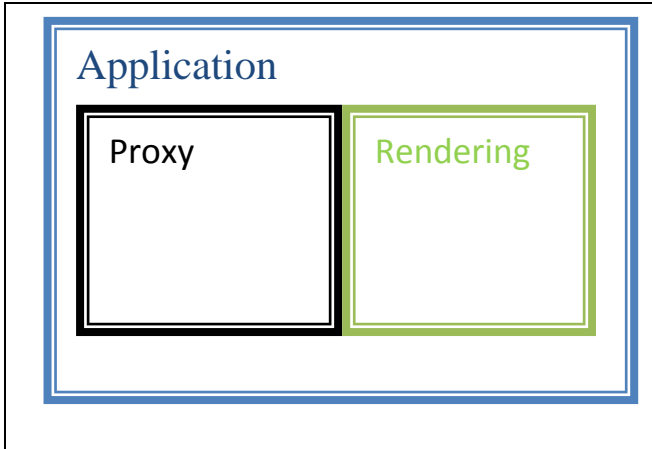
In Fig. 2, the proxy is represented as a separate part of the application than the rendering. The first keeps the state of the application and ensures the core functionalities, while the second displays the user interface. Application supporting DUI allows the rendering to be distributed on other platforms while the proxy stays where the application has been created. The toolkit works in Mozart environment supported by Microsoft Windows operating systems (XP and newer), Apple Mac OS X, Linux and Android. And we are currently working on the full support for Apple iOS.

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The applications created with this toolkit are multi-platform. Each graphical component is described as a record containing several keys and values. It ensures compatibility with XML because the keys/values become the name/value pairs of the XML markup. The DUI can be controlled by a command line interface, a meta-UI or even by the applications themselves. A model-based approach closely related to the toolkit has already been described in a paper that has been accepted to EICS 2011 [2].



**Figure 2. Structure of a DUI application.**

The definitions and examples presented in this paper come from the paper.

### Definitions

As observed in the related work section, the distribution logic of DUIs is often hard-coded and is not represented explicitly, which prevents us from reasoning on how distribution is operated. In order to address this issue, we now provide a catalogue of *distribution primitives* that will operate on CUI models of the cluster. We first define these distribution primitives in natural language, then in an Extended Backus-Naur Form (EBNF) format. In this notation, brackets indicate an optional section, while parentheses denote a simple choice in a set of possible values. In the following definitions, we use only one widget at a time for facilitating understanding. In the EBNF, we will use the four selector mechanism for generalization.

**SET <Widget.property> TO {value, percentage} [ON <Platform>]:** assigns a value to a CUI widget property or a percentage of the actual value on a platform identified in a cluster. For instance, SET “pushButton\_1.height” TO 10 will size the push button to a height of 10 units while SET “pushButton\_1.height” TO +10 increases its height by 10%. Note that the platform reference is optional: when it is not provided, we assume that the default platform is used.

**DISPLAY <Widget> [AT x,y] [ON <Platform>]:** displays a CUI widget at a x,y location on a platform identified in a cluster, where x and y are integer positions (e.g., in characters or pixels). For instance, DISPLAY

“pushButton\_1” AT 1,1 ON “Laptop” will display an identified push button at coordinates 1,1 on the laptop. **UNDISPLAY <Element> [AT x,y] [ON <Platform>]** is the inverse operation. **DISPLAY <Message> [AT x,y] [ON <Platform>]** displays a given message on a designated platform in the cluster (mainly for user feedback in an optional console).

**COPY <Widget> [ON <SourcePlatform>] TO [<Widget>] [ON <TargetPlatform>]:** copies a CUI widget from a source platform identified in a cluster to a clone on a target platform, thus creating a new identifier. This identifier can be provided as a parameter to the primitive or created automatically by the primitive to handle it.

**MOVE <Widget> TO x,y [ON <TargetPlatform>] [IN n steps]:** moves a CUI widget to a new location indicated by its coordinates x and y, possibly in a fixed amount of steps, on a target platform in the cluster.

**REPLACE <Widget1> BY <Widget2>:** replaces a CUI widget Widget1 by another one Widget2. Sometimes the replacement widget could be determined after a (re-)distribution algorithm, thus giving the following definition: **REPLACE <Widget1> BY <Algo>:**. This mechanism could be applied to contents and image transformations: images are usually transformed by local or remote algorithms (e.g., for resizing, converting, cropping, clipping, repositioning), thus giving the following definition: **TRANSFORM <Image1> BY <ImageAlgo:URL>.**

**MERGE <Widgets> [ON <SourcePlatforms>] TO [<Widget>] [ON <TargetPlatform>]:** merges a collection of CUI widgets from a source platform identified in a cluster into a container widget on a target platform, thus creating a new identifier. Again, when source and target platforms are not provided, we assume that the default platform is used. **SEPARATE** is the inverse primitive. **SEPARATES <Widgets> [ON <SourcePlatforms>] TO [<Widgets>] [ON <TargetPlatforms>]:** splits a collection of CUI widgets (typically, a container) from a source platform identified in a cluster into CUI widgets on one or many target platforms.

**SWITCH <Widget> [ON <SourcePlatforms>] TO [<Widget>] [ON <TargetPlatform>]:** switches two CUI widgets between two platforms. When the source and target platforms are equal, the two widgets are simply substituted.

**DISTRIBUTE <Elements> INTO <Containers> [BY <DistribAlgo:URL>:** computes a distribution of a series of UI Elements into a series of UI Containers, possibly by calling an external algorithm, local or remote.

**EBNF Grammar.** In order to formally define the language expressing distribution primitives, an Extended Backus Naur Form (EBNF) grammar has been defined. EBNF only differs from BNF in the usage of the following symbols: “?” means that the symbol (or group of symbols in parenthesis) to the left of the operator is optional, “\*”

means that something can be repeated any number of times, and “+” means that something can appear one or more times. EBNF has been selected because it is widely used to formally define programming languages and markup languages (e.g., XML and SGML), the syntax of the language is precisely defined, thus leaving no ambiguity on its interpretation, and it is easier to develop a parser for such a language, because the parser can be generated automatically with a compiler (e.g., YACC). Instances of distribution primitives are called by *statements*. The definitions of an operation, a source, a target, a selector and some other ones are defined in Fig. 3 and 4 (excerpt only). The definitions could be extended later to support more operations or features.

```
statement = operation , white_space , source , white_space , "TO" ,
white_space , target ;
operation = "SET" | "DISPLAY" | "UNDISPLAY" | "COPY" |
"MOVE" | "REPLACE" | "TRANSFORM" | "MERGE" | "SWITCH" |
"SEPARATE" | "DISTRIBUTE";
source = selector ;
target = displays | selector , white_space , "ON" , white_space ,
displays ;
displays = display_platform , { "," , display_platform }
display_platform = display , [ white_space , "OF" , white_space ,
platform ] ;
selector = identifier , { "," , identifier } | universal ;
display = identifier ;
platform = identifier ;
```

Figure 3. EBNF grammar for distribution primitives (excerpt).

**Examples**

In order to illustrate how distribution primitive could behave, we hereby provide a series of progressively more complex examples. In Fig. 4, a display of the platform by default has been modified in the following way: DISPLAY “pushButton\_1” AT 5,5 ON “defaultPlatform” followed by SET “pushButton\_1.label” TO “B”, thus creating a CUI model attached to this platform.

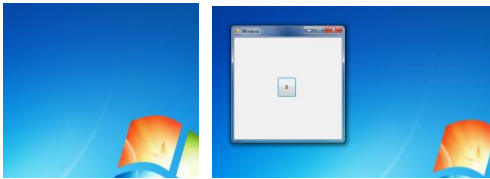


Figure 4. Example of a simple display primitive.

Obviously distribution operations could be more complex than the example provided in Fig. 4. Here is a series of examples for the COPY primitive:

1. COPY button\_1 TO shared\_display: simple copy of button\_1 sent to shared\_display without specifying neither an identifier nor a container
2. COPY button\_1 TO button\_2 ON shared\_display: copy button\_1 on shared\_display and identify it as button\_2
3. COPY button\_1 TO button\_2 ON shared\_display of

shared\_platform: the same but we specify the shared\_platform to avoid searching through all the platforms

4. COPY button\_1, button\_2 TO shared\_display: copy button\_1 and button\_2 to shared\_display in a single operation
5. COPY button\_1 TO shared\_display, my\_display: copy button\_1 to shared\_display and also to my\_display
6. COPY button\_1 TO shared\_display OF shared\_platform AND my\_display OF my\_ipad: copy button\_1 to both shared\_display and my\_display, specifying on which platform is each display
7. COPY \* TO shared\_display: copy all the graphical components from the current UI to shared\_display
8. COPY ALL buttons TO shared\_display: copy all buttons to shared\_display
9. COPY individuals TO shared\_display: copy any individual CUI widgets to shared\_display

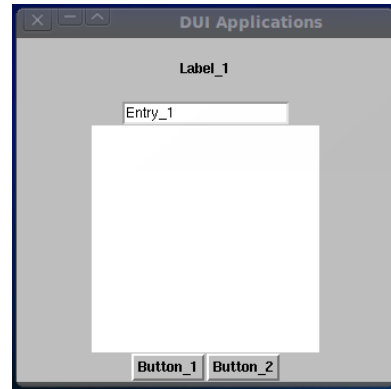
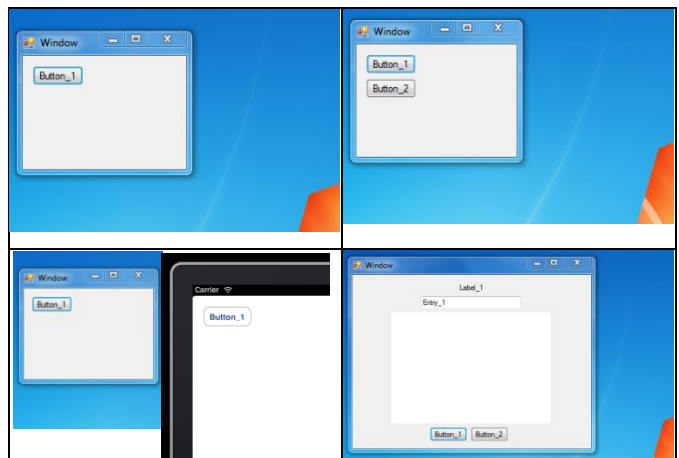
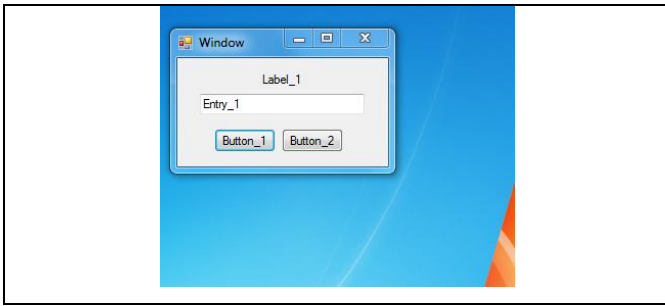


Figure 5. Source CUI for the COPY examples.





**Figure 6.** Results of examples 1, 2 & 3 (top left), 4, 8 (top right), 5 & 6 (middle left), 7 (middle right), 9 (bottom).

The source CUI associated to these examples is reproduced in Fig. 5, while the results of the nine above copy operations are reproduced respectively in the different regions of Fig. 6.

*Meta-User Interface for Distribution Primitives.* The distribution primitives defined in the previous subsection could be called in two ways:

1. *Interactively* through a meta-UI [9] providing a command line equipped with a command language: in this way, one can type any distribution primitive through statements that are immediately interpreted and provide immediate feedback. This meta-UI adheres to usability guidelines for command languages (such as consistency, congruence, and symmetry), but does not provide for the moment any graphical counterpart of each statement or graphical representation of the platforms of the cluster. Actually, each platform is straightforwardly addressed at run-time. It is of course possible to see the results of a distribution primitive immediately by typing it by a “errors and trials” process until the right statement is reached. Fig. 7 reproduces a screen shot of this meta-UI, which also serve as a tutorial to understand how to use the distribution primitives. Indeed, any statement type in the command language can be stored in a list of statements that could be recalled at any time.
2. *Programmatically*: each statement representing an instance of a distribution primitive can be incorporated in an interactive application in the same way since the parser will be called to interpret it. It is therefore no longer needed to program these primitives.

## FUTURE WORK

These distribution primitives have been defined in such a way that it allows distributing any graphical widget without focusing on how the value is shared when distributed. There are two important aspects in a User Interface: the

*presentation* and the *behavior* of the UI. The presentation part is the graphical representation of a widget. If the widget is moved to another platform, it means that the same widget will be displayed on the destination platform. This leads to an ambiguous solution about the behavior. Is the widget still acting like it was on the other platform? Is the action taking place locally (to the new platform) or globally (in the same way than before being moved, like a remote)? There importance of the behavior is an importance future work to keep in mind.

## CONCLUSION

In this paper, we have introduced the concept of distribution primitives and a toolkit based on them. The goal is to provide a catalog of distribution primitives as a common base for researchers on DUIS. They now have the same set of primitives. It allows them to share the same possibilities independently of the UI implementation.

A toolkit based on this catalog has also been introduced and allows developers to see the powerfulness of this catalog.

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