Software Engineering

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User Interface Design

Contents...

Introduction

In any software product,

- user interface portion is responsible for all interactions with the user.

Almost every software product has a user interface:

- can you think of any software product that does not have any user interface?

In the early days of computer, no software product had any user interface:

- all computers were batch systems
- no interactions with users were supported.

We know that things are very different now:

-almost every software product is highly interactive.

Introduction [CONTD.]

In the early days of computer, no software product had any user interface:	- all computers were batch systems - no interactions with users were supported.
We know that things are very different now:	- almost every software product is highly interactive.
Users interact with a software product through its user interface:	- user-interface portion of any software is directly relevant to the users. - many users judge a software from its user interface.
User interface design:	- a practical and important problem.

Introduction [CONTD.]

Aesthetics apart, a difficult to use interface:

-leads to higher levels of user errors

-leads to user dissatisfaction

.

Users become particularly irritated when a system behaves in unexpected ways,

-issued commands do not carry out actions according to intuitive expectations of users.

A significant portion of the total development effort:

- spent in developing the user interface.

For many interactive applications:

- as much as 50% of the total development effort is spent on the user interface part

Introduction [CONTD.]

If the user interface is not developed systematically:

effort required to develop the interface would increase tremendously :

- leading to customer dissatisfaction.

It is important to carefully study

user interface design concepts.

Let us examine what a good interface is:

Unless we know what a good user interface really is,

- we cannot possibly design one.

Characteristics of Good User Interfaces

- Speed of learning:
  - ✓ A good user interface should be simple to learn.
  - ✓ Most users are put off by complex syntax and semantics of the command issue procedures.

Speed of learning

A good user interface should not require

users to memorize commands.

An important factor affecting the speed of learning is consistency:

Once, a user learns about a command,

should be able to use similar commands

- even in different circumstances for carrying out similar actions.

Speed of learning

- Users can learn about an interface faster, if it is based on:
  - day-to-day real-life examples (aka metaphors)
  - use concepts with which users are already familiar.
- For example, interface of a text editor:
  - can use concepts like writing on paper:
    - such as cutting lines and paragraphs and pasting it at other places,
    - users can immediately relate to it.
- Also, learning is facilitated by:
  - intuitive command names
  - symbolic command issue procedures.

Speed of use

Speed of use is determined by:

- the time and effort necessary to initiate and execute different commands.
- The time and user effort necessary to execute different commands should be minimal.

Examples of bad interfaces:

- users required to type in lengthy commands
- command issue involves moving the mouse to widely different areas of the screen
- can slow down the operating speed of users.

Speed of recall

- Once users learn how to use an interface:
  - ✓ their speed of recall about using the interface should be maximized.
- The speed of recall is improved if the interface is based on:
  - ✓ metaphors
  - ✓ symbolic command issue procedures
  - ✓ intuitive command names.

Error rate

A good user interface should

- minimize the scope of committing errors.

Error rate can be easily measured:

- count the errors committed by different users.

Error monitoring can be automated:

- instrument user interface with monitoring code
- record the frequency and types of errors committed by different users
- later display statistics of various kinds of user errors.

How to reduce error possibilities?

- Consistency of command names,
- Consistency of command issue procedures,
- Consistency in behaviour of similar commands
- Simplicity of command issue procedure, etc.

Attractiveness

- A good user interface should be attractive:
  - ✓ An attractive user interface catches user attention and fancy.
  - ✓ In this respect,
    - ❑ graphics-based user interfaces have a definite advantage over text-based interfaces.

Consistency

- Consistency of commands is very desirable.
  - ✓ allow users to generalize the knowledge about one aspect of the interface to another.
- Consistency helps in:
  - ✓ speed of learning,
  - ✓ speed of recall,
  - ✓ also helps in reduction of error rate.

Feedback

A good user interface must provide constant feedback to user actions:

For example, if any user request takes more than few seconds to process,

- the user must be informed that his/her request is still being processed.

If possible, the user should be periodically informed about the progress made in processing the command.

In the absence of any response from the computer for a long time:

a novice user might even start recovery/shutdown procedures in panic.

Support for multiple skill levels

- A good user interface:
  - ✓ should support different levels of sophistication in command issue procedures:
  - ✓ users with different experience levels prefer different types of interfaces.
- Experienced users are more concerned about speed of command issue:
  - ✓ whereas novice users pay prime importance to usability aspects.

Support for multiple skill levels

- Novice users discouraged by:
  - ✓ cryptic command names
  - ✓ complex command issue procedures.
- Elaborate commands:
  - ✓ slow down command issue procedure
  - ✓ put off experienced users.
- As users become familiar with an interface:
  - ✓ look for faster command issue procedures such as "hot-keys", "macros", etc.

Error Recovery (Undo facility)

All categories of users commit errors.

A good interface should allow users to undo mistakes.

Users are inconvenienced:

if they can not recover from even simple errors.

User Guidance and On-line Help

- Users might need guidance
  - ✓ or seek help from the system.
- User Guidance is provided through two broad category of methods:
  - ✓ On-line help system
  - ✓ Guidance and error messages produced
    - ❑ in response to user actions.

On-line Help System

Generic help messages are not very useful:

- on-line help messages should be tailored to the context in which help is invoked.

A good on-line help should:

- provide messages in context-dependent way.
  - ✓ keep track of what a user is doing
- help messages should be tailored to user's experience level.
- should take advantage of graphics capabilities of the screen
  - ✓ not just be a copy of the user manual.

Guidance Messages

- The guidance messages should be carefully designed:
  - ✓ prompt the user:
    - ❑ next actions he/she might take,
    - ❑ current status of the system,
    - ❑ progress made so far in processing the command
- A good guidance system should have:
  - ✓ different levels of sophistication for different categories of users.
  - ✓ users should have an option to turn off detailed messages.

Error Messages

- Error messages should be polite.
- Error messages should not be associated with noise:
  - ✓ might embarrass the user.
- The messages should suggest how a given error can be rectified.
- If appropriate,
  - ✓ the user should be given the option of invoking on-line help
  - ✓ to find out more about the error situation.

Improper Error Message

STOP
File not found!

Mode-Based versus Modeless Interface

- A mode is a state or collection of states:
  - ✓ in each state (or mode) different types of commands are available.
- Modeless interface:
  - ✓ same set of commands are available at all times.
- Mode-based interface:
  - ✓ different sets of commands are available depending on the mode in which the system is, i.e.
  - ✓ based on the past sequence of the user commands.

Mode-Based versus Modeless Interface

- A mode-based interface can be represented using a state transition diagram:
  - ✓ each node (state) of the state transition diagram represents a mode.
  - ✓ Every state (node) of the diagram
    - ❑ annotated with command names meaningful in that state.

Graphical User Interface (GUI) versus Text-Based User Interface

In a GUI:

- several windows with different information can be simultaneously displayed on user’s screen.
- This is perhaps the biggest advantage of GUI
- user can simultaneously interact with several related items at any time
- can even run many unrelated applications

Iconic information representation and symbolic information manipulation is possible in a GUI.

Graphical User Interface (GUI) versus Text-Based User Interface

Symbolic information manipulation:

such as pulling an icon representing a file into a trash can for deleting

intuitively very appealing

- user can instantly remember it.

A GUI can support command selection:

using an attractive and user-friendly menu selection system.

In a GUI, a pointing device can be used:

a mouse or a light pen to issue commands.

The use of a pointing device

- makes command issue procedure simpler.

Graphical User Interface (GUI) versus Text-Based User Interface

- On the flip side, a GUI requires:
  - ✓ special terminals with graphics capabilities
  - ✓ requires special input devices such a mouse.
- In contrast, a text-based interface:
  - ✓ can run even on cheap alphanumeric terminals:
  - ✓ Graphics terminals are usually much more expensive than alphanumeric terminals.

Graphical User Interface (GUI) versus Text-Based User Interface

- Increasing availability of:
  - ✓ terminals with graphics capability
  - ✓ bit-mapped high-resolution displays
  - ✓ significant amount of local processing power.
- We will concentrate our attention to GUIs

Types of User Interfaces

- User interfaces can be classified into three categories:
  - ✓ Command language-based interface
  - ✓ Menu-based interface
  - ✓ Direct manipulation interface

Types of User Interfaces

- Each category of interface has its advantages and disadvantages:
  - ✓ Modern applications sport a combination of all the three types of interfaces.

Choice of Interface

- Which parts of the interface should be implemented using what type of interface?
  - ✓ No simple guidelines available
  - ✓ to a large extent depends on the experience and discretion of the designer.
  - ✓ a study of characteristics of the different interfaces would give us some idea.

Command Language-Based Interface

As the name itself suggests:

- incorporates some language to form commands.

Users frame the required commands in the language:

- type them in whenever required.

Design of command language interface

Simple command language interface:

- determine all the commands needed to be supported
- assign unique names to the different commands.

A more sophisticated command language interface:

- allow users to compose primitive commands to form more complex commands.
  - Consider `cat x.dat | grep 123`
- Like a programming language.

Command Language-Based Interface

- The facility to compose commands:
  - ✓ dramatically reduces the number of command names users would have to remember.
  - ✓ Commands can be made concise
    - ❑ requiring minimal typing by the user.
  - ✓ allow faster interaction with the computer
  - ✓ simplify input of complex commands.

Advantages of Command Language Interfaces

- Easy to develop:
  - compiler writing techniques are well developed.
- Can be implemented even on cheap alphanumeric terminals.
- Much more efficient:
  - compared to other types of interfaces.

Disadvantages of Command Language Interfaces

Difficult to learn:
- Require the user to memorize primitive commands.

Require user to type in commands.

Users make errors while:
- formulating commands in the command language
- typing them in.

All interactions are through key-board:
- cannot take advantage of effective interaction devices such as a mouse.
- For casual and inexperienced users,
  - ✓command language interfaces are not suitable.

Issues in Designing a Command Language Interface

- Design of a command language interface:
  - ✓ involves several issues.
- The designer has to decide
  - ✓ what mnemonics are to be used for the commands.
  - ✓ mnemonics should be meaningful
    - ❑ yet be concise to minimize the amount of typing required.
- The designer has to decide:
  - ✓ whether users will be allowed to redefine command names to suit their own preferences.
    - ❑ Letting a user define his own mnemonics for various commands is a useful feature,
    - ❑ but increases complexity of user interface development.

Issues in Designing a Command Language Interface

- Designer has to decide:
  - ✓ whether it should be possible to compose primitive commands to create more complex commands.
  - ✓ syntax and semantics of command composition options has to be clearly and unambiguously decided.
- The ability to combine commands is a powerful facility for experienced users:
  - ✓ but quite unnecessary for inexperienced users.

Menu-Based Interface

- Advantages of a menu-based interface over a command language interface:
  - ✓ users are not required to remember exact command names.
  - ✓ typing effort is minimal:
    - ❑ menu selections using a pointing device.
    - ❑ This factor becomes very important for the occasional users who can not type fast.

- For experienced users:
  - ✓ menu-based interfaces is slower than command language interfaces
  - ✓ experienced users can type fast
  - ✓ also get speed advantage by composing simple commands into complex commands.

Menu-Based Interface

Composition of commands in a menu-based interface is not possible.

- actions involving logical connectives (and, or, all, etc.)
  - awkward to specify in a menu-based system.

If the number of choices is large,

- it is difficult to design a menu-based interface.
- Even moderate sized software needs hundreds or thousands of menu choices.

A major problem with the menu-based interface:

- structuring large number of menu choices into manageable forms.

Structuring Menu Interface

- Any one of the following options is adopted to structure menu items.
  - ✓ Walking menu
  - ✓ Scrolling menu
  - ✓ Hierarchical menu

Scrolling Menu

Used when the menu options are highly related.

- For example text height selection in a word processing software.

Scrolling of menu items

- lets the user to view and select the menu items that can not be accommodated on one screen.

Walking Menu

Walking menu is commonly used to structure large menu lists:

- when a menu item is selected,
- it causes further menu items to be displayed adjacent to it in a submenu.

A walking menu can successfully structure commands only if:

- there are tens rather than hundreds of choices
- each adjacently displayed menu does take up some screen space
  - the total screen area is after all limited.

Hierarchical menu

- Menu items are organized in a hierarchy or tree structure.
  - ✓ Selecting a menu item causes the current menu display to be replaced by an appropriate submenu.
  - ✓ One can consider the menu and its various submenu to form a hierarchical tree-like structure.
- Walking menu are a form of hierarchical menu:
  - ✓ practicable when the tree is shallow.
- Hierarchical menu can be used to manage large number of choices,
  - ✓ but, users face navigational problems
    - ❑ lose track of where they are in the menu tree.

Direct Manipulation Interface

- Present information to the user
  - as visual models or objects.
- Actions are performed on the visual representations of the objects, e.g.
  - pull an icon representing a file into an icon representing a trash box, for deleting the file.
- Direct manipulation interfaces are sometimes called as iconic interfaces.

Direct Manipulation (Iconic) Interface

- Important advantages of iconic interfaces:
  - ✓ icons can be recognized by users very easily,
  - ✓ icons are language-independent.
- However, experienced users consider direct manipulation interfaces too slow.
- It is difficult to form complex commands using a direct manipulation interface.
- For example, if one has to drag a file icon into a trash box icon for deleting a file:
  - ✓ to delete all files in a directory one has to perform this operation again and again
  - ✓ very easily done in a command language-interface by issuing a command delete *.*

Windowing Systems

- Most modern GUIs are developed using some windowing system.
- A windowing system can generate displays through a set of windows.
- Since a window is a basic entity in such a graphical user interface:
  - ✓ we need to first discuss what exactly a window is.

Window

A window is a rectangular area on the screen.

A window is a is a virtual screen:

* it provides an interface to the user for carrying out independent activities,

* one window can be used for editing a program and another for drawing pictures, etc.

A window can be divided into two parts:

-- client part,

-- non-client part.

Window

- The client area makes up the whole of the window,
  - ✓ except for the borders and scroll bars.
- The client area is available to the programmer.
- Non-client area:
  - ✓ under the control of window manager.

Window management system (WMS)

- A graphical interface might consist of a large number of windows,
  - ✓ necessary to have some systematic way to manage the windows.
  - ✓ Window Management System (WMS)
- GUIs are developed using a window management system (WMS):
  - ✓ A window management system is primarily a resource manager.
  - ✓ keeps track of screen area resource
  - ✓ allocates it to the different windows which are using the screen.

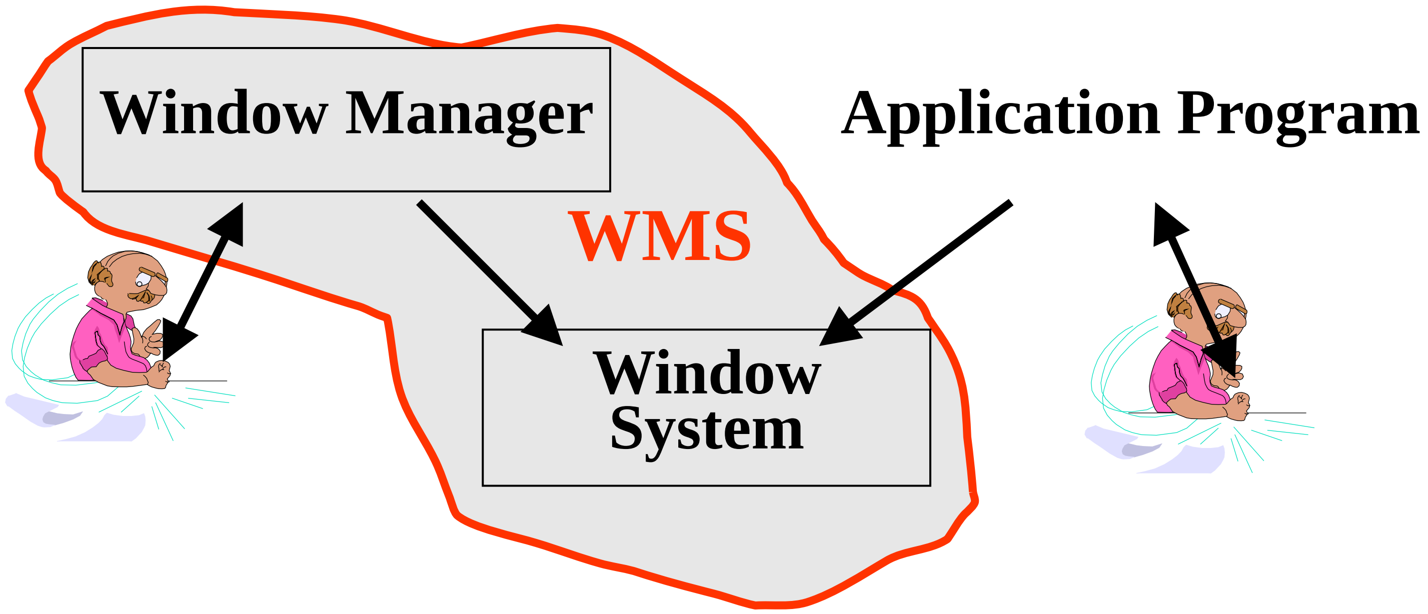
Window management system (WMS)

- From a broader perspective, a WMS can be considered as a user interface management system (UIMS) ---
  - ✓ not only does resource management,
  - ✓ also provides the basic behaviour to windows
  - ✓ provides several utility routines to the application programmer for user interface development.

- A WMS simplifies the task of a GUI designer to a great extent:
  - ✓ provides the basic behaviour to the various windows such as move, resize, iconify, etc.
  - ✓ provides routines to manipulate windows such as:
    - ❑ creating, destroying, changing attributes of the windows, and drawing text, lines, etc.

Window management system (WMS)

- A WMS consists of two part:
  - ✓ a window manager
  - ✓ a window system.



Window Manager and Window System

- User interacts with window manager to do various window-related operations such as:
  - ✓ window repositioning,
  - ✓ window resizing,
  - ✓ iconification, etc.
- Window manager also controls the screen's real estate policy.

Window manager

The window manager is built on the top of the window system:	makes use of the basic services provided by the window system.
The window manager determines how the windows look and behave.	several kinds of window managers can be based on the same window system.
Window manager can be considered as a special program:	makes use of the services (function calls) of the window system.
Application programs	invoke the window system for user interface-related functions.

Window System

- Provides a large number of routines for the programmer

- It is very cumbersome to use these large set of routines:
  - ✓ most WMS provide a higher-level abstraction called widgets.

Window Management System

- A widget is the short form for a window object.
- Widgets are the building blocks in interface design.
- We know that an object is essentially a collection of:
  - ✓ related data with several operations defined on these data.

Widgets

- The data of an window object are:
  - ✓ the geometric attributes (such as size, location etc.)
  - ✓ other attributes such as its background and foreground color, etc.
- The operations defined on these data include, resize, move, draw, etc.

Advantages of Widgets

- One of the most important reasons to use widgets as building blocks:
  - ✓ provide consistency.
- Consistent user interfaces
  - ✓ improve the user's productivity and
  - ✓ lead to higher performance with fewer errors.
- Widgets make users familiar with standard ways of using an interface ---
  - ✓ users can easily extend their knowledge of interface of one application to another
  - ✓ the learning time for users is reduced to a great extent.
- Next lecture we will identify standard widgets used to design GUIs.

Summary

- User interface is an important component of any software product.
- We first discussed some important concepts associated with user interface design.
- We discussed some desirable properties of a good user interface.
- There are 3 main types of interfaces:
  - ✓ command language interface
  - ✓ menu-based interface
  - ✓ iconic interface
- Each type of interface has its own advantages and disadvantages:
  - ✓ most modern interfaces use a combination of all the three types.

Summary

- We finally discussed concepts associated with a window management system (WMS):
  - ✓ consists of a window manager and a window system.
  - ✓ we discussed the use of widgets as the basic building blocks in GUI design.