User interface toolkits

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Outline

Software layers

Graphical libraries

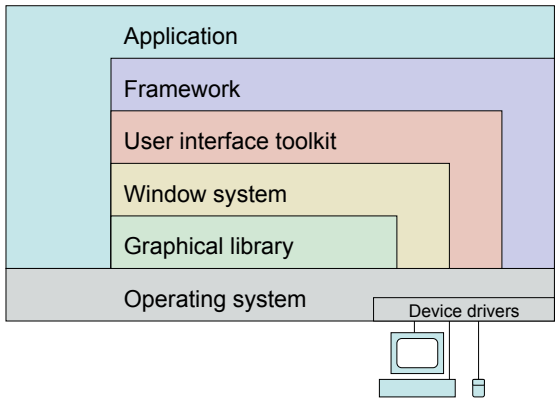
Window systems

User interface toolkits

Applications frameworks

Interface builders

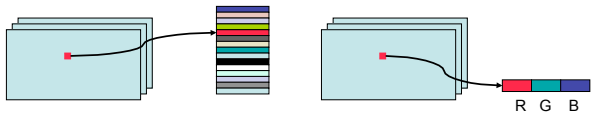
Software layers



Output devices

Bitmap screens

- CRT, LCD, Plasma, …
- Spatial resolution: about 100dpi
- Color resolution (« color depth ») :
  - B&W, grey levels, color table, direct color



- Temporal resolution: 10 to 100 frames per second
- Bandwidth:
  - 25 img/s * 1000x1000 pixels * 3 bytes/pixel = 75 Mb/s
- GPU : Graphics Processing Unit

Input devices

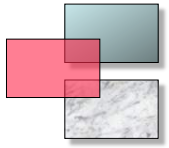
2D input devices
- Mouse, Tablet, Joystick, Trackball, Touch screen
- Type of user control
  - position, motion, force, … ; linear, circular, …
- Mapping of input dimensions
  - position, speed, acceleration
  - transfer function (gain)
- Motor space vs. visual space
  - separate or identical

Other input devices
- Keyboards, Button boxes, Sliders
- 3D position and orientation sensors
- Simulated devices

Graphical libraries

Drawing model
- Direct drawing (painter's algorithm)
- Structured drawing: scene graph
  - Edit the data structure

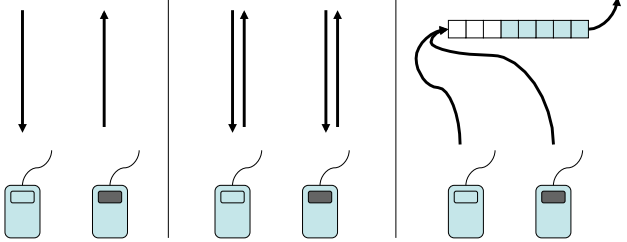
Graphical objects are defined by:
- Their geometry
- Their graphical attributes
  - color, texture, gradient, transparency, lighting



Graphical libraries
- Direct drawing: Xlib, Java2D, OpenGL
- Structured drawing: Inventor (3D), SVG

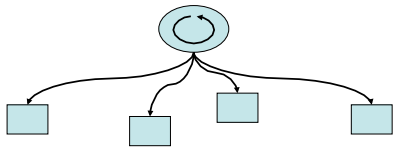
Managing input in an interactive system

Query	Sampling	Events
Blocking	Busy waiting	Event queue



Event-driven programming

```
while running do
   wait until event queue not empty      // blocking
   ev := first event from queue          // extract event
   target := findTarget(ev)
   if target ≠ NIL then target.handleEvent(ev)
end while
```



Very different from traditional algorithmic approach

Window systems

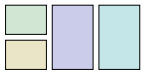
Organize display space in independent areas
- Resource sharing

Window = autonomous area on the screen
- for display
- for input (event dispatching)

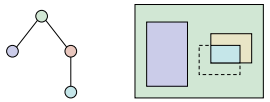
Window management
- User interface: « window manager »
- Application programming interface

Windowing models

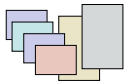
Tiling



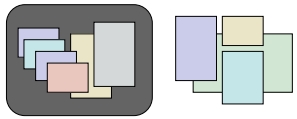
Hierarchical



Overlapping

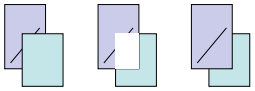


Virtual screens



Window systems

Drawing model
- Redraw hidden parts

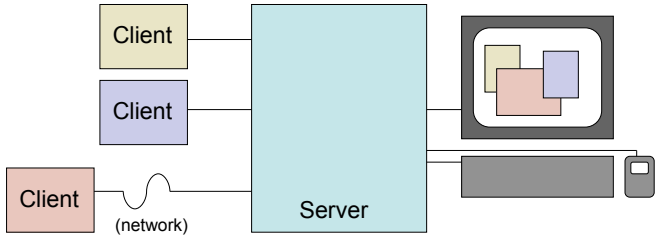


Input management
- Demultiplex event across applications
  - Concept of « focus »
- New events
  - Window system:
    - request redraw, create/delete window
  - Input devices:
    - focus changes, cursor enters/leaves window

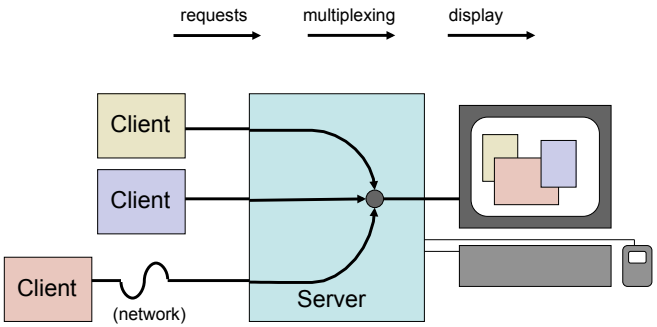
Client-server architecture

Virtual terminals
- Clients are independent of each other

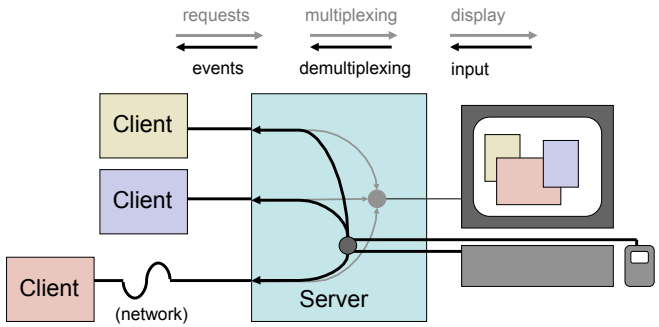
Example : X Window System



Client-server architecture



Architecture client-serveur



User interface toolkits

Abstraction : the *widget*

- Interactive object, component
- Button, menu, scrollbar, dialog box, …

A widget = three facets

- Presentation – Behavior – Application interface

Interface = widget tree

- Nodes: containers (windows, menu bar, dialog box, …)
- Leaves: simple widgets (buttons, scrollbars, …)

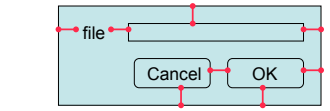
Widget layout

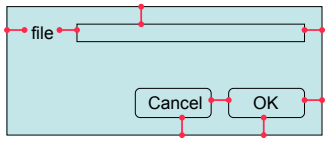
General rules

- A widget is geometrically enclosed in its parent
- The parent controls the layouts of its children

Layout algorithm

- Natural size of each child
- Final size and positions imposed by the parent
- Constraints :
  - Grid, form, etc.





- Dynamic layout

Facets of a widget

Presentation
- Visual appearance
- Configurable (« resources »)

Behavior
- Reaction to user actions
- Non configurable (or very limited)

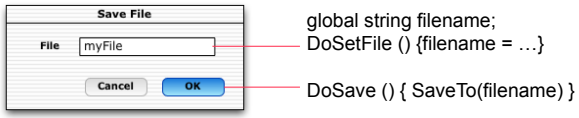
Application interface
- Notification of state changes

Application interface: callback functions

1. Registration of callback when widget is created

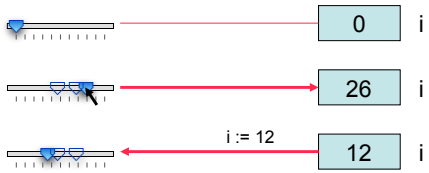
2. Callback function is called when widget is activated

Problem: « spaghetti » of callbacks
- Sharing state among widgets and callbacks using global variables



Application interface: active values

Bi-directional link between a state variable of the widget and a variable of the application



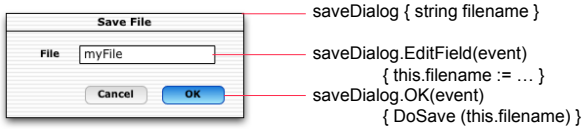
Problems
- Limited to simple data types
- Back link (widget to app) can be costly

Advantages
- Multiples views

Application interface: message passing

An object is associated to a widget,
its methods are called when a state of the widget changes

Better encapsulation



User interface toolkits

Many available toolkits
- Xt, Motif – historical (X Windows)
- Qt, GTK – Linux
- AWT, Swing – Java
- Tck/Tk – multi-plateformes [active values]

Many limitations
- Programming is cumbersome
- Interaction limited to the interior of the widget
  - example : no drag-and-drop
- Limited extensibility : adding new widgets types is difficult

Application frameworks

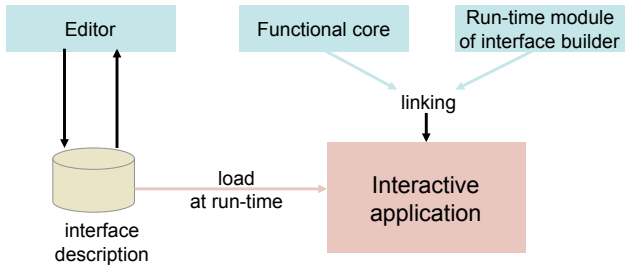
Application skeleton
- Incomplete code: general structure of theapplication
- Includes what is not supported by the toolkit
  - Global structure of the application
  - Global functions (history, copy-paste, …)
  - Non-widget interaction (e.g., drag-and-drop)

Shows the limitations of the programming language

Example : MacApp (Apple, 1986)
- Concept of a document (content of a window)
- Concept of action (that can be done and undone)

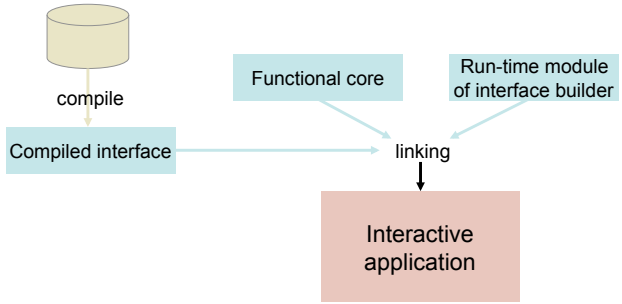
Interface builders

Description (text or graphics) of part of the interface
Generation of a runnable version



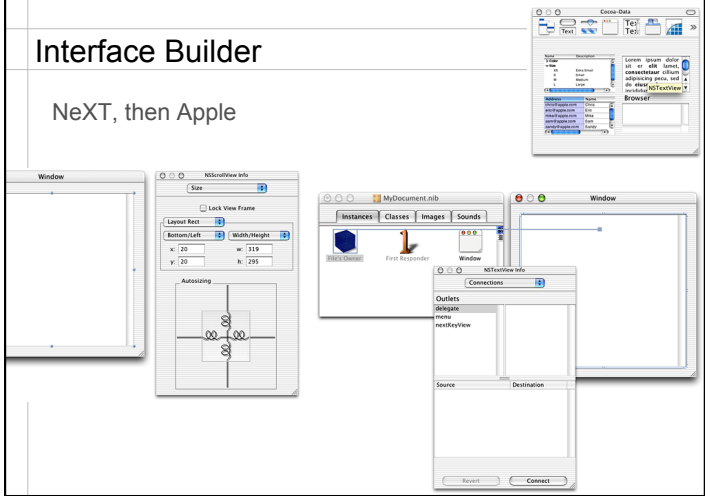
Interface builders

Generating the final application



Interface Builder

NeXT, then Apple



Conclusion

Advantages of these tools
- Reduce development and maintenance costs
- Facilitate compliance with style guides

Limitations of these tools
- Interaction style based on widgets
- Limited extensibility
- Difficult to program non-standard interactions

Research issues
- Beyond the widget model
- Define better languages and environments