Event Dispatch

Interactor Tree

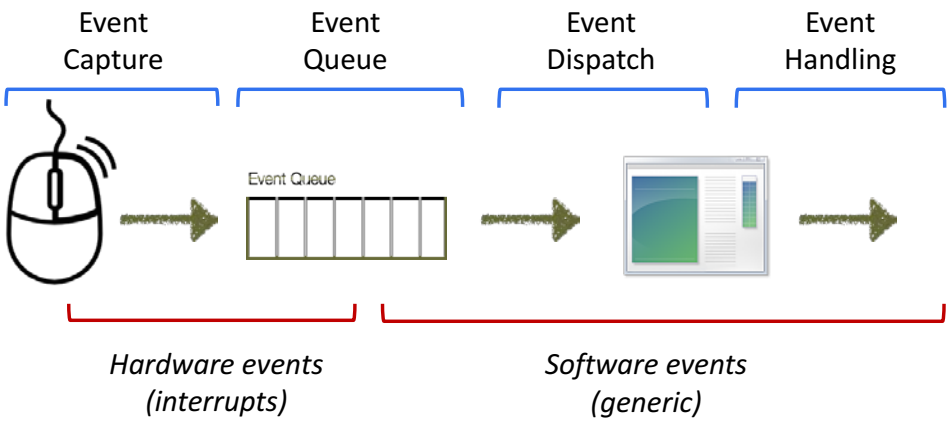
Lightweight vs. Heavyweight

Positional Dispatch

Focus Dispatch

Event Architecture

- A pipeline:
  - **Capture** and **Queue** low-level hardware events
  - **Dispatch** events to correct window and widget
  - **Handle** event with application code

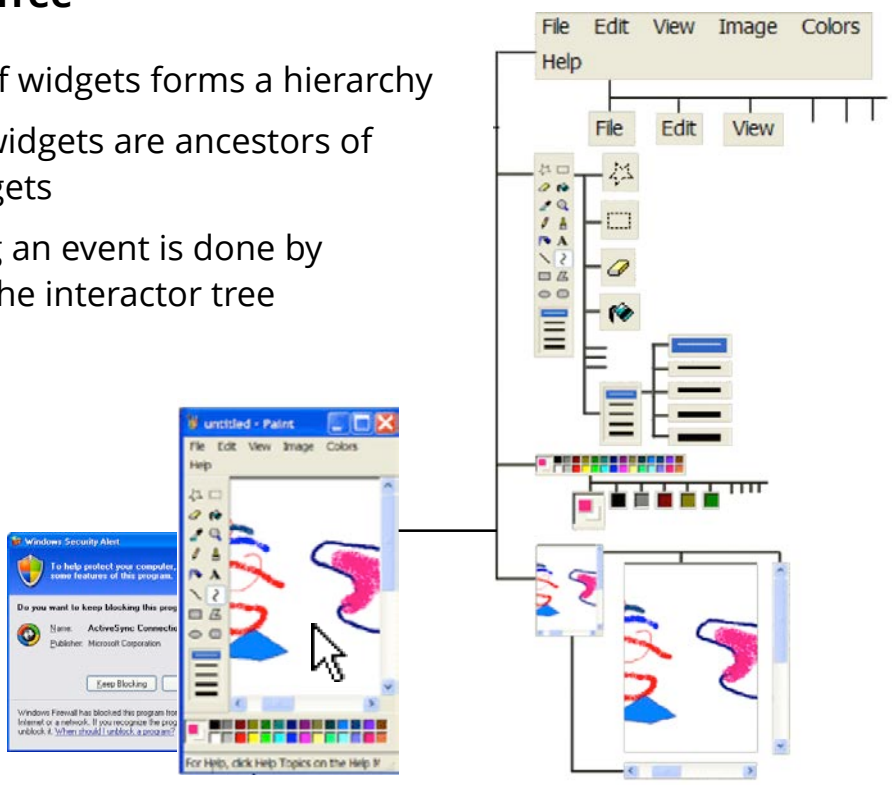


Event Loop

- Iterate through event queue, and dispatch event to handler(s)
  - Low-level mechanism for event dispatch
- BWS event queue always dispatches to an application window
  - what window triggered the event
  - what window has mouse or keyboard “focus”
- Final dispatch depends on what manages application-level events:
  - BWS could dispatch to widget level (heavyweight)
  - application could manage dispatch (lightweight, e.g. Xlib)
  - toolkit could dispatch to widgets (lightweight, JVM/Swing)

Interactor Tree

- 2D layout of widgets forms a hierarchy
- Container widgets are ancestors of simple widgets
- Dispatching an event is done by traversing the interactor tree

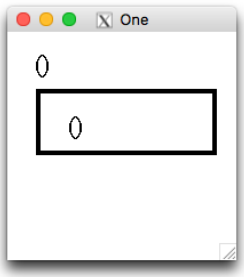


Lightweight vs. Heavyweight Widgets

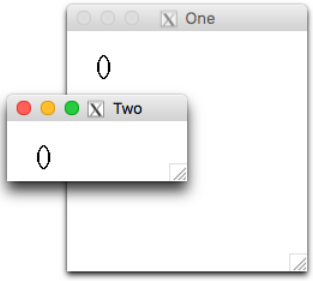
- Heavyweight widgets
  - Widget toolkit wraps native-OS widgets
  - BWS/OS provides a hierarchical "windowing" system for all widgets across all applications, and treats a widget essentially as a window
  - BWS can dispatch events to a specific widget
  - e.g. nested X Windows, Java's AWT, HTML forms, Windows MFC
- Lightweight widgets
  - The widget toolkit draws its own widgets and is responsible for mapping incoming events to widgets
  - BWS/OS dispatches to the window (NOT the widget)
  - e.g. Java Swing, JQuery UI, Windows WPF

multiwindow.cpp (xLib Heavyweight Widgets)

```
// true: window is like heavyweight widget
// false: window is just another window
bool isSibling = false;
```

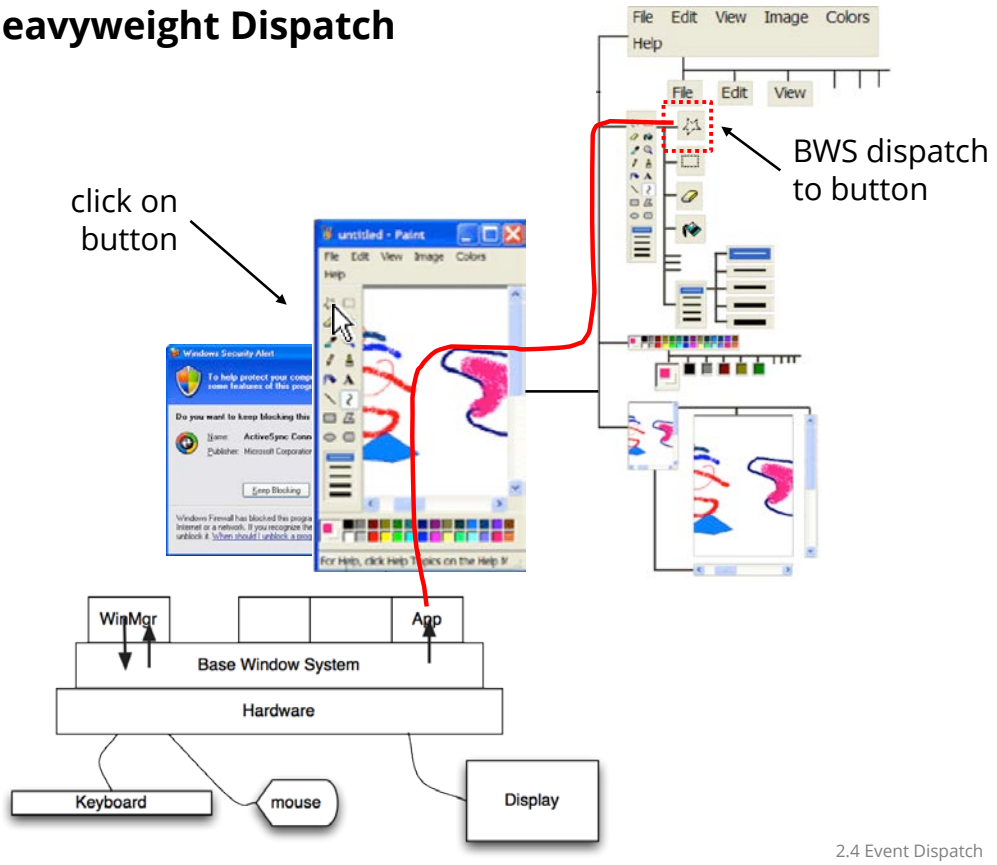


window like
heavyweight widget

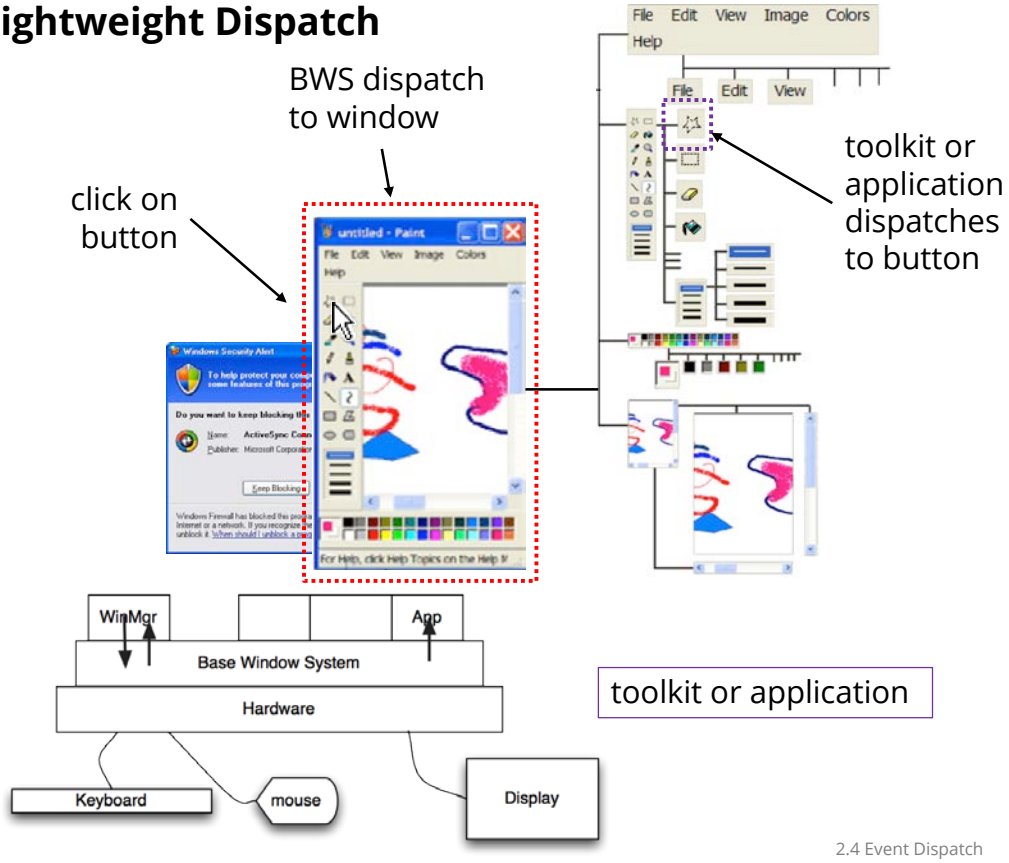


window just
another window

Heavyweight Dispatch

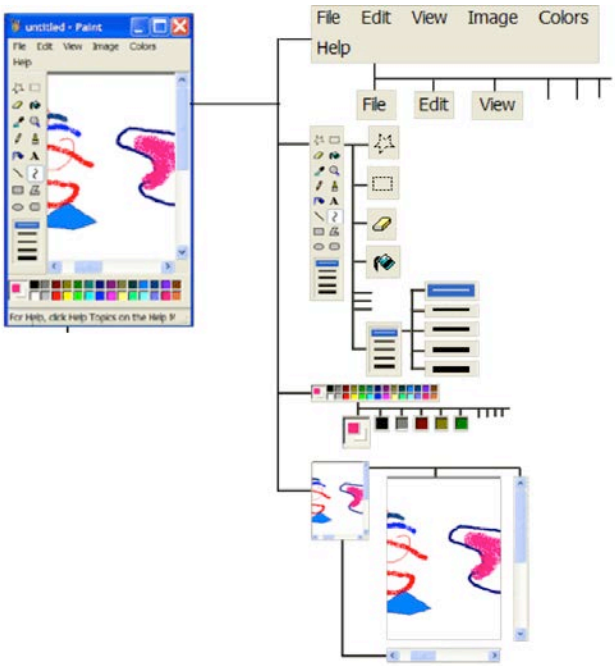


Lightweight Dispatch



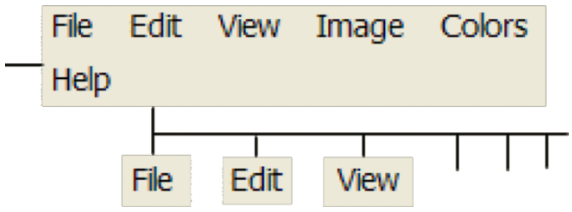
Positional Dispatch

- *Strategy:* send input to widget "under" mouse cursor
- *Issue:* many widgets overlap, which one receives event?
- Two methods:
  - Bottom-up
  - Top-down



Bottom-up Positional Dispatch

- Lowest-level node has first chance to handle event
- Event is dispatched to **leaf node widget in the UI tree** that contains the mouse cursor
- The leaf node widget can either:
  1. handle the event itself
  2. pass the event to its parent
     (who can process it or send to its parent...)



Passing to Parent

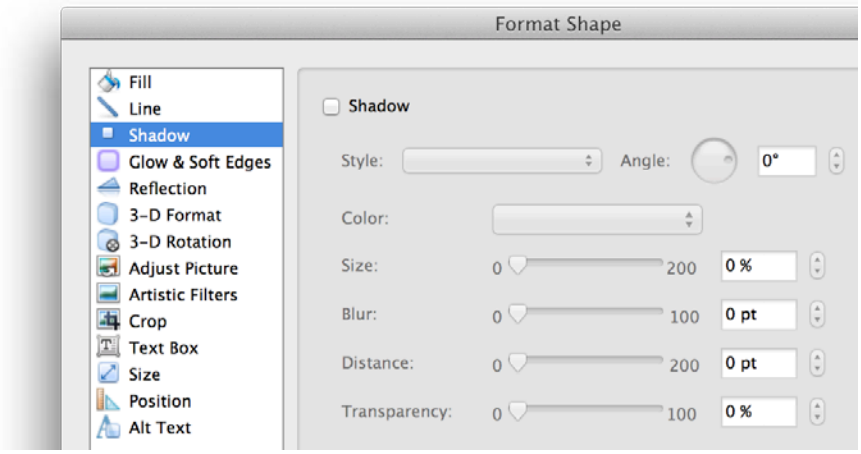
- Why would a widget pass an event to its parent?
  - Example: A palette of colour swatches may implement the colours as buttons. But palette needs to track the currently selected colour. Easiest if the palette deals with the events.

Top-down Positional Dispatch

- Highest-level node has first chance to handle event
- Event is dispatched to widget in the **highest level node** in the UI tree that contains the mouse cursor.
- The top node widget can either:
  1. handle the event itself
  2. pass the event to the child "under" the mouse (who can process it or send to its child...)

Top-down vs. Bottom-up Dispatch

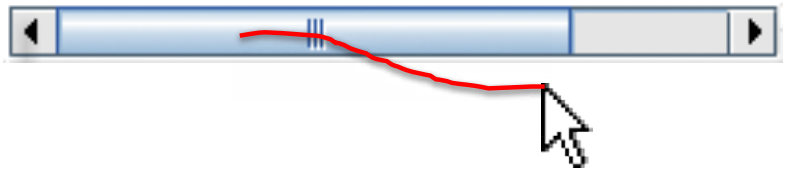
- When do these behave the same way?
- Advantages of top-down?



disabled container widget policy

Positional Dispatch Limitations

- Positional dispatch can lead to odd behaviour:
  - Send keystrokes to scrollbar if mouse over the scrollbar?
  - Mouse drag starts in a scrollbar, but then moves outside the scrollbar: send the events to the adjacent widget?
  - Mouse press event in one button widget but release is in another: each button gets one of the events?
- Sometimes position isn't enough, also need to consider which widget is "in focus"



Focus Dispatch

- Events dispatched to widget regardless of mouse cursor position
- Needed for all keyboard and some mouse events:
  - Keyboard focus: Click on text field, move cursor off, start typing
  - Mouse focus: Mouse down on button, move off, mouse up … also called “mouse capture”
- Maximum one keyboard focus and one mouse focus
  - why?
- Need to gain and lose focus at appropriate times
  - Transfer focus on mouse down (“capture”)
  - Transfer focus when TAB key is pressed

Focus Dispatch *Needs* Positional Dispatch

- But if a widget has focus, it should not receive every event:
  - mouse down on another suitable widget should change focus
- Often helpful to have an explicit focus manager in a container widget to manage which widget has the focus.

Accelerator Key Dispatch

- Keyboard events dispatched based on **which keys** are pressed
- Register special keyboard accelerators with specific commands
  – commands are often the target of menu item events
- The GUI toolkit intercepts accelerators and forwards to the appropriate command handler

Dispatch Summary

- Mouse-down events are almost always positional:
  dispatched to widget under cursor (top-down or bottom-up)
- Other mouse and keyboard events go to widget in focus
- Non-input events may go elsewhere
  – Paint/damage events not necessarily associated with widget which receives input events
  (e.g. slider events ultimately effect other widgets to be repainted)