GUI & WIMP Interaction

- WIMP Interfaces
- Window System & Window Manager
- Direct Manipulation
- Instrumental Interaction

Graphical User Interface (GUI)

Hardware

- High resolution, high refresh graphics
- Keyboard e.g. mechanical, touchscreen
- Pointing device e.g. mouse, touchpad

Capabilities

- Display graphics, animation and text
- Manage text entry
- Point-and-click interaction

The system needs to

- **Handle input** devices - keyboard (text) and pointing (mouse/touch)
- **Provide output** methods - drawing primitives, bitmaps, text
- **Wait for user input** and respond to it in a timely manner.

Desktop GUI: WIMP

WIMP (Windows, Icons, Menus, Pointers) is the most common instantiation of a Graphical User Interface.

- Interaction: points + click (drag, double-click).

Advantages of WIMP interface design

- Each application is isolated within its own window(s).
  - Drawing and interacting with an application is restricted.
  - Applications have their own memory, resources.
  - Isolation between applications.
- System supports methods to move, resize, re-order, re-draw windows.
- System supports common presentation of applications/elements.
  - Provide common GUI elements for building apps (e.g. buttons).
  - Emphasizes recognition of interface features over recall of commands.
- Uses metaphor and direct manipulation to facilitate learning

Window controls

Titlebar

Menu

Toolbar (tools)

Tooltip

Cursor

Slide (object)

Status bar

Graphical User Interface (GUI)

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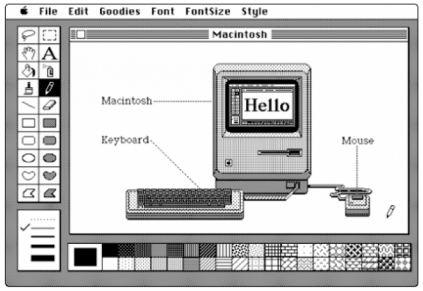

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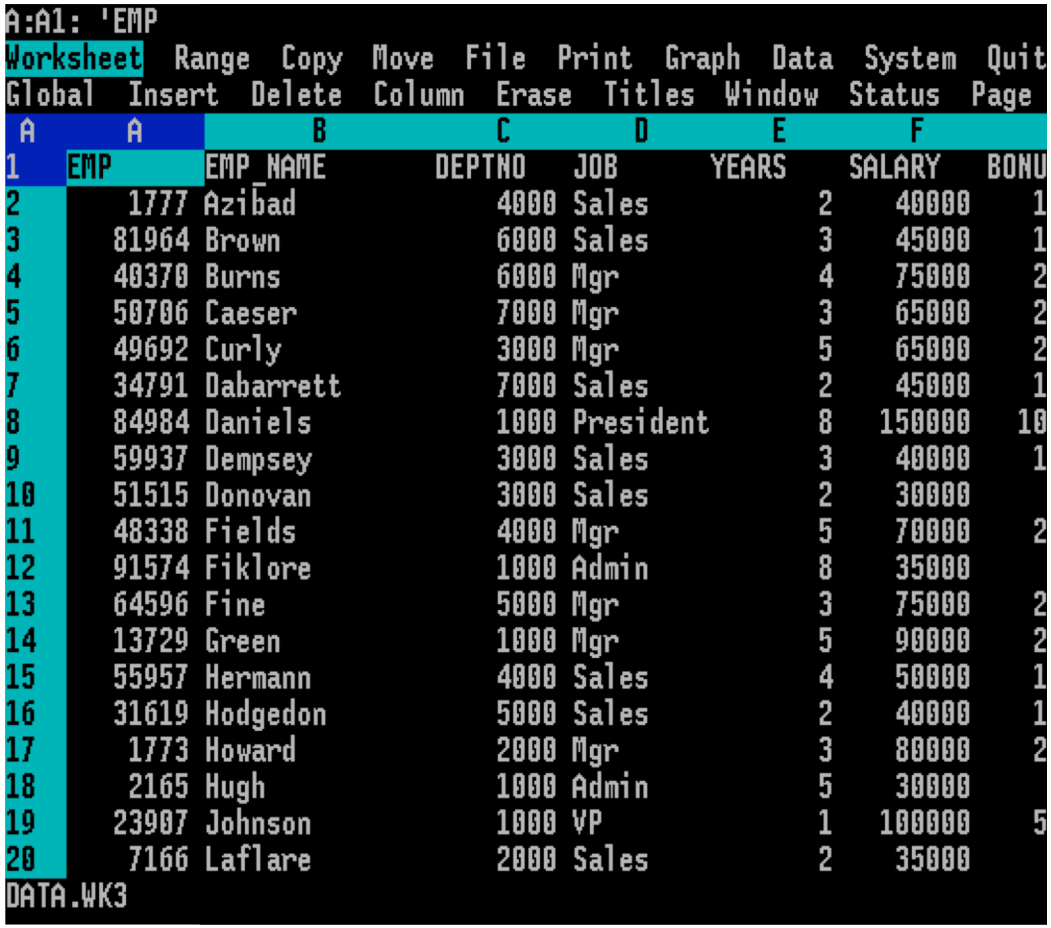
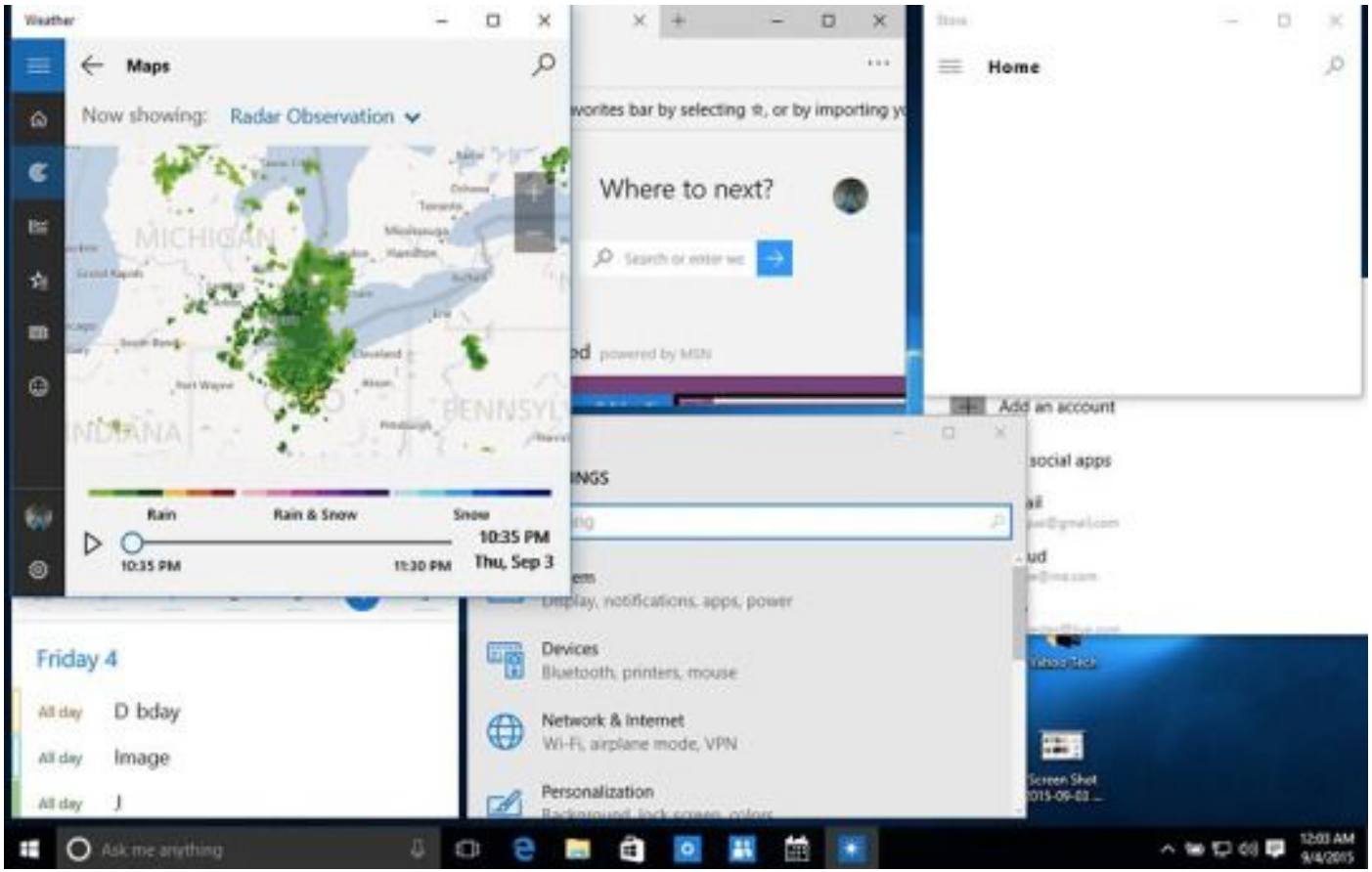
Before Windowing Systems

- Systems typically ran a single “full screen” application

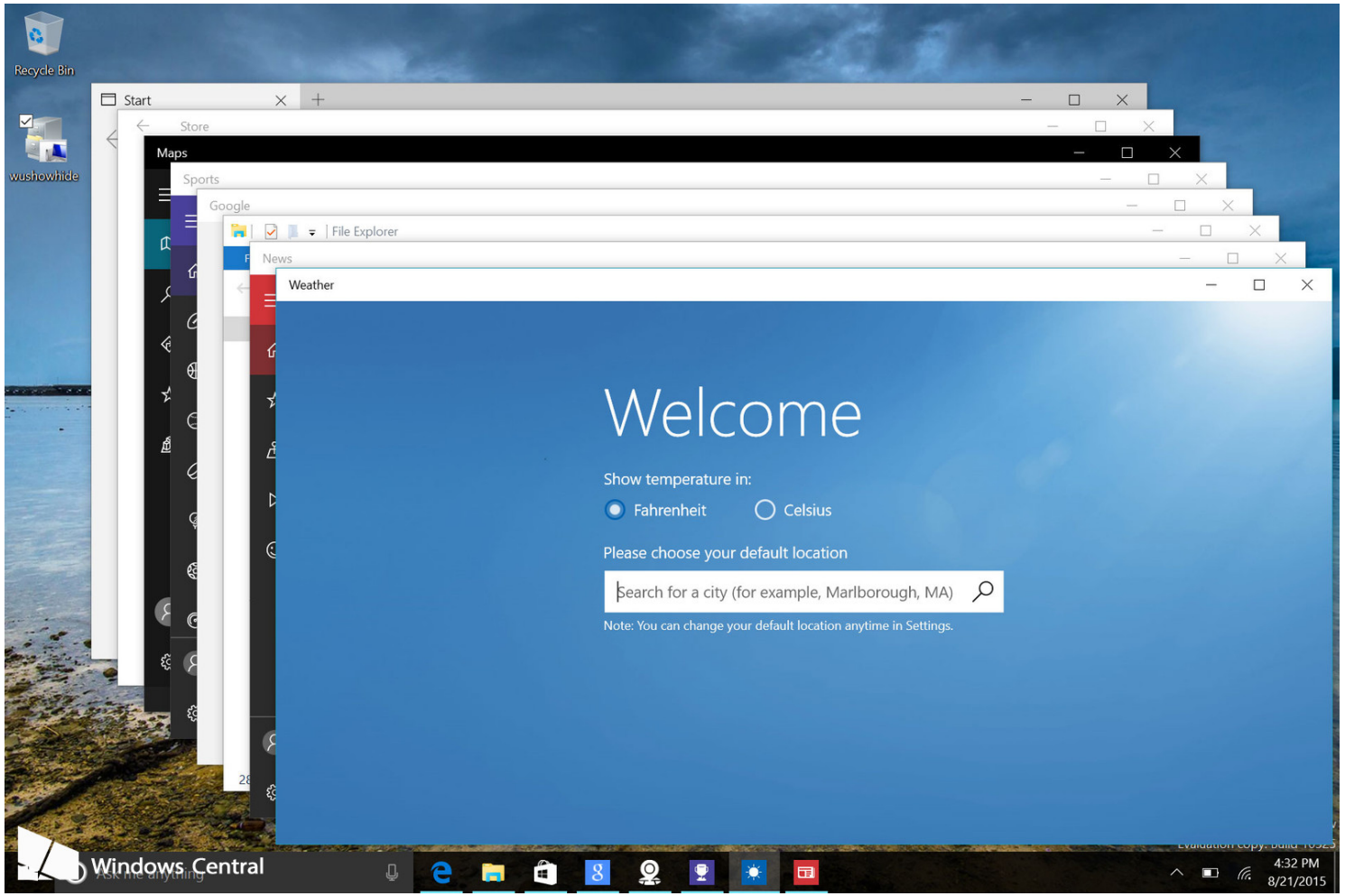


After Windowing Systems



- Programs run simultaneously, each in their own separate window(s).
- Windows are independent of one another; they don't need to know where they're located on the screen, or what other apps are running.

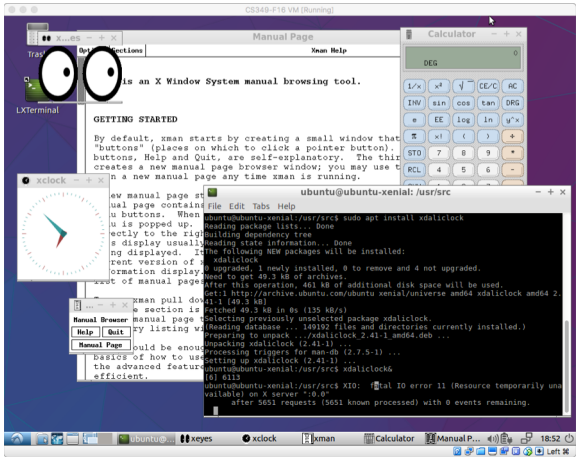
Managing Windows

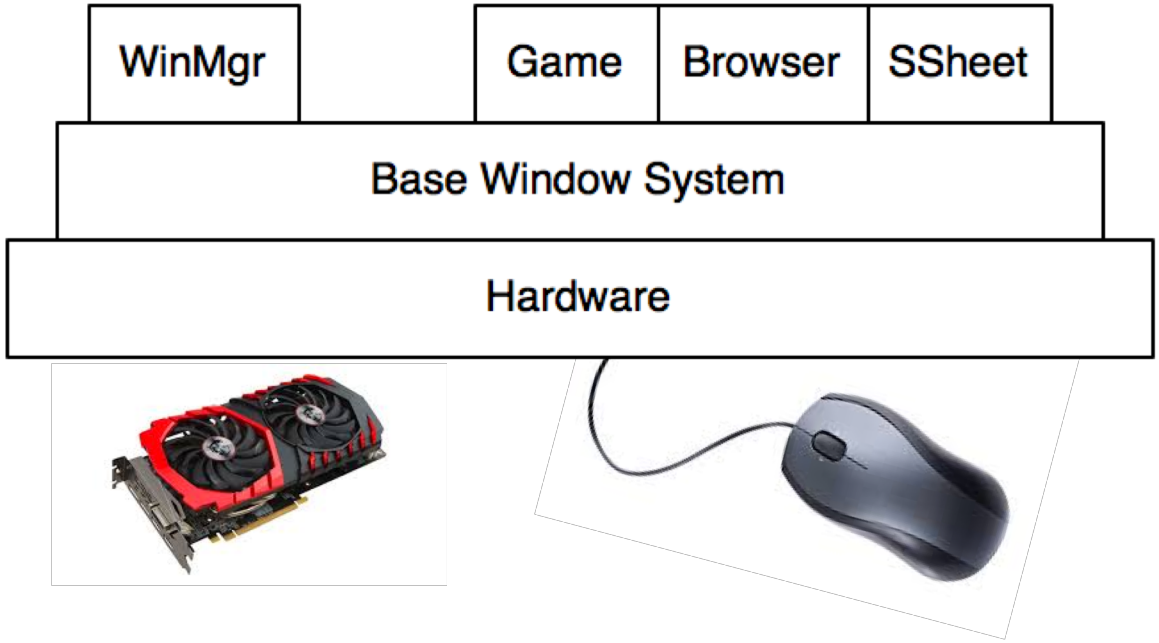


The Windowing System keeps windows separate, provides top-level functionality for managing how they overlap, and determines how input is directed to the correct window.

Windowing System (WS)

A **windowing system** is a software layer that provides these services - “low-level” input, output and window management capabilities – to the operating system.

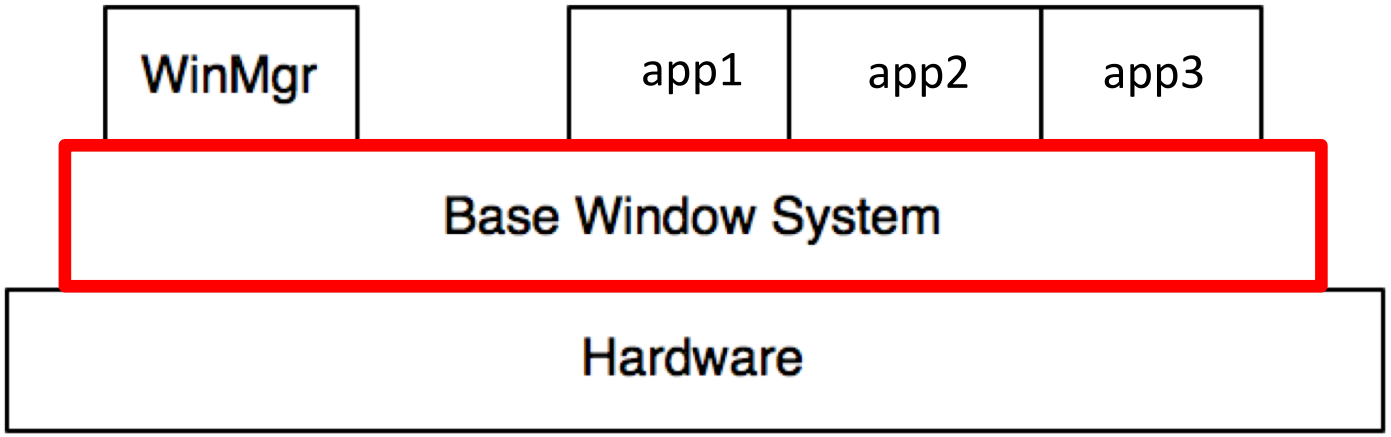




Windowing System Functions

A Windowing System provides the following functionality:

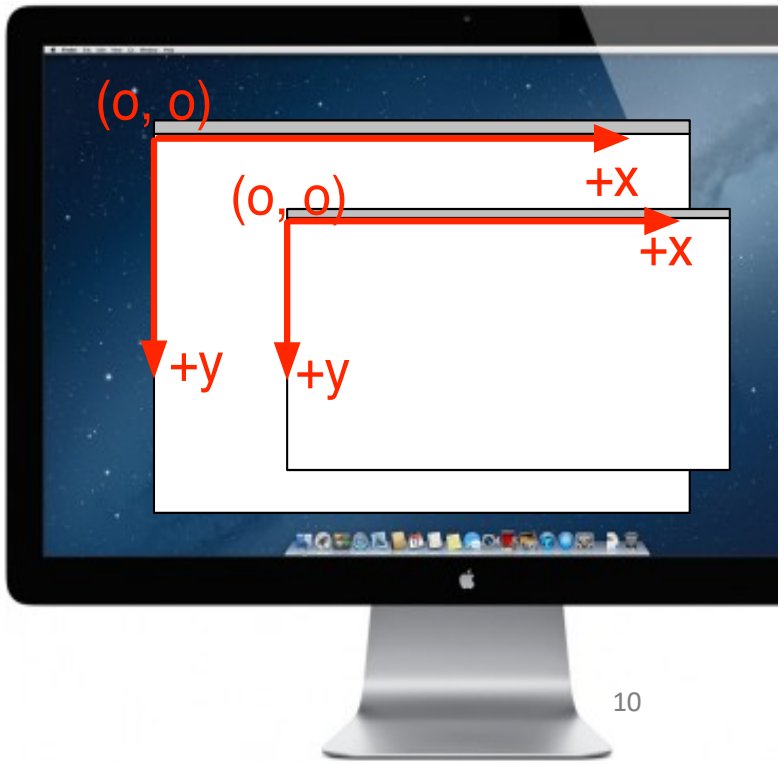
1. Provides OS -level routines for creating, destroying, and managing active application windows. This includes overlapping windows, tiling windows etc.
2. Routes mouse and keyboard input to the correct window. Typically the window that “has focus” receives input.
3. Manages access to underlying graphics hardware. Prevent simultaneous writes to the frame buffer (or video memory).



Canvas Abstraction

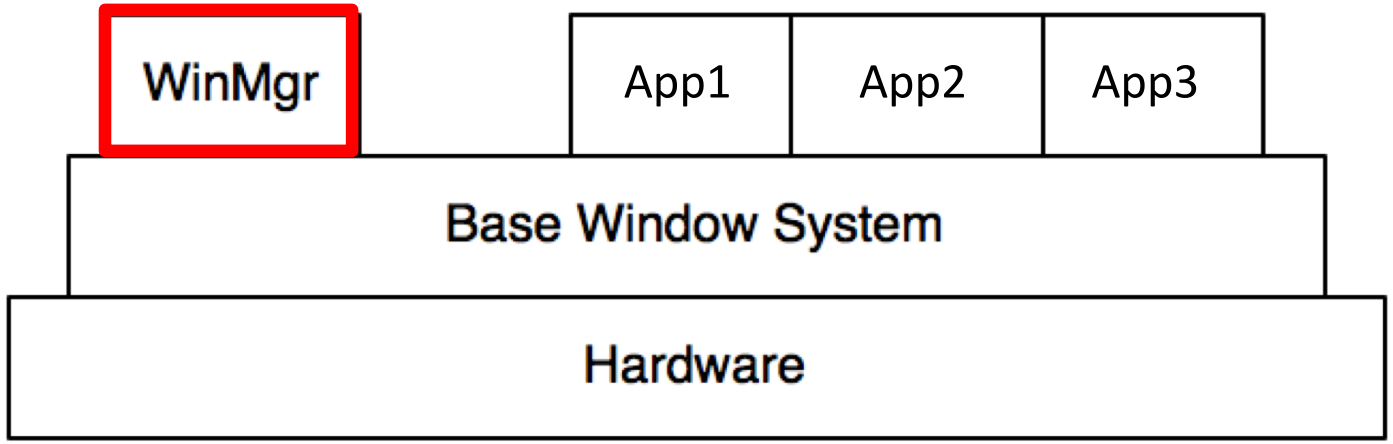
WS controls access to window contents using a “drawing canvas abstraction”

- The application is shielded from details of frame buffer, visibility of window, and all other application windows.
- Each window represents a “canvas” or drawing area for the application.
- Each window is independent and has no-knowledge of other windows
- Each window has its own coordinate system
  - WS transforms between global (screen) and local (window) coordinate systems
  - A window doesn’t worry where it is on screen; program assumes its top-left is (0,0)
- WS provides access to graphics routines for drawing



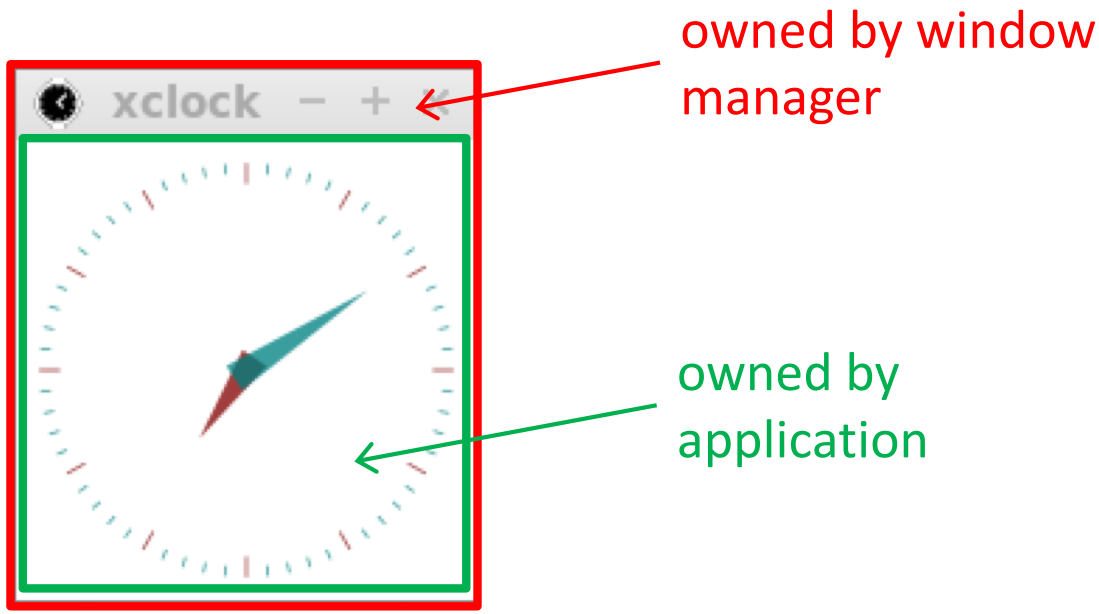
Window Manager (WM)

- Provides conceptually different functionality
  - Can be layered on top of Window System
  - Provides interactive components for windows (close button, resize handle)
  - Creates the “look and feel” of each window
- Application ”owns” the contents of the window, but the WM and BWS “own” the application window itself!



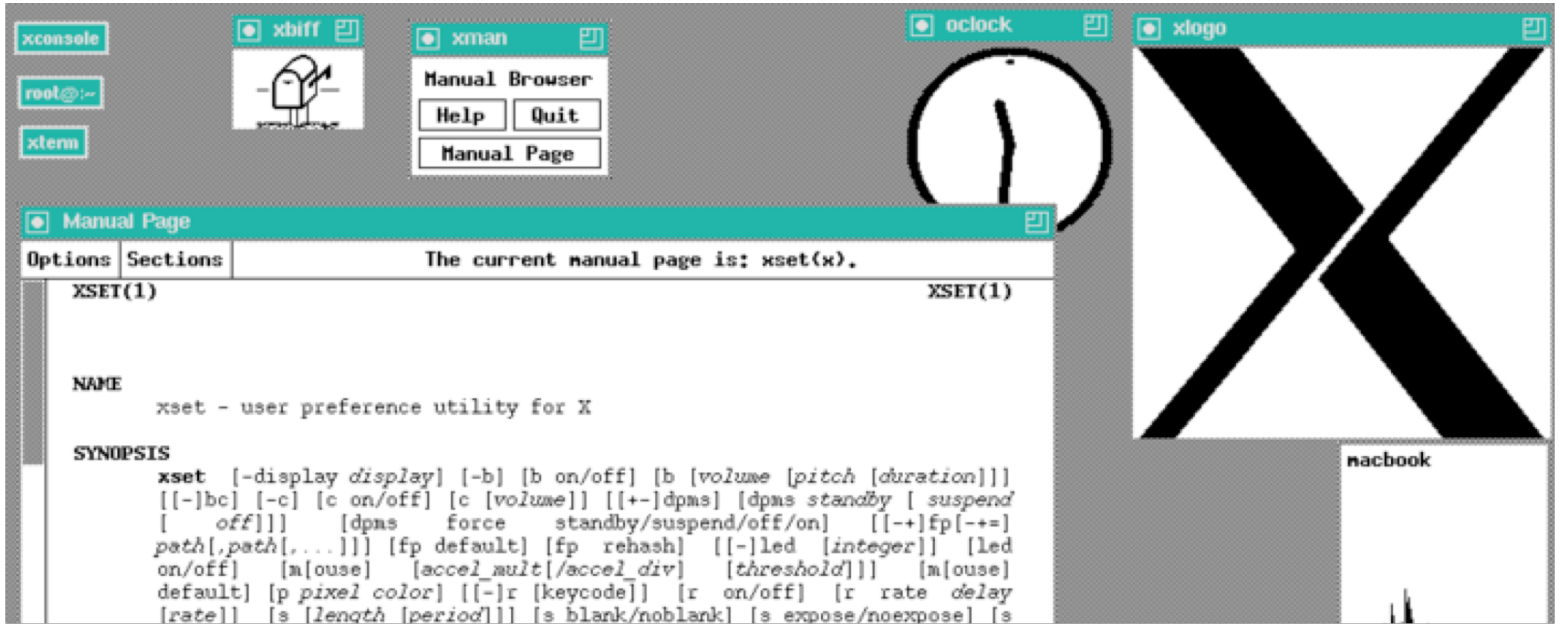
Roles in Managing the Window

- Window vs. Canvas
  - the Windowing System creates the window
  - the Window Manager manages interaction with the window (including its min/max/restore controls, and titlebar)
  - the application manages the contents of the canvas



Example: X Windows as a Windowing System

- Developed in 1984 at MIT, extended by a consortium (HP, Sun)
- XWindows is the Unix standard **Windowing System**
  - Provides “low-level” input, output and window management capabilities to the underlying operating system.
  - Separate layer from operating system
- Essentially a protocol (X11) to manage input, output/graphics, windows
- Modern alternatives for Linux include Wayland, Metisse



X Window Managers

- X Windows supports a pluggable **Window Manager**
- The window manager defines the look-and-feel of the application (e.g. colors, border width, font used).
- Commercial examples: motif

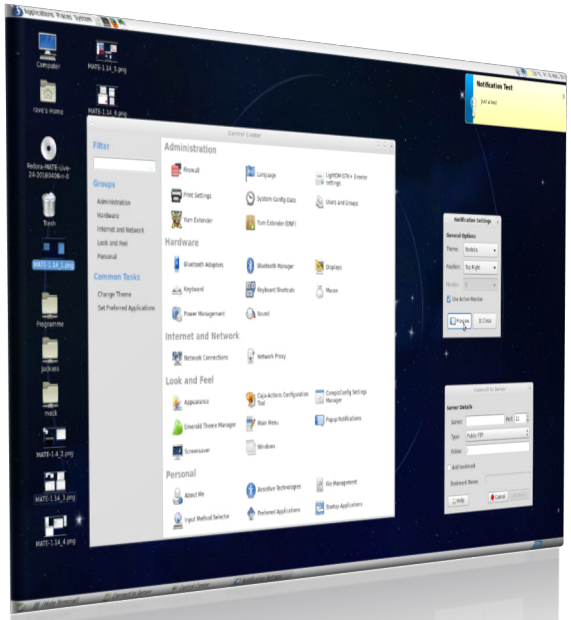
motif

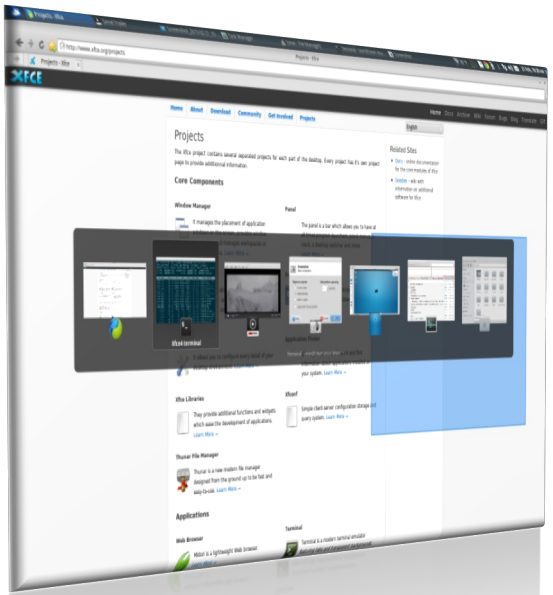
fvwm

xfce

Why Separate Window Manager from WS?

- Enables alternative “look and feels” for windowing system (i.e. “Desktops” like Unity, GNOME, KDE, Xfce…)
- Enables different windowing paradigms (i.e. Xmonad for tiled windows)
- macOS and Windows don’t expose a Window Manager (why?)

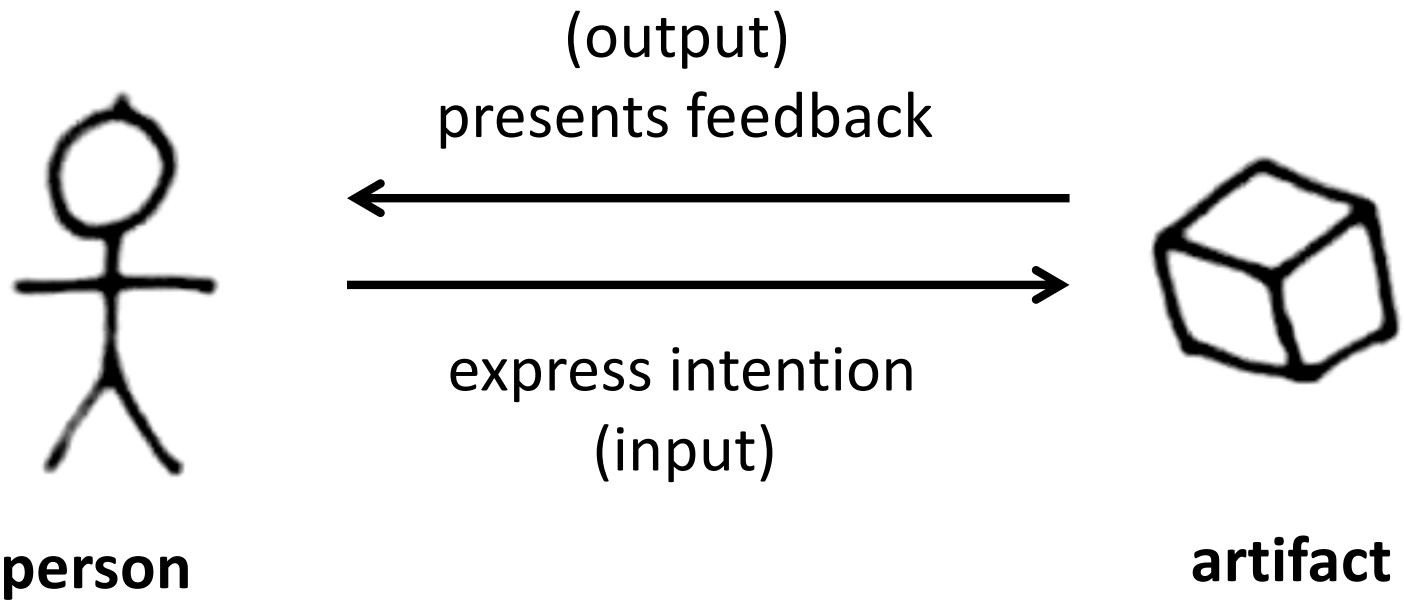




User Interaction

People typically interact with technology to perform a task.

They determine what they want to do, and provide guidance to the system, which gives them feedback.



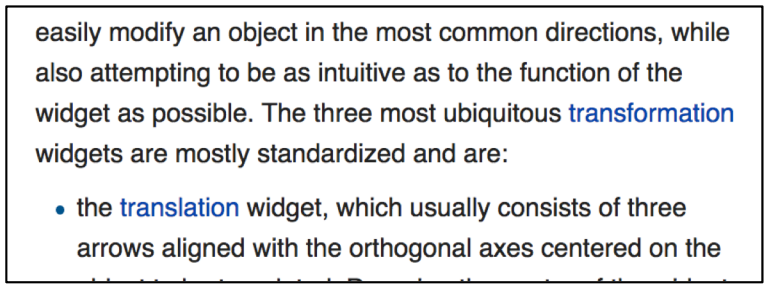
WIMP Interaction

- Each application is represented by one or more windows
- Each window can be moved and resized, and overlap other window
- The background (desktop) can hold icons, representing documents, folders or applications.
- Interaction consists of moving the mouse over a graphical element or **widget**, and clicking to interact.

Direct Manipulation

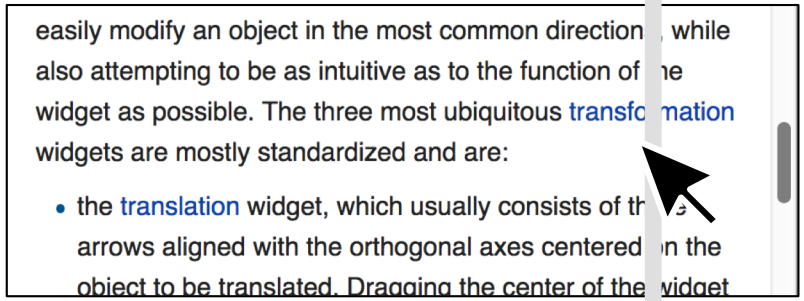
- Direct manipulation is when a *virtual representation of an object* is manipulated in a similar way to a real–world object.
- traced back to Ivan Sutherland's Sketchpad (see History lecture)
- proposed in 1983 by Ben Schneiderman

Indirect Manipulation




```
>scroll –down 500
```

Direct Manipulation



"Direct manipulation allows people to feel that they are directly controlling the objects represented by the computer." (Apple)

Direct Manipulation Principles

Goal of Direct Manipulation is to make the interaction feel as-if the user was manipulating a “real object” instead of working through an intermediary.

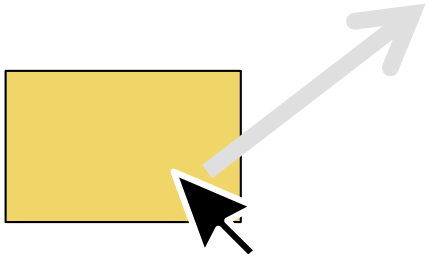
All related to manipulating the “objects of interest” or task objects.

1. Continuous representation of task objects and actions.
2. Task objects are manipulated by physical actions, not complex syntax
3. Fast, incremental, and reversible actions with effects on task objects immediately apparent.
4. Layered, self-revealing approach to learning

(from Schneiderman, 1983)

Benefit of Direct Manipulation

While interacting with DM interfaces, users feel as if they are interacting with the *domain rather than with the interface*, so they *focus on the task rather than on the technology*. There is a feeling of direct involvement with a world of task objects rather than communication with an intermediary.



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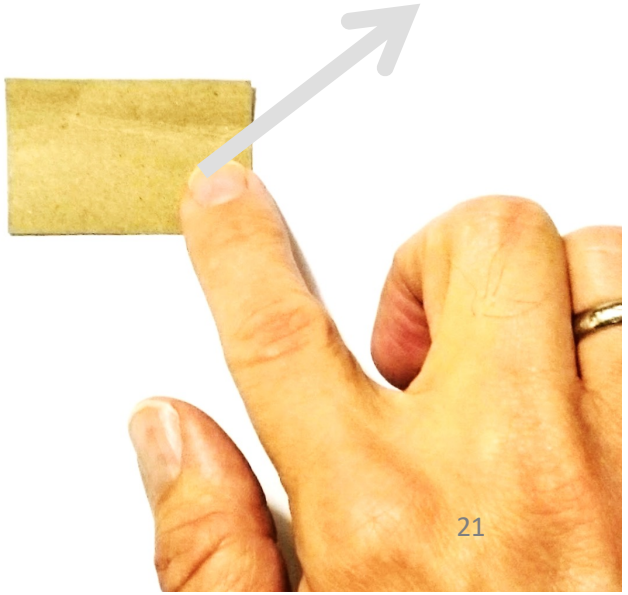


Direct Manipulation on Desktop

- How does this apply to WIMP interfaces?
- Where do we see Direct Manipulation?
  - Desktop (container)
  - Click to activate (e.g. buttons, toolbars, other objects)
  - Click and drag to move icons or reposition elements (e.g. icon, file)
- Desktop metaphor is prevalent
  - Doesn’t really use DM (e.g. we don’t drag to open folders)

A GUI Doesn't Always Use Direct Manipulation

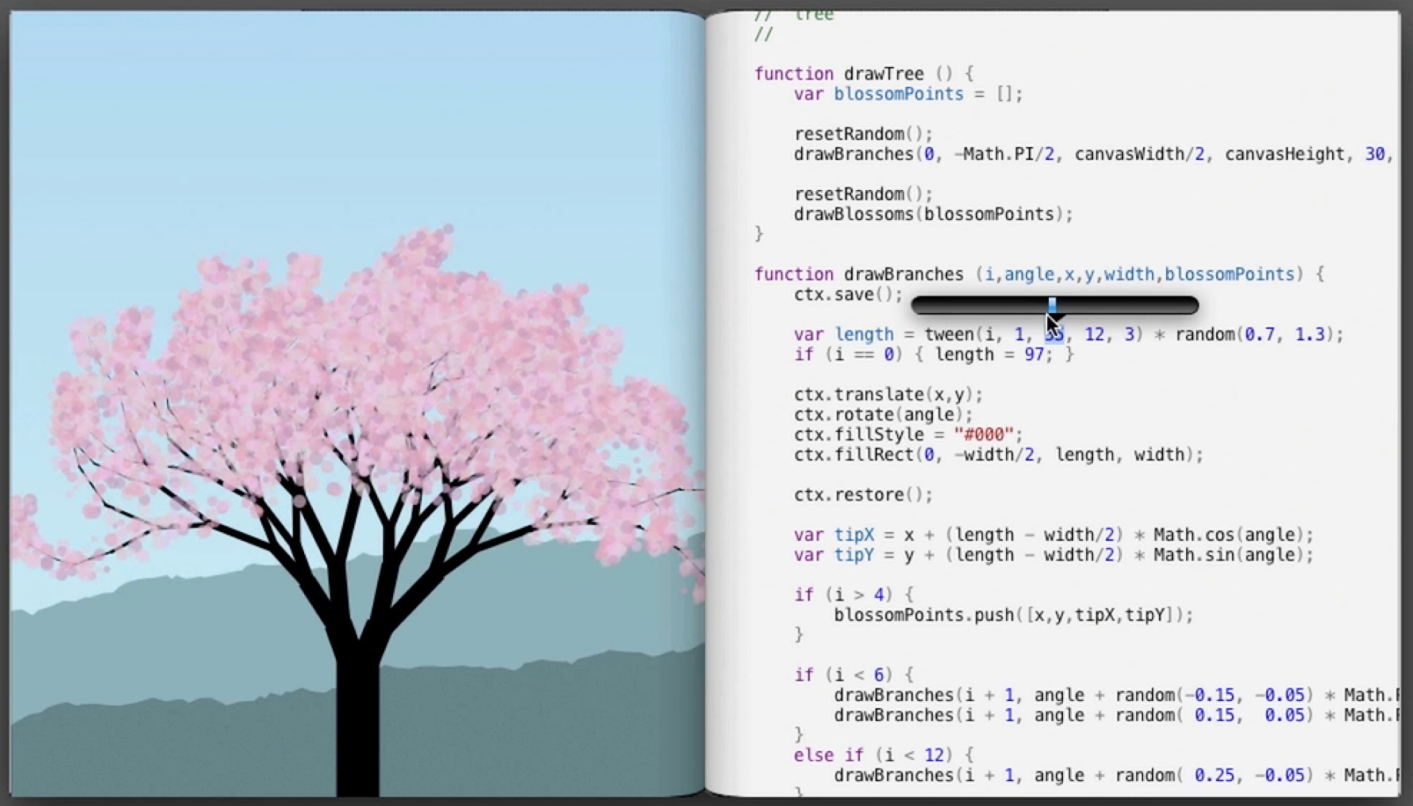
Desktop interfaces do a poor job of modeling Direct Manipulation (DM)

- Many commands are invoked *indirectly*
  - Menus, dialog boxes, toolbars are not really direct manipulation … they're "tools" that pull users away from objects of interest
- Many objects of interest are *hidden*
  - Text styles, page layout,
- Many objects in the interface *are not objects of interest*
  - Toolbar palettes
- Desktop interfaces don't really feel like physical interactions.

-- Michel Beaudoin-Lafon, 2000

Direct Manipulation Issues

- Visually impaired users can't see the graphics; no linear flow for screen readers; physically impaired may have difficulty with required movements
- Consumes valuable screen space, forcing valuable information off-screen.
- Switching between keyboard and pointer is time consuming
- Analogies may not be clear
  - Users need to learn meaning of visual representations
  - Visual representations may be misleading



Bret Victor, Inventing on Principle (talk from CUSEC 2012)

- http://vimeo.com/36579366
- https://www.student.cs.uwaterloo.ca/~cs349/videos/Bret Victor - Inventing on Principle-HD.mp4

Interaction Model

"An interaction model is a set of principles, rules, and properties that guide the design of an interface. It describes **how to combine interaction techniques in a meaningful and consistent way** and defines the look and feel of the interaction from the user's perspective. Properties of the interaction model **can be used to evaluate specific interaction designs**." (Lafon, 2000)

We want to define an interaction model that describes typical desktop interaction, and is compatible with Direct Manipulation.

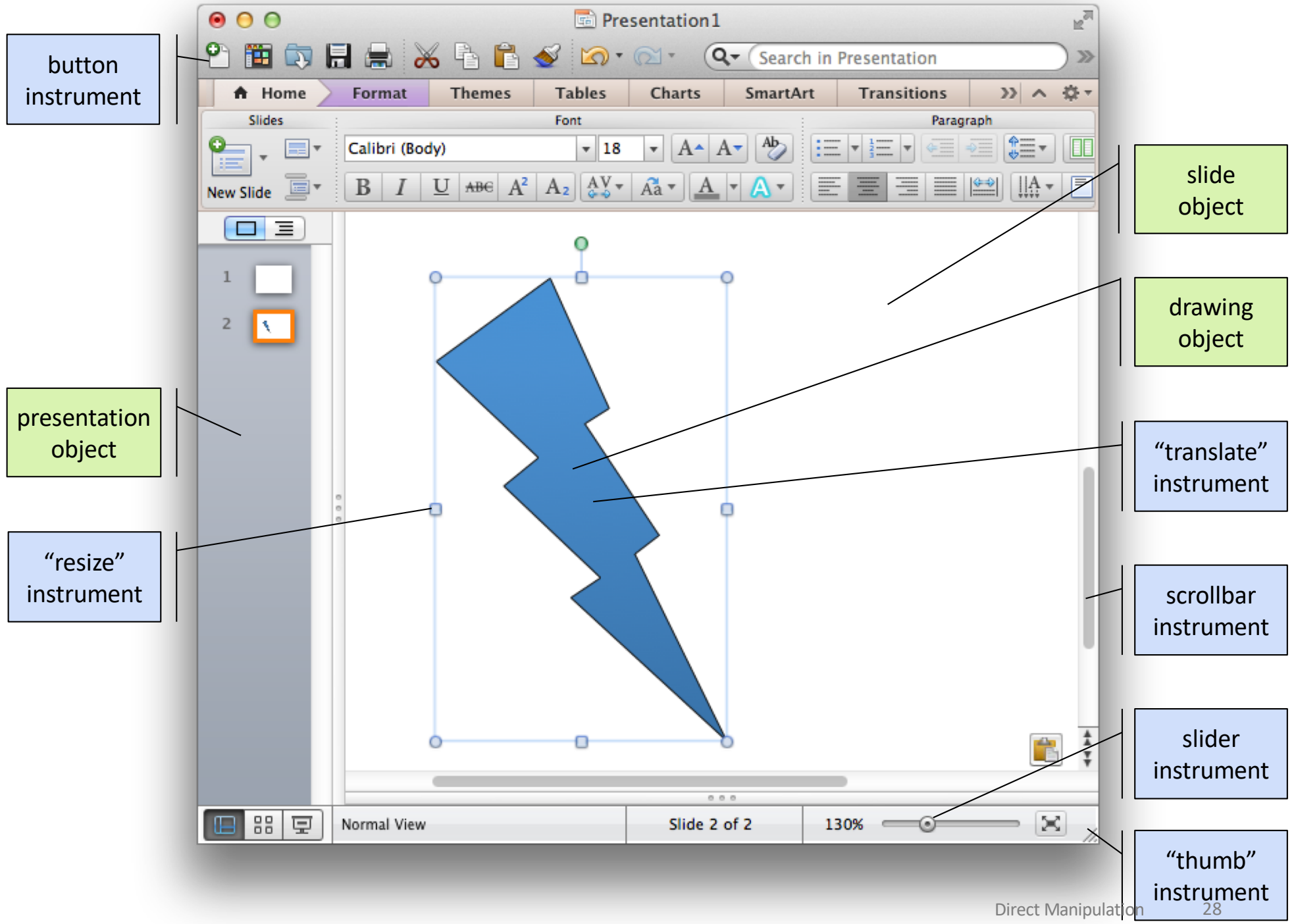
Beaudouin-Lafon. 2000.
Instrumental interaction: an interaction model for designing post-WIMP user interfaces. Proceedings of CHI '00, 446-453.
http://doi.acm.org/10.1145/332040.332473

Instrumental Interaction

"A model of interaction based on how we naturally use tools (or instruments) to manipulate objects of in the physical world."

- Interfaces have *interaction instruments* and *domain objects*
  - **Interaction instrument**: a necessary mediator between the user and domain objects
  - **Domain objects:** the thing of interest, data and associated attributes, which is manipulated using an interaction instrument

(Beaudoin-Lafon, 2000)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slide object
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"translate" instrument
"resize" instrument
scrollbar instrument
slider instrument
"thumb" instrument
Normal View
Slide 2 of 2
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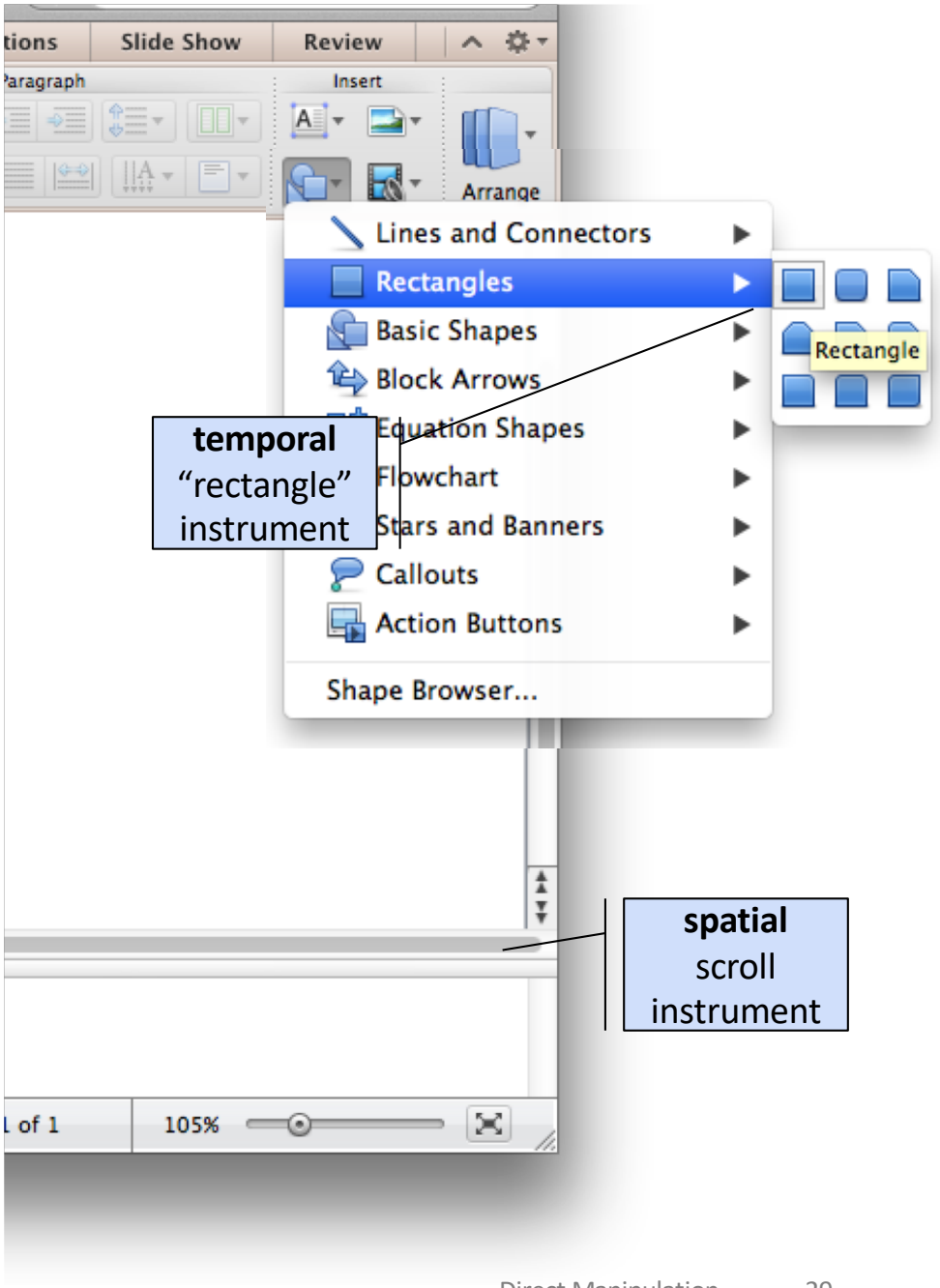
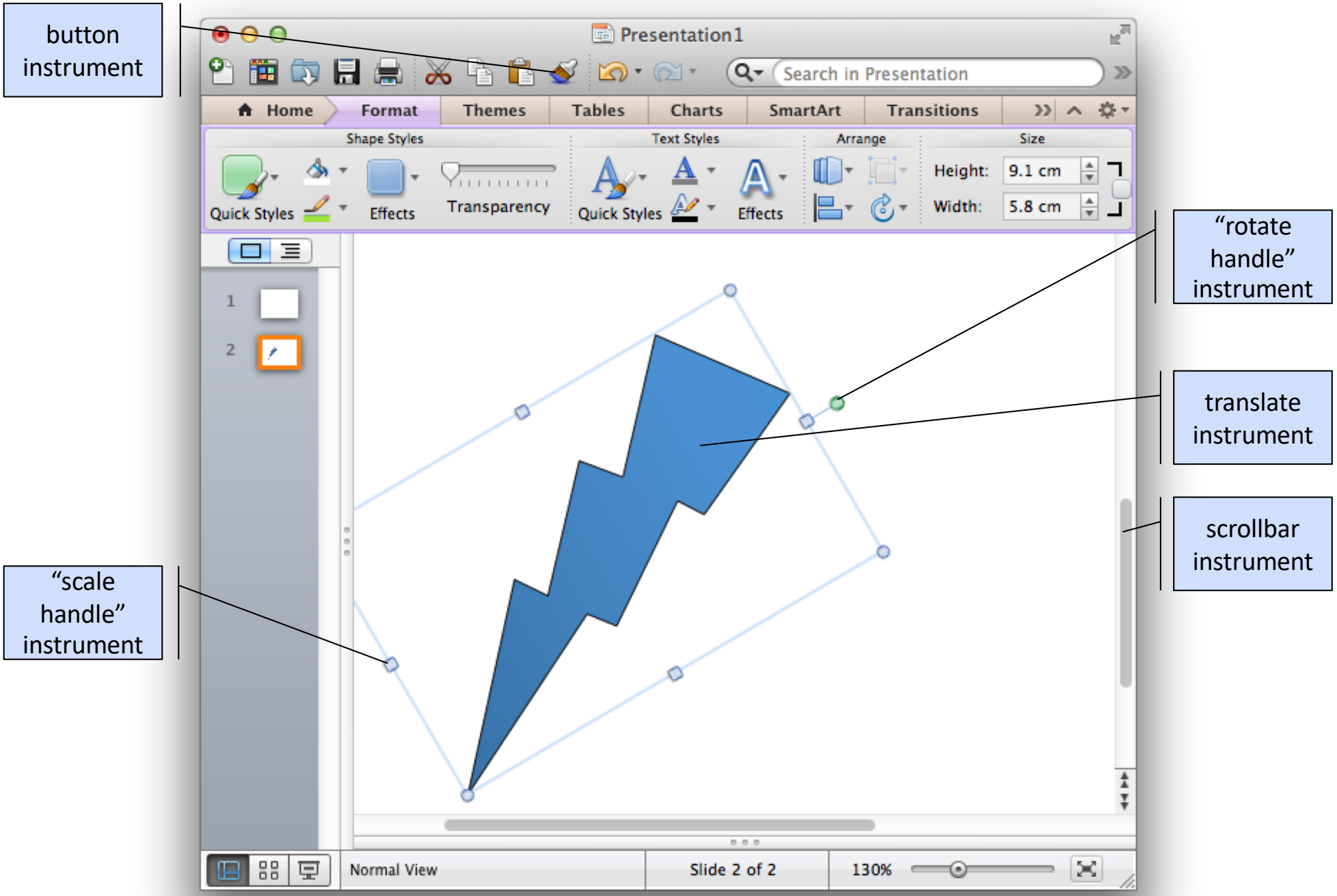
Instrument Activation

- When instrument is under user's control
- WIMP instruments activated **spatially** and **temporally**
  - spatially has a *movement* cost
  - temporally has a *time* cost
- UI layout and design is concerned with the tradeoff of these costs

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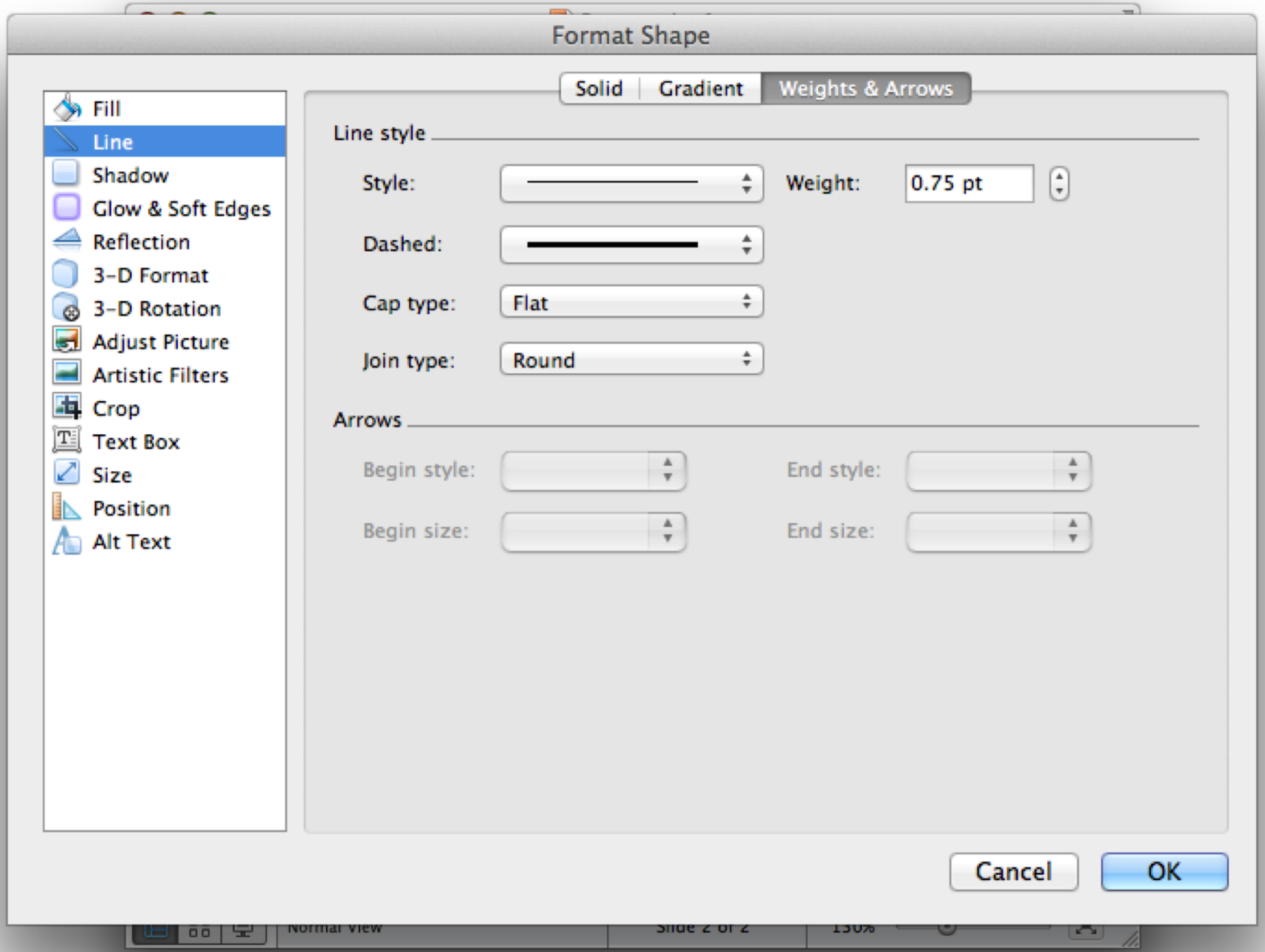
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Round
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Begin style:
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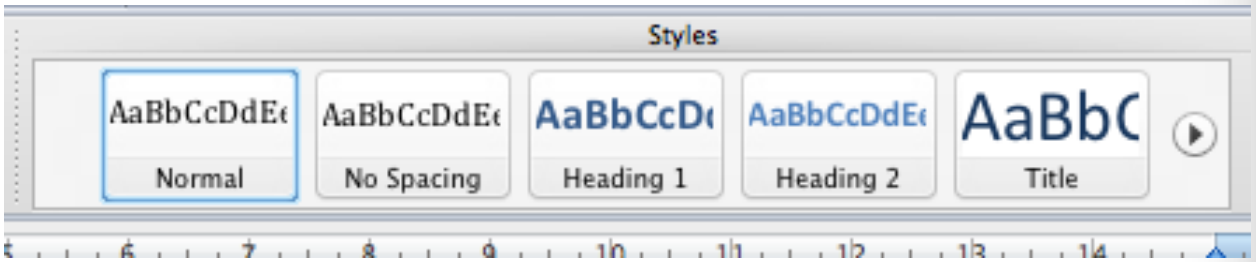
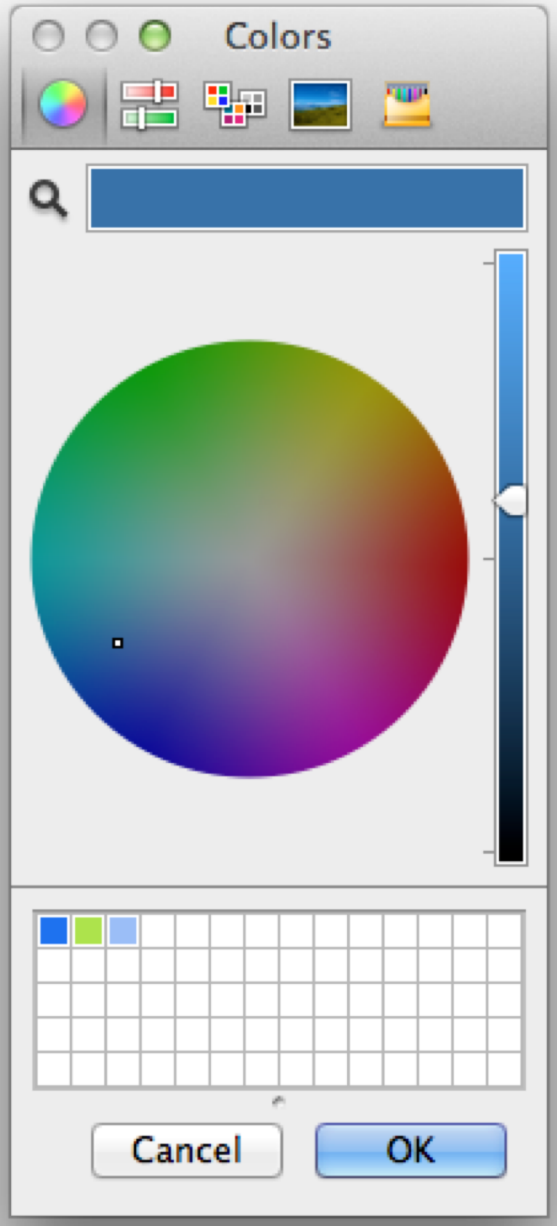
Reification and Meta-Instruments

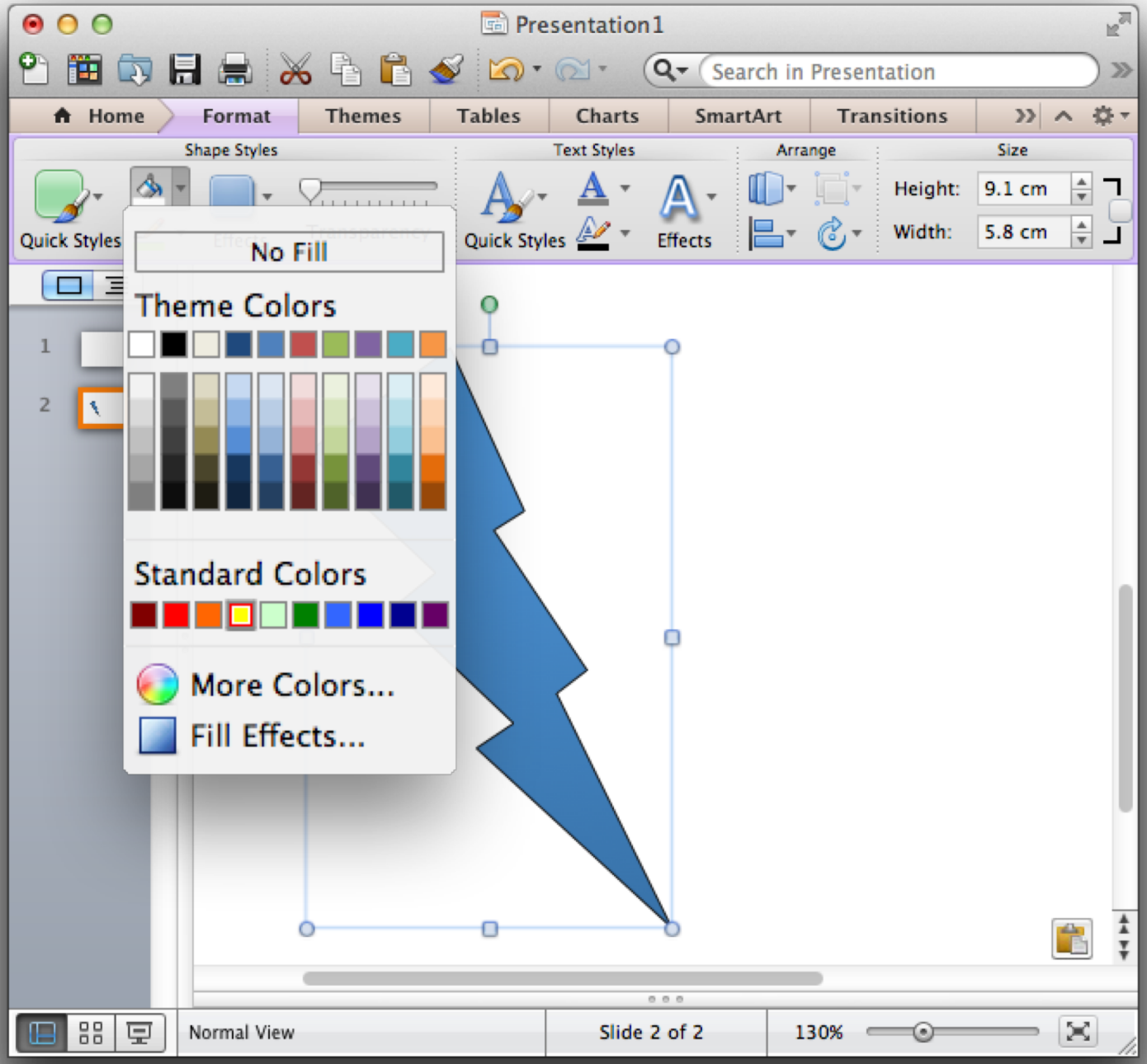
- **Reification:** turning concepts into something concrete
  - i.e. an instrument is the *reification* of a command
  - e.g. a scrollbar *reifies* scroll commands
- **Meta-instrument:** an instrument that acts on another instrument
  - the other instrument become an object of interest
  - e.g. a pencil is an instrument to manipulate the object “paper”, but when the pencil tip breaks, the pencil becomes an object of interest manipulated by a sharpener *meta-instrument*
  - GUI examples?

Object Reification

- Turning attributes of a primary object into other objects of interest
  - e.g. colour swatch, font styles, shader materials



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Evaluating Instruments

How do we describe instruments?

How do we evaluate their effectiveness?

- Degree of **indirection**
  - Spatial/temporal offset between instrument and action on object
- Degree of **integration**
  - Ratio of degrees of freedom of instrument to degrees of freedom of input device
- Degree of **compatibility**
  - Similarity of action on control device/instrument to action on object

Degree of Indirection

- 2D measure of spatial and temporal offsets of instrument (*lower==better*)
- Spatial Dimension
  - e.g. *near*: drag to translate, handles on to resize
  - e.g. med: scrollbars
  - e.g. *far*: dialog boxes
- Temporal Dimension
  - e.g. *short*: direct dragging response
  - e.g. med: activate tool in toolbar, start direct manipulation
  - e.g. *long*: using dialog, finishing drag-and-drop

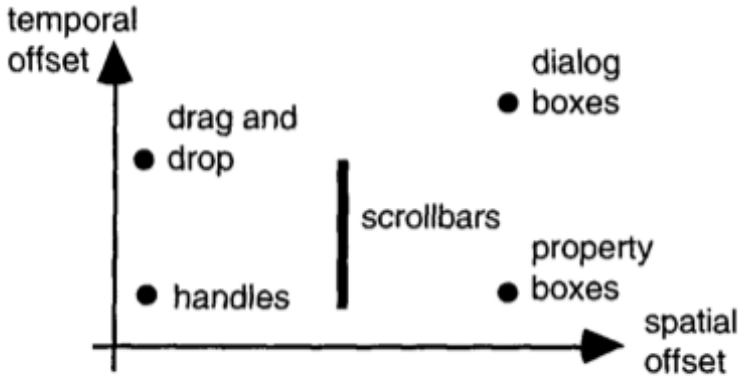


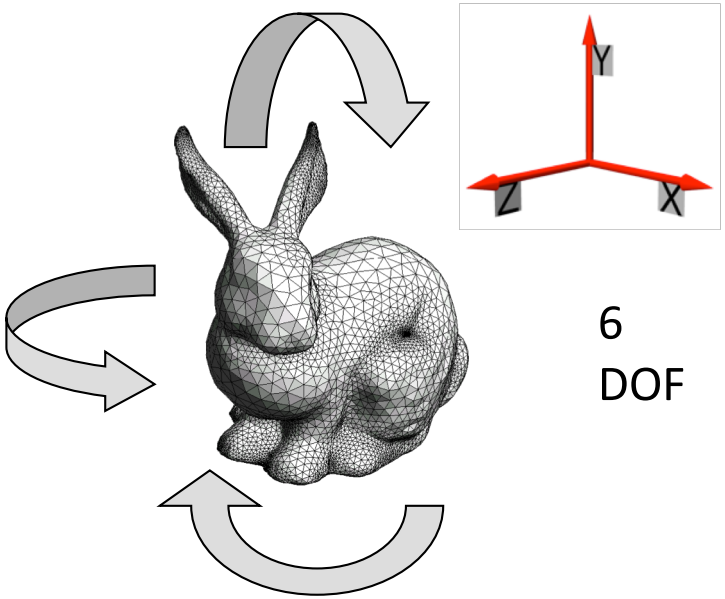
Figure 2: Degree of indirection

(image: lafon 2000)

Degree of Integration

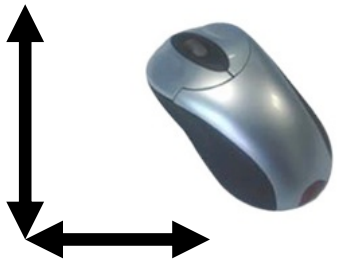
- the ratio between the number of degrees of freedom (DOF) of the instrument and the DOF captured by input device (reflects *suitability*)

2 DOF

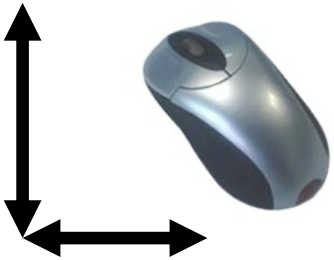


6 DOF

4 DOF



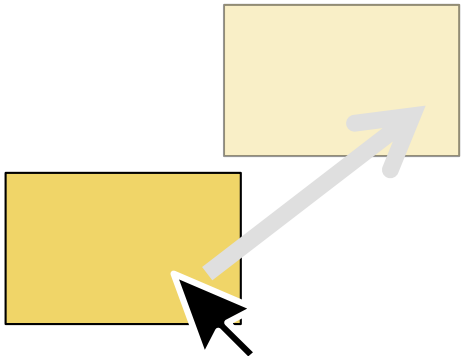
4 DOF



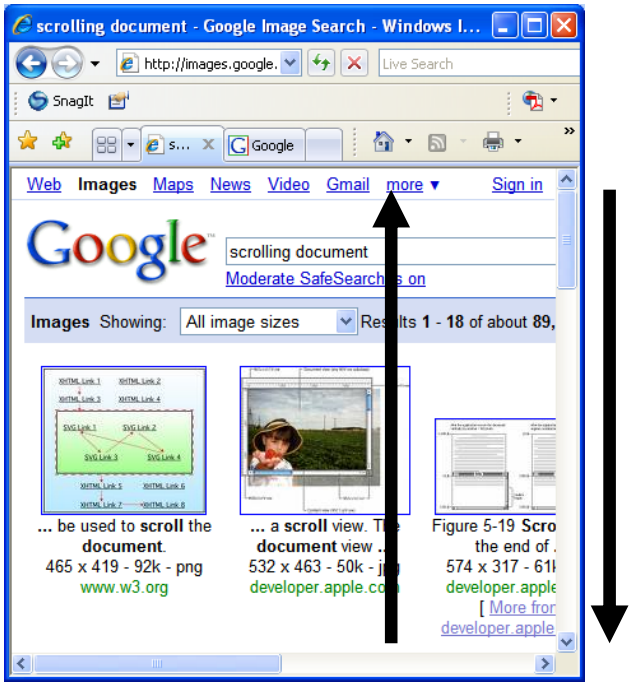
Degree of Compatibility

- the similarity between the physical actions on the instrument and the response of the object (similarity makes actions feel *natural* or *intuitive*).

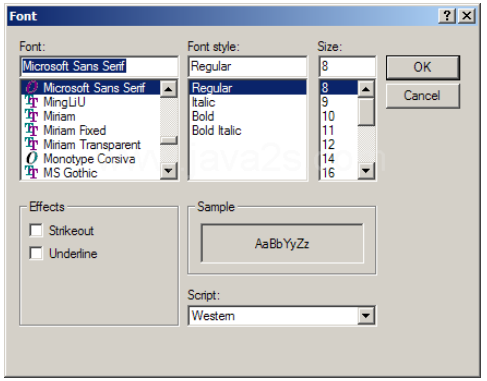
Dragging = high



Scrolling = medium



Dialog = low



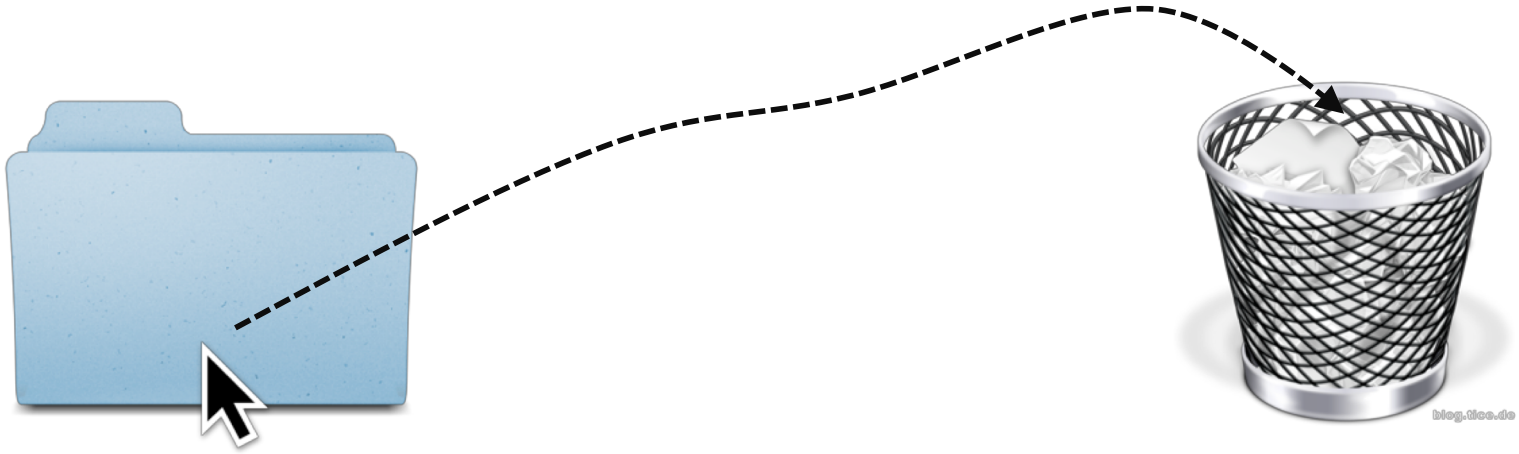
Direct Manipulation

- A direct manipulation interface allows a user to *directly* act on a set of objects in the interface.
  - Low indirection (low spatial and temporal offsets)
  - High integration (1:1 correspondence)
  - High compatibility (similarity of action and effect)
- Direct means *instruments* are visually indistinguishable from *objects* they control
  - The actions on instrument/object entities are analogous to actions on similar objects in the real world.
  - The actions on instrument/object entities preserve the conceptual linkage between instrument and object.

Using Analogy in Direct Manipulation

- Perceived affordance: what the user believes that they can do with an object, based on it's appearance. Actions that are suggested by the object.
  - e.g. handles should be grasped, knobs should be turned.

- "Affordances in the interface are like affordances for analogous actions in the real world"
  - Should build on existing experiences and intuitions to aid learning



Analyzing an Analogy

Real World	DM Interface
Object to be discarded	Icon of object to be discarded
Move hand to object	Move pointer to object
Pick up object with hand	Click to acquire object
Waste basket	Waste basket icon
Move to waste basket	Drag to waste basket icon
Release object from hand	Release button to discard object