Review

- Pros and cons of production rules?
- Advantages of controlled experiments over other methods?
- Six steps of controlled experiments?
  - Two types of variables?
  - Two types of hypotheses?
  - Two types of experimental designs? Pros & cons?
- How can the order of treatments affect the experiment?
  - How can you prevent their interference?
- Four types of validity?
- Reliability?

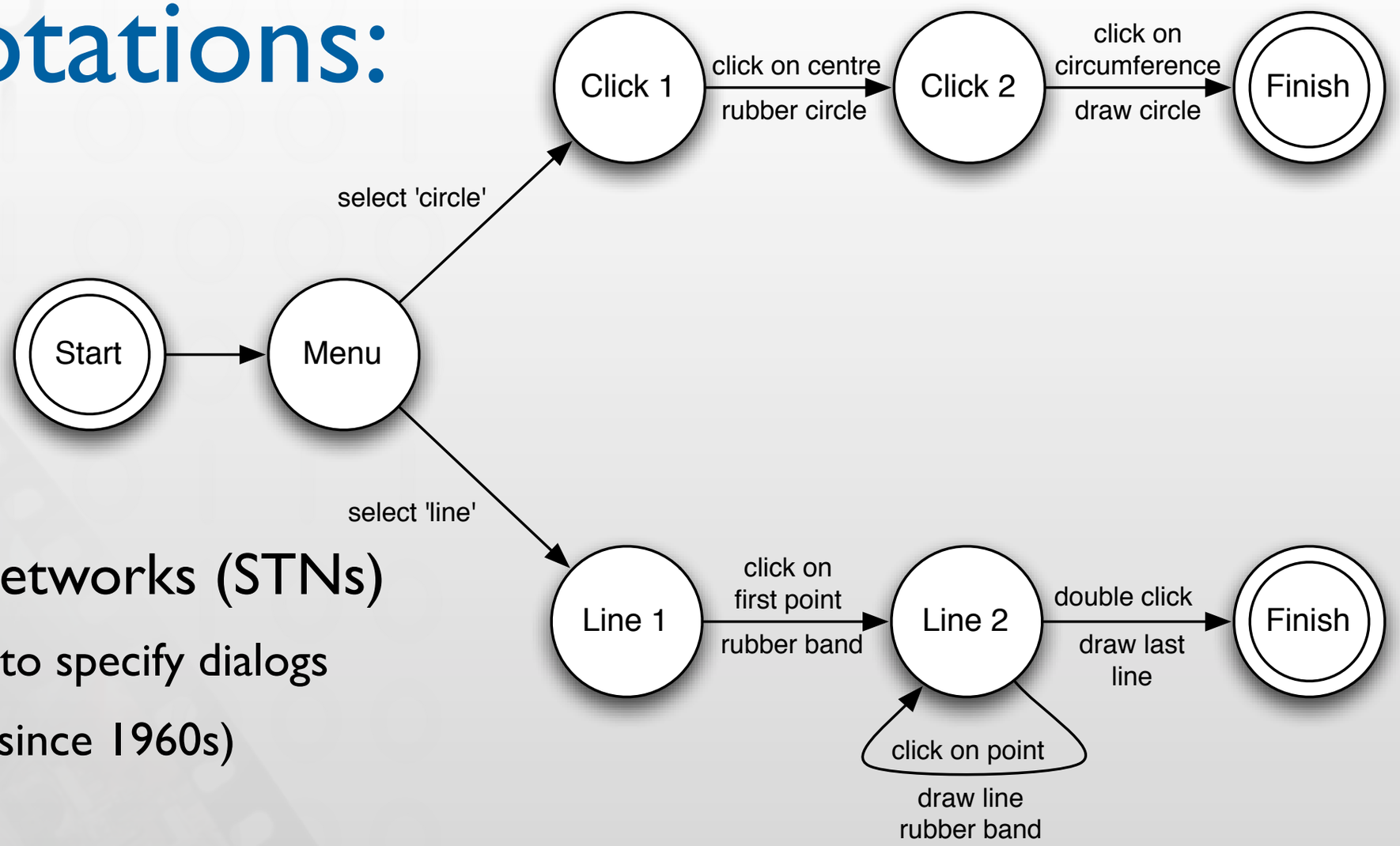
Theory

- ✓ Models of interaction
  - ✓ Affordances, mappings, constraints, types of knowledge, errors
- ✓ Design principles
- ✓ Human cognition and performance
- ⇒ Interaction design notation
- • History and vision of HCI

Practice

- ✓ Sketching
- ✓ User observation
- ✓ Iterative design
- ✓ Prototyping
- ✓ Ideation
- ⇒ User studies and evaluation

Graph Notations: STNs



- State Transition Networks (STNs)
  - Most common tool to specify dialogs
  - Established format (since 1960s)
- Consisting of:
  - States (usually the system waiting for some user action)
  - Transitions (which have a user action and a system response associated with them)
- Describes sequences of user actions and system responses

The following slides use examples from Dix et al.

Checking STN Properties: Transitions

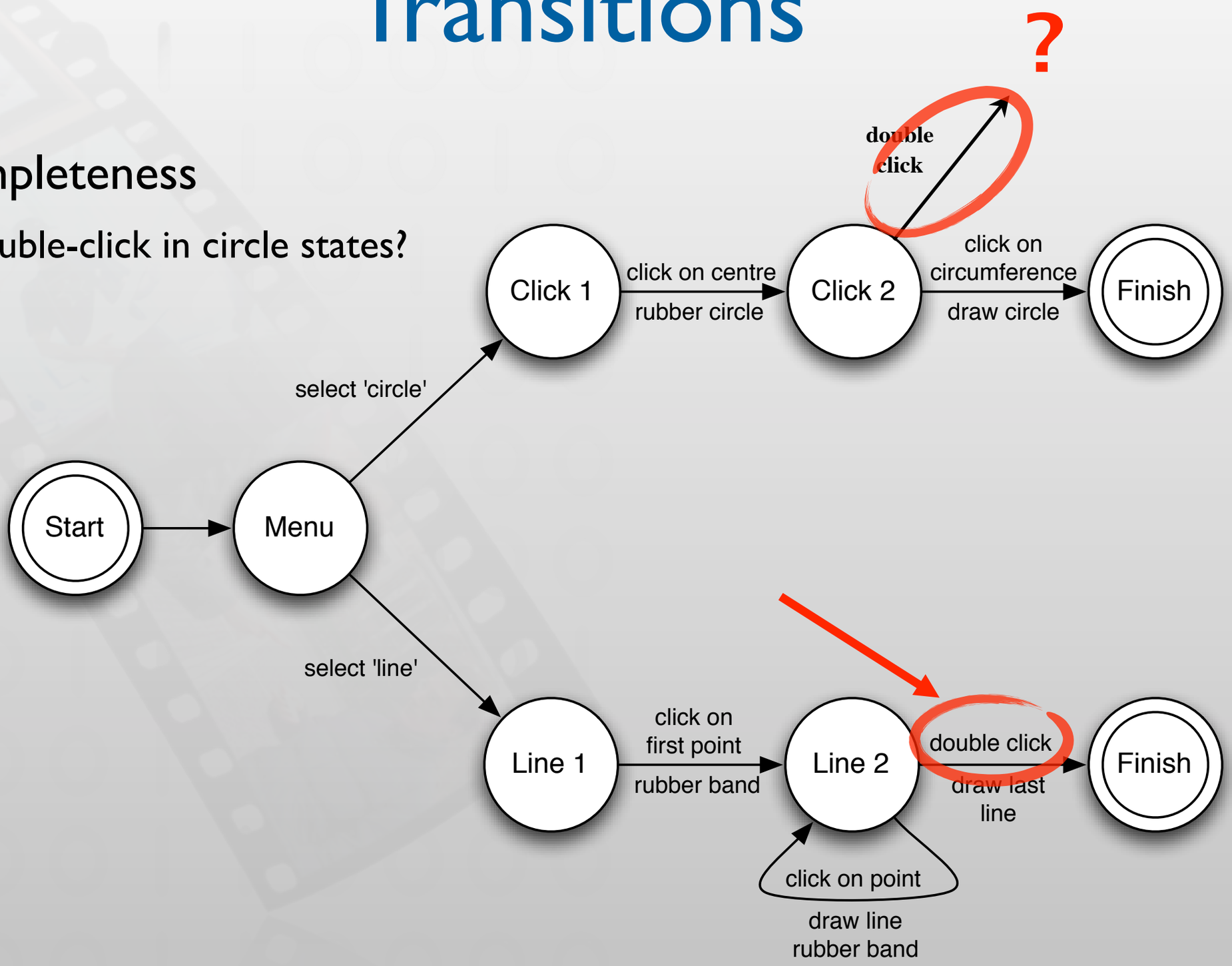
- Completeness
  - Missed arcs
  - Unforeseen circumstances
- Determinism
  - Several arcs for one action

    Deliberate: application decides

    Accidental: production rules
- Nested escapes
- Consistency
  - Same action, same effect?
  - Modes and visibility

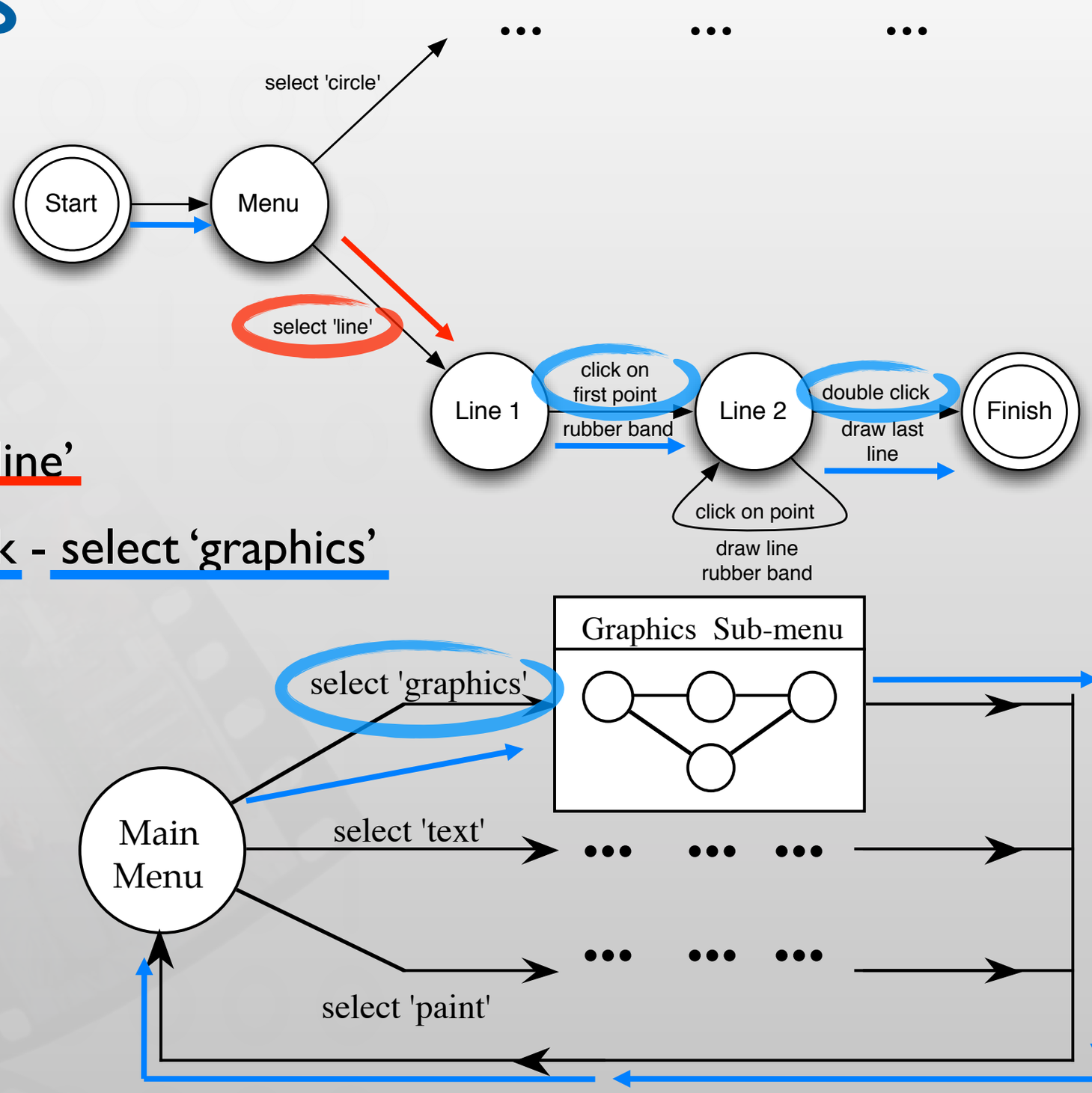
Checking STN Properties: Transitions

- Completeness
  - Double-click in circle states?



Checking STN Properties: Transitions

- Reversibility:
  - To reverse select ‘line’
  - Click - double click - select ‘graphics’
  - (3 actions)
- N.B. not undo



Checking STN Properties: States

- Reachability
  - Can you get anywhere from anywhere?
  - How easily
- Reversibility
  - Can you get to the previous state?
  - But NOT undo
- Dangerous states
  - Some states you don't want to get to

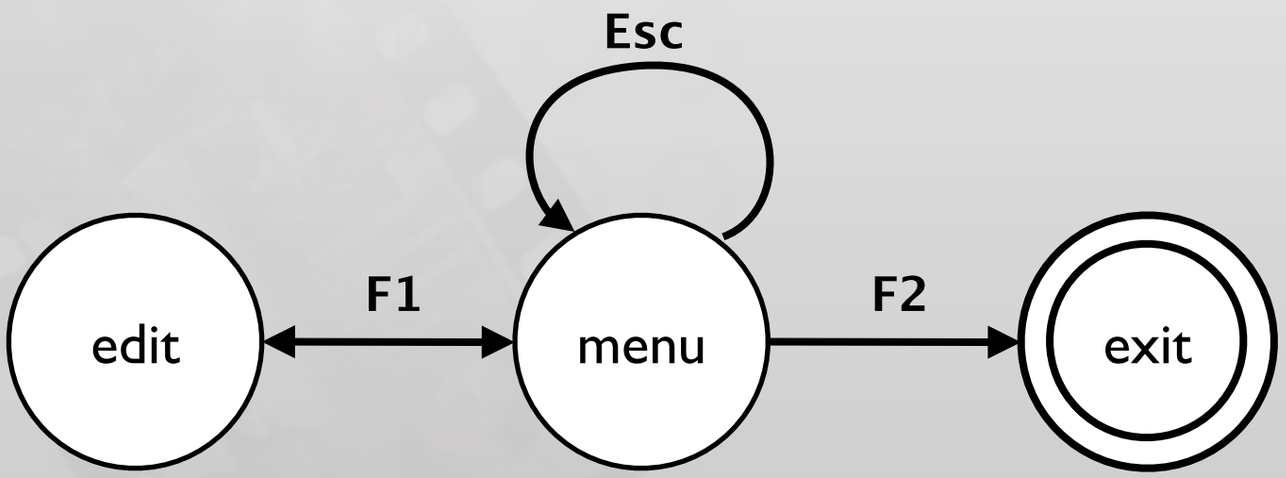
Dangerous States Example

- Word processor: two modes and exit

  F1 - changes mode

  F2 - exit (and save)

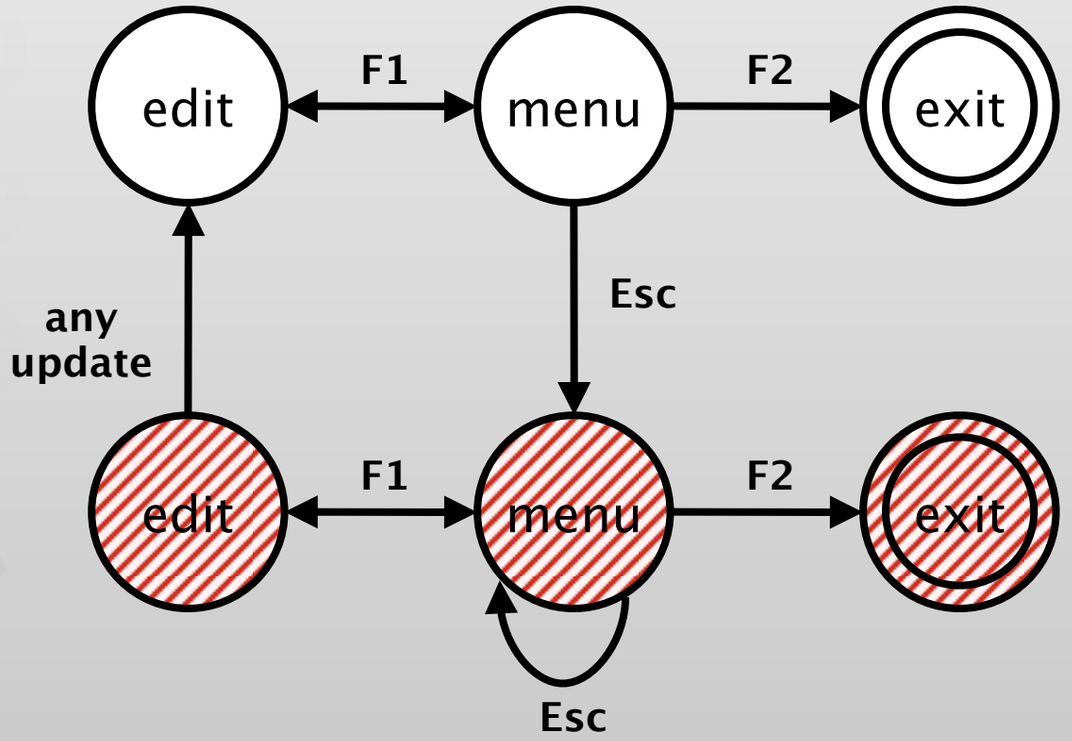
  Esc - no mode change



- But ... Esc resets autosave

Dangerous States Example

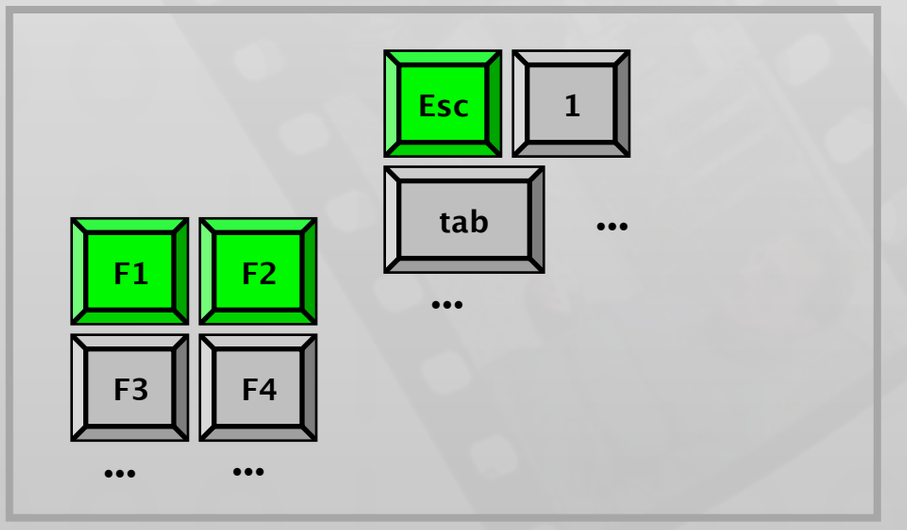
- Exit with/without save ⇒ dangerous states
- Duplicate states - semantic distinction

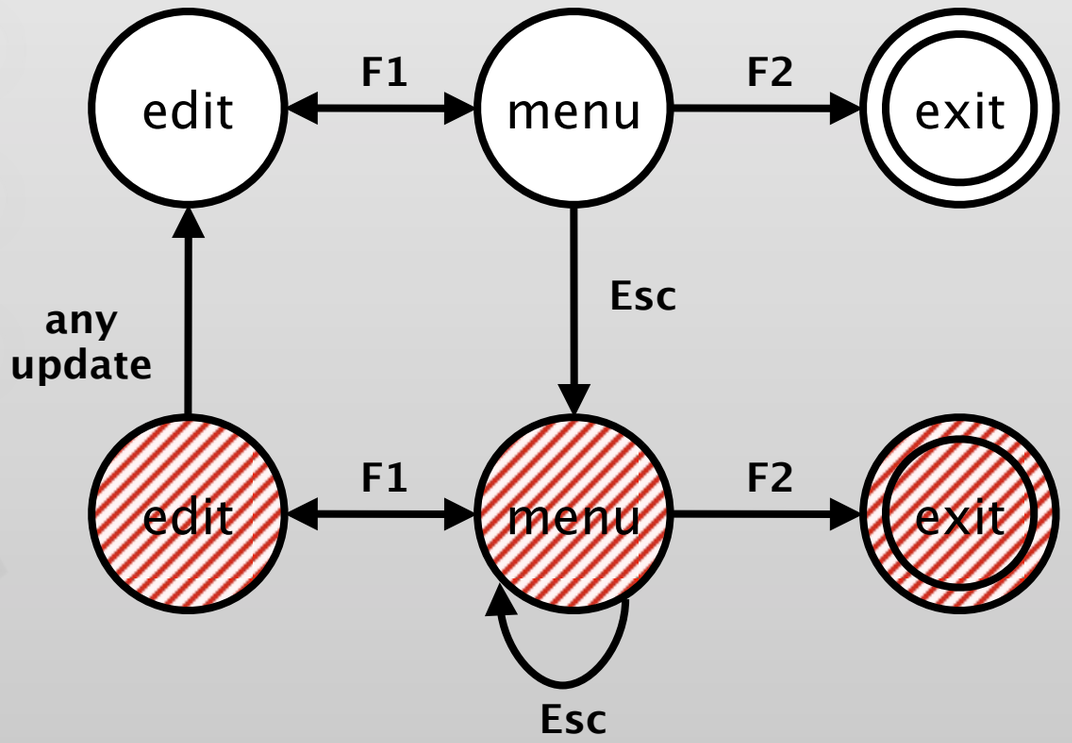


- F1-F2 - exit with save
- F1-Esc-F2 - exit with no save

Dangerous States Example: Layout Matters

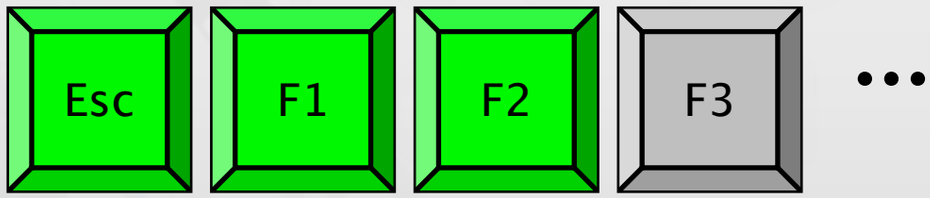
old keyboard - OK





Dangerous States Example: Layout Matters

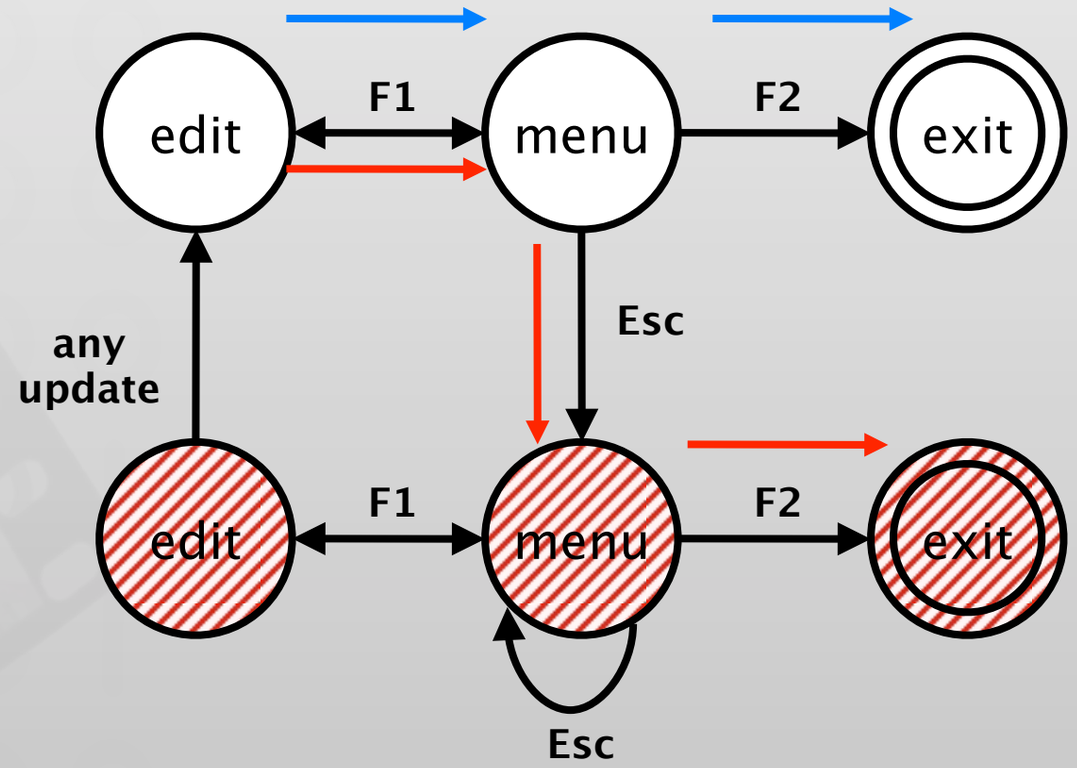
new keyboard layout



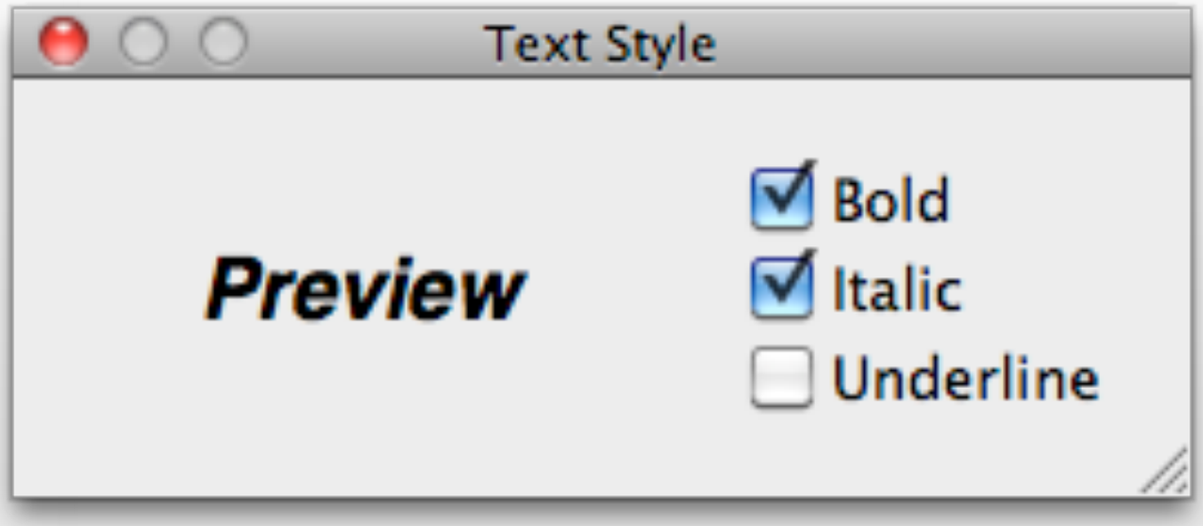
Intend F1-F2 (save)

Finger catches Esc

F1-Esc-F2 - disaster!

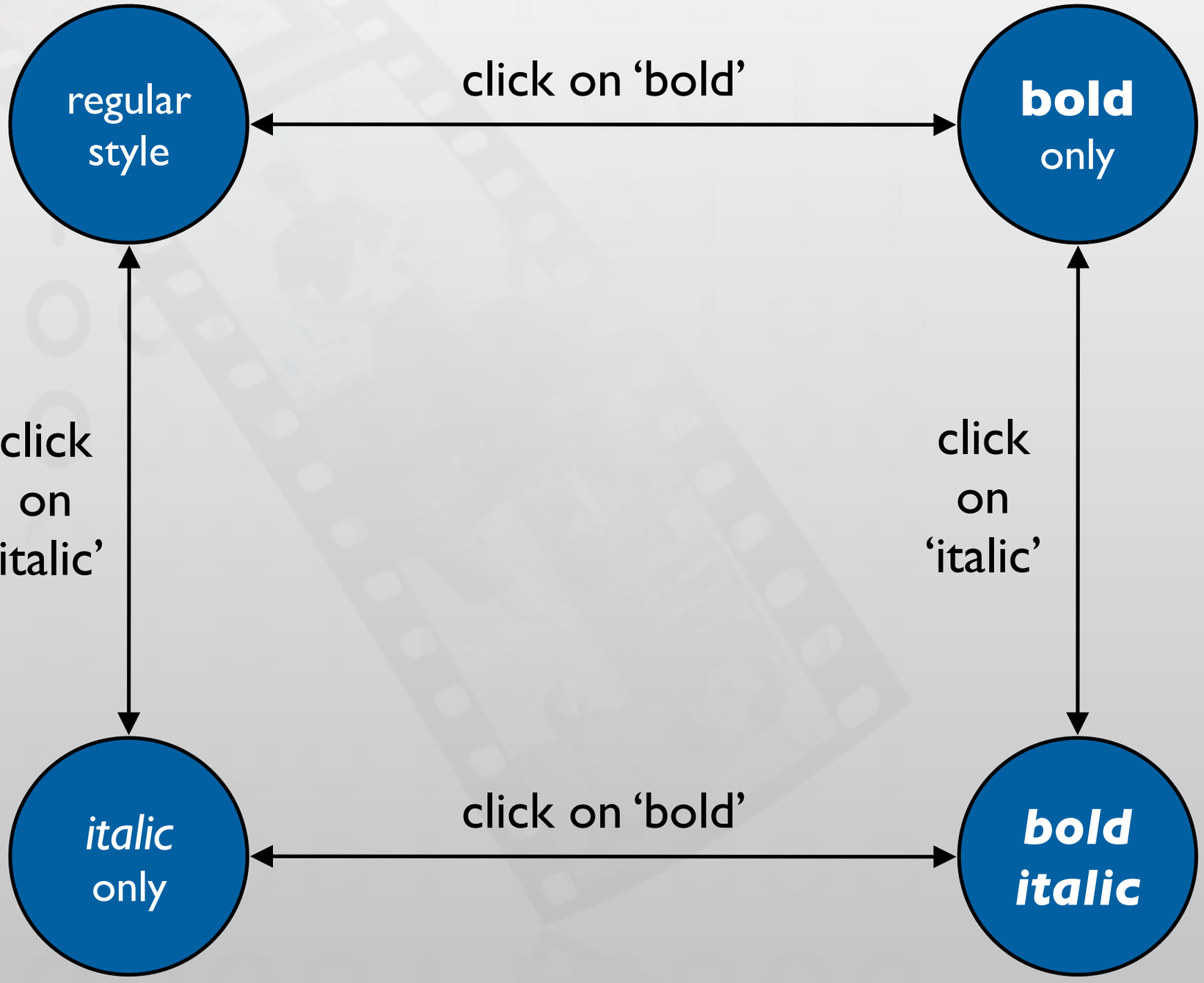


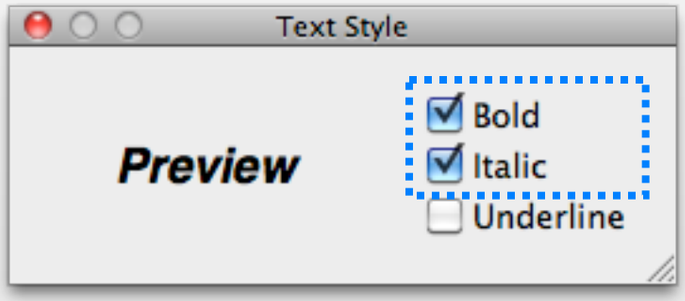
STNs: State Explosion



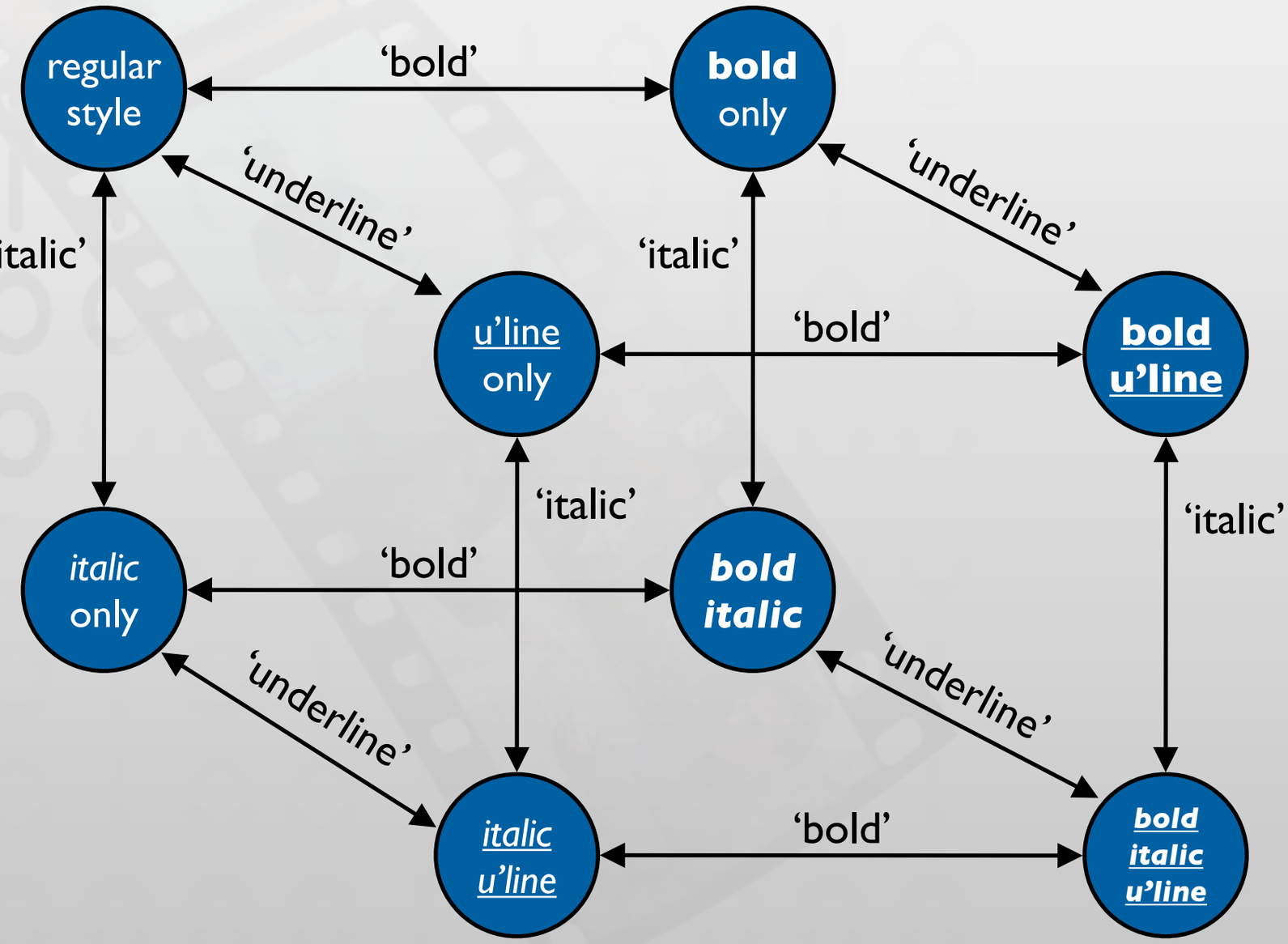
- STNs fail when describing dialogs with several concurrent parts
- Example: Simple dialog to select bold, italics, and/or underline
- What does the state diagram look like?

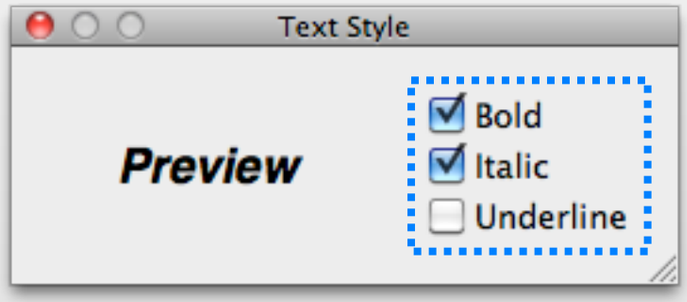
Bold & Italic Combined





All Three Options

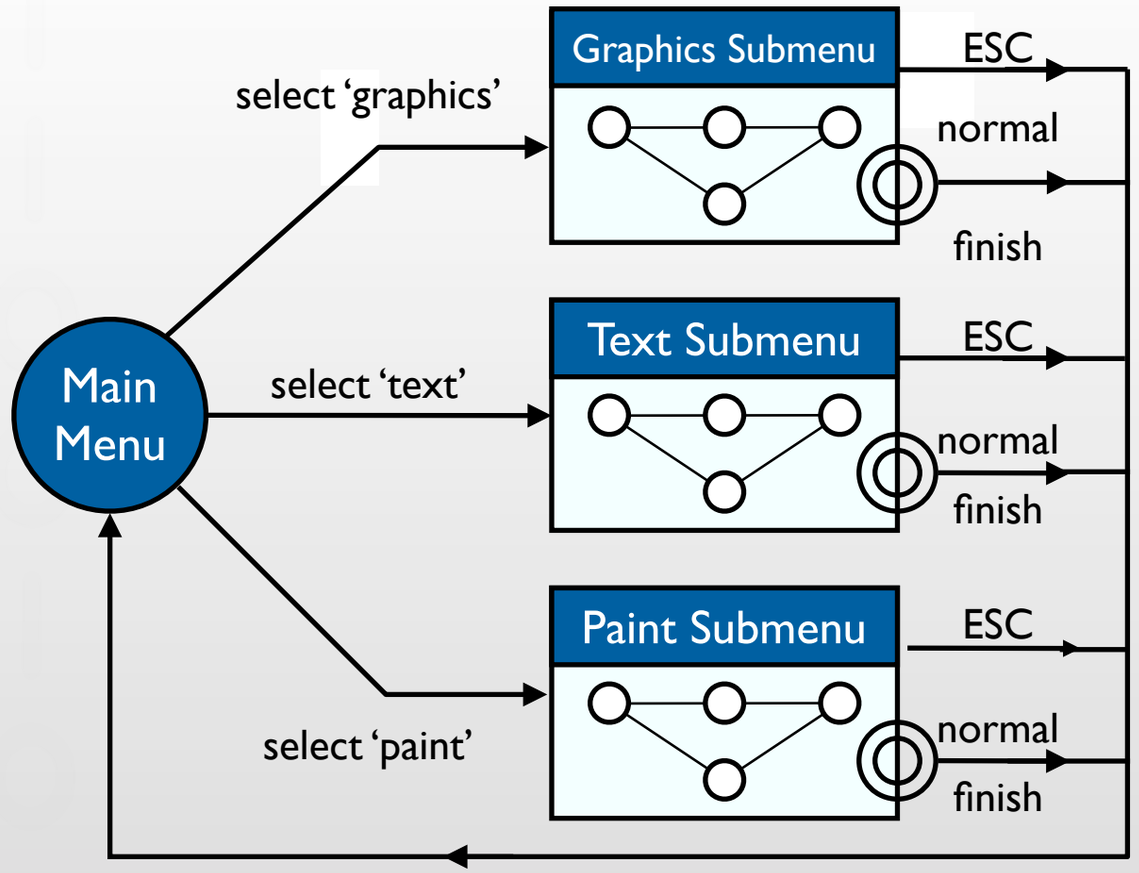


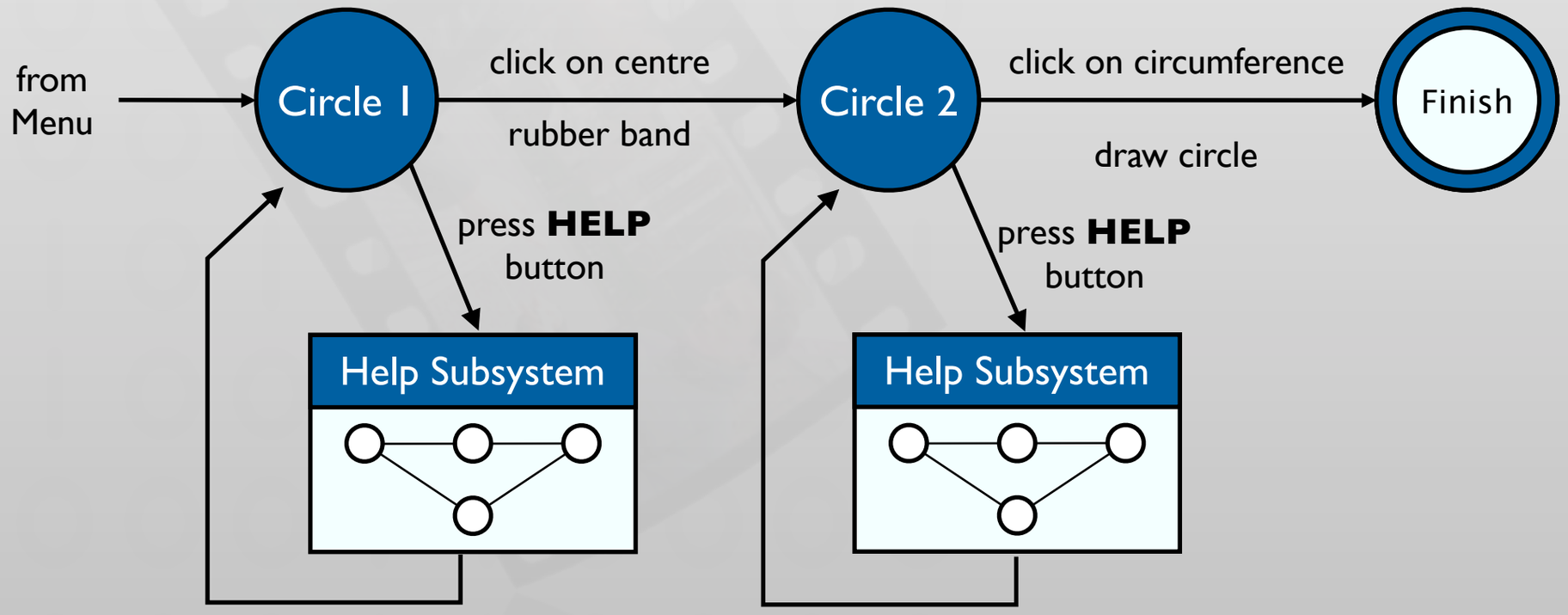


STNs: State Explosion

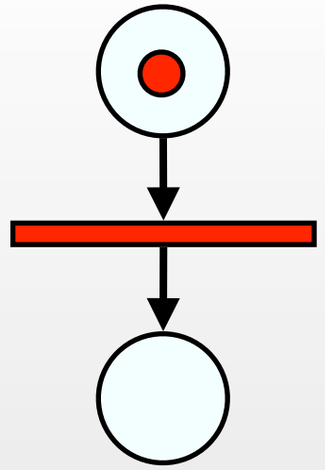
- Problem: Combining two concurrent STNs with *N* and *M* states leads to new STN with *N* × *M* states
- STN hides clear structure of the dialog
- Especially problematic with modern GUIs
- Similar problems with “Escape” and “Help” options
  - ESC can be modeled as special second “Finish” exit active throughout subdialog
  - Help can be modeled as little subdialog hanging off every single state in the STN
  - Gets messy

Example: ESC & Help in STNs

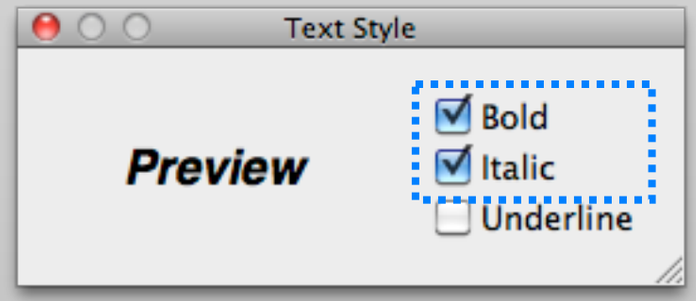




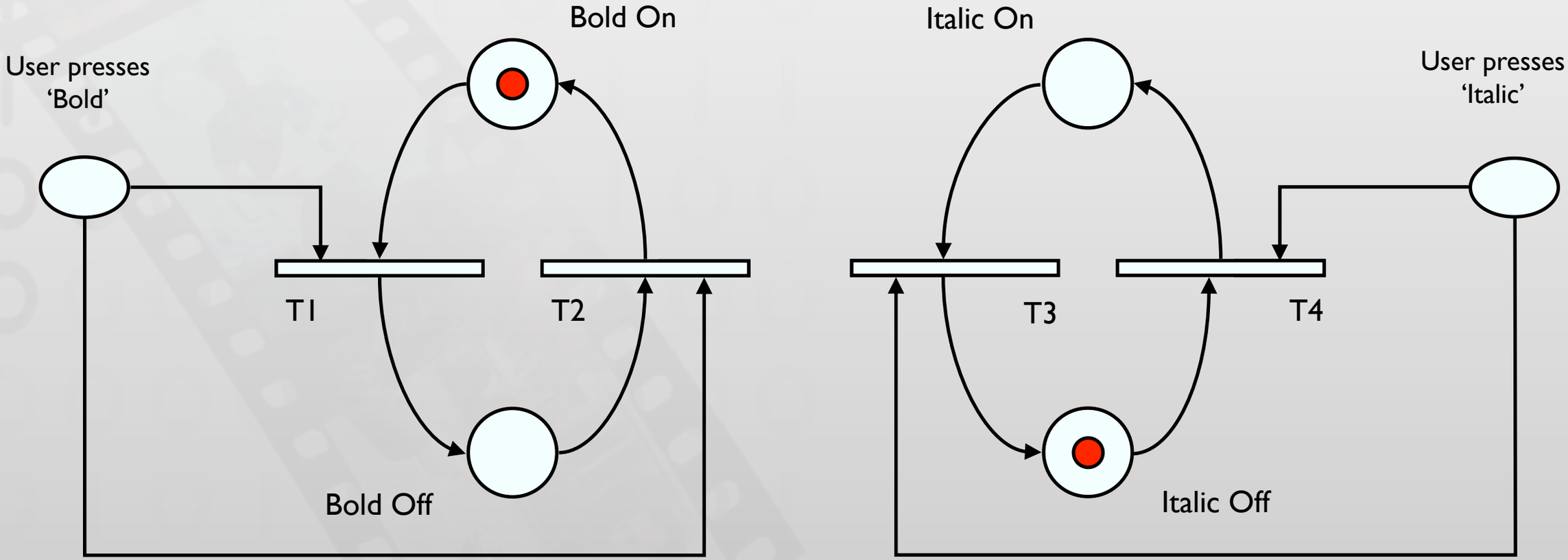
Petri Nets



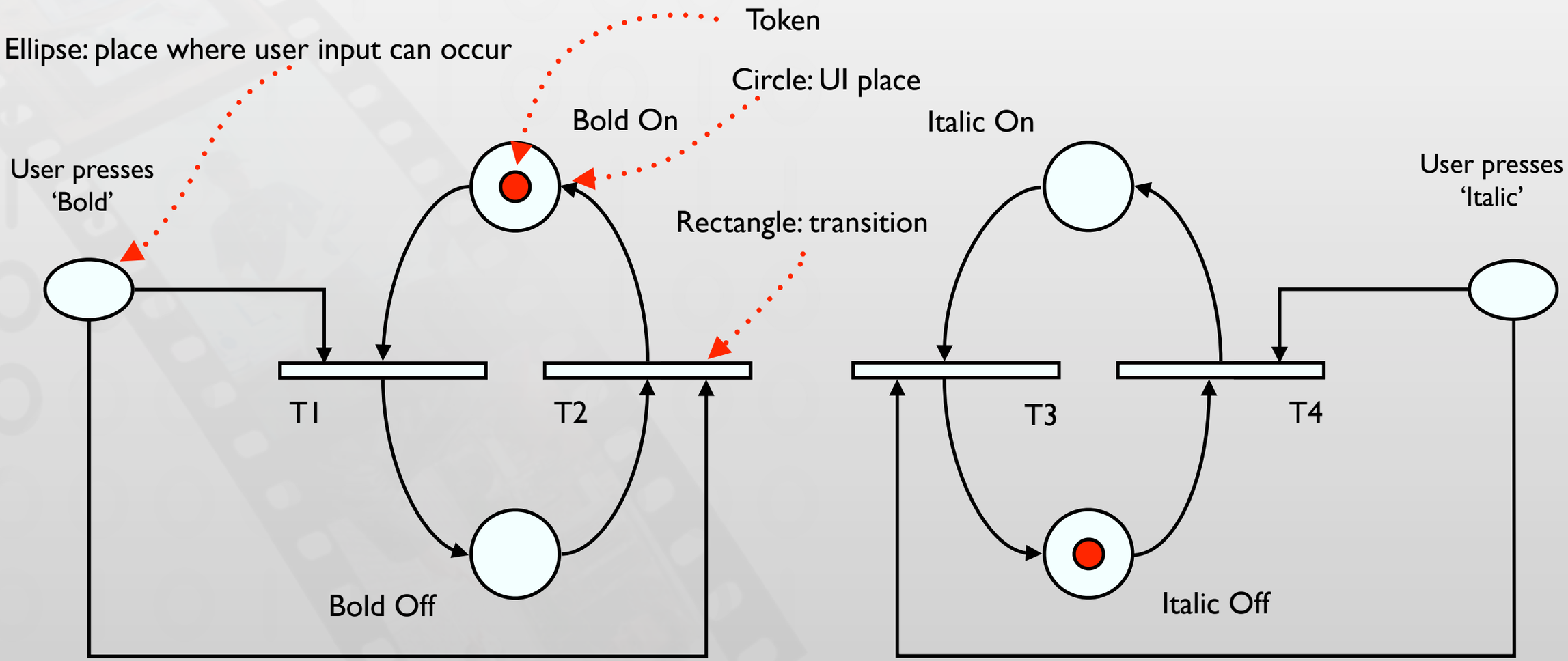
- Better approach to dialogs that have several states at once
- But not better for sequential dialogs and mutually exclusive UI elements (radio buttons)
- Relatively old formalism to model concurrency
- In-class exercise: Draw the Petri net for our dialog box with concurrent "Bold" and "Italic" options (ignore "Underline" for now)



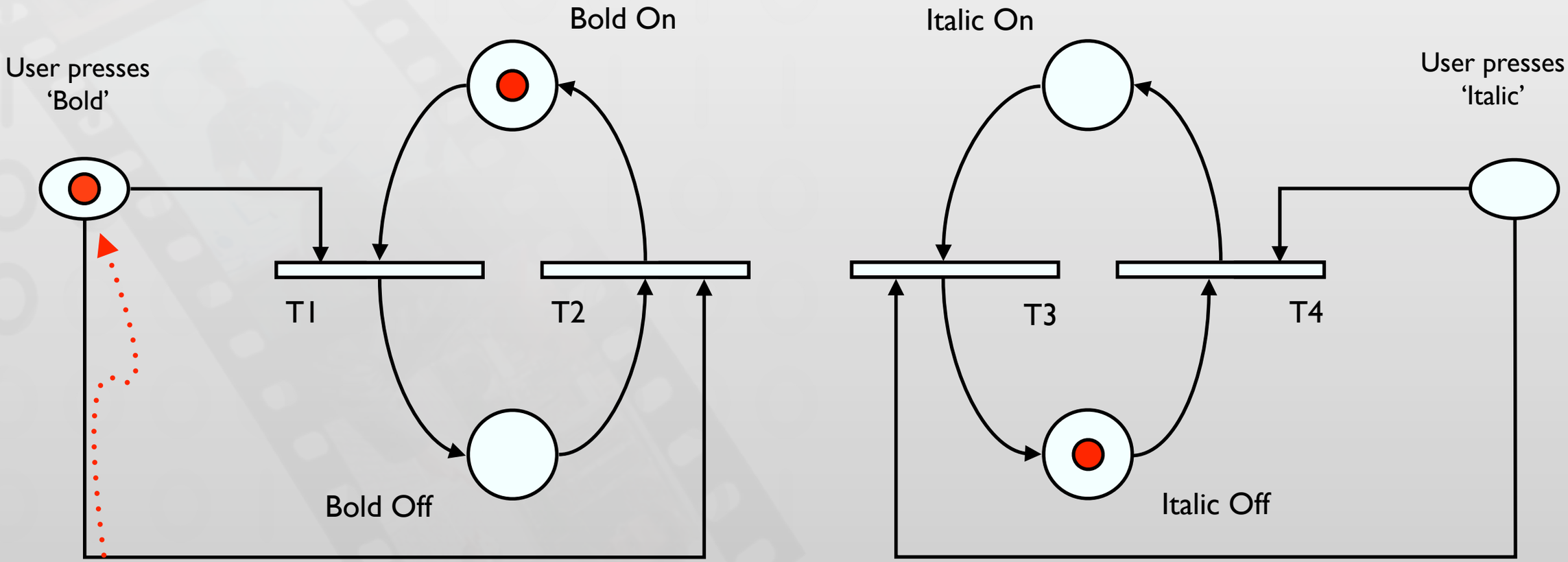
Petri Net For “Bold & Italic” Dialog



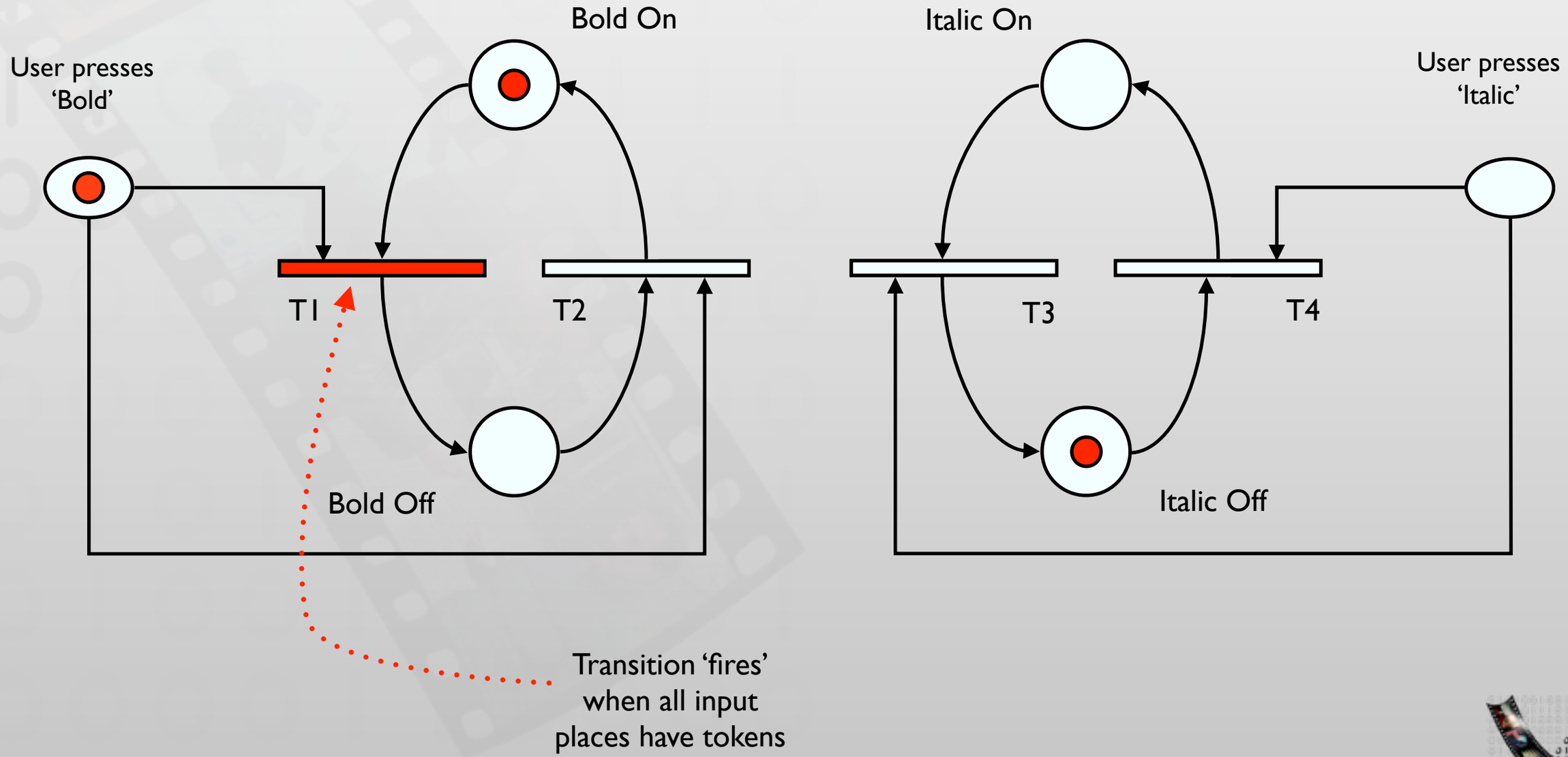
Petri Net For “Bold & Italic” Dialog



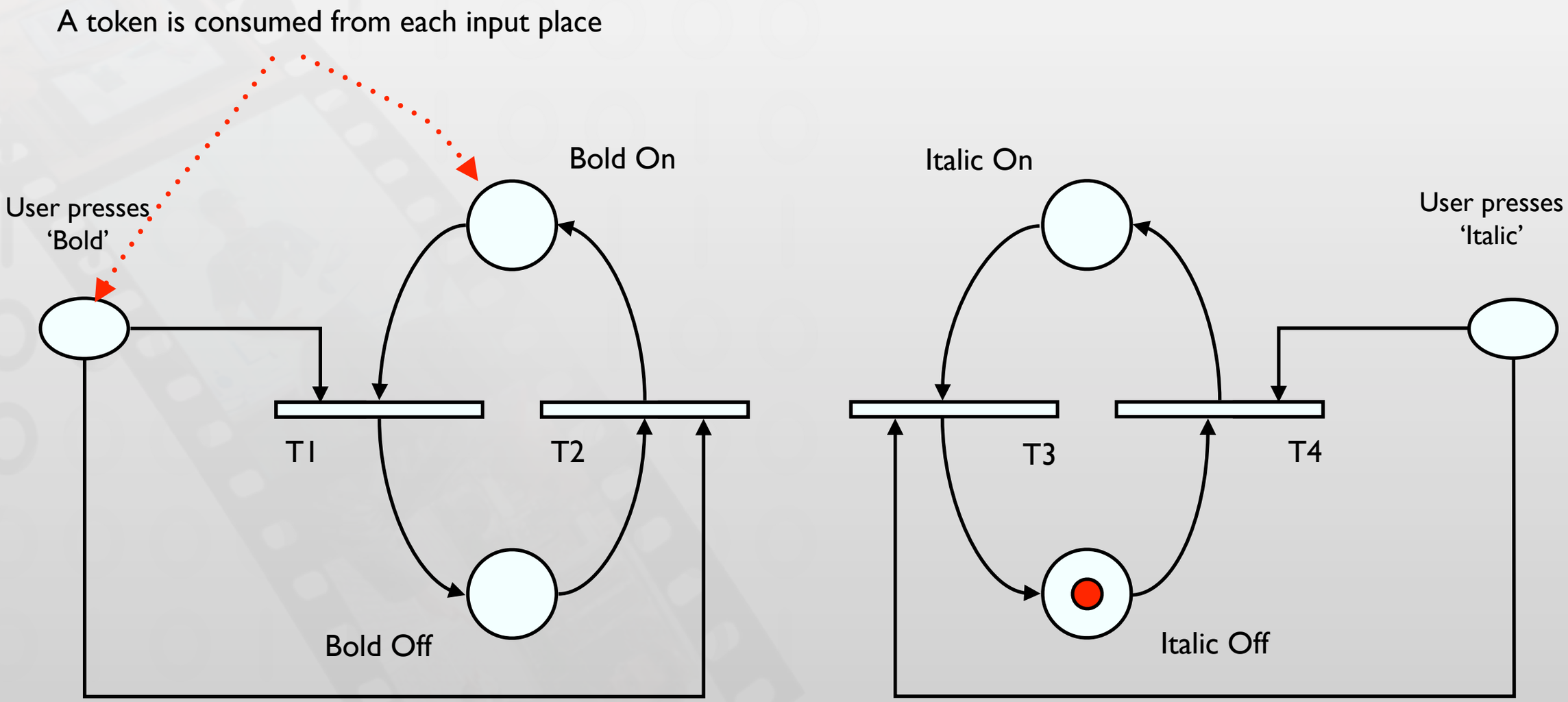
Petri Net For “Bold & Italic” Dialog



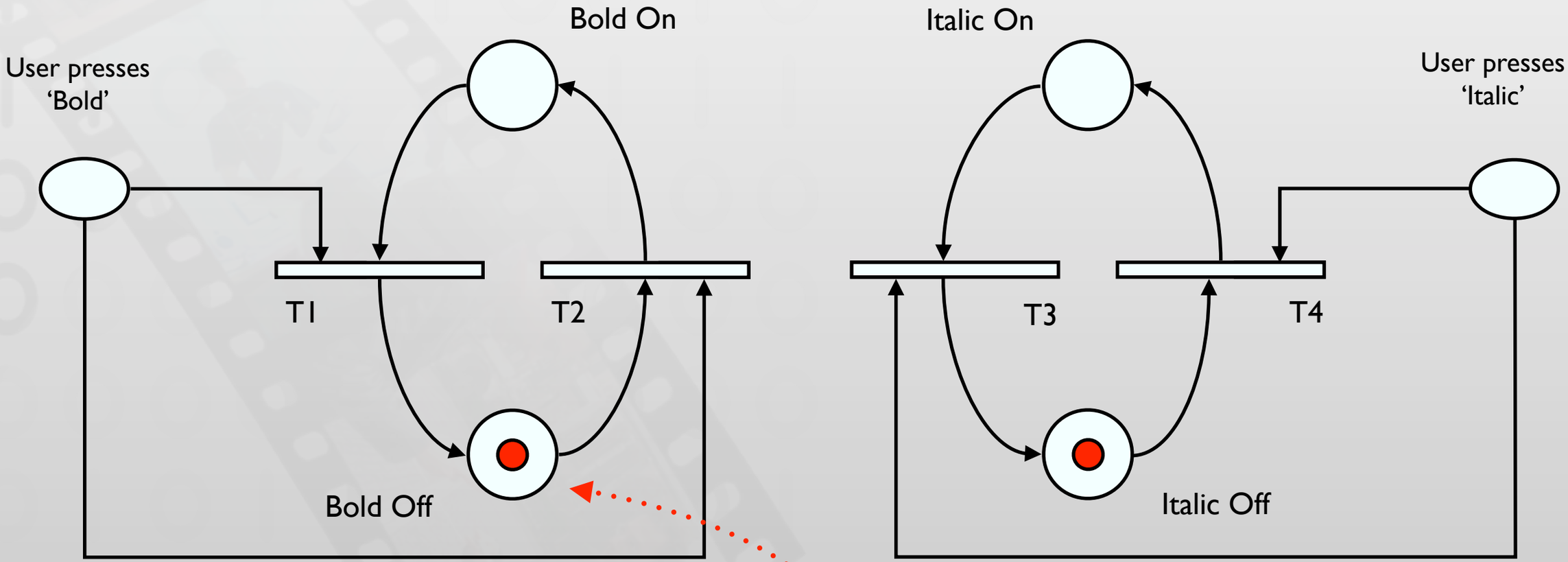
Petri Net For “Bold & Italic” Dialog



Petri Net For “Bold & Italic” Dialog



Petri Net For “Bold & Italic” Dialog



A token is produced in each output place

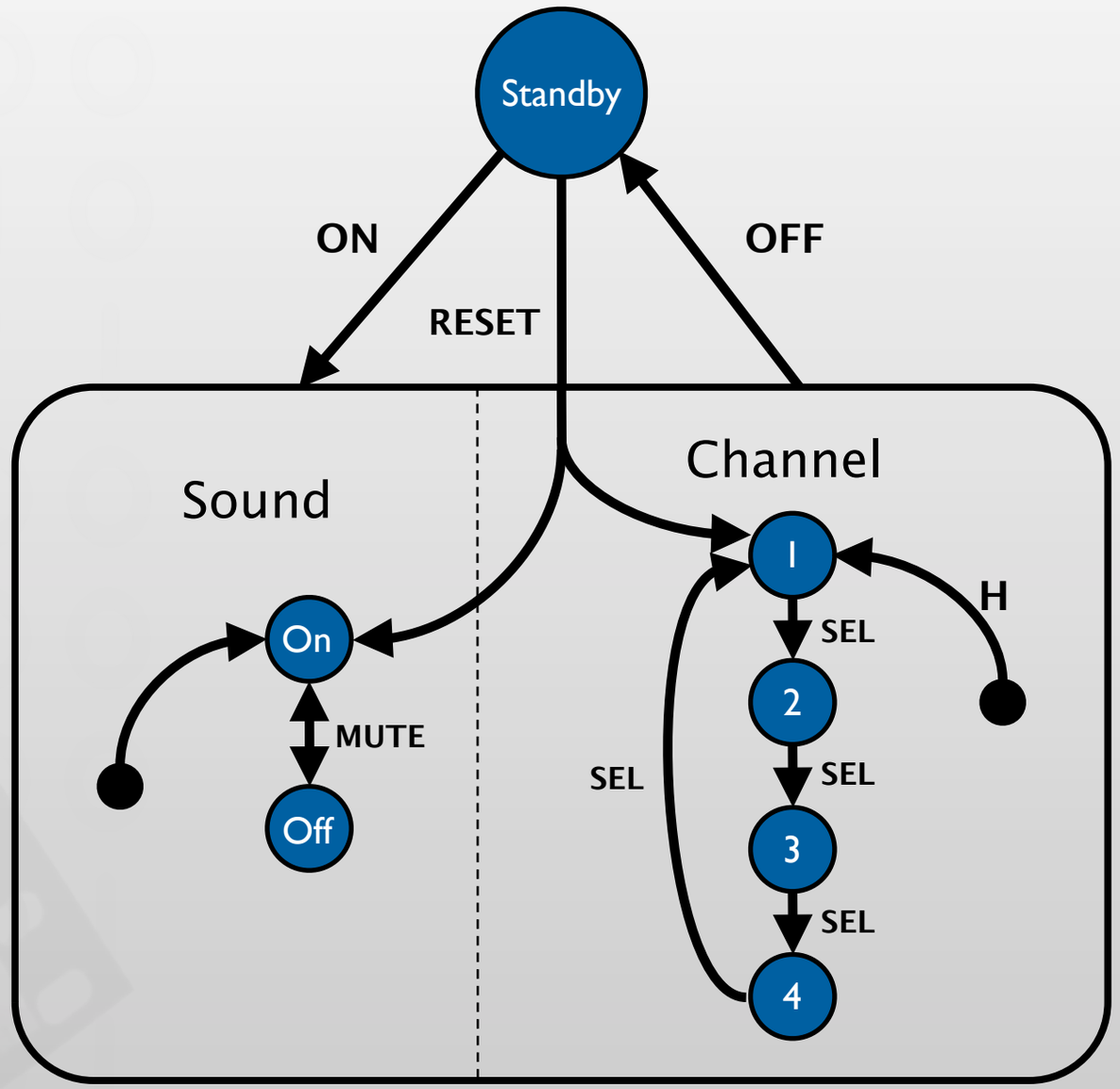
State Charts

- By Harel; used in UML
- Example: TV Control Panel
- State Charts extend STNs
  - Hierarchy
  - Concurrent sub-nets

    ON resumes both state machines
  - Escapes

    OFF always active
  - History

    Link marked "H" goes back to last state on re-entering subdialog

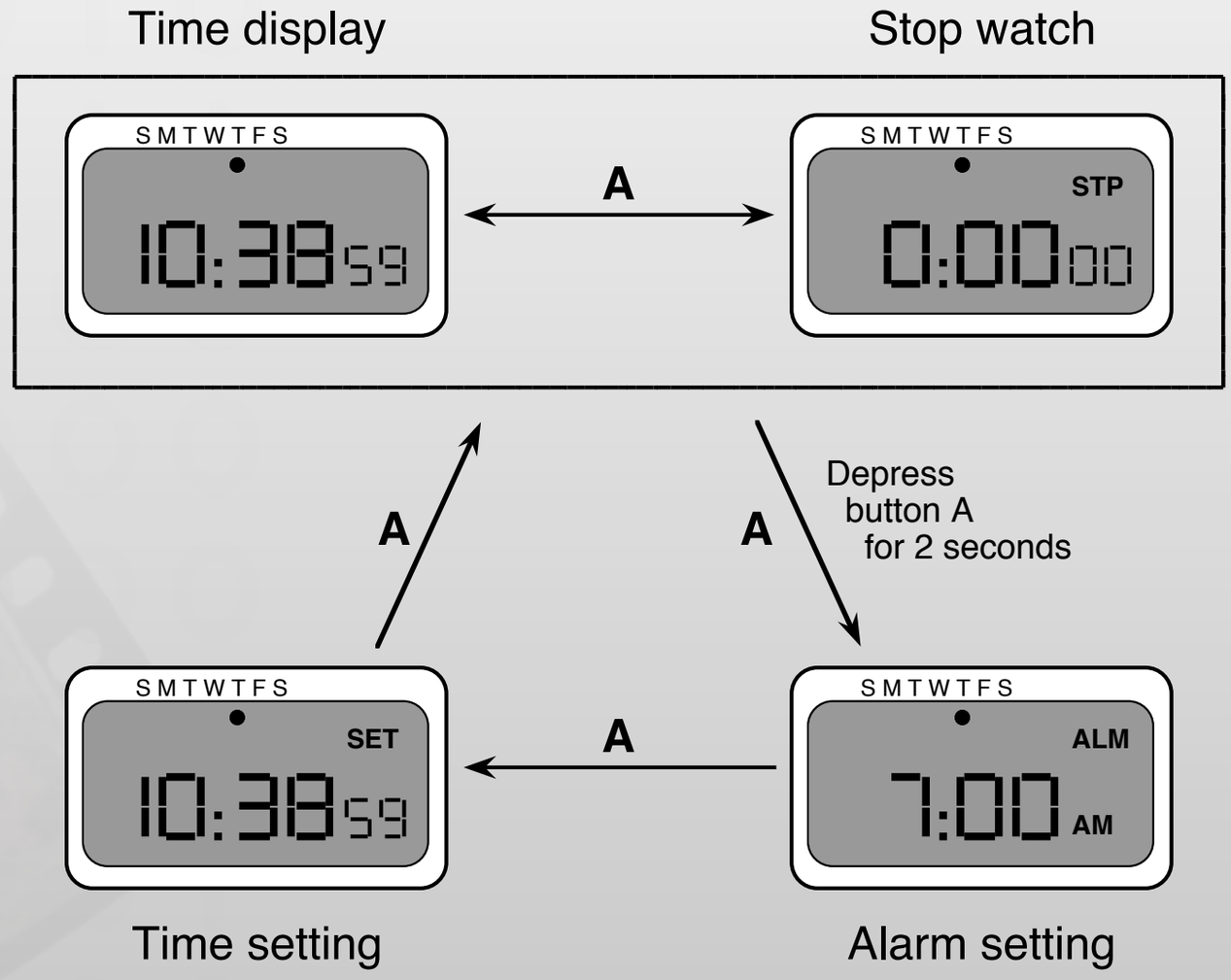


Diagrams For User Documentation

- Some dialog descriptions are clear enough to serve as user documentation (similar to GOMS)
- Especially if description uses screen shots and is semi-formal

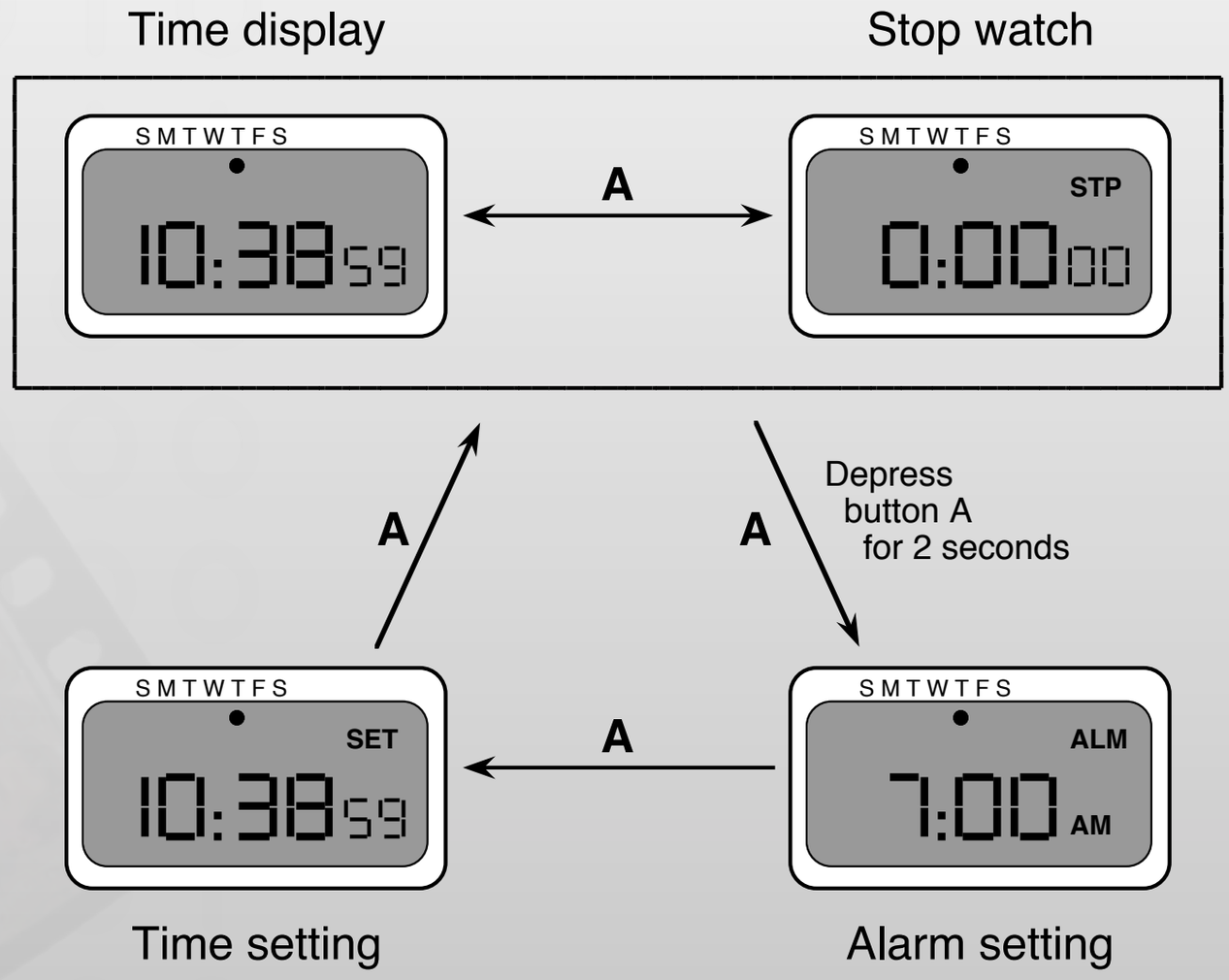
Digital Watch – User Instructions

- Two main modes
- Limited interface
  - 3 buttons
- Button A changes mode



Digital Watch – User Instructions

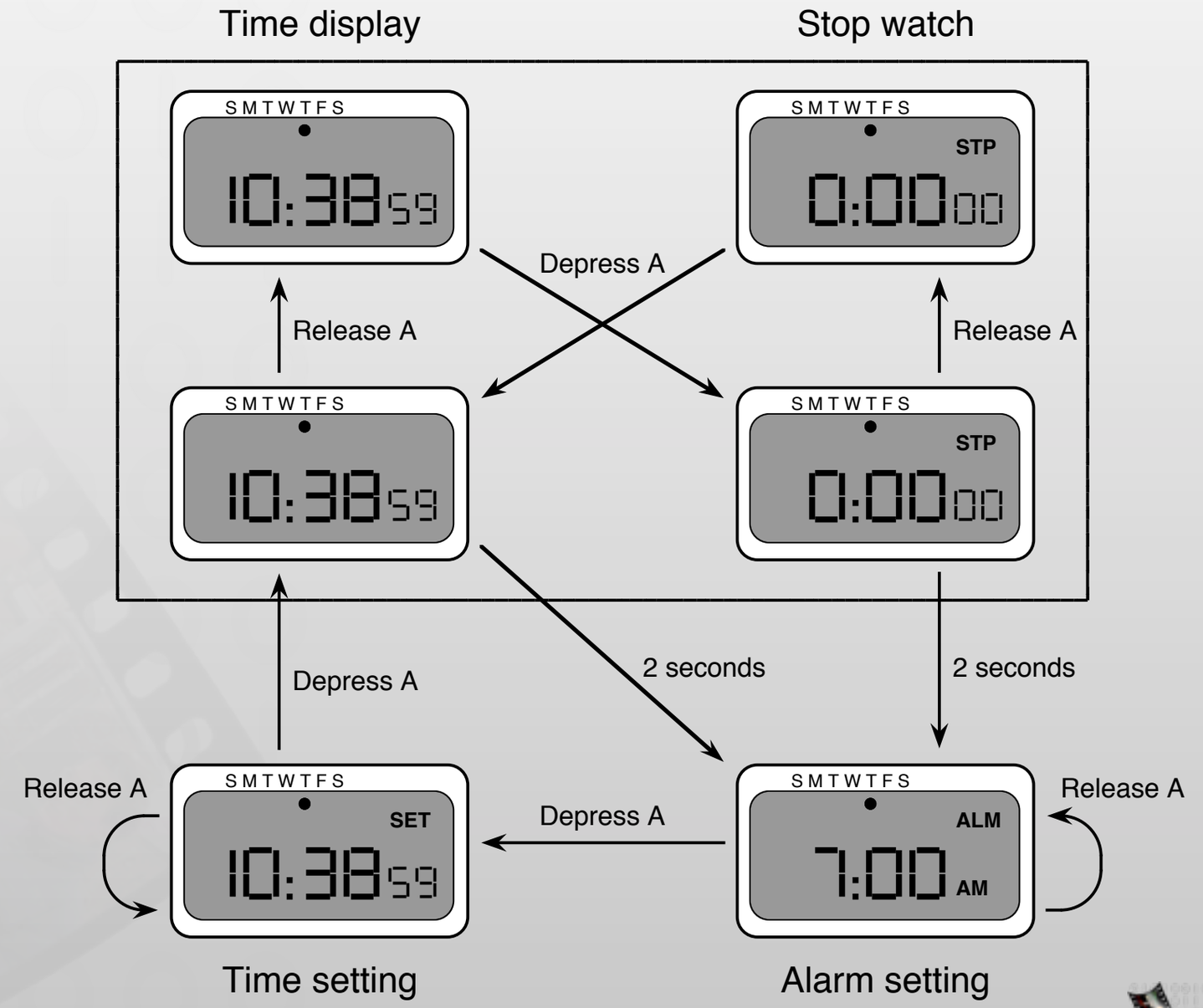
- Dangerous states
- Completeness
  - Distinguish depress A and release A
  - What do they do in all modes?



Digital Watch: Designers Instructions

and …

that's just one button



Semantics - Raw Code

- Event loop for word processor
- Dialogue description
  - Very distributed
- Syntactic/semantic trade-off
  - Terrible!

```
switch ( ev.type ) {
  case button_down:
    if ( in_text ( ev.pos ) ) {
        mode = selecting;
        mark_selection_start(ev.pos);
    }
    ...
  case button_up:
    if ( in_text ( ev.pos )
              && mode == selecting ) {
        mode = normal;
        mark_selection_end(ev.pos);
    }
    ...
  case mouse_move:
    if (mode == selecting ) {
        extend_selection(ev.pos);
    }
    ...
} /* end of switch */
```

Further Reading

- Alan Dix et al.: Human-Computer Interaction, 3rd ed. (2003), Chapter 16

Theory

- ✓ Models of interaction
  - ✓ Affordances, mappings, constraints, types of knowledge, errors
- ✓ Design principles
- ✓ Human cognition and performance
- ✓ Interaction design notation
- ⇒ History and vision of HCI

Practice

- ✓ Sketching
- ✓ User observation
- ✓ Iterative design
- ✓ Prototyping
- ✓ Ideation
- ⇒ User studies and evaluation

Radically New Interface

Released in 1984

Image: Buxton Collection

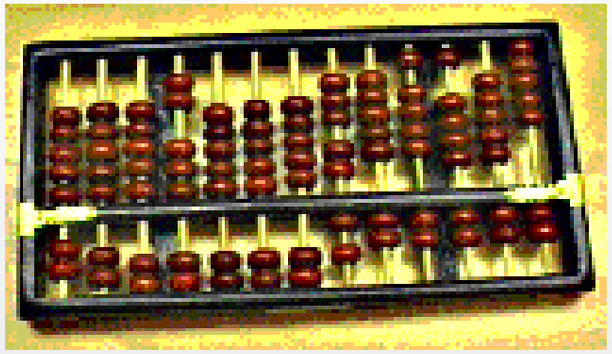
"Picasso knew everything about art history, because he had to know the rules before he could break them."

— Bill Buxton, CHI '11

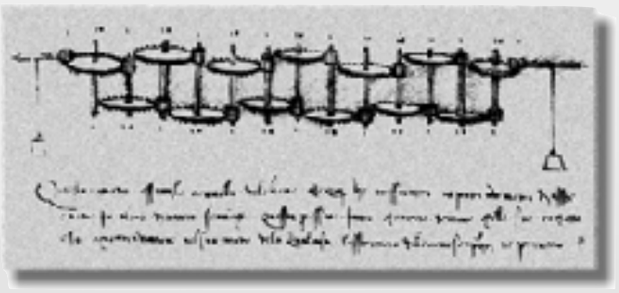
Three Lessons from HCI History

- "Without history, we are all lost." — Bill Buxton, CHI '11
- No Single Hero: Even interfaces that seem "radically new" build on many previous iterations (mouse, touch screens,...)
- Forces Shift During Technology Phases: New technologies create technical solutions for geeks, then usability becomes more important as technology matures, until it over-saturates — unfortunately this usually repeats itself with new technologies

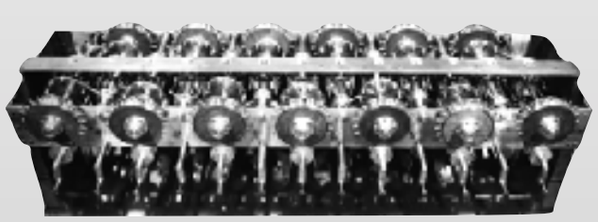
Pre-Computing



- Abacus (Babylon, ~1000 BC)
  - First known mechanical calculating aid



- Da Vinci's mechanical calculator (1500s)
  - First design of mechanical calculator

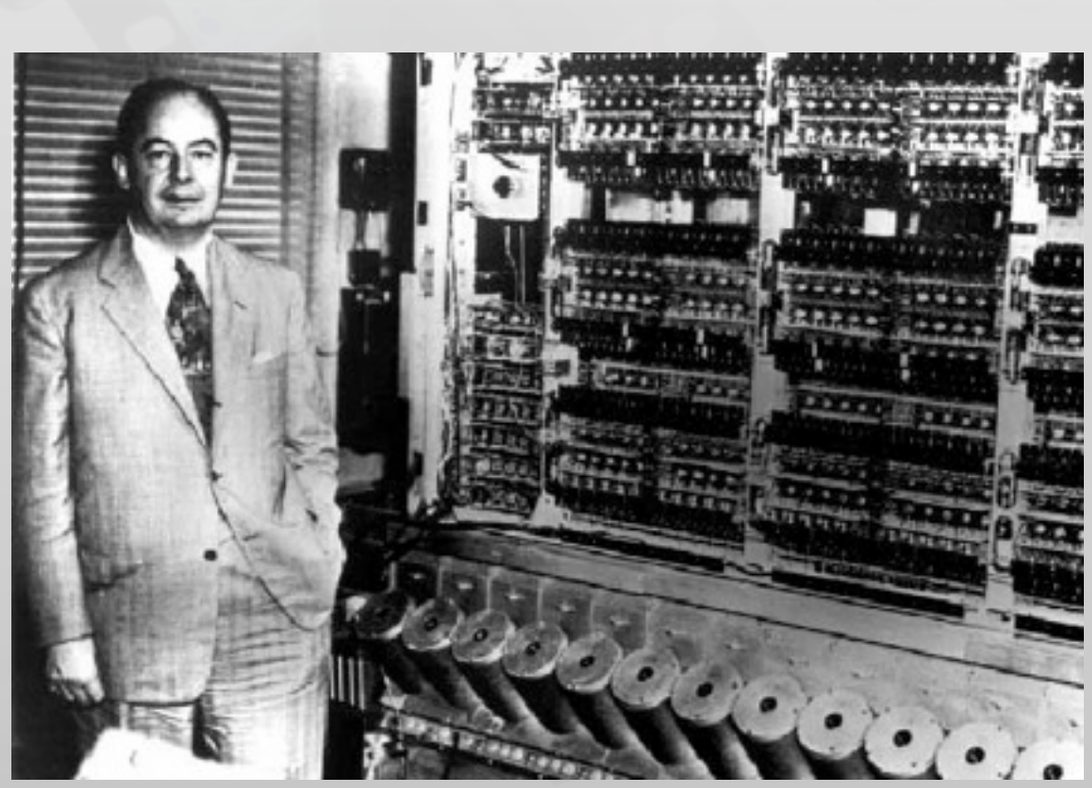


- Pascal's Arithmetic Machine (1642)
  - First working model, +/–
  - ~ Leibniz, Schickard

- Driving force
  - Early: direct representation of conceptual model
  - Later: increasing level of abstraction

First Computers

- Plugboards (e.g., ENIAC 1946)
  - Just data, no program memory

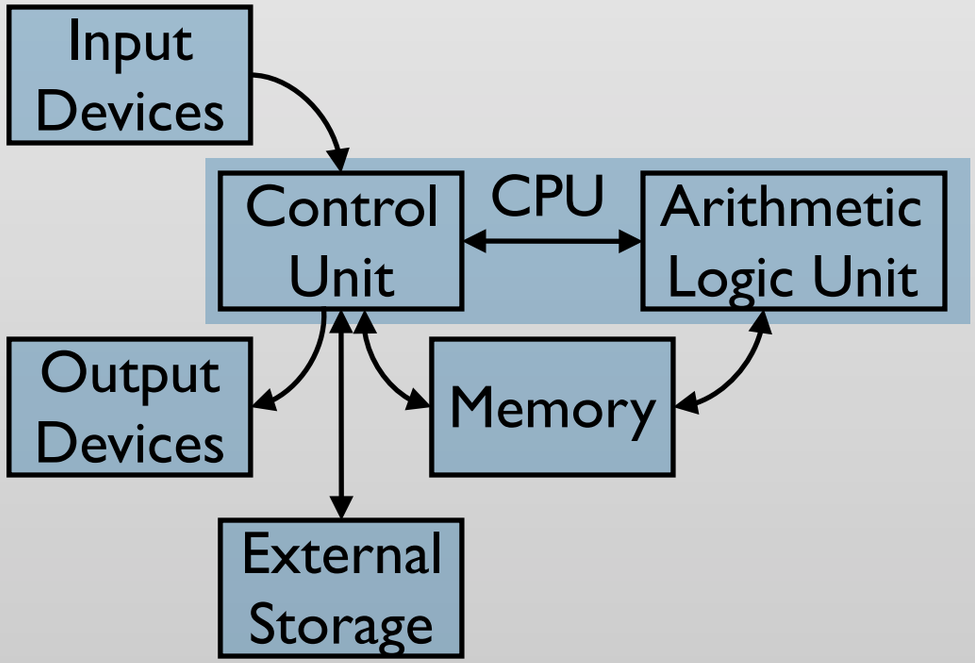


Von Neumann in front of ENIAC, 1946

IBM 557 plugboard and resistor plugs, ca. 1965

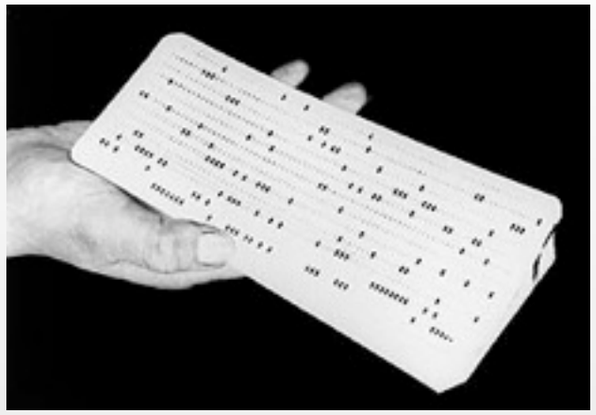
First Computers

- Von Neumann architecture (1945)
  - Key: Defined basic components of today's computer, storing instructions in memory
  - ~ Zuse Z1–Z4 (1936–45)



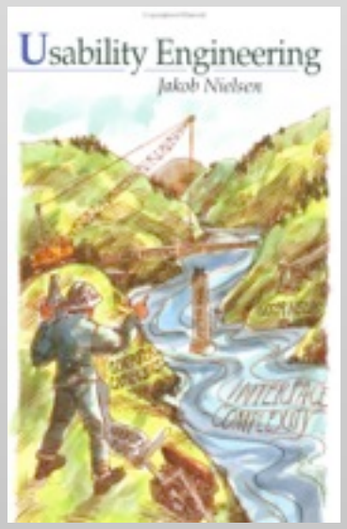
Von Neumann architecture

Mainframes & Batch Processing



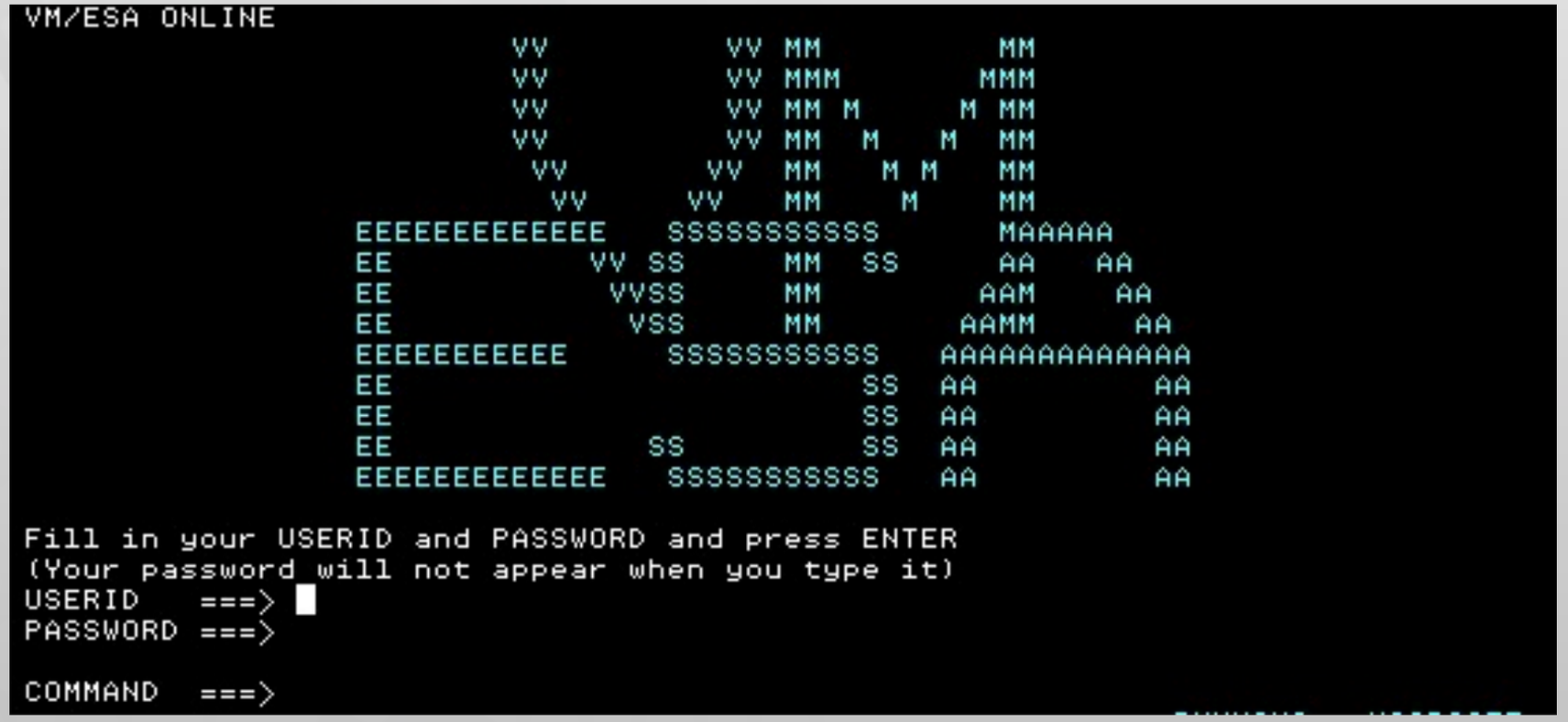
Machine for punching cards

- Prepare data on punch cards—submit—wait for result as printout offline
- Main mode on mainframes of 60's & 70's
- Efficient use of machine, no waiting for human input
- "0-D user interface" [Nielsen'93]
  - Single point in time for submission of the batch job as a single unit



Transaction Systems

- 3270 Terminals
- Key advances: Immediate response for lots of users from distant terminals (for a special-purpose application)



Time Sharing

- Key advances: Provide general purpose interactive response efficiently to many users simultaneously with one computer
  - Dartmouth Basic early 1960s
  - MIT CTSS/ITS/Unix etc.
  - Teletypes
  - Glass teletypes
  - Addressable character Terminals
  - Command-line interfaces
- "1-D interfaces" [Nielsen'93]
  - User can interact on the single line before press SEND
  - Hit return and cannot modify the input anymore

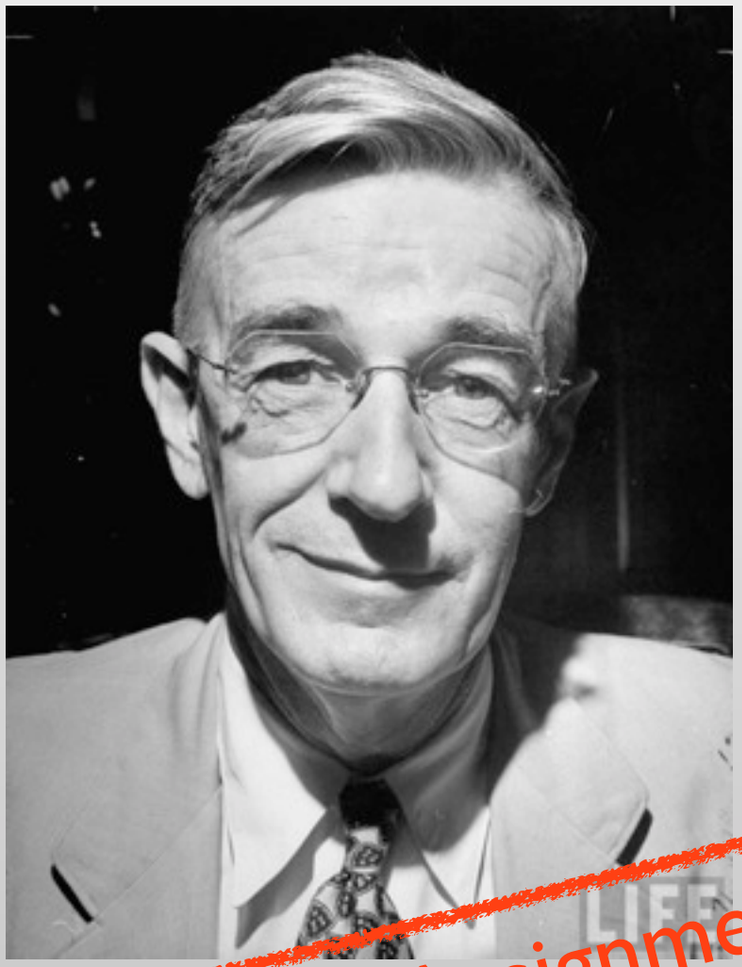
Teletype

Memex: A Vision of Computer

- Vannevar Bush. "As We May Think", The Atlantic Monthly, July 1945

- Memex is a device in which:
  - Stores all individual's books, records, and communications
  - May be consulted with exceeding speed and flexibility

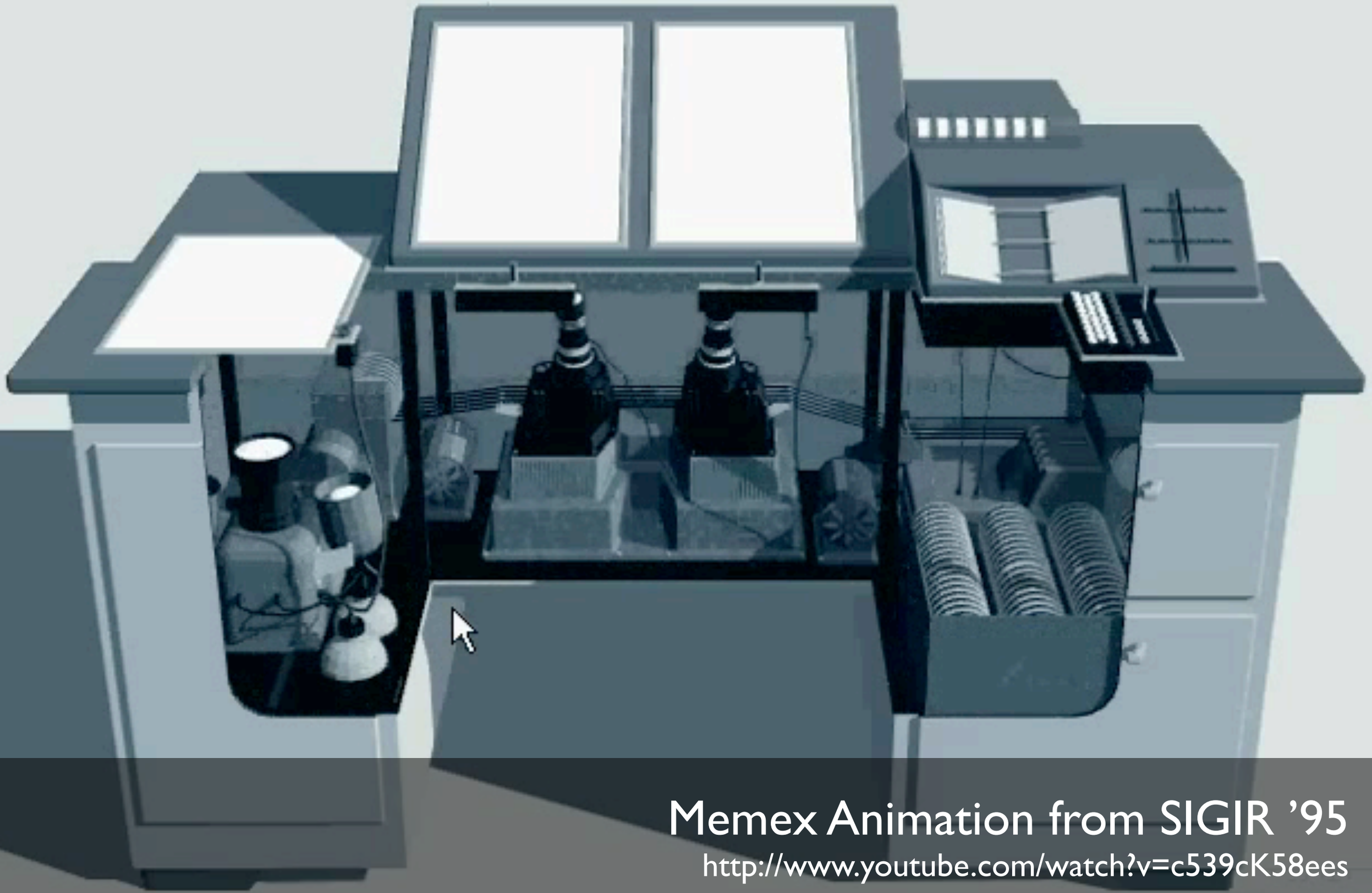
- Predicted: Hypertext, PC, Internet, WWW, Speech recognition, Online encyclopedias



Reading Assignment

Demo

Done



Memex Animation from SIGIR ’95

http://www.youtube.com/watch?v=c539cK58ees

Radar Systems

- Example: SAGE Air Defense (MITRE, 1963)
- Key advances: Real-time response for complex (but specific) tasks, including graphics

The SAGE control center in 1958.

Sketchpad (Sutherland, 1963)

Video assignment

- First interactive computer graphics program
- Key advances: Techniques for direct manipulation of graphics on a screen, including constraint satisfaction

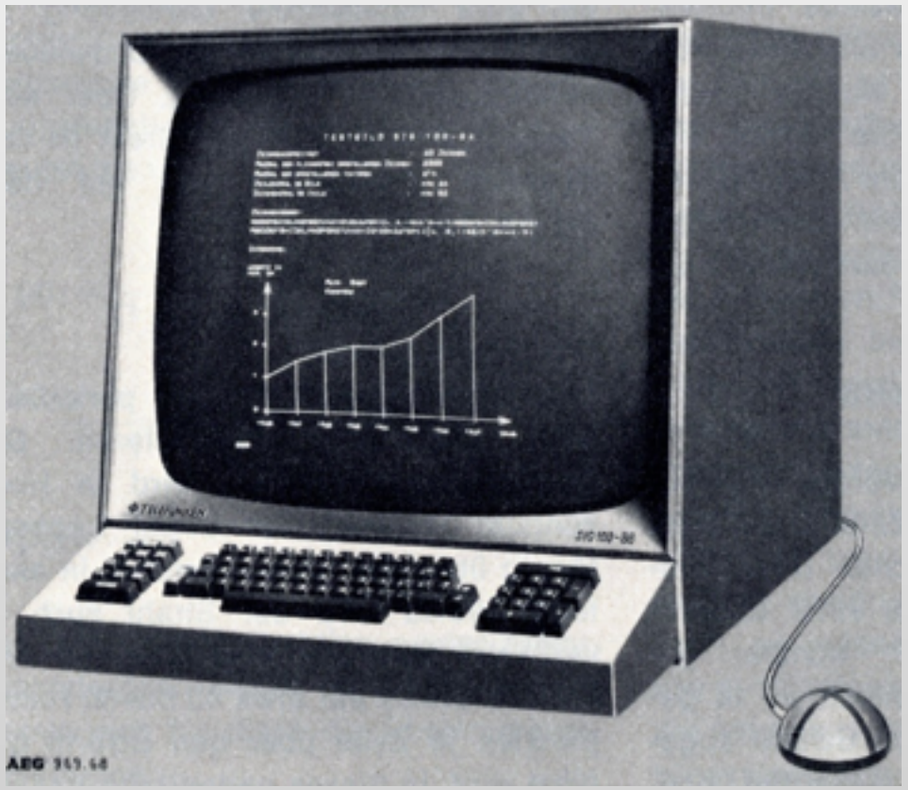
Engelbart's First Mouse (1964)

- Two wheels, wire is on the back, one button
- Won the test when comparing with other pointing devices at the time:
  - Light pen, tracking balls, foot-pedal, knee-operated devices, head-operated devices

www.dougengelbart.org

Telefunken's Rollkugel (October 1968)

- Optional input device for SIG-100 monitor
- Rolling mouse to displace cursors, drawing polygons
- Introduced a few weeks before Engelbart's demo



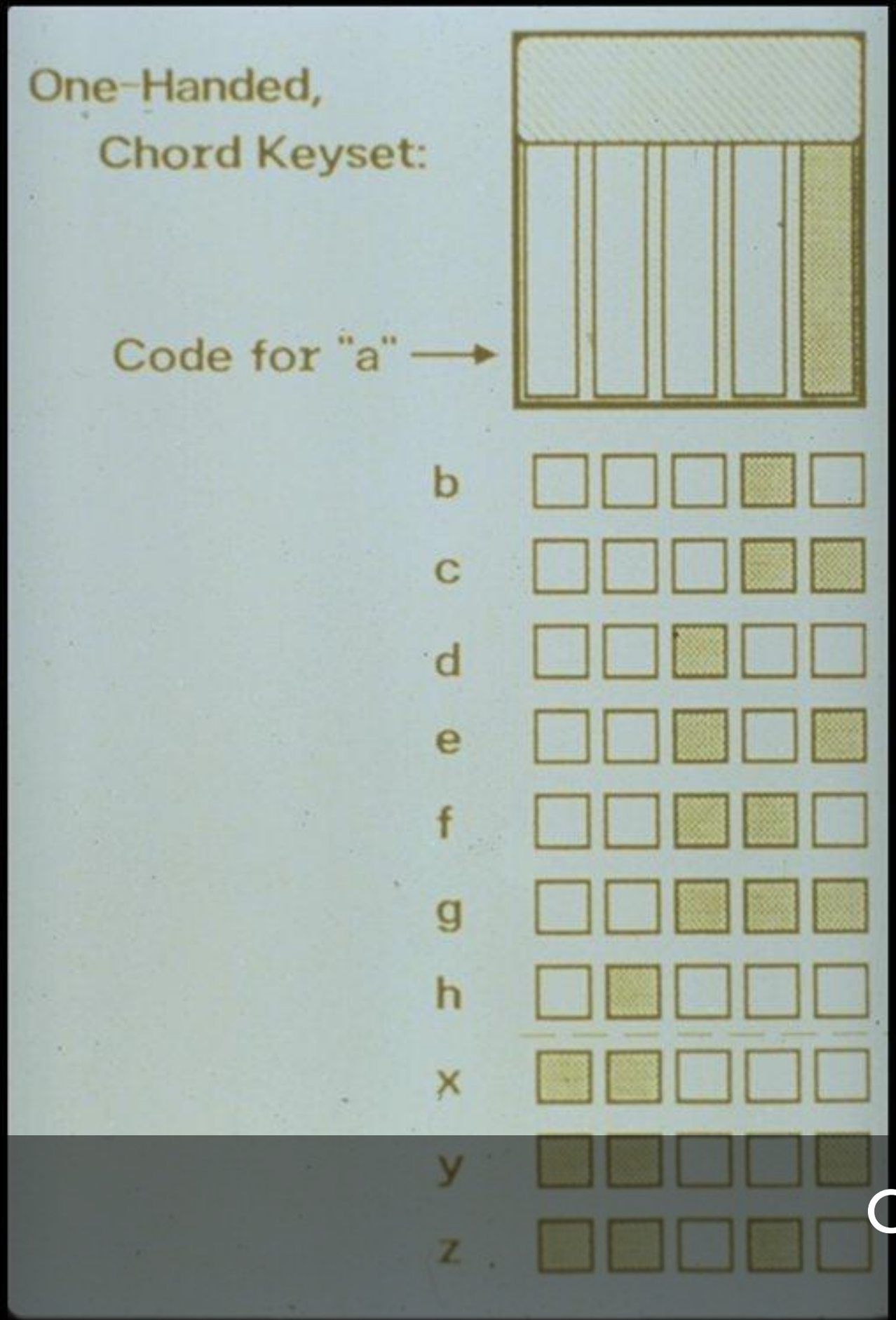
www.netclique.net

NLS: oNLine System (Engelbart, 1968)

- Word processing and linking
- Key advances: Mouse, hyperlinking, direct manipulation of text, outlining, word processing, multi-function integration
- Focused on enhancing expert performance, not on initial ease of use
  - Failed in user tests because of its complexity
  - Perfect for trained users with 4 hands :)

[Moggridge, 2007]

www.dougengelbart.org

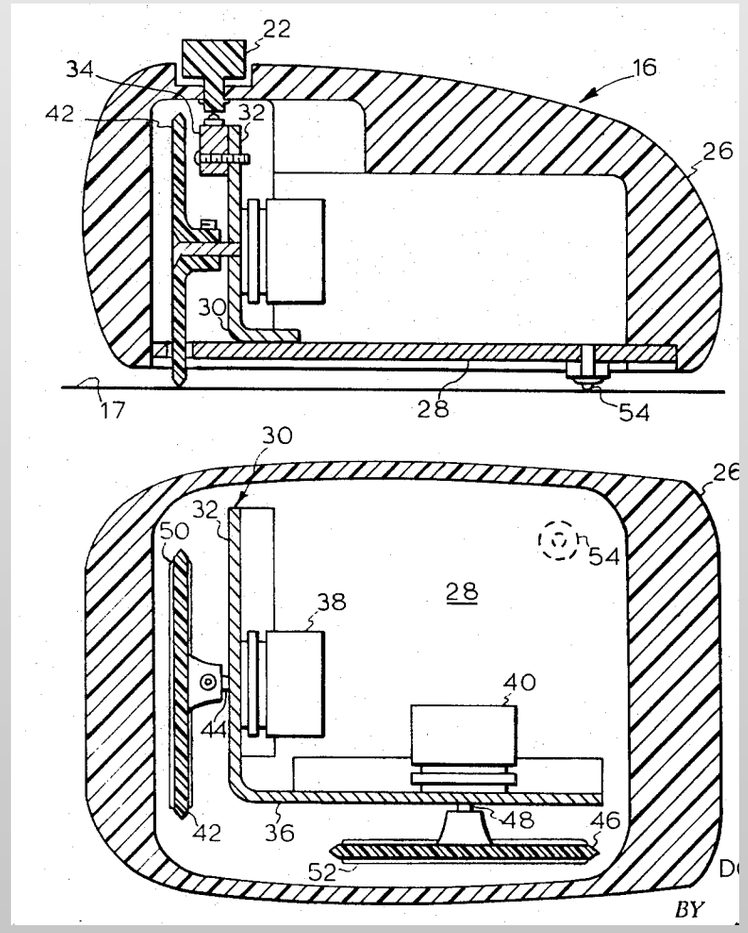


Complexity: Chording Keyboard

www.dougengelbart.org

Mouse in NLS Demo

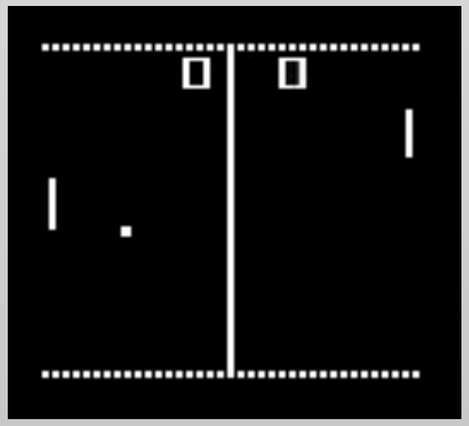
- Two wheels, three button
  - Click
  - Command accept
  - Command delete (undo)
- E.g., Delete
  - Chord: d (3rd key)
  - Mouse: point at the beginning + click
  - Mouse: point at the end + click
  - Mouse: command accept



www.dougengelbart.org

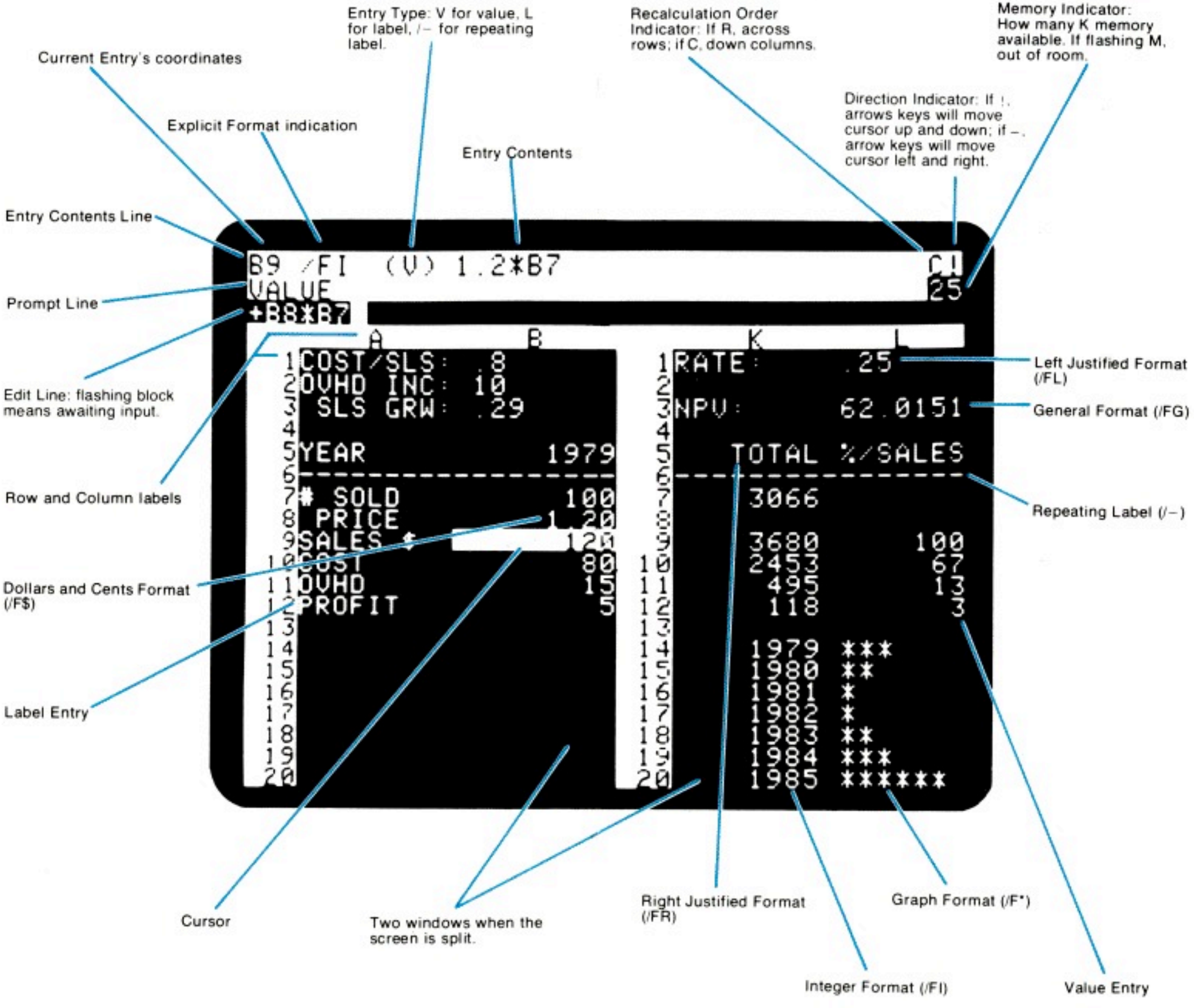
Early Hobbyist PCs & Games

- Atari PONG (Bushnell, 1972)
- MITS Altair (1975)
- Key advances: Machines cheap enough to be used by someone other than government and big business or research labs



Early Personal Computers

- Apple II, 1977
  - Key advances: First general purpose personal computer used widely in business (because of VisiCalc)


Current Entry's coordinates
Entry Type: V for value, L for label, /– for repeating label.
Recalculation Order Indicator: If R, across rows; if C, down columns.
Memory Indicator: How many K memory available. If flashing M, out of room.
Explicit Format indication
Entry Contents
Direction Indicator: If ↑, arrows keys will move cursor up and down; if –, arrow keys will move cursor left and right.
Entry Contents Line
Prompt Line
Edit Line: flashing block means awaiting input.
Left Justified Format (/FL)
General Format (/FG)
Row and Column labels
Repeating Label (/–)
Dollars and Cents Format (/F$)
Label Entry
Cursor
Two windows when the screen is split.
Right Justified Format (/FR)
Graph Format (/F*)
Integer Format (/FI)
Value Entry
B9 /FI (V) 1.2*B7
C I
25
VALUE
+B8*B7
A B K L
1 COST/SLS: .8 RATE: .25
2 OVHD INC: 10
3 SLS GRW: .29 NPV: 62.0151
4
5 YEAR 1979 TOTAL %/SALES
6
7 # SOLD 100 3066
8 PRICE 1.20
9 SALES $ 120 3680 100
10 COST 80 2453 67
11 OVHD 15 495 13
12 PROFIT 5 118 3
13
14 1979 ***
15 1980 **
16 1981 *
17 1982 *
18 1983 **
19 1984 ***
20 1985 ******

Early Personal Computers

- IBM PC, 1981
  - Key advances: Making the PC respectable to business in general by putting the IBM label on it

- Features
  - Character terminal
  - Text UI standards (IBM CUA)
  - Graphics: non-standard

Xerox Alto (PARC, 1973)

- Bitmap Displays & GUIs
- 2.5MB removable HD (pre-floppy), 128-256K RAM, 600x800, mouse, Ethernet, not commercialized
- Smalltalk platform, Bravo WYSIWYG editor, email
- Key advances: Menus, windows, pointing, dragging, etc., as we now know them

Xerox Star (1981)

- Introduced windows commercially, $17K
- Key advances: Integrated networked document environment, WYSIWYG text editing, icons, property sheets, window management, …
- Built to improve Alto
- Unique design process (8 years of prototyping)
- "2.5-D interfaces" [Nielsen'93]
  - Interacting with 2D display + overlapping windows

12294 Free Disk Pages

Help

Example ViewPoint Document

Close | Save | Reset | Save&Edit

XEROX
6085 Workstation

User-Interface Design

To make it easy to compose text and graphics, to do electronic filing, printing, and mailing all at the same workstation, requires a revolutionary user interface design.

Bit-map display - Each of the pixels on the 19" screen is mapped to a bit in memory; thus, arbitrarily complex images can be displayed. The 6085 displays all fonts and graphics as they will be printed. In addition, familiar office objects such as documents, folders, file drawers and in-baskets are portrayed as recognizable images.

The mouse - A unique pointing device that allows the user to quickly select any text, graphic or office object on the display.

See and Point

All functions are visible to the user on the keyboard or on the screen. The user does filing and retrieval by selecting them with the mouse and touching the MOVE, COPY, DELETE or PROPERTIES command keys. Text and graphics are edited with the <u>same</u> keys.

Shorter Production Times

Experience at Xerox with prototype work stations has shown shorter production times and thus lower costs, as a function of the percentage of use of the workstations. The following equation can be used to express this:

Year	Non 6085	6085
1978	85.2	15.8
1980	61.1	39.9
1982	45	55
1984	30	70
1986	10	90
1988	5	95

Table 1: Percentages of use of methods.

Activity under the old and the n

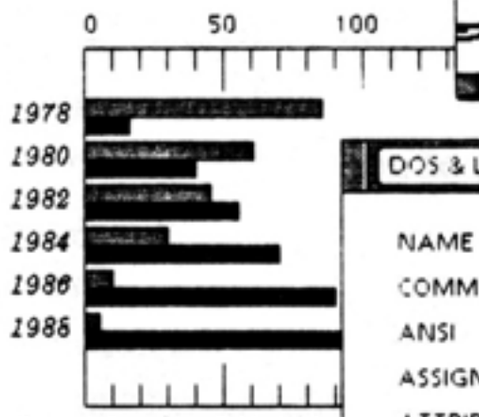


Figure 1: Data from Table 1 drive

$$X(n) = \sum_{i=1}^{n} \int_{a}^{b} \frac{A + FF_n^i}{denominator +}$$

Workstation usage percentage
Table 1 and illustrated in Figur
6085 users are likely to do mo
composition and layout, contro
process including printing and di

Text and Graphics

To replace typesetting, the 6085 offers a choice of type fonts and sizes, from 6 point to 36 point:

Here is a sentence of 8-point text.
Here is a sentence of 10-point text.
Here is a sentence of 12-point text.
18-point text.
24-point text.
36-point text.

Brother Dominic

DOS & Lotus data:

Close | Redisplay

NAME	EXTENSION	SIZE	DAT
COMMAND	COM	22677	15-N
ANSI	SYS	2556	18-S
ASSIGN	COM	864	28-N
ATTRIB	EXE	15091	14-N
BACKUP	COM	17024	28-A
CHKDSK	COM	9435	24-O
CHMOD	COM	6528	27-A
COMP	COM	3018	10-S
DEBUG	EXE	15364	15-N

9:27:24 10-29-88 N.H.

Local

Kevin J.

Outbaske

Mail Merge

Mail from Ken

Brother Domini c

Calendar

Calc

Loader

Blank User Dictionar

Empty Dictionar y

Blank Record File

Blank Docum ent

2.0

TTY Beechnut

Monthly Profit

Blank Folder

C Tools

ILLUS Blank Illustrator

Blank Canvas

PC Emulator

Converter

Blank Shared Book

Blank Book

Emulated Rigid Disk

Virtual Floppy

Exampl e ViewPo

Remote Files

Drawers in Japan

Swaps

DOS & Lotus

4427 Blank Referenc e

Mackey

OSBU

Xerox

Tape Drive

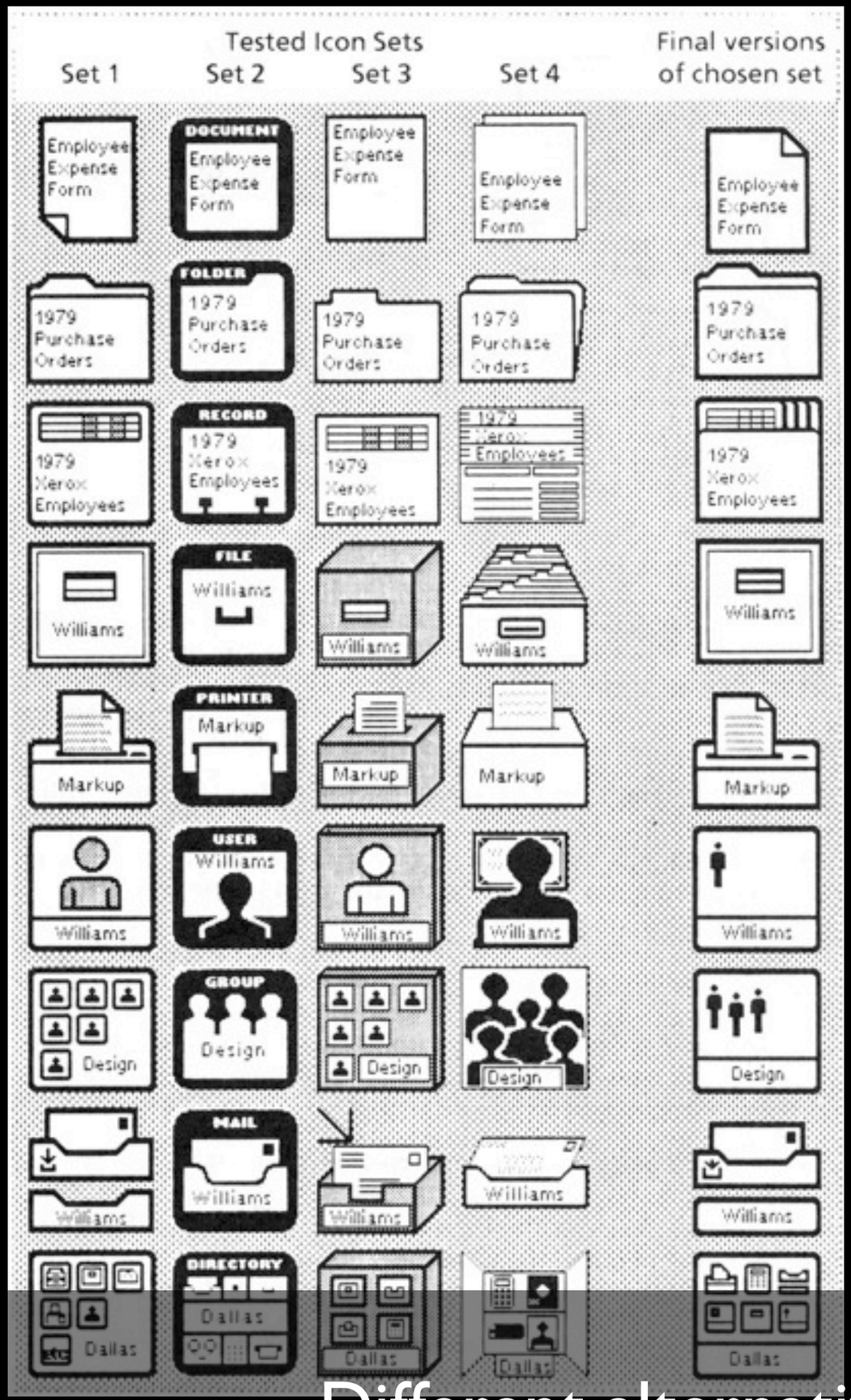
Floppy

Wasteb

Directory

Xerox Star User Interface

www.digibarn.com



Different alternatives of icon designs

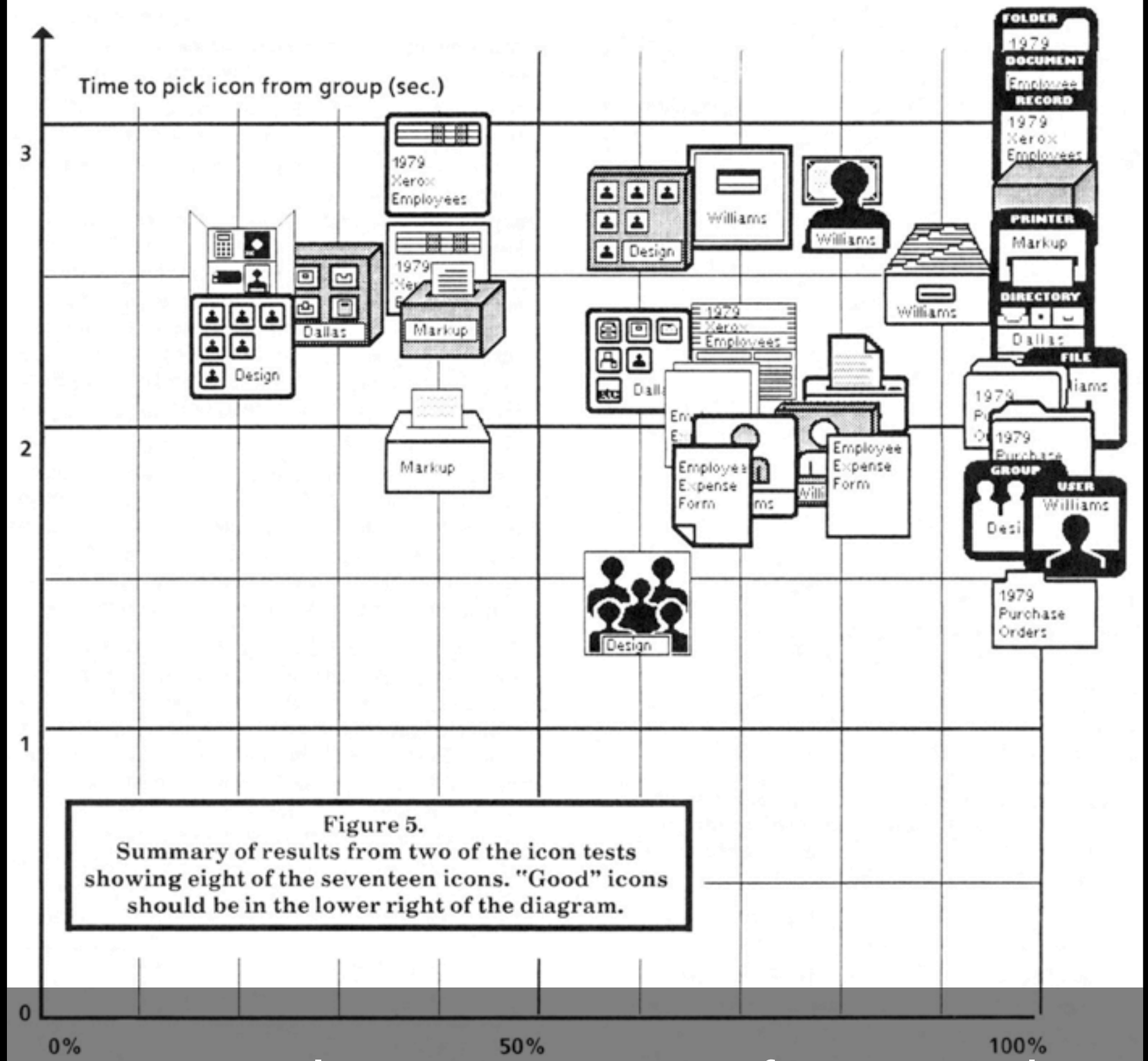


Figure 5.
Summary of results from two of the icon tests showing eight of the seventeen icons. "Good" icons should be in the lower right of the diagram.

Intensive user test for icon style recognition

Xerox Star keyboard and mouse

www.digibarn.com

Star: Design Lessons

- ✓ Design first, then code
- ✓ Objects & Actions
- ✓ Detail
- ✓ Graphic designers
- ✓ DIA cycle

But:

- ✗ Industry trends
- ✗ Customer focus
- ✗ Extensibility
- ✗ Responsiveness
- ✗ Metaphor limits
- ✗ Selling radical innovation

Apple Lisa (1983)

- Apple's first bitmapped-GUI computer
- Inspired by Alto (not Star)
  - 1-button mouse
- Key advances:
  - Menu bar (instead of pop-up menus)
- But: underpowered, bad marketing ($10K)

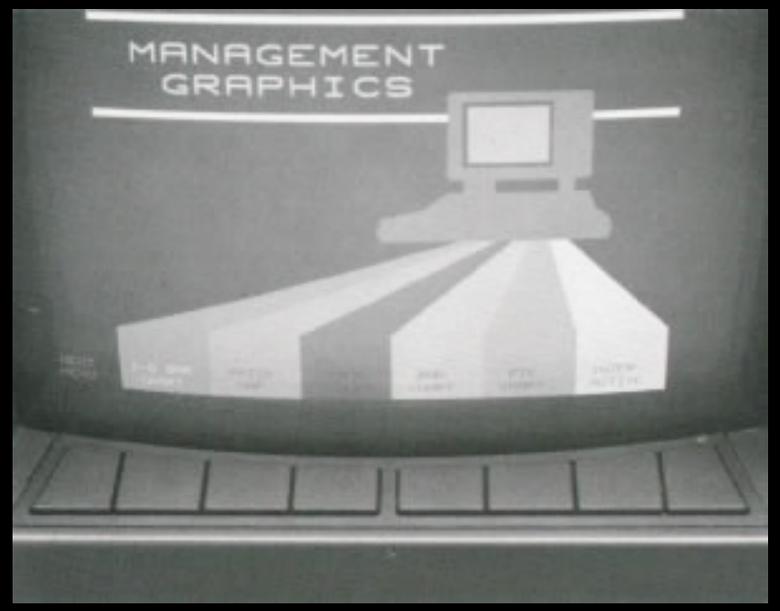
Bill Atkinson

(Night shift: design & code prototypes)

Larry Tesler

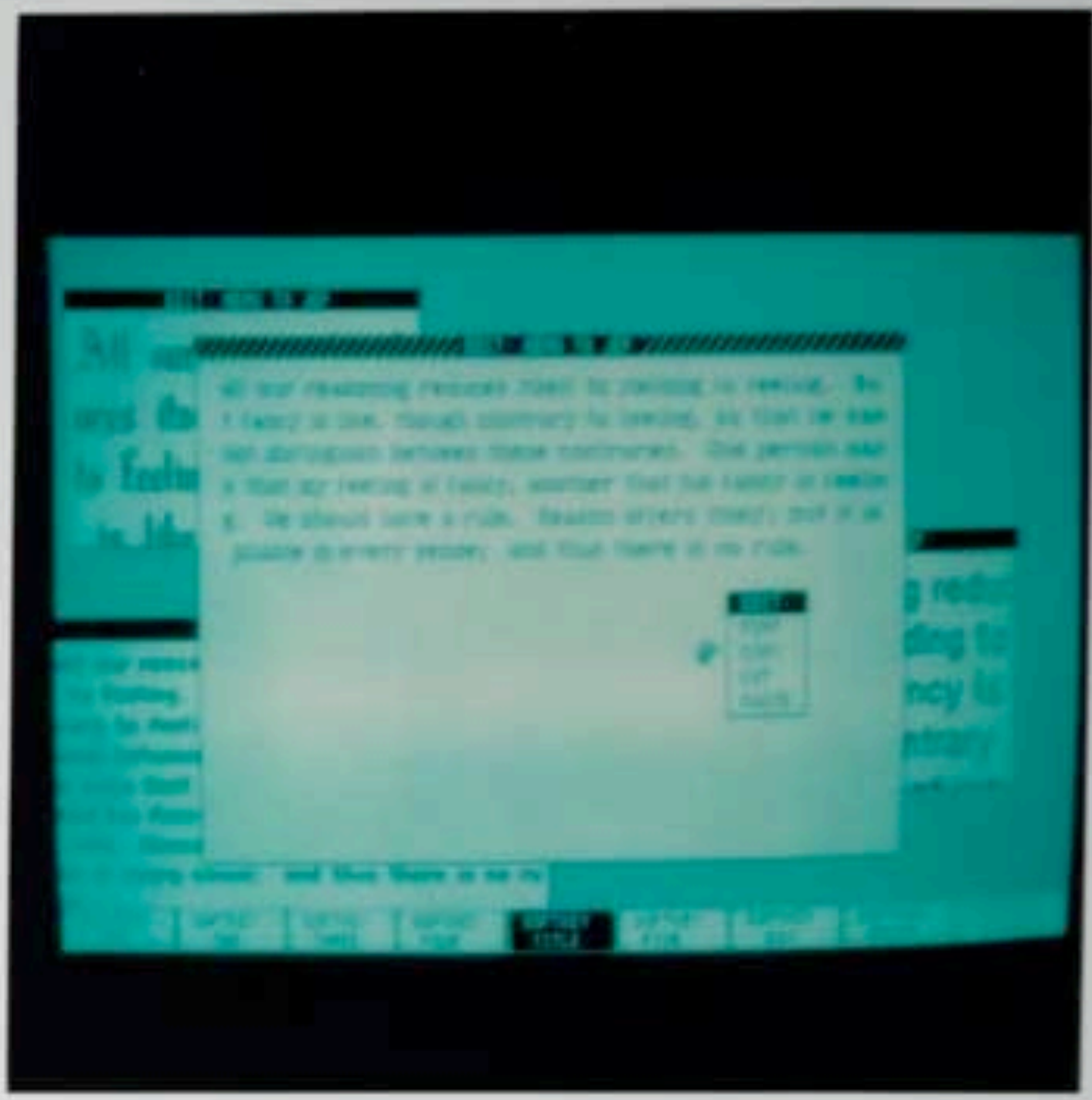
(Day shift: user tests)

Photos: www.wired.com, www.designinginteractions.com/



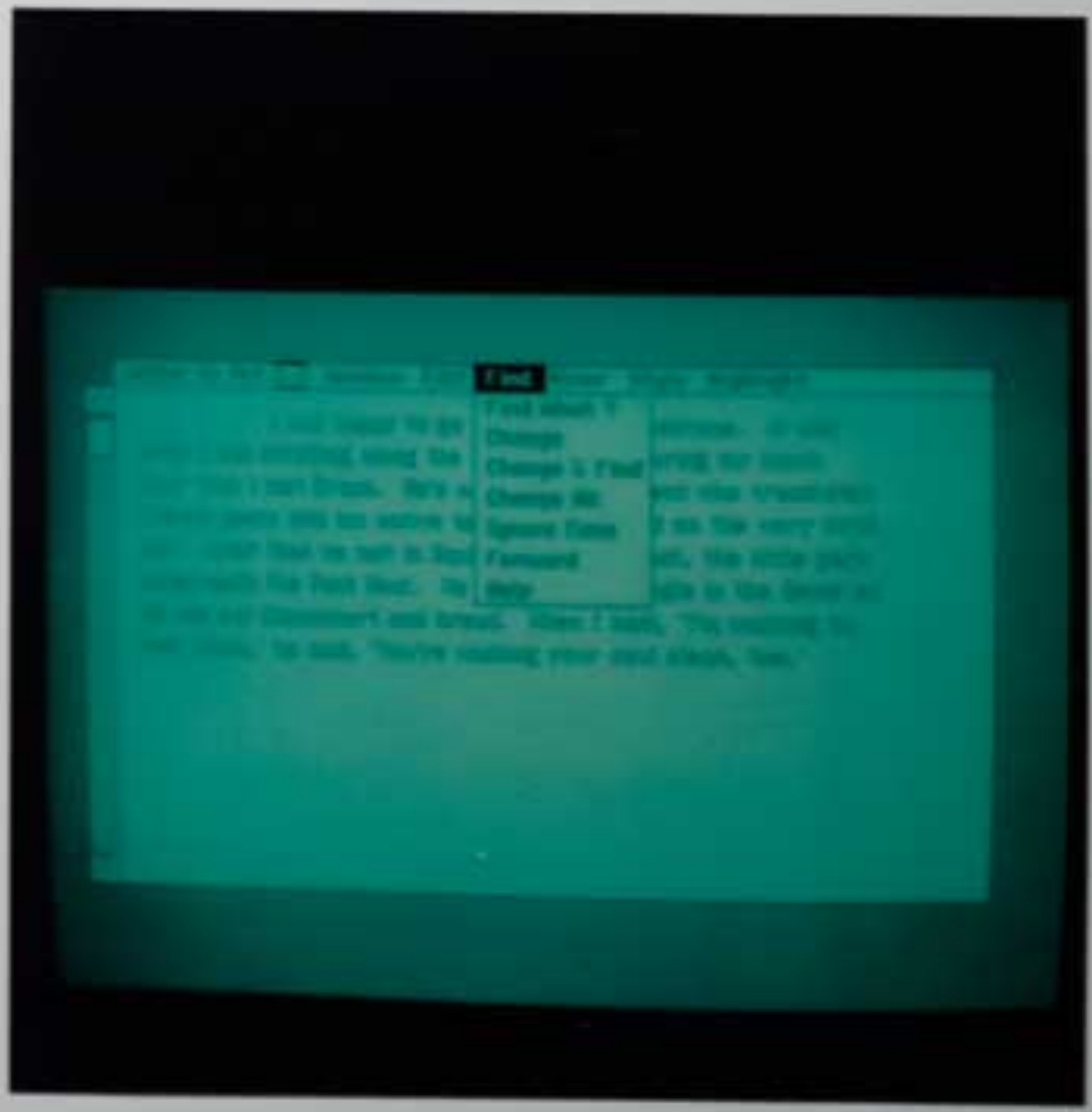
HP 6845C Soft-key menus

Initial Lisa
User Interface



windows + soft keys
pop-up menus

http://www.folklore.org

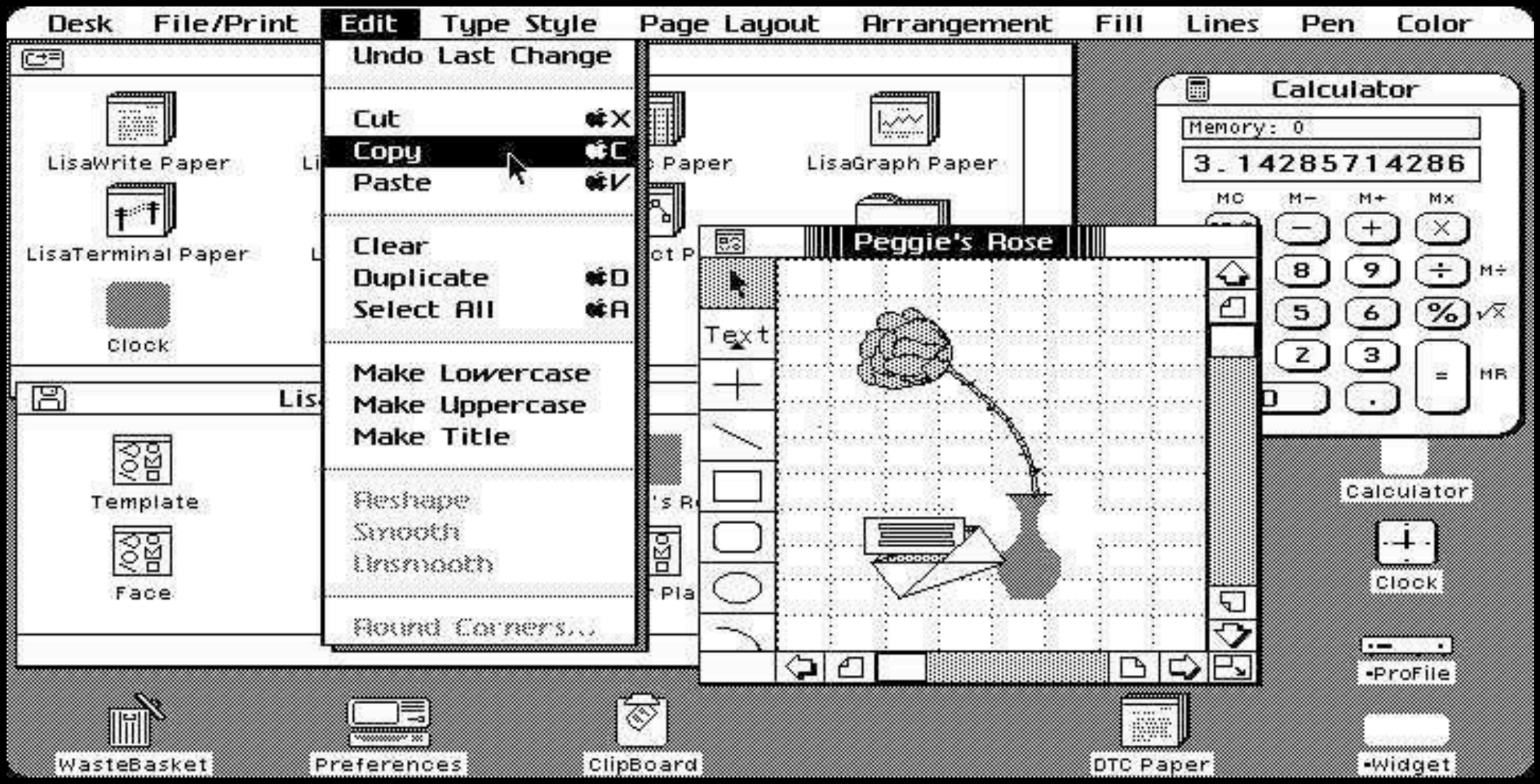


pull down menus, grow icon next to title, seperate horiz & vert scroll bars

http://www.folklore.org

Menus moved to top.
Grow icon in bottom right.
Both scroll bars required

http://www.folklore.org



Lisa User Interface

[Craig, 1993]

Auto Save in Lion (2011)

http://www.apple.com/macosx/

Auto Save in Lisa (1983)

Demo at CHI ’98: www.guidebookgallery.org/videos/lisachi98

New Feature in Mac OS X Lion (2011)

- Auto Save: Versions of documents are automatically saved.
  - Never lost hours of work after forgetting to save

- Resume: Restarting Mac or Application brings back the documents you opened

- Guess what? Lisa had these features since 1983!
  - Got lost in Mac due to hardware/software limitation at the time

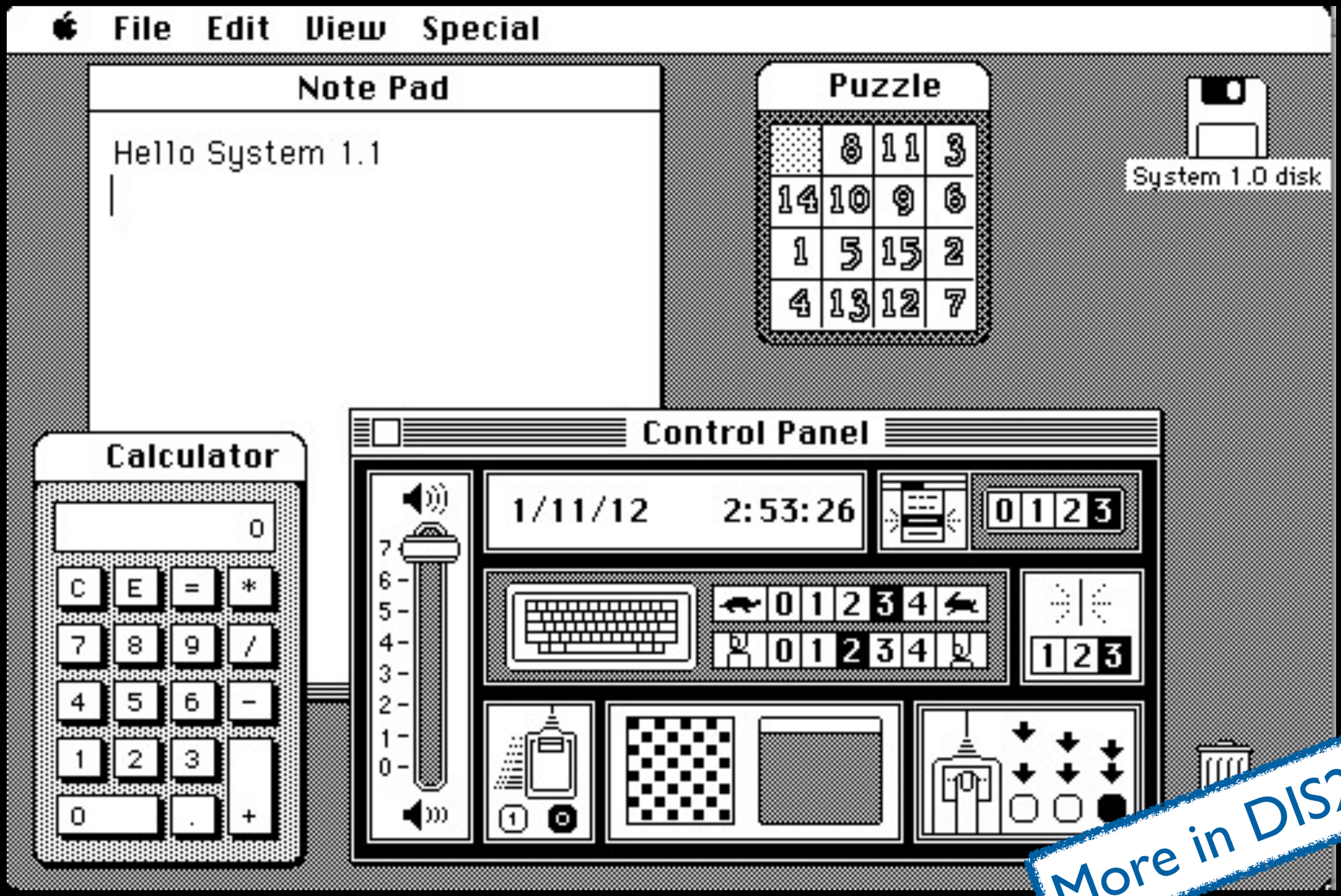
Apple Macintosh (1984)

- Lisa follow-up
- Key advances:
  - First commercially successful WIMP system, $2500
  - GUI affordable to huge new user community
  - Targeted at hobbyists, not just office use
  - Most consistent commercial WIMP UI

    Macintosh Human Interface Guidelines

    Apple Evangelists

- MacPaint & Quickdraw now open source
  - (http://www.computerhistory.org/highlights/macpaint/)

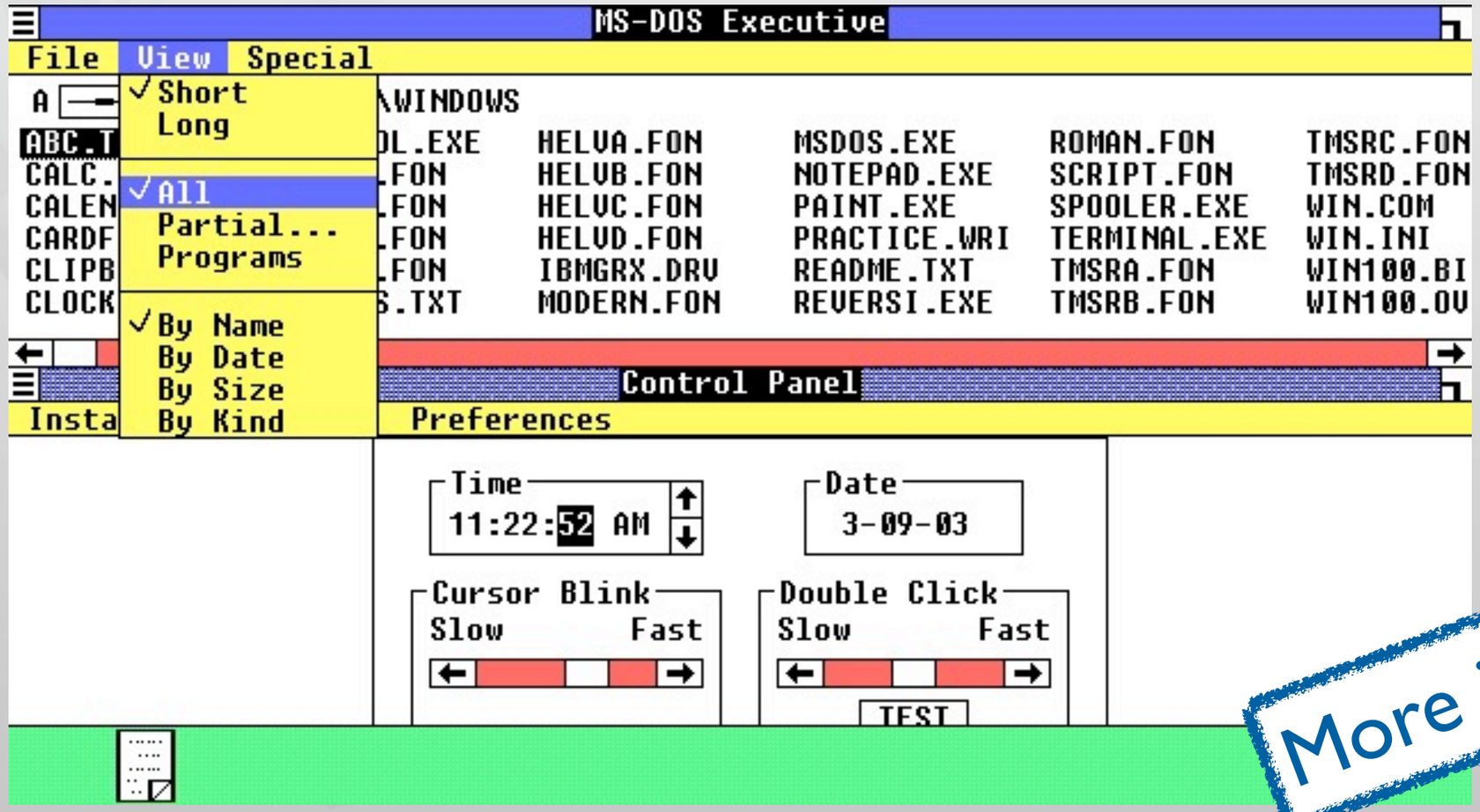


Macintosh System 1.1

Backspace
Tab
Q
W
E
R
T
Y
U
I
O
P
Caps Lock
A
S
D
F
G
H
J
K
L
Return
Shift
Z
X
C
V
B
N
M
Shift
Enter
Option
Option

Microsoft Windows (1985)

- Key advances: Bringing Alto/Star/Mac interaction style to huge populations of DOS and Unix computers

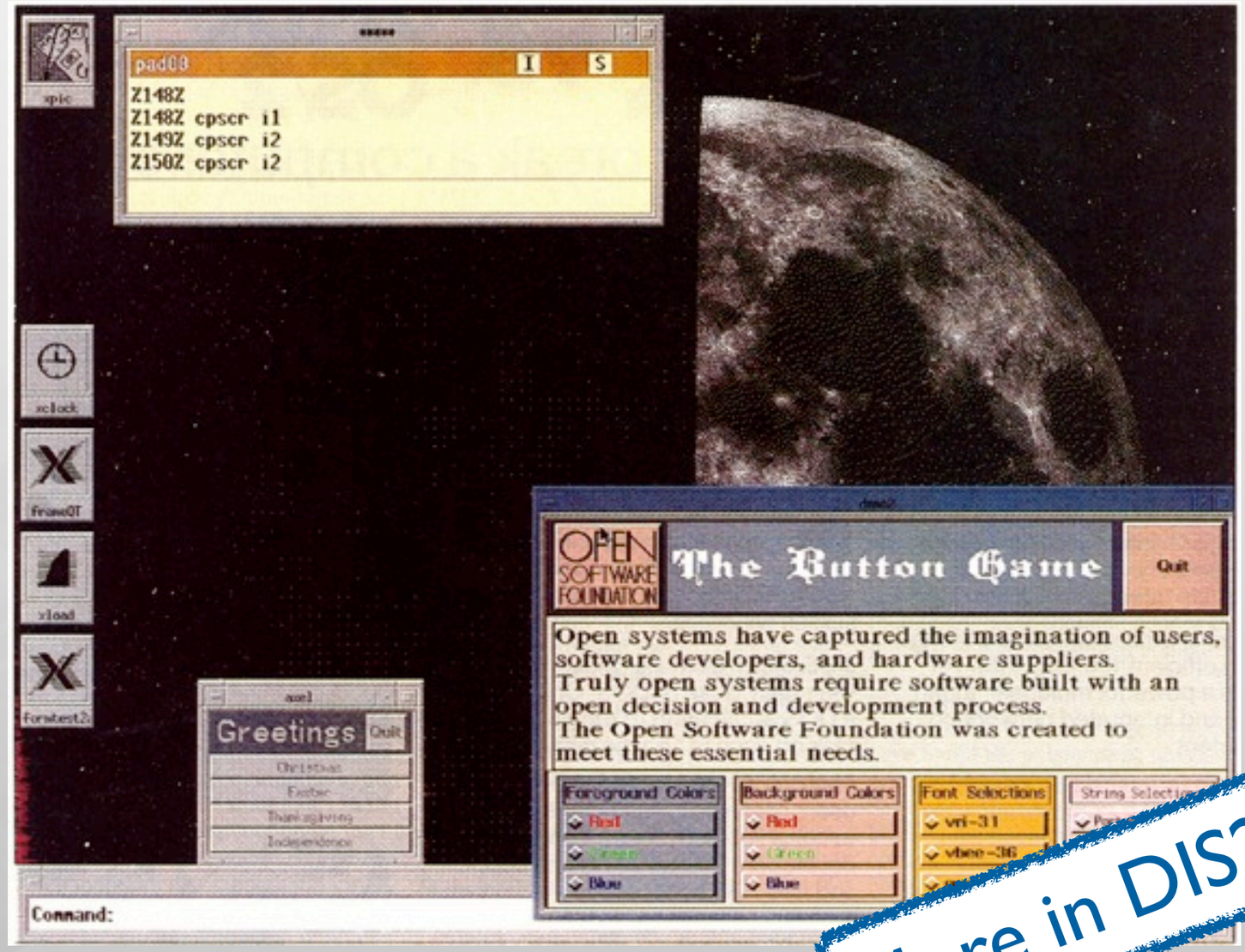


More in DIS2

www.guidebookgallery.org

OSF/Motif (1980's)

- Key advances: OO toolkit architecture (simpler dev.)



www.guidebookgallery.org

More in DIS2

Reading & Video Assignment

- Read "As we may think" by Vannevar Bush

- Watch videos and answer questions
  - Sketchpad
  - NLS Demo
  - Xerox Star

- Links & information will be announced on L²P