

The Alto and Ethernet System Xerox PARC in the 1970's

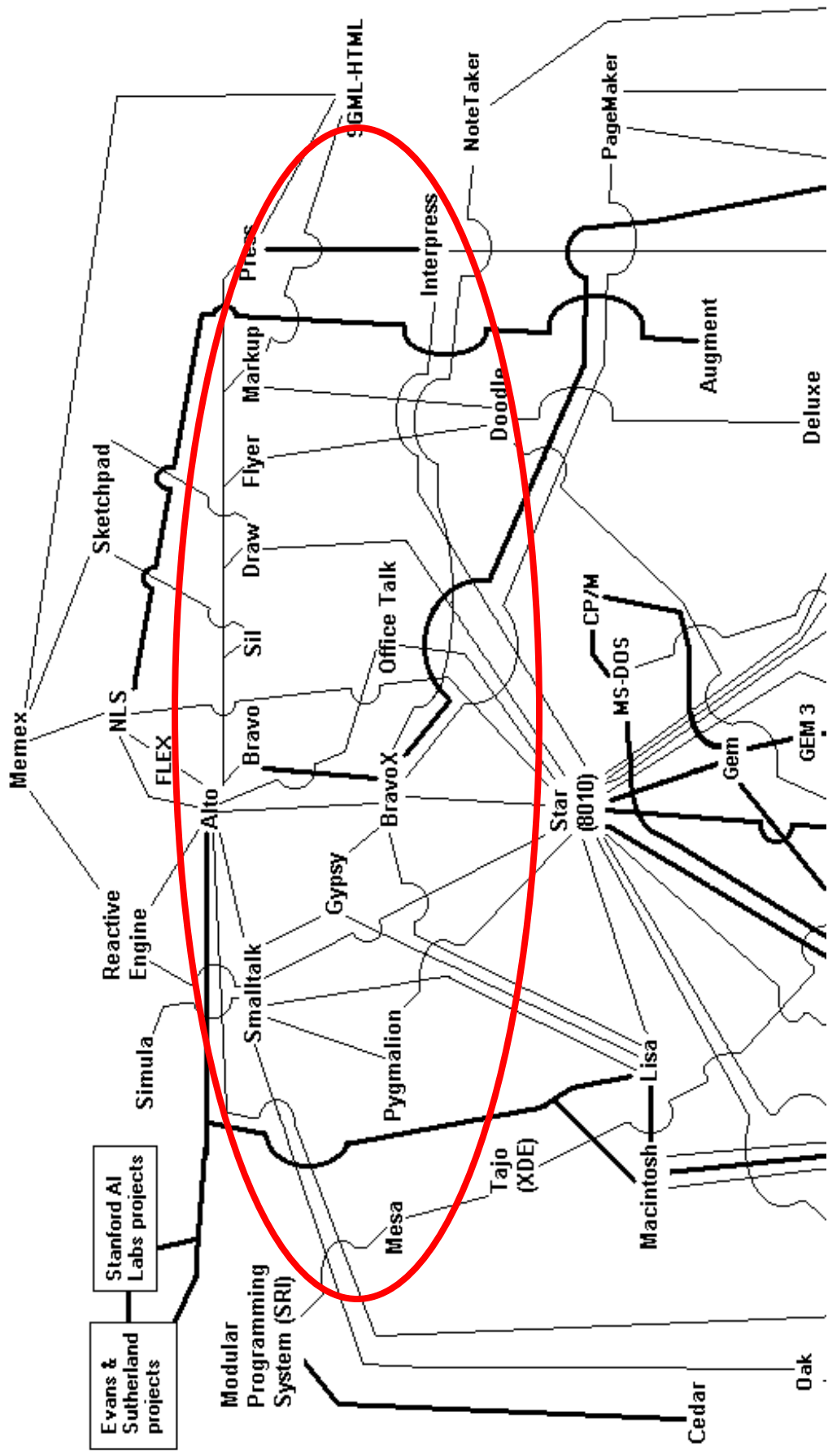


Butler Lampson
Microsoft Research
October 17, 2006

Influences—“On the shoulders of giants”

- ARPA community
 - Man-computer symbiosis—Licklider
 - Time-sharing: CTSS, SDS 940, Tenex
 - Engelbart’s On-Line System
 - Flex machine—Kay
 - Arpanet
 - Aloha packet radio network
- Xerox—“Office of the future”
 - The electronic office

Alto in Context



Organization

- CSL
 - Hardware: Alto, Ethernet
 - OS, Languages (BCPL, Mesa, Lisp)
 - Printing, file servers
 - Networking
 - Bravo (→ Word), Draw (→ Illustrator), fonts
 - Grapevine (email transport, server)
 - Laurel (email client)
- SSL
 - Printing, file servers
 - Smalltalk
 - Gypsy (→ Word)
 - Markup (→ Paint)

Timeline

- 1960s Time-sharing, Sketchpad, NLS
- 1970s Xerox PARC
Alto, Ethernet, laser printers
Bravo, Draw, Pup, Smalltalk
Altair, Apple II
Internet
- 1980s
81 Xerox Star, IBM PC
84 Macintosh, Laserwriter, MS Word/Excel
- 1990s Windows, Web

Themes

*But a man's reach should exceed his grasp, or
what's a heaven for? —Browning*

- Computers can be used as tools to help people think and communicate
 - Licklider
 - ARPA time-sharing and networking
 - Engelbart and NLS
 - Alan Kay and Flex
- Xerox: Office of the Future
 - How do we grow after copiers?

Personal Distributed Computing

- Personal
 - Under the control of a person and serves his needs.
 - Performance is predictable, and *fast enough*
 - Reliable and available.
 - Not too hard to use
- Distributed
 - Everything in the real world is distributed
 - The computer is a communication device
 - Personal + communication = distributed
 - Need to share expensive devices too, esp. printers
- Computing
 - We programmed, but users didn't

Information Convenient For A Person

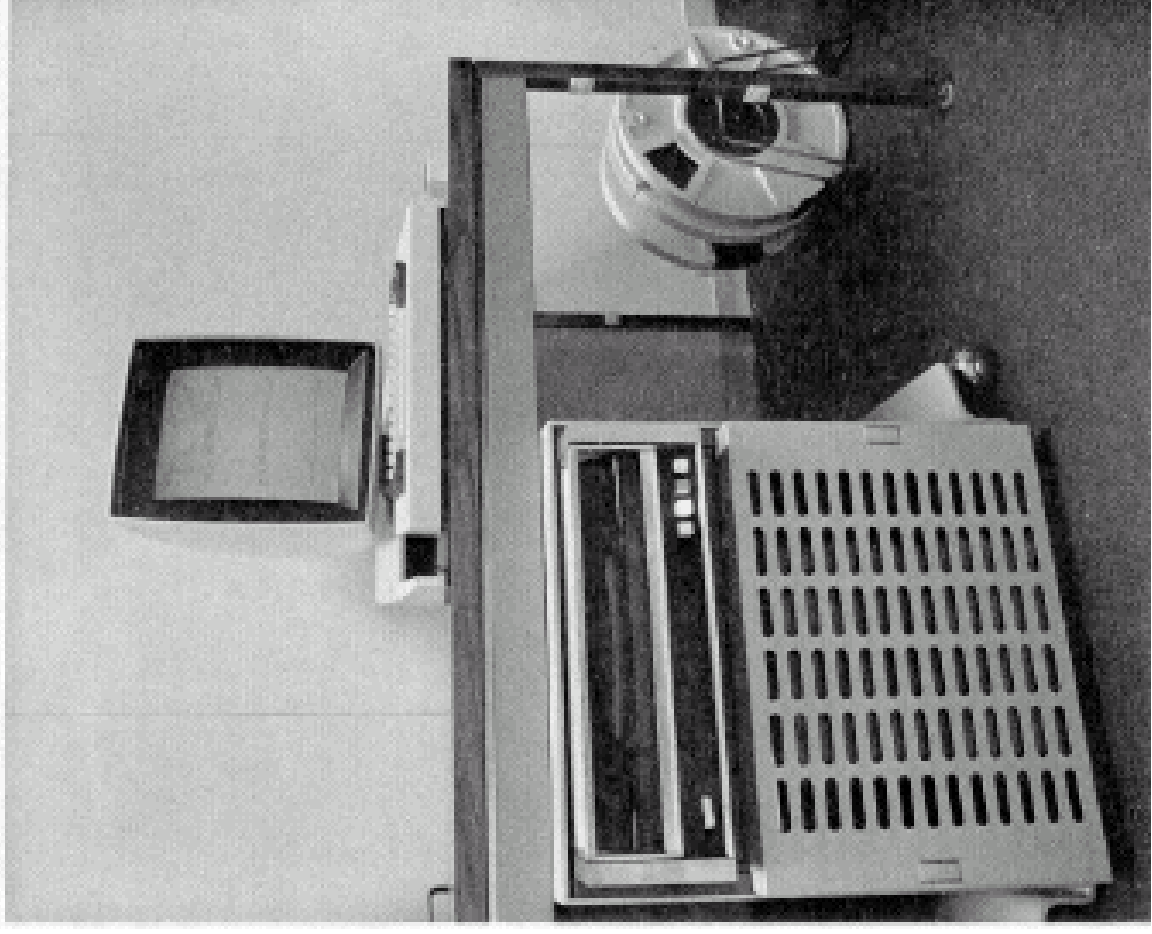
- **Universal**
 - Any (black-and-white) image, data, any software
 - Words, pictures, music, ...
 - Specialize with software
- **Ink on paper**
 - Present images
 - Point at places in the image
- **The Alto can do this quite well**
 - For a single 8.5" x 11" sheet of paper
 - With black ink
 - No restrictions on the form of the images
 - Cannot read images
- **Voice and other sounds.**
 - Later, less important

Principles

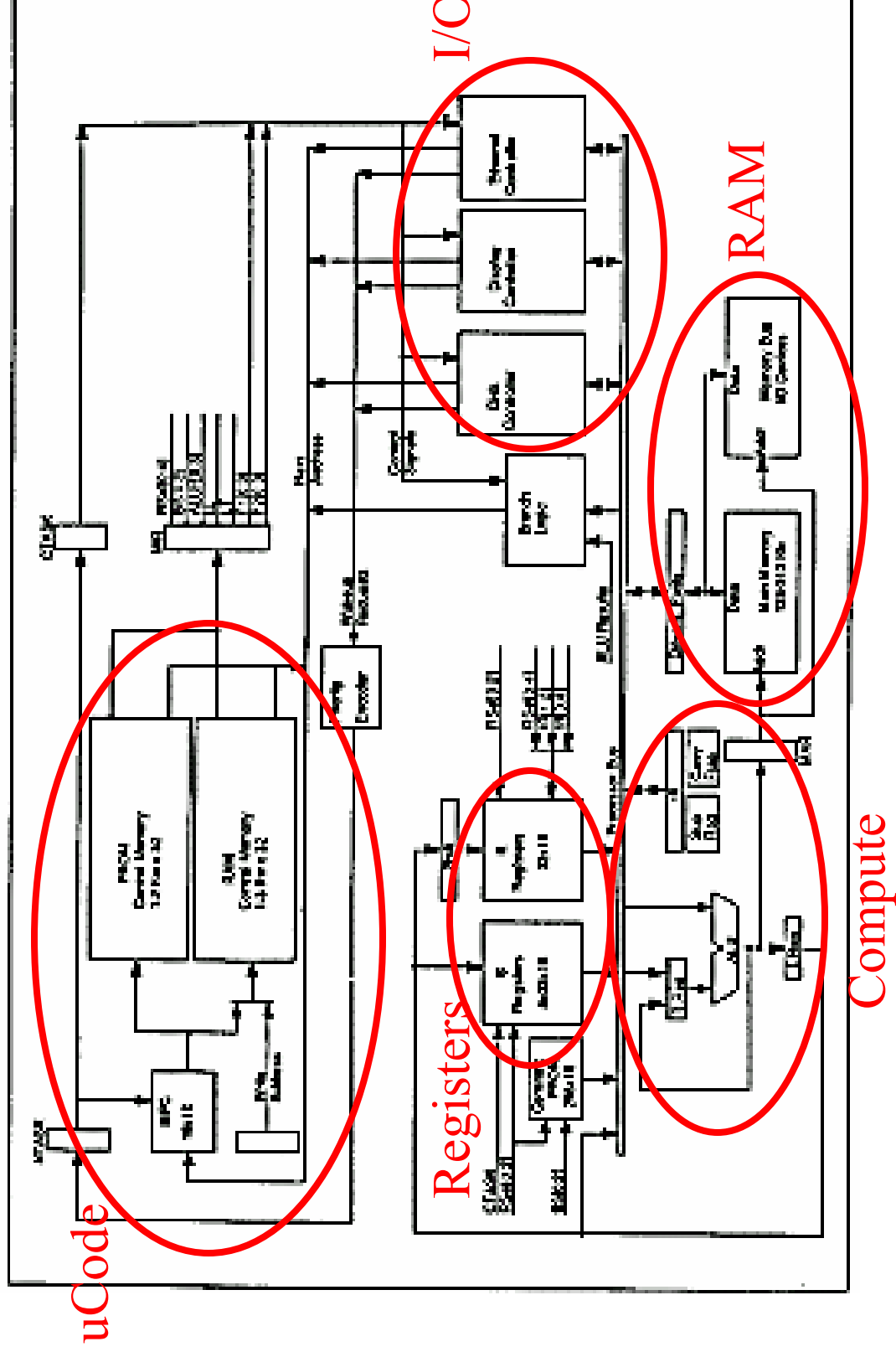
- “Time machine”—simulate the future
- Use what you build
 - Good for text, pictures, printing, sound, email
 - Bad for spreadsheets, databases
- Personal machine
 - “People are fast, machines are slow”
 - Performance is predictable
- No grand plan for the system: ~~integration~~
 - Not enough experience, cycles or memory
 - Open OS, world-swap
 - Exception: Smalltalk

Alto Hardware

- 0.3 MIPS
- 128 KB RAM
- 2.5 MB disk
- 3 Mbit Ethernet
 - for 50 Altos
- 600x800 x 1 display
- \$12,000 to make



Alto Block Diagram



Hardware

■ Moore's law: live in the future if you can

	Price	X	CPU	RAM	Disk	Net
		Alto	MIPS	MB	MB	MB/s
■ 1974: Alto	\$40k	1	0.3	0.1	2.5	.05
■ 1984: Mac	\$3k	1	1	0.5	1.5	.03
■ 1995: PC	\$3k	100	50	16	300	.1
■ 2006: PC	\$1k	10000	2000	1000	300G	100

Hardware Comparison

Item	Alto, 1973	Desktop PC 2006	Factor
CPU clock	6 MHz	3 GHz	500
RAM size	128 KB	1 GB	8000
RAM access	850 ns	100 ns	8.5
Display pixels	606 x 808 x 1	1600 x 1200 x 32	4 (pixels) 128 (bits)
Network	3 Mb Ethernet	1 Gb Ethernet	300
Disk capacity	2.5/5 MB	250 GB	100K
Cost	\$12,000 to make	\$1,000 to buy	12

Key Ideas For Hardware

■ KISS

- Had to be cheap enough to build lots of them

■ Bitmap display

- Display anything – like paper

■ Programmable at all levels

- Could change the instruction set and add new operations easily

■ Flexible and powerful input-output

- Ethernet and Laser Printer controllers were add-ins

■ Distributed system

- Connect many systems together with Ethernet

Alto In Use



Alto Awaiting Restoration



Ethernet

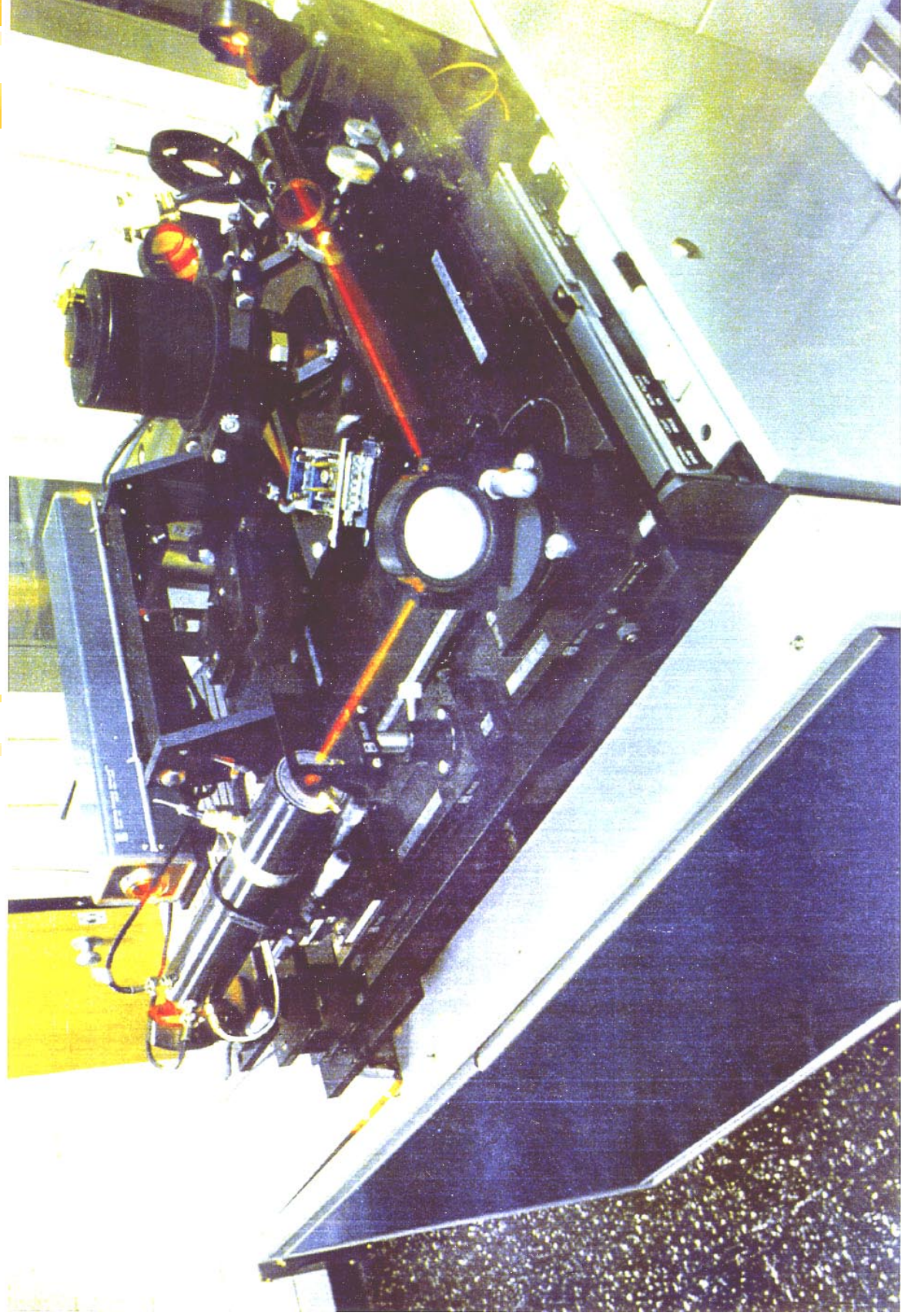
- CSMA/CD
 - Based on Aloha
 - Collision detect
 - Exp. Backoff
- 3 Mbits/sec
- Shared by 50 Altos
- Repeaters
- Much later, switches



Laser Printers

- Marriage of Xerography and Computing
- EARS was the first (1974) print *server*
 - Ethernet
 - Alto
 - Research Character Generator
 - Scanning Laser Output Terminal
- 1 copy/second, 500 dots/inch
- Lower-cost and color versions developed later
 - Dover: 300 dpi, small Alto interface. 100 copies
- Xerox understood it, built a successful business

SLOT Printer, 1972



10/17/06

Alto Personal Distributed Computing

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The software



- Programming
- Servers
- User interface
- Applications

- Software is “thought-stuff”

Programming: OS, languages

- Main problem: live with
 - .1 MIPS, 128 KB RAM, 5 MB disk
- OS: files, programs, network, command line
 - *Open*: get rid of any parts you don't need
 - World-swap to change environments
- Languages
 - BCPL: father of C
 - Mesa
 - Smalltalk

Servers

- Network: Ethernet and Pup
 - First internet: Ethernet, Arpanet, phone lines, ...
- Printing
 - 3 generations of laser printer hardware
 - 3 generations of imagers: Ears, Press, Interpress
- Files
 - “Interim” file system
 - Research file systems
- Email
 - Tenex Arpanet email
 - Grapevine distributed naming and email

User interfaces



- Windows
- Smalltalk pioneered overlapping windows
- Other software used tiled windows

Smalltalk

- Complete system
- OO language
- Integrated edit/debug
- Windows
- BitBlit

The screenshot shows the Smalltalk environment. On the left is a class browser with a tree view containing classes like `System Browser`, `Collections-Stream`, `Graphics-Display C`, and `Graphics-Media`. The main area is a code editor showing Smalltalk code for a `collect: aBlock` method and a `controlActivity` method. On the right, a graphical window displays a 3D bolt and nut. The window's title bar includes a menu bar with 'File', 'Edit', and 'Help', and a toolbar with icons for file operations and editing. The window content shows a bolt and nut with a 'FilledSkate.form' object associated with them.

Fig. 1.

```

collect: aBlock
    "Evaluate aBlock with each of my elements as the argument. C
    resulting values into a collection that is like me. Answer with
    collection. Override superclass in order to use add:, not at:put:."
    | newCollection |
    newCollection ← self species new.
    self do: [:each | newCollection add: (aBlock value: each)].
    ↵newCollection

User Interrupt
Paragraph>>characterBlockA tPoint:
Paragraph>>mouseSelectto:
CodeController(ParagraphEditor)>>processRedButton
CodeController(ParagraphEditor)>>processMouseButtons
CodeController(ParagraphEditor)>>controlActivity
CodeController(Controller)>>controlLoop

controlActivity
self scrollbarContainsCursor
ifTrue:
    [self scroll]
ifFalse:
    [self processKeybo
    self processMouseE

blueButt 31@537 corner:
scrollBar 68@770
marker
savedAre
paragrap
startBloc

[File] [Robson>SF>ScreenForm.st
[File] [Robson>SF>ScreenFormChanges.st
[File] [Robson>SF>WordGraphics.form
Rectangle fromUser origin
ScreenForm setFullPageWidth.
(Form readFrom: 'FilledSkate.form') edit
    
```


Bravo

■ First WYSIWYG editor

■ Prototype for MS Word

■ Initial ideas

□ Piece table for document

□ Cache line bit maps

■ Later

□ Fonts and layout

□ High-quality printing

□ Styles

■ Modeless UI from Gypsy

READY: Select operand or type command
Last command was LOOK
{A_substa...!_way_↓} {Computer...↓XEROX_↓}\$

Personal Distributed Computing The Alto and Ethernet Software

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Digital Equipment Corp. Systems Research Center

Abstract

The personal distributed computing system based on the Alto and the Ethernet was a major effort to make computers help people to think and communicate. A complex and diverse collection of software was built to pursue this goal, ranging from operating systems, programming environments, and communications software to printing and file servers, user interfaces, and applications such as editors, illustrators, and mail systems.

1. Introduction

A substantial computing system based on the Alto [Thacker et al.

Computer Science Laboratory
Xerox Palo Alto Research Center
3333 Coyote Hill Road
Palo Alto, California 94304

XEROX

Glen J. Culler
608 Litchfield Lane
Santa Barbara, CA 93109

Dear Glen:

This is a follow-up to earlier correspondence you received from Alan Perlis regarding the ACM Conference on the History of Personal Workstations. As you know, the conference is scheduled for January

User interfaces

- Windows
 - Smalltalk pioneered overlapping windows
 - Other software used tiled windows
- Views—compute what you see
 - Smalltalk browser
 - Bravo multiple document views
 - Laurel email folders

System Browser

Collections-Sequence
Collections-Text
Collections-Array
Collections-Stream
Collections-Support
Graphics-Primitives
Graphics-Display
Graphics-Media
Graphics-Paths

Interval
LinkedList
MappedCollection
OrderedCollection
SortedCollection

instance class

accessing
copying
adding
removing
enumerating
private

collect:
do:
do:andBetweenDo:
promoteFirstSuchT
reverse
reverseDo:
select:

collect: aBlock

"Evaluate aBlock with each of my elements as the argument. Collect the resulting values into a collection that is like me. Answer with a collection. Override superclass in order to use add:, not at:put:."

```
| newCollection |  
newCollection ← self species new.  
self do: [:each | newCollection add: (aBlock value: each)].  
↑newCollection
```

Laurel Email Header Pane

Laurel 6
Login please.
Friday May 1, 1981 11:07 am PDT
891 free disk pages
User {LaurelSupport.PA} New Mail Mail File {Tutorial} Quit

? 1 Apr. 27 LaurelSupport TO START YOUR TUTORIAL SESSION:
Point cursor at "Display" and click the left
mouse button

? 2 Apr. 27 LaurelSupport Displaying a selected message

? 3 Apr. 27 LaurelSupport Message number 3 in Tutorial.mail

? 4 Apr. 27 LaurelSupport "Delete" and "Undelete"

? 5 Apr. 27 LaurelSupport Movable boundaries

? 6 Apr. 27 LaurelSupport Thumbing

? 7 Apr. 27 LaurelSupport "New mail"

? 8 Apr. 27 LaurelSupport "Hardcopy"

? 9 Apr. 27 LaurelSupport Composing messages

? 10 Apr. 27 LaurelSupport Recipient names

Laurel/Grapevine

■ Distributed email system

- Multiple servers
- Names, mailboxes
- Eventual consistency

■ 3-pane window

- Headers
- Message in
- Message out

Laurel 6
Login please.
User {LaurelSupport.PA} New Mail Mail File {Tutorial} Quit

Friday May 1, 1981 11:07 am PDT

891 free disk pages

Quit

? 1 Apr. 27 LaurelSupport

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"Delete" and "Undelete"

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Movable boundaries

? 6 Apr. 27 LaurelSupport

Thumbing

? 7 Apr. 27 LaurelSupport

"New mail"

? 8 Apr. 27 LaurelSupport

"Hardcopy"

? 9 Apr. 27 LaurelSupport

Composing messages

? 10 Apr. 27 LaurelSupport

Recipient names

Display Delete Undelete Move to { } Hardcopy

Date: 27 April 1981 10:36 am PDT (Monday)

From: LaurelSupport.PA

Subject: TO START YOUR TUTORIAL SESSION: Point cursor at "Display" and
click the left mouse button

To: @NewUsers

Welcome to the community of Laurel Users. Laurel is the Alto program that
serves as your mail reading, composition and filing interface to the Distributed
Message System. Since you are reading this message, you have already learned to
use the "Display" command.

While reading a message in this middle region you have the ability to scroll up and
down as in Bravo, using the double-headed arrow cursor in the left margin. You
may also notice that if you hold down the left or right mouse button in the scroll
area, then continuous scrolling is performed. If the words End of Message in
italics are not visible, then there is more message to be seen, and you should scroll
up to see more.

When Laurel started up, it read in this mail file named Tutorial.mail. An index

New form Answer Forward Get Put Copy Run

Subject: ? Topic?

To: ? Recipients?

cc: ? CopiedTo? , LaurelSupport

? Message?

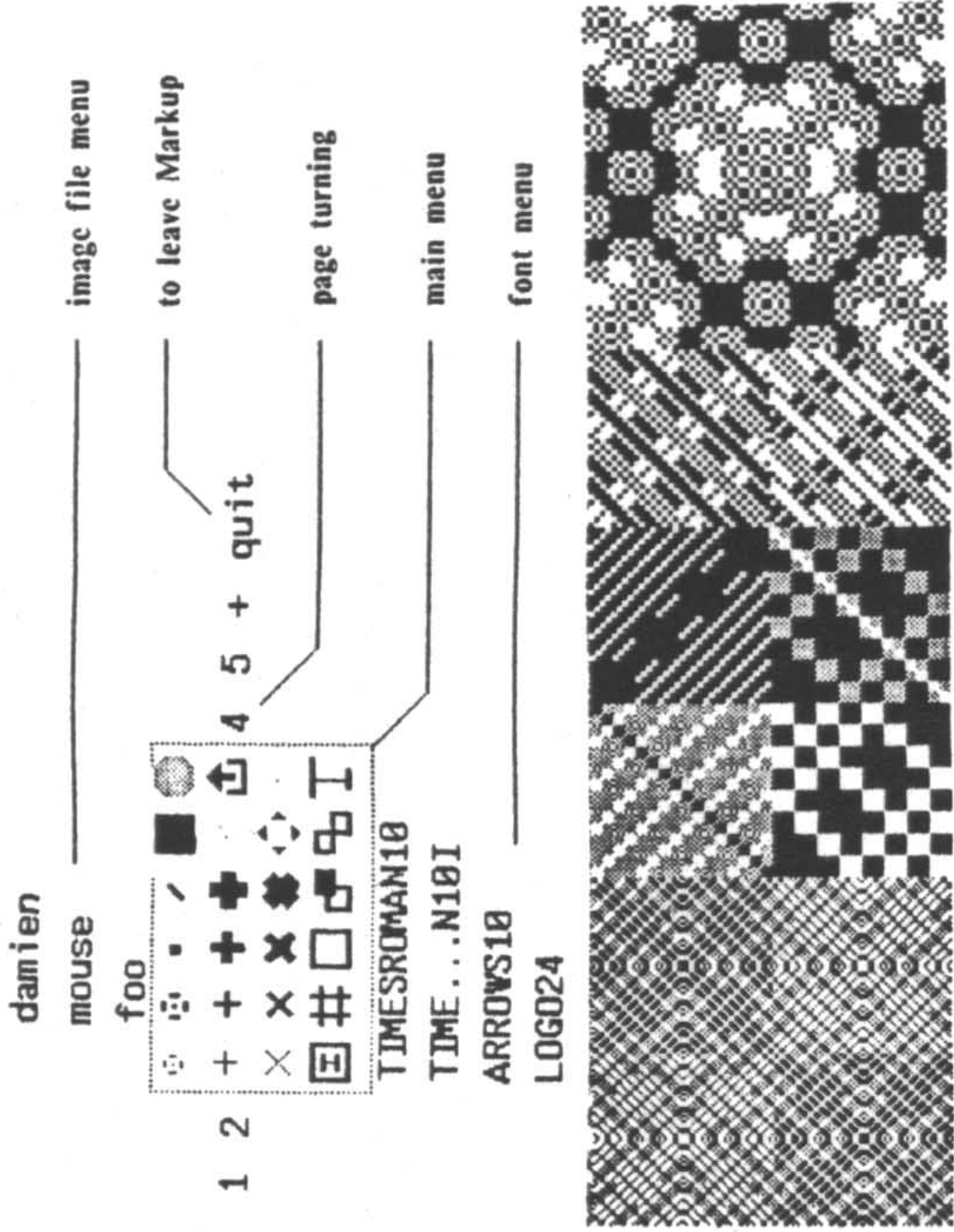
End of Message

Alto Personal Distributed Computing

User interfaces

- **Windows**
 - Smalltalk pioneered overlapping windows
 - Other software used tiled windows
- **Views—compute what you see**
 - Smalltalk browser
 - Bravo multiple document views
 - Laurel email folders
- **Menus**
 - Markup had pop-up menus
 - Smalltalk had the first icons

Markup's Popup Menu

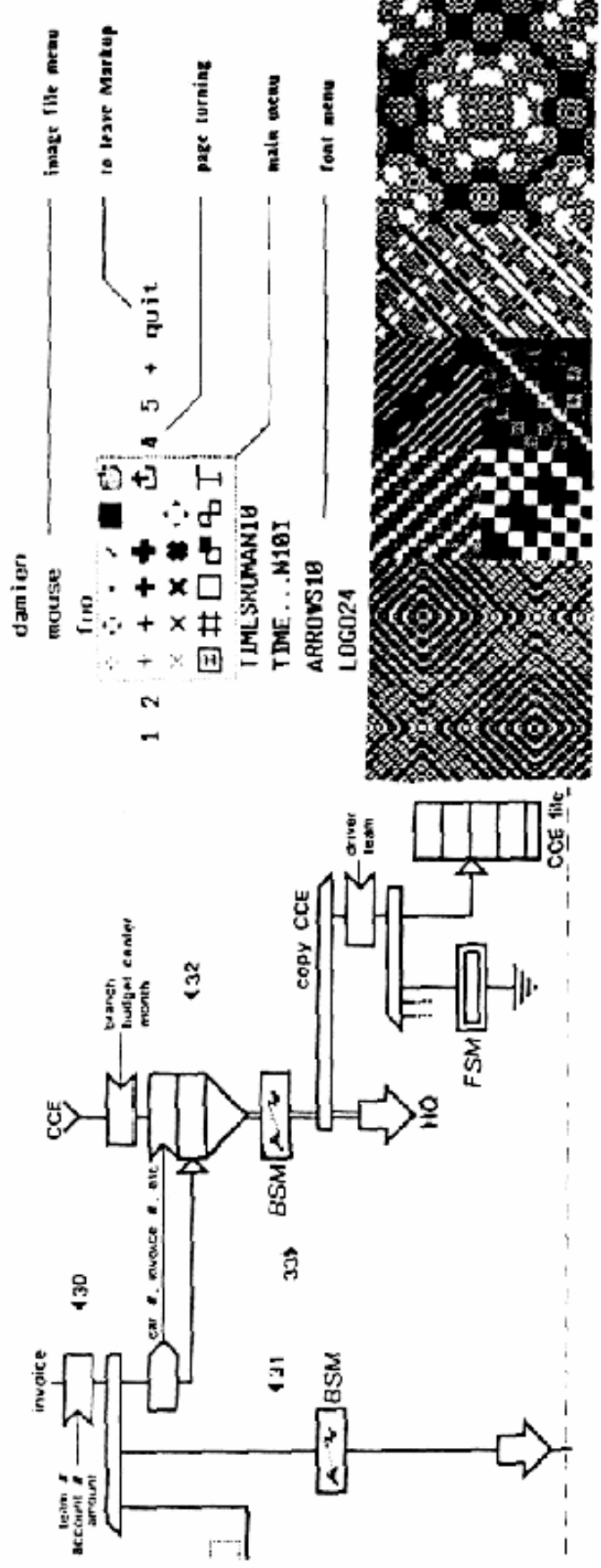


User interfaces: Displaying things

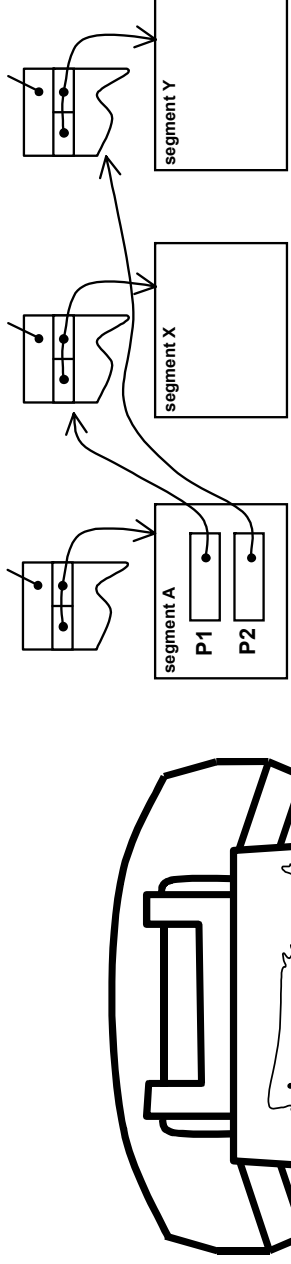
- Images
 - Bit-maps (as in Paint and Photoshop)
 - Object graphics (as in MacDraw and Illustrator)
- Fonts
 - Spline outlines for scalable fonts
 - Screen versions hand-drawn—hinting much later
- BitBlt
 - Computing with rectangular bitmaps

Markup

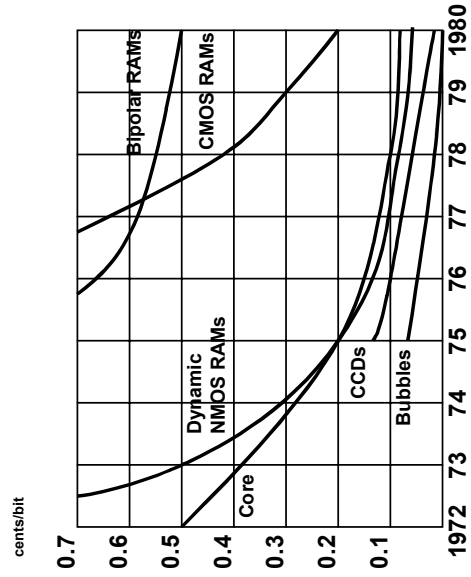
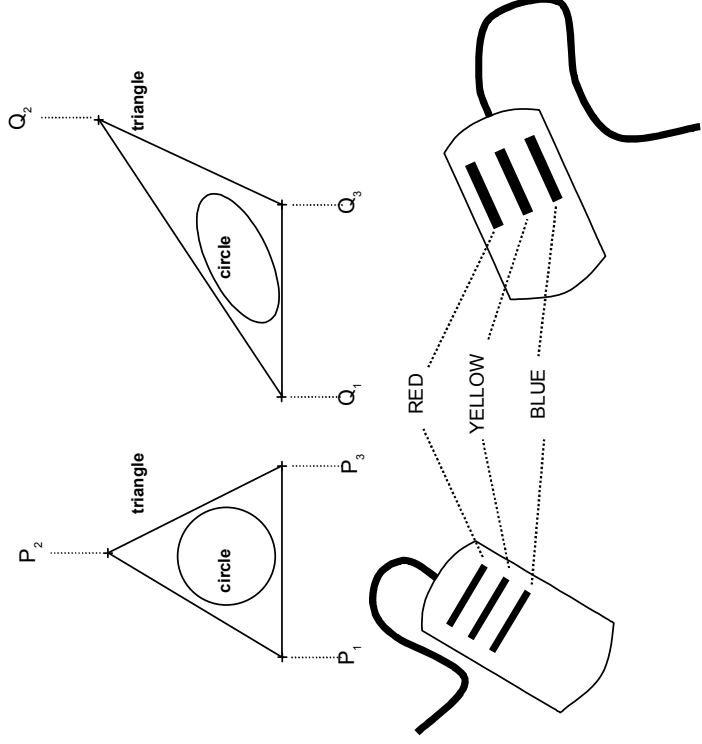
- Pure bit-map editing
- Arbitrary images
- Low resolution
- Popup menu



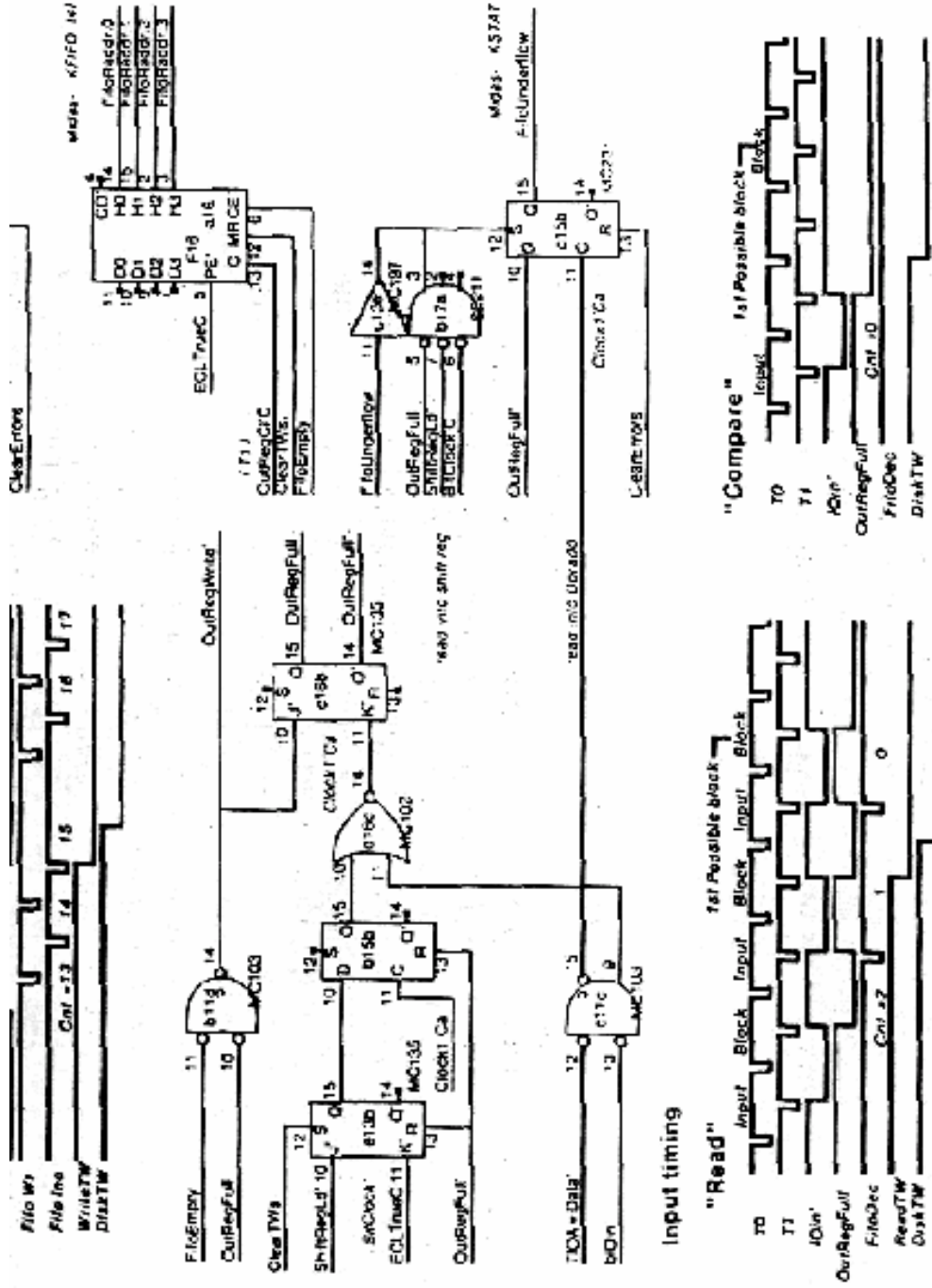
Draw



The transformation is specified by six points (say, in the order of input: $P_1, P_2, P_3, Q_1, Q_2,$ and Q_3). It is defined by the mapping of the source triangle $P_1P_2P_3$ into the target triangle $Q_1Q_2Q_3$ as illustrated here:



SIL for Logic Drawings



Author XEROX PARC	Drawing DORBOC	F. # FIFO Control	Design TriccnD08.sil	Date 9/24/79	Page 4
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Cedar

The screenshot shows the Cedar desktop environment. At the top is a menu bar with options like File, Edit, and Help. Below it is a toolbar with various icons. The main window, titled "A Cedar ToolBox", contains several tool icons arranged in a grid. These include "Type address", "Debug Tool", "MISP", "Cedar Mail Tools", "Performance Wats", "Need on Interpreter?", "Watch", "Tools", "Component", "Interface", "Performance Tools", "Component", "MISP", "Cedar Mail Tools", "Type address", "Debug Tool", "MISP", "Cedar Mail Tools".

Below the tool icons, there is a message window with the following content:

Message: cedartell@3
Date: 35-Nov-82 16:44 14 PST
Subject: phones & addresses
From: cedartell.pa
To: CedarDeleaver.pa
Reply-To: cedartell.pa
Categories: Addresses

I've made two programs for printing out phones and addresses sorted by people's last names CedarDB. It makes a little pocket listing suitable to put in your wallet (see me for example assumes you have phone and address relations such as the ones I use in PDB, and it only people in your database that (1) have phone numbers and/or addresses specified, and (2) are connected by a member relation to a "phone list" entry (in case you have some you want to

The bottom of the screen shows a task bar with icons for "Messages", "Mail", "Tools", "Performance Wats", "Need on Interpreter?", "Watch", "Tools", "Component", "Interface", "Performance Tools", "Component", "MISP", "Cedar Mail Tools", "Type address", "Debug Tool", "MISP", "Cedar Mail Tools".

Applications

- Writing: Bravo → Microsoft Word
- Drawing
 - Markup → Paint programs
 - Draw → MacDraw, Illustrator, Powerpoint, etc.
 - Sil → CAD programs
- Email: Laurel → mh, Eudora, Outlook, etc.

What the Alto system was like

- Just like today's personal computing world
 - Writing, drawing, music, networks, printing, email
- Except
 - The Web, search engines
 - Spreadsheets
 - Integration
 - Speed

Boca Raton—1976

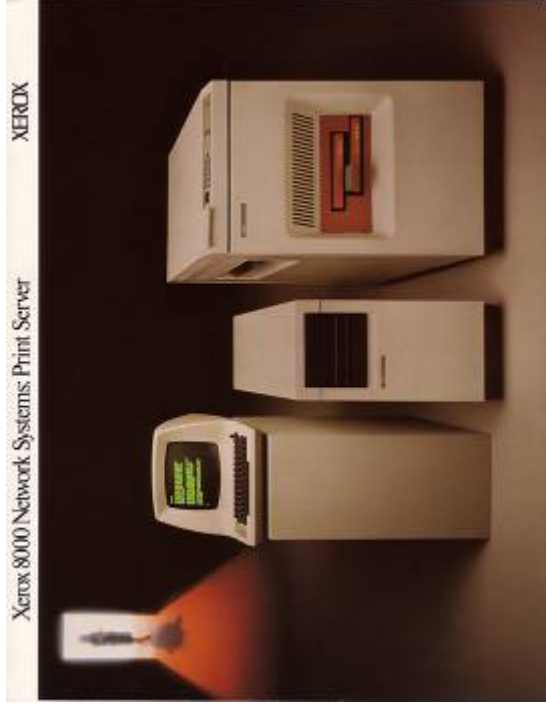
- Big show-and-tell for Xerox execs
 - Lots of Altos
 - Ethernet
 - Laser printers
 - The apps you've seen
- Goal: Get Xerox to make products
- Result: Systems Development Division
 - Star office system
 - Limited sales of Alto office systems
 - E.g., to White House

What Xerox did with the Alto

- Electronic printing—many billions of dollars
- Xerox Star—Office system
- Fumbled the future?
 - Yes, but the real story is more interesting
- “It’s easier to get a venture capitalist to give you money than to persuade the management of a large, successful company to try something new.”
—Gordon Moore

Xerox Products: Printing

- 9700—2 pages/sec computer printer
 - Based on Xerox 9200 copier
 - Hence sheet fed, good paper handling
 - Hence blue laser
 - “Character generator” based on PARC RCG
 - Competition: IBM laser printer
 - Fan-fold paper
- Low end printers
 - First for Star—8000 print server
 - Later OEMed, but too expensive
- Interpress—ancestor of Postscript



Xerox Products: Star Office System

- Star, shipped 1981 (same as IBM PC)
 - Ran on Dandelion processor
- Built on Mesa and Pilot
 - Reliable, somewhat slow
- Highly integrated
 - Editing, spreadsheet, filing, printing
- Best office system for at least 10 years
 - Roughly = 1995 MS Windows /Office
 - Didn't sell—too expensive, closed
 - \$20-25k/workstation in total; 25,000 sold
 - Apple Lisa in 1982 failed for the same reasons
- Irony: researchers wanted a much simpler product



What Went Wrong?

■ Printing

- ❑ Xerox focus on high end copiers and printers
 - “No money in low end”
- ❑ Target existing markets: computer printing
 - Office printing ignored. Apple, HP won this in 1985

■ Star Office System

- ❑ Engineers had a vision, and achieved it
 - A wonderful system: 10 years ahead of its time
 - Too expensive, inflexible
- ❑ Overwhelmed by IBM PC wave
- ❑ Researchers pushed for something more like Alto

What Others Did with the Alto



Ethernet

Xerox-DEC-Intel

Laser printing, Postscript

Adobe, Canon, HP

Lisa, Macintosh

Apple

Windows, Word

Microsoft

Workstations

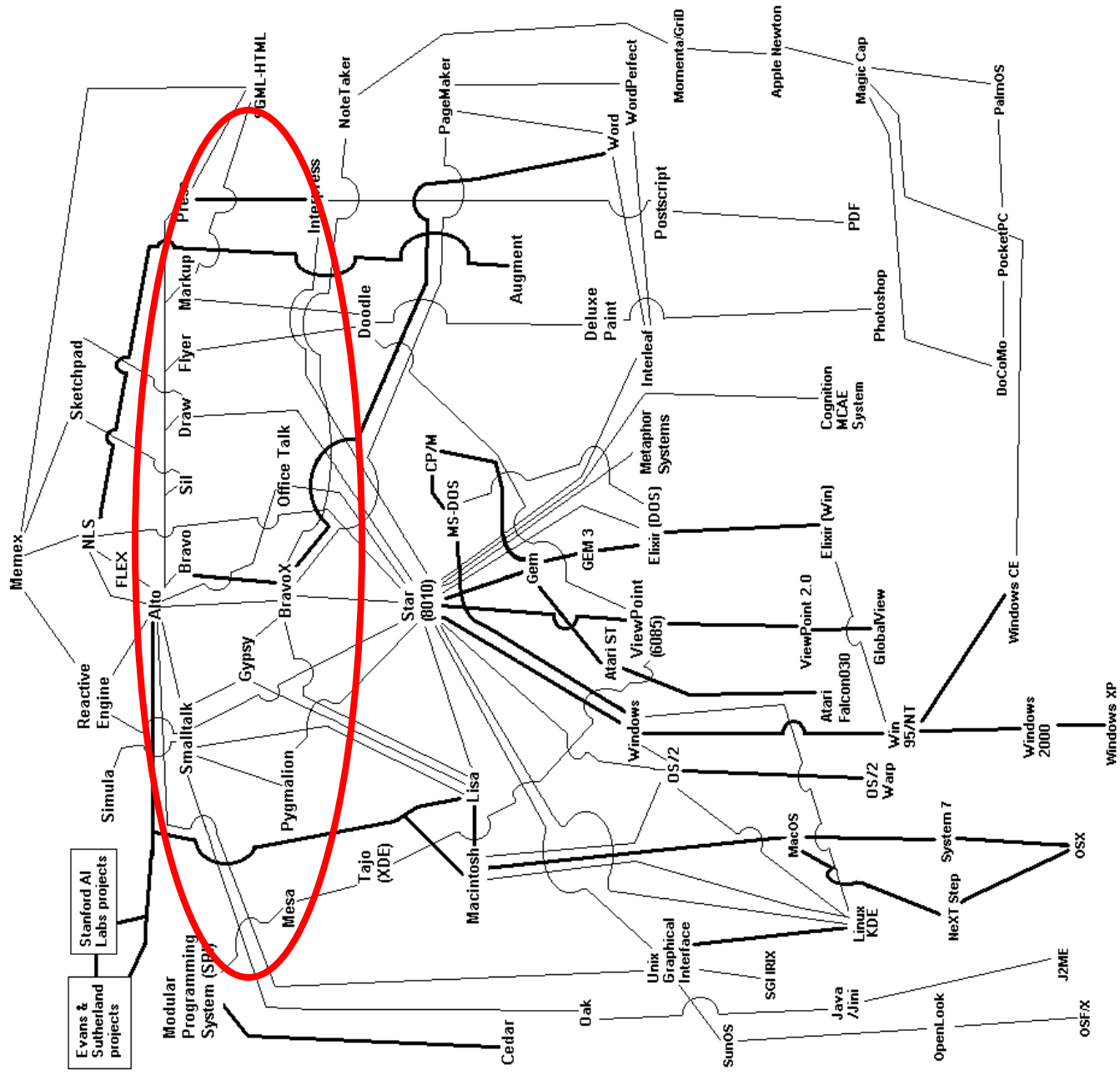
Apollo, Sun, Lisp machines

Networking

Internet, Novell

File and print servers

Novell



Today

- Today's PC is about 10,000 X an Alto
- Where did all the resources go?
 - Visual fidelity and elegance
 - Integration
 - Backward compatibility
 - Scale—books, not just memos
 - Time to market
 - Response time
- Did we foresee it?
 - Of course: Moore's law.

Tomorrow

- “The best way to predict the future is to invent it.”
- Are computers boring now? Hardly!
- Computers are good for three things:
 - 1955: Simulation
 - 1980: Communication
 - 2005: Embodiment—interact with the physical world
- The best is yet to come—see research.microsoft.com/gray
 - Robots
 - Computers that see, hear, talk, understand
 - Information at your fingertips