Ignored
Disposed of
Revived

Four Decades of Apple's Lisa

Michael Engel, VCFB, October 15th, 2023

How It Began

…from the Garage to a UFO

- 1976 **Apple I**
- 1977 **Apple][/][+**
- 1980 **Apple ///**
- 1983 **Apple //e**

- All use a **6502 CPU**
  - 8 bit, 1–1.8 MHz

A Walk in the PARC

The famous Xerox visits of 1979

- 1973: **Xerox Alto** innovations
  - Bitmapped display
  - GUI, windows, mouse
- 1979: **Xerox Star**
  - also: Ethernet, laser printing
- **Smalltalk**: inspiration for early UI experiments at Apple [1,2]

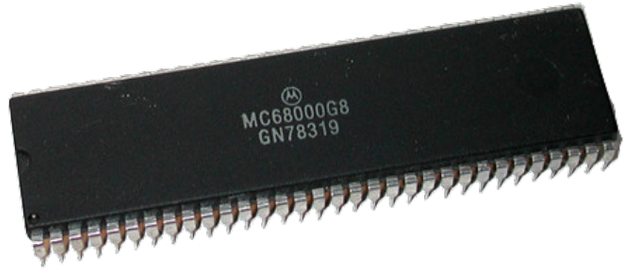
Something New

…the Apple][was sooo old!

- 1978: New projects at Apple
  - **Sara**: successor to the Apple II, using the same CPU, an 80-column display, additional memory, intended for small businesses ☞ **Apple ///**
- **Lisa**: ambitious, more expensive, easy-to-use, next generation office computer featuring a "revolutionary "graphical user interface (GUI)

The Lisa is born

…January 19, 1983: Lisa 1



- Uses the "new" **Motorola 68000**, 5 MHZ
  - So far only used in "Unix-y" micros (Sun 1, SGI Iris, Apollo)
- Memory: **1 MB RAM**, 16 kB ROM
- Screen: 12" b/w, ***rectangular pixels***, 720x364
- "Twiggy" floppy drives: 5.25", 871,424 bytes
- **5 MB** ProFile **hard disk**
- Price: **US$ 9,995 (!)**

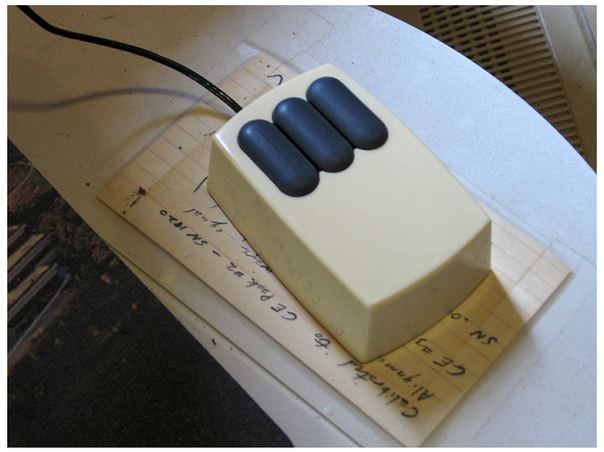
Lisa Hardware

…evolution

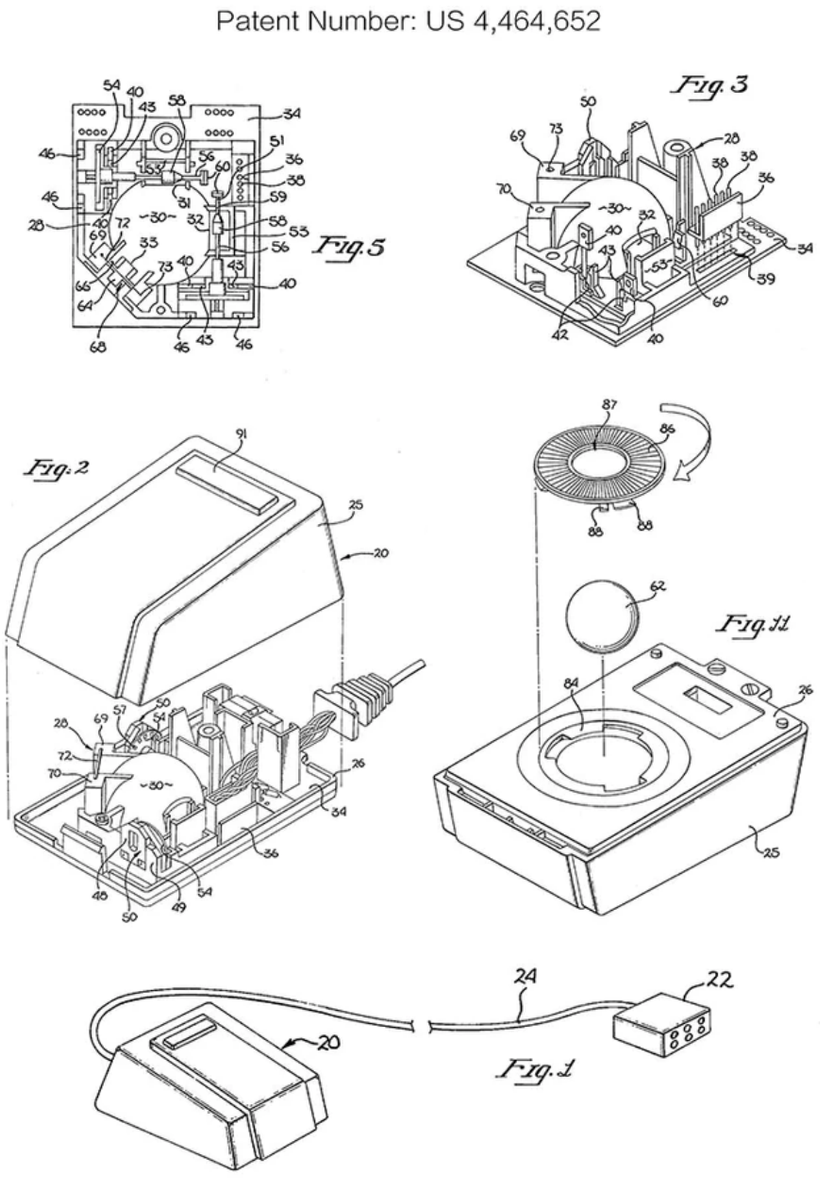
- Twiggy drives were unreliable
- 1984: **Lisa 2** introduced
  - Two Twiggys replaced by a single **400kB 3.5" Sony floppy**
  - Same drive as in Mac 128/512k
- Variants:
  - Lisa 2/5 – with 5 MB ProFile
  - Lisa 2/10 – internal 10 MB Widget

Mouse!

...Apple's own way



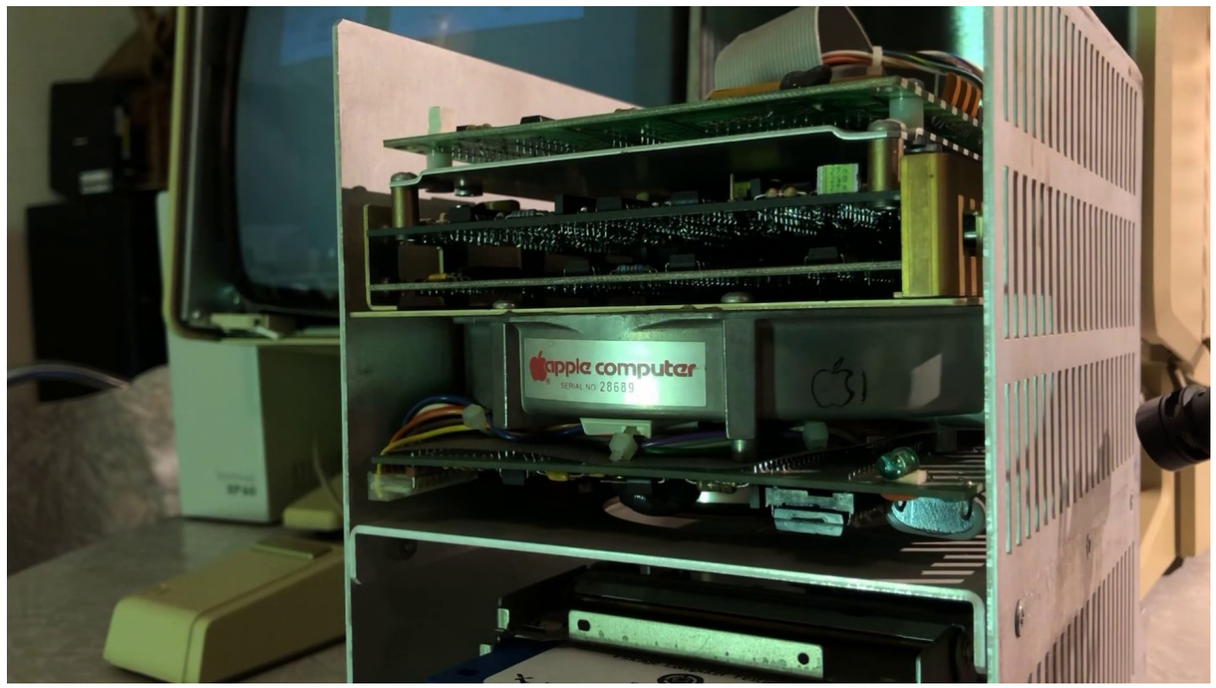
- Xerox mouse uses **three buttons**
  - "Too complicated" –
    which button for which function?
- Apple implements **single button mouse**
  - Uses a roller ball, quadrature encoding
- Later Lisas were delivered with the
  M0100 Mac mouse
  - Protocol and connector identical



Lisa Hard Disks

…ProFile vs. Widget

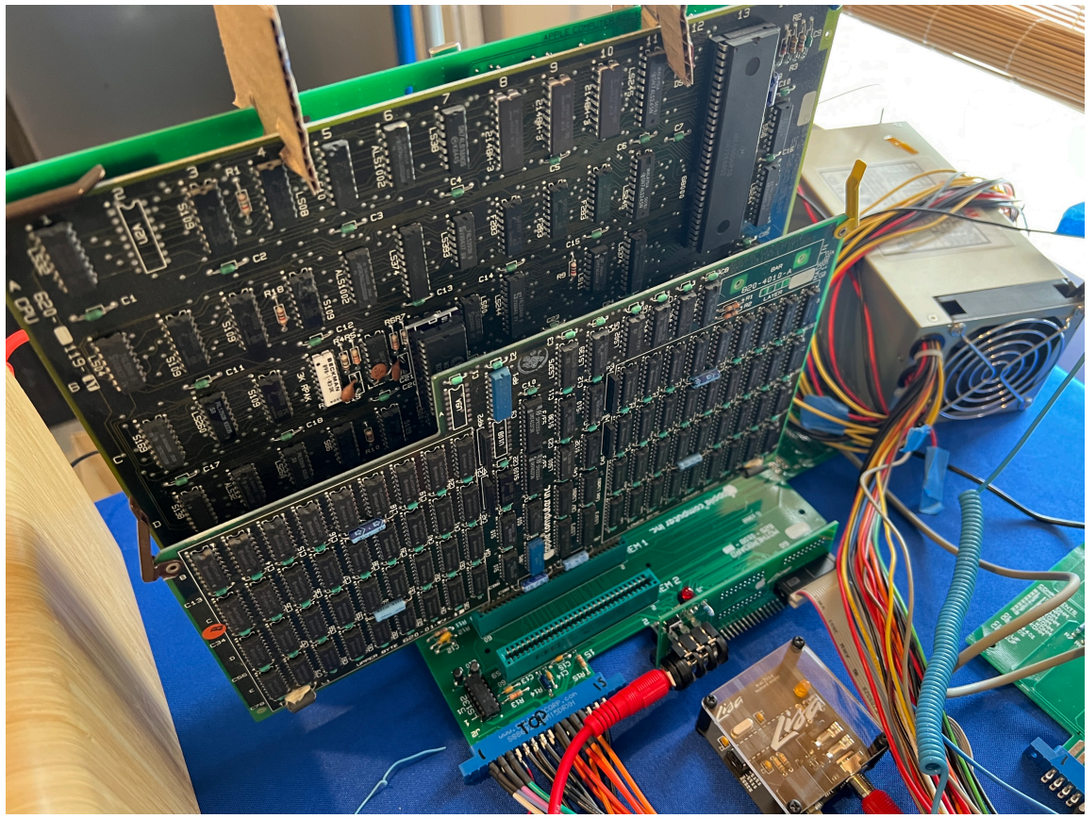
- **ProFile**
  - Seagate ST-506 stepper motor drive and mechanism
  - Without usual Seagate electronics
  - Digital and analog circuit board designed & manufactured by Apple
  - Also used for the Apple ///
  - Proprietary parallel interface
- **Widget**
  - 10 MB, Apple internally developed
  - Uses three Z8 microcontrollers



A Modular System

…wish we had this today…

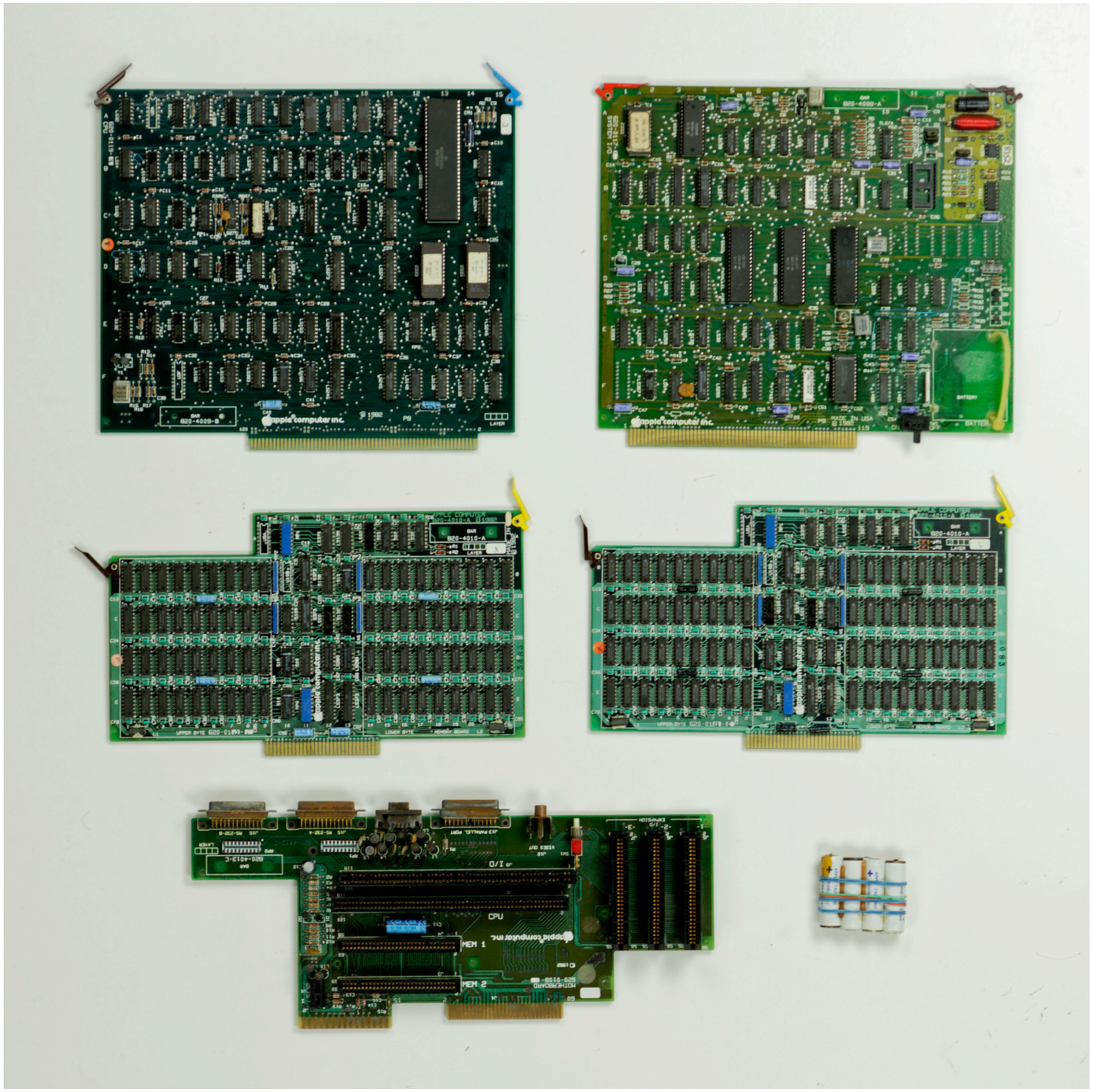
- Modular construction
  - Easy service
  - Thumbscrews
  - Safety interlock switches
- Expandable
  - Two RAM slots
  - Three I/O expansion slots



Lisa PCBs

…modularity!

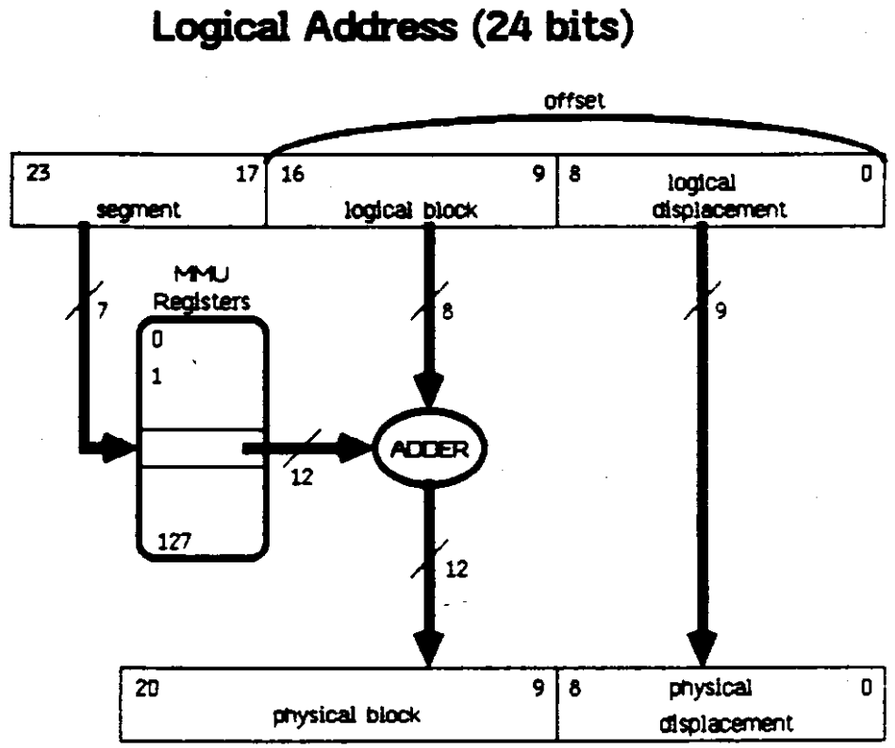
- **CPU board**
  - 68000 Processor + ROM
  - MMU, video
- **I/O board**
  - Parallel and serial interfaces
  - Floppy, keyboard, mouse
  - Power management
- **Memory board**(s)
  - Lots of 4164 DRAMs…
- "Mainboard" (**backplane**)

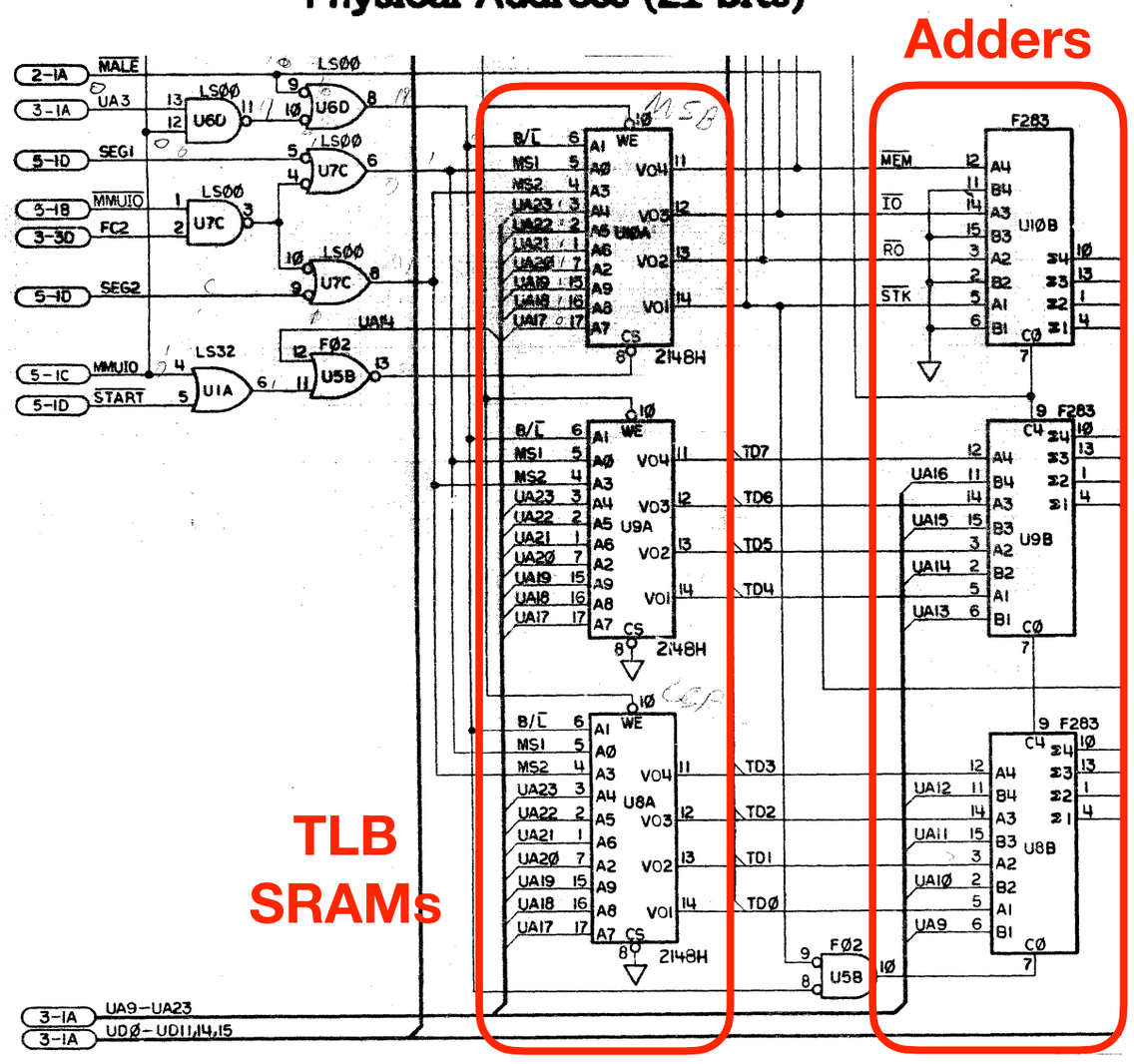


Hardware Details

…advanced features!

- **No custom ASICs** used [6]
  - Mostly 74-series TTL logic
  - VLSI chips: 68000, 6522, Z8530
  - Two bipolar 256x8 bit PROMs
- **MMU** uses discrete components [4]
  - SRAMs (2148, 1k x 4 bits)
  - fast adders (74F283)
- **I/O coprocessors**
  - 6504 – a tiny Apple][subset
  - COPS421 4-bit controller

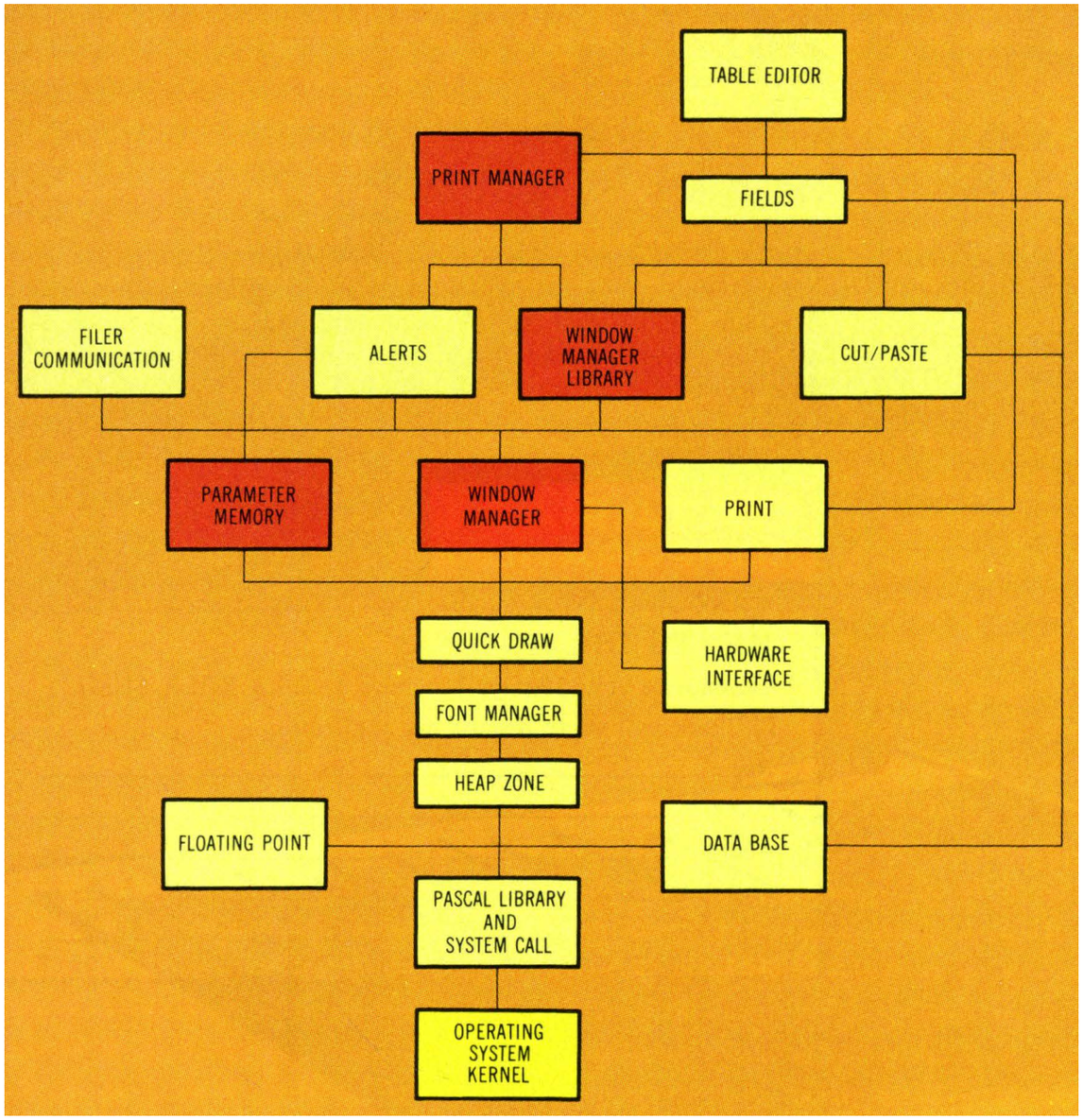




Lisa Software

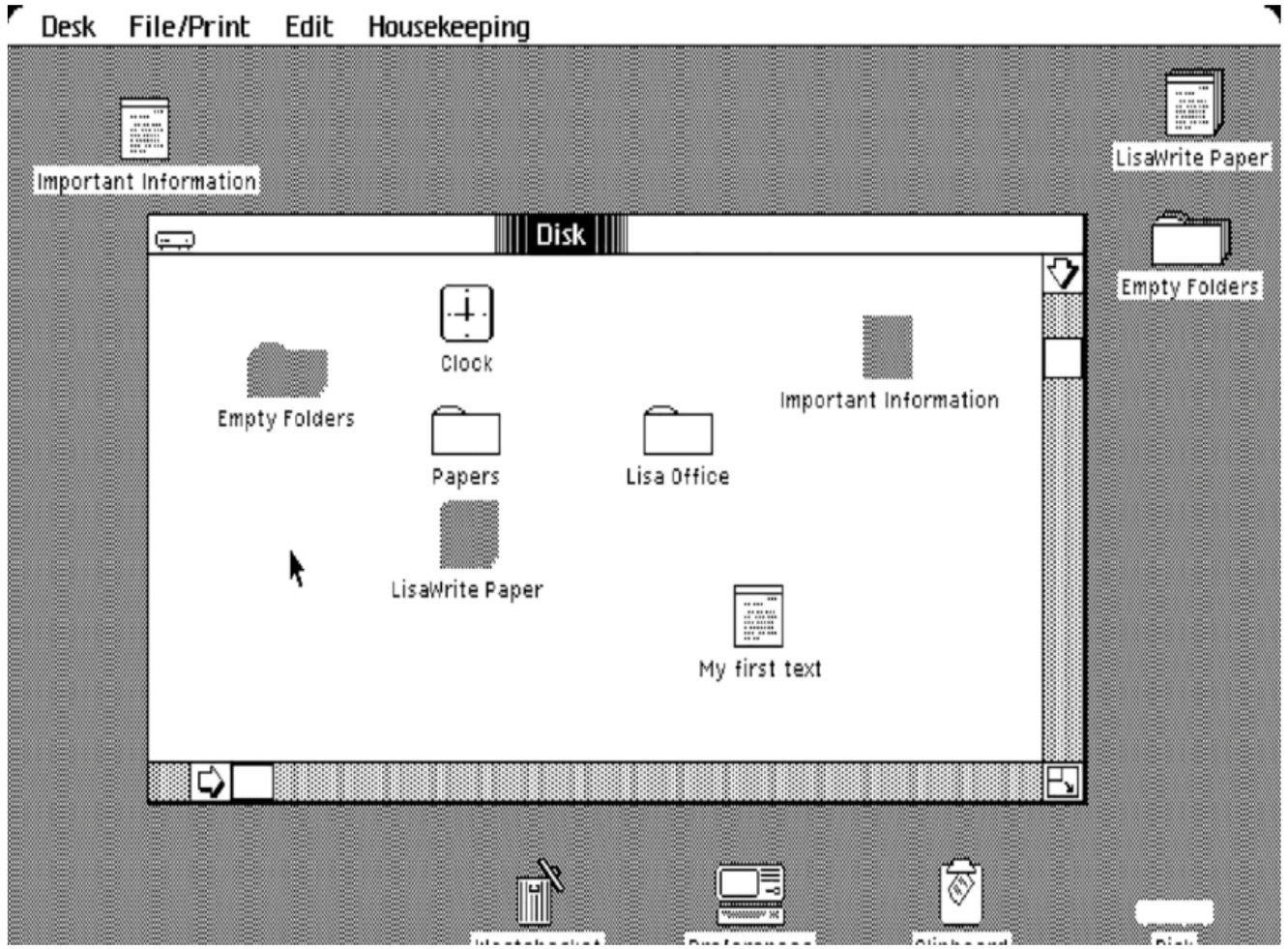
...operating system

- **LOS**: Lisa Office System / OS [5]
  - "Local Integrated Software Architecture"
    - Idea: build an office system
- OS and apps written in Pascal
- Cooperative multitasking
- Protected virtual memory
- Hierarchical file management

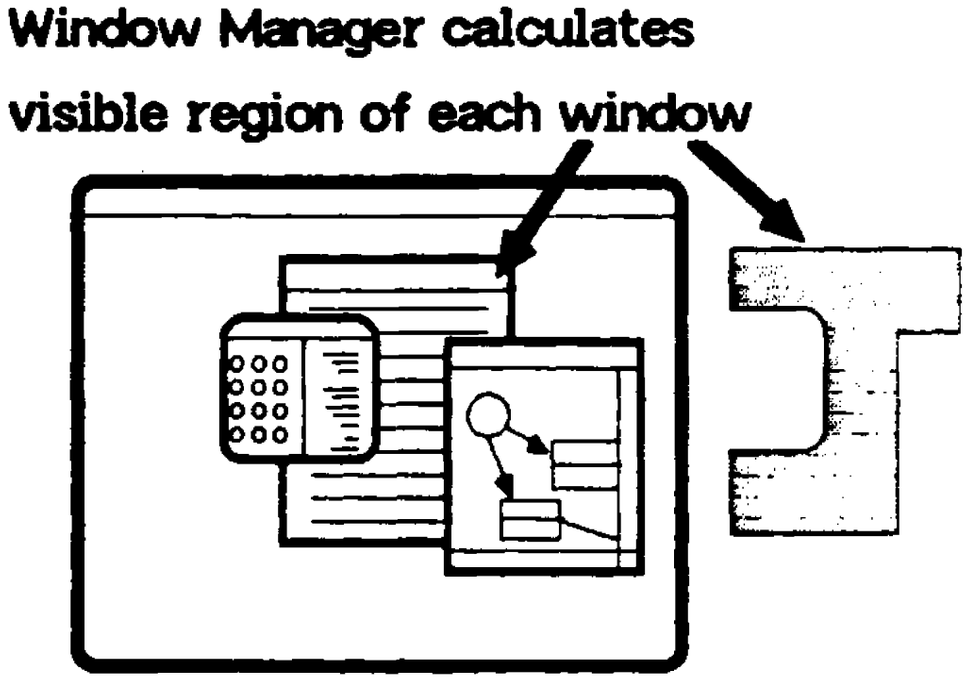


Lisa Software

…innovations

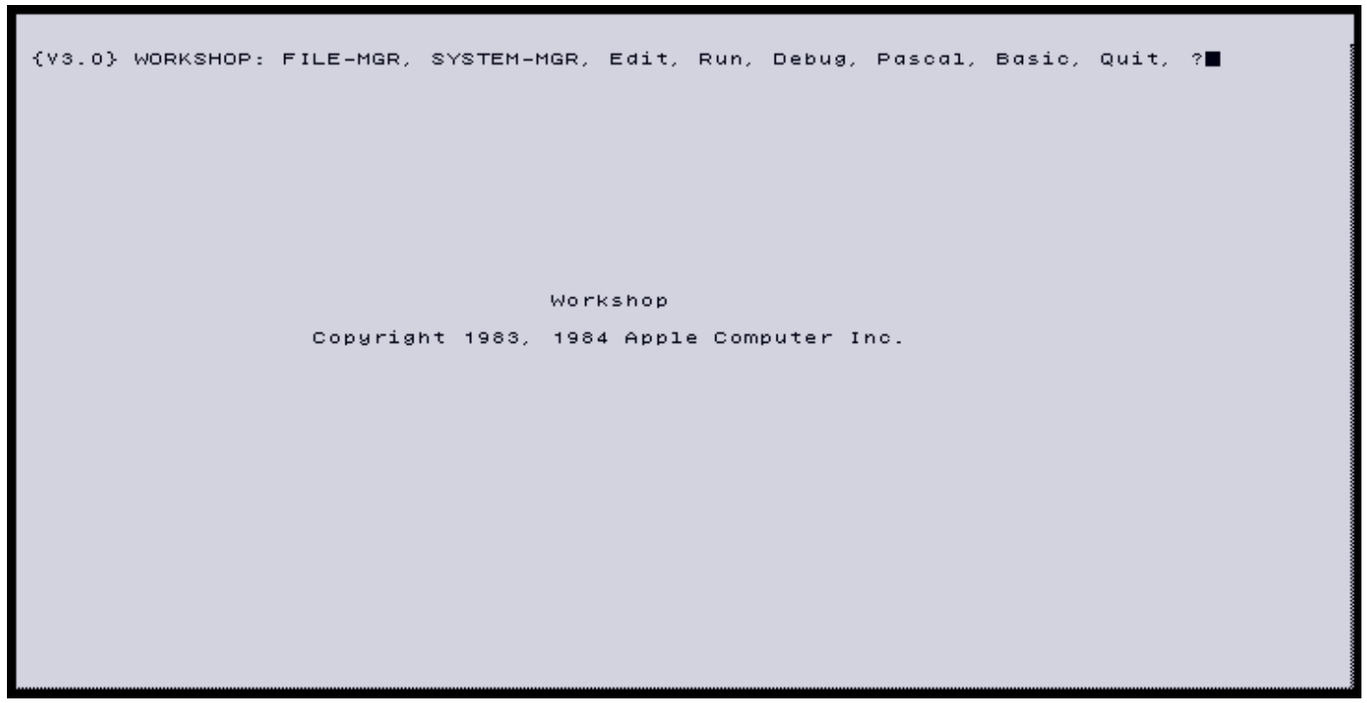


- Introduction of the **menu bar**
- **Task-oriented workflow**
  - Uses "stationery": document templates
- **Internationalization**
  - OS and applications in US and British English, French, German, Italian, Spanish, Scandinavian languages
- **Regions**:
  efficient handling of overlapping windows [7]
  - Atkinson thought he reimplemented stuff the way Xerox did it
    - …turned out they did not 😀

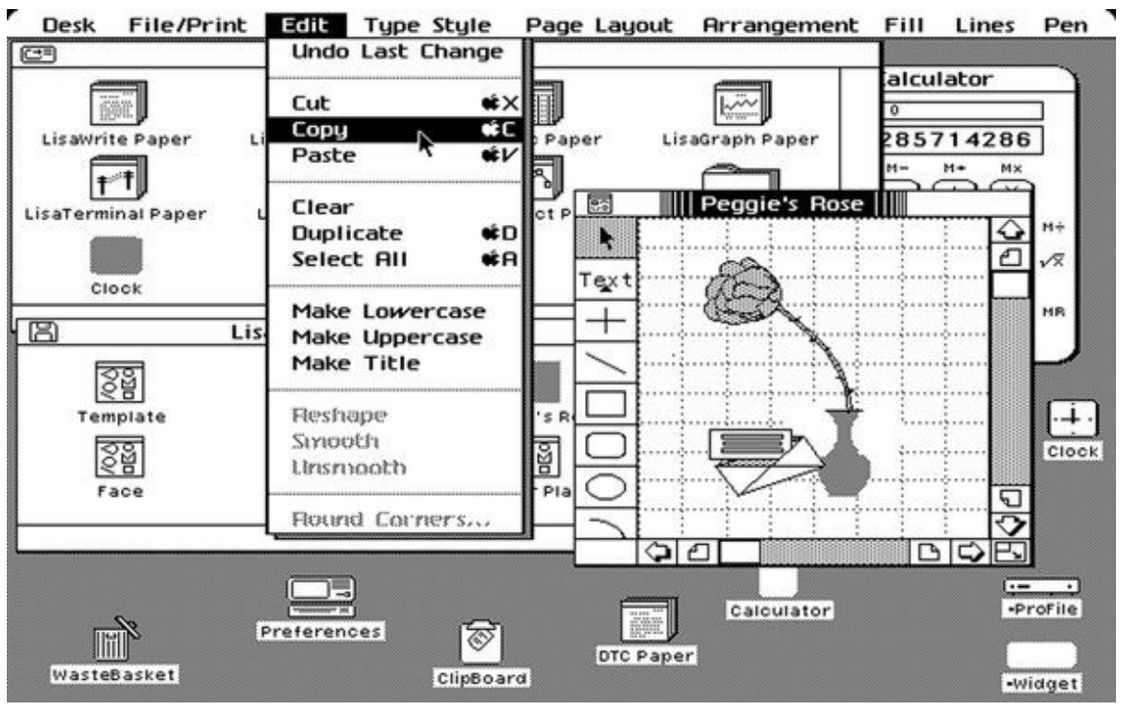


Lisa Software

…applications



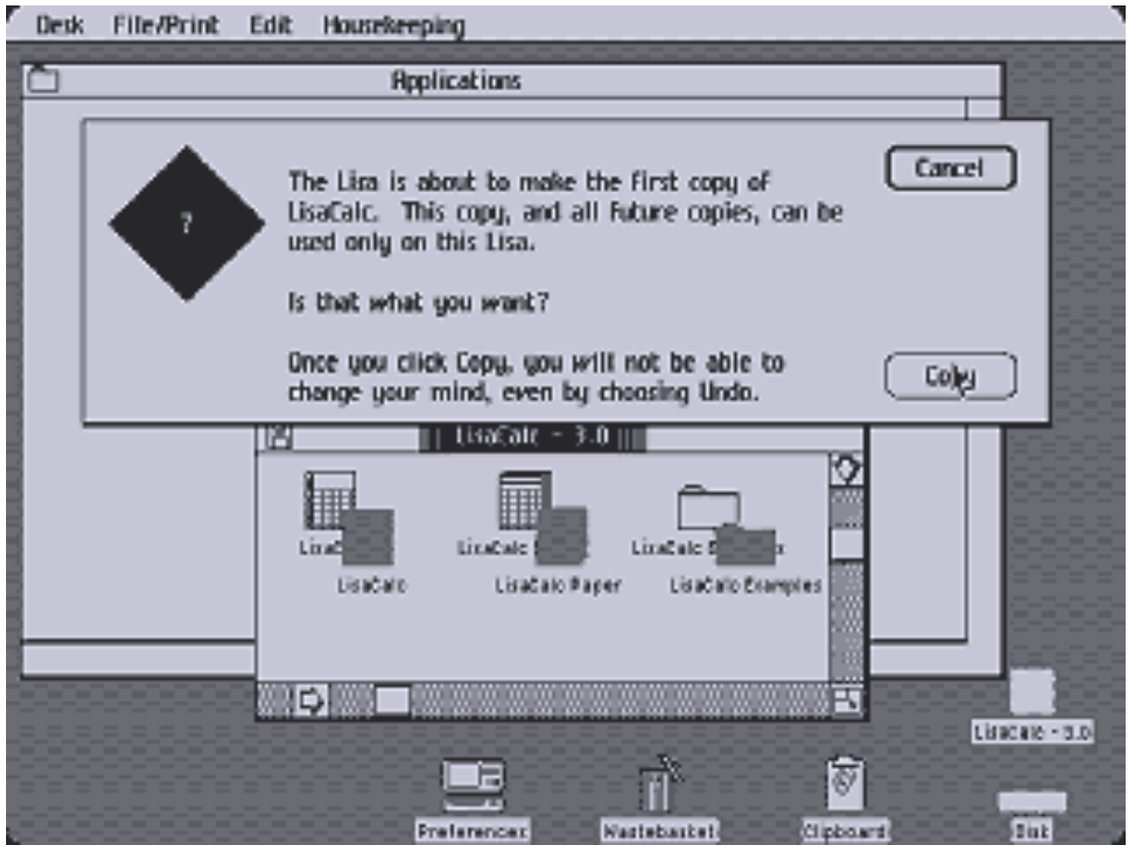
- Lisa came with **seven applications** ("7/7 office system")
  - LisaWrite, LisaCalc, LisaDraw, LisaGraph, LisaProject, LisaList, and LisaTerminal
- Lisa Office System could not be used to write programs for itself:
  - a separate development OS was required – Lisa Workshop
  - similar to UCSD Pascal
- Third-party software initially poor
  - new paradigms
  - inexperienced programmers
  - Programming languages: BASIC, Cobol

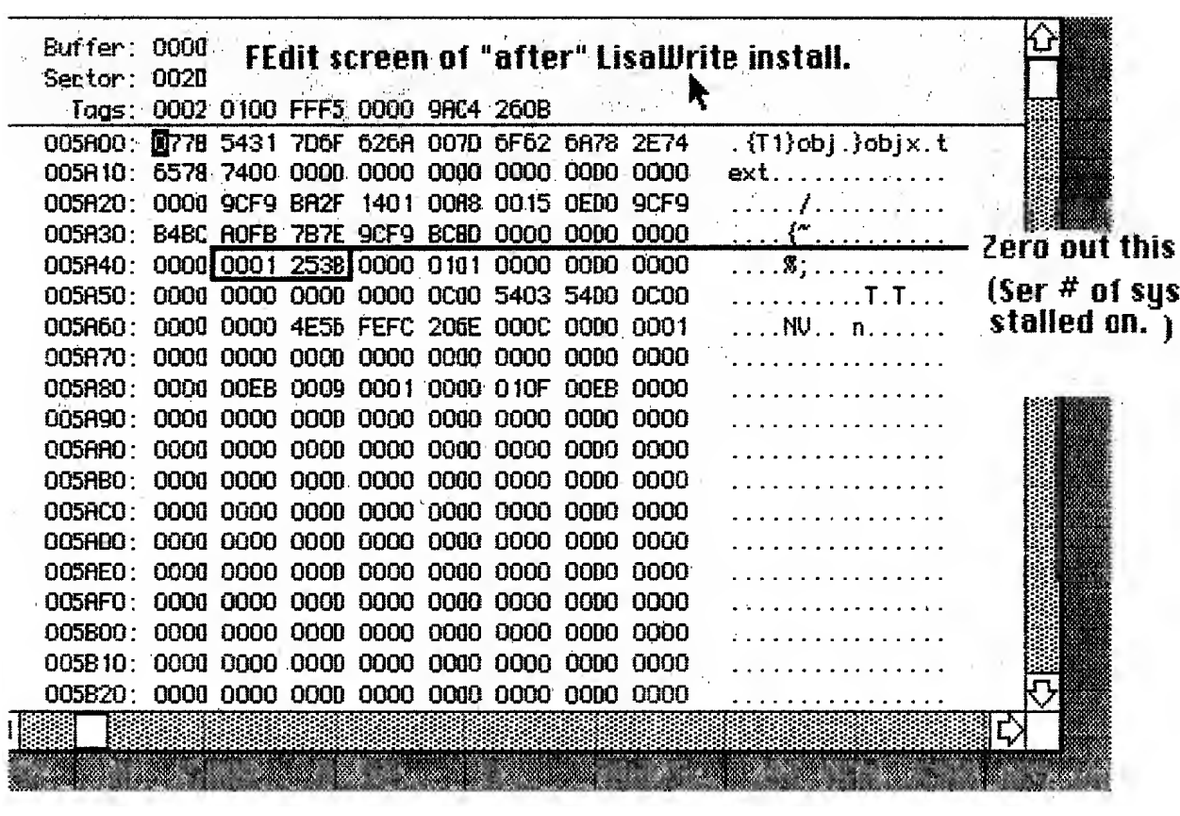


Lisa Software

…atrocities

- Lisa used simple **copy protection**
  - Floppy disks were serialized during software installation to hard disk
- Serial number was stored in video state PROM
  - Well hidden, took long to find
  - Deserialization tools available today…

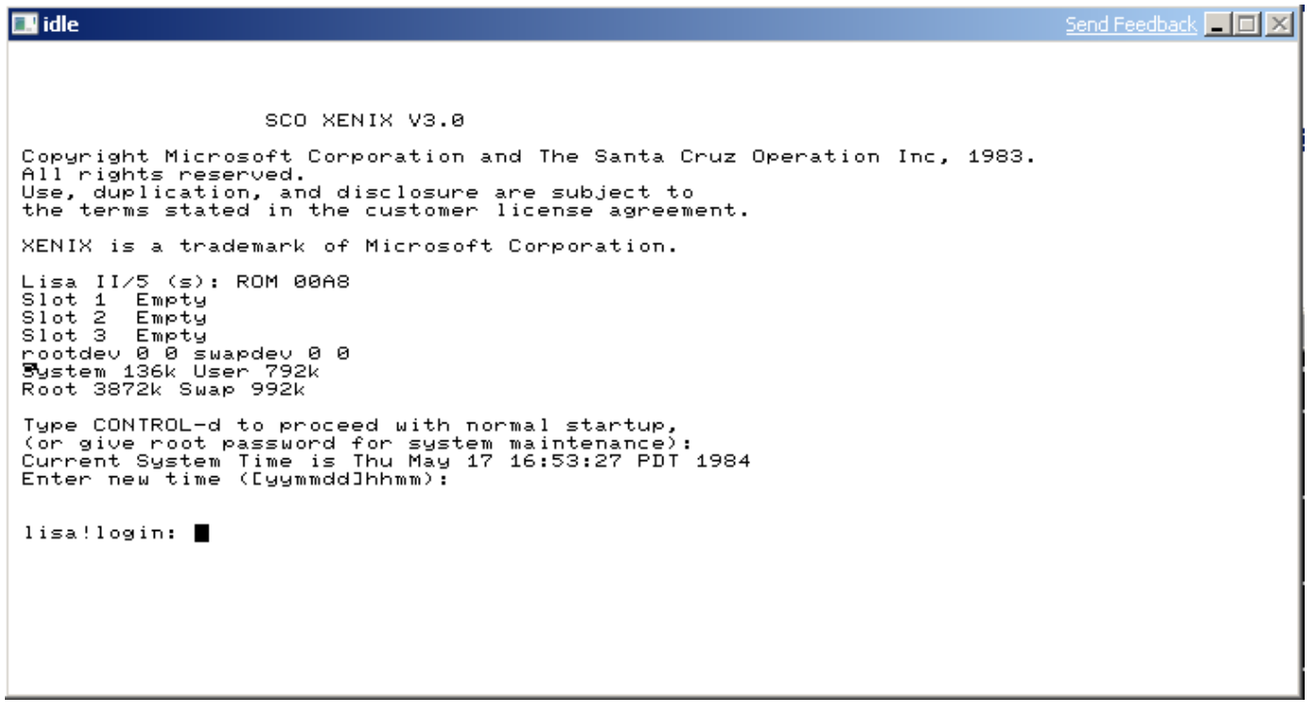


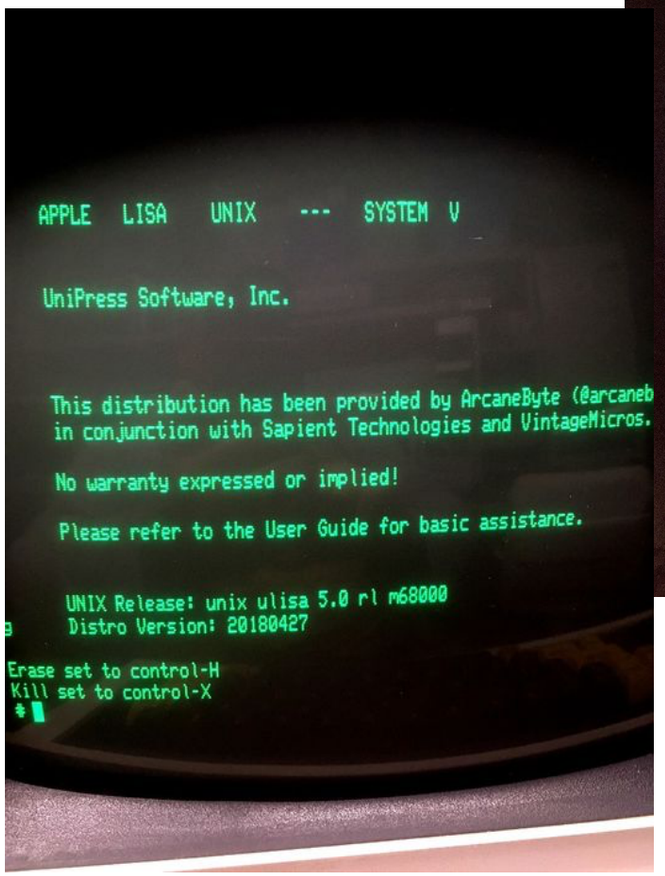


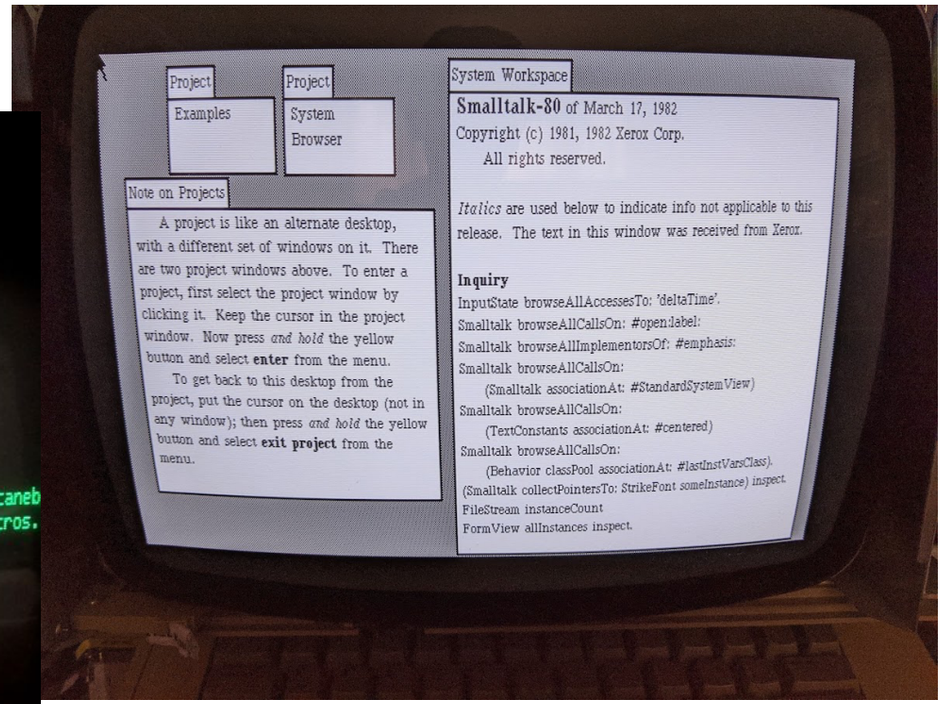
Lisa Software

...alternative OSes

- SCO Xenix 3.0 [8]
- Unisoft UniPlus Unix
- Smalltalk-80 [9]
- CP/M 68k



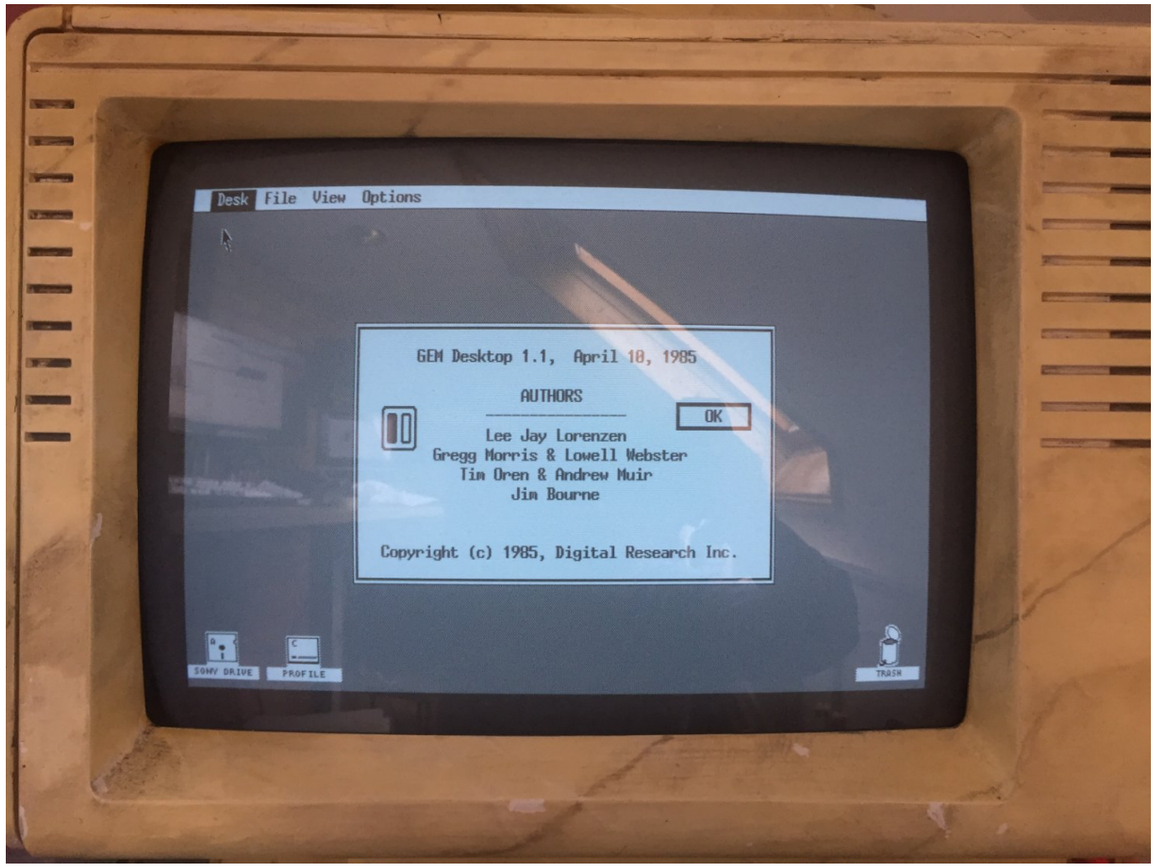




Lisa Software

...GEM?!?

- GEM code open-sourced by Caldera/Lineo 1999
- Lisa used as example platform
  - Digital Research distributed the source code for the Lisa-specific bits of GEMDOS in their "porting kit" [10]
  - Porting kit included in the open source release [11]

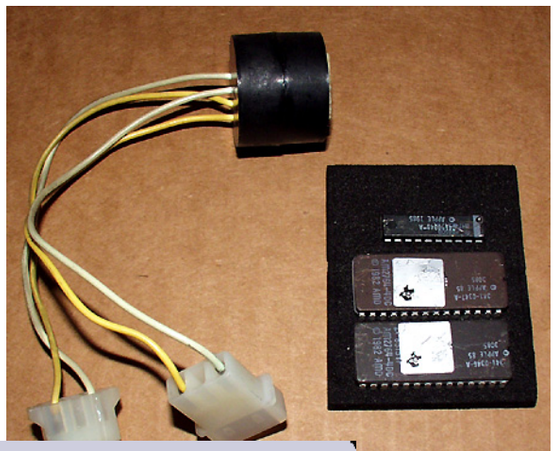


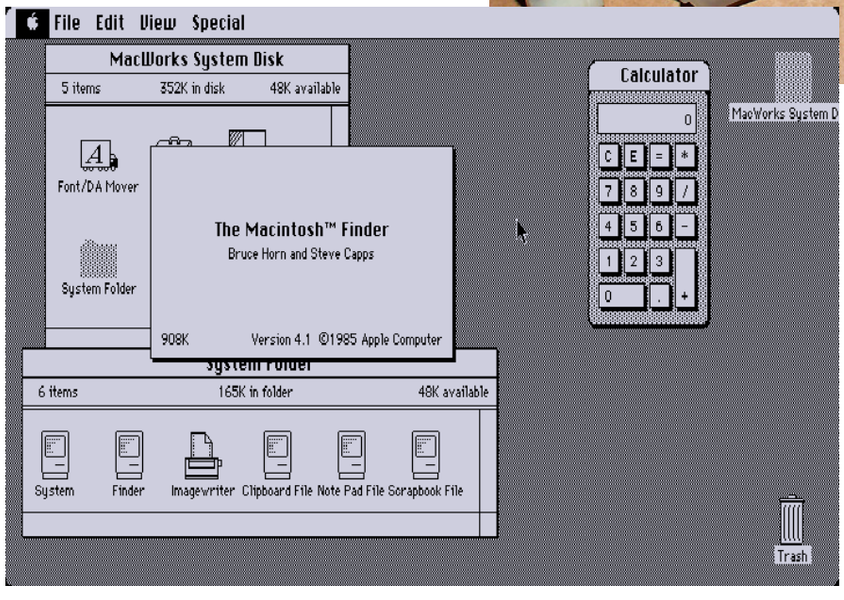
The Fate of Lisa

…killed by the Mac?

Macintosh XL

- 1985: Lisa 2/10 ➙ Macintosh XL
  - shipped with **MacWorks XL**, a Lisa program that allowed 64 K Macintosh ROM emulation
- Hardware identical to Lisa 2/10
- **Square Pixels**! (optional) [12]
  - "Screen mod kit": new firmware, video PROM, CRT transformer
  - New resolution: 608 x 431 pixels

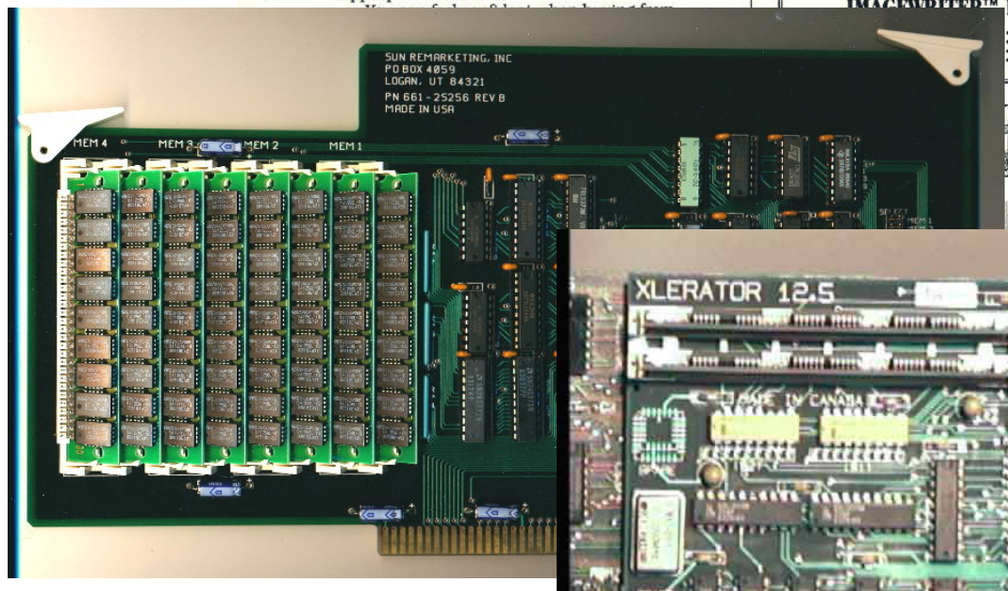


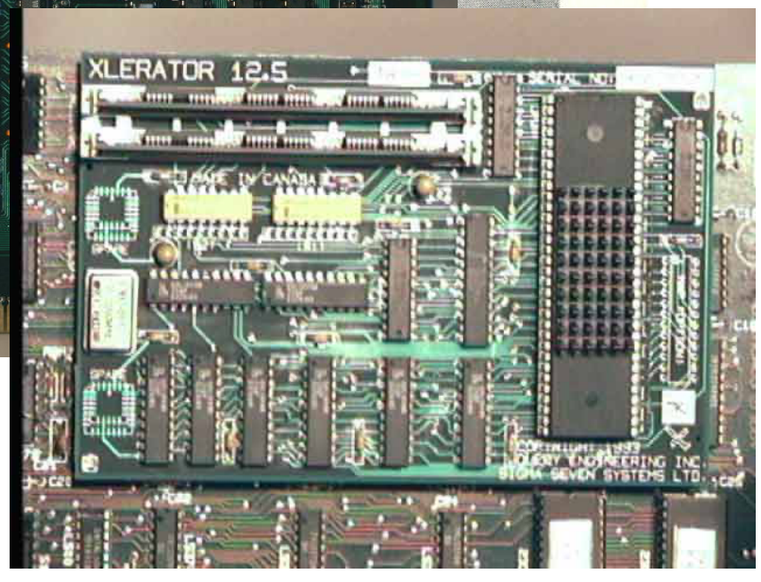


Postmarket

...Sun Remarketing

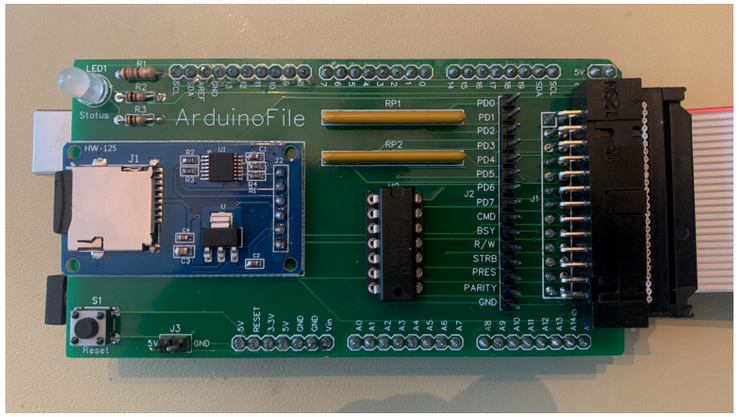
- **XLerator**: 12–18Mhz 68000 CPU
- **2 MB Memory** card
- **800K floppy** upgrade
- **20 MB SCSI HD** + controller
- **New MacWorks** emulation
  - Support for 128 kB ROM (from Mac 512ke/Plus)
  - Runs System 6 and 7 (up to 7.5.5)!

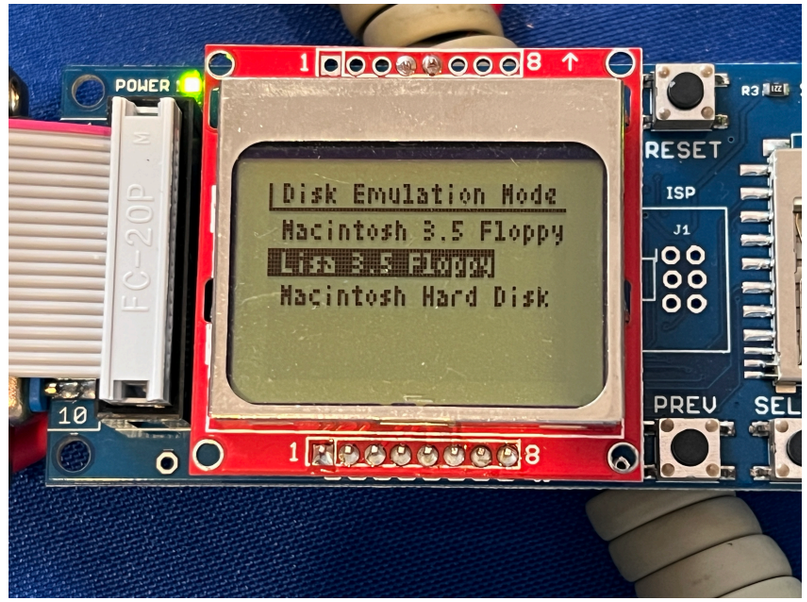


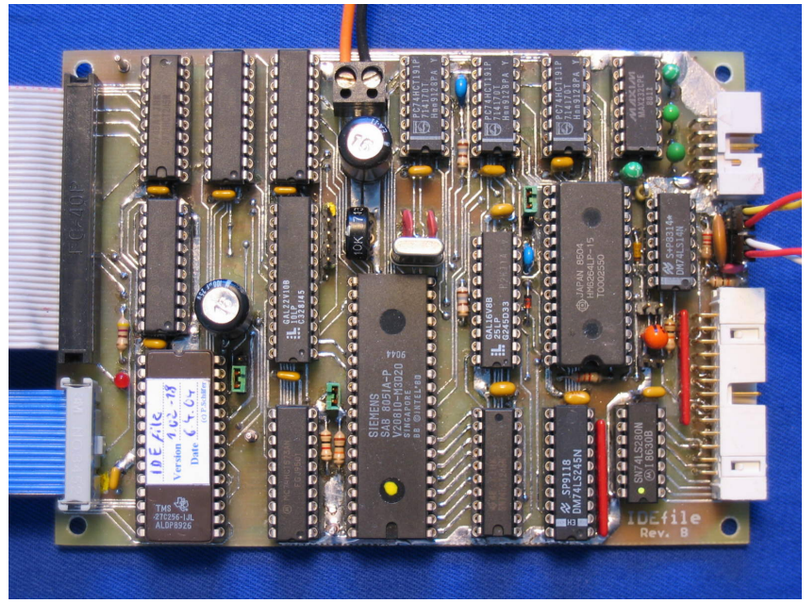


Useful bits

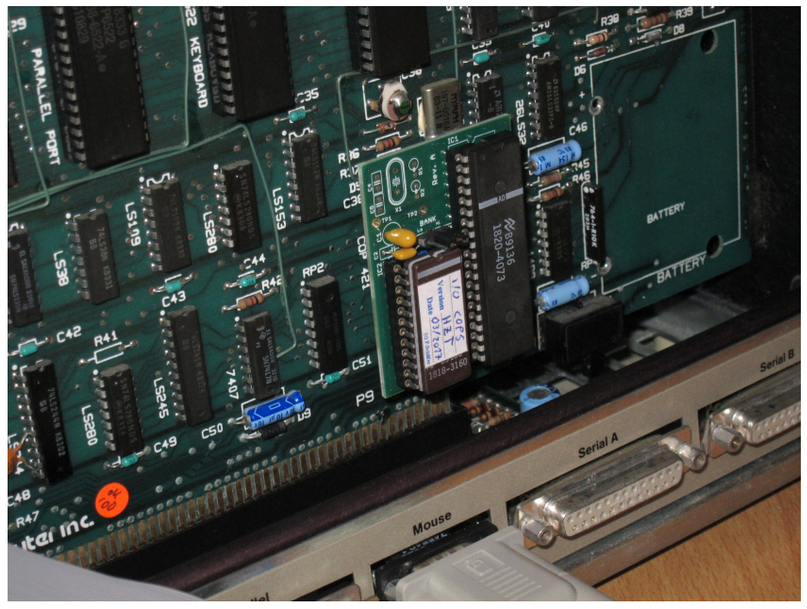
...more hardware







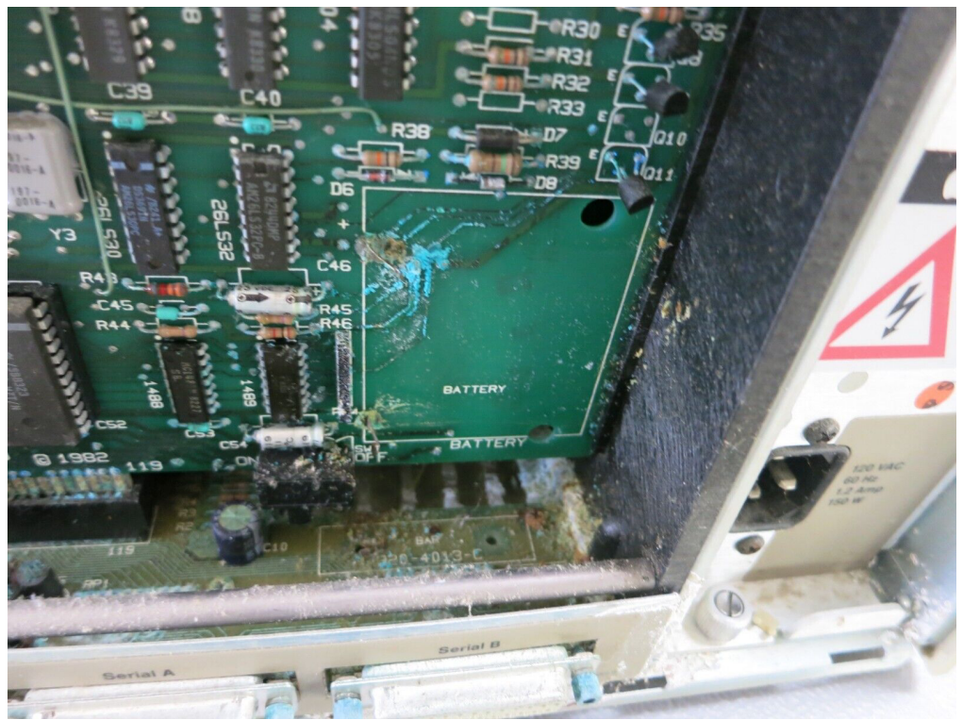
- Steve Chamberlain's FloppyEmu [17]
- Patrick Schäfer's IDEfile [18]
- X/ProFile disk emulator [19]
- ArduinoFile AVR [20]
- Patrick Schäfer's COP421 [21]
- Keyboard emulator [23]



Taking Care of Your Lisa

…how to keep it alive?

- **Battery** on I/O board (not in 2/10) – leaks, corrodes board
- **RIFA capacitors** in power supply – rupture, release their magic smoke 😀
- **Sony Floppy** stuck – resin formation
- **Hard disk** – Widgets break easily
- **Keyboard** – foam in keys deteriorates
- **Capacitors** – as in most retro systems



The End of Lisa

…killed by the IRS?

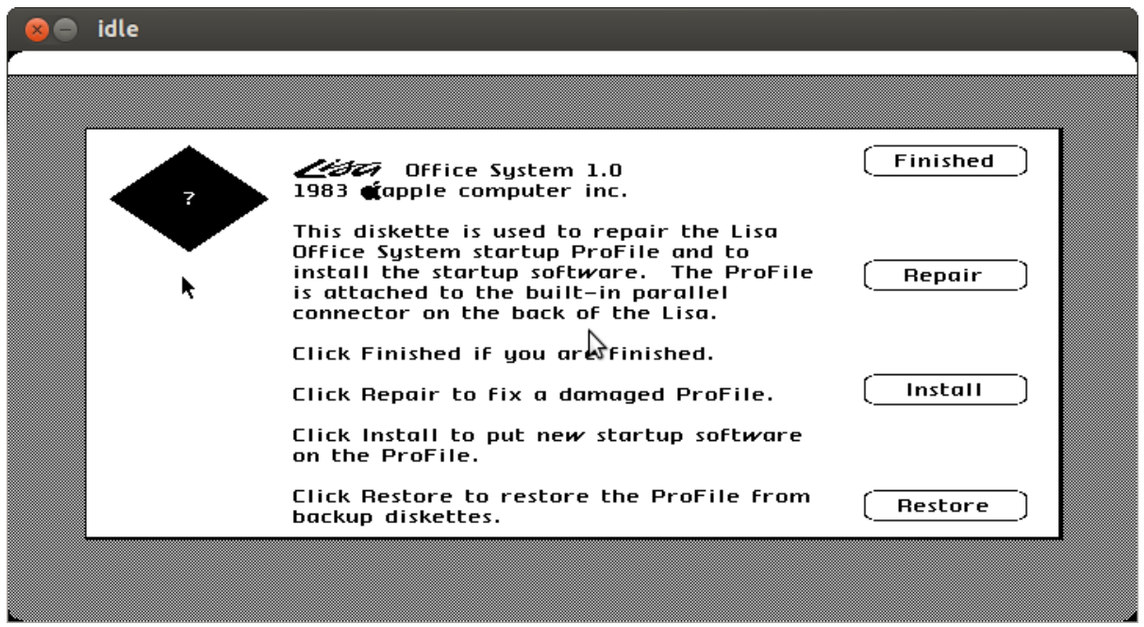
- 1985 – lots of Lisas (~5-7k) still in stock
  - Sun Remarketing acquired the rights to sell remaining Lisas
    - Consignment from Apple, not a sale
- 1989 – Remaining Lisas still on Apple's books still counted as unsold inventory for tax purposes
- Sept. 1989 – 2,700 Lisas buries in Utah landfill
- Company could receive about $34 for every $100 of depreciated value as a tax break

The End?

…is there still hope?

Two emulators are available:

- 1997: **LisaEm** [14]
  - "provide as much of the experience of using an actual Lisa and several of its peripherals"
  - case view, floppy sound, power light
- 2006: **IDLE** [15]
  - "Incomplete Draft of a Lisa Emulator"
- Both run Lisa OS and MacWorks XL
  - Support for other OSes imperfect
- Some support in recent MAME



Sources!

…Lisa opens up

```
Program Preference;

{ Welcome to the ALL Create Preferences Window.


  Through the extensive use of hallucenogens I have found truth and beauty. However,
  those same hallucenogens have also made me incapable of getting to Dodge Ridge to sell
  reclaimed ski wax in the parking lot.}



USES
     {$U libos/SysCall  }  SysCall,
     {$U libos/PSysCall }  PSysCall,
     {$U Obj:UnitStd    }  UnitStd,
     {$U Obj:UnitHz     }  UnitHz,
```

CHM Computer History Museum

Lisa_Source/APPS/APPW/appw-prefmain.text

- "Release and long-term preservation of the source code for the Apple Lisa, including its system and applications software, as part of [the CHM's] Art of Code series" [13]
- Announced 2018, realized 2023
- Apple Academic License:
  "for non-commercial, academic research, educational teaching, and personal study purposes only"
- Included Pascal and assembly sources:
  - Lisa OS and toolkit
  - 7/7 Office applications

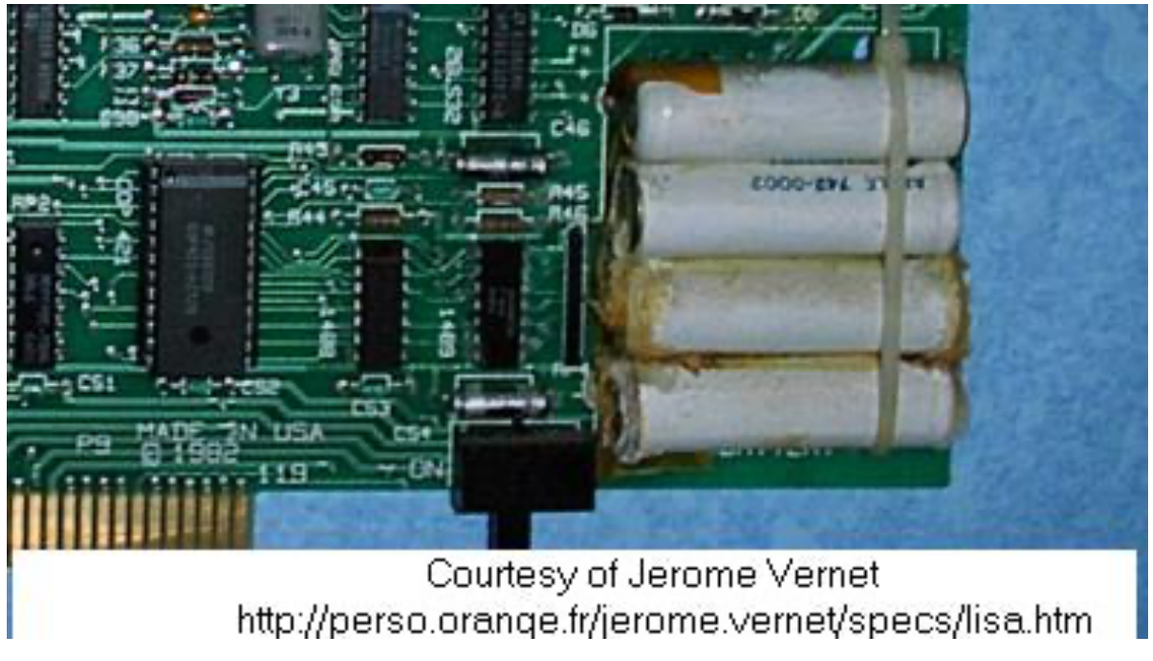
```
UNIT syscall;                          (* system call definitions unit *)
INTRINSIC;

  { Copyright 1983, 1984, Apple Computer Inc. }

INTERFACE

  CONST
    max_ename = 32;          (* maximum length of a file system object name *)
    max_pathname = 255;      (* maximum length of a file system pathname *)
    max_label_size = 128;    (* maximum size of a file label, in bytes *)
    len_exname = 16;         (* length of exception name *)
    size_exdata = 11;        (* 48 bytes, exception data block should have the same
                                size as r_eventblk, received event block *)

    size_etext = 9;          (* event text size - 40 bytes *)
    size_waitlist = 10;      (* size of wait list - should be same as reqptr_list *)

                                 (* exception kind definitions for 'SYS_TERMINATE'
                                    exception   *)
    call_term = 0;               (* process called terminate_process *)
    ended     = 1;               (* process executed 'end' statement *)
    self_killed = 2;             (* process called kill_process on self *)
    killed      = 3;             (* process was killed by another process *)
    fthr_term   = 4;             (* process's father is terminating *)
    bad_syscall = 5;             (* process made invalid sys call - subcode bad *)
    bad_errnum  = 6;             (* process passed bad address for errnum parm *)
    swap_error  = 7;             (* process aborted due to code swap-in error *)
    stk_overflow = 8;            (* process exceeded max size (+T nnn) of stack *)
    data_overflow = 9;           (* process tried to exceed max data space size *)
    parity_err  = 10;            (* process got a parity error while executing *)
```

Lisa_Source/LISA_OS/OS/source-syscall.text

New Life!

…"The reports of my death are greatly exaggerated"

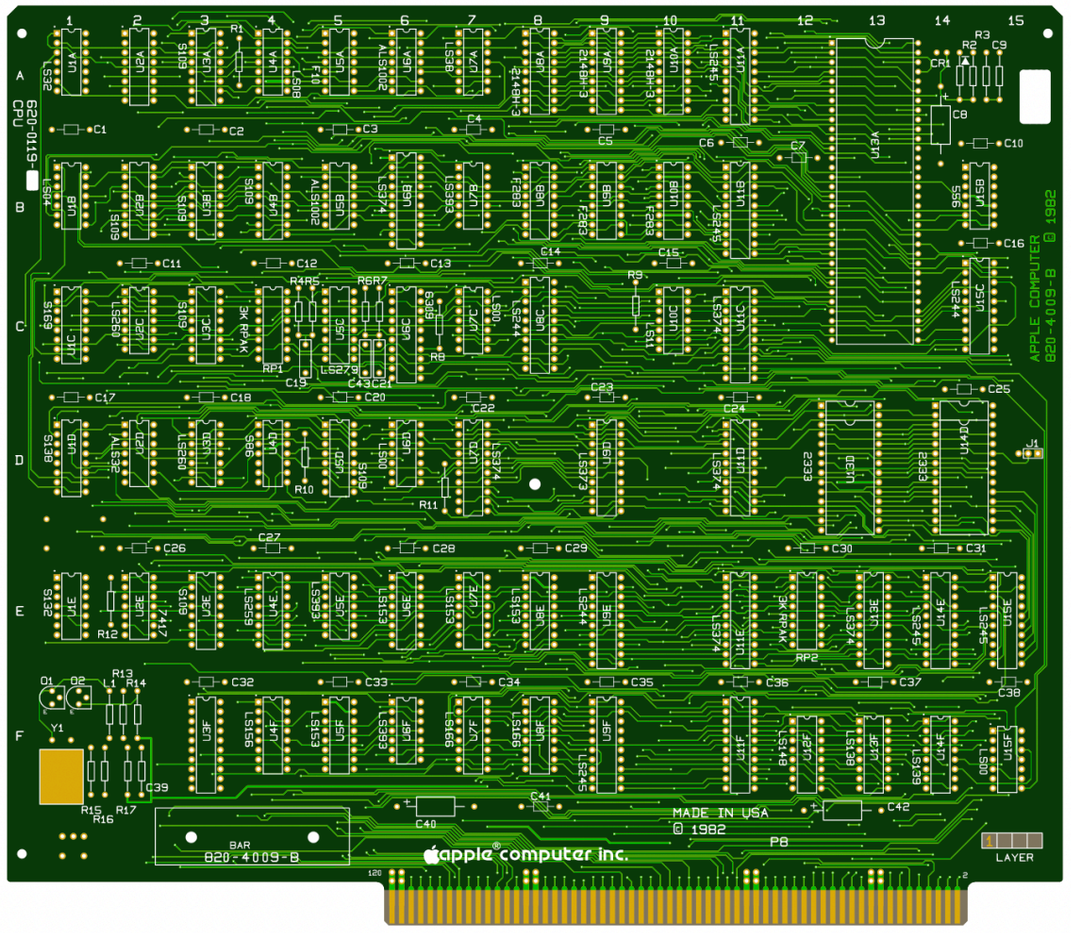
- Battery leakage damaged a lot of I/O and backplane boards
  - Replacement boards designed by Sapient Technologies [24]
- Rights to products developed by Sun Remarketing (SCSI board, SIMM memory board, and Sun20 hard drive controller) were transferred to Vintage Micros
  - Some spare parts still available
  - New CPU PCB, X/Profile, X/COPS
- Recreation as **open source projects**
  - started in 2022…



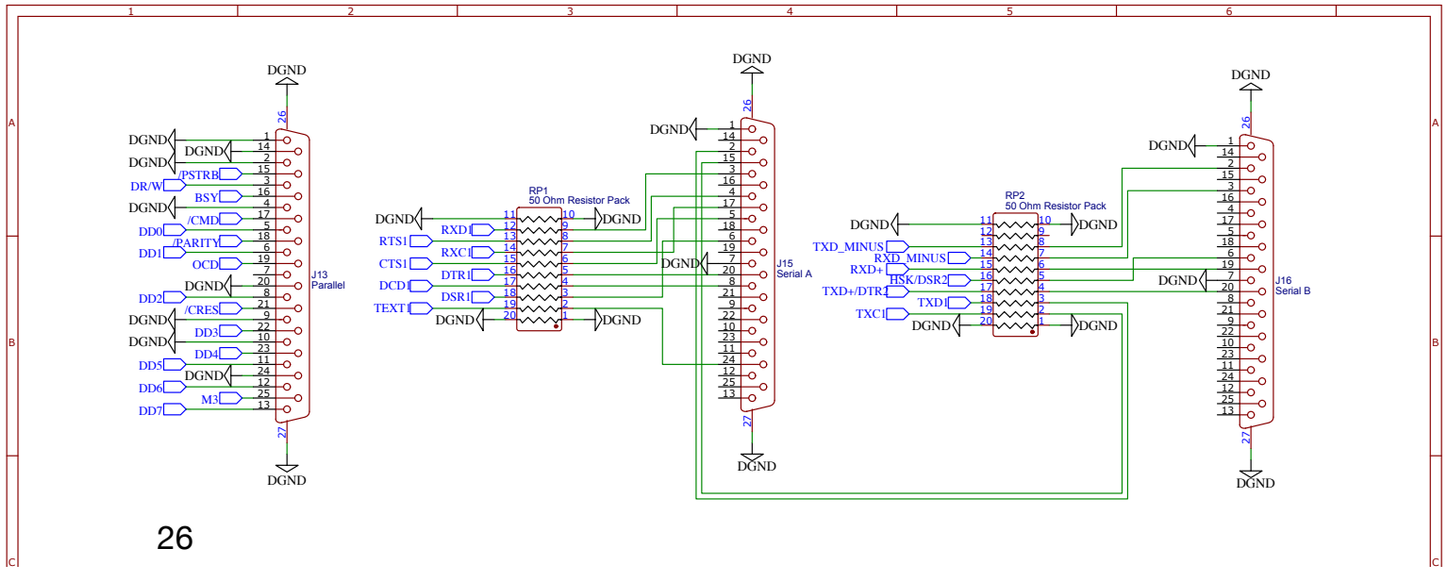
Courtesy of Jerome Vernet
http://perso.orange.fr/jerome.vernet/specs/lisa.htm

Building a New Lisa

...parts and pieces



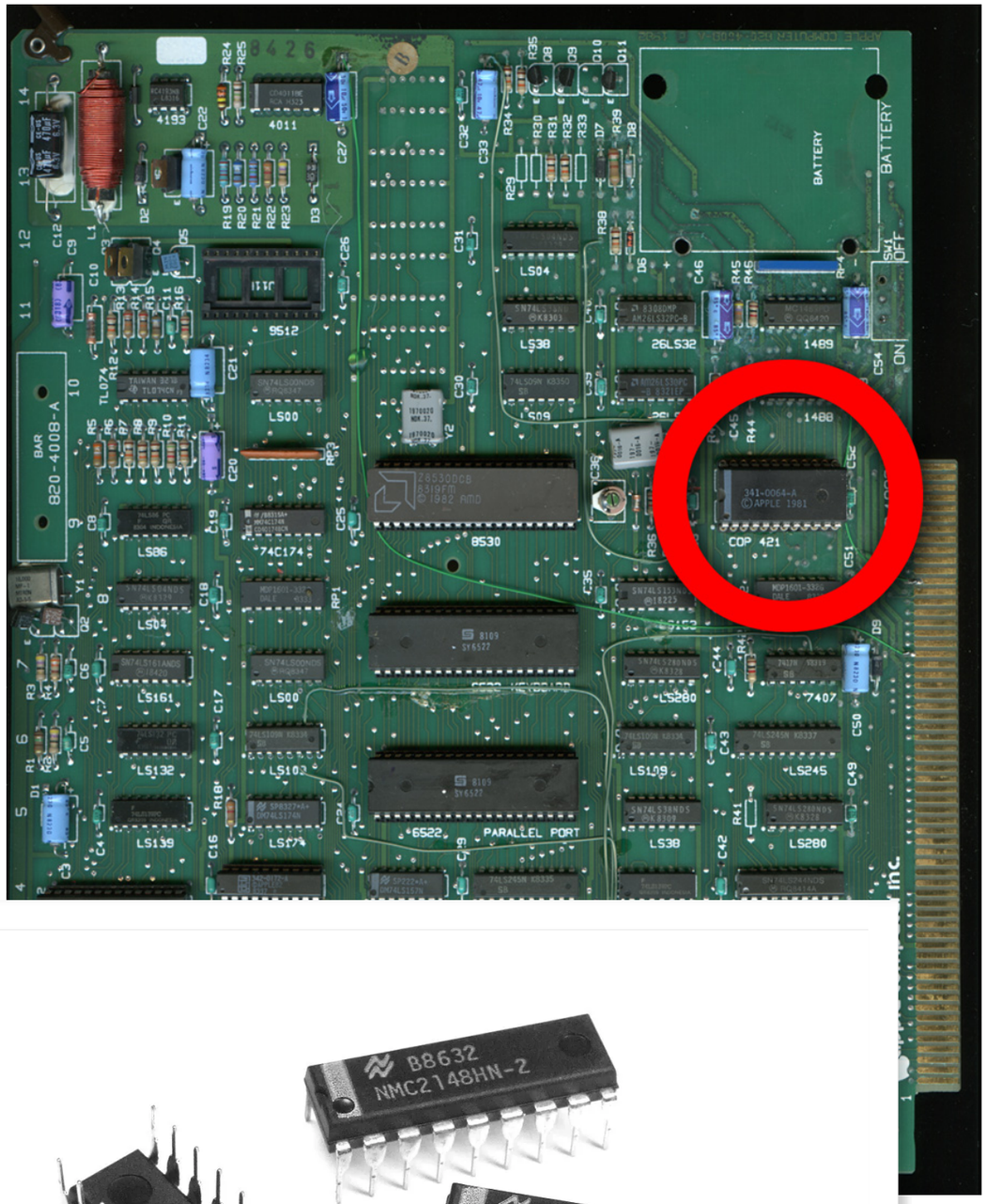
- **Recreation**
  - CPU board: 4 layers [25]
  - I/O, mainboard: 2 layers [26]
  - No memory board so far
- Schematics (Altium/ EasyEDA/PDF) and Gerber files available on github

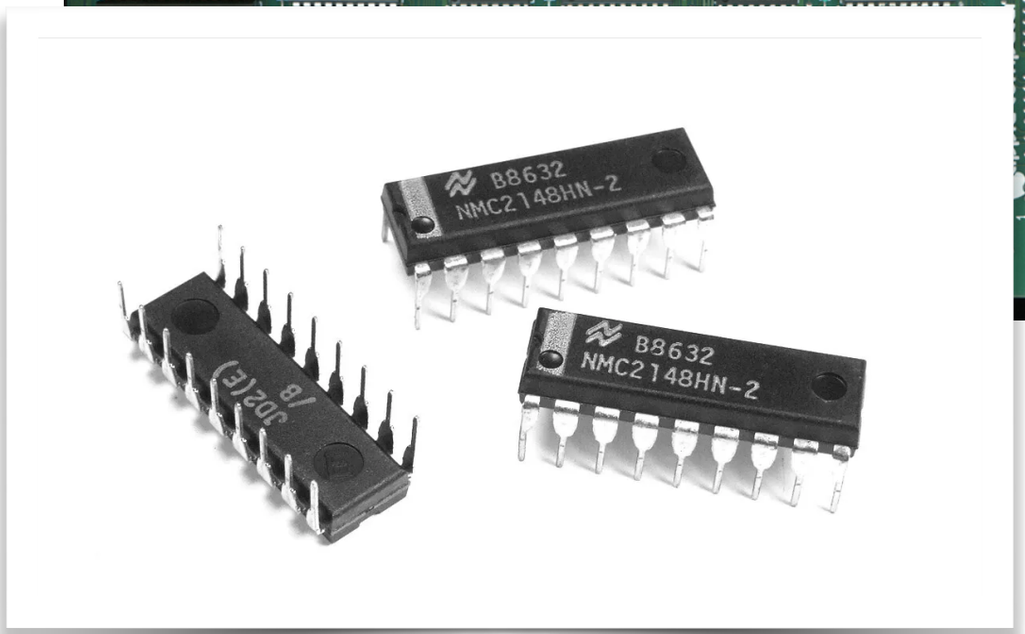


Challenges Building a New Lisa

…40 year old ICs?

- "***Unobtainium***" ICs
  - **COPS421** microcontroller [22]
  - Bipolar **PROMs**: 6309 or similar
    - Programming with modern EPROMers difficult
  - Fast **SRAMs**: 2148-55ns used for MMU
  - Lisa uses a **strange mix of** 74xx, 74LSxx, 74ALSxx, 74Cxx **ICs** – why?
- **RAM boards** – not yet recreated
- **Video** – uncommon frequencies
- **Power supply** – replacement available

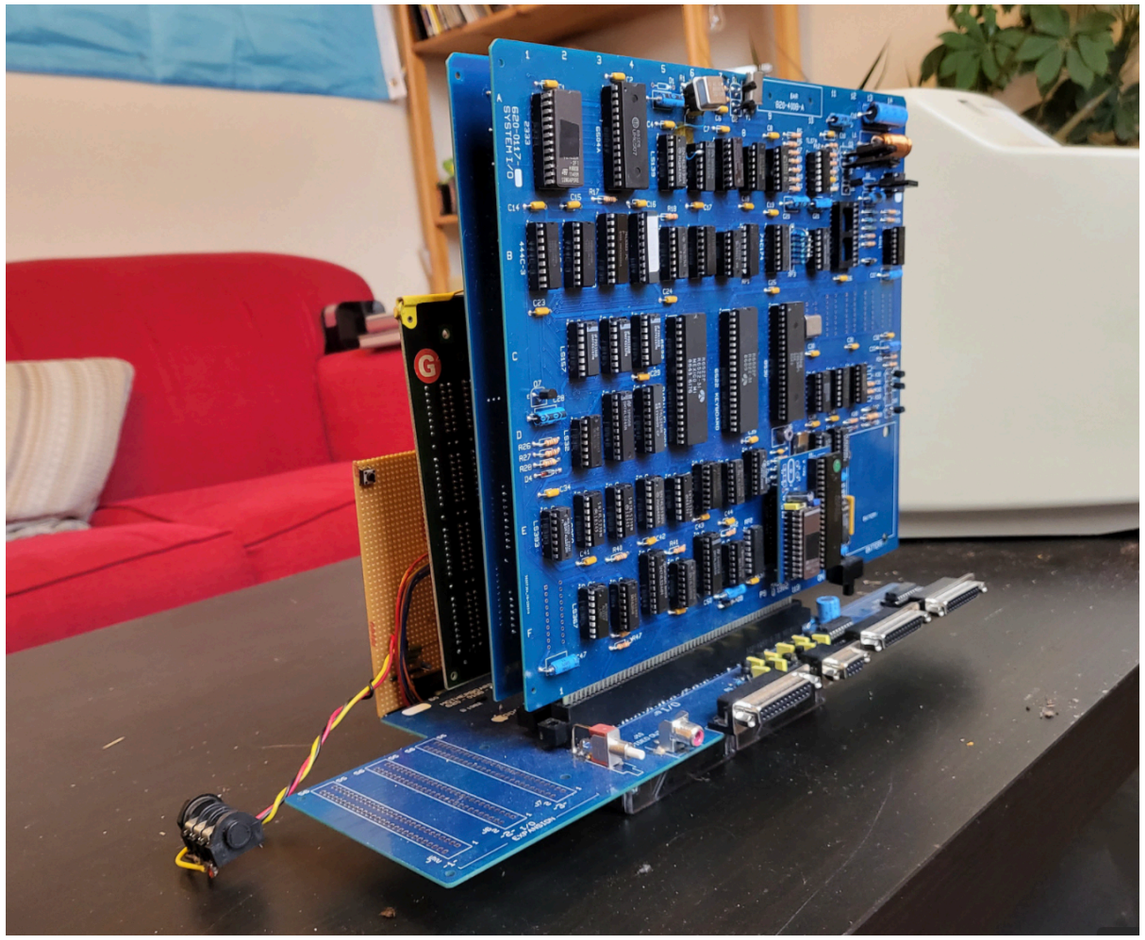




Show me!

…first prototypes working

- Boards can easily be produced by most PCB manufacturers
  - Cost:
    $12 (CPU), $6.50 (I/O),
    $4.50 (backplane)
  - Component costs vary significantly
    - Expect several US$100
- Prototype in CNC cut plexiglass case by DosFox [27]
- Replacement power supply, keyboard adapter, I/O card PCBs also available
- RAM board has to be repurposed from existing Lisa for now…



Work at Bamberg University

…Chair of Systems Programming

- Build our **own Lisa clone** (WiP) – three exist in the US already
  - Also try to build **CMOS SMD** and **FPGA versions** (future)
- **Replace the bipolar PROMs** with GALs [28]
- **Replace the COPS421 with an AVR** microcontroller (WiP)
  - …using real-time aware **binary translation** of assembler source
- Develop a **RAM board** using modern SRAM chips (future)
- Analyze, use and improve the **Lisa** HW and its OS **in projects**

The Future?

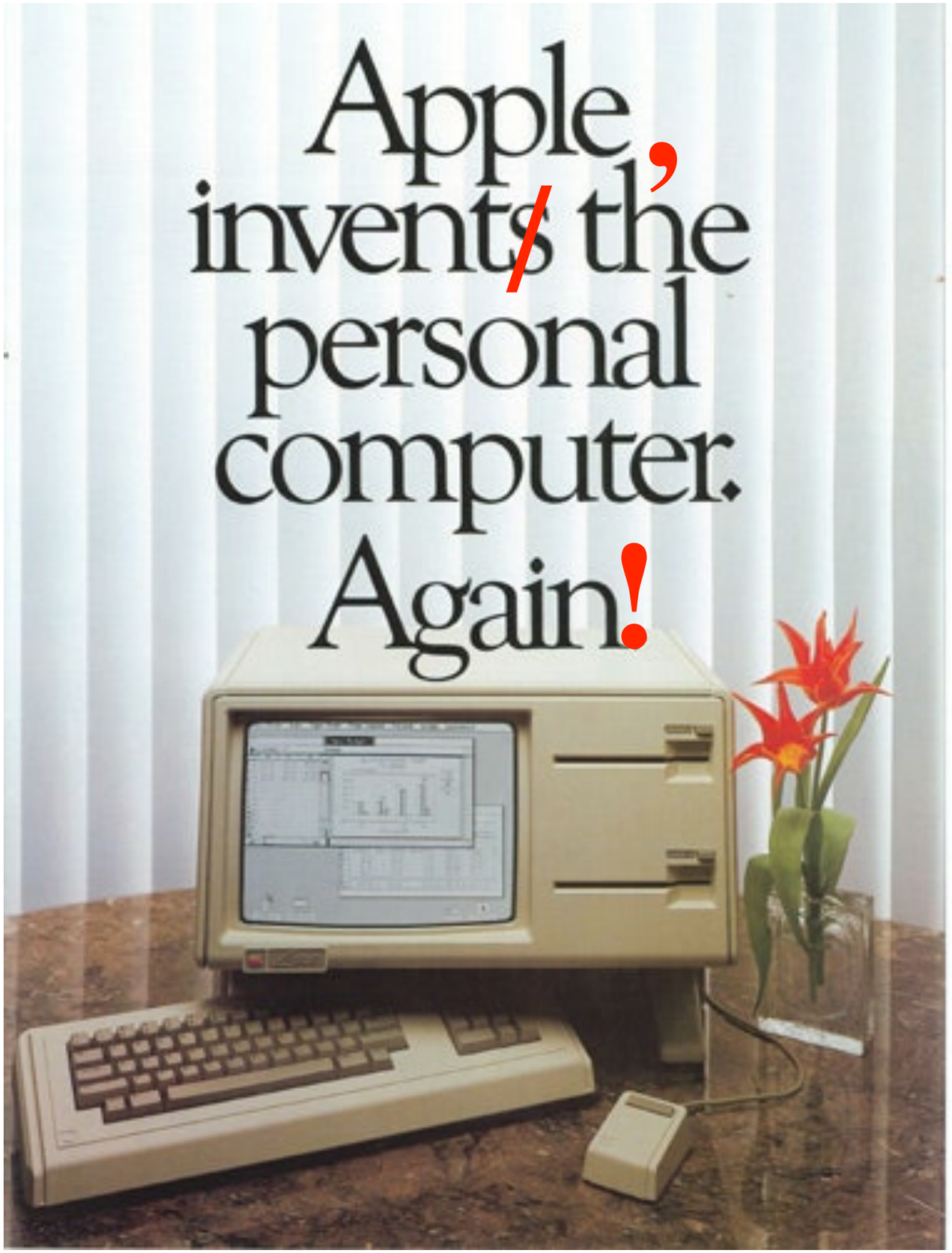
…what will it bring?

- 1983: Frog Design Lisa concept
  - Inspiration for Portrait Display?
- 2015: Antonio de Rosa Lisa concept [29]
  - Similar aluminium Mac design idea by curved/labs

Lisa and the Mac

…It's complicated…

- **Mac 128k** introduced in 1984
  - Only cost US$2,500 – but significantly weaker hardware
    - less RAM, no HD, lower resolution – higher CPU speed (7.83 MHz)
    - Mac uses a set of **early programmable logic ICs** (PALs)
  - Mac did **more in software** – no I/O coprocessors
  - Initially, Mac software developers had to use a Lisa!
- **QuickDraw** shared between Lisa and Mac
  - Source code of QuickDraw and MacPaint published in 2010 [30]
- **Mac System**: singletasking, simple FS (MFS), large parts in ROM


Apple
invents the
personal
computer.
Again!

References

…dig deeper!

1. Dan Ingalls, et al., ***Reviving Smalltalk-78: The First Modern Smalltalk Lives Again***, https://www.freudenbergs.de/bert/publications/Ingalls-2014-Smalltalk78.pdf
2. Andy Hertzfeld, ***Busy Being Born, Part 2***, https://www.folklore.org/StoryView.py?project=Macintosh&story=Busy_Being_Born,_Part_2.txt
3. Adam Goolevitch, ***Apple Lisa 1 Prototypes and other Artifacts***, Digibarn, https://digibarn.com/collections/systems/apple-lisa1/lisa1-prototype/index.html
4. Paul A. Baker et al., ***Memory Management Unit with Overlapping Control for Accessing Main Memory of a Digital Computer***, US Patent 4,926,316, May 15, 1990
5. Bruce Daniels, ***The Architecture of the Lisa Personal Computer***, Proc. of the IEEE, Vol. 72, No. 3, March 1984
6. Bruce Daniels, ***Lisa's Alternative Operating System***, Computer Design, August 1983
7. Andy Hertzfeld, ***I Still Remember Regions***, April 1982, https://www.folklore.org/StoryView.py?project=Macintosh&story=I_Still_Remember_Regions.txt
8. neozeed, ***Apple Lisa Xenix***, February 2009, https://virtuallyfun.com/2009/02/10/apple-lisa-xenix/
9. Glenn Krasner, ***Smalltalk-80: Bits of History, Words of Advice***, Ch. 10, Longman 1983, http://stephane.ducasse.free.fr/FreeBooks/BitsOfHistory/BitsOfHistory.pdf
10. cheesey, ***GEM and the Apple Lisa***, https://stardot.org.uk/forums/viewtopic.php?t=20964
11. cheesestraws, ***GEMDOS for the Apple Lisa*** (source code), https://github.com/cheesestraws/lisa-gemdos
12. Andy Hertzfeld, ***Square Dots***, April 1981, https://www.folklore.org/StoryView.py?project=Macintosh&story=Square_Dots.txt
13. Hansen Hsu, ***The Lisa: Apple's Most Influential Failure***, https://computerhistory.org/blog/the-lisa-apples-most-influential-failure/
14. Ray Arachelian, ***LisaEm***, https://github.com/rayarachelian/lisaem
15. Gilles Fétis, ***IDLE Lisa Emulator***, https://idle-lisa-emu.sourceforge.net/
16. Tom Stepleton, ***lisa-fig68k: Standalone 68000 fig-Forth for the Apple Lisa***, https://github.com/stepleton/lisa-fig68k
17. Steve Chamberlain, ***Floppy Emu***, https://www.bigmessowires.com/floppy-emu/
18. Patrick Schäfer, ***IDEfile***, http://john.ccac.rwth-aachen.de:8000/patrick/idefile.htm
19. Sigma Seven Systems, ***X/Profile***, http://sigmasevensystems.com/xprofile
20. Alex Anderson-McLeod, ***ArduinoFile*** (source code), https://github.com/alexthecat123/ArduinoFile
21. Patrick Schäfer, ***COP400 ROM dumper – COP4 Emulator Boards***, http://john.ccac.rwth-aachen.de:8000/patrick/COPSreader.htm
22. Eric Smith, ***lisaio - Apple Lisa I/O processor firmware, partially reverse-engineered***, https://github.com/brouhaha/lisaio
23. Rebecca G. Bettencourt, ***Apple Lisa Keyboard Tester/Translator/Emulator***, https://github.com/RebeccaRGB/lisakeys
24. James Denton, ***This Old Lisa: Hands-on With the Sapient Technologies Lisa 1 & 2/5 Motherboard***, 2018, https://www.jimmdenton.com/sapient-motherboard/
25. warmech, ***Lisa Hardware***, https://github.com/warmech/lisa-hardware
26. Alex Anderson-McLeod, ***Lisa-PCBs***, https://github.com/alexthecat123/Lisa-PCBs
27. DosFox, ***A Brand New Apple Lisa***, https://hackaday.io/project/192235-a-brand-new-apple-lisa
28. Michael Engel, ***lisaprom source code***, https://github.com/michaelengel/lisaprom
29. Antonio de Rosa, ***The new Apple Lisa***, https://antonioderosa.com/apple-lisa
30. Computer History Museum, ***MacPaint and QuickDraw Source Code***, https://computerhistory.org/blog/macpaint-and-quickdraw-source-code/
31. Michael Engel, ***mfsreader***, https://github.com/michaelengel/mfsreader