

IEEE Consumer Electronics Society

Three generations of animation machines: Atari and Amiga



Joe Decuir, IEEE Fellow
UW Engineering faculty

Agenda

- Why are you here?
- How I got here: design three retro machines
 - Atari Video Computer System (2600)
 - Atari Personal Computer System (400/800)
 - Amiga computer (1000, etc)
- Today:
 - Stories punctuated by technical detail
- Resources:
 - Where to find the hardware
 - Where to find the emulators

Why are you here?

- Many of you are fans of vintage computers:
 - Find and restore old machines
 - Run productivity applications
 - Play games
- Some people also write new applications
 - E.g. PlatoTerm on several retro computers
- More people write and play new games

Agenda for today: stories, interrupted by technical detail

1. How I got hired at Atari
2. Epiphany: Atari needed a roadmap
3. Visiting San Antonio Sears
4. Inventing a serial bus
5. Proximity to Atari Coin-op designers
6. Discovering the Minitel: internet prototype
7. First GPU, collaborate with Ron Nicholson
8. Recorded Amiga FA-18 demonstration

How I got here

My work is here:



First Video Games

- Ralph Baer was a pioneer, recognizing that it was possible to bring entertainment home.
- He imagined a machine which allowed electronic gaming on a “Brown Box” in a family home.
- Ralph was unlucky – he worked in defense
- His employee licensed his design to Magnavox – as the Odyssey, 1972



Ralph Baer
in his basement
lab, 2014

Atari Video Computer concepts

- Atari was founded on arcade video games
- First big hit: Pong (derived from Odyssey)
- Second hits: more complex arcade games
 - E.g. Tank, Breakout
- Third hit: Pong for home use
- Big question: what to do next?
- Choices:
 - Random logic games
 - Microprocessor-based games

I got lucky: Atari Video Computer

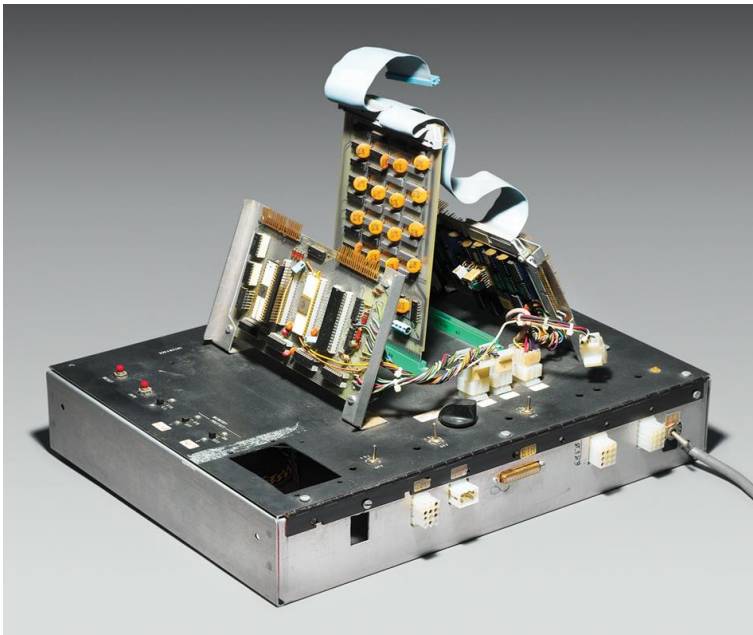
- I was hired to finish debugging the first concept prototype of the Atari Video Computer System (2600).
- I made several contributions to it.
 - We joked about paying to work.

WESCON75

Electronics in the next thousand days

Sept 16-19, Brooks Hall/Civic Auditorium, San Francisco

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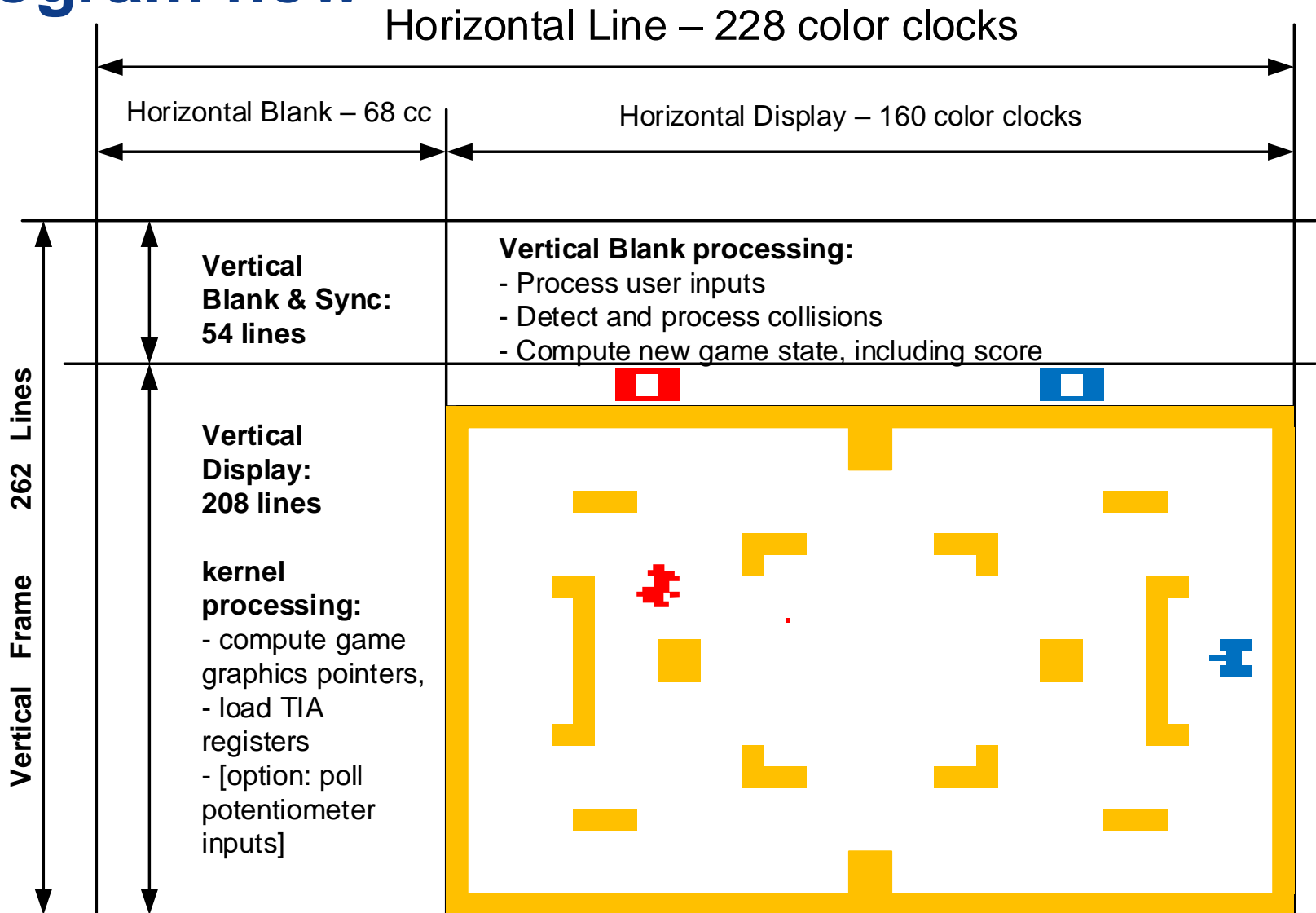


THE SYSTEM SUCCEEDED BY THE SHEER SIMPLICITY OF ITS ENGINEERING: AN OUTSOURCED 8-BIT PROCESSOR AND A CRAFTY CRT TELEVISION-SPECIFIC GRAPHICS/SOUND CHIP DEVELOPED IN-HOUSE BY JOE DECUIR AND JAY MINER.

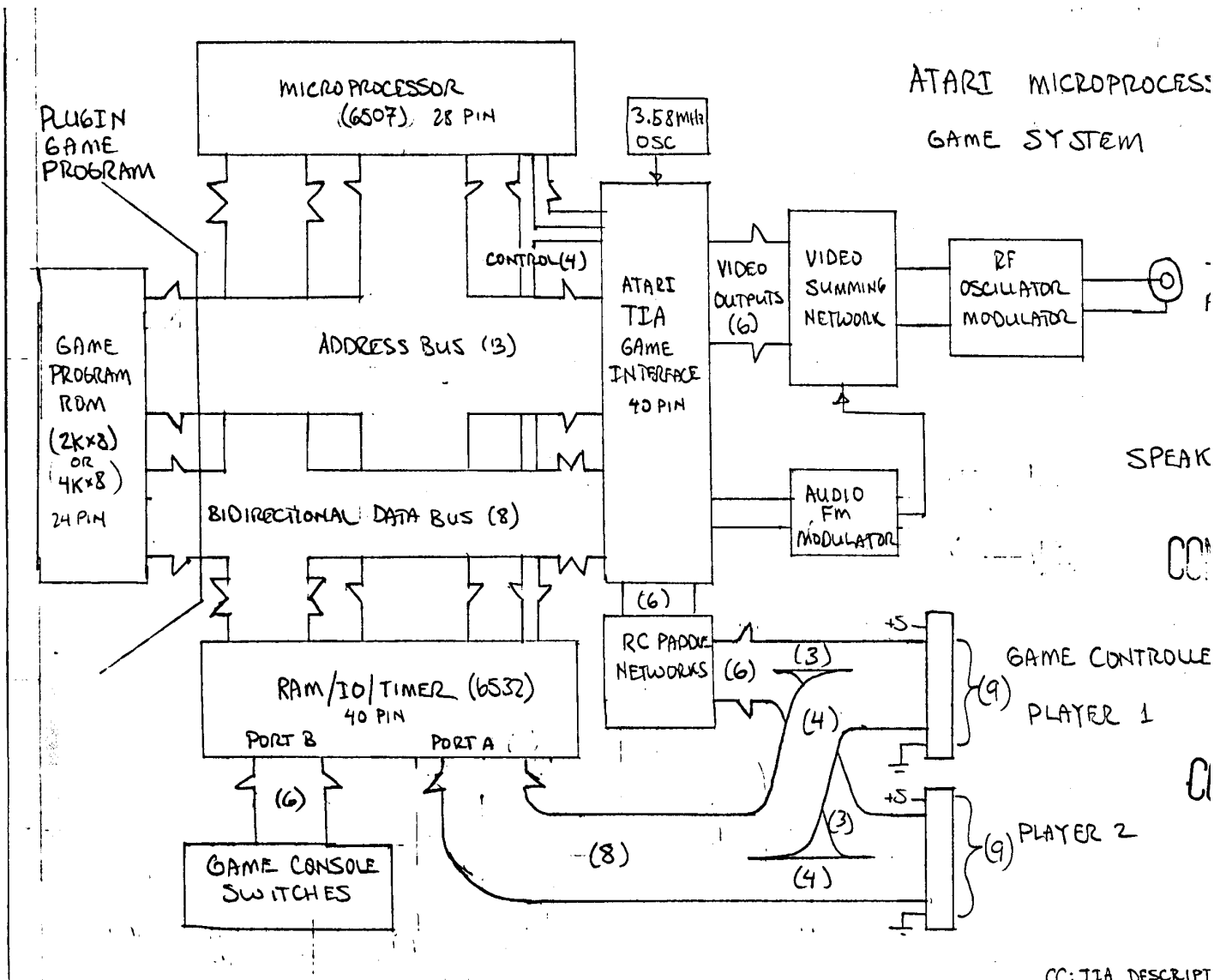


I chose the Atari job for the mentor, Jay Miner

Program flow



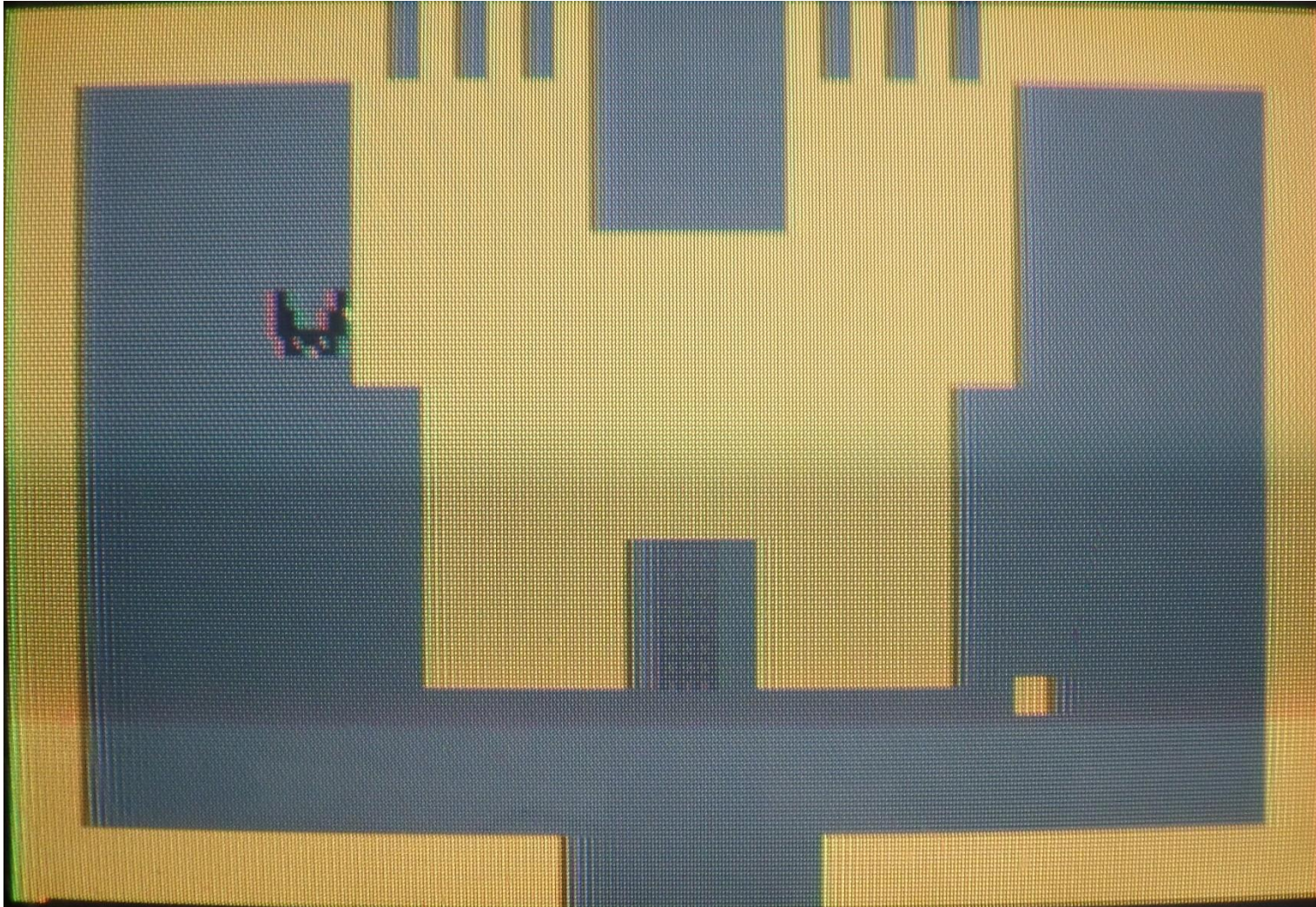
Atari VCS system diagram



CC: TIA DESCRIPT



Best original games: Adventure



Best original games: Pitfall



Best original games: River Raid



Lessons learned

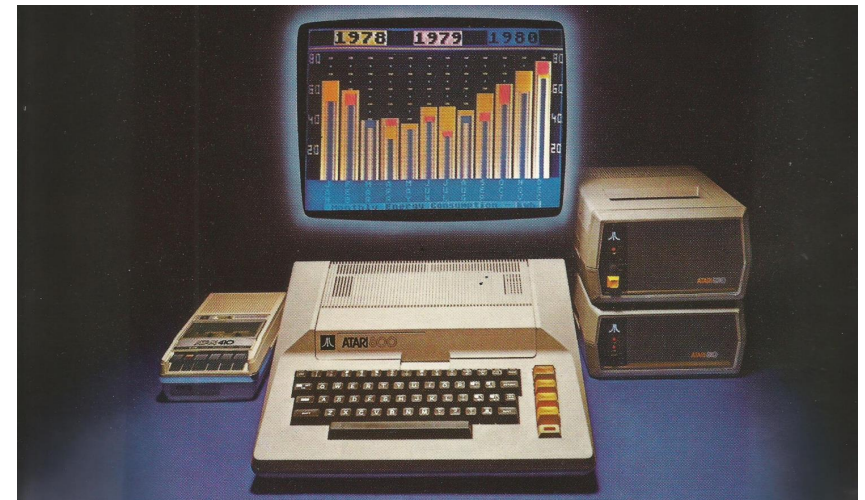
- We put the definition of the display in the hands of the game designers, who were smarter than we hardware designers expected.
- Our conclusion was that our second system should not simply be a bit map and a processor.
- We had created a platform for the art of others, and we planned to build on that for the next system.
- We thought we needed to move fast. The Atari PCS came out two years later, in 1979.

Two VCS Stories

- Winter 1977: we need a roadmap
- Asked to spend another \$1 on a 40-pin 6502 and 30-pin cartridge connector.
- Answer: too late to make the changes
- November 1977: happy children
- I visited the San Antonio Sears Store on Black Friday 1977. Nailed down VCS playing Combat
- Clouds of children waited their turns to play
- They learned game play from each other

Luckier: I got to do it again

- Continue advancing technology.
- We had a hard decision: is the next machine a better game console (Atari 400), a personal computer (Atari 800), or both?



For a better game player

- Support memory-mapped video display
 - We could afford at least 4-8K of DRAM
- Use that memory in various ways:
 - 4-color bit maps up to 160x192 pixels
 - Monochrome up to 320x192 pixels
 - Color and monochrome character modes
- More sprite engines, easy to reuse vertically
- Provisions for vertical and horizontal scrolling
- Add simple video co-processor (display list processor) which can change modes

It helped that we worked with Atari coin-op game developers!

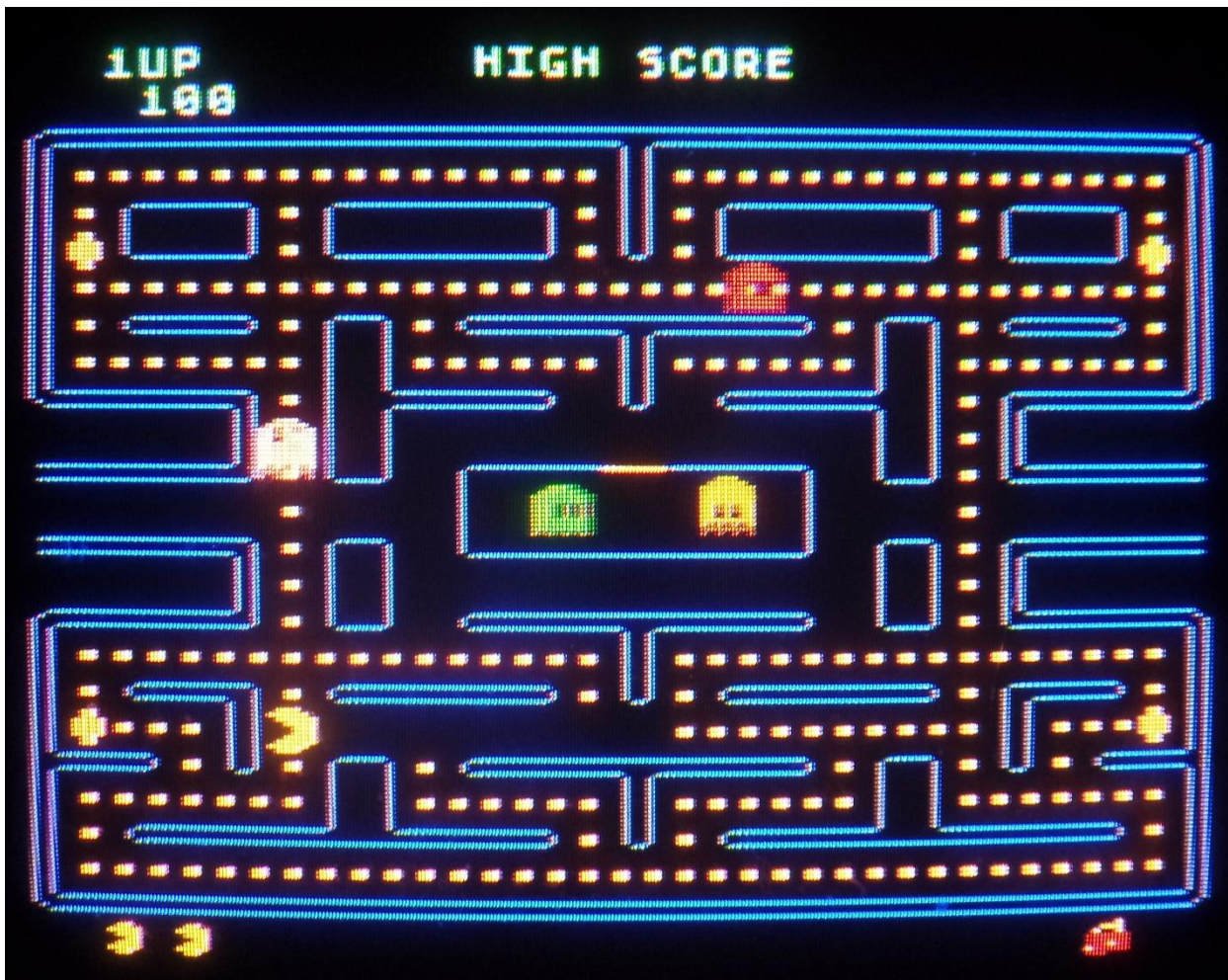
- They worked in nearby. We at together.
- We (PCS designers) got to visit and see their work – e.g. Mike Albaugh, in the audience
- We explicitly designed our hardware to make it possible to port their games to homes
- All this is illustrated in some subsequent slides
- It can games like Superbug, too.

**We played
music
with the
other Atari
engineers,
too.**

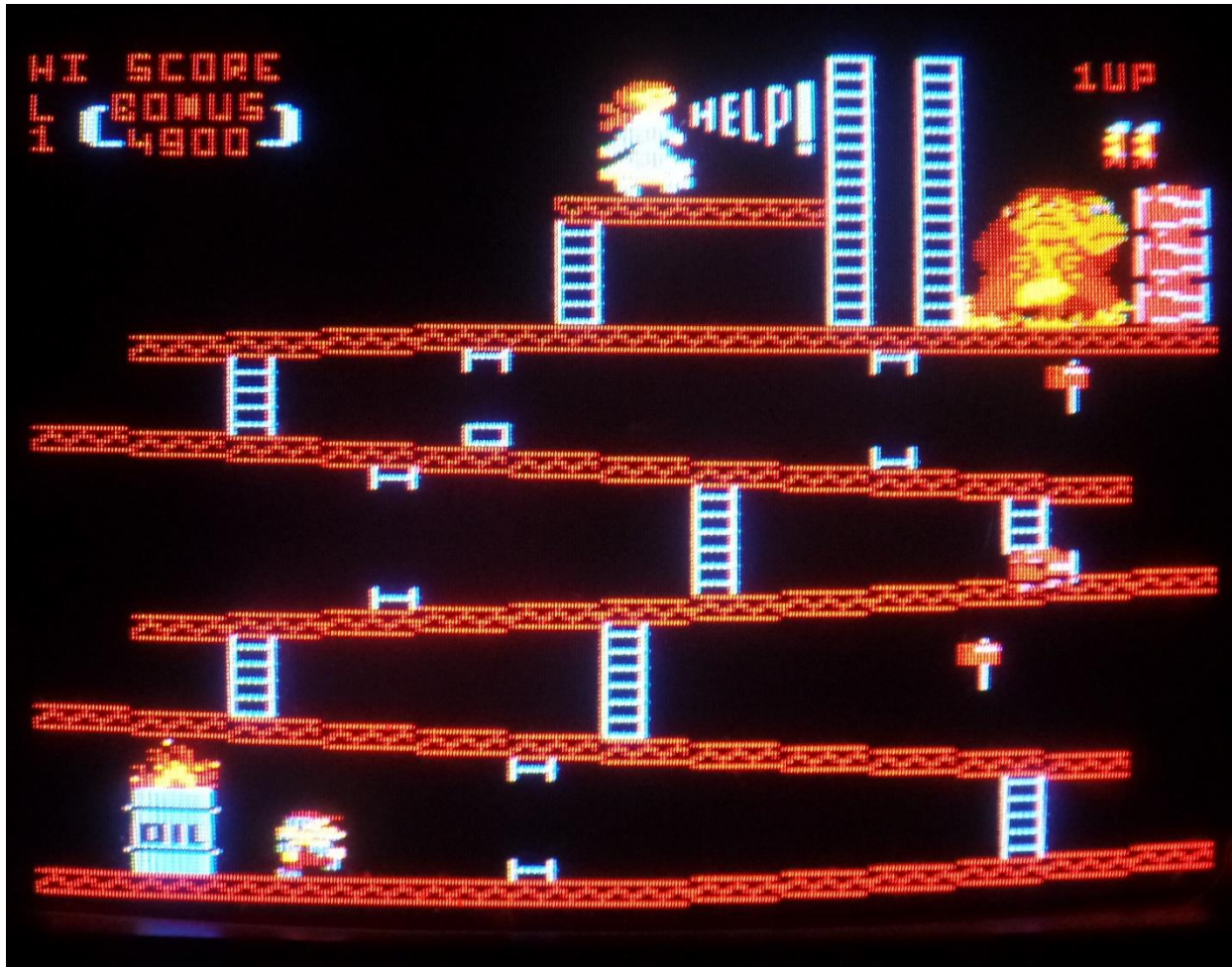


Star Raiders: best original game

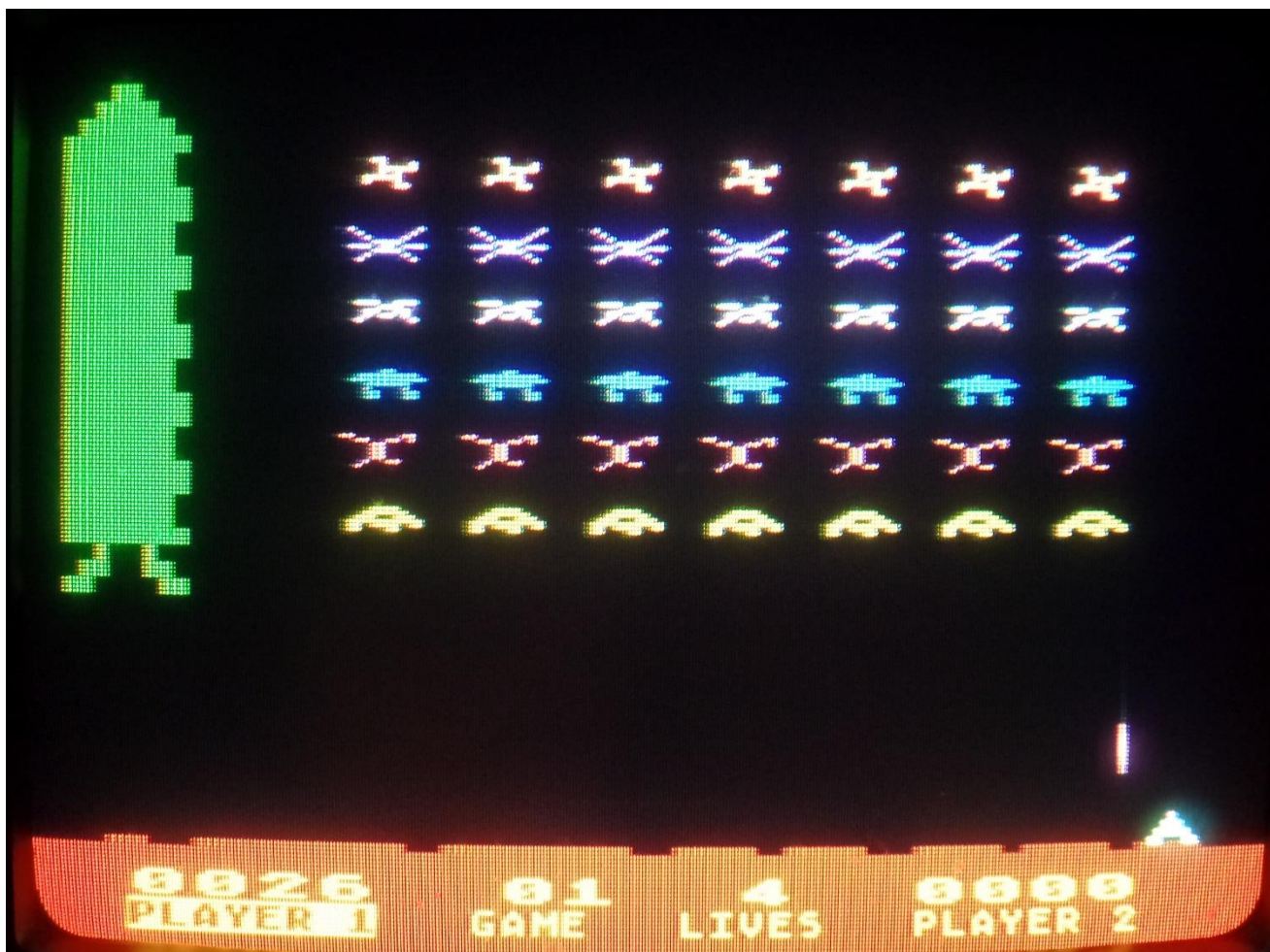




Porting
Arcade
Games was
easy on the
Atari PCS
machines:
Pac Man



Donkey Kong



Space Invaders



Galaxian

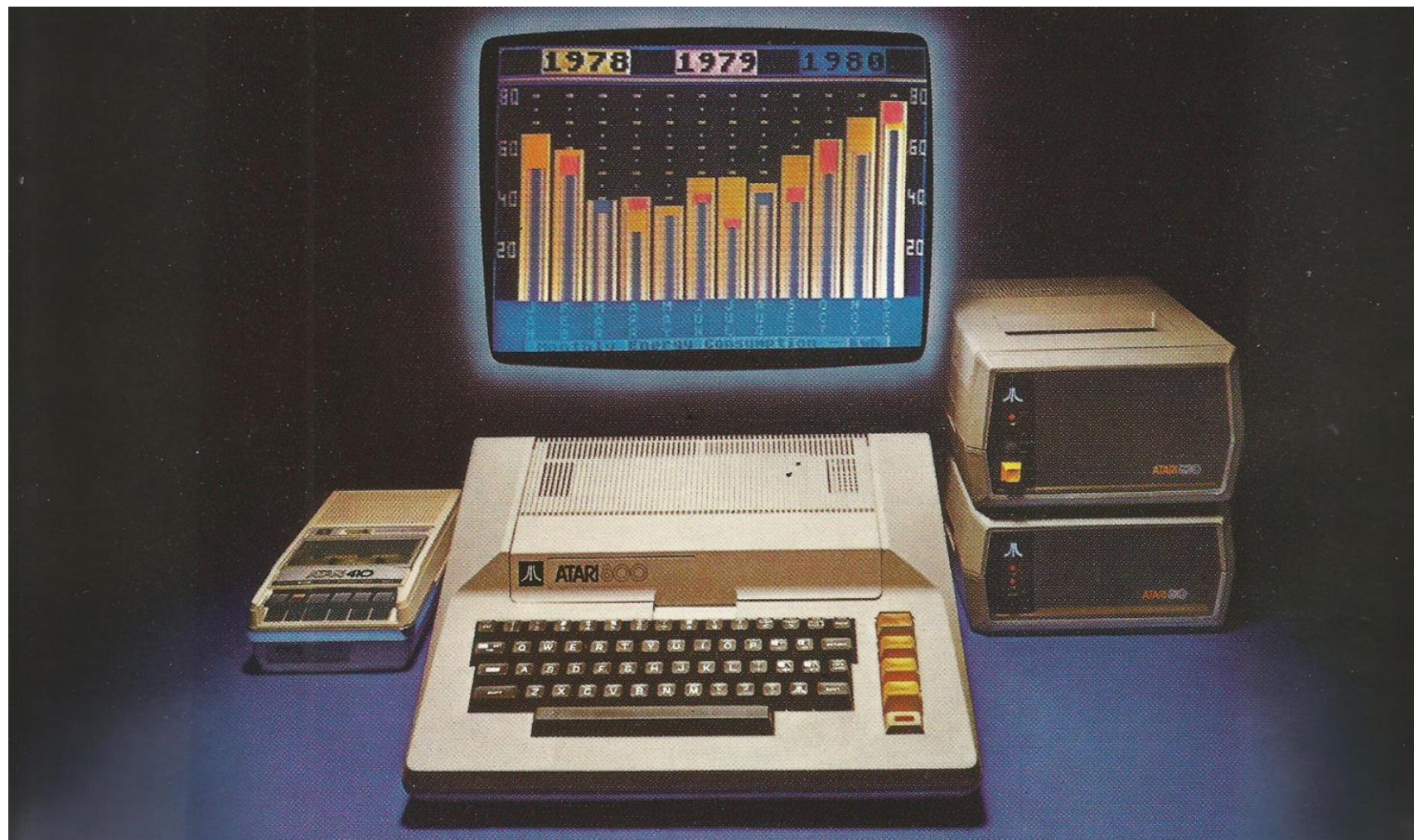
For a personal computer

- Provide character display
 - TVs limited us to 40 characters/line
- Provide a keyboard
- Provide for peripheral expansion for:
 - Printers
 - Communications
- We wanted slots (like the Apple II and S-100 machines) but FCC rules would prevent that
- Necessity: design a serial bus (SIO)
 - Direct ancestor to USB

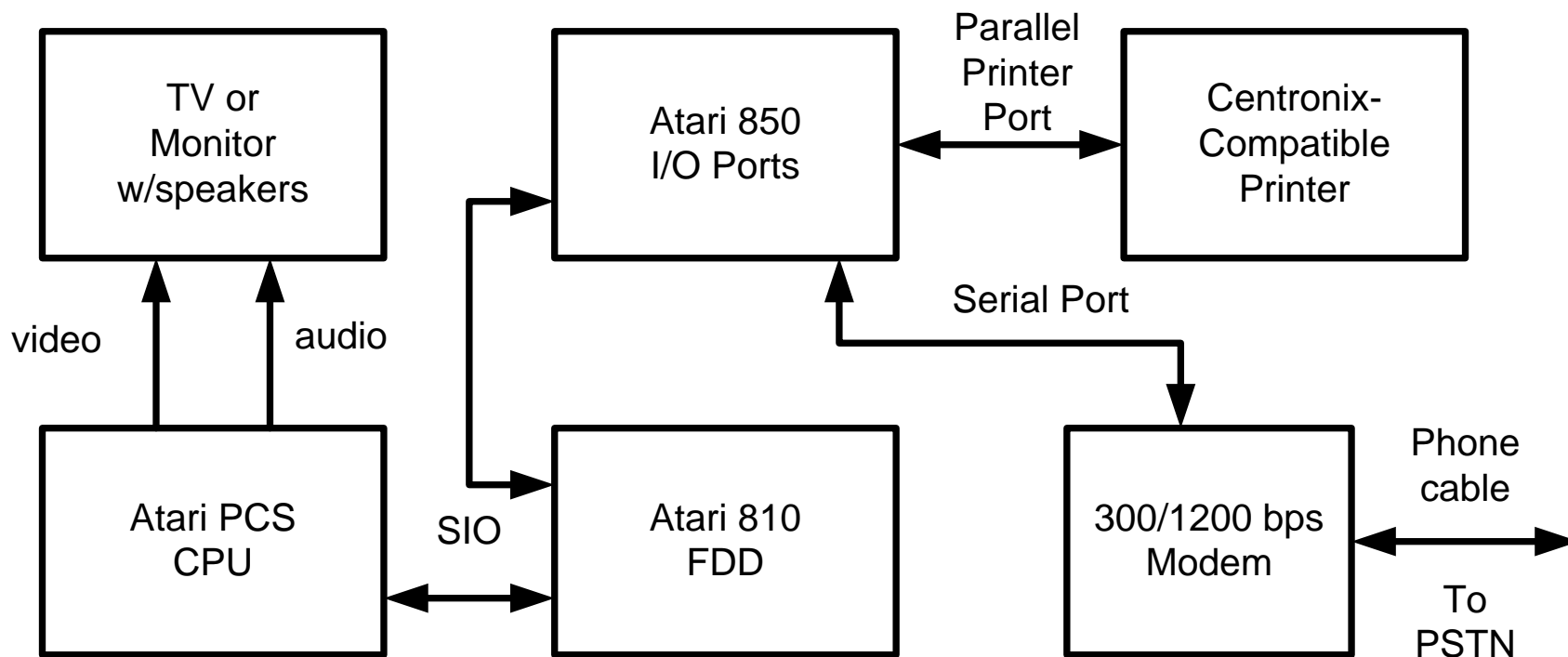
Inventing a serial bus

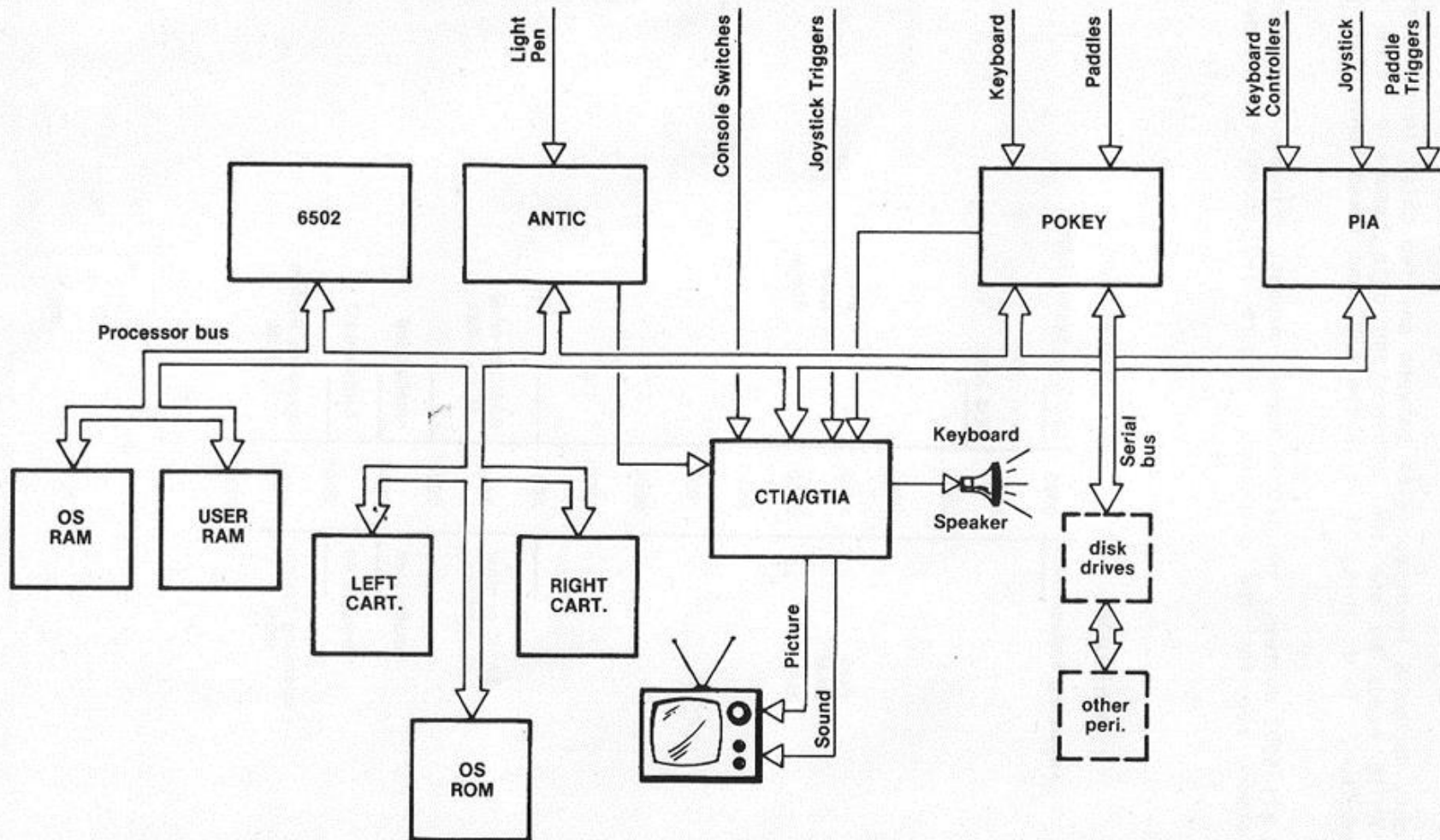
- We could not have an RFI noisy CPU bus
 - Unlike our friends in the Apple II or S-100 bus
- We had to put another processor in each peripheral, e.g. FDD, printer, port expansion
- We tied them together with a 19.2kps serial bus SIO = higher system cost
- Commodore, in 1982, serialized IEEE-488 for another serial bus
- In the 1990s, contributing to USB, patent trolls attacked the USB-IF; we pointed to prior art from Atari and Commodore

Atari 800 computer w/peripherals



Complete Atari system diagram: 800 CPU, 810 FDD, 850 I/O ports





ATARI 400/800

Lessons learned, and not learned

■ As a game console:

- We provided good self-development tools to attract developers
- The founders of Activision and Imagic had not left yet, so Atari was not afraid of third-party developers – that happened later

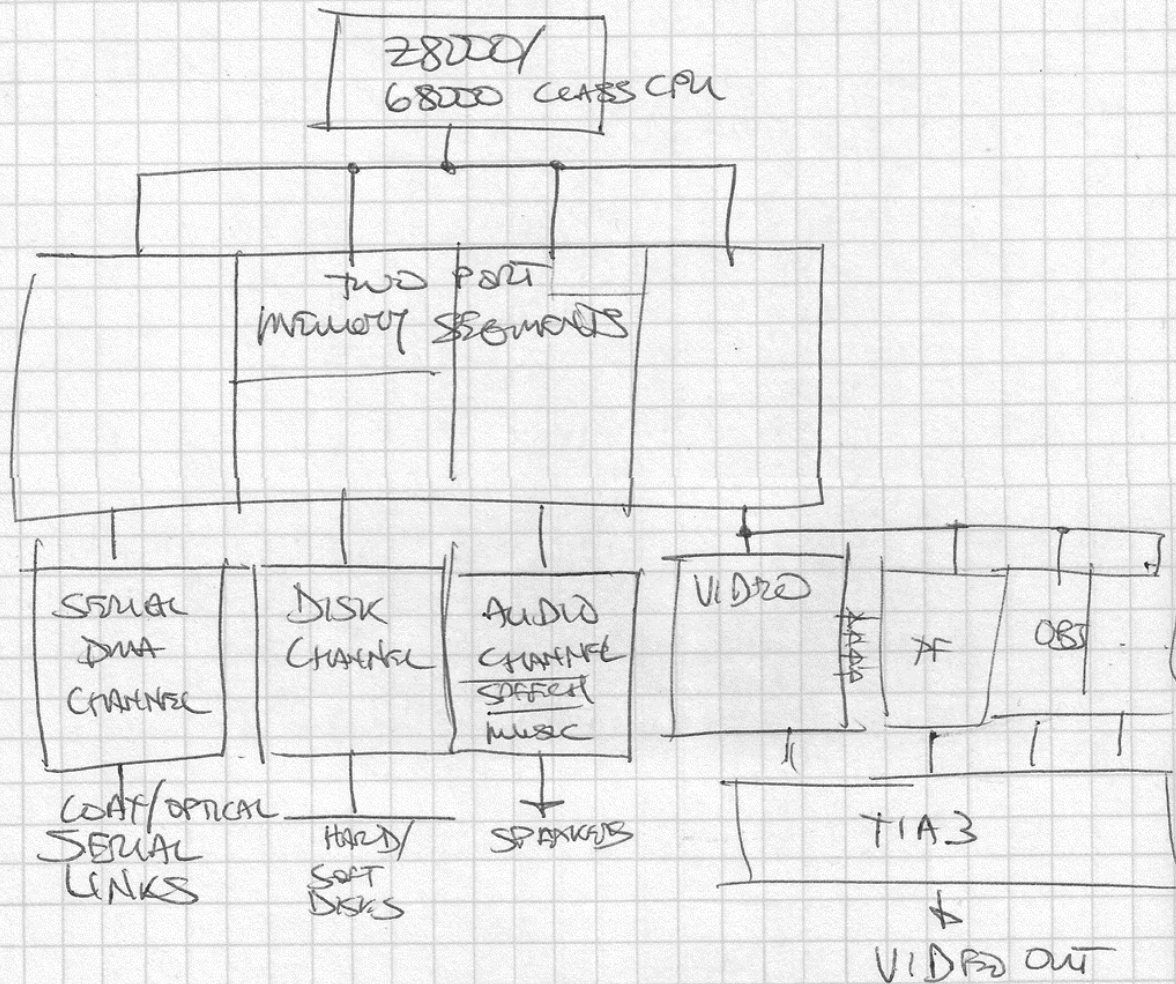
■ As a computer:

- Massive cost reduction possible after FCC changed the rules, e.g. 800XL
- The Commodore C64 passed Atari at this point
- Atari should build a unit with integrated FDD
- Atari could build an expansion unit with hardware slots

Atari 800XL, cost reduction



PROPOSAL FOR 'STOPS OUT'
 HIGH POWER ENTERTAINMENT COMPUTER



Last day at Atari:
 Proposal for a 'stops out next generation machine

Distraction: discovering Minitel

- I am a longtime IEEE member, elevated to Fellow, cited for the three machines featured here. See Wikipedia article
- I read IEEE Spectrum. The June 1978 issue had an article about the French Minitel system. My head exploded.
- I thought: ROM-based cartridges will not scale. The future is computer assisted communication.
- After PCS hit production, I cofounded my first startup to pave the Internet.

Luckier: we build a 3rd system

- We reunited for a third system: Amiga
- It was a groundbreaking animation machine.



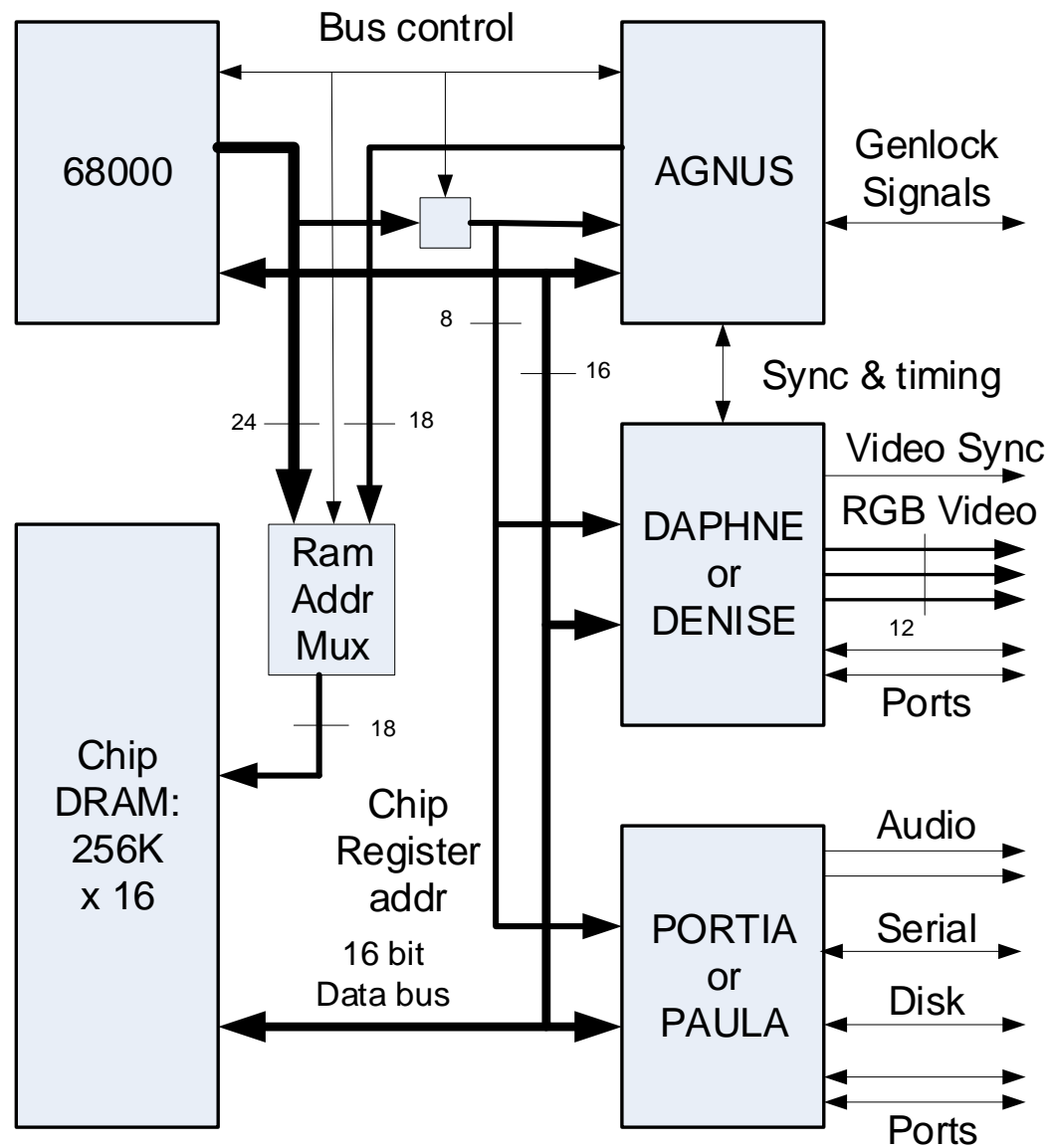
Concepts for a third system

- As a game console:
 - Cartoon-level animation
 - Accelerate bit map manipulation in hardware
 - Synchronize with external video (genlock)
- As a computer:
 - 80 column character displays
 - Enough bit mapped memory for a Xerox Alto-like 'window' OS
 - Larger memory: 128KB or more
 - Built in 3.5" FDD; Expansion to HDD

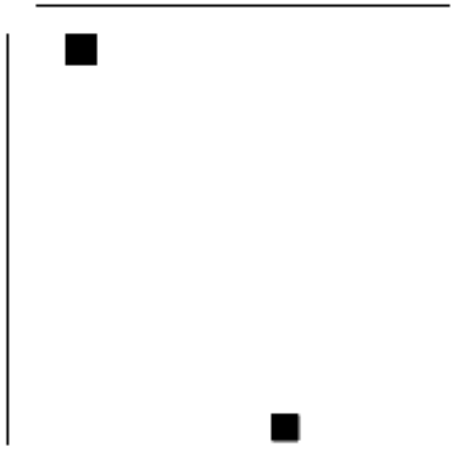
Story: inventing a GPU

- Amiga hired Ron Nicholson, who had work on the original Apple Macintosh
- He had learned about software graphics manipulation.
- To meet Dave Morse' requirements for an animation machine, we developed Amiga AGNES chip hardware for bit manipulation:
 - Create images with line draw & area fill
 - Manipulate images with bit blitter
- First GPU; I have had to testify in court

Simplified Amiga Core system diagram

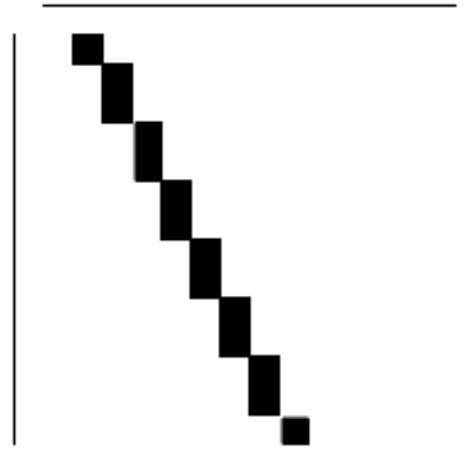


Line Draw & Area Fill



16 x 16 pixel array

Line Draw

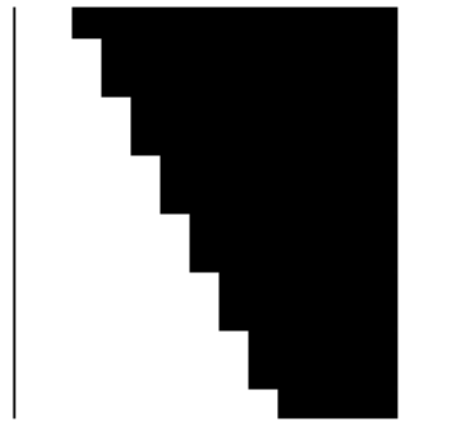


16 x 16 pixel array

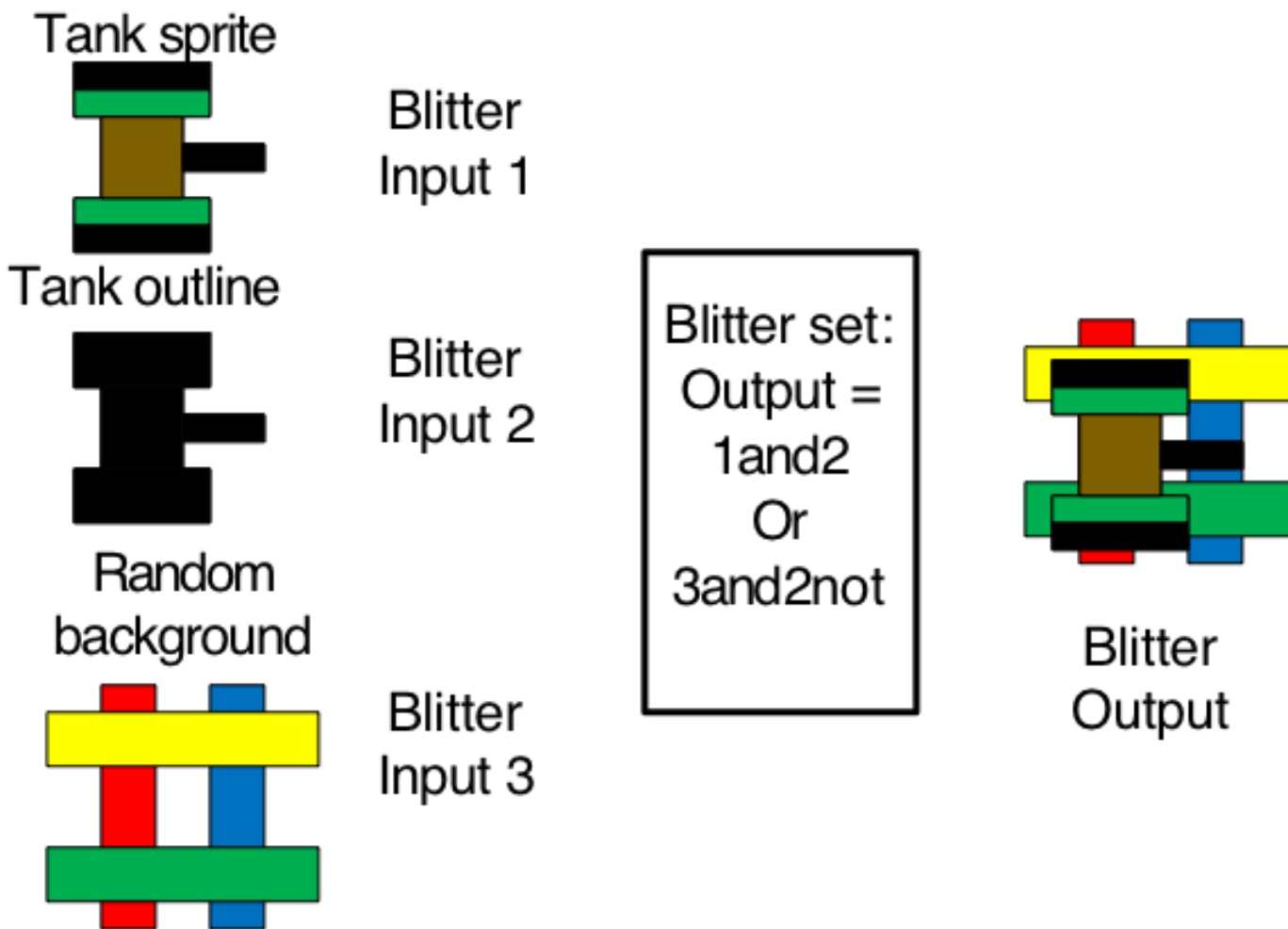


Add a second line

Apply Line Draw



Illustrate Bit-blitter Splicing a Sprite



Live animation: FA-18 demo

- Demonstrates constructing moving images using AGNUS bit-blitter:
 - Color compression (slide 37)
 - Plot points, draw lines, area fill (slide 41)
 - Merging images (slide 42)
- 7 minutes long. MP4 file here:
<https://drive.google.com/file/d/1OSzZC07q0-w3rwhMq3mdbVRszZ4IVPGK/view?usp=sharing>
 - I will play it out of my PC now

Lessons learned

- The collapse of the video game market in 1984 caused a pivot to a computer
- The 1985 Amiga was better than the Super NES in 1992, but it cost a lot more to make in 1985.
- Amiga OS was the first multimedia multitasking OS, 10 years before Windows 95 or MacOS
- Commodore was unable to exploit this market niche, which was too small vs IBM and Mac

- IT HIPSTER -



Critical success

Market success
in Europe

Retro Machine Futures

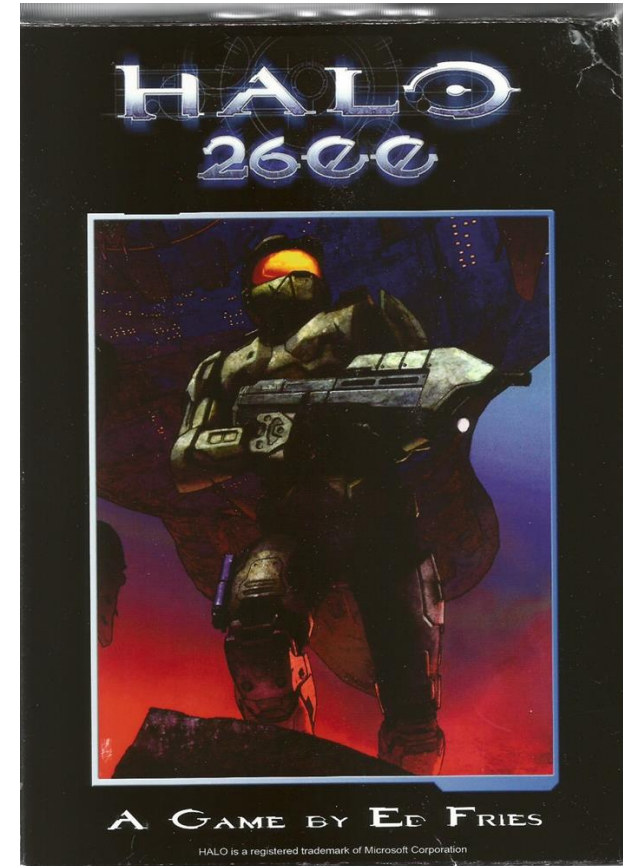
Software emulation
Retro game development
New hardware development
Networking

Software emulation of hardware

- Atari 2600 emulators:
 - <https://stella-emu.github.io/>
 - <https://sourceforge.net/projects/stella/>
 - <http://8bitworkshop.com/> (write new games)
- Atari 800 “8bit” emulators
 - <https://atari800.github.io/>
 - <https://sourceforge.net/projects/atari800/>
- Amiga computer emulators
 - <http://www.winuae.net/>

Modern Atari game development

- There is a development community devoted to generating new 2600 games.
- Visit <http://www.atariage.com/>
- Example of modern video game design: Halo 2600
 - Developed by Ed Fries, who lead original HALO game design at Microsoft
 - Vastly simplified graphics, but playable



Modern retro software development

- See www.8bitworkshop.com
- Steve Hugg's game development web site.
- I supports game development:
 - Atari VCS/2600
 - Atari PCS
 - Nintendo NES
 - Arcade games in Z80 assembly code
 - Arcade games in FPGA code

Modern Atari hardware: Flashback



Modern Atari computer hardware

- Two directions: FPGA and original chips
- Eclair 3.0
 - Mark Watson and Panos Santos, have prototyped and shipped a small number of FPGA-based Atari 800 XL implementations
- Atariage XEL 1088
 - Alternative Motherboard project

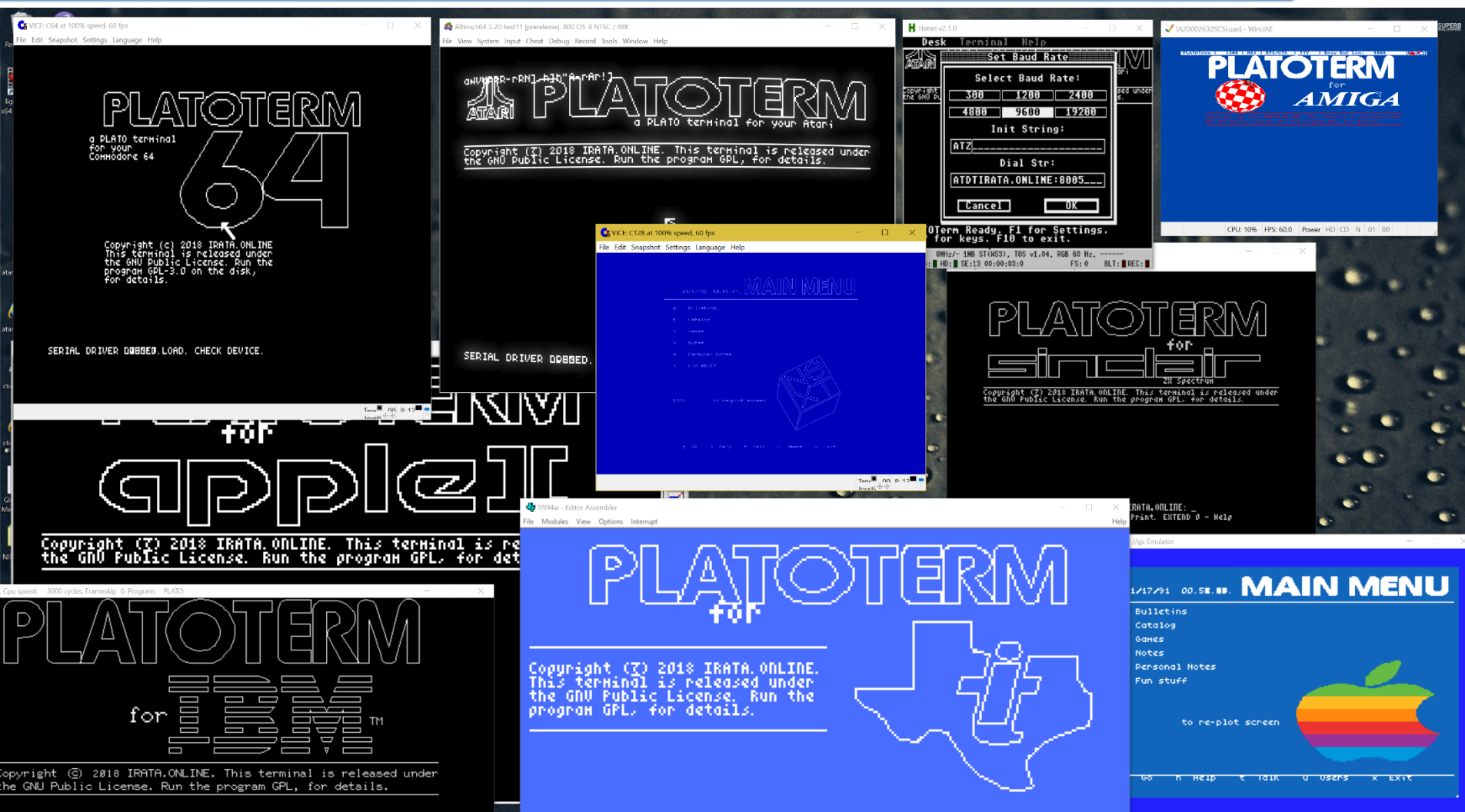
<http://atariage.com/forums/topic/272817-1088xel-atari-itx-motherboard-diy-builders-thread/>

European Amiga redesign

- A Polish designer Przemyslaw Krawczyk (Lotharek”) has done a lot of interesting design work: <http://www.lotharek.pl/>
- The MIST board uses modern hardware to implement classic 16 Bits computers like Amiga, Atari, and 8 Bits systems like C64, ZX-Spectrum, MSX, Atari XL/VCS, Apple II, Colecovision, Sega, NES, etc.
- The MIST is a re-implementation of the original hardware in a FPGA.

Modern computer applications

- Most of the vintage computers were designed with computing resources far inferior to current common PCs or mobile phones
 - iPhone X has a hex-core ARM
 - Intel CORE i7 is a quad core beast
 - Lots of video display resolution
 - Lots of communication bandwidth
- Thomas Cherryhomes has designed a cross-platform communications platform.
 - See illustration on next slide



C64, Atari 8-bit, Atari ST, Amiga, Apple II, NeXT, Sinclair, IBM PC, TI 99/4, Apple MAC

Even more modern: FujiNet

- A team led by Tom Cherryhomes had developed a series of network adaptors for retro computers:
 - Atari PCS family
 - Apple II family
 - Commodore 64
 - Adam
- Common: WiFi-enabled microcontroller hooked into a communications port
 - E.g. Atari PCS SIO serial bus

Resources

**Learn more
contacts**



To learn more, 1 of 2

- **Racing the Beam:** MIT Press published a Platform Series book on the Atari VCS (2600).
- **Breakout, How Atari 8-bit Computers Defined a Generation,** Jamie Lendino
- **The Future Was Here,** MIT Press, Amiga Computer, Maher
- **Atari: Business is Fun,** Goldberg & Vendel. This is the definitive *social* history of Atari, 1972 - 1984.
- **The Annotated Adventure:** Warren Robinett is working on a book about the 2600 Adventure game design.
- **Making Games for the Atari 2600,** Steven Hugg
- **De Re Atari,** Chris Crawford, program Atari 8-bit PCs

To learn more, 2 of 2

- **“Game On!”** about the Atari 2600 design, IEEE CES Magazine, Decuir, July 2015
- **Encore: Atari’s Second System**, IEEE CES Magazine article, Decuir, Jan 2016
- **The Amiga: a Hardware Engineering Story**, Advancing multimedia computing capability, IEEE CES magazine, Decuir & Nicholson, Oct 2016
- **Design Case History: the Atari Video Computer System**, IEEE Spectrum, March 1983
- **The Computer that Would not Die**, Paul Wallich, IEEE Spectrum, March 2001
- Online: **Atari Museum**: <http://www.atarimuseum.com/>

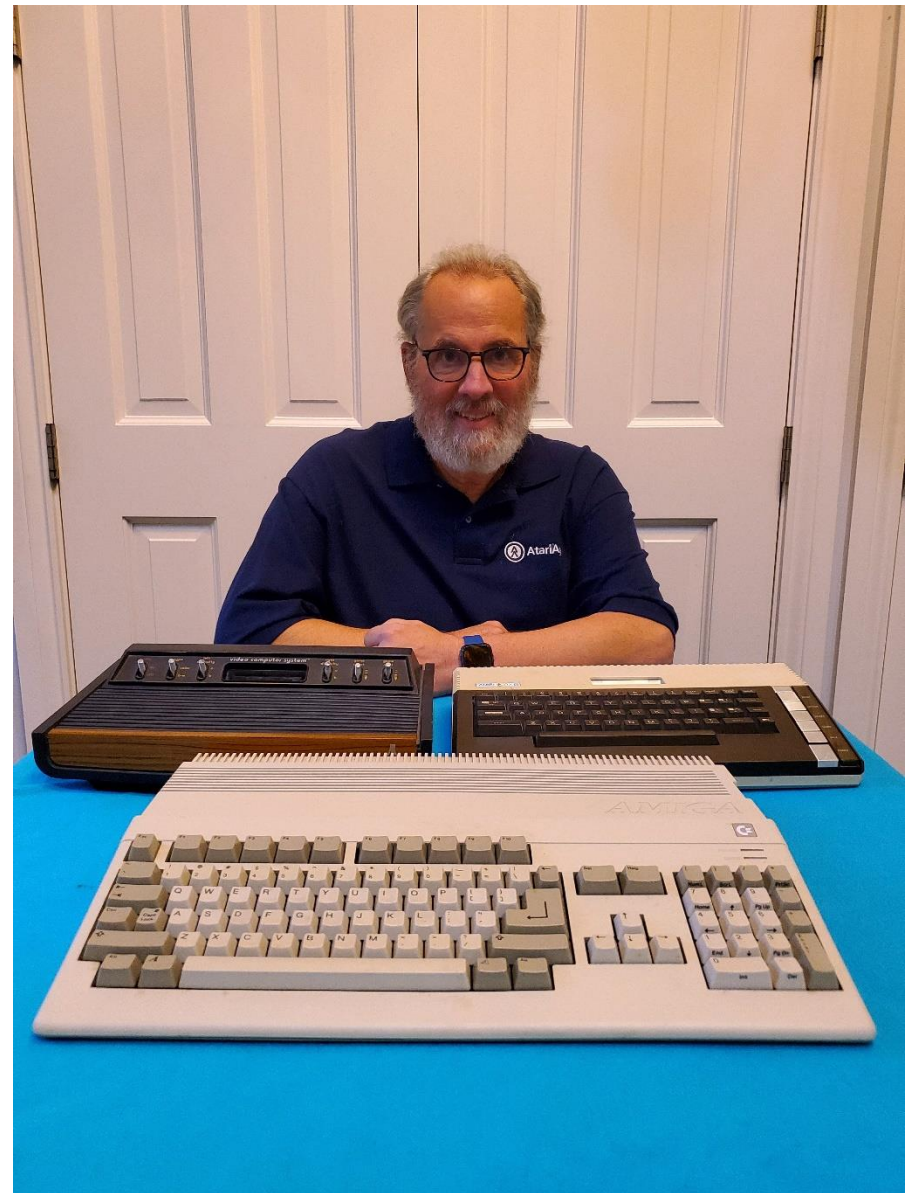
Contact

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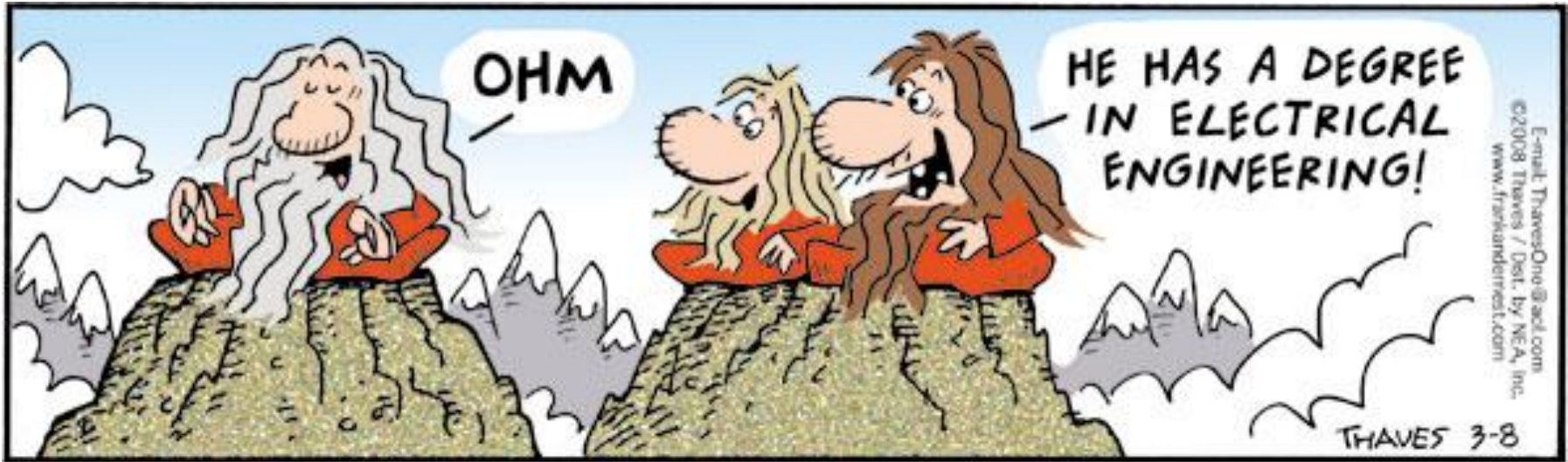
IEEE Fellow, for
contributions to
computer graphics and
video games = Atari
and Amiga

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electrical engineering
faculty

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jdecur@uw.edu



Questions?



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- I brought demos: w/composite video-to-VGA adaptor
1. Atari Flashback 2 (FPGA) w/game carts
 2. Atari 800XL, w/game carts
 3. Amiga 500, with F/A-18 Flight Simulator game