Introducing the X68000: Japan’s 16-Bit Beast

Ford Seidel
Japanese Home Computers Circa 1987

Unlike today where nearly all machines are boring x86 boxes, there were several wildly different options back then

- MSX
- NEC PC-88 and PC-98
- IBM PC Compatibles
- Fujitsu FM series
- Sharp X1
- Sega SC-3000
- Way too many to list here
**MSX: Dominant Japanese Computer Standard**

- Created by Microsoft in 1983 in an attempt to standardize the PC market
- Manufacturers would implement their own machine within the MSX standard
- Z80 CPU at 3.58MHz
- Also sold in Europe and the Middle East
- In 1987, current standard was MSX2/2+
  - >= 64KB main RAM
  - >= 128KB VRAM
  - AY-3-8910/YM2149 sound chip
    - 3 square waves and a noise generator
  - 512 color palette
  - 256 colors at 256x212 or 16 colors at 512x512
MSX2 Graphics

- Hardware only supports vertical scrolling
- To avoid this, games were often restricted to 1 screen
Nemesis 2: a Fairly Standard MSX2 game

https://www.youtube.com/watch?v=ZfZf8XF7_o
Good Scrolling (REALLY hard to do)

https://www.youtube.com/watch?v=gcZJ64PgtgA
Sharp X1

- Not super popular, but also not unpopular by any means
- Technically inferior to MSX2
- Z80 CPU at 4MHz
- 8 colors
- 320x200 or 640x200 resolution
- AY-3-8910/YM2149 sound chip
- Optional YM2151 FM synth soundchip
X1 Twin

- Contains an X1 and a PC Engine/TurboGrafx-16
- Inspired X68000’s design
Space Harrier on X1

https://youtu.be/RUad5Vr0QsY?t=47s
The Sharp X68000

- Sharp realized that there was space in the high end market not occupied by MSX
- Aimed to design machine vastly more powerful than anything else on the market
- Spent a lot of time creating tools and libraries to help game developers
- Significantly more expensive than anything else on the market
  - ¥369,000 = $6000 USD in today’s money
- No backwards compatibility with X1
- Quite possibly the most powerful machine of the 16-bit era
- Able to outperform machines released several years later (Genesis/SNES)
- Huge homebrew following
General Specs (original 1987 model)

- Motorola 68000 at 10MHz
  - upgradable to a 68030 at 16MHz with an über-rare “xellent030” card
- 1MB system RAM (upgradable to 12MB)
- 1MB VRAM
- 2 sound chips
  - YM2151FM Synth
  - Okidata MSM6258 ADPCM sampler
  - optional MIDI card
- I/O: DB-25 serial, 2 expansion slots, 3D glasses controller, video genlock, external SASI
- Dual 5.25” high density soft eject floppy drives (1.2MB per disk)
- Dual tower case with expandable carry handle
- Weight: enough to make shipping one here from Japan really expensive
Coolest looking PC ever?
OSes

- Stock OS: Human68K
- Boring MS DOS clone
- GUI: SX-Window
- 3rd party: KO-Window
Peripherals: Because $6000 Just Wasn’t Enough

- tons of different upgrades available
- both first and third party options
- even some homebrew stuff
- most of these range from hard to find to unobtanium
  - some are rare enough that I couldn’t actually find any pictures of them
CPU and Memory Upgrades

- Floating point units
- 68030/040/060 CPU accelerators
- XSIMM SIMM adaptor (the only way to max out an X68K’s RAM)
Multimedia Expansions

- 8 channel PCM sound card (“Mercury Unit”/PCM-8)
- MIDI board: connect your standard PC MIDI card to the X68K
  - popular choices include Roland MT-32 and SC-55
- TS-6BGA graphics accelerator
  - 16.7 million colors
  - CD quality audio
  - not a 3D accelerator
Video Hardware: An in-depth look

- 1MB VRAM split into two 512KB sections
  - TVRAM = high resolution 1024x1024 text display layer at 4bpp (16 colors)
    - each bit in a separate “plane”, hard to do color
  - GVRAM = 512x512 or 256x256 bitmap graphics display
    - several modes (selectable 256x256 or 512x512 resolution)
      - 4 16-color planes
      - 2 256-color planes
      - 1 65536-color plane
- 128 sprites, each 16x16, with 16 colors
- sprite controller can also generate tilemap background plane
Sound Hardware

- YM2151
  - 8 channels of 4 operator FM Synthesis
  - same chip used in most arcade boards at the time
- OKI MSM6258
  - 1 channel of 4-bit ADPCM at one of several predefined sample rates
  - decent quality
Also Released in 1987: The Amiga 500

- Classic Amiga
  - $699 on launch = $1500 in today’s dollars
  - 7.16MHz Motorola 68000
  - 512KB RAM shared between CPU and graphics
  - Several video modes
    - 1 layer with 32 colors on screen
    - 2 layers with 16 colors on screen
  - 736x483 at 4bpp or 368x483 at 6bpp (extra bit halves brightness)
  - 8 sprites (16 px wide, arbitrary height)
  - 4 channels of DMA-driven PCM audio
  - Blitter
  - “Copper” state machine to control video hardware mid-frame
Enough Numbers, Let’s Look at Some Games!
Nemesis 2 on X68000

https://youtu.be/S3C6UYVcHjg?t=4m59s
Space Harrier on X68000

https://www.youtube.com/watch?v=nhymlDtiZmQ
Yeah, those look nice, but what can it REALLY do?
- “超連射68K” (Cho Ren Sha = Ultra Fire) (1995)
- Produced by 2 people
  - Music by Ruzarin “Loser” Kashiwagi
  - EVERYTHING ELSE by Koichi “Famibe no Yosshin” Yoshida
- 512 sprites on screen at once thanks to crazy sprite multiplexing hackery
- FM synth soundtrack and sampled sound effects
- Coded almost entirely in C (Assembly is the norm)
- X68K and Windows versions available for free from the author’s website
Backup Video

https://www.youtube.com/watch?v=ymf_e0Y4iZA
I’m not impressed unless it can do 3D

- “Geograph Seal” (1994)
- Developed by Exact (Excellent Applications Create Team)
- Yes, that’s the real title, and yes, that’s the official acronym
- Realtime filled 3D polygons without any hardware acceleration
- Precursor to “Jumping Flash” on PS1, also developed by Exact
Video Clip

https://www.youtube.com/watch?v=pNYLREOG52k
So, you’ve just made the most powerful PC on the market. Now what?

- In the years following 1987, Sharp made minimal improvements to the X68000
- All models except original were available in normal and “HD” (hard drive) versions
  - 1988:
    - ACE: board layout difference, 20MB HD
  - 1989:
    - EXPERT: 2MB RAM now standard, 40MB HD
      - this is the model CMUCC owns
      - original cost: ¥466,000 = ~$7500 in today’s money
    - PRO: basically an x68000 with more addon slots in a standard PC case
      - only 1MB RAM
- 1990:
  - EXPERT II: board layout revision, 40MB HD
  - PRO II: just a PRO with a board revision, still only 1MB RAM stock
  - SUPER: SASI replaced with SCSI, 80MB HD

1991:
  - XVI: CPU upgraded to 16MHz (10MHz mode available for compatibility)

1992:
  - Compact XVI: smaller form factor with 3.5” floppies
    - no HD variant available
Surely they didn’t expect a modest CPU boost to keep a 5 year old machine current...

1993:

- X68030: 68030 CPU at 25MHz, 4MB RAM
  - mediocre backwards compatibility with games
- X68030 Compact: like the XVI compact but with the X68030’s specs
The Whole Family
The downfall of the X68000

- Sharp went 6 years without upgrading the video or audio hardware
- by 1993, you could buy a decent PC with nice graphics and sound
- Moral of the story: just because your computer was better than your competitors’ products 6 years ago doesn’t mean it’s still better now
- Sharp quietly discontinued the X68000 line
  - planned PowerPC model canceled
It’s 2016: Let’s Write Code for This Thing!

- There’s a ton of documentation for this machine, but it’s all in Japanese
- a programmer going under the pseudonym “lydux” released a full GCC toolchain, newlib implementation, and dos call wrappers for the X68K, documented in English
  - also from lydux: a version of GDB that can debug your X68K over serial
- Tons of music composition tools, sound drivers, graphics editors, and other stuff have all been released for free on the internet
- If you’re interested in developing for the X68K, talk to us :)
Wow, I want one!

- The X68000 has the ability to break your wallet very quickly
  - most games need 2MB of RAM, so you want a later model
  - rare and expensive
  - heavy = expensive shipping from Japan
  - everything is proprietary, so prepare to put up serious cash for accessories
  - even the keyboard and mouse are expensive
- Horrible power supply caps = low chance of it working out of the box
  - Some sellers will replace the caps, but these usually go for more money
- 30 year old mechanical hard drives are unreliable
  - SCSI2SD is an excellent replacement (even works on SASI models)
- EVERYTHING IS IN JAPANESE
- Doesn’t play nicely with LCDs, so you probably want a nice CRT
  - the “lcdnix” driver isn’t compatible with many games
Any Questions?