Sega Saturn (1995)

- Two ≈29 MHz Hitachi SuperH-2 7604 32-bit
- Hitachi SuperH-1 - controller for CD-ROM
- 11.3 MHz Motorola 68EC000 sound controller
- 22.6 MHz Yamaha FH1 DSP sound processor
- 1 MB SDRAM, 1 MB DRAM
- 1.5 MB VRAM
- 4 KB VDP2 on-chip color RAM
- 512 KB audio RAM
- 512 KB CD-ROM cache
- 32 KB nonvolatile RAM
- Initial launch price $400
  - Not initially sold at a loss
- 10 million sold

Photo and info from Wikipedia

Sega Saturn - Complexity

“One very fast central processor would be preferable.

I don’t think all programmers have the ability to program two CPUs — most can only get about one-and-a-half times the speed you can get from one SuperH-2.

I think that only one in 100 programmers are good enough to get this kind of speed [nearly double] out of the Saturn.”

- Yu Suzuki, on Saturn Virtua Fighter development

Quote from Wikipedia

Sega Saturn - Graphics

- ≈7.1590 MHz “VDP 1” 32-bit Video Display Processor
- ≈7.1590 MHz “VDP 2” 32-bit
- Quadrilaterals - not triangles!
- No hardware decompression

Quote from Wikipedia
Sony Playstation (1995)

- ≈34 MHz MIPS R3000A-type (R3051) 32 bit
- 2M main RAM
- 1M video RAM
- 512K sound RAM
- 32K CD-ROM Buffer
- 512K OS ROM
- 128K Memory cards
- $300 at launch
- 102 million sold

Pics & info from Wikipedia & www.insomniacgames.com

Sony Playstation - Graphics

- 24-bit color, 256x224 to 640x480 resolution
- “Geometry Transformation Engine”
  - Built into same chip with MIPS R3000A CPU
  - 66 MIPS
  - 360,000 flat-shaded polygons per second
  - 180,000 texture mapped, Gouraud shaded polygons per second
- “Data Decompression Engine”
  - 16x16 Inverse Discrete Cosine Transforms (ICDT)
  - DMA transfer of uncompressed images to GPU

Photo and info from Wikipedia

Full motion cheese

- Insomniac’s “Disruptor” (1996)
- Excellent gameplay, but badly acted live action cutscenes

Gameplay: http://www.youtube.com/v/Vg8v78fYVFk
Cutscene: http://www.youtube.com/v/ireaHGUcJ1uM

Increasing trend: in-engine cutscenes

- Konami’s “Metal Gear Solid” (1998)

Konami’s “Metal Gear Solid” (1998)

http://www.youtube.com/v/5snv3RfMYMU

Pictures from Wikipedia
Nintendo 64 (1996)

- ≈94 MHz MIPS R4300i-type
  - 64 bit registers, instructions, internal data path
  - 32 bit external data path
- 4M RAM - unified address space
- 32K colors, 256x224 to 640x480 resolution
- $200 at launch
- 32 million sold
- SGI CPU/GPU combo design
  - SGI bought out MIPS
  - Originally for Sega, but deal fell through

Photo and info from Wikipedia

Nintendo 64 - Graphics

- ≈65 MHz “Reality Coprocessor” (RCP)
  - Designed by SGI
- “Reality Signal Processor” (RSP)
  - MIPS R4000-based 8-bit integer vector processor
  - Programmable through microcode
  - Geometry transforms, clipping, lighting
  - SGI Fast3D microcode: ~100,000 polygons per second
  - Can also handle some sound duties
  - Presages some of the programmability of modern GPUs
- “Reality Drawing Processor” (RDP)
  - Rasterizer (turns triangles into pixels)

Photo and info from Wikipedia

Nintendo 64 Killer App - Rare’s “Goldeneye 007”

- 4-way split screen multiplayer
  - [http://www.youtube.com/v/7cf5kkoYexI](http://www.youtube.com/v/7cf5kkoYexI)

Picture from Wikipedia

Nintendo 64 - Last console to use cartridges

- 4 MB to 64 MB (Resident Evil 2)
- Some cartridges have nonvolitale RAM for saved games
- Pros
  - More piracy resistant than CDs
  - Faster loading time (CD-ROMs slow at the time)
  - No lengthy load screens like on Playstation
  - More durable (important for children)
- Cons
  - Small capacity compared to CD
  - Higher manufacturing costs and lead times - turned off third-party vendors, ate into profit margins

Info from Wikipedia
**Sega Dreamcast (1999)**

- 200 MHz Hitachi SuperH
  - 32-bit instruction set, 128-bit FPU functions
- 16M main ram, 8M video RAM, 2M sound RAM
- Launch price: $200
- 10.6 million sold

**Sega Dreamcast - Graphics**

- Imagination Technologies PowerVR2
  - PowerVR series competed with Voodoo series by 3dfx
  - Both companies eventually killed by ATI & NVIDIA
- Over 5 million polygons/second (7 million peak)
- Hardware gouraud shading, z-buffering, anti-aliasing and bump mapping

**Microsoft Xbox (2001)**

- Sony’s success with PS1 worried Microsoft
- 32-bit 733 MHz Pentium III-based Celeron
- 64 MB main RAM
- Development very much like developing Windows PC games
  - DirectX API
  - Easy to make PC and Xbox versions
- DVD movie playback
- $300 at launch
- Killer app - Halo: Combat Evolved
<table>
<thead>
<tr>
<th><strong>Microsoft Xbox - Graphics</strong></th>
<th><strong>Nintendo Gamecube (2001)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- 233 MHz NVIDIA “NV2A” GPU</td>
<td>- “Gekko” - 485 MHz PowerPC 750CXe-based core</td>
</tr>
<tr>
<td>- Similar to GeForce 3 and GeForce 4</td>
<td>- Nonstandard, small optical disk</td>
</tr>
<tr>
<td>- 485,416 triangles per frame at 60fps</td>
<td>- Can’t be used as a standard DVD player</td>
</tr>
<tr>
<td>- 970,833 triangles per frame at 30fps</td>
<td>- Some protection from piracy</td>
</tr>
<tr>
<td>- Bilinear, trilinear, and anisotropic texture filtering</td>
<td>- Avoid DVD Consortium licensing fees</td>
</tr>
<tr>
<td>- Texture compression, full scene anti-aliasing</td>
<td>- 24M main RAM</td>
</tr>
<tr>
<td></td>
<td>- 1M texture buffer</td>
</tr>
<tr>
<td></td>
<td>- 2M frame buffer</td>
</tr>
<tr>
<td></td>
<td>- 21 million sold (as of June 2007)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Nintendo Gamecube - Graphics</strong></th>
<th><strong>Sony Playstation 2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- 24-bit color, 640x480 interlaced or progressive scan</td>
<td>- 140 million sold as of mid-2008</td>
</tr>
<tr>
<td>- “Flipper” - 162 MHz, co-designed by Nintendo and ArtX</td>
<td>- Emotion Engine:</td>
</tr>
<tr>
<td>- TEV “Texture EnVironment” engine</td>
<td>- 300 MHz</td>
</tr>
<tr>
<td>- Similar to “pixel shader”</td>
<td>- MIPS III core</td>
</tr>
<tr>
<td>- Fixed-function hardware transform and lighting</td>
<td>- Two “Vector Units”</td>
</tr>
<tr>
<td>- 12+ million polygons/second</td>
<td>- Graphics Interface (GIF) for talking to Graphics Synthesizer (GS)</td>
</tr>
<tr>
<td>- Bilinear, trilinear, and anisotropic texture filtering</td>
<td>- Image Processing Unit</td>
</tr>
<tr>
<td>- Bump mapping, reflection mapping</td>
<td>- MPEG2 decoder</td>
</tr>
<tr>
<td></td>
<td>- Macroblock decoding</td>
</tr>
<tr>
<td></td>
<td>- Vector quantization</td>
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</table>
Emotion Engine


Vector Processing Units

- VPU0: intended for “thought simulation and physical simulation”
  - Outputs to ScratchPad RAM (SPR) for use by GS for VPU1
- VPU1: intended for graphics pipeline
  - Geometry transformation
  - Vertex lighting
  - Outputs triangles (display list) to Graphic Synthesizer

Graphics Synthesizer (GS)

- 16, 16-bit integer registers
- 32, 128-bit floating point registers
  - Split into 32 bit words (x,y,z,w)
- Four FMACs in one clock cycle
- Two sets of drawing environments (internal contexts)
  - GS knows which instructions came from VPU0 and VPU1
  - Merges sequences

Microsoft XBox 360 (2005)

- 3.2 GHz “Xenon” triple-core PowerPC
  - 2 hardware threads per processor
- 256 MB main RAM
- 500 MHz ATI “Xenos” GPU
- Xbox Live online service
  - “Live arcade” game distribution
- HD-DVD drive available as ad-on
- Launch price: $399 premium, $299 core (kind of useless)
- Power Mac G5 early devkits?

Photo and info from Wikipedia
Sony Playstation 3 (2006)

- IBM/Toshiba/Sony Cell processor
  - PowerPC Processing Element (PPE)
  - 8 Synergistic Processing Elements (SPE)
- 256M main RAM, 256M graphics RAM
- Blu-Ray drive
  - Part of Sony’s strategy of establishing Blu-Ray movie format
- Launch price: $500 (crippled), $600 (“real” version)
- Sold at an estimated loss of around $250
- Original $600 model recently dropped to $500
- New $600 (80 gig) model released

Sony Playstation 3 - Graphics

- 550 MHz NVIDIA RSX
- Closely related to NVIDIA 7800
- Sadly, Linux users currently do not have access to the accelerated graphics
  - Stuck using frame buffer mode

Nintendo Wii (2006)

- Not a lot of info publicly released
- “Broadway” - 729 MHz PowerPC core
- 243 MHz ATI “Hollywood” GPU
- 88 MB main RAM
- 24 MB RAM in GPU
- 64 MB external video RAM
- Regular sized DVDs
  - But original Wii won’t play DVD movies
- Bundled with Wii Sports - “killer app”

State of Mac Gaming

- PowerPC Mac OS users were lucky to get a few ports here and there
- Intel Mac OS users often boot into Windows for their gaming needs
- At MacWorld 2007, Electronic Arts Chief Creative Officer Bing Gordon announced renewed interest in supporting Mac OS X
- Latest id game engine - “id tech 5” (“Rage”) will spit out Xbox 360, PS3, Windows, and Mac OS executables in a single build
  www.youtube.com/watch?v=HvuTtrkVtns