Nintendo 64 Architecture

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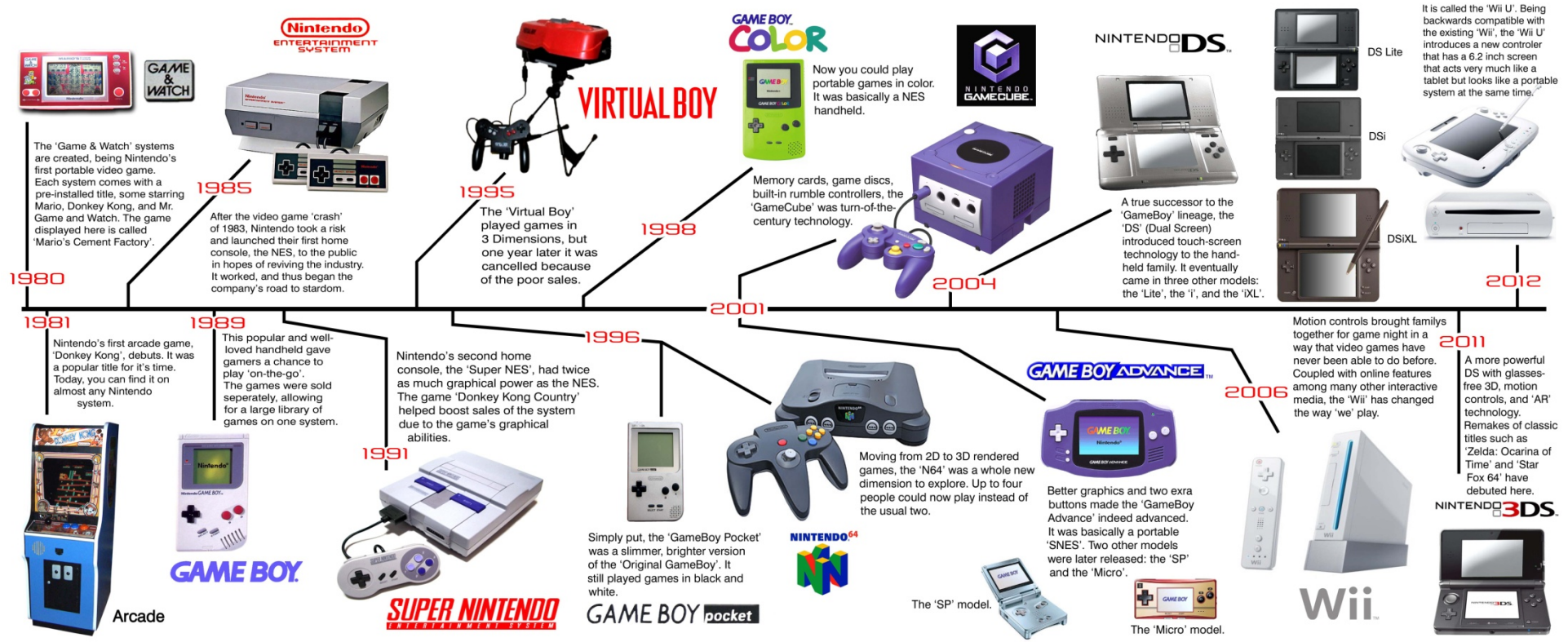
AGENDA

- History
- Introduction to the Nintendo 64 Architecture
- CPU
- Memory
- Game Pak
- Reality Coprocessor (RCP)
  - Reality Signal Processor
  - Reality Display Processor
- I/0
- Weaknesses
- Impact

HISTORY

- Nintendo was founded in 1889 as a playing card company
- Nintendo 64 was Nintendo's 3rd game console for an international market
- Released in 1996
- Nintendo's last home console to use ROM cartridges

HISTORY OF NINTENDO

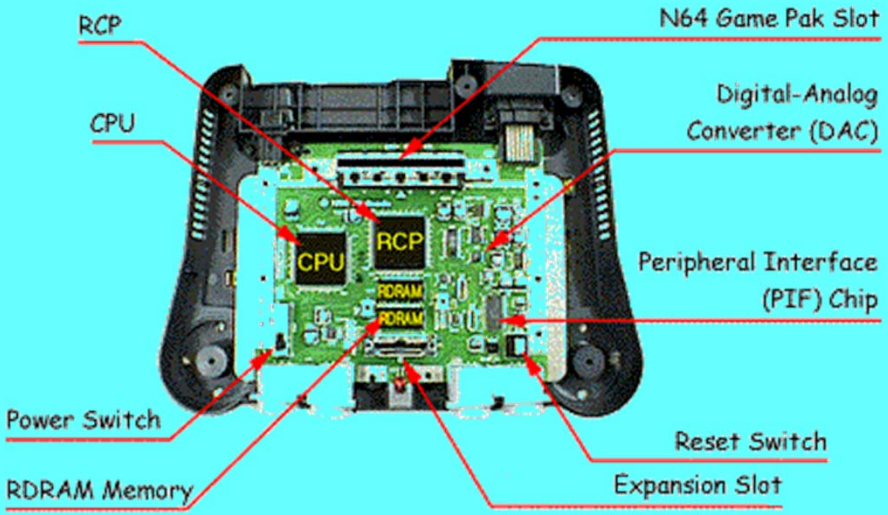


Game Console History

- Main competitors at the time were the Sony Playstation and Sega Saturn
- Nintendo 64 was created in response to the competing products and a Japanese recession
- First console to truly use 64 bit processor
- With the release of the Nintendo 64, the Sega Saturn sales dropped significantly

Introduction to the Nintendo 64 Architecture

- 64 bit RISC CPU
  - NEC VR4300
- 4 MB RDRAM
- Reality Coprocessor
  - Reality Signal Processor
  - Reality Display Processor
- 4-64 MB ROM Game Cartridges (Game Pak)

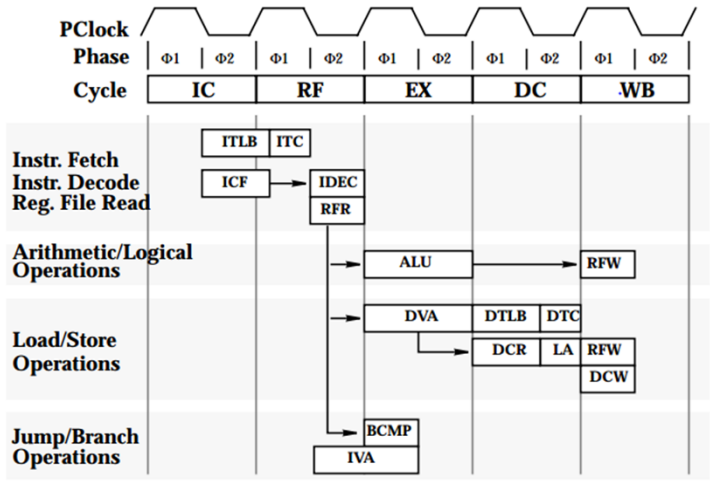


CPU

- NEC VR4300: RISC MIPS III ISA
  - Derivative of R4300i
- 64-bit processor
  - 32-bit system bus
  - 64-bit arithmetic operations
- Classic 5-stage scalar pipeline
  - Fetch, Decode, Execute, Memory, Writeback

CPU CONT.

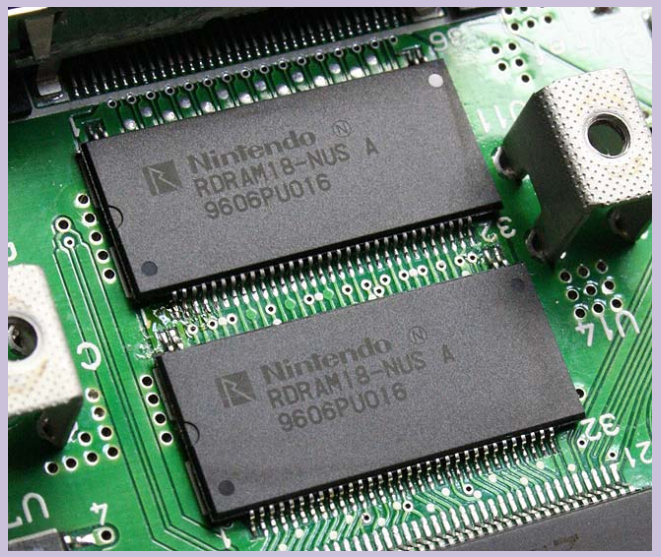
- 93.75 MHz clock speed
- 250 MB/s max throughput
- Integrated FPU
- Shared integer-FP pipeline
- Split 24 KB L1 Cache
  - Instruction cache: 16K bytes
  - Data cache: 8K bytes
  - Parallel access
- No direct memory access



Cycle	Phase	Mnemonic	Descriptions
IC	Φ1		No activity
	Φ2	ICF ITLB	Instruction Cache Fetch Instruction micro-TLB read
RF	Φ1	ITC	Instruction cache Tag Check
	Φ2	RFR IDEC IVA	Register File Read Instruction Decode Instruction Virtual Address Calculation
EX	Φ1	BCMP ALU DVA	Branch Compare Arithmetic Logic Operation Data Virtual Address Calculation
	Φ2		No new activity started
DC	Φ1	DCR DTLB	Data Cache Read Data TLB look-up
	Φ2	LA DTC	Load Data Alignment Data Cache Tag Check
WB	Φ1	DCW RFW	Data Cache Write Register File Write
	Φ2		No activity

MEMORY

- 4 MB RDRAM
  - DRAM developed by Rambus, Inc.
  - Two chips of 2 MB each
- 9-bit data bus
  - Simplified circuit board design
- High bandwidth
  - 500 MB/s
- Very high random-access latency
- Expandable to 8 MB with Expansion Pak

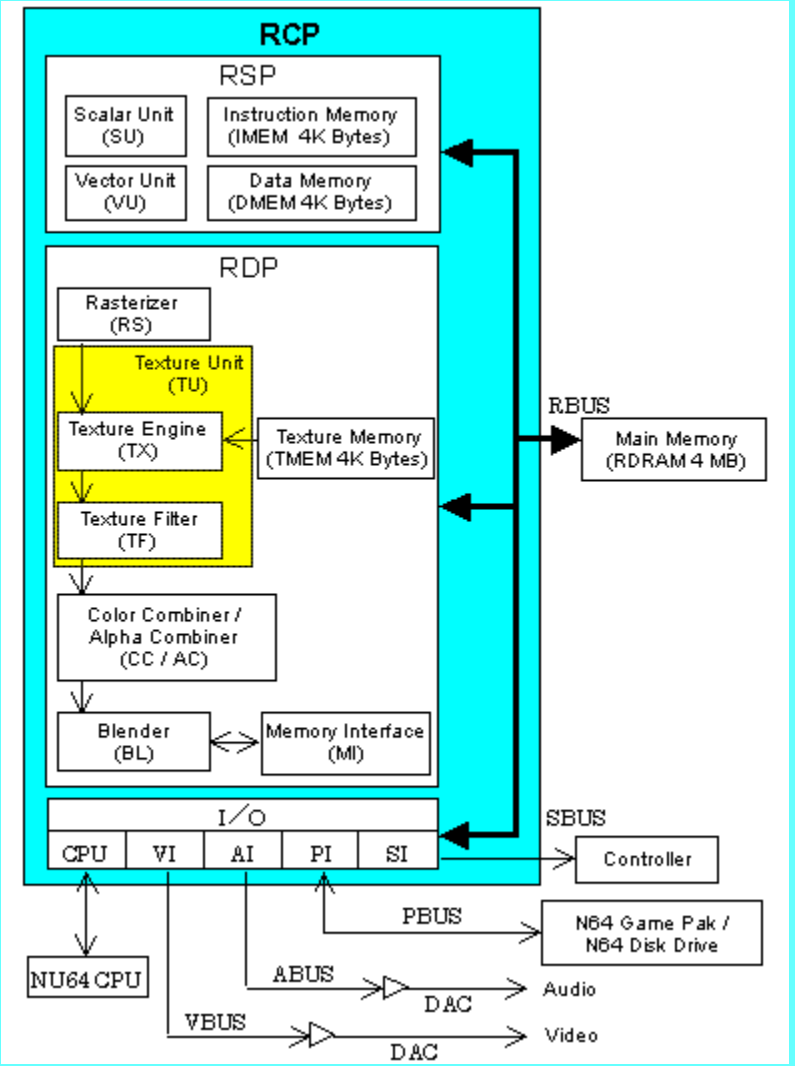


Game Pak

- 4-64 MB Mask ROM
  - Much less storage space than CD
- Saving capability
  - EEPROM, 4Kb to 16Kb
  - Battery-backed SRAM, 256Kb
- Data transfer 5MB/s-50MB/s
  - Faster than CD

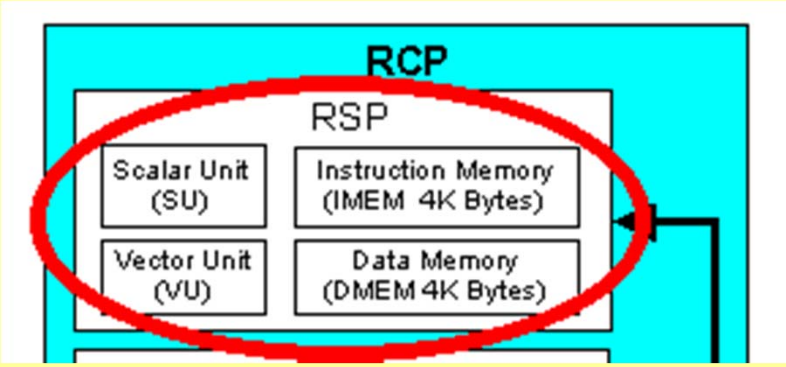
Reality Coprocessor

- Interfaces directly to CPU
- Handles most of the audio and graphics processing
- Handles timing and signals for game cartridges
- Two Processors in RCP
  - Reality Signal Processor (RSP)
  - Reality Drawing Processor (RDP)



Reality Signal Processor

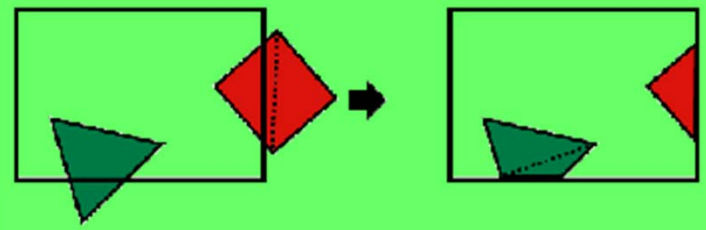
- Performs all 3D manipulations and audio functions
  - Geometric Transformations
  - Clipping and Culling
  - Lighting Calculations

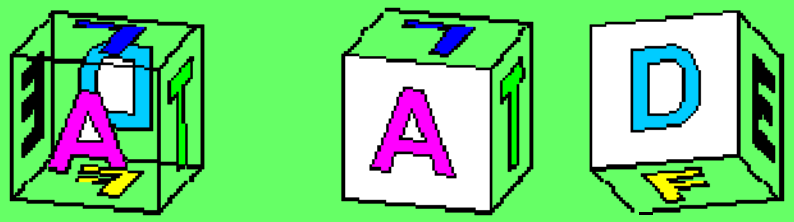


- Configurable using microcode which allows the system to be optimized by developers
- Altering the microcode allowed for new effects, better speed or better quality etc.

Reality Display Processor

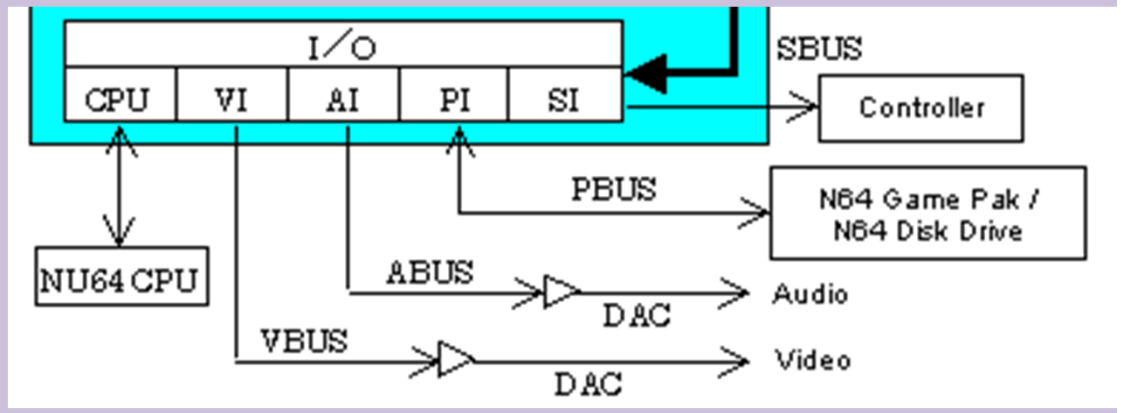
- Performs all pixel-level operations
  - Texture Mapping
  - Anti-Aliasing
  - Polygon Rasterization
  - Mipmapping
  - Z-Buffering
- 4kB Texture Cache
- Has four cycle modes where the individual process units are collaborating to produce pixels
  - Fill Mode
  - Copy Mode
  - One Cycle Mode
  - Two Cycle Mode





I/O

- I/O handled by RCP made up of several interfaces
  - Video Interface
  - Audio Interface
  - Parallel Interface
  - Serial Interface



Weaknesses

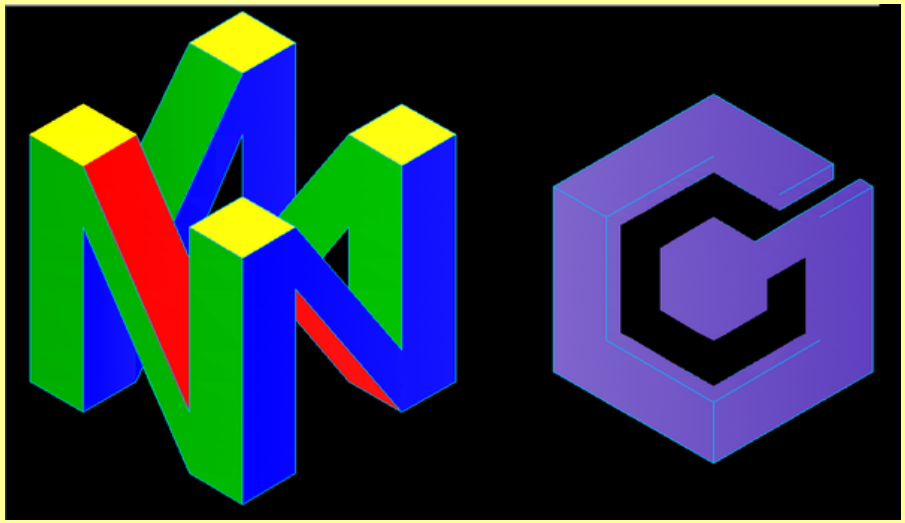
- Limited texture cache of 4 kB which could be halved if mipmapping was used
- Z-Buffering was controlled by programmer, not RDP
- 64 bit instructions were rarely used
  - 32 bit instructions faster and smaller code size

Weaknesses continued

- Fillrate limited, not geometry limited
- High latency Memory
- CPU doesn't have DMA
  - Went through RCP for memory accesses
- No memory prefetch
- Game Pak had limited space compared to competing consoles with discs

END OF LIFE CYCLE

- GameCube addressed the two main limitations: small texture cache and use of Game Paks
- Discontinued in 2002-2003, following the release of the game cube in 2001



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ANY QUESTIONS?