Nintendo Entertainment System

Now you’re playing with power!

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Agenda

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2. History
3. Console Specifications
4. CPU (2A03)
5. Picture Processing Unit (PPU)
6. Cartridges
7. Memory Management
8. Conclusion
What is video gaming?

- Popular pastime of today’s youth, and other’s not so youthful
- Video gamers
  - Excited about gaming
  - Want to see continual progress
- Market
  - Several competing companies
  - Satisfy gamer’s needs
  - Nintendo, Sony, Microsoft, etc.
  - Strategy is different based on company
- Nintendo
  - Hardware is traditionally less expensive
  - Cost is generally lower per console unit with higher market longevity
History

- Nintendo released the FAMICOM (FAMily COMputer) in Japan in 1984 [2]
- Despite the video game crash in the US, Nintendo released the N.E.S. in 1986.
  - $250 version came with R.O.B., Gyromite, Super Mario Bros, 2 controllers, Duck Hunt, and a light gun
  - $200 version came with Super Mario Bros, and 2 controllers.
- Nintendo designed the N.E.S. to look like a VCR instead of a Video Game System due to the crash.
History

- 1993: Nintendo released the N.E.S. 2
- 1995: Nintendo discontinued the N.E.S.
- The N.E.S. sold 62 million systems and over 500 million games
  - One of the most popular game systems of all time.
Console Specifications

- 8-bit CPU
- 1.79 MHz
- PPU
- 64 Value Color Palette
- System Memory - 2KB
- VRAM - 2KB
- Program ROM - 32+ KB
- Character ROM - 8+ KB
- Sprite RAM - 256 Bytes
- Temporary Sprite RAM - 24 bytes
- Color palette RAM - 32 bytes
CPU - 2A03

Overview [2, p.9]:
- Ricoh - 2A03
- NMOS
- Little Endian
- 8-bit data bus
- MMC
- 8-bit control
- 16-bit address
**CPU - 2A03**

### Memory Access [2, pp. 9, 10]:
- **ROM**
  - Read-only
  - Accessed via MMC
- **MMC**
  - Controller for ROM access
  - Allows for bank swapping
- **RAM**
  - Mirroring
  - Zero Page
  - PRG-ROM

### Address Bus
- 16-bit
- Set address
- Support for 64KB
  - $0000-$FFFF

### Control Bus
- Read or Write?
- Screen Mirroring
- Disk IRQs

### I/O
- PPU and control
CPU - 2A03 - Registers

- Registers [2, pp. 11-13]
  - 16-bit Program Counter (PC)
    - Games could only be 64 Kb
  - 8-bit Stack Pointer (SP)
  - 8-bit Accumulator (A)
  - 8-bit Index Register X (X)
  - 8-bit Index Register Y (Y)

- 8-bit Processor Status
  - N - is number negative
  - V - overflow
  - B - set if the BRK instruction occurs
  - D - Used to switch into BCD mode
  - I - Disable interrupts
  - Z - Zero
  - C - Carry
CPU - 2A03 - ISA

- Instruction Set Architecture [8]
  - Load/Store operations
    - LDA, LDX, LDY, STA, STX, STY, etc.
  - Register Transfer Operations
    - TAX, TAY, TSX, TXA, TXY, etc.
  - Stack Operations
    - PHA, PLA, etc.
  - Arithmetic Operations
    - ADC, AND, etc.
  - Increments / Decrements
    - INX, INY, DEX, DEY, etc.
- Shifts
  - ASL, LSR
- Jumps/calls
  - JMP, JSR
- Branches
  - BNE, BEQ
- Status Register Operations
  - CLC, CLI, SEC, SEI
The Picture Processing Unit (PPU)

- The CPU by itself was not enough power [3]
- The Picture Processing unit could:
  - Generate Colors
  - Move characters on the Screen
  - Display 52 colors
    - 24 allowed on the screen at the same time
    - Other video game units only had 6-8 colors.
## Memory Map [2, p. 17]
- Pattern Tables
- Name Tables
- Palettes
- Mirrors

### Table 1

<table>
<thead>
<tr>
<th>Pattern Table 0</th>
<th>Pattern Table 1</th>
<th>Name Table 0</th>
<th>Name Table 1</th>
<th>Attribute Table 0</th>
<th>Attribute Table 1</th>
<th>Attribute Table 2</th>
<th>Attribute Table 3</th>
<th>Mirror $2000-$2EFF</th>
<th>Sprite Palette</th>
<th>Image Palette</th>
<th>Mirror $3F00-$3F1F</th>
<th>Mirror $3F20</th>
<th>$4000</th>
<th>$10000</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0000</td>
<td>$1000</td>
<td>$2000</td>
<td>$2400</td>
<td>$2700</td>
<td>$2800</td>
<td>$2B00</td>
<td>$2C00</td>
<td>$2F00</td>
<td>$3F00</td>
<td>$3F10</td>
<td>$3F20</td>
<td>$4000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pattern Tables [3]

- The sprites and background images are saved in here
- Sprites are 8X8 pixel titles
  - Titles are 16 bytes (128 bits)
  - Each byte (bits) is a row in the sprite
  - The sprites have 2 layers
    - First 8 bytes are the first layer
    - Second 8 bytes are the second layer
  - Each sprite can have 4 possible colors
Layer 1

Layer 2

Combined

$00 = 00000000
$00 = 00000000
$00 = 00000000
$00 = 00000000
$00 = 00000000
$0E = 01111110
$3C = 00111100
$3C = 00111100
$7E = 01111110
$7E = 01111110
$7F = 11111111
$FF = 11111111
$FF = 11111111
$42 = 01000010
$00 = 00000000

Layer 2

Layer 1

Overall

Palette Assignment

Color 0
Color 1
Color 2
Color 3

“Layer 2” + “Layer 1” = Final Palette Assmnt
Name Tables [3]

- Backgrounds are stored here
- PPU supports 4 name tables
- NES RAM can only support 2
  - Other 2 tables are mirrored
- Each table has 30, 32-byte strings of data
  - tiles assigned left-to-right, top-to-bottom
- Remaining 64 bytes are for background palette assignments
Picture Processing Unit (PPU)

- Scrolling with nametables [3]

Image from Badder Hacks

Image from NES System Documentation
Picture Processing Unit (PPU)

Palettes [3]

- Consists of four colors chosen from NES’ internal index
- Tiles are colored by assigning them a palette
- Background tiles can be assigned to any of four palettes
- Sprite tiles can be assigned to any of a separate set of four palettes
Cartridges

- Unlike previous systems, Nintendo released a cartridge standard.
- The FAMICOM cartridge
  - Smaller than the N.E.S. Cartridge
  - 60 pin connection
- The N.E.S. Cartridge
  - Bigger than the FAMICOM’s
  - 72 - pin connection
  - Mostly empty space
  - Had a “Lock out system.”
- The N.E.S. had enough memory for early games
  - Some games needed more
  - Cartridges could have their own ROM.
Memory Management

- Game Specific MMC [6]
  - Nintendo made 9
  - Konami made 4
  - Namco
  - Sunsoft

- Supplement On-Board MMC
  - More complexity → Increasing demand
  - Swappable memory
Memory Management

● How Memory Mapping works [6]:
  ○ The N.E.S. used bank switching
  ○ MMC monitors memory writes for specific address (or range)
  ○ When the system needs access to data on a ROM bank and the data is not in PRG-ROM yet, software indicates the need to switch banks.
  ○ The selected memory is loaded into the bank in PRG-ROM from the cartridge.

● The use of memory mappers helped the N.E.S. to survive technological limitations and extend the life of their product
Conclusion

- The NES uses the 6502 Microprocessor
- The NES has its own custom PPU
- The NES can swap memory between it and the cartridge
- The NES was one of the most popular Video Game Systems
- The Super NES was the NES’s replacement (1990 Japan, 1991 US).
- Nintendo continues to follow practices regarding selling their consoles that started with the NES today.
THANK YOU!

Any Questions, Comments, Queries, or Threats?
References