Embedded System case study

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New Nintendo 3DS XL

Device Overview: The New Nintendo 3DS XL is a handheld game console developed by Nintendo. The new "Super-Stable 3D" system was successful in improving the consistency and viewing angles of the device's stereoscopic 3D effects by using a sensor to detect the angle that the player is viewing the screen at, and adjusting the effects to compensate., especially in games that require use of its gyroscope. The sensor is also used as an ambient light sensor for automatic brightness adjustment

Processor(s) - Two ARM processors and one GPU

1) **804 MHz ARM11 MPCore quad-core**

ARM11 is a group of older 32-bit RISC ARM processor. The ARM11 microarchitecture introduced the **ARMv6** architectural additions. These include SIMD media instructions, multiprocessor support and a new cache architecture. The implementation included a significantly improved instruction processing pipeline. ARM11 cores target more demanding applications.

Microarchitecture of ARM11 cores include:

- SIMD instructions which can double MPEG-4 and audio digital signal processing algorithm speed
- Cache is physically addressed, solving many cache aliasing problems and reducing context switch overhead.
- Unaligned and mixed-endian data access is supported.
- Reduced heat production and lower overheating risk
- Redesigned pipeline, supporting faster clock speeds (target up to 1 GHz)
    - Longer: 8 (vs 5) stages
    - Out-of-order completion for some operations (e.g. stores)
    - Dynamic branch prediction/folding (like XScale)
    - Cache misses don't block execution of non-dependent instructions.
    - Load/store parallelism
    - ALU parallelism
- 64-bit data paths
- trace semantics were updated to address parallel instruction execution and data transfers.

Drawback - ARM makes an effort to promote good. Verilog coding styles and techniques. This ensures semantically rigorous designs, preserving identical semantics throughout the chip design flow, which included extensive use of formal verification techniques. Without such attention, integrating an ARM11 with third-party designs could risk exposing hard-to-find latent

bugs. Due to ARM cores being integrated into many different designs, using a variety of logic synthesis tools and chip manufacturing processes, the impact of its register-transfer level (RTL) quality is magnified many times. The ARM11 generation focused more on synthesis than previous generations, making such concerns be more of an issue.

2) 4x VFPv2 Co-Processor (vector processors, also processes sound output)

VFPv2 is the single-core coprocessor ARM gives as an extension to the ARM main processor that provides support for all vector processes.

3) 204 MHz DMP PICA200

PICA200 is a 204 MHz-clocked GPU from PICA family. PICA200 has an instruction-programmable core (IPC) that gives it capability to change configuration based on demands for specific target system, which will manage with its 3D graphics engine. The 3D processing core of PICA200 consists of up to four programmable vertex pipelines that can be rearranged as four pixel pipelines. The number of IPCs and pipelines will depend on the target processor core and may change in the future. For 2D graphics rendering there are two ways: the image post-processing module PICA-FBM (*"Frame Buffer Object"*) that can be used as an anti-aliasing filter with support for some specific 2D functions and the vector graphics module PICA-VG (*"Vector Graphics"*) as PICA-FBM extension.

Memory -

1) **256MB FCRAM (64MB dedicated to the OS)**

Fast Cycle DRAM (FCRAM) is a type of synchronous dynamic random-access memory. CRAM has a shorter data access latency compared to contemporary commodity SDRAMs; and is used in this device as the lower data access latency is more desirable than low cost and high capacity. FCRAM achieves its low latency by dividing each row into multiple sub-rows, only which one is activated during a row-activation operation. This has the effect of reducing the effective array size, improving the access time.

2) **10 MB VRAM**

VRAM, is a dual-ported variant of dynamic RAM (DRAM). VRAM has two sets of data output pins, and thus two ports that can be used simultaneously. The first port, the DRAM port, is accessed by the host computer in a manner very similar to traditional DRAM. The second port, the video port, is typically read-only and is dedicated to providing a high throughput, serialized data channel for the graphics chipset. VRAM improves the overall framebuffer throughput, allowing low cost, high-resolution, high-speed, color graphics. VRAM operates by not discarding the excess bits which must be accessed. To use the video port, the controller first uses the DRAM port to select the row of the memory array that is to be displayed. The VRAM then copies that entire row to an internal row-buffer which is a shift register. The controller can then continue to use the DRAM port for drawing objects on the display. Meanwhile, the controller feeds a clock called the *shift clock* (SCLK) to the VRAM's video port. Each SCLK pulse causes the VRAM to

deliver the next data bit, in strict address order, from the shift register to the video port. The graphics adapter is usually designed so that the contents of a row, and therefore the contents of the shift-register, corresponds to a complete horizontal line on the display.

Storage -

1) **1 GB internal flash memory**

Flash memory is an electronic (solid-state) non-volatile computer storage medium that can be electrically erased and reprogrammed.

2) **Micro SD removable storage**

Input / Output Devices -

Input -

1) A/B/X/Y buttons
2) Circle Pad

A variation of an **analog stick** which is an input device for the controller that is used for two-dimensional input. They use continuous electrical activity running through potentiometers.

3) C-Stick (nubbin)
4) L/R and ZL/ZR bumpers
5) D-pad

A **D-pad** is a flat, usually thumb-operated four-way directional control with one button on each point.

6) Start/Select buttons
7) Home button
8) 3D depth slider
9) Volume slider
10) Power button
11) Accelerometer
12) three-axis Gyro sensor

A gyro sensor, angular rate sensor or angular velocity sensor is a device that can sense angular velocity. Gyro sensors can sense rotational motion and changes in orientation and therefore augment motion. Vibration gyro sensors can sense angular velocity due to the Coriolis force which is applied to a vibrating element. This motion produces a potential difference from which angular velocity is sensed. The angular velocity is converted into an electrical signal output.

13) 3D digital camera
14) front-facing VGA camera
15) microphone

Output -

1) Stereo speakers (pseudo-surround)
2) Two 3D colour display touch screens with 16.7 million colors support

Operating System and other Softwares-

1) **Operating Software - Nintendo 3DS system software**

The Nintendo 3DS system software is a set of updatable firmware versions and software frontend. The Nintendo OS is capable of suspending an application and running one of six multitasking applications. The Nintendo OS can run in four different modes. **NATIVE_FIRM** is the native running firmware for Nintendo 3DS software (including the Home Menu). **SAFE_MODE_FIRM** is used for safe mode applications, such as the System Settings and System Updater. **TWL_FIRM** is the Nintendo DSi's native firmware and it is used for Nintendo DS/DSi backward compatibility. Finally, **AGB_FIRM** is the Game Boy Advance's native firmware and it is used to run Game Boy Advance Virtual Console games.

2) **Other Softwares - Dedicated Hardware Video Decoder, StreetPass Mii Plaza, SpotPass and StreetPass, Nintendo Network , Nintendo eShop , Browser.**

Communications -

1) **2.4 GHz 802.11b/g Wi-Fi**

802.11 is a set of media access control (MAC) and physical layer (PHY) specifications for implementing wireless local area network (WLAN) computer communication. It supports bandwidth up to 54 Mbps, and it uses the 2.4 Ghz frequency for greater range.

2) **NFC**

Near-field communication (NFC) is a set of communication protocols that enable two electronic devices, one of which is usually a portable device, to establish communication by bringing them within 4 cm (1.6 in) of each other. It is included in the Nintendo 3DS range (being built into the New Nintendo 3DS/XL and in a separately sold reader which uses Infrared to communicate to the system).

3) **Infrared**