

Digital Photo Frame and Clock

Embedded System Design

Spring 2010

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Overview of Project

- Combination of digital photo frame and clock
- Bitmap images are saved on SDRAM
- The NIOS processor does timekeeping and image selection
- Hardware composites images and time onto VGA monitor

Layout

12:13

: 12 PM

05 / 13 / 10

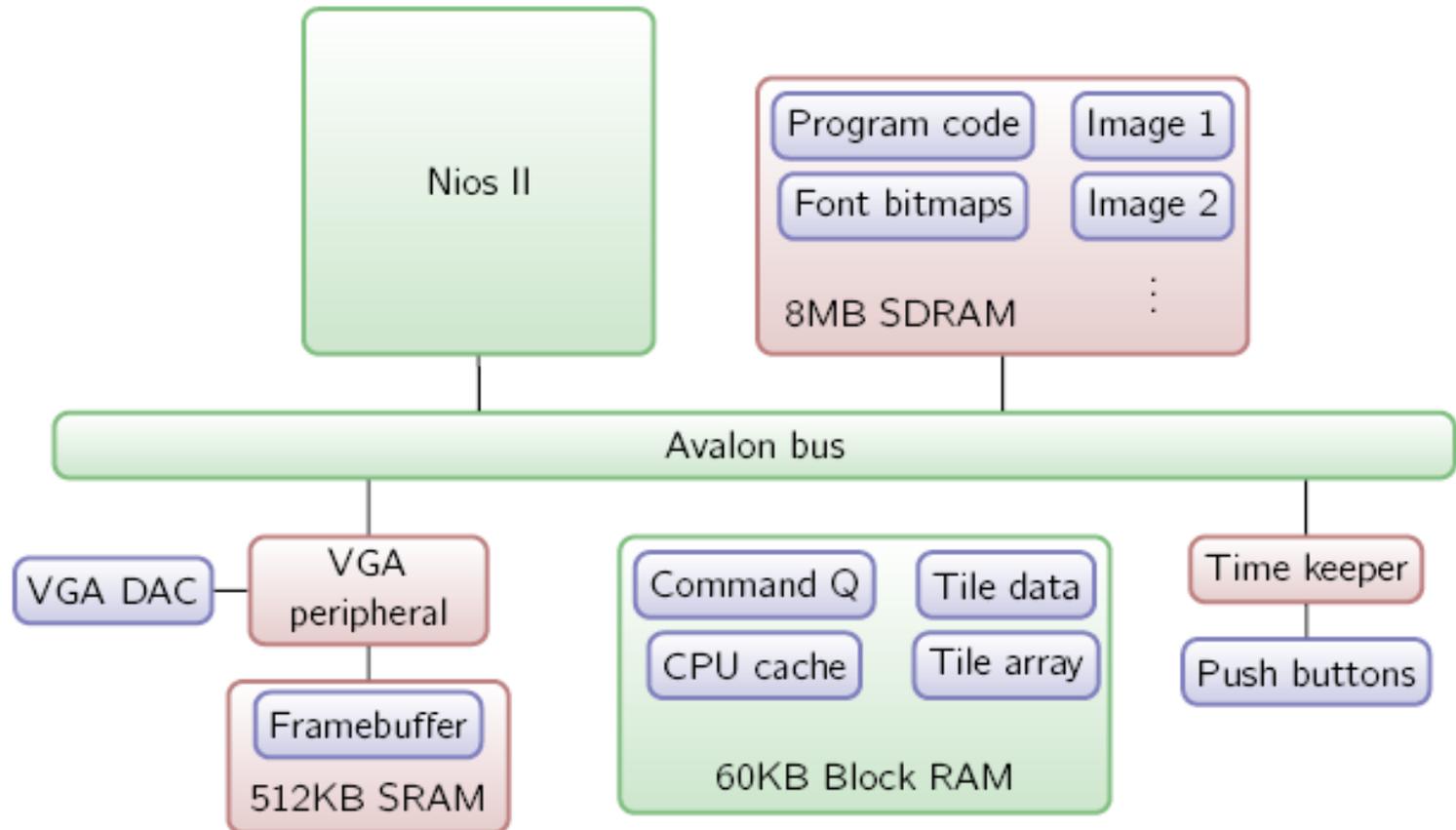
Thursday



Objectives

- Displaying images in random order scrolling on screen
- Displaying time and date textually
- Letters and numbers should change by flipping animation
- Each frame should pixel-perfect (no tearing and no visual artifacts)
- Additional graphical effects (shading)

Hardware: Overview



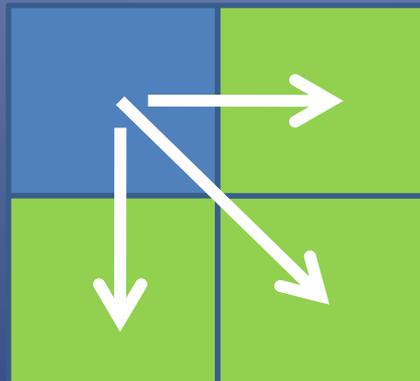
VGA Controller

SRAM directly integrated into VGA controller
16-bit R5G6B5 pixel format

1. 160×1024 pixels frame buffer stored SRAM
2. Processor commands queued before execution to arbitrate RAM access
3. VGA peripheral reads SRAM when painting right half of screen
4. Queue is emptied and data written to SRAM/block RAM when painting left side and not painting tiles

SRAM

- 256 × 1024 buffer of 16-bit pixels
- 160 × 240 region of buffer is visible at any given instant
 - Pixels quadrupled when displayed to fix 320 x 480 area of screen



Tiles

- Tiles bitmaps located in block RAM
 - Organizational choice
- 72 tiles: 32×32 pixels, 4 bits alpha each
- 61% of 60KB block RAM used

Tiles

- 40 tiles consist of 0 – 9 in “large format” sets of 4 tiles
- 10 tiles consists of the digits 0 - 9
- Remaining tiles are letters and punctuation



Example of a large
format tile

Tiles

0	1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18	19

← MM:HH in large text

20	21	22	23	24	25	26	27	28	29
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← SS and AM/PM

30	31	32	33	34	35	36	37	38	39
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← MM/DD/YYYY

40	41	42	43	44	45	46	47	48	49
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← Day of week

Blending and the Alpha Channel

$$c_o = c_f \alpha + c_b(1 - \alpha)$$

- C_f : Current foreground value
- C_b : Current background value
- α : Alpha value (“0000” to “1111”)
- 1 : Value of “1111”
- C_o : Final channel value sent to VGA DAC

Hardware: Animation States

- Flipping action modeled after gravitational acceleration



Interlacing due to poor cell phone video quality

Software

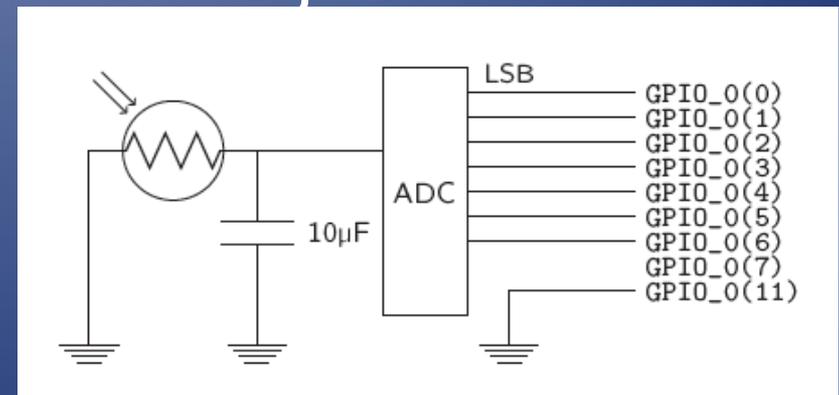
- Series of command codes are used to call hardware functions
- Hardware functions fill tile display array with number pointers to current tile, pointer to animate tile, animation state and tinting of tile

Timer Module

- Counts clock cycles and interrupts NIOS every second
- Interrupts NIOS if button was pressed
- Additional timer debounces
- Supplies address with which NIOS checks reason for interrupt

Light Sensor

- Photoresistor is exposed to incident light
- Microchip coded in PBASIC acts as an A/D converter
- Microchip outputs 8-bit unsigned to DE2 board's parallel I/O part from 8 pins
- Hardware interprets data and adjusts background brightness



Timing

- SRAM VGA buffer is filled 64 rows below current level of visible pictures
- All our peripheral read/write requests operate in one cycle (no stalling)
- Block RAM requires one cycle read and two cycle write, solution entails compensated address decleration one pixel ahead
- SDRAM timing implemented automatically by SOPC builder, required 3ns clock advancement for SDRAM clock via PLL

Issues

- SDRAM requires 3ns clock advance versus main clock
- Implementation of block RAM requires explicit declaration and read write timing constraints for large read write arrays
- Occasional visual artifacts present in animation

Lessons Learned

Advice for Future Students

- Focus on one area of interest rather than trying to add in every cool feature you can think of
- Reusing other peoples code is not simple and usually a great deal of additional work and may cause errors in external cause caused by integration
- SRAM data pins must be set to tri-state when done writing

Lessons Learned Continued

- All group members don't have to be present to work on the project, sometimes work can not be parallelized and one member may have to work alone
- Keep regular backups of your source code (or use a source control system) and realize that if you go over your account quota you will end up saving a blank file in the place of your code