ECE 598 – Advanced Operating Systems
Lecture 21

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Announcements

- Project status report due Tuesday
- HW#9 will be posted (Graphics)
- You will need an HDMI monitor for the HW. The electronics lab has some you can use (probably).

How to send to a mailbox

- To write a mailbox:
  - sender waits until the Status field has a 0 in the MAIL_FULL bit
  - sender writes to Write such that the lowest 4 bits are the mailbox to write to, and the upper 28 bits are the message to write.

    How can you make the address of the message have the bottom 4 bits be zero?
- To read a mailbox:

- receiver waits until the Status field has a 0 in the MAIL_EMPTY
- receiver reads from Read.
- receiver confirms the message is for the correct mailbox, and tries again if not.

Raspberry Pi Framebuffer Interface

- You can send it an address to a piece of memory to use as a framebuffer and it will draw it to the screen over HDMI.

-
  ```
  struct frame_buffer_info_type {
          int phys_x,phys_y;      /* IN: Physical Width / Height*/
          int virt_x,virt_y;      /* IN: Virtual Width / Height */
          int pitch;              /* OUT: bytes per row */
          int depth;              /* IN: bits per pixel */
          int x,y;                /* IN: offset to skip when copying fb */
          int pointer;            /* OUT: pointer to the framebuffer */
          int size;               /* OUT: size of the framebuffer */
  };
  ```
- Write the address of FrameBufferInfo + 0x40000000 to

mailbox 1 (40000000 means don't cache)

Read the result from mailbox 1. If it is not zero, we didn't ask for a proper frame buffer.

GPU firmware returns a framebuffer you can write to.

Copy our images to the pointer, and they will appear on screen!

Using a Framebuffer

- How big is it?
- Why might it not just be X*Y*(bpp/8) bytes big? Alignment issues? Powers of two? Weird hardware reasons?
- Things like R/G/B order, padding bits, bits grouped together (on Apple II groups of 7 bytes), etc
- Otherwise it's just an exercise is calculating start address and then copying values

- How do you calculate colors?

Putting a Pixel

- Depends a bit on the graphics mode you request
- For simplicity, request 800x600x24-bit
- Get back pointer, size, pitch
- Each X row has R,G,B bytes repeated for each pixel
- To get to next row increment by pitch value (bytes per row)
  fb[(x*3)+(y*pitch)]=r

fb[(x*3)+(y*pitch)+1]=g
fb[(x*3)+(y*pitch)+2]=b

- pitch returned by the GPU. Normally it would just be (maxy*bpp)/8, but it can vary depending on how the hardware arranges the bits.

Drawing a Gradient

- Just draw a horizontal line, incrementing the color for each line

Console Display

- Font / VGA Fonts
- console framebuffer. Color?
- scrolling
- backspace
- ANSI emulation

Bitmapped Font

- Each character an 8x8 (or 8x16, or similar) pattern

-
  ```
  unsigned char smiley[8]={
      0x7e,   /*    ******    */
      0x81,   /*   *      *   */
      0xa5,   /*   * *  * *   */
      0x81,   /*   *      *   */
      0xa5,   /*   * *  * *   */
      0x99,   /*   *  **  *   */
      0x81,   /*   *      *   */
      0x7e,   /*    ******    */
  };

  void put_smiley(int xoff, int yoff, int color) {
      for(y=0;y<8;y++) {
          for(x=0;x<8;x++) {
              if (simley[y]&(1<<(7-x))) {
                  putpixel(color,x+xoff,y+yoff);
  ```

```
            }
        }
    }
}
```

- Can find source of fonts online, VGA fonts. Just a binary set of bitmapped characters indexed by ASCII code.
- Usually 8x16 though; the custom font used in the homework is a hand-made 8x8 one

Other topics

- Graphics image, image formats
  PNG, JPG, PBM, PNM
- Windowing systems. X11, etc
- 3D graphics
- Writing a video game: input, blitting, page-flipping