ECE471: Embedded Systems
Fall 2018 Midterm Exam

Name: Spencer Goodchild

Closed Book, Closed Notes.

This page intentionally left blank.

Q_1: 15/15
Q_2: 20/20
Q_3: 25/25
Q_4: 10/10
Q_5: 27/30

+1

98/100

15/15

1. Embedded Systems

For each of the following, state whether the device described is an embedded system, and why. For each answer use at least one of the characteristics of embedded systems as described in class in your answer.

(a) A high-end smartphone (iPhone 8, Galaxy Note 8, etc.)

Not an embedded system because it has more than one purpose and doesn't use low resources.

(b) The controller inside of a washing machine that controls the front panel display and all of the various motors and timers.

Is an embedded system because all of it is within the washing machine and is designed for one purpose, which is to wash your clothes properly.

(c) Sunway TaihuLight, the second fastest computer on the Top500 Supercomputers in the world list. It has 40,960 nodes with 10,649,000 cores, 1.3 PetaBytes of RAM and calculates at 93 petaFLOP/s while drawing 15.37 Megawatts of power.

Not an embedded system since it doesn't use low resources. I mean with all that no wonder it is a super computer.

20/20

2. Operating Systems

(a) What is one benefit of using an operating system on an embedded device?

Time to Market

✓ more explanation would be nice

(b) What is one drawback of using an operating system on an embedded device?

Timing and overhead

✓

(c) Your company is designing a wall thermostat using a microcontroller that has a small LCD display, 4 buttons, and a temperature sensor. This is all controlled by an 8-bit CPU with 8kB of flash storage. Would you recommend using an operating system on this device? Why or why not?

✓ No, the overhead of the operating system would be too much. Not really enough resources

(d) Your company also offers an advanced thermostat with a 640x480 graphical display, a touch screen, wi-fi connectivity, and the ability to download the local weather report (to auto-set the temperature settings). This is all powered by a 32-bit ARM CPU with 256MB of RAM and 1GB of flash storage. Would you recommend an operating system for this device? Why or why not?

✓ Yes, there are a lot of resources that'll allow you to have an OS, plus it'll make handling these applications easier.

25/25

3. C Coding

(a) As part of your job you come across the below piece of code that is missing some comments. Place meaningful comments next to the code where indicated, describing what the code is doing.

```
void temp_loop(int fd) {

    unsigned char buffer[4],output_buffer[2];
    int temperature,output_fd;

    while(1) {                                  // keeps checking temperature

        read(fd,buffer,4);                      // read 4 bytes from file descriptor

        memcpy(&temperature,buffer,4);          // copy raw value into an integer
                                                // the value is temp in degrees C

        output_buffer[0]='0';                   // set output as ASCII '0'
        if (temperature>100) {                  // checks if above 100°C
            output_bufer[0]++;                  // increment to ASCII '1'
        }

        output_fd=open("/sys/class/gpio/gpio13/value",O_WRONLY);
                                                // prepare gpio13 for writing
        write(output_fd, output_buffer,1);      // writes 1 or 0 to gpio13

        close(output_fd);                       // close our file descriptor

        usleep(100);                            // wait/sleep for 100 µse
    }
}
```

output_buffer undefined
I'll assume output_buffer

(b) Briefly describe in one sentence what the above code is doing.

The code checks to see if the temperature is above 100°C and then pulls gpio13 high if it is.

10/10

4. Code Density

(a) Name one of the many changes in instruction encoding made between ARM32 and THUMB that allowed the instructions to fit in 16 (rather than 32) bits.

✓ no conditionals and less registers; r0 - r7

(b) Describe a benefit (when designing embedded systems) of using an instruction set with better code density.

✓ Smaller size, which helps if it is space constrained

5. GPIO / I²C

27/30

(a) Your boss wants you to design a device that can output a complex pattern of '1' and '0' with 1ns (1GHz) resolution. Can you use a Raspberry Pi GPIO pin and the Linux /sys gpio interface for this? Why or why not?

No, I²C's max speed is less than 1 GHz. You aren't able to get that resolution

↳ asked about GPIO

-3

(b) You are designing an embedded system that controls the various per-floor displays for an elevator. An LED display is placed above the elevator doors on each floor (the building has 5 stories). Your boss wants to use a Raspberry Pi to control the displays, with the Pi in the basement, and an i2c bus (4 wires) connecting the Pi to the displays on all 5 floors. Will this setup work? Why or why not?

No, the i2c has a max wiring length of a couple meters. Anything longer will not work properly. ✓

(c) There are numerous errors in the following GPIO code that is trying to set GPIO17 to a high output. Circle at least 4 of the errors and for each give a brief explanation of what the error is.

```
FILE *fd;                                   → should be an int ✓

/* Open GPIO17 direction file */
fd=open("/sys/class/gpio/gpio17/direction",O_WRONLY);
if (fd<17) fprintf(stderr,"Error!\n");      ✓
                                            ↳ should be 0 to check for errors
/* Change direction to output */
write(fd,"out",2);                          → more than 2 ✓
close(fd);

/* Open GPIO17 value file */
fd=open("/sys/class/gpio/gpio17/value",O_RDONLY);   → You're trying to write so should be O_WRONLY ✓
if (fd<0) fprintf(stderr,"Error opening!\n");

/* Set GPIO17 to high */
write(fd,'1',1);
close(fd);
```

6. **Bonus Linux Question**

You are planning a party for the end of October so you run the command `cal 10 18` to get a quick calendar. You end up confusing everyone by having the invitations list the wrong day of the week. What happened?

+1 When doing cal 10 18, you are choosing the year 18, instead of 2018, which is why the dates are wrong. Instead, you should have done cal 10 2018.