

ECE 471 – Embedded Systems

Lecture 29

Vince Weaver

`https://web.eece.maine.edu/~vweaver`

`vincent.weaver@maine.edu`

18 November 2024

Announcements

- Midterm on Wednesday
- Don't forget projects
- Don't forget HW#9
- Project status report due 25th (Monday before Thanksgiving). We discussed this briefly in class Friday, but be sure to follow what's needed in the pdf project handout, including the “identify a problem” item, and also which day you'd prefer to present



HW#6 Review (Real Time Systems)



HW#6 – Question 2

- My results on a Pi3
- min: 1979 ns / max: 5469 ns / average: 2646 ns
- What is a safe value to use? Average + 10%? Max + 10%? Double? There is no safe value?
- Note: average itself not necessarily good, half the time you'd miss the deadline
- Also note, we want higher to be safe, not lower.



HW#6 – Question 3 (Under Load)

- min: 2396 ns / max: 25,913,564 ns (25ms), average: 9,465,773 ns
- Much worse



HW#6 – Question 4 (Under Load + chrt 70)

- min: 2084 ns / max: 7917 ns / average: 2740 ns
- Using real-time priorities can make a general purpose Linux OS give you more reasonable timings under load



HW#6 – Question 5 (Under Load 70)

- For me took too long didn't bother to let finish
- But if load 70 / our job bumped to 75
min: 1980 ns / max: 6979 ns / average: 2739 ns
back to somewhat reasonable



HW#6 – Question 6

- Why sysadmin not let anyone set priority? They could essentially prevent other jobs from running at all, including important system background tasks



HW#6 – Something Cool

- Standard Deviation. Is an occasional outlier OK? Within two standard deviations?



HW#6 – Question 8 Type of Real Time

- Brakes: hard real time, disaster/failure if not met in time
- Radio: soft real time. Probably still want to change station even if takes a while to do it
- Video: firm. If you miss deadline the frame decoded is useless



HW#7 Review – Code

- Be sure to `memset(&spi,0,sizeof(struct spi_ioc_transfer));` Not the strings
Note saw this in practice. It's tricky to catch as it's a Heisenbug (other code you add can disrupt stack enough to not trigger)
- People managed merging 2 bytes into one OK
- What is the max frequency? Last year someone setting to 500kHz by accident, a few degrees different. Data sheet unclear
- Be sure to check for error on `open()`, biggest source



of errors. Linux won't crash, it will happily just report errors that your code is likely ignoring.

- Errors: exiting. Not print plausibly real invalid values. In our case, printing 0V when actually 3.3V not an issue, but imagine if it were 10,000V and you print 0V



HW#7 Review – Questions

- Disadvantage of SPI?
More wires, no standard, no errors
- Advantage of SPI?
Lower Power, Full Duplex, No max speed
- TMP36 on end of cable.
Voltage Drop, Noise?
Datasheet has two options, convert to current, or an extra resistor.
- Minimum frequency of 10kHz or results invalid. Maybe



cannot go this fast if bitbanging via GPIO. Also context switch in middle, Linux not realtime?



HW#7 Review – Linux “fun”

- Devices here for compatibility with ancient UNIX
 - /dev/null
 - /dev/full
 - /dev/zero, holes in files
 - /dev/random – random numbers (see next slide)
- Windows has ancient compatibility devices too, cause lots of trouble as they are invalid for use in filenames (in any directory, not just /DEV)



HW#7 Aside – Random Numbers

- Strong random numbers needed for unpredictable crypto, ssh, tls (secure web connections)
- How do you generate random numbers?
- CPUs can provide this. Do you trust them not to have backdoored things? Do the Linux devs?
- Can generate entropy with random I/O, like mouse movements, incoming packets, etc
- Can have pseudo-random number generators (PRNG)
Look random, but can predict next result if know seed



Often used in less critical cases like games and such
Also if you need reproducible random sequences
(debugging)



Homework 8 – Code

- Error checking. Exit if cannot open. If you don't, can segfault if try to fscanf a NULL FILE*
- Returning -1 on error might be bad idea
- Compiler warning: strncpy() comparing if src longer than count and you don't NUL terminate
- What to report on error? What's an invalid temperature? Not just unlikely? (Below Absolute zero)
- If using streams (FILE *fff), on fopen() error it returns NULL, not -1.



- Be sure to close files, otherwise leak file descriptors Be careful if multiple exit points, must close at all (goto)
- Be careful with your $9/5$ Fahrenheit conversion!
- Finding a file using C. `opendir()` `readdir()`, horrible interface
Bit of a tangent on the downsides of the `readdir()` interface



HW#8 – Questions

- Why need Vdd? To provide enough current for this particular chip needs extra current if you want parasite mode.

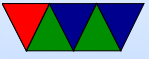
You can try without Vdd but you will always read out 85C.

Manual suggests MOSFET, but apparently it's possible on Pi if use 4.7k resistor as well as “strong-pullup=y” kernel command line option.

- (have sensor 100 meters away what bus to use?) Because



of distance, 1-wire



HW#8 – More Questions

- What is generic term for program that loads OS? bootloader (note: asked for generic, so not uboot or grub or whatever the pi specific code is)
- Why boot partition FAT32? It needs to be really simple, simple enough you possibly write it in assembly language and fit in a tiny chunk of ROM. FAT is an extremely simple filesystem from the 1970s and doesn't require many resources



HW#8 – Shell Script

- `#!/bin/sh` should be first line (magic number)
- Trouble if edit on windows, why (linefeed vs carriage return)
shebang description
- Making executable with `chmod`
- Default shell, can put other things there, like python or perl, etc, even ARM emulator
- sh vs bash

