ECE 471 – Embedded Systems
Lecture 17

Vince Weaver

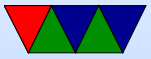
http://www.eece.maine.edu/~vweaver

vincent.weaver@maine.edu

3 November 2015

Announcements

- HW6 grades were posted. Let me know if somehow you aren't getting your grades.
- Project ideas! Remember to send them by Friday!
- 8-bit supercomputer – "applecrate" 8-bit 64-k 6502 processors. Connected by the "cassette port" which is an analog audio connector more or less, newer version uses joystick port instead
  `http://hackaday.com/2011/05/04/applecrate-ii-do`

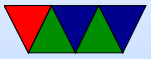


Brief HW#7 Comments

- Why is the kernel erroring out if the empty "pad" bit not zero?

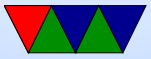
  Forward compatibility. You want to make sure that any empty bits stay that way. If you want to add new functionality in the future you have to ensure reserved bits are all zero, otherwise old programs will do unexpected things (or break) if they had been accidentally setting those bits.

  So why were the pad bits non-zero? Bad luck. Local



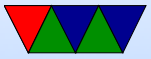
struct allocated on the stack, so if there were old values on the stack the pad value could be non-zero.

- Talk about ADC accuracy. 10-bits, but can we return a value of 1024?
  No max is 1023.

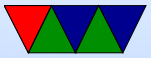


One-Wire Bus

- From Dallas Semiconductor
- One data wire plus ground (how do you get power?)
- Open collector, data line pulled high
- Devices have capacitor to provide power when data line low
- Low speed data and power over one wire (you also need ground)
- One master
- Can have many slaves

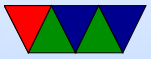


- 16.3kbit/s
- Up to 300m twisted pair (phone or ethernet wire)



One-Wire Protocol

- Each device has unique 64-bit ID; 8-bits of type, 48 bit ID, 8-bit CRC
- Typically 8-bit command followed by 8-bit data chunks



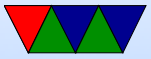
One-Wire Protocol – Detailed

1. Open Collector (BJT equivalent of MOSFET Open Drain)

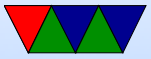
2. Write 1 – Master pull bus low for 1-15us

3. Write 0 – Master pull bus low for 60-120us

4. Read – Master pull bus low for 15us (checks after another 15us). Slave does nothing if it's a 1. If it's a 0 it pulls the bus low for another 45us.

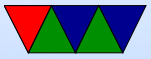


5. Reset/Presence – master pulls bus low for 480us. If a device is present it bus pull bus low for 60us starting within 60us after the reset pulse.



Enumerating BUS (ROM commands)

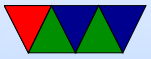
- How can you probe all 2^{64} possible addresses? `https://www.maximintegrated.com/en/app-notes/index.mvp/id/187`
- send a READ ROM request, returns 64-bit address. If multiple slaves, then and of all of them. (How do you detect this? Invalid CRC).
- SKIP ROM request sends command to all devices
- MATCH ROM request sends 64-bit address and only matched slave responds



- SEARCH ROM –
  - Read first address bit from all devices on bus. Devices send their bit, followed by complement.

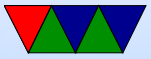
1	1	nothing there
0	1	all slaves have 0 there
1	0	all slaves have 1 there
0	0	conflict, you will have to probe both ways

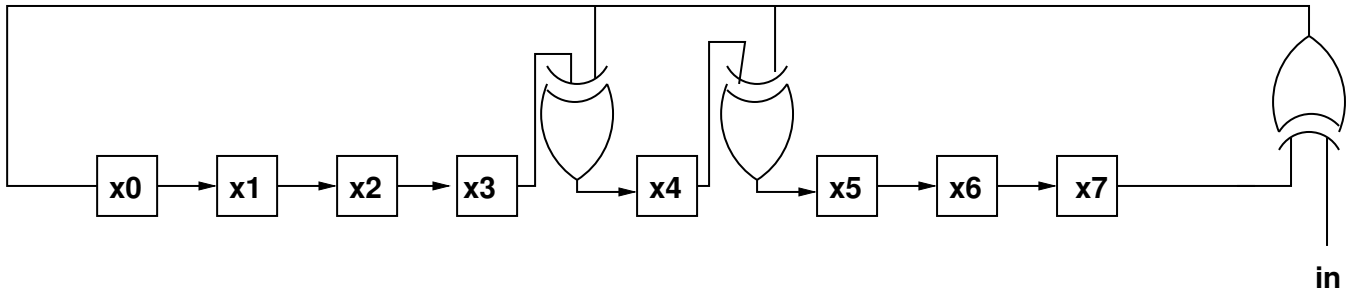
  - Then it does a binary search to enumerate all devices on bus.
  - Faster than probing all 2^{64} possible.

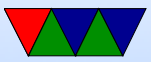


CRC check

- Can detect all double-bit errors, any double bit errors, any cluster within an 8-bit window
- if CRCs with itself gets 0 at the end, how hardware detects correct address.
- $X^8 + X^5 + X^4 + X^1$
- Fill with zero, shift values in.



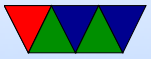

x0
x1
x2
x3
x4
x5
x6
x7
in



Hardware Interface

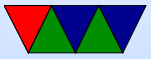
Possible ways to implement this:

- Use a GPIO and a pull-up resistor
- Use a serial UART. Needs extra circuitry to hook both TXD and RXD to bus
- USB/i2c/network connected
- Dedicated hardware?



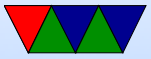
Linux Interface

- "w1" driver merged in 3.6 kernel (fairly recently)
  - Driver for various interfaces, including bit-banging over GPIO (w1-gpio)
  - `/sys/bus/w1/devices/22-0000001d84f2/w1_slave`
  - read value and get ASCII dump of transaction
- OWFS – another driver, not in main kernel. Lets you export one-wire devices as a filesystem



One-Wire on Raspberry Pi

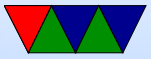
- by default driver expects to be hooked up to GPIO4.
  On newer systems need to enable in device-tree, so edit `/boot/config.txt`, add the line `dtoverlay=w1-gpio` to end and reboot.
  (This is more or less what raspi-config did for you for i2c and spi, only 1-wire is not as common)
  Why is it not default on? Well people might want it to stay GPIO.
- `sudo modprobe w1-gpio`



- `sudo modprobe w1-therm`
- `cd /sys/bus/w1/devices/`
- `ls`
- `cd 28-000005aaf7ed` The serial number will differ (each unique)
- `cat w1-slave`

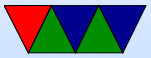
```
82 01 4b 46 7f ff 0e 10 70 : crc=70 YES
82 01 4b 46 7f ff 0e 10 70 t=24125
```

- Valid if the last value in first line is YES (passes CRC)
- second line has temperature in mili-degrees Celsius



DS18B20

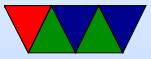
- -55 to 125C
- +/- 0.5C from -10 to 85C
- 9 to 12 bit resolution (configurable)
  Takes longer to convert more bits
- Converts temp in 93ms - 750ms
- Can set alarm (if go over a temp, a high bit set in result)



- 9 bytes from device:

```
82 01 4b 46 7f ff 0e 10 70 :  crc=70 YES
```

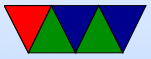
Byte 0/Byte1 = LSB/MSB Temperature = 0x0182
Byte 2 = TH register (high temp alarm, 8-bit)
Byte 3 = TL register (low temp alarm, 8-bit)
Byte 4 = config register 7f = 12 bit
Byte 5,6,7 reserved (5=0xff, 7=0x10)
Byte 8 = CRC



- Temperature is signed fixed point...

```
0x0182 = SSSS S654 3210 -1-2-3-4
         0000 0001 1000  0 0 1 0
```

$$2^4 + 2^3 + 2^{-3} = 16 + 8 + \frac{1}{8} = 24.125^oC = 75F$$

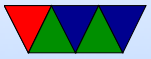


C review

As always with C, there are many ways to get the "YES" and "t=24125" values out of the text file. Any you choose is fine.

- You can use fscanf() to read the file. Putting a '*' in a conversion (like %*s tells scanf to read in the value but ignore it.

- Converting string to decimal or floating point
  atoi(), atof(), strtod()



- Comparing strings. Can you just use ==? NO!
  Be careful using strcmp, has odd return value
  less than, 0 or greater than depending. 0 means match

- If you had a string that was "V=YES" how could you start a string compare starting with the 2nd byte? Pointer math? Use `string+2` or even `&string[2]`.