ECE 471 – Embedded Systems
Lecture 30

Vince Weaver

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

vincent.weaver@maine.edu

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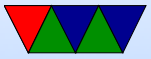
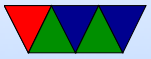
Announcements

- HW#11 will be posted this week
- Feel free to return borrowed hardware.



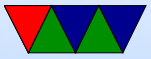
HW#9

- C code review
- Do note, it's an LED display not LCD
- Error checking. 0 points if segfaults. Also if prints a wrong value to display.
- Leaking file descriptors. Close (or keep open) instead of just re-opening
- How do you convert from float to decimal?
  - Lots of people miss 0 due to gt/lt
  - 45.9 print as 45.8?

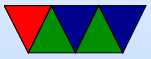


Floating point math is a pain! What do you get if you do `int fp=10*(45.9-45);`? 9.000000? Print more digits 8.999999999999857891452847979963 for fp to int conversion just drops the floating point part, doesn't round

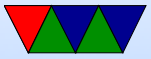
- Following a spec?
  - Corner cases
  - Spec says degree symbol, not F or C
  - Single-digit temps (unclear spec) Leading zeroes. Spec says 02.0 not 2.0 or 2.00
  - is Zero negative?



- Rounding
- Do you need a . after a three digit temp?
- Left/right justified for single digit
- Reporting error! Must be sure display not printing invalid info! (door on walk-in oven. If it goes from 70F to 1000F (off scale) between readings, don't want it to stay at 70F, you want ERR or HOT or some way to notify something is wrong) More realistically, probe wire broke, should it just report last reading? Or maybe go blank?
- What to do if temperature is -99.4 degrees?

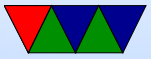


- Check inputs! Recent problem with europe Mars probe crashing! Was invalid input causing it to think it was below the ground.
- Error checking Most handled i2c error OK, but not 1-wire error.
- Buffer overruns
  sprintf into a too-small buffer, over-writing key variables
- List an *example* of poorly written embedded code.
- Why write good code?
  Cut-and-pasting, good practice, among other reasons.
- Why is touch useful? force make to rebuild



- 2038 problem
  Time in Linux is seconds since 1-1-1970. Not a problem 64-bit machines, but overflows in 2038 for 32-bit. Can avoid with a 64-bit system or else a specially patched Linux system
  * discuss y2k problem ** worst problem year 19100 on websites

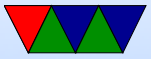
- ctime – last status (metadata) change (originally create time) things like permissions change, ownership change, rename



mtime – last modified

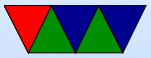
atime – last access

- In stat syscall. `stat` command. Why atime bad? noatime, relatime
- utime() used by touch. Cannot change ctime, set to current time
- why not believe timestamp? maybe could look at ctime. also set clock back if own machine.
  HW assignment at Cornell



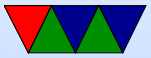
Camera Port

- The SoC has dedicated hardware for driving cameras
- 5megapixel, CSI port (Camera Serial Interface) plus i2c bus to command it.
- Can read data in parallel, directly, without needing USB overhead.
- These chips often used in cell-phones, so makes sense to have support for camera-phone without extra chip being needed.



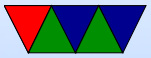
Ethernet

- Old, complicated standard, whole way up to 100GBps
- Modern form is often RJ-45, twisted pairs
- Power over ethernet (no pi support)
- Board has 10/100 Mbpss ethernet port
- Connected to on-board USB hub

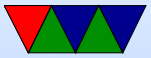


UART – serial port

- Often useful on embedded boards and old systems, might be only way to reliably connect
- RS-232, originally for teletypes
- 3-15V high, -3 to -15V low
- start/stop bits, parity, bit-size
- Hardware vs Software flow control

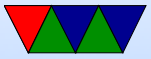


- Speeds 300bps - 115000bps and beyond
- 50feet (15m) w/o special cables
- 3-pin version (transmit, receive ground). Also 5-pin HW flow control (CTS/RTS). Can have 2-pin version if only want to transmit
- These days often hook up USB connector

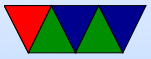


HDMI

- High-Definition Multimedia Interface (2003)
- Compatible with DVI (if no copy protection used)
- Video, audio (up to 8 channels), CEC (consumer electronics control), ethernet
- No support for captions
- DDC – i2c bus, used for EDID (getting device info) and HDCP (copy protection)

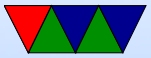


- TDMS – transition minimized differential signaling
  Video, then during scan line breaks, audio, etc
- CEC – control up to 15 devices with one remote control
  (one wire serial bus)
- Various versions, various fees

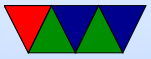


Other video ports

- NTSC
- VGA (analog)
- DVI
- Thunderbolt
- Displayport
- USB?

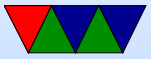


Other Busses not found until RPI-3



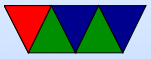
Wireless

- Wireless ethernet
- 2.4GHz or 5GHz

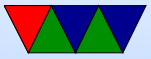


Bluetooth

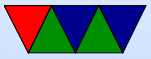
- Basic unit: piconet, master node and up to seven *active* slave nodes within 10m
- Many can exist in an area, and can be connected by a bridge. Connected piconets are called a scatternet
- There can also be up to 255 “parked” nodes in a picnoet
- When parked, can only respond to activation on beacon
- Hold and siff?
- Slaves designed to be cheap, so dumb. Master is smart and runs them. slave/slave communication not possible



- Master broadcasts clock 312.5us. Master transmits in even, slave in odd.
- Radio layer – 2.4GHz, 10 meters. 79 channels of 1MHz.
- pairing
- Bluetooth V1.1 has 13 different application protocols.
- Bluetooth 4.0 (Bluetooth Low Energy) (2010)
  - 25Mbps/200 feet
  - Entirely new stack, designed for low power rapid setup links
  - Not backwards compatible, but same frequency range
  - New profiles

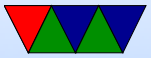


- Linux interface: depends on type. Filetransfer/obex. Audio (looks like an audio driver) network device, serial device



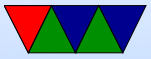
CANbus

- Automotive. Introduced by BOSCH, 1983
- One of OBD-II protocols
- differential, 2 wires, 1MBps important things like engine control
- single wire, slower cheaper, hvac, radio, airbags

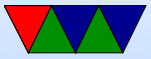


CANbus Protocol

- id, length code, up to 8 bytes of data id (usually 11 or 29 bits) type and who is sending it. Also priority (lower is higher) length is 4 bits. some always send 8 and pad with zeros
- Type is inferred from id. Can be things like engine RPM, etc
- DBC database has the ids and values. ASCII text database, hard to get legally.

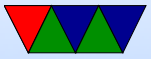


- Dominant/Recessive. Message with lowest ID wins arbitration.
- CAN-FD – extended version with larger sizes



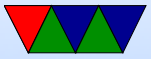
CANbus Linux

- Can4linux – `open("/dev/can0"); read(); write();` External project?
- SocketCAN – contributed by Volkswagen. In kernel. Uses socket interface. /Documentation/networking/can.txt



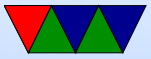
CANbus on Pi

- No

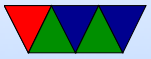


ISA Bus

- Introduced with IBM-PC in 1981
- 8-bit (4.77MHz) then 16-bit (8MHz)
- +/-5V, +/-12V, 8 data, 20 address, DMA, IRQ
- Replaced by VLB (more pins, extra header), EISA (double pins in same connector), MCA micro-channel (different proprietary from IBM)

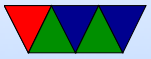


- Not enumerable at first, set jumpers. Later “Plug-n-Play”



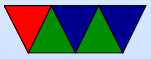
LPC Bus

- Low-pin-count bus
- Intel, 1998, try to get rid of ISA
- Things like PS/2, Serial ports, floppy, etc.
  Still used for TPM Trusted Computing nonsense
- Replace 16-bit 8.33MHz parallel bus with 4-bit wide 33.3MHz bus. Only 7 wires. Easier to route than 72



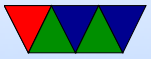
“Conventional” PCI Bus

- Peripheral Component Interconnect
- Enumerable
- 1993, intel
- 62-pins, parallel, 133MB/s
- Extended with 32 or 64-bit versions, 33 or 66MHz, 3.3 or 5V. All slight differences in connectors to support all that.



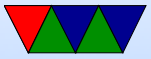
- AGP (Accelerated Graphics Card) for graphics cards. 1997. Direct connect to CPU (not shared), multiple channels, faster clock

- PCI-X 1998, extension to 133MHz. Not to be confused with PCI-Express (PCIe)



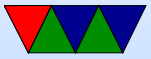
PCI protocol

- 256B Config space, mapped into CPU address. Small area system can probe, used to setup larger mappings
- Can have on-board ROM that can be executed. Problem when using on non-x86 systems (emulators needed? special [expensive] PowerPC versions?)
- Latency timers keep bus-master from hogging bus
- 4 interrupt lines, can be shared. Level rather than edge-triggered interrupts make sharing easier

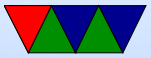


PCIe

- PCI-express, 2003
- Serial, replaced point-to-point with lanes, packet-based x1, x2, x4, x8 x16, x32
- Compatible with PCI at software level
- Differential Signaling
- External – Thunderbolt

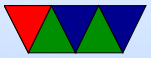


- Serial better due to timing skew
- New x86 audrino quark has PCIe



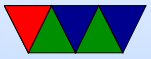
PCIexpress Mini

- PCIe x1, USB, SMBus, etc
- Smaller card



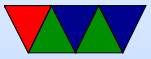
PCMCIA Bus

- Personal Computer Memory Control International Association
- 16-bit
- Cardbus, 32-bit
- Mostly replaced these days



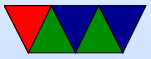
PC/104 Bus

- Stackable small x86 boards usually
- Run ISA or PCI signals up vertically



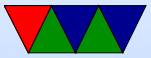
VME Bus

- m68k bus but generic enough
- Still found in some embedded systems



Other

- SATA, eSATA, PATA, SCSI (disk drives)
- Firewire
- RapidIO
- Quickpath QPI
- Hypertransport
- Thunderbolt (requested)



- List of competing busses at end of USB wiki article