ECE 471 – Embedded Systems Lecture 16

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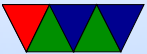
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Announcements

- HW#4 out soon

- Project out soon

More Busses

USB Bus

- USB 1.0 – 1996 – 1.5Mbit/s (keyboard, etc), 12Mbit/s (disk)

- USB 1.1 –

- USB 2.0 – 2000 – 470MBit/s

- USB 3.0 – 2008 – 5GBit/s

- 3-5m

- 4 pins. 5V, GND, D+, D-. Differential signalling. More resistant to noise.

- Unit load, 100ma. Can negotiate up to 500ma (more USB 3.0)

- Up to 127 devices (by using hubs)

- Enumeration

USB Protocol

- Each device has endpoint

- isochronous – guaranteed data rate but with some potential data loss (video)

- interrupt – low-latency, like keyboards

- bulk – disk access

USB Linux

- Linux drivers

  - Device classes – HID, audio, etc. One common driver can handle all devices of a class
  - Specific – device driver is board specific and must have a list of all vendor/device IDs that are supported

- libusb
  Allow direct userspace access to USB interface
  Used by low-level things that might not need driver

old cameras (not standardized), custom hardware
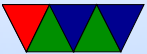
USB on Gumstix

- USB-OTG – on the go. Allows device to act like a host (so can hook up devices as per normal) or as normal USB device. Decides which based on whether A or B cable plugged in, check ID pin (micro/mini have 5th pin)

- USB-host – standard USB port. Cannot provide high current, so use a powered hub if using anything more than keyboard or mouse

- USB-serial – FTDI converter, used for console

Audio Ports

- In the old days audio used to be just open /dev/dsp or /dev/audio, then ioctl(), read(), write()

- These days there's ALSA (Advanced Linux Sound Architecture)
  The interface assumes you're using the ALSA library, which is a bit more complicated.

SDIO/MMC

- MultiMediaCard (MMC) 1997

- SD is an extension (1999)

- SDSC (standard capacity), SDHC (high capacity), SDXC (extended capacity), SDIO (I/O)

- Standard/Mini/Micro sizes

- SDHC up to 32GB, SDCX up to 2TB

- Support different amounts of sustained I/O. Class rating 2, 4, 6, 10 (MB/s)

- SDIO – can have I/O like GPS, wireless,

- Patents. Need license for making.

- SPI bus mode

- One bit mode – separate command and data channels

- Four-bit mode

- 9 pins

- Initially communicate over 1-bit interface to report sizes, config, etc.

- Starts in 3.3V, can switch to 1.8V

Camera Port

- OAP chips have dedicated hardware for driving cameras Have an "ISP" Image Signal Processor that reads out 10-bit images via a parallel interface

- There is an external Linux driver for this

- It's a similar idea to the pi-cam for raspberry pi

- These chips often used in cell-phones, so makes sense to have support for camera-phone without extra chip being needed.

Ethernet

- Board has ethernet port. Beyond the scope of this. Just use the Linux interfaces.

Wireless

- Like ethernet, but no wires, and more complicated interface due to various standards plus the need for encryption

- Easiest to use high-level Linux utils

Bluetooth

- Makes more sense for embedded systems, especially new low-power Bluetooth.

- Not going to go over it in detail in this class though.

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 Busses not found on Gumstix

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 Gumstix

- 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
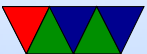
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PCIe

- 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