

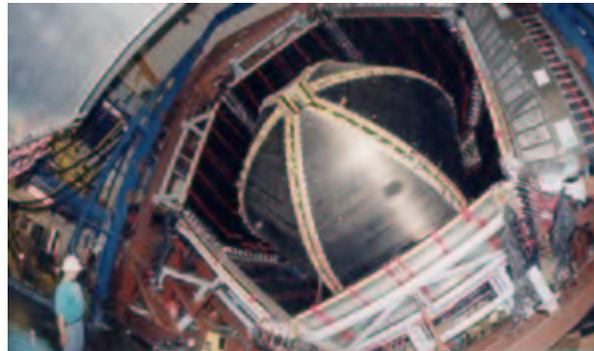
pc104 & epics-3.14 & (linux) Creating an Epics Appliance

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Outline:

1. pc104 and pc104+ specifications
2. Serial example
3. Other pc104 projects in progress
4. Future pc104 projects
5. Hiccups along the way
6. Summary/Resources



What is pc104 & pc104+

- ✓ 586 compatible CPU with ISA bus (pc104).
- ✓ 586 compatible CPU with ISA and PCI bus (pc104+).
- ✓ cards are stackable so the bus gets created as it is needed (no half empty racks).
- ✓ Many CPU and stacking cards are available.
 - ✓ 32->1000MHz speeds, 8->128Mbyte of memory
 - ✓ ADC's, DAC's, frame grabbers, video out, DIO
 - ✓ Linux, RTEMS, RTLinux, VxWorks plus other OS's available
- ✓ Cheap, CPU's cost from \$200->\$1k and cards are in the same price range.



Figure 1: typical pc104 card, 90x95mm



Serial Example-NMR probe

- ✓ slow serial device, we operate it at 2400baud.
- ✓ portability, this device moves to the magnet (across subnets....) so it's a bit of pain to have to drag the NMR chassis around AND a VME crate.
- ✓ OS choice- Linux, no need for real-time, not a mission critical app, not part of any machine protection.....remember it is communicating at 2400baud!!!.
- ✓ existing VxWorks/mv162 software [database, serial communication library and SNL code]

Porting the epics software to pc104/Linux

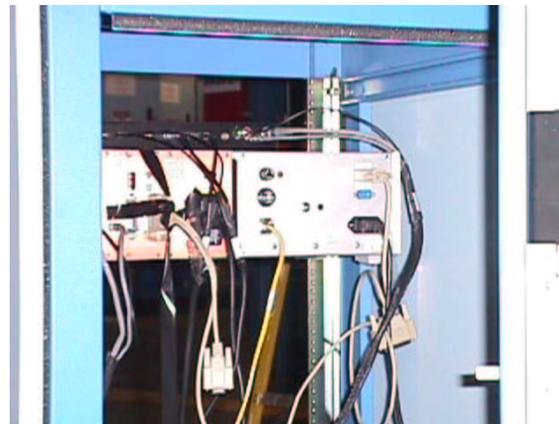
- ✓ database - no changes!!!
- ✓ SNL code - no changes!!!!
- ✓ serial communication library
 - ✓ POSIX open calls replace VxWorks open calls
 - ✓ POSIX semaphores replace VxWorks semaphores [should use EPICS semaphores....update in progress]
- ✓ nmr chassis is rack-mountable with plenty of empty space, install pc104 card inside chassis.



NMR hardware



(a) rear of NMR chasis, pc104 inside



(b) rear of NMR chasis, NMR cable mess



NMR/pc104 in Action

nmr_control.adl

NMR PROBE REMOTE CONTROL

DAC PRESETTING **NMR STATUS**

1 1

0 1 4096 Field Locked ● **LOW**

Serial Stat ●

FIELD READBACK Field Polarity **Positive** - +

0.6687575 Tesla Units **Tesla** MHz Tesla

Man/Auto Mode **Manual** Manual Auto

Search Mode **Off** OFF ON

Control Mode Local Remote

Active MUX **A** A B

Trigger NMR To Re-initialize

Re-INIT NMR

Terminal

File Edit Settings Help

7:17am up 20 days, 14:20, 1 user, load average: 0.02, 0.06, 0.00

50 processes: 49 sleeping, 1 running, 0 zombie, 0 stopped

CPU states: 2.8% user, 5.1% system, 0.0% nice, 92.0% idle

Mem: 14140K av, 11608K used, 2532K free, 0K shrd, 352K buff

Swap: 0K av, 0K used, 0K free, 6300K cached

| PID | USER | PRI | NI | SIZE | RSS | SHARE | STAT | %CPU | %MEM | TIME | COMMAND |
|-----|------|-----|----|------|------|-------|------|------|------|--------|----------------|
| 135 | root | 17 | 0 | 916 | 916 | 708 | R | 4.7 | 6.4 | 0:14 | top |
| 83 | root | 9 | 0 | 2228 | 2228 | 1212 | S | 2.2 | 15.7 | 757:12 | iocSh |
| 61 | root | 9 | 0 | 288 | 288 | 244 | S | 0.1 | 2.0 | 16:19 | caRepeater |
| 123 | root | 9 | 0 | 788 | 784 | 620 | S | 0.1 | 5.5 | 0:00 | in.telnetd |
| 1 | root | 8 | 0 | 472 | 472 | 400 | S | 0.0 | 3.3 | 0:06 | init |
| 2 | root | 9 | 0 | 0 | 0 | 0 | SU | 0.0 | 0.0 | 0:00 | keventd |
| 3 | root | 19 | 19 | 0 | 0 | 0 | SUN | 0.0 | 0.0 | 2:05 | ksoftirqd_CPU0 |
| 4 | root | 9 | 0 | 0 | 0 | 0 | SU | 0.0 | 0.0 | 0:00 | kswapd |
| 5 | root | 9 | 0 | 0 | 0 | 0 | SU | 0.0 | 0.0 | 0:00 | bdflush |
| 6 | root | 9 | 0 | 0 | 0 | 0 | SU | 0.0 | 0.0 | 0:00 | kupdated |
| 27 | root | 9 | 0 | 588 | 588 | 488 | S | 0.0 | 4.1 | 0:00 | syslogd |
| 29 | root | 9 | 0 | 492 | 492 | 360 | S | 0.0 | 3.4 | 0:00 | klogd |
| 43 | root | 9 | 0 | 512 | 512 | 436 | S | 0.0 | 3.6 | 0:00 | inetd |
| 47 | root | 9 | 0 | 2228 | 2228 | 1212 | S | 0.0 | 15.7 | 0:02 | iocSh |
| 49 | root | 9 | 0 | 1796 | 1796 | 1084 | S | 0.0 | 12.7 | 0:00 | nmr |
| 52 | root | 9 | 0 | 452 | 452 | 372 | S | 0.0 | 3.1 | 0:00 | getty |
| 54 | root | 9 | 0 | 1796 | 1796 | 1084 | S | 0.0 | 12.7 | 0:00 | nmr |



Other pc104 projects

RTEMS Agilent GPIB/LAN Eric Norum (eric.norum@usask.ca) has RTEMS and epics-3.14 running on a pc104. He is presently using it to communicate to devices through an Agilent E2050 GPIB/LAN adapter.

Many Serial Port controller Steve Wood (saw@jlab.org) in end-station C here at JLAB has 1 CPU plus 2 4-port serial cards for a 10 serial port CPU. All for ~\$600, or \$60/serial port. Much cheaper than a VME crate, CPU and IPoctal card.



Future pc104 projects

CCD camera self contained camera control, readout and image processing. Astronomy CCD camera controlled via parallel port.

serial Hall-B has several large power supplies and a few other devices controlled by serial lines via mv162's and/or IPoctal. These will be replaced by pc104 cards embedded in the supplies/devices. The goal is to not have serial devices controlled by VME hardware. Hall-C is moving in the same direction, but with a more centralized pc104 box controller up to 10 serial devices.

frame grabbers for CCD cameras that provide a video out, pc104+ cpu + frame grabber provides a mechanism to have cheap dedicated image processing.

The Generic Box some pc104 cards come with many built in functions (DIO, ADC, wireless....), the idea is to implement epics records for all the available options so that the box can be used in emergencies. TS-5500 [would need to add DAC card for completeness].

- ✓ 40 Digital I/O
- ✓ 3 serial ports
- ✓ 1 USB port
- ✓ 10/100baseT ethernet
- ✓ 8 ADC lines [12 bit]
- ✓ PCMCIA slot for wireless card!!!



Hiccups(epics-R3.14.0.beta1)

wrong date The pc104 card came with the clock set to 1970. This caused SNL code to crash. Tried to debug on a linux desktop machine, but could not get it to crash (desktop had the correct date). Finally debugged the problem with plenty of printf's and executing on the pc104 card.

gdb to avoid the printf debug situation it would have been better to get gdb running on the pc104. This is possible, although has not happened yet.

debugging code on desktop linux having your desktop running the same OS as your embedded application makes the development/debug cycle a bit more straight forward than dealing with a cross compiling environment (although this did not help solving the "wrong date" problem).

NIS passwords The iocSh will not run if the user's UID and GID are served via NIS.



Other Benefits

Hall-B is a collaboration of many institutions/universities. Many of these groups want to contribute via control/monitoring projects but usually the overhead of VxWorks/VME prevents them from taking on such projects. Or worse they show up with a PC running labview. pc104/epics/Linux greatly diminishes that overhead.

1. much lower cost than VME
2. Linux OS is familiar to most people
3. no cross compiling
4. focus on learning/developing EPICS application not VxWorks/VME.

Network not needed for rebooting as the pc104 card has a compact flash that holds the OS plus the epics application.



Resources

www.pc104.org generic pc104 website

<http://www.embeddedx86.com> technologic systems, pc104's with Linux pre-installed (we used the TS-5300)

http://www.jlab.org/ccc/mail_archives/ELECTRONICS/pc104/CURRENT/ local JLAB majordomo list for pc104 projects

http://www.jlab.org/ccc/mail_archives/ELECTRONICS/pc104/CURRENT/msg00004.html entry on loading the example database application onto the pc104 card (R3.14.0.beta1).

<http://hallbeng.jlab.org/pc104/index.html> Some of links on the Hall-B initial research on pc104 cards.



Summary & Experience

- ✓ everything works, even better than it did on a mv162!!!
- ✓ porting an existing app to R3.14.0beta1 was straightforward
- ✓ having a typical unix tool-set is great: minicom, top, kill
- ✓ hats off to the R3.14.0 team....

Outstanding issues:

- ✓ need to step back and develop a standard set of tools [gdb, perl...] that should be part of every pc104 tool-set to help debugging problems
- ✓ user vs. root space? more sophisticated drivers that use interrupts will need to be run as root and custom kernels will need to be compiled. We've compiled the pc104 kernel so in principle this is possible.
- ✓ Linux boot is a bit different than VxWorks, need to come up with a consistent way to start iocSh and SNL code upon reboot. Presently we've added some calls to rc.local perhaps this is good enough.
- ✓ How long will ISA chips be available [1980's technology]? If this is a concern, use pc104+ cards with PCI stackable plug-ins.

