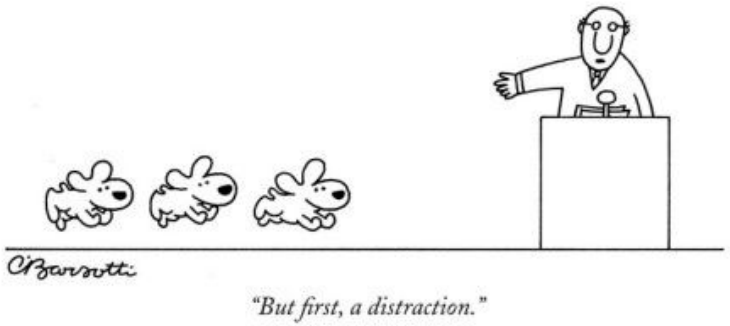
Debugging

Oops - what happened?

ECE 373

But first...

- `write()` in kernel takes `char __user *buf`
  - How to convert?
- How to convert in normal C programs?
  - atoi()
  - Manpage!!
- How to find?
  - Google is your friend
  - LXR is a better friend then
  - http://lxr.free-electrons.com/source/include/linux/kernel.h#L291



"But first, a distraction."

What does a bug look like?

- Kernel panic – the machine is dead
- Odd messages on the console or in the /var/log/{messages|syslog} file
- The network messages are garbled
- The light won't stop blinking
- The robot fell over

Stack Trace

- Printed to console when something bad happens

```
Fedora release 14 (Laughlin)
Kernel 2.6.35.13-92.fc14.x86_64 on an x86_64 (/dev/ttyS0)

ppwaskie-fed14-vm login: [  585.128074] hello kernel...
[  585.129248] BUG: unable to handle kernel NULL pointer
dereference at (null)
[  585.130106] IP: [<ffffffffa003a01b>]
ece_foobar_init+0x1b/0x2f [ece_foobar]
[  585.130106] PGD 37c81067 PUD 37f3d067 PMD 0
[  585.130106] Oops: 0002 [#1] SMP
[  585.130106] last sysfs file:
/sys/devices/pci0000:00/0000:00:01.2/usb1/1-1/dm
[  585.130106] CPU 0
[  585.130106] Modules linked in: ece_foobar(+) tcp_lp fuse
sunrpc ip6t_REJECT ]
```

More indicators...

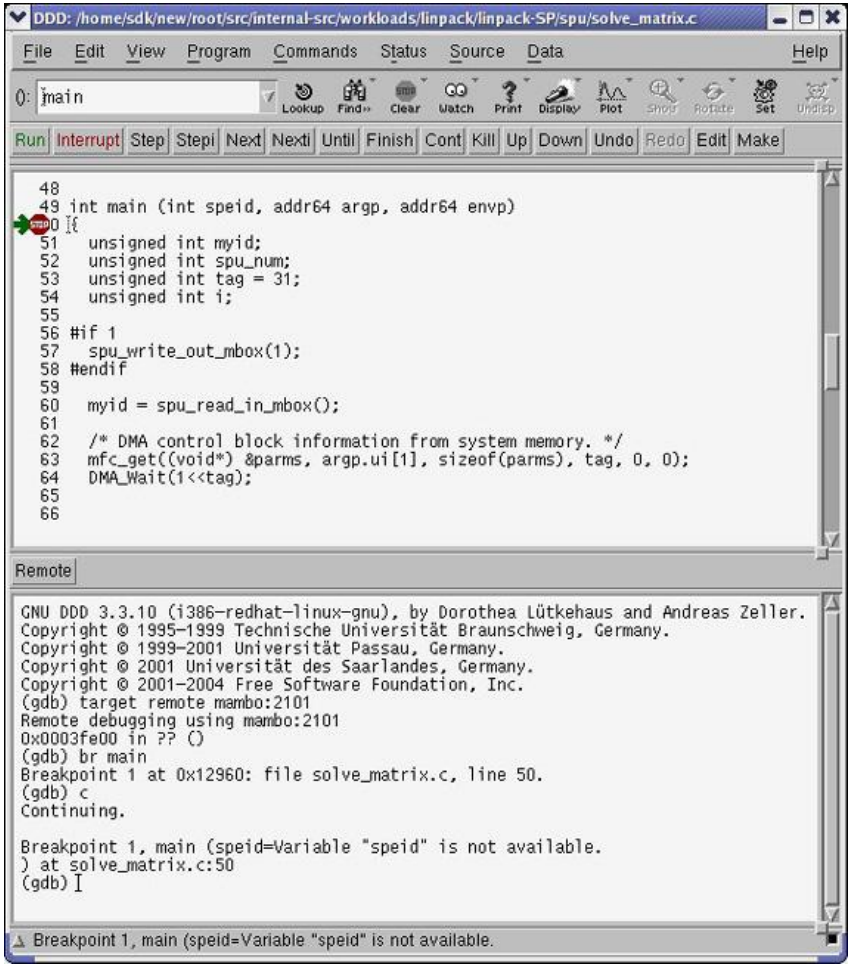
- "Uh, that was weird..."
- "How did that happen?"
- "Why did it do that?"

- Now what?

kgdb - Kernel source debugger

- Support in kernel
- DDD user interface
- Remote debugging

- Can be hard to set up
- Need know where to start looking



Gathering Clues

- What are the symptoms?
- How do you reproduce the problem
  - Easy, 100% reproducible?
  - Only happens once in a blue moon?
  - Special hw or sw involved?
- What sw versions?
- What else is going on in the system?

Printk

- Easy to use
  - Sprinkle around code while debugging
  - Print interesting information
    - current values of interesting variables
    - on entry/exit of interesting routines
  - Recompile/relink/test is fast now-a-days
- Don't forget to remove when done
  - Linux community frowns on noisy drivers

Printk

- printk(KERN_INFO "chainlink=%d\n", chain);
  - KERN_EMERG, KERN_ALERT, KERN_CRIT, KERN_ERR, KERN_WARNING, KERN_NOTICE, KERN_INFO, KERN_DEBUG
- tail -f /var/log/messages
  - filtered by kernel param "loglevel=n"
    - See <linuxsrc>/Documentation/kernel-parameters.txt
  - saved on disk
- dmesg
  - not filtered, all msgs show up
  - not saved on disk

Printk takes time

- Buffered data not saved before crash
- Print slows time-sensitive operations
  - Use "global" status variables, counters, print later
- Print too much on loops
  - Print only every 100th time

pr_info() and friends

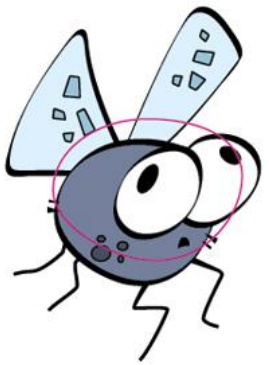
- Friendly wrappers around printk
- Annotates and stamps who printed the message
- Can be compiled out based on debug levels
- Makes printk more portable

trace_printk()

- Part of the ftrace function-tracer framework
- Unbuffered, has much less impact to performance/timing
- More desirable to use during interrupts
- Can be enabled/disabled on the fly

WARN, BUG

- Code warnings
  - BUG(), BUG_ON(expr)
  - WARN(), WARN_ON(expr), WARN_ONCE()
    - https://elixir.bootlin.com/linux/latest/source/drivers/net/ethernet/intel/ice/ice_base.c#L206
- BUG stops the kernel thread
- Both produce stack dump output



Objdump -S -d ece_foobar.o

- Decode exact spot of stack dump cause
- Need to compile with '-g' for debug symbols

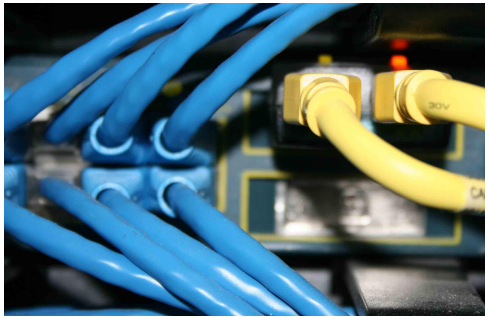
```
    printk(KERN_INFO "%s: cmd=%d\n", __FUNCTION__, cmd);
2c: 31 c0                   xor    %eax,%eax
2e: 48 c7 c6 00 00 00 00    mov    $0x0,%rsi
35: 48 c7 c7 00 00 00 00    mov    $0x0,%rdi
3c: 89 da                   mov    %ebx,%edx
3e: e8 00 00 00 00          callq  43 <timer_cb+0x43>
    switch (cmd) {
43: 83 fb 01                cmp    $0x1,%ebx
46: 74 20                   je     68 <timer_cb+0x68>
48: 7e 36                   jle    80 <timer_cb+0x80>
4a: 83 fb 02                cmp    $0x2,%ebx
4d: eb 01                   jmp    50 <timer_cb+0x50>
4f: 90                      nop
50: 74 47                   je     99 <timer_cb+0x99>
52: 83 fb 03                cmp    $0x3,%ebx
55: eb 01                   jmp    58 <timer_cb+0x58>
57: 90                      nop
58: 74 52                   je     ac <timer_cb+0xac>
```

Ethtool

- ethtool -i: network device info

```
$ ethtool -i eth0
driver: e1000
version: 7.3.21-k8-NAPI
firmware-version: N/A
bus-info: 0000:02:01.0
```

- ethtool -S: network statistics

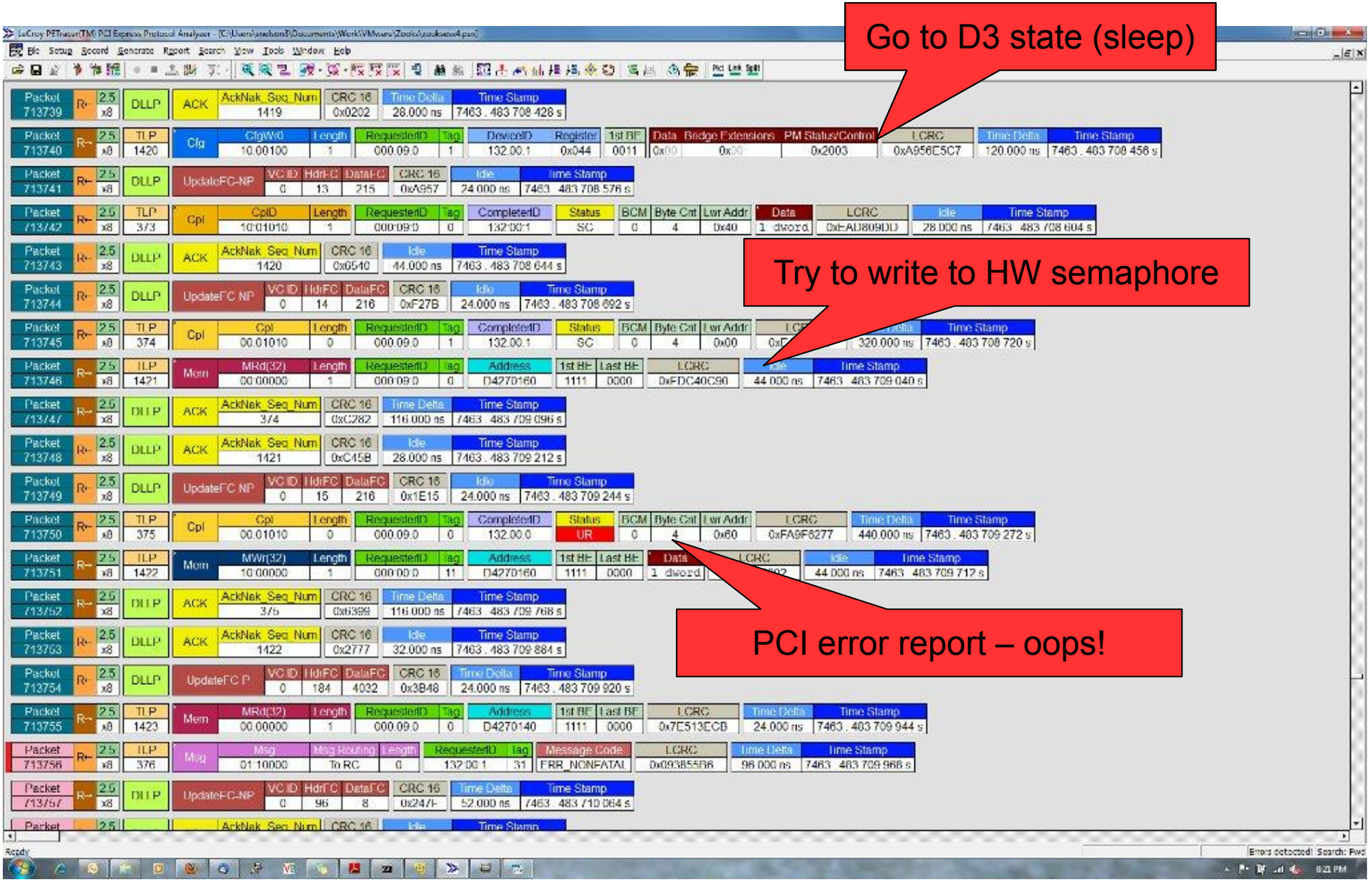


```
$ sudo ethtool -S eth0
NIC statistics:
     rx_packets: 1200
     tx_packets: 648
     rx_bytes: 530648
     tx_bytes: 87288
     rx_broadcast: 0
     tx_broadcast: 0
     rx_multicast: 0
     tx_multicast: 0
     rx_errors: 23
     tx_errors: 0
     tx_dropped: 0
     multicast: 0
     collisions: 0
     rx_length_errors: 47
     rx_over_errors: 0
     rx_crc_errors: 35
```

PCI bus trace

- Hardware to capture PCI data on the bus
  - Case 1: PCI error on initialization
    - Similar network chips, slightly different register sets
    - Code for 82599 was writing to non-existent config registers on 82598, cause "odd" things to happen
  - Case 2: Occasional PCI error on system shutdown
    - Network board put into D3 (sleep) mode
    - Check-status timer expired, tried to read from sleeping board

PCI case 2


Go to D3 state (sleep)
Try to write to HW semaphore
PCI error report – oops!

kdump

- Kernel crash dump capture facility
- Not straight forward to configure
- Requires deep kernel bits to work
- Target scratch device
- Very similar to core dump

crash

- Used to analyze kdump crashes
- Similar to gdb
- Requires environment to get running

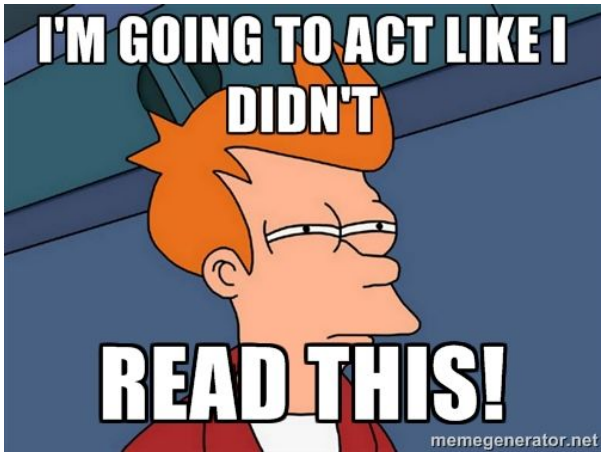
Other

- /proc
  - Interrupts, iomem, ioports,
- watch -d "cmd"
  - Repeats commands, show differences
- Diff from previously working code

Time for a Scooby Snack!

- Lots of tools for sniffing out problems
- Gather data before fixing
- Use repeatable tests
  - First to track the problem...
  - ... then to prove it is fixed
- When stymied
  - take a break, ask for suggestions, read up ...
  - ... and try, try again.

Reading



- Debugging:
  - LDD3, chapter 4
  - ELDD, chapter 21
    - Loose focus on kgdb, kexec, kdump
- Upcoming reading – Memory!:
  - Linux Drivers, Chapters 11 and 12
  - LDD3, Chapter 8
  - ELDD, Pages 49 - 51