

Debugging

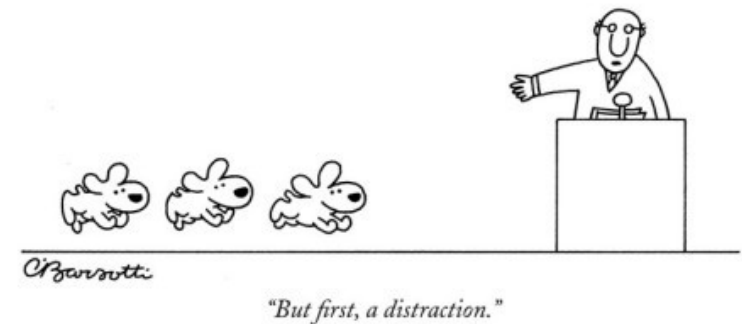


Oops - what happened?

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/kernel.h#L291>



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: [<fffffffffa003a01b>]
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..."

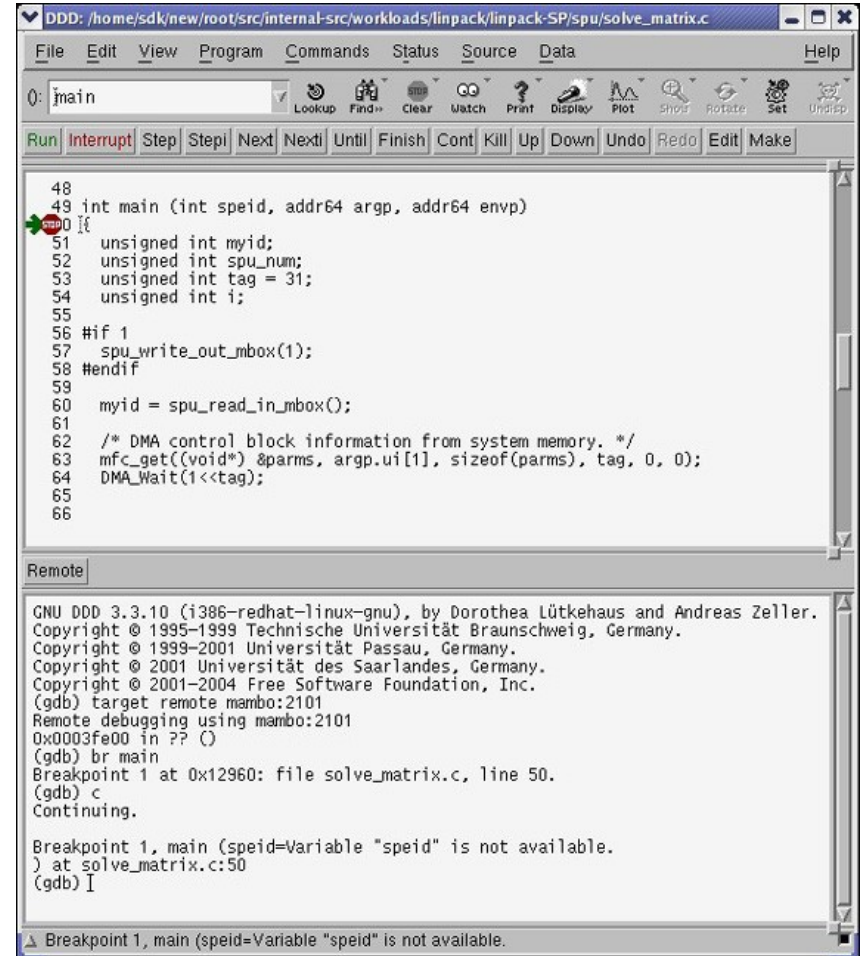
"How did that happen?"

"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



The screenshot shows the GNU DDD 3.3.10 interface. The top menu bar includes File, Edit, View, Program, Commands, Status, Source, Data, and Help. Below the menu is a toolbar with icons for various debugging actions. The main window displays a C source file named `solve_matrix.c` with line numbers 48 to 66. A red arrow points to line 50, indicating a breakpoint. The code includes a `main` function with several variables and a loop. The bottom panel, titled "Remote", shows the output of the debugging session, including the GNU DDD version, copyright information, and the results of the `target remote mambo:2101` command. It also shows the `breakpoint 1` command and the `continue` command.

```
GNU DDD 3.3.10 (i386-redhat-linux-gnu), by Dorothea Lütkehaus and Andreas Zeller.  
Copyright © 1995-1999 Technische Universität Braunschweig, Germany.  
Copyright © 1999-2001 Universität Passau, Germany.  
Copyright © 2001 Universität des Saarlandes, Germany.  
Copyright © 2001-2004 Free Software Foundation, Inc.  
(gdb) target remote mambo:2101  
Remote debugging using mambo:2101  
0x0003fe00 in ?? ()  
(gdb) br main  
Breakpoint 1 at 0x12960: file solve_matrix.c, line 50.  
(gdb) c  
Continuing.  
  
Breakpoint 1, main (speid=Variable "speid" is not available.  
) at solve_matrix.c:50  
(gdb) I
```

Breakpoint 1, main (speid=Variable "speid" is not available.

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

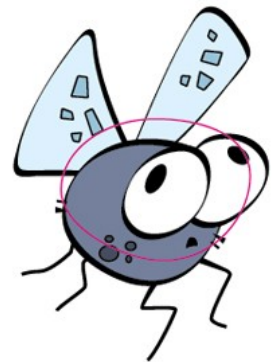
- Friendly wrappers around printf
- Annotates and stamps who printed the message
- Can be compiled out based on debug levels
- Makes printf more portable

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()`
 - http://lxr.free-electrons.com/source/drivers/net/e1000/e1000_main.c#L551
- `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>
```

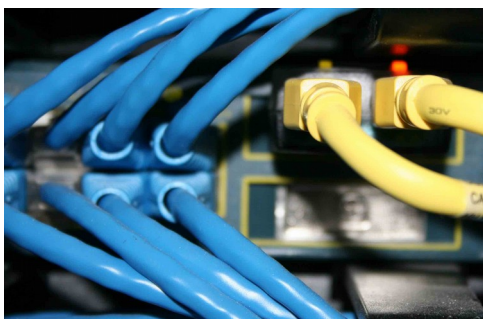


Ethtool

- `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!

Packet	Rx	2.5	DLLP	ACK	AckNak_Seq Num	CRC 16	Time Delta	Time Stamp									
713739	Rx	2.5	DLLP <td>ACK<td>1419</td><td>0x0202</td><td>28.000 ns</td><td>7463.483708428 s</td></td>	ACK <td>1419</td> <td>0x0202</td> <td>28.000 ns</td> <td>7463.483708428 s</td>	1419	0x0202	28.000 ns	7463.483708428 s									
713740	Rx	2.5	TLP <td>Cfg<td>CfgWid</td><td>Length</td><td>RequesterID</td><td>Tag</td><td>DeviceID</td><td>Register</td><td>1st BF</td><td>Data</td><td>Bridge Extensions</td><td>PM Status/Control</td><td>LCRC</td><td>Time Delta</td><td>Time Stamp</td></td>	Cfg <td>CfgWid</td> <td>Length</td> <td>RequesterID</td> <td>Tag</td> <td>DeviceID</td> <td>Register</td> <td>1st BF</td> <td>Data</td> <td>Bridge Extensions</td> <td>PM Status/Control</td> <td>LCRC</td> <td>Time Delta</td> <td>Time Stamp</td>	CfgWid	Length	RequesterID	Tag	DeviceID	Register	1st BF	Data	Bridge Extensions	PM Status/Control	LCRC	Time Delta	Time Stamp
713740	Rx	2.5	TLP <td>Cfg</td> <td>10.00100</td> <td>1</td> <td>000.09.0</td> <td>1</td> <td>132.00.1</td> <td>0x044</td> <td>0011</td> <td>0x00</td> <td>0x00</td> <td>0x2003</td> <td>0xA956E5C7</td> <td>120.000 ns</td> <td>7463.483708458 s</td>	Cfg	10.00100	1	000.09.0	1	132.00.1	0x044	0011	0x00	0x00	0x2003	0xA956E5C7	120.000 ns	7463.483708458 s
713741	Rx	2.5	DLLP <td>UpdateFC-NP<td>VC ID</td><td>Hdr C</td><td>Data C</td><td>CRC 16</td><td>Idle</td><td>Time Stamp</td><td colspan="7"></td></td>	UpdateFC-NP <td>VC ID</td> <td>Hdr C</td> <td>Data C</td> <td>CRC 16</td> <td>Idle</td> <td>Time Stamp</td> <td colspan="7"></td>	VC ID	Hdr C	Data C	CRC 16	Idle	Time Stamp							
713741	Rx	2.5	DLLP <td>UpdateFC-NP<td>0</td><td>13</td><td>215</td><td>0xA957</td><td>24.000 ns</td><td>7463.483708576 s</td><td colspan="7"></td></td>	UpdateFC-NP <td>0</td> <td>13</td> <td>215</td> <td>0xA957</td> <td>24.000 ns</td> <td>7463.483708576 s</td> <td colspan="7"></td>	0	13	215	0xA957	24.000 ns	7463.483708576 s							
713742	Rx	2.5	TLP <td>Cpl<td>CplID</td><td>Length</td><td>RequesterID</td><td>Tag</td><td>CompleterID</td><td>Status</td><td>BCM</td><td>Byte Cnt</td><td>Lwr Addr</td><td>Data</td><td>LCRC</td><td>Idle</td><td>Time Stamp</td></td>	Cpl <td>CplID</td> <td>Length</td> <td>RequesterID</td> <td>Tag</td> <td>CompleterID</td> <td>Status</td> <td>BCM</td> <td>Byte Cnt</td> <td>Lwr Addr</td> <td>Data</td> <td>LCRC</td> <td>Idle</td> <td>Time Stamp</td>	CplID	Length	RequesterID	Tag	CompleterID	Status	BCM	Byte Cnt	Lwr Addr	Data	LCRC	Idle	Time Stamp
713742	Rx	2.5	TLP <td>Cpl<td>10.01010</td><td>1</td><td>000.09.0</td><td>0</td><td>132.00.1</td><td>SC</td><td>0</td><td>4</td><td>0x40</td><td>1 dword</td><td>0xA1809D0D</td><td>28.000 ns</td><td>7463.483708604 s</td></td>	Cpl <td>10.01010</td> <td>1</td> <td>000.09.0</td> <td>0</td> <td>132.00.1</td> <td>SC</td> <td>0</td> <td>4</td> <td>0x40</td> <td>1 dword</td> <td>0xA1809D0D</td> <td>28.000 ns</td> <td>7463.483708604 s</td>	10.01010	1	000.09.0	0	132.00.1	SC	0	4	0x40	1 dword	0xA1809D0D	28.000 ns	7463.483708604 s
713743	Rx	2.5	DLLP <td>ACK<td>AckNak_Seq Num</td><td>CRC 16</td><td>Idle</td><td>Time Stamp</td><td colspan="9"></td></td>	ACK <td>AckNak_Seq Num</td> <td>CRC 16</td> <td>Idle</td> <td>Time Stamp</td> <td colspan="9"></td>	AckNak_Seq Num	CRC 16	Idle	Time Stamp									
713743	Rx	2.5	DLLP <td>ACK<td>1420</td><td>0x0540</td><td>44.000 ns</td><td>7463.483708644 s</td><td colspan="9"></td></td>	ACK <td>1420</td> <td>0x0540</td> <td>44.000 ns</td> <td>7463.483708644 s</td> <td colspan="9"></td>	1420	0x0540	44.000 ns	7463.483708644 s									
713744	Rx	2.5	DLLP <td>UpdateFC-NP<td>VC ID</td><td>Hdr FC</td><td>Data FC</td><td>CRC 16</td><td>Idle</td><td>Time Stamp</td><td colspan="7"></td></td>	UpdateFC-NP <td>VC ID</td> <td>Hdr FC</td> <td>Data FC</td> <td>CRC 16</td> <td>Idle</td> <td>Time Stamp</td> <td colspan="7"></td>	VC ID	Hdr FC	Data FC	CRC 16	Idle	Time Stamp							
713744	Rx	2.5	DLLP <td>UpdateFC-NP<td>0</td><td>14</td><td>216</td><td>0xF27B</td><td>24.000 ns</td><td>7463.483708692 s</td><td colspan="7"></td></td>	UpdateFC-NP <td>0</td> <td>14</td> <td>216</td> <td>0xF27B</td> <td>24.000 ns</td> <td>7463.483708692 s</td> <td colspan="7"></td>	0	14	216	0xF27B	24.000 ns	7463.483708692 s							
713745	Rx	2.5	TLP <td>Cpl<td>CplID</td><td>Length</td><td>RequesterID</td><td>Tag</td><td>CompleterID</td><td>Status</td><td>BCM</td><td>Byte Cnt</td><td>Lwr Addr</td><td>Data</td><td>LCRC</td><td>Time Delta</td><td>Time Stamp</td></td>	Cpl <td>CplID</td> <td>Length</td> <td>RequesterID</td> <td>Tag</td> <td>CompleterID</td> <td>Status</td> <td>BCM</td> <td>Byte Cnt</td> <td>Lwr Addr</td> <td>Data</td> <td>LCRC</td> <td>Time Delta</td> <td>Time Stamp</td>	CplID	Length	RequesterID	Tag	CompleterID	Status	BCM	Byte Cnt	Lwr Addr	Data	LCRC	Time Delta	Time Stamp
713745	Rx	2.5	TLP <td>Cpl<td>00.01010</td><td>0</td><td>000.09.0</td><td>1</td><td>132.00.1</td><td>SC</td><td>0</td><td>4</td><td>0x00</td><td>0x00</td><td>0x00</td><td>320.000 ns</td><td>7463.483708720 s</td></td>	Cpl <td>00.01010</td> <td>0</td> <td>000.09.0</td> <td>1</td> <td>132.00.1</td> <td>SC</td> <td>0</td> <td>4</td> <td>0x00</td> <td>0x00</td> <td>0x00</td> <td>320.000 ns</td> <td>7463.483708720 s</td>	00.01010	0	000.09.0	1	132.00.1	SC	0	4	0x00	0x00	0x00	320.000 ns	7463.483708720 s
713746	Rx	2.5	TLP <td>Mem</td> <td>MRd(32)</td> <td>Length</td> <td>RequesterID</td> <td>Tag</td> <td>Address</td> <td>1st BF</td> <td>Last BF</td> <td>LCRC</td> <td>Idle</td> <td>Time Stamp</td> <td colspan="3"></td>	Mem	MRd(32)	Length	RequesterID	Tag	Address	1st BF	Last BF	LCRC	Idle	Time Stamp			
713746	Rx	2.5	TLP <td>Mem</td> <td>00.00000</td> <td>1</td> <td>000.09.0</td> <td>0</td> <td>D4270160</td> <td>1111</td> <td>0000</td> <td>0xFDC40C90</td> <td>44.000 ns</td> <td>7463.483708940 s</td> <td colspan="3"></td>	Mem	00.00000	1	000.09.0	0	D4270160	1111	0000	0xFDC40C90	44.000 ns	7463.483708940 s			
713747	Rx	2.5	TLP <td>ACK<td>AckNak_Seq Num</td><td>CRC 16</td><td>Time Delta</td><td>Time Stamp</td><td colspan="9"></td></td>	ACK <td>AckNak_Seq Num</td> <td>CRC 16</td> <td>Time Delta</td> <td>Time Stamp</td> <td colspan="9"></td>	AckNak_Seq Num	CRC 16	Time Delta	Time Stamp									
713747	Rx	2.5	TLP <td>ACK<td>3/4</td><td>0xC282</td><td>116.000 ns</td><td>7463.483709096 s</td><td colspan="9"></td></td>	ACK <td>3/4</td> <td>0xC282</td> <td>116.000 ns</td> <td>7463.483709096 s</td> <td colspan="9"></td>	3/4	0xC282	116.000 ns	7463.483709096 s									
713748	Rx	2.5	DLLP <td>ACK<td>AckNak_Seq Num</td><td>CRC 16</td><td>Idle</td><td>Time Stamp</td><td colspan="9"></td></td>	ACK <td>AckNak_Seq Num</td> <td>CRC 16</td> <td>Idle</td> <td>Time Stamp</td> <td colspan="9"></td>	AckNak_Seq Num	CRC 16	Idle	Time Stamp									
713748	Rx	2.5	DLLP <td>ACK<td>1421</td><td>0xC45B</td><td>28.000 ns</td><td>7463.483709212 s</td><td colspan="9"></td></td>	ACK <td>1421</td> <td>0xC45B</td> <td>28.000 ns</td> <td>7463.483709212 s</td> <td colspan="9"></td>	1421	0xC45B	28.000 ns	7463.483709212 s									
713749	Rx	2.5	DLLP <td>UpdateFC-NP<td>VC ID</td><td>Hdr FC</td><td>Data FC</td><td>CRC 16</td><td>Idle</td><td>Time Stamp</td><td colspan="7"></td></td>	UpdateFC-NP <td>VC ID</td> <td>Hdr FC</td> <td>Data FC</td> <td>CRC 16</td> <td>Idle</td> <td>Time Stamp</td> <td colspan="7"></td>	VC ID	Hdr FC	Data FC	CRC 16	Idle	Time Stamp							
713749	Rx	2.5	DLLP <td>UpdateFC-NP<td>0</td><td>15</td><td>216</td><td>0x1E15</td><td>24.000 ns</td><td>7463.483709244 s</td><td colspan="7"></td></td>	UpdateFC-NP <td>0</td> <td>15</td> <td>216</td> <td>0x1E15</td> <td>24.000 ns</td> <td>7463.483709244 s</td> <td colspan="7"></td>	0	15	216	0x1E15	24.000 ns	7463.483709244 s							
713750	Rx	2.5	TLP <td>Cpl<td>CplID</td><td>Length</td><td>RequesterID</td><td>Tag</td><td>CompleterID</td><td>Status</td><td>BCM</td><td>Byte Cnt</td><td>Lwr Addr</td><td>Data</td><td>LCRC</td><td>Time Delta</td><td>Time Stamp</td></td>	Cpl <td>CplID</td> <td>Length</td> <td>RequesterID</td> <td>Tag</td> <td>CompleterID</td> <td>Status</td> <td>BCM</td> <td>Byte Cnt</td> <td>Lwr Addr</td> <td>Data</td> <td>LCRC</td> <td>Time Delta</td> <td>Time Stamp</td>	CplID	Length	RequesterID	Tag	CompleterID	Status	BCM	Byte Cnt	Lwr Addr	Data	LCRC	Time Delta	Time Stamp
713750	Rx	2.5	TLP <td>Cpl<td>00.01010</td><td>0</td><td>000.09.0</td><td>0</td><td>132.00.0</td><td>UR</td><td>0</td><td>4</td><td>0x60</td><td>0xFA9F6277</td><td>440.000 ns</td><td>7463.483709272 s</td></td>	Cpl <td>00.01010</td> <td>0</td> <td>000.09.0</td> <td>0</td> <td>132.00.0</td> <td>UR</td> <td>0</td> <td>4</td> <td>0x60</td> <td>0xFA9F6277</td> <td>440.000 ns</td> <td>7463.483709272 s</td>	00.01010	0	000.09.0	0	132.00.0	UR	0	4	0x60	0xFA9F6277	440.000 ns	7463.483709272 s	
713751	Rx	2.5	TLP <td>Mem</td> <td>MWrt(32)</td> <td>Length</td> <td>RequesterID</td> <td>Tag</td> <td>Address</td> <td>1st BF</td> <td>Last BF</td> <td>Data</td> <td>LCRC</td> <td>Idle</td> <td>Time Stamp</td> <td colspan="2"></td>	Mem	MWrt(32)	Length	RequesterID	Tag	Address	1st BF	Last BF	Data	LCRC	Idle	Time Stamp		
713751	Rx	2.5	TLP <td>Mem</td> <td>10.00000</td> <td>1</td> <td>000.00.0</td> <td>11</td> <td>D4270160</td> <td>1111</td> <td>0000</td> <td>1 dword</td> <td>0x00</td> <td>44.000 ns</td> <td>7463.483709312 s</td> <td colspan="2"></td>	Mem	10.00000	1	000.00.0	11	D4270160	1111	0000	1 dword	0x00	44.000 ns	7463.483709312 s		
713752	Rx	2.5	TLP <td>ACK<td>AckNak_Seq Num</td><td>CRC 16</td><td>Time Delta</td><td>Time Stamp</td><td colspan="9"></td></td>	ACK <td>AckNak_Seq Num</td> <td>CRC 16</td> <td>Time Delta</td> <td>Time Stamp</td> <td colspan="9"></td>	AckNak_Seq Num	CRC 16	Time Delta	Time Stamp									
713752	Rx	2.5	TLP <td>ACK<td>3/5</td><td>0x6399</td><td>116.000 ns</td><td>7463.483709368 s</td><td colspan="9"></td></td>	ACK <td>3/5</td> <td>0x6399</td> <td>116.000 ns</td> <td>7463.483709368 s</td> <td colspan="9"></td>	3/5	0x6399	116.000 ns	7463.483709368 s									
713753	Rx	2.5	DLLP <td>ACK<td>AckNak_Seq Num</td><td>CRC 16</td><td>Idle</td><td>Time Stamp</td><td colspan="9"></td></td>	ACK <td>AckNak_Seq Num</td> <td>CRC 16</td> <td>Idle</td> <td>Time Stamp</td> <td colspan="9"></td>	AckNak_Seq Num	CRC 16	Idle	Time Stamp									
713753	Rx	2.5	DLLP <td>ACK<td>1422</td><td>0x2777</td><td>32.000 ns</td><td>7463.483709384 s</td><td colspan="9"></td></td>	ACK <td>1422</td> <td>0x2777</td> <td>32.000 ns</td> <td>7463.483709384 s</td> <td colspan="9"></td>	1422	0x2777	32.000 ns	7463.483709384 s									
713754	Rx	2.5	DLLP <td>UpdateFC-NP<td>VC ID</td><td>Hdr FC</td><td>Data FC</td><td>CRC 16</td><td>Time Delta</td><td>Time Stamp</td><td colspan="7"></td></td>	UpdateFC-NP <td>VC ID</td> <td>Hdr FC</td> <td>Data FC</td> <td>CRC 16</td> <td>Time Delta</td> <td>Time Stamp</td> <td colspan="7"></td>	VC ID	Hdr FC	Data FC	CRC 16	Time Delta	Time Stamp							
713754	Rx	2.5	DLLP <td>UpdateFC-NP<td>0</td><td>184</td><td>4032</td><td>0x3B48</td><td>24.000 ns</td><td>7463.483709320 s</td><td colspan="7"></td></td>	UpdateFC-NP <td>0</td> <td>184</td> <td>4032</td> <td>0x3B48</td> <td>24.000 ns</td> <td>7463.483709320 s</td> <td colspan="7"></td>	0	184	4032	0x3B48	24.000 ns	7463.483709320 s							
713755	Rx	2.5	TLP <td>Mem</td> <td>MRd(32)</td> <td>Length</td> <td>RequesterID</td> <td>Tag</td> <td>Address</td> <td>1st BF</td> <td>Last BF</td> <td>LCRC</td> <td>Time Delta</td> <td>Time Stamp</td> <td colspan="3"></td>	Mem	MRd(32)	Length	RequesterID	Tag	Address	1st BF	Last BF	LCRC	Time Delta	Time Stamp			
713755	Rx	2.5	TLP <td>Mem</td> <td>00.00000</td> <td>1</td> <td>000.09.0</td> <td>0</td> <td>D4270140</td> <td>1111</td> <td>0000</td> <td>0x7E513ECB</td> <td>24.000 ns</td> <td>7463.483709344 s</td> <td colspan="3"></td>	Mem	00.00000	1	000.09.0	0	D4270140	1111	0000	0x7E513ECB	24.000 ns	7463.483709344 s			
713756	Rx	2.5	TLP <td>Msg</td> <td>Msg</td> <td>Msg Routing</td> <td>Length</td> <td>RequesterID</td> <td>Tag</td> <td>Message Code</td> <td>LCRC</td> <td>Time Delta</td> <td>Time Stamp</td> <td colspan="4"></td>	Msg	Msg	Msg Routing	Length	RequesterID	Tag	Message Code	LCRC	Time Delta	Time Stamp				
713756	Rx	2.5	TLP <td>Msg</td> <td>01.10000</td> <td>To RC</td> <td>0</td> <td>132.00.1</td> <td>31</td> <td>FRR_NONFATAL</td> <td>0x093855B6</td> <td>96.000 ns</td> <td>7463.483709368 s</td> <td colspan="4"></td>	Msg	01.10000	To RC	0	132.00.1	31	FRR_NONFATAL	0x093855B6	96.000 ns	7463.483709368 s				
713757	Rx	2.5	TLP <td>UpdateFC-NP<td>VC ID</td><td>Hdr C</td><td>Data C</td><td>CRC 16</td><td>Time Delta</td><td>Time Stamp</td><td colspan="7"></td></td>	UpdateFC-NP <td>VC ID</td> <td>Hdr C</td> <td>Data C</td> <td>CRC 16</td> <td>Time Delta</td> <td>Time Stamp</td> <td colspan="7"></td>	VC ID	Hdr C	Data C	CRC 16	Time Delta	Time Stamp							
713757	Rx	2.5	TLP <td>UpdateFC-NP<td>0</td><td>96</td><td>8</td><td>0x247F</td><td>52.000 ns</td><td>7463.483710064 s</td><td colspan="7"></td></td>	UpdateFC-NP <td>0</td> <td>96</td> <td>8</td> <td>0x247F</td> <td>52.000 ns</td> <td>7463.483710064 s</td> <td colspan="7"></td>	0	96	8	0x247F	52.000 ns	7463.483710064 s							
713758	Rx	2.5	TLP <td>ACK<td>AckNak_Seq Num</td><td>CRC 16</td><td>Idle</td><td>Time Stamp</td><td colspan="9"></td></td>	ACK <td>AckNak_Seq Num</td> <td>CRC 16</td> <td>Idle</td> <td>Time Stamp</td> <td colspan="9"></td>	AckNak_Seq Num	CRC 16	Idle	Time Stamp									
713758	Rx	2.5	TLP <td>ACK<td>1423</td><td>0x0000</td><td>28.000 ns</td><td>7463.483710064 s</td><td colspan="9"></td></td>	ACK <td>1423</td> <td>0x0000</td> <td>28.000 ns</td> <td>7463.483710064 s</td> <td colspan="9"></td>	1423	0x0000	28.000 ns	7463.483710064 s									

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

