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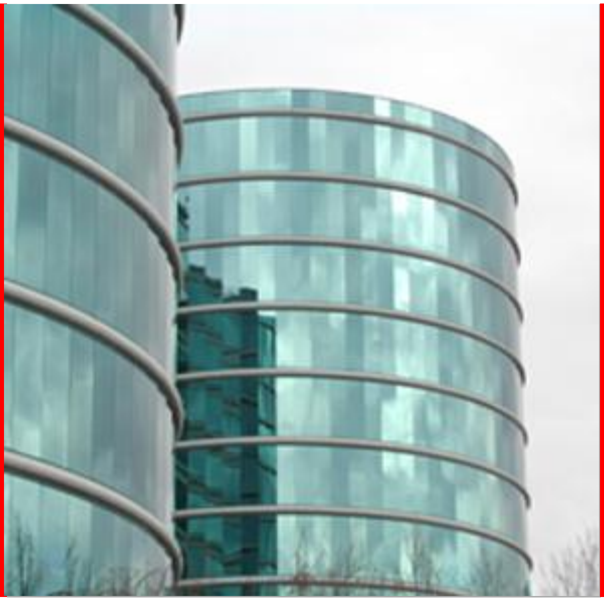

From printk to QEMU: Xen/Linux Kernel debugging

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Presentation plan

- printk and companions
- gdb
- kgdb, GDB stub, …
- QEMU
- kdump

- Documentation

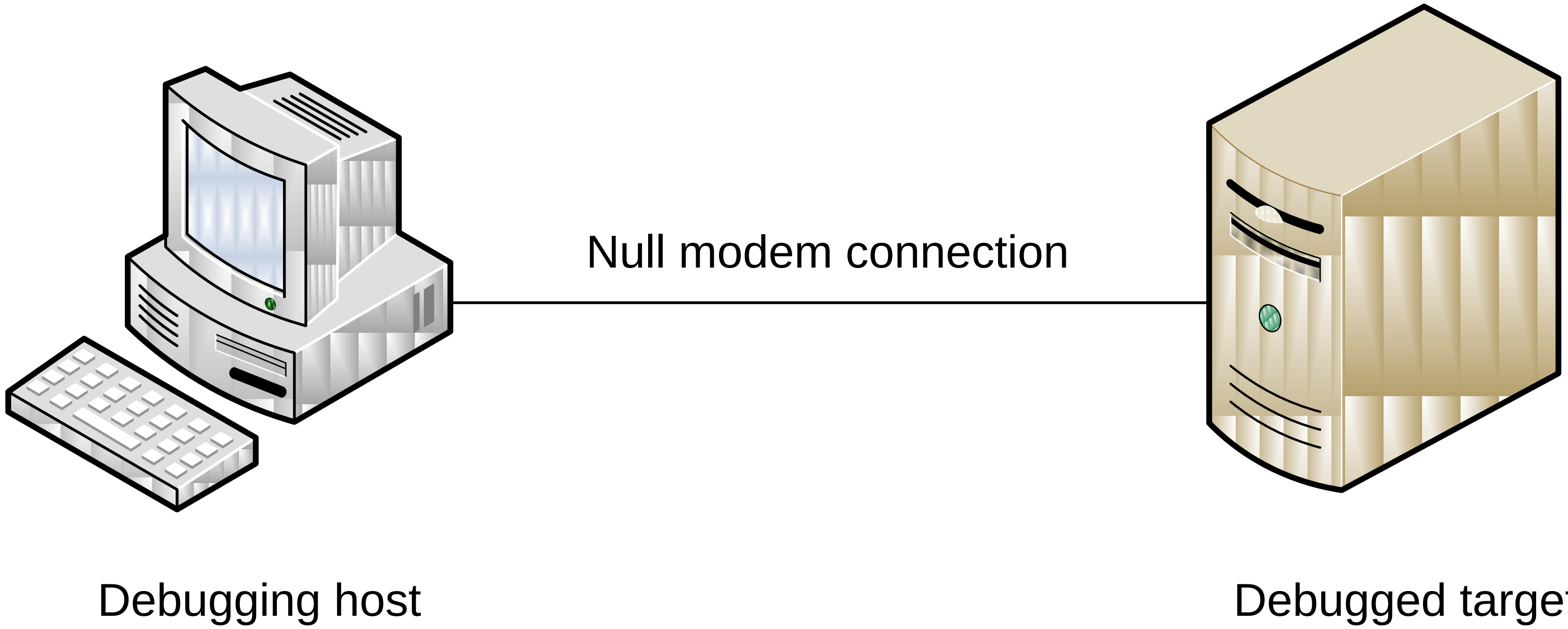
- Questions and Answers

printk usage

```
…
printk(KERN_DEBUG ”Something went wrong\n”)
…
```

- Linux Kernel has some useful abreviations: `pr_info(),pr_debug(),…`
- … and `pr_info_once(),pr_debug_once(),…`
- All functions/macros accept most of standard C `printf()` format strings
- `/proc/sys/kernel/printk` controls log levels

serial console scenario



printk and Linux serial/early console

- printk output is send usualy to graphic card by default
- This behavior is not very useful for debugging because output may disappear
- Serial console is a solution in this case
- Linux Kernel serial console activation:

```
    /boot/vmlinuz … console=ttyS0,115200n8 …
```

- Linux Kernel early console activation:

```
    /boot/vmlinuz … earlyprintk=ttyS0,115200 …
```

- Other useful Linux Kernel logging options:
  - `debug`
  - `loglevel=<0-7>`

printk and Xen serial console

- Xen serial console activation:

```
      /boot/xen.gz … com1=115200,8n1 console=com1 …
```

- Other Xen useful logging options:
  - `sync_console`
  - `console_to_ring`
  - `loglvl=all`
  - `guest_loglvl=all`
  - `apic_verbosity=debug`

serial console and asm x86
USB debug port

- Serial port requires some initialization
- Good and working asm x86 example could be found in kexec-tools source (kexec-tools/purgatory/arch/i386/console-x86.c)

- USB EHCI debug port is similart solution to serial console
- Linux Kernel has support for USB debug port
- There is a RFC implementation for Xen, too
- However, machines must be connect through special device ☹

How to check logs

- Linux logs:
  - `/var/log/dmesg`
  - `/var/log/syslog`
  - `/var/log/messages`
- Xen logs:
  - `xm dmesg`
  - `xl dmesg`

printk summary

- Simple and reliable
- Does not interfere program run
(in contrast to e.g. gdb)
- Every change in printk debugging code requires recompilation and restart (time and labor consuming)
- It is quiet difficult to use printk to analyze large structures and complicated code

gdb

- gdb/GDB is feature rich debugger known as GNU Debugger
- It allows developer to do:
  - virtual memory analysis
  - structures analysis
  - multithreaded processes analysis
  - many more…
- gdb could use scripts to automate tasks
- gdb could be used to do remote debugging
- gdb is core element in other debugging tools (e.g. crash)
- gdb requiers symbols to work properly

gdb - Linux Kernel simple usage

-
  ```
  # gdb vmlinux /proc/kcore
  (gdb) p/x max_pfn
  ```
- This could be used only to do live memory, variables and structures analysis

Linux Kernel debuging over serial connection - kgdb

- Support for kgdb must be enabled in Linux Krenel

```
      /boot/vmlinuz … kgdboc=ttyS0,115200 …
```

- kgdb could be configured from live system by:

```
# echo ttyS0 > /sys/module/kgdboc/parameters/kgdboc
```

- kgdb must be activated by `Alt-SysRq-g` or

```
      # echo g > /proc/sysrq-trigger
```

- kgdb could be activated at boot by passing `kgdbwait` to Linux Kernel, too

-
  ```
  # gdb vmlinux
  (gdb) set remotebaud 115200
  (gdb) target remote /dev/ttyS0
  ```
- There is another debugging feature in Linux Kernel known as kdb

Xen dom0 debugging over serial connection - GDB stub

- Boot Xen with following options:

```
    /boot/xen.gz … com1=115200,8n1 \
        com2=115200,8n1 \
            console=com1 gdb=com2…
```

- Press `Ctrl-a` * 3 and then `%` on serial console

-
  ```
  # gdb xen-syms
  (gdb) set remotebaud 115200
  (gdb) target remote /dev/ttyS0
  ```

Xen domU debugging - gdbsx

- Start new domain as usual
- Start `gdbsx`
- `# gdbsx -a <domid> <32|64> <port>`
- `# gdbsx -a 1 64 1234`

-
  ```
  # gdb vmlinux
  (gdb) target remote :1234
  ```
- There are other Xen tools which could support problem solving like `xenctx`, `xentrace` or `xl/xm dump-core`

gdb summary

- gdb is powerfull tool
- gdb is quite diffcult to use especially by begginers
- …but there are some graphical frontends
  like GNU DDD

QEMU

- *QEMU is a generic and open source machine emulator and virtualizer* (http://wiki.qemu.org/Main_Page)
- Good to do some arch testing and virtualization (as is) but also excellent for debugging

- `# qemu … -serial \`
  ```
      telnet:127.0.0.1:10232,server …
  ```
- `# telnet 127.0.0.1 10232`

- `# qemu … -debugcon \`
  ```
      telnet:127.0.0.1:10233,server,nowait …
  ```
- asm x86: `outb` to `0xe9` port
- `# telnet 127.0.0.1 10233`

QEMU

- `# qemu … -monitor \`
  `    telnet:127.0.0.1:1233,server,nowait …`
- `# telnet 127.0.0.1 1233`

- `# qemu … -gdb tcp:127.0.0.1:1234 …`
- `# gdb vmlinux`
  `(gdb) target remote :1234`

QEMU summary

- Easy to use
- A lot of debugging options to choose from
- Fast boot (contrary e.g. rack servers)
- Debugging is possible from ”first intruction”
- Sometimes emulation is slow and not perfect
- Final testing should be <u>always</u> done on real hardware

kdump - Xen dom0 support

- Nice tool for crash dump collection (very useful for support departments)
- It works under Linux Kernel since 2.6.13 version
- It is supported on a lot of architectures
- kexec/kdump for Xen dom0 is under development; patches will be published soon
- kexec-tools patches will be published soon
- crash tool contains all required patches (backward compatibility with older version of Xen and Linux is mainatined)

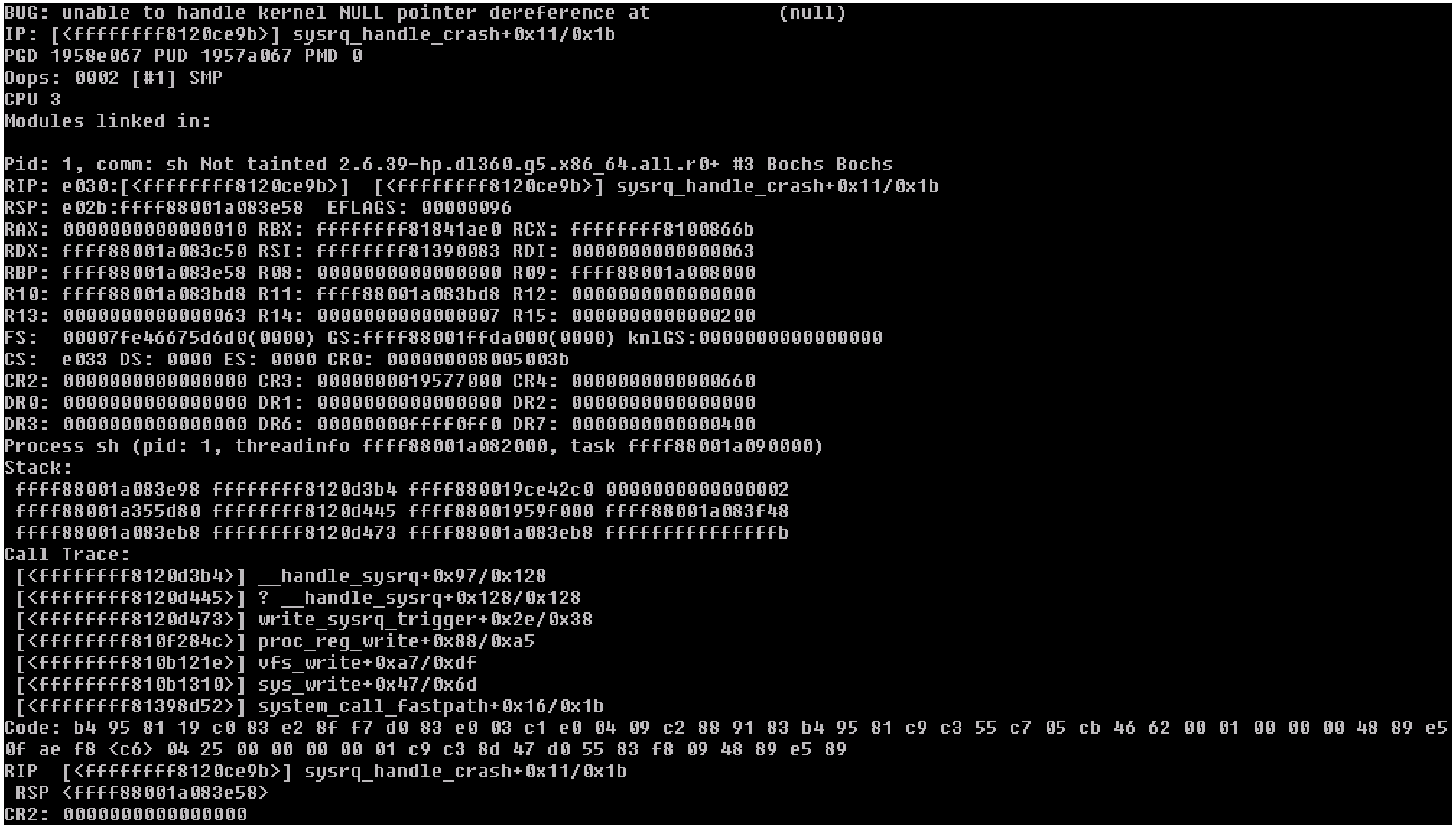
kdump - Xen domU support

- It could be useful when there is no access to `xl/xm dump-core` (e.g. some virtualization companies provides virtualized servers without access to dom0)
- Linux Kernel Xen dom0 changes are required for Xen domU kdump support
- Some Xen hypervisor changes are also required
- kexec-tools changes are required, too
- Acunu Limited sponsored work on initial domU development for Xen Linux Kernel Ver. 2.6.18
- Solution is ready and will be used as a base for upstream development

Documentation

- linux/Documentation/sysctl/kernel.txt
- linux/Documentation/kernel-parameters.txt
- http://wiki.xen.org/
- http://wiki.xen.org/wiki/Xen_Serial_Console
- http://www.gnu.org/software/gdb/
- http://www.gnu.org/software/ddd/
- http://kgdb.wiki.kernel.org/
- http://kernel.org/doc/htmldocs/kgdb.html
- http://wiki.qemu.org/Main_Page
- http://zhigang.org/wiki/XenDebugging

Questions and Answers ?



```
BUG: unable to handle kernel NULL pointer dereference at           (null)
IP: [<ffffffff8120ce9b>] sysrq_handle_crash+0x11/0x1b
PGD 1958e067 PUD 1957a067 PMD 0
Oops: 0002 [#1] SMP
CPU 3
Modules linked in:

Pid: 1, comm: sh Not tainted 2.6.39-hp.dl360.g5.x86_64.all.r0+ #3 Bochs Bochs
RIP: e030:[<ffffffff8120ce9b>]  [<ffffffff8120ce9b>] sysrq_handle_crash+0x11/0x1b
RSP: e02b:ffff88001a083e58  EFLAGS: 00000096
RAX: 0000000000000010 RBX: ffffffff81841ae0 RCX: ffffffff8100866b
RDX: ffff88001a083c50 RSI: ffffffff81390083 RDI: 0000000000000063
RBP: ffff88001a083e58 R08: 0000000000000000 R09: ffff88001a008000
R10: ffff88001a083bd8 R11: ffff88001a083bd8 R12: 0000000000000000
R13: 0000000000000063 R14: 0000000000000007 R15: 0000000000000200
FS:  00007fe46675d6d0(0000) GS:ffff88001ffda000(0000) knlGS:0000000000000000
CS:  e033 DS: 0000 ES: 0000 CR0: 000000008005003b
CR2: 0000000000000000 CR3: 0000000019577000 CR4: 0000000000000660
DR0: 0000000000000000 DR1: 0000000000000000 DR2: 0000000000000000
DR3: 0000000000000000 DR6: 00000000ffff0ff0 DR7: 0000000000000400
Process sh (pid: 1, threadinfo ffff88001a082000, task ffff88001a090000)
Stack:
 ffff88001a083e98 ffffffff8120d3b4 ffff880019ce42c0 0000000000000002
 ffff88001a355d80 ffffffff8120d445 ffff88001959f000 ffff88001a083f48
 ffff88001a083eb8 ffffffff8120d473 ffff88001a083eb8 fffffffffffffffb
Call Trace:
 [<ffffffff8120d3b4>] __handle_sysrq+0x97/0x128
 [<ffffffff8120d445>] ? __handle_sysrq+0x128/0x128
 [<ffffffff8120d473>] write_sysrq_trigger+0x2e/0x38
 [<ffffffff810f284c>] proc_reg_write+0x88/0xa5
 [<ffffffff810b121e>] vfs_write+0xa7/0xdf
 [<ffffffff810b1310>] sys_write+0x47/0x6d
 [<ffffffff81398d52>] system_call_fastpath+0x16/0x1b
Code: b4 95 81 19 c0 83 e2 8f f7 d0 83 e0 03 c1 e0 04 09 c2 88 91 83 b4 95 81 c9 c3 55 c7 05 cb 46 62 00 01 00 00 00 48 89 e5
0f ae f8 <c6> 04 25 00 00 00 00 01 c9 c3 8d 47 d0 55 83 f8 09 48 89 e5 89
RIP  [<ffffffff8120ce9b>] sysrq_handle_crash+0x11/0x1b
 RSP <ffff88001a083e58>
CR2: 0000000000000000
```

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