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kexec based bootloaders on RISC-V: Use-cases & Advantages

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Red Hat
bhsharma@redhat.com

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$ whoami

- Part of Red Hat kernel team.
- Been hacking on bootloaders and kernel since past 14 years.
- Contribute to:
  - Linux,
  - EFI/u-boot bootloader, and
  - User-space utilities like:
    - kexec-tools, and
    - makedumpfile.
- Co-maintain crash-utility tool

Outline

- About kexec – What?
- About kexec – How?
- Linux booting Linux – kexec based bootloaders
- Case for kexec based bootloaders on RISC-V
- So everything works fine, or does it ..
- Pain Points
- Suggestions

About kexec – What?

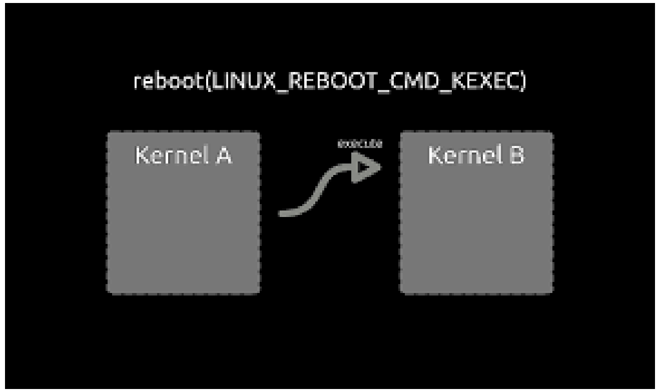
- kexec enables you to load and boot into **another kernel** from the currently running kernel.
- **Standard** system boot v/s **kexec** boot:
  - **kexec** boot - skips hardware initialization performed by BIOS / firmware.
- So, overall **kexec** reboot time reduces ⚡
- Related **syscalls**
  - kexec_load()
  - kexec_file_load()

About kexec – What?

- Related kernel **CONFIG** options
  - CONFIG_KEXEC
  - CONFIG_KEXEC_FILE

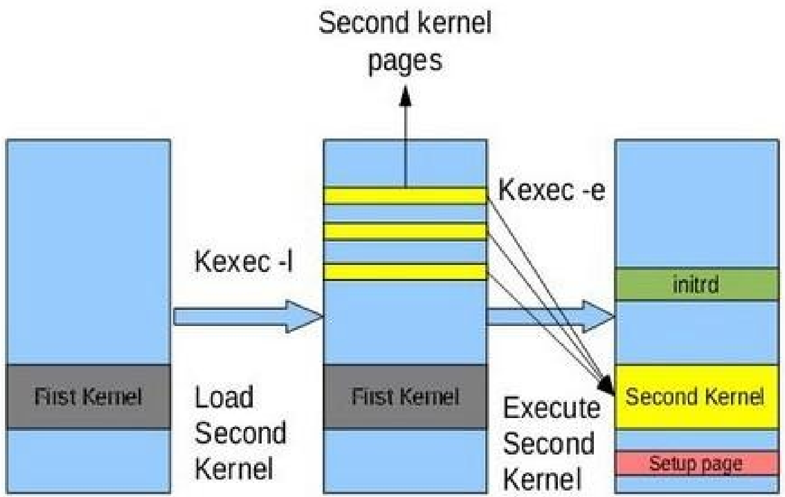
- Supported **architectures**
  - x86_64,ppc64/ppc64le,s390/s390x,arm,arm64

About kexec – How?



- **2-Step** process
  - **Kernel** space support
    - kexec_load() and kexec_file_load() syscall(s) loads a new kernel into memory.
    - reboot(LINUX_REBOOT_CMD_KEXEC) syscall reboots into the new kernel.
  - **User** space support
    - /usr/bin/kexec - provided by **kexec-tools** package

Kexec design



About kexec – How?

- **2-Step** process
  - **Load** a new kernel into the physical memory:

```
# kexec -l <kernel-image>  --initrd=<initramfs-image> --reuse-cmdline
```

from the context of running kernel

  - **Boot** into the new kernel:

```
# kexec -e
```

  - **Unload** the loaded kernel *(if need be)*:

```
# kexec -u
```

Linux booting Linux – kexec based bootloaders

- Several kexec based open-source bootloaders are available:
- LinuxBoot
- Petitboot
- kexecboot
- kboot, several more ...

Case for kexec based bootloader on RISC-V

- Fast reboot / Warm booting remains an important feature for RISC-V platforms as well.

- Kernel kexec patches were proposed for RISC-V
  - But seems further work still needed to upstream them.

- User-space kexec-tools patches were proposed for RISC-V
  - But seems further work still needed to upstream them.

- Requests have also come up for crash-utility support for RISC-V

- Look here (riscv-for-next) for more developmental features.

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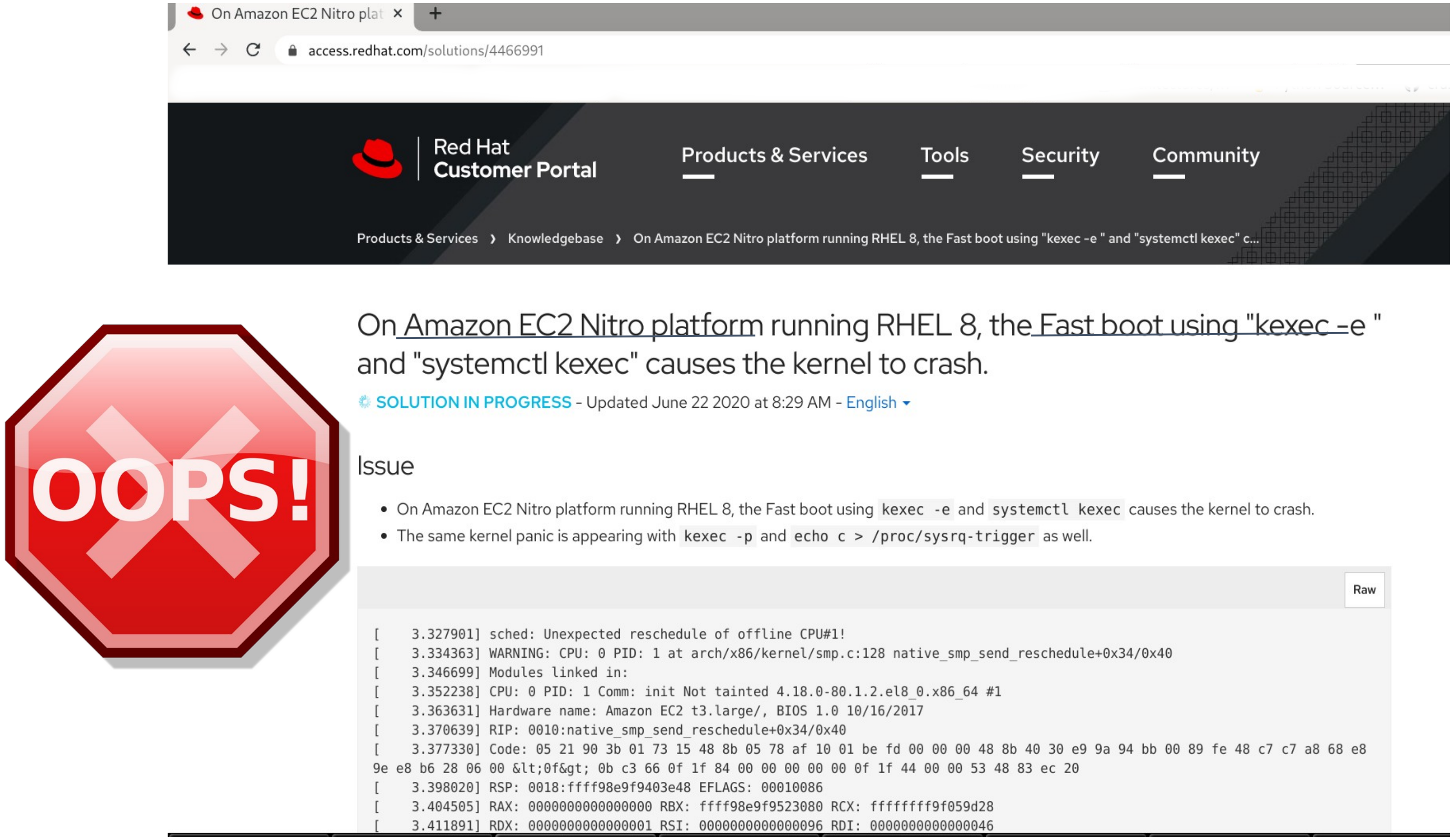
So everything works fine, or does it ...



Products & Services › Knowledgebase › On Amazon EC2 Nitro platform running RHEL 8, the Fast boot using "kexec -e " and "systemctl kexec" c...

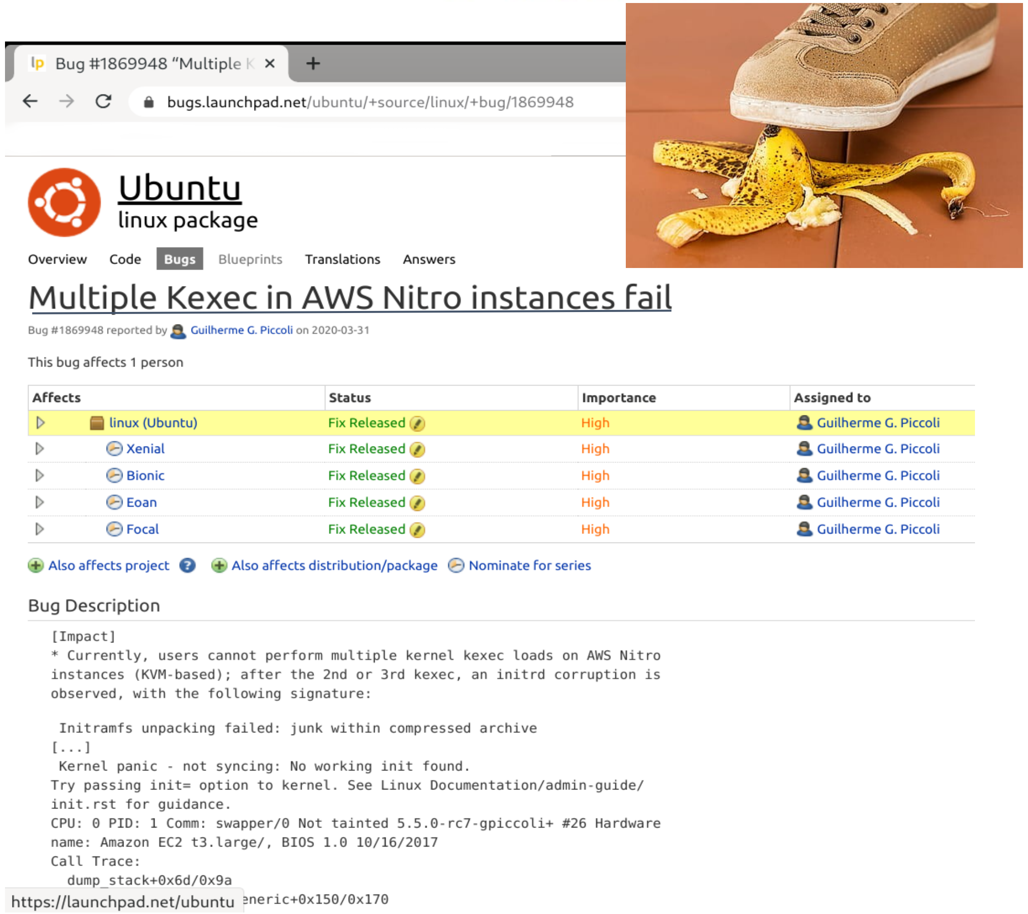
On Amazon EC2 Nitro platform running RHEL 8, the Fast boot using "kexec -e " and "systemctl kexec" causes the kernel to crash.

SOLUTION IN PROGRESS - Updated June 22 2020 at 8:29 AM - English

Issue

- On Amazon EC2 Nitro platform running RHEL 8, the Fast boot using `kexec -e` and `systemctl kexec` causes the kernel to crash.
- The same kernel panic is appearing with `kexec -p` and `echo c > /proc/sysrq-trigger` as well.

```
[    3.327901] sched: Unexpected reschedule of offline CPU#1!
[    3.334363] WARNING: CPU: 0 PID: 1 at arch/x86/kernel/smp.c:128 native_smp_send_reschedule+0x34/0x40
[    3.346699] Modules linked in:
[    3.352238] CPU: 0 PID: 1 Comm: init Not tainted 4.18.0-80.1.2.el8_0.x86_64 #1
[    3.363631] Hardware name: Amazon EC2 t3.large/, BIOS 1.0 10/16/2017
[    3.370639] RIP: 0010:native_smp_send_reschedule+0x34/0x40
[    3.377330] Code: 05 21 90 3b 01 73 15 48 8b 05 78 af 10 01 be fd 00 00 00 48 8b 40 30 e9 9a 94 bb 00 89 fe 48 c7 c7 a8 68 e8
9e e8 b6 28 06 00 &lt;0f&gt; 0b c3 66 0f 1f 84 00 00 00 00 00 0f 1f 44 00 00 53 48 83 ec 20
[    3.398020] RSP: 0018:ffff98e9f9403e48 EFLAGS: 00010086
[    3.404505] RAX: 0000000000000000 RBX: ffff98e9f9523080 RCX: ffffffff9f059d28
[    3.411891] RDX: 0000000000000001 RSI: 0000000000000096 RDI: 0000000000000046
```


Bug #1869948 "Multiple K ×
bugs.launchpad.net/ubuntu/+source/linux/+bug/1869948
Ubuntu
linux package
Overview
Code
Bugs
Blueprints
Translations
Answers
Also affects project
Also affects distribution/package
Nominate for series
https://launchpad.net/ubuntu

Multiple Kexec in AWS Nitro instances fail

Bug #1869948 reported by Guilherme G. Piccoli on 2020-03-31

This bug affects 1 person

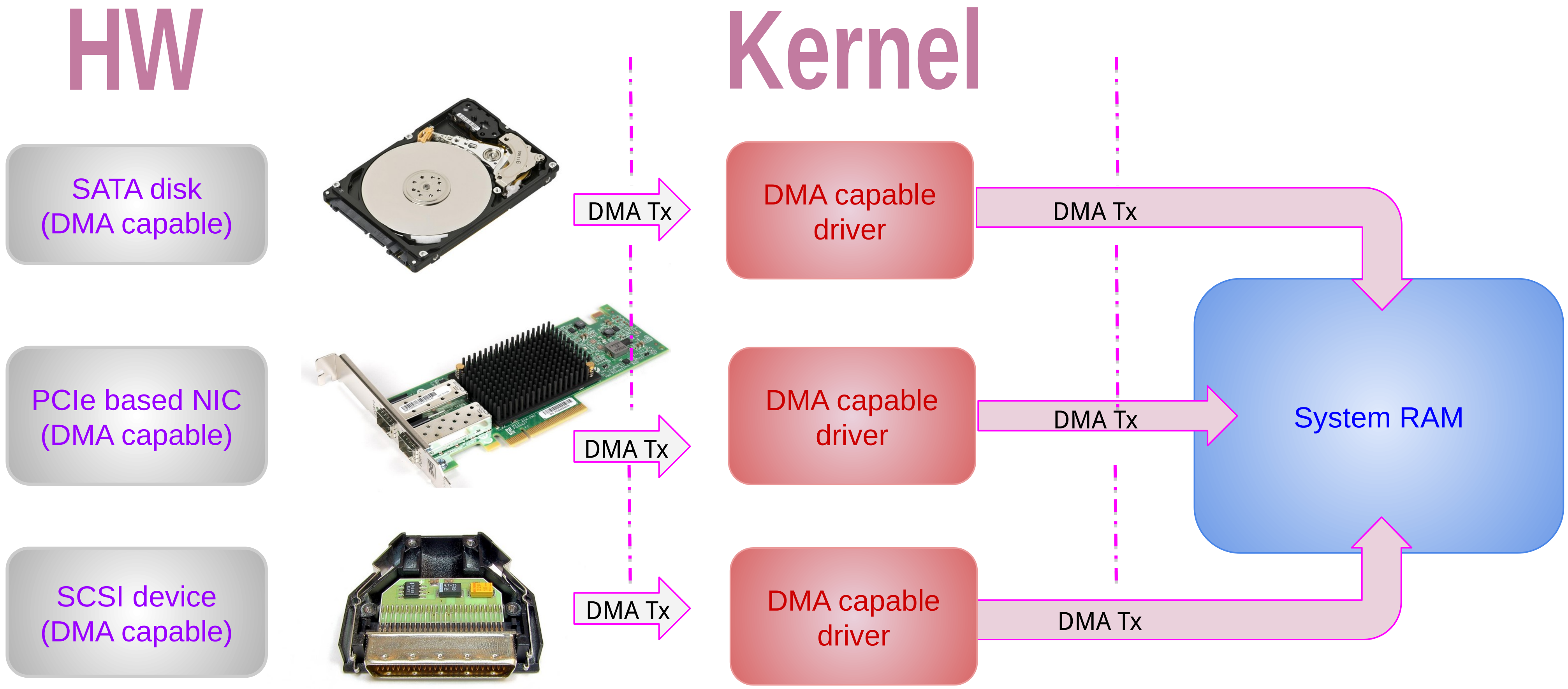
Affects	Status	Importance	Assigned to
linux (Ubuntu)	Fix Released	High	Guilherme G. Piccoli
Xenial	Fix Released	High	Guilherme G. Piccoli
Bionic	Fix Released	High	Guilherme G. Piccoli
Eoan	Fix Released	High	Guilherme G. Piccoli
Focal	Fix Released	High	Guilherme G. Piccoli

Bug Description

```
[Impact]
* Currently, users cannot perform multiple kernel kexec loads on AWS Nitro
instances (KVM-based); after the 2nd or 3rd kexec, an initrd corruption is
observed, with the following signature:

 Initramfs unpacking failed: junk within compressed archive
[...]
 Kernel panic - not syncing: No working init found.
Try passing init= option to kernel. See Linux Documentation/admin-guide/
init.rst for guidance.
CPU: 0 PID: 1 Comm: swapper/0 Not tainted 5.5.0-rc7-gpiccoli+ #26 Hardware
name: Amazon EC2 t3.large/, BIOS 1.0 10/16/2017
Call Trace:
  dump_stack+0x6d/0x9a
eneric+0x150/0x170
```

So everything works fine, or does it ...



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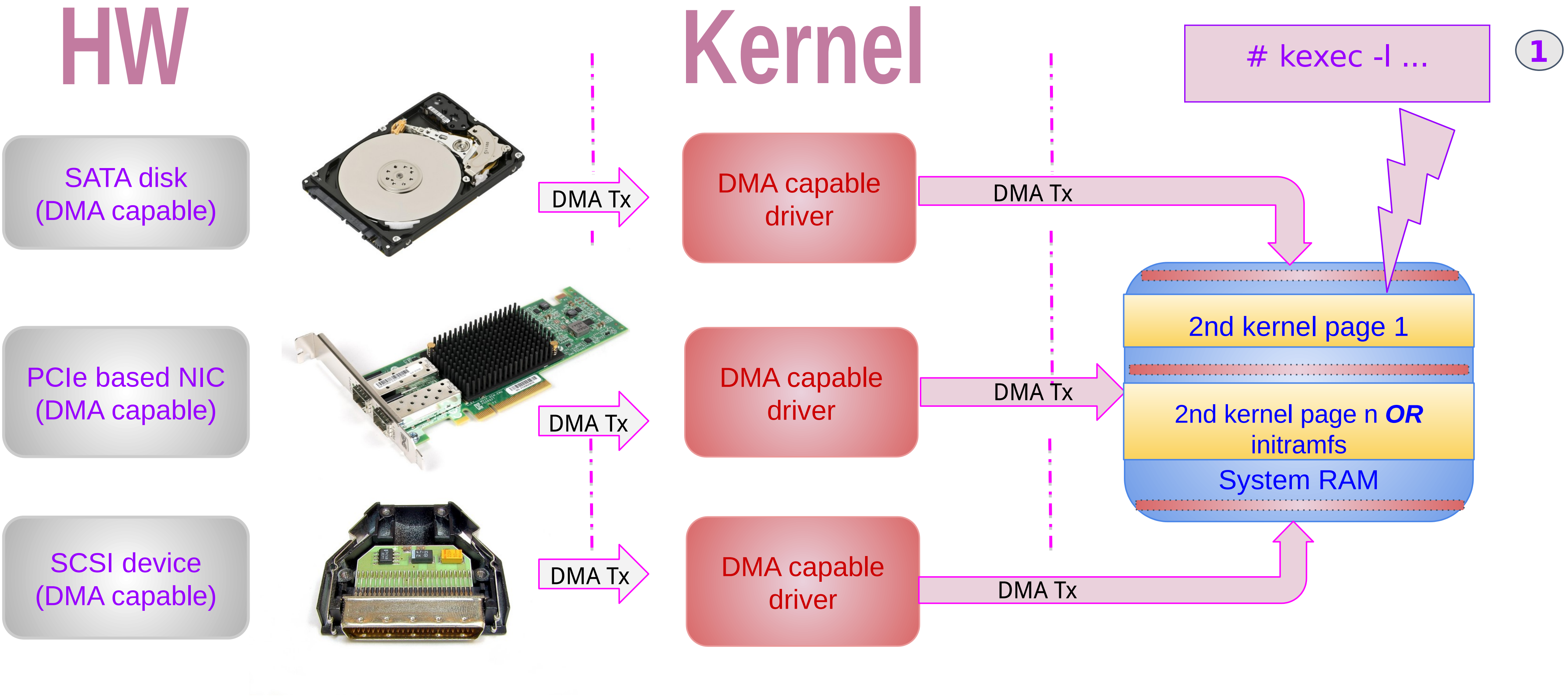

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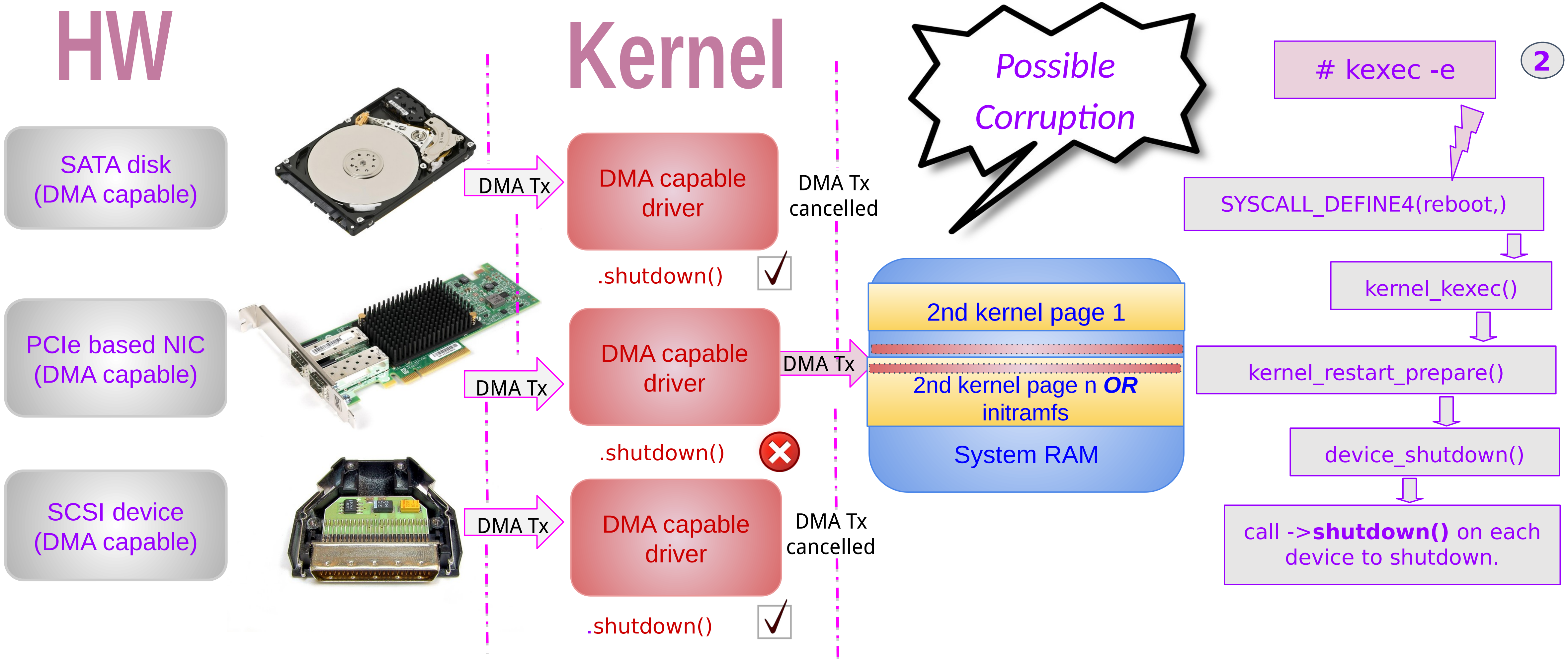


HW

Kernel

SATA disk (DMA capable)

DMA Tx

DMA capable driver

DMA Tx cancelled

.shutdown() ✓

PCIe based NIC (DMA capable)

DMA Tx

DMA capable driver

DMA Tx

.shutdown() ✗

SCSI device (DMA capable)

DMA Tx

DMA capable driver

DMA Tx cancelled

.shutdown() ✓

Possible Corruption

2nd kernel page 1

2nd kernel page n ***OR*** initramfs

System RAM

# kexec -e

2

SYSCALL_DEFINE4(reboot,)

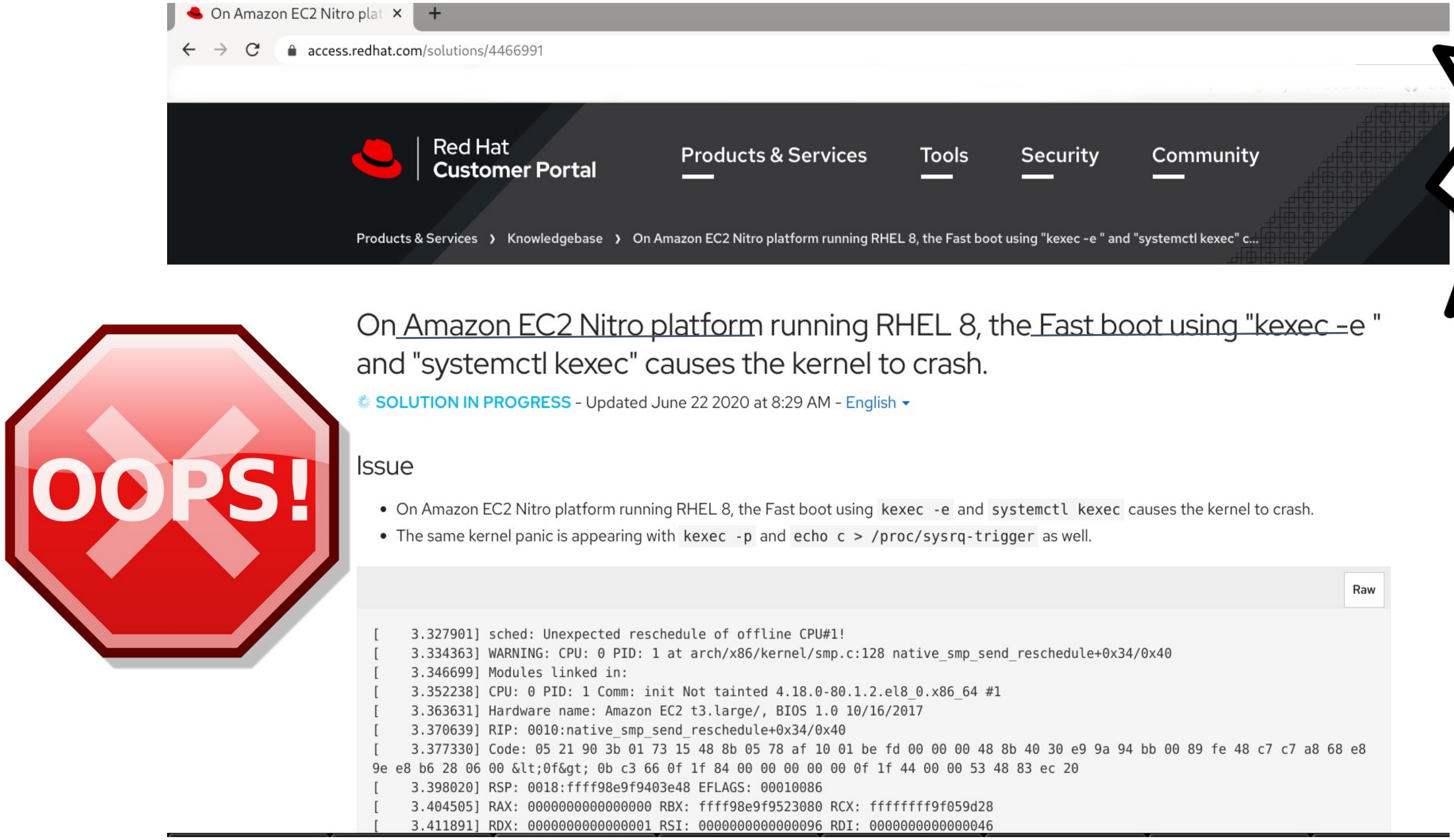
kernel_kexec()

kernel_restart_prepare()

device_shutdown()

call ->**shutdown()** on each device to shutdown.

So sometimes kexec ****does not work**** as intended


On Amazon EC2 Nitro plat ×
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Products & Services › Knowledgebase › On Amazon EC2 Nitro platform running RHEL 8, the Fast boot using "kexec -e " and "systemctl kexec" c...
Raw
OOPS!

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```

kexec'ed kernel fails to boot

Suggestions

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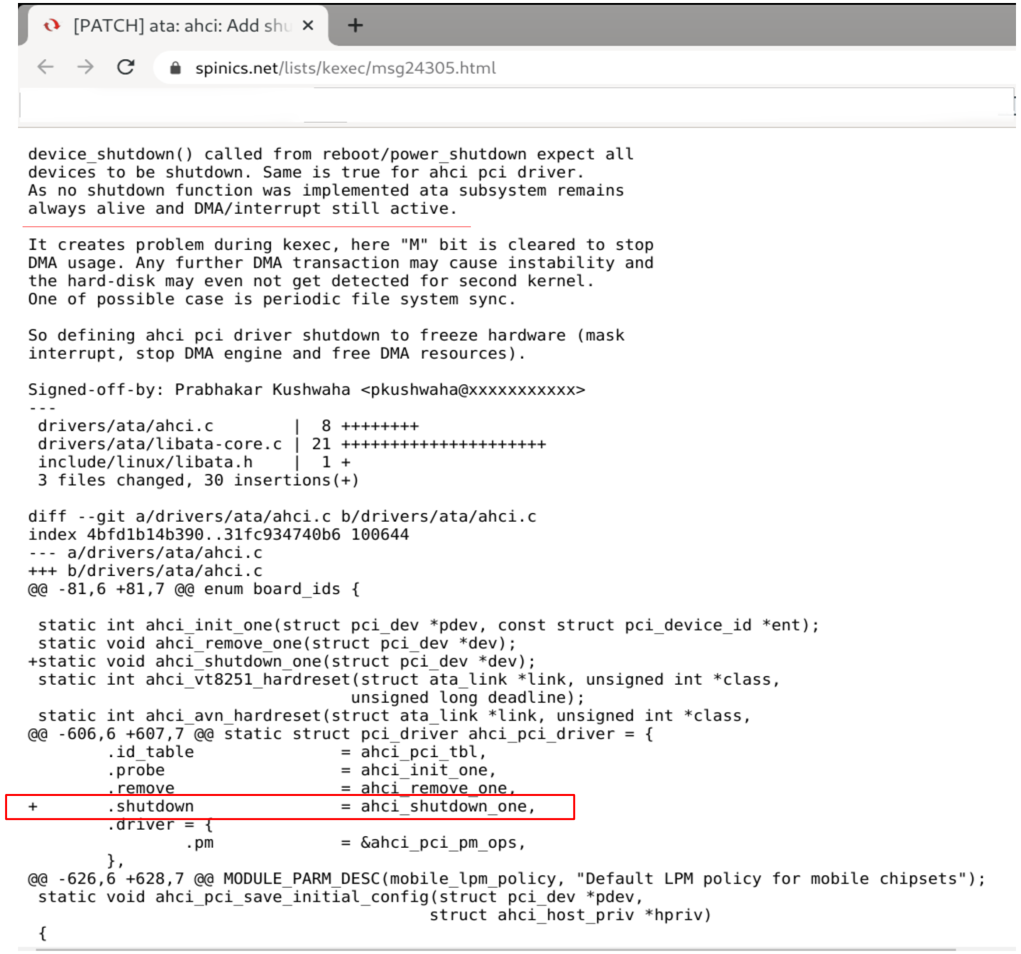
Add shutdown() callbacks in your driver code



[PATCH] ata: ahci: Add shu ×
+
spinics.net/lists/kexec/msg24305.html

```
device_shutdown() called from reboot/power_shutdown expect all
devices to be shutdown. Same is true for ahci pci driver.
As no shutdown function was implemented ata subsystem remains
always alive and DMA/interrupt still active.

It creates problem during kexec, here "M" bit is cleared to stop
DMA usage. Any further DMA transaction may cause instability and
the hard-disk may even not get detected for second kernel.
One of possible case is periodic file system sync.

So defining ahci pci driver shutdown to freeze hardware (mask
interrupt, stop DMA engine and free DMA resources).

Signed-off-by: Prabhakar Kushwaha <pkushwaha@xxxxxxxxxxx>
---
 drivers/ata/ahci.c        |  8 ++++++++
 drivers/ata/libata-core.c | 21 +++++++++++++++++++++
 include/linux/libata.h    |  1 +
 3 files changed, 30 insertions(+)

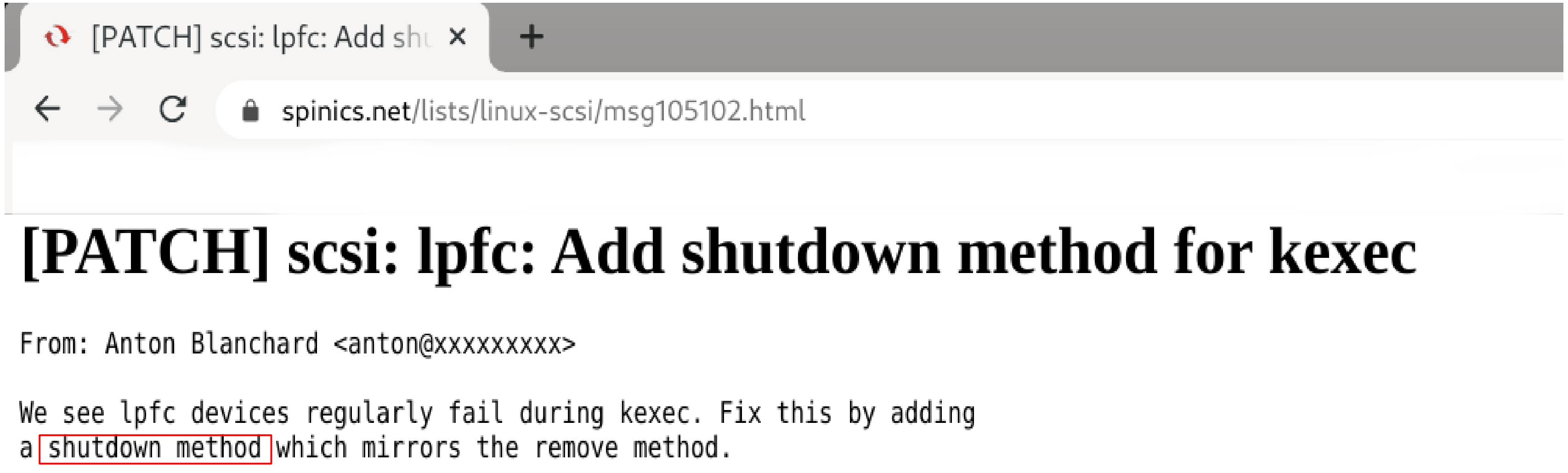
diff --git a/drivers/ata/ahci.c b/drivers/ata/ahci.c
index 4bfd1b14b390..31fc934740b6 100644
--- a/drivers/ata/ahci.c
+++ b/drivers/ata/ahci.c
@@ -81,6 +81,7 @@ enum board_ids {

 static int ahci_init_one(struct pci_dev *pdev, const struct pci_device_id *ent);
 static void ahci_remove_one(struct pci_dev *dev);
+static void ahci_shutdown_one(struct pci_dev *dev);
 static int ahci_vt8251_hardreset(struct ata_link *link, unsigned int *class,
                                  unsigned long deadline);
 static int ahci_avn_hardreset(struct ata_link *link, unsigned int *class,
@@ -606,6 +607,7 @@ static struct pci_driver ahci_pci_driver = {
        .id_table               = ahci_pci_tbl,
        .probe                  = ahci_init_one,
        .remove                 = ahci_remove_one,
+       .shutdown               = ahci_shutdown_one,
        .driver = {
                .pm             = &ahci_pci_pm_ops,
        },
@@ -626,6 +628,7 @@ MODULE_PARM_DESC(mobile_lpm_policy, "Default LPM policy for mobile chipsets");
 static void ahci_pci_save_initial_config(struct pci_dev *pdev,
                                          struct ahci_host_priv *hpriv)
 {
```

[PATCH] ata: ahci: Add shutdown to freeze hardware resources of ahci

Suggestions

Add shutdown() callbacks in your driver code



[PATCH] scsi: lpfc: Add shu ×
+
spinics.net/lists/linux-scsi/msg105102.html

[PATCH] scsi: lpfc: Add shutdown method for kexec

From: Anton Blanchard <anton@xxxxxxxxx>

We see lpfc devices regularly fail during kexec. Fix this by adding a shutdown method which mirrors the remove method.

Next Steps

- There is still work to be done for enabling kexec fully on RISC-V in upstream communities.

- Report kexec **reboot** failures @ kexec@lists.infradead.org

- kexec failures can be related to missing shutdown() callbacks in *DMA capable drivers*, e.g.
  - SATA, USB, NIC, PCIe driver

- Add more *debugging capabilities* to your kexec based bootloader.
  - console logs ⇨ pretty useful.

Questions?

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