Kdump on the Mainframe

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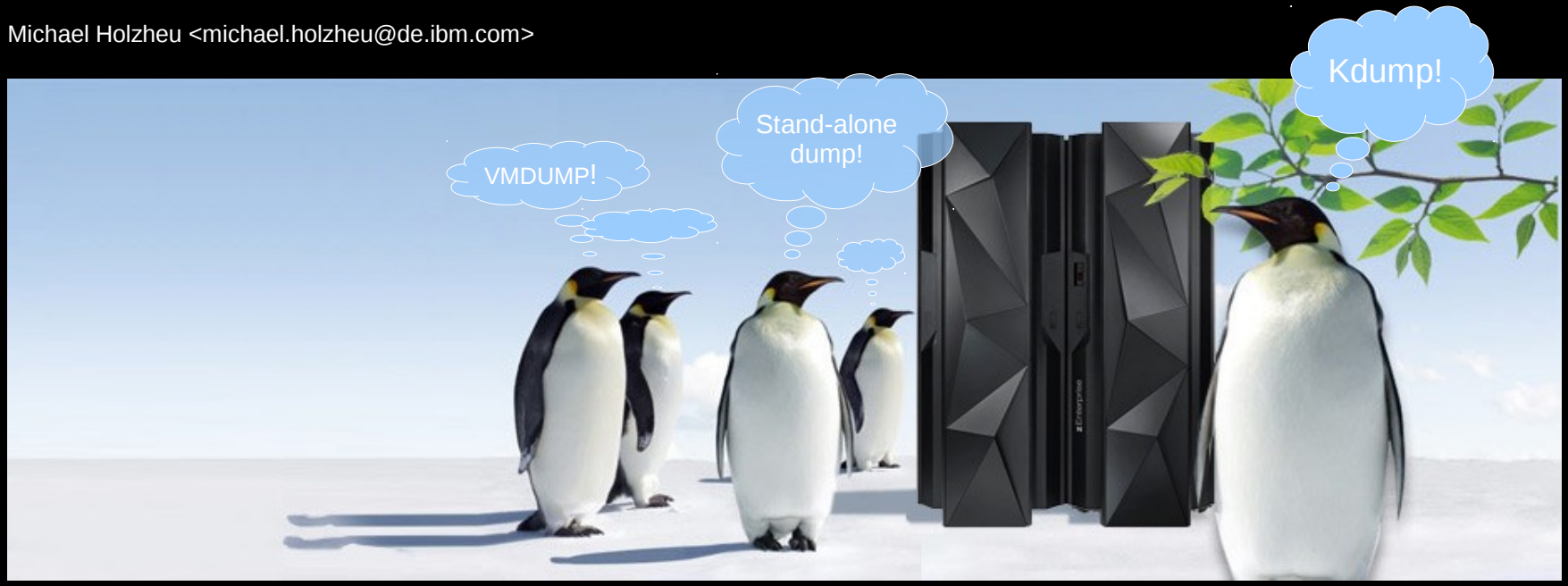

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Before we start - Terms

- Mainframe
  - Big iron made by IBM
  - Long tradition (System/360 - 1964)
  - Very reliable
  - Other terms: System z, s390
- Linux on the mainframe
  - Since 1999 (2.2.13)
- Hypervisors: LPAR and z/VM
- Kernel dump
  - For kernel problems
  - Dump analysis tool “crash”

Linux kernel dump history

- 1999: Linux kernel crash dumps (LKCD)
- 2001: Linux on System z stand-alone dump
- 2002: Red Hat's Netdump
- 2004: Red Hat's Diskdump
- 2005: Kdump in Linux 2.6.13
- 2011: Kdump for Linux on System z

Traditional Linux on System z dump mechanisms

System z stand-alone dump

- IBM: The term stand-alone means that the dump is performed separately from normal system operations and does not require the system to be in a condition for normal operation.

- Stand-alone dump tools are completely independent from the crashed OS.

System z stand-alone dump: How it works

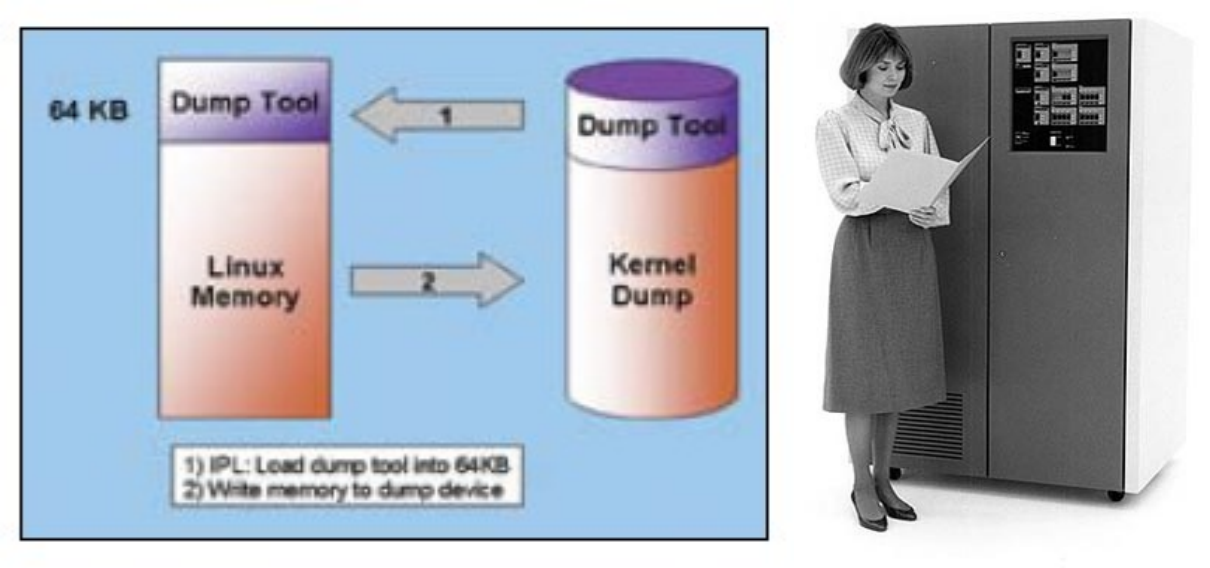
- Dump program is installed on dump device
- To trigger a dump the dump device is booted (IPLed)
  - Before dump program is loaded registers of boot CPU are stored
  - System resources survive boot process:
    - Memory
    - Register sets of non-boot CPUs
  - Dump program collects register sets of non-boot CPUs
  - Dump program writes dump do dump device
- Original OS is restarted and dump is copied from dump device
- Dump devices under Linux: DASD, Tape, and SCSI disks

Stand-alone dump: DASD and Tape

- DASD (also multi volume) or Tape cartridge prepared with small dump program written in assembler using CCWs

  $ zipl -d /dev/dasdc1

- Loaded into first 64 KiB (reserved by Linux on System z)
- Dump is written to dump device



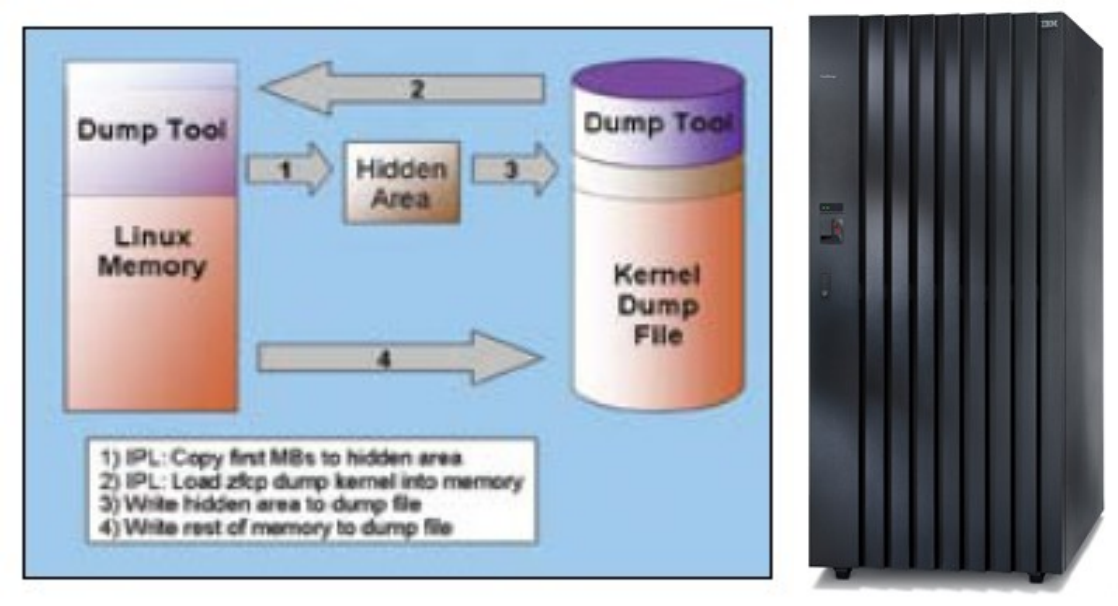
IBM DASD 3380 model CJ2 (1987)

Stand-alone dump: SCSI (zfcpdump)

- SCSI disk is prepared with Linux dump kernel and ramdisk

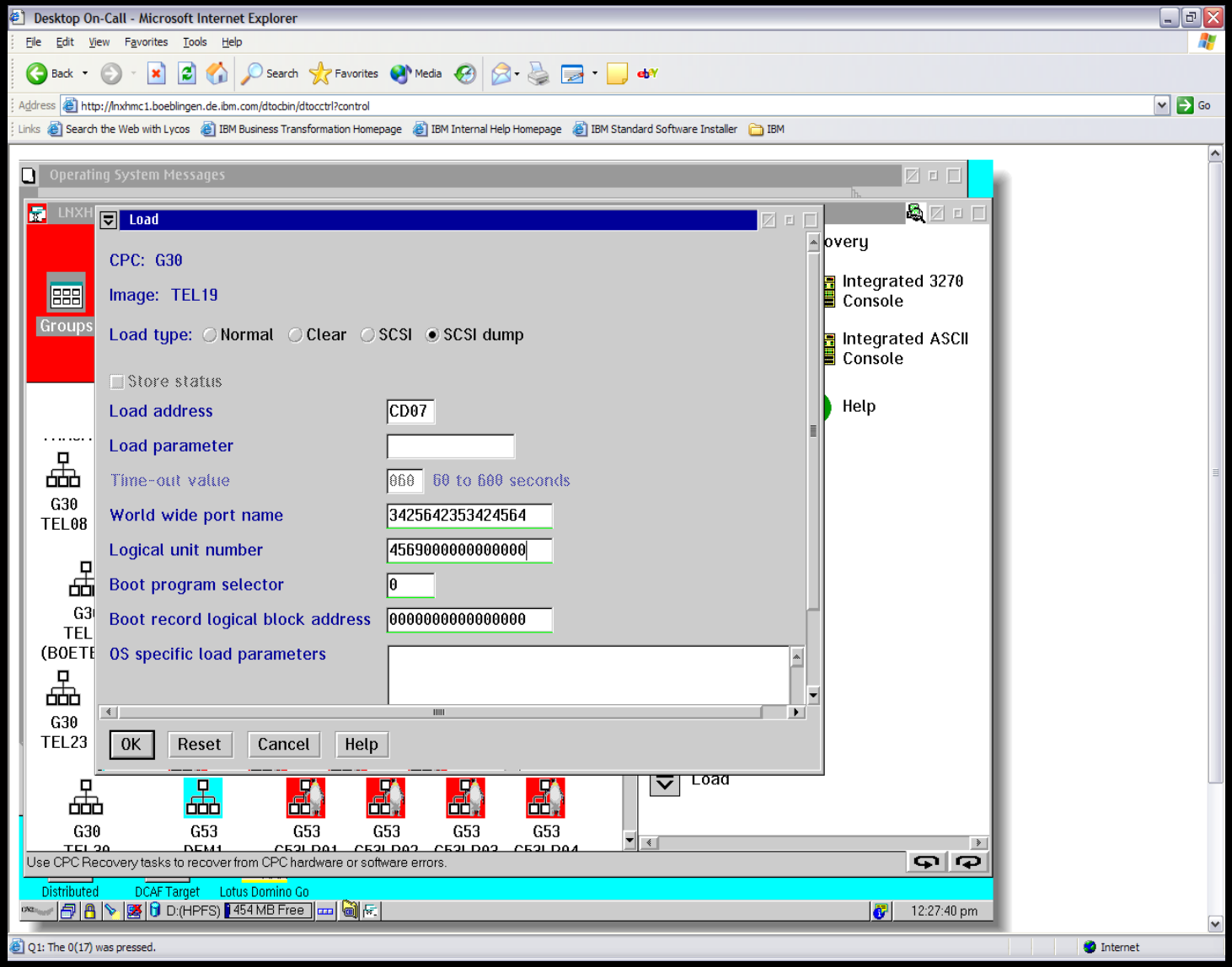
  $ zipl -D /dev/sda1

- At IPL time first part of memory and boot CPU registers are stored into data area provided by Hypervisor
- Linux dump tool reads saved memory from Hypervisor



IBM DS-8000

Trigger SCSI stand-alone dump via HMC IPL



Stand-alone dump: Accessing the dump

- Print information on dump

```
$ zgetdump -i /dev/dasdc1
General dump info:
  Dump created.......: Tue, 11 Sep 2012 08:18:14 +0200
  UTS node name......: r17lp31
  UTS kernel release.: 3.5.3-55.x.20120910-s390xdefault
  System arch........: s390x (64 bit)
  CPU count (real)...: 3

  Memory map:
    0000000000000000 - 00000000f7ffffff (3968 MB)
```

- Copy the dump

```
$ zgetdump /dev/dasdc1 > dump.s390
$ zgetdump /dev/ntibm0 -f elf > dump.elf
```

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Stand-alone dump: Accessing the dump

- Mount the dump (also multi-volume)

```
$ zgetdump -m /dev/dasdc1 -f elf /mnt/
$ ls /mnt
dump.elf
```

- Compress dump with makedumpfile

```
$ makedumpfile -d 31 /mnt/dump.elf dump.filtered
```

- Start crash dump analysis tool on dump

```
$ crash vmlinux /dev/dasdc1
$ crash vmlinux dump.filtered
$ crash vmlinux /mnt/dump.elf
```

Linux on System z dump mechanisms: Hypervisor dump

- z/VM VMDUMP
- Hypervisor writes dump to SPOOL space that can be accessed by the Linux guest OS
- Dump is non-disruptive
- Linux guest OS can receive dump with *vmur* tool
- Example:
  - Trigger VMDUMP via hypervisor console: `#cp vmdump`
  - Reboot Linux (optional) and logon
  - Receive dump:

```
$ vmur list
ORIGINID FILE CLASS DATE  TIME     NAME   TYPE DIST
T6360025 0463  DMP  06/11 15:07:42 VMDUMP FILE T6360025

$ vmur rec -c 463 dump
```

Linux on System z dump mechanisms: Automatic dump

- The dumpconf service (init script)
- Stand-alone dump and VMDUMP can be configured
- /etc/sysconfig/dumpconf

```
ON_PANIC=dump_reipl
DUMP_TYPE=ccw
DEVICE=0.0.4e13
```

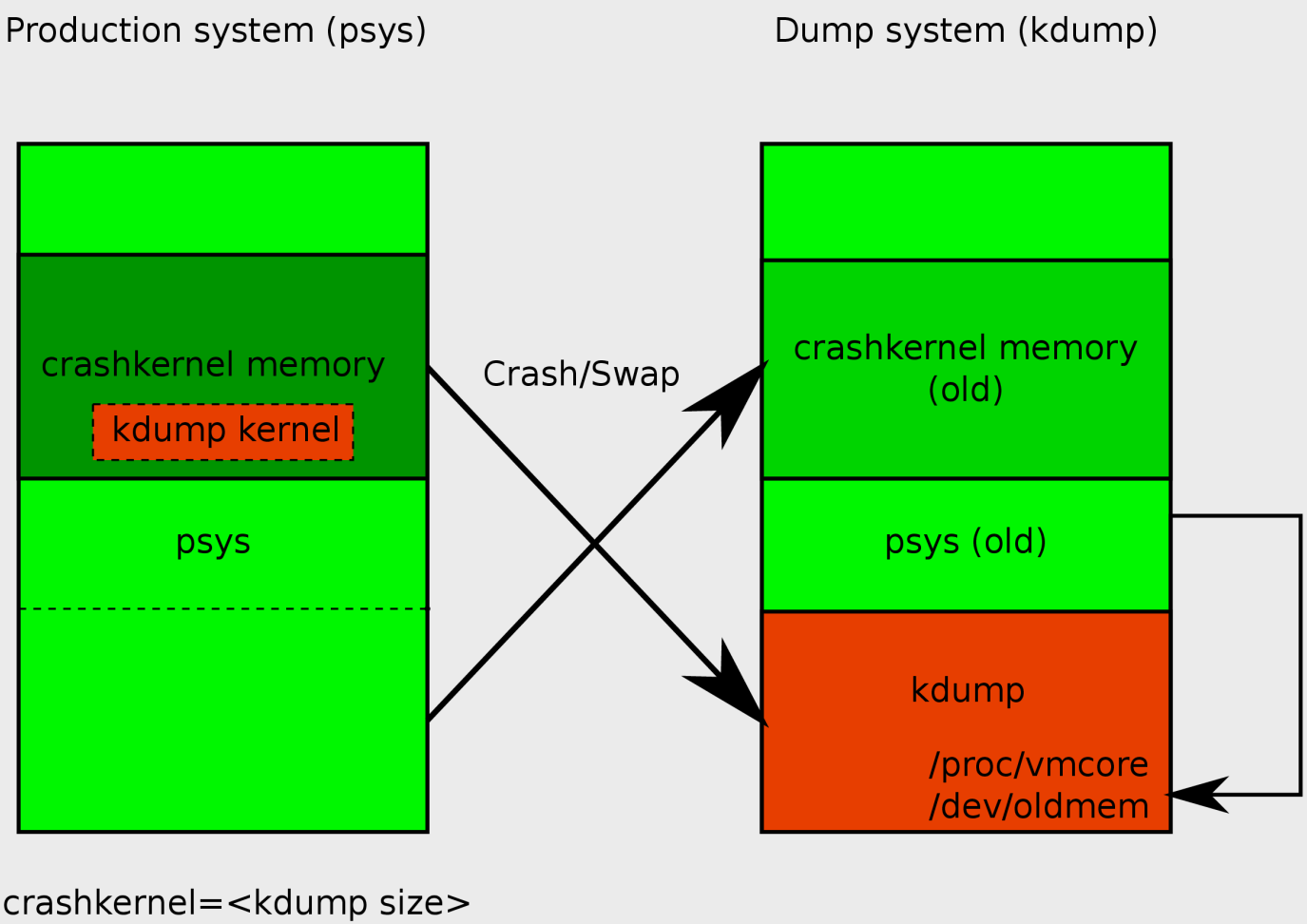
- System z Linux kernel panic code triggers IPL of stand-alone dump tool or VMDUMP

Advantages of traditional System z dump

- Trigger is almost 100% reliable (IPL and VMDUMP always works)
- No memory overlay of dump program and dump trigger code possible
- Different code (to the crashed one) writes dump (DASD, Tape and VMDUMP)
- Very little memory overhead
- Early and late kernel problems can be dumped
- Full device reset is done by IPL (no pending interrupts)

Kdump on System z

Kdump on System z: Overview



Kdump on System z: How to prepare?

- Reserve memory for kdump kernel with “crashkernel” parameter
  - Example: **`crashkernel=128M`**
- Boot production system
- Load kdump kernel into production system
  - Service kdump:

```
# service kdump start
```

  - Manual:

```
# kexec -p /boot/image \
    --command-line="$(cat /proc/cmdline | \
    sed -e 's/crashkernel=[^ ]*//')"
```

Kdump on System z: How to verify the setup?

- Is crashkernel memory defined?

```
$ grep Crash /proc/iomem
30000000-3fffffff : Crash kernel
```

- Is kdump kernel loaded?

```
$ lsshut
Trigger           Action
=======================
Halt              stop
Restart           kdump,stop
Panic             kdump,stop

$ service kdump status
kdump is operational
```

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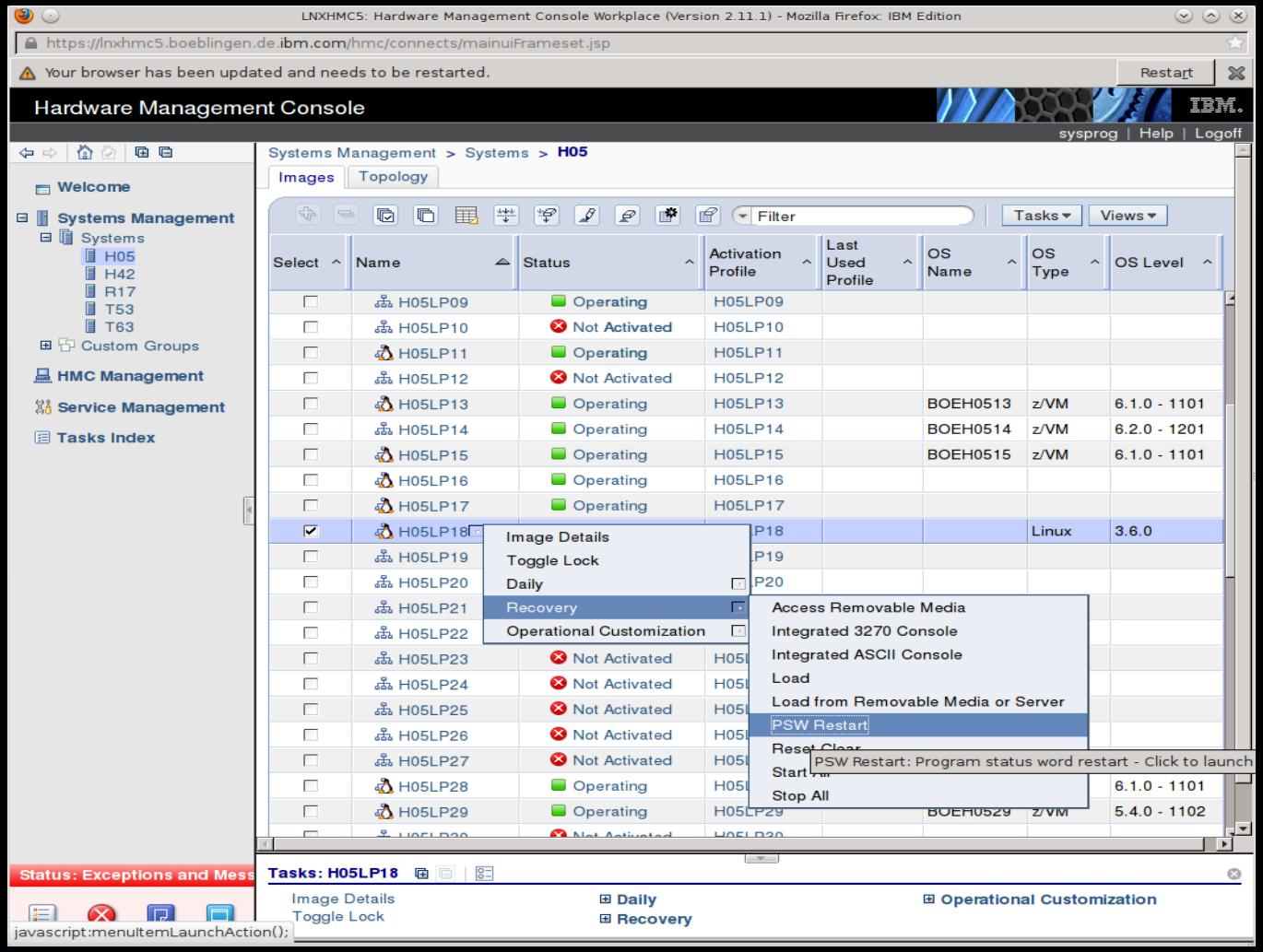
Kdump on System z: How to trigger the dump?

- Kernel panic (automatically)
- PSW restart (manually)
  - **z/VM**: `#cp system restart`
  - **LPAR / HMC**: LPAR->Recovery->PSW Restart
- PSW restart (automatically with z/VM watchdog)
  - `$ modprobe vmwatchdog cmd="system restart" nowayout=1`
  - Start watchdog timer:
    `$ echo 1 > /dev/watchdog`
- Magic sysrq 'c'rash (manually - forced panic)
  - `"^-c"` on 3270 or HMC console
  - `$ echo c > /proc/sysrq-trigger`

Kdump on System z: PSW restart on HMC (LPAR)



Kdump on System z: Copy dump from /proc/vmcore

- Copy uncompressed to local / remote disk:

```
# cp /proc/vmcore /dumps
```

```
# scp /proc/vmcore user@host:mydumps/
```

- Copy compressed and filtered to local disk:

```
# makedumpfile -c -d 31 /proc/vmcore dump.kdump
```

- Copy compressed and filtered to remote disk:

```
# makedumpfile -F -c -d 31 /proc/vmcore | \
    ssh user@tuxmaker "cat > dump.kdump_flat"
```

- Run crash directly on /proc/vmcore

```
# crash vmlinux vmlinux.debug /proc/vmcore
```

- Normally the kdump service script copies /proc/vmcore

Kdump on System z: Reboot original system

- After /proc/vmcore has been processed, production system can be rebooted:

```
# reboot
```

- Normally the kdump service script does reboot automatically

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Disadvantages of kdump

- Pre-loaded kdump kernel can be overlayed
- Kdump trigger code can be overlayed
- Kdump needs quite a lot of memory
- Early boot problems can't be dumped

So why kdump on System z?

- Dump time and size can be reduced by page filtering with makedumpfile
- Dump disk space sharing is possible for server farms using network dump
- Dump setup is made easier using existing kdump setup GUIs of Linux distributions, e.g. system-config-kdump or yast
- The integration with the Linux on System z stand-alone dump tools ensures that the dump reliability with kdump can be almost as high as with the current solution

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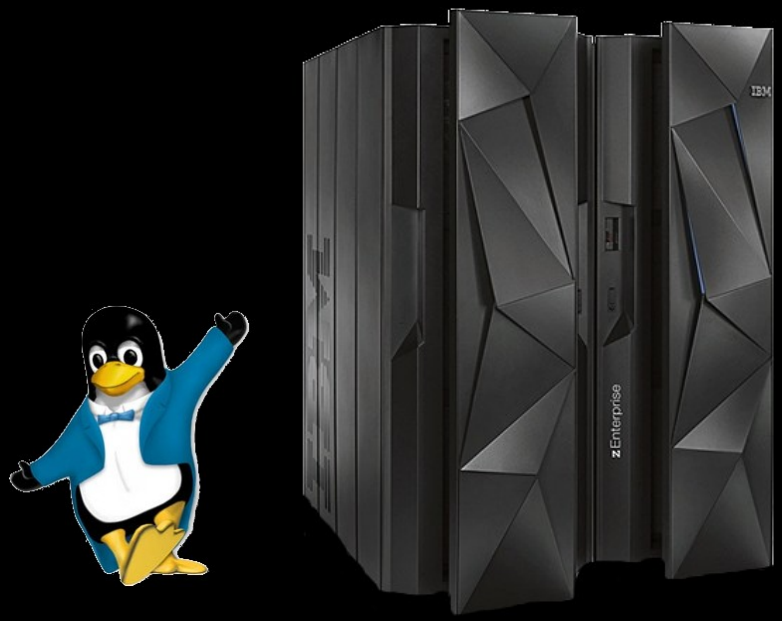
What is special for kdump on System z?

- On z/VM diagnose 10 is used to release the reserved crashkernel memory. Real/backed memory is required only for the kdump image and ramdisk (currently about 10 MiB). After some time z/VM will page out even this memory. Then no real memory will be wasted.
- On System z crashkernel memory is removed from the kernel page tables. Therefore the likelihood of memory corruption is reduced.
- On System z diagnose 308 is called before kdump is executed. That performs a CPU and I/O subsystem reset. So kdump on s390 is safe against old pending/ongoing I/O.
- No mem/cpu hotplug issues. Especially important because of cpuplugd.



Kdump integration into System z environment

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Use stand-alone dump tools for kdump failure recovery (1/2)

- Kdump is still not 100% reliable
  - Pre-loaded kdump kernel / ramdisk can be overwritten by device DMA
  - Kdump trigger code (panic/PSW restart) might be not functional
  - Early boot problem cannot be dumped until kdump is loaded
  - Kdump system itself can have problems (e.g. not enough memory)
- Automatic kdump failure recovery:
  - Configure traditional System z dump on panic (dumpconf)
  - When it is detected that kdump is corrupt (via checksums), instead of kdump the System z shutdown actions for panic and PSW restart will be run and stand-alone dump is created
- Manual intervention:
  - If kdump failed, it is still possible to create a manual s390 stand-alone dump

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Use stand-alone dump tools for kdump failure recovery (2/2)

- When kdump failed during kdump execution and afterwards a stand-alone dump is created, the resulting dump contains two system states:

```
# zgetdump -i /dev/dasdb1
zgetdump: The dump contains "kdump" and "production system"
          Access "production system" with "-s prod”
          Access "kdump" with "-s kdump"
          Send both dumps to your service organization
```

- Then copy both dumps for analysis:

```
# zgetdump /dev/dasdb1 -s kdump > dump.kdump.s390

# zgetdump /dev/dasdb1 -s prod > dump.prod.s390
```

- ... or mount dumps, for example:

```
# zgetdump -m /dev/dasdb1 -s prod /mnt
```

Summary

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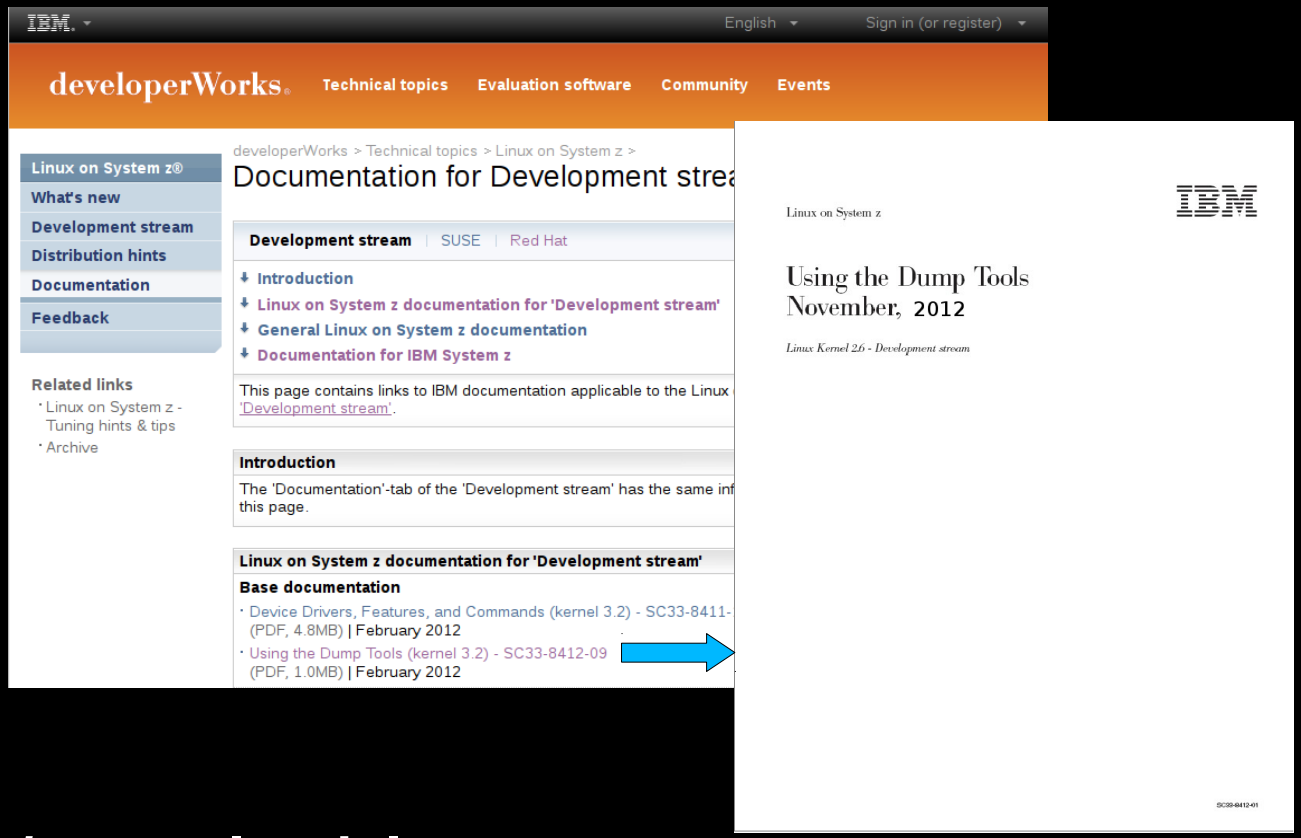
Get the best of both worlds

- Get great kdump features like dump filtering for System z
- Get reliable and resource friendly kdump implementation using System z features
- Still have stand-alone dump tools in the unlikely case that kdump fails, for example early crashes or kdump memory overlay

More Information

- **Using the dump tools book**
  http://www.ibm.com/developerworks/linux/linux390/documentation_dev.html



- **z/Journal article**
  http://enterprisesystemsmedia.com/article/linux-on-system-z-kernel-dumps