Operation System Homework #3: Virtual Memory

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IMPLEMENTATIONS DETAILS

1. Make sure the system has all the necessary packages installed.

$ su -c 'yum install rpmdevtools yum-utils'

$ su -c 'yum install qt3-devel libXi-devel'

2. Prepare a RPM package building environment in home directory.

$ rpmdev-setuptree

3. Get the source.

$ yumdownloader --source kernel

```
[demore@demore ~]$ ls -lt
total 70912
drwxrwxr-x. 7 demore demore    4096 Jan  1 01:45 rpmbuild
drwxr-xr-x. 2 demore demore    4096 Jan  1 01:21 Music
drwxr-xr-x. 2 demore demore    4096 Jan  1 01:21 Pictures
drwxr-xr-x. 2 demore demore    4096 Jan  1 01:21 Videos
drwxr-xr-x. 2 demore demore    4096 Jan  1 01:21 Desktop
drwxr-xr-x. 2 demore demore    4096 Jan  1 01:21 Documents
drwxr-xr-x. 2 demore demore    4096 Jan  1 01:21 Downloads
drwxr-xr-x. 2 demore demore    4096 Jan  1 01:21 Public
drwxr-xr-x. 2 demore demore    4096 Jan  1 01:21 Templates
-rw-rw-r--. 1 demore demore 72576399 Jul 14 23:22 kernel-3.9.10-100.fc17.src.rpm
[demore@demore ~]$
```

4. Install build dependencies for the kernel source.

$ su -c 'yum-builddep kernel-3.9.10-100.fc17.src.rpm'

5. Install the kernel source.

$ rpm -Uvh kernel-3.9.10-100.fc17.src.rpm

> *warning: user mockbuild does not exist - using root*
>
> *warning: group mockbuild does not exist - using root*
>
> [root]$ useradd mockbuild

6. Prepare the kernel source tree.

$ cd ~/rpmbuild/SPECS

$ rpmbuild -bp --target=$(uname -m) kernel.spec

```
[demore@demore linux-3.9.10-100.fc17.x86_64]$ ls
arch                    config-x86-32-generic   Makefile
block                   config-x86_64-generic   merge.pl
config-arm-generic      config-x86-generic      mm
config-arm-kirkwood     COPYING                 net
config-armv7            CREDITS                 README
config-armv7-generic    crypto                  REPORTING-BUGS
config-armv7-tegra      Documentation           samples
config-debug            drivers                 scripts
config-generic          firmware                security
config-i686-PAE         fs                      sound
config-local            include                 temp-armv5tel-kirkwood
config-nodebug          init                    temp-armv7
config-powerpc32-generic ipc                    temp-armv7-tegra
config-powerpc32-smp    Kbuild                  temp-x86-32
config-powerpc64        Kconfig                 temp-x86-64
config-powerpc-generic  kernel                  tools
configs                 lib                     usr
config-s390x            MAINTAINERS             virt
[demore@demore linux-3.9.10-100.fc17.x86 64]$ █
```

7. Add a custom system call to the syscall table.

`$ vim rpmbuild/BUILD/kernel-3.9.fc17/linux-3.9.10-100.fc17.x86_64/arch/x86/syscalls/syscall_64.tbl`

```
309     common  getcpu              sys_getcpu
310     64      process_vm_readv    sys_process_vm_readv
311     64      process_vm_writev   sys_process_vm_writev
312     common  kcmp                sys_kcmp
313     common  finit_module        sys_finit_module

314     common  lookup_paddr        sys_lookup_paddr

#
# x32-specific system call numbers start at 512 to avoid cache impact
# for native 64-bit operation.
#
512     x32     rt_sigaction        compat_sys_rt_sigaction
```

8. Add the system call definition to the system call interface.

`$ vim rpmbuild/BUILD/kernel-3.9.fc17/linux-3.9.10-100.fc17.x86_64/include/linux/syscalls.h`

```
asmlinkage long sys_kcmp(pid_t pid1, pid_t pid2, int type,
                    unsigned long idx1, unsigned long idx2);
asmlinkage long sys_finit_module(int fd, const char __user *uargs, int flags);

asmlinkage unsigned long sys_lookup_paddr(pid_t pid, unsigned long vaddr);

#endif
```

9. Implement the custom system call.

`$ vim rpmbuild/BUILD/kernel-3.9.fc17/linux-3.9.10-100.fc17.x86_64/kernel/lookup_paddr.c`

10. Modify the Makefile.

`$ vim rpmbuild/BUILD/kernel-3.9.fc17/linux-3.9.10-100.fc17.x86_64/kernel/Makefile`

```
#
# Makefile for the linux kernel.
#

obj-y       = fork.o exec_domain.o panic.o printk.o \
              cpu.o exit.o itimer.o time.o softirq.o resource.o \
              sysctl.o sysctl_binary.o capability.o ptrace.o timer.o user.o \
              signal.o sys.o kmod.o workqueue.o pid.o task_work.o \
              rcupdate.o extable.o params.o posix-timers.o \
              kthread.o wait.o sys_ni.o posix-cpu-timers.o mutex.o \
              hrtimer.o rwsem.o nsproxy.o srcu.o semaphore.o \
              notifier.o ksysfs.o cred.o \
              async.o range.o groups.o lglock.o smpboot.o \
              lookup_paddr.o
```

11. Configure kernel options.

$ cd ~/rpmbuild/BUILD/kernel-3.9.fc17/linux-3.9.10-100.fc17.x86_64

$ make xconfig

   /bin/sh: g++: command not found

   $ su -c 'yum install gcc-g++'

12. Give the new kernel a unique name by changing EXTRAVERSION in Makefile.

```
VERSION = 3
PATCHLEVEL = 9
SUBLEVEL = 10
EXTRAVERSION = -OShw3
NAME = Black Squirrel Wakeup Call

# *DOCUMENTATION*
# To see a list of typical targets execute "make help"
# More info can be located in ./README
# Comments in this file are targeted only to the developer, do not
# expect to learn how to build the kernel reading this file.
```

13. Build kernel image.

$ make bzImage

```
  CC      arch/x86/boot/version.o
  CC      arch/x86/boot/video-vga.o
  CC      arch/x86/boot/video-vesa.o
  CC      arch/x86/boot/video-bios.o
  LD      arch/x86/boot/setup.elf
  OBJCOPY arch/x86/boot/setup.bin
  OBJCOPY arch/x86/boot/vmlinux.bin
  HOSTCC  arch/x86/boot/tools/build
  BUILD   arch/x86/boot/bzImage
Setup is 16924 bytes (padded to 17408 bytes).
System is 4919 kB
CRC b2d90b4c
Kernel: arch/x86/boot/bzImage is ready  (#1)
[demore@demore linux-3.9.10-100.fc17.x86_64]$ ▊
```

14. Build modules.

$ make modules

```
IHEX      firmware/edgeport/down3.bin
IHEX2FW firmware/whiteheat_loader.fw
IHEX2FW firmware/whiteheat.fw
IHEX2FW firmware/keyspan_pda/keyspan_pda.fw
IHEX2FW firmware/keyspan_pda/xircom_pgs.fw
IHEX      firmware/cpia2/stv0672_vp4.bin
IHEX      firmware/yam/1200.bin
IHEX      firmware/yam/9600.bin
[demore@demore linux-3.9.10-100.fc17.x86_64]$ █
```

15. Install modules.

`$ su -c 'make modules_install'`

```
[demore@demore linux-3.9.10-100.fc17.x86_64]$ ls -l /lib/modules/3.9.10-0Shw3/
total 2676
lrwxrwxrwx.  1 root root     72 Jan  1 07:45 build -> /home/demore/rpmbuild/BUILD/ke
rnel-3.9.fc17/linux-3.9.10-100.fc17.x86_64
drwxrwxr-x. 12 root root   4096 Jan  1 08:15 kernel
-rw-r--r--.  1 root root 700683 Jan  1 08:26 modules.alias
-rw-r--r--.  1 root root 693451 Jan  1 08:26 modules.alias.bin
-rw-rw-r--.  1 root root   6350 Jan  1 08:12 modules.builtin
-rw-r--r--.  1 root root   8346 Jan  1 08:26 modules.builtin.bin
-rw-r--r--.  1 root root 243985 Jan  1 08:26 modules.dep
-rw-r--r--.  1 root root 355739 Jan  1 08:26 modules.dep.bin
-rw-r--r--.  1 root root    274 Jan  1 08:26 modules.devname
-rw-rw-r--.  1 root root  94937 Jan  1 08:12 modules.order
-rw-r--r--.  1 root root    131 Jan  1 08:26 modules.softdep
-rw-r--r--.  1 root root 262313 Jan  1 08:26 modules.symbols
-rw-r--r--.  1 root root 331539 Jan  1 08:26 modules.symbols.bin
lrwxrwxrwx.  1 root root     72 Jan  1 08:12 source -> /home/demore/rpmbuild/BUILD/k
ernel-3.9.fc17/linux-3.9.10-100.fc17.x86_64
```

16. Install kernel image.

`$ su -c 'make install'`

```
[demore@demore linux-3.9.10-100.fc17.x86_64]$ ls -l /boot/
total 48689
-rw-r--r--. 1 root root   115179 May  8  2012 config-3.3.4-5.fc17.x86_64
drwxr-xr-x. 4 root root     1024 May 23  2012 efi
-rw-r--r--. 1 root root   178436 Mar 27  2012 elf-memtest86+-4.20
drwxr-xr-x. 2 root root     1024 May 23  2012 grub
drwxr-xr-x. 6 root root     1024 Jan  1 08:27 grub2
-rw-rw-r--. 1 root root 17473629 Jan  1 01:07 initramfs-3.3.4-5.fc17.x86_64.img
-rw-rw-r--. 1 root root  9516806 Jan  1 08:27 initramfs-3.9.10-0Shw3.img
drwx------. 2 root root    12288 Jan  1 01:01 lost+found
-rw-r--r--. 1 root root   176760 Mar 27  2012 memtest86+-4.20
lrwxrwxrwx. 1 root root       29 Jan  1 08:26 System.map -> /boot/System.map-3.9.10-0Shw3
-rw-------. 1 root root  2412391 May  8  2012 System.map-3.3.4-5.fc17.x86_64
-rw-rw-r--. 1 root root  2588270 Jan  1 08:26 System.map-3.9.10-0Shw3
-rw-rw-r--. 1 root root  2588270 Jan  1 08:21 System.map-3.9.10-0Shw3.old
lrwxrwxrwx. 1 root root       26 Jan  1 08:26 vmlinuz -> /boot/vmlinuz-3.9.10-0Shw3
-rwxr-xr-x. 1 root root  4662160 May  8  2012 vmlinuz-3.3.4-5.fc17.x86_64
-rw-rw-r--. 1 root root  5054000 Jan  1 08:26 vmlinuz-3.9.10-0Shw3
-rw-rw-r--. 1 root root  5054000 Jan  1 08:21 vmlinuz-3.9.10-0Shw3.old
```

17. Boot with the new kernel.

```
                    GNU GRUB   version 2.00~beta4

  ┌─────────────────────────────────────────────────────────────┐
  │ Fedora (3.9.10-OShw3)                                         │
  │ Fedora Linux                                                  │
  │ Advanced options for Fedora Linux                            │
  │                                                               │
  │                                                               │
  │                                                               │
  │                                                               │
  │                                                               │
  │                                                               │
  │                                                               │
  │                                                               │
  └─────────────────────────────────────────────────────────────┘

       Use the ↑ and ↓ keys to select which entry is highlighted.
       Press enter to boot the selected OS, `e' to edit the commands
       before booting or `c' for a command-line.
     The highlighted entry will be executed automatically in 5s.
```

```
[demore@demore ~]$ uname -a
Linux demore 3.9.10-OShw3 #1 SMP Wed Jan 1 04:45:52 CST 2014 x86_64 x86_64 x86_6
4 GNU/Linux
```

TEST

```
$ gcc fork_ex.c
```

```
[demore@demore Downloads]$ ./a.out
Parent pid: 1621. [Var 'mem_alloc']vaddr: 0x2002010, paddr: 0x800000000787b010, val: 1000
Child pid: 1622.  [Var 'mem_alloc']vaddr: 0x2002010, paddr: 0x800000000787b010, val: 1000

*** Modify variable 'mem_alloc' from 1000 to 1 ***

Parent pid: 1621. [Var 'mem_alloc']vaddr: 0x2002010, paddr: 0x800000000787b010, val: 1000
Child pid: 1622.  [Var 'mem_alloc']vaddr: 0x2002010, paddr: 0x800000000dd99010, val: 1
[demore@demore Downloads]$ ./a.out
Parent pid: 1623. [Var 'mem_alloc']vaddr: 0xf5c010, paddr: 0x800000000e74f010, val: 1000
Child pid: 1624.  [Var 'mem_alloc']vaddr: 0xf5c010, paddr: 0x800000000e74f010, val: 1000

*** Modify variable 'mem_alloc' from 1000 to 1 ***

Parent pid: 1623. [Var 'mem_alloc']vaddr: 0xf5c010, paddr: 0x800000000e74f010, val: 1000
Child pid: 1624.  [Var 'mem_alloc']vaddr: 0xf5c010, paddr: 0x800000000e076010, val: 1
```