Working With OS/161

1、You can get the complete version of this tutorial in

https://www.student.cs.uwaterloo.ca/~cs350/common/WorkingWith161.html

There are a few differences between those two. To be honest, I recommend this one, because it suits our class more.

2、NOTE:

①You'd better use your own account on your machine instead of root.

②Those red words are some important information such as commands and filenames.

This document provides information about working with OS/161 and sys/161. It assumes that you've already installed OS/161 by following the instructions in the installation guide. In the remainder of this document, the symbol $OS161TOP refers to the top-level OS/161 directory that was created when you installed OS/161 into your account. If you followed the installation instructions, $OS161TOP refers to the directory cs350-os161 in your course account.

Building an OS/161 Kernel

If you followed the instructions in the installation guide, you have already configured, built, and installed an OS/161 kernel. However, as you modify the OS/161 source code during your assignments, you will want to prepare new kernels so that you can test your changes.

Preparing a kernel involves several steps: configuration, building, and installation:

1、configure:

You performed an initial kernel configuration when you followed the instructions for installing OS/161 for the current assignment. Normally, it is not necessary to re-configure each time you prepare a new kernel. One exception to this when you have added new kernel source files or removed kernel source files. In that case, you must edit the kernel configuration file and reconfigure the kernel before you attempt to build it. The other exception is when you are first starting a new assignment. Kernel configuration is assignment-specific, so you when you start a new assignment you should re-configure before building the kernel for the first time.

At first, you should type these commands before configuring:

```
cd $HOME/cs350-os161/os161-1.99
./configure --ostree=$HOME/cs350-os161/root --toolprefix=cs350-
```

The main kernel configuration file is located in the directory $OS161TOP/os161-1.99/kern/conf in a file called conf.kern. This file defines various kernel options and devices. Towards the end of conf.kern you will find file declarations like this

```
file    thread/spinlock.c
```

for each section of the kernel code, e.g., the thread section or the file system section. If you add a new file to the kernel code, you must add a corresponding file declaration in conf.kern and then reconfigure the kernel. Once you have changed conf.kern, you reconfigure the kernel by running

./config ASSTX

in the same directory. Here, the ASSTX parameter indicates which assignment you are working on. For the first assignment, use ASST1, for the second assignment, use ASST2, and so on. (in our task, X is 0)

2、build:

Kernels should always be built in the kernel build directory, which is $OS161TOP/os161-1.99/kern/compile/ASSTX for the Xth assignment. (This directory is created when you configure the kernel.) To build a new kernel, issue the following commands in the kernel build directory:

bmake depend

bmake

If your kernel builds successfully, you should see a line similar to this near the end of the output from bmake:

```
*** This is ASST0 build #1 ***
mips-harvard-os161-gcc -g -Wall -W -Wwrite-strings -Wmissing-prototypes -Werror
-std=gnu99 -mno-abicalls -fno-pic -ffixed-23 -nostdinc -I../../include -I../../d
ev -I. -Iincludelinks -ffreestanding -D_KERNEL -DUW -c vers.c
mips-harvard-os161-ld   -nostdlib -T ../../arch/mips/conf/ldscript __printf.o sn
printf.o atoi.o bzero.o memcpy.o memmove.o strcat.o strchr.o strcmp.o strcpy.o s
trlen.o strrchr.o strtok_r.o autoconf.o beep.o console.o random.o rtclock.o beep
_ltimer.o con_lser.o emu_att.o emu.o lamebus.o lhd_att.o lhd.o lrandom_att.o lra
ndom.o lser_att.o lser.o ltimer_att.o ltimer.o ltrace_att.o ltrace.o random_lran
dom.o rtclock_ltimer.o sfs_fs.o sfs_io.o sfs_vnode.o array.o bitmap.o bswap.o kg
ets.o kprintf.o misc.o queue.o uio.o proc.o main.o menu.o file_syscalls.o loadel
f.o proc_syscalls.o runprogram.o time_syscalls.o arraytest.o bitmaptest.o fstest
.o malloctest.o synchtest.o threadtest.o tt3.o uw-tests.o clock.o spinlock.o spl
.o synch.o thread.o threadlist.o device.o devnull.o vfscwd.o vfslist.o vfslookup
.o vfspath.o vnode.o kmalloc.o uw-vmstats.o trap.o syscall.o cpu.o switchframe.o
 switch.o thread_machdep.o threadstart.o dumbvm.o ram.o adddi3.o anddi3.o ashldi
3.o ashrdi3.o cmpdi2.o divdi3.o iordi3.o lshldi3.o lshrdi3.o moddi3.o muldi3.o n
egdi2.o notdi2.o qdivrem.o subdi3.o ucmpdi2.o udivdi3.o umoddi3.o xordi3.o setjm
p.o copyinout.o cache-mips161.o exception-mips1.o tlb-mips1.o lamebus_machdep.o
start.o vers.o -o kernel
mips-harvard-os161-size kernel
   text    data     bss     dec     hex filename
 196200     528    7872  204600   31f38 kernel
```

3、install:

If everything goes smoothly with the kernel build, you may then install the new kernel. Do this by running the command

bmake install

in the kernel build directory. This will put a copy of your newly-built kernel in the directory $OS161TOP/root in a file called kernel-ASSTX. It will also set the symbolic link kernel (also in the $OS161TOP/root directory) to refer to the newly-installed kernel.

Building the OS/161 User-Level Programs

OS/161 comes with a variety of user-level programs that can run on top of the OS/161 kernel. These include standard UNIX-style utility programs, like ls and cat, and variety of test

programs. The source files for the utility programs are located in $OS161TOP/os161-1.99/user/{bin,sbin}. The source files for the test programs are located in $OS161TOP/os161-1.99/user/{uw-testbin,testbin}.

Note that many user programs will not run with OS/161 as it is initially distributed, since many system calls are not implemented in this version of the operating system.

User-level programs are built and installed from the directory $OS161TOP/os161-1.99/. To build and install all of the user-level programs, simply run

```
bmake
bmake install
```

User-level programs are installed under $OS161TOP/root/ in the bin, sbin, testbin and uw-testbin directories.

Running OS/161

Above all, the SYS/161 simulator requires a configuration file in order to be run. To obtain one, do this:

```
cd $HOME/cs350-os161/root
cp $HOME/sys161/sys161.conf .
```

Note: Don't miss the "."

The OS/161 kernel, as well as OS/161 user-level programs, run on the sys/161 machine simulator. To run your OS/161 kernel, you start up the simulator and you pass it the name of the file that contains your kernel binary.

When you run OS/161, you should be in the runtime root directory, which is $OS161TOP/root. From the runtime root directory, use the command

```
sys161 kernel-ASSTX
```

or simply:

```
sys161 kernel
```

Both do the same thing, because bmake install makes kernel a symbolic link to kernel-ASSTX.

If the system doesn't recognize the sys161 command, this probably means that you've not properly set up your environment variables as described in the installation guide. Also, the sys/161 simulator expects to find a configuration file called sys161.conf in the directory in the runtime root directory. Again, if you followed the installation instructions, that file should be there.

The kernel will print various messages as it boots. When it has finished booting, it will present you with a command prompt. The output should look something like this:

```
dasiyqu@ubuntu:~/cs350-os161/root$ sys161 kernel
sys161: System/161 release 1.99.06, compiled May 20 2018 05:03:48

OS/161 base system version 1.99.05
Copyright (c) 2000, 2001, 2002, 2003, 2004, 2005, 2008, 2009
   President and Fellows of Harvard College.  All rights reserved.

Put-your-group-name-here's system version 0 (ASST0 #1)

304k physical memory available
Device probe...
lamebus0 (system main bus)
emu0 at lamebus0
ltrace0 at lamebus0
ltimer0 at lamebus0
beep0 at ltimer0
rtclock0 at ltimer0
lrandom0 at lamebus0
random0 at lrandom0
lhd0 at lamebus0
lhd1 at lamebus0
lser0 at lamebus0
con0 at lser0

cpu0: MIPS r3000
OS/161 kernel [? for menu]:
```

You can type q at the command prompt to cause the kernel to shut down. Typing ? will show you other commands. Note that some menu commands will not work properly at the beginning, because they depend on kernel functionality that you have not yet implemented. One particular thing that you can do from the kernel menu is to launch an initial user-level program, such as a command shell or some test program. (The p and s commands do this. For more information, see the on-line help for the operations menu.) Again, most of these programs will not work initially because they depend on unimplemented kernel functionality.

One thing you should notice, near the beginning of the kernel's boot messages, is the line:

```
Put-your-group-name-here's system version 0 (ASST0 #1)
```

What the kernel is doing here is printing its "build number" – the same number that was displayed in the bmake output when the kernel was built. This is a great way for you to ensure that the kernel that you are running is actually the kernel that you built, and not some earlier version of your kernel.

Debugging an OS/161 Kernel using GDB

To debug OS/161, you should use the CS350 version of GDB, which is called cs350-gdb. This version of GDB has been configured for the MIPS architecture and has been patched to be able to talk to System/161. The difference between debugging a regular program and debugging an OS/161 kernel is that the kernel is running in a machine simulator. You want to debug the kernel; running the debugger on the machine simulator is not very illuminating and we hope it will not be necessary. If you were to issue the command:

cs350-gdb sys161

from the runtime root directory, you would be attempting to debug the simulator (sys161). This will not work, because the simulator is not compiled for MIPS. If you were instead to issue the command

cs350-gdb kernel

to try to debug the kernel, you would find that this also does not work, because the kernel has to be run on System/161.

Instead, what you need to do is start your kernel running in sys/161 and then run cs350-gdb and tell it to attach to sys161's debugger port. This is easiest to do using two windows, one to run sys/161 in and one to run GDB in. Note that you must be logged in to the **same machine** in both windows. If you are logged in to mef-linux018 in one window and mef-linux002 in another, this will not work. You can use the hostname command in a window to check which machine that window's commands are running on.

To debug, first start OS/161 on sys/161 in one of the windows.

sys161 -w kernel

Make sure that you are in the runtime root directory when you do this. The -w option tells sys/161 to wait for a debugger connection. You should see output that looks something like this:

```
dasiyqu@ubuntu:~/cs350-os161/root$ sys161 -w kernel
sys161: System/161 release 1.99.06, compiled May 20 2018 05:03:48
sys161: Waiting for debugger connection...
```

At this point, sys161 is paused, waiting for a connection from the debugger.

Next, in the other window (your debug window), move into the runtime root directory – the same directory in which you are running sys161 – and run cs350-gdb on the kernel and tell GDB to connect to sys/161:

cs350-gdb kernel

You should see some output like this from the debugger:

```
dasiyqu@ubuntu:~/cs350-os161/root$ cs350-gdb kernel
GNU gdb 6.6
Copyright (C) 2006 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and you are
welcome to change it and/or distribute copies of it under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for details.
This GDB was configured as "--host=x86_64-unknown-linux-gnu --target=mips-harvar
d-os161"...
(gdb)
```

The (gdb) is the debugger's command prompt. The debugger is now stopped, waiting for you to enter a command. You want to give it the following commands:

(gdb) dir ../os161-1.99/kern/compile/ASST0

(gdb) target remote unix:.sockets/gdb

The first command just tells gdb where to find the .o files for your kernel. The second command tells gdb to connect to the waiting sys161 program that is running in your other window. (Don't forget the "." before sockets/gdb.) You should see output something like this in the debugger window:

```
(gdb) dir ../os161-1.99/kern/compile/ASST0
Source directories searched: /home/dasiyqu/cs350-os161/root/../os161-1.99/kern/c
ompile/ASST0:$cdir:$cwd
(gdb) target remote unix:.sockets/gdb
Remote debugging using unix:.sockets/gdb
__start () at ../../arch/sys161/startup/start.S:54
54          addiu sp, sp, -24
Current language:  auto; currently asm
(gdb)
```

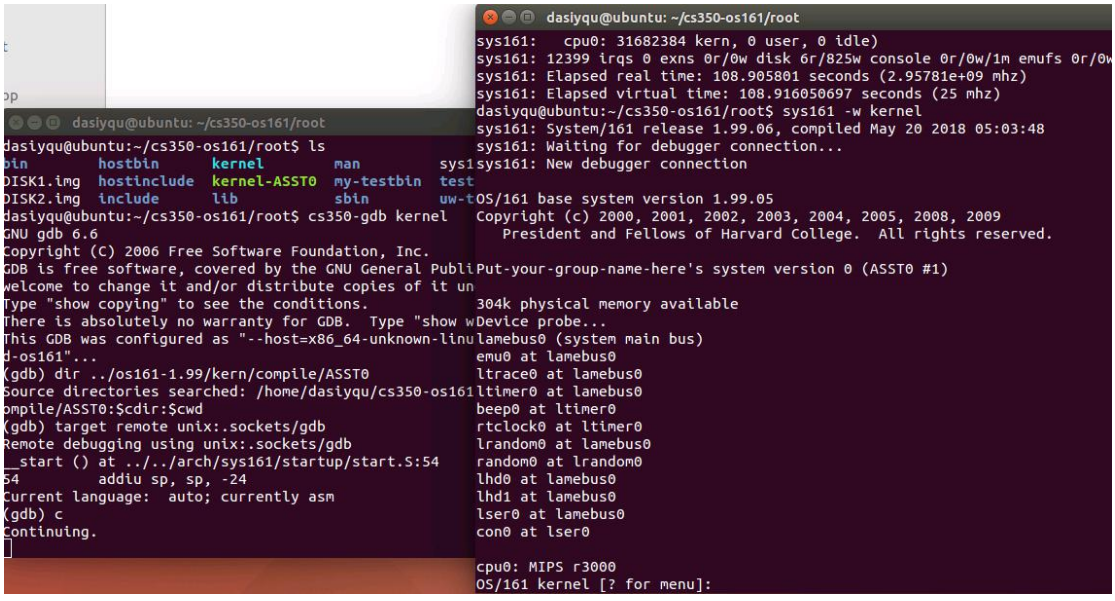
and you should see a message like sys161: New debugger connection in the sys161 window.

```
sys161: System/161 release 1.99.06, compiled May 20 2018 05:03:48
sys161: Waiting for debugger connection...
sys161: New debugger connection
```

At this point, your kernel is running under control of the debugger. Your kernel is waiting to start its execution (in the assembly language function start.S) as soon as the debugger allows it to proceed. You may now issue any gdb commands that you would like to, e.g., you may set breakpoints to force kernel execution to halt wherever you want. When you are ready to go, you can use gdb's continue command to allow the kernel's execution to proceed:

```
(gdb) c
```

When you do this, the kernel should start running in the other window. Unless you've set breakpoints, the kernel should print its usual boot messages and eventually provide you with the kernel command prompt.



For more information about using GDB, see Debugging with GDB.