Sysvinit 项目分析报告

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Sysvinit 项目工具简介

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安装的程序 halt, init, killall5, last, lastb (链接到 last), mesg, pidof (链接到 killall5), poweroff (链接到 halt), reboot (链接到 halt), runlevel, shutdown, sulogin, telinit (链接到 init), utmpdump, wall 简要描述

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Chapter 2

Sysvinit 项目概要分析

2.1 工具安装使用流程

Sysvinit 软件包包含控制启动，运行和关闭所有其他程序的工具。

2.1.1 工具安装

```
$ find sbin/ bin/ | xargs ls -l
-rwxr-xr-x 1 akaedu akaedu  7708 Jun 23 17:20 bin/mountpoint
lrwxrwxrwx 1 akaedu akaedu    14 Jun 23 17:20 bin/pidof -> /sbin/killall5
-rwxr-xr-x 1 akaedu akaedu 18162 Jun 23 17:20 sbin/bootlogd
-rwxr-xr-x 1 akaedu akaedu  7402 Jun 23 17:20 sbin/fstab-decode
-rwxr-xr-x 1 akaedu akaedu 17625 Jun 23 17:20 sbin/halt
-rwxr-xr-x 1 akaedu akaedu 42121 Jun 23 17:20 sbin/init
-rwxr-xr-x 1 akaedu akaedu 22259 Jun 23 17:20 sbin/killall5
lrwxrwxrwx 1 akaedu akaedu     4 Jun 23 17:20 sbin/poweroff -> halt
lrwxrwxrwx 1 akaedu akaedu     4 Jun 23 17:20 sbin/reboot -> halt
-rwxr-xr-x 1 akaedu akaedu  7368 Jun 23 17:20 sbin/runlevel
-rwxr-xr-x 1 akaedu akaedu 27547 Jun 23 17:20 sbin/shutdown
-rwxr-xr-x 1 akaedu akaedu 17677 Jun 23 17:20 sbin/sulogin
lrwxrwxrwx 1 akaedu akaedu     4 Jun 23 17:20 sbin/telinit -> init
```

所有工具编译之后都生成在 src 源码目录树下，同时，这些命名的帮助文件在 man 目录下。

```
$ ls -l
```

```
total 108
-rw-r--r-- 1 akaedu akaedu  2847 Jun 23 11:13 bootlogd.8
-rw-r--r-- 1 akaedu akaedu  1971 Jun 23 11:13 bootlogd.8.todo
-rw-r--r-- 1 akaedu akaedu  1444 Jun 23 11:13 fstab-decode.8
-rw-r--r-- 1 akaedu akaedu  3957 Jun 23 11:13 halt.8
-rw-r--r-- 1 akaedu akaedu 12124 Jun 23 11:13 init.8
-rw-r--r-- 1 akaedu akaedu  2428 Jun 23 11:13 initscript.5
-rw-r--r-- 1 akaedu akaedu  8290 Jun 23 11:13 inittab.5
-rw-r--r-- 1 akaedu akaedu  1866 Jun 23 11:13 killall5.8
-rw-r--r-- 1 akaedu akaedu  4242 Jun 23 11:13 last.1
-rw-r--r-- 1 akaedu akaedu    16 Jun 23 11:13 lastb.1
-rw-r--r-- 1 akaedu akaedu  1867 Jun 23 11:13 mesg.1
-rw-r--r-- 1 akaedu akaedu  1886 Jun 23 11:13 mountpoint.1
-rw-r--r-- 1 akaedu akaedu  3230 Jun 23 11:13 pidof.8
-rw-r--r-- 1 akaedu akaedu    16 Jun 23 11:13 poweroff.8
-rw-r--r-- 1 akaedu akaedu    16 Jun 23 11:13 reboot.8
-rw-r--r-- 1 akaedu akaedu  1872 Jun 23 11:13 runlevel.8
-rw-r--r-- 1 akaedu akaedu  8017 Jun 23 11:13 shutdown.8
-rw-r--r-- 1 akaedu akaedu  3309 Jun 23 11:13 sulogin.8
-rw-r--r-- 1 akaedu akaedu    16 Jun 23 11:13 telinit.8
-rw-r--r-- 1 akaedu akaedu  1949 Jun 23 11:13 utmpdump.1
-rw-r--r-- 1 akaedu akaedu  1960 Jun 23 11:13 wall.1
```

通过使用 man 命令，加上 -l 参数，例如 man -l init.8 我们可以了解到这些命令的用法。

- 注意

我们这里没有直接使用例如 man init 这样的命令，而是改用 man -l init.8，这是因为前者是查看当前系统的帮助，而当前系统是 ubuntu 12.04 已经改用 upstart 作为 init 进程。后者才是针对 sysvinit 工具中的可执行文件配套的帮助信息。

下面我们针对这些命令的帮助信息，来给出每个命令的具体用法，在测试案例报告中，我们会详细说明每个命令如何使用。

2.1.2 init 命令

init 命令说明

init 进程是所有进程的父进程。它的主要任务就是从/etc/inittab 文件中读取命令行，从而创建出一系列后继进程。init 进程本身是被 Kernel 所启动，Kernel 将控制权交给它之后，用它来负责启动所有其他的进程。inittab 文件中通常有关于登录接口的定义，就是在每个终端产生 getty，使用户可以进行登录.

命令格式

```
/sbin/init [ -a ] [ -s ] [ -b ] [ -z xxx ] [ 0123456Ss ]
```

运行级别

运行级别是 Linux 操作系统的一个软件配置，用它来决定启动哪些程序集来运行。系统启动时，可以根据/etc/inittab 文件的配置，进入不同的运行级别。每个运行级别可以设置启动不同的程序。

启动的每个程序都是 init 的进程的子进程，运行级别有 8 个，分别是 0-6,S 或 s。运行级别 0,1 和 6 是系统保留的。

- 运行级别 0 用来关闭系统，
- 运行级别 1 先关闭所有用户进程和服务，然后进入单用户模式。
- 运行级别 6 用来重启系统。
- 运行级别 S 和 s，会直接进入到单用户模式。
  - 这种模式下不再需要/etc/inittab 文件。
  - /sbin/sulogin 会在/dev/console 上被启动。
  - 运行级别 S 和 s 的功能是相同的。

启动过程

在 kernel 启动的最后阶段，会调用 init。init 会查找/etc/inittab 文件内容，进入指定的运行级别。其中 initdefault 代表着系统默认要进入的运行级别，如果用户指定了，就会进入到 initdefault 代表的那个运行级别。如果用户没有指定，则系统启动时，会通过 console 来要求用户输入一个运行级别。

当启动一个新进程时，init 会先检查/etc/initscript 文件是否存在。如果存在，则使用这个脚本来启动那个进程。

选项

- -s, S, single
  进入单用户模式.
- 1-5
  启动进入的运行级别.
- -b, emergency
  直接进入单用户 shell，不运行任何其他的启动脚本。

- -a, auto
  如果指定该参数，init 会将 AUTOBOOT 环境变量设置为 yes。

- -z xxx
  -z 后面的参数将被忽略。可以使用这种方法将命令行加长一点，这样可以增加在堆栈中占用的空间。

2.1.3 shutdown 命令

shutdown 命令说明

shutdown 以一种安全的方式终止系统，所有正在登录的用户都会收到系统将要终止的通知，并且不准新的登录。

命令格式

```
/sbin/shutdown [-akrhPHfFnc] [-t sec] time [warning message]
```

参数选项

- -h
  将系统关机，在某种程度上功能与 halt 命令相当。

- -k
  只是送出信息给所有用户，但并不会真正关机。

- -n
  不调用 init 程序关机，而是由 shutdown 自己进行（一般关机程序是由 shutdown 调用 init 来实现关机动作），使用此参数将加快关机速度，但是不建议用户使用此种关机方式。

- -r
  shutdown 之后重新启动系统。

- -f
  送出警告信息和关机信号之间要延迟多少秒。警告信息将提醒用户保存当前进行的工作

2.1.4 halt 命令

halt 命令说明

halt 用来停止系统。正常情况下等效于 shutdown 加上 -h 参数（当前系统运行级别是 0 时除外)。它将告诉内核去中止系统，并在系统正在关闭的过程中将日志记录到/var/log/wtmp 文件里。

命令格式

```
/sbin/halt [-n] [-w] [-d] [-f] [-i] [-p] [-h]
```

主要选项

- -n
  reboot 或者 halt 之前，不同步（sync）数据.
- -w
  仅仅往/var/log/wtmp 里写一个记录，并不实际做 reboot 或者 halt 操作.
- -f
  强制 halt 或者 reboot，不等其他程序退出或者服务停止就重新启动系统. 这样会造成数据丢失，建议一般不要这样做.
- -i
  halt 或 reboot 前，关闭所有网络接口.
- -h
  halt 或 poweroff 前，使系统中所有的硬件处于等待状态.
- -p
  在系统 halt 同时，做 poweroff 操作. 即停止系统同时关闭电源.

2.1.5 poweroff 命令

poweroff 告诉内核中止系统并且关闭系统（参见 halt）

命令格式

```
poweroff [OPTION]...
```

主要选项

```
   -f, --force
          Does not invoke shutdown(8)  and  instead  performs  the  actual
          action you would expect from the name.

   -p, --poweroff
          Instructs the halt command to instead behave as poweroff.

   -w, --wtmp-only
          Does  not  call  shutdown(8)  or  the  reboot(2) system call and
          instead only writes the shutdown record to /var/log/wtmp

   --verbose
          Outputs slightly more verbose messages  when  rebooting,  useful
          for debugging problems with shutdown.
```

2.1.6 reboot 命令

reboot 告诉内核重启系统（参见 halt）

命令格式

```
reboot [OPTION]...
```

主要选项

```
   -f, --force
          Does not invoke shutdown(8)  and  instead  performs  the  actual
          action you would expect from the name.

   -p, --poweroff
          Instructs the halt command to instead behave as poweroff.

   -w, --wtmp-only
          Does  not  call  shutdown(8)  or  the  reboot(2) system call and
```

```
           instead only writes the shutdown record to /var/log/wtmp

    --verbose
          Outputs slightly more verbose messages  when  rebooting,  useful
          for debugging problems with shutdown.
```

2.1.7 telinit 命令

telinit 告诉 init 该进入哪个运行级。

telinit 告诉 init 将切换到那一个运行级

命令格式

```
init [OPTION]...
```

主要选项

2.1.8 killall5 命令

killall5 发送一个信号到所有进程，但那些在它自己设定级别的进程将不会被这个运行的脚本所中断。

killall5 就是 SystemV 的 killall 命令。向除自己的会话 (session) 进程之外的其它进程发出信号，所以不能杀死当前使用的 shell。

命令格式

```
killall5  -signalnumber  [-o  omitpid[,omitpid..]]   [-o omitpid[,omit -
pid..]..]
```

主要选项

```
   -o omitpid
          Tells killall5 to omit processes with that process id.
```

2.1.9 pidof

pidof 报告给定程序的 PID 号

pidof 找出程序的进程识别号 (pid)，输出到标准输出设备。

命令格式

```
pidof  [-s] [-c] [-n] [-x] [-o omitpid[,omitpid..]]  [-o omitpid[,omit -
pid..]..]  program [program..]
```

主要选项

```
   -s     Single shot - this instructs the program to only return one pid.

   -c     Only  return  process  ids  that  are running with the same root
          directory.  This option is ignored for non-root users,  as  they
          will  be unable to check the current root directory of processes
          they do not own.

   -n     Avoid stat(2) system function call on  all  binaries  which  are
          located  on  network  based  file  systems like NFS.  Instead of
          using this option the the variable PIDOF_NETFS may  be  set  and
          exported.

   -x     Scripts  too  -  this  causes the program to also return process
          id's of shells running the named scripts.

   -o omitpid
          Tells pidof to omit processes with that process id. The  special
          pid  %PPID  can  be used to name the parent process of the pidof
          program, in other words the calling shell or shell script.
```

2.1.10 last/lastb 命令

last 给出哪一个用户最后一次登录 (或退出登录)，它搜索/var/log/wtmp 文件，出给出系统引导、关闭、运行级别改变等信息。lastb 给出登失败的尝试，并写入日志/var/log/btmp last 回溯/var/log/wtmp 文件（或者 -f 选项指定的文件），显示自从这个文件建立以来，所有用户的登录情况。

lastb 显示所有失败登录企图，并记录在/var/log/btmp.

命令格式

```
last  [-R] [-num] [ -n num ] [-adFiowx] [ -f file ] [ -t YYYYMMDDHHMMSS] [name...]  [tty...
```

主要选项

```
   -f file
          Tells last to use a specific file instead of /var/log/wtmp.
```

2.1.11 mesg 命令

该命令的作用是，控制是否允许在当前终端上显示出其它用户对当前用户终端发送的消息。

命令格式

```
mesg [y|n]
```

主要选项

```
   y      Allow write access to your terminal.

   n      Disallow write access to your terminal.

   If no option is given, mesg prints out the current access state of your
   terminal.
```

2.1.12 mountpoint 命令

mountpoint 检查给定的目录是否是一个挂载点

命令格式

```
/bin/mountpoint [-q] [-d] /path/to/directory
   /bin/mountpoint -x /dev/device
```

主要选项

```
   -q      Be quiet - don't print anything.

   -d      Print major/minor device number of the filesystem on stdout.

   -x      Print major/minor device number of the blockdevice on stdout.
```

查看一个目录是否为一个挂载点：

```
[root@test ~]# df
Filesystem           1K-blocks      Used Available Use% Mounted on
/dev/hda2              9918956   8036580   1370388  86% /
/dev/hda1                99043     20891     73038  23% /boot
/dev/hda5              9612604   6545956   2578352  72% /data
tmpfs                   123444         0    123444   0% /dev/shm
[root@test ~]# mountpoint /
/ is a mountpoint
[root@test ~]# mountpoint /boot
/boot is a mountpoint
[root@test ~]# mountpoint /home/
/home/ is not a mountpoint
```

而且，还可以查看某个文件系统的主/从设备号：

```
[root@test ~]# df
Filesystem           1K-blocks      Used Available Use% Mounted on
/dev/hda2              9918956   8036580   1370388  86% /
```

```
/dev/hda1                 99043     20891     73038  23% /boot
/dev/hda5               9612604   6545956   2578352  72% /data
tmpfs                    123444         0    123444   0% /dev/shm
[root@test ~]# mountpoint -d /
3:2
[root@test ~]# mountpoint -d /boot
3:1
```

2.1.13 runlevel 命令

runlevel 告前一个和当前的系统运行级别，并且将最后一些运行级别写入/var/run/utmp

runlevel 读取系统的登录记录文件（一般是/var/run/utmp）把以前和当前的系统运行级输出到标准输出设备。

命令格式

```
runlevel [utmp]
```

主要选项

```
utmp   The name of the utmp file to read.
```

2.1.14 sulogin 命令

sulogin 允许 root 登录，它通常情况下是在系统在单用户模式下运行时，由 init 所派生。

sulogin 允许超级用户登陆。通常是系统进入单用户模式时调用的。

命令格式

```
sulogin [ -e ] [ -p ] [ -t SECONDS ] [ TTY ]
```

主要选项

2.1.15 wall 命令

wall 命令说明

`wall` 命令用来向所有用户的终端发送一条信息。发送的信息可以作为参数在命令行给出，也可在执行 `wall` 命令后，从终端中输入。使用终端输入信息时，按 `Ctrl-D` 结束输入。`wall` 的信息长度的限制是 `20` 行。

只有超级用户有权限，给所有用户的终端发送消息。

命令格式

```
wall [-n] [ message ]
```

- 用法
  `usage: wall [message]`
- 举例
  `wall ``hello msg''`

2.1.16 bootlogd 命令

命令格式

```
/sbin/bootlogd [-c] [-d] [-r] [-s] [-v] [ -l logfile ] [ -p pidfile ]
```

主要选项

```
   -d      Do not fork and run in the background.

   -c      Attempt  to  write to the logfile even if it does not yet exist.
           Without this option, bootlogd  will  wait  for  the  logfile  to
           appear before attempting to write to it.  This behavior prevents
           bootlogd from creating logfiles under mount points.
   -r     If there is an existing logfile called logfile rename it to log -
          file~ unless logfile~ already exists.

   -s     Ensure  that  the data is written to the file after each line by
          calling fdatasync(3).  This will slow  down  a  fsck(8)  process
          running in parallel.

   -v     Show version.

   -l logfile
          Log to this logfile. The default is /var/log/boot.
```

2.1.17 utmpdump 命令

utmpdump 以一个多用户友好的方式列出已经给出的登录文件的目录 utmpdump 以一种用户友好的格式向标准输出设备显示/var/run/utmp 文件的内容。

命令格式

```
utmpdump [-froh] filename
```

主要选项

```
   -f     output appended data as the file grows.

   -r     reverse. Write back edited login information into utmp  or  wtmp
          files.

   -o     use old libc5 format.

   -h     usage information.
```

2.2 代码实现概要分析

2.2.1 源码目录结构

```
$ make distclean
make -C src distclean
make[1]: Entering directory `/home/akaedu/Github/sysvinit/sysvinit-2.88dsf/src'
rm -f *.o *.bak
rm -f  mountpoint init halt shutdown runlevel killall5 fstab-decode sulogin bootlogd last
make[1]: Leaving directory `/home/akaedu/Github/sysvinit/sysvinit-2.88dsf/src'
$ make clean
$ tree
.
├── contrib
│   ├── alexander.viro
│   ├── notify-pam-dead.patch
│   ├── start-stop-daemon.c
│   ├── start-stop-daemon.README
│   ├── TODO
│   └── zefram-patches
├── COPYING
├── COPYRIGHT
├── doc
│   ├── bootlogd.README
│   ├── Changelog
│   ├── Install
│   ├── Propaganda
│   └── sysvinit-2.86.lsm
├── Makefile
├── man
│   ├── bootlogd.8
│   ├── bootlogd.8.todo
│   ├── fstab-decode.8
│   ├── halt.8
│   ├── init.8
│   ├── initscript.5
│   ├── inittab.5
│   ├── killall5.8
│   ├── last.1
│   ├── lastb.1
│   ├── mesg.1
│   ├── mountpoint.1
│   ├── pidof.8
│   ├── poweroff.8
│   ├── reboot.8
│   ├── runlevel.8
│   ├── shutdown.8
│   ├── sulogin.8
│   ├── telinit.8
│   ├── utmpdump.1
│   └── wall.1
├── obsolete
│   ├── bootlogd.init
│   ├── powerd.8
│   ├── powerd.c
│   ├── powerd.cfg
│   ├── powerd.README
│   ├── README.RIGHT.NOW
│   └── utmpdump.c.OLD
├── README
└── src
    ├── a.out
    ├── bootlogd.c
    ├── dowall.c
    ├── fstab-decode.c
    ├── halt.c
    ├── hddown.c
    ├── ifdown.c
    ├── init.c
    ├── init.h
    ├── initreq.h
    ├── initscript.sample
    ├── killall5.c
    ├── last.c
    ├── Makefile
    ├── mesg.c
    ├── mountpoint.c
    ├── oldutmp.h
    ├── paths.h
    ├── reboot.h
    ├── runlevel.c
    ├── set.h
    ├── shutdown.c
    ├── sulogin.c
    ├── utmp.c
    ├── utmpdump.c
    └── wall.c

5 directories, 69 files
```

2.2.2 Makefile 分析

```
init:           LDLIBS += $(INITLIBS) $(STATIC)
init:           init.o init_utmp.o

halt:           halt.o ifdown.o hddown.o utmp.o reboot.h

last:           last.o oldutmp.h

mesg:           mesg.o

mountpoint:     mountpoint.o

utmpdump:       utmpdump.o

runlevel:       runlevel.o

sulogin:        LDLIBS += $(SULOGINLIBS) $(STATIC)
sulogin:        sulogin.o

wall:           dowall.o wall.o

shutdown:       dowall.o shutdown.o utmp.o reboot.h

bootlogd:       LDLIBS += -lutil
bootlogd:       bootlogd.o
```

Chapter 3

Sysvinit 项目详细分析

3.1 init 进程代码分析

3.2 相关其他进程分析

Chapter 4

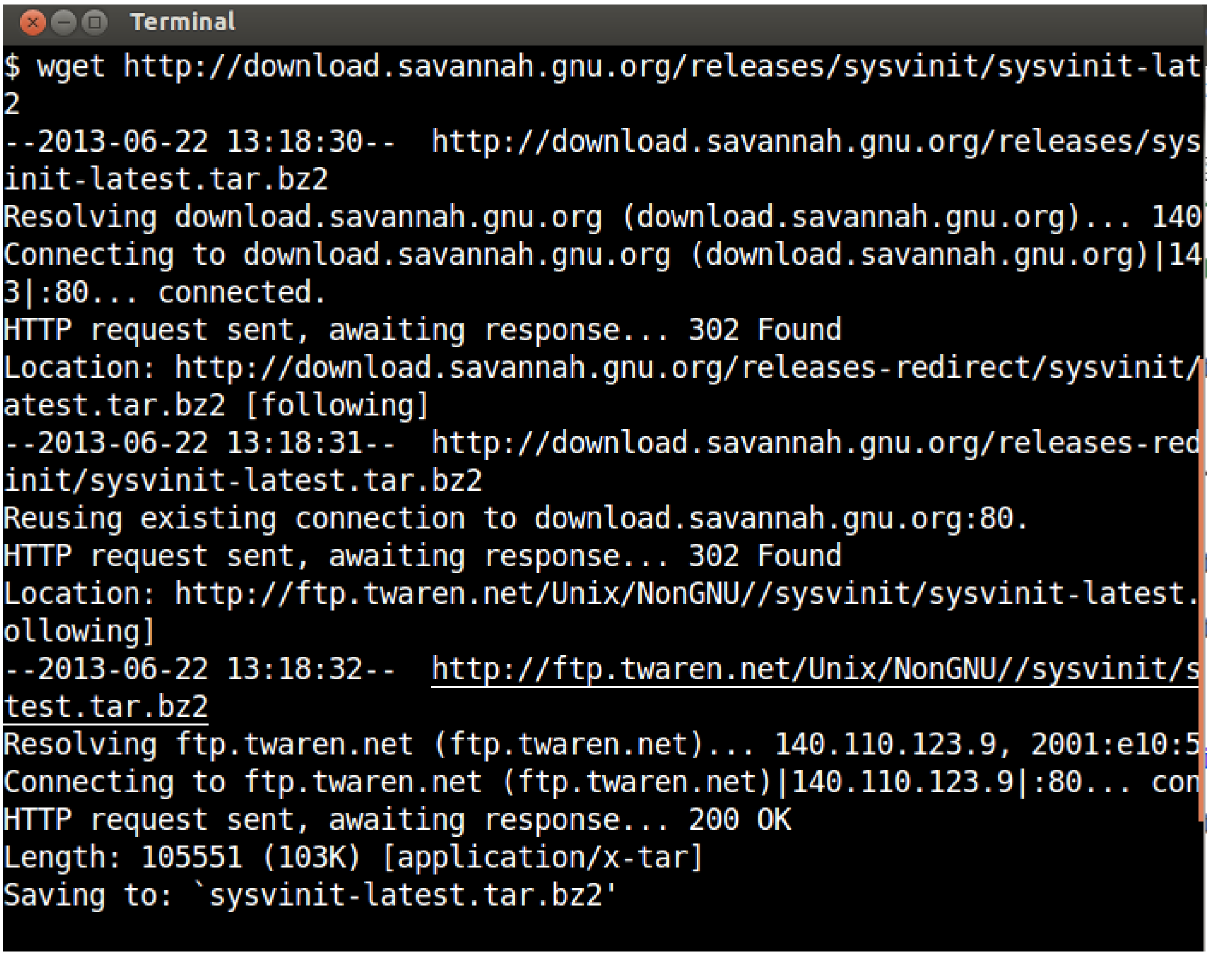
Sysvinit 项目安全漏洞

Chapter 5

Sysvinit 项目运行时调试图

5.1 编译安装运行调试图

5.1.1 wget 下载源码包



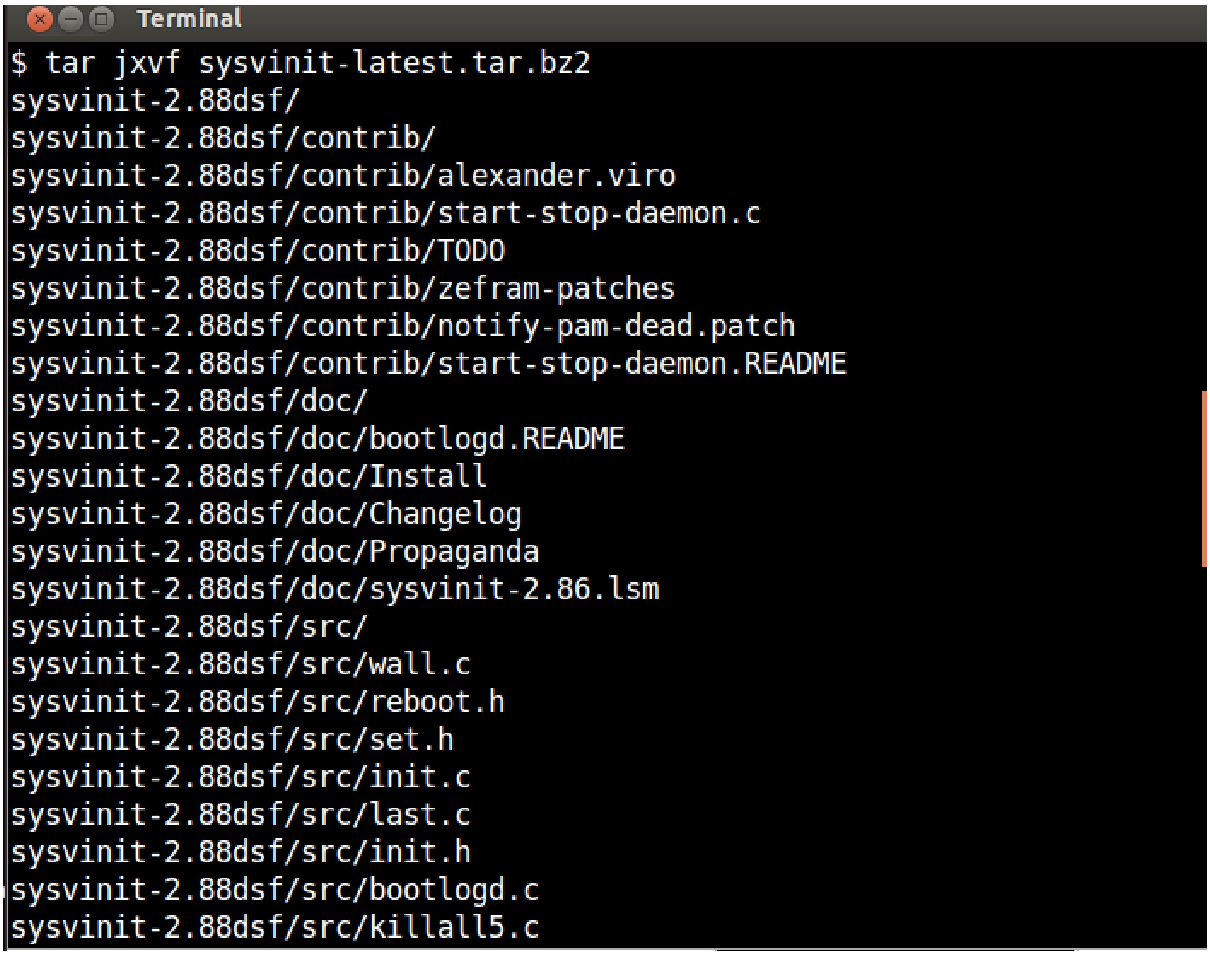
```
$ wget http://download.savannah.gnu.org/releases/sysvinit/sysvinit-lat
2
--2013-06-22 13:18:30--  http://download.savannah.gnu.org/releases/sys
init-latest.tar.bz2
Resolving download.savannah.gnu.org (download.savannah.gnu.org)... 140
Connecting to download.savannah.gnu.org (download.savannah.gnu.org)|14
3|:80... connected.
HTTP request sent, awaiting response... 302 Found
Location: http://download.savannah.gnu.org/releases-redirect/sysvinit/
atest.tar.bz2 [following]
--2013-06-22 13:18:31--  http://download.savannah.gnu.org/releases-red
init/sysvinit-latest.tar.bz2
Reusing existing connection to download.savannah.gnu.org:80.
HTTP request sent, awaiting response... 302 Found
Location: http://ftp.twaren.net/Unix/NonGNU//sysvinit/sysvinit-latest.
ollowing]
--2013-06-22 13:18:32--  http://ftp.twaren.net/Unix/NonGNU//sysvinit/s
test.tar.bz2
Resolving ftp.twaren.net (ftp.twaren.net)... 140.110.123.9, 2001:e10:5
Connecting to ftp.twaren.net (ftp.twaren.net)|140.110.123.9|:80... con
HTTP request sent, awaiting response... 200 OK
Length: 105551 (103K) [application/x-tar]
Saving to: `sysvinit-latest.tar.bz2'
```

Figure 5.1: wget 下载源码包

```
$ wget http://download.savannah.gnu.org/releases/sysvinit/sysvinit-latest.tar.bz2
--2013-06-22 13:18:30-- http://download.savannah.gnu.org/releases/sysvinit/sysvinit-l
Resolving download.savannah.gnu.org (download.savannah.gnu.org)... 140.186.70.73
Connecting to download.savannah.gnu.org (download.savannah.gnu.org)|140.186.70.73|:80.
HTTP request sent, awaiting response... 302 Found
Location: http://download.savannah.gnu.org/releases-redirect/sysvinit/sysvinit-latest
--2013-06-22 13:18:31-- http://download.savannah.gnu.org/releases-redirect/sysvinit/s
Reusing existing connection to download.savannah.gnu.org:80.
HTTP request sent, awaiting response... 302 Found
Location: http://ftp.twaren.net/Unix/NonGNU//sysvinit/sysvinit-latest.tar.bz2 [followi
--2013-06-22 13:18:32-- http://ftp.twaren.net/Unix/NonGNU//sysvinit/sysvinit-latest.t
Resolving ftp.twaren.net (ftp.twaren.net)... 140.110.123.9, 2001:e10:5c00:5::9
Connecting to ftp.twaren.net (ftp.twaren.net)|140.110.123.9|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 105551 (103K) [application/x-tar]
Saving to: `sysvinit-latest.tar.bz2'

100%[======================================>] 105,551    45.1K/s   in 2.3s

2013-06-22 13:18:35 (45.1 KB/s) - `sysvinit-latest.tar.bz2' saved [105551/105551]
```

5.1.2 tar 解压源码包

```
$ tar jxvf sysvinit-latest.tar.bz2
sysvinit-2.88dsf/
sysvinit-2.88dsf/contrib/
sysvinit-2.88dsf/contrib/alexander.viro
sysvinit-2.88dsf/contrib/start-stop-daemon.c
sysvinit-2.88dsf/contrib/TODO
sysvinit-2.88dsf/contrib/zefram-patches
sysvinit-2.88dsf/contrib/notify-pam-dead.patch
sysvinit-2.88dsf/contrib/start-stop-daemon.README
sysvinit-2.88dsf/doc/
sysvinit-2.88dsf/doc/bootlogd.README
sysvinit-2.88dsf/doc/Install
sysvinit-2.88dsf/doc/Changelog
sysvinit-2.88dsf/doc/Propaganda
sysvinit-2.88dsf/doc/sysvinit-2.86.lsm
sysvinit-2.88dsf/src/
```



```
$ tar jxvf sysvinit-latest.tar.bz2
sysvinit-2.88dsf/
sysvinit-2.88dsf/contrib/
sysvinit-2.88dsf/contrib/alexander.viro
sysvinit-2.88dsf/contrib/start-stop-daemon.c
sysvinit-2.88dsf/contrib/TODO
sysvinit-2.88dsf/contrib/zefram-patches
sysvinit-2.88dsf/contrib/notify-pam-dead.patch
sysvinit-2.88dsf/contrib/start-stop-daemon.README
sysvinit-2.88dsf/doc/
sysvinit-2.88dsf/doc/bootlogd.README
sysvinit-2.88dsf/doc/Install
sysvinit-2.88dsf/doc/Changelog
sysvinit-2.88dsf/doc/Propaganda
sysvinit-2.88dsf/doc/sysvinit-2.86.lsm
sysvinit-2.88dsf/src/
sysvinit-2.88dsf/src/wall.c
sysvinit-2.88dsf/src/reboot.h
sysvinit-2.88dsf/src/set.h
sysvinit-2.88dsf/src/init.c
sysvinit-2.88dsf/src/last.c
sysvinit-2.88dsf/src/init.h
sysvinit-2.88dsf/src/bootlogd.c
sysvinit-2.88dsf/src/killall5.c
```

Figure 5.2: tar 解压源码包

```
sysvinit-2.88dsf/src/wall.c
sysvinit-2.88dsf/src/reboot.h
sysvinit-2.88dsf/src/set.h
sysvinit-2.88dsf/src/init.c
sysvinit-2.88dsf/src/last.c
sysvinit-2.88dsf/src/init.h
sysvinit-2.88dsf/src/bootlogd.c
sysvinit-2.88dsf/src/killall5.c
sysvinit-2.88dsf/src/utmpdump.c
sysvinit-2.88dsf/src/shutdown.c
sysvinit-2.88dsf/src/mountpoint.c
sysvinit-2.88dsf/src/sulogin.c
sysvinit-2.88dsf/src/fstab-decode.c
sysvinit-2.88dsf/src/initreq.h
sysvinit-2.88dsf/src/dowall.c
sysvinit-2.88dsf/src/hddown.c
sysvinit-2.88dsf/src/paths.h
sysvinit-2.88dsf/src/utmp.c
sysvinit-2.88dsf/src/ifdown.c
sysvinit-2.88dsf/src/initscript.sample
sysvinit-2.88dsf/src/halt.c
sysvinit-2.88dsf/src/oldutmp.h
sysvinit-2.88dsf/src/mesg.c
sysvinit-2.88dsf/src/Makefile
sysvinit-2.88dsf/src/runlevel.c
sysvinit-2.88dsf/COPYING
sysvinit-2.88dsf/COPYRIGHT
sysvinit-2.88dsf/man/
sysvinit-2.88dsf/man/bootlogd.8
sysvinit-2.88dsf/man/killall5.8
sysvinit-2.88dsf/man/shutdown.8
sysvinit-2.88dsf/man/bootlogd.8.todo
sysvinit-2.88dsf/man/sulogin.8
sysvinit-2.88dsf/man/fstab-decode.8
sysvinit-2.88dsf/man/mesg.1
sysvinit-2.88dsf/man/initscript.5
sysvinit-2.88dsf/man/inittab.5
sysvinit-2.88dsf/man/poweroff.8
sysvinit-2.88dsf/man/wall.1
sysvinit-2.88dsf/man/halt.8
sysvinit-2.88dsf/man/reboot.8
sysvinit-2.88dsf/man/last.1
sysvinit-2.88dsf/man/runlevel.8
sysvinit-2.88dsf/man/lastb.1
sysvinit-2.88dsf/man/pidof.8
```

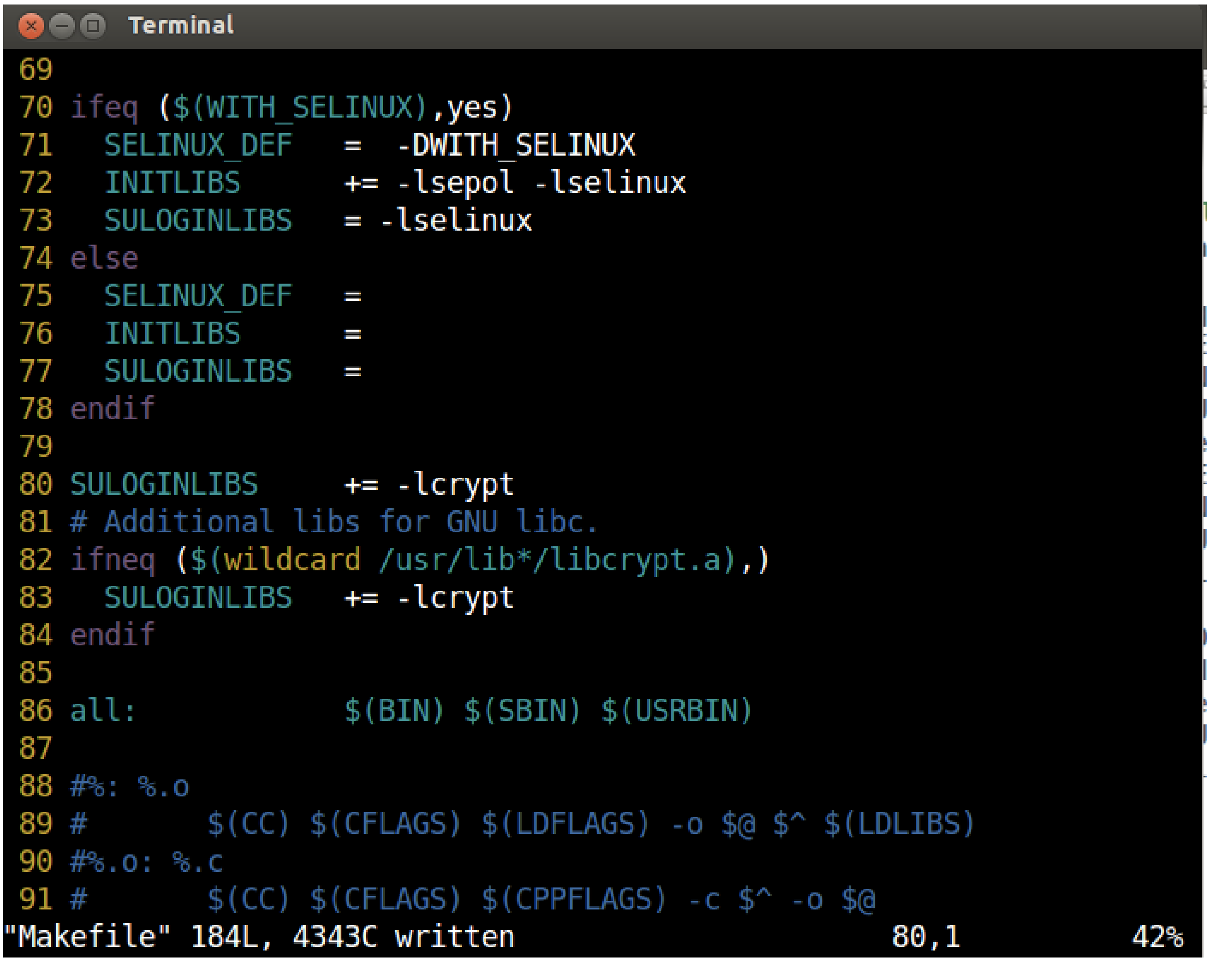
```
sysvinit-2.88dsf/man/init.8
sysvinit-2.88dsf/man/utmpdump.1
sysvinit-2.88dsf/man/mountpoint.1
sysvinit-2.88dsf/man/telinit.8
sysvinit-2.88dsf/obsolete/
sysvinit-2.88dsf/obsolete/powerd.c
sysvinit-2.88dsf/obsolete/powerd.8
sysvinit-2.88dsf/obsolete/utmpdump.c.OLD
sysvinit-2.88dsf/obsolete/README.RIGHT.NOW
sysvinit-2.88dsf/obsolete/bootlogd.init
sysvinit-2.88dsf/obsolete/powerd.README
sysvinit-2.88dsf/obsolete/powerd.cfg
sysvinit-2.88dsf/Makefile
sysvinit-2.88dsf/README
$

$ ls
Makefile  pdf  sysvinit-2.88dsf  sysvinit-latest.tar.bz2

$ ls sysvinit-2.88dsf/
contrib  COPYRIGHT  Makefile  obsolete  src
COPYING  doc        man       README
$
```

5.1.3 编译项目源码

```
$ cd sysvinit-2.88dsf/
$ make
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o mountpoint.o mountpoint.
cc   mountpoint.o   -o mountpoint
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o init.o init.c
init.c: In function ‘telinit’ :
init.c:2737:7: warning: ignoring return value of ‘chdir’
, declared with attribute warn_unused_result [-Wunused-result]
init.c: In function ‘get_record’ :
init.c:377:11: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:380:11: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:383:11: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
```

```
init.c:386:11: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:389:11: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:392:11: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:395:11: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:398:11: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:401:11: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:404:11: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:423:10: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:426:10: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
init.c: In function ‘spawn’ :
init.c:1064:10: warning: ignoring return value of ‘dup’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:1065:10: warning: ignoring return value of ‘dup’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:1133:7: warning: ignoring return value of ‘dup’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:1134:7: warning: ignoring return value of ‘dup’
, declared with attribute warn_unused_result [-Wunused-result]
init.c: In function ‘ask_runlevel’ :
init.c:1673:10: warning: ignoring return value of ‘write’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:1675:9: warning: ignoring return value of ‘read’
, declared with attribute warn_unused_result [-Wunused-result]
init.c: In function ‘make_pipe’ :
init.c:1960:6: warning: ignoring return value of ‘pipe’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:1965:7: warning: ignoring return value of ‘write’
, declared with attribute warn_unused_result [-Wunused-result]
init.c: In function ‘process_signals’ :
init.c:2411:7: warning: ignoring return value of ‘read’
, declared with attribute warn_unused_result [-Wunused-result]
init.c:2420:7: warning: ignoring return value of ‘read’
, declared with attribute warn_unused_result [-Wunused-result]
init.c: In function ‘coredump’ :
init.c:666:7: warning: ignoring return value of ‘chdir’
```

```
, declared with attribute warn_unused_result [-Wunused-result]
init.c: In function ‘print’ :
init.c:821:8: warning: ignoring return value of ‘write’
, declared with attribute warn_unused_result [-Wunused-result]
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE -DINIT_MAIN -c -o init_utmp.o ut
cc   init.o init_utmp.o    -o init
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o halt.o halt.c
halt.c: In function ‘main’ :
halt.c:242:2: warning: ignoring return value of ‘chdir’
, declared with attribute warn_unused_result [-Wunused-result]
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o ifdown.o ifdown.c
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o hddown.o hddown.c
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o utmp.o utmp.c
cc   halt.o ifdown.o hddown.o utmp.o reboot.h   -o halt
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o shutdown.o shutdown.c
shutdown.c: In function ‘main’ :
shutdown.c:485:10: warning: variable ‘realuid’
set but not used [-Wunused-but-set-variable]
shutdown.c:630:9: warning: ignoring return value of ‘fscanf’
, declared with attribute warn_unused_result [-Wunused-result]
shutdown.c:719:7: warning: ignoring return value of ‘chdir’
, declared with attribute warn_unused_result [-Wunused-result]
shutdown.c: In function ‘spawn’ :
shutdown.c:289:7: warning: ignoring return value of ‘chdir’
, declared with attribute warn_unused_result [-Wunused-result]
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o dowall.o dowall.c
cc   shutdown.o dowall.o utmp.o reboot.h   -o shutdown
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o runlevel.o runlevel.c
cc   runlevel.o   -o runlevel
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o sulogin.o sulogin.c
sulogin.c: In function ‘sushell’ :
sulogin.c:407:2: warning: ignoring return value of ‘chdir’
, declared with attribute warn_unused_result [-Wunused-result]
sulogin.c:427:8: warning: ignoring return value of ‘getcwd’
, declared with attribute warn_unused_result [-Wunused-result]
cc   sulogin.o    -o sulogin
sulogin.o: In function `main':
sulogin.c:(.text.startup+0x1e2): undefined reference to `crypt'
collect2: ld returned 1 exit status
make: *** [sulogin] Error 1
$
```



```

ifeq ($(WITH_SELINUX),yes)
  SELINUX_DEF    =  -DWITH_SELINUX
  INITLIBS       += -lsepol -lselinux
  SULOGINLIBS    = -lselinux
else
  SELINUX_DEF    =
  INITLIBS       =
  SULOGINLIBS    =
endif

SULOGINLIBS      += -lcrypt
# Additional libs for GNU libc.
ifneq ($(wildcard /usr/lib*/libcrypt.a),)
  SULOGINLIBS    += -lcrypt
endif

all:             $(BIN) $(SBIN) $(USRBIN)

#%: %.o
#       $(CC) $(CFLAGS) $(LDFLAGS) -o $@ $^ $(LDLIBS)
#%.o: %.c
#       $(CC) $(CFLAGS) $(CPPFLAGS) -c $^ -o $@
"Makefile" 184L, 4343C written                        80,1          42%
```

Figure 5.3: 修改 Makefile

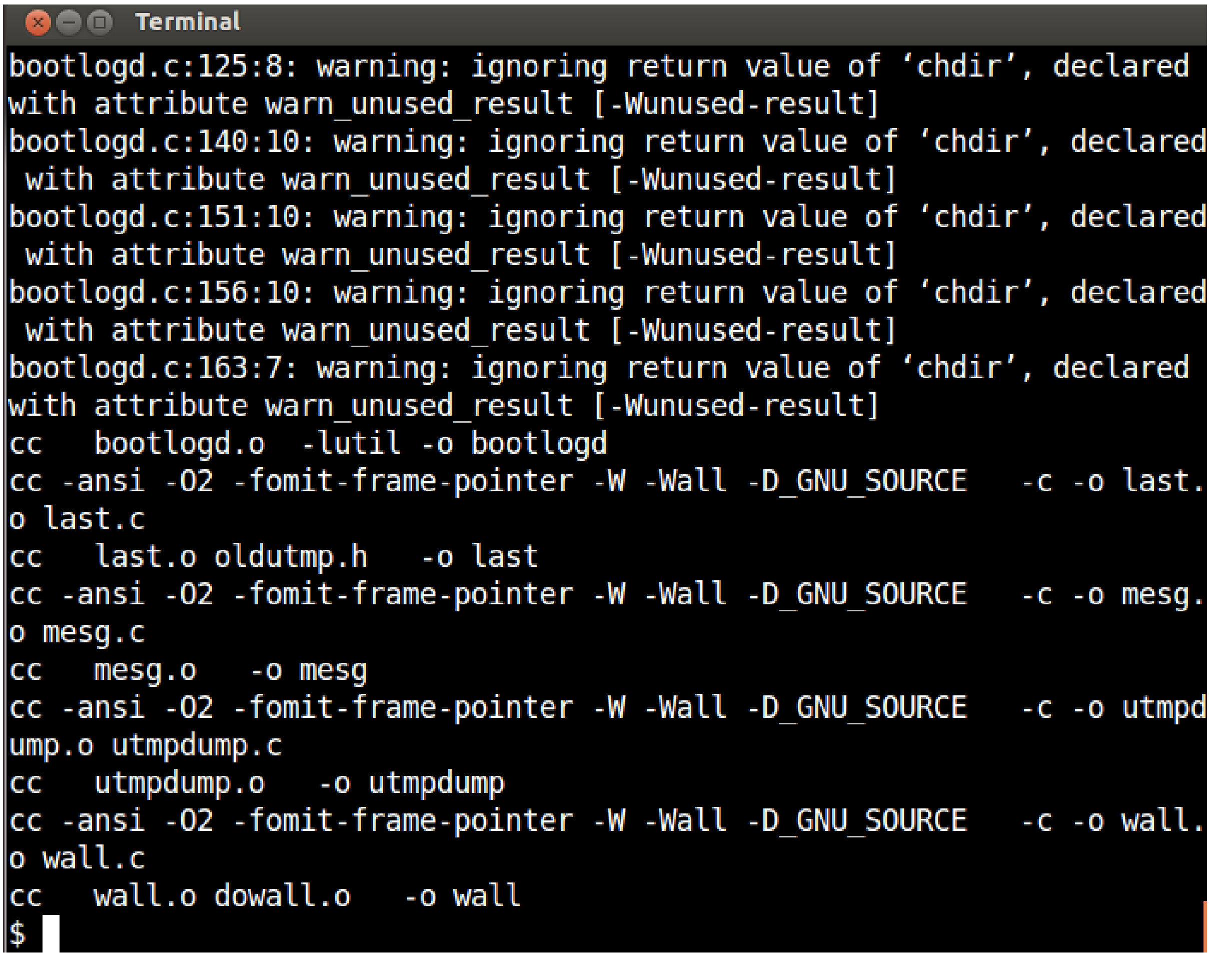
5.1.4 修改 Makefile 使之能够编译通过

```
$ vi Makefile
69
70 ifeq ($(WITH_SELINUX),yes)
71   SELINUX_DEF   =  -DWITH_SELINUX
72   INITLIBS      += -lsepol -lselinux
73   SULOGINLIBS   = -lselinux
74 else
75   SELINUX_DEF   =
76   INITLIBS      =
77   SULOGINLIBS   =
78 endif
79
80 SULOGINLIBS     += -lcrypt
81 # Additional libs for GNU libc.
82 ifneq ($(wildcard /usr/lib*/libcrypt.a),)
83   SULOGINLIBS   += -lcrypt
84 endif
85
86 all:            $(BIN) $(SBIN) $(USRBIN)
87
88 #%: %.o
89 #       $(CC) $(CFLAGS) $(LDFLAGS) -o $@ $^ $(LDLIBS)
90 #%.o: %.c
91 #       $(CC) $(CFLAGS) $(CPPFLAGS) -c $^ -o $@
```

在 80 行处添加 83 行处的赋值，增加链接时 -lcrypt 选项

5.1.5 继续编译项目源码，成功

```
$ make
cc   sulogin.o   -lcrypt  -o sulogin
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o bootlogd.o bootlogd.c
bootlogd.c: In function ‘findtty’:
bootlogd.c:125:8: warning: ignoring return value of ‘chdir’
, declared with attribute warn_unused_result [-Wunused-result]
bootlogd.c:140:10: warning: ignoring return value of ‘chdir’
, declared with attribute warn_unused_result [-Wunused-result]
```



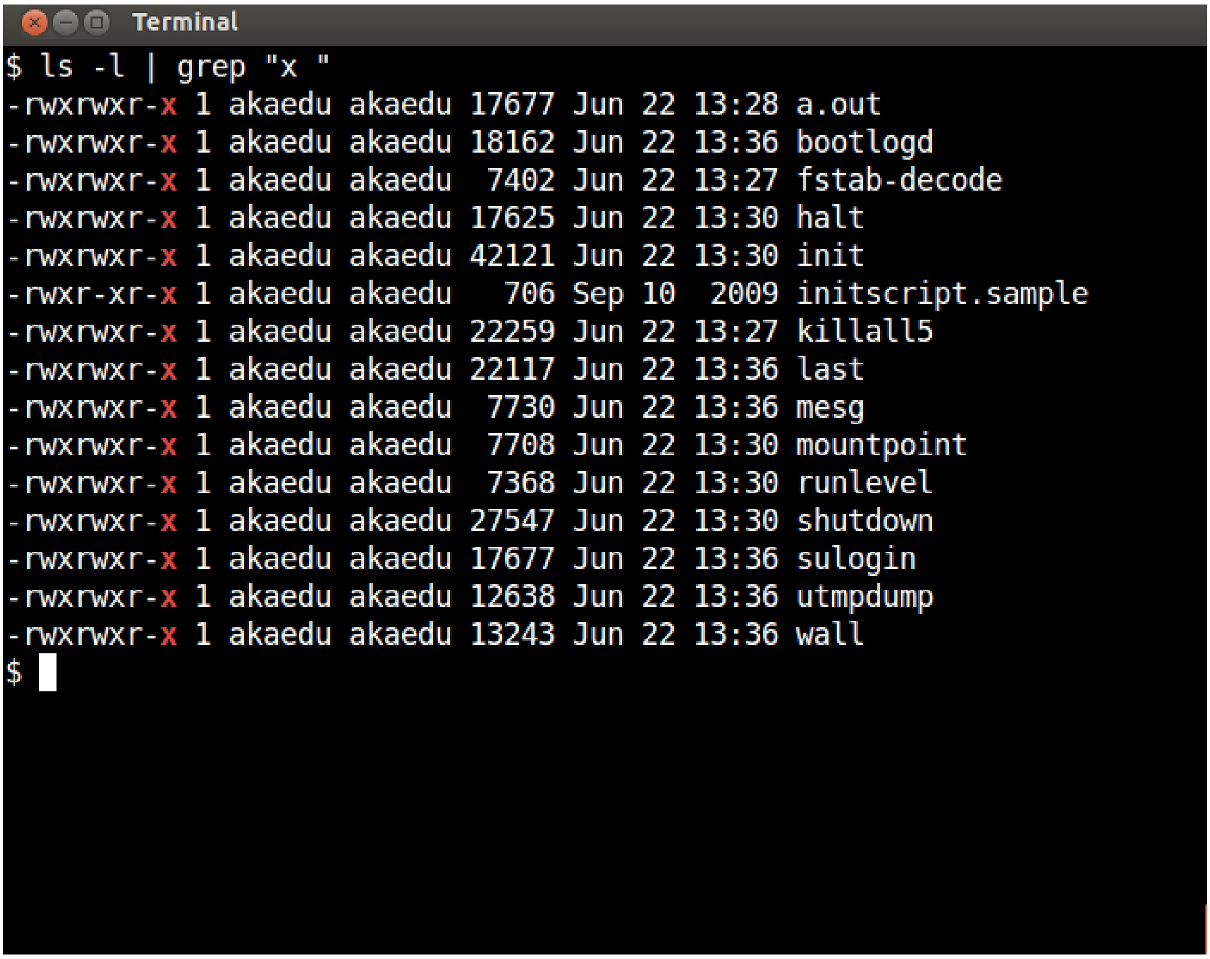
```
bootlogd.c:125:8: warning: ignoring return value of ‘chdir’, declared
with attribute warn_unused_result [-Wunused-result]
bootlogd.c:140:10: warning: ignoring return value of ‘chdir’, declared
 with attribute warn_unused_result [-Wunused-result]
bootlogd.c:151:10: warning: ignoring return value of ‘chdir’, declared
 with attribute warn_unused_result [-Wunused-result]
bootlogd.c:156:10: warning: ignoring return value of ‘chdir’, declared
 with attribute warn_unused_result [-Wunused-result]
bootlogd.c:163:7: warning: ignoring return value of ‘chdir’, declared
with attribute warn_unused_result [-Wunused-result]
cc    bootlogd.o  -lutil -o bootlogd
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE   -c -o last.
o last.c
cc    last.o oldutmp.h   -o last
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE   -c -o mesg.
o mesg.c
cc    mesg.o    -o mesg
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE   -c -o utmpd
ump.o utmpdump.c
cc    utmpdump.o    -o utmpdump
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE   -c -o wall.
o wall.c
cc    wall.o dowall.o    -o wall
$ 
```

Figure 5.4: make 编译源码包

```
bootlogd.c:151:10: warning: ignoring return value of ‘chdir’
, declared with attribute warn_unused_result [-Wunused-result]
bootlogd.c:156:10: warning: ignoring return value of ‘chdir’
, declared with attribute warn_unused_result [-Wunused-result]
bootlogd.c:163:7: warning: ignoring return value of ‘chdir’
, declared with attribute warn_unused_result [-Wunused-result]
cc   bootlogd.o  -lutil -o bootlogd
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o last.o last.c
cc   last.o oldutmp.h   -o last
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o mesg.o mesg.c
cc   mesg.o   -o mesg
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o utmpdump.o utmpdump.c
cc   utmpdump.o   -o utmpdump
cc -ansi -O2 -fomit-frame-pointer -W -Wall -D_GNU_SOURCE  -c -o wall.o wall.c
cc   wall.o dowall.o   -o wall
$
```

5.1.6 查看生成的可执行文件

```
$ ls -l | grep "x "
-rwxrwxr-x 1 akaedu akaedu 17677 Jun 22 13:28 a.out
-rwxrwxr-x 1 akaedu akaedu 18162 Jun 22 13:36 bootlogd
-rwxrwxr-x 1 akaedu akaedu  7402 Jun 22 13:27 fstab-decode
-rwxrwxr-x 1 akaedu akaedu 17625 Jun 22 13:30 halt
-rwxrwxr-x 1 akaedu akaedu 42121 Jun 22 13:30 init
-rwxr-xr-x 1 akaedu akaedu   706 Sep 10  2009 initscript.sample
-rwxrwxr-x 1 akaedu akaedu 22259 Jun 22 13:27 killall5
-rwxrwxr-x 1 akaedu akaedu 22117 Jun 22 13:36 last
-rwxrwxr-x 1 akaedu akaedu  7730 Jun 22 13:36 mesg
-rwxrwxr-x 1 akaedu akaedu  7708 Jun 22 13:30 mountpoint
-rwxrwxr-x 1 akaedu akaedu  7368 Jun 22 13:30 runlevel
-rwxrwxr-x 1 akaedu akaedu 27547 Jun 22 13:30 shutdown
-rwxrwxr-x 1 akaedu akaedu 17677 Jun 22 13:36 sulogin
-rwxrwxr-x 1 akaedu akaedu 12638 Jun 22 13:36 utmpdump
-rwxrwxr-x 1 akaedu akaedu 13243 Jun 22 13:36 wall
$
```



```
$ ls -l | grep "x "
-rwxrwxr-x 1 akaedu akaedu 17677 Jun 22 13:28 a.out
-rwxrwxr-x 1 akaedu akaedu 18162 Jun 22 13:36 bootlogd
-rwxrwxr-x 1 akaedu akaedu  7402 Jun 22 13:27 fstab-decode
-rwxrwxr-x 1 akaedu akaedu 17625 Jun 22 13:30 halt
-rwxrwxr-x 1 akaedu akaedu 42121 Jun 22 13:30 init
-rwxr-xr-x 1 akaedu akaedu   706 Sep 10  2009 initscript.sample
-rwxrwxr-x 1 akaedu akaedu 22259 Jun 22 13:27 killall5
-rwxrwxr-x 1 akaedu akaedu 22117 Jun 22 13:36 last
-rwxrwxr-x 1 akaedu akaedu  7730 Jun 22 13:36 mesg
-rwxrwxr-x 1 akaedu akaedu  7708 Jun 22 13:30 mountpoint
-rwxrwxr-x 1 akaedu akaedu  7368 Jun 22 13:30 runlevel
-rwxrwxr-x 1 akaedu akaedu 27547 Jun 22 13:30 shutdown
-rwxrwxr-x 1 akaedu akaedu 17677 Jun 22 13:36 sulogin
-rwxrwxr-x 1 akaedu akaedu 12638 Jun 22 13:36 utmpdump
-rwxrwxr-x 1 akaedu akaedu 13243 Jun 22 13:36 wall
$ 
```

Figure 5.5: 查看可执行文件

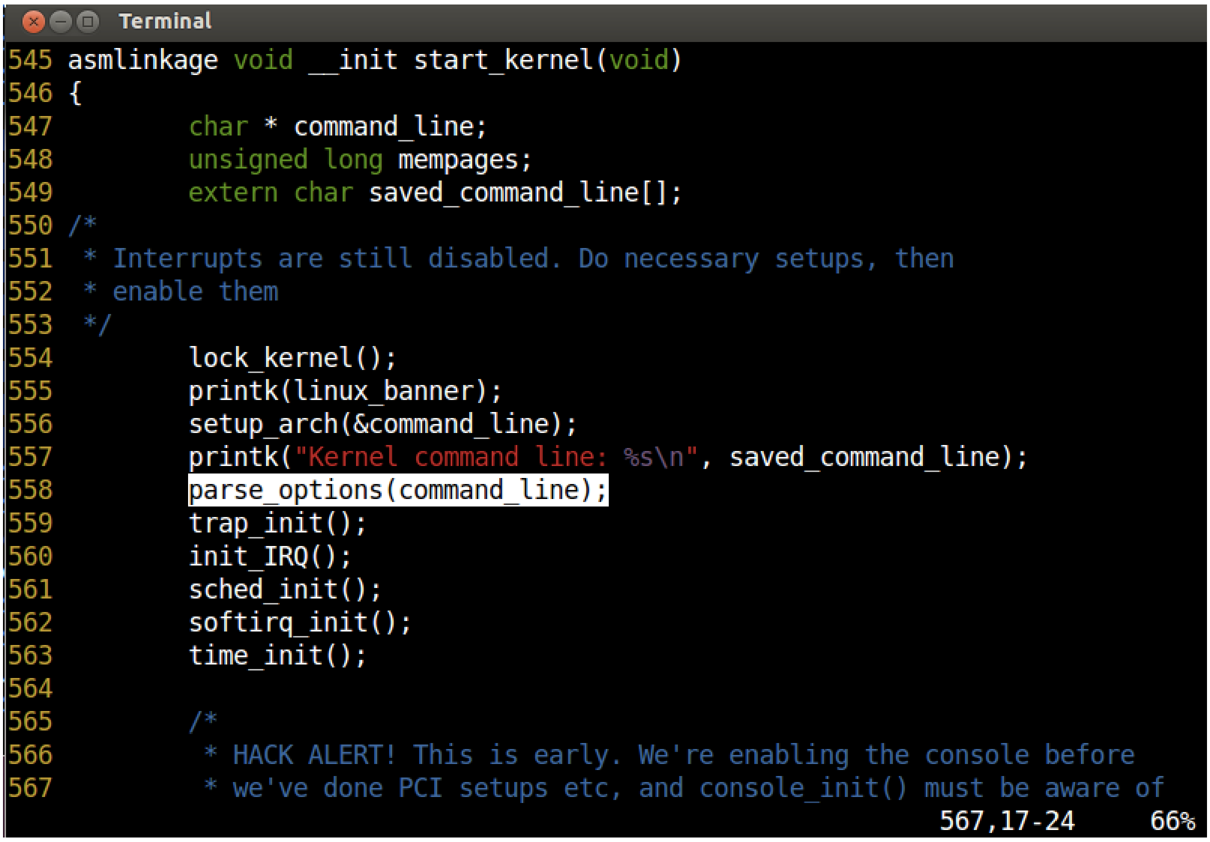
5.2 Linux 内核启动 init 进程

5.2.1 start_kernel

```
asmlinkage void __init start_kernel(void)
{
        char * command_line;
        unsigned long mempages;
        extern char saved_command_line[];
/*
 * Interrupts are still disabled. Do necessary setups, then
 * enable them
 */
        lock_kernel();
        printk(linux_banner);
        setup_arch(&command_line);
        printk("Kernel command line: %s\n", saved_command_line);
        parse_options(command_line);
        trap_init();
        init_IRQ();
        sched_init();
        softirq_init();
        time_init();

.....
        /*
         *      We count on the initial thread going ok
        *     Like idlers init is an unlocked kernel thread, which will
         *      make syscalls (and thus be locked).
         */
        smp_init();
        rest_init();
}

```

5.2.2 parse_options

```
static void __init parse_options(char *line)
{
        char *next,*quote;
```



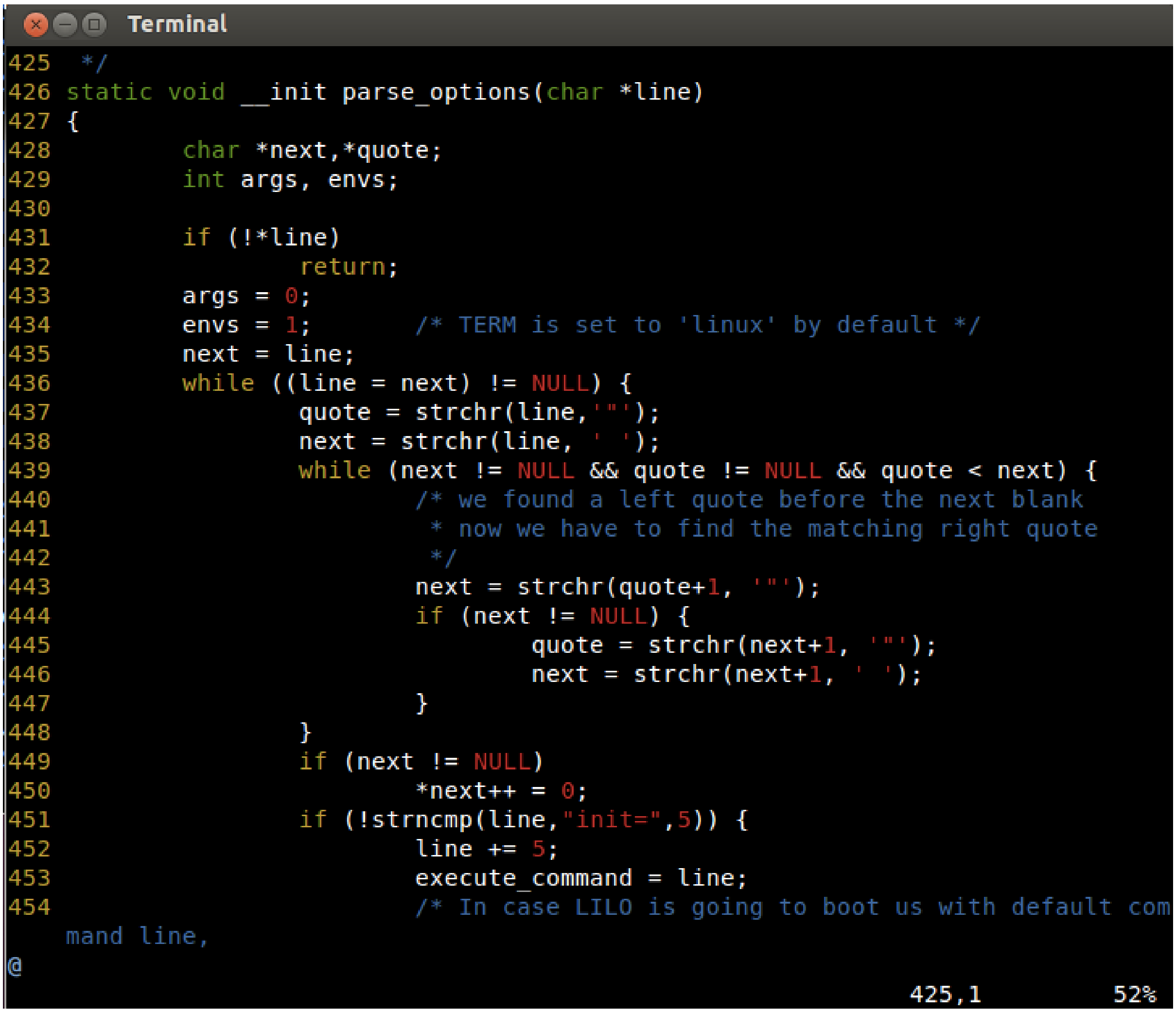
```
asmlinkage void __init start_kernel(void)
{
        char * command_line;
        unsigned long mempages;
        extern char saved_command_line[];
/*
 * Interrupts are still disabled. Do necessary setups, then
 * enable them
 */
        lock_kernel();
        printk(linux_banner);
        setup_arch(&command_line);
        printk("Kernel command line: %s\n", saved_command_line);
        parse_options(command_line);
        trap_init();
        init_IRQ();
        sched_init();
        softirq_init();
        time_init();

        /*
         * HACK ALERT! This is early. We're enabling the console before
         * we've done PCI setups etc, and console_init() must be aware of
                                                              567,17-24      66%
```

Figure 5.6: 内核 start_kernel 函数

```
        int args, envs;

        if (!*line)
                return;
        args = 0;
        envs = 1;       /* TERM is set to 'linux' by default */
        next = line;
        while ((line = next) != NULL) {
                quote = strchr(line,'"');
                next = strchr(line, ' ');
               while (next != NULL && quote != NULL && quote < next) {
                        /* we found a left quote before the next blank
                        * now we have to find the matching right quote
                         */
                        next = strchr(quote+1, '"');
                        if (next != NULL) {
                                quote = strchr(next+1, '"');
                                next = strchr(next+1, ' ');
                        }
                }
                if (next != NULL)
                        *next++ = 0;
                if (!strncmp(line,"init=",5)) {
                        line += 5;
                        execute_command = line;
                    /* In case LILO is going to boot us with default com
```

5.2.3 rest_init

```

static void rest_init(void)
{
      kernel_thread(init, NULL, CLONE_FS | CLONE_FILES | CLONE_SIGNAL);
        unlock_kernel();
        current->need_resched = 1;
        cpu_idle();
}

```



```
 */
static void __init parse_options(char *line)
{
        char *next,*quote;
        int args, envs;

        if (!*line)
                return;
        args = 0;
        envs = 1;       /* TERM is set to 'linux' by default */
        next = line;
        while ((line = next) != NULL) {
                quote = strchr(line,'"');
                next = strchr(line, ' ');
                while (next != NULL && quote != NULL && quote < next) {
                        /* we found a left quote before the next blank
                         * now we have to find the matching right quote
                         */
                        next = strchr(quote+1, '"');
                        if (next != NULL) {
                                quote = strchr(next+1, '"');
                                next = strchr(next+1, ' ');
                        }
                }
                if (next != NULL)
                        *next++ = 0;
                if (!strncmp(line,"init=",5)) {
                        line += 5;
                        execute_command = line;
                        /* In case LILO is going to boot us with default com
mand line,
@
                                                            425,1          52%
```

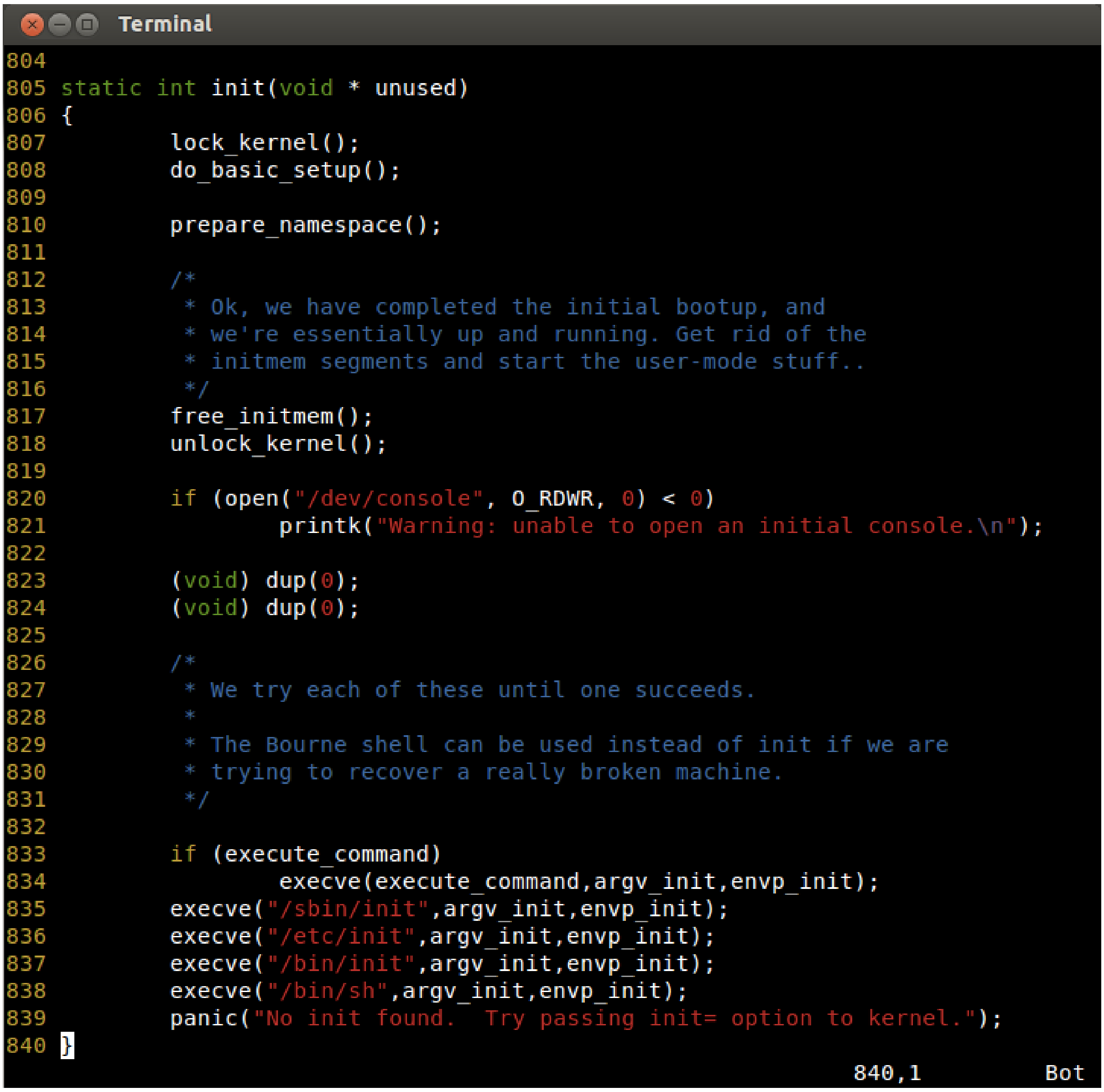
Figure 5.7: 内核 parse_options 函数

5.2.4 init 函数

```
static int init(void * unused)
{
        lock_kernel();
        do_basic_setup();

        prepare_namespace();

        /*
         * Ok, we have completed the initial bootup, and
         * we're essentially up and running. Get rid of the
         * initmem segments and start the user-mode stuff..
         */
        free_initmem();
        unlock_kernel();

        if (open("/dev/console", O_RDWR, 0) < 0)
              printk("Warning: unable to open an initial console.\n");

        (void) dup(0);
        (void) dup(0);

        /*
         * We try each of these until one succeeds.
         *
         * The Bourne shell can be used instead of init if we are
         * trying to recover a really broken machine.
         */

        if (execute_command)
                execve(execute_command,argv_init,envp_init);
        execve("/sbin/init",argv_init,envp_init);
        execve("/etc/init",argv_init,envp_init);
        execve("/bin/init",argv_init,envp_init);
        execve("/bin/sh",argv_init,envp_init);
        panic("No init found.  Try passing init= option to kernel.");
}
```

至此我们找到了一条路径，使得内核从 start_kernel 的主函数，进入到 init 进程。这里涉及到了 4 个重要的函数和 1 个重要的变量，这些都是和 init 进程如何启动直接相关的，对于我们了解在 init 进程启动之前的逻辑流程有重要作用。

- start_kernel()



```
static int init(void * unused)
{
        lock_kernel();
        do_basic_setup();

        prepare_namespace();

        /*
         * Ok, we have completed the initial bootup, and
         * we're essentially up and running. Get rid of the
         * initmem segments and start the user-mode stuff..
         */
        free_initmem();
        unlock_kernel();

        if (open("/dev/console", O_RDWR, 0) < 0)
                printk("Warning: unable to open an initial console.\n");

        (void) dup(0);
        (void) dup(0);

        /*
         * We try each of these until one succeeds.
         *
         * The Bourne shell can be used instead of init if we are
         * trying to recover a really broken machine.
         */

        if (execute_command)
                execve(execute_command,argv_init,envp_init);
        execve("/sbin/init",argv_init,envp_init);
        execve("/etc/init",argv_init,envp_init);
        execve("/bin/init",argv_init,envp_init);
        execve("/bin/sh",argv_init,envp_init);
        panic("No init found.  Try passing init= option to kernel.");
}
```

Figure 5.8: 内核 init 函数

- parse_options()
- rest_init()
- init()
- execute_command

我们用下面这张图来表示这些函数和变量之间的关系，可以更直观的看到内核启动 init 进程的流程。

/sbin/init

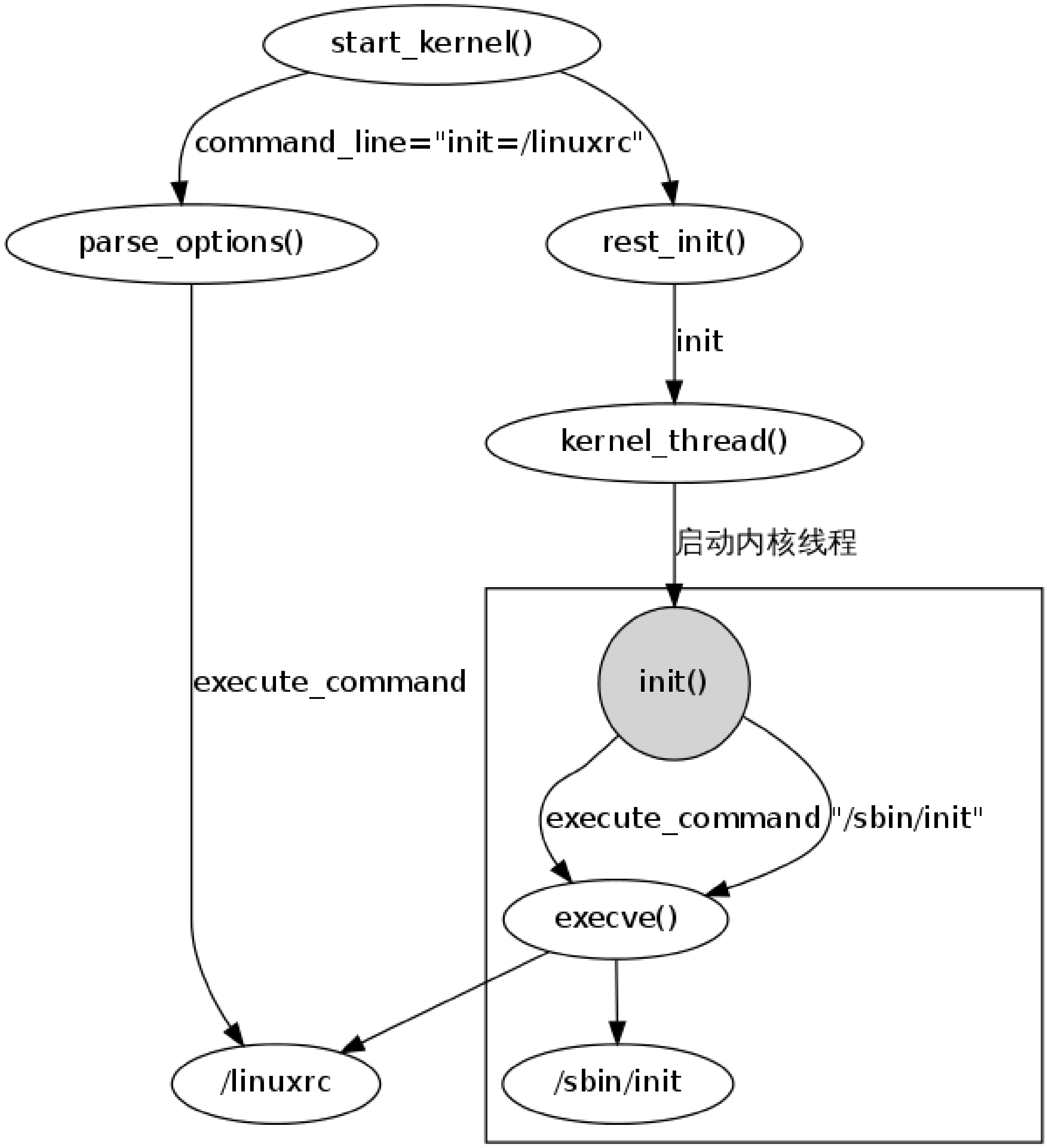


Figure 5.9: Linux 内核启动 init 进程