CSGE602055 Operating Systems
CSF2600505 Sistem Operasi
Minggu 09: File System & Persistent Storage

Rahmat M. Samik-Ibrahim

Universitas Indonesia

http://rms46.vlsm.org/2/207.html

REV104 17-JAN-2018

Operating Systems 2018-1 (Room 3114 Tue/Thu)
Class: A (10:00-12:00) | B (13:00-15:00) | C (16:00-18:00)

Week 00	06 Feb - 12 Feb 2018	Intro & Review1
Week 01	13 Feb - 19 Feb 2018	Review2 & Scripting
Week 02	20 Feb - 26 Feb 2018	Protection, Security, Privacy, & C-language
Week 03	27 Feb - 05 Mar 2018	I/O, BIOS, Loader, & Systemd
Week 04	06 Mar - 12 Mar 2018	Addressing, Shared Lib, & Pointer
Week 05	13 Mar - 19 Mar 2018	Virtual Memory
Reserved	20 Mar - 24 Mar 2018	
Mid-Term	26 Mar - 03 Apr 2018	(UTS)
Week 06	05 Apr - 11 Apr 2018	Concurency: Processes & Threads
Week 07	12 Apr - 18 Apr 2018	Synchronization
Week 08	19 Apr - 25 Apr 2018	Scheduling
Week 09	26 Apr - 05 May 2018	File System & Persistent Storage
Week 10	07 May - 16 May 2018	I/O Programming & Network Sockets Programming
Reserved	17 May - 22 May 2018	
Final	23 May - 26 May 2018	(UAS)

Agenda

Week 09: File System & Persistent Storage

- Reference: (OSCE2e ch9/10/11) (UCB 17A/18/19) (UDA P4L2 P4L2) (OLD 07 09) (SUP WEEK09)
- File System Interface
- File Attribute
- File Operation
- Disk Stucture and Organization
- File Systen Types
- Directory
- FS Mounting vs. Volume Based System
- FS Structure and Implementation
- File Control Block
- FS In Memory Structure
- VFS
- Directory Implementation

File Systems

- File System Layers
  - Application Programs
  - Logical File Systems
  - File-Organization Module
  - Basic File Systems
  - I/O Control
  - Hardware Device
- Allocation Method
  - Contiguous
  - Linked
  - Indexed
  - Combined Scheme
- Cache
- STREAMS

Mass Storage Systems

- Mass Storage Structure
  - Solid State Disk
  - Storage Array
  - SAN
  - NAS
  - Scheduling: FCFS, SSTF, SCAN, C-SCAN, C-LOOK.
  - Disk Management
- Linux I/O Scheduling Algorithm.
  - Deadline Scheduler
  - Completely Fair Queueing (CFQ)

RAID

- RAID 0, 1, 5, 6, 10, 100
- Note (`http://www.commodore.ca/windows/raid5/raid5.htm`):
  - RAID was created to enhance data performance, reliability and availability.
  - Striping, parity checking and mirroring are three primary functions of RAID systems.
  - RAID performs its functions transparent to the operating system.
  - Systems are typically defined by ranks consisting of five disks each connected to one or two Disk Array Controllers.
  - Different RAID levels provide varying degrees of speed and data protection.

Devices

- the `/dev/` directory
  - `/etc/fstab`: configuration of filesystems
  - `/etc/mtab` $\rightarrow$ `/proc/mounts`: mounted filesystems
  - `/proc/swaps`: swap filesystems
  - `df`: checking diskspace and filesystems
  - Device Major and Minor Numbers
  - UUID - Universally Unique IDentifier (128 bits)
  - GUID - Globally Unique IDentifiers: `ls -al /dev/disk/by-uuid`
  - practically is NOT guaranteed unique
  - FUSE: Filesystem in Userspace
  - BBFS: Big Brother File System

FUSE

```
>>>>> $ ls -al
total 16
drwxr-xr-x  3 demo demo 4096 May  2  2017 .
drwxr-xr-x 13 demo demo 4096 Sep 22 15:03 ..
drwxr-xr-x  5 demo demo 4096 Aug 27 15:28 fuse-tutorial-2016-03-25
-rw-r--r--  1 demo demo  192 May  2  2017 readme.txt

>>>>> $ cat readme.txt
REV01 Tue May  2 10:21:45 WIB 2017
START Mon Nov 21 14:39:48 WIB 2016
==================================

1. cd fuse-tutorial-2016-03-25
2. lynx index.html
3. make
4. cat example/ZREADME.txt
```

FUSE (2)

```
>>>>> $ lynx index.html
>>>>> $ lynx -dump index.html > tmptmp.txt
>>>>> $ vi tmptmp.txt
>>>>> $


                    Writing a FUSE Filesystem: a Tutorial

  Joseph J. Pfeiffer, Jr., Ph.D.
  Emeritus Professor
  Department of Computer Science
  New Mexico State University
  [1]pfeiffer@cs.nmsu.edu

   Version of 2016-03-25

   One of the real contributions of Unix has been the view that
   "everything is a file". A tremendous number of radically different
   sorts of objects, from data storage to file format conversions to
   internal operating system data structures, have been mapped to the file
   abstraction.

   One of the more recent directions this view has taken has been
   Filesystems in User Space, or FUSE (no, the acronym really doesn't
   work. Oh well). The idea here is that if you can envision your
   interaction with an object in terms of a directory structure and
   filesystem operations, you can write a FUSE file system to provide that
   interaction. You just write code that implements file operations like
   open(), read(), and write(); when your filesystem is mounted, programs
   are able to access the data using the standard file operation system
   calls, which call your code.
[........]
```

FUSE (3)

```
>>>>> $ make clean
Making clean in example
make[1]: Entering directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/example'
rm -rf mountdir rootdir
rm -rf bbfs.log
make[1]: Leaving directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/example'
Making clean in html
make[1]: Entering directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/html'
make[1]: Nothing to be done for 'clean'.
make[1]: Leaving directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/html'
Making clean in src
make[1]: Entering directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/src'
test -z "bbfs" || rm -f bbfs
rm -f *.o
make[1]: Leaving directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/src'
make[1]: Entering directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25'
make[1]: Nothing to be done for 'clean-am'.
make[1]: Leaving directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25'
```

FUSE (4)

```
>>>>> $ make
Making all in example
make[1]: Entering directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/example'
mkdir -p mountdir
mkdir -p rootdir
echo "bogus file" > rootdir/bogus.txt
make[1]: Leaving directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/example'
Making all in html
make[1]: Entering directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/html'
make[1]: Nothing to be done for 'all'.
make[1]: Leaving directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/html'
Making all in src
make[1]: Entering directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/src'
make  all-am
make[2]: Entering directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/src'
gcc -DHAVE_CONFIG_H -I.    -D_FILE_OFFSET_BITS=64 -I/usr/include/fuse  -g -O2 -MT bbfs.o -MD -MP -MF
      .deps/bbfs.Tpo -c -o bbfs.o bbfs.c
mv -f .deps/bbfs.Tpo .deps/bbfs.Po
gcc -DHAVE_CONFIG_H -I.    -D_FILE_OFFSET_BITS=64 -I/usr/include/fuse  -g -O2 -MT log.o -MD -MP -MF
      .deps/log.Tpo -c -o log.o log.c
mv -f .deps/log.Tpo .deps/log.Po
gcc -D_FILE_OFFSET_BITS=64 -I/usr/include/fuse  -g -O2   -o bbfs bbfs.o log.o -lfuse -pthread
make[2]: Leaving directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/src'
make[1]: Leaving directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/src'
make[1]: Entering directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25'
make[1]: Nothing to be done for 'all-am'.
make[1]: Leaving directory '/home/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25'
>>>>> $
```

FUSE (5)

```
>>>>> $ cd example/

>>>>> $ ls -al
total 24
drwxr-xr-x 4 demo demo 4096 Nov 14 11:08 .
drwxr-xr-x 5 demo demo 4096 Nov 14 09:52 ..
-rw-r--r-- 1 demo demo  207 Nov 14 09:59 Makefile
drwxr-xr-x 2 demo demo 4096 Nov 14 11:08 mountdir
drwxr-xr-x 2 demo demo 4096 Nov 14 11:08 rootdir
-rw-r--r-- 1 demo demo  576 Nov 14 11:06 ZREADME.txt

>>>>> $ cat ZREADME.txt
REV01 Tue Nov 14 11:05:17 WIB 2017
START Mon Nov 21 14:41:33 WIB 2016
============================

TO TRY:
$ ls -al rootdir
$ ls -al mountdir
$ ../src/bbfs rootdir/ mountdir/
$ df
$ ls -al rootdir
$ ls -al mountdir

TO PLAY:
$ cd mountdir
$ touch blah-blah-blah.txt
$ ls -al
$ cd ..
$ ls -al rootdir

[.....]
```

FUSE (6)

```
>>>>> $ ls -al rootdir/
total 12
drwxr-xr-x 2 demo demo 4096 Nov 14 11:08 .
drwxr-xr-x 4 demo demo 4096 Nov 14 11:08 ..
-rw-r--r-- 1 demo demo   11 Nov 14 11:08 bogus.txt

>>>>> $ ls -al mountdir/
total 8
drwxr-xr-x 2 demo demo 4096 Nov 14 11:08 .
drwxr-xr-x 4 demo demo 4096 Nov 14 11:08 ..

>>>>> $ df
Filesystem     1K-blocks     Used Available Use% Mounted on
udev              10240        0     10240   0% /dev
tmpfs           1639432    29352   1610080   2% /run
/dev/vda2       9515660  1061184   7948060  12% /
/dev/vdc1      32895760 12041032  19160676  39% /usr
tmpfs           4098580        0   4098580   0% /dev/shm
tmpfs              5120        0      5120   0% /run/lock
tmpfs           4098580        0   4098580   0% /sys/fs/cgroup
/dev/vdb1     515929528 20127528 469571268   5% /home
tmpfs            819716        0    819716   0% /run/user/1002
tmpfs            819716        0    819716   0% /run/user/5428

>>>>> $ ../src/bbfs rootdir/ mountdir/
Fuse library version 2.9
about to call fuse_main
```

FUSE (7)

```
>>>>> $ df
Filesystem     1K-blocks     Used Available Use% Mounted on
udev               10240        0     10240   0% /dev
tmpfs            1639432    29352   1610080   2% /run
/dev/vda2        9515660  1061184   7948060  12% /
/dev/vdc1       32895760 12041032  19160676  39% /usr
tmpfs            4098580        0   4098580   0% /dev/shm
tmpfs               5120        0      5120   0% /run/lock
tmpfs            4098580        0   4098580   0% /sys/fs/cgroup
/dev/vdb1      515929528 20127532 469571264   5% /home
tmpfs             819716        0    819716   0% /run/user/1002
tmpfs             819716        0    819716   0% /run/user/5428
bbfs           515929528 20127532 469571264   5%
      /home/demo/git/demo/demos/week09-File-Storage-System/fuse-tutorial-2016-03-25/example/mountdir

>>>>> $ ls -al mountdir/
total 12
drwxr-xr-x 2 demo demo 4096 Nov 14 11:08 .
drwxr-xr-x 4 demo demo 4096 Nov 14 11:13 ..
-rw-r--r-- 1 demo demo   11 Nov 14 11:08 bogus.txt

>>>>> $ ls -al rootdir/
total 12
drwxr-xr-x 2 demo demo 4096 Nov 14 11:08 .
drwxr-xr-x 4 demo demo 4096 Nov 14 11:13 ..
-rw-r--r-- 1 demo demo   11 Nov 14 11:08 bogus.txt

>>>>> $
```

FUSE (8)

```
>>>>> $ touch mountdir/adding-something-to-mountdir.txt

>>>>> $ ls -al mountdir/
total 12
drwxr-xr-x 2 demo demo 4096 Nov 14 11:19 .
drwxr-xr-x 4 demo demo 4096 Nov 14 11:13 ..
-rw-r--r-- 1 demo demo    0 Nov 14 11:19 adding-something-to-mountdir.txt
-rw-r--r-- 1 demo demo   11 Nov 14 11:08 bogus.txt

>>>>> $ ls -al rootdir/
total 12
drwxr-xr-x 2 demo demo 4096 Nov 14 11:19 .
drwxr-xr-x 4 demo demo 4096 Nov 14 11:13 ..
-rw-r--r-- 1 demo demo    0 Nov 14 11:19 adding-something-to-mountdir.txt
-rw-r--r-- 1 demo demo   11 Nov 14 11:08 bogus.txt

>>>>> $ fusermount -u mountdir

>>>>> $ ls -al mountdir/
total 8
drwxr-xr-x 2 demo demo 4096 Nov 14 11:08 .
drwxr-xr-x 4 demo demo 4096 Nov 14 11:13 ..

>>>>> $ ls -al rootdir/
total 12
drwxr-xr-x 2 demo demo 4096 Nov 14 11:19 .
drwxr-xr-x 4 demo demo 4096 Nov 14 11:13 ..
-rw-r--r-- 1 demo demo    0 Nov 14 11:19 adding-something-to-mountdir.txt
-rw-r--r-- 1 demo demo   11 Nov 14 11:08 bogus.txt

>>>>> $
```

The End

- This is the end of the presentation.