

CSGE602055 Operating Systems

CSF2600505 Sistem Operasi

Week 10: I/O Programming & Network Sockets Programming

Rahmat M. Samik-Ibrahim

University of Indonesia

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

Always check for the latest revision!

REV133 12-Apr-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	Schedule	Topic	OSC9
Week 00	06 Feb - 12 Feb 2018	Overview 1	Ch. 1, 16
Week 01	13 Feb - 19 Feb 2018	Overview 2 & Scripting	Ch. 1, 2
Week 02	20 Feb - 26 Feb 2018	Protection, Security, Privacy, & C-language	Ch. 14, 15
Week 03	27 Feb - 05 Mar 2018	I/O, BIOS, Loader, & Systemd	Ch. 13
Week 04	06 Mar - 12 Mar 2018	Addressing, Shared Lib, & Pointer	Ch. 8
Week 05	13 Mar - 19 Mar 2018	Virtual Memory	Ch. 9
Reserved	20 Mar - 24 Mar 2018		
Mid-Term	03 Apr 2018	13:00 - 15:30 (UTS)	
Week 06	05 Apr - 11 Apr 2018	Concurrency: Processes & Threads	Ch. 3, 4
Week 07	12 Apr - 18 Apr 2018	Synchronization	Ch. 5, 7
Week 08	19 Apr - 25 Apr 2018	Scheduling	Ch. 6
Week 09	26 Apr - 07 May 2018	File System & Persistent Storage	Ch. 10, 11, 12
Reserved	08 May - 14 May 2018		
Week 10	15 May - 21 May 2018	I/O Programming & Network Sockets Programming	
Reserved	22 May - 22 May 2018		
Final	23 May - 26 May 2018	(UAS)	
Deadline	07 Jun 2018 16:00	Extra assignment deadline	

• The Check List (Operating Systems)

- ☐ **Starting Point:** <http://rms46.vlsm.org/2/207.html>
- ☐ **Text Book:** any recent/decent OS book but map it to **OSC9**.
- ☐ Create **public** project "os181" on your github.com account.
 - ☐ Create file "README.md" and add an extra line every week. For e.g.¹:
ZCZC Sistem Operasi 2018 Awal (1)
ZCZC W01 Have tried demo for week 01.
ZCZC W02 Week 02 is done.
ZCZC W03 Week 03 is done.
- ☐ Encode your **QRC** with image size of approximately 250x250 pixels:
"OS181 CLASS ID GITHUB-ACCOUNT SSO-ACCOUNT SIAK-Full-Name"
Special for Week 00: Mail your **embedded** QRC to: os181@vlsm.org
with Subject: [W00] CLASS ID SIAK-NAME.
- ☐ Write your Memo (with QRC) **every week**.
- ☐ Using your **SSO** account, login to badak.cs.ui.ac.id via kawung.cs.ui.ac.id.
 - ☐ Check folder badak:///extra/Week00/
 - ☐ Every week, copy the weekly demo files to your own home directory.
Eg. for Week00:
cp -r /extra/Week00/W00-demos/ W00-demos/

¹Week 00 line is optional. The following "ZCZC WXX" weekly tags are mandatory.

Agenda

- 1 Start
- 2 Agenda
- 3 Week 10
- 4 Body of Knowledge
- 5 Issues
- 6 50-get-put — 51-get-put-loop
- 7 52-open-close
- 8 53-file-pointer
- 9 54-write
- 10 55-write
- 11 56-copy
- 12 57-dup
- 13 58-dup2
- 14 59-io
- 15 60-readwrite
- 16 The End

Week 10: I/O Programming & Network Sockets Programming

- Reference: (demo-w10)

- 18 Knowledge Area (IEEE/ACM 2013)

AL - Algorithms and Complexity	AR - Architecture and Organization
CN - Computational Science	DS - Discrete Structures
GV - Graphics and Visualization	HCI - Human-Computer Interaction
IAS - Information Assurance and Security	IM - Information Management
IS - Intelligent Systems	NC - Networking and Communications
OS - Operating Systems	PBD - Platform-based Development
PD - Parallel and Distributed Computing	PL - Programming Languages
SDF - Software Development Fundamentals	SE - Software Engineering
SF - Systems Fundamentals	SP - Social Issues and Professional Practice

- OS - Operating Systems (IEEE/ACM 2013)

- OS/Overview of Operating Systems (T1:2)
- OS/Operating System Principles (T1:2)
- OS/Concurrency (T2:3)
- OS/Scheduling and Dispatch (T2:3)
- OS/Memory Management (T2:3)
- OS/Security and Protection (T2:2)
- OS(Electives): Virtual Machines, Device Management, File Systems, Real Time and Embedded Systems, Fault Tolerance, System Performance Evaluation.

- General View (IEEE/ACM 2013)
- The Amnesia and Tabula Rasa Problem
- MEMOS: QRC
- EXAM: Open/Close/Memo
- LABS?
- The "Monkey Book"
- Weeks 0-9
- Week10?
- Week11 Extra

50-get-put — 51-get-put-loop

```
#include <stdio.h>

void main (void) {
    int cc = getchar();
    putchar(cc);
    putchar('\n');
}
```

```
>>>> $ 50-get-put
x
x
>>>> $ 50-get-put
abcde
a
```

```
=====
#include <stdio.h>

void main (void) {
    int cc;
    while((cc = getchar()) != EOF) {
        putchar(cc);
    }
}
```

```
>>>> $ 51-get-put-loop
xxxx
xxxx
```


52-open-close

```
* === umask() ===
* int open(const char* pathname, int flags, mode_t mode);
* === FLAGS: ===
* O_RDONLY      Open the file so that it is read only.
* O_WRONLY      Open the file so that it is write only.
* O_RDWR       Open the file so that it can be read from and written to.
* O_APPEND      Append new information to the end of the file.
* O_TRUNC       Initially clear all data from the file.
* O_CREAT       If the file does not exist, create it.
*               You must include the third parameter.
* O_EXCL        With O_CREAT: exists, the call will fail.
* === MODE ===
* S_IRWXU       00700 user (file owner) has read, write and execute permission
* S_IRUSR       00400 user has read permission
* S_IWUSR       00200 user has write permission
* S_IXUSR       00100 user has execute permission
*
* S_IRWXG       00070 group has read, write and execute permission
* S_IRGRP       00040 group has read permission
* S_IWGRP       00020 group has write permission
* S_IXGRP       00010 group has execute permission
*
* S_IRWXO       00007 others have read, write and execute permission
* S_IROTH       00004 others have read permission
* S_IWOTH       00002 others have write permission
* S_IXOTH       00001 others have execute permission
```

52-open-close (2)

```
#define FILE1 "demo-file1.txt"
#define FILE2 "demo-file2.txt"
#define FILE3 "demo-file3.txt"

#include <stdio.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>
void main(void) {
    char*   file1=FILE1;
    char*   file2=FILE2;
    char*   file3=FILE3;

    int fd; /* to hold a file descriptor */
    /* umask(0);      ***** */
    fd = open (file1, O_CREAT | O_RDWR, S_IRWXU);
    close(fd);
    fd = open (file2, O_CREAT | O_RDWR, S_IRWXU|S_IRGRP|S_IWGRP|S_IROTH);
    close(fd);
    fd = open (file3, O_CREAT | O_RDWR, 0711);
    close(fd);
    fd = open (file3, O_CREAT | O_RDWR, 0700);
    close(fd);
}

>>>> $ ls -al demo-file[234].txt
-rwxr--r-- 1 demo demo  0 Oct  5 17:49 demo-file2.txt
-rwx--x--x 1 demo demo  0 Oct  5 17:49 demo-file3.txt
-rw-r--r-- 1 demo demo 75 Oct  5 17:49 demo-file4.txt
>>>> $
```

53-file-pointer

```
#define FILE4 "demo-file4.txt"
#include <stdio.h>
#include <stdlib.h>

void main(void) {
    FILE* fp;
    int    cc;

    printf ("*** Open and listing file %s ***\n\n", FILE4);
    if ((fp=fopen(FILE4, "r")) == NULL) {
        printf("fopen error...\n");
        exit(1);
    }
    while((cc=fgetc(fp)) != EOF) {
        printf("%c", cc);
    }
    printf("\n");
    fclose(fp);
}
```

*** Open and listing file demo-file4.txt ***

Line 1: Blah Blah Blah 1
Line 2: Blah Blah Blah 2
Line 3: Blah Blah Blah 3

54-write

```
#include <stdio.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>
#include <string.h>

#define FILE5    "demo-file5.txt"
static char* str1 = "AAAXBBB\n";
static char* str2 = "CCC\n";

void main(void) {
    int fd1, fd2;
    fd1 = open (FILE5, O_RDWR | O_CREAT, 0644);
    fd2 = open (FILE5, O_RDWR | O_CREAT, 0644);
    printf("File Descriptors --- fd1 = %d, fd2 = %d\n", fd1, fd2);
    write(fd1, str1, strlen(str1));
    write(fd2, str2, strlen(str2));
    close(fd1);
    close(fd2);
    printf("See output file %s\n", FILE5);
}
```

```
#####
File Descriptors --- fd1 = 3, fd2 = 4
See output file demo-file5.txt
```

```
#####
demo-file5.txt:
CCC
BBB
```

55-write

```
#define FILE6 "demo-file6.txt"
char buf1[] = "abcdefgh";
char buf2[] = "ABCDEFGH";

void main(void) {
    int fd;
    fd = creat(FILE6, 0644);
    if (fd < 0) {
        perror("creat error");
        exit(1);
    }
    if (write(fd, buf1, 8) != 8) {
        perror("buf1 write error");
        exit(1);
    } /* offset now = 8 */
    if (lseek(fd, 32, SEEK_SET) == -1) {
        perror("lseek error");
        exit(1);
    } /* offset now = 32 */
    if (write(fd, buf2, 8) != 8) {
        perror("buf2 write error");
        exit(1);
    } /* offset now = 40 */
    close(fd);
    printf("Run: hexdump -c %s\n", FILE6);
}
```

```
>>>> $ hexdump -c demo-file6.txt
00000000  a  b  c  d  e  f  g  h  \0  \0  \0  \0  \0  \0  \0  \0
00000100  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0
00000200  A  B  C  D  E  F  G  H
```

```
#include <stdio.h>
#include <errno.h>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#define BUF_SIZE 16

void main(int argc, char* argv[])
{
    int            fdread, fdwrite;
    unsigned int  total_bytes = 0;
    ssize_t       nbytes_read, nbytes_write;
    char buf[BUF_SIZE];
    if (argc != 3) {
        printf("Usage: %s source destination\n",
            argv[0]);
        exit(1);
    }
    fdread = open(argv[1], O_RDONLY);
    if (fdread < 0) {
        perror("Failed to open source file");
        exit(1);
    }
    fdwrite = creat(argv[2], S_IRWXU);
    if (fdwrite < 0) {
        perror("Failed to open destination file");
        exit(1);
    }
}
```

56-copy (2)

```
do {
    nbytes_read = read(fdread, buf, BUF_SIZE);
    if (nbytes_read < 0) {
        perror("Failed to read from file");
        exit(1);
    }
    nbytes_write = write(fdwrite, buf, nbytes_read);
    if (nbytes_write < 0) {
        perror("Failed to write to file");
        exit(1);
    }
} while (nbytes_read > 0);
close(fdread);
close(fdwrite);
exit(0);
}
```

#####

```
>>>> $ ./56-copy demo-file4.txt demo-copy.txt
>>>> $ ls -al demo-file4.txt demo-copy.txt
-rwx----- 1 demo demo 75 Oct  5 18:12 demo-copy.txt
-rw-r--r-- 1 demo demo 75 Oct  5 17:49 demo-file4.txt
>>>> $
```

57-dup

```
#include <stdio.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>
#include <string.h>
#define FILE1 "demo-file7.txt"
```

```
static char* str1 = "AAAXBBB\n";
static char* str2 = "CCC\n";
```

Coming Soon

```
void
{
    int fd1, fd2;
    fd1 = open (FILE1, O_RDWR | O_CREAT, 0644);
    fd2 = dup(fd1);
    printf("File Descriptors --- fd1 = %d, fd2 = %d\n", fd1, fd2);
    write(fd1, str1, strlen(str1));
    write(fd2, str2, strlen(str2));
    close(fd1);
    close(fd2);
    printf("**** Please check file %s *****\n", FILE1);
    printf("**** Compare with 54-write\n");
}
```

```
#####
```

```
>>>> $ 57-dup
```

```
File Descriptors --- fd1 = 3, fd2 = 4
```

```
**** Please check file demo-file7.txt ****
```

```
**** Compare with 54-write
```

```
>>>> $ cat demo-file7.txt
```

```
AAAXBBB
```

```
CCC
```

```
>>>> $
```


58-dup2

```
#include <stdio.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>
#include <string.h>
#define FILE1 "demo-file8.txt"

static char* str1 = "AAAXBBB\n";
static char* str2 = "CCC\n";

void main(void) {
    int fd1, fd2;
    fd1 = open (FILE1, O_RDWR | O_CREAT, 0644);
    dup2(fd1, fd2);
    printf("File Descriptors --- fd1 = %d, fd2 = %d\n", fd1, fd2);
    write(fd1, str1, strlen(str1));
    write(fd2, str2, strlen(str2));
    close(fd1);
    close(fd2);
    printf("**** Please check file %s *****\n", FILE1);
    printf("**** Compare with 54-write\n");
}
```

```
#####
>>>> $ 58-dup2
File Descriptors --- fd1 = 3, fd2 = 0
**** Please check file demo-file8.txt ****
**** Compare with 54-write
>>>> $ cat demo-file8.txt
AAAXBBB
CCC
>>>> $
```

59-io

```
#include <stdio.h>
#include .....
#define FILE1 "demo-file9.txt"

void main(void) {
    int fd1, fd2;
    char strvar[100];
    printf ("***** Please check file %s *****\n", FILE1);
/* BLOCK *****
    close(STDERR_FILENO);
    close(STDOUT_FILENO);
    BLOCK ***** */
    fd1 = open (FILE1, O_RDWR | O_CREAT | O_TRUNC, 0644);
    fd2 = dup(fd1);
    printf(          "AAAAA print to standard output!!\n");
    fprintf(stdout, "BBBBB print to standard output!!\n");
    fprintf(stderr, "CCCCC print to standard error!!!\n");
    sprintf(strvar, "DDDDD print to fd1=%d!!!\n", fd1);
    dprintf(fd1,      "%s", strvar);
    dprintf(fd2,      "EEEEE print to fd2=%d!!!\n", fd2);
    close(fd1);
    close(fd2);
}

>>>> $ 59-io ; echo "~~~~~";cat demo-file9.txt
***** Please check file demo-file9.txt *****
AAAAA print to standard output!!
BBBBB print to standard output!!
CCCCC print to standard error!!!
~~~~~
DDDDD print to fd1=3!!!
EEEEE print to fd2=4!!!
```

59-io (2)

```
#include <stdio.h>
#include .....
#define FILE1 "demo-file9.txt"

void main(void) {
    int fd1, fd2;
    char strvar[100];
    printf ("***** Please check file %s *****\n", FILE1);
    close(STDERR_FILENO);
    /* BLOCK *****
    close(STDOUT_FILENO);
    BLOCK ***** */
    fd1 = open (FILE1, O_RDWR | O_CREAT | O_TRUNC, 0644);
    fd2 = dup(fd1);
    printf("AAAAA print to standard output!!\n");
    fprintf(stdout, "BBBBB print to standard output!!\n");
    fprintf(stderr, "CCCCC print to standard error!!!\n");
    sprintf(strvar, "DDDDD print to fd1=%d!!!\n", fd1);
    dprintf(fd1, "%s", strvar);
    dprintf(fd2, "EEEEE print to fd2=%d!!!\n", fd2);
    close(fd1);
    close(fd2);
}

>>>> $ 59-io ; echo "~~~~~";cat demo-file9.txt
***** Please check file demo-file9.txt *****
AAAAA print to standard output!!
BBBBB print to standard output!!
~~~~~
CCCCC print to standard error!!!
DDDDD print to fd1=2!!!
EEEEE print to fd2=3!!!
```

59-io (3)

```
#include <stdio.h>
#include .....
#define FILE1 "demo-file9.txt"

void main(void) {
    int fd1, fd2;
    char strvar[100];
    printf ("***** Please check file %s *****\n", FILE1);
    close(STDERR_FILENO);
    close(STDOUT_FILENO);
    /* BLOCK *****
    BLOCK ***** */
    fd1 = open (FILE1, O_RDWR | O_CREAT | O_TRUNC, 0644);
    fd2 = dup(fd1);
    printf(          "AAAAA print to standard output!!\n");
    fprintf(stdout, "BBBBB print to standard output!!\n");
    fprintf(stderr, "CCCCC print to standard error!!!\n");
    sprintf(strvar, "DDDDD print to fd1=%d!!!\n", fd1);
    dprintf(fd1,      "%s", strvar);
    dprintf(fd2,      "EEEEE print to fd2=%d!!!\n", fd2);
    close(fd1);
    close(fd2);
}

>>>> $ 59-io ; echo "~~~~~";cat demo-file9.txt
**** Please check file demo-file9.txt ****
~~~~~

AAAAA print to standard output!!
BBBBB print to standard output!!
CCCCC print to standard error!!!
DDDDD print to fd1=1!!!
EEEEE print to fd2=2!!!
```

60-readwrite

```
#define FILE1 "demo-fileA.txt"
#define OLOOP 10
#define ILOOP 3650
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <time.h>
#include <fcntl.h>
#include <dirent.h>
void rwfile (char* fname);
void dirfile(char* dname);
void error (char* msg);
/* MAIN ===== */
void main(void) {
    printf("Listing current directory...\n");
    dirfile(".");
    printf("Testing read-write speed...\n");
    rwfile(FILE1);
}
/* DIRFILE ===== */
void dirfile(char* dname) {
    DIR*          ddir;
    struct dirent* dp;
    printf("      ");
    ddir = opendir(dname);
    if (ddir != NULL) {
        while ((dp=readdir(ddir))!= NULL)
            printf("%s ", dp->d_name);
        closedir(ddir); }
    printf("\n\n"); }
```

60-readwrite (2)

```
/* ERROR ===== */
void error(char* msg){
    perror(msg);
    exit(0); }
/* RWFILE ===== */
void rwfile(char* fname) {
    time_t tt;
    int    fd, ii, jj;
    char    buf[] = "Achtung... Achtung... AAAA BBBB CCCC DDDD\n";
    time(&tt);
    for (ii=0;ii<OLOOP;ii++) {
        if ((fd=creat(fname,00644)) < 0 )
            error("RWFILE: can not create file\n");
        for (jj=0;jj<ILOOP;jj++) {
            write(fd,buf,sizeof(buf)-1);
            fsync(fd); }
        close(fd);
        putchar('.') ;
        fflush(NULL); }
    tt=time(NULL)-tt;
    putchar('\n');
    printf("Total time: %d seconds\n", (int) tt);
}

#####
>>>> $ time 60-readwrite
Listing current directory...
      .shsh 52-open-close.c demo-file4.txt 02-pointers.c ...
Testing read-write speed...
.....
Total time: 10 seconds
real    0m9.998s  -----  user    0m0.024s  -----  sys      0m0.576s
```

The End

- ☐ This is the end of the presentation.
- ☒ This is the end of the presentation.
 - This is the end of the presentation.