

CSGE602055 Operating Systems

CSF2600505 Sistem Operasi

Week 04: Addressing, Shared Lib, & Pointer

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

Always check for the latest revision!

REV119 20-FEB-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 | Intro & Review1 | Ch. 1, 16 |
| Week 01 | 13 Feb - 19 Feb 2018 | Review2 & 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 | 26 Mar - 03 Apr 2018 | (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 - 05 May 2018 | File System & Persistent Storage | Ch. 10, 11, 12 |
| 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) | |
| Deadline | 07 Jun 2018 16:00 | Extra assignment deadline | |

● Operating Systems Check List

- ☐ Trace this document from <http://rms46.vlsm.org/2/207.html>
- ☐ Have a decent OS Book and map it to **OSC9**.
- ☐ Create **public** project "os181" on your github.com account.
 - ☐ Write in "README.md" file:
Special for Week 00: "**ZCZC Sistem Operasi 2018 Awal (1)**".
Add line on Week01: "**ZCZC W01 ...**".
On Week02: "**ZCZC W02 ...**".
On WeekXX: "**ZCZC WXX ...**".
- ☐ 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/
 - ☐ Week00: Copy the folder to your home directory:
cp -r /extra/Week00/W00-demos/ W00-demos/
 - ☐ For WeekXX: Copy the folder to your home directory:
cp -r /extra/WeekXX/WXX-demos/ WXX-demos/ (XX=01, 02,... 10).
- ☐ **How to improve this document?**

Agenda I

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- 2 Agenda
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Agenda II

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- 18 50-get-put — 51-get-put-loop
- 19 52-open-close
- 20 53-file-pointer
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- 23 56-copy
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- 26 59-io
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Week 04: Addressing, Shared Lib, & Pointer

- Reference: (OSC9-ch09 demo-w04)
- This will be a difficult week
 - Pray! Pray! We got to pray just to make it today (McH)!
 - Goosfraba: Turn To Page 394 (AM-HP3)!
- 8 bit Variable (eg. `int ii=10;`)
 - Value ($10_{10} == 0x\ 0A$)
 - Logical Address (eg. `0x\ 0040`)
 - Meaning & Context (Variabel "ii" is an integer).
 - `[0x\ 0040] == 0x\ 0A`
- Multiple Address Variable (> 1 byte size)
 - Little-Endian (LE)
 - Big-Endian (BE)
 - Bi-Endian
- Executable File Format
 - Ancient Linux/Unix: Assembler Output \rightarrow `[a.out]`.
 - iOS, MacOS: Mach-Output (Mach-O).
 - Linux: Executable and Linking Format (ELF).
 - Windows: Portable Executable (PE) \rightarrow
`[.acm, .ax, .cpl, .dll, .drv, .efi, .exe, .mui, .ocx, .scr, .sys, .tsp]`.

Programming

- `putchar(char)`
- `getpid()`
- `getppid()`
- `sprintf(char*, const char*)`
- `fflush(NULL)`
- MSIZE1 (10k) MSIZE2 (20k) MSIZE3 (50k) MSIZE4 (100k)
MSIZE5 (1M) MSIZE6 (10M) MSIZE1
- `top`
 - PID (Process Id), PPID (Parent PID), %MEM (Memory), VIRT (Virtual Image KiB), RES (Residen Size KiB), SHR (Shared Memory KiB), SWAP (Swapped Size KiB), CODE (Code Size KiB), DATA (Data+Stack KiB), USED (Res+Swap Size KiB).
 - Save: `~/.toprc`
 - `top -b -n 1 -pYOUR_PID`
- `malloc(size_t)`
- `free(void*)`
- `system(const char*)`

Addressing (Eg. 16 bits)

| 16 Bits Logical Address Table (HEX) | | | | | | | | | | | | | | | | | Examples | | | |
|-------------------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--|-----|--------|-------------|
| ADDR | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F | bits | L/B | PTR | VALUE |
| 000X | A0 | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | AA | AB | AC | AD | AE | AF | 8 | — | [0008] | A8 |
| 001X | B0 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 | B9 | BA | BB | BC | BD | BE | BF | 8 | — | [0014] | B4 |
| 002X | C0 | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | CA | CB | CC | CD | CE | CF | 8 | — | [0015] | B5 |
| 003X | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | DA | DB | DC | DD | DE | DF | 16 | LE | [0014] | B5 B4 |
| 004X | 0A | | | | | | | | | | | | | | | | 16 | BE | [0014] | B4 B5 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | 32 | LE | [0014] | B7 B6 B5 B4 |
| FFFX | | | | | | | | | | | | | | | | | 1 address == 1 byte LE: Little Endian BE: Big Endian | | | |

Makefile

```
CC=gcc
P00=00-global-variables
P01=01-local-variables
...

EXECS= \
    $(P00) \
    $(P01) \
...

DEMOFILES=\
    demo-file1.txt \
    demo-file2.txt \
...

all: $(EXECS)

$(P00): $(P00).c
    $(CC) $(P00).c -o $(P00) -Xlinker -Map=$(P00).map

$(P01): $(P01).c
    $(CC) $(P01).c -o $(P01) -Xlinker -Map=$(P01).map
...

$(P04): $(P04).c
    $(CC) $(P04).c -o $(P04)
...
clean:
    rm -f ${EXECS}
...
demo:
    bash .shsh
```

00-global-variables

```
/* Global Variables in Data Segment*/
```

```
char   varchr0='a';
```

```
char   varchr1='b';
```

```
char   varchr2='c';
```

```
char   varchr3='d';
```

```
char   varchr4='e';
```

```
char   varchr5='f';
```

```
char   varchr6='g';
```

```
char   varchr7='h';
```

```
VARIABLE  +++  VALUE  +CHR+  + ADDRESS+
```

```
varchr0 =          0X61 = a      0x601038
```

```
varchr1 =          0X62 = b      0x601039
```

```
varchr2 =          0X63 = c      0x60103a
```

```
varchr3 =          0X64 = d      0x60103b
```

```
varchr4 =          0X65 = e      0x60103c
```

```
varchr5 =          0X66 = f      0x60103d
```

```
varchr6 =          0X67 = g      0x60103e
```

```
varchr7 =          0X68 = h      0x60103f
```

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|--------|---|---|---|---|---|---|---|---|-----|-----|-----|-----|-----|-----|-----|-----|
| 60103X | | | | | | | | | 'a' | 'b' | 'c' | 'd' | 'e' | 'f' | 'g' | 'h' |

Memory Map

Memory Configuration (00-global-char.map)

| Name | Origin | Length | Attributes |
|-----------|--------------------|--------------------|-----------------------------|
| *default* | 0x0000000000000000 | 0xffffffffffffffff | PLT=Procedure Linkage Table |
| .plt | 0x0000000000400420 | 0x30 | /usr/lib/.../crt1.o |
| | 0x0000000000400430 | | puts@@GLIBC_2.2.5 |
| | 0x0000000000400440 | | printf@@GLIBC_2.2.5 |
| .text | 0x0000000000400450 | 0x282 | |
| .data | 0x0000000000601028 | 0x18 | |
| .data | 0x0000000000601038 | 0x8 | /tmp/cc0DQ6w0.o |
| | 0x0000000000601038 | | varchr0 |
| | 0x0000000000601039 | | varchr1 |
| | ... | | ... |
| | 0x000000000060103e | | varchr6 |
| | 0x000000000060103f | | varchr7 |
| .bss | 0x0000000000601040 | 0x8 | |

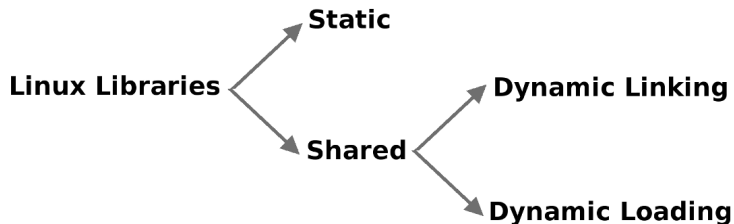


Figure: Linux Libraries

- Static Libraries (embedded in the program).
 - Self contained
 - StaticLib.a
- Shared Libraries
 - Dynamic Linking (run-time.so).
 - Dynamic Loading (controlled by the program, DL-API).

01-local-variables

```
/* Local Variables in Stack Segment */
```

```
char   varchr0='a';
```

```
char   varchr1='b';
```

```
char   varchr2='c';
```

```
char   varchr3='d';
```

```
char   varchr4='e';
```

```
char   varchr5='f';
```

```
char   varchr6='g';
```

```
char   varchr7='h';
```

```
VARIABLE  +++  VALUE  +CHR+  +++  ADDRESS  +++
```

```
varchr0 =          0X61 = a      0x7ffcc188b51f
```

```
varchr1 =          0X62 = b      0x7ffcc188b51e
```

```
varchr2 =          0X63 = c      0x7ffcc188b51d
```

```
varchr3 =          0X64 = d      0x7ffcc188b51c
```

```
varchr4 =          0X65 = e      0x7ffcc188b51b
```

```
varchr5 =          0X66 = f      0x7ffcc188b51a
```

```
varchr6 =          0X67 = g      0x7ffcc188b519
```

```
varchr7 =          0X68 = h      0x7ffcc188b518
```

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|-------------------|---|---|---|---|---|---|---|---|-----|-----|-----|-----|-----|-----|-----|-----|
| 00007ffc-c188b51X | | | | | | | | | 'h' | 'g' | 'f' | 'e' | 'd' | 'c' | 'b' | 'a' |

02-pointers (LE: Little Endian)

```
char   varchr0='a';
char   varchr1='b';
char   varchr2='c';
char   varchr3='d';
char*  ptrchr0=&varchr0;
char*  ptrchr1=&varchr1;
char*  ptrchr2=&varchr2;
char*  ptrchr3=&varchr3;
```

| VARIABLE | +++ | VALUE | +CHR+ | +ADDRESS | +POINTS TO+ |
|----------|-----|----------|-------|----------|-------------|
| varchr0 | = | 0X61 | = a | 0x601038 | |
| varchr1 | = | 0X62 | = b | 0x601039 | |
| varchr2 | = | 0X63 | = c | 0x60103a | |
| varchr3 | = | 0X64 | = d | 0x60103b | |
| ptrchr0 | = | 0x601038 | | 0x601040 | a |
| ptrchr1 | = | 0x601039 | | 0x601048 | b |
| ptrchr2 | = | 0x60103a | | 0x601050 | c |
| ptrchr3 | = | 0x60103b | | 0x601058 | d |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|-------------------|-------------------|----|----|----|----|----|----|----|-------------------|-----|-----|-----|----|----|----|----|
| 00000000-0060103X | | | | | | | | | 'a' | 'b' | 'c' | 'd' | | | | |
| 00000000-0060104X | 00000000-00601038 | | | | | | | | 00000000-00601039 | | | | | | | |
| 00000000-0060105X | 3A | 10 | 60 | 00 | 00 | 00 | 00 | 00 | 3B | 10 | 60 | 00 | 00 | 00 | 00 | 00 |

03-pointers-of-pointers (LE)

```
=====
/* Global Variables in Data Segment*/
char   varchr0='a';
char   varchr1='b';
char   varchr2='c';
char   varchr3='d';
char*  ptrchr0=&varchr0;
char*  ptrchr1=&varchr1;
char*  ptrchr2=&varchr2;
char*  ptrchr3=&varchr3;
char** ptrptr0=&ptrchr0;
char** ptrptr1=&ptrchr1;
char** ptrptr2=&ptrchr2;
char** ptrptr3=&ptrchr3;
VARIABLE  +++  VALUE +CHR+ +ADDRESS + +POINTS TO+
varchr0 =      0x61 = a      0x601038
varchr1 =      0x62 = b      0x601039
varchr2 =      0x63 = c      0x60103a
varchr3 =      0x64 = d      0x60103b
ptrchr0 = 0x601038      0x601040      a
ptrchr1 = 0x601039      0x601048      b
ptrchr2 = 0x60103a      0x601050      c
ptrchr3 = 0x60103b      0x601058      d
ptrptr0 = 0x601040      0x601060 0x601038
ptrptr1 = 0x601048      0x601068 0x601039
ptrptr2 = 0x601050      0x601070 0x60103a
ptrptr3 = 0x601058      0x601078 0x60103b
=====
```

03-pointers-of-pointers (2)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|--------|--------|---|---|---|---|---|---|---|--------|-----|-----|-----|---|---|---|---|
| 60103X | | | | | | | | | 'a' | 'b' | 'c' | 'd' | | | | |
| 60104X | 601038 | | | | | | | | 601039 | | | | | | | |
| 60105X | 60103A | | | | | | | | 60103B | | | | | | | |
| 60106X | 601040 | | | | | | | | 601048 | | | | | | | |
| 60107X | 601050 | | | | | | | | 601058 | | | | | | | |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|-------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 00000000-0060103X | | | | | | | | | 61 | 62 | 63 | 64 | | | | |
| 00000000-0060104X | 38 | 10 | 60 | 00 | 00 | 00 | 00 | 00 | 39 | 10 | 60 | 00 | 00 | 00 | 00 | 00 |
| 00000000-0060105X | 3A | 10 | 60 | 00 | 00 | 00 | 00 | 00 | 3B | 10 | 60 | 00 | 00 | 00 | 00 | 00 |
| 00000000-0060106X | 40 | 10 | 60 | 00 | 00 | 00 | 00 | 00 | 48 | 10 | 60 | 00 | 00 | 00 | 00 | 00 |
| 00000000-0060107X | 50 | 10 | 60 | 00 | 00 | 00 | 00 | 00 | 58 | 10 | 60 | 00 | 00 | 00 | 00 | 00 |

04-pointers-of-pointers-of-pointers (LE)

```
/* Global Variables in Data Segment*/
```

```
char   varchr0='a';  
char   varchr1='b';  
char   varchr2='c';  
char   varchr3='d';  
char*  ptrchr0=&varchr0;  
char*  ptrchr1=&varchr1;  
char*  ptrchr2=&varchr2;  
char*  ptrchr3=&varchr3;  
char** ptrptr0=&ptrchr0;  
char** ptrptr1=&ptrchr1;  
char** ptrptr2=&ptrchr2;  
char** ptrptr3=&ptrchr3;  
char*** ppptr0=&ptrptr0;
```

| VARIABLE | +++ | VALUE | +CHR+ | +ADDRESS + | +POINTS TO+ |
|----------|-----|----------|-------|------------|-------------|
| varchr0 | = | 0X61 | = a | 0x601038 | |
| varchr1 | = | 0X62 | = b | 0x601039 | |
| varchr2 | = | 0X63 | = c | 0x60103a | |
| varchr3 | = | 0X64 | = d | 0x60103b | |
| ptrchr0 | = | 0x601038 | | 0x601040 | a |
| ptrchr1 | = | 0x601039 | | 0x601048 | b |
| ptrchr2 | = | 0x60103a | | 0x601050 | c |
| ptrchr3 | = | 0x60103b | | 0x601058 | d |
| ptrptr0 | = | 0x601040 | | 0x601060 | 0x601038 |
| ptrptr1 | = | 0x601048 | | 0x601068 | 0x601039 |
| ptrptr2 | = | 0x601050 | | 0x601070 | 0x60103a |
| ptrptr3 | = | 0x601058 | | 0x601078 | 0x60103b |
| ppptr0 | = | 0x601060 | | 0x601080 | 0x601040 |

04-pointers-of-pointers-of-pointers (2)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|--------|--------|---|---|---|---|---|---|---|--------|-----|-----|-----|---|---|---|---|
| 60103X | | | | | | | | | 'a' | 'b' | 'c' | 'd' | | | | |
| 60104X | 601038 | | | | | | | | 601039 | | | | | | | |
| 60105X | 60103A | | | | | | | | 60103B | | | | | | | |
| 60106X | 601040 | | | | | | | | 601048 | | | | | | | |
| 60107X | 601050 | | | | | | | | 601058 | | | | | | | |
| 60108X | 601060 | | | | | | | | | | | | | | | |

- `***ppptr0 = **ptrptr0 = *ptrchr = varchr0`
- `ppptr0 = [601080] = 601060`
- `ptrptr0 = [601060] = 601040`
- `ptrchr0 = [601040] = 601038`
- `varchr0 = [601038] = 'a'`

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|-------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 00000000-0060103X | | | | | | | | | 61 | 62 | 63 | 64 | | | | |
| 00000000-0060104X | 38 | 10 | 60 | 00 | 00 | 00 | 00 | 00 | 39 | 10 | 60 | 00 | 00 | 00 | 00 | 00 |
| 00000000-0060105X | 3A | 10 | 60 | 00 | 00 | 00 | 00 | 00 | 3B | 10 | 60 | 00 | 00 | 00 | 00 | 00 |
| 00000000-0060106X | 40 | 10 | 60 | 00 | 00 | 00 | 00 | 00 | 48 | 10 | 60 | 00 | 00 | 00 | 00 | 00 |
| 00000000-0060107X | 50 | 10 | 60 | 00 | 00 | 00 | 00 | 00 | 58 | 10 | 60 | 00 | 00 | 00 | 00 | 00 |
| 00000000-0060108X | 60 | 10 | 60 | 00 | 00 | 00 | 00 | 00 | | | | | | | | |

05-chrptr-vs-intptr (LE)

```
=====
/* Global Variables in Data Segment*/
int    varint0=0x41424344;
char   varchr0='a';
char   varchr1='b';
char   varchr2='c';
char   varchr3='d';

int*   ptrint0=&varint0;
char*  ptrchr0=&varchr0;

ptrint0=(int*) &varchr2;
varint0=*ptrint0;

ptrchr0=(char*) &varint0;
varchr0=*ptrchr0;

ptrchr0++;
varchr0=*ptrchr0;
=====
```

05-chrptr-vs-intptr (2)

```
VARIABLE  +++  VALUE +CHR+ +ADDRESS + +POINTS TO+++
varint0 = 0X41424344 = D      0x601038
varchr0 =           0X61 = a      0x60103c
varchr1 =           0X62 = b      0x60103d
varchr2 =           0X63 = c      0x60103e
varchr3 =           0X64 = d      0x60103f
ptrint0 = 0x601038           0x601048  0X41424344
ptrchr0 = 0x60103c           0x601050      a
!!! ptrint0=(int*) &varchr1; varint0=*ptrint0; !!!
VARIABLE  +++  VALUE +CHR+ +ADDRESS + +POINTS TO+++
ptrint0 = 0x60103d           0x601048  0X65646362
varint0 = 0X65646362 = b      0x601038
```

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|-------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 00000000-0060103X | | | | | | | | | 44 | 43 | 42 | 41 | 61 | 62 | 63 | 64 |
| 00000000-0060104X | 65 | | | | | | | | 38 | 10 | 60 | 00 | 00 | 00 | 00 | 00 |
| 00000000-0060105X | 3C | 10 | 60 | 00 | 00 | 00 | 00 | 00 | | | | | | | | |

| | | | | | | | | | | | | | | | | |
|-------------------|----|--|--|--|--|--|--|--|----|----|----|----|----|----|----|----|
| 00000000-0060103X | | | | | | | | | 62 | 63 | 64 | 65 | 61 | 62 | 63 | 64 |
| 00000000-0060104X | 65 | | | | | | | | 3D | 10 | 60 | 00 | 00 | 00 | 00 | 00 |

05-chrptr-vs-intptr (2)

```
!!! ptrchr0=(char*) &varint0; varchr0=*ptrchr0; !!!  
VARIABLE  +++  VALUE +CHR+ +ADDRESS + +POINTS TO+++  
ptrchr0 =    0x601038          0x601050          0X62  
varchr0 =          0X62 = b    0x60103c  
!!!! !!!!! ptrchr0++; varchr0=*ptrchr0; !!!!! !!!!!  
VARIABLE  +++  VALUE +CHR+ +ADDRESS + +POINTS TO+++  
ptrchr0 =    0x601039          0x601050          0X63  
varchr0 =          0X63 = c    0x60103c
```

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|-------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 00000000-0060103X | | | | | | | | | 44 | 43 | 42 | 41 | 61 | 62 | 63 | 64 |
| 00000000-0060104X | 65 | | | | | | | | 38 | 10 | 60 | 00 | 00 | 00 | 00 | 00 |
| 00000000-0060105X | 3C | 10 | 60 | 00 | 00 | 00 | 00 | 00 | | | | | | | | |
| 00000000-0060103X | | | | | | | | | 62 | 63 | 64 | 65 | 61 | 62 | 63 | 64 |
| 00000000-0060104X | 65 | | | | | | | | 3D | 10 | 60 | 00 | 00 | 00 | 00 | 00 |
| 00000000-0060103X | | | | | | | | | 62 | 63 | 64 | 65 | 62 | 62 | 63 | 64 |
| 00000000-0060105X | 38 | 10 | 60 | 00 | 00 | 00 | 00 | 00 | | | | | | | | |
| 00000000-0060103X | | | | | | | | | 62 | 63 | 64 | 65 | 63 | 62 | 63 | 64 |
| 00000000-0060105X | 39 | 10 | 60 | 00 | 00 | 00 | 00 | 00 | | | | | | | | |

06-pointer-address (LE)

```
unsigned char   varchr0='a';
unsigned char*  ptrchr0=&varchr0;
unsigned char*  ptrcopy=(char *) &ptrchr0;
```

| VARIABLE | +++ | VALUE | +++ | +CHR+ | +++ | ADDRESS | +++ | +PTS | TO+ |
|-----------|----------------|-------|-----|-------|-----|----------------|-----|------|-----|
| varchr0 = | | 0X61 | = a | | | 0x7ffe7bb7369f | | | |
| ptrchr0 = | 0x7ffe7bb7369f | | | | | 0x7ffe7bb73690 | | 0X61 | |

```
!!! !!!!! ptrcopy++; ptrcopy++; ptrcopy++; ... !!!!! !!!
ptrcopy = 0x7ffe7bb73690      0x7ffe7bb73688      0X9F
ptrcopy = 0x7ffe7bb73691      0x7ffe7bb73688      0X36
ptrcopy = 0x7ffe7bb73692      0x7ffe7bb73688      0XB7
ptrcopy = 0x7ffe7bb73693      0x7ffe7bb73688      0X7B
ptrcopy = 0x7ffe7bb73694      0x7ffe7bb73688      0XFE
ptrcopy = 0x7ffe7bb73695      0x7ffe7bb73688      0X7F
ptrcopy = 0x7ffe7bb73696      0x7ffe7bb73688      00
ptrcopy = 0x7ffe7bb73697      0x7ffe7bb73688      00
```

06-pointer-address (2)

```

!!! !!!!! ptrcopy++; ptrcopy++; ptrcopy++; ... !!!!! !!!
VARIABLE  +++  VALUE  +++ +CHR+  +++ ADDRESS  +++ +PTS TO+
ptrchr0 = 0x7ffe7bb7369f          0x7ffe7bb73690      0X61
ptrcopy = 0x7ffe7bb73690          0x7ffe7bb73688      0X9F
ptrcopy = 0x7ffe7bb73691          0x7ffe7bb73688      0X36
ptrcopy = 0x7ffe7bb73692          0x7ffe7bb73688      0XB7
ptrcopy = 0x7ffe7bb73693          0x7ffe7bb73688      0X7B
ptrcopy = 0x7ffe7bb73694          0x7ffe7bb73688      0XFE
ptrcopy = 0x7ffe7bb73695          0x7ffe7bb73688      0X7F
ptrcopy = 0x7ffe7bb73696          0x7ffe7bb73688        00
ptrcopy = 0x7ffe7bb73697          0x7ffe7bb73688        00

```

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|-------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 00007FFE-7BB7368X | | | | | | | | | 90 | 36 | B7 | 7B | FE | 7F | 00 | 00 |
| 00007FFE-7BB7369X | 9F | 36 | B7 | 7B | FE | 7F | 00 | 00 | | | | | | | | 61 |
| 00007FFE-7BB7368X | | | | | | | | | 91 | 36 | B7 | 7B | FE | 7F | 00 | 00 |
| 00007FFE-7BB7368X | | | | | | | | | 92 | 36 | B7 | 7B | FE | 7F | 00 | 00 |
| 00007FFE-7BB7368X | | | | | | | | | 93 | 36 | B7 | 7B | FE | 7F | 00 | 00 |
| 00007FFE-7BB7368X | | | | | | | | | 94 | 36 | B7 | 7B | FE | 7F | 00 | 00 |
| 00007FFE-7BB7368X | | | | | | | | | 95 | 36 | B7 | 7B | FE | 7F | 00 | 00 |
| 00007FFE-7BB7368X | | | | | | | | | 96 | 36 | B7 | 7B | FE | 7F | 00 | 00 |
| 00007FFE-7BB7368X | | | | | | | | | 97 | 36 | B7 | 7B | FE | 7F | 00 | 00 |

07-addresses (LE)

```
unsigned int  glInt1 = 0x41;
unsigned int  glInt2 = 0x42;
unsigned int  glInt3 = 0x43;
unsigned int  glInt4 = 0x44;
unsigned int  glInt5 = 0x45;
unsigned int* heapArray[] =
    {&glInt1, &glInt2, &glInt3, &glInt4, &glInt5};
```

| Variable Name | Address | Size(S)/Value(V) |
|---------------|----------|------------------|
| ===== | | |
| glInt1 | 0x601060 | 0X41 (V) |
| glInt2 | 0x601064 | 0X42 (V) |
| glInt3 | 0x601068 | 0X43 (V) |
| glInt4 | 0x60106c | 0X44 (V) |
| heapArray--- | 0x601080 | 0X601060 (V) |
| heapArray[0] | 0x601080 | 0X601060 (V) |
| heapArray[1] | 0x601088 | 0X601064 (V) |
| heapArray[2] | 0x601090 | 0X601068 (V) |
| heapArray[3] | 0x601098 | 0X60106C (V) |
| heapArray[4] | 0x6010a0 | 0X601070 (V) |

07-addresses (2)

```
#define ALLOC0 0x4BD8
#define ALLOC1 0xFF8
#define ALLOC2 0x18
#define ALLOC3 0x19
#define ALLOC4 1
heapArray[0]=malloc(ALLOC0);
heapArray[1]=malloc(ALLOC1);
heapArray[2]=malloc(ALLOC2);
heapArray[3]=malloc(ALLOC3);
heapArray[4]=malloc(ALLOC4);
```

| Variable Name | Address | Size(S)/Value(V) |
|---------------|----------|------------------|
| heapArray--- | 0x601080 | 0X23CF420 (V) |
| heapArray[0] | 0x601080 | 0X23CF420 (V) |
| heapArray[1] | 0x601088 | 0X23D4000 (V) |
| heapArray[2] | 0x601090 | 0X23D5000 (V) |
| heapArray[3] | 0x601098 | 0X23D5020 (V) |
| heapArray[4] | 0x6010a0 | 0X23D5050 (V) |

07-addresses (3)

```
long printVariable(char* varName, void* varValue, long endAddr) { ... }
long printHeapArray(int mode) { ... }
long demoMalloc(int mode) { ... }
long tripleLoop(int mode) { ... }
void main(void)          { ... }
```

| Variable Name | Address | Size(S)/Value(V) |
|----------------|----------|------------------|
| printf | 0x400480 | |
| malloc | 0x400490 | |
| printVariable | 0x400596 | 0XBE (S) |
| printHeapArray | 0x400654 | 0XA3 (S) |
| demoMalloc | 0x4006f7 | 0X7E (S) |
| tripleLoop | 0x400775 | 0XFC (S) |
| main | 0x400871 | 0X148 (S) |

07-addresses (3)

#####

Memory Configuration

| | | |
|-------|--------------------|---|
| | 0x0000000000400238 | (SEGMENT-START ("text-segment", 0x400000) + SIZEOF-HEADERS) |
| .plt | 0x0000000000400460 | 0x40 /usr/lib/gcc/.../x86-64-linux-gnu/crt1.o |
| | 0x0000000000400470 | puts@@GLIBC_2.2.5 |
| | 0x0000000000400480 | printf@@GLIBC_2.2.5 |
| | 0x0000000000400490 | malloc@@GLIBC_2.2.5 |
| .text | 0x00000000004004a0 | 0x592 |
| .text | 0x0000000000400596 | 0x41d /tmp/ccU78N7D.o |
| | 0x0000000000400596 | printVariable |
| | 0x0000000000400654 | printHeapArray |
| | 0x00000000004006f7 | demoMalloc |
| | 0x0000000000400775 | tripleLoop |
| | 0x0000000000400871 | main |
| .data | 0x0000000000601060 | 0x48 /tmp/ccU78N7D.o |
| | 0x0000000000601060 | glInt1 |
| | 0x0000000000601064 | glInt2 |
| | 0x0000000000601068 | glInt3 |
| | 0x000000000060106c | glInt4 |
| | 0x0000000000601070 | glInt5 |
| | 0x0000000000601080 | heapArray |

#####

08-passing-parameters

```
#define NOP()    __asm__ ("nop") /* No Operation inline gcc ASM *** */
#include <stdio.h>
int  varInt1    = 0x01;
int  varInt2    = 0x02;
int* ptrInt1    = &varInt1;
int* ptrInt2    = &varInt2;
void function1(void) {
    NOP();
}
void function2(int iif2) {
    printf("function2:    iif2 = %d\n", ++iif2);
}
void function3(int* iif3) {
    printf("function3:    iif3 = %d\n", ++(*iif3));
}
int  function4(void) {
    NOP();
}
int* function5(void) {
    NOP();
}
void main(void) {
    function1();
    printf("main-1:    *ptrInt1 = %d\n", *ptrInt1);
    function2(*ptrInt1);
    printf("main-2:    *ptrInt1 = %d\n", *ptrInt1);
    printf("main-3:    varInt1 = %d\n",  varInt1);
    function3(&varInt1);
    printf("main-4:    varInt1 = %d\n",  varInt1);
}
```

*// main-1: *ptrInt1 = 1*
// function2: iif2 = 2
*// main-2: *ptrInt1 = 1*
// main-3: varInt1 = 1
// function3: iif3 = 2
// main-4: varInt1 = 2

09-struct

```
#include <stdio.h>

typedef struct {
    char* nama;
    int umur;
    int semester;
    char* NIM;
} student;

void printStruct(student* ss) {
    printf("%-10s %11s %3d %2d\n", ss->nama, ss->NIM, ss->umur, ss->semester);
}

student global;
void init(void) {
    global.nama      = "Burhan";
    global.NIM       = "1205000003";
    global.umur      = 10;
    global.semester  = 2;
}

void main(void) {
    student mhs = {"Ali", 12, 1, "1205000001"};
    printStruct(&mhs);
    init();
    printStruct(&global);
}

=====
Ali          1205000001  12  1
Burhan       1205000003  10  2
```

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
00000010  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0  \0
00000020  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
>>>> $
```

```

#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.