CSGE602055 Operating Systems
CSF2600505 Sistem Operasi
Week 04: Addressing, Shared Lib, & Pointer

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https://os.vlsm.org/
Always check for the latest revision!

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Operating Systems 2019-1

A (Rm 3114) [Tu/Th 10-12] — B (Rm 3114) [Tu/Th 13-15] — C (Rm 3114) [Tu/Th 16-18] — D (Rm 2401) [Tu/Th 10-12] — E (Rm 2306) [Tu/Th 13-15]

Week	Schedule	Topic	OSC10
Week 00	07 Feb - 13 Feb 2019	Overview 1, Virtualization & Scripting	Ch. 1, 2, 18.
Week 01	14 Feb - 20 Feb 2019	Overview 2, Virtualization & Scripting	Ch. 1, 2, 18.
Week 02	21 Feb - 27 Feb 2019	Security, Protection, Privacy, & C-language	Ch. 16, 17
Week 03	28 Feb - 06 Mar 2019	File System & FUSE	Ch. 13, 14, 15
Week 04	12 Mar - 18 Mar 2019	Addressing, Shared Lib, & Pointer	Ch. 9
Week 05	19 Mar - 25 Mar 2019	Virtual Memory	Ch. 10
Mid-Term	23-30 Mar 2019 (tba)	MidTerm (UTS)	
Week 06	02 Apr - 08 Apr 2019	Concurency: Processes & Threads	Ch. 3, 4
Week 07	09 Apr - 15 Apr 2019	Synchronization & Deadlock	Ch. 6, 7, 8
Week 08	16 Apr - 22 Apr 2019	Scheduling	Ch. 5
Week 09	23 Apr - 29 Apr 2019	Storage, BIOS, Loader, & Systemd	Ch. 11
Week 10	30 Apr - 06 May 2019	I/O & Programming	Ch. 12
Reserved	07 May - 17 May 2019		
Final	18-25 May 2019 (tba)	Final (UAS)	This schedule is subject to change.
Extra	27 Jun 2019	Extra assignment confirmation	

The Weekly Check List

- **Resources**: `https://os.vlsm.org/`
  - **(THIS) Slides** — `https://github.com/UI-FASILKOM-OS/SistemOperasi/tree/master/pdf/`
  - **Demos** — `https://github.com/UI-FASILKOM-OS/SistemOperasi/tree/master/demos/`
  - **Extra** — `BADAK.cs.ui.ac.id:///extra/`
  - **Problems** — `rms46.vlsm.org/2/195.pdf`, `196.pdf`, ..., `205.pdf`
- **Text Book**: any recent/decent OS book. Eg. (**OSC10**) Silberschatz et. al.: **Operating System Concepts**, 10^{th} Edition, 2018.
- Encode your **QRC** with size upto 7cm x 7cm (ca. 400x400 pixels): **"OS182 CLASS ID SSO-ACCOUNT Your-Full-Name"**
- For **Week 00**, send your **embedded** QRC **before the** 2^{nd} **lecture**
  `mailto:operatingsystems@vlsm.org`
  With Subject: `OS182 CLASS ID SSO-ACCOUNT Your-Full-Name`
- Write your Memo (with QRC) **every week**.
- Login to `badak.cs.ui.ac.id` via `kawung.cs.ui.ac.id` for at least **10 minutes** every week. Copy the weekly demo files to your own home directory.
  Eg. (Week00): `cp -r /extra/Week00/W00-demos/ W00-demos/`

Agenda

1. Start
2. Schedule
3. Agenda
4. Week 04
5. Week 04: Addressing, Shared Lib, & Pointer
6. Paging
7. Addressing
8. Translation
9. Memory
10. Variables and File Formats
11. Linux Libraries (1)
12. Linux Libraries (2)

Agenda (2)

13. Makefile
14. 00-global-variables
15. Memory Map
16. 01-local-variables
17. 02-pointers
18. 03-pointers-of-pointers
19. 04-pointers-of-pointers-of-pointers
20. 05-chrptr-vs-intptr
21. 06-pointer-address
22. 07-addresses
23. 08-passing-parameters
24. 09-struct
25. The End

Week 04 Addressing: Topics[1]

- Bits, bytes, and words
- Numeric data representation and number bases
- Representation of records and arrays

[1] Source: ACM IEEE CS Curricula 2013

Week 04 Addressing: Learning Outcomes[1]

- Explain why everything is data, including instructions, in computers. [Familiarity]
- Explain the reasons for using alternative formats to represent numerical data. [Familiarity]
- Describe the internal representation of non-numeric data, such as characters, strings, records, and arrays. [Familiarity]

[1] Source: ACM IEEE CS Curricula 2013

Week 04: Addressing, Shared Lib, & Pointer

- Reference: (OSC10-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)!
- Hardware Address Protection
- Binding & Linking
  - Address Binding
  - Address Space: Logical & Physical
  - Dynamic & Static Linking
  - MMU: Memory Management Unit
  - Base and Limit Registers
  - Swapping
  - Mobile Systems Problem: no swap
- Memory Allocation
  - Contiguous Allocation
  - Multiple-variable-partition Allocation
  - First, Best, Worst Fit Allocation Strategy
- Fragmentation: External / Internal / Compaction

Paging

- Logical/Virtual Address
  - Logical Memory Blocks: Pages
  - Page Number
  - Page Offset
- Page Table
  - Page number index $\Rightarrow$ frame number
  - PTE: Page Table Entry
  - Page Flags: Valid/ Invalid
  - TLB: Translation Look-aside Buffer (Associative Memory).
  - Two-Level Page-Table Scheme
    - OPT: Outer Page Table (P1)
    - PT: Page Table (P2)
  - Three-Level Page-Table Scheme
  - Hashed Page Tables
  - Inverted Page Table
- Physical Address
  - Physical Memory Blocks: Frames
  - Offset (D)
  - Hierarchical Page Tables

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			

Address Translation Scheme

Address		Binary								
DEC	HEX	OFFSET	PG	OFF	PG	OFF	PAGE	OFF	PAGE	OFF
00	00	00000	0	0000	00	000	000	00	0000	0
01	01	00001	0	0001	00	001	000	01	0000	1
02	02	00010	0	0010	00	010	000	10	0001	0
03	03	00011	0	0011	00	011	000	11	0001	1
04	04	00100	0	0100	00	100	001	00	0010	0
05	05	00101	0	0101	00	101	001	01	0010	1
06	06	00110	0	0110	00	110	001	10	0011	0
07	07	00111	0	0111	00	111	001	11	0011	1
08	08	01000	0	1000	01	000	010	00	0100	0
09	09	01001	0	1001	01	001	010	01	0100	1
10	0A	01010	0	1010	01	010	010	10	0101	0
11	0B	01011	0	1011	01	011	010	11	0101	1
12	0C	01100	0	1100	01	100	011	00	0110	0
13	0D	01101	0	1101	01	101	011	01	0110	1
14	0E	01110	0	1110	01	110	011	10	0111	0
15	0F	01111	0	1111	01	111	011	11	0111	1
16	10	10000	1	0000	10	000	100	00	1000	0
17	11	10001	1	0001	10	001	100	01	1000	1
18	12	10010	1	0010	10	010	100	10	1001	0
19	13	10011	1	0011	10	011	100	11	1001	1
20	14	10100	1	0100	10	100	101	00	1010	0
21	15	10101	1	0101	10	101	101	01	1010	1
22	16	10110	1	0110	10	110	101	10	1011	0
23	17	10111	1	0111	10	111	101	11	1011	1
24	18	11000	1	1000	11	000	110	00	1100	0
25	19	11001	1	1001	11	001	110	01	1100	1
26	1A	11010	1	1010	11	010	110	10	1101	0
27	1B	11011	1	1011	11	011	110	11	1101	1
28	1C	11100	1	1100	11	100	111	00	1110	0
29	1D	11101	1	1101	11	101	111	01	1110	1
30	1E	11110	1	1110	11	110	111	10	1111	0
31	1F	11111	1	1111	11	111	111	11	1111	1

Memory (20 bits)

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00000	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE	AF
00010	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	BA	BB	BC	BD	BE	BF
00020	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF
00030	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE	DF
FFFF0																

Variables and File Formats

- 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].

Linux Libraries (1)

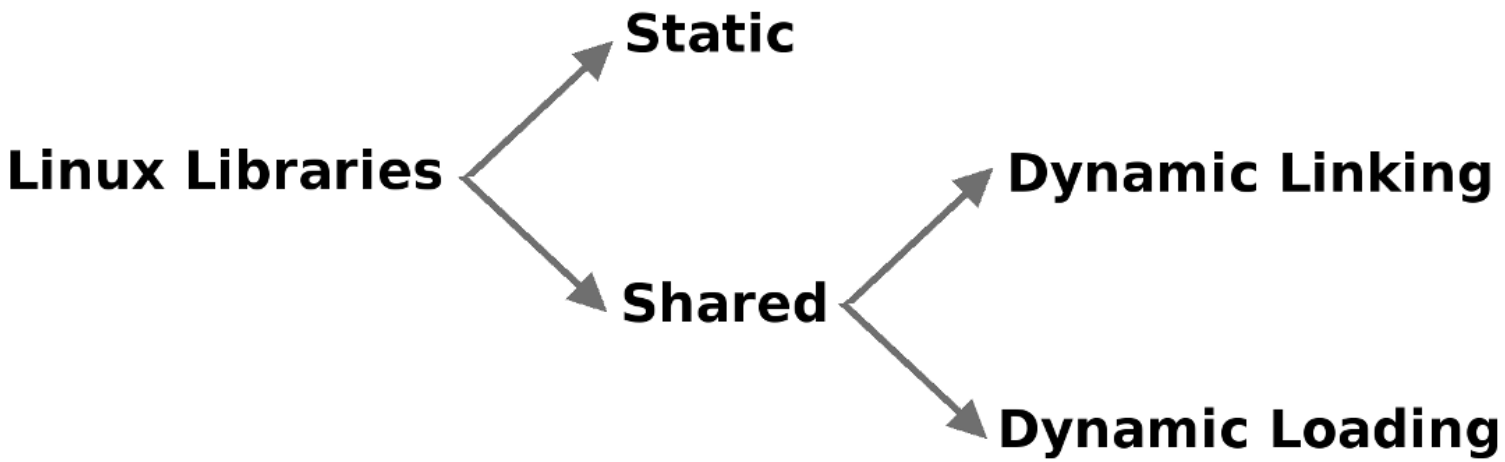

Figure: Linux Libraries

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

Linux Libraries (2)

- `putchar(char)`
- `getpid()`
- `getppid()`
- `sprintf(char*, const chat*)`
- `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*)`

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
```

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) {                                    // main-1:    *ptrInt1 = 1
   function1();                                      // function2:     iif2 = 2
   printf("main-1:    *ptrInt1 = %d\n", *ptrInt1);  // main-2:    *ptrInt1 = 1
   function2(*ptrInt1);                              // main-3:     varInt1 = 1
   printf("main-2:    *ptrInt1 = %d\n", *ptrInt1);  // function3:     iif3 = 2
   printf("main-3:     varInt1 = %d\n",  varInt1);   // main-4:     varInt1 = 2
   function3(&varInt1);
   printf("main-4:     varInt1 = %d\n",  varInt1);
}
```

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
```

The End

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- This is the end of the presentation.