

CS1010

<http://www.comp.nus.edu.sg/~cs1010/>

Programming Methodology

UNIT 7

Pointers



NUS
National University
of Singapore

School of
Computing

Unit 7: Pointers

Objective:

- Learning about pointers and how to use them to access other variables

Reference:

- Section 6.1 Pointers and the Indirection Operator

Unit 7: Pointers

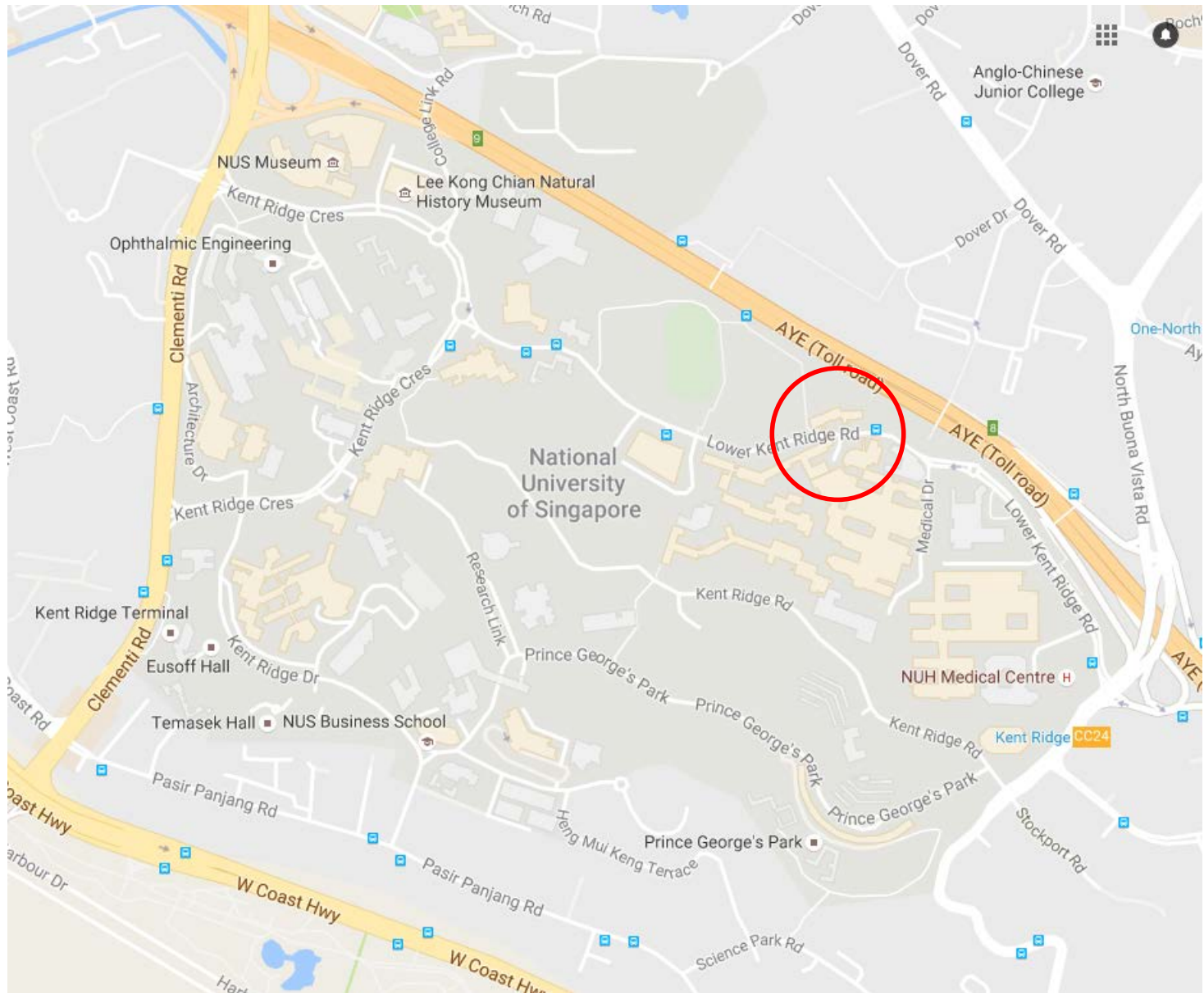
1. Variable and Its Address
2. Pointer Variable
3. Declaring a Pointer
4. Assigning Value to a Pointer
5. Accessing Variable Through Pointer
6. Examples
7. Common Mistake
8. Why Do We Use Pointers?

HOW DO YOU TELL
OTHERS WHERE YOUR
HOME IS?

Real Life Address Example

- Back in 2002, School of Computing is in another corner of NUS





Real Life Address Example

- The address of SOC at that time

- 3 Science Drive 2, 117543
- 6 Science Drive 2, 117546

- But now, no more SOC but

- Quantum Tech
- Graphene Research Centre
- NUS Dept of Math

“Contents”

Addresses



Real Life Address Example

Addresses

- In the past
 - 3 Science Drive 2, 117543
 - 6 Science Drive 2, 117546
- Now
 - 3 Science Drive 2, 117543
 - 6 Science Drive 2, 117546

Contents

- In the past
 - SOC
 - SOC
- Now
 - **Quantum Tech**
 - **Graphene Research Centre**

1. Variable and Its Address (1/2)

- A **variable** has a unique **name** (identifier) in the function it is declared in, it belongs to some **data type**, and it contains a **value** of that type
- A variable occupies some space in the memory, and hence it has an **address**
- The programmer usually does not need to know the address of the variable (she simply refers to the variable by its name), but the system keeps track of the variable's address

Data type Name

```
int a;  
a = 123;
```

May only contain integer value

a

| |
|-----|
| 123 |
|-----|

*Where is variable **a** located in the memory?*

1. Variable and Its Address (2/2)

- You may refer to the address of a variable by using the **address operator**: **&** (ampersand)

```
int a = 123;
printf("a = %d\n", a);
printf("&a = %p\n", &a);
```

```
a = 123
&a = ffbff7dc
```

- %p** is used as the format specifier for addresses
- Addresses are printed out in **hexadecimal** (base 16) format
- The address of a variable varies from run to run, as the system allocates any free memory to the variable
- Test out [Unit7_Address.c](#)

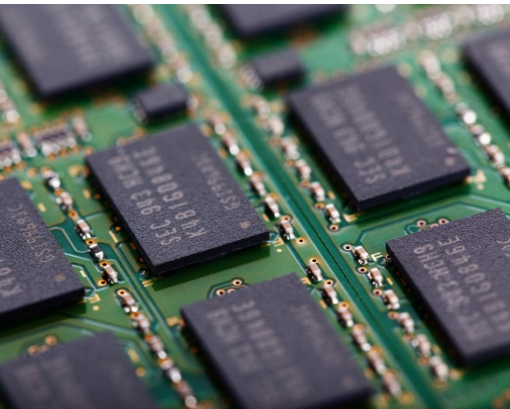
Computer Memory

The address of the variable a

| Address | Content |
|----------|-------------|
| ffbff7d8 | |
| ffbff7d9 | |
| ffbff7da | |
| ffbff7db | |
| ffbff7dc | 123 |
| ffbff7dd | |
| ffbff7de | |
| ffbff7df | |
| ffbff7e0 | 3.141592654 |
| ffbff7e1 | |
| ffbff7e2 | |

The content is an integer

Some others maybe float, double, etc.

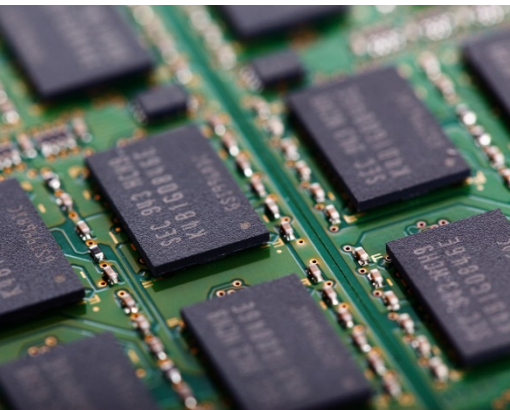


How about?

The address of the variable **a_ptr**

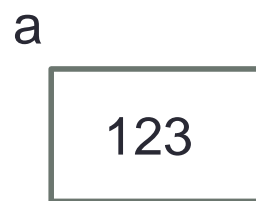
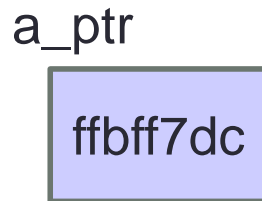
| Address | Content |
|----------|-------------|
| ffbff7d8 | ffbff7dc |
| ffbff7d9 | |
| ffbff7da | |
| ffbff7db | |
| ffbff7dc | 3 |
| ffbff7dd | |
| ffbff7de | |
| ffbff7df | |
| ffbff7e0 | 3.141592654 |
| ffbff7e1 | |
| ffbff7e2 | |

The content of the address is an address



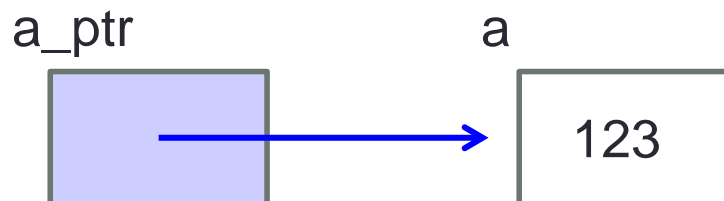
2. Pointer Variable

- A variable that contains the address of another variable is called a **pointer variable**, or simply, a **pointer**.
- Example: a pointer variable **a_ptr** is shown as a blue box below. It contains the address of variable **a**.



*Assuming that variable **a** is located at address ffbff7dc.*

- Variable **a_ptr** is said to be **pointing to** variable **a**.
- If the address of **a** is immaterial, we simply draw an arrow from the blue box to the variable it points to.



How about?

The address of the variable **a_ptr**

| Address | Content |
|----------|-------------|
| ffbff7d8 | ffbff7dc |
| ffbff7d9 | |
| ffbff7da | |
| ffbff7db | |
| ffbff7dc | 123 |
| ffbff7dd | |
| ffbff7de | |
| ffbff7df | |
| ffbff7e0 | 3.141592654 |
| ffbff7e1 | |
| ffbff7e2 | |

ffbff7dc

123

3.141592654

3. Declaring a Pointer

Syntax:

```
type *pointer_name;
```

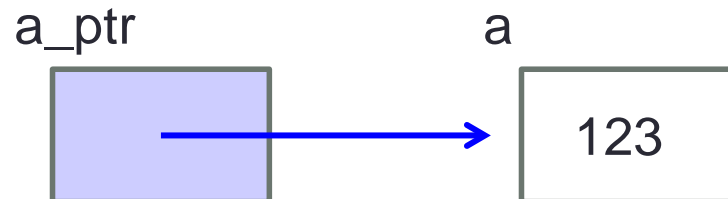
- **pointer_name** is the name (identifier) of the pointer
- **type** is the data type of the variable this pointer may point to
- Example: The following statement declares a pointer variable **a_ptr** which may point to any **int** variable
- Good practice to name a pointer with suffix **_ptr** or **_p**

```
int *a_ptr;
```

4. Assigning Value to a Pointer

- Since a pointer contains an address, only addresses may be assigned to a pointer
- Example: Assigning address of `a` to `a_ptr`

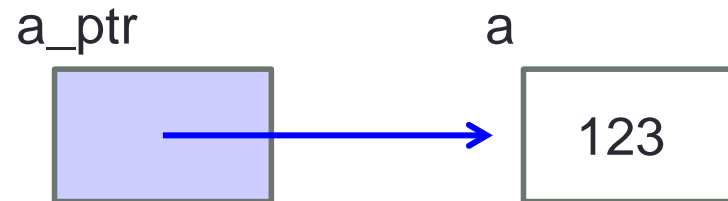
```
int a = 123;  
int *a_ptr; // declaring an int pointer  
a_ptr = &a;
```



- We may initialise a pointer during its declaration:

```
int a = 123;  
int *a_ptr = &a; // initialising a_ptr
```


5. Accessing Variable Through Pointer



- Once we make `a_ptr` points to `a` (as shown above), we can now access `a` directly as usual, or indirectly through `a_ptr` by using the **indirection operator** (also called **dereferencing operator**): `*`

```
printf("a = %d\n", *a_ptr);
```

=

```
printf("a = %d\n", a);
```

```
*a_ptr = 456;
```

=

```
a = 456;
```

Hence, `*a_ptr` is synonymous with `a`

```
int a = 123;
```

```
int a_ptr = &a;
```

| | | Remark |
|--------|--|--|
| a | integer 123 | |
| &a | the address of a | |
| a_ptr | pointer = the address of a | Can change to the address of other variables |
| *a_ptr | get the content in the address, in which is the content of 'a' now | |
| &a_ptr | The address of a_ptr | Not now |
| *a | Treat a as a pointer | You will not have a good time with it |
| | | |

6. Example #1

```
int i = 10, j = 20;
int *p; // p is a pointer to some int variable
```

```
p = &i; // p now stores the address of variable i
```

Important!

Now *p is equivalent to i

```
printf("value of i is %d\n", *p);
```

value of i is 10

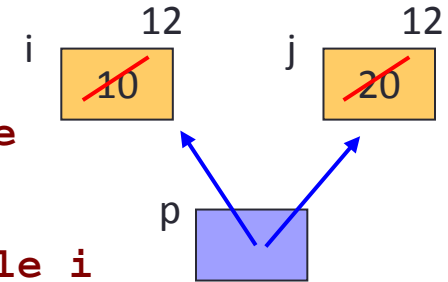
```
// *p accesses the value of pointed/referred variable
*p = *p + 2; // increment *p (which is i) by 2
           // same effect as: i = i + 2;
```

```
p = &j; // p now stores the address of variable j
```

Important!

Now *p is equivalent to j

```
*p = i; // value of *p (which is j now) becomes 12
        // same effect as: j = i;
```



6. Example #2 (1/2)

Unit7_Pointer.c

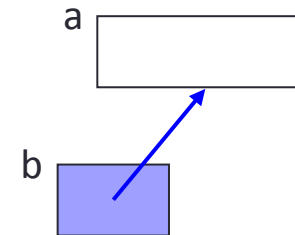
```
#include <stdio.h>

int main(void) {
    double a, *b;

    b = &a;
    *b = 12.34;
    printf("%f\n", a);

    return 0;
}
```

Can you draw the picture?
What is the output?



12.340000

What is the output if the `printf()` statement is changed to the following?

```
printf("%f\n", *b);
```

12.340000

```
printf("%f\n", b);
```

Compile with warning

```
printf("%f\n", *a);
```

Error

What is the proper way to print a pointer?
(Seldom need to do this.)

Value in hexadecimal;
varies from run to run.

```
printf("%p\n", b);
```

ffbf6a0

6. Example #2 (2/2)

- How do we interpret the declaration?

```
double a, *b;
```

- The above is equivalent to

```
double a; // this is straight-forward: a is a double variable
double *b;
```

- We can read the second declaration as

- `*b` is a double variable, so this implies that ...
- `b` is a pointer to some double variable

- The following are equivalent:

```
double a;
double *b;
b = &a;
```

```
double a;
double *b = &a;
```

But this is not the same as
above (and it is not legal):

```
double a;
double b = &a;
```



Exercise #1: Tracing Pointers (1/2)

- Trace the code below manually to obtain the outputs.
- Compare your outputs with your neighbours.

Unit7_TracePointers.c

```
int a = 8, b = 15, c = 23;
int *p1, *p2, *p3;

p1 = &b;
p2 = &c;
p3 = p2;
printf("1: %d %d %d\n", *p1, *p2, *p3);

*p1 *= a;
while (*p2 > 0) {
    *p2 -= a;
    (*p1)++;
}
printf("2: %d %d %d\n", *p1, *p2, *p3);
printf("3: %d %d %d\n", a, b, c);
```

Exercise #2: Choose the Correct Codes

- Pick the correct codes to read a value into the float variable var.

(A)

```
float var;  
scanf( "%f", var)
```

(B)

```
float var;  
scanf( "%f", &var)
```

(C)

```
float var;  
float *p;  
p = &var;  
scanf( "%f", p)
```

(D)

```
float var;  
float *p;  
p = &var;  
scanf( "%f", &p)
```

Exercise #3: Incrementing a Pointer

- If p is a pointer variable, what does it mean by $p = p + 1$ (or $p++$)?

Unit 4 Exercise #1:

`int` takes up 4 bytes

`float` takes up 4 bytes

`char` takes up 1 byte

`double` takes up 8 bytes

Unit7_IncrementPointers.c

```
int a, *ap;  
float b, *bp;  
char c, *cp;  
double d, *dp;
```

```
ap = &a; bp = &b; cp = &c; dp = &d;  
printf("%p %p %p %p\n", ap, bp, cp, dp);
```

```
ap++; bp++; cp++; dp++;  
printf("%p %p %p %p\n", ap, bp, cp, dp);
```

```
ap += 3;  
printf("%p\n", ap);
```




7. Common Mistake

Unit7_Common_Mistake.c

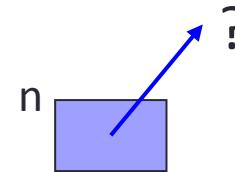
```
#include <stdio.h>

int main(void) {
    int *n;

    *n = 123;
    printf("%d\n", *n);

    return 0;
}
```

What's wrong with this?
Can you draw the picture?



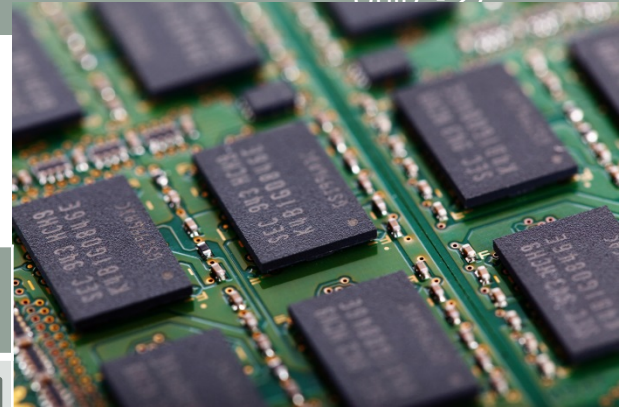
- Where is the pointer `n` pointing to?
- Where is the value `123` assigned to?
- Result: Segmentation Fault (core dumped)
 - Remove the file “core” from your directory. It takes up a lot of space!

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glasbergen.com



“Your shipment was delivered to the wrong address, so technically, it’s your fault for choosing not to live there!”

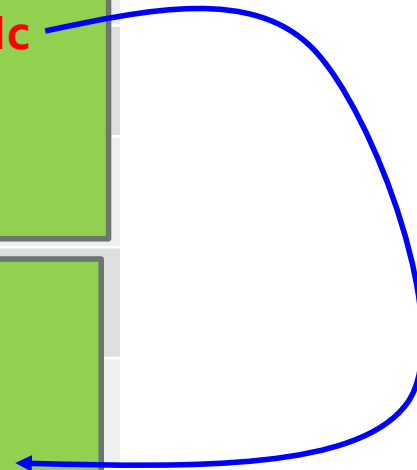
Valid if a is allocated



The address
of the variable
a_ptr



| Address | Content |
|----------|----------|
| ffbff7d8 | ffbff7dc |
| ffbff7d9 | |
| ffbff7da | |
| ffbff7db | |
| ffbff7dc | 123 |
| ffbff7dd | |
| ffbff7de | |
| ffbff7df | |
| ffbff7e0 | |
| ffbff7e1 | |



The address
of the variable
a



What if...?

The address
of the variable
a_ptr

| Address | Content |
|---------|---------|
|---------|---------|

| | |
|----------|----------|
| ffbff7d8 | aabbccdd |
|----------|----------|

| |
|----------|
| ffbff7d9 |
|----------|

| |
|----------|
| ffbff7da |
|----------|

| |
|----------|
| ffbff7db |
|----------|

The address
of the variable
a

| | |
|----------|-----|
| ffbff7dc | 123 |
|----------|-----|

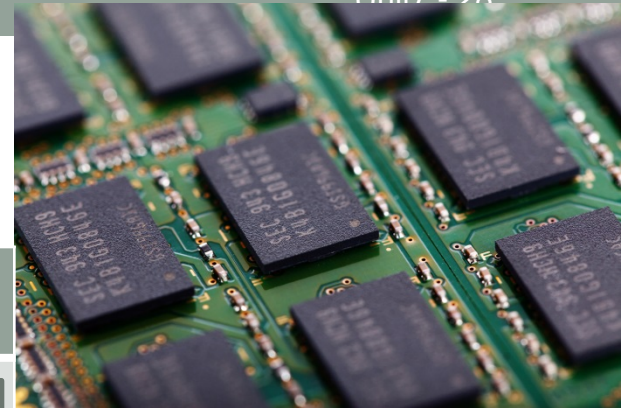
| |
|----------|
| ffbff7dd |
|----------|

| |
|----------|
| ffbff7de |
|----------|

| |
|----------|
| ffbff7df |
|----------|

| |
|----------|
| ffbff7e0 |
|----------|

| |
|----------|
| ffbff7e1 |
|----------|



?

Computer Memory

- For storage of data

```
int a = 3;
```

This space is allocated and labeled as "a". And we store '3' inside

Computer Memory



Are you ready for

Computer Memory

- For storage of data

```
int a = 3;
```

```
int a_ptr = &a;
```

Computer
Memory

a_ptr



Are you ready for

Computer Memory

- For storage of data

```
int a = 3;
```

```
int a_ptr; //can be rubbish
```

Computer
Memory

a_ptr



Invalid Area (Address)

- For storage of data

```
int a = 3;
```

```
int a_ptr; //can be rubbish
```

Computer
Memory

a_ptr

Segmentation
Fault!!!!!!!

Windo
Operatin
System

3

aabbccdd

Your program

Other
app

Other
app

Are you ready for



8. Why Do We Use Pointers?

- It might appear that having a pointer to point to a variable is redundant since we can access the variable directly
- The purpose of pointers is apparent later when we pass the address of a variable into a function, in the following scenarios:
 - To pass the address of the first element of an array to a function so that the function can access all elements in the array (Unit 8 Arrays, and Unit 9 Multidimensional Arrays)
 - To pass the addresses of two or more variables to a function so that the function can pass back to its caller new values for the variables (Unit 14 Functions with Pointer Parameters)

Summary

- In this unit, you have learned about
 - Declaring a pointer variable
 - Using a pointer variable to point to a variable
 - Hence, accessing a variable through the pointer variable that points to it

End of File