Computer Programming 143 – Lecture 18
Pointers I

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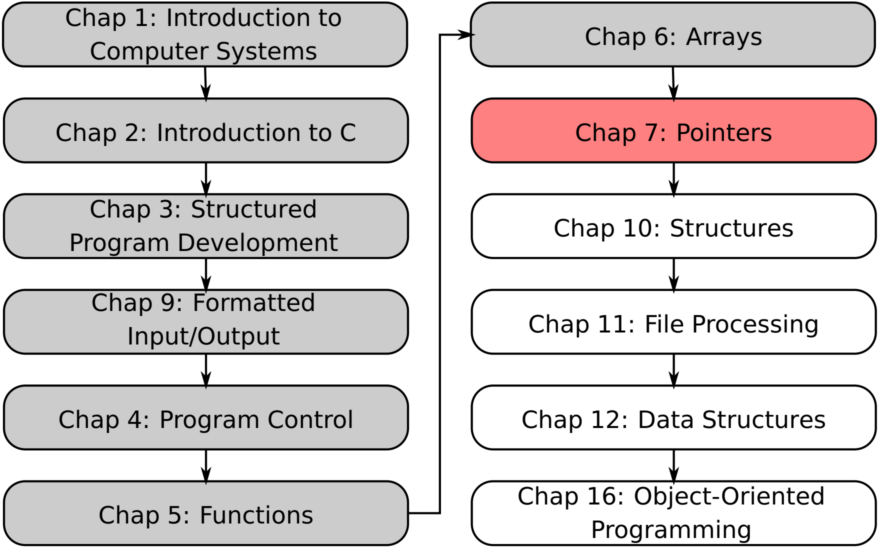
Module Overview



Chap 1: Introduction to Computer Systems

Chap 2: Introduction to C

Chap 3: Structured Program Development

Chap 9: Formatted Input/Output

Chap 4: Program Control

Chap 5: Functions

Chap 6: Arrays

Chap 7: Pointers

Chap 10: Structures

Chap 11: File Processing

Chap 12: Data Structures

Chap 16: Object-Oriented Programming

Lecture Overview

1. Introduction (7.1)
2. Pointer Variable Declaration and Initialisation (7.2)
3. Pointer Operators (7.3)

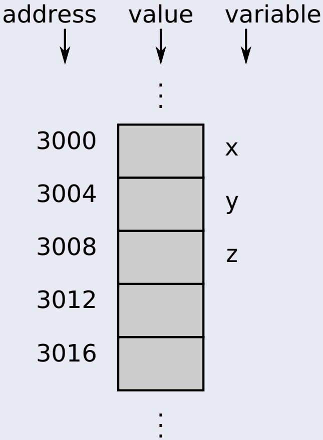
7.1 Introduction

Pointers

- So far, we have used two kinds of variables:
  - **scalar** variable: *single value*
  - **array** variable: *several values* (of same type)
- Today we encounter a whole new kind of variable:
  - **pointer** variable: *memory location of a value*
- Very powerful
- Simulate call-by-reference
- Close relationship with arrays and strings

7.2 Memory Concepts

Memory visualisation

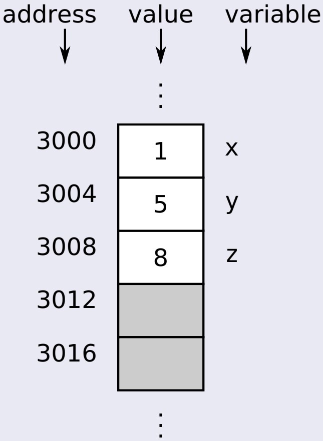


address	value	variable
⋮		
3000		x
3004		y
3008		z
3012		
3016		
⋮		

```c
int x, y, z;
```

7.2 Memory Concepts

Memory visualisation



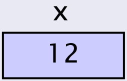
address	value	variable
	⋮	
3000	1	x
3004	5	y
3008	8	z
3012		
3016		
	⋮	

```c
int x, y, z;
x = 1;
y = 5;
z = 8;
```

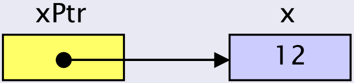
7.2 Pointer Variable Declaration and Initialisation I

Pointer variables

- Each variable has a name, value, and memory address
- Access variable's value through variable name (direct reference)
- (Before, values were numbers, characters, or arrays thereof)



- Pointers contain memory addresses as their values
- A pointer's value is the memory address of a(nother) variable
- That variable can then be accessed through the pointer (indirect reference)



- Indirection – Using an address (pointer) to access a variable

7.2 Pointer Variable Declaration and Initialisation II

Pointer declaration

- * used to declare pointer variables

```
int *myPtr;
```

Defines a pointer to an int value (pointer of type `int`)

- Multiple pointers require using a * before each variable definition

```
int *myPtr1, *myPtr2, myInt;
```

  - Pointer and scalar variables can be declared on the same line
- Can define pointers to any data type
- Initialise pointers to `0`, NULL, or an address
  - `0` or NULL – points to nothing (NULL preferred)

```
int *myPtr1 = NULL;
int *myPtr2;
myPtr2 = 0x22FF7C; /* Hardware address */
```

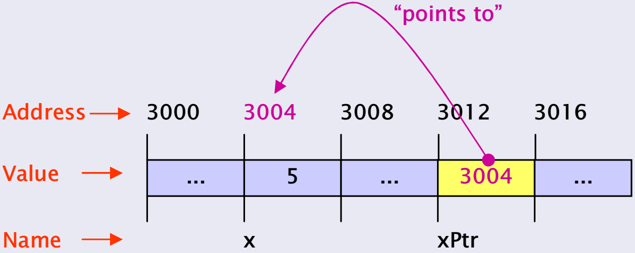
7.3 Pointer Operators I

& (address operator)

- Returns address of operand

```
int x = 5;
int *xPtr;
xPtr = &x;     /* value of xPtr becomes address of x */
```

Variable xPtr is then said to "point to" x



7.3 Pointer Operators II

∗ (indirection/dereferencing operator)

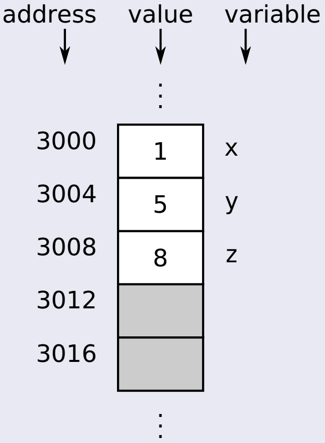
- ∗ not limited to pointer declaration, also used as operand
- ∗ provides access to memory/variable that its operand points to
- Access can be to read the value or to change the value

```
int x = 5; // assign 5 to x (direct reference)
int ∗xPtr; // declare an integer pointer
xPtr = &x; // assign the address of x to xPtr
printf("%d", ∗xPtr); // indirect reference to x, prints 5
∗xPtr = 7; // indirect reference, same effect as x = 7
```

  - Note: The names of pointer and variable are independent
- Dereferenced pointer (operand of ∗) must be an address (**lvalue**) (no constants)
- ∗ and & are inverses
  - They cancel each other out

7.3 Memory Concepts

Memory visualisation

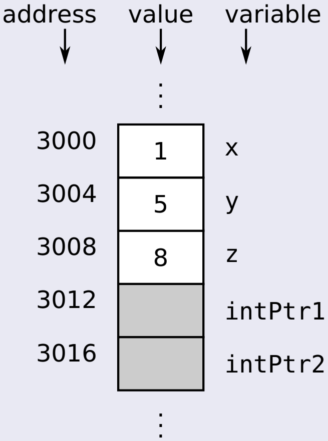


address	value	variable
	⋮	
3000	1	x
3004	5	y
3008	8	z
3012		
3016		
	⋮	

```
int x = 1;
int y = 5;
int z = 8;
```

7.3 Memory Concepts

Memory visualisation

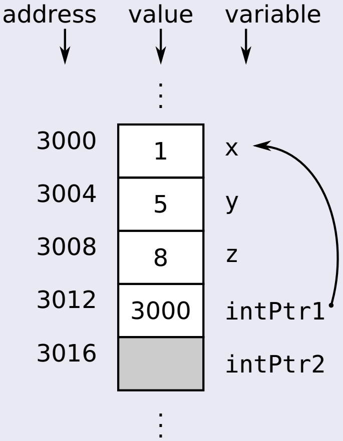


address	value	variable
	⋮	
3000	1	x
3004	5	y
3008	8	z
3012	▨	intPtr1
3016	▨	intPtr2
	⋮	

```
int x = 1;
int y = 5;
int z = 8;
int *intPtr1, *intPtr2;
```

7.3 Memory Concepts

Memory visualisation

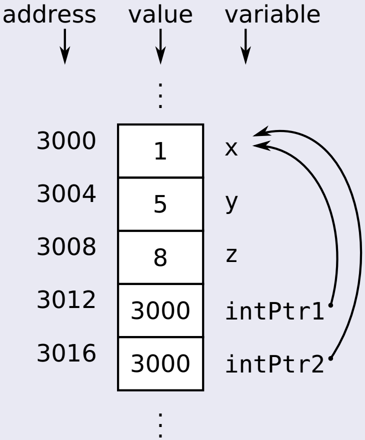


address	value	variable
⋮	⋮	
3000	1	x
3004	5	y
3008	8	z
3012	3000	intPtr1
3016	▨	intPtr2
⋮	⋮	

```
int x = 1;
int y = 5;
int z = 8;
int *intPtr1, *intPtr2;
intPtr1 = &x;
```

7.3 Memory Concepts

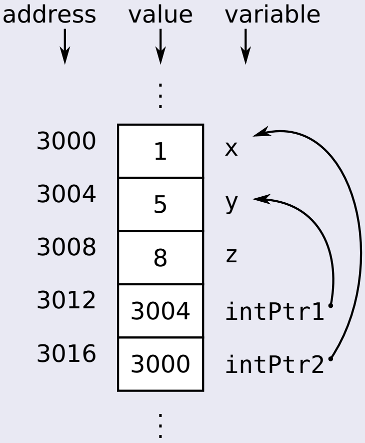
Memory visualisation



```
int x = 1;
int y = 5;
int z = 8;
int ∗intPtr1, ∗intPtr2;
intPtr1 = &x;
intPtr2 = intPtr1;
```

7.3 Memory Concepts

Memory visualisation

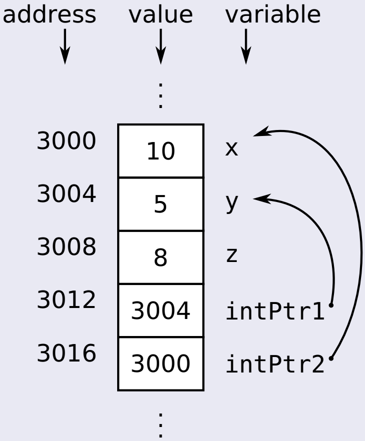


address	value	variable
	⋮	
3000	1	x
3004	5	y
3008	8	z
3012	3004	intPtr1
3016	3000	intPtr2
	⋮	

```
int x = 1;
int y = 5;
int z = 8;
int *intPtr1, *intPtr2;
intPtr1 = &x;
intPtr2 = intPtr1;
intPtr1 = &y;
```

7.3 Memory Concepts

Memory visualisation

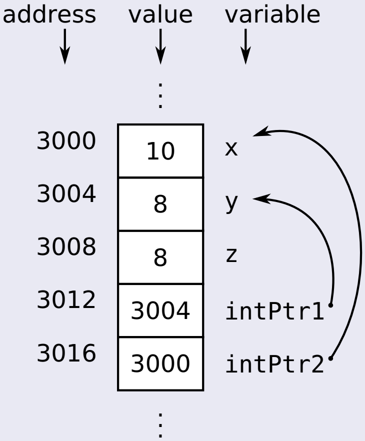


address	value	variable
	⋮	
3000	10	x
3004	5	y
3008	8	z
3012	3004	intPtr1
3016	3000	intPtr2
	⋮	

```c
int x = 1;
int y = 5;
int z = 8;
int *intPtr1, *intPtr2;
intPtr1 = &x;
intPtr2 = intPtr1;
intPtr1 = &y;
*intPtr2 = 10;
```

7.3 Memory Concepts

Memory visualisation

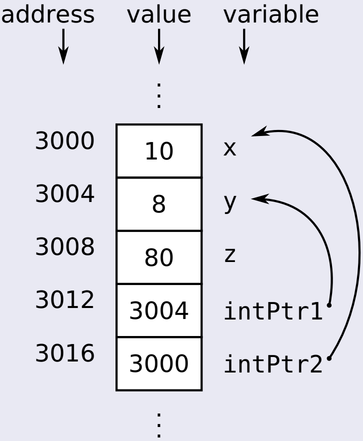


address	value	variable
⋮	⋮	
3000	10	x
3004	8	y
3008	8	z
3012	3004	intPtr1
3016	3000	intPtr2
	⋮	

```
int x = 1;
int y = 5;
int z = 8;
int *intPtr1, *intPtr2;
intPtr1 = &x;
intPtr2 = intPtr1;
intPtr1 = &y;
*intPtr2 = 10;
*intPtr1 = z;
```

7.3 Memory Concepts

Memory visualisation



```c
int x = 1;
int y = 5;
int z = 8;
int ∗intPtr1, ∗intPtr2;
intPtr1 = &x;
intPtr2 = intPtr1;
intPtr1 = &y;
∗intPtr2 = 10;
∗intPtr1 = z;
z = (∗intPtr1) ∗ (∗intPtr2);
```

```c
// Code to demonstrate pointer properties

#include <stdio.h>

int main()
{
   int a;        /* a is an integer */
   int *aPtr;    /* aPtr is a pointer to an integer */
   a = 7;
   aPtr = &a;    /* aPtr set to address of a */

   printf( "The address of a is %d"
           "\nThe value of aPtr is %d", (int) &a, (int) aPtr );
   printf( "\n\nThe value of a is %d"
           "\nThe value of *aPtr is %d", a, *aPtr );
   printf( "\n\nShowing that * and & are complements of "
           "each other\n&*aPtr = %d"
           "\n*&aPtr = %d\n", (int) &*aPtr, (int) *&aPtr );
   return 0;
}
```

Output

```
The address of a is  2686748
The value of aPtr is 2686748

The value of  a    is 7
The value of *aPtr is 7

Showing that * and & are complements of each other
&*aPtr = 2686748
*&aPtr = 2686748
```

7.3 Pointer Operators (cont...)

Operator precedence

	Operators							Associativity	Type
[]	()							left to right	highest
-	+	++	−−	!	*	&	(type)	right to left	unary
*	/	%						left to right	multiplicative
+	−							left to right	additive
<	<=	>	>=					left to right	relational
==	!=							left to right	equality
&&								left to right	logical and
||								left to right	logical or
?:								right to left	conditional
=	+=	−=	*=	/=	%=			right to left	assignment
,								left to right	comma

Perspective

Today

Pointers I

- Pointer definition
- Pointer declaration
- Pointer operations

Next lecture

Pointers II

- Passing pointers to functions

Homework

1. Study Sections 7.1-7.3 in Deitel & Deitel
2. Do Self Review Exercise 7.1 in Deitel & Deitel