C/C++ Programming Language

CS219 Fall

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Lecture 4

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Content

- Brief Review
- Pointer
- Managing Memory for Data
- Loops and Relational Expressions
- Summary

Brief Review

Compound Types

- Array Types
- Strings
  - C-style String
  - string-class string
- Structure
  - Structure: struct
  - Union: union
  - Enumeration: enum

Pointers

Why Needs a Pointer Type?

- Three fundamental properties of declaration
  - Where the information is stored
  - What value is kept there - know
  - What type of information is stored - know
- How to know where the values are stored?
  - Using address operator & to access the address
  - Using hexadecimal notation to display the address values
- Run address.cpp
  - /address.cpp -- using the & operator to find addresses

Identity

Student number

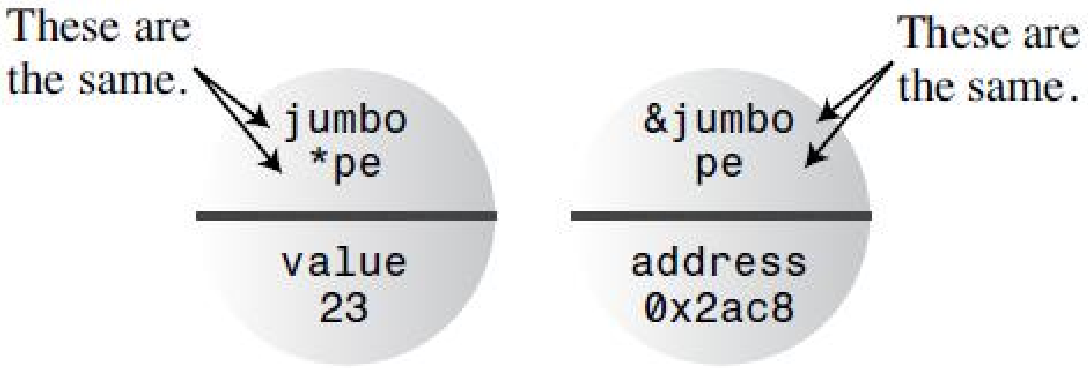
Address

Mobile number

Pointer Type

- Using ordinary variables
  - Naturally, the value is treated as a named quantity
  - The location as the derived quantity
- Using new strategy: pointer type
  - Inverse way
- Operator of asterisk * :
  - Indirect value
  - The dereferencing operator
- Run pointer.cpp
  - // pointer.cpp -- our first pointer variable

```
int jumbo = 23;
int * pe = &jumbo;
```



These are the same.

jumbo
*pe

value
23

&jumbo
pe

address
0x2ac8

These are the same.

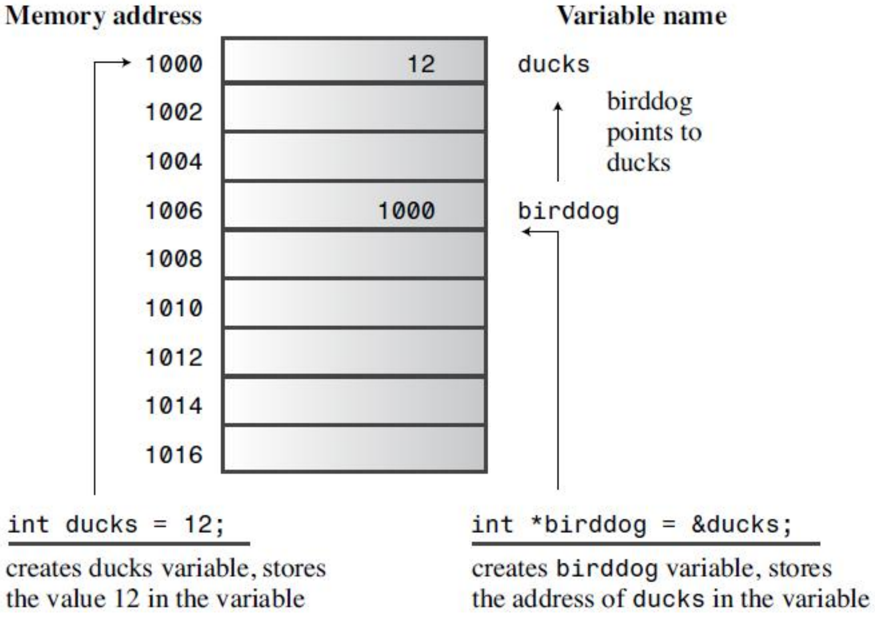
Importance of pointers

- One essential to the C/C++ programming philosophy of is the **memory management**

- Pointers would be the C/C++ Philosophy

Declaring and Initializing Pointers

- Example: int* birddog;
  - * birddog is a int type variable
  - birddog is a pointer type variable
  - The type for birddog is pointer-to-int
  - Put the white space before or behind the * or no spaces
- int * is a compound type
  - double *, float *, char *



Memory address		Variable name
1000	12	ducks
1002		
1004		
1006	1000	birddog
1008		
1010		
1012		
1014		
1016		

birddog points to ducks

```
int ducks = 12;
```

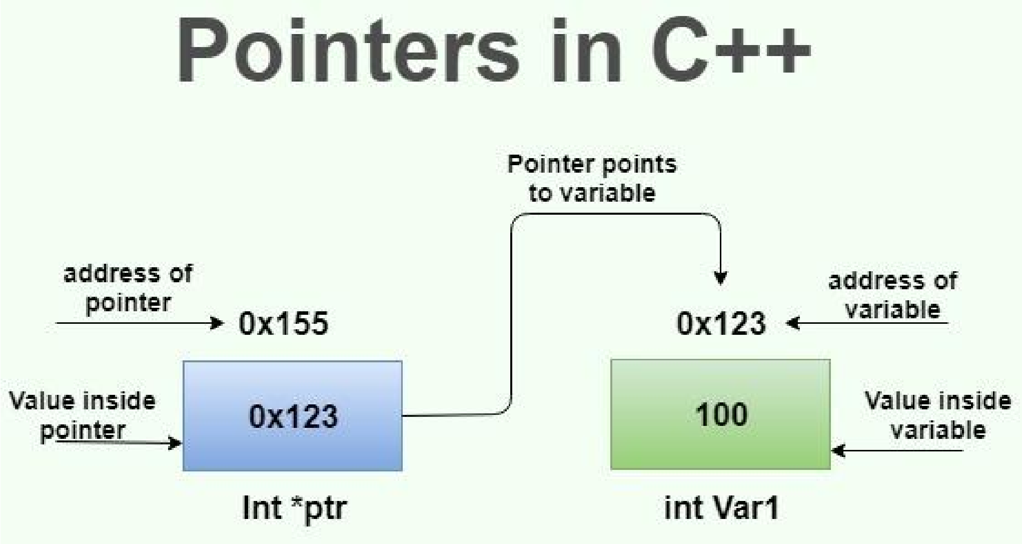
creates ducks variable, stores the value 12 in the variable

```
int *birddog = &ducks;
```

creates birddog variable, stores the address of ducks in the variable

Pointer Danger

- A confusion for beginners
  - Creating a pointer in C++ means the computer allocates memory to **hold an address**
  - BUT it **does not** allocate memory to hold the **data**
    - ✓ int * ptr;   // create a pointer-to-int: **NULL**
    - ✓ *ptr= 223323;   // place a value in never-never land: **disaster**



Pointers and Numbers

- Similarities and differences between pointer and integer
  - They are both **integers** but pointers are not the integer **type**
  - Both are numbers you can add and subtract but it doesn't make sense to multiply and divide two locations
- Why we need addition and subtraction operations?
- Can't simply assign an integer to a pointer
- You can do like this:
  - 0xB8000000 is an address literal (hexadecimal)
  - int * ptr = (int *) 0xB8000000;

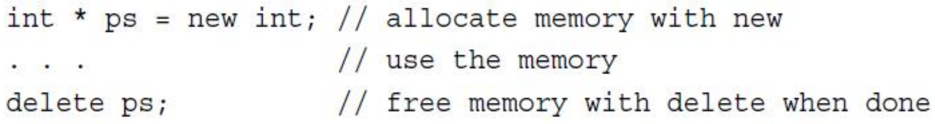
Danger!!!

Allocating Memory with **new**

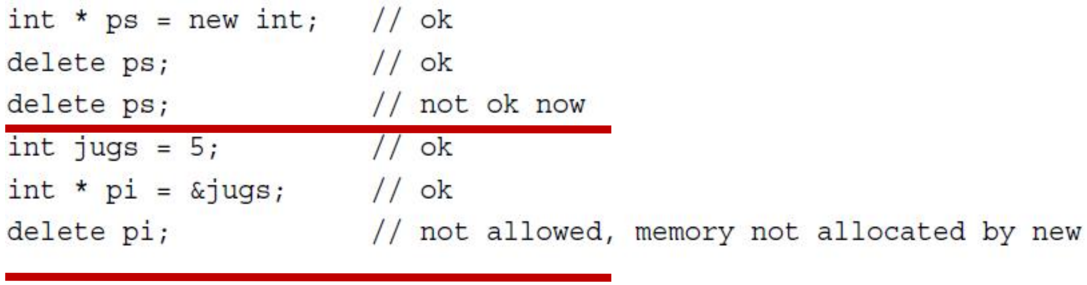
- What is the problem of the pointer? Remember disaster?
- How to solve it?
  - ➢ The key is the C++ **new** operator
    - ① Tell new for what data type you want memory
    - ② Let new find a block of the correct size
    - ③ Return the address of the block
    - ④ Assign this address to a pointer
    - ⑤ This is an example: int * ptr_int = new int; * ptr_int = 1;
- Now, we have three ways of initialization for a pointer type
- Program use_new.cpp
  - ➢ Operation: sizeof
  - ➢ // use_new.cpp -- using the new operator

Freeing Memory with **delete**

- delete operator enables you to return memory to the memory pool
  - ➢ The memory can then be reused by other parts of the program
  - ➢ Balance the uses of new and delete
  - ➢ Memory leak—memory has been allocated but no longer being used
- Beware of
  - ➢ Cannot free a block of memory that you have previously freed
  - ➢ Cannot use delete to free memory created by ordinary variable



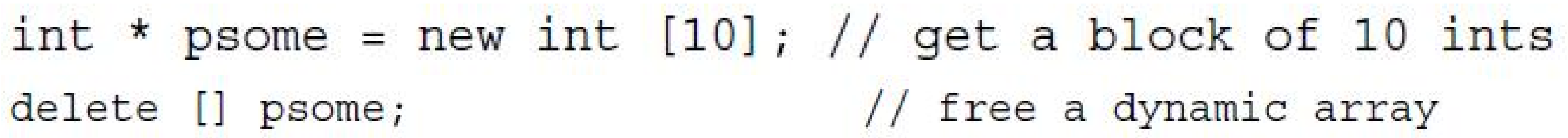
```
int * ps = new int; // allocate memory with new
. . .               // use the memory
delete ps;          // free memory with delete when done
```



```
int * ps = new int;    // ok
delete ps;             // ok
delete ps;             // not ok now
int jugs = 5;          // ok
int * pi = &jugs;      // ok
delete pi;             // not allowed, memory not allocated by new
```

Using **new** to Create Dynamic Arrays

- Use **new** with larger chunks of data, such as arrays, strings, and structures
  - ➢ Static binding: the array is built in to the program at compile time
  - ➢ Dynamic binding: the array is created during runtime
    - ✓ The size of block can be confirm during runtime



```
int * psome = new int [10]; // get a block of 10 ints
delete [] psome;                    // free a dynamic array
```

① Don't use delete to free memory that new didn't allocate

② Don't use delete to free the same block of memory twice in succession

③ Use delete [] if you used new [] to allocate an array

④ Use delete (no brackets) if you used new to allocate a single entity

⑤ It's safe to apply delete to the null pointer (nothing happens)

Using a Dynamic Array

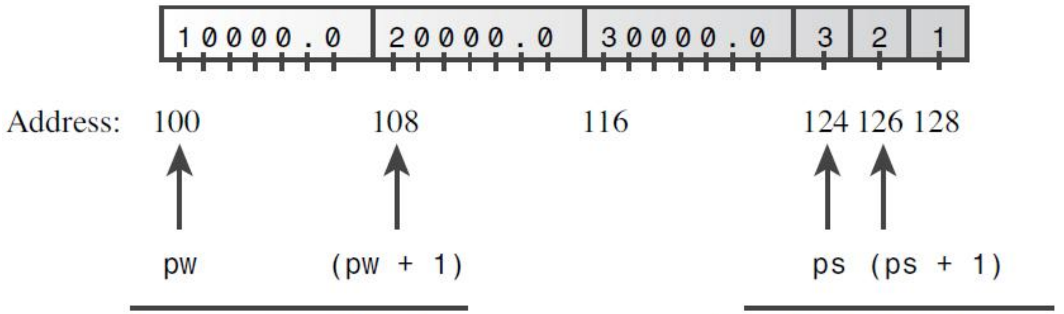
- How do you use the dynamic array?
  - Identify every element in the block
  - Access one of these elements
- Program arraynew.cpp
  - // arraynew.cpp -- using the new operator for arrays

  - A pointer points to the first element
  - double * p3 = new double [3]; // space for 3 doubles
  - p3 = p3 + 1; // increment the pointer
  - p3 = p3 - 1; // point back to beginning

Pointers, Arrays, and Pointer Arithmetic

- Adding one to a pointer variable increases its value by **the number of** bytes of the **type** to which it points
- Program addpntrs.cpp
  - ➢ You can use pointer names and array names in the same way
  - ➢ Differences between them
    - ① You can change the value of a pointer, whereas an array name is a **constant**
    - ② Applying the sizeof operator to an array name yields the size of the array, but applying sizeof to a pointer yields the size of the pointer

```
double wages[3] = {10000.0, 20000.0, 30000.0};
short stacks[3] = {3, 2, 1};
double * pw = wages;
short * ps = &stacks[0];
```



pw points to type *double*, so adding 1 to *pw* changes its value by 8 bytes.

ps points to type *short*, so adding 1 to *ps* changes its value by 2 bytes.

The Address of an Array

What, where and size

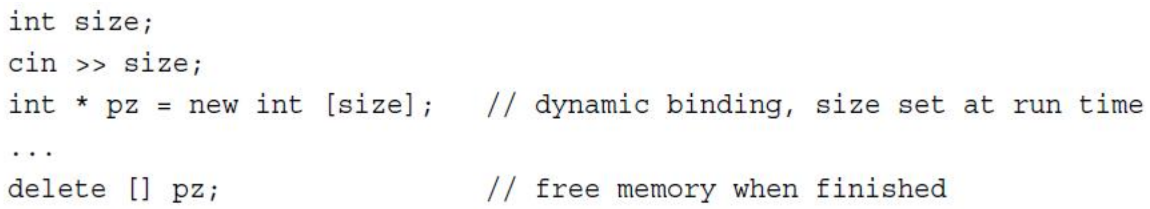
- Program addpntrs-2.cpp
  - short tell[10];
  - tell is type pointer-to-short
  - &tell is type pointer-to-array of 10 shorts
  - short (*pas)[10] = &tell;   // try to replace 10 by 20
  - (*pas) = tell is type pointer-to-short
  - pas=&tell is type pointer-to-array of 10 shorts
  - short* pas[10];
  - pas is an array of 10 pointers-to-short

The name of a variable can refer to a value and other information as well

- **&tell**   **short (*pas)[10]**
  - Applying the address operator yields the address of the whole array

Summarizing Pointer Points

- Pointers
  - Declaring pointers
  - Assigning values to pointers (three ways)
  - Dereferencing pointers: mean referring to the pointed-to value
  - Distinguishing between a pointer and the pointed-to value
- Array names
  - Bracket array notation is equivalent to dereferencing a pointer
- Pointer arithmetic
- **Dynamic** binding and static binding for arrays



```
int size;
cin >> size;
int * pz = new int [size];    // dynamic binding, size set at run time
...
delete [] pz;                 // free memory when finished
```

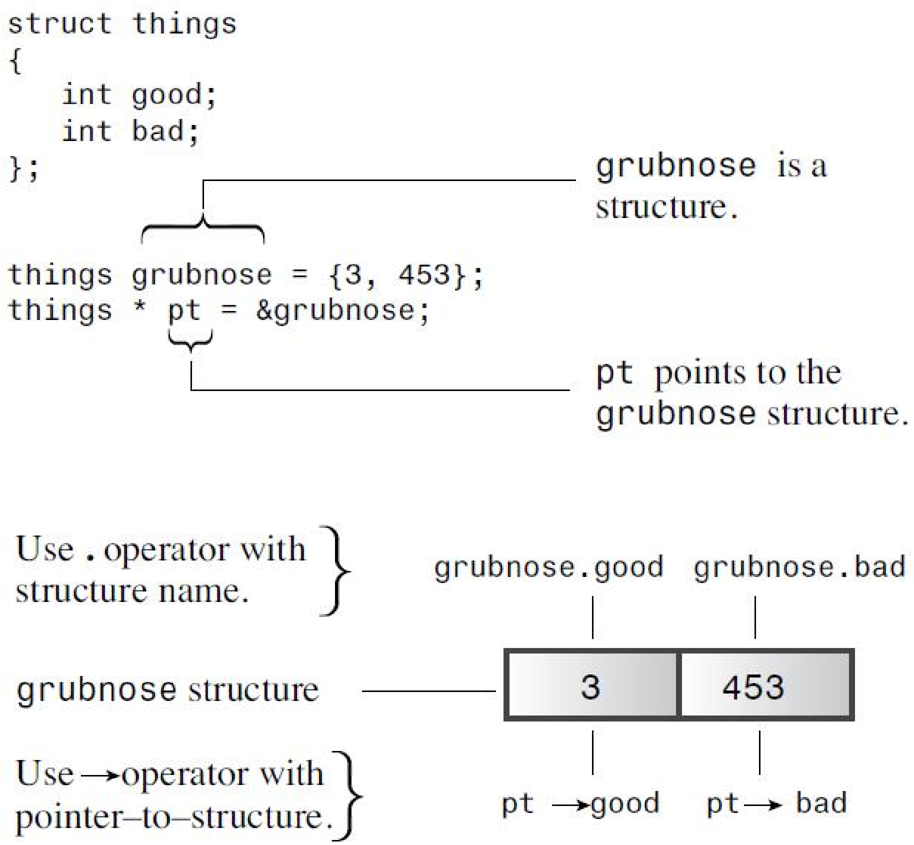
Using **new** to Create Dynamic Structures

- Dynamic means the memory is allocated during runtime
  - ➢ Creating the structure
  - ➢ Accessing its members

```
inflatable * ps = new inflatable;
```

  - ➢ The arrow membership operator (->) of a hyphen and then a greater-than symbol

- Program newstrct.cpp



```
struct things
{
    int good;
    int bad;
};

things grubnose = {3, 453};
things * pt = &grubnose;
```

grubnose is a structure.
pt points to the grubnose structure.
Use . operator with structure name.
grubnose.good
grubnose.bad
grubnose structure
3
453
Use →operator with pointer–to–structure.
pt →good
pt→ bad

An Example of Using **new** and **delete** for Functions

- Program delete.cpp
  - Return the address of the string copy
  - It's usually not a good idea to put new and delete in separate functions

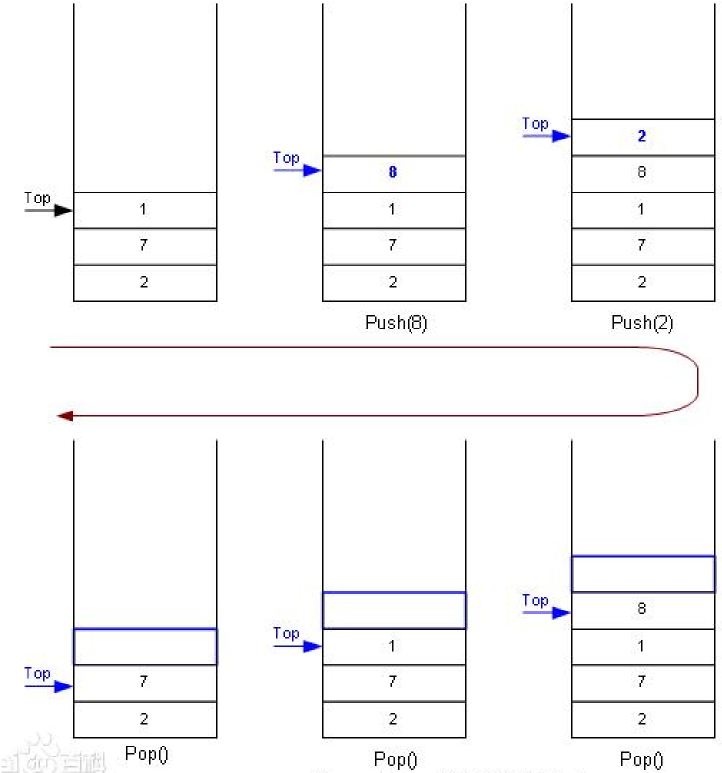
Address Types

- Pointer
  - Address operator: &
  - Indirect value operator: *
  - Allocate memory: new
  - Release memory: delete

Managing memory for data

Automatic Storage

- Automatic Storage
  - Ordinary variables defined inside a function use automatic storage and are called automatic variables
  - They expire when the function terminates
  - Automatic variables typically are stored on a **stack**
  - A last-in, first-out, or LIFO, process



Stack的Push和Pop，遵循先进后出规则

Static Storage

- Static Storage
  - ➢ Static storage is storage that exists throughout the execution of an entire program
  - ➢ Two ways

    ① Define it externally, outside a function

    ② Use the keyword static when declaring a variable

    static double fee = 56.50;

Dynamic Storage

- Dynamic Storage
  - ➢ The new and delete operators provide a more flexible approach than automatic and static variables
  - ➢ Refer to as the free store or heap
  - ➢ Lifetime of the data is not tied arbitrarily to the life of the program or the life of a function

Combinations of Types

- Combinations
  - Include arrays, structures, and pointers

- Program mixtypes.cpp: array of structures
  - const antarctica_years_end * arp[3] = {&s01, &s02, &s03};
  - const antarctica_years_end ** ppa = arp;
  - Distinguish the following (again)

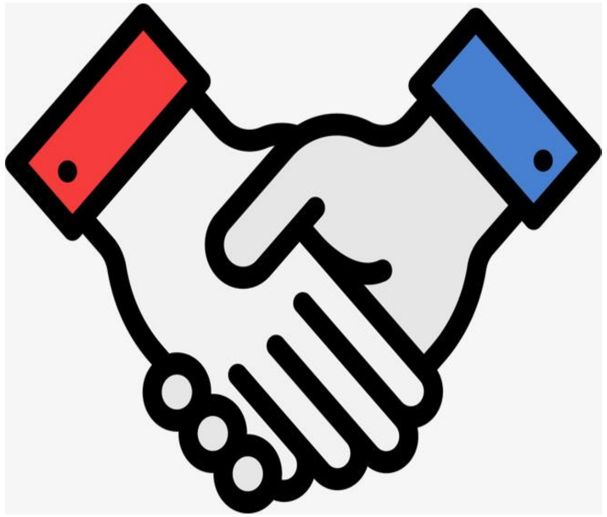
type_name * variable_name[10]   ----- type_name (*variable_name)[10]

const type_name * variable_name   ----- type_name * const variable_name

Array Alternatives

Template??

- The vector Template Class
  - It is a **dynamic** array (Similar to the string class)
  - Use new and delete to manage memory
  - The vector identifier is part of the std namespace
- The array Template Class
  - The array identifier is part of the std namespace
  - The number of elements can't be a variable
  - **Static** memory allocation
- Run choices.cpp
  - Comparing Arrays, Vector Objects, and Array Objects



Thanks

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