Pointers

- To understand pointers, you should first know how data is stored on the computer.
- Each variable you create in your program is assigned a location in the computer's memory. The value the variable stores is actually stored in the location assigned.
- To know where the data is stored, C++ has an & operator.
- **The & (reference) operator gives you the address occupied by a variable.**
- **If var is a variable then, &var gives the address of that variable.**

Example 1: illustrate the Address in C++

```
#include <iostream>
using namespace std;

int main()
{
    int var1 = 3;
    int var2 = 24;
    int var3 = 17;
    cout << &var1 << endl;
    cout << &var2 << endl;
    cout << &var3 << endl;
}
```

Output

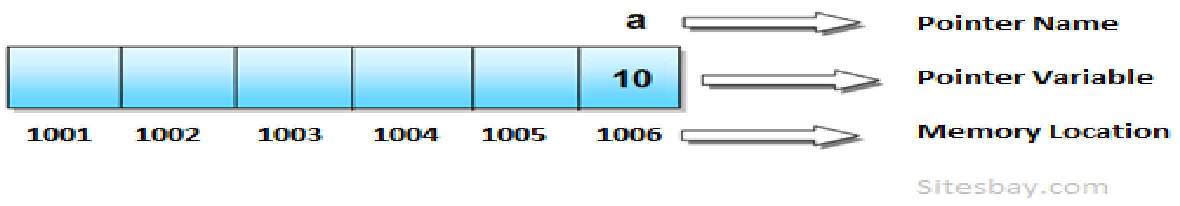
```
0x7fff5fbff8ac
0x7fff5f bff8a
8
0x7fff5f bff8a
4
```

توضيح

- You may not get the same result on your system.
- The ox in the beginning represents the address is in hexadecimal form.
- Notice that first address differs from second by 4-bytes and second address differs from third by 4-bytes.
- This is because the size of integer (variable of type int) is 4 bytes in 64-bit system.

Pointers

- A pointer is the memory address of a variable.
- A **pointer** is a variable that contains the address of a variable.
- Using pointer we can pass argument to the functions. Generally we pass them by value as a copy. So we cannot change them. But if we pass argument using pointer, we can modify them
- Let us imagine that a computer memory is a long array and every array location has a distinct memory location.
- A pointer variable contains a representation of an address of another variable (P is a pointer variable in the following):



Example: (pointer declarations)

float *p; //To declare a pointer variable p that can "point" to a variable of type float

int *K; //To declare a pointer variable K that can "point" to a variable of
type int

Example: If a number variable is stored in the memory address **0x123**, and it contains a value **5**.

- The **reference (&)** operator gives the value **0x123**, while the **dereference**
  (*) operator gives the value **5**.

Pointer Variable Definition

Syntax: *Type* **Name;*

Examples:

```
int    *P;          //  P is varaible  that can point to an integer  var
float *Q;           //  Q is a float pointer
char *R;            //   R is a char pointer
```

Example:

```
int *AP[5];         /* AP is an array of 5 pointers to ints */
```

Address (&) Operator

- An address used to tell where a variable is stored in memory is a pointer
- Pointer variables must be declared to have a pointer type
- Reference operator (&) as discussed above gives the address of a variable.

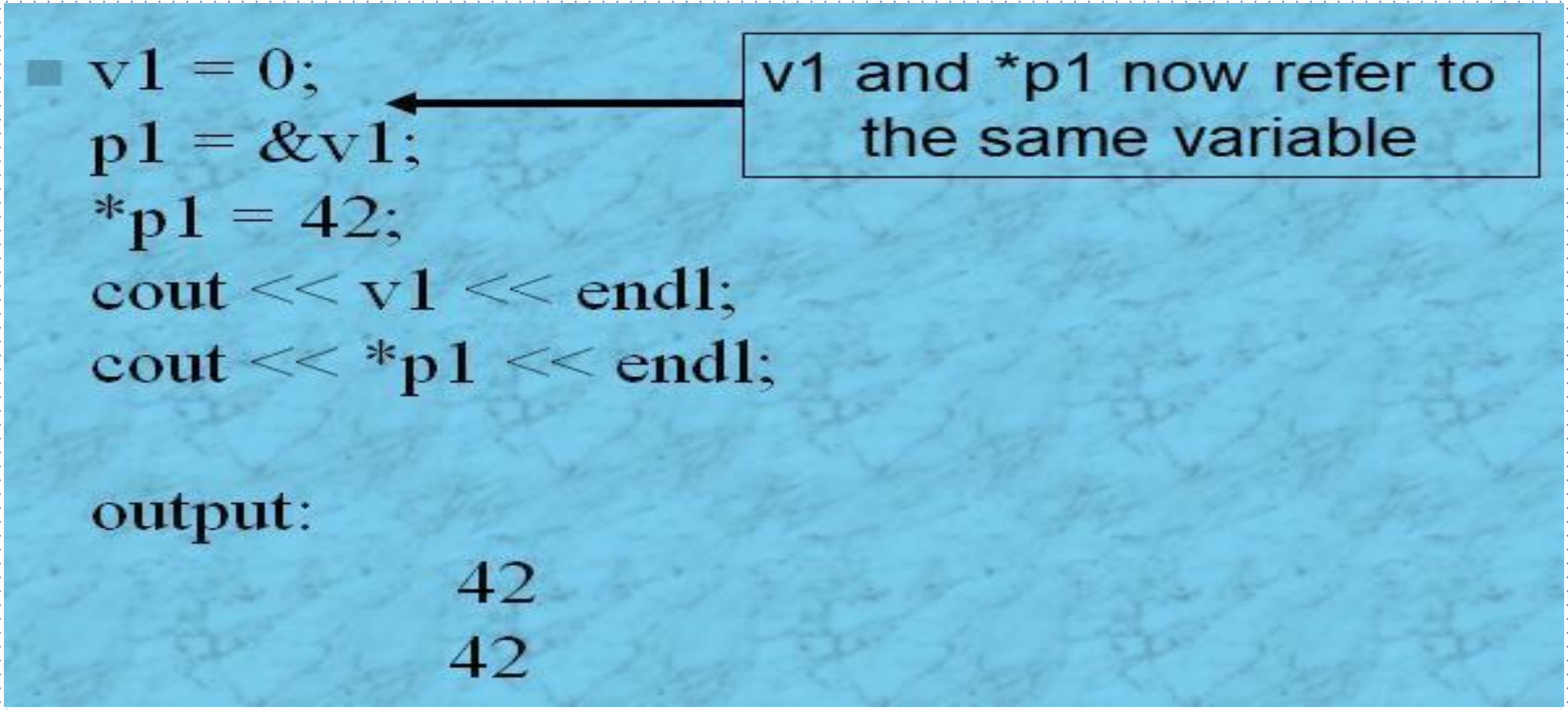
The Dereferencing Operator

To get the value stored in the memory address, we use the dereference operator (*).

Example: p1 = &v1;

- p1 is now a pointer to v1
- v1 can be called v1 or "the variable pointed to by p1"

Example 2:



```
v1 = 0;
p1 = &v1;
*p1 = 42;
cout << v1 << endl;
cout << *p1 << endl;

output:
              42
              42
```

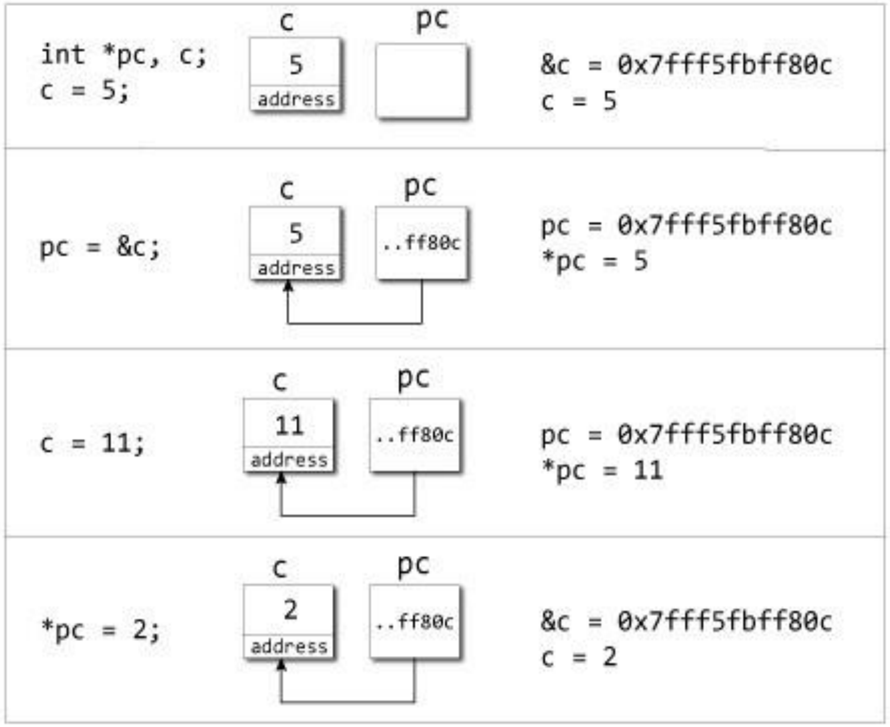
v1 and *p1 now refer to the same variable

Example 3: C++ Pointers

C++ Program to demonstrate the working of pointer.

```
#include      <iostream>
using   namespace   std;
int main() {
int *pc, c;
   c = 5;
 cout << "Address of c (&c): " << &c << endl;
 cout << "Value of c (c): " << c << endl << endl;
   pc = &c;                // Pointer pc holds the memory address
of variable c  cout << "Address that pointer pc holds (pc):
"<< pc << endl;
cout << "Content of the address pointer pc holds (*pc): " << *pc <<
endl

  c = 11;   // The content inside memory address &c is changed from
5 to 11.  cout << "Address pointer pc holds (pc): " << pc << endl;
cout << "Content of the address pointer pc holds (*pc): " << *pc <<
endl;
   *pc = 2;
  cout << "Address of c (&c): " << &c << endl;
  cout << "Value of c (c): " << c << endl << endl;
   return 0;
}
```

The output for Example 3



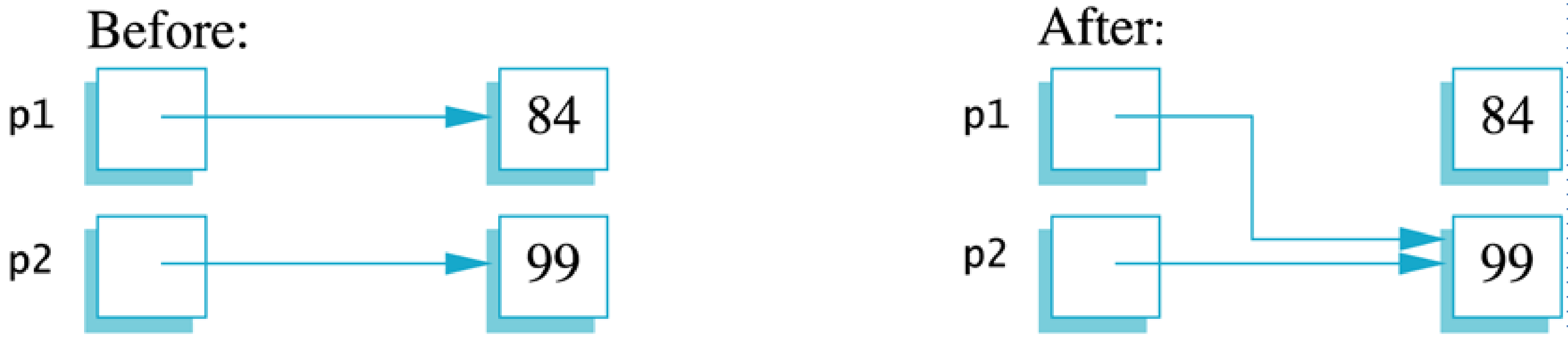
```
Address of c (&c): 0x7fff5fbff80c
Value of c (c): 5

Address that pointer pc holds (pc): 0x7fff5fbff80c
Content of the address pointer pc holds (*pc): 5

Address pointer pc holds (pc): 0x7fff5fbff80c
Content of the address pointer pc holds (*pc): 11

Address of c (&c): 0x7fff5fbff80c
Value of c (c): 2
```

Pointer Assignment

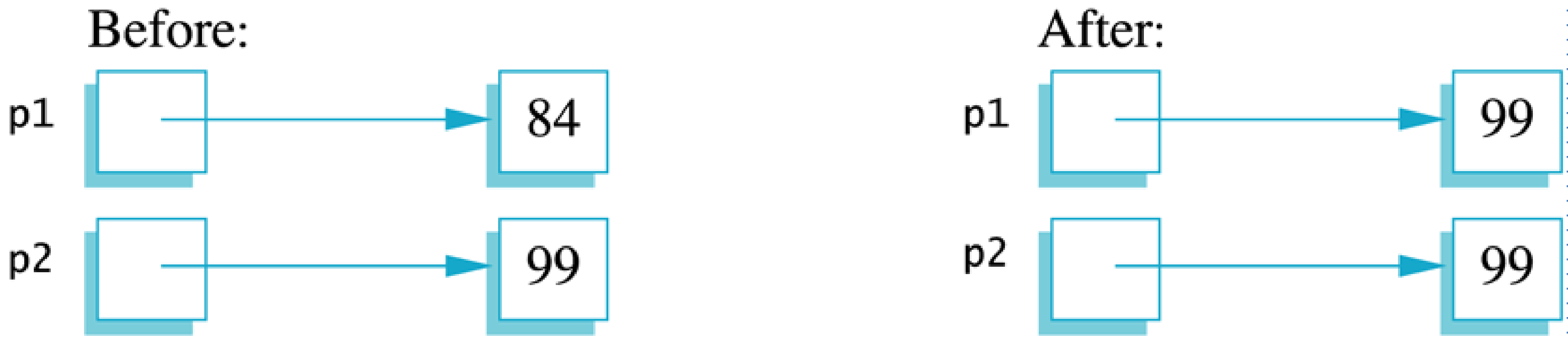
- The assignment operator = is used to assign the value of one pointer to another
  - Example: If p1 still points to v1 (previous slide) then
    p2 = p1;
  - causes *p2, *p1, and v1 all to name the same variable
- Some care is required making assignments to pointer variables
  - p1= p2; // changes the location that p1 "points" to
  - *p1 = *p2; // changes the value at the location that p1 "points" to

Uses of the Assignment Operator

```
p1 = p2;
```

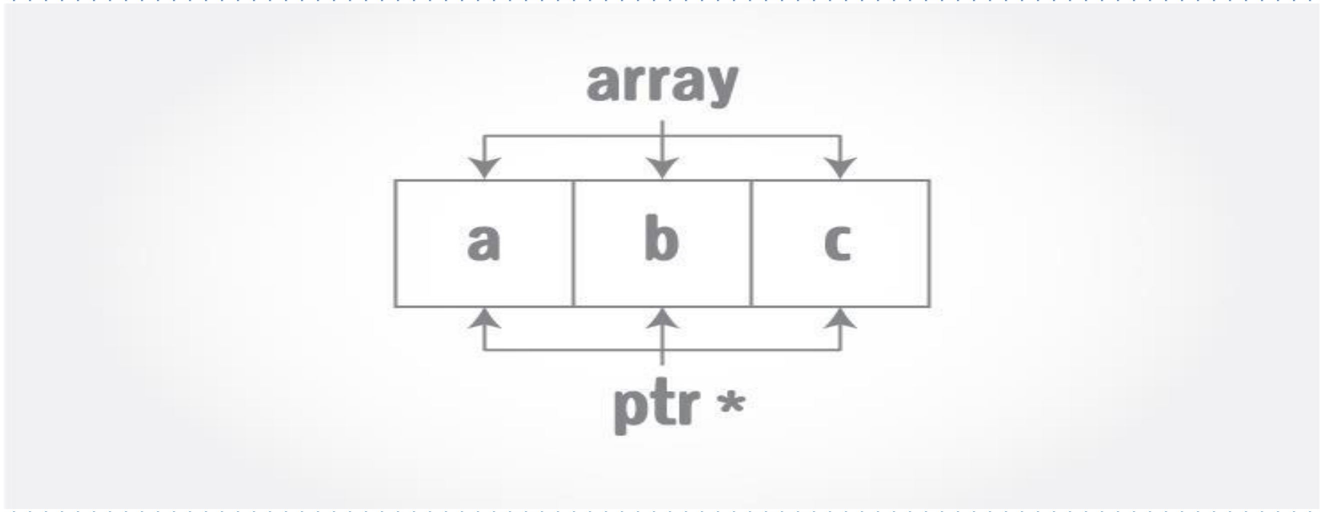


```
*p1 = *p2;
```



C++ Pointers and Arrays

- In this article, you'll learn about the relation between arrays and pointers, and use them efficiently in your program.



- Pointers are the variables that hold address. Not only can pointers store address of a single variable, it can also store address of cells of an array.

For example:

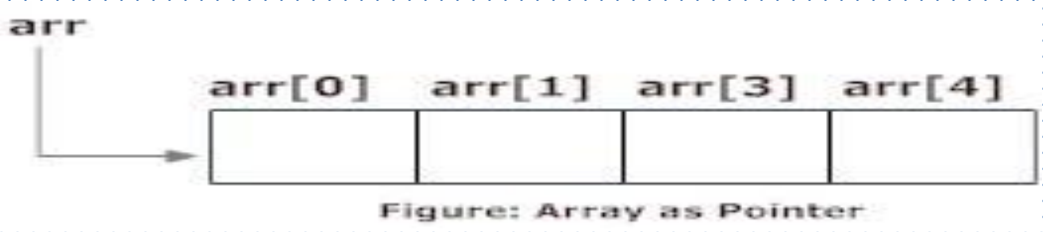


Figure: Array as Pointer

Int *ptr;
int a[5];
Ptr = &a[2]; // &a[2] is the address of third element of a[5].

- Suppose, pointer needs to point to the fourth element of an array, that is, hold address of fourth array element in above case.
- Since ptr points to the third element in the above example, ptr + 1 will point to the fourth element.
- You may think, ptr + 1 gives you the address of next byte to the ptr. But it's not correct.
- This is because pointer ptr is a pointer to an **int and size of int is fixed for a operating system (size of int is 4 byte of 64-bit operating system).** Hence, the address between ptr and ptr + 1 differs by 4 bytes.
- If pointer ptr was pointer to char then, **the address between ptr and ptr + 1 would have differed by 1 byte since size of a character is 1 byte.**

Example 4: C++ Pointers and Arrays

C++ Program to display address of elements of an array using both array and pointers

```
#include <iostream>
using namespace std;

int main()
{
   float arr[5];
   float *ptr;

   cout << "Displaying address using arrays: " << endl;
   for (int i = 0; i < 5; ++i)
   {
      cout << "&arr[" << i << "] = " << &arr[i] << endl;
   }

   // ptr = &arr[0]
   ptr = arr;

   cout<<"\nDisplaying address using pointers: "<< endl;
   for (int i = 0; i < 5; ++i)
   {
      cout << "ptr + " << i << " = "<< ptr + i << endl;
   }


   return 0;
}
```

Output of Eample 4:

```
Displaying address using arrays:
&arr[0] = 0x7fff5fbff880
&arr[1] = 0x7fff5fbff884
&arr[2] = 0x7fff5fbff888
&arr[3] = 0x7fff5fbff88c
&arr[4] = 0x7fff5fbff890

Displaying address using pointers:
ptr + 0 = 0x7fff5fbff880
ptr + 1 = 0x7fff5fbff884
ptr + 2 = 0x7fff5fbff888
ptr + 3 = 0x7fff5fbff88c
ptr + 4 = 0x7fff5fbff890
```

يضوت

In the above program, a different pointer ptr is used for displaying the address of array elements arr.

But, array elements can be accessed using