9. Pointers

[ECE10002/ITP10003] C Programming

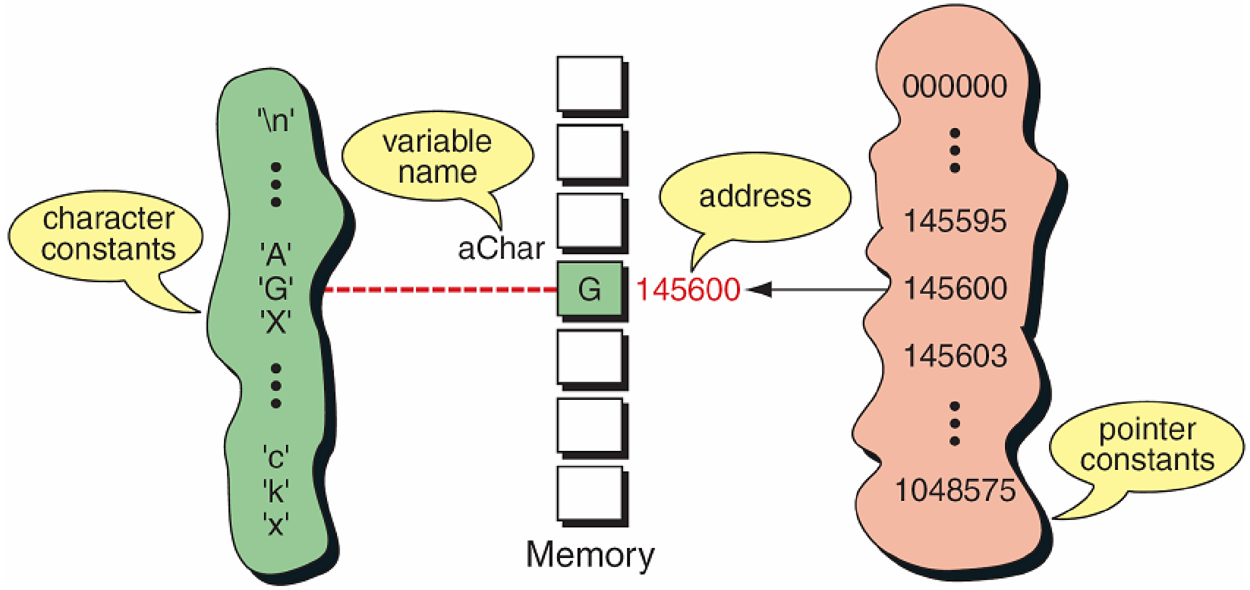
Agenda

- Introduction
- Pointer for Inter-Function Communication
- Pointers to Pointers
- Compatibility
- (Lvalue and Rvalue)

Introduction

- Pointer: constant or variable that contains an address that can be used to access data
  - Range of pointer: address space of computer

    Ex) char aChar = ‘G’;   // assume &aChar = 1465600



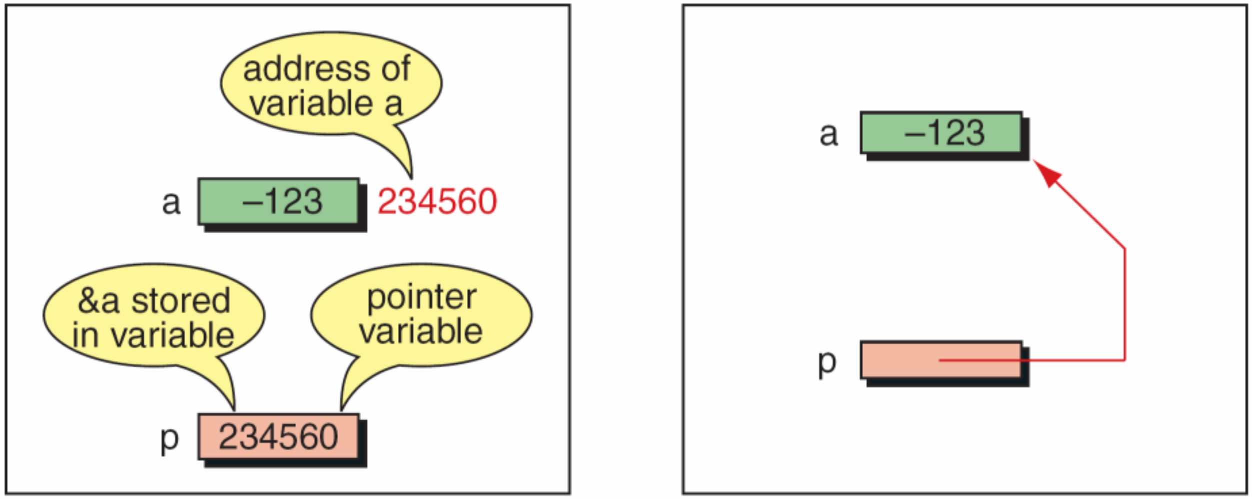
Operations of Pointers

- Compile the following program and find out what operations are possible on pointers.

```
int main()
{
    int i = 0, j = 0;
    int *p1 = &i;
    int *p2 = &j;
    int *result = NULL;

    result = p1 + 10;                // pointer + integer
    result = p1 - 10;                // pointer - integer

    result = p1 + p2;                // pointer + pointer
    int diff = p1 - p2;              // pointer – pointer (Note the type of diff.)

    result = p1 * p2;                // pointer * pointer
    result = p1 / p2;                // pointer * pointer

    return 0;
}
```

Pointer Variables

- Pointer variable: a variable to store an address



Physical representation
Logical representation

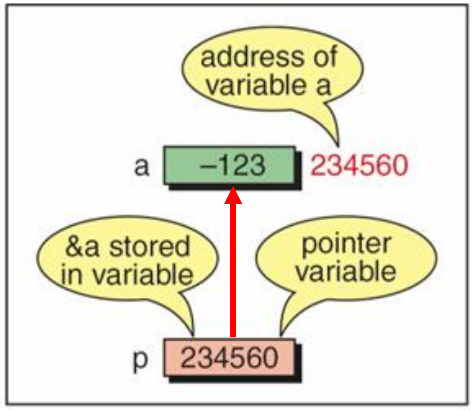
- We can access value of **a** through **p**, but the opposite is impossible.

Using Pointer Variables

- Declaration
  - int *p = NULL; // initialize by NULL pointer
    - NULL is defined as '#define NULL ((void*)0)' in stdio.h.
- Extracting address of a variable (address operator &)
  - p = &a;
- Dereferencing (dereferencing operator *)
  - *p = 89;
  - c = *p * 2;
- Address operator vs. dereferencing operator
  - & is inverse of *

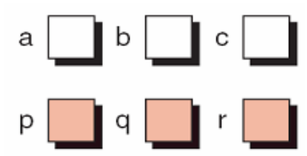
    Ex) *&a ≡ a; // * and & cancel each other

    cf. How about &*a ?

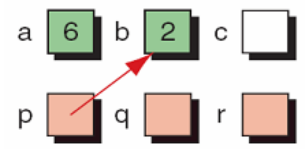


Example

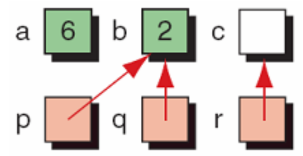
```
int a = 0, b = 0, c = 0;
int *p = NULL, *q = NULL, *r = NULL;
```



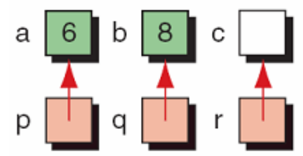
```
a = 6;
b = 2;
p = &b;
```



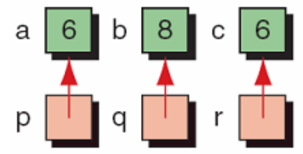
```
q = p;
r = &c;
```



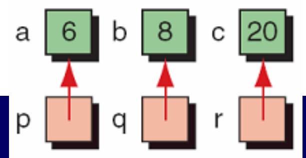
```
p = &a;
*q = 8;
```



```
*r = *p;
```



```
*r = a + *q + *&c;
```



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Pointers for Inter-Function Communication

- Passing addresses

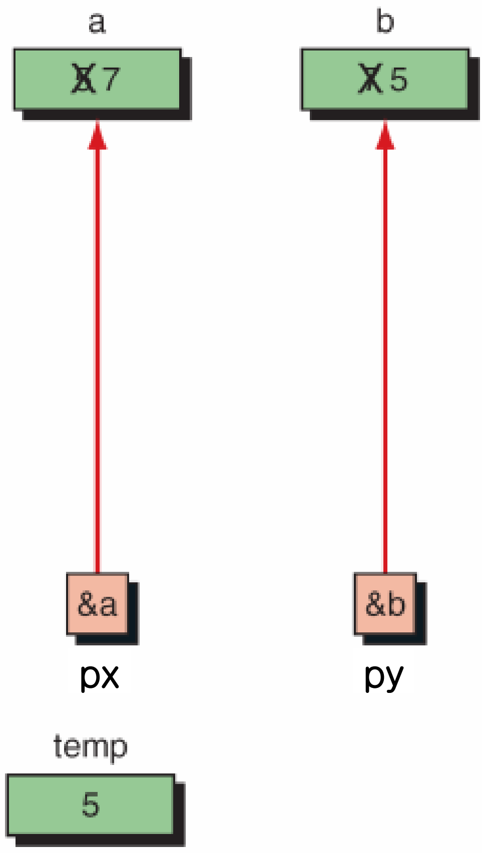
```
// Function Declaration
void exchange (int*, int*);

int main (void)
{
   int a = 5;
   int b = 7;

   exchange (&a, &b);
   printf("%d %d\n", a, b);
   return 0;
} // main
```

```
void exchange (int* px, int* py)
{
   int temp;

   temp = *px;
   *px  = *py;
   *py  = temp;
   return;
} // exchange
```



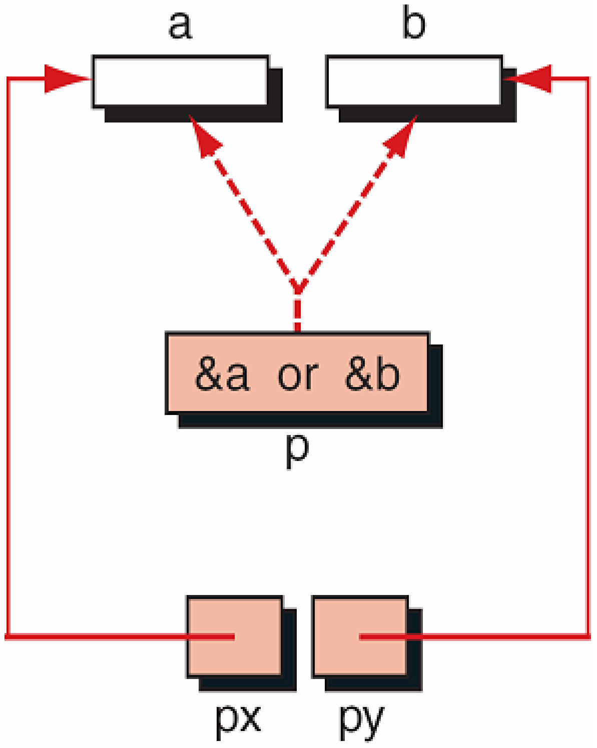
Pointers for Inter-Function Communication

- Functions returning pointers

```
// Prototype Declarations
int* smaller (int* p1, int* p2);

int main (void)
   …
   int  a;
   int  b;
   int* p;
   …
   scanf ( "%d %d", &a, &b );
   p = smaller (&a, &b);
   …
```

```
int* smaller (int* px, int* py)
{
   return (*px < *py ? px : py);
} // smaller
```



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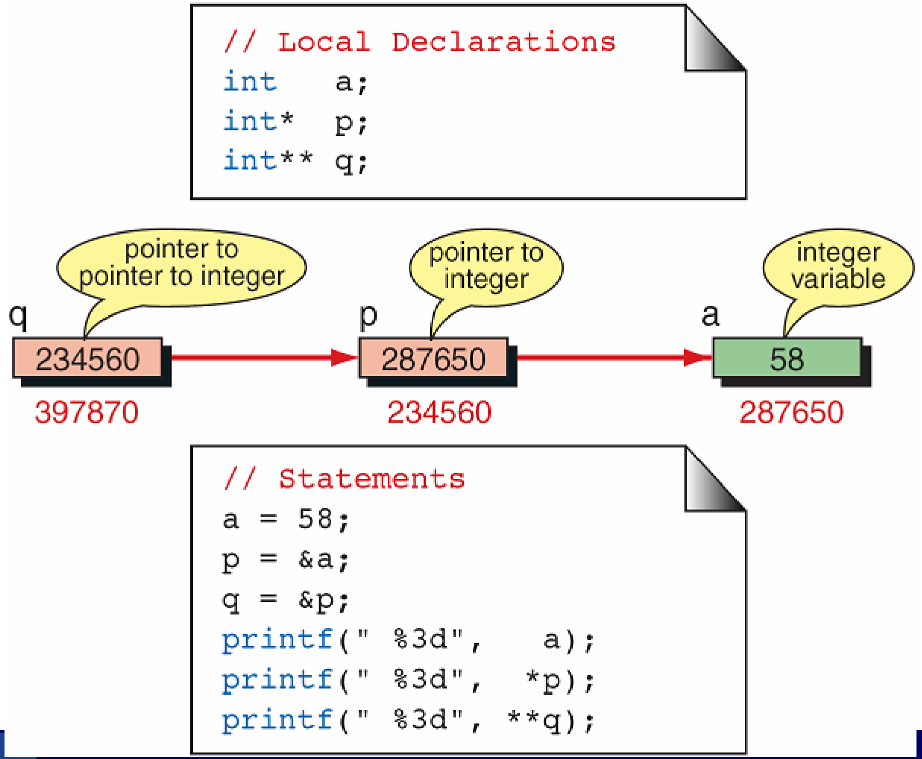
Pointers to Pointers

- Pointer to pointer (double pointer): a pointer that points a pointer variable
  - Note! Pointer variable itself occupies memory space



```
// Local Declarations
int    a;
int*   p;
int**  q;
```

```
// Statements
a = 58;
p = &a;
q = &p;
printf(" %3d",   a);
printf(" %3d",  *p);
printf(" %3d", **q);
```

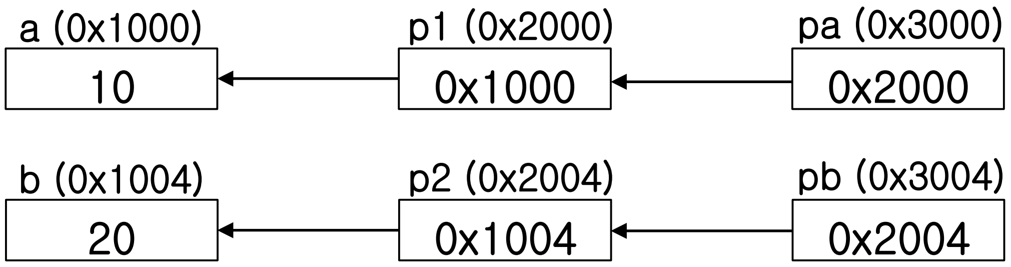
Example: Double Pointers

- Exchange pointer variables

```
int main()
{
   int a = 10, b = 20;
   int *p1 = &a, *p2 = &b;

   ExchangePointers(&p1, &p2);
   printf("*p1 = %d, *p2 = %d₩n",
    *p1, *p2);
}
```

```
void ExchangePointers(
        int **pa, int **pb)
{
   int *temp = *pa;
   *pa = *pb;
   *pb = temp;
}
```

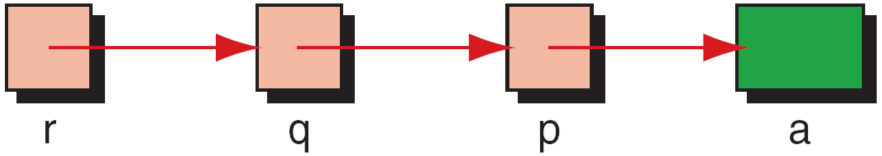


Pointers to Pointers

- Triple pointer

```
int a = 0;
int *p = &a;            // same with "int *p; p = &a;"
int **q = &p;
int ***r = &q;

// Note a ≡ *p ≡ **q ≡ ***r
```



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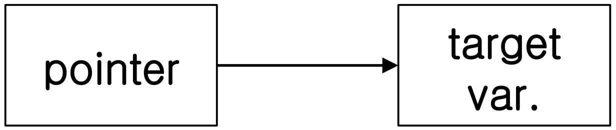
Compatibility

- Pointer type compatibility
  - A pointer variable can store a pointer of the same type.

```
Ex) char c = '₩0', *pc = NULL;
    int a = 0;
    pc = &c;     // no problem
    pc = &a;     // prohibited
```



- Pointer size compatibility
  - Although size of a variable vary with types, size of all pointers are the same.
    - int   i, *pi;
    - char   c, *pc;
    - float f, *pf;

    sizeof(i) ≠ sizeof(c) ≠ sizeof(f)

    sizeof(pi) = sizeof(pc) = sizeof(pf)

Pointer to Void

- void type pointer (void *) is just to store a generic address
  - A generic type that is not associated with a reference type

- void pointer can store any type of pointers

```
void *vp = NULL;
int a = 0;
char c = '₩0';
vp = &a;      // assigning integer pointer to vp
vp = &c;      // assigning character pointer to vp
```

- NULL pointer
  - #define NULL ((void*)0)   // in stdio.h
  - Frequently used to initialize pointer variables

```
Ex) int a = 0;
    int *p = 0;         // type mismatched
    int *p = NULL;      // OK
```

Pointer to Void

- void pointer cannot be dereferenced as it is

```
int a = 10;
void *pVoid = &a;
*pVoid = 10;          // illegal
```

To be dereferenced, void pointer should be casted.

- void pointer can be dereferenced by casting

```
int a = 10;
void *pVoid = &a;
printf("*(int)pVoid = %d₩n", *(int*)pVoid);
```