Pointers
(review + memory allocation)

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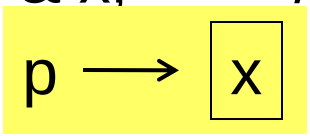
Pointers in C

- Understanding pointers is **critical** in learning C.
- In a computer, data are stored in memory as
  address - data pairs
- A pointer's data field is an address.
- Programmers have **no** control of the addresses of data.
- Programmers **can** control the data of pointers, i.e. where they point to.

Address	Data
0X00000000	…
…	…
0x08001F00	'a'
…	…
0X1A0088F0	642
…	…
0X1BFF0000	0X1A0088F0

Pointer Operation (review)

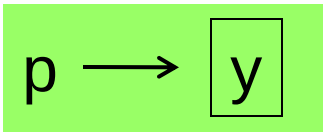
```
int * p;          /* p is a pointer to an integer */
int x = 123;
int y = 987;
p = & x;          /* p points to x */
```




```
*p = 456;         /* x is 456 now */
```

Address	Data
somewhere (&x)	456
…	…
somewhere (&p)	& x
somewhere (&y)	987

```
p = & y;          /* p points to y */
```




```
*p = -765;        /* y is -765 now */
```

Address	Data
somewhere (&x)	456
…	…
somewhere (&p)	& y
somewhere (&y)	-765

Terminal

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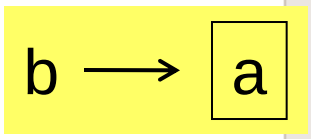
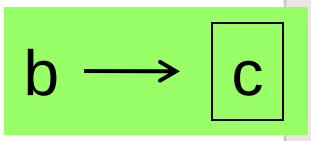
```
[Ubuntu Linux ] more pointer1.c
#include <stdio.h>
int main(int argc, char * argv[])
{
  int a = 100;
  int * b;    /* b is a pointer to an integer */
  b = &a;     /* b points to a */
  *b = 200;   /* The value where b points to
                 is changed to 200 */
  printf("a's value is %d\n", a);
  int c = 300;
  b = & c;    /* b points to c */
  * b = 400; /* The value where b points to
                 is changed to 400 */
  printf("c's value is %d\n", c);
  return 0;
}
[Ubuntu Linux ] gcc pointer1.c -o pointer1
[Ubuntu Linux ] ./pointer1
a's value is 200
c's value is 400
[Ubuntu Linux ]
```





Common Mistake

A program cannot control addresses.

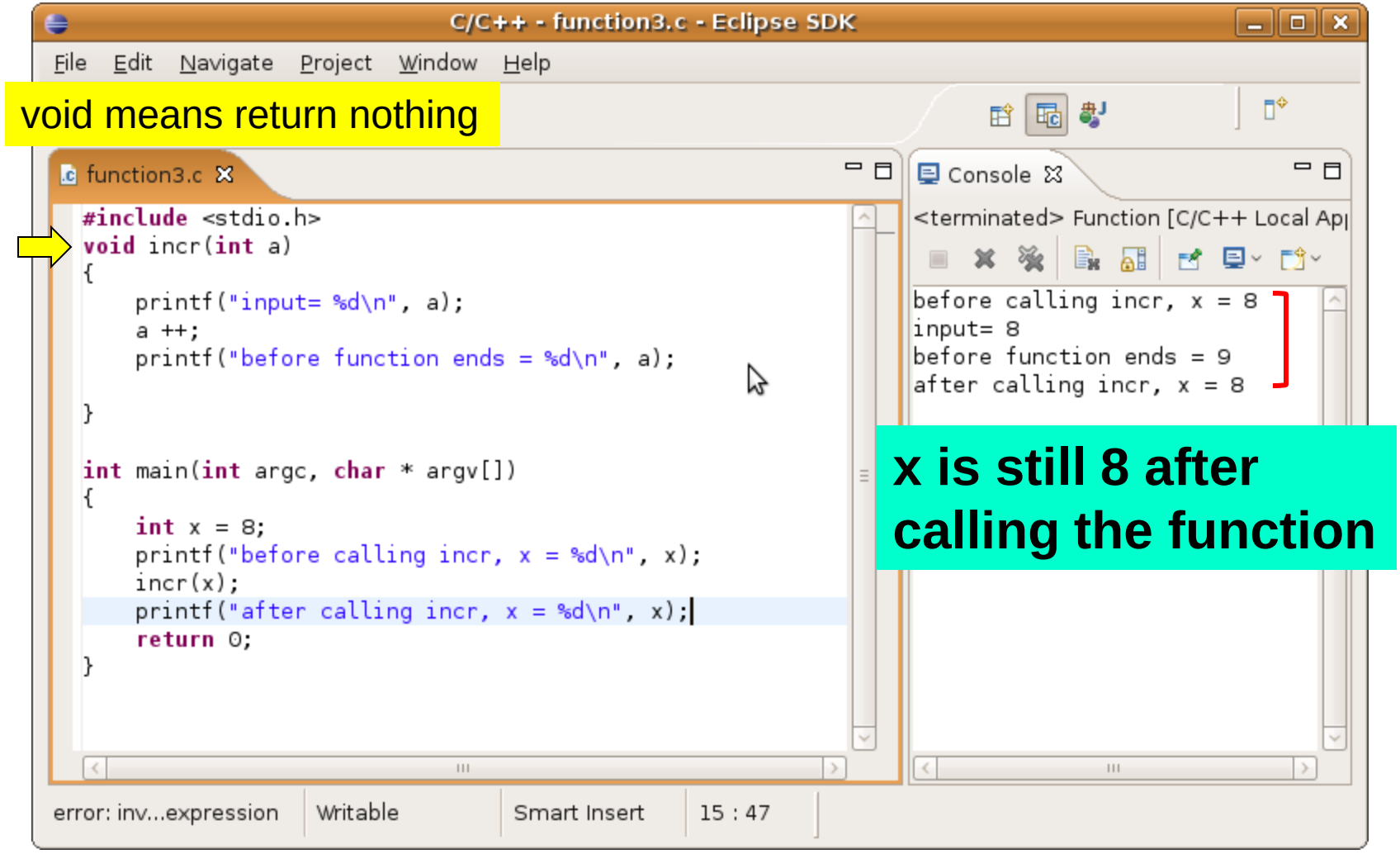
```
65 = 123;
/* cannot assign value 123 to the address 65 */
```

```
int * p = 86;
/* warning message,  the
      address is likely occupied by another program. */
```

Address	Data
86	…
somewhere (&p)	86

```
double d = 0.84;
int * p = & d;        /* warning message */
```

Modify the Argument



Call by Value

A function **copies** the **value** to the function's argument.

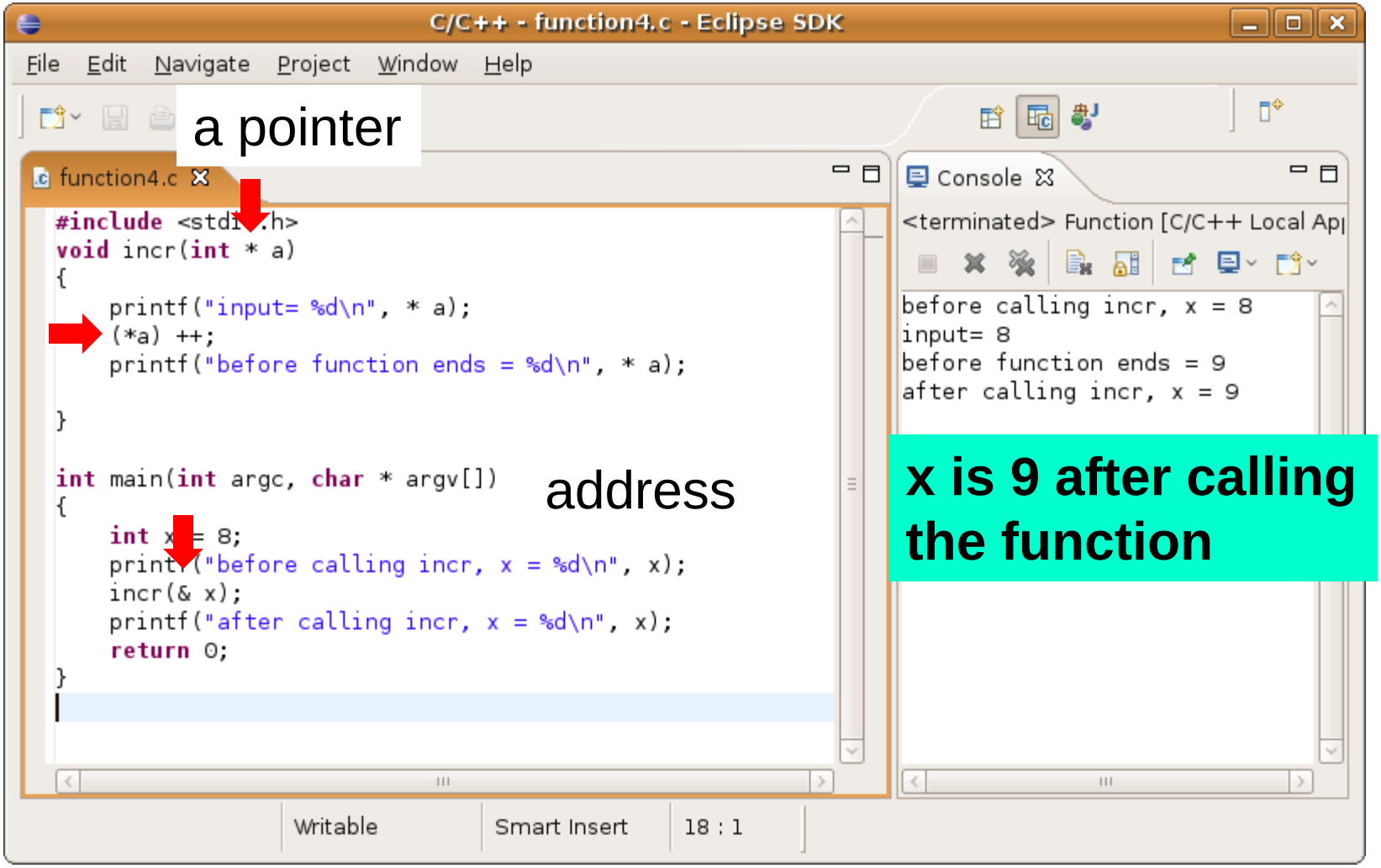
```
void incr(int a) …

int x = 8;
incr(x);        /* copy x's value to a */
a ++;           /* a becomes 9, x is still 8 */
```

similar to

```
int x = 8;
int y = x;
y ++;           /* y is 9, x is still 8 */
```

Address	**Data**
somewhere (&x)	8
somewhere (&a)	8 → 9

Address as Argument



Call by Address

A function **copies** the **address** to the argument.

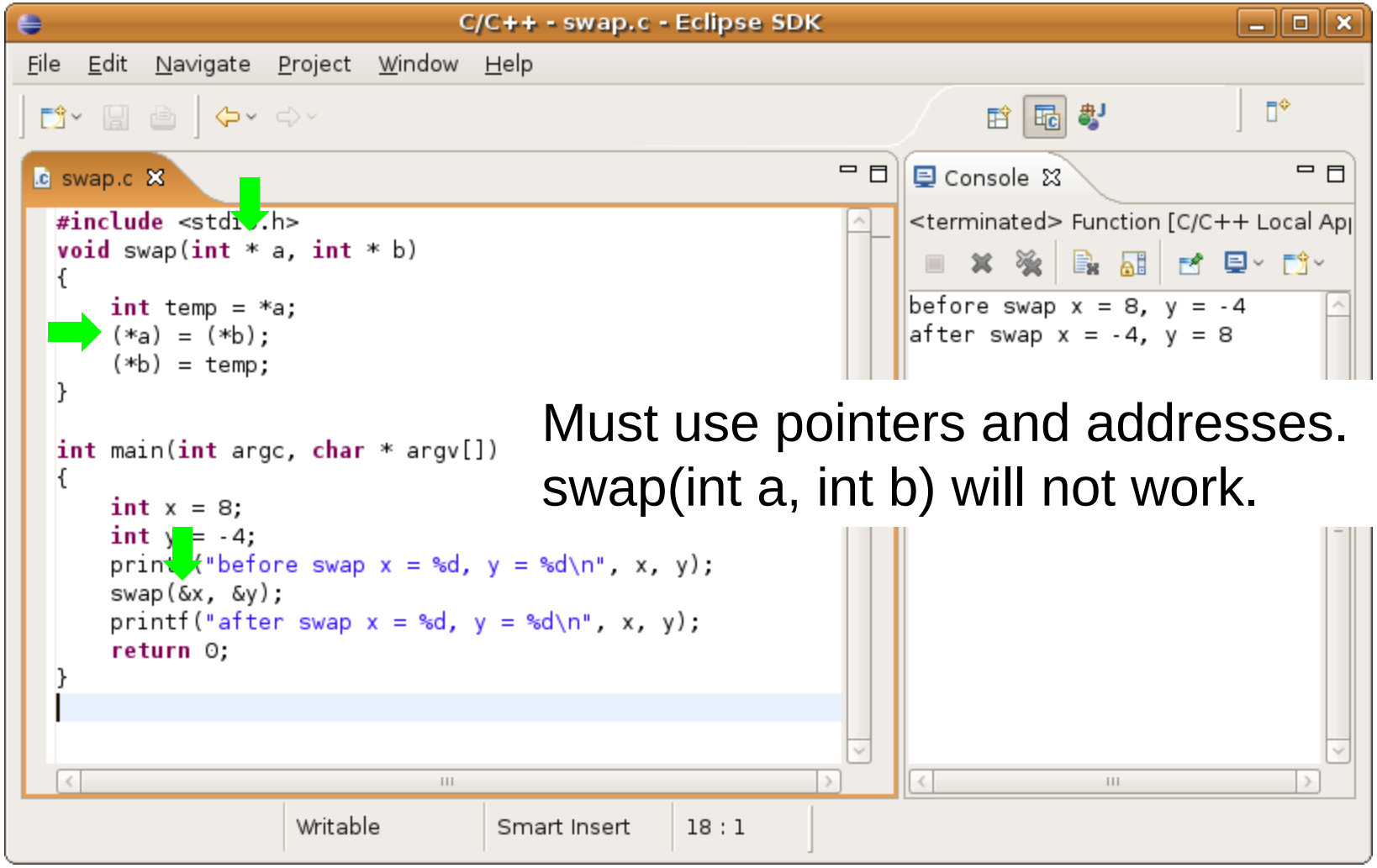
```
void incr(int * a) …

int x = 8;
incr(& x);      /* copy x's value to a */
(*a) ++;                /* a becomes 9, so is x */
```

similar to

```
int x = 8;
int * y = & x;
(*y) ++;        /* x is 9 */
```

Address	**Data**
somewhere (&x)	8
somewhere (&a)	& x

Swap Function



Must use pointers and addresses.
swap(int a, int b) will not work.

Pointer as Function Argument

Terminal

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```
[Ubuntu Linux ] more pointer2.c
#include <stdio.h>
void f(int * * a, int * b)
{
  * a = b; /* a points to where b points to */
}

int main(int argc, char * argv[])
{
  int x = 100;
  int * y;
  f(& y, & x);
  * y = 200;
  printf("x's value is %d\n", x);
  return 0;
}
[Ubuntu Linux ] gcc pointer2.c -o pointer2
[Ubuntu Linux ] ./pointer2
x's value is 200
[Ubuntu Linux ]
```

Address	Data
&x	100
&b	& x
&a	& y
&y	change

If we want to change where a pointer points to inside a function, we have to provide the address of the pointer.

General Rules

To change the value inside a function and to keep this change after the function returns

- The caller must use the **address**

  f(**&**x);

- The function's argument adds **one ***

  f(int ***x**) { … }

- If the argument is already a pointer, use two *

  f(int ****x**) { … }

- Inside the function, changes the value by adding *

  ***** a = b;

Allocate Memory in a Function

```
#include <stdio.h>
#include <stdlib.h>
const int arraySize = 10;
void printArray(int * a)
{
  int index;
  for (index = 0; index < arraySize; index ++)
    { printf("%d ", a[index]); }
  printf("\n");
}
void f(int * * a)
{
  * a = malloc(arraySize * sizeof(int));
}
int main(int argc, char * argv[])
{
  int * x;
  f(& x);
  int index;
  for (index = 0; index < arraySize; index ++)
    {  x[index] = index * 10; }
  printArray(x);
  free (x);
  return 0;
}
[Ubuntu Linux ]
```