

# C/C++ Function Pointer

**Data Structures**  
**C++ for C Coders**

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## Functions as pointers

- **Function code is stored in memory**
- **Start of the function code or the address of a function is a “function pointer”**
- **Function pointer is “different” from other pointers since you do not allocate or deallocate memory with them**
- **Function pointers can be passed as arguments to other functions or return from functions**

# Why use function pointers?

- **Efficiency**
- **Elegance**
- **Runtime binding**
  - Determine sorting function based on type of data **at run time**
  - Eg: insertion sort for smaller data sets ( $n < 100$ )
  - Eg: Quicksort for large data sets ( $n > 100000$ )
  - Other sorting algorithms based on type of data set

# Defining a function pointer

- For example,

```
int gcd(int x, int y) {  
    if (y == 0) return x;  
    return gcd(y, x % y);  
}
```

```
int main() {  
    int (*fn)(int, int);  
    fn = gcd;  
    int ans = fn(259, 111);  
    cout << ans << endl;  
}
```

# Defining a function pointer

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

int fun(int x, int y) {
    return x * 2 + y;
}

int foo(int x, int y) {
    return x + y * 2;
}

int add(int x, int y) {
    return x + y;
}
```

```
int main() {
    // using function pointer
    int (*fp) (int, int) = fun;
    cout << "fp(): " << fp(2,3) << endl;
    fp = foo;
    cout << "fp(): " << fp(2,3) << endl;
}
```

# Arrays of Function Pointers

- **C/C++ treats pointers to functions just like pointers to data therefore we can have arrays of pointers to functions**
- **This offers the possibility to select a function using an index.**

# Arrays of Function Pointers

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

int fun(int x, int y) {
    return x * 2 + y;
}

int foo(int x, int y) {
    return x + y * 2;
}

int add(int x, int y) {
    return x + y;
}
```

```
int main() {
    // fp is an array of fp
    int (*fp[])(int, int) = {fun, foo, add};
    for (int i = 0; i < 3; i++)
        cout << "fp(" << i << "): "
              << fp[i](2, 3) << endl;;
}
```

# qsort

function

## qsort

<stdlib.h>

```
void qsort (void* base, size_t num, size_t size,  
           int (*compar)(const void*,const void*));
```

### Sort elements of array

Sorts the *num* elements of the array pointed to by *base*, each element *size* bytes long, using the *compar* function to determine the order.

The sorting algorithm used by this function compares pairs of elements by calling the specified *compar* function with pointers to them as argument.

The function does not return any value, but modifies the content of the array pointed to by *base* reordering its elements as defined by *compar*.

The order of equivalent elements is undefined.

```
void qsort (void* base, size_t num, size_t size,  
           int (*compar) (const void*,const void*)) ;
```



## using qsort

**A**



11 22 40 29 50 32 21 78 23

A is an array of integers.

Sort it using qsort with natural integer order

Write the compare function:

```
int (*intcomp)(const void* a, const void* b))
```

```
void qsort (void* base, size_t num, size_t size,  
            int (*compar)(const void*,const void*));
```

## using qsort

**A**



"hat" "put" "ace" "bat" "cat"

A is an array of strings or char \*'s.  
Sort it using qsort with alphabetical order

Write the compare function:

```
int (*strcmp)(const void* a, const void* b))
```

```
void qsort (void* base, size_t num, size_t size,  
            int (*compar)(const void*,const void*));
```

## using qsort

**A**



**An array of node \*'s**

**mat 10**

**cat 5**

**pot 7**

A is an array of data structure such as node \*'s.  
Sort it using qsort with alphabetical order

Write the compare function to sort by name:

```
int (*nodecomp)(const void* a, const void* b))
```

```
void qsort (void* base, size_t num, size_t size,  
            int (*compar)(const void*,const void*));
```

## qsort example

```
#include <iostream>
int values[] = { 4, 1, 7, 9, 2, 3 };

int compare (const void *a, const void *b) {
    return ( *(int*)a - *(int*)b );
}

int main () {
    int n = sizeof(values)/sizeof(values[0]);
    qsort (values, n, sizeof(int), compare);

    for (int i=0; i<n; i++)
        std::cout << values[i] << " ";
    return 0;
}
```

# bubblesort

- **Function bubblesort takes a function pointer**
- **The argument in bubblesort for the function pointer:**
  - `int (*compare) (int a, int b)`  
tells bubblesort to expect a pointer to a function that takes two ints and returns an int
- **If the parentheses were left out:**
  - `int *compare(int a, int b)`

# bubblesort

- **Function `bubblesort` takes a function pointer**
- **The argument in `bubblesort` for the function pointer:**
  - `int (*compare) (int a, int b)`  
tells `bubblesort` to expect a pointer to a function that takes two `ints` and returns an `int`
- **If the parentheses were left out:**
  - `int *compare(int a, int b)`
  - **Defines a function that receives two integers and returns a pointer to a `int`**

# bubblesort example

```
void bubblesort(int *list, int n) {  
    int i, j, temp;  
  
    for (i = 0; i < n - 1; i++) {  
        for (j = 0; j < n - i - 1; j++)  
            if (list[j] > list[j + 1]) {  
                temp = list[j];  
                list[j] = list[j + 1];  
                list[j + 1] = temp;  
            }  
        }  
    }  
}
```

← **no function pointer used**

# bubblesort example

```
void bubblesort(int *list, int n) {
    int i, j, temp;

    for (i = 0; i < n - 1; i++) {
        for (j = 0; j < n - i - 1; j++)
            if (list[j] > list[j + 1]) {
                temp = list[j];
                list[j] = list[j + 1];
                list[j + 1] = temp;
            }
    }
}
```

```
int main() {
    int list[] = { 3, 4, 1, 7, 9, 5 };
    int N=sizeof(list)/sizeof(list[0]);

    cout << "UNSORTED: " << endl;
    for (int i = 0; i < N; i++)
        cout << list[i] << " ";
    cout << endl;

    bubblesort(list, N);
    cout << "SORTED: " << endl;
    for (int i = 0; i < N; i++)
        cout << list[i] << " ";
    cout << endl;
}
```

**no function pointer used**



Use function pointer for ascending or descending sort

# Use function pointer for ascending or descending sort

```
int main() {  
    int list[] = { 3, 4, 1, 7, 9, 5 };  
    int N=sizeof(list)/sizeof(list[0]);  
  
    cout << "UNSORTED: " << endl;  
    for (int i = 0; i < N; i++)  
        cout << list[i] << " ";  
    cout << endl;  
  
    bubblesort(list, N, ascending);  
    cout << "SORTED: " << endl;  
    for (int i = 0; i < N; i++)  
        cout << list[i] << " ";  
    cout << endl;  
}
```

# Use function pointer for ascending or descending sort

```
void bubblesort(int *list, int n  
                _____) {  
    int i, j, temp;  
  
    for (i = 0; i < n - 1; i++) {  
        for (j = 0; j < n - i - 1; j++)  
            if _____ {  
                temp = list[j];  
                list[j] = list[j + 1];  
                list[j + 1] = temp;  
            }  
        }  
    }  
}
```

```
int main() {  
    int list[] = { 3, 4, 1, 7, 9, 5 };  
    int N=sizeof(list)/sizeof(list[0]);  
  
    cout << "UNSORTED: " << endl;  
    for (int i = 0; i < N; i++)  
        cout << list[i] << " ";  
    cout << endl;  
  
    bubblesort(list, N, ascending);  
    cout << "SORTED: " << endl;  
    for (int i = 0; i < N; i++)  
        cout << list[i] << " ";  
    cout << endl;  
}
```

```
int ascending (int a, int b) {return a - b;}  
int descending(int a, int b) {return b - a;}
```