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;
  fp = add;
  cout << "fp(): " << fp(2,3) << endl;
}
```

Using an Array 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() {
  // fps[] is an array of fp
```

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.**

qsort

function

qsort

<cstdlib>

```
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


```
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


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

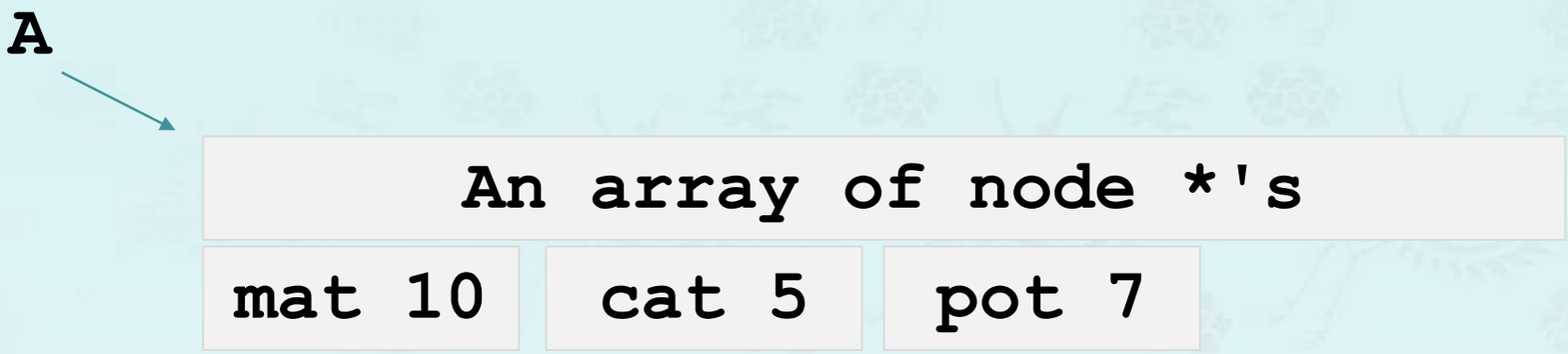
A is an array of strings or char *'s.
Sort it using qsort with alphabetical order

Write the compare function:

```
int (*strcomp)(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 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;}
```