CS 103 Unit 13 Slides

C++ References
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Swap Two Variables

- Classic example of issues with local variables:
  - Write a function to swap two variables
- Pass-by-value doesn't work
  - Copy is made of x,y from main and passed to x,y of swapit...Swap is performed on the copies
- Pass-by-reference (pointers) does work
  - Addresses of the actual x,y variables in main are passed
  - Use those address to change those physical memory locations

```cpp
int main()
{
    int x=5, y=7;
    swapit(x, y);
    cout <<"x,y=
        " << x << "," << y << endl;
}

void swapit(int x, int y)
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}

int main()
{
    int x=5, y=7;
    swapit(&x, &y);
    cout <<"x,y=
        " << x << "," << y << endl;
}

void swapit(int *x, int *y)
{
    int temp;
    temp = *x;
    *x = *y;
    *y = temp;
}
```

Output: x=5,y=7

Output: x=7,y=5
C++ Reference Variables

• So you want a function to actually modify a variable from another function but you don’t like pointers and they confuse you?
  – Too bad. Don’t give up!
    You CAN understand pointers...keep working at it
  – BUT...
  – You can also use C++ Reference variables

• C++ reference variables essentially pass arguments via pointer/address behind the scences but use the syntax of pass-by-value (i.e. no more de-referencing)
  – So we needed you to know what's actually happening behind the scenes, thus we taught you pointers.
  – But now you can use the simplified syntax with C++ references
Using C++ Reference Variables

- To declare a reference variable, use the ‘&’ operator in a **declaration**!
  - Poor choice by C++ because it is confusing since ‘&’ is already used for the ‘address of operator’ when used in an expression (i.e. non-declaration)
- Behind the scenes the compiler will essentially access variable with a pointer
- But you get to access it like a normal variable without dereferencing
- Think of a reference variable as an alias

```cpp
int main()
{
    int y = 3;
    doit(&y); //address-of oper.
    cout << y << endl;
    return 0;
}
int doit(int *x)
{
    *x = *x - 1;
    return *x;
}
```

Using pointers

```cpp
int main()
{
    int y = 3;
    doit(y);
    cout << y << endl;
    return 0;
}
```

Using C++ References

```
int doIt(int &x)
    // Ref. declaration
{
    x = x - 1;
    return x;
}
```

Output: ‘2’ in both programs
Swap Two Variables

- Pass-by-value => Passed a copy
- Pass-by-reference =>
  - Pass-by-pointer/address => Passed address of actual variable
  - Pass-by-C++-reference => Passed an alias to actual variable

```c
int main()
{
    int x=5, y=7;
    swapit(x, y);
    cout <<"x,y=""<< x<<","<< y;
    cout << endl;
}

void swapit(int x, int y)
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}
```

**Output:** x=5,y=7

```c
int main()
{
    int x=5, y=7;
    swapit(&x, &y);
    cout <<"x,y=""<< x<<","<< y;
    cout << endl;
}

void swapit(int *x, int *y)
{
    int temp;
    temp = *x;
    *x = *y;
    *y = temp;
}
```

**Output:** x=7,y=5

```c
int main()
{
    int x=5, y=7;
    swapit(x, y);
    cout <<"x,y=""<< x<<","<< y;
    cout << endl;
}

void swapit(int &x, int &y)
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}
```

**Output:** x=7,y=5
When to Use References

- **Reason 1:** Whenever you want to actually **modify an input parameter/argument** (i.e. a local variable from another function)
- **Reason 2:** To avoid making a **copy** when passing big struct or class objects
  - Because no copy will be made, (pass-by-value would have wasted time copying contents to new memory)

```cpp
class GradeBook{
    public:
        int grades[8][100];
};
int main()
{
    GradeBook gb;
    ...
    double average = process_it(gb);
    return 0;
}
double process_it(GradeBook& mygb)
{
    double sum = 0;
    for(int i=0; i < 8; i++)
        for(int j=0; j < 100; j++)
            sum += mygb.grades[i][j];

    mygb.grades[0][0] = 91;
    sum /= (8*100);
    return sum;
}
```
An aside:

- If we want an extra safety precaution for our own mistakes, we can declare arguments as `const`.
- The compiler will produce an error to tell you that you have written code that will modify the object you said should be constant.
- Doesn’t protect against backdoors like pointers that somehow point at these data objects (compiler check only)

```cpp
class GradeBook{
    public:
        int grades[8][100];
};
int main()
{
    GradeBook gb;
    ...
    double average = process_it(gb);
    return 0;
}
double process_it(const GradeBook &mygb)
{
    double sum = 0;
    for(int i=0; i < 8; i++)
        for(int j=0; j < 100; j++)
            sum += mygb.grades[i][j];
    mygb.grades[0][0] = 91; // modification of const Gradebook
    // compiler will produce ERROR!
    sum /= (8*100);
    return sum;
}
Vector/Deque/String Suggestions

- When you pass a vector, deque, or even C++ string to a function a deep copy will be made which takes time.
- **Copies** may be desirable in a situation to make sure the function alter your copy of the vector/deque/string.
- But passing by **const reference** saves time and provide the same security.

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

int main()
{
    vector<int> my_vec;
    for(int i=0; i < 5; i++){
        // my_vec[i] = i+50; // recall doesn't work
        my_vec.push_back(i+50);
    }

    // can myvec be different upon return?
    do_something1(myvec);

    // can myvec be different upon return?
    do_something2(myvec);
    return 0;
}

void do_something1(vector<int> v)
{
    // process v;
}

void do_something2(const vector<int>& v)
{
    // process v;
}
```
Don't Make This Mistake!

- Returning a reference to a dead variable (i.e. a local variable of a function that just completed)
- `avg` was a local variable and thus was deallocated when `process_it` completed
MORE C++ REFERENCE FACTS
Using C++ References

- Mainly used for parameters, but can use it within the same function
- A **variable/type** declared with an ‘&’ doesn’t store any data, but references/aliases some other actual variable
- MUST assign to the reference variable when you declare it.

```cpp
int main()
{
    int y = 3, *ptr; // address-of operator
    ptr = &y; // address-of operator

    int &z; // NO! must assign
    int &x = y; // reference declaration
    // we've not copied
    // y into x
    // we've created an alias

    x++; // y just got incr.
    cout << y << endl; // y just got incr.
    return 0;
}
```

Output: y=4 in both programs