CS 161
Introduction to CS I
Lecture 14

- Manipulating data in memory
  - Pointers
  - And how they differ from references

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Week 5 Tips

- Midterm #2 will be cumulative
  - Pick up Midterm #1 review your answers and the solutions
  - Pick up (bring ID) at KEC 1148 by 2/14, or after that from my office
- Variable shadowing: good to know about so you can read and trace through code, **not** recommended style
- Assignment 3 questions?
- Next Monday: guest instructor for lecture +
  no office hours for Dr. Wagstaff

Passing arguments to functions

- `int v = 3;`
- `void fn(int w);`
- `void fn2(int& w);`

- Pass by value: make a copy
  - `fn(v);`
- Pass by reference: pass the address of the variable
  - `fn2(v);` `/* NOT fn2(&v); */`

Your turn: predict the output

```
1. void get_max(int a, int b, int& m) {
2.   m = (a < b) ? a : b;  /* ternary/conditional operator */
3. }

4. int main() {
5.   int f = 17, g = 19, mx = -1;
6.   get_max(f, g, mx);
7.   cout << mx << endl;
8.   return 0;
9. }
```

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(be sure you read the code!)

Why pass arguments by reference?

- Consumes less space: no need to make a copy
  - (As is done when passing by value)
  - This matters more when you work with large objects
- Slightly faster: no need to make a copy
- **** Since you can modify their values in the function, this is one way to get multiple results from one function

Pass multiple arguments by reference

```
1. void split_string(string s, int i,
2.                   string& s1, string& s2) {
3.   s1 = s.substr(0, i);    /* get from index 0 to i-1 */
4.   s2 = s.substr(i);       /* get from index i to end */
5. }
6. int main() {
7.   string input, first_part, second_part;
8.   cin >> input;
9.   split_string(input, 3, first_part, second_part);
10.  cout << input << " : " << first_part << ", "
11.       << second_part << endl;
12.  return 0;
13.}
```

Pointers!

- Pointer = variable that stores a memory location (address)
- Examples:
  - `char* cptr;`
  - `int* iptr;`
- If not initialized, could point to invalid memory location
  - You could write over your own data by accident
  - You could also get a segmentation fault (what does this mean?)
- Good practice:
  - `char* cptr = NULL;`
  - `int* iptr = NULL;`

Review: Pass by reference

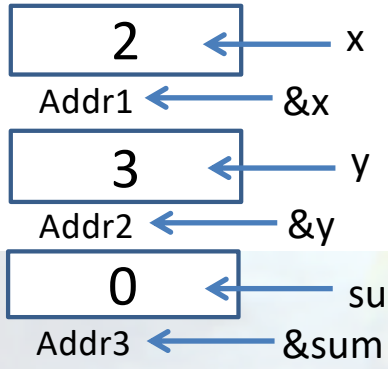
```
1. void compute_sum(int a, int b, int& s) {
2.   s = a + b;
3. }

4. int main() {
5.   int x = 2, y = 3, sum = 0;
6.   compute_sum(x, y, sum);     /* no &sum in function call */
7.   cout << sum << endl;
8.   return 0;
9. }
```

Pass arguments as pointers

```
1. void compute_sum(int a, int b, int* s) {
2.   *s = a + b; /* note *s to dereference */
3. }

4. int main() {
5.   int x = 2, y = 3, sum = 0;
6.   compute_sum(x, y, &sum);     /* note &sum in call */
7.   cout << sum << endl;
8.   return 0;
9. }
```



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4. int main() {
5.   int x = 2, y = 3, sum = 0;
6.   compute_sum(x, y, &sum);    /* note &sum (NOT *sum) */
7.   cout << sum << endl;
8.   return 0;
9. }
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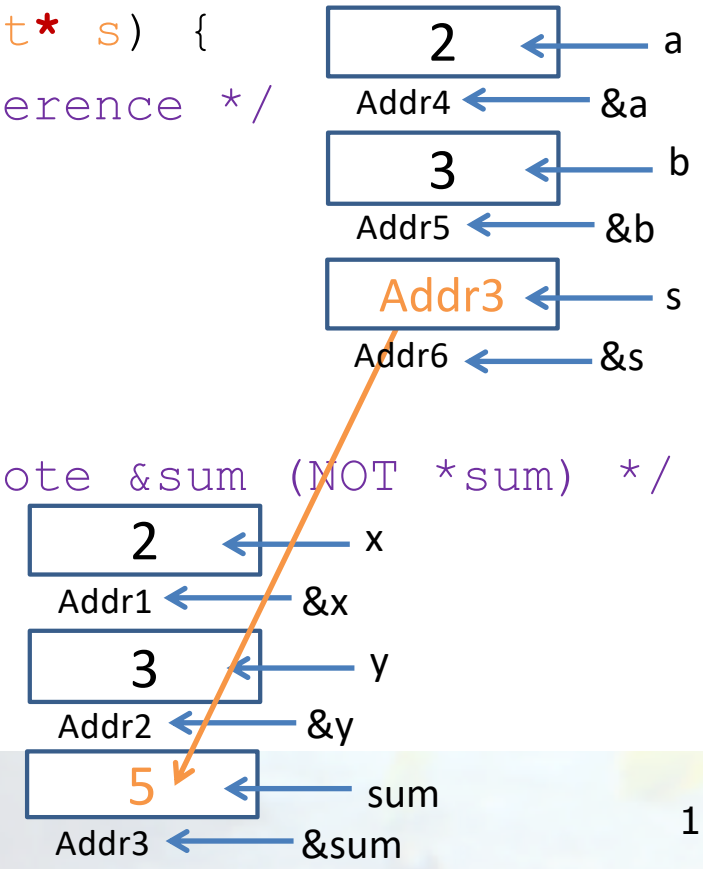

Pass arguments by reference (compare)

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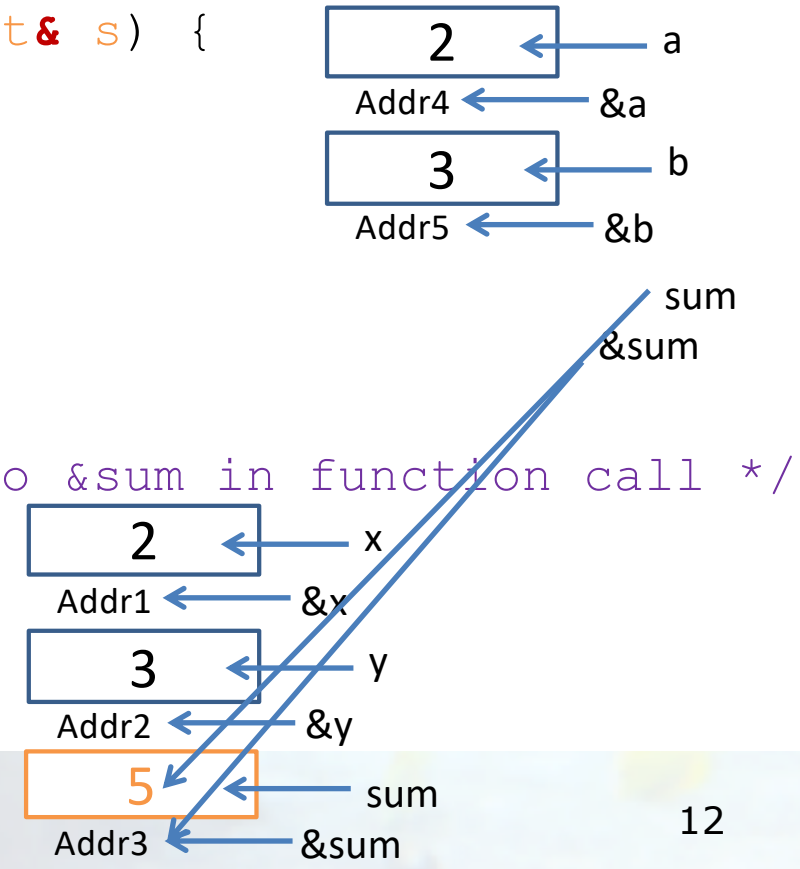

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Memory operators

- & and * can be used to specify data types
  - `int& z = n;  /* declare a reference (alias) */`
  - `int* p;  /* declare a pointer */`
- & and * can also be used as operators in expressions to perform actions
  - &: address-of
    - `p = &n;`
    - `&n = 5234;  /* not allowed! (what would it mean?) */`
  - *: dereference (value-of): access the value at memory address
    - `cout << *p << endl;  /* read */`
    - `*p = 27;  /* write/change */`

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"It Was A Dark and Stormy Pointer": A Play

- int* witch;
- witch = NULL;
- int cat = 7;
- int dog = 3;
- int mouse = 1;
- cat = dog + mouse;
- mouse *= 2;
- witch = &cat; /* address-of */
- *witch = 5;
- dog = *witch; /* dereference */
- witch = &mouse;
- *witch = cat;

References versus Pointers

- Do not confuse "reference" (a data type) with "pass by reference" (something that happens when you call a function)
- Reference: an alias to some variable (permanent)
  - `int& r = s;`
  - Can assign new values to `r` (which is `s`), but cannot make `r` be an alias to another variable later
  - Must be initialized when declared
- Pointer: stores the address of some variable
  - `int* p = &s;`
  - Can change what address `r` contains (where it points to) anytime
  - Can be declared, then initialized later

What vocabulary did we learn today?

- Pointers
- & (address-of) operator
- * (dereference) operator

What ideas and skills did we learn today?

- How to declare pointers
- How to pass pointers as function arguments
- How to trace through memory values when pointers are used

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Week 5 nearly done

- ❑ Attend lab (laptop required)
- ❑ Read **Rao Lesson 8** (pp. 177-186) – pointers and memory and https://www.geeksforgeeks.org/pointers-vs-references-cpp/
- ❑ Finish up **Assignment 3** (due **Sunday, Feb. 9**)

Guest lecture on Monday!