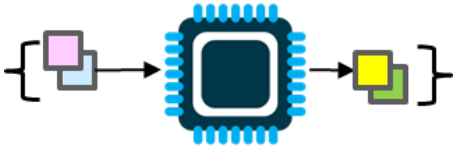
Unit 4a

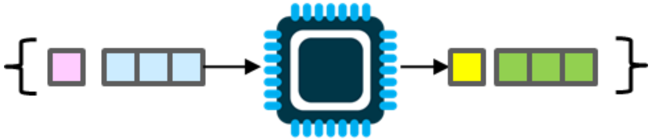
Calling and Using Functions

Unit 4

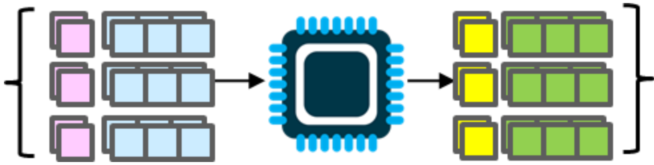
- **Unit 1**: Scalar processing
  - aka IPO=Input-Process-Output Programs



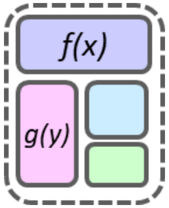
- **Unit 2**: Linear (1D) Processing



- **Unit 3**: Multidimensional Processing

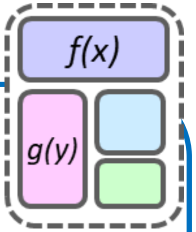


- **Unit 4**: Divide & Conquer (Functional Decomposition)



Functional Decomposition Overview

- **Idea**: Extract *common* (small) code sequence into separate blocks (aka functions, procedures, subroutines, or methods) that we can "call" from anywhere in our code
- By decomposing our software into functions, we can:
  - Reduce coding effort
  - Reuse code
  - Increase maintainability
  - Increase readability (the name of a function is often a "comment" about what that function's code does
  - Build up large solutions from smaller pieces



```
int main() {
  // setup array with data
  int n, val, data[100];
  cin >> n;
  for(int i=0; i < n; i++)
    { cin >> data[i]; }
  bool found100 = false, found0 = false;
  // Find 100
  for(int i=0; i < n; i++) {
    if(100 == data[i]){
       found100 = true;
       break;
  } }
  // Find 0
  for(int i=0; i < n; i++) {
    if(0 == data[i]){
       found0 = true;
       break;
  } }
  cout << "found 100: " << found100 << endl;
  cout << "found   0: " << found0 << endl;
  return 0;
}
```

Functional Decomposition Overview

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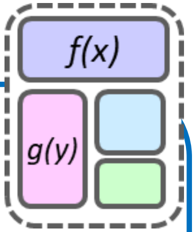
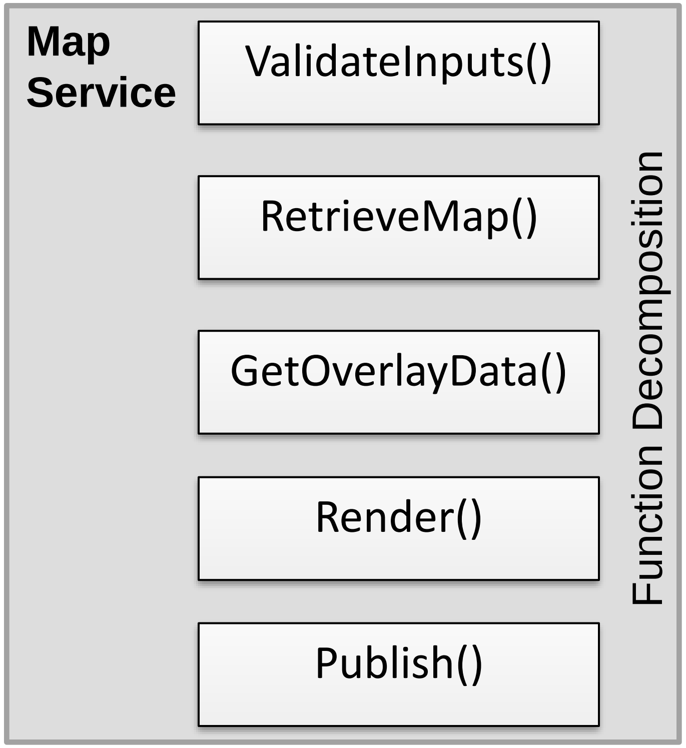


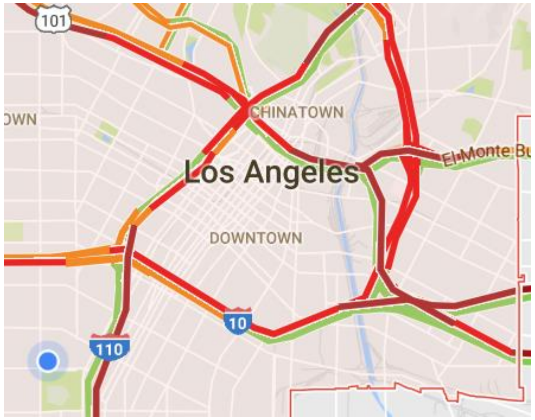
```
bool find(int d[], int len, int v)
{
  for(int i=0; i < len; i++) {
    if(v == d[i]){ return true; }
  }
  return false;
}

int main() {
  // setup array with data
  int n, val, data[100];
  cin >> n;
  for(int i=0; i < n; i++)
    { cin >> data[i]; }
  bool found100 = false, found0 = false;
  // Find 100
  found100 = find(data, n, 100);
  // Find 0
  found0 = find(data, n, 0);
  cout << "found 100: " << found100 << endl;
  cout << "found   0: " << found0 << endl;
  return 0;
}
```

Functions Overview

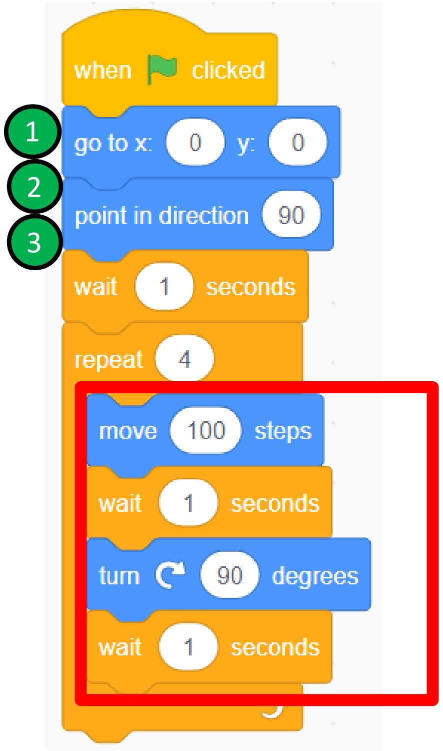
- Functions (aka procedures, procedures, or methods) are the unit of code decomposition and abstraction
  - Decomposition: Breaking programs into smaller units of code
  - Abstraction: Generalizing an action or concept without specifying how the details are implemented



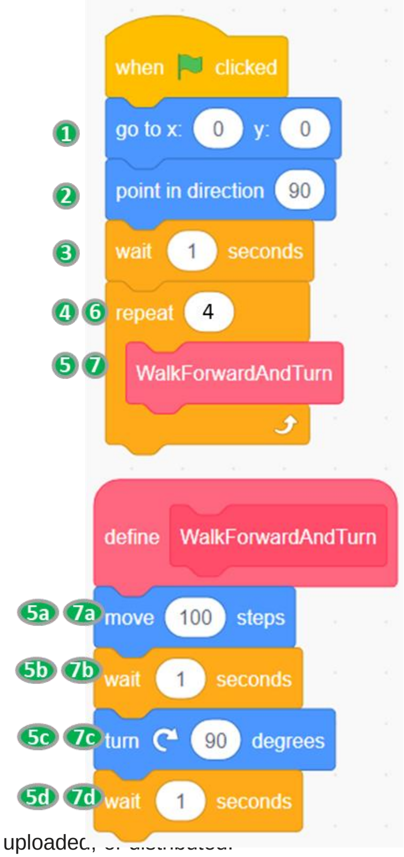


Recall: Walking a Square in Scratch

- We can define a function (i.e. block of code) once and then "call" it any time we want to execute that block of code.
- Can provide different **input values (aka "arguments" / "parameters")** and even get an **output (aka "return" value)**.

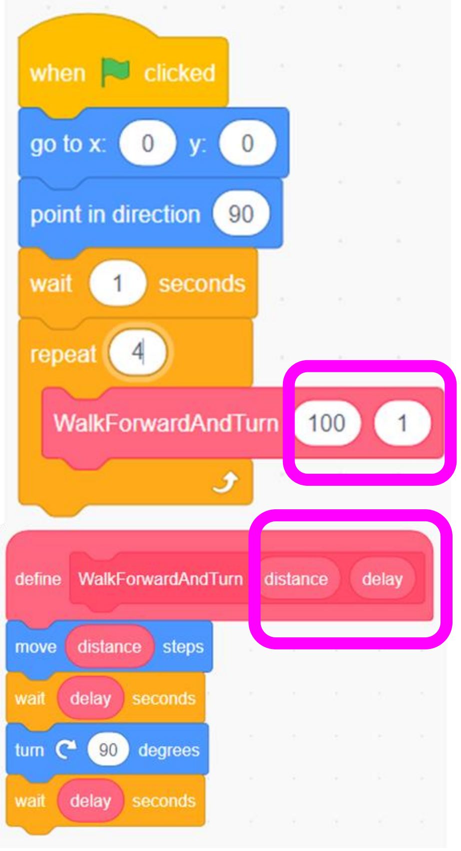


```
when [flag] clicked
go to x: 0 y: 0
point in direction 90
wait 1 seconds
repeat 4
    move 100 steps
    wait 1 seconds
    turn ↻ 90 degrees
    wait 1 seconds
```



```
when [flag] clicked
go to x: 0 y: 0
point in direction 90
wait 1 seconds
repeat 4
    WalkForwardAndTurn

define WalkForwardAndTurn
move 100 steps
wait 1 seconds
turn ↻ 90 degrees
wait 1 seconds
```

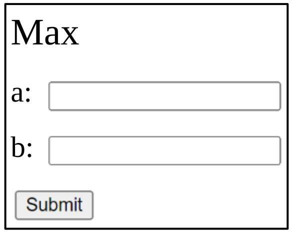


```
when [flag] clicked
go to x: 0 y: 0
point in direction 90
wait 1 seconds
repeat 4
    WalkForwardAndTurn 100 1

define WalkForwardAndTurn distance delay
move distance steps
wait delay seconds
turn ↻ 90 degrees
wait delay seconds
```

Function Signatures/Prototypes

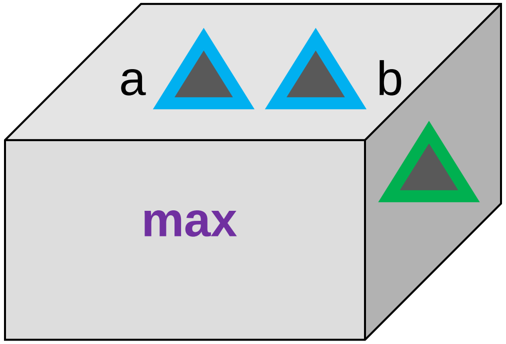
- We think of a function as a blackbox (don't know or care how it does the task internally) of code where **we can provide inputs and get back a value**
  - Or think of it as a web-app (or form) where you supply data to "named" inputs and get back a value
- In C/C++, a function has:
  - A **name**
  - Zero or more input parameters
  - 0 or 1 return (output) values
    - We only specify the type
    - 0 return values is indicated with `void` type
- The signature (or **prototype**) of a function specifies these aspects so others know how to "call" the function



Max

a:

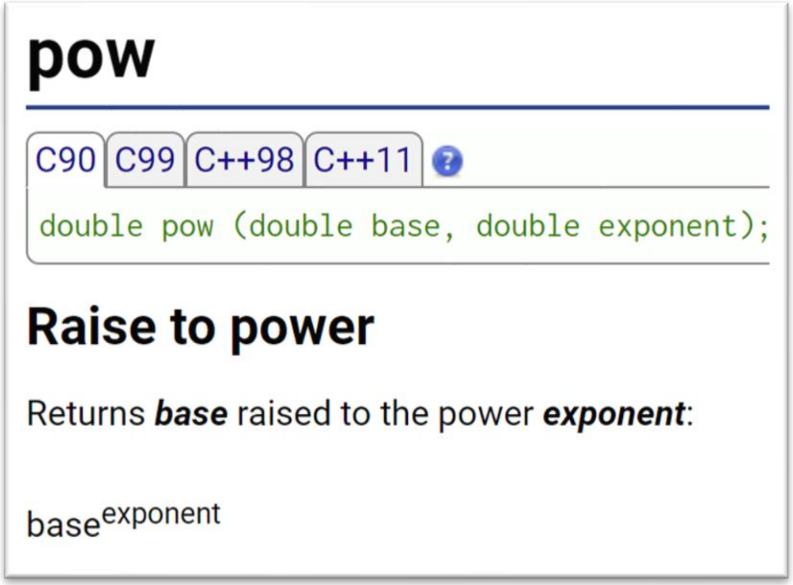
b:



```
int max(int a, int b);
```

Function Signature/Prototype

Common Functions



pow

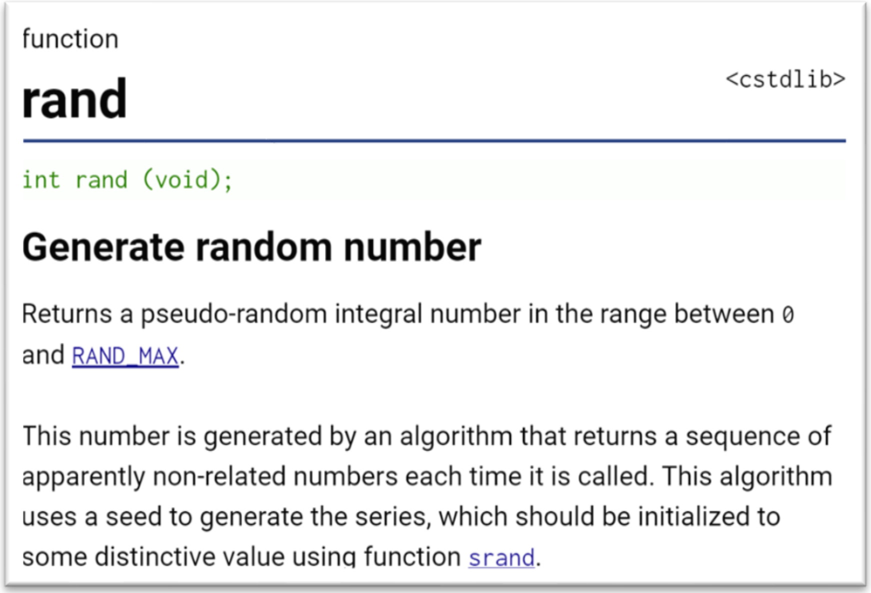
C90 | C99 | C++98 | C++11 | ?

```
double pow (double base, double exponent);
```

Raise to power

Returns ***base*** raised to the power ***exponent***:

$base^{exponent}$



function

rand

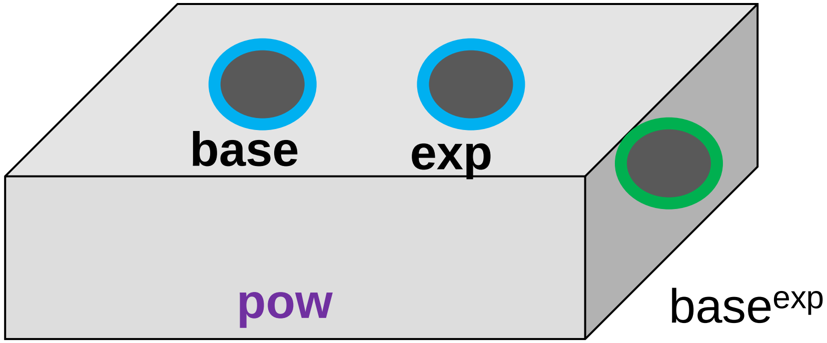
<cstdlib>

```
int rand (void);
```

Generate random number

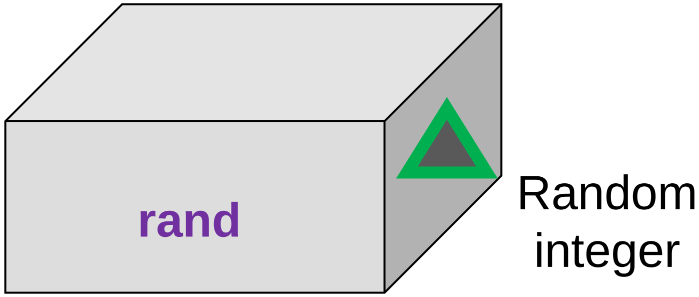
Returns a pseudo-random integral number in the range between `0` and RAND_MAX.

This number is generated by an algorithm that returns a sequence of apparently non-related numbers each time it is called. This algorithm uses a seed to generate the series, which should be initialized to some distinctive value using function srand.



```
double pow(double base, double exp);
```

Function Signature/Prototype



```
int rand();
```

Function Signature/Prototype

"Functional" Programming

- While we can write arithmetic expressions directly in C++, let's practice using functions to perform the same operations.
- Suppose you are given:
  - `int add(int p, int q); // returns p+q`
  - `int sub(int p, int q); // returns p-q`
  - `int mul(int p, int q); // returns p*q`
  - `int div(int p, int q); // returns p/q`
- Convert the following expressions to use functions and no operators (+,-,*,/)
- Key Ideas:
  - Execution works from **inside to outside** (i.e. **f(g(x))** invokes **g(x)** first)
  - The return value of a function is **substituted and used** in the larger expression

```
  // Add 3 numbers
  a = x + y + z;
  // which upholds the order of ops
  a = add(add(x,y),z);
  a = add(x,add(y,z));

  // Exercise 1
  a = x / y + y * z – x;

  a = ________________________________

 // Exercise 2
  a = x * (y – z) / z;

  a = ________________________________
```

Disclaimer: These functions (add, sub, etc.) are fictitious and in C++ we just use the +, -, etc. operators, but this is to practice using functions.

Function call statements

- Reminder that you can call a function anywhere
- Result is replaced into bigger expression
- Take care to "save" the result
  - If you don't save the return value into a variable or use it immediately, the result is lost

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

int main()
{
  // can call functions
  //  in an assignment
  double res = cos(0); // res = 1.0

  // can call functions in an
  //  expression
✗ sqrt(2) / 2; // forgot to save result

  res =  sqrt(2) / 2; // save 1.414/2 in res

  cout << max(34, 56) << endl;
  // outputs 56

  return 0;
}
```

http://www.cplusplus.com/reference/cmath/

Reading Documentation

- Much of programming is calling other library functions which do small pieces of work in an effort to accomplish the overall application
  - Learn to read documentation
- Documentation at:
  - http://www.cplusplus.com/reference/cmath/
  - http://www.cplusplus.com/reference/cctype/
  - http://www.cplusplus.com/reference/cstdlib/

SOLUTIONS

"Functional" Programming

- While we can write arithmetic expressions directly in C++, let's practice using functions to perform the same operations.
- Suppose you are given:
  - `add(p, q) // returns p+q`
  - `sub(p, q) // returns p-q`
  - `mul(p, q) // returns p*q`
  - `div(p, q) // returns p/q`
- Convert the following expressions to use functions and no operators (`+,-,*,/`)
- Key Ideas:
  - Execution works from inside to outside (i.e. f(g(x)) invokes g(x) first
  - The return value of a function is substituted and used in the larger expression

```
// Add 3 numbers
a = x + y + z;
// which upholds the order of ops
a = add(add(x,y),z);
a = add(x,add(y,z));

// Exercise 1
a = x / y + y * z – x;
a = sub(add(div(x,y),mul(y,z)),x);

// Exercise 2
a = x * (y – z) / z;
a = div(mul(x, sub(y,z)), z);
```

Disclaimer: These functions (add, sub, etc.) are fictitious and in C++ we just use the +, -, etc. operators, but this is to practice using functions.