Week 3

This Week

- GDB
- Arrays
- Call Stack
- Recursion
- Search
- Asymptotic Notation & Running Time
- Sort

GDB

break – tell the program to ‘pause’ at a certain point (either a function or a line number)

step – ‘step’ to the next executed statement

next – moves to the next statement WITHOUT ‘stepping into’ called functions

continue – move ahead to the next breakpoint

print – display some variable’s value

backtrace – trace back up function calls

Arrays

- Set of variables of the same type sharing a name.
- Access each individual element in an array using an index value.
- Passed by reference, rather than by value.

Passing By Reference

Pass by Value – passing a copy of the data stored in a variable.

Pass by Reference – passing the address at which the original copy of the data is stored.

Passing By Reference

Mailing Address vs. Contents of Mailbox

Mail Center
Cambridge, MA
02138

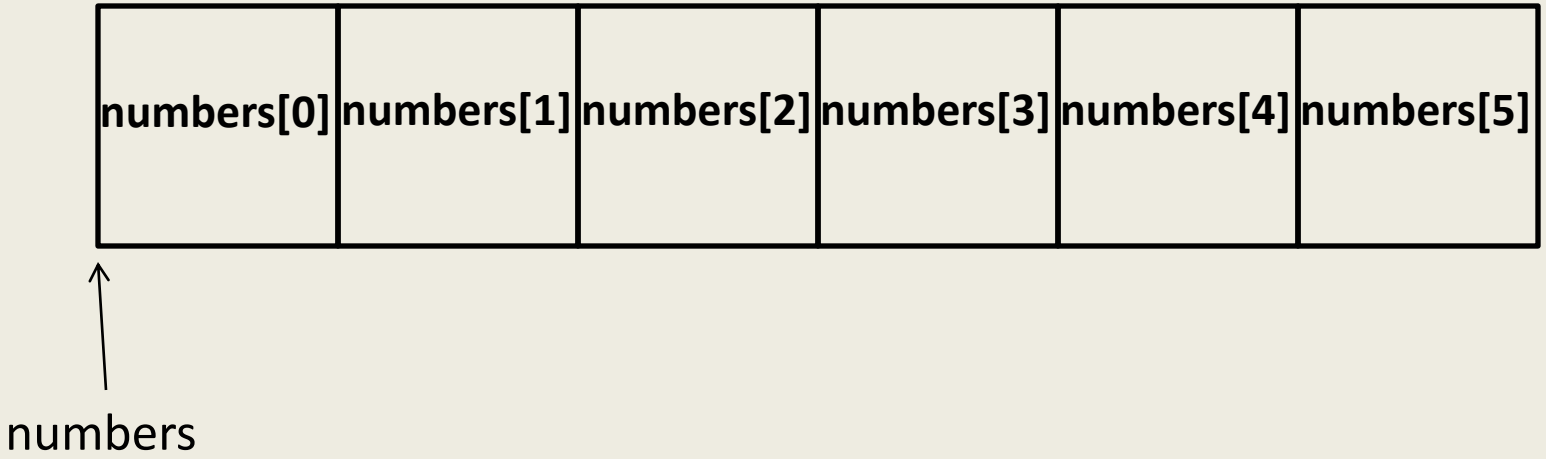
Reference

Value

Arrays

- Arrays are passed by reference.
- Passing an array gives a function the address of the *start of the array*.

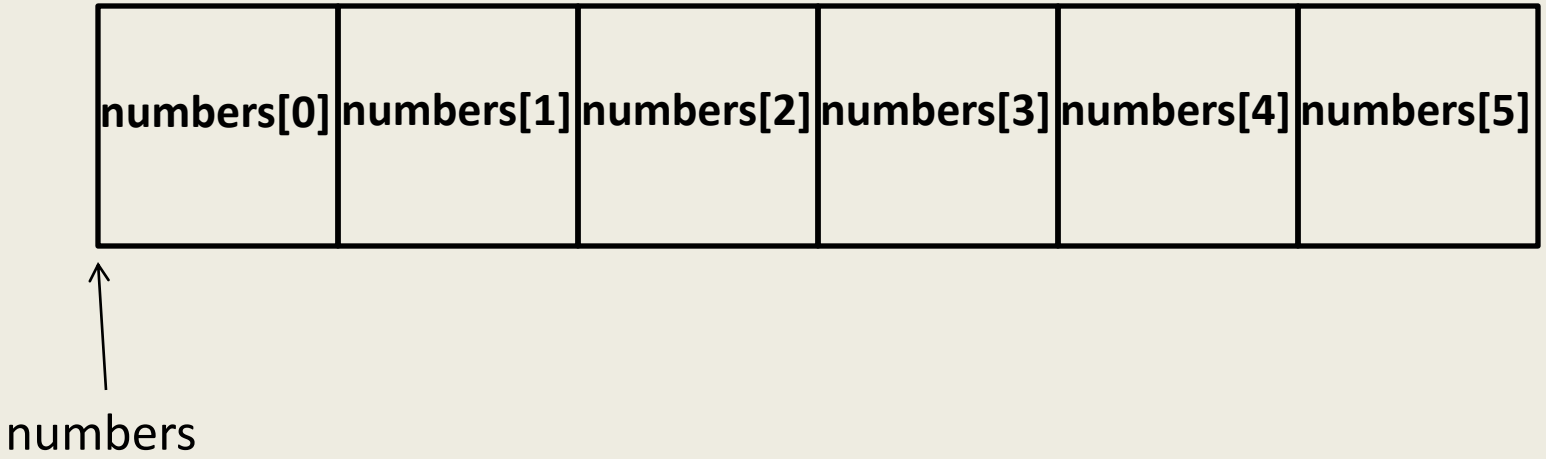
int numbers[6];



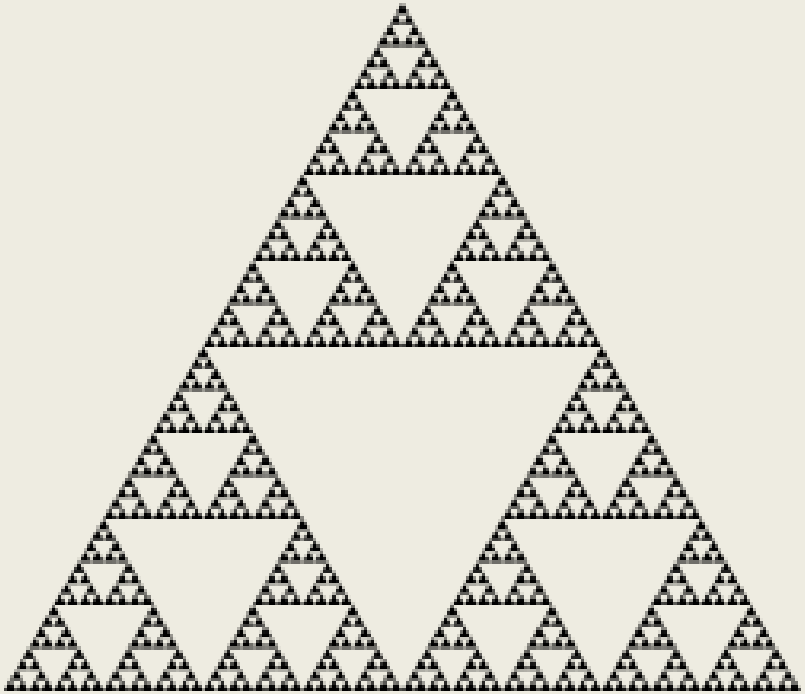
Arrays

- Name of the array refers to starting position.
- numbers[i] accesses the ith element

int numbers[6];



Recursion



What is Recursion?

- *Recursion* - a method of defining functions in which the function being defined is applied within its own definition

- A recursive function is a function which *calls itself*

Components of Recursive Function

- Recursive Call – part of function which calls the same function again.
- Base Case – part of function responsible for halting recursion when appropriate.

Recursion Example

- Natural recursive function: Factorial

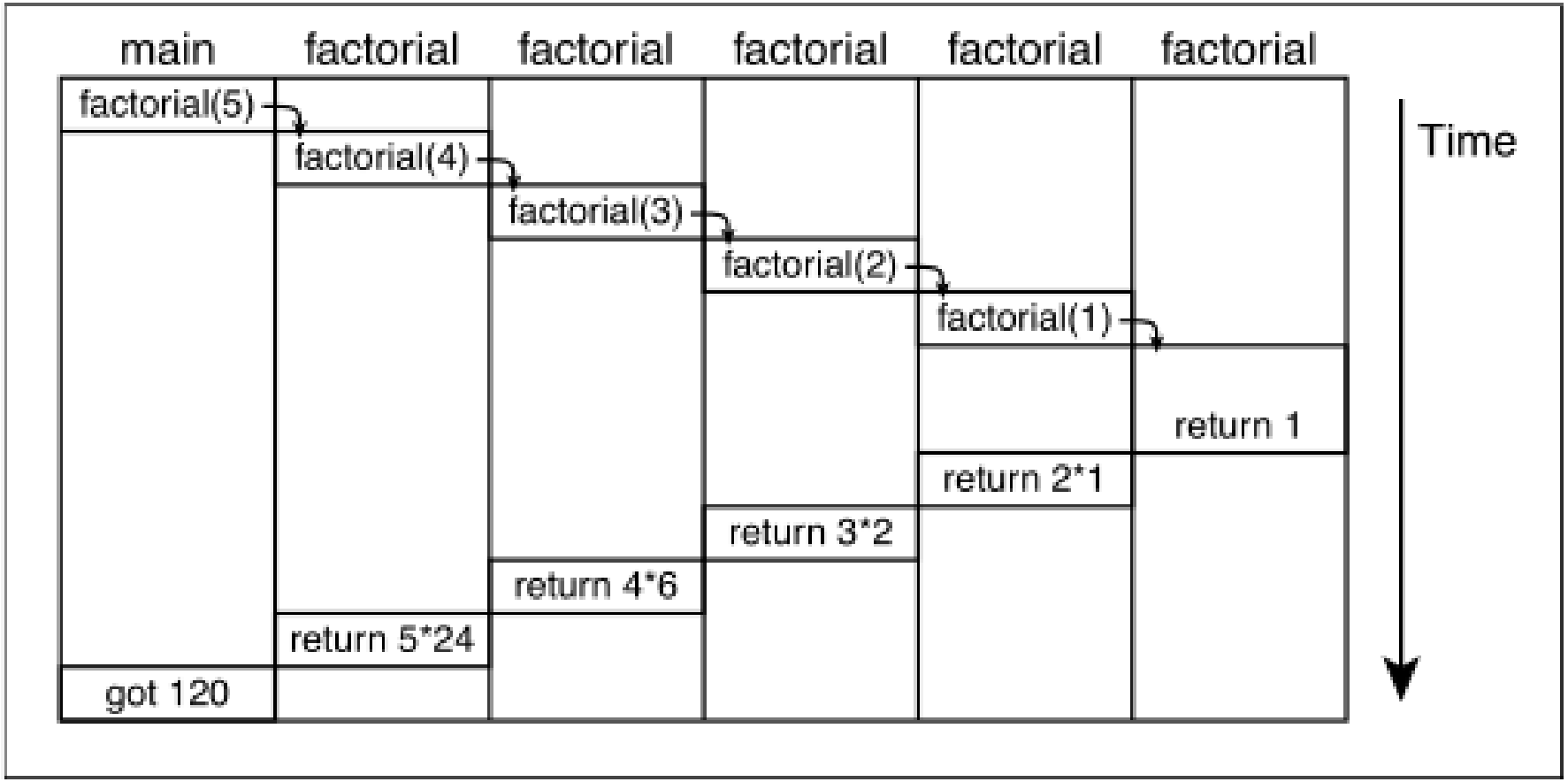
$$n! = \begin{cases} 1 & n = 1 \\ n * (n-1)! & n > 1 \end{cases}$$

Recursion Example

```
int
factorial (int n)
{
    //Base Case
    if (n == 1)
        return 1;

    //Recursive Call
    else
        return n * factorial(n - 1);
}
```

Recursion Example

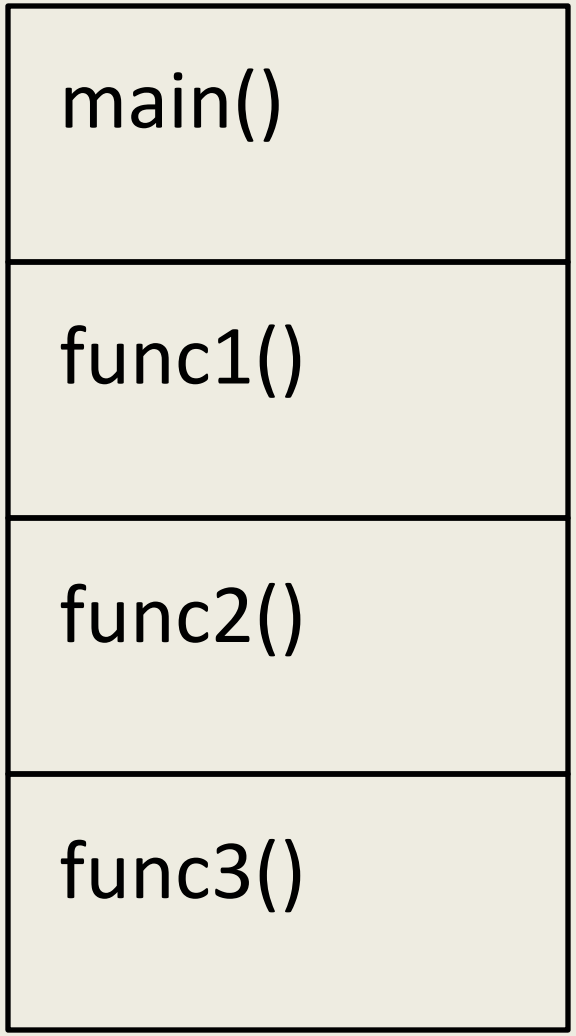


Call Stack

- Each call to a function gets its own stack ‘frame’ containing that particular instance’s local variables.

- When a function calls a function, it creates a new stack frame ‘below’ the previous one.

Call Stack

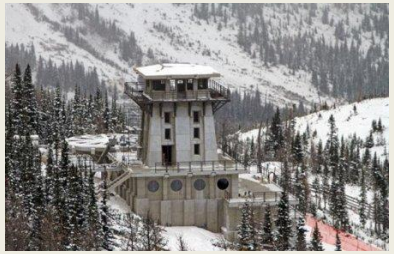


I N C E P T I O N

Images: “Inception”, Warner Bros. Pictures

We Need To Go Deeper

INCEPTION



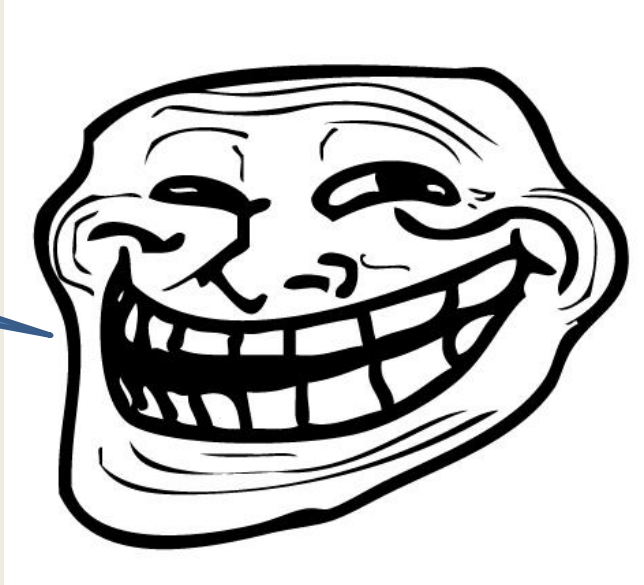
reality?
dream1
dream2
dream3

“The Kick”

Linear Search

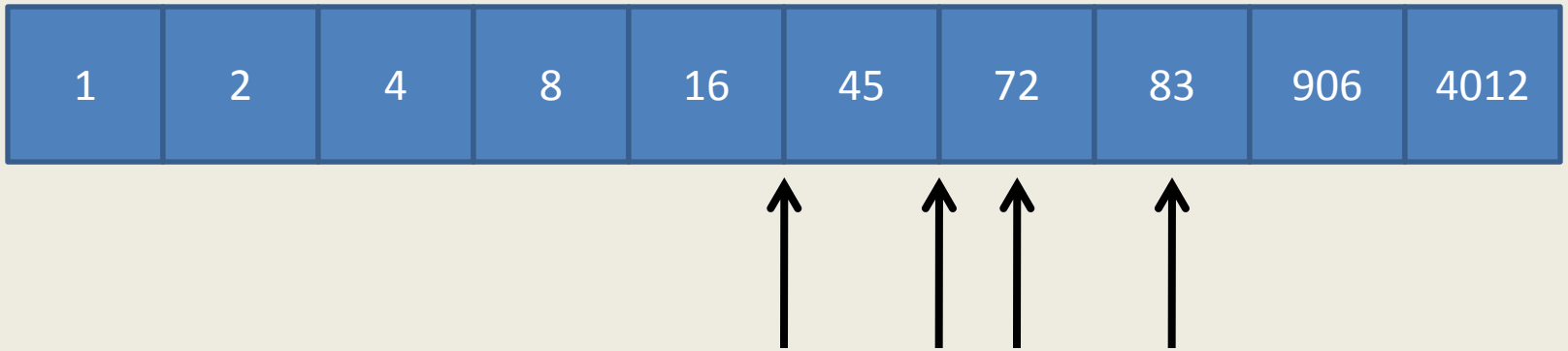
- Want to find a particular element in an array?
- Search through each element until we find it!

Have you tried linear search?



Binary Search

- Like searching through the phone book.
- Identify whether it's in the first or second half, dividing the problem in two. Repeat until we're down to one element.



Asymptotic Notation

- Used to describe the runtime of an algorithm.
- Runtime measured in terms of how the amount of time taken changes as input size increases.

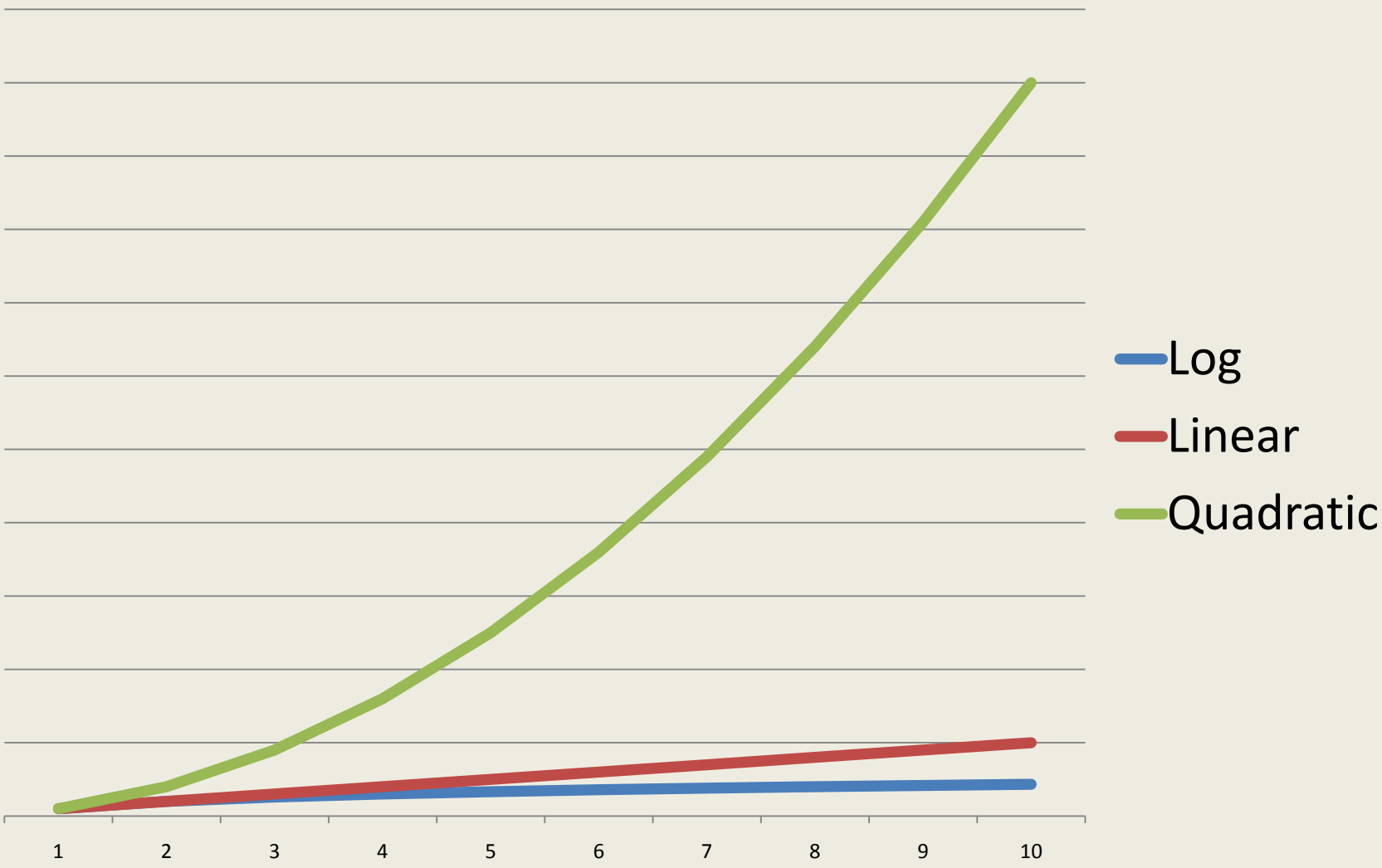
Asymptotic Notation

- Big O notation describes an upper bound on runtime.
- Ω describes a lower bound on runtime.
- θ describes both an upper and lower bound.

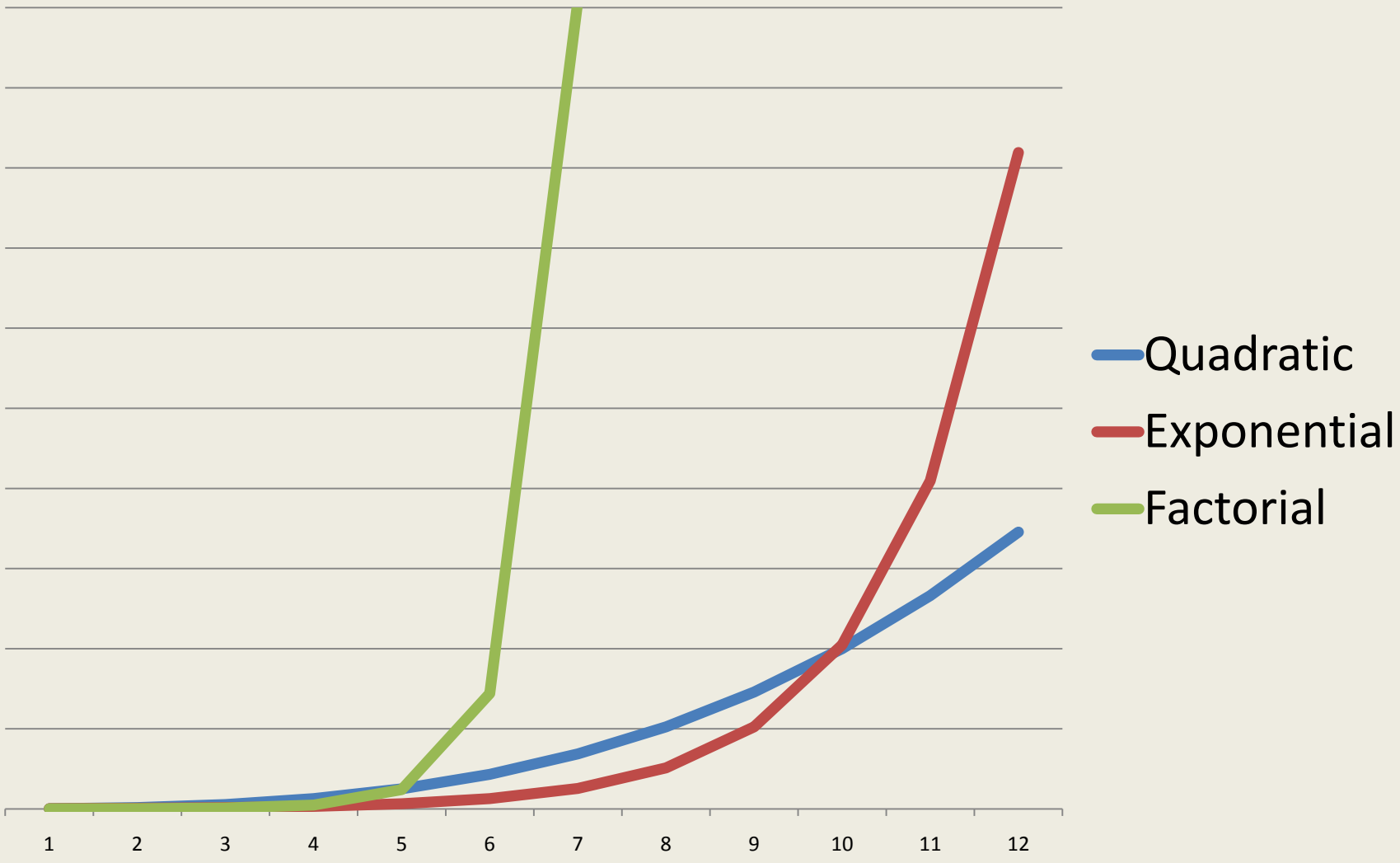
Asymptotic Notation

- 1 – Constant Time
- log n – Logarithmic Time
- n – Linear Time
- n^2 – Quadratic Time
- n^p – Polynomial Time
- 2^n – Exponential Time
- n! – Factorial Time

Runtime



Runtime



Runtime of Search

So...

What's the asymptotic running time of:

- Linear Search?
- Binary Search?

Bubble Sort

- Sorting an array of size *n*.
- Iterate through the array, comparing each pair as you go. If array[i + 1] < array[i], swap them!
- Repeat up to *n - 1* times (or until array is completely sorted...).

Selection Sort

- Grab the smallest and swap it with whatever is at the front of the array.
- Now grab the next smallest and swap with what is in position 2.
- Repeat until entire array is sorted

  (again, up to $n - 1$ times).