# CS151 Intro to Data Structures

Stacks

Junit

Queues

# Announcements

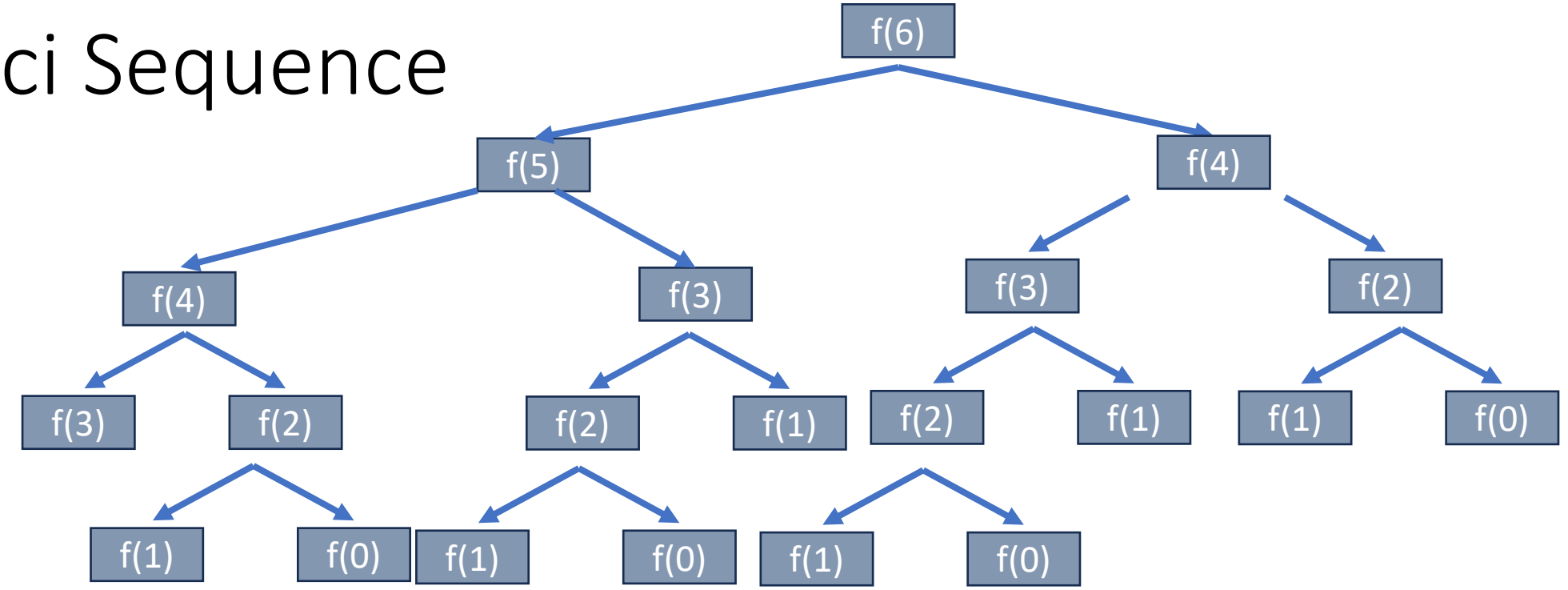
- HW02 due ~~Thursday October 5~~th
  Friday October 6th

- Lab checkoff, deadline is when corresponding HW is due

# Outline

- Stacks
- Junit
- Queues

# Fibonacci Sequence




```
public static int fib(int n) {
        if (n <= 1) {
                return 1; }
        return fib(n-1) + fib(n-2);
}
```

# Stacks

Simple and surprisingly useful data structure

Can store any number of items

User can only interact with the top of the stack:

- Push: add a new element to the top
- Pop: take off the top element
- Top/Peek: view the top element without removing it

# Stacks - Applications

Hardware call stack

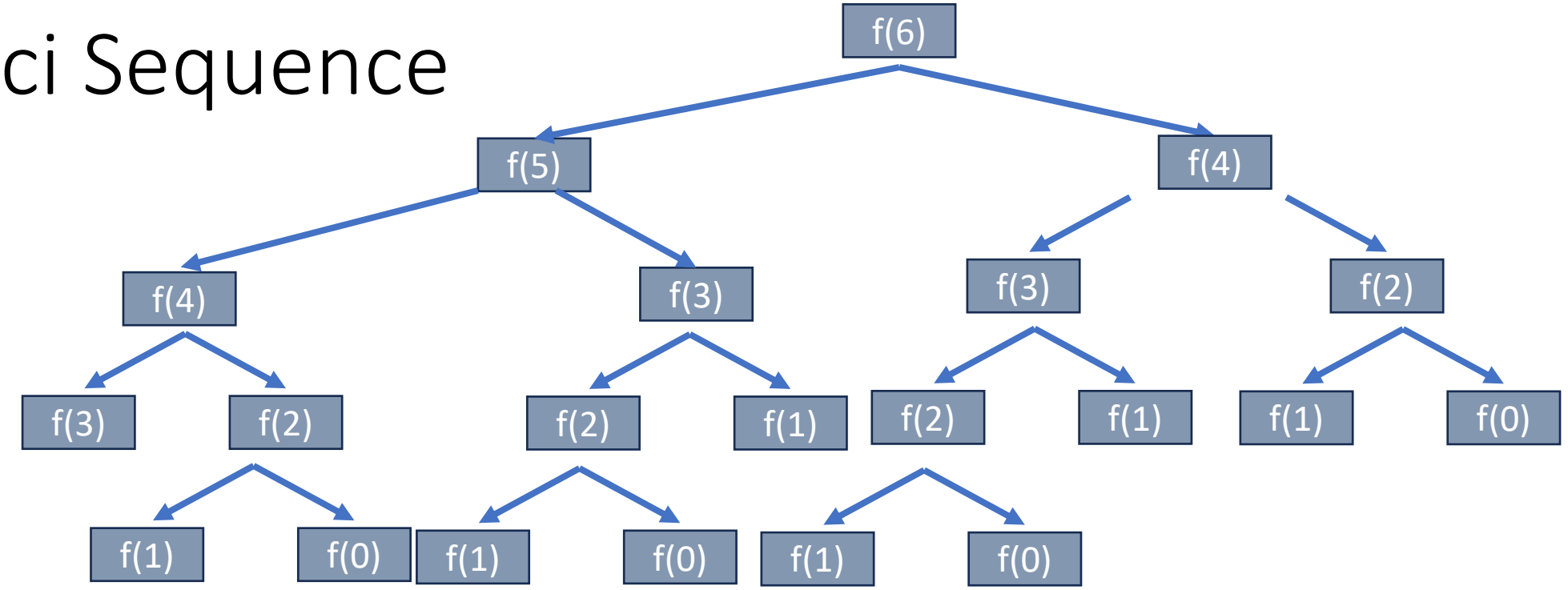
Memory Management

Parsing arithmetic instructions:

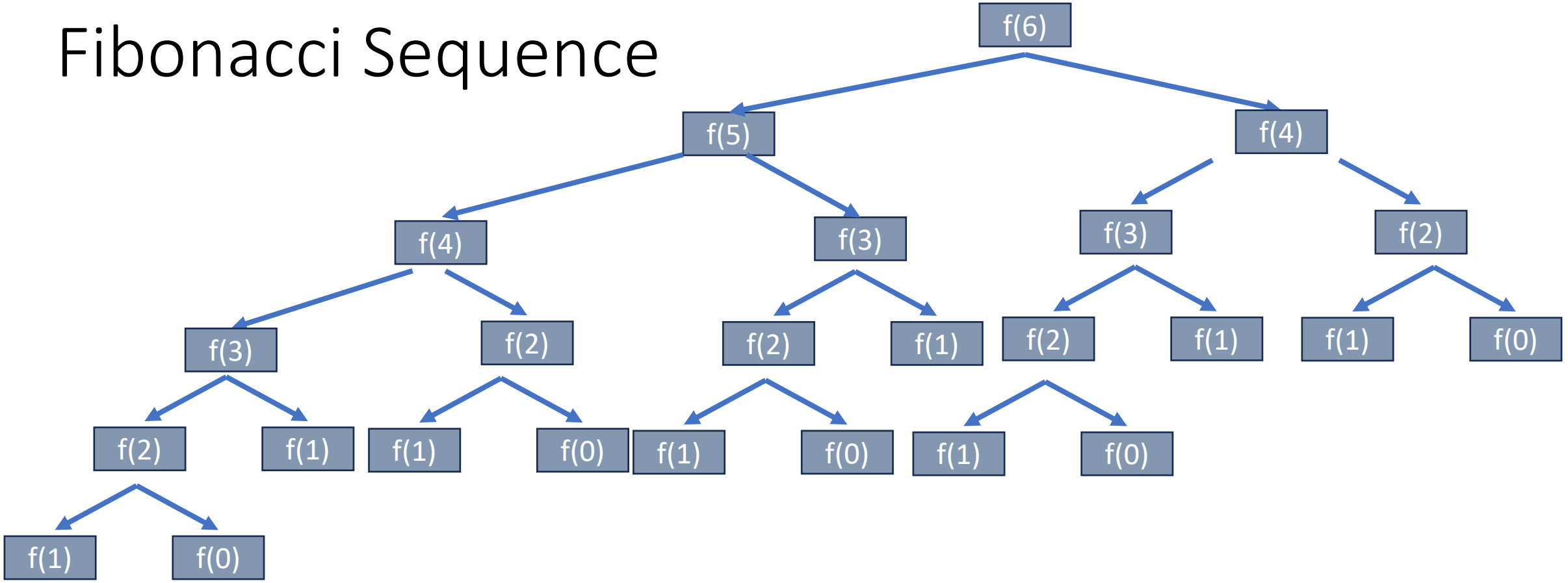
((x*2) + (4 + x)) * (3 * cos(x))

Back-tracing (e.g. searching in a maze)

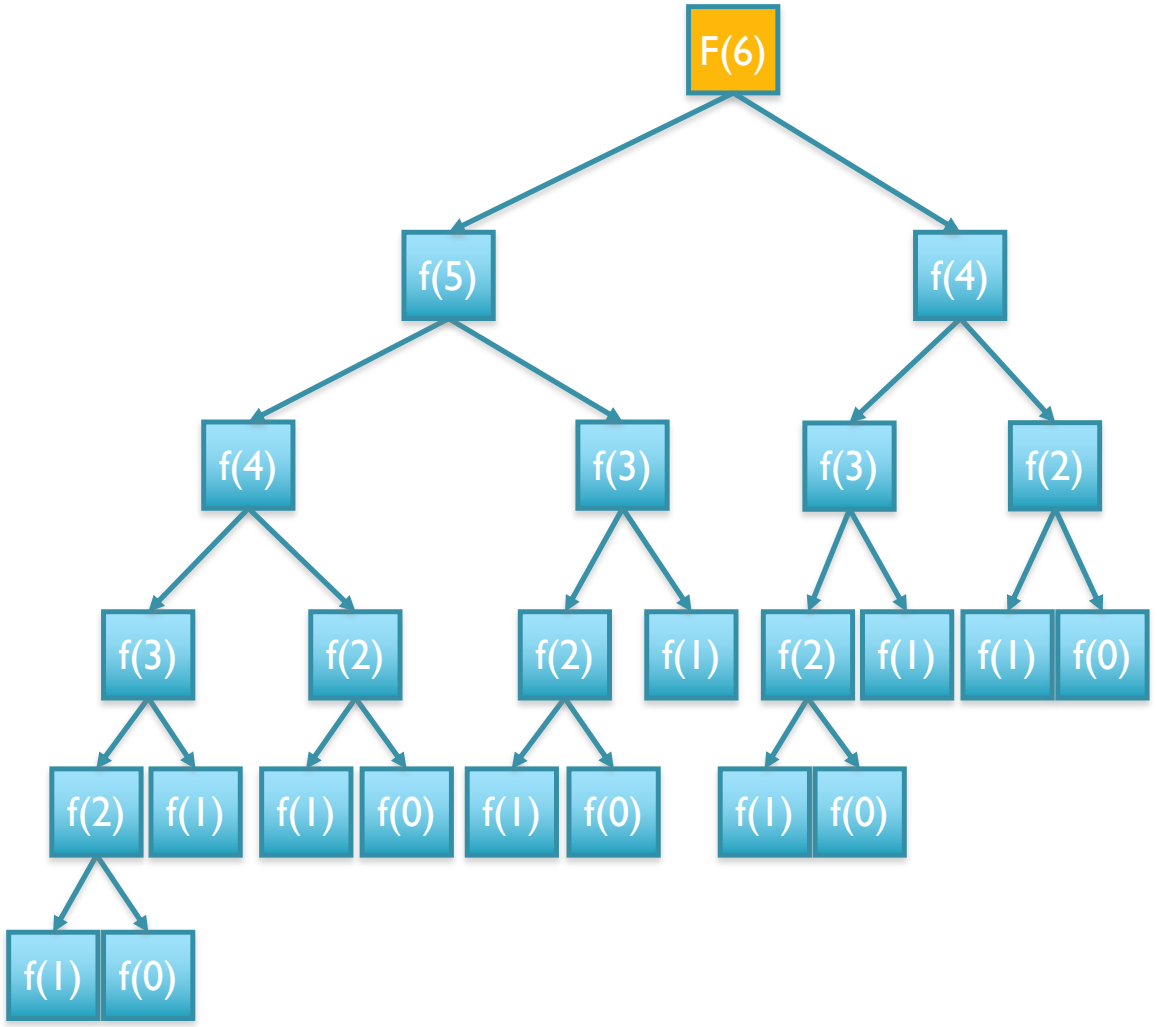
# Fibonacci Sequence



# Fibonacci Sequence

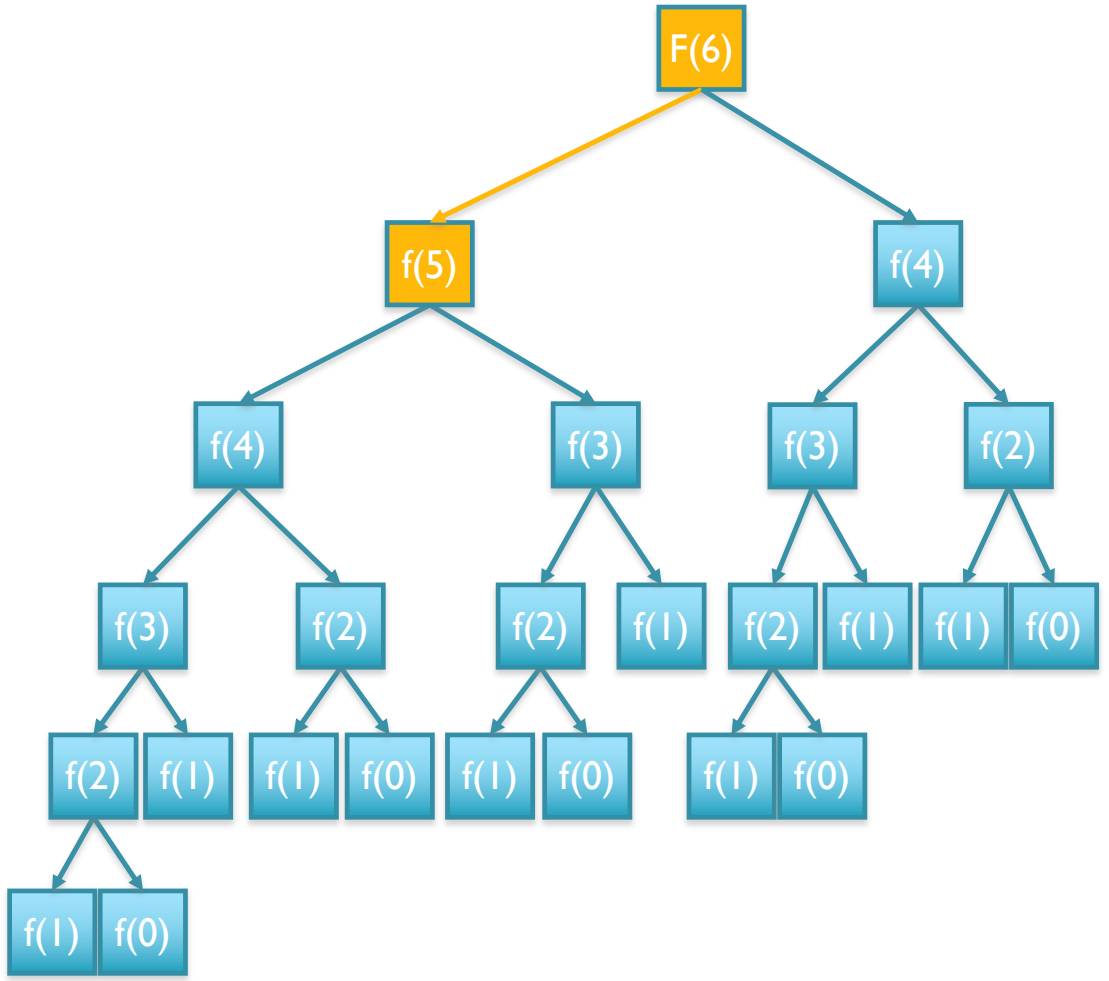


# Fibonacci Sequence




***F(6)***
a = F(5)

# Fibonacci Sequence




***F(5)***
a = F(4)

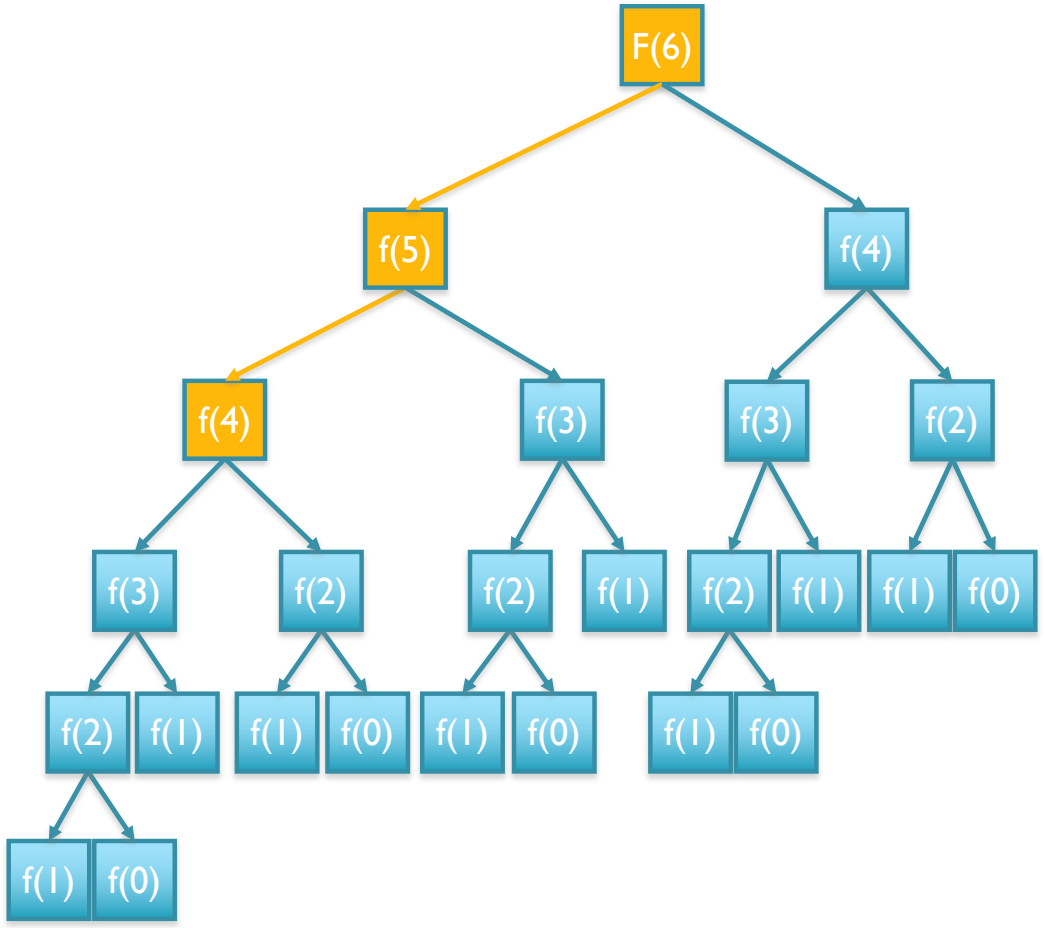
***F(6)***
a = F(5)

# Fibonacci Sequence

***F(4)***
a = F(3)

***F(5)***
a = F(4)

***F(6)***
a = F(5)



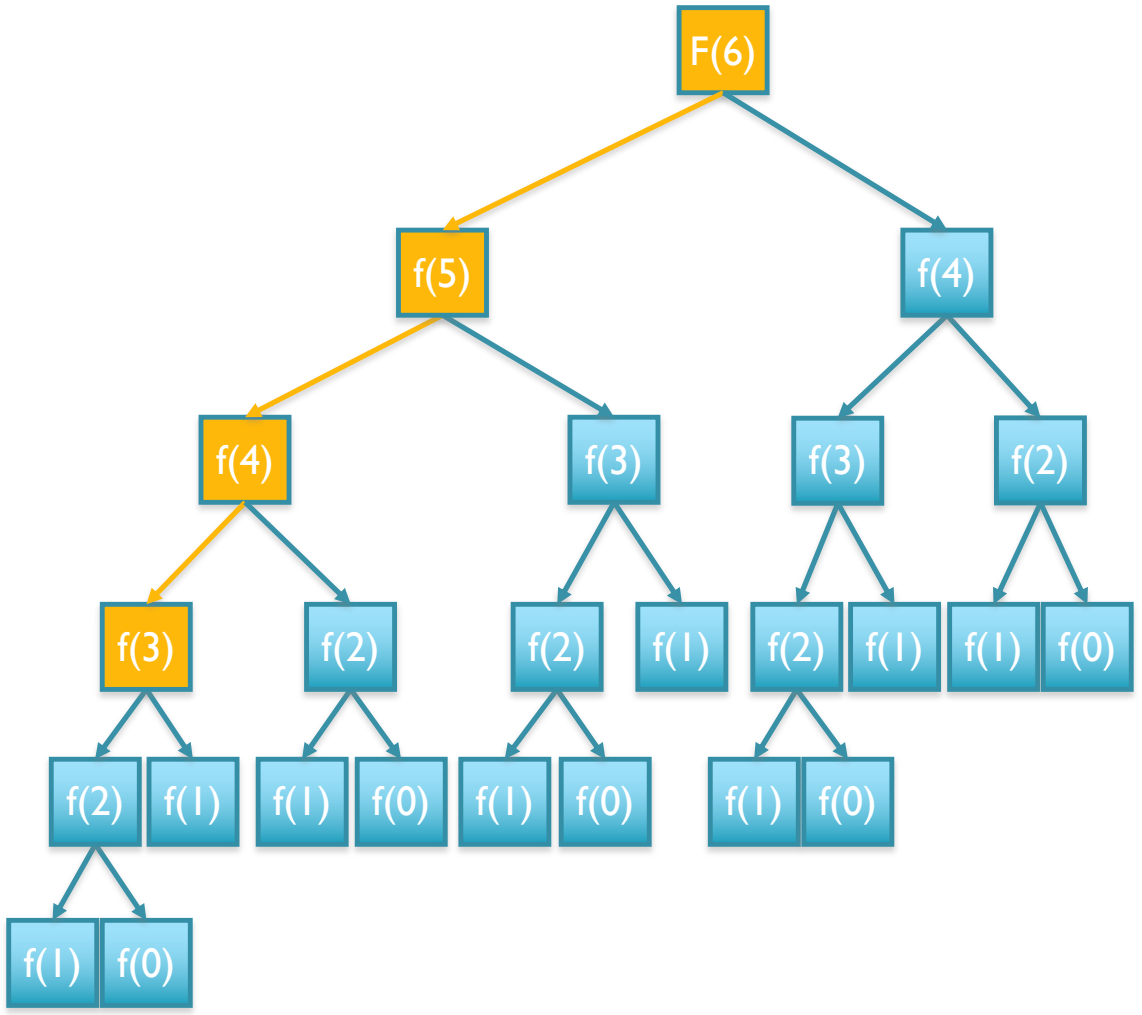
# Fibonacci Sequence

***F(3)***
a = F(2)

***F(4)***
a = F(3)

***F(5)***
a = F(4)

***F(6)***
a = F(5)



# Fibonacci Sequence

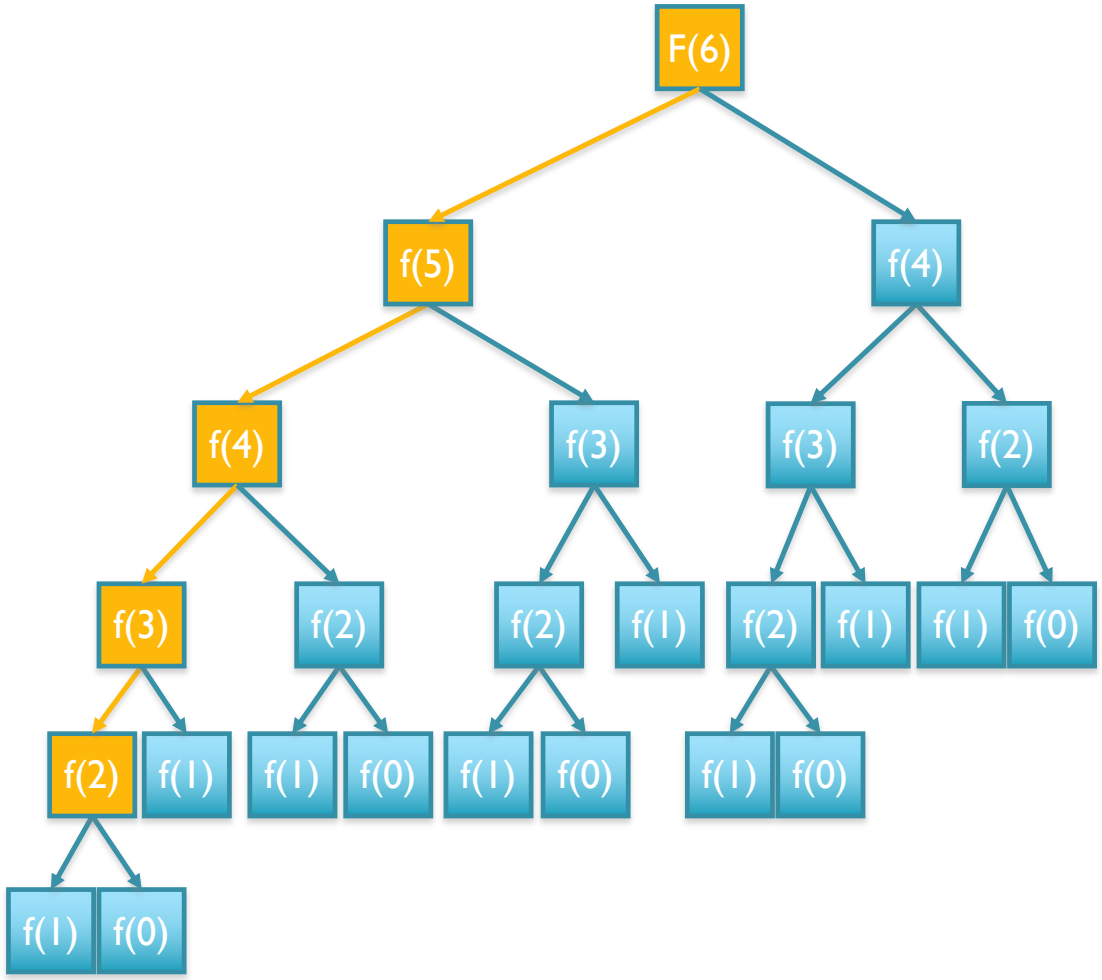
***F(2)***
a = F(1)

***F(3)***
a = F(2)

***F(4)***
a = F(3)

***F(5)***
a = F(4)

***F(6)***
a = F(5)



# Fibonacci Sequence

```
public static int fib(int n) {
        if (n <= 1) {
                return 1;
        }
        return fib(n-1) + fib(n-2);
}
```

***F(1)***
return 1

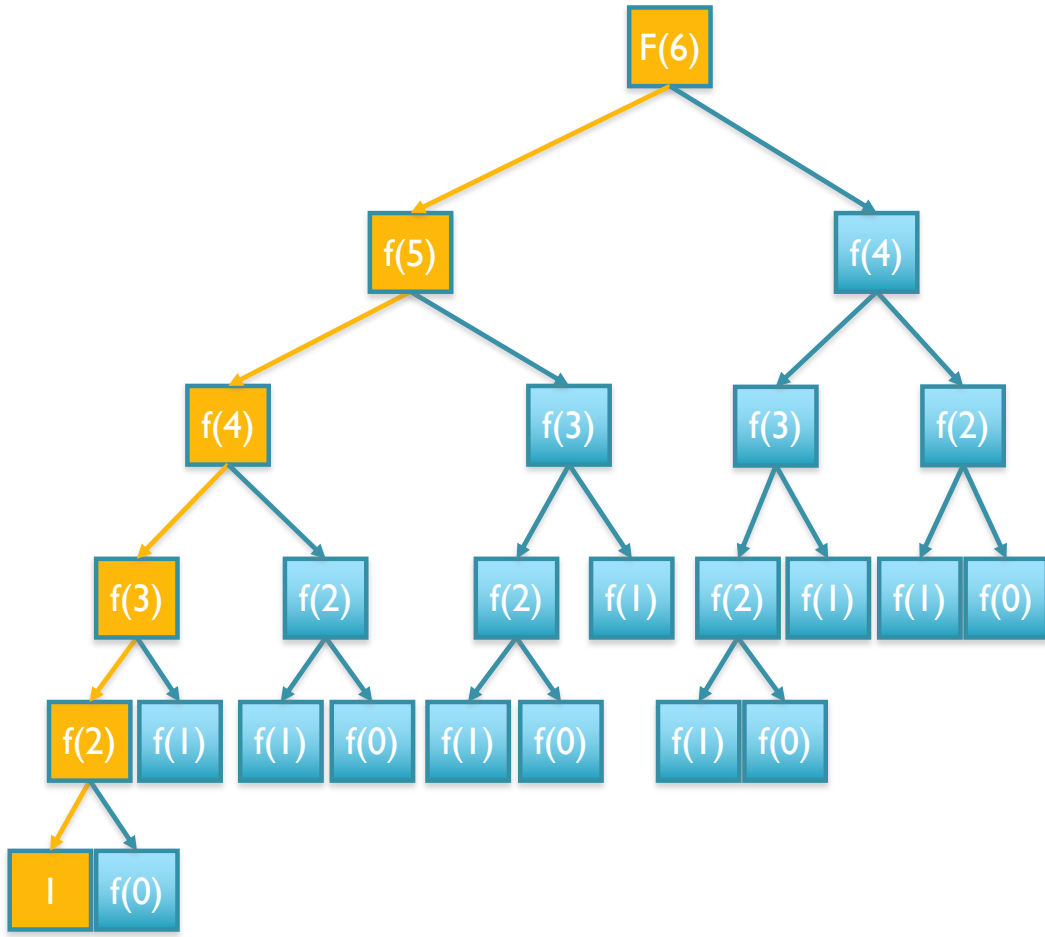
***F(2)***
a = F(1)

***F(3)***
a = F(2)

***F(4)***
a = F(3)

***F(5)***
a = F(4)

***F(6)***
a = F(5)



# Fibonacci Sequence

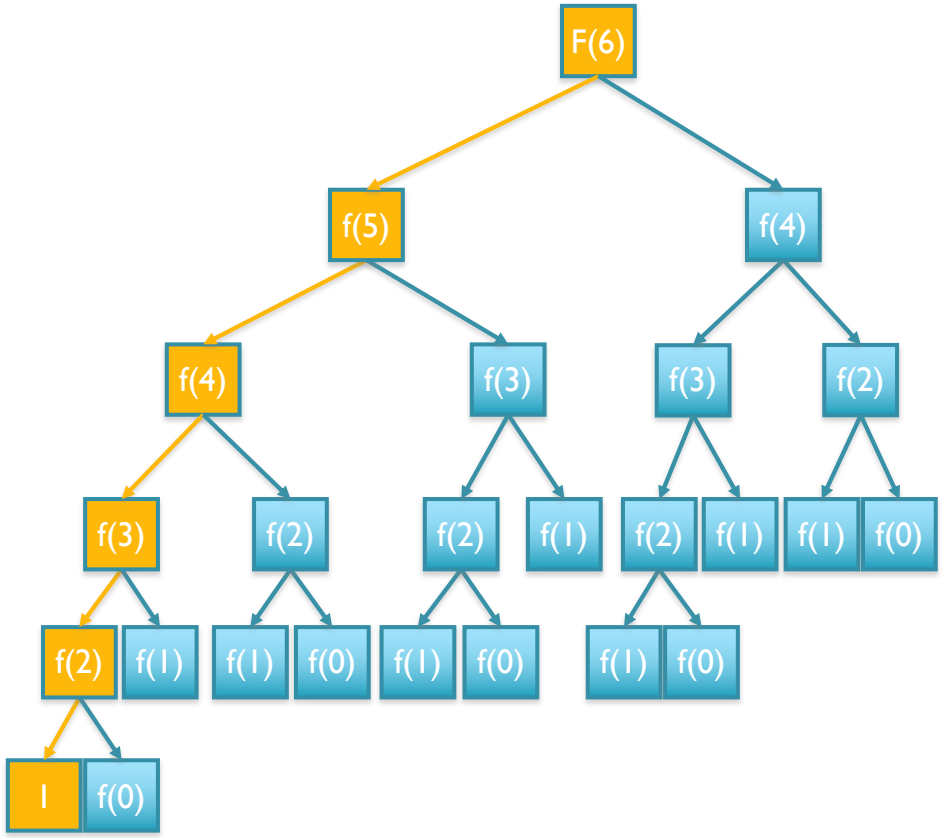
***F(2)***
b = F(0)

***F(3)***
a = F(2)

***F(4)***
a = F(3)

***F(5)***
a = F(4)

***F(6)***
a = F(5)



# Fibonacci Sequence

```
public static int fib(int n) {
        if (n <= 1) {
                return 1;
        }
        return fib(n-1) + fib(n-2);
}
```

***F(0)***
return 1

***F(2)***
b = F(0)

***F(3)***
a = F(2)

***F(4)***
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***F(5)***
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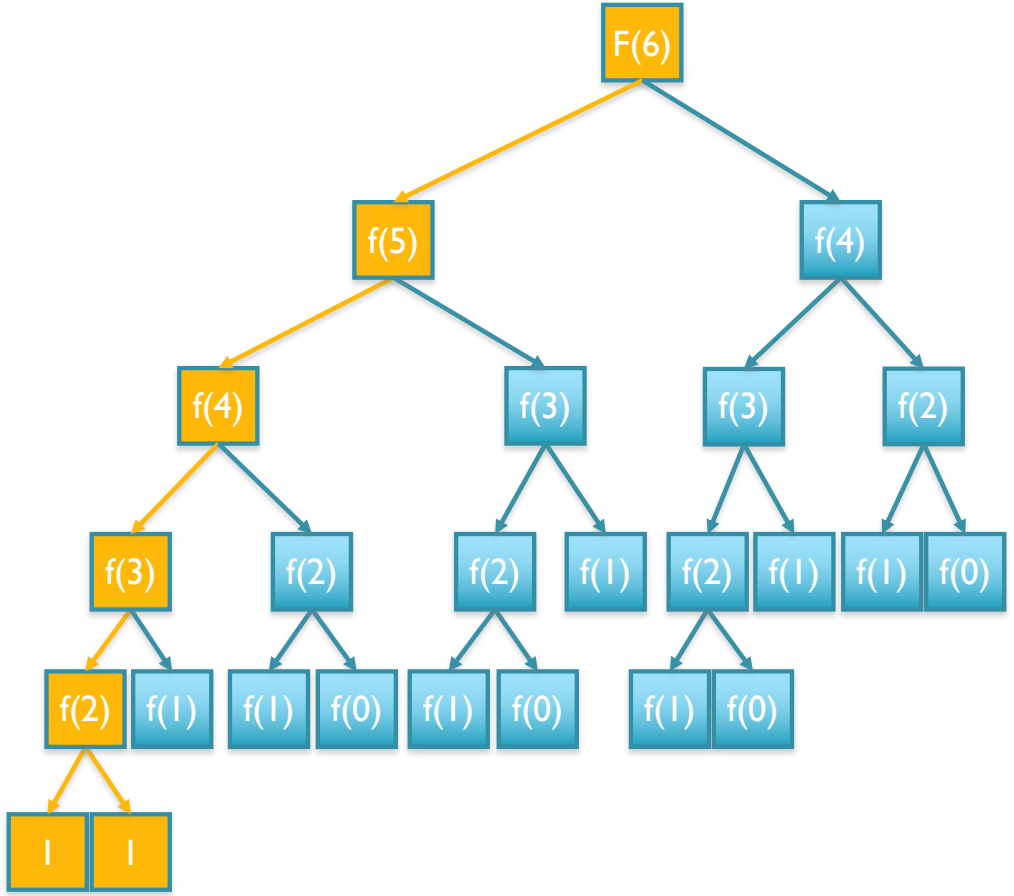


# Fibonacci Sequence

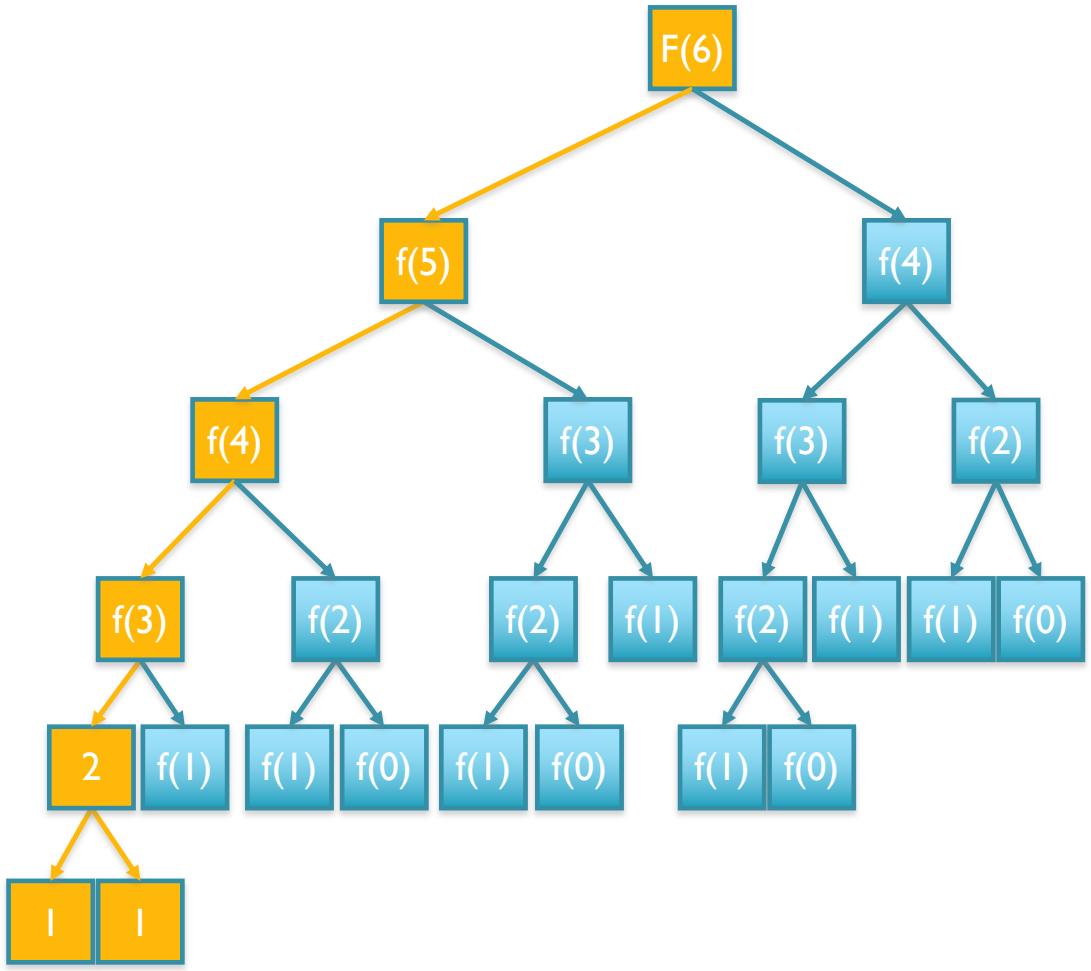
***F(2)***
return 2

***F(3)***
a = F(2)

***F(4)***
a = F(3)

***F(5)***
a = F(4)

***F(6)***
a = F(5)



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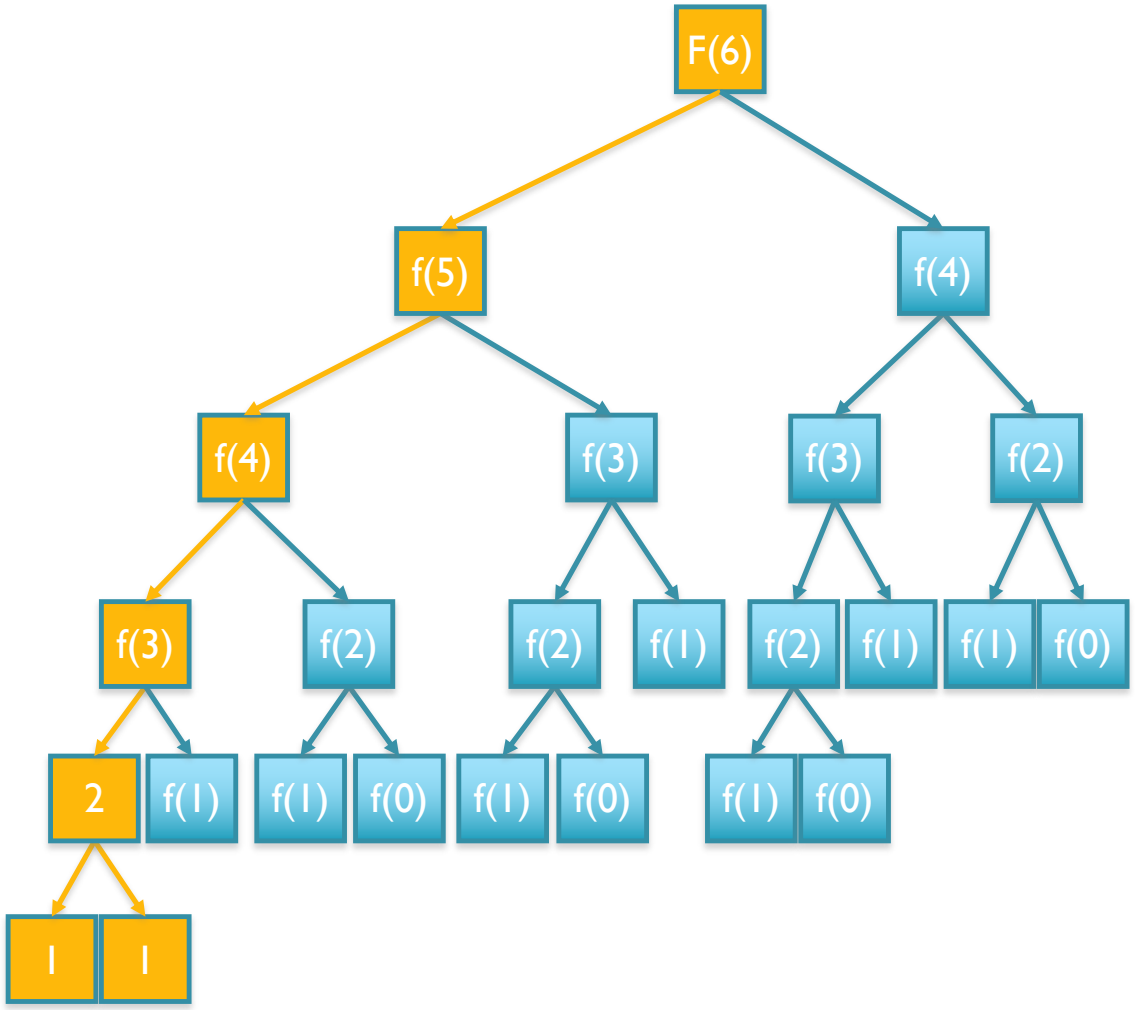

# Fibonacci Sequence

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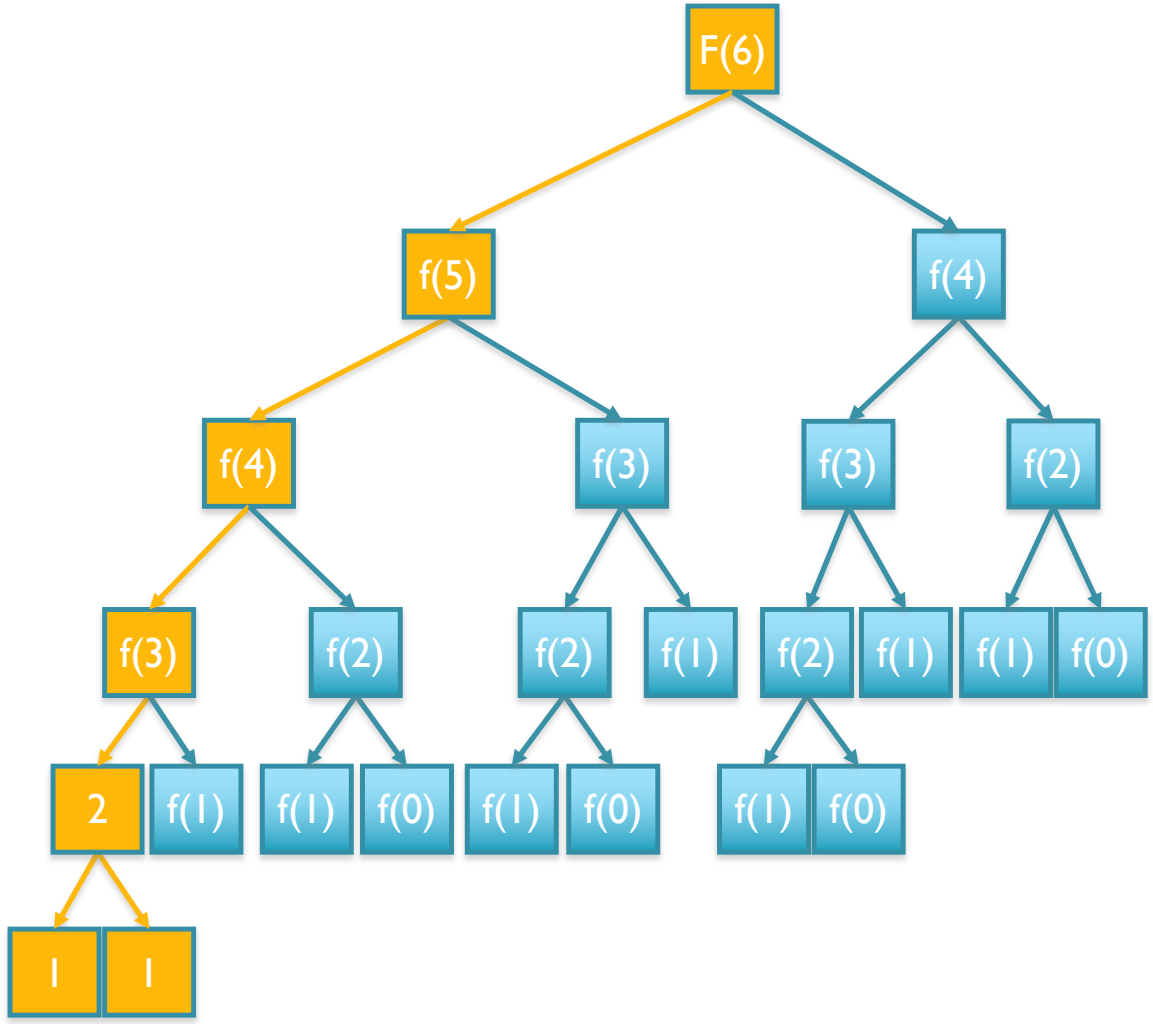

# Fibonacci Sequence

```
public static int fib(int n) {
        if (n <= 1) {
                return 1;
        }
        return fib(n-1) + fib(n-2);
}
```

***F(1)***
return 1

***F(3)***
b = F(1)

***F(4)***
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***F(5)***
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***F(6)***
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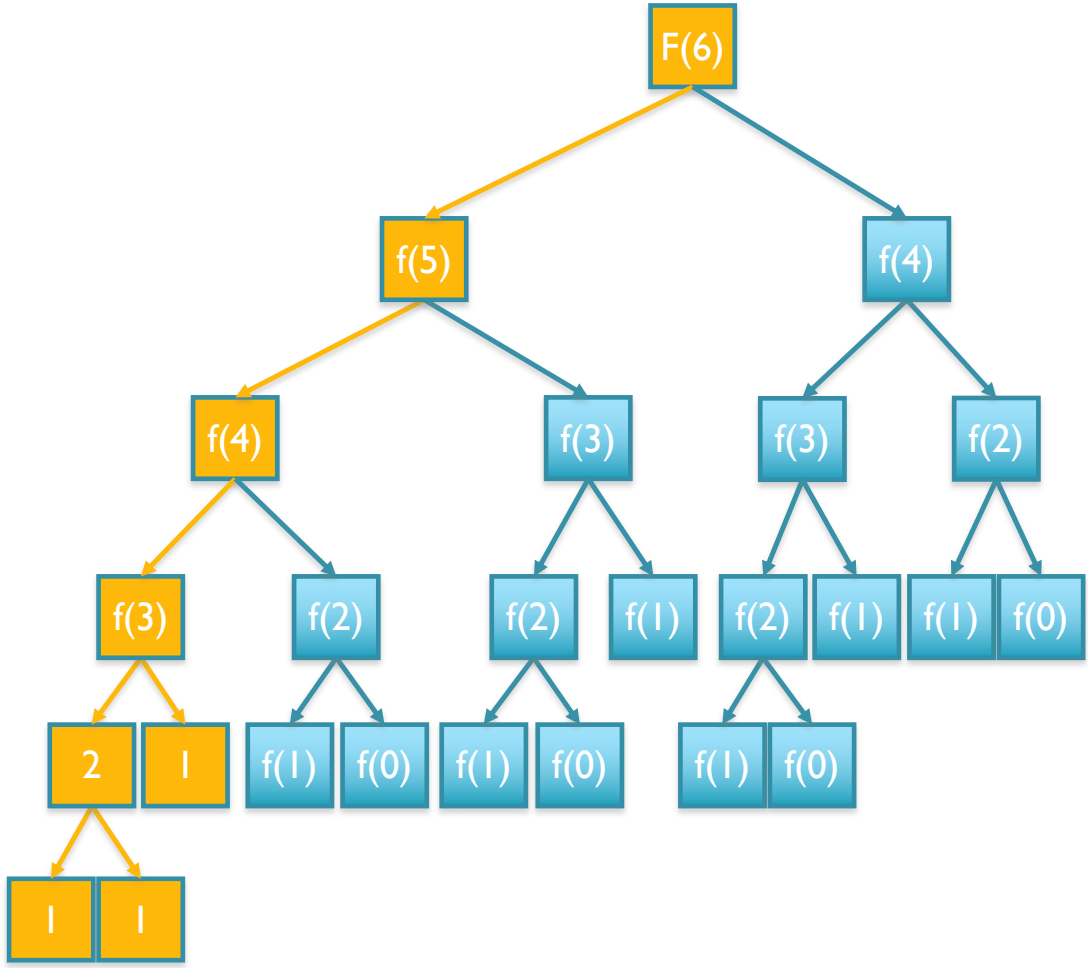


# Stack Applications

- Reversing
- Matching
  - ( )(( )){([( )])}
  - ((( )(( )))){([( )])}
  - ()}
  - ({[ ])}
  - )(( )){([( )])}
  - (

```
for each symbol s:
  if s = ( or [ or {
    push(s)
  if s = ) or ] or }
    t = pop()
    if s doesn't match t
      reject
if stack is empty
  accept
else
  reject
```

# Stack Applications

Postfix notation

- 5 6 * 2 +
  5*6 + 2
- 3 4 5 * –
  3 – 4 * 5
- 3 4 – 5 *
  (3 – 4) * 5

Evaluating postfix expressions with a stack

- operands – push
- operator – pop top two operands, perform operation and push results back on

# Stack Applications

Evaluating postfix expressions with a stack

- operands – push
- operator – pop top two operands, perform operation and push results back on

- 15 7 1 1 + – / 3 * 2 1 1 + + –
- ((15/(7−(1+1)))*3)−(2+(1+1))

# Testing Stack Implementation

new stack is empty

Pushing ”hello”, then top return “hello”

Push, pop, then stack should be empty

# JUnit

JUnit 4 / About — Version: 4.13.2 | Last Published: 2021-02-13

JUnit is a simple framework to write repeatable tests. It is an instance of the xUnit architecture for unit testing frameworks.

```
@Test
public void newArrayListsHaveNoElements() {
    assertThat(new ArrayList<Integer>().size(), is(0));
}

@Test
public void sizeReturnsNumberOfElements() {
    List<Object> instance = new ArrayList<Object>();
    instance.add(new Object());
    instance.add(new Object());
    assertThat(instance.size(), is(2));
```

**Annotations**

Start by marking your tests with `@Test`.

Let's take a tour »

**Welcome**

- Download and install
- Getting started
- Release Notes
  - 4.13.2
  - 4.13.1
  - 4.13
  - 4.12
  - 4.11
  - 4.10
  - 4.9.1
  - 4.9
- Maintainer Documentation
- I want to help!
- Latest JUnit Questions on StackOverflow
- JavaDocs
- Frequently asked questions
- Wiki
- License

**Usage and Idioms**

- Assertions
- Test Runners
- Aggregating tests in Suites
- Test Execution Order
- Exception Testing
- Matchers and assertThat
- Ignoring Tests
- Timeout for Tests
- Parameterized Tests
- Assumptions with Assume
- Rules
- Theories
- Test Fixtures
- Categories
- Use with Maven
- Multithreaded code and Concurrency
- Java contract test helpers
- Continuous Testing

**Third-party extensions**

- Custom Runners
- net.trajano.commons:commons-testing for UtilityClassTestUtil per #646
- System Rules – A collection of JUnit rules for testing code that uses java.lang.System.
- JUnit Toolbox - Provides runners for parallel testing, a `PoolingWait` class to ease asynchronous testing, and a `WildcardPatternSuite` which allow you to specify wildcard patterns instead of explicitly listing all classes when you create a suite class.
- junit-quickcheck - QuickCheck-style parameter suppliers for JUnit theories. Uses junit.contrib's version of the theories machinery, which respects generics on theory parameters.

# Why use Junit over asserts?

Modularize tests

- Large projects will have as much testing as program code

Run all test cases every time

- When an assert fails, program throws an Exception and stops
- Can get all feedback at once

Future class and jobs will expect familiarity with testing frameworks

# Using JUnit

Import Test Annotation Framework

```
import org.junit.Test;
```

Write tests using @Test annotation

```
@Test
public void testEmpty() {
    ArrayStack<String> stack = new ArrayStack<String>(10);
    assertTrue(stack.isEmpty());
}
```

# Testing Guidelines

Test every method for correct outputs:

- Try simple and complext examples

Every exception and error condition should be tested too

Write test cases first, then implement

- Will make it easy to know when you are done

# Queues

# Stack Property

First-in Last-out (FILO)

- Applications:
  - browser history (Ctrl+H)
  - Undo (Ctrl+Z)
- Applications where we don’t want FILO:
  - Queuing system
  - Cash register
  - Scheduling tasks

# First-in First-out

The first item in, is the first item out

Add-to the back, remove from the front

This is a **Queue**

Inserting – `enqueue`

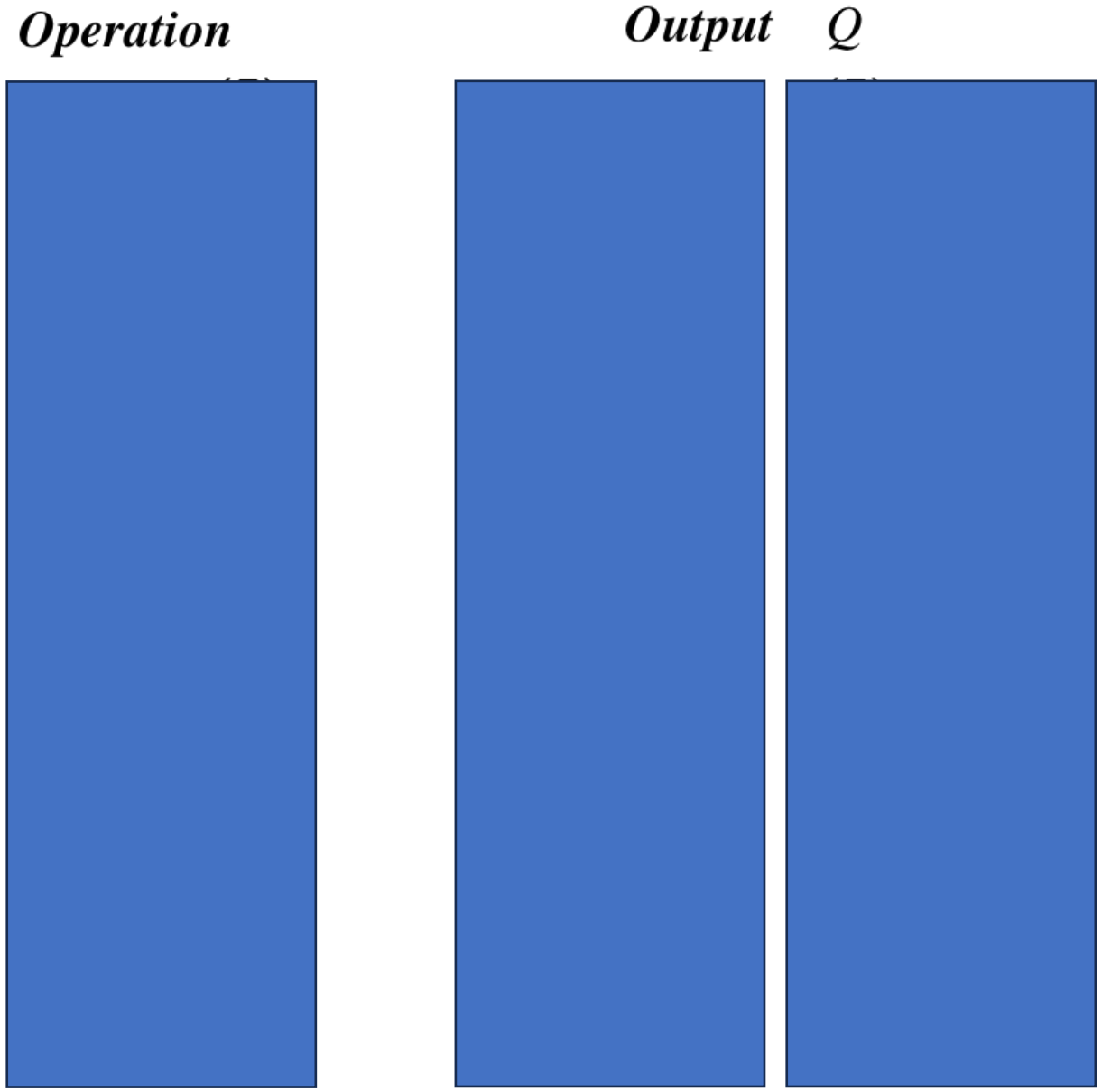
Removing - `dequeue`

# Queue Interface

```
public interface Queue<E> {
   int size();
   boolean isEmpty();
   E first();
   void enqueue(E e);
   E dequeue();
}
```

- `null` is returned from `dequeue()` and `first()` when queue is empty

# Example



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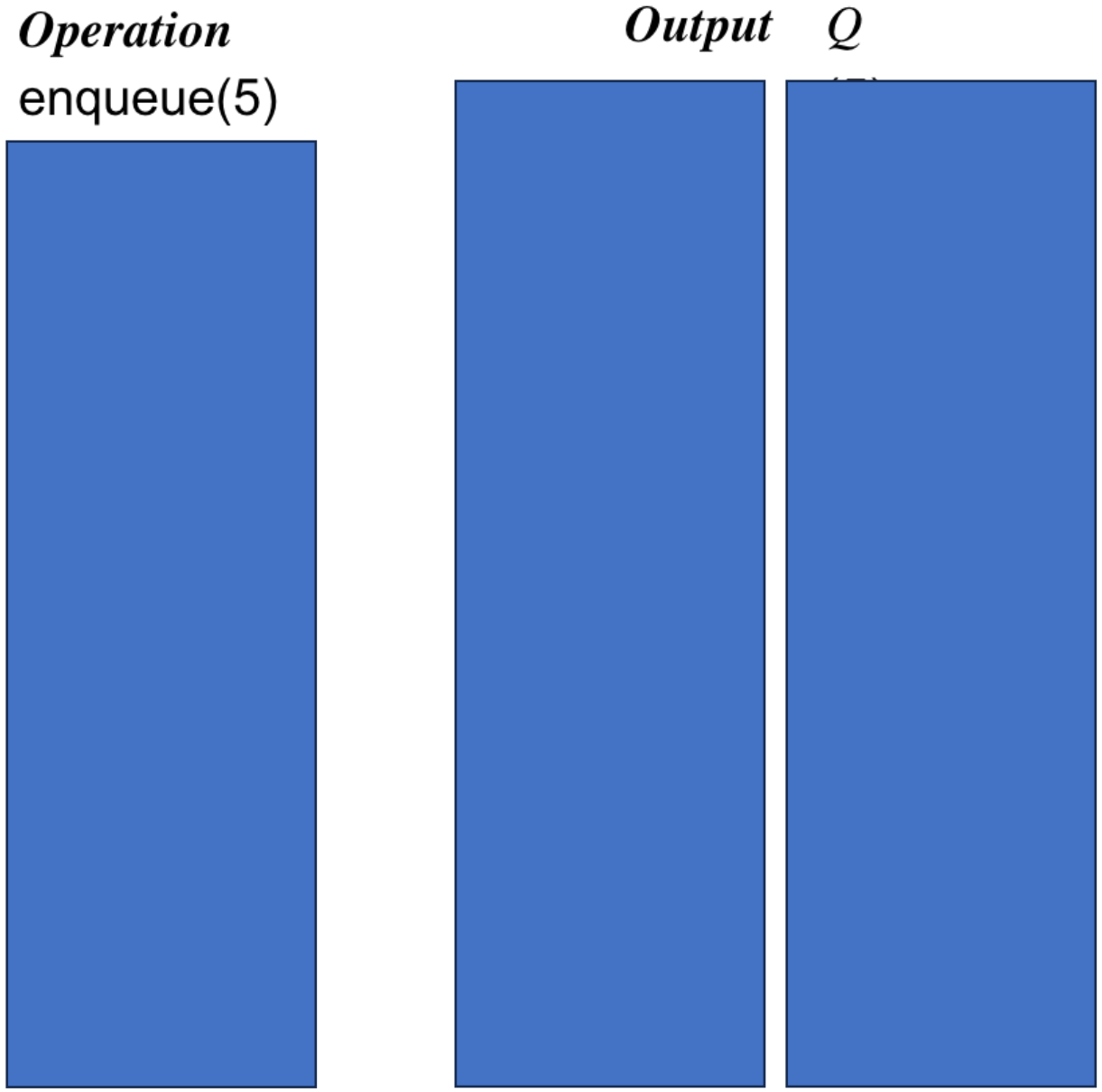
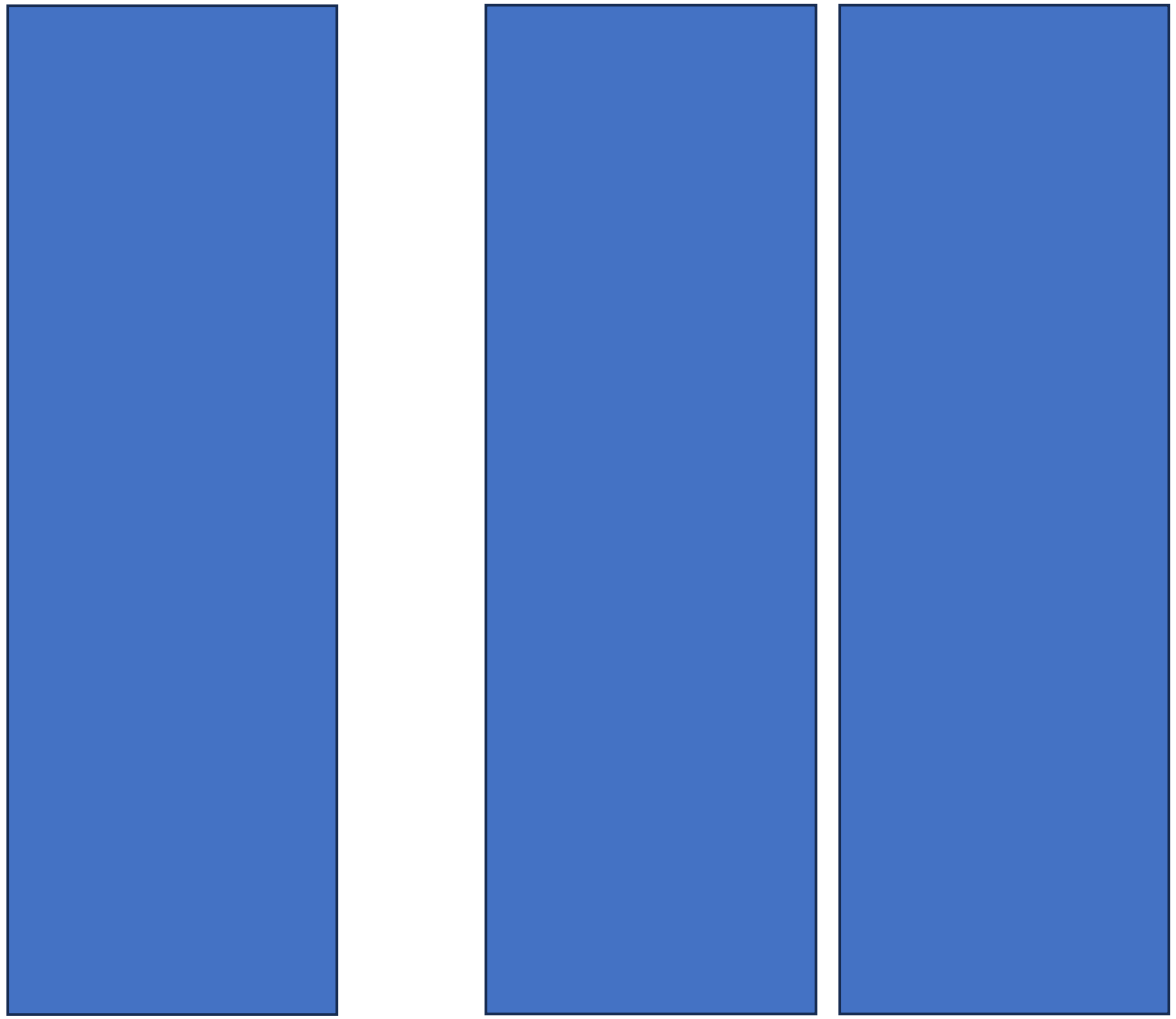


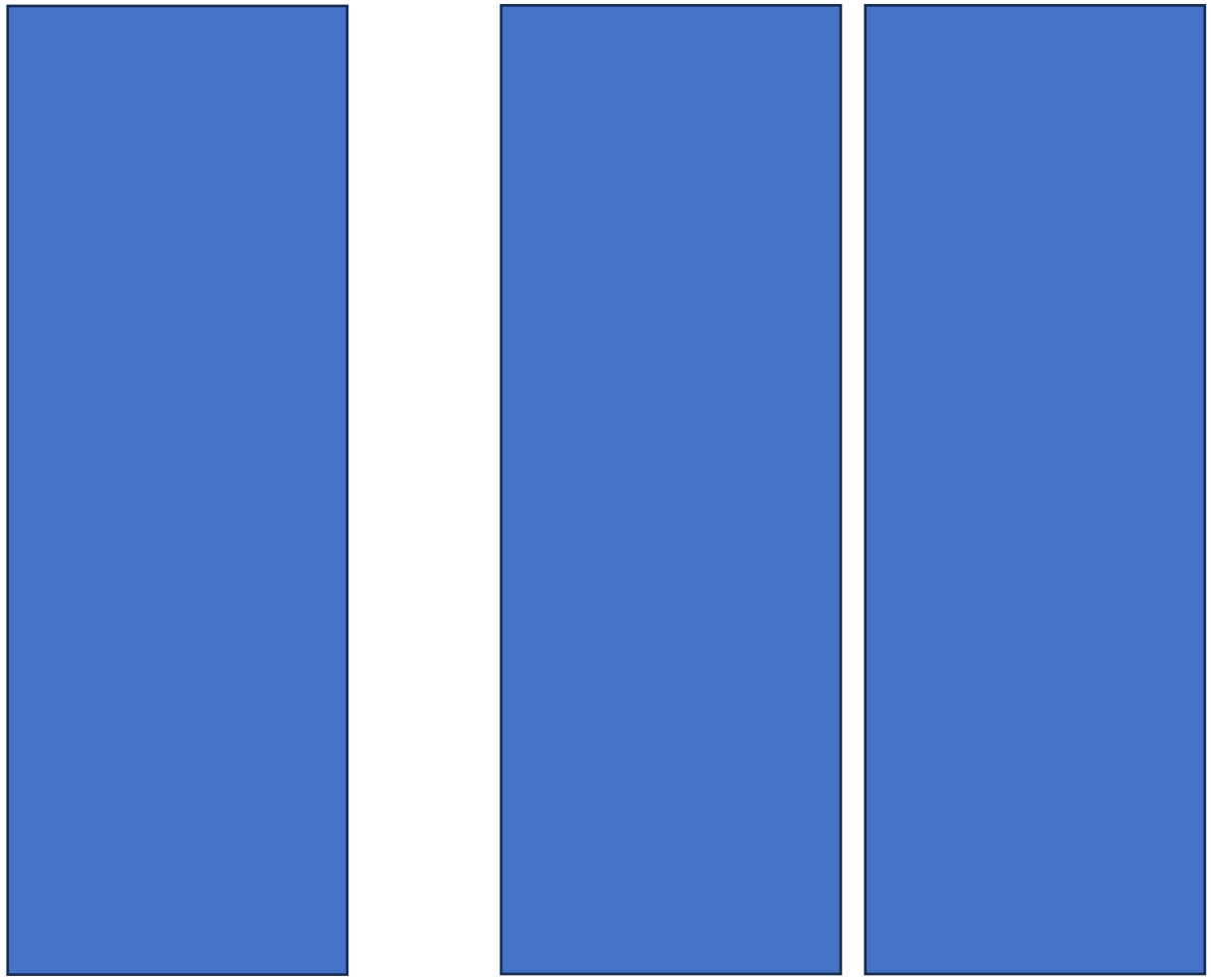
# Example

| *Operation* | *Output* | *Q* |
| --- | --- | --- |
| enqueue(5) | – | (5) |



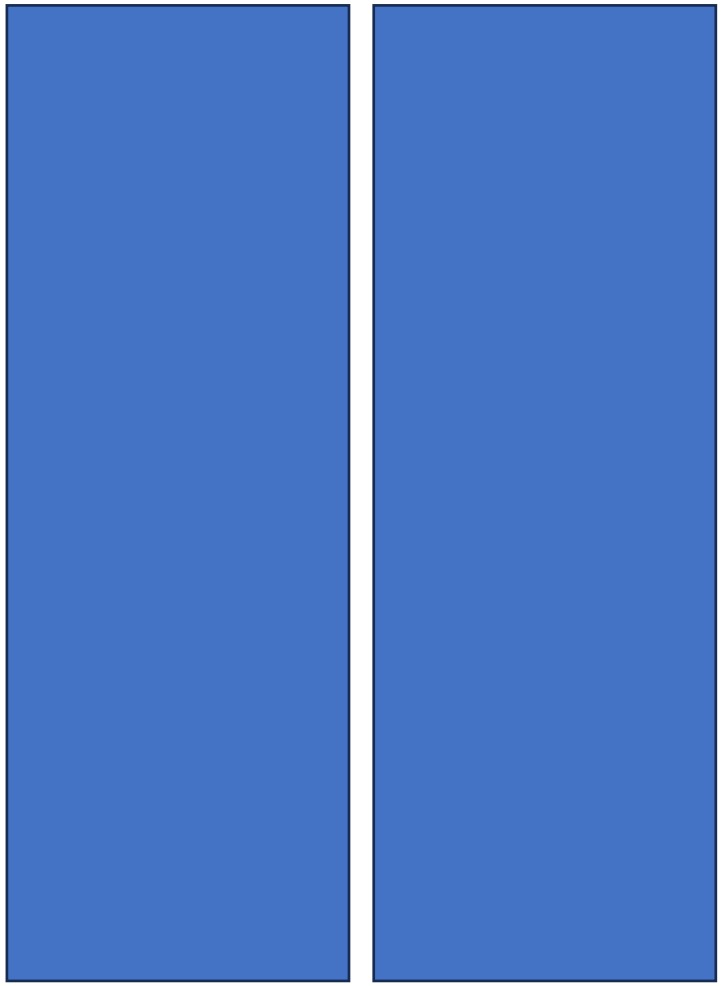
# Example

| *Operation* | *Output* | *Q* |
| --- | --- | --- |
| enqueue(5) | – | (5) |
| enqueue(3) | – | (5, 3) |



# Example

| *Operation* | *Output* | *Q* |
|---|---|---|
| enqueue(5) | – | (5) |
| enqueue(3) | – | (5, 3) |
| dequeue() | | |
| enqueue(7) | | |
| dequeue() | | |
| first() | | |
| dequeue() | | |
| dequeue() | | |
| isEmpty() | | |
| enqueue(9) | | |
| enqueue(7) | | |
| size() | | |
| enqueue(3) | | |
| enqueue(5) | | |
| dequeue() | | |



# Skip slide

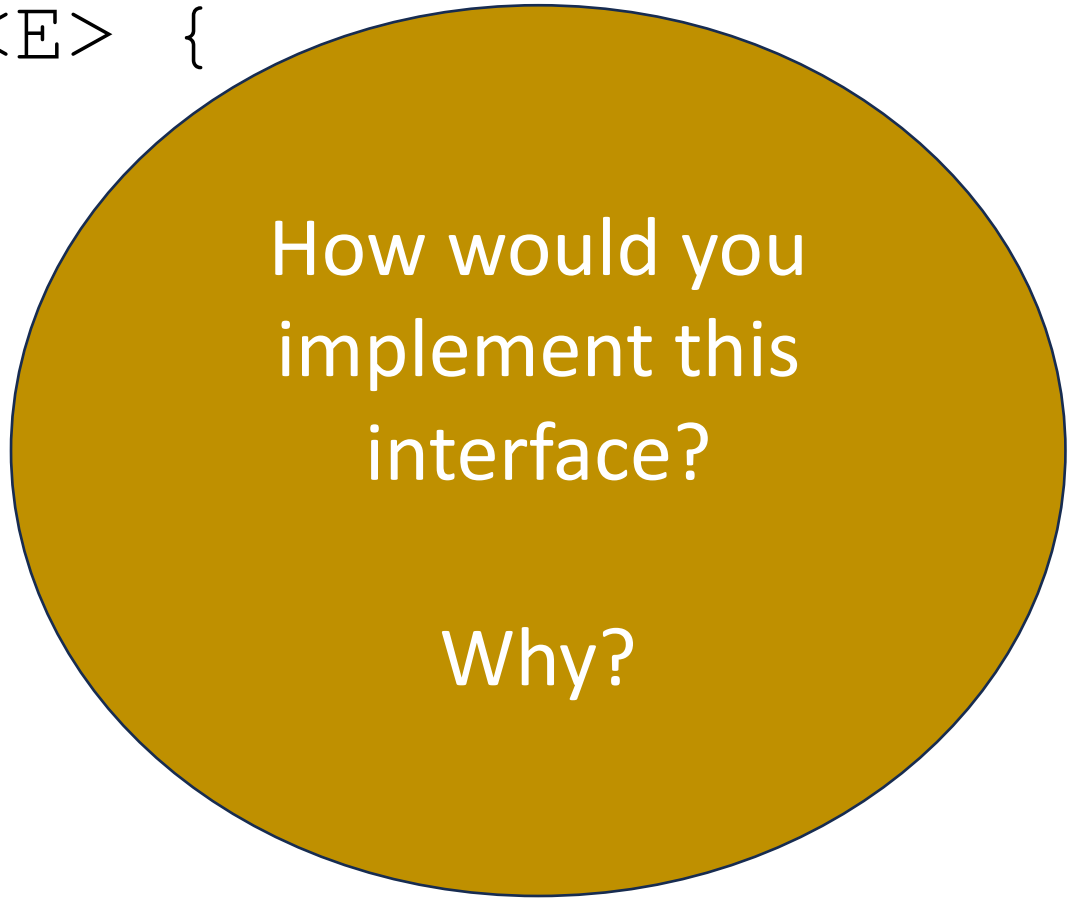
# Skip slide

# Example

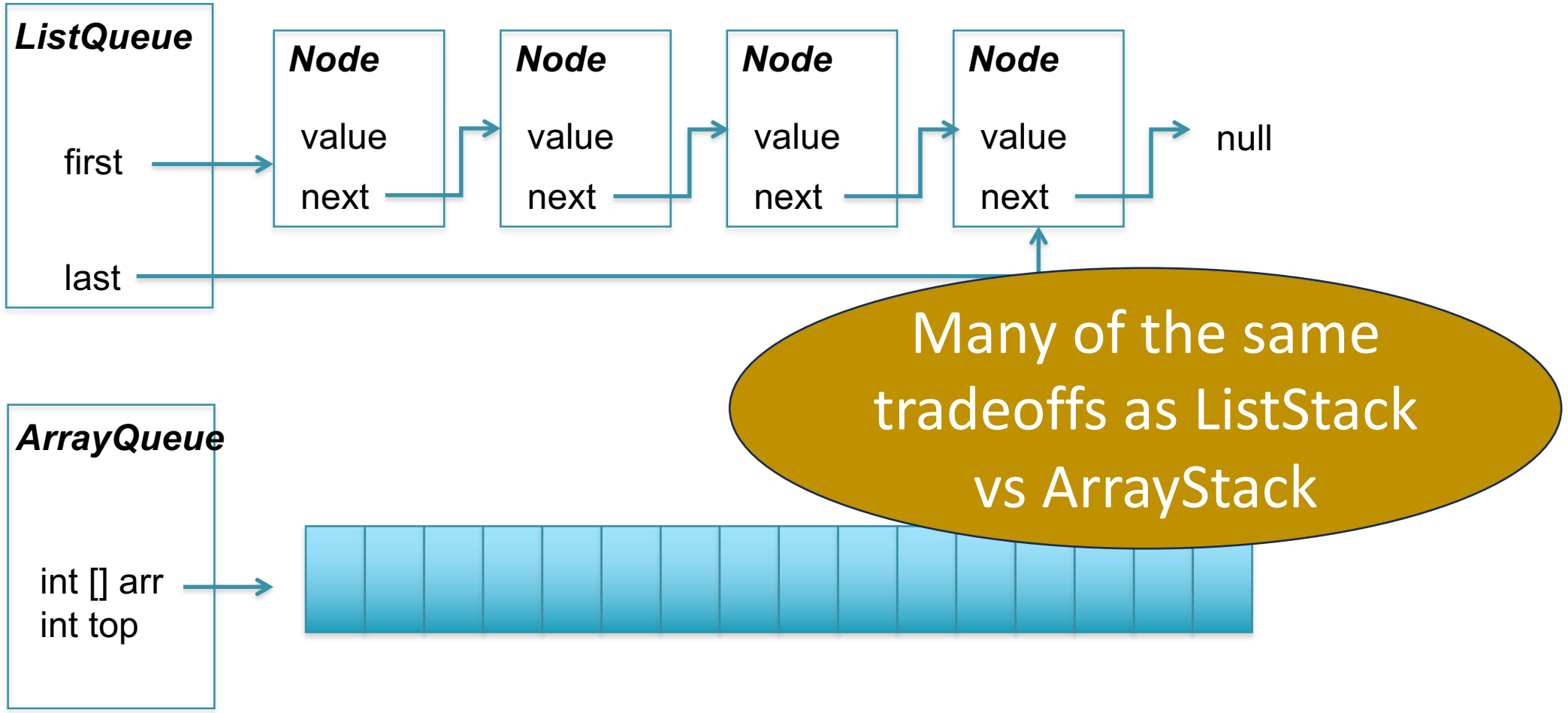
| *Operation* | *Output* | *Q* |
|---|---|---|
| enqueue(5) | – | (5) |
| enqueue(3) | – | (5, 3) |
| dequeue() | *5* | (3) |
| enqueue(7) | – | (3, 7) |
| dequeue() | *3* | (7) |
| first() | *7* | (7) |
| dequeue() | *7* | () |
| dequeue() | *null* | () |
| isEmpty() | *true* | () |
| enqueue(9) | – | (9) |
| enqueue(7) | – | (9, 7) |
| size() | *2* | (9, 7) |
| enqueue(3) | – | (9, 7, 3) |
| enqueue(5) | – | (9, 7, 3, 5) |
| dequeue() | *9* | (7, 3, 5) |

# Queue Interface

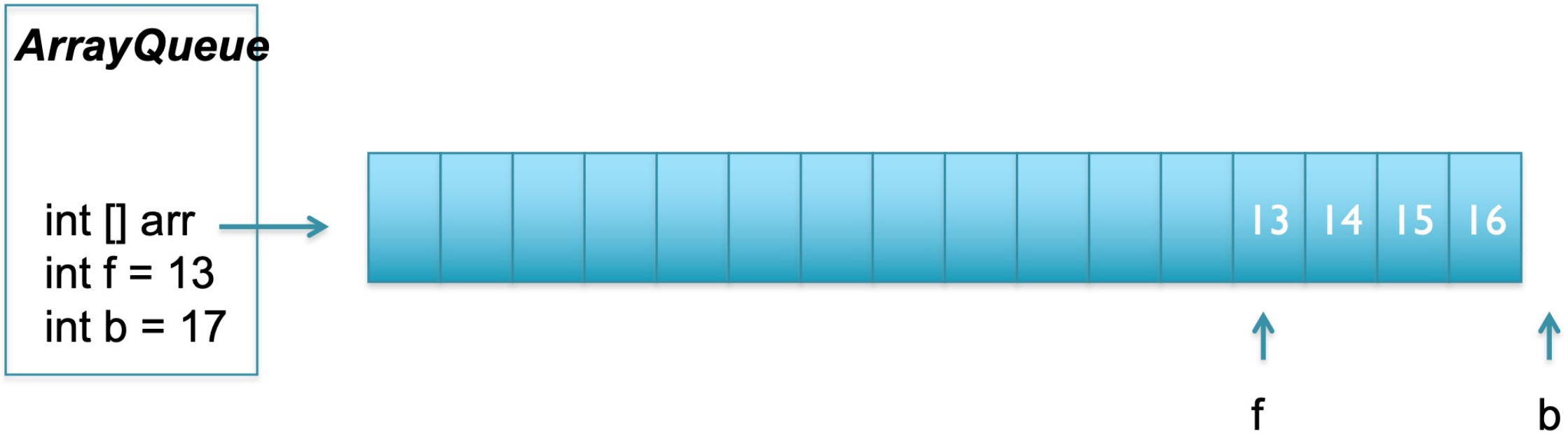
```
public interface Queue<E> {
   int size();
   boolean isEmpty();
   E first();
   void enqueue(E e);
   E dequeue();
```



# ListQueue vs ArrayQueue



# ArrayQueue




What should we do if we insert?

# Comparison to `java.util.Queue`

| **Our Queue ADT** | **Interface java.util.Queue** | |
|---|---|---|
| | throws exceptions | returns special value |
| enqueue($e$) | add($e$) | offer($e$) |
| dequeue( ) | remove( ) | poll( ) |
| first( ) | element( ) | peek( ) |
| size( ) | size( ) | |
| isEmpty( ) | isEmpty( ) | |