CS 106B
Lecture 1: Welcome!

Monday, April 2, 2018

Programming Abstractions
Spring 2018
Stanford University
Computer Science Department

Lecturer: Chris Gregg

Today's Topics

- Instructor Introductions
- What is CS 106B?
  - Goals for the Course
  - Components of CS 106B
  - Assignments, Grading scale, Due dates, Late days, Sections, Getting Help
  - Is CS 106B the right class?
- C++
  - Why C++?
  - QT Creator
  - Our first program
  - Our second program
  - The importance of Data Structures
- Assignments 0 and 1

Chris Gregg

- Career:
- Johns Hopkins University Bachelor's of Science in Electrical and Computer Engineering
- Seven years active duty, U.S. Navy (14+ years reserves)
- Harvard University, Master's of Education
- Seven years teaching high school physics (Brookline, MA and Santa Cruz, CA)
- University of Virginia, Ph.D. in Computer Engineering
- Three years teaching computer science at Tufts University
- Stanford! (arrived, Fall 2016)
- Personal website: http://ecosimulation.com/chrisgregg

CS106B Staff

Head TA: Nick Troccoli

Section Leaders

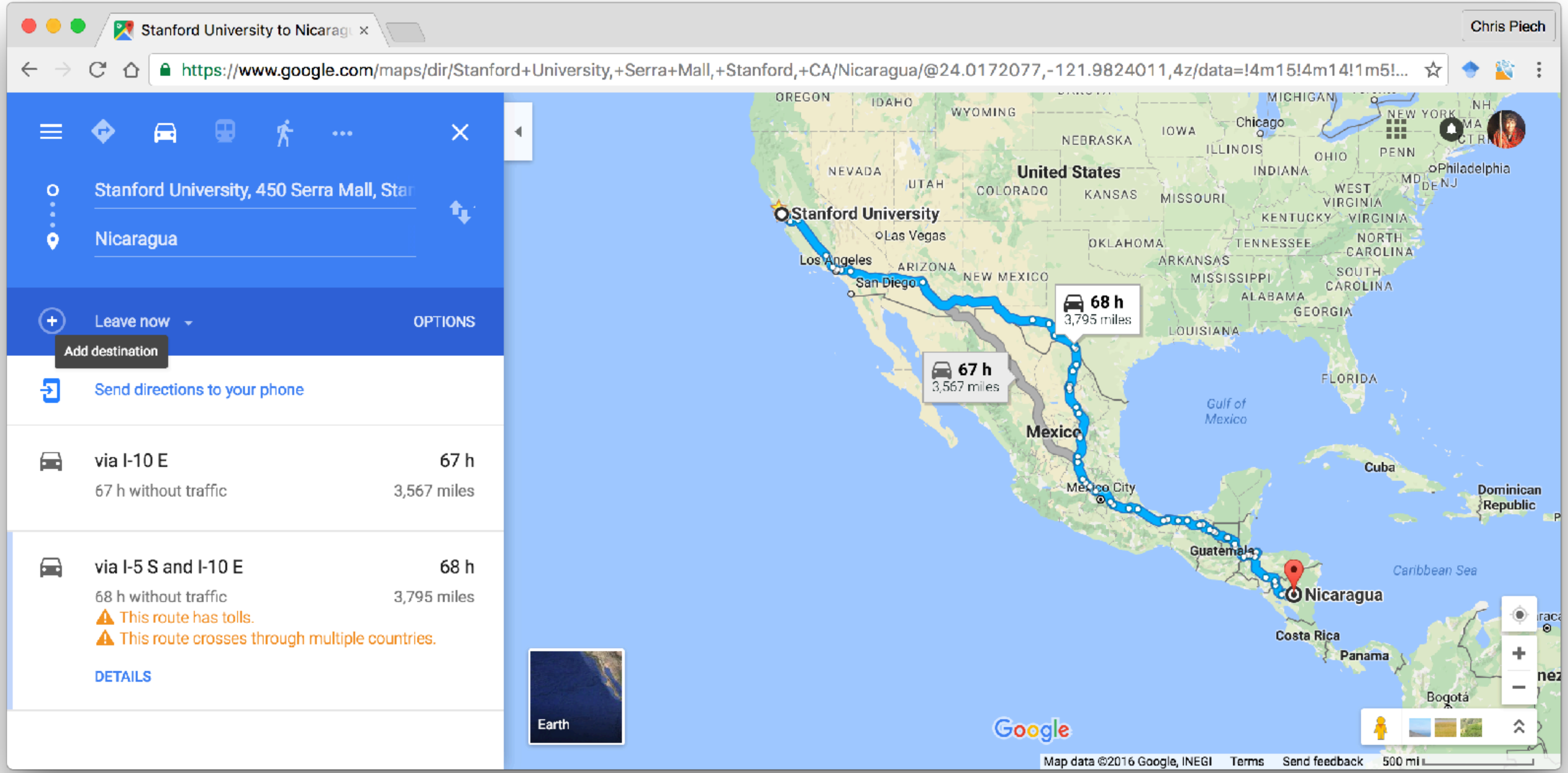
What is CS 106B?

CS106B: Learn core ideas in how to model and solve complex problems with computers

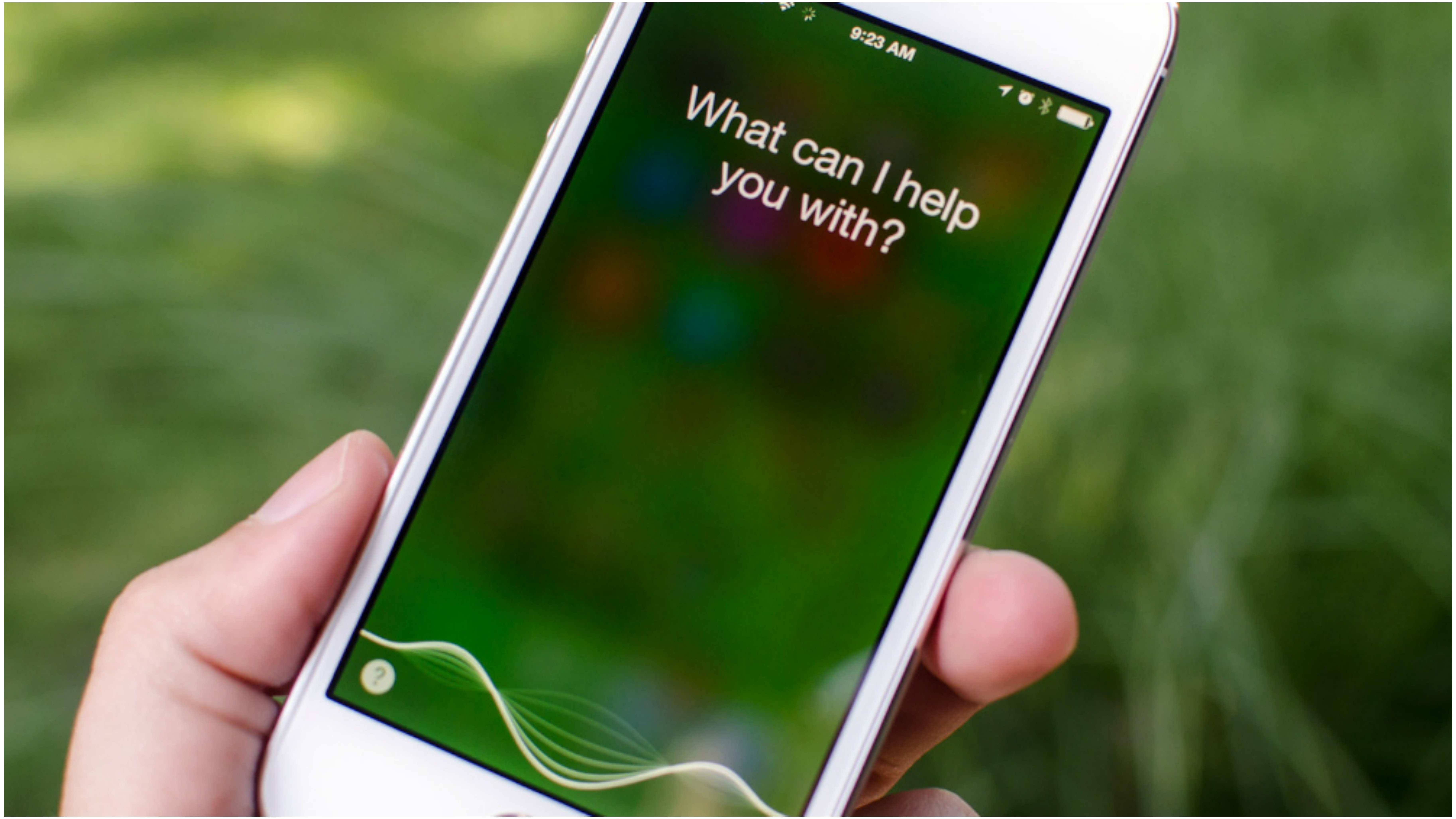
Complex Problems: Self Driving Cars

Stanford's Stanley Self Driving Car, DARPA Grand Challenge, 2006

Complex Problems: Instantaneous Directions

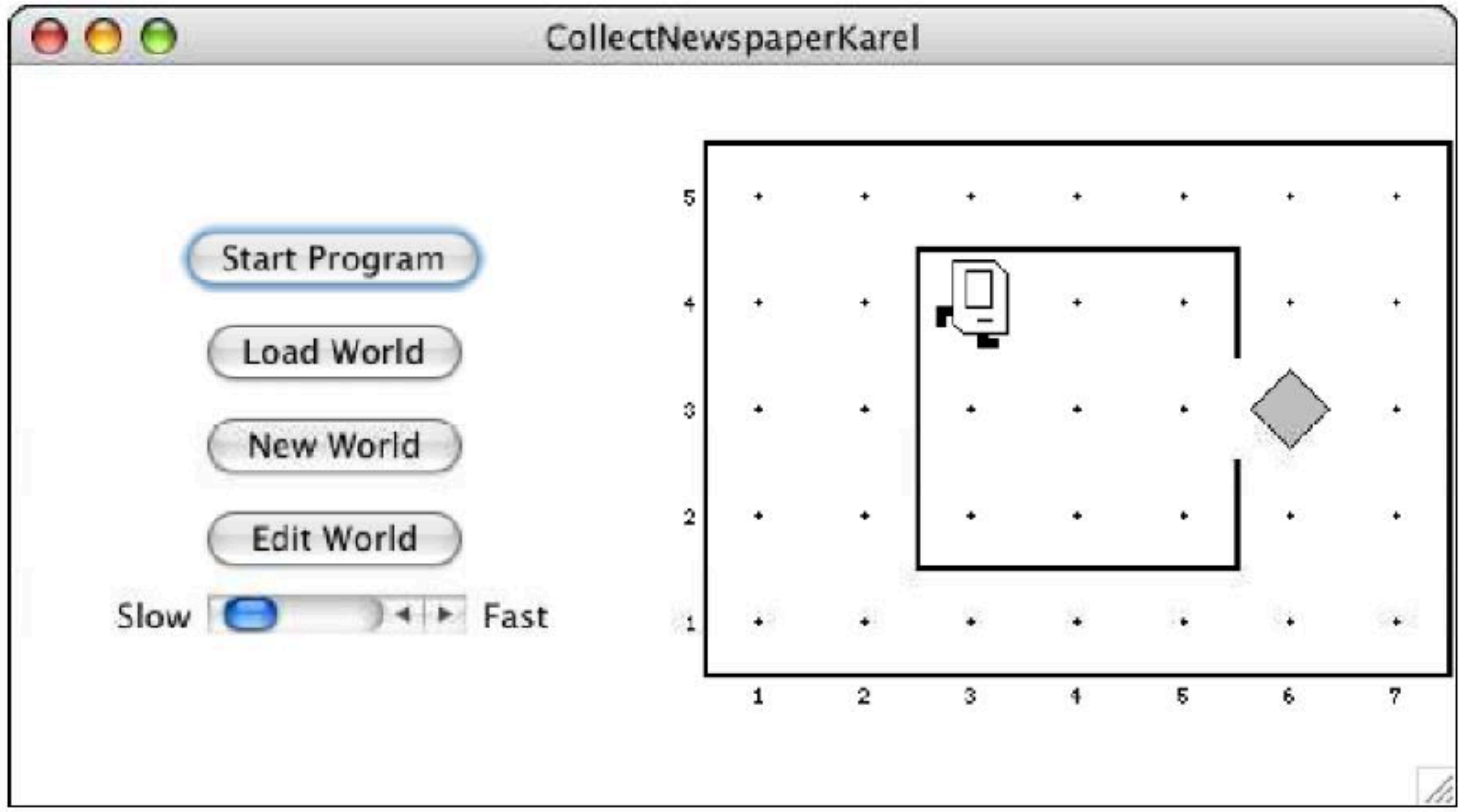


Complex Problems: Speech Recognition



How does Stanford get you there?

CS106A



In CS106A (or CS 106AJ or CS 106AP) is a first course in programming, software development

There is more to learn…

Full disclosure, CS106B is necessary but not sufficient to make a self driving car ☺️

Goals for CS 106B

Learn core ideas in how to model and solve complex problems with computers.

To that end:

Explore common abstractions

Harness the power of recursion

Learn and analyze efficient algorithms

Goals for CS 106B

Learn core ideas in how to model and solve complex problems with computers.

To that end:

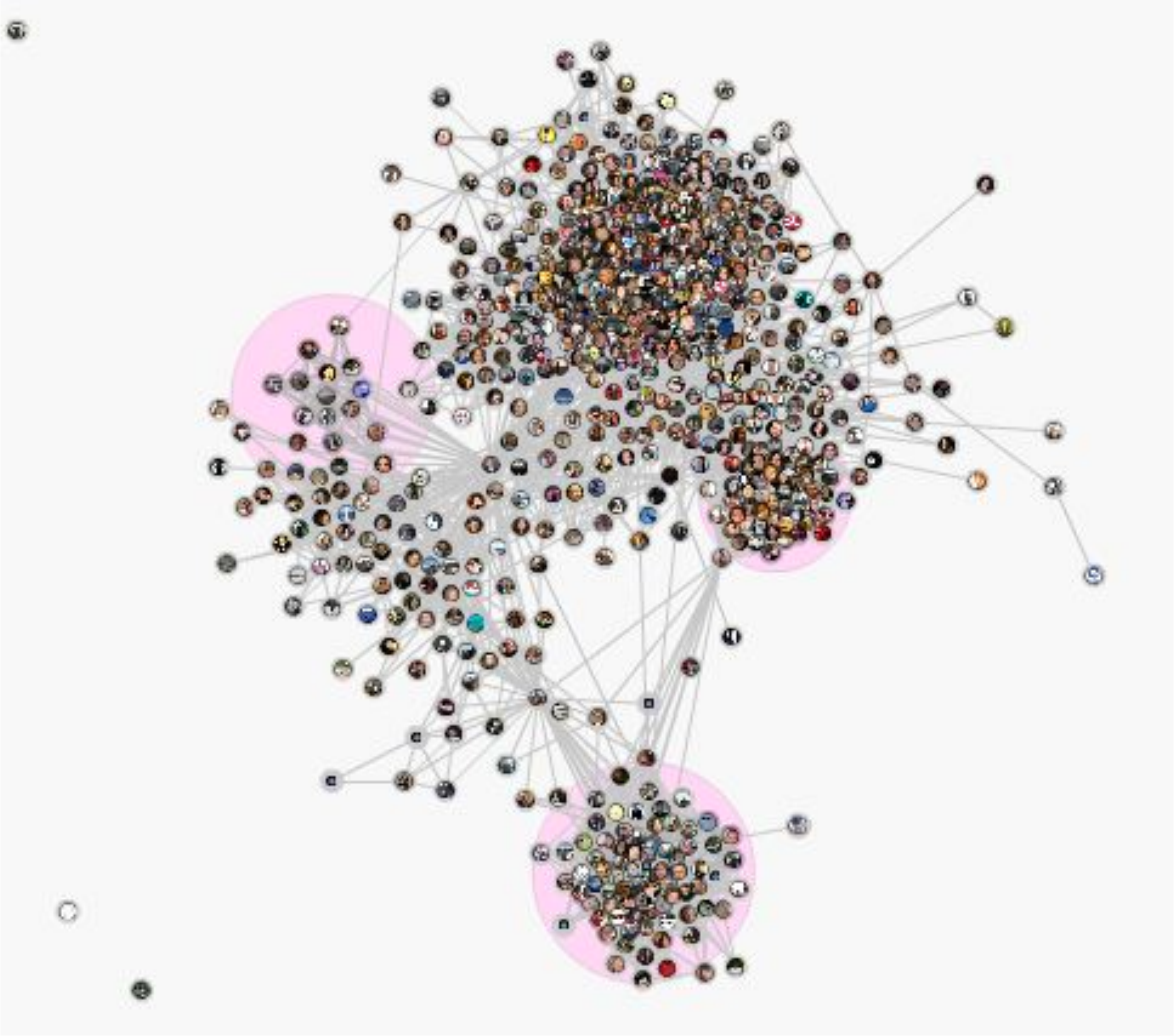
Explore common abstractions

Harness the power of recursion

Learn and analyze efficient algorithms

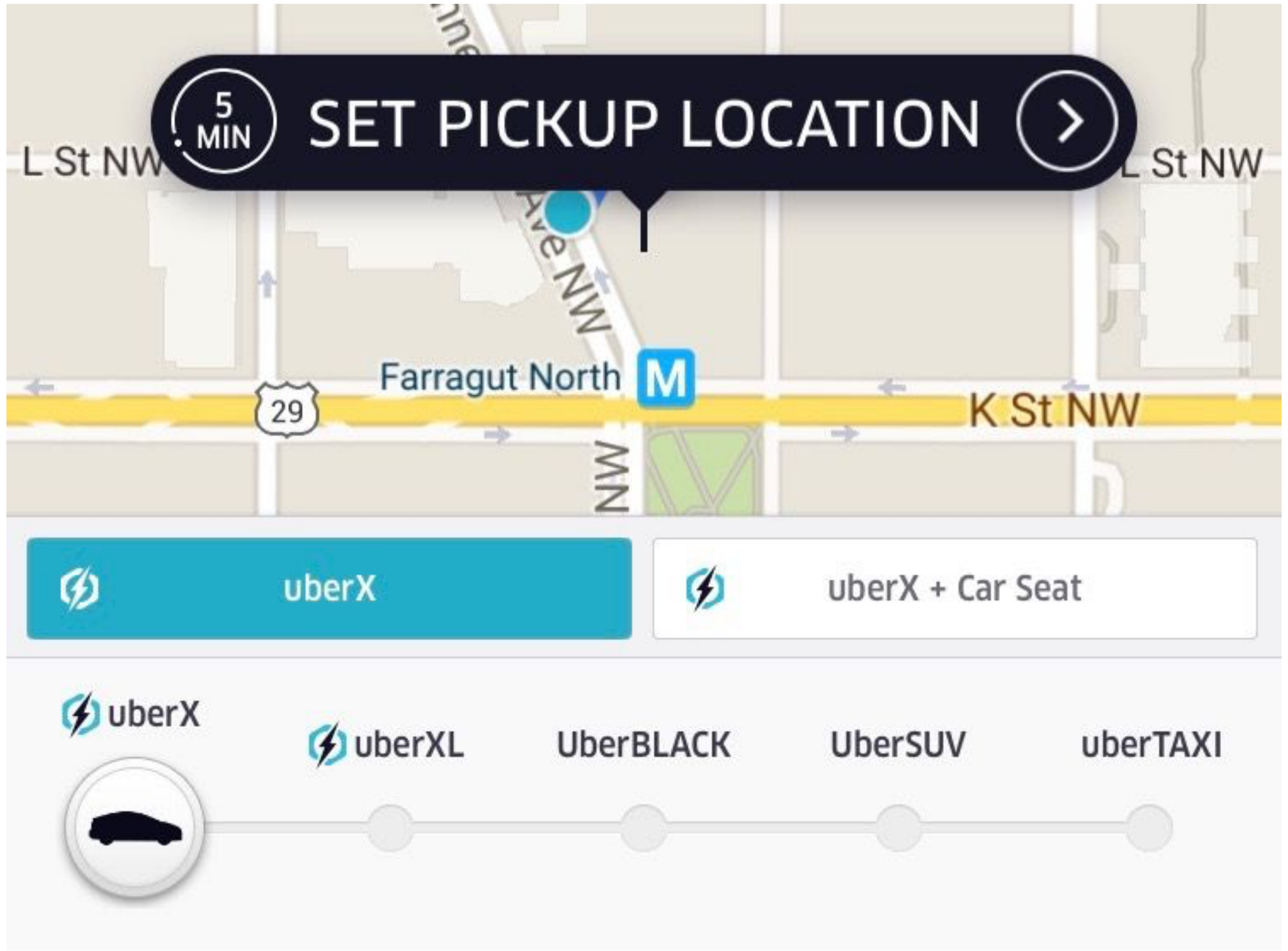
Common Abstractions

- What is the average friend distance between two random Facebook users?



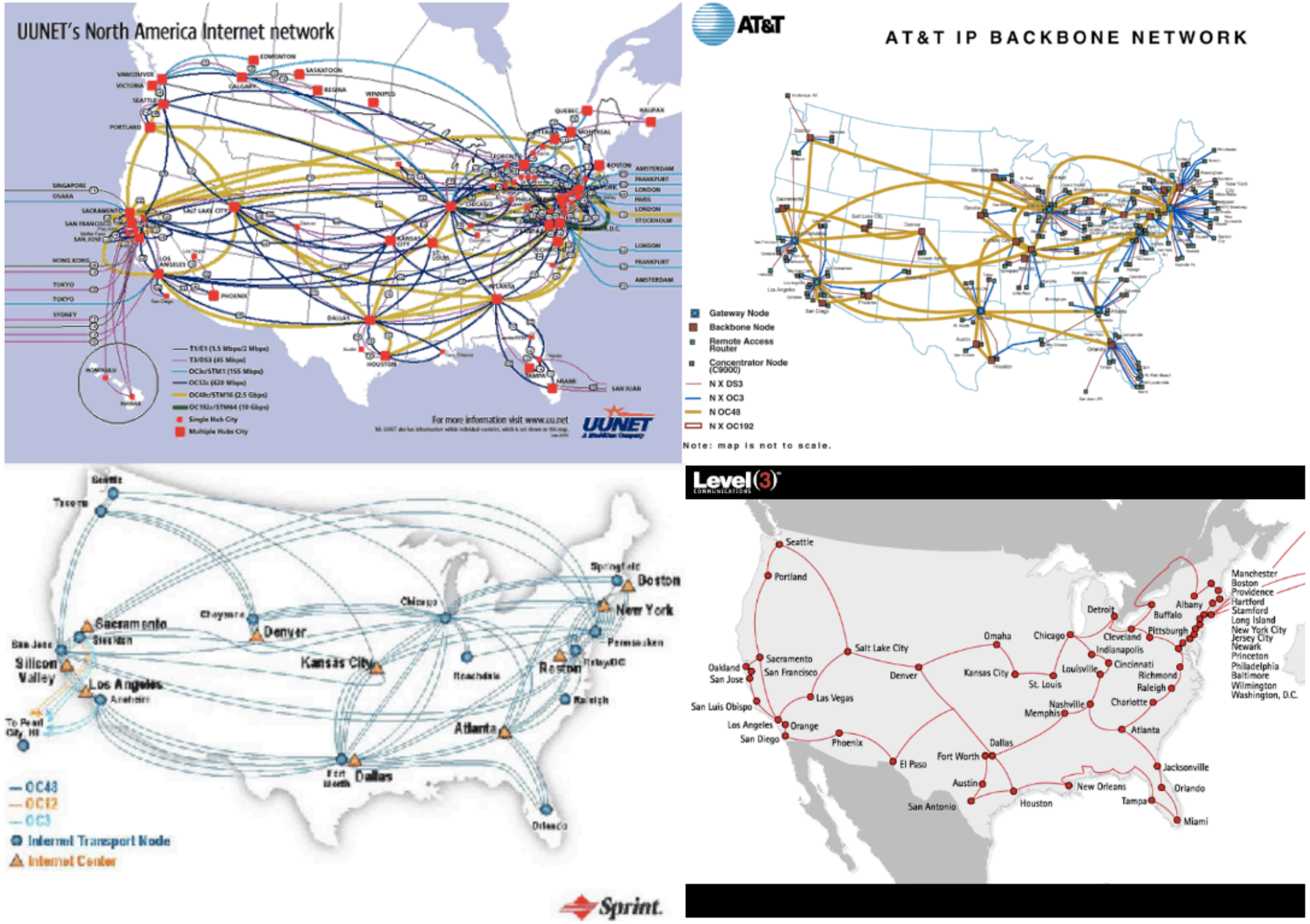
Common Abstractions

- How should Uber direct drivers in San Francisco at 5pm on a Tuesday, when there are *x* number of people who want a ride, and *y* number of drivers?



Common Abstractions

- How does email get from Dallas, Texas to Miami, Florida?



Common Abstractions

- What is the average friend distance between two random Facebook users?
- How should Uber direct drivers in San Francisco at 5pm on a Tuesday, when there are *x* number of people who want a ride, and *y* number of drivers?
- How does email get from Dallas, Tx to Miami, FL?

- These are all solved with the same abstraction! (using a "graph," which we will learn about near the end of the course)
- By learning common abstractions, we can use those abstractions to solve many problems.
- See the course website to see the list of topics we will cover.

Goals for CS 106B

Learn core ideas in how to model and solve complex problems with computers.

To that end:

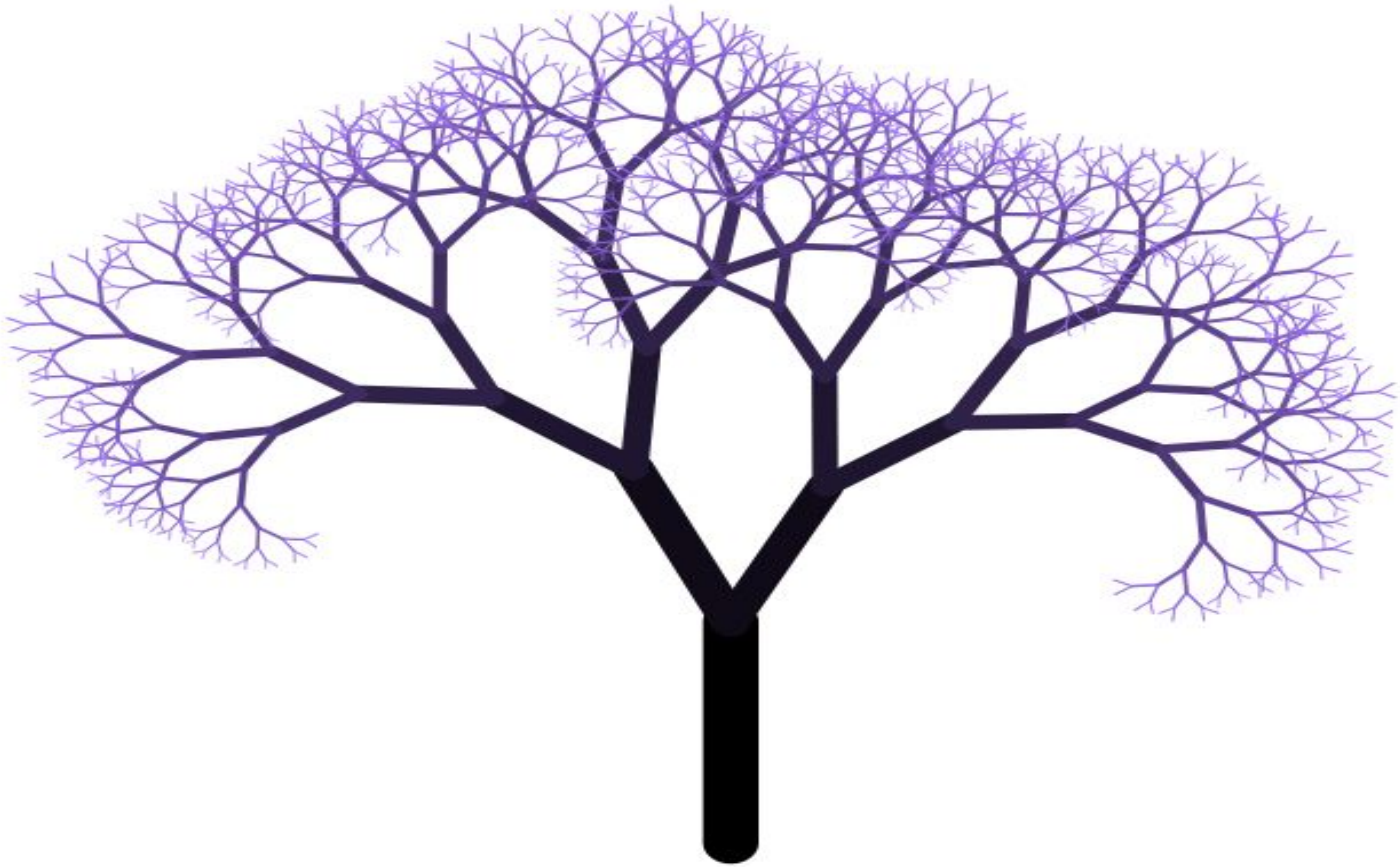
Explore common abstractions

Harness the power of recursion

Learn and analyze efficient algorithms

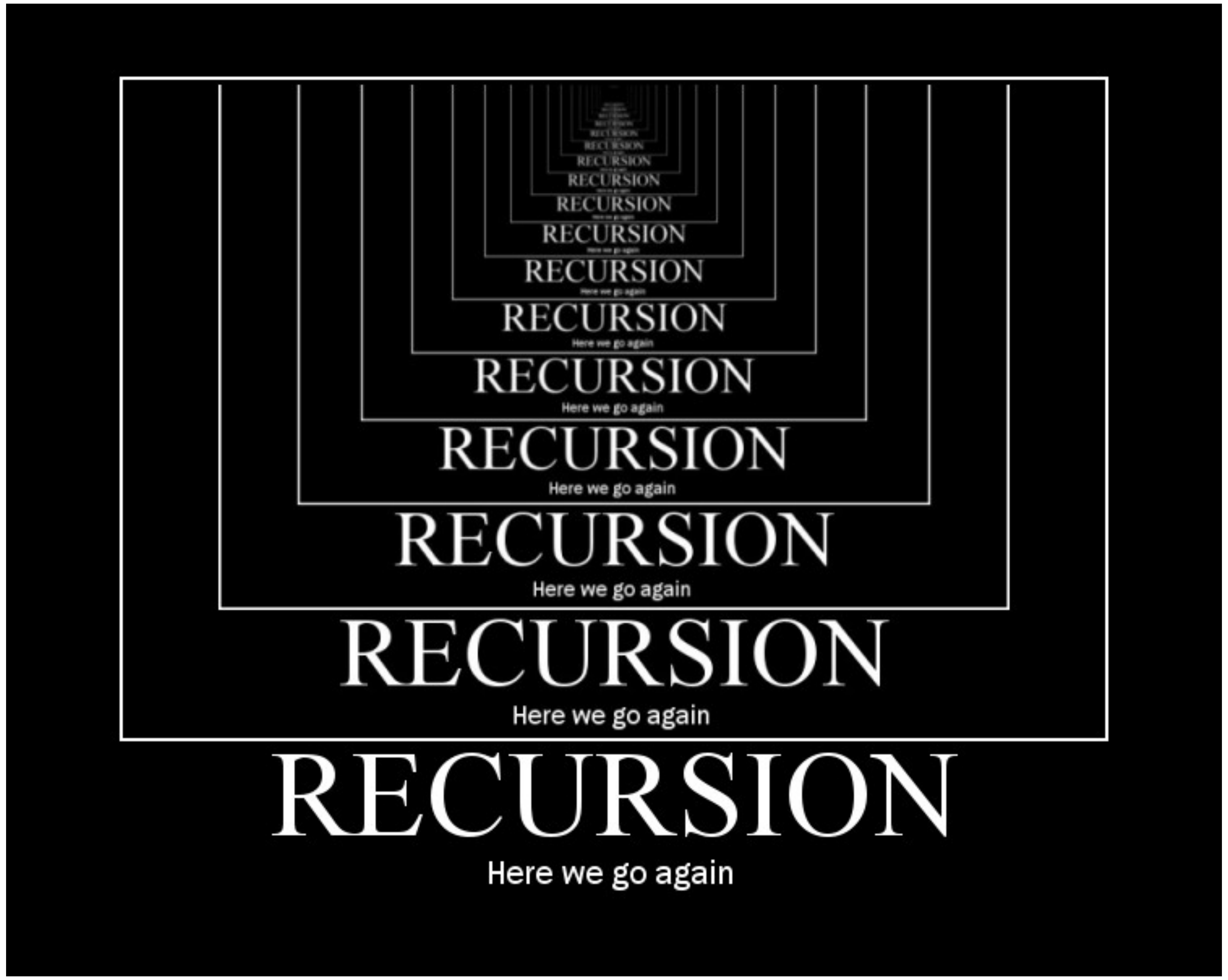
Recursion

In order to understand recursion, you must understand recursion.



Recursion

Recursion is a powerful tool that we will learn — once you start "thinking recursively", you will be able to solve many problems that would be extremely hard to solve without it.



Goals for CS 106B

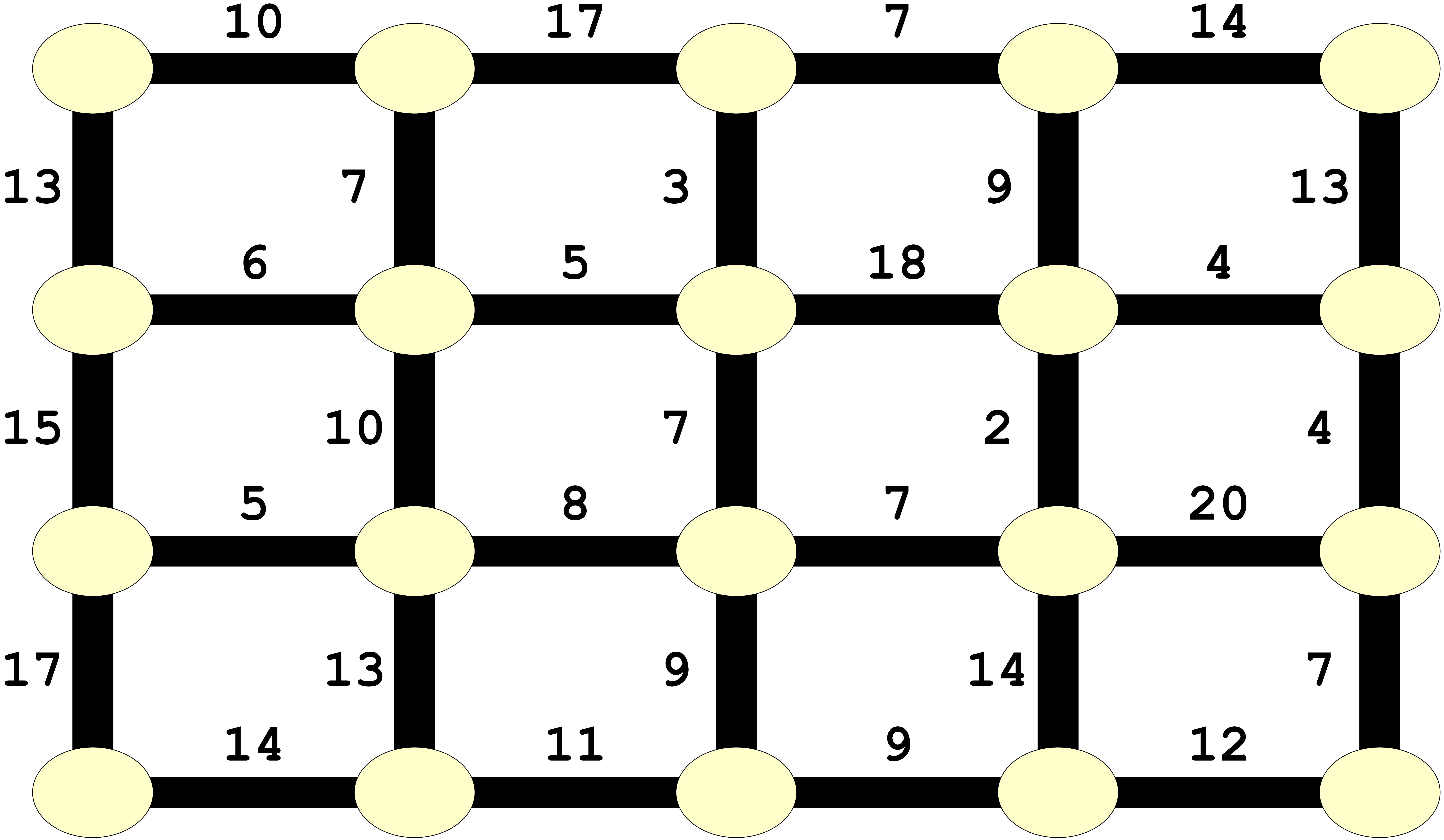
Learn core ideas in how to model and solve complex problems with computers.

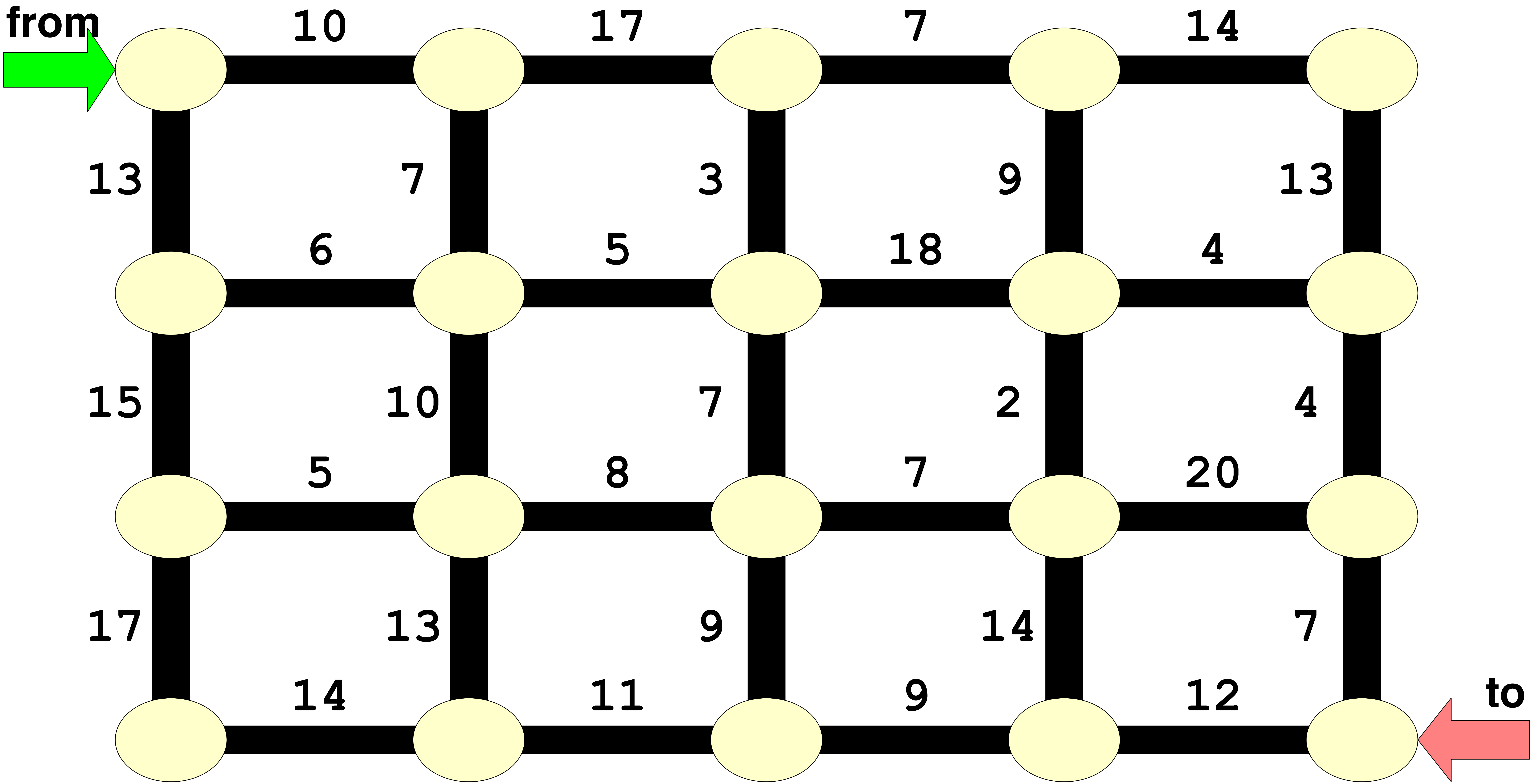
To that end:

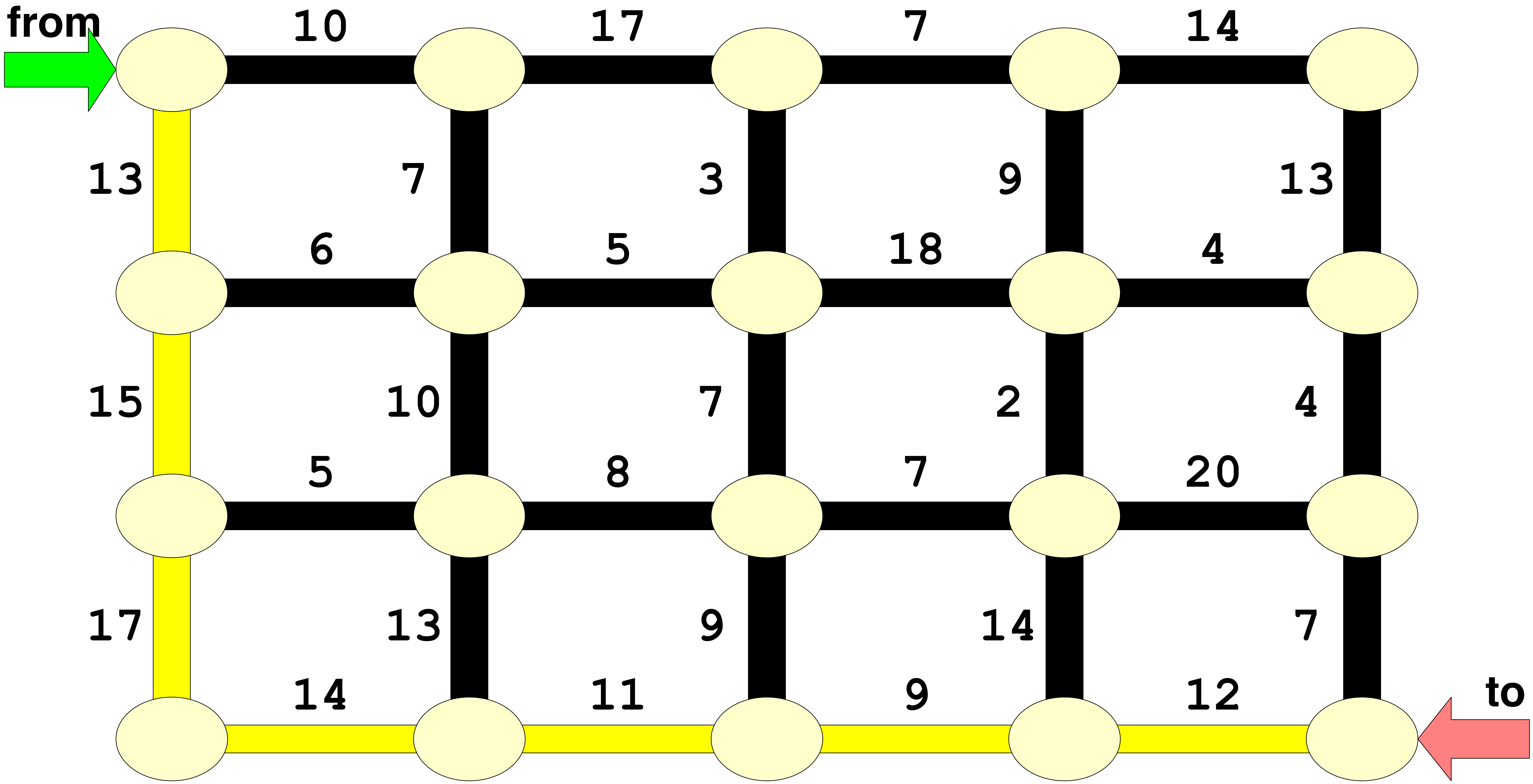
Explore common abstractions

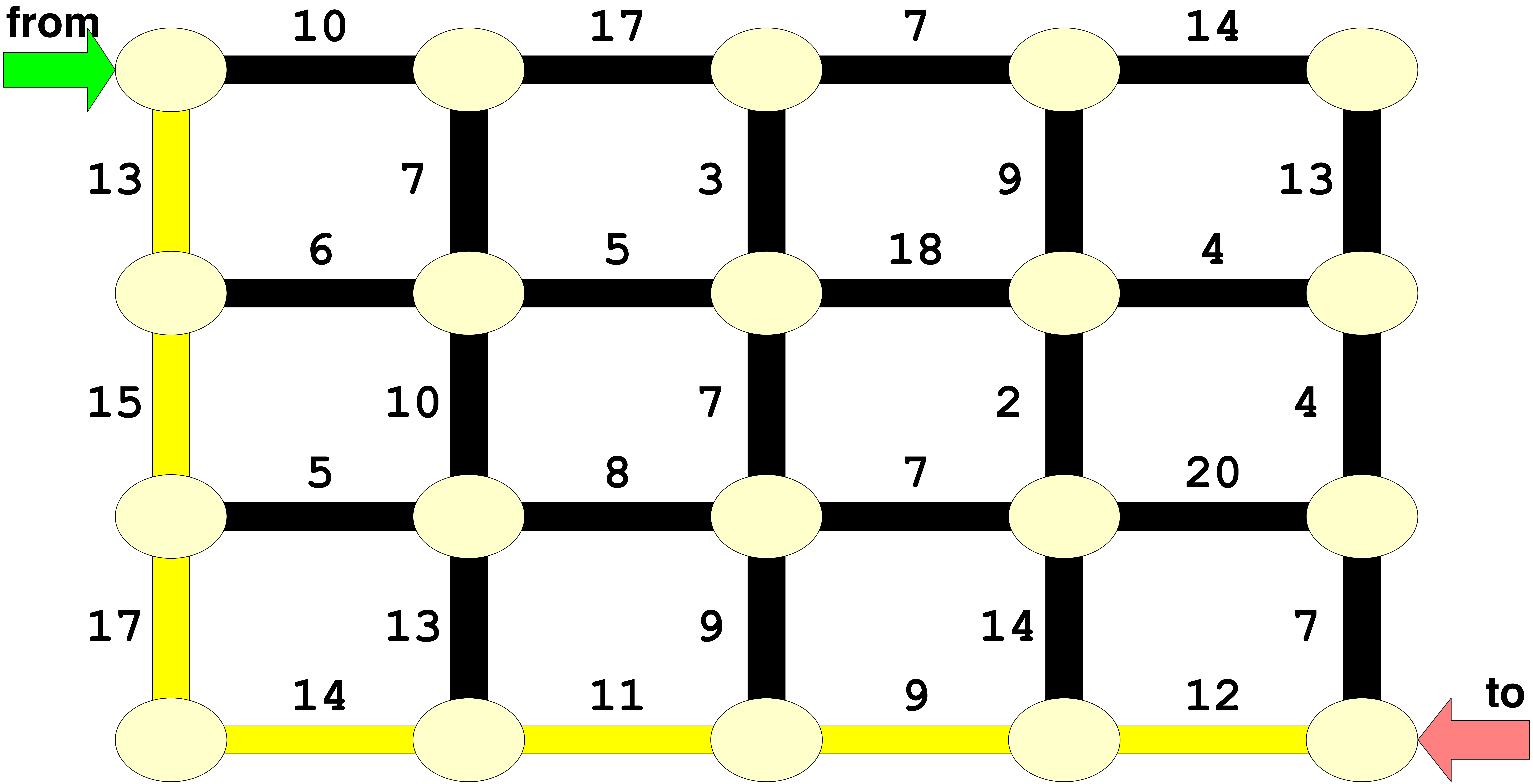
Harness the power of recursion

Learn and analyze efficient algorithms

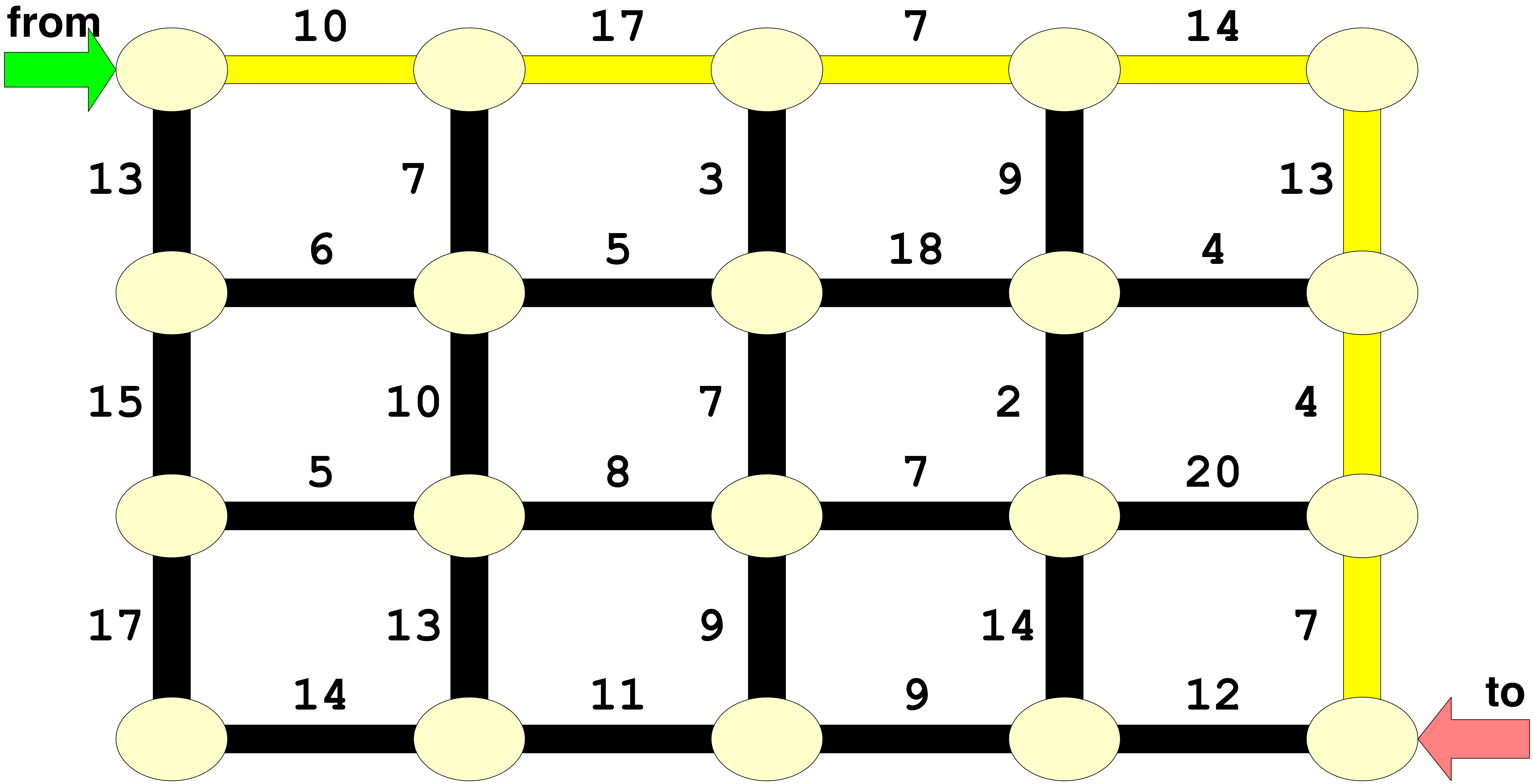

10
17
7
14
13
7
3
9
13
6
5
18
4
15
10
7
2
4
5
8
7
20
17
13
9
14
7
14
11
9
12

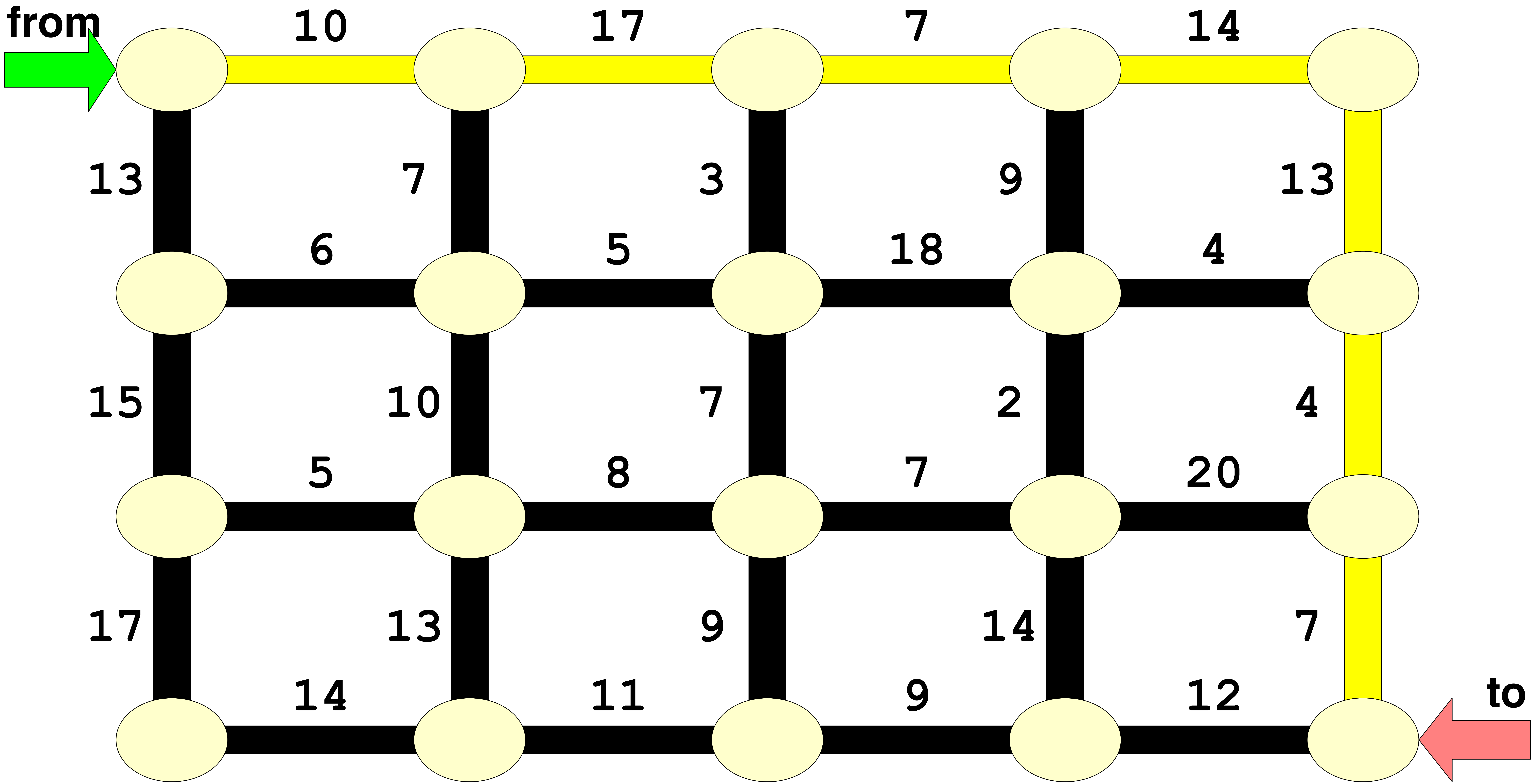

from
10
17
7
14
13
7
3
9
13
6
5
18
4
15
10
7
2
4
5
8
7
20
17
13
9
14
7
14
11
9
12
to


from
10
17
7
14
13
7
3
9
13
6
5
18
4
15
10
7
2
4
5
8
7
20
17
13
9
14
7
14
11
9
12
to

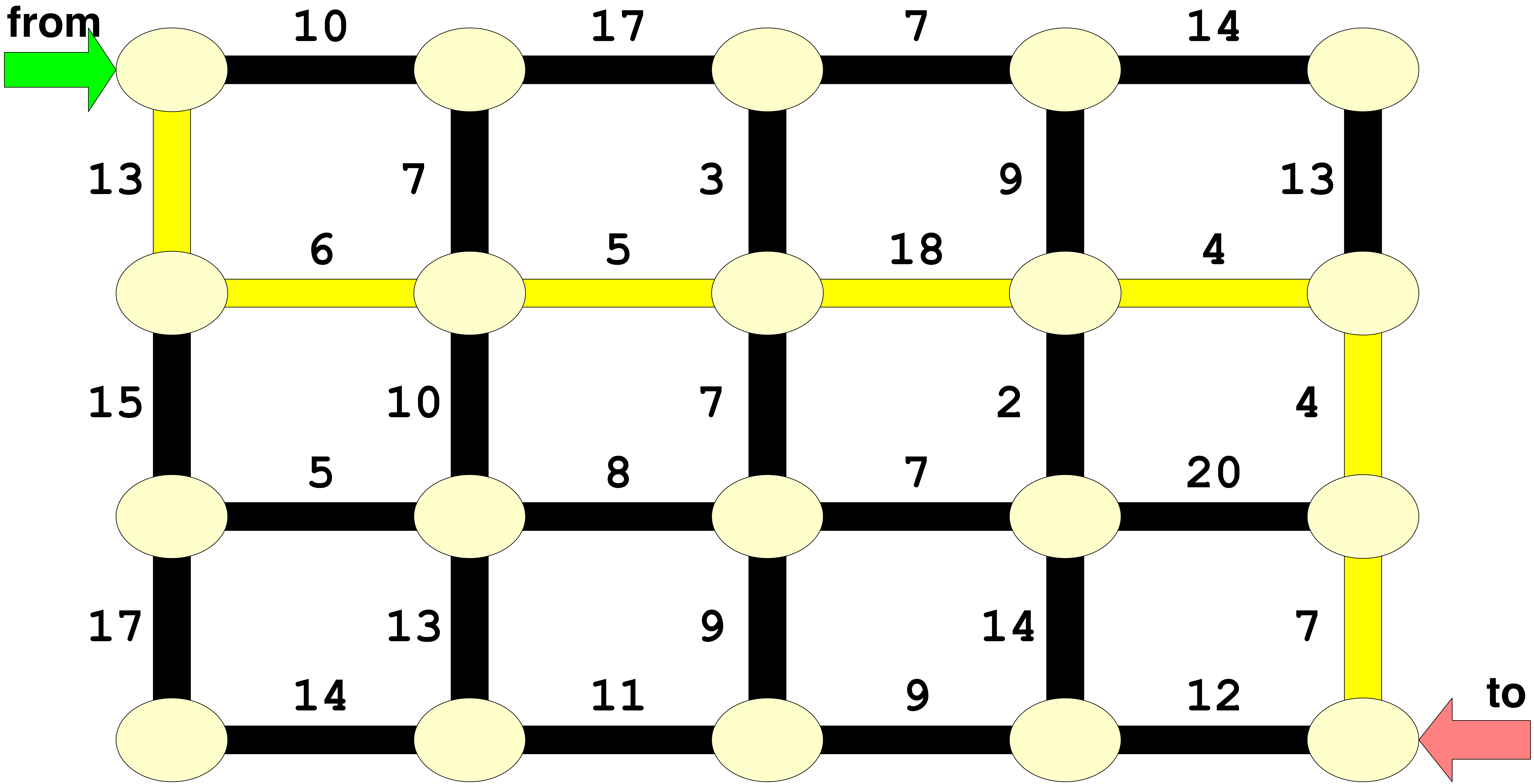


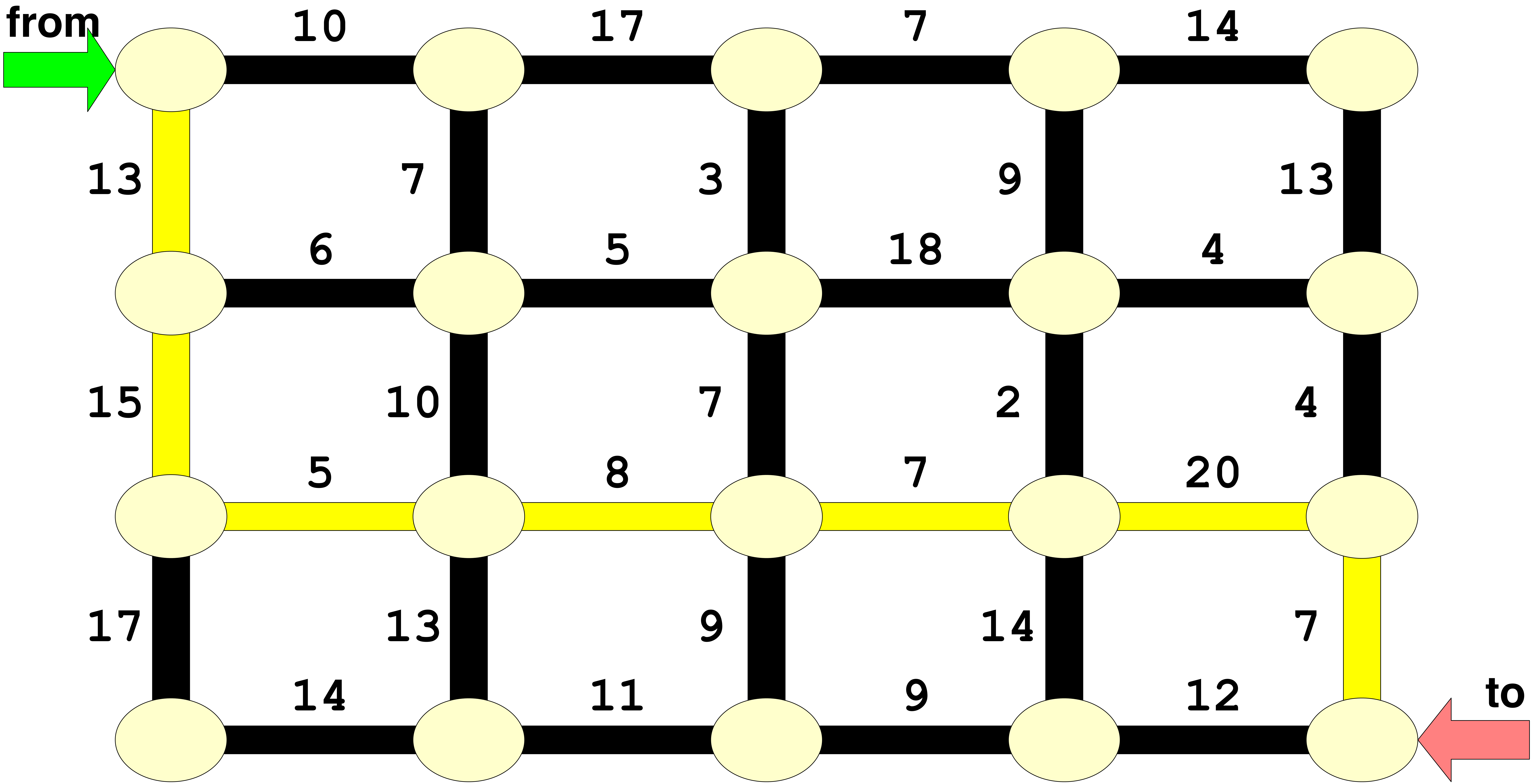
Travel Time: 13 + 15 + 17 + 14 + 11 + 9 + 12 = **91**

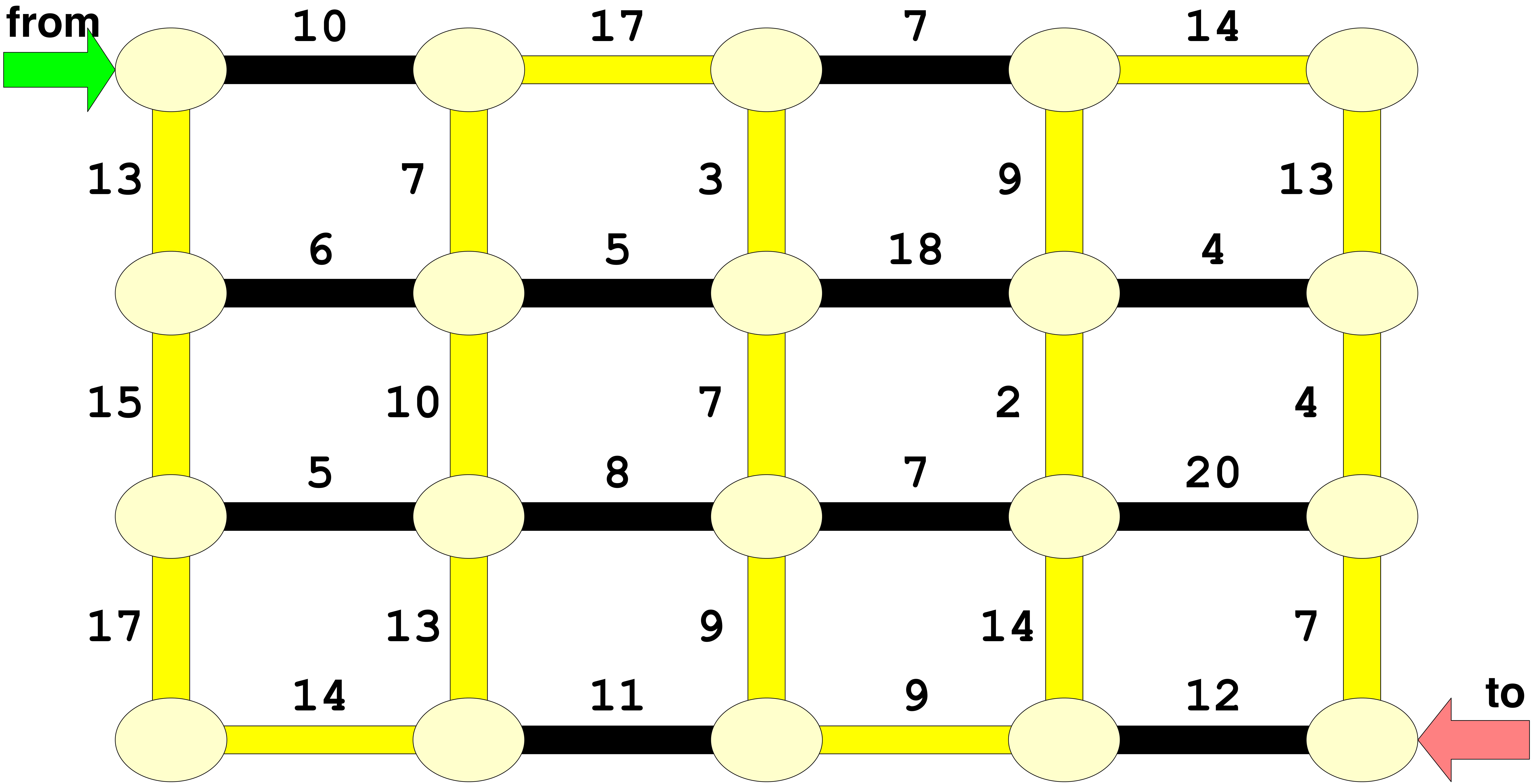

from
10
17
7
14
13
7
3
9
13
6
5
18
4
15
10
7
2
4
5
8
7
20
17
13
9
14
7
14
11
9
12
to

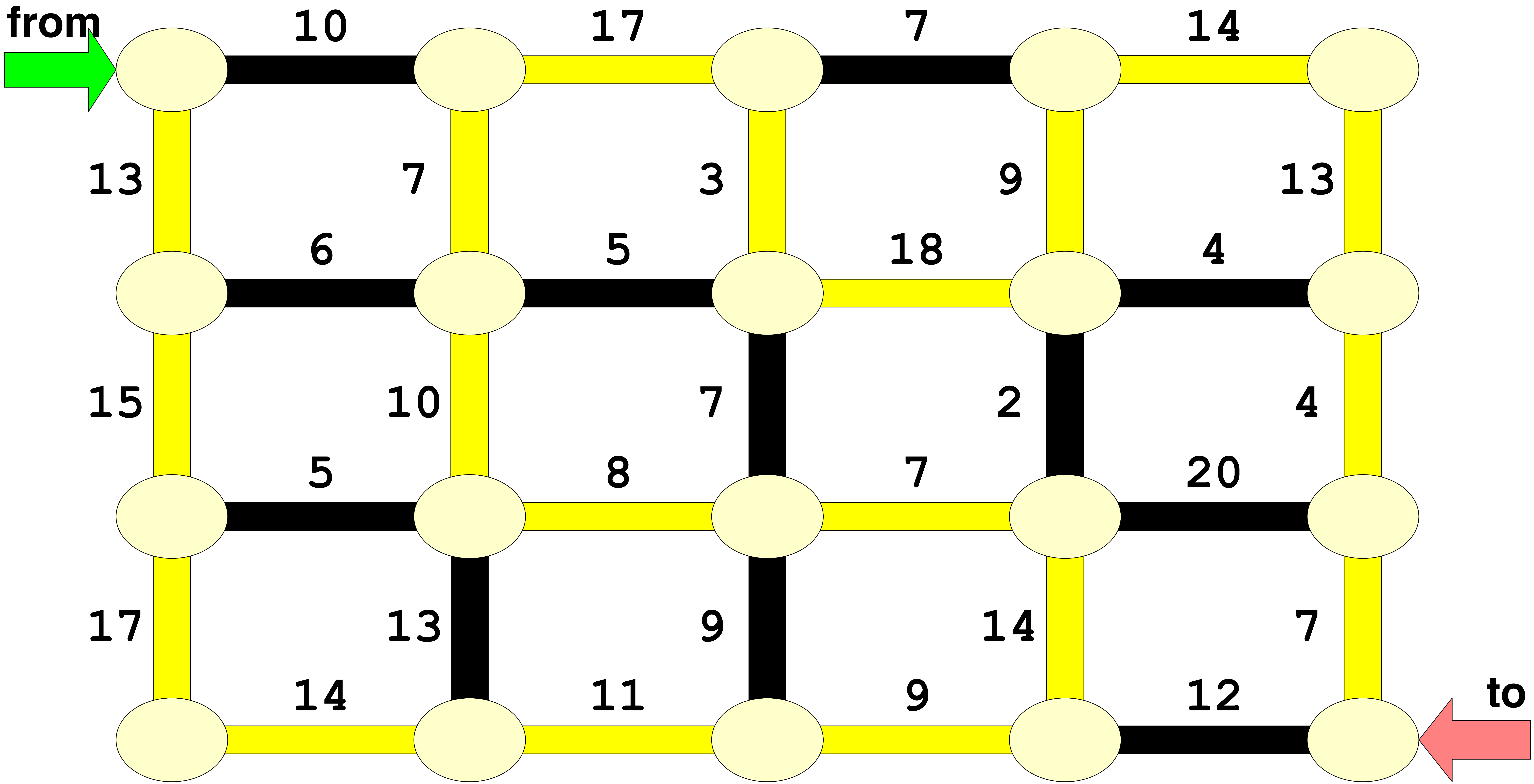


Travel Time: 10 + 17 + 7 + 14 + 13 + 4 + 7 = **72**

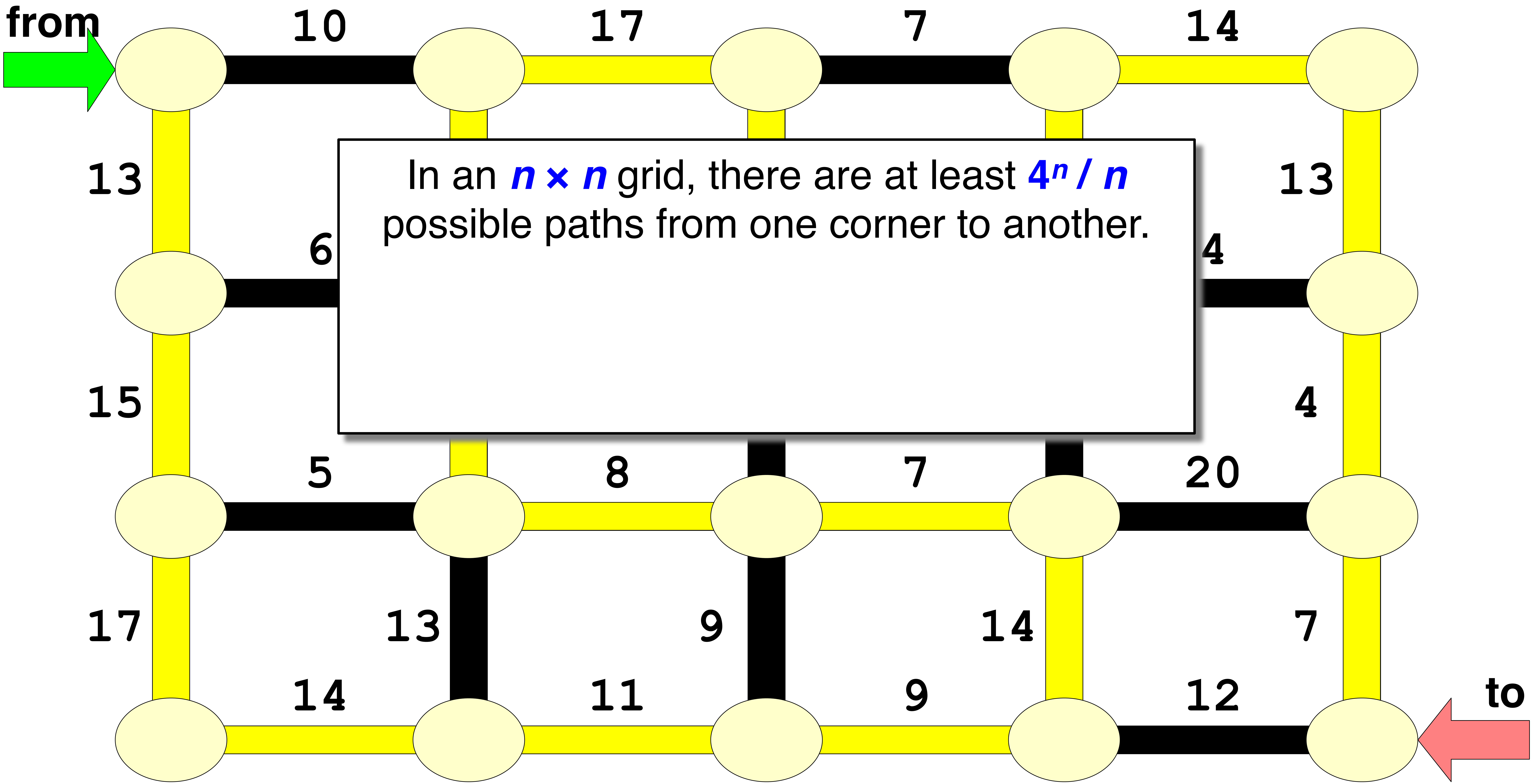

from
10
17
7
14
13
7
3
9
13
6
5
18
4
15
10
7
2
4
5
8
7
20
17
13
9
14
7
14
11
9
12
to


from
10
17
7
14
13
7
3
9
13
6
5
18
4
15
10
7
2
4
5
8
7
20
17
13
9
14
7
14
11
9
12
to

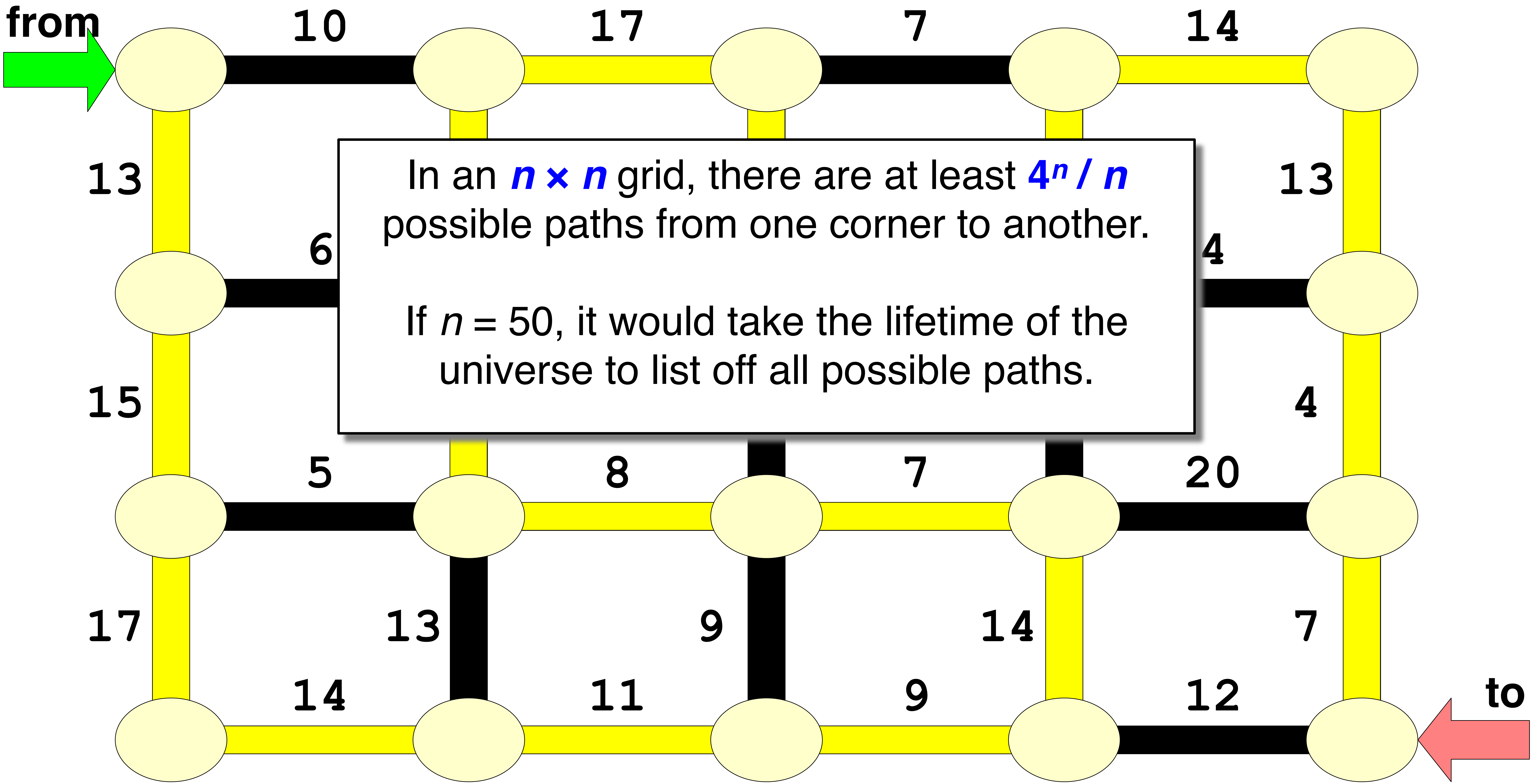

from
10
17
7
14
13
7
3
9
13
6
5
18
4
15
10
7
2
4
5
8
7
20
17
13
9
14
7
14
11
9
12
to



from
to
10
17
7
14
13
7
3
9
13
6
5
18
4
15
10
7
2
4
5
8
7
20
17
13
9
14
7
14
11
9
12

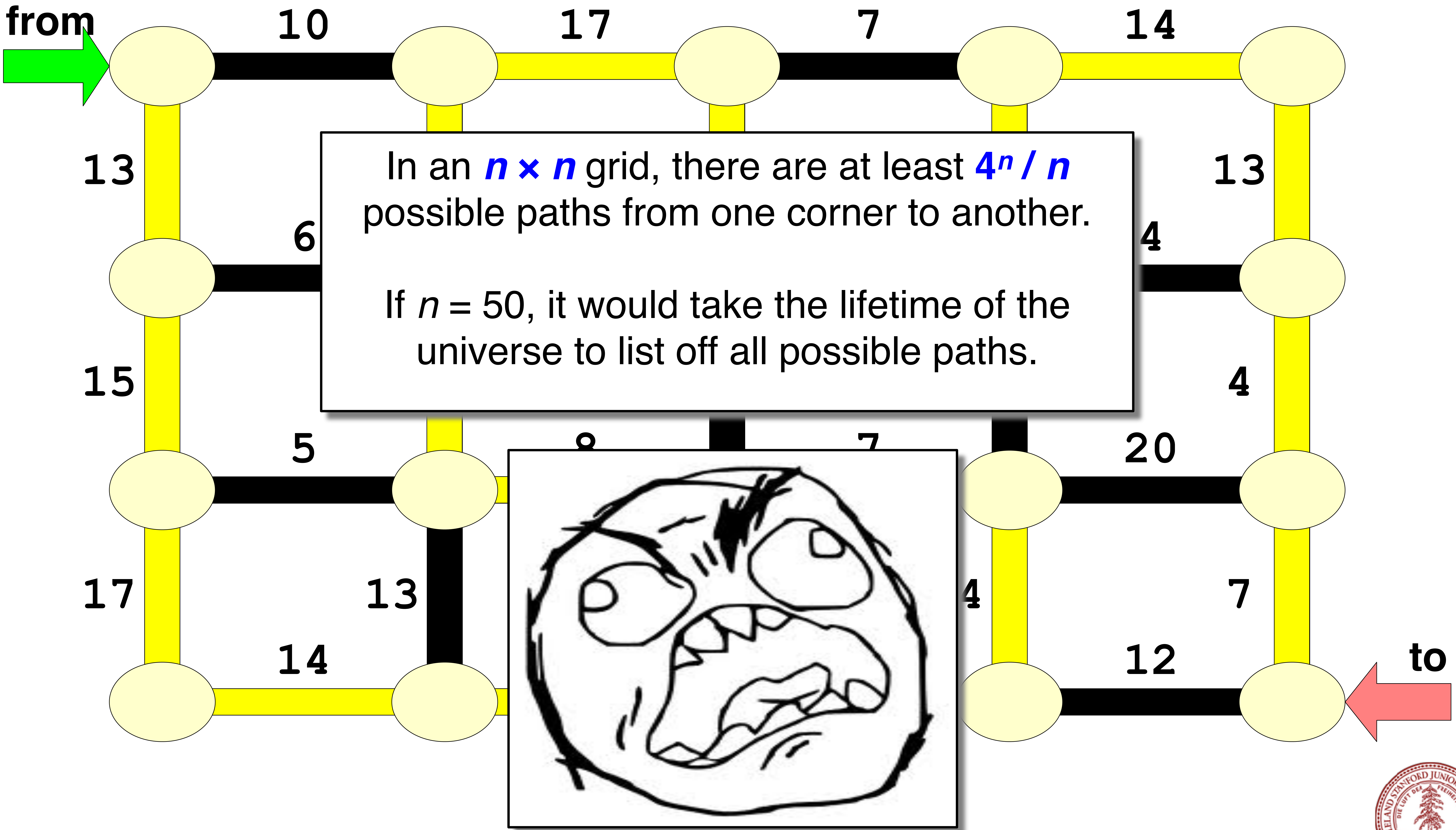


In an $n \times n$ grid, there are at least $4^n / n$ possible paths from one corner to another.



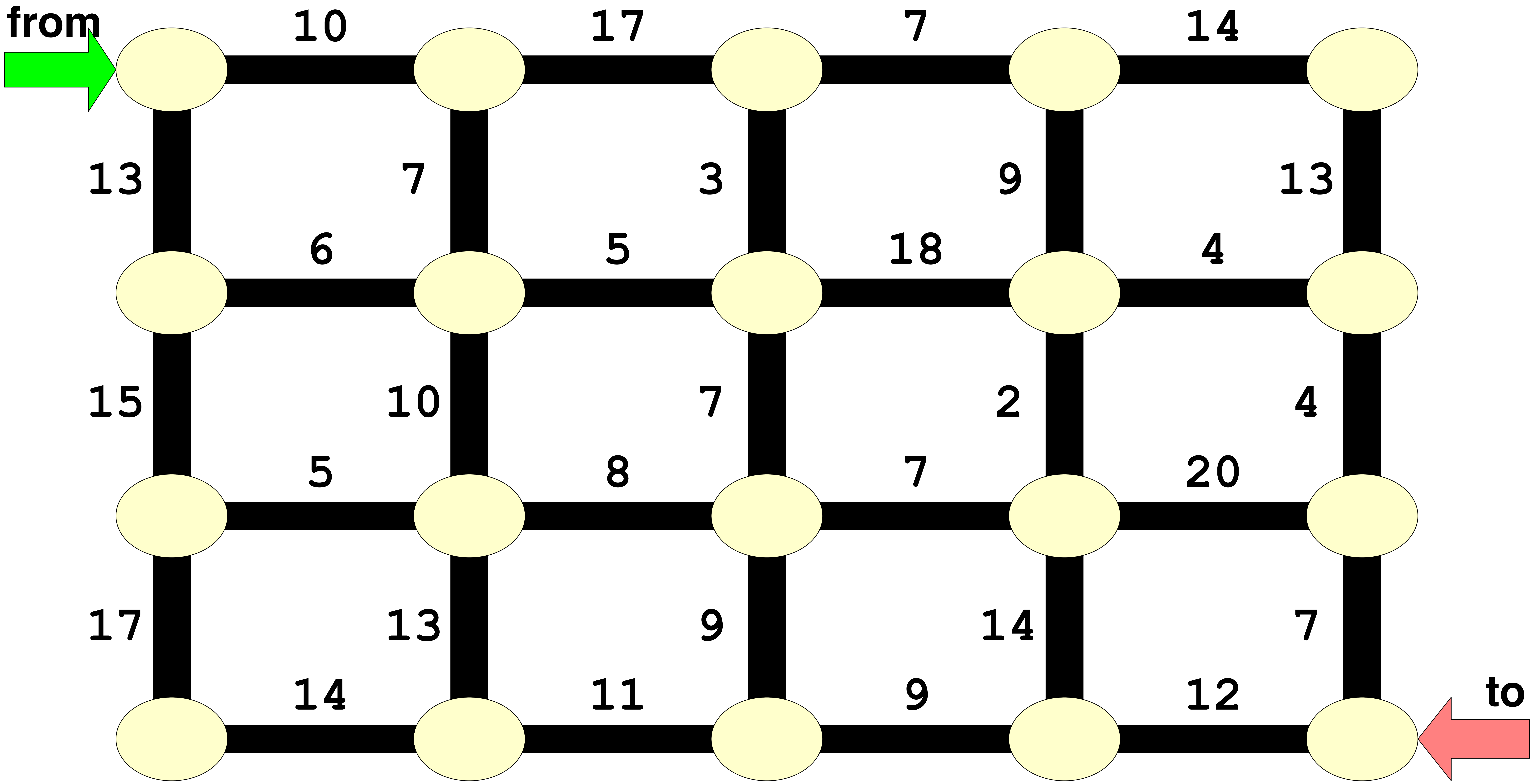
In an $n \times n$ grid, there are at least $4^n / n$ possible paths from one corner to another.

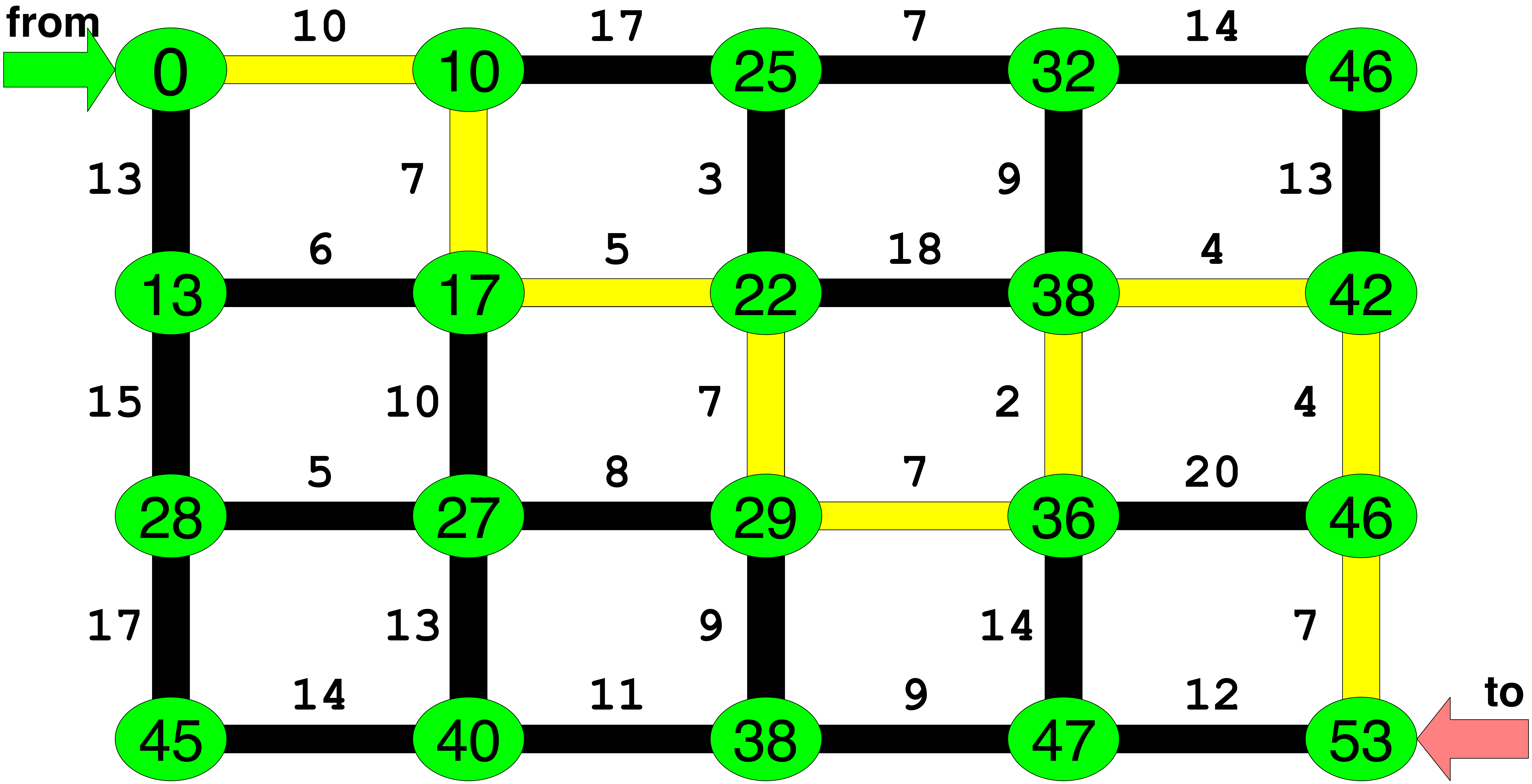
If $n = 50$, it would take the lifetime of the universe to list off all possible paths.

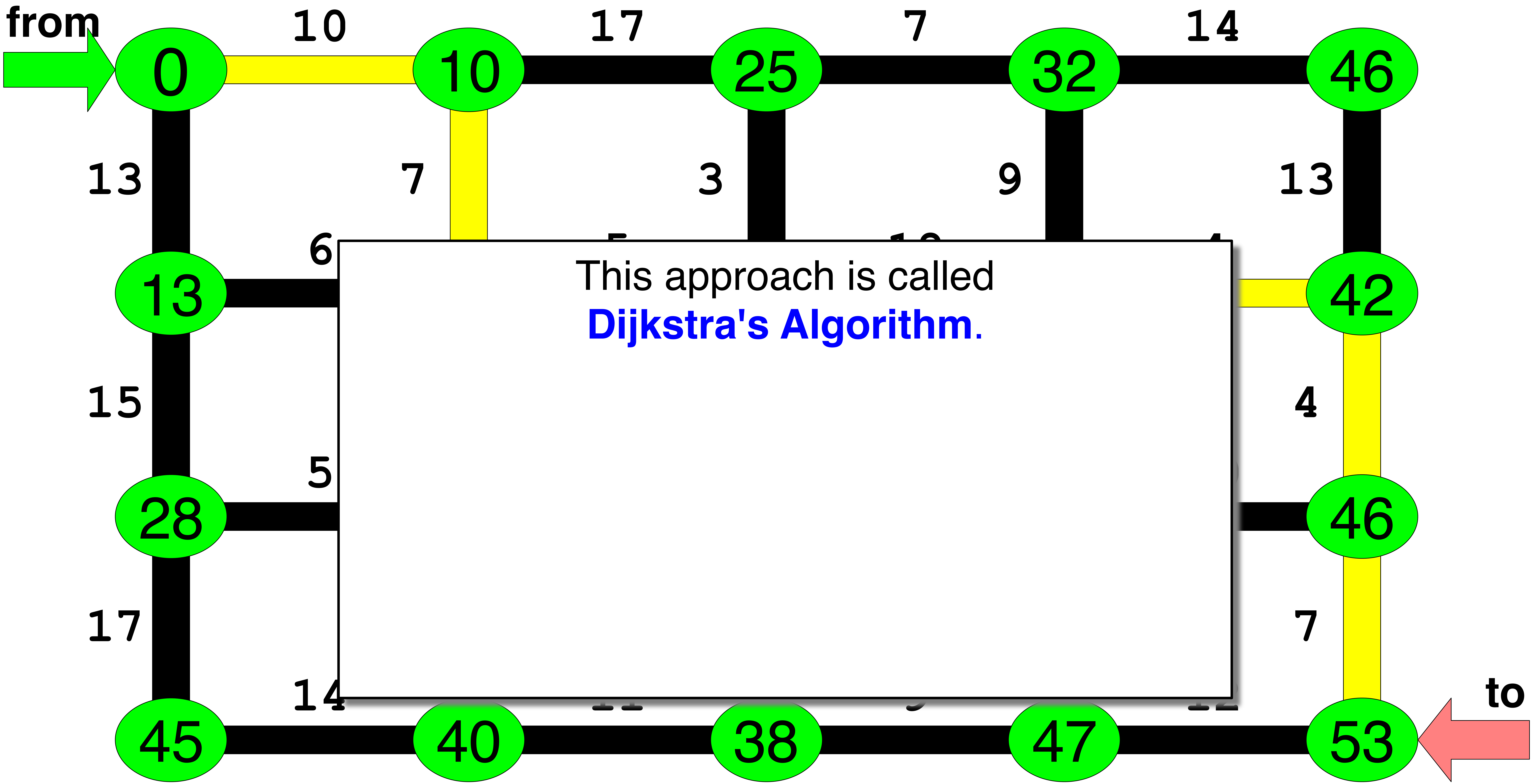


In an $n \times n$ grid, there are at least $4^n / n$ possible paths from one corner to another.

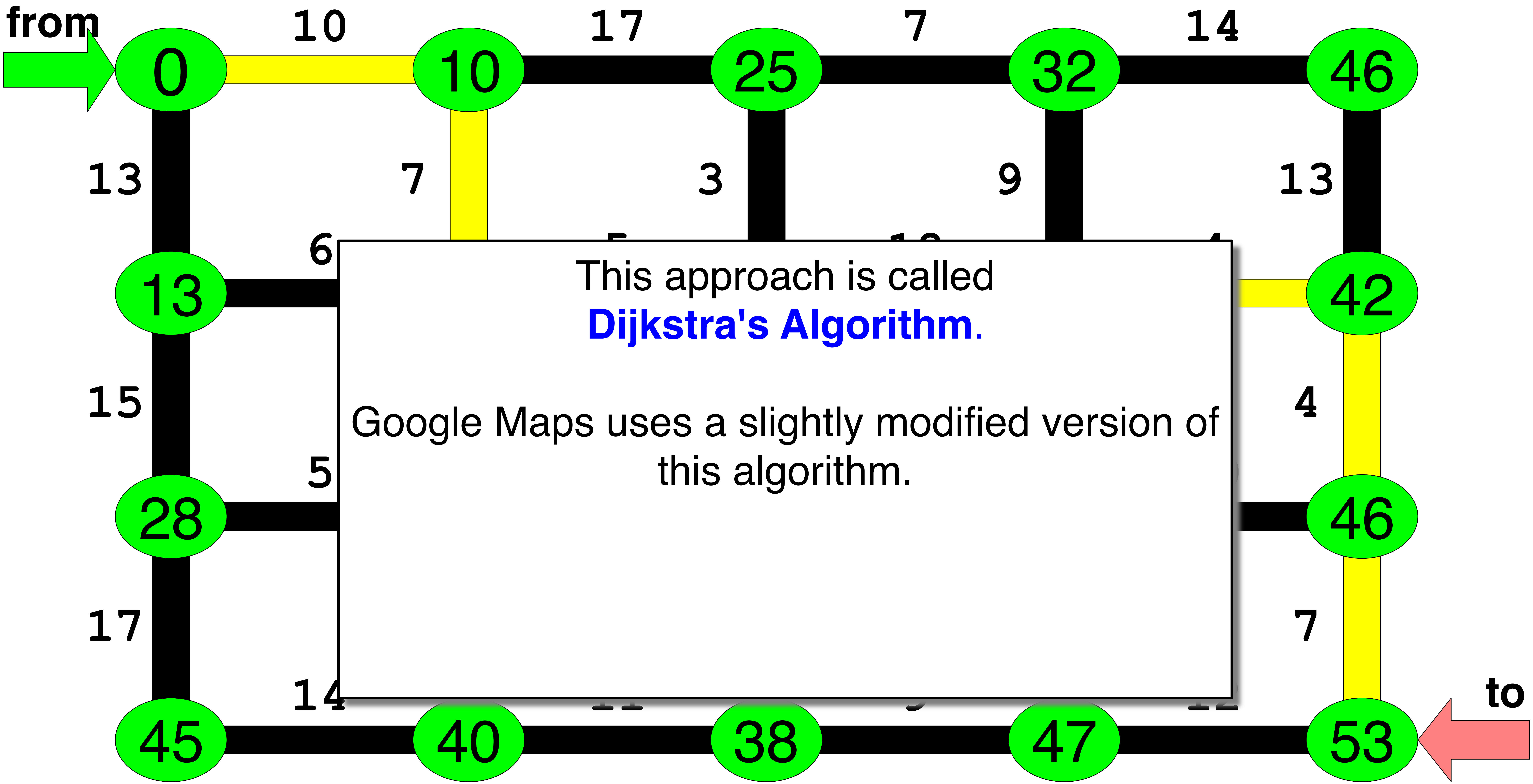
If $n = 50$, it would take the lifetime of the universe to list off all possible paths.


from
10
17
7
14
13
7
3
9
13
6
5
18
4
15
10
7
2
4
5
8
7
20
17
13
9
14
7
14
11
9
12
to


from
10
17
7
14
0
10
25
32
46
13
7
3
9
13
6
5
18
4
13
17
22
38
42
15
10
7
2
4
5
8
7
20
28
27
29
36
46
17
13
9
14
7
14
11
9
12
to
45
40
38
47
53

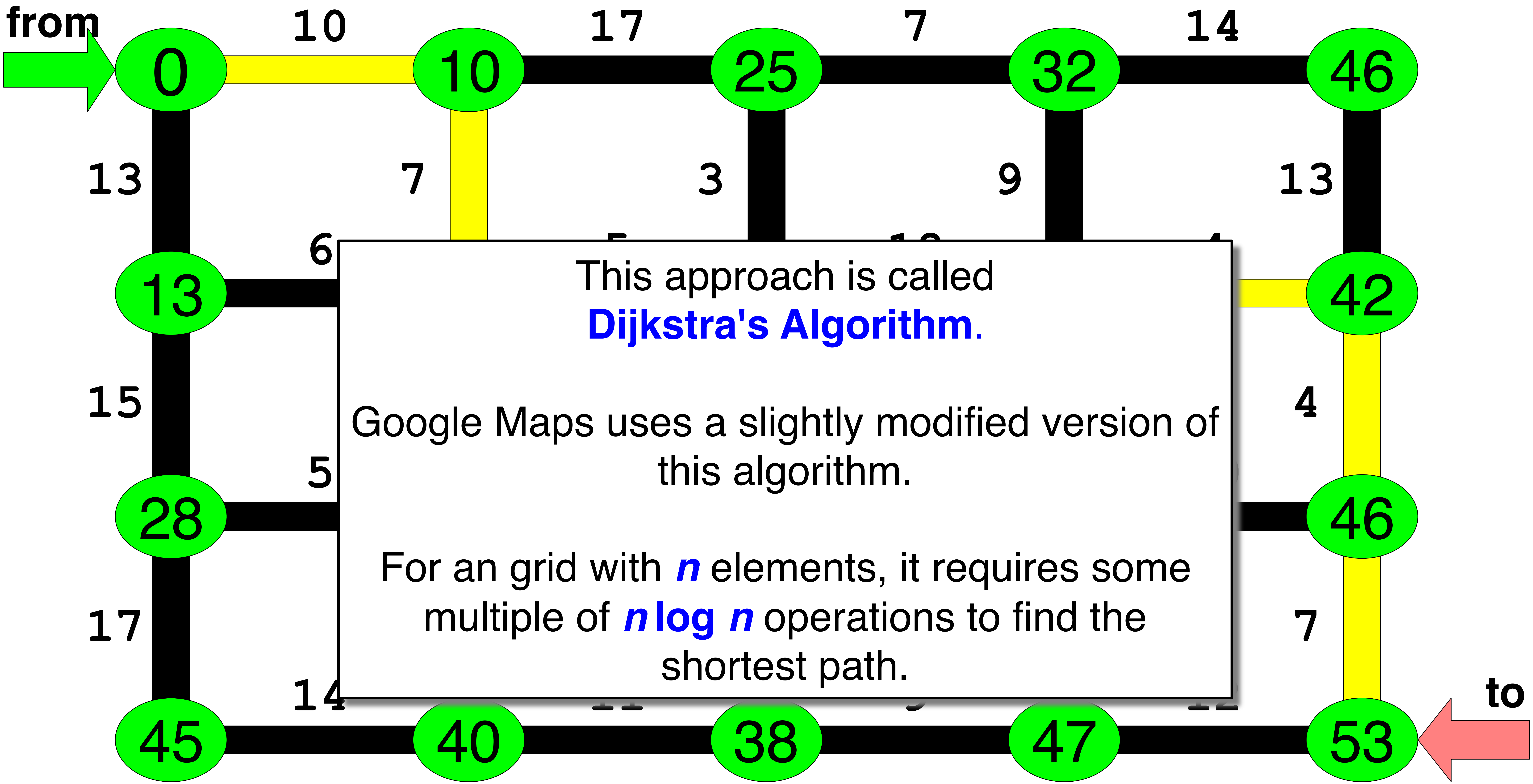


This approach is called
Dijkstra's Algorithm.



This approach is called
Dijkstra's Algorithm.

Google Maps uses a slightly modified version of this algorithm.



This approach is called
Dijkstra's Algorithm.

Google Maps uses a slightly modified version of this algorithm.

For an grid with ***n*** elements, it requires some multiple of ***n* log *n*** operations to find the shortest path.

Course Information

Most important!

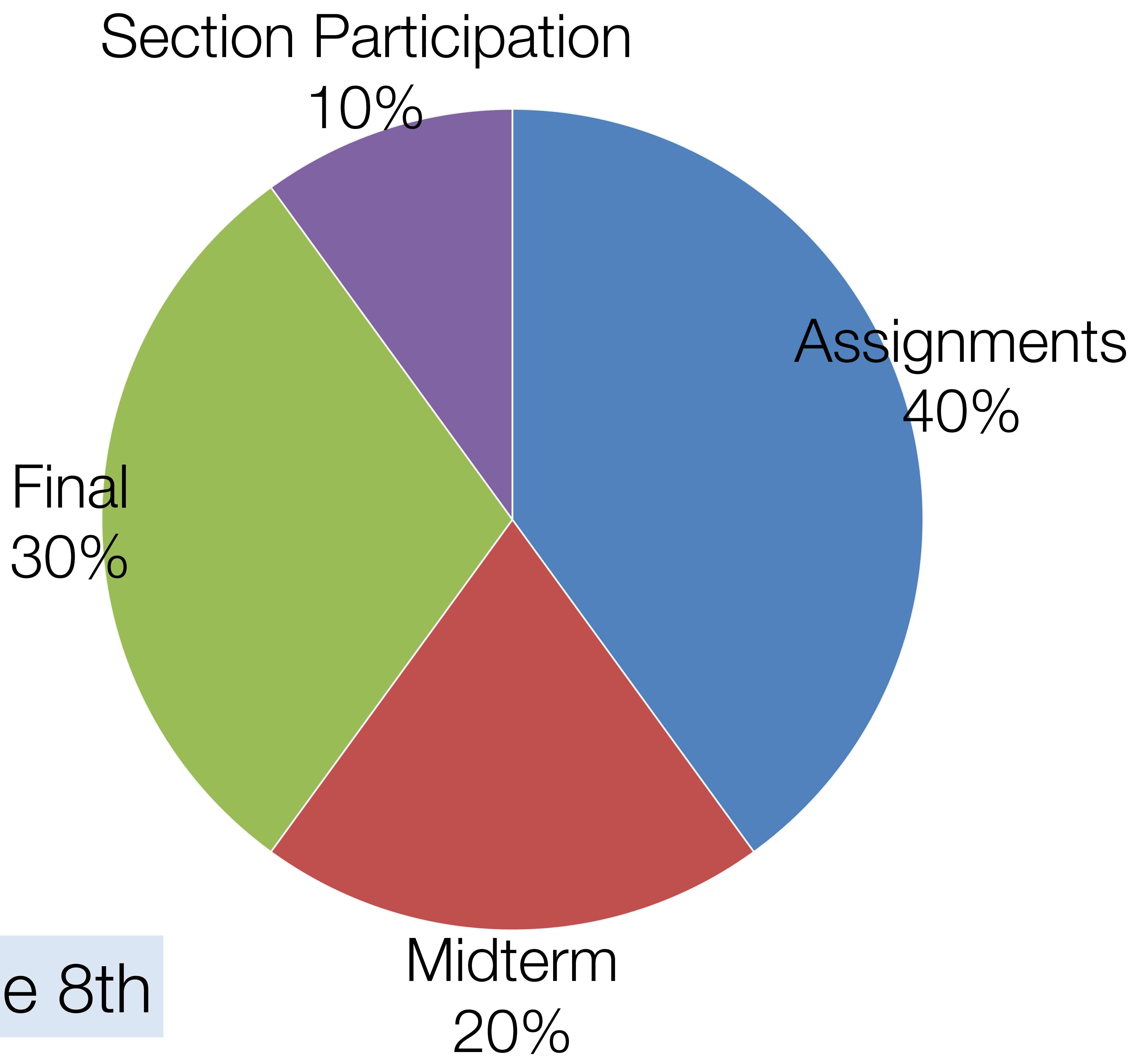
https://cs106b.stanford.edu

Course Information

2nd Most important!

https://piazza.com/stanford/spring2018/cs106b/home

Components of CS 106B



Final: Friday, June 8th

Assignments in CS106B

- Due at 12:00P.M.
- Two free “late days” (class days)
- Extensions approved by Chris or Nick.
- Graded by your section leader
- Interactive, one-on-one grading session.
- Graded on Style and Functionality.

Grading Scale

Functionality and style grades for the assignments use the following scale:

++	A submission so good it "makes you weep."
+	Exceeds requirements.
✓+	Satisfies all requirements of the assignment.
✓	Meets most requirements, but with some problems.
✓−	Has more serious problems.
−	Is even worse than that.
−−	Better than nothing.

Sections

- Weekly 50-min section led by awesome section leaders (the backbone of the class!)
- Signups begin Thursday at 5:00pm
- Signups close Sunday at 5:00pm

You need to ask questions if you are confused

You are here only to learn. Your intelligence is unquestioned.

Getting Help

1

Review Piazza

2

Go to the LaIR / OH

3

Contact your Section Leader

4

Email Chris or Nick

Is CS106B The Right Class?

CS106A/AP/AJ

CS106B

CS106X

CS107

CS106L

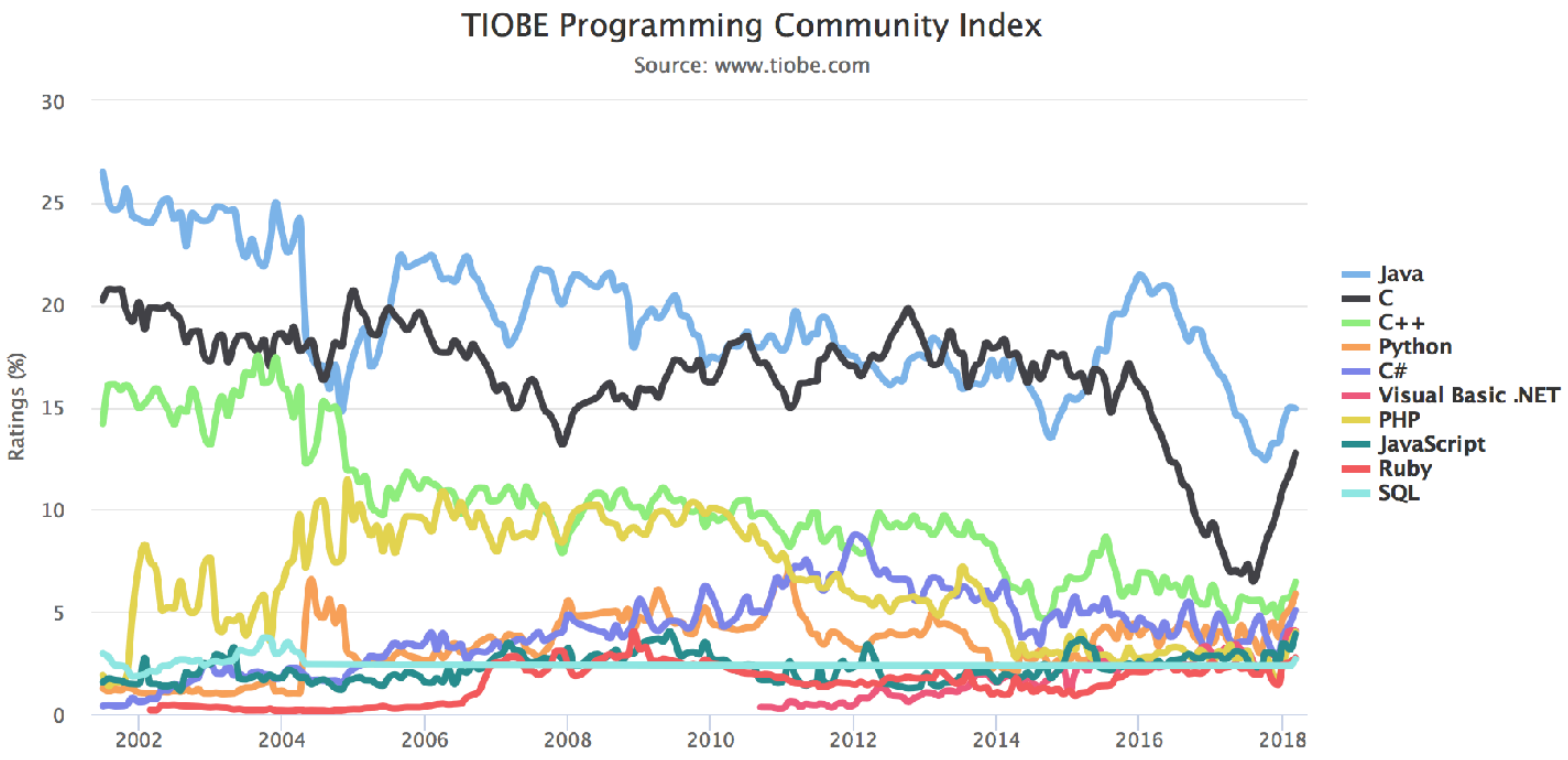
CS106S

One last detail…

C++

C++

Although there are [hundreds of computer languages](), in CS 106B we will be using the C++ language, which is not the easiest language to learn, but it is powerful and popular (and will help you get an internship!)



What is the most used language in programming?

Profanity!

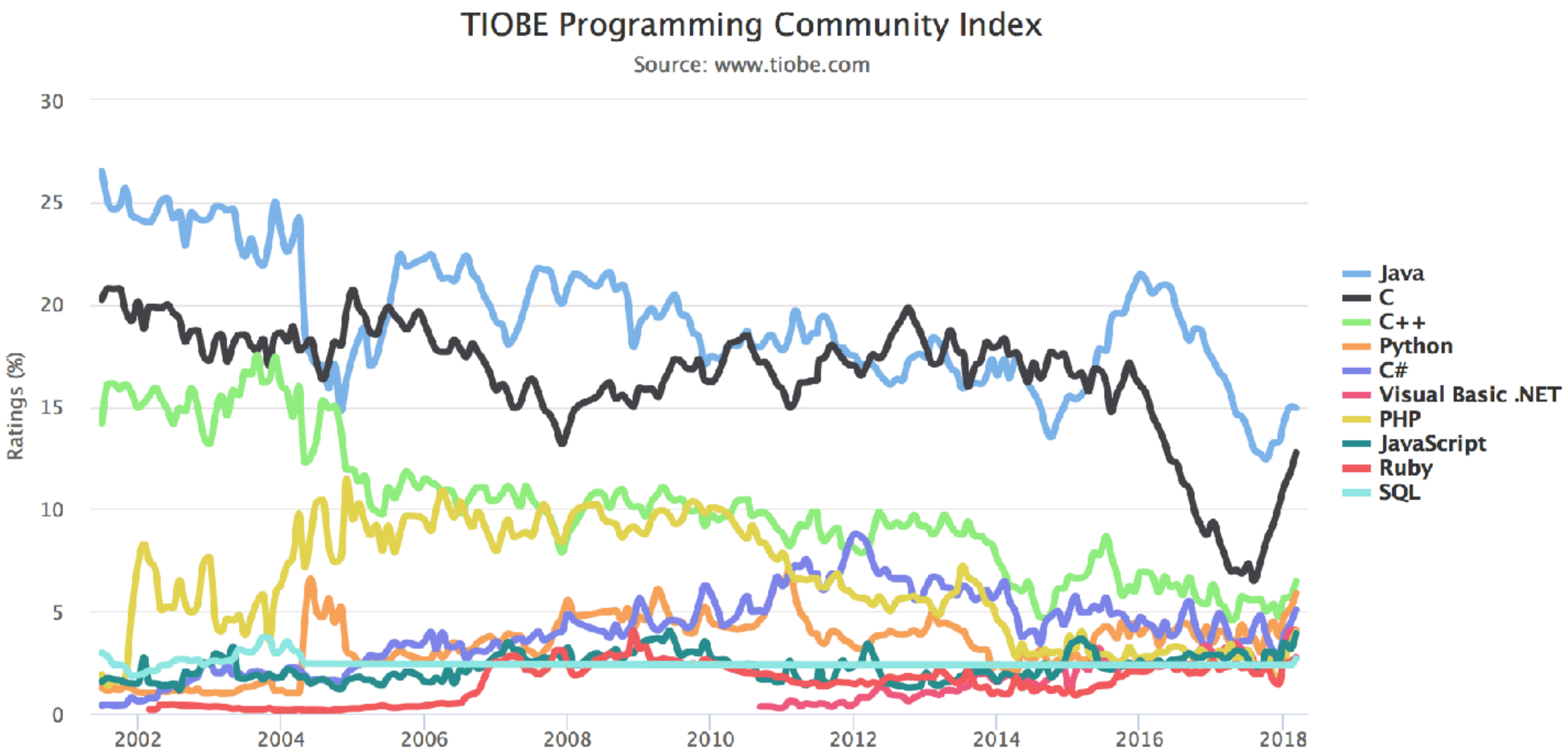
CS 106/107 Languages

The 106/107 languages:

```
106A  : Java (1995)
106AJ : Javascript (1995)
106AP : Python (1991)
106B  : C++  (1983)
107   : C    (1972!)
```

Java, Javascript, and C++ have their syntax based on C (Python is a bit different)

The languages are different enough that each does take time to learn.



Your First C++ Program!

As you'll find out, learning a new language when you already know a language is not really that hard, especially for "imperative" languages like Java, C++, and C (and Javascript, Python, and Ruby, etc.)

Non-imperative languages —"functional" languages — (LISP, Haskell, ML, etc.) take a completely different mentality to learn, and you'll get to those in later CS classes, like Programming Languages.

Let's write our "Hello, World!" program in C++.

Your First C++ Program!

Steps:
1. Install QT Creator (see Assignment 0!)
2. Download the example "simple-project": http://web.stanford.edu/class/cs106b/qtcreator/simple-project.zip
3. Rename the .pro file **`hello-world.pro`**
4. Open the src folder, delete **`hello.h`** and rename **`hello.cpp`** to **`hello-world.cpp`**
5. Open **`hello-world.pro`**
6. Click "Configure Project"
7. Open Sources->src->**`hello-world.cpp`**
8. Delete everything!
9. Now we're ready to code…

Your First C++ Program!

```
// Our first C++ program!

// headers:
#include <iostream>
#include "console.h" // Stanford library

using namespace std;

// main
int main()
{
    cout << "Hello, World!" << endl;
    return 0;
}
```

To compile: Select Build->Build Project "hello-world" (or ⌘-B or Alt-B)

To run in "Debug" mode: Select Debug->Start Debugging->Start Debugging (or ⌘-Y or Alt-Y)

You should see a console window pop up that says, "Hello, World!"

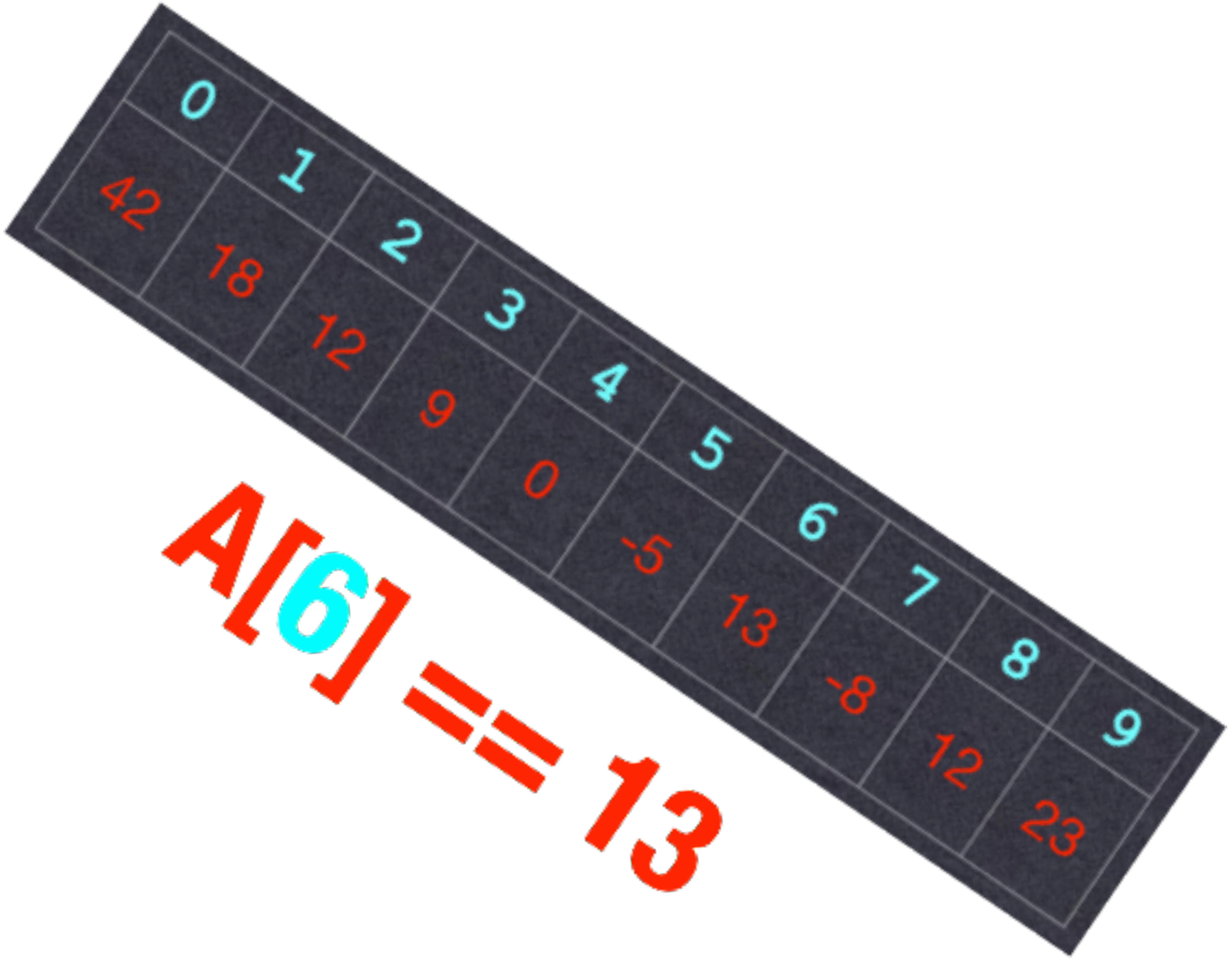
Your *Second* C++ Program!

Let's write a more advanced program, one that creates a list, and populates the list with 100,000 even integers from 0 to 198,998.

You'll see that this looks strikingly familiar to Java, with a few C++ differences.

The list object we will use is called a "Vector," which is very similar to a Java ArrayList.

For time reasons, we'll just write it in the same hello-world.cpp file.



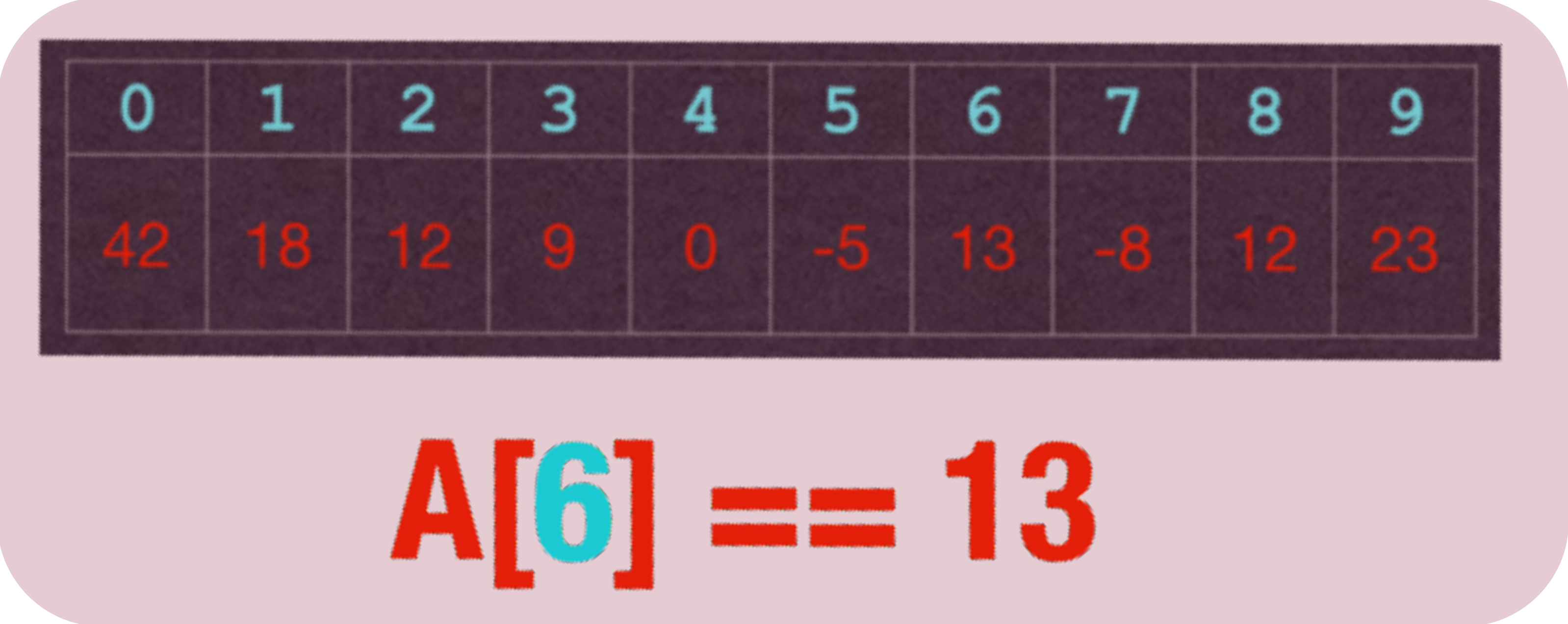
Your *Second* C++ Program!

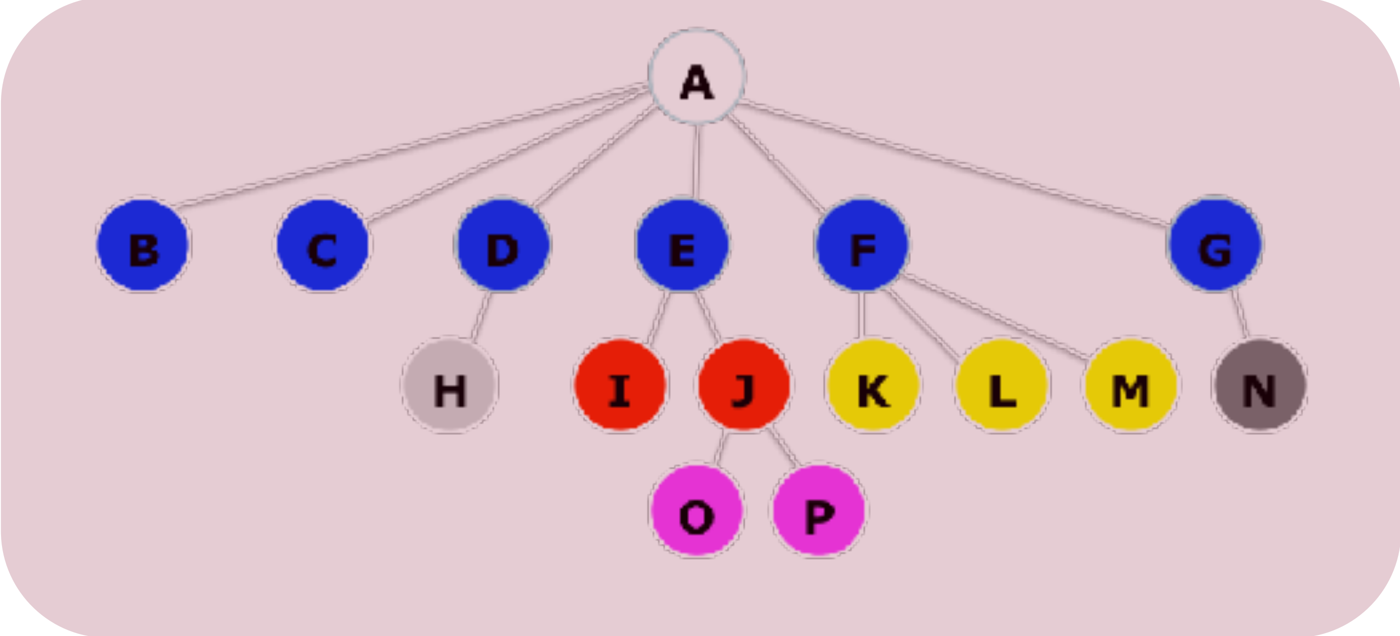
```
// Populate a Vector

// headers:
#include <iostream>
#include "console.h" // Stanford library
#include "vector.h" // Stanford library

using namespace std;

const int NUM_ELEMENTS = 100000;
```

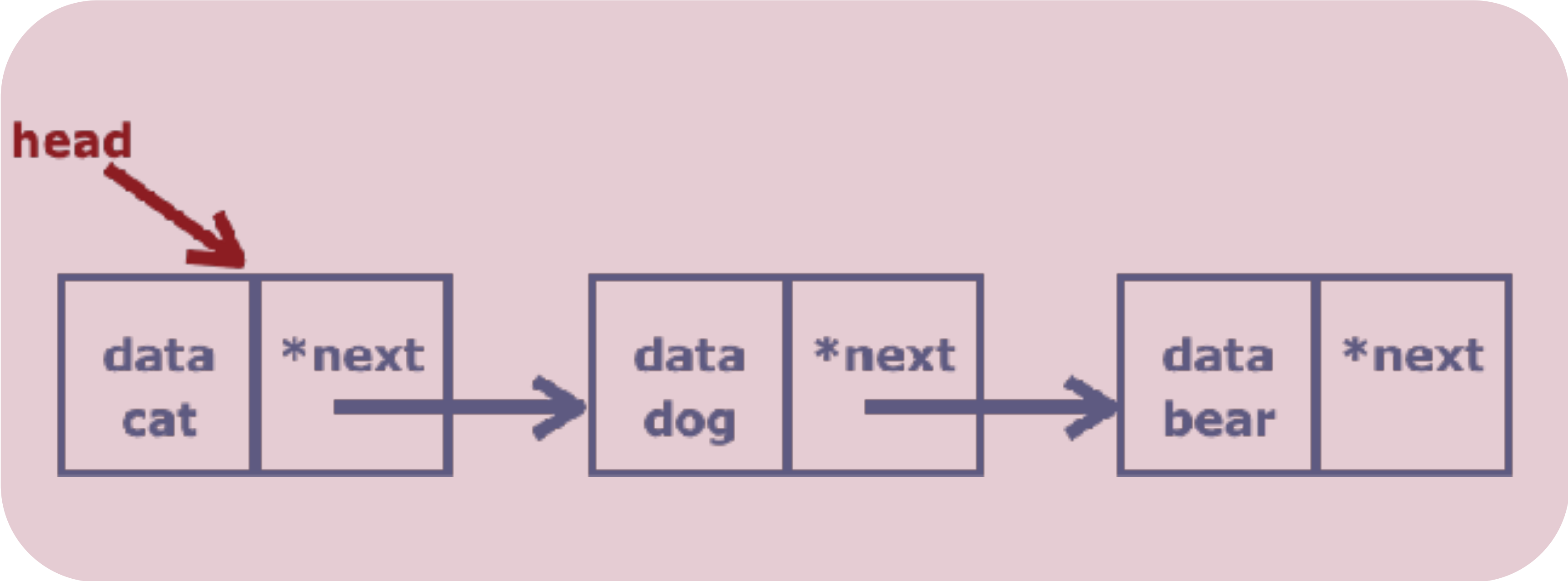
(continued!)

```
// main
int main()
{
    Vector<int> myList;
    cout << "Populating a Vector with 
even integers less than "
         << (NUM_ELEMENTS * 2) << endl;

    for (int i=0; i < NUM_ELEMENTS; i++){
        myList.add(i*2);
    }

    for (int i : myList) {
        cout << i << endl;
    }
    return 0;
}
```

The Importance of Data Structures







Why Data Structures are Important

One reason we care about data structures is, quite simply, time. Let's say we have a program that does the following (and times the results):

- Creates four "list-like" containers for data.
- Adds 100,000 elements to each container – specifically, the even integers between 0 and 198,998 (sound familiar?).
- Searches for 100,000 elements (all integers 0-100,000)
- Attempts to delete 100,000 elements (integers from 0-100,000)

What are the results?

The Importance of Data Structures

Results:

Structure	Overall(s)
Unsorted Vector	15.057
Linked List	92.202
Hash Table	0.145
Binary Tree	0.164
Sorted Vector	1.563

A factor of 103x

A factor of 636x!

Processor: 2.8GHz Intel Core i7 (Macbook Pro)
Compiler: clang++

Overall, the Hash Table "won" — but (as we shall see!) while this is generally a *great* data structure, there are trade-offs to using it.

Note: In general, for this test, we used optimized library data structures (from the "standard template library") where appropriate. The Stanford libraries are not optimized.

Full Results

Structure	Overall(s)	Insert(s)	Search(s)	Delete(s)
Unsorted Vector	15.057	0.007	10.307	4.740
Linked List	92.202	0.025	46.436	45.729
Hash Table	0.145	0.135	0.002	0.008
Binary Tree	0.164	0.133	0.010	0.0208
Sorted Vector	1.563	0.024	0.006	1.534

Why are there such discrepancies??

Bottom line:

- **Some structures carry more** *information* **simply because of their design.**
- **Manipulating structures takes time**

HW 0 and HW 1

- HW 0 is a "get to know the tools" assignment.

- You can find it here: https://web.stanford.edu/class/archive/cs/cs106b/cs106b.1186/assn/NameHash.html

- It should not take more than an hour to complete, and it includes setting up Qt Creator, running an example program, learning about the debugger, signing up for CodeStepByStep, and filling out a form.

- Thursday night there will be a special LaIR to help install tools if necessary.

- Due: **Friday, April 6th, at Noon**

HW1

- HW 1 is the first coding assignment -- you will have to learn some C++ to do it!
- We will talk more about it on Wednesday
- There will be a YEAH hours information session video to get you started on the assignment.
- HW1 will be due on **Thursday, April 12th, at noon**.

Logistics

- Signing up for section: you must put your available times by Sunday April 8th at 5pm (opens Thursday at 5pm).
  - Go to cs198.stanford.edu to sign up.

- Qt Creator installation help: Thursday at 8pm, in Tressider (eating area). Please attempt to install Qt Creator before you arrive (see the course website for details).

- Remember, Assignment 0 is due Friday at Noon

- Anonymous feedback for the class: https://sayat.me/chrisgregg
  - (you can get feedback from me and remain anonymous, too!)