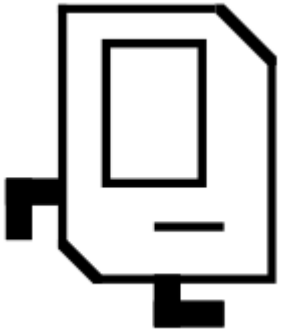
Designing Abstractions

Roy Lichtenstein, *Bull Profile I – VI*

A Quick Pitch: ***Apply to Section Lead!***

CS198 Section Leading



cs198@cs.stanford.edu

Who should section lead?

For this round of applications, we are looking for applicants who are currently enrolled CS106B… and that's you!

We are looking for section leaders from all backgrounds who can relate to students and clearly explain concepts.

What do section leaders do?

- Teach a weekly 1 hour section
- Help students in the LaIR
- Grade CS106 assignments
- Hold IGs with students
- Grade midterms and finals
- Get paid $18.50/hour (more with seniority)
- Have fun!

Time and requirements

You'll need to:

- Section lead for **two quarters!**
- Take CS198 for 3-4 units (1st quarter only)
- Attend staff meetings (Monday, 4:30-5:30PM)
- Attend workshops (Mon/Wed evenings, 1st quarter only)
- Fulfill all teaching, LaIR, and grading responsibilities

Why section lead?

- “Learn to teach; teach to learn”
- Work directly with students
- Participate in fun events
- Join an amazing group of people
- Leave your mark on campus

Participate in fun events

- LaIR Formal
- Special D
- Movie Nights
- BAWK
- Lecturer Hangouts
- New SL Picnic
- Swag
- And more!

Apply Now

Applications are open!

Deadlines:

Saturday, February 15th at 11:59PM PT for students who are currently enrolled in CS106B

Online application: cs198.stanford.edu

Contact us: cs198@cs.stanford.edu

Outline for Today

- ***Apply to Section Lead!***
  - A quick recruiting pitch.
- ***Review: What's an Abstraction?***
  - You're well acquainted with them – but let's take stock anyway.
- ***A Missing Container***
  - Some motivating problems.
- ***Creating Our Own Classes***
  - Expanding our toolkit.

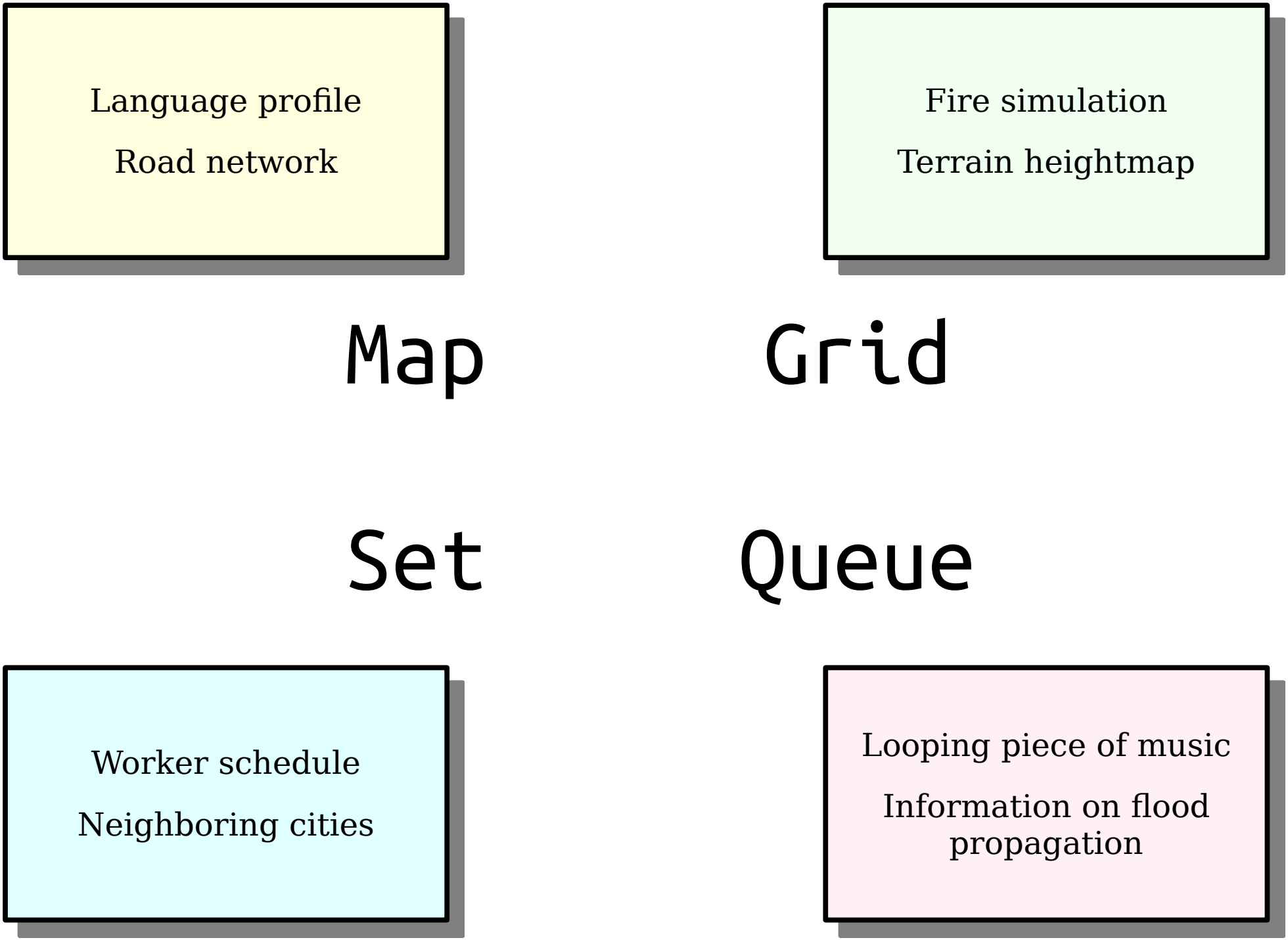
Designing Abstractions

ab·strac·tion

[...]

the process of considering something independently of its associations, attributes, or concrete accompaniments.

Source: Oxford Languages


Language profile
Road network
Fire simulation
Terrain heightmap
Map
Grid
Set
Queue
Worker schedule
Neighboring cities
Looping piece of music
Information on flood propagation

Building a rich vocabulary of abstractions makes it possible to ***model and solve*** a wider class of problems.

Question One:

How do we create new abstractions to model ideas not precisely captured by the standard container types?

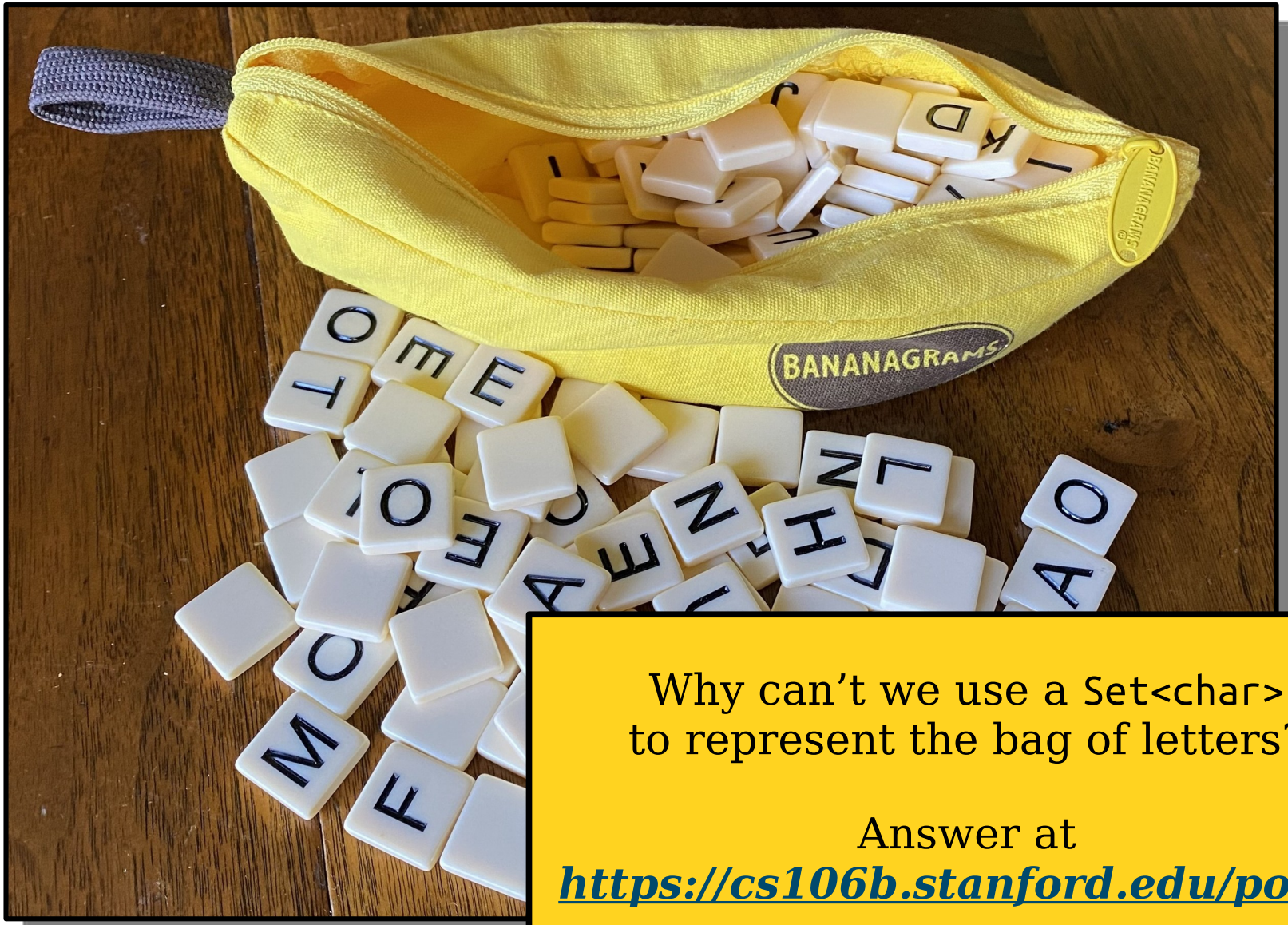
Question Two:

How do the abstractions we've been using so far work, and how can we use that knowledge to build richer abstractions?

Expanding Our Abstraction Vocabulary

Bananagrams Tiles

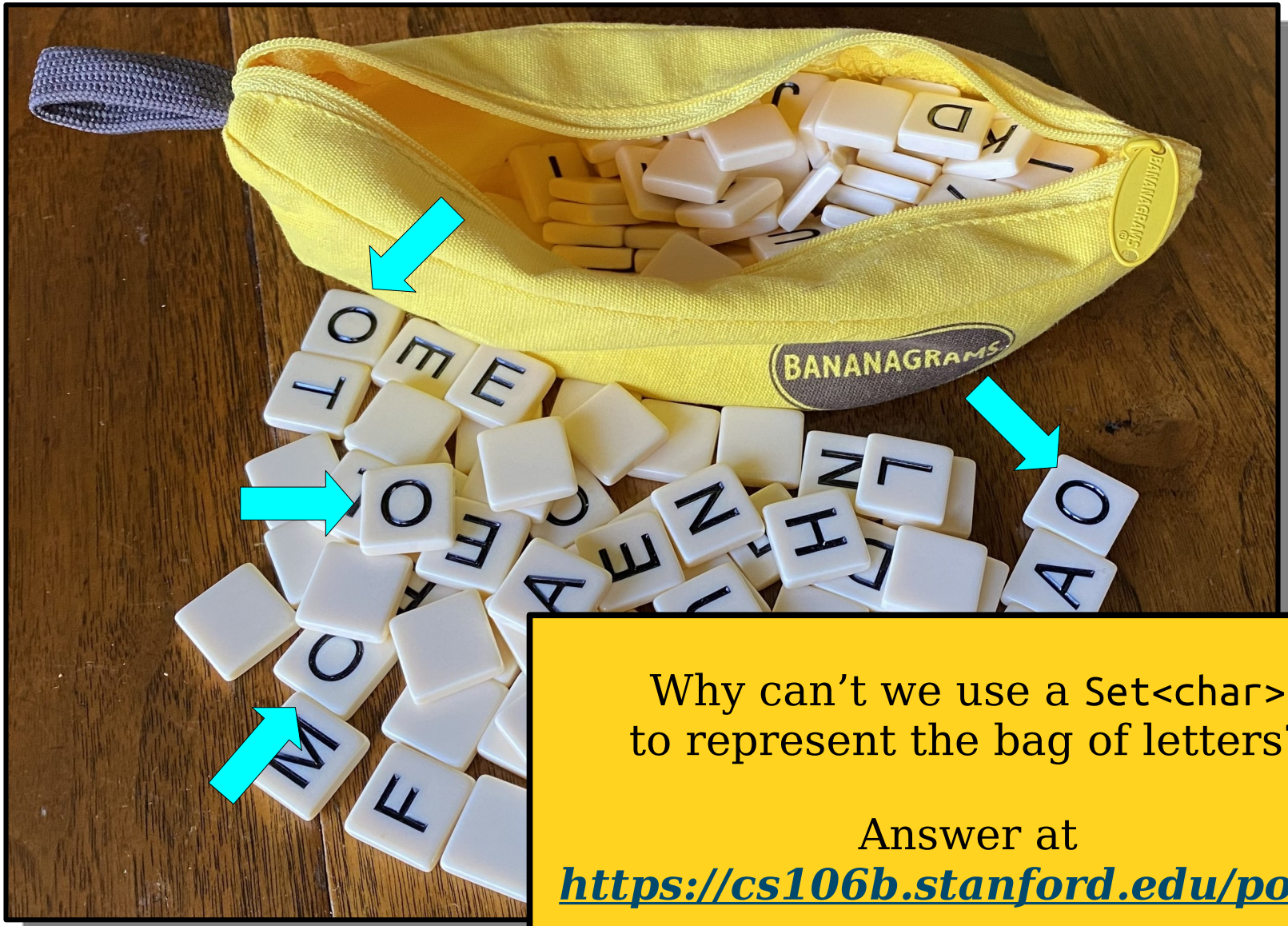
Bananagrams Tiles



Why can't we use a `Set<char>` to represent the bag of letters?

Answer at
https://cs106b.stanford.edu/pollev

Bananagrams Tiles



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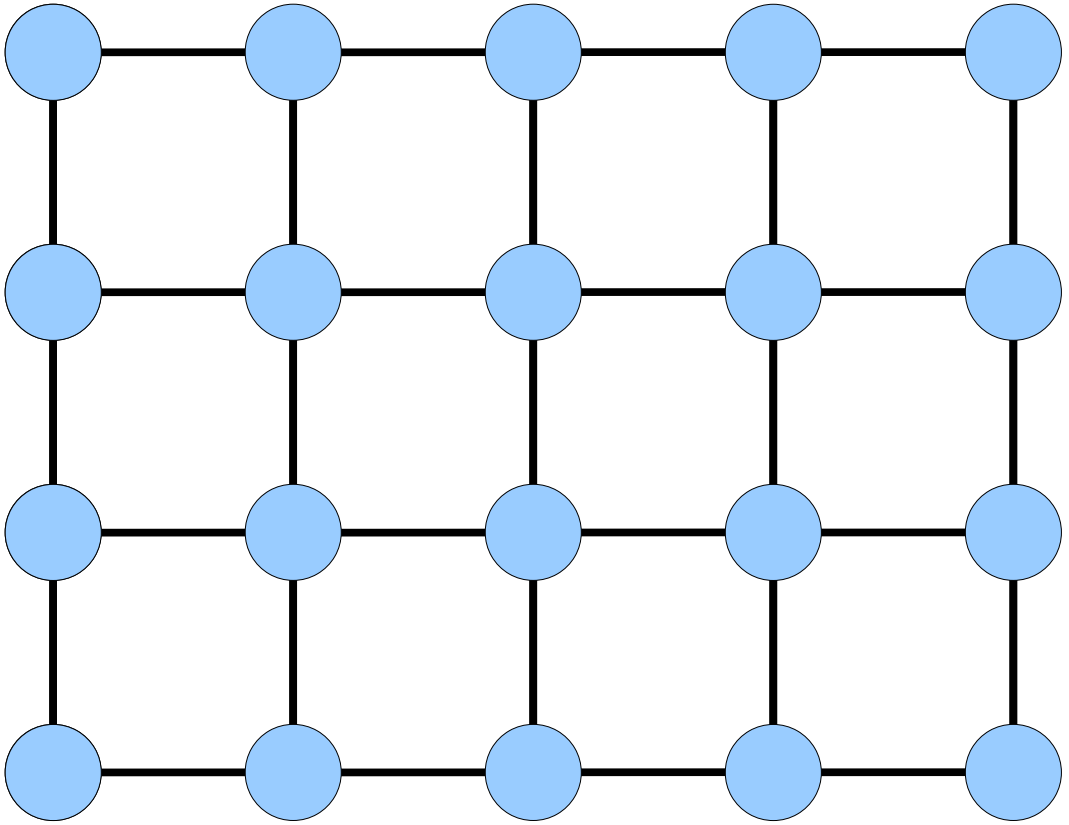
Creating a Maze



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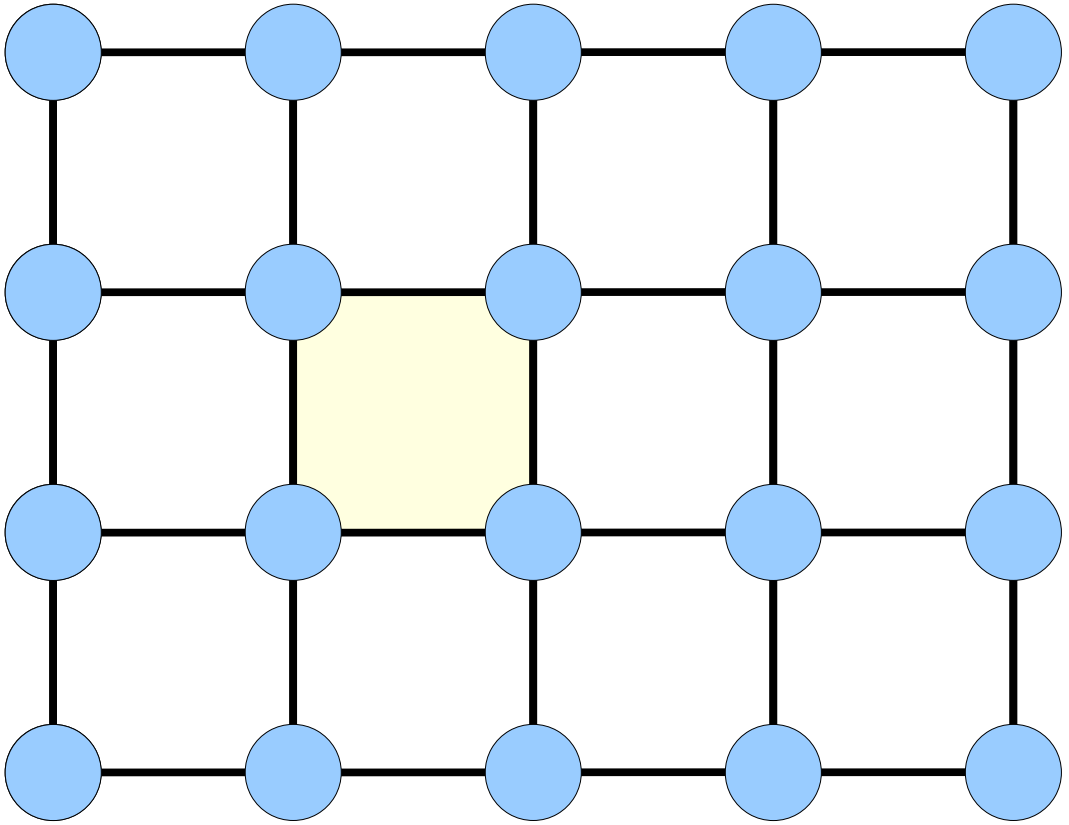

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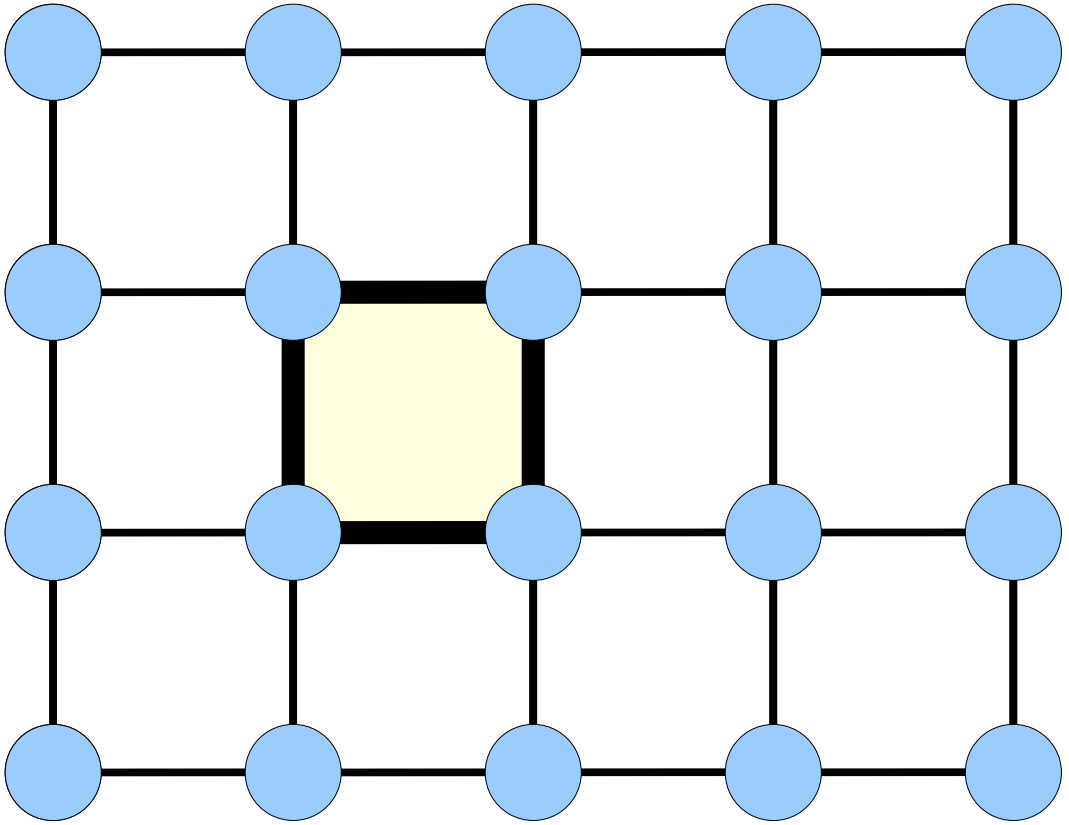

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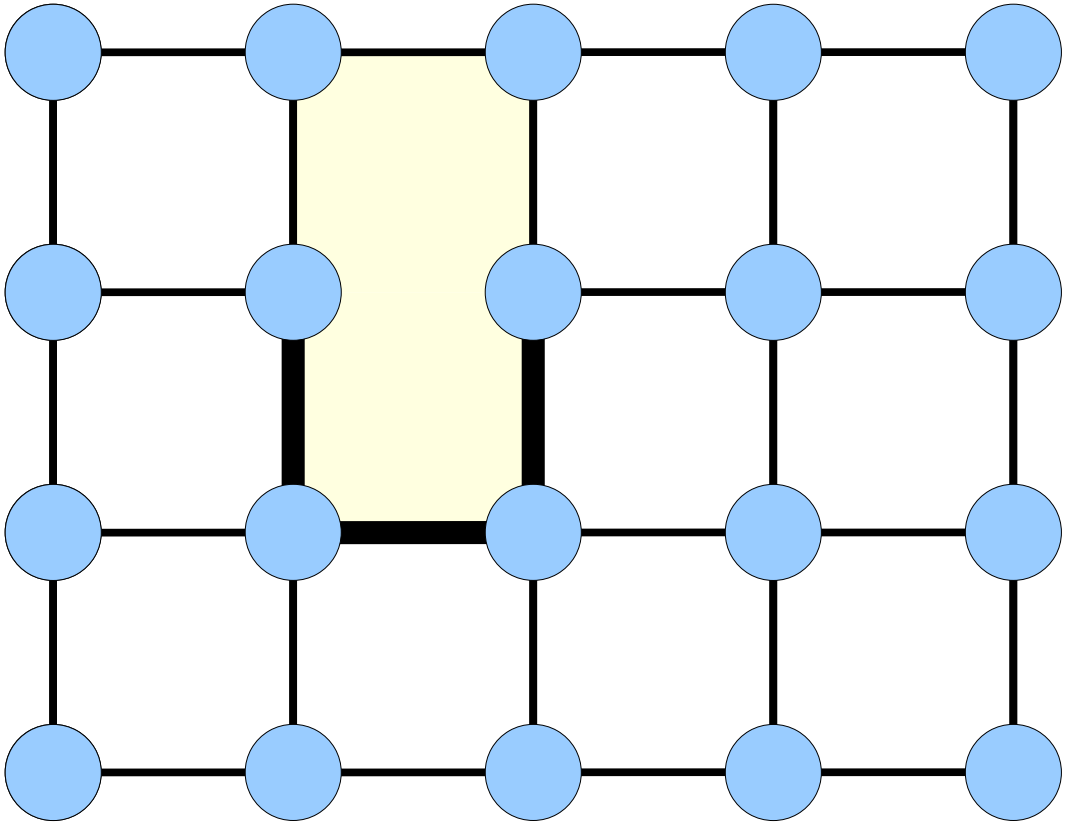

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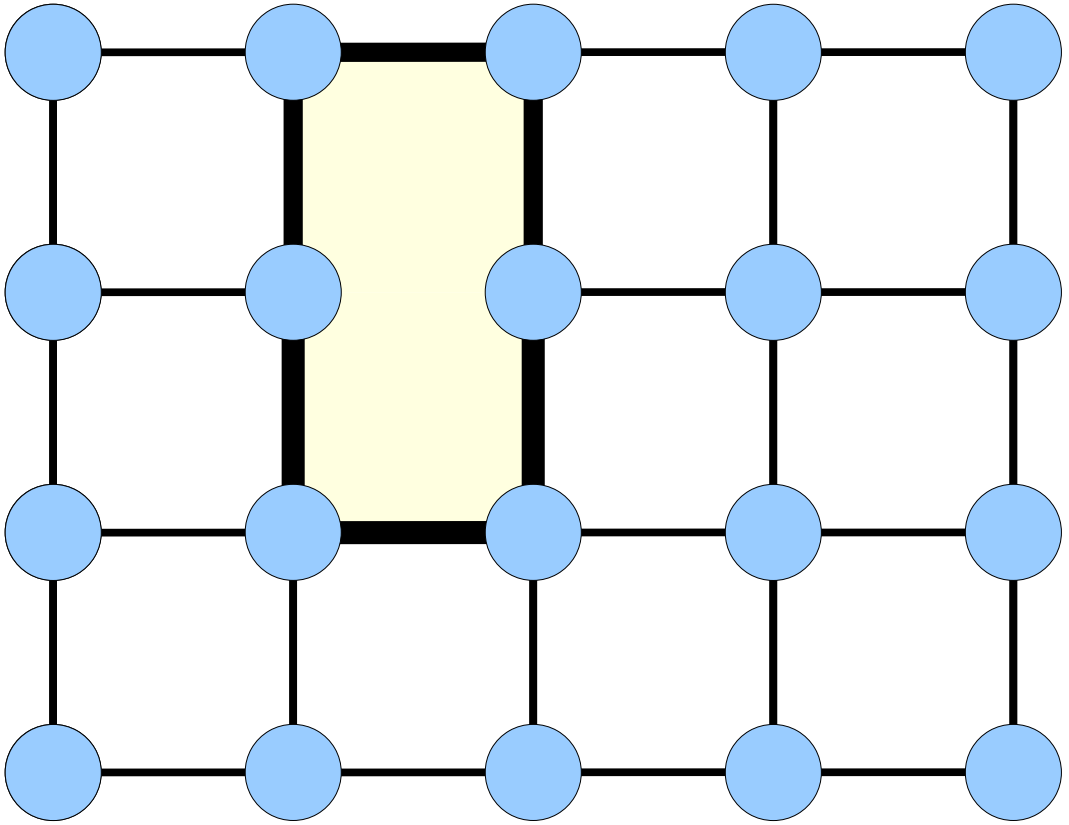

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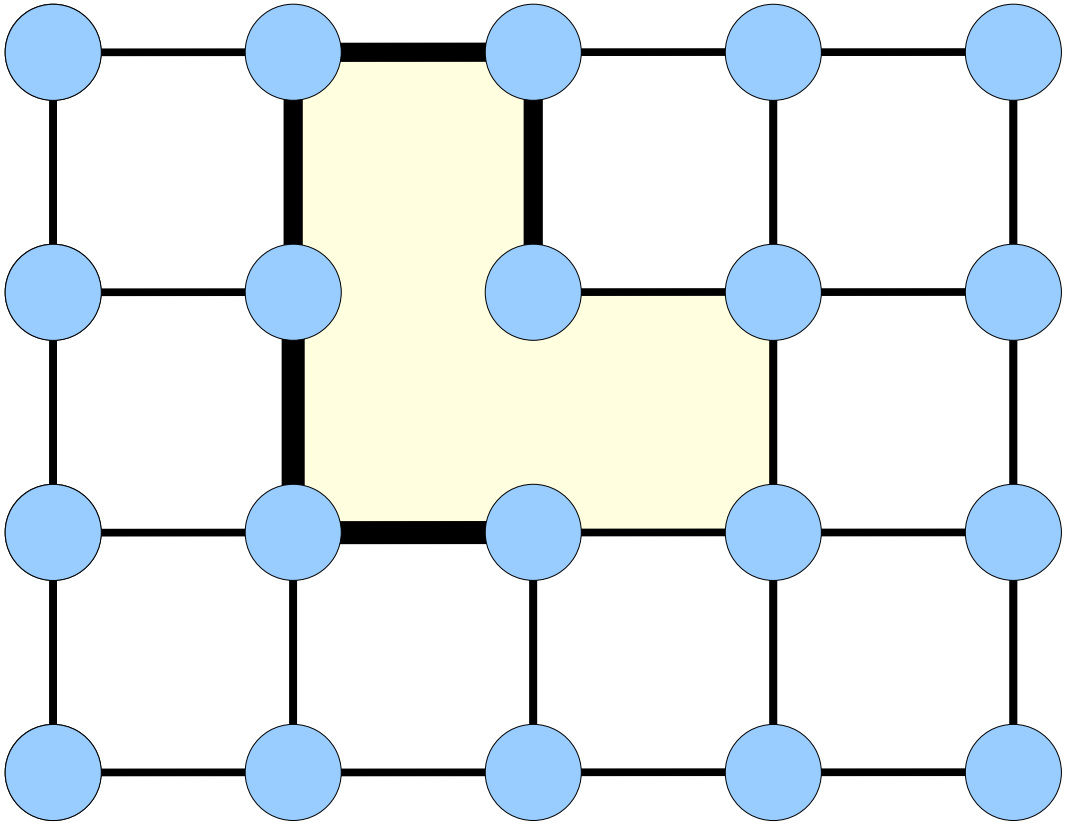

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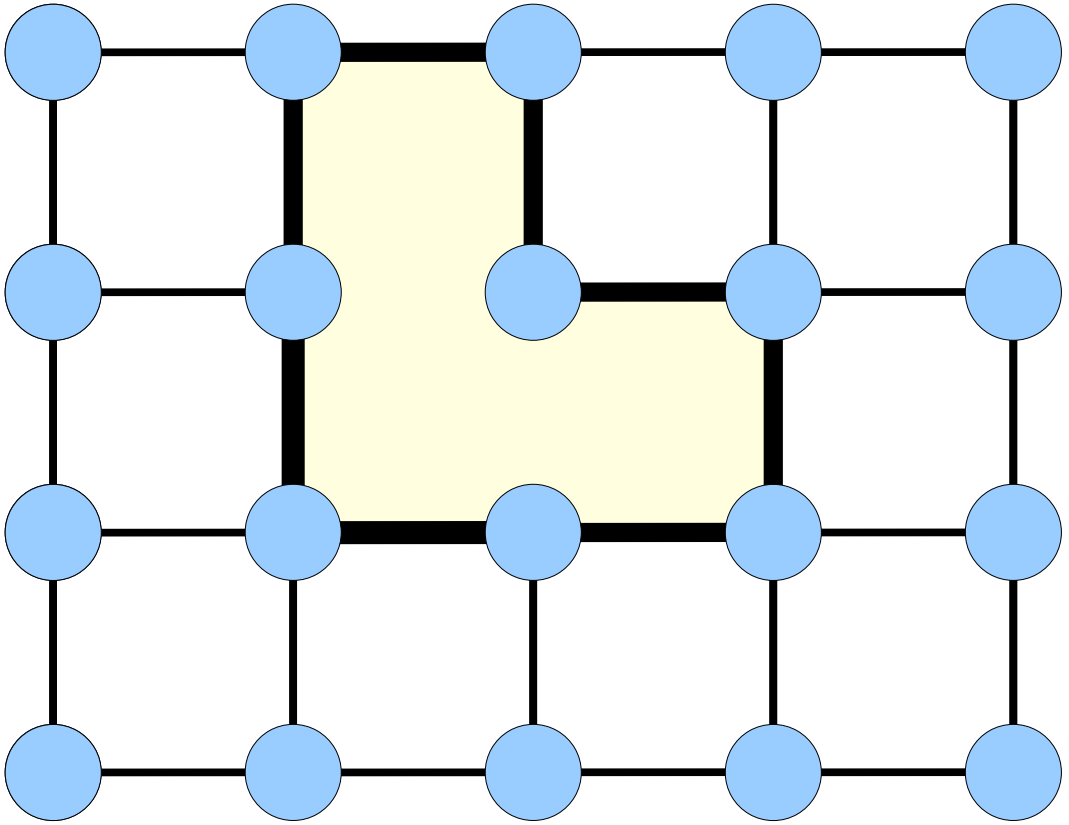

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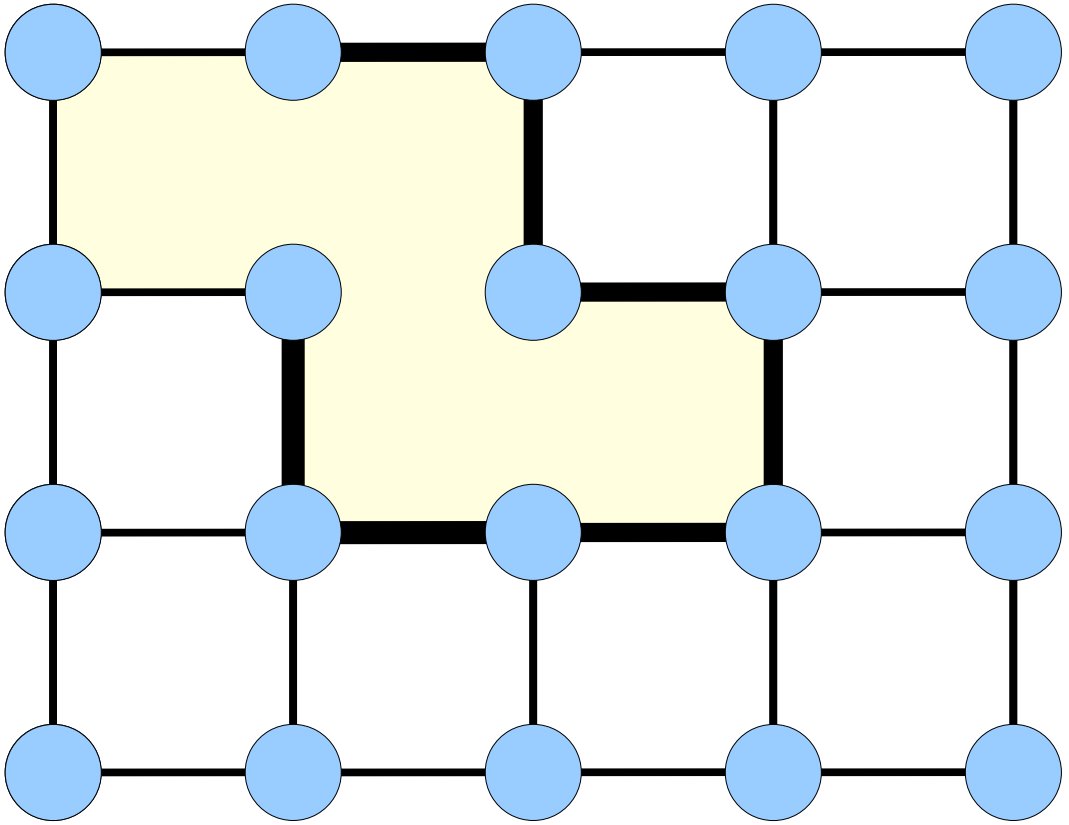

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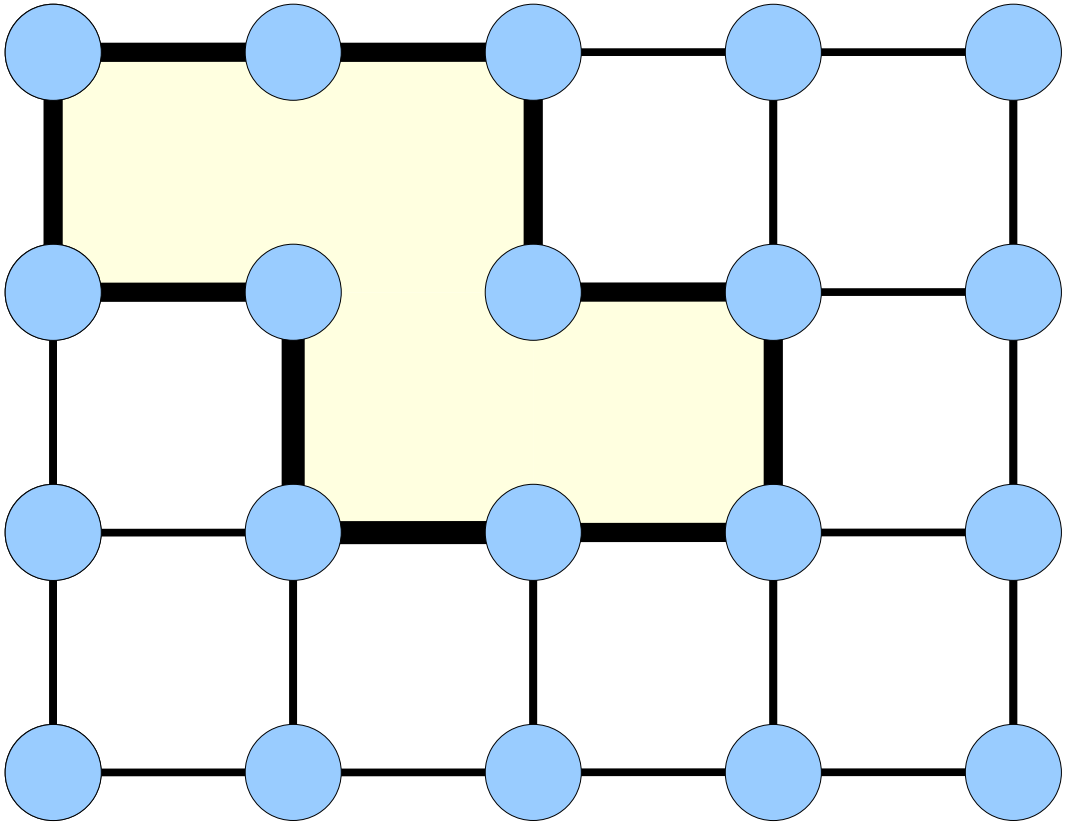

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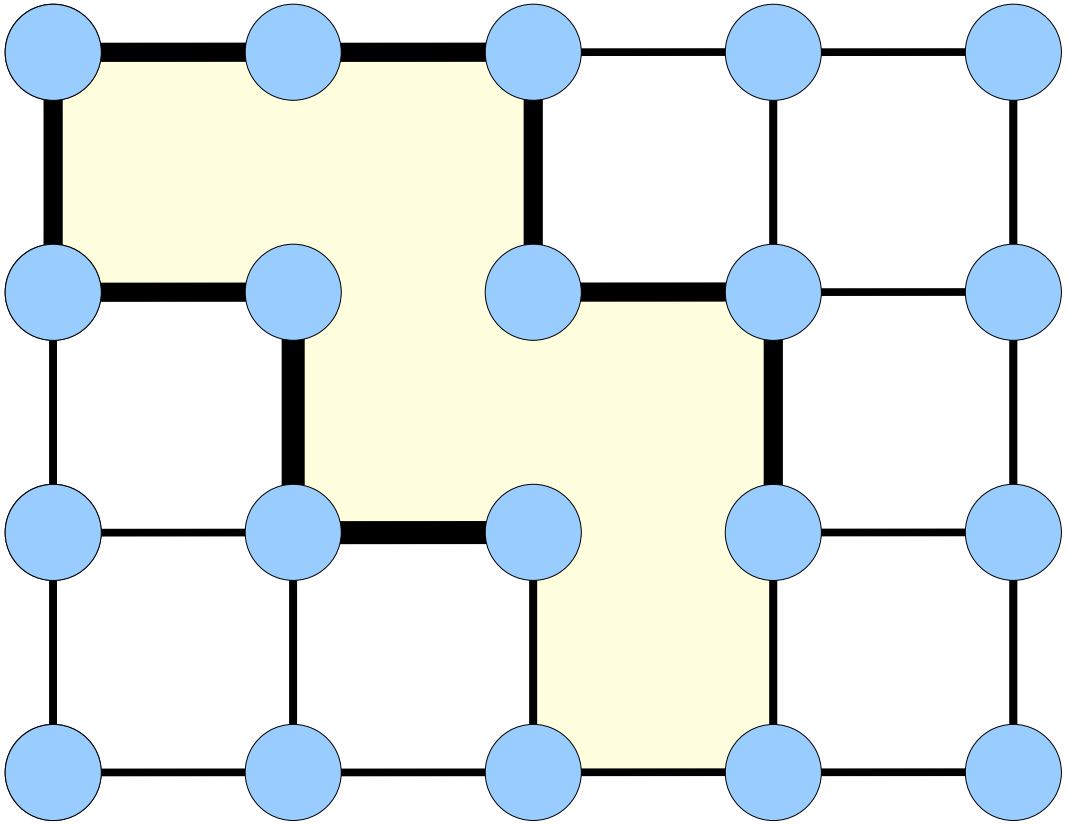

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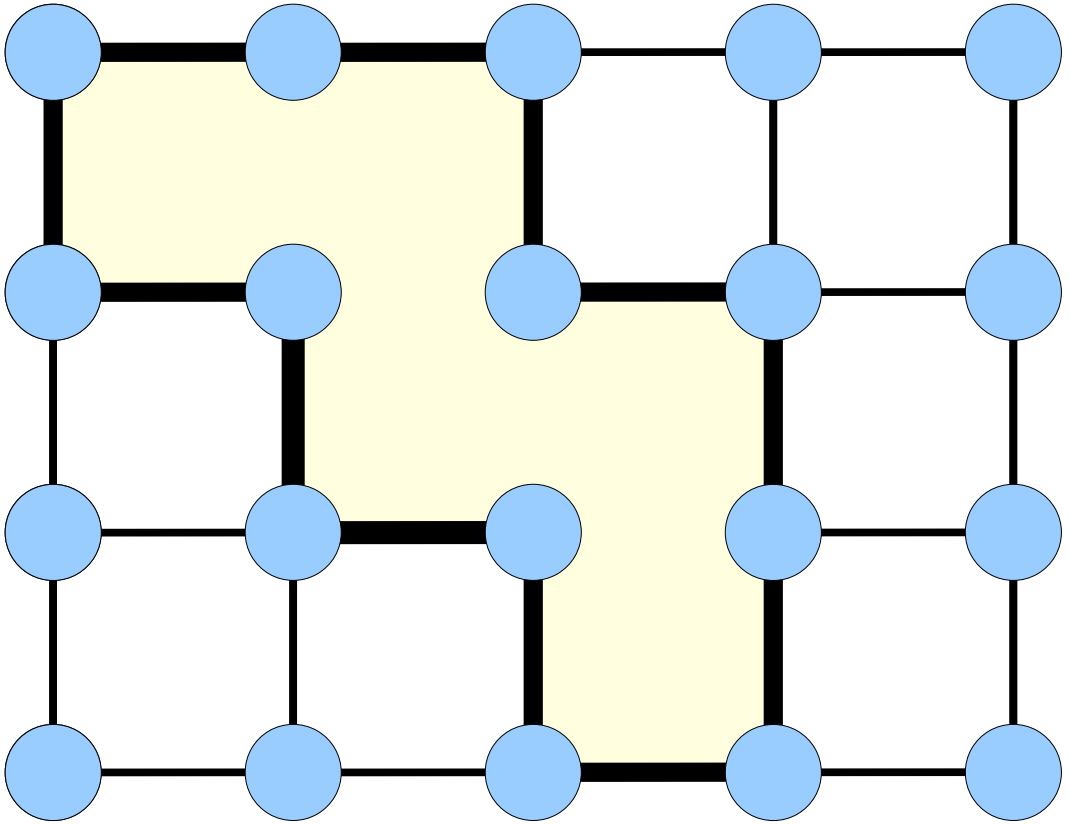

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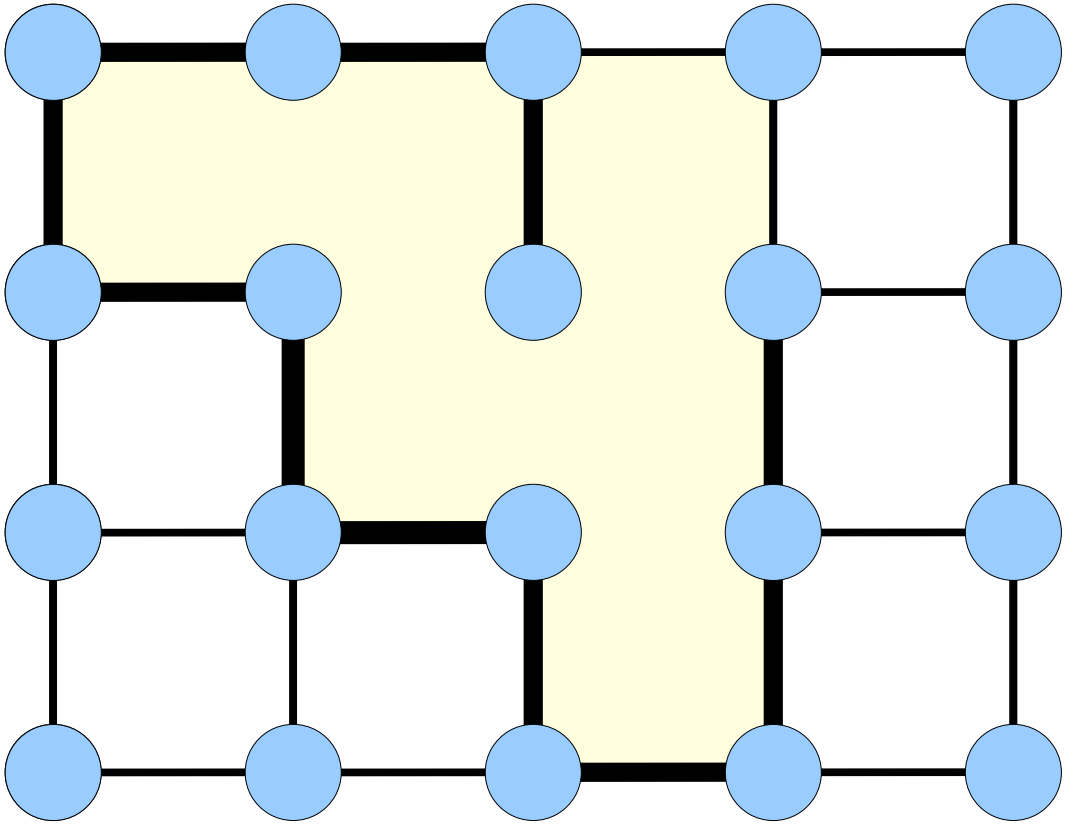

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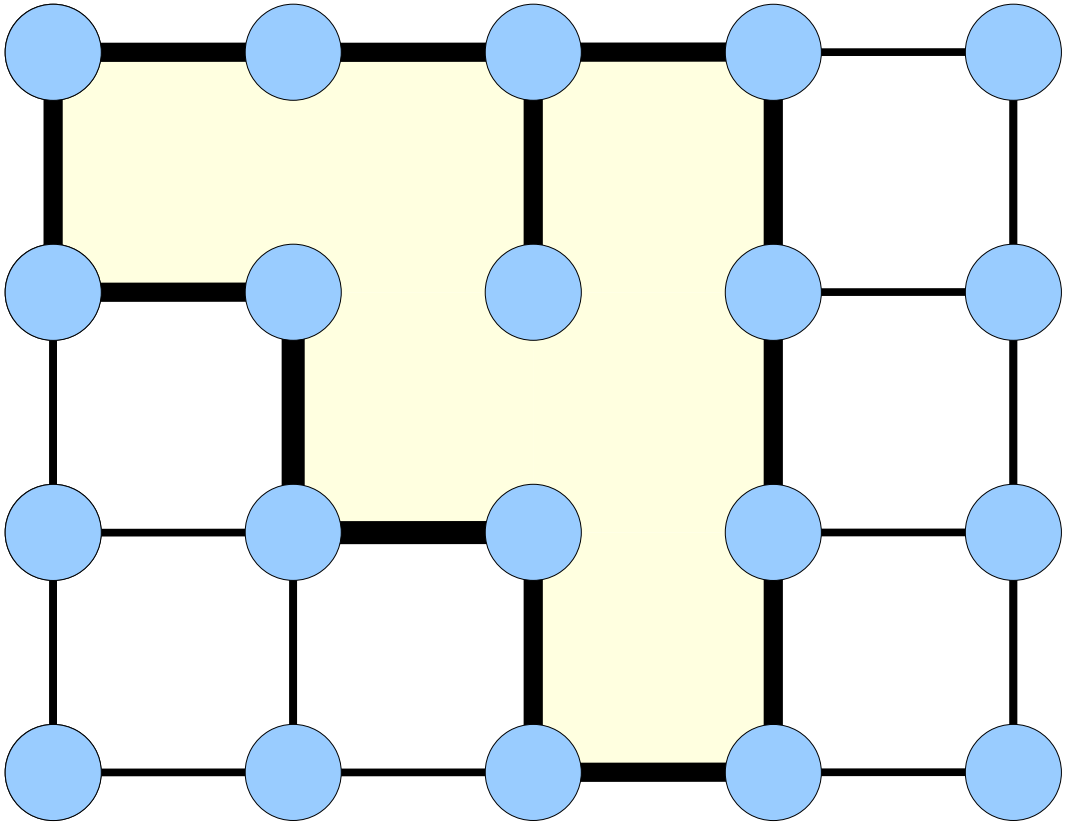

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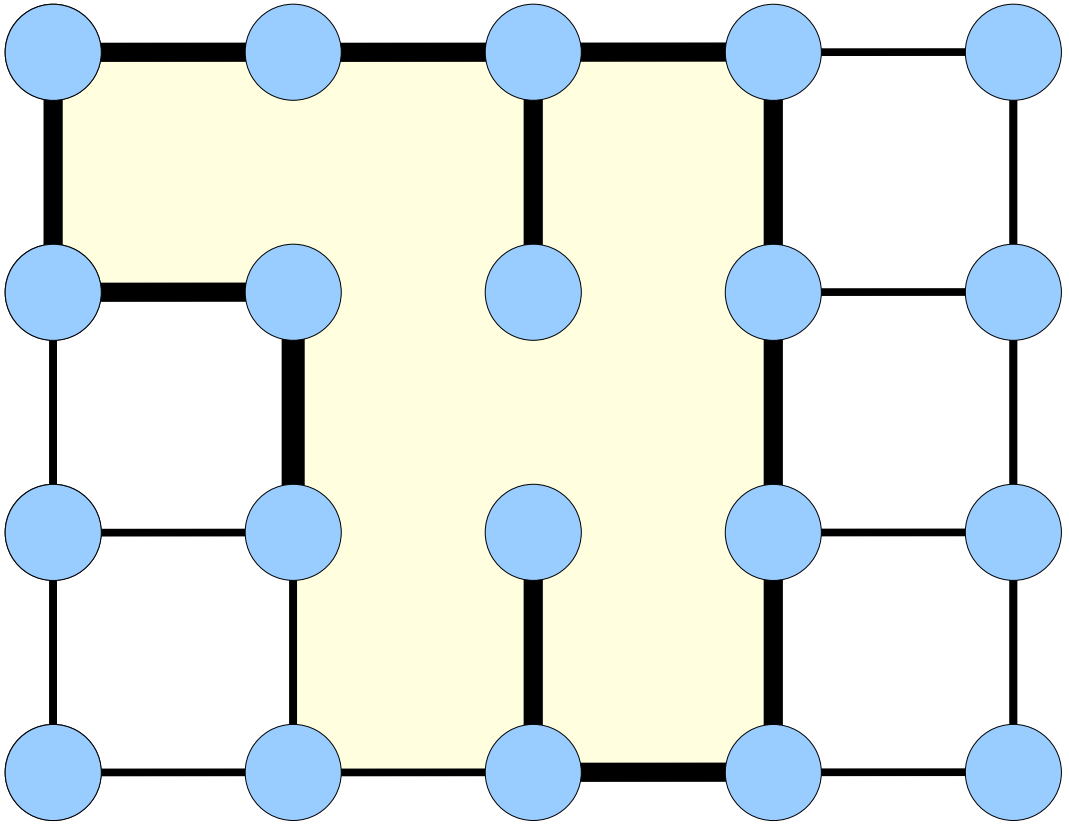

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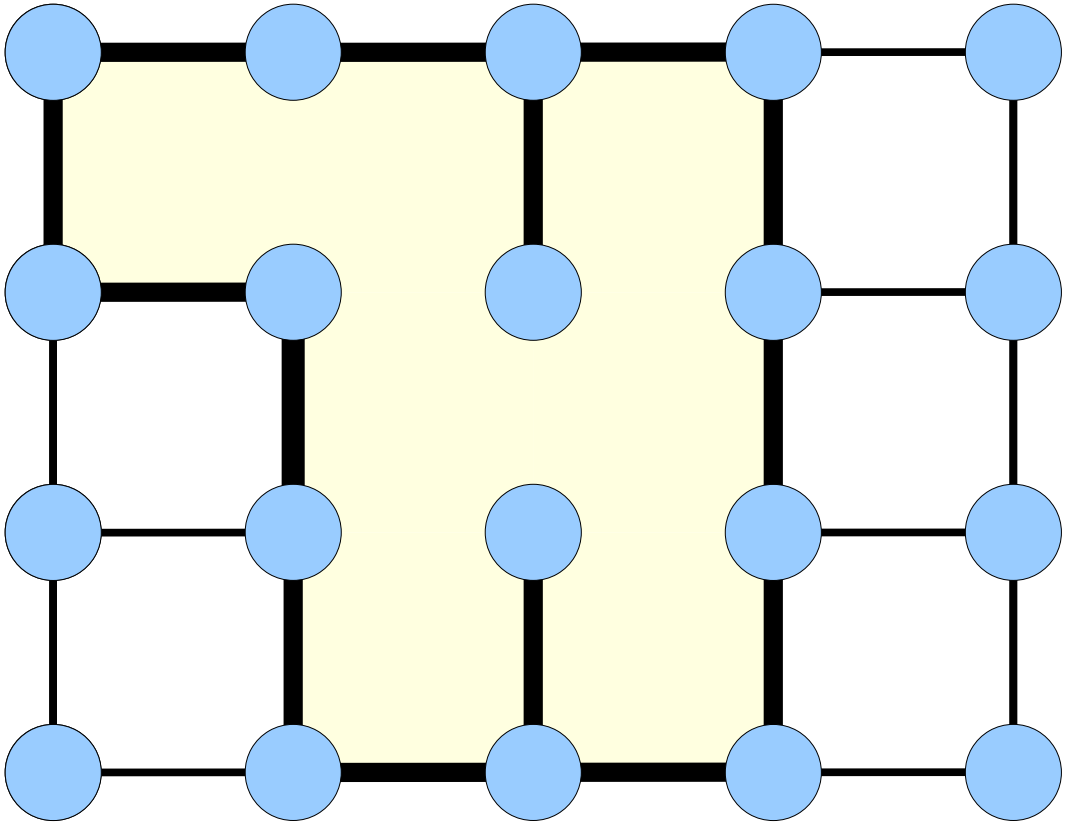

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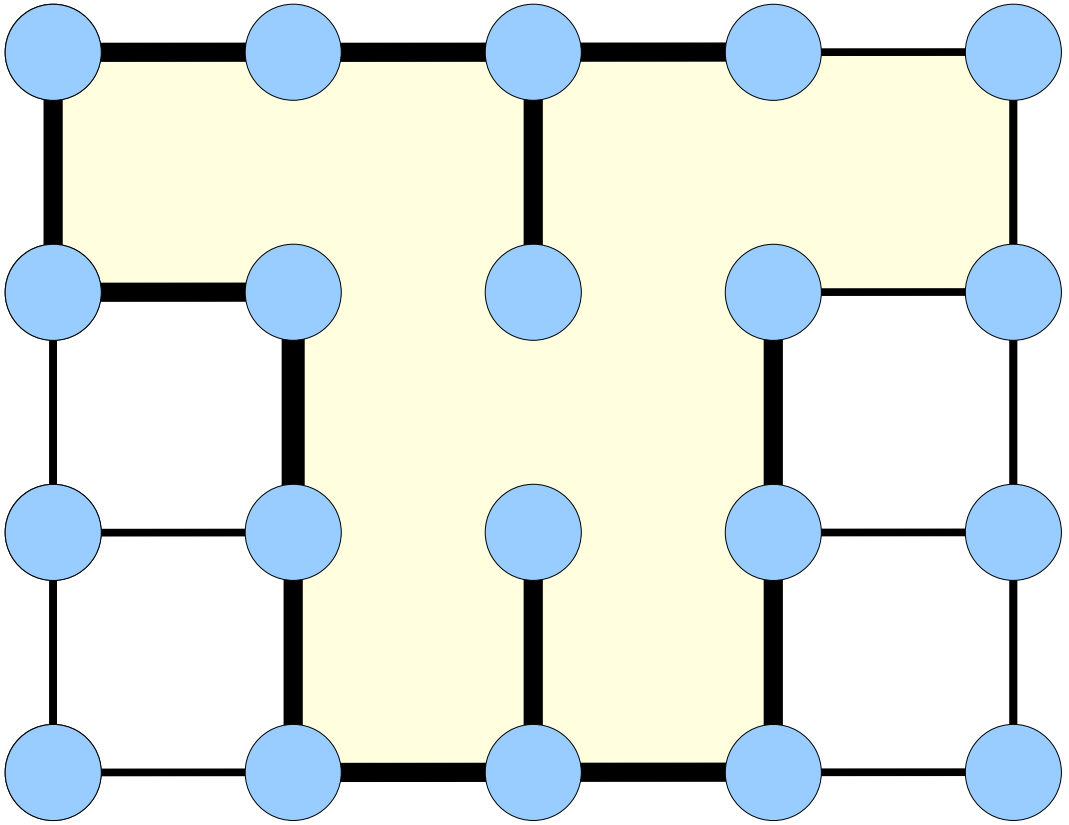

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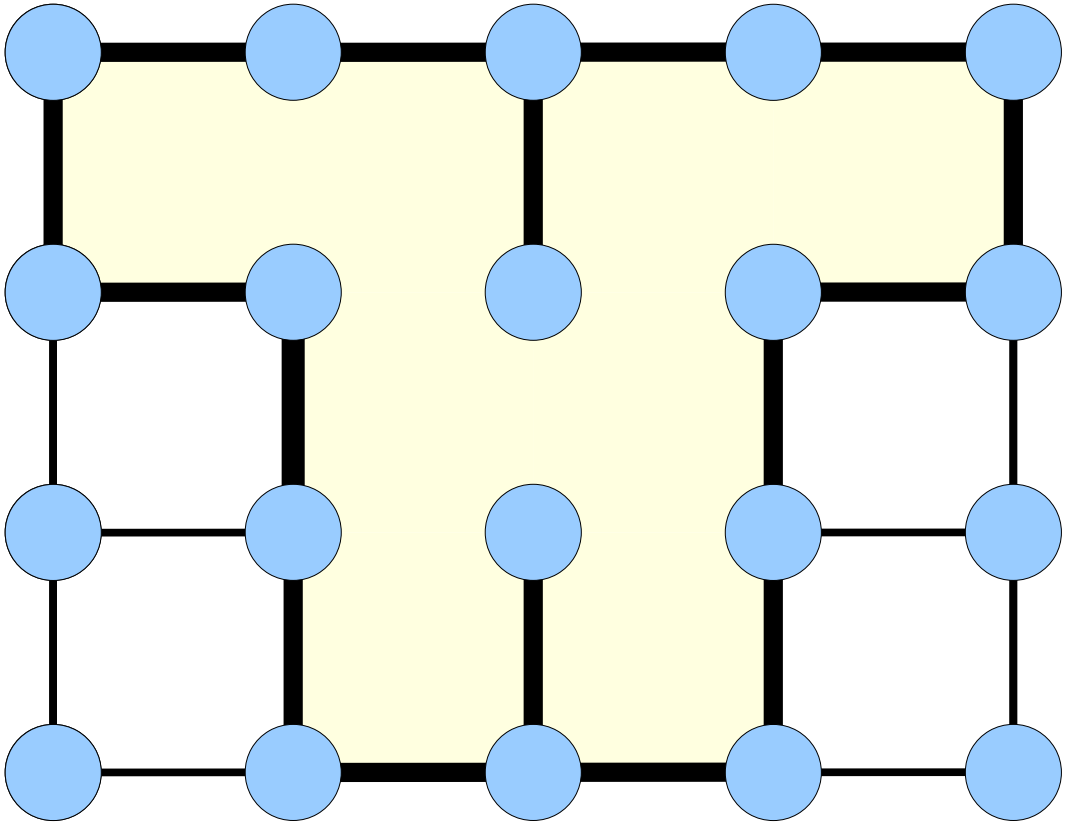

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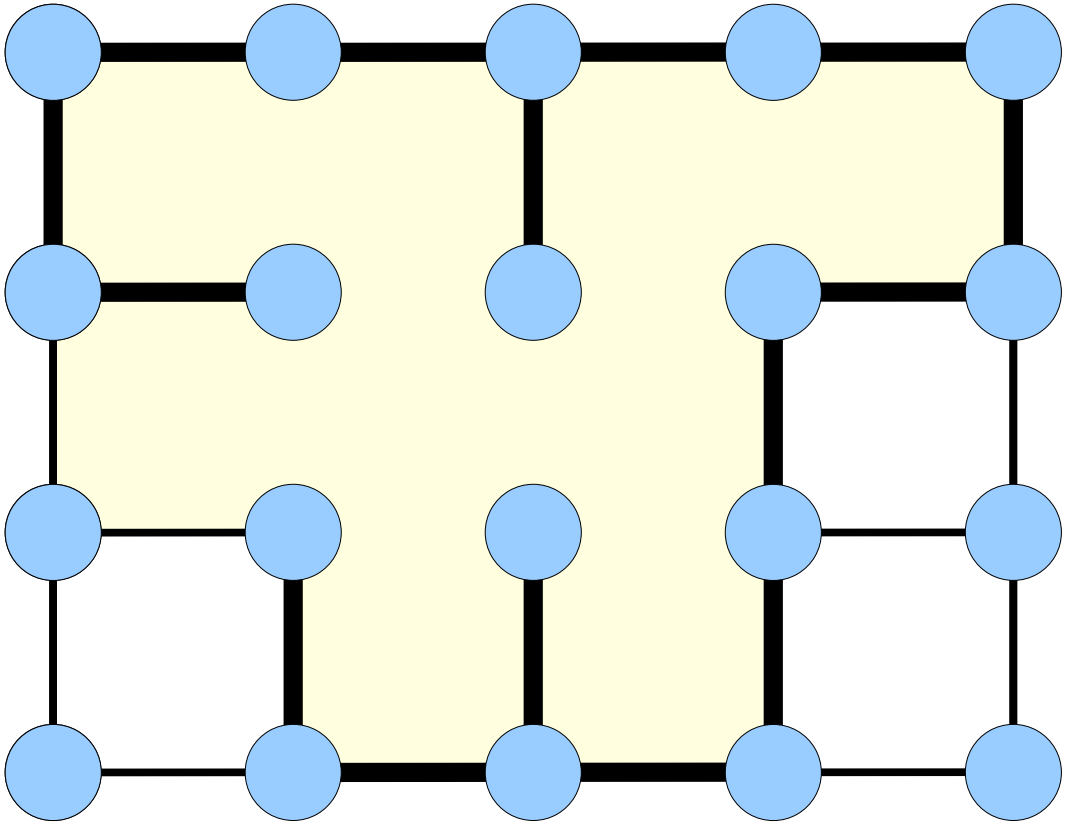

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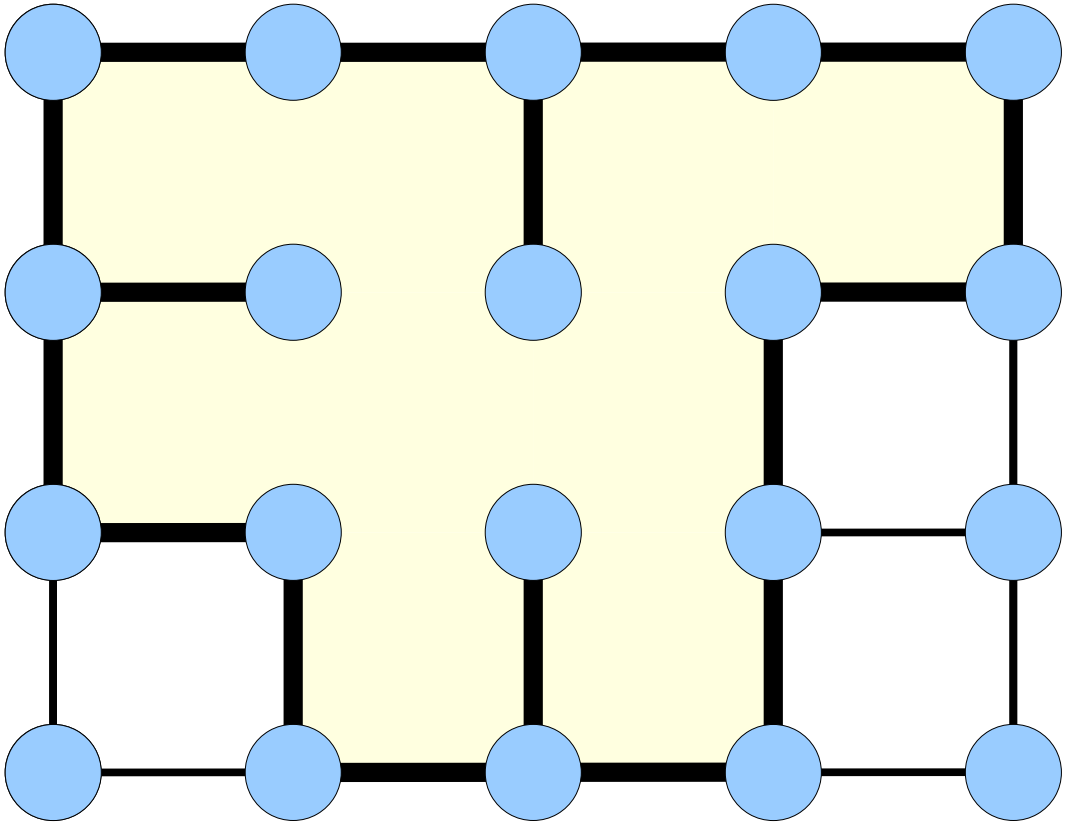

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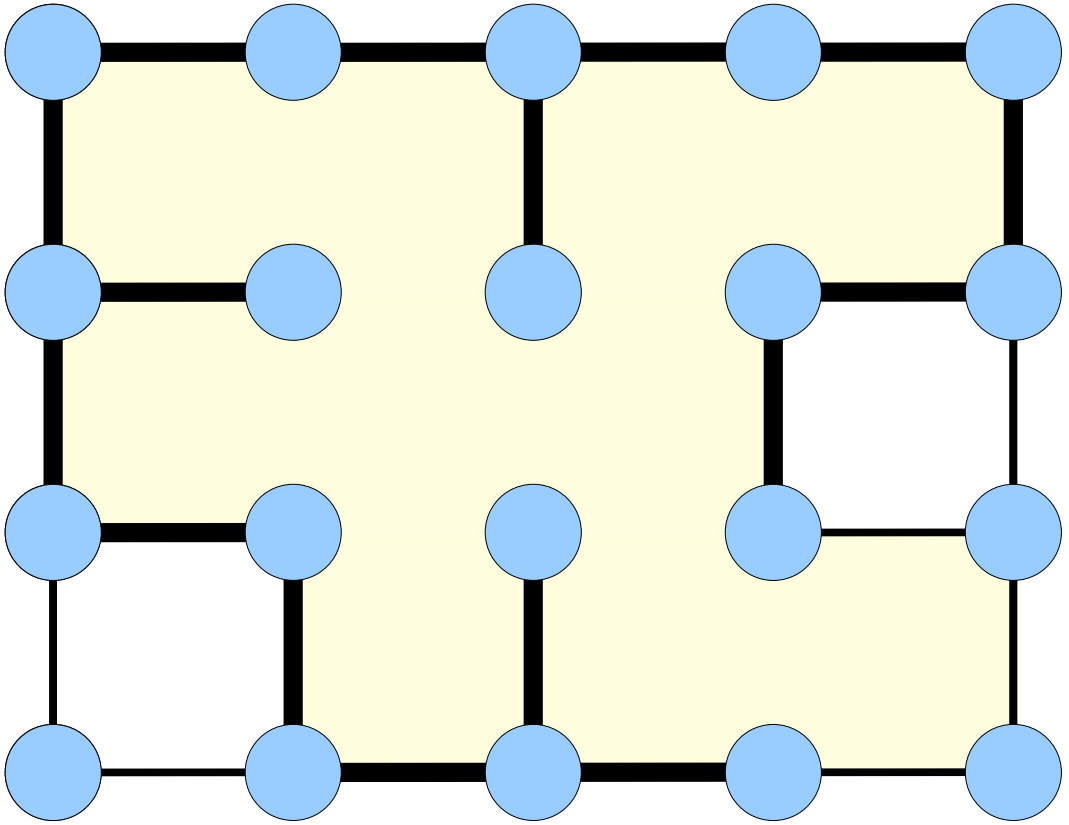

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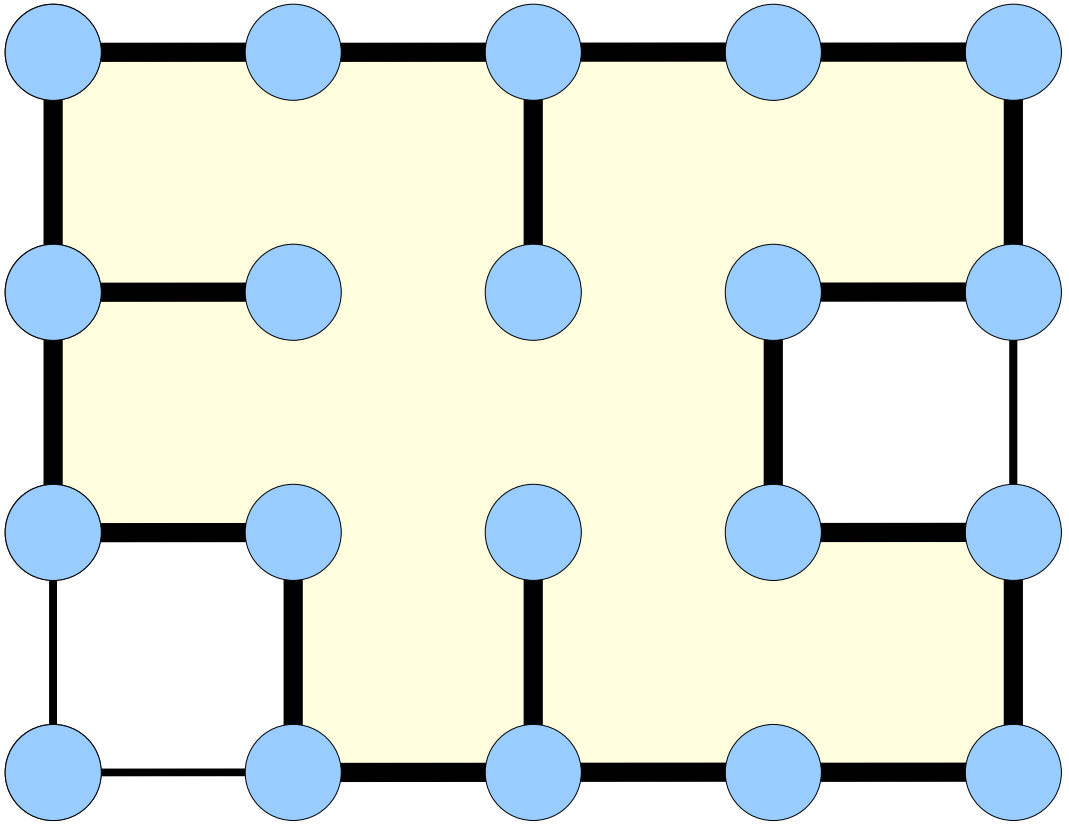

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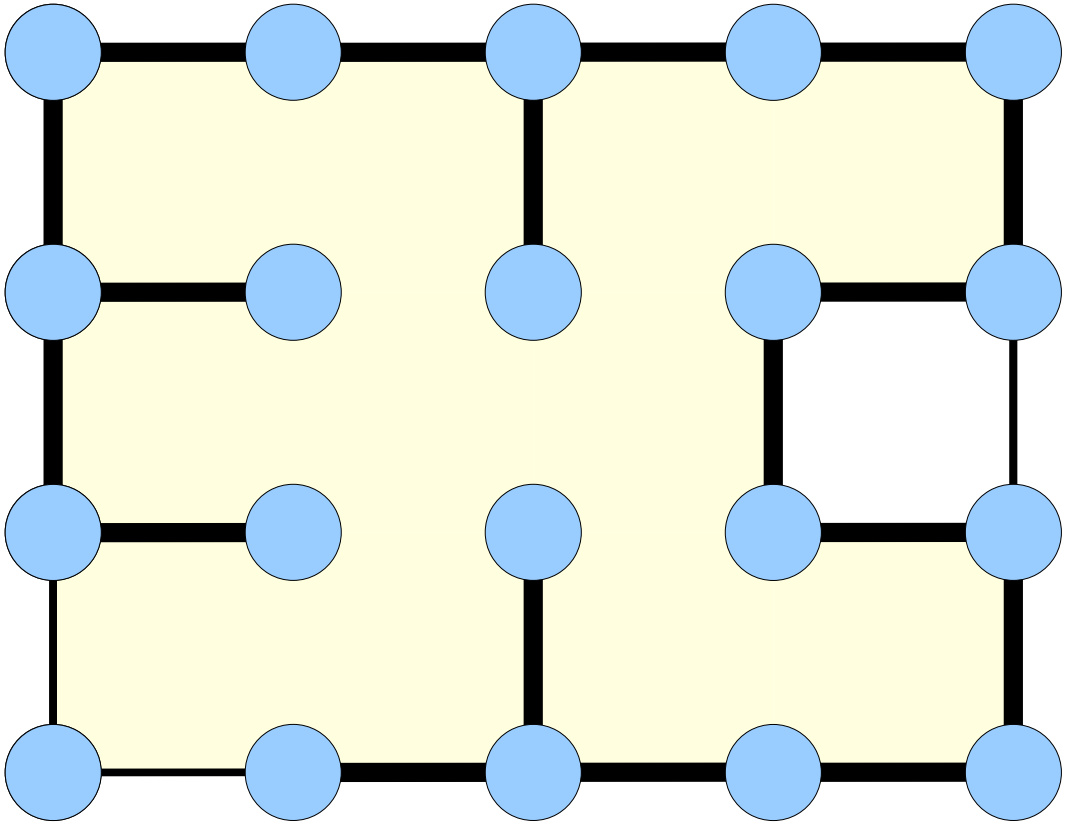

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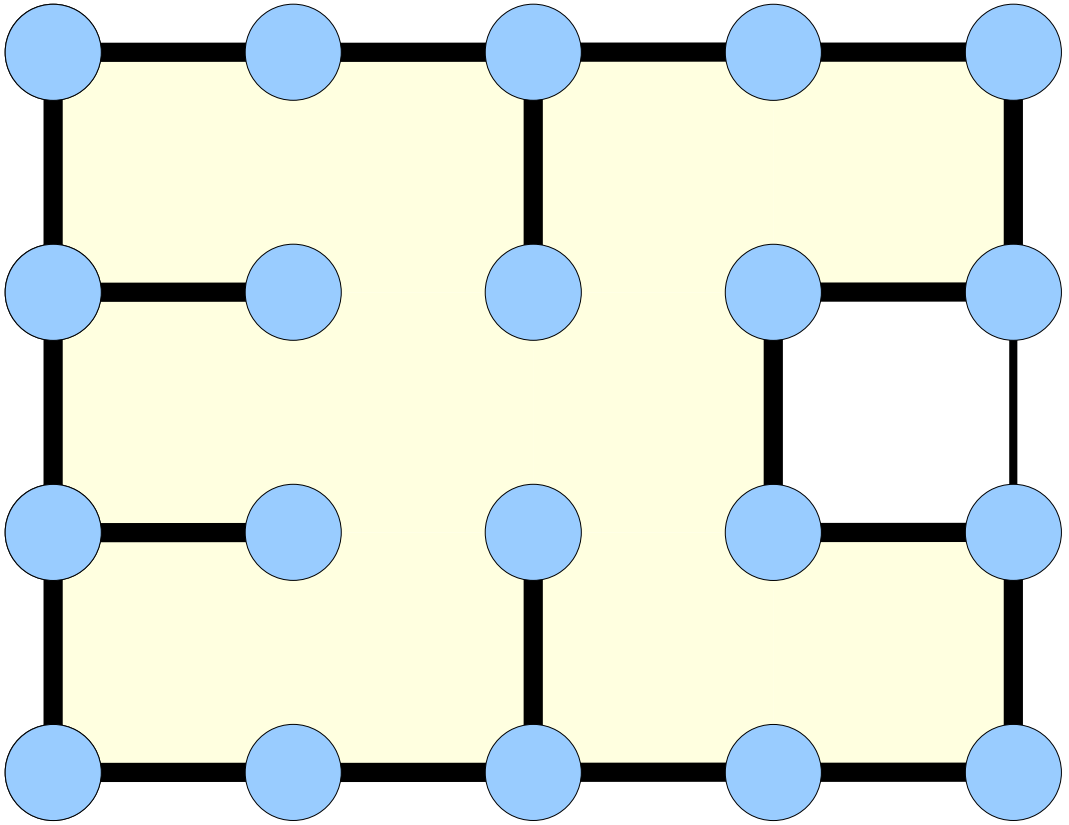

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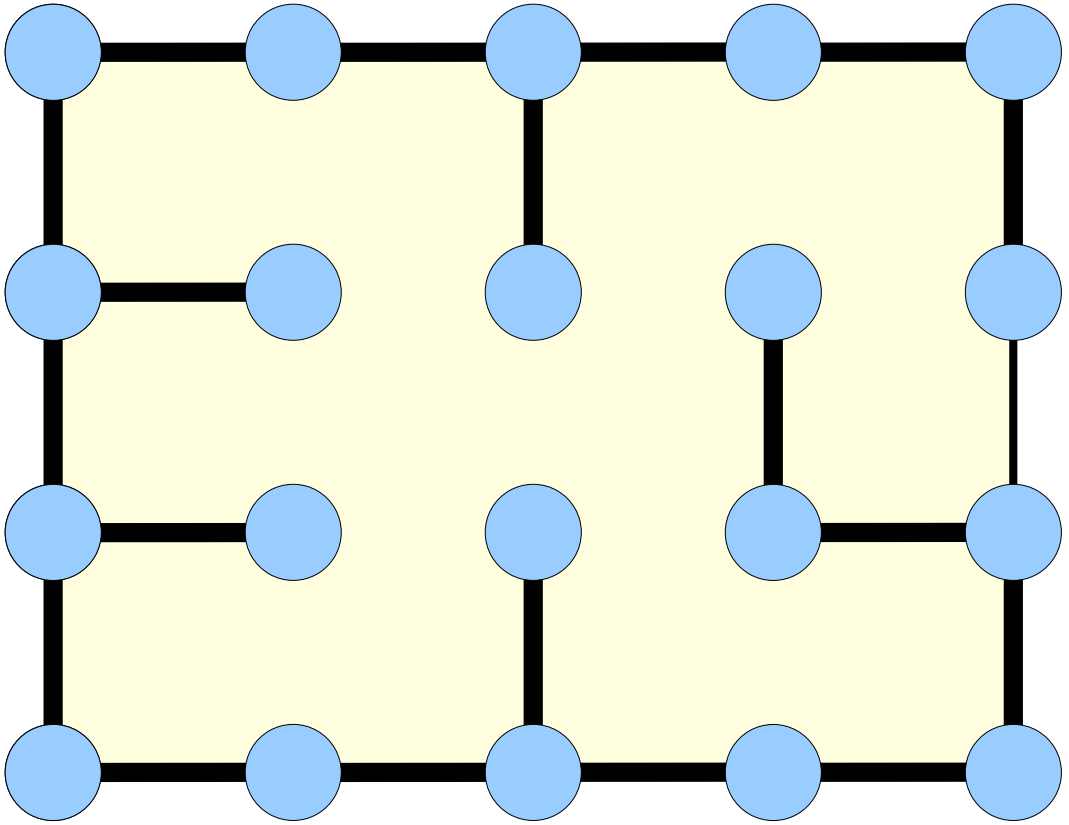

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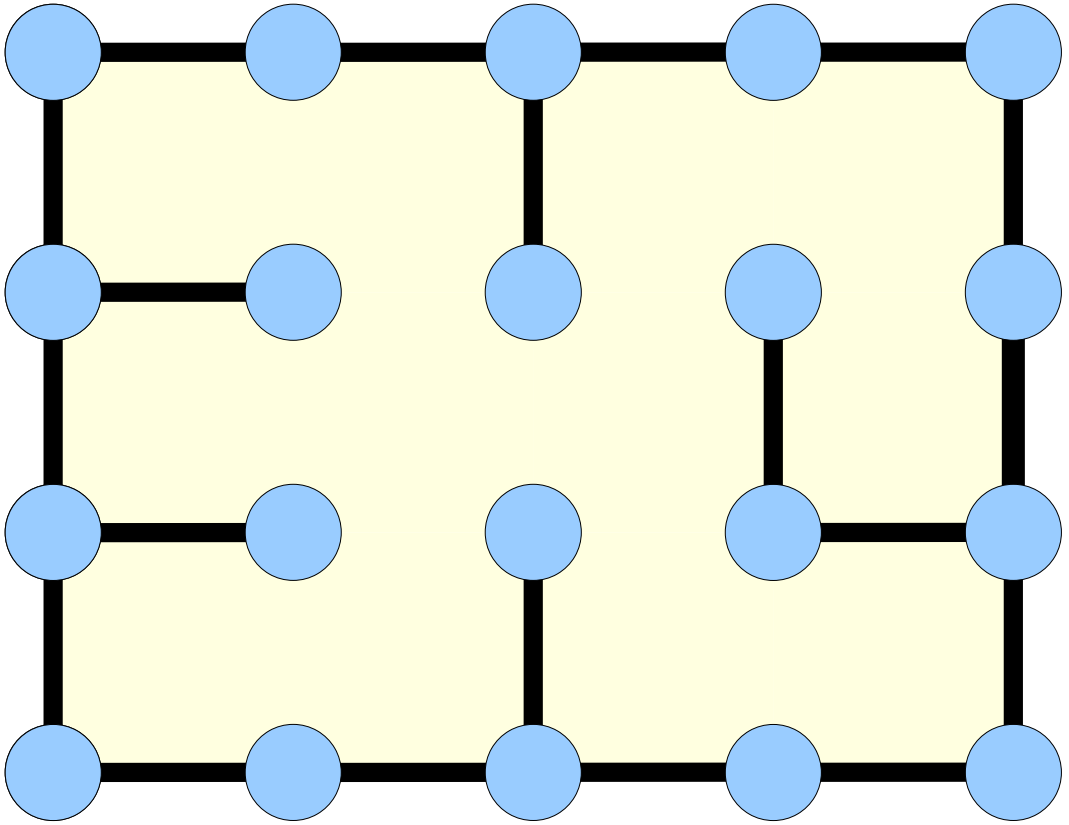


Generating Music

https://dice.humdrum.org/

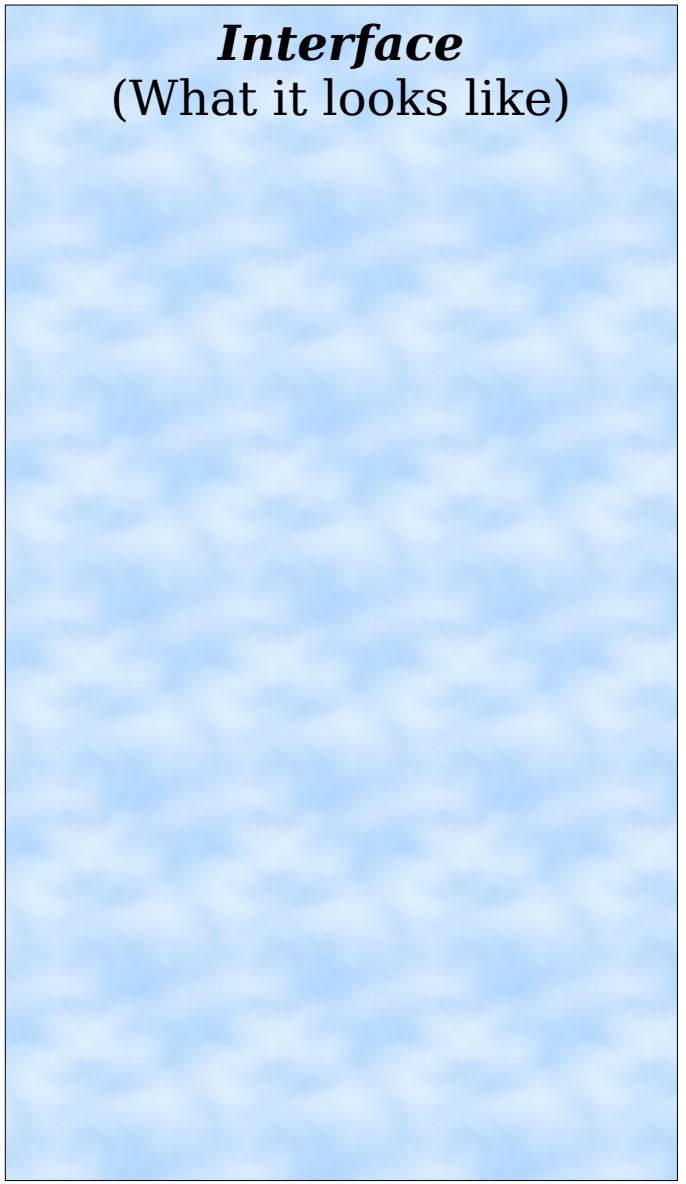
Random Bags

- A ***random bag*** is a container similar to a stack or queue. It supports two operations:
  - ***add***, which puts an element into the random bag, and
  - ***remove random***, which returns and removes a random element from the bag.
- This is exactly what we need for these examples:
  - ***Bananagrams:*** We ***add*** all the tiles to the bag. Whenever we need to draw, we call ***remove random*** to get another.
  - ***Mazes:*** We ***add*** the walls of the initial cell to the bag. Then we repeatedly ***remove random*** a wall, knock it down if it doesn't cause a loop, and add all walls of the new square into the maze.
  - ***Generating Music:*** We ***add*** all the music measures to the bag, then ***remove random*** enough to make a small tune.
- Unfortunately, there is no `RandomBag` type the way there's `Stack`, `Queue`, etc. How would we create one?

Classes in C++

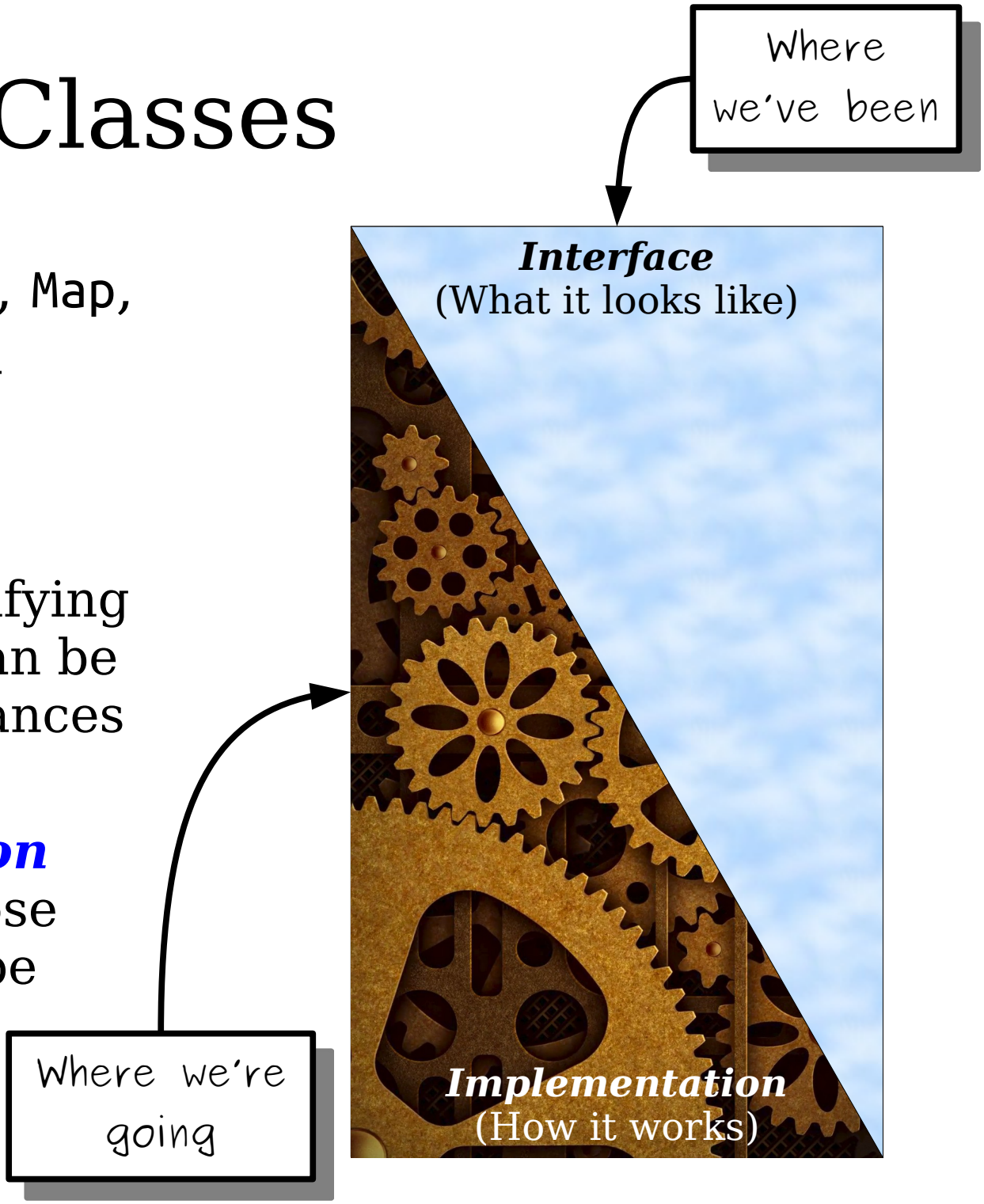
Classes

- `Vector`, `Stack`, `Queue`, `Map`, etc. are ***classes*** in C++.
- Classes contain
  - an ***interface*** specifying what operations can be performed on instances of the class.



Classes

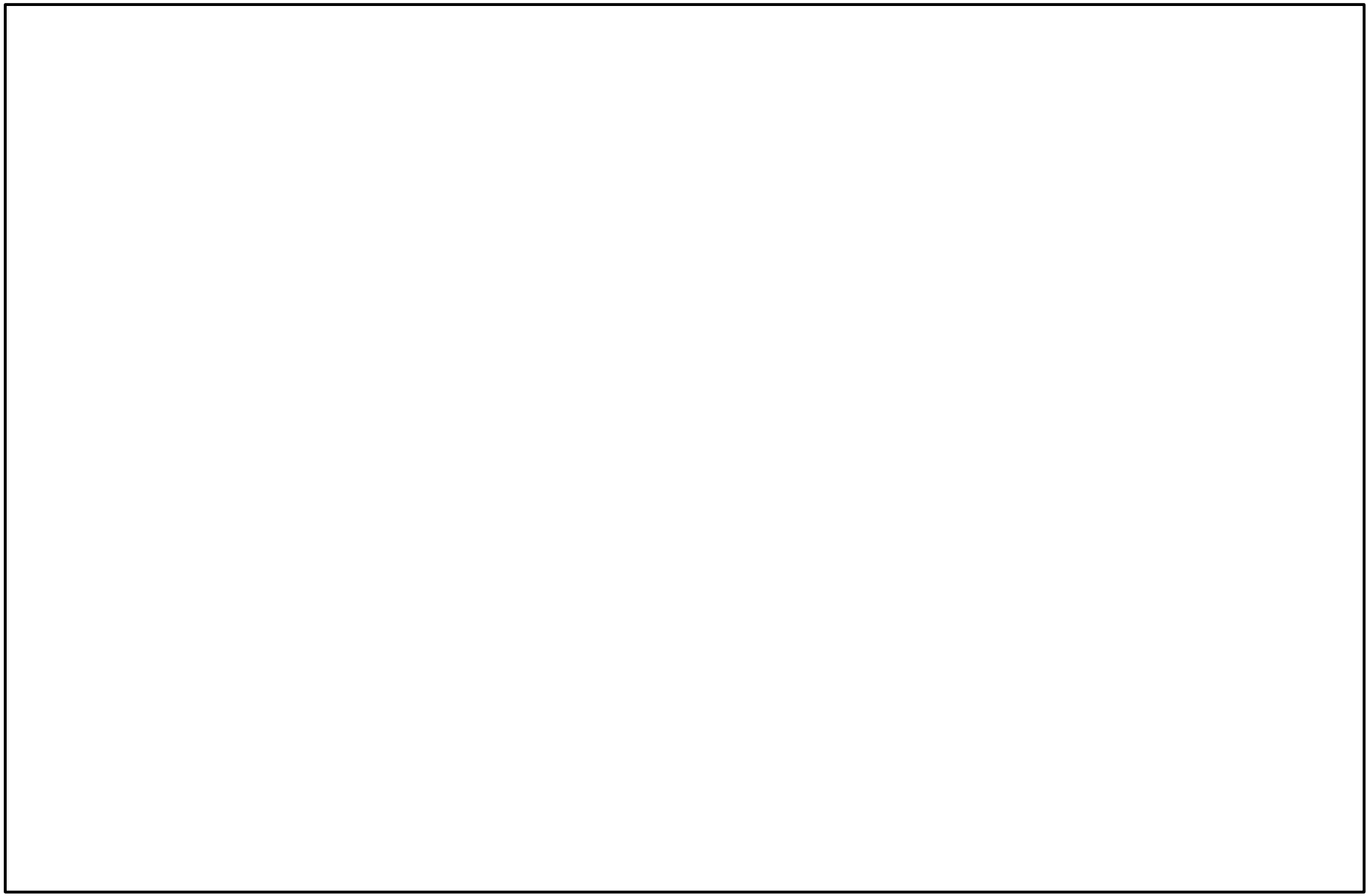
- `Vector`, `Stack`, `Queue`, `Map`, etc. are ***classes*** in C++.
- Classes contain
  - an ***interface*** specifying what operations can be performed on instances of the class, and
  - an ***implementation*** specifying how those operations are to be performed.



Classes

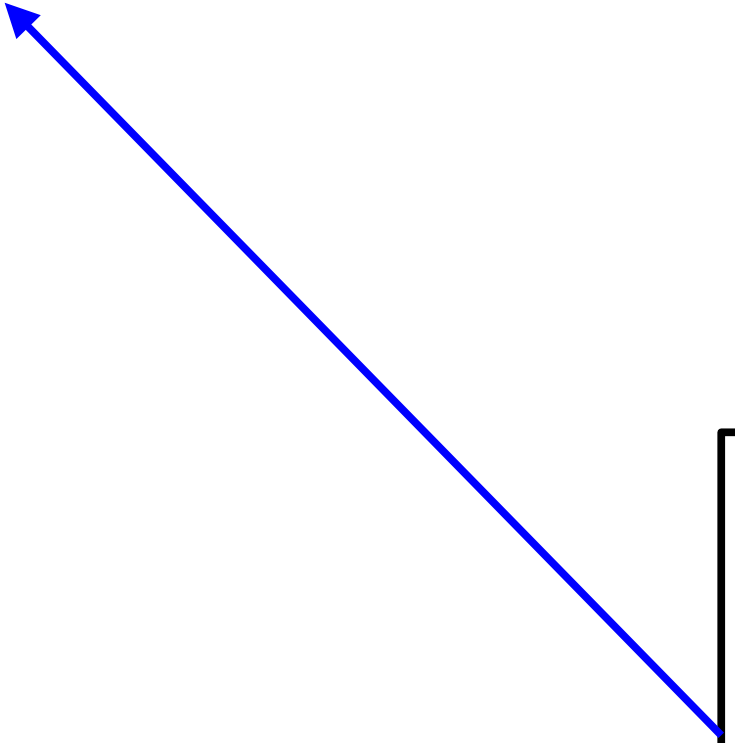
- Defining a class in C++ (usually) takes two steps:
  - Create a ***header file*** (ends in `.h`) specifying the interface and a few implementation details.
  - Create an ***implementation file*** (ends with `.cpp`) containing the class implementation.
- Clients of the class can then include the header file to use the class.

What’s in a Header?



What's in a Header?

```
#pragma once
```



This is called an ***include guard***. It's used to make sure weird things don't happen if you include the same header twice.

Curious how it works? Come talk to me after class!

What's in a Header?

```
#pragma once


class RandomBag {




};
```

This is a ***class definition***. We're creating a new class called `RandomBag`. Like a `struct`, this defines the name of a new type that we can use in our programs.

What's in a Header?

```
#pragma once


class RandomBag {



};
```

Don't forget to add this semicolon! You'll get some Hairy Scary Compiler Errors if you leave it out.

What's in a Header?

```
#pragma once


class RandomBag {
public:




private:

};
```

What's in a Header?

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class RandomBag {
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What's in a Header?

```
#pragma once


class RandomBag {
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private:

};
```

The ***public interface*** specifies what functions you can call on objects of this type.

Think things like the `Vector`'s `.add()` function or the `string`'s `.find()`.

What's in a Header?

```
#pragma once


class RandomBag {
public:



private:

};
```

The ***public interface*** specifies what functions you can call on objects of this type.

Think things like the `Vector`'s `.add()` function or the `string`'s `.find()`.

The ***private implementation*** contains information that objects of the class type will need in order to do their job properly. This is invisible to people using the class.

What's in a Header?

```
#pragma once


class RandomBag {
public:
    void add(int value);
    int  removeRandom();



private:

};
```

These are ***member functions*** of the `RandomBag` class. They're functions you can call on objects of the type `RandomBag`.

All member functions need to be declared in the class definition. We'll implement them in our .cpp file.

What's in a Header?

```
#pragma once

#include "vector.h"

class RandomBag {
public:
    void add(int value);
    int  removeRandom();




private:
    Vector<int> elems;
};
```

This is a ***data member*** of the class. This tells us how the class is implemented. Internally, we're going to store a `Vector<int>` holding all the elements. The only code that can access or touch this `Vector` is the `RandomBag` implementation.

What's in a Header?

```
#pragma once

#include "vector.h"

class RandomBag {
public:
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```
class RandomBag {
public:
    void add(int value);
    int  removeRandom();

    int  size();
    bool isEmpty();

private:
    Vector<int> elems;
};
```

```
class RandomBag {
public:
    void add(int value);
    int  removeRandom();

    int  size() const;
    bool isEmpty() const;

private:
    Vector<int> elems;
};
```

Your Action Items

- ***Prepare for the Midterm***
  - There's the review session slides, three practice exams up on the course website, and a huge searchable bank of practice problems to pull from. Best of luck – ***you can do this!***
- ***Read Chapter 6 of the textbook.***
  - There's a ton of goodies in there about class design that we'll talk about later on.

Next Time

- ***Midterm on Monday – No Class***
- ***Then, When We Get Back…***
  - ***Dynamic Allocation***
    - Where does memory come from?
  - ***Constructors and Destructors***
    - Taking things out and putting them away.
  - ***Implementing the Stack***
    - Peering into our tools!