

A *Cognitive* Computational Complexity Project

Simone Severini
University College London

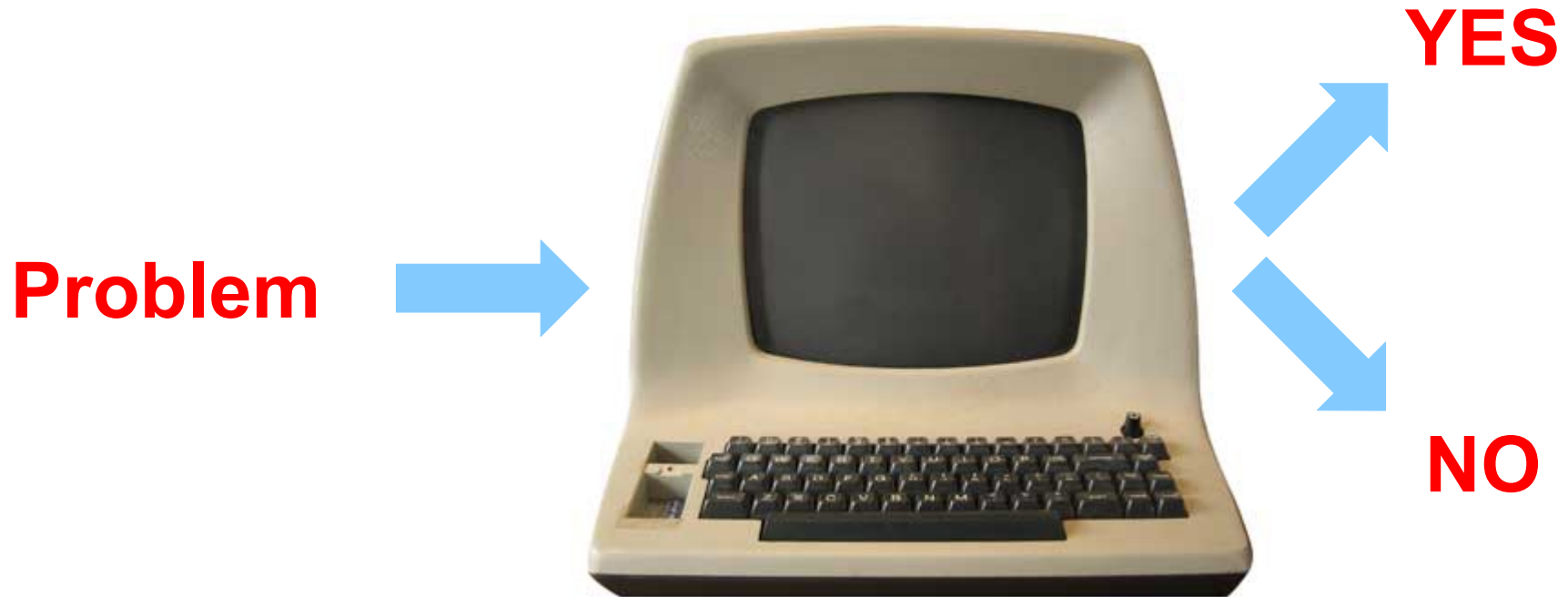


Oxford, April 2013



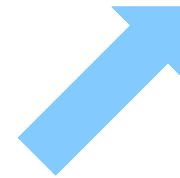
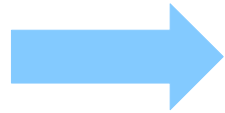
**This talk is about
a citizen science project
involving
*computation and cognition***

Computational problems



Computational problems

2 + 2 = 4?



YES

**There is wide belief that
all problems can be classified
into *two families***

**There is wide belief that
all problems can be classified
into *two families***

Easy problems

Hard problems

**There is wide belief that
all problems can be classified
into *two families***

Easy problems

Hard problems



Solved quickly

Solved slowly

Easy problem

Easy problem



Put some letters in alphabetical order

Hard problem

Hard problem



Find the shortest route between multiple cities

**Hard problems are
*important and unavoidable***

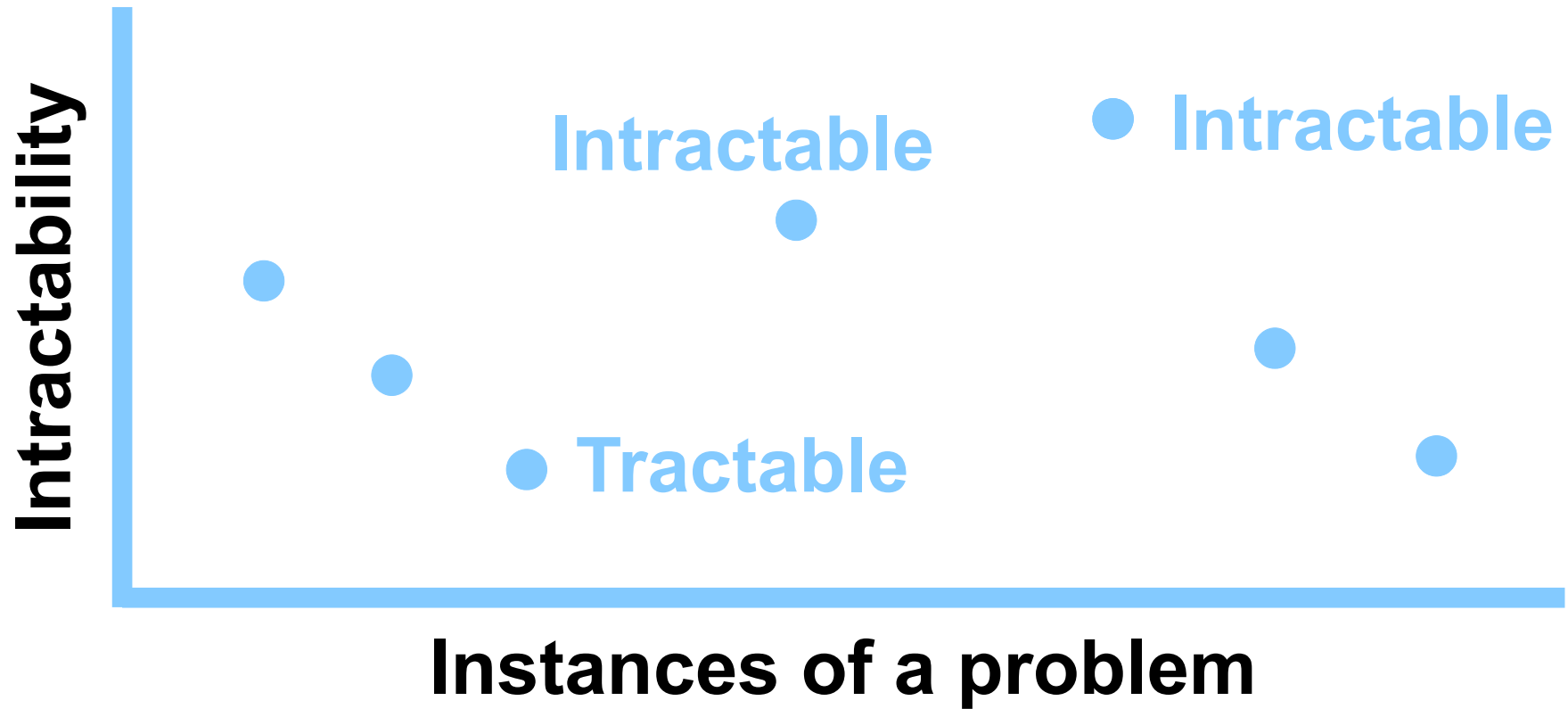


They guarantee information security



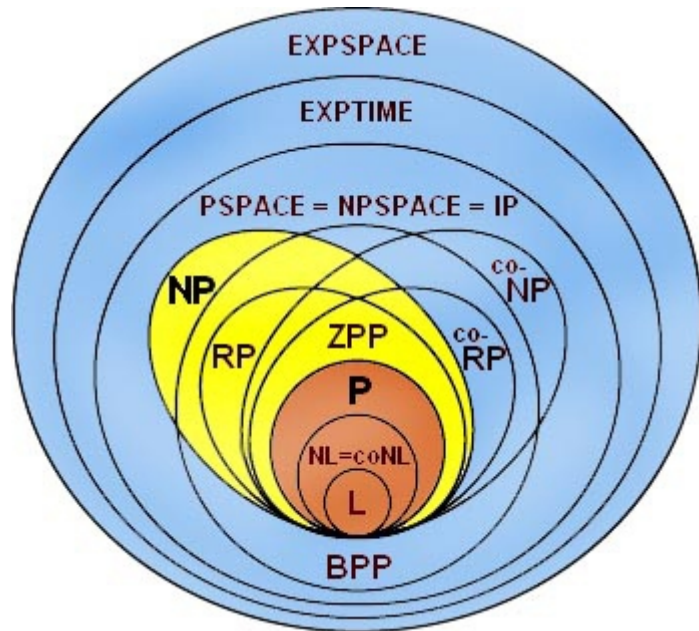
They are ubiquitous in science

Not every instance of a hard problem is hard



There are parameters telling us how *intractable* a hard problem is

Parametrizing complexity is fundamental



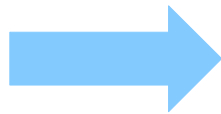
In mathematics

In practice

**What about *cognitive*
complexity parameters?**

What about *cognitive complexity* parameters?

2 + 2 = 4?



YES

Paradoxically, we replace computers with human beings

Observation:

**when we program a computer
to solve a problem,
we think like a computer**

Observation:

**when we program a computer
to solve a problem,
we think like a computer**

**when we use our brain
to solve a problem,
we (often) just solve the problem**

Caveat:

**Computational
complexity**



**Well
defined**

**Cognitive
computational
complexity**



**A bit
fuzzy**

Main question:

Does it make sense to define cognitive computational complexity parameters and *compare* those with (standard) computational complexity parameters

Main question:

Does it make sense to define cognitive computational complexity parameters and *compare* those with (standard) computational complexity parameters

Today, this is plausible because of citizen science (crowdcrafting)

How do we do that?

How do we do that?



**Let the crowd play
some “mathematical games”**

Is this weird?

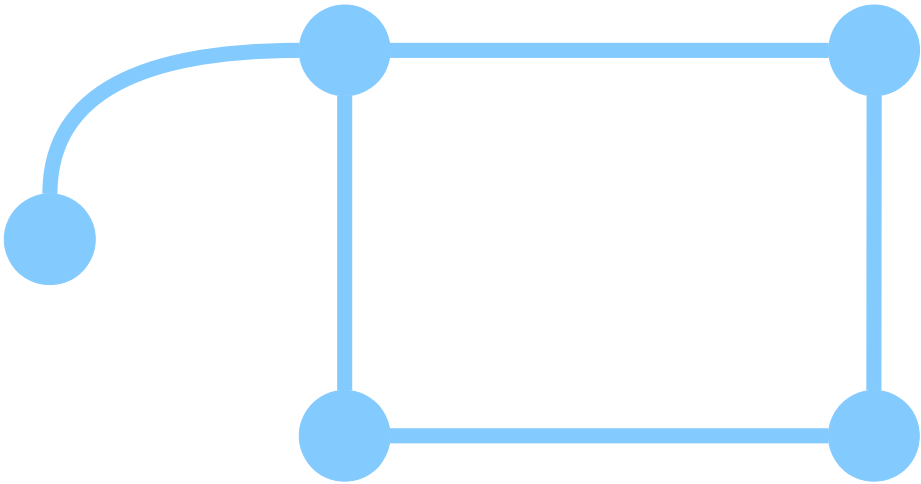
Is this weird?

5	3	4	6	7	8	9	1	2
6	7	2	1	9	5	3	4	8
1	9	8	3	4	2	5	6	7
8	5	9	7	6	1	4	2	3
4	2	6	8	5	3	7	9	1
7	1	3	9	2	4	8	5	6
9	6	1	5	3	7	2	8	4
2	8	7	4	1	9	6	3	5
3	4	5	2	8	6	1	7	9



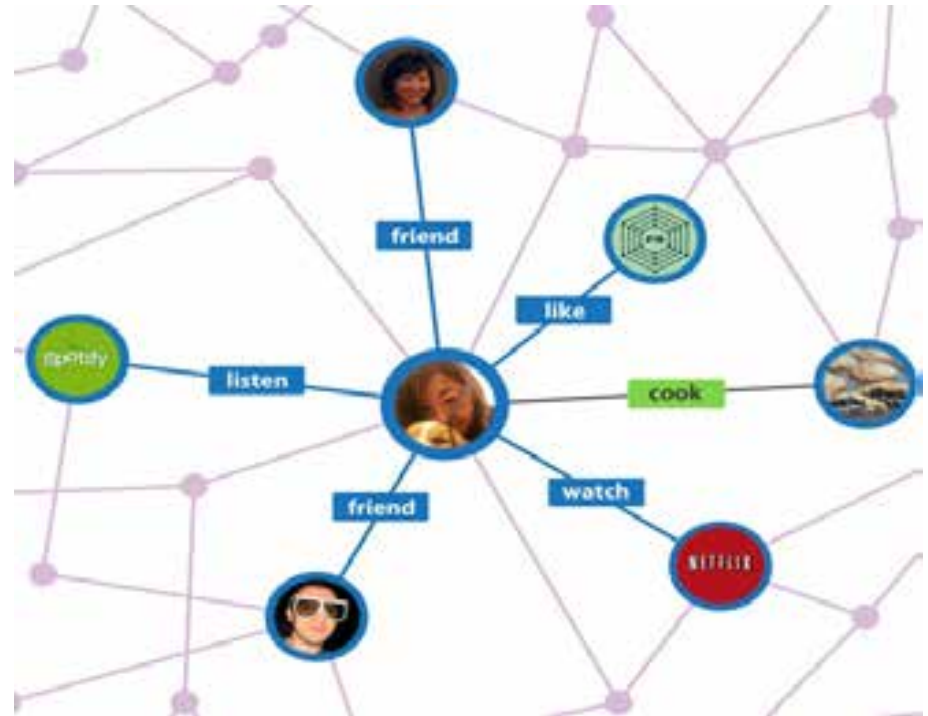
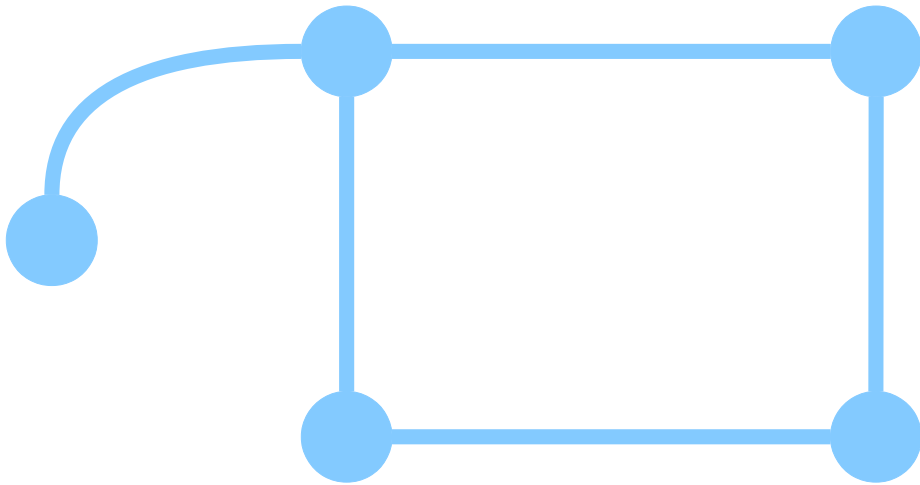
Not really :-)

Graphs

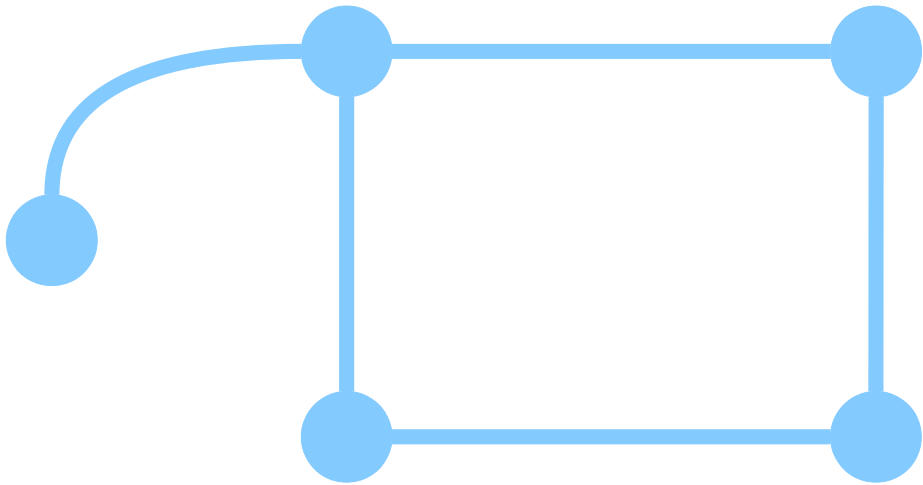


**What game should we play to
start with?**

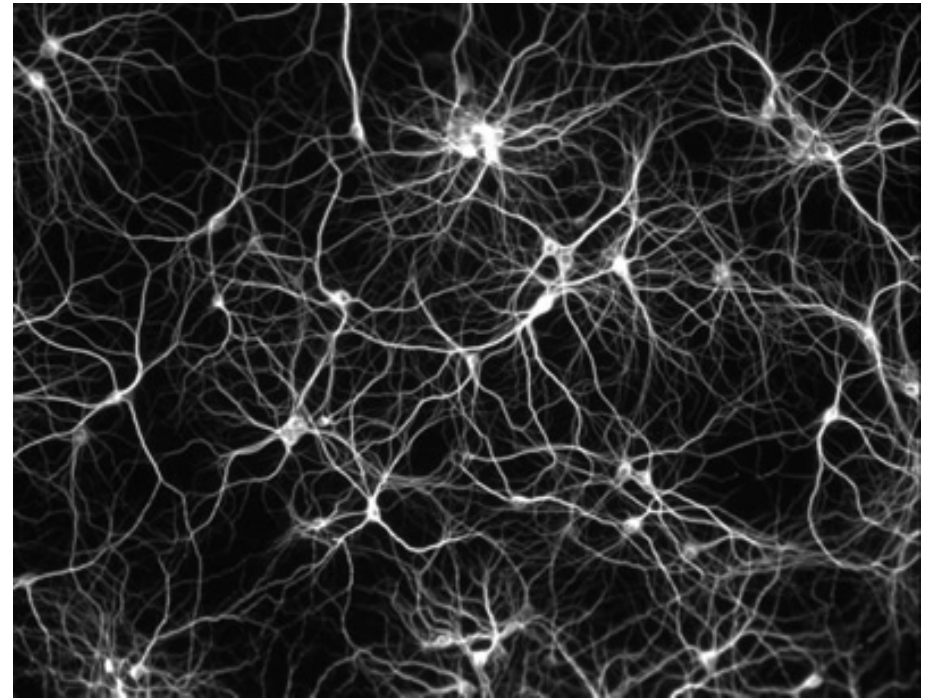
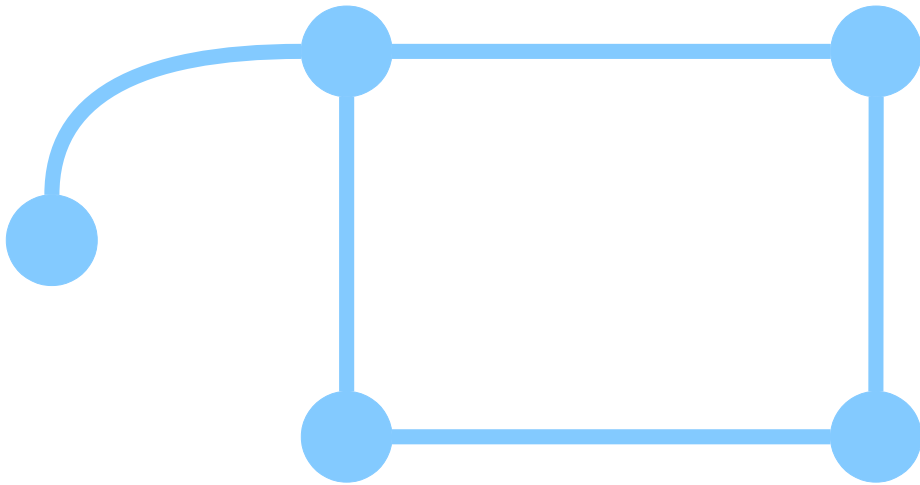
Graphs



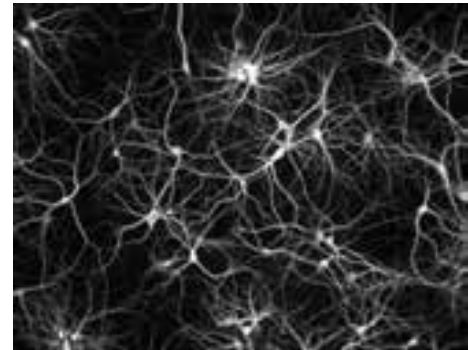
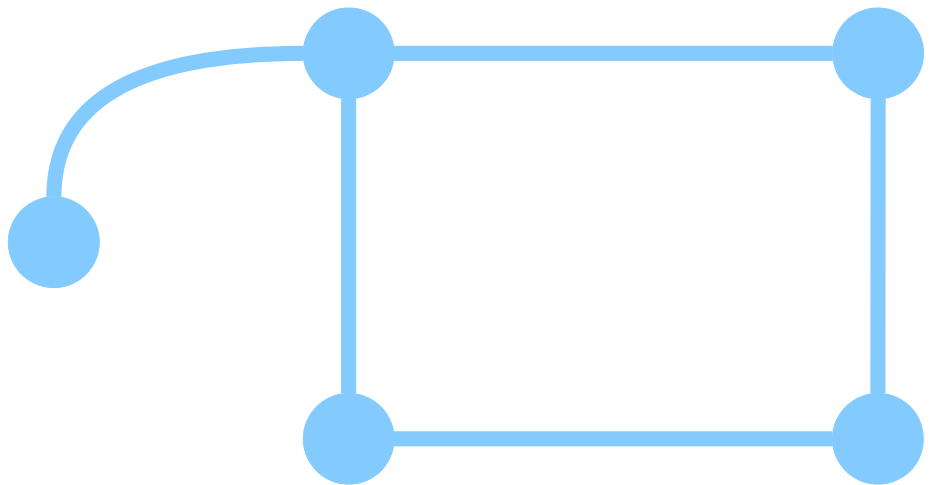
Graphs



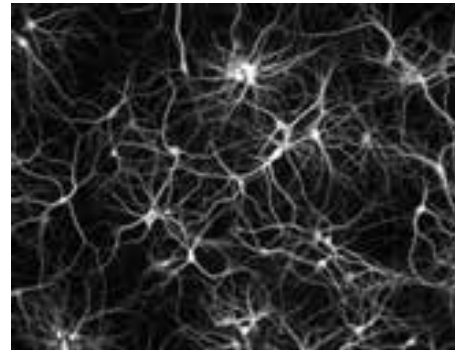
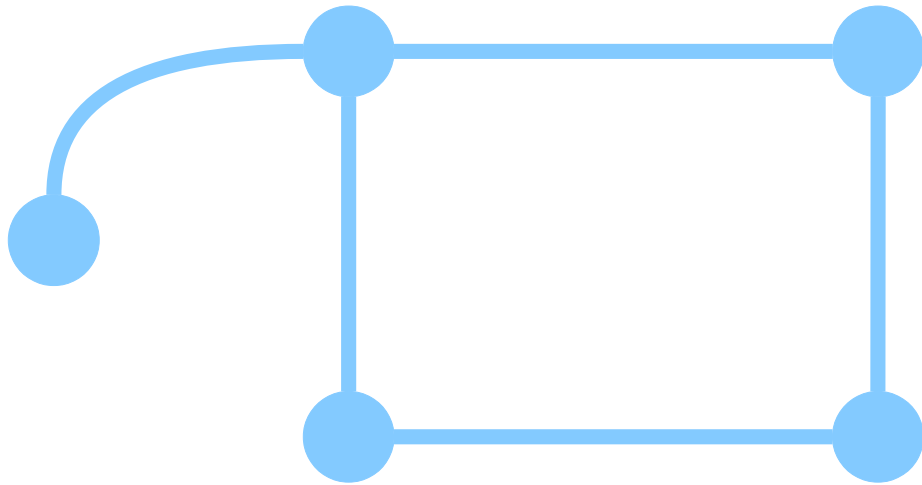
Graphs



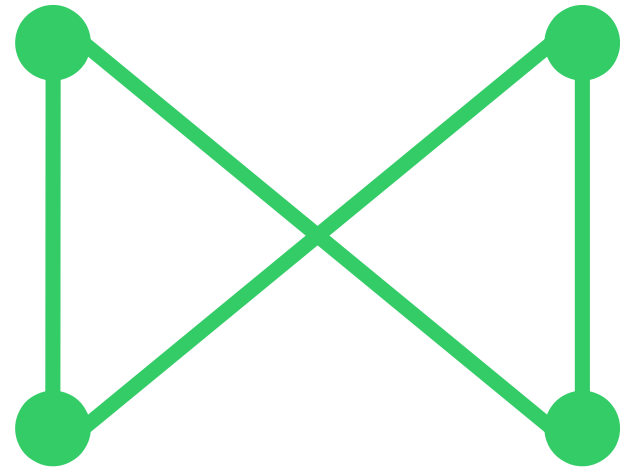
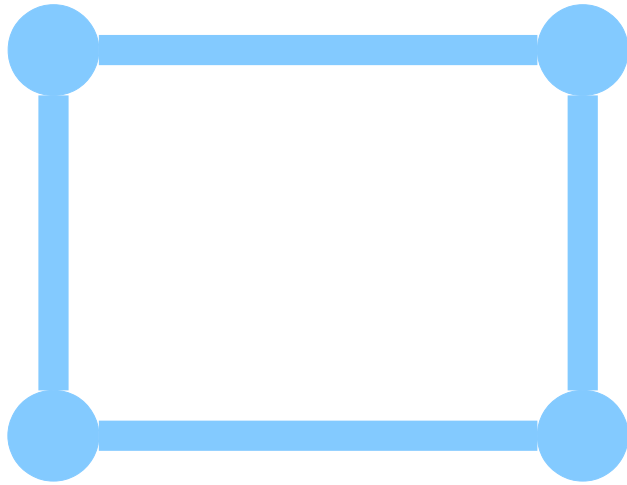
Graphs



Graphs

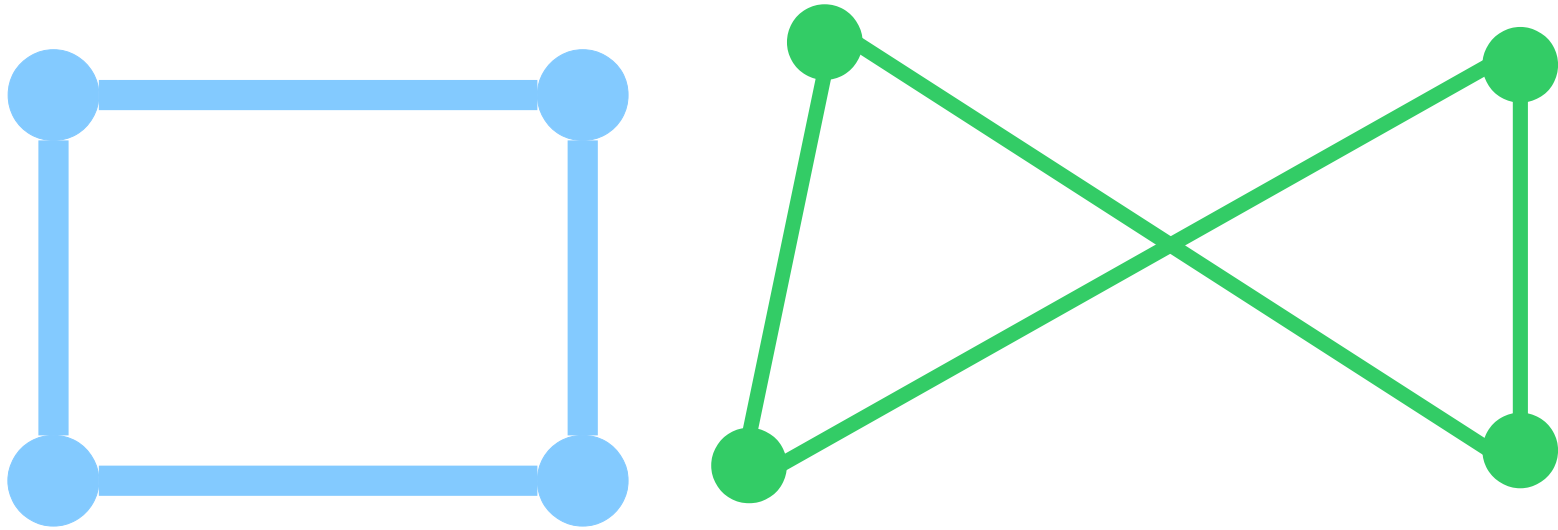


Isomorphism testing



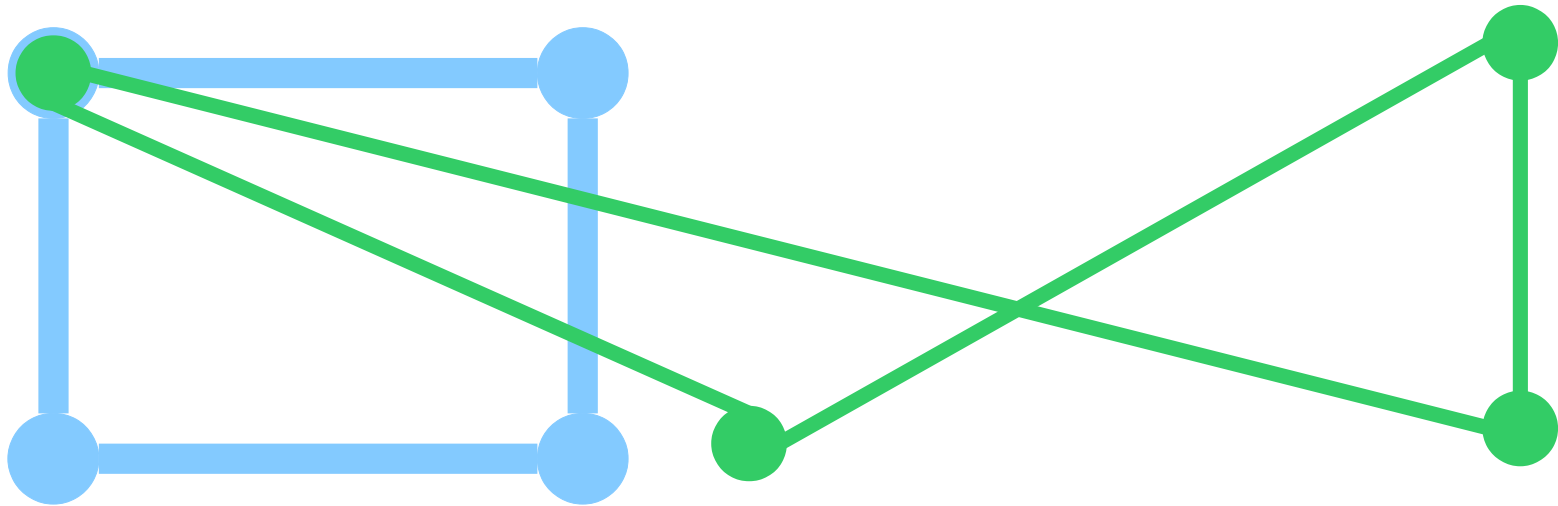
**Given two graphs,
can we “superimpose” them perfectly?**

Isomorphism testing



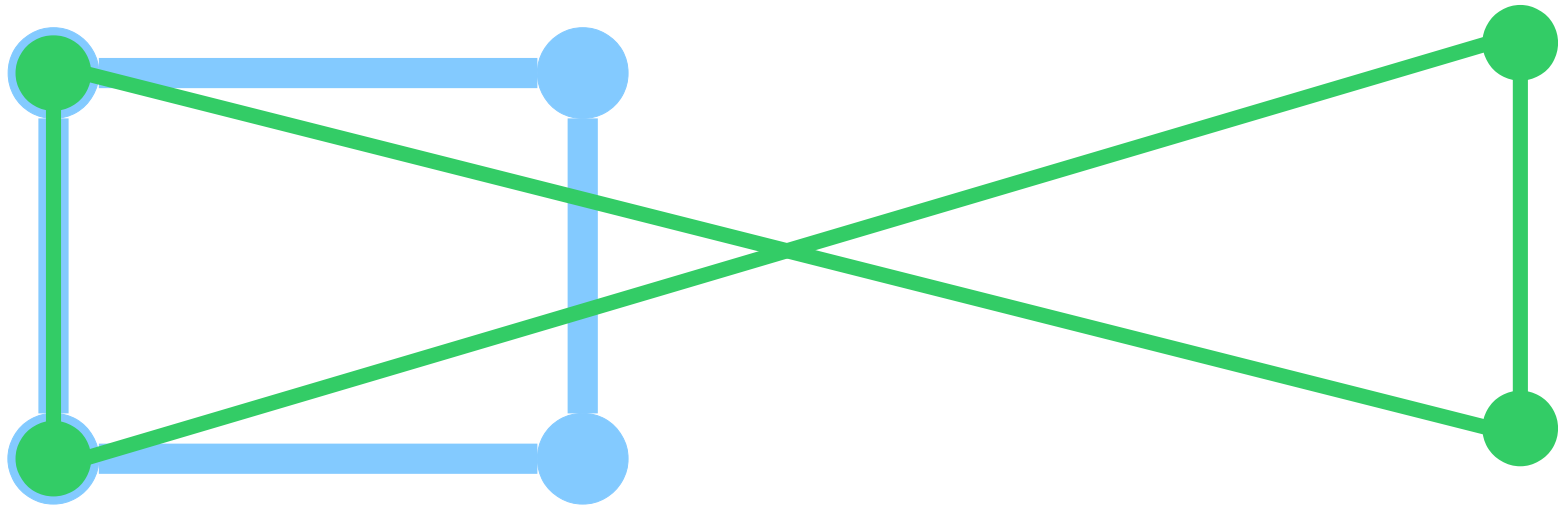
**Given two graphs,
can we “superimpose” them perfectly?**

Isomorphism testing



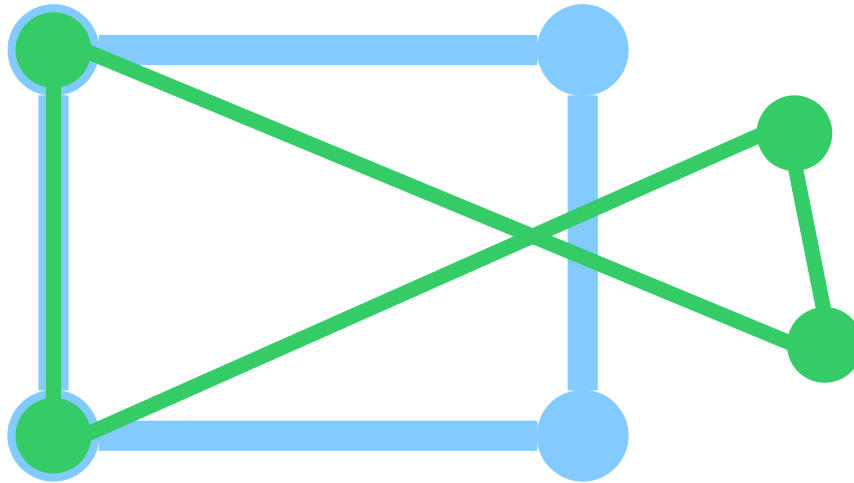
**Given two graphs,
can we “superimpose” them perfectly?**

Isomorphism testing



**Given two graphs,
can we “superimpose” them perfectly?**

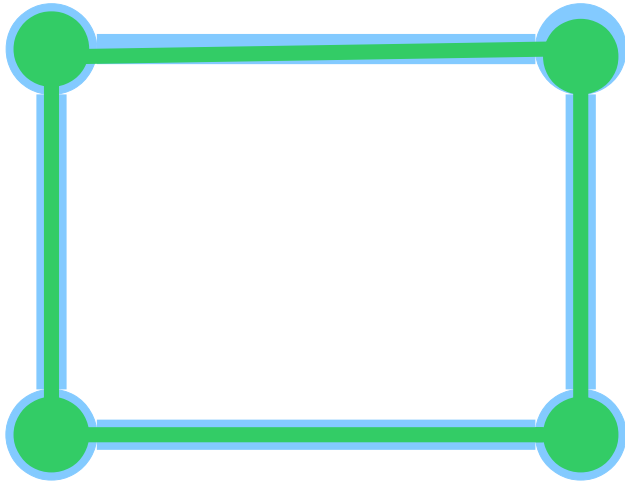
Isomorphism testing



YES

**Given two graphs,
can we “superimpose” them perfectly?**

Isomorphism testing



**Given two graphs,
can we “superimpose” them perfectly?**

Why is this game good?

1) *Isomorphism testing* is an interesting problem of *unclear* computational complexity;

2) Popularize *real mathematical questions* and engage the players;

3) Complexity parameters for graphs are *useful*;

4) This game is very *easy to describe*;

5) There are *lots of other games* we could play with graphs (e.g., colouring).



GAME

What do we need to do?

1) The *data collected* could be used to define a new graph parameter: graphs for which the game takes longer may be considered “more complex”;

2) *Rewards* for good players (e.g., badges, etc.);

3) *Crowdcrafting* on the web (crowdcrafting.org), smartphones apps, etc.;

4) Of course, it all depends on the *number* of players. :-/

What is the next step?

What is the next step?

To play the games