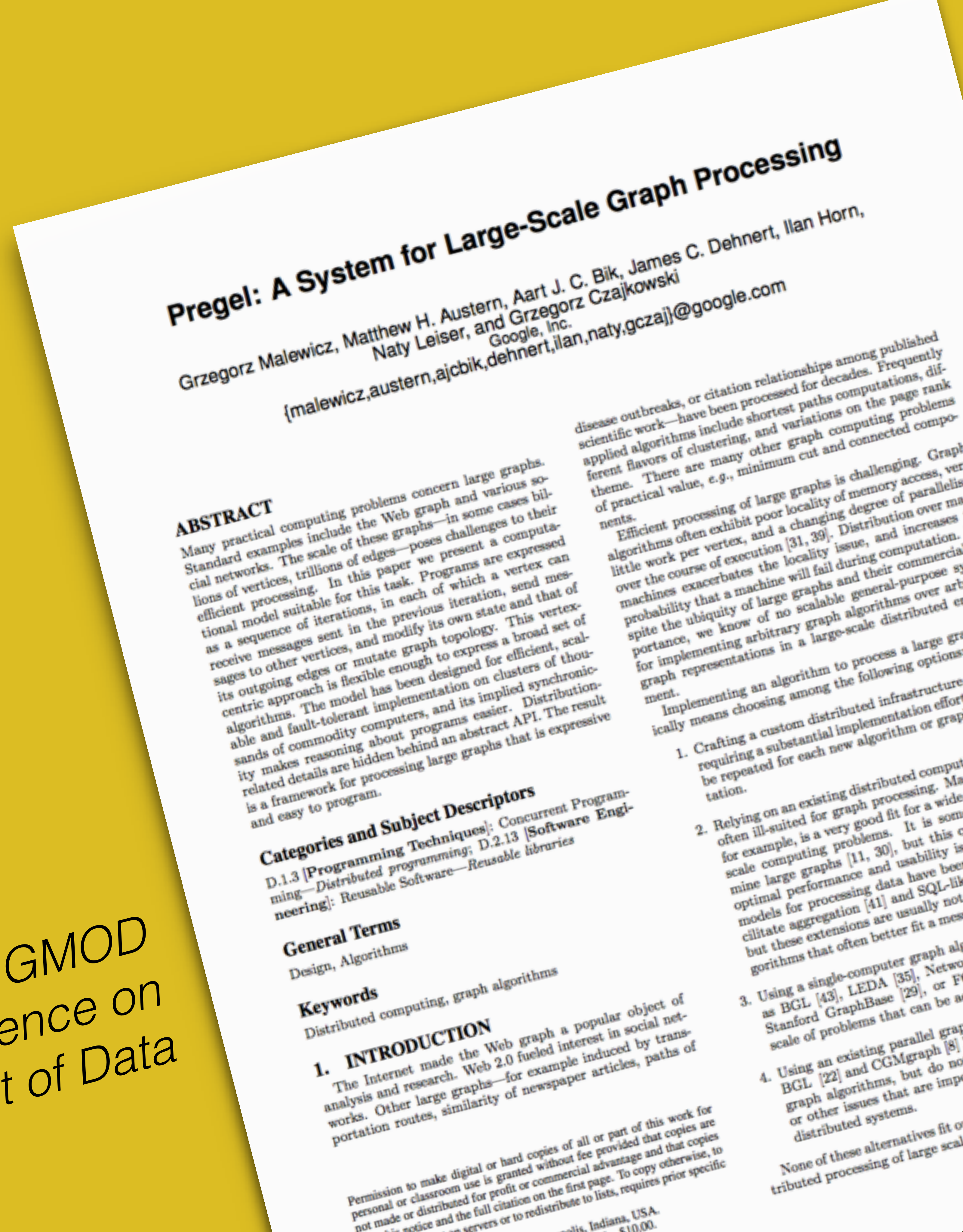
Pregel: A System for Large Scale Graph Processing

Malewicz, et.al

Presenter: Stephan Brandauer

This talk:
- High level intro



Pregel: A System for Large-Scale Graph Processing

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ABSTRACT

Many practical computing problems concern large graphs. Standard examples include the Web graph and various social networks. The scale of these graphs—in some cases billions of vertices, trillions of edges—poses challenges to their efficient processing. In this paper we present a computational model suitable for this task. Programs are expressed as a sequence of iterations, in each of which a vertex can receive messages sent in the previous iteration, send messages to other vertices, and modify its own state and that of its outgoing edges or mutate graph topology. This vertex-centric approach is flexible enough to express a broad set of algorithms. The model has been designed for efficient, scalable and fault-tolerant implementation on clusters of thousands of commodity computers, and its implied synchronicity makes reasoning about programs easier. Distribution-related details are hidden behind an abstract API. The result is a framework for processing large graphs that is expressive and easy to program.

Categories and Subject Descriptors

D.1.3 [Programming Techniques]: Concurrent Programming—*Distributed programming*; D.2.13 [Software Engineering]: Reusable Software—*Reusable libraries*

General Terms

Design, Algorithms

Keywords

Distributed computing, graph algorithms

1. INTRODUCTION

The Internet made the Web graph a popular object of analysis and research. Web 2.0 fueled interest in social networks. Other large graphs—for example induced by transportation routes, similarity of newspaper articles, paths of

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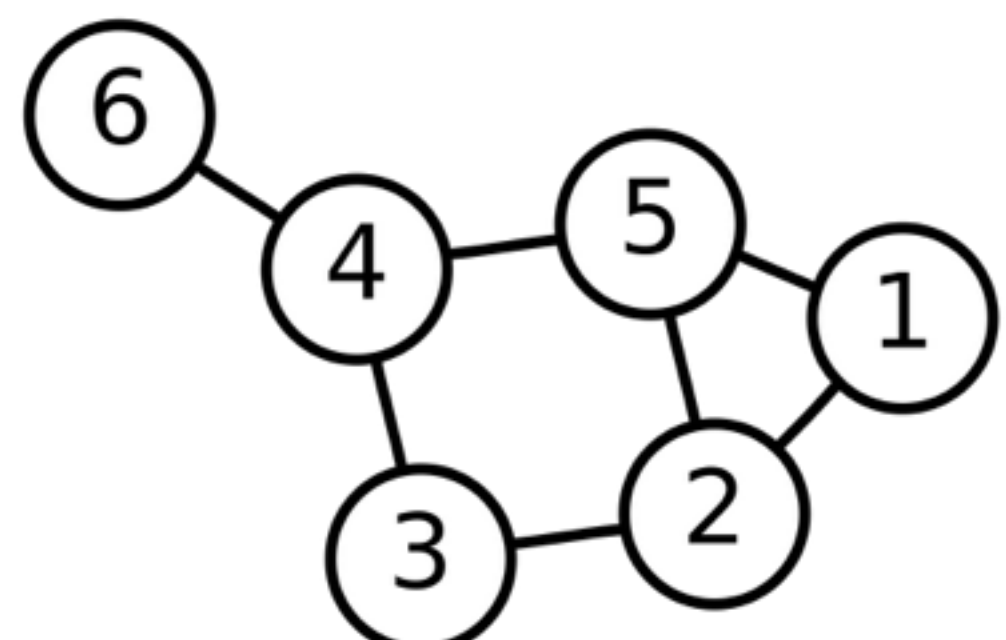
I like high level abstractions that carefully exploit their semantics for optimisations.

Pregel is a particularly pretty case.

Graph Processing: hard to **parallelise**

Graphs are connected by nature — it's easy to get data races.



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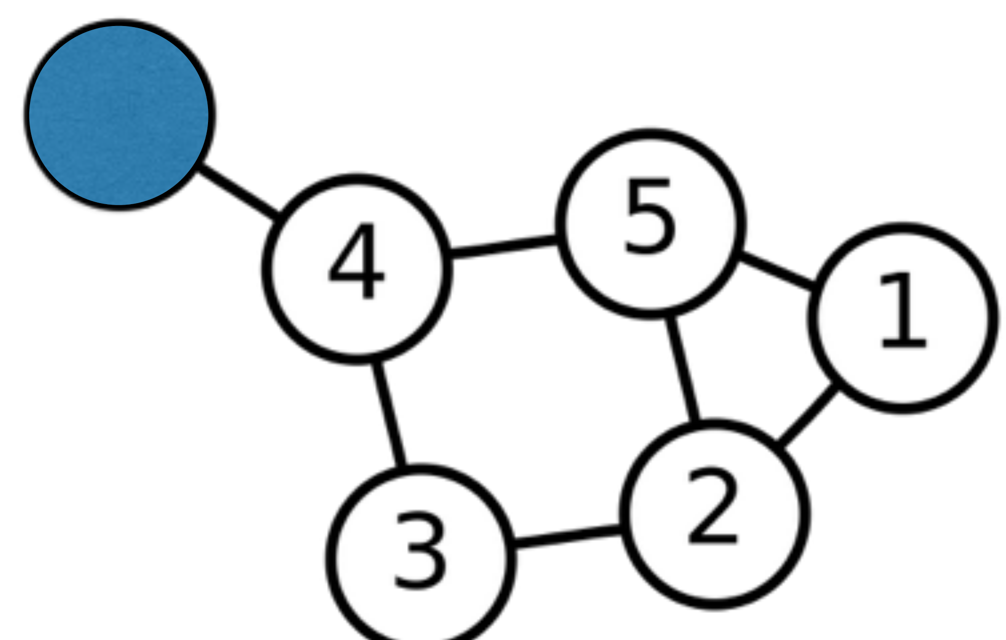

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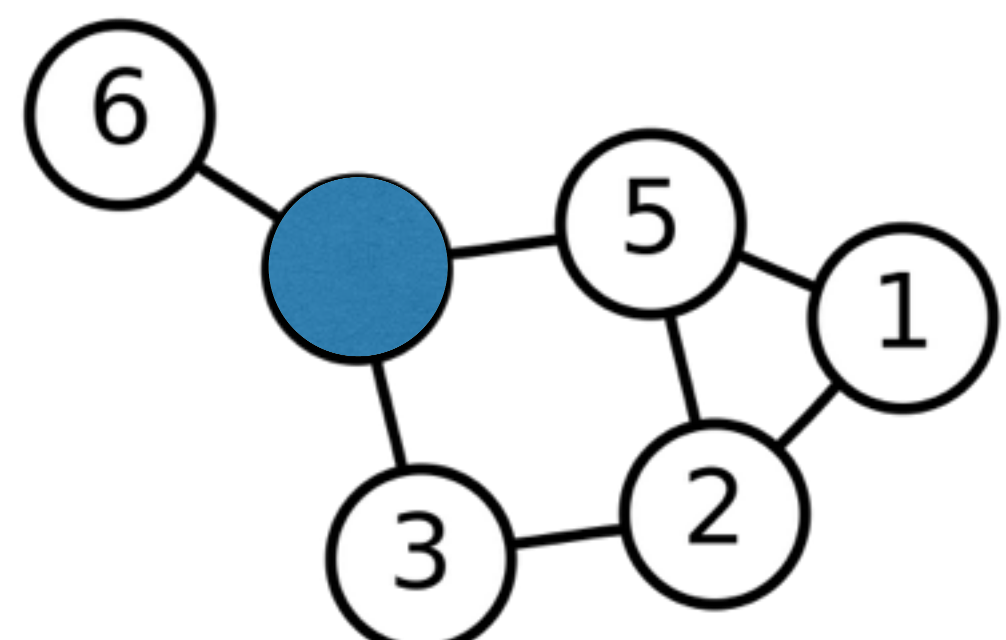

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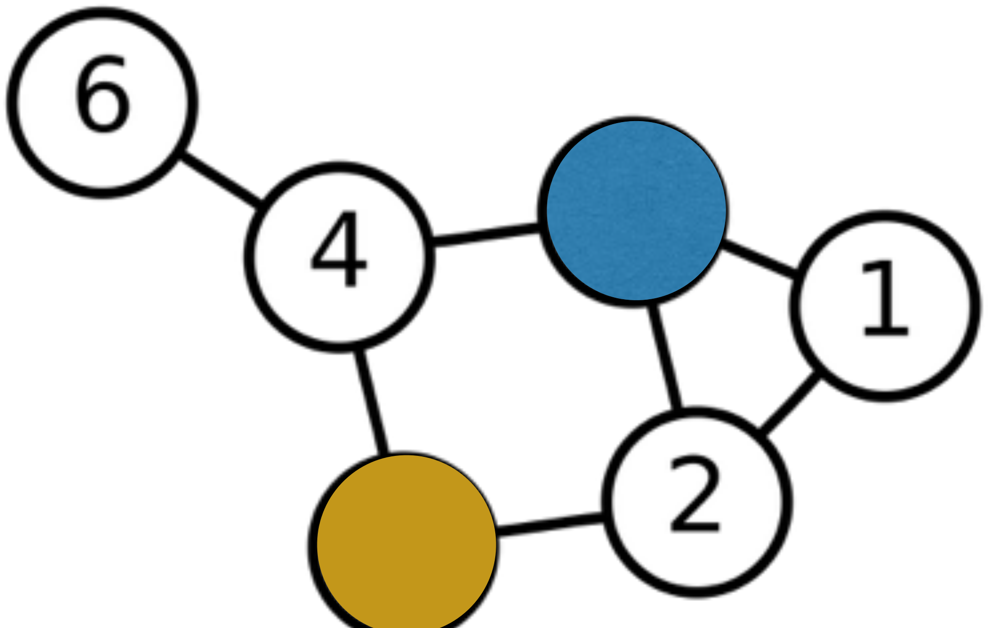

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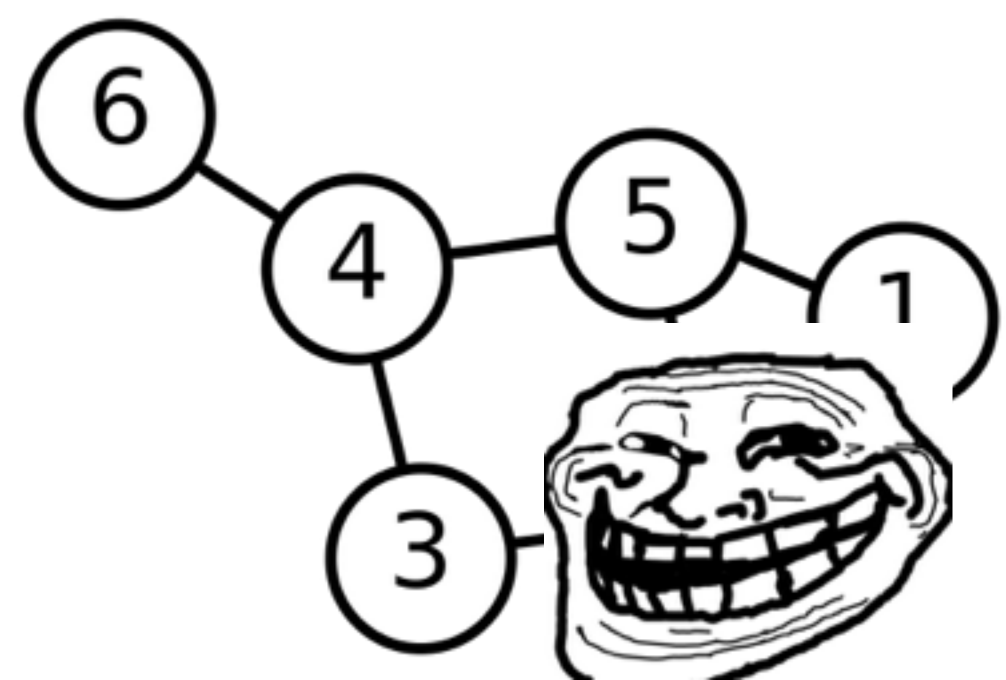
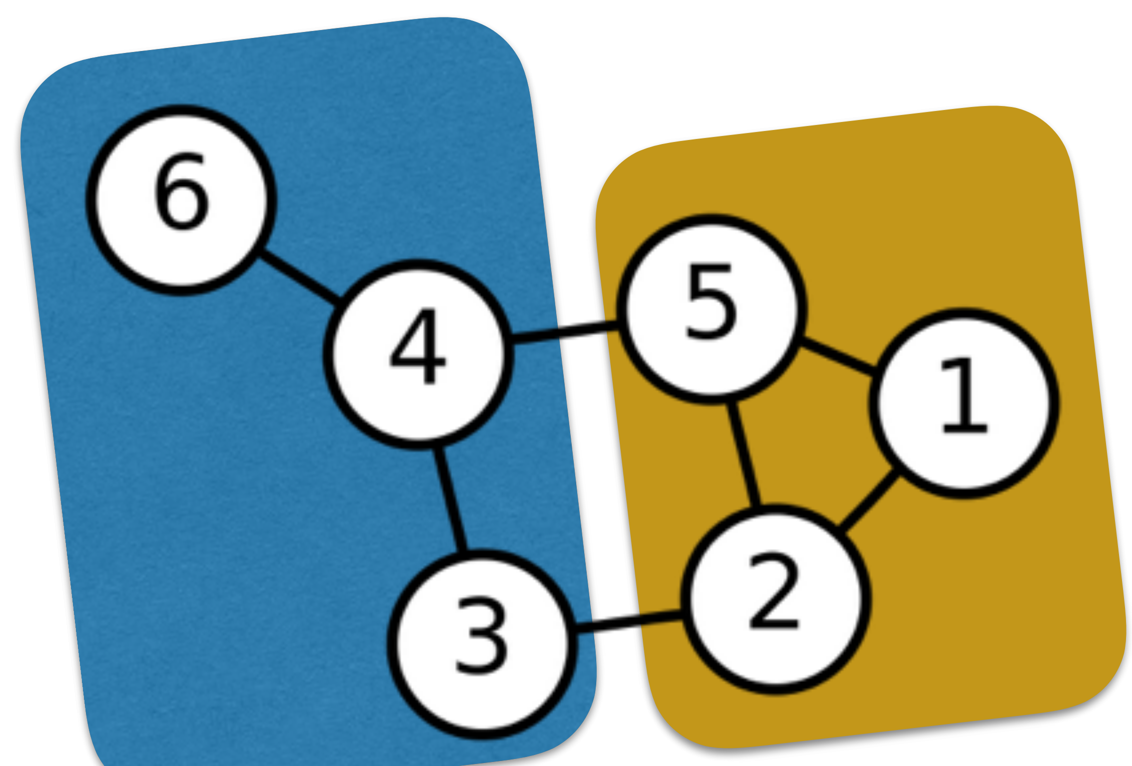


Graph Processing: hard to **distribute**

Same problems as parallelisation AND
deal with machine failures



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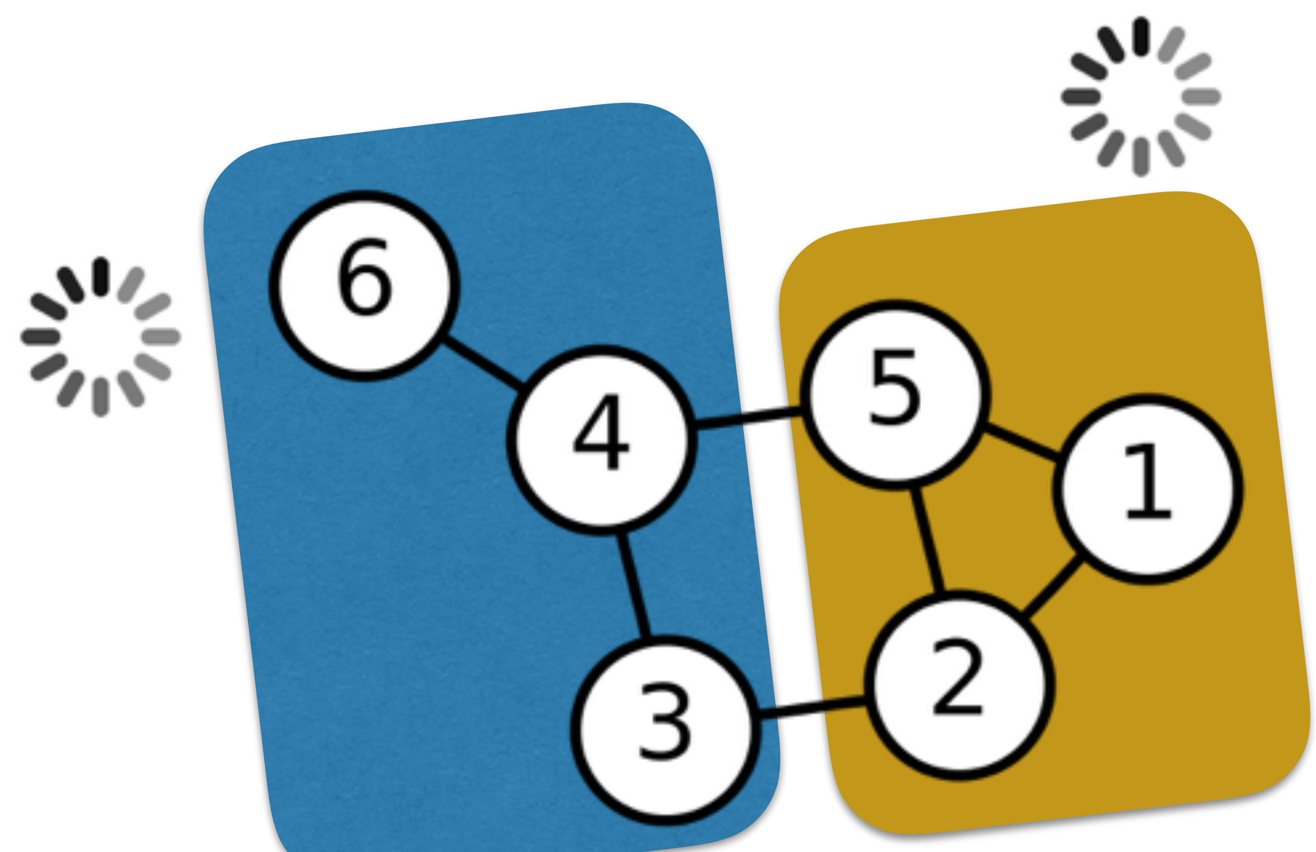

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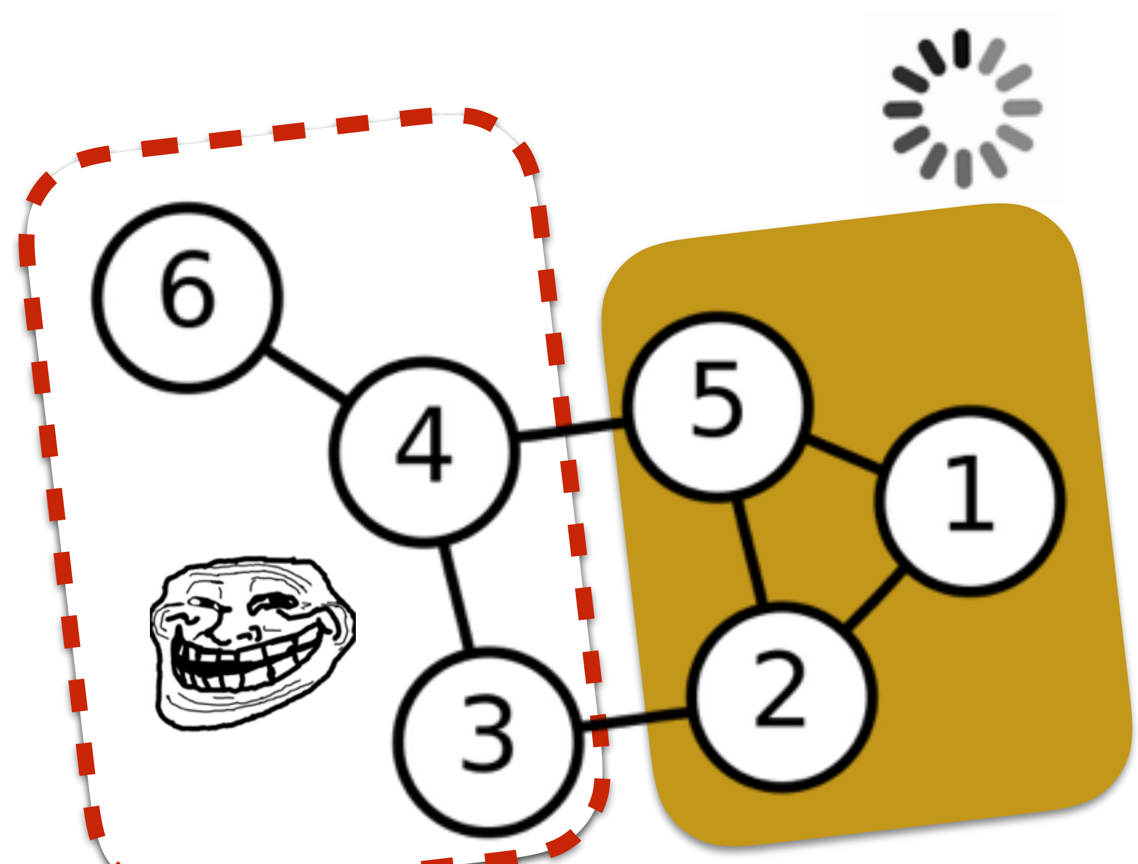

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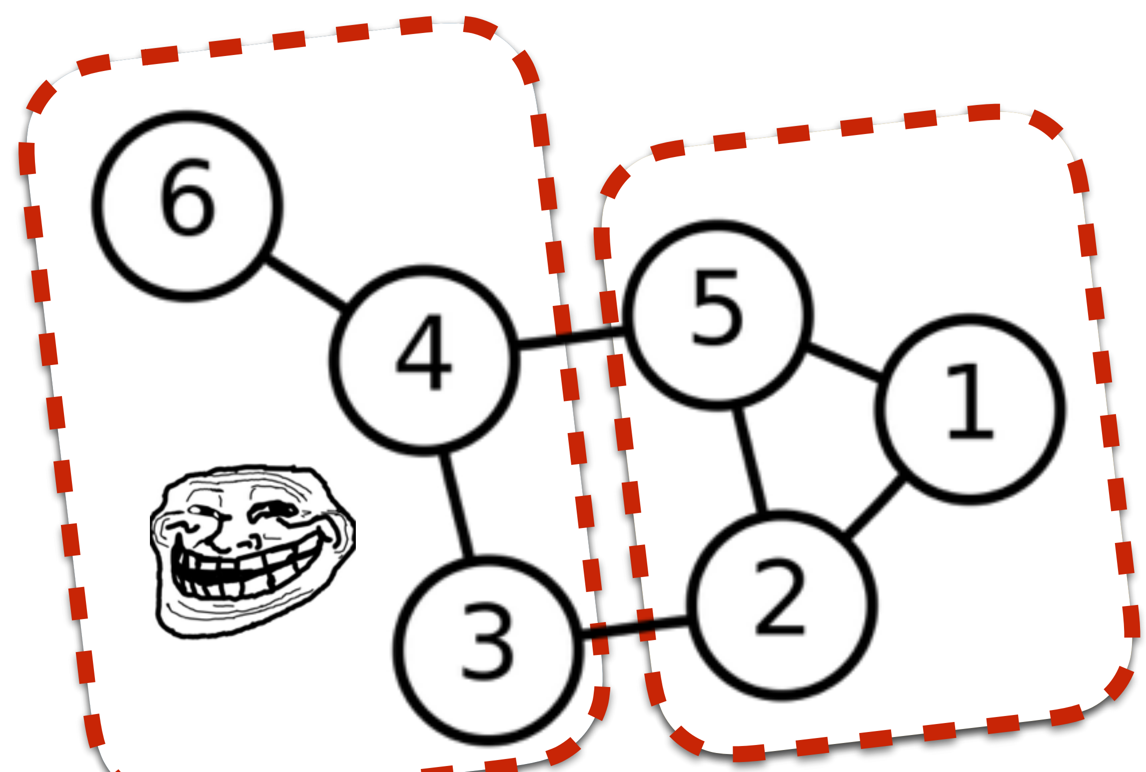

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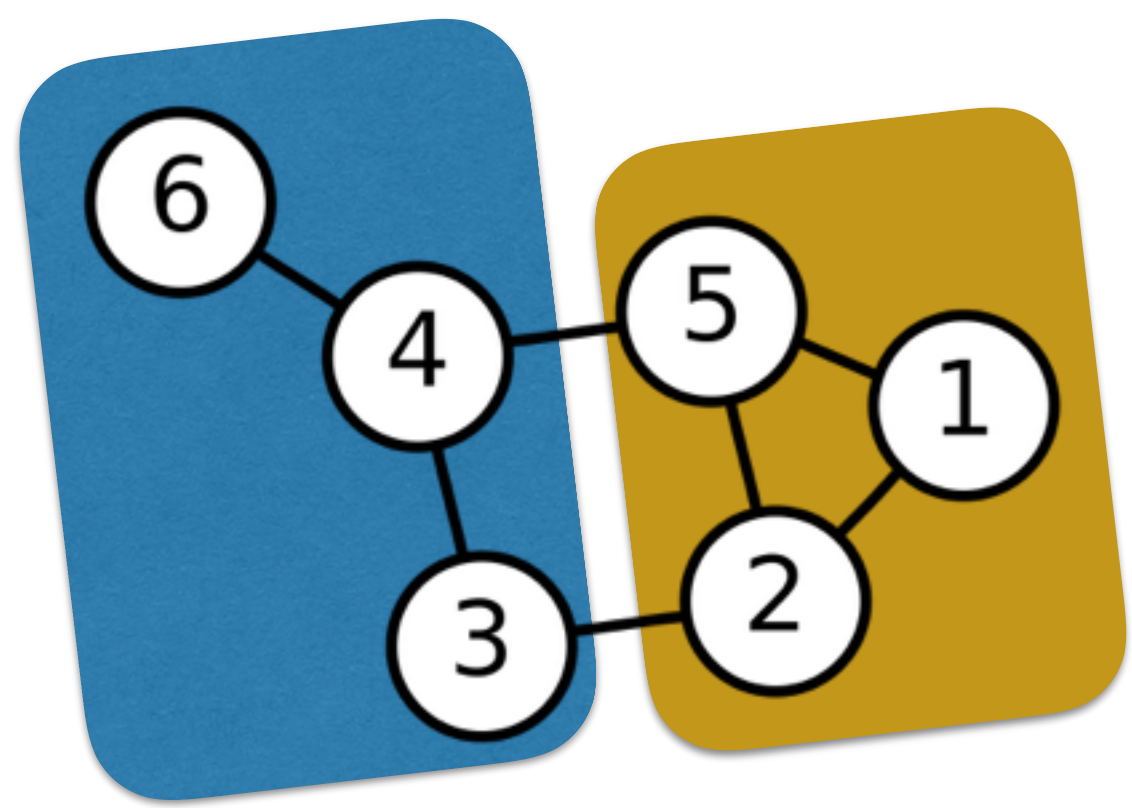

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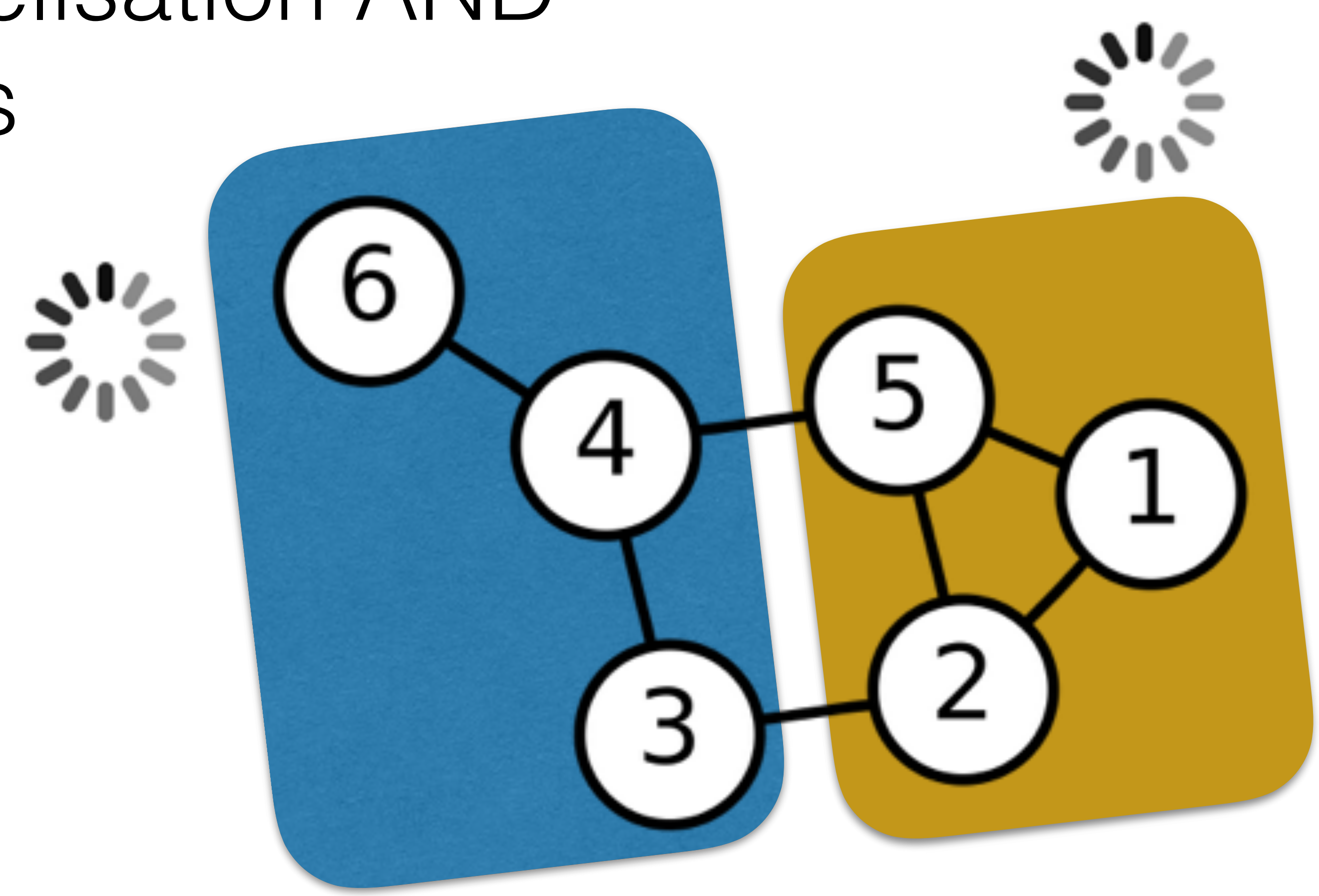

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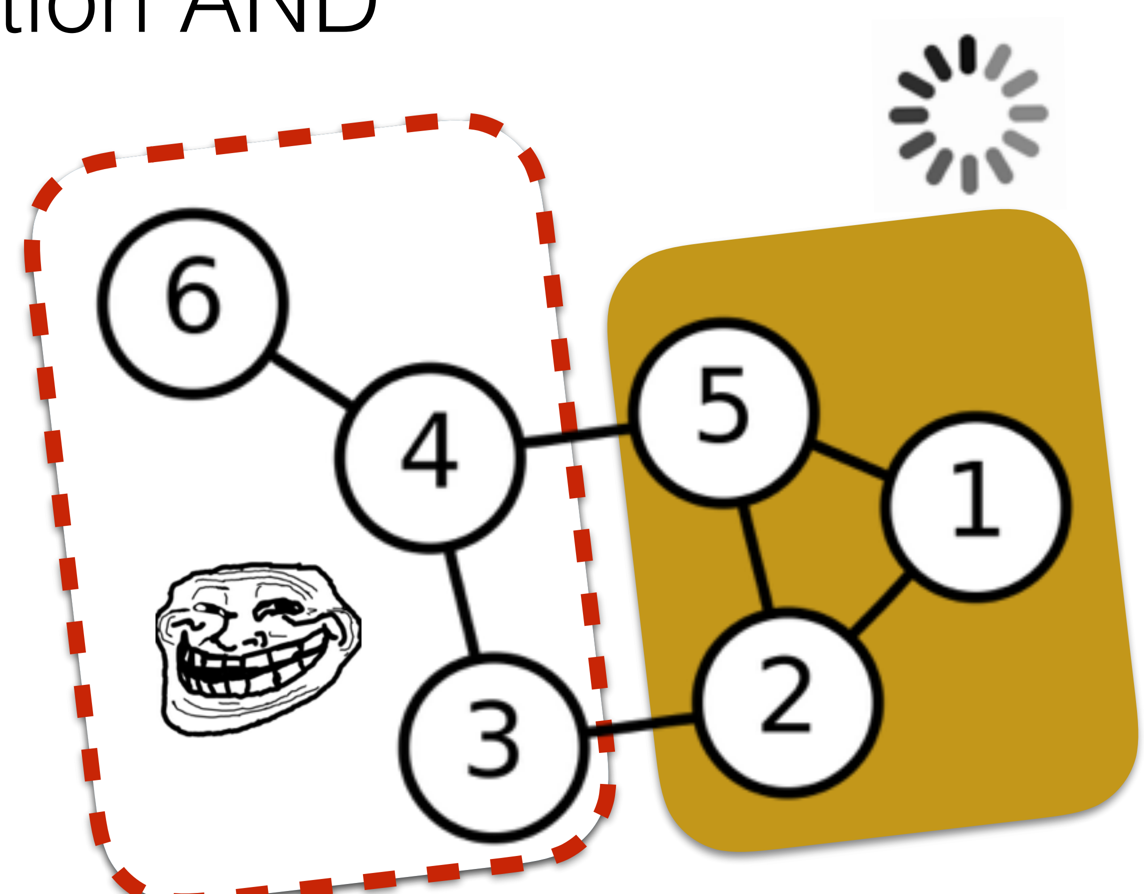

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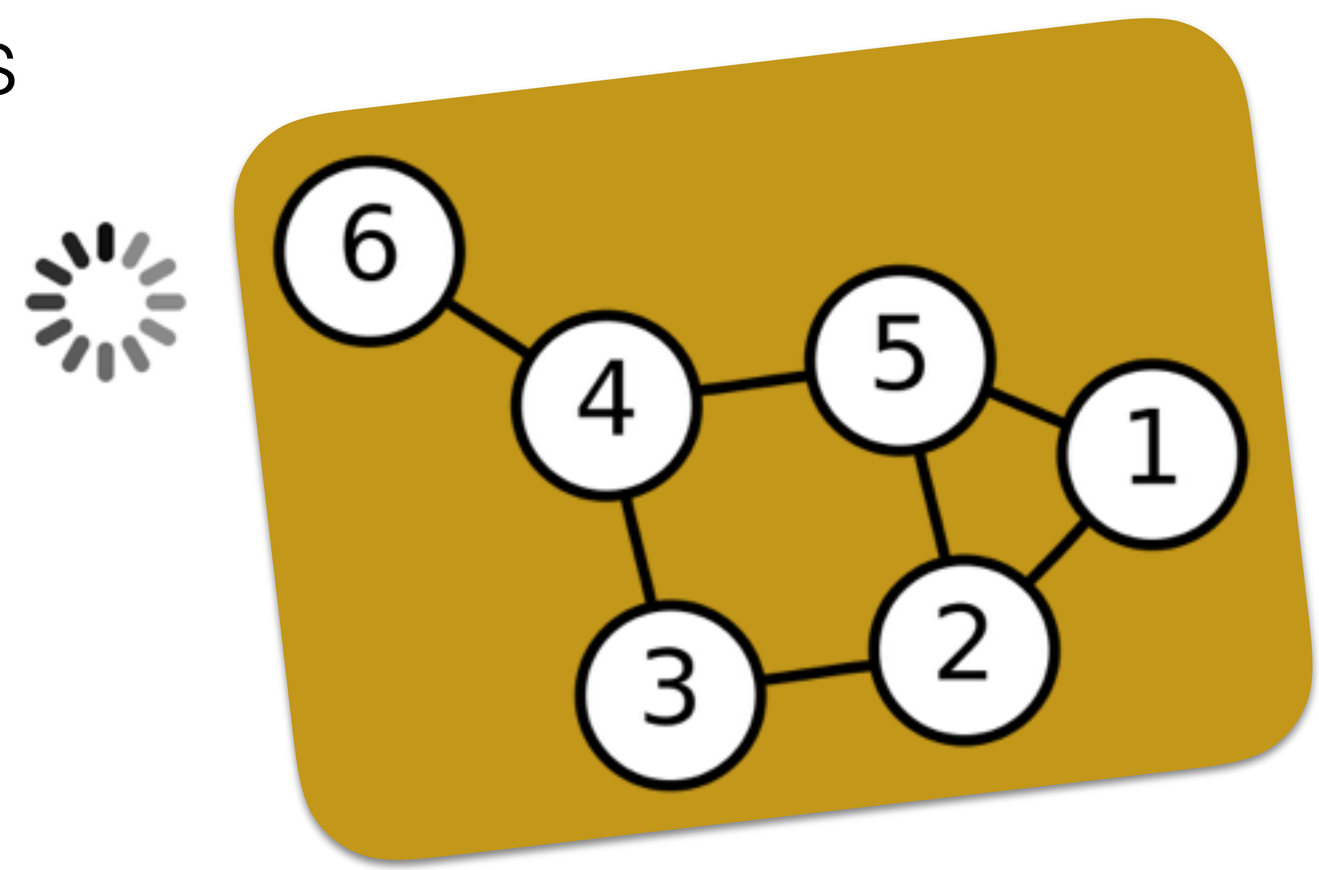

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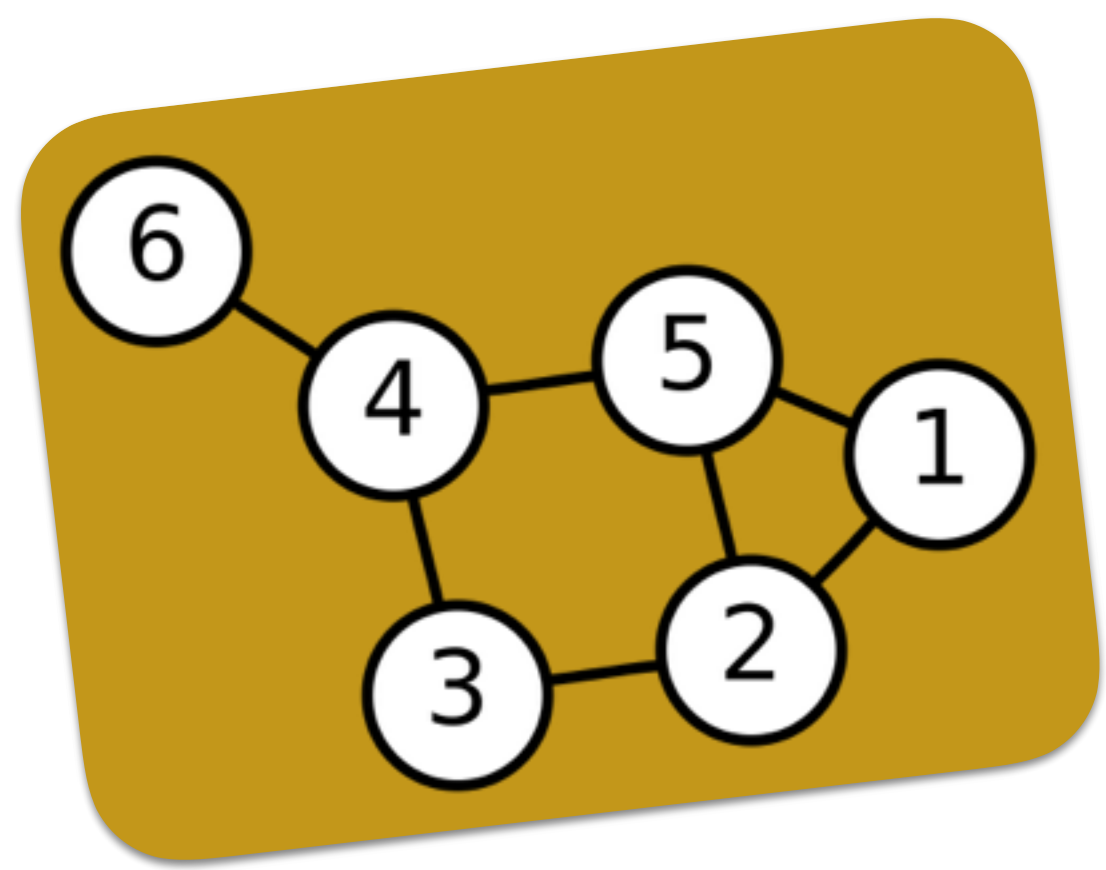

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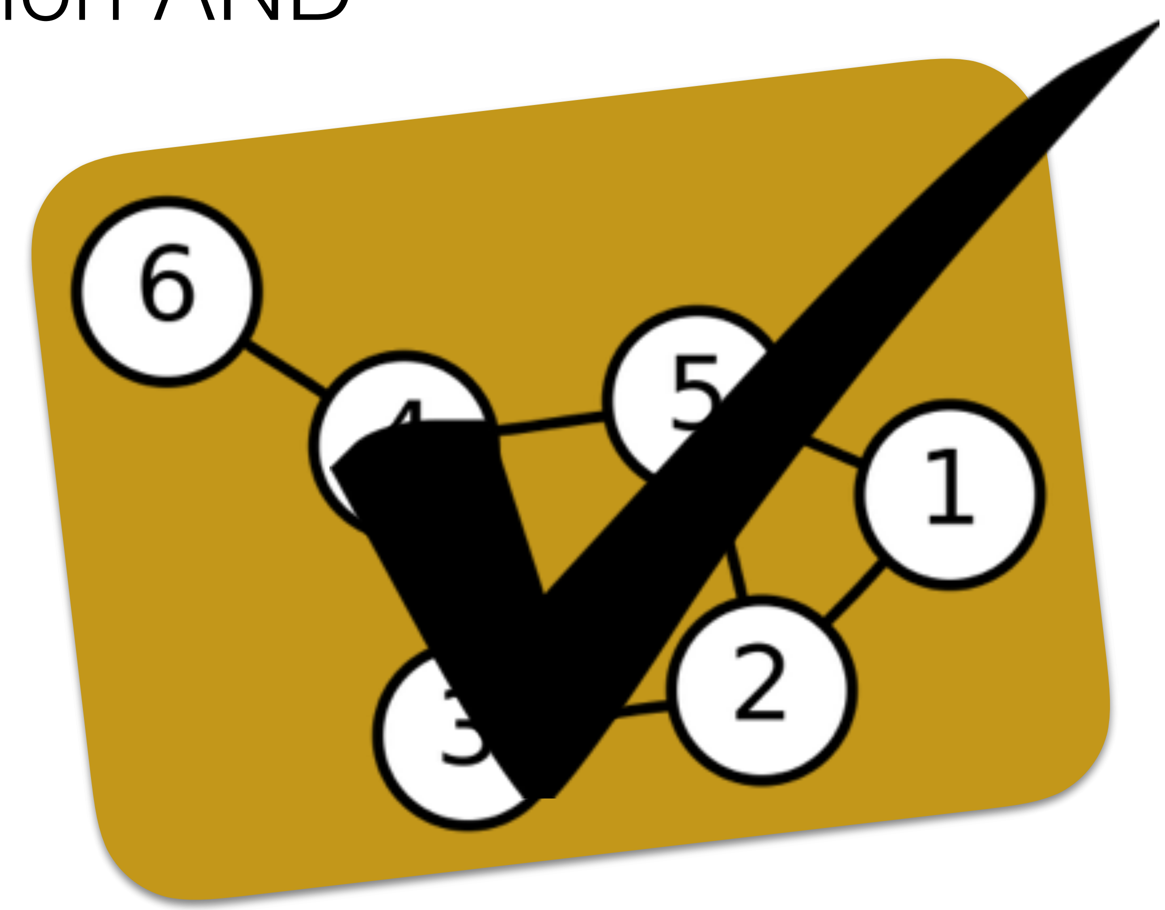

Two Birds

Two Birds

race conditions

double espresso

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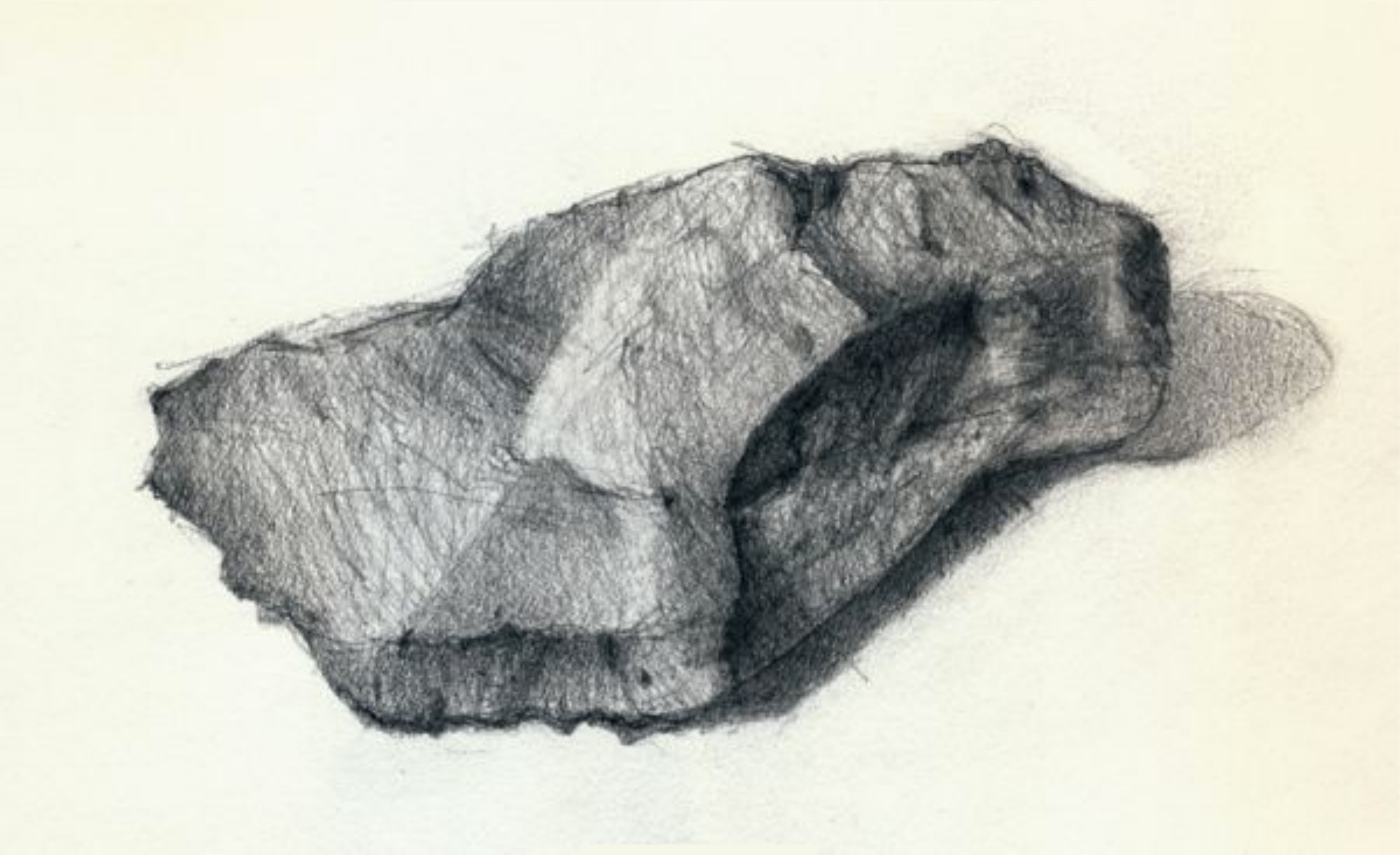
race conditions

fault tolerance

One Stone



Pregel

One Stone

A programming abstraction/library

- actor based, with only local state
- message passing only

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Example: Graph connectedness:

- One message: `PING`
- local state: a bool (inital: □ = `false`)

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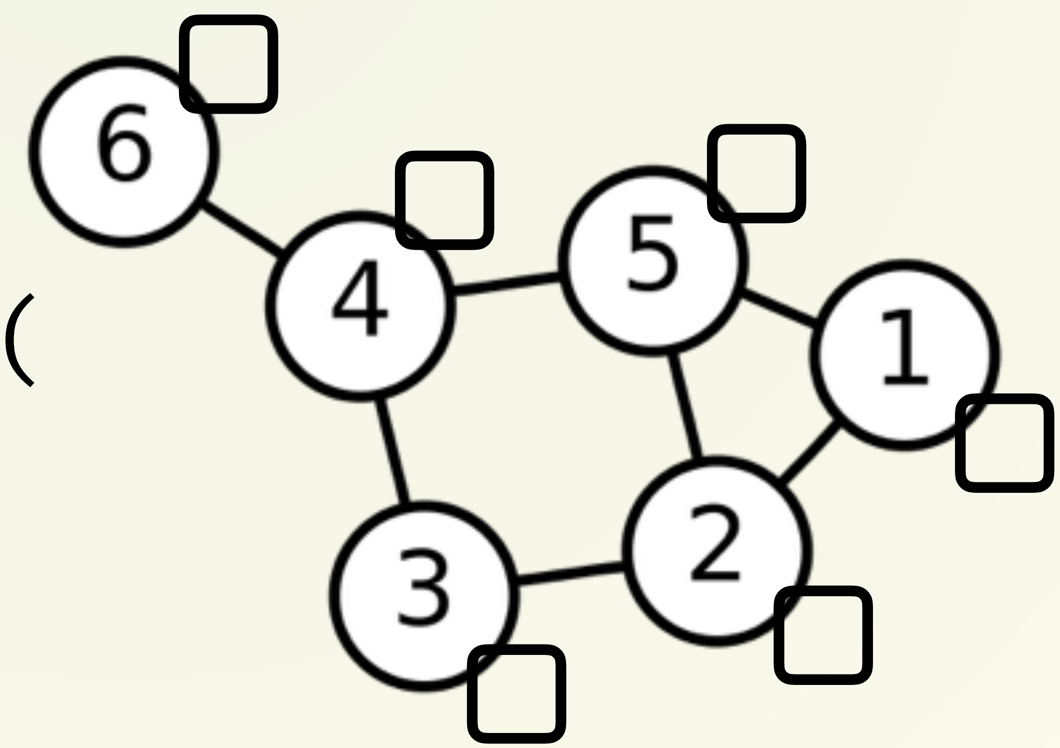

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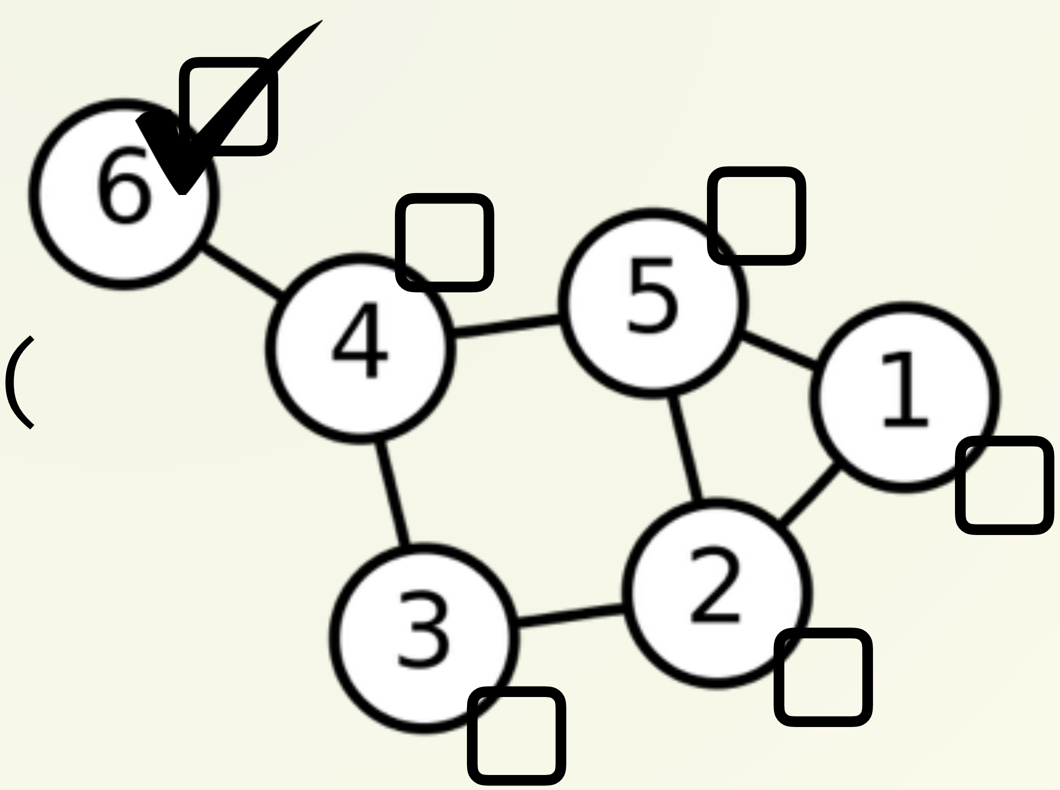
`assert(is_connected(`  `))`

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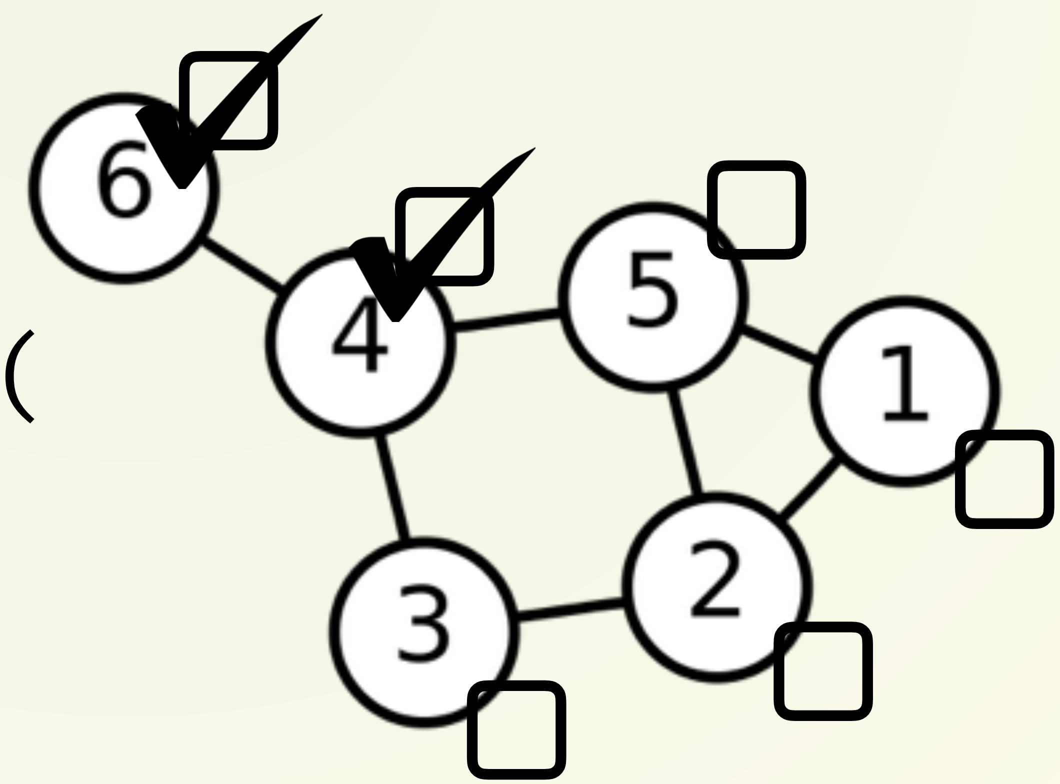
`assert(is_connected(`  `))`

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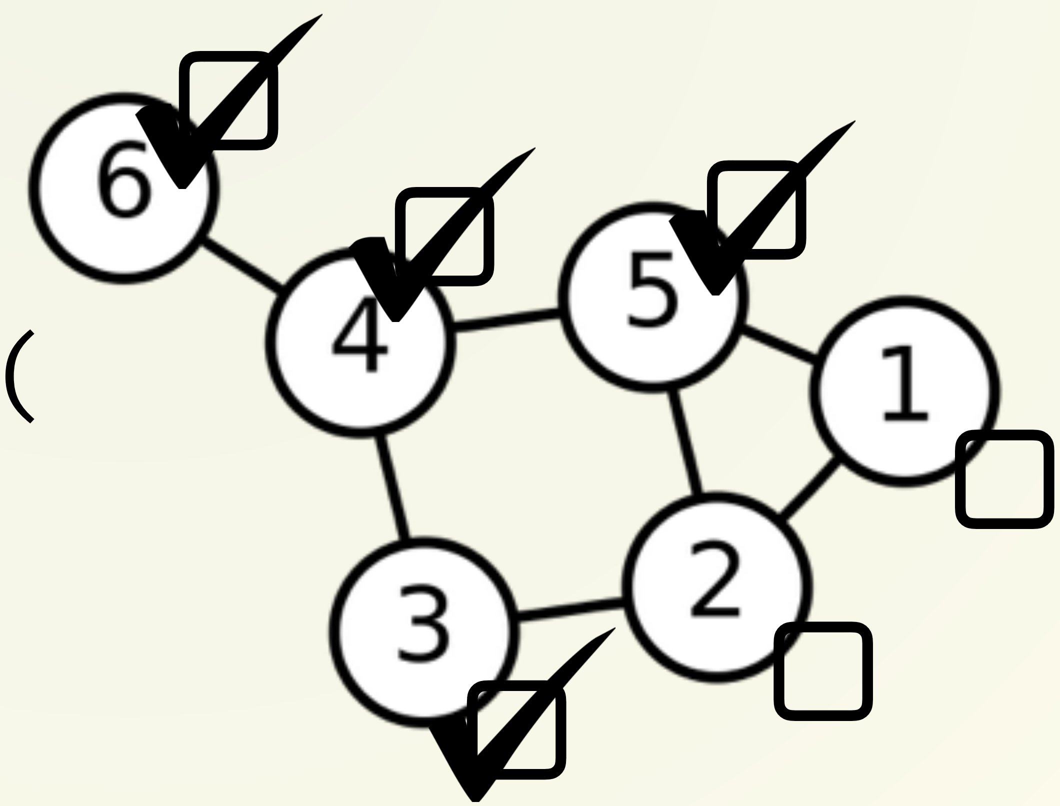

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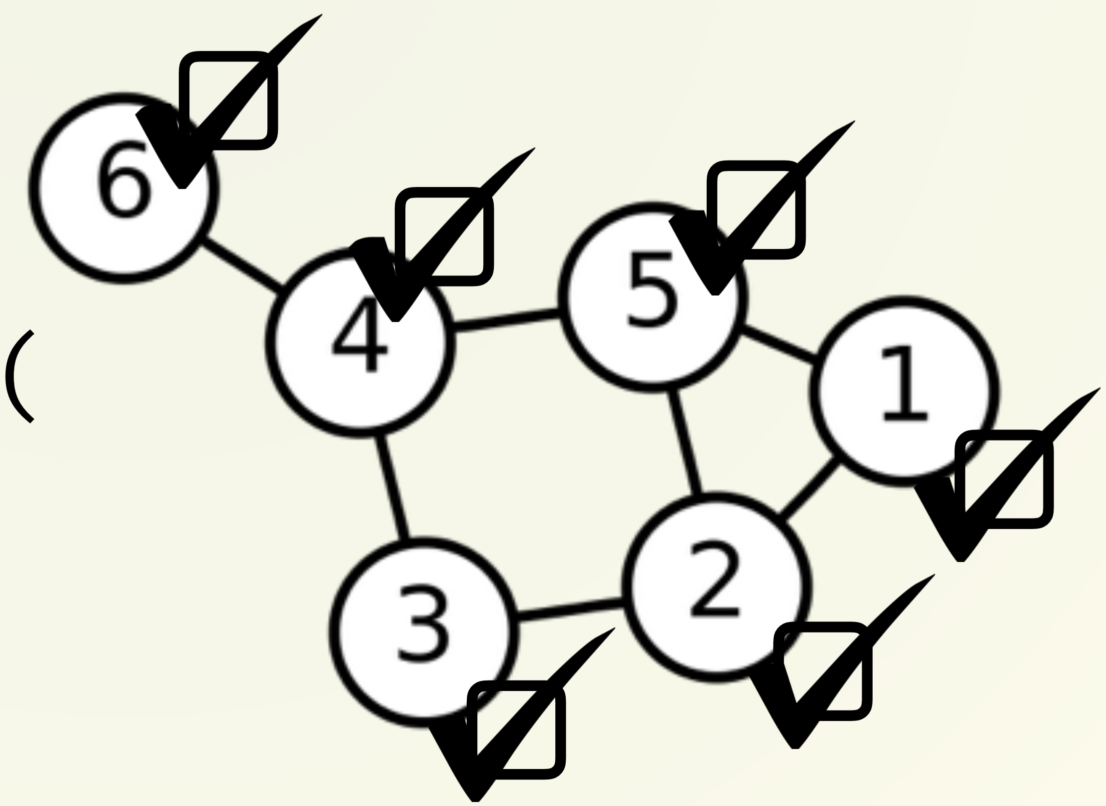
`assert(is_connected(`  `))`

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⇒ **All state changes** have to go through the abstraction.

```
this.f.change()  /  send(CHANGE, this.f)
```

⇒ Can choose **when/how often to apply** state changes.

- message passing only

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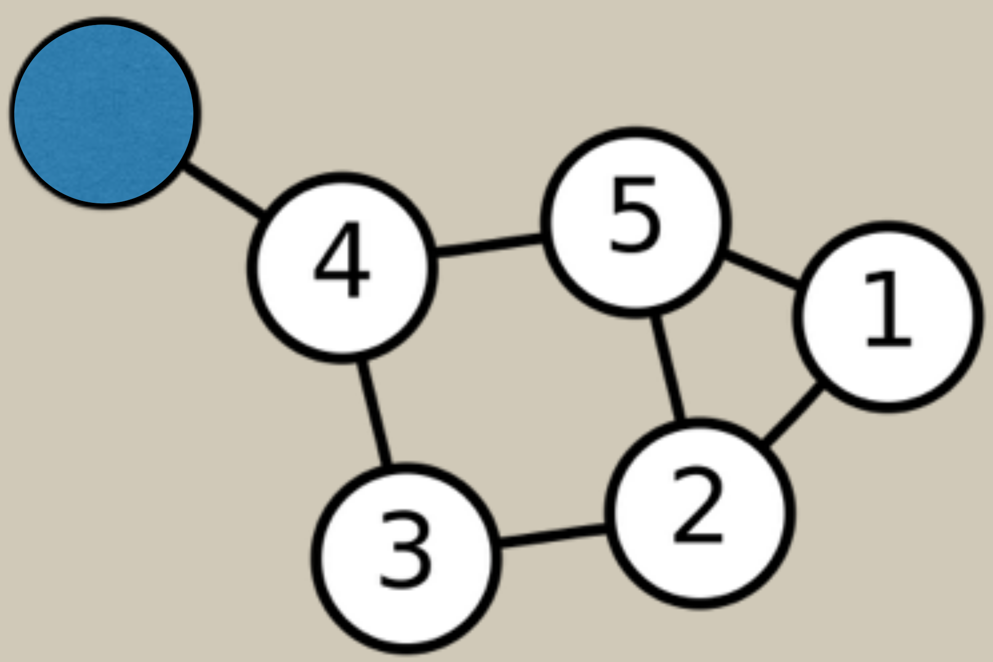
That's all we need! :-)
We deliver all messages in an arbitrary, but deterministic order!

race conditions

Step 1



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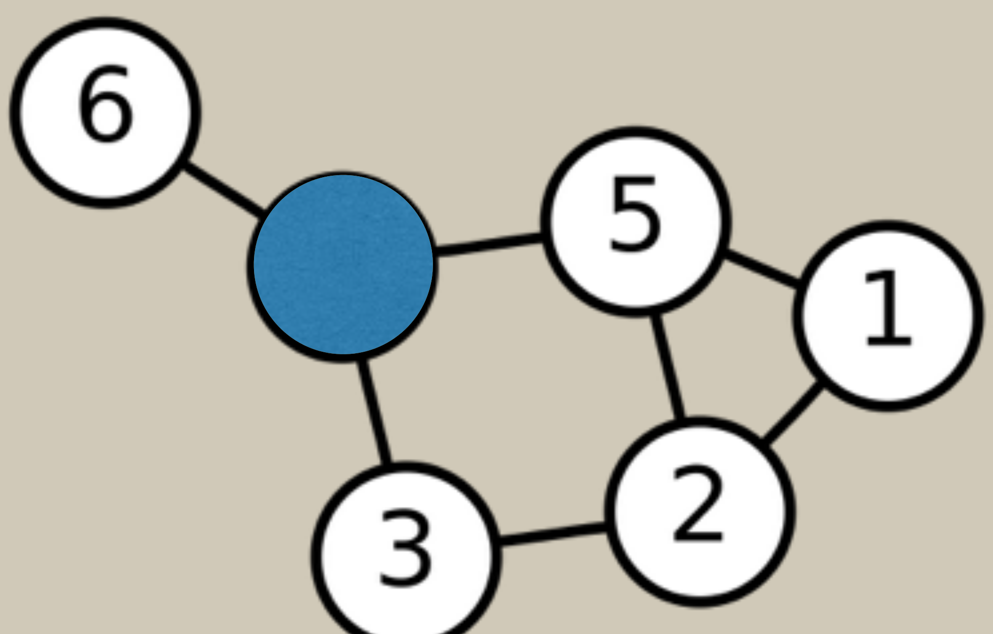

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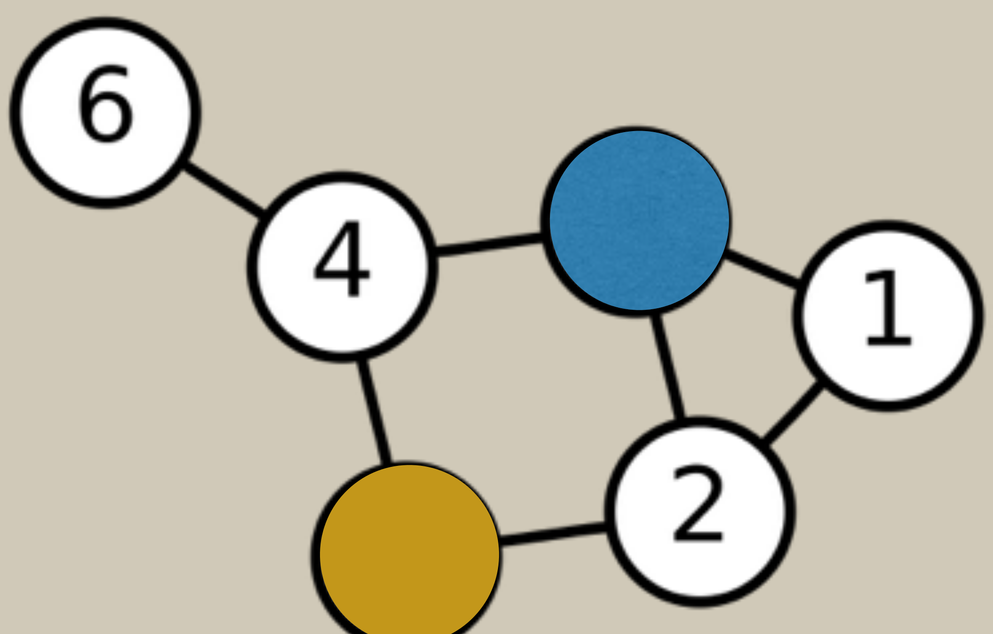

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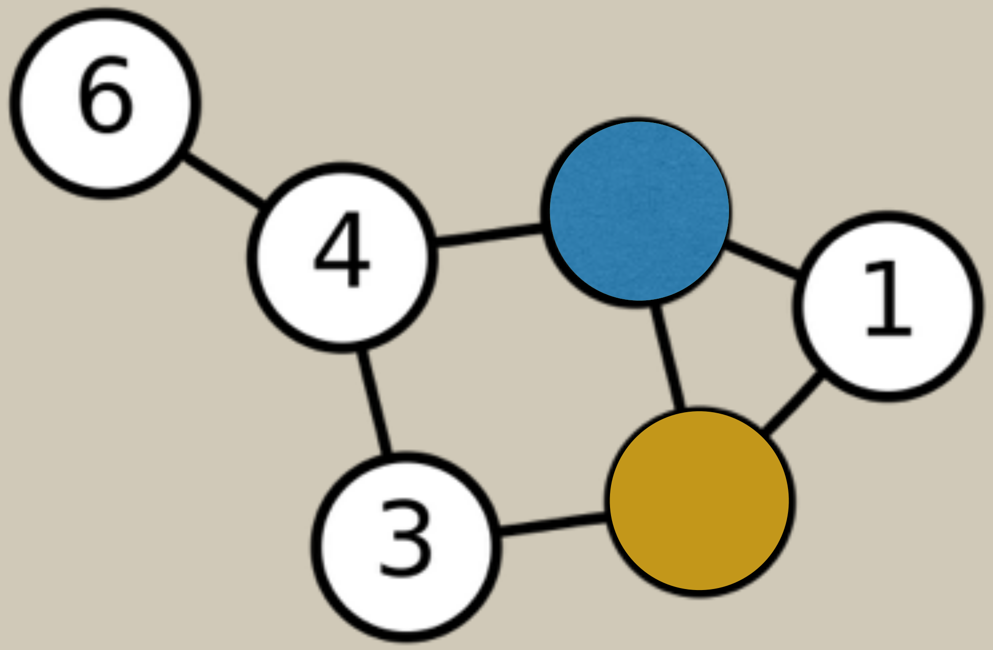

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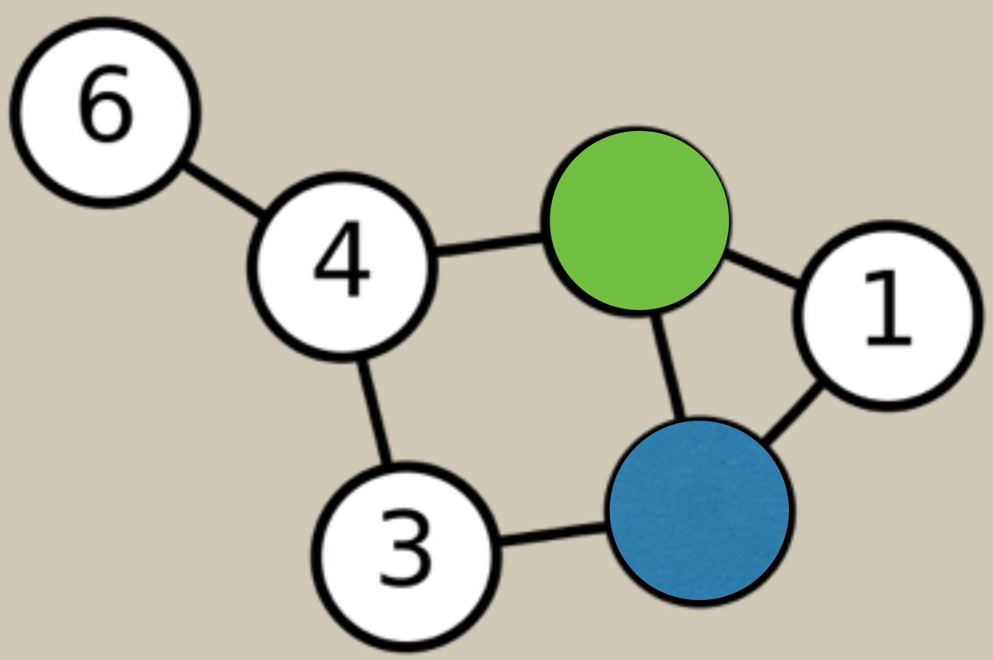

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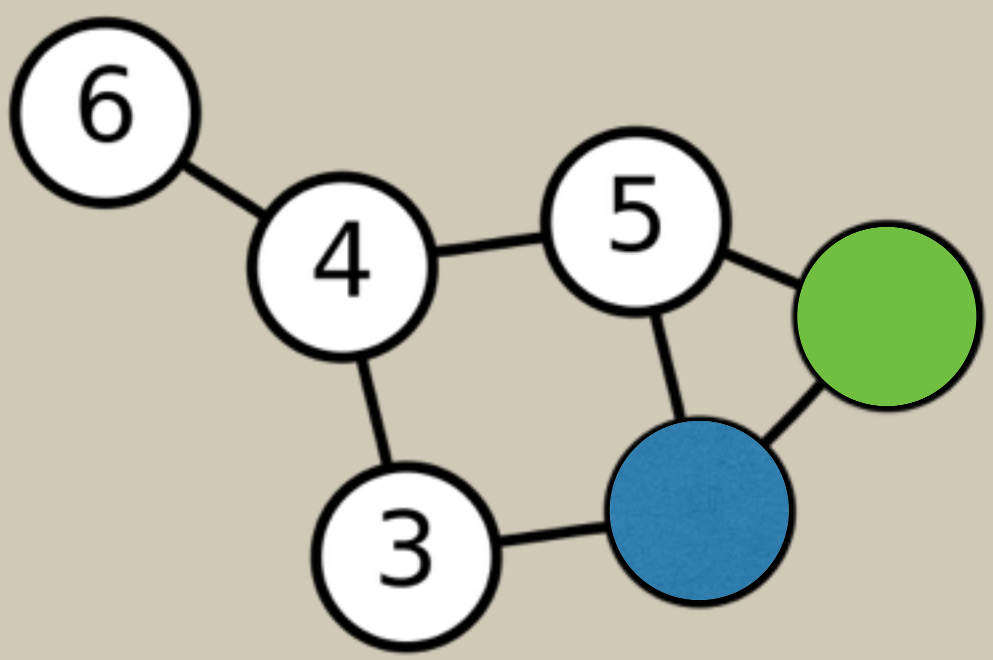

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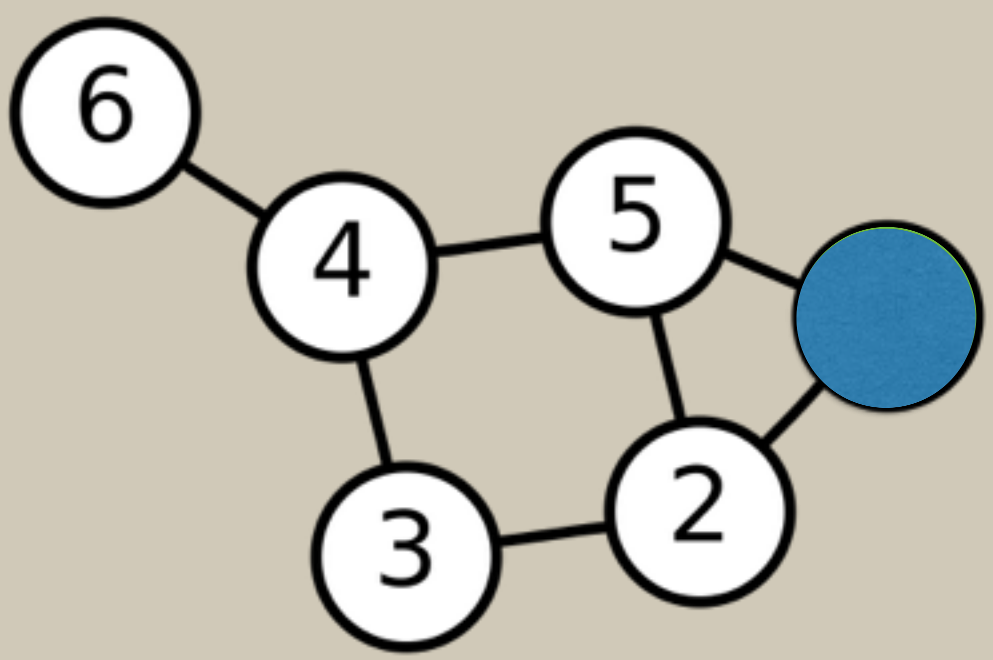

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Invariant: only successful states are persisted

Safety for performance tradeoff.

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Slides at: http://stbr.me/pregel-presentation