Gathering Asynchronous Robots in a Tree

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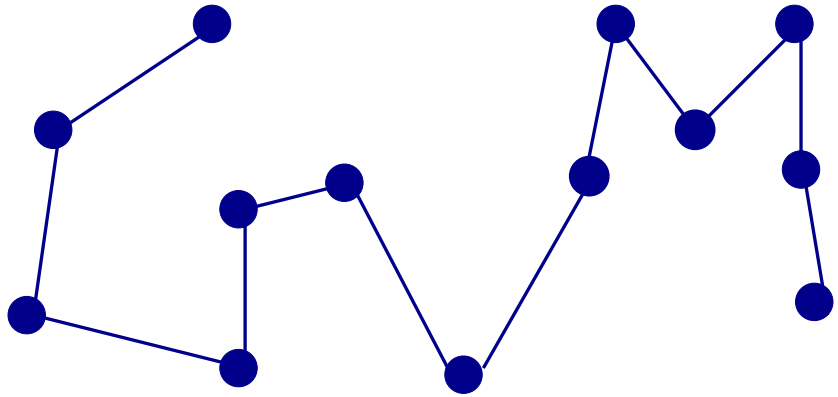
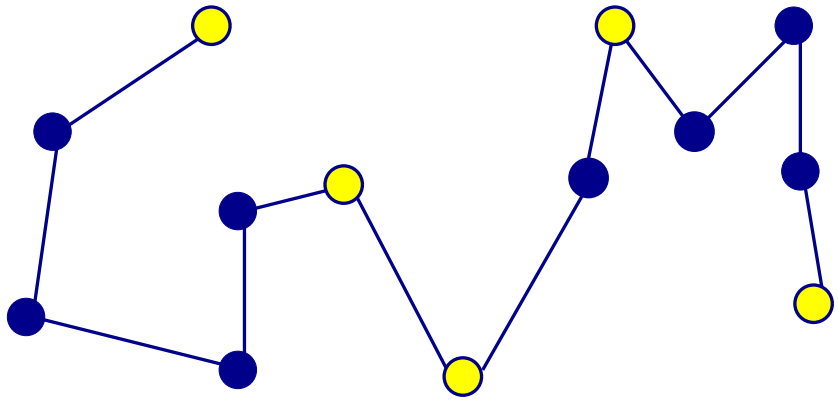
Definition of the problem

- Given a tree



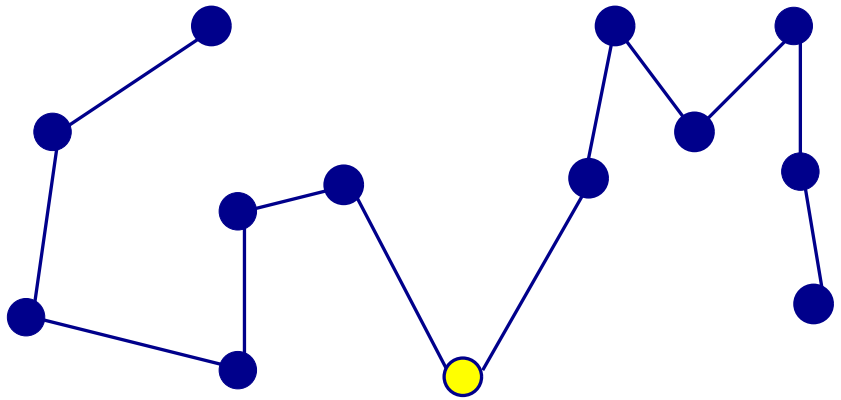
Definition of the problem

- Given a tree
- Randomly distributed mobile agents/robots (**autonomous, homogeneous, non distinguishable, silent**) in nodes



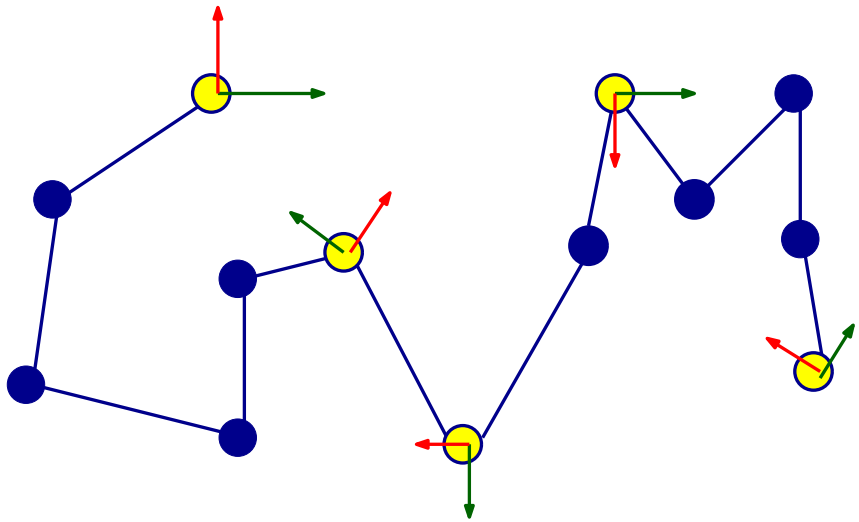
Definition of the problem

- Given a tree
- Randomly distributed mobile agents/robots (**autonomous, homogeneous, non distinguishable, silent**) in nodes
- The robots have to gather at a single node

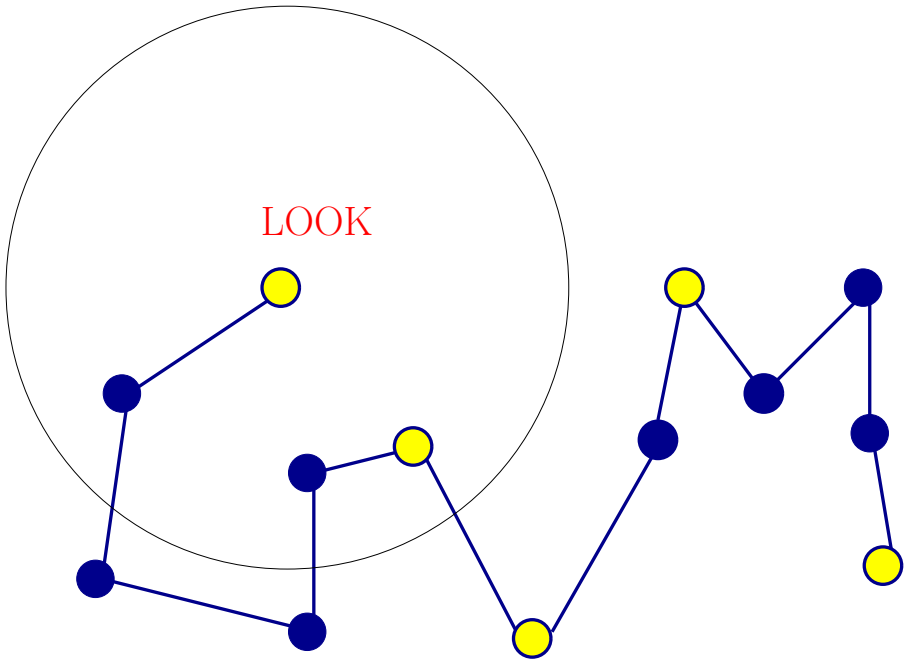


Computational model

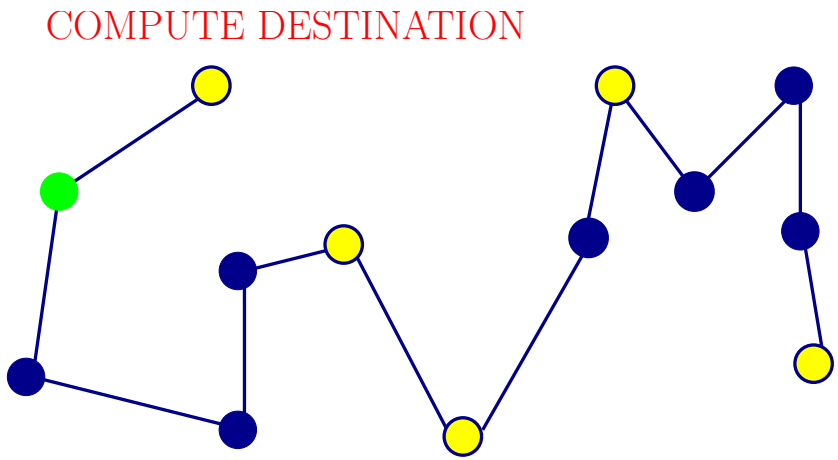
- Robots have no identity
- Nodes and edges of the graphs are not marked
- The robots have their local coordinate systems



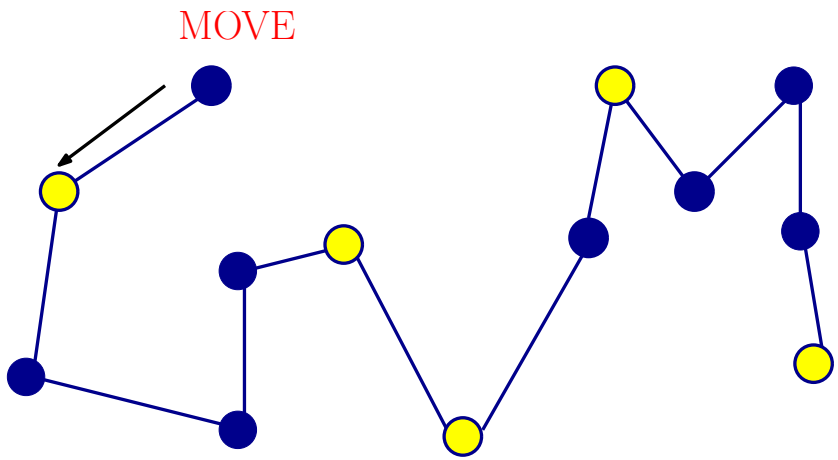
Computational model



Computational model



Computational model



Computational model

- Oblivious: forget earlier computations.
- No multiplicity detection capabilities.
- Activation Schedule: Synchronous/Semi synchronous/Asynchronous

Motivation

Results 1:

Gathering in graph in general is not possible even with synchronicity.
Ref: Gabriele Di Stefano, Alfredo Navarra, **Optimal Gathering of Oblivious Robots in Anonymous Graphs**, SIROCCO 2013, Volume 8179 of the series Lecture Notes in Computer Science pp 213-224.

Results 2

Gathering in plane in general is not possible.
(Ref: 1. Pierre Courtieu, Lionel Rieg, Sébastien Tixeuil, Xavier Urbain, **Impossibility of gathering, a certification**, Information Processing Letters, Volume 115, Issue 3, March 2015, Pages 447-45.
2. Paola Flocchini, Giuseppe Prencipe, Nicola Santoro, **Distributed Computing by Oblivious Mobile Robots**, Synthesis Lectures on Distributed Computing Theory August 2012, Chapter 3, pages 17 - 61.)

Results 3

Gathering in plane is possible with agreement in coordinate axes even when the robots have limited visibility.
Ref: Paola Flocchini, Giuseppe Prencipe, Nicola Santoro, Peter Widmayer, **Gathering of asynchronous robots with limited visibility**, Theoretical Computer Science, Volume 337, Issues 1–3, 9 June 2005, Pages 147-168,

Results 4

Samuel Guilbault, Andrzej Pelc, **Gathering asynchronous oblivious agents with local vision in regular bipartite graphs**, Journal Theoretical Computer Science, Volume 509, October, 2013 Pages 86-96.

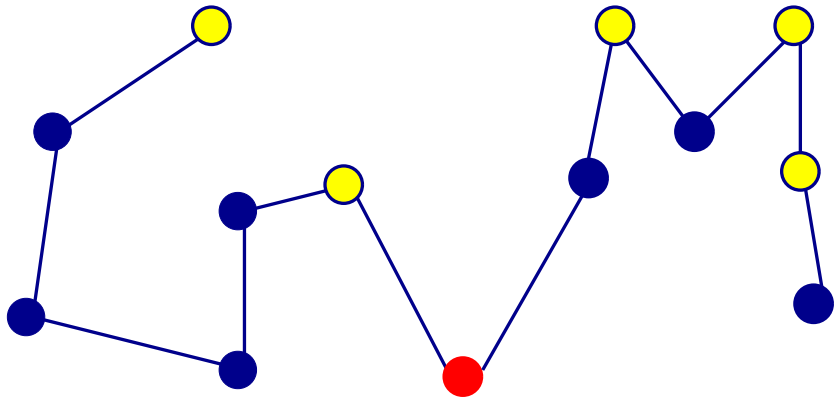
Some open questions

- Many results in gathering in grid, ring consider the knowledge of multiplicity detection. Can we remove this?
- All the results in continuous domain under Synchronous, Semi synchronous or Asynchronous model, do not hold in discrete domain. E.g., Gathering is possible under synchronous model in continuous domain but not in discrete domain.
- Whan happens in Limited visibility in general graph?

Gathering in tree under limited visibility

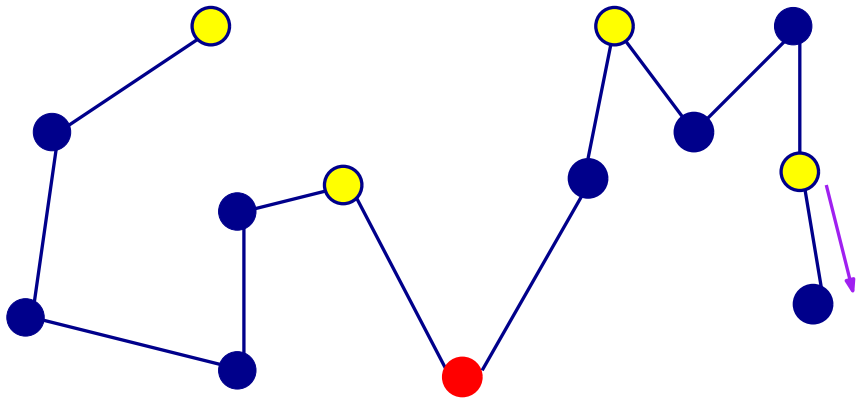
- No multiplicity detection
- Asynchronous
- Limited visibility

When destination is given



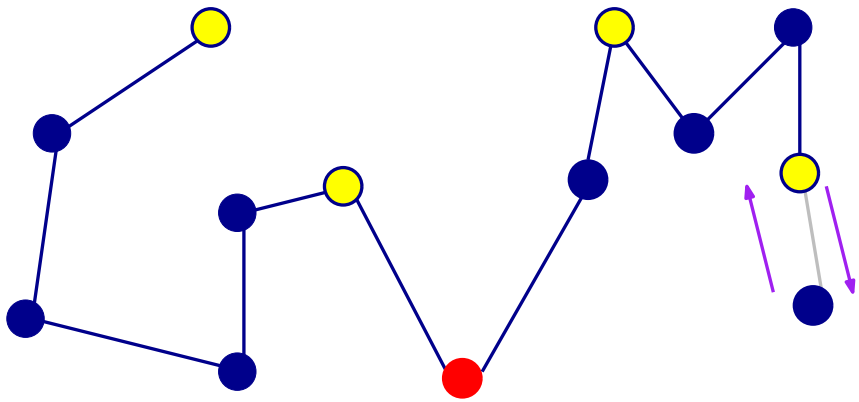
When destination is given

- Eliminate the peripheral nodes
- The robots only remember their parents



When destination is given

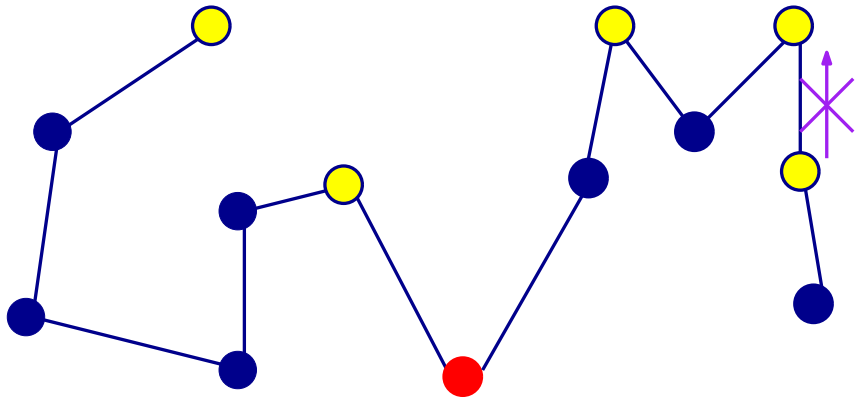
- Eliminate the peripheral nodes
- The robots only remember their parents
- Use pebbles [1] to mark path towards leaf



[1] Balasingham Balamohan, Stefan Dobrev, Paola Flocchini, and Nicola Santoro. Asynchronous exploration of an unknown anonymous dangerous graph with o (1) pebbles. In SIROCCO, pages 279–290. Springer, 2012.

Movement strategy for a robot

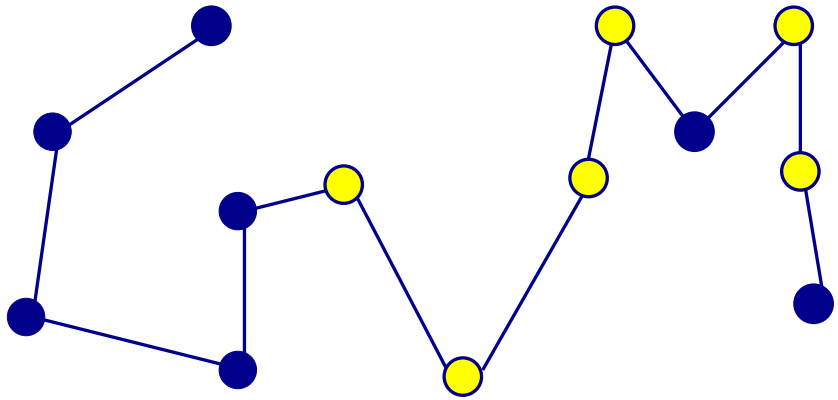
- If I see a robot in neighbor(which is not destination) node, I will not move



Assured

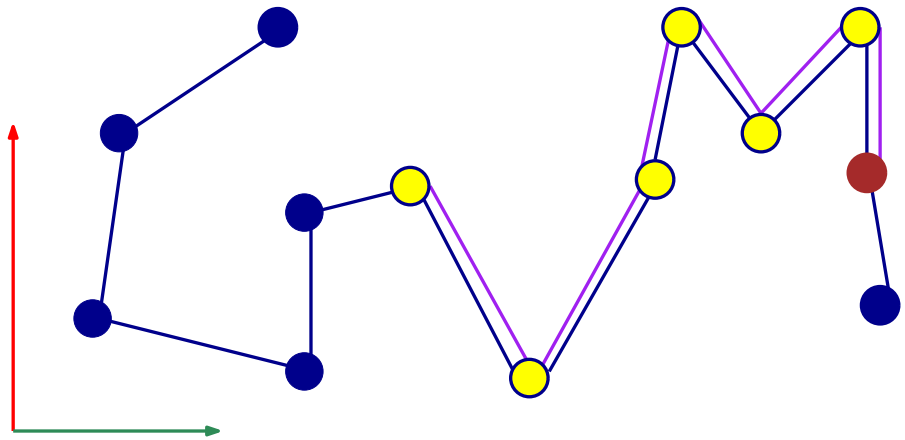
- The robots will not toggle
- The robots will not be in deadlock: there always be a robot which will move unless it is already in destination.

When the destination is not given



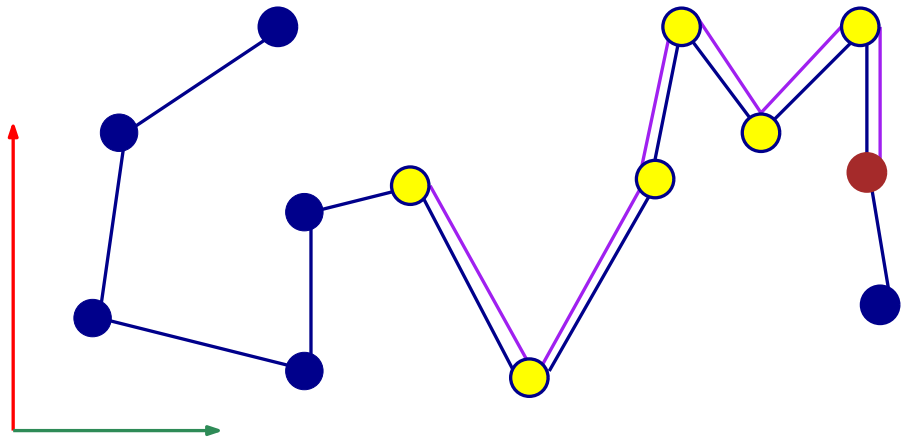
When the robots are completely oblivious

- The graph (drawing) is oriented.
- Visibility graph of the robots is connected.



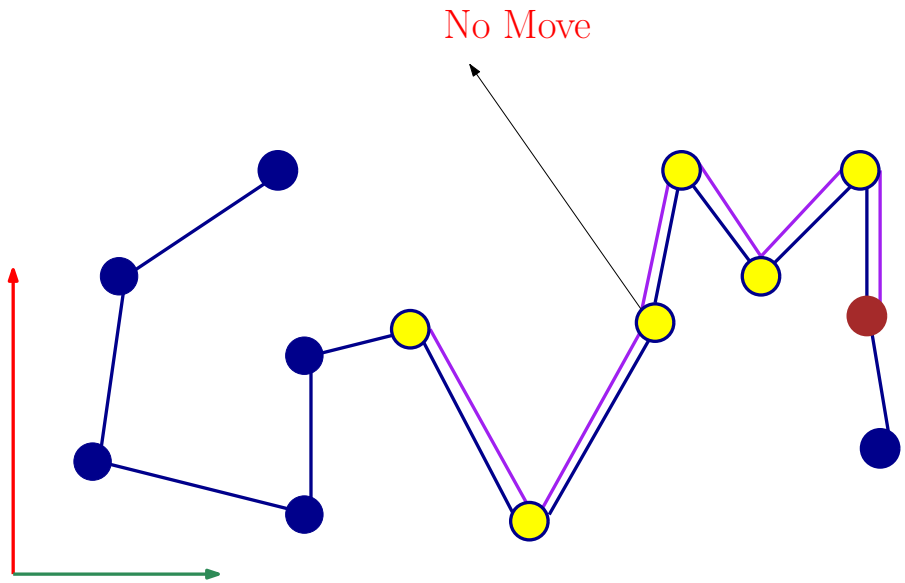
When the robots are completely oblivious

- The graph (drawing) is oriented.
- Visibility graph of the robots is connected.
- **The robots gather to one of the corner most nodes, e.g., at down-right most node which has a robot.**



Movement strategy for a robot

- If I see a robot in more than one neighboring nodes, I will not move.

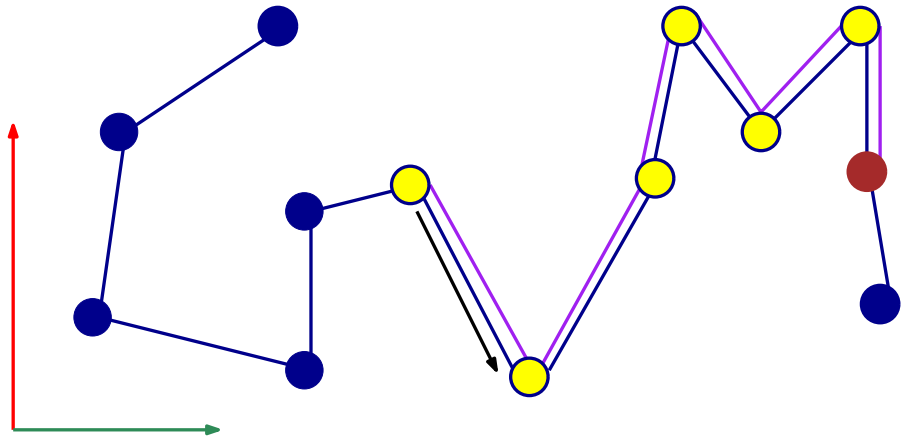


Assured

- The visibility graph will not be disconnected.

Movement strategy for a robot

- If I see a robot in more than one neighboring nodes, I will not move.
- Else If I see a robot below my horizontal axis , I move to that node.

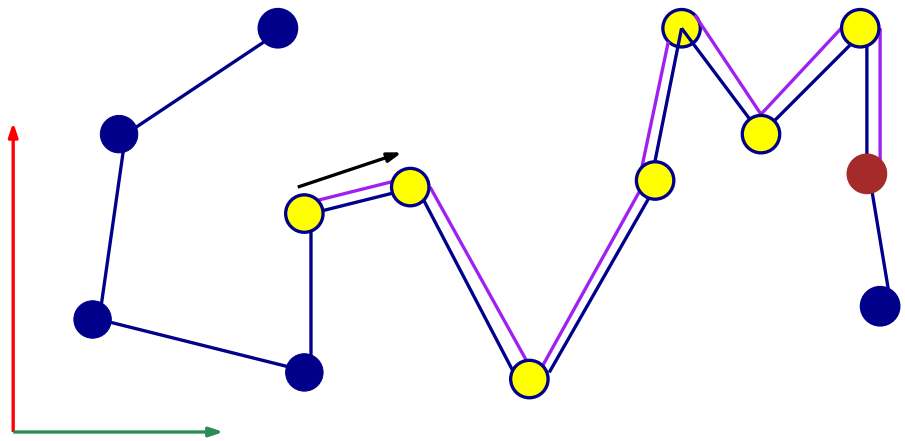


Assured

- The visibility graph will not be disconnected.

Movement strategy for a robot

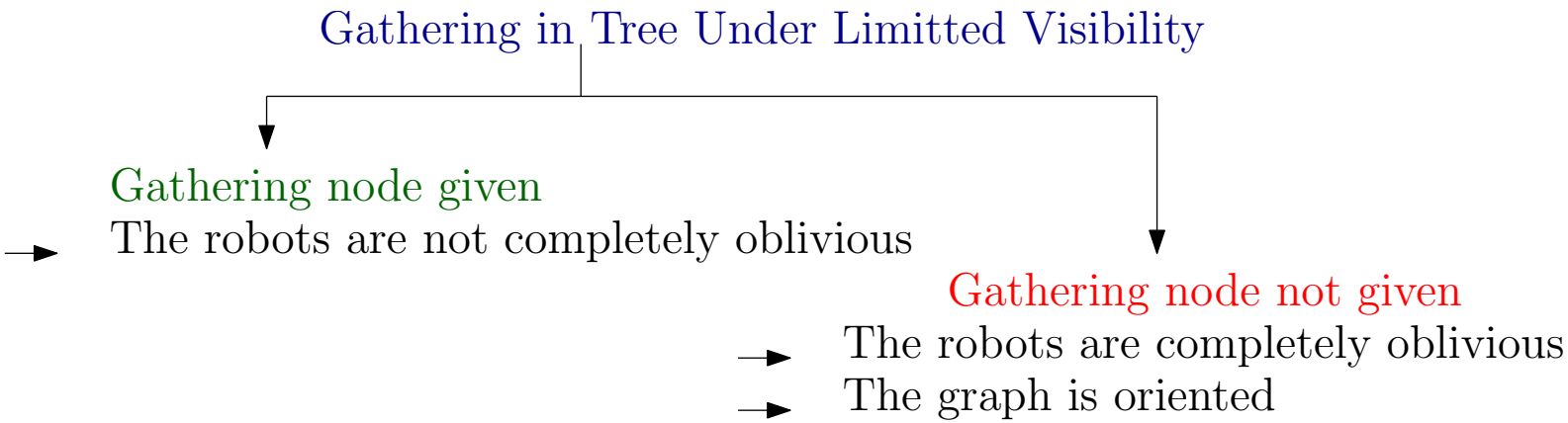
- If I see a robot in more than one neighboring nodes, I will not move.
- Else If I see a robot below my horizontal axis , I move to that node.
  OR
  If I see a robot right to my vertical axis, I move to that node.



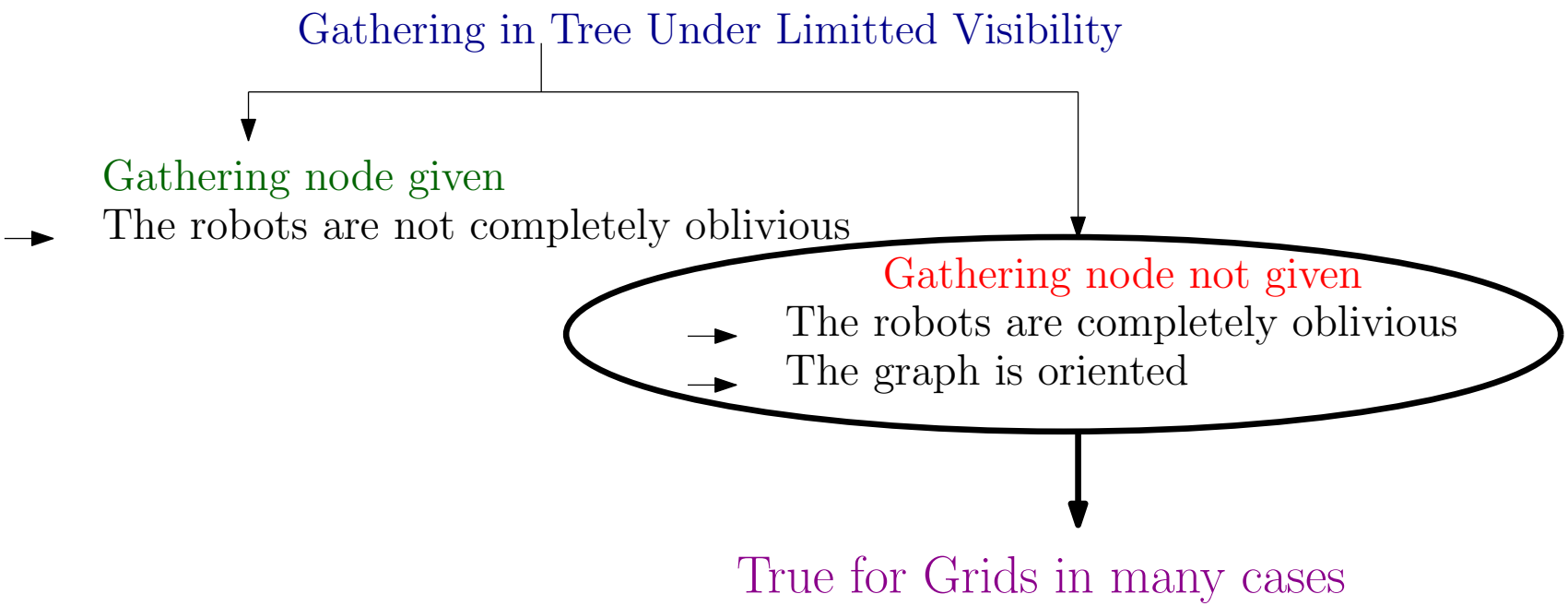
Assured

- The visibility graph will not be disconnected.
- The robots will move to the right-down most roots.

Gathering in tree under limited visibility



Gathering in tree under limited visibility



On going development

- What happens if the Graph is not oriented?
- To explore the limited visibility model in general graph
- Optimizing the robots movement
- Collision avoidence algorithm
- Directed Graph (characterization)
- ...

Acknowledgement

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Thank You