Infection Propagation Problem

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Outline

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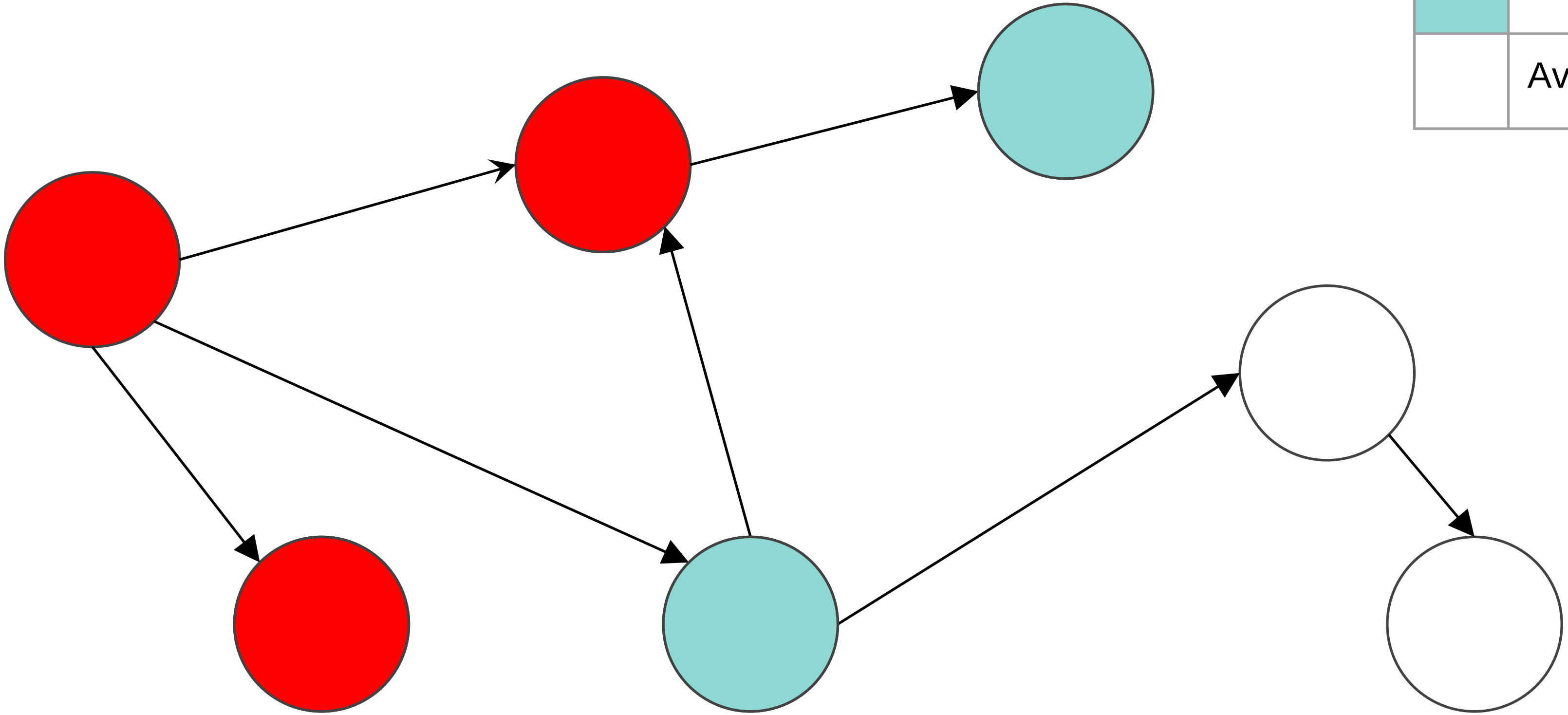
Problem Definition

- A network of connected computers
- Infection starts with 1 computer and can propagate only if there is a connection between the 2 computers
- Infection cannot propagate via a safe computer
- Protector can mark any one computer as a safe computer by shutting it down
- The infection ends when no more nodes can be infected or the protector cannot mark any more computers as safe
- Goal is to minimize the the number of infected nodes

Problem Formulation

- The problem is formulated as a 2 player graph game.
- Each computer is a node and each connection is an edge.
- The infection can choose any one node to infect from the neighbours of the already infected nodes which are not safe
- The protector can choose any one node which is neither safe or infected to save.
- Each player will select only one node at a time

Sample Problem



	Infected
	Safe
	Available

Greedy Algorithm

- The next node to be saved should be the the node with maximum number of adjacent nodes.

- This approach is not optimal

- In worst case will infect N/2 nodes

Generating the Pruned Graph

- From the start of the infection the infection will reach a particular node in at least n steps where n is its shortest distance from that node
- If there are K nodes at depth M and if K< M we do not need to consider the nodes after depth M

MiniMax Algorithm

- MiniMax Tree is generated from the graph
- A leaf nodes is given the value of it’s depth
- Every path from the root to a leaf node will define strategy
- The protector is trying to minimize the the length of this path and the attacker is maximizing the same

Alpha Beta Pruning

- It stops completely evaluating a move when at least one possibility has been found that proves the move to be worse than a previously examined move.
- The algorithm maintains two values:
  - Alpha - the minimum score for max. Player
  - Beta - the maximum score for min. player
- Initially Alpha is -inf. and Beta is +inf.

Results and Analysis

- *[number of vertices, number of edges, rank using minimax algo, nodes visited using minimax algo, rank using minimax_ab_pruning, nodes visited using minimax_a_b_pruning]*

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[10,10,6,52882,6, 3710]
[10,10,8,87098,8, 5397]
[10,10,2,2,2, 2]
[10,10,2,2,2, 2]
[10,10,2,2,2, 2]
[10,10,4,46,4, 34]
[10,10,6,2676,6, 572]
```

Results and Analysis

- We infer from the obtained results that both the Algorithms are giving the correct outputs and the number of nodes visited by Minimax using alpha beta is less than Minimax without using alpha beta.
- Therefore, the Minimax algorithm with alpha beta is more optimal.

Limitations

- The current problem definition is very limited in scope as to the speed with which the infection is spreading and that the infection can only add one node at a time
- The proposed algorithms works well for sparse graph but the efficiency decreases as the graph becomes more dense
- Approximate approaches may not give the optimal solution but will definitely may be a lot quicker

Future Work

- To expand the scope of the problem to include the functionality of multiple infected nodes at a time.

- Enhance the efficiency of the Program for Dense Graphs.

Thanks!