Interference and Topology Control

Does Topology Control Reduce Interference ?

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Feb 15, 2010
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Interference and Topology Control

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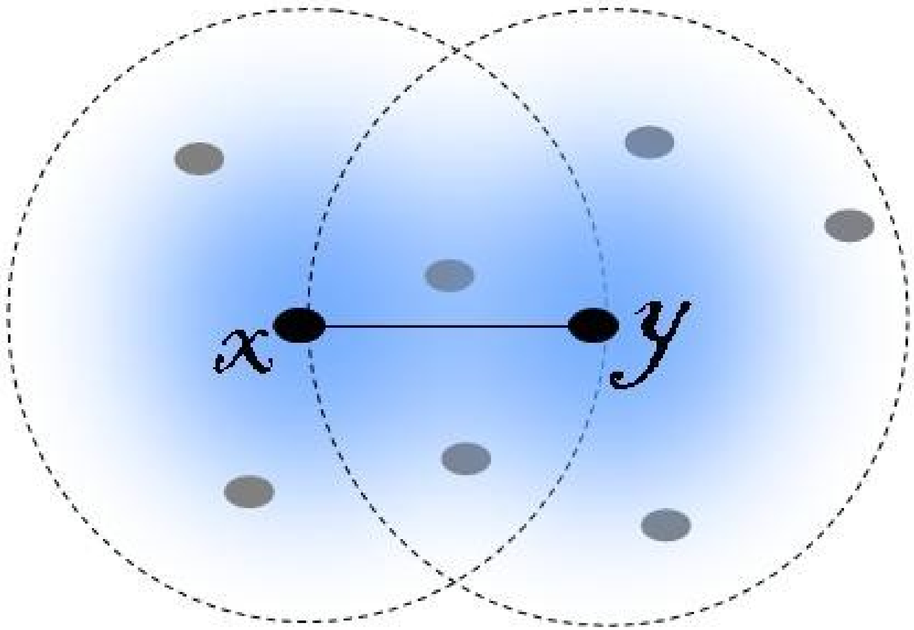
2. Goals desired to achieve
   - -Spanner graph
3. Problems and study cases
4. Algorithms
   - -LIFE
   - -LISE
   - -LLISE
5. Conclusion

Motivation

How to construct the network so that :

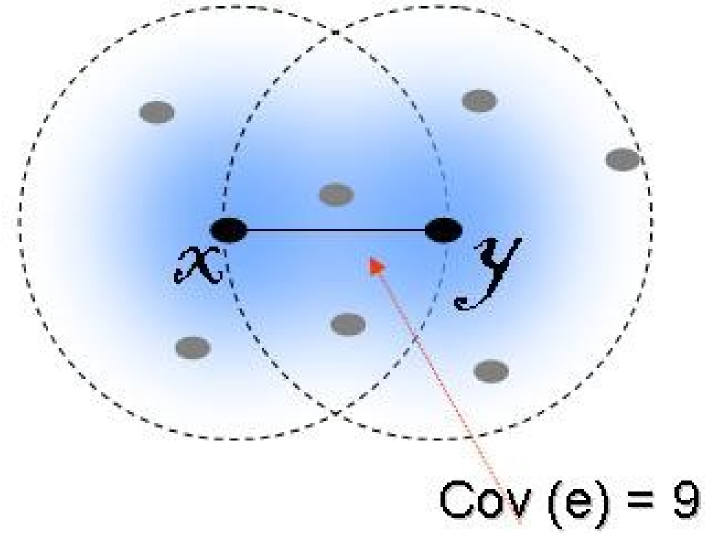
- All vertices are connected.
- Minimum energy consuming, to
- Extend network lifetime.
- Collision handling.
- Low Interference.

How the communication is established



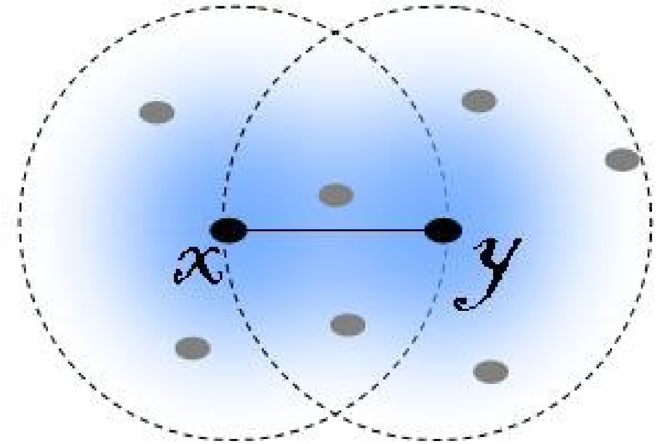
Interference

Scenario:



- |x,y| refers to the transmission discs radii of x,y .
- A connection will be established if both radii were identical.
- Two nodes x,y are connected if their edge is symmetric.
- In this scenario 9 nodes are influenced by this communication including x and y.
- Interference of a node is the number of cycles in which this node is located.

Interference



Definition:

Given a graph G (V,E)

I (G) = max (Cov (e)) , $e \in E$

Lowering a graphs interference is excluding all possible edges with high coverages without loosing connectivity.

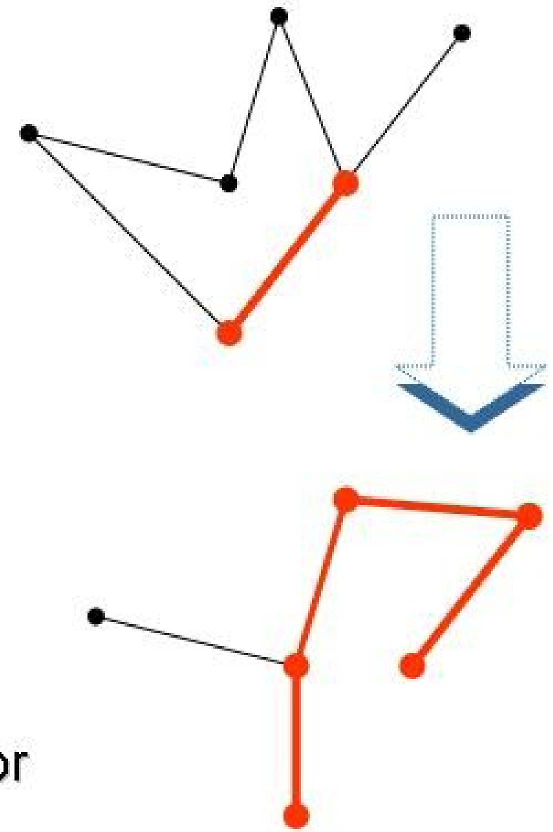
What kind of graph can guarantee that ?

Goals

Desired graph:

- Low interference
- Connectivity
- Spanner graph
- Planar graph

Spanner graph



Given a graph G(V,E)
G* would be a t-spanner for V if

$|x,y|_{PG^*} \leq t.|x,y|_{PG}$ where t is the stretch factor

The path between these pair of nodes in G* should be equal to at most the shortest path between them in the original graph G time the stretch factor t.

Besides spanner graph, what else we need to consider ?

Study cases

- Sparseness
- Chain of nodes
- Worst case graph
- Planar graph

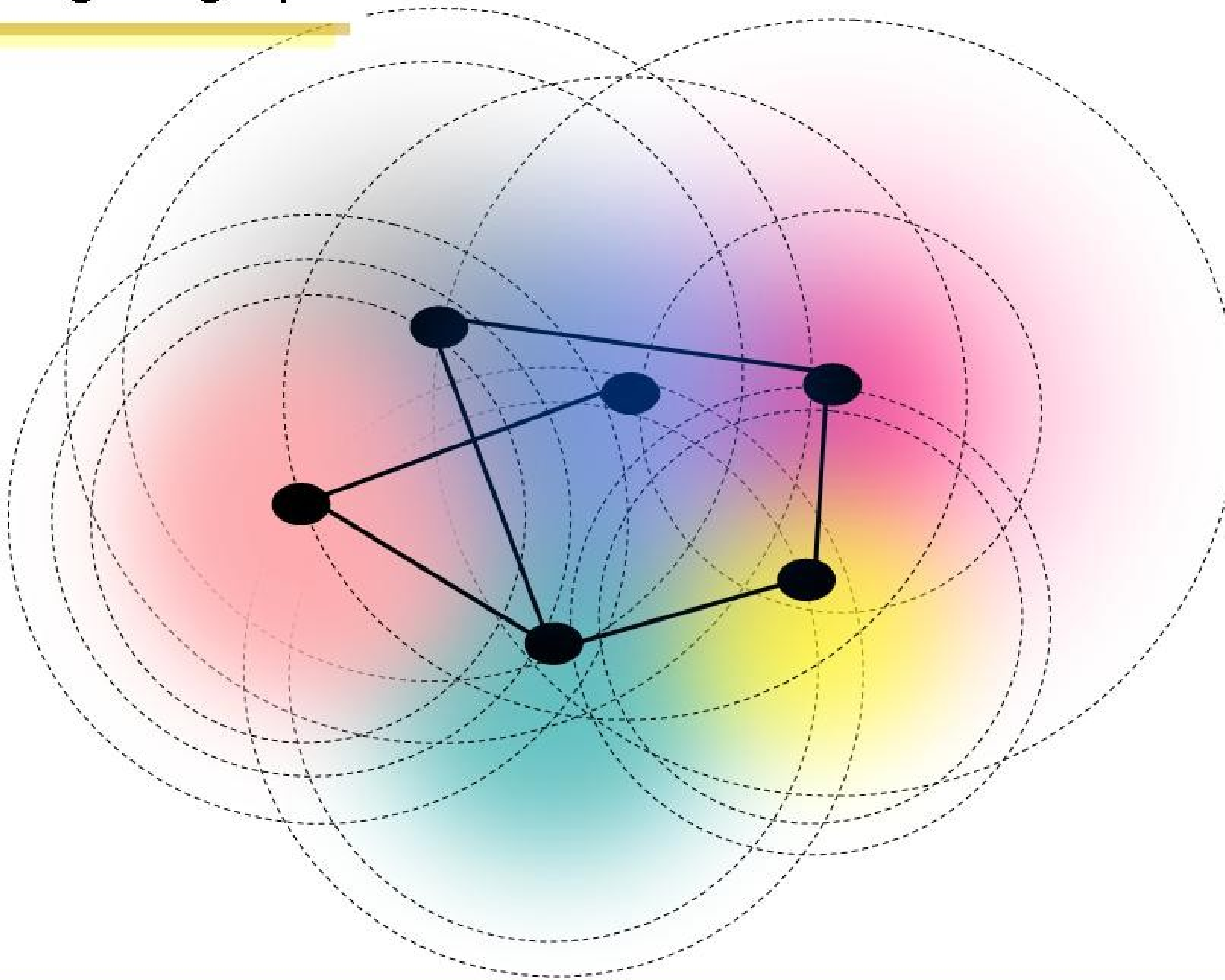
Sparseness

Claim :

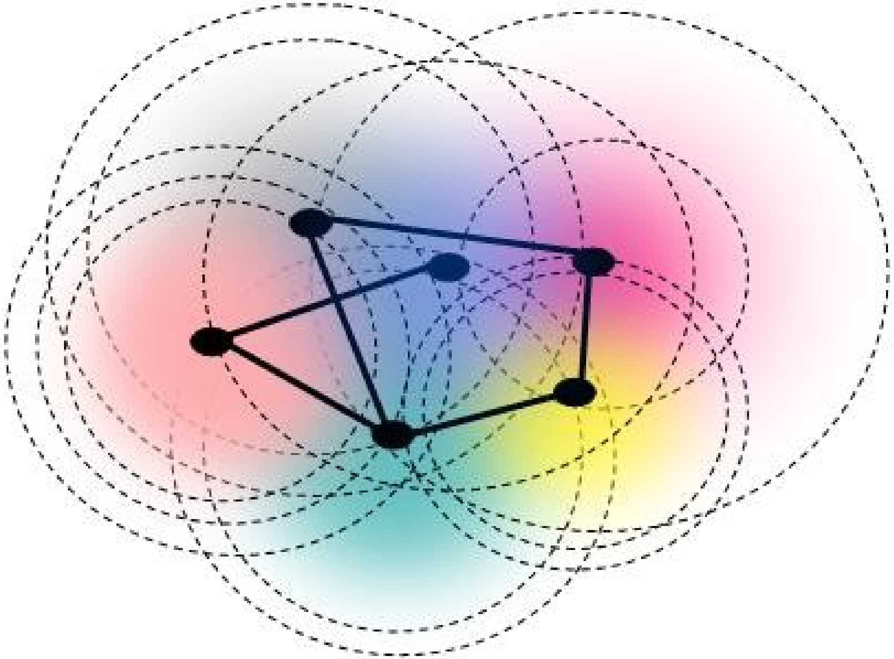
If the graphs degree could be lowered, then the interference will be lowered as well

...?

Low degree graph



Sparseness



Claim :

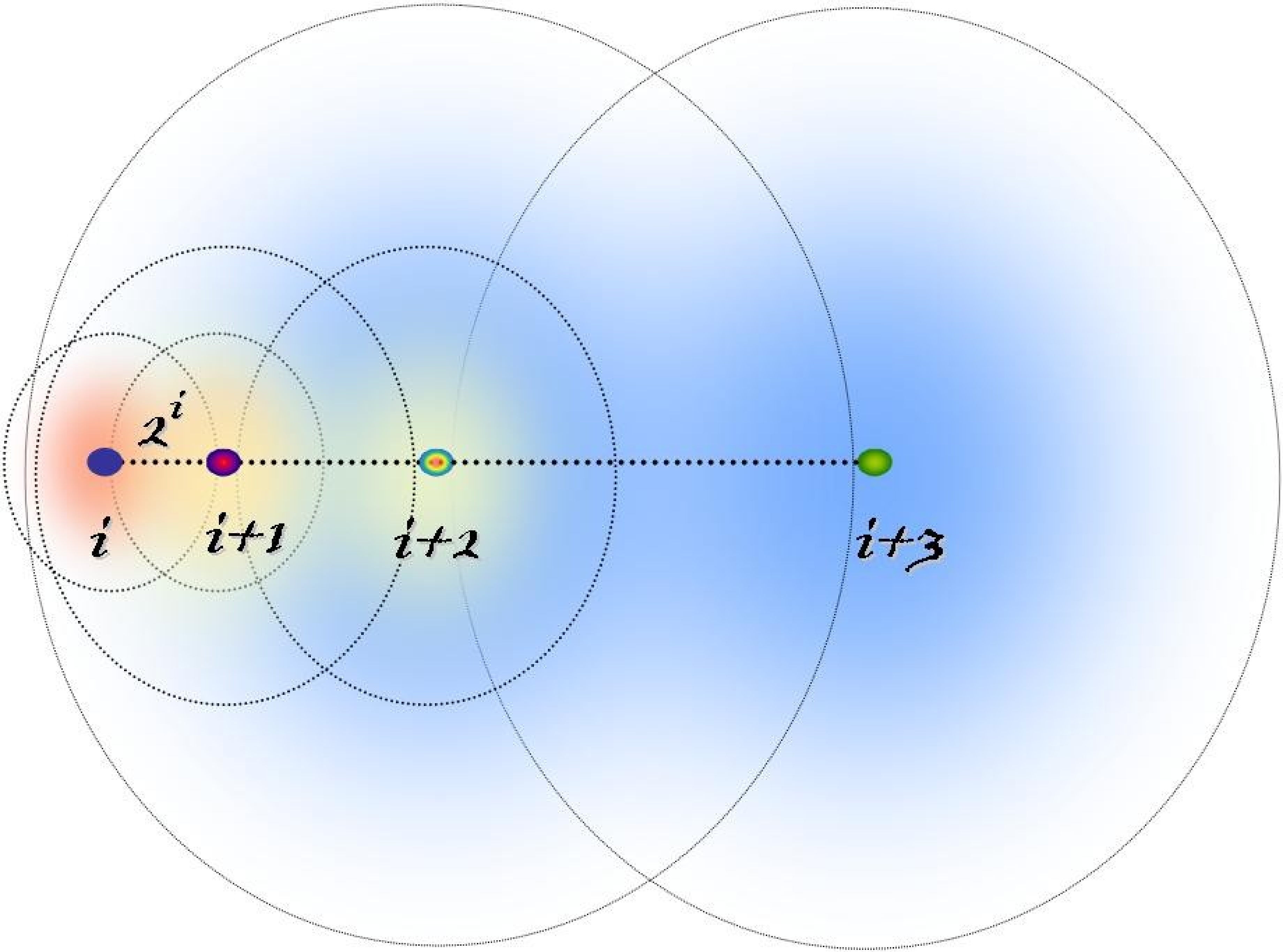
If the graphs degree could be lowered, then the interference will be lowered as well

The claim doesn't hold, the interference of this graph is O(n).

Chain of nodes

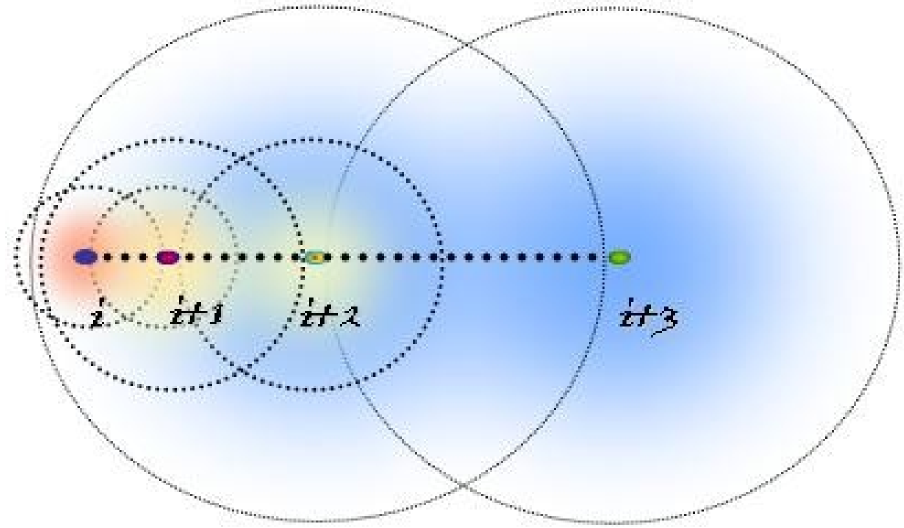
Set of n vertices V, in between the distance grows exponentially.
$|x_i,x_{i+1}|= 2^i$ where I {1,…,n}

$|x_i,x_{i+1}|$ is the radius of these nodes discs :
When x_i,x_{i+1} communicate, they interfere all other nodes in range (1,…i)



2^i
i
i+1
i+2
i+3

Chain of nodes

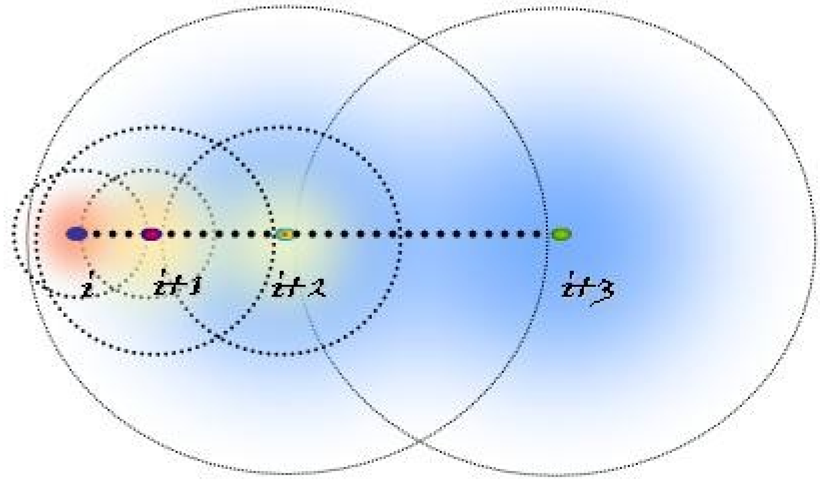


Current solution :

Some approaches will choose the greedy way, i.e. connect the nearest neighbor.

Minimum Spanning Tree, or Related Neighbor Graph will push the interference of such a graph to $\Omega(n)$.

Chain of nodes



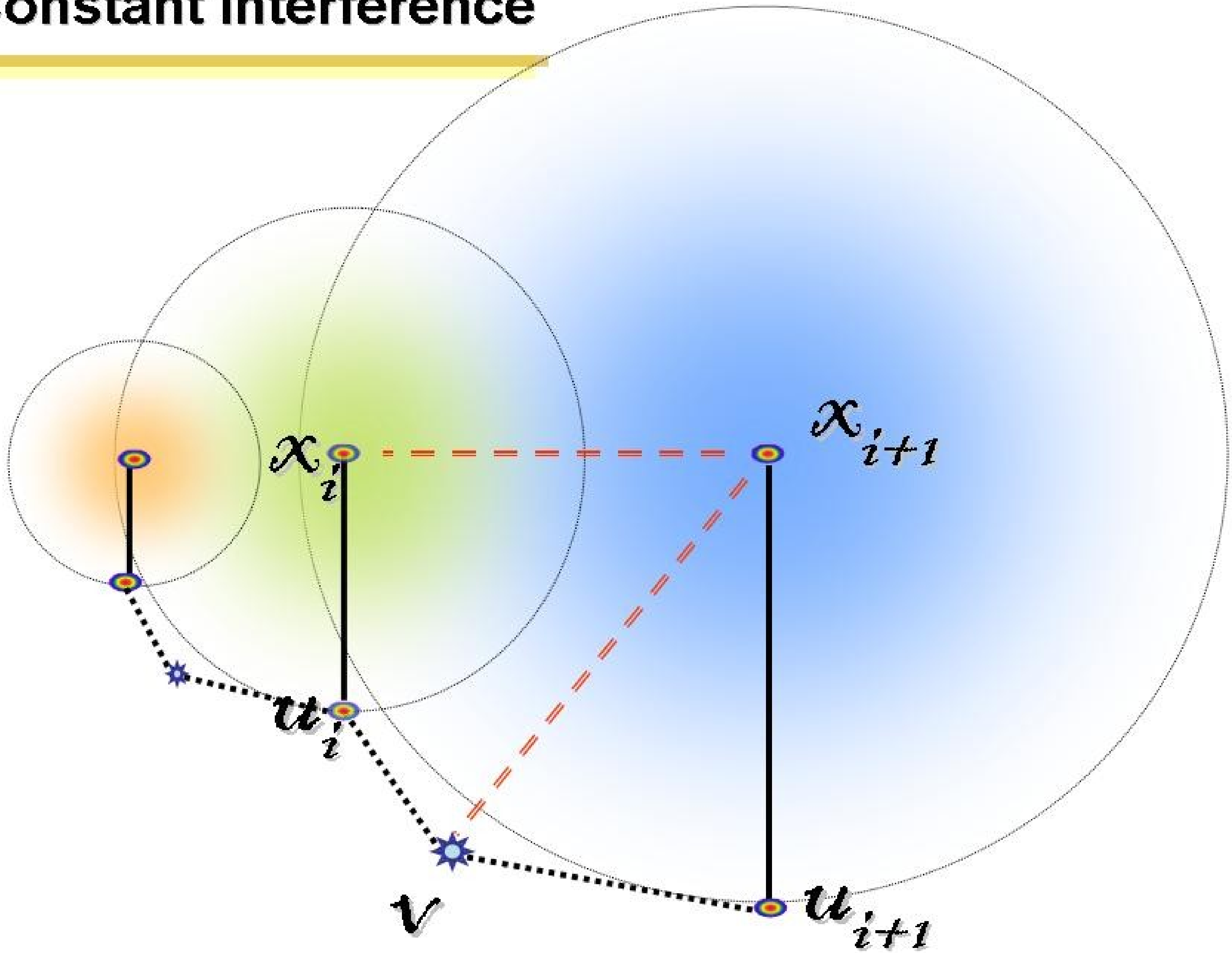
Suggested solution :

Ask for help from the nodes in similar situation!

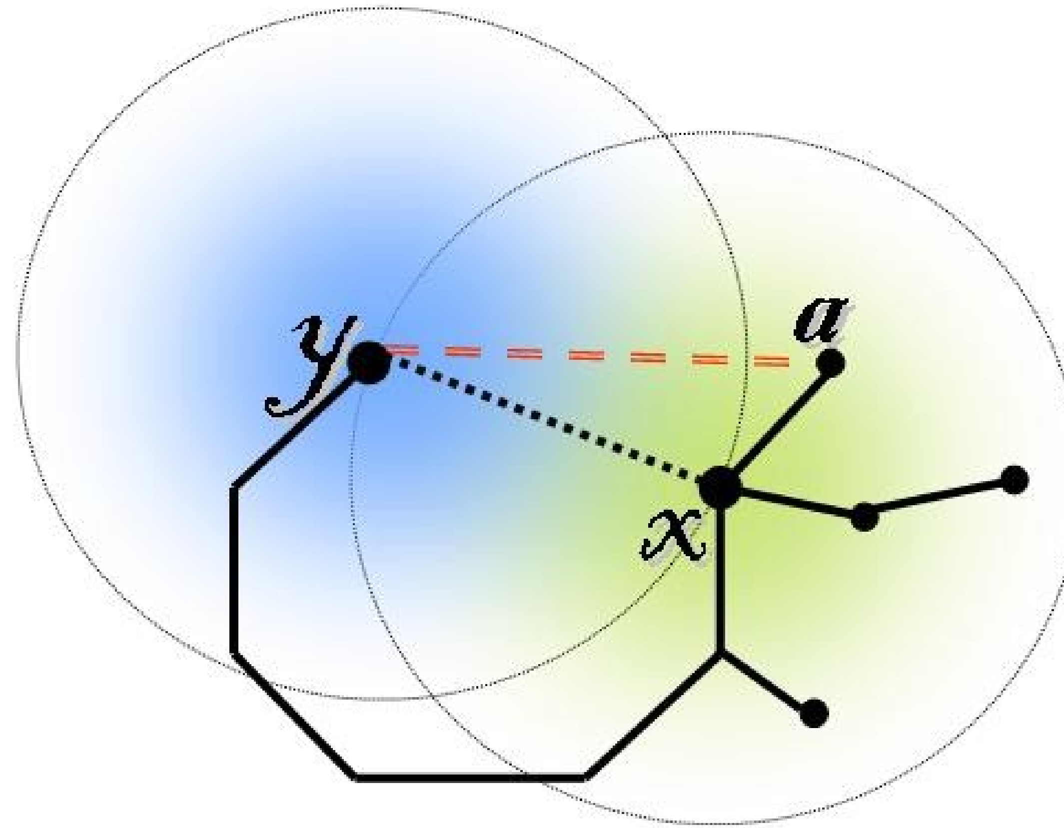
$|x_i, x_{i+1}| = 2^i$ where I {1,…,n}
$|u_i, u_{i+1}| = 2^i$ where I {1,…,n}

Pick a helping node v so that:
$|x_i, u_i| < |x_i, v| < |x_i, u_i|$

Constant interference



Worst case graph



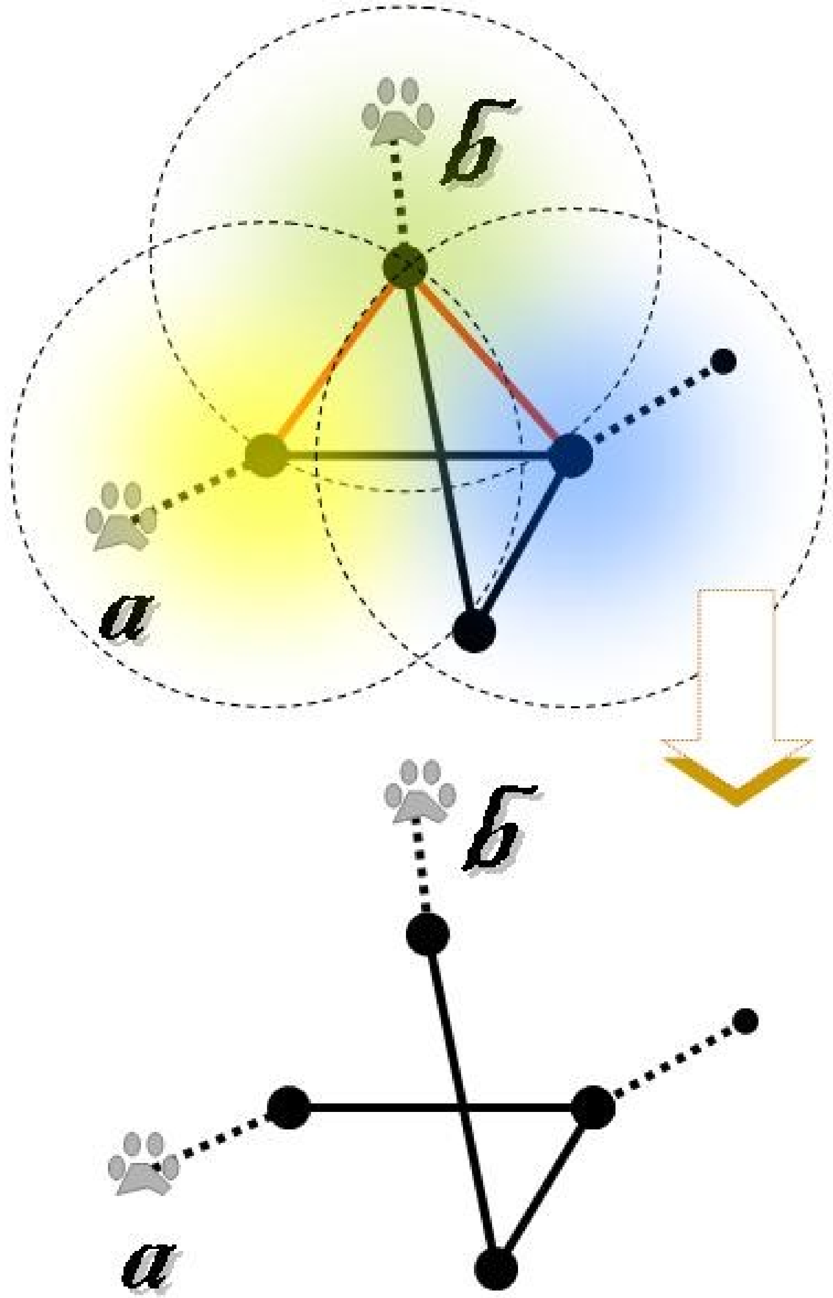
Given a graph G (V,E)
The vertices are located equally to each other.
Except two nodes x,y :
|x,y| > |u,v| where { u,v ϵ V }
For connectivity reason, this edge must be set.
The edge |x,y| increases the interference.

Planar graph

A Planar graph, is a graph in which no two edges intersect.

Planarity doesn't have to increase / decrease graphs interference.

Our desired graph might be a planar one.



a,b are small groups of nodes

Then how can the optimal graph be constructed **?**

Algorithms

Algorithms

- LIFE
- LISE
- LLISE

LIFE

Low Interference Forest Establisher

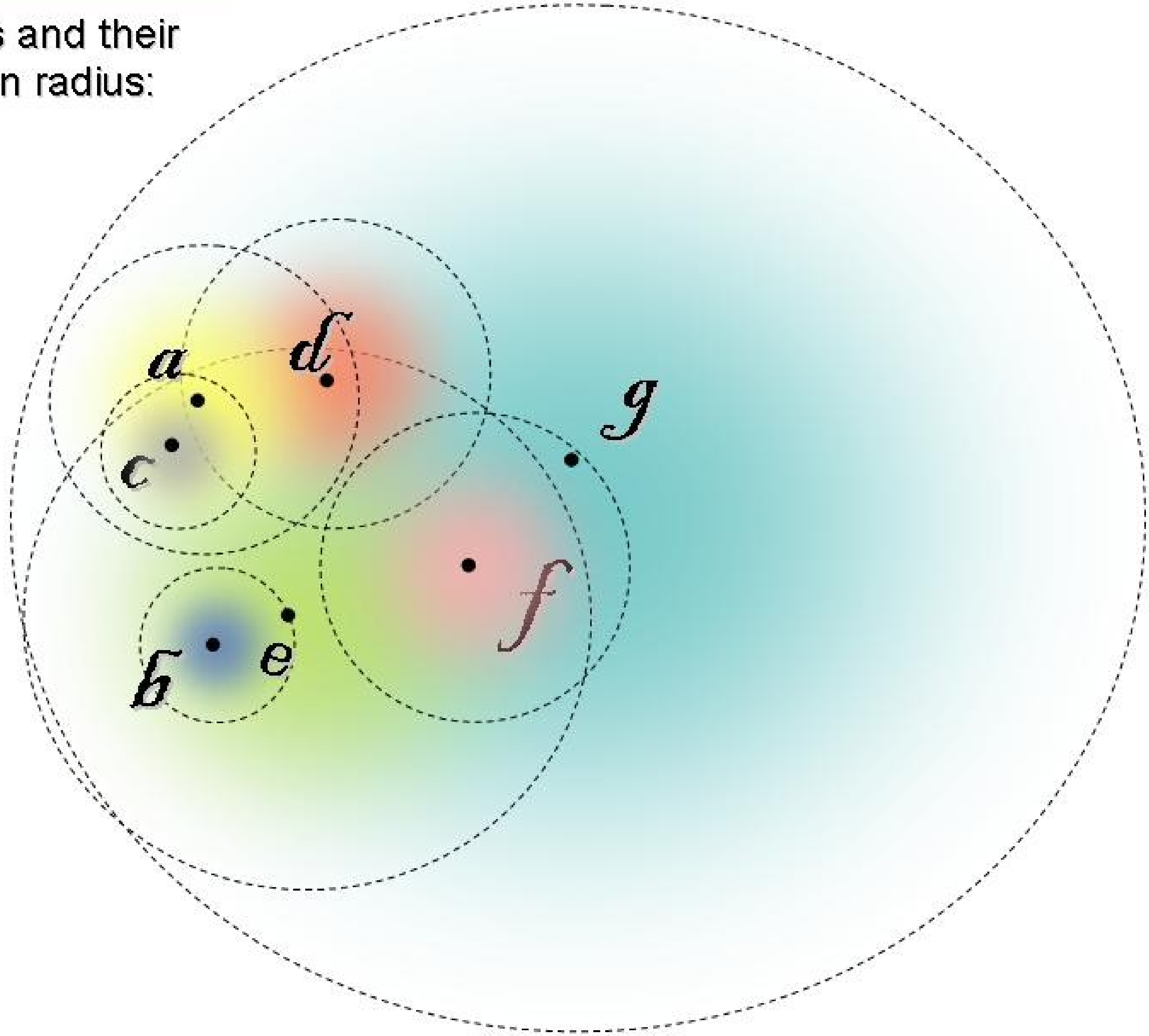
Hence the algorithm constructs Minimum Spanning Trees, the constructed graph is a forest.
If two nodes in range of each other, pick the edge with minimum coverage.

Input :
Set of vertices, no more requirements.
Running time : O (n^2 log n)

Simulating LIFE

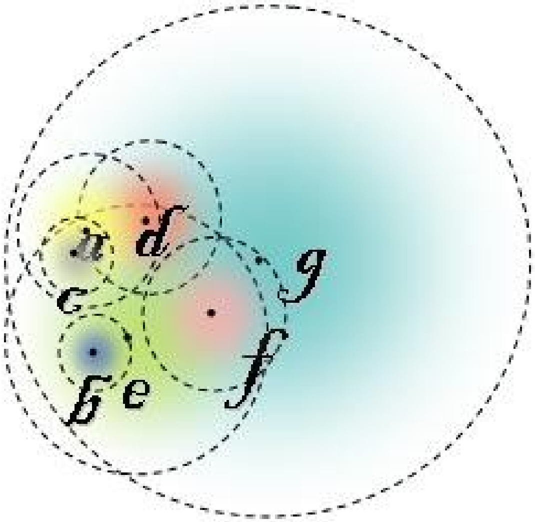
Given a set of vertices and their maximum transmission radius:

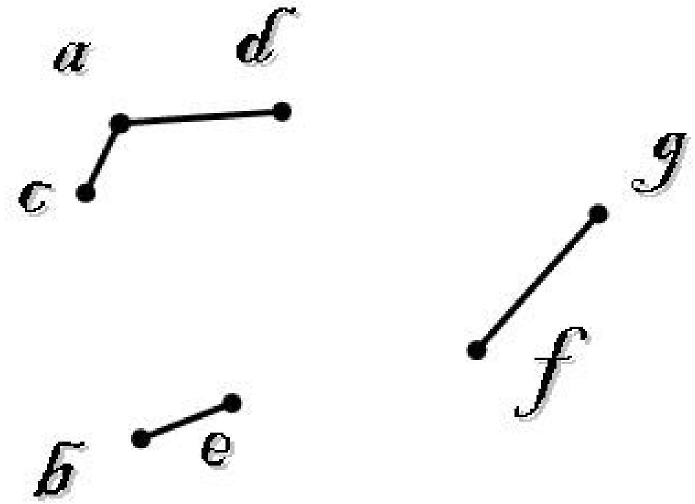
a	3
b	2
c	2
d	3
e	4
f	3
g	5

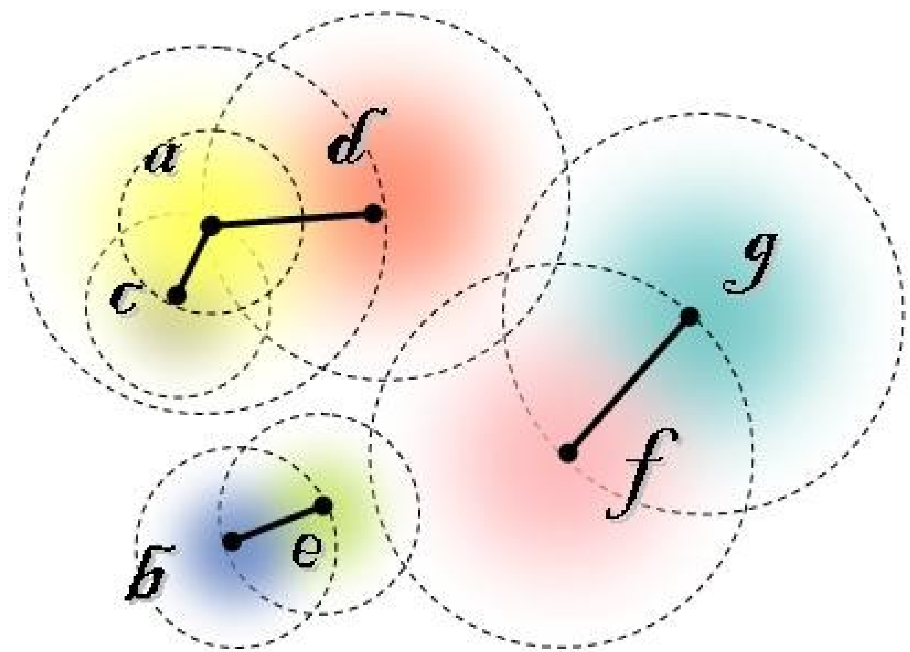


Simulating LIFE

Then the constructed graph would look like …







The connectivity is violated.

There are three MST, which are not connected.

LISE

Low Interference Spanner Establisher

The algorithm constructs Spanner graph.
Shortest path is computed separately.
Low weighted (low coverage) edges are inserted to the graph.

Input :
Set of vertices, Stretch factor (t).
Running time : polynomial.

LLISE

Local Low Interference Spanner Establisher

The algorithm applied locally for edge e.
Search within t/2 neighbors for eligible paths.
Find the optimal interference path among these paths.
Inform the neighbors to use this path only.

Input :
Set of vertices, stretch factor.

Conclusion

LISE and LLISE are a good start although certain information is required :

1. Stretch factor

For some kind of graphs, stretch factor is known.
Compute the stretch factor considered to be very expensive.

2. Networks knowledge

Either to find the neighbors, or to find the shortest path.
In LIFE it is required to set the edge with minimum coverage.

Conclusion

3. Shortest path computation

The running time of the algorithms depends on the implementation of this point.

The proofs trigger many arguments!

Algorithms performance is close to the optimal if the stretch factor has large value. Nevertheless for small values the algorithms performance doesn't differ from Related neighbor Graphs.

Thank you!

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