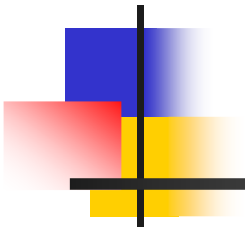
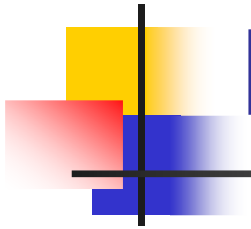


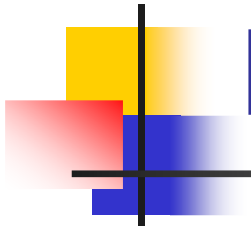
Component Based Localization in Sparse Wireless Ad Hoc and Sensor Networks

Xiaoping Wang, Jun Luo,
Shanshan Li, Dezun Dong,
Weifang Cheng



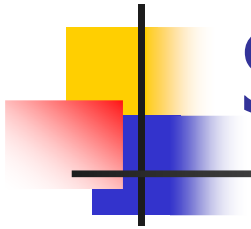
Roadmap

- Motivation
- Problem formulation
- Node base algorithms
- Component bAsed Localization aLgorithm (CALL)
- Experimental evaluations
- Future work



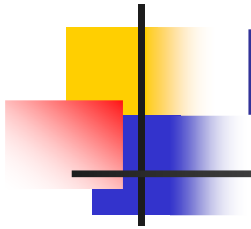
Motivation

- Location information is critical context
  - WSN: Fire alarm!
  - Manager: Where? Where?
  - WSN: I don't know! I have no location knowledge!
- Location information facilitates many network designs
  - Geographic routing, coverage, boundary/ hole detection, …



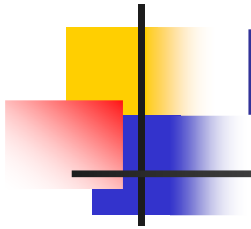
Sparseness in Localization

- Localization depends on inter-node distances
  - Naïve approaches are not feasible
- Information insufficiency influences localization much
  - The distance-measurement ranges are typically much less than that of communication range for many ranging systems



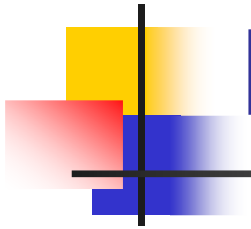
Roadmap

- Motivation
- Problem formulation
- Node base algorithms
- Component bAsed Localization aLgorithm (CALL)
- Experimental evaluations
- Future work



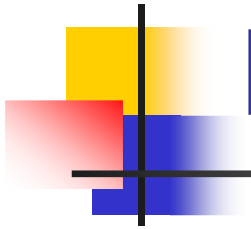
Basic Assumptions

- Localization in a 2-D plane
- Accurate ranging
- General graph



Problem Formulation

- Given
  - Anchor positions
  - A set of inter-node distances
- Objective
  - Find a mapping of node-positions
  - Fulfills all the anchor positions and inter-node distances constraints
  - The result set is finite
  - The real position of each node must be a candidate in the result set

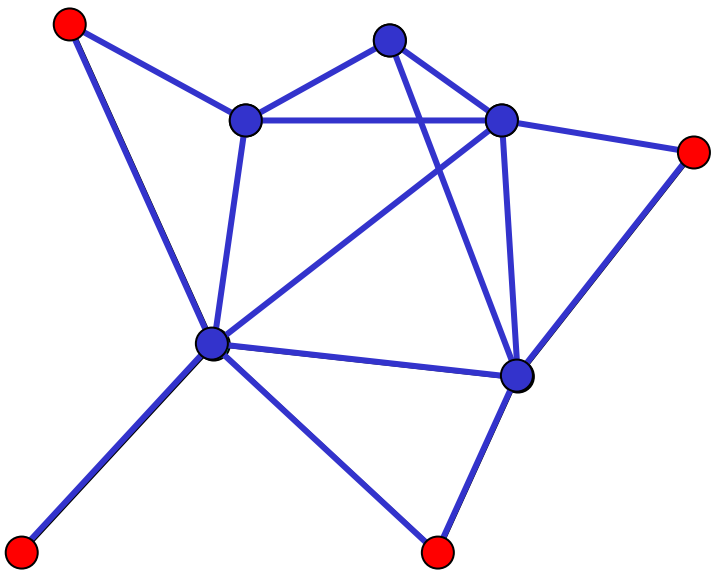


Roadmap

- Motivation
- Problem formulation
- Node base algorithms
- Component bAsed Localization aLgorithm (CALL)
- Experimental evaluations
- Future work

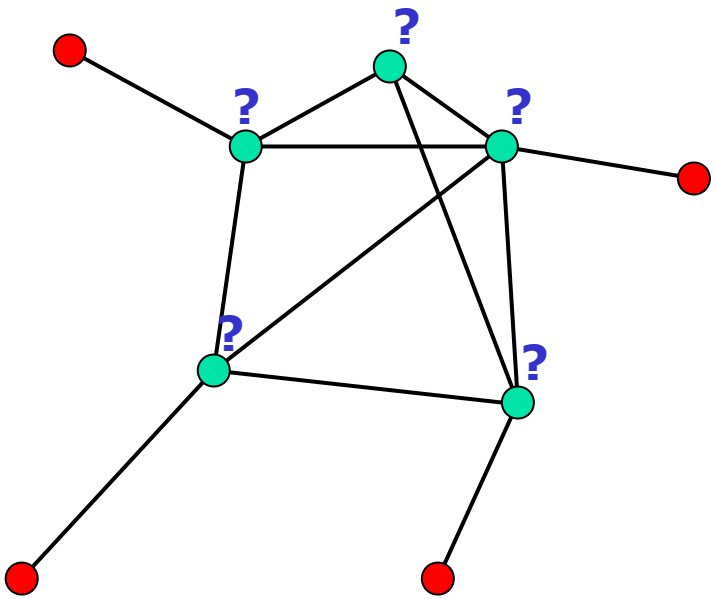
Node Based Algorithms

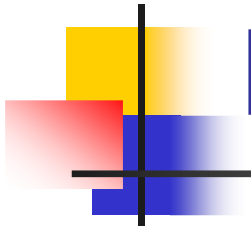
- Localizing nodes by a series of trilaterations or bilaterations



Node Based Algorithms

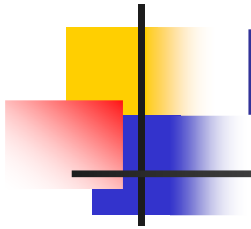
- When network becomes sparse …
- None of them can be localized!





Node Based Algorithms

- Require anchor proximity
  - Nodes must find enough anchors in direct neighbors to start the localization procedure
- Restrict nodes to be localized in order
  - Halt when no single node can perform trilateration or bilateration, no matter whether there are localizable nodes

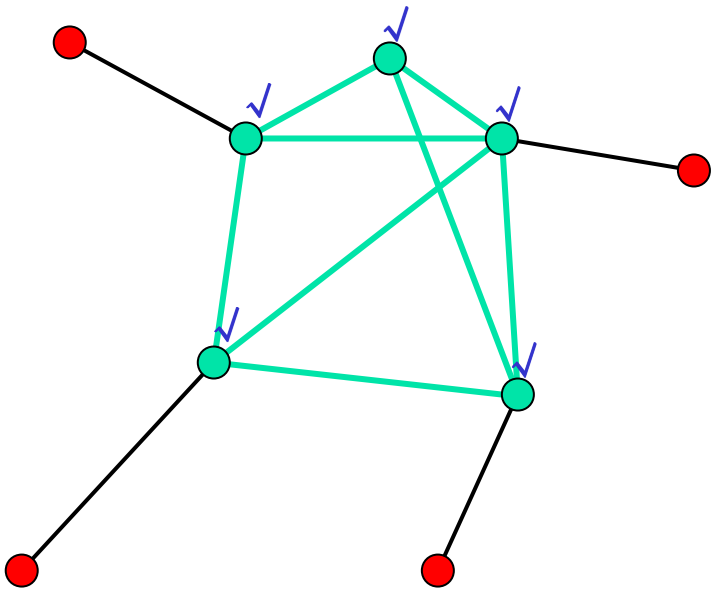


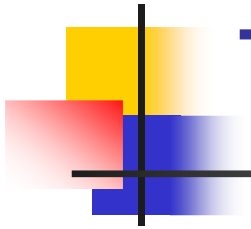
Roadmap

- Motivation
- Problem formulation
- Node base algorithms
- Component bAsed Localization aLgorithm (CALL)
- Experimental evaluations
- Future work

Component Based Localization

- Take the five nodes as a whole
- They are all localizable nodes!

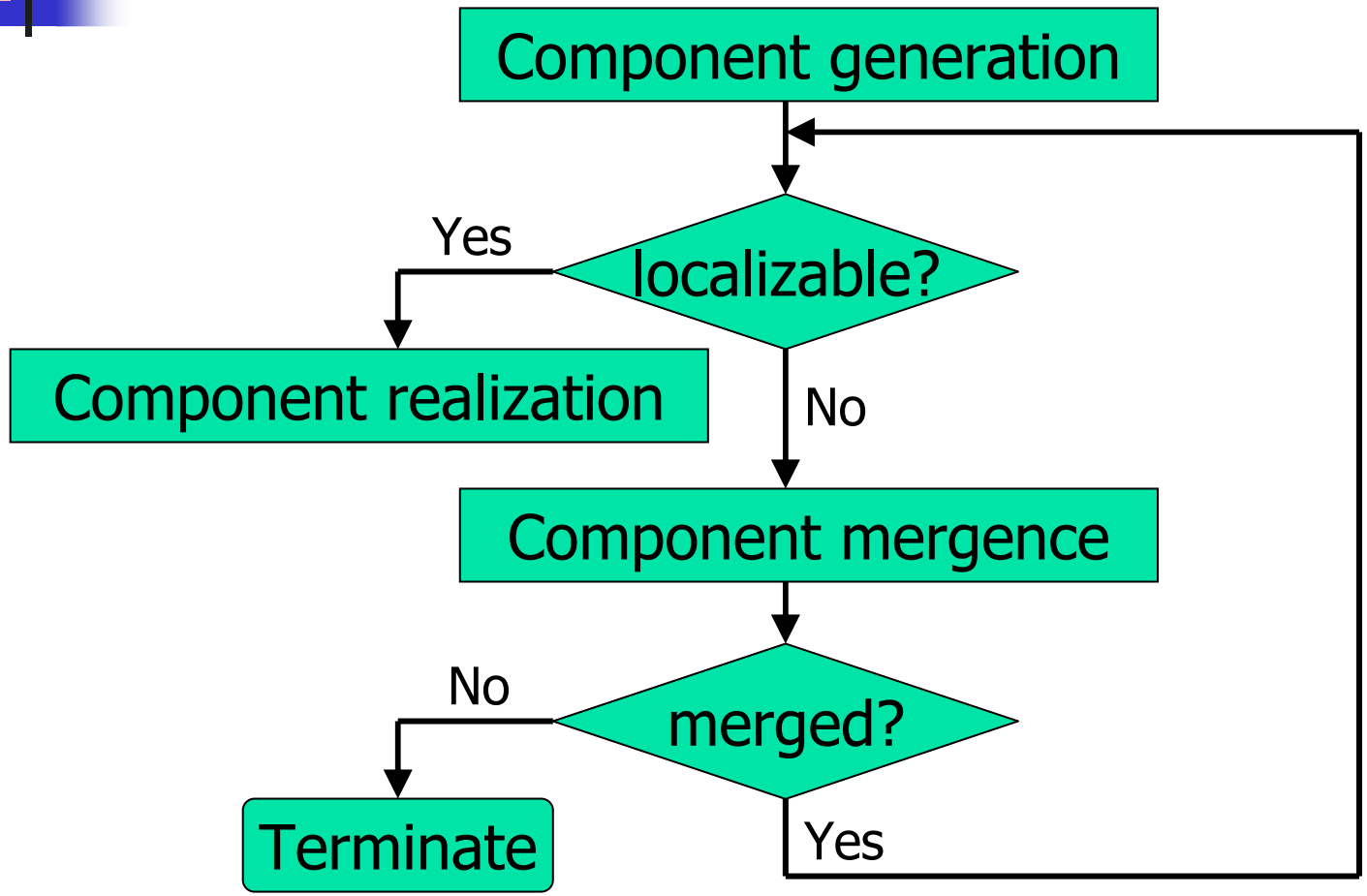


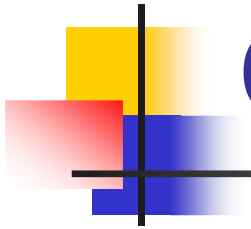


The Concept of Component

- A **component** is a group of vertices that have finite realization possibilities
  - A node can join only one component
  - Any component pair shares no common nodes
- A component is **globally rigid** if and only if there is a unique realization in a plane
- Besides each single node, components are also basic unit for localization

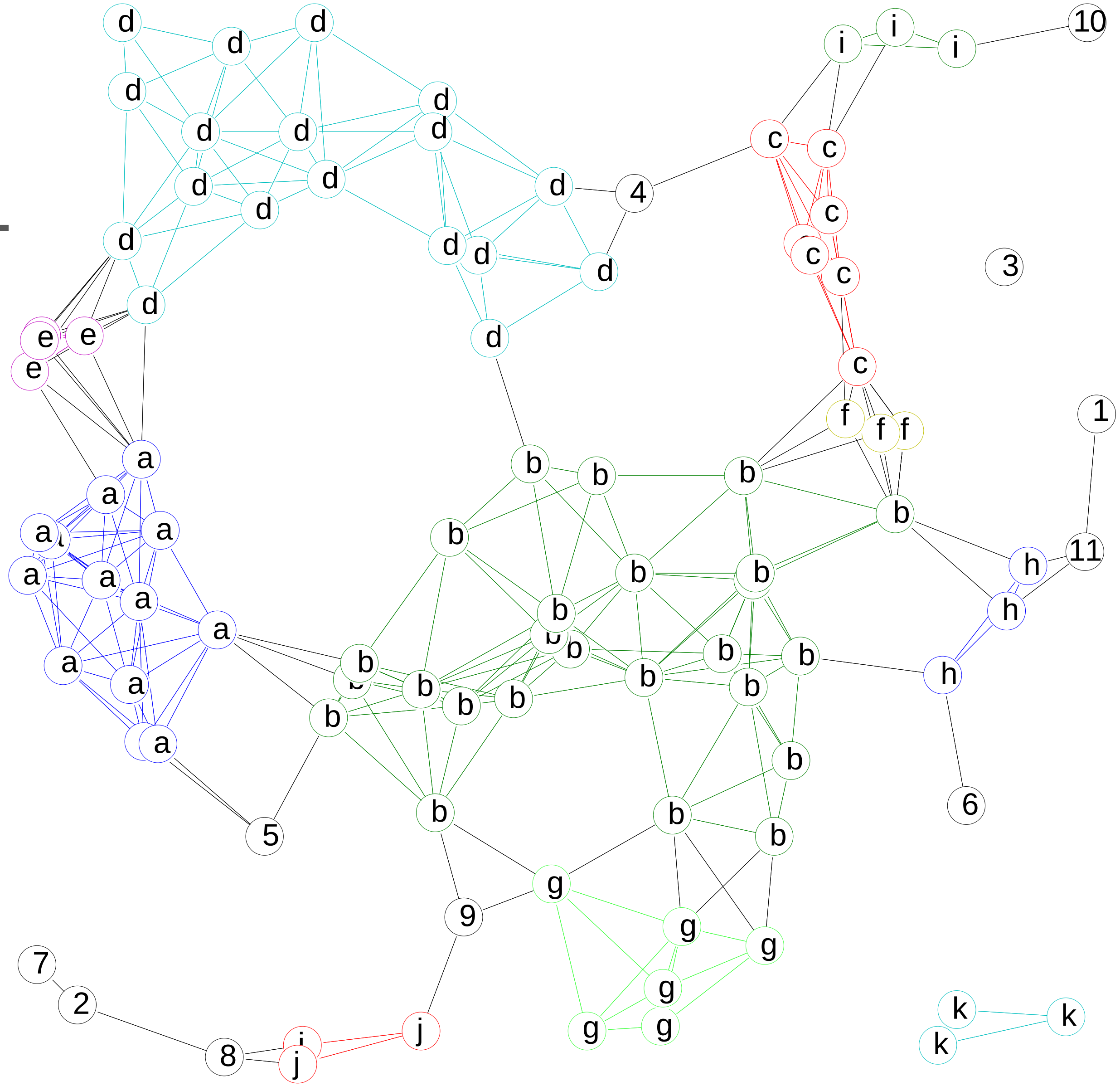
Overview

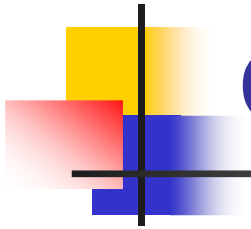

Component generation
localizable?
Yes
Component realization
No
Component mergence
merged?
No
Terminate
Yes



Component Generation

- Goal
  - Partition the network into components and isolated nodes
  - Generate local coordinate system to convert distance information into virtue coordinates
- Method
  - A component is formed by a triangle initially
  - Other nodes can join the component by trilateration
- Note that
  - All generated components are globally rigid
  - We do not differentiate anchor node and general node in this step


d
i
10
c
4
3
e
f
1
a
b
h
11
5
9
g
6
7
2
8
j
k

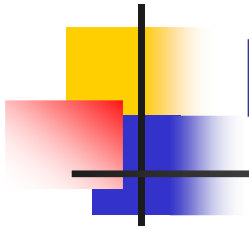


Component Mergence and Realization

- Component mergence: integrate both components and their anchor information
- Component realization: map the virtue coordinates to the physical ones
- For we have generated local coordinate system, we can do these two operations by coordinate system convention

CALL vs. BCALL

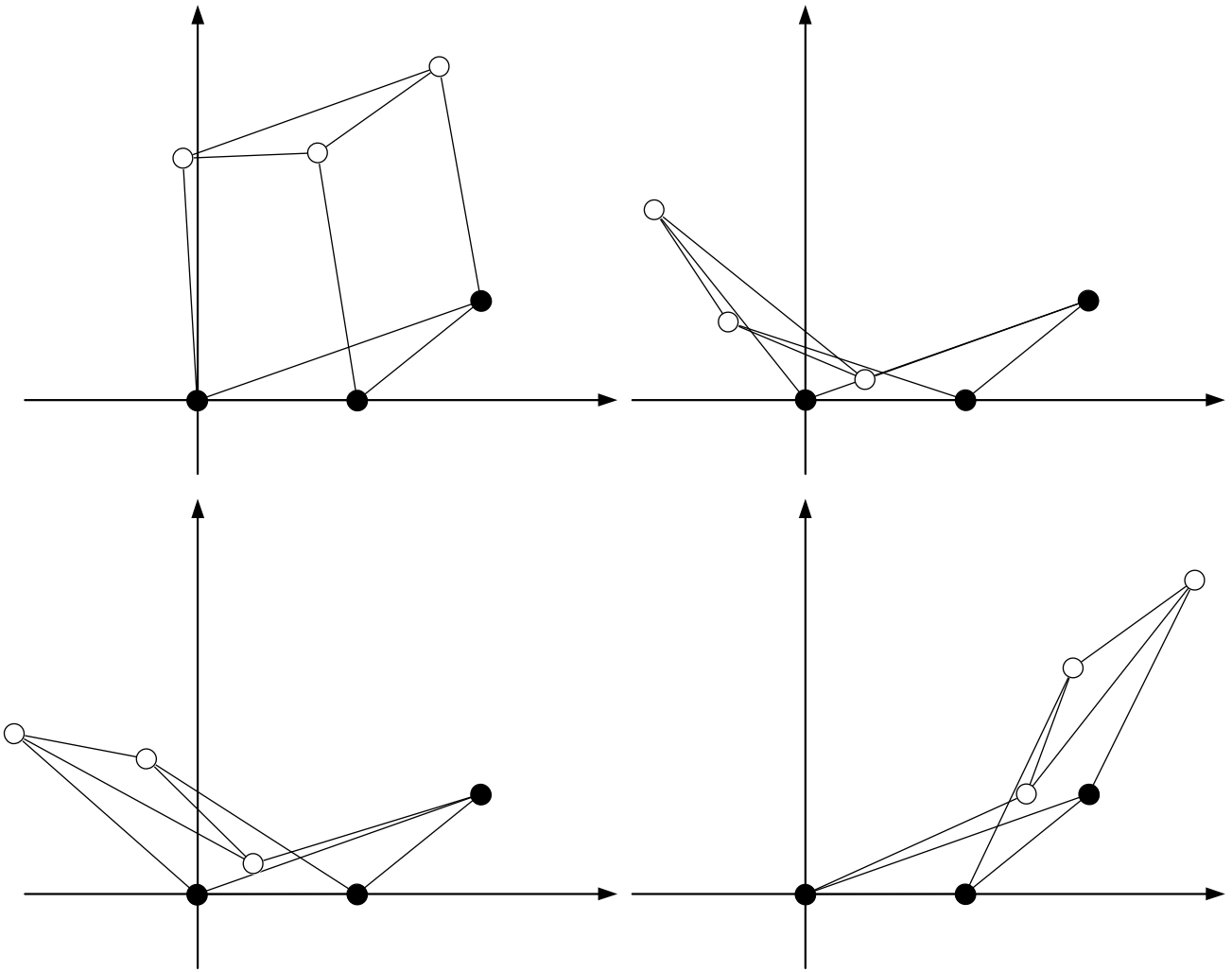
	CALL	BCALL
Result	Finite localization	Unique localization
Proportion of nodes localized	High (super set of BCALL)	Low
Worst case complexity	Exponential	Polynomial
Analogue	Bilateration	Trilateration

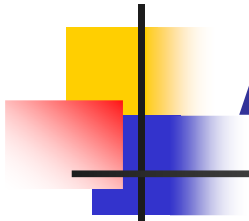


Rules for Components Mergence

Edges/Associated Nodes	Finite (CALL)	Unique (BCALL)
Isolated node	2/1	3/1
Component	3/2	4/3

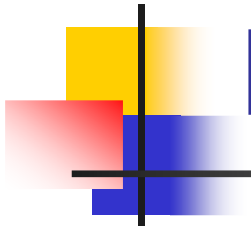
Example of Finite Mergence





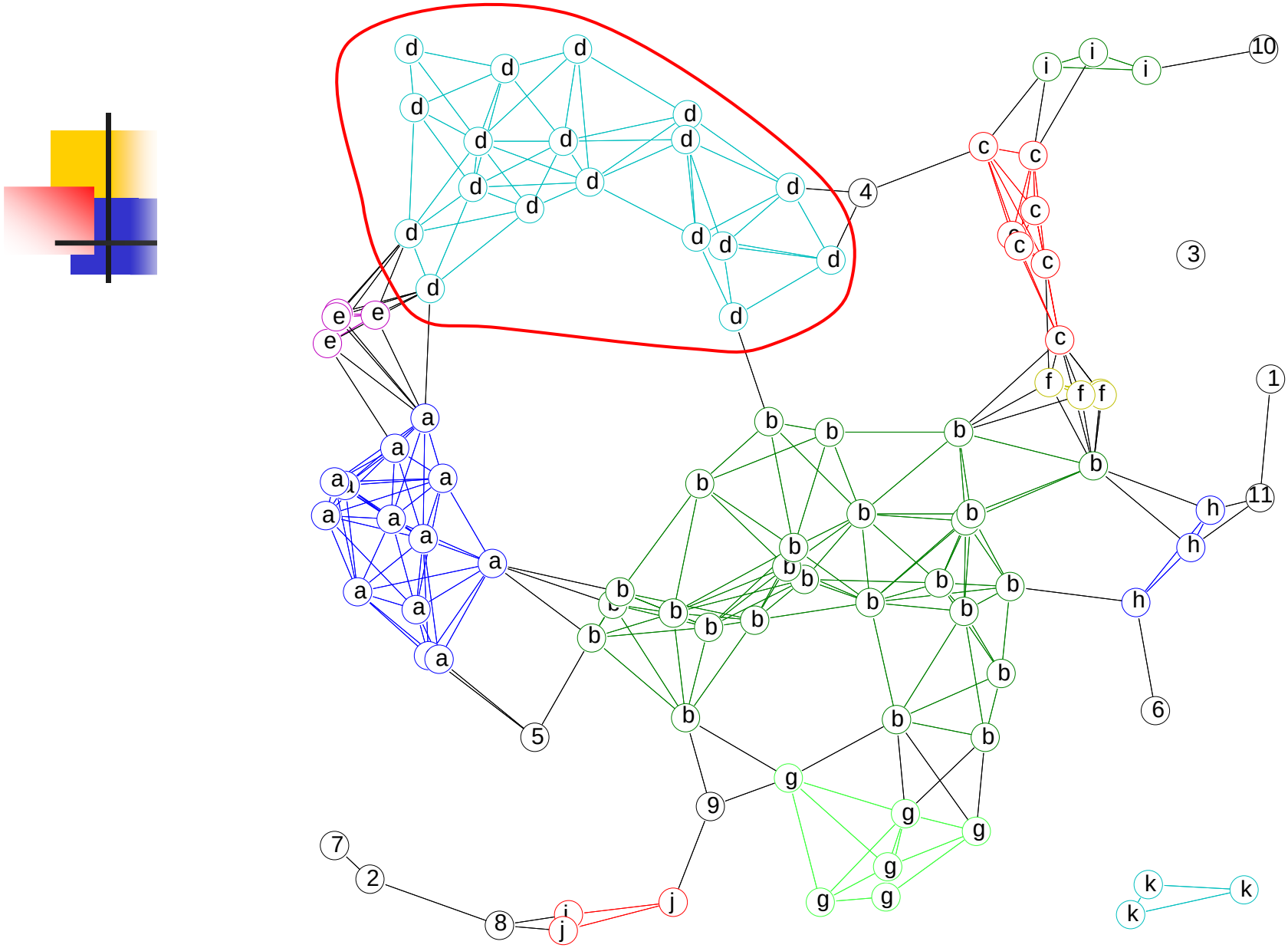
Anchor Requirement

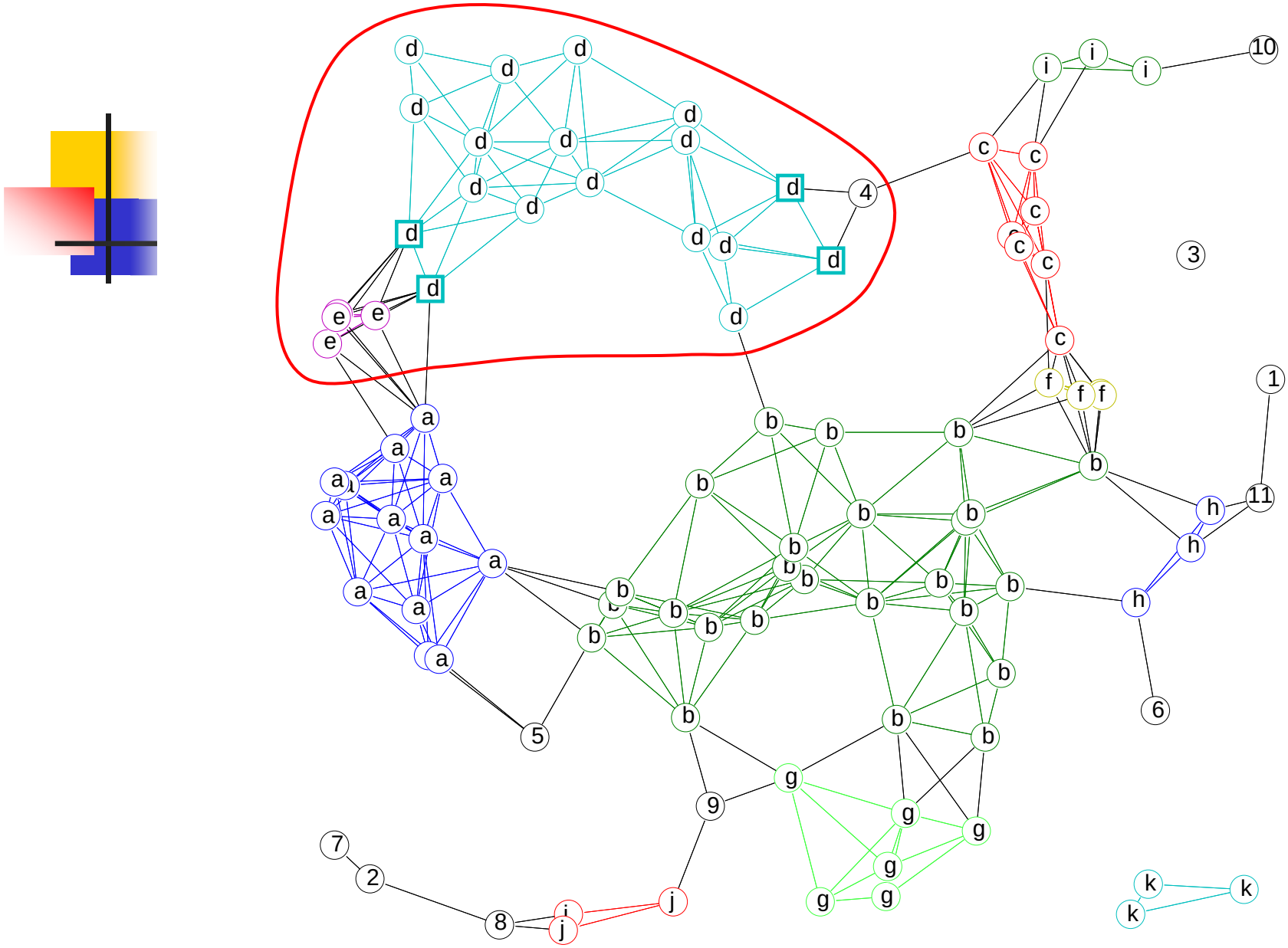
Finite (CALL)		Unique (BCALL)	
Anchors	Edges	Anchors	Edges
--	--	3	0
2	0	2	1
1	1	1	2
0	3	0	4

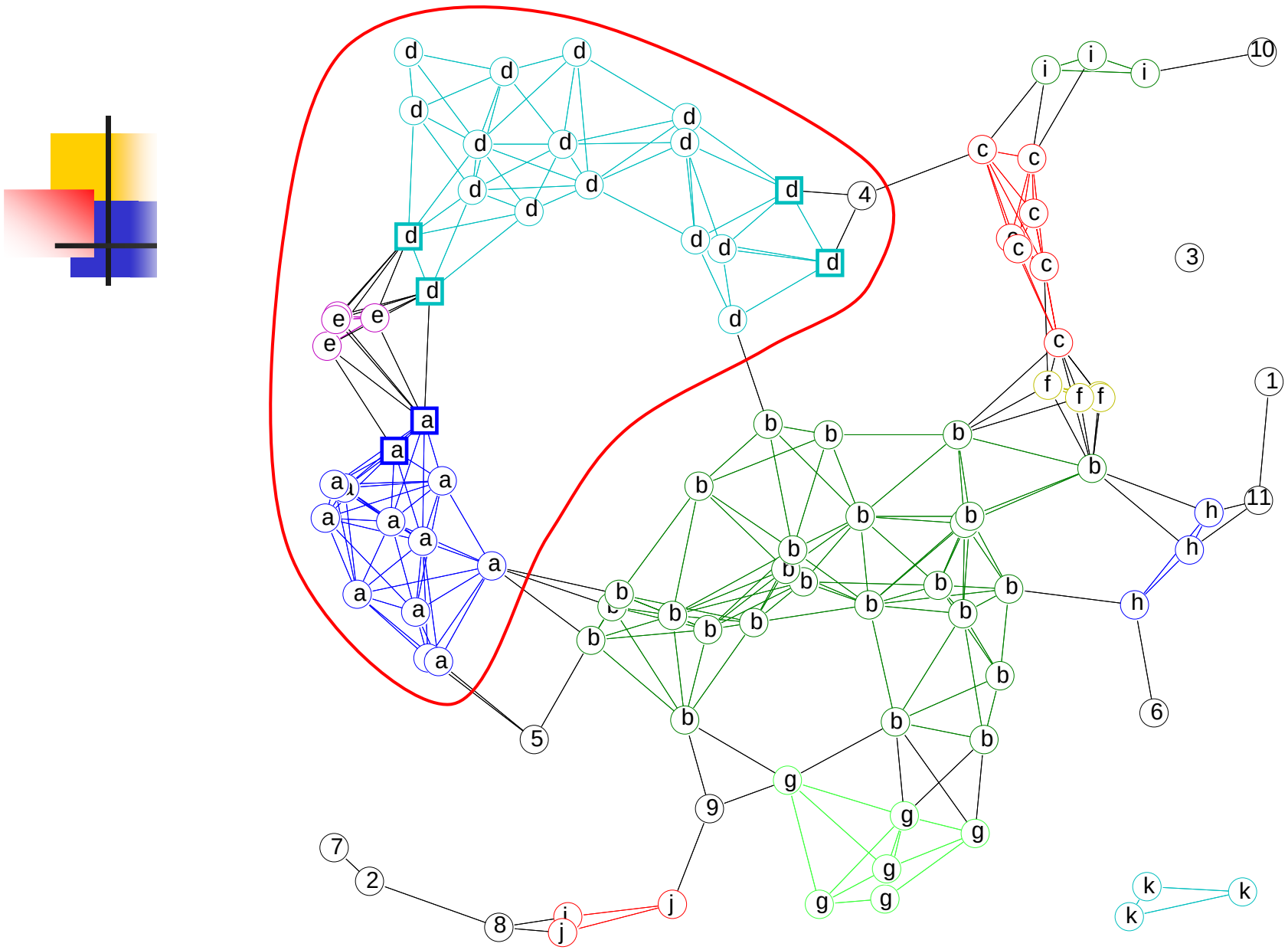


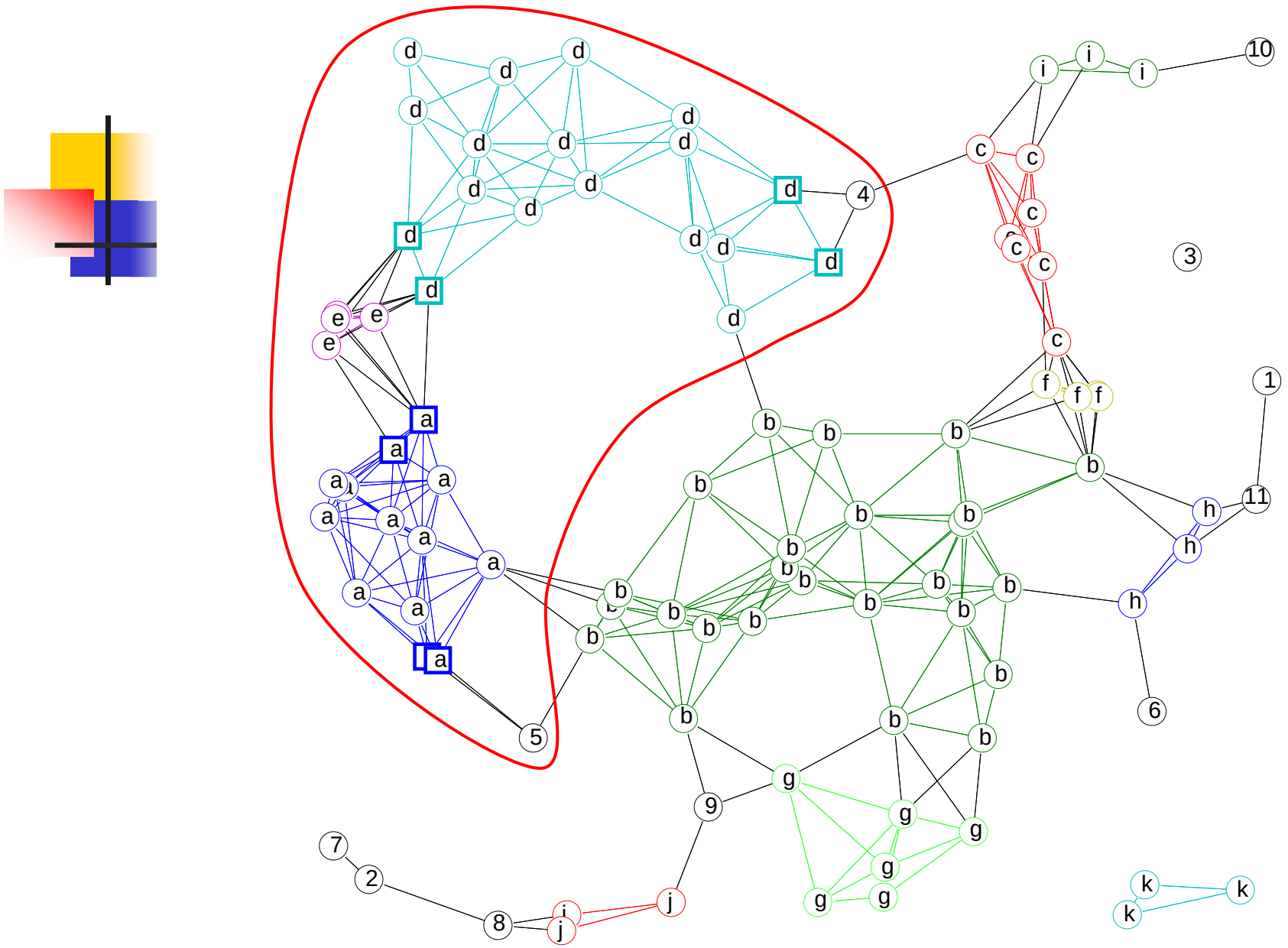
For CALL

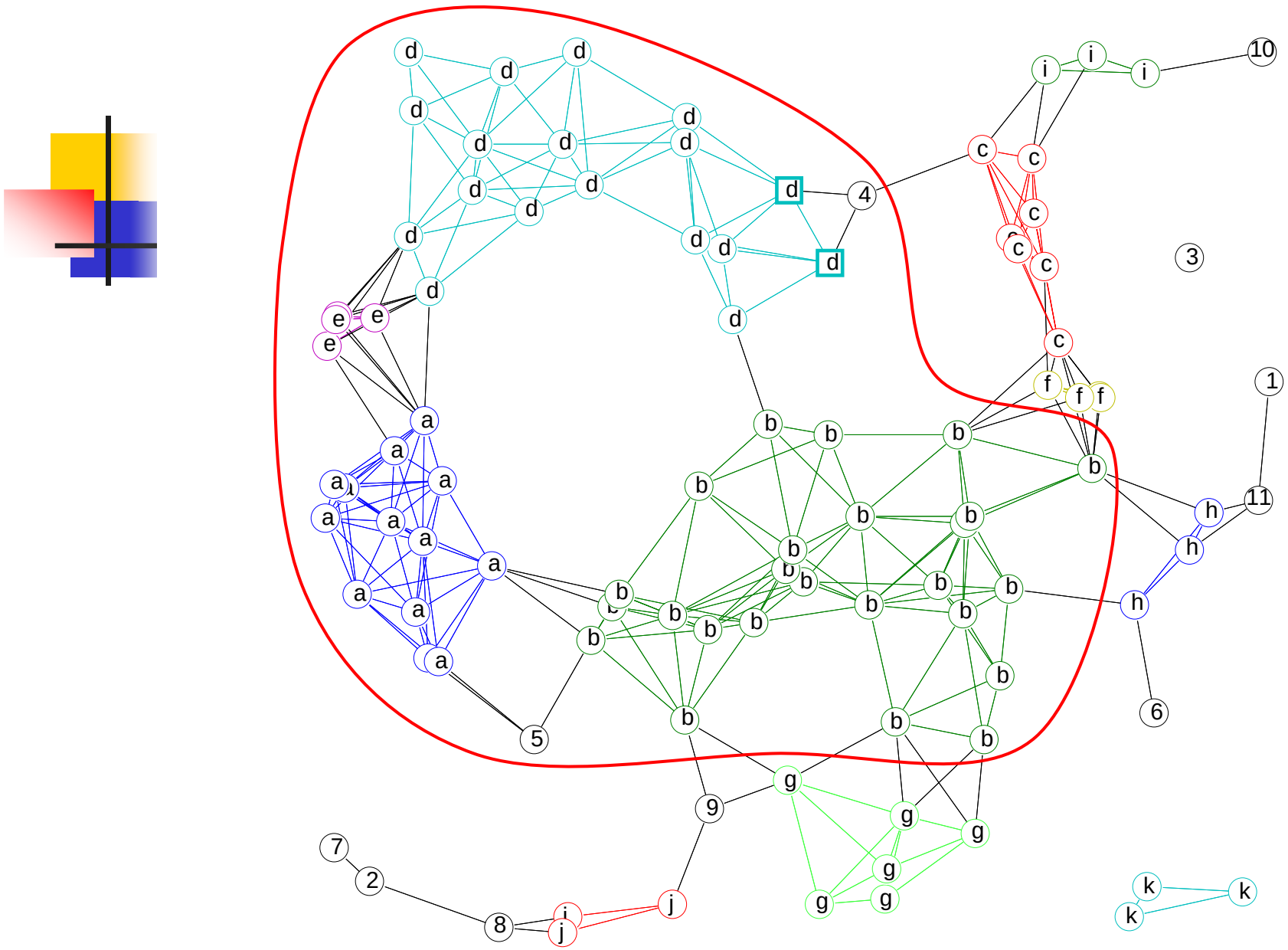
- Nodes keep all their possible locations in their potential position sets
- After each mergence or realization, nodes will prune the incompatible items in their potential position sets

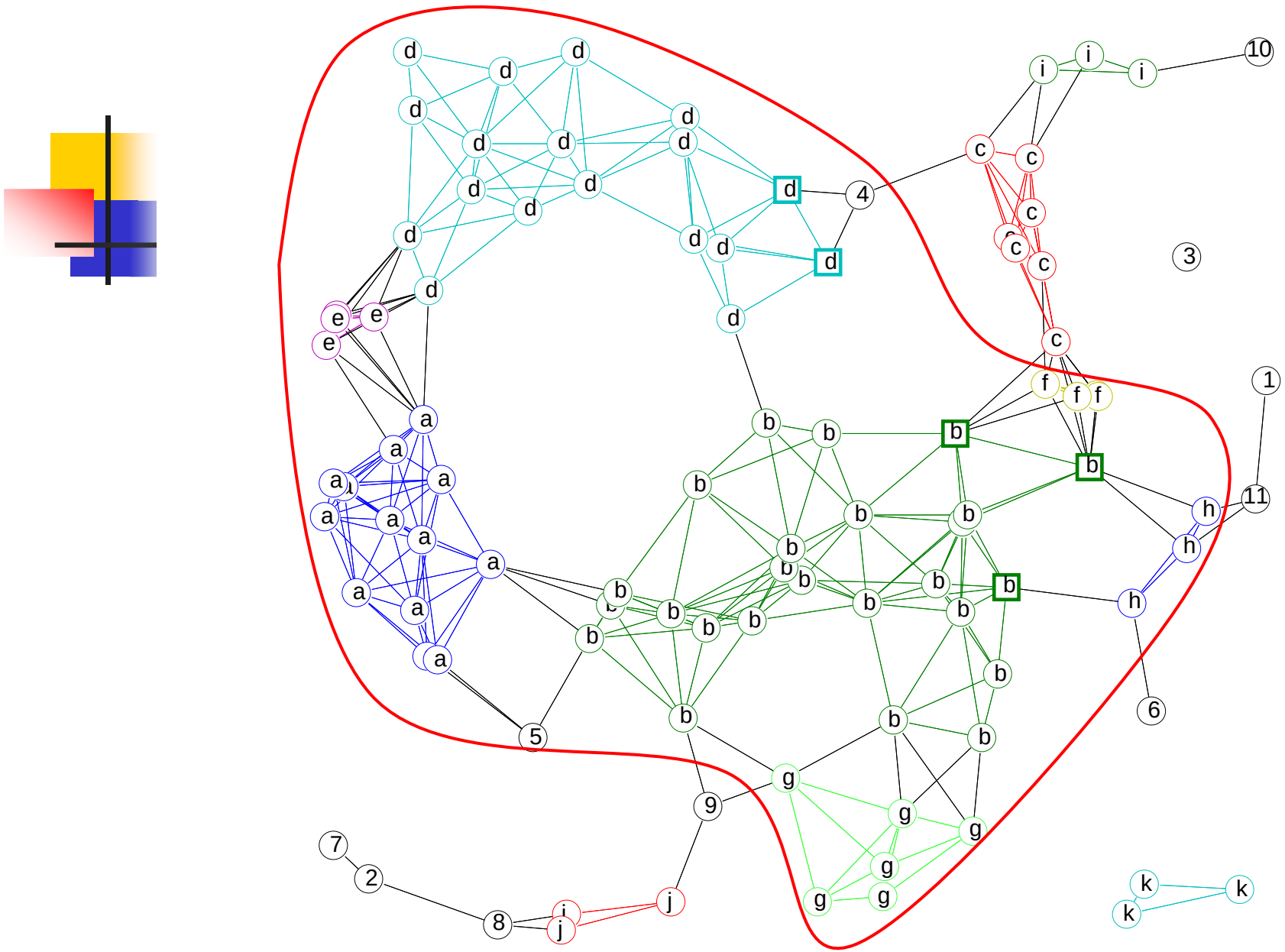

d
e
a
b
c
f
i
h
g
k
j
1
2
3
4
5
6
7
8
9
10
11

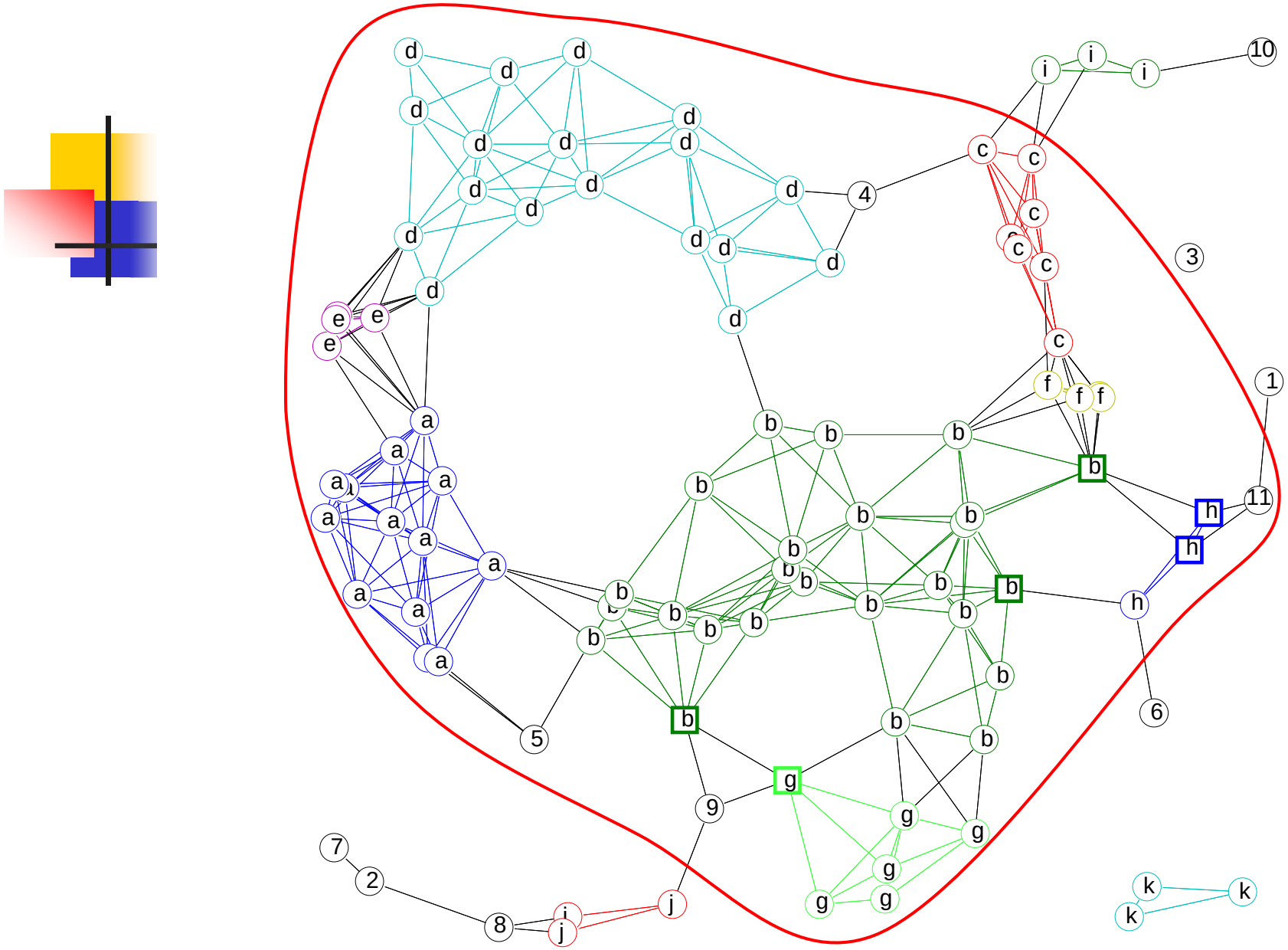

d
e
a
b
c
f
i
10
4
3
1
11
h
6
5
g
9
7
2
8
j
k

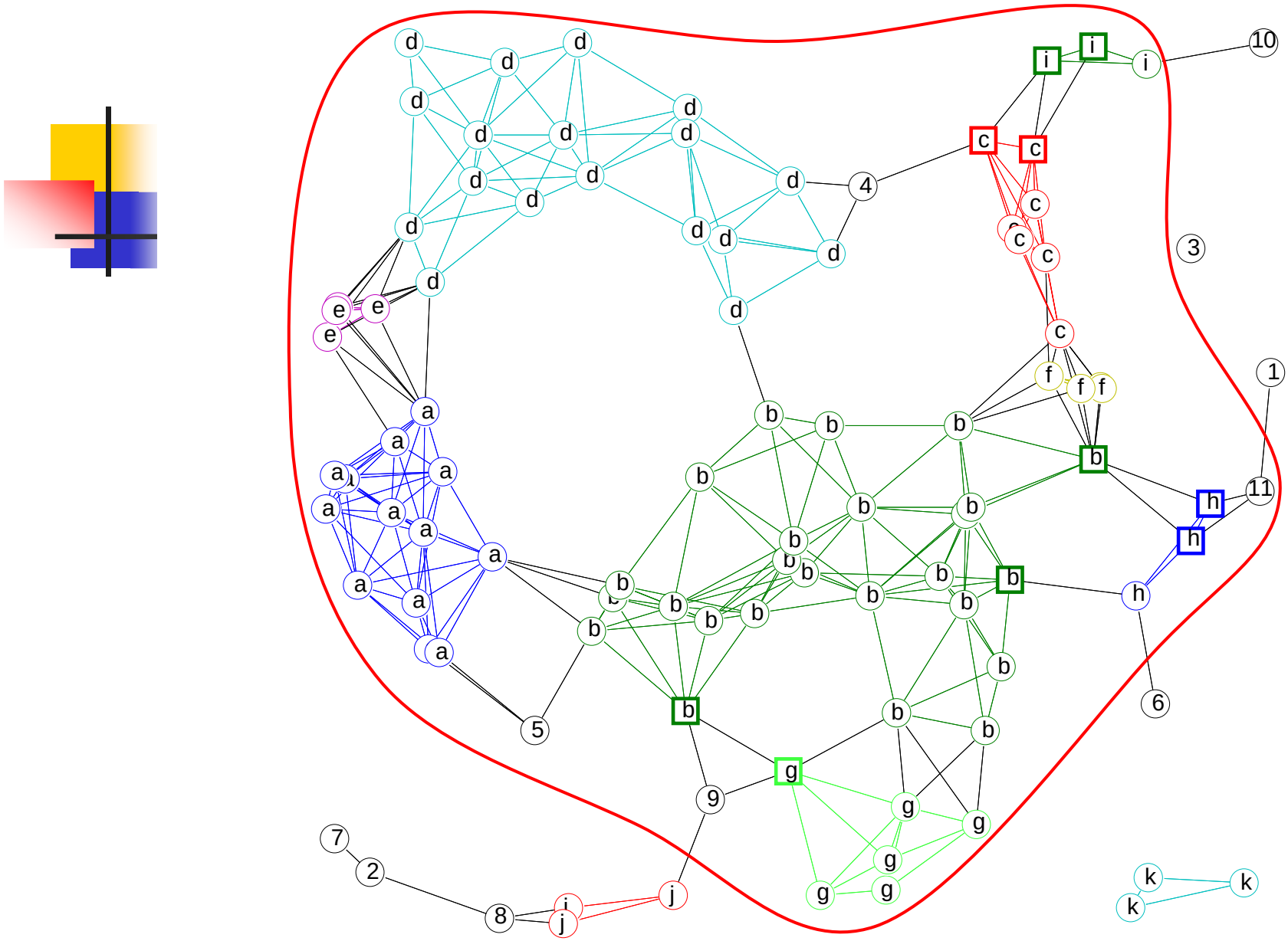

d
e
a
b
c
i
f
h
g
k
j
1
2
3
4
5
6
7
8
9
10
11

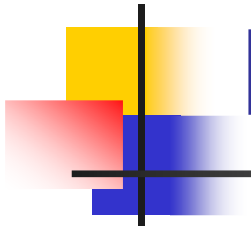

d
e
a
b
c
f
g
h
i
j
k
1
2
3
4
5
6
7
8
9
10
11


d
4
c
i
10
3
e
f
1
a
b
h
11
6
5
g
9
7
2
8
j
k


d
4
c
i
10
3
e
f
1
a
b
11
h
6
5
g
9
7
2
8
j
k


d
i
10
c
4
3
e
f
1
a
b
h
11
g
9
7
2
8
j
k

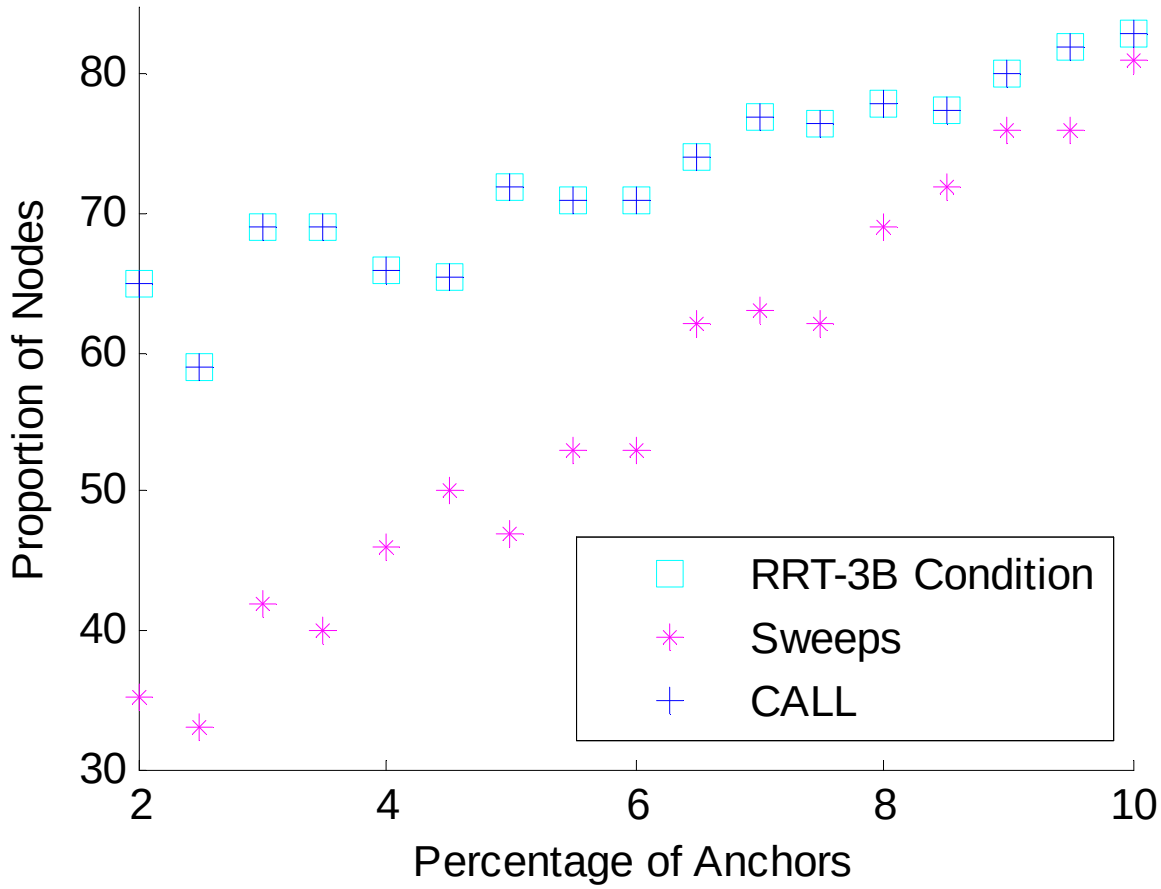

d
4
c
i
10
3
e
1
f
a
b
11
h
5
6
g
9
7
2
8
j
k



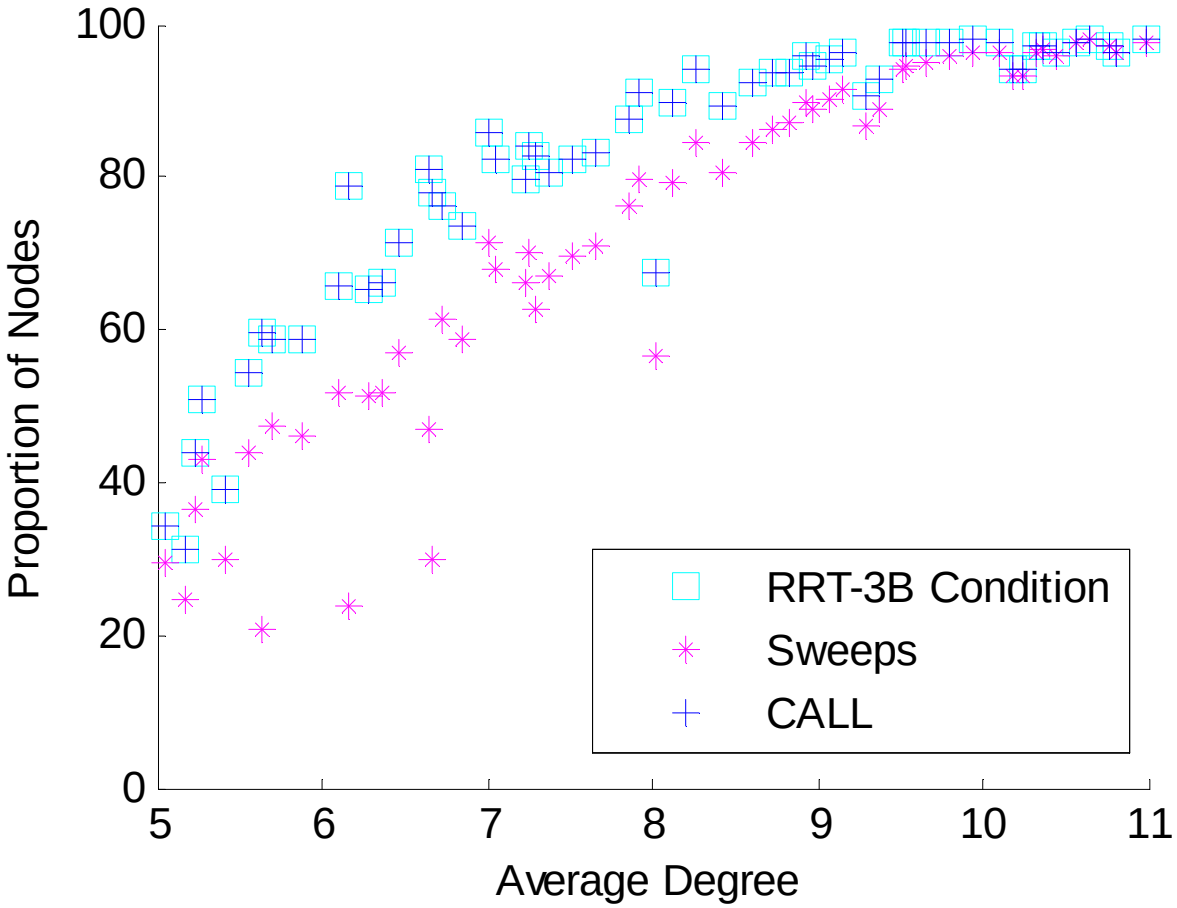
Roadmap

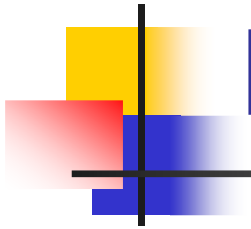
- Motivation
- Problem formulation
- Node base algorithms
- Component bAsed Localization aLgorithm (CALL)
- Experimental evaluations
- Future work

Nodes-Anchor



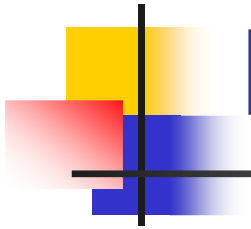
Nodes-Degree





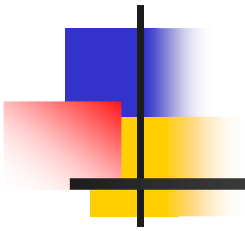
Roadmap

- Motivation
- Problem formulation
- Node base algorithms
- Component bAsed Localization aLgorithm (CALL)
- Experimental evaluations
- Future work



Future Work

- Investigating theoretical bound of localizability using polynomial spatial-temporal cost
- Extending CALL to handle ranging errors
- Extending CALL to 3-D



Thank You!