Node State Switching in a Distributed Sensor Network

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The GNATs
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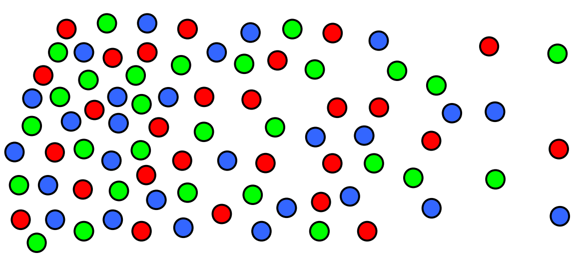
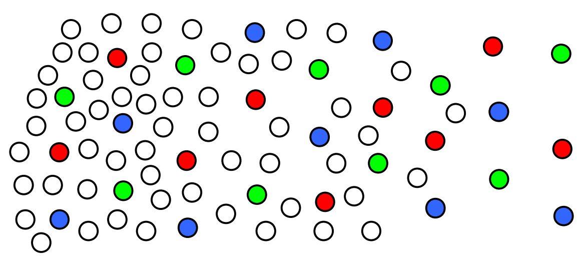
State Switching

- Goal:
  - Prescribe node state densities or proportions
  - Nodes locally determine which state to be in
- Assumptions:
  - Local neighbor estimations will result in proper global behavior
  - Not trying for optimal or minimal arrangement

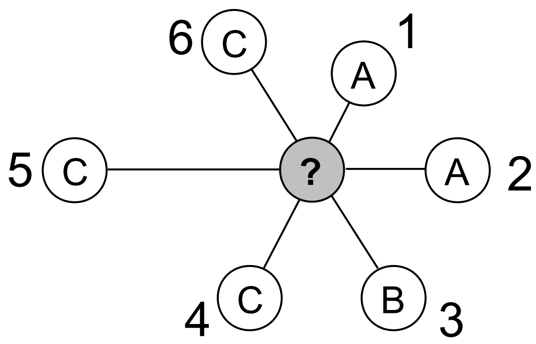


Uniform State Proportions



Uniform State Density

Setup



Desired Densities

State	Percentage or Density
A	2
B	2
C	3

- "Our" node (gray in center) has 6 neighbors it can see.
- When nodes communicate, they also transmit their current state.
- We are given the desired state densities. (In units of nodes per communication radius circle).
- Some nodes are closer than others, (for example neighbor 1 to us than 5), but this information cannot be determined from the Gnat communication protocol. But we can infer this distance.

Procedure

1. Make educated guess about neighbor’s states and how much we should listen to them.
2. Compare this density estimate with desired.
3. Choose appropriate state to be in, or sleep.
4. Wait some time, and repeat.

Step 1a

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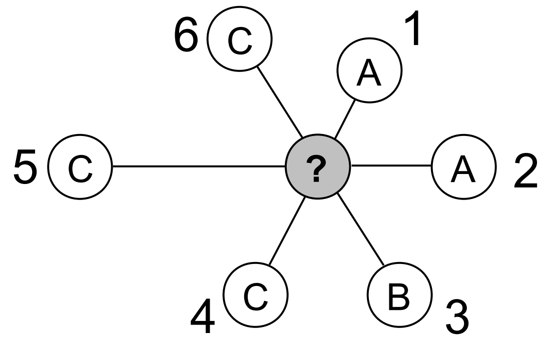


Message List

Time ↓

Neighbor	State
1	A
3	B
6	C
6	C
4	C
2	A
1	A
3	B
5	C
4	C
2	A
1	A
1	B
6	C

Neighbor 1 recently changed its state.

- Keep a history of the past N messages received.
- This allows for rough estimation of distance, (by number of messages received).
- Can assume number of messages received from a neighbor is inversely proportional to its distance.
- A neighbor-centric scheme does not keep a message list. It goes straight to the neighbor list. (next slide)

Step 1b

- Convert "Message List" into "Neighbor List".
- Use either a "majority" or "most recent" heuristic.
- Using the majority heuristic may help reduce state transition oscillations.

Message List

Neighbor	State
1	A
3	B
6	C
6	C
4	C
2	A
1	A
3	B
5	C
4	C
2	A
1	A
1	B
6	C

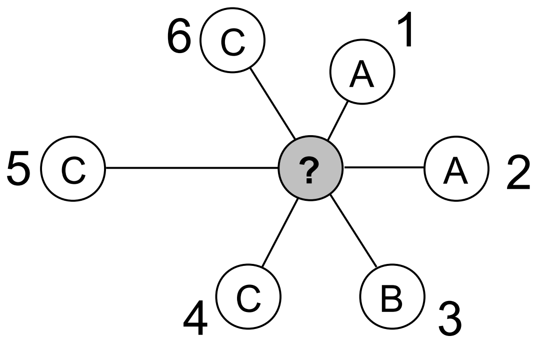
Majority, or Most Recent →

Neighbor List

Neighbor	State
1	A / B
2	A
3	B
4	C
5	C
6	C

Neighbor 1 will either be recorded as state A or B depending on heuristic.

Steps 2 & 3



- Convert “Neighbor List” into a “State List”
- The difference between the observed and desired densities is computed.
- The state with the maximum difference is chosen
- If all differences are less than or equal to zero, go to sleep
- Procedure exactly the same for percentages / densities

Neighbor List

Neighbor	State
1	A
2	A
3	B
4	C
5	C
6	C

Sum for each state

State List

State	Observed Density	Desired Density	Desired – Observed
A	2	2	0
B	1	2	1
C	3	3	0

Choose state B

Future Work

- Large scale experiments (simulation and GNATs)
- Entropy methods (optimality)
- Determine parameters that cause oscillations
- Extend to algorithm to allow “clumpy” behavior
- Combine ideas of state proportion / density
- Combine with deployment?