On some Opinion Dynamics in Multi-Agent Systems

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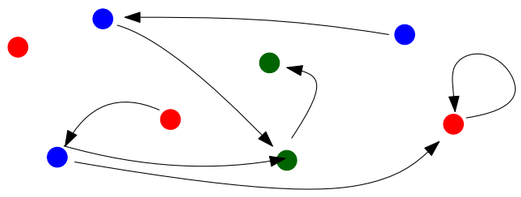
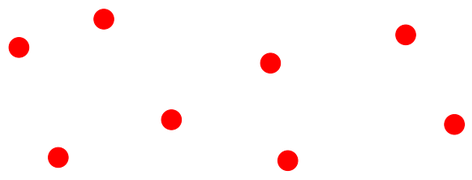
Multi-Agent System

MAS = set of n agents interacting between each others, each supporting some opinion.



Agreement Task

The **whole** (or **parts** of the) system must agree on some opinion.



Opinion Dynamics with Noise

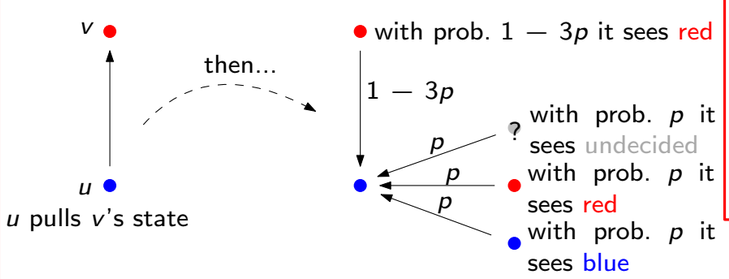
Class of simple algorithms for the Majority Consensus Problem with noise perturbing communications. The dynamics **must bring** the system into a config. satisfying:

1. **Almost-Agreement**: the *majority* of agents agree on some opinion;
2. **Majority**: this opinion is the initial majority one;
3. **Almost-Stability**: such a configuration lasts for time $\mathrm{poly}(n)$.

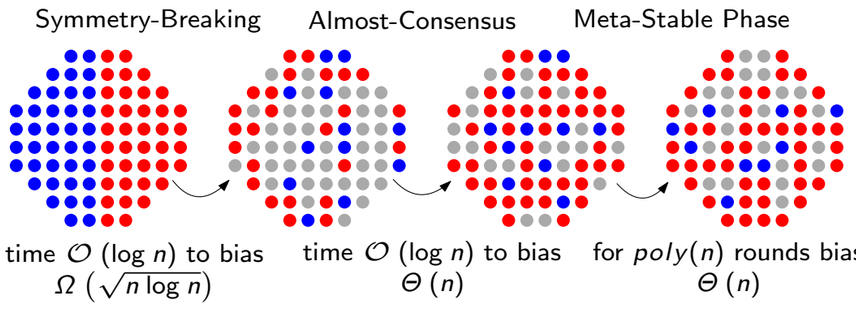
Applications in sensor networks [1], chemical reaction networks [3], biological systems [8], ecc.

Noise Model and Results

We introduce a simple model of uniform noise, bio-inspired [8].



We prove [7] the following holds w.h.p. for $p < 1/6$:



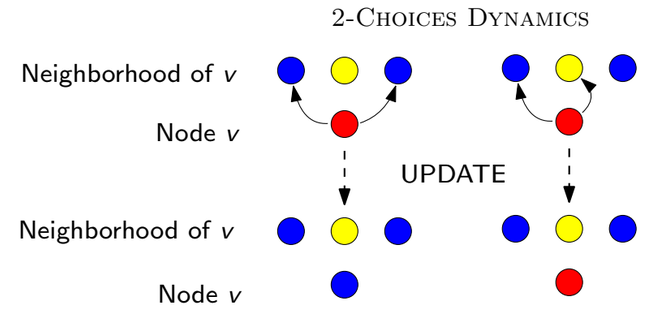
Note: if $p > 1/6$ every information about the majority color is lost in time $\mathcal{O}(\log n)$, w.h.p.

Label Propagation Algorithms

LPAs = class of algorithms for community detection in MAS:

1. an initial label/opinion to each agent;
2. activation rule for each agents;
3. **majority-based update rule** for labels.

At the end, each **community** agrees on some different label.



The 2-Choices Dynamics

Opinion Dynamics for majority consensus studied also in non-complete topologies (e.g., **expanders**) [4,6].

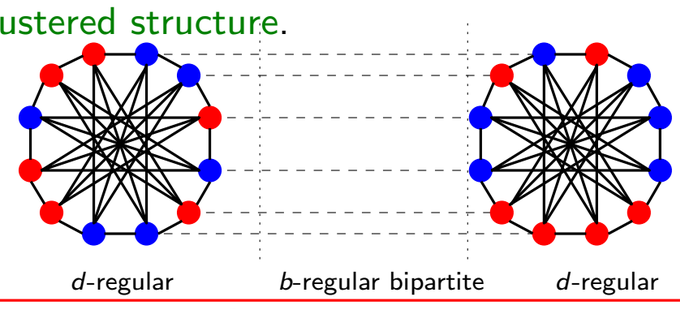
Here, we consider it as a **LPA**.

Initialization: random binary state, red or blue.

Activation: all nodes active in each round.

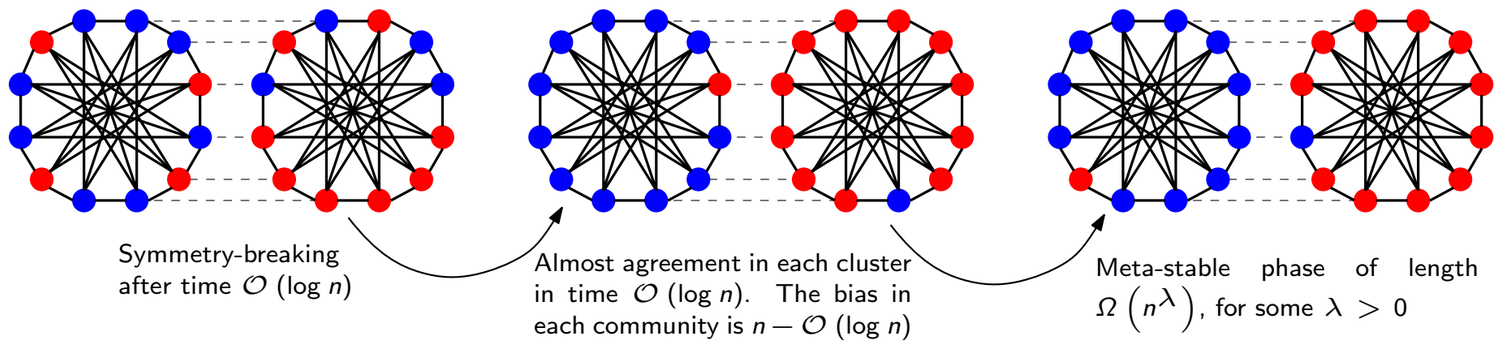
Update: each node samples two neighbors and, *if the have the same state*, updates to that state.

Underlying graph: $(2n, d, b)$-clustered regular graph [2] with $d > 2b$, which exhibits nice clustered structure.



Result

Result: with constant prob. the initialization is **asymmetric** and, w.h.p., it holds that [5]

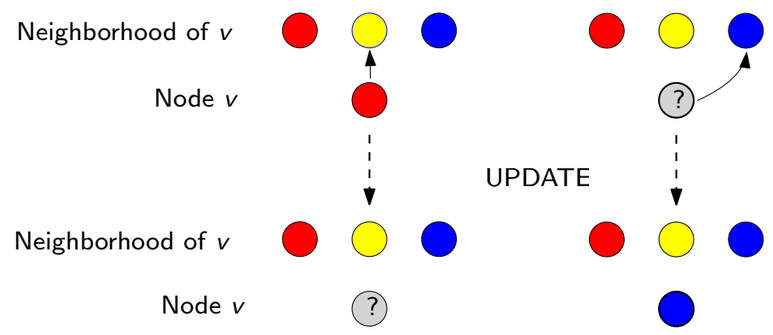


The Undecided-State Dynamics

Introduced by [1] as a fast, robust and simple dynamics for the majority consensus problem.

Rule:

1. each agent u samples one neighbor and look at its state x;
2. if x is different from $state(u)$, then u becomes undecided;
3. if u is undecided, then it copies what it sees.



[3] has completely characterized the parallel binary case in the complete graph.

References

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2. Becchetti et al., "*Average Whenever You Meet*", ESA 2018
3. Clementi et al., "*A Tight Analysis of the Parallel Undecided-State Dynamics with Two Colors*", MFCS 2018
4. Cooper et al. ,"*Fast plurality Consensus in Regular Expanders*", DISC 2017
5. **Cruciani et al., "Distributed Community Detection via Metastability of the 2-Choices Dynamics", AAAI 2019, https://arxiv.org/abs/1805.01406**
6. Cruciani et al., "*Phase Transition of the 2-Choices Dynamics on Core Periphery Networks*", AAMAS 2018
7. **d'Amore et al., "Phase Transition of a Non-Linear Opinion Dynamics with Noisy Interactions", SIROCCO 2020, https://arxiv.org/abs/2005.07423**
8. Reina et al., "*Model of the best-of- N nest-site selection process in honeybees*", Physical Review 2016