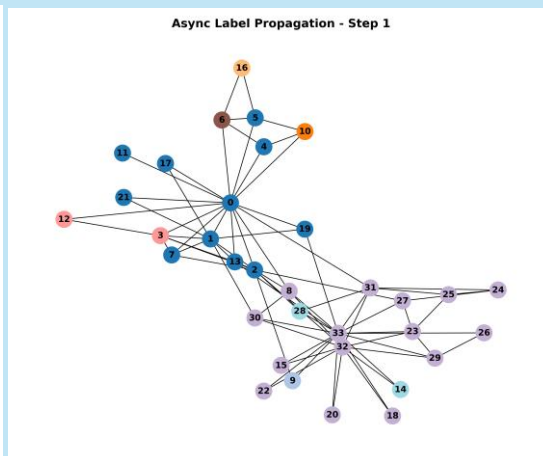
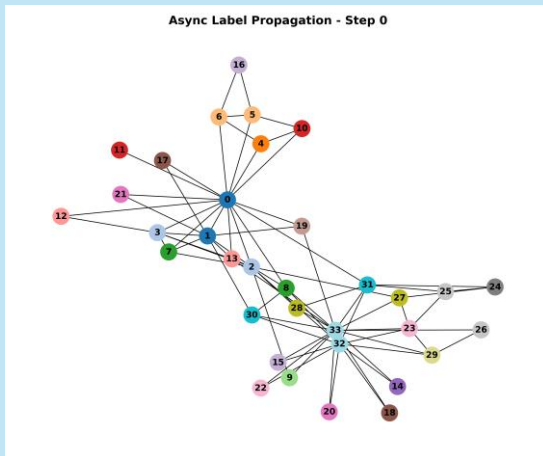


Background : Label Propagation



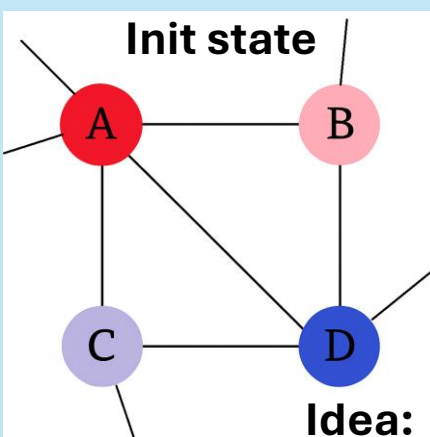
Asynchronous update
: When a node determines the next label, it is **immediately applied** and affects the next node update

Synchronous update
: Once all nodes decide on their next labels, the **node labels are updated simultaneously.**
→ Multiprocessing

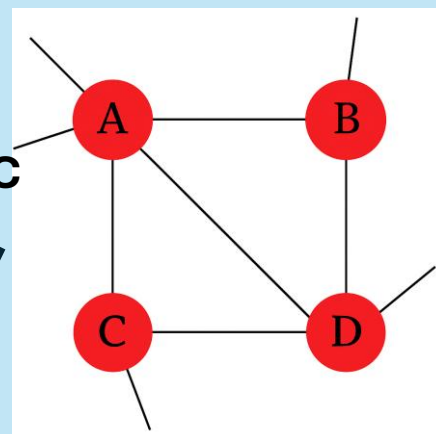
Over-propagation problem:

propagates far beyond, and **form overly large clusters.**
→ decrease model prediction accuracy
→ **Unstable (Results may vary widely)**

Observation



B→D→C



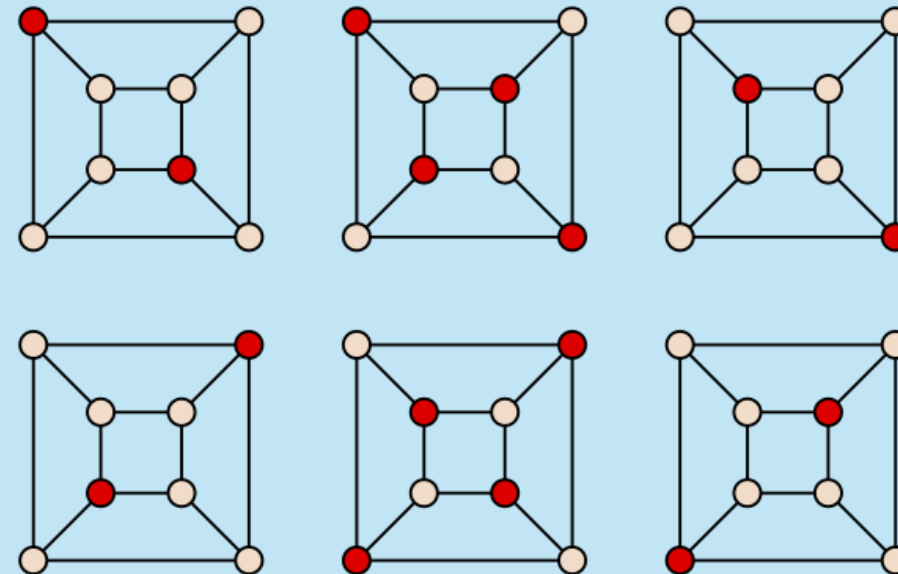
Idea:

we should not update a node and its any adjacent node sequentially

Proposed Algorithm

Maximal Independent Set (MIS)

1. No adjacent nodes
2. No any additional nodes can be added



https://en.wikipedia.org/wiki/Maximal_independent_set

Sync LPA with MIS Algorithm

At each round:

1. Each node must update at least once
2. MIS (Maximal Independent Set) must include nodes that haven't been updated yet in this round
3. When all nodes are updated, start a new round

Termination conditions:

1. **Convergence:** No actual updates occur
2. **Max iteration:** Predetermined hyperparameter limit

Time Complexity : $O(\text{max_iteration} \times n^3)$

Experiment Results

Benchmark dataset

Dataset	# of nodes	# of edges
Karate	34	78
Dolphin	62	159
Football	115	613

Accuracy Comparison: NMI Values by Algorithms

Algorithm	Karate	Dolphin	Football
Async LPA	0.6064	0.0250	0.4769
Sync LPA	0.4854	0.0236	0.4778
Sync LPA with MIS	0.6592	0.0354	0.4873

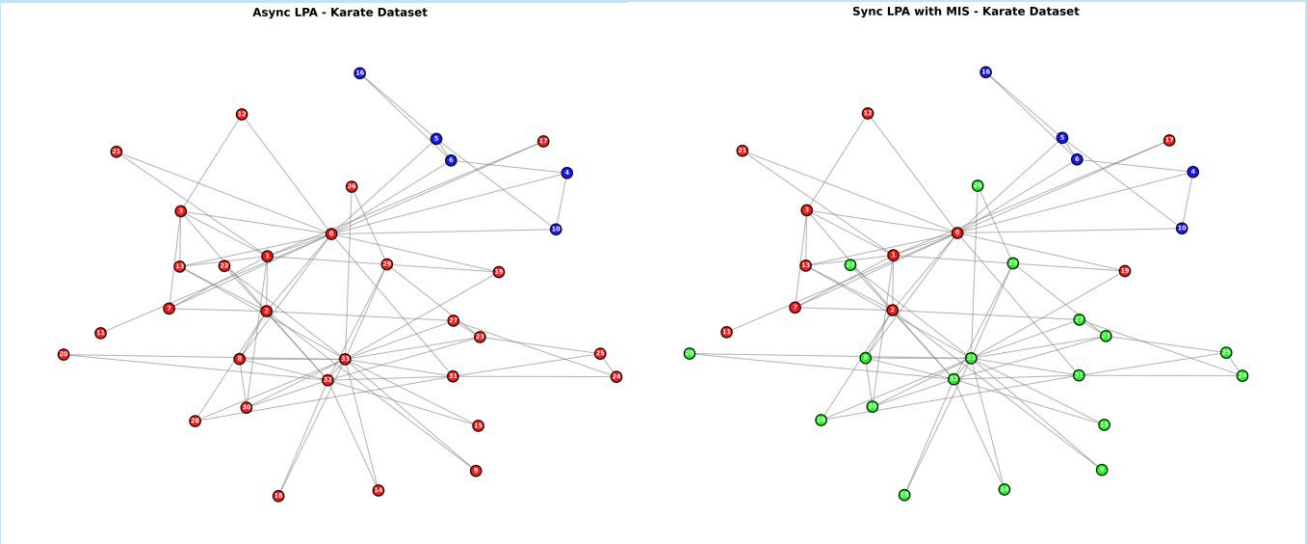
Stability Comparison: Standard Deviation

Algorithm	Karate	Dolphin	Football
Async LPA	0.1951	0.0155	0.0272
Sync LPA	0.2081	0.0111	0.0188
Sync LPA with MIS	0.1253	0.0251	0.0210

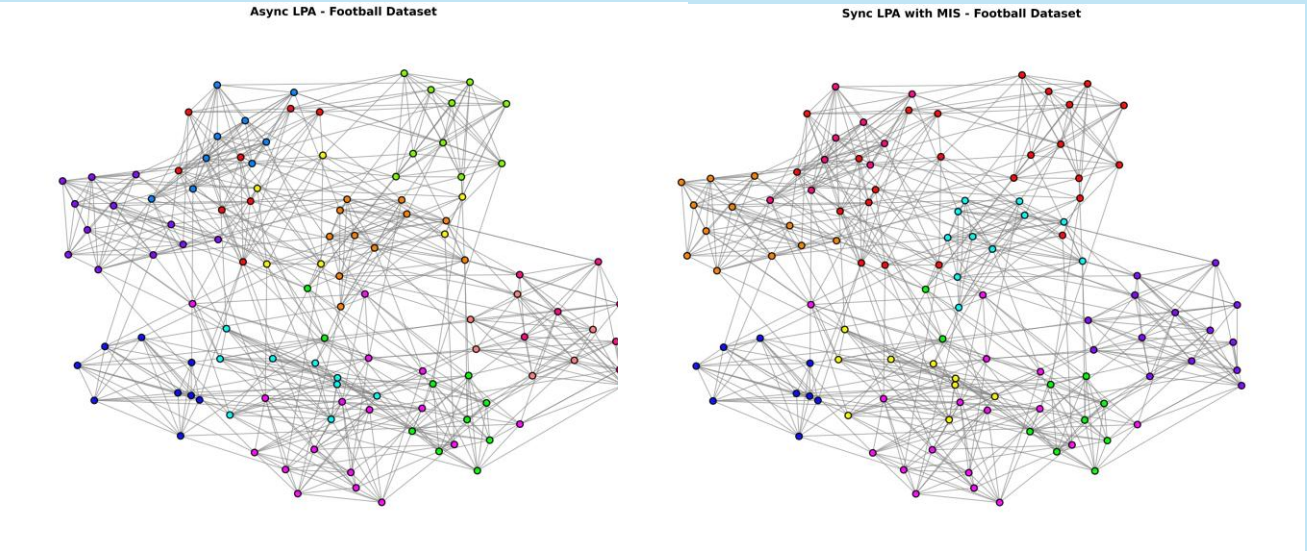
Execution Time (Without Multiprocessing)

Algorithm	Karate	Dolphin	Football
Async LPA	0.46	7..65	6.95
Sync LPA	19.54	33.63	36.24
Sync LPA with MIS	8.78	47.60	64.74

Clustering Results



LPA with MIS can **capture smaller cluster better**



Conclusion

- LPA with MIS **captures smaller clusters** than traditional LPA.
- It **mitigates the over-propagation problem**. This **improves accuracy and stability**.