Crawling the Community Structure of Multiplex Networks

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Multiplex Networks

- ***Multiplex Network***: A type of multilayer network in which all nodes can participate in all layers.
- Challenges of data collection in multiplex networks:
  - Different layers have different data collection costs.
  - Data collected from different layers have different reliabilities.

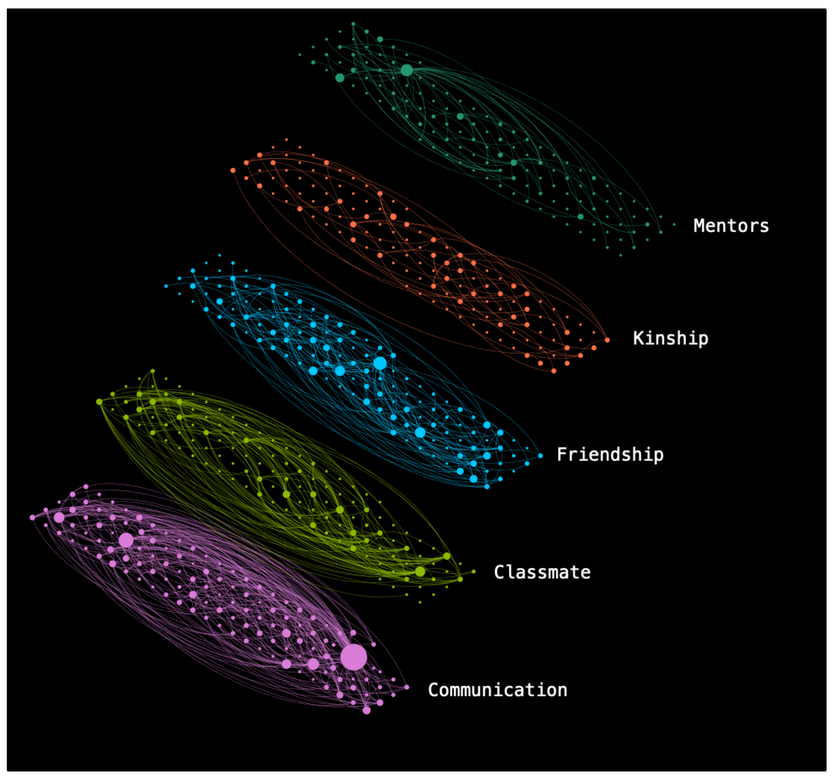


Figure: NoordinTop Multiplex Network

Problem

- Let M be a multiplex network with layers $L_0, L_1, \ldots$ as the different layers.
- Query costs of the layers: $c_0, c_1, \ldots$.
- Given an initial set of nodes V', query budget B, and layer of interest L_0; how can we sample M through crawling so that the sample of L_0 found is community representative of L_0 without exceeding the query budget?

Query Response Models

- ***Reliable Query Response (RQR)***: A query for neighbors of a node returns all the neighbors. Example: Twitter API.
- ***Unreliable Query Response (UQR)***: A query for the neighbors of a node may not return all the neighbors. Example: Interview people for friends.

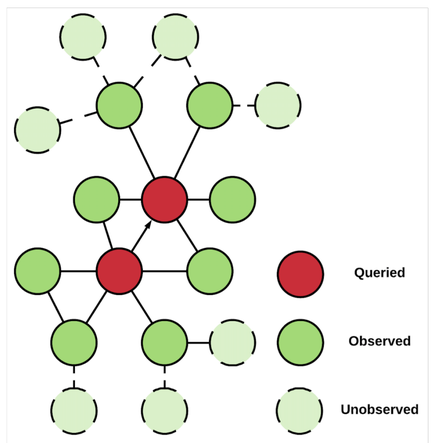


Figure: Reliable Query Response

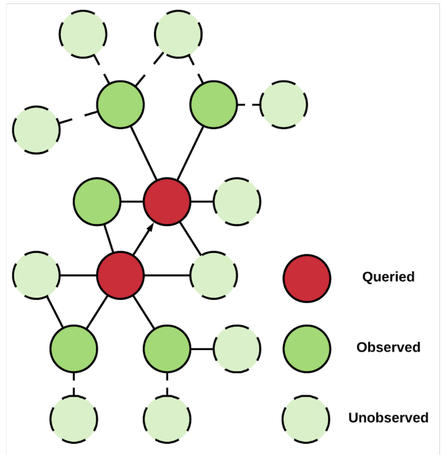


Figure: Unreliable Query Response

MCS

MCS consists of two steps:

- **RNDSample**: Sample the 'cheaper' layers.
- **MABSample**: Sample the 'layer of interest' using information from RNDSample.

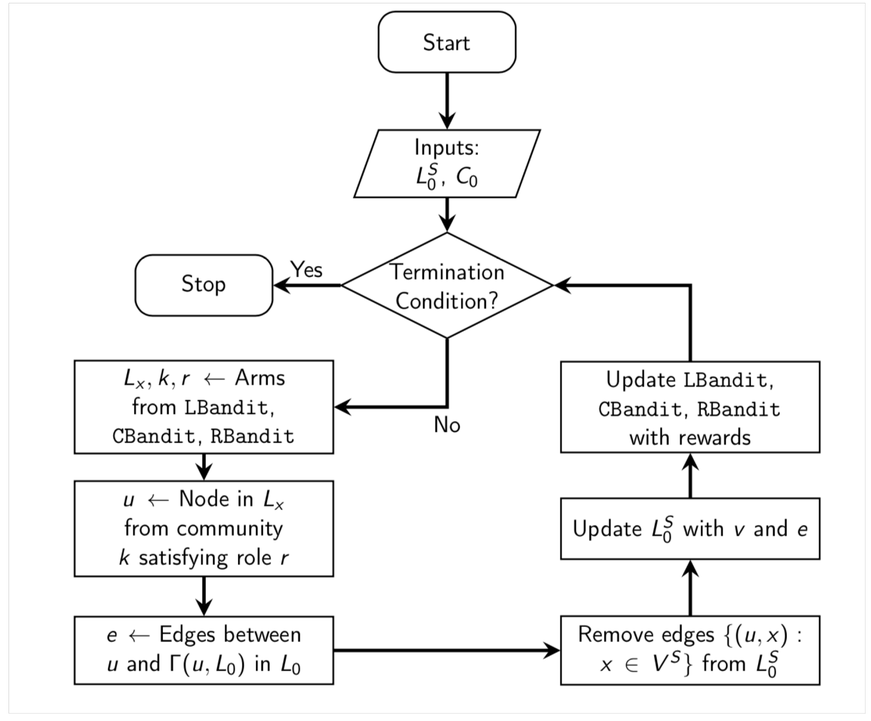
RNDSample:

- Each layer is allocated some fraction of the budget.
- Random walk (with jump) on layers with the allocated budget.

MABSample:

- Operates on the 'layer of interest'.
- Consists of three multi-armed bandits:
  - **LBandit**: Selects layer that is more likely to have high edge overlap with L_0.
  - **CBandit**: Selects community in the layer selected by LBandit.
  - **RBandit**: Selects node in the community selected by CBandit.

MABSample



MABSample Rewards

- **LBandit**: Edge Overlap.
- **CBandit** and **RBandit**: Community update distance.

(Edge overlap and Community update distance are calculated only from the observed sample.)

RQR vs UQR

- ***RQR***: If a node is queried, it is never queried in that layer again.
- ***UQR***: Estimate the uncertainty of the layers. Queried nodes have a chance of being queried again.

Performance Comparison

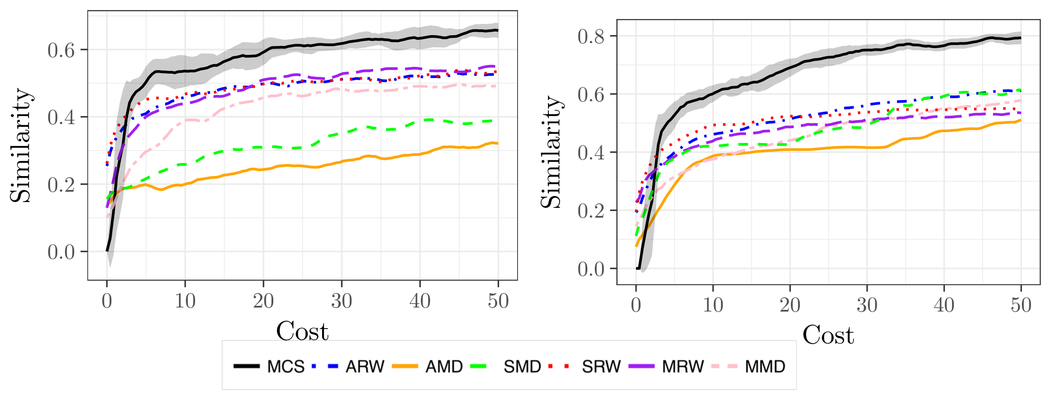


Figure: Results for UQR.

Figure: Results for RQR.

- MCS outperforms all the baselines in finding samples whose community structure is more closes to the original network.

Regret Analysis

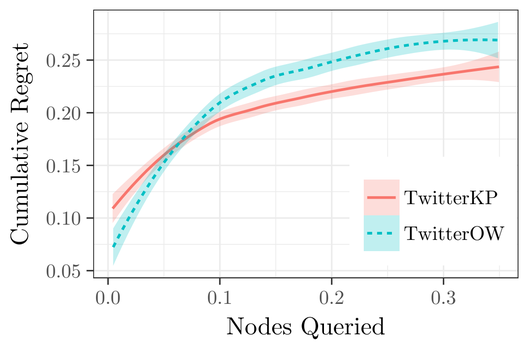


Figure: Cumulative regret of MCS for TwitterKP and TwitterOW networks.

- **MCS** gets close to the oracle after around 10%-20% of the nodes has been queried.

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