Network Diffusion — Framework to Simulate Spreading Processes in Complex Networks

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Introduction

Spreading phenomena are one of the issues considered by a network science. They can be obeserved in various areas like: dynamics of political opinions, marketing campaigns, spread of epidemics, etc. With the advancement of network science analytical approaches became insufficient for large graphs, prompting researchers to use computational methods. In recent years, the scope of network science has significantly expanded beyond static graphs to encompass more complex structures. The introduction of streaming, temporal, multilayer, and hypernetwork approaches has brought new possibilities and imposed additional requirements. Unfortunately, the pace of advancement is often too rapid for existing computational packages to keep up with the functionality updates...

Problem

There is a bunch of very good and robust tools that helps in sumulating diffusion processes in networks, e.g. `ndlib` (which we love).

However, if we consider...

...more complex network models,...

...spreading multiple processes at the same time...

...**a gap among the available toolkits** emerges.

Our Contribution

In order to address the issue, we decided to redesign, polish, and share our internal environment which we are using in the lab. Thus, in our recent work [1], we presented `network-diffusion`. To start using the library just type in your shell:

```
pip install network-diffusion
```

Or scan this code to reach the docs with more examples:

Key Features of `network-diffusion`

- End-to-End Simulation Workflow
- Support for Temporal Network Models
- Support for Multilayer Network Models
- A Bunch of Predefined Spreading Models
- An Interface for Implementing Custom Spreading Models
- New Centrality Measures
- NetworkX Compatibility

Example

Linear Threshold Model in Multilayer Networks

In a diffusion under Linear Threshold Model, each node:

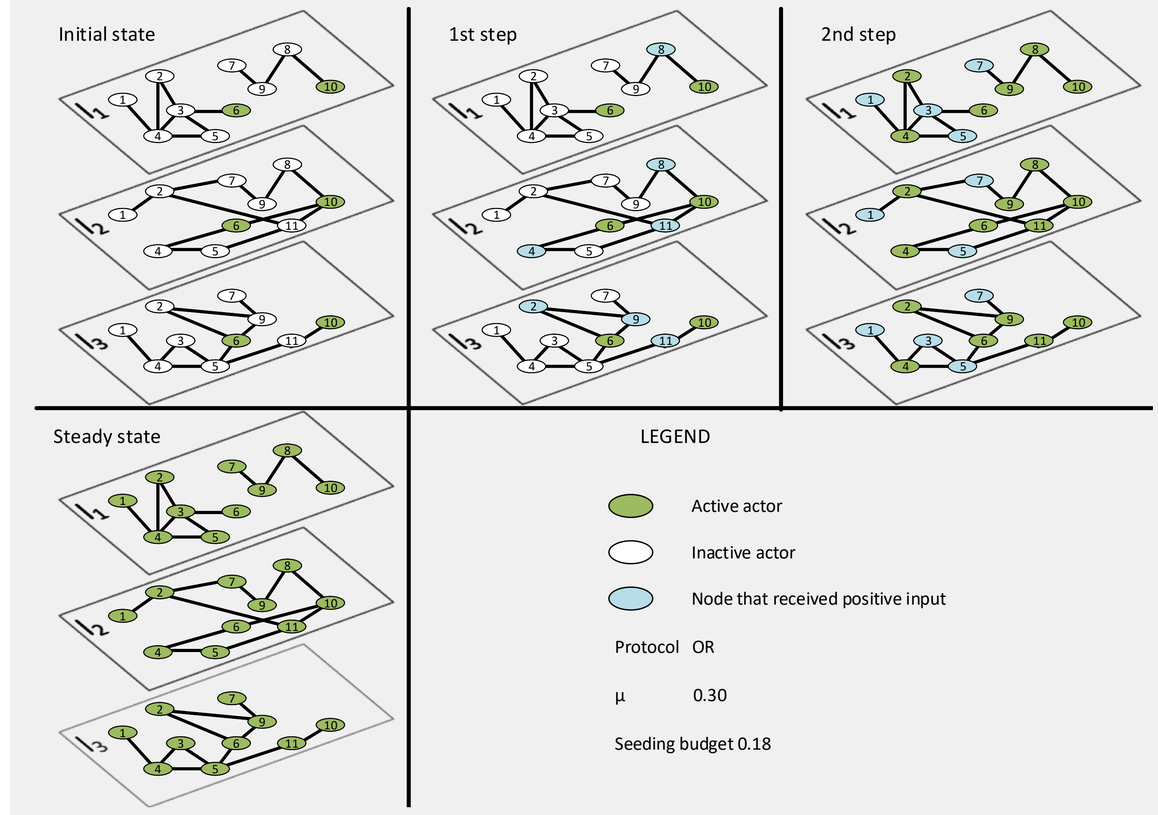
- can fall in two states: *active* and *inactive*,
- becomes *active* if the fraction of its *active* neighbors to all neighbours exceeds certain threshold (μ).

In case of multilayer networks — actors are the subject of the process, while the nodes are their auxiliary representation. Thus, we have to define how to aggregate impulses from the layers. In this example we will consider OR strategy (aka protocol) which says that the actor can be activated if any of nodes representing it gets activated.

Example

Scenario to Simulate

A Figure below shows the case we would like to model with `network-diffusion` — MLTM with homogeneous threshold $\mu = 0.3$ and protocol OR. The process will diffuse in a network with eleven actors, starting from the agent six and ten.

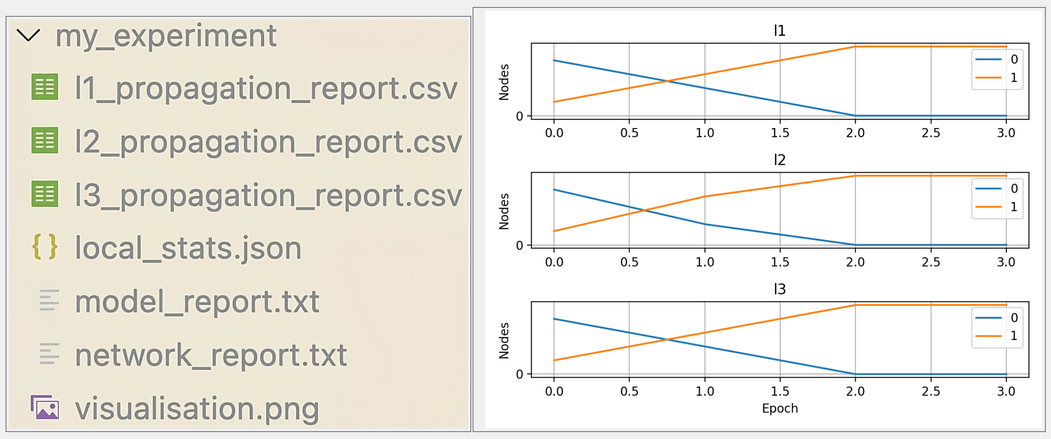


Modelling this case with `network-diffusion`

```python
import network_diffusion as nd

# get the graph - a medium for spreading
net = nd.mln.functions.get_toy_network_piotr()

# set actor 6 and 10 as seeds (we can use another heuristic here as well)
ac_6, ac_10 = net.get_actor(6), net.get_actor(10)
ranking_list = [ac_6, ac_10, *set(net.get_actors()).difference({ac_6, ac_10})]
seed_selector = nd.seeding.MockingActorSelector(ranking_list)
seed_quota = 100 * 2 / net.get_actors_num()

# define the model according to the given parameters
spreading_model = nd.models.MLTModel(
    seeding_budget=[100 - seed_quota, seed_quota],
    seed_selector=seed_selector,
    protocol="OR",
    mi_value=0.3,
)

# perform the simulation that lasts four epochs
simulator = nd.Simulator(model=spreading_model, network=net)
logs = simulator.perform_propagation(n_epochs=3)

# obtain detailed logs for each actor in the form of JSON
raw_logs_json = logs.get_detailed_logs()

# or obtain aggregated logs for each of the network's layer
aggregated_logs_json = logs.get_aggragated_logs()

# or just save a summary of the experiment with all the experiment's details
logs.report(visualisation=True, path="my_experiment")
```

Outcomes

The output logs can be used for further analysis and contain:



References

[1] Michał Czuba et al. “Network Diffusion — Framework to Simulate Spreading Processes in Complex Networks”. In: *Big Data Mining And Analytics* (2024), pp. 1–13. DOI: `10.26599/BDMA.2024.9020010`. URL: `https://doi.org/10.26599/BDMA.2024.9020010`.