Dynamics of Information Propagation in Large Networks

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Understanding how information propagates in a network of connected nodes (or agents) is fundamental in many applications including social networks, distributed computing (e.g., blockchains), and statistical physics. In all such applications, a set of network nodes exchange information and update their beliefs (on some underlying truth, e.g., the utility of a vaccine for some disease) through local interactions with neighbours. The central question in this context is whether such local interaction leads to the emergence of some intended global behaviour.

One such global behaviour of interest in many applications is *consensus*, where all nodes adopt the same belief or state. The local interaction rules which lead to consensus are called *consensus protocols*. Examples of consensus protocols include *voter* and *majority rules* [1, 2]. The main goal of consensus protocols is to achieve consensus on an intended state as fast as possible and with as little interactions as possible. Therefore, for a given consensus protocol, the following are some key issues of interest:

- **Consensus state**: This is defined as the final state achieved by each node at consensus. Consensus protocols should be designed to achieve a desired consensus state. For example, in many applications, the consensus state is required to the belief held by the majority of nodes initially. Can such desired behaviour be guaranteed under a given consensus protocol. If not, then can we at least say something with high probability?
- **Convergence time**: This is defined as the time required for the network to converge to consensus. For most practical applications, the consensus time should be small even for large set of nodes. For example, a convergence time of $O(\log n)$ is preferred over that of $O(n)$, where n denotes the number of nodes in the network. Can we design consensus protocols with small consensus time?
- **Communication complexity**: This is defined as the number of communication per node needed to achieve consensus. For most applications, nodes have limited computational capacity and power. So, it is important to minimise the number of interactions needed to achieve consensus. Can we design consensus protocols with small communication complexity?

The aim of the project will be to answer some of the above questions for a given network topology of interest, namely, *random regular graph.* We shall first analyse some known consensus protocols on random regular graphs. If time permits, we shall further attempt at designing new consensus protocols that outperform the existing ones in terms of convergence time.

References

[1] A. Mukhopadhyay, R. R. Mazumdar, and R. Roy, "Voter and majority dynamics with biased and stubborn agents," *J Stat Phys*, vol. 181, pp. 1239–1265, 2020.

[2] E. Perron, D. Vasudevan, and M. Vojnovic, “Using three states for binary consensus on complete graphs,” in *IEEE INFOCOM 2009*, pp. 2527–2535, 2009.