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Conclusion and Future work

In this chapter we summarize the results obtained in the thesis and discuss some possible extension of these results in future. In this research work we considered the paradigm of parametric network modeling which are of paramount interest due to many aspects. We first introduced the context dependent modeling approach for generation of networks in which the link formation process is adopted from social theory of selection. A person chooses an another person to make a relationship on the basis of multiple attributes or qualities of the person. In context dependent preferential attachment model (CDPAM), degree and average relative degree are considered to define the probability of link formation which leads to generation of networks having properties of real networks such as power-law degree distribution and small diameter. Parametric network modeling is extended to model signed social networks. Besides societal observations, the chemical process such as nucleation is adopted to model social networks. We proposed a parametric network generation model which we call network reconstruction model (NRM) for structural reconstruction of scale-free real networks with power-law exponent greater than 2 in the tail of its degree distribution. The reconstruction method for a real network is concerned with finding the optimal values of the model parameters by utilizing the power-law exponents of model network and the real network. The method is validated for certain real world networks. The usefulness of NRM in order to solve structural reconstruction problem is demonstrated by comparing its performance with some existing popular network generative models. We showed that NRM can generate networks which follow edge-densification and densification power-law when the model parameters satisfy an inequality. Computable expressions of the expected number of triangles and expected diameter are obtained for model networks generated by NRM. Finally, we numerically establish that NRM can generate networks with shrinking diameter and modular structure when specific model parameters are chosen.

We observe certain limitations of NRM for reconstruction of classes of real scale-free networks. For example, the entire NRM network is generated by assuming fixed values of the parameters β and p. Thus each incoming node has the same fraction of preferential attachment β that corresponds to the constant power-law exponent during the growth of the network. However many real scale-free networks have time varying power-law exponent. Thus the NRM can be modified and improved in different dimensions for reconstruction of such networks. Firstly, the parameters β and p can be replaced with time varying functions that can incorporate more flexibility and reality in the model. Secondly, local dynamics can be converted into semi-local dynamics in which we can replace it with the random walk or local linking up to l^{th} neighbors. Besides, the aging factor is not incorporated in NRM that can be observed in many real networks. Thus the proposed NRM model can be improved in multiple aspects. This can lead to realize a better understanding of the evolution of real networks in different domains. In future, it can be extended in other directions to reduce the computation complexity as well as space complexity (constant time and constant space complexity) of finding the optimal values of the parameters for a given degree sequence or limited information of a real-world scale-free network.

In a network with power-law degree distribution, there are a large number of nodes which have fewer connections and a few nodes in the network are well connected in the network that are known as *hubs*. Preferential growth of networks is considered to explain such behavior of degree distribution in real networks. We establish an explanation for such behavior of the growth process in a network considering the diffusion dynamics on the networks in the form of biased random walks. We studied simple biased random walks in which a random walker can walk forever and transition probability of a link depends on the degrees of the participating nodes of that link. The assumption of transition probability is adapted from Barrat *et al.* [2004]. Secondly, we also consider a discontinued truncated biased random walk on networks, in which a walker can stop while travelling in the network. Information diffusion is a real-life example of such phenomena. The results obtained in the form of mean-first-passage-time (MFPT) in the case of continuous biased random walks and the probability distribution of visiting a node in discontinued truncated biased random walk support the preferential growth of real networks. We can conclude that diffusion dynamics on a node which considers the effect of its neighboring nodes provide a feedback force for biased growth similar to preferential attachment. We mention that the proposed biased random walks can also be adopted in packet switching, searching, marketing in online social networks.

Discontinued truncated random walk is adopted to calculate PageRank in a network which is simply projected as the density distribution of users in a network under the repeated truncated random walk dynamics proposed in the thesis. In this method of PageRank calculation, distributed local dynamics leads to the desired collective behavior in the form of the density distribution of users in the network. In the simulation, a high correlation is observed between the density distribution of users and the PageRank that justifies the consideration of density distribution of users for the purpose of ordering or ranking.

A diffusion protocol is defined on static and dynamics networks that can address the following problems. How can diffusion dynamics be utilized for link failure detection? How can resources be distributed optimally in a network? How can underutilization of diffusive resources be avoided during the damage of the networks? As we know that *Dynamics on the networks* and *Dynamics of the networks* are interdependent, then how can the connection pattern in a network be retrieved using diffusion dynamics?

Simulated results are verified in this context for different examples. In future, we plan to implement these protocols practically in real networked systems. Finally, a framework is developed for investigating existence of links in a network by using the data of Susceptible-Infected-Susceptible (SIS) diffusion dynamics on the network.

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