ANALYSIS OF NODE BASED EPIDEMIC SPREADING PROCESSES OVER MULTIPLEX SOCIAL NETWORKS AND WIRELESS SENSOR NETWORKS

ABSTRACT

The proliferation of epidemic processes (such as malware, memes, rumors, etc.) in the network has attracted substantial attention from the social scientists, data scientists, and communication engineers to control the outbreak of the epidemic. Epidemic modeling plays a vital role in describing the dynamic behavior of spreading processes over the network to control and to prevent. Optimal control of epidemics is an emerging research area that mitigates the epidemic spreading in large scale networks. Hence, the analysis of node-based epidemic spreading models should be an appropriate approach for studying the dynamic behavior of the epidemic spreading over networks in comparison with population-based epidemic models. In this dissertation, the dynamic behavior of competing memes over multiplex social networks, optimal control of malware propagation in wireless sensor networks, virus spreading over computer networks with partial immunization, and optimal control of competing for rumor spreading in multiplex social networks has been investigated. The dynamic behaviors of the two competing epidemics (meme) spreading model with the alert of memes over multiplex social networks are analyzed. Each meme spreads over two distinct Contact Networks (*CNs*) of the undirected multiplex social networks. The behavioral responses of agents (alerts) to the spread of competing memes are disseminated through the Information Dissemination Network (*IDN*). The analytical treatment of this model is studied through the mean-field approximation of the epidemic process. To describe the characteristics of memes, extinction, coexistence, and absolute dominance are analytically found. Moreover, the co-existence of both the memes, the survival threshold, the absolute dominance threshold of the two competitive memes, and the alert threshold for minimizing the severity of meme spread are numerically illustrated.

Wireless Sensor Networks (*WSNs*), which emerge from un-attended environment monitoring, are deployed for monitoring purposes in a different environment. But, *WSN* suffers from vulnerable malware to propagate via

the exploiting message exchange among the sensor nodes. To draw attention to this issue, an optimal control strategy to reduce the spread of malware in wireless sensor networks is investigated. A node-based epidemic model, namely, Susceptible Infected Traced Patched Susceptible (*SITPS*) model is analyzed, and the optimal control strategies are analytically investigated. The proposed optimal strategy achieves a low level of infections at a low cost. Numerical illustrations are presented to show the spread of malware through infected nodes, which can be effectively suppressed by adopting an optimal control strategy.

Susceptible Infected Susceptible Recovered Susceptible (*SISRS*) computer virus spreading model with partial immunization is designed as a dynamic control problem to optimize the control cost and epidemic spread. Moreover, the optimal control strategies are examined analytically. The proposed optimal immunization scheme obtains a low level of infection at a minimum cost. It is numerically substantiated that the spread of infected nodes and the immunity loss can efficiently be controlled by adopting an optimal control strategy. Further, the *SISRS* model is validated through stochastic simulation.

The effective optimal control approach for competitive rumor dissemination in multiplex social networks is proposed. The theoretical framework of the rumor spreading model is developed through the mean-field approximations of the epidemic process. To describe the characteristics of the rumor spreading process in the multiplex network, stability, survival threshold, and the absolute dominance threshold are derived. Moreover, this competitive rumor spreading model is controlled by adopting an optimal control strategy. Further, the competitive rumor diffusion model is validated through the stochastic and numerical simulations. Finally, the thesis discusses concluding remarks and further possible research directions.