Syllabus for Ph.D. course Network Dynamics

Lecturer: Giacomo Como

September 3, 2013

Introduction to and analysis of the main mathematical models used to describe large networks and dynamical processes that evolve on networks. Motivation and applications drawn from social, economic, natural, and infrastructure networks, as well as networked decision systems such as sensor networks.

(1) Basic graph theory: adjacency and Laplacian matrices, their spectrum and its relationships with geometric properties of the graph, conductance, network flows and min-cut theorems [2, 6]

(2) Random walks on graphs: hitting times, mixing times, reversible Markov chains. [1]

(3) Random graphs: Branching processes. Static models of random graphs (Erdös-Rényi, networks with prescribed degree distributions, power-law degree distributions, small world networks, geometric random graphs). Preferential attachment and other graph evolution models. [3]

(4) Dynamics in networks: interacting particle systems, distributed averaging. Epidemic propagation, opinion dynamics, games in networks, bargaining, evolutionary dynamics, Bayesian learning. Mean field, branching process, and cavity approximations. [7, 8, 5, 4]

References

[1] D. Aldous and J. Fill, *Reversible Markov chains and random walks on graphs*, monograph in preparation, 2002.

[2] B. Bollobás, *Modern graph theory*, Springer, 1998.

[3] R. Durrett, *Random graph dynamics*, Cambridge University Press, 2006.

[4] D. Easley and J. Kleinberg, *Networks, crowds, and markets: reasoning about a highly connected world*, Cambridge University Press, 2010.

[5] M.O. Jackson, *Social and economic networks*, Princeton University Press, Princeton, New Jersey, 2008.

[6] D.A. Levin, Y. Peres, and E.L. Wilmer, *Markov chains and mixing times*, American Mathematical Society, 2010.

[7] T.M. Liggett, *Interacting particle systems*, Springer-Verlag, 1985.

[8] F. Vega-Redondo, *Complex social networks*, Cambridge University Press, 2006.