# Dynamics over networks

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**Timetable:** 20 hours. Every Tuesday and Thursday from 10:30 to 12:30. First lecture on Tuesday, May 10, 2011. Room DEI/G (Dept. of Information Engineering, Via Gradenigo 6/a). The lecture of Thursday, June 2, will be made on Wednesday June 1.

**Course requirements:** Basic probability and calculus.

**Examination and grading:** homeworks.

**Aim:** In a large variety of scientific and technological fields (social and economic sciences, computer science, engineering, biology), mathematical models based on networks are rapidly increasing their importance. The unifying setting is a large number of 'atoms' possessing a relatively simple time dynamics, who are interconnected together. As a consequence of this interaction, complex global properties emerge in the network: asymptotic convergence to an equilibrium typically dependent on the initial condition, correlation phenomena on several possible network length scales, local and global clustering phenomena. The course wants to give an introduction to some of the hottest and most promising research topics on dynamics over networks. The examples we have in mind and which we want to cover in this course include: epidemics diffusions, opinion spreading models in social and economic networks, cooperative algorithms over sensor networks (consensus), Bayesian learning and games over networks.

**Course contents:**

- A bunch of examples. Social, information, technological, biological networks. Properties of real-world networks: small world effect, clustering, power law degree distribution, scale-free properties. Examples of dynamics on networks: epidemics diffusions, discrete and continuous opinion dynamics models, cooperative algorithms over sensor networks, learning models and strategic games.
- Random graph models. Brief recap of graph concepts: paths, cycles, connectivity, geodetics, diameter, degrees. Branching processes. The Erdos-Renji model: Poisson degree distribution, giant component, phase transitions, diameter. The configuration model: graphs with given degree distributions. Geometric random graphs. The preferential attachment model by Price- Albert-Barabasi.
- A recap of Markov chains: random walks on graphs, invariant probability distributions, convergence, spectral theory, mixing times. Discrete dynamics over networks. Epidemic diffusions: SI and SIR models. Discrete opinion dynamics: voter model, majority models.
- Locally averaging algorithms, convergence to consensus. Gossip models. Continuous opinion dynamics models: The Hegselman-Krause and the Deffuant-Weisbuch models.
- Network learning and games. Bayesian learning on networks. Iterative models. Strategic games on networks. Nash equilibria and convergence issues.

**References:**

- Jackson, Matthew O., Social and economic networks, Princeton Univ. Press, 2008.
- Vega-Redondo, Fernando, Complex social networks, Cambridge Univ. Press, 2007.
- Durrett, Richard, Random graph dynamics, Cambridge Univ. Press, 2007.