

# Advanced Topics in Network Science 2019/20

- **F1-F4** Fundamentals of network science (4 weeks)
- **A1-A6** Advanced topics in network science (6 weeks)
- **T1-Tx** Invited talks and presentations (1++ weeks)

## Course overview and logistics

---

*Course overview, logistics and syllabus. Coursework description, instructions and other details.*

- **F1** Course overview and syllabus
- **F1** Course logistics and coursework
- **F3** Course project and paper details

## From graph theory to network science

---

*From classical graph theory to social network analysis and modern network science. Graphology and networkology.*

- **F1** Networks introduction and motivation
- **F1** Graph theory and network science
- **F1** Graphology and networkology
- **F4** Networks in modern science
- **A2** Network science journals
- **A2** Network science events

## Large-scale structure and models

---

*Random graphs and real networks. Degrees of separation in small-world networks, power-law distributions of scale-free networks and mixing in networks.*

- **F2** Random graph models
- **F2** Configuration graph model
- **A3** Exponential random graph model
- **F2** Small-world networks and models
- **F2** Scale-free networks and models
- **Tx** Node mixing in networks

# Mesoscopic structure and fragments

---

*Network community and core-periphery structure. Graph partitioning, blockmodeling and community detection. Network motifs, graphlets and node orbits.*

- **F3** Weak ties and network community structure
- **F3** Graph partitioning and community detection
- **A1** Blockmodeling and stochastic block models
- **A2** Network motifs, graphlets and node orbits

# Node position and similarity

---

*Measures of node position and centrality, measures of link importance and bridging, and link analysis algorithms. Node similarity and equivalence.*

- **F3** Measures of node centrality
- **A1** Node similarity and equivalence
- **A1** Measures of link bridging
- **F3** Link analysis algorithms

# Network formation and evolution

---

*Generative models of network evolution and link copying models. Network optimization models and random geometric graphs.*

- **A3** Models of network evolution
- **A3** Network optimization models

# Network inference and prediction

---

*Network inference and link prediction methods. Network-based clustering, classification and regression. Network influence maximization and outbreak detection.*

- **A5** Network inference and link prediction
- **A5** Network-based clustering and classification
- **A4** Network influence maximization<sup>‡</sup>
- **A4** Network outbreak detection<sup>‡</sup>

# Network sampling and comparison

---

*Fractal networks and self-similarity, network sampling, backbones and skeletons. Network comparison by*

*fragments and statistical comparison of network metrics.*

- **A2** Network self-similarity and sampling
- **A3** Network backbones and skeletons
- **A2** Structural network comparison

## Network dynamics and processes

---

*Decentralized search and network navigation. Percolation theory and network robustness. Spreading and diffusion on networks. Game theory and networks.*

- **A4** Search and network navigation<sup>‡</sup>
- **A5** Percolation and network robustness
- **A5** Epidemic spreading on networks
- **A4** Network diffusion and contagion<sup>‡</sup>
- **Tx** Game theory and networks<sup>§</sup>

## Alternative types of networks

---

*Attributed, valued and signed networks. Multi-relational, multilayer and higher-order networks. Temporal and spatial networks.*

- **A6** Attributed, valued and signed networks
- **A6** Multi-relational and multilayer networks
- **A6** Higher-order dependencies in networks
- **A6** Temporal and spatial networks<sup>§</sup>

## Empirical analysis of networks

---

*Network representations, data structures, fundamental algorithms, programming libraries and software. Node layout and network visualization.*

- **F4** Network representations and data structures
- **F4** Fundamental network analysis algorithms
- **A1** Node layout and network visualization
- **F4** Network libraries and software

## Applications of network analysis

---

*Detecting automobile insurance fraudsters. Mining software dependency networks. Comparing bibliographic databases, clustering and modeling scientific publications, and analyzing scientific coauthorships.*

- **T1** Fraud detection
- **T1** Software engineering
- **T1** Bibliometrics & scientometrics

## Network analysis challenges

---

*Tentative list of short weekly challenges on network concepts and techniques.*

- **F1** Four knights challenge
- **F2** Random selection challenge
- **F3** Low complexity challenge
- **F4** Grand graph challenge
  
- **A1**  $\div$ -vector centrality challenge
- **A3** Five networks challenge
- **A5** Unreal network challenge

---

‡ Video lecture   § Tentative talk