SYLLABUS

Complex Networks: Data Analysis Using Network Science

University year 2025-2026

1. Information regarding the programme

1.1. Higher education institution	**Babeş Bolyai University**
1.2. Faculty	**Faculty of Mathematics and Computer Science**
1.3. Department	**Department of Computer Science**
1.4. Field of study	**Computer Science**
1.5. Study cycle	**Master**
1.6. Study programme/Qualification	**Artificial Intelligence for Connected Industries**
1.7. Form of education	**Full time**

2. Information regarding the discipline

2.1. Name of the discipline	**Complex Networks: Data Analysis using Network Science**					Discipline code	**MME8218**
2.2. Course coordinator				**Prof. Dr. Camelia Chira**			
2.3. Seminar coordinator				**Prof. Dr. Camelia Chira**			
2.4. Year of study	**1**	2.5. Semester	**2**	2.6. Type of evaluation	**E**	2.7. Discipline regime	**Compulsory**

3. Total estimated time (hours/semester of didactic activities)

3.1. Hours per week	**4**	of which: 3.2 course	**2**	3.3 seminar/laboratory/project	**1 lab + 1 project**
3.4. Total hours in the curriculum	**56**	of which: 3.5 course	**28**	3.6 seminar/laboratory/project	**28**

Time allotment for individual study (ID) and self-study activities (SA)	**hours**
Learning using manual, course support, bibliography, course notes (SA)	32
Additional documentation (in libraries, on electronic platforms, field documentation)	32
Preparation for seminars/labs, homework, papers, portfolios and essays	36
Tutorship	5
Evaluations	14
Other activities:	-

3.7. Total individual study hours	**119**
3.8. Total hours per semester	**175**
3.9. Number of ECTS credits	**7**

4. Prerequisites (if necessary)

4.1. curriculum	Algorithms and Programming, OOP
4.2. competencies	Good programming skills

5. Conditions (if necessary)

5.1. for the course	Projector
5.2. for the seminar /lab activities	Computers, Network visualization tools, Python/Java/C++ programming environment

6. Specific competencies acquired [1]

Professional/essential competencies	• Develop software prototype • Translate requirements into visual design • Create data models
Transversal competencies	• think analytically • work in teams

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	• Introduce the interdisciplinary academic field of network science and the modern theory and applications of network science
7.2 Specific objective of the discipline	• Describe the concepts and methods used in complex network analysis, define network models (random, small-world, scale-free) and processes on networks, theory and modelling of complex networks, analysis of real-world network datasets.

8. Content

8.1 Course	Teaching methods	Remarks
1. Introduction to Network Science. Real-world networks	• Interactive exposure • Presentation • Explanation • Practical examples • Case-study discussions	
2. Network properties and basic definitions		
3. Network metrics and centrality measures		
4. Random networks		
5. Small world networks		
6. Scale-free networks		
7. Growth and preferential attachment		
8. Community detection in networks		
9. Spreading phenomena		
10. Epidemic models over networks		
11. -12. Applications		
13. -14. Student presentations		

Bibliography

1. Albert-Laszlo Barabasi, Network Science, Cambridge University Press, 2016.

[1] One can choose either competences or learning outcomes, or both. If only one option is chosen, the row related to the other option will be deleted, and the kept one will be numbered 6.

2. Mark Newman, Networks: An Introduction, Oxford University Press, 2010.
3. David Easley, Jon Kleinberg, Networks, Crowds, and Markets: Reasoning About a Highly Connected World, Cambridge University Press, 2010.
4. Ernesto Estrada, The Structure of Complex Networks Theory and Applications, Oxford University Press, 2011.
5. Melanie Mitchell, Complexity: A Guided Tour, Oxford University Press, 2009.
6. Robert A. Hanneman, Mark Riddle. 2005. Introduction to social network methods. Riverside, CA: University of California, Riverside (published in digital form at http://faculty.ucr.edu/~hanneman)
7. D. J. Watts, P. S. Dodds, M. E. J. Newman. Identity and Search in Social Networks. Science, 296, 1302-1305, 2002.

8.2 Seminar / laboratory	Teaching methods	Remarks
The goal is to use network analysis methods and tools in real-world applications. Each student will work within a team to implement a project focusing on applying network analysis to **real data**. To achieve these goals, seminar/laboratory work (2 hours every 2 weeks) will have the following structure:		
1. Introduction - Explore social network analysis tools. - Familiarize with the representation of networks.		
2. Network analysis and visualization - Investigate network properties such as node degree distribution, clustering coefficient, and centrality in network datasets. - Discover ways to visualize social networks.		
3. Network models - Investigate network models (random graphs, small worlds, power-law)		
4. Network analysis project I - Specify a theme for the project. - Define your own complex networks from fiction and/or non-fiction.		
5. Network analysis project II - Network visualization - Explore the properties of the networks analysed e.g. node degree distribution, clustering coefficient, centrality, communities.		
6-7. Network analysis project III - Analyse results - Prepare project presentation		

Bibliography

1. Albert-Laszlo Barabasi, Network Science, Cambridge University Press, 2016.
2. Mark Newman, Networks: An Introduction, Oxford University Press, 2010.
3. David Easley and Jon Kleinberg, Networks, Crowds, and Markets: Reasoning About a Highly Connected World, Cambridge University Press, 2010.

4. Ernesto Estrada, The Structure of Complex Networks Theory and Applications, Oxford University Press, 2011.
5. Jure Leskovec, Andrej Krevl, SNAP Datasets: Stanford Large Network Dataset Collection, http://snap.stanford.edu/data, 2014.

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

- The course exists in the studying program of all major universities abroad.

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	Know basic concepts, models and theories from the domain of complex networks	Written exam	10%
		Research paper and presentation	40%
10.5 Seminar/laboratory	Use network science and apply known concepts to perform complex network analysis	Project implementation and presentation	50%
10.6 Minimum standard of performance			
Each student should obtain minimum 5 for the written exam /research paper and presentation, as well as for the final grade.			

11. Labels ODD (Sustainable Development Goals)[2]

Not applicable.

Date:

14.04.2025

Signature of course coordinator

Prof. dr. Camelia Chira

Signature of seminar coordinator

Prof. dr. Camelia Chira

Date of approval:

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Signature of the head of department

Assoc.prof.phd. Adrian STERCA

[2] Keep only the labels that, according to the *Procedure for applying ODD labels in the academic process*, suit the discipline and delete the others, including the general one for *Sustainable Development* – if not applicable. If no label describes the discipline, delete them all and write „*Not applicable*.".