COURSE DESCRIPTION CARD - SYLLABUS

Course name
Network algorithms [S1MiKC1>AS]

Course

Field of study
Microelectronics and digital communications

Year/Semester
3/6

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
30

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

dr Joanna Weissenberg
joanna.weissenberg@put.poznan.pl

Lecturers

Prerequisites

Student enrolled in this course should have a basic understanding of programming, algebra and graph theory. They should also possess the ability to learn independently, be aware of the need to expand their compentencies, and demonstrate a willingness to collaborate within a team.

Course objective

The course aims to equip students with the skills to solve fundamental engineering computational problems in electronics and telecommunications using an algorithmic approach. It fosters a structured and mathematically rigorous understanding of network algorithms. Additionally, students will learn to select appropriate algorithms for network optimisation problems and evaluate the complexity of chosen algorithms in specific optimisation scenarios.

Course-related learning outcomes

Knowledge:
1. Has a structured, mathematically supported knowledge of network algorithms.
2. Has the knowledge necessary to select an appropriate algorithm for the network optimisation problem being solved.

3. Has knowledge of computer science and graph theory.

Skills:
1. Can evaluate the complexity, chosen independently, of an algorithm for solving a specific network problem.
2. Is able to solve typical problems related to optimization of ICT networks.

Social competences:
He understands that with the development of computer systems, computational algorithms are becoming increasingly improving, but at the same time is aware of their limited application

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The knowledge gained from lectures is assessed through a final assessment. The assessment is written and consists of 45-60 multiple-choice questions, true/false questions, and open-ended questions. Students receive one point for each correct answer, and a minimum of 50% of the total points is required to pass the assessment.
The knowledge and skills acquired in exercises are assessed based on student activity during classes (20%) and a final assessment (80%). The final assessment consists of 5-10 tasks to be solved, with the number of points awarded for each task depending on the complexity of the question. To pass the test, students must score at least 50% of the total points.

Programme content

The curriculum covers graph theory and algorithms for graph traversal, minimum spanning trees, single-source shortest paths, all-pairs shortest paths, K-shortest paths, and topological sorting of graphs.

Course topics

Lecture
1. Fundamentals of Graph Theory in Telecommunications Networks
• Definition and properties of graphs used in telecommunications network modelling
• Types of graphs: directed and undirected, weighted, dynamic
• Graph representations in networks:
o Adjacency matrix vs. adjacency list - choosing the optimal representation for different problems
o Data structures for storing and processing networks (heaps, Union-Find, segment trees)
2. Graph Traversal Algorithms and Their Applications
• BFS and DFS algorithms - their role in analysing the structure of telecommunications networks
• Cycle detection in networks
• Topological sorting
3. Routing Algorithms in Networks
• Shortest path algorithms (used in IP routing and network optimisation):
o Dijkstra's algorithm - application in OSPF (Open Shortest Path First)
o Bellman-Ford algorithm - foundations of RIP (Routing Information Protocol)
o Floyd-Warshall algorithm - computation of full delay matrices in networks
o Johnson's algorithm - efficient processing of large-scale network graphs
• K-shortest path algorithms (e.g., Yen's algorithm) - multiple path routing, load balancing
• Constrained Shortest Path First (CSPF) - applications in QoS-aware routing (e.g., VoIP, 5G networks)
4. Network Infrastructure Construction and Optimisation Algorithms
• Minimum Spanning Tree (MST):
o Prim's and Kruskal's algorithms - constructing efficient backbone networks
o Applications in fibre-optic and mobile network topology planning
• Maximum Spanning Tree (MaxST) - optimising connectivity in ad-hoc networks
• Steiner Tree Problem - cost minimisation in multicast network design
5. Flow Network Algorithms and Their Applications
• Maximum flow in telecommunications networks:
o Ford-Fulkerson method - analysing transmission channel capacity
o Edmonds-Karp algorithm - data transmission optimisation

o Dinic’s algorithm - scaling bandwidth for broadband networks
• Minimum-cost flow
• Matching and resource allocation problems:
o Maximum matching in graphs - optimisation of bandwidth and transmission time allocation
Laboratory Classes
Implementation and computational complexity analysis of selected algorithms discussed during the lectures.

Teaching methods

Lecture - Multimedia presentations illustrated with examples
Laboratory Classes - Implementation and/or complexity analysis of selected algorithms

Bibliography

Basic:
1. T. Cormen: "Introduction to algorithms", PWN, Warszawa, wydanie 2013,2012,2007,2005
2. R. J. Wilson: "Introduction to graph theory", PWN, Warszawa 2000

Additional:
1. M Sysło: "Algorytmy optymalizacji dyskretnej", PWN, Warszawa,
2. R. Diestel: "Graph Theory", Electronic Edition 2000 cc Springer-Verlag New York 1997, 2000
3. MATLAB i Simulink : poradnik użytkownika / Bogumiła Mrozek, Zbigniew Mrozek
4. Algorytmizacja i programowanie w Matlabie / Kazimierz Banasiak MATLAB : dla naukowców i inżynierów / Rudra Pratap

Breakdown of average student's workload

	Hours	ECTS
Total workload	85	3,00
Classes requiring direct contact with the teacher	45	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	40	1,50