Z1-PU7	WYDANIE N1	Strona 1 z 3

(*faculty stamp*)

COURSE DESCRIPTION

1. Course title: INTRODUCTION TO PERFORMANCE EVALUATION OF INTERNET AND COMPUTER SYSTEMS

2. Course code: WM2

3. Validity of course description: 2019/2020

4. Level of studies: BA

5. Mode of studies: intramural studies

6. Field of study: computer science (informatics) — (FACULTY SYMBOL) **RMS**

7. Profile of studies: general academic

8. Programme: all specialties

9. Semester: VI

10. Faculty teaching the course: Institute of Mathematics

11. Course instructor: Prof. dr hab. inż. Tadeusz Czachórski

12. Course classification: monographic / block of subjects of limited selection

13. Course status: elective

14. Language of instruction: English

15. Pre-requisite qualifications: knowledge of probability theory and stochastic processes on the level taught at BA courses; rudiments of computer networks and computer systems architectures and principles of their performance

16. Course objectives: to achieve skills in the use of mathematical methods used in modeling and performance evaluation of computer systems and computer networks, especially Internet.

17. Description of learning outcomes:

Nr	Learning outcomes description	Method of assessment	Teaching methods	Learning outcomes reference code
1.	Student gets knowledge on operational models, mean value analysis, fluid flow approximation, diffusion approximation, and Markov models of computer systems and Internet	test	Lecture, class	K1A_W06 +++ T1A_W04 ++
2.	Student acquires knowledge on network models and principles of Internet transmission protocols modeling	test	Lecture, class	K1A_W06 +++ T1A_W04 ++
3.	Student knows state of the art and perspectives of several methods used in modeling and performance evaluation of computer networks (Internet) and is acquainted of the need on constant development of mathematical models and related software	test	Lecture, class	K1A_W06 +++ T1A_W04++
4.	Student is able to use learnt methods to in case studies analysis	test	Lecture, class	T1A_K01 +
5.	Student is able to follow the English literature of the subject and apply new models to study the performances of computer systems and computer networks	test	Lecture, class	T1A_U01 ++

18. Teaching modes and hours

Lecture / BA /MA Seminar / Class / Project / Laboratory

Sem 6: lecture - 30 h, class - 30 h

19. Syllabus description:

Lecture: Operational models of computer systems: basic laws for the resource utilization, throughput and response time. Definition of a system bottleneck. Asymptotic and based on balanced systems bounds on a system throughput and response time. The use of bounds in analysis of the impact of various modifications (exchange of disks, balancing disks, faster processor, virtual memory) on the performance of a computer

system.
Mean value analysis (MVA) applied to model open, closed and mixed networks for single and multiple classes of customers. Approximate MVA (Schweitzer's) algorithm. MVA for modelling TCP congestion avoidance mechanism and evaluation of transmission time. Optimization of a "connection power" parameter. Fluid flow approximation (FFA) as a MVA applied to transient analysis. Application of FFA to study the dynamics of TCP flows for various types of TCP (Reno, Vegas) with various Active Queue Management algorithms in IP routers: application of Random Early Deletion (RED) algorithm and its modifications, PID controllers, PID with non-integer integration and differentiation. TCP traffic control as closed control loop, application of control theory to investigate the stability of TCP control. FFA tool to model very large Internet topologies.
Single server models based on Markov chains, introduction of limited queue and loss probability, parallel service channels, infinite and finite set of customers. Queueing Markov models of open, closed and mixed networks (Jackson, Newell, Baskett-Chandy-Munts-Palatios, Gelenbe networks). Related computational algorithms. Statistical properties of internet traffic (self-similarity, long term autocorrelation) and their influence on network performance. Models of traffic intensity based on Markov chains (On-Off sources, Markov-Modulated Poisson process) and hidden Markov chains. Markov models with very large state space solved numerically (transient and steady state analysis). Their application in detailed, based on real data collected in Internet Markov models of flow intensities and IP packet sizes resulting in detailed model of IP router queues and router delays. Tools (OLYMP, PRISM) to solve Markov models. Models of congestion avoidance (threshold, leaky-bucket, sliding window, jumping window, push-out queue) algorithms. Models of all-optical networks routing, a model of electrical-optical edge router. Models based on imbedded Markov chains (M/G/1 and G/M/1) stations, introduction of priority queues. Markov models of wireless networks.
Analytical and numerical solution of diffusion equations, diffusion approximation in steady and transient state analysis of queueing systems, case of single and multiple parallel service channels, models of large network topologies. A case study: MVA, Markov models, and diffusion approximation applied to study a real IP applications based system, comparison of results, difficulties and errors. Diffusion approximation models of priority queues and active queue management in IP routers. Erlang and Engset telecommunication models revisited with diffusion approximation. Diffusion models of call centers and of boot-up storms.

Classes: computational examples in the following topics:

1. Operational models of a computer system. 2. Bounds on a system response time and throughput. 3. Mean value analysis, open networks. 4. Mean value analysis, closed networks. 5. Mean value analysis, multiple classes of customers – exact and simplified algorithms. 6. Markov models, single service station. 7. Markov models, open networks. 8. Markov models, closed networks. 9. Transient analysis - Markov models, 10 Transient analysis – fluid flow approximation. 11. Transient analysis - diffusion approximation. Principles of computing flow intensities in networks. 12. Telecommunication traffic models. 13. Application of Erlang and Engset models to compute transmission loss probabilities.

20. Examination: no examination

21. Primary sources:

1. T. Czachórski, "Modele kolejkowe w ocenie efektywności sieci i systemów komputerowych", Wydawnictwo Pracowni Komputerowej Jacka Skalmierskiego, Gliwice 1999.

22. Secondary sources:

1. M. Hassan and R. Jain, "High Performance TCP/IP Networking: Concepts, Issues, and Solutions", Prentice-Hall, 2003, ISBN:0130646342, ISBN:0131272578.

2. R. Jain, The Art of Computer Systems Performance Analysis, Wiley Interscience 1991.

23. Total workload required to achieve learning outcomes

Lp.	Teaching mode :	Contact hours / Student workload hours
1	Lecture	30/30
2	Classes	30/30
3	Laboratory	/
4	Project	/
5	BA/ MA Seminar	/
6	Other	/
	Total number of hours	60/60

24. Total hours: 120

25. Number of ECTS credits: 4

26. Number of ECTS credits allocated for contact hours: 4

27. Number of ECTS credits allocated for in-practice hours (laboratory classes, projects): 0

26. Comments:

Approved:

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(date, Instructor's signature)

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(*date , the Director of the Faculty Unit signature)*