1. Course title: PERFORMANCE EVALUATION OF COMPUTER NETWORKS

2. Course code: PECN


4. Level of studies: MSc

5. Mode of studies: intramural studies

6. Field of study: informatics

7. Profile of studies: general academic

8. Programme: -

9. Semester: 2

10. Faculty teaching the course: Faculty of Automatic Control, Electronics and Computer Science

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

12. Course classification: common

13. Course status: compulsory

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 architectures and principles of their performance, especially of the performance of communication protocols (TCP/IP)


17. Description of learning outcomes:

<table>
<thead>
<tr>
<th>Nr</th>
<th>Learning outcomes description</th>
<th>Method of assessment</th>
<th>Teaching methods</th>
<th>Learning outcomes reference code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Student gets knowledge on operational models, Markov chain models, diffusion approximations queueing models of computer networks</td>
<td>test</td>
<td>Lecture</td>
<td>K_W04</td>
</tr>
<tr>
<td>2.</td>
<td>Student gets knowledge on mean value analysis applied to model computer networks.</td>
<td>test</td>
<td>Lecture</td>
<td>K_W01</td>
</tr>
<tr>
<td>3.</td>
<td>Student is able to apply analytical models, e.g. Markov chain models, in the performance analysis of computer networks.</td>
<td>test</td>
<td>Lecture, Laboratory</td>
<td>K_U10</td>
</tr>
<tr>
<td>4.</td>
<td>Student is able to apply the acquired knowledge of simulation models to evaluate performances of computer networks. Student is able to evaluate simulation errors.</td>
<td>test</td>
<td>Laboratory</td>
<td>K_U09</td>
</tr>
<tr>
<td>5.</td>
<td>Student is able to apply the acquired knowledge to study the performances of a proposed topology of a computer networks.</td>
<td>test</td>
<td>Laboratory</td>
<td>K_U08</td>
</tr>
</tbody>
</table>

18. Teaching modes and hours

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

Sem 8: lecture - 15 h, laboratory - 15 h

19. Syllabus description:

Lecture:

Operational models of computer networks: basic laws for the resource utilization, throughput and response time. Definition of a network bottleneck. Queueing networks as a model of a communication network - the use of mean value analysis (MVA), models of the open and closed network, introduction of multiple classes of customers, the use of approximate MVA algorithm. MVA algorithm in analysis of TCP congestion avoidance mechanism and the transport time evaluation. Optimization of a “connection power” parameter. Investigation of TCP connection stability with the use of control theory approach.

Simple probabilistic queueing models and their justification. Single server models based on Markov chains, introduction of limited queue and loss probability, parallel service channels, limited set of customers; examples of a router and a local network models.

Queueing Markov models of an open and closed network, related computational algorithms. Models of traffic intensity based on Markov chains and hidden Markov chains. Markov models solved numerically and their application in the analysis 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. Diffusion and fluid flow approximations in the analysis of transient states, application to the analysis of packet queues in IP routers, models of active queue management (e.g. random early deletion) in IP routers. Statistical properties of internet traffic (self-similarity, long term autocorrelation) and their influence on network performance.

**Laboratory:** Simple simulation queueing models and models of computer networks written with the use of OMNET++ system.

**20. Examination:** no examination

**21. Primary sources:**


**22. Secondary sources:**


**23. Total workload required to achieve learning outcomes**

<table>
<thead>
<tr>
<th>Lp.</th>
<th>Teaching mode</th>
<th>Contact hours / Student workload hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lecture</td>
<td>15/15</td>
</tr>
<tr>
<td>2</td>
<td>Classes</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Laboratory</td>
<td>15/15</td>
</tr>
<tr>
<td>4</td>
<td>Project</td>
<td>/</td>
</tr>
<tr>
<td>5</td>
<td>BA/ MA Seminar</td>
<td>/</td>
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<tr>
<td>6</td>
<td>Other</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>Total number of hours</td>
<td>/</td>
</tr>
</tbody>
</table>

**24. Total hours:** 30

**25. Number of ECTS credits:** 2

**26. Number of ECTS credits allocated for contact hours:** 1

**27. Number of ECTS credits allocated for in-practice hours (laboratory classes, projects):** 1

**26. Comments:**

Approved:

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(date, Instructor’s signature) (date, the Director of the Faculty Unit signature)