Random Multiple Access

2019 Edition (20 hours, 4 credits)

Course objective

The course introduces the fundamentals of random access protocols modeling, performance evaluation and optimization.
It aims at giving a full understanding of the basic performance trade-offs, addressing throughput, delay, fairness and stability issues.
Special emphasis is placed on modeling and on applications to wireless technologies.
The Wi-Fi random MAC component is analyzed in detail as a major example of random access engineering.

Prerequisites

Basic knowledge of probability (e.g., the Poisson process) and Markov chain theory. Elementary notions of communications and networking.

Timetable

Tuesday, November 5,	11.00 am – 1.00 pm, Lecturing Room, DIET, 2nd floor.
Thursday, November 7 ,	10.00 am – 1.00 pm, Lecturing Room, DIET, 2nd floor.
Tuesday, November 12,	11.00 am – 1.00 pm, Lecturing Room, DIET, 2nd floor.
Thursday, November 14 ,	10.00 am – 1.00 pm, Lecturing Room, DIET, 2nd floor.
Tuesday, November 19,	11.00 am – 1.00 pm, Lecturing Room, DIET, 2nd floor.
Thursday, November 21 ,	10.00 am – 1.00 pm, Lecturing Room, DIET, 2nd floor.
Tuesday, November 26,	11.00 am – 1.00 pm, Lecturing Room, DIET, 2nd floor.
Thursday, November 28,	10.00 am – 1.00 pm, Lecturing Room, DIET, 2nd floor.

Lecturer

Andrea Baiocchi has been a Professor of Telecommunications at DIET, University of Roma "La Sapienza", since January 2005. His main scientific contributions are on telecommunications network traffic modeling, control and engineering, queuing theory, wireless, cellular and vehicular networks. His current research interests are focused on the evolution of Wi-Fi, vehicular networking, traffic monitoring and analysis. Andrea's research activities have been carried out also in the framework of many national (CNR, MIUR) and international (European Union, ESA) projects; main results are reported in about 160 publications on international journal and conference proceedings. Andrea teaches classes in Network Traffic Engineering, Networking for Big Data and Telecommunications.

Syllabus

Lecture 1 – Slotted ALOHA. Finite population model. Discussion of performance trade-offs: the load line diagram and system working regimes.

Lecture 2 – Slotted ALOHA. Stability analysis. Jamming theorem. Stabilized Slotted ALOHA. Delay analysis.

Lecture 3 – Pure ALOHA. Multi-packet reception and variable packet size: modeling and performance evaluation. Fairness.

Lecture 4 – CSMA. Channel sensing, persistence and re-transmissions. Finite population model of non-persistent CSMA. Poisson arrival approximation: analysis of non-persistent and 1-persistent CSMA.

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Lecture 5 – CSMA. Extension to multi-packet reception. Stability analysis. Bayesian stabilization of CSMA. Delay analysis.

Lecture 6 – Wi-Fi: brief introduction to standards. Description of IEEE 802.11 MAC DCF (CSMA/CA). Classic model of CSMA/CA: assumptions, back-off analysis, throughput analysis.

Lecture 7 – Wi-Fi service time analysis. Trade-off between throughput and service time jitter. Criticism of Binary Exponential Back-off (BEB).

Lecture 8 – Optimization of CSMA/CA throughput by means of contention window adaptation: Idle Sense. Wi-Fi: long-term and short-term fairness. Performance anomaly. Airtime fairness. Outline of the emerging standard IEEE 802.11ax.

Exam

Small project assignment on one of the topics of the course.

Support material

Lecture notes and slides, provided by the lecturer.