Noncooperative Distributed Systems

lecturer: Jerzy Konorski; 15 h

Course scope and objectives

Looking at the communicating parties in an ICT system, e.g., human users, intelligent terminals, software agents or autonomous subsystems, one notices the following changes taking effect over the last decades:

- Communicating parties no longer trust one another or the communication system they are part of. Being distrustful towards the system (e.g., network operator or intolerant user community), they seek *anonymity* by withholding or changing their identities, possibly pretending to have multiple identities or none.
- Communicating parties are no longer unconditionally cooperative. They expect value for money and if not satisfied with the offered resource or service level, may become *noncooperative*, i.e., selfishly grab a larger-than-fair resource share at the cost of other communicating parties, which potentially also disrupts the system as a whole. To this end, a noncooperative party may modify the standard system interface provided, which it gets away with it owing to their anonymity. Most distributed systems of today were conceived with a sense of a social goal, e.g., high system-wide performance; with that sense gone, there may be no mechanisms to prevent noncooperative behavior.
- Communicating devices are increasingly autonomous both by design, to enable stand-alone operation in case of a system breakdown or in a system too complex to be centrally supervised, and because their users are no longer computer illiterate. With the key functions gradually migrating from hardware to software, skillful users can easily reprogram a device to act noncooperatively.

Noncooperative behavior defies the traditional engineering paradigm of systems design, which optimizes a multivariate performance criterion subject to feasibility and cost constraints. In this course we take a "microeconomic" approach that has recently gained importance in autonomous system design, whereby a device's noncooperative behavior is regarded as rational and thus predictable. It recognizes that little can be done by administrative means, since anonymous devices are hard to single out and punish. Instead, incentive compatibility measures should be applied so that selfish devices find themselves worse off than they would be when acting cooperatively. In particular, we are interested in situations where noncooperative behavior backfires, or even contributes to a social goal. We analyze interactions between rational devices and the impact of their noncooperative behavior

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upon system-wide performance. The main formal apparatus here is that of game theory, an operational research tool largely borrowed from modern economics and sociology. Throughout the course we give an overview of basic game models applicable in the context of distributed computer and communication environments, along with the corresponding solution concepts. Among others, we give semiformal explanations of rational preferences, strategy dominance, common knowledge, pure- and mixed-strategy Nash equilibria and the price of anarchy. These are accompanied by a large number of educational examples that illustrate the differences between decision problems and simple games, as well as brief studies of noncooperative ICT settings in which the above notions can serve to characterize the devices' individual strategies and overall system performance.

Course description

30 lecture hours with the following topics, each covered within approximately one hour.

1. Introduction: paradigm shift in systems design from centralized to decentralized to secure to noncooperative
2. Distributed noncooperative environments in the ITC world: P2P communities, multiagent systems, data forwarding, interdomain routing, multiple access, IDS, user-to-network interface, Cognitive Radio
3. Cooperation security and violator types: Bully Contender, Fake VIP, Free Rider
4. Rationality under uncertainty and competition: outcomes and lotteries, axioms of utility theory and real-life behavior
5. Game-theoretic models of rational interactions: information, strategies, payoffs, cooperative vs. noncooperative, zero- vs. nonzero-sum
6. Strategy dominance in one-shot games: auctions for resource allocation, adverse selection
7. Building incentives in reputation systems
8. Decision problems vs. games: the flavor of strategic reasoning
9. Solomon's judgment revisited
10. Prediction of system's behavior: from global optima to solution concepts of various strength and precision
11. Iterated strict dominance, Nash equilibrium and related notions: common knowledge, best response, Pareto effectiveness, risk dominance, focal points, Stackelberg games
12. Price of anarchy: tragedy of the commons in power and multiple access games, collective security
13. Selfish routing and Braess paradox
14. Mixed-strategy equilibria: Nash's theorem, principle of indifference, civic duty and bystander effect
15. Firewall deployment and network selection

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Recommended reading

1. E. Rasmussen, Games and Information: An Introduction to Game Theory, Blackwell Publishers 2001
2. D. Fudenberg and D. K. Levine, The Theory of Learning in Games. MIT Press 1998
3. C. Courcoubetis and R. Weber, Pricing Communication Networks, J. Wiley 2003
4. H. Gintis, Game Theory Evolving, Princeton University Press 2009
5. S. Lasaulce and H. Tembine, Game Theory for Wireless Networks, Academic Press 2011

TERMINY WYKŁADÓW			
Data	**Dzień tygodnia**	**Godzina**	**Sala**
29.10.2013	Wtorek	16.15-19.00	208 NE (Nowy Gmach WETI)
05.11.2013	Wtorek	16.15-19.00	208 NE (Nowy Gmach WETI)
12.11.2013	Wtorek	16.15-19.00	208 NE (Nowy Gmach WETI)
19.11.2013	Wtorek	16.15-19.00	208 NE (Nowy Gmach WETI)
26.11.2013	Wtorek	16.15-19.00	208 NE (Nowy Gmach WETI)

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