A branch of the United States FBI has requested to use a version of BitThief as a tool to uncover illegal activities. About half of the former PhD students are in academic positions, some others founded startup companies. Some of the software developed by our students is very popular, such as BitSplitters. Several projects have been covered by popular media and blogs, e.g. Gizmodo, Lifehacker, New York Times, NZZ, PC World Magazine, Red Herring, or Technology Review. Some of the software developed by our students is very popular: The music application Jukebox and the peer-to-peer client BitThief have together more than 1 million downloads.

We are interested in both theory and practice of computer science and information technology. In our group we cultivate a large breadth of areas, reflecting our different backgrounds in computer science, mathematics, and electrical engineering. This gives us a unique blend of basic and applied research, proving mathematical theorems on the one hand, and building practical systems on the other.

We currently study the following topics: Distributed computing (computability, locality, complexity), distributed systems (Bitcoin, wired/wireless networks, software-defined networks), social networks (influence), algorithms (online algorithms, game theory, learning theory [recommendation theory and practice]), and building practical systems. Members of our group have won several best paper awards at top conferences such as PODC, SPAA, DISC, MobiCom, or P2P. Roger Wattenhofer has won the Prize for Innovations in Distributed Computing in 2012, for "extensive contributions to the study of distributed approximation". Some projects turned into startup companies, e.g. Wuala, StreamForge, BitSplitters. Several projects have been covered by popular media and blogs, e.g. Gizmodo, Lifehacker, New York Times, NZZ, PC World Magazine, Red Herring, or Technology Review. Some of the software developed by our students is very popular: The music application Jukebox and the peer-to-peer client BitThief have together more than 1 million downloads.

A branch of the United States FBI has requested to use a version of BitThief as a tool to uncover illegal activities. About half of the former PhD students are in academic positions, some others founded startup companies.

Mission
We are interested in both theory and practice of computer science and information technology. In our group we cultivate a large breadth of areas, reflecting our different backgrounds in computer science, mathematics, and electrical engineering. This gives us a unique blend of basic and applied research, proving mathematical theorems on the one hand, and building practical systems on the other.

We currently study the following topics: Distributed computing (computability, locality, complexity), distributed systems (Bitcoin, wired/wireless networks, software-defined networks), social networks (influence), algorithms (online algorithms, game theory, learning theory [recommendation theory and practice]), and building practical systems. Members of our group have won several best paper awards at top conferences such as PODC, SPAA, DISC, MobiCom, or P2P. Roger Wattenhofer has won the Prize for Innovations in Distributed Computing in 2012, for "extensive contributions to the study of distributed approximation". Some projects turned into startup companies, e.g. Wuala, StreamForge, BitSplitters. Several projects have been covered by popular media and blogs, e.g. Gizmodo, Lifehacker, New York Times, NZZ, PC World Magazine, Red Herring, or Technology Review. Some of the software developed by our students is very popular: The music application Jukebox and the peer-to-peer client BitThief have together more than 1 million downloads.

A branch of the United States FBI has requested to use a version of BitThief as a tool to uncover illegal activities. About half of the former PhD students are in academic positions, some others founded startup companies.

Mission
We are interested in both theory and practice of computer science and information technology. In our group we cultivate a large breadth of areas, reflecting our different backgrounds in computer science, mathematics, and electrical engineering. This gives us a unique blend of basic and applied research, proving mathematical theorems on the one hand, and building practical systems on the other.

We currently study the following topics: Distributed computing (computability, locality, complexity), distributed systems (Bitcoin, wired/wireless networks, software-defined networks), social networks (influence), algorithms (online algorithms, game theory, learning theory [recommendation theory and practice]), and building practical systems. Members of our group have won several best paper awards at top conferences such as PODC, SPAA, DISC, MobiCom, or P2P. Roger Wattenhofer has won the Prize for Innovations in Distributed Computing in 2012, for "extensive contributions to the study of distributed approximation". Some projects turned into startup companies, e.g. Wuala, StreamForge, BitSplitters. Several projects have been covered by popular media and blogs, e.g. Gizmodo, Lifehacker, New York Times, NZZ, PC World Magazine, Red Herring, or Technology Review. Some of the software developed by our students is very popular: The music application Jukebox and the peer-to-peer client BitThief have together more than 1 million downloads.

A branch of the United States FBI has requested to use a version of BitThief as a tool to uncover illegal activities. About half of the former PhD students are in academic positions, some others founded startup companies.

Mission
We are interested in both theory and practice of computer science and information technology. In our group we cultivate a large breadth of areas, reflecting our different backgrounds in computer science, mathematics, and electrical engineering. This gives us a unique blend of basic and applied research, proving mathematical theorems on the one hand, and building practical systems on the other.

We currently study the following topics: Distributed computing (computability, locality, complexity), distributed systems (Bitcoin, wired/wireless networks, software-defined networks), social networks (influence), algorithms (online algorithms, game theory, learning theory [recommendation theory and practice]), and building practical systems. Members of our group have won several best paper awards at top conferences such as PODC, SPAA, DISC, MobiCom, or P2P. Roger Wattenhofer has won the Prize for Innovations in Distributed Computing in 2012, for "extensive contributions to the study of distributed approximation". Some projects turned into startup companies, e.g. Wuala, StreamForge, BitSplitters. Several projects have been covered by popular media and blogs, e.g. Gizmodo, Lifehacker, New York Times, NZZ, PC World Magazine, Red Herring, or Technology Review. Some of the software developed by our students is very popular: The music application Jukebox and the peer-to-peer client BitThief have together more than 1 million downloads.

A branch of the United States FBI has requested to use a version of BitThief as a tool to uncover illegal activities. About half of the former PhD students are in academic positions, some others founded startup companies.
Research Activities and Achievements

In the following, we discuss a few examples of our ongoing research projects in more detail.

One of our main theoretical interests is algorithmic theory that does not follow the traditional input/output model of computation. One may call this "physical algorithms", algorithms that live in networked systems of active agents. As many physical systems (cars, financial agents, animals, brain cells, you name it) show "algorithmic" behavior, we would like to understand the fundamentals of such networked systems. Let us give a few examples.

Distributed Complexity: What can be computed, and how efficiently, are probably the core questions of computer science. Not surprisingly, in distributed systems and networking research, a core question is what can be computed in a distributed fashion, in a network. More precisely, if nodes of a network must base their decision on their local neighborhood only, how well can they compute or approximate a global optimization problem? Throughout the years, we studied different aspects and problems of locality in great detail – today this body of work has developed into what is known as distributed complexity theory. In 2012, Roger Wattenhofer received the Prize for Innovation in Distributed Computing for this line of work.

Clock Synchronization: Networks often need a common notion of time; consequently clock synchronization in networked systems seems to be such a fundamental and practically important question that it should have been solved a long time ago. Surprisingly, this is not the case. In a series of papers we studied the theory of clock synchronization, proving the surprising result that two neighboring nodes cannot synchronize their clocks arbitrarily well; indeed one can show that even the best possible protocol will produce a clock skew between neighbors that scales with the logarithm of the network size. This result is tight, as we discovered an algorithm that achieves this lower bound. We also looked into the practical side of clock synchronization, and developed protocols that beat the state of the art in sensor networks considerably.

Wireless Algorithms: Despite the omnipresence of wireless networks, surprisingly little is known about their computational complexity and efficiency. We developed techniques to understand the fundamental communication limits of arbitrary wireless networks, in a reasonable physical model such as SINR. We published several papers tackling this question. These papers were the seed of a new community, now called WRAWN, dedicated to this subject.

Software Defined Networks (SDNs): Large providers such as Microsoft, Amazon, or Google operate their own wide area networks that cost them hundreds of millions of dollars a year, yet even their busier links are only utilized 50% on average. This gives rise to SDNs, where the data and control plane are separated, allowing a controller to update network constraints lie at the core of this emerging technology. Starting in 2013, we proved various hardness results and designed efficient update schematics, which were tested in collaboration with industry partners.

Biological Algorithms: They operate without any central control. Their collective behavior arises from local interactions. This is the mantra of our main research area, distributed computing, however, in this quote, “they” are not nodes in a distributed system. Rather, the quote is taken from a biology paper that studies social insect colonies. Understanding the behavior of insects is interesting both from a biological and a computational perspective. In recent years, we studied various aspects of such systems and focused our efforts particularly on developing mathematical models that allowed us to make both qualitative and quantitative statements on the capabilities of insects. We showed, for example, that ants can effectively collaborate to locate a food source in an infinite grid in nearly optimal time even if each ant only possesses a constant amount of memory.

Bitcoin: Money facilitates the exchange of goods and services (and organizing debt, more honestly). Bitcoin is an attempt to revolutionize the concept of money, using computational methods. While Bitcoin is already operational and is used to buy just about everything, from alpaca socks to flights into space, it still faces some major challenges: How can it scale to handle truly global adoption? How can we enforce security? How can we improve on the overall experience? We are at the forefront of research regarding the networking aspects of Bitcoin.

Social Networks: Social interaction is a big part in everyone’s life. Facebook and similar services collect big data sets of digital interactions and relationships between people. We analyze such networks and model the evolution of networks such as co-authorship in publications. This helps to understand social phenomena such as the glass ceiling effect and gives insights in possible counter measures. We also study purely graph theoretic notions of social interactions, e.g. the complexity of social influence.

Recommendation: The goal of a recommendation system is to provide users with an efficient way to find items (books, movies, songs, apps) that they will like. The system can learn the preferences by asking the users about their preferences – the challenge is to minimize the number of questions. We study recommendation systems with the goal to find at least a single good item per user. We designed an algorithm that is nearly optimal and performs well even when compared to an algorithm that knows a probability distribution on the preferences of the users.
Selected Publications


C.-Y. Hong et al.: Achieving High Utilization with Software-Driven WN, Annual Conference of the ACM Special Interest Group on Data Communication (SIGCOMM), 2013

H. H. Liu et al.: ziplDate: Updating Data Center Networks with Zero Loss, Annual Conference of the ACM Special Interest Group on Data Communication (SIGCOMM), 2013

Y. Emek, R. Wattenhofer: Stone Age Distributed Computing, 31st Annual ACM SIGACT-SIGOPS Symposium on Principles of Distributed Computing (PODC), 2013

A. Das Sarma et al.: Distributed Verification and Hardness of Distributed Approximation, SIAM Journal on Computing, 2012 (Special issue of selected papers at STOC 2011)


Ch. Lenzen, R. Wattenhofer: Tight Bounds for Parallel Randomized Load Balancing, 43rd Symposium on Theory of Computing (STOC), 2011


F. Kuhn et al.: Tight Bounds for Distributed Selection, 19th ACM Symposium on Parallelism in Algorithms and Architectures (SPAA), 2007 (Best paper award, a popular variant of this paper has been invited by the Communications of the ACM (CACM) magazine, published in the Section Research Highlights, Volume 51, Issue 9, 93-99, Sept. 2008)

Teaching Activities

Roger Wattenhofer currently teaches three courses, plus a seminar. Distributed Systems is a Computer Science 3rd year core course, taught with Friedemann Mattern from the Computer Science department, with about 100 students. In our part of the course, we primarily discuss fault-tolerance issues (models, censensus, agreement) as well as replication issues (primary copy, 2PC, 3PC, Paxos, quorum systems, distributed storage) and problems with asynchronous multiprocessing (shared memory, spin locks, concurrency).

Discrete Event Systems is an Electrical Engineering 3rd year selective course, with about 50 students. We start out the course by studying popular models of discrete event systems, such as automata, languages, or Petri nets. In the second part of the course, we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective, using the theory of online algorithms, adversarial, and queuing, and network calculus.

Principles of Distributed Computing is an advanced graduate level course, taught to students from both Computer Science and Electrical Engineering, with about 120 students. Distributed computing is essential in modern computing and communication systems. Examples are on the one hand large-scale networks such as the Internet, and on the other hand multiprocessors such as multi-core laptops. This course introduces the principles of distributed computing, emphasizing the fundamental issues underlying the design of distributed systems and networks: communication, coordination, fault-tolerance, locality, parallelism, self-organization, symmetry breaking, synchronization, uncertainty. We explore essential algorithmic ideas and lower bound techniques, basically the “pearls” of distributed computing.

In addition, we currently supervise about 20 student projects each semester. These projects are about the areas of our expertise, however, sometimes we also do some highly speculative and/or fun projects with students. Pictures of these fun projects illustrate this brochure.

Outlook

In the reviewing period, Roger Wattenhofer has served as program committee chair or general chair of several renowned international conferences, such as P2P 2014, ICALP 2012, ICDCN 2012, SSS 2011, ICDCN 2009, ITPPS 2007, and PODC 2007. In addition, he was the Committee Chair of the Edsger W. Dijkstra Prize in Distributed Computing in 2008. Moreover, he is a steering committee member of numerous conferences and workshops such as PODC, WRAWN, ICDCN, TAPAS, FOWANC, and a council member of EATCS, the European Association for Theoretical Computer Science. He was also a local organizer of PODC 2010, the annual flagship conference of the Distributed Computing community, for the first time held outside North America, and a co-organizer of several seminars at Schloss Dagstuhl. In addition, during the review period, he was a member of the program committee of 30 international conferences and workshops, and an external examiner for more than a dozen election committees, tenure cases, and PhD defenses. Among the services at ETH Zurich are: Head of the Computer Engineering and Networks Laboratory, 2008-2009, and again since 2012. Member of the Commission for Studies (“Unterrichtskommission”) at the ITET Department, since 2011. Chair of the Commission of Computing Projects (KIM) at the ITET Department, 2009-2012. Member of the Admission Board for Graduate Studies at the ITET Department, since 2014. Representing the ITET Department to prospective students, 2004-2010. Moreover, member of several Election Committees.

A bit more than half of the PhD graduates joined a university or research lab after their PhD: IBM Research (3 PhD students), Microsoft Research [2], ABB Research [2], CSiRO Australia, Hebrew University, MIT, and TU Munich.

Among the services at ETH Zurich are: Head of the Computer Engineering and Networks Laboratory, 2008-2009, and again since 2012. Member of the Commission for Studies (“Unterrichtskommission”) at the ITET Department, since 2011. Chair of the Commission of Computing Projects (KIM) at the ITET Department, 2009-2012. Member of the Admission Board for Graduate Studies at the ITET Department, since 2014. Representing the ITET Department to prospective students, 2004-2010. Moreover, member of several Election Committees.

A bit more than half of the PhD graduates joined a university or research lab after their PhD: IBM Research (3 PhD students), Microsoft Research [2], ABB Research [2], CSiRO Australia, Hebrew University, MIT, and TU Munich.

Some PhD graduates founded a startup company: 3 former PhD students founded StreamForge, a startup company in the area of video and audio streaming, and one former PhD student founded BitSplitters, a startup company developing a wearable gadget that measures UV radiation. Wuala, a startup company working on secure storage with more than a dozen engineers, was founded by former Master students, and has recently been acquired by Seagate.

Finally, some PhD graduates joined a company: Google [3], AppleTornade, Ergon. Our only PostDoc Yuval Emek joined the Technion.