

Preface to Special Issue on Algorithmic Game Theory Dedicated to the Memory of Berthold Vöcking

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This special issue of TOCS contains selected papers of the 6th edition of the Symposium on Algorithmic Game Theory (SAGT). The purpose of SAGT is to bring together researchers from Computer Science, Economics, Physics, Biology and Mathematics to present and discuss original research at the intersection of Algorithms and Game Theory.

We devote this issue to the memory of Berthold Vöcking, who died on June 11th, 2014, after a long struggle with cancer. Berthold was a leading scientist in the area of Algorithmic Game Theory and very active in our community. He had been a member of the Steering Committee of SAGT since its very beginning. In October 2013, he organized the 6th Symposium on Algorithmic Game Theory at RWTH Aachen University, in Germany, where he also acted as the Program Committee chair. During the symposium, Berthold asked us to become co-editors for this special issue.

The symposium received 65 submissions and the Program Committee selected 24 papers, among which we decided to pick four excellent papers composing this special issue. These journal papers have been rigorously reviewed according to the usual high journal standards.

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- The paper “Imperfect best-response mechanisms”, by Ferraioli and Penna, studies convergence properties of imperfect best-response dynamics for a certain class of games. They show that even if the players make mistakes in their best-response with exponentially small probability, there is a game and an adversarial schedule so that with high probability an equilibrium will never be reached.
- Anshelevich, Bhardwaj and Usher investigate in their paper “Friend of my friend: network formation with two-hop benefit” a network formation game in which the players care only for their immediate and two-hop neighbors of the network. Several new characterizations of the resulting equilibrium networks are derived.
- The paper “Copula-based randomized mechanisms for truthful scheduling on two unrelated machines”, by Chen, Du and Zuluaga, describes a new randomized scheduling mechanism based on the concept of Copula distributions. A careful analysis reveals an improved approximation ratio for makespan minimization on two unrelated machines that becomes almost optimal for the case of two jobs.
- Anagnostopoulos, Becchetti, de Keijzer, and Schäfer consider the price of anarchy of strategic games that take place in a restricted altruistic social context. In their paper “Inefficiency of games with social context”, they prove that altruism does not significantly harm efficiency of equilibria if each player cares for herself at least as much as she cares for the cost of any other player.

To honor the memory of Berthold we asked several people who were close to Berthold for many years to contribute to this special issue by sharing their memories and thoughts of Berthold. All of them accepted and their contributions appear before the regular journal publications in an “In Memoriam” part.

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1 In Memoriam, Berthold Vöcking

I have known Berthold for almost two decades, from his time as a graduate student in Paderborn, through his time in Berkeley and Amherst, until his return to Germany in Saarbrücken, Dortmund and Aachen. He was a very good friend and I will always feel privileged that I had a chance to work with him. We had five joint papers, many fascinating discussions about research, about personal life, and we shared many great memories. I am sure I will not be alone in saying that Berthold was one of the most brilliant and influential researchers around, an amazing problem-solver, very well organized, very consistent in delivering great research (his record

of consecutive papers at STOC 1996–2006 is unparalleled) and he was a real giant in algorithmic game theory, as well as in approximation algorithms, randomized algorithms, and parallel algorithms.

In 2001, I had a pleasure to work with Berthold on his first project in algorithmic game theory. In 1999, in one of the papers founding the area of algorithmic game theory, Koutsoupias and Papadimitriou (STACS'1999) initiated the study of the price anarchy (or the coordination ratio, as it was called back then), which is the ratio of the cost in the worst-case Nash equilibrium to the optimal cost in a game. The central question asked by Koutsoupias and Papadimitriou was about the price of anarchy in a selfish routing model, in which the goal is to route the traffic on parallel links with linear latency functions. Koutsoupias and Papadimitriou gave some partial results, which were later extended by Mavronicolas and Spirakis (STOC'2001), leading to a conjecture that the price of anarchy for such games is $\Theta\left(\frac{\log m}{\log \log m}\right)$, where m is the number of parallel links. We saw this problem as an instance of a special (“selfish”) process of allocating weighted balls into bins, the area we both have had good expertise in (partially thanks to the beautiful paper of Berthold about the Always-go-left protocol, FOCS'1999). After not so long work (including a few days in Greece, where we both were enjoying great weather, local beaches, and STOC, ICALP, and SPAA conferences, and where after returning back home, Berthold wrote me — in loose translation — “*I’ve been thinking too much about the coordination ratio, so that I missed my plane ;-(*”) we have resolved the conjecture, with a very elegant and also a very short proof. Oddly enough, we thought that our proof is too short and too simple to be well published, and so we decided to work on the extension of the original conjecture. This resulted in a SODA'2002 paper, where we gave tight bounds for the price of anarchy for various models of selfish routing in the model on parallel links with linear latency functions. Yes, the price of anarchy for links with identical speeds is $\Gamma^{(-1)}(m) + \Theta(1) = \frac{\log m}{\log \log m}(1 + o(1))$, but if we allow the links to have different speeds, then the price of anarchy is $\Theta\left(\frac{\log m}{\log \log \log m}\right)$. Over three hundred citations in Google Scholar and counting; not bad for a “simple” paper, and our first paper in the area.

After this very positive first experience, we got attracted to the area and started working on further extensions and explored related problems. With Piotr Krysta (STOC'2002), we studied the price of selfish routing for various general families of cost functions in networks, and with Rene Beier and Piotr Krysta (SODA'2004), we analyzed the complexity of computing equilibria in service-provider games. Berthold, as a more persistent soul, continued this path of research to become one of the international leaders of the area of algorithmic game theory. In the following years, he has published many strong and influential papers in this area, including several best papers in leading conferences, EC and ICALP, he has organized a recent conference on markets and auctions in Dagstuhl (which he could not attend because of his poor health) and chaired the recent SAGT conference in Aachen. He was an inspiring teacher and he trained many students and young academics, showing them the meaning of excellent research.

To me and to many of colleagues and friends, we will remember him not only for his great research, but also for his enthusiasm, his leadership, the influence he has been spreading around. A very good friend will be sadly missed.

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Berthold was a brilliant researcher, over the years he did excellent and impressive fundamental work on many aspects of the theory of computing. His contributions to randomized and networking algorithms, smoothed analysis, and algorithmic game theory are seminal, and many of his papers are beautifully written.

What I liked most about him was his open and humble personality. When I came to Aachen as a postdoc in 2007, he had formed an impressive group. Somehow he always attracted the best students, and under his mentorship they developed into excellent scientists. He managed to maintain a great environment, very dedicated and collaborative. It sure was a great pleasure to work there.

Berthold liked the sweet things in life – on one occasion he came to pick me up at my place. He rang the bell, and when I came down I saw him stepping out of the small shop on the ground floor of my house – with a large bag of sweets he had just bought. With a smile he told me that such a kiosk in his house would be “the worst thing ever”.

It was a shock when he first told us about his illness, but over time one got used to it. After about a year he was “back to normal”, and we were concerned about the usual aspects of academic life - students and teaching, administration and organization, and, of course, solving problems and writing papers - the things he loved to do. On very rare occasions, it became clear that aspects other than science had started to play a larger role in his life, such as settling down and building a home with his wife and son. And even though it became apparent that his health had taken a turn for the worse the months before SAGT '13, I did not accept the possibility that he would be gone until it happened soon after.

Personally, I cherish the time we had and value the many things I learned from him. Moreover, Berthold will continue to inspire future generations of students and researchers through his great contributions to our field.

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I first met Berthold at the Max Planck Institute for Informatics in Saarbrücken. He became a post-doc at this institute while I was finishing my PhD study there. It was the year 2000, just after the famous paper of Koutsoupias and Papadimitriou about price of anarchy was published. Inspired by this paper, we decided together to enter the area of algorithmic game theory. We began our long enjoyable relationship as research collaborators and friends.

After we split geographically, Berthold settling in Aachen and myself eventually in Liverpool, we continued our collaboration through many mutual visits. These meetings were full of endless research debates intertwined with discussing non-scientific and personal subjects. We were often talking about life, marriage and family, sharing our experiences. It was wonderful to witness Berthold's excitement when he spoke about his marriage and later his son Jakob. It was a lot of fun watching Berthold's film with Jakob crawling on the floor with his beaming smile. We had a memorable walk during the ISMP conference in Berlin in 2012 with a long such chat and Berthold (as always) avoiding the camera.

Berthold was a great scientist with exceptional mathematical intuition. He made seminal contributions in several areas of theoretical computer science. His impressive list of results covered analysis of routing protocols in networks, average and smoothed case analyses of optimisation problems, algorithmic game theory and mechanism design, online algorithms and optimisation problems in wireless networks. His favourite set of tools was probabilistic analysis, but his expertise was very broad.

Berthold helped shape my research tastes and taught me much of his understanding of probability and randomness. Our joint research focused on algorithmic game theory and especially on mechanism design. He was a great mentor too, convincing me to apply for the fantastic Emmy Noether Fellowship of the German Research Foundation, which funded my research for many years. I was always struck by Berthold's modesty about his academic work and admired his braveness throughout his long illness. He will be sadly missed.

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Berthold Vöcking passed away in June 2014, after a long struggle with leukemia. Many of you know him as an excellent scientist, a leading expert in areas like approximation and online algorithms, algorithmic game theory and mechanism design, randomized algorithms and probabilistic analysis, and algorithms for graphs and interconnection networks.

Berthold obtained his PhD degree in my research group in Paderborn in 1998. He then joined the theory group headed by Richard Karp at the International Computer Science Institute in Berkeley, stayed as visiting assistant professor at the University of Massachusetts (UMASS) at Amherst, and was a member of the Algorithms and Complexity group of Kurt Mehlhorn at the Max-Planck-Institute für Informatik (MPII) in Saarbrücken. In 2002, he joined Dortmund University as an associate professor, before he became full professor in the CS department at RWTH Aachen University in 2004.

I met Berthold first in 1994, when he was a student in my course on parallel algorithms. After the course, he came into my office and complained that he has solved an open problem I had posed in a lecture, by the teaching assistant did not

believe him. This was the first of his deep results, namely the growing rank protocol for oblivious routing in arbitrary networks along shortest paths. It was the topic of his great master thesis and was later published in the *Journal of Algorithms*. Already as a PhD student, his creativity, his impressive algorithmic and mathematical skills, and especially his great taste for interesting research problems became visible.

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My first encounter with Berthold was in the winter semester 2002/03. At that time he was a newly appointed professor at the University of Dortmund and I was a third-year student attending his first lecture on randomized algorithms. I was curious to get to know the new professor on whose website there was a photo of him sitting on the roof of a big old American car. In this lecture Berthold presented some highlights of his research, including the smoothed analysis of the knapsack problem and the analysis of the Always-Go-Left algorithm for load balancing. The lecture was a lot of fun and after the semester I was determined to write my diploma thesis with Berthold.

I was not only impressed by the results but also by Berthold's intuitive and elegant way to solve problems. One exercise that occurred in the lecture is the following: Let n points be placed independently and uniformly at random on a circle of circumference one. What is the expected length of the interval that contains twelve o'clock? While I mindlessly calculated some integrals, Berthold obtained the correct answer, $2/(n + 1)$, right away without any calculation. (I don't know if this exercise is originally from him but it excellently illustrates his way of solving problems.) Also later when reading one of Berthold's articles or when we worked together on some problem, I admired his way of doing research. He almost never scribbled complicated formulas or arguments on the whiteboard but he solved most problems by some brilliant insight that was easy to understand but extremely hard to find without his amount of intuition.

In October 2004 Berthold moved to RWTH Aachen and I became a PhD student in his research group. I had a great and very productive time there and Berthold was the perfect advisor. He always took time to talk about research (and other things) and I could always count on his guidance while he left me a lot of freedom at the same time. The collaborative atmosphere he created in his group was exceptional. Now that I can better estimate how busy he must have been at that time with other responsibilities, I am even more thankful that he took so much time to intensively work together and guide his students.

We always stayed in contact after I left RWTH Aachen and Berthold was not only my PhD advisor but he had also become a good friend. I miss his modest and

humorous personality and his thoughtful advice. His death is a great loss to his family, his friends, and the scientific community.

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1.1 Of Cats and Cars (How Cat Litter Got Us Back on Track)

Berthold was an outstanding scientist, who was not afraid to work on important and difficult questions until he could answer them fully. But above all, he had a remarkable and very likable personality. What is less known is that he was the proud owner and driver of a series of interesting cars.

I got to know Berthold during our studies in Paderborn, first as undergraduates and later as PhD students. Initially, he drove a Seat Marbella which he affectionately called “Kartoffelkiste” (“potato box”). Even if you do not remember the model, which was discontinued in 1998, this nickname tells you everything you need to know about the car: It was a small, rectangular box on four tiny wheels. It was always a remarkable sight when the “potato box” arrived, the door opened, and Berthold unfolded to his full size while emerging from the driver’s seat.

Berthold and I worked together extensively during his PhD from 1995 to 1998. On the side, we established the tradition of meeting up during the Christmas break in order to spend a few days on the development of a fun and imaginative business plan for a startup company. As a running joke, we kept saying that we should do something with cats, because, in the future, they surely would rule the Internet. As it turns out, we weren’t completely wrong, although we were actually more thinking about cat food and litter.

Every year, we submitted our business plan to a different competition for entrepreneurs of which there were many at the time. The submissions were thoroughly evaluated and compared to the elite of the entrepreneurial scene. Clearly, we should have had no chance. But surprisingly – or frighteningly – this wasn’t the case. We always finished close to the top.

Back to the cars. Berthold drove a Cadillac Coupe De Ville during his time as a postdoc in Berkeley. This was in 1999. The car offered plenty of space and a lot of plush. The seats resembled lounge chairs that were erroneously installed in a car. This appealing interior, in combination with the brand Cadillac, made the car popular among “The Honored Society” (at least Hollywood suggests this). A chauffeur, also responsible for daily maintenance, would have been necessary since even experts didn’t seem to be up to the task. After changing a light bulb in the headlights – a lot of parts need to be removed to be able to access it – in an unauthorized garage, Berthold was floating in the 5000 lbs vehicle through the steep streets of San Francisco, without fully functional breaks. We managed, nevertheless, to successfully complete a Traveling Salesperson Tour given by the most popular landmarks of California. We

enjoyed the Cadillac to its fullest. The view from the stable roof of the car was breathtaking and on the road and at our various stops, the classic cruiser brought us respect and, at times, more attention than we would have liked.

I visited Berthold during the winter, in the beginning of 2000, when he was a visiting professor at the University of Massachusetts Amherst. For his time there, he had bought a Subaru Legacy. In this region, the winter can be harsh and the Subaru, with its four wheel drive, seemed to be ideal for the masses of snow. However, the car salesman, who had sold Berthold the car, was certainly not ideal. One should have taken note when the rear wiper didn't work and Berthold realized that the wiper motor – a valuable spare part – was simply missing.

The situation got worse when we heard unsettling noises from the tires. Since we had been planing a sight-seeing tour for the next days, we needed to find a solution fast. The spare tire – a valuable spare part – was, of course, missing. Fortunately, Berthold was living in the house of a professor who was spending a semester in Europe. Another Subaru Legacy was sitting in the garage of the house but we were lacking a key to the locked car. Instead of borrowing the car, we decided to borrow one tire and intended to switch it out with the tires from Berthold's car, one by one, testing after each one, whether the sounds we noticed earlier were gone. Only having a single car-jack, we needed to prop the locked car with the missing tire up somehow. At nightfall, the search for a suitable object for the task began. Finally, our experience with cat startups came in handy and a few cat litter bags replaced the missing tire. Naturally, switching the first three tires didn't improve the noises in any way, but when we started to switch the last tire, we realized what the problem was: It was so worn out that its entire metal mesh was exposed. A new tire – a valuable spare part – was desperately needed. No sooner said than done and the next morning, we started our tour through a snow-covered Massachusetts. The cats had, once again, served us well.

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