On a journey of discovery in the digital world

He was one of the first computer science students in Germany. Today, **Kurt Mehlhorn**, Director at the **Max Planck Institute for Informatics** in Saarbruecken, can look back on the many problems he has solved – with solutions that are also applicable to navigation systems and search engines. At least as important to him, however, are the numerous academic careers that began in his group. And he still has ideas for new research projects.

TEXT **TIM SCHROEDER**

If you talk to people who work with Kurt Mehlhorn, there is one word they are bound to use: relaxed. They will also tell you that he never greets new colleagues or employees with the formal German "Sie", instead simply saying "Hi, I'm Kurt." Every day at twelve o'clock sharp, Kurt Mehlhorn heads to the cafeteria for lunch with his working group. He greets people to his left and right as he climbs the stairs, exchanging a few words with closer acquaintances. "I just really enjoy living in an environment that works well," he says.

Kurt Mehlhorn cares about the people he works with – and has quite clearly kept his feet on the ground despite the numerous accolades he has accumulated over his lifetime. He belongs to the first generation of German computer scientists, who learned the subject from scratch. In 1968, computer science was introduced as a field of study at six of the country's universities, and Kurt Mehlhorn was among the first students to register for the subject at the Technical University of Munich (TUM). At that time, computer science was a new world that was aching to be explored. The first students at TUM studied under Friedrich Ludwig Bauer, one of the pioneers of German computer science. "He made us realize that computer science was an exciting new world and that we were all a bit like Columbus," says Mehlhorn.

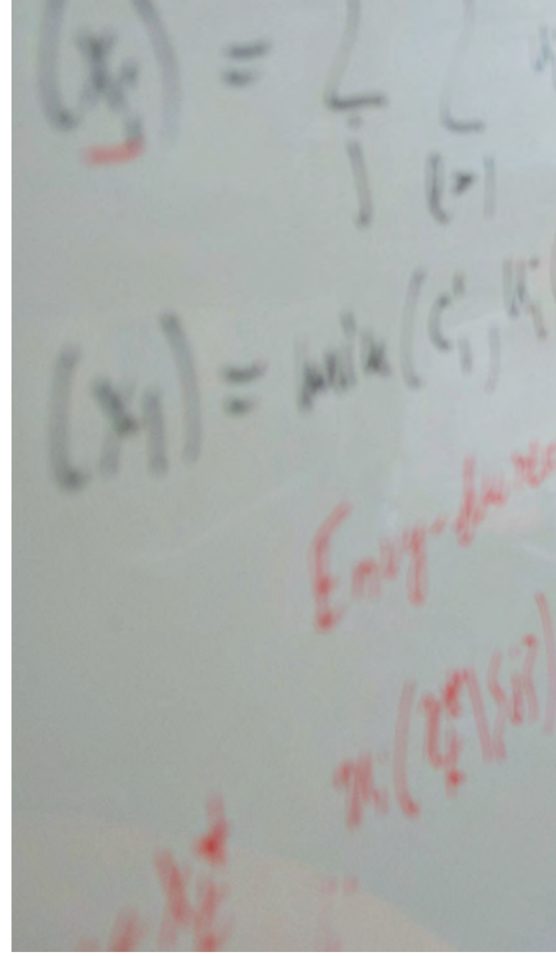
AIMING FOR BETTER INTELLIGENCE AMPLIFIERS

Today, 50 years on, computer science encompasses countless fields and niche areas and has millions of applications – it is thanks to computer science that we can shop for shoes online, find our way using a satnav, and send WhatsApp messages. Over the years, however, Kurt Mehlhorn has remained faithful to the aspect of computer science that always fascinated him the most: the mathematical side. "In the first ten years, all I needed for my work was a pencil and paper," he laughs, "and even now, many a working day results in nothing more than a full wastepaper basket."

Math and computer science deal in truths, he says. You can derive proofs and thereby clarify, once and for all, that something is the way it is. Though he has enjoyed math since his school days, computer science eventually became his subject of choice: "Because math is about taking a purely structural approach and explaining principles. In computer science, I can develop solutions that allow people to do something new. Here, mathematical proofs can be put to direct use – to create new methods and better or more reliable computing processes." For him, computers are amplifiers of intelligence, just as other machines are amplifiers of forces – and his aim has always been to improve these intelligence amplifiers.

Kurt Mehlhorn has been Director at the Max Planck Institute for Informatics in Saarbruecken since 1990 and served as Vice President of the Max Planck Society between 2002 and 2008. >

A passionate computer scientist and cyclist: Kurt Mehlhorn always cycles to his Institute – and he's recently started using an e-bike.



A troubleshooter: Kurt Mehlhorn believes it is important to support his members of staff, one of whom is doctoral student Bhaskar Ray Chaudhury. He therefore takes the time to discuss their research projects whenever possible.

He is considered one of the world's leading theorists. However, when it comes to the question of his lifelong contribution to computer science, the first thing that enters his mind are not his specialist articles or books, but rather the people he has accompanied on their academic careers. "I've supervised some 80 doctoral students and about as many postdocs – and many of them now have really good jobs all over the world." Apparently, many of his former students are now professors themselves, including at every computer science department of the Indian Institutes of Technology, for example.

CHARACTER-BUILDING: TEAM SPIRIT THANKS TO ROWING

On the way back from the cafeteria, Kurt Mehlhorn greets a young Asian student who is standing in the corridor outside his office. Taken aback, he asks: "Are you waiting for me? We didn't have an appointment, did we?" – "No, it's okay, I'm waiting for something else." The young woman is one of the new postdocs in his working group. In her home country, South Korea, she studied under computer scientists who had in turn been supervised by computer scientists who had studied under Kurt Mehlhorn's former doctoral students. "That's great," says the scientist. "Let me check my sums. Yes, you could actually say I'm her doctoral great-great-grandfather, so to speak."

It is no coincidence that the young people who began their research careers with him are so successful: "You have to give people challenging tasks and present them with interesting problems in order to hone their skills of perception." And perhaps a working group of this kind also requires a certain degree of team spirit, which Mehlhorn is good at nurturing – perhaps partly because it shaped him as a teenager back in his rowing days. "I was part of a rowing team until the age of 18. That's a really character-building sport, an extreme team sport if you will. You can only train together. If someone in the boat is missing, it doesn't work. And you need shared powers of endurance – you have to train a lot, for just a very small number of competitions." Perhaps it is the same sporting camaraderie that drives the people working in his team. While studying in Munich, Kurt Mehlhorn was one of the best students in his year group. After three years, a scholarship from the German Academic Exchange Service (DAAD) took him to Cornell University in Ithaca, U.S., where he went on to complete his PhD in 1974. He received an offer of an assistant professorship at Carnegie Mellon University, but his wife wanted to return to Germany instead. Mehlhorn therefore applied for assistant professorships at TUM and Saarland University in Saarbruecken.

He received a letter of acceptance from Saarland just a week later, but there was no word from Munich. "Today, you would make a quick call or send an email to enquire. In those days, however, phone calls were so expensive that it didn't even enter my mind to contact Munich and follow up." After five weeks of radio silence from Munich, Kurt Mehlhorn accepted the offer from Saarland University. It was not until a few months later that he found out what the problem was at TUM: the secretary had forgotten to put an airmail stamp on the acceptance letter for the position of research assistant in Munich, and so the good news from Bavaria was condemned to several weeks on a ship. "Sometimes these

Photo: Tom Pingel

things happen, and that's how I ended up in Saarbruecken," says Mehlhorn.

At Saarland University, he started working with the pioneering computer scientist Guenter Hotz, who held the university's first professorship in computer science. In September 1974, Hotz took Mehlhorn to a meeting of international computer scientists at the prestigious conference center in Oberwolfach, which was a customary meeting place for mathematicians in those days. "Back then, the meeting played host to the great minds of the computer science world. I presented two of my papers, in which I had tackled current problems in computer science. The results went down very well," says Mehlhorn.

One of the topics was matrix multiplication, a classical method of linear algebra in which values from two tables are multiplied together. "The mathematician Volker Strassen had discovered that matrix multiplication could be sped up by performing intermediate subtractions, to put it in simple terms," says Kurt Mehlhorn. "Following on from this, I provided the mathematical proof that multiplication actually couldn't be sped up without subtraction." The astonishment in Oberwolfach was palpable.

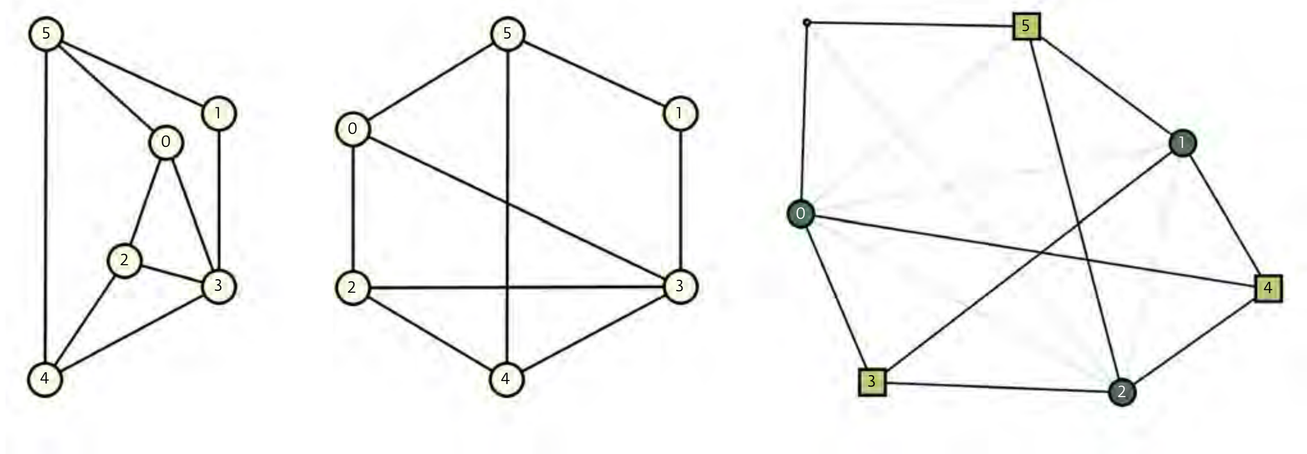
Mehlhorn suspects that his appearance in Oberwolfach might have contributed to his appointment as a professor a few months later, shortly before his 26th birthday. After the conference in Oberwolfach, he was offered a professorship at the University of Frankfurt and traveled there to attend the interview. It was then that Guenter Hotz made his move: he wanted to keep Kurt Mehlhorn and offered him a professorship in Saarbruecken. "As you officially needed to be 27 years old to become a professor in Saarland at the time, I then had to deputize myself in my own post for just over a year."

ALL ASPECTS OF THEORETICAL COMPUTER SCIENCE

At that time, the initial focuses of his theoretical work included search trees. Tools of this kind are used by computers to work their way through a data set, step by step and branch by branch. "It's a bit like a phone book, where you begin by searching for the first letter of a surname and then jump to the second letter, and the third, before finally narrowing the search down based on the first name," Mehlhorn explains.

At the time, the problem facing computer scientists was that the search appeared to become more and more complex the more changes and additions you made to the tree. It was as if the computer had to search a phone book in which entries were constantly being added or modified. "In Saarbruecken, we succeeded in developing a method that allowed the computer to perform the search with a consistent level of effort despite this problem." As search trees are needed in many applications, such as determining the shortest route between locations, Mehlhorn's method for the amortized analysis of search trees continues to be of fundamental importance today.

In the years he spent in Saarbruecken, Mehlhorn worked on all aspects of theoretical computer science and authored not only numerous specialist articles but also a three-volume textbook. The topics included searching in data sets, computational geometry, the analysis of graphs and the machine sorting of data – central processes that now play a key role in every computer and



every application of computer science. For example, the sorting and searching of data are part of the core functionality of search engines.

According to other present-day experts, one of Mehlhorn's greatest achievements is that he made the theoretical knowledge available in a practically useful form: together with his staff in Saarbruecken, he created a library of programming tools that allow computer scientists and engineers at today's companies and research facilities to write their own computer programs quickly and easily without always having to develop complex new software from the ground up. "Our idea was simply to pool our technical knowledge into this software platform and then offer it as a product," Mehlhorn explains. "And we thought we could easily finish the job in one year. We were wrong. In the end, it took us more than a decade, and back then the development process almost cost me my reputation."

PROGRAMMING WAS CONSIDERED MUNDANE WORK

To be precise, in the 1980s, programming was seen as somewhat mundane in the world of theoretical computer science. Writing software was dismissed as being intellectually nonchallenging. "People were surprised that I wanted to waste my time on the banalities of programming. Accordingly, I made a grandiose announcement in 1989 that we would have the tool finished within a few months," Kurt Mehlhorn recalls.

At first, everything seemed to be going well. The software worked – for example for calculating graphs. Graphs are made up of dots connected by lines, and these dots and lines are referred to as nodes and edges. You can imagine the graphs like cities on a map that you join up to plan the route for your next holiday, which is precisely how they are used by navigation systems. They are also used for surveying the surface of the Earth using drones.

Computer scientists differentiate between non-planar graphs, in which edges intersect no matter how the graph is drawn, and planar graphs, in which there are no points of intersection. Contrary to what the terms planar and non-planar might suggest, the question is not whether the body is flat or three-dimensional, but whether there are mathematical intersections in a plane. For numerous computer science applications, the question of whether graphs are planar or non-planar is of vital importance. Mehlhorn's team therefore developed an algorithm that can test graphs for planarity so that this could be included in the software library.

"However, a mathematician then sent us a graph with over 20,000 nodes, for which our software spat out an incorrect result. It was a disaster. My colleague Stefan Naeher came to me and said: 'Your master's student programmed it, so now you'll have to fix it.'" Mehlhorn spent a whole day looking for the error in the software – and he found it.

CERTIFYING ALGORITHMS WERE A KEY MILESTONE

However, he did not reprimand the student, because he now realized that the system had a fundamental weakness. It delivered results such as "is planar" but no information about the reliability of this result. "To make our software platform truly perfect, we needed a function that identified incorrect statements, an algorithm that checked the result itself." And so, the work continued.

It was worth it, because Mehlhorn and his team ultimately developed certifying algorithms that could check every result – a milestone not only for Mehlhorn but also for computer science in general. Now, for every non-planar graph, the program delivered an accompanying diagram showing the points of intersection. The software was now perfect. It performed complex calculations relating to planarity and other mathematical questions and, thanks to the certifying algorithms, also delivered instant quality control.

This meant that, in 1995, Mehlhorn and his colleagues Stefan Naeher and

Graphic: MPI for Informatics

Left-hand page With or without a point of intersection? Graphs made up of nodes (colored squares and circles) and lines, referred to as edges, feature in many computer science problems. However, the key question is often whether they are planar, meaning the edges do not cross (left), or non-planar, meaning there are intersections between the lines (center). The algorithm used in LEDA highlights a substructure (light-grey lines), proving that the graph is non-planar (right).

Right Analog computer science: Kurt Mehlhorn deliberates over many questions using a pen and paper, quite a lot of which ends up in the wastepaper basket.

Christian Uhrig were able to establish their own company, Algorithmic Solutions Software GmbH, which distributes the software under the name "LEDA" (Library of Efficient Data types and Algorithms). LEDA and the subsequent CGAL software library for geometric calculations are now used by numerous companies around the world – for example to analyze deformations in crash tests or to control sawbench conveyor belts. Here, a piece of software calculates in a matter of seconds how the machine needs to cut up the panels in order to remove knotholes while simultaneously minimizing waste.

In recognition of his development work, Kurt Mehlhorn had the exceptional honor of being elected to the National Academy of Sciences (NAS) in the U.S. as a Foreign Associate in 2015. The NAS is a community of scholars that only admits some two dozen researchers from abroad each year. Kurt Mehlhorn is one of only five computer scientists from outside the U.S. to be granted this honor. The NAS paid tribute not least to the development of LEDA as one of Mehlhorn's particularly important achievements. His research has also been honored with the Leibniz Prize, the Zuse Medal and numerous other awards. When he received the Beckurts Prize, he invested the prize money into his company.

In his office, however, there is nothing to be seen of these accolades. The

Photo: Tom Pingel

An explanation or a reference to a past hairstyle? At any rate, Kurt Mehlhorn delivers carefully prepared talks and lectures that are highly relatable to everyday life. One thing is for certain, however: his hair and beard were much more extravagant in the early 1980s than they are now.

only exception is a mortarboard on the windowsill, which he was given when he was awarded an honorary doctorate at the University of Gothenburg. “That’s something truly special. The cap is adjusted, heated and formed directly on the head – quite a lot of effort goes into it.” Next to the cap on the windowsill stand photos of his grandchildren and his three grown-up children, and there are also photos hanging on the walls and door. His daughter is artistically talented and creates figures that are somewhat reminiscent of *Nanas* by Niki de Saint Phalle. Two such figures stand on pillars beside the door, and one can even be seen on Mehlhorn’s website, adorning a book about LEDA.

A MODEL FOR THE MOLD’S ROUTE TO THE OAT FLAKE

Even though Kurt Mehlhorn has already achieved a great deal, the research work is ongoing. In his group, some 30 people are currently working on a variety of theoretical questions. While Mehlhorn doesn’t want to highlight a specific project, he does mention a worry he once had in relation to his research topics: “It must sound strange, but for years my only fear was that I would run out of ideas at some point.” He’s now been in the business for 50 years – and it hasn’t happened yet. “Probably because I keep my eyes open and am interested in lots of different things. Twice a week, we meet here in the Institute to discuss current topics.”

Sometimes, he also stumbles across something interesting purely by chance. In a TV program some time ago, he saw a report about an experiment by Japanese researchers. On a chip containing a network of channels, they had grown *Physarum polycephalum*, a mold that spreads by forming tentacle-like appendages. The idea was that, in the maze of pathways, the slime mold would find its way to a food source, in this case an oat flake. In the experiment, it only took a few hours for the fungus to find the shortest route to the food source. The appendage on this express route became thicker, while the fungus withdrew itself from the other routes. “The search for the shortest route is an age-old topic in computer science,” says Mehlhorn. “For a mathematical model relating to the development of the fungus, we demonstrated that it always finds the shortest path.”

Kurt Mehlhorn is undoubtedly a key figure in the history of German computer science and, as he says, he is the most senior professor of “real” computer science in Germany. Nevertheless, he has clearly never adopted any airs or graces. For years, he has traveled to work by bicycle or – weather and fitness permitting – by racing bike, touring bike, mountain bike or, most recently, e-bike. People say the special thing about Kurt Mehlhorn is that he can relate to people and hasn’t lost touch with the real world. Mehlhorn also endeavors to connect with his students when he is giving lectures – using examples from everyday life or stories about search engines or satnavs. He says he puts a great deal of work into his lectures, because they need to be prepared perfectly in order to get the message across to the students. “I also speak freely, without a script – that’s important for building a good rapport. I often hear it said that I express myself in a way that’s easy to understand. And, ultimately, that’s also how I bring in talented young people” – people who are inclined to join the working group and carry on its research long into the future. ◂

GLOSSARY

Algorithm: A detailed calculation rule used – by computers, for example – to solve a problem step by step.

Graph: In graph theory, an abstract structure of nodes and edges. Examples include family trees and network maps of underground railways. These are not to be confused with graphs of mathematical functions, which plot output values against their corresponding input values.

Photos: Tom Pingel (left), own collection (right)

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