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The electric supply needs actively engaged customers

Could we as consumers actually make the future electricity grid more stable? A research team headed by Rolf Egert and Max Mühlhäuser is working on exactly this kind of vision.

— By Boris Hänßler

Power outages are a rare phenomenon in Germany but this could all soon change: Extreme weather conditions – such as those that recently caused blackouts in North America – are also being seen more and more often here and are pushing our comparatively robust grid to its limits. Our infrastructure is also under threat from cyberattacks and physical attacks. Several homes in Munich were recently left without electricity for two days following an arson attack. Although the continental networking of energy supply systems can help balance out differences in supply and demand, it can also lead to a snowball effect – for example, a small issue in Croatia caused a power cut across large parts of Southern Europe as recently as January this year. And last but not least, large power plants are being replaced by numerous small photovoltaic and wind power plants. This decentralised and increasingly smart grid, however, bears stability risks.

How can we develop a resilient smart grid against this background? Research groups at TU Darmstadt are examining precisely this question. A team headed by Professor Max Mühlhäuser in the Department of Computer Sciences is, for example, developing algorithms that split the smart grid into viable islands in the event of a power outage. These islands would then automatically reunite again as soon as possible. Rolf Egert, doctoral candidate and head of the group “Smart Protection in Infrastructures and Networks” (SPIN) wants to integrate consumers into the process to a much greater extent: “We need their cooperation in order to develop a robust electricity grid – and not just as investors in renewable energy”. Egert is focussing above all on private households. “They are responsible for around one quarter of the electricity consumed in Germany – and the proportion of them who are also electricity producers is growing at the same time”, he says.

Egert, Mühlhäuser and other researchers have published a vision paper that was preceded by a

scientific survey of private citizens. The aim was to gain an initial impression of how aware customers are about existing problems and how willing they are to play their part. If there is a power cut on the national grid in the future, the researchers anticipate that, for example, solar power plants, wind power plants and batteries will still be able to supply some electricity decentrally but demand will typically exceed supply. In the event of an extreme shortage in supply, the local operator is currently forced to intervene, leaving some streets with a full supply of electricity while shutting off the supply to others – and potentially also shutting down vital equipment and local energy producers.

In a smart grid, the households who draw electricity should be able to decide which devices remain switched on and which are turned off. This creates a complex problem: How can a fluctuating supply satisfy the various needs of different people?

“We believe that the key lies in whether people have sufficient knowledge about the current electricity grid and the potential of the smart grid”.

In general, consumers could allow their devices to be switched on and off remotely. If there were a supply shortage, the grid operators would switch off, for example, any heat pumps or water boilers. This idea horrifies many people because of the fear that their energy provider would, for instance, suddenly switch off the warm water while they are taking a shower. Therefore, it would be much more sensible for consumers to actively get involved with the smart grid.

The team headed by Egert is developing a prototypical framework that can intelligently network local resources. This requires them to overcome numerous challenges – many things that work successfully in industrial companies cannot simply be transferred to private households. It is also important to take the preferences of each household into account. “As a private citizen, I can then define which devices can be switched off and at what times”, says Egert. “For example, I can permit my air conditioning system to be switched off on workdays for up to five hours when I am not at home”. Machine learning can be used to help understand the habits of electricity customers and then make appropriate recommendations. But this also requires people to engage with the subject matter and make decisions.

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Photo: Katrin Birmer

In addition, it is important to prevent antisocial behaviour. Some individuals could fool the system by pretending that they have high priority needs, thus ensuring that their local neighbourhood is hit even harder. How can people be motivated to make a positive contribution instead? “It seems reasonable to believe that people would respond to a reduced electricity bill or financial incentives”, says Egert, who is working together with experts from the field of psychology. “However, this type of extrinsic motivation usually only works in the short term”. Even ideas such as simply visualising consumption data, as is possible on some smart meters, or green electricity suppliers providing the customer with information on how much CO₂ has been saved are not sufficient – both of these things are too abstract. “People would be much more motivated if they knew precisely what could be achieved through their engagement”, says Egert. “For example, they could be informed that by sacrificing their own comfort, it will be possible to continue supplying the local school with electricity.”

This approach could be combined with nudging. Nudging is effective in many different sectors: It is already known, for example, that people will impulsively buy sweets in a supermarket if they are placed near to the cash till. If healthier dishes are placed in the same location, they are also purchased more frequently instead. Nudging has also proved to be helpful when users are asked to define a password on the Internet – some websites indicate how secure the selected password is while it is being entered by the user. Similar techniques could be used to highlight the consequences of the decisions customers make about their energy consumption. Another possible option is so-called gamification which utilizes

principles found in video games: A consumer receives points for adapting their electricity consumption and they can then look to see where they stand in the local rankings – anonymously – with respect to their neighbours.

It is important for electricity suppliers to have a clear overview of not only their active customers and their preferences but also the possible costs of offering different supply tariffs and where possible negotiated feed-in remuneration for households that produce electricity. Operators must be able to quickly decide which resources they can utilize in the event of a shortage or surplus of supply. The framework conditions can be technically complex. For example, it is not advisable to always switch the same devices on and off because they could wear out more quickly. The physical proximity of consumers to the source of the power cut is also sometimes decisive.

However, the biggest challenge is generating awareness about a resilient energy grid. “We believe that the key lies in whether people have sufficient knowledge about the current electricity grid and the potential of the smart grid”, says Egert. More knowledge creates a greater affinity for energy-related themes and motivates people to switch between their dual roles of consumer and producer. “Actively engaged consumers are also more receptive to the energy transition – and the more of them there are, the quicker the political decision-making process and the transfer of technology will tend to be”. Both of these things are indispensable for the resilience of the grid.

The author is a technology journalist.

Professor Max Mühlhäuser and his doctoral candidate Rolf Egert are developing the foundations for a smart grid that will be able to distribute electricity much better under fluctuating conditions.

Publication:

“Exploring energy grid resilience: The impact of data, prosumer awareness, and action”, Rolf Egert, Jörg Daubert, Stephen Marsh, Max Mühlhäuser. *Patterns*, Vol. 2, Issue 6, 100258, June 11, 2021 (Open Access)

Architectural calling cards abroad

Embassy buildings are both political symbols and social expressions of their era. The architect and art historian Dr.-Ing. Christiane Fülischer has analysed and compared German embassies and consulates abroad.

Mrs. Fülischer, embassy buildings are considered “architectural calling cards”. What significance do they have for foreign policy?

States use new buildings for diplomatic missions to present a certain image and transfer their own specific concept of society. The main question in said representation is how a country wishes to be perceived abroad. Architecture is a key tool in this context. In contrast to other state buildings, new foreign embassies are the result of highly complex diplomatic processes. Political messages are not only communicated by the presence and size of the building itself but also by the buildings’ ability to humbly integrate into the scenery and local context of the host country. This can also be influenced by the choice of materials or through specific architectural forms.

You primarily focus in your dissertation on the history of the diplomatic missions of both German states between 1949 and 1972. What was the situation in the post-war period?

Since the establishment of the Federal Republic of Germany (FRG) and the German Democratic Republic (GDR) in 1949, it had been the occupying powers that decided how these two countries would develop their external relationships with other countries. After it was given full sovereignty in 1955, the FRG gained greater independence towards its foreign policies. Although the GDR had already been permitted the establishment of a foreign office in 1949, it had not been accompanied by any real decision-making authority. Overall, the reconstruction of the state and society and its representations abroad after the Second World War were associated with architecture that demonstrated their political commitment to the respective occupying power.

How did this present itself in the embassy buildings?

A good example is the building project of the GDR embassy in Warsaw. The first design was clearly based on guidelines issued by the USSR. Inspiration had been taken from the Soviet embassy in Berlin. The plans involved the construction of a three-wing building in a prominent position in the city – essentially a form of palace architecture for the working classes in the style of socialist realism. However, even though Moscow adopted a more functional architectural language after the death of Stalin, this major project was never realised due to political and

financial reasons. Despite some references to Western examples, the embassy project in Budapest was also meant to reflect the socialist ideal by making use of architecture. This was achieved by emphasising the artistic features and dispensing any standard hierarchies: for instance a ground-level entrance without any stairs, a rather unprestigious ambassador’s residence, and building extensions for apartments and social facilities.

Did the GDR use its embassy buildings to further its foreign policy goals?

For certain. This can be clearly seen in the trade mission that was built in Helsinki in the middle of the 1960s. Finland was neutral and therefore granted privileges to the trade missions from both German states that were usually reserved for diplomatic missions. The GDR purposely commissioned a local architect to produce a design that would attract international recognition. With this project, the East German state abandoned its aim of reflecting socialism in architecture and instead based the building completely on US embassies. In the struggle for international recognition, the building was supposed to reflect GDR on an equal footing as a German state with the FRG. The West German state, in response, observed this project with extreme suspicion.

What was the development in the Federal Republic of Germany?

In contrast to the GDR, the Federal Republic of Germany soon had a much larger operating radius. It still struck the Government as important, however, to be initially represented in a more reserved manner towards western countries. The first embassies were thus highly inspired – both in their architecture and facilities – by the three-storey elongated buildings of the US general consulates that had been constructed in the Federal Republic of Germany from 1952 onwards. In the 1960s, the embassy buildings started to reflect the country’s growing self-confidence as it grew to be increasingly accepted by the western community. The architects were able to add individual accents, which lead to the development of two different tendencies: the organic approach in which the building formed a harmonious whole with its surroundings, such as the embassy in Vienna, and the stringent functionalist approach that was reflected in the chancellery of the embassy in Washington.

Information

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The embassy built by the FRG in the newly created diplomatic district in Brasilia marked a major turning point.

That's right. The Federal Republic of Germany was one of the first countries to move its embassy from Rio de Janeiro to the newly established capital city in the centre of Brazil. This meant that the architect Hans Scharoun was not compelled to integrate the building into an established group of diplomatic missions and had much greater freedom in his design. He chose to let the building rise vividly from the landscape and to merge the chancellery and ambassador's residence in order to form a unified architectural design. Scharoun's design had a decisive influence on the representative buildings constructed abroad by the FRG

Did the East-West conflict influence the building projects?

In the Cold War, the rivalry between the competing systems was present in the field of architecture as well. The so-called "Hallstein doctrine" from 1955 dominated everything. It was enacted by the Federal Republic of Germany after it established a second German embassy in Moscow. The doctrine served as a warning that the Federal Republic of Germany would break off diplomatic relations to other states as soon as these would start negotiating with the GDR. This meant that the GDR could only send ambassadors and engage on an international stage to socialist or communist states. The Federal Republic of Germany was often the more attractive partner for neutral countries such as the former colonial states.

What changes did the Basic Treaty in 1972 bring about?

The Federal Republic of Germany recognised the GDR as a sovereign state with the signing of the Basic Treaty. This ended the international isolation of the GDR and opened diplomatic relations with 73 states over the following two years. Nevertheless, the GDR only planned and built about a dozen new buildings for diplomatic missions after 1972. Its freedom of action still remained limited.

What happened after 1989?

That is a very sensitive subject. The GDR had already withdrawn its diplomats before reunification and abandoned its embassy buildings. This was primarily for financial reasons. Aside from a very few exceptions, such as the embassies in Sofia, Pjöngjang or Phnom Penh, the reunified Germany closed down the East German buildings and building projects. The embassy building in Helsinki was sold to the Ukraine and a new building was constructed. The embassy in Budapest was converted into an administration building and the one in Cairo was handed over to the Goethe Institute.

*The interview was conducted by Jutta Witte.
The author is a science writer and holds a doctorate in History.*

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In her dissertation, Christiane Fülischer reconstructs the origins of the German diplomatic missions abroad and classifies them according to their historical, political and institutional context for the first time. The resulting publication maps these building projects from the time of the German Empire and National Socialism through to the post reunification period. The main focus is placed on the period between 1949 and the signing of the Basic Treaty in 1972.

Book:

Christiane Fülischer: Deutsche Botschaften. Zwischen Anpassung und Abgrenzung (German Embassies. Between Adaptation and Distinction). Jovis-Verlag, 536 pages, ISBN 978-3-86859-652-6 (brochure), <https://doi.org/10.1515/9783868599640> (e-book)



Photo: Katrin Binner

Dr.-Ing. Christiane Fülischer teaches and conducts research on the theory and history of modern architecture in the Department of Architecture.

Using climbing gear to scale the mountains of mathematics

The mathematician Anton Freund from TU Darmstadt is founding a junior research group. He hopes that it will provide new creative impulses in Mathematical Logic.

— By Christian J. Meier

If the old cliché about mathematicians were true, the lack of contact during the coronavirus pandemic would barely have hindered the work of Dr. Anton Freund. Don't mathematicians usually just brood over tricky problems on their own? But it may be a surprise to learn that they also need close dialogue with their specialist colleagues. "It is unbelievably important", emphasises Freund, a researcher in the Logic Group at the Technical University of Darmstadt. This is because he believes that mathematics is a creative process that can only succeed if mathematicians work together.

Freund says that he has really missed his discussions with colleagues over the last few months. That's why he is particularly pleased about his successful application for funding from the Emmy Noether Programme at the German Research Foundation (DFG). It will allow the 31 year old mathematician to head his own junior research group. "The exchange of information and ideas in the group that I will head will be really amazing", says Freund enthusiastically. Even if a conversation may not lead to a solution directly, "it is very often the case that people have new ideas after a discussion". Freund is also looking forward to discussing his work with the students who attend his lectures, which he will hold from October 2021 onwards.

His specialist field of logic was already a fundamental tool for Aristotle. The ancient Greek philosopher asked himself how new discoveries could be derived using logical reasoning. It was Aristotle who defined the concept of inference through syllogism. Two premises such as "all men are mortal" and "Socrates is a man" can be used to derive a third statement, in this case "Socrates is mortal". These simple beginnings have been transformed into a highly complex logical structure over the centuries: mathematical logic.

Information

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The latter deals with mathematical proofs. Mathematicians use a few fundamental assumptions – known as axioms – to derive lots of new statements. One such axiom is for example: "Every natural number has a successor". "This method has proven to be a very powerful tool", explains Freund. Mathematicians explore further and further, like discoverers of a new continent, by constructing propositions out of axioms and finding new ways to combine them in order to build other propositions. In mathematical logic, these discoveries are analysed at a fundamental level. Logic thus creates a map of the continent of mathematics.

Anton Freund wants to further explore this mathematical landscape. When he describes the key questions behind his research, he starts to gesticulate and you can see the joyful anticipation of new, exciting insights on his face. "What mathematical axioms do I need to achieve which mathematical results?", is one question that he asks. Or: "Can I differentiate between mathematical results that are achieved with fewer axioms and others that require more axioms?"

Although mathematicians have already been exploring the landscape of their subject for many decades, it is a very diverse environment made up of rivers, mountains and forests. It is not as straightforward to forge into as many laypeople may imagine. The principle problem was identified by the Austrian-American mathematician Kurt Gödel 90 years ago. His incompleteness theorem says that mathematics as a whole can never be derived from one single set of axioms.

Therefore, there are multiple systems of axioms with which different areas of mathematics can be opened up. Described in pictures: Some summits can be reached with walking shoes, while others require climbing gear. Mathematical logicians like Freund investigate what is the minimum needed to achieve a certain goal. They try to make Gödel's general finding more concrete. The fact that this is at all possible with the help of logic is what fascinates Freund the most about his specialist subject.

Freund is investigating, for example, a theorem that can only be proven using a complex system of axioms. This means that it doesn't fit, so to speak, in its own natural environment in which things are easier to prove. "We do not yet know enough to be able to classify this graph minor theorem precisely", explains Freund. It can only be derived in any case from extraordinarily strong axioms. But how strong do they actually have to be? And what precisely can be proven with the graph minor theorem?



Anton Freund and his colleagues in the Logic Group are creating a map of the continent of mathematics.

Photo: Katrin Binner

“What we are doing is very abstract”, explains Freund. “However, it has links to practical applications”. The graph minor theorem helps computer scientists to, for example, decide whether certain complex algorithms will reach a result within an acceptable period of time or not. The findings of the researchers at TU Darmstadt may help to improve these methods.

Freund is thus following a long tradition of logic research at the Technical University of Darmstadt where there is a strong application-oriented focus, according to Ulrich Kohlenbach, who since 2004 has been the Professor of the Logic Group where Anton Freund works. “Darmstadt is one of the most renowned universities worldwide for proof theory”, says the mathematician. “We are known for applying mathematical logic to mathematical proofs and also to the area of computer science”. The roots of this work go back many decades. Pioneers in artificial intelligence – such as the computer scientist Wolfgang Bibel and the mathematician Rudolf Wille – worked in Darmstadt. According to Kohlenbach, the current Logic Group can be traced back, in particular, to Wille, who was a professor in Darmstadt from 1970, and to Klaus Keimel (who worked in Darmstadt from 1971).

There are also connections to the computer sciences in teaching, says Kohlenbach. “Logic-related lectures for the computer sciences at TU Darmstadt are traditionally held by mathematicians”. A third of the participants in the logic lectures are often computer science students. This may be the case in the lectures held by Anton Freund from this autumn onwards.

In addition, he will also supervise two doctoral students working on his research questions. “The opportunity to head a small team is something that is normally not possible at my career level”, says Freund excitedly. He hopes that the joint research will produce significant advances. “We want to combine two fields of research with one another”, explains the mathematician. “This is how we discover new methods for answering our most fundamental questions”, he says. Amongst other things, the research will also focus on the graph minor theorem mentioned above. Freund is looking forward to the group experience: “Although the doctoral students will be learning from me, they will also have the opportunity to contribute their own ideas”, says Freund. “The shared creative process will be extremely exciting”. Maybe the young researchers will even discover a whole new landscape on the continent of mathematics.

The author is a science writer and holds a doctorate in Physics.

Publication:

Anton Freund, Π^1_1 -comprehension as a well-ordering principle, *Advances in Mathematics* 355, 2019, article no. 106767, 65 pp., <https://doi.org/10.1016/j.aim.2019.106767>.

Emmy Noether Programme at the DFG:

https://www.dfg.de/en/research_funding/programmes/individual/emmy_noether/index.html

Switchable antibodies for cancer treatment

Tremendous hope is being placed on the use of therapeutic antibodies in cancer treatment. Researchers at the TU Darmstadt and Merck have found a way to activate antibodies only on the tumour itself. This prevents unwanted side effects in healthy tissue. The results of this research have been published in the journal "Frontiers in Immunology".

Antibodies have been used for decades, in particular in the treatment of numerous serious diseases. As recently as May 2021, the US Food and Drug Administration approved the hundredth antibody drug for clinical use.

Tailor-made antibodies are currently a great hope in the treatment of tumours. They specifically identify tumour cells and use them to recruit defence cells of the immune system that are able to detect and destroy tumour cells. These immune cells carry so-called Fc-gamma receptors on their surface that they use to identify therapeutic antibodies that are bound to the tumour cells. "However, this receptor-mediated interaction can also lead to unwanted side effects of the antibody's active ingredient and trigger an unwanted immune reaction in healthy tissue," explains Professor Harald Kolmar of the Applied Biochemistry working group at the Department of Chemistry, Technical University of Darmstadt. "The aim of our work was to find a way to temporarily block the immune stabilisation of the antibody and only activate it directly on the tumour. This novel technology is based on the targeted blockage of the antibody with a protein that sits on the antibody like a lid, which prevents it from interacting with the immune cells. Enzymes produced by the tumour cells can then cleave the protein lid and reactivate the antibody."

Above all, the principle should be suitable for general use and for use, in the same way, on most therapeutic antibodies in cancer treatment. In order to illustrate that this is possible, PhD student Adrian Elter applied the concept to two different therapeutic antibodies, that are approved for the treatment of breast cancer and leukaemia, respectively. "Using immune cells from blood donors, we were able to demonstrate that in both cases, the antibody is only activated after cleavage by the enzymes associated with the tumour, which means that a controllable drug with potentially reduced side effects is a possibility," Elter summarises the results of his doctoral thesis.

Information

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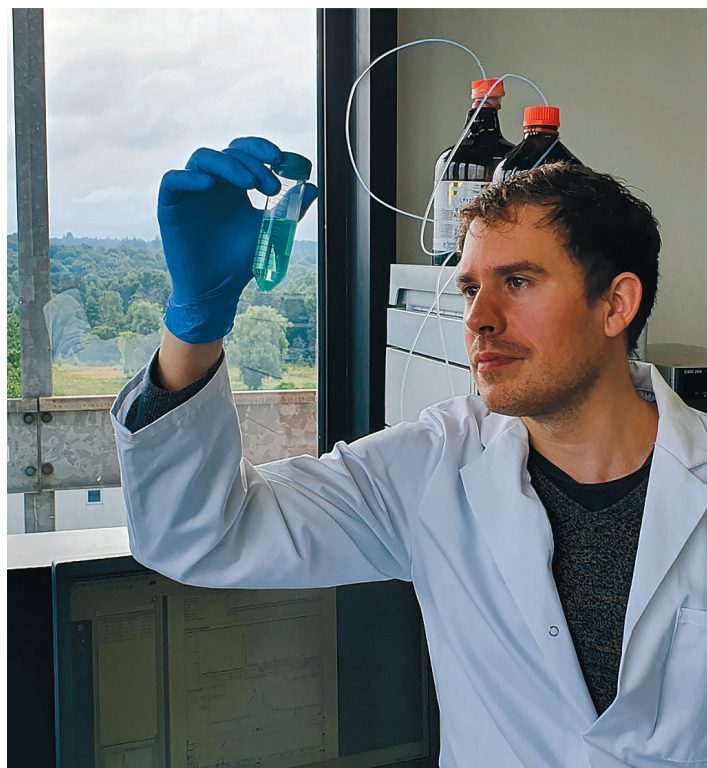


Photo: Olga Avrutina

D. student Adrian Elter is conducting research on therapeutic antibodies in Professor Harald Kolmar's research group.

The results of the strategic cooperation between the Technical University of Darmstadt and Merck have been published in the journal "Frontiers in Immunology". The idea for the project goes back to the "Merck Innovation Cup", for which students from all over the world are invited to a summer camp at Merck and develop their own ideas for a complete innovative project plan under the guidance of experienced Merck researchers.

"We are delighted" with the success of the ideas developed at the Merck Innovation Cup, which we have already been able to validate with great success several times in cooperation with Professor Kolmar of the TU Darmstadt," says Ulrich Betz, Vice President Innovation at Merck.

Working Group Applied Biochemistry/Silke Paradowski

Information

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