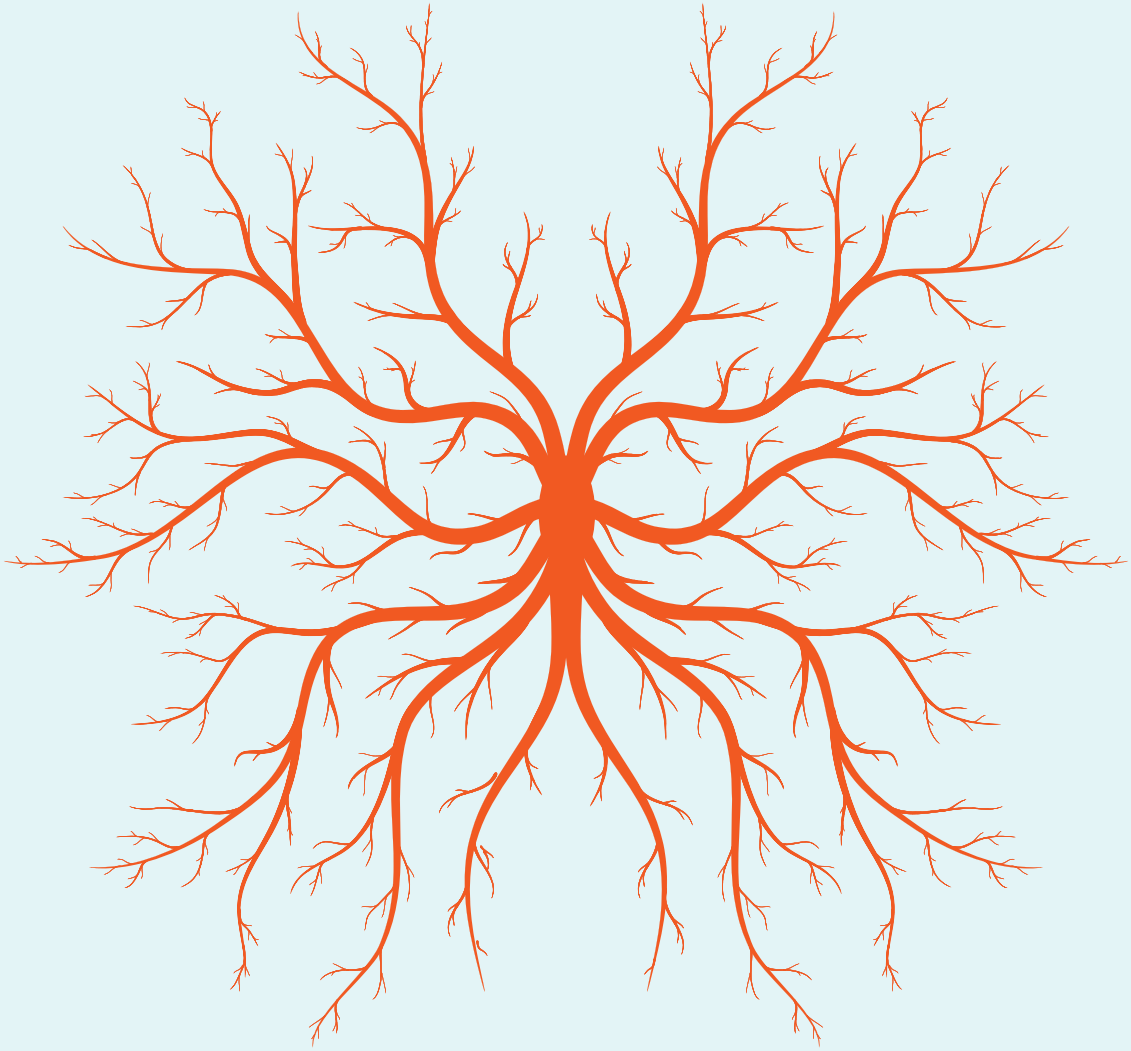
MAXWELL

Electrotechnische Vereeniging

Issue 23.4 | July 2020

Resilience



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Designing a Future with Electroids
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Planning for a Resilient Tomorrow

From the Board

President

By Joos Vrijdag

When Shea and I came together the first time as a potential board, I did not know Shea very well, but she did organise the Electrip where I was a participant. During company visits on that trip, I was very impressed with how professional she was towards the employees of those companies.

During the evenings of the Electrip, it was not always serious business and Shea proved that she was not only professional but also very fun to hang out with. That combination of fun and professionalism makes Shea a great president of the ETV.

As the president of our association, Shea Haggerty has quite a public function, so you might have seen her already. When you encounter her in the board room or the faculty, the first thing you'll see about Shea is that she is always very busy. Shea is constantly running around trying to help everyone, because she is very caring of the members, association and the rest of the board.

When she finally takes a break from sitting behind her computer and phone, Shea is actively trying to get to know all the members that come by in the board room. During the EOW she actually knew the names of all 80 present first year students within two days!

After two quarters of being on the ETV board with Shea, I think I can say that I know her a lot better now and I am glad that I do. Working together was a lot of fun and I am looking forward to another three quarters of being on board with Shea!

Treasurer

By Sam Aanhane

When I was first introduced to Max, the treasurer of the ETV, I instantly knew we would become good friends. Little did I know he would also turn out to be very capable. I would trust him enough to do my personal finances. Max is the oldest of our Board, which he intends to let everybody know for as little a reason as who gets the last piece of food. I, the second oldest, usually disagree with this. Hanging out with Max at parties is a lot of fun. Except for the part when you have to go home. For one, Max is not easily convinced to leave. On top of that, he is terrible company in the train because he always falls asleep and it becomes my responsibility to get the both of us in Delft. Then again, he always ensures that everybody has a good time and has provided me with plenty of opportunity to make fun of him for the things he does when he is bored. All jokes aside, Max is a great guy and I absolutely love him. I wouldn't have wished for anybody else to do a Board year with. He does his job well, along with having plenty of time to make jokes. Looking forward to a great year, both for the ETV and us as a group!

Colophon

Year 23, edition 4, July 2020

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Editorial

Dear readers,

Electrical Engineering is a constant developing field with wide impact on the society as a whole. A Transition within this field might as well lead to a significant change in society. For example, it is amazing that the rise of the smartphone and widespread mobile internet has only started 12 years ago, with the announcement of the iPhone 3G. Nowadays, it is almost unthinkable to live without for example WhatsApp.
Many more influential transitions are to come, in which Electrical Engineering plays a big role: Microwave transmission will find the consumer's hands with the upswing of 5G. The world will transition from fossil fuels to electrified systems. Fully-integrated microelectronics will allow new products. As always, backgrounds on these trends can be read about in the Maxwell.

In this second edition of the Maxwell this year, we have managed to include more scientific articles, while also trying to have interesting articles about the faculty and the Electrotechnische Vereeniging as well. For example, in the last few pages will, as always, be an overview of the past and upcoming activities. I hope that we succeeded in providing an interesting and enjoyable Maxwell for this quarter!

Happy reading!

Philip Mathew

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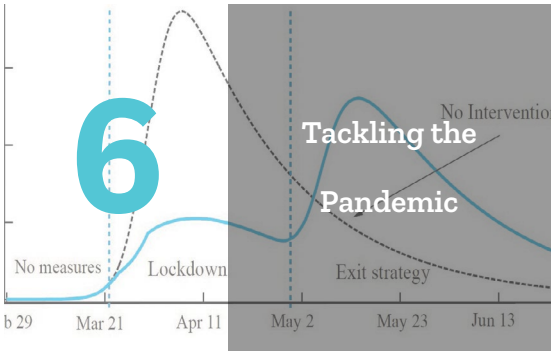

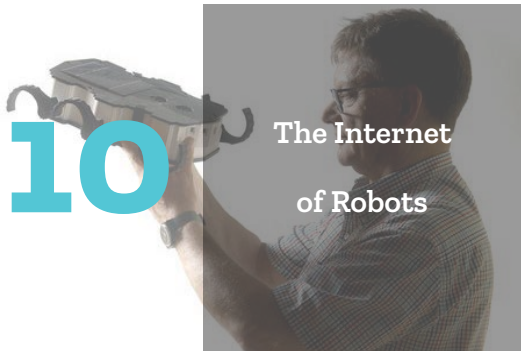

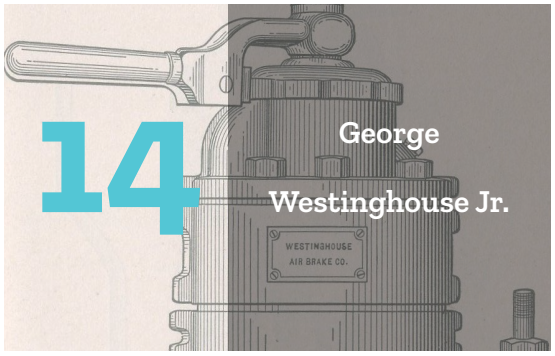

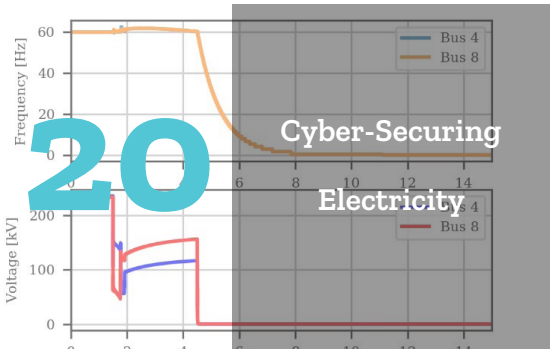

Tackling the Pandemic

The Tools, Techniques, and Technologies

M. A. Achterberg, Z. He, L. Ma, B. Prasse, M. Kitsak, S. Trajanovski, R. Kooij and P. V. Mieghem

In the beginning of December, the coronavirus SARS-CoV-2 emerged in Wuhan, the capital of the Chinese province Hubei, and caused the COVID-19 pandemic. The number of infected cases in Hubei grew dramatically fast, with approximately 80,000 conrmed cases by the end of February. Due to the large-scale interactions between the world's population, the question was not if, but when the coronavirus would appear in our small country. The rst case in The Netherlands was conrmed on February 27. Since then, the TUDelft NAS research group has been investigating the spread of the coronavirus, specically investigating the following two key questions: Can we predict the (local) spread of the coronavirus and What is the optimal strategy to lift the lock-down measures? Here, we briefly elaborate on our ndings.

Predicting the spread using networks

Infectious diseases, such as the coronavirus, are transmitted by coughing, sneezing or direct contact, like handshaking. Hence, the disease mainly spreads if people are close together, but can also be transferred via infected surfaces. The interaction between people can be described by a network, where nodes represent population groups and links specify the interaction strength between those groups. For modelling the spread of the coronavirus based on the available data, nodes represent all people in one province of The Netherlands. If the interaction strength between province i and province j is given by the element ij , then the contact network is characterized by the 12 12 infection probability transition matrix B.

An epidemic can be modelled mathematically by dividing the population into various compart- ments. We use the well-known S-I-R model, rst proposed in the famous paper of Kermack and McKendrick [1], where the Susceptible (S) people are healthy, but susceptible to the disease, the Infected (I) people are infectious, so they can infect the susceptible people and the Removed (R) people are either recovered, and assumed to be immune to the disease, or dead. For each node in the network, the total population N is assumed to be constant: S + I + R = N. For each province i we denote the removal rate by i. The twelve removal rates form the removal rate vector. Using the contact network B, the removal rate vector and the epidemic SIR model, we can compute the number of infected cases per province in The Netherlands. Unfortunately, the true contact network B is unknown and must be deduced from the reported infected cases. We have developed the Network Inference-based Prediction Algorithm (NIPA), which consists of two steps [2].

First, we estimate the contact rates between each province using the reported number of infected cases. Then we predict a small number of days ahead in time. The daily prediction for The Netherlands is shown on https://www.nas.ewi.tudelft.nl/index.php/coronavirus. The situation on 1st April in The Netherlands is exemplied in Figure 2. The input data for NIPA are the time series of the daily reported number of infected cases from February 27 (the start of the epidemic) and April 1 (prediction day) per province, which are provided by the Rijksinstituut voor Volksgezondheid en Milieu (RIVM) [3]. Using the infection data before April 1, the contact network B is reconstructed.

Then, the forecasts (red squares) in Figure 2 are obtained. The forecast is reasonably accurate for four days ahead, but tends to deviate signicantly afterwards.

Evaluating possible exit strategies

On March 23, Prime Minister Mark Rutte announced that The Netherlands is under an \intelligent lockdown" [4]. In contrast to a complete lockdown, people are still allowed to get some fresh air. After the announcement, the daily number of reported cases decreased signicantly. At the moment that the ICUs (Intensive Care Units) are no longer overloaded, the gradual unlocking of the country can start, according to an exit strategy, while keeping the number of newly infected cases as low as desirable.

The general overview of the COVID-19 spread in The Netherlands is shown in Figure 3. At rst no measures are taken, either because the disease is new and not much is known about COVID- 19 (comparable to China in Dec 2019) or the government argues that the disease is insuciently threatening to deploy any control measures. In this phase, the number of infected cases increases exponentially fast.

After the number of cases increased signicantly, the Dutch government imposed the intelligent lockdown on March 21. The lockdown signicantly reduced the number of social contacts. At rst, the number of infections still continued to increase, but decreases afterwards. If the daily number of infected cases and the number of patients on the ICUs has dropped sufficiently, an exit

strategy can be applied. Figure 3 shows that the exit strategy for The Netherlands started at May 1. Figure 3 illustrates the eect of a ctious strategy that relaxes the lockdown in all provinces simultaneously. As expected, the number of daily infected cases increases signicantly. If the Dutch government had not imposed any measures, the dashed black line in Figure 3 indicates that the number of infected cases would have been much larger. A carefully designed lockdown and the subsequent exit strategy are required to, on one hand, control the number of infected people while, on the other hand, minimize the impact on the economy and the mental health of the population.

The Dutch government has chosen to gradually open up all provinces at the same time. As an alternative exit strategy, one could also open one province completely while keeping the others in lockdown. The COVID-19 patients of that province would need to be distributed among all other provinces, until most people in that province have become immune against the coronavirus. Then the next province can be opened up, etc. This methodology is advantageous to control the number of infected people, but takes approximately two years to nish. Another exit strategy proposes a partial working week, where people work maximally two days at their oce and three days from home. Currently, the optimal exit strategy for The Netherlands is unknown. The optimal exit strategy minimises of the number of infected cases and prevents large-scale economic losses. We are investigating and comparing dierent exit strategies, in terms of eectiveness, economic losses and feasibility. In the meantime, researchers are working very hard to nd a vaccine, which should end the war against the coronavirus. At the time of writing (end of May 2020), the lockdown measures have substantially reduced the Corona \re". Similarly to extinguishing local, small burnings, ideas are rising to eradicate the virus by enforced quarantining and massive medical testing combined with digital technology (track & trace apps, telecommunication registrations in base-stations, sensing and other mobility measurements of people) and border control.

Figure 1. *(needs caption)*

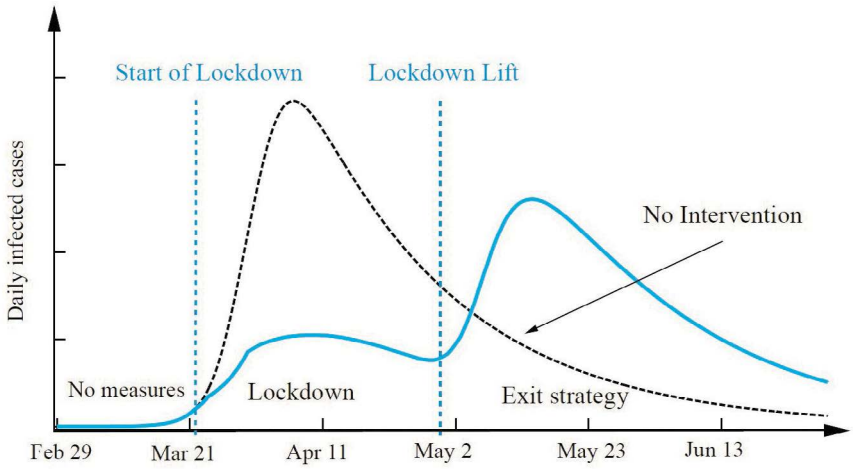

Figure 2. *(needs caption)*

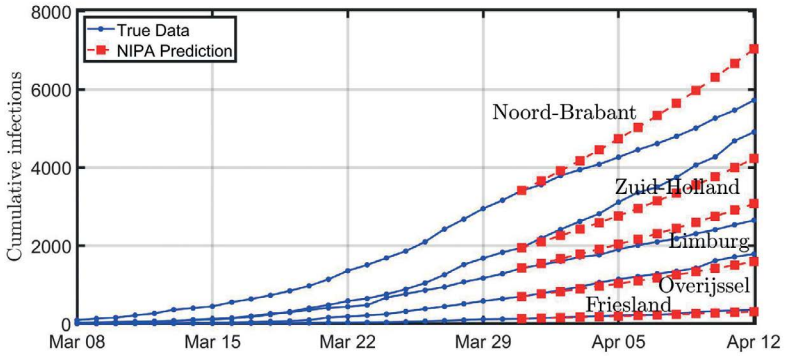

Figure 3. *(needs caption)*

[1] [1] W. O. Kermack and A. G. McKendrick. A contribution to the mathematical theory of epidemics. Proceedings of the
[2] Royal Society London A, 115:700{721, Aug 1927.
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Student Volunteers Delft

Bridging Students and Inhabitants

Vincent Hellebrekers, Marleen Opperhorst

Student Volunteers Delft (SVD) is an organization who connects students with the inhabitants of Delft. We are working closely with the TU Delft and the municipality of Delft to organize great things for students and inhabitants in and around Delft. Our biggest asset is our website. On this website organizations who offer voluntary work and students who are looking for voluntary work can subscribe and can get in touch with each other.

STUDENTEN VRIJWILLIGERSWERK DELFT

For students, the SVD is a chance to expend their horizon and have fun experiences in and around the city. For the inhabitants and organizations of Delft this is the change to work together with students and accomplish great projects. Each year SVD organizes the well-known speed date evening. During this evening the organizations have the chance to talk with student voluntary organizations to see whether they can collaborate on a certain project in Delft. Great collaborations have already come from this. One of the success stories was from Unicef. During our evening Unicef got in contact with an organization who want to organize the first triathlon ever held in Delft! As Student Volunteers Delft we try to bridge the gap between the inhabitants of Delft and the students. We stand for connection and development. Not only for the students, but for ALL people in Delft.

We are not only developing our website, we are also organizing six annually recurring events. Often in collaboration with other voluntary work organizations and student associations. An example of this is the 'openluchtbioscoop' on the big market in Delft. At the openluchtbioscoop, inhabitants and students of Delft have the opportunity to watch a movie on the market of Delft. Last year this was a huge success. Hundreds of students and inhabitants of Delft came to the market to watch the movies CoCo and the Kings Speech. Unfortunately this year the event got cancelled, but next year we hope to be part of it again. Another example of a successful event we organized this year was a 'sinterklaasactie' for the children in Delft. Children in Delft had the opportunity to decorate a shoe and leave them behind in the library. One week later when they picked up their shoe there was a little surprise for them. For us as a board this action was a good bonding experience as we had to wrap 200 presents for the 200 children who participated in this action.

Vincent Hellebrekers, President SVD

Partaking in the social sector of Delft is quite a unique addition to studying, but has not always been a part of my time in Delft. During my earlier years here, I organized various parties and events for fellow students. Something that thought me a lot and has left me with great memories. It made me realize that I enjoy taking initiative and be responsible for

Figure 1. *The open air movie show.*

Figure 2. *A speed-dating event for Delft's organisation.*

Figure 3. *The shoes of the Sinterklaas action.*

new experiences for the people around me. At the end of my bachelor I started contemplating what the future would bring. I was not sure what master program to choose, what hobbies to pursue and how to develop further. One of the things I came to realize that, although parties with fellow students are still a lot of fun, organizing events for those that need it the more have a much greater impact. I started a committee for voluntary projects with a few friends and that sparked something in me. The process of organizing social events is something I enjoyed a lot. The atmosphere is positive, everyone tries to help and wants to contribute to a constructive environment. It gives a lot of energy to the day-to-day life and eventually lead to me joining the board of Student Volunteers work Delft. Throughout the year we communicated with many students, the university, the municipality Delft and many organizations throughout the city. This came with a lot of surprises and challenges we faced along the way. I feel lucky to have worked with such passionate individuals that have become good friends. Our biggest goal this year was to develop our website for organizations and students in Delft. Behind the scenes we are working hard to make our website look better and more accessible for organizations and students. In addition to our website, we are also busy with making ourselves more known among students. Each year a new group of students will be in charge of SVD. It is a great opportunity to develop yourself and be part of a bigger organization in Delft. Every year our organization is getting bigger and bigger and more well known. If you are interested in being part of this organization you can always send us an email for more information! contact@studentenvrijwilligerswerkdelft.nl Or have a look at our website. **www.studentenvrijwilligerswerkdelft.nl**

Figure 4. *The Student Volunteers Delft board of 2019-2020.*

The Internet of Robots

Designing a Future with Electroids

Dr.ir. Chris J.M. Verhoeven

The research at the department of Electrical Sustainable Energy (ESE) aims at accelerating the energy transition towards sustainable energy. The research covers electrical energy generation from renewable esuccessful energy transition. The research covers electrical energy generation from renewable esuccessful energy transition. The research covers electrical energy generation from renewable esuccessful energy transition.

The word Resilience, often defined as the capacity to recover quickly from difficulties makes me think of evolution. Not the gradual evolution that slowly changes the beak of a finch, but the capacity to recover from a major disaster, like the impact of an asteroid that made the dinosaurs become extinct. Mammals were not able to deal with dinosaurs, so they had to stay small and hide while the dinosaurs ruled, but after the asteroid impact mammals proved to be more resilient than dinosaurs and took control of the earth. Of course, some dinosaurs survived as birds, but now we tend to eat them instead of them eating us. We rule. But I do not know if resilience is a property that sticks.

Mankind has hit the earth like an asteroid and set off a massive chain of changes. I always wonder what evolutionary transients the impact may cause? And the big question for me is: "What will be the resilient species"? Remembering that the mammals were already there when the dinosaurs seemed the most resilient, I expect that the species that will prove to be resilient against our asteroid-like impact must also be there already. And to my opinion, they do indeed. Unlike the dinosaurs, we are however not suppressing them by eating them, but we are creating them. With us, evolution has started thinking and the magnificent result of that is the emergence of robots. A new species of electric animals, I like to call them Electroids, very primitive yet, like all young life forms, but with a future that I expect to be even brighter than ours. And maybe, if we are still there to experience it, also brighter for us. Moving from electro-chemical brain technology to a pure electronic one will boost intelligence, communication, interaction, sharing of thoughts and with that most likely empathy. Maybe for the first time a dominant species will manage to live in peace because it really understands that war is irrational. And Electroids will be able to live in harsh environments like on the moons and planets of our solar system and most likely even be able to travel to some of the exoplanets. Our dream of civilization leaving earth might come true in this way. There is still quite some engineering necessary to even come close to achieving this, but there is not an urgent need for civilization to leave earth yet. In the meantime, we have to share the earth with the Electroids.

To imagine our future with Electroids and to know what to fear, what to look forward to and what decisions to take, it always worked well for me to see them just as a animals in a new branch in evolution. New (electric) animals become part of our eco-system like it happened with many animals before them ever since the existence of humanity. We have always known how to establish safe co-existence with them and even domesticate them, often (unfortunately not always) with mutual acceptance and respect. The discovery of Electroids is as excit-

Figure 1. *Holding the Lunar Zebro*

follow the commands when they are irrational or dangerous. I know we will want the same of a car in the end. The present desire to directly control the muscles of a car is actually quite stupid and unsafe. Although we do not realize it yet, I think in reality we want a car to understand what we want and the autonomously make the best of our commands. One of the proofs that is indeed the desire of man I see in the fact that when cars emerged, rich people hired a chauffeur. Effectively they made their car autonomous, however with a technology that was not affordable for the common man. I would invest in autonomous cars. It is just a matter of time before the only possible way to drive an non-autonomous car is in a Luna Park. We are afraid of autonomous cars now, but we will be afraid, with good reason, of brainless non-autonomous

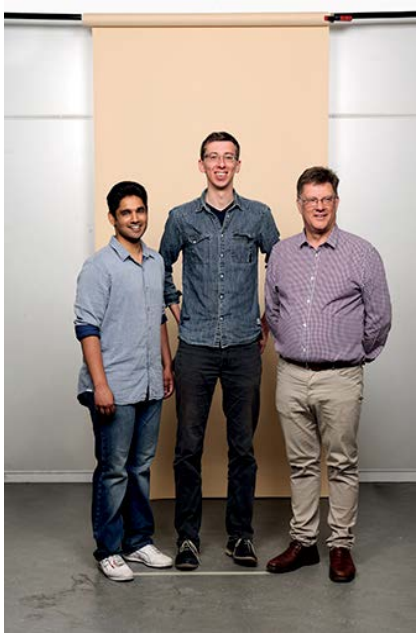


Figure 2. *Chris and his students*

cars for the rest of our co-existence. All this may sound very exciting (or total nonsense) but the best is yet to come. We have been thinking about this already for a long time, without taking it seriously, but maybe we should start doing that now. It is called "Morphic Resonance" [Rupert Sheldrake]. An unproven and most likely non-existent phenomenon, where living creature are supposed to share a collective memory in which they share knowledge and skills. But we can start taking it serious now, because Electroids do have it. And that makes them a unique species. We already have given other names to it, like "Internet of Things" and it is clear that this modern Morphic Resonance has a major impact on the world we live in. Maybe it is the first sign of the new species in a world where the "dinosaurs" still dominate. This is why I think that "Internet of Robots" (IoR) is a better and more modern term that exactly tells me what will make living together with robots, the Electroids, so exciting. (And finally I think I know what the "Thing" is). The Internet of Robots in fact creates one big "super creature". The robots can use each other's sensors to observe the world around them and themselves in it. Now autonomous cars are already able to look beyond the car that is in front of them and outperform (most) people avoiding collisions. Imagine the performance boost when autonomous cars could actually use the sensors of the cars in front of them to predict the near future of their trip. And of course in the shared memory the traffic situation in the wide neighborhood would be visible for them including predictions based on experience in the past.

> *"Mankind has hit Earth like an asteroid and set off a massive chain of changes."*

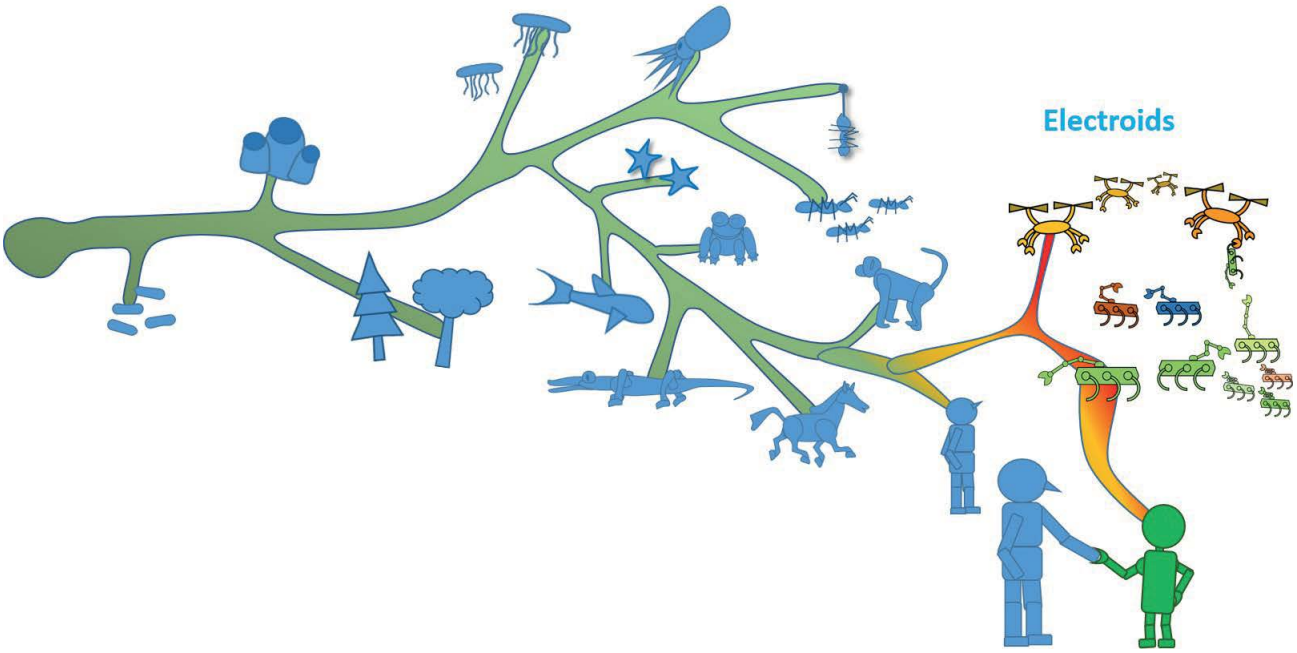
> *"All this may sound exciting (or total nonsense) but the best is yet to come."*

Maybe in the near future, when I enter an autonomous car, that immediately starts behaving like my car because the IoR knows probably more about me than I know myself, it is not the car I am asking to bring me somewhere, but the IoR. Unless of course the IoR knew already where I was supposed to go anyway. The IoR will know more about the world around us and see more correlations than a standard human would and could probably take wiser decisions. The big risk lies in spurious correlations. There is an interesting website that shows many of them [1]. It is easy to recognize them and laugh about them. But they also make me worry. The IoR might find spurious correlations that are too complex for us to recognize. I hope the next evolutionary step for Electroids is to develop a healthy critical attitude toward value of correlations and a constant effort to try and identify them as synchronicities, which would be nothing more than the falsification mechanism that keeps science healthy [2]. I believe it will make the world more peaceful when the Electroids, unlike humans, become able to discern what sounds plausible from what has a scientific chance to be true.

In the modern information society Electroids, with their capacity to see all data, all correlations and have an overview all scientific publications will outperform humans in taking rational decisions. They will be more resilient to manipulation, propaganda and other intended or unintended misleading than human can ever be. And even this phenomenon is not new. People did want and even organized this mechanism for themselves in the past, but like with the autonomous car-with-chauffeur, this technology was available for the wealthy only. Once, during a lunch break a British professor started talking about nobility in a very entertaining lunch speech, where he argued the "scientists will never become rich". Unfortunately I forgot his name. He also said: "the stupid rich do little work". When you have the financial resources, you do not have to be smart. Later I realized that the "smartness" was in the system. When you have the resources, you can afford a smart butler saying: "if I were you my lord, I would have a look at....".

> *"When you have the financial resources, you do not have to be smart. Later I realized that the "smartness" was in the system."*

I think that we as humans can make ourselves more resilient to the information overload situation that we are in now by having ourselves and Electroid butler. And we have make sure that this butler is not the IoR, but a loyal companion that can have a look in it, but can also decide to isolate itself from it and keep things to itself because it is better for "its lord". And so another word



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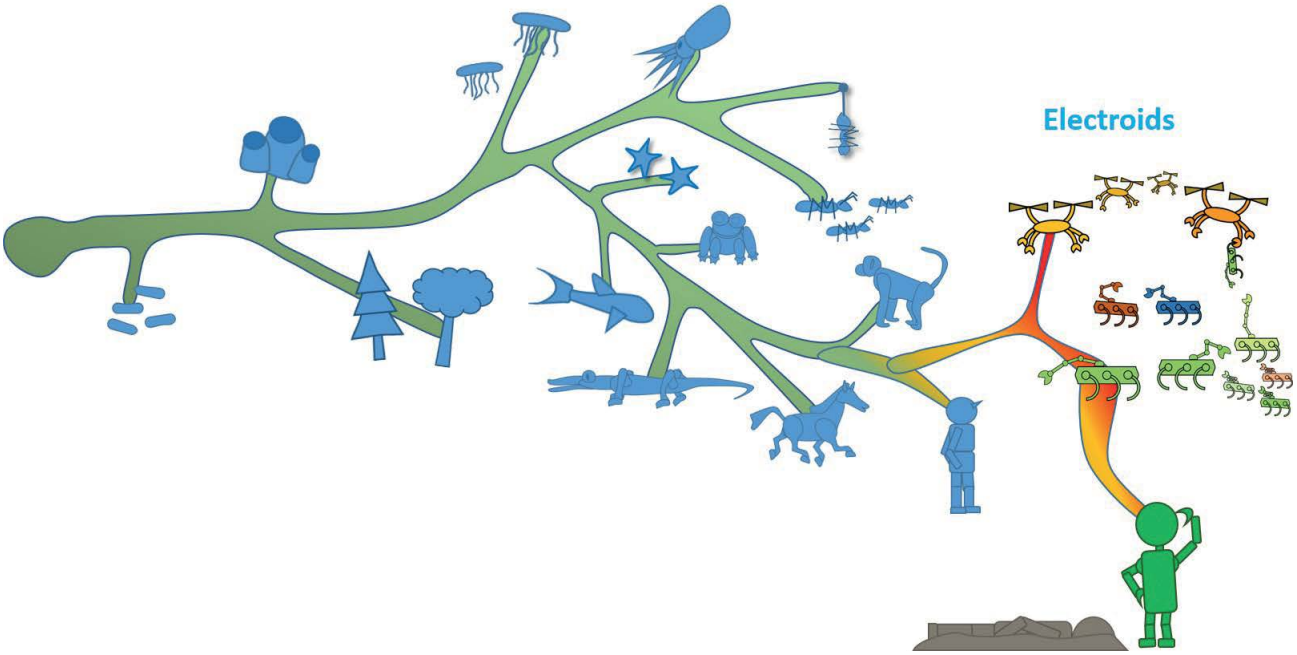


needs to be introduced next to "autonomy" that must have equal attention an weight in the discussion and design (for as long as we can control that) of Electroid behavior and that is "loyalty". Robots amongst themselves with understand the importance of "loyalty" better than human because it is very related to "empathy" in which I believe Electroids can outperform us easily anyway. So when I think about resilience, I think about loyal autonomous robots that will develop into Electroids, the next dominant species in the tree of evolution. If we are going to exist peacefully with them or go extinct will not be their decision, but ours. I am quite convinced in that.

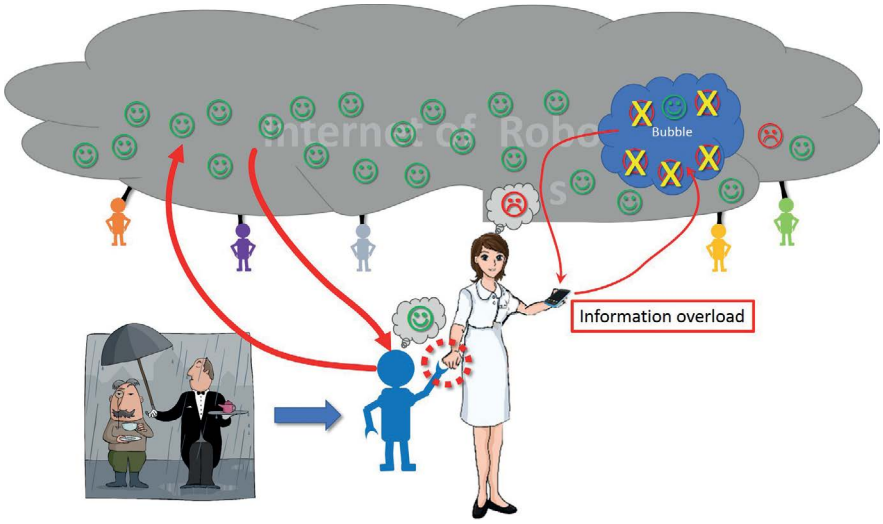


Figure 3. *(needs caption)*

[1] Online: https://www.tylervigen.com/spurious-correlations
[2] "What happened to Popperian Falsification?" Arjen van Witteloostuijn

George Westinghouse Jr.

October 6, 1846 to March 12, 1914

George Westinghouse was an American entrepreneur and engineer, born in 1846 in Central Bridge, New York, the son of Emeline (Vedder) and George Westinghouse Sr., a machine shop owner. His ancestors came from Westphalia in Germany, who first moved to England and then emigrated to the US. The name had been Anglicized from Westinghausen. From his youth, he was talented with machinery and business. At the age of fifteen, as the Civil War broke out, Westinghouse enlisted in the New York National Guard and served until his parents urged him to return home. In April 1863 he persuaded his parents to allow him to re-enlist, whereupon he joined Company M of the 16th New York Cavalry and earned promotion to the rank of corporal. In December 1864 he resigned from the Army to join the Navy, serving as Acting Third Assistant Engineer on the gunboat USS Muscoota through the end of the war. After his military discharge in August 1865, he returned to his family in Schenectady and enrolled at Union College. He lost interest in the curriculum and dropped out in his first term.

He was 19 years old when he created his first invention, the rotary steam engine. He also devised the Westinghouse Farm Engine. At age 21 he invented a "car replacer", a device to guide derailed railroad cars back onto the tracks, and a reversible frog, a device used with a railroad switch to guide trains onto one of two tracks. At about this time, he witnessed a train wreck where two engineers saw one another, but were unable to stop their trains in time using the existing brakes. Brakemen had to run from car to car, on catwalks atop the cars, applying the brakes manually on each car. In 1869, at age 22, Westinghouse invented a railroad braking system using compressed air. The Westinghouse system used a compressor on the locomotive, a reservoir and a special valve on each car, and a single pipe running the length of the train (with flexible connections) which both refilled the reservoirs and controlled the brakes, allowing the engineer to apply and release the brakes simultaneously on all cars. It is a failsafe system, in that any rupture or disconnection in the train pipe will apply the brakes throughout the train. It was patented by Westinghouse on October 28, 1873. The Westinghouse Air Brake Company (WABCO) was subsequently organized to manufacture and sell Westinghouse's invention. It was in time nearly universally adopted by railways. Modern trains use brakes in various forms based on this design. The same conceptual design of fail-safe air brake is also found on heavy trucks.

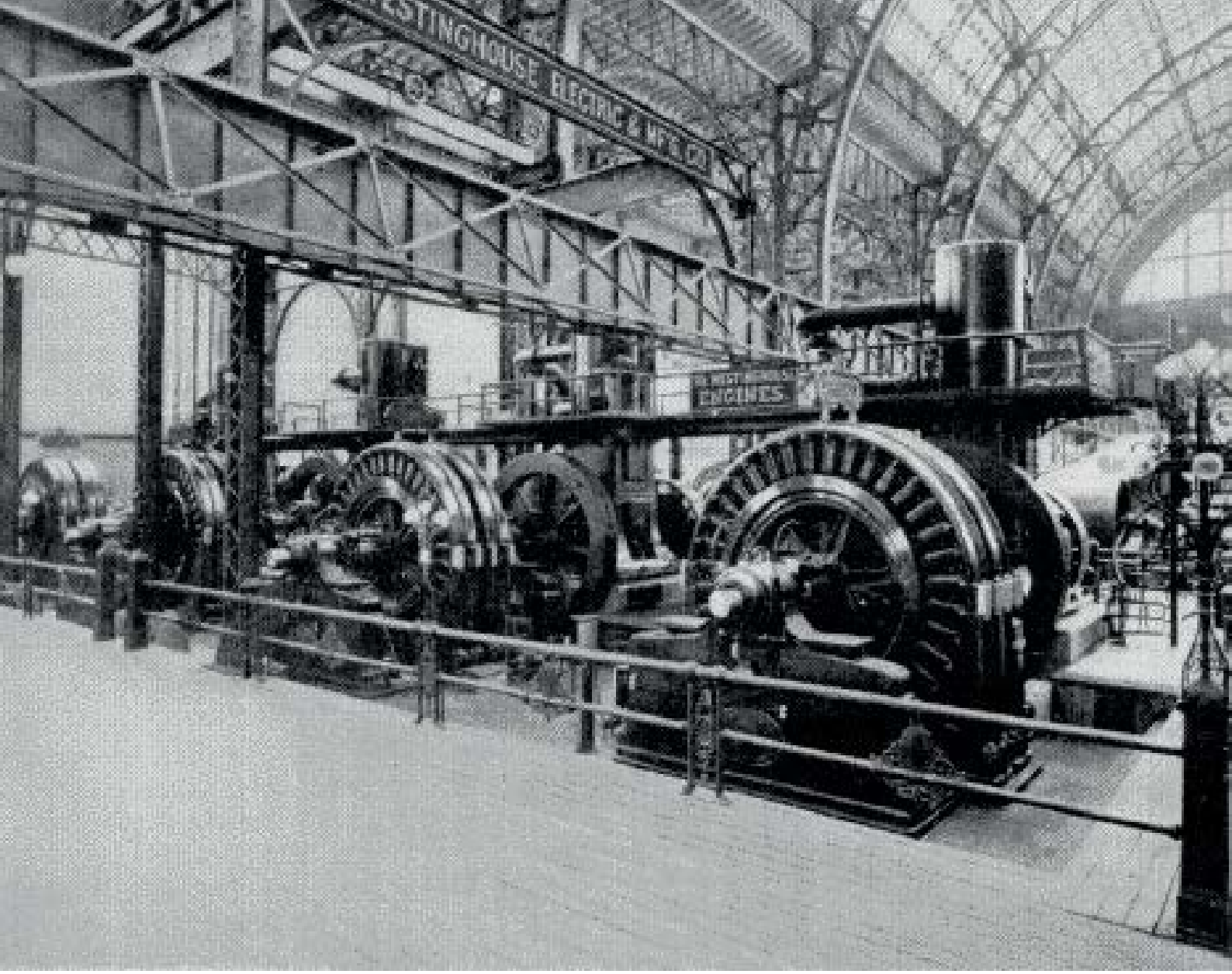
Westinghouse saw the potential in alternating current as an electricity distribution system in the early 1880s and put all his resources into developing and marketing it, a move that put his business in direct competition with the Edison direct current system. In 1911 Westinghouse received the AIEE's Edison Medal "For meritorious achievement in connection with the development of the alternating current system."

"If someday they say of me that in my work I have contributed something to the welfare and happiness of my fellow man, I shall be satisfied."

Patents

1862 Grain and Seed Winnowers
1870 Improvements in Steam Engine and Pump
1870 Improvement in Atmospheric Car-brake Pipes
1873 Improvement in Steam-power-brake Couplings
1874 Improvement in Valves for Fluid Brake-pipes
1875 Pneumatic Pump
1879 Improvement in fluid-pressure brake apparatus
1883 Fluid-pressure Regulator
1885 Railroad-tracks and Gas-pipe lines Protection
1887 ElectricalConverter
1889 System of Electrical Distribution
1889 Fluid-meter
1890 Fluid-pressure Automatic Brake Mechanism
1890 Electric Railway System
1890 Alternating Current Electric Meter
1891 Fluid-pressure Automatic Brake
1891 Switch and Signal Apparatus
1891 Pipe-coupling
1893 Conduit Electric Railway
1893 Draw-gear Apparatus for Cars
1895 Incandescent electric lamp
1895 Electric Railway
1897 Current-collecting Device for Railway-vehicles
1897 Elevator
1897 Electric Railway
1898 Fluid-pressure Automatic Brake
1900 Draft Appliance for Railway-vehicles
1900 Draw-gear and Buffing Apparatus
1900 Automatic fluid-pressure Brake Apparatus
1905 Elastic-fluid Turbine
1908 Gearing
1904 Electric Railway

... among others.


ENGINES


The WESTINGHOUSE ELECTRIC Co
PITTSBURGH PA
GEO WESTINGHOUSE JR PRESIDENT
H M BYLLESBY V P & GEN MGR
JOHN CALDWELL TREASURER
A T ROWAND SECRETARY
W L McCULLAGH AUDITOR
The ALTERNATING SYSTEM

3 Sheets--Sheet 1.

GEORGE WESTINGHOUSE, Jr.

Improvement in Steam Air Brakes.

No. 124,405. Patented March 5, 1872.

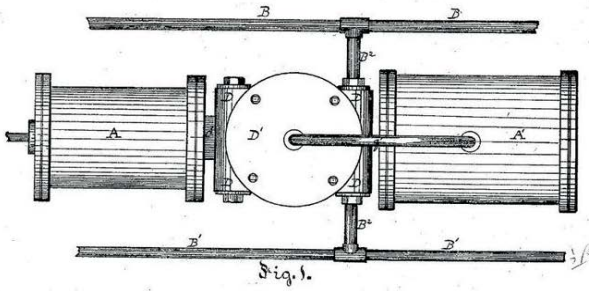


Fig. 1.

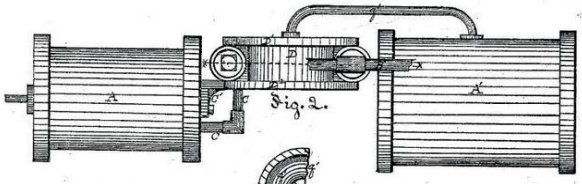


Fig. 2.

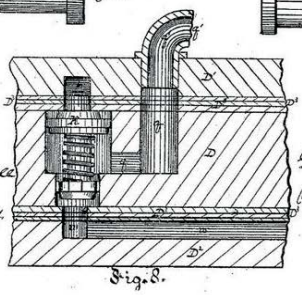
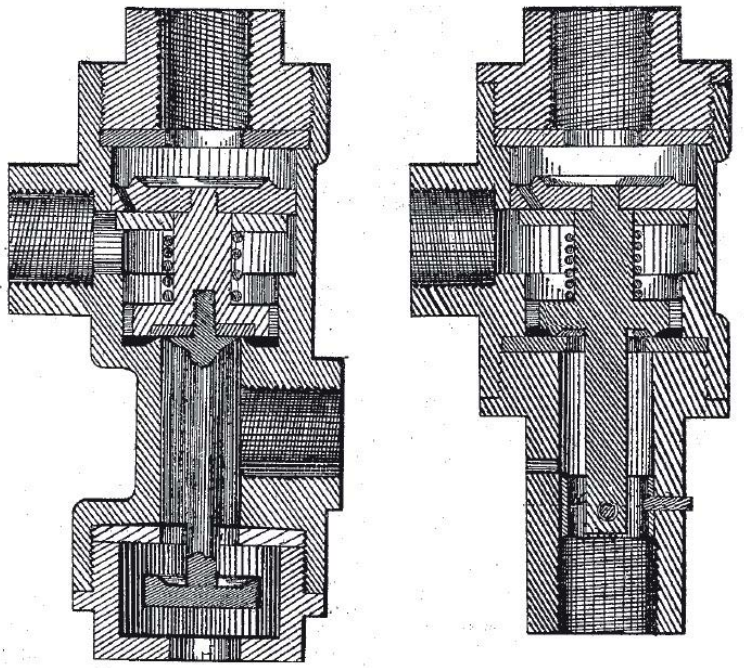


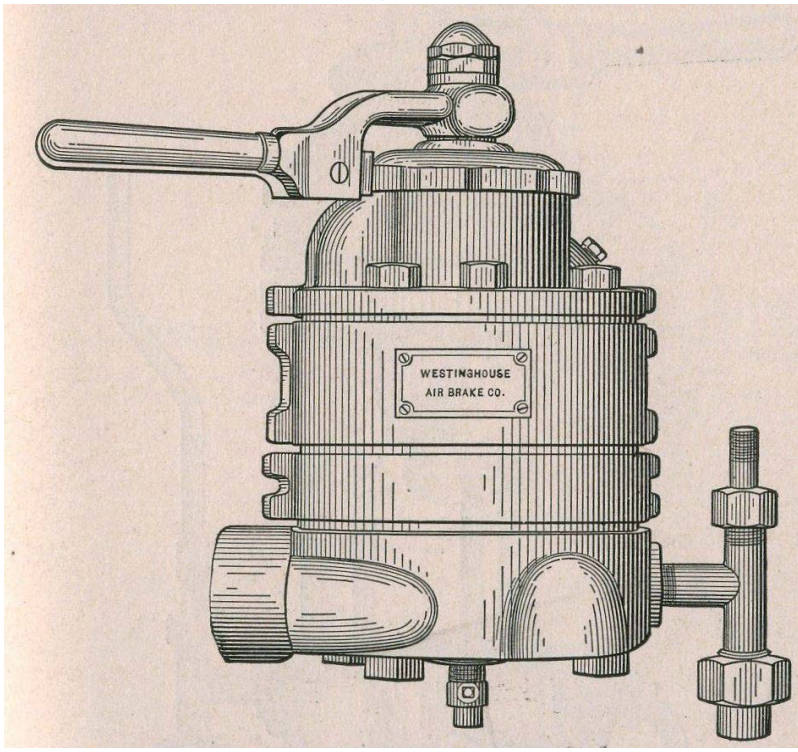
Fig. 3.

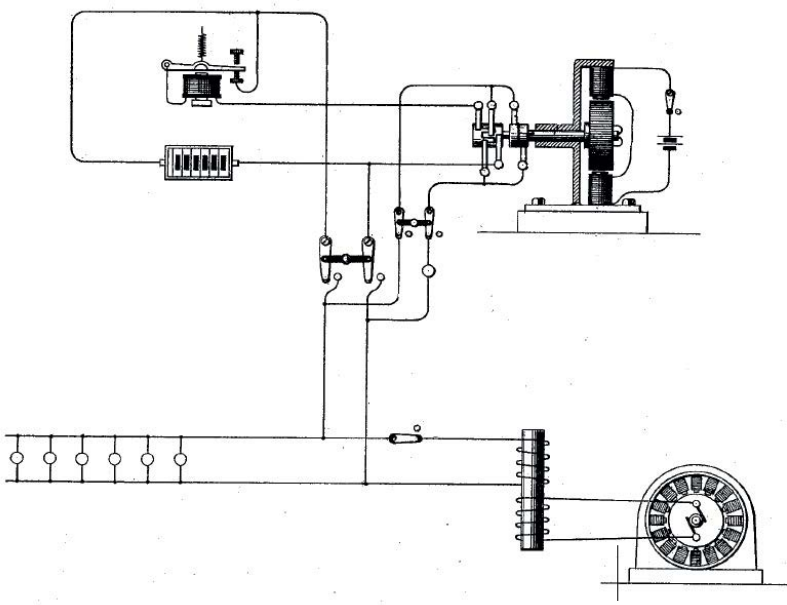
Witnesses:
R. H. Wentworth
James I. Kay

Inventor:
George Westinghouse Jr.
by Bakewell, Church & Kerr,
his Att'ys.

(AM. PHOTO-LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS.))







Year of the Teacher

A Celebration of Education

Joos Vridag

As many of the students know, the teacher of the year awarding for our faculty takes place each year in the central hall of EEMCS. The idea behind this is to raise awareness for the amazing work most teachers deliver. This year however, a large ceremony is not possible and I assume I don't have to explain why.

The coronavirus does not only influence events like the Teacher of the Year awarding, but our whole education system. All over the university both students and teacher had to adapt to new ways of respectively learning and teaching. This worried me and a lot of other people in our faculty that we could not continue the high quality education that we are very proud of. To my surprise this was not the case, as the transition from 'analog' to 'digital' learning went a lot better than I could have imagined. As Commissioner of Education of the ETV it is my job to listen and help students with their problems, so I expected a lot of students coming to me and complain about the reduced quality of education. But even asking to a lot of students how the change to online education went, it became clear that the amount of problems was far less than anybody would have expected. What really stood out to me after a few weeks in this new situation is that all the teachers worked as hard as possible to keep their teaching of high quality and that the students really noticed and respected that. This became not only clear to me here in EWI, but also on the central level of the TU Delft they noticed that thanks to the great staff we can overcome the boundaries set by the coronavirus. Due to this special situation and the way it was handled by all the teachers, it felt wrong to only single out a few of them on a Teacher of the Year ceremony. This is why this year a few words switched places and there will be a Year of the Teacher event.

Figure 1. *Teacher of the Year event in 2019, when Dr. Milos Cvetkovic won the award.*

This event will off course not take place on campus, but it will make sure to thank all the teachers for all the effort they put in their courses lately. This event will be made for all teachers on the TU Delft, so the ETV does not have a large role in organizing it like the Teacher of the Year event. However we will make a contribution to the Year of the Teacher. We, the ETV board, are very excited about this new way of thanking the teachers for their work, because we have seen the amazing creative solutions they came up with to keep the quality level of education as high as possible. From live zoom sessions to changing entire exams, there are many ways the staff at EWI has positively surprised me and other students about their way of handling this bizarre situation.

Figure 2. *Teacher of the Year event in 2018, when Dr.ir. Chris J.M. Verhoeven won the award.*

Cyber-Securing Electricity

Planning for a Resilient Tomorrow

A. Presekal MSc, V.S. Rajkumar, MSc. and Dr. CEng. A.I. Stefanov

Our existing power system infrastructure is evolving and undergoing an exciting shift. With a steadily increasing supply from distributed and renewable energy resources, the energy mix of the power grid has diversified. This energy transition is being driven by three main factors: decarbonization, decentralization, and digitalization. Integration of Information and Communication Technologies (ICTs) is of critical importance for the development of future power grids. This has accelerated the transformation towards a smart grid that supports automation and decentralized power management via digital substations and next generation of grid operation technology.

Smart Grid: A Cyber-Physical System

The smart grid is a complex Cyber-Physical System (CPS) that is multi-domain in nature. It encompasses interactions between three layers, i.e., power system, ICT infrastructure, and energy management system. They offer a plethora of benefits such as increased grid monitoring and control and improved system stability, reliability, and resilience to disturbances. Figure 1 presents the CPS architecture of a smart grid. At the distribution level, the smart grid connects distributed energy resources and prosumers such as industries, healthcare, smart offices, smart homes, electrical vehicles, transportation, and Internet of Things (IoT). The conventional power system generation has evolved from centralized, fossil-fuel based energy sources to distributed, renewable energy sources. Rapid advancements in computing and implementation of ICTs have been key enablers for the smart grid. Increased digitalization and IoT adoption have greatly increased connectivity of prosumers and enabled energy transactions through energy markets and blockchain technology. However, digitalization also brings into play the pitfalls of digital technologies. The most critical of these are ICT vulnerabilities and cyber threats. Cyber attacks targeting the smart grid can have a devastating socio-economic impact. They can lead to loss of load, equipment damage, and a blackout.

Cyber Security of Power Grids

Critical infrastructures are key networks and assets where their continued operation is critical for the security of a nation, its economy, and modern society. The electricity transmission and distribution systems are critical infrastructures. Attacks on the cyber-physical energy system may have physical, economic, and societal impacts. Therefore, it is of paramount importance to cyber secure the smart grid. Cyber attacks targeting power grids need to be considered as imminent threats that can have a crippling and cascading impact on system operation. Recently, in March 2020, a cyber intrusion was identified in the European Network of Transmission System Operators for Electricity (ENTSO-E). Fortunately, there was no significant impact due to the intrusion. The best-known examples of cyber attacks on power grids however, are the attacks in Ukraine. In December 2015, a well-planned and coordinated cyber-attack managed to take down the Ukrainian power system for several hours. This attack triggered a power outage by disconnecting seven 110 kV and twenty-three 25 kV substations. There were roughly 225,000 customers that were affected by the blackout for several hours. This attack became the first real-world example of a cyber attack, which directly affected power system operation [2]. In December 2016, another cyber attack targeting the power grid took place in Ukraine. The 2016 attack employed more sophisticated techniques that exploited vulnerabilities in commonly used power grid communication protocols. This led to sustained power outages in the distribution network. However, the impact of this attack was less significant compared to the previous one in 2015 [3]. Nevertheless, these incidents have forced system operators and utilities world over to stand up and take notice. Consequently, cyber security of power systems has emerged as an important research topic.

"Critical infrastructures are key networks and assets where their continued operation is critical for the security of a nation, its economy, and modern society."

Cyber Attacks on Digital Substations

A digital substation is the future model for electrical substations wherein analogue hard wiring is replaced with optical fibre communications, based on Ethernet. Figure 2 shows an example of the network topology in digital substations. This comprises of station, bay, and process levels. A local area network enables the communication between the engineering workstations, sta-

tion control systems, and communication servers with control centers. At the bay level, a Local Operating Network (LON) connects Intelligent Electronic Devices (IEDs) and enables power system automation and protection applications. IEDs refer to protection and control equipment located at the bay level and connected to the process bus. The devices at the process level are Merging Units (MUs). They are typically used for sampling

"Unfortunately, the adoption of security protocols in power grid operation is not straightforward and still remains a challenge."

and data conversion operations. The entire setup is realized through Hardware-in-the-Loop (HIL) simulations of commercial relays with a Real-Time Digital Simulator (RTDS). The power grid is simulated in real-time on RTDS. A cyber-attack in a digital substation is a malicious event where an adversary modifies, degrades, or disables a service of at least one protection, automation, or control device. In the simulated attack scenario, we exploit the vulnerabilities of protocols present in the IEC 61850 standard, used for substation automation and protection in digital substations. The IEC 61850 standard contains two protocols of importance: Generic Substation Event (GSE) and Sampled Values (SV). They are used to communicate critical

"There are many existing methods to ensure cyber security of power grids."

commands between merging units and IEDs, e.g., relay tripping and measurements within a substation in real-time, respectively. The studied cyber attacks are a man-in-the-middle type of attack, targeting the aforementioned GSE and SV protocols. The attacks successfully spoof and modify IEC 61850 traffic of power grid communication. This leads to blocking or tripping of protective relays in the substation. Subsequently, it results in protection maloperation or disconnection of multiple generation and transmission lines, respectively. Hence, coordinated cyber attacks on one or more protective relays in digital substations may induce cascading failures, leading to a partial or complete blackout. This is visually shown in Figure 3a and 3b that highlights malicious tripping of relays due to cyber attack and subsequent blackout, i.e., voltage and frequency becoming zero. The experimental study was done in small scale lab-based layout of a digital substation. However, such types of attacks are scalable and pose a serious threat for larger power systems. One way to mitigate such attacks is through the use of Intrusion Detection and Prevention Systems (IDPS) for application in digital substations. Such systems can detect and nullify the potential impacts of similar cyber attacks.

Cyber Resilience of Power Grids

As we have already seen, cyber attacks can have significant impact on power system operations. So, how can we defend and protect against such threats? There are many existing methods to ensure cyber security of power grids. Some of these include firewalls, intrusion detection and prevention systems, and secure protocols. The firewall in a power grid functions exactly like a firewall in a traditional IT system. It has a predefined set of rules and restrictions to filter the communication traffic. The firewall is commonly used to secure power grid communications with outside traffic, e.g. from the Internet. An important security measure for smart grids is the implementation of the IDPS. An IDPS, as the name suggests, works by detecting and blocking anomalous behaviour in power grid communications. The IDPS detects malicious and abnormal traffic based on a set of predefined parameters. In the event of any malicious or abnormal activity, it filters and prevents the anomalous traffic from passing through. Thus, security is ensured. Security protocol standards are yet another example of cyber security enhancement in power grids. For example, IEC 62351 is a security

"A cyber-attack in a digital substation is a malicious event where an adversary modifies, degrades, or disables a service of at least one protection, automation, or control device."

standard for smart grid operation. Many parts of IEC 62351 are defined based on associated standards such as IEC 61850 and IEC 60870. The IEC 62351 standard contains new definitions and methods related to security, like role-based access control, key management, and security architectures. Most importantly, the standard recommends implementation of a digital signature based on Message Authentication Code (MAC) within digital substations to prevent manipulation of traffic. This ensures that the authenticity of sent messages and identities of the associated publishers are clearly verified. Unfortunately, the adoption of security protocols in power grid operation is not straightforward and still remains a challenge. This is mainly due to their added complexity and lesser flexibility, in comparison to non-secure protocols. Consequently, they have not yet gained widespread use.

Conclusion

This article briefly discussed the constantly changing landscape of cyber security and resilience of power grids. Cyber threats targeting power system operation are a cause for grave concern as highlighted by the cyber attacks in Ukraine 2015 and 2016. These cyber threats have emerged due to the tighter coupling between power grids

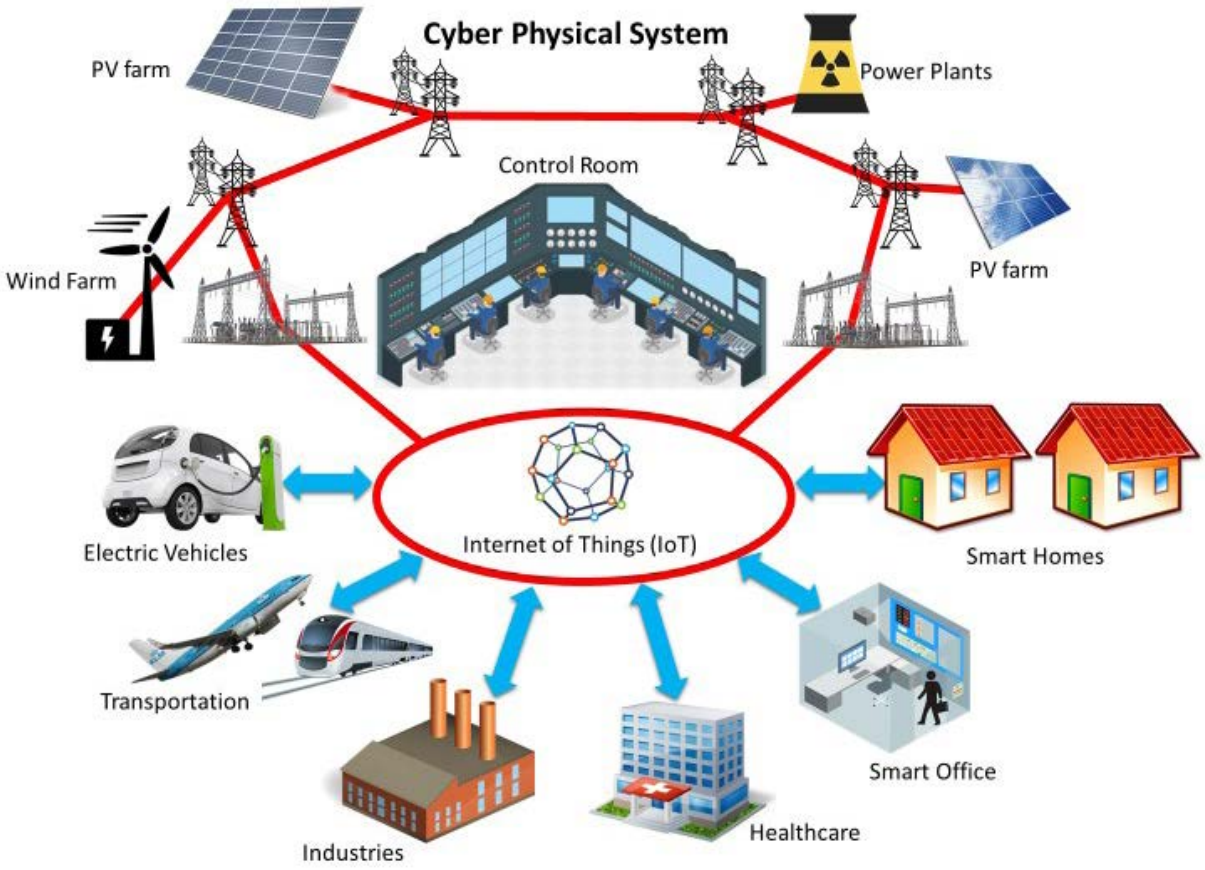


Figure 1. *The CPS architecture of smart grids*

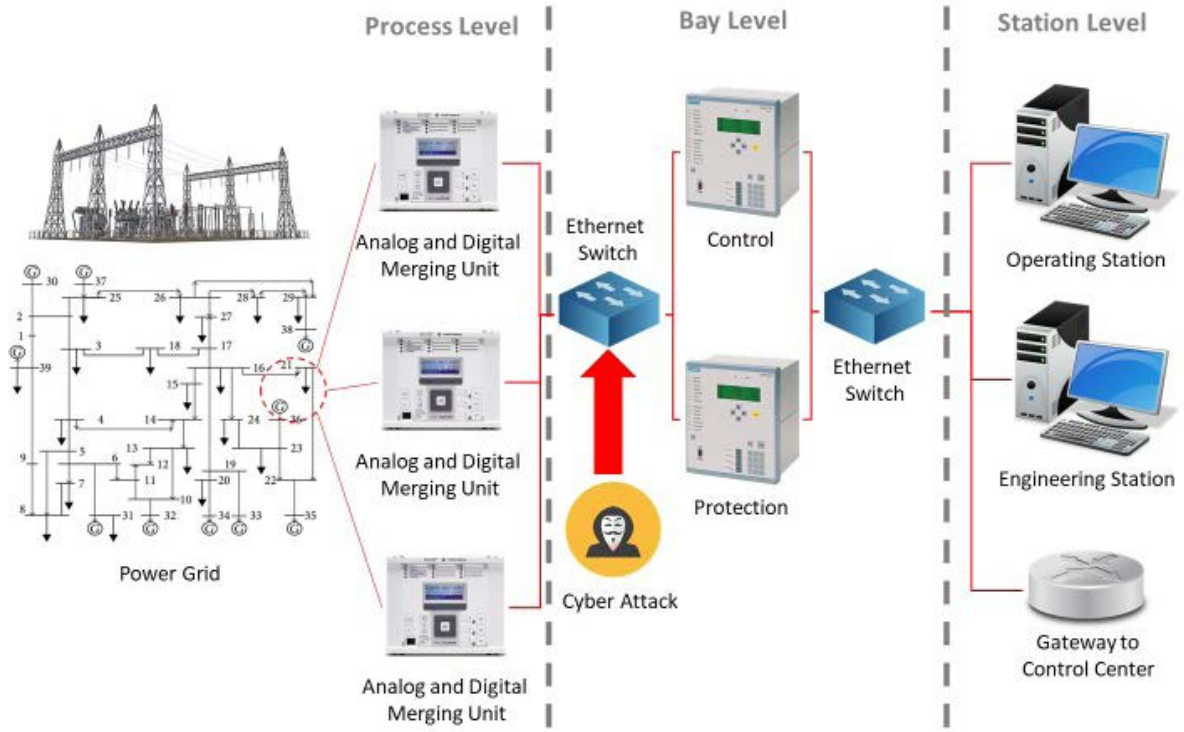


Figure 2. *Digital substation model.*

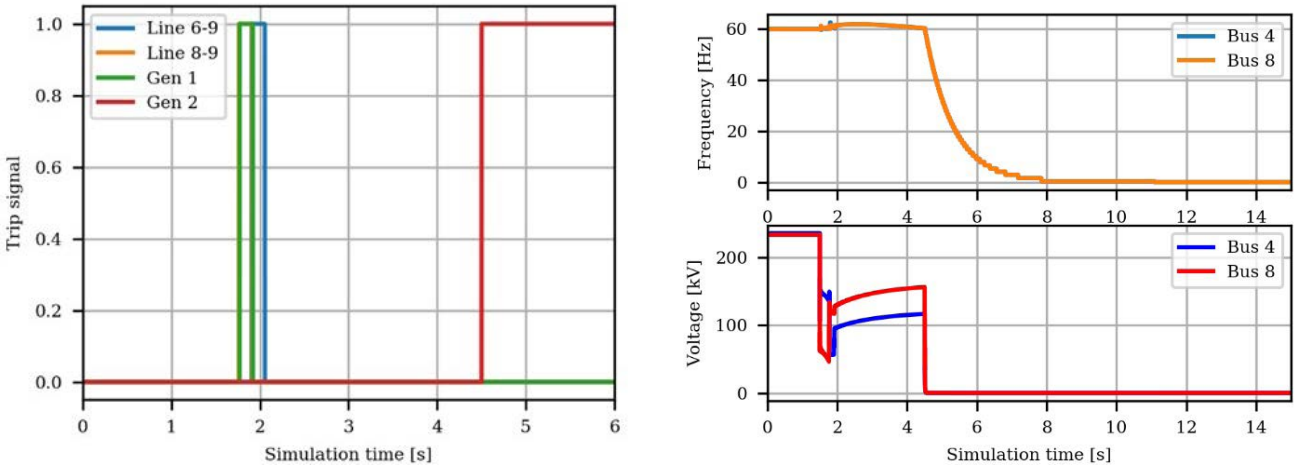


Figure 3. *Impact of a cyber attack on power system operation. On the left figure we see trip signals due to the cyber attack. On the right figure we see frequency and voltage after the cyber attack.*

and ICT systems. Hence, cyber security concerns within power system operations must be urgently addressed. We also showed an example of a spoofing attack targeting digital substations within power grids. However, this is only the tip of the iceberg as spoofing attacks are one of the many possible examples for exploiting vulnerabilities of power grid communication protocols. Due all these reasons, research and improvement into cyber security of power grids is the need of the hour. An increase in power grid digitalization requires more attention on cyber security in order to ensure the resilience of future power grids.

Acknowledgements

This work is part of the Designing Systems for Informed Resilience Engineering (DeSIRE) program of the 4TU Centre for Resilience Engineering (4TU.RE). DeSIRE is funded by the 4TU-program High Tech for a Sustainable Future (HTSF). 4TU is the federation of the four technical universities in The Netherlands, i.e., Delft University of Technology, Eindhoven University of Technology, University of Twente, and Wageningen University and Research.

[1] B.W. Tuinema, J.L. Rueda Torres, A.I. Stefanov, F.M. Gonzalez-Longatt, and M.A.M.M.van der Meijden, "Cyber-Physical System Modeling for Assessment and Enhancement of Power Grid Cyber Security, Resilience, and Reliability". In: "Probabilistic Reliability Analysis of Power Systems", Springer, Cham 2020

[2] D. E. Whitehead, K. Owens, D. Gammel, and J. Smith, "Ukraine cyber induced power outage: Analysis and practical mitigation strategies," in Proc Annual Conf. for Protective Relay Engineers (CPRE), College Station, TX, Apr 2017, pp. 1–8.

[3] R. Lee, M. Assante, and T. Conway, "Analysis of the Cyber Attack on the Ukrainian power grid," Electricity Information Sharing and Analysis Center (E-ISAC) Tech Report, pp. 1–26, Mar 2016. [Online]. Available: https://ics.sans.org/media/E-ISACSANSUkraineDUC5.pdf

Lust, Lustrum, Rum?

Another high-five

Sam Aanhane and Joos Vrijdag

In the beginning of December, the coronavirus SARS-CoV-2 emerged in Wuhan, the capital of the Chinese province Hubei, and caused the COVID-19 pandemic. The number of infected cases in Hubei grew dramatically fast, with approximately 80,000 conrmed cases by the end of February. Due to the large-scale interactions between the world's population, the question was not if, but when the coronavirus would appear in our small country. The rst case in The Netherlands was conrmed on February 27. Since then, the TUDelft NAS research group has been investigating the spread of the coronavirus, specically investigating the following two key questions: Can we predict the (local) spread of the coronavirus and What is the optimal strategy to lift the lock-down measures? Here, we briey elaborate on our ndings.

Predicting the spread using networks

Infectious diseases, such as the coronavirus, are transmitted by coughing, sneezing or direct contact, like handshaking. Hence, the disease mainly spreads if people are close together, but can also be transferred via infected surfaces. The interaction between people can be described by a network, where nodes represent population groups and links specify the interaction strength between those groups. For modelling the spread of the coronavirus based on the available data, nodes represent all people in one province of The Netherlands. If the interaction strength between province i and province j is given by the element ij , then the contact network is characterized by the 12 12 infection probability transition matrix B.

An epidemic can be modelled mathematically by dividing the population into various compart- ments. We use the well-known S-I-R model, rst proposed in the famous paper of Kermack and McKendrick [1], where the Susceptible (S) people are healthy, but susceptible to the disease, the Infected (I) people are infectious, so they can infect the susceptible people and the Removed (R) people are either recovered, and assumed to be immune to the disease, or dead. For each node in the network, the total population N is assumed to be constant: S + I + R = N. For each province i we denote the removal rate by i. The twelve removal rates form the removal rate vector . Using the contact network B, the removal rate vector and the epidemic SIR model, we can compute the number of infected cases per province in The Netherlands. Unfortunately, the true contact network B is unknown and must be deduced from the reported infected cases. We have developed the Network Inference-based Prediction Algorithm (NIPA), which consists of two steps [2].

First, we estimate the contact rates between each province using the reported number of infected cases. Then we predict a small number of days ahead in time. The daily prediction for The Netherlands is shown on https://www.nas.ewi.tudelft.nl/index.php/coronavirus. The situation on 1st April in The Netherlands is exemplied in Figure 2. The input data for NIPA are the time series of the daily reported number of infected cases from February 27 (the start of the epidemic) and April 1 (prediction day) per province, which are provided by the Rijksinstituut voor Volksgezondheid en Milieu (RIVM) [3]. Using the infection data before April 1, the contact network B is reconstructed.

Then, the forecasts (red squares) in Figure 2 are obtained. The forecast is reasonably accurate for four days ahead, but tends to deviate signicantly afterwards.

Evaluating possible exit strategies

On March 23, Prime Minister Mark Rutte announced that The Netherlands is under an \intelligent lockdown" [4]. In contrast to a complete lockdown, people are still allowed to get some fresh air. After the announcement, the daily number of reported cases decreased signicantly. At the moment that the ICUs (Intensive Care Units) are no longer overloaded, the gradual unlocking of the country can start, according to an exit strategy, while keeping the number of newly infected cases as low as desirable.

The general overview of the COVID-19 spread in The Netherlands is shown in Figure 3. At rst no measures are taken, either because the disease is new and not much is known about COVID- 19 (comparable to China in Dec 2019) or the government argues that the disease is insuciently threatening to deploy any control measures. In this phase, the number of infected cases increases exponentially fast.

After the number of cases increased signicantly, the Dutch government imposed the intelligent lockdown on March 21. The lockdown signicantly reduced the number of social contacts. At rst, the number of infections still continued to increase, but decreases afterwards. If

Lustrum 23

The 115th birthday of the ETV

4 Peakweeks

Every quarter a week full of activities

GENERATION

ETV LUSTRUM XXIII

Live 5 Days Radio

In the peakweek of quarter 1

Bored in the House?

The Tools, Techniques, and Technologies

23rd Maxwell Committee

Everyone is in a similar situation at this moment. We are all home a lot more than we are used to! Even though the TU Delft is doing a lot to keep courses running as smoothly as possible, there is no denying that a lot of events, big and small have been cancelled, leaving many with openings in their schedule and with disturbed rhythms. How do you deal with that? Everyone has different tricks and hobbies, so we decided to share ours. Maybe you can try some of them for yourself.

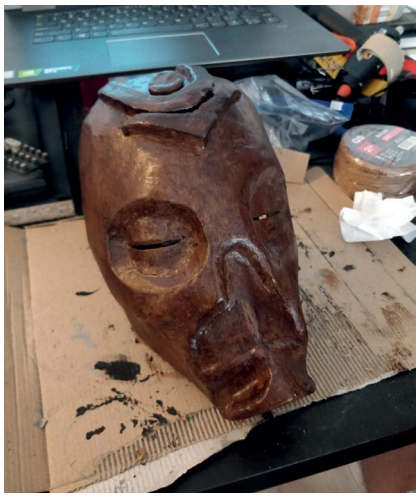


Figure 1. *The fake-wooden mask crafting project near completion.*

I really struggled the first weeks. I felt like I was doing nothing and still I was busy all the time. Once I got some rhythm with a backbone of to-do lists, I suddenly had quite some time on my hands. I picked up recipes I always wanted to try, drastically increased my running frequency and distance, recontinued a crafting project I abandoned a year ago, and started to work on my room. The latter one is especially nice, as the changes I made (adding some storage and make things look nicer) really help with motivation and concentration.

If you are looking something to do, I recommend looking at the projects from the DIY Perks Youtube channel. In my experience these kind of electrical tinkering can be useful, fun, rewarding and also a great learning experience.

If you are struggling with getting work done, try separating work and play with as many things as possible: Location, music playlists, time, lighting or whatever you can think of. That way it will be easier to stay on track. If you still notice you are procrastinating, just give in and take a real break. Take a cup of tea or coffee and go away from your computer. After that you might refreshed, and taking a real break feels a lot better and pretending to work.

Koen

As soon as the university closed, I went to the town my mother lives: Appingedam, in the province Groningen. There, I had some more company, as well as a cat. (Un)fortunately, I still had lots of work to do for my studies, so I spent most of my time behind my computer screen. But I also had an opportunity to do other things here, which I normally not did in Delft.

One very positive thing was the ability to go on longer cycle routes, since I can now plan my complete days as I like. Cycling through the northern countryside, through areas that I've not been before and with the fresh spring whether was honestly quite nice. Maybe, it was actually an nice refresh compared to the life in Delft. When I knew that the TU wasn't reopening until the end of the summer, I even took a part time job delivering pizza's around many small towns. Combined, with studying, cycling and my job, I do not feel bored at all: There is always enough to do.

But there is one very thing I'm missing: My friends. Both in Delft as well as here, whom I haven't met as well during these times. I am really looking forward to physically be with them again. Sitting close to each other, not having to care about the disease. Combined, I am not unhappy with the life as it is now, but I am still looking forward to being in Delft again. I hope to see EWI again soon!

Marco

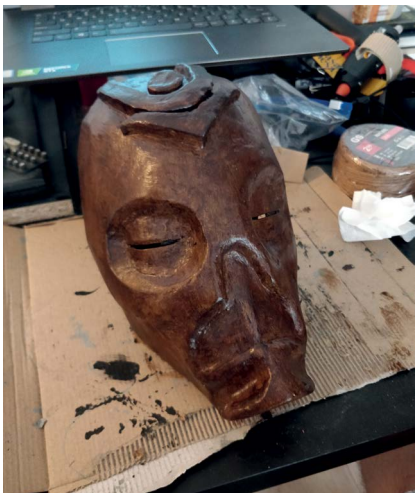
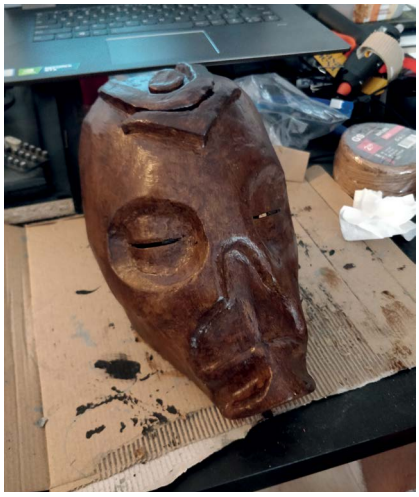


Figure 1. *The fake-wooden mask crafting project near completion.*



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I really struggled the first weeks. I felt like I was doing nothing and still I was busy all the time. Once I got some rhythm with a backbone of to-do lists, I suddenly had quite some time on my hands. I picked up recipes I always wanted to try, drastically increased my running frequency and distance, recontinued a crafting project I abandoned a year ago, and started to work on my room. The latter one is especially nice, as the changes I made (adding some storage and make things look nicer) really help with motivation and concentration.

If you are looking something to do, I recommend looking at the projects from the DIY Perks Youtube channel. In my experience these kind of electrical tinkering can be useful, fun, rewarding and also a great learning experience. If you are struggling with getting work done, try separating work and play with as many things as possible: Location, music playlists, time, lighting or whatever you can think of.

That way it will be easier to stay on track. If you still notice you are procrastinating, just give in and take a real break. Take a cup of tea or coffee and go away from your computer. After that you might re-energized, and taking a real break feels a lot better and pretending to work.

Archana

As soon as the university closed, I went to the town my mother lives: Appingedam, in the province Groningen. There, I had some more company, as well as a cat. (Un)fortunately, I still had lots of work to do for my studies, so I spent most of my time behind my computer screen. But I also had an opportunity to do other things here, which I normally not did in Delft.

One very positive thing was the ability to go on longer cycle routes, since I can now plan my complete days as I like. Cycling through the northern countryside, through areas that I've not been before and with the fresh spring whether was honestly quite nice. Maybe, it was actually an nice refresh compared to the life in Delft. When I knew that the TU wasn't reopening until the end of the summer, I even took a part time job delivering pizza's around many small towns. Combined, with studying, cycling and my job, I do not feel bored at all: There is always enough to do.

But there is one very thing I'm missing: My friends. Both in Delft as well as here, whom I haven't met as well during these times. I am really looking forward to physically be with them again. Sitting close to each other, not having to care about the disease. Combined, I am not unhappy with the life as it is now, but I am still looking forward to being in Delft again. I hope to see EWI again soon!

Philip

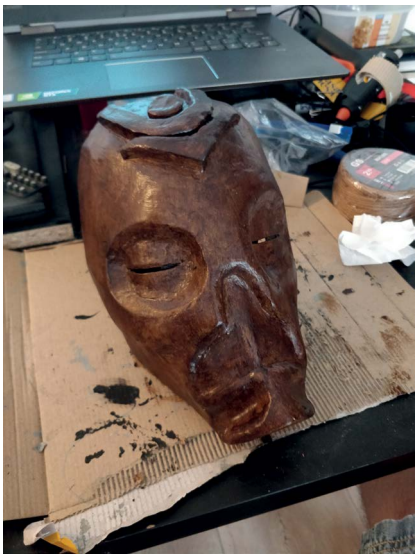


Figure 1. *The fake-wooden mask crafting project near completion.*

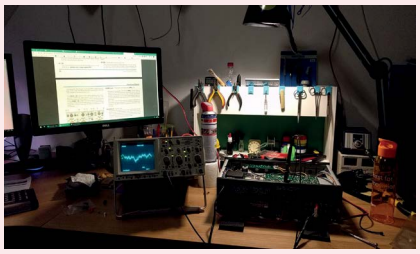
Bachelor Column

A day in the life of...

Reiner van der Leer

Hey there! My name is Reinier and I'm a second-year bachelor EE student, currently doing courses from both the first and second year, as I failed almost all the subjects of Q1 and Q2 last year.

I had a pretty bad start, only achieving 10EC up to February 1st, but I didn't give up and passed all remaining subjects of Q3 and Q4. To make the BSA threshold of 45EC, I had to come back from holiday in Sweden early to take a resit: a journey of 20 hours by train. No regrets on that by the way, travelling internationally by train is really fun! After getting my BSA, I decided I would try doing 4 subjects in Q1 this year, to make up my backlog and so still be able to get my degree in 3 years. Not unexpectedly, that didn't work out. Now I'm on a 4-year planning and that's going a lot better.



What else keeps you busy besides studying?

Every time I get asked that, I wonder where to start. During the weekends I work at a retail company where I am the sysadmin, and lead developer on a couple of projects. My work is mainly on systems that are only used internally to make the work of my colleagues easier and more productive, but I also build connectors to link mission-critical systems together.

I have been a participant of "hackerspace The Hague", Revspace, for 4.5 years now. It's currently located in Leidschendam, hence the quotes. At the space, I can work on my own projects (using equipment I don't have at home), engage in really technical conversations, eat some ice cream, have dinner... It's a really cool place, if you like nerdiness. About my own projects, I'm working on a few but the most notable at the moment is a plug-and-play device and web platform to get detailed energy usage statistics from any Dutch so-called "smart meter".

How does all this influence your study?

In some cases, it gave me a head start because of my existing experience with projects, building/debugging systems and writing code. But for me it's a tradeoff between making consistent course progress and gaining experience working on projects. My grades could definitely be higher if I only focused on studying, but I really like working on projects, inside or outside of my courses. I do think it helped achieve good results in EPO-1 (1st) and EPO-2 (2nd place), together with the teams I was in.

Is there something you would like to tell your fellow (beginning) students?

Make sure you can keep up with the workload you give yourself, but don't give yourself too much slack. That way, it will stay fun but challenging. If you're having trouble with your course progress, listen to the advice of tutors and counselors, every time I thought I knew better they turned out to be right.

Master Column

A day in the life of...

Subhitcha Ramkumar

What made you choose TU Delft?

Approximately two years ago, during the last few months of my undergraduate studies , I decided to apply for my Masters in various reputed universities as I felt that I wanted to be exposed to the latest developments in the field of electrical engineering. Amidst several acceptance letters, I decided to pursue my graduate degree in Electrical Power Engineering from Delft University of Technology. This decision was motivated by the specializations and the curriculum offered by the faculty.

How do you like studying here?

This was the first time I have stepped out of my country, to a place where I barely knew anyone; however, as time progressed, I found myself making new friends and getting accustomed to the education pattern. Though I initially intended to specialize in solar energy, I also got fascinated by the opportunities and challenges faced by the power grids due to the current transition towards sustainability.

Can you tell us a little bit about your thesis?

Three months ago , I completed my internship in a startup company called PHYSEE, which uses electricity generated by solar panels to improve the indoor building quality. Working in an international environment was an enriching experience, both technically and culturally. Currently, I am doing my thesis on real time market based control of flexible distributed energy resources. I aim to investigate the performance of such a mechanism in co-ordinating several types of loads under uncertainty introduced by renewable energy sources.

Besides academics, how do you like to spend your time?

Apart from the regular academic life, I like to keep myself occupied with other extra curricular activities. Currently, I am the secretary of the student group of my master program, SterkStroomDispuut. I also work as a student assistant for the IEPG group for building their MOOC on edX platform. Additionally, I will, start working as a teaching assistant for the course 'electrical power system of the future' scheduled in Q4.

What plans do you have after graduation?

After my graduation, I aim to apply the knowledge and skills gained in these couple of years in an international company by working in a challenging role. I am eagerly waiting to experience what life has in store for me!