

# DE VONK

Periodical of  E.T.S.V. Scintilla

Main Article:  
Back to Scintilla's roots

Junction:  
Hugo Masselink

Master Thesis:  
Spatial Multiplexing



Ricardo  
Rail

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# Presidential note

*Author: Koen Raben*

This edition of de Vonk will have a certain focus on the history of Scintilla, and with more than 50 years of activism there is quite some history to tell. And therefore in this presidential note, I will focus on a piece of history I have witnessed first-hand, and you might even say I have played a part in these stories.

It all began much like the start of the honorary Dutch republic, with an important meeting. But instead of meeting on the 23rd of January 1579 in Utrecht, we met on the 5th of September in the area of Drienerlo. All the representatives of the respectful association for Electrical Engineering, Scintilla, were present. There were the always passionate hardcore electrical engineers, who had set aside their hobby projects for a few hours and made their way over to the Carré on that faithful evening. A delegation of the beer enthusiasts could also be seen, even though they may have just been there for the complementary beer afterwards. Concluding, there were several veterans who have been to these kinds of meetings before and who found themselves capable of giving feedback wherever they could. Whether they were capable is something we shall not discuss. But I digress.

On this meeting the all wise conclusion was made that the new leaders of this much beloved association should consist of a certain group of young men, who with all their enthusiasm should lift this association to new levels! And so, the 88th board of E.T.S.V. Scintilla was charged.

Then came the first weeks, much like the battles at the Sommes the standoffs

between the groups lasted for weeks, with the loyalties changing so fast it made us all look Italian. These constitution drinks did however strengthen the bond between us and several of our allies, resulting in a strong central position on the balcony, ensuring our relevance in the world and giving us the tools to carry out our goals.

Then came the times of peace, where focus was put upon building and enhancing the association. And much like the start of the Dutch republic set the foundation of the golden age of Holland, there was also a certain age that followed the charging of this board. Whether it's golden is something that shall be concluded, as often happens with history, only after the age has passed.

During this age many things have happened, many events that shall hopefully not be forgotten. But even if they are, there will still be one group of six men who shall always look back at this period as one with lots of ups and downs, but certainly one we do not wish to forget. Because as a board you get the chance of standing at the steering wheel of the Santa Maria like Columbus and even though you may not always find the India you were looking for, you certainly find something interesting.



But something is brewing in the depths of the association and I feel that our time may be coming to an end soon. Just as on the 14th of July in 1789 in Paris, the 4th of September 2018 may be the date where our fortress of government will be stormed and our heads will get chopped off to make room for a new set of heads. And so this cycle continues, as it has done through the course of history.

And with this piece of history coming to an end, so is my last presidential note. It has been an honour and I hope to keep seeing Scintilla shine throughout the years!

Dames en Heren,  
Op de koningin, op Scintilla!

Koen Raben  
President of the 88th board of E.T.S.V. Scintilla

# Masthead

## De Vonk

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## 08 Main Article

In 2015, Scintilla celebrated 50 years of existence. We have collected some historic moments from the extensive history of the association and the UT.

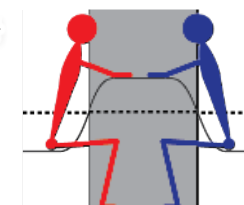


## 34 ICD Excursion

On the 18th of May, Scintilla went on an excursion to Innovatie Cluster Drachten in the north of the Netherlands. Go to page 34 to read more about this excursion.

## Junction 24

Since February, Hugo Masselink is the new staff member for Bureau Onderwijs-Zaken (BOZ, or the educational support department) for Electrical Engineering. We had a nice talk with him.



## Batavierenrace 36

As a rich tradition, Scintilla participates in the Batavierenrace every year. The 2018 edition took place on the 20th and 21st of April. We asked two people to describe their experiences.



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# Editorial

Dear reader,

In front of you is a new edition of De Vonk. It has once again been filled with a wide range of interesting articles.

The theme of the main article is somewhat special as it winks to the past. An overview of not only Scintilla's history, but also that of the entire UT, will probably make anyone long for those good old days. Our cover artist, Matthijs, even made a matching cover! Question is of course if anyone will recognize the design of the cover. This time, however, we decided not to make a puzzle about it. For those interested, the cover of this De Vonk matches those of the first few editions of the magazine ever (going back all the way to 1982!).

The rest of De Vonk has been filled with a Master's assignment written by Jippe, an article on evaluation mechanisms in education, an interview with Hugo Masselink and much, much more. The Puuzle in this edition presents another challenge to you as a reader and will hopefully provide you with something to do during all the spare time of the summer holidays.

Speaking of the summer holidays, I wish you a great time for the remainder of this relaxation period. I am personally greatly looking forward to the Kick-In, where we will hopefully be able to welcome many new students to the Electrical Engineering, Embedded Systems and Robotics and Mechatronics programmes!

See you around!

Stef



# News for the Electrical Engineer

## A smartphone that works in every frequency band

With 4G and soon 5G, the number of frequency bands that a smartphone needs to handle has increased dramatically. These bands are usually handled by a dedicated set of discrete bandpass filters between the antenna and the transceiver. Switches determine which filter is selected, and thus which band is passed and which signals (interferers) are blocked. The interferers can have a billion times more power than the signal that we try to receive, and thus must be removed as soon as possible.

These filters are more expensive and physically larger than the transceiver itself, while the switches, the filters, and the connections to the chip introduce losses for the signal to be received. In the past few years, ICD has worked on providing the required filtering on-chip using so-called N-path filters [1]. By changing the clock frequency, the center frequency of the resulting bandpass-filter can be changed, which essentially means that one N-path filter could replace the complete set of external filters!

In the basic form shown, the filtering performance is not good enough, and unfortunately even deteriorates at hi-

gher interferer powers. Moreover, it is somewhat noisy, which makes receiving the signal of interest more difficult. Using several improvements to the standard topology, the ICD-group has been able to tackle all of these problems, resulting in a receiver that is suitable for receiving any cellular signal at any frequency below 6GHz [2]. It reduces cost, precious PCB-area, and can be used on every continent, so it is probably a matter of time before all smartphones will exploit this technique!

*Written by the Integrated Circuit Design group*

[1] Klumperink, E. A. M., Westerveld, H. J., & Nauta, B. (2017). *N-path filters and Mixer-First Receivers: A Review*. In *Custom Integrated Circuits Conference (CICC), 2017 IEEE Piscataway: IEEE*. DOI: 10.1109/CICC.2017.7993643

[2] Lien, Y.-C., Klumperink, E. A. M., Tenbroek, B., Strange, J., & Nauta, B. (2018). *Enhanced-Selectivity high-linearity low-noise mixer-first receiver with complex pole pair due to capacitive positive feedback*. *IEEE journal of solid-state circuits*, 53(5), 1348-1360. DOI: 10.1109/JSSC.2018.2791490

## Two groups join nano-forces

The groups of Semiconductor Components and Micro Sensors and Systems have decided to merge into one new

*Author: Maarten Thoonen*



group last year. You've probably met the lecturers from these groups on several occasions (or you skip class too much): Cora Salm, Remco Wiegerink, Alexey Kovalgin, Ray Hueting and Jurriaan Schmitz. We all work on micro devices, either purely electrical (SC group) or electromechanical (MSS group).

What does it mean to merge? We're only halfway discovering just that. Both groups had a kind of Christmas party, but the one person who attended both can testify that major cultural differences still need to be overcome. While the MSS group went to the Munster Christmas Market and mostly drank beer, the SC group had a wine tasting experience in Haaksbergen, of all places. Is it possible to bring beer drinkers and wine drinkers together? We hope that the bachelor and master students in our group can give us some advice on the matter. We particularly favour experimental approaches in this respect. There

# In other news

are rumors about a Karaoke party somewhere in Delden where people from both groups made their first attempts to drink beer together.

The one thing we agreed upon immediately, is that we needed a new name for the formed group. As many as 35 names were suggested... We had to apply a bio-inspired genetic algorithm to select the best one. The result is: Integrated Devices and Systems, abbreviated as IDeas. Come to think of it, one of the best ideas of the year!

*Written by the Integrated Devices and Systems group*

## RFID tags have now been configured to work as sensors

These days, many retailers and manufacturers are tracking their products using RFID, or radio-frequency identification tags. Often, these tags come in the form of paper-based labels outfitted with a simple antenna and memory chip. When slapped on a milk carton or jacket collar, RFID tags act as smart signatures, transmitting information to a radio-frequency reader about the identity, state, or location of a given product.

Now engineers in a research group at MIT are flipping the technology toward a new function: sensing. They have de-

veloped a new ultra-high-frequency, or UHF, RFID tag-sensor configuration that senses spikes in glucose and wirelessly transmits this information. In the future, the team plans to tailor the tag to sense chemicals and gases in the environment, such as carbon monoxide.

*From: MIT engineers configure RFID tags to work as sensors written by Jennifer Chu, <http://news.mit.edu/2018/mit-engineers-configure-rfid-tags-to-work-as-sensors-0613>*

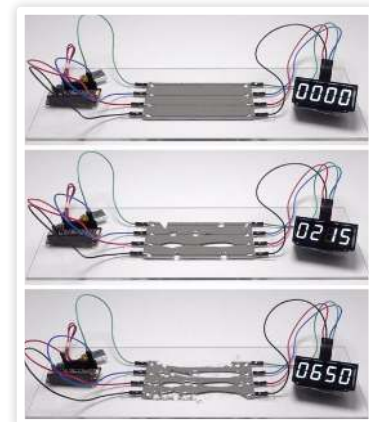
## Self-healing material a breakthrough for bio-inspired robotics

Many natural organisms have the ability to repair themselves. Now, manufactured machines will be able to mimic this property. In findings published this week in *Nature Materials*, researchers at Carnegie Mellon University have created a self-healing material that spontaneously repairs itself under extreme mechanical damage.

This soft-matter composite material is composed of liquid metal droplets suspended in a soft elastomer. When damaged, the droplets rupture to form new connections with neighboring droplets and reroute electrical signals without interruption. Circuits produced with conductive traces of this material remain fully and continuously operational when severed, punctured, or had material removed.

Applications for its use include bio-inspired robotics, human-machine interaction, and wearable computing. Because the material also exhibits high electrical conductivity that does not change when stretched, it is ideal for use in power and data transmission.

*From: Self-healing material a breakthrough for bio-inspired robotics on <https://www.sciencedaily.com/releases/2018/05/180521131748.htm>*



*Figure 1: A digital clock continues to run as damaged circuits instantaneously heal themselves, rerouting electrical signals without interruption.*

*Credit: Nature Materials*

# A brief history of Scintilla

In 2015, Scintilla celebrated 50 years of existence. A lot of things have happened since the establishment of the association in 1965. Rich traditions were born that have shaped not only the history of Scintilla, but also that of the University of Twente. We have collected some historic moments from the extensive history of the association and the UT.

Author: The 88th board



## 1960

**1961**  
Establishment Technische Hogeschool Twente  
The University of Twente was established on the 23rd of November, 1961. Originally, the educational institution was named Technische Hogeschool Twente. Her Majesty Queen Juliana opened the THT on September 14th, 1964.

There were only 4 departments in the early days of the UT; Mechanical Engineering, Electrical Engineering, Chemical Engineering and General Sciences.



**1965**  
Establishment E.T.S.V. Scintilla  
A number of Electrical Engineering students united and established the study association for Electrical Engineering on the 9th of September, 1965. The name 'Scintilla' was convincingly chosen over others after a vote at the general meeting.

In the first few years the association focussed on organizing small symposia where speakers would gather to discuss recent Electrical Engineering related developments.

- |               |                 |
|---------------|-----------------|
| 1. Scintilla  | : 6 stemmen.    |
| 2. Panta Rhei | : geen stem.    |
| 3. E.S.D.     | : twee stemmen. |
| 4. Edison     | : een stem.     |

Result of the vote on the association's name.



Buildings the Hogenkamp and Bastille in 1969.

**1969**  
Scintilla receives royal recognition  
On the 12th of December, 1969, Queen Juliana grants royal recognition to the association. The document with the recognition can still be found in Scintilla's association room.

**1970**  
Invention of the microprocessor

**1970**  
Expansion of the THT  
Next to the four 'original' departments, the THT was expanded with new study programmes in 1970, such as applied mathematics and applied physics. In addition, several non-beta degrees were introduced.

**1970**  
S.c.v.m.d.d.v.s.h.g. Arago founded  
With the new applied physics degree (that was back in those days closely tied to Electrical Engineering) several physics students wanted to start their own association. The board of Scintilla interpreted this as a need for a new committee that would be involved with this new Electrical Engineering movement called physics, hence it established s.c.v.m.d.d.v.s.h.g. Arago, the committee for people who chose the wrong study.



A picture of the Batavierenrace from Nijmegen to Enschede in 1975.

**1974**  
First Batavierenrace from Nijmegen to Enschede  
The Batavierenrace that still followed the route Nijmegen-Rotterdam in 1973 was remapped in 1974 to follow the route Nijmegen-Enschede. This race is still being ran on a yearly basis. Scintilla's president traditionally runs the last stage.

**1971**  
Establishment of Scintilla's committee for component sales  
The need for supply of electronic components for study and hobby projects resulted in the establishment of a committee that would handle component sales. 'Commissie Componenten Verkoop Scintilla' is the predecessor of the STORES and was founded in 1971.

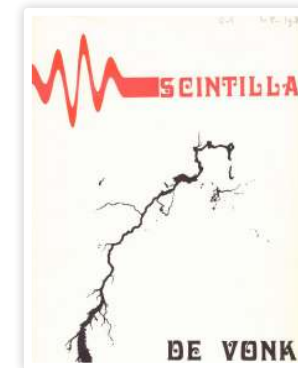


An Electrical Engineering student in a laboratory in 1971.

**1973**  
Invention of the mobile phone

**1980**  
Establishment of the study programme for Computer Science

**1982**  
Publication of the first 'Vonk'  
In 1982, Scintilla published two try-out versions of an association magazine called 'de Vonk'. The editions turned out to be a success and paved the way to the 36 years in which the Vonk has been published up to now.



**1983**  
Invention of C++

**1984**  
Invention of the CD-ROM

**1986**  
THT changes name to Universiteit Twente  
With the national establishment of Technical Highschools (HBO), the Technische Hogeschool Twente changed name to Universiteit Twente to prevent confusion.

**1989**  
Campusnetwork in use  
The big computer network of the UT was first used in 1989. Back in the days the network comprised a rough 2000 connections.

## 1990



**1989**  
Scintilla introduces the cantus in Twente  
A delegation of Scintilla members was invited to a cantus in Leuven, Belgium, in 1989. They were seriously impressed by this amazing combination of discussing, singing and drinking beer.

In September 1989, Scintilla hosted the first cantus in Twente.



1990  
**5th lustrum of E.T.S.V. Scintilla**  
 In October 1990, Scintilla celebrated 25 years of existence. This 'lustrum of the lustra' was full of activities, such as a concert, an attempt to break the record for putting as many people in the car 'de Eend' as possible and of course a lustrumcactus.

Next to the fun activities, there was also a symposium with many interesting speakers.



Logo of the 5th lustrum of Scintilla.

## 1990

1990  
**Establishment of the STORES**  
 Scintilla's committee for component sales changed into Scintilla's Trading-Organization for Reduced-priced Electronics and Study-needs in 1990. The STORES still sells a wide range of electronic components today and is one of the biggest committees of Scintilla.



1991  
**Establishment of SCALA**  
 Scintilla's commissie voor allerlei leuke activiteiten (committee for all kinds of likeable activities) started in 1991. Over the years, SCALA has established many traditional activities, such as the EEF-BA, Christmas Dinner and computer destruction.



Screenshot of the Scintilla website in February 1997.

1994  
**Invention of Bluetooth**

1997  
**Scintilla launches its first website**  
 The first website of Scintilla was launched in 1997. It contained information on activities, the STORES, the study and had an exam database.

2002  
**Bastille is handed over to the Student Union**  
 As of 2002, the Student Union is responsible for the Bastille building. The Union represents most student bodies of the UT and has several committees that help the board with its tasks, such as the management of the Bastille.

2001  
**Reorganisation of the faculties**  
 The University of Twente executed an impactful reorganisation of the faculties in 2001. The number of different faculties was reduced to only 5 of which the new faculty of Electrical Engineering, Mathematics and Computer Science was one. As a result of this new division, Scintilla eventually relocated to the Zilverling along with Abacus and Inter-Actief. This relocation brought an end to multiple decades with Arago in the Hogenkamp.



2002  
**Fire in the TWRC building**  
 On the 20th of November, 2002, a large part of the TWRC building burnt down. The fire destroyed sections A and D of the building. When the name of the building changed to Cubicus, the sections B and C were preserved in memory of the old building.

2006  
**Publication of the compendium**  
 In 2006, several people at Scintilla published a compendium with relevant knowledge for electrical engineers.

2006  
**Protocol de Jong**  
 Back in 2005, a treasurer turned out to be quite the fan of a nice bottle of wine. Of course, red wine had the preference as red is the traditional colour of Scintilla. He developed a standardized way to enjoy a bottle of wine with the entire board. This rich tradition is still present within the association and is the preferred way to consume a bottle of wine with the Scintilla board.

2007  
**Establishment Stichting Borrelbeheer Zilverling**  
 In 2007, several associations combined their strengths in the organization of the drinking rooms and the acquisition of drinks. The Abscint and MBasement are being managed by SBZ.

2010  
**IKEL becomes SKIC**  
 The committee responsible for the organization of the introductory camps for new students in Electrical Engineering changes to its new name in 2010.

2012  
**The Electrical Engineering programme switches to English**  
 The Electrical Engineering programme staff implemented the language change in 2012. English as the primary language at Dutch universities remains a hot topic, even today. With only 4 programmes left that are being taught in Dutch, the change in language has been thorough. Question remains if the language impacts the quality of the programmes; the UT is facing several parties in court that are convinced that this development poses a threat.

2013  
**Introduction of the Twente Educational Model**  
 In 2013, the UT introduced the TEM after a few pilots in which the Electrical Engineering programme took part. The UT wanted to educate its students to the professionals that can add new knowledge to their area of expertise through a critical and curious attitude.

2015  
**10th lustrum of E.T.S.V. Scintilla**  
 2015 marks the 50th year since Scintilla's establishment in 1965. The many activities made the lustrum a success, even the first board made its appearance.



Logo of the 10th lustrum 'To infinity'.

2017  
**Start renovation building the Hogenkamp**  
 After several years of vacancy, the UT has repurposed the Hogenkamp building as a student hotel. The old home of Scintilla and Arago will be renovated over the course of 2017 and 2018 to include several studios for students and the Drienerburgh hotel.

2017  
**100th Cantus Scintillae**  
 After the successful introduction of the Cantus to Twente in 1989, 2017 marks the 100th edition of this festive activity. In the 30 years since the first edition, other associations have taken over the example set by Scintilla. In addition, the Cencores Cantus Scintillae has recently published already the 3rd edition of the Codex Scintillae.

2018  
**Scintilla study tour to China**  
 Every couple of years, Scintilla organizes a large trip to several foreign destinations. The study tour allows students to visit companies and universities abroad and is partly being financed by executing business cases. The 2018 edition of the study tour will be visiting China.

Other examples of trips that are being organized by Scintilla on a frequent basis are the EEMCS-trip to a European destination and the skiing trip to a ski resort.

2018+  
**Future plans**  
 Several longer running projects are being worked on, such as a new website for the association.

## 2020

What will the future bring?

Scintilla is thriving. The past 50 years have shaped an association that is supporting its members in their education and business orientation and is offering students a second home. Long term policy plans are ensuring that Scintilla will continue fulfilling this role for the near and not-so-near future and we as the 88th board are longingly looking forward to what future boards will bring.

But whatever the future may bring, it is important that we frequently look back at what has been accomplished in the past. We hope that the next 50 years will be as thriving as the past half century has been.

# Alliander and the energy transition

The Netherlands wants to become a society without CO2 emissions as soon as possible but in 2050 at the latest. One of the major challenges to achieve this feat is to put an end to the use of natural gas as the main source of the heating of homes in every part of the country.

This means that alternative options need to be investigated for all 1000 districts within the 160 municipalities in Liander's service area. Alliander is an independent network company and secures the public interest during the (re-)arrangement of the energy infrastructure: we ensure an energy supply which is reliable, affordable and sustainable, and available to everyone under equal conditions. How does gas and electricity distribution grid operator Liander contribute to that?

## Phasing out the use of natural gas

Together with 200 other countries, the Netherlands has agreed to the Paris climate agreement. Following this commitment, the government has set the target to reduce carbon-emissions to almost zero by 2050 in the National Energy Agenda. Part of the agenda is reducing the use of fossil fuels such as natural gas. This has of course a direct impact on the current distribution network. Every gas pipe which is installed today, will have to be written-off sooner than its economic life of 40 years. The costs of the infrastructure are ultimately divided

and paid by all clients connected to the network. This means that the right timing is critical in order to minimize the social cost for all residents, companies and organizations which are affected by the energy transition. The decision

*"The electricity grid historically was not designed for the large peaks induced by these novel technologies."*

to use an alternative source of energy is ultimately not decided by the economic value of the current network assets, but the social cost of becoming more sustainable in a district where the gas network was recently reconstructed are evidently higher than in a district with older infrastructure. Electrification is a large trend which will be accelerated due to the phasing out of natural gas. Besides the rise of electric vehicles and decentral photovoltaics, households will increasingly make use of heat pumps for heating and more flexible solutions such as home battery solution. The electricity grid historically was not



Author: ir. S. Bal

designed for the large peaks induced by these novel technologies. In the light of these changes, Liander wants to be a facilitator in the energy transition by pro-actively sharing knowledge about the existing energy networks, possible alternatives and the technical and financial consequences of those alternatives. Part of this builds further on the (electro-)technical knowledge that has ensured the stable energy distribution all these decades, but part of it also requires innovation and use of data and analytics.

## Insight through analytics

Use of the vast collection of data and extracting insights from these using advanced analytics has become indispensable for almost any company. The shift from fossil-fueled (steady), central energy production to a more renewable (intermittent), decentral system requires a new approach to operate and design the electricity network. Impacts of novel techniques need to be quantified on various levels.

The core business remains to build a sta-

ble, accessible energy infrastructure and in order to do so, we need it to be able to cope with photovoltaics on rooftops, charging Teslas and electric heat pumps. To avoid netplanners and net architects to be flooded with the rapid changing environment, various teams investigate how load profiles of households/utilities/etc. will look like in the future. The new load profiles are then incorporated in the design cycle. Not only the how, but also the when and where are important questions. Spreading models such as the Fysher and Pry model are used to model adoption of PV/EV/HP:

$$f(Y_t) = \frac{1 + \text{TANH}(\alpha * (t - t_k))}{2} * (Y_{max} * P)$$

In the above equation,  $t$  denotes the time and  $t_k$  the half point year where half of the investigated households have adopted the technology,  $Y_{max}$  the maximum number of households and  $P$  the current saturation level of adoption rate. The outcome gives an indication of where to expect the impact of the energy transition on a local level. Using this tool strategically, deeper net investments such as the construction of new substations can be seen coming more in advance.

## Fact-based decision-making

Having an insight in the technical impact is still only part of the solution. The energy transition has a playing field with many actors on local, national and international level. In order to combine

*"The energy transition has a playing field with many actors on local, national and international level."*

as much information and points of view, a dedicated team of data analysts has developed an internal GIS application which very quickly shows all data available on these districts of towns. Basic information such as the amount of households/companies, the level of isolation or energy consumption. But also the state and age of the gas network, the reserve capacity of the electricity network. Furthermore, use of knowledge on alternative solutions and historical data

gives an indication of how likely it is that a district will choose a certain option in the future.

By combining these different insights and overlaying the data in the GIS tool, it is possible to construct a heat map where the best locations to start with are. Relation managers can then get into contact with the municipalities to provide a substantiated view of Liander's view, which incorporates the social interest. Opportunities for transitioning can be identified together and disinvestments due to the transitioning in a district where a new gas network was put in place the year before can be reduced.

## Conclusion

During the shift of energy system, the role of the distribution network operator will change. Liander does not want to be an impediment, but uses its knowledge and innovation to prioritize the most favorable locations in order to put the renewable ambitions of households and companies into practice.

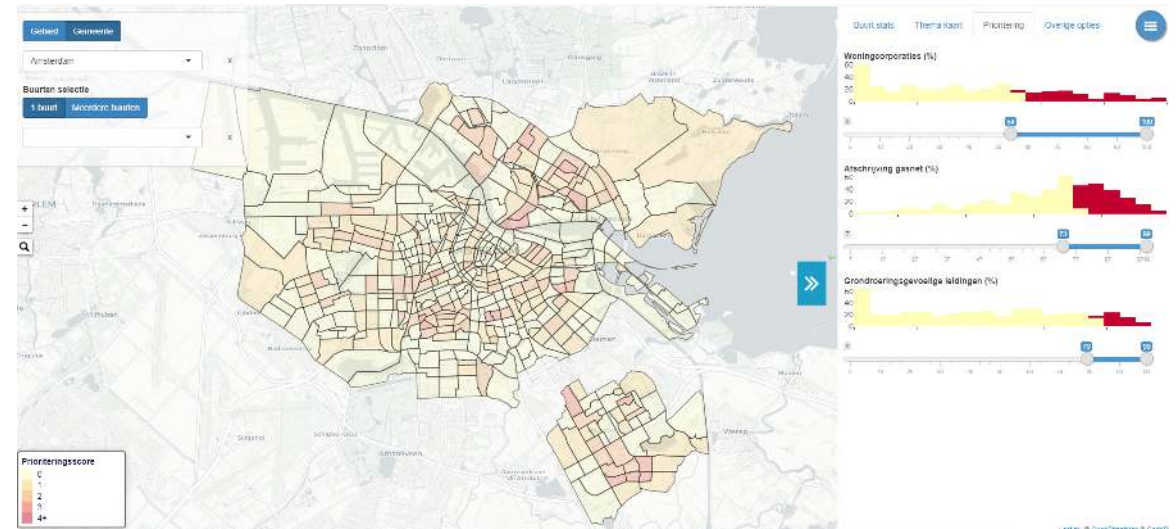


Figure 1: example of the GIS tool



# Spatial Multiplexing

With the progress in processing power in digital communication systems, many new techniques to increase performance have been invented. There remain, however, a few complications in such systems. Multi path fading causes systems to introduce self-interference when communication signals in the form of electromagnetic signals are reflected by objects along the transmission path. These reflections cause delayed instances of the original signal on the receiver of the communication line. These delayed instances add to other interference signals and deteriorate the Signal to Noise Ratio (SNR).

By employing Direction of Arrival (DOA) estimation techniques it is possible to determine the angle of incidence of incoming signals. The receiver can be tuned to only receive signals from a particular direction and effectively cancels undesired signals from other directions. This technique is called beamforming.

When the transmitter is also equipped with an array of antennas, also the transmitted beamfront can be steered. By using superposition, multiple signals can be transmitted in multiple directions. When these techniques are used at the same time, many different combinations of transmit and receive angles

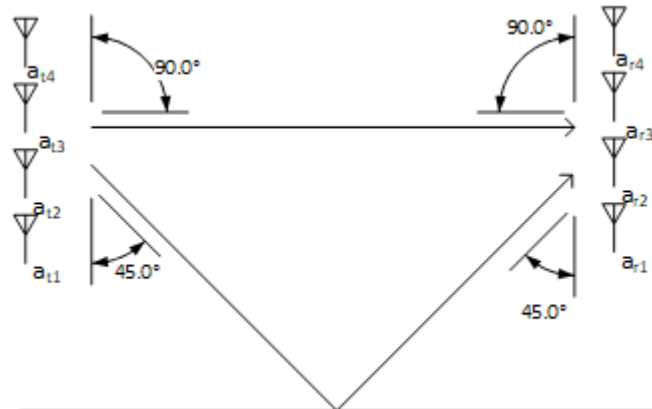


Figure 1: Arbitrary room with two antenna arrays. Between the arrays a direct path is present as well as a path along a reflector.

Author: Jippe Rossen



are possible. This will change the system into a multiple-input-multiple-output (MIMO) system. Figure 1 shows a simple case illustrating such a scenario.

## Finding the spatial paths

To be able to exploit these spatial paths and send different bitstreams over different paths, two key aspects need to be achieved. The first is that all possible paths between the transmitter array and the receiver array need to be characterized. For every transmitter receiver antenna pair, each path will have a certain characteristic in phase and gain. By the superposition principle, the combination of all these paths will determine the total dependency concerning phase and gain of the path between these antenna

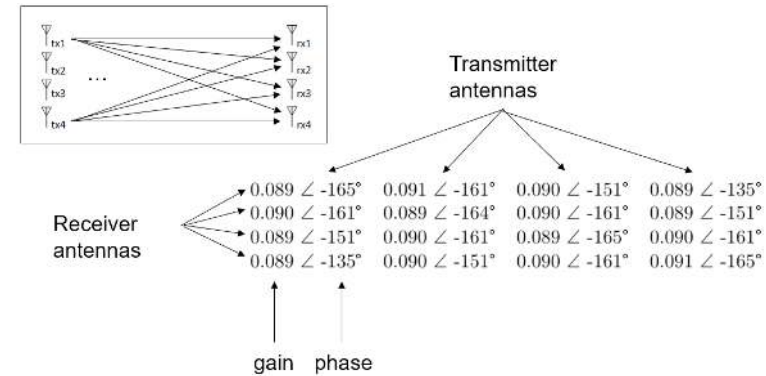


Figure 2: Polar representation of a typical channel matrix. Each cell contains a relation for both the phase and the magnitude between a transmitter- receiver antenna pair.

pairs. When this relation is determined for every antenna pair possible, the channel matrix H is determined. Figure 2 shows such a channel matrix in polar notation. It is easily identified that each cell contains a phase shift and a gain.

The matrix H incorporates information about all the possible paths between each antenna pair between transmitter and receiver. Equation 1 shows the relation between a transmitted signal, the received signal and the transmission matrix H.

$$y = Hx + w \quad (\text{eq. 1})$$

Linear algebra shows that every matrix can be decomposed into three other matrices; a rotation matrix, a scaling matrix and another rotation matrix, which is called a Singular Value Decomposition. This operation can be interpreted as

two coordinate transformations and a simple scaling operation. The coordinate transformations effectively map the multipath channel into multiple single path channels which can be called eigenmodes. Each of these eigenmodes can be used to transfer individual data signals, increasing the total transmission capacity. Equation 2 shows this decomposition mathematically and figure 3 shows how the result of this operation can be interpreted as multiple single path channels[1][2].

$$H = UAV^* \quad (\text{eq. 2})$$

The operator \* denotes the Hermetian, or complex conjugate transpose, the values in the vector x are the signals broadcast by the transmitter array antennas and the values in the vector y are signals that are received by the receiver array antennas.

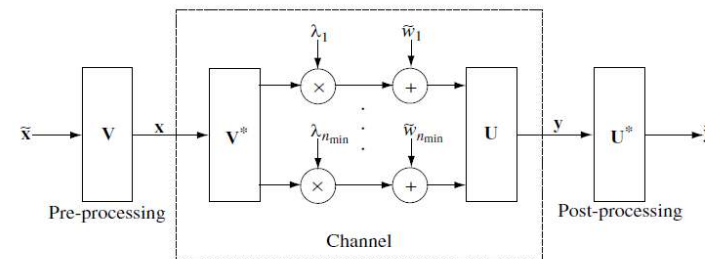


Figure 3: Graphical representation of how a singular value decomposition can be used to interpret a multipath channel as multiple single path channels.

Figure 3 shows that the vectors of these matrices are used for coordinate transformations at both the receiver as the transmitter. These transformations map the signals onto the eigenmodes and afterwards map them back to the original coordinate frame. The eigenmodes are thus in fact the spatial paths, which take care of the required phase shifts for each of the antennas in both the transmitter as the receiver array. The phase shifts of each of these vectors (left singular vectors for U and right singular vectors for V\*) should thus relate to the physical direction the array sends or receives most of its transmitter power from.

The coordinate transformations also imply that the maximum number of eigenmodes available is equal to the smallest number of antennas in either of the arrays. The dimensions of the channel matrix H are dependent on the number of antennas in either of the arrays and thus also determine the amount of eigenmodes described by the singular value decomposition.

The singular values found in the matrix  $\Lambda$  indicate the suitability of an environment for spatial multiplexing. The singular values each correspond to an eigenmode and are ordered from strongest to weakest. For a perfect scenario, all these singular values would have the same value. In that case the power could be distributed equally giving the maximum link capacity. This scenario only exists when the eigenmodes are guided from transmitter to receiver through cables, which isolates each eigenmode completely from one another.

For a wireless system the signals do interfere with one another causing the singular values to drop. The lower a singular value is, the weaker the corresponding eigenmode is. The singular values should be assessed simultaneously with the SNR to see whether it makes sense to allocate power to a specific eigenmode at the SNR of that eigenmode. This

allocation of power is generally done using waterfilling techniques. During waterfilling, power is allocated to the eigenmodes to achieve optimal link capacity.

### Estimating the channel matrix

So far it was assumed that H was known to both receiver and transmitter. In any realistic scenario this is not the case, thus it must be estimated. To do this, a training sequence is required. The training sequence is known to both the receiver and the transmitter and is used to determine the transfer function between all possible combination pairs of transmitter and receiver antennas. A lot of research has been done on the topic of optimal training sequences for specific systems and environments. As the proposed setup is a stand-alone communication system in an arbitrary environment, the transfer function and noise distributions are unknown. Therefore, a least squares estimation is best suited to find the H matrix, see equation 3.

$$H_{LS-estimate} = YP^*(PP^*)^{-1} \text{ (eq.3)}$$

In this equation Y denotes the received samples. It is an n-by-k matrix in which n is the number of antennas in the receiver array and k the number of training samples. P is the training set consisting of k samples for the m transmit antennas. P is chosen such that  $PP^*$  is an m-by-m diagonal matrix.

### Spatial multiplexing applied

To test the theory concerning spatial multiplexing, both simulations as experiments can be performed. The steps taken are as following:

- Use a training signal to perform a least squares estimation to find the channel matrix H.

- Perform a singular value decomposition to obtain the singular values and to find the singular vectors that reside in the matrices of U and  $V^*$ .
- Analyze the found singular values and vectors and relate them to the physical/simulated setup.

The simulations and experiments are both performed using a modulation frequency of 1.4GHz. The antenna arrays are spaced three meters apart and the distance between the antennas in each array is 107mm (which is half the wavelength of a 1400MHz signal). The experiment is performed inside an anechoic chamber. In such a room, reflections are being absorbed by the cone shaped material which is attached to the walls of the room. A reflection can be created by introducing a reflective surface to the room.

The two antenna arrays are positioned in the room such that they face right at one another so that the maximum gain for both the transmitter as the receiver is located at 0 degrees. Figures 4 and 5 show the resulting angular sensitivity of the receiver array for the simulation and the experiment respectively. It is seen that the maximum gain for the strongest eigenmode is close to 0 degrees.

When the receiver array is rotated, the angular sensitivity of the receiver array should change accordingly. Figures 6 and 7 show the angular sensitivity of the receiver array when the array is rotated 30 degrees counterclockwise. It is observed that the maximum gain of the array indeed is shifted towards 30 degrees, showing that the system is capable of adjusting itself accordingly.

A reflection can be induced by introducing a sheet of metal to the room. In this case the reflective surface was positioned in such a way that it induces a reflection with an angle of -45 degrees at the receiver. For the experiment, the receiver array is still in a rotated position of -30 degrees. This setup would imply that the strongest eigenmode is expected at an angle of 30 degrees and that the second eigenmode is expected at an angle of -15 degrees.

The results for both the simulation and the experiment can be seen in figures 8 and 9. Comparing the results to the case without the reflection (figures 6 and 7), the behavior of the second eigenmode (ev2) changes drastically. In the simulations, the maximum gains are located at -18 degrees and 29 degrees, while in the experiment angles of -8 degrees and 22 degrees are found. The differences between the simulations and the actual experiment are most likely caused by differences in phase offsets and gain between each of the antennas.

According to the theory concerning the Singular Value Decomposition, the singular values should also indicate that the second eigenmode has increased in strength by the addition of the reflective surface. Table 1 shows that the second singular value went up from 0.05 to 0.09, indicating that indeed a secondary channel has been induced into the system.

### Conclusion

During my research I have successfully created a setup by which spatial multiplexing can be evaluated in real life ex-

	SV1	SV2	SV3	SV4
With reflector	0.1890	0.0923	0.0363	0.0074
Without reflector	0.2201	0.0544	0.0313	0.0063

Table 1: Found singular values for the experiment with and without a reflector present in the anechoic chamber.

periments. The setup is likely to be used for demonstrations and further research at the CAES and ICD research groups and although MIMO is already featured

in 4G (and soon 5G as well), research is still ongoing on how to improve the techniques even further.

[1] Andreas F Molisch. *Wireless communications, volume 34*. John Wiley & Sons, 2012.

[2] Rohde & Schwarz GmbH & Co KG. *Assessing a mimo channel | - 8nt01 | rohde & schwarz, 2017.*

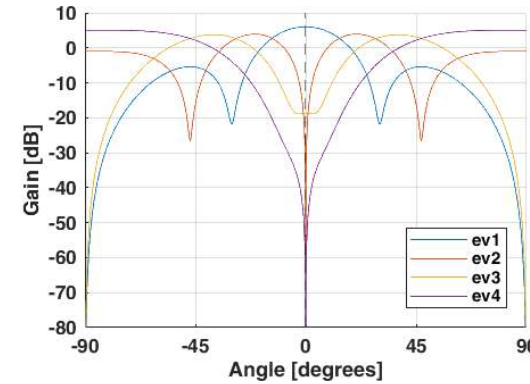


Figure 4: Angular sensitivity of the receiver array for the simulation with only a direct path present.

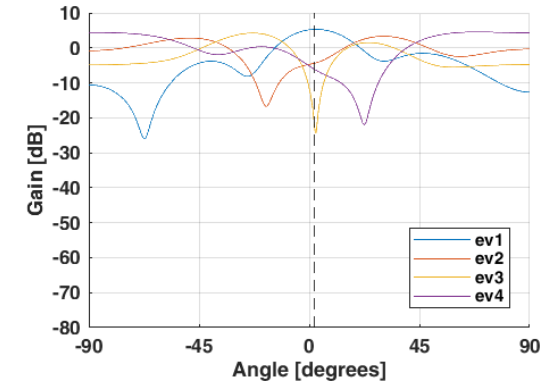


Figure 5: Angular sensitivity of the receiver array for the experiment with only a direct path present.

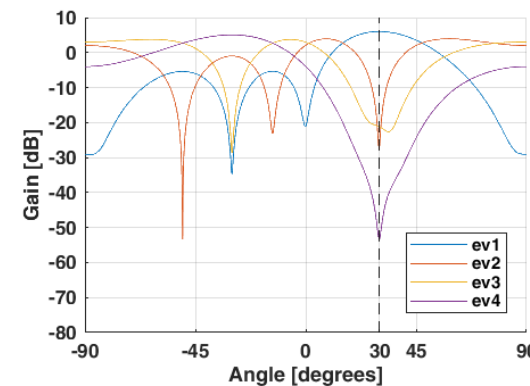


Figure 6: Angular sensitivity of the receiver array (rotated -30 degrees) for the simulation with only a direct path present.

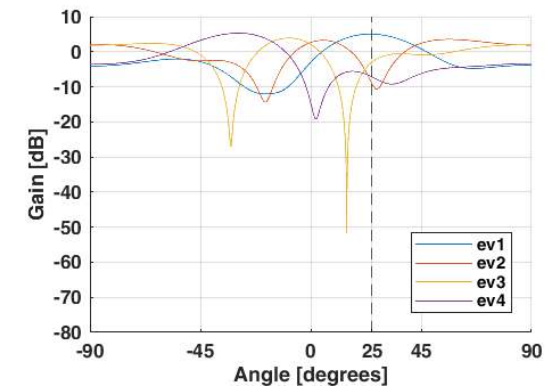


Figure 7: Angular sensitivity of the receiver array (rotated -30 degrees) for the experiment with only a direct path present.

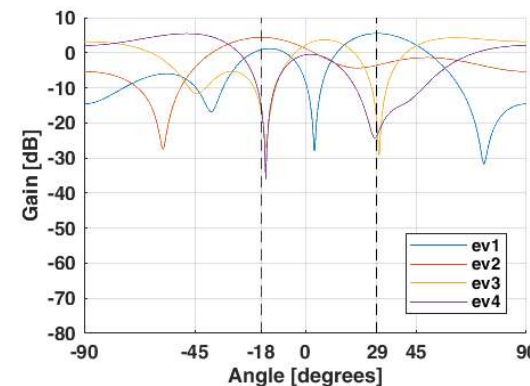


Figure 8: Angular sensitivity of the receiver array (rotated -30 degrees) for the simulation with a direct path and a reflection present.

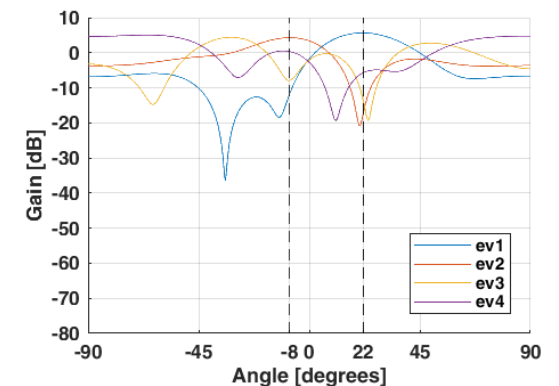


Figure 9: Angular sensitivity of the receiver array (rotated -30 degrees) for the experiment with a direct path and a reflection present.



# Evaluation mechanisms

Remember that time when mobile phones still had the size of a brick? In roughly 30 years' time, mobile phones have developed to the incredibly fast and powerful smartphones of today. To make sure we can keep innovating the technology of today, we need flexible education that cannot only keep up with these advancements, but education that is one step ahead. In our common effort to tackle the challenge to deliver such a degree of flexibility, we are constantly advancing our university programmes. But at what cost? Are the innovations we introduce in education actually effective?

Answering these questions is rather difficult. The quality of education cannot simply be measured through an oscilloscope or multimeter. Of course, one could argue that simply comparing a new form of teaching (think of Problem Based Learning) to the previous one is a way to establish at least relative quality. But what criteria would you compare? And how would they stack up to form a final verdict? Establishing these criteria has become a distinct science within academic education.

## Evaluation methods

To make comparison of evaluation results possible not only between the various editions of for instance a module, but also between the various modules or even between those of other programmes, the University of Twente has developed a standardized questionnaire. It has several indicators that score a value

on a 5 point-scale to a certain property, think of quality of teachers, division of study load, etc. Standardized questionnaires are very strong tools to compare educational units on a select set of fixed criteria. Unfortunately, they fail to capture problems that are beyond the scope of the formulation of the questions and heavily rely on a significant response rate to be of any use.

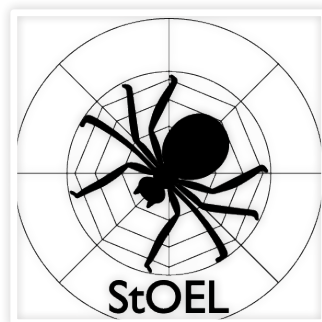
To cover these shortcomings, one would need a dynamic form of evaluation that

“The combination of standardized questionnaires and deepening interviews is the backbone of the university safeguarding its education.”



Author: Stef van Zanten

provides a much more complete picture. The programme staff foresees in this need for thorough evaluations through the OpleidingsKwaliteitCommissie (OKC) or Programme Quality Committee in English. The OKC evaluates education by interviewing students and publishes these results in reports that are presented to the programme committee. Also Scintilla's educational committee, StOEL, applies this evaluation technique. Restrictions on available manpower limit the use of these interviews to



exceptional cases, like 'problematic' situations or recent educational innovation. The combination of standardized questionnaires and deepening interviews is the backbone of the university safeguarding its education. With this knowledge in mind you might wonder how this benefits students; let us have a look at a recent case.

## Digital testing case

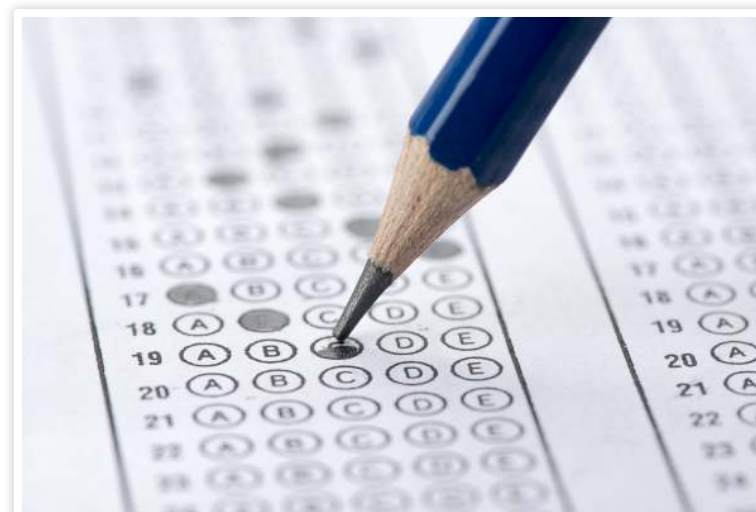
In the last few years, the vast increase of the student influx at the UT has surpassed the growth of the mathematics department. With a rough 1000 students each quarter, the number of students following the mathematics line is becoming too big to deliver test results in time. This is mainly why the UT has initiated a project group that is working on the implementation of digital testing. When implemented properly, this new method of testing has several benefits:

- Students receive instantaneous feedback
- The degree of flexibility of the tests increases
- There is a significant reduction in workload for teachers, saving time the teachers can invest in other tasks

There are many new concepts that have to be implemented to enable digital testing; an entirely new infrastructure is needed for formulating questions and collecting student responses. The project group has been working on developing these concepts, but the uncharted terrain requires thorough evaluation to determine the effectiveness.

“Digital testing results in a significant reduction in workload for teachers, saving time the teachers can invest in other tasks.”

Already back in 2015 have pilots been conducted with both of these concepts. The first digital tests were made on the laptops of students in a lock-down browser. It turned out that this lock-down browser was very easy to breach and that students were able to use other tools during the test. After this pilot, the project group interviewed students to ask them for alternatives. This has resulted in a close and very unique collaboration between the university and computer



science students to develop the use of a combination of Chromebooks, VLAN, IP-restriction and whitelisting for making the digital tests.

Also in the formulation of questions has evaluating proven to be very useful. The very first digital test was fully graded on final answers only. Students indicated they were doubting the fairness of such a system in the online questionnaires. The project group subsequently adjusted the composition of the mathematics tests to be 67% digital and 33% written.

Through the feedback provided by students in the online questionnaire, other drawbacks and pitfalls were easily identified. The initial estimate of the project group that students would be used more to digital testing in the current digital era turned out to be mostly incorrect. Not only did students indicate they need a lot of time to get accustomed to the new method of testing, they also indicated they were making much less use of scrap paper than when making written tests, resulting in more calculation errors.

The project group for digital testing is constantly analyzing all the evaluation results and using them for improvements. Their focus is now on developing a hybrid test that can measure the knowledge and skills in the first-years mathematics line, but feels familiar to students.

## Closing remarks

I personally think the digital testing case shows that evaluations are a very powerful tool in the process to improve education. It is very important for all students to continue providing feedback on their education, only then can we identify flaws and work on improving them. Feel free to send an email to [education@scintilla.utwente.nl](mailto:education@scintilla.utwente.nl) with any suggestions or questions you might have left.

# Scintilla's Power-Plant Committee

Author: Melissa Tijink

Although our favorite colour will always be red, you might have noticed that the Scintilla room has turned a bit greener lately. In the windowsill you can find sunflowers and tomato plants. It all started a couple of months ago, when a supermarket gave away plant seeds. They were placed in the Scintilla room and at first it looked like a funny experiment. Then the plants started to grow and grow and grow... While getting bigger and bigger, they still lived in the small carton boxes that came with the seeds.

As the plants grew, so did the enthusiasm from the members. The SPPC started, Scintillas Power Plant Committee. In this committee we discuss serious matters. The carton boxes were getting too small and plastic boxes and buckets were used to accommodate all the plants. The plants kept growing and



Figure 1: Shortly after the sunflower started blooming.

To be in this committee you do not need to be the best gardener (yet). The most important thing is that you like the plants. You might think, they are just green sticks in a box, what's so cool about that? Well... I will tell a bit about the plants that you can find in the Scintilla room.

While I'm writing this, I'm stuck at home and I have not seen the plants lately. Luckily the committee sends pictures of the blooming sunflowers.



## Sunflowers

To start with the sunflower. Sunflowers can grow to a height of 3 meters! The sunflowers in the Scintilla room keep growing so check them out once in a

“Sunflowers will tilt during the day to follow the sun!”

while to see how they grow. As the name suggests, sunflowers like sun. They will grow in the direction of the sun. They will tilt during the day to follow the sun! There is a nice mathematical model for the pattern of the florets (small flowers) in the head of the sunflower. H. Vogel made this model and it can be expressed in polar coordinates:

$$r = c\sqrt{n}$$

$$\theta = n \cdot 137.5^\circ$$

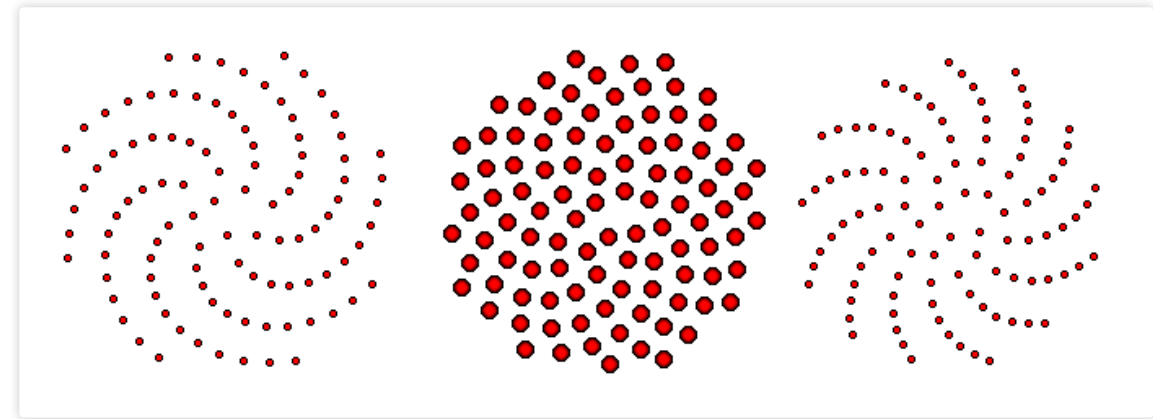


Figure 2: The pattern of florets produced by Vogel's model. The other two images show the patterns for slightly different values of the angle. By Salix alba at English Wikipedia.

Theta is the angle,  $r$  the radius (from center) and  $n$  is the index number of the floret.  $c$  is a constant. The angle is called the golden angle, because it is related to the golden ratio. This follows from the number of florets, these are Fibonacci Numbers. [1]. Nature is wonderful. The model looks like Figure 2.

## Cherry tomato

Another plant that you can find in the Scintilla room is the cherry tomato plant. The tomatoes in the Scintilla room will get our favorite color: red! But did you know that there also exist yellow, green and even black cherry tomatoes? And as we Scintillians like to discuss about anything, I have a question for you: is the tomato a fruit or a vegetable? Well at the next drink you can



Figure 3: Tomato plants just after transfer to their new home in the bucket.

show off with this tomato knowledge: botanically the tomato is considered a fruit, but culinary as a vegetable. Tomatoes have less sugar in them than other fruits, and that's why we eat them in a salad and not as a dessert.

“Botanically the tomato is considered a fruit, but culinary as a vegetable.”

As you can see there is much more about plants than you might have expected. Besides some colour and oxygen, these plants will hopefully also add to the relaxing environment in the Scintilla room. Gardening is experienced as a

“Besides some colour and oxygen, these plants will hopefully also add to the relaxing environment in the Scintilla room.”

very relaxing hobby. As students we spend a lot of time stuck inside, staring at our computers. Gardening brings

some healthy refreshment in this pattern.

Hopefully I have made you a bit more enthusiastic about these organisms that belong to the vegetable kingdom. When you think you don't have green fingers, but you want to start gardening you can try cress (tuinkers). It is really easy and you can eat it! If not, you can always go to the Scintilla Room and enjoy the plants there. And don't worry, they will be taken care of in the summer break.

[1] H. Vogel. A better way to construct the sunflower head. Elsevier North Holland 1979.

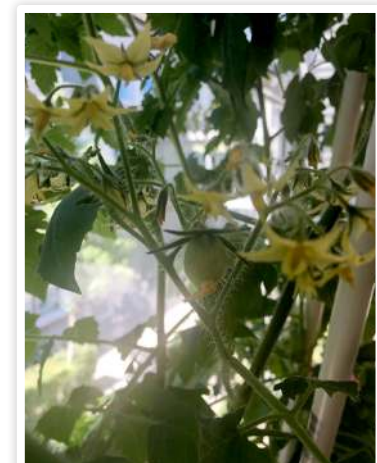


Figure 4: The first tomatoes appeared just before summer break.





**Voort Scrapheap Challenge**

**Active Member Activity**

**STAF Tournament**

**Game of Thrones**

**Sing the Stars from the Sky Drink**

**EEMCS Trip**



# Junction

A chat with: Hugo Masselink

Since February, Hugo Masselink is the new staff member of Bureau OnderwijsZaken (BOZ, or the Educational Support Department in English) for Electrical Engineering. We had a very interesting talk on his job, his experiences and his background.

Where would your dream holiday go to and why?

My dream vacation would go to the Antillen, I would really like to visit Curaçao, I've never been there. From what I have seen from the video footage of the island, it looks really awesome. I would actually combine it with a trip to the North-American continent I think, where I would especially like to visit the cities. I have also never been in North America.

What does your dream car look like?

I am a real fan of classic cars. Especially of the Mercedes Benz 300SL, that is a model from the sixties with those wing doors. They are being auctioned at the moment for over a million euros, but unfortunately I cannot afford that with my current salary, haha. Maybe when I win the lottery.

What hobbies do you have?

I am a drummer and guitarist at bands

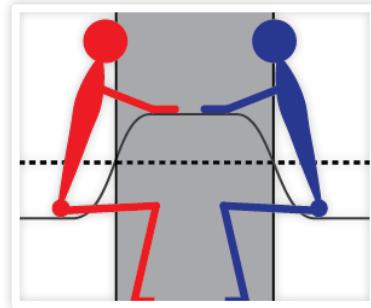
and orchestras. I play everywhere in the region where it's nice. Regularly I do things together with SHOT here at the UT, I know the conductor of SHOT quite well, he used to be my old conductor back in the days. The drumming takes up a lot of time, so I do not really have time for other hobbies. In total it

**"I am a drummer and guitarist at bands and orchestras."**

is taking me I think at least 1 or 2 evenings every week. And when it comes to concerts, it really depends on the



Author: Stef van Zanten, Bas van Laerhoven



season. There are months where there aren't many concerts, but there are also months that are really busy. Usually I am being 'lend out' to associations that have a shortage of musicians.

A nice recent example was the big concert of musicals in the Volkspark here in Enschede at the start of June for the 50th anniversary of the amateur club for art in the Volkspark. There were two musical pieces which will be on show

coming year at the Wilminktheatre so they were also there.

What did you want to become when you were young?

That is something I find really hard and actually still don't know. I know I really like to work with people and to help people further, but the precise job description still is unclear to me.

What have you studied?

I have done all kinds of things. I started off as teacher in primary education, but I never finished that study. After that I took one step back and started a study in accounting, for business administration. I had a job at the Belastingdienst for a while, but currently I am returning more and more to the educational side. Still I am not completely sure what I want to be doing later, I am a bit of a late bloomer.

Could you give a description of your work?

Bureau Onderwijszaken is very broad, that makes it quite hard to give a precise job description. But to give some examples you could think of preparations for the examination board; preparing all the documents and making sure they are complete. In addition, I also make sure students are being informed on the decisions of the examination board and make sure the minutes are properly archived for the visitation committees. Next to that, I am closely involved with students that are doing their thesis research, I check whether or not they are complying with all the rules from the Teaching and Examination Regulations. I make a monthly overview of



## Hugo Masselink

Age	29
Favourite colour	Blue
Favourite artist	The Beatles
Favourite food	Kapsalon
Favourite drink	Cola

the progress of these students and I monitor whether or not they need to take action, sometimes I make students aware that they have to do something when they are not taking the initiative themselves. These two things take up most of my time, there are some minor things that take less time, such as the monthly meetings of the programme committees for which I collect the documents and draft the agenda. That takes me only several hours each month.

## Compared to your job at the Belastingdienst, what do you like about your current job?

What I really like about my job at the UT is the freedom that you have to give shape to your processes. There are a lot of possibilities and of course there are restrictions on what you can and cannot do as fixed in the TER, but the activities on my working days are free to schedule. My job at the Belastingdienst involved a lot of coaching of people handing in their tax applications which made my

“What I really like about my job at the UT is the freedom that you have to give shape to your processes.”

schedule very dependent on those of other people. So there was much less freedom than at my current job.

## Are there fixed activities you do every week?

Not so much on a weekly basis, more on a monthly one. For example, I pro-

cess the documents for the examination board every month and I draft and print the reports on thesis students every month. Much of the other work I do is very dependent on the season, currently I am for instance especially busy with all the students writing their thesis, whereas in September I am helping much more students with choosing and registering their courses.

## Can you describe a typical day at work?

That varies a lot and it really depends on how many emails I receive on a day. I am sometimes quite busy with answering all emails from students that need assistance, but it can also be that there are barely any emails.

## Are there more things you really like about this job?

I really enjoy adding something to the organization. The moment a student comes with a question or the need for assistance, I really enjoy it if I can help that student out. Also, I have quite a lot of contact with master students that are writing their thesis, helping them in the planning for the final weeks, like the room for the presentation and other organizational things. I am actively involved with these students and that is

“The moment a student comes with a question or the need for assistance, I really enjoy it if I can help that student out.”

something I genuinely enjoy. So not really related to the research itself, but

more to the organization around it.

## Are there things you do not really like about your job?

The work pressure can vary a lot and sometimes it can be really busy and other moments it is not busy at all. I sometimes fall somewhat behind and students start sending 4 or 5 reminders, maybe I should not spoil students too much with quick replies to their emails, haha.

## We notice that there are students that are not so familiar with the contents of the TER, why do you think that is?

What I notice is that the TER has been written by staff members that are not directly involved with educational processes. Currently they are already keeping this into account more, but it still remains a quite formal document. To give you an example, only for the word ‘internship’ are already 4 different words in the document. This can make it very complex for students to understand all regulations, especially for international students of whom English is not their mother tongue. I think this is the main issue students experience, maybe also a little bit of upbringing on where the regulations can be found.

## What is keeping you up at night?

In general not that much, I sleep well. I do not have a hard time leaving my work behind when I leave the UT. Sometimes it really is a lot of work, in which case

I incidentally check my email at home, but since all the documents are at the UT, I cannot do much work. The large pile of work can sometimes keep me awake in those cases.

## Do you have any advice for students?

Get the best out of yourself! Use the means that are available as there are so many possibilities within Electrical Engineering. The programme is really good in being small and familiar, but offering numerous possibilities, you just have to know about them. That is where I can

“The programme is really good in being small and familiar, but offering numerous possibilities, you just have to know about them.”

help out, so if there are any questions you can always come to me, I can help out.

## What do you think of Electrical Engineering itself?

I think it is really interesting, a really interesting field of work. Maybe nice to know some more about my background: my grandfather used to be radio technician with his own business. He used to tinker continuously with these old tube radios and televisions, and I used to be next to him as a small boy looking at it. For him these devices were very nostalgic, he collected all these tube radios and made sure they worked. If they were broken, he worked tirelessly to fix them

and I helped him out with the soldering and stuff, so I actually know how to solder and how to read schematics although I do not know much of how they

“The nice thing is that the archives in my own system go as far back as 1988 and if you look in Osiris it goes even further back, that is really cool to see.”

actually work. I just about know how to operate measurement equipment. Nice thing about my grandfather is that these old devices end up in my house now and then, I have an old THT (Technische Hogeschool Twente) multimeter and oscilloscope at home.

## We heard rumours that you are the only man in your office, what is that like?

At office it feels like I have 3 mums, haha, no just kidding. My colleagues are very nice and it is really nice to work together with so many people. They know

a lot, so that is really helpful.

## What is it like to succeed Marian Tibben, who worked for BOZ for over 40 years?

Marian has been doing this work almost since the start of the UT, 40 years ago. The nice thing is that the archives in my own system go as far back as 1988 and if you look in Osiris it goes even further back, that is really cool to see. It was quite hard to succeed her as there was a gap between her departure and my starting date, but the nice thing about that is that I can give my own twist to the work processes.

## Is there anything else you would like to add?

Maybe nice to know is that I am not only staff member for BOZ, but now also for the faculty of EEMCS. We are trying to centralize BOZ within the faculties since every programme now has its own BOZ and this could be made more efficient. Across the University we are working on drawing one line for every educational support department, but that is a really interesting but difficult challenge due to all the differences between programmes.





# The scaling of flash memory

Author: Thomas Hoen



I did my internship at ASML in Veldhoven, but contrary to what you might think, I did not work on one of the well-known lithography machines. Instead, I did research on the scaling of flash memory. What's in it for ASML then? Well, they would like to know how much, and what types of lithography are needed in the processing of the next generation of memory to create their own machine roadmap. Due to company secrets of memory manufacturers, reverse engineering state-of-the-art memory and making predictions is the only way to find out, and that is exactly what I did.

You all know flash memory from your USB drives, memory in your smartphone and SSDs. Flash memory is already around for decades as it is an almost logical extension of standard CMOS. It consists of a CMOS transistor, but with an extra gate on top. In the middle, floating, gate one can store electrons by letting them tunnel through the gate oxide, which is an insulating layer. The stored electrons now influence the threshold voltage of the device, as can be seen schematically in figure 1.

Such flash transistors are connected in series, and by setting a high gate voltage on all but one transistor (which will

have a medium high read voltage) one can check the bit value by measuring the current through the string. This is why it is called NAND memory. This reading (and programming as well) is done in so-called pages, in several strings of transistors at once. Although the reading is not that fast (think 100 microseconds), the sheer amount of parallel bits (16kB) make it a very fast type of memory for large amounts of data. One can only erase blocks of complete strings, which can be done "in a flash".

There are up to around 2000 electrons on a device at most. Nowadays flash controllers can very precisely control this amount, which can then be used

to create different 'levels'. Eight levels are already very common, resulting in a storage of 3 bits in a single transistor. To guarantee a reliable memory, you can only afford a few electrons per year to spontaneously tunnel out again!

Around 2014, the 16nm flash node appeared. These devices suffered (amongst many other things) from severe capacitive coupling between cells, which is solved by using on-chip air gaps (with low permittivity) between them. A SEM (Scanning Electron Microscope) image of such a string of memory can be seen in figure 2. Even the most advanced ECC (Error Correcting Code) in the flash

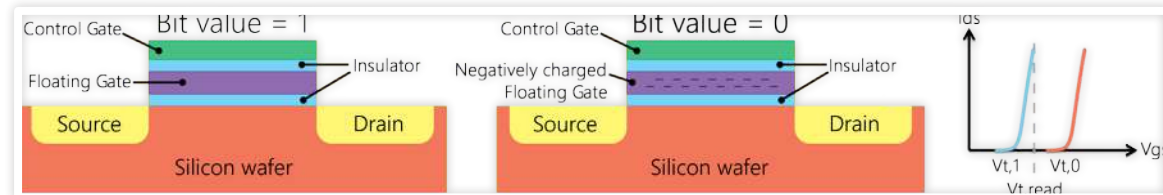


Figure 1: Schematic cross section of a flash transistor with threshold voltages. Adapted from <https://tinyurl.com/y7nmkk6x> and <https://tinyurl.com/y9xlu7bj>.

controller cannot fix many more of the remaining errors: the scaling of flash simply ends here. But then, a revolution took place. Traditional CMOS was put aside, and a completely new process was engineered and put into mass production: a true masterpiece of engineering.

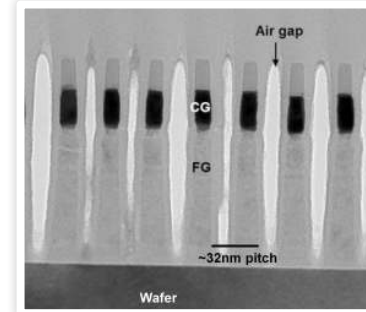


Figure 2: SEM cross section of a 16nm flash transistor string with a Control Gate and Floating Gate indicated. Adapted from TechInsights.

The transistor strings were effectively rotated 90 degrees upwards and fully around themselves, resulting in so-called gate-all-around 'macaroni' channel transistors. The electrons are stored in dielectric layers instead of a floating gate: it is called Charge Trap Flash. A TEM (Transmission Electron Microscope) top view of such devices can be seen in figure 3. The dots in the image on the right are not because of a bad resolution, those are actual atoms! A few less, and your memory will become volatile.

By stacking the memory cells in 3D, the density can be increased while cells can be further apart to prevent coupling. A cross section of the resulting stacked memory can be seen in figure 4. Apart from

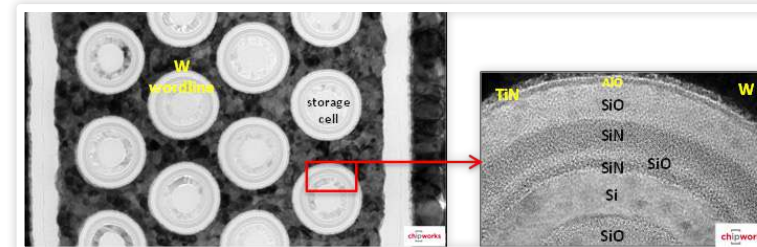


Figure 3: TEM top view of gate-all-around 'macaroni' FETs. The channel is now on the inside of the tube while the charge is stored inside the dielectric layers (note the atoms!). Source: Chipworks.

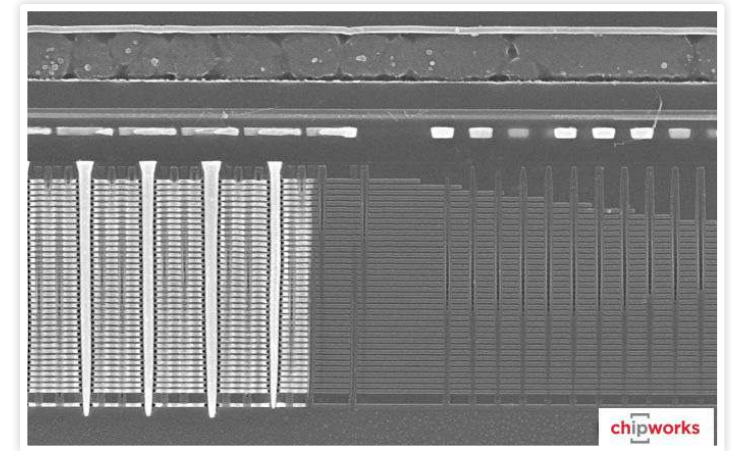


Figure 4: SEM cross section of a 32 layer 3D NAND CTF IC. Memory to the left, characteristic 'staircase' contacts to the right. Metal wiring on top. Source: Chipworks.

all the technological challenges (mechanical stress, chemical high-aspect ratio etching, topography, atomic layer deposition, ...), the new transistors have their own pro's (better gate control) and con's (polysilicon, low mobility channel) too. You can imagine that the read current will decrease if you keep on stacking cells. To find out how high you can stack before you run into (serious) trouble, I modelled the cells, but I also researched different materials and the processing (fabrication) of these ICs. Even though there are some publications, most of them don't tell you the complete story: they leave out crucial details or even labels to axis. Even worse, they might show you something different than what is actually fabricated. Eventually I ended up with an approximate amount of read current, which is of course only half the story. The next step was the reverse engineering of the read circuitry, to find out how sensitive the measurements actually

are, and where improvements can be made. For this, I viewed large areas of SEM images on different levels of the IC. It was a very labour intensive job (as you for example cannot see the difference between a PMOS and an NMOS, or trace all connections), but also very instructive from the perspective of a circuit designer to see how people actually build things in mass production. Note that everything is about minimizing the cost per bit, in which you can see that different trade-offs are being made: the use of lousy materials can be compensated by better circuits or the other way around, depending on the manufacturer. Finally, critical components could be identified and an estimation could be made on how much the read circuits and the IC (-processing) have to change for the next stacking generation of memory. Unfortunately for you, that is a company secret :-).

I came into contact with ASML via Juriaan Schmitz of the Integrated Devices and Systems group (former Semiconductor Components). I found my internship very instructive and I learned about a wide variety of things. This is best described by the fact that I have had discussions with chemists, (laser) physicists, marketers, electrical engineers, embedded software programmers, process integrators and even some external experts.



# Datasheet

This edition of the datasheet will include cake! Although the Da(p)hne has already been, it might give you some inspiration for the next. Do you have a receipt that is worth sharing? Do not hesitate and send it to [vonk@scintilla.utwente.nl](mailto:vonk@scintilla.utwente.nl)!

Whole of a half (cheesecake Oreo, Tony's chocolonely and raspberries)

- 2 bars Tony's Chocolonely raspberry
- Fresh raspberries

What to do:

1. Crumble the Oreo's for the bottom of the cake in the blender. Melt in the meantime the butter.
2. Mix the butter and the crumbled Oreo's.
3. Cover the springform pan with aluminium foil and add the butter Oreo mix. Use the back of the spoon to press and spread the mix.
4. Beat the whipped cream with a mixer.
5. Mix the whipped cream with the monchou. In the mean-

Ingredients:

- 75 g butter
- 2 packages monchou
- 250 ml whipped cream
- 3 sheets of gelatine
- 2 packages Oreo's



Author: Celine Steenge



6. while, put the sheets of gelatine in a tray with hot water. Melt 1,5 bar of Tony's in a pan. (do this or au bain marie or on low heat)
7. Mix the "sheets" of gelatine with some hot water and mix with the chocolate and whipped cream.
8. When the mix is lump free, put the mix on top of the cake bottom
9. Put the cake for at least 3 hours in the refrigerator (a whole night is better to make sure the cake is good)
10. Remove the springform pan and decorate the cake with Oreo's, raspberries and whatever else you would like!

Going round and round (Malteser cake)

This cake may look like hell to make, but is in reality really simple! Also chocolate lovers will love this cake due to the large amount of chocolate in it. Give it a try and you will fall in love too!



Ingredients:  
Cake

- 200 g self-raising flour
- 200 g dairy butter
- 4 eggs
- 75 g cacao
- Bit of cinnamon
- Bit of salt

Butter cream

- 250 g dairy butter
- 250 g powdered sugar
- 100 g pure chocolate
- 20 ml milk
- 2 bags of Maltesers

What to do:

1. Heat the oven at 180 degrees and make sure the butter is at room temperature.
2. Mix all the ingredients (self-raising flour, dairy butter, eggs, cacao, cinnamon and salt) of the cake in a bowl.
3. Grease the springform and put baking paper at the bottom. Use flour at the edges so the cake will not stick.
4. Put the cake for 40 minutes in the oven.
5. Let the cake cool down before putting the butter cream on top.
6. Melt the chocolate au bain-marie.
7. Add the milk to the chocolate and stir the powdered sugar through the

8. Put the dairy butter in a bowl and mix it airy.
9. Mix the airy dairy butter with the chocolate/milk/sugar mix till it is a smooth mix.
10. Put the butter cream on top of the cake.
11. Put the Maltesers on top of the butter cream.
12. Let the cake stiffen in the fridge for at least 3 hours.

Variation tip:

Put some chocolate sauce on top to make your cake look like it came from the patisserie.

Nice ice (Caramel ice cake)

Since you also want to cool down a bit during the summer, this is an ice cake! You do not need many ingredients for this delicious cake, so give it a try.



Ingredients:

- 1 can of sweetened condensed milk (397 ml)
- 500 ml of whipped cream
- ½ vanilla pod, the marrow
- Caramel sauce
- 100 g pure chocolate

What to do:

1. Cover a cake tin with plastic foil.
2. Put the condensed milk, whipped cream and vanilla pod in a bowl and beat this into a creamy whole.
3. Put a small layer of the mixture at the bottom of the tin and make it smooth.
4. Sprinkle some molten chocolate and caramel sauce over.
5. Repeat step 3 and 4 till the tin is full. (the top layer does not need chocolate and caramel, but be my guest!)
6. Put the cake for at least 1 night in the freezer.
7. Serve the cake with some last minute caramel sauce topping.

Variation tips:

Of course the chocolate and caramel could be changed to whatever you like, for example strawberry sauce.

# Advertorial

## Ricardo Rail

Je kent het waarschijnlijk wel. Het is maandagochtend. Je staat op het station te wachten op de trein naar Enschede. De trein die je wil nemen zorgt ervoor dat je 10 minuten voordat het college begint aanwezig bent. Maar dan klinkt er een luide “Ding dong DING!” “Beste reizigers.... De trein naar Enschede van .... Heeft een vertraging van .... Minuten...” Iets chagrijniger kijk je op je horloge of telefoon en je bedenkt, dat kon weleens wat langer gaan duren... gelukkig heb ik vandaag geen tentamen!

Ik zou jullie graag iets willen vertellen over een van de vele mogelijke redenen voor vertraging; namelijk, de stoorstromen. Als technisch expert bij Ricardo Rail komen we regelmatig in aanraking met dit fenomeen. Een van onze kernac-

tiviteiten is het meten van o.a. stoorstromen. Vanuit deze rol dan ook een blik op deze mogelijke reden voor vertraging.

Stoorstromen worden vaak geproduceerd door de tractie installatie van een

trein. Deze stoorstromen kunnen in hetzelfde frequentiegebied komen als de veiligheidssystemen in het spoor, waardoor de veiligheid niet meer gegarandeerd kan worden en de trein automatisch wordt afgeschakeld en stilgezet.

Eerst een korte toelichting op hoe de veiligheidssystemen in het spoor werken. Op het spoor bevinden zich diverse treindetectie systemen die gebruikt worden om te weten waar treinen zich bevinden. De oudste en nog steeds meest gebruikte vorm van treindetectie in Nederland is de laagfrequente spoorstroomloop. Tussen beide spoorstaven is hierdoor een spanning die een relais ophoudt. De assen en de wielen van een trein veroorzaken een kortsluiting waardoor het relais afvalt en de spoorsectie bezet gemeld wordt.

Author: Merlijn van Rij



Als er echter een stoorstroom met de verkeerde frequentie door dat detectie circuit loopt, dan bestaat het risico dat het systeem onterecht denkt dat er een trein op dat stuk spoor aanwezig, of nog erger, dat er wel een trein op dat stuk zit terwijl het systeem denkt dat dat niet zo is.

Zulke situaties kunnen rampzalig uitpakken, vandaar dat er wetten zijn die vereisen dat al het materieel dat in Nederland op het spoor rijdt niet teveel stoorstroom mag produceren. Tevens moeten alle treinen een stoorstroom-detector aan boord moeten hebben die de trein stilzet en het elektrische contact met de bovenleiding verbreekt als deze om wat voor reden dan ook teveel stoorstroom produceert. Deze zit er als extra veiligheidsmaatregel in, omdat men vooraf niet kan voorspellen hoeveel stoorstroom een trein zal produceren als deze ergens een defect heeft.

Doordat het systeem automatisch de trein stilzet en afschakelt wanneer er teveel stoorstroom geproduceerd wordt, kan er een hoge mate van veiligheid gecreëerd worden. Het afschakelen van de trein gaat zo snel dat het detectie systeem niet beïnvloed kan worden en aankomende treinen op hetzelfde spoor tijdig worden gewaarschuwd.

“Ricardo helpt fabrikanten van treinen en geeft advies zodat de installatie aangepast kan worden om aan de Nederlandse eisen te voldoen.”

Voor al het nieuwe materieel wordt er door middel van metingen op een testbaan gecontroleerd of de nieuwe treinen

aan de Nederlandse eisen voldoen. Dit zijn typisch metingen die Ricardo regelmatig uitvoert. Ricardo helpt fabrikanten van treinen met het meten en geeft advies zodat de installatie aangepast kan worden om aan de Nederlandse eisen te voldoen.

Als dat allemaal in orde is worden er vaak ook nog metingen uitgevoerd op het Nederlandse spoor zelf. Vaak in de nacht, maar als de trein goed genoeg is, ook weleens tijdens de normale dienstregeling.

Mocht je een keer een “vreemde” trein zonder passagiers voorbij zien komen, dan zou het zomaar kunnen dat daar Ricardo medewerkers aan boord aan het meten zijn!





# ICD Excursion

On the 18th of May, Scintilla went on an excursion to Innovatie Cluster Drachten or ICD for short. ICD is a collaboration project between various technical companies in the north of the Netherlands. On 8:30 we departed from the Spiegel by bus to Drenthe to go to Astron. In the bus it was clearly noticeable that some people had a little too much to drink the last day, so fortunately for them they had some time to sleep in the bus.

At around 10:00 we arrived at Astron. Astron is a company that specializes in mapping space by using big telescope arrays and data processing. The company headquarters is located inside a dense forest and looked very modern which made the entry by bus very spectacular.

Inside Astron we went to a large presentation room and some companies including Astron presented what they do and answered our questions about their business. I particularly liked a company called Ziuz, which makes software and

hardware for visual intelligence. Most of these companies were quite small and ranged from hardware to software companies.

After the presentations we got to see some of the work the employees of Astron do. We got to see some very big FPGAs that were used for their data processing with their testing setup and after that we saw their collaborative project with China to launch an antenna behind the moon to measure frequencies shielded from the earth. Another cool thing



Author: Harm Reurslag



was Astron's very big testing safes which cancelled out all electromagnetic interference. Because we had a very tight schedule we got a lunch package for in the bus and went to Drachten. In Drachten we went to the industrial centre of Phil-

*"The Astron company headquarters is located inside a dense forest and looked very modern which made the entry by bus very spectacular."*

lips where we first got to see a company called FMI which specialises in automating industry. We got to see their 'cobot' (cooperative robot) which aims to work together with humans but unfortunately that concept was not viable yet as robot are just better and require less regulation compliance. The people we talked to at FMI did not seem to be excited about the 'cobot' technology either, which made that visit a little bit weird, but they had a cool workshop which was nice.

The final company we went to visit was Phillips which is of course known worldwide for their consumer electronics and they did not disappoint us with their facilities. We started of in an even bigger presentation hall than that of Astron and had another talk about some of the companies on their terrain and of course Phillips themselves. By now everybody was a bit exhausted from all the listening to company commercials but that quickly faded away when we went to see their factory.

Phillips's factory was a massive assembly line of robots and humans to quickly manufacture shaving machines. It was very beautiful to see the precision and speed at which all the tiny parts became one whole. What I found interesting was that humans were better at assembling some parts of the shaving machines as machines are not good at clicking things together. Most of the hand work however is

done in Romania as the labour costs are too high here so the finished shavers are shipped and packaged by hand in Roma-

*"It was very beautiful to see the precision and speed at which all the tiny parts became one whole."*

nia and then send back again. In the factory we also got to see a 3D metal printer which could print very weird shapes to optimize some metal parts, they showed a very tiny light block that they printed that could handle 3 people standing on it and a small coat hanger which could easily hold 20kg, they said however that every print takes 6 days so they could not use this everywhere yet. They said that this technology is already used for

jewellery and will have many more applications if printing time is reduced.

Another thing Phillips was working on was an assembly line part which could transport parts to another robot which was currently done by the workers. After all this exciting stuff we went to a nice display room of all Philips products which was very cool as you could also find the shavers which they built in 1950 and because of the order in the display see the technological progress they made over the years, it started with a clearly handmade square box with a shaving head to the smooth plastic devices we have now. In the display room we had a drink with some employees and had Chinese food for dinner. As always with Chinese food I ate too much, but that was not a big deal as we went back to the bus. Back in the bus we sang songs together and I witnessed Herjan being able to finish a Rubik's cube.



# Batavierenrace

*Author: Koen Raben and Matthijs van Minnen*

As a rich tradition, Scintilla participates in the Batavierenrace every year. Following every year's race is a bbq where the participants (and others) can relax after the efforts they have invested in the race. The 2018 edition took place on the 20th and 21st of April; two perfect days for a bit of running. We asked two participants to describe their experiences.



## Running an afternoon stage

*By Matthijs van Minnen*

After almost a year without doing some actual running, I needed the weeks leading up to the Batavierenrace to optimally prepare. All in all, I had to run just 7.4km which is certainly doable with a limited amount of training.

It was up to me to run the second-to-last leg. This had both pros and cons... The main advantage of this leg is that it is a straight run home. You're running towards the city centre of Enschede and you know exactly how far to run. This meant I could speed up after each corner, if it wasn't for the heat. Which brings us to the main drawback of running late in the afternoon. The sun had been shining all day and the temperature was nearing 28°C. In all my wisdom I spend all my time in the Bata-van, which was the entire morning and most of the afternoon, drinking water. This resulted in a bathroom break every time we stopped at one of the switching points.

But in the end, it doesn't really matter. As after every turn I had to slow down further in order to even make the finish

line. All-in-all I was able to finish in 36:21 which was changed by the organisation into 50:53 since I was running a women's leg. This is the Sparks4Ever team afterall...

## The final lap

*By Koen Raben*

Running the last lap. With a long tradition of presidents having done it before me this was something I was actually quite looking forward to. This was my third year of running a batavierenrace lap and as the previous two years were longer distances than this year I was not really worried.

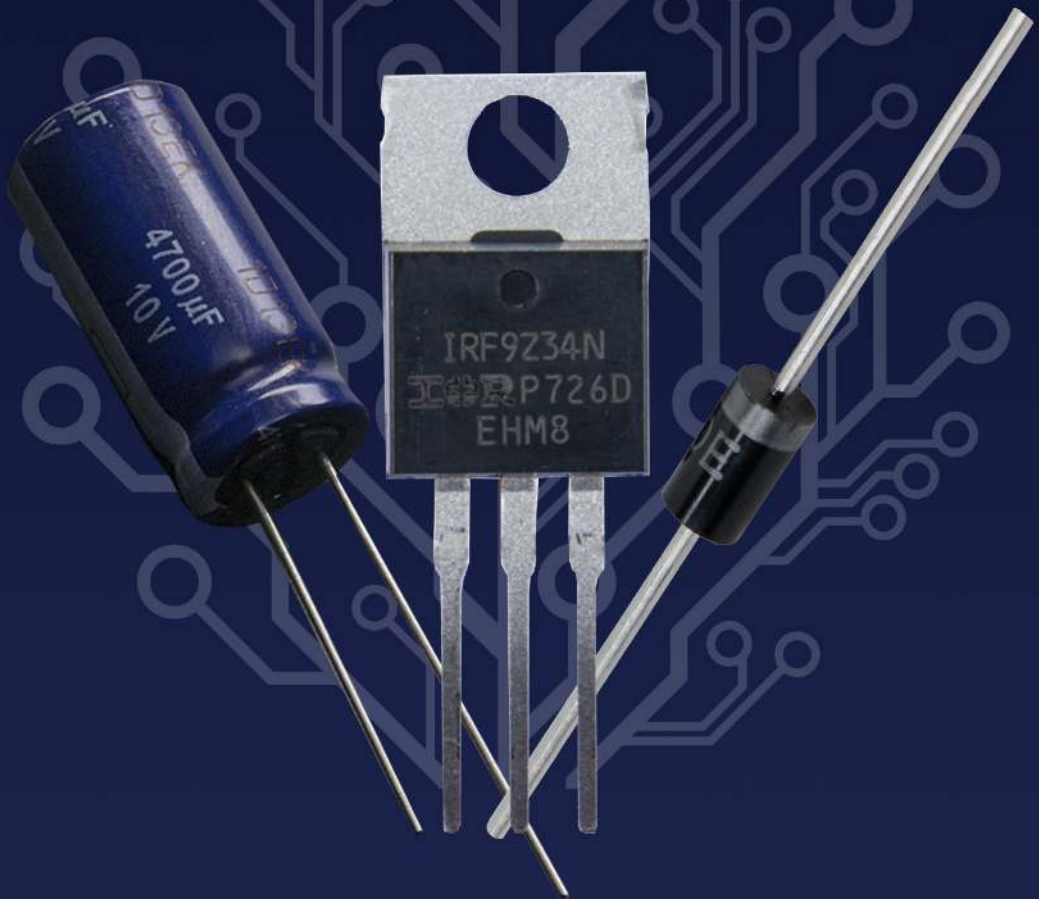
And as you may know there is another catch to running the last lap for Scintilla, since a few years the tradition exists that the president should run the last lap in his suit. Being the competitive person I am I could of course not refuse and so there I stood, in almost 25 degrees in the city centre of Enschede, waiting for the start signal. Then a loud bang and we were loose, rushing through the streets. The most beautiful thing about the last lap is the amount of cheers you get along the way, and boy did I need those cheers. Because not only did I decide to put on

a suit for this lap, I had also already ran a lap at 3:00 on which I may have gone a little too fast. So my legs found I really was an idiot and I should just stop. But I didn't. And with the cheers surrounding me I came running on the campus and from there it doesn't matter how little you have slept, how hot you are or how much your legs hurt, you just continue with a smile on your face! Coming up on the UTrack I was handed a lovely half liter of Grolsch Premium Pilsner and while stopping once on the track to deliver a toast and nearly vomit because I tried to tank half a liter of beer I went on and finished. With quite a decent time actually!





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# The Yellow Power Rangers

A column on the honorary members of W.S.G. Abacus

Author: Mariya Karlasbchuk

Dearest readers,

History is a very important thing. Not only just so we can learn from it, but it is also good to know what has been done in the past and why we can be proud (or ashamed, who knows) about certain events or people. It is also good to know a little about your neighbours; I mean, our associations have grown up together since we have been put together on the beautiful balcony.

I don't know much about the history of E.T.S.V. Scintilla, neither do I know a lot of epic events of the past 48 years of W.S.G. Abacus or Applied Mathematics (except for the fire at the Cubicus and the infamous cocktail party). But what I do know is that we have some very interesting people that have done a lot for

Somewhere 48 years ago W.S.G. Abacus was just a simple association which needed to grow. And a couple members have done more than just organising simple things for the association. Some of them have been in the board multiple times. This is the case for Henk Cammaert, Jaap Doosje and Olf Broenink. Henk has been not only General Adjunct four times, but he has also supported Abacus financially on behalf of the study department. This has resulted in a lot of fun drinks and activities. Jaap has been a board member three times and has had many different functions, such as officer Excursions and Chairman (twice). Next to this he has organised the an excursion abroad for the very first time. Olf has not been in the board for multiple years, but he has been in the audit committee for 10 (!!!) years. Sick, right? Furthermore he has helped to automatise the members administration.

“Our associations have grown up together since we have been put together on the beautiful balcony.”

Abacus. Yes, I'm talking about honorary members here! So let me take you back in time and guide you through the valiant deeds of these nine great persons.



And of course, all those three honorary members have been valued for their great feedback and advise. This was very special back then, because there was no Advisory Council to support the board.

Frits van Beckum is also an interesting one to mention. He has been a General

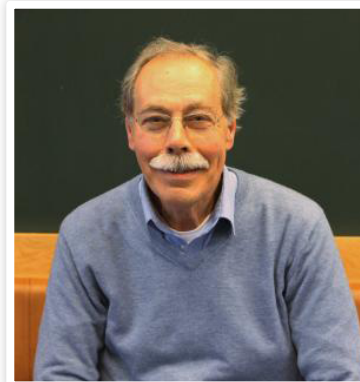


Figure 1: Frits van Beckum



Figure 2: Michel ten Bulte

Adjunct as well and he has kept up good contact with the Institute Technology Badung. Many people of Applied Mathematics adored him and his very low voice. Personally I have met him once, and we was a very tall and sweet old man. And yes, his voice was just as low as is stated in the description on our website! He loved making music, which resulted in fun 'barbersjopies' during music nights or parties.

A man that I have never met – but hope to meet once – is Piet le Grand. Piet has supported the board in the most heroic way possible: when there was no one around to write a financial report right before a GMA, Piet has taken up this task as an Audit committee member (not only once). Next to that he has been an Ideaal!-member for 10 years, which makes him my personal hero.

Another person that I have met real-life is Erjen Lefeber, he once gave a lecture during one of the Mathematical Lounges about traffic lights. One of the most mentionworthy things about him, is that he founded the CoCo, our computer committee which is inevitable at this moment. He has done lots of committees and has been a board member as well. The thing that I also remember from him is that he is tall as well. Yes,

tiny people remember tall people :)

“We can find Michel ten Bulte often walking around the Zilverling carrying a yellow Abacus cup full of fresh coffee.”

A very special honorary member that we have is the one and only Michel ten Bulte a.k.a. MTB. Not only has he ben in the board four times, he has done a lot for Abacus during his time as employee. You need the Educafé for an activity? Call MTB. Want a broken key locker to be removed? Drop by MTB's office. Want some correct furniture for your dishwasher, because the first one is too small? Send MTB a message! We can find this man often walking around the Zilverling carrying a yellow Abacus cup full of fresh coffee.

Of course there are two women that we cannot forget. They are known as the 'momma's' of Abacus. First, let's talk about Trudie Hondelink. She was an employee at the canteen in the Cubicus and fixed nurture for things such as drinks, parent days and open days. She was the helpful lady which everyone adored. At this moment she is working at Boerderij Bosch and takes not only care of the Applied Mathematics students anymore.

The other mama of Abacus is Diana Dalenoord. In some way she always knows someone who knows someone who knows someone who might be interesting for a lecture or for some data that you need to retrieve. She is the bridge between students and employees and has helped a lot with AM-related activities. And besides all of this she is a great

cook! There have been many drinks that included Diana's amazing creations.

I hope I have taught you at least a little bit about the history that has been made brighter by the above mentioned people. If you want to see what our heroes look like, just walk by the Abacus room where we have their portraits hanging



Figure 3: Diana Dalenoord

above the computers. Or just put a box of Speculaas Torondo's in the SK and probably you will meet one honorary member in real life, who knows... We also have one spot left for a picture, so you can also do great deeds for our association to make sure your picture will be hanging there as well.

“Just put a box of Speculaas Torondo's in the SK and probably you will meet one honorary member in real life, who knows...”

# Eyes and Turtles

Excursion Ansem

*Author: Jippe Rossen*

**No, this is not some creepy dish prepared at Halloween. It is two of the foremost and fascinating products of AnSem. But before we dive deeper in that let's give a general overview of AnSem first.**

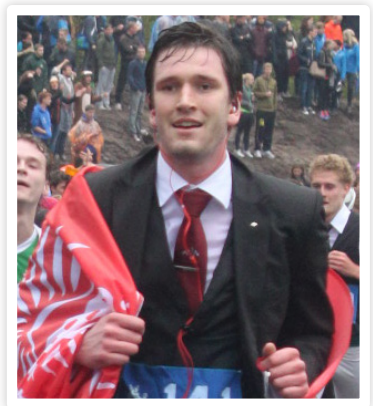
AnSem is a company originating in Leuven. They specialize in custom made products which 'are the best' and they do not kid around with that. The constraints that their customers, but also they themselves, put on their products are most challenging. Whether it being a demand on the dissipated power of a product, or the noise figure of a transceiver systems, they live for the challenge. In the past they have had a close relation with the Integrated Chip Design (ICD) group on the University of Twente which tempted them to also open up a location next-door of the university.

We were welcomed at twelve on the Colosseum and as soon as all of the 31 attendees were seated, the day was kicked off. It was not long until it was proven that this truly was an electrical engineering activity; it hardly took two minutes before Moore's law was mentioned (if

only ECTS were accredited for noticing every mention of the law...).

After the opening presentation the group was divided into three separate groups, which rotated through separated activities. The first activity (for me) involved a deeper look into their portfolio. Various projects were mentioned including a satellite transceiver system for tracking wildlife (in this case turtles) and also contact lenses that measure the intraocular pressure in the eye of the wearer.

For the second activity a tour was given around the facility which included some demos of their projects, as well as prototypes of some of their projects. A lot of printed circuit boards were carefully displayed in their offices, with each their own story behind it. After this tour, one of their employees (and former Scintilla



board member Dirk-Jan) gave a presentation on what it is like to work within AnSem, what the challenges are, and how you can develop yourself during your employment there.

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*"AnSem specializes in custom made products which 'are the best' and they do not kid around with that."*

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The day was concluded with a very pleasant drink, during which we were also given the opportunity to go for a short ride with the director of AnSem in his Tesla Model X. All together it was a very interesting day with lots of great stories about AnSem and electronics in general!



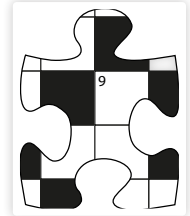


# Puuzle

*Author: Truusje*

Dear sparkling friends,

Last edition's puuzle turned out to be quite a challenge! Luckily, at least one of you has sent the correct answer to the Vonk, congratulations Wouter Horlings! You may contact the Vonk to collect your well-deserved price. The picture directly to the right shows the original image.




While writing this, it is a nice 25 degrees outside with lots of sunshine. Perfect weather for the BBQ season! Since past month has been filled with many great BBQs and many are still to come also during the Kick-In, I have decided that the theme of this puuzle will be in line with this fun activity. Essential to the solution of this puuzle is the grill, which turns out to also be quite essential for a BBQ. This should be enough information for you to find the phrase I am looking for. However, the summer weather is boosting my mood, so I'll give you another hint: the grill has been filled with 50% useful stuff, let's say meat.

You can send in solutions until October 1st, 2018. I will be looking forward to many responses!

Love, Truusje

HZAPPTWYSZUVMNFMERRIRHOOJMLIIDNPALVYMW





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