Towards a sensible digital society

Prof. Dr. John Schmitz Dean EEMCS Faculty

TU Delft

Outline

Introduction
Education
Research
The human factor
Valorisation

TU Delft

TU Delft

Our Ambition

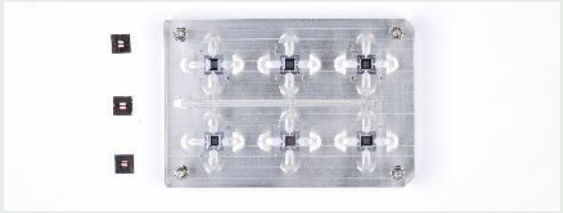
“EEMCS’s ambition is
to give society the technology
to create a better world”

TU Delft


1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRIE, INNOVATIE EN INFRASTRUCTUUR
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

TU Delft

Faculty of **Electrical Engineering, Mathematics** & **Computer Science**



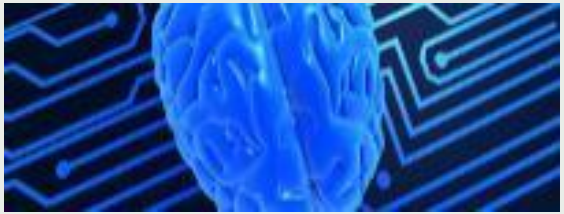
MICRO ELECTRONICS

QUANTUM & COMPUTER ENGINEERING

ELECTRICAL SUSTAINABLE ENERGY

APPLIED MATHEMATICS

SOFTWARE TECHNOLOGY



INTELLIGENT SYSTEMS

EEMCS **Facts and Figures**

48 full professors	**130** associate/assistant professors	**210** permanent scientific staff	**132** support staff
463 PhD students	**66** Postdocs	**1556** MSc students **1729** BSc students	**€ 65M** annual turnover

What's in a **smartphone**?

Electrical Engineering

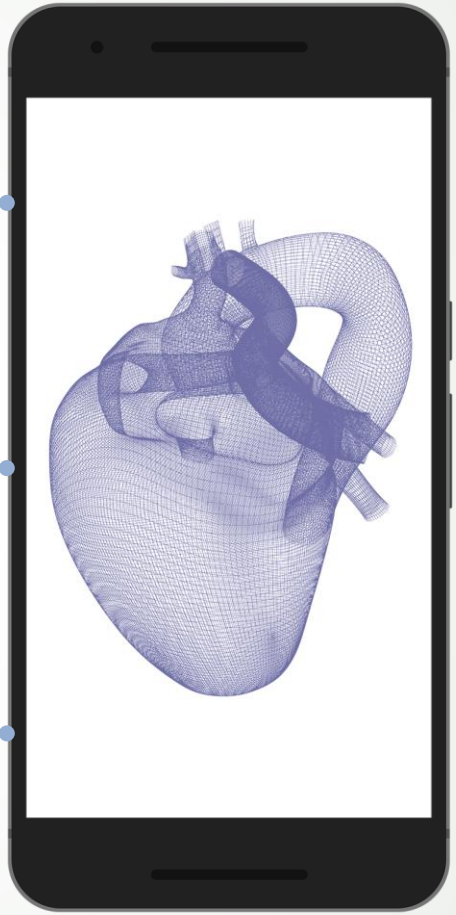
- Sensors/5G/RF transceivers/sound processing/memory/processor/GPS/NFC/signal optimization

Computer Science

- Android/IoS/Windows/Apps/GUI/encryption /access control/augmented reality

Mathematics

- IC design/Signal optimization/EM theory/algorithms /net work analysis/RF optimization



How many sensors are there in your smartphone?

A. 2
B. 5
C. 7
D. 10

Votes: 1 ● Closed

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Which sensors are in a smartphone?

- Accelerometer
- Ambient Temperature
- Gravity
- Gyroscope
- Light
- Linear Acceleration
- Magnetic Field - *Creating a compass*
- Orientation - *Determining device position*
- Pressure
- Proximity

Topics

EDUCATIONAL INNOVATION

MATHEMATICS

ELECTRICAL ENGINEERING

COMPUTER SCIENCE

THE HUMAN FACTOR

Topics

EDUCATIONAL INNOVATION

Micro-Master on Solar Energy Engineering
(MOOC = Massive Open Online Course)

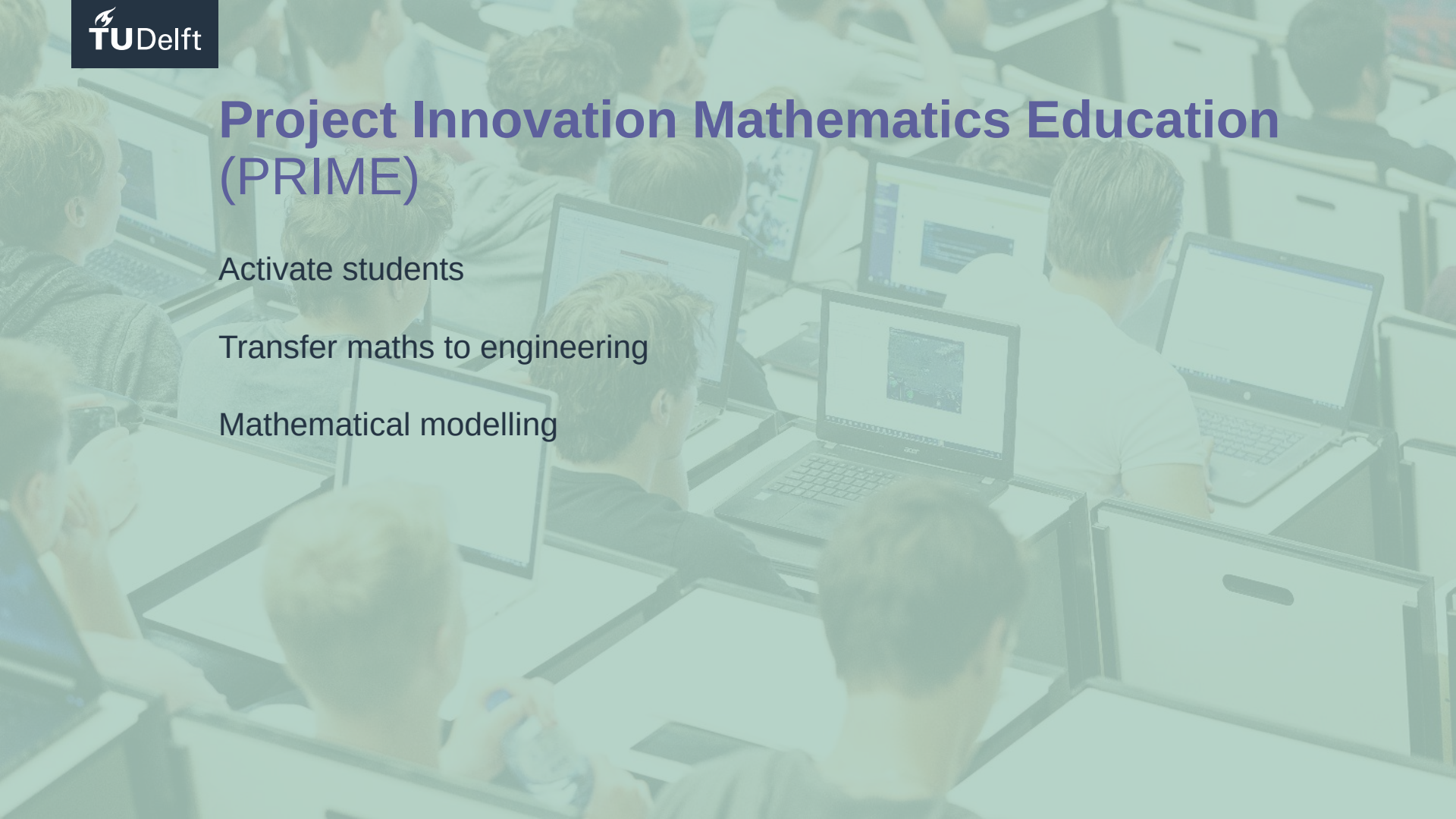
	**Energy Conversion** Apr 25 to Jul 11, 2017	**250** paid 31500 registered
	**Technology** Sep 5 to Nov 21, 2017	**135** paid 14500 registered
	**Systems** Nov 28, 2017 to Feb 20, 2018	**94** paid 13000 registered
	**Photovoltaics in Microgrids** Feb 20 to May 8, 2018	**61** paid 10000 registered
	**Capstone project** Jun – Jul 2018	**0** paid 21 registered

Project Innovation Mathematics Education (PRIME)

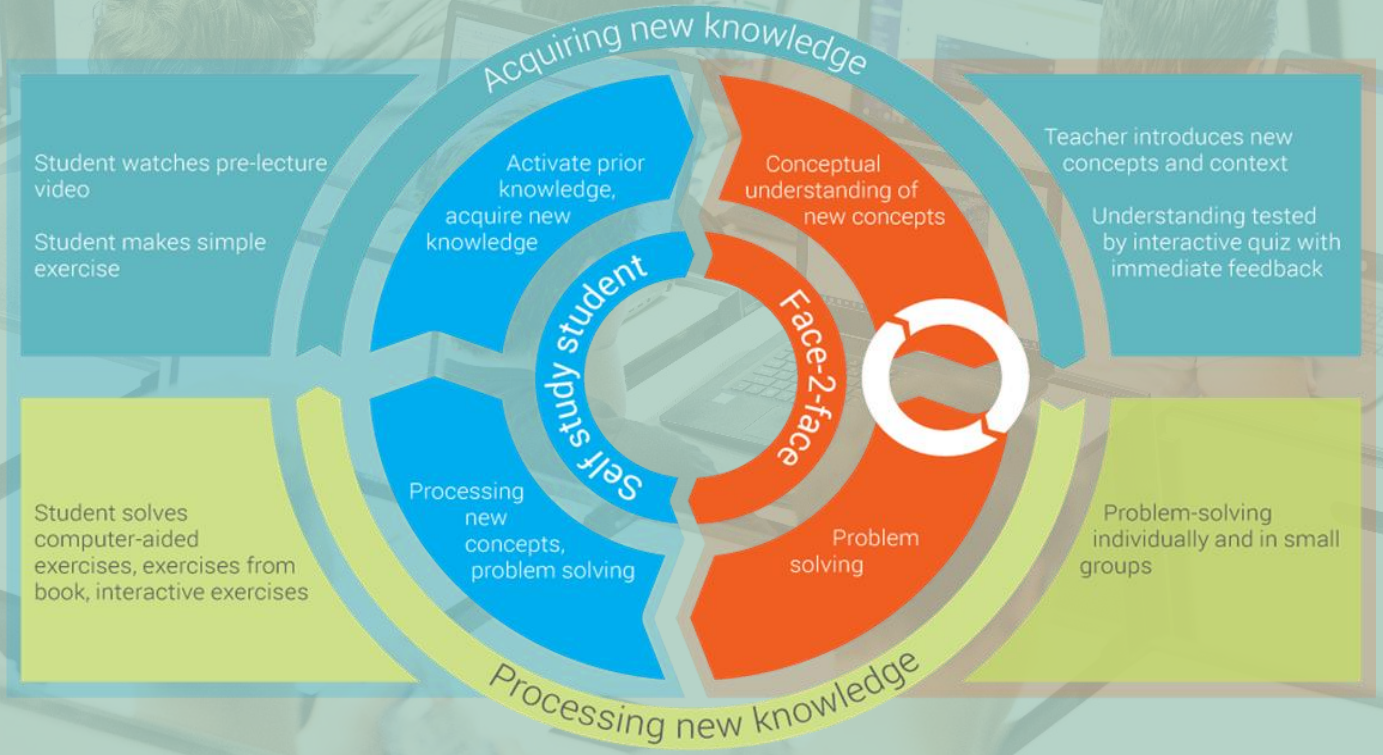
Activate students

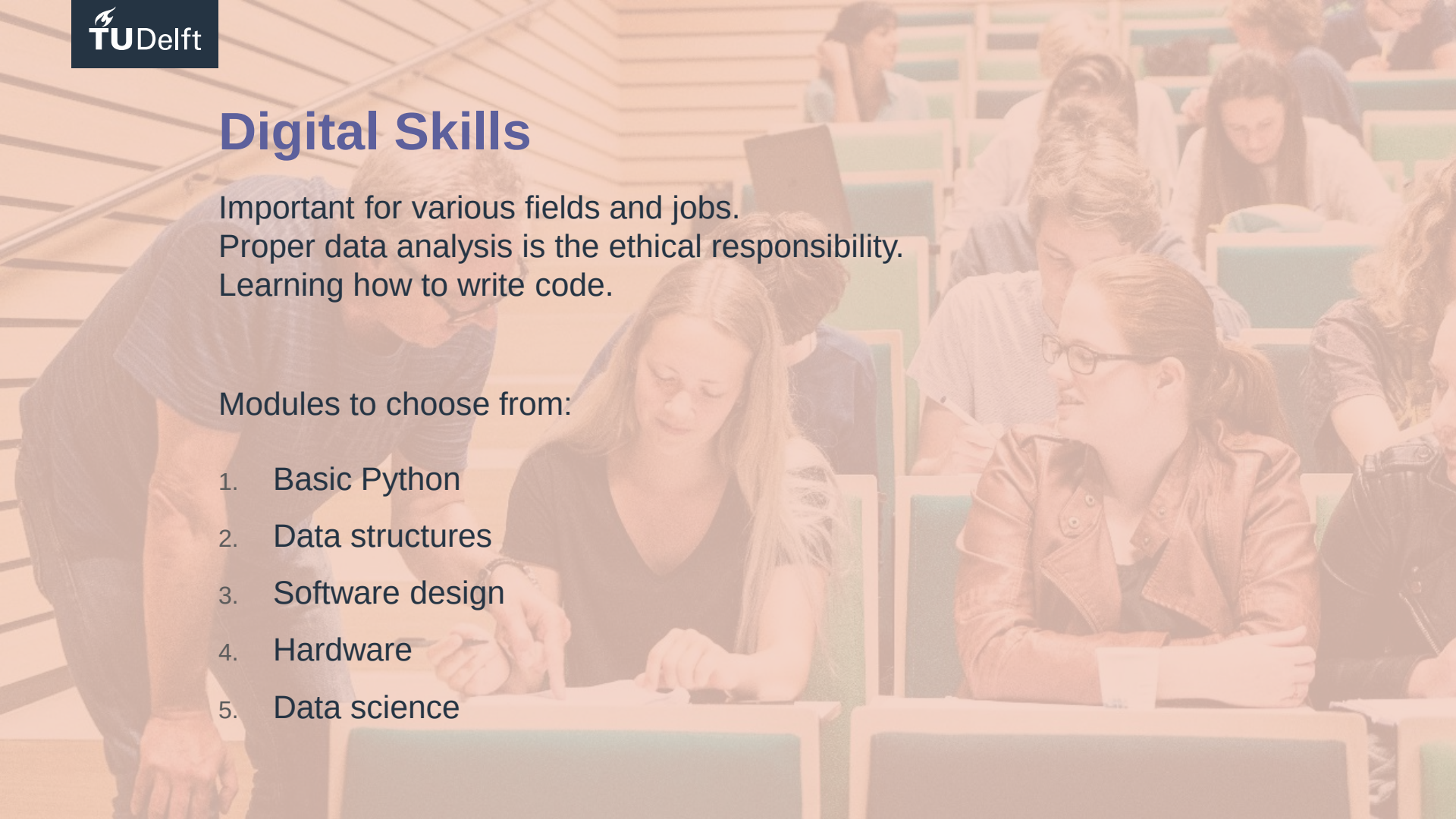
Transfer maths to engineering

Mathematical modelling



Prepare, Participate, Practice





Digital Skills

Important for various fields and jobs.
Proper data analysis is the ethical responsibility.
Learning how to write code.

Modules to choose from:

1. Basic Python
2. Data structures
3. Software design
4. Hardware
5. Data science

Massachusetts Institute of Technology (MIT) Report:
TU Delft Engineering Teaching is in the Top 5 of the World!

Topics

EDUCATIONAL INNOVATION

MATHEMATICS

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THE HUMAN FACTOR

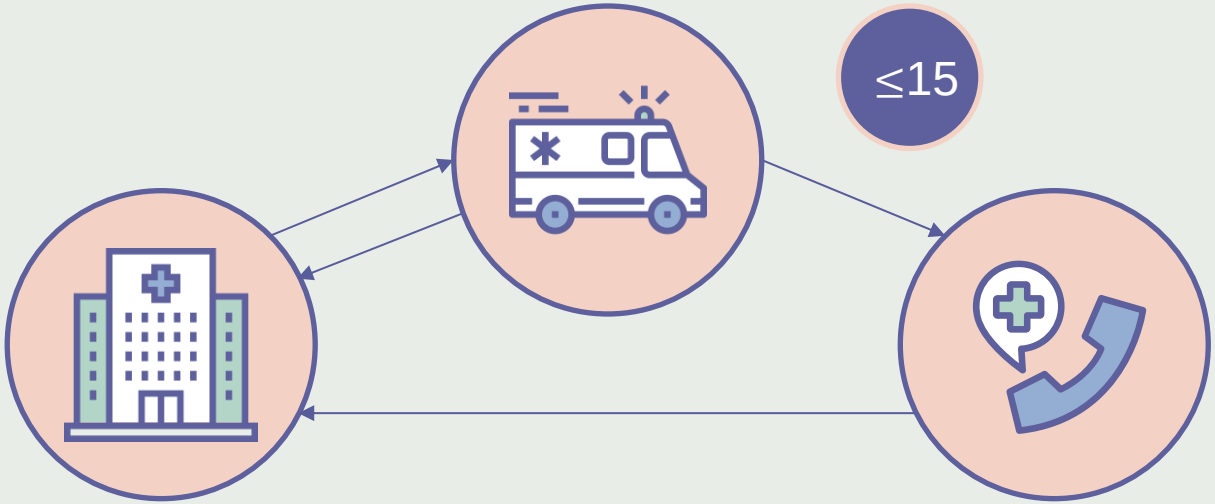
Topics

MATHEMATICS

Project **REPRO**

Looking for the optimal emergency vehicle distribution to save lives

Goal: within 15 min at scene in 95%



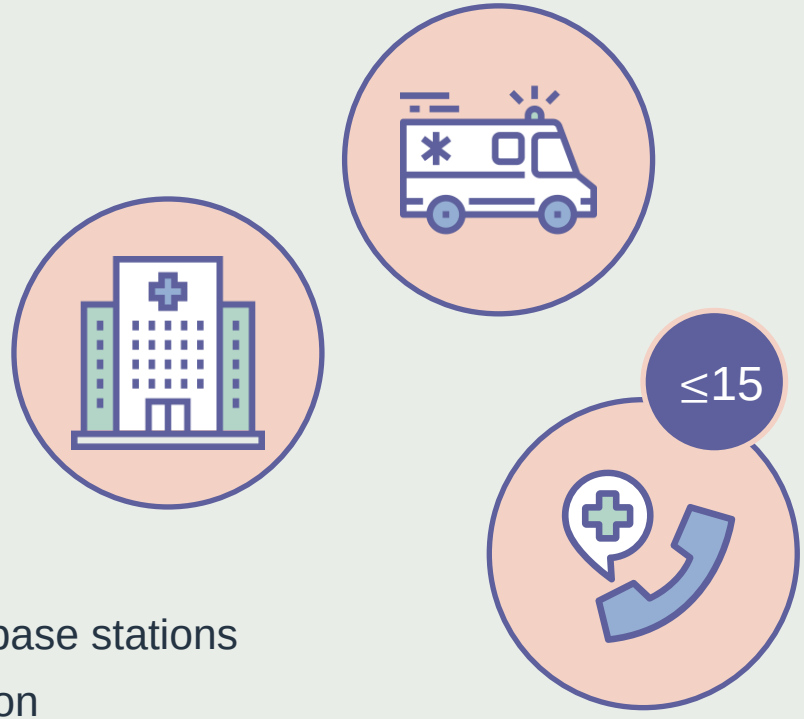
How

- How to handle peak demands?
- How many ambulance base stations are needed and in which locations?
- How many ambulance teams do we need in base station and when?
- How to realize a maximum coverage by a smart dynamic and proactive real-time repositioning of the ambulances?

Location model

Input

- Demand locations with demand
- Potential base stations
- Driving time between all locations
- Number of available ambulances
- Busy fraction of the ambulances



Model

- Determines location of base stations
- Determines number of ambulances for each base stations
- Maximizes the expected coverage of the region

Location model

- Maximize expected coverage
- Determine number of ambulances available within 15 minutes
- Limit total number of ambulances

$$Max \sum_{i \in I} \sum_{k=1}^{p} d_i (1-q) q^{k-1} y_{ik}$$

$$\sum_{j \in J_i} x_j \geq \sum_{k=1}^{p} y_{ik}, \forall i \in I$$

$$\sum_{j \in J} x_j \leq p$$

$$x_j \in \mathbb{N}, \forall j \in J$$

$$y_{ik} \in \{0,1\}, \forall i \in I, k = 1, \dots, p$$

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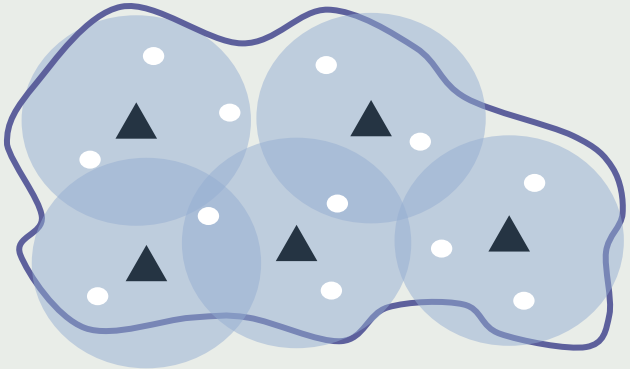
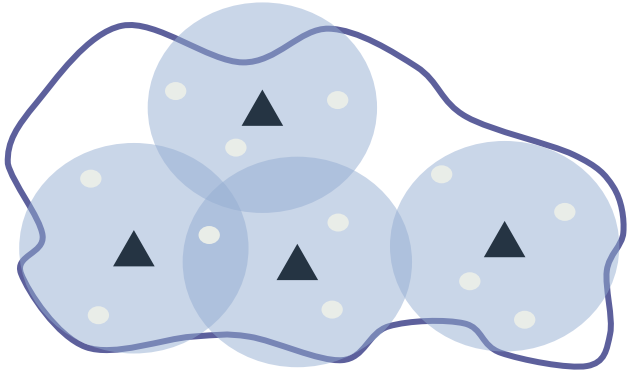
Ambulance **planning**

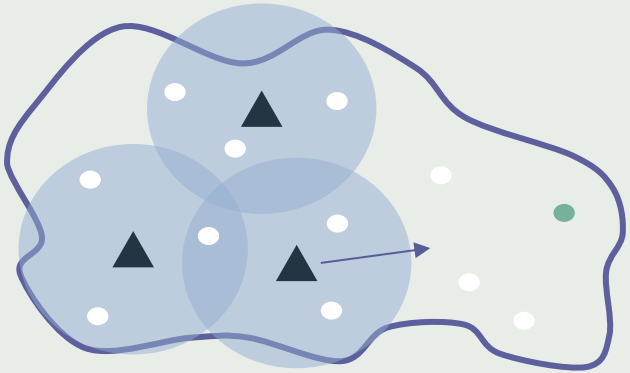


- 12 locations within 15 min with **5** base stations

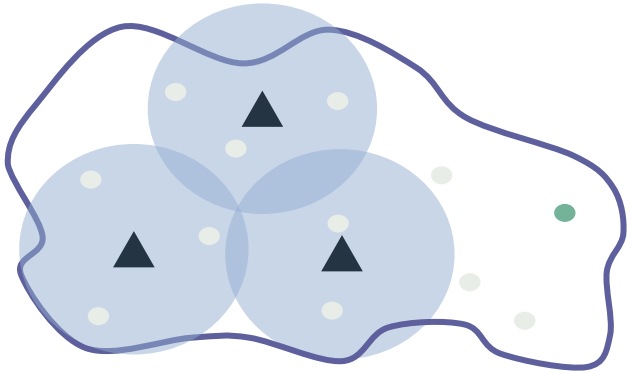


- All 12 locations within 15 min with only **4** base stations

Ambulance **planning**



- Dynamic Maximum Expected Coverage Location Problem (D-MEXCLP)-algorithm



- With this algorithm the time to arrival can be reduced with 15-20% in the province of Utrecht

Which section worked on the ambulance case?

A. Analysis
B. Mathematical Physics
C. Numerical Mathematics
D. Optimization
E. Statistics

Votes: 1 ● Closed

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Topics

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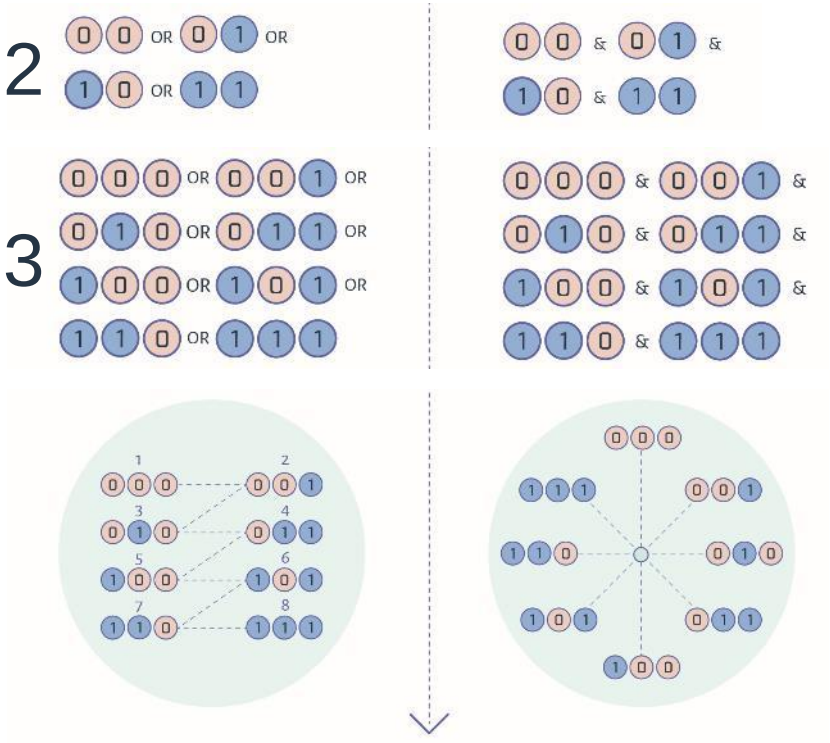
ELECTRICAL ENGINEERING

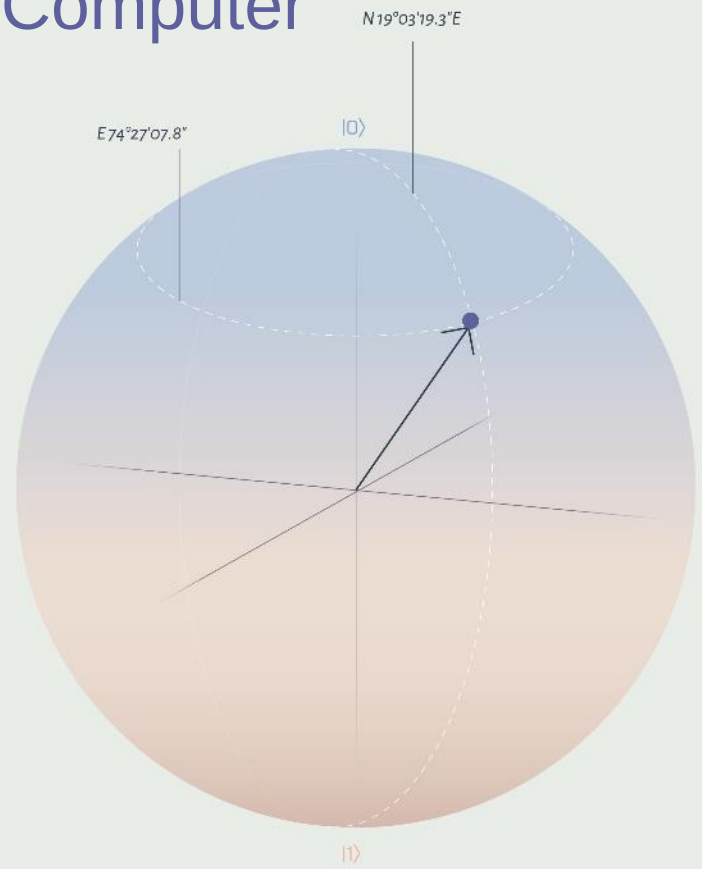
COMPUTER SCIENCE

QUANTUM

THE HUMAN FACTOR

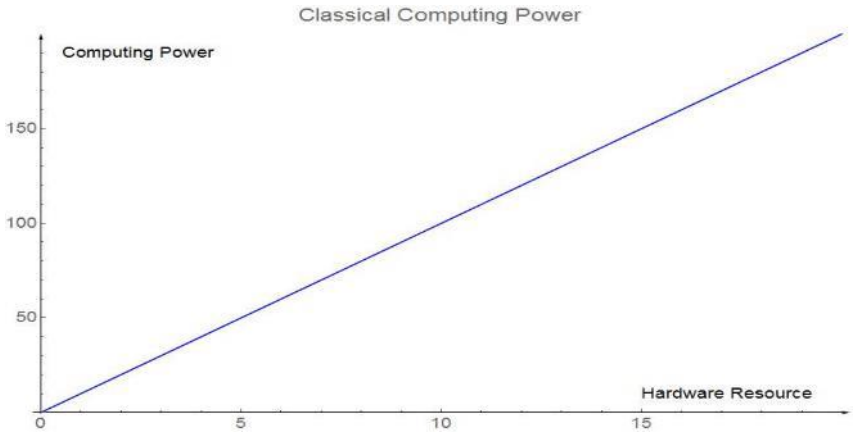
Building Blocks of the Quantum Computer





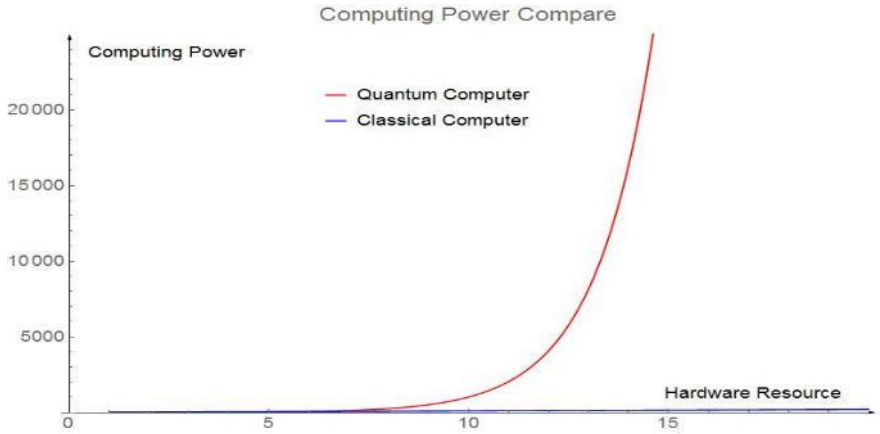
Classical vs. Quantum Computing

Classical Computer



Linear speedup

Quantum Computer



Exponential speedup

Doubling the computation power: adding only one qubit!

The power of quantum computers

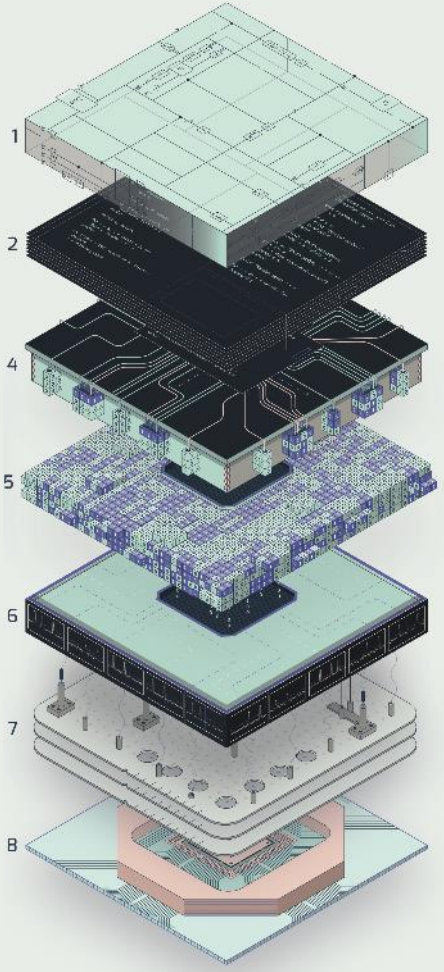
Problem: factoring 2048 bit number (2x3x5x7x11x13x……..)

- **100 Years**
- **105 Trillion €**
- **107 TWatts**
- **Consume all earth's energy in 1 month**

A quantum computer would need 26 hours

Quantum system stack

1. Quantum algorithms
2. Quantum programming language
3. Quantum error correction (QEC)
4. Compiler
5. Quantum instruction set architecture (QISA)
6. Microarchitecture
7. Quantum to classical interface
8. Quantum processor



The power of quantum computers

En/Decryption

Diagnose DNA sequence

Big data

Optimization

Applications for Quantum Computing

Green aircraft: Predict airflow over a wing

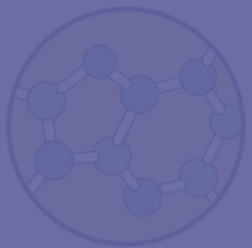
Secure communication technology

Flood predictions

Catalyst analysis

Protein folding

New medicine



Molecule simulation

Which statement about classical computers and quantum computers is true?

A. Quantum computers will overtake all classical computers
B. Soon the quantum computer will be in every smartphone
C. Quantum computers work with qubits and classical computers with bits
D. The fact that both bits and qubits can be green and blue at the same time

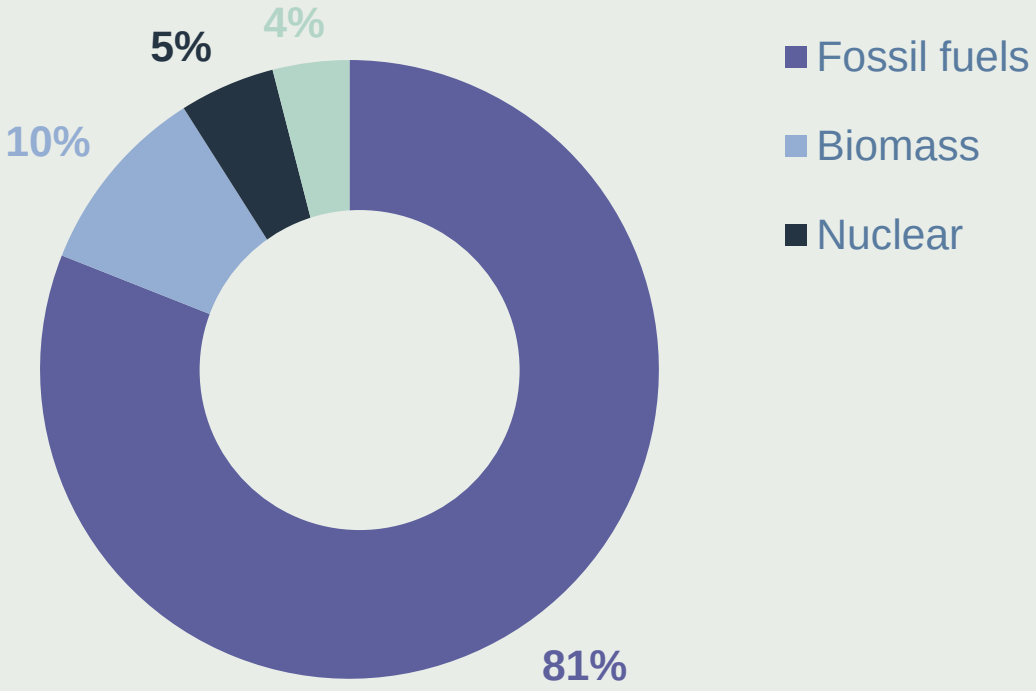
Votes: 1 ● Closed

Topics

ELECTRICAL ENGINEERING

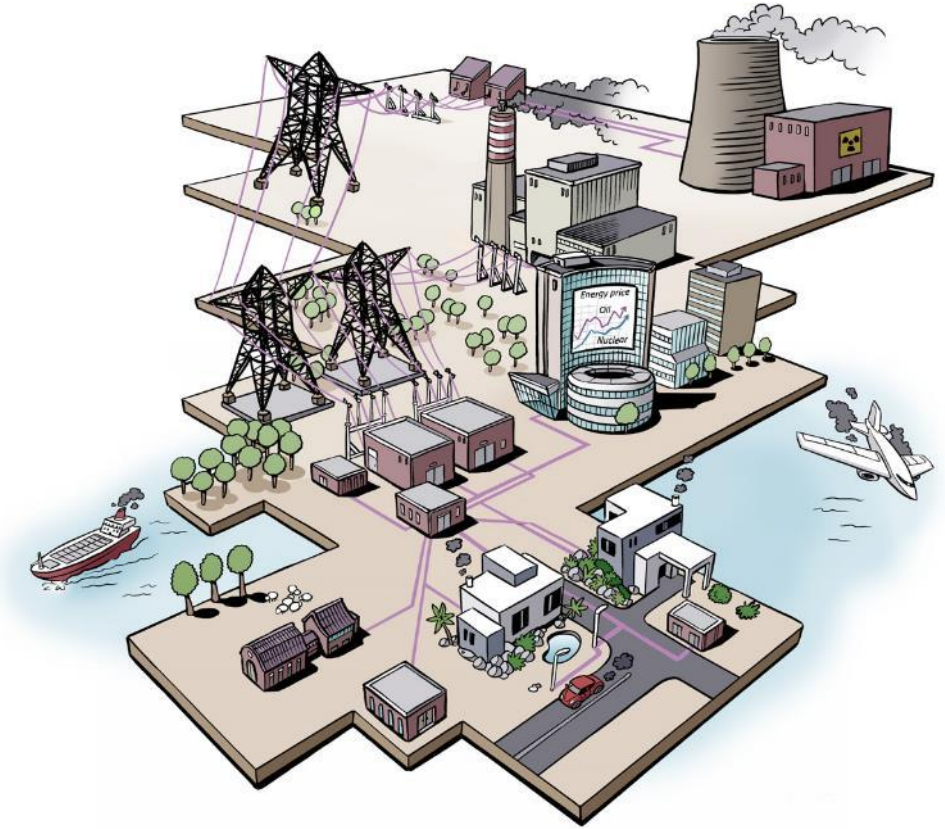
ENERGY TRANSITION

Primary energy consumption in 2015



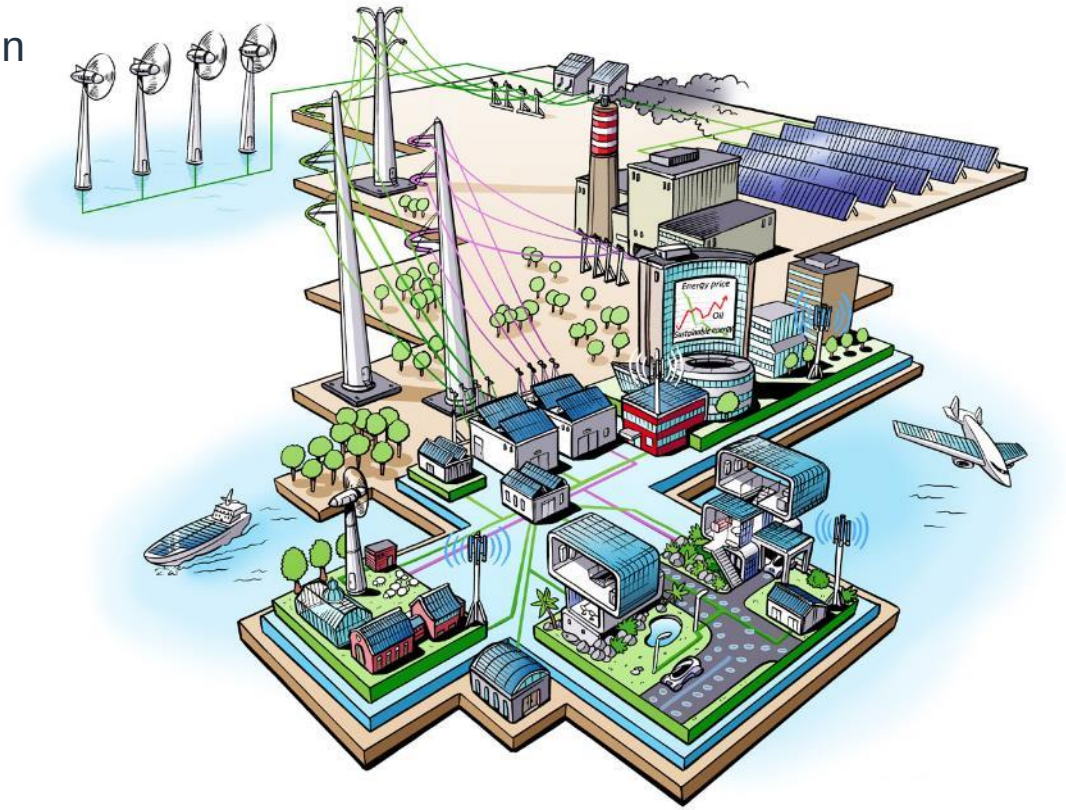
Energy transition in the power sector

- Central generation
- Supply follows demand
- One-directional flow



Energy transition in the power sector

- Central and distributed generation
- Intermittent supply
- Demand follows supply
- Bi-directional flow
- DC transmission and systems



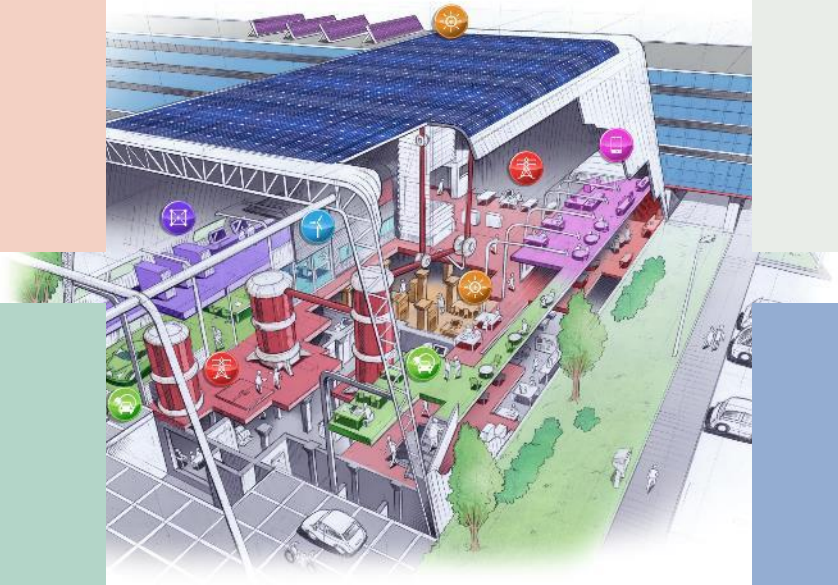
Energy Initiative-related leading programs

DUWIND

Wind energy

Urban Energy

Smart cities



PowerWeb

Smart grid

E-refinery

From electrons to molecules

ESP Lab: System integration

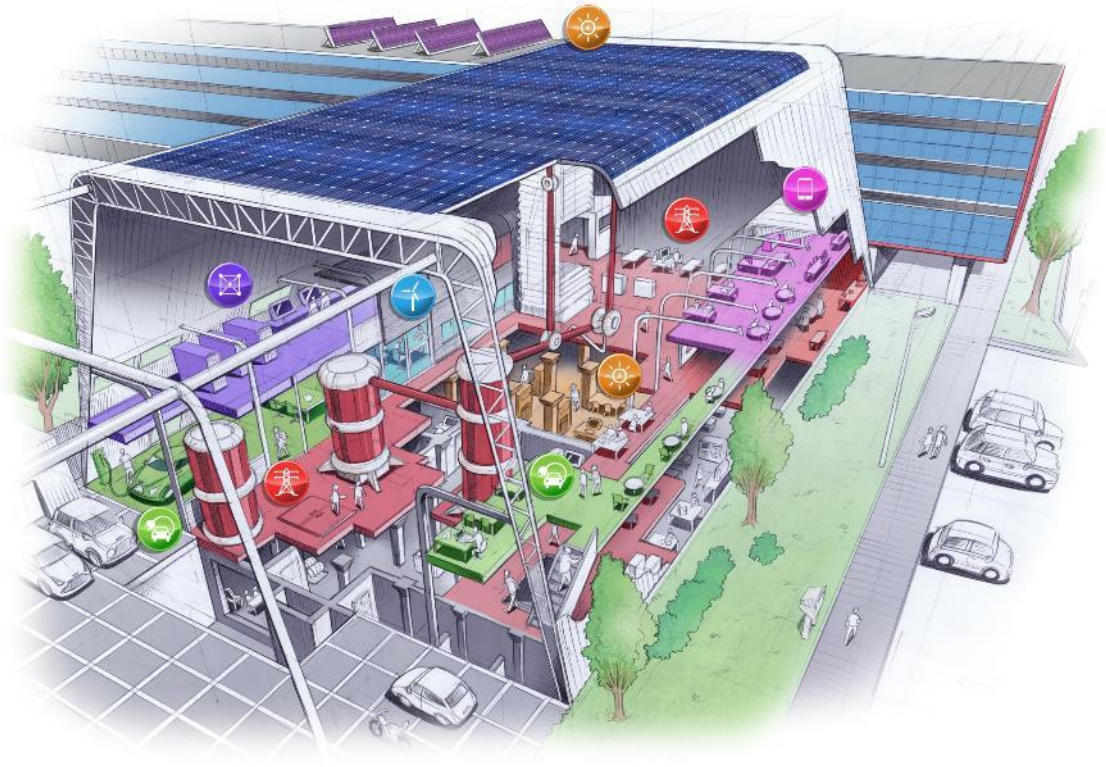
Electrical Sustainable Power Lab

Microgrid
Local e-generation,
E-vehicles, Storage
House appliances

Digitalization
Data centre, IT,
Super computers,
Security

E-generation
Photovoltaics
Wind energy

System grid
HV components
Assets, Diagnostics



How many times larger is the energy received from the sun than the global energy demands?

A. 9
B. 90
C. 900
D. 9000

Votes: 1 ● Closed

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Topics

ELECTRICAL ENGINEERING

MICROELECTRONICS

Organ-on-Chip Technology: The Revolution in Health Care

The Problem

- Too many ineffective medicines and high cost
- Medicine side effects: a significant cause of death

Why?

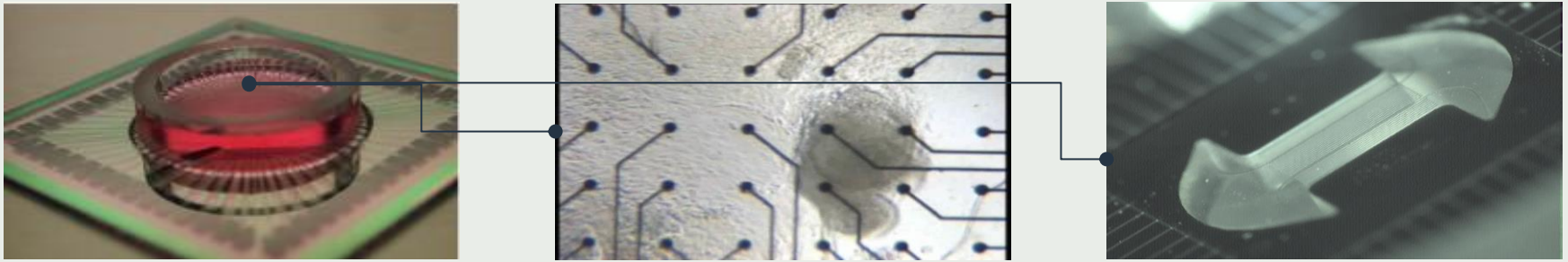
- Limited understanding in disease processes in humans
- Limited prediction in a patient's response to a medicine
- Animal models; not good/optimal for humans

The Solution: Organ-on-Chip Technology

Heart-on-a-Chip: proof of concept

Chip

Human heart cells

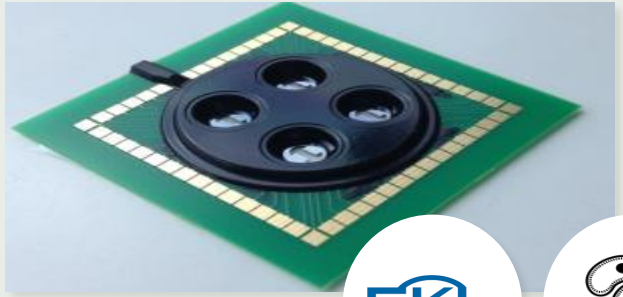


Wat is **Organ-on-Chip**

- Create the smallest functional modules of healthy or diseased tissues using microfluidics, microelectronics and microfabrication

Cells

- Combination of cell culture and a micro-fabricated chip
  that replicates the minimal functional unit of an organ



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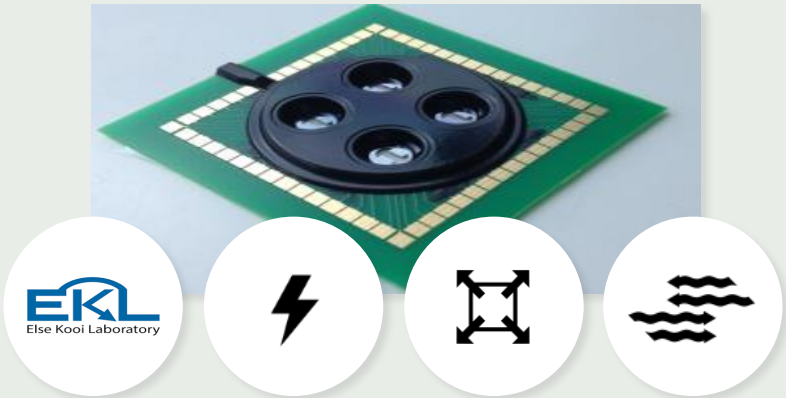
- Create the smallest functional modules of healthy or diseased tissues using microfluidics, microelectronics and microfabrication

Stimulation

- The chip replicates the dynamic conditions of the body

Cells



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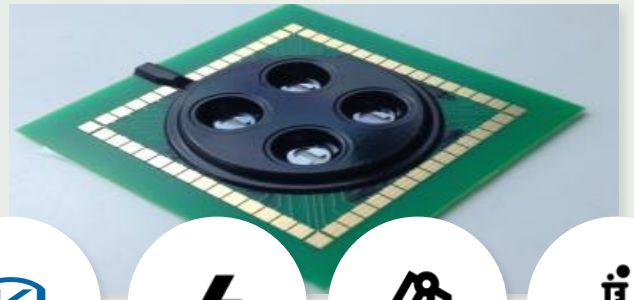
Stimulation

Cells



Output

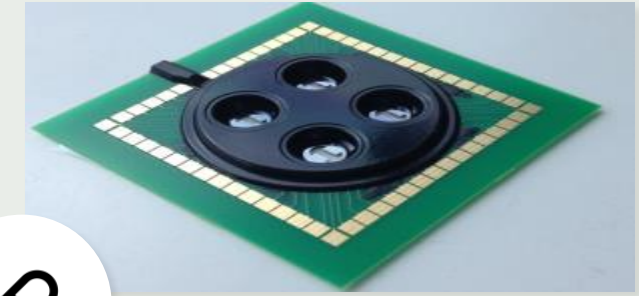
- The cells conditions can be monitored on-line thanks to embedded sensors

Wat is **Organ-on-Chip**

- Create the smallest functional modules of healthy or diseased tissues using microfluidics, microelectronics and microfabrication

Stimulation

Cells

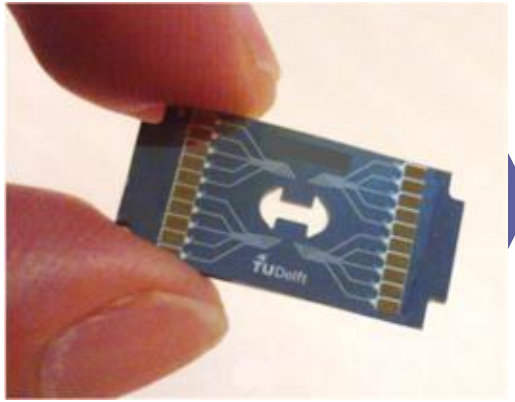


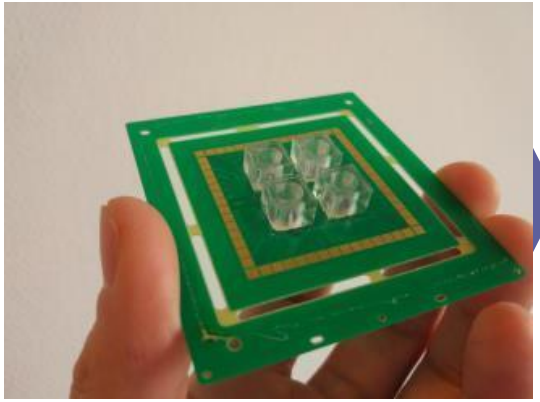
Output

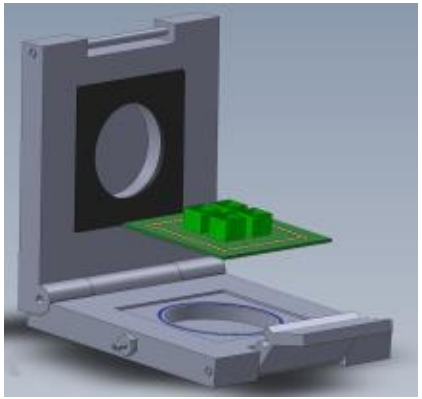
Medicine

- The system provide a predictive model to test medicine

From **chip to system**







Chip

Integration

Read out

Topics

EDUCATIONAL INNOVATION

MATHEMATICS

ELECTRICAL ENGINEERING

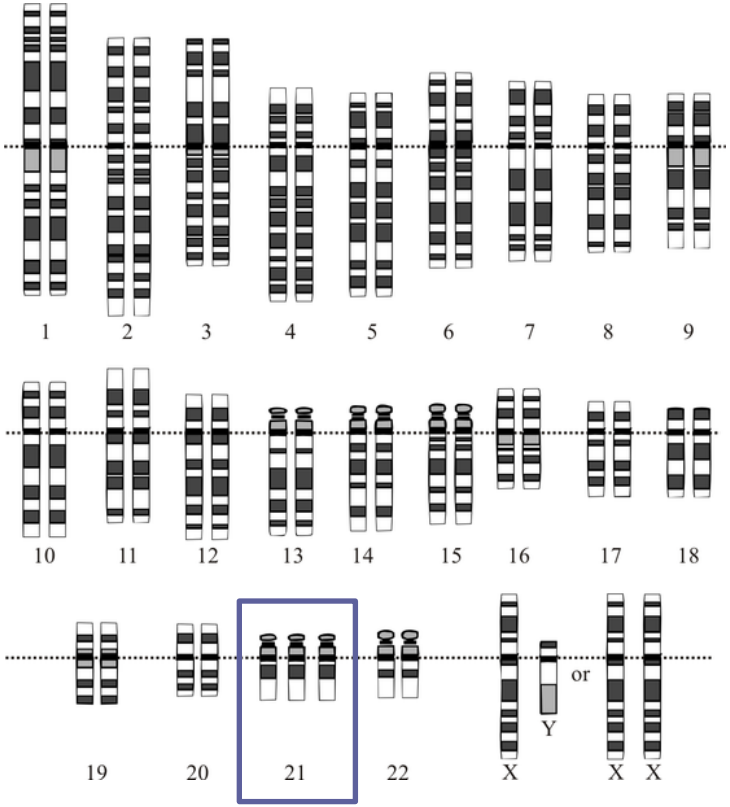
COMPUTER SCIENCE

THE HUMAN FACTOR

NIPT TEST

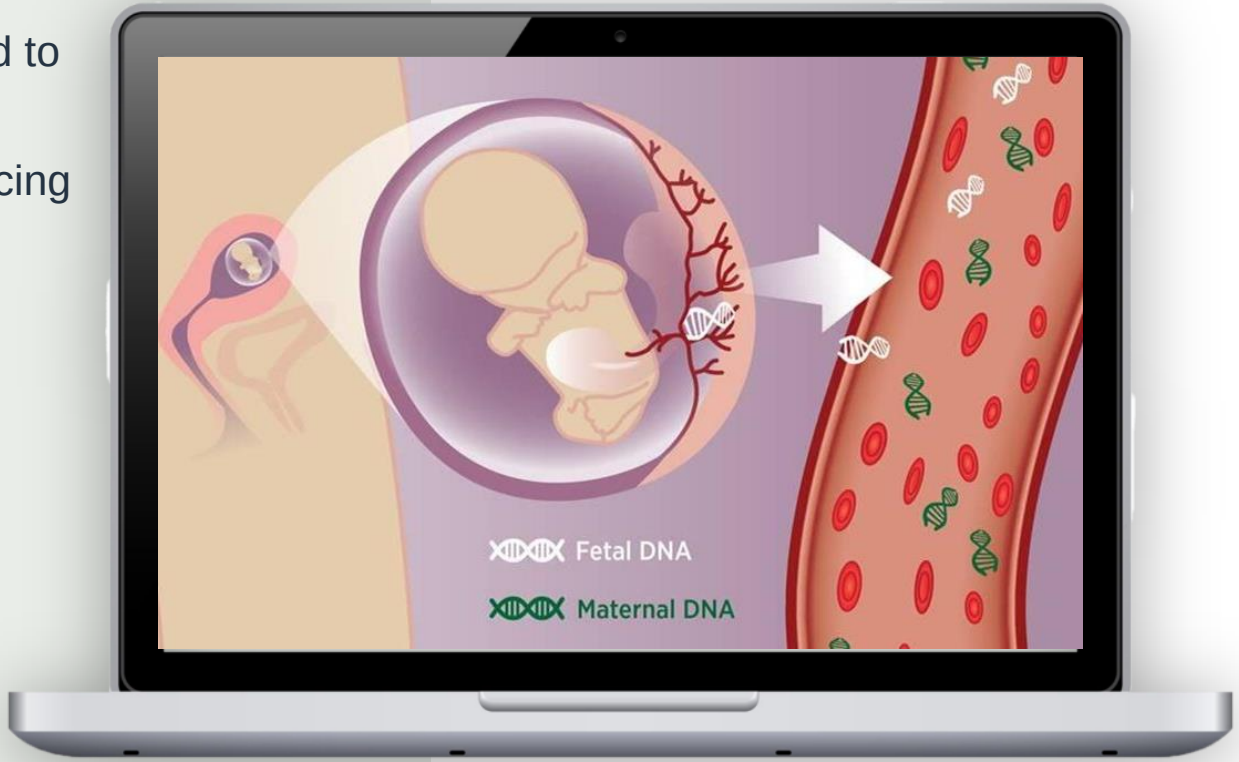
Non-Invasive Pregnancy Test (NIPT)

- Women over 36 years who have increased risk
  of a baby with Down syndrome
- Testing was invasive with a needle to sample small amount of tissue from the placenta
- This comes with a 1% chance of miscarriage



Non-Invasive Pregnancy Test

- External reference is needed to detect abnormalities
- High coverage DNA sequencing required
- Making it an expensive test



Non-Invasive Pregnancy Test

- TUD contribution leads to low cost test because of
  - Within sample comparison: no requirement to re-run healthy references!!
  - Affordable low coverage Next Generation Sequencing
- NIPT can detect Down syndrome and other genome deviations
- Test done on plasma from maternal blood: no risk of miscarriage
- Used in most Dutch medical centers

WISECONDOR: detection of fetal aberrations from shallow sequencing maternal plasma based on a within-sample comparison scheme

Roy Straver[1,2,*], Erik A. Sistermans[2], Henne Holstege[2], Allerdien Visser[3], Cees B. M. Oudejans[3] and Marcel J. T. Reinders[1,*]

[1]Delft Bioinformatics Lab, Delft University of Technology, Mekelweg 4, 2628 CD Delft, The Netherlands, [2]Department of Clinical Genetics, VU University Medical Center Amsterdam, van der Boechorststraat 7 (BS7/J377), 1081 BT Amsterdam, The Netherlands and [3]Department of Clinical Chemistry, VU University Medical Center Amsterdam, van der Boechorststraat 7 (BS7/J377), 1081 BT Amsterdam, The Netherlands

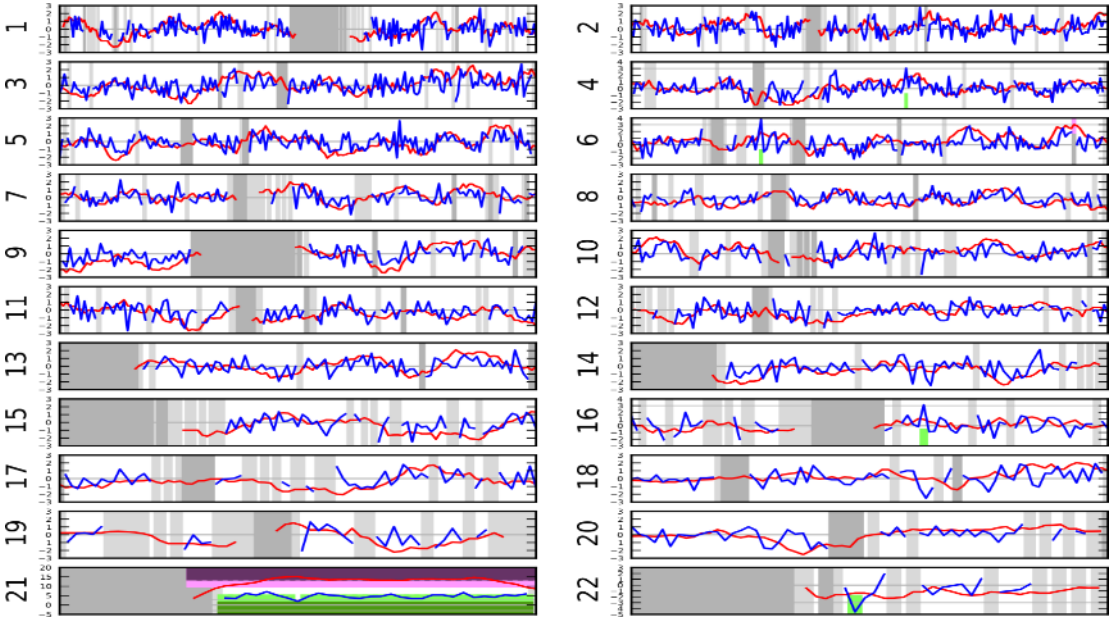
Results
Non-Invasive Pregnancy Test

- Bin z-score
- Window z-score

- Uncallable bin, reference set
- Uncallable bin, mappability

- Bin is aberrated
- Bin is called

- Window is aberrated
- Window is called



Which of the three was leading this effort?

A. Electrical Engineering
B. Mathematics
C. Computer Science

Votes: 1 ● Closed

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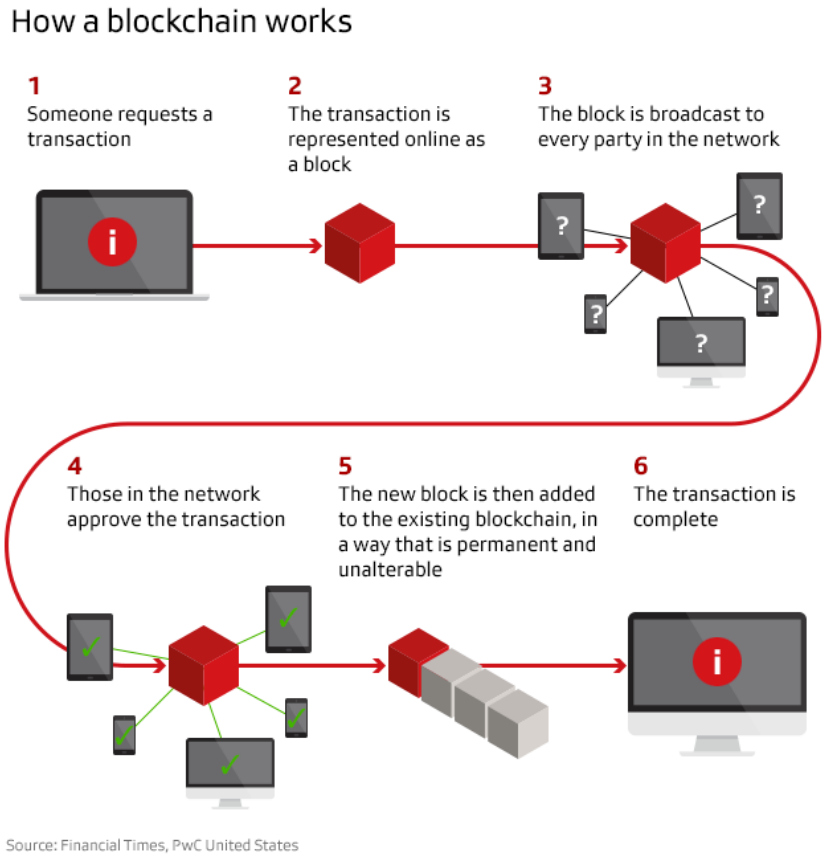
TUDelft
COMPUTER SCIENCE
BLOCKCHAIN

How does blockchain work?

- Create trust through software
  → Secure
- Unalterable copies of the blocks:
  Mathematical protection (hashing)
- Distributed
  → No single point of failure
- No third party involvement
  → Reduce costs and transaction time



Delft Blockchain Lab

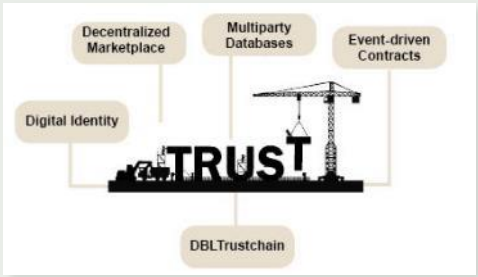
Digitizing trust for society and the economy

Largest academic blockchain lab in EU

- 70 master students / year – 8 professors

Key achievements:

- Trustchain - draft IETF Internet Standard
- Prototype blockchain-based digital identity

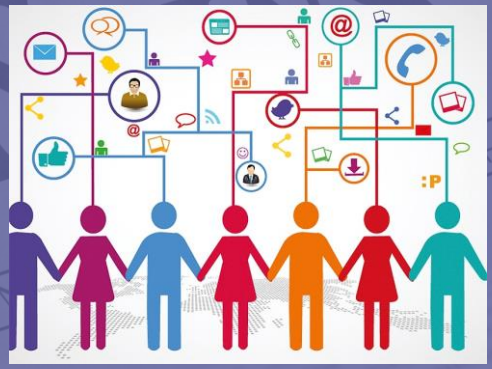


Dutch Blockchain Coalition

connect and create


EUROPESE UNIE
KONINKRIJK DER NEDERLANDEN
PASPOORT
JE MAINTIENDRAI

Digital ID based on trustchain technology



European Commission › Strategy › Digital Single Market › News ›

Digital Single Market

IN THE PRESS | 7 June 2018

TU Delft helps develop digital ID for use on your phone

Home / Binnenlands Nieuws / ID-Plicht - Paspoort / Utrecht en Eindhoven gaan digitale identiteitskaart testen

Utrecht en Eindhoven gaan digitale identiteitskaart testen

Geschreven op 08 juni 2018. Gepost in ID-Plicht - Paspoort

De Nederlandse overheid gaat in de gemeenten Utrecht en Eindhoven voor het eerst een digitaal alternatief voor de identiteitskaart testen die volledig vanaf de smartphone te gebruiken is. Een groep proefpersonen krijgt dan een identiteitsapp die alleen te openen is met biometrische gegevens, zoals een gezichts- of vingerafdrukscan.

Eenmaal geopend toont de app een foto van de gebruiker en een QR-code. Die kan worden gescand door de persoon die de identiteit van de gebruiker wil weten. Wie de app scant, krijgt niet de volledige persoonsinformatie te zien, alleen relevante informatie wordt getoond. In een slijterij ziet een werknemer na een scan bijvoorbeeld alleen of de klant meerderjarig of niet is. In een hotel kan de gebruiker met de app bewijzen dat hij is wie hij zegt dat hij is, zonder onnodige persoonlijke details te delen.

De echtheid van de digitale identiteitskaart wordt gecontroleerd aan de hand van een blockchaintechnologie van de TU Delft, de zogenoemde Trustchain. Als de test succesvol is, ziet de TU Delft mogelijkheden om met de app zowel offline als online de identiteit aan te tonen.

Alles bij de bron; NU

Topics

EDUCATIONAL INNOVATION

MATHEMATICS

ELECTRICAL ENGINEERING

COMPUTER SCIENCE

THE HUMAN FACTOR

Ethical dilemma examples of autonomous systems

- Autonomous vehicles will be faced with decisions that will result in fatalities
- Can an algorithm replace a recruiter?
- Google Images search for “C.E.O.” produced 11 percent women, even though 27 percent of United States chief executives are women

Recommender systems: hazards

Over-personalization (“Algorithmic bias”)

intellectual isolation (filter bubble)

confirmation bias

frictionless information sharing (social media)

groups around same opinions (echo chambers)

tunnel vision

Intellectual segregation

Image source: medium.com

Image source: theday.co.uk

Autonomous Intelligent Technology (AiTech)

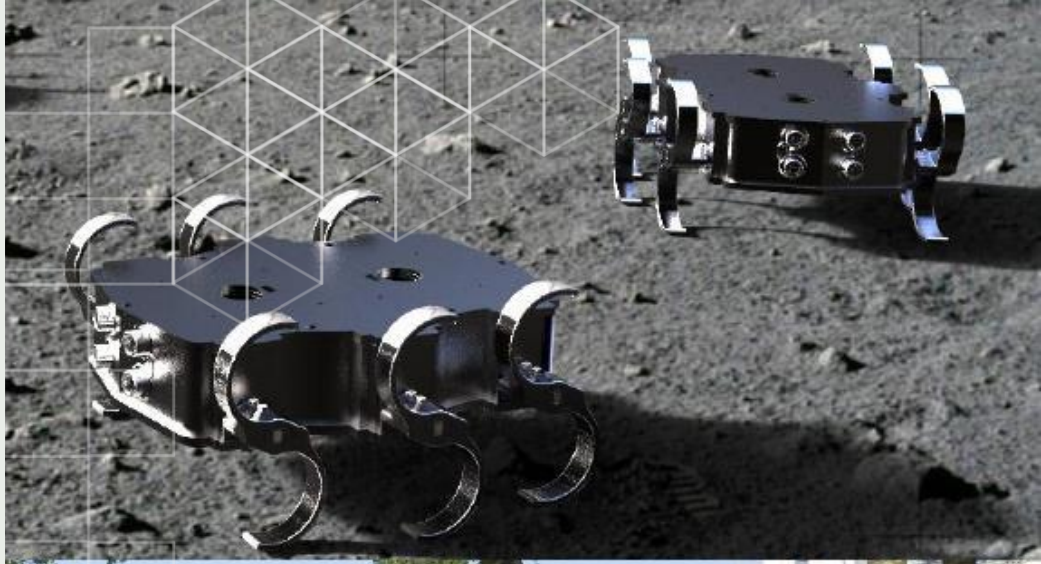
- Executive Board of the TUD has formed a taskforce to develop a program in which designing and engineering autonomous technology is done with a focus on human responsibility and the need of meaningful control
  - Create awareness and ownership of responsible computing-based engineering and design
  - Transparency, confidentiality, fairness, explainability, and trustworthiness
  - Develop definitions and (quantifiable) criteria for algorithm and system properties as well as for the overall concept of ‘meaningful human control
  - Design and engineer concrete autonomous systems that are under meaningful human control.
- Joint forces of 4 faculties: EEMCS, Industrial Design Engineering, Mechanical, Materials and Maritime engineering and Technology, Policies and Management

TU Delft

Swarm Robot

Joint effort: 3ME, AE, IDE, EEMCS

TU Delft Robotics Institute



Swarm Robots: The Ideal platform

- To show power of EEMCS expertise:
  - AI, RF, Communication, Sensors, Signal processing, Optimization, Power electronics, Self deploying sensor networks etc.
- To test at low cost use cases:
  - Find people in earthquake situations
  - Find explosives/chemicals/gas leaks in dangerous situations
  - Intruder detection (perimeter defence)
  - Waste collection

Concluding slides

Our Ambition

"EEMCS's ambition is
to give society the technology
to create a better world"

- For this to happen we do research in all of the three EEMCS disciplines: electrical engineering, computer science and mathematics and create useful knowledge
- Often a combination these three disciplines is needed to come to powerful solutions
- We will need skilled and responsible engineers to realize these solutions
- We must not forget about the human factor

Acknowledgement

My family and especially
my wife Pieternel

Executive Board

The entire EEMCS
scientific and support staff

All who helped me to prepare
this presentation

TU Delft

QUANTUM & COMPUTER ENGINEERING

ELECTRICAL SUSTAINABLE ENERGY

SOFTWARE TECHNOLOGY

MICRO ELECTRONICS

APPLIED MATHEMATICS

INTELLIGENT SYSTEMS

TU DELFT


TUDelft
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