Hacking

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Computer systems keep getting hacked...

1,912 views | Aug 16, 2019, 01:56am

European Central Bank Breach: ECB Confirms Hack And Shuts Down Website

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Blake Sobczak, E&E News reporter

Published: Monday, August 19, 2019

UN: North Korean Hackers Raised $2B to Fund Weapons Program

ETHICAL HACKERS SABOTAGE F-15 FIGHTER JET, EXPOSE SERIOUS VULNERABILITIES

BY JASON MURDOCK ON 8/15/19 AT 8:19 AM EDT

How come this keeps happening?

- **Why can we not make computer systems without security flaws?**
- **Why are these flaws so dangerous?**

Exploring this will lead us to special properties of computers and central research questions in computing science

How to hack a computer system

Basically, two ways to do this :

1. **Attack the user**
   - **eg. phishing email to get username & password**
   - **aka social engineering**

1. **Attack the software**
   - **find flaw & exploit it**
   - **‘real’ hacking**

Hacking

Hacking = using something in a way it was not intended to be used,

getting it to behave in an unintended way

More hacking

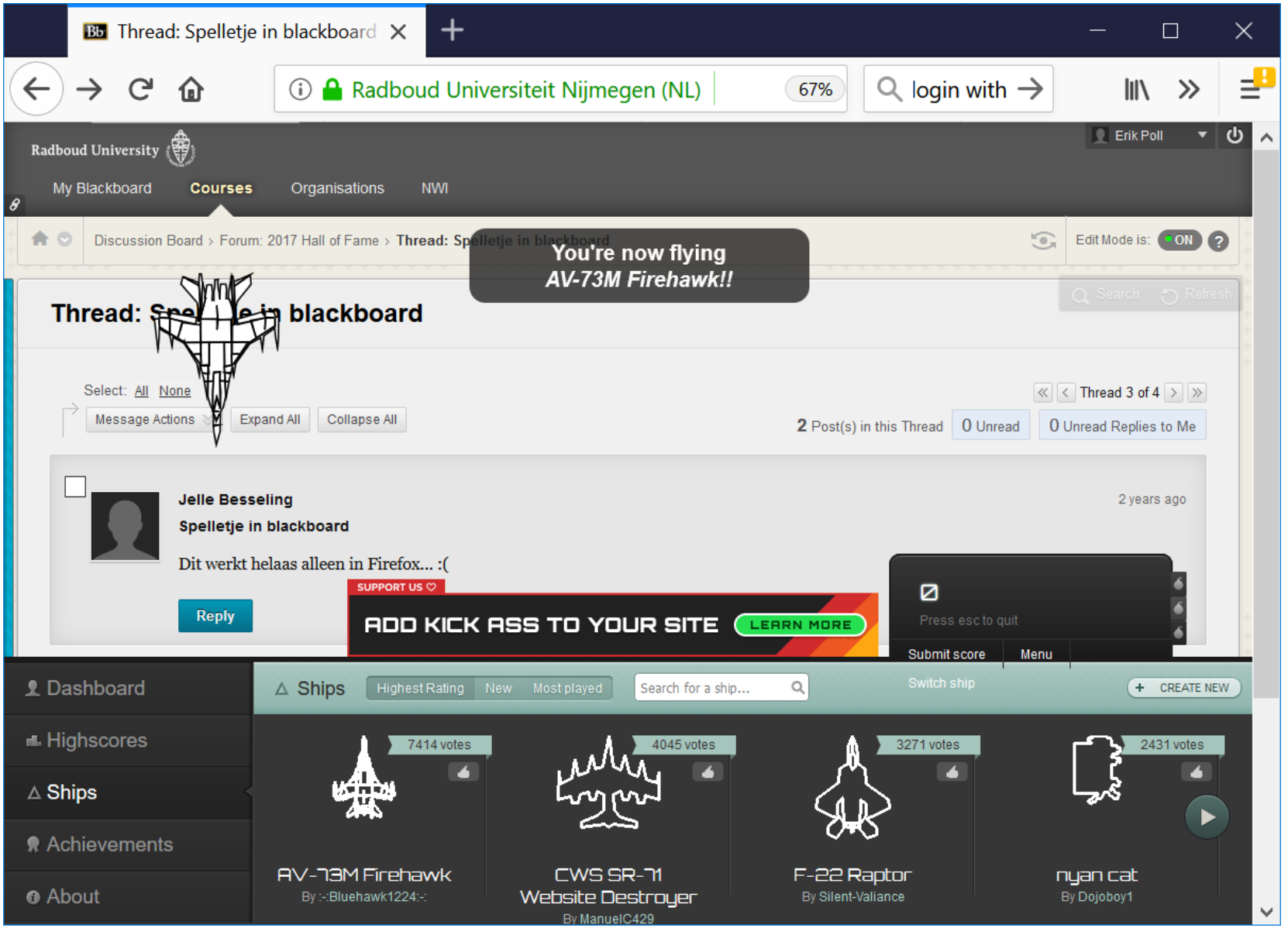
[Simone Giertz, shitty robot]

https://www.youtube.com/watch?v=D3sTjj1eeAA

Using charge pole to cook waffles

[Matthias Dalheimer, CCC'2018, https://evsim.gonium.net]

Hacking: game inside RU website



Hacking computers vs hacking mechanical devices

- Hacking the RU website you can re-program it to do ***anything***
  - e.g. play computer game, change your grades, mine bitcoin, use it to hack or DoS other computers, …
- Hacking a power drill, washing machine, hard disk you can only make it do variations of the same theme
  - unless there is a computer in it …

Special property 1: Software & programmability

Software can do *anything*

- Software gives computers the power & flexibility to do anything
  - Eg. smartphone can be used to text, surf the web, listen to music, watch videos, play games, online shopping, internet banking, …
  - Here we also use the power & flexibility of digital information
    - Digital information used to represent text, images, sound, video, digital money in your online bank account, digital items in online shopping basket, …

Downside: if an attacker gets in, this power can be used against you

Special property 2: Digital vs Analog

- Mechanical systems are analog systems
  - the speed of hard disk can be anything, giving an infinite number of possibilities for the speed

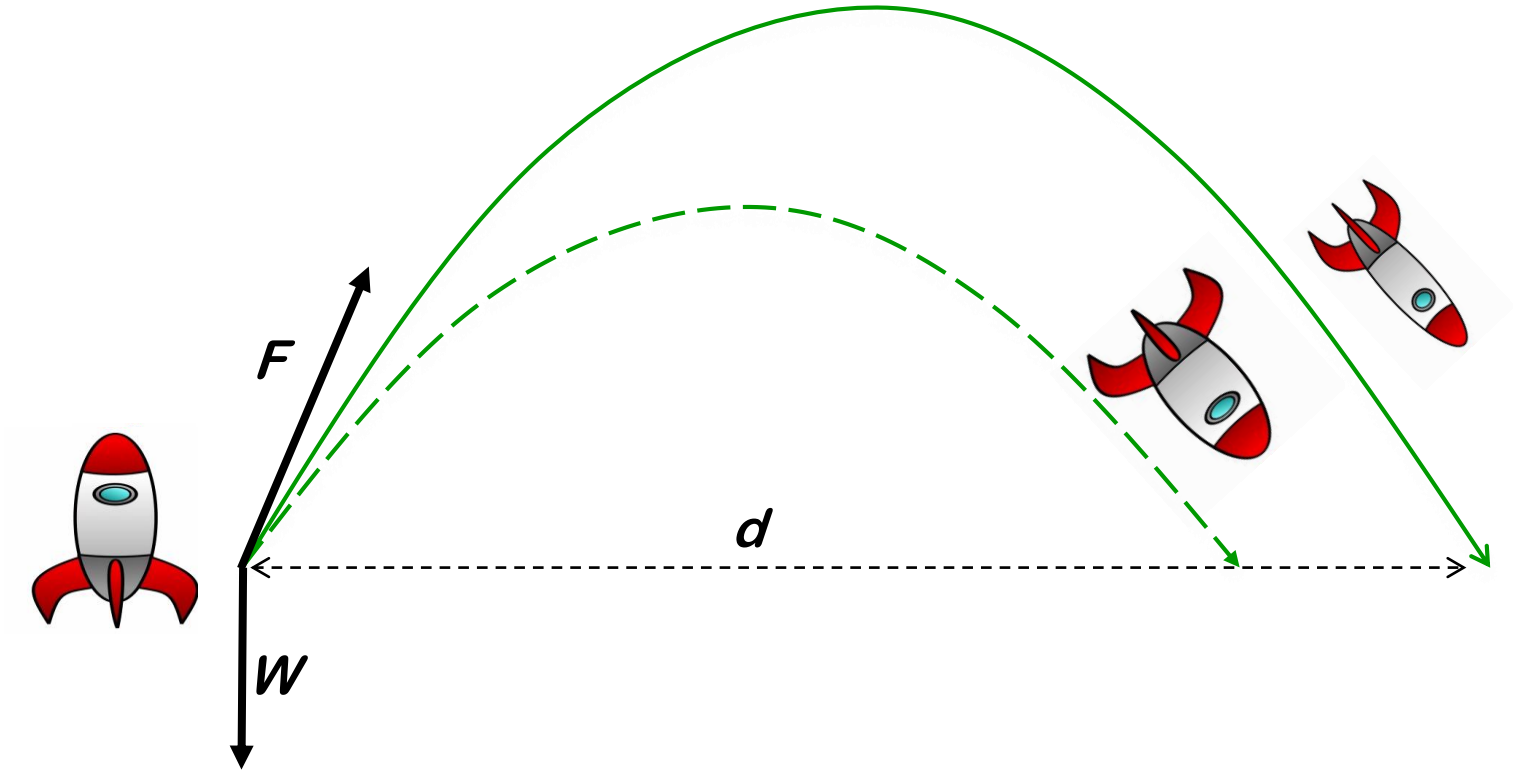
- Computers are digital or discrete systems
  - a bit is 0 or 1, byte can have 256 values, etc.
  - finite (but very large) number of possibilities
    - a computer with 35 byte memory has more states than there are sub-atomic particles in the universe

Paradox: understanding the finite behaviour of a computer is much harder than understanding the infinite behaviour of spinning hard disk

Understanding analog systems: rocket science

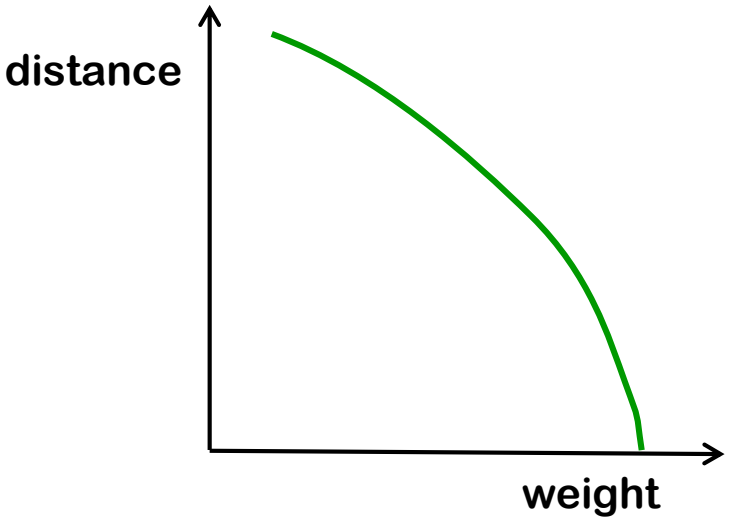
Mathematical model of flight path,
allows us to define for example $\mathbf{f} \in \mathbb{R} \longrightarrow \mathbb{R}$

where $\mathbf{f}(\mathit{Weight})$ is distance d travelled

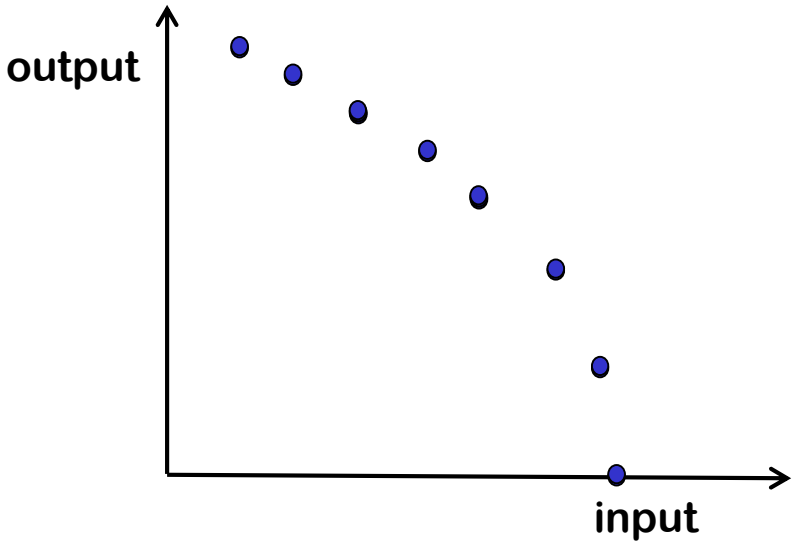


Analog vs DIGITAL systems

Analog system can be described with 'smooth' mathematical functions



Digital systems are very different:



Small changes in input typically give small changes in output

Analog vs DIGITAL systems

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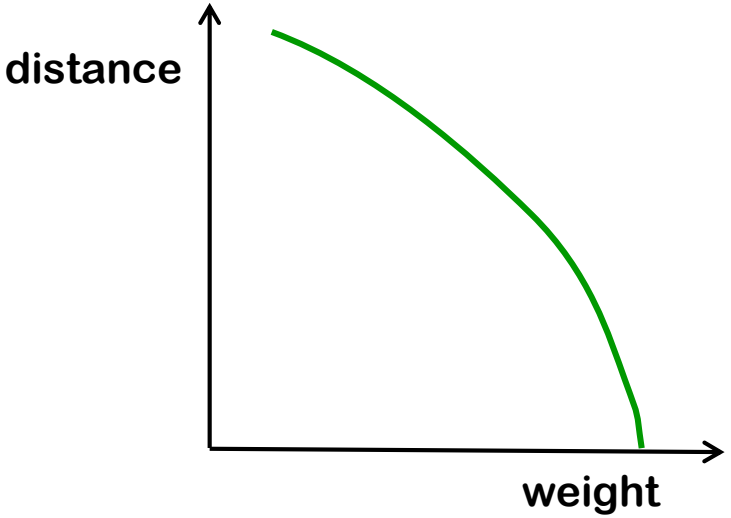

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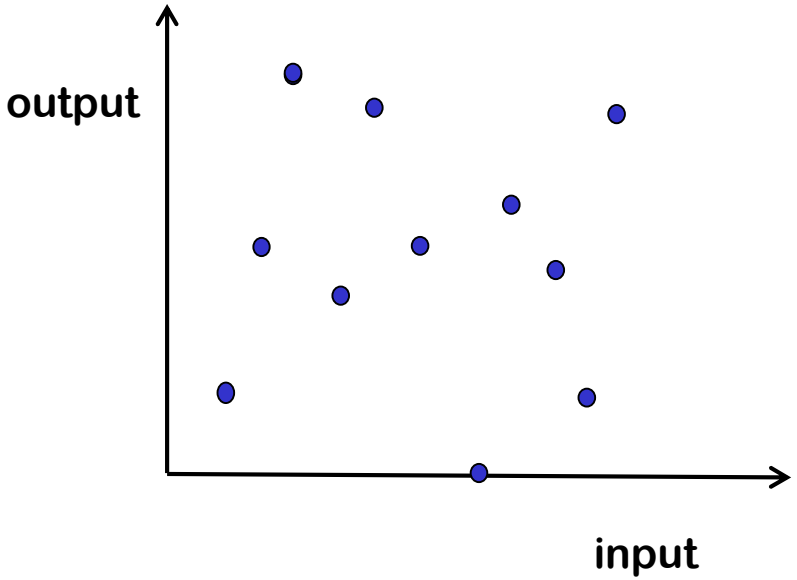

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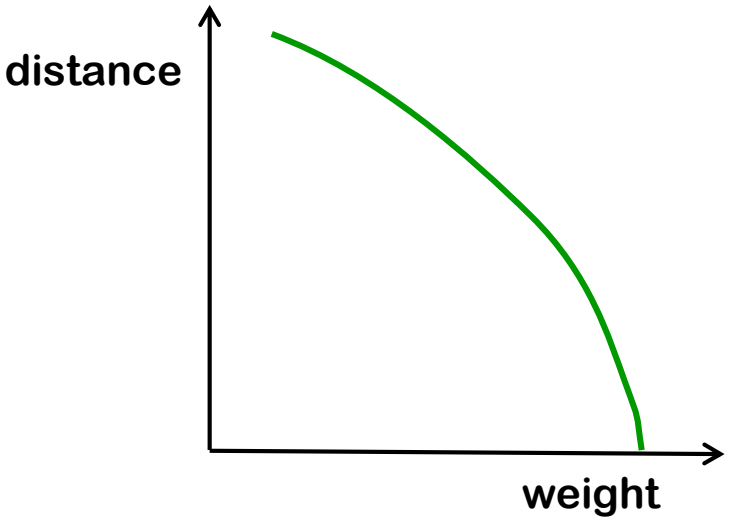

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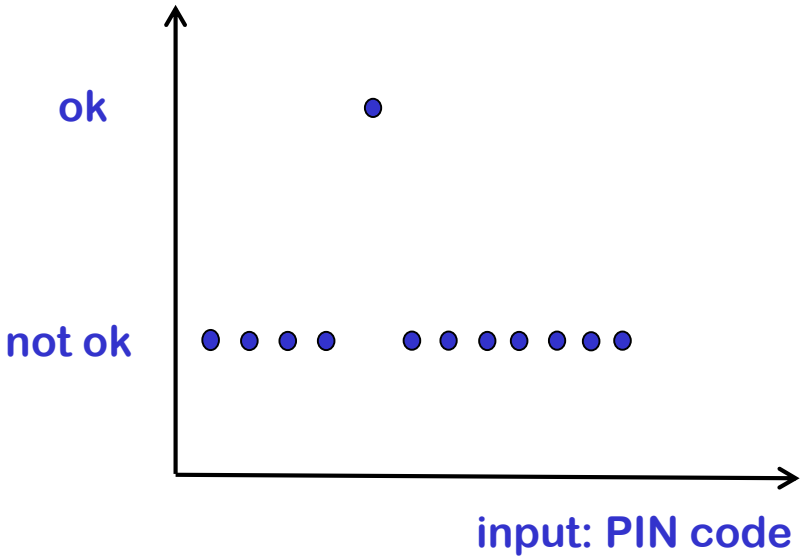

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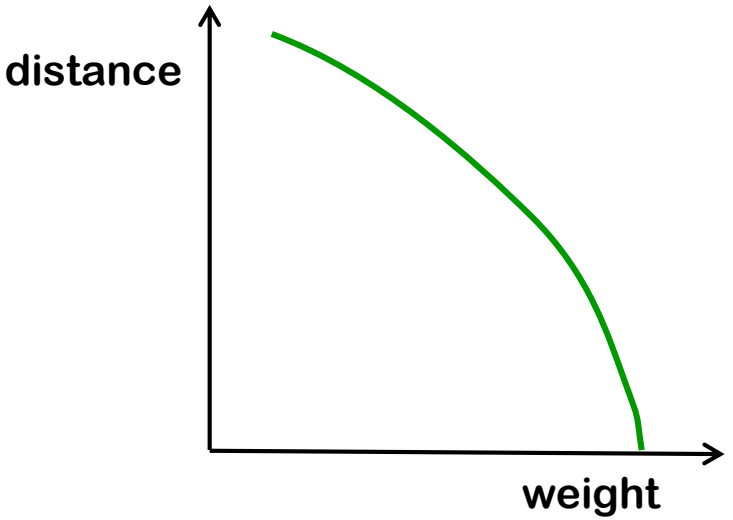


Small changes in input typically give small changes in output.

Digital systems are very different:

- Tiny change in input can completely change the behaviour
- Also, digital systems have memory, so they behave different over time

This makes understanding computer systems *much* more difficult.

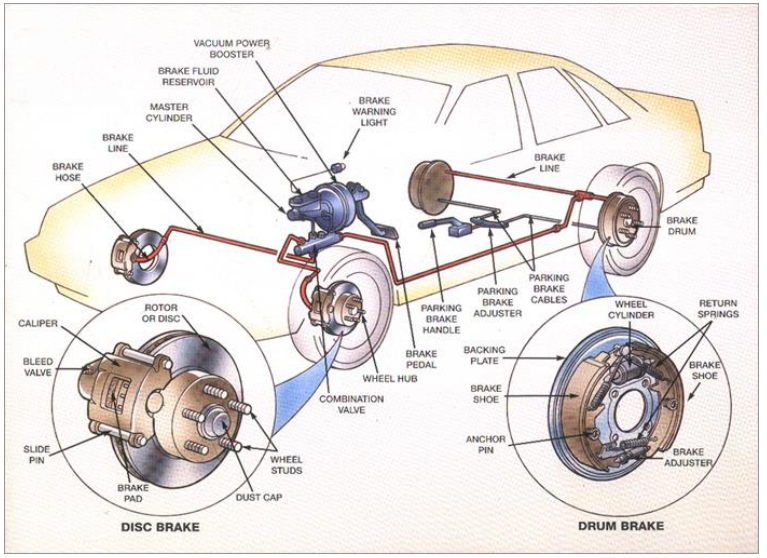
First launch of Ariane V rocket

Costly software bug:
converting from 64-bit floating point number to 16-bit signed integer

[https://www.youtube.com/watch?v=kYUrqdUyEpI]

Analog vs DIGITAL systems

- If an analog, mechanical braking system can stop the car at 40 km/h, it can also stop the car at 30 km/h



- If a digital, computerised braking system can stop a car at 40 km/h, it might fail to stop at car at 32.767 km/h

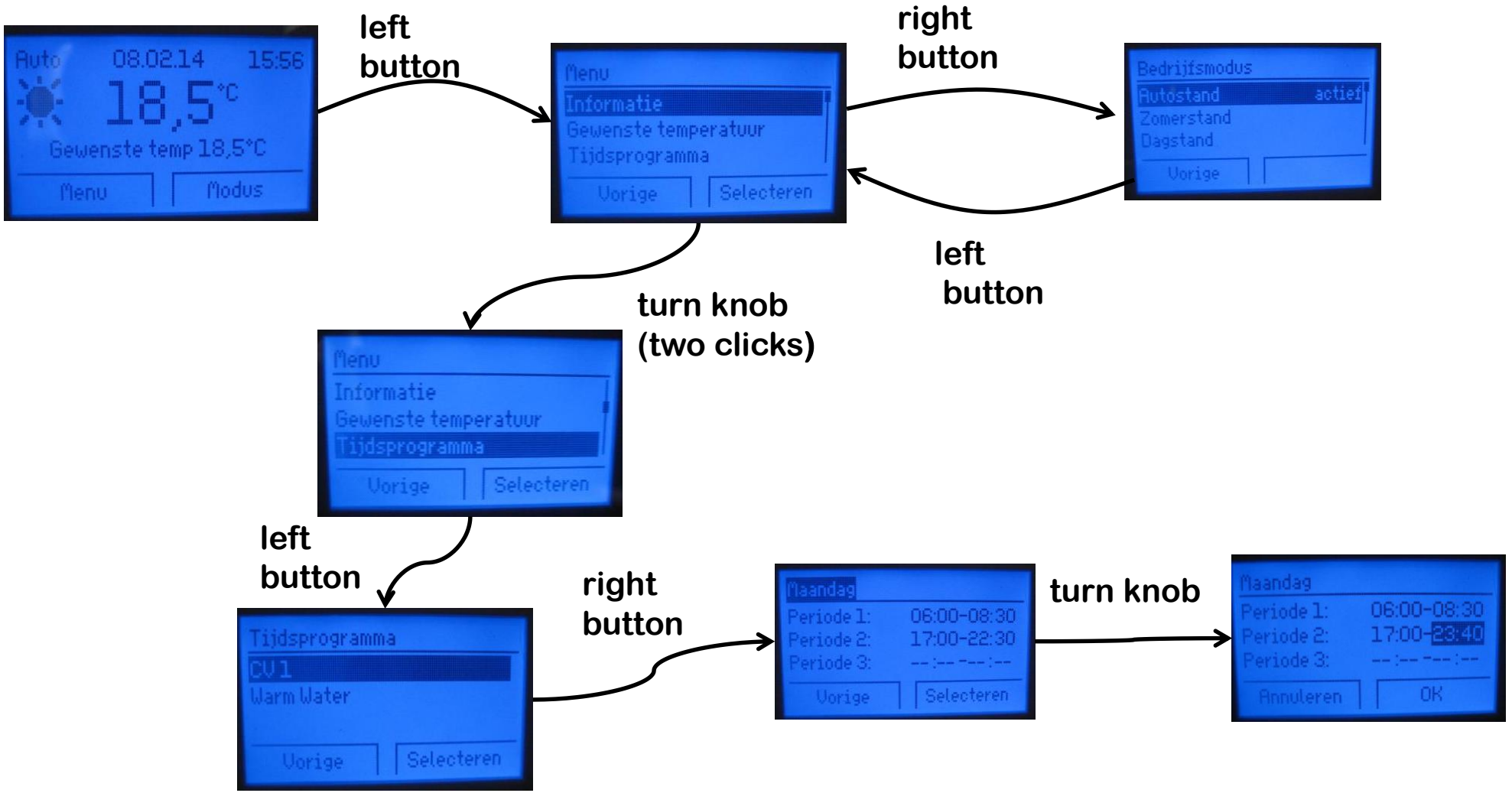
Example computer

How to understand – or *model* - this software?

Two ways to understand how it works

1. **read the manual**
2. **mess around to discover how it work**

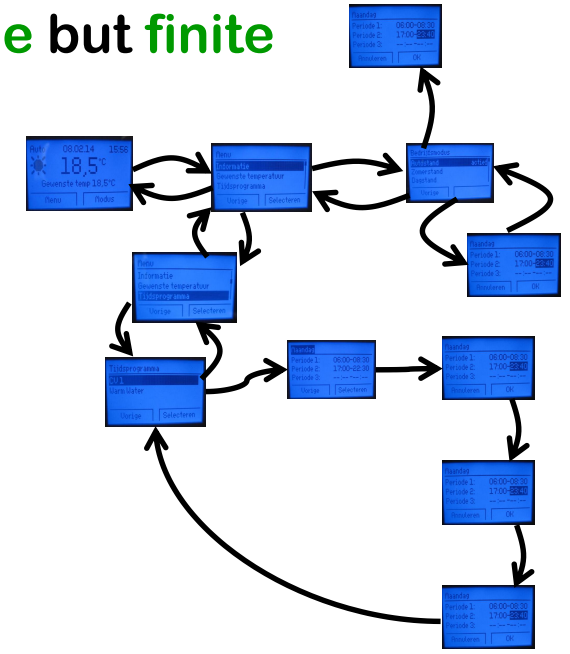
Understanding – or *modelling* – this software



This type of model is called a finite automaton

Understanding – or *modelling* – this software

Automaton describes the state space, which is huge but finite



- Exploring *enough* of the state space
  to operate the heating system is doable
- Exploring the *whole* state space is infeasible.
  There could be a bug somewhere, and
  an attacker might find & abuse it…

Central research questions in computing science:

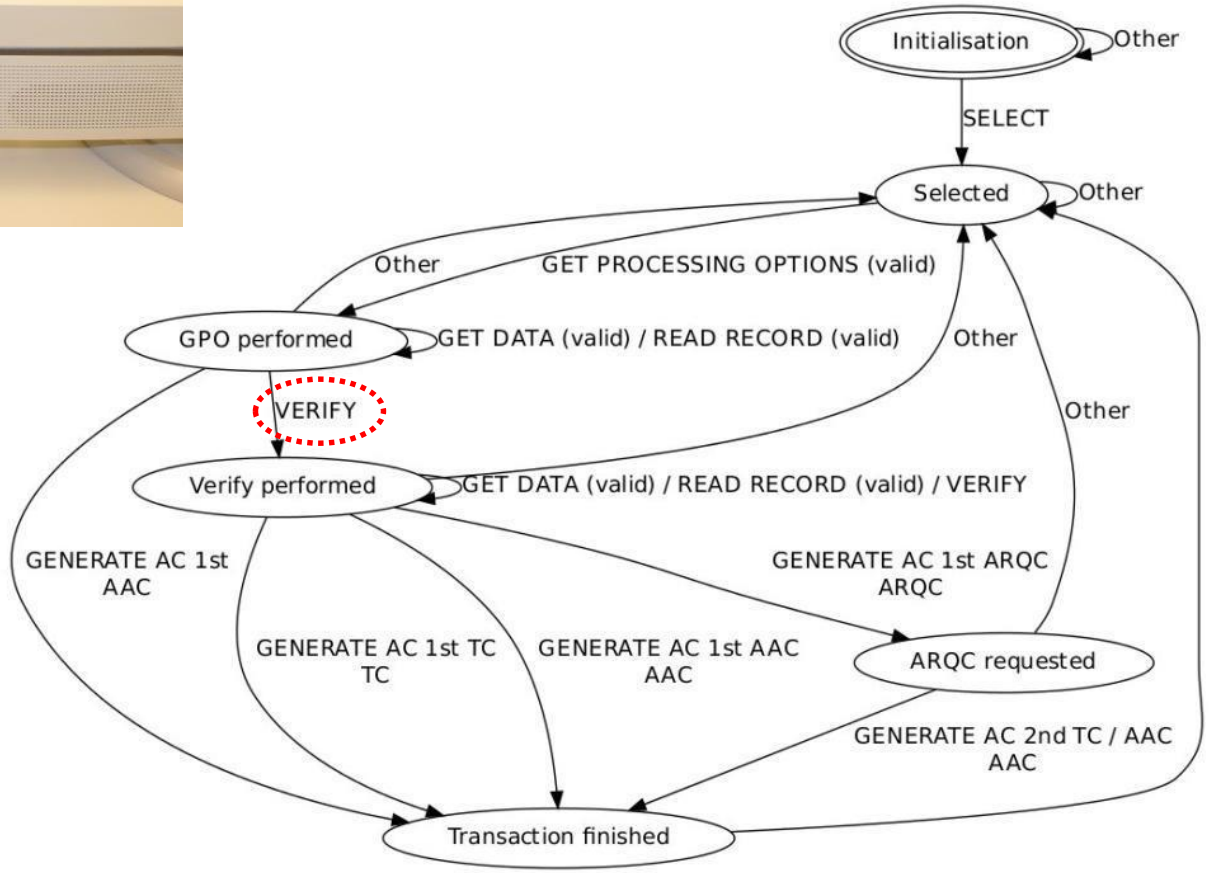
- How can we analyse such a system to know there are no bugs?
- Or: how can we construct it in such a way that there are no bugs?

Another example of a computer

Bank card has small computer inside, that you can talk to

- via **contact interface** 
- via **contactless interface**

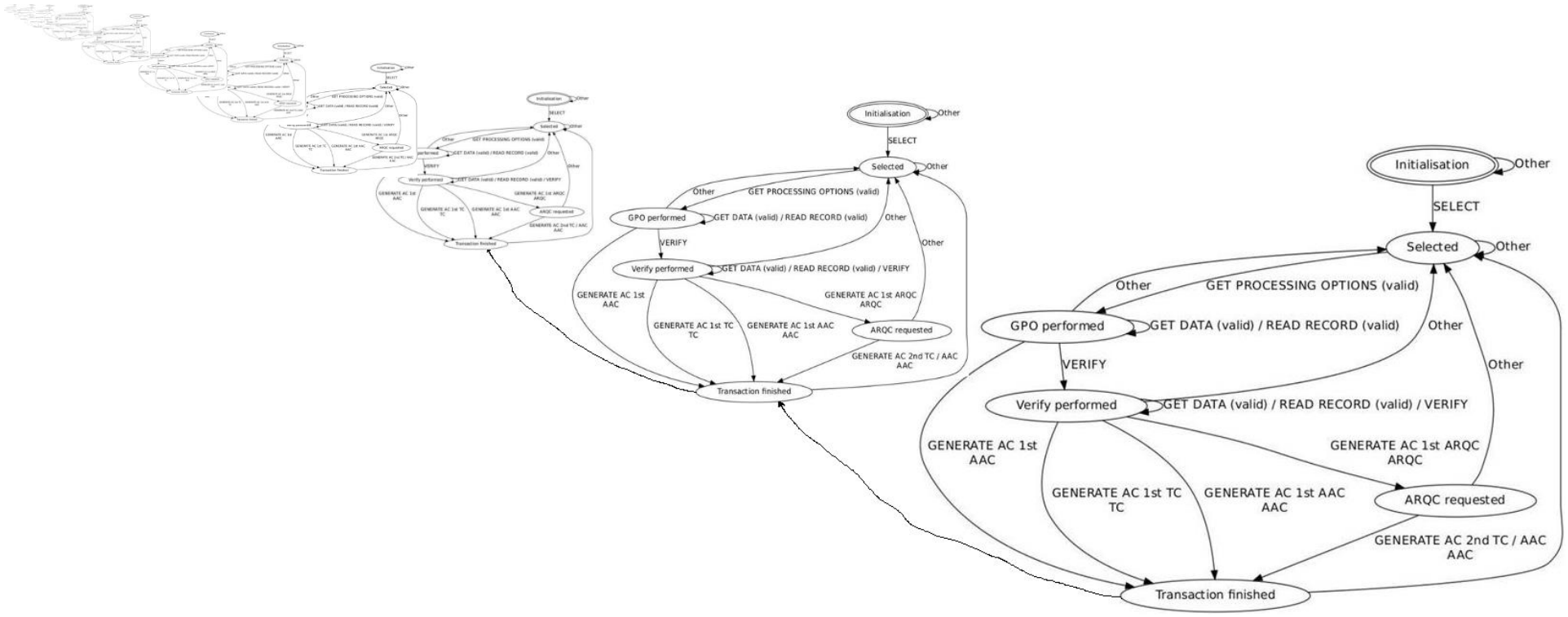
Exploring the behaviour of



Exploring the behaviour of

This is a simplification, or an abstraction

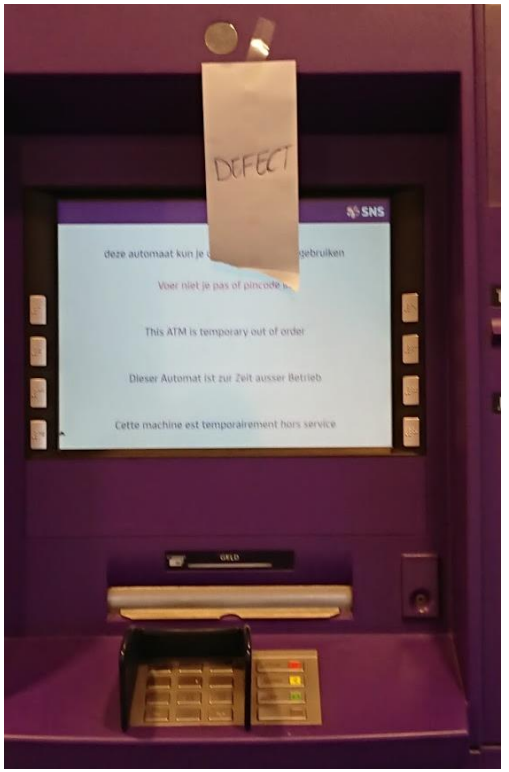
The real state space is 2.45 x 10^{55} times as big



Problems found in bank cards & terminals

We found no expoitable mistakes, but students did find some Denial of Service (DoS) possibilities

- in contactless payment terminals, causing them to crash
- in the first contactless bankcards of two Dutch banks, which enabled access to PIN functionality via contactless interface



Conclusions

- Computing Science is not rocket science:
  it's way more complicated than that
  - Software is *the* most complex artefact engineered by humankind

- What makes computing science special (but tricky)
  1. Software gives amazing power & flexibility.
     But for security this is our Achilles' heel:
     an attacker can exploit this to re-program a hacked device
  2. We are dealing with digital, discrete systems, where
     a tiny change can completely change the behaviour

Some links with first year courses

- **Imperative programming:** How do you program a computer?
- **Processors**: How does a computer execute software to do anything?
- **Hacking in C**: How can attackers abuse this to make a computer do different things than intended?
- **Security**: How can to prevent people getting free electricity at charge pole?
- **Languages & Automata:** How can we describe/model the behaviour of dynamic systems and their input languages?
- **Combinatorics**, **Mathematical Structures**, and **Matrix Calculation:** mathematics to reason logically about discrete structures
- **Information Modelling & Databases:** How can all sorts of information be digitally represented in a computer system?

Thanks for your attention!