Overview of the ReAct project

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FORTH

Ack: The research leading to these results has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement No. 786669. The content of this talk reflects reflect the views only of their author. The European Commission/ Research Executive Agency are not responsible for any use that may be made of the information it contains.

Roadmap

- CyberSecurity
  - Then and Now
- The heart of the problem
- The solution
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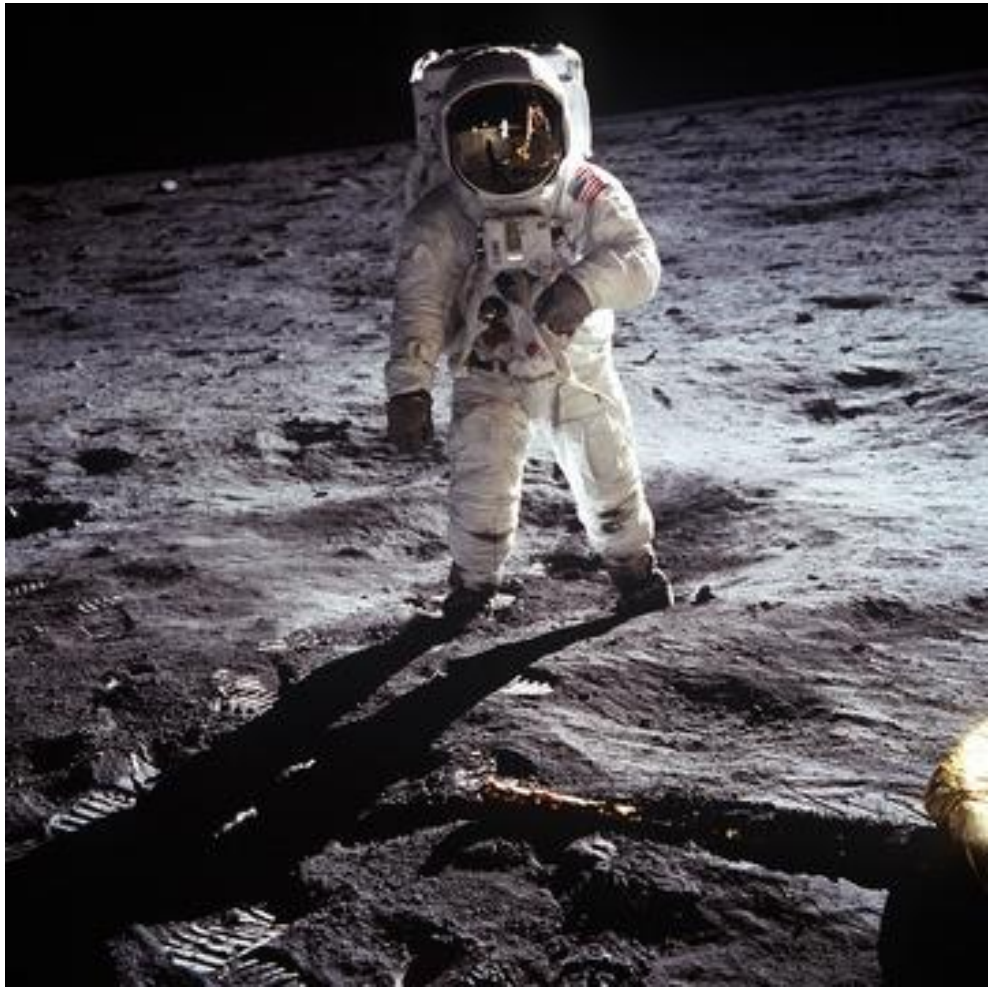
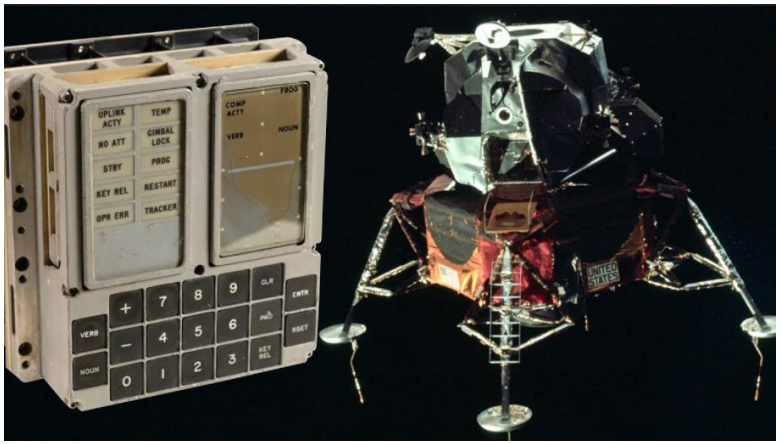
CyberSecurity: Old or New?

- Why are we talking about cybersecurity?
- Is this a new problem?
- Didn’t we have this problem
  - 20 years ago?
  - 30 years ago?
  - 40 years ago?
  - 50 years ago?

A trip down Memory Lane: 1969

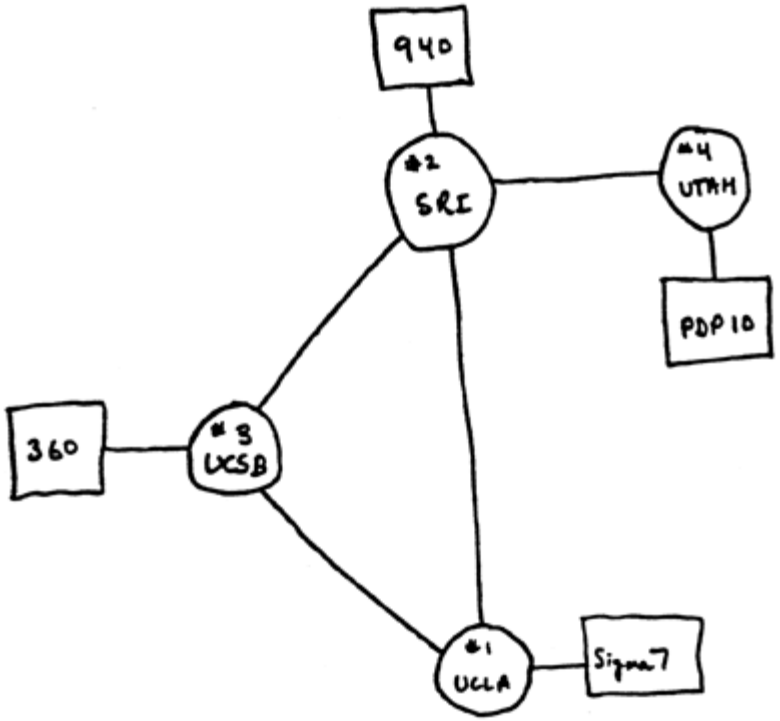
1969: Man Landed on the Moon





1969: The Internet (ARPANET) was invented

- The Internet (ARPANET) in Dec 1969:

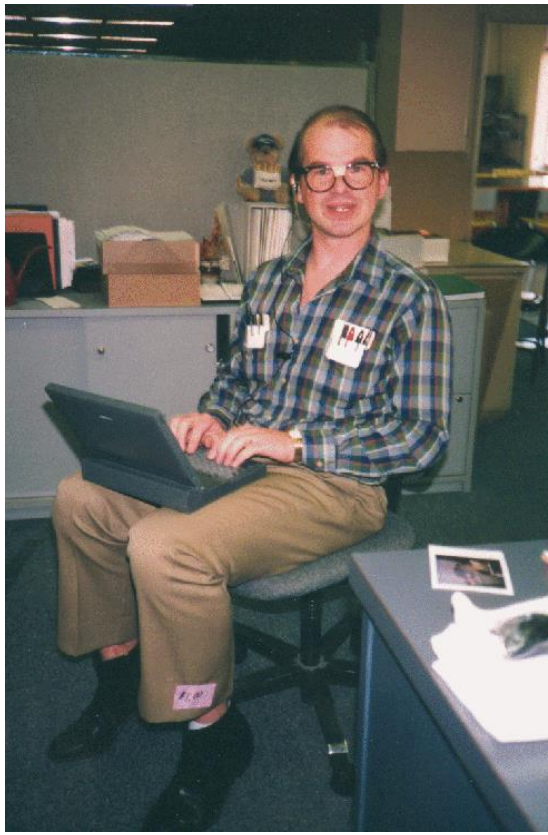


So, in 1969

- We had computers
  - They landed the man on the moon
- We had the Internet
  - It was called ARPANET, but still…
- We had software
- Did we have any cybersecurity issues?

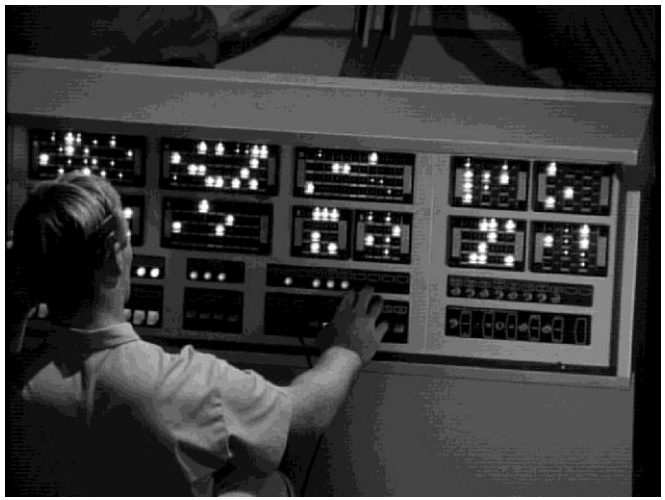
Cyber Security Problems in 1969

- CyberSecurity in 1969
  - Existed but
  - Not a major problem
- Because:
  - **Closed Community**
    - mostly academics had access
  - **Boring applications**
    - mostly numerical analysis
  - Computers **did not have a lot of value**
    - No data
    - No financial value
  - **Small scale**:
    - just four nodes



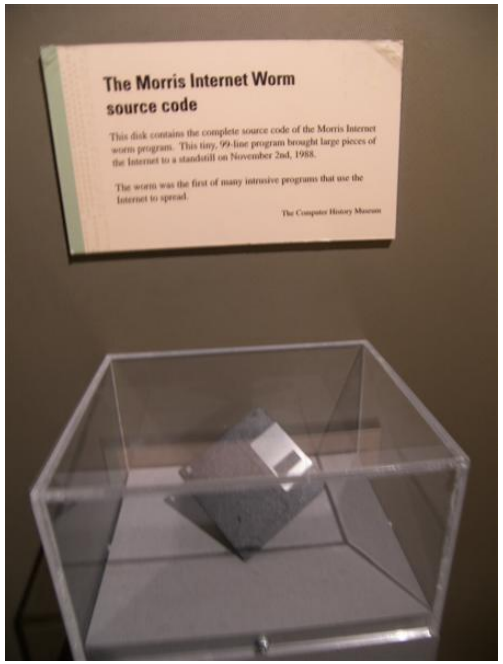
The end result

- So, because cybersecurity was not a major issue in 1969
- **The Internet was not designed with security in mind**
  - Small Academic community
  - Restricted physical (and virtual) access



The situation did not change

- For 25 years computers
- Internet kept on being
  - Boring
    - Mostly numerical analysis
  - Closed Community
    - Mostly academics had access
- There was an occasional cyberattack
  - But people (out there) did not take notice…
  - They did not have an Internet connection
  - They did not have a facebook account…
  - They did not have a smartphone…



And then… in mid 90's

- Something changed!
- People started connecting to the Internet
  - The ISPs started offering Internet Connections
- People of all realms – not only academics
- Computers **started storing data**
  - Lots of data!
  - Interesting data!
  - Personal Data: Email - Gossip!
  - Financial data: Credit card numbers

And then…

- Things changed even more!
- Computers started **doing** things
  - In the **physical world**
- Such as
  - Controlling appliances (refrigerators, etc.)
  - Controlling machinery
  - Running factories
  - Controlling Medical equipment
  - Self-Driving cars!

THE Question

- Now it is time to pose THE Question:

How **valuable** is a computer to a cyberattacker?

Computers started to have value for attackers!

- **Compromising a computer in the 70's**
  - **had little value**
- What could an attacker do with it?
- Solve equations?
- Do numerical analysis?
  - So what?

Computers started to have value!

- Compromising a computer today
  - has a lot value!
- Cyberattackers can **monetize** it in several ways:
  - Steal the personal/professional stored data
  - Ask for ransom
  - Send SPAM
  - Host illegal markets
  - Mine Cryptocurrencies
  - Host illegal services (fake DNS, etc.)
  - Industrial espionage
  - …

Major Damage

- Compromised computers can now do major damage

MIT Technology Review

Topics Mag

CAMILO JIMENEZ ON UNSPLASH

Computing / Cybersecurity

A patient has died after ransomware hackers hit a German hospital

This is the first ever case of a fatality being linked to a cyberattack.

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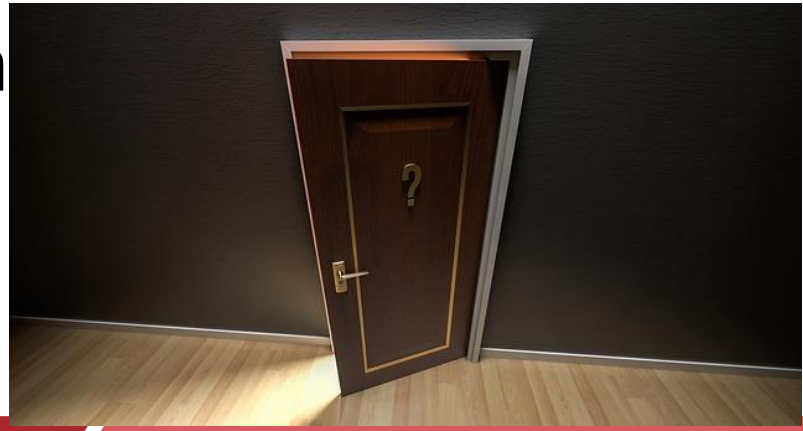
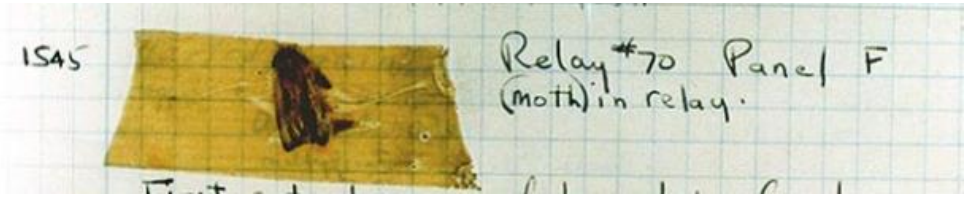
What is the problem? I

- We have lots of cyberattacks because:
  - Computers are vulnerable
    - They contain mistakes (bugs)!
    - Software bugs (overflows etc.)
    - Hardware bugs (rowhammer, etc.)
- Bugs are programming mistakes
- Human errors
  - Left in a computer program



What is the problem? II

- Hackers are using these bugs (human mistakes)
  - to compromise computers
- How?
  - Hackers search for bugs
  - If they find a bug
  - They keep it secret
    - So that no one fixes it… ☹
  - And then they ATTACK! (**ZERO day**)
  - After that companies create a software patch
    - That removes the bug
    - Users apply the PATCH (**PATCH day**)



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The ReAct approach

- The solution lies in
- a **fundamental change of our mindset**

We should

change the way we think about cybersecurity

An example: securing your home

- Suppose that you have just bought a new home and
- You would like to make your new home more secure.

- You think:
  - More secure front door
  - Better alarm, stronger fence, etc.
- We say:
  - No! Before securing your home **try to break into it!**
  - Do not purchase a new front door before you break into it!
  - In your effort to break into your new home consider the following:

Breaking into your house

- Did you consider the back door?
- How about the skylight on the roof?
- Or the stone under which you store the spare key?
- Or the garage door that opens with a remote?
- Or the digital assistant that you can ask to
  - "open the front door"?
- Or that loose board in the fence that you can remove and squeeze through?
- Did you know that people can "saw" their way in?
  - By "cutting" through your lightweight walls?

Breaking and Fixing

- OK!
- Now that **you know how to break in**
- You can **make your home more secure**

- In ReAct we do exactly the same:
- We break into systems
- In order to know how to fix them

Our approach

- Do not rush into protecting systems
  - Before you know how to break them
- Do not purchase a more secure front door
  - Before you know how to break in your house
- Do not try to secure your system
  - Before you know how to break it
- This is ReAct's approach:
- **Break things first**, and then try to fix them

What does this mean in the digital word?

- Try to “break” programs
- Try to **make systems fail**
- Once you break them
  - Try to understand why they failed
- And finally,
- Try to fix them

How do we break things?

- **Fuzzing**
  - Run the program
    - with every possible input
    - every possible combination of values
    - every possible “unexpected” thing you can think of
  - See if it crashes…
    - If it does this is **good news!**
  - But… all possible inputs take exponential time
    - Needs guidance from algorithms to do it in reasonable time

How do we break things? II

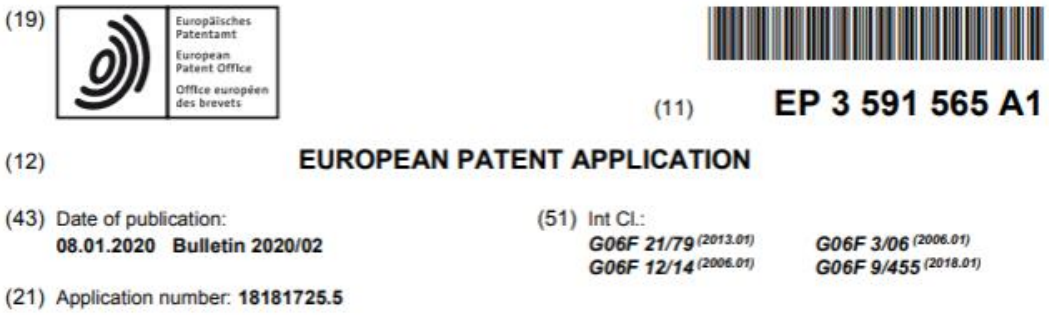
- **Manual Analysis**
  - Hack the system
  - Needs ingenuity…
  - And lots of hardware…

Did we find any bugs?

- YES!
- A bug in INTEL's processors:
  - CrossTalk
  - They leak sensitive data!
- What happened?
  - VUA (the finders) notified INTEL
  - Intel issued a microcode update
    - June 2020
  - Intel gave the VUA a bug bounty award!
- For more info see:
  - https://www.vusec.net/projects/crosstalk/
- Same thing for cache side-channel attacks with NETCAT!
  - https://www.vusec.net/projects/netcat/

Any other bugs?

- Rowhammer
- When you read memory too fast
  - Some bit in another application's address space changes
- VUA disclosed the bug and developed a solution:
  - ZebRAM
- The solution has been patented!



(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 591 565 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
08.01.2020 Bulletin 2020/02

(21) Application number: **18181725.5**

(51) Int Cl.:
G06F 21/79 *(2013.01)*
G06F 12/14 *(2006.01)*
G06F 3/06 *(2006.01)*
G06F 9/455 *(2018.01)*

Any more bugs?

- Lots of CVEs from (RUB):
  - CVE-2018-10191
  - CVE-2018-10199
  - CVE-2018-11743
  - CVE-2018-12247
  - CVE-2018-12248
  - CVE-2018-12249

To summarize: ReAct's innovation

Change your way of thinking about cybersecurity:

Break things first!

Before you try to protect them

- ReAct has applied this approach and:
  - Discovered two major hardware bugs
  - Discovered several software bugs
  - Received several bug bounty awards
  - Filled a patent application
  - Was assigned several CVEs
  - Developed several fuzzing/protection methods!

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React - Who

- FORTH
- Vrije Universiteit
- U of Cyprus
- EURECOM
- RUHR UNIVERSITAT BOCHUM
- NortonLifeLock

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Summary

- The Internet was not designed with security in mind
- Systems contain bugs/vulnerabilities
- ReAct's approach is:
  - **Break** the system
  - Before
  - You try to fix it
- ReAct develops mechanisms to protect
  - computers from attackers and cyberattacks

Acks

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Thank-you

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FORTH-ICS and ReAct

https://react-h2020.eu/
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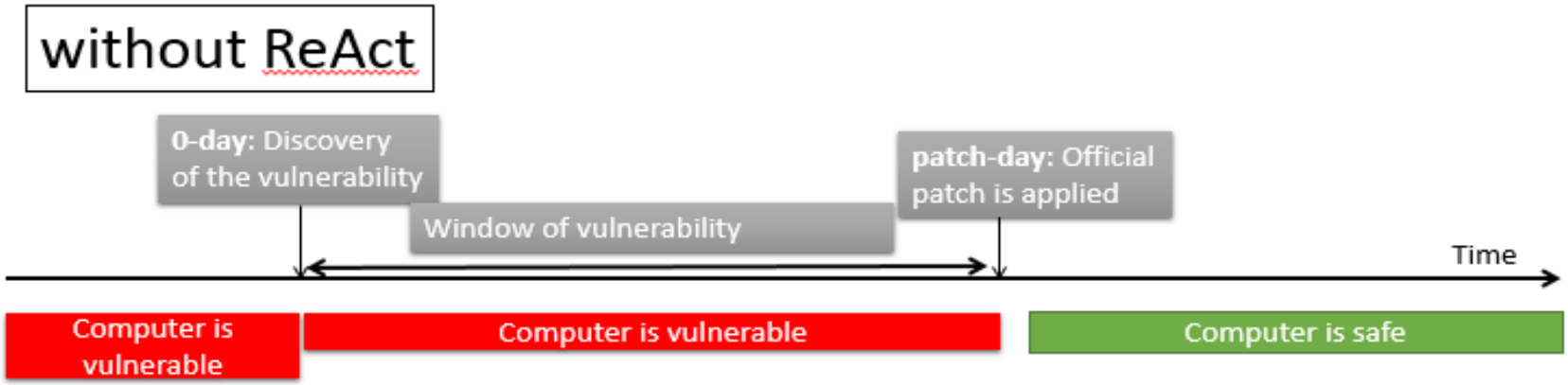
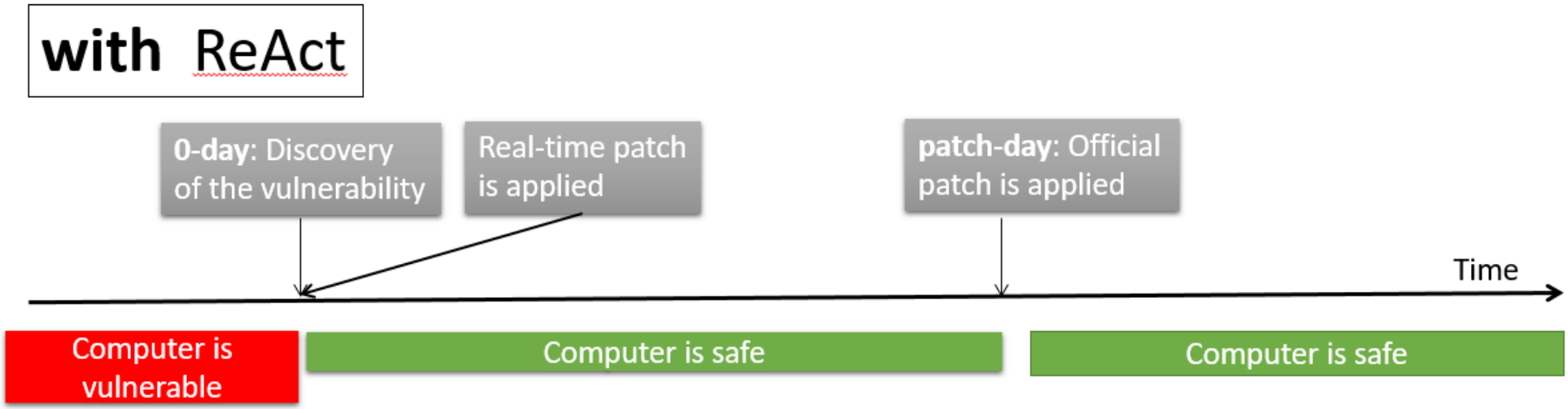
ReAct: What is it about?

- Time line: before and after **ZERO-day**
  - Before the vulnerability is found (i.e. before ZERO-day)
    - Computer is vulnerable
  - Before the patch is applied
    - Computer is vulnerable
- After the patch is applied
  - Computer is safe



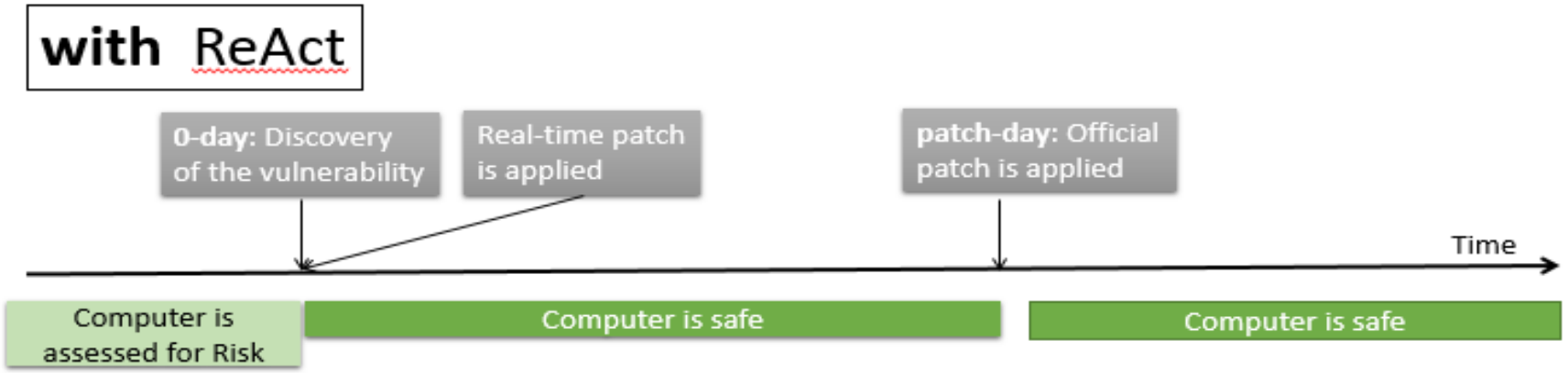
ReAct

- Can we improve the situation?
- Can we do something before the patch is applied?
  - YES!
  - Real-time patch!! (Selective Fortification)
    - Instrumentation, binary re-writing, memory protection, etc. to isolate the bug
    - Note: it does not *remove* the bug – it isolates the bug



ReAct

- Can we do any better?
- *Can we do something before the bug is found???*
  - ???
  - YES!
    - Prediction
    - Find the bug first!!



What's next? A glimpse into the future

- Ransomware
  - In 2017 Wannacry attacked thousands of computers
    - Encrypted the files
    - Asked owners for money
- What's next?
  - Lock us our of our car?
  - Lock us out of our home?
  - Disable our car's breaks?
  - What?
  - Attackers will just follow the computers….