Lecture TU Darmstadt

From Science to Products – Security Research at Intel Labs

Matthias Schunter + slides from Steffen Schulz, Rafael Misozky, Jan Richter, …

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“In theory, theory and practice are the same. In practice, they are not.”

Outline

1. Security in practice – does anyone care?
2. Industrial vs. Basic Security Research
3. Example Research Projects
   a) Fuzzing Low-level Software
   b) Post Quantum Crypto
4. Discussion / Q&A

Case Study: Secure electronic cash anyone?

Excercise (via chat)

- *Advantages wrt Cash/CC?*
- *Disadvantages wrt Cash/CC?*

Cash → ? → Digital Cash in Digital Wallet

Credit Card → ?

Source: tellermate.com
eenewseurope.com
ECONOMICTIMES:COM

Case Study: Secure electronic cash anyone?

Cash

?

Digital Cash in Digital Wallet

Multiple Choice
- *Yes – this will work in practice*
- *No – this will not work in practice*

+why (into chat)

- Expensive & i

- e & Anonymous
- Efficient
- Remote value transfers

Credit Card

?

- Insecure; privacy-invasive

Source: tellermate.com
eenewseurope.com
ECONOMICTIMES:COM

Case Study: Secure electronic cash anyone?

Cash

?

Digital Cash in Digital Wallet

- Trusted anonymity

- Requires infrastructure
- Breaks habits
- Cost higher than insurance
- Interesting main usecase…

Credit Card

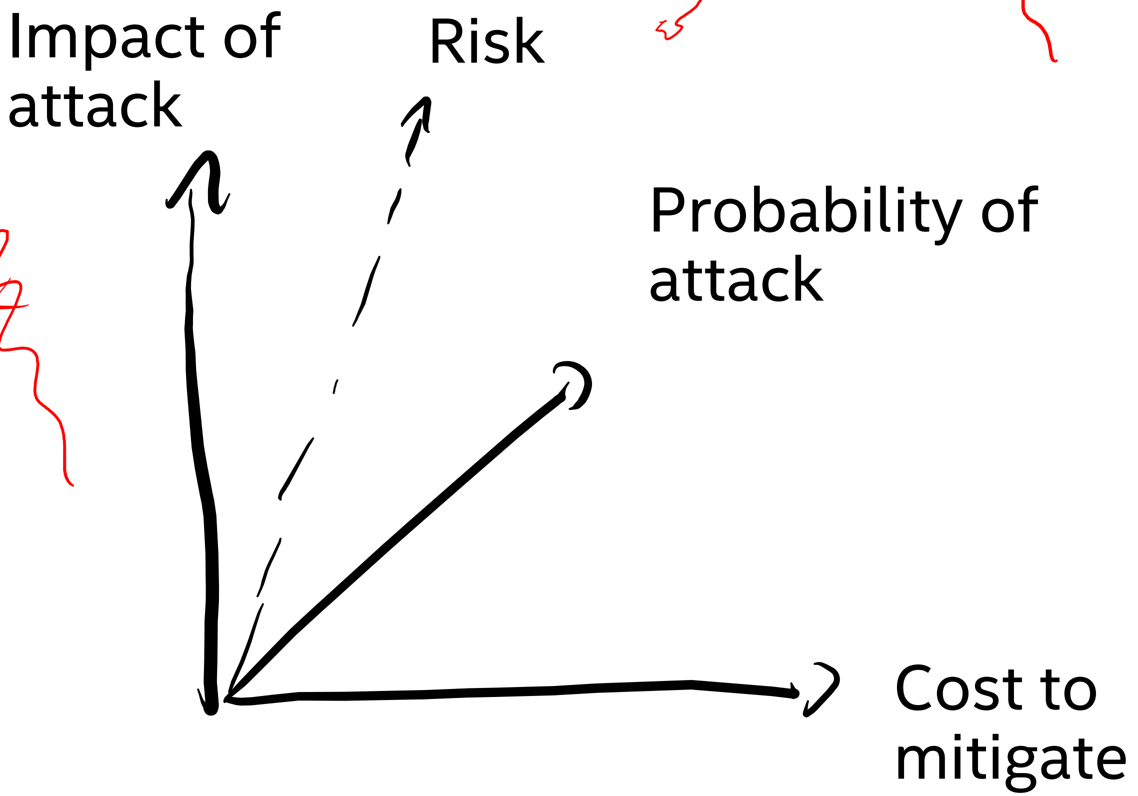
?

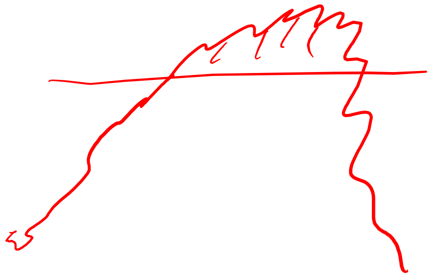
- Cheap insurance

Source: tellermate.com
eenewseurope.com
ECONOMICTIMES:COM

Is security important in the real world?

- Aim for a Rational Decision
  - Impact of attacks (cost+scale)
  - Probability of attacks
  - Cost to mitigate risk

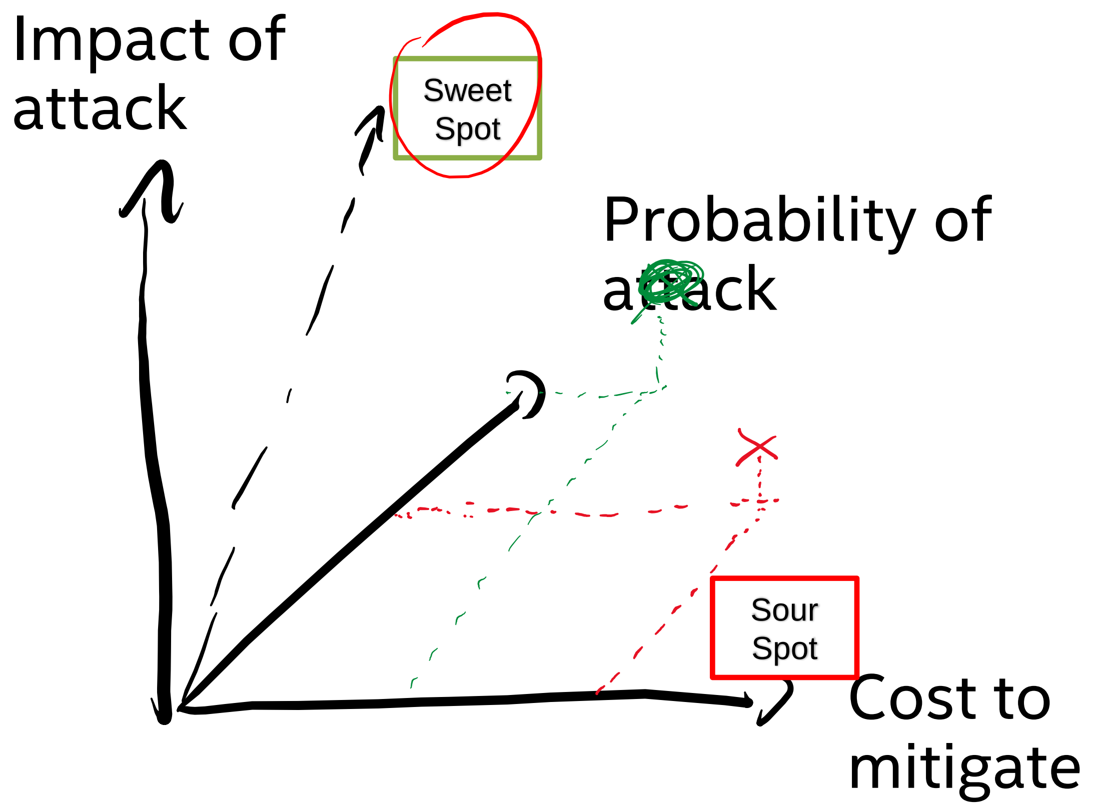




- But: Moving targets…

+ Incomplete Info.

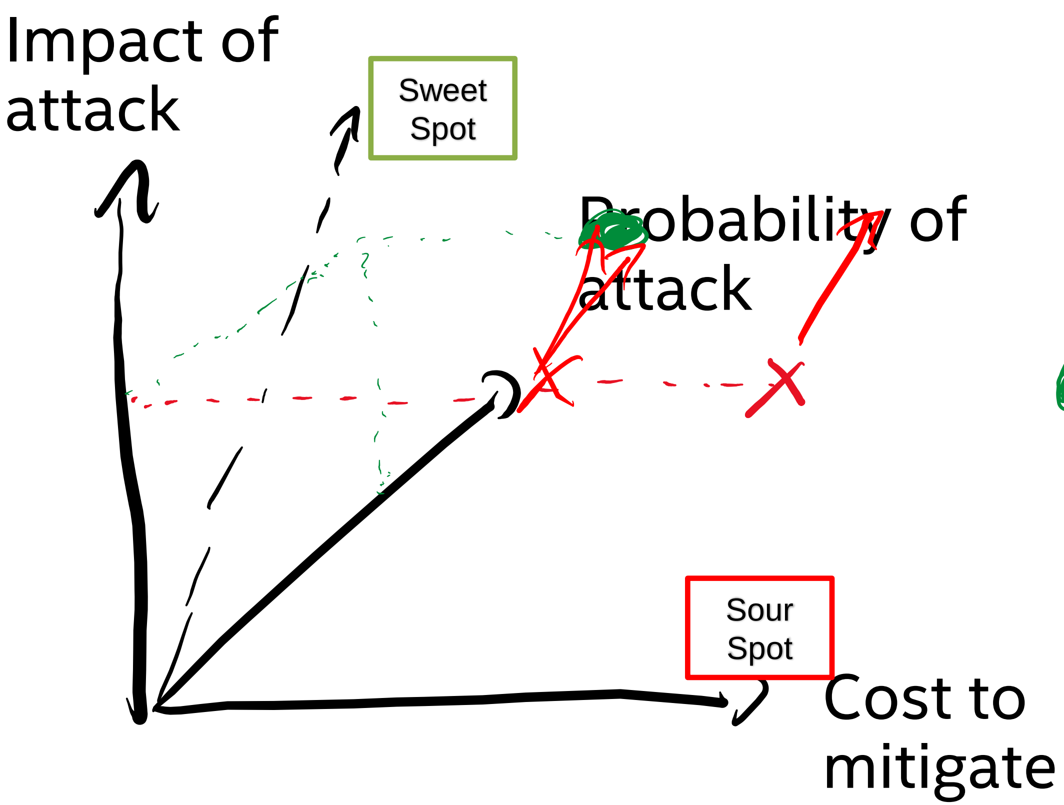
Is security important in the real world?



Security for Credit Cards

- 90s: No internet – limited scaling
  - Medium probability of attack
  - Limited cost per attack
  - High cost of mitigation (usability!)
- 2000s: Internet and ecommerce
  - High probability of attack
  - Limited cost
  - Medium cost of fixing

Is security important in the real world?



- Post quantum secure signatures
  - Today – no quantum computer
    - Zero probability of attack
    - High impact (*0 = zero risk)
    - High cost of mitigation
  - Once the QC machine has arrived
    - Medium probability of attack
    - High impact (high risk risk)
    - High cost of mitigation
  - But: Long life-time of HW

Security in Practice: Some lessons learnt

- Security is an attribute
  - Often engineered after the fact
    - Example: Security of neuro compute anyone?
  - Dynamically adjusted

- Security is a process
  - Secure Development Lifecycle
  - Includes response and repair!
    CVEs important for customer awareness!
  - Monitoring the environment is important!
    (90's PC on the Internet)
  - CVE counts have many causes and are no reliable metric across products/companies..

CVE Counts:

Product Name	Vendor Name	Product Type	Number of Vulnerabilities	
1	Debian Linux	Debian	OS	5078
2	Android	Google	OS	3651
3	Ubuntu Linux	Canonical	OS	2984
4	Mac Os X	Apple	OS	2759
5	Linux Kernel	Linux	OS	2668
6	Iphone Os	Apple	OS	2300
7	Windows 10	Microsoft	OS	2260
8	Chrome	Google	Application	2161
9	Windows Server 2016	Microsoft	OS	2021
10	Windows Server 2008	Microsoft	OS	1973
11	Fedora	Fedoraproject	OS	1959
12	Firefox	Mozilla	Application	1916
13	Windows 7	Microsoft	OS	1854
14	Windows Server 2012	Microsoft	OS	1728
15	Windows 8.1	Microsoft	OS	1636

Source: https://www.cvedetails.com/top-50-products.php

Security in Practice: Some lessons learnt

- Risk Management Decision
  - Risk = probability x impact
  - Mitigation cost
- Many moving targets…

Excercise (via chat or audio)
- *Any questions?*
- *Any feedback*

- Non-technical parameters are important!
  - Humans and training
  - Usage patterns and environment
  - All Employees play a role in security…
- Many important roles:
  - Crypto experts, SW security, SDL, …
  - Developers, users, …

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   a) Fuzzing Low-level Software
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Break...

Mission of Intel Labs

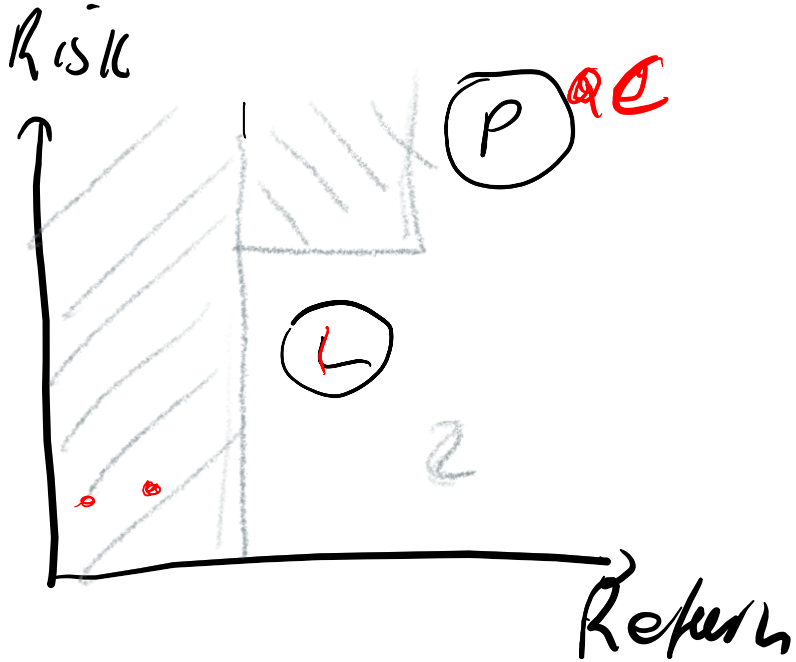
Mission

- Pioneering industrial research (P)
- Research on future products (L)
- Validation o

Excercise (via chat or audio)
What would you expect from an industrial research lab?

Porfolio Approach important

- Goal
- Life-cycle of research



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      Slides: Steffen Schulz, Brian Delgato
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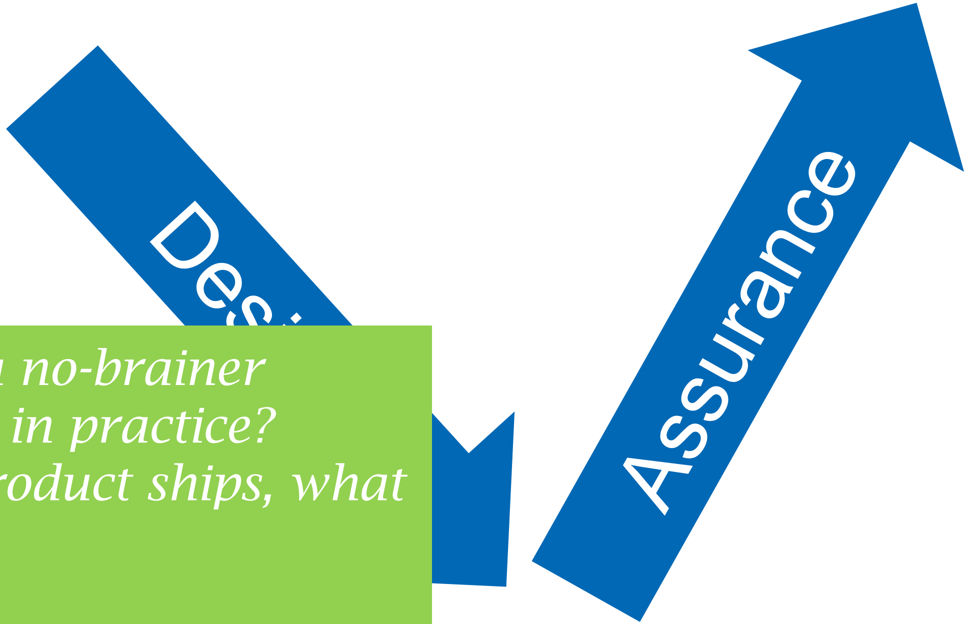
Secure Development Lifecycle (SDL)

- Some Goals:
  - Security by design
  - Well-defined security quality of all products
- V-Model
  - Design: Require
    Implementatio
  - **Assurance: Tes**
    Maintenance and CERT
  - Fuzzing as one tool to validate software



Excercise (chat): SDL seems a no-brainer
- *Why is it hard to establish in practice?*
- *Once a perfectly secure product ships, what can still go wrong?*

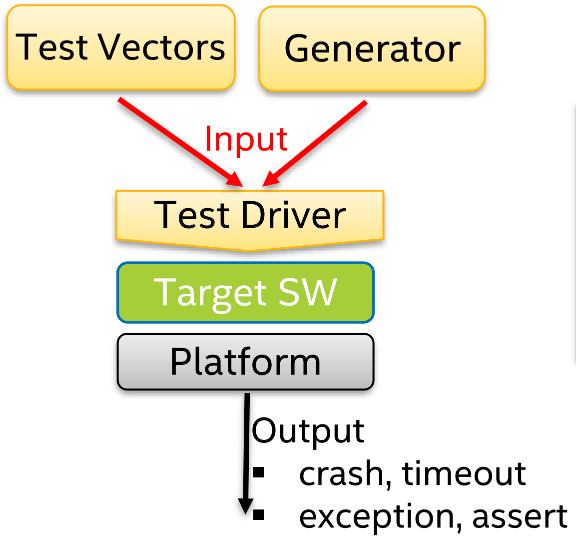
What is Fuzzing?

- “Smart“ randomized testing of software at scale
- Find inputs that crash, violate assertions or other checks

JPEG images generated from initial seed value „hello“
lcamtuf.blogspot.com/2014/11/pulling-jpegs-out-of-thin-air.html

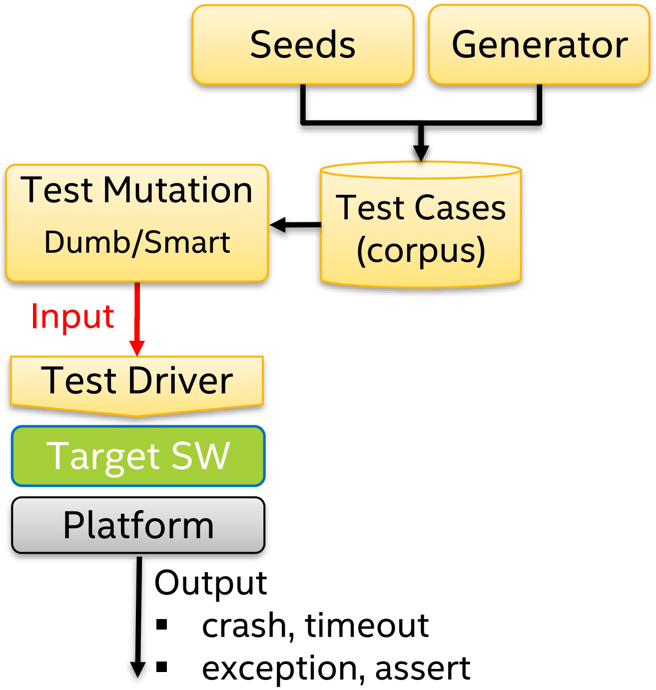
(Random) Testing

- Needs good inputs/generators
- High effort, small targets



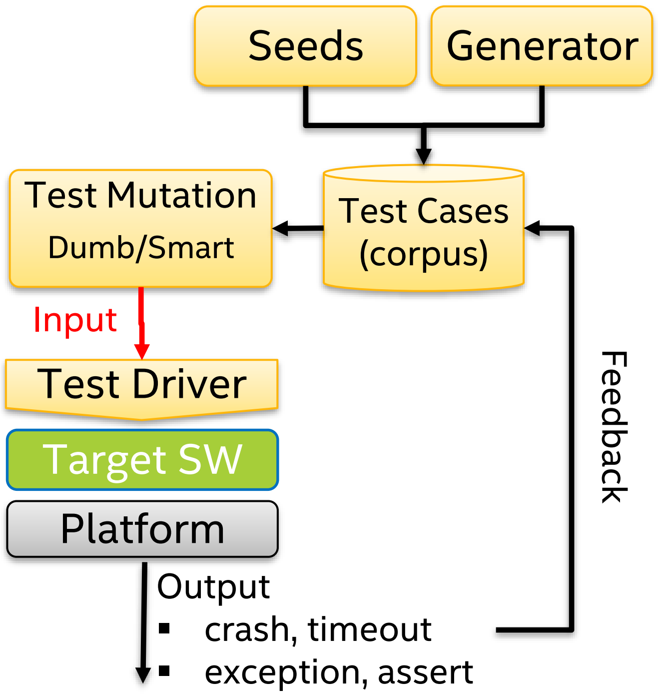
Mutation-based Fuzzing

- Expansion of simpler inputs/generators
- Execution focused around test corpus



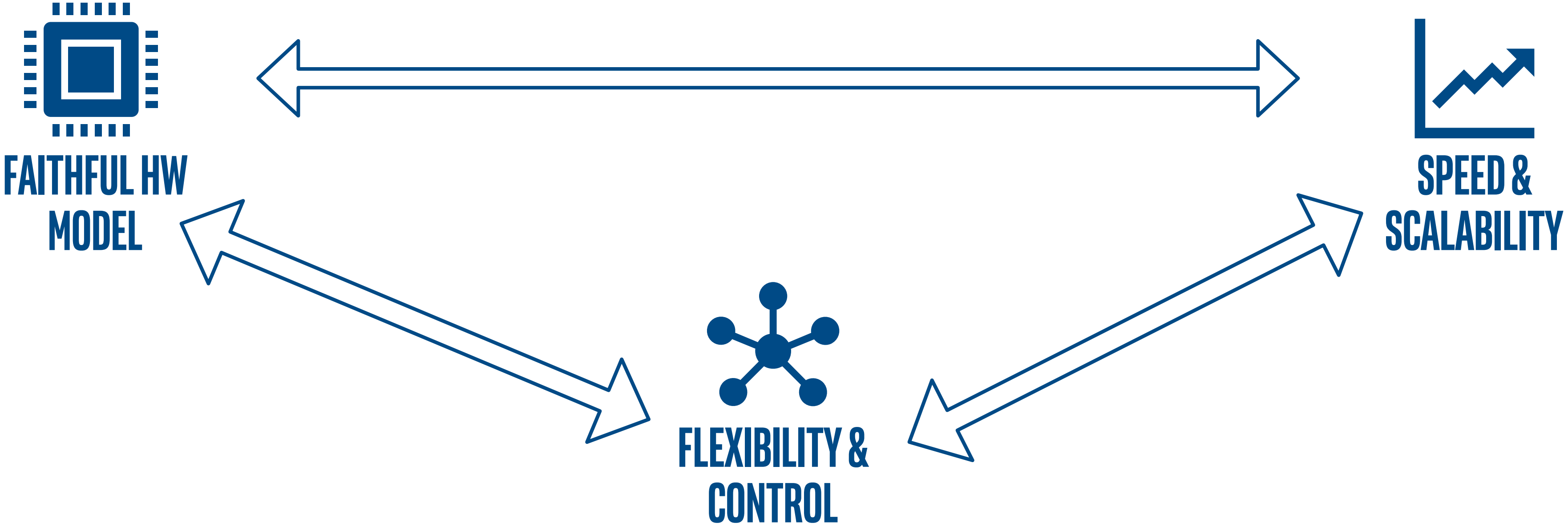
Feedback Guided Fuzzing

- Infinite, generic test expansion
- *Iteratively discover completely new inputs*



SUCCESS CRITERIA FOR SCALABLE FUZZING

- Although successful in software, fuzzing is difficult to deploy in low-level code
- It's also difficult to create an environment that is "real" and fast at the same time



Citate as mentioned: Avatar, Pretender..

THREE APPROACHES FOR SCALABLE FUZZING

Excercise (chat): Advantages / Disadvantages of
- *Life platform = real hardware*
- *Emulation the hardware*
- *Re-hosting (running firmware as SW)*

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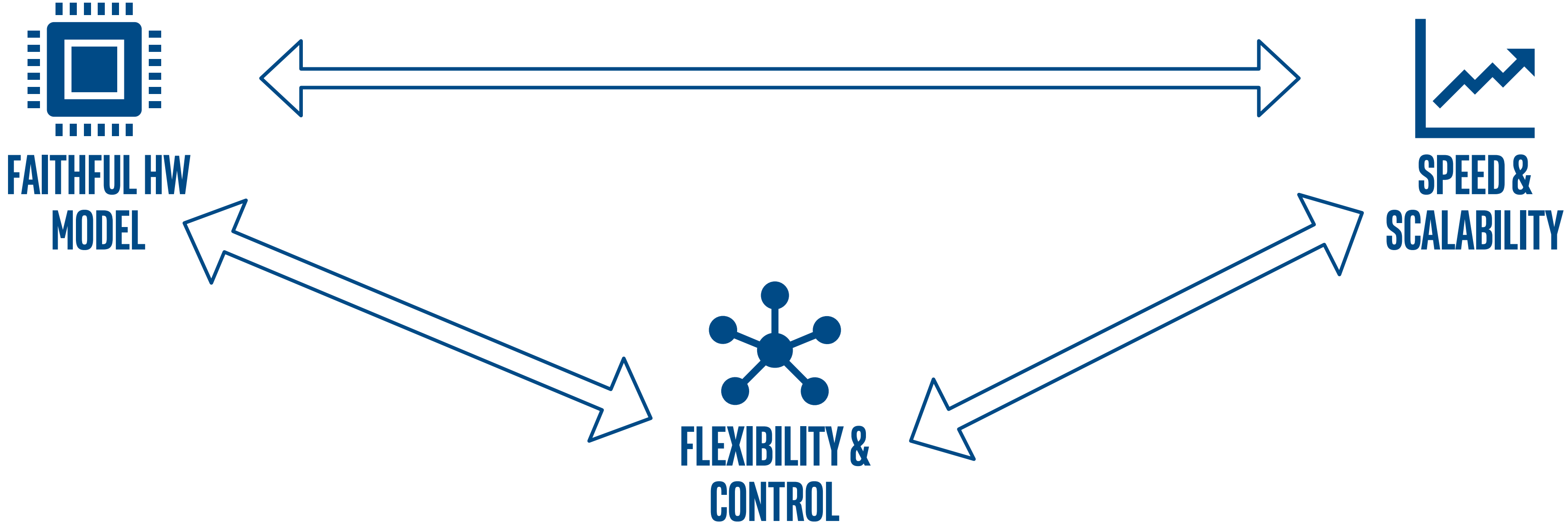
- It’s also difficult to create an environment that is “real” and fast at the same time

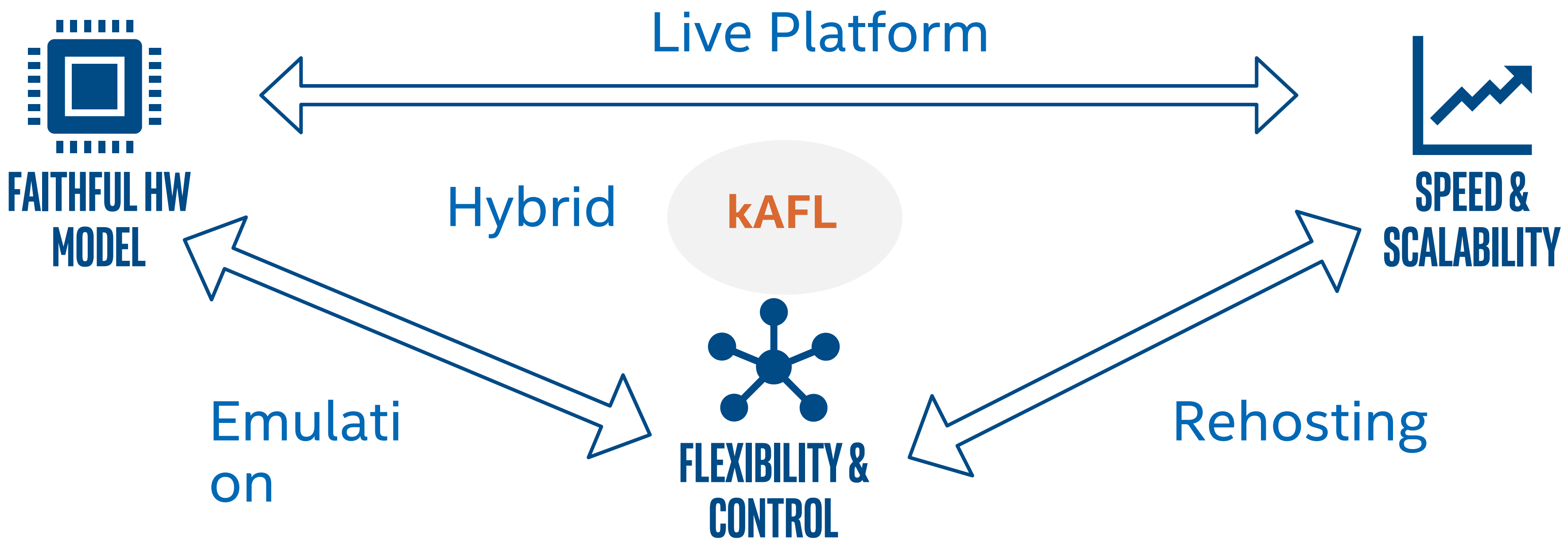


APPROACHES

1. Live HW
2. HW Emulation
3. Re-hosting

FIRMWARE FUZZING FOR VIRTUAL MACHINES

- Kernel AFL (kAFL): research vehicle developed at Ruhr-University Bochum
  - Accelerated execution & feedback using Intel® Virtualization Technology & Intel® Processor Trace features
  - Simple and fast, no assumptions on toolchain or target SW



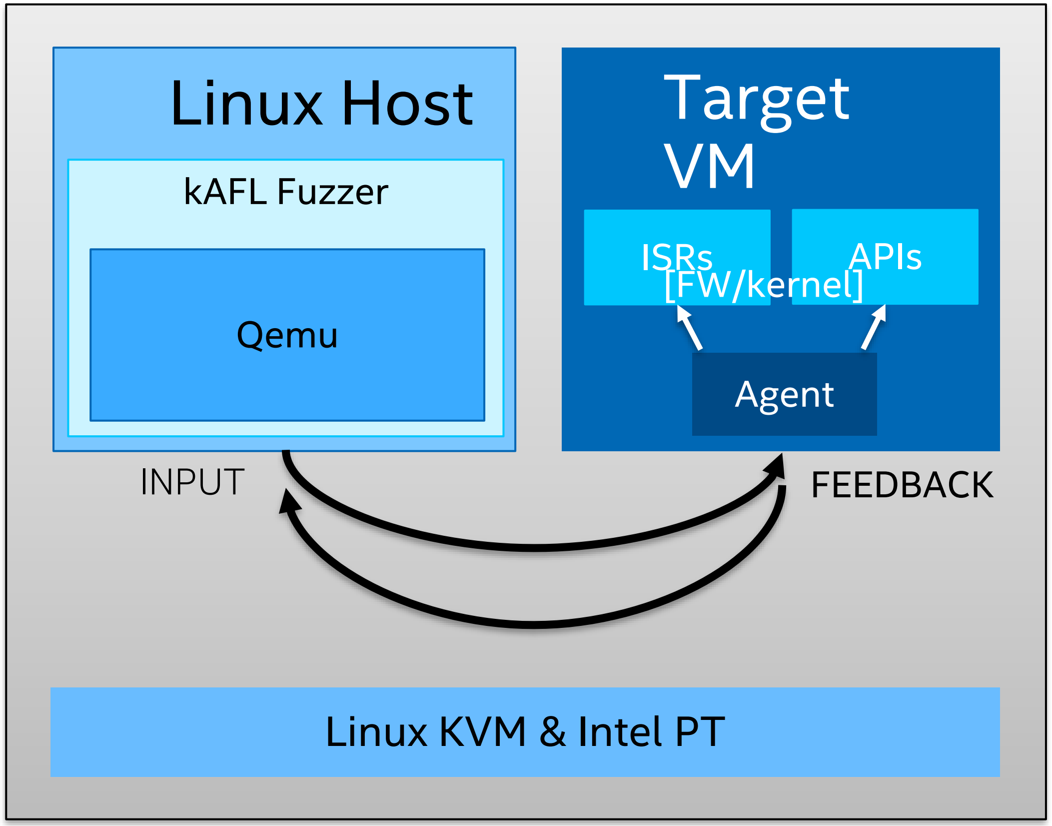
FIRMWARE FUZZING USING VIRTUAL MACHINES

Kernel AFL (kAFL) - No assumptions on toolchain or guest OS

- ✓ Usability: Easy to get started on UEFI, Zephyr RTOS and others
- ✓ Flexibility: Fast snapshot/reset, attach serial console or debugger
- ✓ Scalability: No special HW, work on laptop and scale on servers

X Open Problems

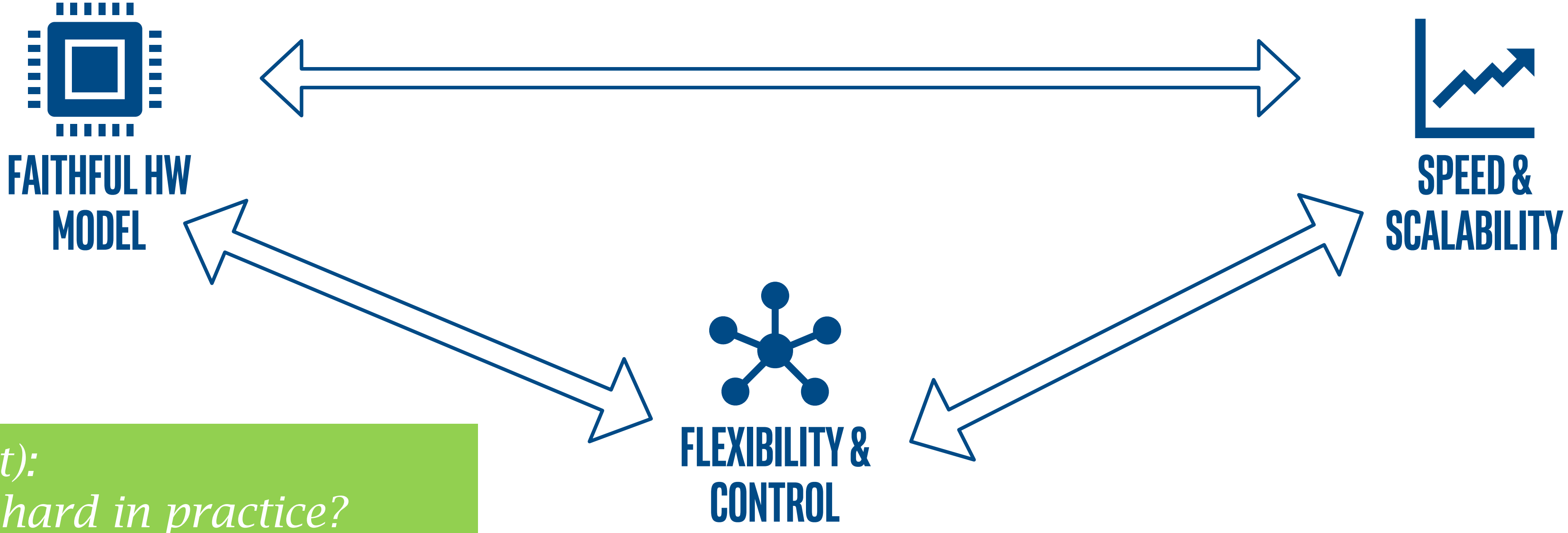
- How do we cope with unsupported devices/peripherals?



kAFL: Hardware-Assisted Feedback Fuzzing for OS Kernels – Schumilo et.al. Usenix 2017
https://www.usenix.org/conference/usenixsecurity17/technical-sessions/presentation/schumilo

RESEARCH CHALLENGE: I/O MODELING

- Faithful device models are a major bottleneck across all approaches
- Test focus typically on higher level parsing & processing, not I/O
- Can we overcome I/O dependencies for more scalable testing?
  - Generalize emulation, use machine learning, or other automation?



Excercise (chat):
- *Why is this hard in practice?*

PROCESS CHALLENGES

Continuous Integration environments can have thousands of check-ins a day

- How to fuzz effectively?
- Testing just the code being modified is helpful
- Tools like AFL Go (Bohme, M., Pham VT. et al) have potential to better target fuzzing

Complex tool-chains make it harder to change/modify compilers

How to handle triage at scale

- Fuzzers can provide a number of findings that require disposition
- How to better remove redundant findings?
- How much crash/hang analysis can be automated?

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Break...

Post-Quantum World

Advances in the development of Quantum-Computers

Public-Key Cryptography is threatened

Post-Quantum Cryptography comes to the rescue

Quantum Attacks and Mitigations

- Symmetric Cryptography:
  - **Issue:** Grover's algorithm [Gro'96] is expected to break AES128 and SHA256
  - **Mitigation:** Increase keys/parameters of algorithms (Ex: AES128 → AES256)
- Public Key Crypto
  - **Issue**: Shor's alg and ECC
  - **Mitigation**: Repl encryption algorithms
- Replacements for

Excercise (chat): You are tasked to introduce PQC at Intel –

- *What obstacles do you expect?*
- *What hinders / accelerates adoption?*
- *Where would you start?*

Quantum Cryptography:

- ✓ Uses quantum physics to achieve higher security
- ✗ Requires quantum infrastructure
- ✗ Restricted to Key Exchange (e.g., [BB84])
- ✗ No standards

Post-Quantum Cryptography:

- ✓ Based on harder math problems
- ✓ Can be implemented in current infrastructure
- ✓ Offers all required features
- ⚠ Standards under development

Changing Tires on a Moving Car

- PQC transition is an unprecedented move – Crypto adoption takes decades
  - Standards are being defined at the same time cryptanalysis is being understood
  - Post-Quantum Crypto literature may not offer drop-in replacements for all features

Post-Quantum Cryptography Families

More Mature

Less Mature

Hash Based Signatures

Security: relies on well-known security notions

Code Based Cryptography

Digital Signatures

Security: (presumably well-known) problems from coding-theory

Lattices Based Cryptography

Security: (presumably well-known) problems from lattices

Multivariate Cryptography

Encryption, Key Exchange, Signatures

Security: other problems from multivariate quadratic equations

Isogeny Based Cryptography

Encryption, Key Exchange, Signatures

Security: other problems from isogenies of super-singular elliptic curves

Digital Signatures

Key Exchange, Signatures

6

Remarks

- PQC transistion is an unprecedented move
- Industry perspective is critical for wide adoption
  - Ease of deployment
  - Scalability
  - Maintenance
- Simple & well-understood is better than complex & less-understood
- Standards are much needed but we should not rush at the cost of security

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This is the last slide…
- *Any questions?*
- *Any feedback/comments (chat/audio)?*