Inside the Machine

How Offensive Security is Defining the Way We Compute

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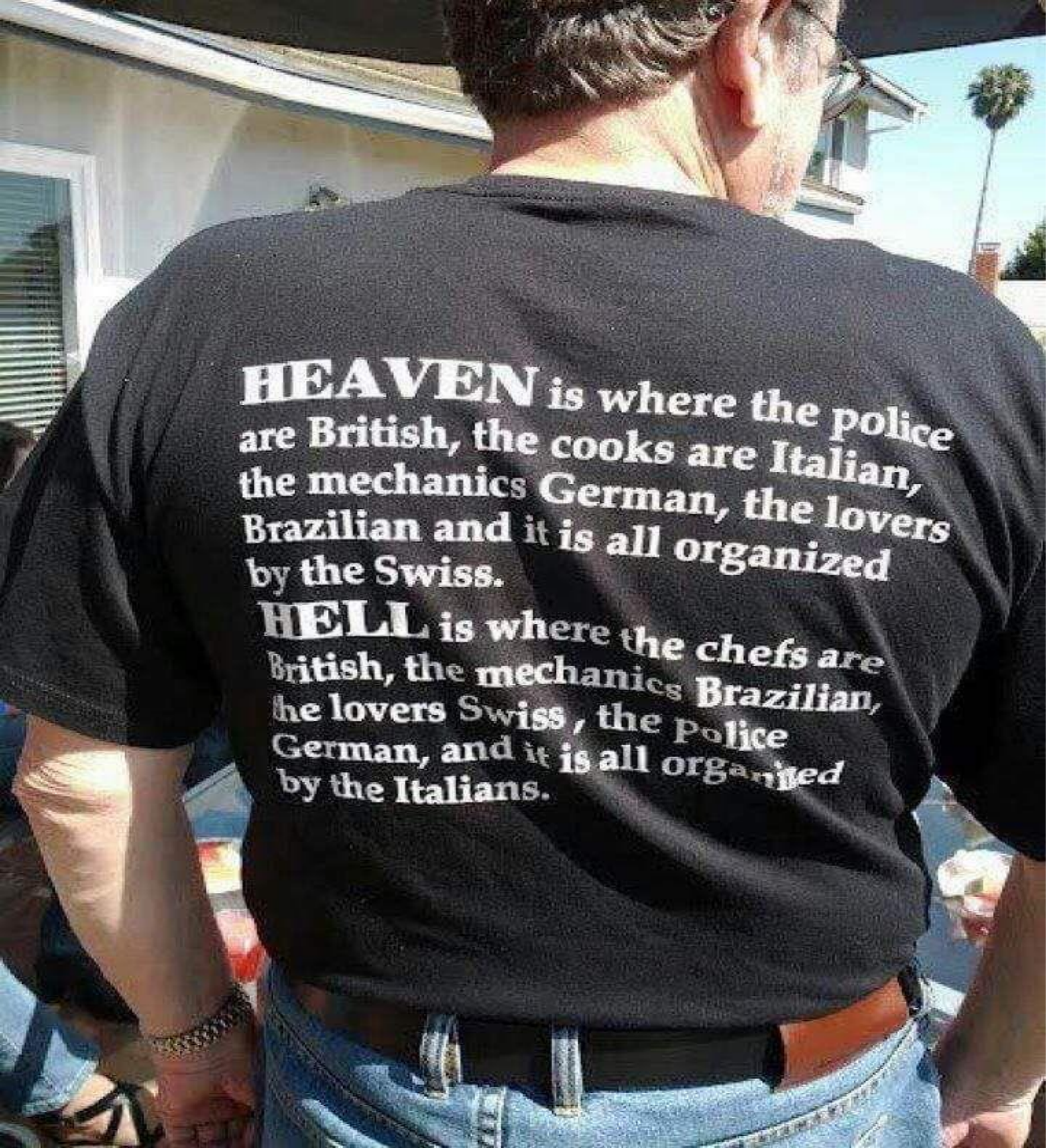
“There is no comfort in the growth zone and no growth in the comfort zone”

Unknown


HEAVEN is where the police are British, the cooks are Italian, the mechanics German, the lovers Brazilian and it is all organized by the Swiss.
HELL is where the chefs are British, the mechanics Brazilian, the lovers Swiss , the Police German, and it is all organized by the Italians.

DISCLAIMER

I don’t speak for my employer. All the opinions and information here are of my responsibility.

Personal:
“If hacking is an art, please excuse me, but I have poetic license”
- BSDaemon

I’m sorry in advance for the excessive usage of generalizations!

FYI: my wife is a lawyer ☺

HEAVEN is where the police are British, the cooks are Italian, the mechanics German, the lovers Brazilian and it is all organized by the Swiss.
~~HELL is where the chefs are British, the mechanics Brazilian, the lovers Swiss, the Police German, and it is all organized by the Italians.~~
HELL: Where laywers do exist.

Objectives

- I’m not here to try to teach the priests how to pray
  - Instead, I’ll try to give sermon arguments (PoC || GTFO inspiration)
  - Propose some baseline for certain discussions (on mitigations and exploitability)
  - In this audience, I expect that most of the points themselves are well known, but hope that neglected ones will be called out and the most important ones will be re-enforced

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Defining the objectives in one image?

Objectives

The attacker when I found a bug
The attacker when I propose a mitigation

Objectives – Halvar’s MitiGator [1]

MitiGator: Raising the bar until no more exploits can be seen.

[1] Halvar Flake. “Weird Machines, Exploitability, and provable Non-Exploitability”. Oxford Presentation 2018.

Three Points to Take Out (1/3)

- Threat Modeling is a relatively mature element of secure system engineering (where system can be hardware and/or software)
  - We have security objectives, attackers in scope (i.e.: physical presence, physical possession, remote, unprivileged, privileged), threats and features (relevant to demonstrate that the identified threats are addressed)
  - **But: We do not apply the same 'mature' process in defining mitigations (against unknown vulnerabilities)**

Three Points to Take Out (1/3)

As a mathematician once **joked** with me
“The Engineer’s Proof by Induction is slightly different:
If it works for n=1, n=2, n=3 it works for all cases”

So here is something to remember:
A new vulnerability mitigation intended to address classes of vulnerabilities should fully mitigate at least 3 real past vulnerabilities to be seriously considered.

Three Points to Take Out (2/3)

- There are not a lot of formalization of exploits (more on this later), which makes exploit writing a mix between deep engineering and art [1]
    - **Understanding a presentation and overall aspects of an exploit instance, is not the same as understanding how vulnerabilities *CAN BE* and *ARE* exploited** (oftentimes, other possible avenues, investigations that did not pan out, other engineering problems that needed to be solved – be it because of the tools that already proportioned it to the researcher, or because the researcher already had the knowledge in his mind - as the real dimensions of time spent are all missed)

[1] Excellent discussion in: “Are Reverse Engineering and Exploit Writing an Art or Science?” at NYUPoly THREADS Conference Panel (Cyber Security Awareness Week), Nov, 2013.

Three Points to Take Out (2/3)

So here is something else to remember:
Those proposing mitigations must understand the problem. Such understanding can be gained through experience writing real exploits (with real limitations and complexities) or by teaming up with someone with that experience.

Disclaimer: Being able to write exploits do not imply liking to do it (I do know developers that work in very good mitigations that do not like to write exploits, but have the full understanding and ability to do so)

Three Points to Take Out (3/3)

- When (we) researchers share the knowledge (be it in a presentation, paper, blog, informal conversations), oftentimes (we/they) simplify the problem
    - **Be it because of lack of space/time, lack of perception (sometimes we do not even see the bigger picture), Dunning-Krueger (they know so much about the problem that they believe they do not know enough and end up not discussing many aspects as they feel unfit to do so) or many others**

- Unfortunately, as a result, there is a misperception of abilities in the industry (as it is believed there are many more people capable of designing proper mitigations than actually there are)
    - That essentially means additional broken mitigations, additional complexity, and additional challenges to actually adopt/propagate the mitigations that do work

Three Points to Take Out (3/3)

So here is the last thing to remember:
Investments in defense should benefit from the investments in offense (be guided by it) [1]. In the mitigations space, implementation details make all the difference and proper architectural definitions are not enough.

[1] Ben Hawkes. "Project Zero – Make 0day Hard". CanSecWest 2015.

The Importance of Formalization

- In the past years we’ve been witnessing an exceptionally important trend in computer security towards formalizing offensive work
  - That is essential to finally migrate from a mix art/engineering form to purely engineering (with all the needed talent that engineering requires)
  - It is also a key element in bringing the academia towards the state-of-the-art and with that, scale offense (currently a big challenge)

- From that trend, terms like weird machine appeared, LangSec gained much more traction/support
  - Opening doors for everyone to understand that data is what drives code, that parsers are recognizers and creating new concepts on secure development
  - But it also demonstrated that even some basic assumptions are in conflict with what was taught by defense

LangSec x Secure Development

- In current secure development guidance, it is a ‘rule’ that input is checked as close as possible to the use of the input, which makes ‘shotgun’ parsing acceptable – while LangSec proposes the recognition to happen at the entry point

- In current development guidance, the rule of intrinsically secure functions seem to make sense (after all, many vulnerabilities arise from copy+paste code from one project to another – without copying the input handling of the parameters – or by adding new functionality – and as so, new paths to vulnerable functions). But once again, due to real life restrictions (development time and performance of having duplicated checks), recognizing everything *and* adding specific checks is hard in practice. Somehow more guidance/discussions are still needed even in basic areas

More formalizations

- In recent years, we’ve also seen the work by Julien Vanegue on heap modeling for exploit writing [1]
    - Which helps rationalizing between different mitigations
    - And move us from art to science state in the subject (improving toolset, enabling real/better automation)
- And more recently, Halvar’s paper [2] providing a theoretical (mathematical) framework to define exploitation (of memory corruptions)

[1] Julien Vanegue; “Heap Models for Exploit Systems”; IEEE S&P LangSec Workshop; 2015

[2] Halvar Flake; “Weird machines, exploitability, and provable unexploitability”; 2018

Not a comprehensive list

- Complexity has been identified in many areas, an example that I like
  "a modern compressor is a bit like a compiler. The compressed data is a kind of program in bytecode, and the decompressor is just an interpreter that runs that bytecode" cbloomrants.blogspot.com

- Obviously, my intent is not to be comprehensive, but to demonstrate an important trend
  - There were many earlier tries on defining exploit writing, like the work by Gerardo Richarte [1]
  - And the conscious effort by Microsoft on using the understanding on exploits to drive mitigation strategies, shared in multiple presentations along the years - See [2] for the latest, which includes HW in the threat scope
  - The ROP definition for example, was very well known by practitioners (exploit writers), but only got widely understood once properly defined (in an academic paper) [3]

[1] Gerardo Richarte; "About exploit writing"; 2002

[2] David Weston; "Hardening with Hardware"; BlueHat IL 2018

[3] H. Shacham; "The geometry of innocent flesh on the bone: return-into-libc without function calls (on the x86)". CCS 2007

Three Points to Take Out (My conclusions!)

- A new vulnerability mitigation intended to address classes of vulnerabilities should fully mitigate at least 3 real past vulnerabilities to be seriously considered

- Those proposing mitigations must understand the problem. Such understanding can be gained through experience writing real exploits (with real limitations and complexities) or by teaming up with someone with that experience

- Investments in defense should benefit from the investments in offense (be guided by it).   In the mitigations space, implementation details make all the difference and proper architectural definitions are not enough

The end!! Really is !?

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OFFENSIVECON