Top Pick 2021

Maya: Using Formal Control to Obfuscate Power Side Channels

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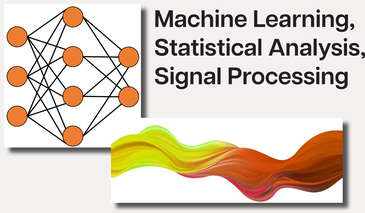
Paper

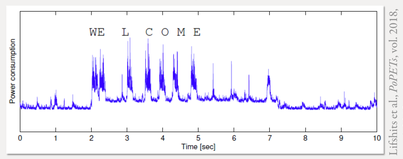
Power is a Powerful Side Channel

Counters,
Trojan chips ...

Power



Machine Learning,
Statistical Analysis,
Signal Processing



Lifshits et al., *PoPETs*, vol. 2018, no. 4, 2018

Passwords, application information, browser, camera, location, cryptographic keys ...

Existing Defenses have Limitations

Obvious approaches are ineffective

E.g., Add random noise

Removed by averaging!

E.g., Measure and correct for constant power

Intrusive changes to systems

Systems in the field are left vulnerable

Typically focus on encryption

Sensitive data (e.g., browser data) can leak through system-level power

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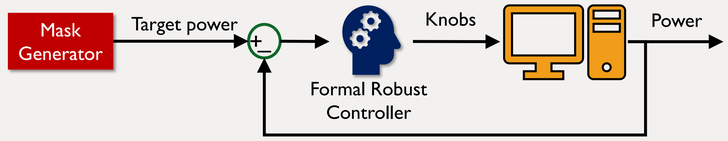
Key Idea

Use formal control to intelligently re-shape a computer's power, transparent to applications.

"Power can be shaped in any desired form, appearing to carry activity information which, in fact, is unrelated to the application."

Maya Architecture



Mask Generator

Creates targets to obfuscate time and frequency patterns

Gaussian Sinusoid: varying sinusoid + Gaussian distribution

Formal Robust Controller

Actuates multiple knobs to reliably keep power close to targets

Knobs

DVFS level, idle cycles, custom balloon application

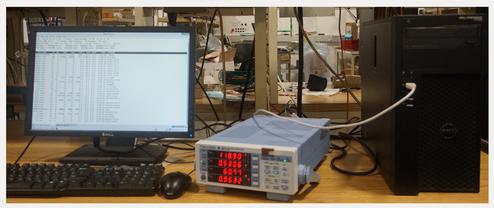
Can be fine-grained: pipeline bubbles, power hungry ops etc.

First application of formal control for side-channel defense

Application-transparent and ready-to-deploy!

Experimental Setup

Maya as admin software on three real systems



Machine Learning (ML) based attacks

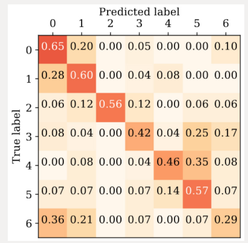
Detect applications, videos, and web-pages

Also use signal analysis (e.g., changepoint analysis)

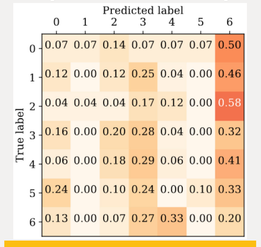
Experimental Highlights

Web page detection

Random knobs (51% accuracy)

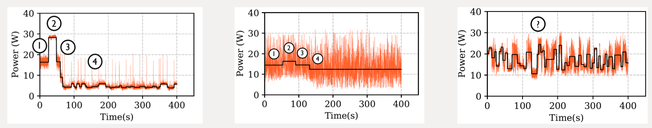


Maya (14% accuracy)



Excellent obfuscation!

Deep dive: application detection



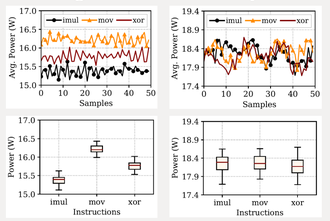
Original · Random Knobs · Maya

Other Attacks

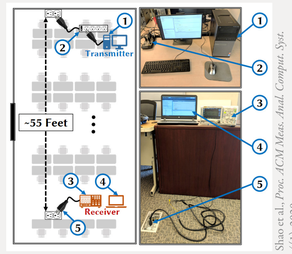
Instruction profiling

(e.g., PLATYPUS)

Run instructions in a loop, and average multiple runs



Covert channel: Power delivery network



Shao et al., *Proc. ACM Meas. Anal. Comput. Syst.* 4(1), 2020

Maya completely blocks it

Maya was developed *before* these attacks!