What if your phone's battery could talk…

Mark Silberstein

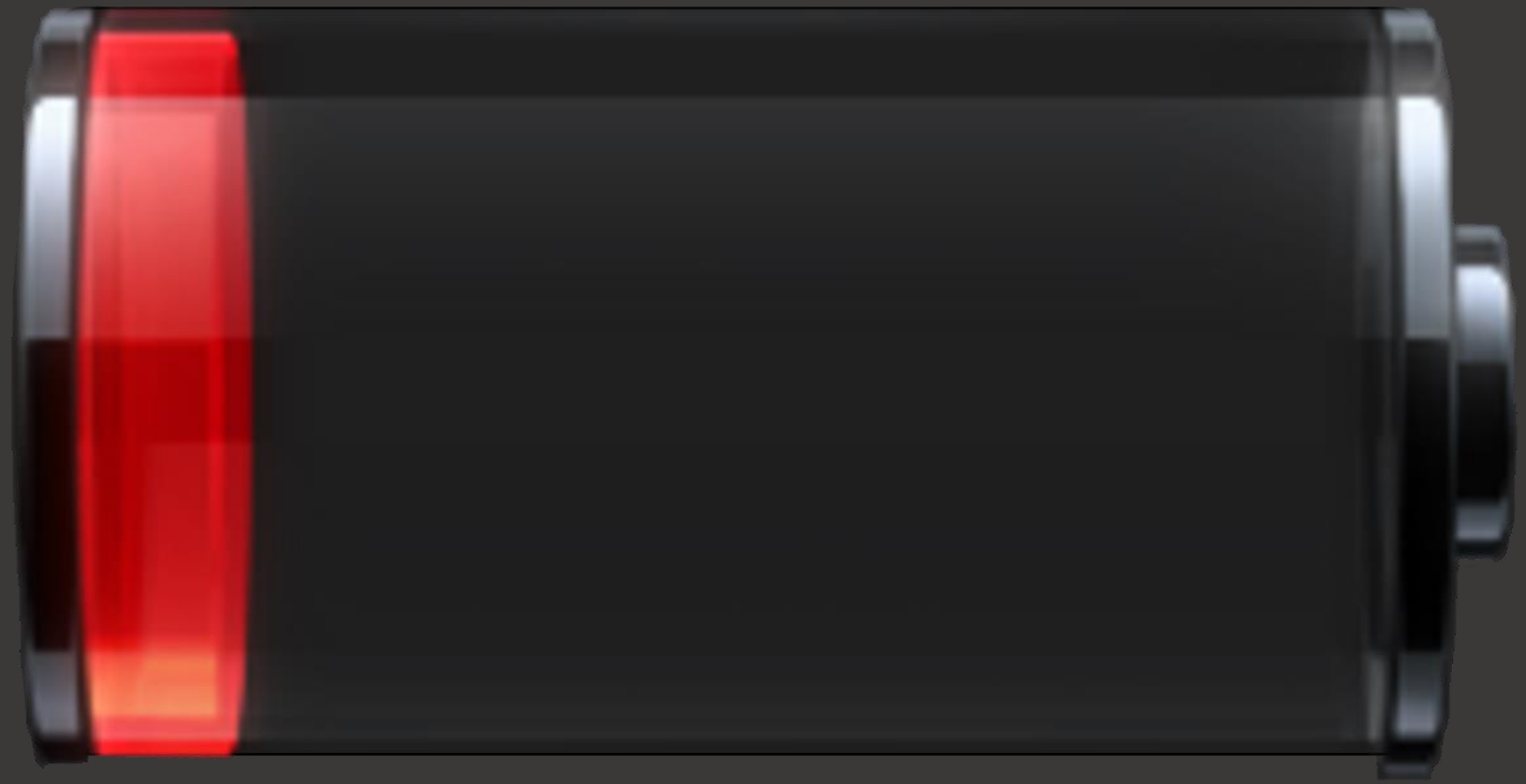
Technion

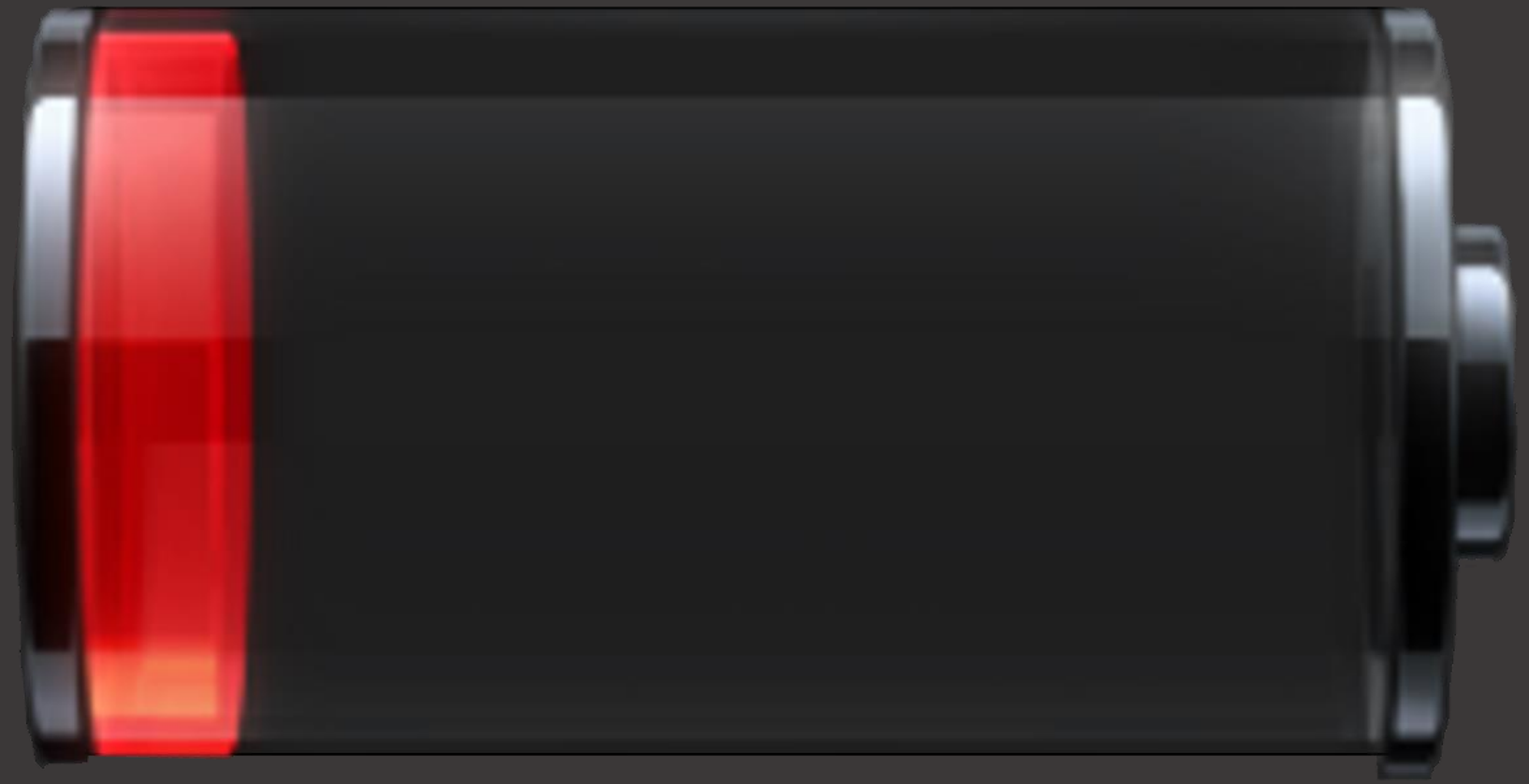
A few words about

- GPUs, FPGAs, SmartNICs, Smart Storage and how to build Operating Systems for them
- SGX, Speculative execution attacks
- …

Power to peep-all:
Inference Attacks by Malicious Batteries on Mobile Devices

Pavel Lifshits, Roni Forte , Yedid Hoshen, Matt Halpern, Manuel Philipose, Mohit Tiwari, and **Mark Silberstein**





Asking a total stranger to charge their smartphone

39%

Arguing with a significant other or romantic interest because of unanswered calls or texts

23%

Ordering something at a bar or restaurant just to use their power outlet

22%

Skipping the gym to charge their smartphone

33%

Secretly 'borrowing' someone else's charger

35%

PNAS
Proceedings of the National Academy of Sciences of the United States of America

OPINION

No Moore's Law for batteries

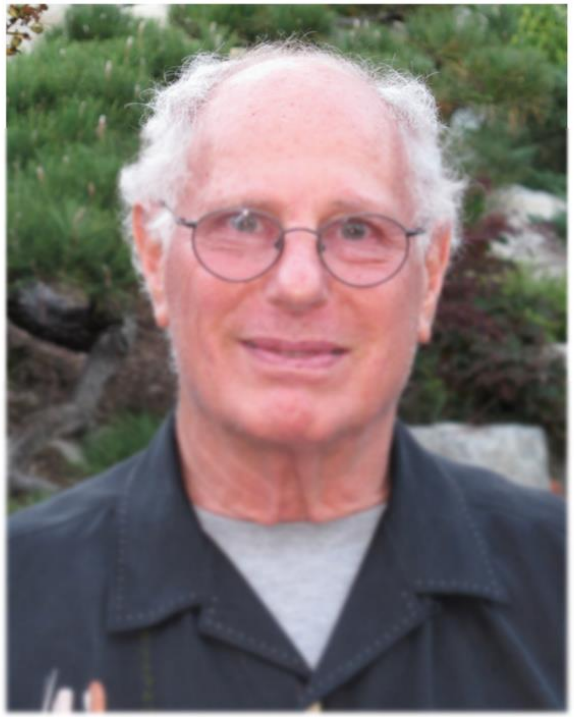
Fred Schlachter[1]
American Physical Society, Washington, DC 20045

The public has become accustomed to rapid progress in mobile phone technology, computers, and access to information; tablet computers, smart phones, and other powerful new devices are familiar to most people on the planet.

These developments are due in part to the ongoing exponential increase in computer processing power, doubling approximately every 2 years for the past several decades. This pattern is usually called Moore's Law and is named for Gordon Moore, a cofounder of Intel. The law is not a law like that for gravity; it is an empirical observation, which has become a self-fulfilling prophecy. Unfortunately, much of the public has come to expect that all technology does, will, or should follow such a law, which is not consistent with our everyday observations: For example, the maximum speed of cars, planes, or ships does not increase exponentially; maximum speed barely increases at all.

there is a Moore's Law for computer processors is that electrons are small and they do not take up space on a chip. Chip performance is limited by the lithography technology used to fabricate the chips; as lithography improves ever smaller features can be made on processors. Batteries are not like this. Ions, which transfer charge in batteries, are large, and they take up space, as do anodes, cathodes, and electrolytes. A D-cell battery stores more energy than an AA-cell. Potentials in a battery are dictated by the relevant chemical reactions, thus limiting eventual battery performance. Significant improvement in battery capacity can only be made by changing to a different chemistry.

Scientists and battery experts, who have been optimistic in the recent past about improving lithium-ion batteries and about developing new battery chemistries—lithium/air and lithium/sulfur are the leading candidates—are considerably less optimistic



Fred Schlachter.

breakthrough in battery technology, we do have a valuable and underutilized resource: energy efficiency, which in many cases is free or even has a negative cost. Cars can be made more energy efficient by reducing size, weight, and power. Incentives to re-

SMART BATTERY

- Programmability
- Sensors: current, voltage, temperature

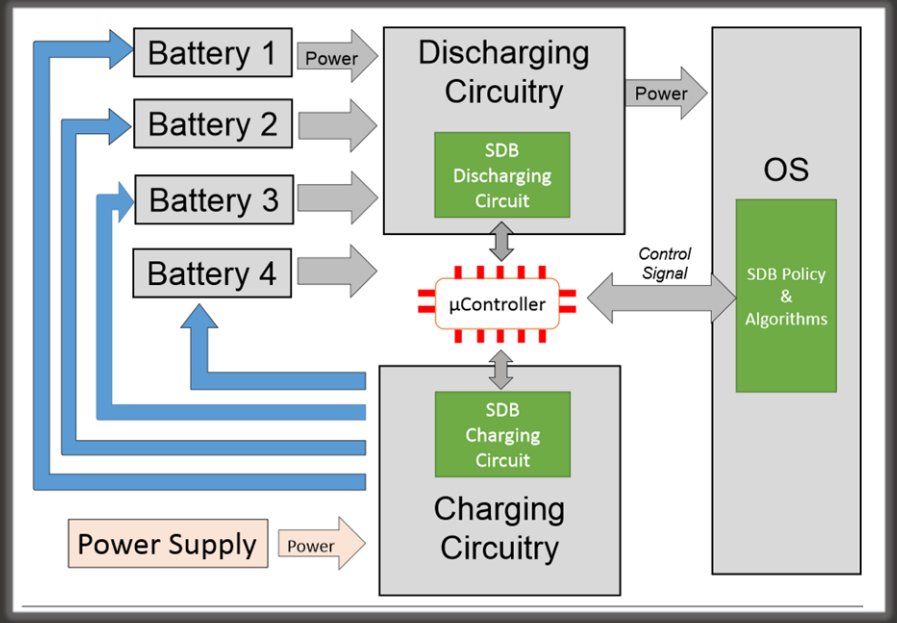
Why?

- ✓ Safety *overheating, over/under voltage*
- ✓ Extend battery life
- ✓ Performance

SMART BATTERY - PROGRAMMABILITY

Software defined battery (SOSP '15)

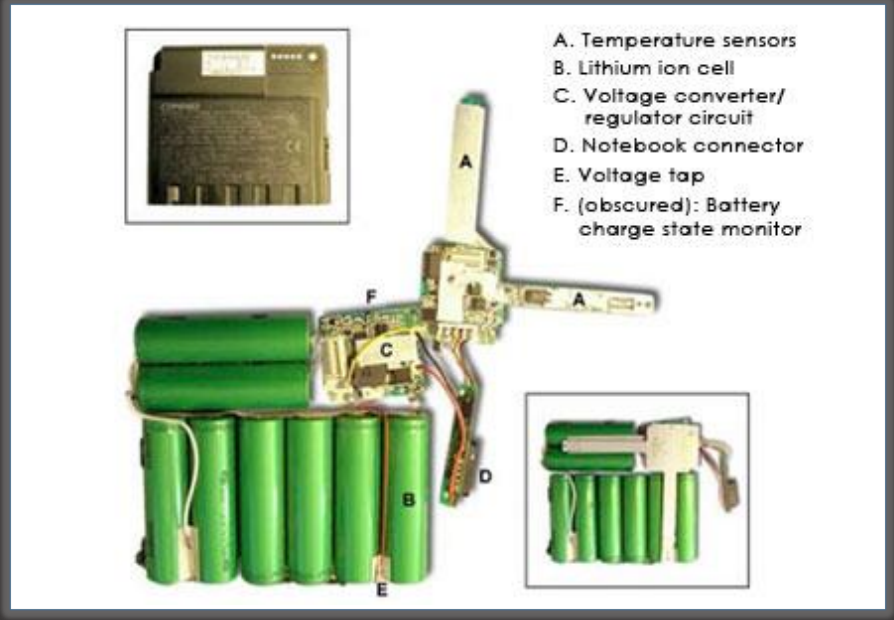
By Microsoft & Tesla



Smart battery System

See spec.

http://sbs-forum.org/specs/



INSIDE SMARTPHONE BATTERY

Btemp

NFC antenna

BSI *(battery size/status/system indicator)*

INSIDE SMARTPHONE BATTERY

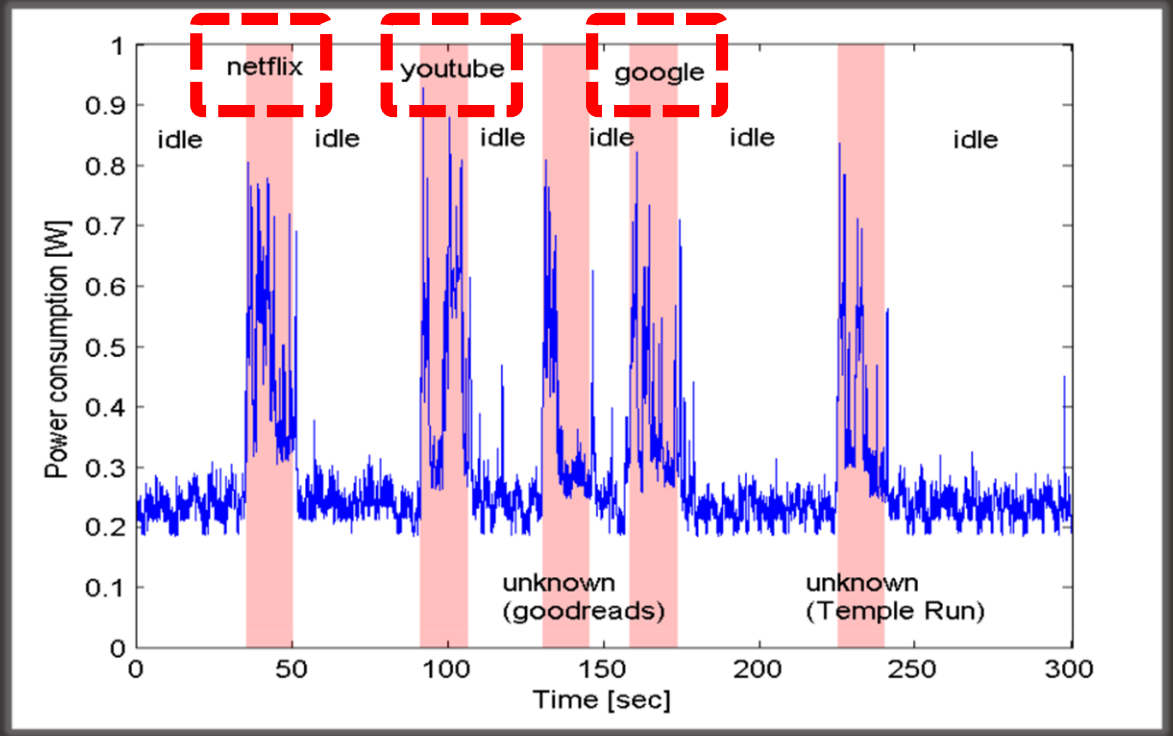
Your phone batteries are getting smarter!

Do the smart batteries create a new privacy threat?

Do the smart batteries create a new privacy threat?

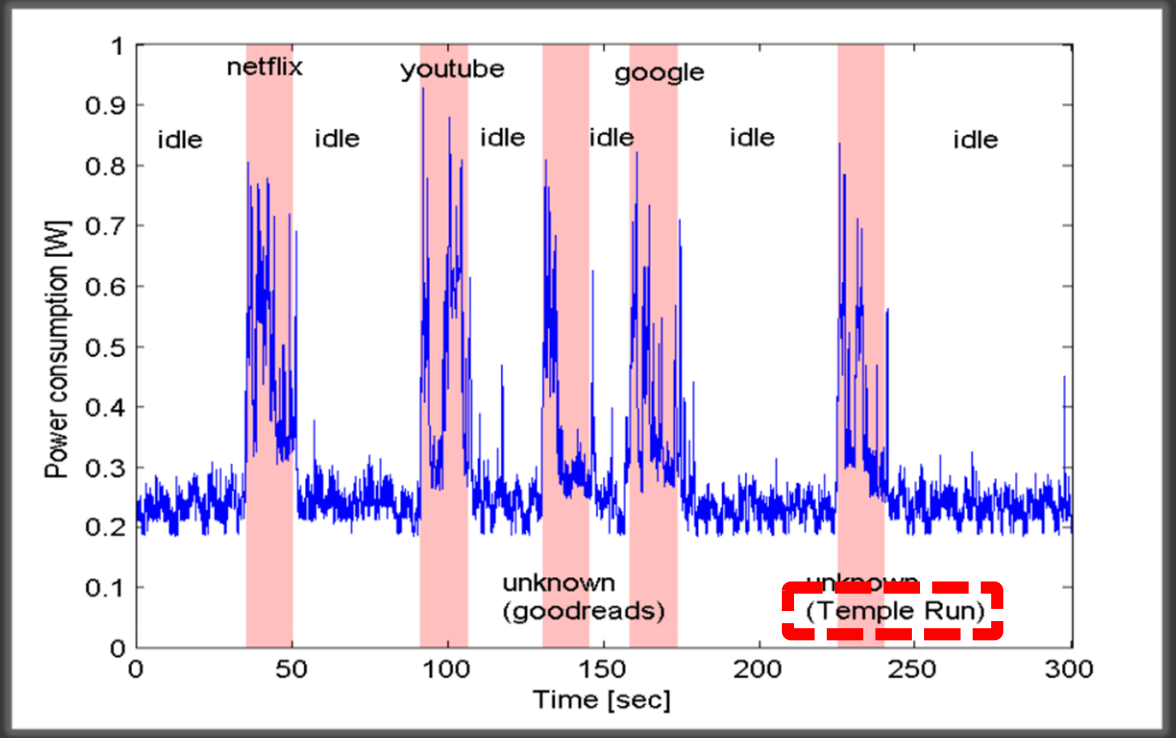
IF THE ATTACKER GETS ON YOUR BATTERY

- Browsing History



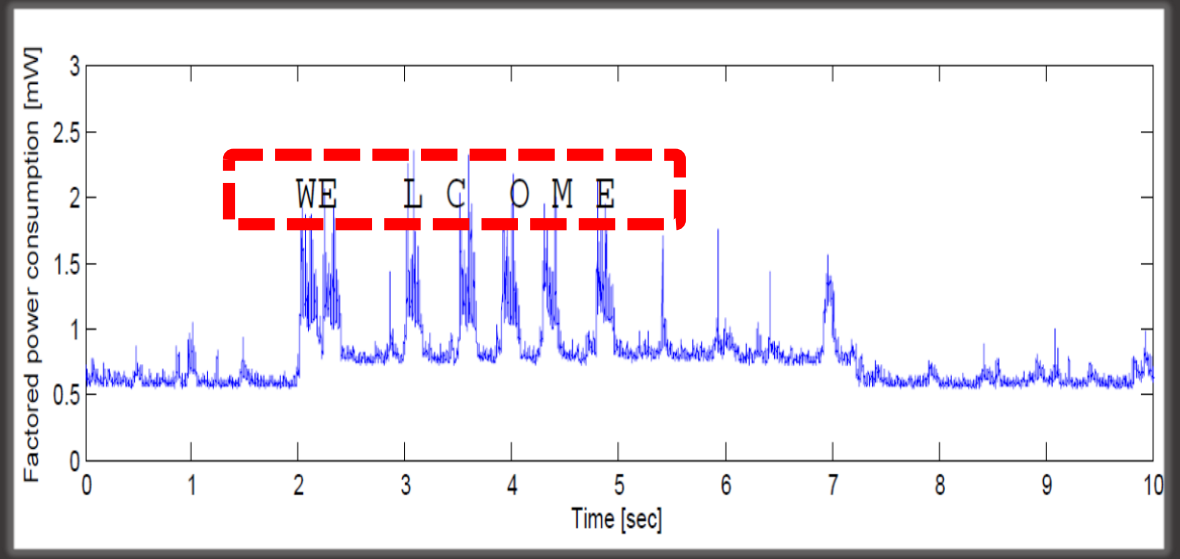
IF THE ATTACKER GETS ON YOUR BATTERY

- Browsing History
- Applications



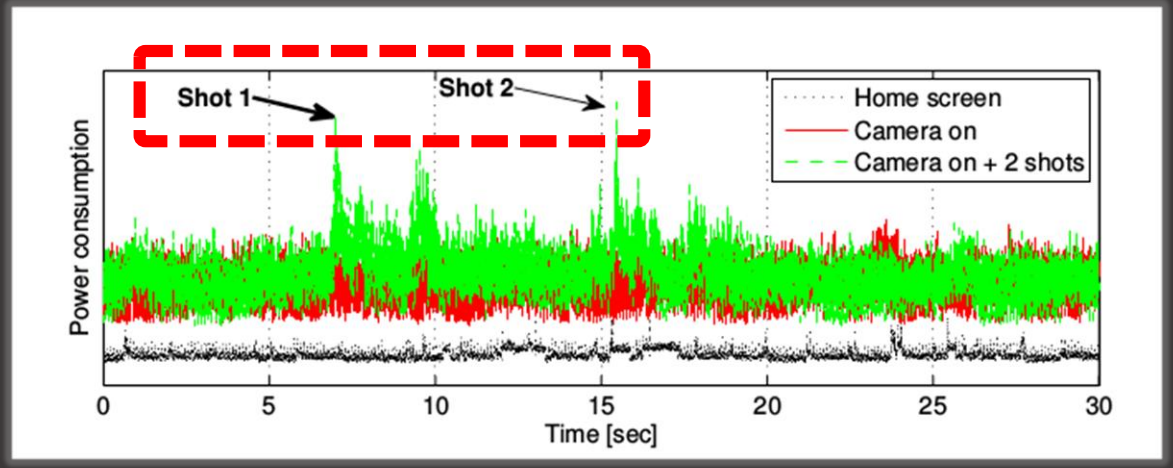
IF THE ATTACKER GETS ON YOUR BATTERY

- Browsing History
- Applications
- Typing



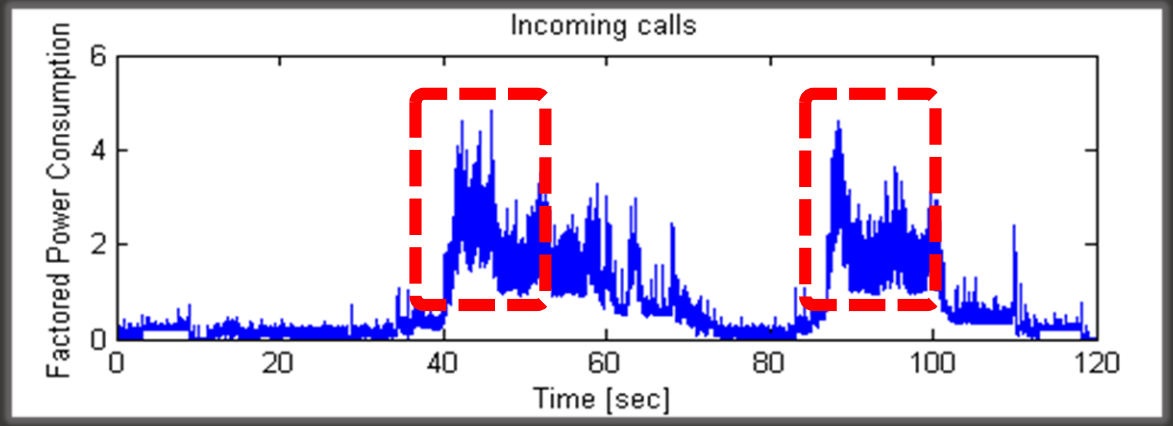
IF THE ATTACKER GETS ON YOUR BATTERY

- Browsing History
- Applications
- Typing
- Photo shot



IF THE ATTACKER GETS ON YOUR BATTERY

- Browsing History
- Applications
- Typing
- Photo shot
- Communication profile –Phone calls

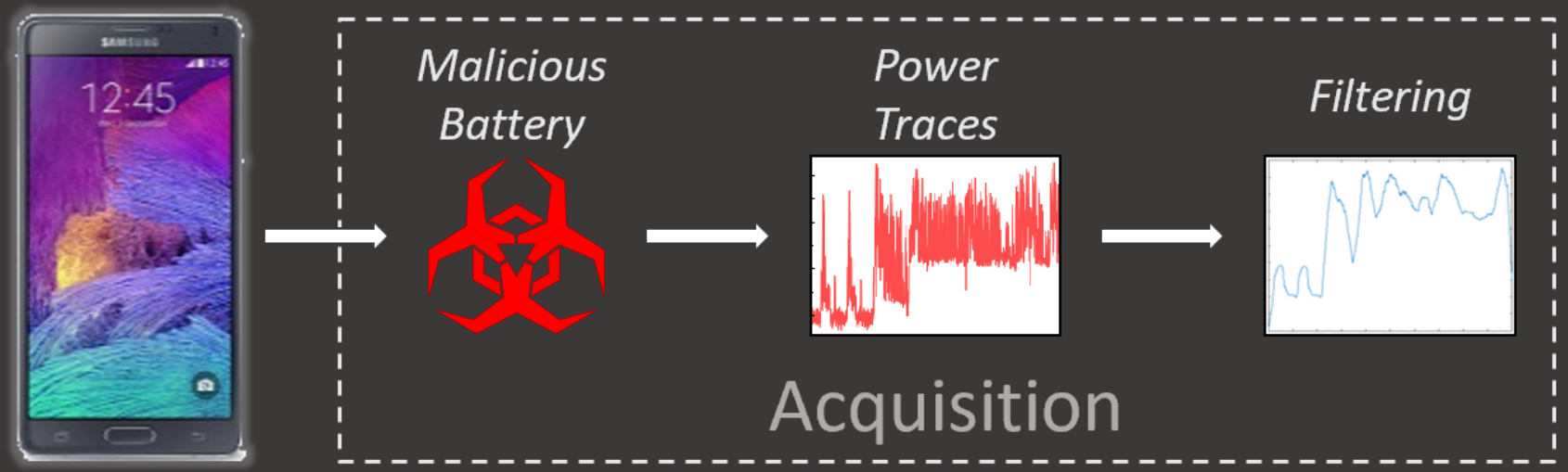


Mobile Device	Huawei Mate 9	Smsng Galaxy Note 4	Smsng Galaxy S4
Chipset	Hisil. Kirin 960	Snapdrgn 805	Snapdrgn 600
CPU	Cortex-A73 & Cortex-A53	Cortex-A57 & Cortex-A53	Krait 300
Display	5.9'	5.7'	5.0'
OS	7.0 (Nougat)	5.1.1 (Lollipop)	4.4.2 (KitKat)
Browser	Chrome 53	Native 6.2 / Chrome 63	Native 2.1 / Chrome 43
Battery	Li-Po 4000mAh	Li-Ion 3220mAh	Li-Ion 2600mAh

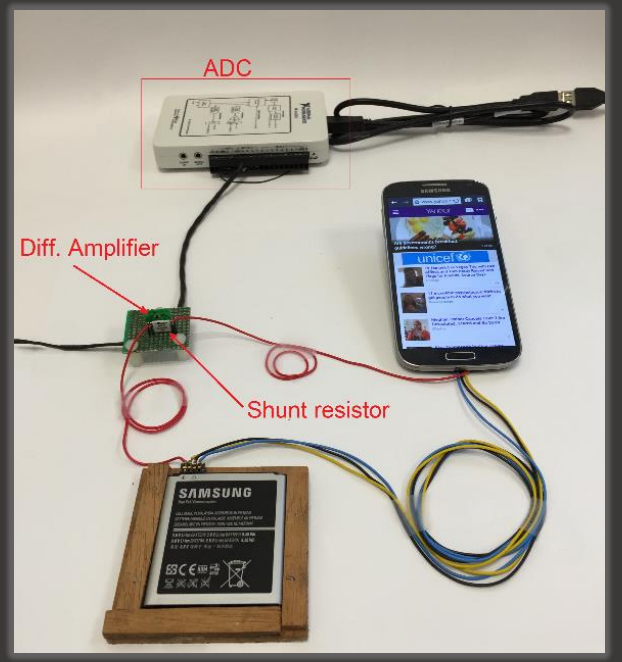
AGENDA

- General scheme for malicious battery attacks
- Examples:
  - *Website inference*
  - *Keystroke inference*
  - *Combination of multiple attacks*
- Data exfiltration mechanism via browser
- Sources of the leaks

METHODOLOGY



METHODOLOGY



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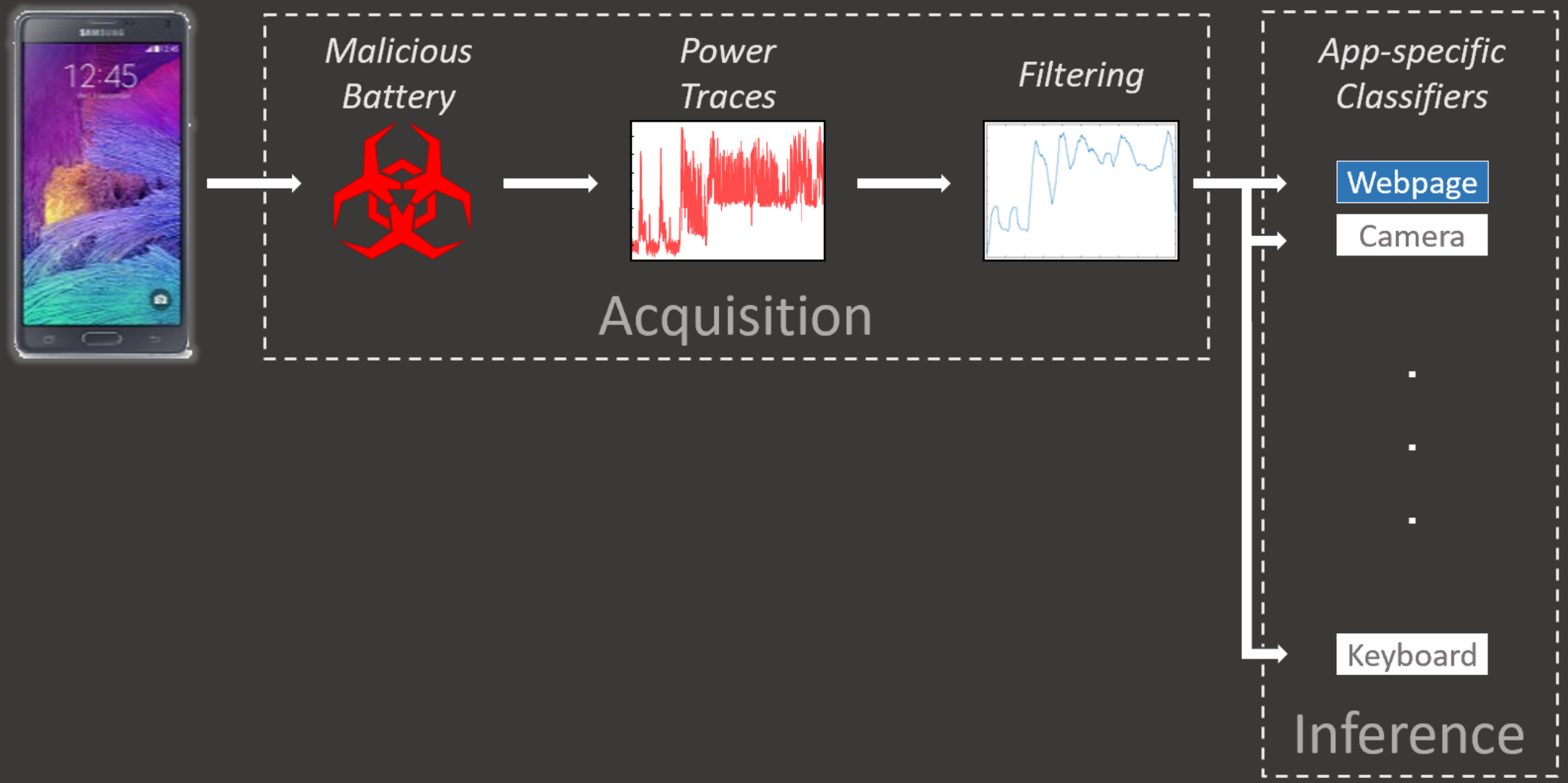

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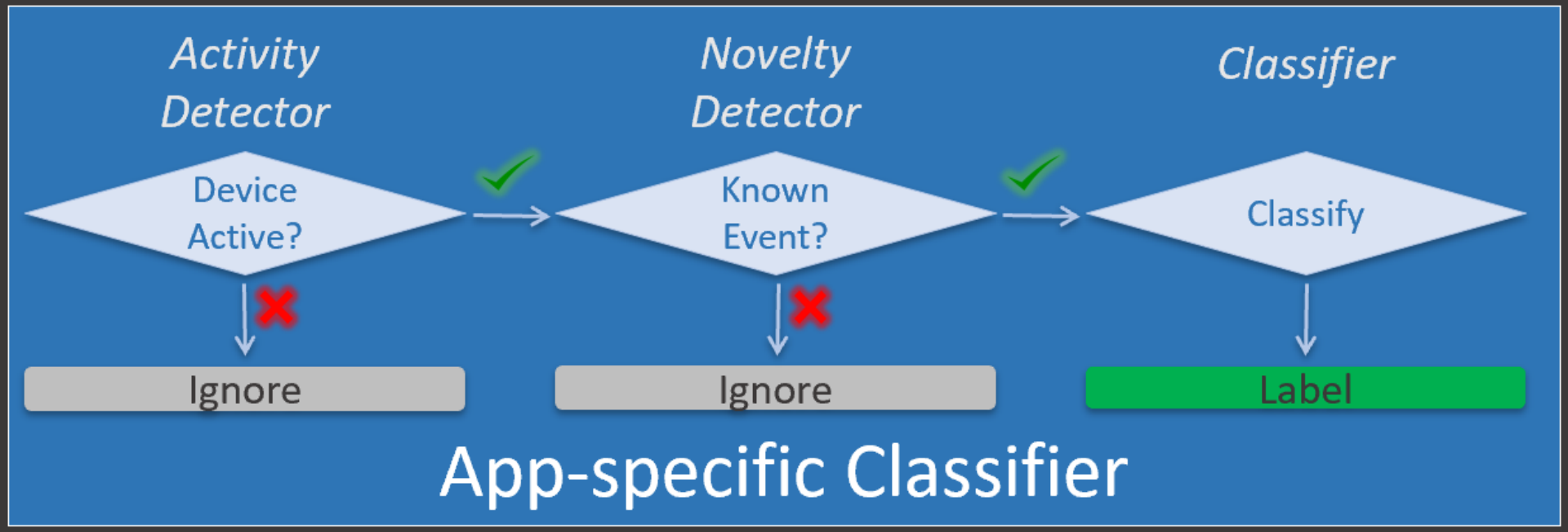
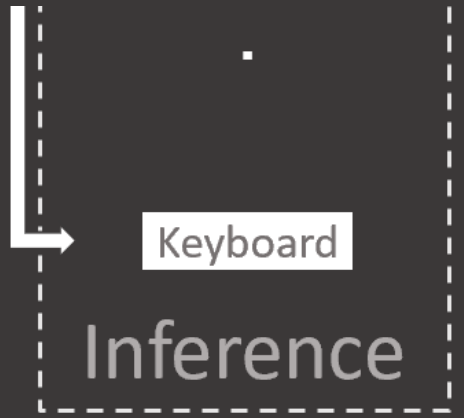
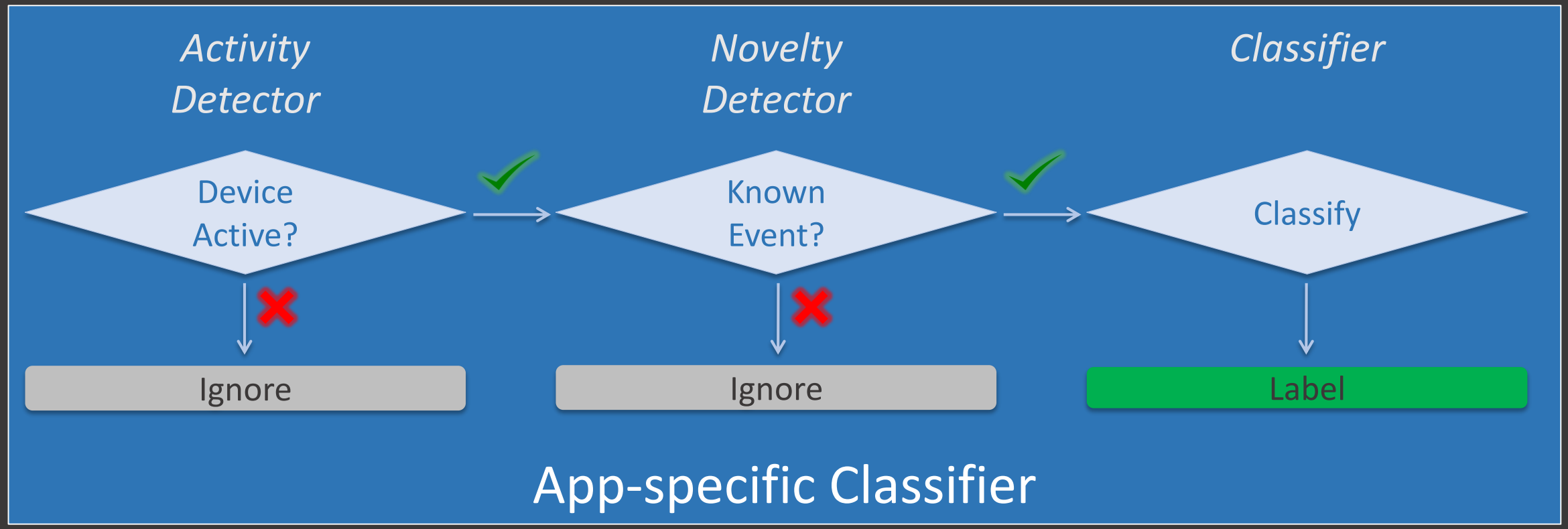
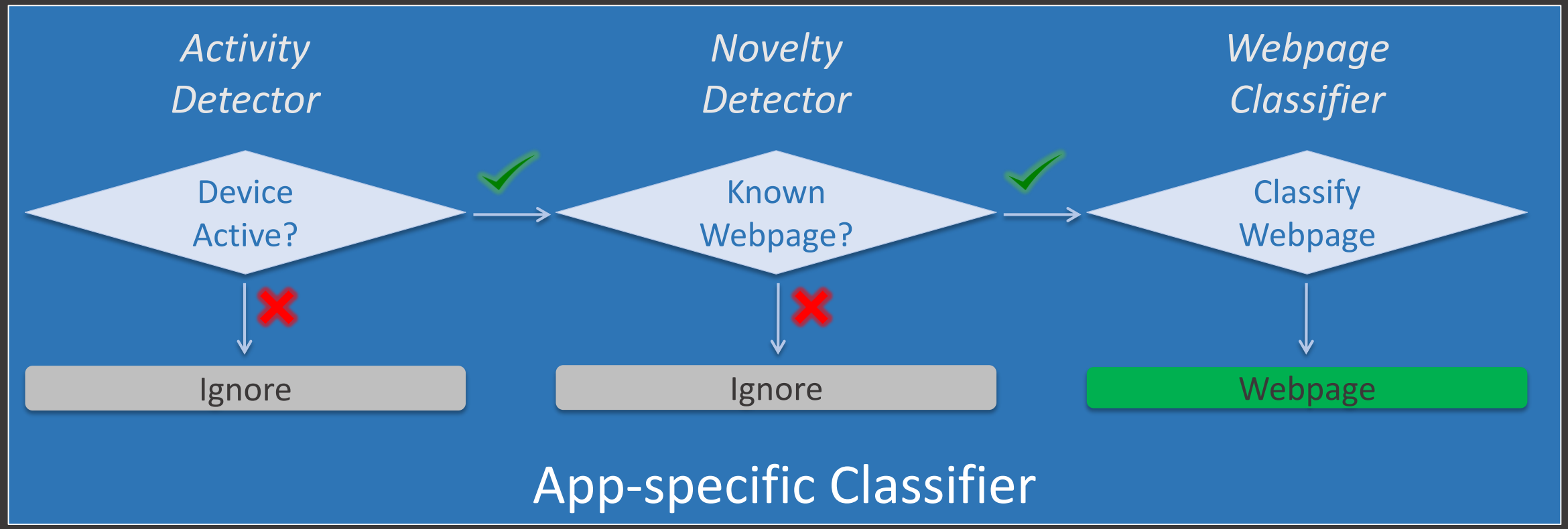




APP SPECIFIC PIPELINE



BROWSING HISTORY ATTACK PIPELINE



Website inference: an Idea

- Collect a set of traces while browsing to webpages that you want
- Train a classifier
- Done

Really?

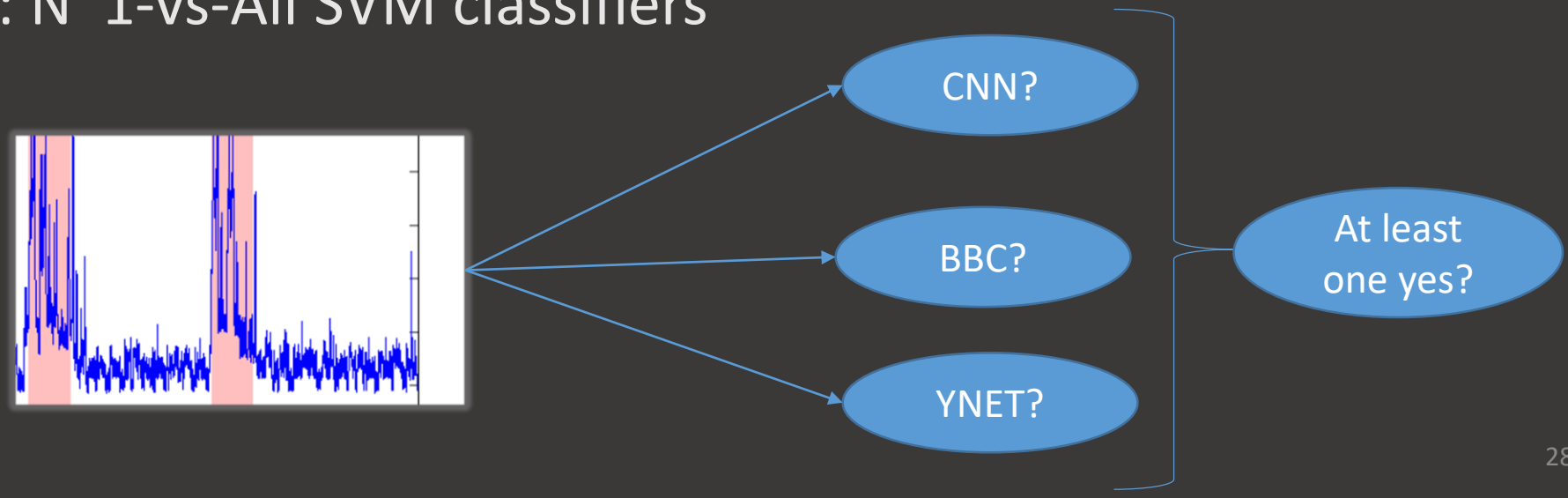
Why we need a novelty detector

- Closed world: everything we know is captured by the classifier
- Open world: classifier captures a small subset, the rest is **unknown**
- Need to filter unknowns!

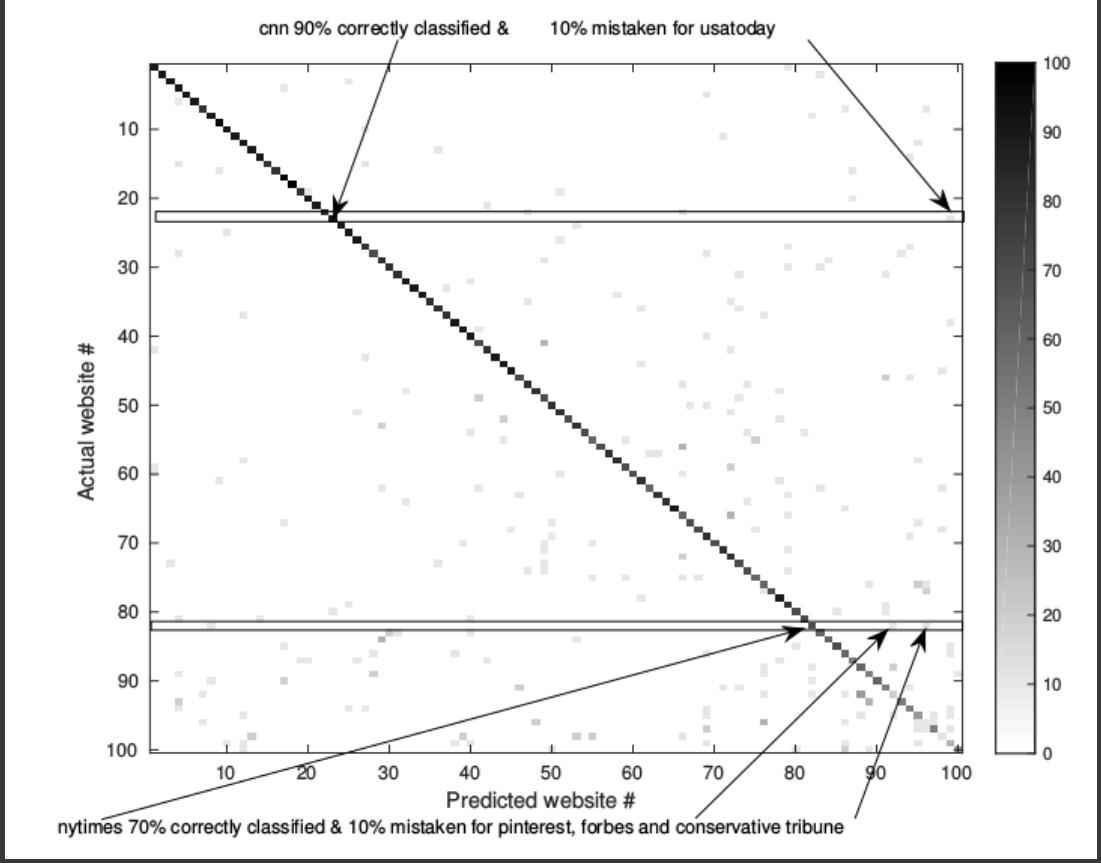
How does it work?

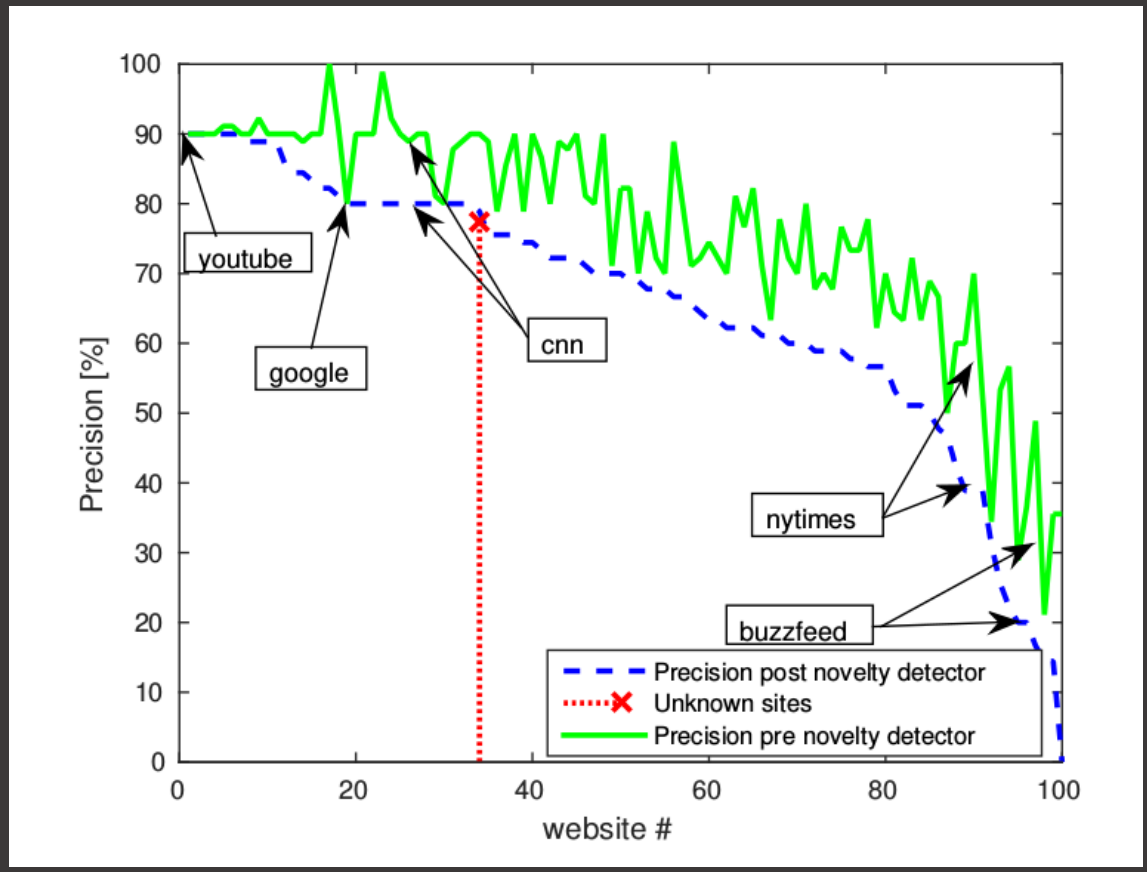
- Power trace: 15K samples (15sec)
- Dictionary: 10 traces per website

- Novelty detector:
- N websites: N 1-vs-All SVM classifiers

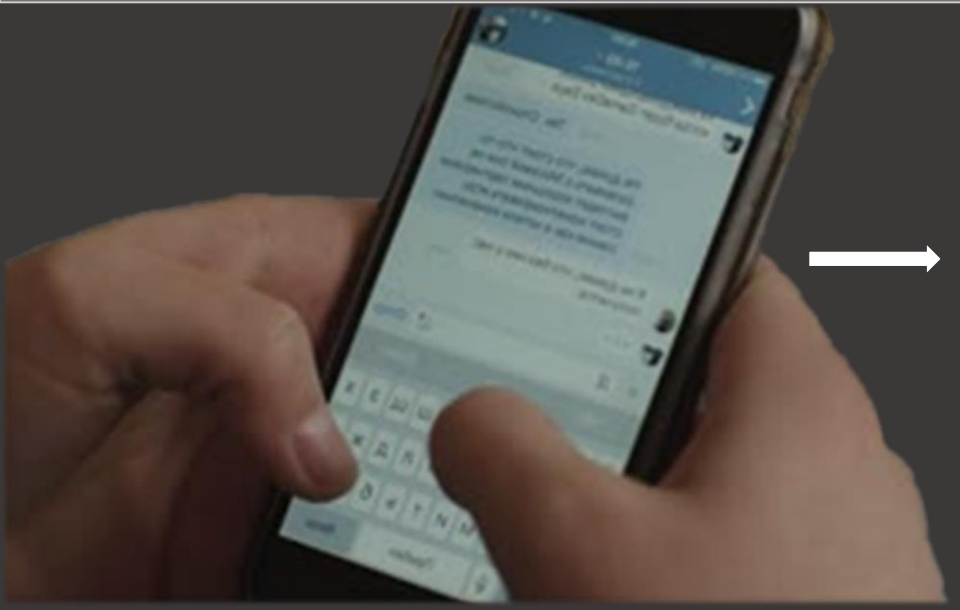


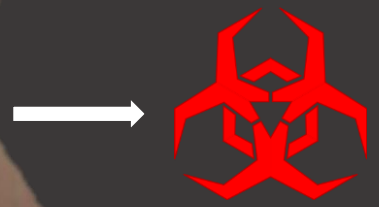
How well does it work?

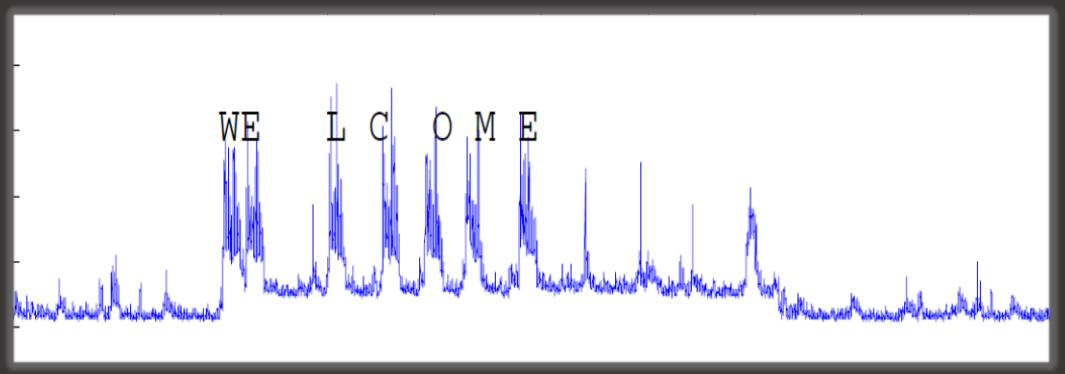




KEYSTROKE INFERENCE







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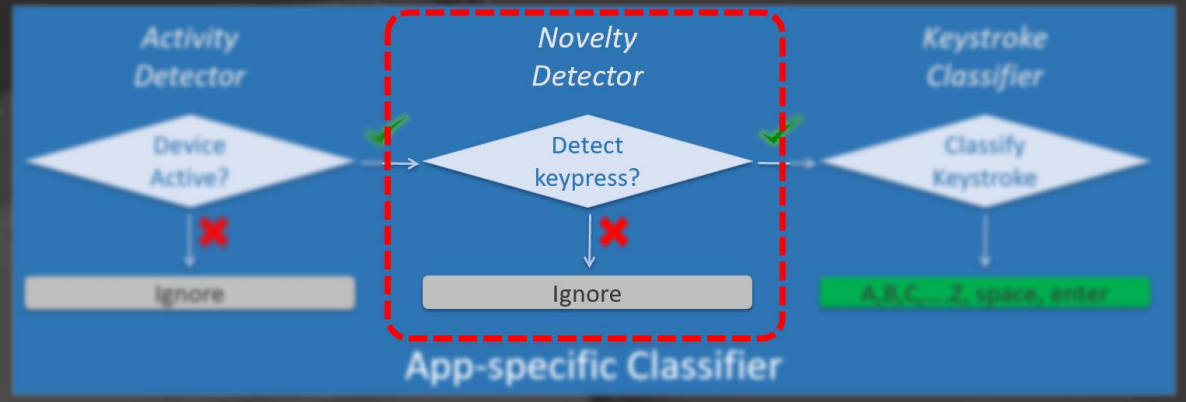

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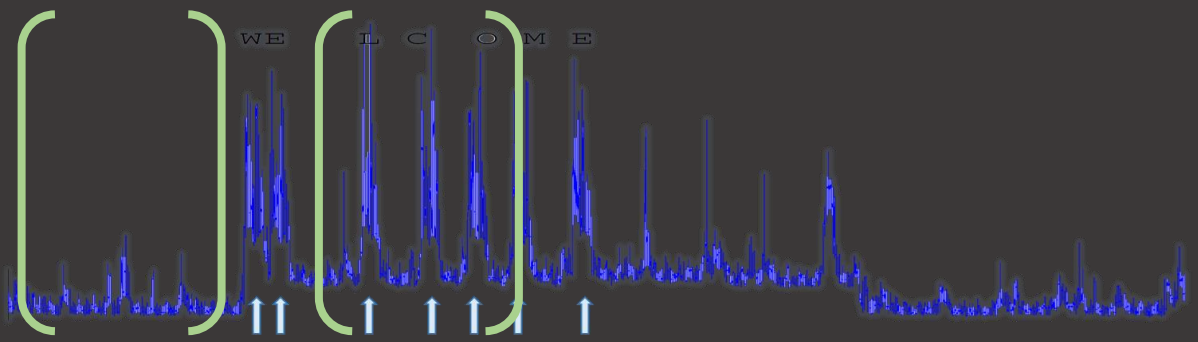
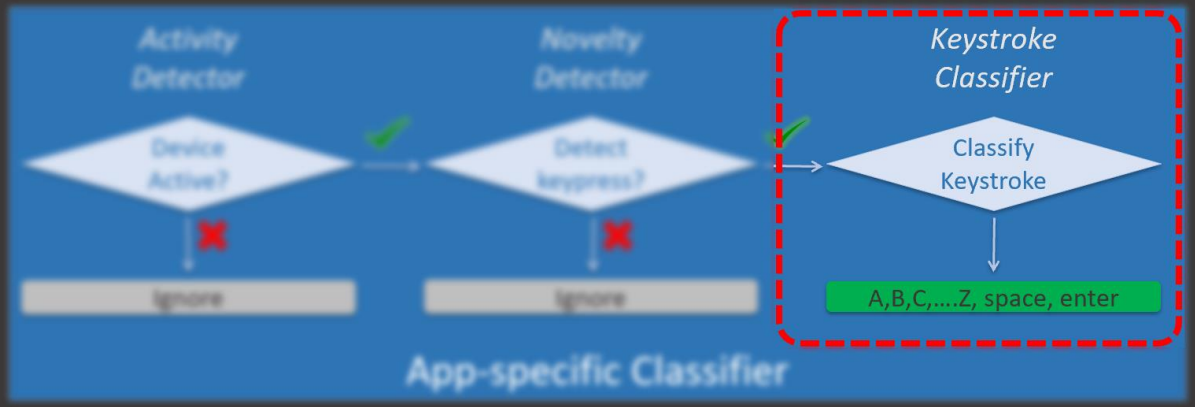
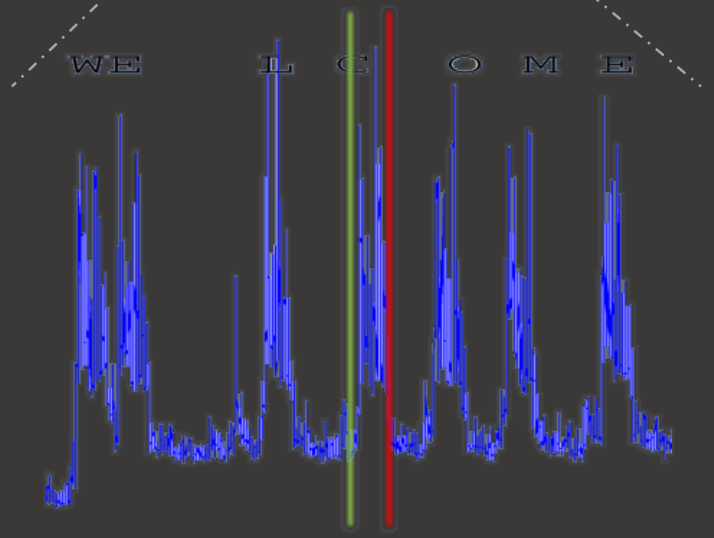


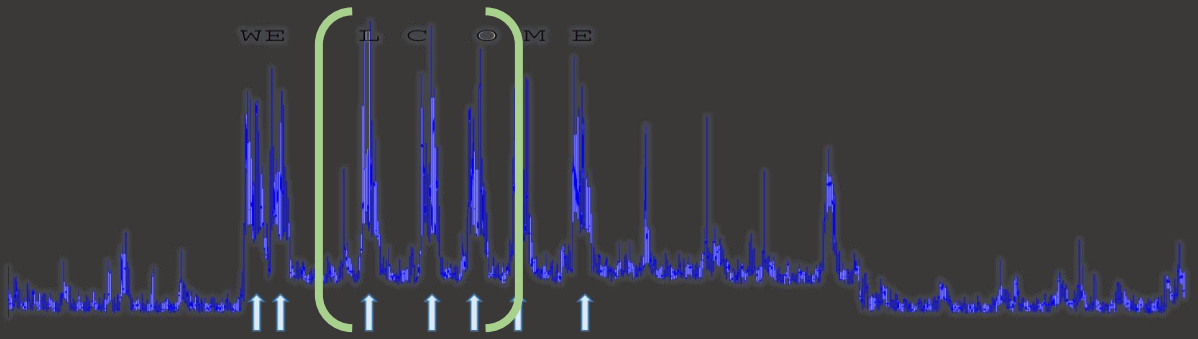


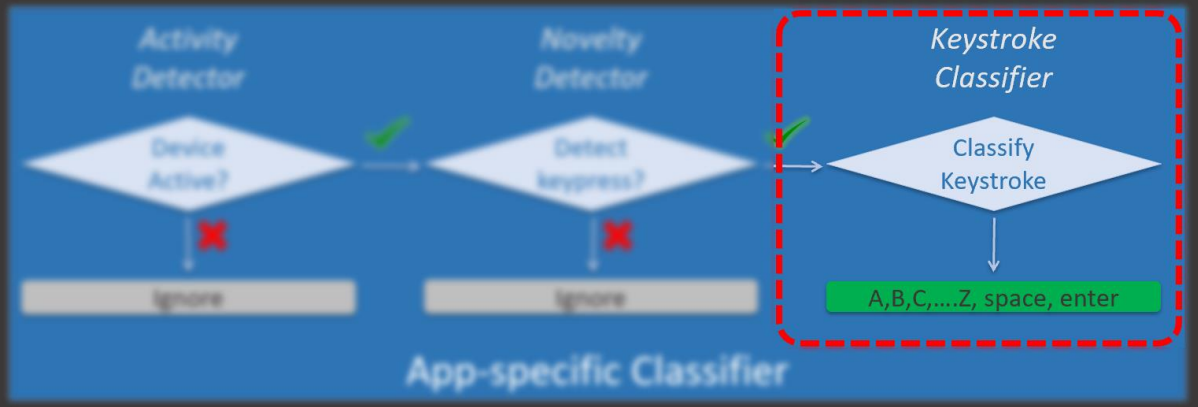


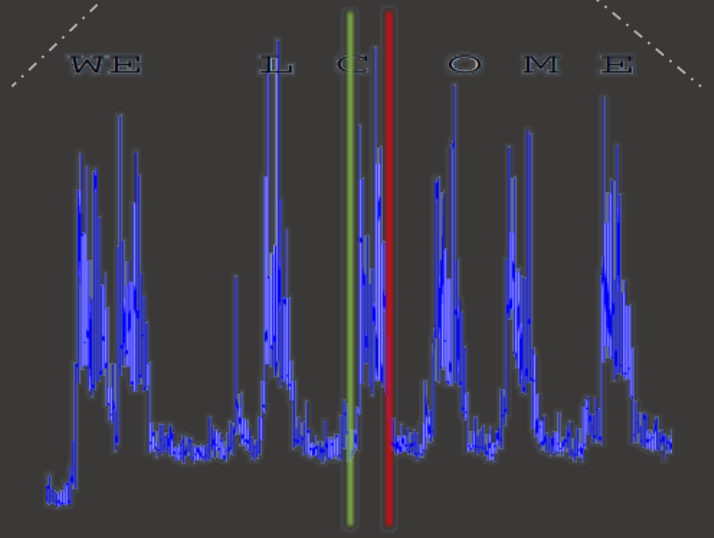
Convolutional Neural Network

'C'

KEYSTROKE INFERENCE



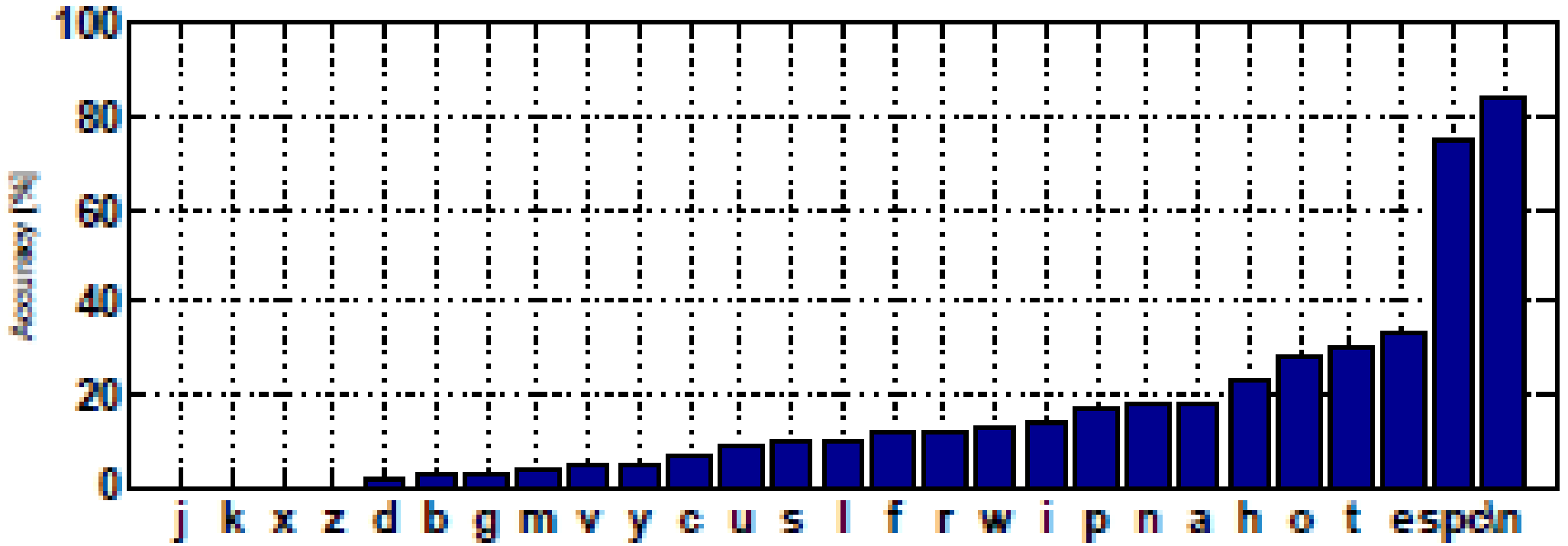




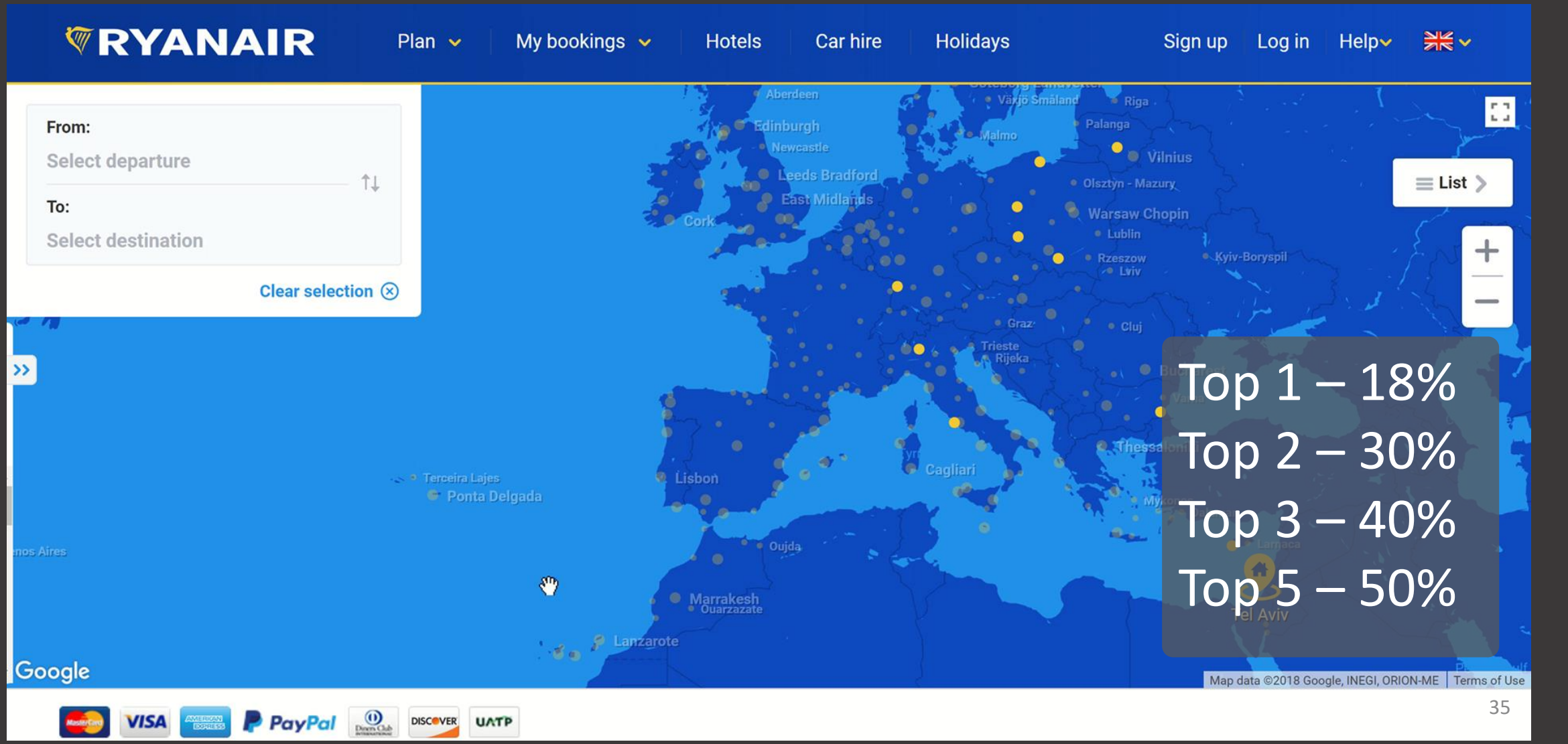
Convolutional Neural Network

'C'

KEYSTROKE INFERENCE - RESULTS



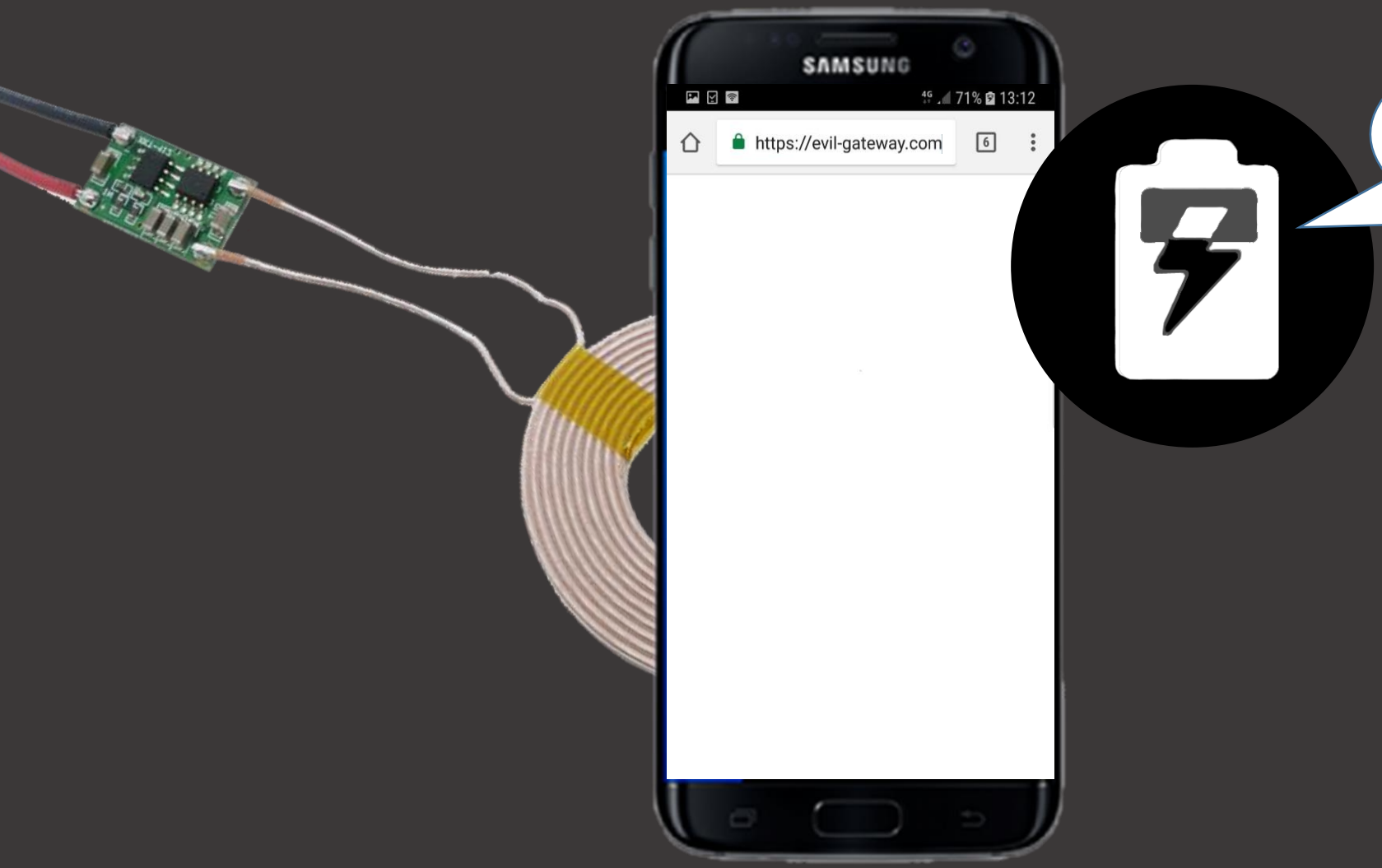
COMBINATION OF KEYSTROKE & WEB INFERENCE



EXFILTRATION

- ✖ Wifi / Bluetooth
- ✖ Manipulate voltage
  - ✖ App
  - ✖ Battery Status API

EXFILTRATION

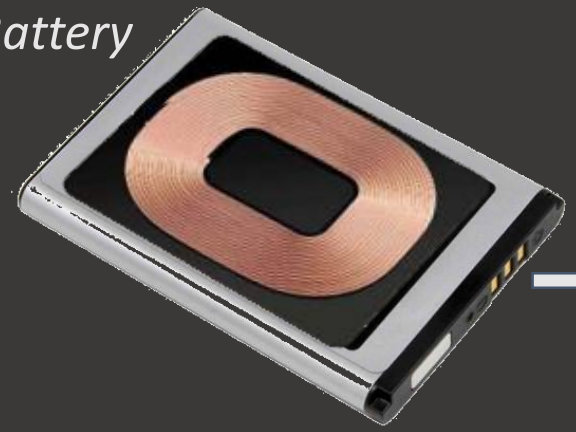


Victim

Update rate not limited by Battery Status API

EXFILTRATION

Malicious Battery



0.5 bit/sec

Attacker

Victim

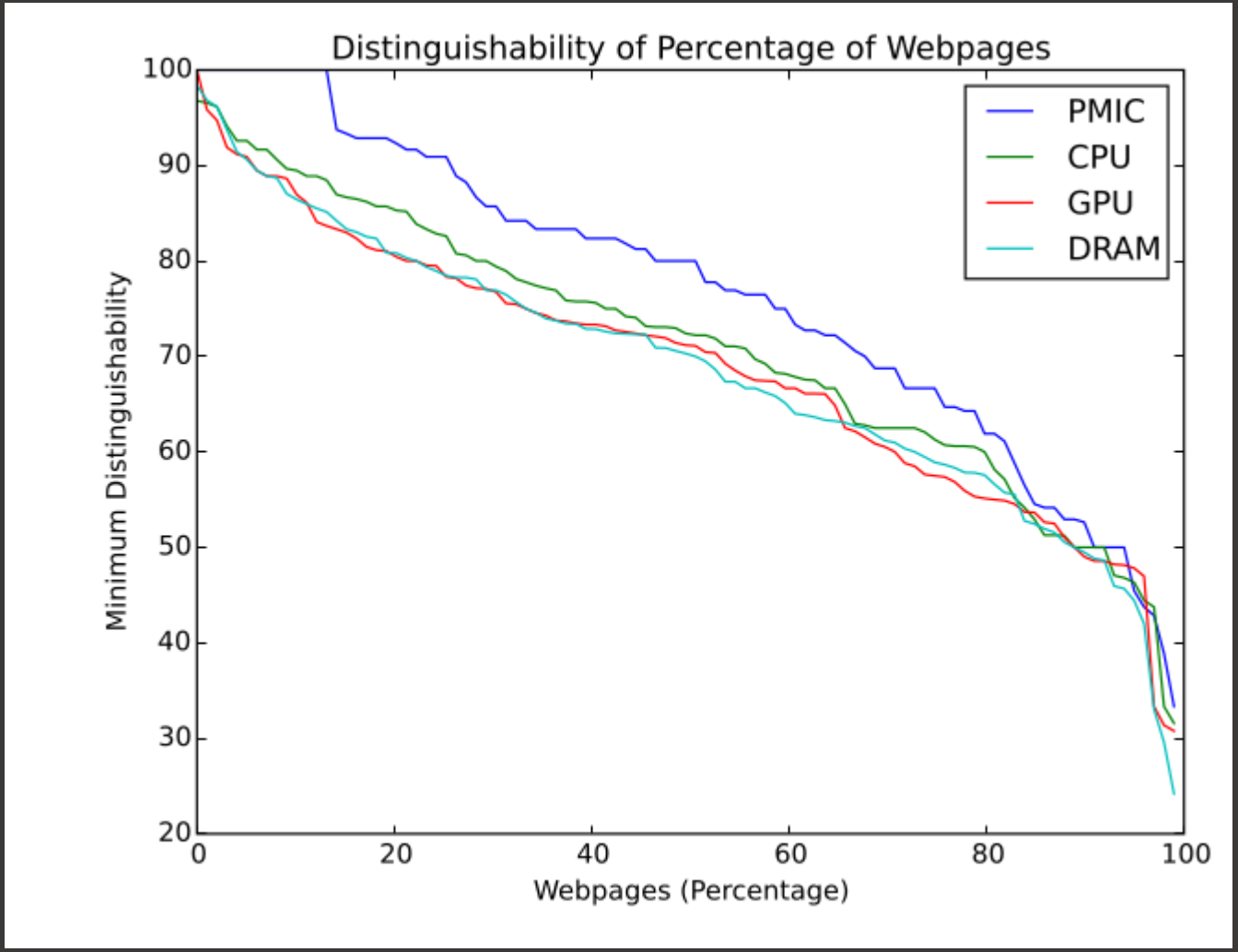
Is it sensitive to…

Attack	Experiment	Outcome
Web browsing	Downsampling	Precision above 50% down to 50Hz
	TOR Browsing	Cross-dictionary precision drops to 23%
	Cross-browser	Requires mixed dictionary
Keystroke inference	Downsampling	Average character accuracy 28% down to 100Hz
	Cross-user	Detection only
All attacks	Cross-phone (same make)	No degradation

Why does it work?

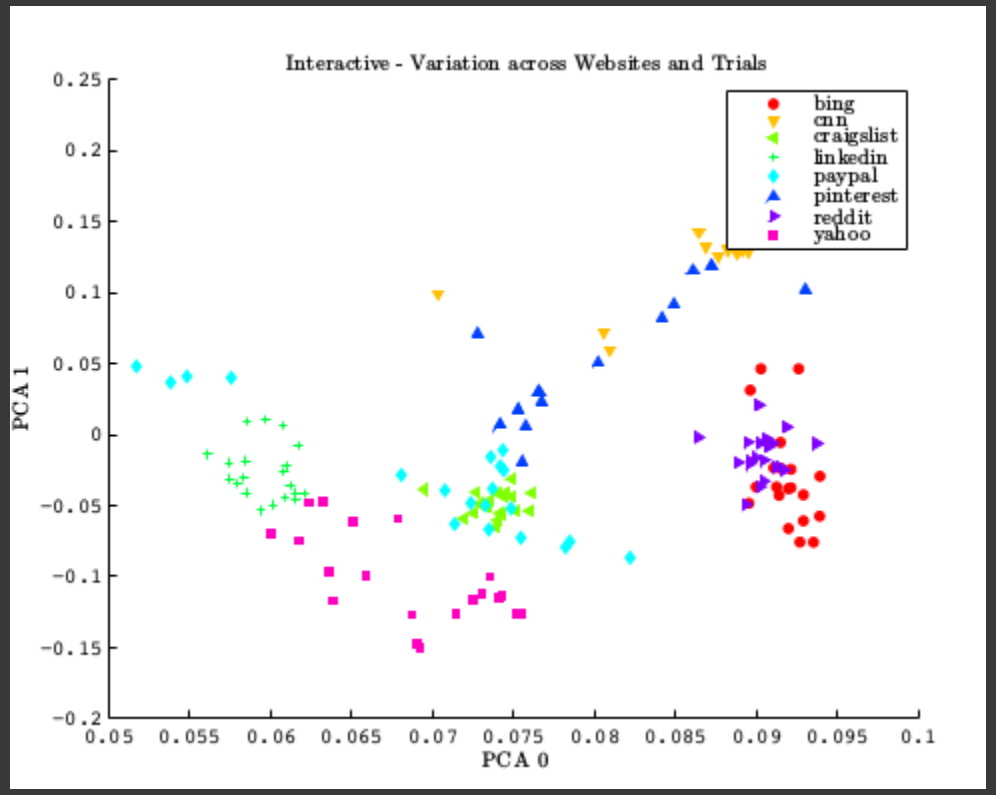
- CPU?
- GPU?
- Camera?
- Capacitive touch screen?

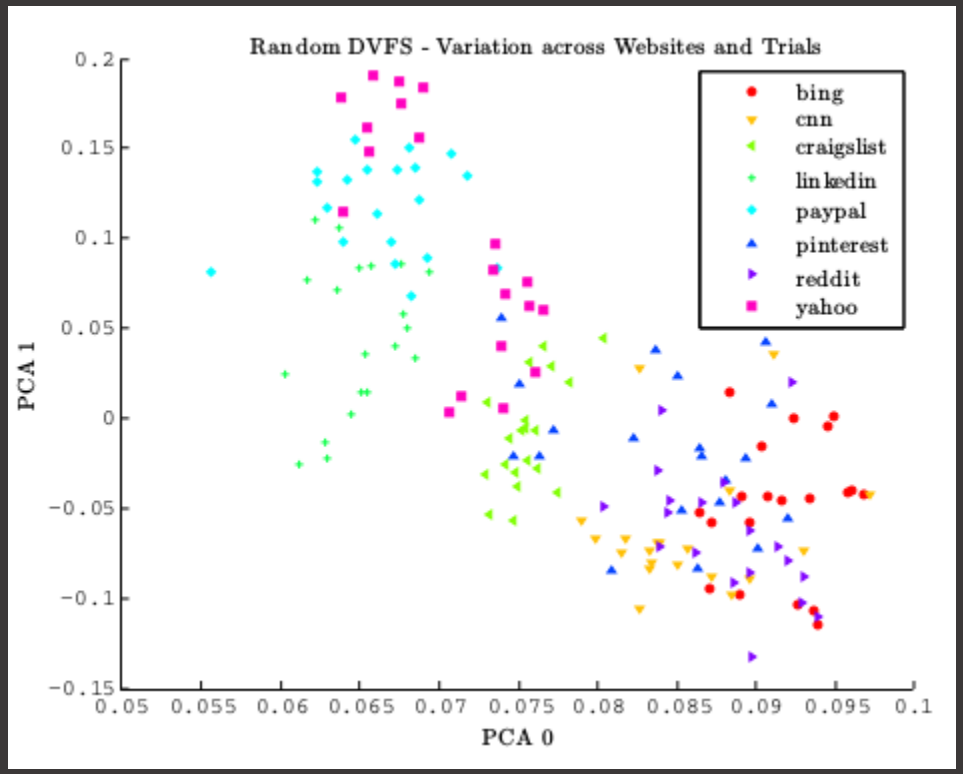
CPU and GPU and DRAM



How do we defend?

- Can we just set fix frequency?
- What if we randomize DVFS?



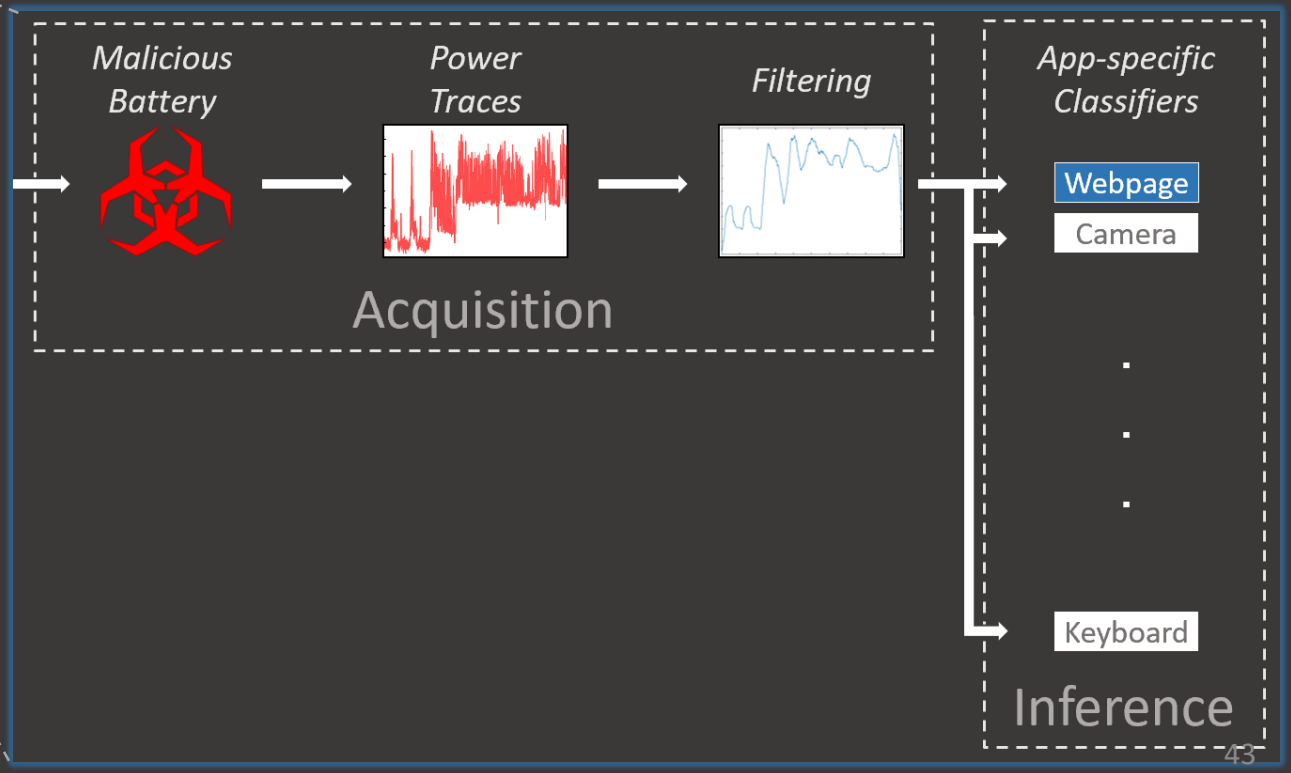


CONSTRAINT - FIT INSIDE THE BATTERY

Power requirements - <70 mA phone at rest
- *Computational complexity*
- *Signal sampling rate*

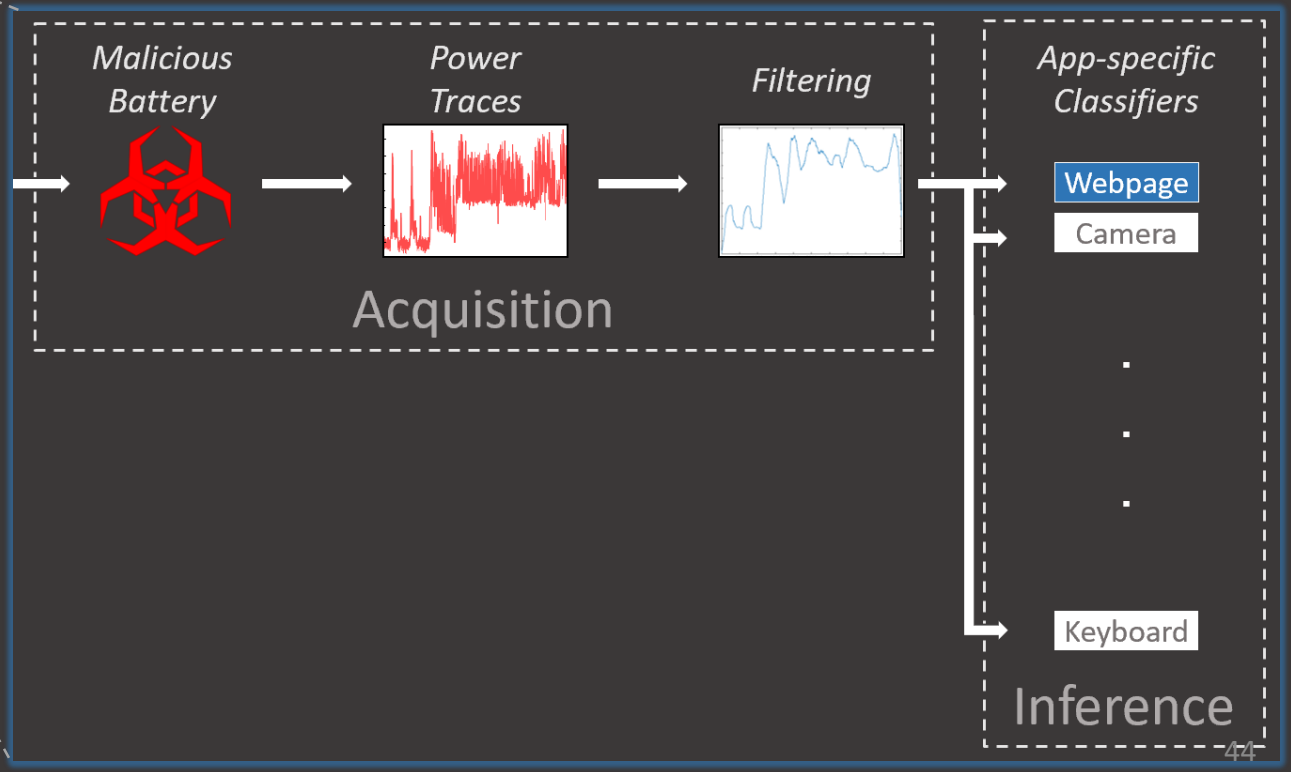
Storage

Our sampling rate:
100Hz – 1KHz



CONSTRAINT - FIT INSIDE THE BATTERY

@1000Hz you can store 1y of trace in 10GB
DSP TI C5504: 10mA + 128MB (~50mA)



THEORETICAL?!

BUSINESS INSIDER

TECH FINANCE POLITICS STRATEGY LIFE INTELLIGENCE ALL

The companies that make your smartphone batteries say they should barely last a year

Antonio Villas-Boas, Tech Insider Oct. 16, 2015, 1:30 PM

Business Insider

The manufacturers that make your smartphone's lithium-ion battery say it'll have a lifespan of 300-500 charging cycles, according to Battery University, a leading resource for information on batteries.

Every time you plug in your phone to charge when its below 70%, it goes through a "charging cycle."

THEORETICAL?!

Counterfeit Cell Phone & Laptop Batteries

Caution, Credibility, Causes and Cures
by Shirley Georgi

Examples are shown of the recent Consumer Product Safety Commission (CSPC) battery related safety recalls. Although there is no accurate report of the number of counterfeit/defective batteries that are currently in the U.S., or seized at point of arrival, the CSPC does keep track of the numbers in its recalls. This year a total of 1,190,000 cell phone batteries (Lithium-ion) were in the hands of the consumer before they were recalled as being potentially dangerous, potentially causing injury if overheating, venting and/or exploding. In addition, another 28,000 laptop batteries had to be recalled for the same reasons.+

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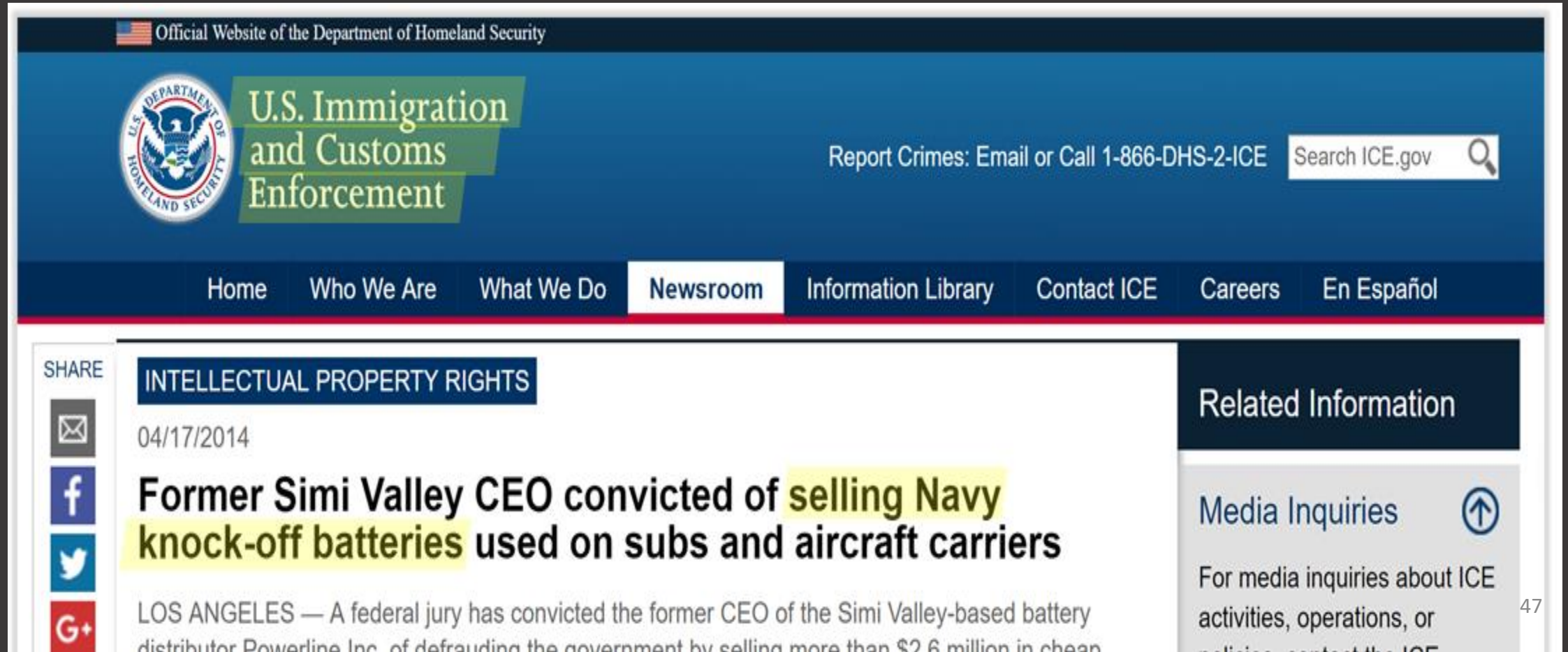
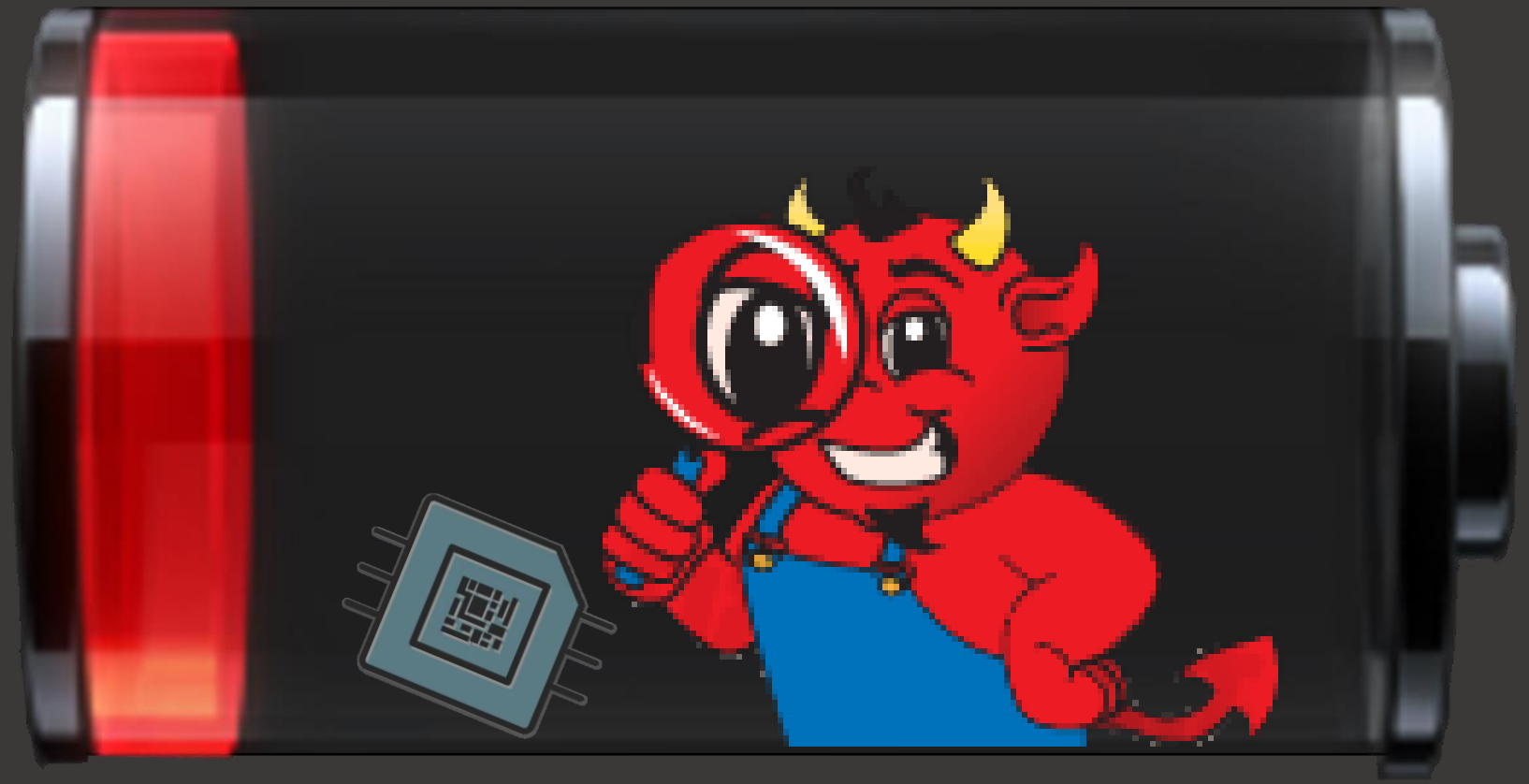
THEORETICAL?!





QUESTIONS?

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