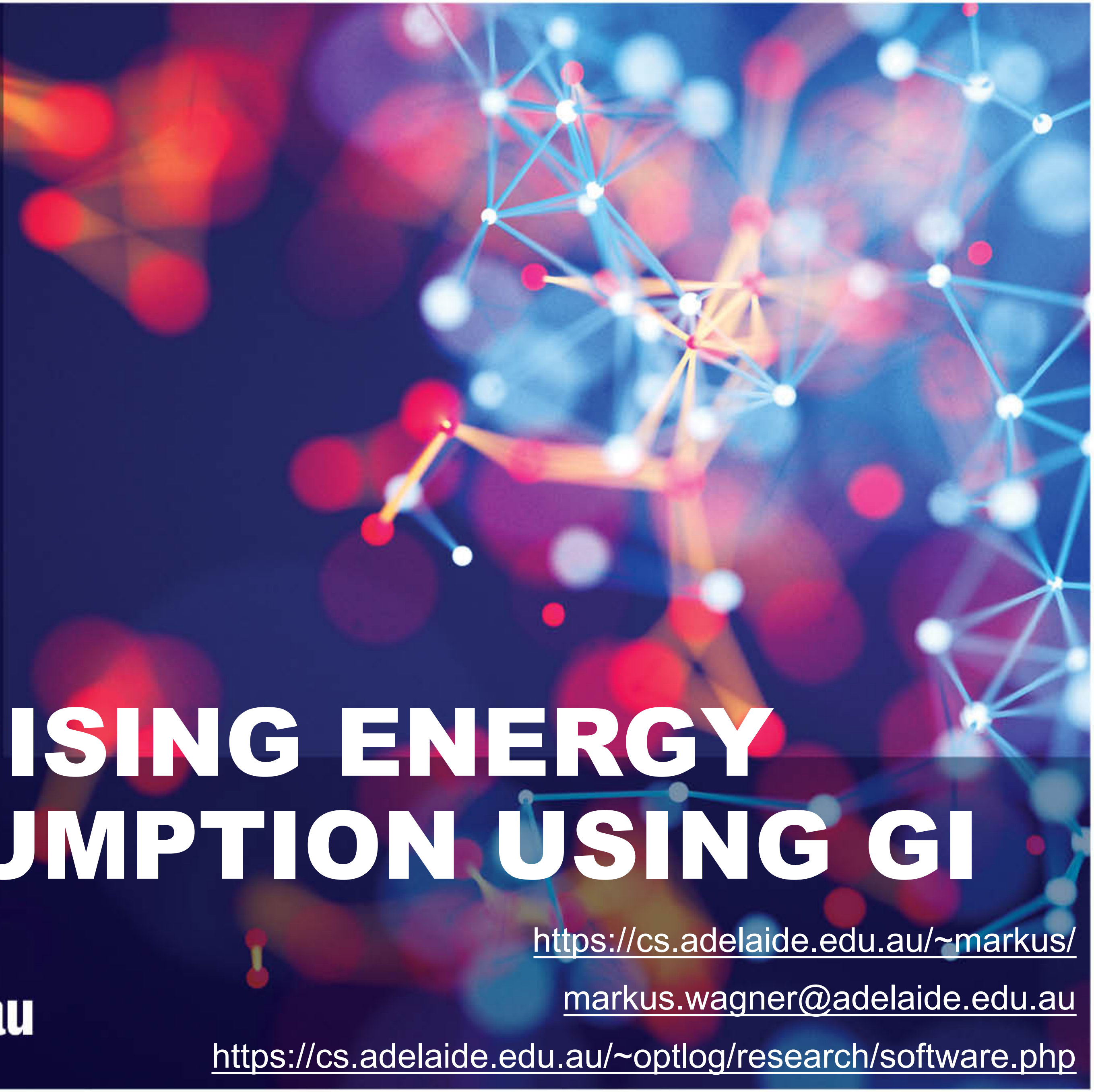

THE UNIVERSITY of ADELAIDE

OPTIMISING ENERGY CONSUMPTION USING GI

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https://cs.adelaide.edu.au/~optlog/research/software.php

adelaide.edu.au

Optimising energy consumption using GI

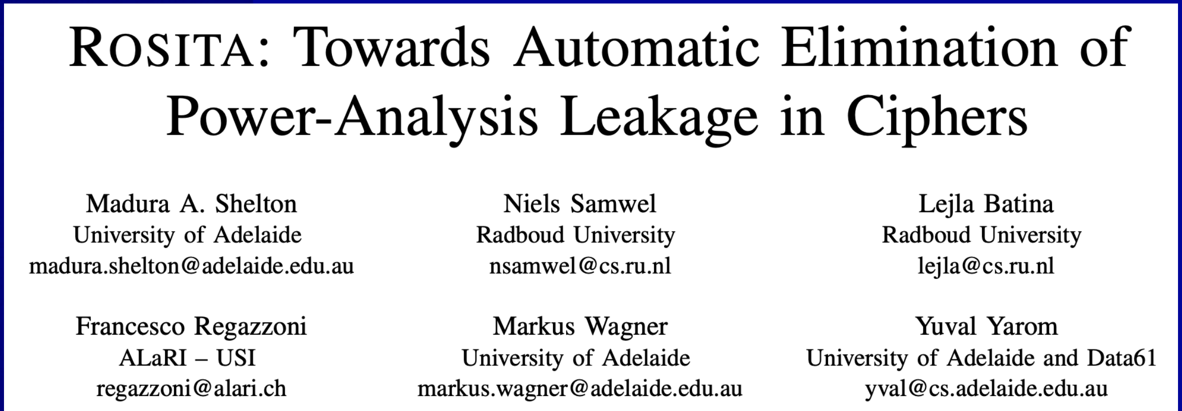
Project 1/2

Project 2/2

➔ Two world-first presentations!!

GI to combat side-channel attacks

Project 1/2



ROSITA: Towards Automatic Elimination of Power-Analysis Leakage in Ciphers

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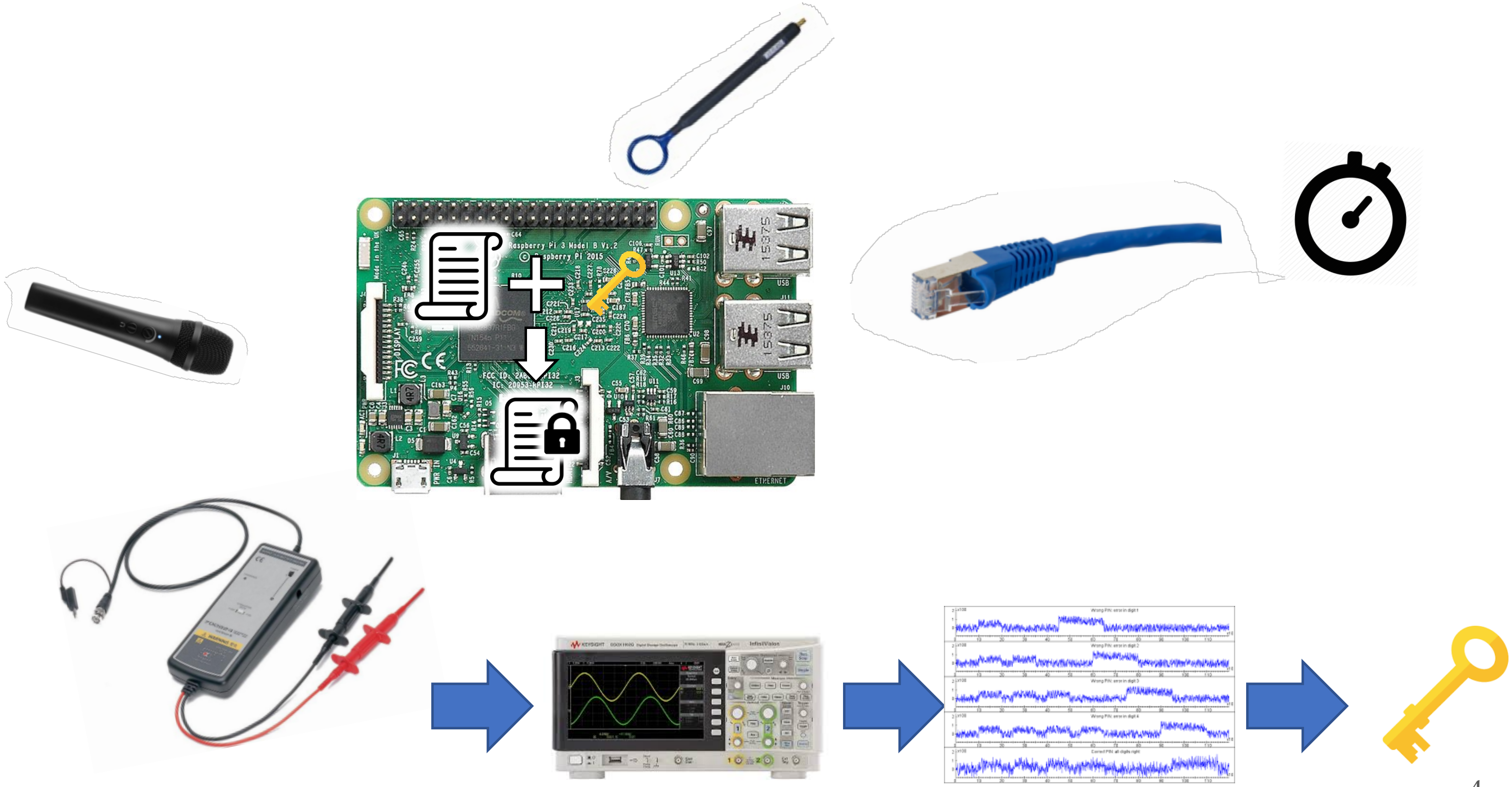
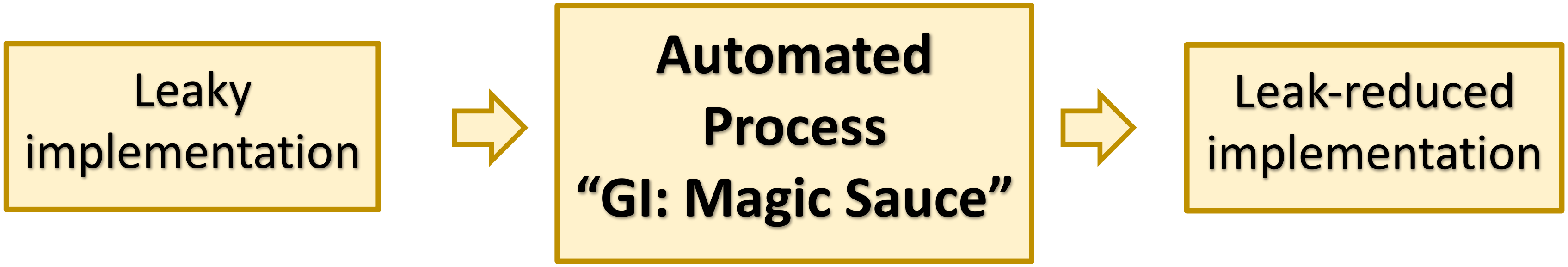
https://arxiv.org/abs/1912.05183

Side Channel Attacks


Wrong PIN: error in digit 1
Wrong PIN: error in digit 2
Wrong PIN: error in digit 3
Wrong PIN: error in digit 4
Correct PIN: all digits right

Our Goal

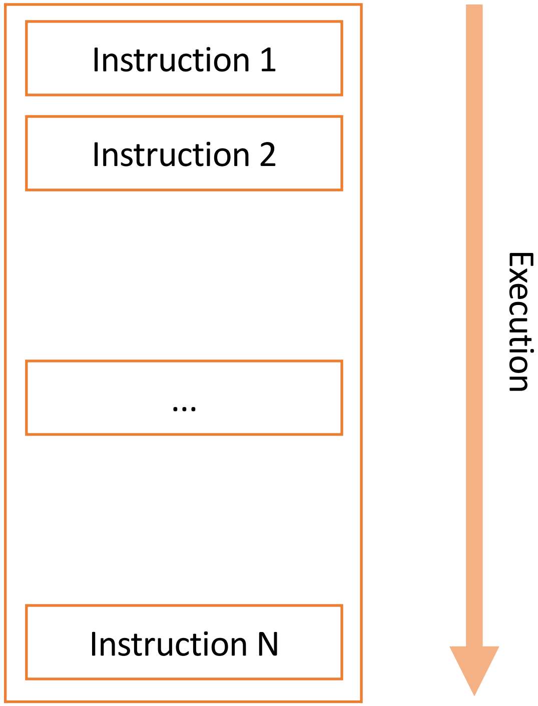


Leaky implementation

Automated Process “GI: Magic Sauce”

Leak-reduced implementation

A Computer Program



Instruction 1

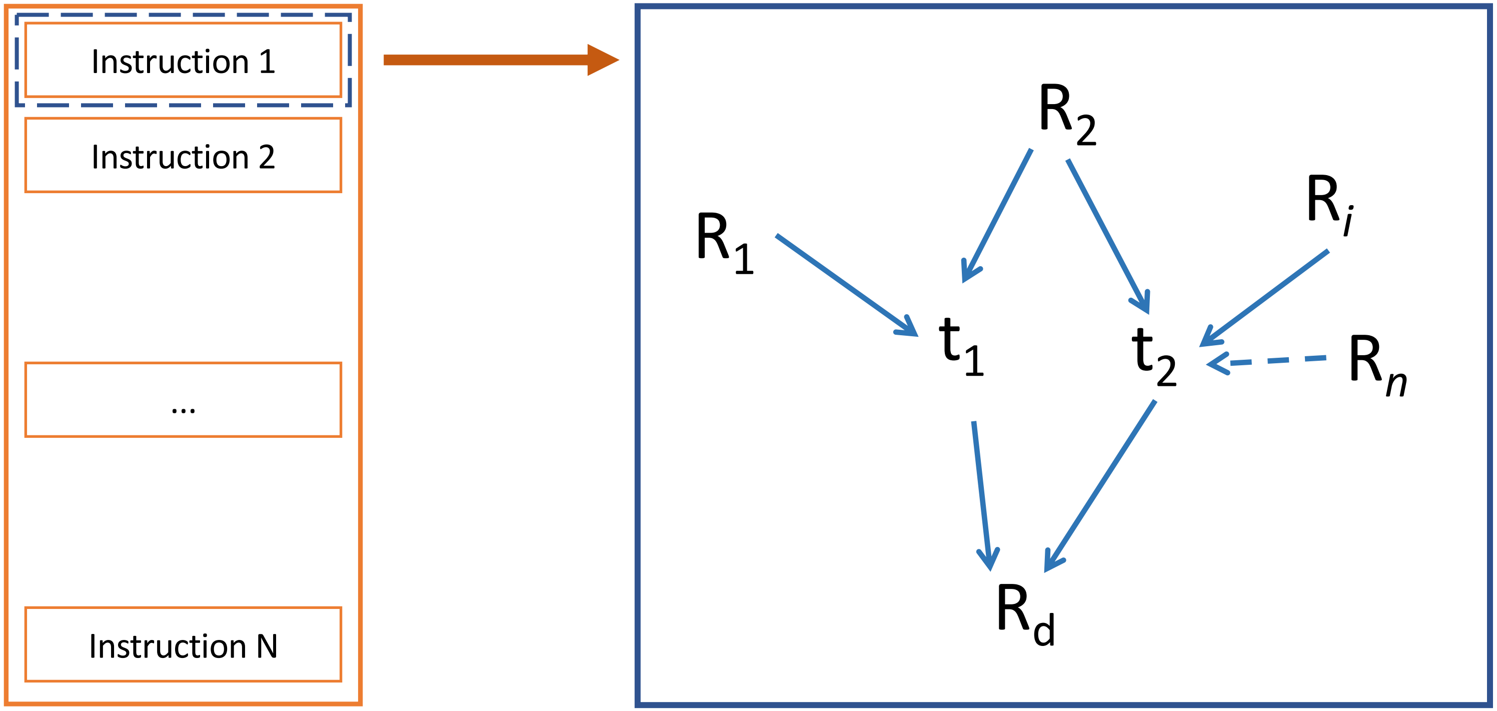
Instruction 2

...

Instruction N

Execution

An Instruction



Instruction 1

Instruction 2

...

Instruction N

R_2

R_1

R_i

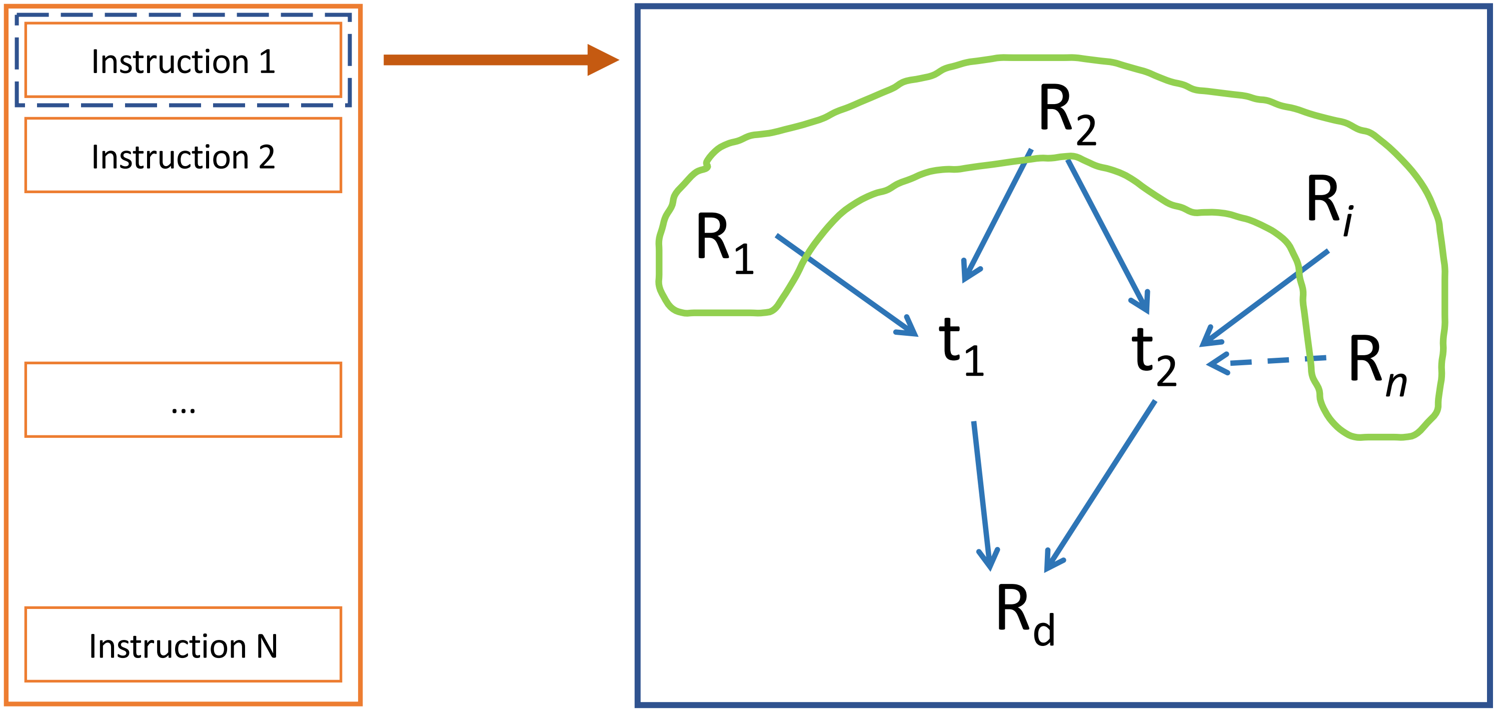
t_1

t_2

R_n

R_d

An Instruction



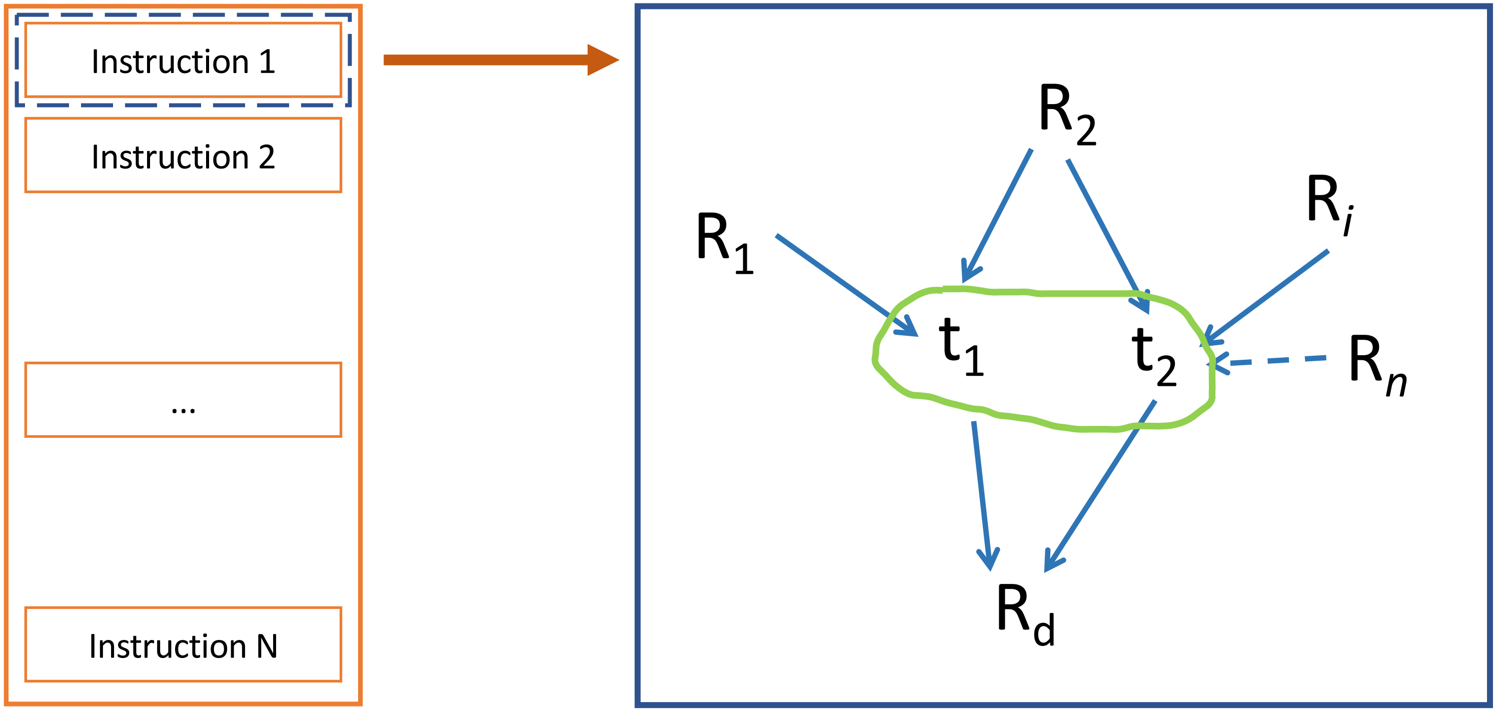
Instruction 1

Instruction 2

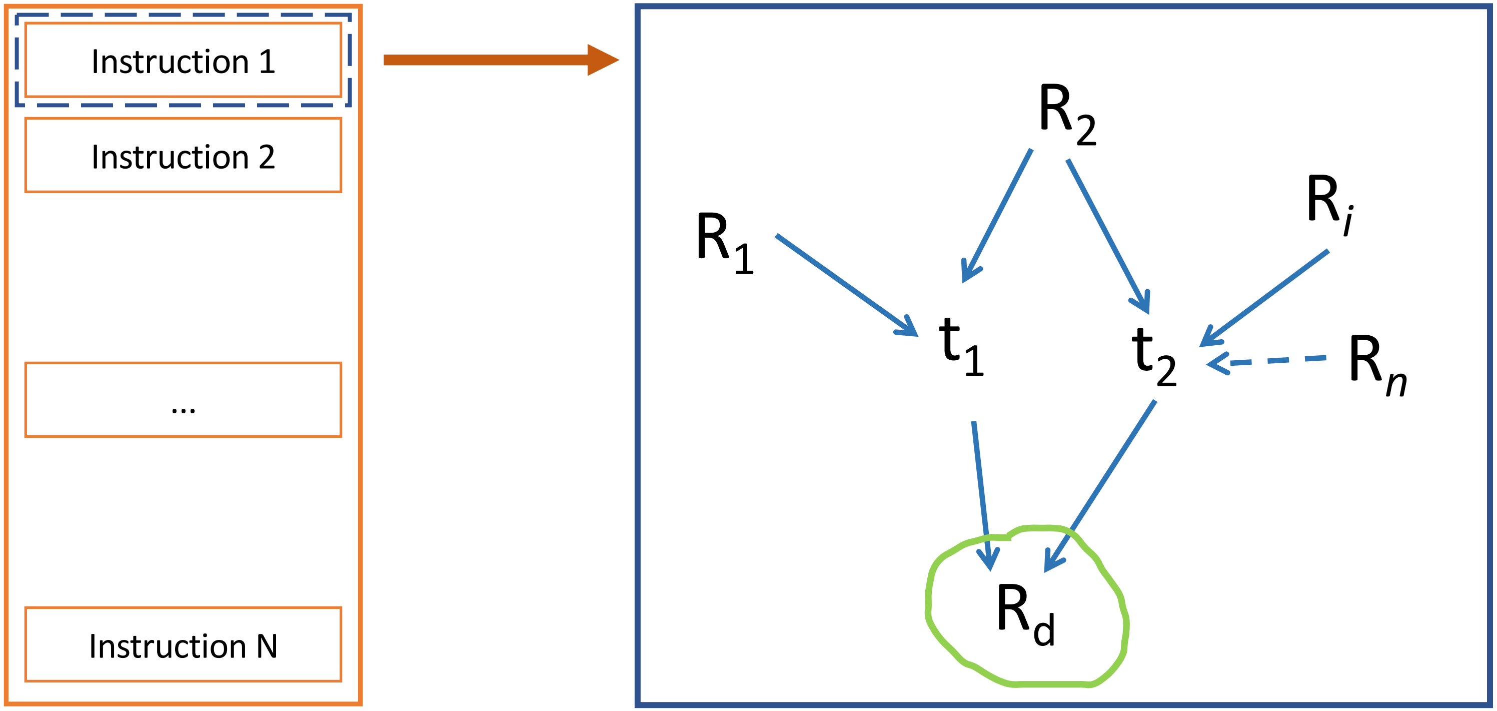
…

Instruction N

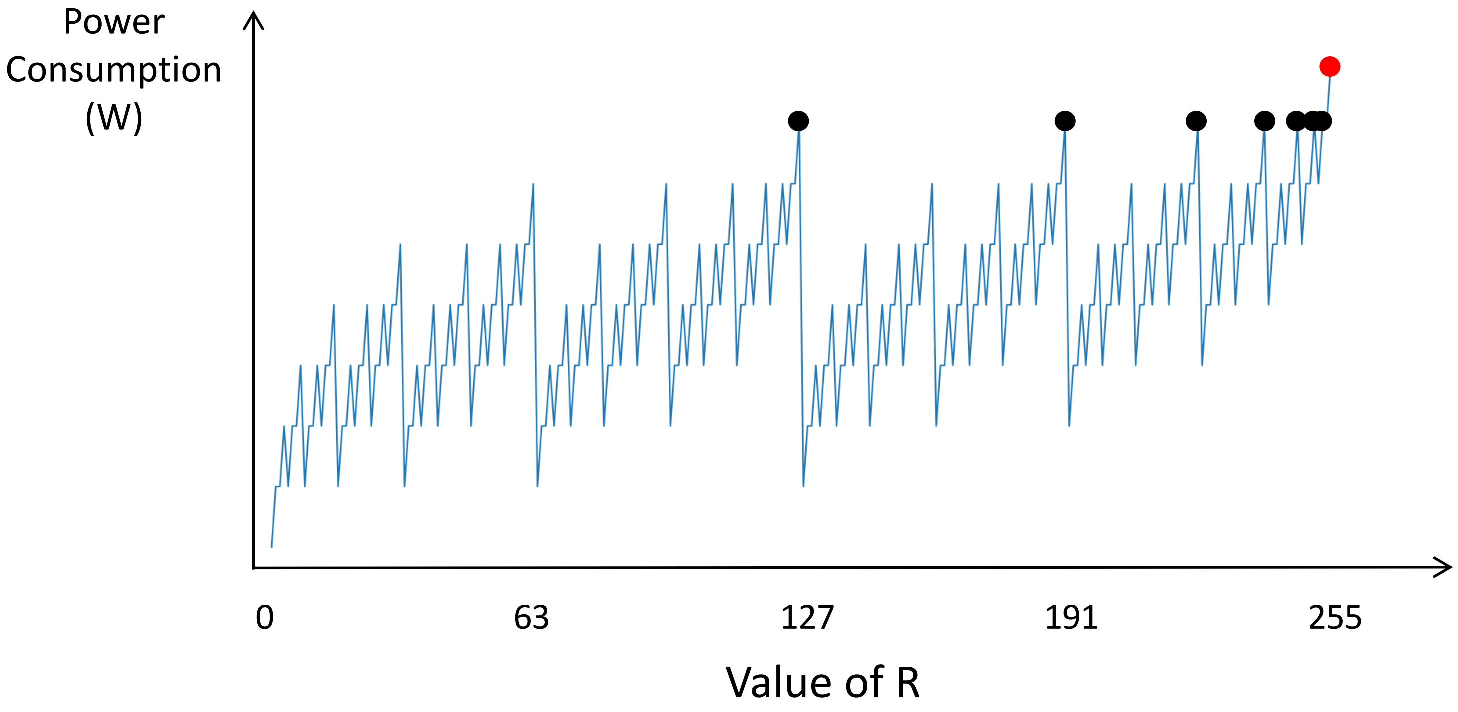
An Instruction



An Instruction

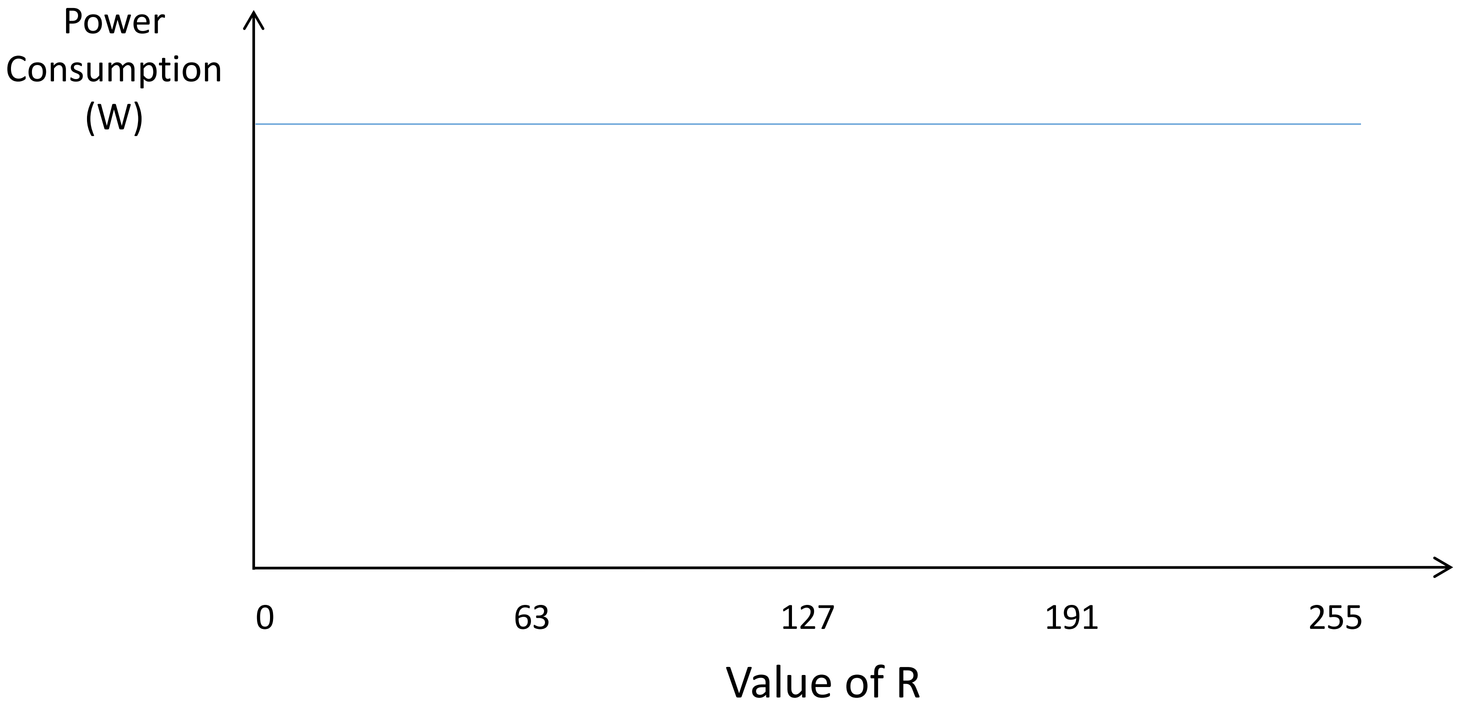


Power consumption of a register



Typical: the power depends on the Hamming weight of the value

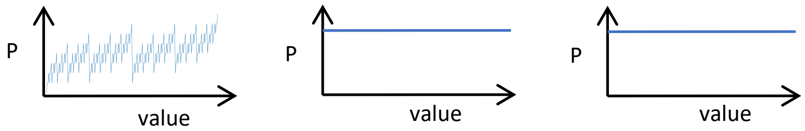
Power consumption of a register - Ideally



Note: the line is horizontal to indicate the average over many repetitions

Masking

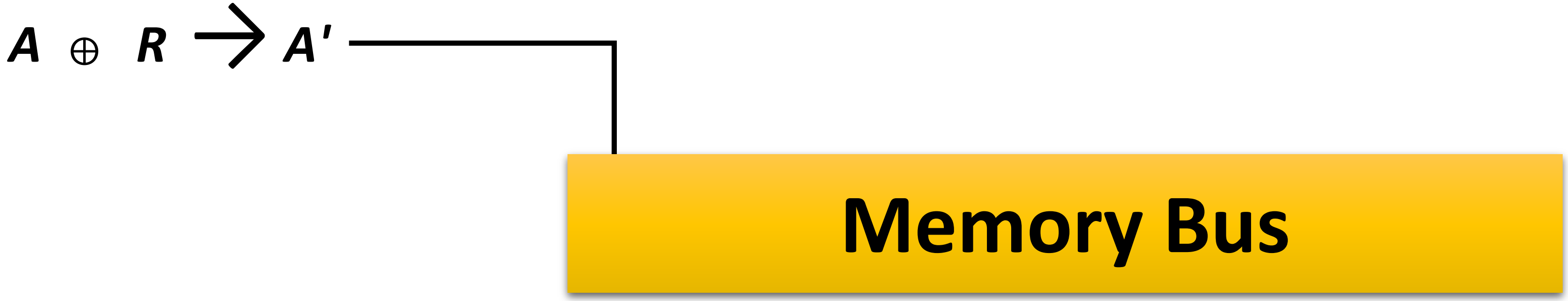
Value ⊕ ***R*** → ***Value'***



Note: the lines are horizontal to indicate the average over many repetitions

Intermediate values are independent of key

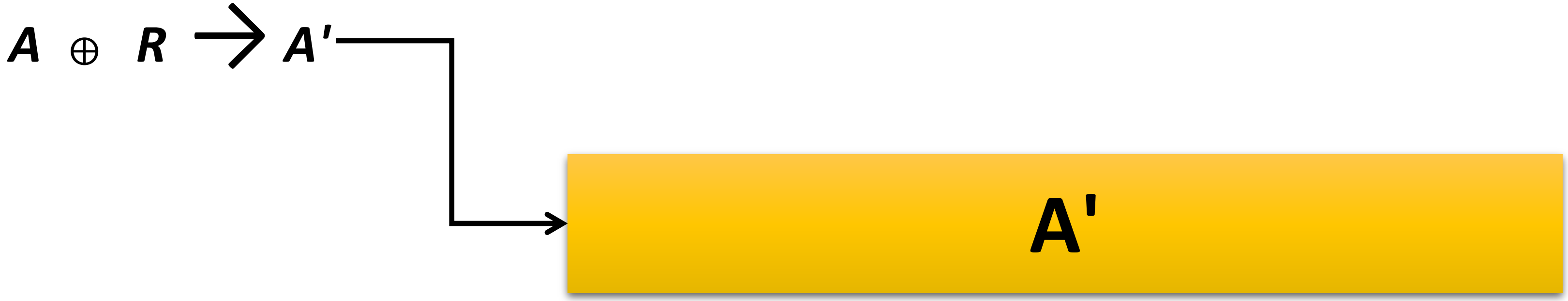
Is masking alone sufficient?



$A \oplus R \rightarrow A'$

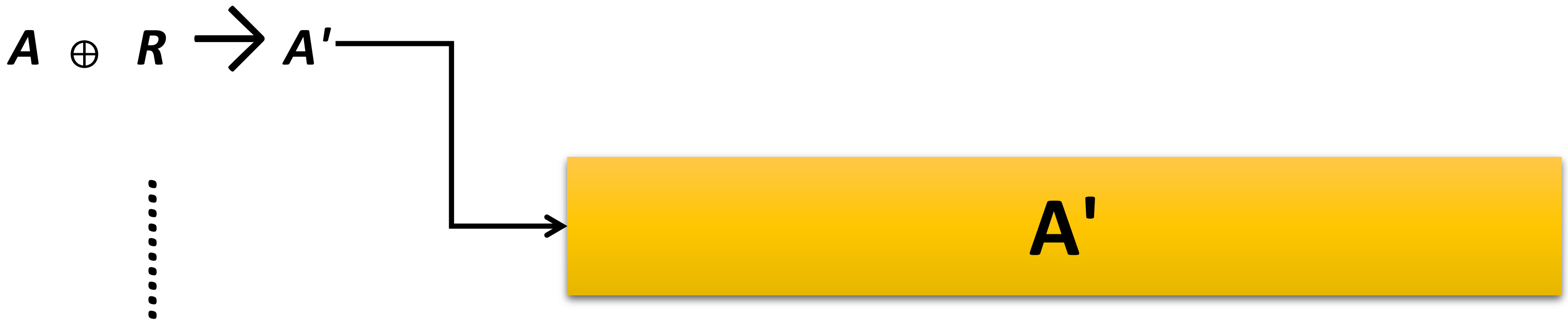
Memory Bus

Is masking alone sufficient?



$A \oplus R \rightarrow A'$

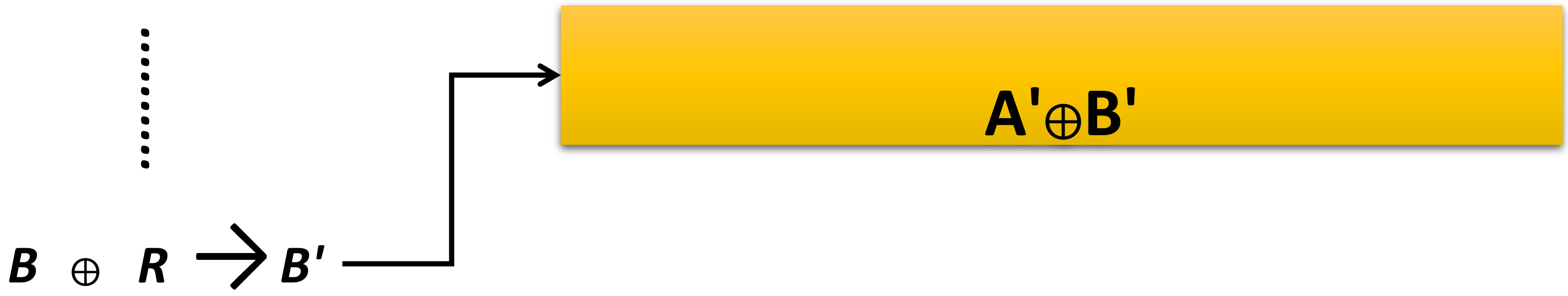
Is masking alone sufficient?



$A \oplus R \rightarrow A'$

A'

Is masking alone sufficient?



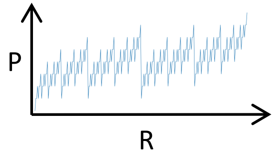
$B \oplus R \rightarrow B'$

$A' \oplus B'$

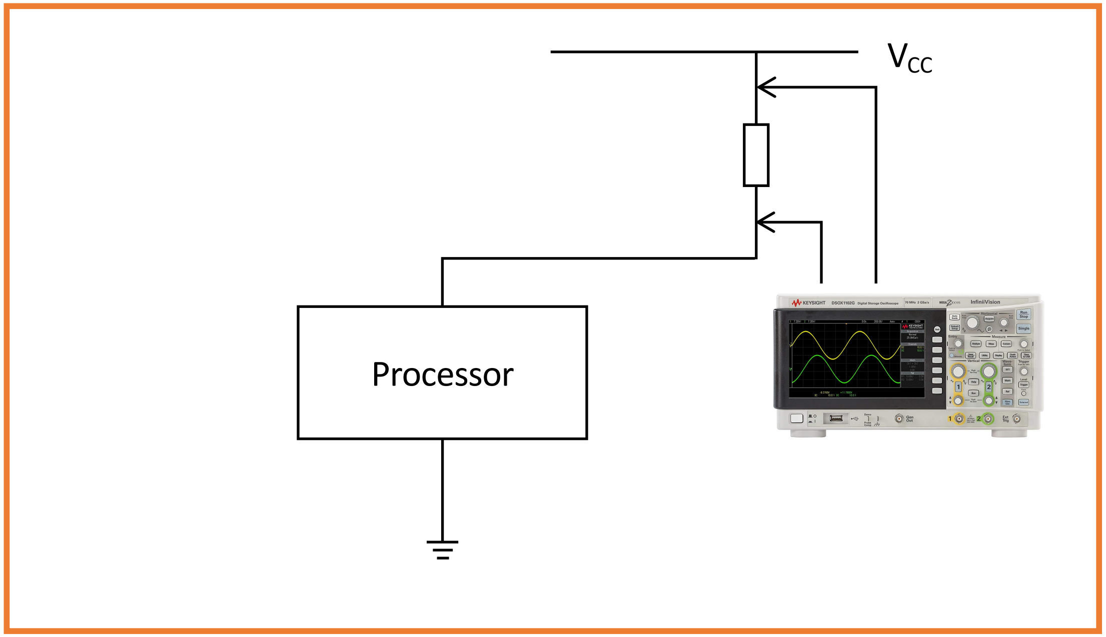
Is masking alone sufficient?

$A' \oplus B' = (A' \oplus R) \oplus (B' \oplus R) = A \oplus B$

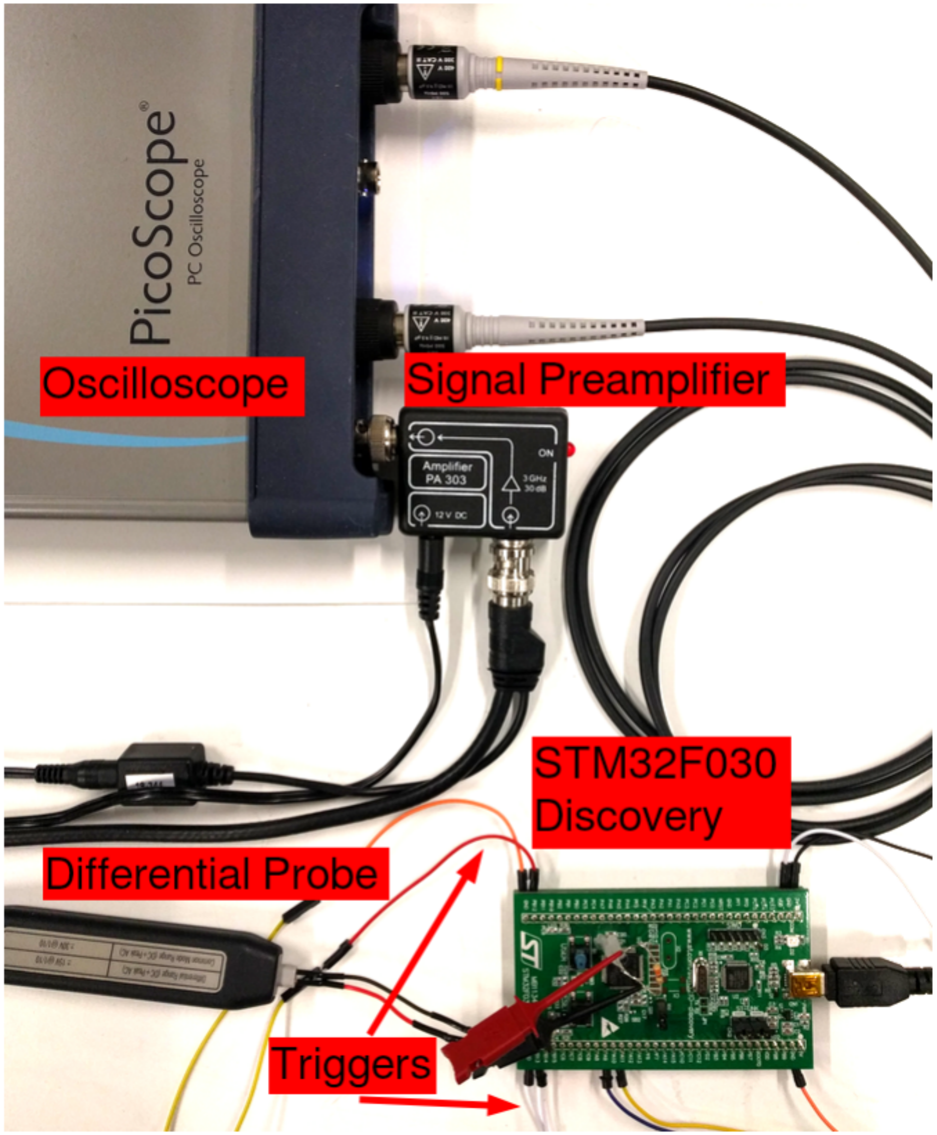
$B \oplus R \rightarrow B'$



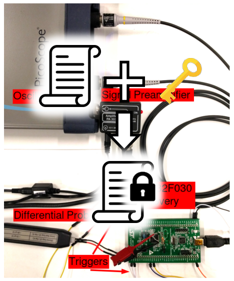
Measuring Power Consumption



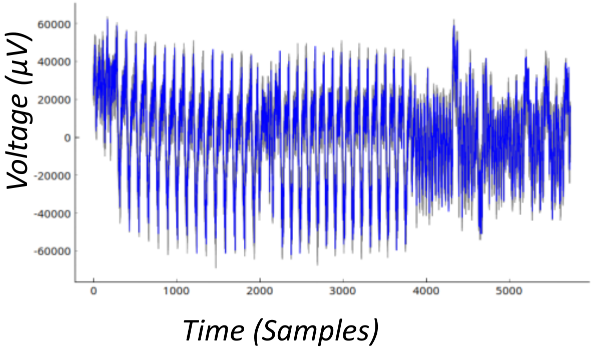
Experimental setup



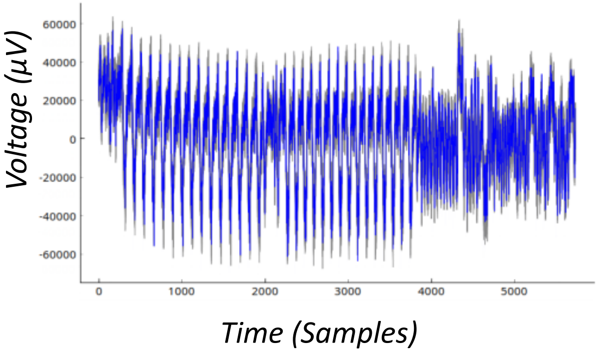
Evaluation - Test Vector Leakage Assessment (TVLA)



Test A - Fixed Input

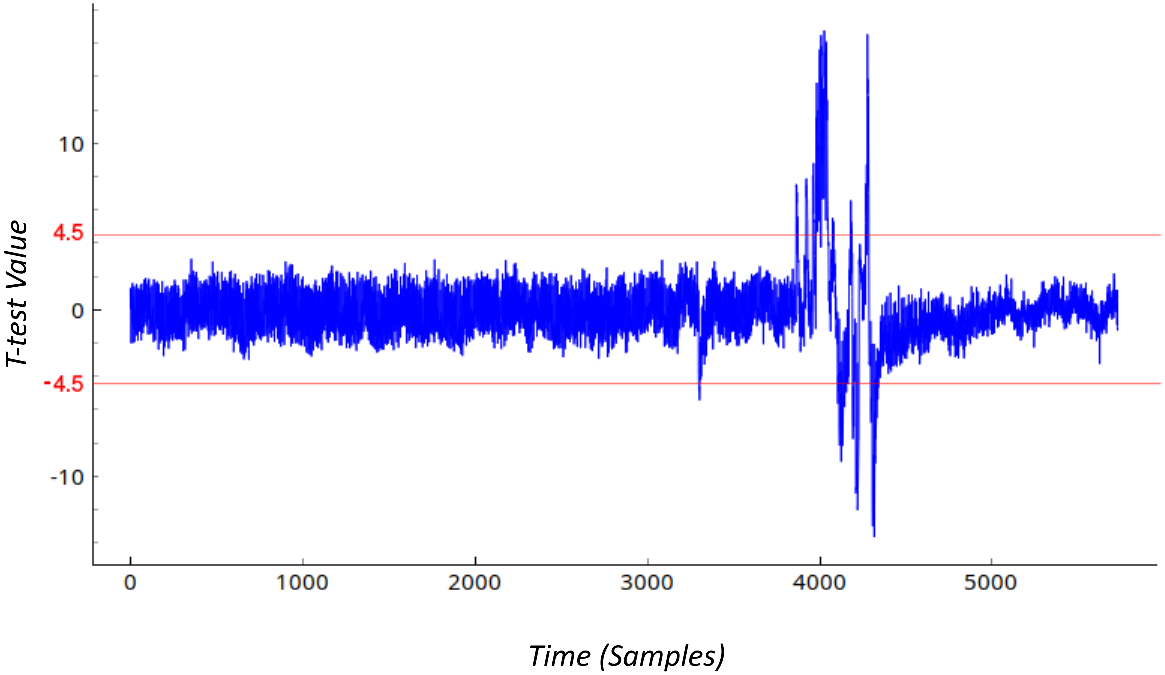


Test B - Random Input

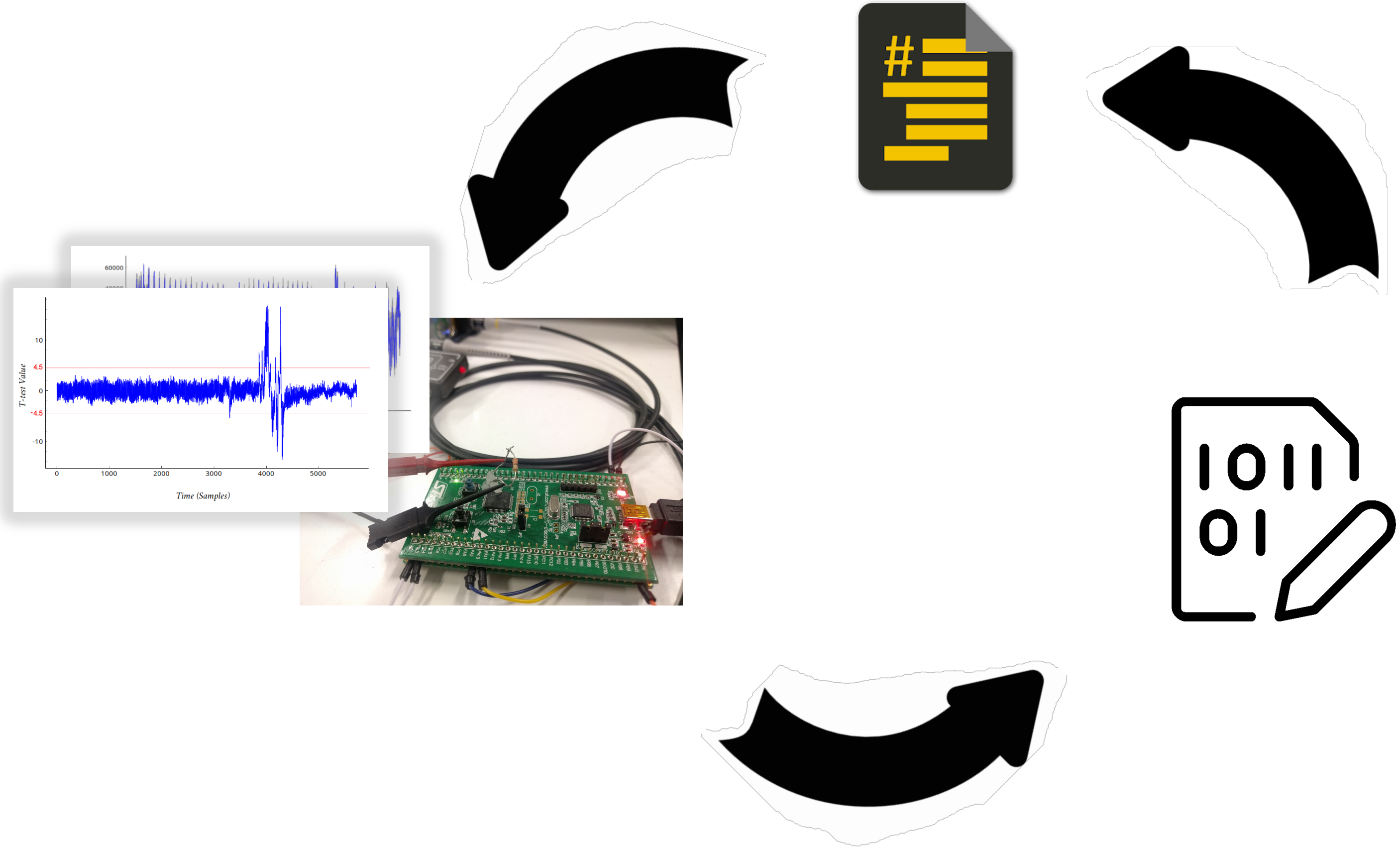


Can you spot the major difference at 4000-4500 samples?

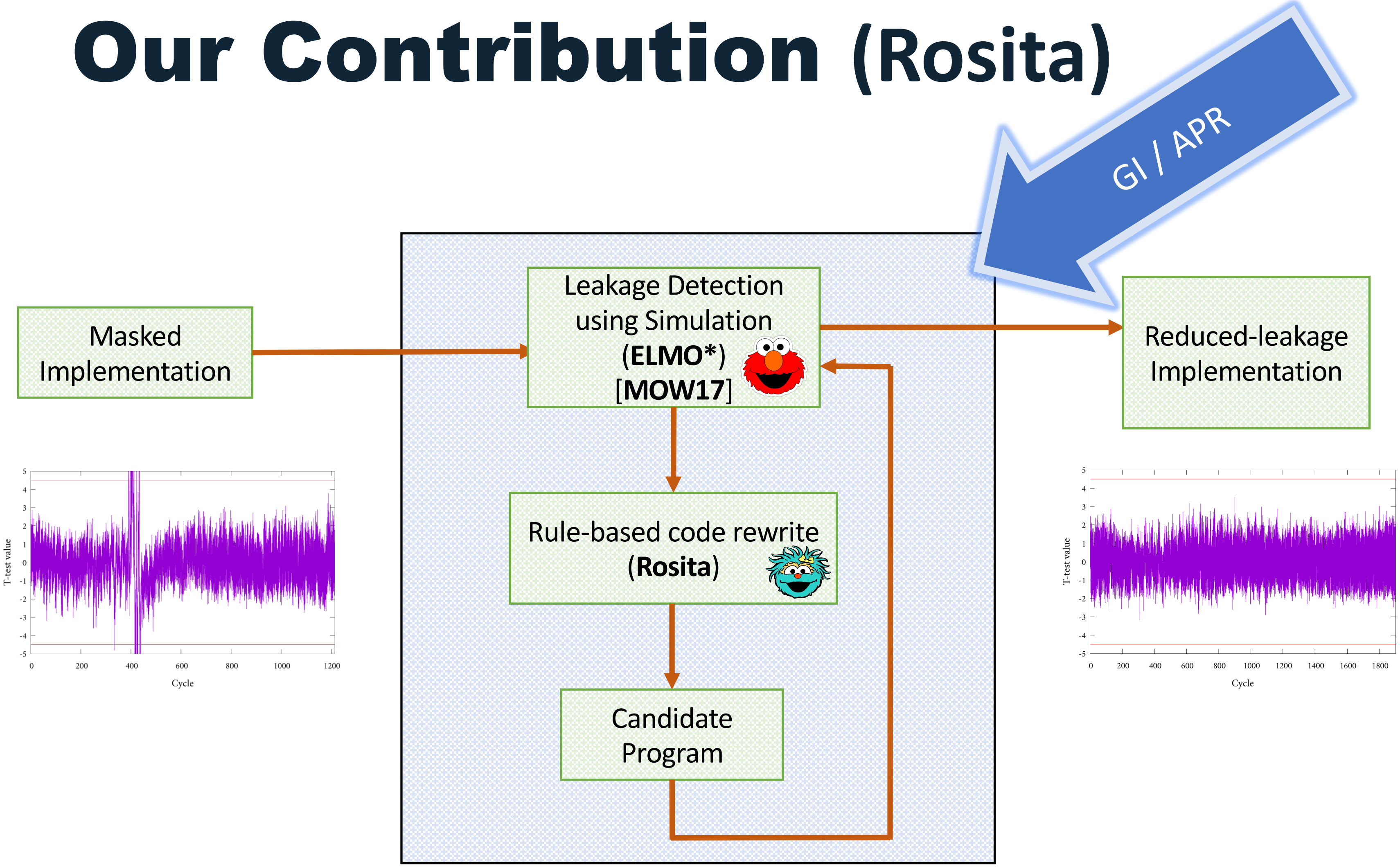
Evaluation - Test Vector Leakage Assessment (TVLA)



Applying Countermeasures (industry standard)



Our Contribution (Rosita)



GI / APR

Masked Implementation

Leakage Detection using Simulation (**ELMO***) [**MOW17**]

Rule-based code rewrite (**Rosita**)

Candidate Program

Reduced-leakage Implementation

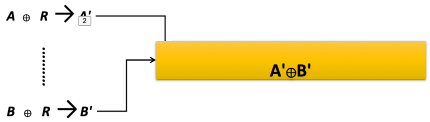
Rule-based code rewrite

At the moment: highly problem-specific.

But to begin with: when to apply which rule? → We have extended the simulator to tell us where the leak occurs and due to which interaction.

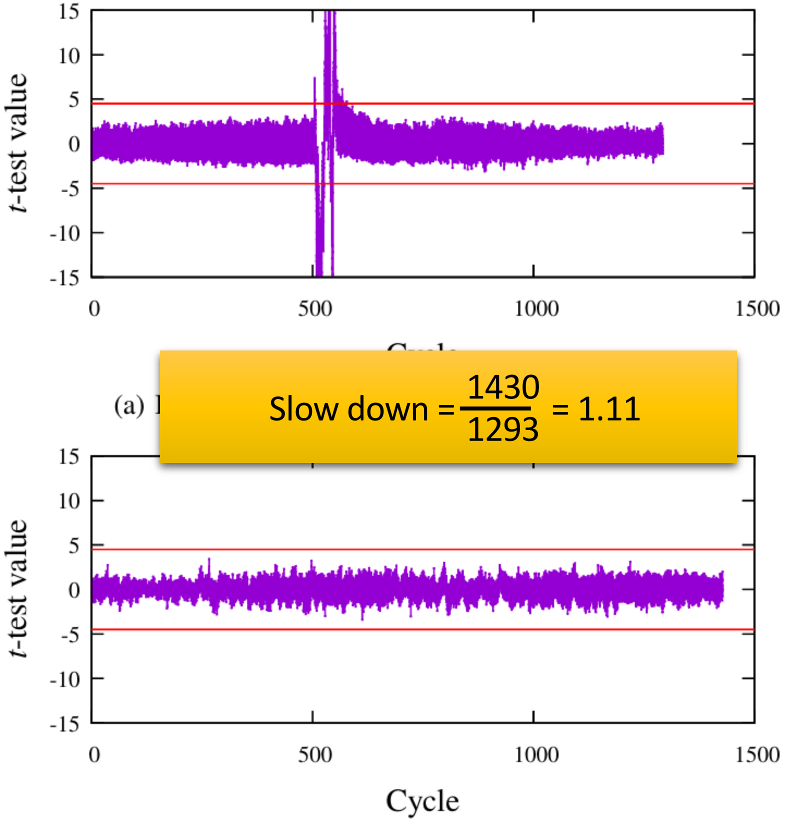
Rules (very different from the GI-usual *swap/copy/delete* operators):

1. Operand interaction via the bus → `movs r7, r7` (we initialised the register r7 with a random value and the cipher is not allowed to use it)



2. Register reuse → overwrite the register with a random value first, e.g. `movs r3, r4` leaks → inserts `movs r3, r7` before this leaking instruction
3. Rotations: word masks and partial rotations
4. Memory interaction: complex, requires push/pop and other operations

Results



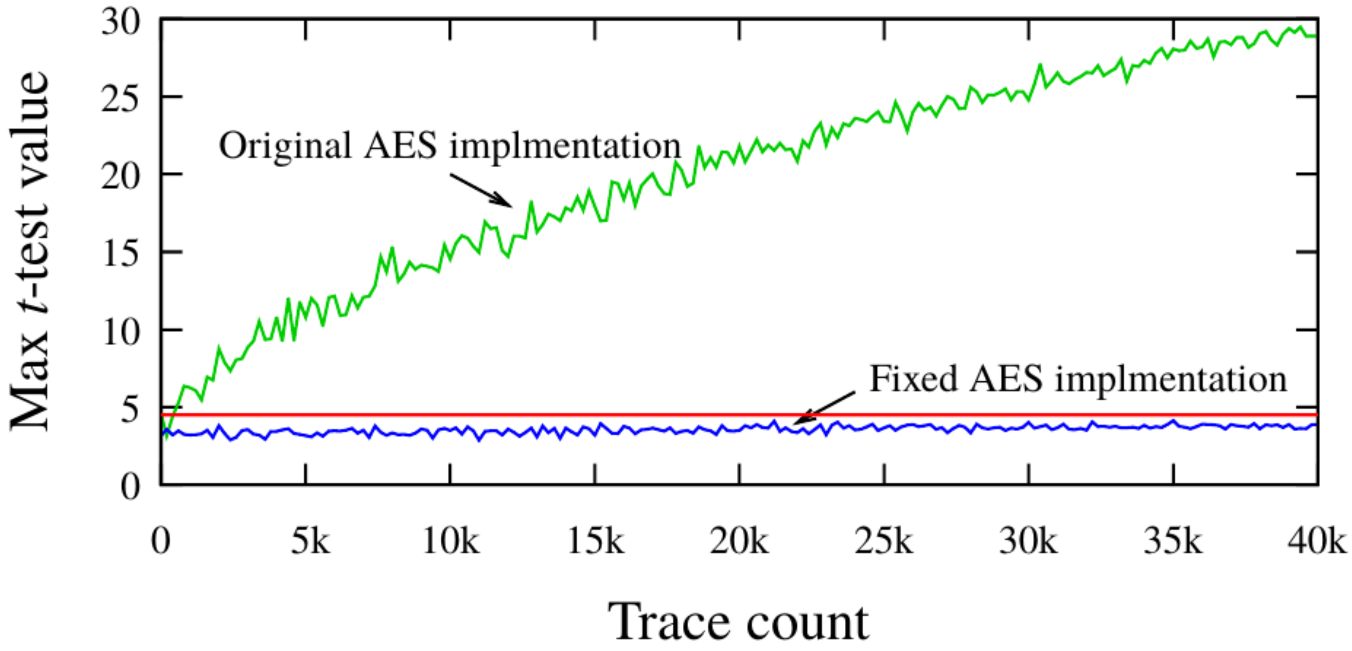
(a) I

$$\text{Slow down} = \frac{1430}{1293} = 1.11$$

(b) After applying code rewrites (1430 cycles)

Part of an AES implementation

Leakage as trace count increases (now: validated on hardware)



ROSITA: Towards Automatic Elimination of Power-Analysis Leakage in Ciphers

https://arxiv.org/abs/1912.05183 (Section 5)

GI to combat side-channel attacks

Project 1/2

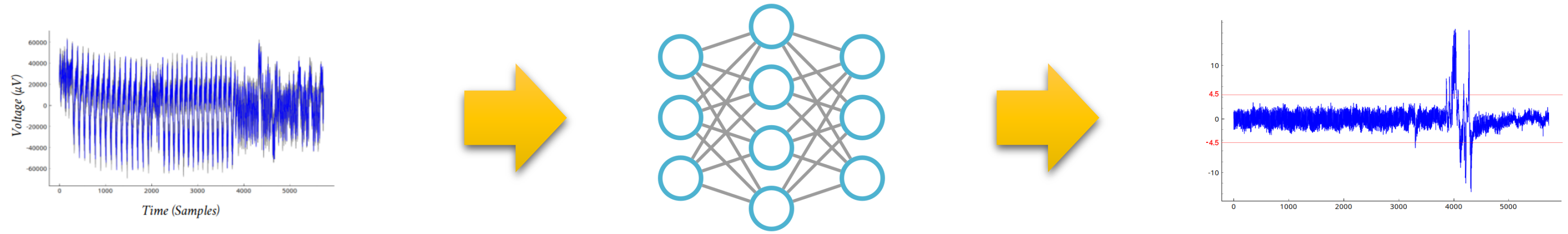
Improve target code performance

Replacement code synthesis

Adapt to multiple architectures

Generalize limitations of code synthesis

Expand ELMO*'s simulation using ML



ROSITA: Towards Automatic Elimination of Power-Analysis Leakage in Ciphers

https://arxiv.org/abs/1912.05183 (Section 5)

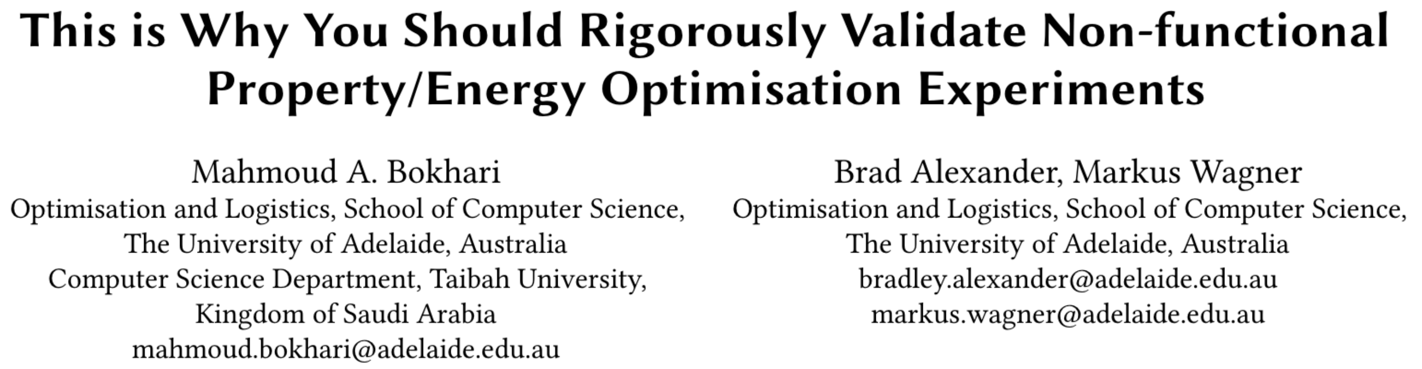
GI to combat the energy hunger of apps

Project 2/2

What to do so that you can use GI to combat the energy hunger of apps

Project 2/2

What to do so that you can use GI to combat the energy hunger of apps and how to make sure that your results hold up



This is Why You Should Rigorously Validate Non-functional Property/Energy Optimisation Experiments

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markus.wagner@adelaide.edu.au

To be submitted…

Why optimise the energy-consumption of apps?

Number of smartphone users >3 billion

Users expect

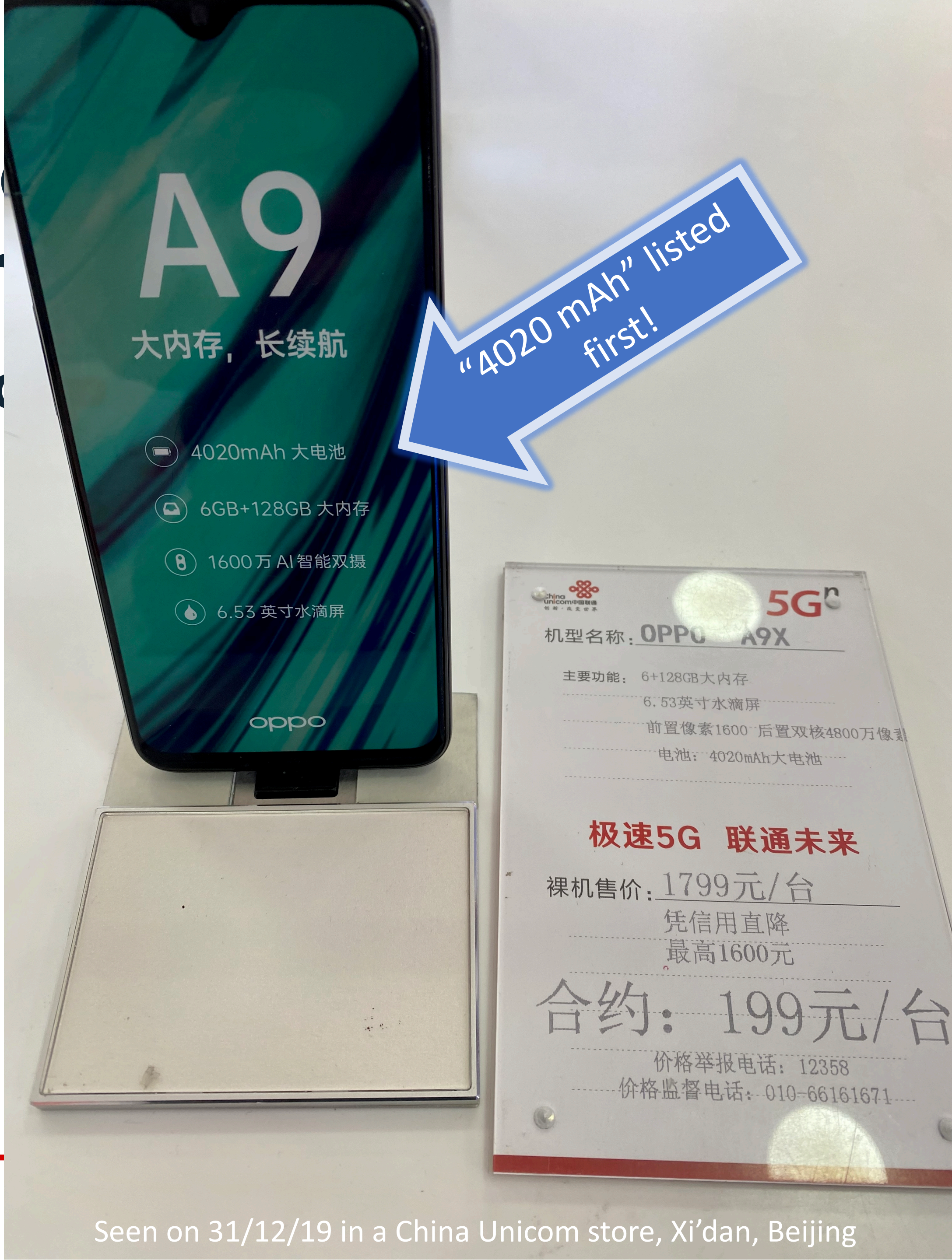
VS

Reality

Why optimis
consumption

Number of smartpho

Users expect



“4020 mAh” listed first!

Seen on 31/12/19 in a China Unicom store, Xi’dan, Beijing

Challenges for developers

Typical challenges

1. Developers lack understanding of the energy consumption
2. Different strategies for mobile devices and PCs
3. Balancing the trade-off between energy and performance for designers

Bonus challenges

1. Internal vs external sensors (noise)
2. Temperature sensitivity (noise)
3. Android debug bridge
4. An OS that keeps developing (read: it’s fighting us) + (noise)
5. Models are incomplete and quickly outdat
6. … more noise.

I envy those of you who work in a noise-free environment!

Challenges for developers

Typic

1. rgy

2. l PCs
3. nd

Bonu

1.
2.
3.
4. hting us) +

5.
6.

Why all this lamenting?

Our observations and conjectures:

- There is little knowledge distributed across different domains on how to deal with these problems in isolation (read: one paper observing/mentioning/dealing with one aspect at a time, making it difficult to get a general overview)
- People avoid super-noisy problems.
- Phones 5 years ago were more deterministic platforms than they are now… and it's just going to get a lot worse still (read: devices get more complex/efficient/dynamic/…)

f you who work in a
vironment!

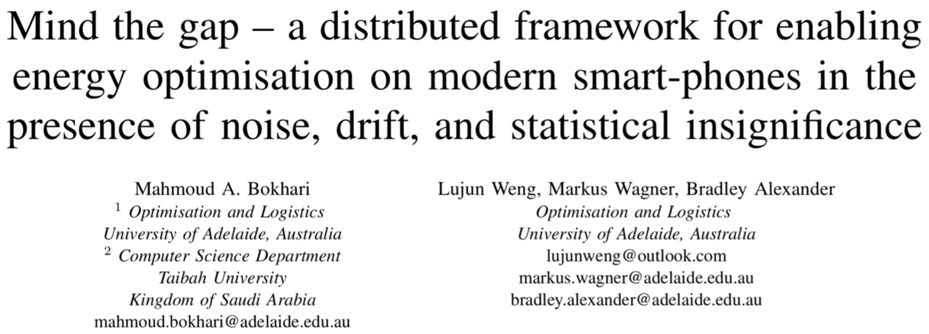
noise-f

How do we validate our experimental results?

aka

How to know that your claims will hold up?

Fragmented Ecosystems



Mind the gap – a distributed framework for enabling energy optimisation on modern smart-phones in the presence of noise, drift, and statistical insignificance

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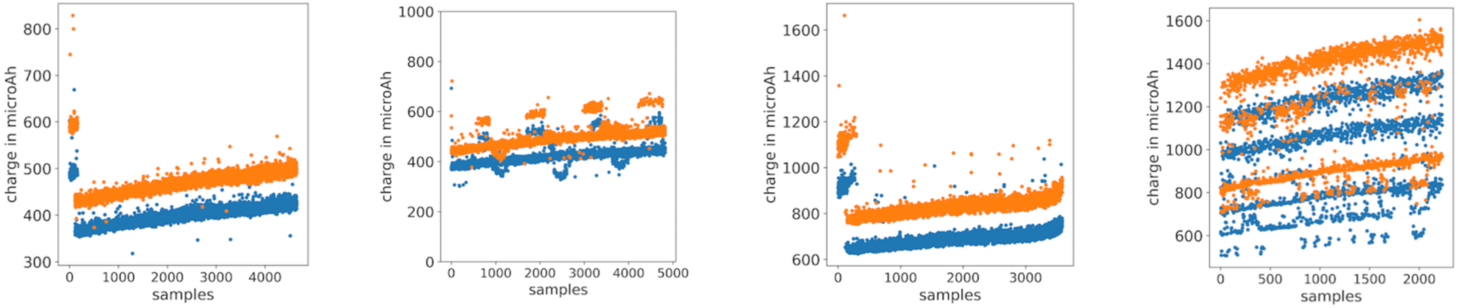
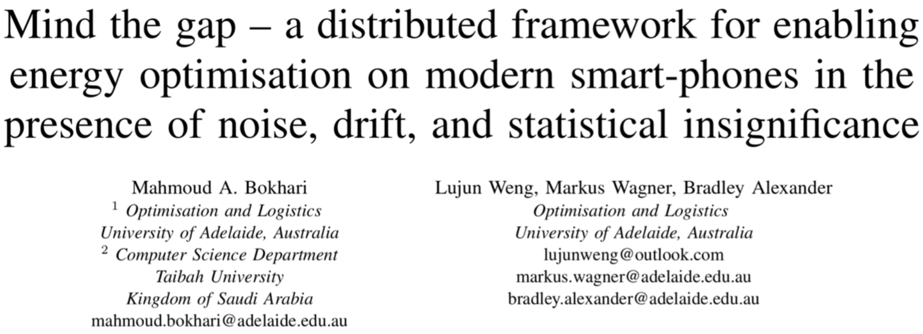
Below: four different phone-OS combinations, orange/blue are two different test loads (but identical across all samples):



Fragmented Ecosystems



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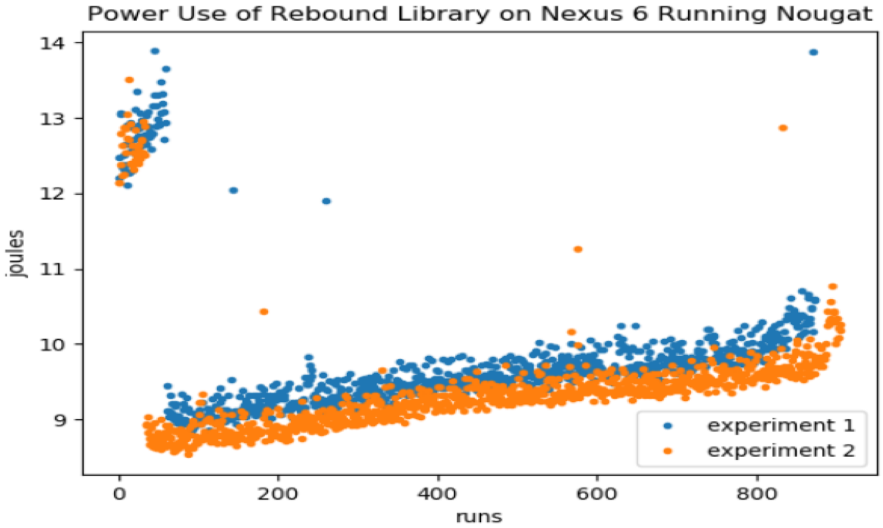
bradley.alexander@adelaide.edu.au

Wait, it is even worse !!!

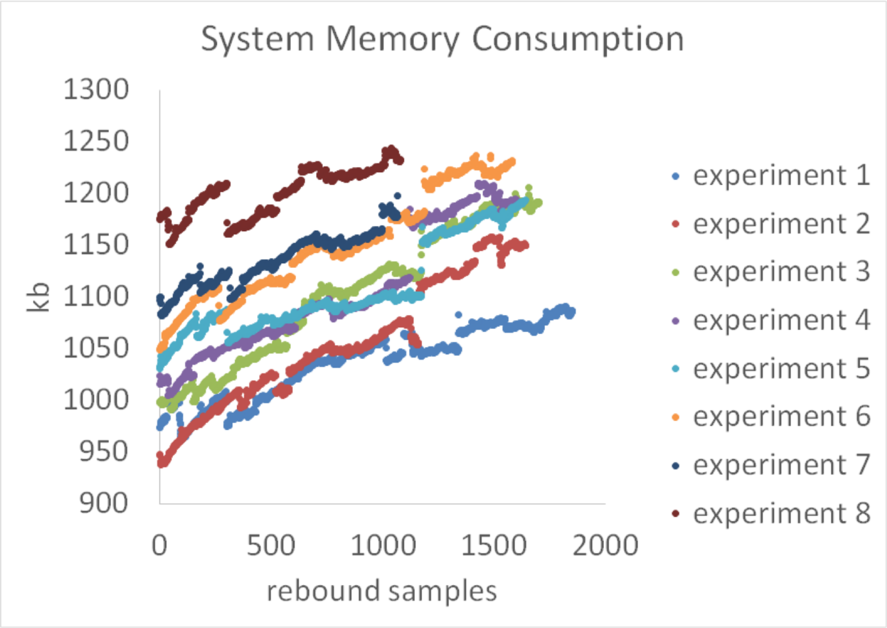
~~Fragmented Ecosystems~~
Same Ecosystem Same Variant

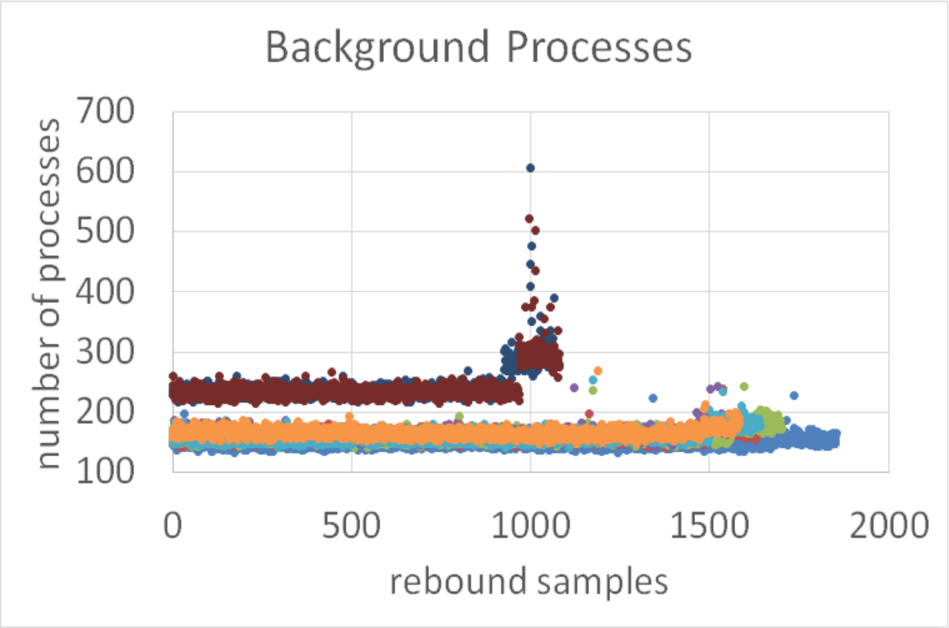


Uploaded by: Mike Dancy @ Youtube

Individual runs of Rebound library (original configuration) in two experiments. The device was rebooted and recharged between the two experiments

Issue: System States



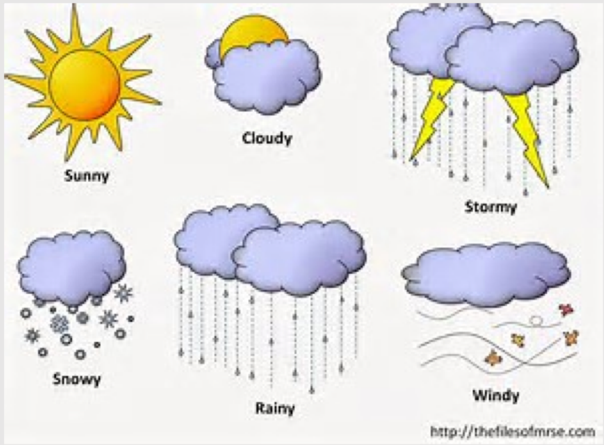


Solution

Be fair and square

Solution

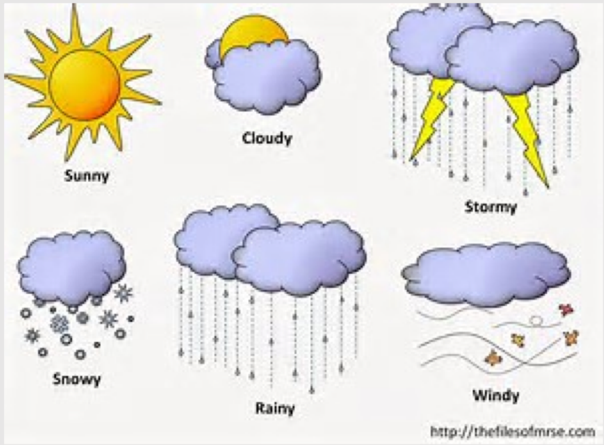
Be fair and square
Run solutions in similar conditions, i.e. system state(s)



Solution

Be fair and square

Run solutions in similar conditions, i.e. system state(s)



Solution

Be fair and ~~squa~~re

Solution

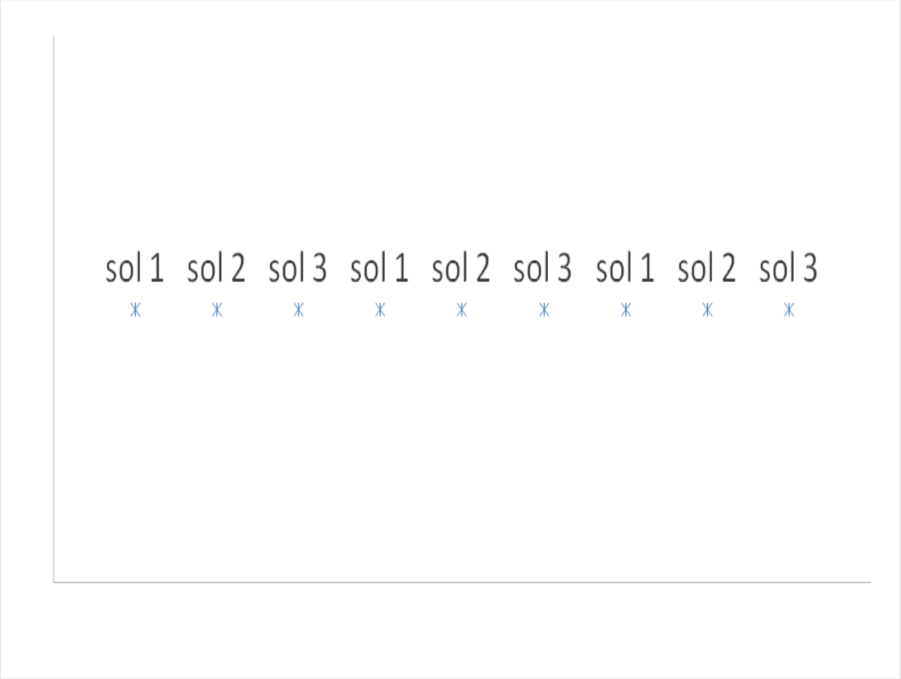
Be fair and round

Solution

Be fair and round
Run solutions in a round robin fashion

Solution

Be fair and round
Run solutions in a round robin fashion
till a termination condition.
e.g.: battery level = 20%, or 10 runs per solution.



Solution

Be fair and round

Run solutions in a round robin fashion
till a termination condition.
e.g.: battery level = 20%, or 10 runs per solution.

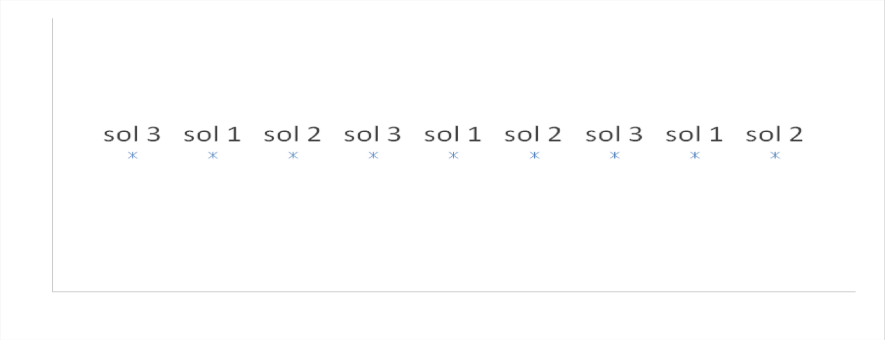
Maintenance: recharge/clean up

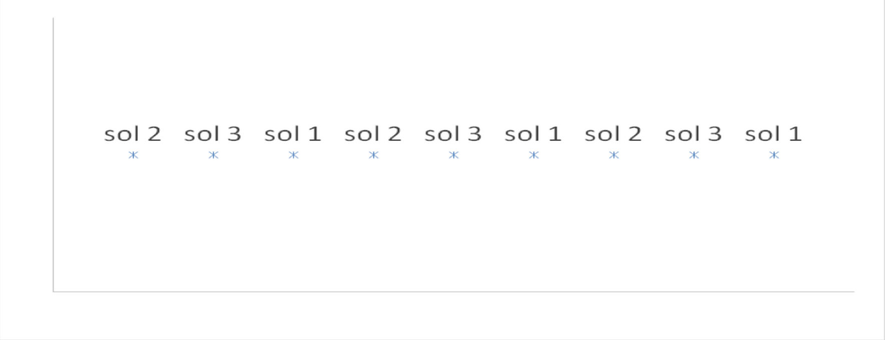
Solution

Be fair and round

Run solutions in a round robin fashion
till a termination condition.
e.g.: battery level = 20%, or 10 runs per solution.
Maintenance: recharge/clean up

Alternate between solution order

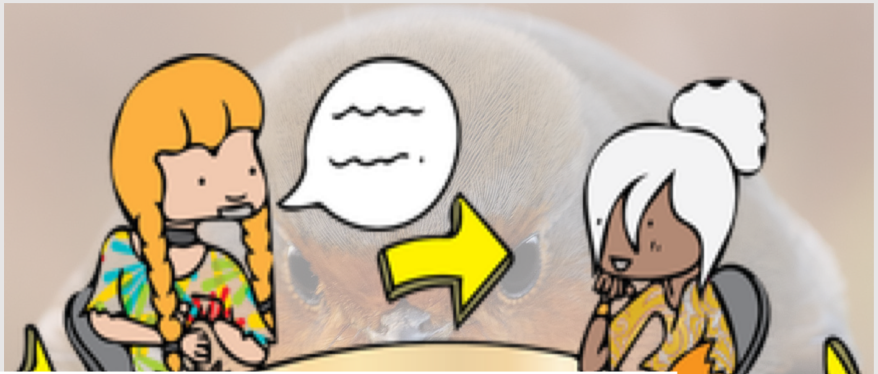


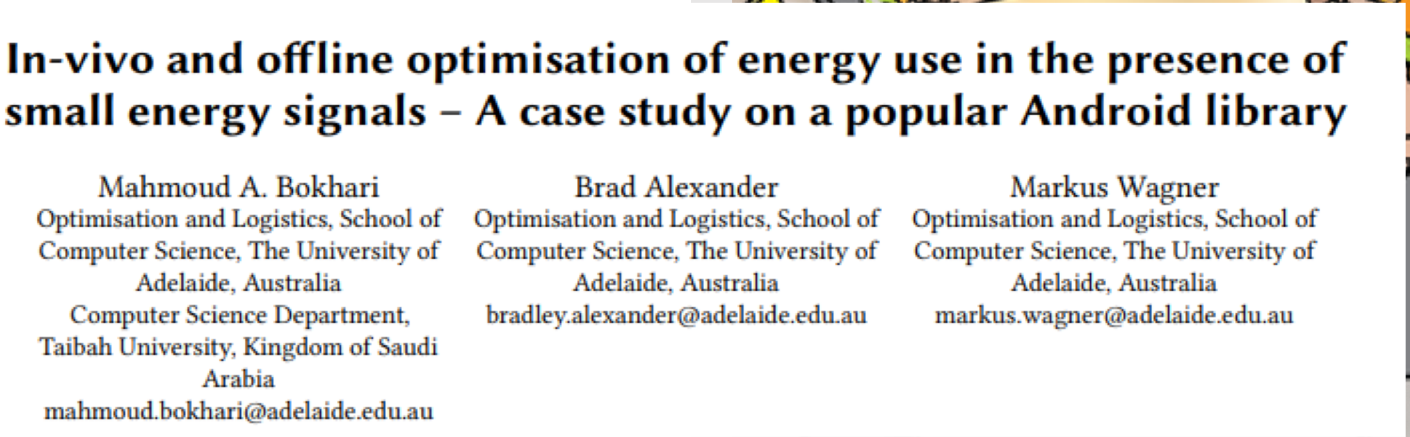


Solution

Be fair and round

Let's try it on





In-vivo and offline optimisation of energy use in the presence of small energy signals – A case study on a popular Android library

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… let's discredit ourselves!

The box contains 13 violins:

- 1 original configuration’s energy consumption
- 12 solutions forming a Pareto front (Mobiquitous’18 paper)

Solution

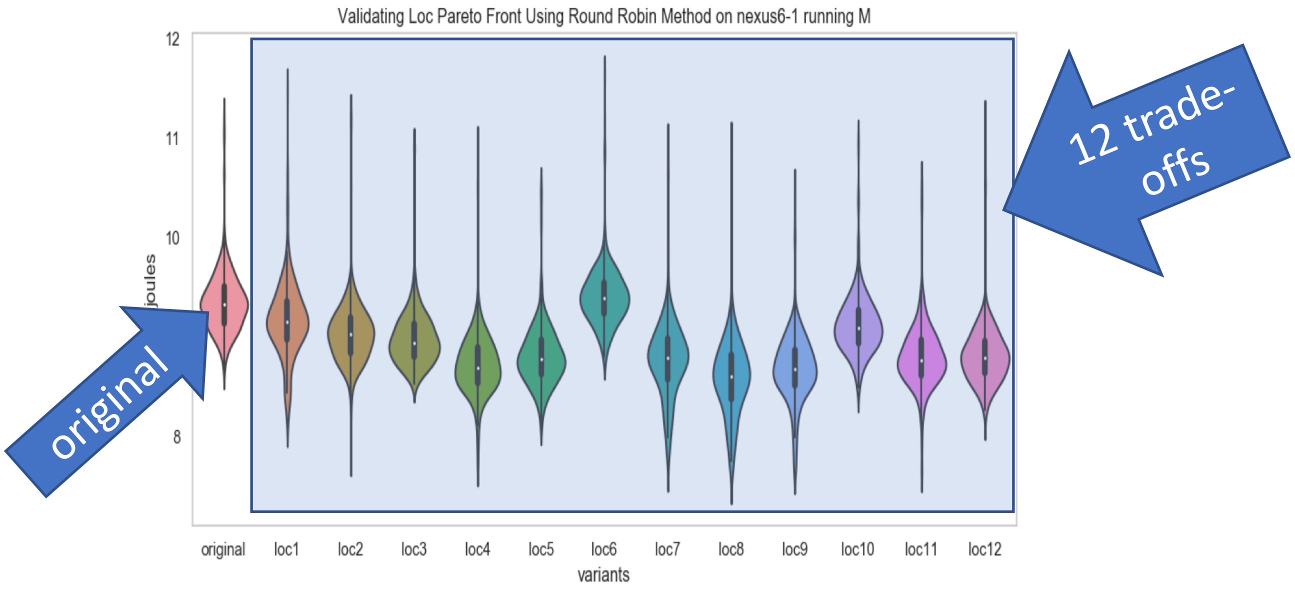
<u>Conventional</u> way: energy results

Expected: violins get lower and lower (as the energy consumption *should* drop)

facebook

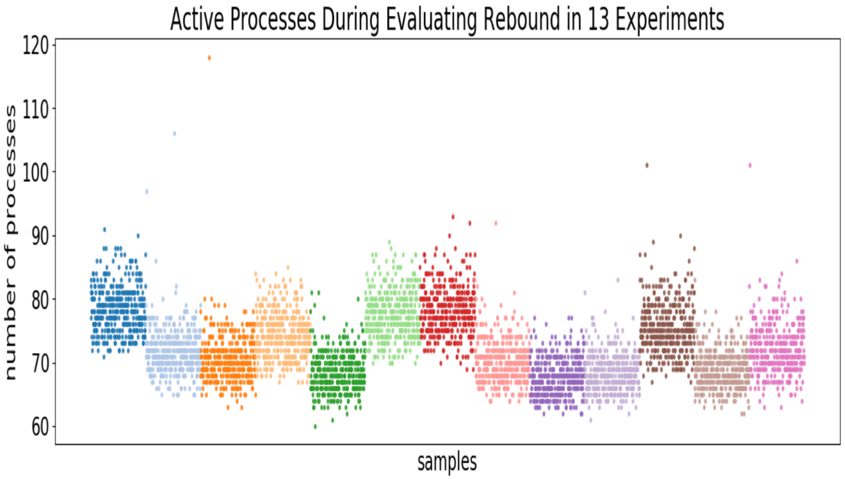
Rebound

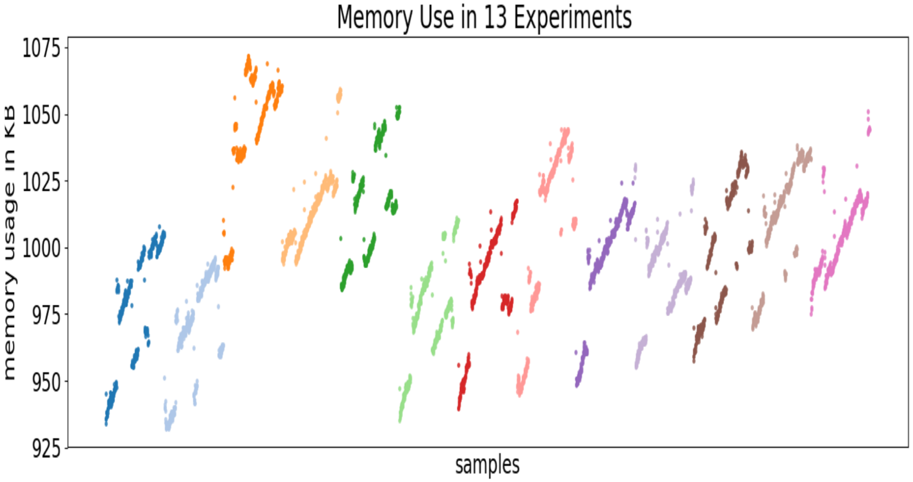
Spring Animations for Android



Solution

Conventional way: system behaviour

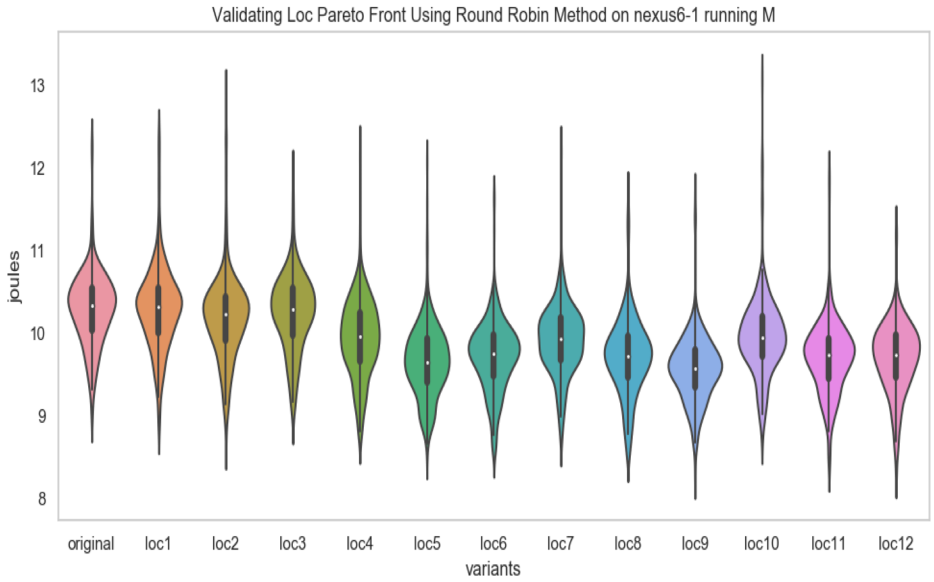




The box contains 13 violins:
- 1 original configuration's energy consumption
- 12 solutions forming a Pareto front (Mobiquitous'18 paper)

Solution

Round Robin + rotate: energy results

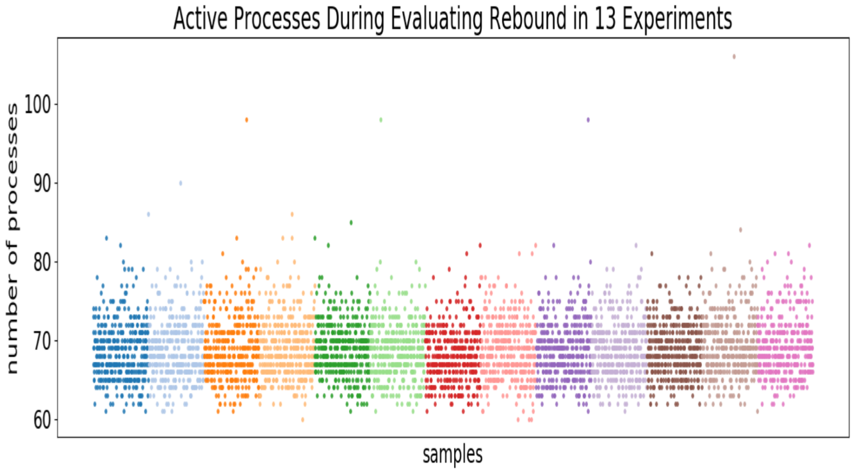


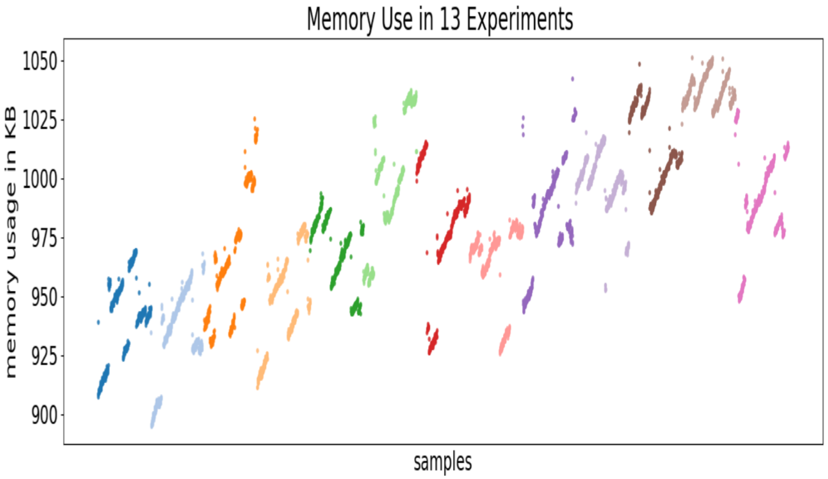
➔ It's not perfect yet, but at least we are trying harder.

Conjecture: maybe the Pareto front contained some dominated solutions after all.
(e.g., purple/loc10 is higher in both setups)

Solution

Round Robin + rotate: system behaviour





...make sure that your results hold up

Project 2/2

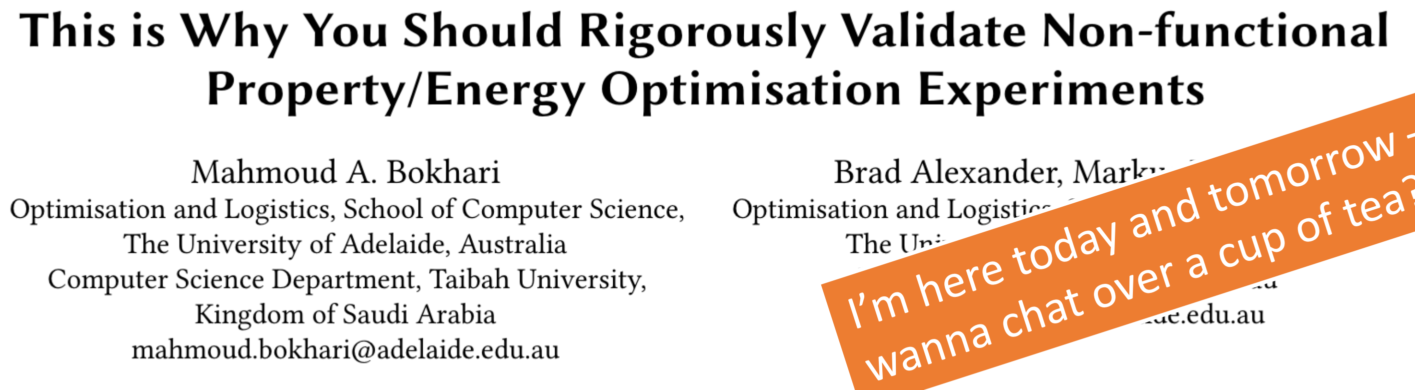
Do you have a noisy system?

Do you have states?

➔ Be fair and ~~square~~
round-robin + rotate your way!

While cute, it's not perfect yet.

Todo: Find cheap, non-intrusive ways to incorporate the system state into the optimisation process.



This is Why You Should Rigorously Validate Non-functional Property/Energy Optimisation Experiments

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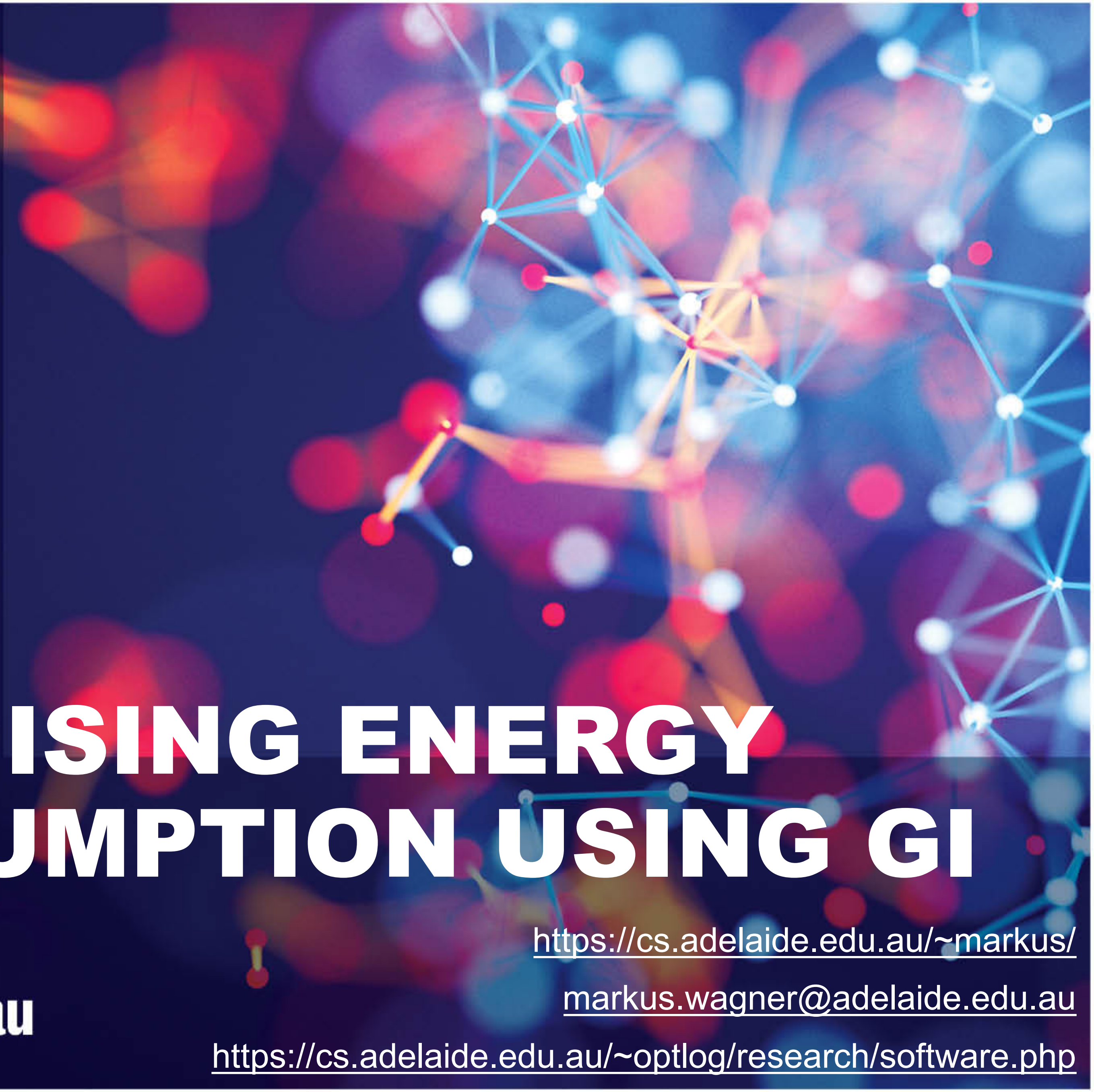
I'm here today and tomorrow –
wanna chat over a cup of tea?

To be
d…



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OPTIMISING ENERGY CONSUMPTION USING GI

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