

Genetic Improvement of Software Efficiency: The Curse of Fitness Estimation

Mahmod A. Bokhari, Markus Wagner and Brad Alexander.

How to measure

Execution time.

1. Test suite time.
 - Test overhead!
2. User time.
3. System time.



Well, this is not complicated!

How to measure

Memory consumption.

1. Overall used/available.
2. Other metrics:
 - Native heap, Dalvik heap, stack ...
 - Pss, dirty, clean swappPss ...

“Pretty much every time I look at memory usage numbers with other engineers, there is always a long discussion about what they actually mean that only results in a vague conclusion.” ~ Android platform developer [1].

Well, this is complicated!

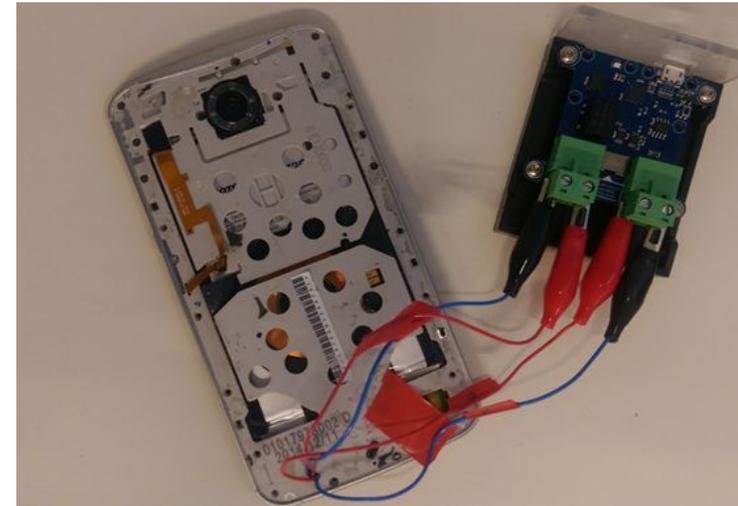
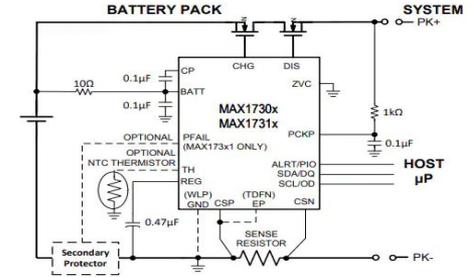


How to measure

Energy.

1. Internal.
2. External.

Well, this seems not too hard.



Do we measure and optimise for only one platform?

Yes: go to end of presentation :)

No, stay alert!

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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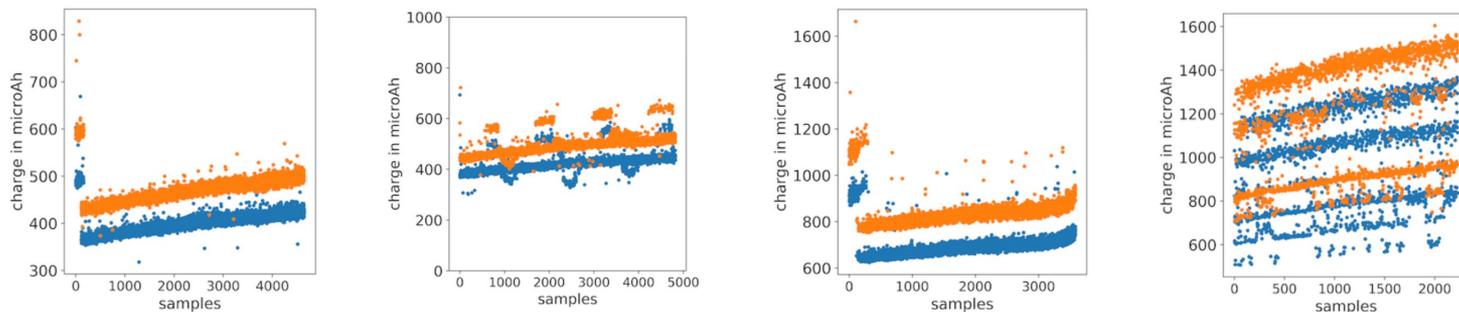
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Below: four different phone-OS combinations, orange/blue are two different test loads (but identical across all samples) [2]:



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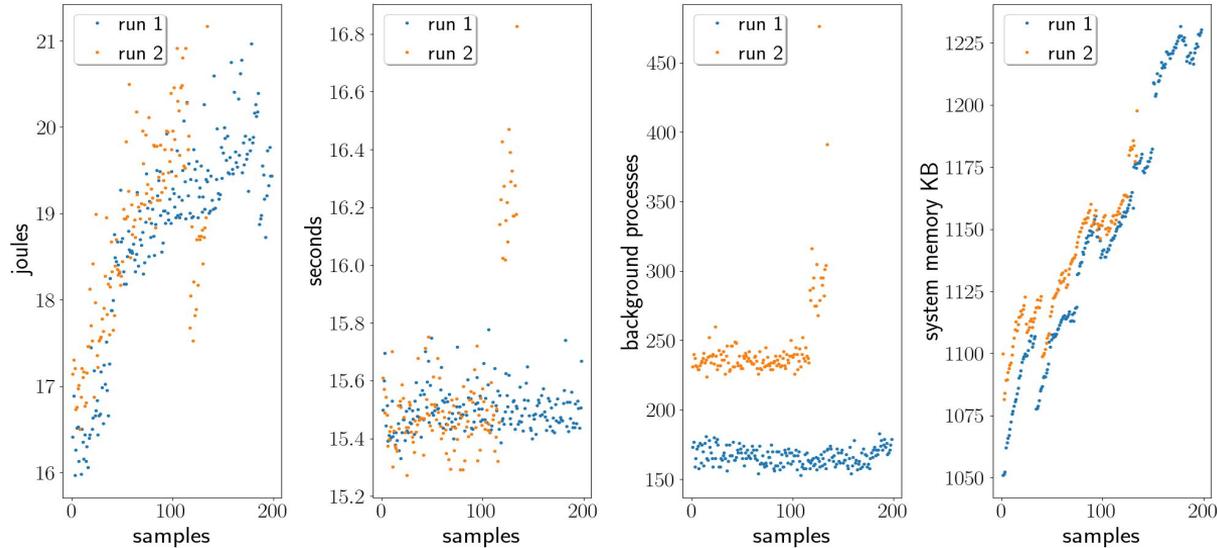


Wait, don't go, it is even worse !!!

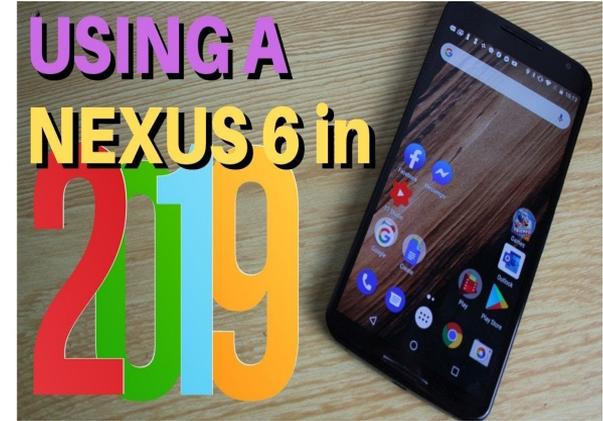


~~Fragmented Ecosystems~~

Same Platform Same Variant



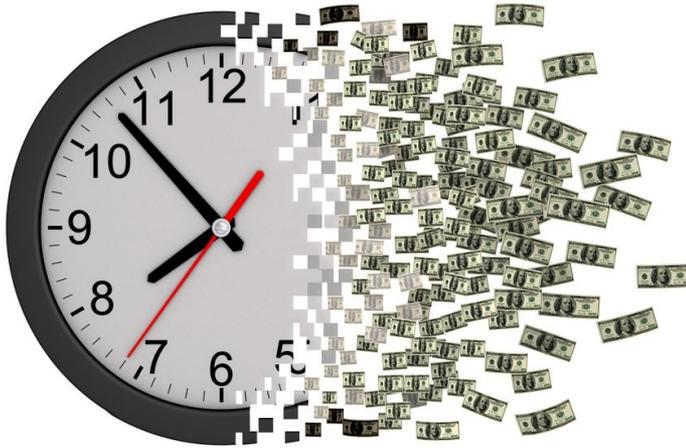
Individual runs of Rebound library (original configuration) in two experiments. The device was rebooted and recharged between the two experiments



Uploaded by: Mike Dancy @ Youtube

How to solve it

1. Run thousands ... millions of trials.



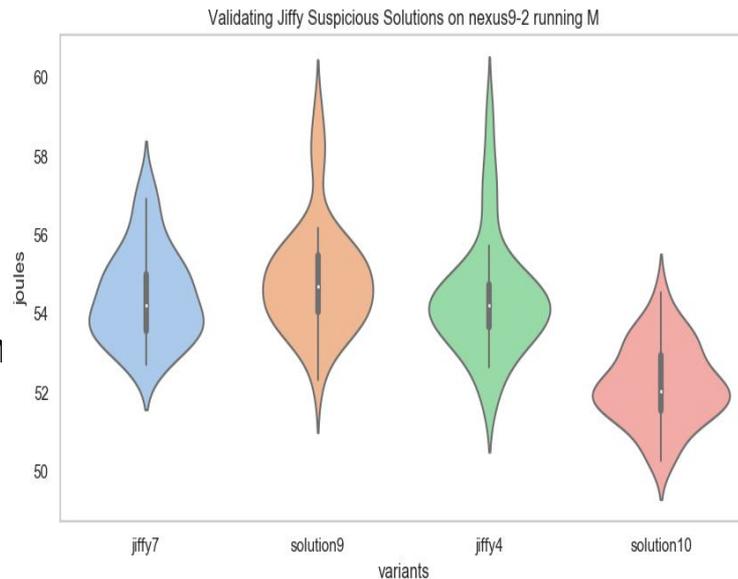
How to solve it

1. Run thousands ... millions of trials.
2. Use simple models or simulators.
 - Generally, describe the system in one variable (cpu utilisation, bytecode, line of code ...).
 - Noise free.
 - Deterministic.

How to solve it

1. Run thousands ... millions of trials.
2. Use simple models or simulator.
 - Traditional ways of data collection.
 - Doesn't capture all system behaviours.
 - Lucky and unlucky generated solutions.
 - Might misguide the search process.
 - One model per device model out of more than 24000 device models.
 - HW non-linear energy usage [3, 4].

Models are only good on what they were trained for.



How to solve it

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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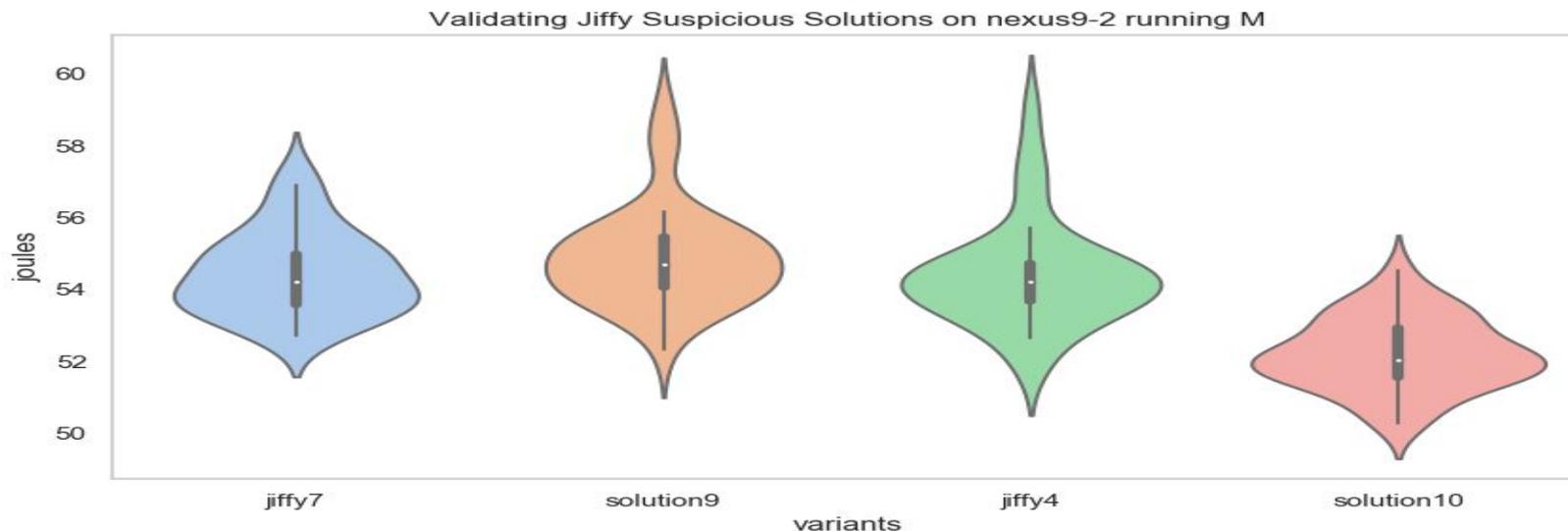
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They are only good on what they were trained for.

How to solve it

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



They are only good on what they were trained for.

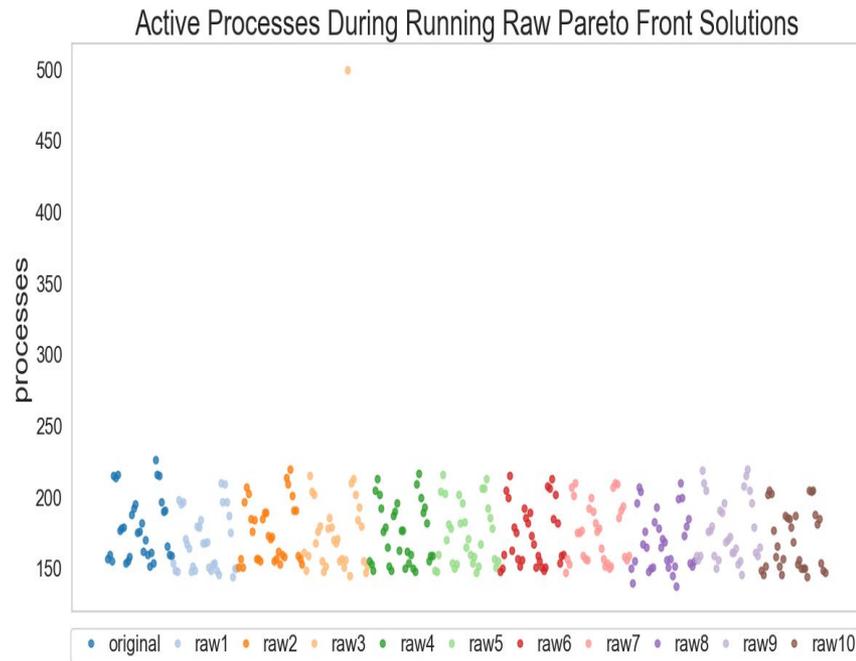
Proposed Solution

- ❑ Data collection.
 - ❑ Considers different system states.
 - ❑ R3-validation approach [6].



Proposed Solution

- ❑ Data collection.
- ❑ ML for GI.
 - ❑ Repeated patterns (background processes).
 - ❑ Voltage variations.
 - ❑ Garbage Collection (GC) impacts.



Proposed Solution

- ❑ Data collection.
- ❑ ML for GI.
 - ❑ Repeated patterns (background processes).
 - ❑ Voltage variations.
 - ❑ Garbage Collection (GC) impacts.
 - ❑
- ❑ ML models + *in-vivo* optimisation (expensive fitness function/surrogate-assisted optimisation [7]).
 - ❑ Adaptive models that get re-calibrated as the optimisation proceeds.
 - ❑ Select representatives of solutions for the *in-vivo* optimisation.
 - ❑ E.g. unseen solutions can trigger new interesting system states (unseen behaviours).
 - ❑ *In-vivo* keeps the real behaviour of the system engaged in the search process.

References

- [1] Stackoverflow, accessed on July 2020, [How do I discover memory usage of my application in Android?](#)
- [2] Bokhari, Mahmoud A. ,Brad Alexander, and Markus Wagner. "Mind the gap—a distributed framework for enabling energy optimisation on modern smart-phones in the presence of noise, drift, and statistical insignificance." *2019 IEEE Congress on Evolutionary Computation (CEC)*. IEEE, 2019.
- [3] De Carvalho, Sidartha Azevedo Lobo, Daniel Carvalho Da Cunha, and Abel Guilhermino Da Silva-Filho. "Autonomous power management for embedded systems using a non-linear power predictor." *2017 Euromicro Conference on Digital System Design (DSD)*. IEEE, 2017.
- [4] Dong, Mian, Yung-Seok Kevin Choi, and Lin Zhong. "Power modeling of graphical user interfaces on OLED displays." *2009 46th ACM/IEEE Design Automation Conference*. IEEE, 2009.
- [5] Bokhari, Mahmoud A., Brad Alexander, and Markus Wagner. "In-vivo and offline optimisation of energy use in the presence of small energy signals: A case study on a popular Android library." *Proceedings of the 15th EAI International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services*. 2018.
- [6] Bokhari, Mahmoud A., Brad Alexander, and Markus Wagner. "Towards Rigorous Validation of Energy Optimisation Experiments." *Genetic and Evolutionary Computation Conference* 2020.
- [7] Santana-Quintero, Luis V., Alfredo Arias Montano, and Carlos A. Coello Coello. "A review of techniques for handling expensive functions in evolutionary multi-objective optimization." *Computational intelligence in expensive optimization problems*. Springer, Berlin, Heidelberg, 2010.