LISA & Friends

Linux Interactive System Analysis

Patrick Bellasi
patrick.bellasi@arm.com

Agenda
Presentation outline

- Short introduction of the main goals of the LISA toolkit
  - What do we need and why?
- Overall view of the main framework components
- Example usage scenario
  - Short introduction of a real (simple) use-case
  - Interactive session with questions

Agenda
Presentation outline

- Short introduction of the main goals of the LISA toolkit
  - What do we need and why?
- Overall view of the main framework components
- Example usage scenario
  - Short introduction of a real (simple) use-case
  - Interactive session with questions

Motivations
What is the aim of LISA[1]

A toolkit** to support **interactive analysis

- Supports the **study of existing behaviours**

  e.g. Helps with - "how the hell does this PELT thing work?"

- Supports the **analysis of new code** being developed

  e.g. What is the impact of code modifications on key behaviours ?

- Get insights on **what's not working** and possibly **why**

- Common language to share reproducible experiments

  Allows to reproduce experiments on different targets

  Flexible enough: programmers like extensible APIs

[1] https://github.com/ARM-software/lisa

Motivations
Why (yet) another toolkit?

- Many different test suite already exist
  - KernelCI: mainly "just" build and boot validation... but a lot of it
  - LTP: “validate the reliability, robustness, and stability of Linux”
  - Intel's 0-day: continuous regression testing for mainline kernel

- These are mainly **black-box analyses** which do not give enough insights
  - Benchmarks **show regressions** but do **not pinpoint their reasons**
  - Brute force analysis can point just to a specific patch
    - *Still just reports what code is broken but usually not **why or how***

Motivations
What do we need?

- Simple yet powerful API to
  - Generate test workloads and execute on test targets
    - *Synthetic workloads allow to **stimulate specific behaviours***
  - Post process collected data to produce stats, plots and reports
    - *A **graphical representation** is usually easy to understand than numbers*
    - *A set of **assertions** on **specific features** are useful for further investigations*
- Main counter arguments
    - *I can do everything with a bash scripts and some other tools*

LISA doesn't want to replace them,
just make them (possibly) more easy to use

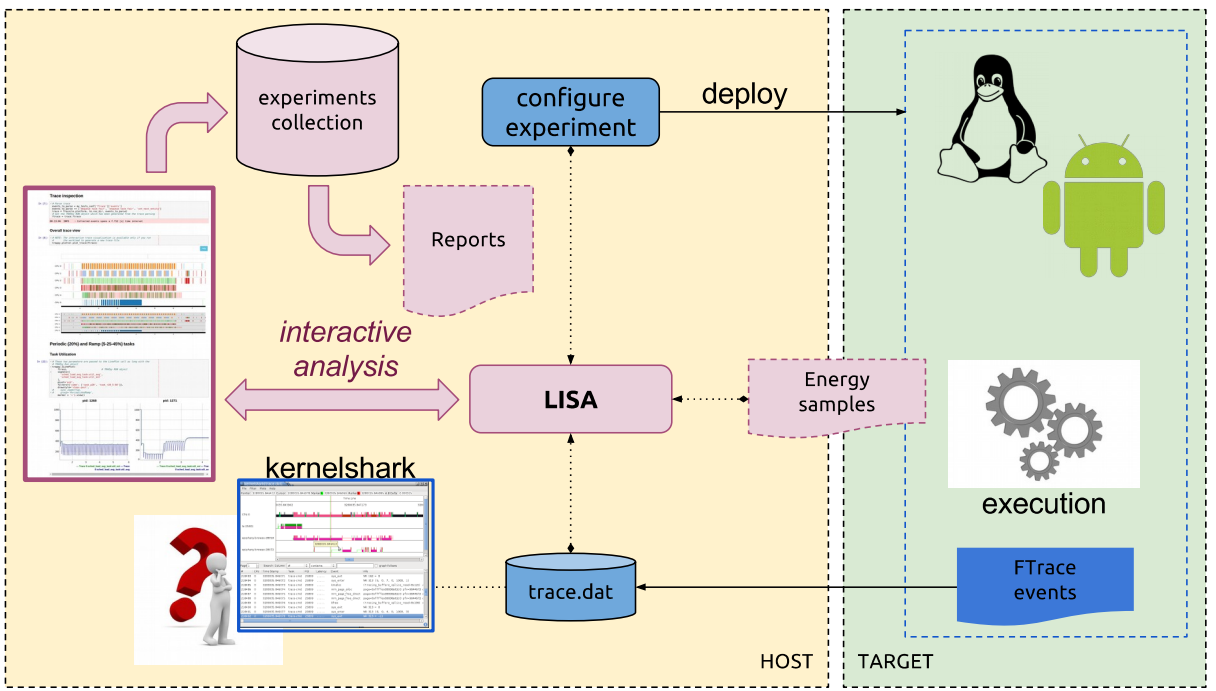
ARM

Agenda
Presentation outline

- Short introduction of the main goals of the LISA toolkit
  - What do we need and why?
- Overall view of the main framework components
- Example usage scenario
  - Short introduction of a real (simple) use-case
  - Interactive session with questions

Toolkit Organization
Abstract view of the flow

- Experimenting using an “interactive environment”
- Data analysis and post-processing
- Tests definitions to support regression analysis



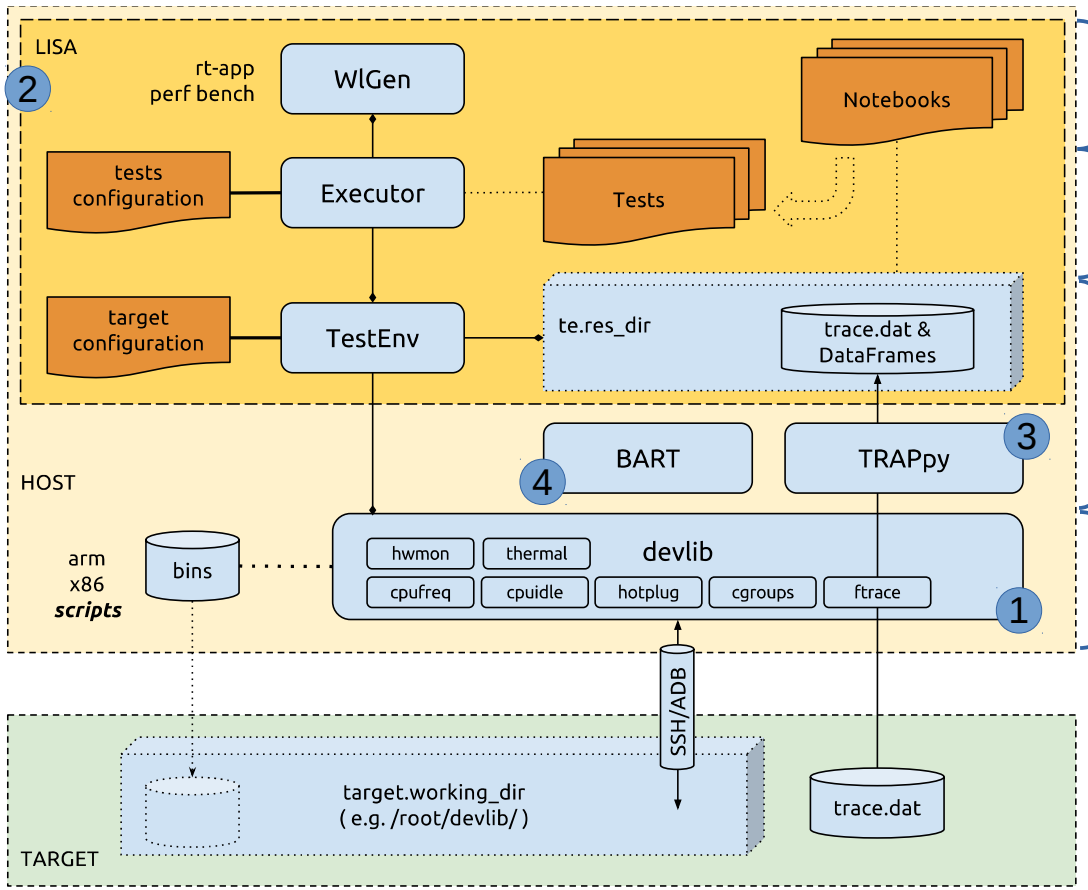
Classical flow vs LISA flow

Evaluate trade-offs on Power/Performances

ARM

Toolkit Organization

Bird's eye view of the main components



Interactive test and analysis

Automated tests

Data Collection and Analysis

Hardware Abstraction Layer

https://github.com/ARM-software/devlib [1]
https://github.com/ARM-software/lisa [2]
https://github.com/ARM-software/trappy [3]
https://github.com/ARM-software/bart [4]

ARM

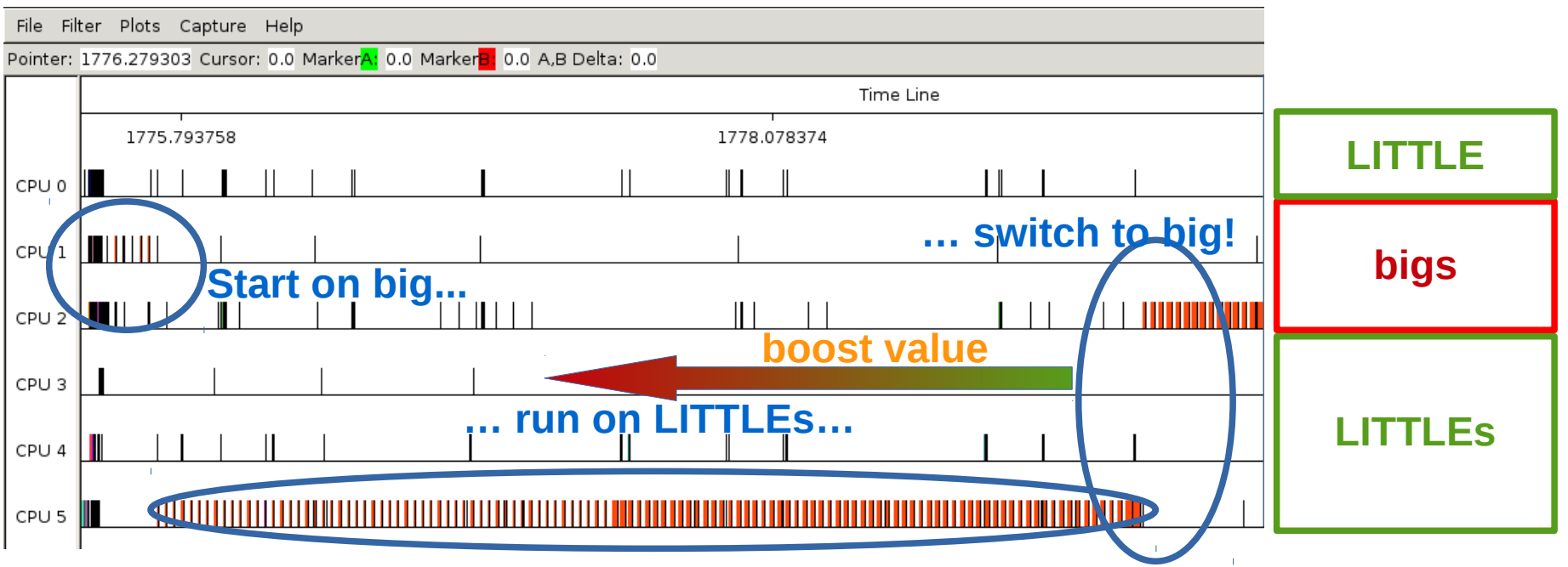
Agenda
Presentation outline

- Short introduction of the main goals of the LISA toolkit
  - What do we need and why?
- Overall view of the main framework components
- Example usage scenario
  - Short introduction of a real (simple) use-case
  - Interactive session with questions

Example Usage Scenario
Analysis of a new Scheduler Feature

- Evaluate the SchedTune extension of the EA scheduler

  A task must run 30% of its time on a big CPU when boosted 15%



Interactive Session

ARM

Thank You!

Patrick Bellasi
patrick.bellasi@arm.com

Detailed Examples

A bottom up presentation of all LISA modules

Main Components
IPython Notebooks: Interactive Python Scripting (and more)

- What is a Notebook?
  - Web based interface for “interactive” code execution
    - *Code organized into cells which can be re-executed out-of-order*
  - Support for different languages and code completion
    - *Easy access to embedded documentation*
  - Key bindings available for all the main actions
- How can a notebook be used?
  - Interactively build experiments
  - Generate reports which can be exported in HTML
    - *Which mixes code and comments*
  - Export code as a standalone python script

Main Components
IPython Notebooks: Example

- Enter the LISA Shell

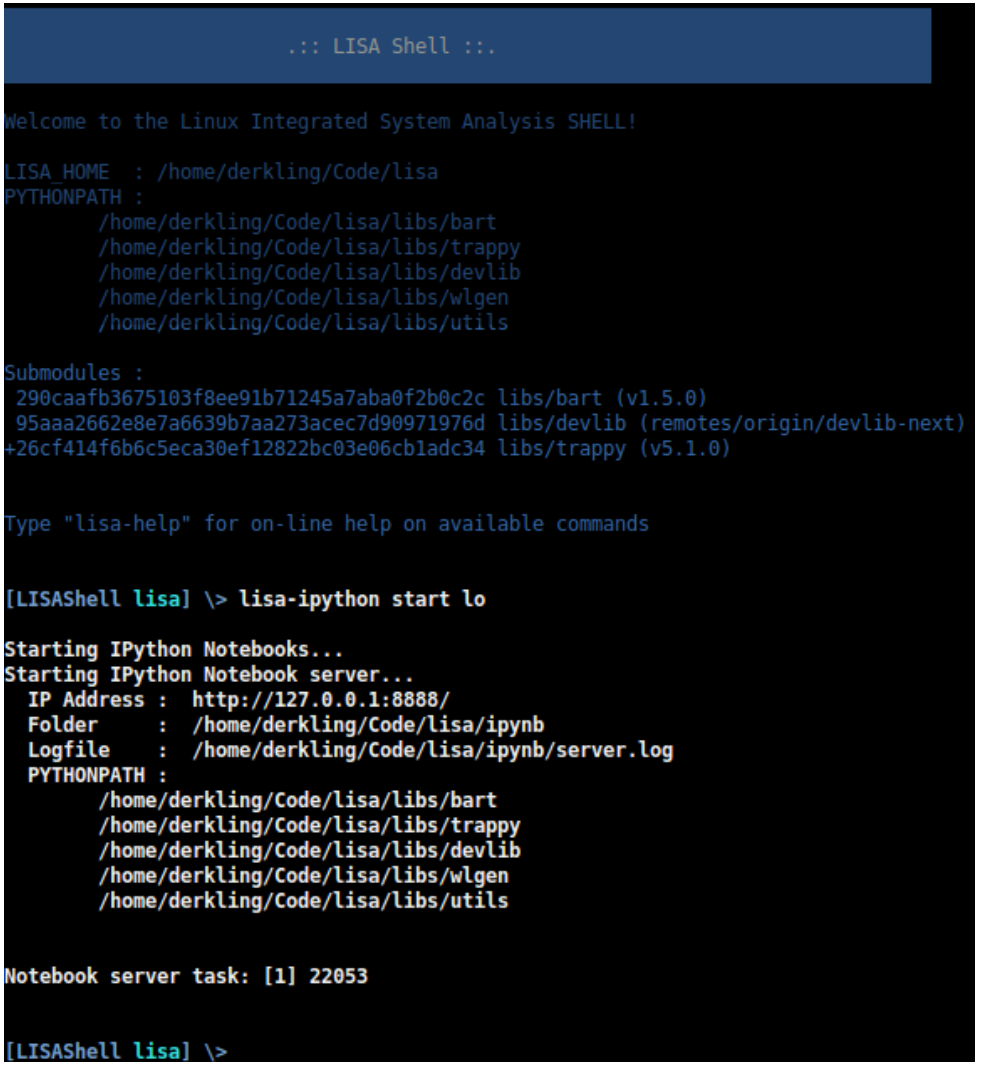
  Custom commands are available for most common operations

- Start the notebook server

  By default uses the local version of needed libraries

  Easy access to the code of internal modules

  Thus you can easily contribute your patches back to the mainline ;-)



Hands On ARM

Docs

Main Components
Devlib[1]: Target Abstraction

- Low-level library used by WorkloadAutomation
- Command execution is on the remote target

  Supports multiple platforms: linux, android (and chromeos)

  Using SSH or ADB as communication channels
  Single connection for all commands

- Provides APIs for the main Linux frameworks

  Generic modules: cgroups, cpufreq, cpuidle, hotplug, hwmon, thermal

  Special modules: android, biglittle

- Support energy measurement instruments

  TC2/Juno energy counters, ARM EnergyProbe, DAQs

[1] https://github.com/ARM-software/devlib
[2] https://github.com/ARM-software/workload-automation

ARM

Main Components

TestEnv: Test Environment setup for specific Targets

- In a nutshell: a wrapper of devlib
  - Simplifies code in notebooks and tests
    - *Provides the glue-code to setup a test environment*
    - *E.g. connect to client, initialize modules, setup the output folder*
  - Allows the definition of the setup in a declarative format
    - *Could be either a file or an inline python dictionary*
  - Exposes the devlib API
- Provides additional APIs for some common tasks
  - E.g. deploy a different kernel, reboot the target

Main Components
WlGen: portable Synthetic Workloads generation

- Synthetic workloads configuration and execution

  perf bench sched

  messaging (aka hackbench) and pipe

  rt-app

  set of base behaviours (periodic, step, ramp, …) which can be composed to create more complex execution scenarios

  custom JSON configuration

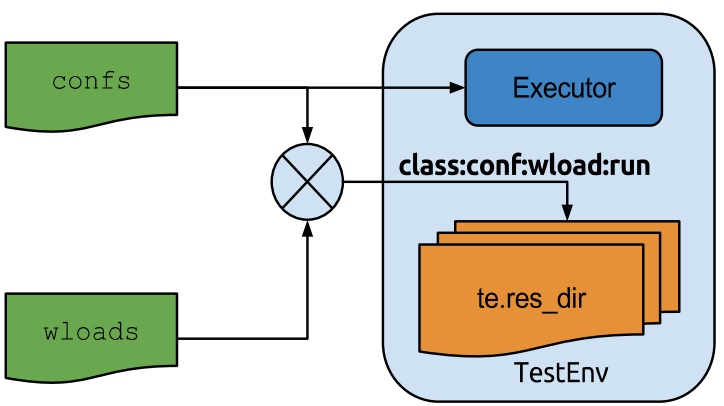
- Execution tunables support:

  CPU pinning, CGroups, FTrace

Main Components
Executor: tests configuration and data collection

- Simple automation for experimental data collection
- Using a simple dictionary or JSON configuration

`confs`	*target configurations to test*
`wloads`	*synthetic workloads to execute on each configuration*
`iterations`	*number of executions for each wload*



Docs

Main Components

TRAPpy[1]: From FTrace events to PANDAS DataFrames

- Based on PANDAS DataFrames

  Python "standard" framework for data analysis and statistics

  ftrace events are translated into tables

  *Events must match a specific template: (**unique_word**): ((**key**)=(**value**))+*

Example (raw trace, i.e. generated by trace-cmd report -r):
sudo-3224 [001] 228774.292951: **sched_switch**: **prev_comm**=sudo **prev_pid**=3224 **prev_prio**=120 **prev_state**=2048
next_comm=kschedfreq:1 **next_pid**=1822 **next_prio**=49

- API for trace event analysis

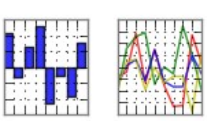
  Plots of **table:key** "signals"

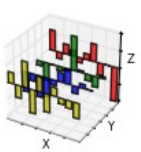
  both static and interactive plots

  Provide data structure support for BART

pandas

$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$





http://pandas.pydata.org/

Hands On

ARM

[1] https://github.com/ARM-software/trappy

Data Analysis
Exploiting Platform Data for Trace Analysis

- Platform specific information can be useful

  e.g. CPU topology, OPP curves, EnergyModel data, …

  Information on these are collected by TestEnv

  platform.json file in the results folder (i.e. te.res_dir)

- TRAPpy is a generic module for trace events parsing

  It does not know about a specific platform

  Even if this information are available via the LISA::TestEnv module

although we can combine "on-demand" TRAPpy with platform data some commonly used analysis are worth to be shared

Data Analysis
Filtering and Plotting Predefined functions

- LISA::Trace glues platform data with TRAPpy DataFrames

  more complete analysis dataset

- LISA::Filters

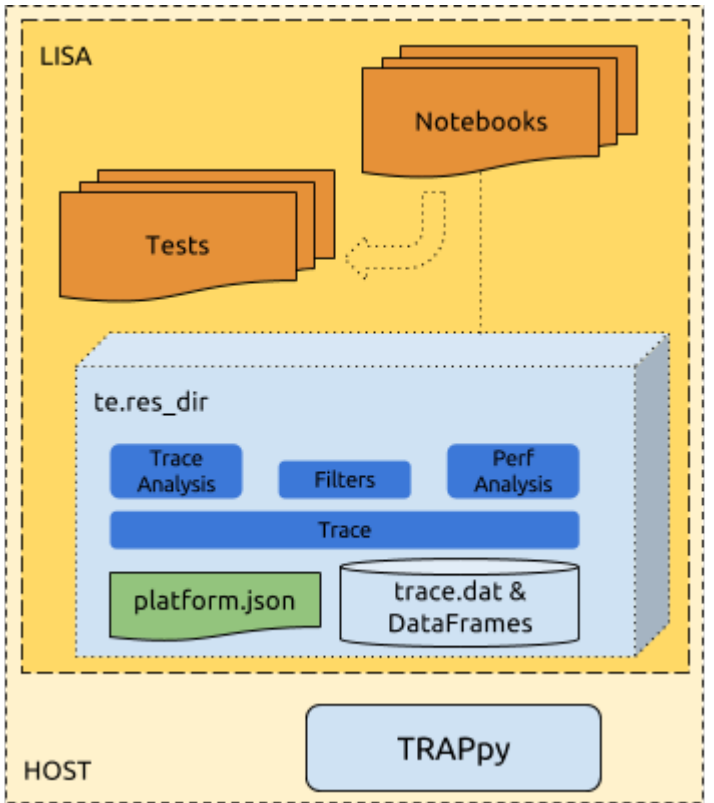
  commonly used events filtering functions

- LISA::TraceAnalysis

  commonly used trace events plots

- LISA::PerfAnalysis

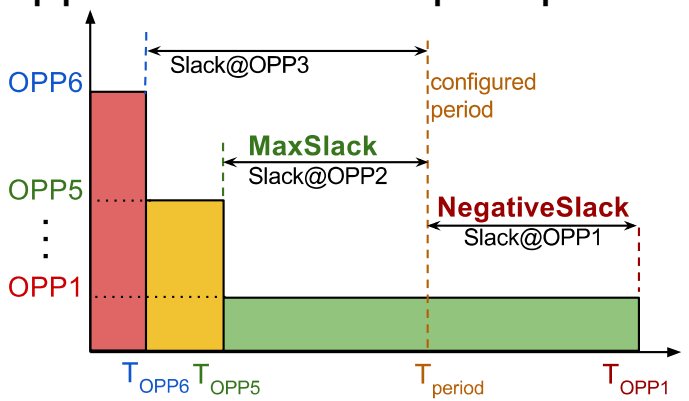
  commonly used performance plots



Hands On ARM

Data Analysis
Using RT-App to evaluate task performances

- RT-App extended to report performance metrics[1]



$$MaxSlack = Period_{conf} - RunTime_{conf}$$

$$PerfIndex = \frac{Period_{conf} - RunTime_{meas}}{MaxSlack}$$

$$NegSlack_{percent} = \frac{\sum Max\left(0, RunTime_{meas} - Period_{conf}\right)}{\sum RunTime_{meas}}$$

suitable to evaluate some EAS behaviors

optimal CPU/OPP selection and SchedTune boosting

too pessimistic on single period missing

we will add an option to reset metrics after each new activation

- Other metrics can be added

Linaro proposed a “dropped-frames” counter,

we should integrate that as well

[1] libs/utils/results.py::RTAppPerf

Hands On ARM

Automated Testing
LisaTest: Regression Testing Analysis

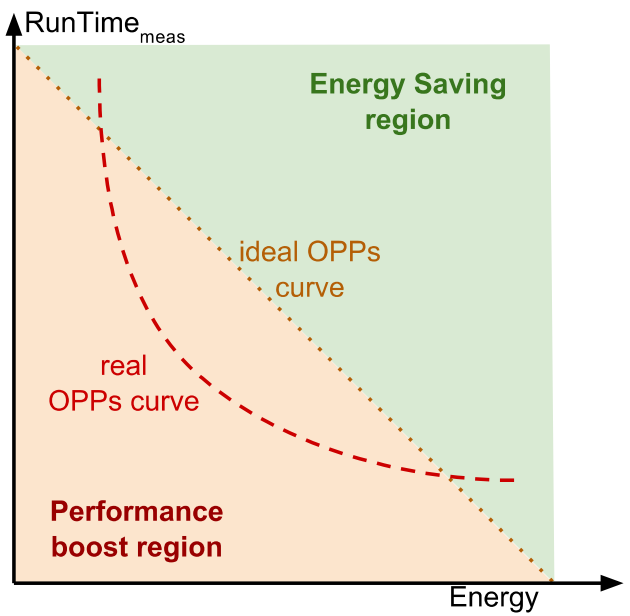
- Support for batch execution of tests
  - data collection driven by the lisa::executor module
    - *easy to develop code on Notebook and than convert to a test*
  - config file based tests definition
    - *a JSON file is used to describe “confs” and “wloads”*
- Tests executes after data collection complete
  - execution model based on standard python nosetest
    - *each test is defined within a function which name starts by “test_”*
- Post processing and reporting functions available

Automated Testing
Evaluation of Energy-Performances tread-offs

- We can spent more energy provided that we get some performance benefits

  SchedTune aims at controling this trade-off at run-time

- Experiments reports Energy-vs-Performance metrics



Energy Delay Product (EDP)

$$EDP = Energy * \sum RunTime_{meas}$$

ARM

Automated Testing
BART[1]: Behavioural Analysis

- Set of APIs on top of TRAPpy DataFrames
  - allows to extract “features” from trace events
    - *How long a task run on a CPU? Does it switch to another CPU?*
    - *How long the temperature remain within a specified range?*
  - Advanced tests for “sched switches” and “thermal events”
    - *the API is (going to be) generic enough to introduce other events*
- Aims at supporting the definition of behavioural tests
  - small and self-contained functional behaviour
    - *e.g. task migration, frequency switch, OPP capping*
  - a failure should pinpoint a specific code path
    - *suitable to evaluate the impact of code additions/updates*

[1] https://github.com/ARM-software/bart