CONCRETE: A benchmarking framework to CONtrol and Classify REpeatable Testbed Experiments

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Introduction

Ø The Problem:
- During experimentation in networking testbeds several different factors may impact the monitored performance of networks under consideration.
- As a result high variation exists among several executions of the same experiment.

Ø The Need:
Stable experimental conditions have to be guaranteed, in order to arrive at solid conclusions.

Ø Our Solution:
The novel CONRETE benchmarking framework that provides for evaluation of experimental stability.
Outline

- Related Projects
- Basic Experimental Scenario
- Interfering Factors
- Building Blocks
- CONCRETE Benchmarking Framework
- Insights and Future work
Related Projects

- **CREW**
  - Establishes an *open federated test platform*, which facilitates experimentally-driven research on advanced *spectrum sensing*, *cognitive radio* and *cognitive networking* strategies in view of horizontal and vertical spectrum sharing in licensed and unlicensed bands.

- **OPENLAB**
  - Delivers *control and experimental plane middleware* to facilitate early use of *testbeds* and exploiting proven technologies, developed in the *OneLab* and *Panlab* initiatives.

- **OPENLAB – CREW Collaboration**
  - In order to improve the *reproducibility of wireless experiments*, OpenLab is interested to augment the OpenLab facilities with the CREW spectrum sensing benchmarking scenarios.
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Basic Experimental Scenario

- 2 pairs of nodes contending for channel use.
- **AP2 -&gt; STA2**: saturated traffic conditions
- **AP1 -&gt; STA1**: varying traffic rate \(TR_{RATE}\) conditions
- We monitor the throughput performance of the **AP2-STTA2** pair
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Interfering Factors (1/5)

Specific executions of the same experiment may present different performance, due to:

**Internal Interference**

generated by testbed nodes, operated by other experimenters, which simultaneously transmit on the same or overlapping frequencies.
Specific executions of the same experiment may present different performance, due to:

**External Interference**

generated by collocated commercial devices belonging to external networks, which simultaneously transmit on the same or overlapping frequencies.
Specific executions of the same experiment may present different performance, due to various factors, such as:

**stopping of normal execution due to hardware or software failure**
Specific executions of the same experiment may present different performance, due to various factors, such as:

**Different node positioning**
(etc. mobile nodes behind obstacles)
Interfering Factors (5/5)

The Result

![Graph showing bandwidth values over time for different experiment runs.](image)

![Bar chart showing average bandwidth values for each experiment run.](image)
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Building Blocks

Advanced Spectrum Sensing Techniques

OMF Control and Management Framework

iMinds w-ilab.t Cognitive Testbed

Long experience with instrumentation of testbed experiments
Building Blocks – Correlation

The well known measure of dependence is Pearson's correlation, which indicates the extent to which two random variables covary.

- The $\mu_x$ and $\mu_y$ represents the mean of the data set $X$ and $Y$ respectively.
- The $\sigma_x$ and $\sigma_y$ represents the standard deviation of the data set $X$ and $Y$ respectively.

$$
\rho_{X,Y} = corr(X, Y) = \frac{cov(X, Y)}{\sigma_x \sigma_y}
$$

$$
r = \frac{1}{(n-1)} \sum \frac{(X-\mu_X)(Y-\mu_Y)}{\sigma_x \sigma_y}
$$
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The 6 main functionalities that are currently supported, are:

1. **Scheduling** the execution of several runs for the same experiment

2. **Visualization** of prevailing **Channel Conditions** before each run and moreover visualization of the **Performance** achieved in each run

3. **Estimation of Correlation** among the different runs, in order to provide an appropriate benchmarking score that describes the stability of each run

4. **Calculation** of average performance and st. deviation values for each run

5. **Automatic** mechanism that selects the most stable runs, based on their correlation score

6. **Calculation of performance over all executed rounds** in comparison with the performance achieved only in the subset of selected rounds.
CONCRETE Benchmarking Framework (1/6)

1. Scheduling the execution of several runs for the same experiment
2. Visualization of Channel Conditions before each run and moreover visualization of the Performance achieved in each run.
3. Estimation of Correlation among the different runs
4. Calculation of AVG performance and ST. DEV. for each run
5. **Automatic mechanism** that selects the most stable runs, based on their correlation score.
6. Calculation of performance over all executed rounds in comparison with the performance achieved only in the subset of selected rounds.
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Insights and Future Work

Experimental Insights:
- Due to the high variation of wireless channel conditions there is a clear need for environment monitoring mechanisms that aid in arriving at CONCRETE conclusions.

Future Work:
- Enable channel monitoring during the experiment execution through Wi-Fi Monitor nodes.
- Implement Feature detection mechanism to enable detection of transmissions generated by devices using heterogeneous technologies
- Examine performance under various experiments and metrics (energy etc.) and propose possible enhancements
Thank You!