SIMBED and SIMBED+
Large Experiments

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Outline

• Background and motivation
• Offline Experimentation Approach
• SIMBED
• SIMBED+
• Conclusions
• Business Impact
Background and Motivation

- Testbeds are getting more complex and costly
- Reproducibility may not be assured
  - Private testbeds
  - Testbeds may be changed / become no longer available
  - Simulation is too optimistic
    - Unstable physical conditions → Link quality, mobility patterns
Offline Experimentation Approach

Wireless Testbed $x$

<table>
<thead>
<tr>
<th>Exp_1</th>
<th>Exp_m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exec_1</td>
<td>Exec_i</td>
</tr>
</tbody>
</table>

Web Portal for Traces Management and Sharing

Automatic Capture of Traces
- RSSI
- Noise Floor
- Positions of Nodes
- Configuration of Wi-Fi card
- ...

Experiments' Traces DB

Trace-Based ns-3 Simulation_1

Wireless Testbed $x'$

Sim. scenario configured as Exp_m

Sim. run(s) based on Exec_k traces

Reproduction of Experiment

Trace-Based ns-3 Simulation_y

Large scale validation needed $\rightarrow$ SIMBED
SIMBED

Offline Real-World Wireless Networking Experimentation using ns-3

(2018-2019)
SIMBED OC3 Large Experiment

OBJECTIVES

- **Repeat** and **Reproduce** past experiments

- **Adapt Offline Experimentation (OE)** approach for Fed4FIRE+
  - Capture traces of **link quality** and **node positions**
  - Reproduce conditions of past experiments using **Trace-based ns-3 Simulations**

- **Validate OE approach** using **NITOS** and **w-iLab.t**

- **Promote interaction** between experimentation and simulation
**SIMBED**

**EXPERIMENT SET-UP**

Some key features

- Baremetal access
- Custom OS image and drivers
  - ath9k
- Easy remote access
- Fast Internet access

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### Static

- A AP
- B STA

### Mobile

- A AP
- B STA

### Multiple STAs

- A AP
- B STA
- C STA

### Bidirectional

- A AP
- B STA
SIMBED

RESULTS

Example of static P2P experiment

Throughput (kbit/s)

Experiment time (s)

Real  Friis  OE
SIMBED
RESULTS

w-iLab.2 P2P (static, auto-rate)
SIMBEd
RESULTS

Example of mobile experiment

Throughput (Kbit/s)

Sample

0 50 100 150 200 250 300 350 400

OE
Real
Friis
LogDist1.7
LogDist2.0
LogDist2.5
SIMBED

RESULTS

w-iLab.2 P2P (mobile, auto-rate)
SIMBED+

Replicable Real Wireless Networking Experiments using ns-3

(2019-2020)
SIMBED+ OC5 Large Experiment

GOAL

- **SIMBED** was focused on controlled scenarios and SISO
- **Validate OE Approach in uncontrolled scenarios**
  - Improve **MIMO** simulation accuracy
    - ns-3 always uses the maximum number of configured radio streams
  - Reproduce **channel occupancy**
    - ns-3 scenarios assume no interference / spectrum sharing from concurrent networks
SIMBED+

OBJECTIVES

• Repeat and Reproduce past experiments executed in non-controlled environments
  • Introduce MIMO and shared radio spectrum support

• Adapt Offline Experimentation (OE) approach for Fed4FIRE+
  • Capture traces of link information and positions of nodes
  • Reproduce conditions of past experiments using Trace-based ns-3 Simulations

• Evaluate OE approach using w-iLab.t and CityLab

• Promote interaction between experimentation and simulation
SIMBEd+ EXAMPLE OF IEEE 802.11A EXPERIMENT
SIMBED+
EXAMPLE OF IEEE 802.11N EXPERIMENT

![Graph showing Goodput (kbit/s) over time for different models: Real, Friis, LogDist1.7, Trace2. The graph demonstrates the comparison of these models over a time period from 0 to 180 seconds.]
SIMBED+
IEEE 802.11A SISO @ 20 MHZ
SIMBED+
IEEE 802.11N MIMO 3X3 @ 20 MHZ
SIMBED+
IEEE 802.11N MIMO 3X3 @ 40 MHZ
Conclusions

- OE approach was evaluated in large scale
- OE approach → repetition & reproduction of experiments
  - Even if real testbed becomes unavailable
- MIMO and Channel Occupancy support
  - Improves OE accuracy for uncontrolled testbed scenarios
Business Impact
Business Impact

IMPACT ON OUR BUSINESS

- SIMBED(+) demonstrated OE is a valid approach
- High impact in all R&D activities depending on experimentation
  - Reduce costs and manpower involved
  - Enable repeatability and reproducibility of experiments
- Validation of OE approach increases confidence to use it in
  - Future projects
  - MSc and PhD theses
Business Impact

VALUE PERCEIVED

- **Gained knowledge**
  - Radio link asymmetry
  - Ath9k debug mode
  - How to use Fed4FIRE+ Wi-Fi resources

- **Acquired new competences**
  - Experimentation over federated testbeds
  - Large experiments orchestration
  - Results/trace data processing

- **New ideas for our roadmap**
  - Keep improving OE approach
  - Work together with Fed4FIRE+
    - Offline Experimentation as a Service (OEaS)
    - Augmented Experimentation as a Service (AEaS)
Business Impact

VALUE PERCEIVED

• 6 scientific publications
  • 5 conference papers (2 in preparation)
  • 1 journal paper (in preparation)
• Contribution for PhD thesis
• OE approach being used in current research projects
Business Impact

VALUE PERCEIVED

• Validation of OE approach through well-known and controlled environments provided by NITOS, w-iLab.t and Citylab

• Without Fed4FIRE+
  • Limited to small-scale custom/private testbeds
  • Need to adapt our methodology to each testbed
  • OE approach validation would be less credible
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