Review Open Call 8 experiments

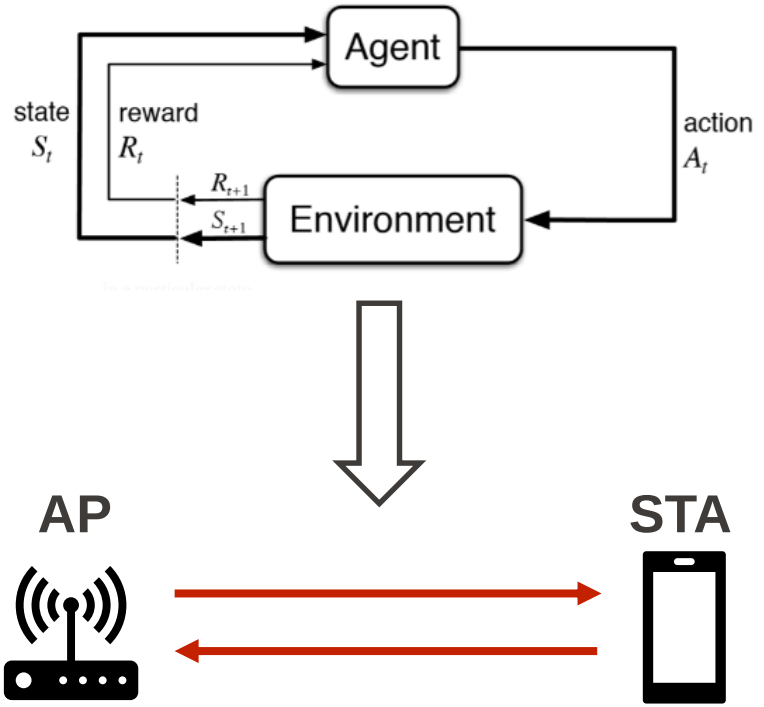
SMART

Rúben Queirós, Eduardo Almeida, Helder Fontes, José Ruela, Rui Campos

INESCTEC

Virtual Review FEC 11

Virtual, 02-05-2022



Self-adaptive Machine learning Approach for Real-time Tuning of IEEE 802.11 PHY and MAC Layers

SMART

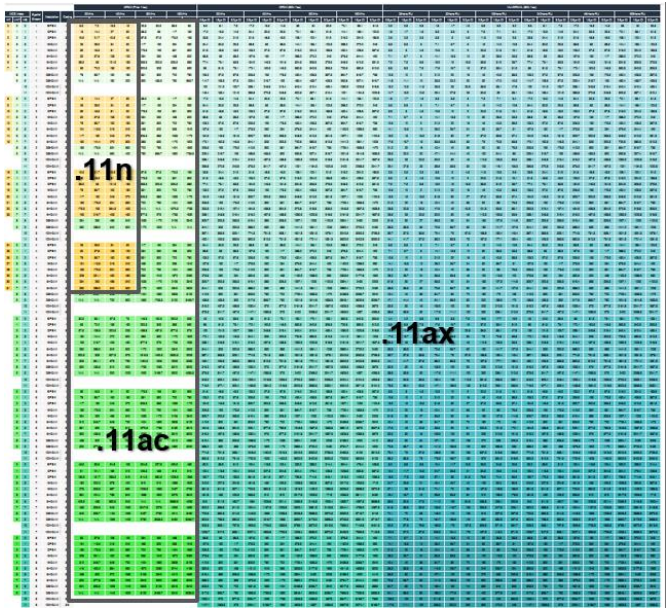
Outline

1. Experiment Description
2. Project Results
3. Business Impact
4. Feedback

Experiment Description

Concept

- Wireless channel conditions **highly variable**
  - No single configuration suits all scenarios
- Recent Wi-Fi amendments with **increasing number of PHY and MAC parameters**
  - Link optimization becoming extremely complex
- **Machine Learning (ML) techniques** being used in wireless networking
- ML-based RA algorithm



IEEE 802.11n/ac/ax PHY rate table comparison

Objectives

1. Evaluate and improve SWOP approach using w-iLab.t
2. Disseminate SWOP and Fed4FIRE platform
3. Increase confidence of networking community and partnering companies in SWOP

SWOP – Smart Wireless Optimisation

Background and Motivation

- Recent Wi-Fi standards introduce **new PHY/MAC features**

  MIMO Spatial Streams, Channel Bonding, Short Guard Interval, Advanced Modulation Coding Schemes, Frame Aggregation, …

- **Optimal configuration** of these parameters is a **challenge**

  Parameters typically configured with default values

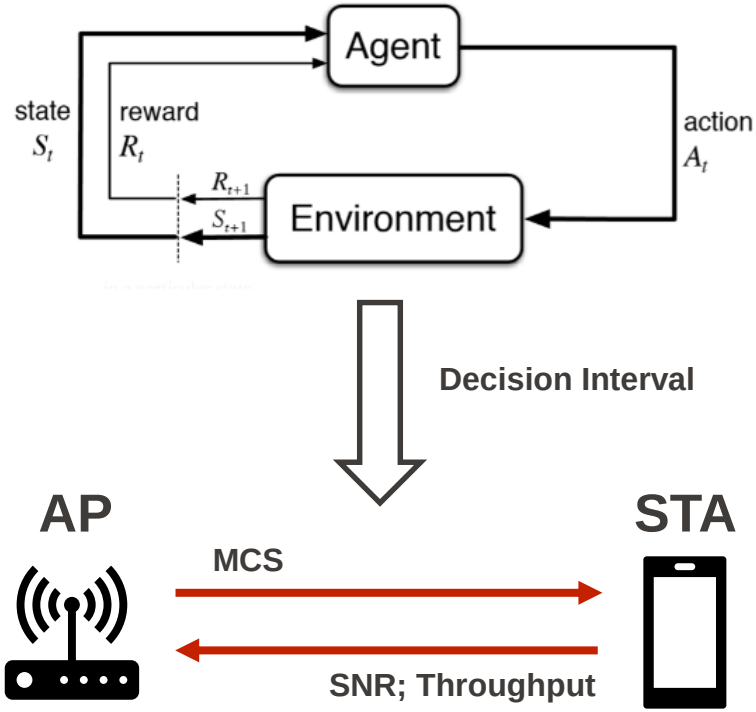
  Dynamic environments require run-time optimization

Experiment Setup I

Data-driven Algorithm for Rate Adaptation (DARA)

- **Agent** → Framework in **STA**
- **Environment** → Wireless Environment
- **Action** → MCS (0 to 7)
- **State** → SNR (Avg received ACKs)
- **Reward** → Success Ratio and Throughput

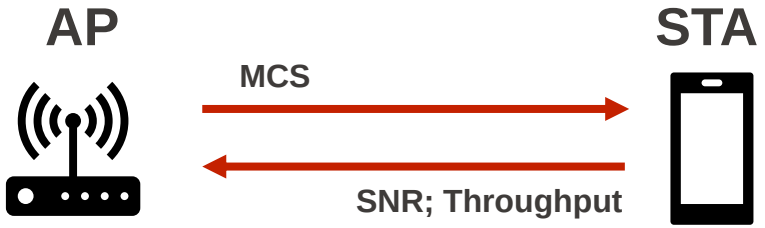
$$reward = \frac{MCS_n}{MCS_7} \times \frac{\#success}{\#attempts}, n \in [0,1,\dots,7]$$

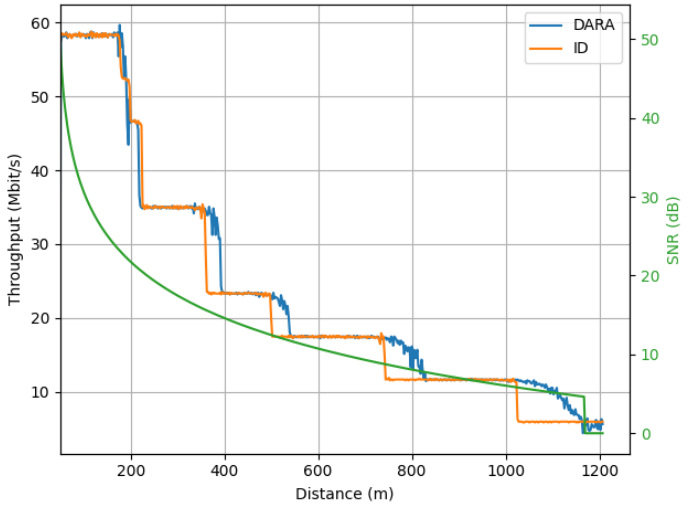


Experiment Setup II

Training methodology for DARA

- Training Scenario
  - AP – STA
  - STA moves away at constant speed (2.5 m/s)
- Rationale
  - Agent observes whole range of possible states
  - Through trial-and-error it learns what is the best MCS for each SNR
- Objective
  - Policy replicating “Ideal” **(ID)** RA algorithm

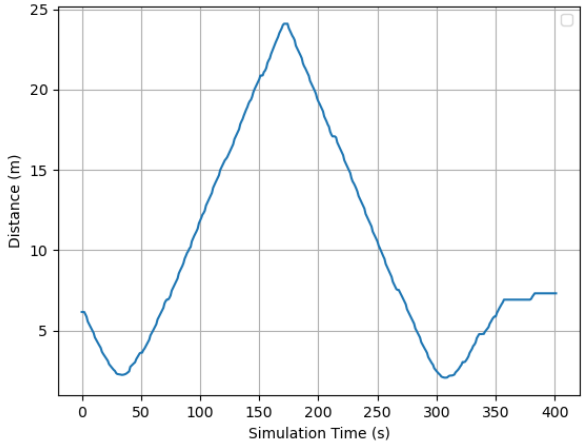


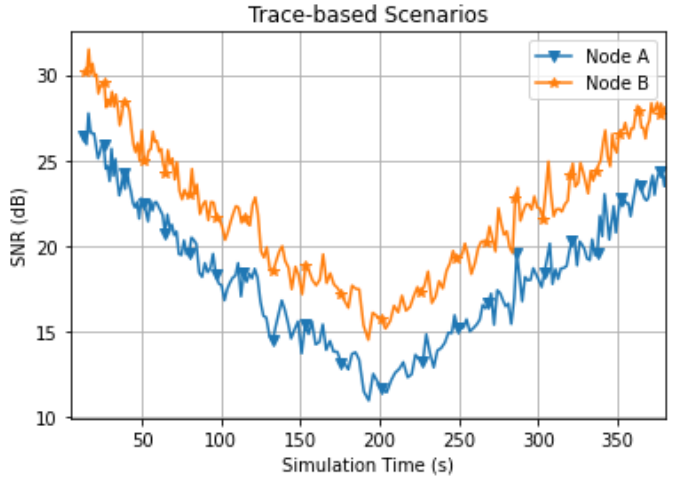


Project Results

Measurements – Trace-based Scenarios

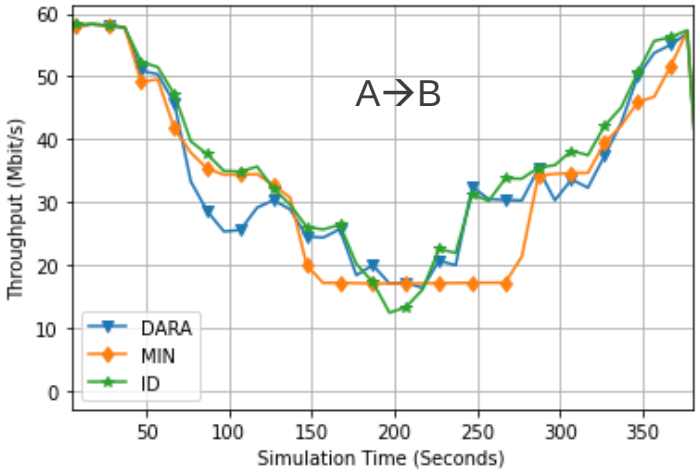
- 2 mobile stations A and B
- Different TX powers, affecting SNR
- Realistic asymmetry

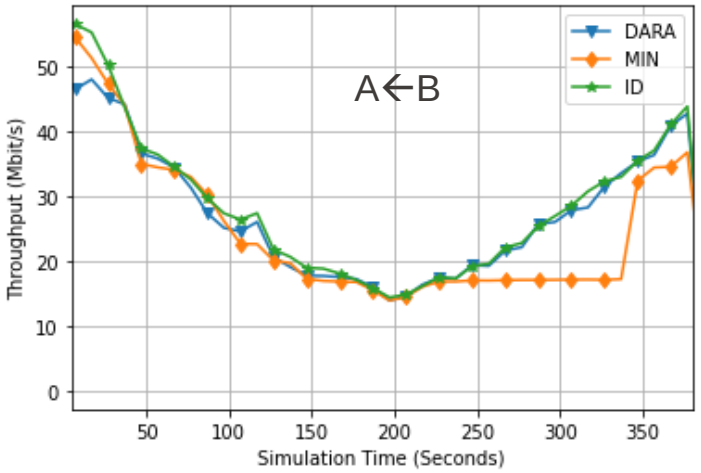




Measurements – Trace-based Scenarios

- TX power → 12 dBm
- Results from both asymmetry perspectives





DARA performance is impacted when deviations from the SNR asymmetry offset are observed.

Lessons Learned

- Simulation environment better for fast prototyping and sol. iterations
- Results show that our approach is not mature yet
- There is room to develop link adaptation algorithms using DRL
- As future work, consider ...
    - more actions – e.g. channel bandwidth, Guard Interval, Frame Aggregation
    - more observation metrics

Business Impact

Impact on our business

- SMART demonstrated SWOP is a **valid approach** with promising results
- **Reusable framework** for other Wi-Fi scenarios
    - Different QoS require adjustments in DRL model
    - UAV positioning and link adaptation joint optimization
- Validation of DARA solution increases confidence to use it in
    - Future projects
    - MSc and PhD theses

Value Perceived

- **Gained Knowledge**
  - Impact of radio link asymmetry
  - Accessing relevant Wi-Fi Link parameters
  - How to use Fed4FIRE+ Wi-Fi resources
- **Acquired new competences**
  - Experimentation over federated testbeds
  - Large experiments orchestration
  - Results/trace data processing
  - Statistical Analysis

Value Perceived

- **New ideas for our roadmap**
  - Add support for configuration of other PHY/MAC parameters
  - Improve the Link Quality observation metrics
  - Explore DARA variant that minimizes delay
  - Explore **real implementation constraints**
  - Joint optimization of Link Adaptation and UAV positioning

Value Perceived

- 2 papers in preparation
    - 1 journal paper related to a survey in link adaptation solutions
    - 1 conference paper related to the results obtained in the project
- Contributions to one ongoing PhD thesis
- SWOP approach being exploited in three MSc theses

Feedback

Used Resources and Tools

USED RESOURCES

- w-iLab.2 – DSS and Zotac Nodes
- Multiple nodes reserved per experiment for a complete range of SNR values
    - Only two nodes used simultaneously

Used Resources and Tools

USED TOOLS

- Fed4FIRE+ web portal
- jFed
- w-iLab.t inventory web GUI
- w-iLab.t documentation

Feedback

ADDED VALUE OF FED4FIRE+

- Easy setup of experiments using jFed and single user account
- Easy reservation of resources
- Diversity of available resources
- Bare-metal access to resources
- Support and documentation
- Inventory of the available resources

Feedback

WHAT IS MISSING?

- New functionalities
    - Reserve spectrum as any other physical resource
    - Change the node image through jFed without manually editing the XML file
- Wireless nodes with higher computational power
    - For Machine Learning solution developments
- Some documentation is outdated
    - Ath9k drive patch for 5 GHz ad-hoc mode did not work properly


Co-funded by the European Union


Co-funded by the Swiss Confederation

This project has received funding from the European Union's Horizon 2020 research and innovation programme, which is co-funded by the European Commission and the Swiss State Secretariat for Education, Research and Innovation, under grant agreement No 732638.

THANK YOU FOR YOUR ATTENTION!

WWW.FED4FIRE.EU