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Colosseum for data-driven real-time optimization

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Colosseum and Open RAN

- Open RAN emulation
- Large-scale
- Virtually infinite scenarios
- Smart data factory

- Support:
 - O-RAN
 - SCOPE [1]



Ideal environment to develop AI-driven solutions for Open RAN

[1] L. Bonati, S. D'Oro, S. Basagni, and T. Melodia, "SCOPE: An Open and Softwarized Prototyping Platform for NextG Systems," in Proceedings of ACM MobiSys, June 2021 Repository: https://github.com/wineslab/colosseum-scope

A practical example: QCell [1]



QCell Architecture

Distributed multi-agent DRL

 DQN agent runs on each cellular BS

- Main components:
 - Agent
 - BS protocol stack
 - BS connector



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QCell DQN Agent

Agent

- Two encoders
- Reward calculator
- DQN

Encoder A:

- Low resolution state
- Used for cooperation

Encoder B:

- High resolution state
- Used for control of each base station



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BS Connector and Protocol Stack

BS connector exchanges:

- Low-resolution State
- Rewards

BS protocol stack:

- Implements the softwarized base station
- Uses SCOPE
- Data collection



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I. Read local state

- 2. Encode and share state
- 3. Receive state from neighbors
- 4. Compute reward
- 5. Feed reward and state to DQN
- 6. Compute new action



• Implemented on the **Colosseum**

- **3GPP-compliant** BSs and UEs w/:
 - 3 interfering BSs
 - Up to 22 UEs

Traffic via iPerf3:





QCell Prototype – Action Space

Setup:

- 2 slices
- 3 scheduling policies
 - Round-robin
 - Waterfilling
 - Proportionally fair

Action	Fraction of Resource Blocks (Slice I)	Fraction of Resource Blocks (Slice 2)	Scheduling Policy
0	50%	50%	Round-robin
I.	50%	50%	Waterfilling
2	50%	50%	Proportional
3	25%	75%	Round-robin
4	25%	75%	Waterfilling
5	25%	75%	Proportional
6	75%	25%	Round-robin
7	75%	25%	Waterfilling
8	75%	25%	Proportional



QCell Training



- Training session \rightarrow more than 150 hours of experiments
- Average loss values decreases over time
- Reward increases until convergence



10000

value for ε

iteration

Final exploration

QCell Testing (average over ~17h tests)



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Federated learning

Distributed RAN optimization

Interference control

Mobility prediction



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QCell: Self-optimization of Softwarized 5G Networks through Deep Q-Learning

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