Flexible SON Function Coordination Framework based on Machine Learning

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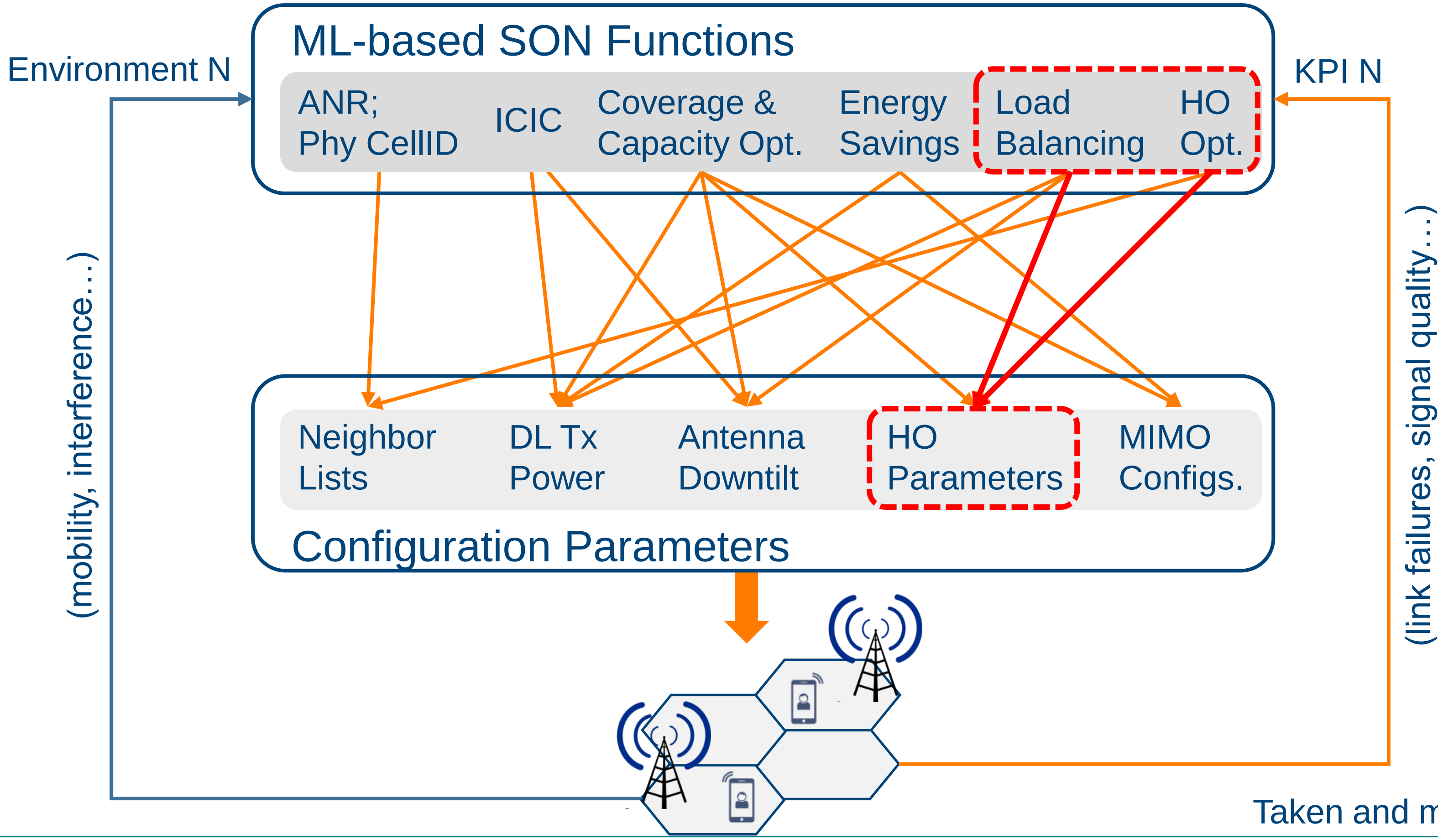
Outline

- Problem Formulation
- Motivation
- Implicit Coordination
- Simulation Results
- Conclusions

Problem Formulation

- Complexity of mobile networks increases – automation is needed

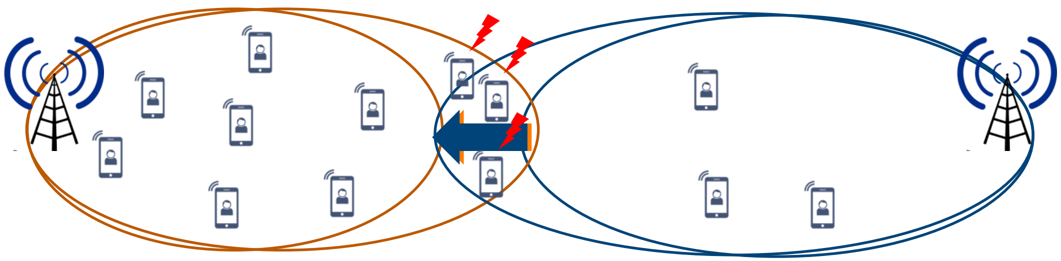


Taken and modified from [1]

Motivation: Implicit Coordination

- Mobility Robustness Optimization (MRO) – handover (HO) optimization
- Mobility Load Balancing (MLB) – minimizing overload in cells

A3 event: $\underbrace{RSRP_s + Hys + CIO_{s,t} < RSRP_t}_{TTT}$



SF	Environment	HO config. Parameters	KPI
MRO	• Velocity	• Hysteresis • Time To Trigger (TTT)	• HOAP= $\frac{0.2*PP+0.4*RLFL+0.4*RLFE}{Users_{cell}}$
MLB	• Users distribution • Cell load	• Cell Individual Offset (CIO)	• # of unsatisfied users (# of UUs)

Minimize GKPI i.e. transferring users from an overloaded cell to neighboring cells while minimizing any HO-related issues for them.

$\text{GKPI}_c = w_1 * HOAP_c + w_2 * UUs_c$

Decentralized Implementation

- Regression ML model derivation pipeline

Cell ID	Environment	Parameters	GKPI
1	V_1, UD_1, CL_1	$Hys_1, TTT_1, CIO_{1_{1\dots n}}$	$GKPI_1$
2	V_2, UD_2, CL_2	$Hys_2, TTT_2, CIO_{2_{1\dots n}}$	$GKPI_2$
…	…	…	…
N	V_N, UD_N, CL_N	$Hys_N, TTT_N, CIO_{N_{1\dots n}}$	$GKPI_N$

Deep Neural Network (DNN)

- Genetic Algorithm (GA) based optimization [2] – more than 10M configuration combinations

Fitness function:

$$F_c = \widehat{GKPI}_c + \sum_{\substack{n=1 \\ n \neq c}}^{N} |\Delta GKPI_n|$$

Penalty for disturbing neighbors

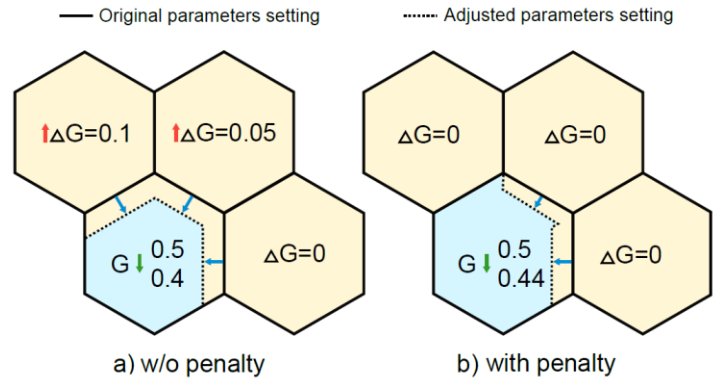
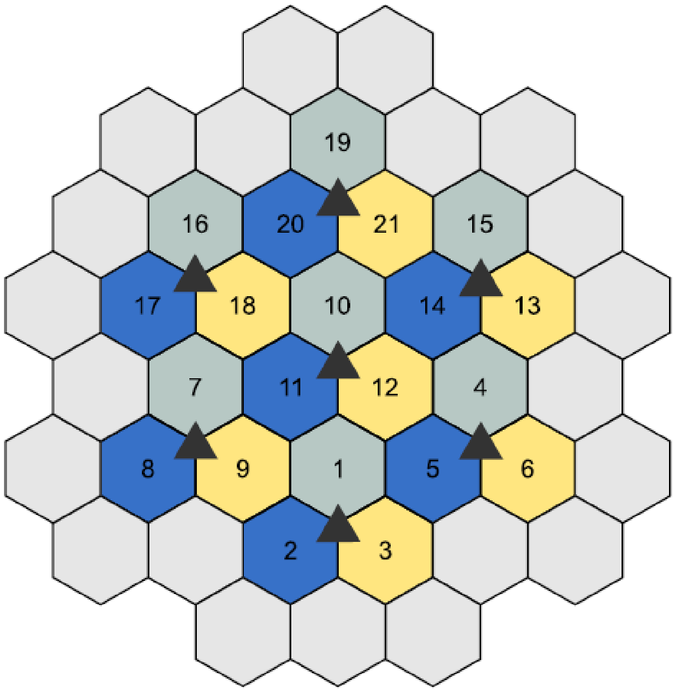
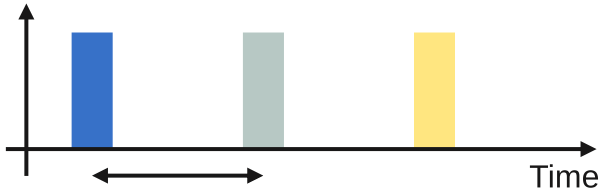


Fig. 1. Applying the two best individuals found using fitness function without a penalization (a) and with a penalization (b).

Simulation Scenario



Network structure [3]



Parameters:

- 7 base station with 3 cells
- 420 mobile, 40 static users
- Random walk model
- User's velocity 10-60 Km/h
- SON interval 5 seconds

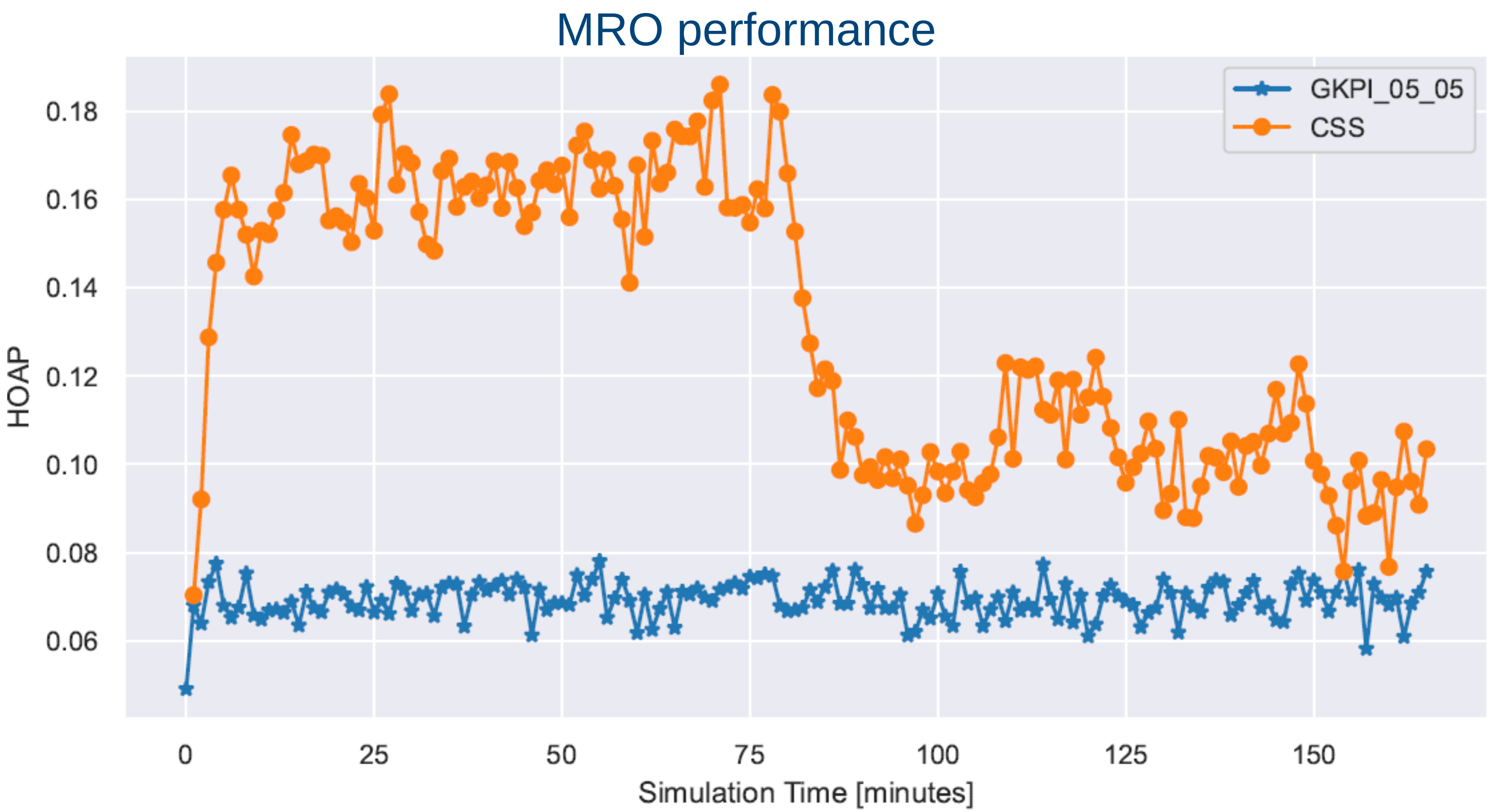
Benchmark:

- Concurrent Spatial Separation (CSS) – reinforcement learning for MLB and MRO [4]

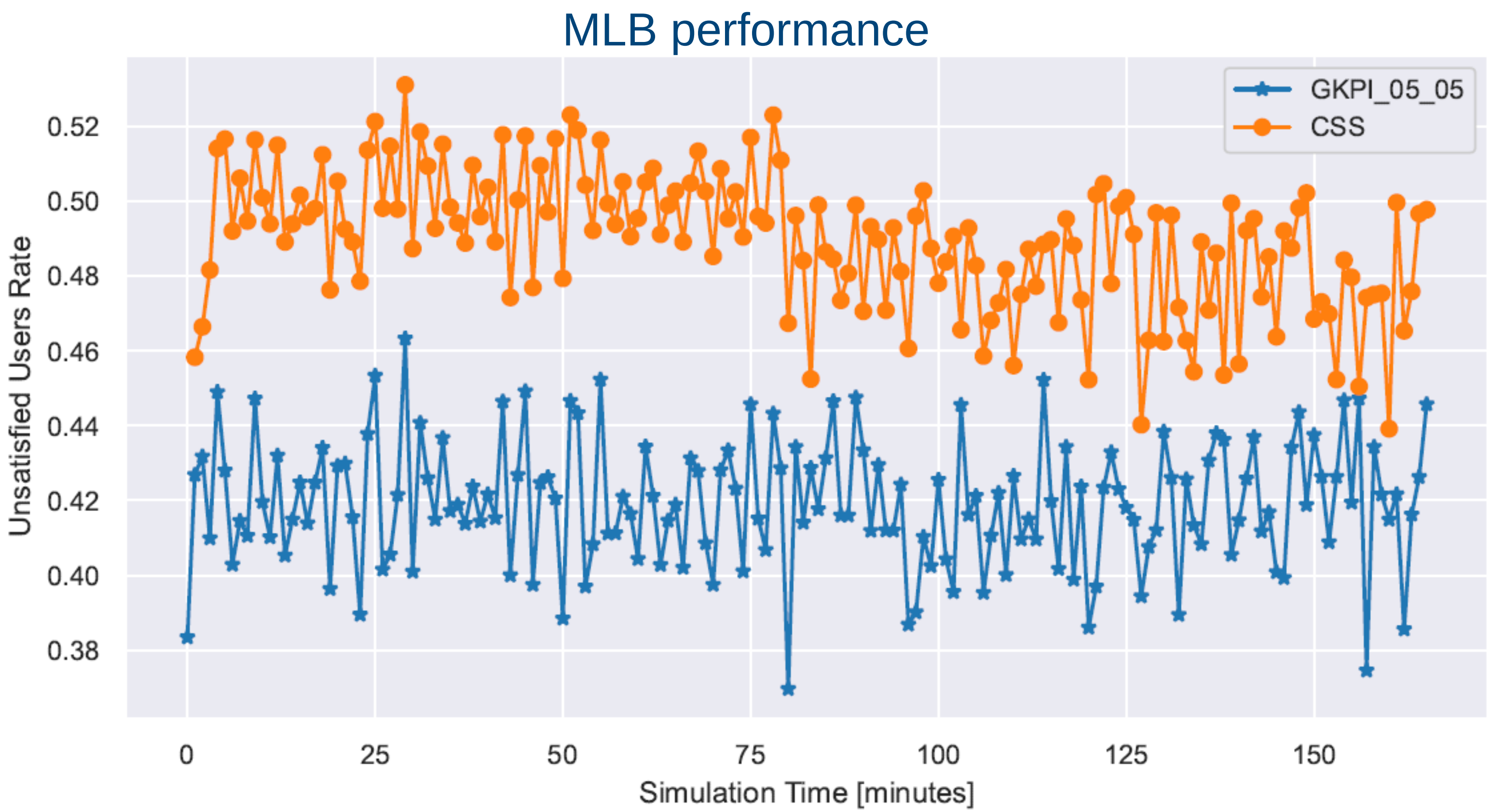
$$\text{GKPI}_c = w_1 * HOAP_c + w_2 * UUs_c$$

GKPI Setups	MRO w_1	MLB w_2
GKPI_05_05	0.5	0.5
GKPI_1_0	1.0	0.0
GKPI_0_1	0.0	1.0

Simulation Results: MRO



Simulation Results: MLB



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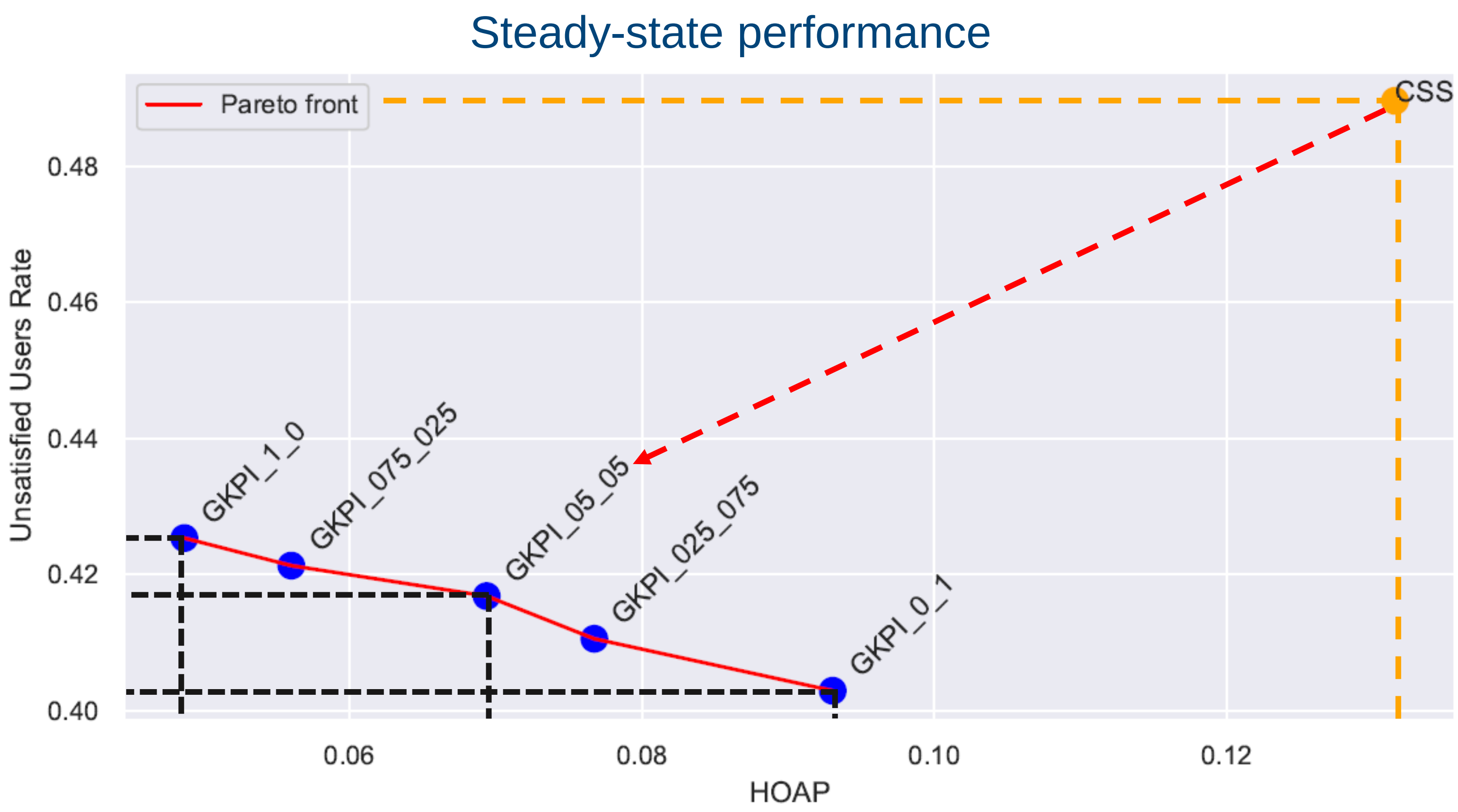
Simulation Results: Steady-State



Conclusions

- Proposed an implicit coordination framework (ML + GA), targeting optimization of GKPI
- It employs a decentralized optimization that considers local neighborhood impacts
- Evaluated the framework on the MRO-MLB conflict
- Simulation results showed minimization of the conflict, outperforming the benchmark scheme
- Demonstrated the flexibility of the framework to adapt to different operator needs by varying GKPI weight combinations

References

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3. J. Sommer and J. Scharf, “IKR simulation library,” in Modeling and Tools for Network Simulation. Springer, 2010, pp. 61–68.

4. S. S. Mwanje and A. Mitschele-Thiel, “STS: space-time scheduling for coordinating self-organization network functions in LTE,” in 2015 IFIP/IEEE International Symposium on Integrated Network Management (IM). IEEE, 2015, pp. 357–362

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Thank You!

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Parameters

TABLE I
SIMULATION PARAMETERS

Parameters	Value
Inter-site distance	500 m
Pathloss	128.1 + 37.6 *$\log_{10}[\max(d[\text{km}], 0.035)]$
Shadowing	Standard deviation = 6 dB; Decorrelation distance = 50 m
eNB Tx power	46 dBm
eNB Tx antennas	gain 15 dBi, height = 32 m
Number of users	420 mobile, 40 static (cell 10)
User's velocity	10-60 Km/h
Mobility model	Random Walk
Positions of users	random, uniform distribution
UE receive antennas	gain 2 dBi, height = 1.5m
User data rate	512 kbps
PP Time	5 seconds
T310	0.2s
TTT	0-1280 ms
Hys	0-7 dB steps: 0.2 dBs
Weights in (2)	$w_1 = 0.2$ $w_2 = 0.4$ $w_3 = 0.4$
SON interval	5 seconds
CIO	$-6\ to + 6\ dB\ steps$: $0.5\ dBs$

TABLE IV
MODEL'S HYPERPARAMETERS

Model	Hyperparameters	RMSE
DNN	units=58/96/96/1, act=RELU	0.032
XGBoost	n_estimators=167, max_depth=9,	0.044
SVR	C=7.5, gamma=0.05, kernel=RBF	0.053

TABLE III
GENETIC ALGORITHM PARAMETERS

Parameters	Value
Number of generations	30
Population size	200
Mutation probability	0.1
Crossover probability	0.6
Number of elites	5