A Performance Evaluation on Channel Assignment based on Deep Reinforcement Learning in Heterogeneous Wireless Network with Unlicensed Bands

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1. Introduction

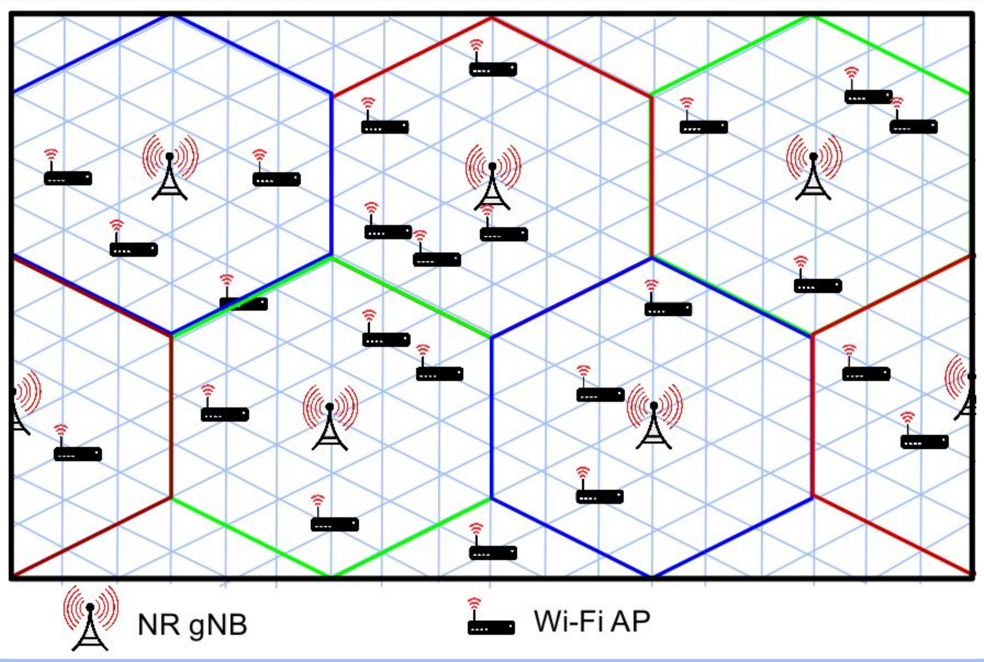
Extending cellular network to unlicensed spectrum

- Growth of mobile data traffic
- Scarcity of licenced band
- Inefficient usage of unlicensed band

Limitation of traditional methods for RRAM

- LBT (LAA R.13, 3GPP)
- CSAT/CA (LTE-U R.10-12, LTE-U forum)
- ABS (LTE R.10 3GPP)

2. Assumed environment



Small areas: covered by one or more APs

Coverage area: same size for AP and BS, hexagonal

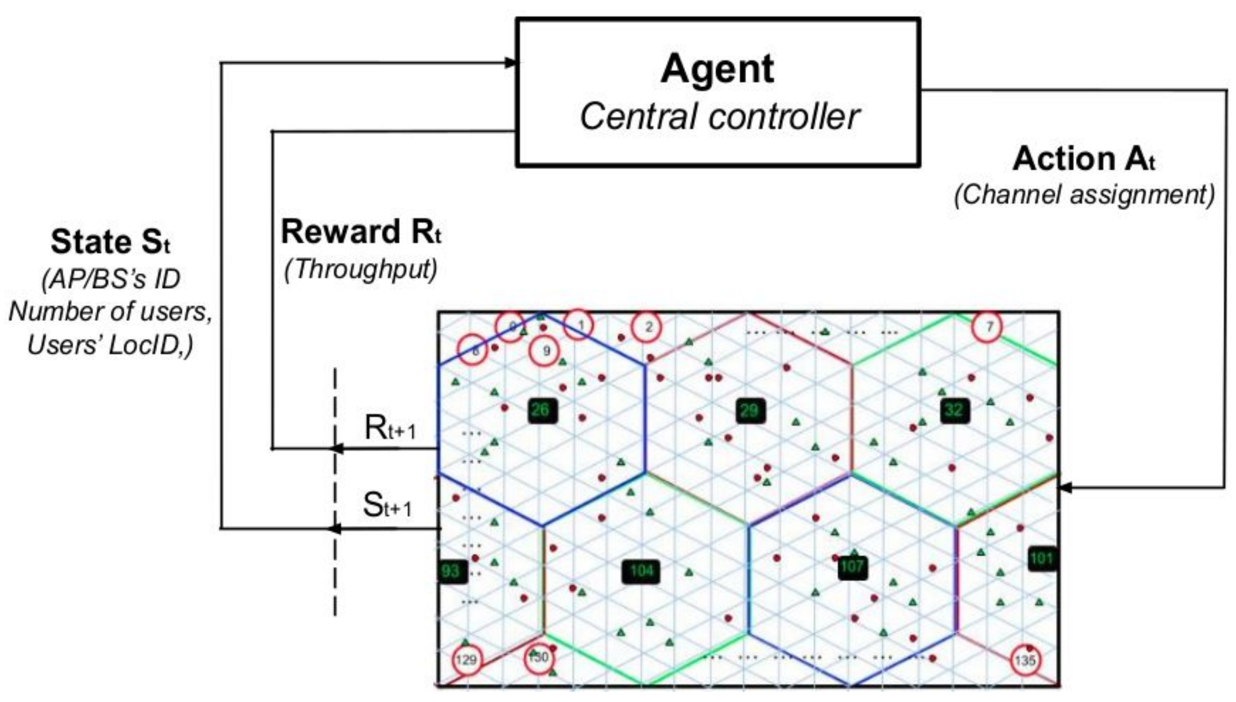
- **Two types of users:**
  - Wi-Fi only users: use the Wi-Fi network only
  - LTE/Wi-Fi combined users: use LTE and Wi-Fi
- **LAA LBT:** Cat 4, Modeled by Markov chain, 5GHz unlicensed

3. Proposed Method

DRL: channel assignment problem →MDP, (S, A, p, R)

- **State space:** # of users and their location ID, channel state
- **Action space:** $A_t \in A=\{0,1,2,3\}$
- **Transition probability:** $p(S_{t+1}, R_t | S_t, A_t) = P_r\{S_t = S_{t+1}, R_t = R_{t+1} | S_{t-1} = S_t, A_{t-1} = A_t\}$
- **Reward function:** $R_t(S_t, A_t)$

Interaction process between an agent and the environment



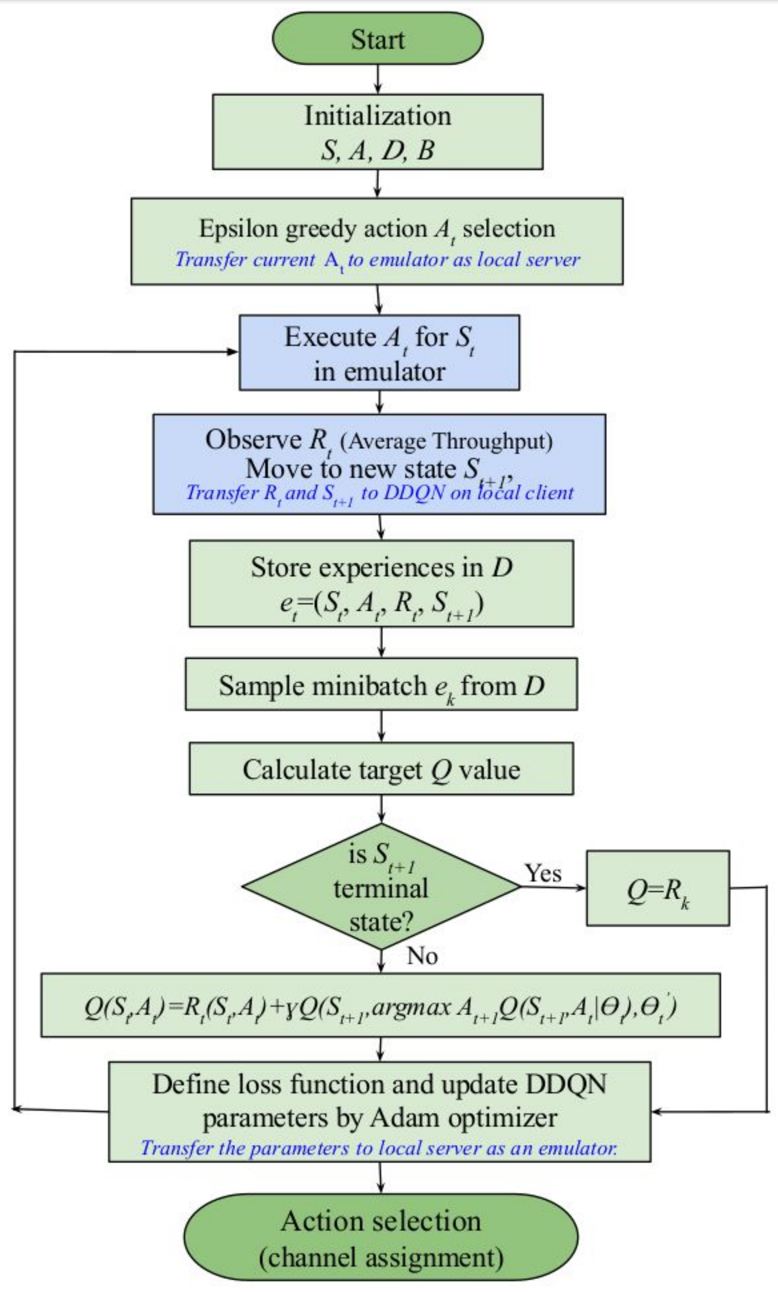
Agent (local client): central controller/ decision maker

Environment (local server): simulator/testbed of agents

$R_t(S_t, A_t)$

Flowchart of DDQN based channel assignment

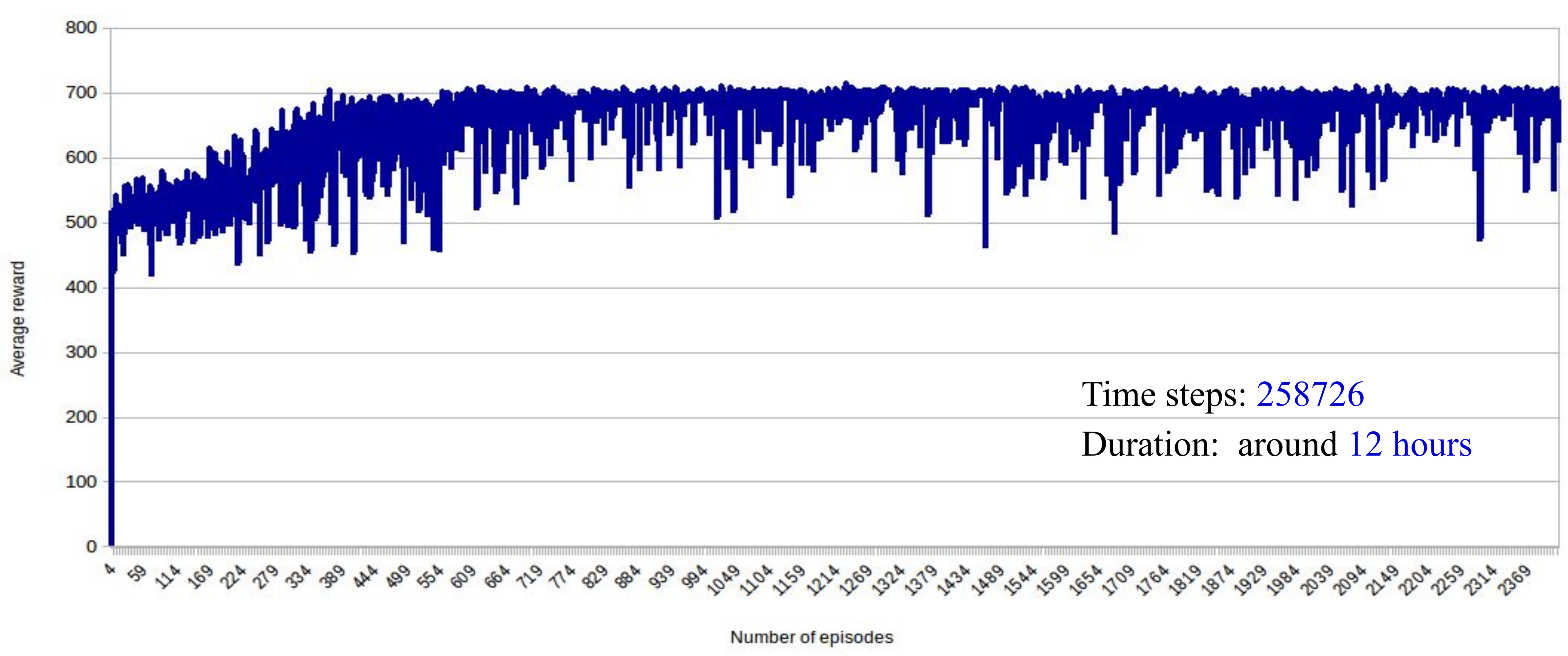
- Time steps: 107
- Epsilon greedy algorithm: $A_t \in A=\{0,1,2,3\}$
- Transfer A_t from DQN (client) to environment (server)
- Calculate $R(S_t, A_t)$
- Transfer R_t, S_{t+1}
- Store $e_t = (S_t, A_t, R_t, S_{t+1})$ in D
- Calculate Q value
- Loss function: Huber
- Optimizer: Adam



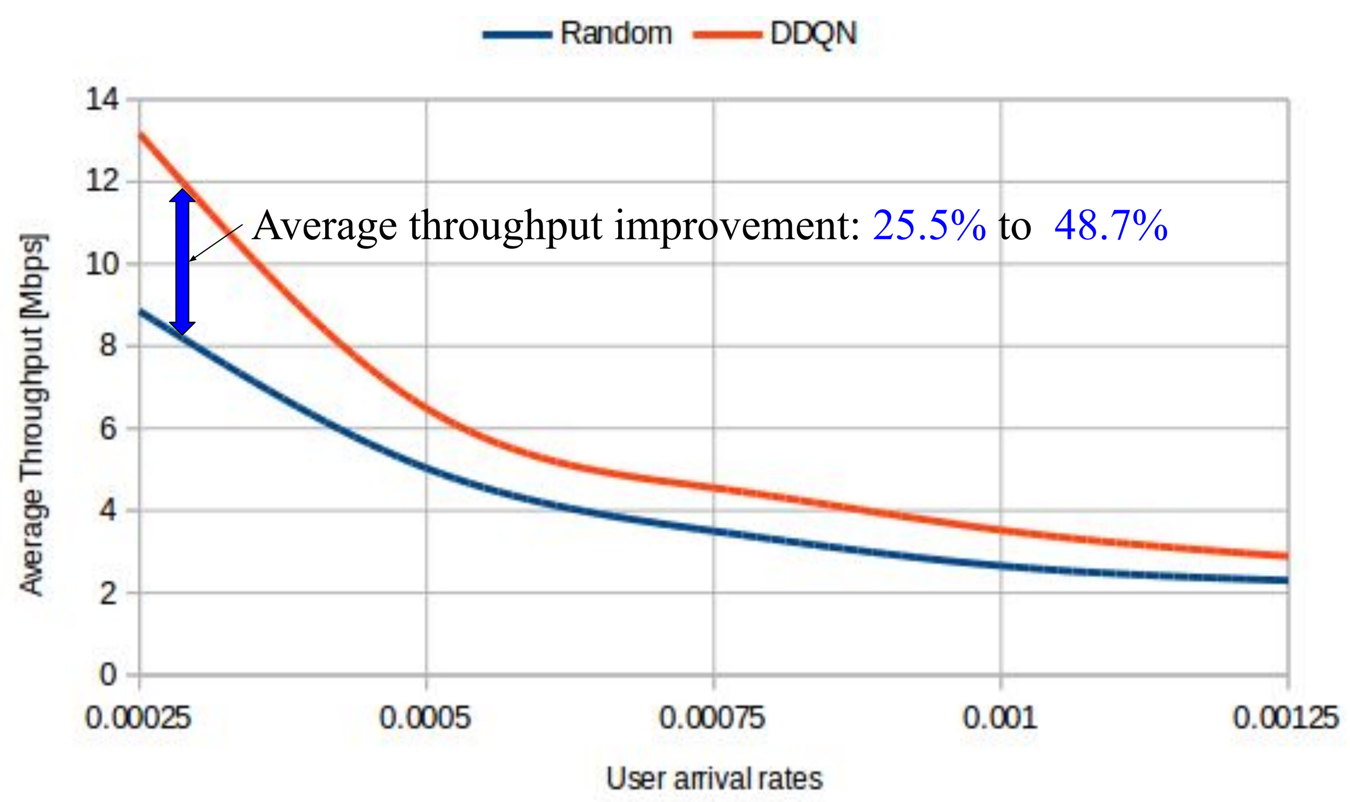
4. Performance Evaluation

Simulation model			
Minimum area:	288	# of channels for AP:	4
Placeable area:	136	# of channels for BS:	3
Coverage area:	54	User arrival rate:	λ (Poisson arrival process)
# of BS:	7	Arrival ratio Wi-Fi and LTE+Wi-Fi users:	1:1
# of AP:	100	Communication time:	300sec (exponential distribution)

Performance of the obtained DDQN model



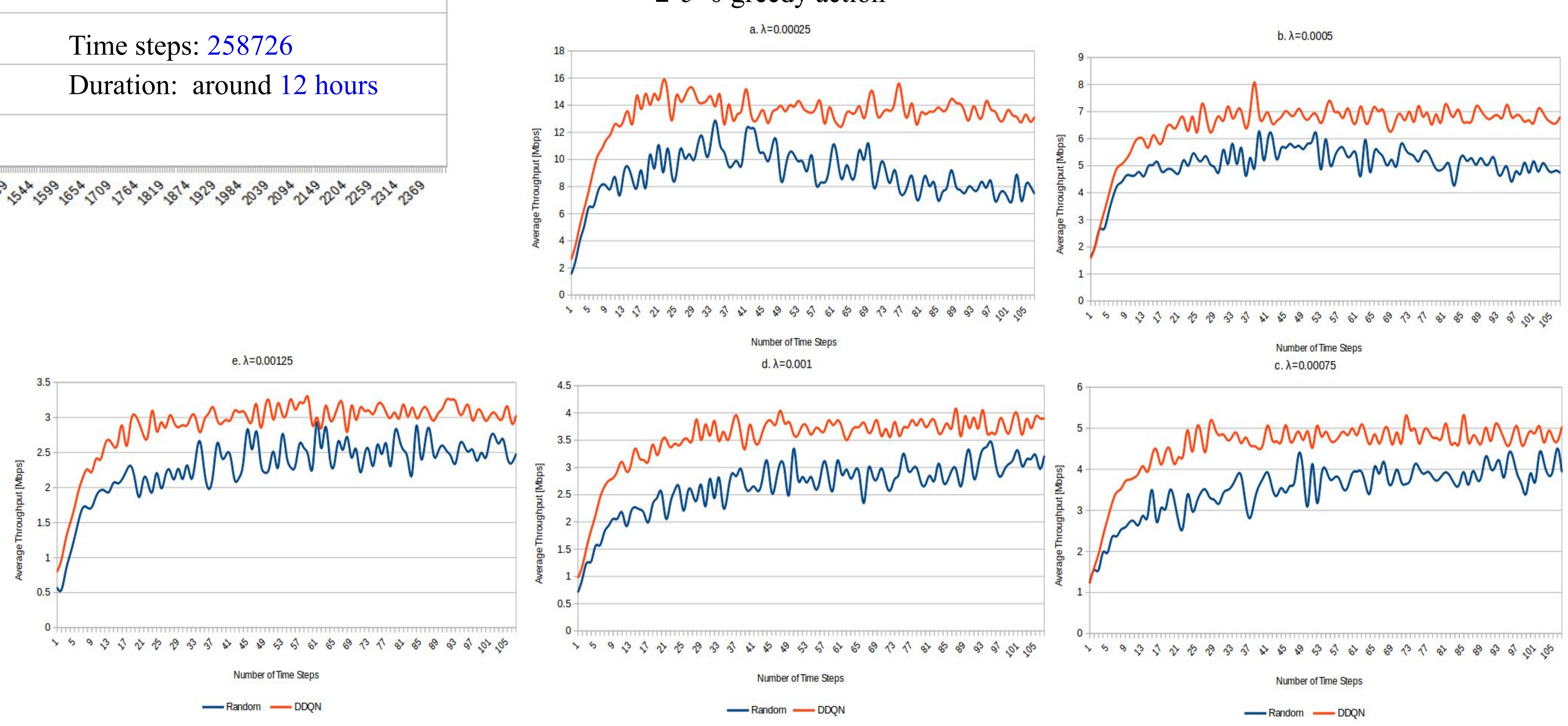
Comparison of average throughput



Validation results in different user arrival rates

Epsilon greedy algorithm: $A_t = \pi(S_t)$; $\pi^* = \max R$

- e=1 random action,
- e=0 greedy action



Network architecture

- Two hidden layer: (tried from 2 to 5)
- Number of nodes per layer (from 8 to 288)

Layer (type)	Output Shape	Total Params	Trainable params	Non-trainable params
dense (Dense)	(None, 60)	6540	8494	0
dense_1 (Dense)	(None, 30)	1830		
dense_2 (Dense)	(None, 4)	124		