Simulation Experiment

2018 11.09

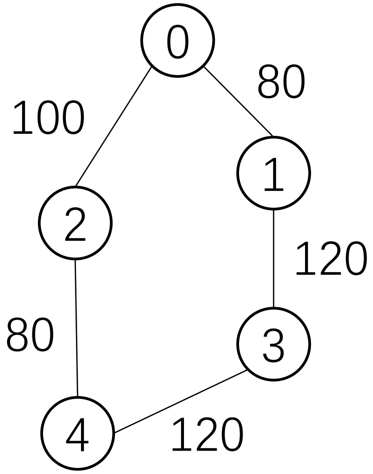
Basic Network Topology

- Domain Relationship:
  - agent 0 is provider of agent 2 and agent1
  - agent 2 is provider of agent 4
  - agent 1 is provider of agent 3
  - agent 3 is provider of agent 4

- Link has capacity as shown, and there is noise when computing throughput.

- The BGP advertisement follows relationships and basic rules:
  - prefer customer and shared-cost to provider
  - prefer customer to shared-cost.

- Static and continuous Traffic Flows in this network.



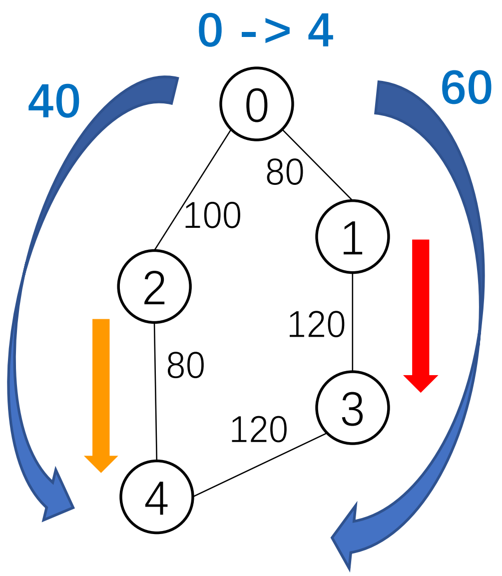
First Case Setting

- To see if the choice of agent 0 will benefit both agent 0 and agent 2, finally converge to an optimum state.

- Traffic flows:
  0 -> 4 2->4 1->3

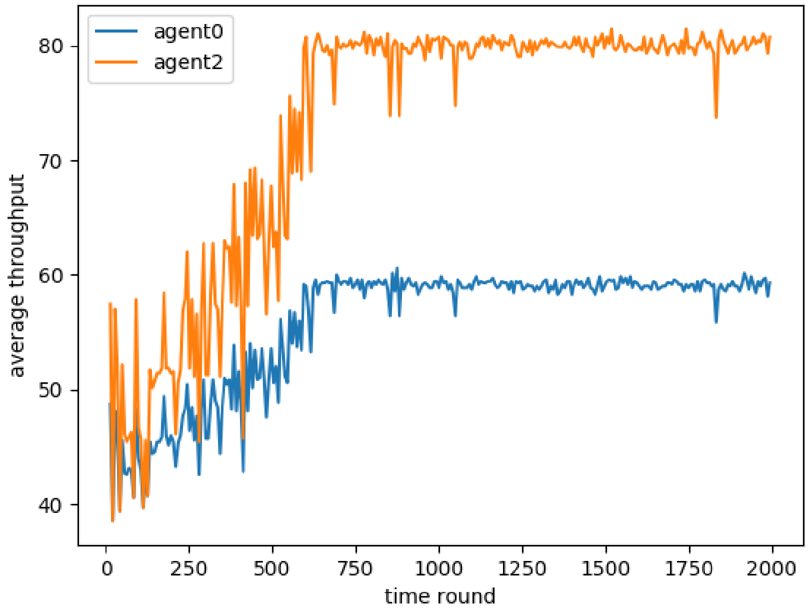
- BGP advertisement for agent 0 to reach 4:
  [0, 2, 4] [0, 1, 3, 4]
  agent 2 only has [2, 4] as valid path
  agent 1 only has [1, 3] as valid path

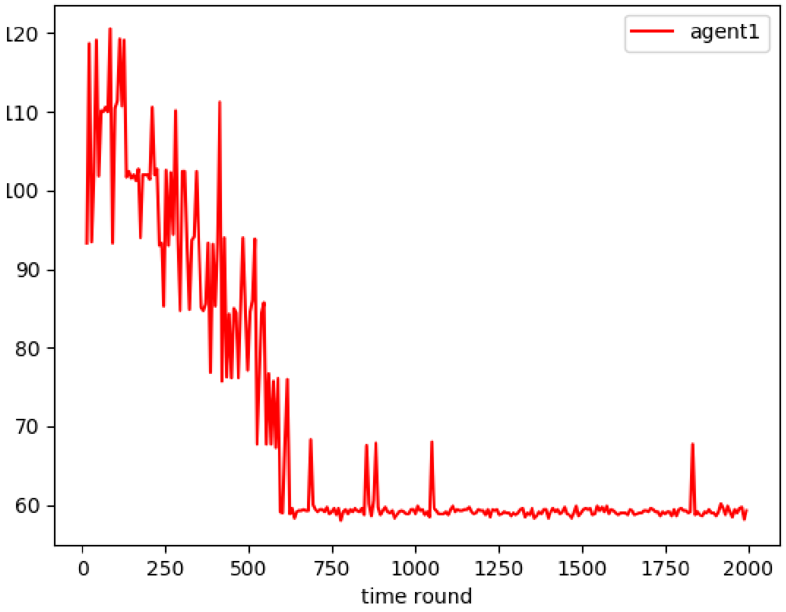
- End-to-end throughputs expectation:
  - agent 0 gets reward 40 when choosing [0, 2, 4]
  - agent 0 gets reward 60 when choosing [0, 1, 3, 4], which benefits both agent 0 and agent 2

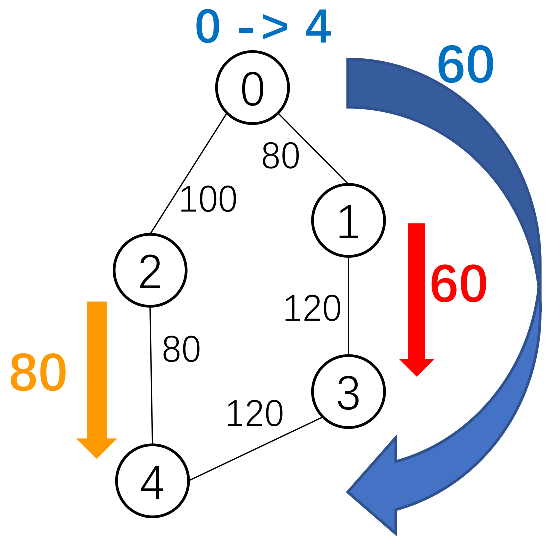


First Case Results

- When agent 0's flow flips strongly during learning:
  - switch between two valid path frequently







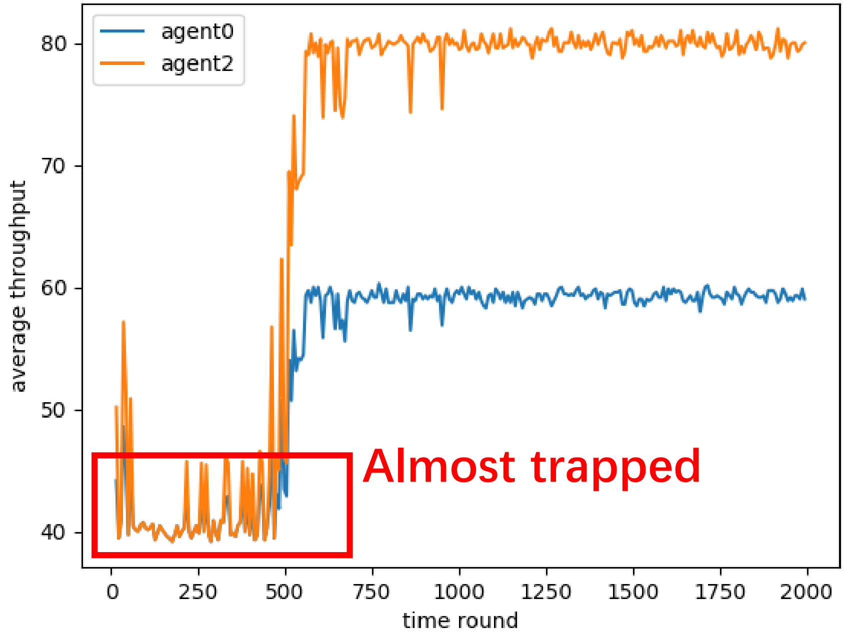
stable state

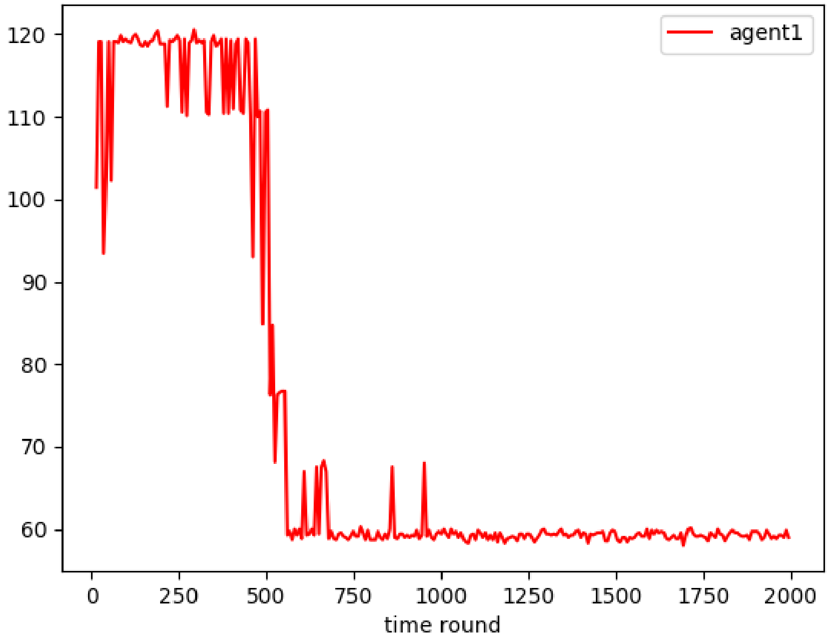
- Finally converge to a stable state (optimum for both 0 and 2):
  - agent 0: 60 agent 2: 80

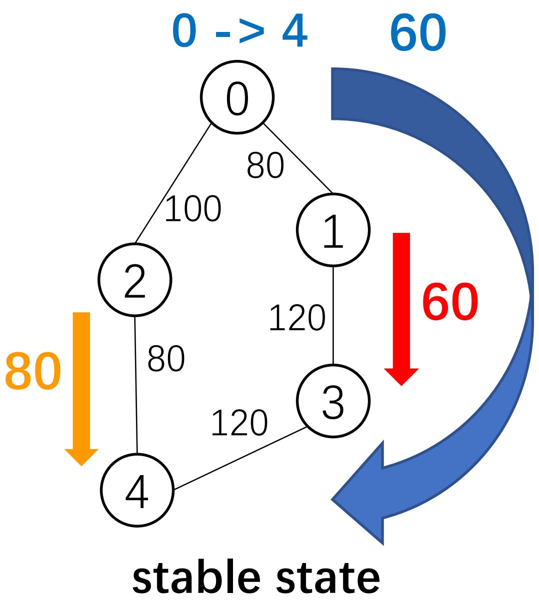
  but agent 1 will be impacted by the action taken by agent 0

First Case Results

- When agent 0 almost trapped into a non-optimum state:
  - frequently choosing 2 as next hop



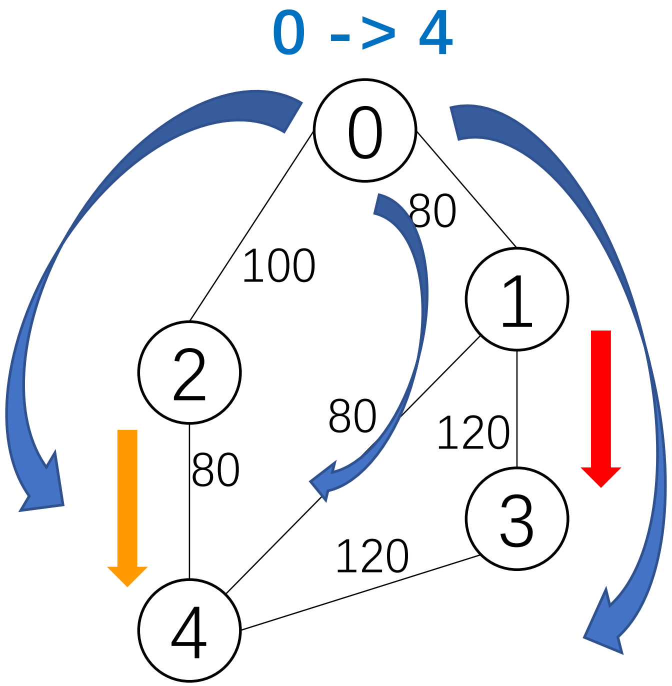




- Agent 0 can still reach the optimum state and be stable.

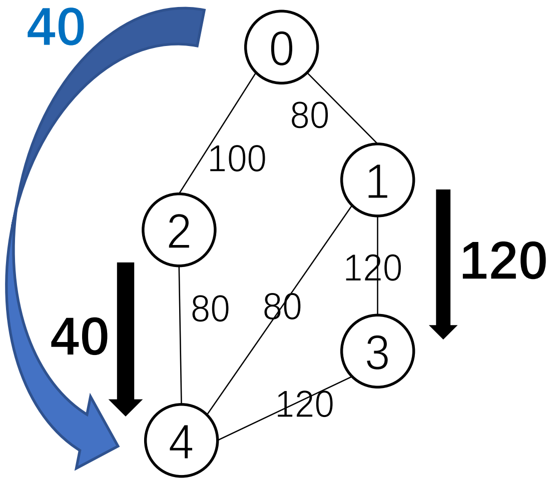
Second Case Setting

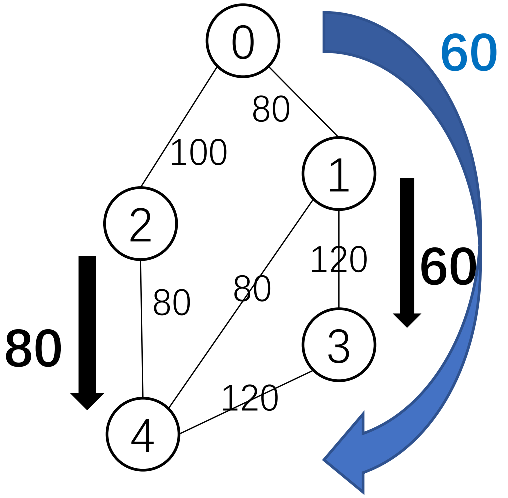
- To see if the choice of agent 0 will also benefit agent 1
- Traffic flows:
  0 -> 4 2->4 1->3
- **Add a new link** 1-4 with capacity 80
- Flow 0->4 has 3 valid paths to forward:
  [0, 2, 4] [0, 1, 4] [0, 1, 3, 4]
- For agent 0, when it chooses 1 as next hop, it benefits both agent 0 and agent 2. For by-passing agent 1, choosing 4 as next-hop benefits both agent 0 and agent 1.



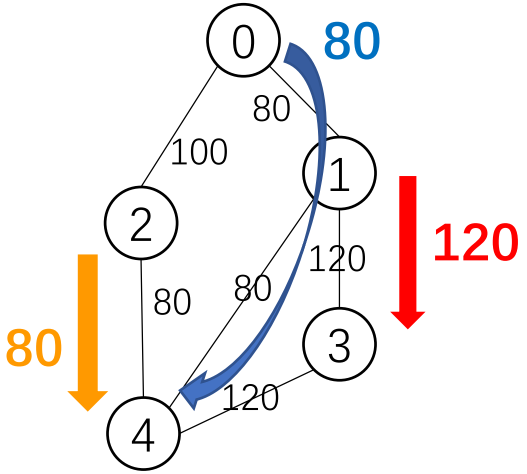
Second Case Results

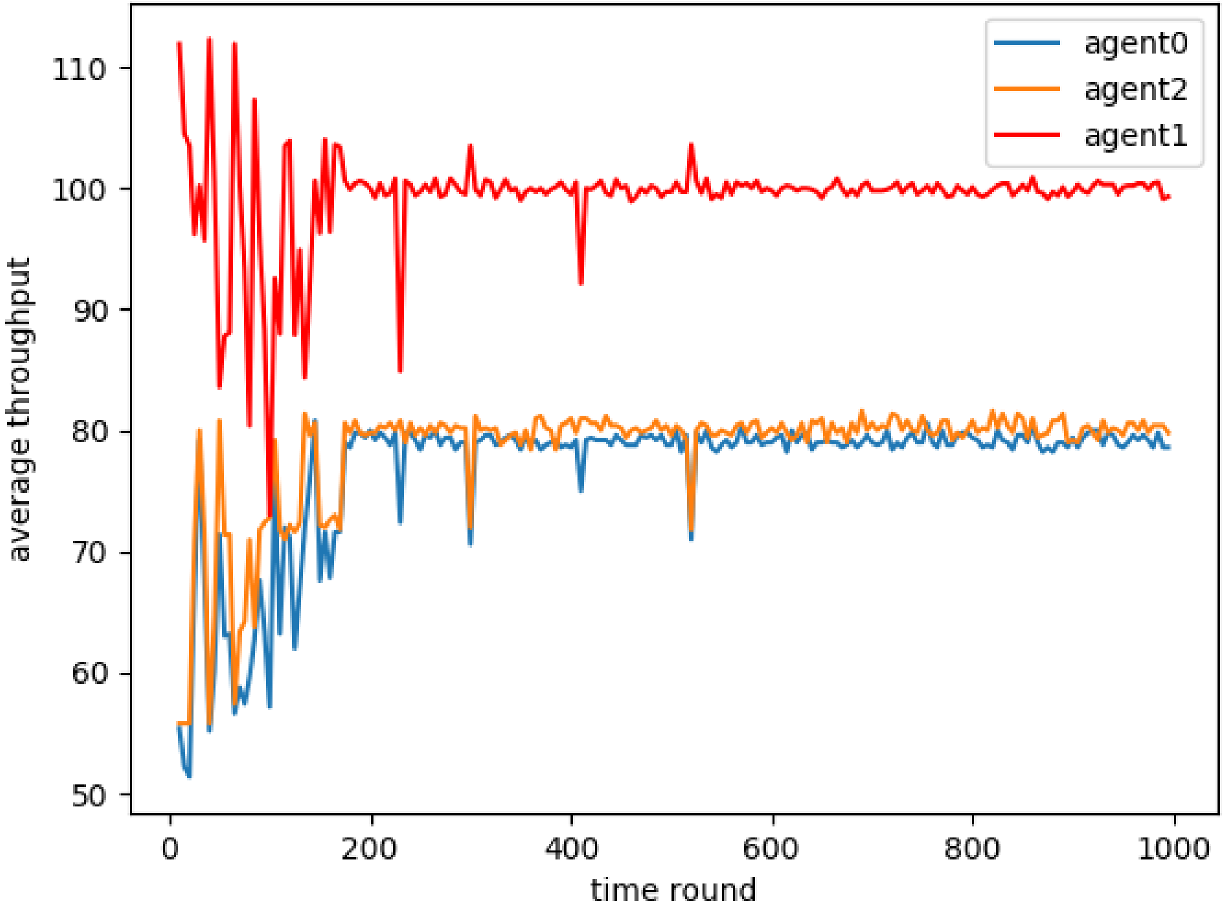
- Non optimum state





- Optimum state (stable)





Average throughput:

Agent 0: 80

Agent 2: 80

Agent 1: (80+120)/2 = 100

Benefit agent 0, agent 2 and also agent 1

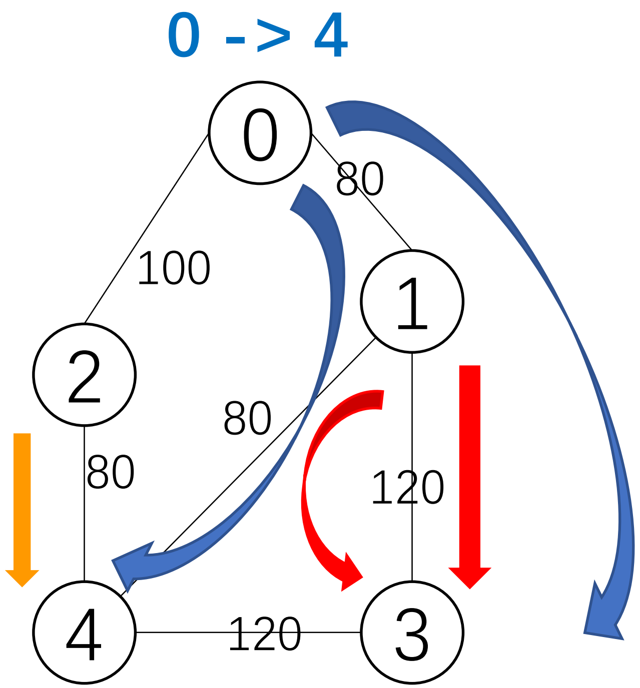
Third Case Setting

- To see when agent 1 has more than one valid actions to choose, if the system can converge to an optimum equilibrium state.

- Change the domain relationship:
  agent 4 and agent 3 are shared-cost

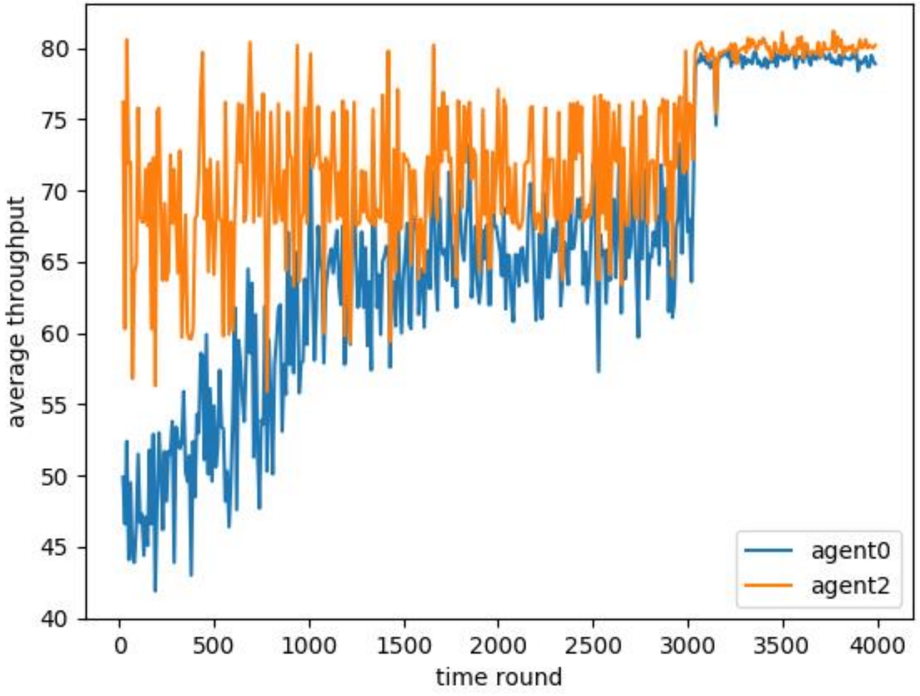
- Traffic Flows
  0->4 2->4 1->3

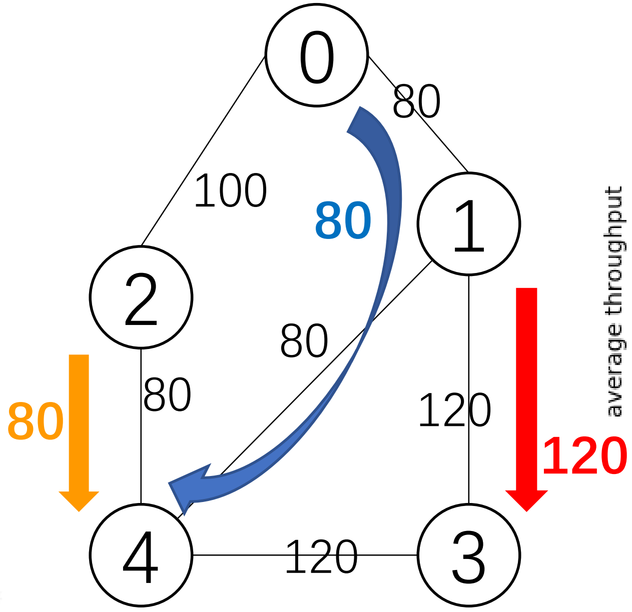
- Valid path for agent 0 to reach 4:
  [0, 2, 4] [0, 1, 4] [0, 1, 3, 4]
  Valid path for agent 1 to reach 3:
  [1, 3] [1, 4, 3]

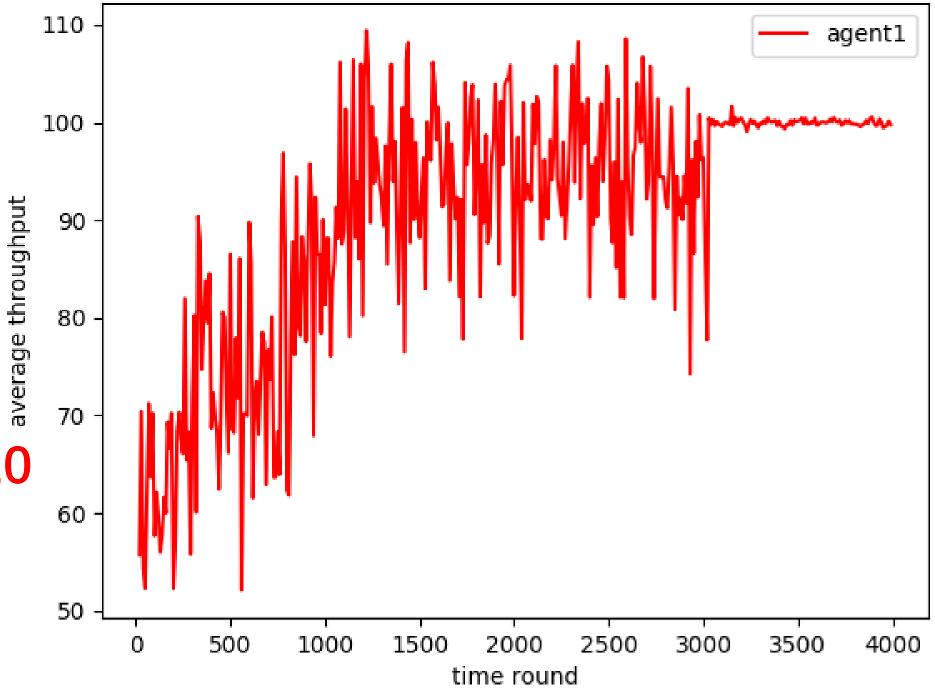


Third Case Results

- Finally reach to an equilibrium state, which is optimum for all agents.







Average throughput:

Agent 0: 80

Agent 2: 80

Agent 1: (80+120)/2 = 100