Dynamic Service Function Chain Embedding for NFV-Enabled IoT: A Deep Reinforcement Learning Approach

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Agenda

- Introduction
- System Model
- Problem Formulation
- Deep Reinforcement Learning Approach
- Simulation Results
- Future Work

Introduction (1)

- Internet of things (IoT) : Heterogeneous nature, challenge for traditional network framework.

- Network Function Virtualization (NFV): Network functions like firewall, load balancing, etc. implemented as software functions on physical nodes called Virtual Network Functions (VNFs).

- Service Function Chain (SFC): Sequential arrangement of VNFs.

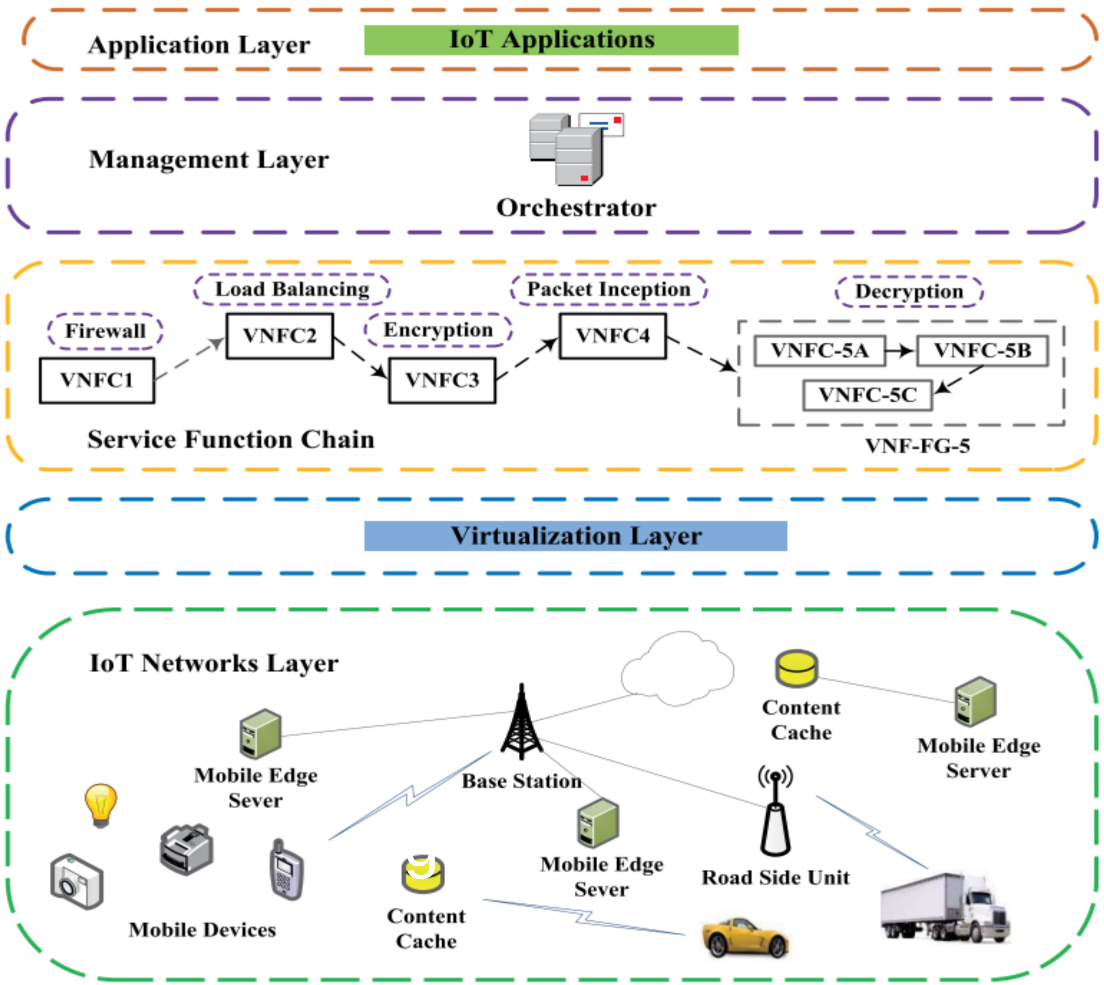
- SFC embedding: Allocation of computing and storage resources for VNFs on physical nodes of substrate network.

Introduction (2)

- Dynamic problem: Diverse applications, unpredictable data for processing in IoT network.

- Proposed Approach: Deep Reinforcement Learning method for SFC embedding in NFV-enabled IoT network.

System Model



SFC embedding in the NFV-enabled IoT network

Problem Formulation (1)

States, Actions and Rewards: IoT network with N nodes

- State space:

$$s = \left\{ \{1_c, 2_{c,}, 3_c, \dots, N_c\}, \{1_m, 2_m, 3_m, \dots, N_m\}, \{b_{ij}\} \right\}$$

where,

- $\{1_c, 2_{c,}, 3_c, \dots, N_c\}$ - Computing resources of IoT network.
- $\{1_m, 2_m, 3_m, \dots, N_m\}$ - Memory resources of IoT network.
- $\{b_{ij}\}$ - Bandwidth between node i and j. where, i, j $\in \{1, 2, 3, \dots, N\}$

Problem Formulation (2)

- Action space:

  action $\in \{ 1, 2, 3, \dots, N \}$

- Rewards:
  - Reward metric: Total delay of allocating resources for an SFC

$$d_{total} = d_t + d_{proc}$$

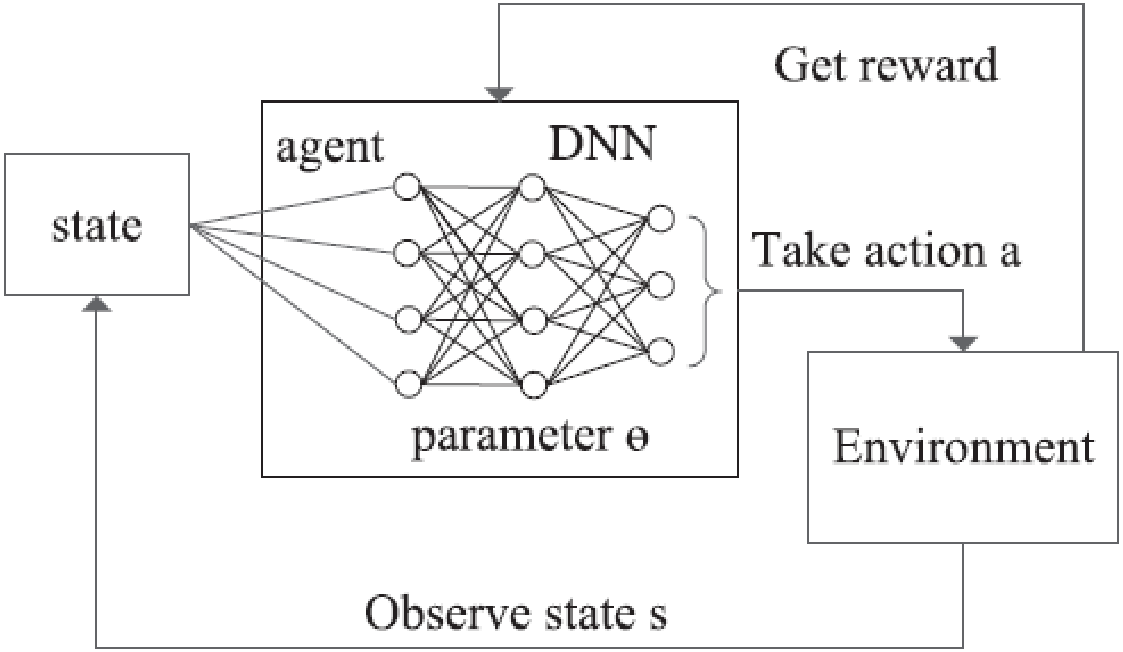
$$where, \quad d_t - transmission\ delay\ between\ two\ VNFCs$$
$$d_{proc} - processing\ delay\ of\ the\ VNFCs\ on\ physical\ nodes$$

  - Reward function at every time step:

$$reward = \alpha \,.\left(f_t + f_{proc}\right)^{-1}$$

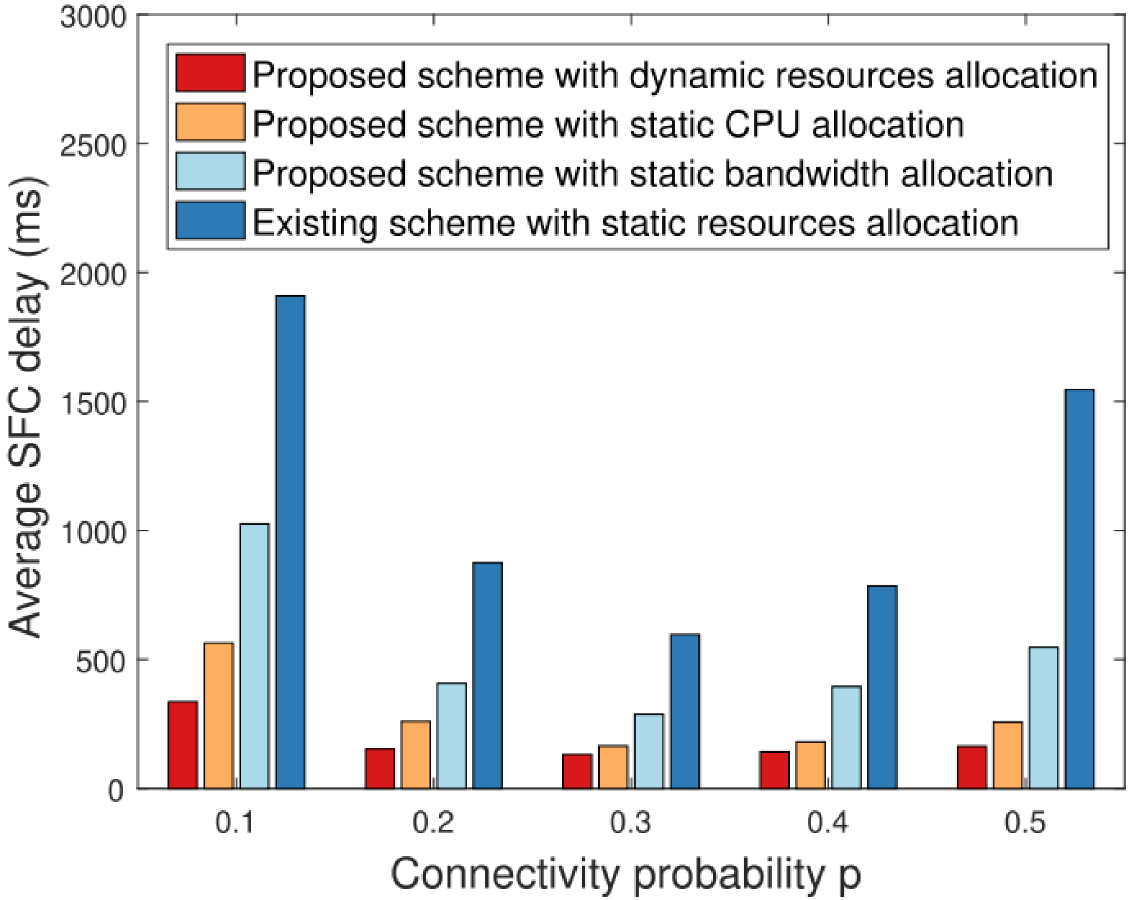
$$where, \quad \alpha - \alpha > 0,\ constant\ reward\ coefficient$$
$$f_t + f_{proc} - total\ delay\ of\ each\ VNFC\ resource\ allocation$$

Deep Reinforcement Learning Approach



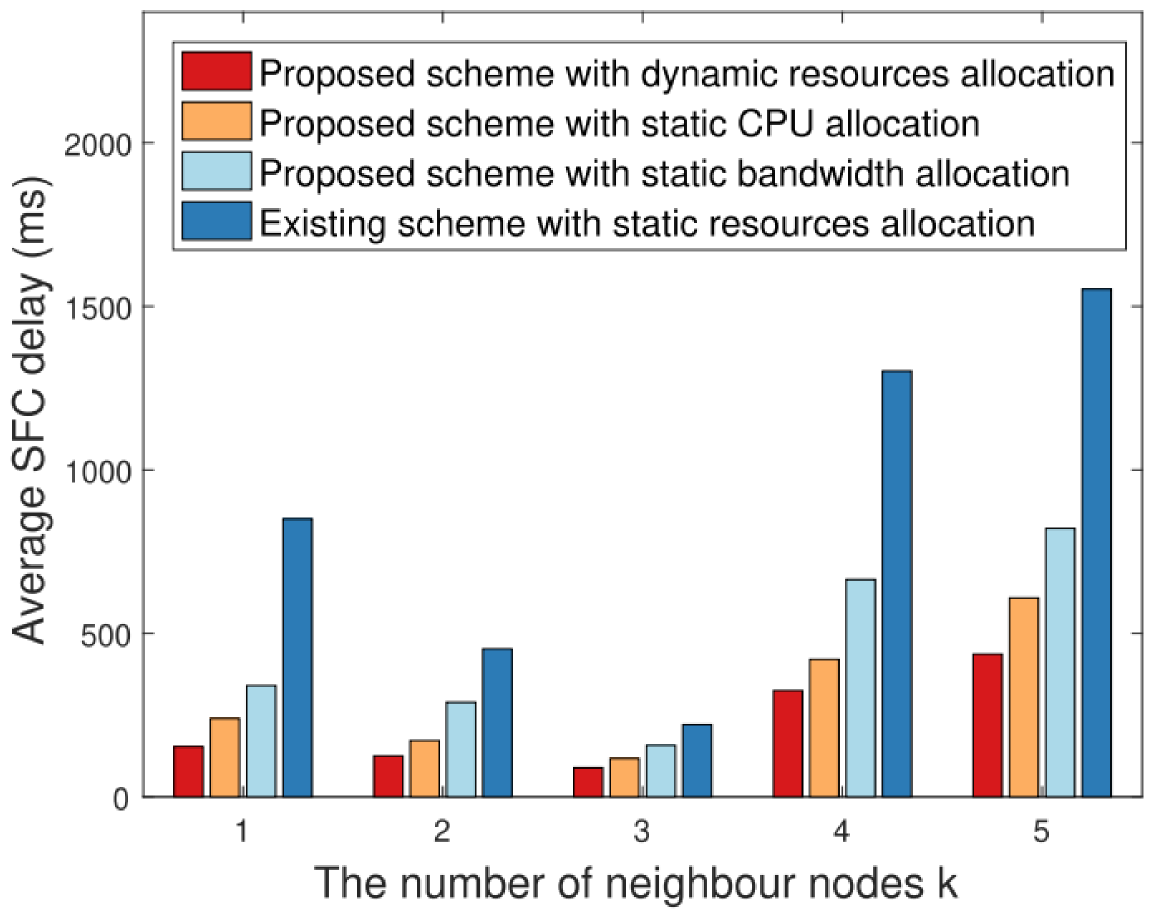
A reinforcement learning model with a deep neural network

Simulation Results (1)



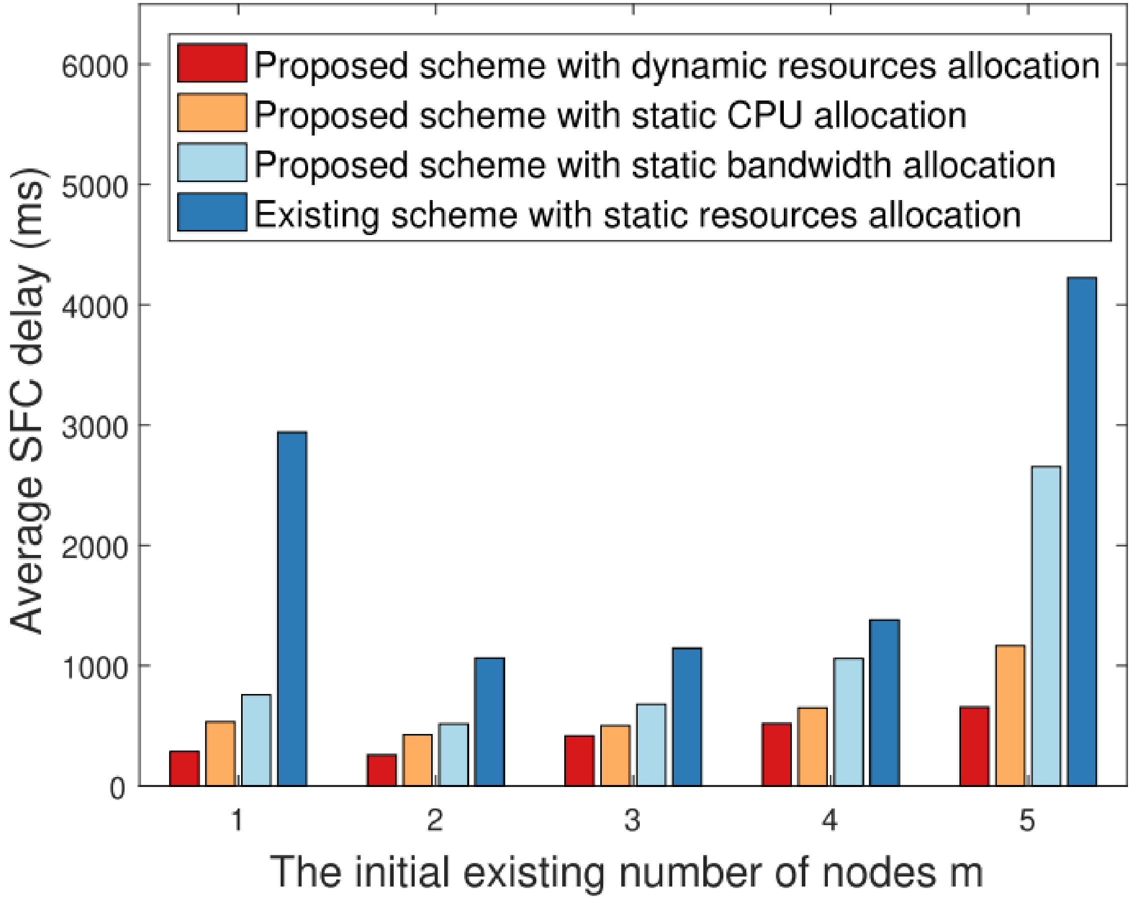
The average delay of a SFC in random network topologies with different node connectivity probabilities.

Simulation Results (2)



The average delay of a SFC in small-world network topologies with different number of neighbor nodes.

Simulation Results (3)



The average delay of a SFC in BA scale-free network topologies with different initial existing nodes.

Future Work

- Evaluate performance with other Reinforcement Learning Algorithms.

- Evaluate with conventional neural networks algorithm for SFC embedding problem in NFV-enabled IoT network (As proposed by authors)

References

Fu, Xiaoyuan, et al. "Dynamic Service Function Chain Embedding for NFV-Enabled IoT: A Deep Reinforcement Learning Approach." IEEE Transactions on Wireless Communications (2019).

Thank You