Latency Aware VNF Deployment at Edge Devices for IoT Services: An Artificial Neural Network Based Approach - Implementation

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April 15, 2021

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Introduction

Abstract

VNF in edge devices is used to improve the response time, to avoid excessive use of core network and reduction in use of user-VNF end to end latency to a considerable extent, while holding Internet of things services in context to Network Function Virtualization (NFV). A new proposal of VNF placement strategy using Artificial Neural Network (ANN) trained by assignments solutions generated by Integer Linear Programming (ILP) model of optimal edge VNF placement method for smaller instances of VNFs. This method resolved problems for VNF assignment problems of edge devices with more number of VNFs with reducing time complexity to be linear and providing similar results as of ILP model in context to latency.

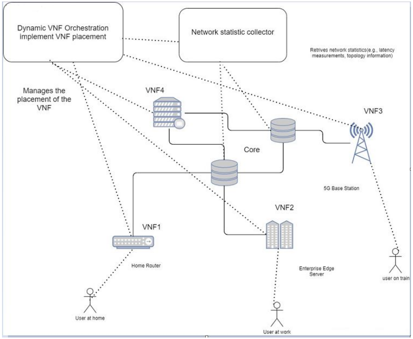
Introduction

- Network functions virtualization (NFV) is a way to virtualize network services, such as routers, firewalls, and load balancers, that have traditionally been run on proprietary hardware. These services are packaged as virtual machines (VMs) on commodity hardware, which allows service providers to run their network on standard servers instead of proprietary ones. NFV architecture consists of VNFs.

Introduction

- Network Function Virtualization (NFV) is a novel networking paradigm that has become a key enabling technology for delivering such services.
- Placing VNFs based on the decision of Artificial Neural Network (ANN) trained by opti-mal solutions approach.
- The Integer Linear Programming(ILP)-based ANN-based approach for assigning VNFs to edge computers, where the training process includes optimal assignment solutions of different VNF and host pairs.

Figure 1: A high level architecture of VNF Placement at IoT edge devices, managed by VNF orchestrator for latency critical IoT services.



System

Model

Using ILP problem VNF are deployed and found the optimal solution for it. The optimal Edge VNF placement strategy aims to find the latency optimal VNF assignments in edge devices or the distant cloud. Training an ANN to predict the optimal VNF placement solution is promising in reducing the optimization time and improving the user experience.

Model

Table 1: Table of parameters for the System model

Network Parameters	Description
M = (*Host*, *Link*, *User*)	Undirected model of network
$Host = \{ h_1, h_2,.....h_H \}$	Host available in the network
$Link = \{ e_1, e_2......e_M \}$	All the links in the network
$User = \{ u_1, u_2......u_U \}$	Users associated with the network

Model

Network Parameters	Description
$lat_i j$	Latency of the networks
cap_j	Hardware capacity of the host
C_{ij}	Capacity of the link between the host and the user

Model

Network Parameters	Description
Network = $\{n_1^1, n_2^2, n_3^3 \ldots\ldots n_n^n\}$	Network function that needs to be allocated
req_i	Host requirement for each VNF $n_i \in$ Network
θ_i	Maximum latency tolerance limit of each VNF $n_i \in$ Network

Model

Decision Variable	Description
x_{ij}	binary variable defining the best VNF and Host pair for the network
Derived Parameter	**Description**
Lat_{ij}	Total latency between the VNF and Host in a network
ban_{ij}	bandwidth required along the path

Model

The objective function of the model has been formulated using Integer Linear Programming(ILP) can be represented by:

$$min \sum_{n_i \in Network} \sum_{h_j \in Host} x_{ij} \times Lat_{ij} \tag{1}$$

Model

The object function looks for yij values when adhering to the following constraints:

$$C1 : \sum_{n_i \in Network} x_{ij} \times req_i \leq cap_j, \forall_{h_j \in Host} \tag{2}$$

$$C2 : \sum_{h_i \in Host} x_{ij} \times Lat_{ij} \leq \theta_i, \forall_{n_i \in Network} \tag{3}$$

$$C3 : \sum_{h_i \in Host} x_{ij} = 1, \forall_{n_i \in Network} \tag{4}$$

$$C4 : \sum_{h_i \in Host} x_{ij} \times ban_{ij} \leq C_{ij}, \forall_{n_i \in Network} \tag{5}$$

$$C5 : x_{ij} \in \{0, 1\} \tag{6}$$

Results

Figure 2: Look of the raw data ANN

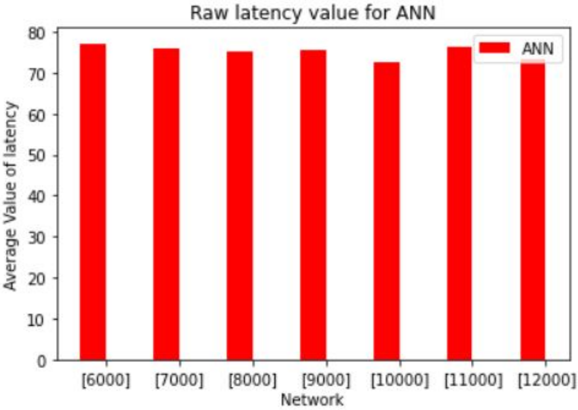


Figure 3: Look of raw data ILP

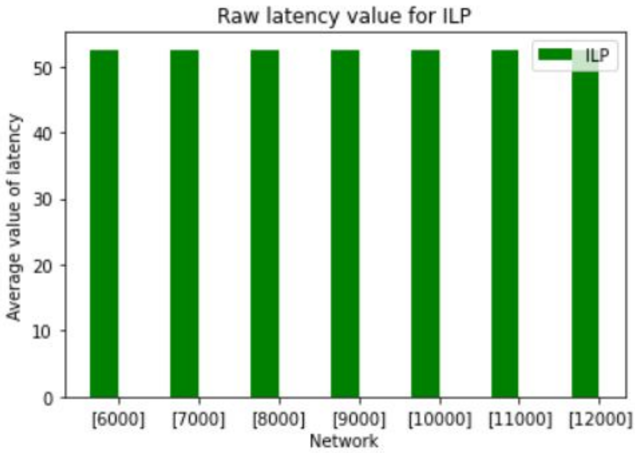
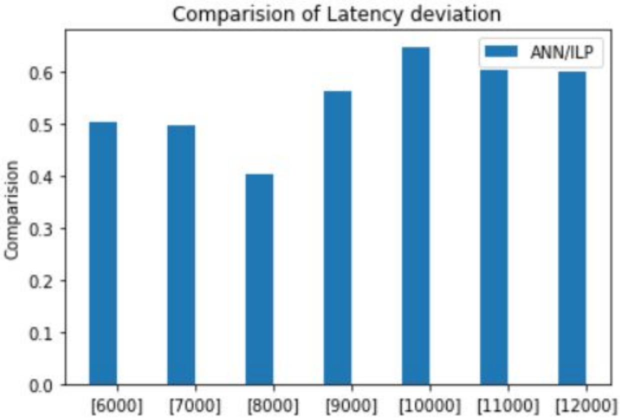
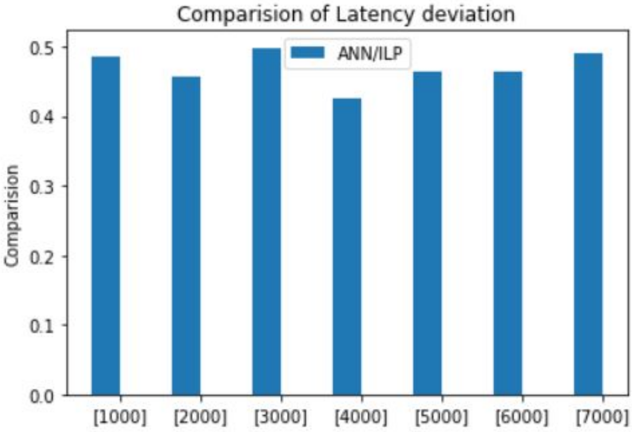


Figure 4: Comparision of latency deviation for 100 hosts



Results

Figure 5: Comparision of latency deviation for 120 hosts



Result

Figure 6: Comparision of latency deviation for 140 hosts

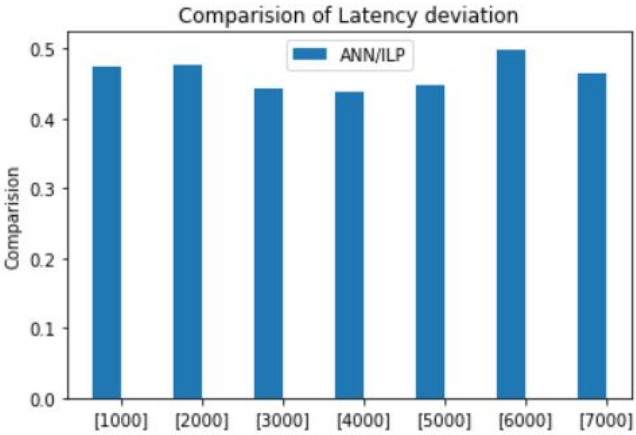


Figure 7: Comparision of latency deviation for 160 hosts

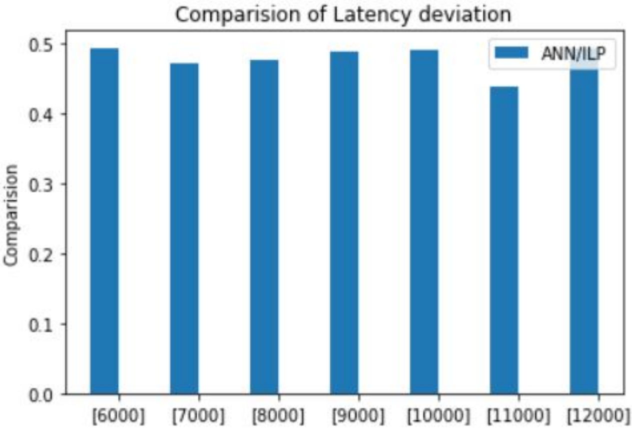
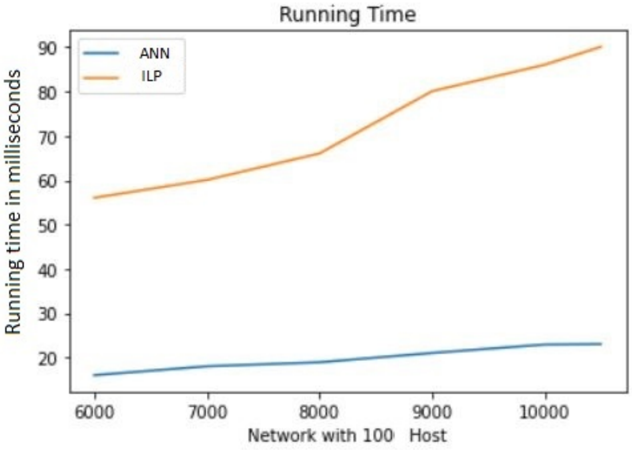
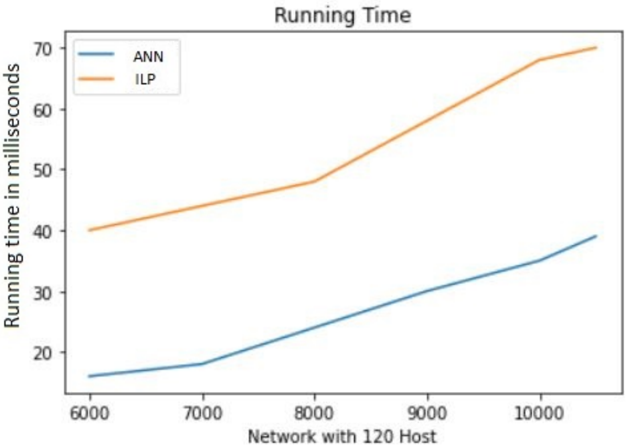


Figure 8: Running time comparison for 100 hosts



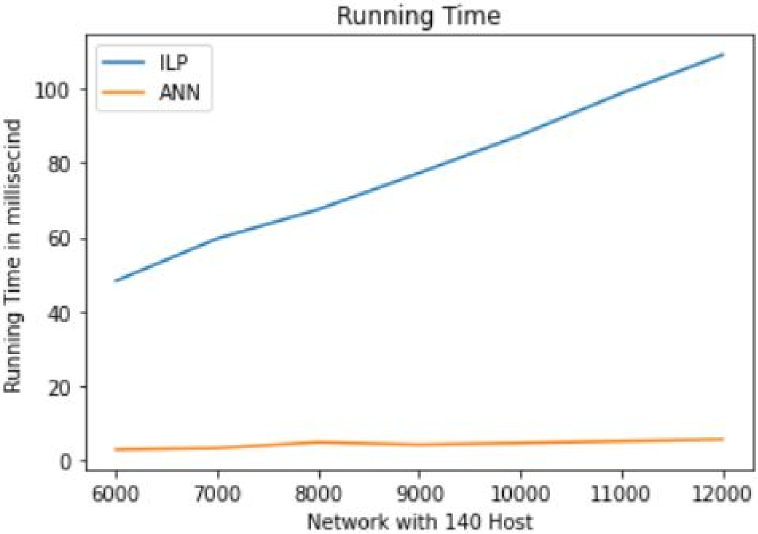
Result

Figure 9: Running time comparison for 120 hosts



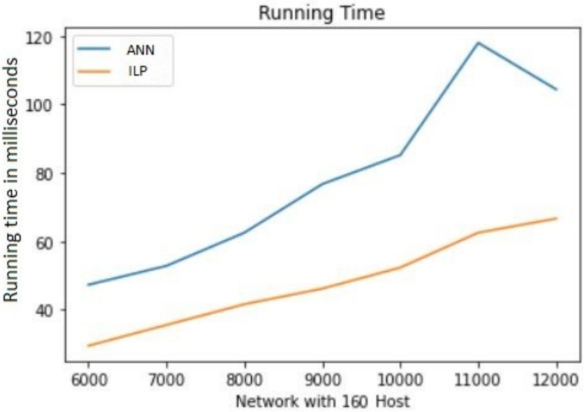
Result

Figure 10: Running time comparison for 140 hosts



Result

Figure 11: Running time comparison for 160 hosts



Conclusion

Conclusion

We argued in this paper that, in order to maintain low end-to-end latency from users to their VNFs in a constantly changing network environment, VNFs must be moved to optimal locations multiple times over the course of an NFV system's lifetime. The goal has been to develop a quicker alternative to the ILP model of optimal edge placement. We used Integer Linear Programming(ILP) to solve the optimal edge VNF placement problem. Because this placement strategy takes exponential time, the trade-off here is between time complexity and latency minimization to ensure optimal latency. As a result, we developed a new placement approach based on the optimal VNF to host assignments created by the ILP model of optimal edge VNF placement for smaller instances, where the training phase is completed based on the optimal VNF to host assignments generated by the ILP model of optimal edge VNF placement for smaller instances.

Acknowledgement

I would like to express my special thanks of gratitude to my professor Dr Salimur Choudhary as well as Mahzabeen Emu who gave me this golden opportunity to do this wonderful project on the topic VNF Deployment at Edge Devices, which also helped me in doing a lot of research and I come to know about so many new things. I am really thankful for all the help and patience given by them towards my progress.

THANK YOU ALL WHO SUPPORTED

Reference

[1] Emu, M., Yan, P., Choudhury, S. (2020). Latency Aware VNF Deployment at Edge Devices for IoT Services: An Artificial Neural Network Based Approach. 2020 IEEE International Conference on Communications Workshops (ICC Workshops), 1–6.