# A Reinforcement Learning Approach for Online Fault-tolerant Chain Placement in Network Function Virtualization*


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***Abstract*—NFV+RL...**



***Index Terms*—component, formatting, style, styling, insert**


## I. Introduction

Currently, regarding that networks are filled with a massive and ever-growing variety of network functions that coupled with proprietary devices, network ossification and difficulty occur frequently in network management and service provision. Network Function Virtualization (NFV) changes such situation by decoupling network functions from the underlying dedicated hardware and realizing them in the form of software, which is called Virtual Network Functions (VNFs) [1]. And usually, a sequence of network functions (NFs) have to be processed in a pre-defined order which is known as service function chain (SFC) [2], [3]. Thus, a critical problem appears, that is, how to determine the positions for deploying SFCs so that the service requirement can be satisfied. Such problem is proved to be NP-hard [4] and nowadays many solutions are proposed to reach different optimization objectives such as maximizing the number of accepted requests or throughput or minimizing the cost of latency.

However, the stability of the system is as important. As we know, middle-box failure appears frequently, leading to degradation of service performance and reliability [5]. Although VNFs which are regarded as virtual middle-boxes take away some hardware faults on account of managed by a centralized software defined mechanism, other failures still live due to several reasons, such as connectivity errors (e.g., link flaps, device unreachability, port errors), misconfiguration (wrong rule insertion, configuration conflicts), software faults (reboot, OS errors) or excessive resource utilization. Packet drops, reset of connections, redundant packet delays and even security issues may happen with temporary failures of NFs [6]. A common approach for achieving VNFs stability is through redundancy, where an additional instance of each SFC active instance acts as a backup [7], [8]. But reserving no resources for backup instances in advance may not work when server resources are not sufficient for the frequency of failures. In the opposition, server resources will be wasted for usually not all the SFCs encounter problems simultaneously. Therefore, a relatively balanced and flexible backup deployment approach is called for, which would relax the rigid requirement of an entire dedicated copy per active instance and work well in most cases.

Nevertheless, network state and traffic typically exhibit real-time unpredictable variations due to stochastically arriving requests [9], [10]. Thus, an online fault-tolerant SFC deployment approach is needed. To conclude, in order to reach this solution, we need to deal with two major tasks: (1) efficiently placing SFCs on commodity servers to maximize the number of accepted requests in chronological order of arrival and (2) effectively duplicating active instances with minimal waste of resources. For the first task, we introduce a deep reinforcement learning based approach to handle the real-time service requests. For the second task, Fig. 1 shows our deploy design to settle it...

Considering several essential restrictions of SFC deployment, we meet three major challenges when tackling these two tasks:

- Since requests arrive randomly with the sequence of time slots, we should decide the positions of both active and backup instances in real time.
- In addition of the positions of instances, the link paths containing active traffic paths, state updating paths and


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backup traffic paths are as important. We are required to provide reliable paths to support the transportation.
- Due to the tremendous waste of duplicating all the entire SFC instances and the unreliability of reserving no resources, finding a way to balance the reservation of server and link resources is our goal of win-win.

Differing from the previous works, our work comprehensively addresses these three challenges. We tackle the first challenge by applying an online deep reinforcement learning approach called DQN (deep Q-networks) to deploy both active and backup instances of every coming requests. For the second challenge, we propose a heuristic algorithm to decide the active traffic paths, state updating paths and backup traffic paths. For the third challenge, we also provide four models to meet different customer needs.

In summary, we study the SFC online backup placement, which is a timely important problem in Network Function Virtualization. The contributions of this paper are as follows:

- We apply the model of DQN to deploy both active and backup SFC instances concurrently. Our model provides an online solution to handle the real-time network variations and various service requests. To our best knowledge, we are the first to use reinforcement learning in SFC backup placement.
- In order to provide a fault-tolerant deployment scheme, we propose a heuristic algorithm to effectively select the transportation links and compare four different cases of resource reservations to satisfy costumer needs.
- experiment results...

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### B. Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive".
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$$a+b=\gamma \tag{1}$$

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Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is "Heading 5". Use "figure caption" for your Figure captions, and "table head" for your table title. Run-in heads, such as "Abstract", will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

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TABLE I
TABLE TYPE STYLES

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[a]Sample of a Table footnote.

Fig. 1. Example of a figure caption.

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## ACKNOWLEDGMENT

The preferred spelling of the word "acknowledgment" in America is without an "e" after the "g". Avoid the stilted expression "one of us (R. B. G.) thanks ...". Instead, try "R. B. G. thanks...". Put sponsor acknowledgments in the unnumbered footnote on the first page.

## REFERENCES

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Unless there are six authors or more give all authors' names; do not use "et al.". Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [**?**]. Papers that have been accepted for publication should be cited as "in press" [**?**]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [**?**].

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