Flexible VNE Algorithms Analysis using ALEVIN

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Abstract — Network virtualization is recognized as an enabling technology for the Future Internet that overcomes network ossification. However, it introduces a set of challenges. In any network virtualization environment, the problem of optimally mapping virtual demands to physical resources, known as virtual network embedding (VNE), is a crucial challenge. This paper analyses the behaviour of the main algorithms proposed to solve VNE by means of the ALEVIN framework. The VNE algorithms are evaluated with regard to appropriate metrics such as: cost, revenue, and virtual network acceptance ratio. We also analyse the impact of the recently introduced hidden hop demand concept in the performance of the VNE algorithms.

I. INTRODUCTION

Network virtualization is expected to deliver the flexibility needed for service-tailored future networks [1]. One key problem to network virtualization is the virtual network embedding (VNE) problem. This problem deals with the question how a set of virtual networks (VN) can be embedded in a substrate network (SN) in an optimal way. ALEVIN [2] is a framework enabling researchers to evaluate and compare novel solutions to the VNE problem according to a wide set of criteria. We have implemented the most popular existing VNE algorithm proposals in ALEVIN. ALEVIN allows researchers to add new algorithms or modify existing algorithms and investigate the result of these modifications. This flexibility is expected to provide novel insights into the VNE problem.

Pre-defined metrics are used to evaluate different VNE algorithms. Several metrics have been proposed and studied so far. The cost-revenue factor and the ratio of accepted VNs have been found to be the main indicators on the quality of the VNE. In this work, a set of VNE algorithms are evaluated using the cost-revenue factor and the VNs acceptance ratio metrics. Moreover, the impact of hidden hop demands on the algorithms is investigated.

II. THE ALEVIN FRAMEWORK

The focus in the development of ALEVIN [2] was on modularity and efficient handling of arbitrary parameters for resources and demands as well as on supporting the integration of new and existing algorithms and evaluation metrics. ALEVIN is fully modular regarding the addition of new parameters to the VNE model.

A set of algorithms from existing publications was implemented in ALEVIN. They were chosen taking into account their novelty and the impact generated by their publication. The complete list of implemented algorithms is given in [3].

Moreover, a set of metrics has been implemented to compare the performance of the algorithms after VNE.

For platform independence, ALEVIN is written in Java. ALEVIN’s GUI and multi-layer visualization component is based on MuLaViTo [4] which enables us to visualize and handle the SN and an arbitrary number of VNs as directed graphs.

III. VNE METRICS AND HIDDEN HOPS

Figure 1 presents the two main metrics that have been used to evaluate the performance of the VNE algorithms. The revenue metric can be seen as the economic benefit of accepting VN requests, while the cost metric measures the resources spent by the substrate network to map a virtual network. The combined cost-revenue ratio is a commonly used metric to evaluate the performance of a VNE algorithm, with the quality increasing the lower the ratio is. A detailed overview of VNE algorithm metrics is presented in [3].

The hidden hop demand concept is introduced in [5]. It takes into account the additional demand on intermediate nodes of a directed path in the SN that is used to map a specific virtual link of a VN. This reflects the fact that, for instance, packet forwarding of traffic on a virtual link requires additional forwarding capacity on intermediate nodes.

The implementation of the hidden hop demand concept in ALEVIN helps to understand the impact of hidden hops on the embedding and to devise modifications in current algorithms to optimally deal with it.

IV. ALGORITHMS AND EVALUATIONS

To compare different VNE algorithms, we create scenarios with different SNs, as well as different VNs, which cause a certain average resource load.

In this work, we consider CPU cycles as a node resource, denoted by NR_cpu, and bandwidth as a link resource, denoted
TABLE I

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>DVINE SP</td>
<td>Coordinated node and link mapping with k-shortest paths</td>
</tr>
<tr>
<td>PS</td>
<td>Coordinated node and link mapping with Path Splitting</td>
</tr>
<tr>
<td>GAR SP</td>
<td>Greedy available resources with k-shortest paths</td>
</tr>
<tr>
<td>PS</td>
<td>Greedy available resources with Path Splitting</td>
</tr>
</tbody>
</table>

Fig. 2. Evaluation of cost-revenue ratio.

Fig. 3. Evaluation of VNRs acceptance ratio with and without hidden hops.

It also shows that algorithms using path splitting (multi-path) solutions to map virtual links, have a better behaviour that those using shortest paths.

The evaluated algorithms were challenged by including a hidden hop demand factor of 0.5, i.e. each hidden hop on a substrate path will have a CPU demand equivalent to the 50% of the realized virtual link’s demand. Figure 3 shows the VN acceptance ratio of the evaluated algorithms with the hidden hop factor and the behaviour of the algorithms without considering hidden hops. The decrease of the VNs acceptance ratio is very noticeable (up to 50% in the worst case).

V. CONCLUSION AND FUTURE WORK

This paper presented an evaluation of VNE algorithms using ALEVIN. It has been shown that different algorithms can be compared by a common set of metrics. Moreover, it became clear that modification of the algorithms, e.g. with the hidden hop demand, can give significantly different results. Taking into account possible further optimization goals, like security, resilience, or energy-efficiency, it becomes clear that further analysis of these effects is needed.

Optimization of energy consumption in the SN will require significant modification of existing algorithms. Likewise, the incorporation of security and resilience goals will have a significant impact on results. We plan to use ALEVIN to investigate these constraints. Moreover, the application to large testbed scenarios (e.g. G-Lab) will be an interesting goal.

ACKNOWLEDGEMENTS

This work received funding from the EC’s Seventh Framework Programme (FP7/2007-2013) in the context of the “Euro-NF” Network of Excellence (grant agreement no. 216366, SJRP “Virtual Network Resource Embedding Algorithms” (VNREAL) and the ResumeNet project (grant agreement no. 224619). It was further supported by the Spanish Government, MCIJNN, under research grant TIN2010-20136-C03, the “Comisionat per a Universitats i Recerca del DIUE” from the “Generalitat de Catalunya”, the Social European Budget (“Fons Social Europeu”), and by the Federal Ministry of Education and Research of the Federal Republic of Germany (BMBF Förderkennzeichen 01BP0775) in the context of the EUREKA project “100 Gbit/s Carrier-Grade Ethernet Transport Technologies (CELTIC CP4-001)”.

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