SDN Traffic Analytics in a WAN distributed setting

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I. Overview of the Research

Over the last years, the use of cloud resources has not only increased in numbers but more and more resource demanding and business critical applications such as High Performance Computing (HPC) simulations or Data intensive computing (DIC), complex scientific work-flows are moving from a traditional server infrastructures towards on-demand cloud infrastructures. These applications need large amount of compute and storage resources and stimulate heavy communication among the hosted Virtual Machines (VM) [1],[3]. Network resource is commonly defined by the data rate of a communication link whereas additional information such as latency or switch topology is often neglected. In order to ensure scalability of resource-demanding applications in cloud environment and an efficient use of the resources with respect to energy and cost inside a data centre and in the data centres connected by a Wide Area Network (WAN), the following questions need to be considered

1. How to allocate resources in the data centres?
2. What is the effective way to find the most appropriate place for a VM?
3. How to implement load-balancing inside a data centre and among the data centres in WAN?

To answer the aforementioned questions, the following critical challenges need to be taken into account.

- How to model the communication behaviour of VMs as well as applications?
- How to collect sufficient data from the network traffic and network device to derive accurate models for making fast placement and migration decisions?
- How to solve the 'black box' problem where the VM is unaware of the physical infrastructure and the system knows only about hardware but nothing about what is happening inside the VM?

II. State of the art

In the past, different approaches have been considered to deal with heavy network traffic load. For example, Diff-Serv was applied to IP based networks and statistical multiplexing has been used in Asynchronous Transmission Mode (ATM) networks where during high traffic load, different levels of priorities have been given to the data streams and bandwidth of a certain communication channel was allocated to the streams based on the priorities [6]. Now-a-days, data centres are adopting heterogeneous physical infrastructure [3] and many promising virtualisation technologies such as Software Defined Networking (SDN) [2], Network Function Virtualisation etc. in order to handle such increasing network traffic and to improve the performance of resource demanding applications. SDN is a concept of separating the data plane and control plane of the network devices such as switch, router.

In recent years, network-aware VM placement and migration schemes have been investigated. When a user demands for a new VM of a certain type associated with number of cores, amount of memory and storage, the current middleware solutions are focused on finding a server with sufficient memory and stay below a given core overbooking factor. A system called 'Oktopus' has been described in [7] which deploys virtual networks and uses an allocation algorithm for placing tenant's VMs in the physical machines. The algorithm has two versions; cluster allocation algorithm for data-intensive applications and oversubscribed cluster allocation algorithm for applications with components. However, for predicting network performance in the cloud data centre, they considered only intra-cloud network. As discussed in [4], the Peer VMs Aggregation (PVA) algorithm determines the communication pattern of the VMs and places the mutual communicative VMs in the same server to decrease the network traffic and increase the energy savings. But they did not scrutinize the real-time transmission traffic behaviour among the VMs and the dynamic change in the network traffic load. VM migration overhead was also overlooked. A two-tier VM placement algorithm has been presented in [5] considering the traffic patterns and the data centre network architecture. But their approach is not efficient with respect to server and network resource utilisation. Moreover, the performance constraints of virtual switches used in the data centre network architecture can deteriorate the overall system performance [3].

Considering the shortcomings and lacking of existing approaches and the gap between communication quality needed by resource demanding applications, my PhD research is targeting to implement a framework for intelligent placement and migration decision of VMs in a distributed Cloud environment such as Cloud data Centre and WAN using SDN technology with respect to network resource consumption and energy and operating cost optimisation. The placement and migration decisions will be based on the analysis of historical communication traffic traces combined with real-time traffic of the VMs and also the performance characteristics of the switch capabilities and topology. The triggering point for VM migration will be the overload at the network interfaces and network resource failure. The framework targets long-time running applications which are computation intensive and their traffic behaviour is predictable and they require less human interaction in traffic generation.

III. Research design and work plan

A. Design

As discussed in [1], the placement and migration problem of VMs is illustrated as a framework based on mathematical optimisation and objective function minimisation. The proposed framework will be integrated into several components; e.g. monitoring, data collector, data analyser and executor. Real-time network traffic from the VMs and from the physical host will be captured and stored periodically. Current data will be used for making VM migration decision and historical data will be used for initial VM placement decision. The traffic analyser will extract the metrics value such as traffic rate and throughput from the trace file and calculate the bandwidth usage of the VMs which will be the input for the traffic model. The model will be executed in the executor component.

In order to allow decisions in real-time if an additional VM is overbooking the available capacity, the model needs to be very simple. The model assumes that the VM traffic behaviour can be described as a set of discrete states, for example, no traffic, 250kbit/s, 1Mbit/s and it's probability for changing the states is based on Markov model. The model will be designed mainly in 2 phases. Initially, a VM overlay model and later it will be enhanced to a virtual switch aware traffic model. The 1st model will initially calculate the average bandwidth usage of VMs inside a physical host. It will then discretise different bandwidth demands into several states and create a combined state model by overlaying the individual states of all VMs. It will further calculate a probability matrix to change the bandwidth states for the VMs using Markov model. From the probability, it will be possible to predict the network load of VMs. The 2nd model will predict the capabilities of a virtual switch by calculating it's saturation bandwidth. Using all the predictions, the model will make VM placement and migration decision. The framework will be further investigated in WAN distributed settings by following similar approaches. Due to limited page constraints, the models have not been presented here. Further information can be found in [3].

B. Work plan

As an initial step, the framework will be realised by using simulation tools for the network and cloud part and potentially a combination of both. Starting from the VM overlay model simulation, a more elaborated switch model will be created. The simulator with virtual switch properties is considering the performance measurements done in [3]. Similar traffic will be generated in the physical environment with different types of virtual software switches and virtualised hardware switches. The probability and prediction results from the VM overlay model, switch model and the synthetic tests will be compared. The framework is open for different optimisation modeling techniques. The model will be further compared with existing algorithms with respect to performance matrices. Finally the framework will be deployed and evaluated in a physical data centre as well as connected data centres with a Wide Area Network. The selection of suitable optimisation techniques and existing algorithms to validate the optimisation level of the proposed algorithm and to make comparison is currently under investigation. Sharing ideas on this issue and asking feedbacks from the audience are the main goals of this proposal submission.

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References

[1] Ferdaus, M. H., Murshed, M., Calheiros, R. N., & Buyya, R. (2015). Network-Aware Virtual Machine Placement and Migration in Cloud Data Centers. In S. Bagchi (Ed.), Emerging Research in Cloud Distributed Computing Systems (pp. 42-91). Hershey, PA: IGI Global. doi: 10.4018/978-1-4666-8213-9.ch002

[2] Ian F. Akyildiz, Ahyoung Lee, Pu Wang, Min Luo, Wu Chou, A roadmap for traffic engineering in SDN-OpenFlow networks, Computer Networks, Volume 71, 4 October 2014, p.p1-30, ISSN 1389-1286, http://dx.doi.org/10.1016/j.comnet.2014.06.002.

[3] Sarker, M., Wesner, S., Siersch, J., and Khan, A., "Towards a Method Integrating Virtual Switch Performance into Data Centre Design" The Fifteenth International Conference on Networks (ICN 2016) IARIA, Feb. 2016, pp.13-21, ISBN:978-1-51082-022-7

[4] I. Takouna, R. Rojas-Cessa, K.Sachs and C. Meinel, "Communication-Aware and Energy-Efficient Scheduling for Parallel Applications in Virtualized Data Centers," 2013 IEEE/ACM 6th International Conference on Utility and Cloud Computing, Dresden, 2013, pp.251-255.doi: 10.1109/UCC.2013.50

[5] Meng, X., Pappas, V., & Zhang, L. (2010). Improving the scalability of data center networks with traffic-aware virtual machine placement. In Proceedings of INFOCOM (pp.1-9). IEEE. Doi:10.1109/INFCOM.2010.5461930

[6] Khalid Ahmad. 2001. *Sourcebook of ATM and IP Internetworking* (1st ed.). John Wiley & Sons, Inc., New York, NY, USA.

[7] Hitesh Ballani, Paolo Costa, Thomas Karagiannis, and Ant Rowstron. 2011. Towards predictable datacenter networks. *SIGCOMM Comput. Commun. Rev.* 41, 4 (August 2011), 242-253. DOI=http://dx.doi.org/10.1145/2043164.2018465