MOSC: a method to assign the outsourcing of service function chain across multiple clouds

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GROUP MEETING PRESENTATION

Introduction

Problems of hardware middleboxes based network function (NF):

- ❖ High maintenance cost
- ❖ Complex to operate
- ❖ Difficult to achieve on-demand NF deployment
- ❖ …

Advantages of outsourcing the service function chain (SFC) to the public cloud:

- ❖ Public cloud provides pay-as-you-go charging model
- ❖ Operational cost and complexity maintenance can be reduced
- ❖ VNF can be deployed according to user requests
- ❖ …

Introduction

Issues to solve when outsourcing SFC to public cloud :

- ❖ There are a large number of cloud providers, which have diverse pricing schemes and different technical specification
- ❖ Redirecting flows to the clouds may introduce extra delays, thus how to guarantee the Quality of Service (QoS) of flows should be considered
- ❖ Some network functions cannot be outsourced due to the security or privacy reasons
- ❖ …

Table 1 Pricing schemes of virtual network functions for flow of unit size

	S3 USA, EU ($)	Rackspace ($)	Nirvanix ($)
Data transfer in (GB)	0.10	0.08	0.18
Data transfer out (GB)	0.15	0.22	0.18
Storage (GB/month)	0.15	0.15	0.25

Google Cloud Platform (GCP)

Custom machine types

Iowa

Monthly Hourly

Item	Price (USD)	Preemptible price (USD)
vCPU	$0.033174 / vCPU hour	$0.00698 / vCPU hour
Memory	$0.004446 / GB hour	$0.00094 / GB hour

General network pricing

Traffic type	Price
Ingress	No charge
Egress* to the same zone	No charge
Egress to Google products (such as YouTube, Maps, Drive), whether from a VM in GCP with a public (external) IP address or a private (internal) IP address	No charge
Egress to a different Google Cloud Platform service within the same region, except for Cloud Memorystore for Redis and for Cloud SQL	No charge
Egress* between zones in the same region (per GB)	$0.01
Egress to Cloud Memorystore for Redis is charged at the rate of "Egress between zones in the same region"	
Egress to Cloud SQL is charged at the rates described in Traffic through external IP addresses	
Egress between regions within the US (per GB)	$0.01
Egress between regions, not including traffic between US regions	At Internet egress rates

“https://cloud.google.com/compute/pricing#custommachinetypepricing”

Motivation

{Firewall → Intrusion Detection System (IDS) → DPI → Traffic Shaper → Wide Area Network (WAN) Optimizer}

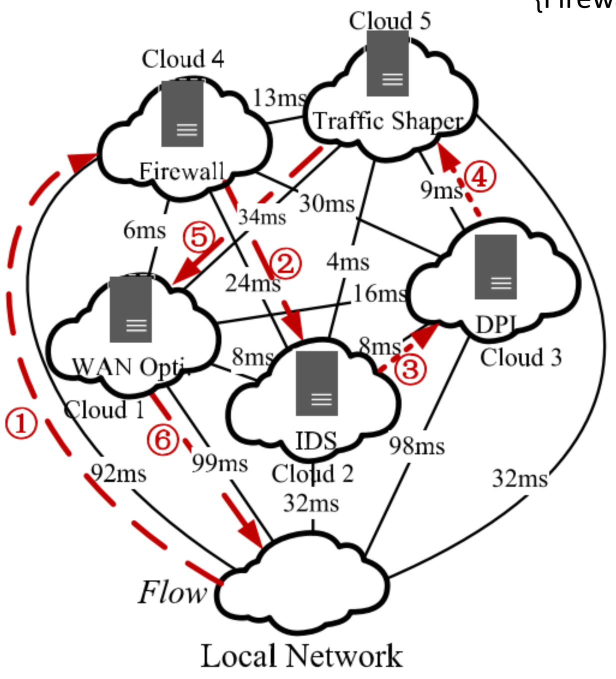


Fig. 1. Motivation example (cost efficient deployment).

Table 2 Pricing schemes of virtual network functions for flow of unit size.

	Firewall ($)	IDS ($)	DPI ($)	Traffic shaper ($)	WAN opti. ($)
Cloud 1	6	8	12	11	3
Cloud 2	13	5	28	19	24
Cloud 3	5	9	8	12	18
Cloud 4	2	9	16	10	13
Cloud 5	8	6	31	5	6
Local Network	13	18	32	22	28

** The cost to set up one virtual link for a flow of unit size is $2*

Table 3 Delay of links.

	Cloud 1	Cloud 2	Cloud 3	Cloud 4	Cloud 5	Local
Cloud 1	0	8 ms	16 ms	6 ms	34 ms	99 ms
Cloud 2	8 ms	0	8 ms	24 ms	4 ms	32 ms
Cloud 3	16 ms	8 ms	0	30 ms	9 ms	98 ms
Cloud 4	6 ms	24 ms	30 ms	0	13 ms	92 ms
Cloud 5	34 ms	4 ms	9 ms	13 ms	0	32 ms
Local	99 ms	32 ms	98 ms	92 ms	32 ms	0

The optimal cost is **$35** compared with **$113** of local placement scheme. The total latency is **266ms** which cannot satisfy the QoS requirements of typical applications

Motivation

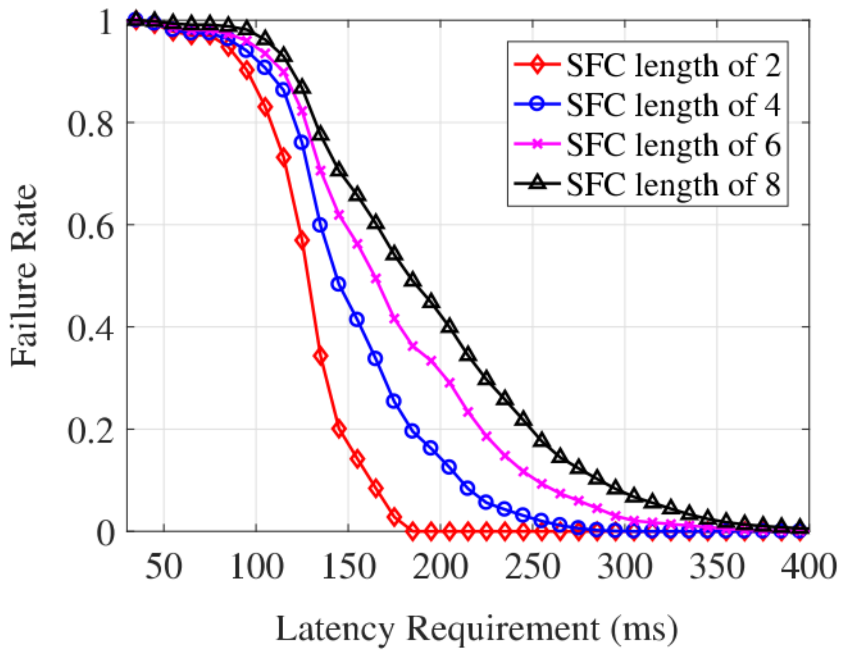


Fig. 4. Failure rate vs. latency requirement.

Delay of the links:

- ❖ Be set to random values with an average of 40 ms

VNF processing time:

- ❖ The processing latency of VNF *i* per 1 Mbps on node *j* which has the lowest price of deploying this function as the maximum processing latency

Motivation

- 64 ms, 75.9% lower
- $91, saves 19% compared with local placement scheme

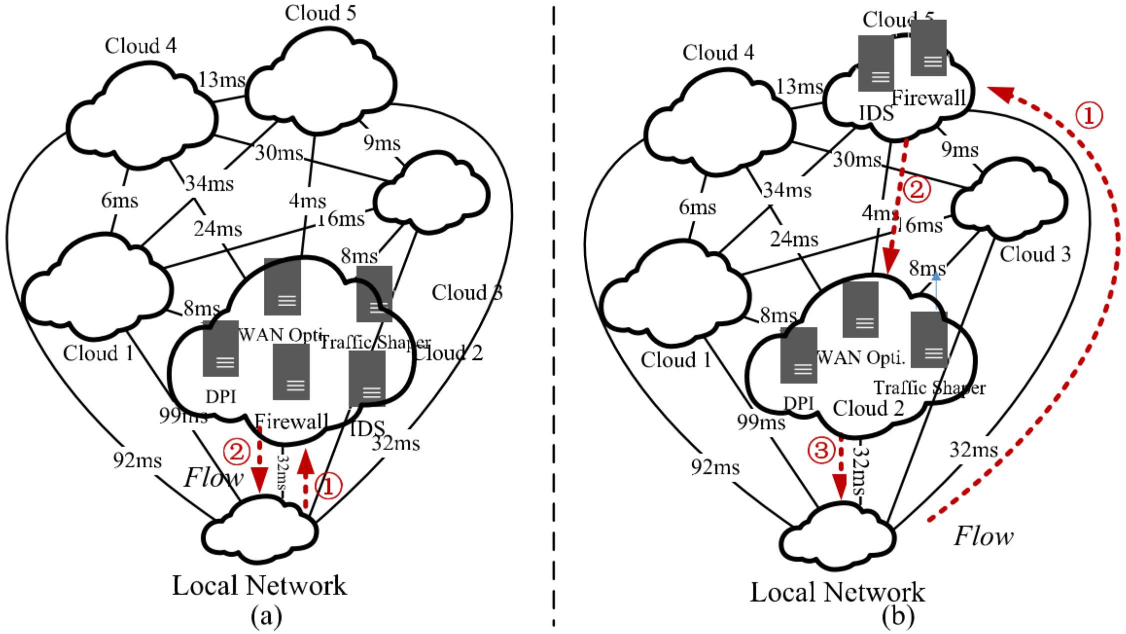


Fig. 5. Motivation example (low latency deployment)

- 68 ms
- $88, 57% higher than that of the cost-efficient placement

Problem formulation

Objective:

$$\text{minimize} \sum_{i \in N, m \in V} \sum_{f_t \in F} f_t z_t^{im} \lambda_{im} + \sum_{(i,j) \in E} \sum_{f_t \in F} \sum_{m,l \in V} f_t n_t^{imjl} \theta_{ij}$$

To minimize the total cost, including the cost for processing data by VNF and the cost for transmission data between different nodes.

Constraints:

$$\sum_{m \in V} \sum_{f_t \in F} f_t z_t^{im} M_m \le C_i \qquad \forall i \in N$$

$$\sum_{f_t \in F} \sum_{m,l \in V} f_t n_t^{imjl} \le B_{ij} \qquad \forall (i,j) \in E$$

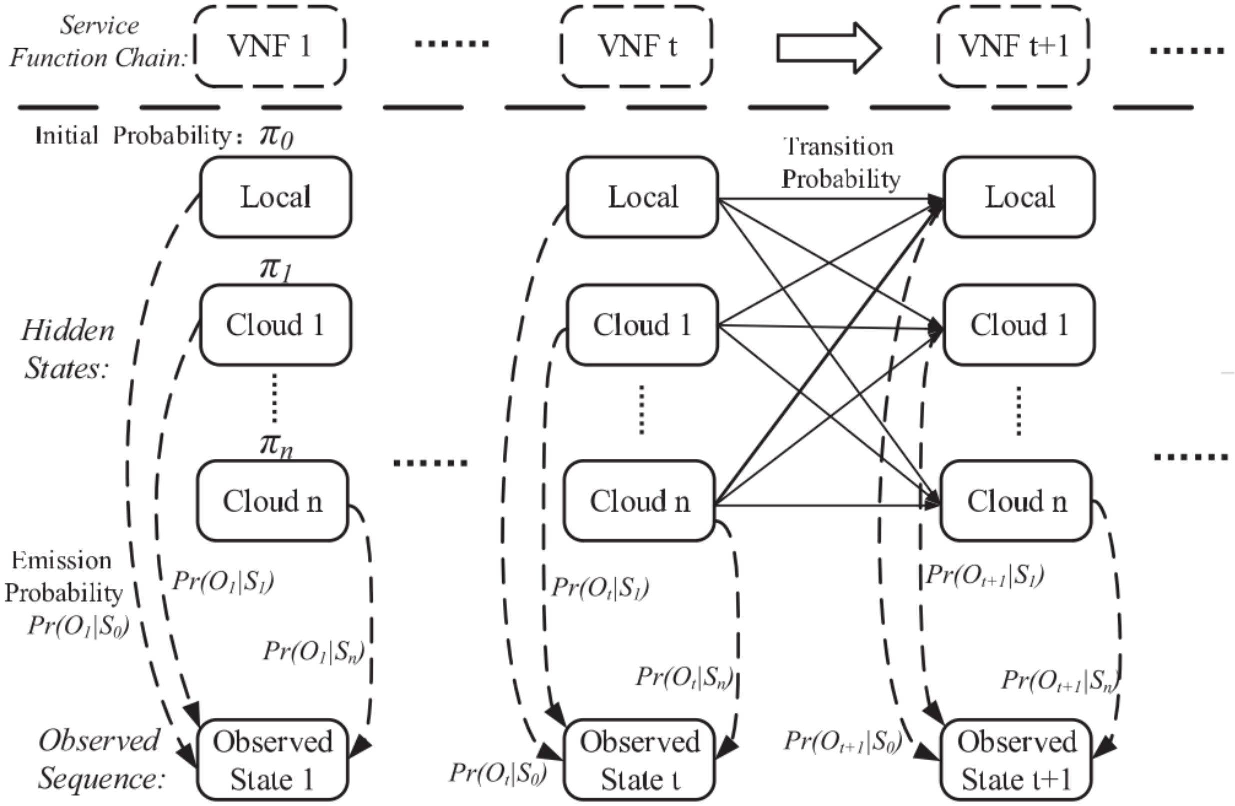
Capacity constraint, consumed resource cannot exceed the node capacity and link capacity.

$$\sum_{(i,j) \in E} \sum_{m,l \in V} n_t^{imjl} d_{ij}^m \le l_t \qquad \forall f_t \in F$$

Total suffered latency should satisfy the requirement of the request.

Heuristic algorithm design

Hidden Markov Model



$$\pi_i = \frac{\sum_{n_i \in N}(\lambda_{n_i v_1} + \theta_{n_0 n_i}) - (\lambda_{n_i v_1} + \theta_{n_0 n_i})}{(|N|-1)\cdot(\sum_{n_i \in N}(\lambda_{n_i v_1} + \theta_{n_0 n_i}))}$$

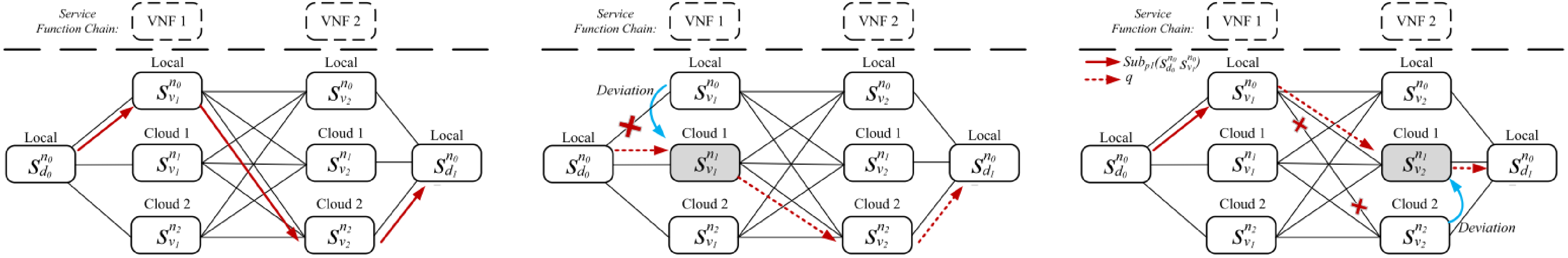
$$Pr(S_{v_i}^{n_y} | S_{v_{i-1}}^{n_x}) = \frac{\sum_{n_y \in N}(\lambda_{n_y v_i} + \theta_{n_x n_y}) - (\lambda_{n_y v_i} + \theta_{n_x n_y})}{(|N|-1)\cdot(\sum_{n_y \in N}(\lambda_{n_y v_i} + \theta_{n_x n_y}))}$$

$$Pr(O_{v_i}^{yes} | s_{v_i}^{n_x}) = U_x/(1+U_x)$$

$$Pr(O_{v_i}^{no} | s_{v_i}^{n_x}) = 1 - Pr(O_{v_i}^{yes} | s_{v_i}^{n_x})$$

Heuristic algorithm design

Deviation Algorithm:
If the path violates the latency requirement of the flow, we need to find a method to eliminate the latency violation by choosing some node with higher cost but lower latency to serve part of these VNFs



(a) p_1 (b) Deviation on $s_{d_0}^{n_0}$ (c) Deviation on $s_{v_1}^{n_0}$

Results

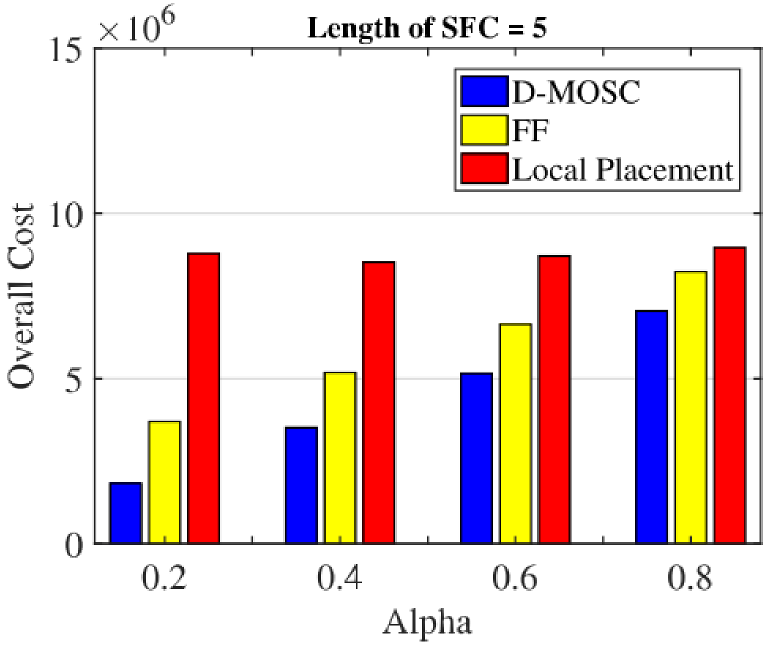


Fig. 6. Overall cost vs. the coefficient α*.

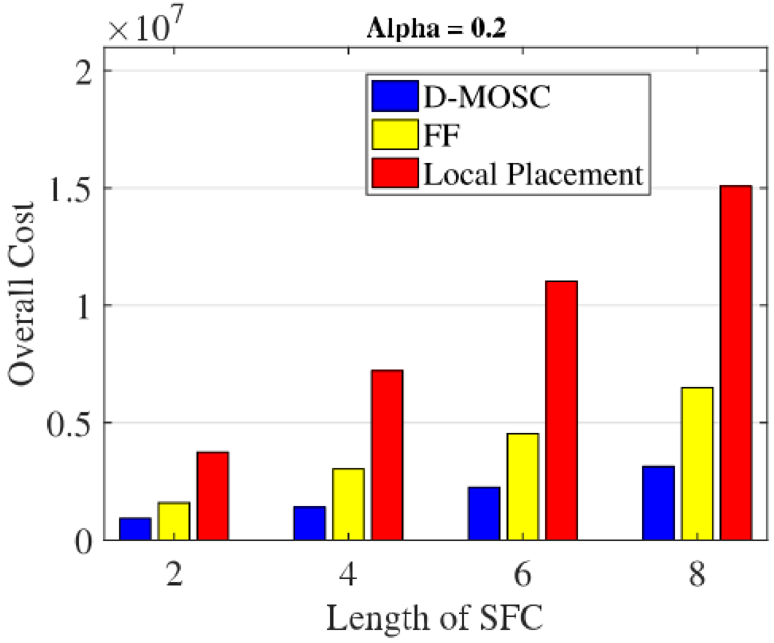


Fig. 7. Overall cost vs. length of service chain.

*$P_{ic} = \alpha P_{ib}$

Results

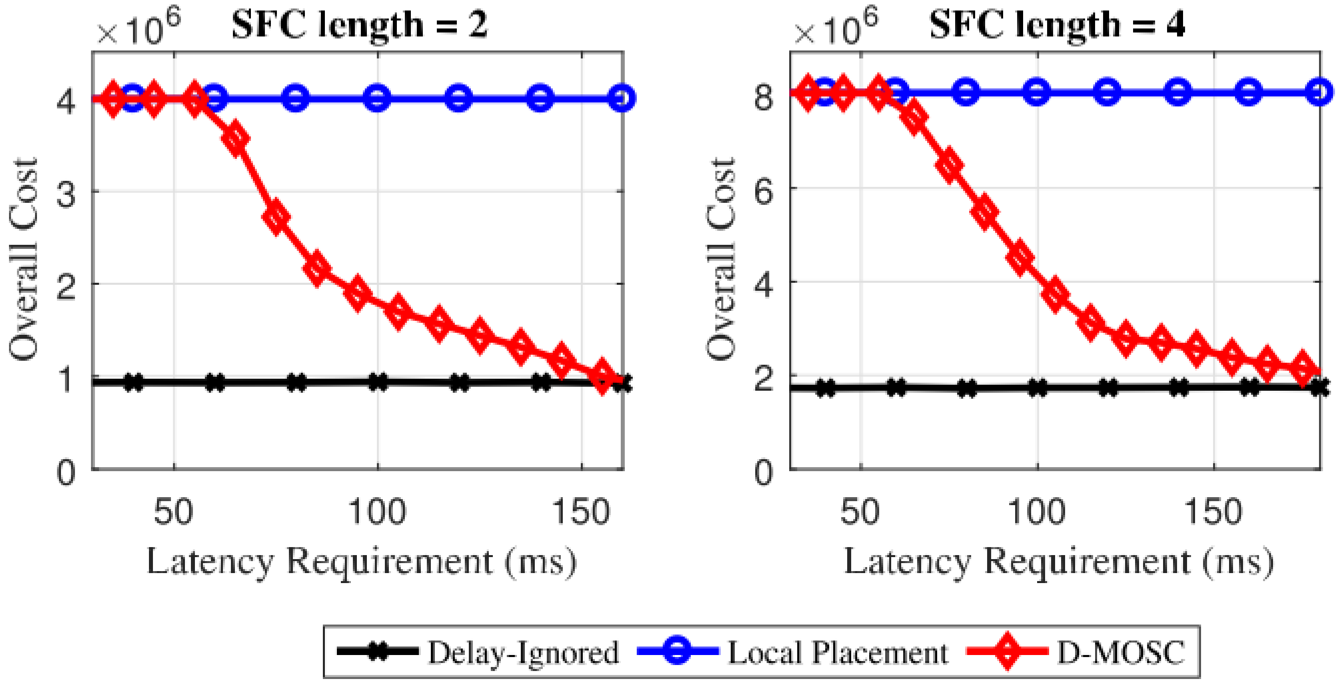


Fig. 8. Overall cost vs. latency requirement.

Different from our work

	This Paper	Our Work
Traffic Scenario	Static	Dynamic
Problem Solved	Placement	Placement & Scheduling
Cloud Network	Multi-cloud	Same cloud service provider but with different regions and zones
VNF Attribute	Just consider higher price can get high throughput (linear relationship)	Throughput is related to the amount of resource allocated to it and the thread application [1].
Network	Latency is a random value. Price is a constant value.	Price is related to the capacity (bandwidth) and transferred data size

[1] A. Sheoran, et al, “An Empirical Case for Container-driven Fine-grained VNF Resource Flexing,” in Proc. 2016 IEEE Conference on Network Function Virtualization and Software Defined Networks, NFV-SDN, 2016.

Thanks!