



# **JOINT BACKHAUL AND ACCESS OPTIMIZATION FOR SERVICE-SEGMENT BASED VN ADMISSION CONTROL**

**Meisam Mirahsan, Carleton University, Ottawa, Canada**

**Hamid Farmanbar, Huawei Canada Research Centre, Ottawa, Canada**

**Halim Yanikomeroglu, Carleton University, Ottawa, Canada**

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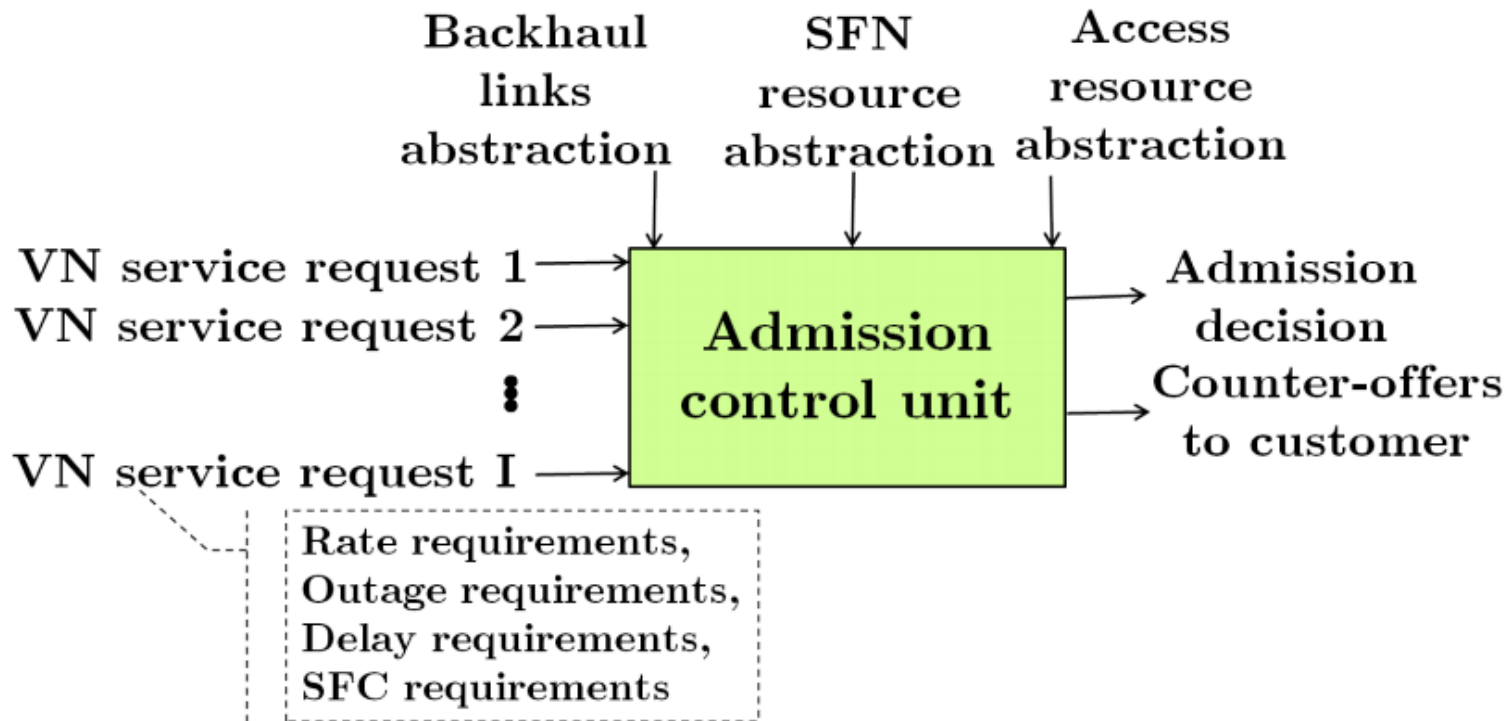
# VIRTUAL NETWORK ADMISSION CONTROL

- Single user admission control
  - Short term
  - Based on deterministic user locations
- VN admission control
  - Long term
  - Based on user distribution probabilities
- Other requirements include
  - QoS
  - Service function chains (SFC)
    - Such as encryption, aggregation, caching, ...

# RESOURCE LIMITATIONS

- Access link limitations:
  - BS to UE wireless connection
- Backhaul limitation:
  - Small cells deployed by customers
- Service function nodes (SFN):
  - Limited processing powers

# VN ADMISSION CONTROL PROCESS



# CONTRIBUTIONS OF THE PAPER

- A novel wireless VN admission control method is proposed which incorporates both the access limitations and backhaul limitations for general network topologies.
- This problem is formulated as a joint convex optimization problem which is computationally tractable.
- Service segments and SFC constraints are included in the problem both in the sense of service function orders and the resource requirements at each service function node.
- A **service-segment-based** approach is put forth which is more scalable than its flow-segment-based counterpart.

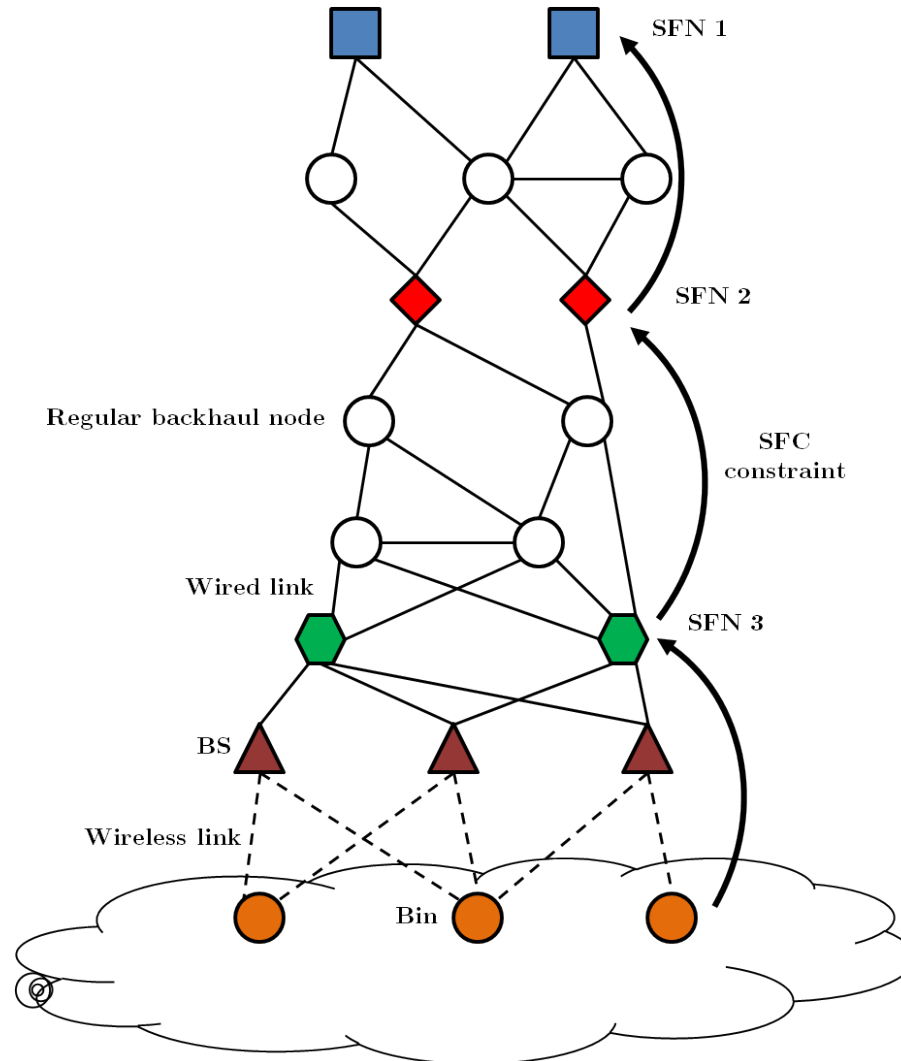
# PREVIOUS WORKS

- Meisam Mirahsan, Gamini Senarath, Hamid Farmanbar, Ngoc Dao, and Halim Yanikomeroglu, “Admission control of wireless virtual networks in HetHetNets”, under review in *IEEE Transactions on Vehicular Technology* (submission: 22 Oct. 2016, 1<sup>st</sup> results: 26 March 2017, 1<sup>st</sup> revision: 20 May 2017).
- Meisam Mirahsan, Halim Yanikomeroglu, Gamini Senarath, and Ngoc-Dung Dao, “Analytic modeling of SIR in cellular networks with heterogeneous traffic”, *IEEE Communications Letters*, vol. 20, no. 8, pp. 1627-1630, August 2016.
- Meisam Mirahsan, Rainer Schoenen, H. Yanikomeroglu, G. Senarath, Ngoc-Dung Dao, “User-in-the-loop for HetHetNets with backhaul capacity constraints”, *IEEE Wireless Communications, Special Issue on Smart Backhauling and Fronthauling for 5G Networks*, vol. 22, no. 5, pp. 50-57, Oct. 2015.
- Meisam Mirahsan, Rainer Schoenen, and Halim Yanikomeroglu, “HetHetNets: Heterogeneous traffic distribution in heterogeneous wireless cellular networks”, *IEEE Journal on Selected Areas in Communications, Special Issue on Recent Advances in Heterogeneous Cellular Networks*, vol. 33, no. 10, pp. 2252-2265, October 2015.

# SYSTEM MODEL

- We consider the downlink of a cellular wireless network with general access and backhaul topologies.
- A geographical region  $Q \subset \mathbb{R}^2$  (i.e., two dimensional plane) which is divided into small bins is assumed as the network layout that is served by a set of BSs  $B$ .
- Each BS is characterized by its available bandwidth  $W_k$ .
- We assume that demand arrivals for the  $i$ th VN service,  $v_i \in V$ , at location  $q$  in bin  $j$ ,  $d_{ij}$ , are random variables that follow arbitrary distributions with mean  $\lambda_{ij}$ , where  $V$  is the set of VN services.
- The backhaul network is modeled as a directional graph  $G(N,L)$ , where  $N$  and  $L$  are the sets of nodes and links in the network, respectively.
- Let  $L_{in}(n)$  and  $L_{out}(n)$  be the sets of links terminating and originating at node  $n \in N$ , respectively.

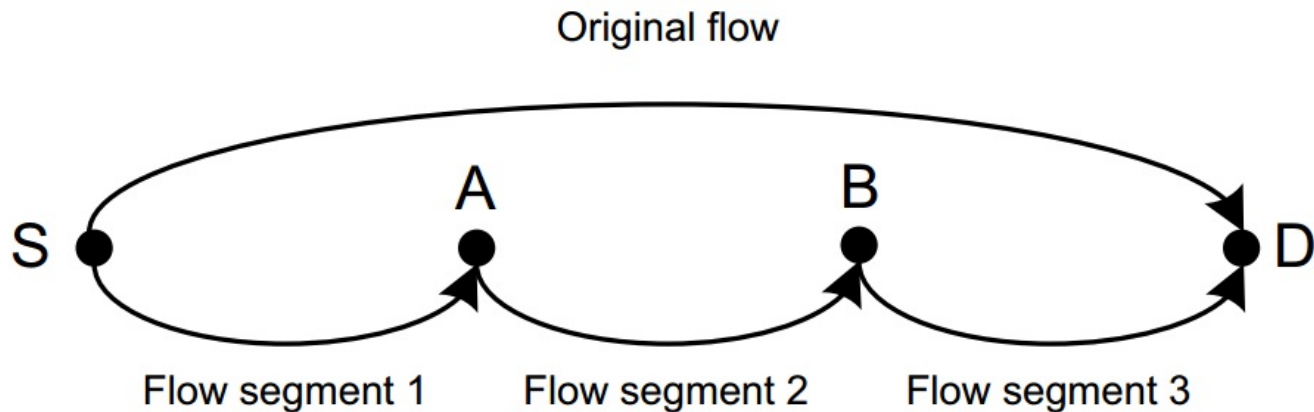
# NETWORK CONFIGURATION





# FLOW SEGMENTATION

- In order to address the flow traversal constraints, each flow is parsed according to its traversal constraints into multiple flow segments.



# FLOW-BASED VN ADMISSION CONTROL

$$\text{C1: } M_k = \sum_{i \in I} \sum_{j \in J} \frac{x_{ijk}}{\eta_{jk}} \leq W_k, \forall k \in K,$$

$$\text{C2: } r_{ij} = \sum_{k \in K} x_{ijk}, \forall i \in I, \forall j \in J.$$

$$\text{C3: } \xi_i \leq O_i, \forall i \in I.$$

$$\text{C4: } \sum_{i \in I} u_{ih} \leq U_h, \forall h \in H,$$

$$\text{C5: } \sum_{l \in L_{in}(n)} z_{ijl} = \sum_{l \in L_{out}(n)} z_{ijl}, \forall n \in N, \forall i \in I, \forall j \in J.$$

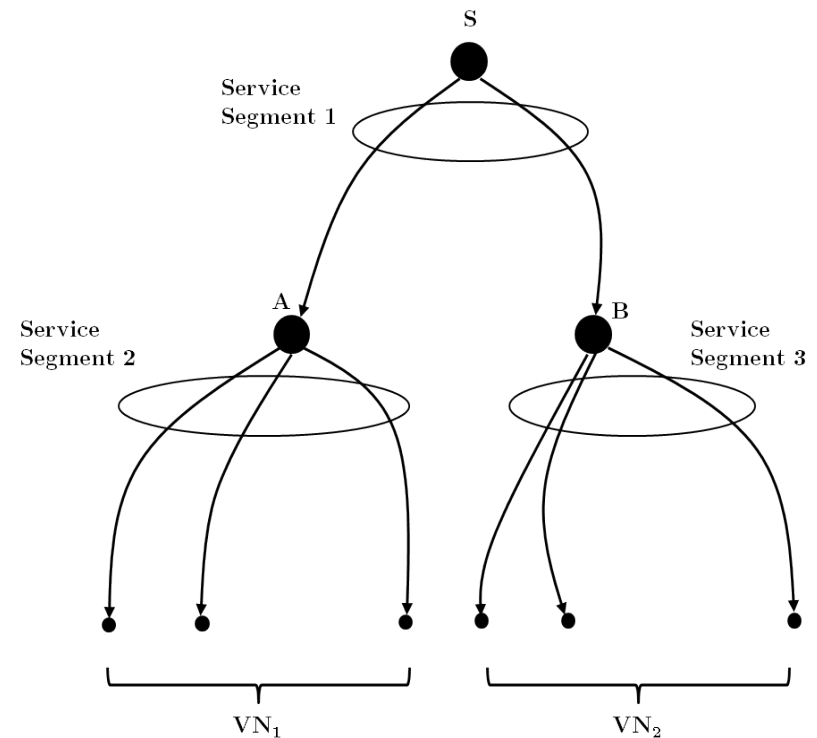
$$\text{C6: } \sum_{l \in L_{in}(k)} z_{ijl} = x_{ijk}, \forall k \in K, \forall i \in I, \forall j \in J.$$

$$\text{C7: } \sum_{i \in I} \sum_{j \in J} z_{ijl} \leq C_l, \forall l \in L,$$

find <sub>$x, z$</sub>   $x, z$  subject to: C1-C7.

# SERVICE-BASED VN ADMISSION CONTROL

- The flow-based approach does not scale with increasing number of flows or flow segments in terms of admission control algorithm complexity.
- We parse flows according to their SFC requirements into flow segments.
- A service segment is defined as a set of flow segments with common source node.



# SERVICE-BASED VN ADMISSION CONTROL

$$\text{C1: } M_k = \sum_{i \in I} \sum_{j \in J} \frac{x_{ijk}}{\eta_{jk}} \leq W_k, \forall k \in K,$$

$$\text{C2: } r_{ij} = \sum_{k \in K} x_{ijk}, \forall i \in I, \forall j \in J.$$

$$\text{C3: } \xi_i \leq O_i, \forall i \in I.$$

$$\text{C4: } \sum_{i \in I} u_{ih} \leq U_h, \forall h \in H,$$

$$\text{C8: } \sum_{l \in L_{in}(n)} y_l = \sum_{l \in L_{out}(n)} y_l, \forall n \in N,$$

$$\text{C9: } \sum_{l \in L_{in}(k)} y_l = x_{ijk}, \forall k \in K, \forall i \in I, \forall j \in J.$$

$$\text{C10: } y_l \leq C_l, \forall l \in L.$$

find <sub>$x, y$</sub>   $x, y$  subject to: C1-C4, C8-C10.

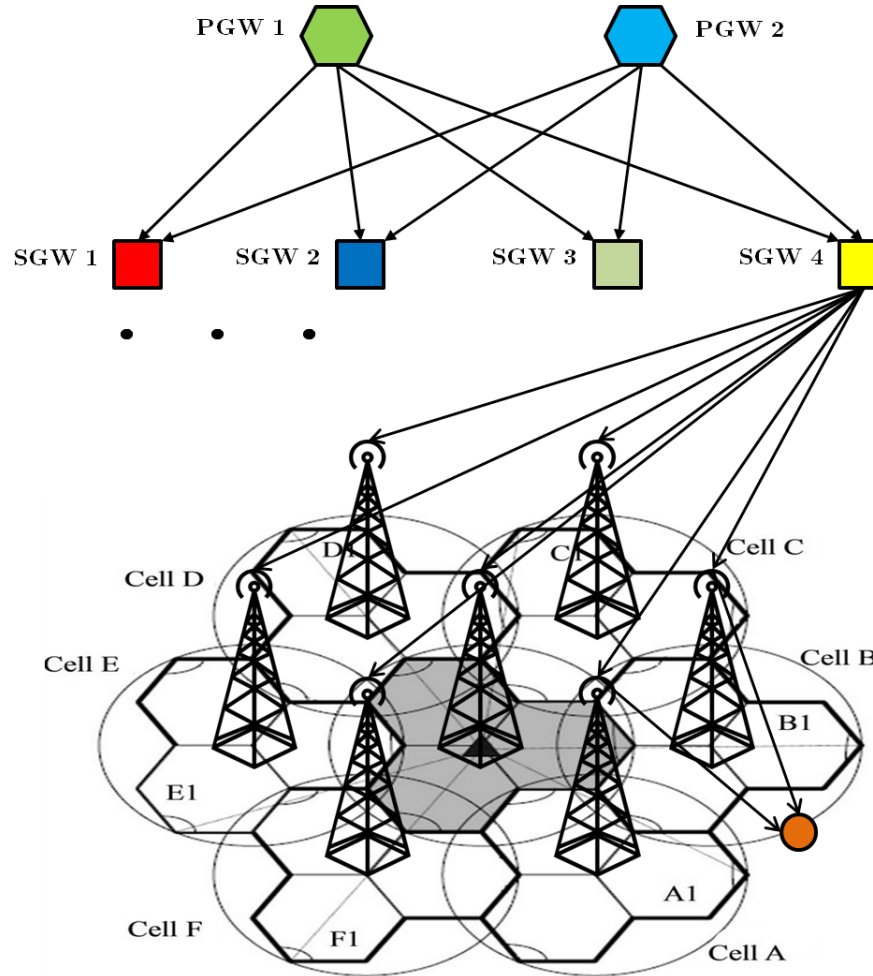
# SERVICE-BASED VS FLOW-BASED

TABLE I

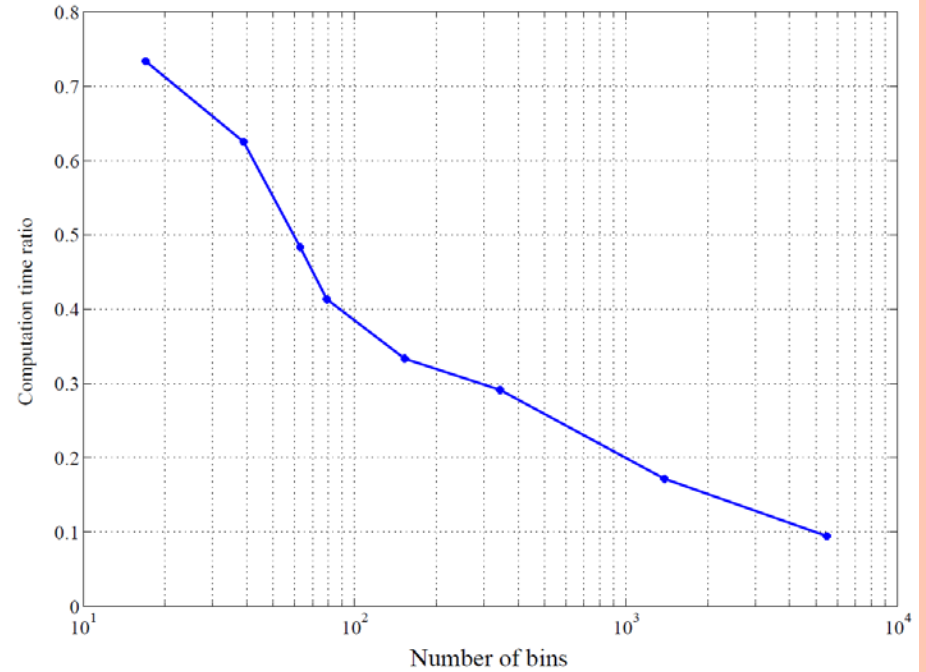
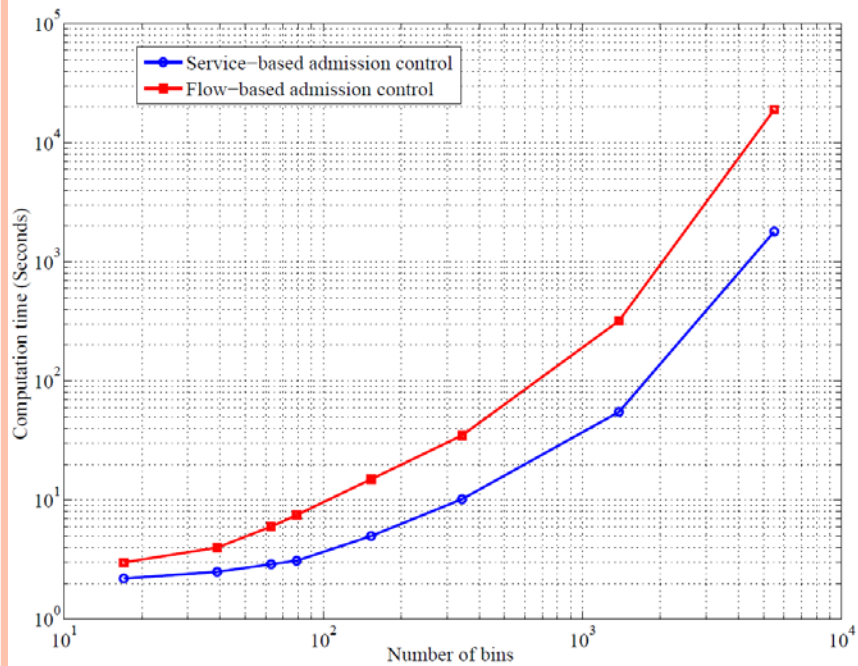
COMPARISON BETWEEN FLOW-BASED AND SERVICE-BASED METHODS IN TERMS OF NUMBER OF VARIABLES AND CONSTRAINTS.

<b>Criteria</b>	<b>Flow-based</b>	<b>Service-based</b>
<b>Var.</b>	$ I  \times  J  \times ( K  +  L )$	$ I  \times  J  \times  K  +  L $
<b>Cons.</b>	$\alpha +  I  \times  J  \times  N $	$\alpha +  N $

# SIMULATION SETUP



# SIMULATION RESULTS



*THANKS!*  
*QUESTIONS?*