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Orchestrating Data-Intensive vNF Service Chains (vNF-SCs) in Inter-DC Elastic Optical Networks

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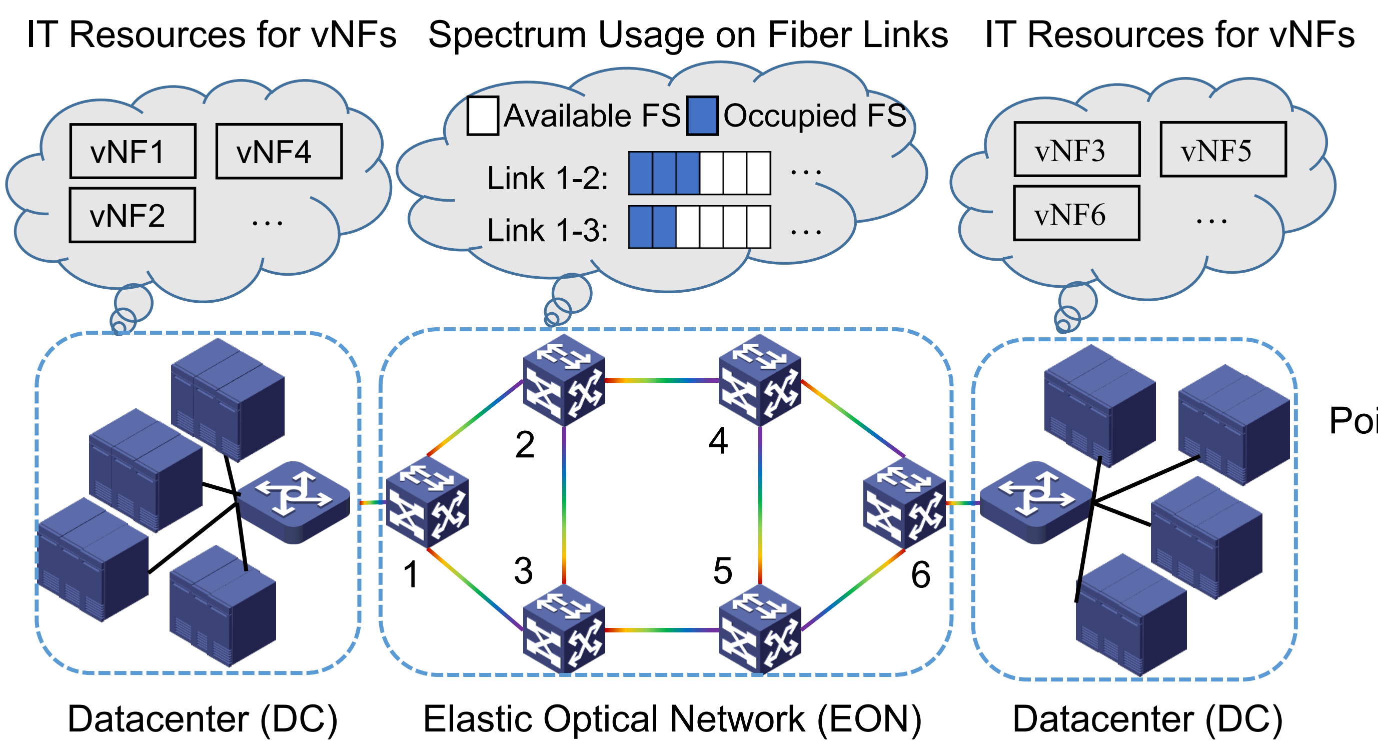
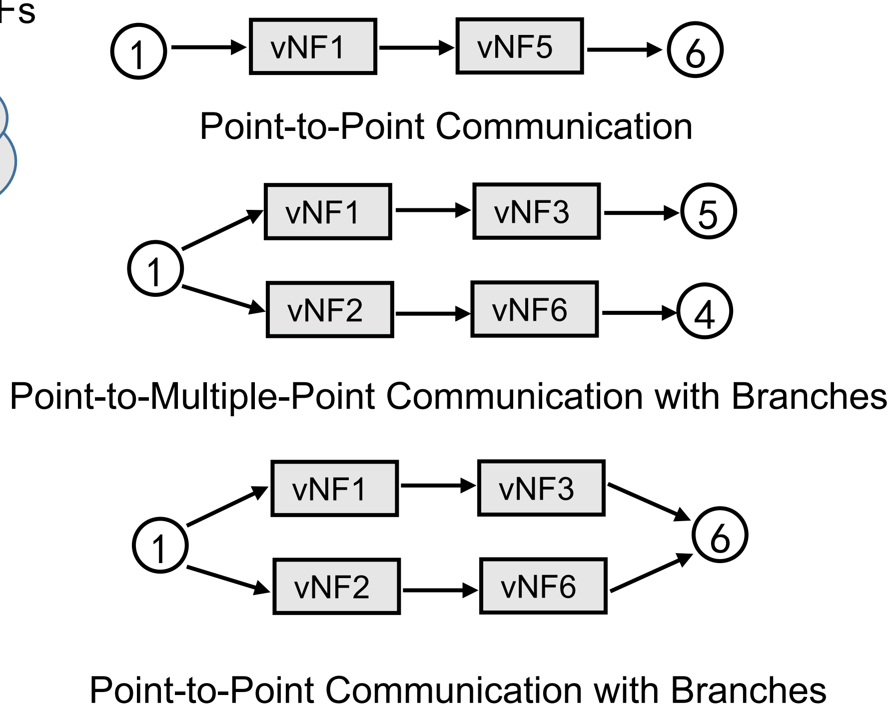
Outline

- Background and Motivations
- Data-Intensive vNF-SC Deployment
- Simulation Results
- Conclusion

Orchestrating Diverse vNF-SCs in an Inter-DC EON





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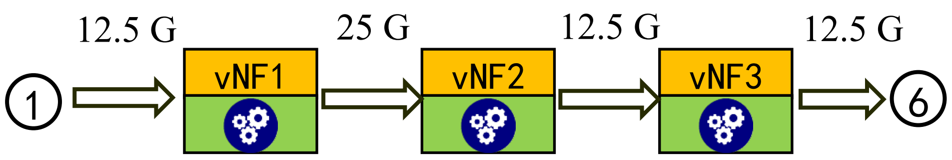
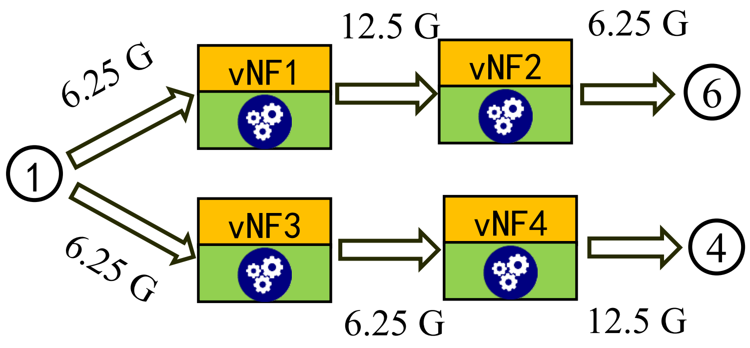
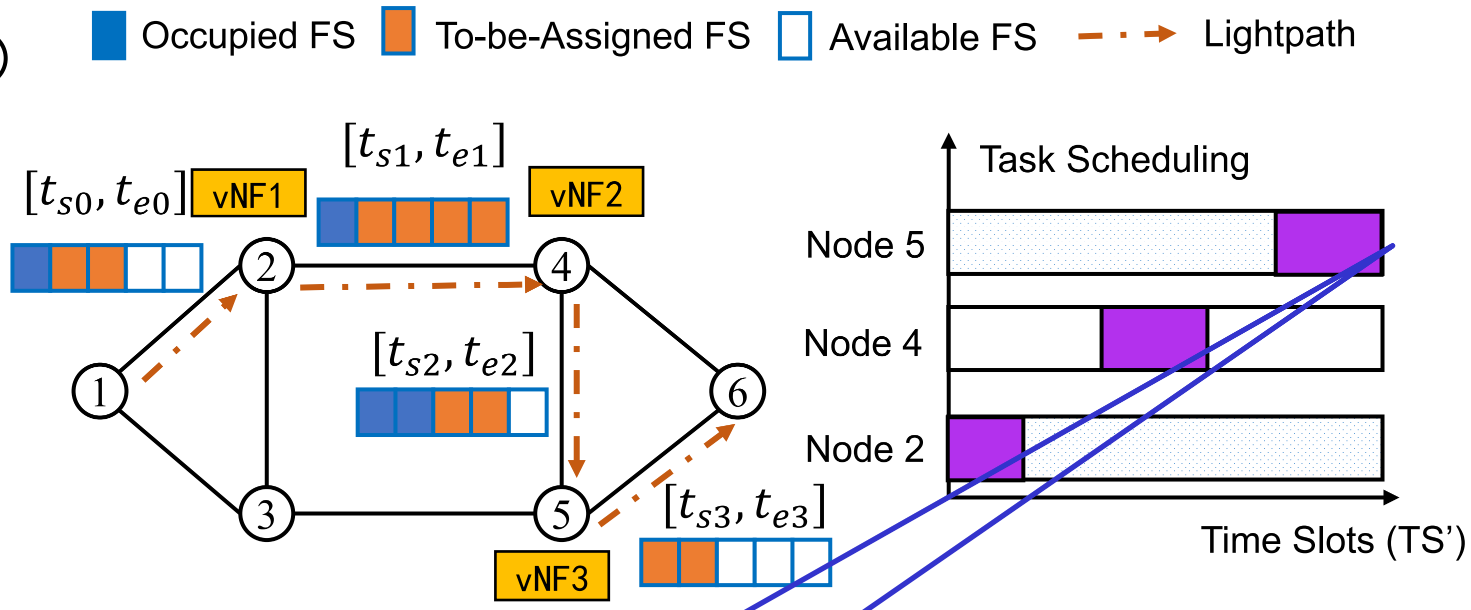
Data-Intensive vNF-SC Deployment



(a) Point-to-Point Data-Intensive vNF-SC Request



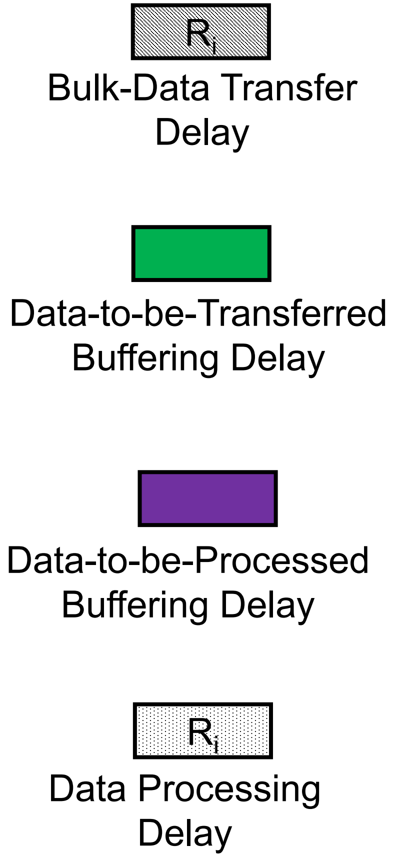
(b) Point-to-Multipoint Data-Intensive vNF-SC Request

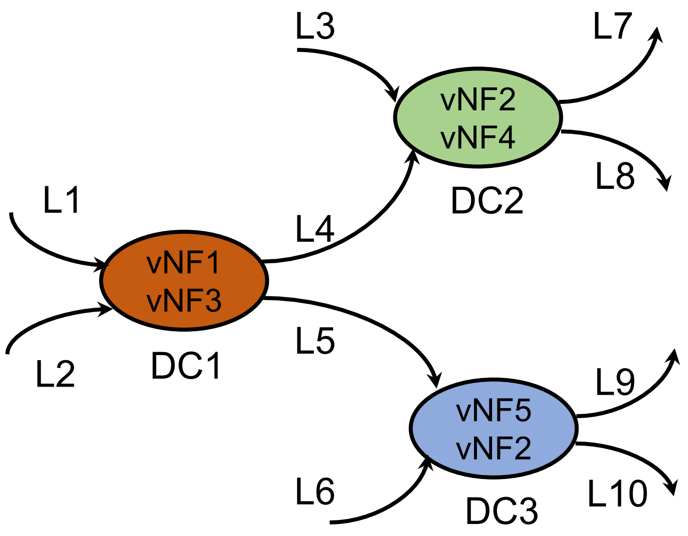


(c) Orchestrating Data-Intensive vNF-SC in an EON

NOTE: the objective is to minimize the service completion time

Service Completion Time (SCT)





Built vNF-SCs for Incoming Requests:

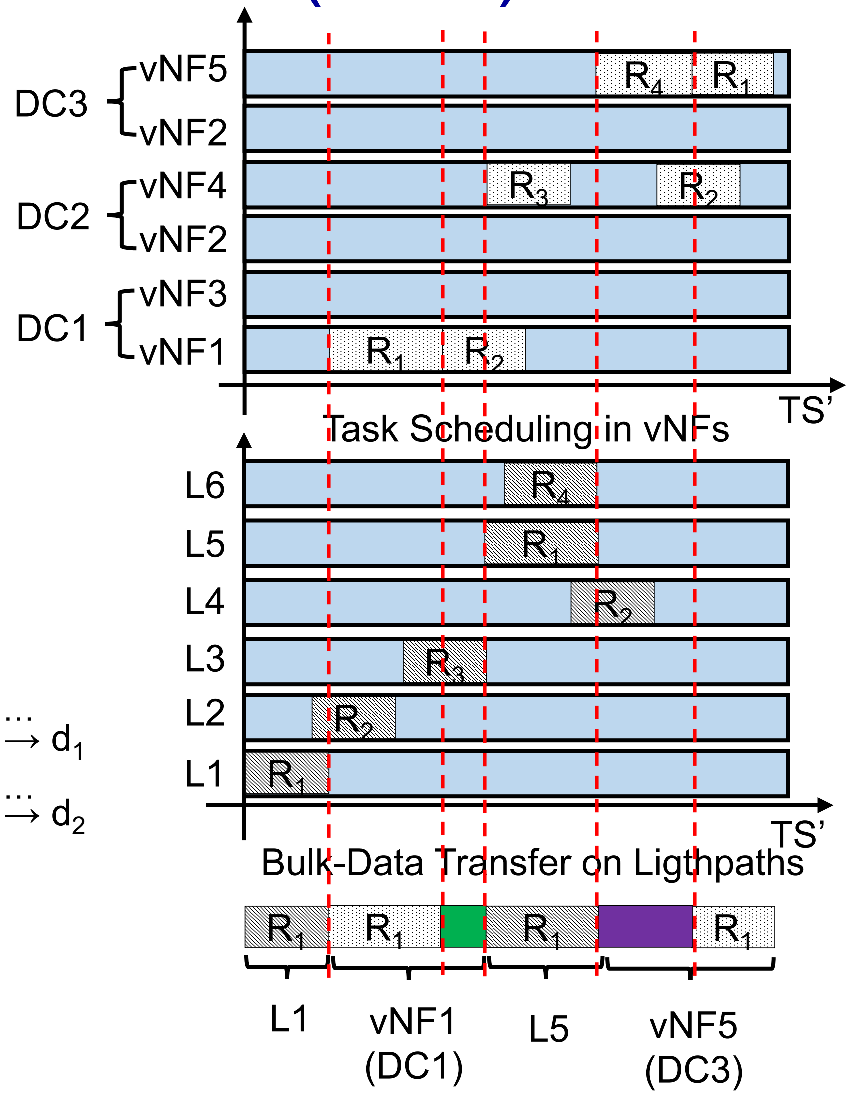
R_1: $s_1 \xrightarrow{\dots} \dots \xrightarrow{L1} vNF_1\ (DC1) \xrightarrow{L5} vNF_5\ (DC3) \xrightarrow{\dots} \dots \xrightarrow{\dots} d_1$

R_2: $s_2 \xrightarrow{\dots} \dots \xrightarrow{L2} vNF_1\ (DC1) \xrightarrow{L4} vNF_4\ (DC2) \xrightarrow{\dots} \dots \xrightarrow{\dots} d_2$

R_3: $s_3 \xrightarrow{\dots} \dots \xrightarrow{L3} vNF_4\ (DC2) \xrightarrow{\dots} \dots \xrightarrow{\dots} d_3$

R_4: $s_4 \xrightarrow{\dots} \dots \xrightarrow{L6} vNF_5\ (DC3) \xrightarrow{\dots} \dots \xrightarrow{\dots} d_4$

(a)



(b)

Solving methodology

- Dynamic programming
- Solution in two phases:
  - Intelligent request sorting
  - Orchestration algorithm

Request Sequencing Optimization

P: Set of data-intensive vNF-SC requests ω: Network Status

$$o(P,\omega,i,j) = g(\omega,i) + g(\tau(\omega,i),j) + o(P/\{i,j\},\tau(\omega,i,j))$$

$$o(P,\omega,j,i) = g(\omega,j) + g(\tau(\omega,j),i) + o(P/\{i,j\},\tau(\omega,j,i))$$

If we have:
$o(P,\omega,i,j) \le o(P,\omega,j,i)$,
request i should be served before request j to minimize the total SCT.

$O(P,\omega,i,j)$: Starting with status (P,ω) and having requests i and j served successively, the smallest total SCT of data-intensive vNF-SCs in $P\ /\ \{i,j\}$ with the optimal serving sequence.

$g(\omega,i)$: A function to calculate the smallest SCT of request i given a network status ω.

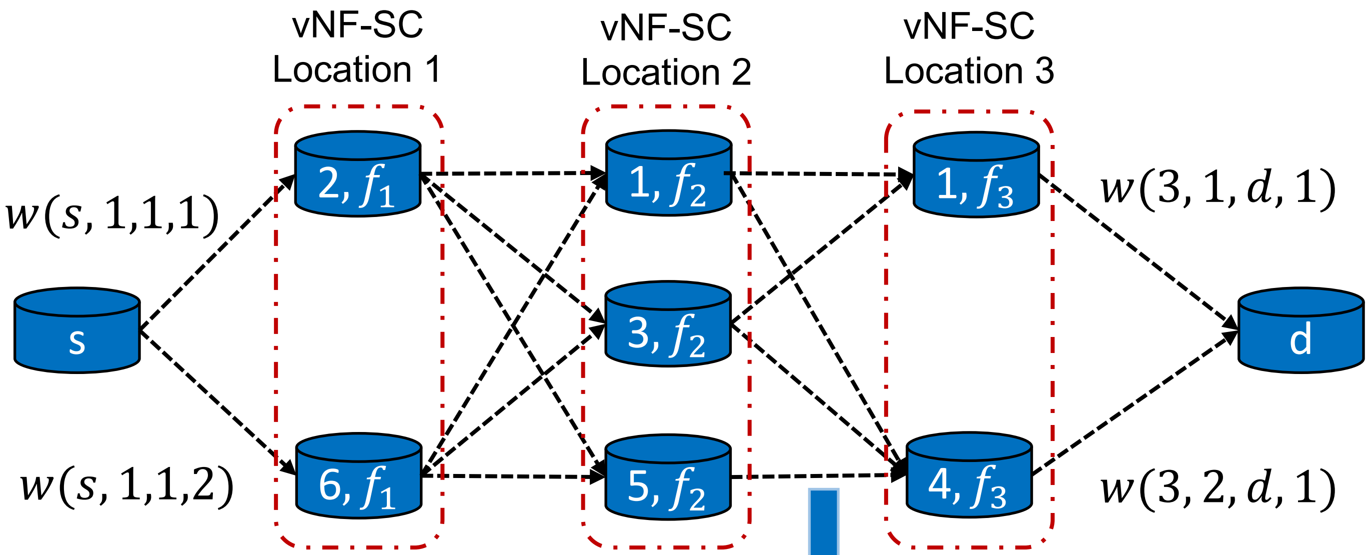
$\tau(\omega,i)$: The network status associated with the result of function $g(\omega,i)$.

$O(P,\omega)$: Starting with status (P,ω), the smallest total SCT of data-intensive vNF-SCs in P with the optimal serving sequence.

Objective: minimize the follow-up effect

$$e(\omega,i) = g(\omega,i) + \sum_{r\in P/\{i\}} g(\tau(\omega,i),r)$$

Data-Intensive vNF-SC Orchestration Algorithm



$$O(s,\ 1,\ i,\ m) = \min\left(\left\{O(s,\ 1,\ i-1,\ m') + w(i-1,\ m',\ i,\ m)\right\} : m'\right)$$

Task Rescheduling in DC

Bulk-Data Transfer

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Simulation Parameters

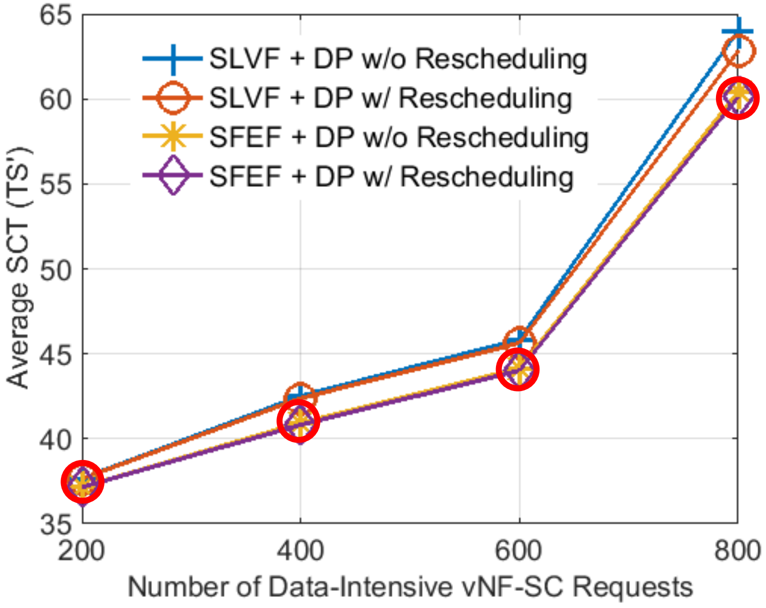
Network Topology	14-Node NSFNET Topology
Types of vNFs	10
Number of Established Lightpaths Between Each DC Pair	2 on Average
Number of FS' Assigned on Lightpaths	11 FS'
Number of Requested vNFs	5 on Average
Initial Data Volume	[2, 6] FS·TS
Processing Rate of a vNF	[0.56, 1.12] Times of the Transmission Rate of an FS
Data Change Ratio of a vNF	[0.7, 1.3]

Light Background Scenario

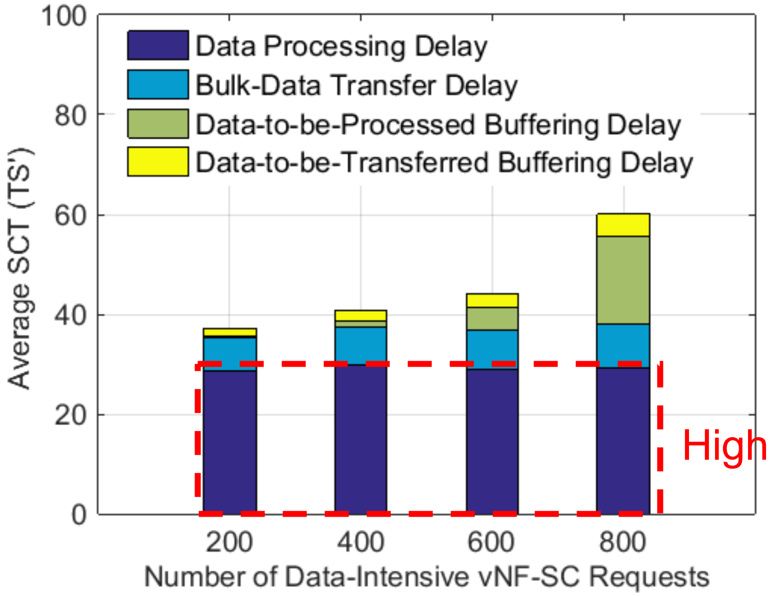
Light background scenario: the background traffic use the lightpaths' bandwidth among the time axis and leave **12.14%** bandwidth on average as the **2D spectrum fragments**;

SLVF: smallest vNF-SC length and data volume first, **benchmark request sorting algorithm**, serve the requests that have less requested vNFs and smaller data volume earlier;

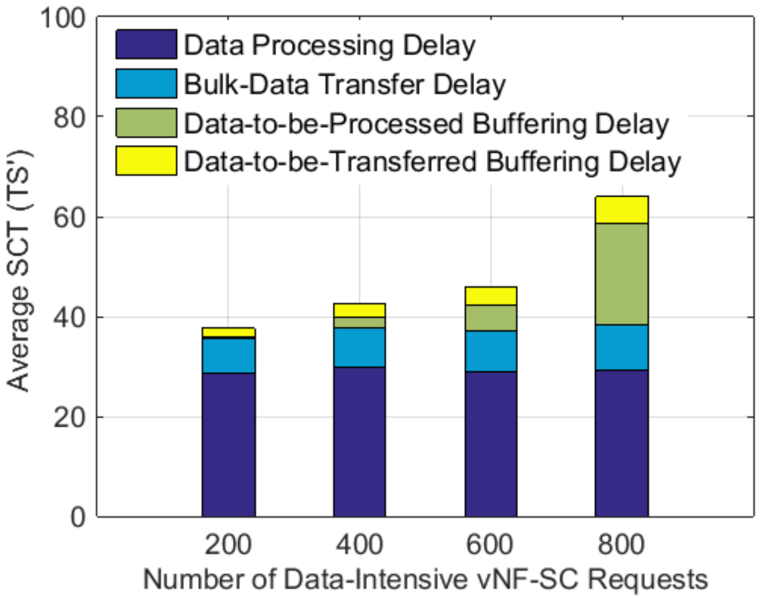
SFEF: smallest follow-up effect first, **proposed request sorting algorithm**.



(a) Average SCT of Data-Intensive vNF-SCs



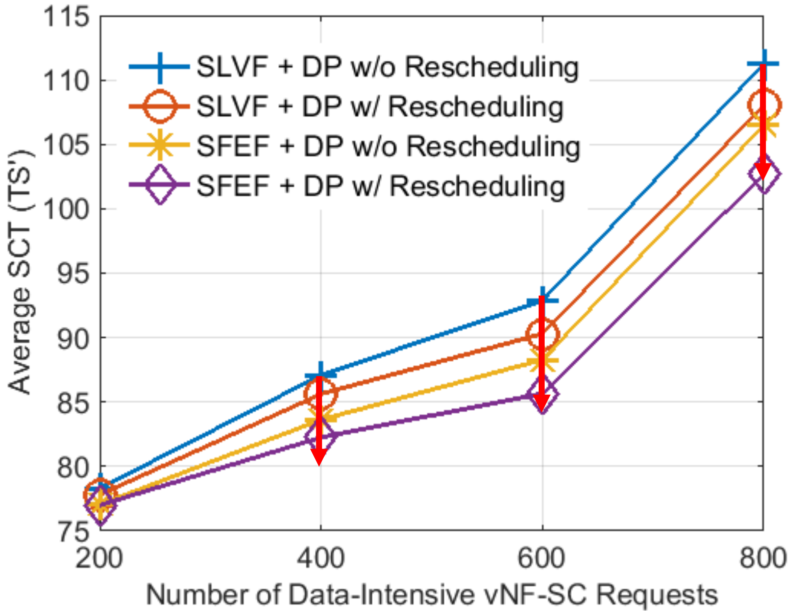
(b) Distribution of average SCT when using "SFEF + DP w/ Rescheduling"



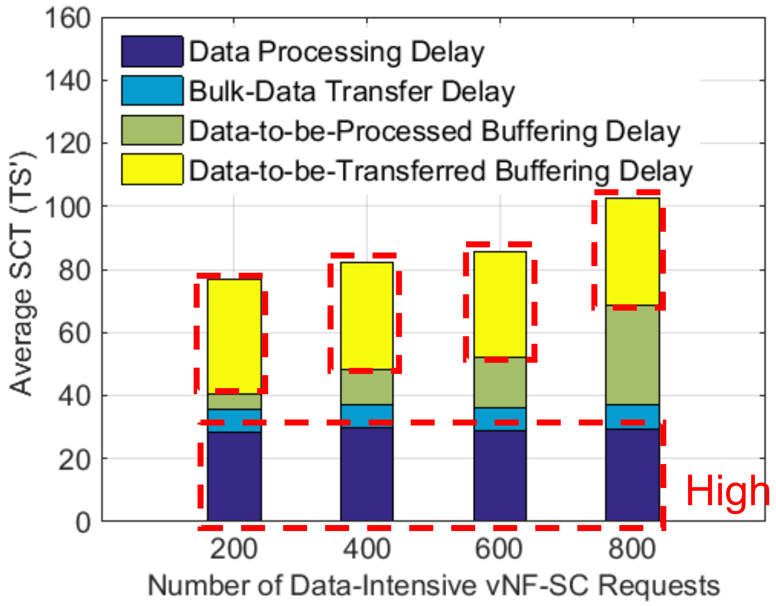
(c) Distribution of average SCT when using "SLVF + DP w/o Rescheduling"

Heavy Background Scenario

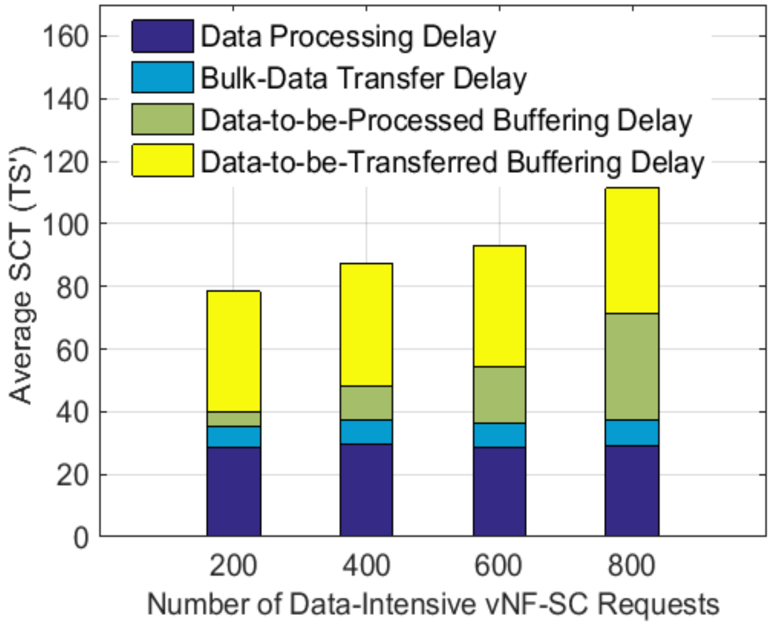
Heavy background scenario: the background traffic use the lightpaths' bandwidth among the time axis and leave **2.67%** bandwidth on average as the **2D spectrum fragments**;
SLVF: smallest vNF-SC length and data volume first, **benchmark request sorting algorithm**, serve the requests that have less requested vNFs and smaller data volume earlier;
SFEF: smallest follow-up effect first, **proposed request sorting algorithm**.



(a) Average SCT of Data-Intensive vNF-SCs



(b) Distribution of average SCT when using "SFEF + DP w/ Rescheduling"



(c) Distribution of average SCT when using "SLVF + DP w/o Rescheduling"

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Conclusion

- We studied how to serve the data-intensive vNF-SCs in an inter-DC EON to minimize their average SCT.
- We proposed a request sorting algorithm to minimize the follow-up effect and a data-intensive vNF-SC orchestration algorithm based on a dynamic programming method.
- Simulation results verified the effectiveness of the proposed algorithms on reducing the average SCT.