Deploying Multiple Service Chain (SC) Instances per Service Chain

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FRIDAY GROUP MEETING
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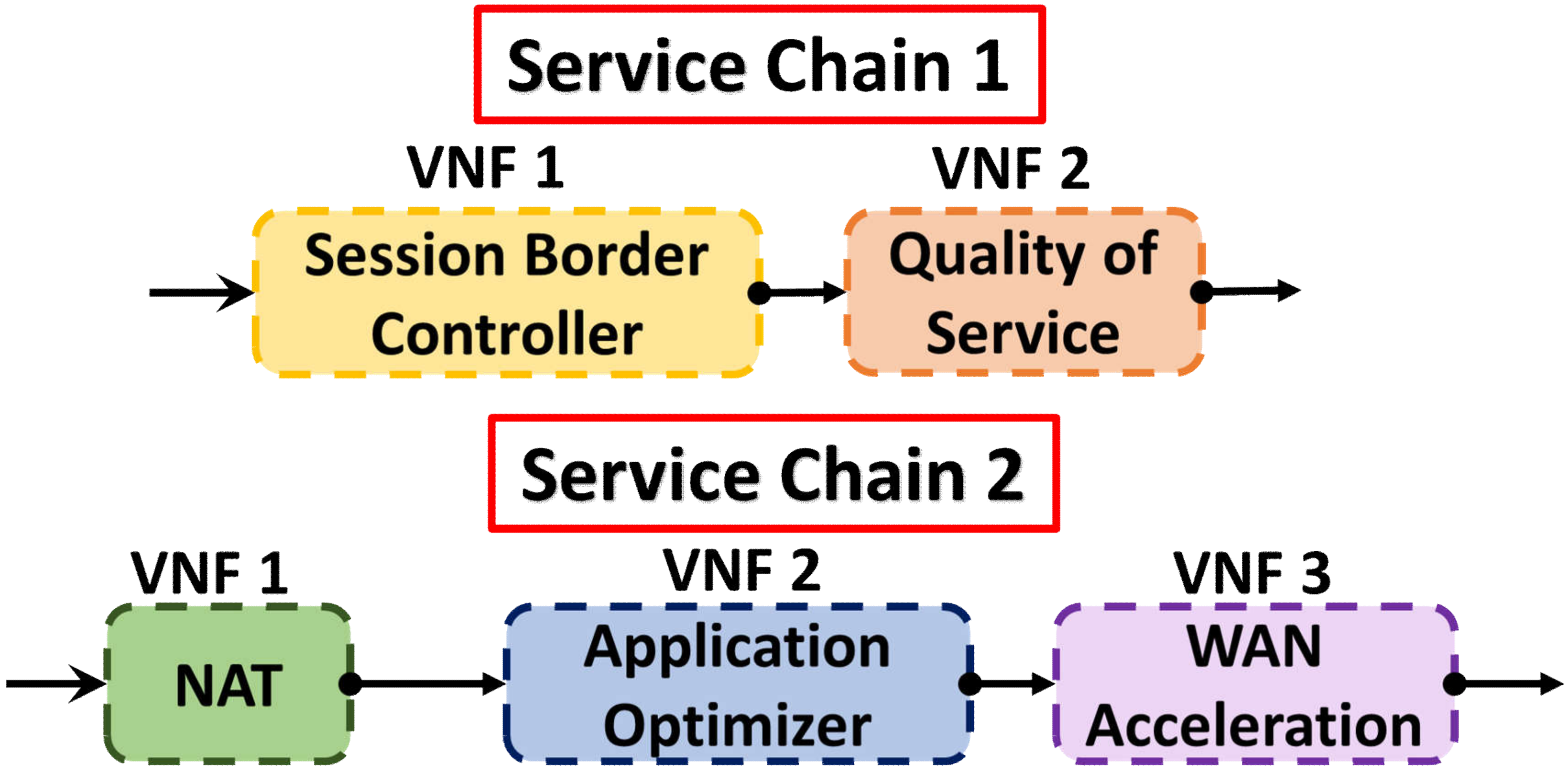
Virtual Network Function (VNF) Service Chain (SC)



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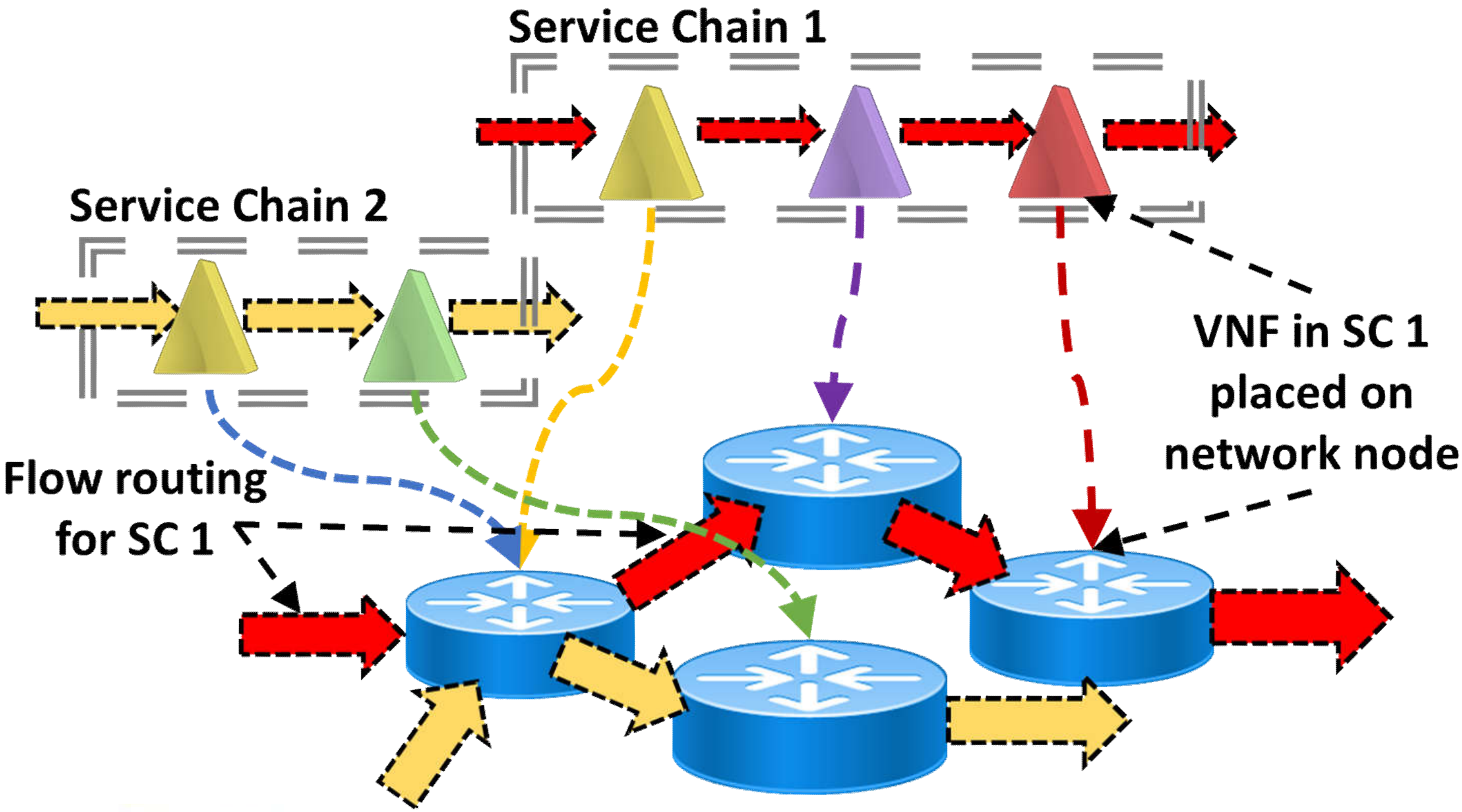
Multiple VNF SC Placement and Routing



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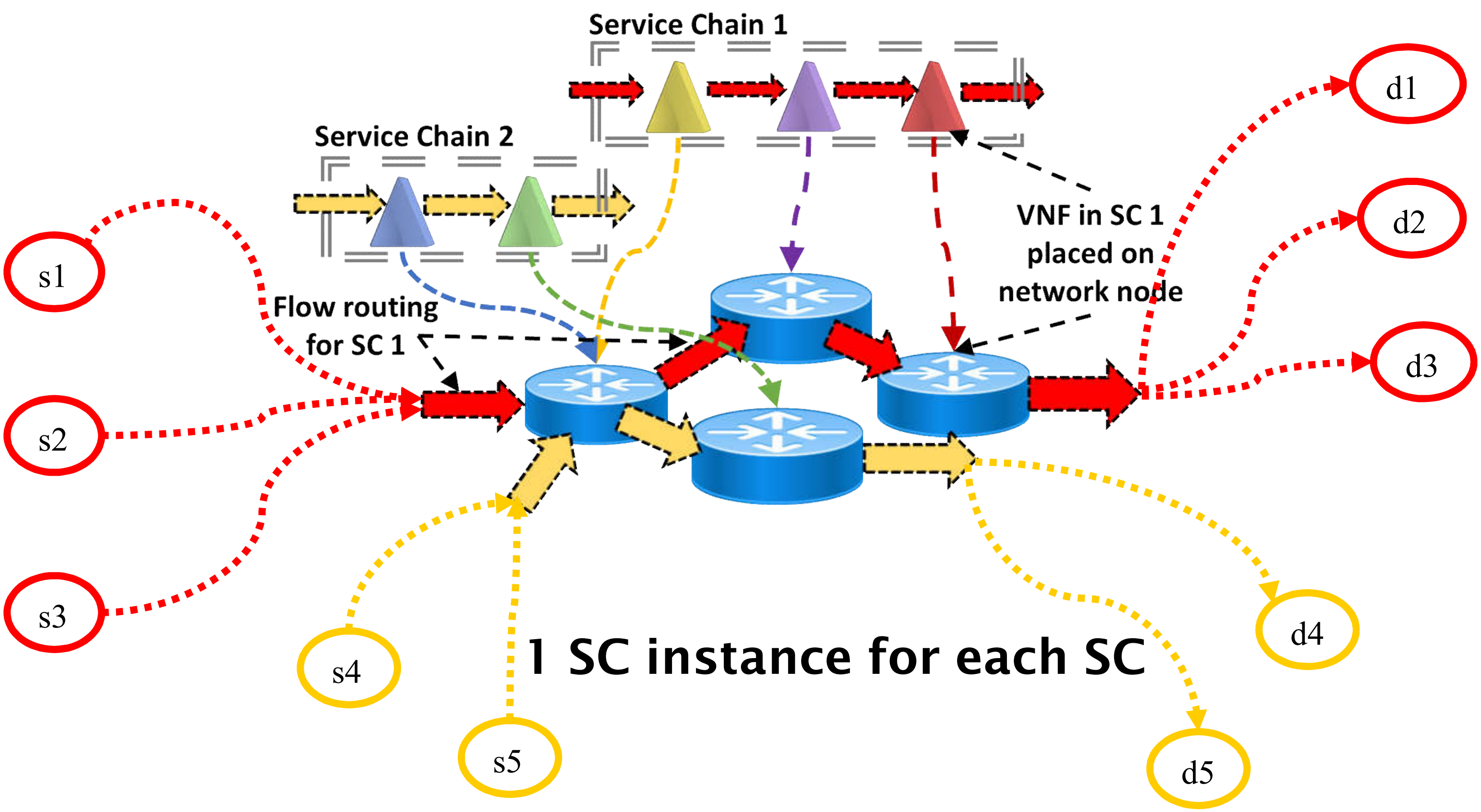
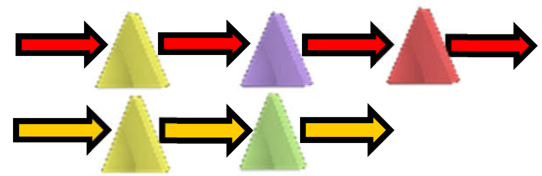


Service Chain 1
Service Chain 2
VNF in SC 1 placed on network node
Flow routing for SC 1
s1
s2
s3
s4
s5
d1
d2
d3
d4
d5
1 SC instance for each SC

Single Instance Per SC



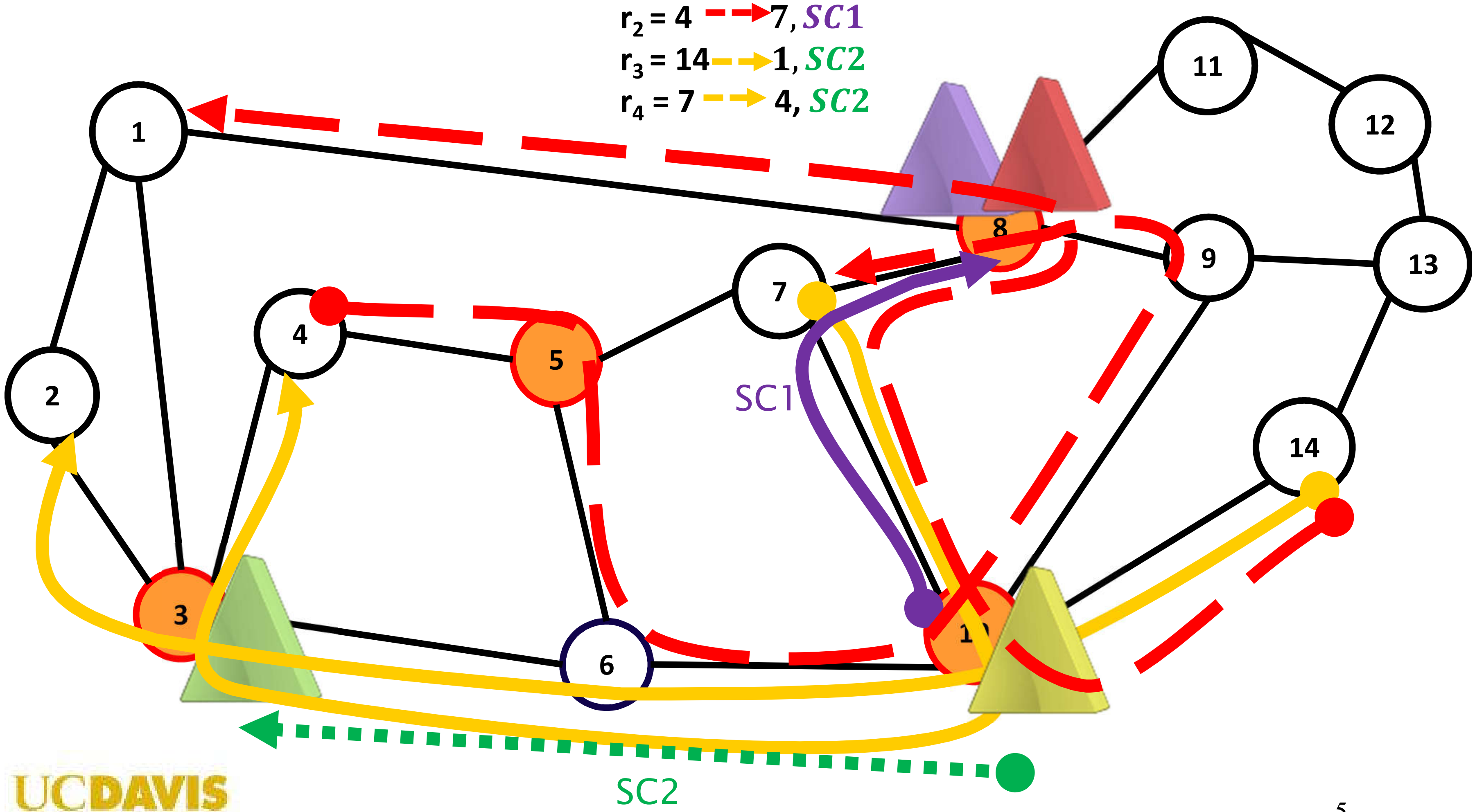
3 Demand Requests

$r_1 = 14 \rightarrow 1, SC1$

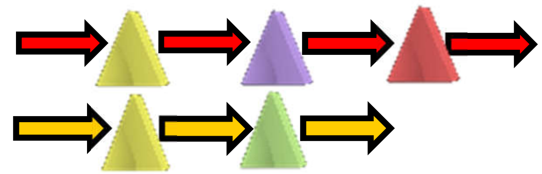
$r_2 = 4 \rightarrow 7, SC1$

$r_3 = 14 \rightarrow 1, SC2$

$r_4 = 7 \rightarrow 4, SC2$



Multiple Instances per SC



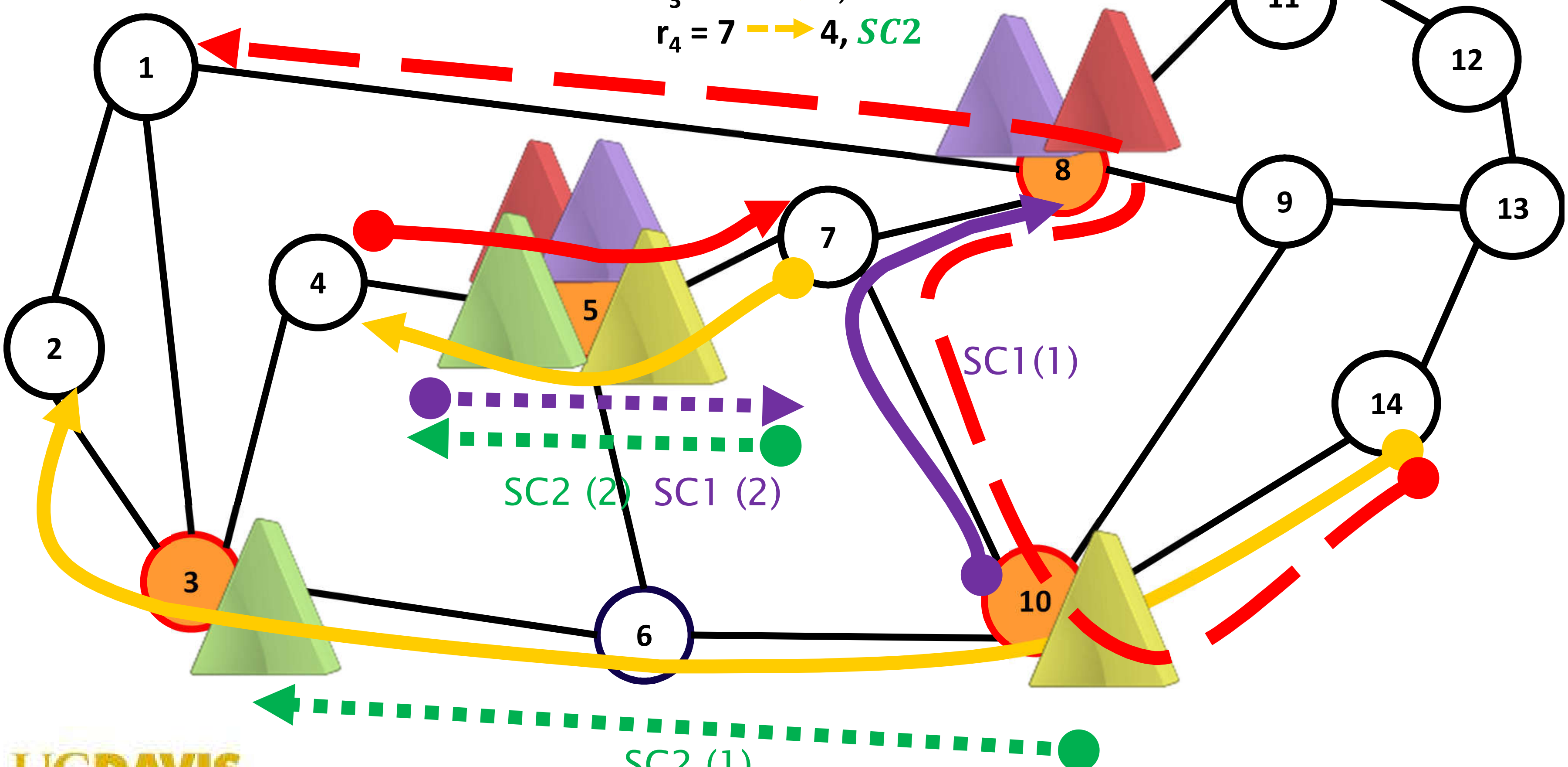
3 Demand Requests

r_1 = 14 → 1, $SC1$

r_2 = 4 → 7, $SC1$

r_3 = 14 → 1, $SC2$

r_4 = 7 → 4, $SC2$



Inferences and Questions

- 1 SC instance per SC leads to suboptimal results
- Having SC instances replicated on every node will lead to to optimal results
  - Large capital expenditure to make all nodes NFV capable
  - High Orchestration Overhead for large number of instances
- The question therefore becomes:
  - **How many SC instances to deploy to reduce bandwidth consumption while also reducing nodes used?**
- **We develop a heuristic to help us chose the right number of instances (SPTG)**

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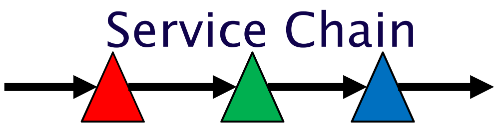
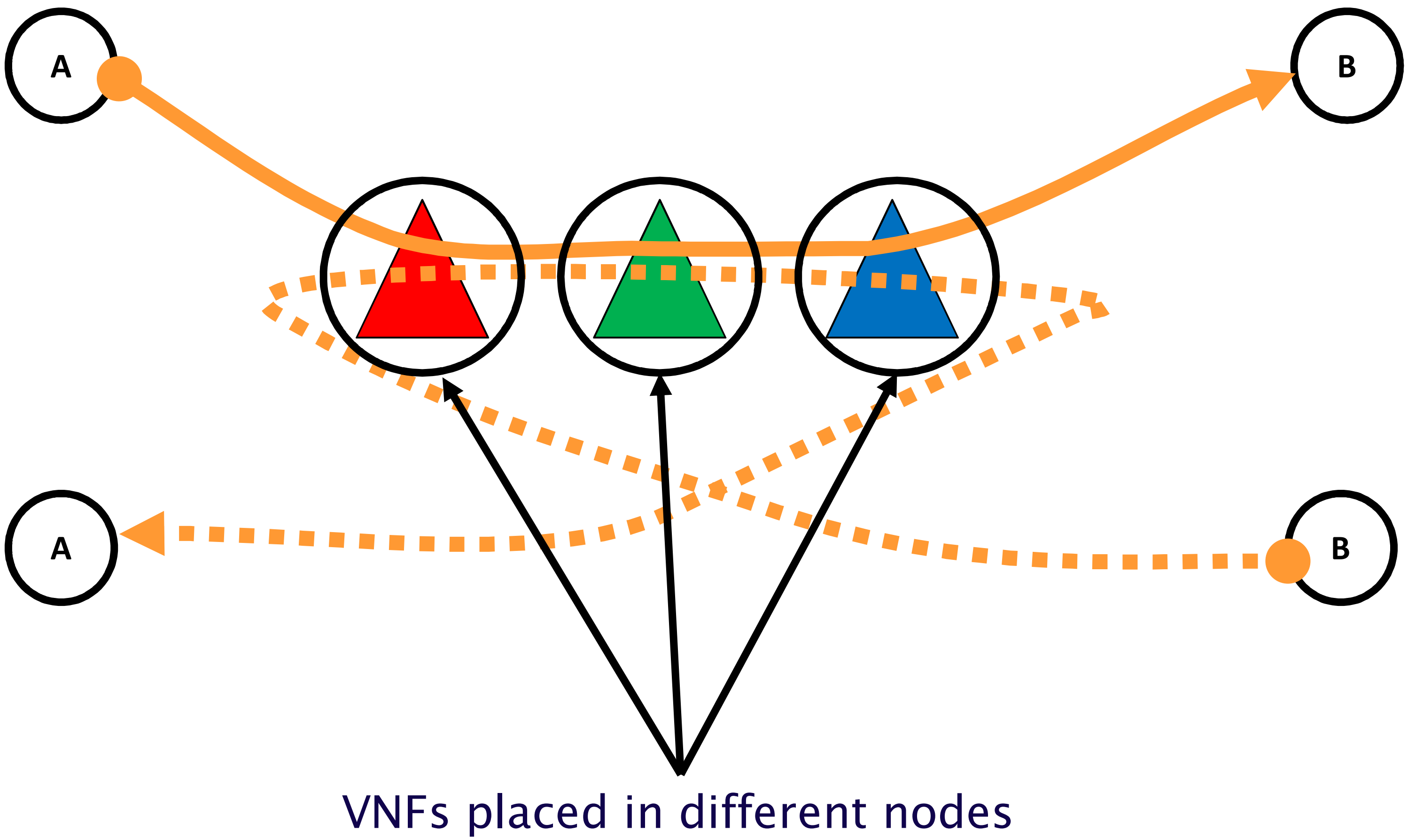
Issue of symmetric flows





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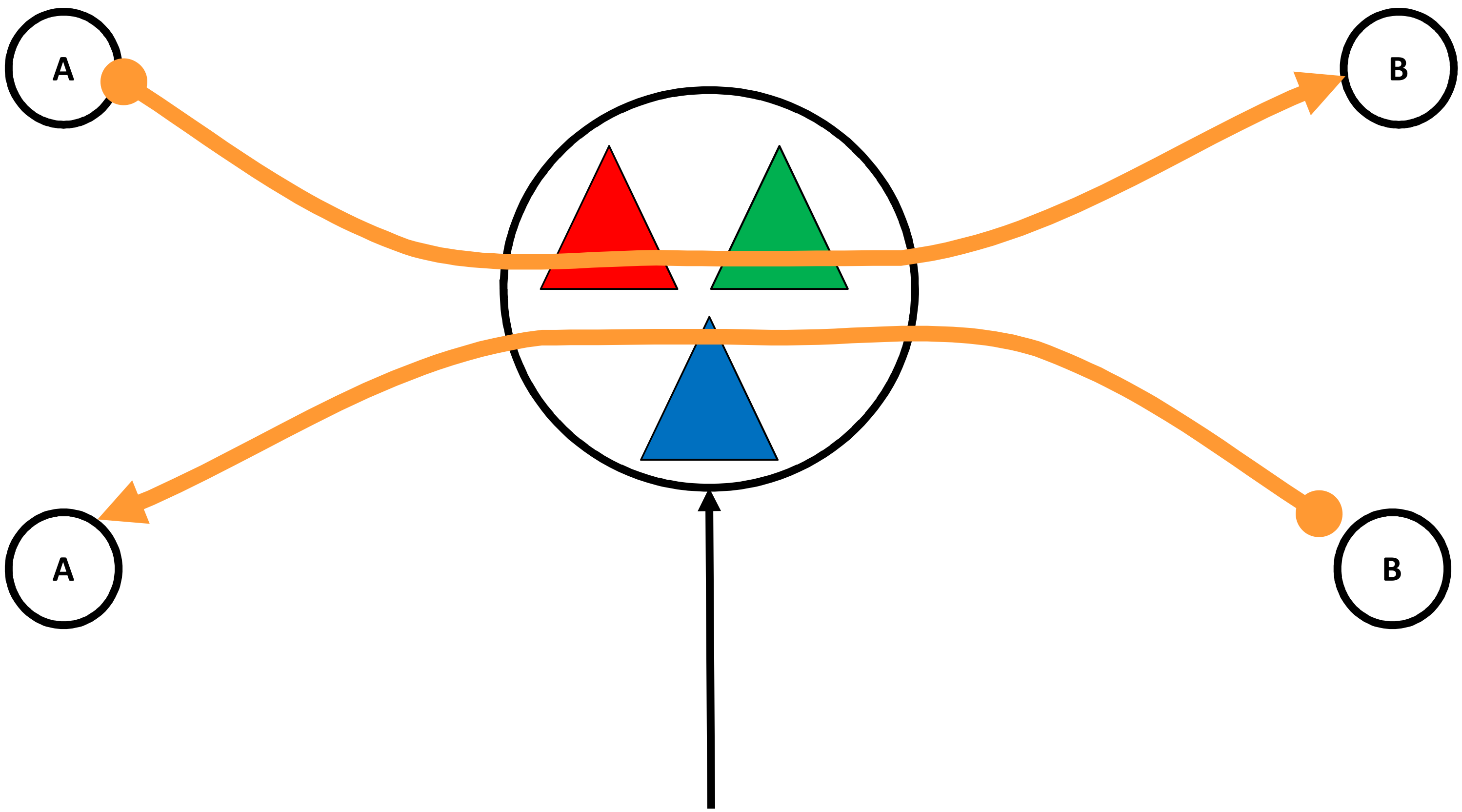

VNFs placed in same node

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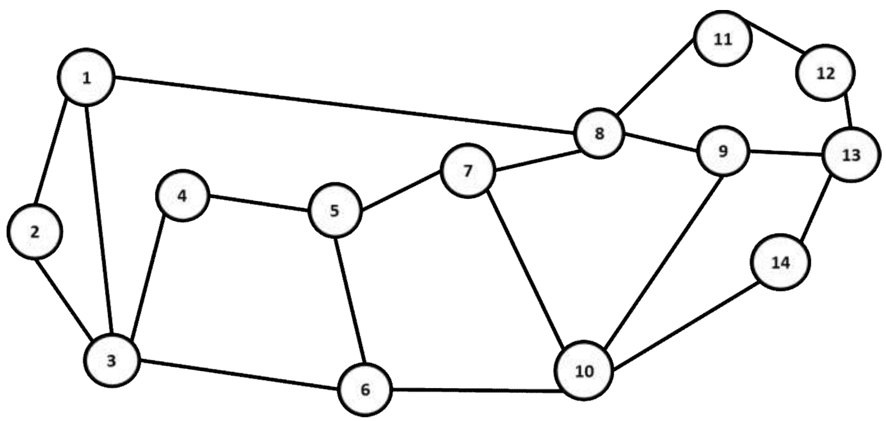
- Placing VNFs for SC at different nodes
  - makes symmetric flow take longer path
- Placing VNFs for SC at one node
  - symmetric flow takes shorter path
  - placement and routing becomes trivial
  - chaining aspect is forgone
  - Is this more realistic?
  - Represents the case of a DC



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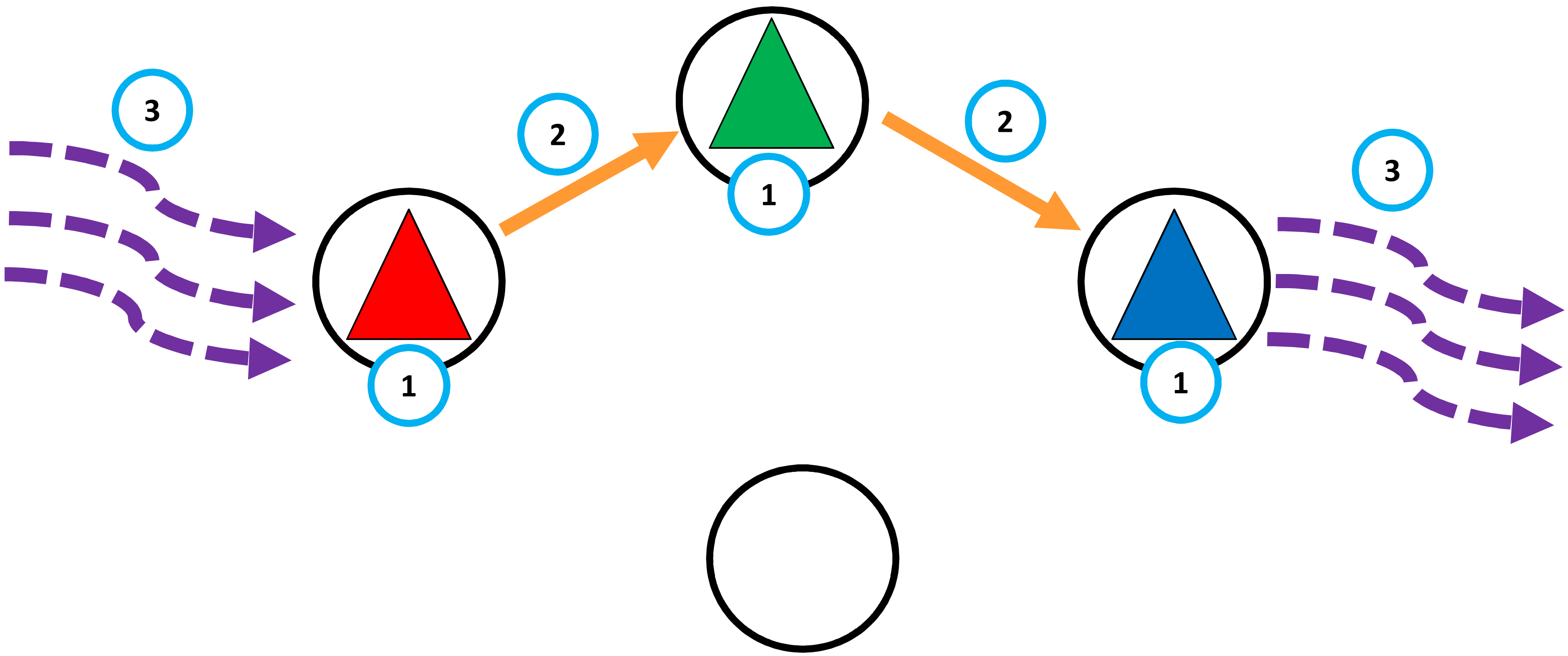
Configuration 1 – (ILP, CG)



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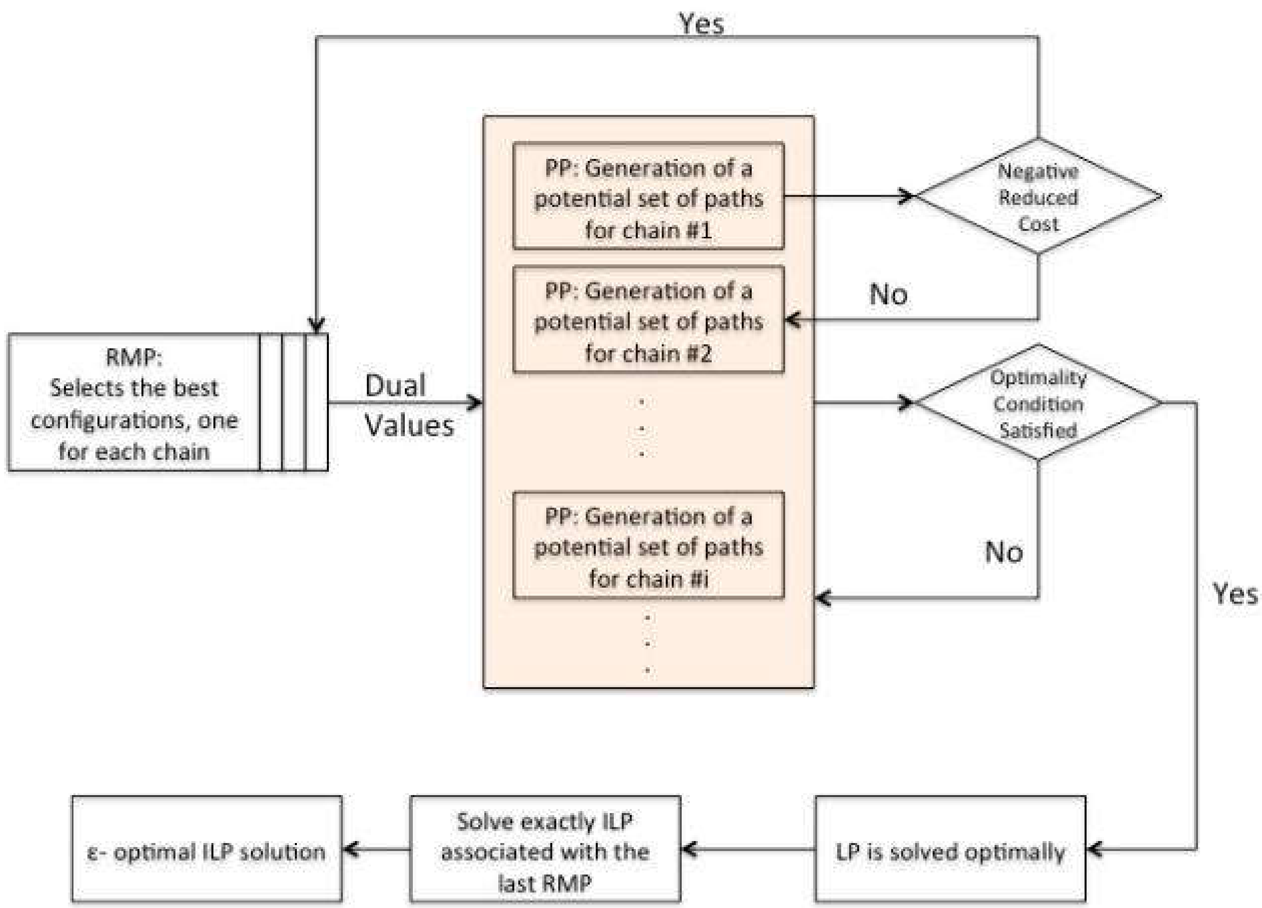
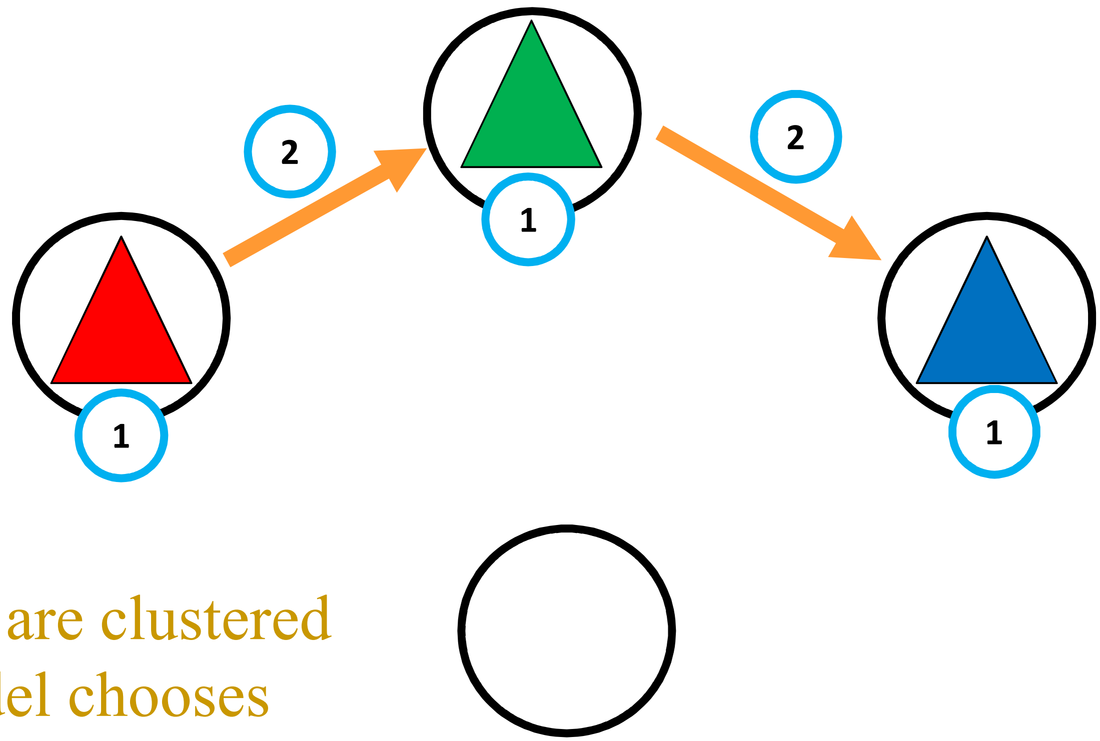
CG Model

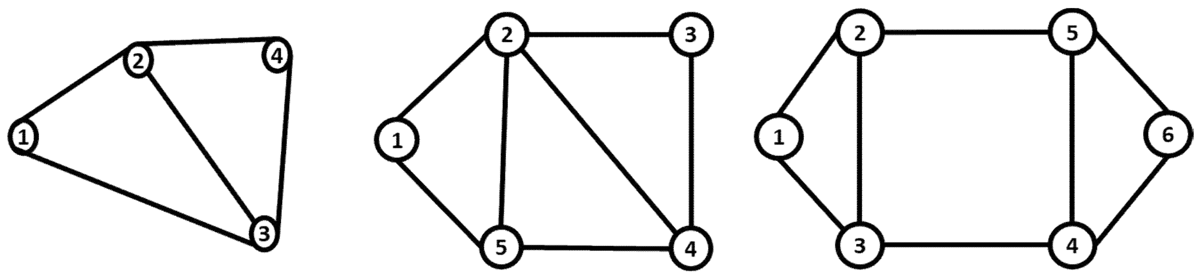

Yes
RMP:
Selects the best
configurations, one
for each chain
Dual
Values
PP: Generation of a
potential set of paths
for chain #1
PP: Generation of a
potential set of paths
for chain #2
PP: Generation of a
potential set of paths
for chain #i
Negative
Reduced
Cost
No
Optimality
Condition
Satisfied
No
Yes
LP is solved optimally
Solve exactly ILP
associated with the
last RMP
ε- optimal ILP solution

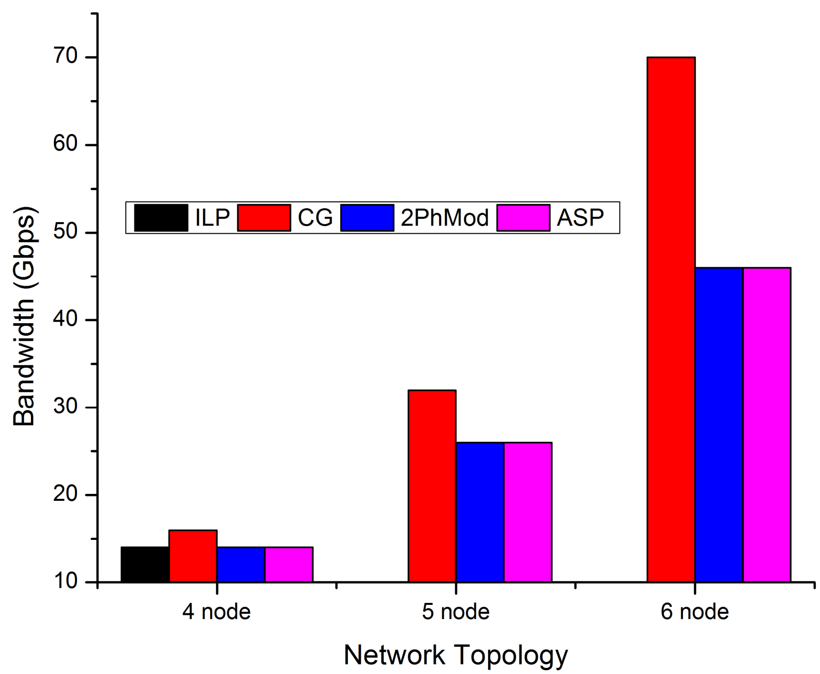
Configuration 2 – (2 Phase Model)



Traffic flows are clustered and then model chooses appropriate configuration

Comparison (ILP, CG, 2 Phase Model)





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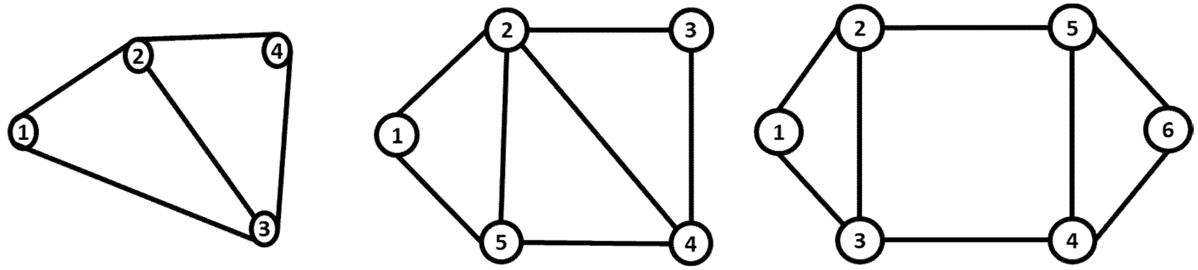

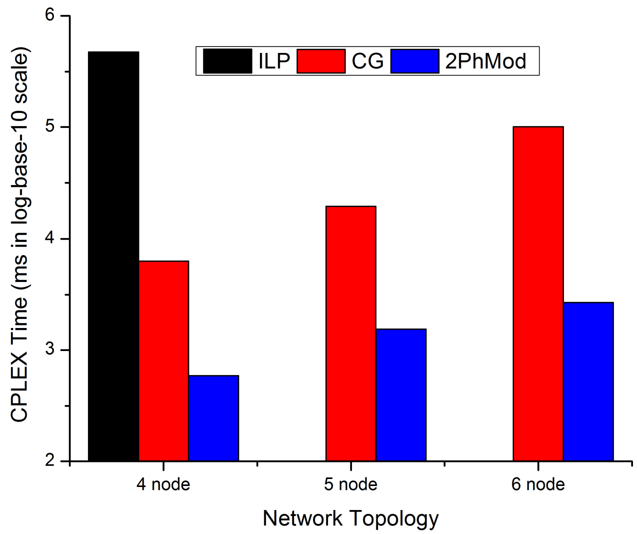

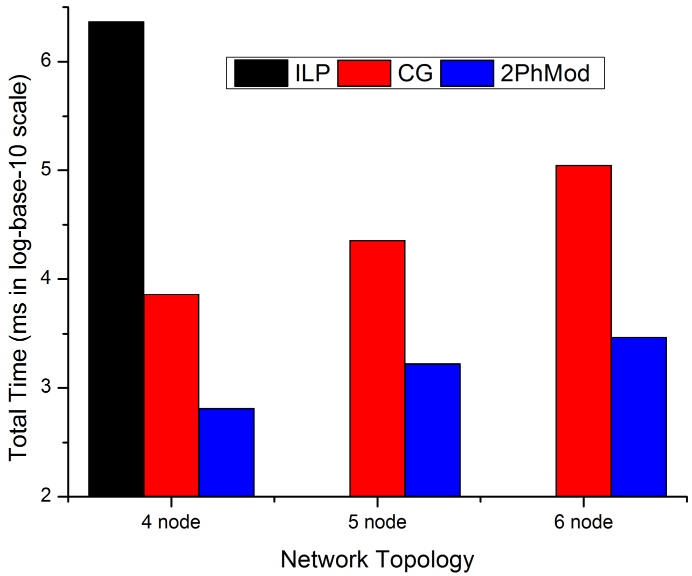

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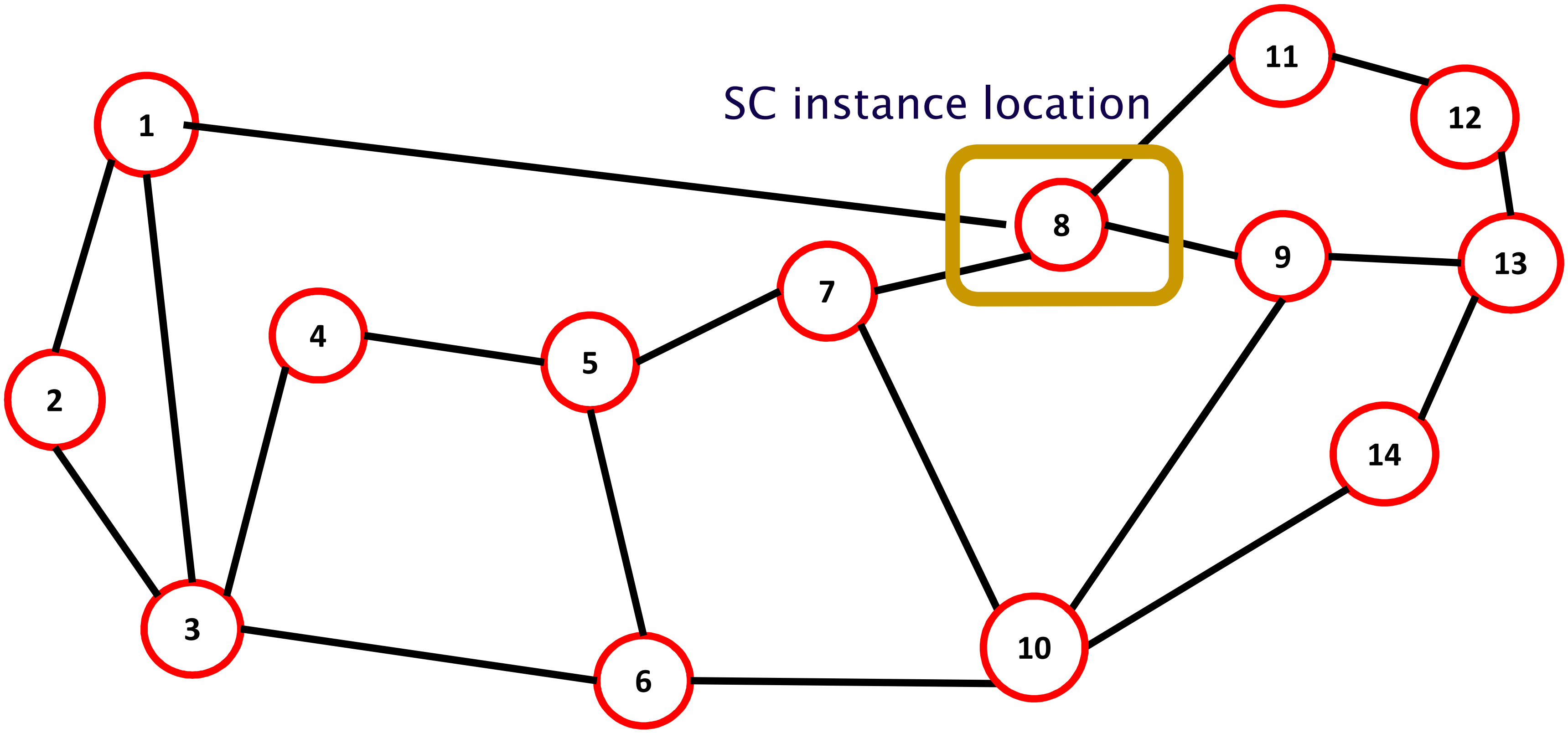
Full Traffic Matrix, 1 SC deployment, 1 SC instance



All nodes are NFV-capable.
All node pairs have requests for the same service chain.

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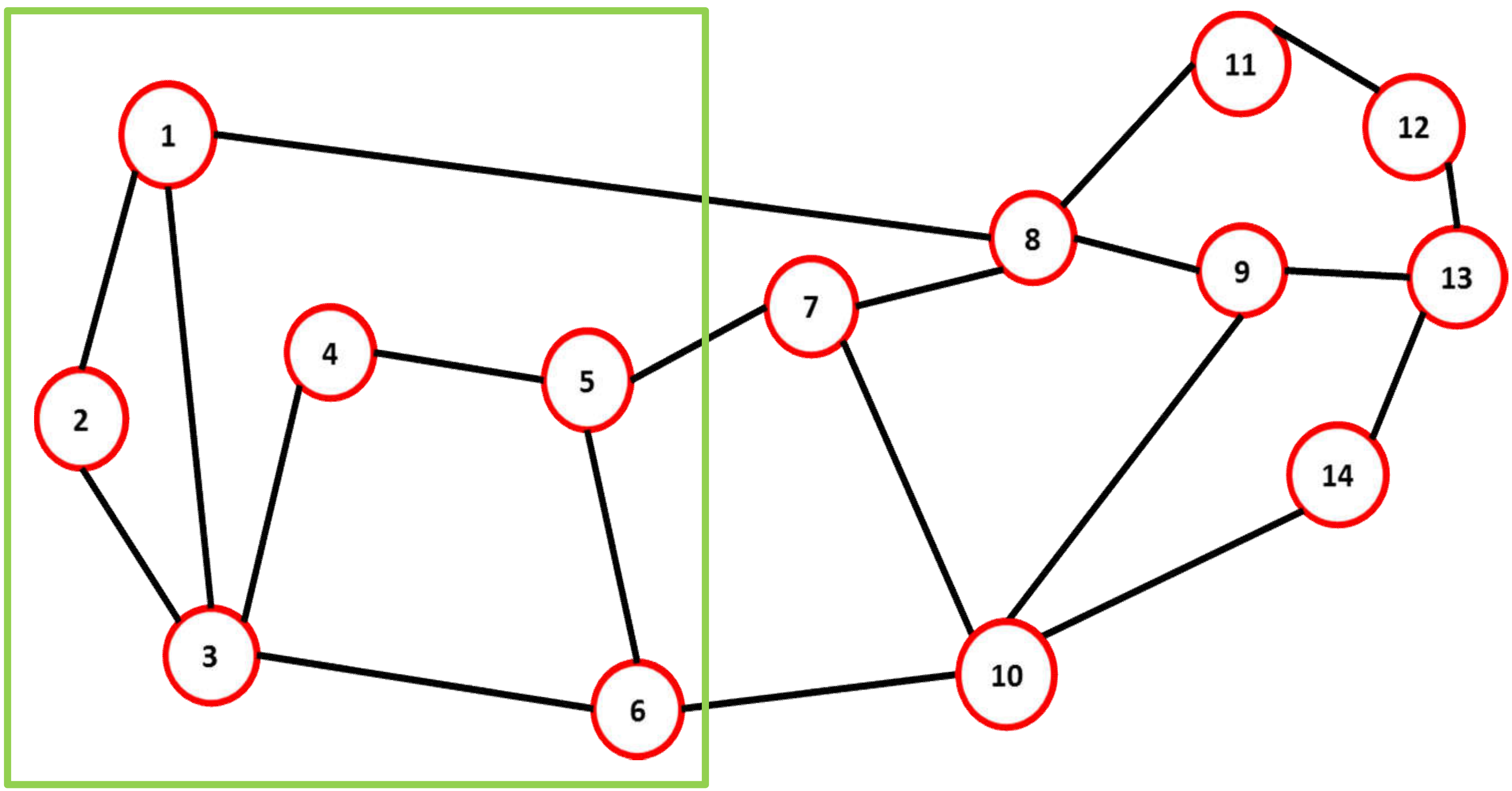
Grouping of traffic pairs



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Continued …

- Create traffic flow groups
- Assign dummy SC Id’s to traffic flow groups
- Big Question: **How to do we make traffic groups?**
- Model accounting for traffic groups becomes quadratic. Subsequent, linearization reduced the scalability of the model
- We, therefore, use a heuristic to do make the traffic groups

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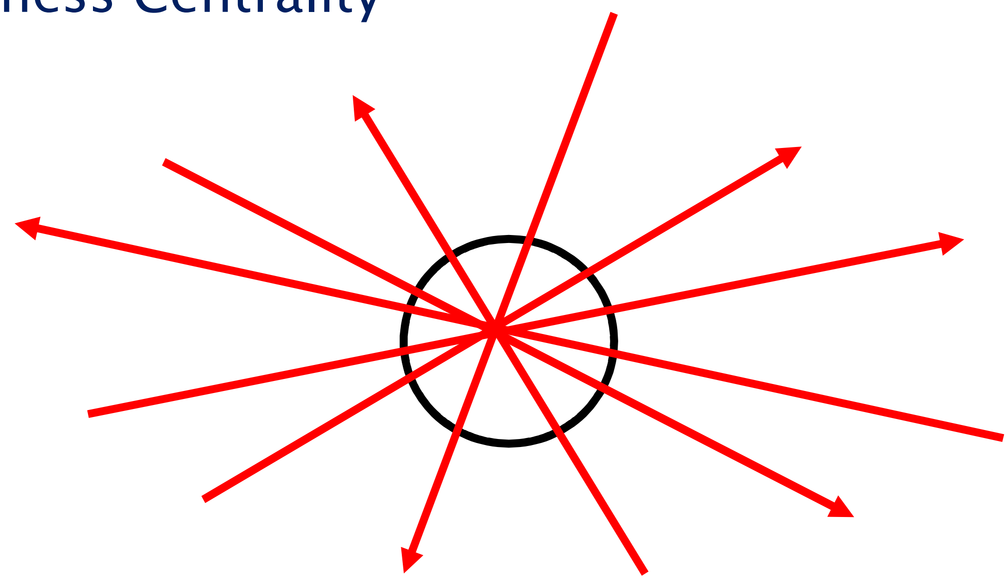
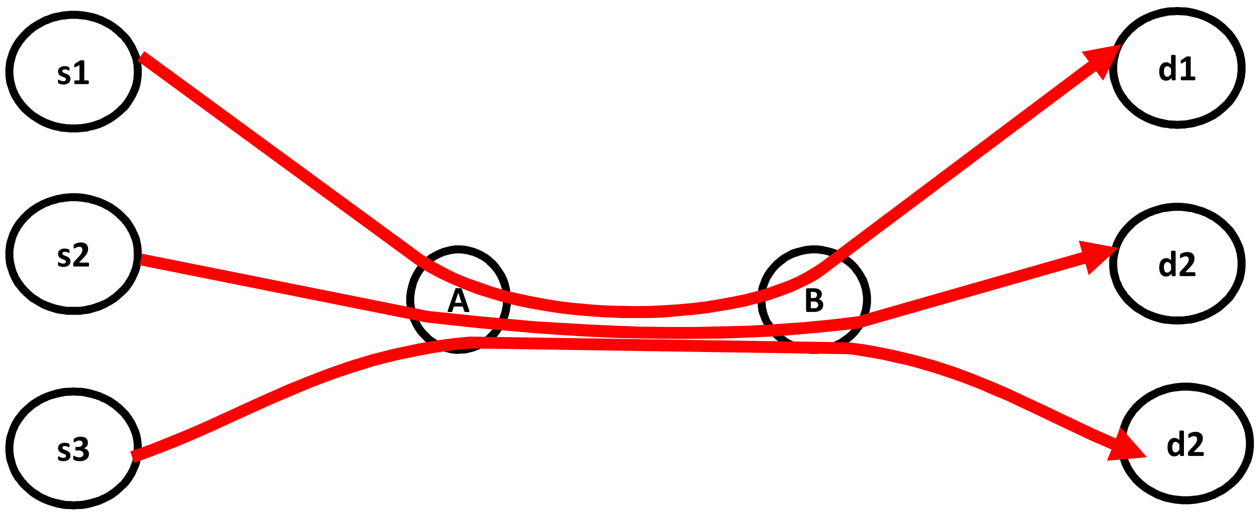
Grouping traffic flows around a node

- Betweenness Centrality



Group around node pairs of the graph

- A and B can also be source and destination
- Done for each SC



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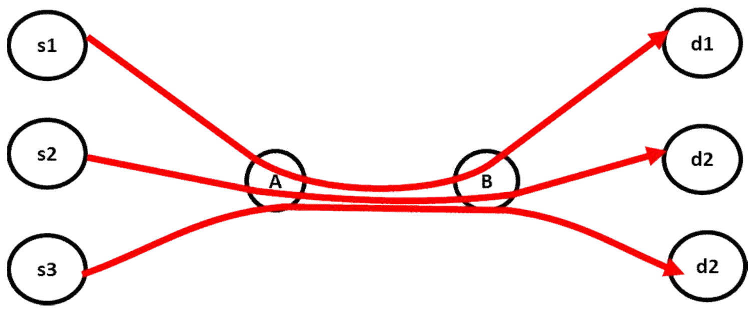
- Ordered node pair with highest traffic flow count passing through on shortest paths



- Traffic flows which share sub-paths in common

- Deploying one SC instance for each such group

Shortest Path Traffic Grouping (SPTG)

- Given: the number of instances for a SC, all node pairs in a graph G

- The heuristic will:
  1. Find the node pair with the largest number of (s, d) pairs
  2. This becomes another (s, d) pair group
  3. All the (s, d) pairs in the group are removed from the global (s, d) pair list
  4. Repeat step 1 to 3 until number of instances is reached
  5. Iterate through the remaining (s, d) pairs:
     1. Find best group based on which path length through node pair
     2. Add (s,d) pair to that group

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2 phase model

- 1st phase
  - Apply SPTG for each SC and create the required number of groups
  - Assign dummy SC ids to groups of (s,d) pairs

- 2nd phase
  - Use the columen generation model which decides on 1 SC instance per SC
  - ***Also we can control the number of nodes that can host VNFs, we refer to this number as 'K'***

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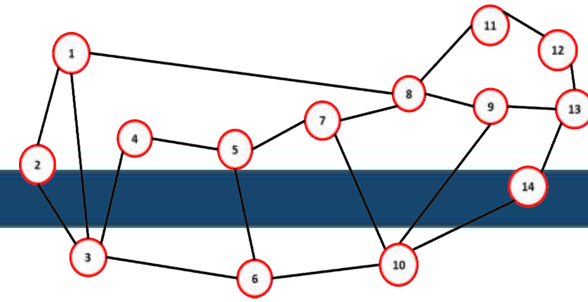
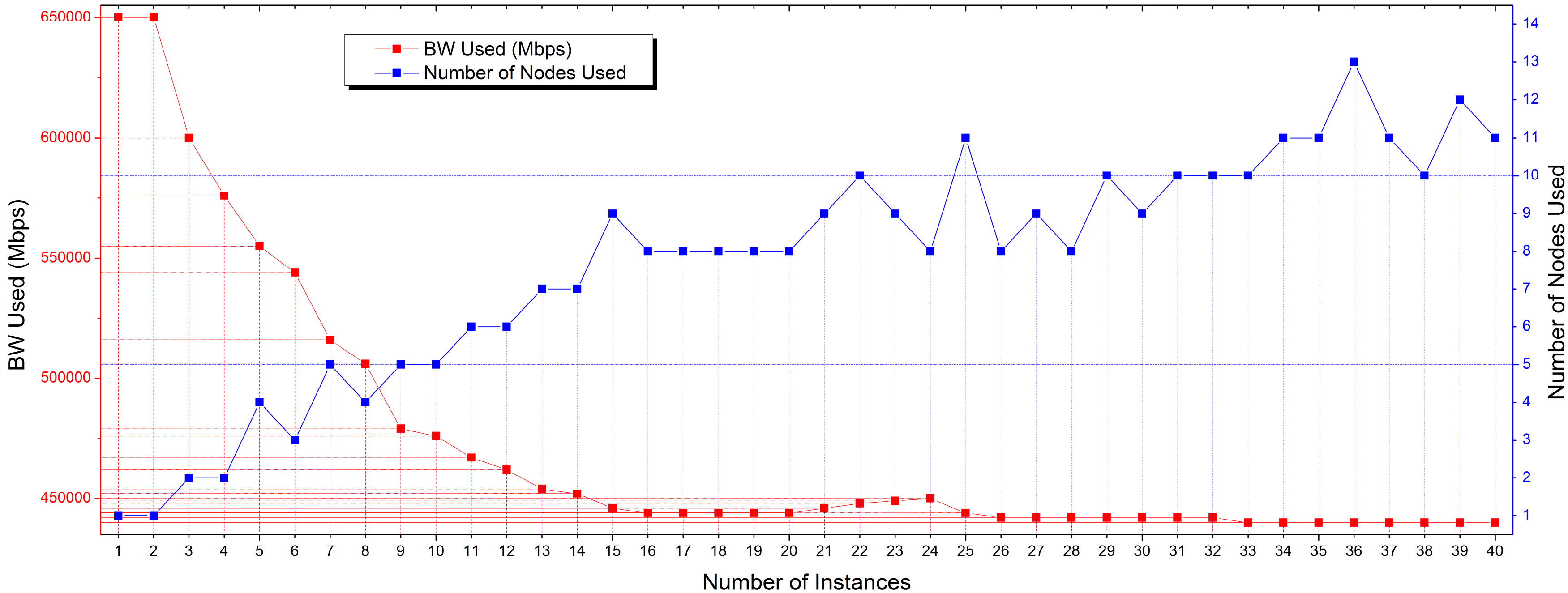
Assumptions

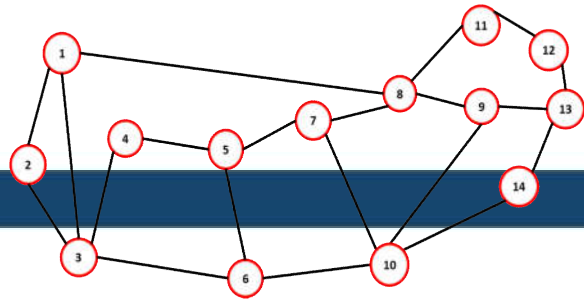
- All nodes are capable of hosting VNFs
- No CPU constraints are enforced
- No link capacity constraints are enforced
- Only one SC instance per SC model
- All traffic pairs have 1Gb traffic flow

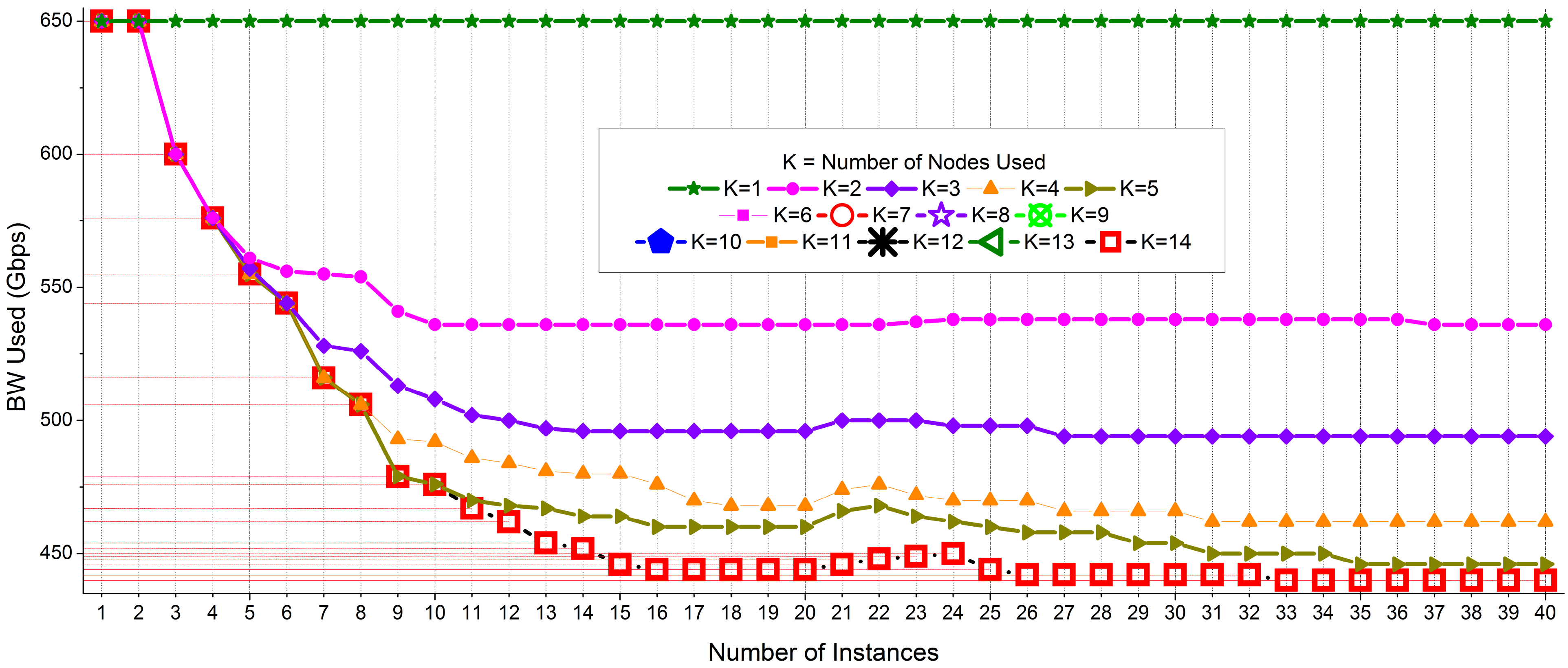
NSFNET K=14


1
2
3
4
5
6
7
8
9
10
11
12
13
14


BW Used (Mbps)
Number of Nodes Used
650000
600000
550000
500000
450000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Number of Instances
14
13
12
11
10
9
8
7
6
5
4
3
2
1

NSFNET K=14,5,4,3,2,1





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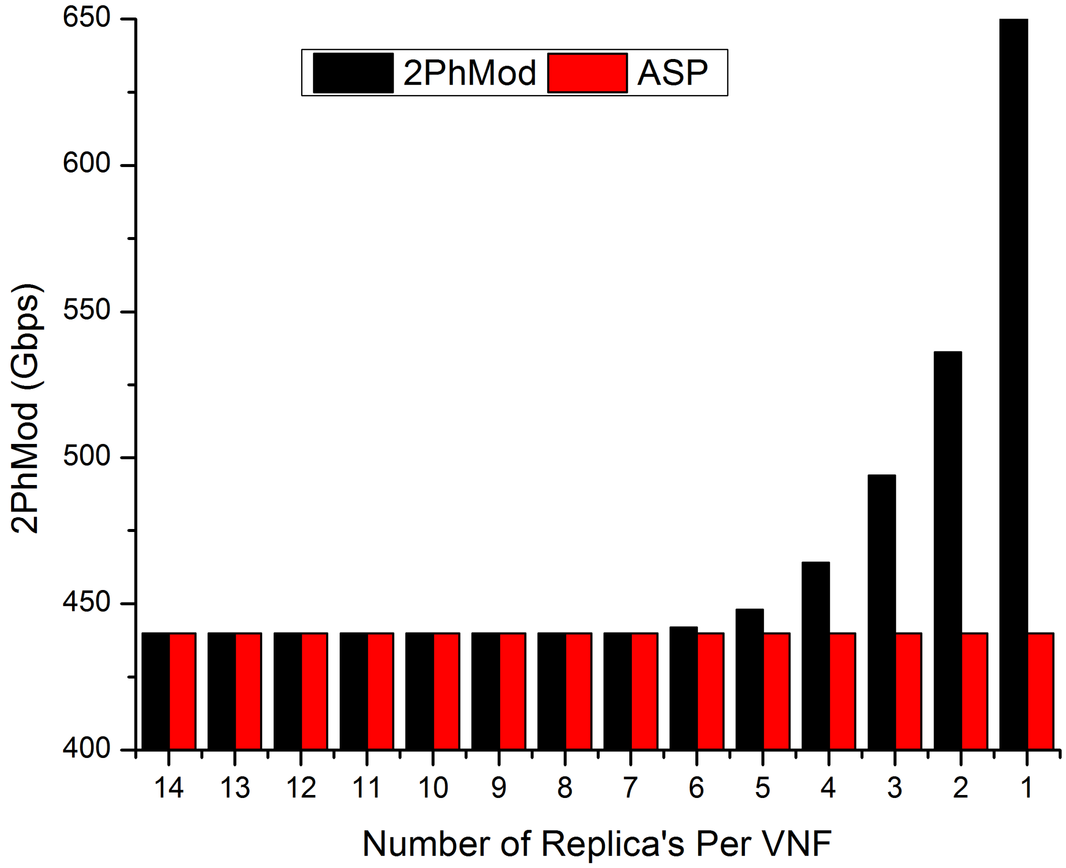
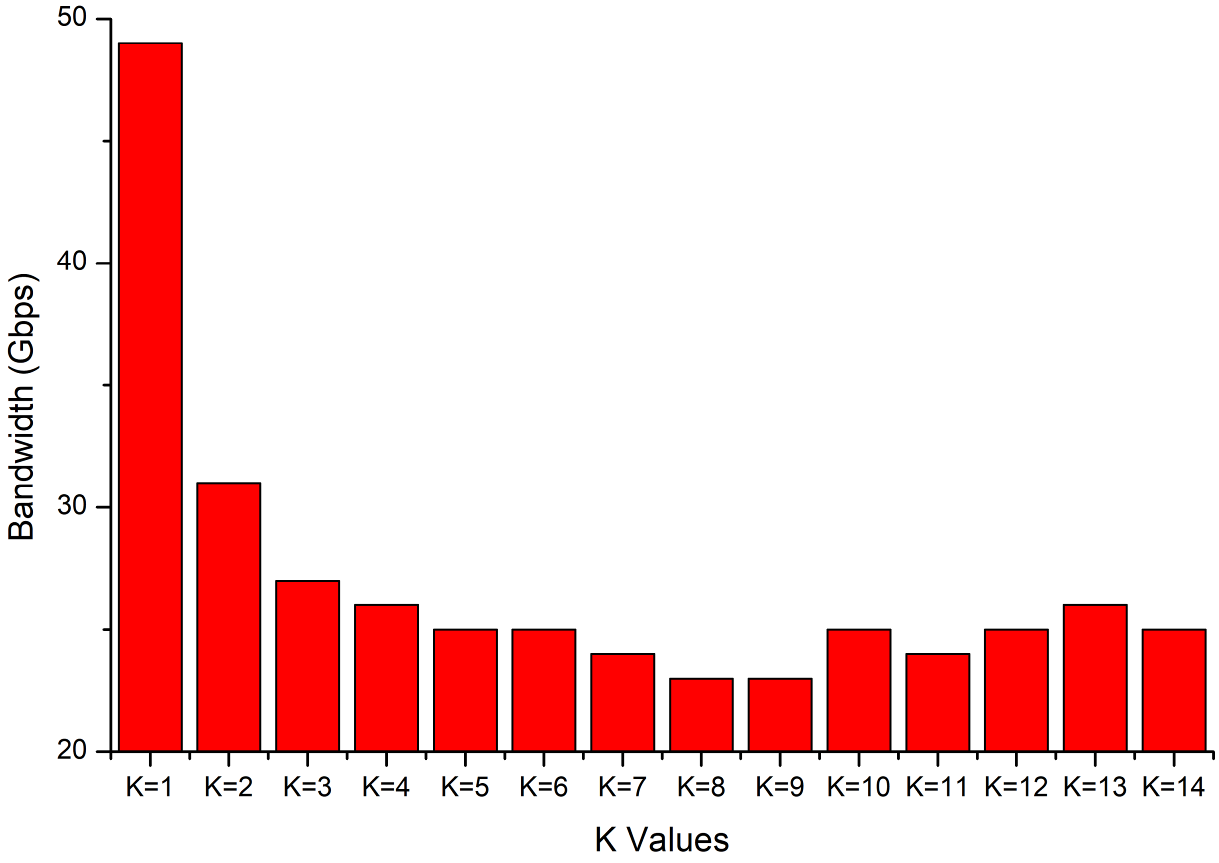
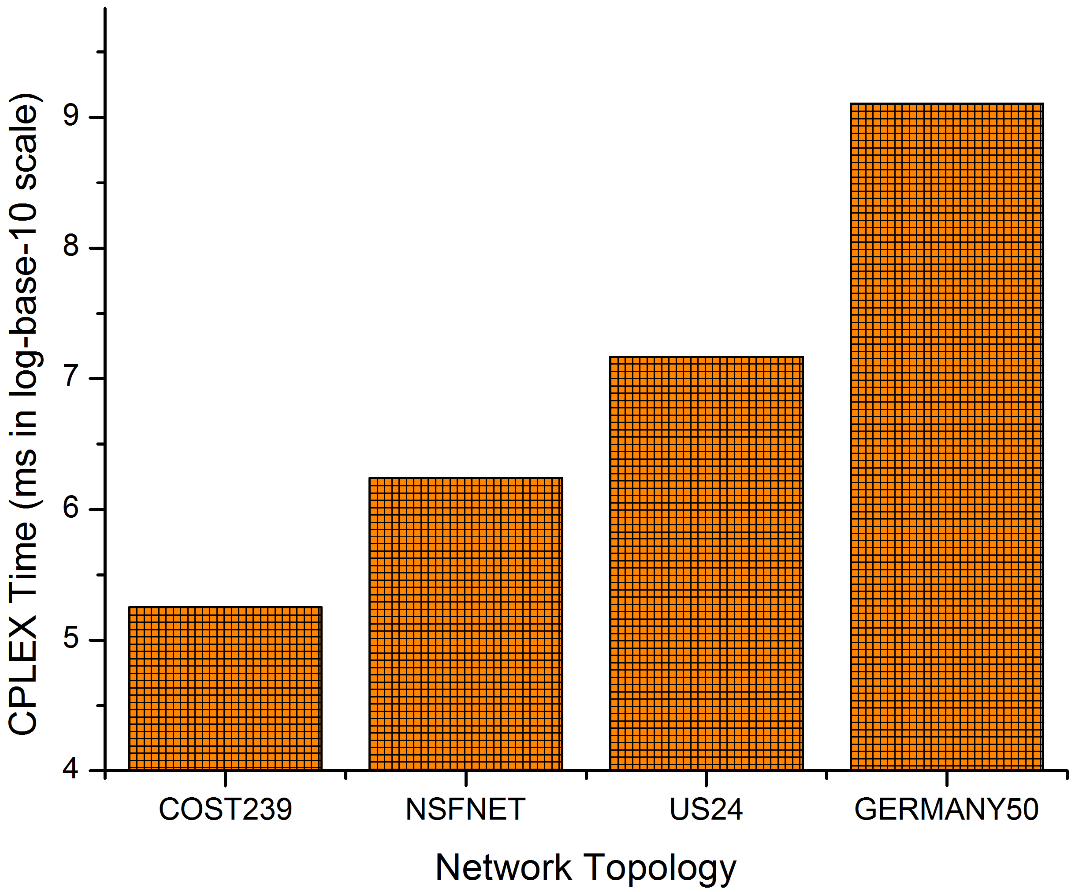
VNF Replica Constraints



Maximum Loaded Link Values for various K



Scalability of 2 Phase Model



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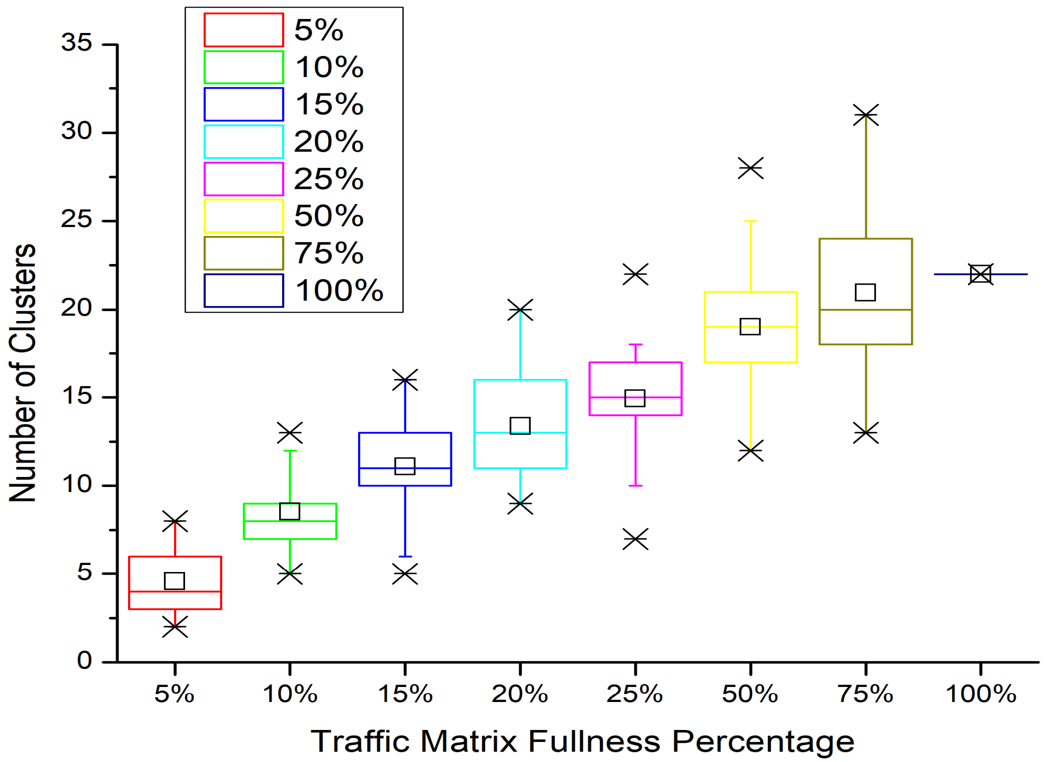
Cluster Counts (Variable Traffic Flows – Uniform)



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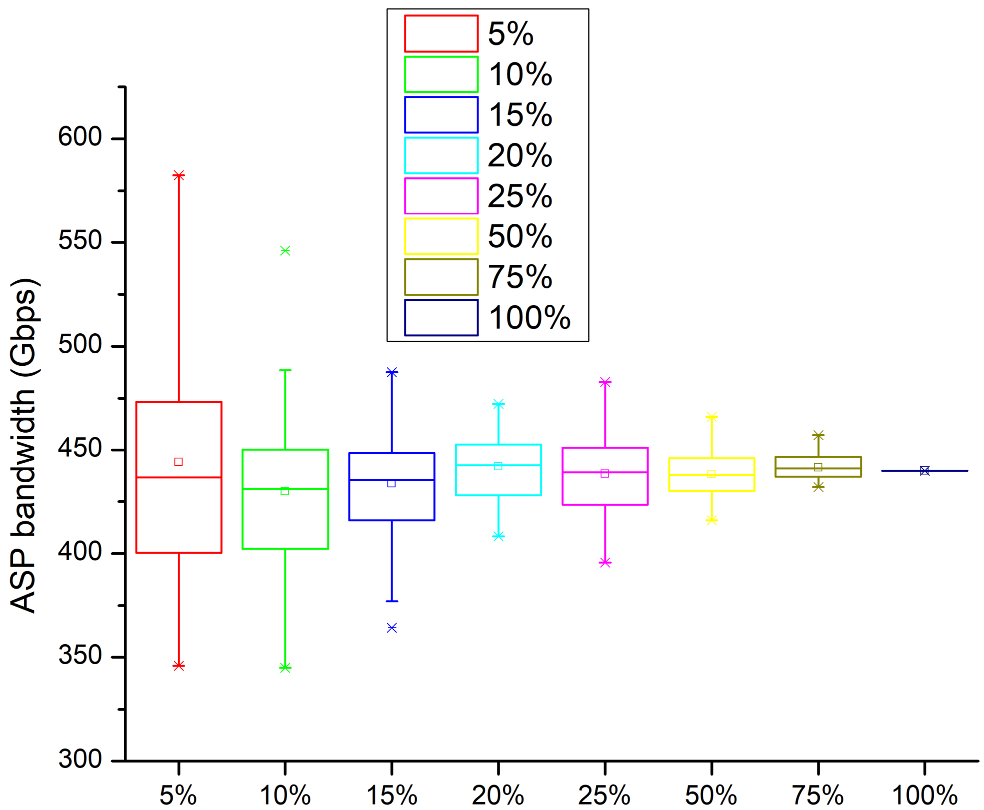
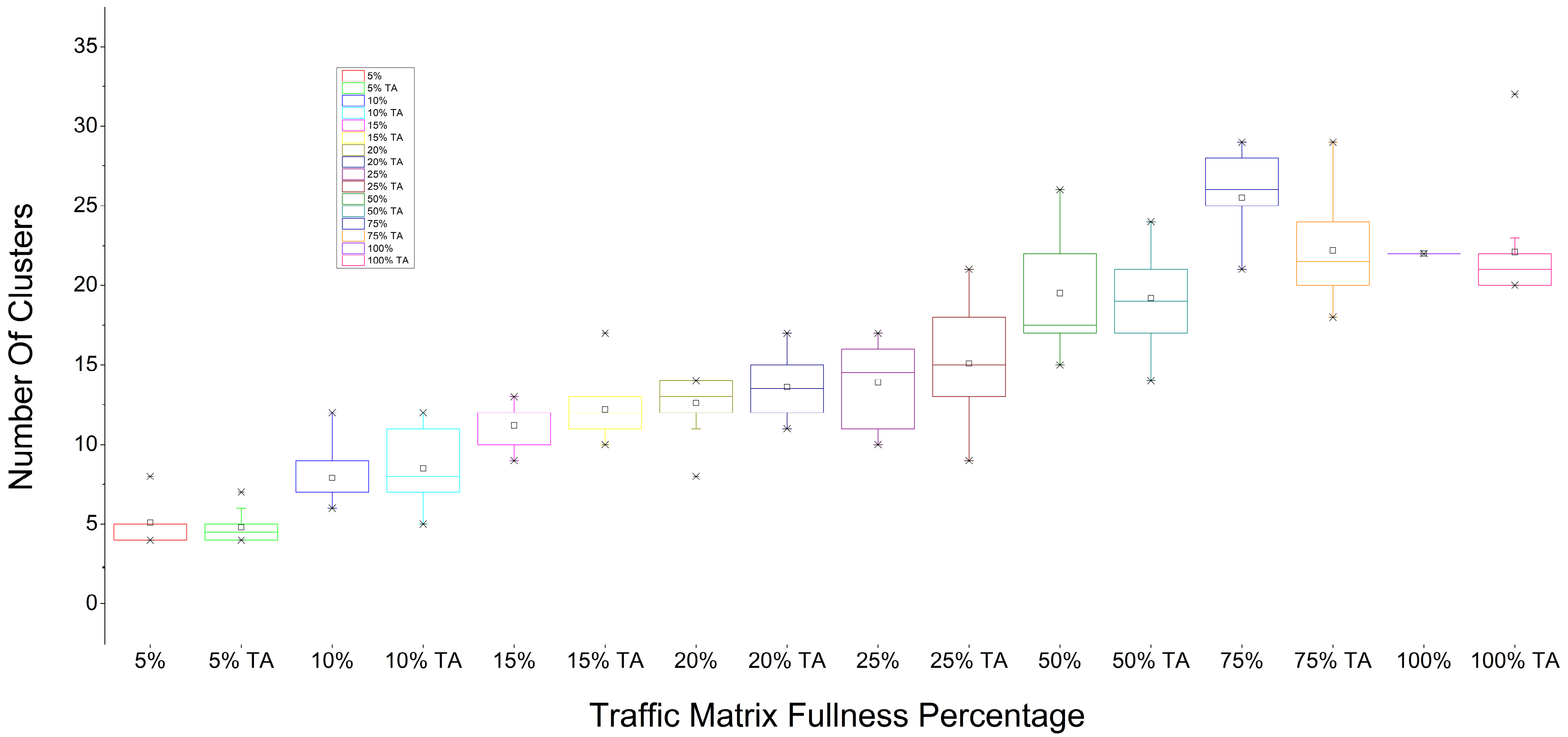


5%
10%
15%
20%
25%
50%
75%
100%
ASP bandwidth (Gbps)
600
550
500
450
400
350
300
5%
10%
15%
20%
25%
50%
75%
100%

Cluster Counts (Variable Traffic Flows – Skewed)



Future Work Directions

- **Cases where distribution of VNFs occur:**
  - Cases where CPU resources are constrained or VNF replicas (because of licenses) are enforced
  - Any additional cases?
- **Current results for only 1 service chain**
  - How to make sense of results in a multi-service chain scenario?
  - Same results repeated for 4 service chains?
  - Not all service chains use complete traffic matrix
  - 2 Phase Model tries to optimize placement and routing of each service chain
  - However, VNF replica enforcement will result in non-optimal placement and routing

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