

Minimizing the Number of Rules to Mitigate Link Congestion in SDN-based Datacenters

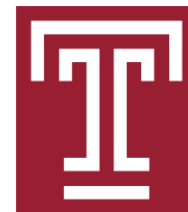
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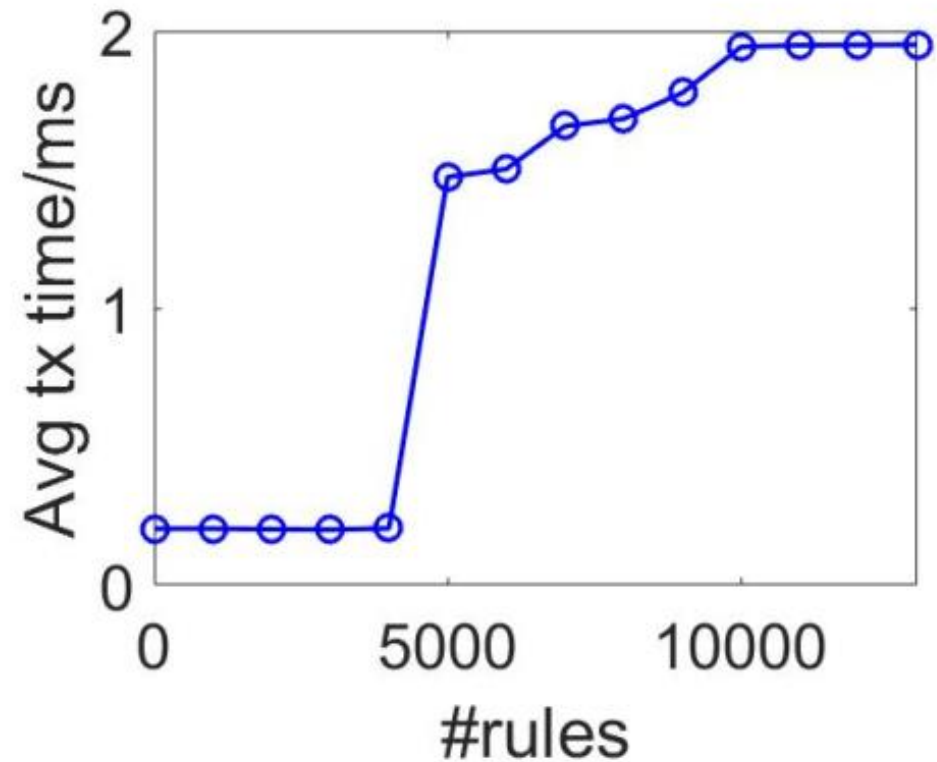
Outline

- Forwarding Time vs. Number of Rules
- Reducing Link Congestions
- Pervious works
- Problem Definitions
- A Dijkstra-based Solution
- A Group-based Solution
- Some Simulation & Experimental results
- Q&A



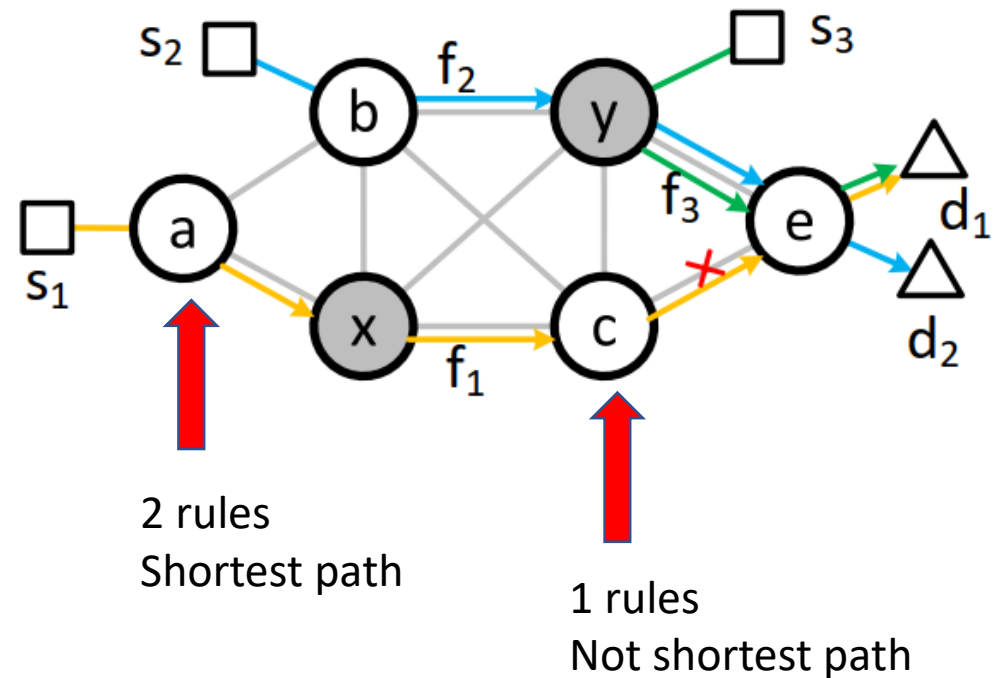
Forwarding Time vs. Number of Rules

- SDN switches have limited capacities for fast accessible rules.
- Once the capacity is exhausted the delay increases suddenly.
- Small Experiment:
 - 2 hop connection
 - Ping delay



Reducing Link Congestions

- Congested Link
 - Redirect some flows
- Redirection Points
 - Each SDN switch on the flow path
- Redirection:
 - Shortest path
 - Minimum number of rules

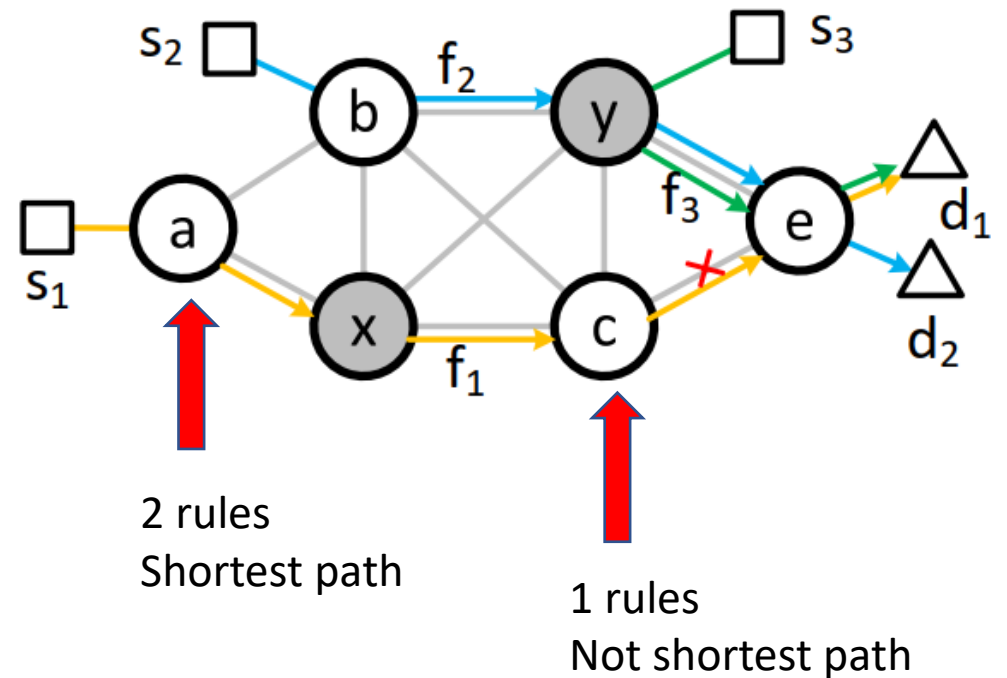


Previous Work

| Systems | Limitations |
|--|--|
| <p>Minimize number of rules using multicast routing.</p> <p>S. Kotachi, T. Sato, R. Shinkuma, and E. Oki, "Multicast routing model to minimize number of flow entries in software-defined network," in 20th Asia-Pacific Network Operations and Management Symposium, 2019</p> | <ul style="list-style-type: none">• Does not consider link congestion and interruption of flows. |
| <p>Link flooding attack mitigation using machine learning.</p> <p>A. Rezapour and W. -G. Tzeng, "RL-Shield: Mitigating Target Link-Flooding Attacks using SDN and Deep Reinforcement Learning Routing Algorithm," in <i>IEEE Transactions on Dependable and Secure Computing</i>, 2021</p> | <ul style="list-style-type: none">• Does not consider interruption of flows. |

Problem: Find a Route to Redirect with The Minimum Number of Rules

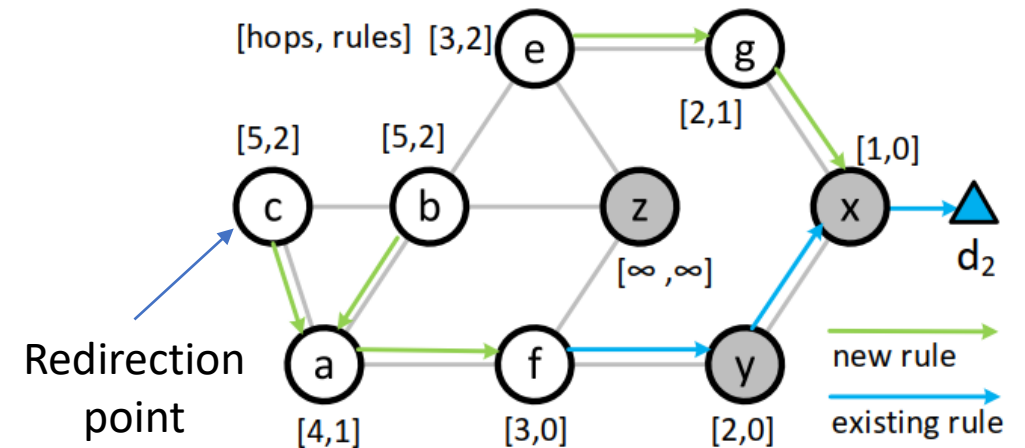
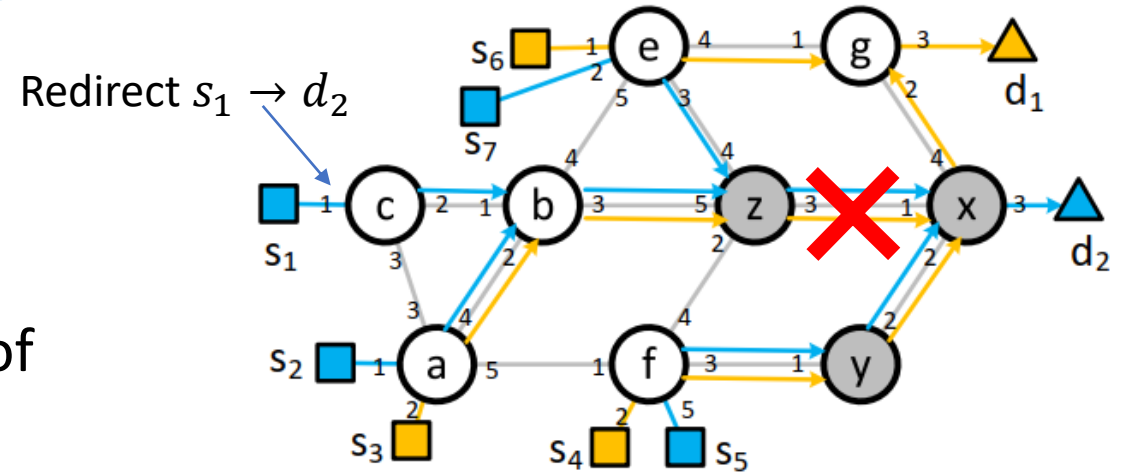
- Minimize:
 - The number of rules needed to redirect a flow.
- Constraints:
 - The redirected path cannot be longer than a threshold.
 - The congested link does not appear on the redirected path.
 - No link can be congested after redirection.



For a single flow it is easy to solve

A Dijkstra-based Solution

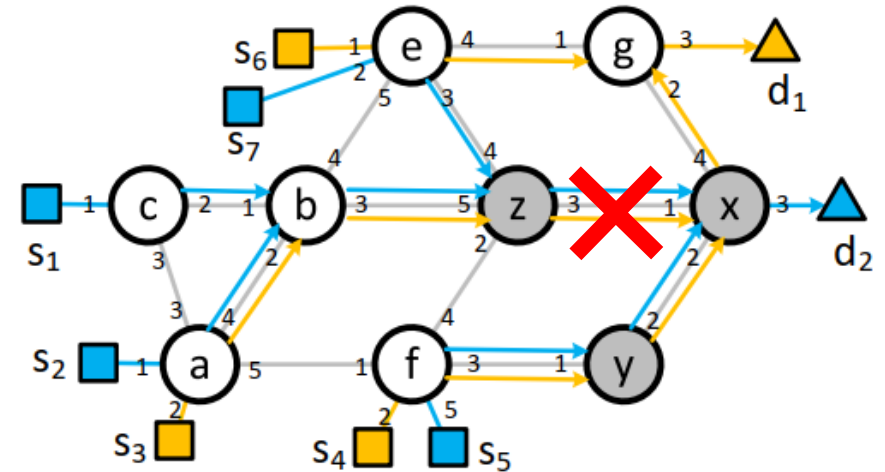
- Formulate Core Tree for the destination of the flow.
 - Dijkstra with weight as the number of rules then number of hops.
- Find the redirection point that minimizes the number of rules
 - If multiple redirection points with same number of rules
 - Choose the point with minimum number of hops







Core Tree for d_2

Problem: Find A Set of Flows to Redirect with the Minimum Number of Rules

- Minimize:
 - The number of rules needed to redirect a set of flow.
- Constraints:
 - The redirected path cannot be longer than a threshold.
 - The congested link does not appear on the redirected path.
 - No link can be congested after redirection.

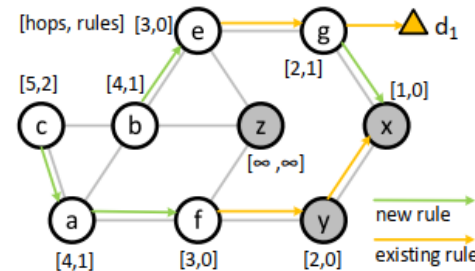
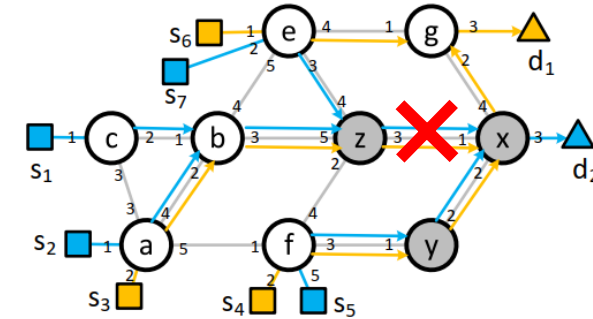


| | | |
|---|-------|-----------------------|
|  | f_0 | $s_1 \rightarrow d_2$ |
|  | f_1 | $s_2 \rightarrow d_2$ |
|  | f_2 | $s_3 \rightarrow d_1$ |
| | f_3 | $s_6 \rightarrow d_1$ |
| | f_4 | $s_4 \rightarrow d_1$ |
| | f_5 | $s_5 \rightarrow d_2$ |
|  | f_6 | $s_7 \rightarrow d_2$ |

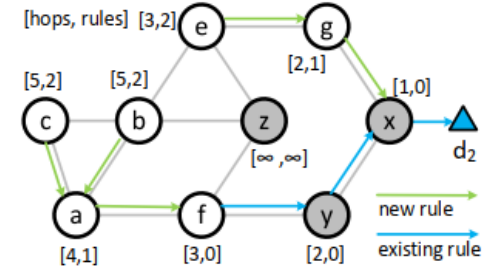
We need to find which flows should be redirected
NP-Hard

A Flow Grouping-based Solution

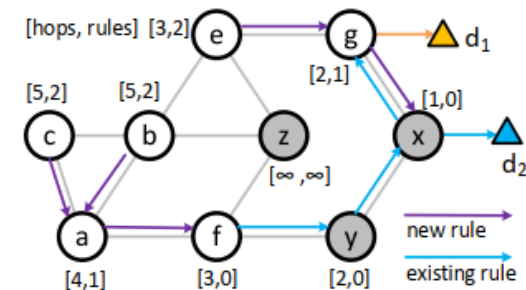
- Group using common k-link policy
 - Flows having same k upstream links from the congested link goes to same group.
 - For k=2: $\{f_0\}$ $\{f_1, f_2\}$ $\{f_6\}$
- Generate core tree for the destinations in each group
 - Create core tree for each destinations
 - Combine core trees
 - Separate forwarding
 - Aggregated forwarding
- Find the best redirect point for each group.
- Redirect the group with minimum number of rules
- Continue until the link is not congested



CoreTree for d_1

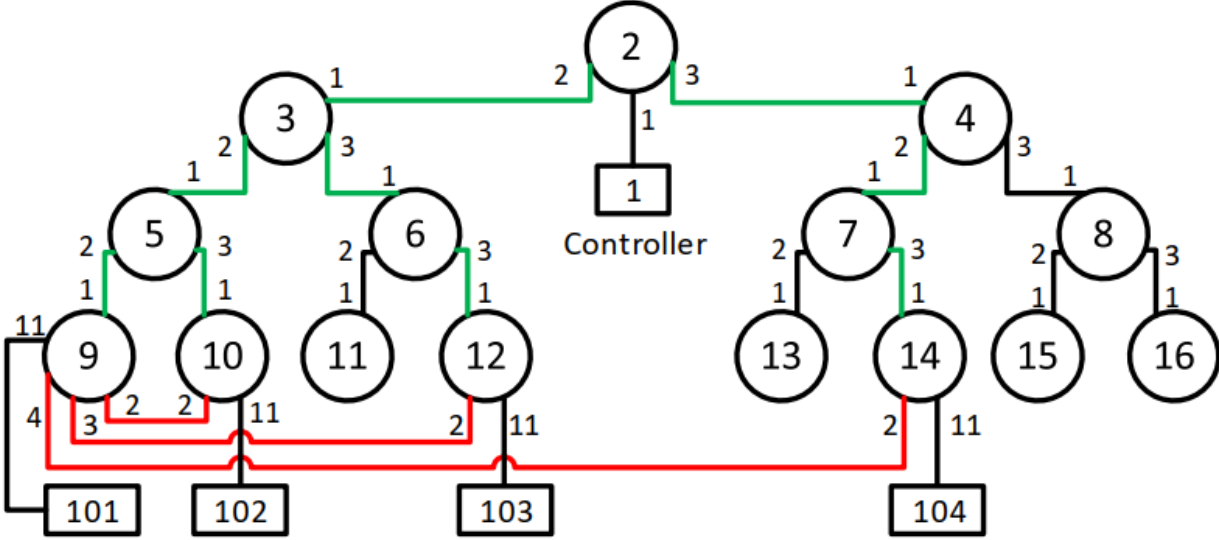


CoreTree for d_2



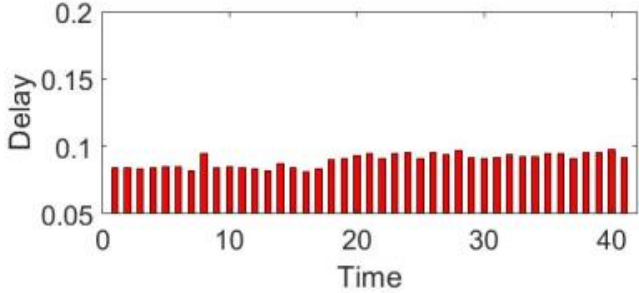
CoreTree for d_1 and d_2

Experiments

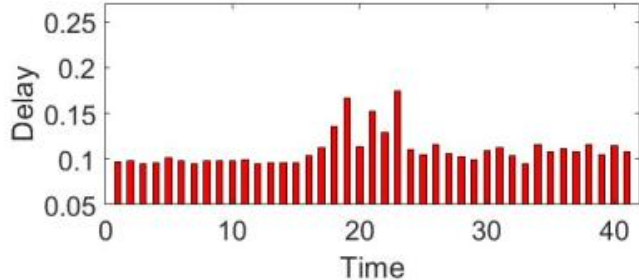


Datacenter topology (partial)

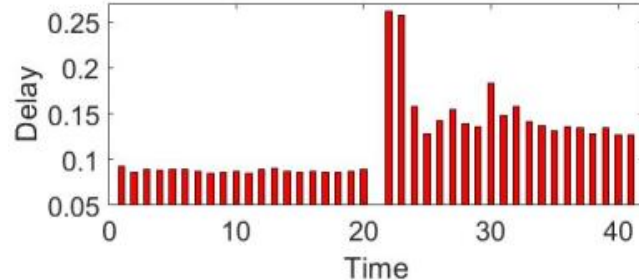
Previous path: 9 → 10
 New path: 9 → 5 → 10



3x2 rules added

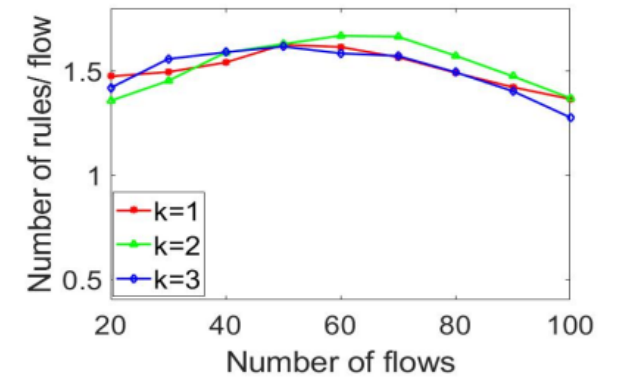
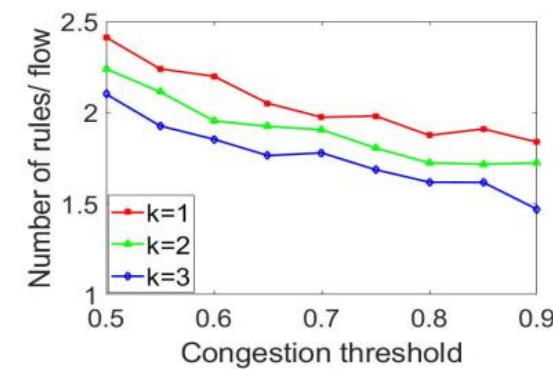
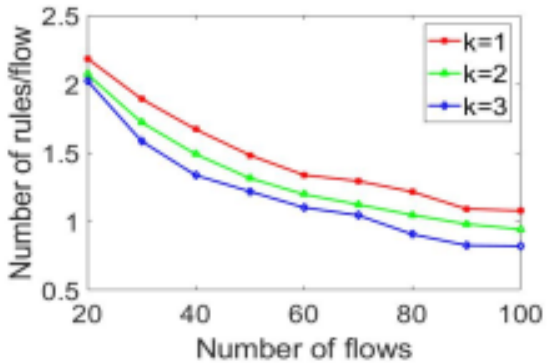
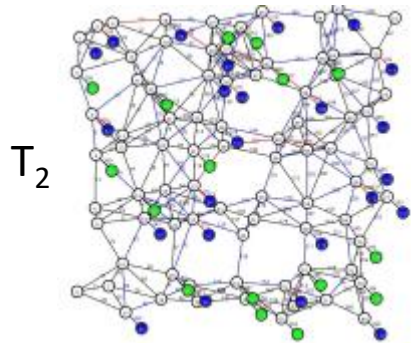
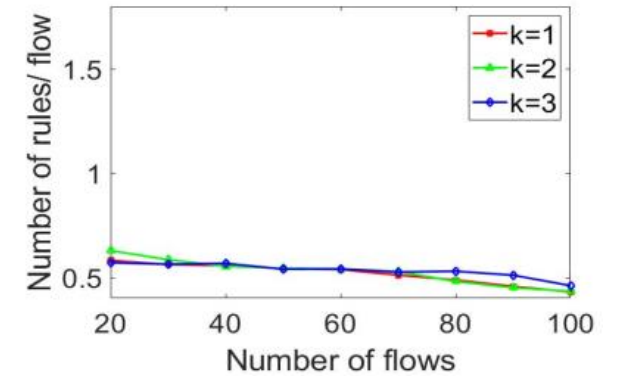
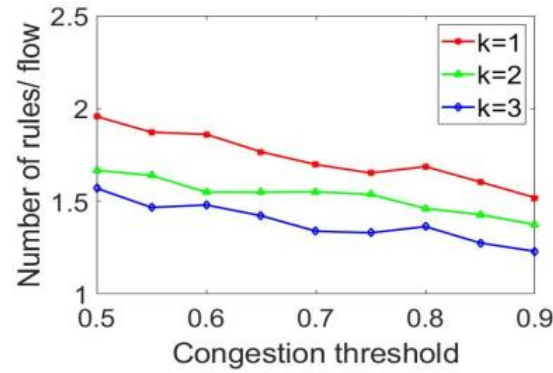
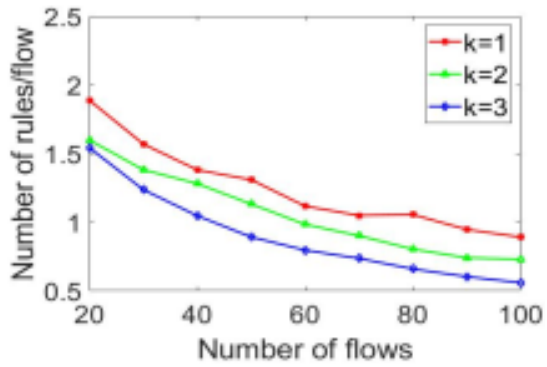
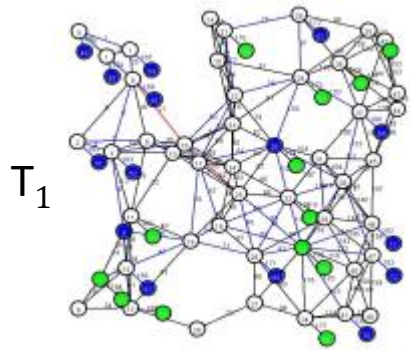


5x2 rules added



7x2 rules added

Simulations



Comparison with
shortest path approach

Summary

- We propose and evaluate performances of k links flow grouping based approach for redirecting flows to mitigate link congestion.
- Changes in 7x2 or more rules might cause interruption to delay sensitive applications.
- We can reduce the interruption to redirecting flow by increasing the number of hops a little.

Thank You !!

Q & A