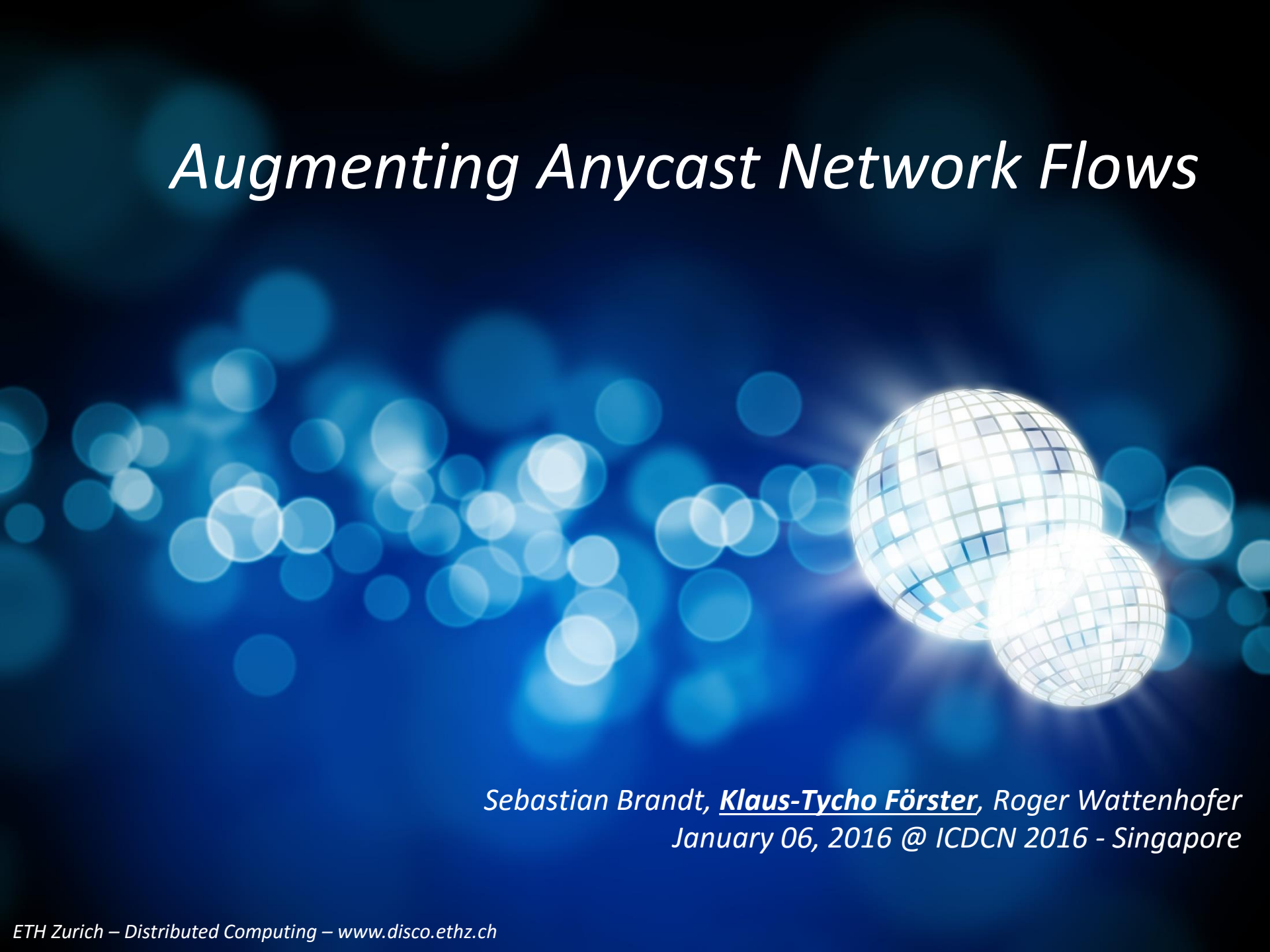
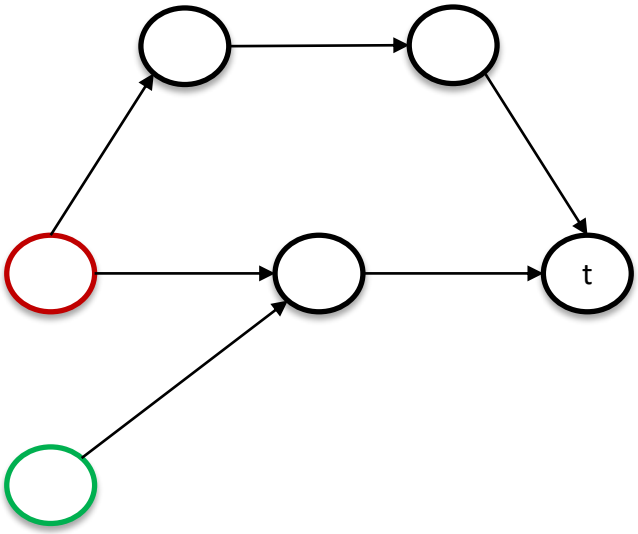
Augmenting Anycast Network Flows



*Sebastian Brandt, **Klaus-Tycho Förster**, Roger Wattenhofer*

January 06, 2016 @ ICDCN 2016 - Singapore

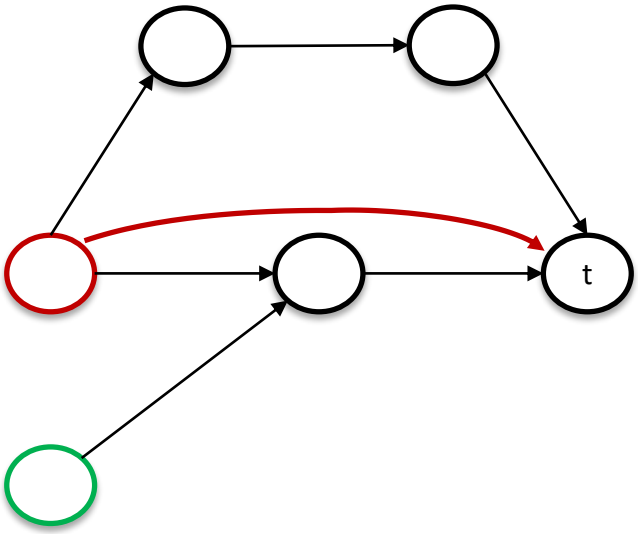
Motivation



size of each flow: 1

capacity of links: 1

Motivation



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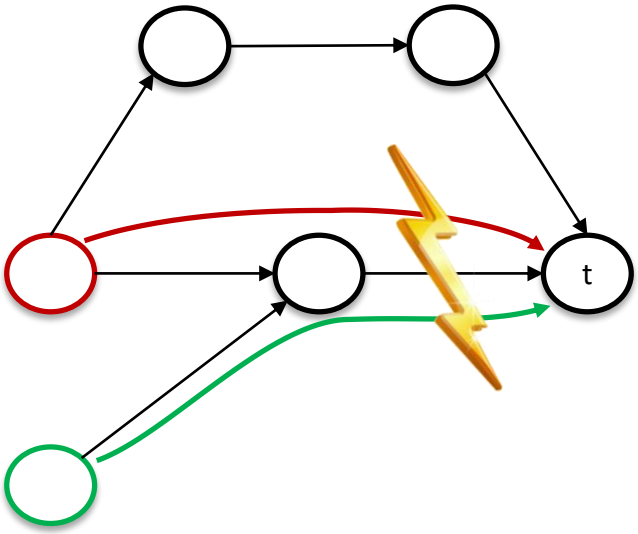
Motivation



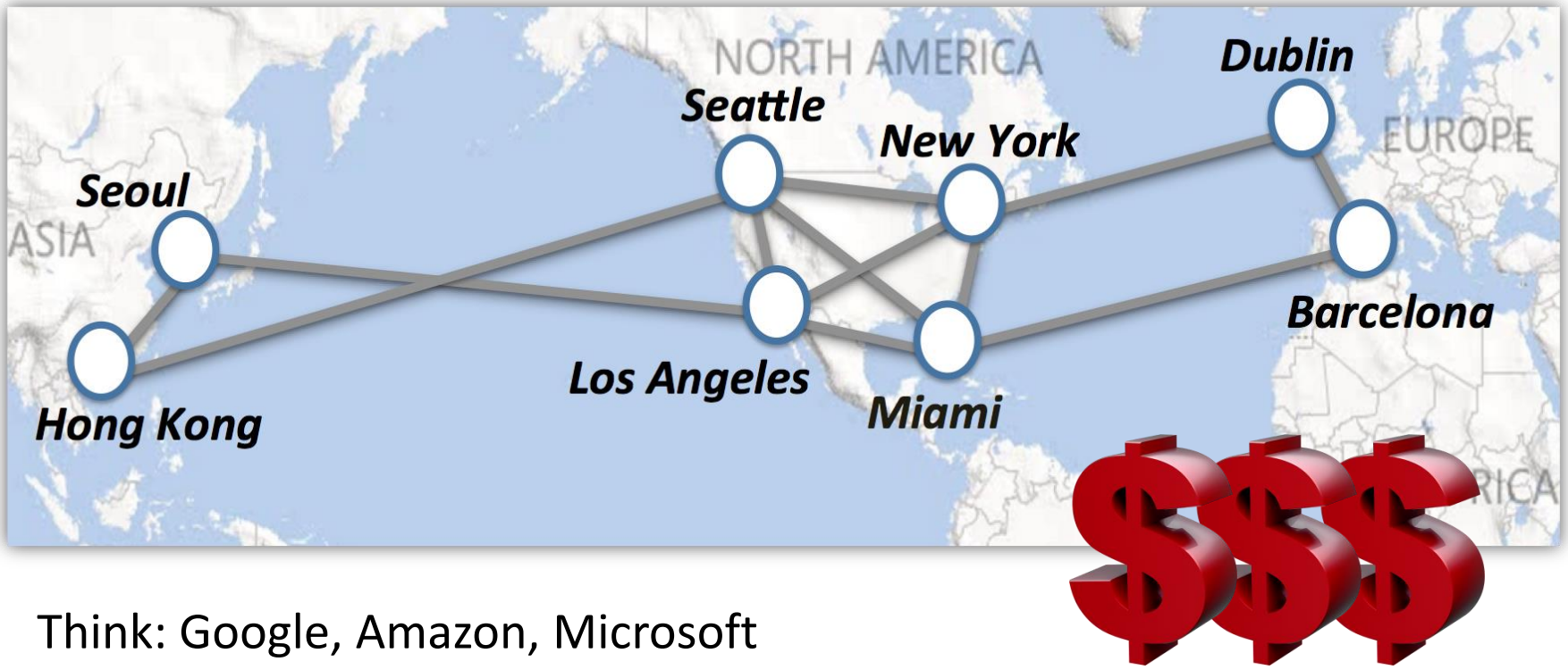
size of each flow: 1

capacity of links: 1

Network Updates

- The Internet: Designed for selfish participants
  - Often inefficient (low utilization of links), but robust
- But what happens if the WAN is controlled by a single entity?
  - Examples: Microsoft & Amazon & Google …
  - They spend hundreds of millions of dollars per year

Network Updates



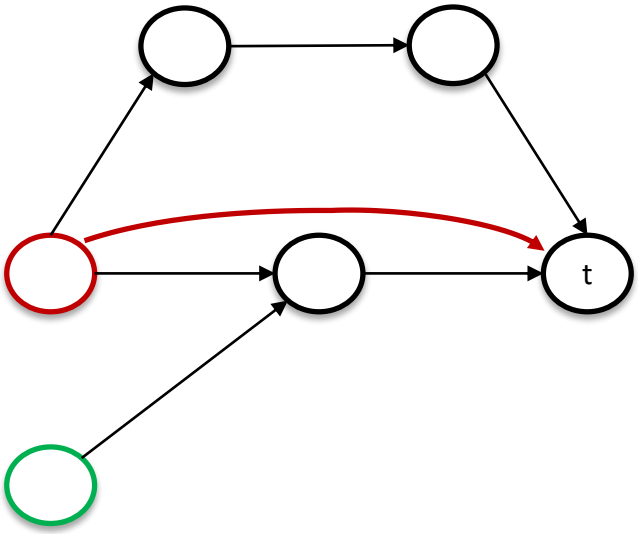
Think: Google, Amazon, Microsoft

Network Updates

- The Internet: Designed for selfish participants
  - Often inefficient (low utilization of links), but robust
- But what happens if the WAN is controlled by a single entity?
  - Examples: Microsoft & Amazon & Google …
  - They spend hundreds of millions of dollars per year
- Possible solution: **S**oftware **D**efined **N**etworking (**SDN**)

- General Idea: Separate data & control plane in a network
- Centralized controller updates networks rules for optimization
  - Controller (*control plane*) updates the switches/routers (*data plane*)

Motivation

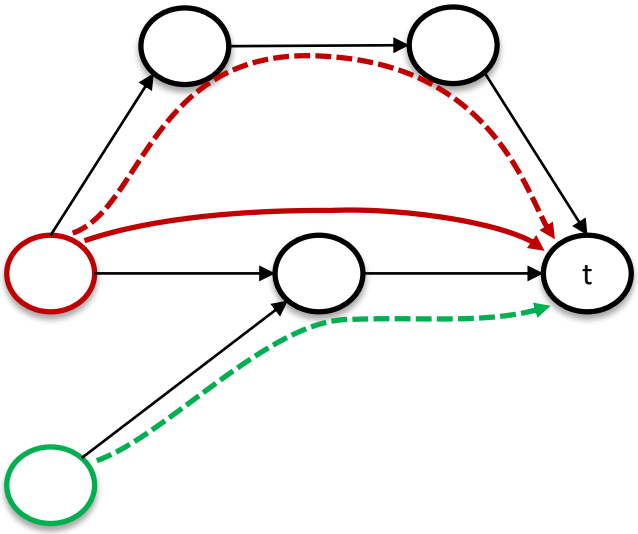


size of each flow: 1

capacity of links: 1

Motivation

network updates

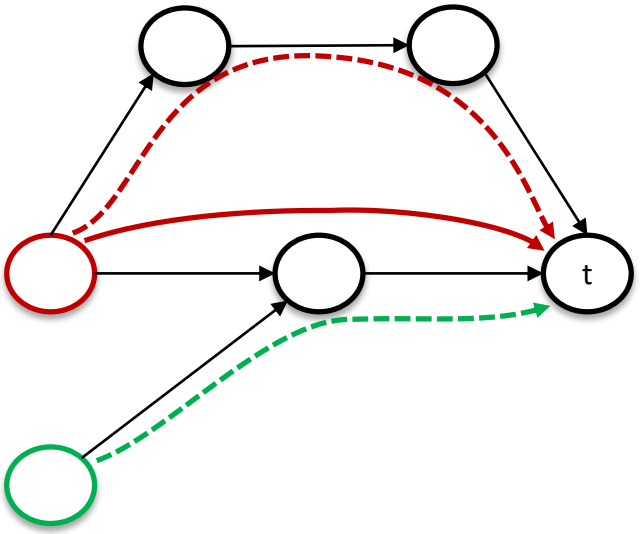


size of each flow: 1

capacity of links: 1

Motivation

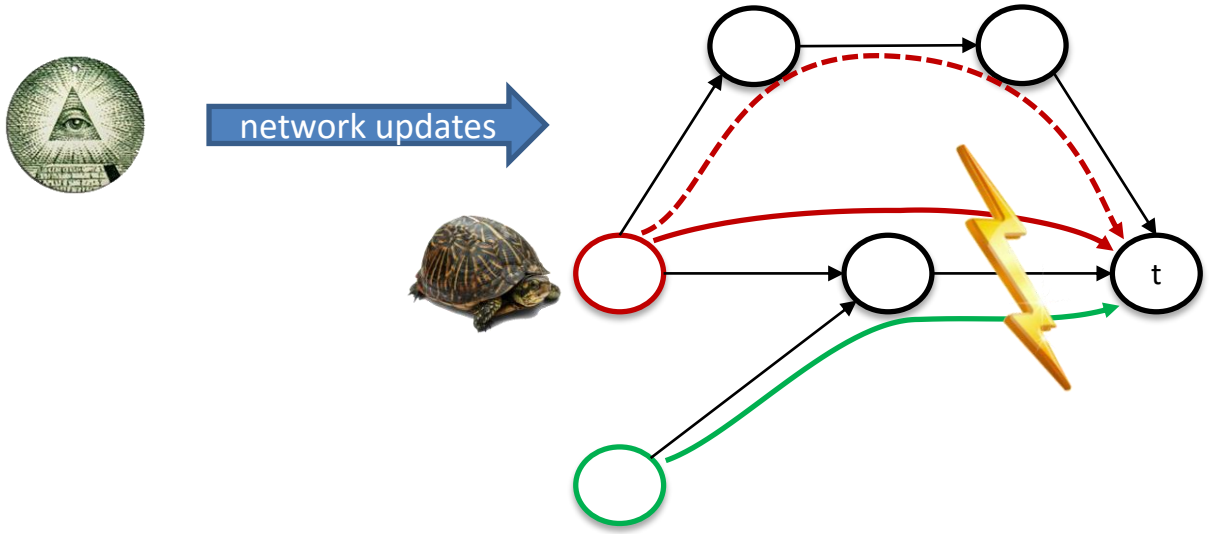
network updates



size of each flow: 1

capacity of links: 1

Motivation

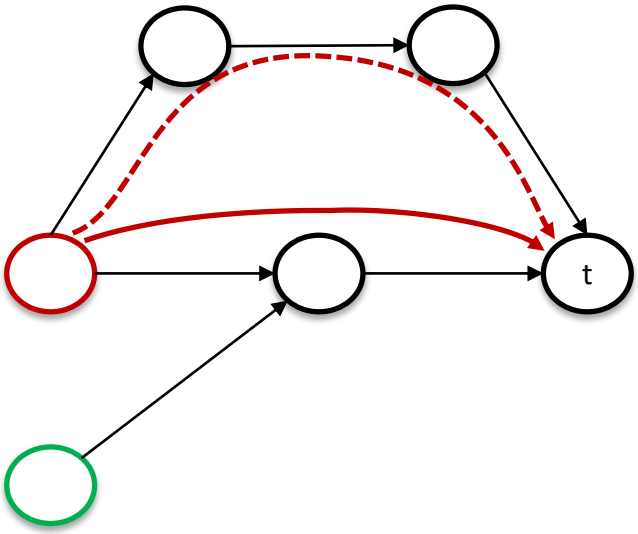


size of each flow: 1

capacity of links: 1

Motivation

network updates



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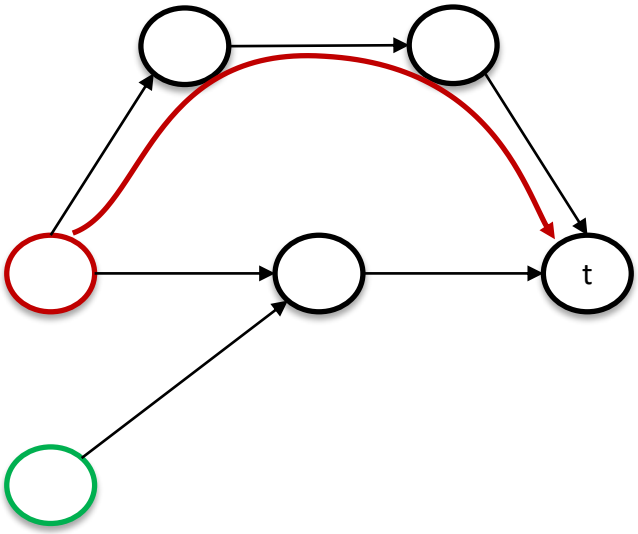
capacity of links: 1

Motivation

network updates

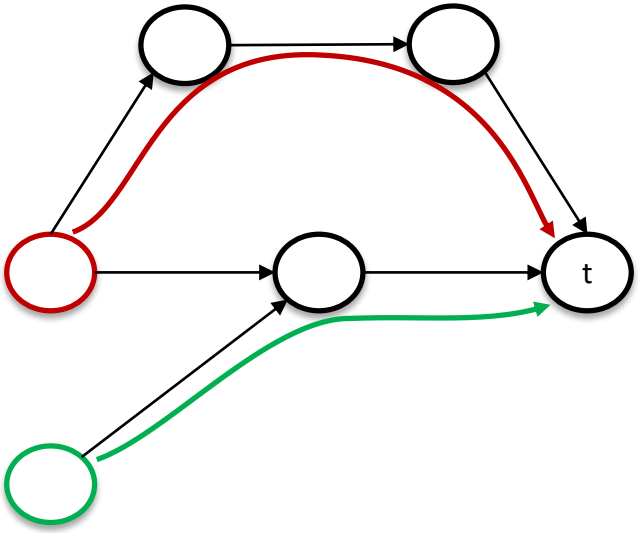


size of each flow: 1

capacity of links: 1

Motivation

network updates



size of each flow: 1

capacity of links: 1

Structure of the Talk

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- **Related Work & Splittable Flows**
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Network Updates of Flows without Congestion

old network rules

network updates

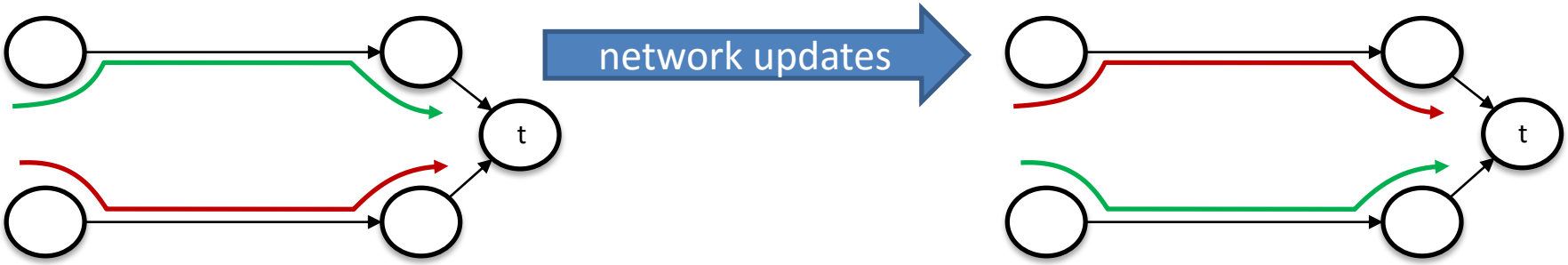
new network rules

- State of the art: (Partial) moves of flows using linear programming (LPs), e.g.,
  - *SWAN* [Hong et al., SIGCOMM 2013], *zUPDATE* [Liu et al., SIGCOMM 2013]
  - *Dionysus* [Jin et al., SIGCOMM 2014]

- Open problems:
  - When are network updates without congestion *possible*?
  - How can we do them *fast*?

- *This paper*: Addresses the case of one (logical) destination for splittable flows

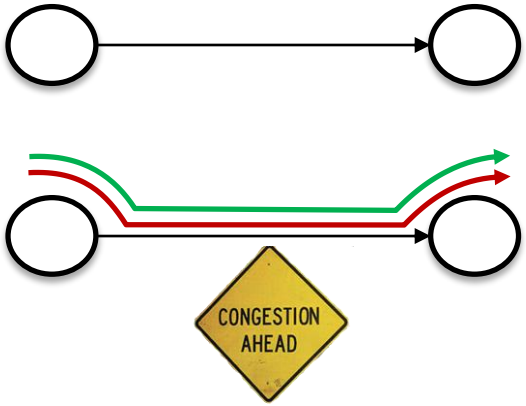
Swapping of Flows



size of each flow: 2

capacity of links: 3

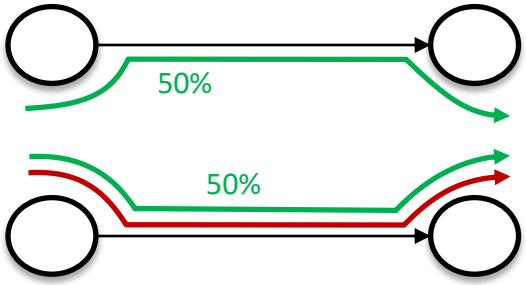
Just Switch? Congestion!



size of each flow: 2

capacity of links: 3

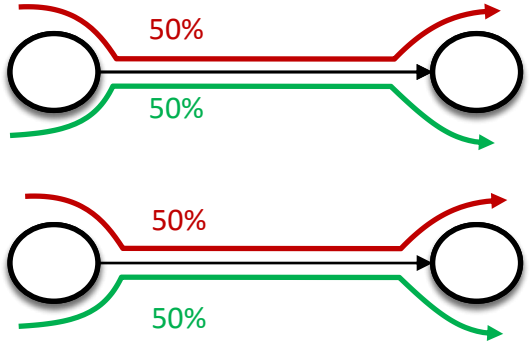
Migrate only parts of the flow



size of each flow: 2

capacity of links: 3

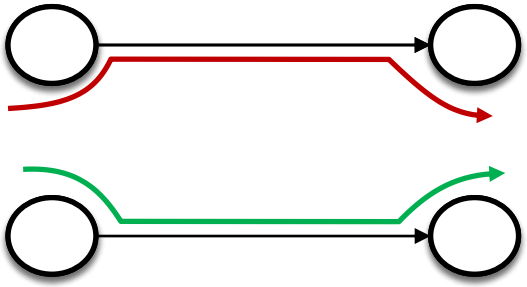
Can even do both flows at once



size of each flow: 2

capacity of links: 3

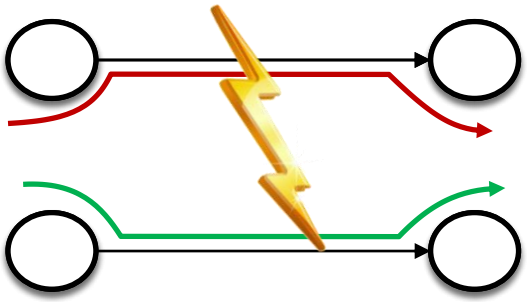
Done in two steps



size of each flow: 2

capacity of links: 3

But not always possible!

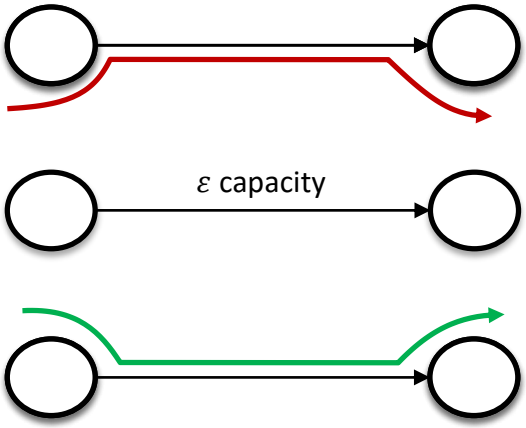


size of each flow: 2

capacity of links: **2**

How about other paths?

Number of steps can be **unbounded**



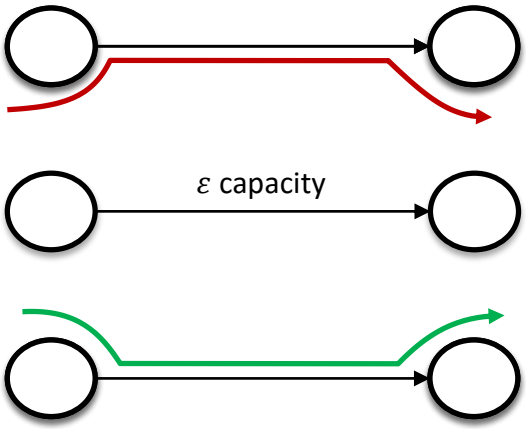
size of each flow: 2

capacity of links: **2**

How about other paths?

Number of steps can be **unbounded**

Binary search with LPs **ineffective**



size of each flow: 2

capacity of links: **2**

Structure of the Talk

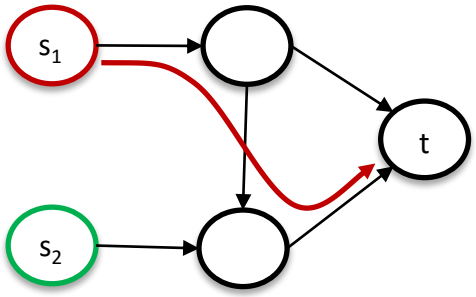
- Motivation & Software Defined Networking
- Related Work & Splittable Flows
- **Our Approach**
- Extension beyond Anycast Flows

Our Approach

- Compute our **own** new rules
  - Based off the new demands

- Deviate from linear programming binary search
  - Go **combinatorial** with augmenting flows
    - *"Push back"* flows for migration

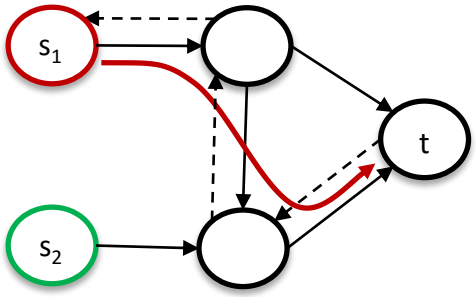
Augmenting Flows



size of each flow: 1

capacity of links: 1

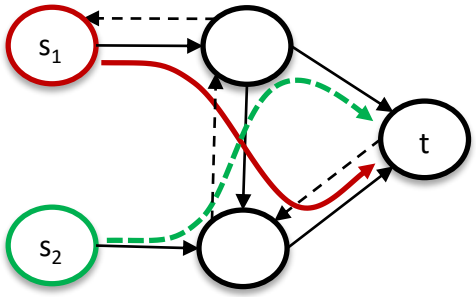
Consider Residual Network



size of each flow: 1

capacity of links: 1

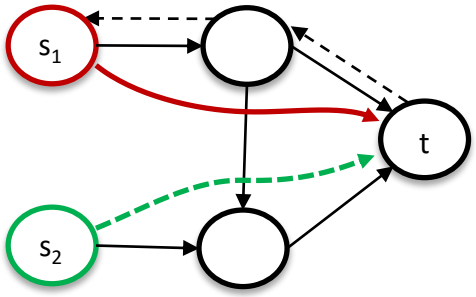
Find a Way in the Residual Network



size of each flow: 1

capacity of links: 1

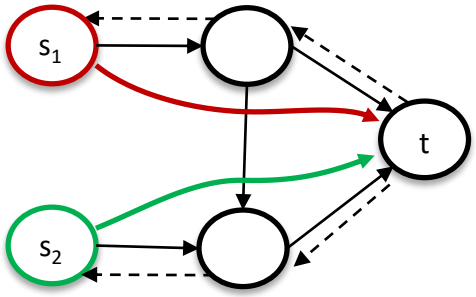
Push back the old Flow



size of each flow: 1

capacity of links: 1

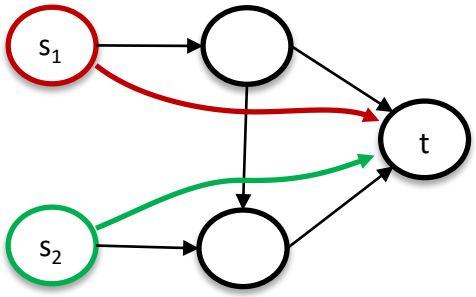
Insert the new Flow



size of each flow: 1

capacity of links: 1

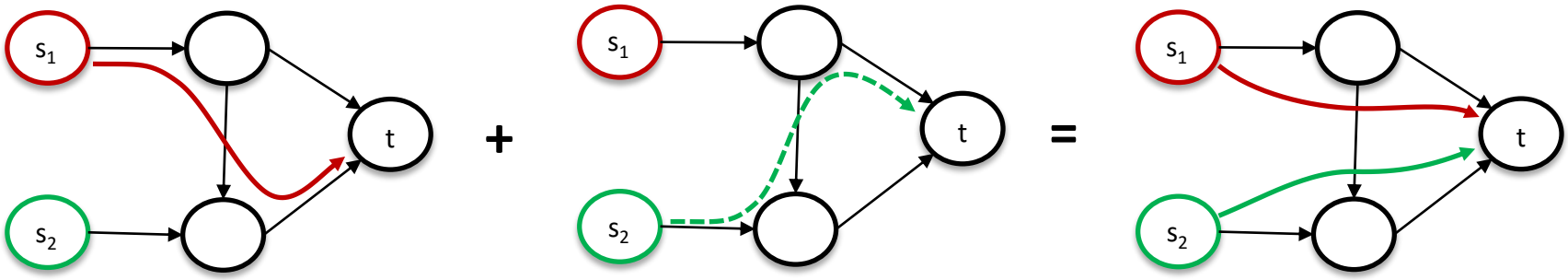
Migrated without Congestion



size of each flow: 1

capacity of links: 1

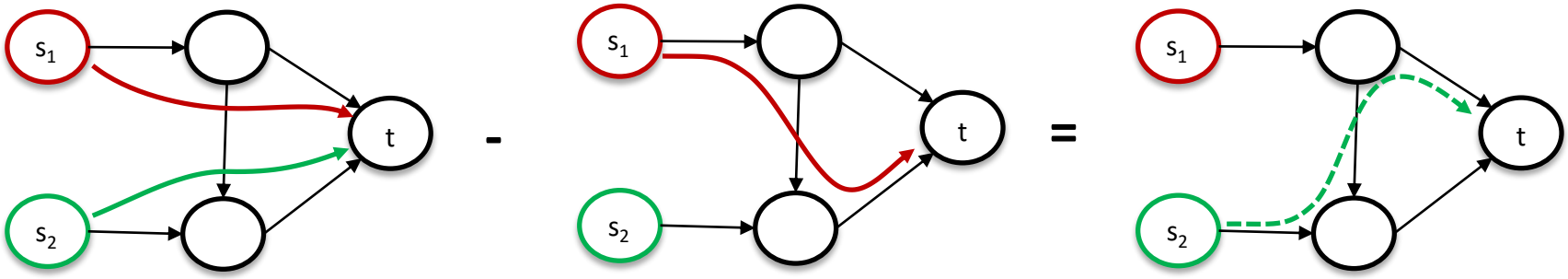
Similar to “Addition”



size of each flow: 1

capacity of links: 1

Also works as “Subtraction”



size of each flow: 1

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High-level Mechanism Idea

For all commodities (iteratively):

- Increase demand and calculate new flow with LP
  - *offline* calculation
- Apply augmenting flow from the difference
  - linear # re-routing *in the network*

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OLD	CURRENT	NEW
1	1	5
1	1	2
2	2	6
3	3	3
2	2	8

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1	1	2
2	2	6
3	3	3
4	2	8

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1	2	2
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3	**3**	**3**
4	2	8

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1	2	2
2	6	6
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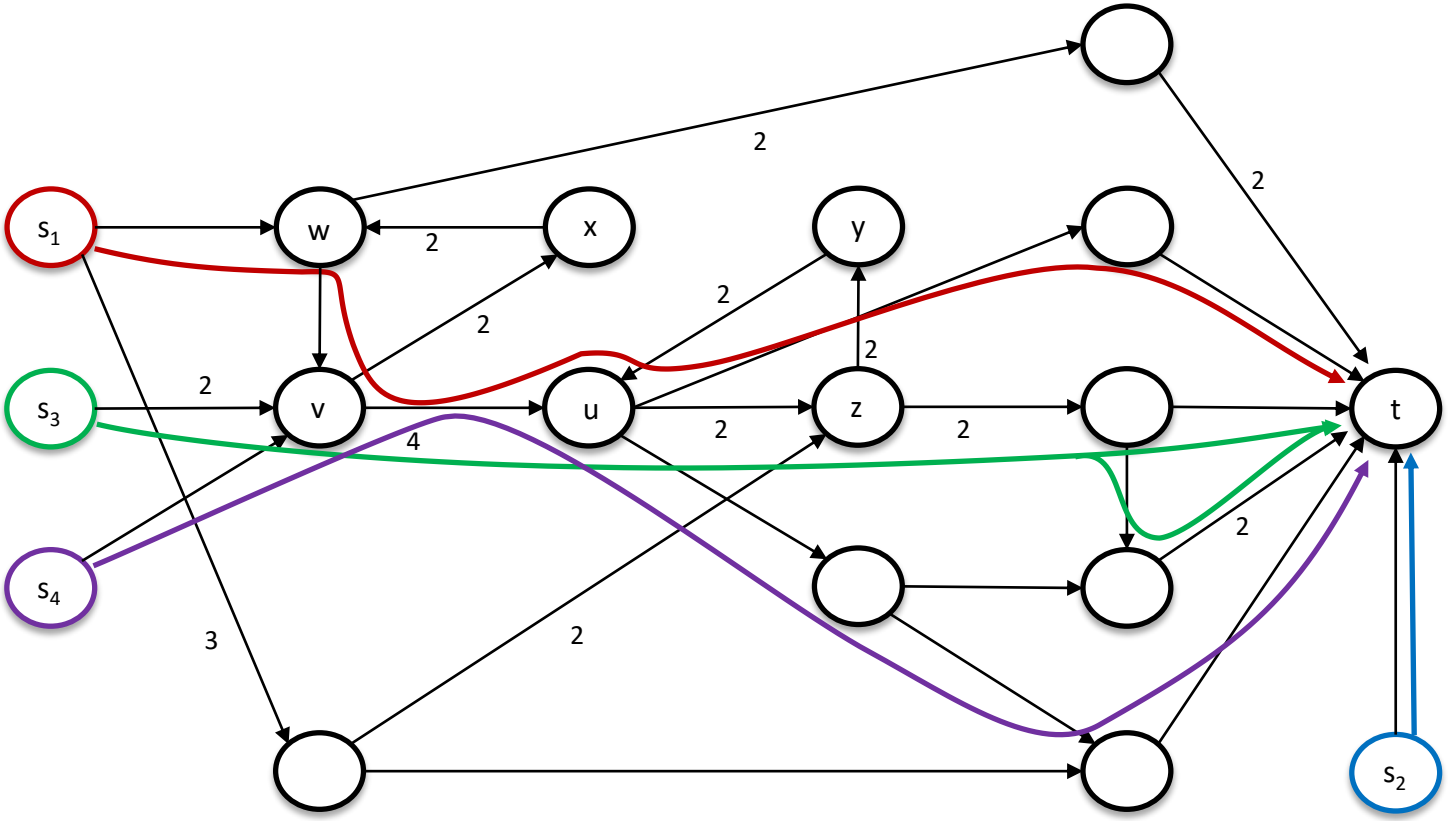
4	**8**	**8**

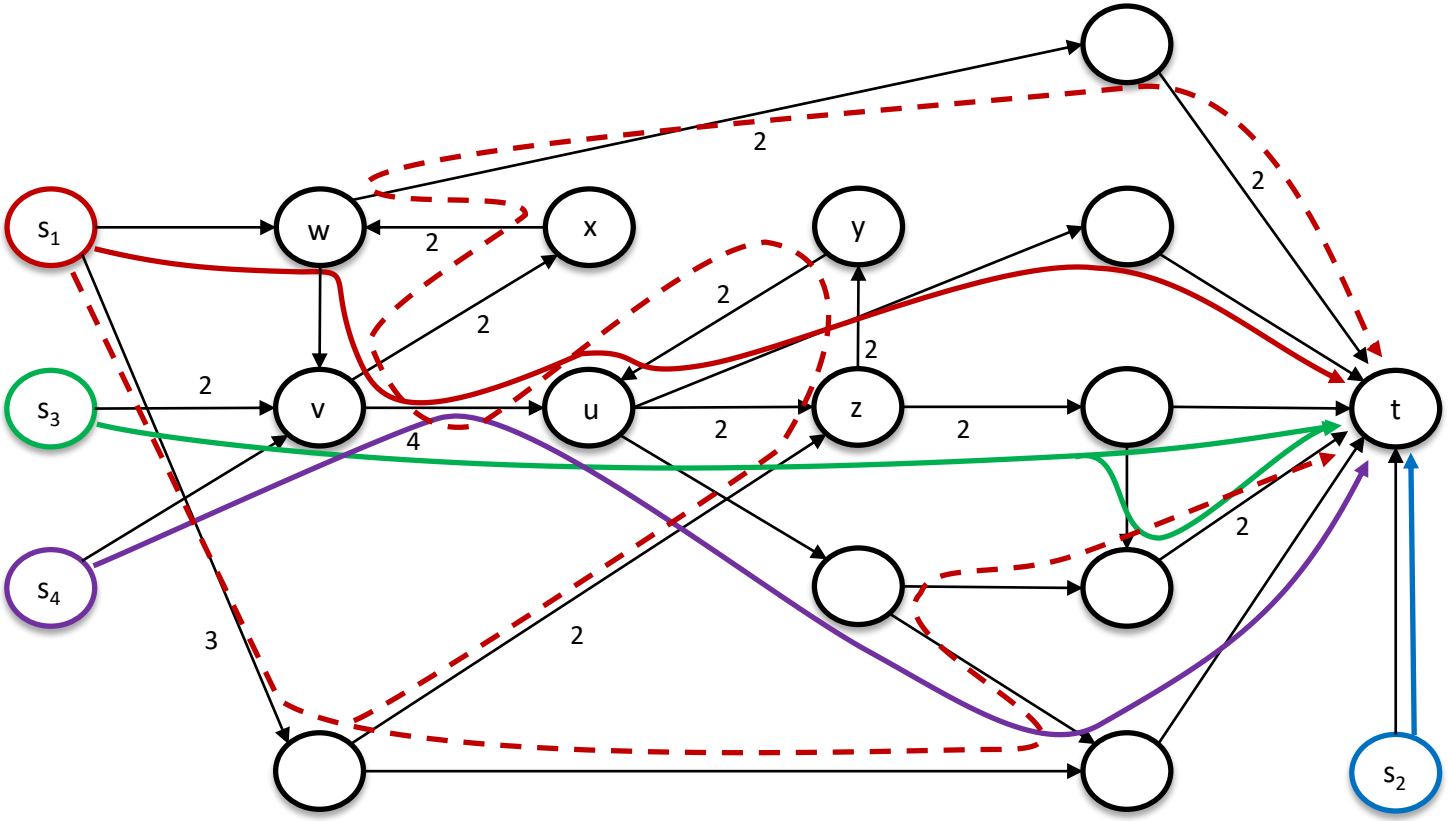
Number of “Push Back”- Links decreases



size of flows: 1, 2, 1, 1

capacity of links: 1 (or marked)

Number of “Push Back”- Links decreases



size of flows: 1, 2, 1, 1

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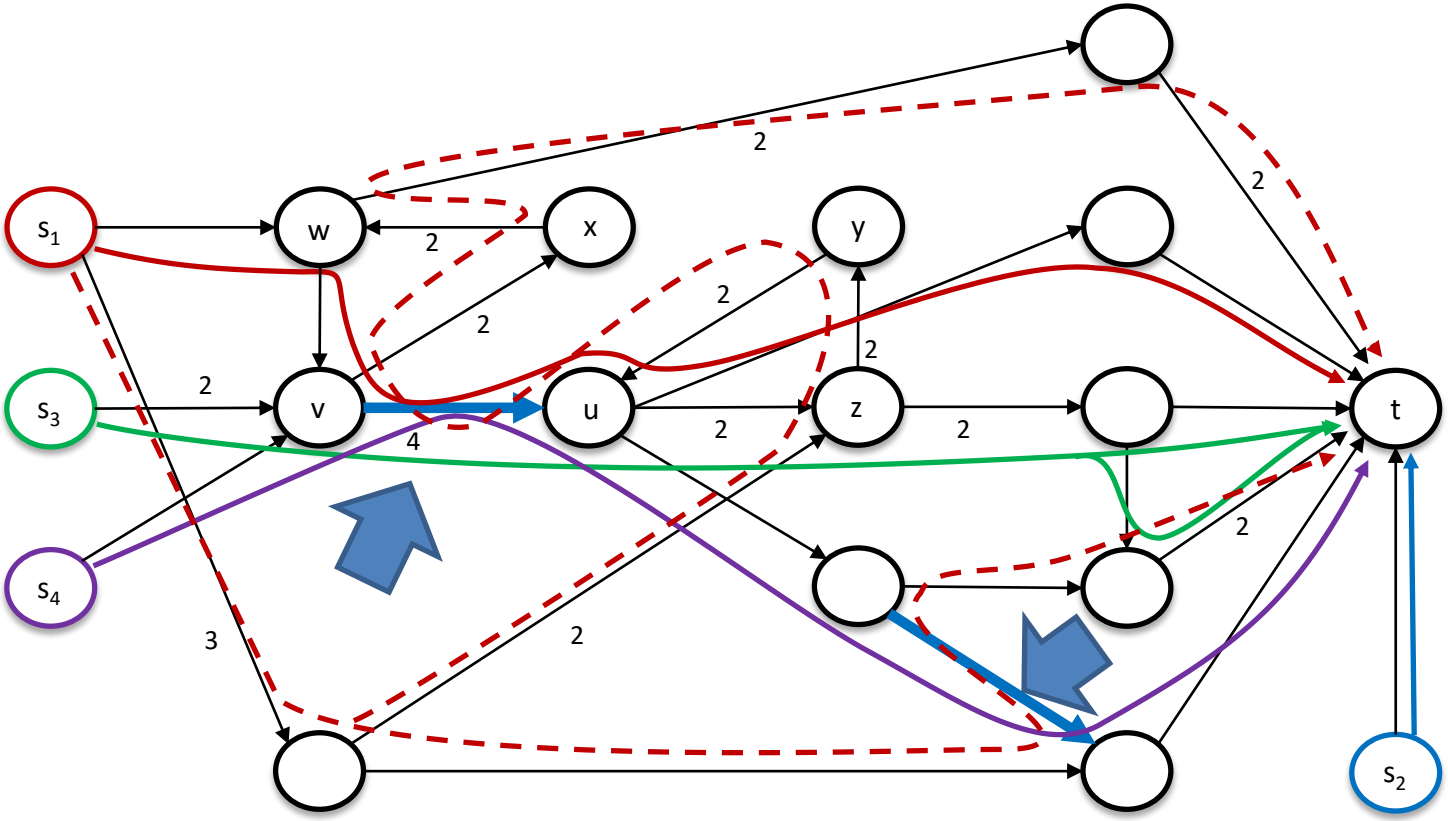

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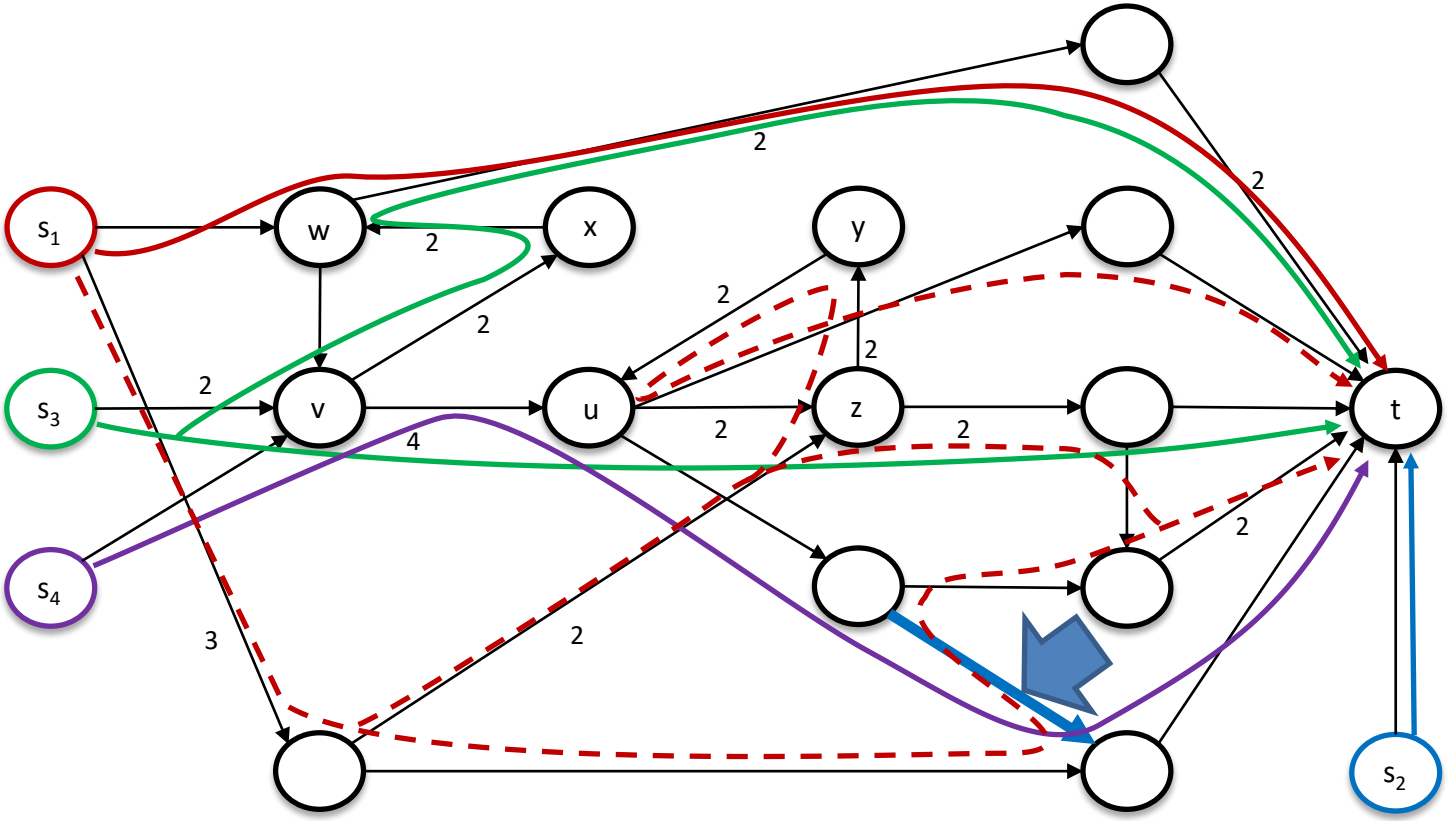

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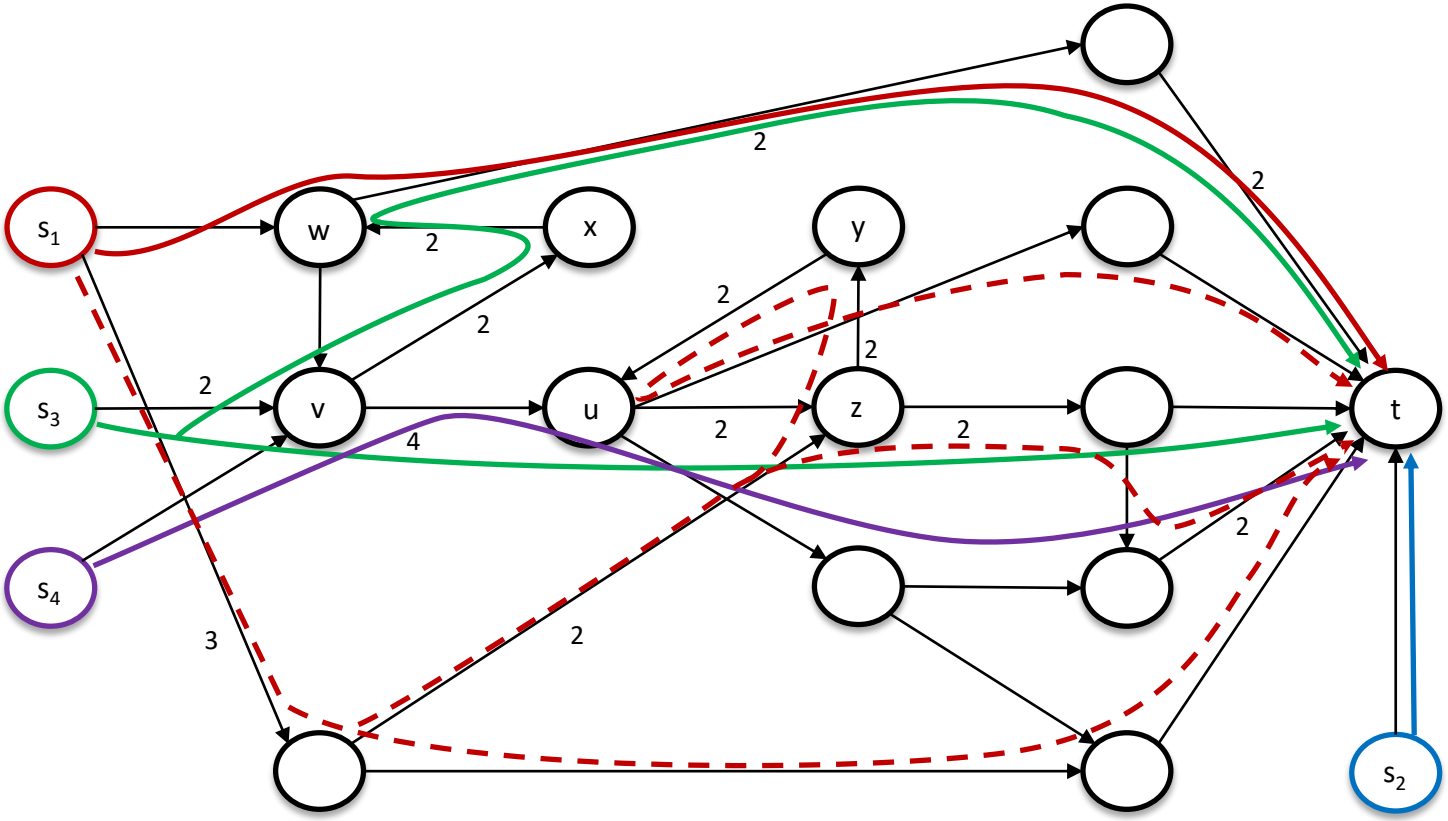

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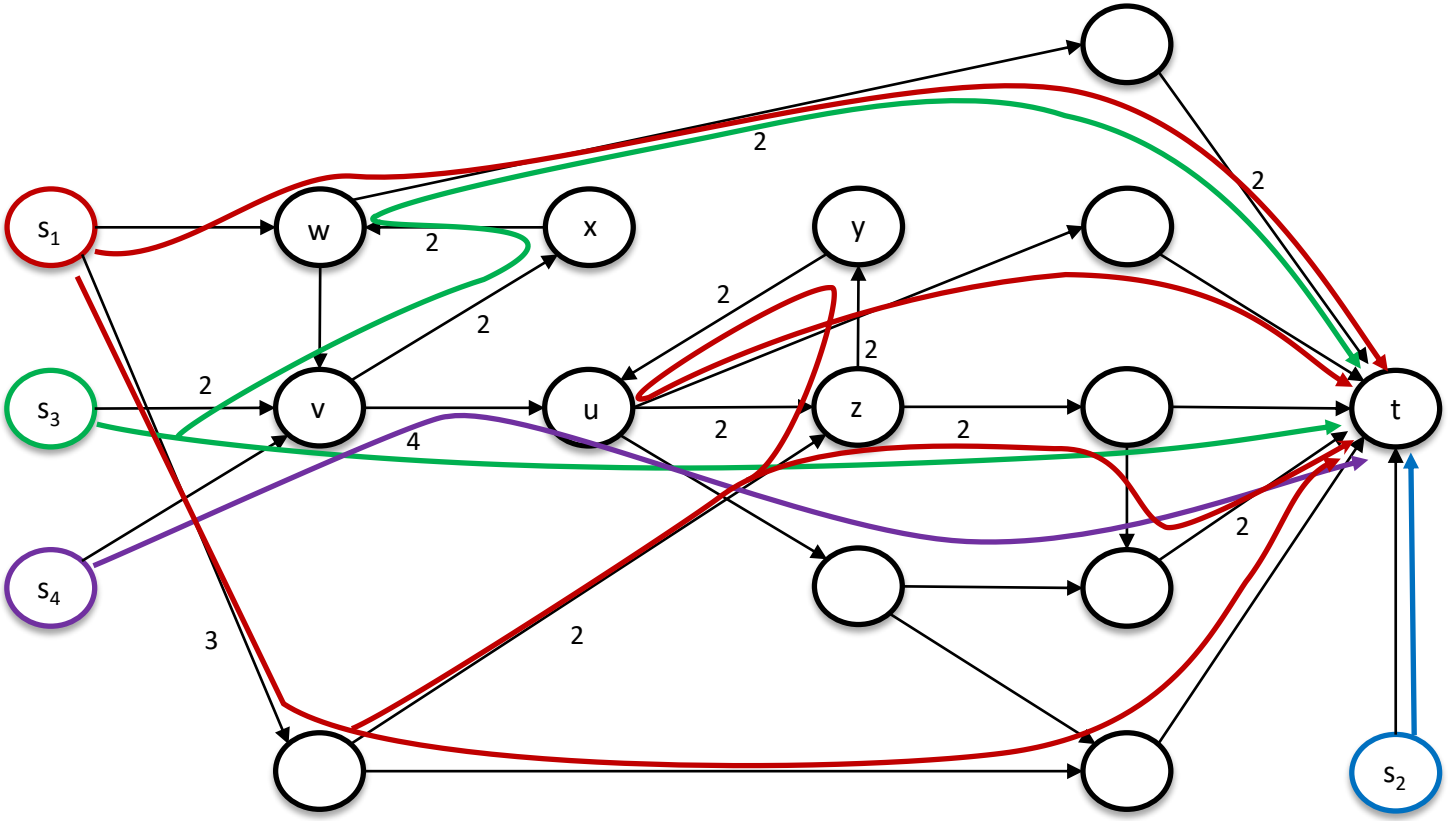

size of flows: 1+3=4, 2, 1, 1

capacity of links: 1 (or marked)

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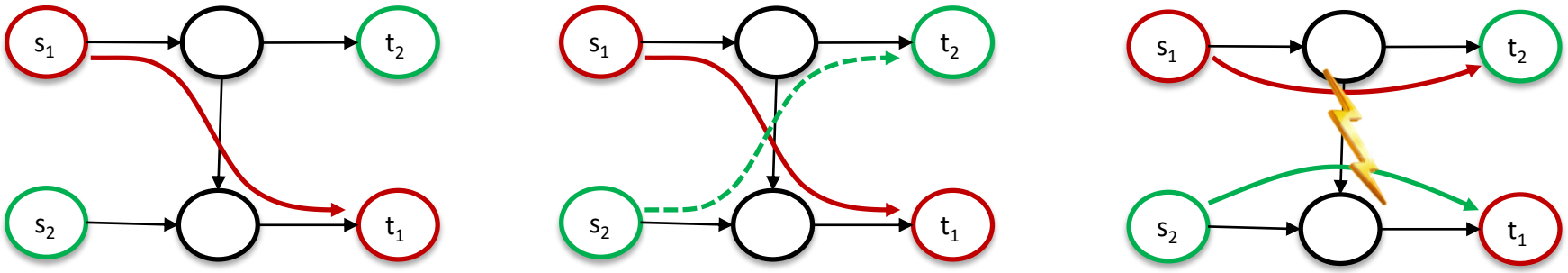
- **Extension beyond Anycast Flows**

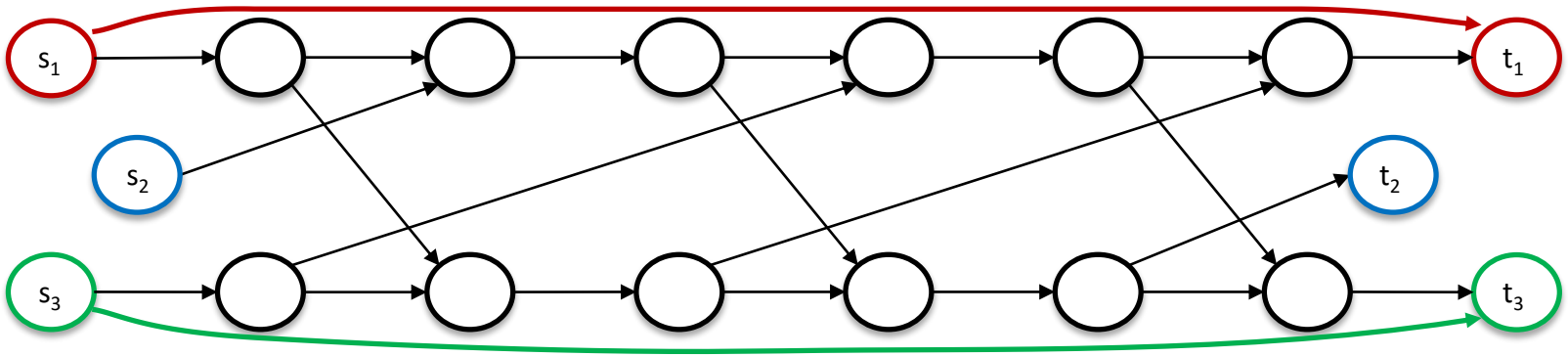
Flow Augmentation for many Destinations



- Flows end up at the wrong destination!

- So let's stick with augmenting flows that don't mix destinations

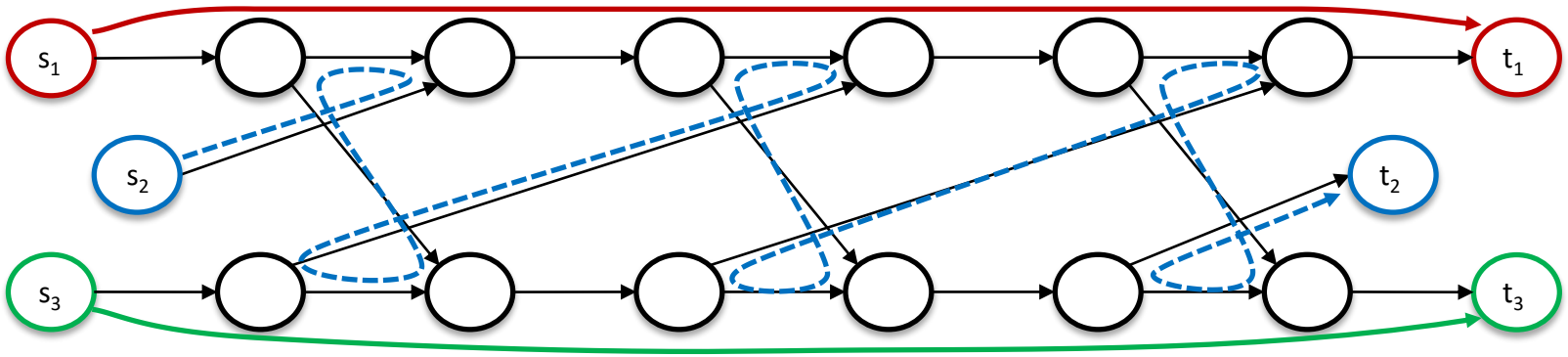
Extension beyond one logical destination?



size of each flow: 1

capacity of each links: 1

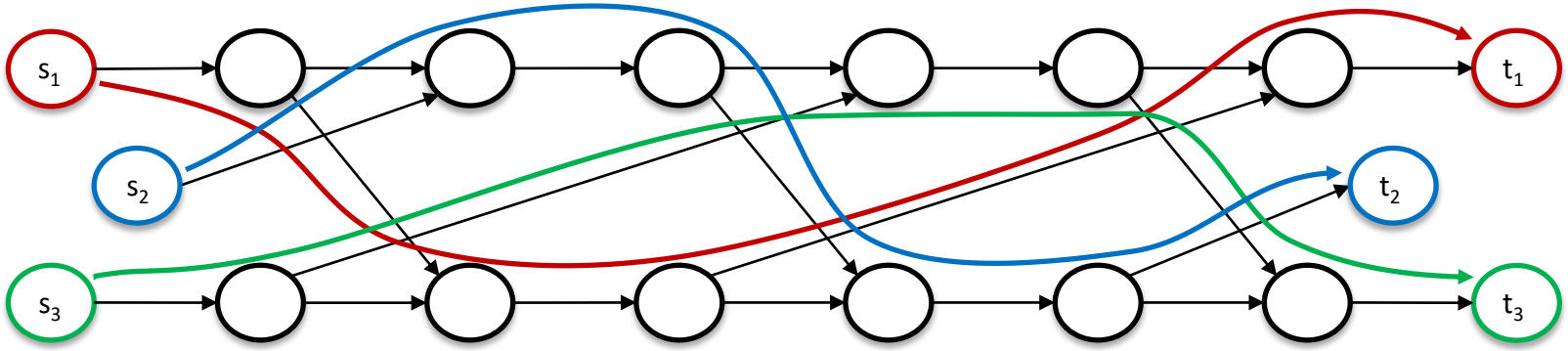
Augmenting flows that don't mix up the destinations?



size of each flow: 1

capacity of each links: 1

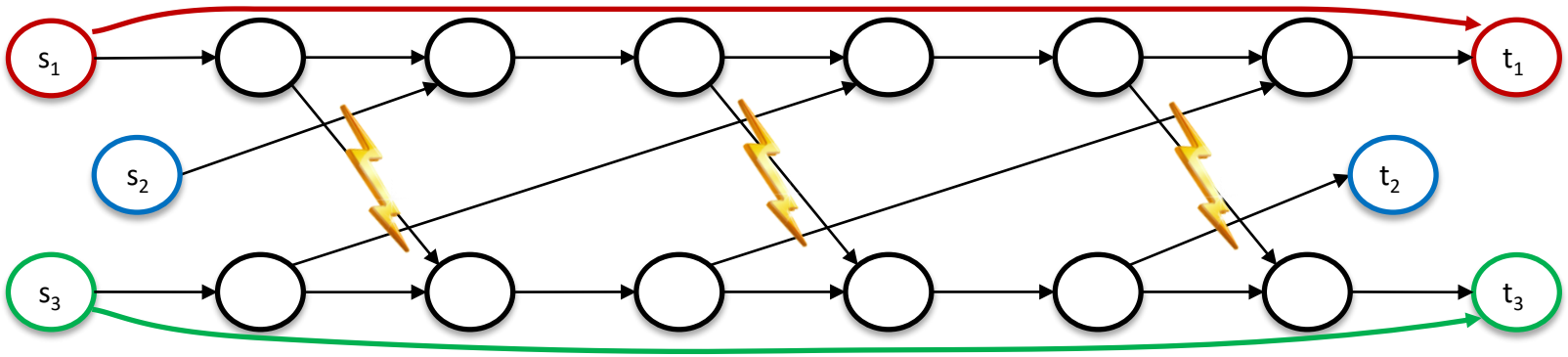
Augmenting flows that don't mix up the destinations?



size of each flow: 1

capacity of each links: 1

But impossible to migrate!



size of each flow: 1

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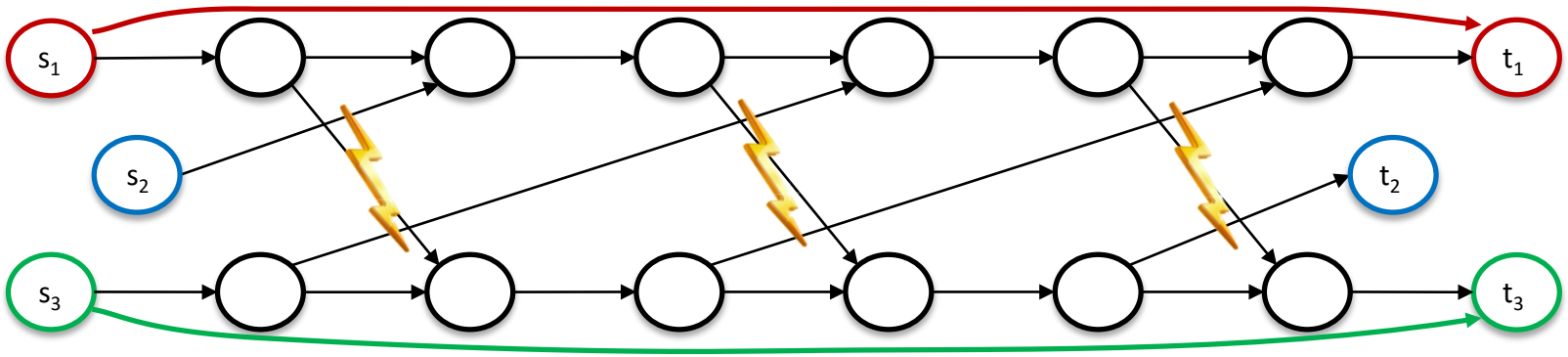
But impossible to migrate!



"it is unlikely that similar techniques can be developed for constructing multicommodity flows"

[Hu, 1963]

size of each flow: 1

capacity of each links: 1

Summary

- We studied how to migrate flows with one logical destination in SDNs without congestion
  - We can decide fast if demands can be met
  - We can migrate with linear # re-routings in the network using augmenting flows
- Open question:
  - How to extend beyond one logical destination?

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January 06, 2016 @ ICDCN 2016 - Singapore