Fibbing: Central Control over Distributed Routing

www.fibbing.net

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Joint work with
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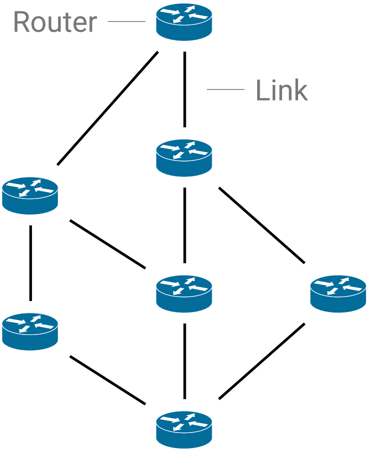
Fibbing

Fibbing

Control routers' FIB, lying to routers

Consider this example network.



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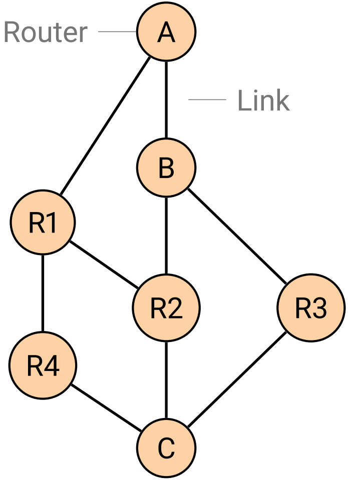
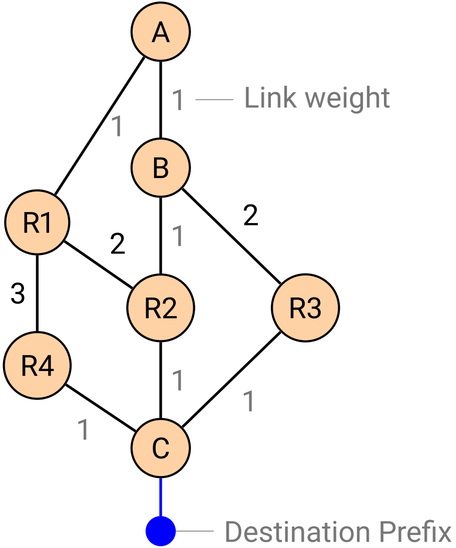
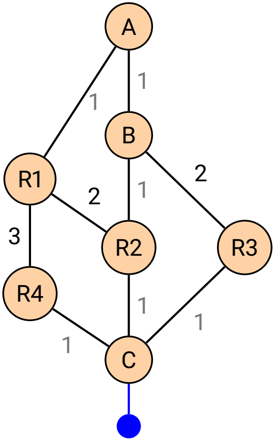


Link-state Interior Gateway Protocols (IGPs) exchange reachability information to infer the topology of the network.

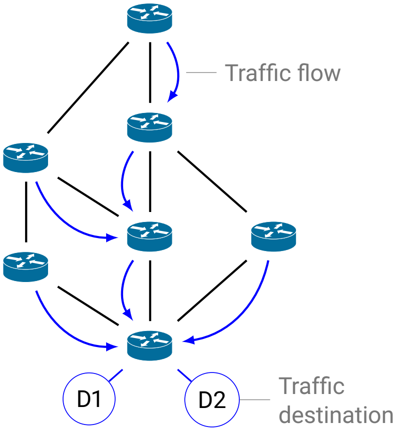


The intra-domain traffic flows along the shortest path on the shared topology.

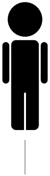
Control-Plane



Data-Plane



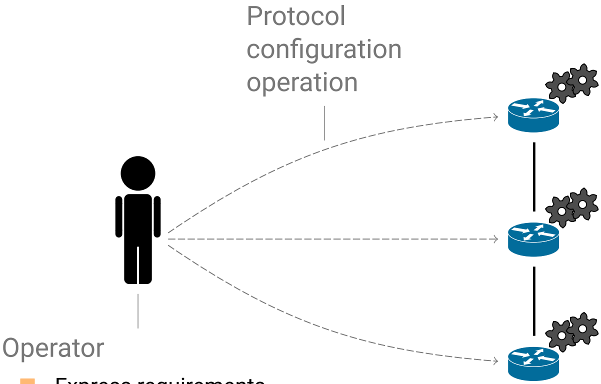
IGPs cause operator to follow a *descriptive* management process.



Operator

- Express requirements

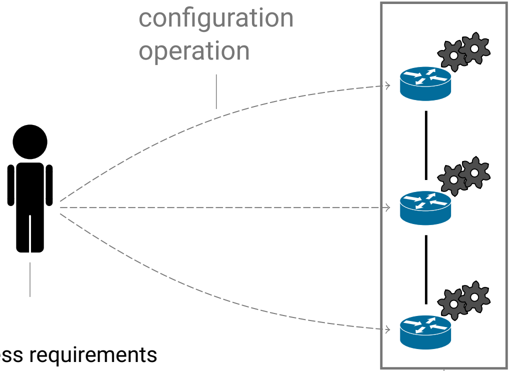
IGPs cause operator to follow a *descriptive* management process.



- Express requirements
- Computes paths
- Figures out how to implement them

IGPs cause operator to follow a *descriptive* management process.

Protocol configuration operation



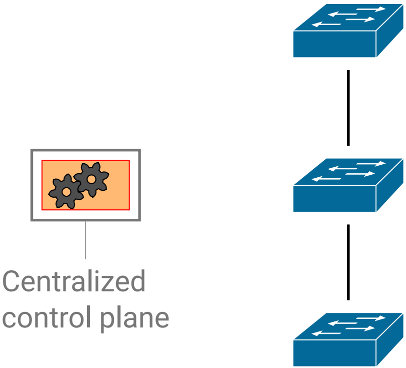
Operator

- Express requirements
- Computes paths
- Figures out how to implement them

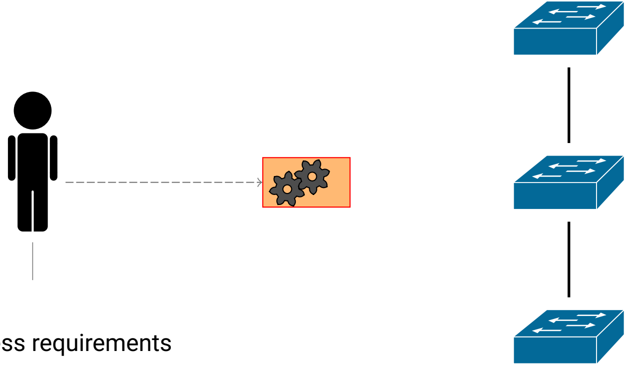
Distributed Control-Plane

- Derives FIB entries
- install FIB entries

Software-Defined Networking (SDN) enables *declarative* management.



Software-Defined Networking (SDN) enables *declarative* management.



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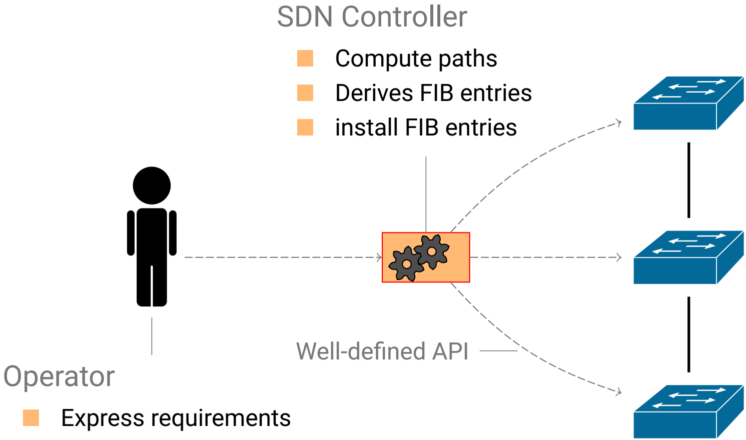
Software-Defined Networking (SDN) enables *declarative* management.



SDN *sacrifices* the robustness and scalability of distributed protocols.

	Traditional	SDN
Manageability	low	**high**
Flexibility	low	**highest**
Scalability	**by design**	ad hoc
Robustness	**high**	low

The networking world has two paradigm, based on opposed principles.

	Traditional		SDN
Manageability	low		**high**
Flexibility	low		**highest**
Scalability	**by design**		ad hoc
Robustness	**high**		low

We propose a middleground approach, named *Fibbing*.

	Traditional	Fibbing	SDN
Manageability	low	**high**	**high**
Flexibility	low	**high**	**highest**
Scalability	**by design**	**by design**	ad hoc
Robustness	**high**	**high**	low

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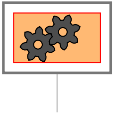
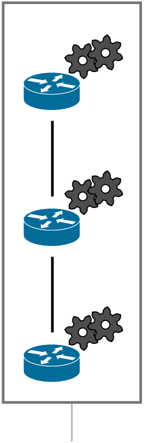
1. Controlling distributed protocols
2. Case study: surviving flash crowds
3. Fibbing today's networks
4. Food for thoughts

Fibbing uses an hybrid control plane.



Centralized
control plane

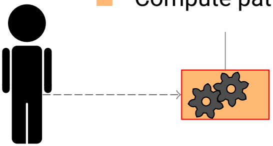


Distributed
control plane

Fibbing centralizes high level routing decisions.

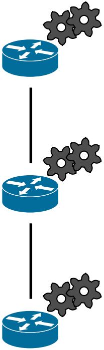
Fibbing Controller

- Compute paths

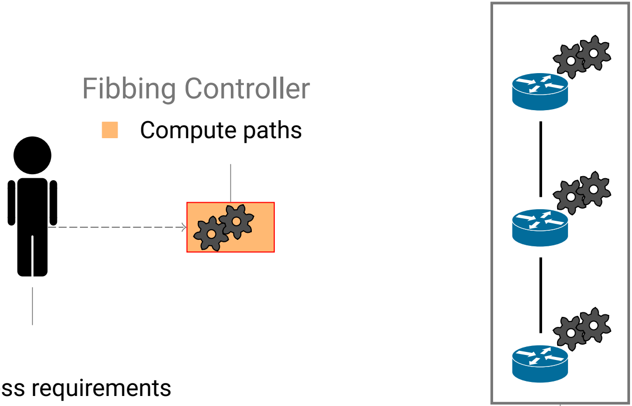


Operator

- Express requirements



Fibbing keeps the route installation distributed.



Fibbing Controller

- Compute paths

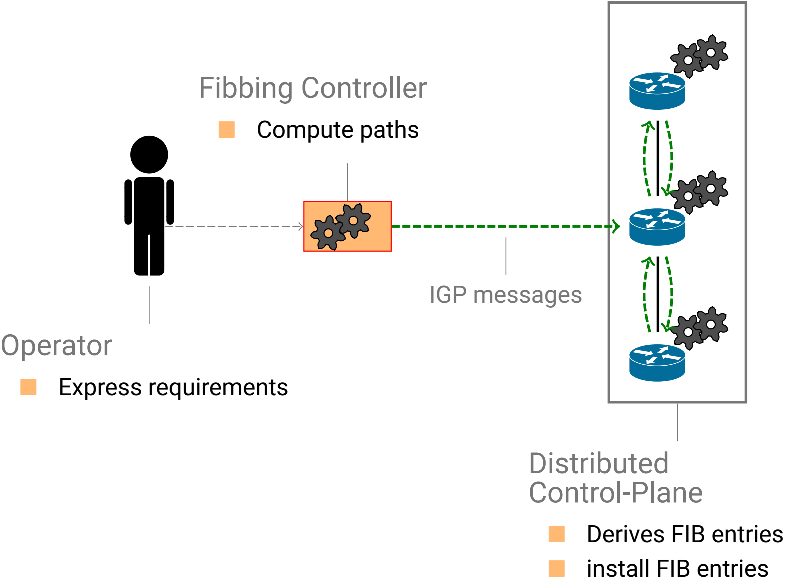
Operator

- Express requirements

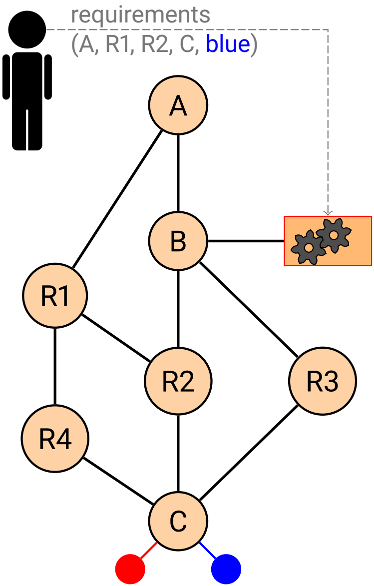
Distributed
Control-Plane

- Derives FIB entries
- install FIB entries

We study which IGP messages to inject.

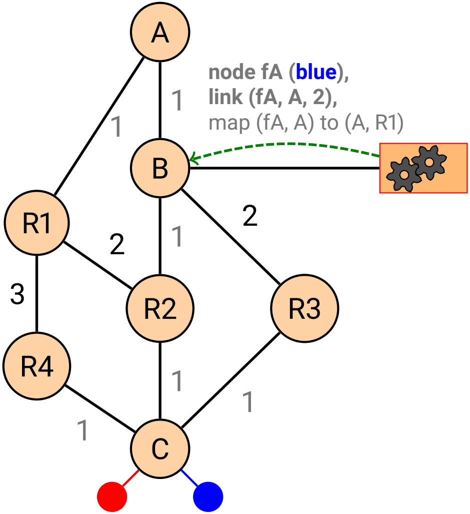


Operators specify paths that must be enforced.

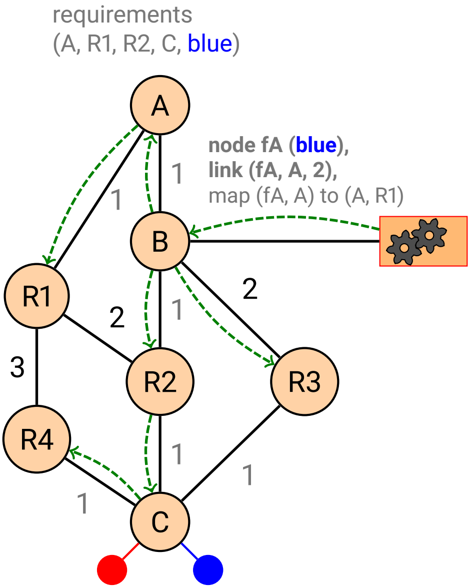


The controller injects one IGP message adding *a fake node and links*.

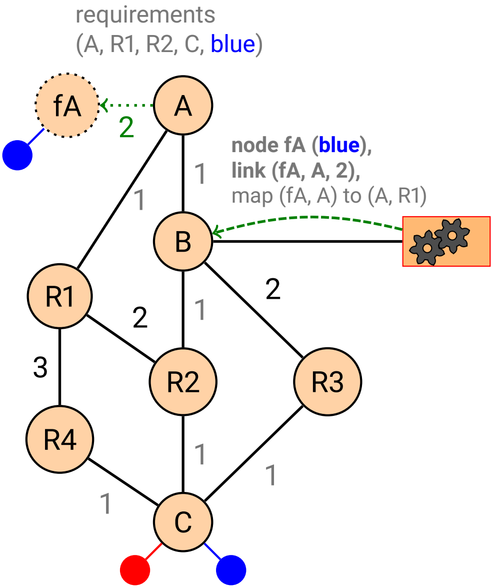
requirements
(A, R1, R2, C, blue)



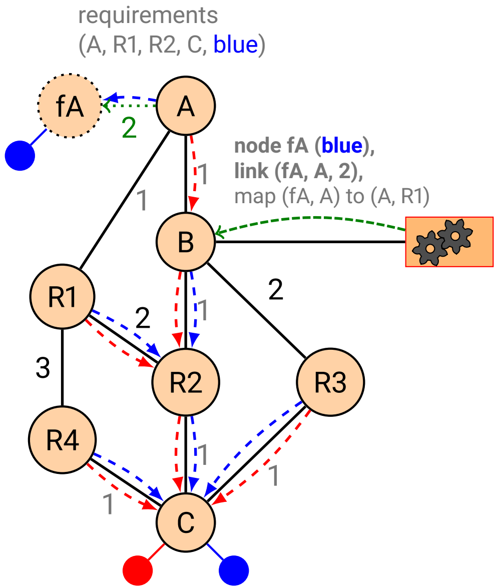
IGP flooding propagates the information.



The Fibbing message *augments* the topology.

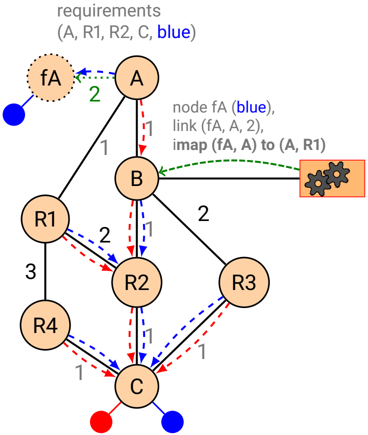


Augmented topologies translate into new control-plane paths.

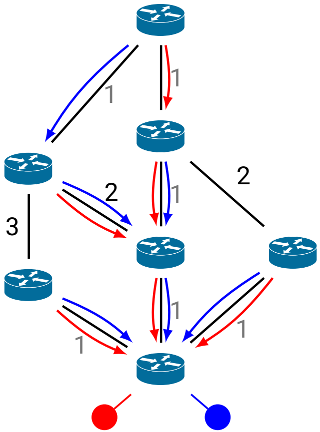


Augmented topologies translate into new data-plane paths.

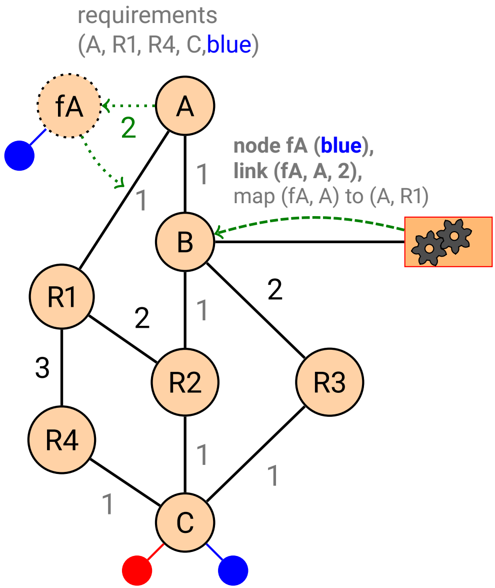
Control-Plane



Data-Plane



Chaining multiple fake nodes enables to program complex paths.



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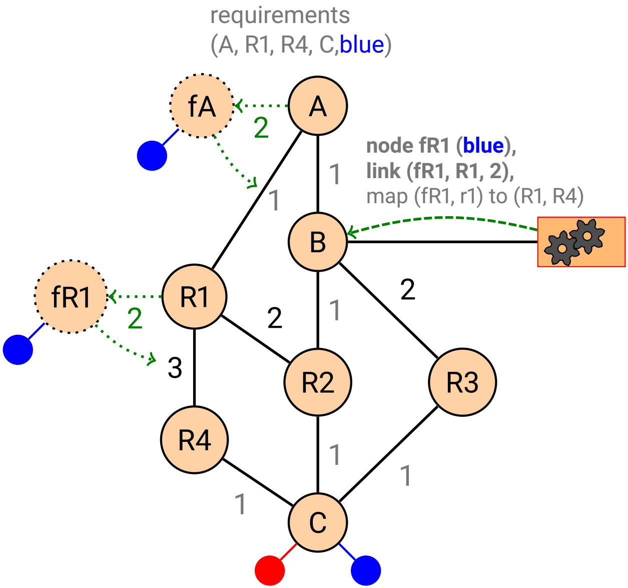

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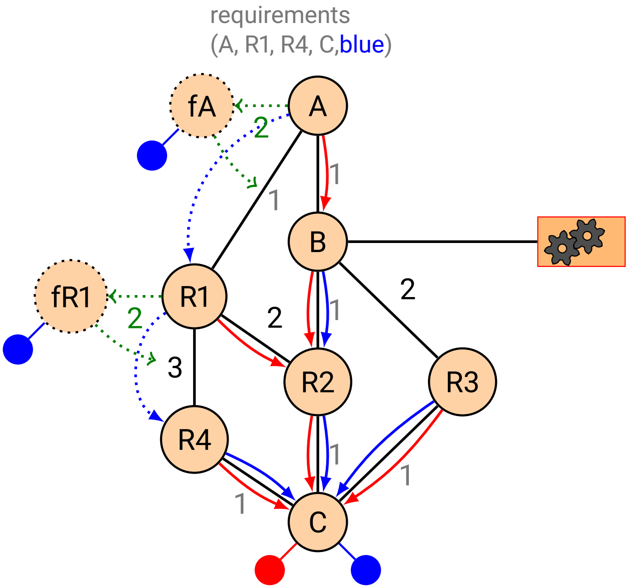
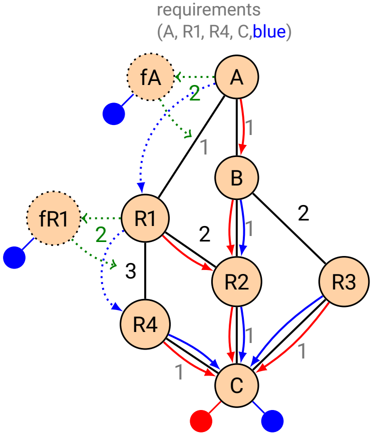
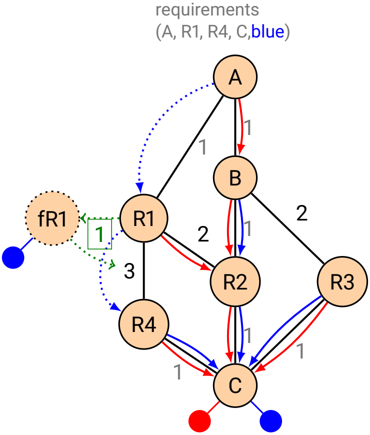


Augmented topologies can be reduced to optimize the number of fake nodes.

Naive augmentation



Reduced augmentation



Fibbing preserves the scalability of IGPs.

- We can compute augmented topologies in $\mathcal{O}(ms)$
  Ensures quick reaction to changes

- We can *reduce* augmented topologies in $\mathcal{O}(s)$
  Ensures limited control-plane overhead

Fibbing leverages the robustness of IGPs.

- Fast failure detection and recovery
- Survive controller failure
- Support fail-close and fail-open semantics

Fibbing can enforce any set of loop-free paths, on a per destination basis.

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Flash crowds cause service disruption.

- Video delivery services require good network performance

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- Protecting the services against flash crowds is challenging:

    1. Traditional traffic engineering techniques perform poorly;

    2. Over-provisioning is expensive.

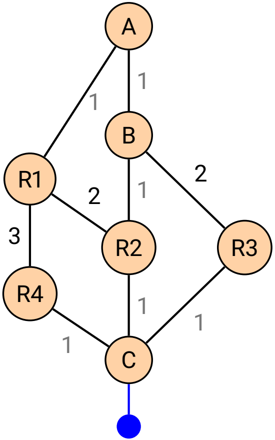
Fibbing reduces the need for over-provisioning by enabling real-time traffic engineering.

Experiment setup

- Network with 2 video streaming servers
- Multiple clients are competing for bandwidth
- The network controller is able to detect flash crowds

The initial IGP configuration has a bottleneck towards router C.

Control-Plane



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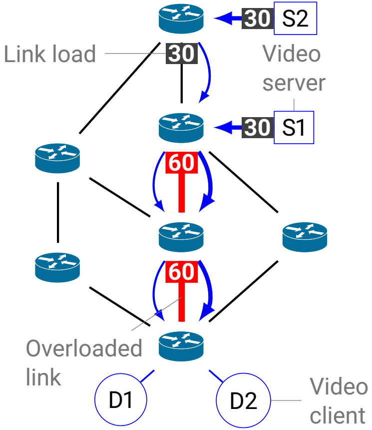
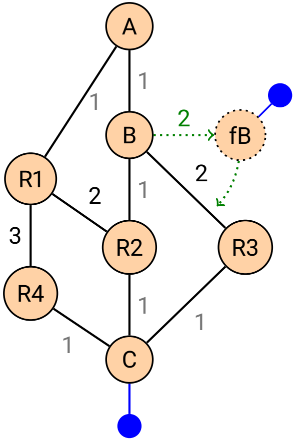


Fibbing can program on-demand ECMP to spread the load

Control-Plane



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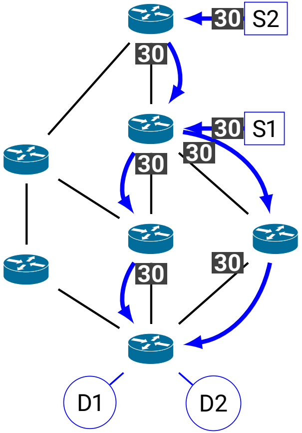

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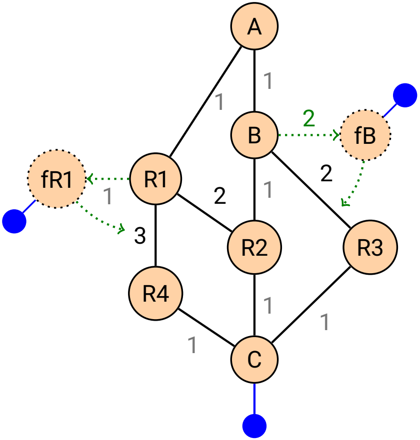

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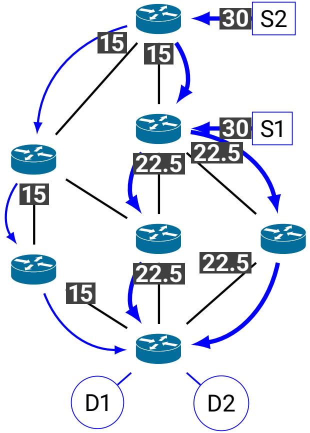
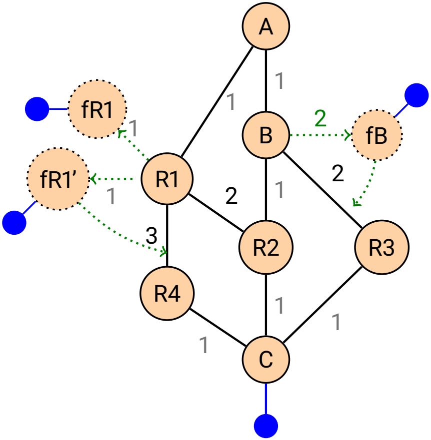


Fibbing controls the splitting ratios across equal-cost paths.

Control-Plane



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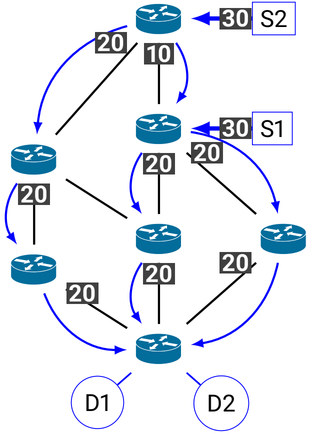
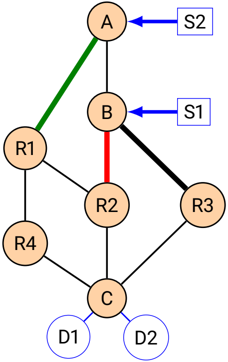
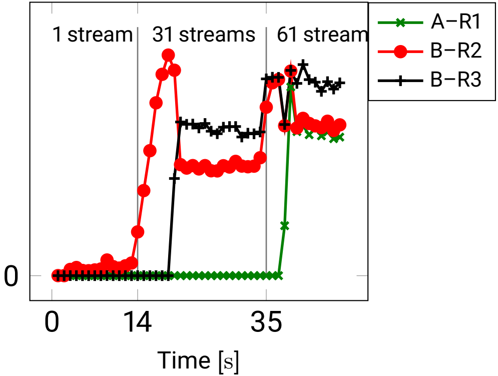


As the demand increases, the Fibbing controller adds more paths to spread the load.





- We initially have 1 video stream from S1 to D1.
  - At time $t = 14s$, we start 30 new streams from S1 to D1.
  - At time $t = 35s$, we start 30 streams from S2 to D2.

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We have a working Fibbing controller prototype

- The controller maintains an OSPF adjacency to one router
- Topology discovery using the adjacency
- Tested against IOS, NX-OS, JunOS

Fake nodes can be injected using LSA types 5/7

- Leverages the forwarding address field
  Advertize reachability towards prefix, with cost, using specified IP next hop

- The controller multiplexes multiple virtual routers
  $\mathcal{N}$ successive fake nodes towards the same prefix require $\mathcal{N}$ different router-ids

Using T5/7 LSAs has (almost) no overhead on routers and is fast.

- No measurable impact on SPF duration
- 10 000 LSAs eat 14.5 MB of DRAM
- 900μs to push one fibbed route to the FIB

Using T5/7 LSAs comes at a price

- Different expressivity model
- Can only affect prefixes from other T5/T7 LSAs
- Does not work with IS-IS!

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Centrally modifying the shared topology is powerful

- Gives *some* control over BGP/MPLS-LDP

- Simplify configurations through exception-based routing

- Enables optimal, real-time TE

What would be the right abstraction?

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Tell me lies, tell me sweet little lies
— Fleetwood Mac

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