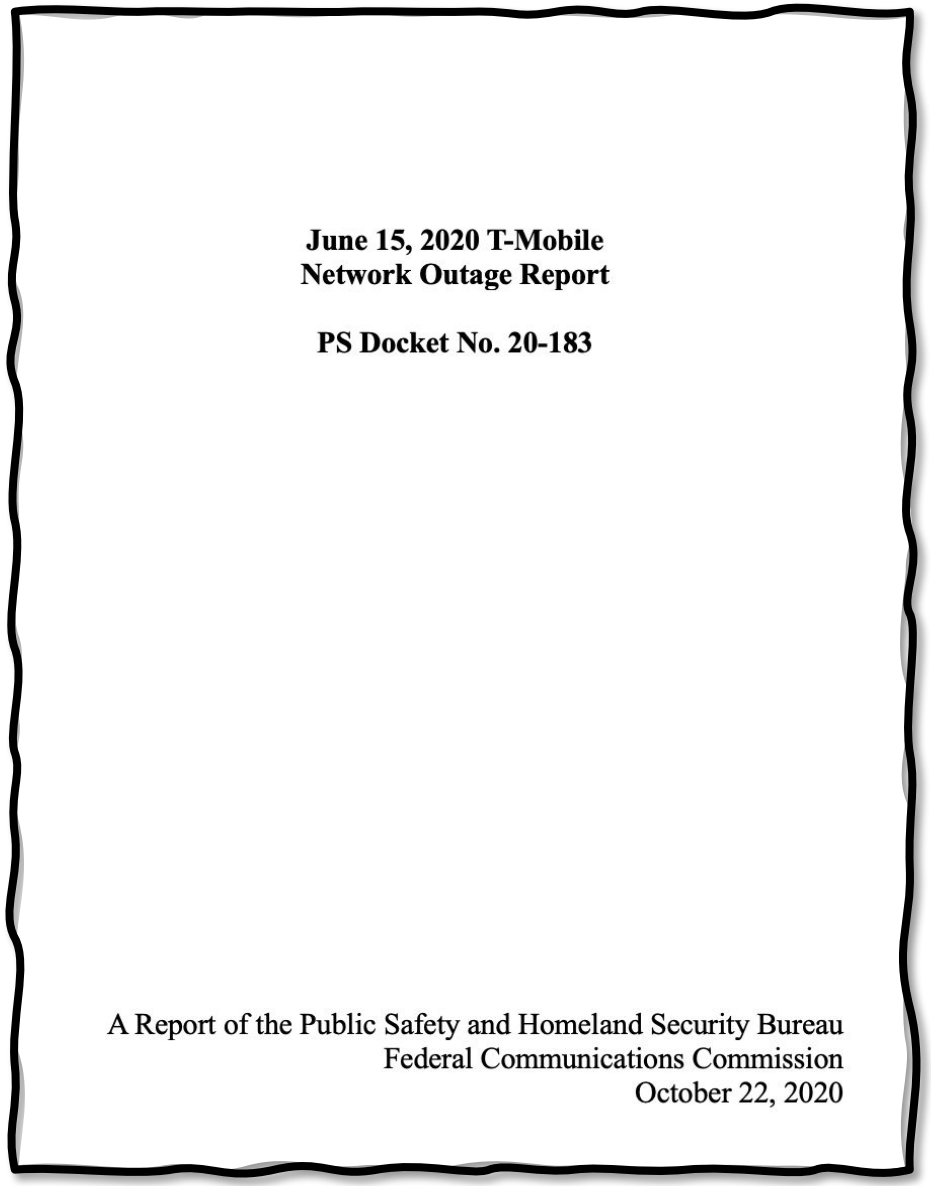
CSE 550: Systems for all

Au 2021

Ratul Mahajan



June 15, 2020 T-Mobile
Network Outage Report

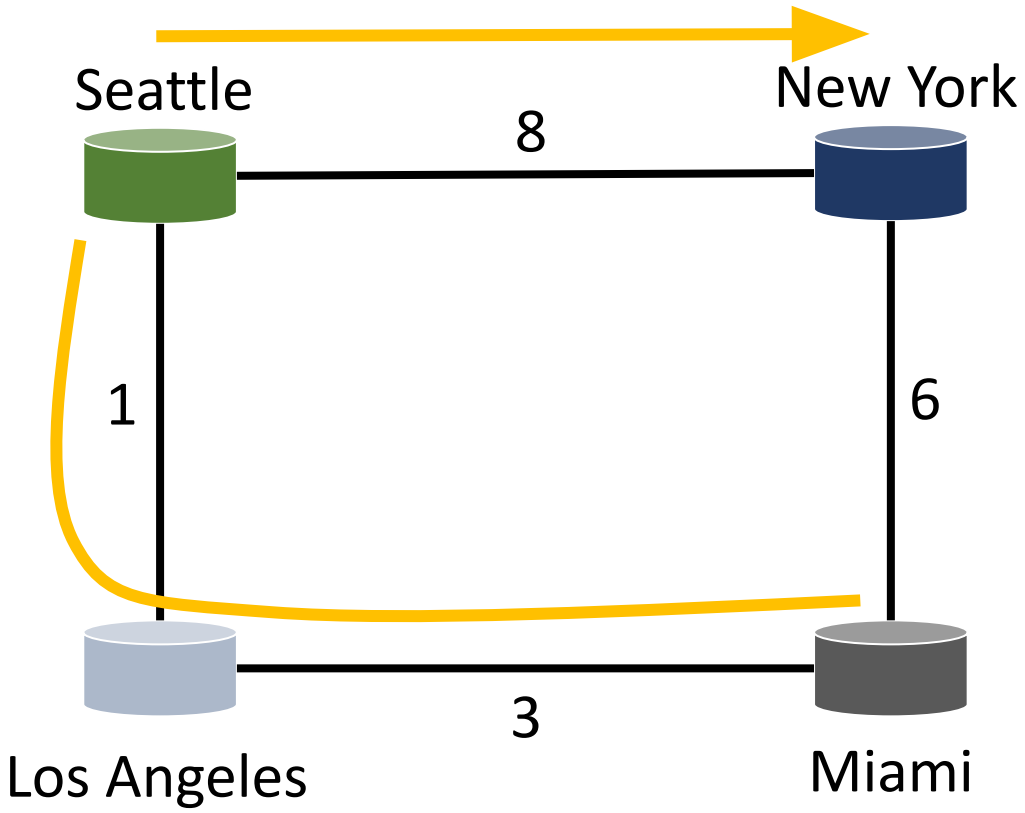
PS Docket No. 20-183

A Report of the Public Safety and Homeland Security Bureau
Federal Communications Commission
October 22, 2020

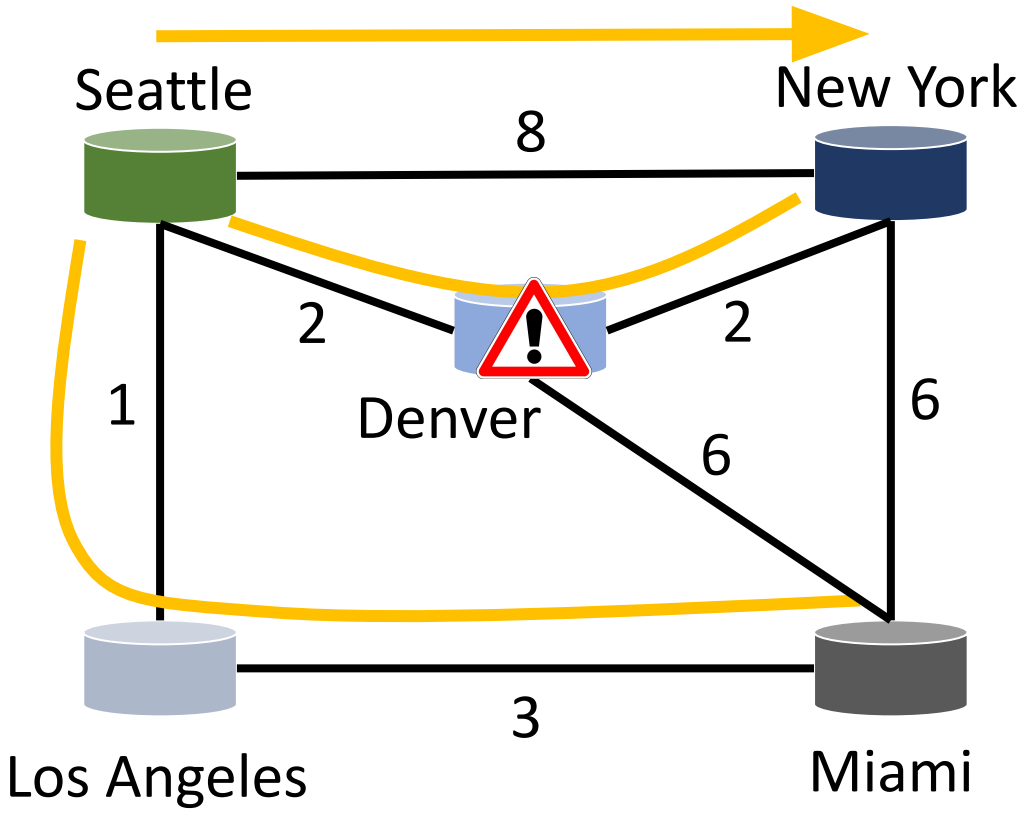
"At least 41% of all calls that attempted to use T-Mobile's network during the outage failed, including at least 23,621 failed calls to 911."

"[An old woman] who has dementia, could not reach [her son] after her car would not start and her roadside-assistance provider could not call her to clarify her location; she was stranded for seven hours"

Anatomy of the outage (illustration)

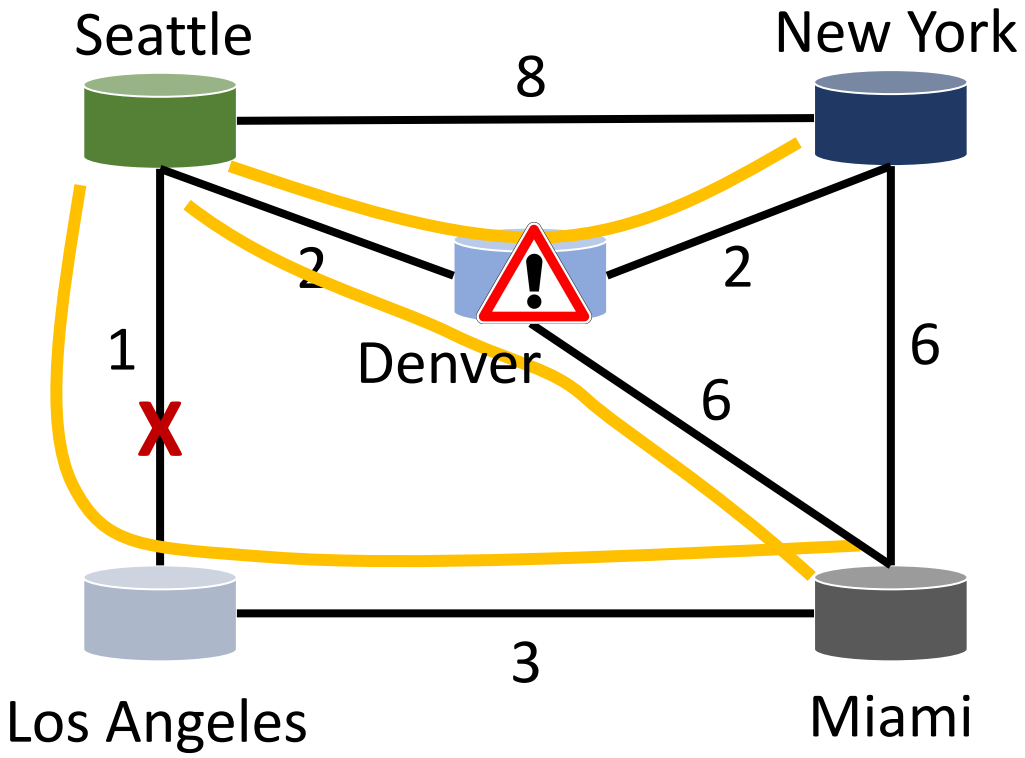


Anatomy of the outage (illustration)



Anatomy of the outage (illustration)

What if T-Mobile could guarantee that no traffic will transit Denver?



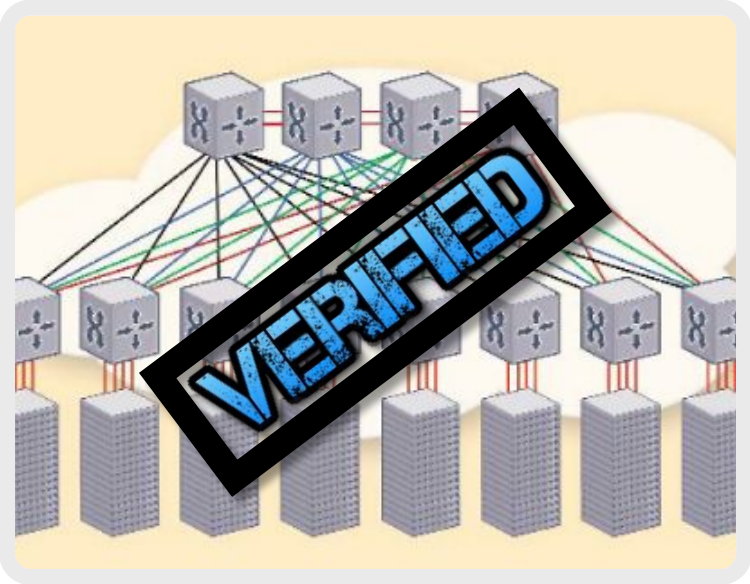
What if T-Mobile could predict the impact of link failure?

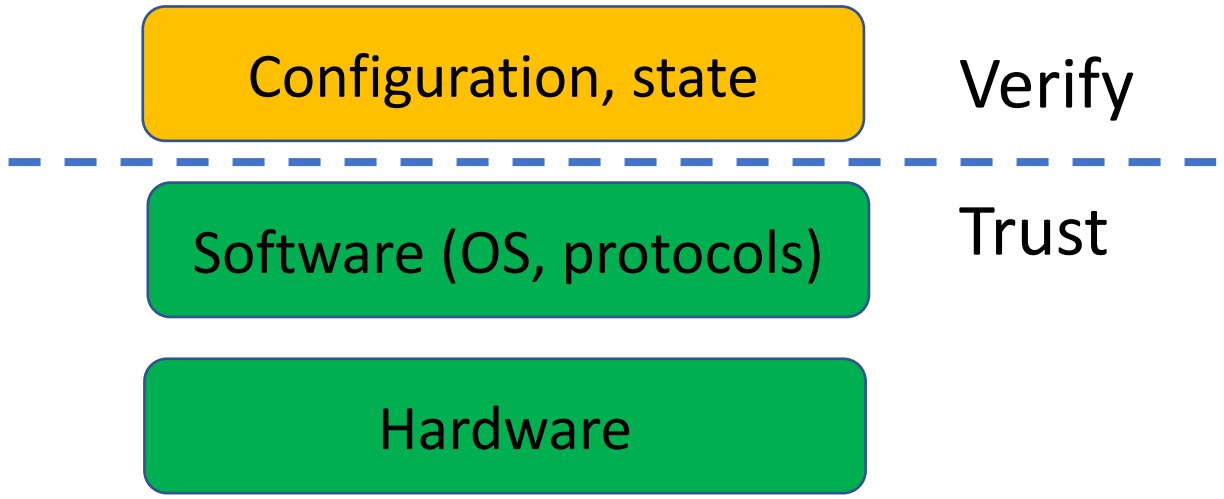
Network verification

Guarantee network behavior*†

** Some aspect of behavior*
† Under some assumptions

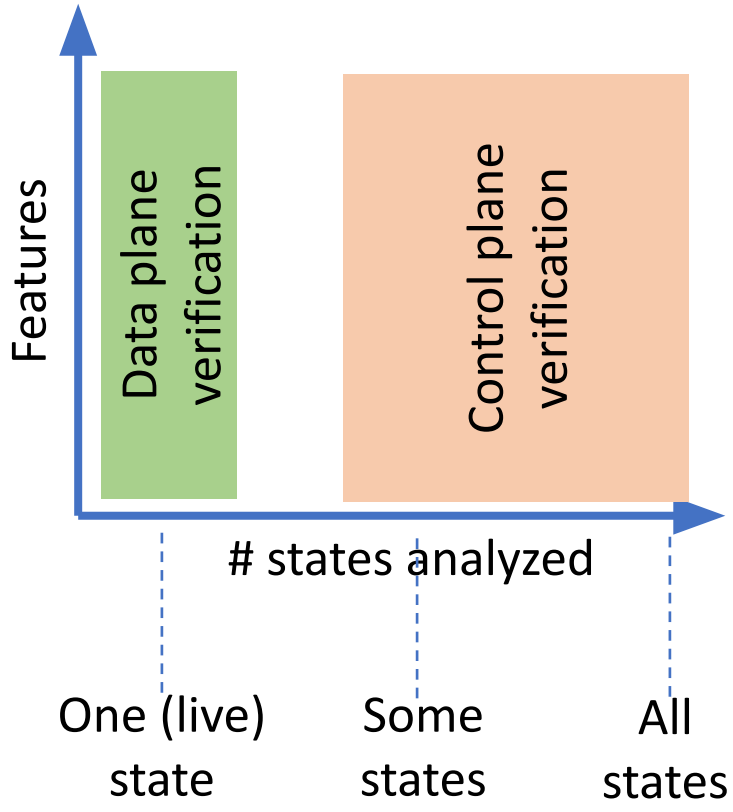
A horizontal slice of the problem





The space of network verification tools

Shortest-path or policy routing?
Are packet transformed?
Stateless or stateful forwarding?
…

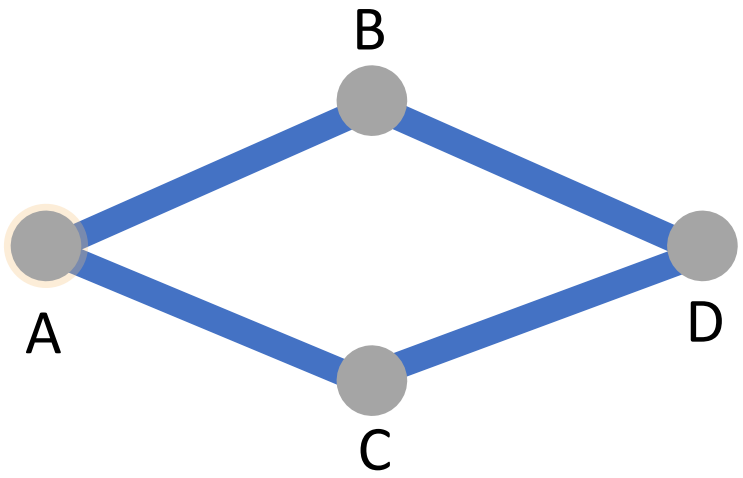


Data plane verification

Who can talk to whom using which ***packets*** and **paths** in **one state** of the network?

10.10.1.0/24	B
10.10.0.0/16	C
0.0.0.0/0	B

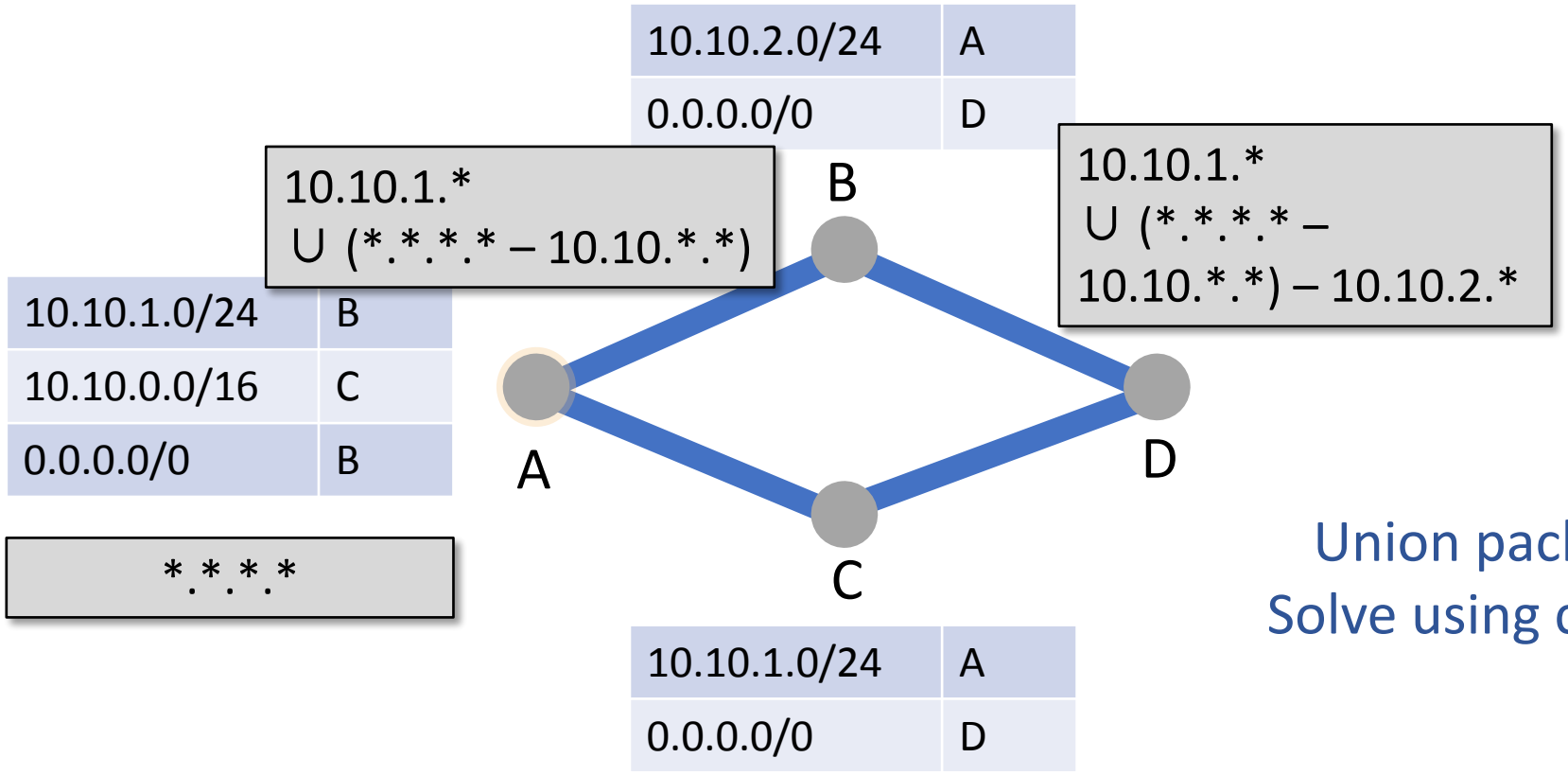
10.10.2.0/24	A
0.0.0.0/0	D



10.10.1.0/24	A
0.0.0.0/0	D

Can A talk to D and using which packets?

DPV idea: Ternary simulation



Union packet sets along possible paths
Solve using custom data structure or BDDs

HSA [2012]

Control plane verification

Who can talk to whom using which ***packets*** and **paths** in **many states** of the network?

✔️ Finds bugs proactively
Enables what if analysis

Verifying distributed control planes

Routers generate and process messages per low-level directives

```
ospf interface int2_1 metric 1
ospf interface int2_1 metric 1
ospf redistributed connected metric 10
```

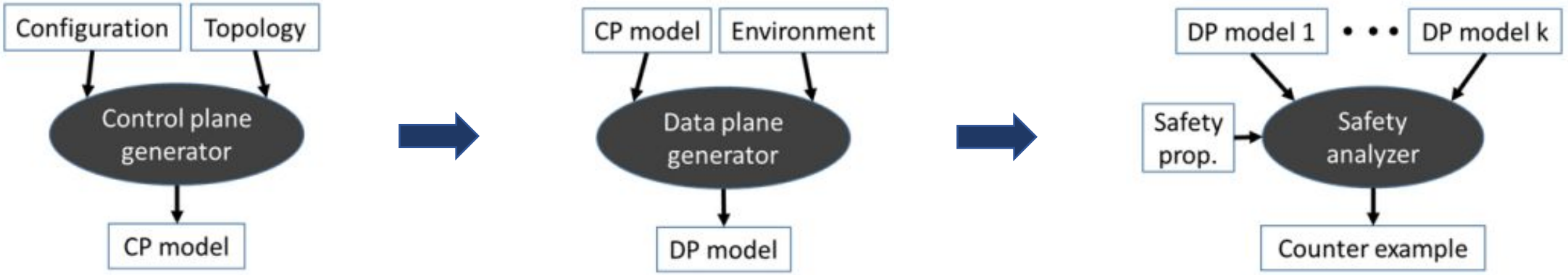
```
ip prefix-list PL1 deny 192.168.0.0/16 le 32
ip prefix-list PL1 allow
route-map FromR2 10
  match ip address prefix-list PL1
  set local-preference 120
```

Goal

Reason about states that emerge when many such programs run concurrently

CPV idea #1: Simulate the control plane

1. Simulate the control plane to generate data plane states
2. Use DPV to analyze the states



Can analyze *any* data plane but not *all* data planes?

Batfish [2015]

CPV idea #2: Encode the fixed point

1. Valid network states are fixed points of the control plane
2. Fixed points can be formally encoded

ARC [2016] use a graph encoding (not general)

Minesweeper [2017] uses SMT encoding

Over to Mike and Yihong

So, what did we learn this quarter?