Advanced Topics in Communication Networks

Internet Routing and Forwarding

Laurent Vanbever

nsg.ee.ethz.ch

3 Nov 2020

Lecture starts at **14:15**

Subsets of the materials inspired and/or coming from Olivier Bonaventure

Let me first quickly answer to your padlet questions

1. Does pure RSVP follow only IGP least cost paths to reserve resources?

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   Yes. That's why RSVP-TE has the ERO

2. Is RSVP *really* used?

   Yes! It's widely deployed, ***but*** there are a few gotchas…

Because paths are allocated greedily,
RSVP-TE can compute suboptimal solutions

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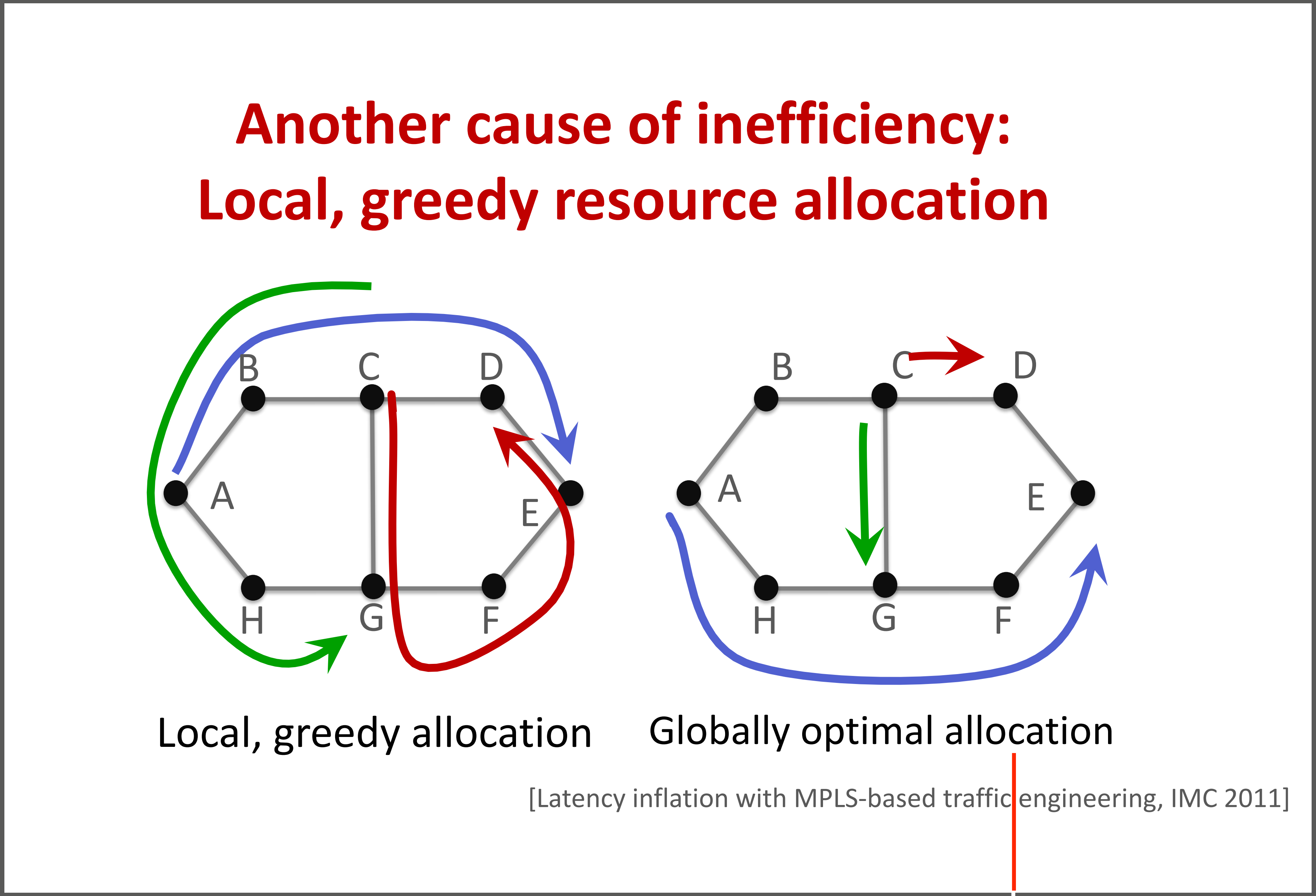

smaller delays *and* less links used!

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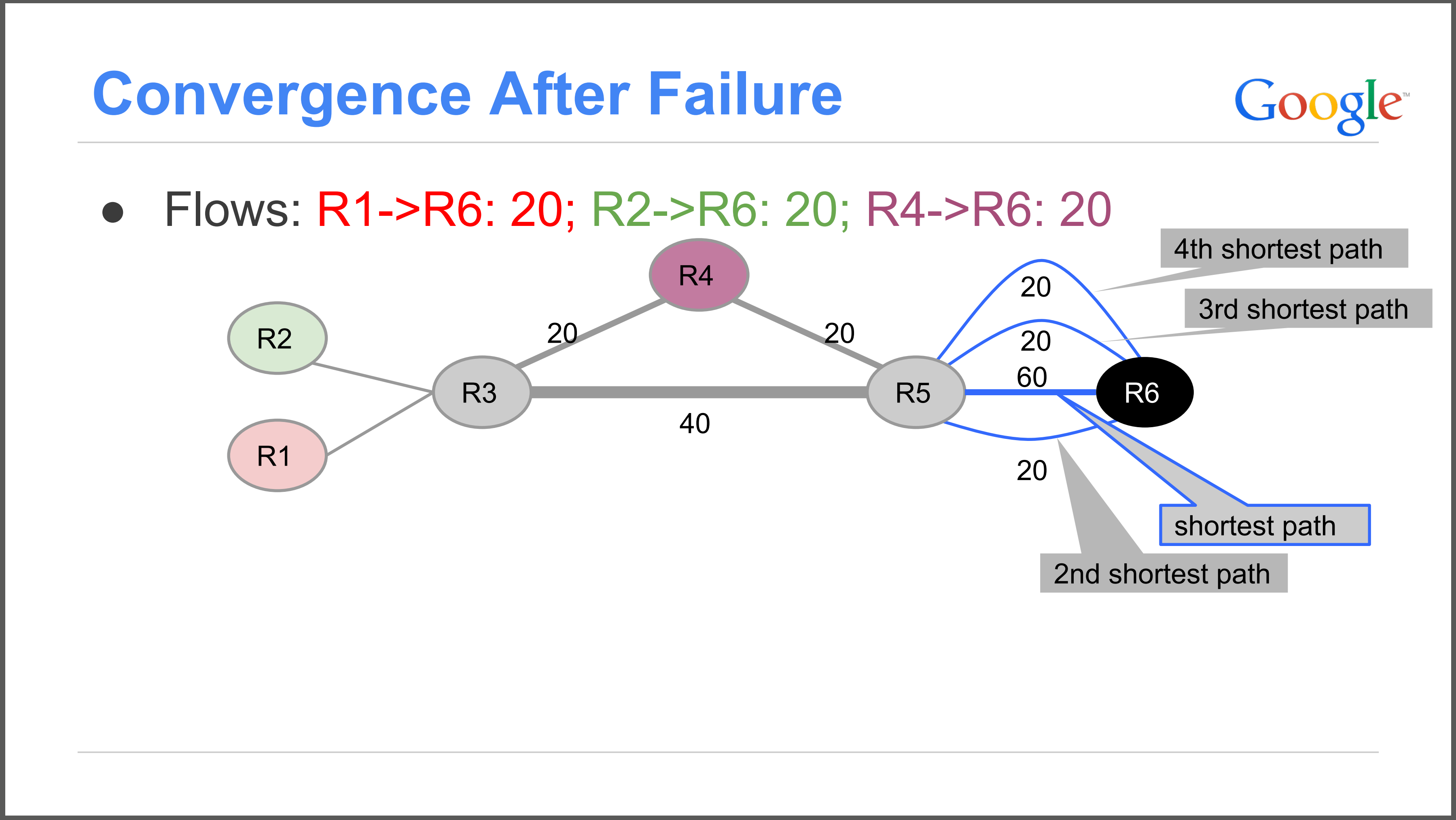

Lessons Learned from B4, Google's SDN WAN [ATC 2015]

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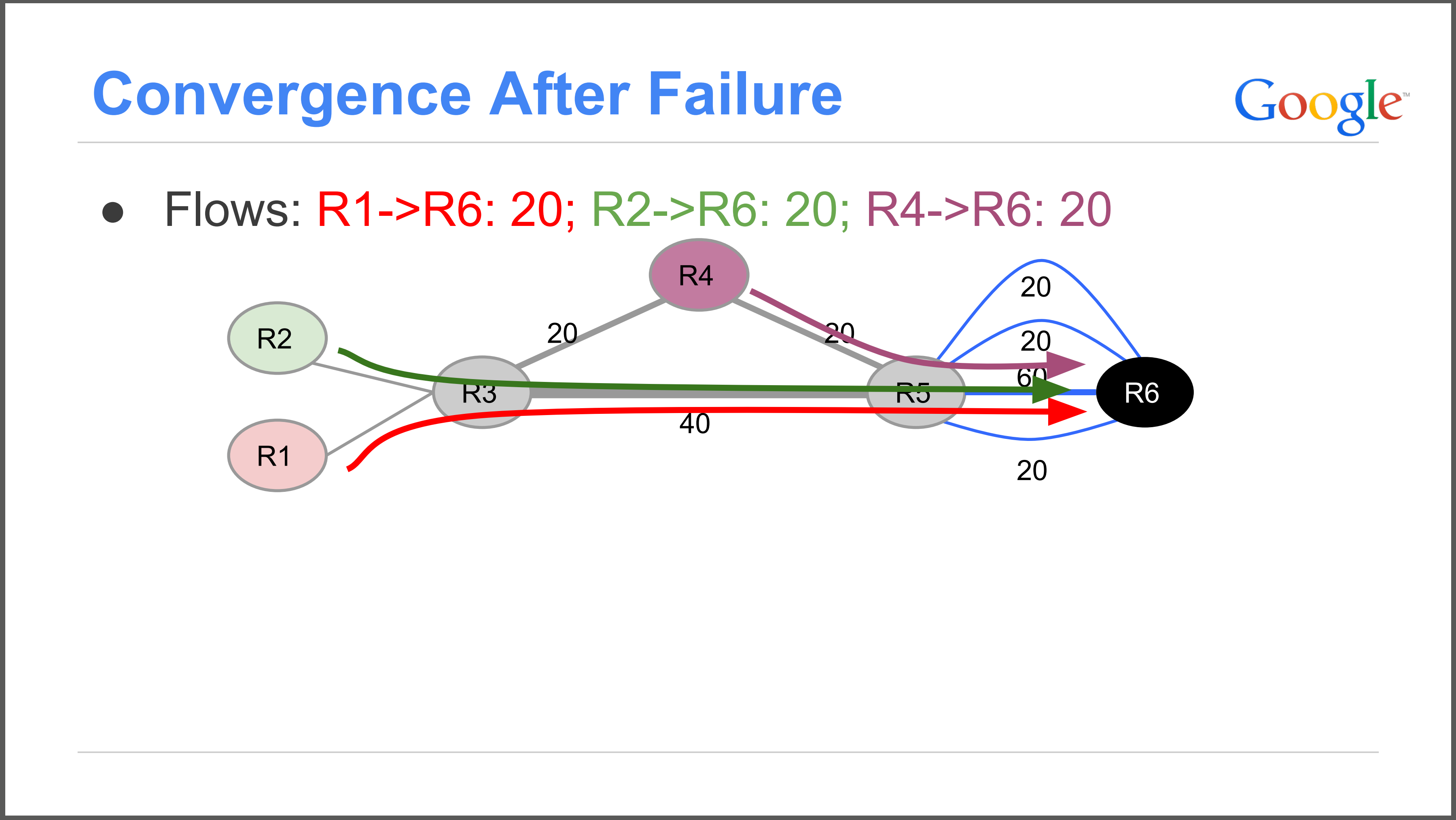

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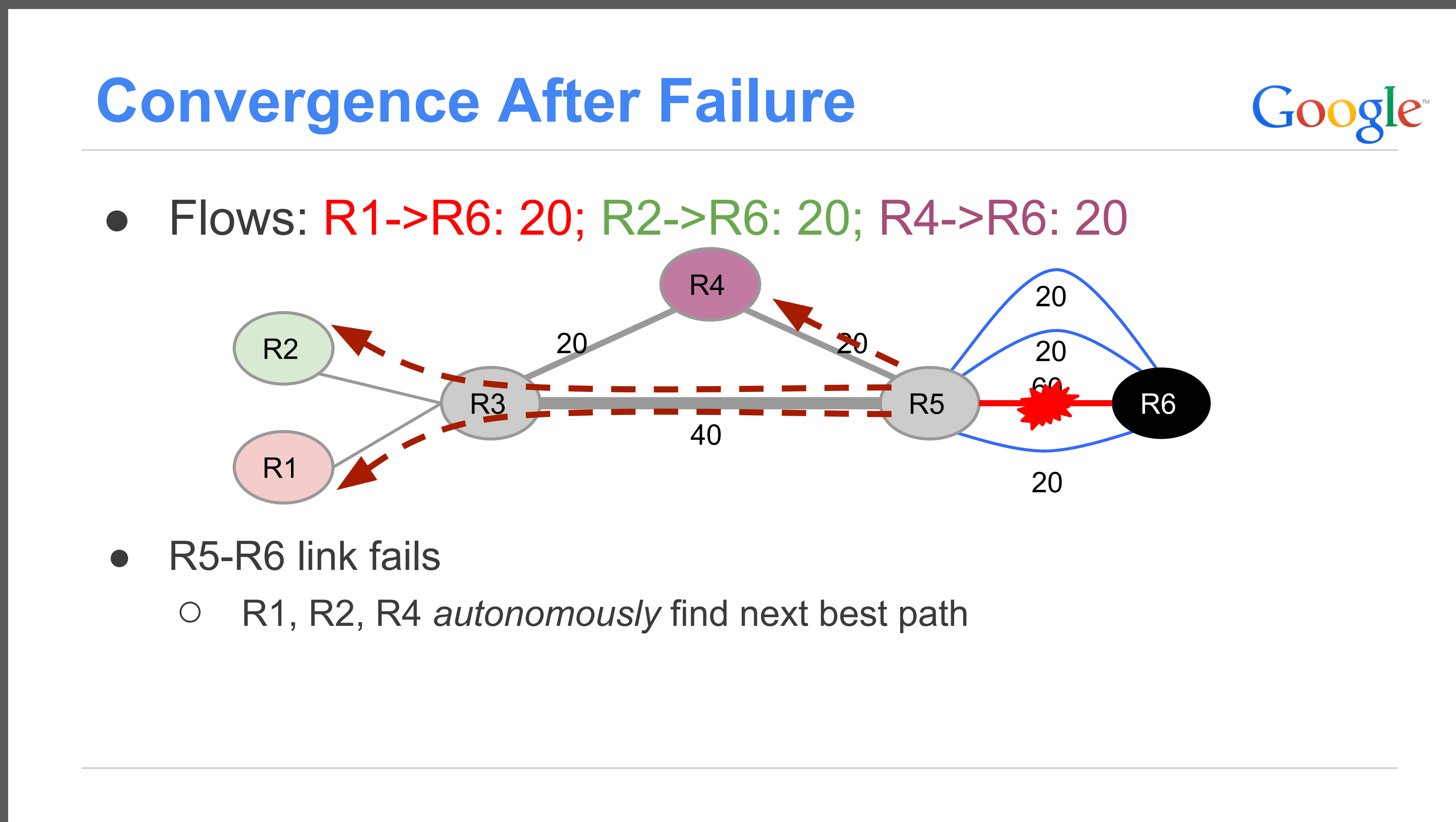

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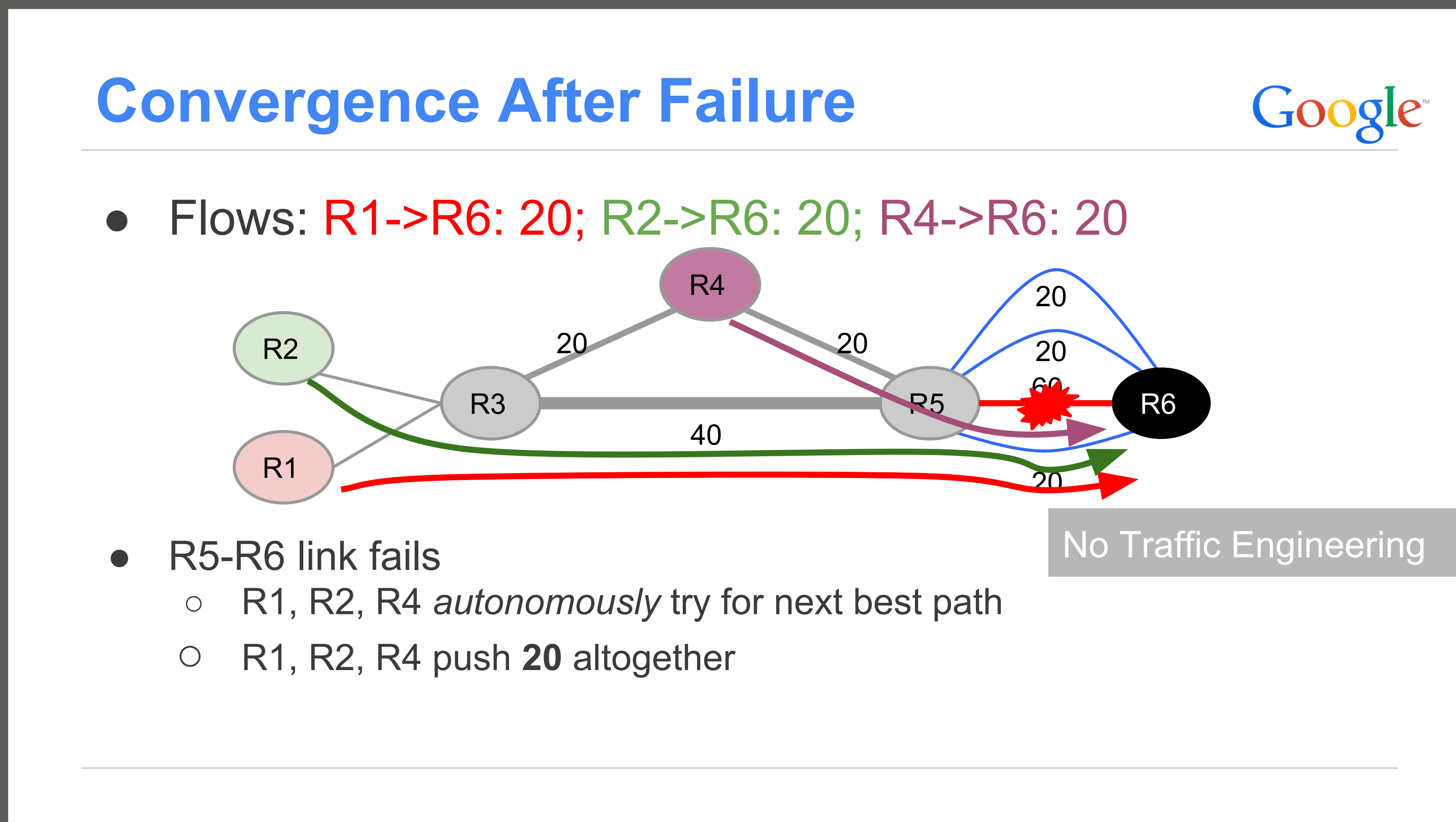

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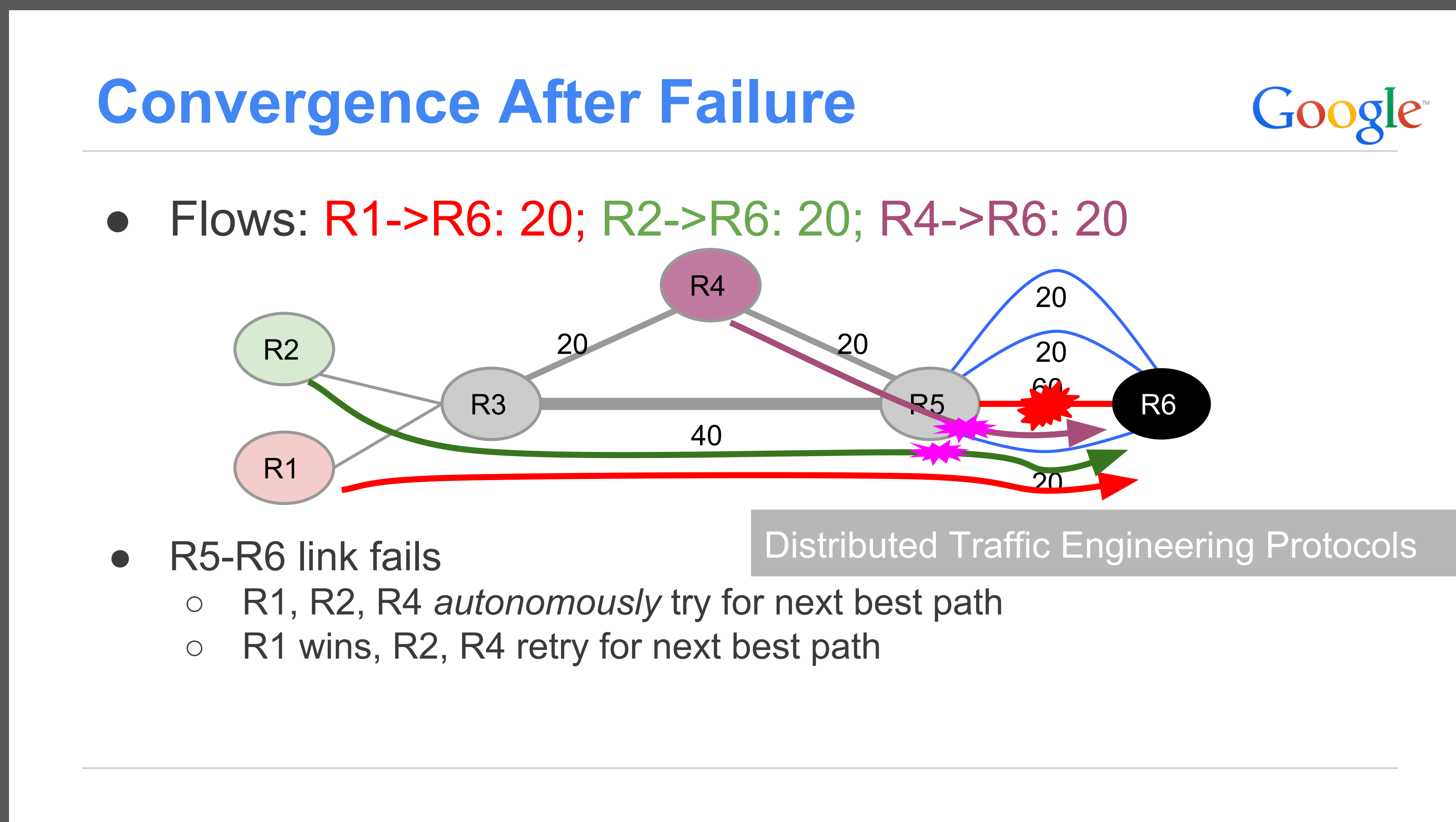

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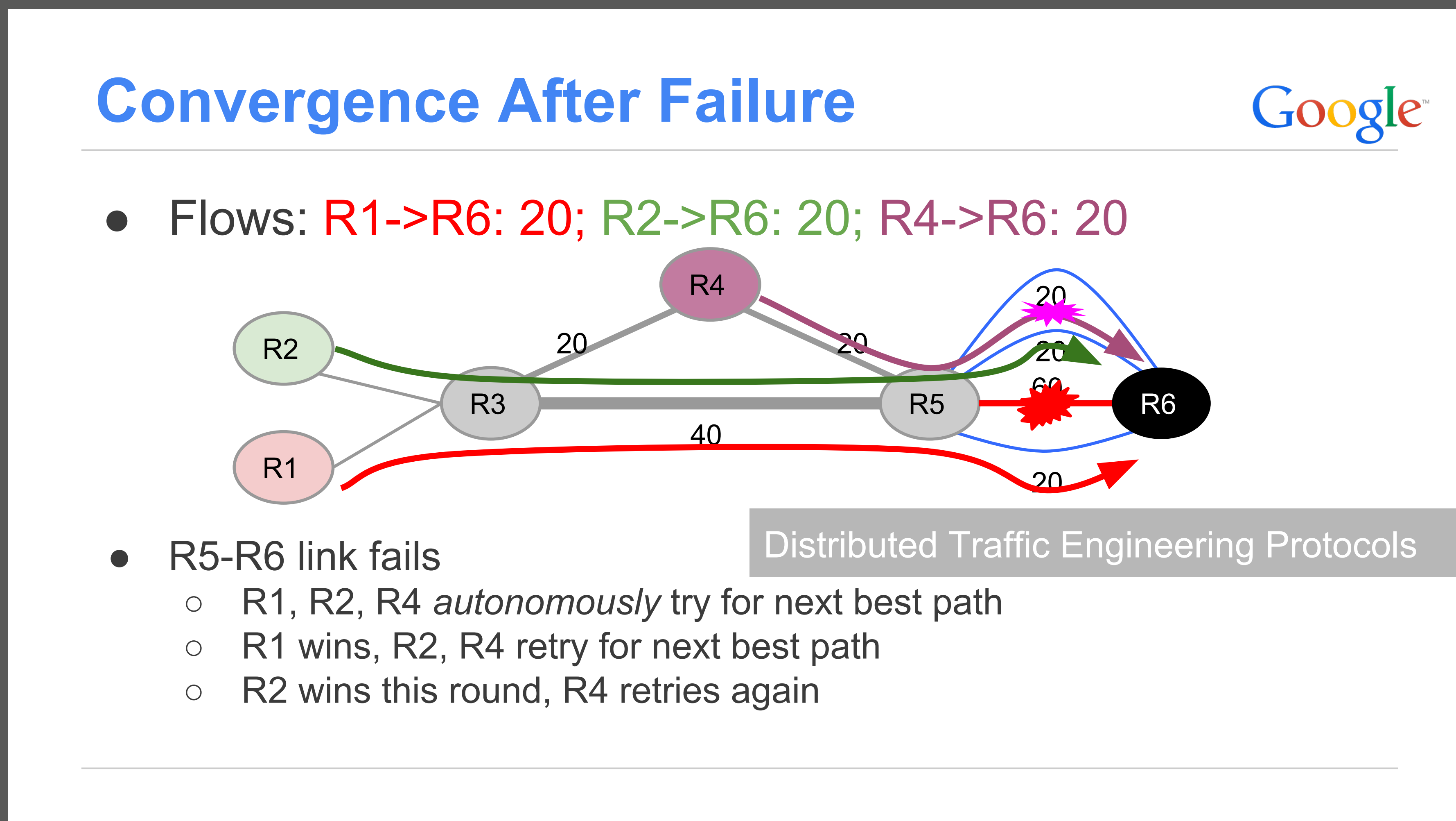

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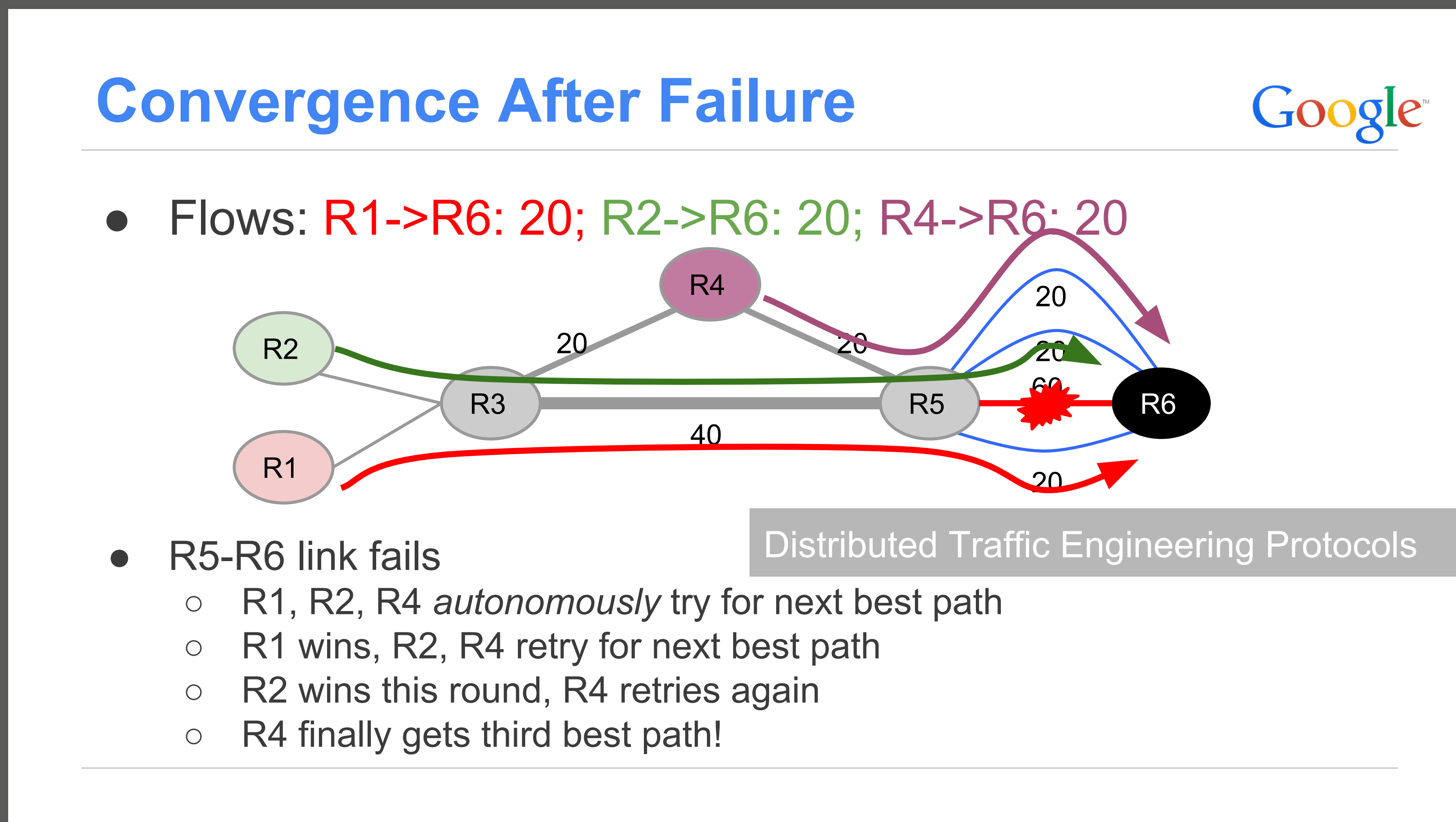
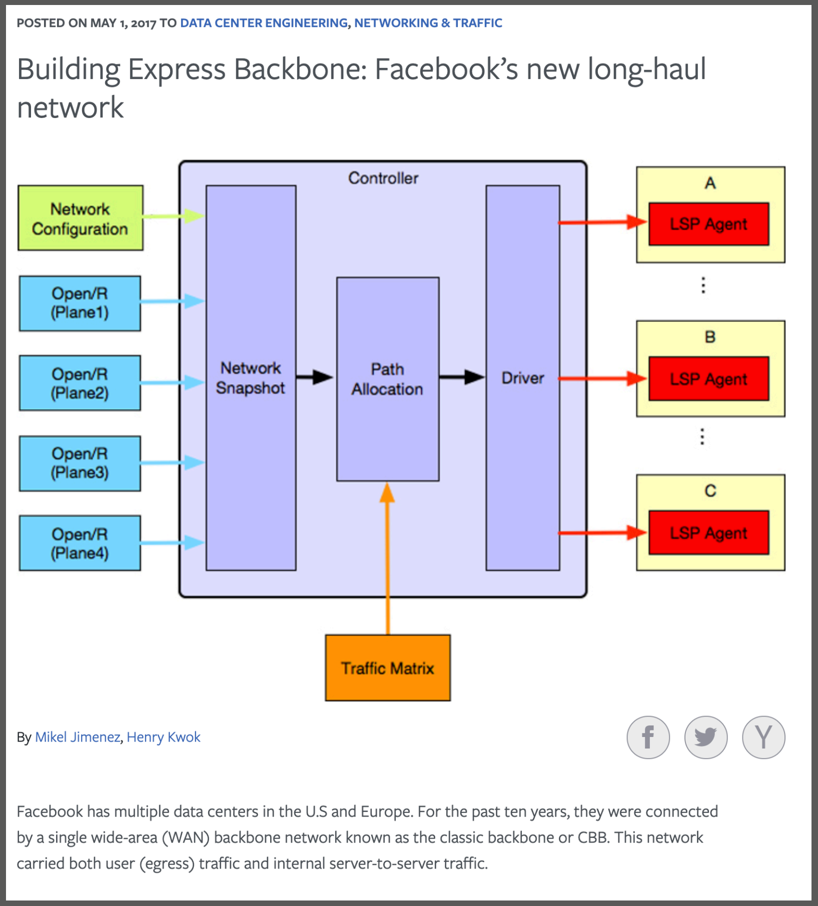


Lessons Learned from B4, Google’s SDN WAN [ATC 2015]

That's why major Wide-Area Networks (WAN) typically rely on centralized versions of RSVP-TE

Like what ***you*** did in the exercises!


POSTED ON MAY 1, 2017 TO DATA CENTER ENGINEERING, NETWORKING & TRAFFIC

Building Express Backbone: Facebook's new long-haul network

By Mikel Jimenez, Henry Kwok

Facebook has multiple data centers in the U.S and Europe. For the past ten years, they were connected by a single wide-area (WAN) backbone network known as the classic backbone or CBB. This network carried both user (egress) traffic and internal server-to-server traffic.

Last week on

Advanced Topics in Communication Networks

Quality of Service

How do we manage congestion?

(locally, on a per link basis)

VPN

How do we interconnect private networks?

(across a shared infrastructure)

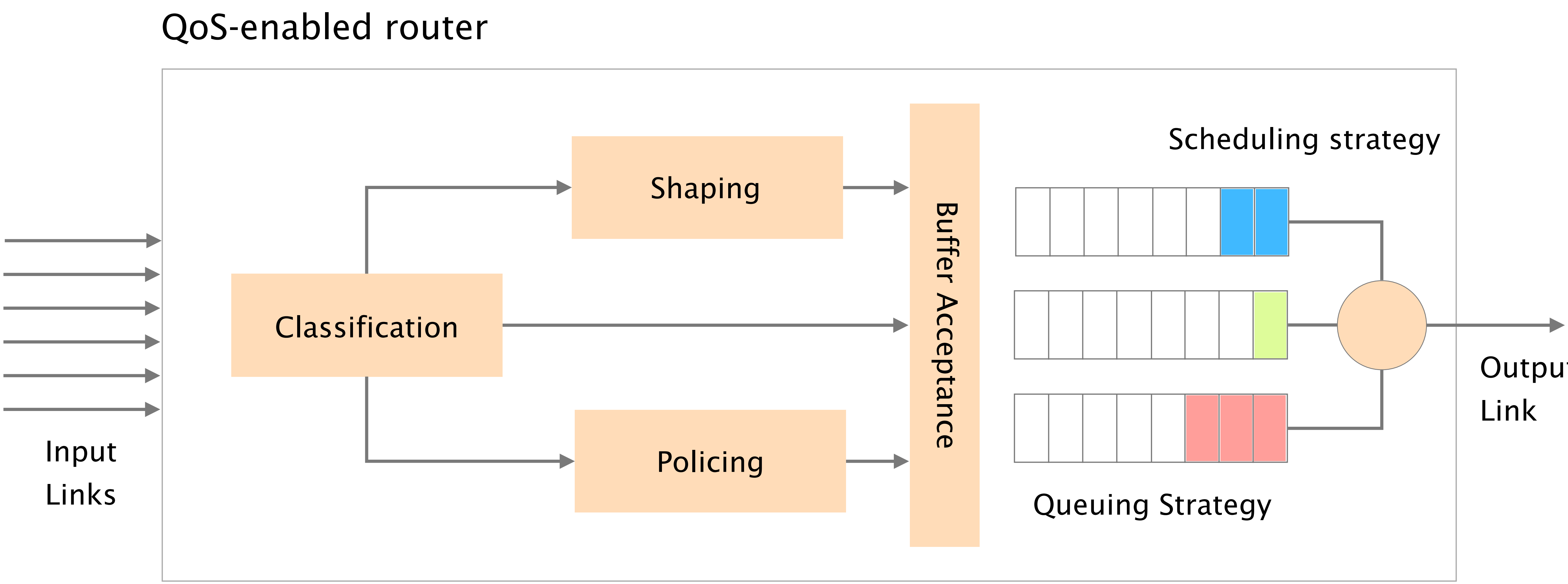
Quality of Service

VPN

How do we manage congestion?

(locally, on a per link basis)

We saw different tools to *locally* manage congestion



A quick reminder on MAX. MIN. FAIRNESS:

Given a set of bandwidth demands r_i
and a total bandwidth C,
the max-min bandwidth allocations a_i
are:

$$a_i = \min\left(f, r_i\right)$$

where f is the unique value s.t. $\sum a_i = C$

Important property:

If you (a flow) don't get your full demand,
no one gets more than you.

Buffer Acceptance Algorithms

Once the router has decided which queue it needs to append the packet to it. At this time, it should decide whether to accept this packet or drop it or mark it.

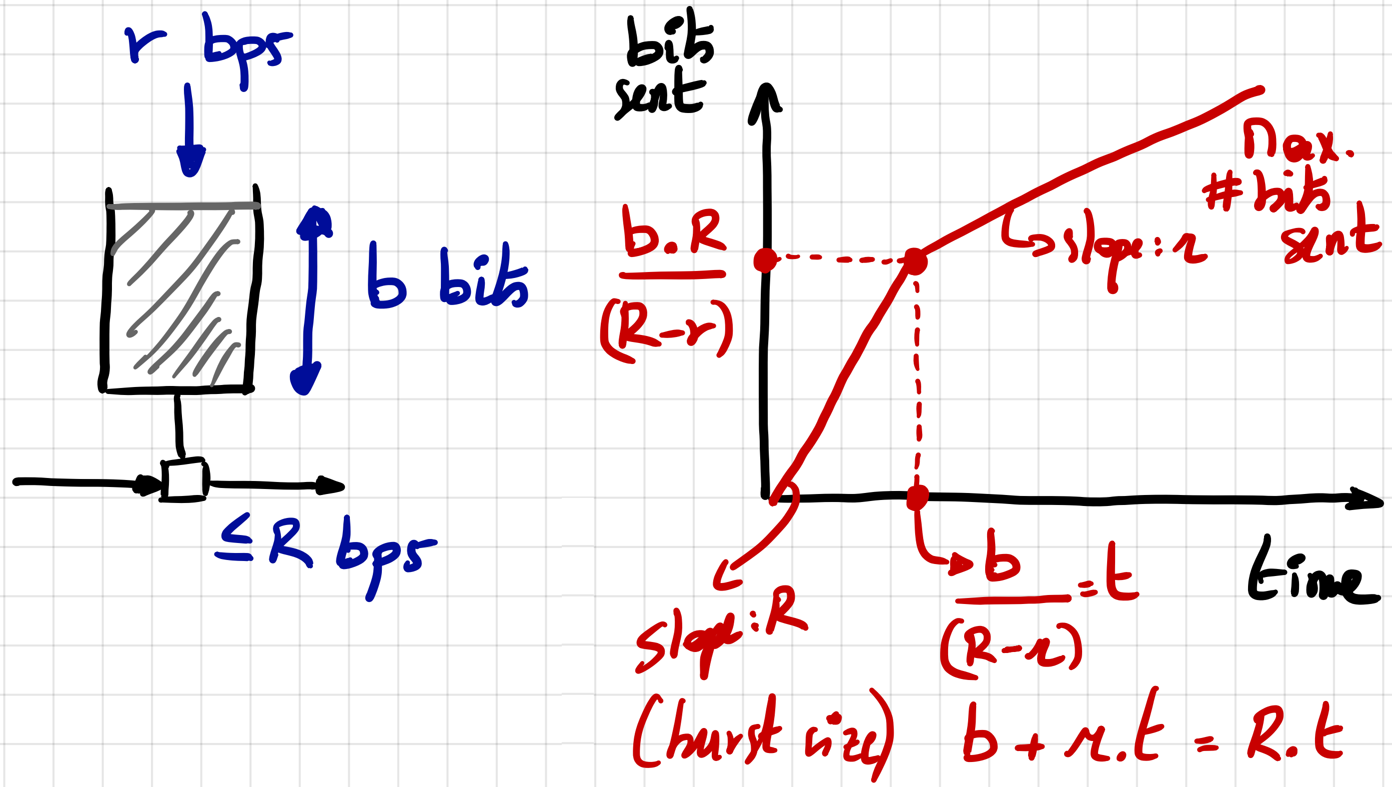
Two common examples:

1. Tail Drop: simply drops any newly arriving packets when the queue is filled to its maximum capacity.

   <u>Pros</u>: dead simple to implement.

   <u>Cons</u>: tends to synchronize the TCP flows when multiple packets are lost.

Token Bucket: Characterizing Burstiness



$$b + r.t = R.t$$
$$b = t(R-r)$$
$$\frac{b}{(R-r)} = t$$

Parameters:

- r bps : bucket filling rate
- b bits : bucket size / max. burst size
- R bps : Maximum link capacity / peak rate

Enforcing traffic specification (using a TB): (3 solutions)

1. <u>Policing</u> : DROP all data in excess of the specification
2. <u>Shaping</u> : DELAY all data in excess of the specification UNTIL it obeys it.
3. <u>Marking</u> : MARK all data in excess of the specification and gives these packets lower priority in the network.

Quality of Service

VPN

How do we interconnect private networks?

(across a shared infrastructure)

How do we interconnect geographically-distributed sites with the "same" privacy and guarantees as a private network?

Today's VPN solutions differ according to whom is responsible for setting them up and managing them

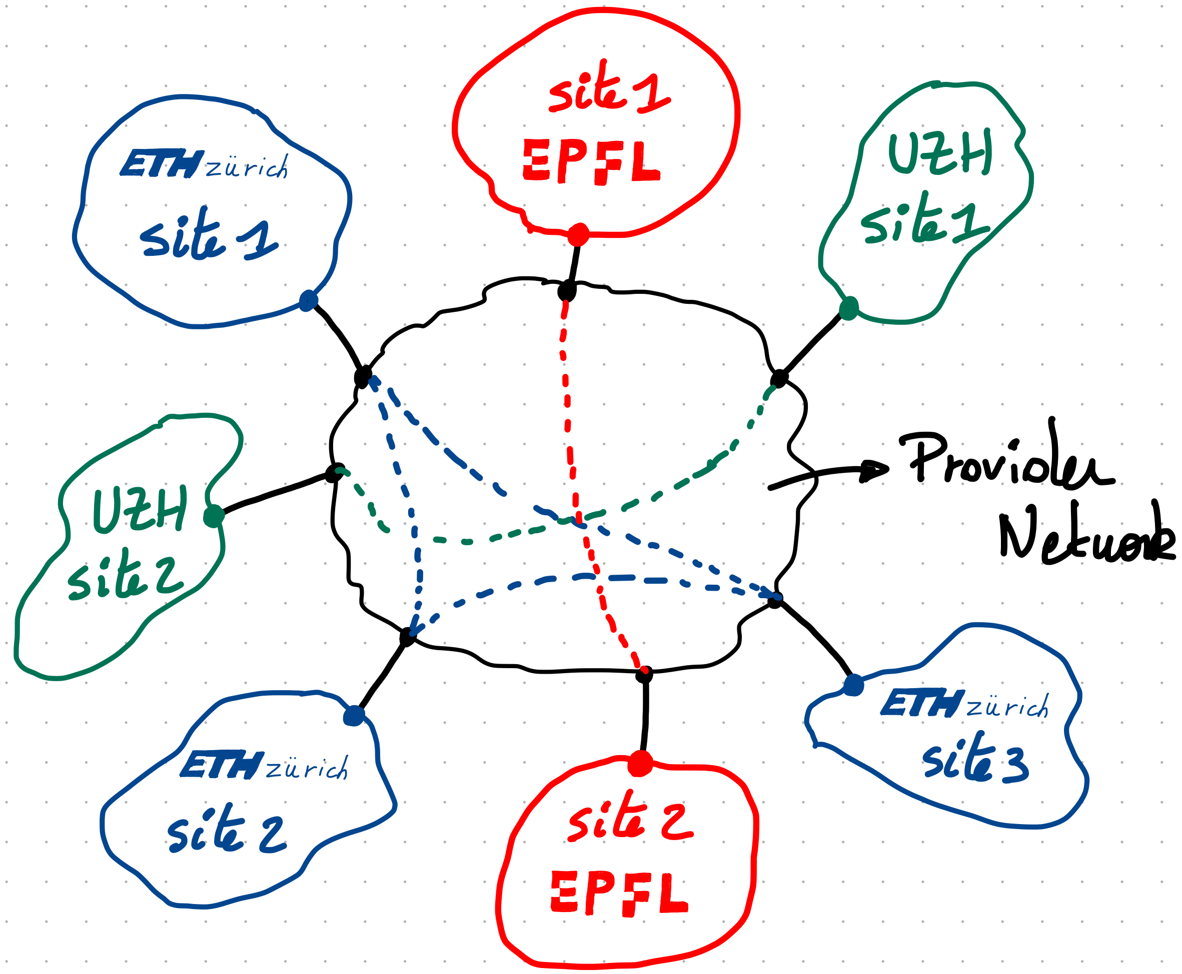
user-managed

PART I

provider-managed

PART II

Part I: Customer-Managed VPNs



In a customer managed VPN, the provider is completely agnostic to the VPN service. It simply provides dedicated physical connections (leased lines) or IP connectivity.

PART I: CUSTOMER-MANAGED VPNS

In a customer managed VPN, the provider is completely agnostic to the VPN service. It simply provides dedicated physical connections (leased lines) or IP connectivity.

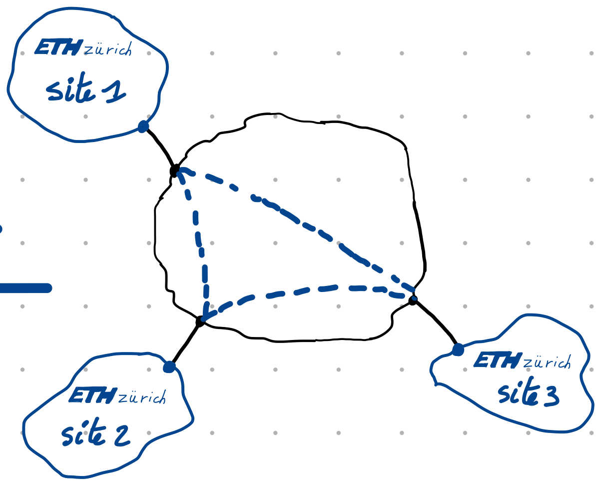
solution 1

Solution 1: LEASED LINES

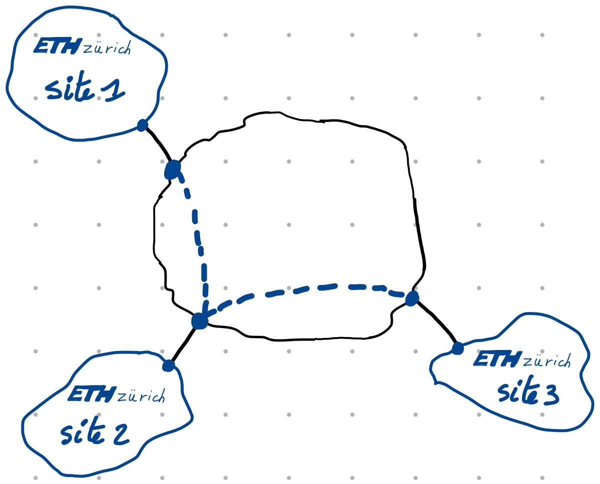
Definition: A Leased Line (LL) is a dedicated (private) connection between two geographically distant sites according to a commercial contract.

Since the connection is dedicated, the provider can provide QoS guarantees such as guaranteed bandwidth.

Typical organizations:



FULL-MESH



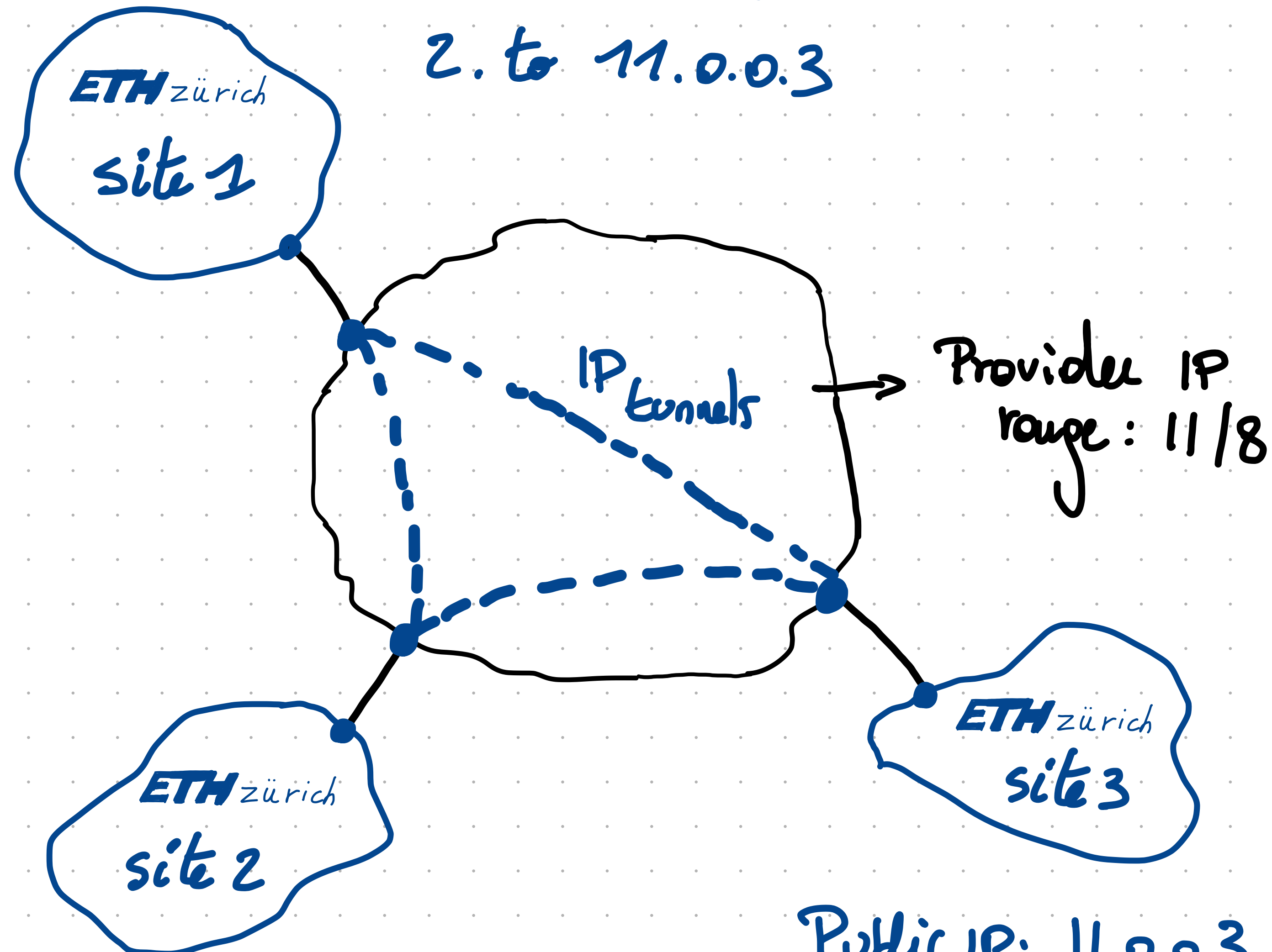
HUB-AND-SPOKE

Part I: Customer-Managed VPNs

In a customer managed VPN, the provider is completely agnostic to the VPN service. It simply provides dedicated physical connections (leased lines) or IP connectivity.

solution 2

Public IP: 11.0.0.1
Private IP range: 10.1.0.0/24
IP tunnels:
1. to 11.0.0.2
2. to 11.0.0.3



Public IP: 11.0.0.2
Private IP range: 10.2.0.0/24
IP tunnels:
1. to 11.0.0.1
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Public IP: 11.0.0.3
Private IP range: 10.3/24
IP tunnels:
1. to 11.0.0.1
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This week on

Advanced Topics in Communication Networks

Provider-managed VPNs

How do we interconnect private networks?

with the help of a provider network

Let's switch to

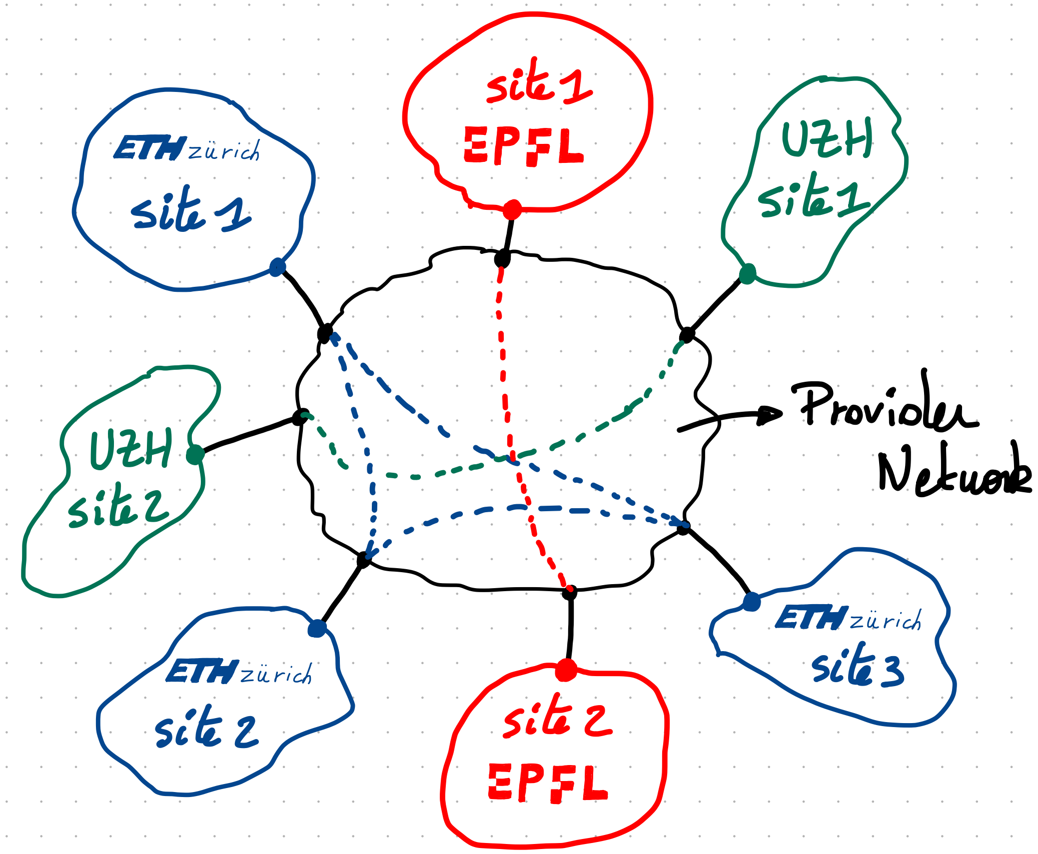
05_vpn_notes.pdf

I'm resuming from

Part II: Provider-Managed VPNs

(page 10/23)

Part II: Provider-Managed VPNs



In a provider-managed VPN, the customer this time is agnostic to the service. For the customer, it is like its different sites are directly connected together through the provider.

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nsg.ee.ethz.ch

ETH Zürich (D-ITET)

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