
facebook
INFRASTRUCTURE

TTLd

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Production Engineer (Network)

TTLd

Total TCP Loss detection (aka fancy acronym)

Pre-requisite:

- Completely own all your infrastructure

Own your datacenter

Own your racks

Own your hosts

Own your network

TTLd

Total TCP Loss detection (aka fancy acronym)

Goal:

- Surface End to End TCP retransmit throughout the network
- Use all production packets as probes

What if every packet was a probe?

- Precise **end to end performance** metric for TCP
- Probes are **following production traffic** (ECMP…)
- Measuring at any network device gives us E2E performance

Network Monitoring

Why “passive” monitoring is not enough?

- SNMP: Trusting network devices...

- Host TCP retransmit: Packet loss, everywhere...

Why “active” monitoring is not enough?

- **Injecting packets** in the network
  - **detect** service/customer impacting loss
  - **triangulate** loss to a device/interface

- Limitations
  - Potentially all injected packets could be dropped without production packets being lost or vice-versa
  - Number of probes is **many orders of magnitude** lower than number of production packets
    - It can miss low signal problems (bit flipping…)

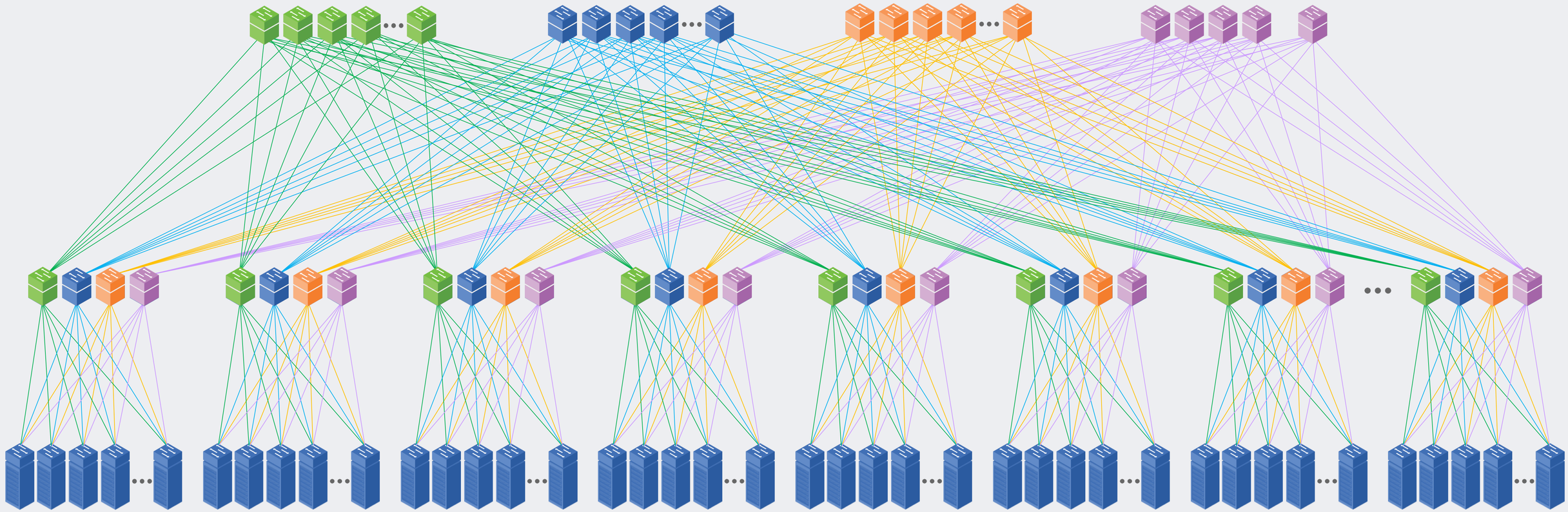
TTLd: a mixed approach

- **Every packet** in the network is a **probe**
- 1 bit in the packet header identifies it as retransmitted
- Use end host **marking** to be **precise**
- **Marked packets** are undistinguishable for network devices, so they **follow the same path**

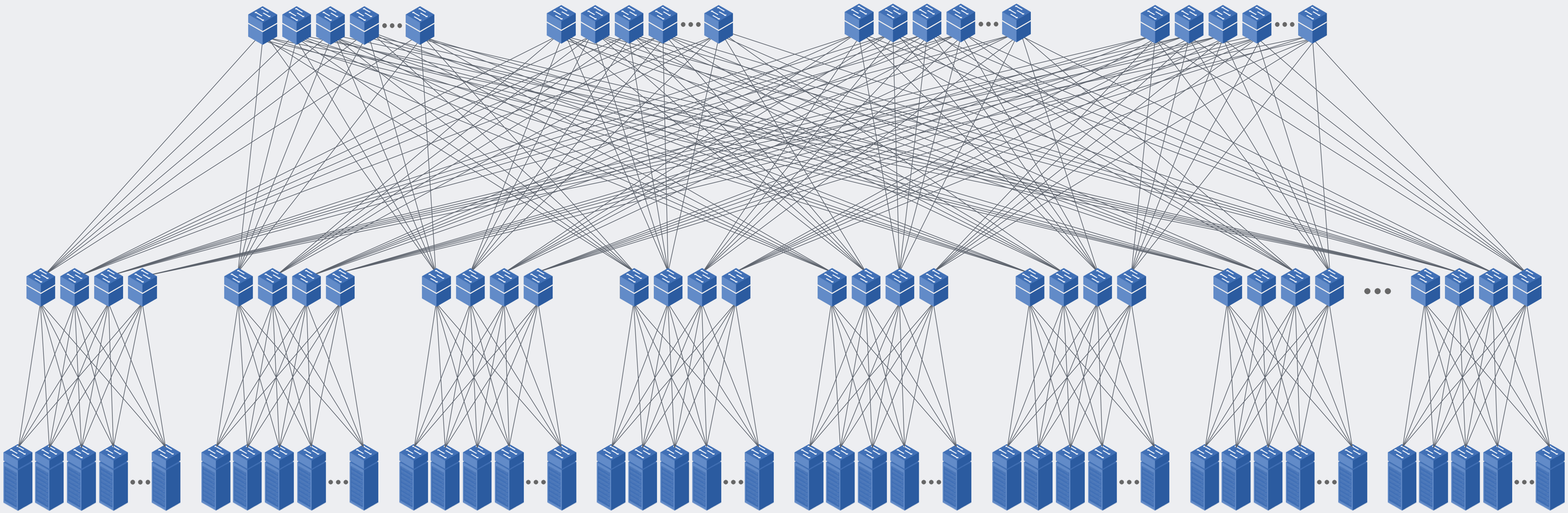
Where does loss come from?

- Network devices from a same “group” **balance traffic** hopefully **equally** according to ECMP hashing
- One device **exposing more retransmit** (in number or percent) than others may be dropping packets
- This also gives a view on **congestion** on devices not as per pure packets transmitted but with **E2E performance** view
- Neighboring device “groups” are seeing the impact of the bad device

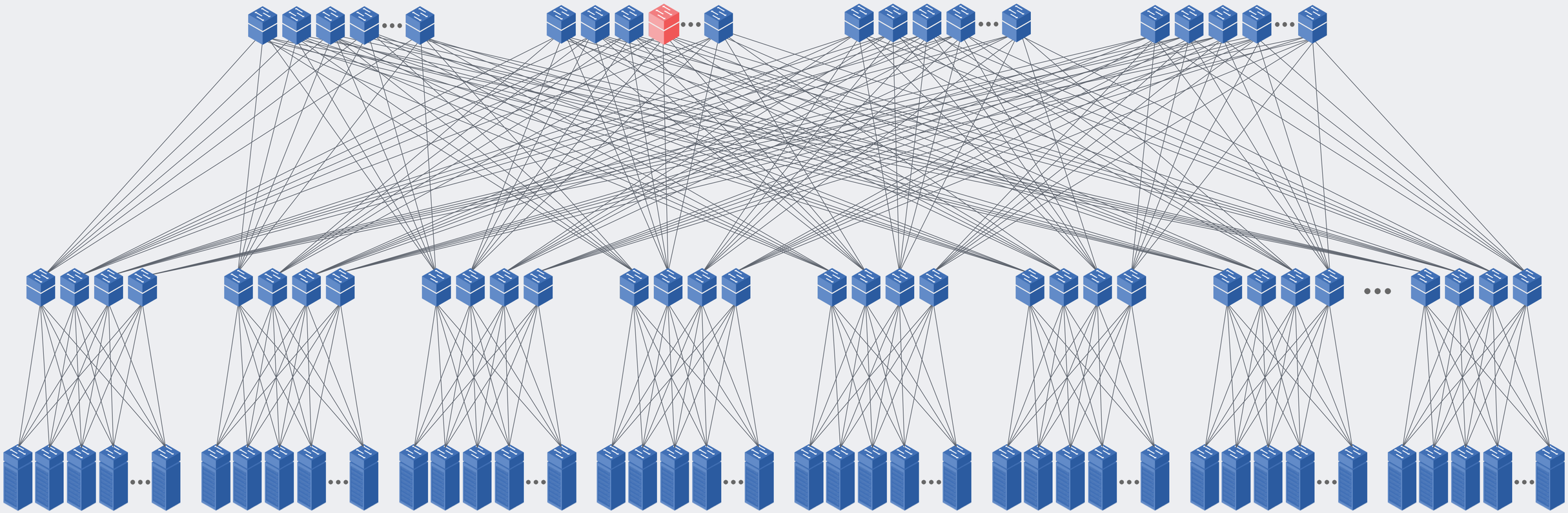
Typical Network Fabric Design



Typical Network Fabric Design



Typical Network Fabric Design



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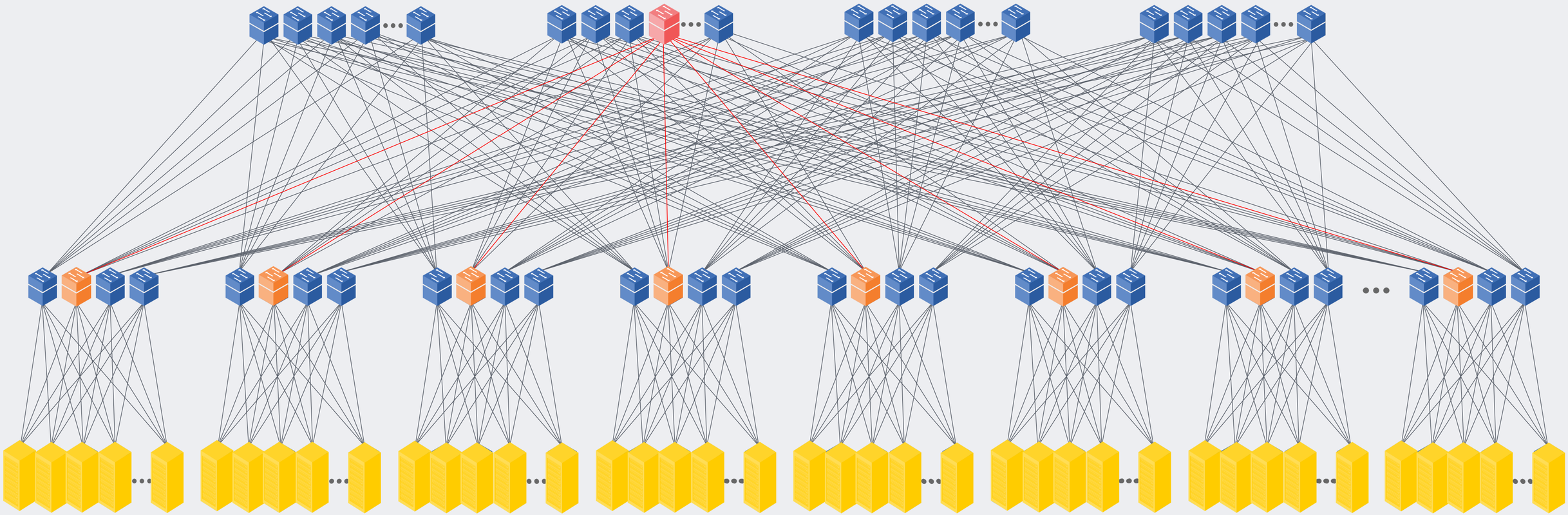
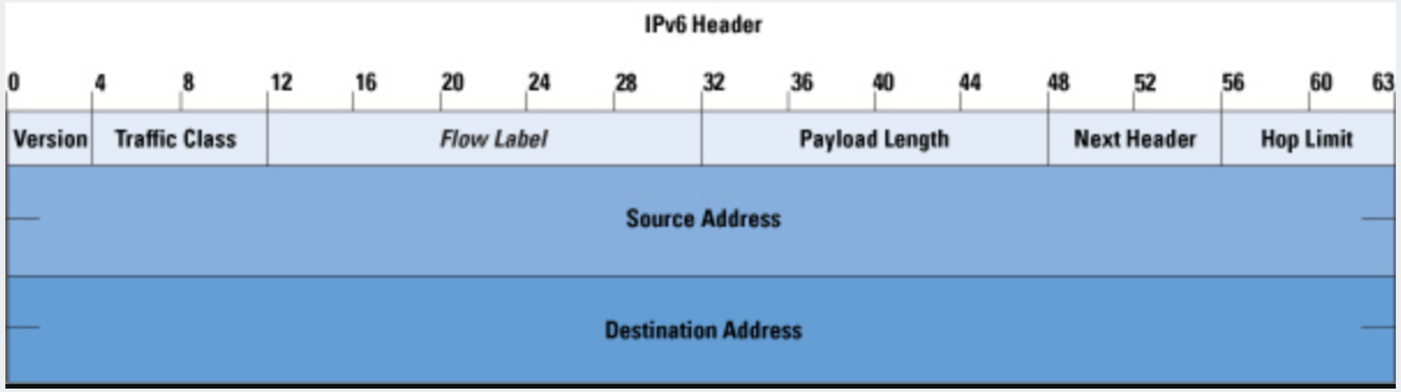


Technical details

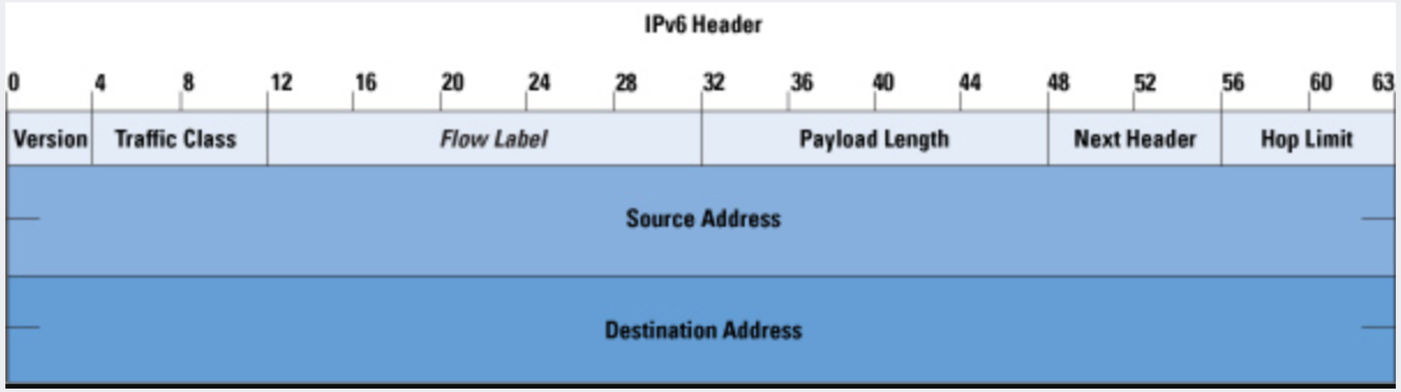
How to expose E2E performance?

- We need to find a **bit** in the **TCP header** that would be
  - easy to check
  - would appear the same to all network devices
  - would not change TCP behavior
  - would not change the packet flow if set or unset



How to expose E2E performance?

- The winner is the Most Significant Bit (MSB) of TTL field (hop limit as we are all IPv6)



eBPF program

- Berkely Packet Filter has grown from filtering packets to tuning kernel handling of network events
  - Promoted by Brendan Gregg (Netflix) and Alexei Starovoitov (Facebook)

- Safe and efficient way to insert hooks in the kernel at runtime
  - ➢ Can be hooked in dedicated places (tc egress)
  - ➢ Can change the behaviour of kernel events (TCP retransmit)

E2E performance exposed

Marking MSB of TTL field (hop limit) via eBPF program

- Use of eBPF to mark retransmitted packets with TTL of 255
  - Marking from TCP stack retransmit hook
- **1 bit in the IP header** of any packet shows if it was **retransmitted**

E2E performance counting

Unsampled data through FBoss devices

- We have a **counter** and bump it through **ACL match** (MSB of TTL)
  - Best part is that as network devices have to decrement TTL of every packet, **checking this bit is practically free**!

- This is currently implemented on all Top Of Rack

Exposing E2E performance

Collect counters on FBoss

- **No sampling**
  - Precise view
  - Aggregation at source is possible via host retransmit dataset
  - Aggregation per destination rack now possible

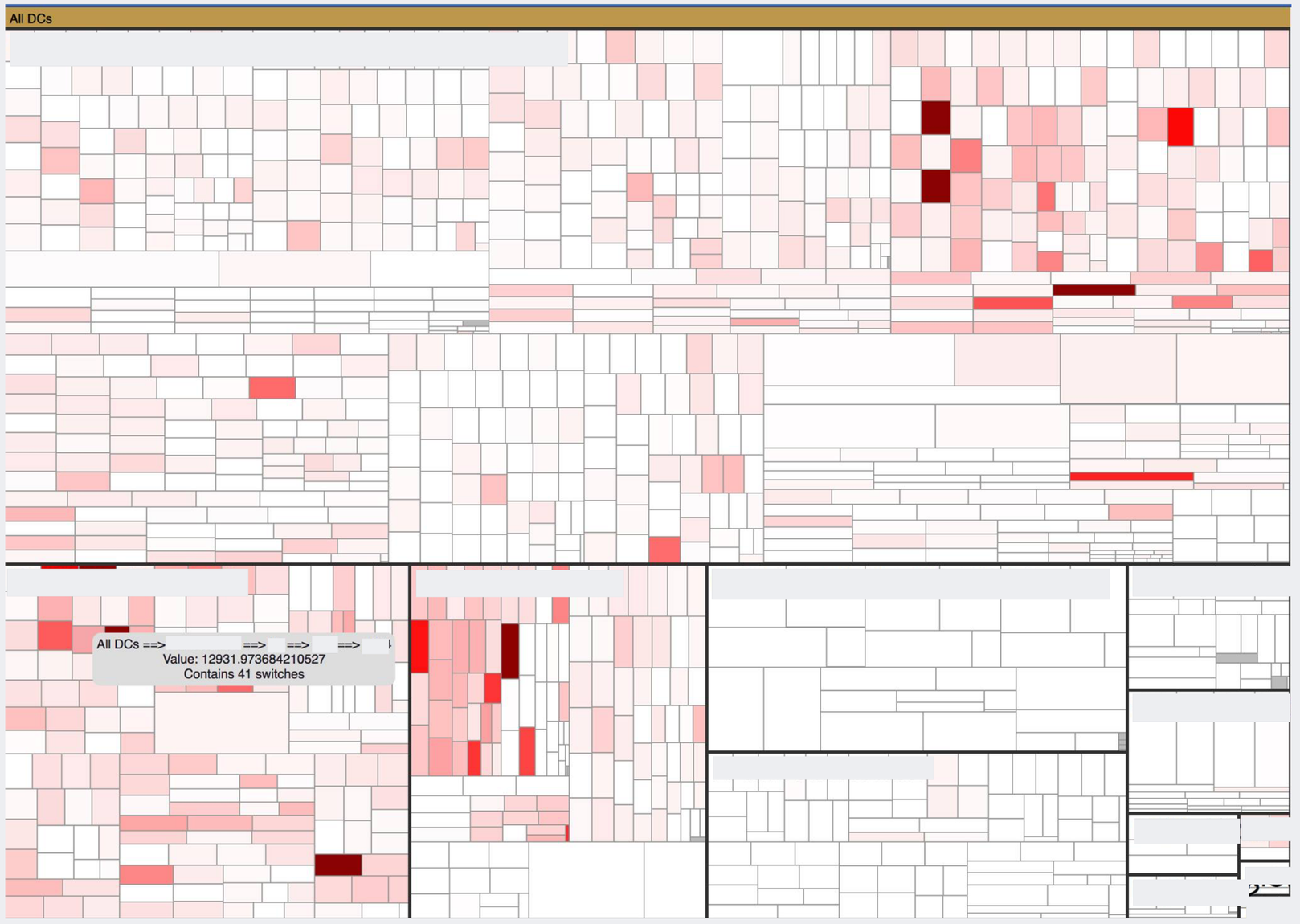
Exposing E2E performance

Collect counters on other providers' network devices

- Use collection framework (Facebook framework to collect counters from any proprietary network device) and ACL matching

- **No sampling**
  - Aggregated per ECMP hashing of production traffic
  - Exposes retransition on a specific device

Visualization through internal tools



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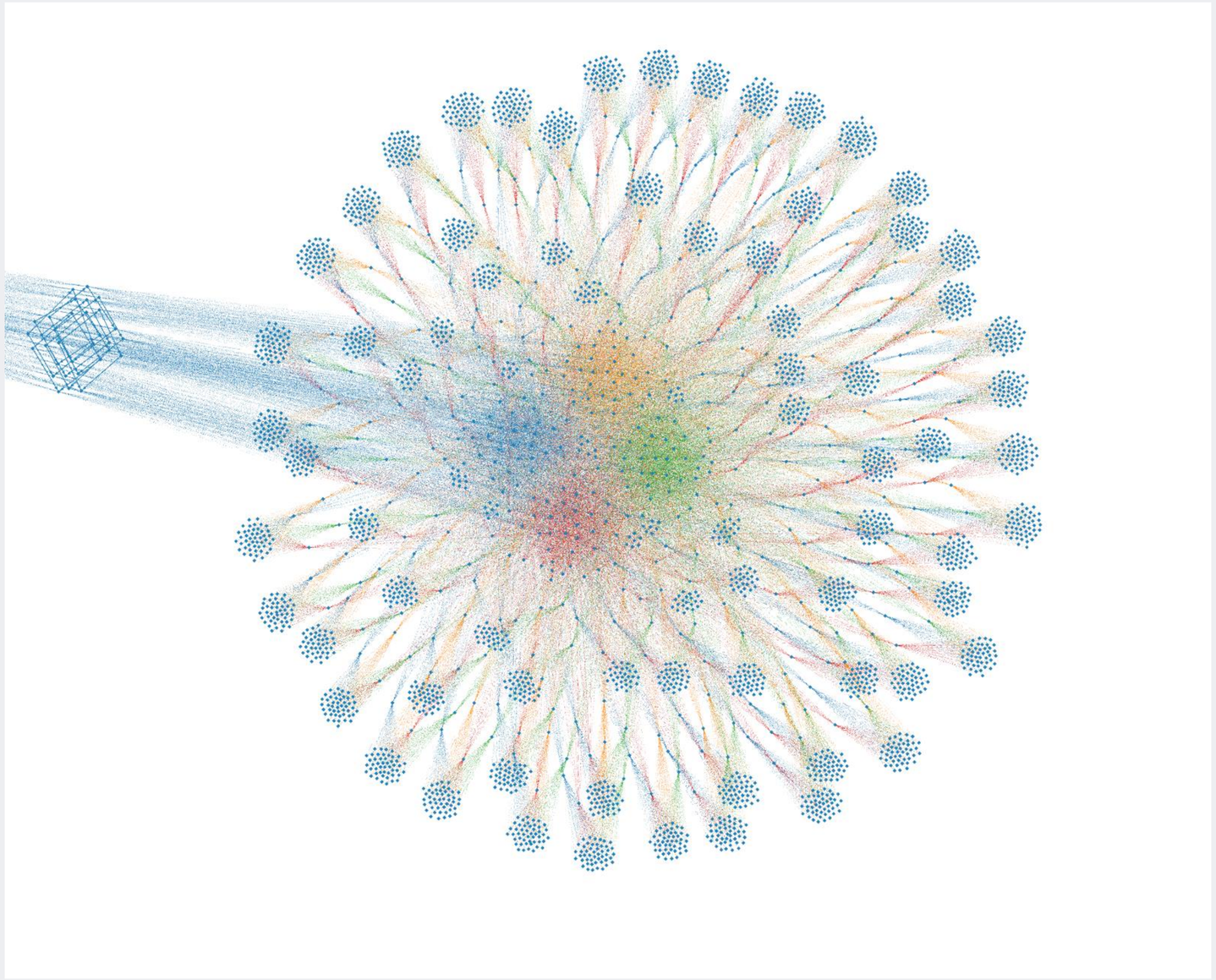

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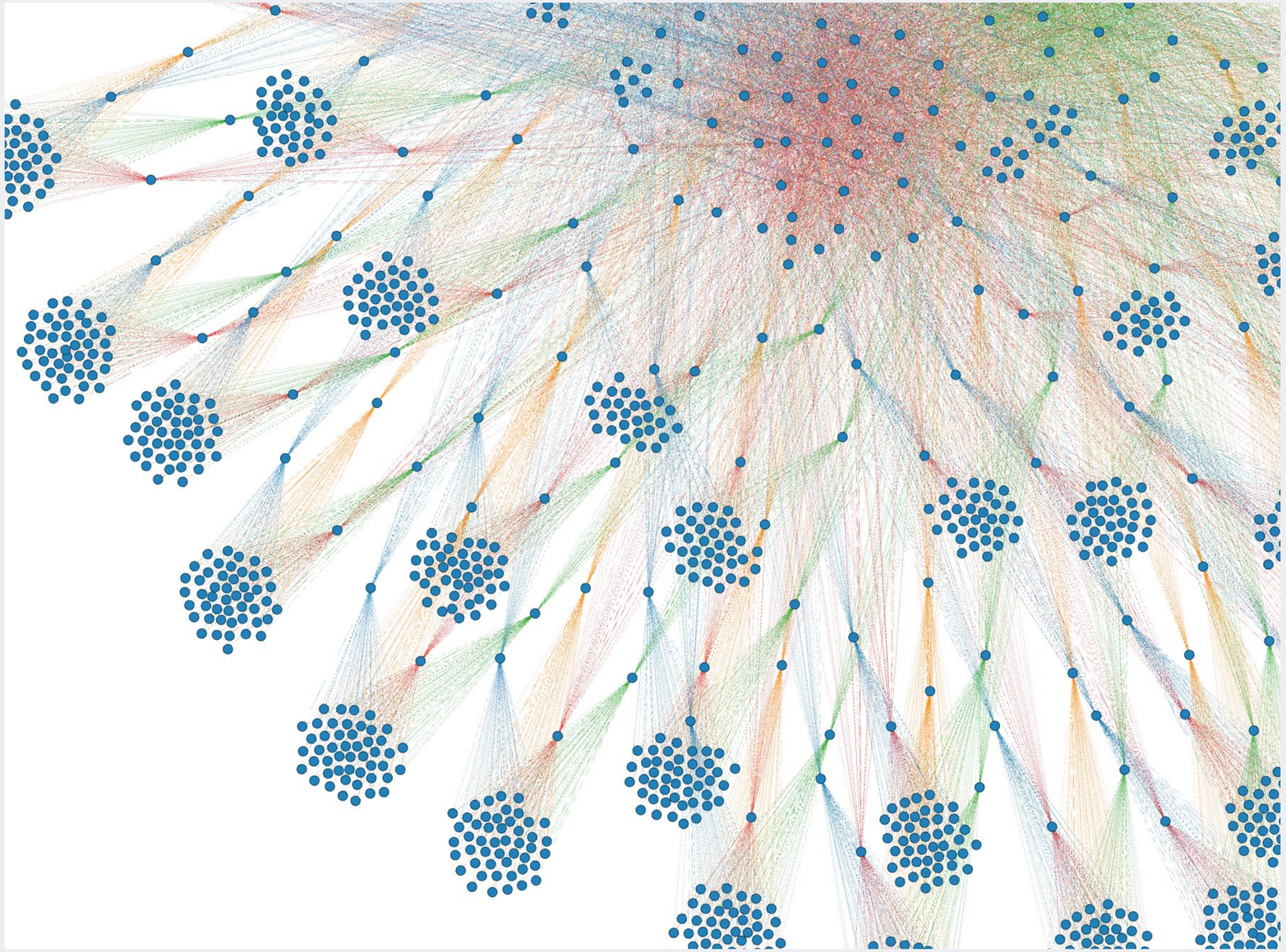

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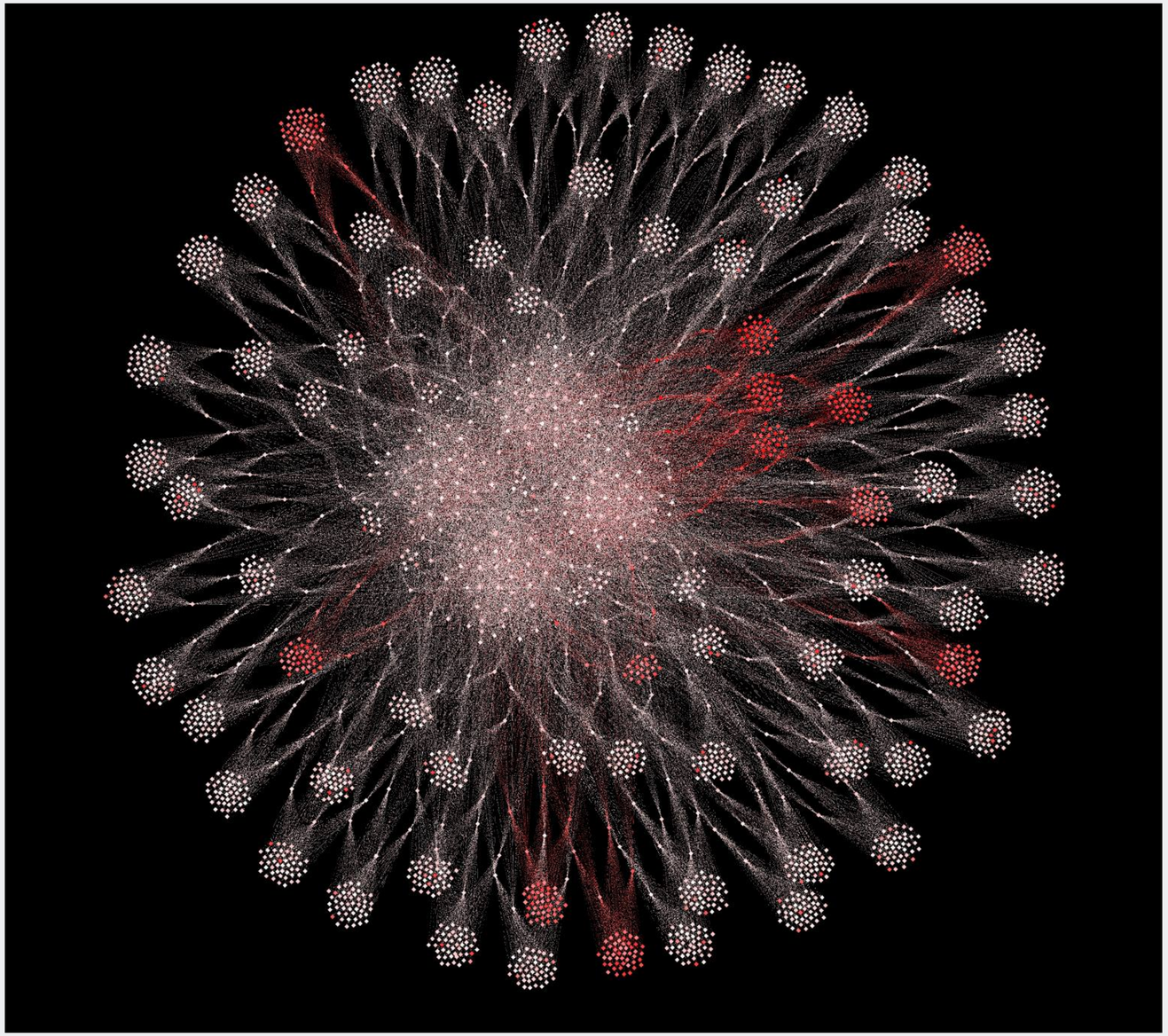

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