Best Practices in DNS Service-Provision Architecture

Version 1.1

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Packet Clearing House

It’s all Anycast

Large ISPs have been running production anycast DNS for more than a decade.

Which is a very long time, in Internet years.

95% of the root nameservers are anycast.

The large gTLDs are anycast.

Reasons for Anycast

Transparent fail-over redundancy

Latency reduction

Load balancing

Attack mitigation

Configuration simplicity (for end users) or lack of IP addresses (for the root)

No Free Lunch

The two largest benefits, fail-over redundancy and latency reduction, both require a bit of work to operate as you’d wish.

Fail-Over Redundancy

DNS resolvers have their own fail-over mechanism, which works... um... okay.

Anycast is a very large hammer.

Good deployments allow these two mechanisms to reinforce each other, rather than allowing anycast to foil the resolvers’ fail-over mechanism.

Resolvers’ Fail-Over Mechanism

DNS resolvers like those in your computers, and in referring authoritative servers, can and often do maintain a *list* of nameservers to which they’ll send queries.

Resolver implementations differ in how they use that list, but basically, when a server doesn’t reply in a timely fashion, resolvers will try another server from the list.

Anycast Fail-Over Mechanism

Anycast is simply layer-3 routing.

A resolver’s query will be routed to the topologically nearest instance of the anycast server visible in the routing table.

Anycast servers govern their own visibility.

Latency depends upon the delays imposed by that topologically short path.

Conflict Between These Mechanisms

Resolvers measure by latency.

Anycast measures by hop-count.

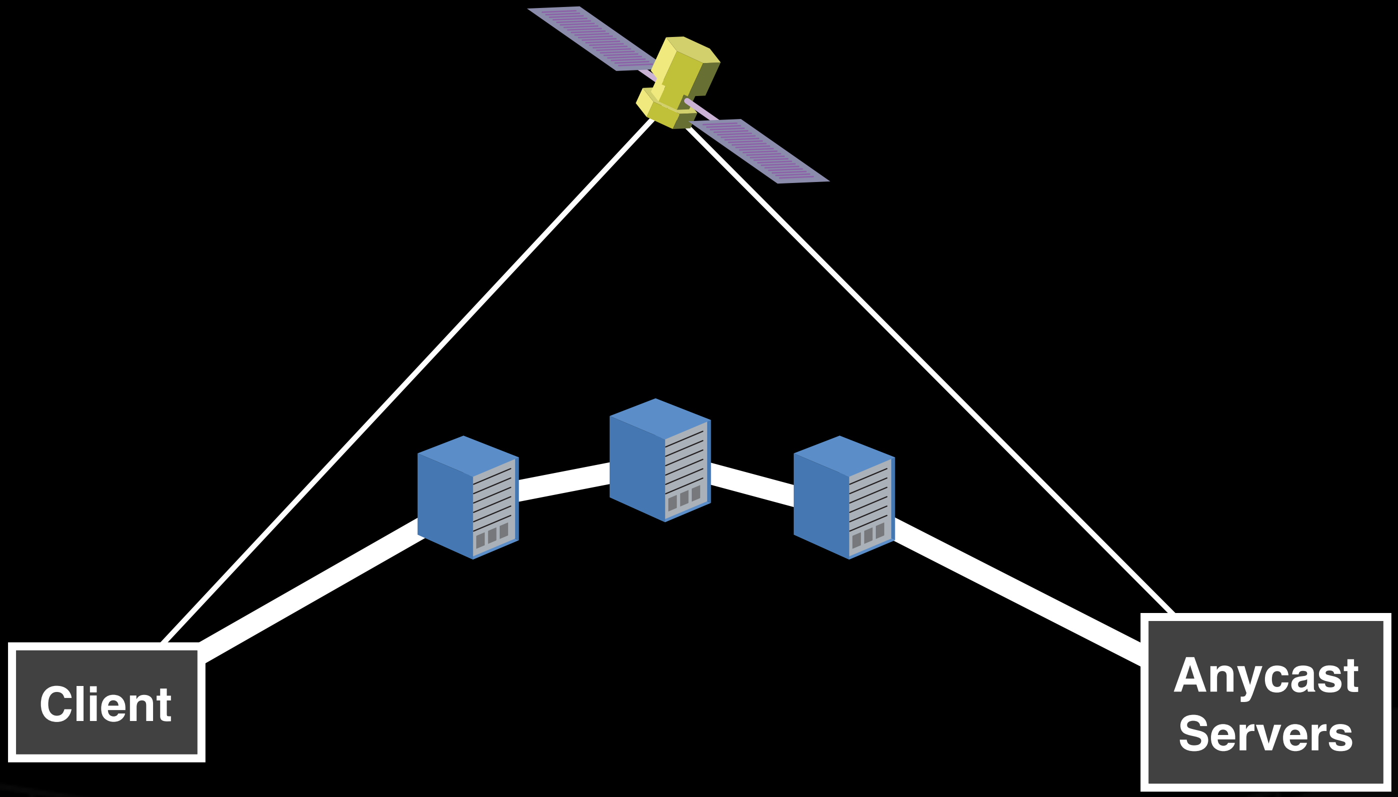
They don’t necessarily yield the same answer.

Anycast always trumps resolvers, if it’s allowed to.

Neither the DNS service provider nor the user are likely to care about hop-count.

Both care a great deal about latency.

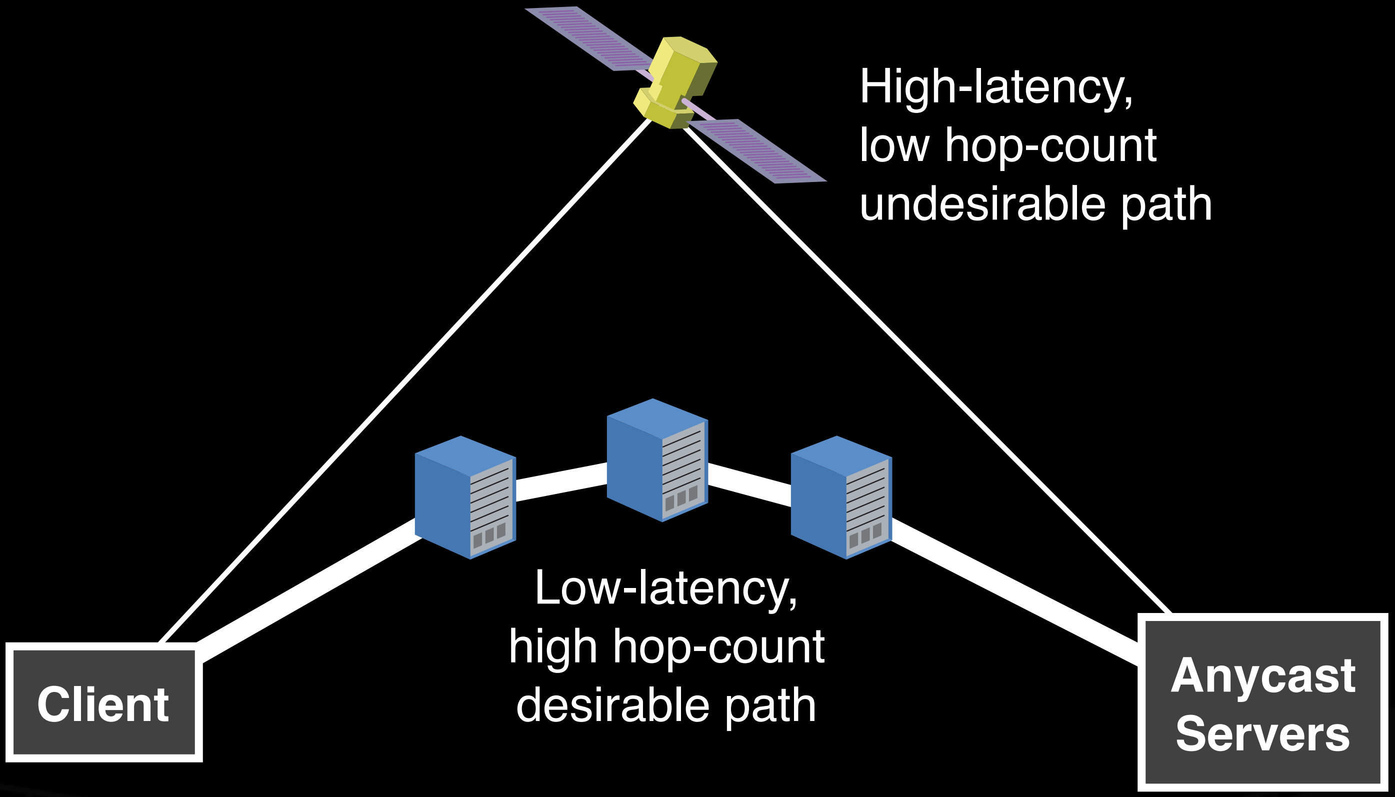
How The Conflict Plays Out



Client

Anycast Servers

How The Conflict Plays Out



High-latency,
low hop-count
undesirable path

Low-latency,
high hop-count
desirable path

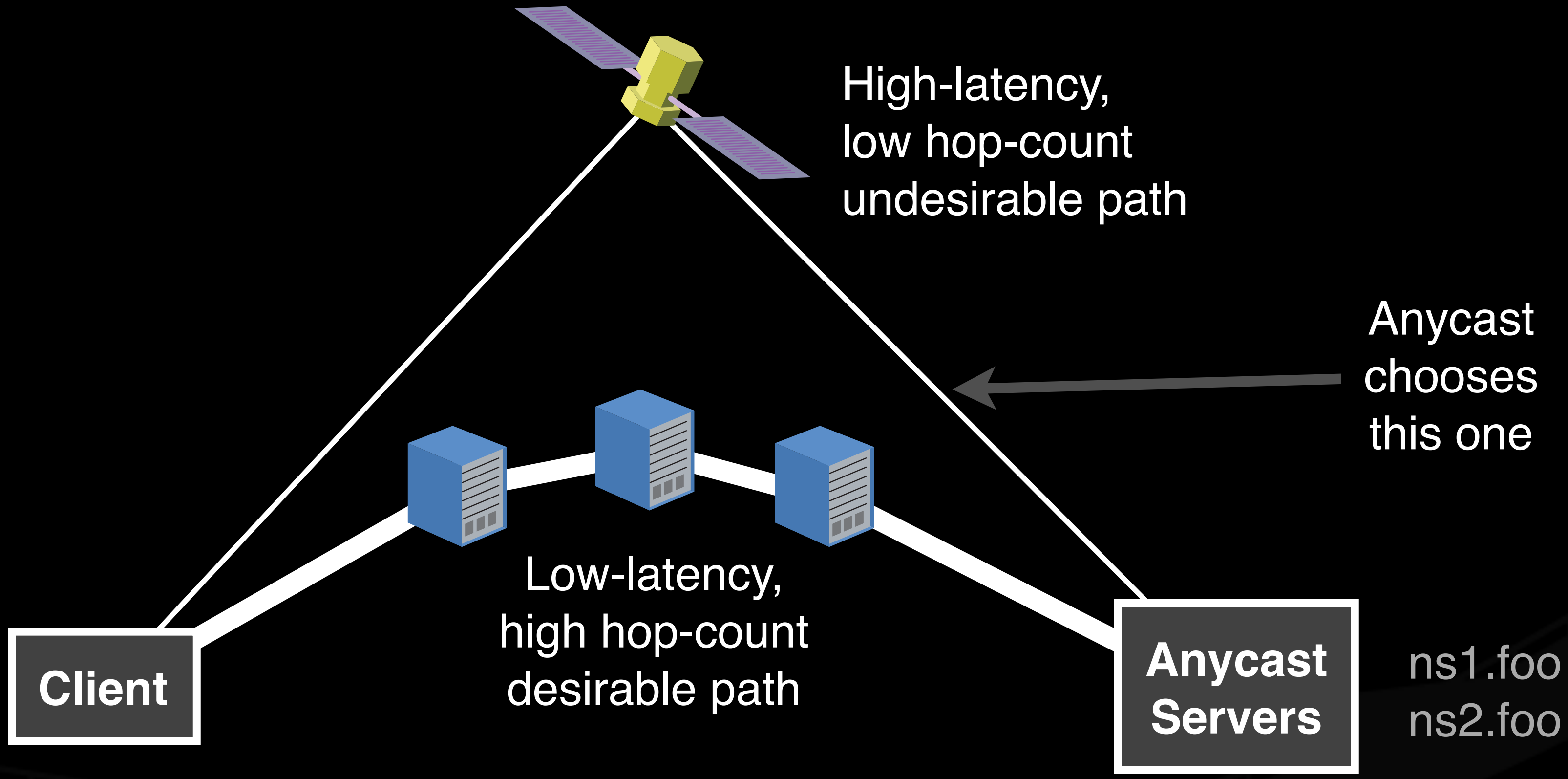
Client

Anycast
Servers

ns1.foo
ns2.foo

Two servers with the
same routing policy

How The Conflict Plays Out



High-latency,
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Anycast
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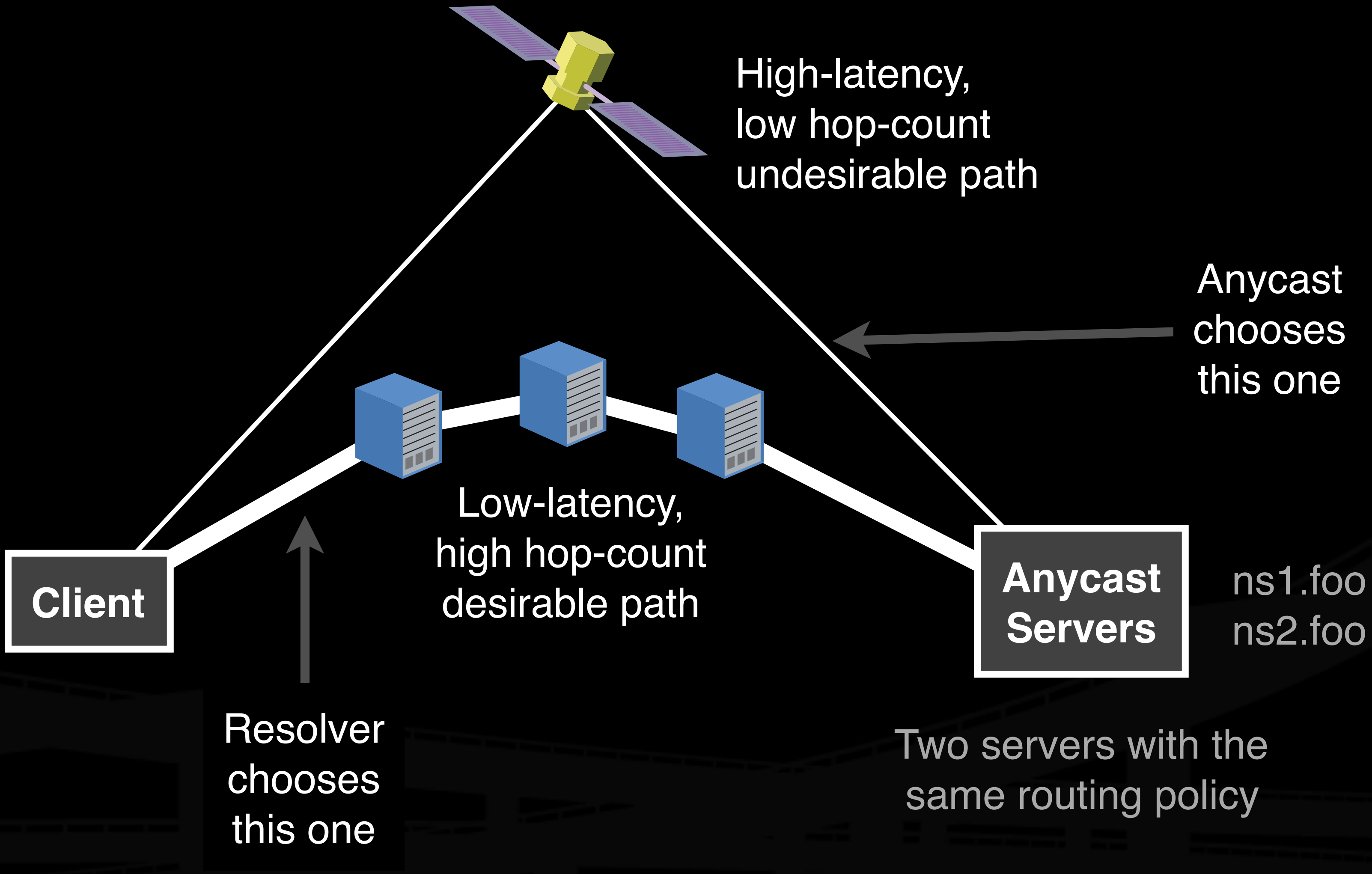

High-latency, low hop-count undesirable path

Anycast chooses this one

Low-latency, high hop-count desirable path

Resolver chooses this one

Two servers with the same routing policy

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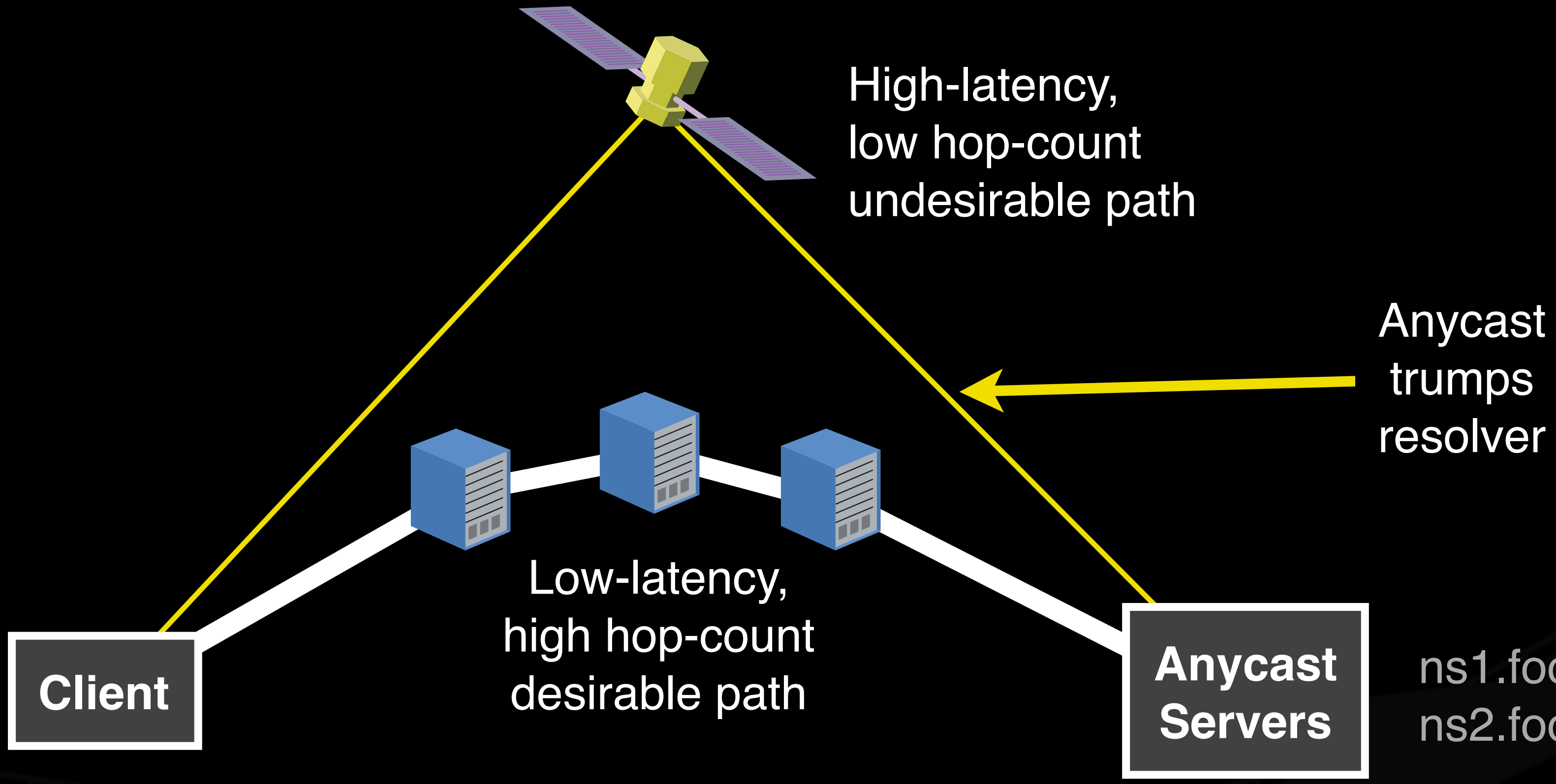
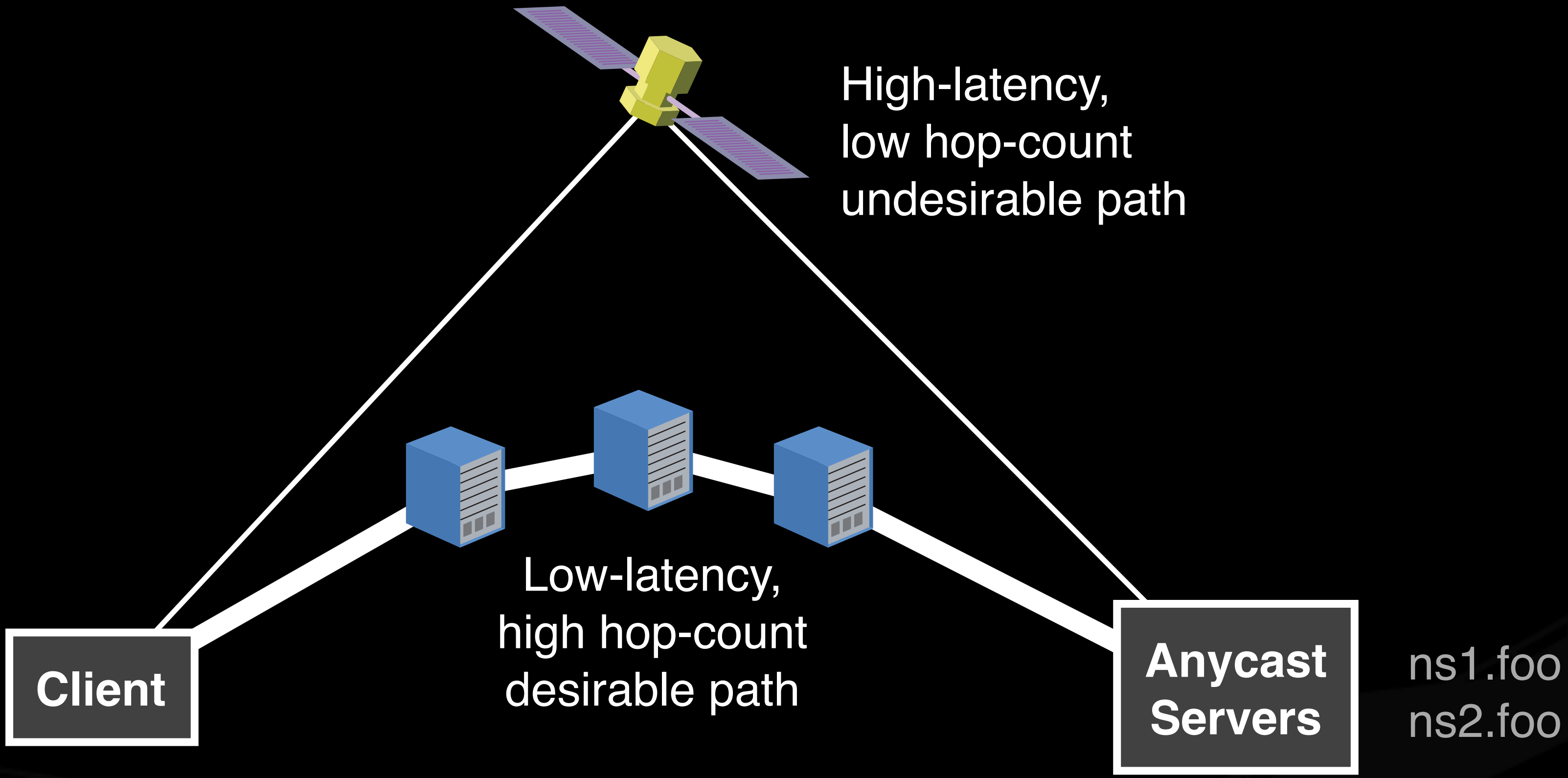


ns1.foo
ns2.foo

Two servers with the
same routing policy

Resolve the Conflict



The resolver uses different IP addresses for its fail-over mechanism, while anycast uses the same IP addresses.

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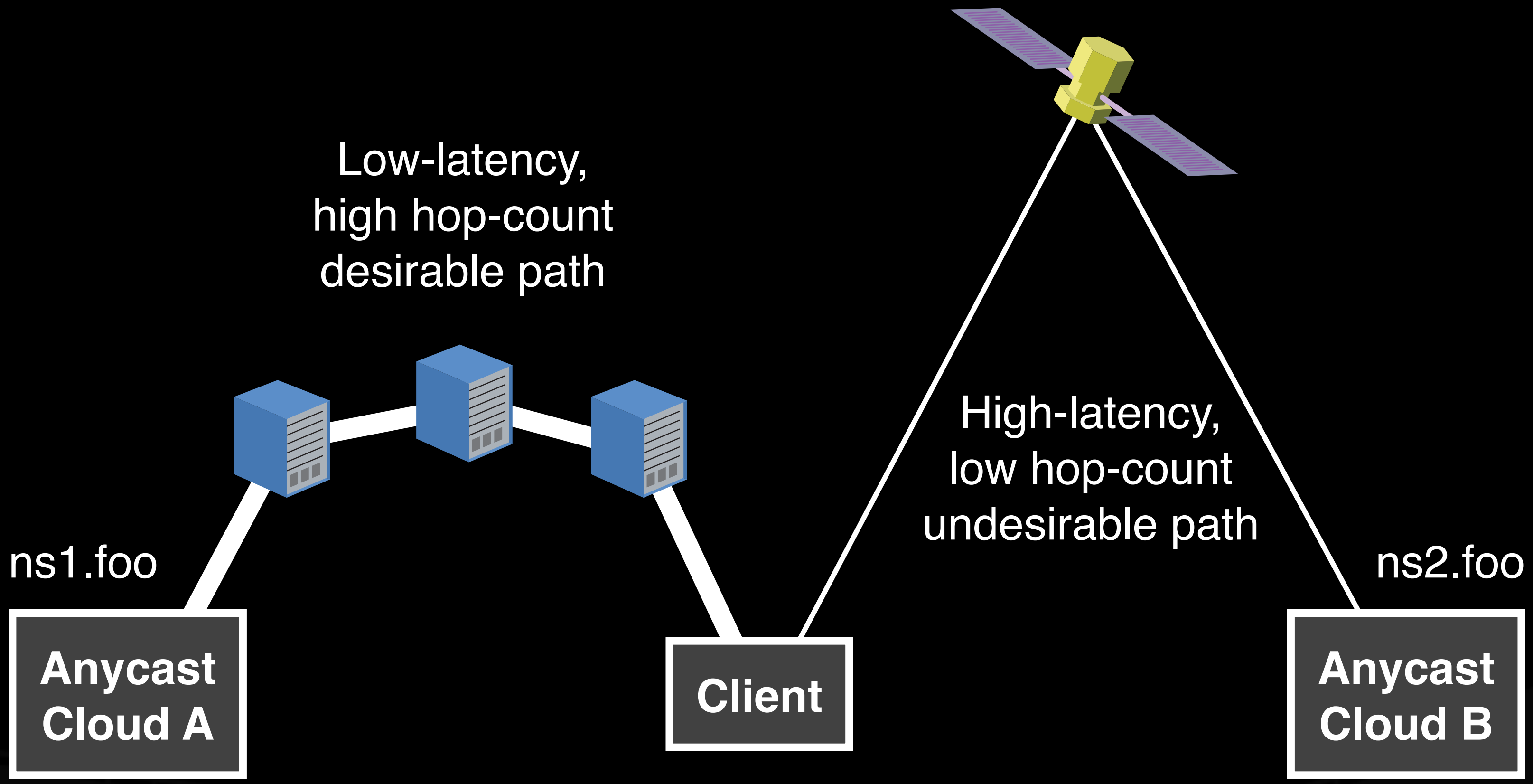
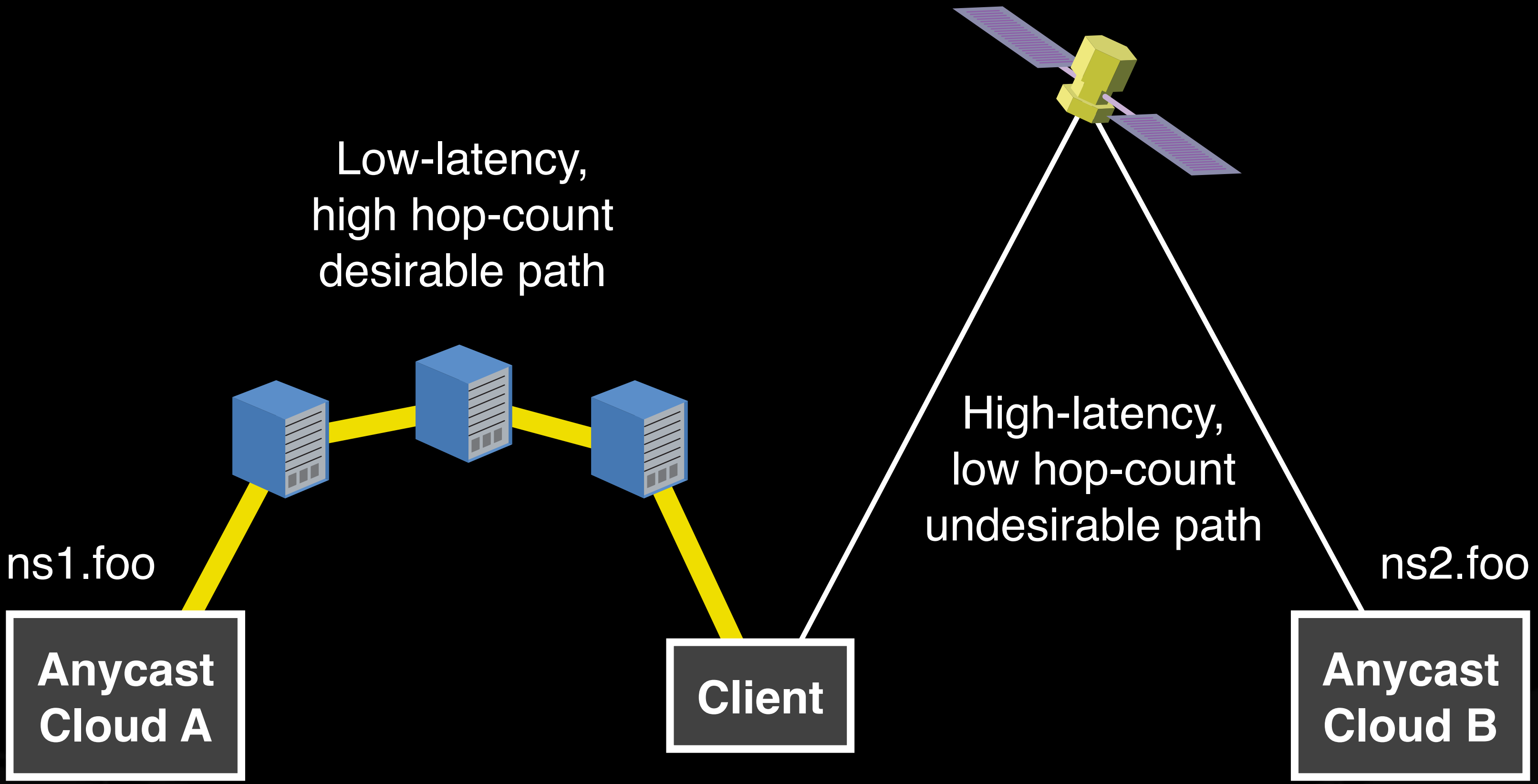
Resolve the Conflict



Split the anycast deployment into “clouds” of locations, each cloud using a different IP address and different routing policies.

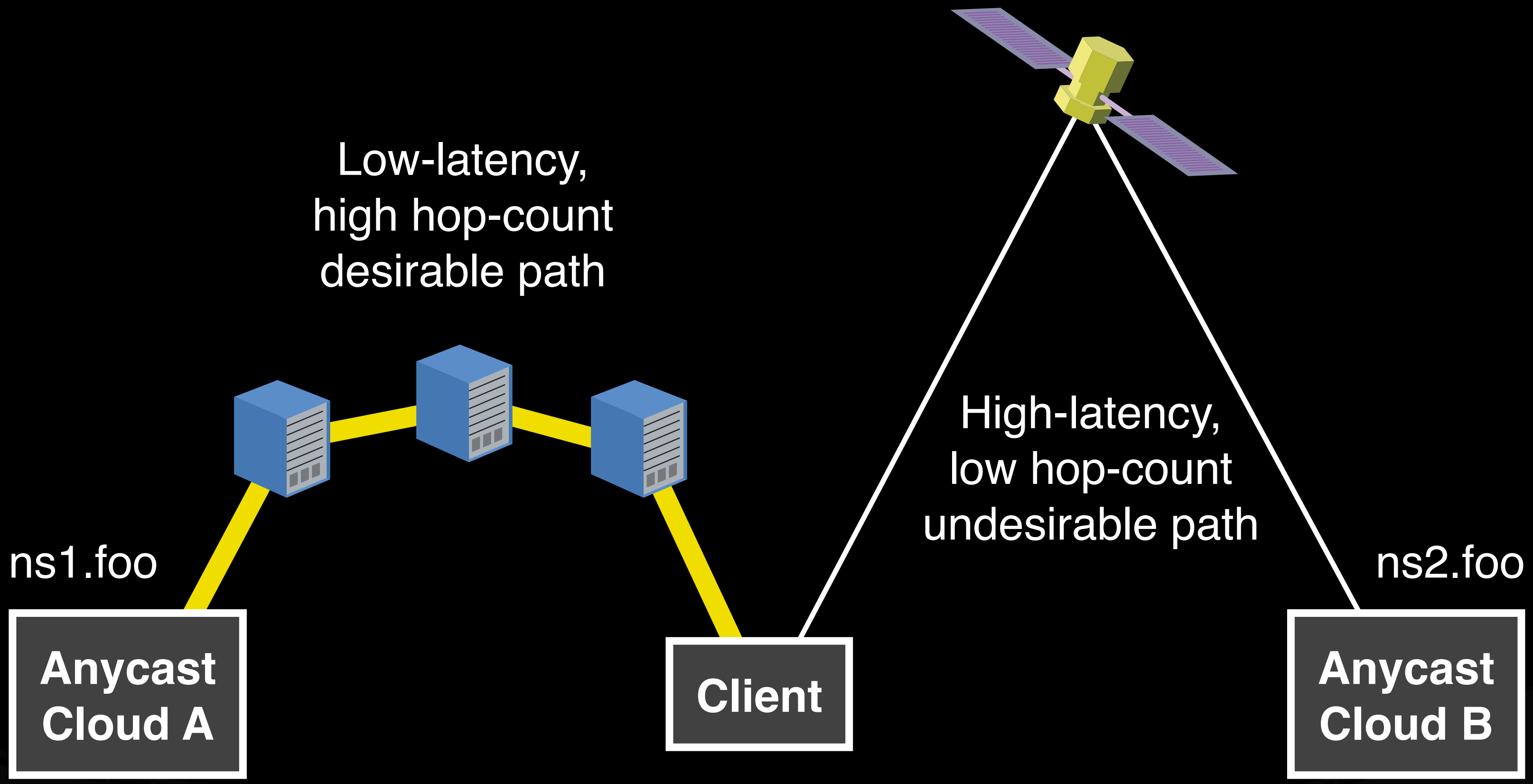
Packet Clearing House

Resolve the Conflict



This allows anycast to present the nearest servers,
and allows the resolver to choose the one which performs best.

Resolve the Conflict



These clouds are usually referred to as "A Cloud" and "B Cloud."
The number of clouds depends on stability and scale trade-offs.

Latency Reduction

Latency reduction depends upon the native layer-3 routing of the Internet.

The theory is that the Internet will deliver packets using the shortest path.

The reality is that the Internet will deliver packets according to ISPs’ policies.

Latency Reduction

ISPs’ routing policies differ from shortest-path where there’s an economic incentive to deliver by a longer path.

ISPs’ Economic Incentives (Grossly Simplified)

ISPs have high cost to deliver traffic through transit.

ISPs have a low cost to deliver traffic through their peering.

ISPs receive money when they deliver traffic to their customers.

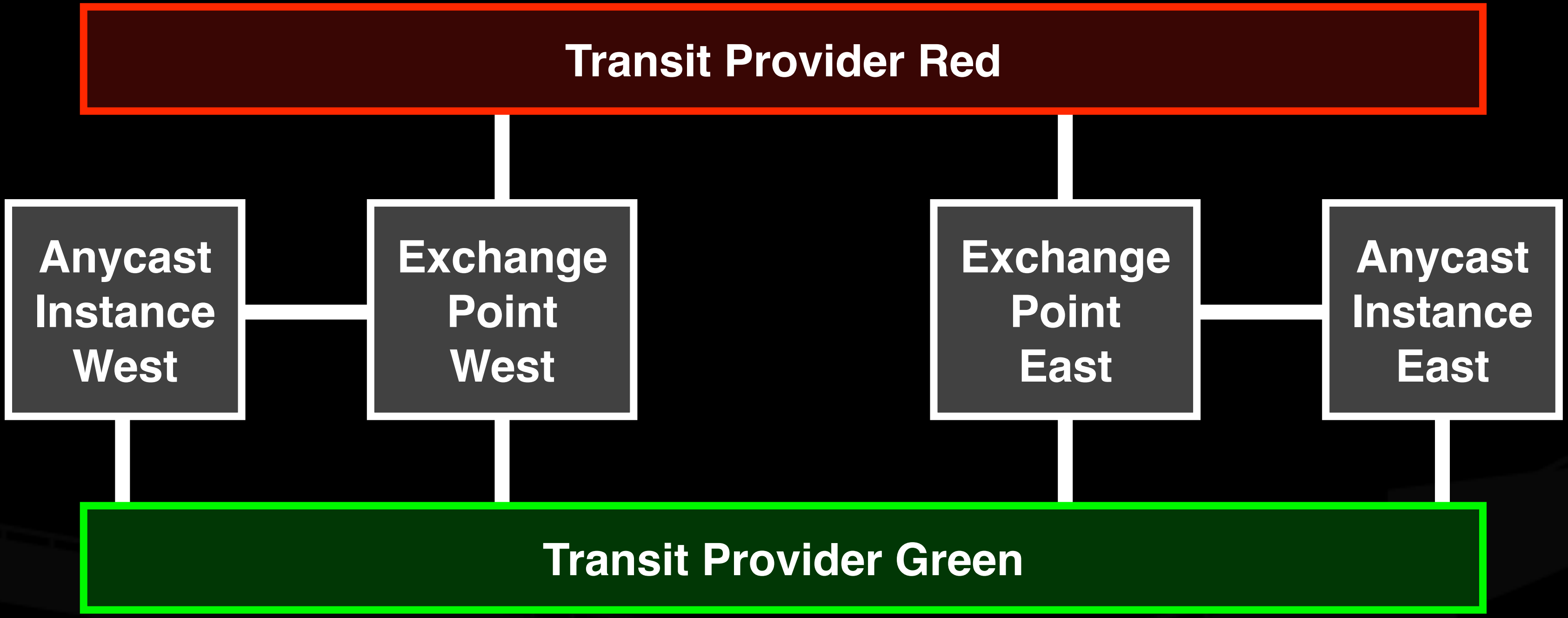
ISPs' Economic Incentives (Grossly Simplified)

Therefore, ISPs will deliver traffic to a customer across a longer path, before by peering or transit across a shorter path.

If you are both a customer, and a customer of a peer or transit provider, this has important implications.

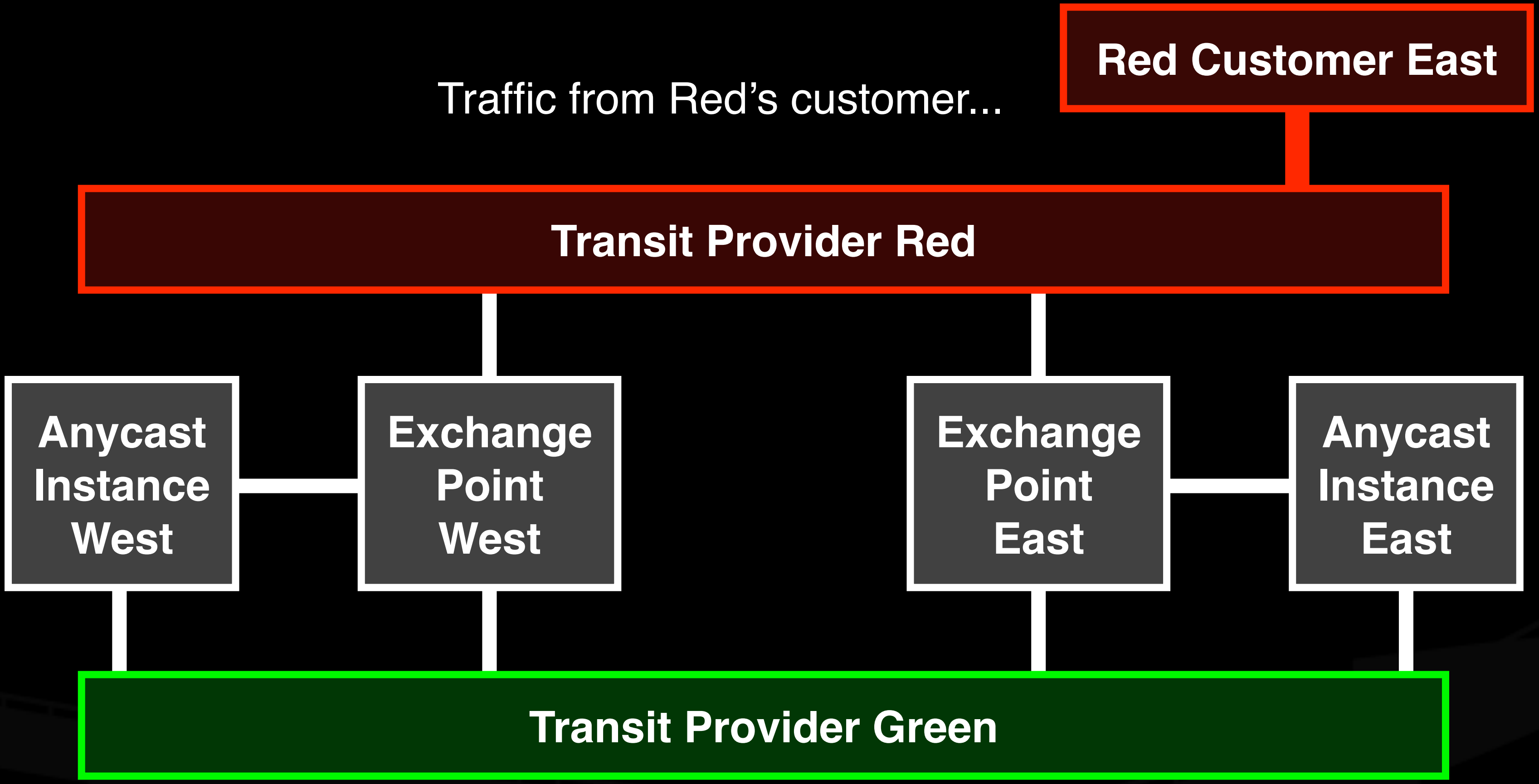
Normal Hot-Potato Routing

If the anycast network is not a customer of large Transit Provider Red...

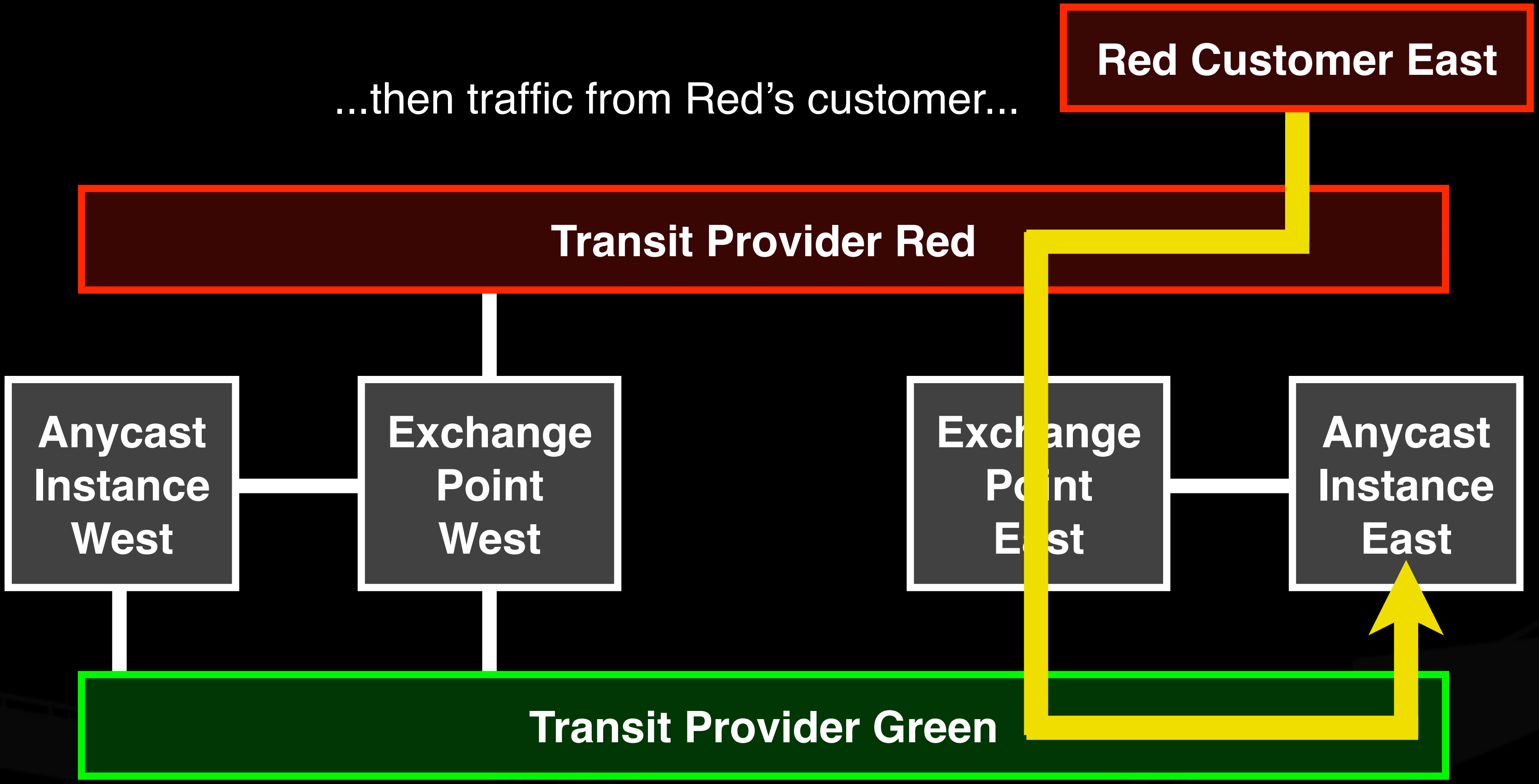


...but is a customer of large Transit Provider Green...

Normal Hot-Potato Routing


Traffic from Red's customer...

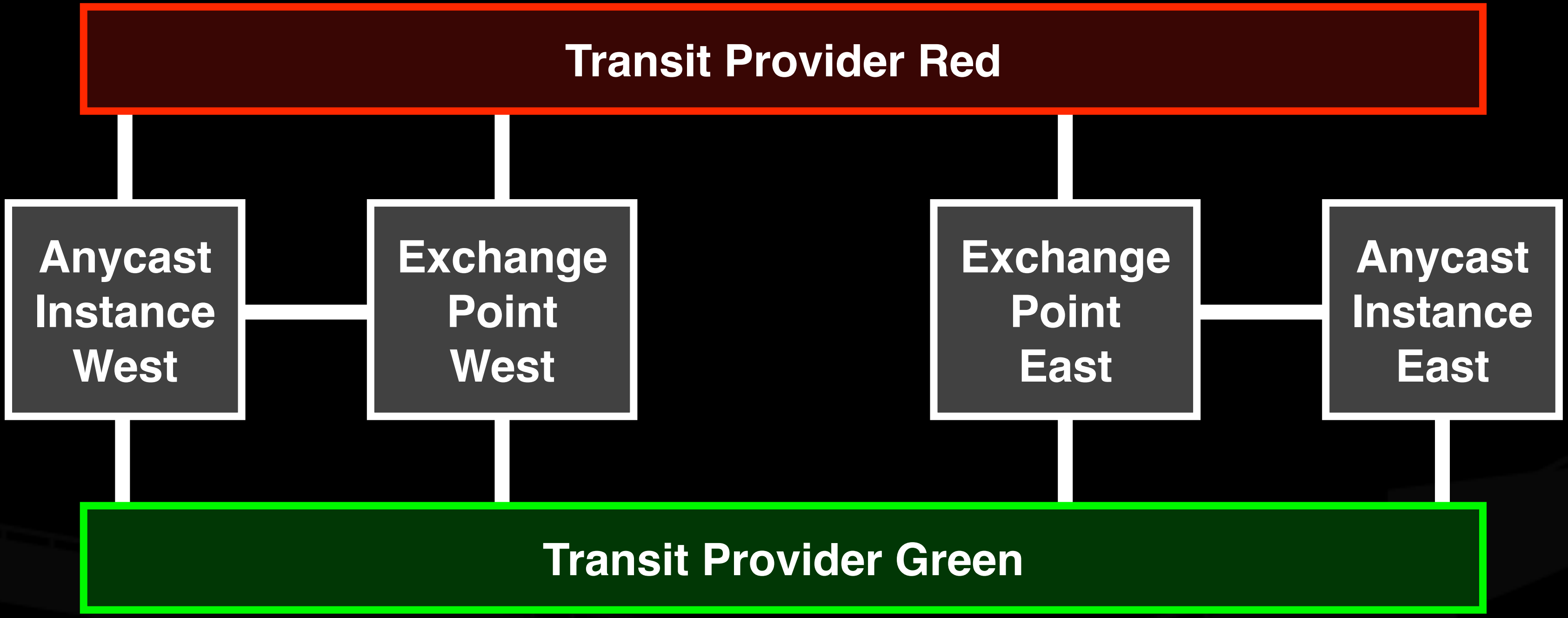
Normal Hot-Potato Routing



...is delivered from Red to Green via local peering, and reaches the local anycast instance.

How the Conflict Plays Out

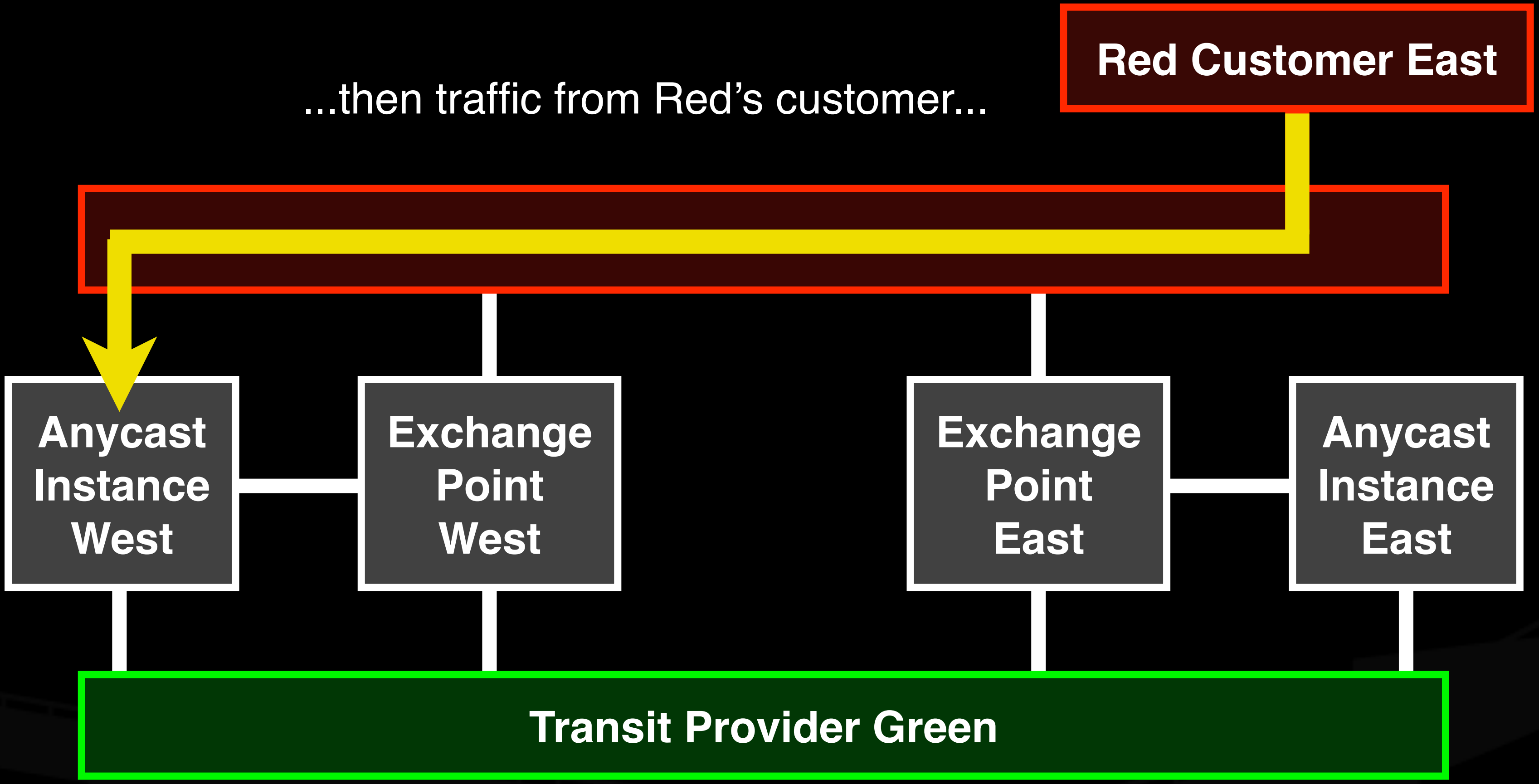
But if the anycast network is a customer of both large Transit Provider Red...



...and of large Transit Provider Green, but not at all locations...

How the Conflict Plays Out

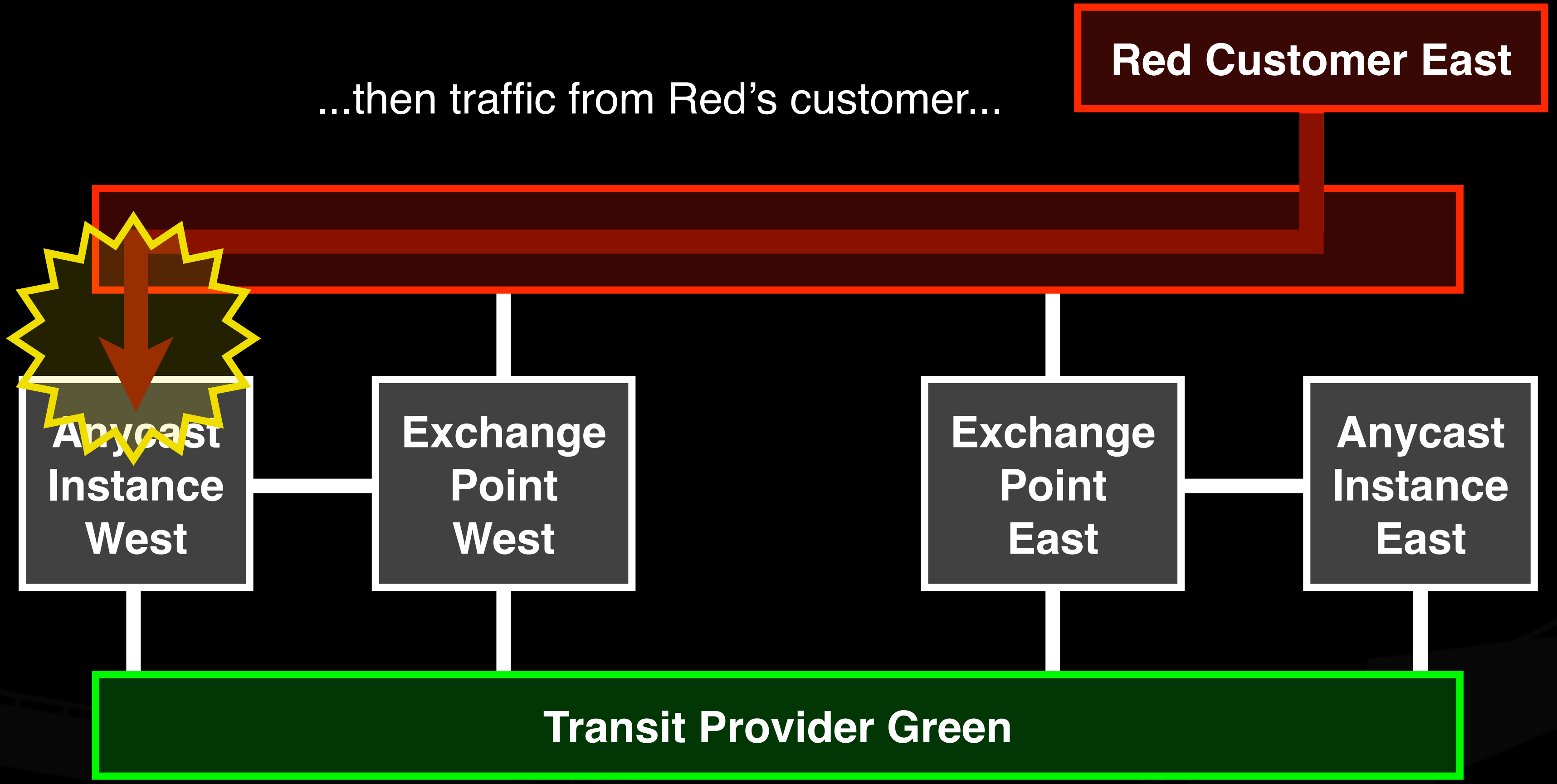
...then traffic from Red's customer...



...will be misdelivered to the remote anycast instance...

How the Conflict Plays Out

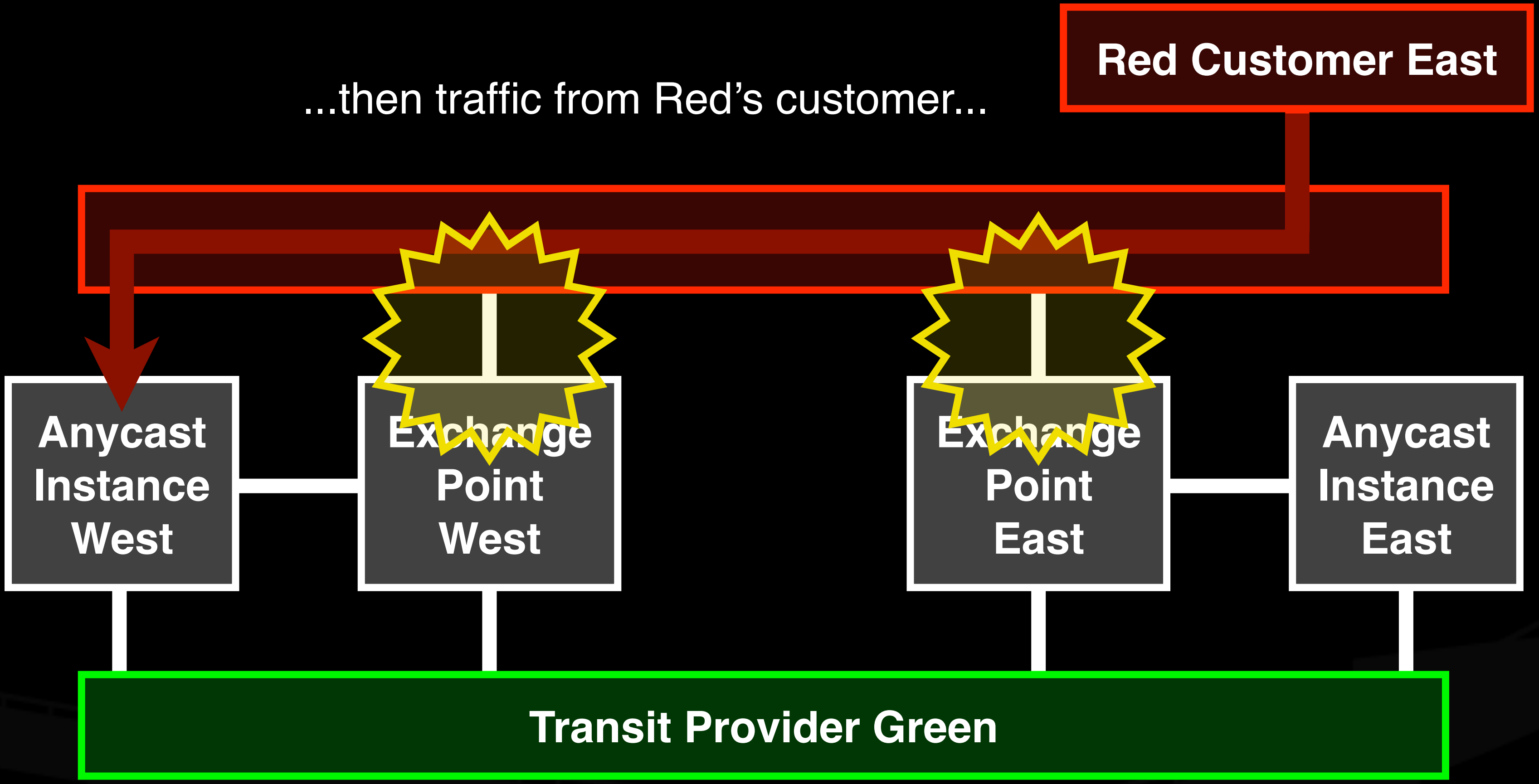
...then traffic from Red’s customer...



...will be misdelivered to the remote anycast instance, because a customer connection...

How the Conflict Plays Out

...then traffic from Red's customer...



...will be misdelivered to the remote anycast instance, because a customer connection is preferred for economic reasons over a peering connection.

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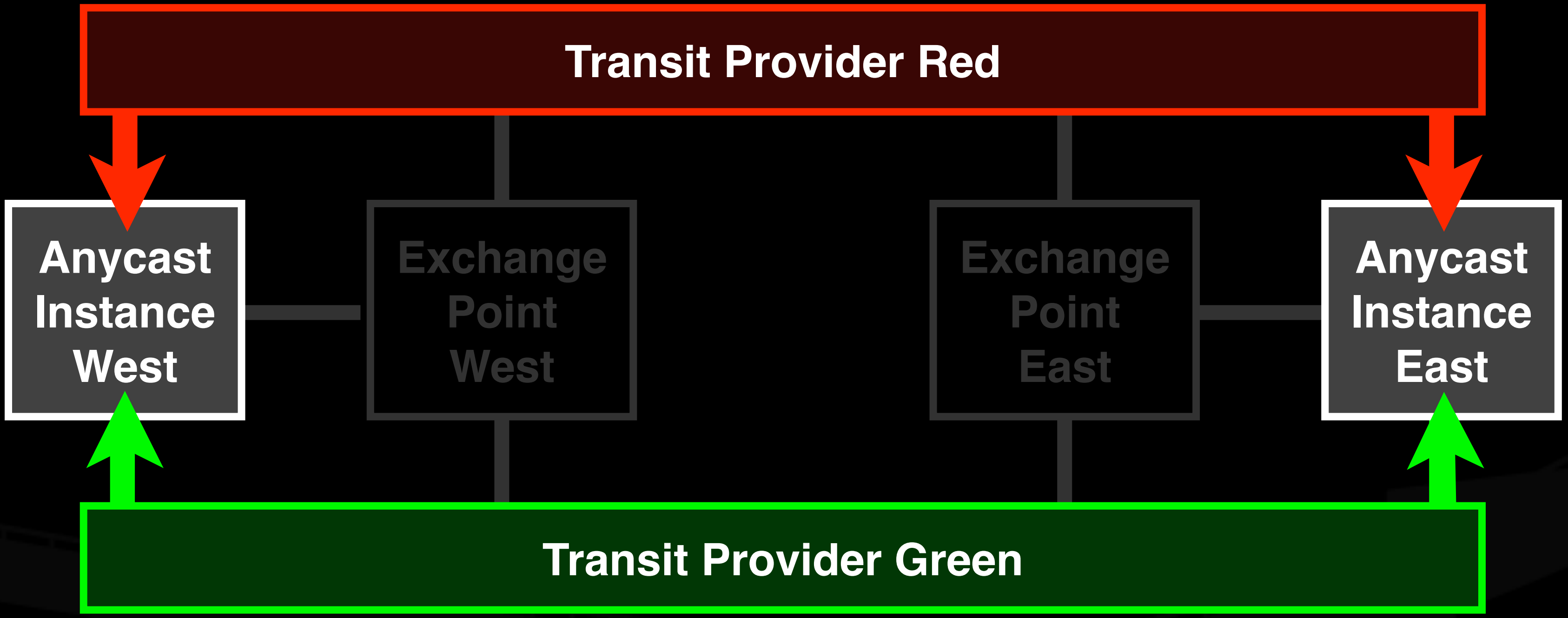
Resolve the Conflict

Any two instances of an anycast service IP address must have the same set of large transit providers at all locations.

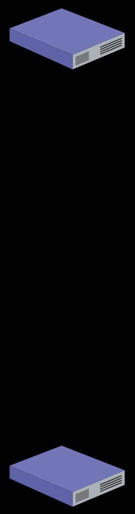


This caution is not necessary with small transit providers who don’t have the capability of backhauling traffic to the wrong region on the basis of policy.

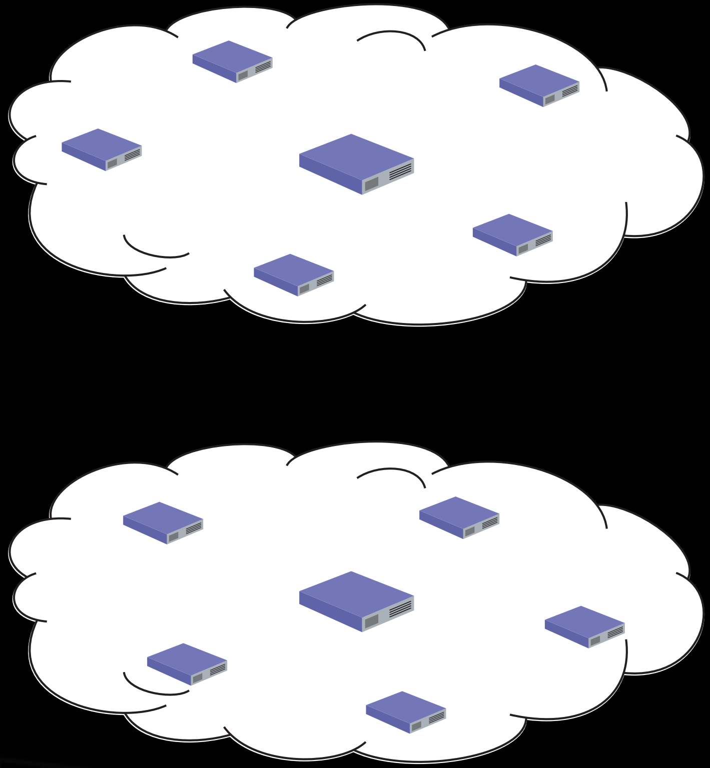
Putting the Pieces Together

- We need an A Cloud and a B Cloud.
- We need a redundant pair of the same transit providers at most or all instances of each cloud.
- We need a redundant pair of hidden masters for the DNS servers.
- We need a network topology to carry control and synchronization traffic between the nodes.

Redundant Hidden Masters

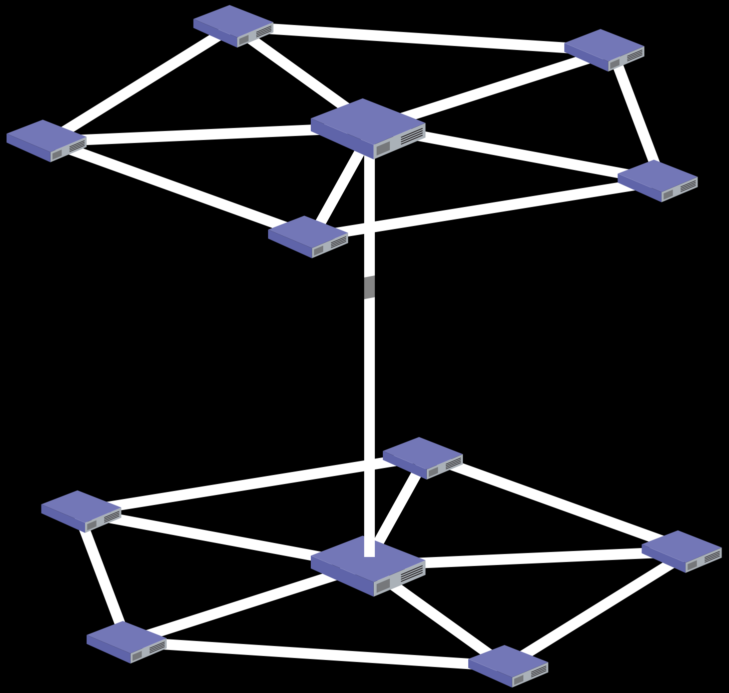


An A Cloud and a B Cloud



A Network Topology

“Dual Wagon-Wheel”

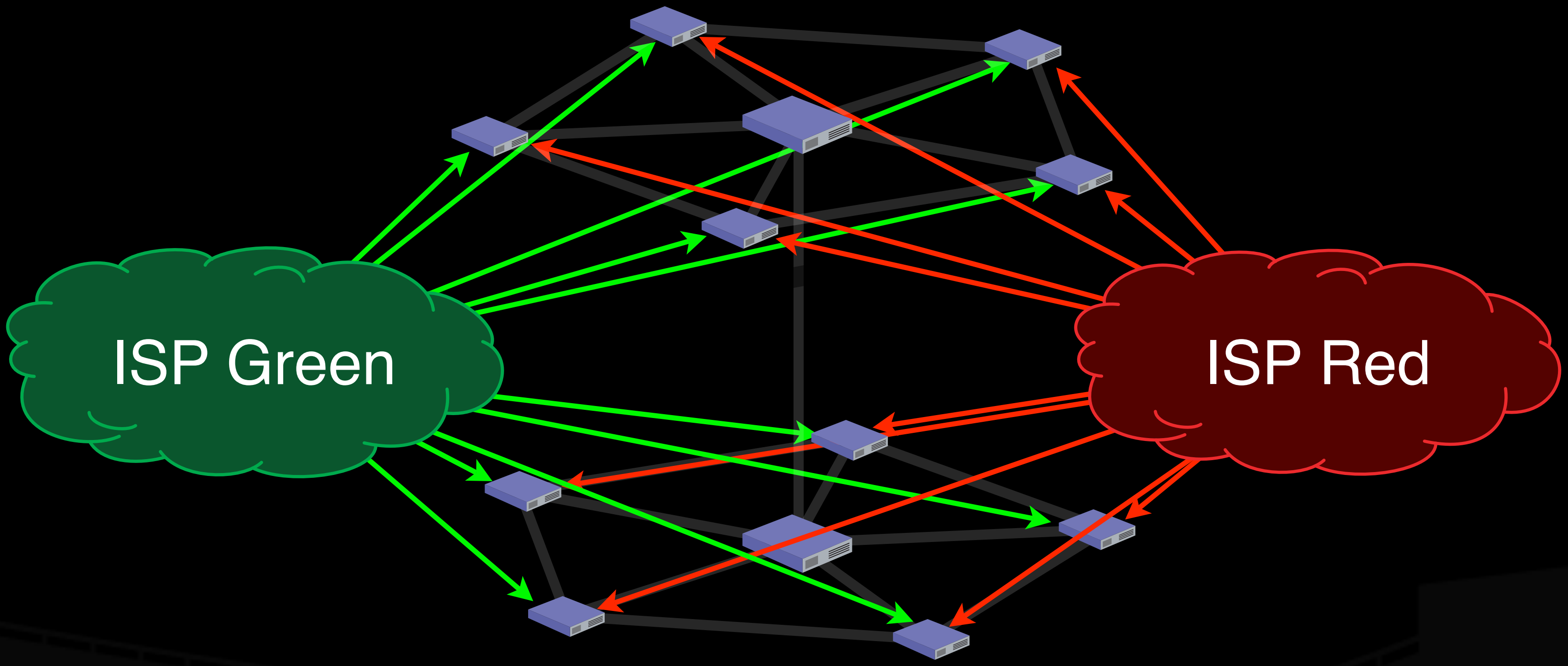


A Ring

B Ring

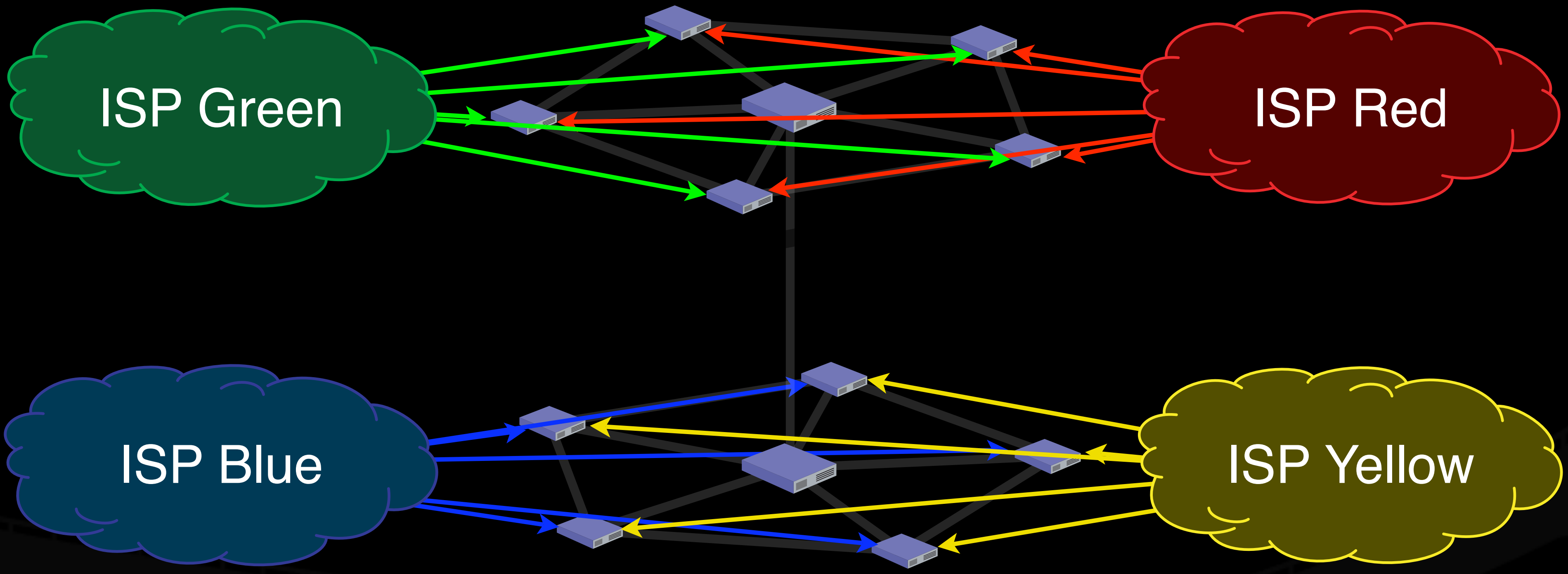
Redundant Transit

Two ISPs

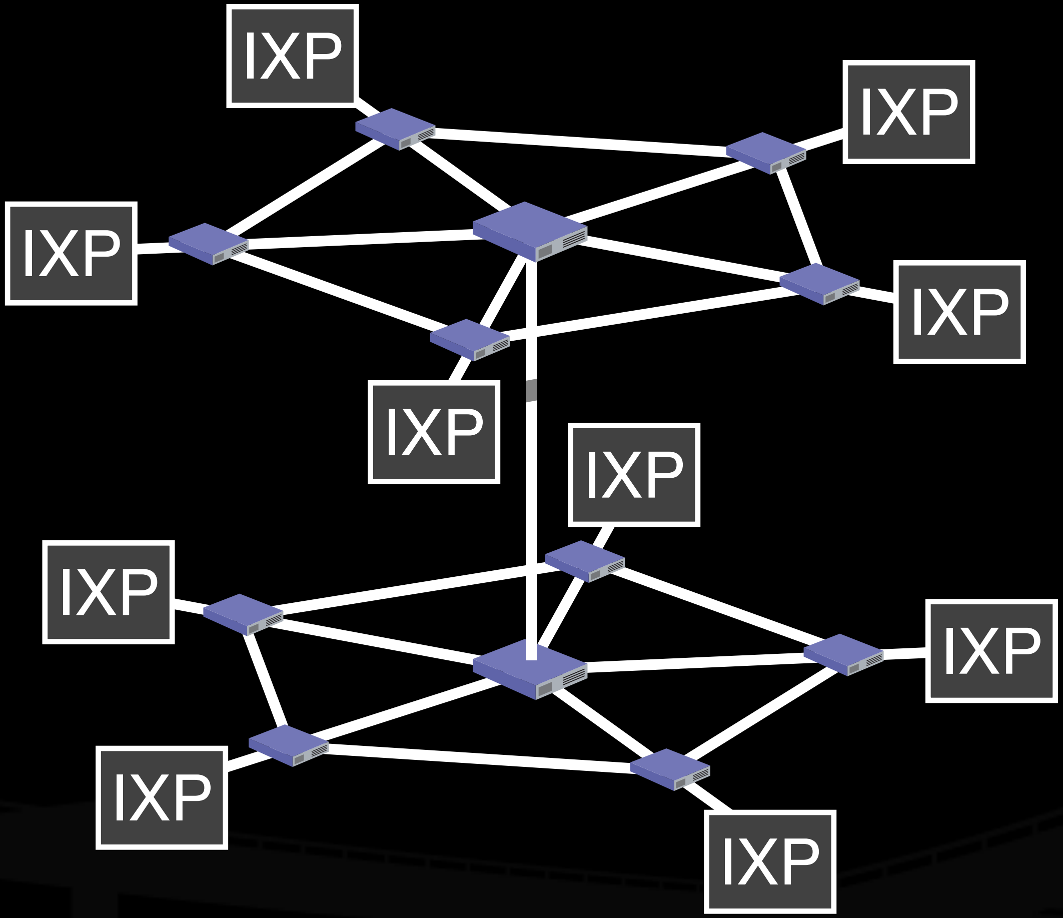


Redundant Transit

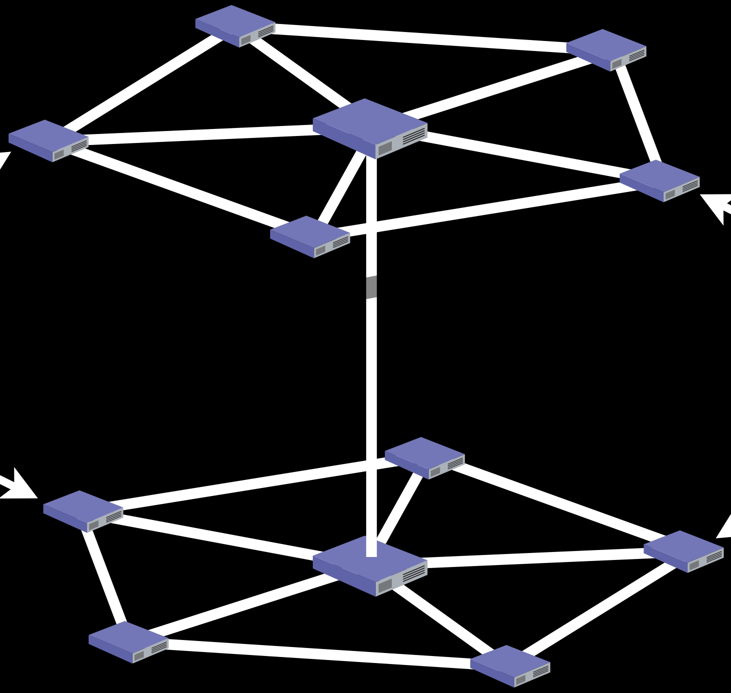
Or four ISPs



Local Peering



Resolver-Based Fail-Over



Customer Resolver Server Selection

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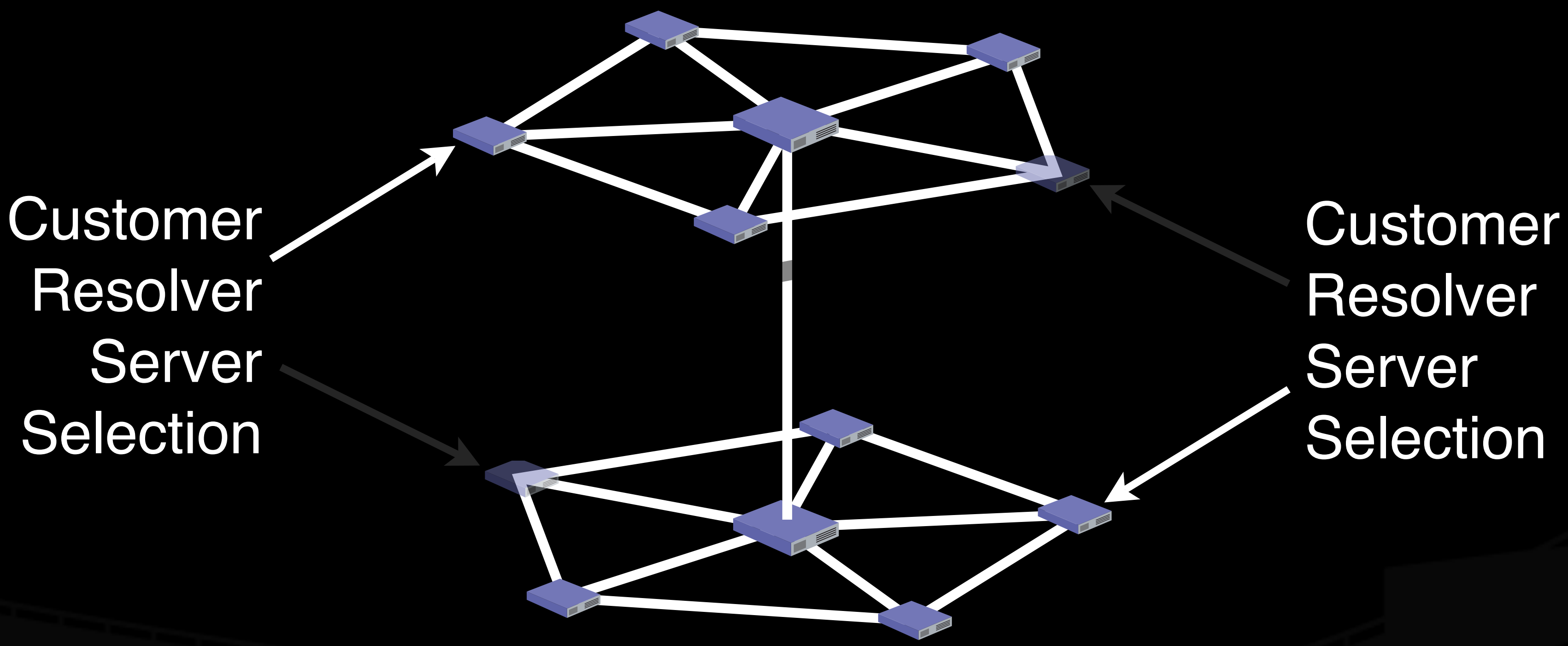
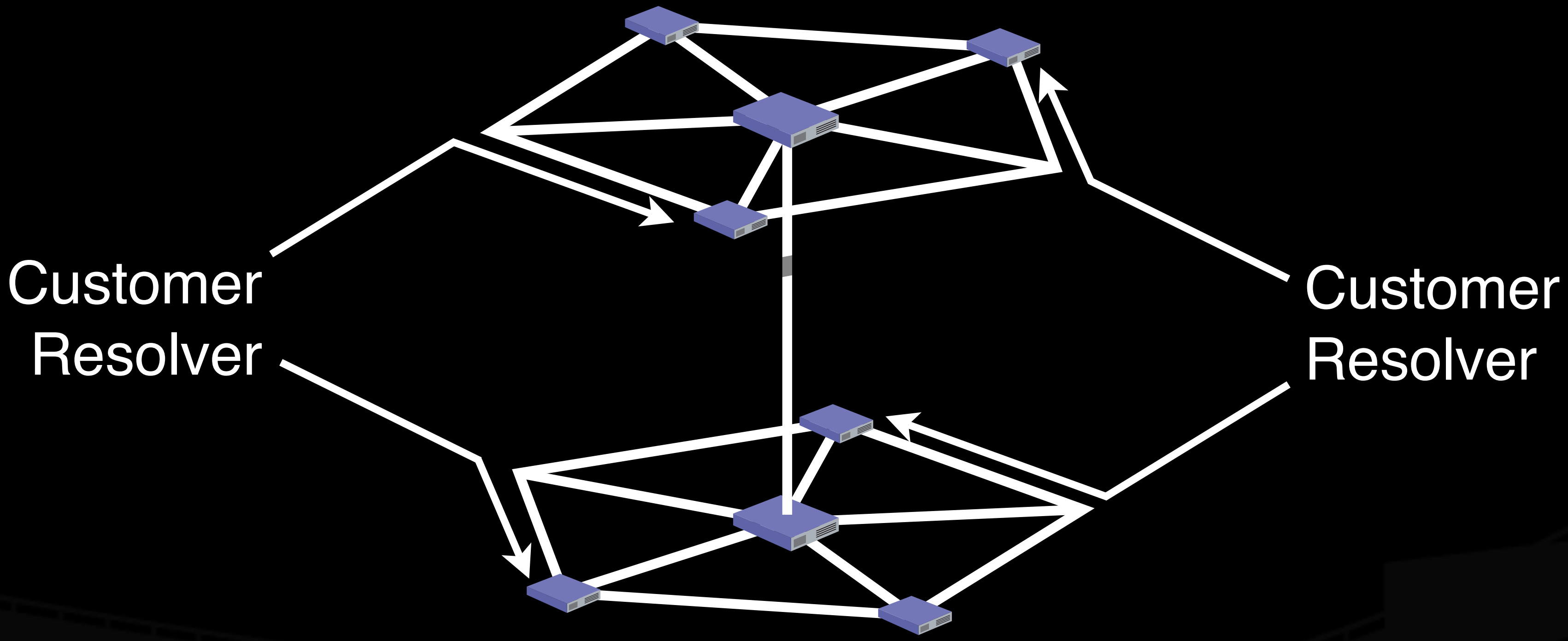
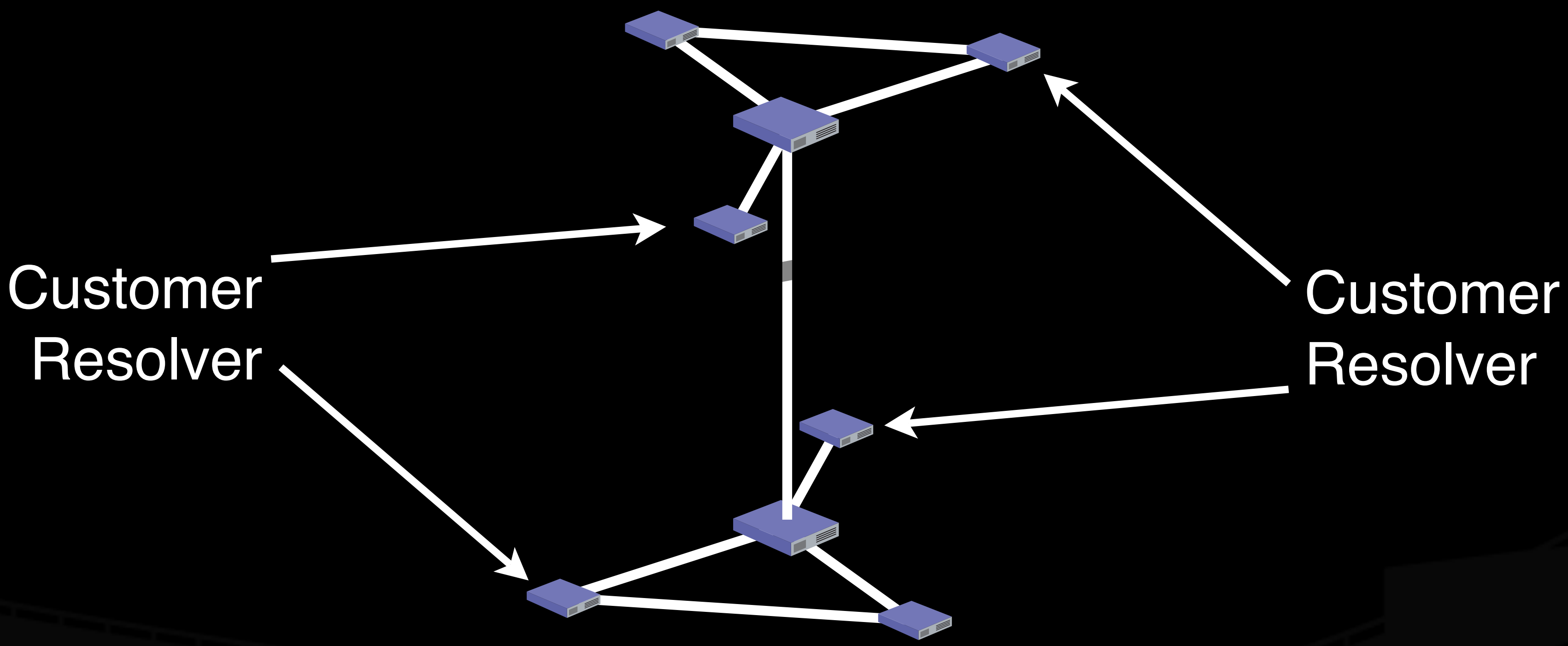
Resolver-Based Fail-Over



Internal Anycast Fail-Over



Global Anycast Fail-Over



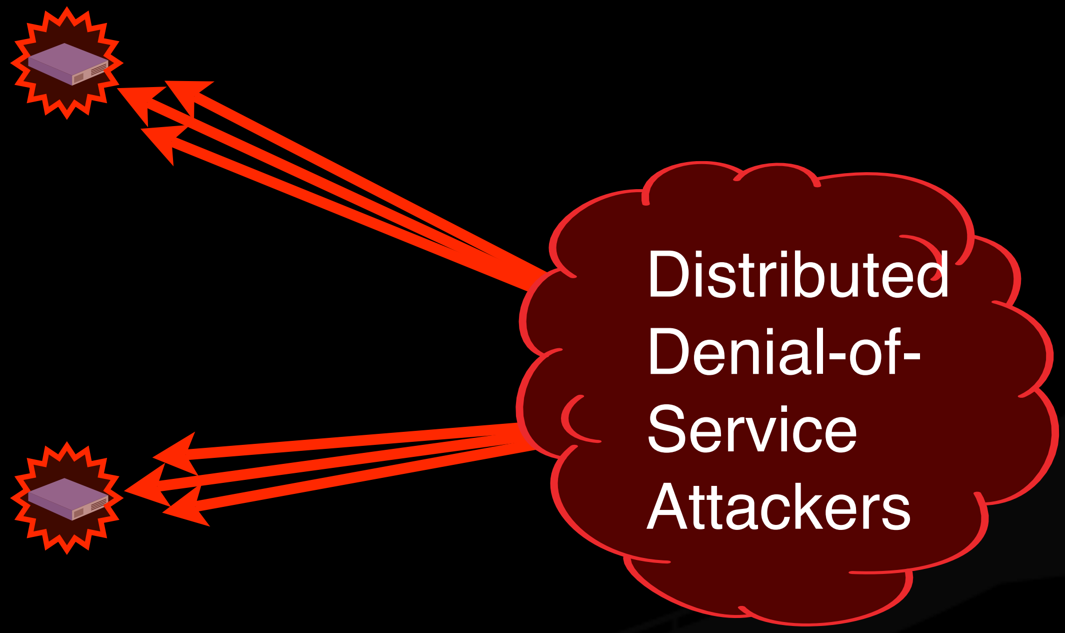
Unicast Attack Effects

Traditional unicast server deployment...

Distributed Denial-of-Service Attackers

Unicast Attack Effects

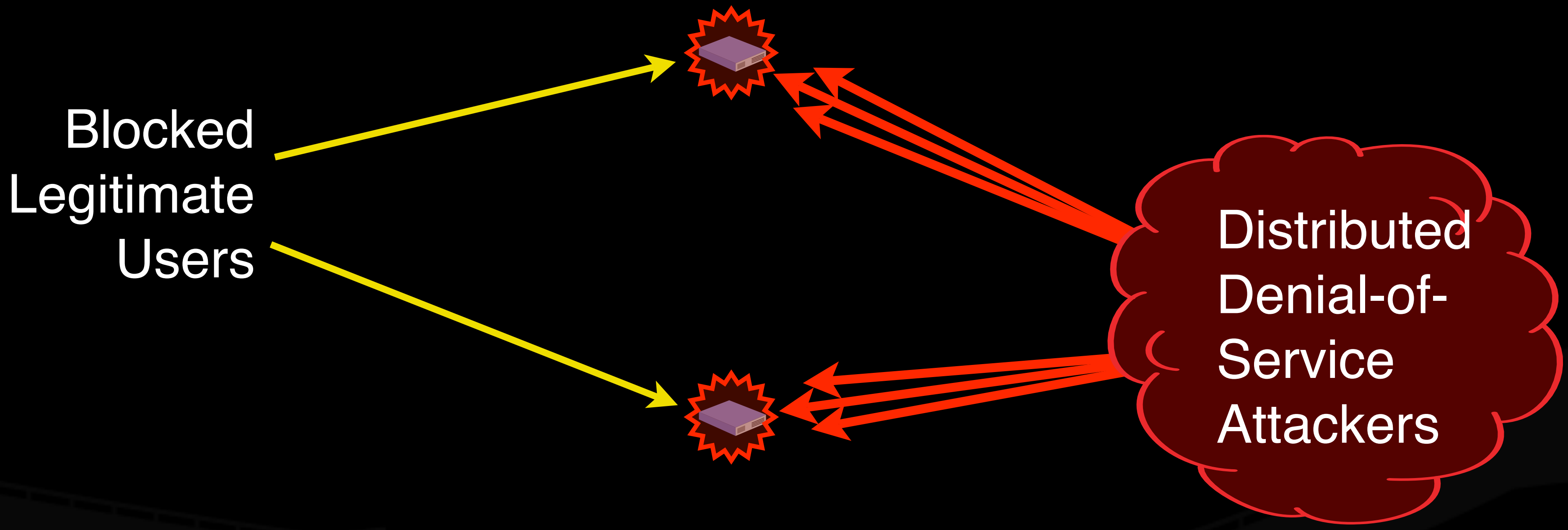
Traditional unicast server deployment...



...exposes all servers to all attackers.

Unicast Attack Effects

Traditional unicast server deployment...

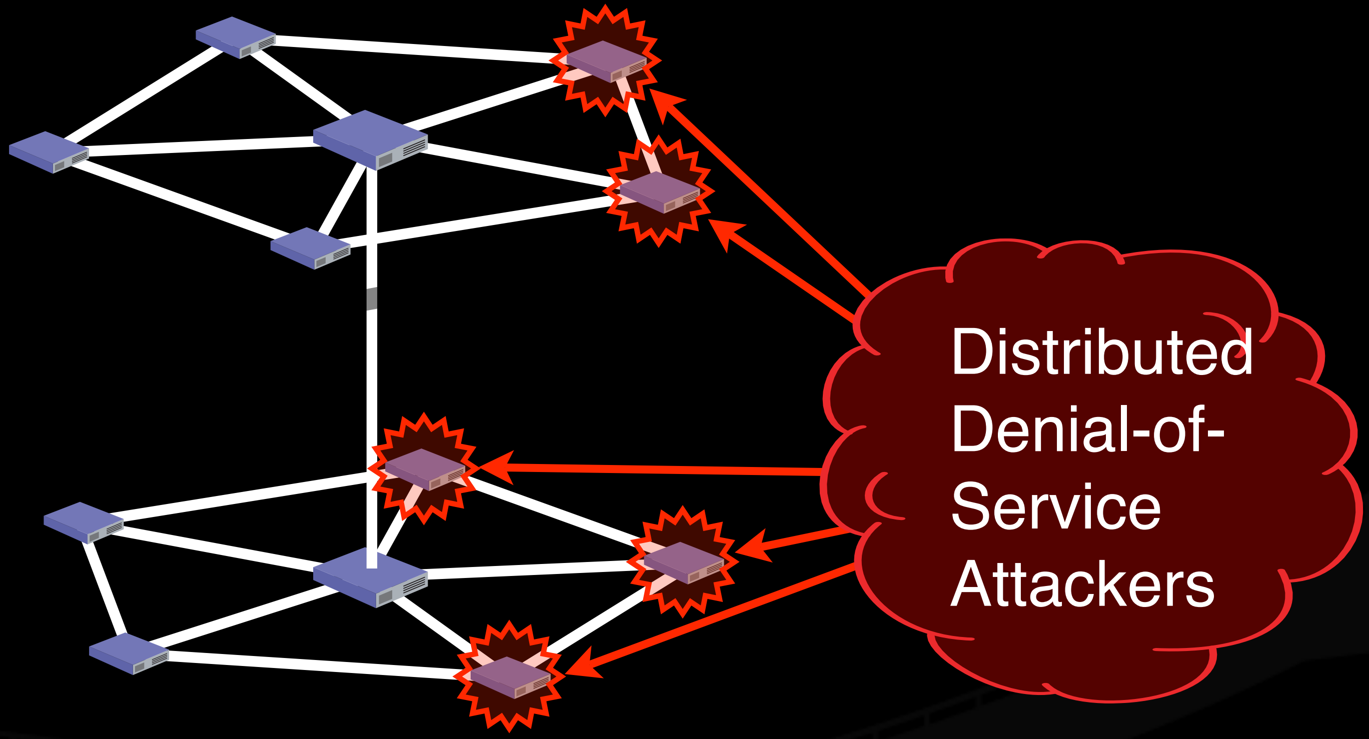


Blocked Legitimate Users

Distributed Denial-of-Service Attackers

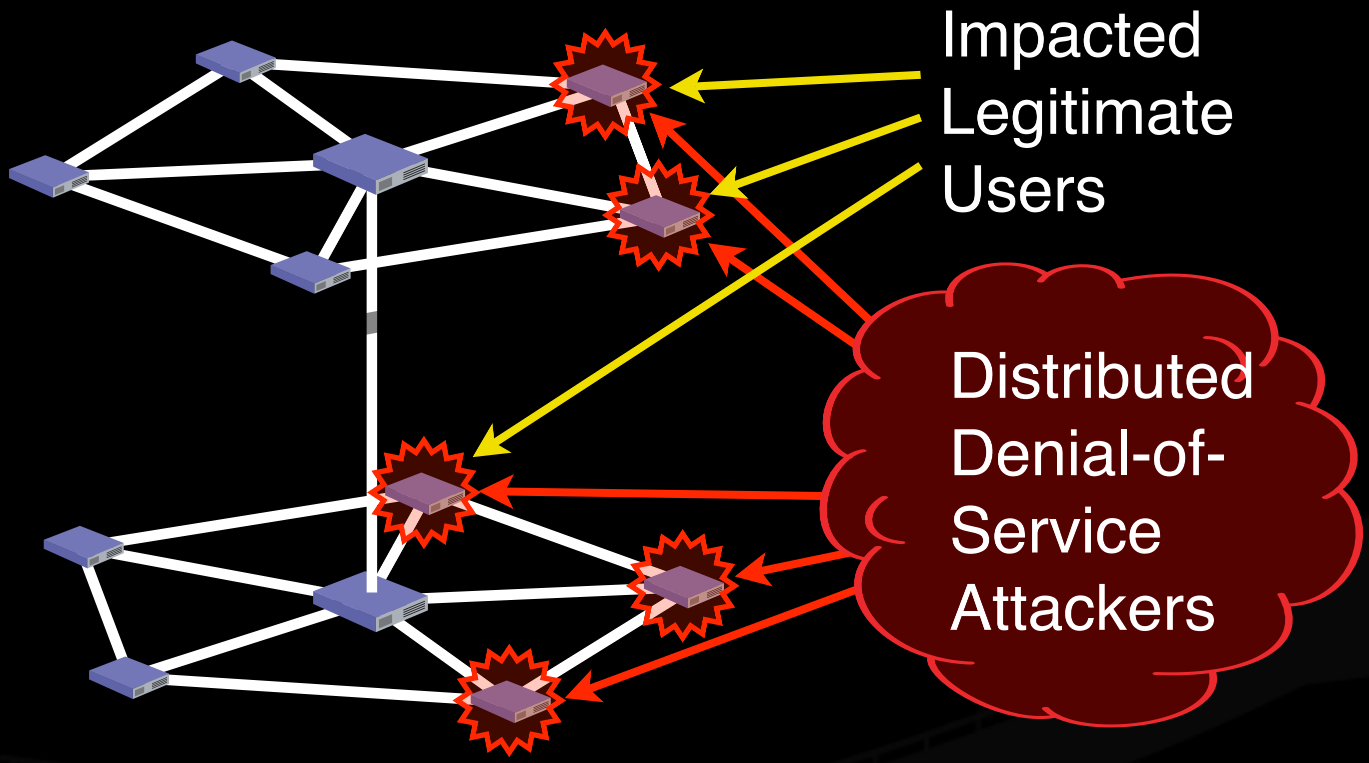
...exposes all servers to all attackers,
leaving no resources for legitimate users.

Anycast Attack Mitigation

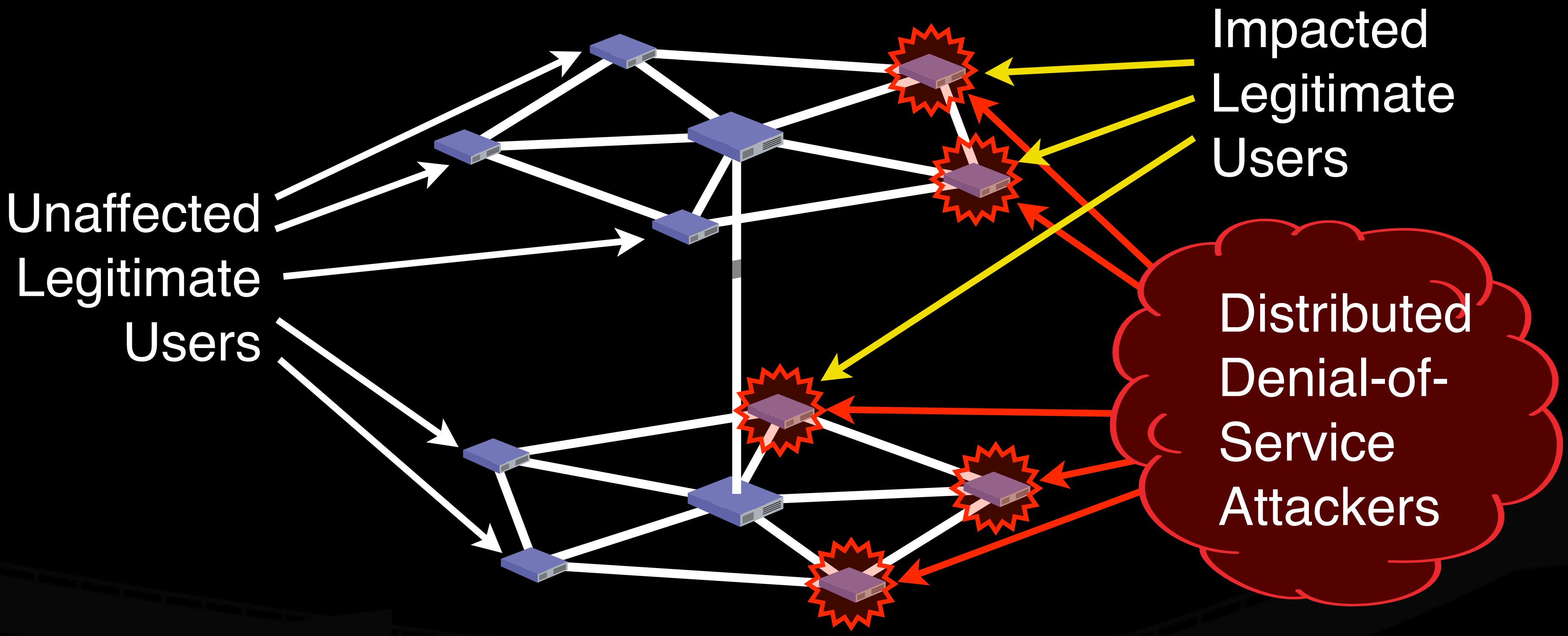


Distributed Denial-of-Service Attackers

Anycast Attack Mitigation


Impacted Legitimate Users
Distributed Denial-of-Service Attackers

Anycast Attack Mitigation



Thanks, and Questions?

Copies of this presentation can be
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http:// www.pch.net / resources / papers / dns-service-architecture

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