Best Practices in IPv4 Anycast Routing

Version 0.7

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Packet Clearing House

What *isn't* Anycast?

- Not a protocol, not a different version of IP, nobody's proprietary technology.
- Doesn't require any special capabilities in the servers, clients, or network.
- Doesn't break or confuse existing infrastructure.

What *is* Anycast?

- Just a configuration methodology.
- Mentioned, although not described in detail, in numerous RFCs since time immemorial.
- It's been the basis for some large-scale content-distribution networks for several years.

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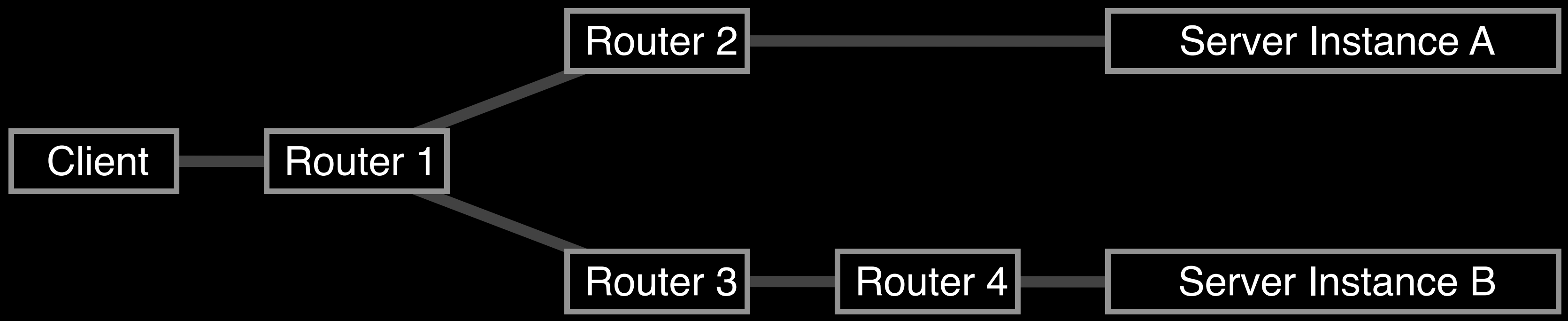
How Does Anycast Work?

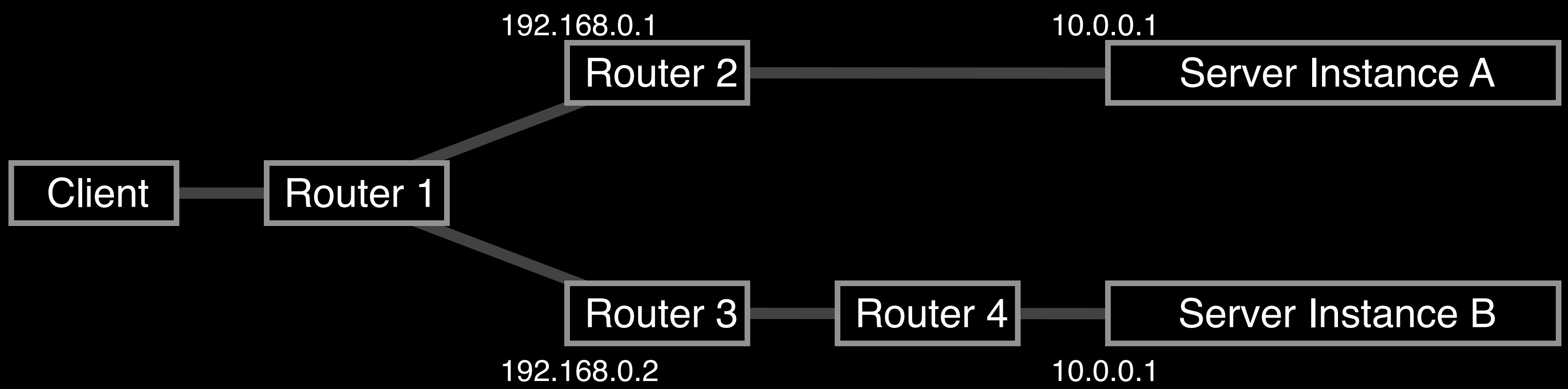
The idea is extremely simple:

- Multiple instances of a service share the same IP address.
- The routing infrastructure directs any packet to the topologically nearest instance of the service.
- What little complexity exists is in the optional details.

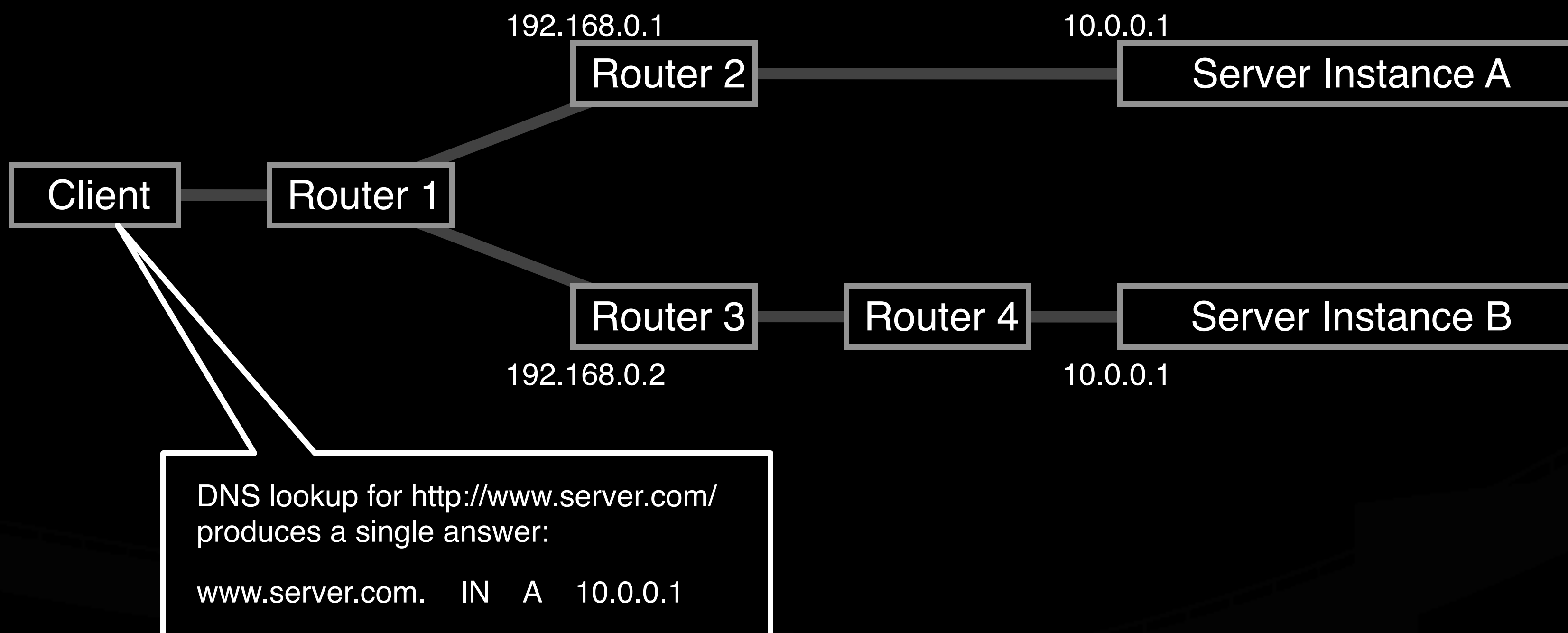
Example


Router 2
Server Instance A
Client
Router 1
Router 3
Router 4
Server Instance B

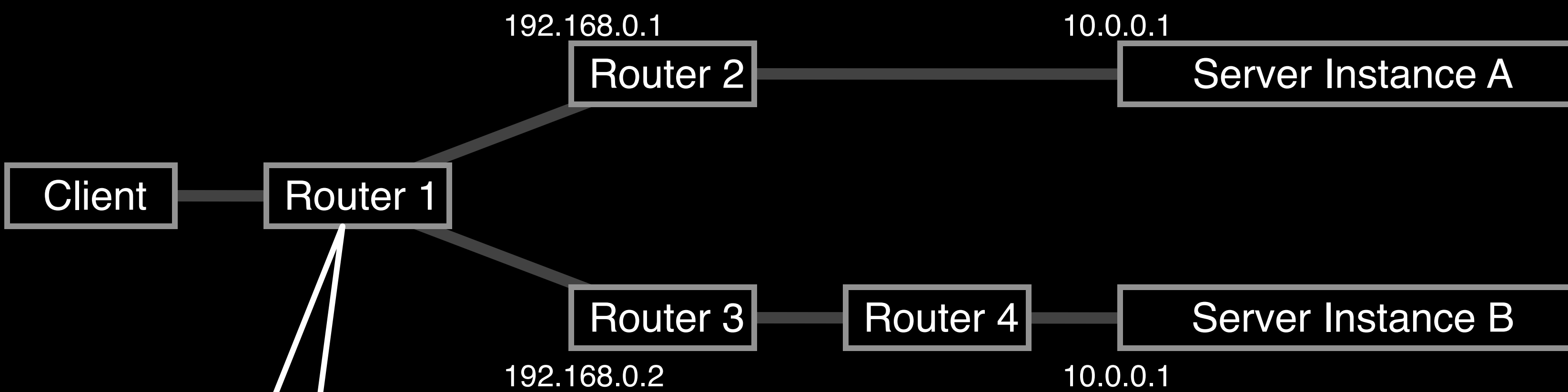
Example


192.168.0.1
10.0.0.1
Router 2
Server Instance A
Client
Router 1
Router 3
Router 4
Server Instance B
192.168.0.2
10.0.0.1

Example


192.168.0.1
10.0.0.1
Router 2
Server Instance A
Client
Router 1
Router 3
Router 4
Server Instance B
192.168.0.2
10.0.0.1
DNS lookup for http://www.server.com/
produces a single answer:
www.server.com. IN A 10.0.0.1

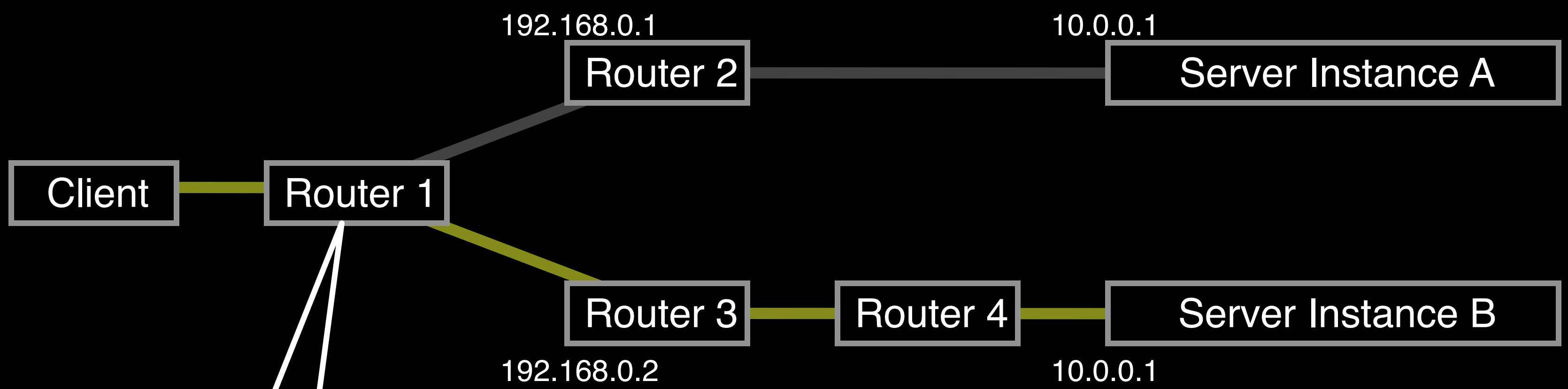
Example



Routing Table from Router 1:

Destination	Mask	Next-Hop	Distance
192.168.0.0	/29	127.0.0.1	0
10.0.0.1	/32	192.168.0.1	1
10.0.0.1	/32	192.168.0.2	2

Example



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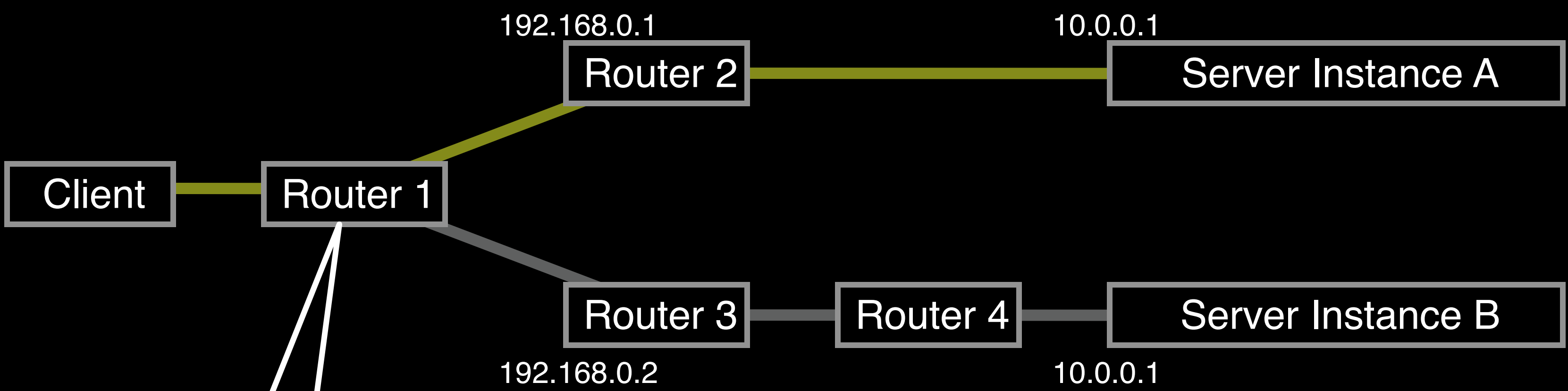

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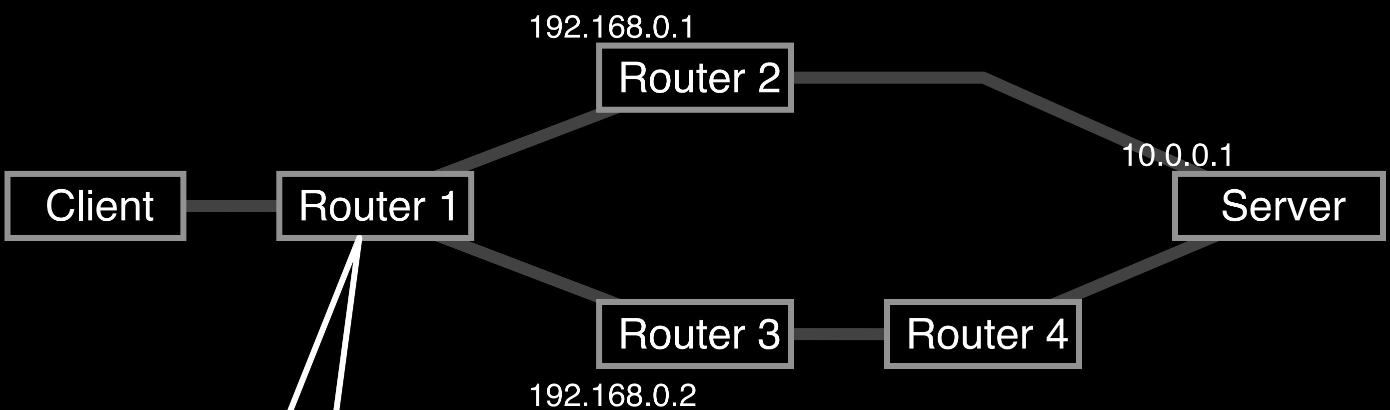
10.0.0.1	/32	192.168.0.1	1
10.0.0.1	/32	192.168.0.2	2

Example

What the routers think the topology looks like:



Routing Table from Router 1:

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10.0.0.1	/32	192.168.0.1	1
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Building an Anycast Server Cluster

- Anycast can be used in building either local server clusters, or global networks, or global networks of clusters, combining both scales.

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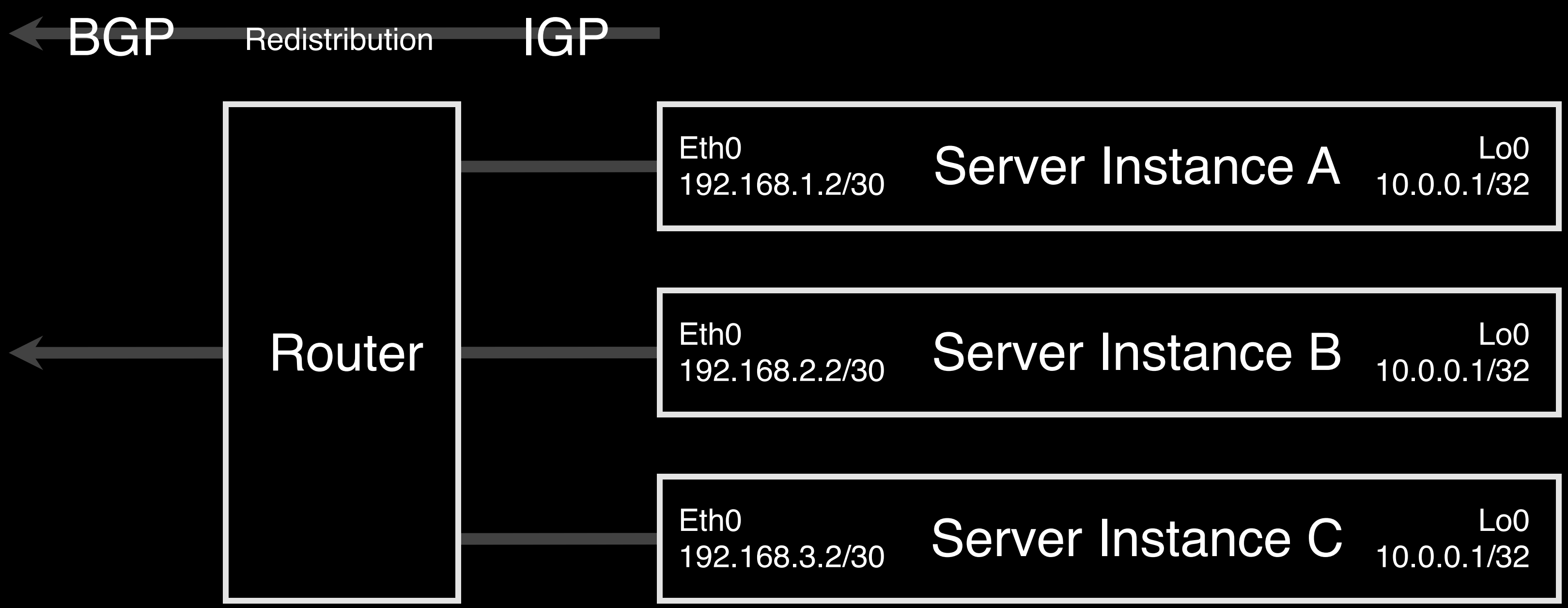
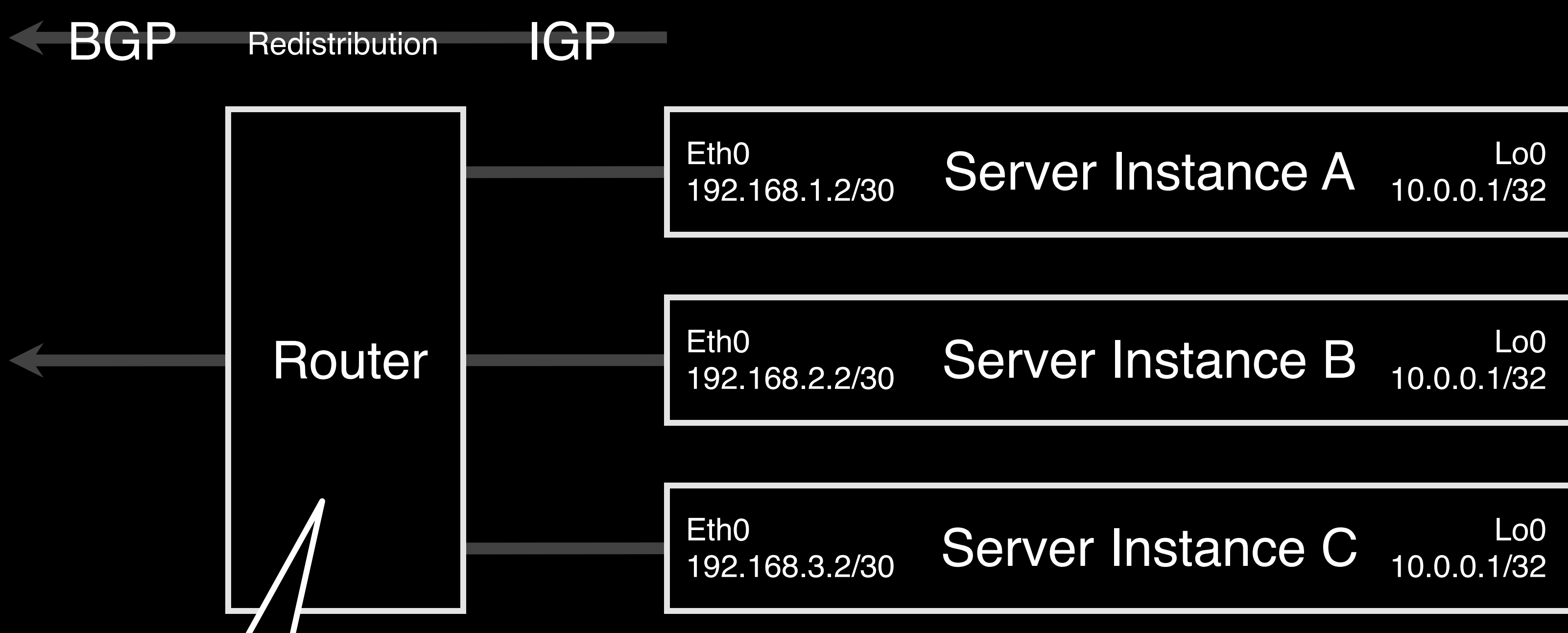
Building an Anycast Server Cluster

- Typically, a cluster of servers share a common virtual interface attached to their loopback devices, and speak an IGP routing protocol to an adjacent BGP-speaking border router.
- The servers may or may not share identical content.

Example

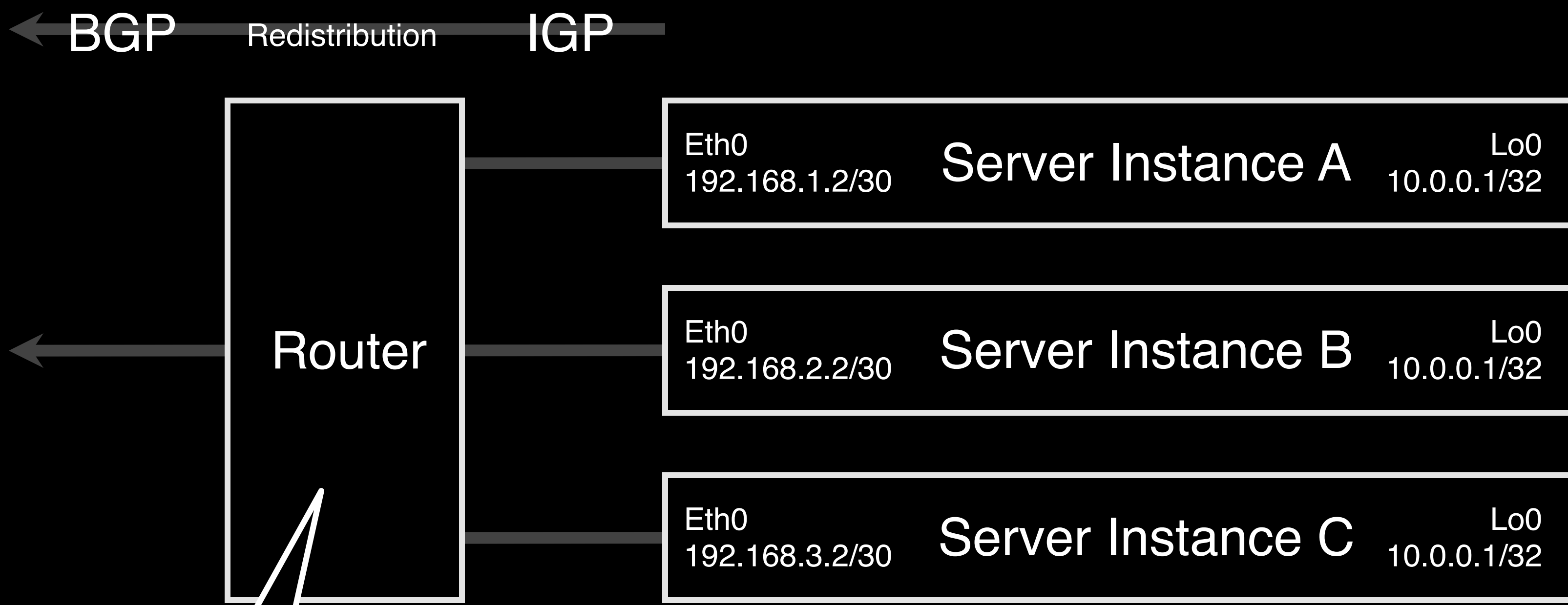

BGP
Redistribution
IGP
Router
Eth0
192.168.1.2/30
Server Instance A
Lo0
10.0.0.1/32
Eth0
192.168.2.2/30
Server Instance B
Lo0
10.0.0.1/32
Eth0
192.168.3.2/30
Server Instance C
Lo0
10.0.0.1/32

Example



Destination	Mask	Next-Hop	Dist
0.0.0.0	/0	127.0.0.1	0
192.168.1.0	/30	192.168.1.1	0
192.168.2.0	/30	192.168.2.1	0
192.168.3.0	/30	192.168.3.1	0
10.0.0.1	/32	192.168.1.2	1
10.0.0.1	/32	192.168.2.2	1
10.0.0.1	/32	192.168.3.2	1

Example



Destination	Mask	Next-Hop	Dist
0.0.0.0	/0	127.0.0.1	0
192.168.1.0	/30	192.168.1.1	0
192.168.2.0	/30	192.168.2.1	0
192.168.3.0	/30	192.168.3.1	0
10.0.0.1	/32	192.168.1.2	1
10.0.0.1	/32	192.168.2.2	1
10.0.0.1	/32	192.168.3.2	1

} Round-robin load balancing (the last three rows)

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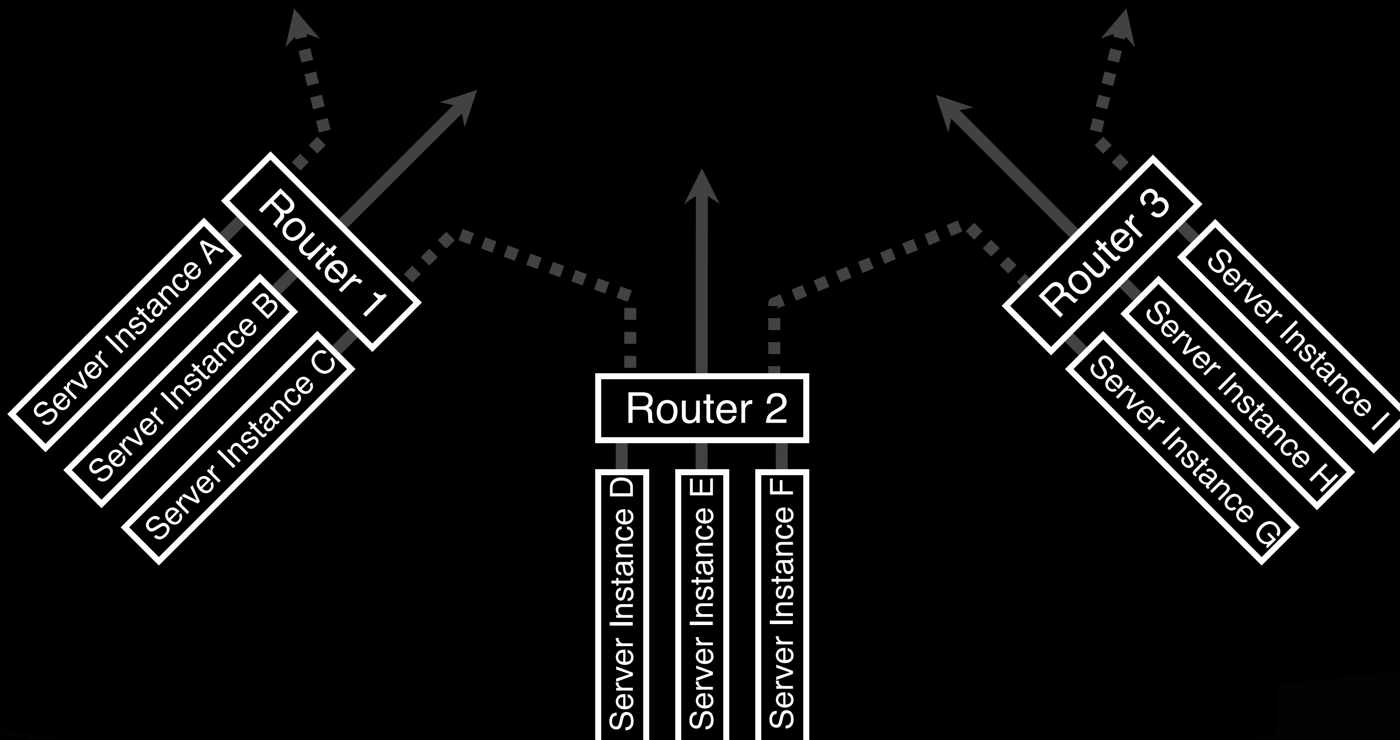
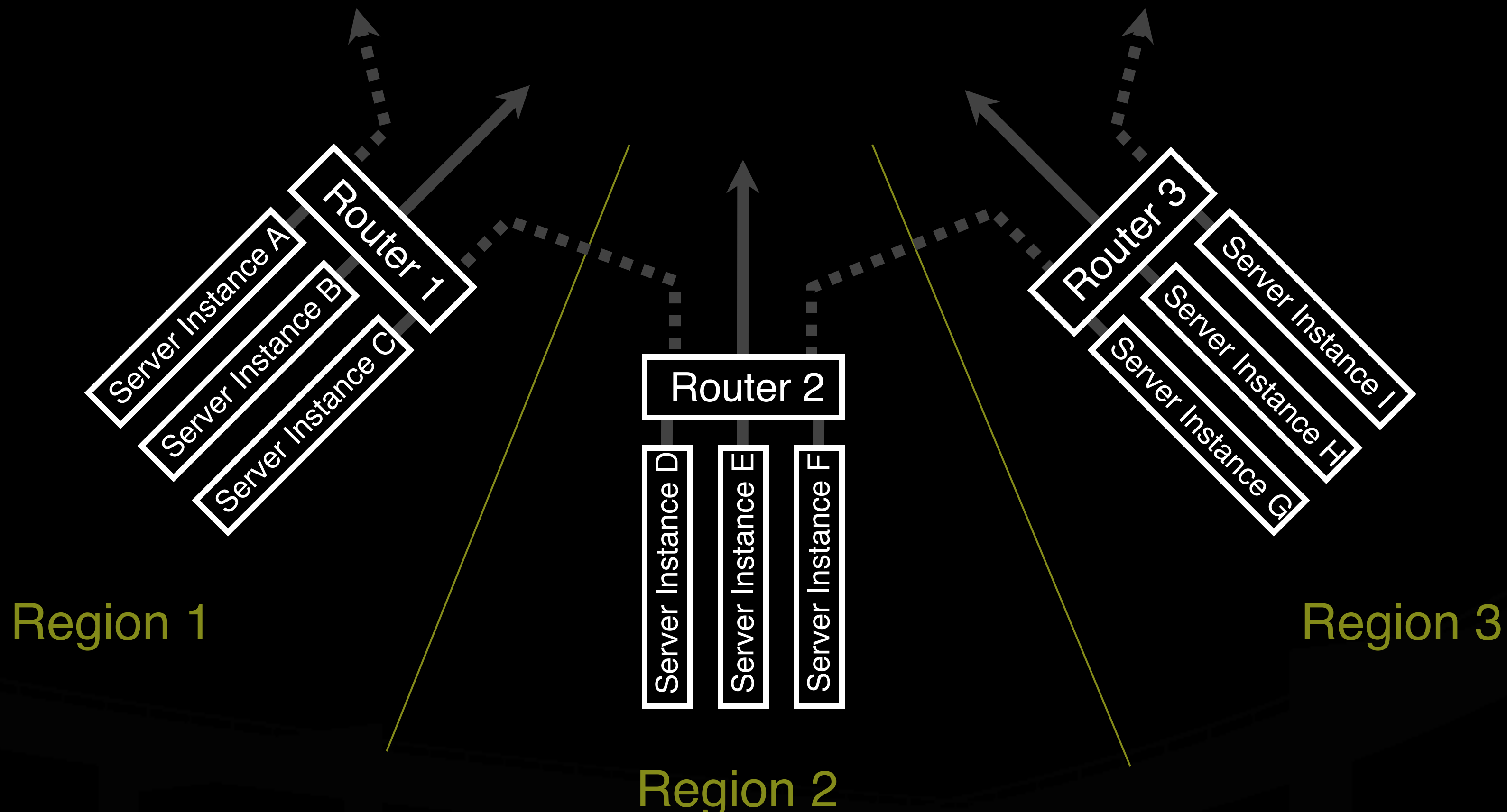
Building a Global Network of Clusters

- Once a cluster architecture has been established, additional clusters can be added to gain performance.
- Load distribution, fail-over between clusters, and content synchronization become the principal engineering concerns.

Example


Router 1
Server Instance A
Server Instance B
Server Instance C
Router 2
Server Instance D
Server Instance E
Server Instance F
Router 3
Server Instance G
Server Instance H
Server Instance I

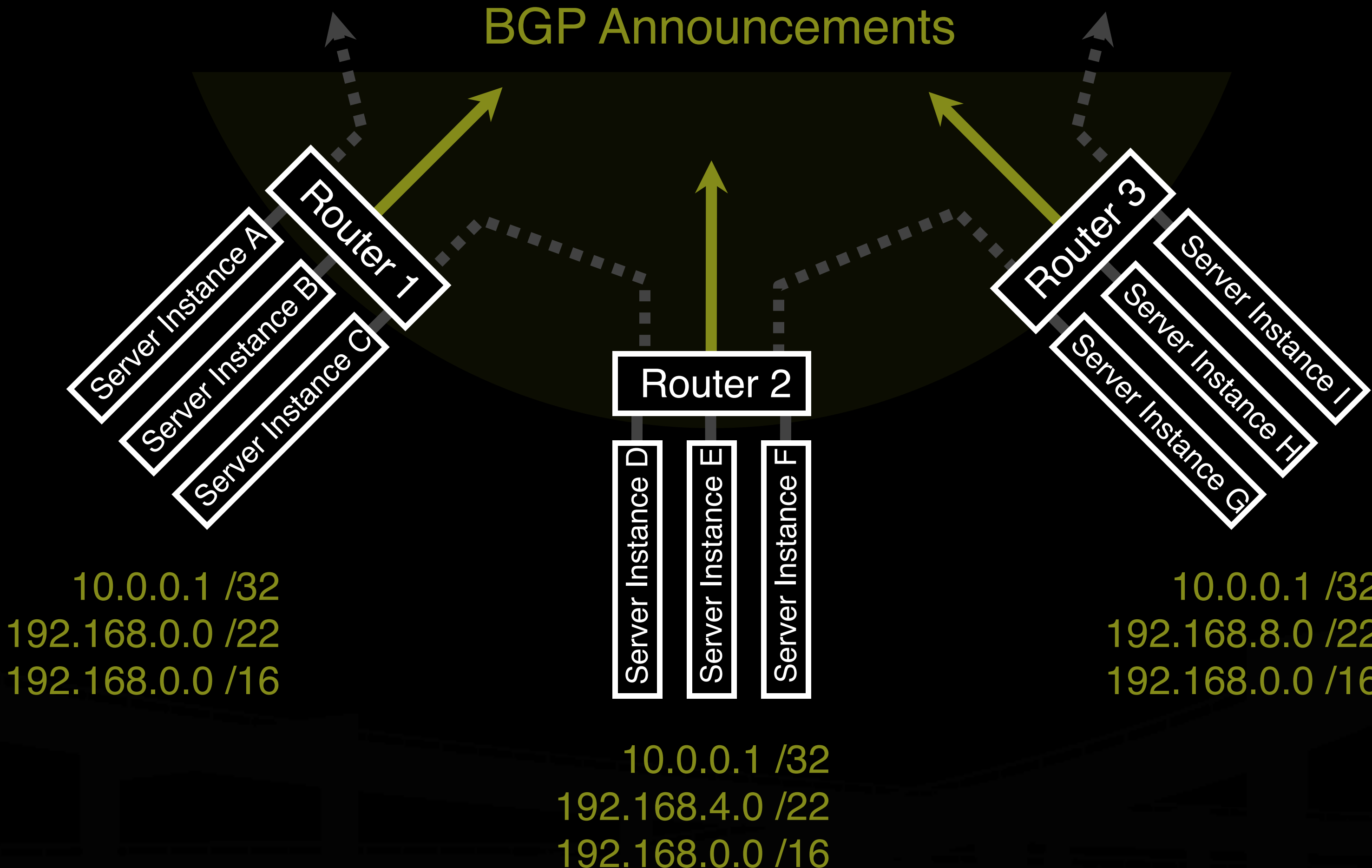
Example



Router 1
Server Instance A
Server Instance B
Server Instance C
Router 2
Server Instance D
Server Instance E
Server Instance F
Router 3
Server Instance G
Server Instance H
Server Instance I
Region 1
Region 2
Region 3

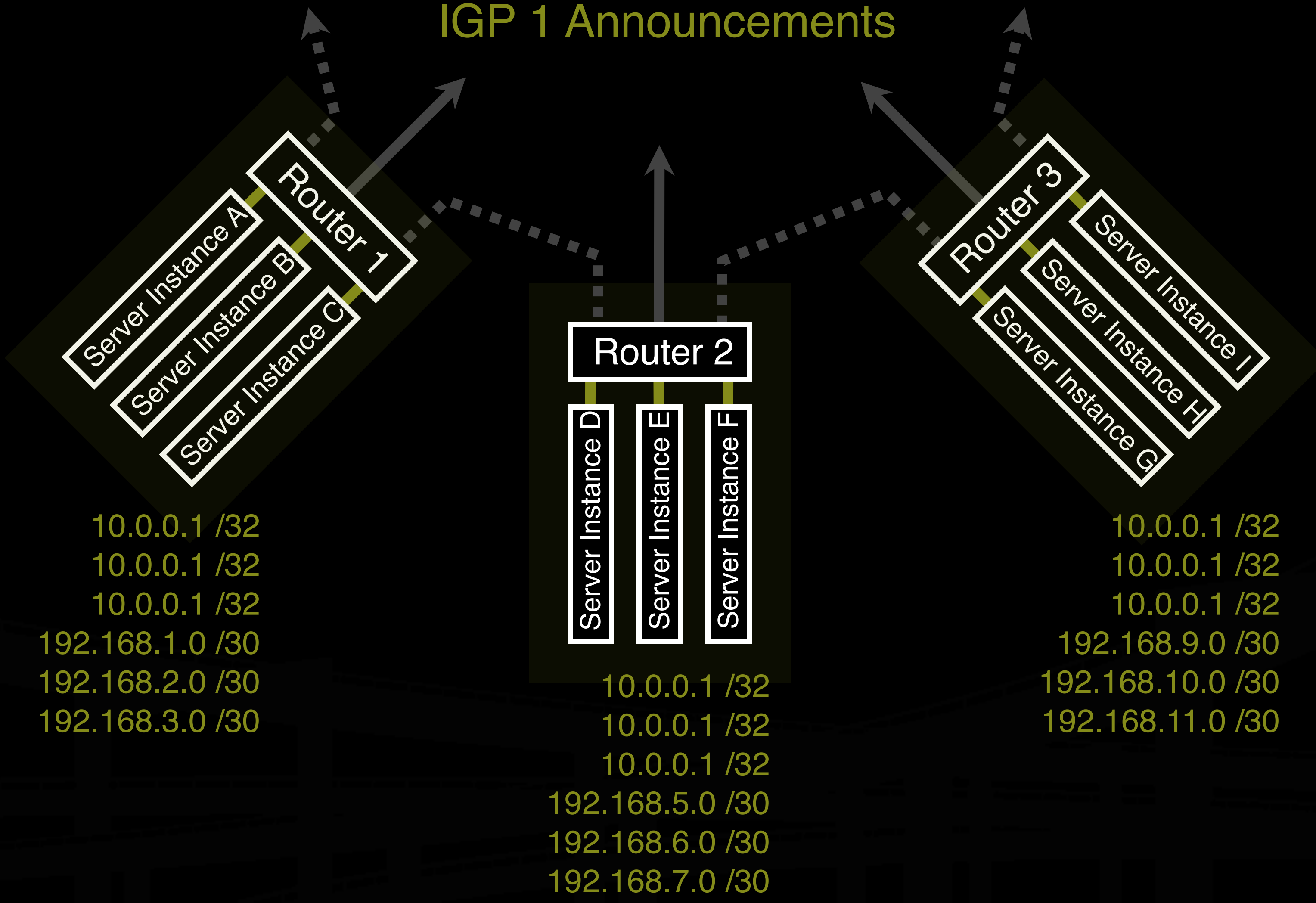
Example

BGP Announcements



Example

IGP 1 Announcements



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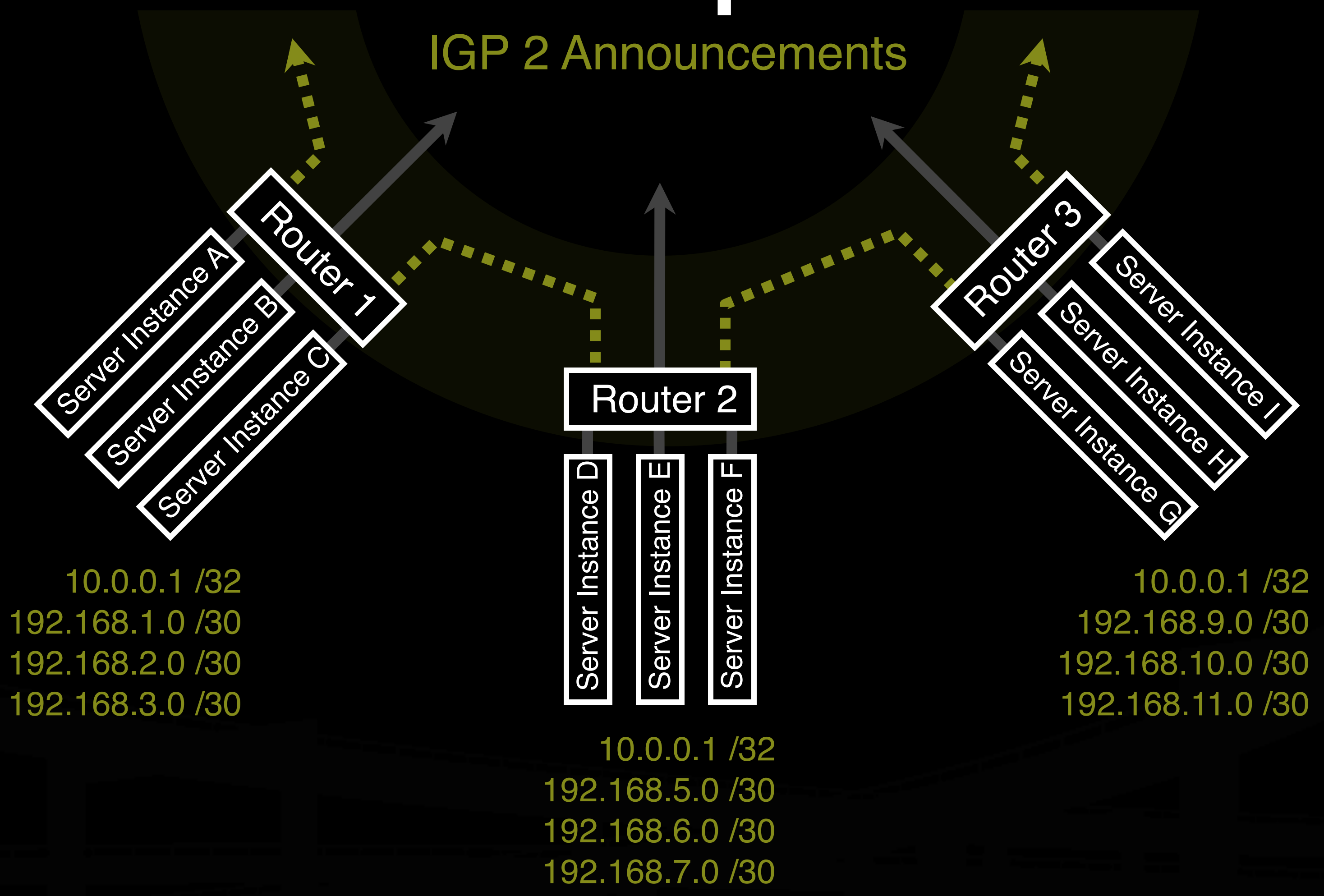
Example



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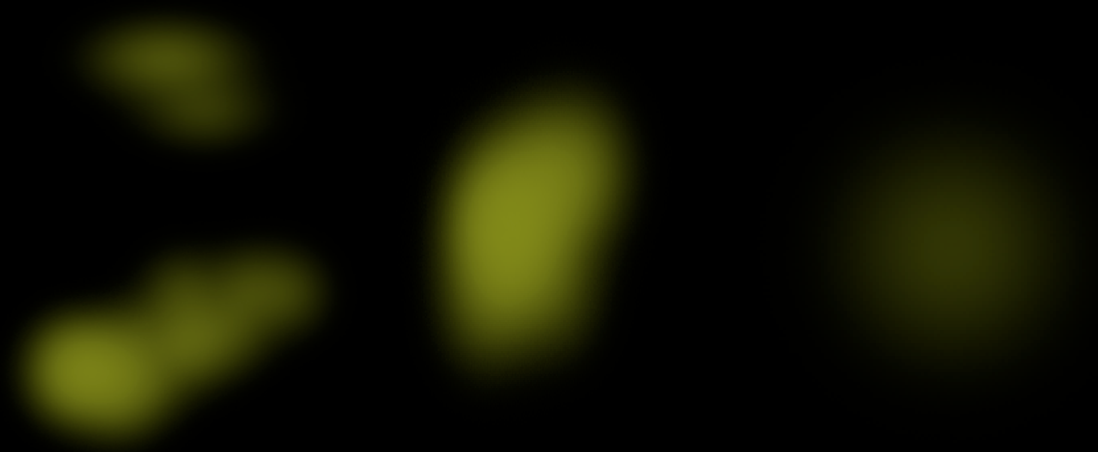
Performance-Tuning Anycast Networks

- Server deployment in anycast networks is always a tradeoff between absolute cost and efficiency.
- The network will perform best if servers are widely distributed, with higher density in and surrounding high demand areas.
- Lower initial cost sometimes leads implementers to compromise by deploying more servers in existing locations, which is less efficient.

Example

Geographic plot of user population density



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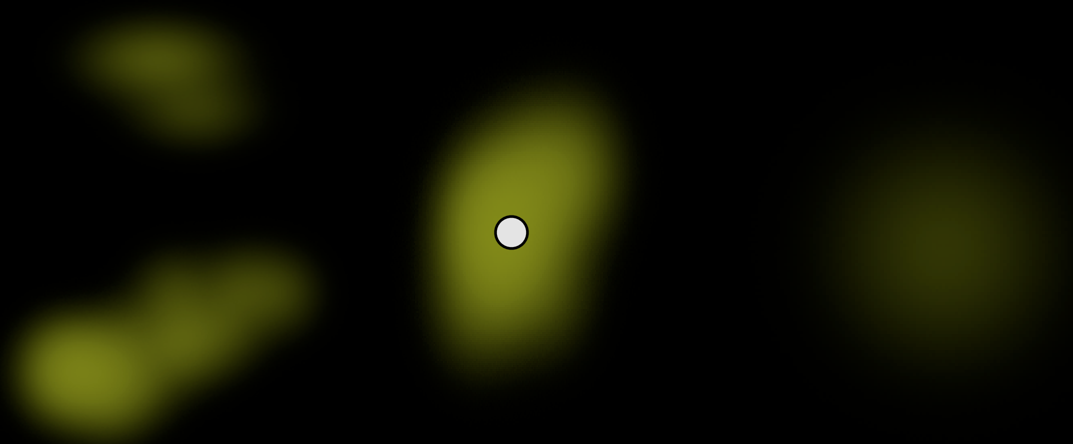
Geographic plot of user population density



Server deployment

Example

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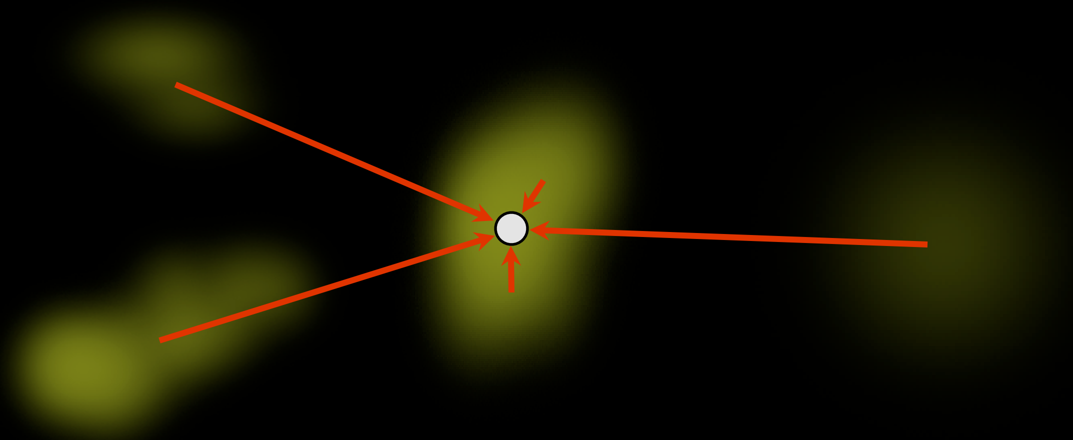
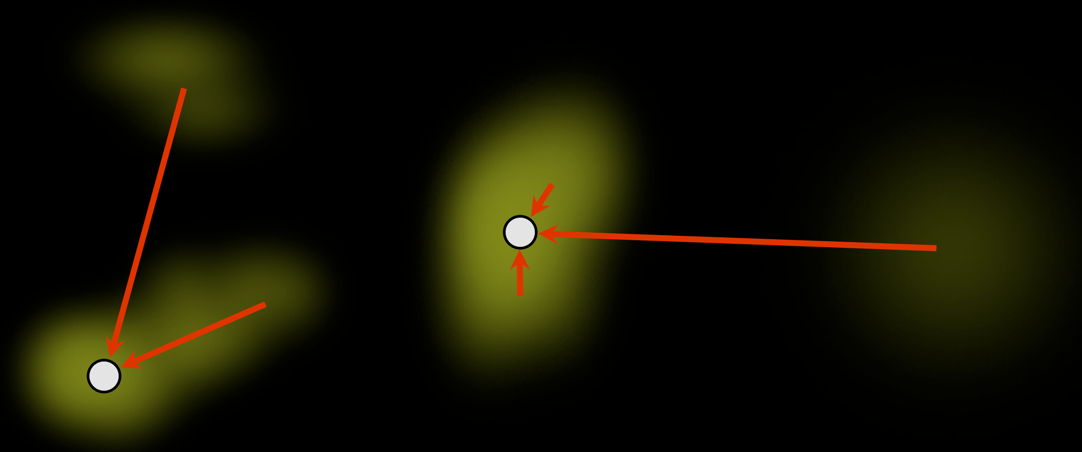


Server deployment

Traffic Flow

Example

Geographic plot of user population density

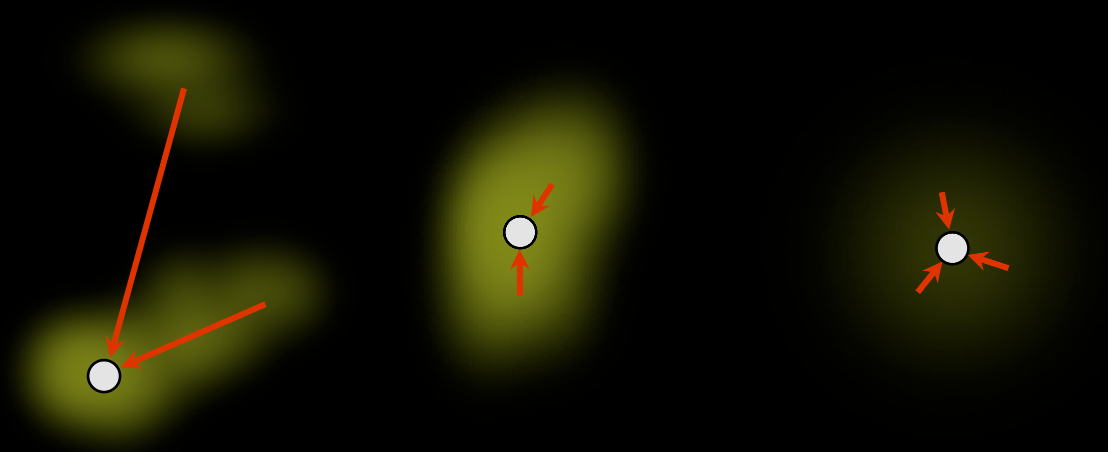


Server deployment

Traffic Flow

Example

Geographic plot of user population density

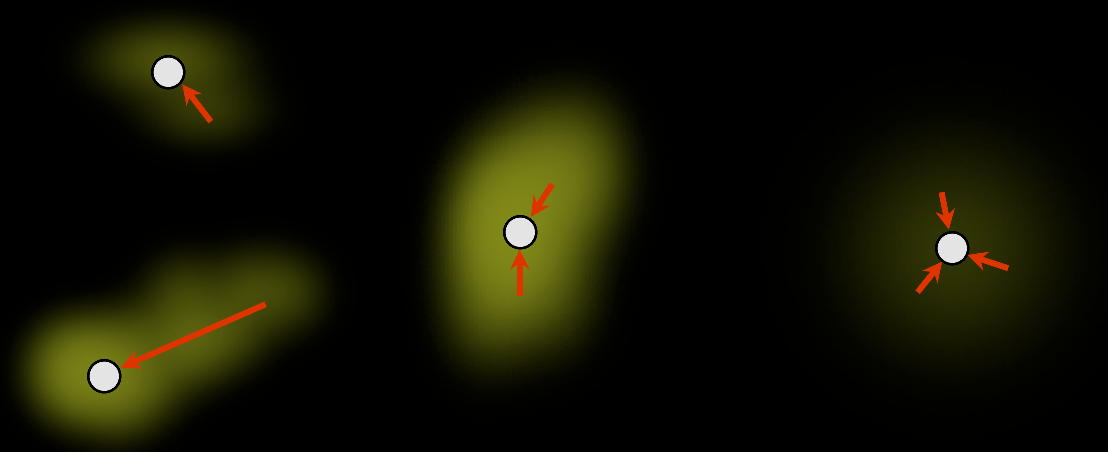


Server deployment

Traffic Flow

Example

Geographic plot of user population density

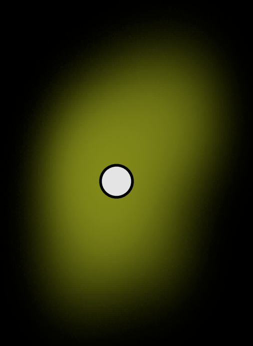


Server deployment

Traffic Flow

Example

Drawing traffic growth away from a hot-spot



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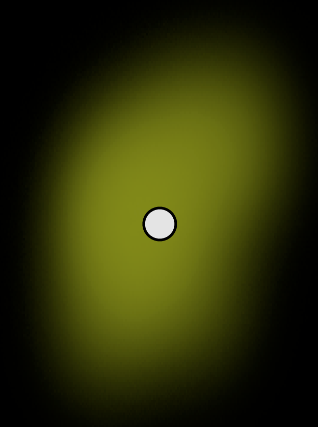

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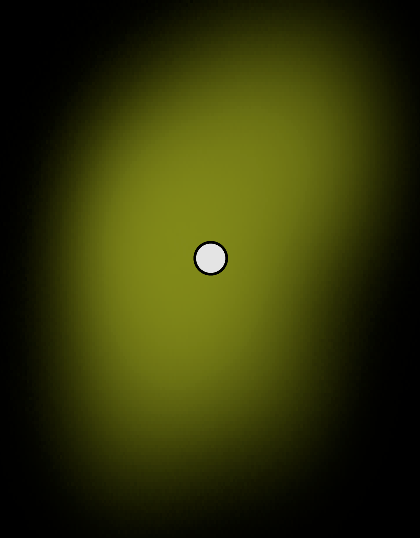

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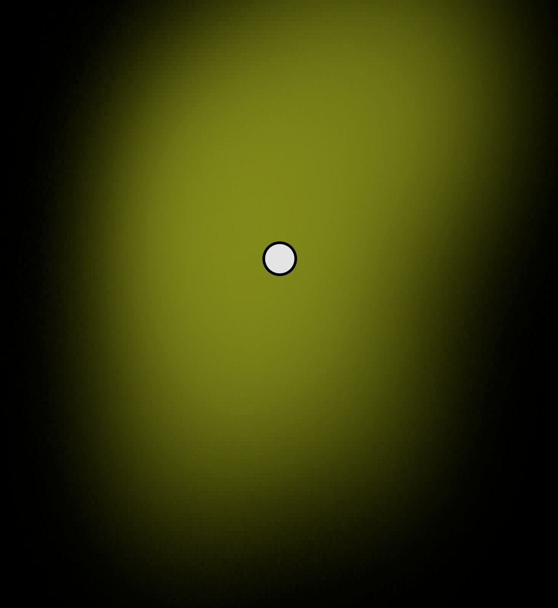

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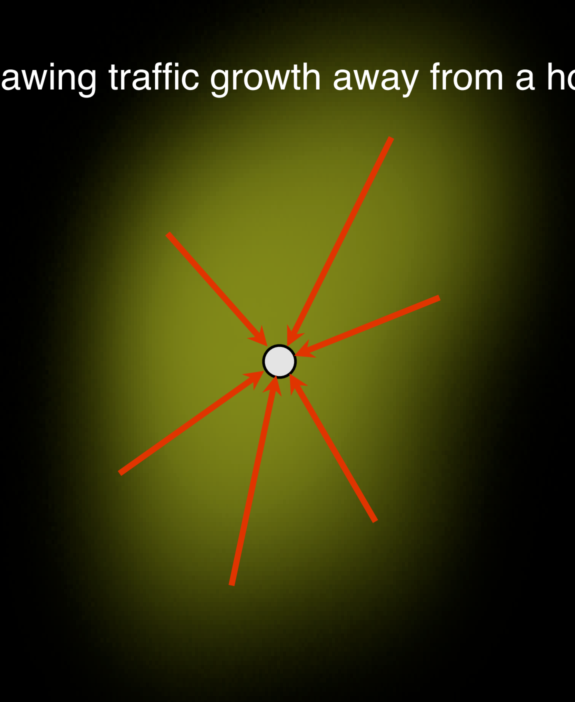

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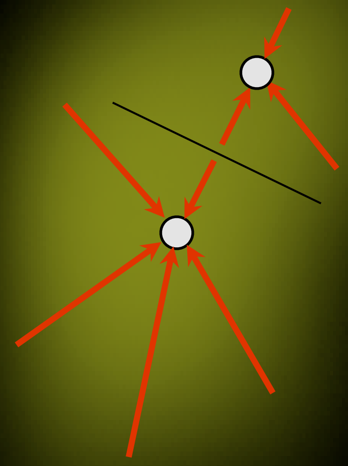

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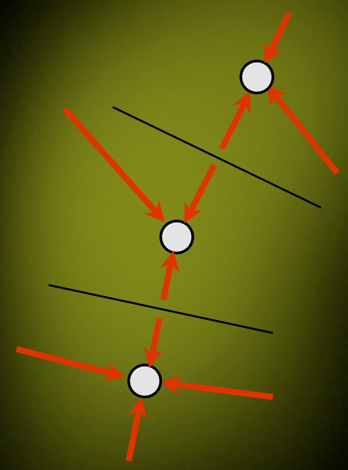

Caveats and Failure Modes

- DNS resolution fail-over
- Long-lived connection-oriented flows
- Identifying which server is giving an end-user trouble

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DNS Resolution Fail-Over

- In the event of poor performance from a server, DNS servers will fail over to the next server in a list.
- If both servers are in fact hosted in the same anycast cloud, the resolver will wind up talking to the same instance again.
- Best practices for anycast DNS server operations indicate a need for two separate overlapping clouds of anycast servers.

Long-Lived Connection-Oriented Flows

- Long-lived flows, typically TCP file-transfers or interactive logins, may occasionally be more stable than the underlying Internet topology.
- If the underlying topology changes sufficiently during the life of an individual flow, packets could be redirected to a different server instance, which would not have proper TCP state, and would reset the connection.
- This is not a problem with web servers unless they're maintaining stateful per-session information about end-users, rather than embedding it in URLs or cookies.
- Web servers HTTP redirect to their unique address whenever they need to enter a stateful mode.
- Limited operational data shows underlying instability to be on the order of one flow per ten thousand per hour of duration.

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Identifying Problematic Server Instances

- Some protocols may not include an easy in-band method of identifying the server which persists beyond the duration of the connection.
- Traceroute always identifies the ***current*** server instance, but end-users may not even have traceroute.

A Security Ramification

- Anycast server clouds have the useful property of sinking DOS attacks at the instance nearest to the source of the attack, leaving all other instances unaffected.
- This is still of some utility even when DOS sources are widely distributed.

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www.pch.net/documents/tutorials/anycast