Keeping the Balance
Load balancing Demystified

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SREcon Americas 2019
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Lapsed computer scientist, turned network engineer, turned network SRE, turned storage SRE.
Some years at Google, with some sailing in the middle.

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Software engineer, SRE, network SRE.
Worked on Google’s edge network, among other things there.
Now at Slack.
Why talk about loadbalancing?

- LB failures are often dropped requests
- It's always in your serving path
- Huge impact on the performance and resiliency of your application
  - For better or for worse
Edge routers advertise 203.0.113.0/24 to the Internet via BGP.
<table>
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Edge routers advertise 203.0.113.0/24 to the Internet via BGP.
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Cached:
Superbowls.com → 203.0.113.21

Superbowls.com → 203.0.113.20
Aside: TTL tradeoffs
DNS TTL tradeoffs

- Long TTLs:
  - Many of your users will not see any change you make for a long period of time
- Very short TTLs:
  - Higher load on DNS infrastructure
  - Clients have to query DNS more often - adds latency
  - If DNS experiences any unavailability, a higher proportion of your users will be affected
  - Many clients will ignore very short TTLs anyway
Back to our story
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<td>Delayed</td>
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Edge routers advertise 203.0.113.0/24 to the Internet via BGP.

Superbowls.com → 203.0.113.200

DNS

192.168.0.20
192.168.0.21
Source address
Source port
Destination address
Destination port
Protocol

Hash of 5-tuple

Selected backend
Edge routers advertise 203.0.113.0/24 to the Internet via BGP.

Superbowls.com → 203.0.113.200

DNS

192.168.0.20
192.168.0.21
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Aside: network load balancing
Stateless network load distribution
Stateless network load distribution

- Availability
Stateless network load distribution

- Availability
Stateless network load distribution

- Availability
Stateless network load distribution
Stateless network load distribution

- Capacity
Network Load Balancing

192.168.0.20

192.168.0.21

203.0.113.200
Network Load Balancing - Proxy

- Inbound and outbound traffic through load balancer.
- Requires state in load balancer
- LB backends can be anywhere in your network.
Network Load Balancing - DSR

- Direct service return
- Inbound path through load balancer
- Outbound path direct, bypassing load balancer
Network Load Balancing - L2DSR

- Load balancer and all backends on the same (layer 2, Ethernet) network.
- Service VIP is still .200.
Network Load Balancing - L3DSR

- Load balancer and all backends on the different networks.
- Service VIP is still 200.

203.0.113.200

192.168.2.20
192.168.50.9
Network Load Balancing - L3DSR

- Internet → loadbalancer (black)
  - Src IP: <user public IP>
  - Dst IP 203.0.113.200 (VIP)
- (MAC addresses not relevant this time)
Network Load Balancing - L3DSR

- Loadbalancer → backend (red)
  - Src IP: <load balancer private IP>
  - Dst IP: 192.168.2.20
  - <Encap header> (GRE/IP-IP)
  - Src IP: <user public IP>
  - Dst IP 203.0.113.200 (VIP)
- Request IP header preserved.
- Backends need to be able to decapsulate.
- Careful about MTU!
Network Load Balancing - L2DSR

- Loadbalancer → backend (blue)
  - Src IP 203.0.113.200 (VIP)
  - Dst IP: <user public IP>
Back to our story
superbowls.com -> 203.0.113.200
Anycast

- It's not loadbalancing.
- What is it?
  - Same address, multiple locations.
  - Network decides where to route each packet.
  - No concept of balancing; still just load distribution
- Caveats
  - Monitoring is hard
  - Capacity planning is hard
  - Cascading failure is easy.
- See Murali’s previous talk at SRECon EMEA 2017
superbowl.com -> 203.0.113.200, 198.51.100.200
Geo-aware DNS

superbowls.com -> 203.0.113.200, 198.51.100.200
Aside: the perils of DNS geo loadbalancing
Problems with geographic balancing

- Internet addressing scheme wasn’t designed to support this
- Blocks of addresses move
- Recursive resolution: the source IP that your DNS sees may not be close to the end user
- Inevitably involves a lot of messing about configuring exceptions or cleaning data - toil
**EDNS0 extension: client subnet**

- Extends DNS with information about the network that originated a query
- Also lets the authoritative nameserver specify the network that the response is intended for
- Implemented by OpenDNS and Google Public DNS
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<td>Point to apply rate limiting and load-shedding</td>
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Layer 7 load balancing

- AKA application loadbalancing, or a reverse proxy
- Terminates the connection from the user, make requests to one or more backend servers, and then returns responses to the user
- Understands the structure of the request -> only kind of balancers that can distribute load based on a cookie, or a parameter or similar
Edge routers advertise 203.0.113.0/24 to the Internet via BGP.
DNS -> Edge routers

Edge routers -> L4 balancer

L4 balancer -> L7 balancer Service Foo, L7 balancer Service Bar

Service Foo, Service Bar -> Servers
Layer 7 load balancing - scalability

- Resources will be held on the LBs for the duration of user requests
- A L7 balancer crashing will be seen by users
  - L4 can often fail transparently
- L7 balancers can retry a request that failed on one of its backends
- Will add more latency to a request than L4 balancers
Layer 7 load balancing - reliability

- Can be load aware
- Rate limiting and load shedding
- Line of defence against application-layer DoS attacks
- Produces much better telemetry than a L4 balancer can
Loadbalancing algorithms

- Balancing in a single pool of backends
  - Stateless hashing
  - Round robin
  - Least-loaded, shortest queue and similar
  - Weighted round robin
  - Probation
  - Choice of 2
- Multiple pools of backends
  - Priority/failover
  - Nearest by location
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Takeaways

● What do you want from your systems?
  ○ More capacity? Higher availability? Higher utilisation?
  ○ Finer grained control?
  ○ More instrumentation and monitoring?

● What constraints do you have?
  ○ Do you trust your clients?
  ○ Do you control your whole stack?
Links

- Google’s maglev paper
- Facebook Katran
- HAProxy
- ucarp
- Google SRE Book loadbalancing chapter
- EDNS0 client subnet RFC
- Summary of Facebook’s Billion User Loadbalancing talk
- Google’s GFS and Bigtable papers
- gRPC load balancing
- Istio, Linkerd
  - Monzo talk on using Linkerd + Kubernetes in production
Loadbalancing has evolved hugely in the last decade.

What do you want from your systems?
  - More capacity? Higher availability? Higher utilisation?
  - Finer grained control? More instrumentation and monitoring?

What constraints do you have?
  - Do you trust your clients?
  - Do you control all layers of your stack?

See the talk slides for more.