gRPC Load Balancing

By **makdharma** (Google) | Thursday, June 15, 2017

This post describes various load balancing scenarios seen when deploying gRPC. If you use gRPC with multiple backends, this document is for you.

A large scale gRPC deployment typically has a number of identical back-end instances, and a number of clients. Each server has a certain capacity. Load balancing is used for distributing the load from clients optimally across available servers.

Why gRPC?

gRPC is a modern RPC protocol implemented on top of HTTP/2. HTTP/2 is a Layer 7 (Application layer) protocol, that runs on top of a TCP (Layer 4 - Transport layer) protocol, which runs on top of IP (Layer 3 - Network layer) protocol. gRPC has many advantages over traditional HTTP/REST/JSON mechanism such as

1. Binary protocol (HTTP/2)
2. Multiplexing many requests on one connection (HTTP/2)
3. Header compression (HTTP/2)
4. Strongly typed service and message definition (Protobuf)
5. Idiomatic client/server library implementations in many languages

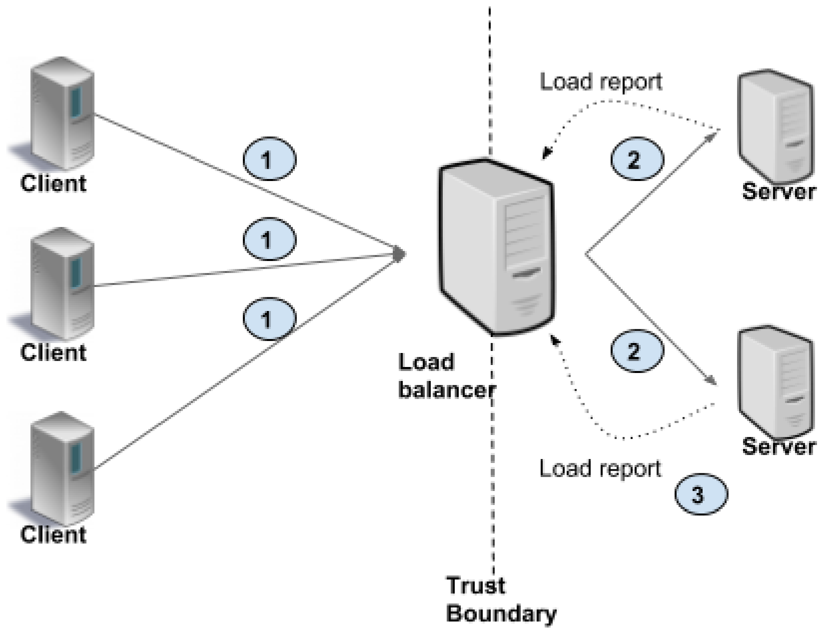
In addition, gRPC integrates seamlessly with ecosystem components like service discovery, name resolver, load balancer, tracing and monitoring, among others.

Load balancing options

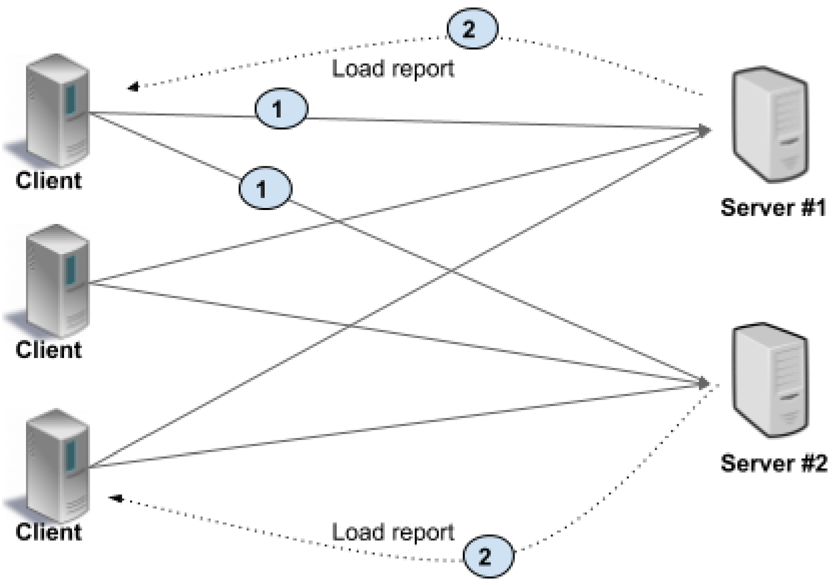
Proxy or Client side?

Note: Proxy load balancing is also known as server-side load balancing in some literature.

Deciding between proxy versus client-side load balancing is a primary architectural choice. In Proxy load balancing, the client issues RPCs to the a Load Balancer (LB) proxy. The LB distributes the RPC call to one of the available backend servers that implement the actual logic for serving the call. The LB keeps track of load on each backend and implements algorithms for distributing load fairly. The clients themselves do not know about the backend servers. Clients can be untrusted. This architecture is typically used for user facing services where clients from open internet can connect to servers in a data center, as shown in the picture below. In this scenario, clients make requests to LB (#1). The LB passes on the request to one of the backends (#2), and the backends report load to LB (#3).



In Client side load balancing, the client is aware of multiple backend servers and chooses one to use for each RPC. The client gets load reports from backend servers and the client implements the load balancing algorithms. In simpler configurations server load is not considered and client can just round-robin between available servers. This is shown in the picture below. As you can see, the client makes request to a specific backend (#1). The backends respond with load information (#2), typically on the same connection on which client RPC is executed. The client then updates its internal state.



The following table outlines the pros and cons of each model.

	Proxy	Client Side
Pros	• Simple client • No client-side awareness of backend • Works with untrusted clients	• High performance because elimination of extra hop
Cons	• LB is in the data path • Higher latency • LB throughput may limit scalability	• Complex client • Client keeps track of server load and health • Client implements load balancing algorithm • Per-language implementation and maintenance burden • Client needs to be trusted, or the trust boundary needs to be handled by a lookaside LB.

Proxy Load Balancer options

Proxy load balancing can be L3/L4 (transport level) or L7 (application level). In transport level load balancing, the server terminates the TCP connection and opens another connection to the backend of choice. The application data (HTTP/2 and gRPC frames) are simply copied between the client connection to the backend connection. L3/L4 LB by design does very little processing, adds less latency compared with L7 LB, and is cheaper because it consumes fewer resources.

In L7 (application level) load balancing, the LB terminates and parses the HTTP/2 protocol. The LB can inspect each request and assign a backend based on the request contents. For example, a session cookie sent as part of HTTP header can be used to associate with a specific backend, so all requests for that session are served by the same backend. Once the LB has chosen an appropriate backend, it creates a new HTTP/2 connection to that backend. It then forwards the HTTP/2 streams received from the client to the backend(s) of choice. With HTTP/2, LB can distribute the streams from one client among multiple backends.

L3/L4 (Transport) vs L7 (Application)

Use case	Recommendation
RPC load varies a lot among connections	Use Application level LB
Storage or compute affinity is important	Use Application level LB and use cookies or similar for routing requests to correct backend
Minimizing resource utilization in proxy is more important than features	Use L3/L4 LB
Latency is paramount	Use L3/L4 LB

Client side LB options

Thick client

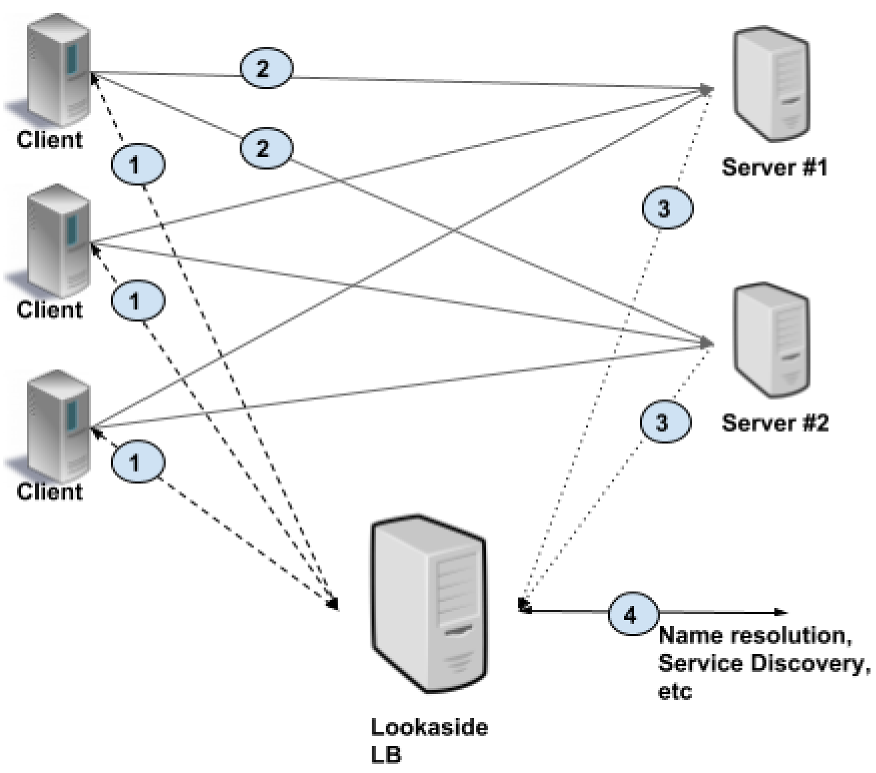
A thick client approach means the load balancing smarts are implemented in the client. The client is responsible for keeping track of available servers, their workload, and the algorithms used for choosing servers. The client typically integrates libraries that communicate with other infrastructures such as service discovery, name resolution, quota management, etc.

Lookaside Load Balancing

Note: A lookaside load balancer is also known as an external load balancer or one-arm load balancer

With lookaside load balancing, the load balancing smarts are implemented in a special LB server. Clients query the lookaside LB and the LB responds with best server(s) to use. The heavy lifting of keeping server state and implementation of LB algorithm is consolidated in the lookaside LB. Note that client might choose to implement simple algorithms on top of the sophisticated ones implemented in the LB. gRPC defines a protocol for communication between client and LB using this model. See Load Balancing in gRPC doc for details.

The picture below illustrates this approach. The client gets at least one address from lookaside LB (#1). Then the client uses this address to make a RPC (#2), and server sends load report to the LB (#3). The lookaside LB communicates with other infrastructure such as name resolution, service discovery, and so on (#4).



Recommendations and best practices

Depending upon the particular deployment and constraints, we suggest the following.

Setup	Recommendation
• Very high traffic between clients and servers • Clients can be trusted	• Thick client-side load balancing • Client side LB with ZooKeeper/Etcd/Consul/Eureka. [ZooKeeper example].
• Traditional setup - Many clients connecting to services behind a proxy • Need trust boundary between servers and clients	• Proxy Load Balancing • L3/L4 LB with GCLB (if using GCP) • L3/L4 LB with haproxy - [config file] • Nginx coming soon • If need session stickiness - L7 LB with Envoy as proxy
• Microservices - N clients, M servers in the data center • Very high performance requirements (low latency, high traffic) • Client can be untrusted	• Look-aside Load Balancing • Client-side LB using [gRPC-LB protocol]. Roll your own implementation (Q2'17), hosted gRPC-LB in the works.
• Existing Service-mesh like setup using Linkerd or Istio	• Service Mesh • Use built-in LB with [Istio], or [Envoy].

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