GRPC

gRPC

- Multi-language RPC for Web Services
- PL-independent IDL
- Generate PL-specific bindings
- Protocol buffers

Principles (1/2)

- Services not Objects,
  Messages not References
  - Fallacies of ignoring network
  - Pitfalls of distributed objects
- Interoperable
- Layered
  - Ex: authentication layer
- Payload agnostic
  - JSON, XML, Thrift, protocol buffers, etc

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Principles (2/2)

- Streaming
- Blocking and Non-blocking
- Lameducking
- Flow Control
- Pluggable
  - security, load-balancing, failover, health-checking
- Meta-data Exchange
- Standardized Status Codes

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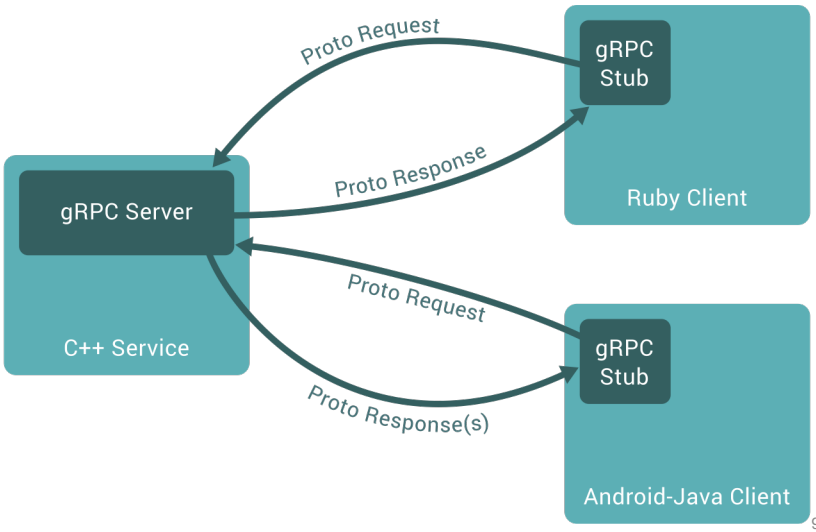
gRPC



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HTTP/1.1

- Connections vs requests
- Keep connections alive for further requests
- Head-of-line blocking

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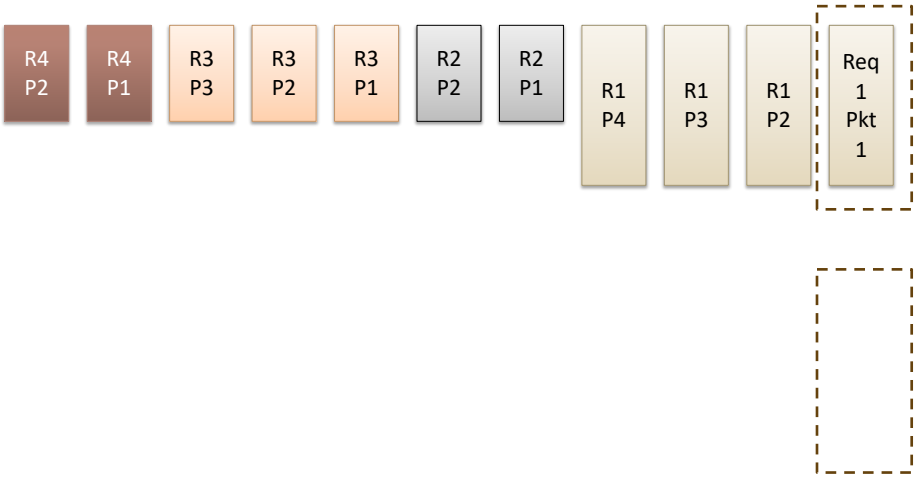
HTTP/1.1: Head of Line Blocking



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HTTP/2

- Semantic layer above connections
- Streams and frames
- Concurrent streams over a connection

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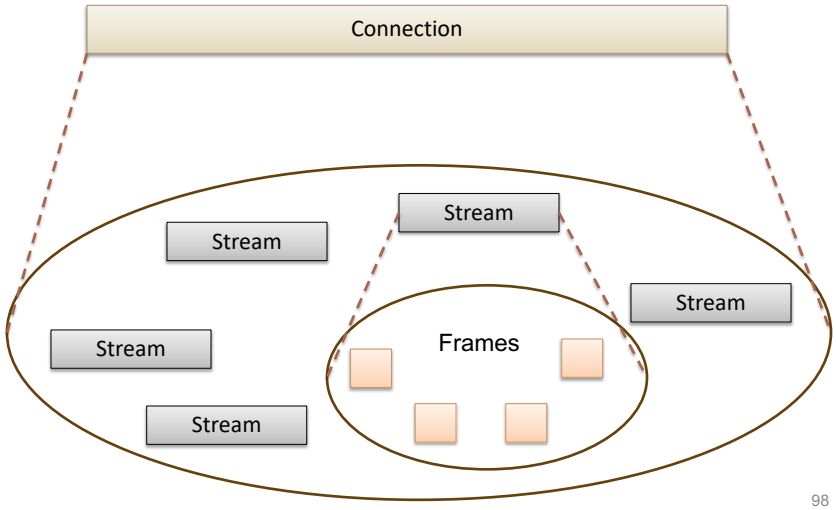
HTTP/2: Streams and Frames



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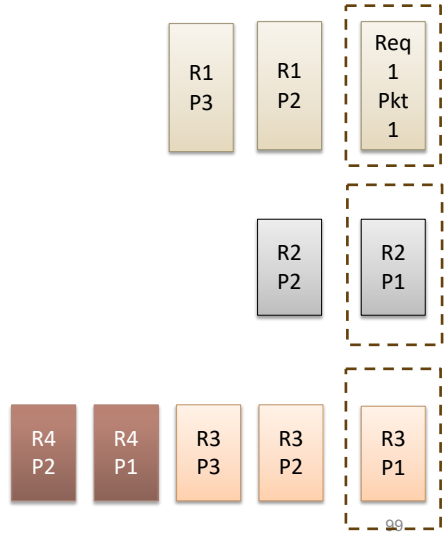
HTTP/2: Concurrency via Streaming



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HTTP/2

- Semantic layer above connections
- Streams and frames
- Concurrent streams over a connection
- Flow Control
  - Clients sharing connection
  - Client gives sender a "budget" (buffer space)
- Smarter Proxies
  - Create min # of connections based on BDP
  - Load balancing across streams, etc

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HTTP/2

- Semantics around graceful close
  - GOAWAY control frame
- Header compression
- Server push
- Pinging
- Stream priority

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gRPC Semantics

- Channels
- Remote Procedure Calls (RPCs)
- Messages

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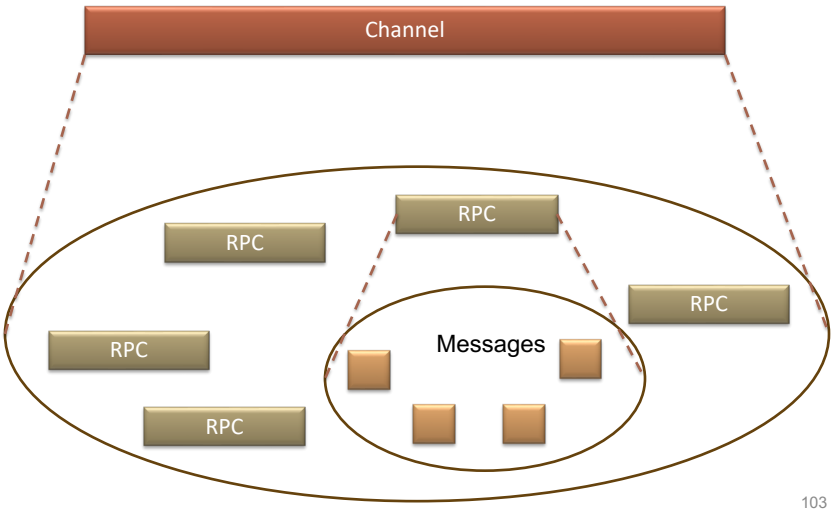
gRPC: RPCs and Messages



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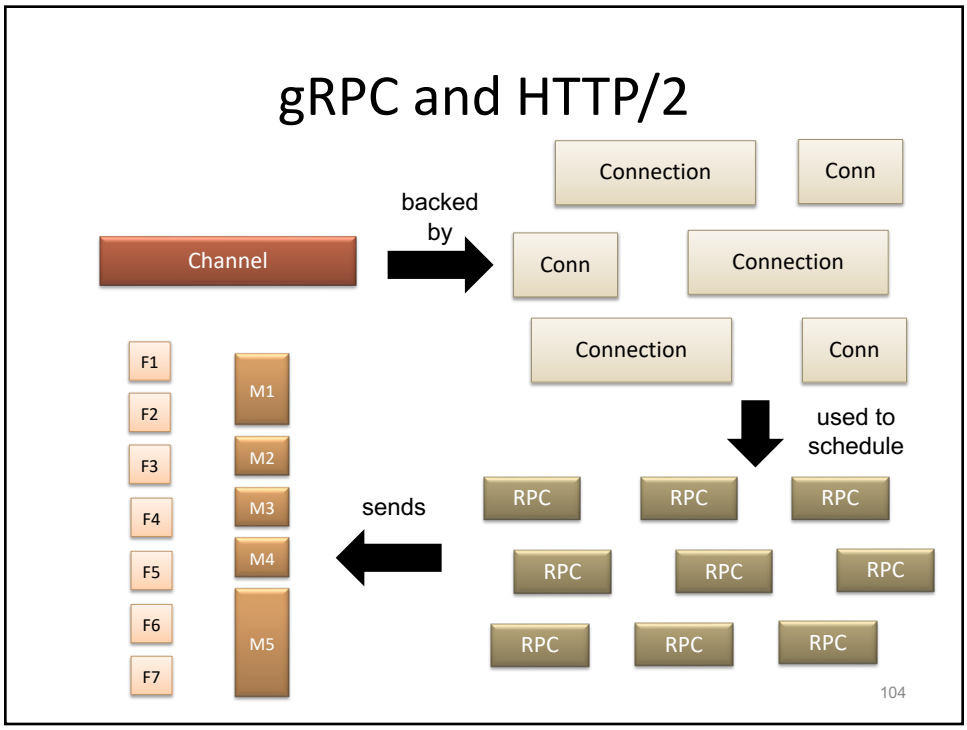
gRPC and HTTP/2
Connection
Conn
backed by
Channel
Conn
Connection
Connection
Conn
used to schedule
F1
F2
F3
F4
F5
F6
F7
M1
M2
M3
M4
M5
sends
RPC
RPC
RPC
RPC
RPC
RPC
RPC
RPC
RPC
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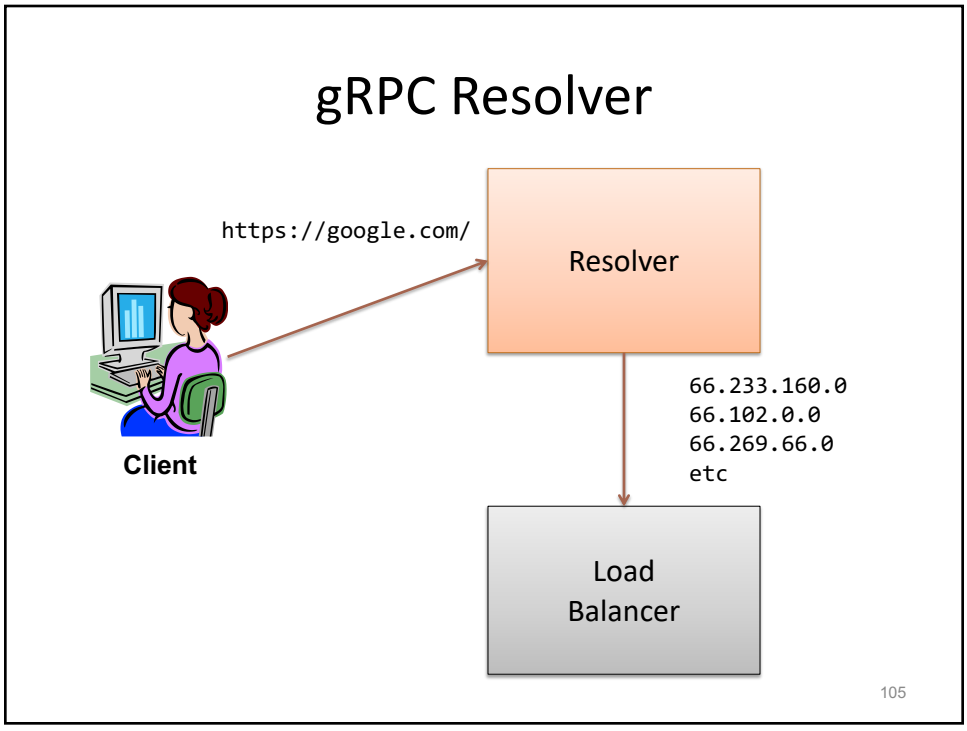
gRPC Resolver
https://google.com/
Resolver
66.233.160.0
66.102.0.0
66.269.66.0
etc
Client
Load Balancer
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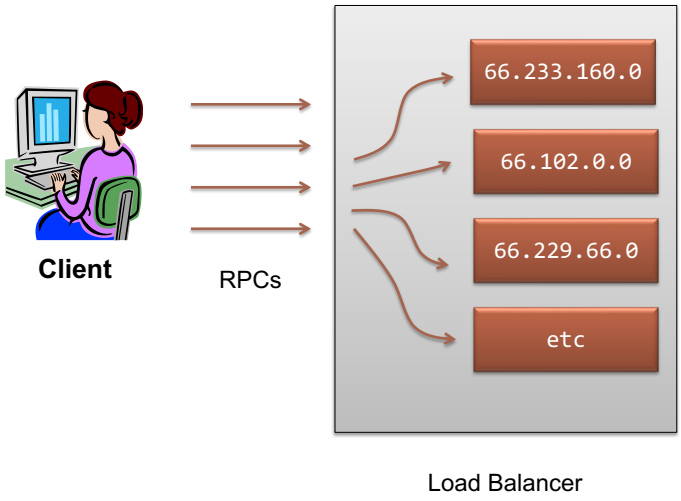
gRPC Load Balancer



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gRPC Connection Management

- Multiple streams over shared connection
- Stream multiplexed over several connections
- Connection failure:
  - Load balancer reconnects using known addresses
  - Resolver re-resolves addresses
- Detecting failed connections
  - Clean failure: TCP FIN
  - Endpoint failure: HTTP/2 PING frames
  - PING frames keep connection alive for proxies

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Messages

- Define message format:

```
message Person {
   string name = 1;
   int32 id = 2;
   bool has_ponycopter = 3;
}
```

- Compile using **proto** compiler

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Service

```
service Greeter {
  // Sends a greeting
  rpc SayHello (HelloRequest) returns (HelloReply) {}
}

message HelloRequest {
  string name = 1;
}

message HelloReply {
  string message = 1;
}
```

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RPC Styles

- Unary RPC

```
rpc SayHello(HelloRequest)
returns (HelloResponse);
```

- Server Streaming

```
rpc LotsOfReplies(HelloRequest)
returns (stream HelloResponse);
```


RPC Styles

- Client Streaming

```
rpc LotsOfGreetings(stream HelloRequest)
returns (HelloResponse);
```

- Bidirectional Streaming

```
rpc BidiHello(stream HelloRequest)
returns (stream HelloResponse);
```

gRPC Features

- Synchronous vs Asynchronous
- Deadlines/Timeouts
  - timeouts (duration of time)
  - deadlines (points in time)
- Termination
  - Independent on client and server
- Cancellation
  - No rollback
- Metadata
  - Name-value pairs
- Channels
  - Channel state (idle, running), compression

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PROTOCOL BUFFERS

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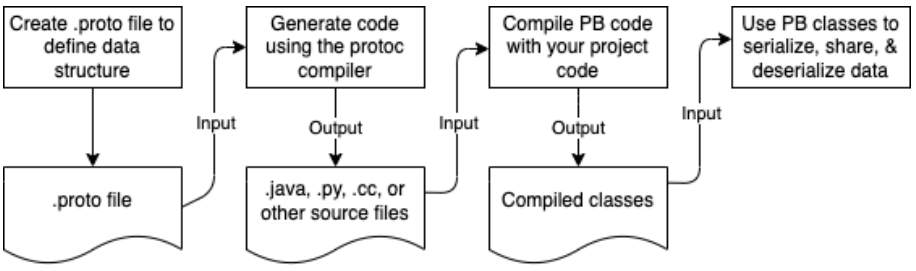
Protocol Buffers

- Alternative to JSON
  - Protocol buffer data definition language
  - Compiler
  - Runtime library
  - Runtime data formats

Protocol Buffers Workflow



Example

- Proto file

```
syntax = "proto3";
message Person {
  optional string name = 1;
  optional int32 id = 2;
  optional string email = 3;
}
```

- Usage

```
Person john = Person.newBuilder()
    .setId(1234)
    .setName("John Doe")
    .setEmail("jdoe@example.com")
    .build();
output = new FileOutputStream(args[0]);
john.writeTo(output);
```

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Protocol Buffer Definitions

- Field numbers (unique)
- Field properties:
  - optional
  - repeated
- Field types:
  - scalar (int32, int64, float, double, bool, string, etc)
  - enumeration
  - message (nested)
  - map

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Protocol Buffer Advantages

- Language independence
- Compact storage
- Fast parsing

- Forward and backward compatibility
  - Addition of fields
  - Deletion of fields

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Protocol Buffer Limitations

- Entire message fits in memory
- Different serialization formats
- Messages are not compressed
- Not efficient for scientific
  - multi-dimensional arrays of floating point
- Not self-describing
  - use reflection with .proto file
- Not an industry standard

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USING GRPC

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Service

```
service Greeter {
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}

message HelloRequest {
  string name = 1;
}

message HelloReply {
  string message = 1;
}
```

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Server

```
class ServerStub extends GreeterGrpc.GreeterImplBase {

  @Override
  public void sayHello(HelloRequest req,
                       StreamObserver<HelloReply> obs) {









  }
}
```

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Stream Observer

```
public interface StreamObserver<T> {
   void onNext(T value);
   void onComplete();
   void onError(Throwable e);
}
```

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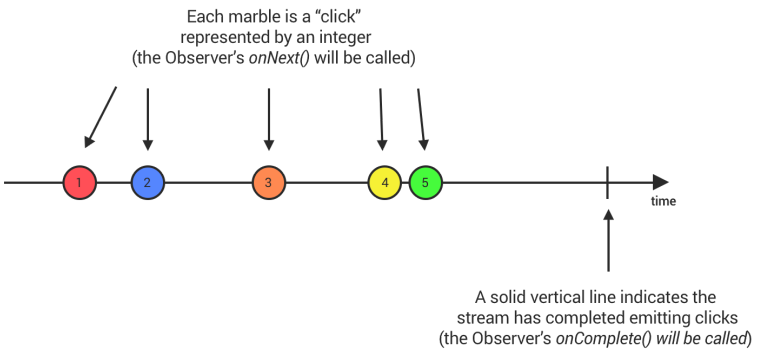
Marble Diagrams



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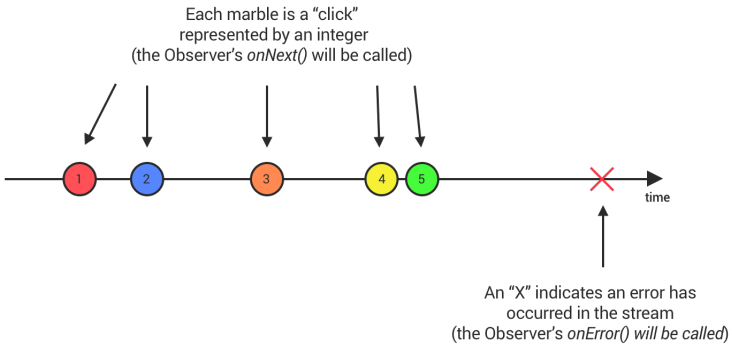
Marble Diagrams



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Server

```
class ServerStub extends GreeterGrpc.GreeterImplBase {

  @Override
  public void sayHello(HelloRequest req,
                       StreamObserver<HelloReply> obs) {
    HelloReply reply =
       HelloReply.newBuilder()
                 .setMessage("Hello " + req.getName())
                 .build();
    responseObserver.onNext(reply);
    responseObserver.onCompleted();
  }
}
```

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Server

```
ServerCredentials cr = InsecureServerCredentials.create();
Server server = Grpc.newServerBuilderForPort(port, cr)
  .addService(new ServerStub())
  .build()
  .start();

Runtime.getRuntime().addShutdownHook(new Thread() {() -> {
  try {
    server.shutdown().awaitTermination(30, TimeUnit.SECONDS);
  } catch (InterruptedException e) {
    e.printStackTrace(System.err);
  }
});

server.awaitTermination();
```

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Client

```
public class ClientStub {

  GreaterRpc.GreeterBlockingStub blockingStub;

  public ClientStub(Channel channel) {
    blockingStub = GreeterRpc.newBlockingStub(channel);
  }

  public String greet(String name) {
    HelloRequest request = HelloRequest
                           .newBuilder()
                           .setName(name).build();
    HelloReply response = blockingStub.sayHello(request);
    return response.getMessage();
  }
}
```

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Client

```
ChannelCredentials cr = InsecureChannelCredentials.create();
ManagedChannel channel = Grpc.newChannelBuilder(..., cr)
  .build();

ClientStub client = new ClientStub(channel);

System.out.println(client.greet("..."));

channel.shutdownNow().awaitTermination(5, TimeUnit.SECONDS);
```

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