



Golang Programming

Building Web Services with gRPC

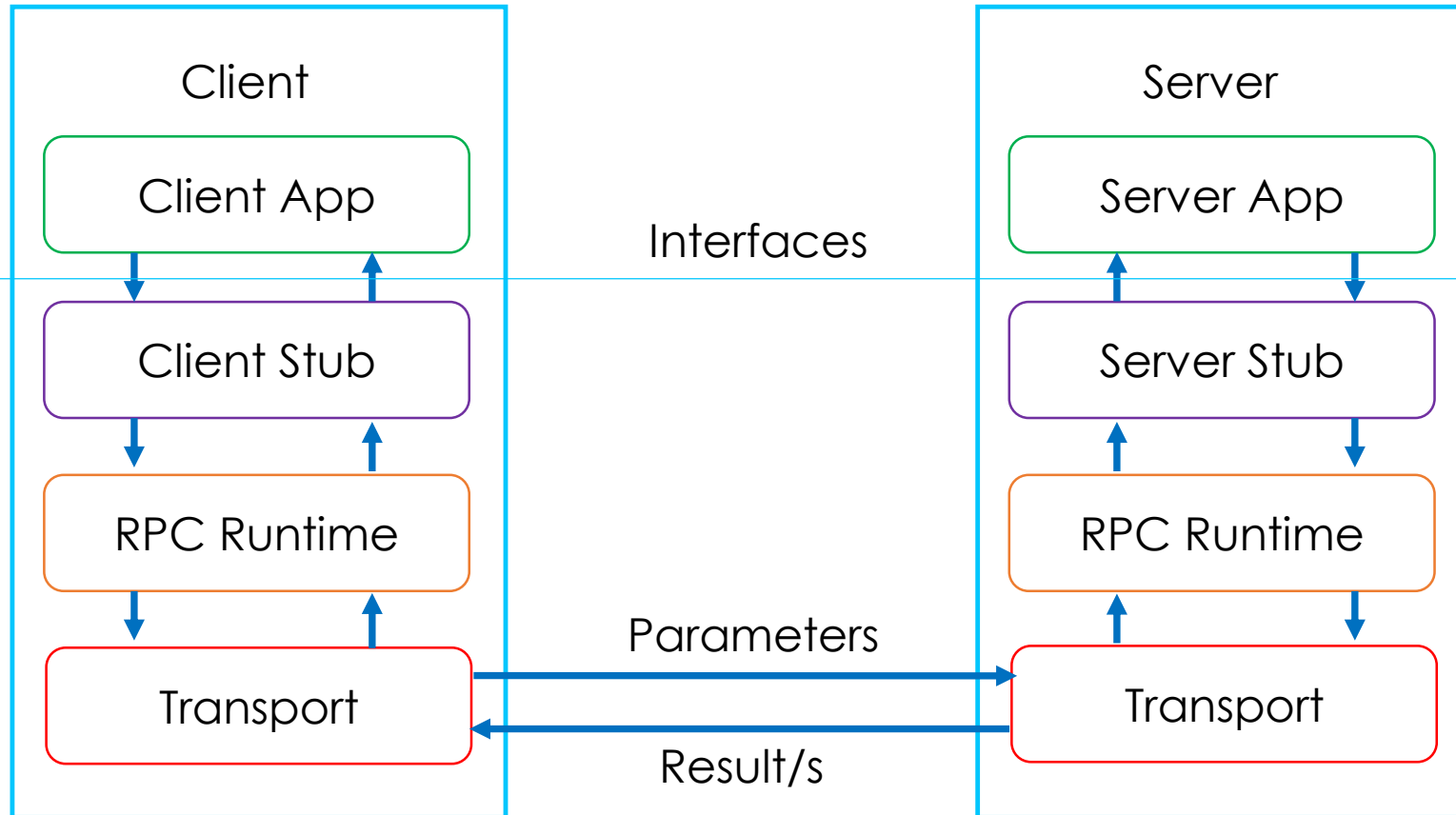
Where to Find The Code and Materials?

<https://github.com/iproduct/coursego>

Remote Procedure Calls (RPC) and gRPC



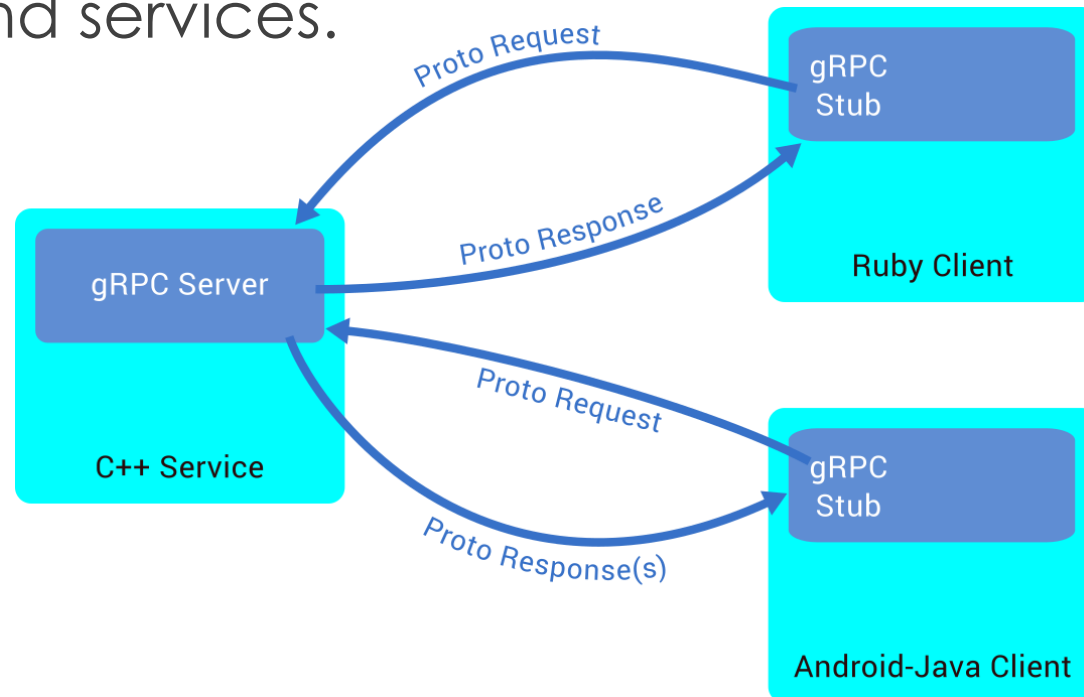
Remote Procedure Call (RPC)



- **Remote Procedure Call (RPC)**
- a form of inter-process communication (IPC), when a computer program causes a procedure (subroutine) to execute in a different address space (commonly on another computer on a shared network), which is coded as if it were a normal (local) procedure call, without the programmer explicitly coding the details for the remote interaction.

gRPC (gRPC Remote Procedure Calls)

- gRPC is a modern open source **high performance RPC framework** that can run in any environment. It can efficiently **connect services** in and across data centers with pluggable support for **load balancing, tracing, health checking** and **authentication**. It is also applicable in last mile of distributed computing to **connect devices, mobile applications** and **browsers** to backend services.



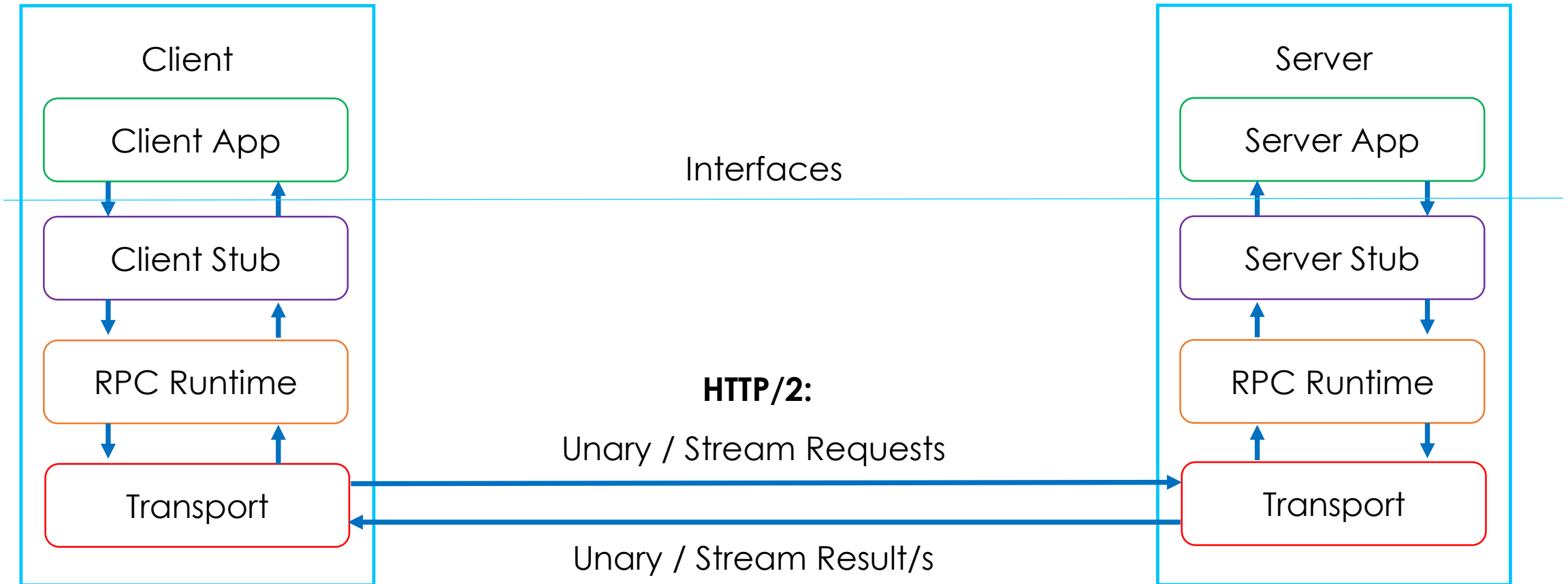
Main Usage Scenarios

- **Microservices** – designed for low latency and high throughput communication, lightweight and efficient polyglot microservices
- **Real-time P2P communication**: bi-directional streaming, client and server push in real-time, “last mile” (mobile, web, and Internet of Things).
- **Connecting mobile devices, browser clients** to backend services, generating efficient client libraries
- **Efficient network transport (constrained environments)**: messages are serialized with lightweight message format called Protobuf – messages are smaller than an JSON equivalents.
- **Inter-process communication (IPC)**: IPC transports such as Unix domain sockets / named pipes can be used with gRPC to communicate between apps on same machine - see [Inter-process communication with gRPC](#).

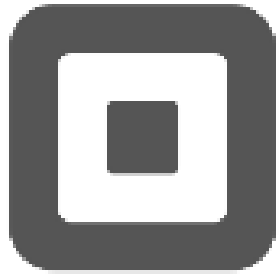
gRPC Core Features

- Idiomatic client libraries in more than 12 languages – C/C++, C#, Dart, Go, Java, Kotlin, Node.js, Objective-C, PHP, Python, Ruby
- Highly efficient on wire and with a simple service definition framework using Protocol Buffers standard
- Bi-directional streaming with http/2 based transport
- Pluggable auth, tracing, load balancing and health checking using unary and stream client and server interceptors

gRPC (gRPC Remote Procedure Calls)



Who Uses gRPC ? [<https://grpc.io/about/>]



Square



Core OS



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NETWORKS

gRPC Design Principles - I

- **Efficiency, security, reliability and behavioral analysis**: Stubby -> SPDY, HTTP/2, QUIC (HTTP/3 – UDP based) public standards
- **Services not Objects, Messages not References** - promote microservices design philosophy of coarse-grained message exchange, avoiding the pitfalls of distributed objects and the fallacies of ignoring the network.
- **Coverage & Simplicity** - stack available on every popular platform, viable for CPU and memory-limited devices.
- **Free & Open** – open-source with licensing that should facilitate adoption.
- **Interoperability & Reach** - wire protocol surviving internet traversal.
- **General Purpose & Performant** – supporting broad class of use-cases.

gRPC Design Principles - II

- **Layered** - key facets of the stack must be able to evolve independently. A revision to the wire-format should not disrupt application layer bindings.
- **Payload Agnostic** - supports different message types and encodings such as protocol buffers, JSON, XML, and Thrift; pluggable compression.
- **Streaming** – Storage systems rely on streaming and flow-control to express large data-sets. Other services, like voice-to-text or stock-tickers, rely on streaming to represent temporally related message sequences.
- **Blocking & Non-Blocking** – support asynchronous and synchronous processing of the sequence of messages exchanged by a client and server.
- **Cancellation & Timeout** – long-lived - cancellation allows servers to reclaim resources, cancellation can cascade; client timeout for a call.

gRPC Design Principles - III

- **Lameducking** – graceful server shutdown: rejecting new, in-flight completed.
- **Flow Control** – allows for better buffer management and DOS protection.
- **Pluggable** – security, health-checking, load-balancing, failover, monitoring, tracing, logging, and so on; extensions points for plugging-in these features.
- **Extensions as APIs** – favor APIs rather than protocol extensions (health-checking, service introspection, load monitoring, and load-balancing).
- **Metadata Exchange** – cross-cutting concerns like authentication or tracing rely on the exchange of data that is not part of the declared interface.
- **Standardized Status Codes** – clients typically respond to errors returned by API calls in a limited number of ways; metadata exchange mechanism.

Protocol Buffers

- Protocol Buffers (Protobuf) – method for serializing structured data, involves an interface description language that describes the structure of some data and a program that generates source code from that description for generating or parsing a stream of bytes that represents the structured data.
- Smaller and faster than XML and JSON
- Basis for a custom remote procedure call (RPC) system that is used for nearly all inter-machine communication at Google.
- Similar to the Apache Thrift (used by Facebook), Ion (created by Amazon), or Microsoft Bond protocols, offering as well a concrete RPC protocol stack to use for defined services – gRPC.

Protocol Buffers [<https://developers.google.com/protocol-buffers/docs/proto3>]

- Data structures (messages) and services are described in a proto definition file (.proto) and compiled with **protoc**. This compilation generates code that can be invoked by a sender or recipient of these data structures. E.g. `example.proto` -> `example.pb.go` and `example_grpc.pb.go`. They define Golang types and methods for each message and service in `example.proto`.

```
protoc --go_out=. --go-grpc_out=. --go_opt=paths=source_relative \
      --go-grpc_opt=paths=source_relative *.proto
```

```
go get google.golang.org/protobuf/cmd/protoc-gen-go \
google.golang.org/grpc/cmd/protoc-gen-go-grpc
```

```
mkdir -p generated
```

```
protoc --proto_path=api/proto/v1 --proto_path=third_party --go_out=./generated \
--go-grpc_out=./generated todo_service.proto
```

Programming with gRPC in 3 Simple Steps:

1. Define a service in a `.proto` file.
2. Generate server and client code using the protocol buffer compiler – `protoc`.
3. Use the `Go gRPC API` to write a simple `client` and `server` for your service.

Example: helloworld.proto

```
syntax = "proto3";
```

```
option go_package = "google.golang.org/grpc/examples/helloworld/helloworld";
```

```
package helloworld;
```

```
// The greeting service definition.
```

```
service Greeter {
```

```
    // Sends a greeting
```

```
    rpc SayHello (HelloRequest) returns (HelloReply) {}
```

```
// The request message containing the user's name.
```

```
message HelloRequest {
```

```
    string name = 1;
```

```
}
```

```
// The response message containing the greetings
```

```
message HelloReply {
```

```
    string message = 1;
```

```
}
```


Example: helloworld server.go

```
package main
import ("context"; pb "github.com/iproduct/coursego/10-grpc-hello/helloworld"; "google.golang.org/grpc"; "log"; "net")
const port = ":50051"

// server is used to implement helloworld.GreeterServer.
type server struct { pb.UnimplementedGreeterServer }

// SayHello implements helloworld.GreeterServer
func (s *server) SayHello(ctx context.Context, in *pb.HelloRequest) (*pb.HelloReply, error) {
    log.Printf("Received: %v", in.GetName())
    return &pb.HelloReply{Message: "Hello " + in.GetName()}, nil
}

func main() {
    lis, err := net.Listen("tcp", port)
    if err != nil { log.Fatalf("failed to listen: %v", err) }
    s := grpc.NewServer()
    pb.RegisterGreeterServer(s, &server{})
    if err := s.Serve(lis); err != nil { log.Fatalf("failed to serve: %v", err) }
}
```

Example: helloworld client.go

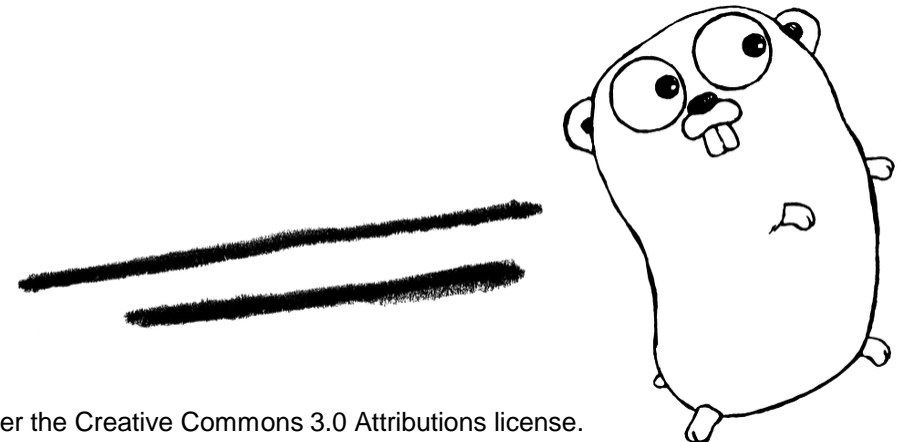
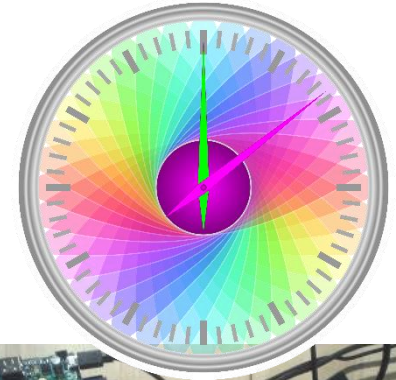
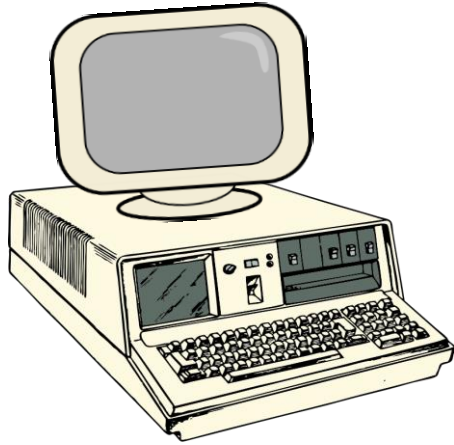
```
package main
import ( "context"; pb "github.com/iproduct/coursego/10-grpc-hello/helloworld"; "log"; "os"; "time";
        "google.golang.org/grpc" )
const ( address      = "localhost:50051"; defaultName = "world" )

func main() {
    // Set up a connection to the server.
    conn, err := grpc.Dial(address, grpc.WithInsecure(), grpc.WithBlock())
    if err != nil { log.Fatalf("did not connect: %v", err) }
    defer conn.Close()
    c := pb.NewGreeterClient(conn)
    // Contact the server and print out its response.
    name := defaultName
    if len(os.Args) > 1 { name = os.Args[1] }
    ctx, cancel := context.WithTimeout(context.Background(), time.Second)
    defer cancel()
    r, err := c.SayHello(ctx, &pb.HelloRequest{Name: name})
    if err != nil { log.Fatalf("could not greet: %v", err) }
    log.Printf("Greeting: %s", r.GetMessage())
}
```

Data Streaming with gRPC

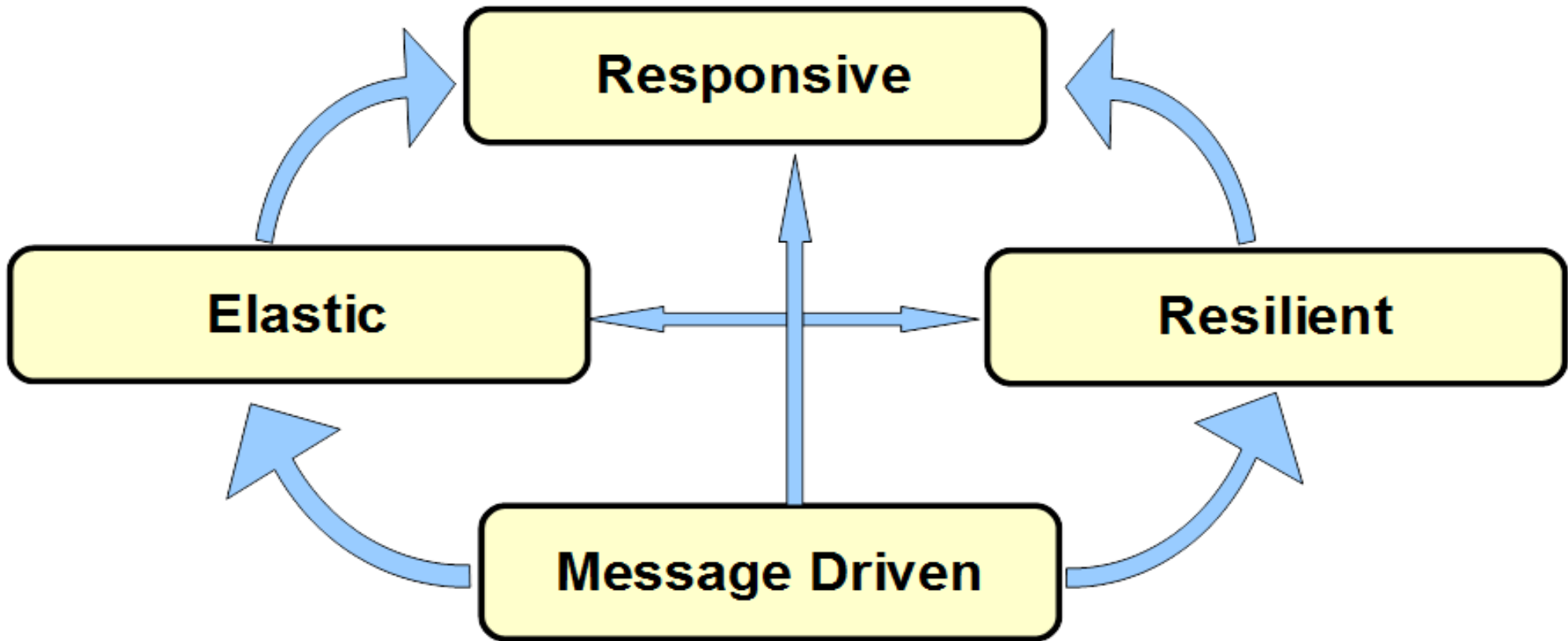


Need for Speed: Data Streaming



Reactive Manifesto

<http://www.reactivemaneifesto.org>



Data / Event / Message Streams

“Conceptually, a stream is a (potentially never-ending) **flow of data records**, and a transformation is an operation that takes one or more streams as input, and produces one or more output streams as a result.”

Apache Flink: Dataflow Programming Model

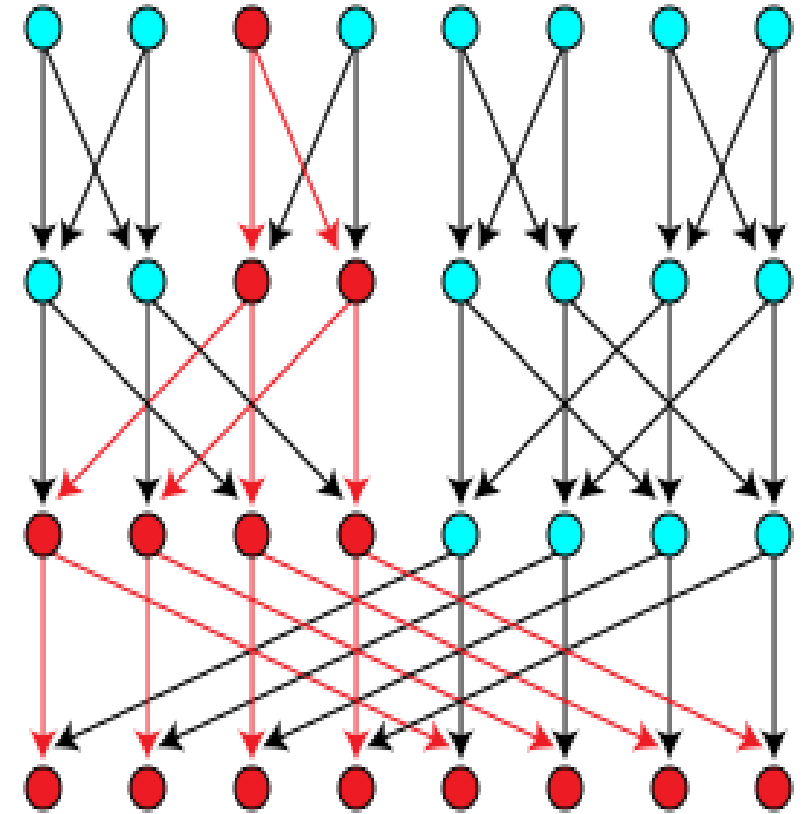
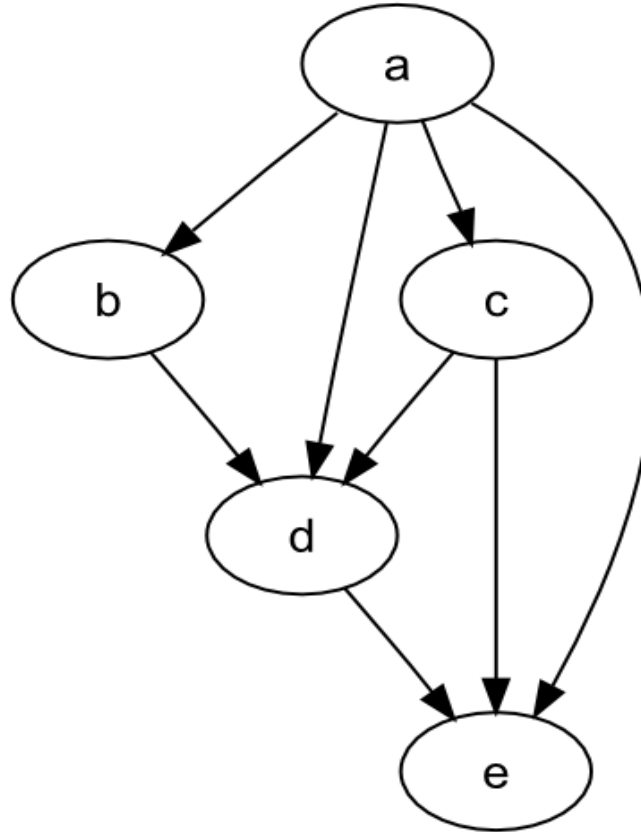
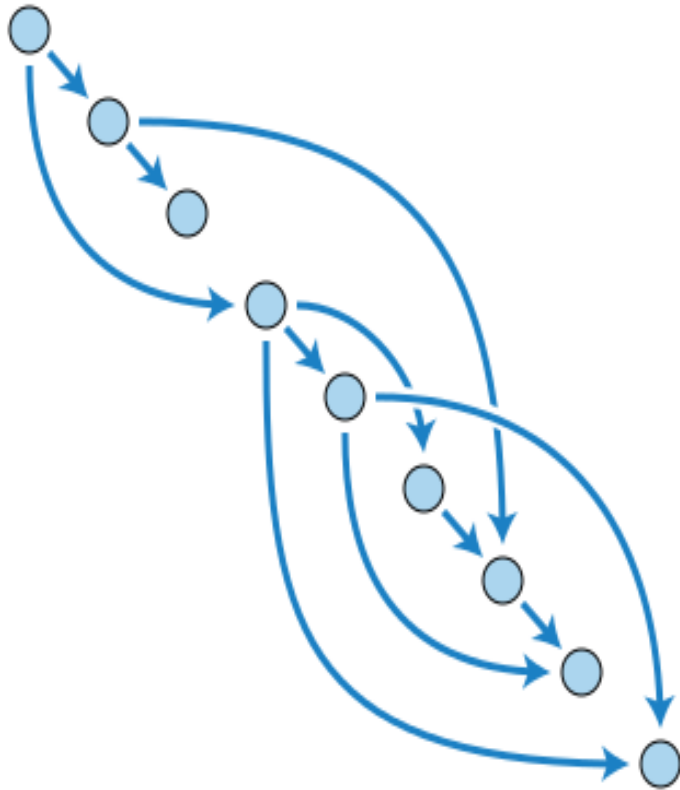
Data Stream Programming

The idea of **abstracting logic from execution** is hardly new -- it was the dream of **SOA**. And the recent emergence of **microservices** and **containers** shows that the dream still lives on.

For developers, the question is whether they want to learn yet **one more layer of abstraction** to their coding. On one hand, there's the elusive promise of a **common API to streaming engines** that in theory should let you mix and match, or swap in and swap out.

*Tony Baer (Ovum) @ ZDNet - Apache Beam and Spark:
New coopetition for squashing the Lambda Architecture?*

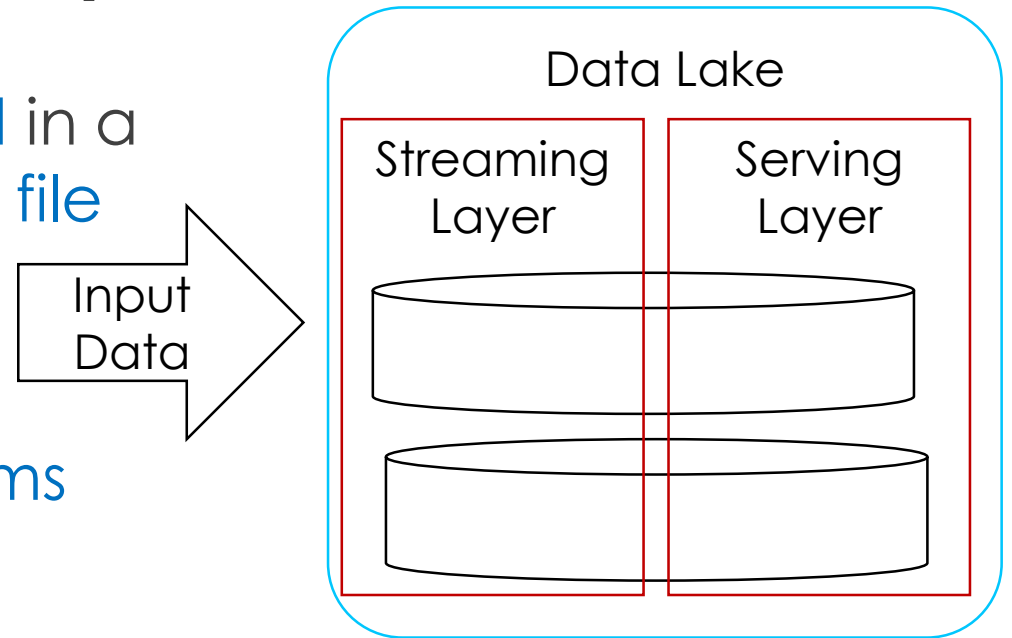
Direct Acyclic Graphs - DAG



Kappa Architecture II

Query = K (New Data) = K (Live streaming data)

- Multiple data events or queries are logged in a queue to be catered against a distributed file system storage or history.
- The order of the events and queries is not predetermined. Stream processing platforms can interact with database at any time.
- It is resilient and highly available as handling terabytes of storage is required for each node of the system to support replication.
- Machine learning is done on the real time basis



Types of Streaming with gRPC – I

- **Simple RPC (no streaming)** – client sends a request to the server using the stub and waits for a response to come back, just like a normal function call:

// Obtains the feature at a given position.

rpc GetFeature(Point) **returns** (Feature) {}

- **Server-side streaming RPC** – client sends a request to the server and gets a stream to read a sequence of messages back. The client reads from the returned stream until there are no more messages - **stream** keyword before the *response* type:

// Obtains the Features available within the given Rectangle. Results are // streamed rather than returned at once (e.g. in a response message with a // repeated field), as the rectangle may cover a large area and contain a // huge number of features.

rpc ListFeatures(Rectangle) **returns** (**stream** Feature) {}

Types of Streaming with gRPC – II

- **Client-side streaming RPC** – client writes a sequence of messages and sends them to the server, again using a provided stream. Once the client has finished writing the messages, it waits for the server to read them all and return its response – **stream** keyword *before the request type*:

// Accepts a stream of Points on a route being traversed, returning a // RouteSummary when traversal is completed.

rpc RecordRoute(**stream** Point) **returns** (RouteSummary) {}

- **Bidirectional streaming RPC** – both sides send a sequence of messages using a read-write stream. The two streams operate independently, so clients and servers can read and write in whatever order they like: for example, the server could wait to receive all the client messages before writing its responses, or it could alternately read a message then write a message, or some other combination of reads and writes. The order of messages in each stream is preserved – **stream** keyword *before both the request and the response*:

// Accepts a stream of RouteNotes sent while a route is being traversed, // while receiving other RouteNotes (e.g. from other users).

rpc RouteChat(**stream** RouteNote) **returns** (stream RouteNote) {}

Example – Bidirectional Streaming: math.proto

- `syntax = "proto3";`

```
package protobuf;
```

```
option go_package = "../protomath";
```

```
service Math {  
  rpc Max (stream Request) returns (stream Response) {}  
}
```

```
message Request {  
  int32 num = 1;  
}
```

```
message Response {  
  int32 result = 1;  
}
```

Example – Bidirectional Streaming: server.go - I

```
type server struct{
    pm.Math_MaxServer
    pm.UnimplementedMathServer
}
func (s server) Max(srv pm.Math_MaxServer) error {
    log.Println("start new server")
    var max int32
    ctx := srv.Context()
    for {
        select {
            // exit if context is done or continue
            case <-ctx.Done(): return ctx.Err()
            default:
        }
        req, err := srv.Recv() // receive data from stream
        if err == io.EOF { // return will close stream from server side
            log.Println("exit")
            return nil
        }
        if err != nil { log.Printf("receive error %v", err); continue }
    }
}
```

Example – Bidirectional Streaming: server.go - II

```
// continue if number received from stream  
// less than max  
if req.Num <= max {  
    continue  
}
```

```
// update max and send it to stream  
max = req.Num  
resp := pm.Response{Result: max}  
if err := srv.Send(&resp); err != nil {  
    log.Printf("send error %v", err)  
}  
log.Printf("send new max=%d", max)
```

```
}
```

```
}
```

Example – Bidirectional Streaming: server.go - II

```
func main() {  
    // create listener  
    lis, err := net.Listen("tcp", ":50005")  
    if err != nil {  
        log.Fatalf("failed to listen: %v", err)  
    }  
  
    // create grpc server  
    s := grpc.NewServer()  
    pm.RegisterMathServer(s, server{})  
  
    // and start...  
    if err := s.Serve(lis); err != nil {  
        log.Fatalf("failed to serve: %v", err)  
    }  
}
```

Example – Bidirectional Streaming : client.go - I

```
func main() {  
    rand.Seed(time.Now().Unix())  
    // dail server  
    conn, err := grpc.Dial(":50005", grpc.WithInsecure())  
    if err != nil {  
        log.Fatalf("can not connect with server %v", err)  
    }  
    // create stream  
    client := pm.NewMathClient(conn)  
    stream, err := client.Max(context.Background())  
    if err != nil {  
        log.Fatalf("openn stream error %v", err)  
    }  
  
    var max int32  
    ctx := stream.Context()  
    done := make(chan bool)
```


Example – Bidirectional Streaming : client.go - II

// first goroutine sends random increasing numbers to stream and closes int after 20 iterations

```
go func() {  
    for i := 1; i <= 20; i++ {  
        // generate random nummber and send it to stream  
        rnd := int32(rand.Intn(i))  
        req := pm.Request{Num: rnd}  
        if err := stream.Send(&req); err != nil {  
            log.Fatalf("can not send %v", err)  
        }  
        log.Printf("%d sent", req.Num)  
        time.Sleep(time.Millisecond * 200)  
    }  
    if err := stream.CloseSend(); err != nil {  
        log.Println(err)  
    }  
}()
```

Example – Bidirectional Streaming : client.go - III

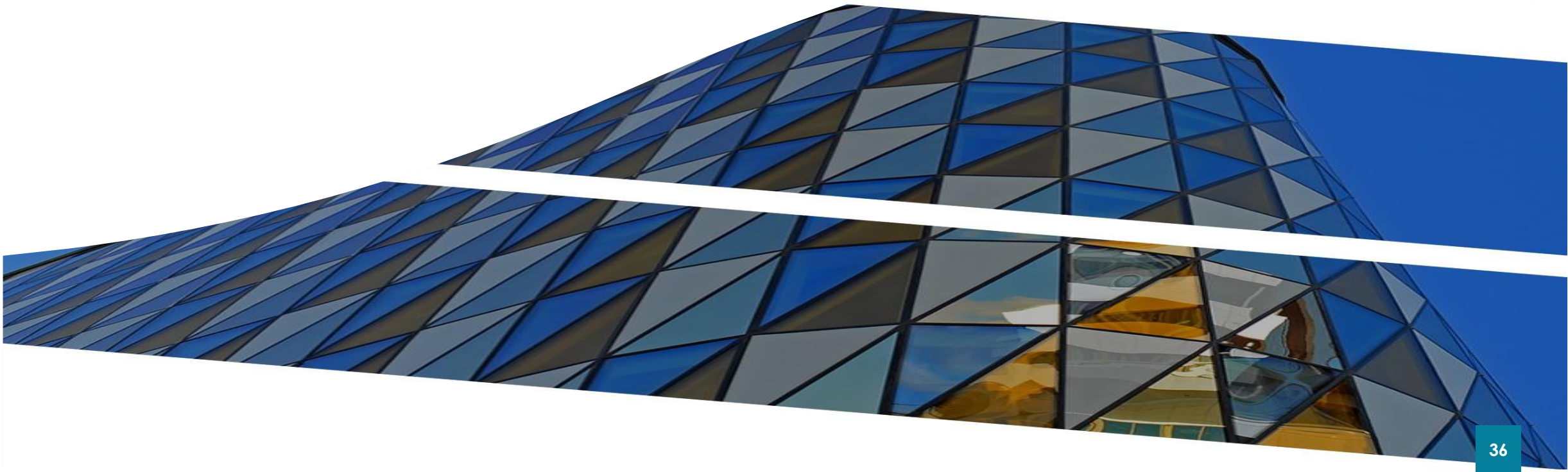
// second goroutine receives data from stream and saves result in max variable
// if stream is finished it closes done channel

```
go func() {  
    for {  
        resp, err := stream.Recv()  
        if err == io.EOF {  
            close(done)  
            return  
        }  
        if err != nil {  
            log.Fatalf("can not receive %v", err)  
        }  
        max = resp.Result  
        log.Printf("new max %d received", max)  
    }  
}()
```

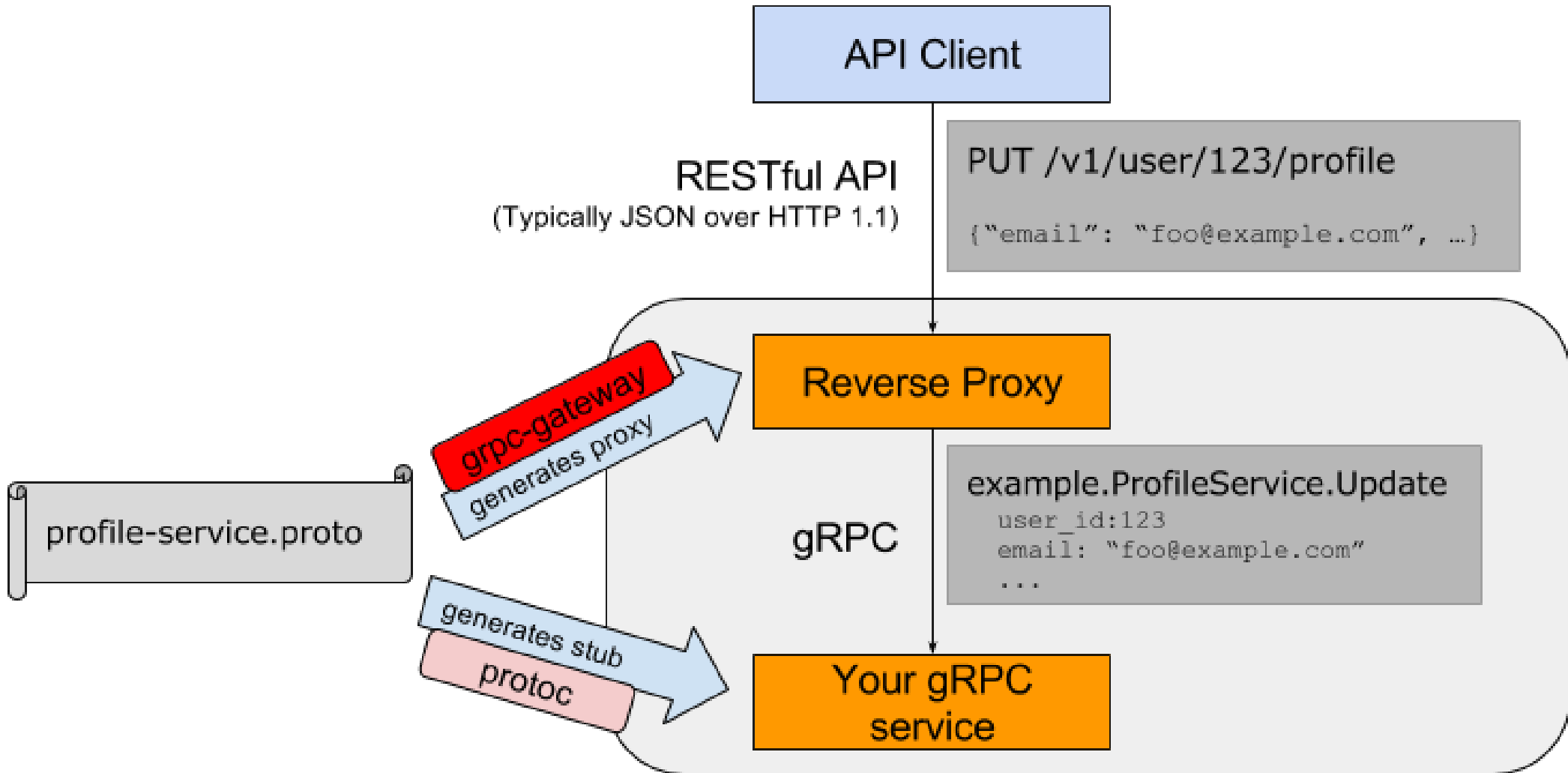
Example – Bidirectional Streaming : client.go - IV

```
// third goroutine closes done channel  
// if context is done  
go func() {  
    <-ctx.Done()  
    if err := ctx.Err(); err != nil {  
        log.Println(err)  
    }  
    close(done)  
}()  
  
<-done  
log.Printf("finished with max=%d", max)  
}
```

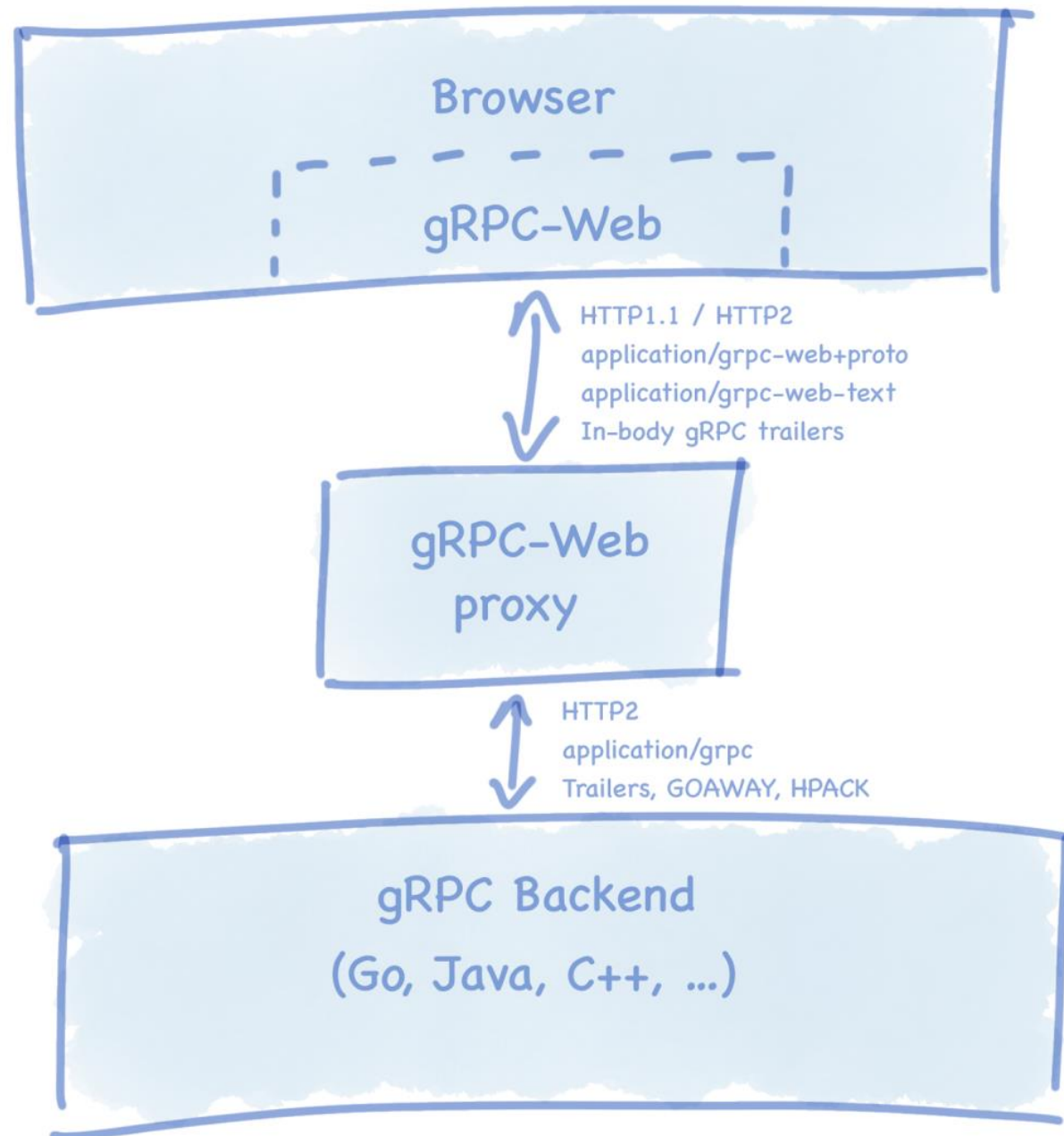
And More ...



Exposing gRPC Service as REST Service



gRPC: Web Clients



Thank's for Your Attention!



Trayan Iliev

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