SERIALIZATION PROTOCOLS IN DISTRIBUTED SYSTEMS

a shootout

I'm Chris

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I work for a munich based startup called Matmatch

Matmatch

We're a development team of 5 (and me) trying to change the world of materials

REASONING

so why is this even important?

SYSTEM DESIGNS ARE CHANGING

1. Microservice architectures are mainstream
2. Queues show up in mainstream architectures
3. CQRS / ES is a common design nowadays
4. We're not using databases as integration layer

Distributed systems are about protocols, not implementations. Forget languages, protocols are everything.

@TimPerret

EVOLVABILITY

... Evolutionary architecture, which supports incremental non-breaking change as a first principle along multiple dimensions ...

Rebecca Parsons, Neil Ford

EVOLVABILITY

The ability of a system and its data to adapt to change

Me, for the lack of a better definition

EVOLVABILITY

In monolithic systems with relational databases, a change in the data model was usually implemented by

- a schema migration
- code changes
- one big deployment

THE NEED FOR EVOLVABILITY

- replicated systems
- distributed systems in our datacenter
- serverless, anyone?
- systems with code distributed to the user

THE NEED FOR EVOLVABILITY

All these systems need to exchange information pretty much all the time

INTERRUPT: WHY DO WE LIKE TO CREATE NEW NAMES SO MUCH?

- to go out, data needs to be encoded/serialized/marshalled
- to get it back you need to decode/deserialize/unmarshall

SO HOW CAN WE DEAL WITH THIS?

USUAL SUSPECTS

PROGRAMMING LANGUAGE PROVIDED SERIALIZATION

we get `java.Serializable` for free, so why not just use it?

No!

NOOOOOOOOOOOOOO

- We are bound to JVM implementation languages (if you are really brave)
- The performance is awful
- It has some serious drawbacks

Implement `Serializable` judiciously

[Joshua Bloch, Effective Java]

- decreases the flexibility to change once released
- the implementation of the class becomes the API
- increases the likelihood of bugs and security holes
- increases the testing burden

SERIALIZATION

Mario Fusco
@mariofusco

Folge ich

Java features which represent the biggest impediments in moving the language forward according to its architects:

1. serialization
2. finalize()
3. protected keyword

#Devoxx #AskArch

PLACES WHERE DEFAULT SERIALIZATION HAS ALREADY BITTEN ME:

- Akka remoting
- Akka cluster
- Spark
- User Sessions with Spring Boot

SOME NOTES ABOUT PERFORMANCE

protocol	create	ser	deser	total	size
protobuf	121	1173	719	1891	239
thrift	95	1455	731	2186	349
kryo-flat	55	705	909	1614	268
avro-generic	329	1721	984	2704	221
scala/java-built-in	514	8280	36105	44385	1293

Source: jvm-serializers wiki

SOME NOTES ABOUT PERFORMANCE

- as long as its one of our four, it's probably fast enough
- if you need it faster, you'll have to do your own research
- just don't use the built in serializer

BUT... HOW ABOUT JSON? OR XML?

- widespread
- somewhat human readable
- still slow (depending on the benchmark)
- verbose
- number handling is difficult
- character encoding is difficult

BUT... HOW ABOUT JSON? OR XML?

There also exists a various range of schema extensions for JSON, like BSON and JSON Schema. Unfortunately they don't provide schema evolvability, so I'll skip them

SCHEMA EVOLVABILITY

READING DATA BETWEEN SCHEMAS

BACKWARDS COMPATIBILITY

This means a newer schema can read data encoded with an older schema.

That's halfway (not) easy. You know how the previous schema was, you can deal with missing things in your code. If you are aware of that.

FORWARDS COMPATIBILITY

Reading data from a schema that is newer that the schema of the running software.

Ouch. How do you deal with things you don't know about?

FORWARDS COMPATIBILITY

Let a protocol handle this for us!

We will compare 4 major Players:

- Protobuf
- Thrift
- Avro
- Kryo

PROTOBUF

WHAT IS PROTOBUF (PROTOCOL BUFFERS)?

Protocol buffers are Google's language-neutral, platform-neutral, extensible mechanism for serializing structured data – think XML, but smaller, faster, and simpler.

Protobuf Website

Besides the specification, Google provides a compiler for Java und uses it as a foundation for the Google Cloud Platform and gRPC

PROTOBUF GRADLE PLUGIN

Google provides a protocol buffer compiler (`protoc`) plugin for gradle. It will generate mighty Java Classes that can map and serialize Protobuf Classes

```
classpath('com.google.protobuf:protobuf-gradle-plugin:0.8.7')
```

SCALAPB

ScalaPB is a protocol buffer compiler (`protoc`) plugin for Scala. It will generate Scala case classes, parsers and serializers for your protocol buffers

Github

SCHEMA SAMPLE

```
syntax = "proto3";

package de.christianuhl.proto;

message Person {
    int32 user_id = 1;
    string firstname = 2;
    string lastname = 3;
}
```

SCALA TIME!

(live Sample)

LET'S CHECK THE ENCODING ON DISK

field tag	type	value	length	bytes / value
00010	010	12	09	43687269 73746961 6E
00011	010	1A	03	0355686C

PROTO 2 VS PROTO 3

Significant changes:

- No presence logic anymore
- All values are optional by default, `required` semantic is removed
- `Map` Type
- Timevalues

WHY THE RADICAL 'EVERYTHING IS OPTIONAL'?

- `required` breaks schema evolvability anyways
- loads of production issues
- was already banned in Google
- `optional` became redundant and was removed as well

JAVA TIME!

(live Sample of an Event Store that accepts Protobuf)

THRIFT

WHAT IS THRIFT?

... is an interface definition language and binary communication protocol that is used to define and create services for numerous languages. It is used as a remote procedure call (RPC) framework

Wikipedia

WHAT IS THRIFT?

- it has large conceptual similarities to protobuf
- originally developed at Facebook
- re-open-sourced later again as fbthrift

JAVA INTEGRATION

- Apache Thrift Stuff exists, but is midldy complicated
- Plugins who work pretty similar to what you've seen on protobuf

Sample

SCALA & SBT INTEGRATION

Twitter supplies scrooge

Scrooge

SCHEMA SAMPLE

```
namespace java de.christianuhl.proto

struct Person {
    1: optional i64     userId,
    2: required string  firstname,
    3: required string  lastname
}
```

SCALA TIME!

(live Sample)

LET'S CHECK THE ENCODING ON DISK

Type	Field Tag	Length	bytes	value
0B	0002	00000009	43687269 73746961 6E	Christian
0B	0003	00000003	55686C	Uhl

WHAT MAKES THRIFT SPECIAL?

- It's more than just serialization, it's a whole RPC framework
- It embraces a whole family of encodings (They call it protocols)
- Scala ecosystem only gets contributions by Twitter
- otherwise, it's remarkably similar to protobuf

AVRO

- started as a subproject of Hadoop, because Thrift was a bad fit for Hadoop
- now an Apache project, supported by Confluent
- Kafka (Confluent) is a large influencer nowadays
- has two schema languages, one for humans and one for machines
- direct mapping from and to JSON

differs from Protobuf and Thrift:

- Reader and writer schema can be different, data brings its own schema
- less type information for the payload needed
- no manually assigned field ids

ALL BOILS DOWN TO HAVING DIFFERENT SCHEMAS FOR READING AND WRITING

SCHEMA SAMPLE

```
@namespace("de.christianuhl.avro")
protocol avrosample {
record Person {
    union {null, long} user_id = null;
    string firstname;
    string lastname;
}}
```

JAVA USAGE

```
<dependency>
    <groupId>io.confluent</groupId>
    <artifactId>kafka-avro-serializer</artifactId>
    <version>${confluent.version}</version>
    <exclusions>

<exclusion>

    <groupId>org.slf4j</groupId>

    <artifactId>slf4j-log4j12</artifactId>

</exclusion>
    </exclusions>
</dependency>
<dependency>
```

Sample

USAGE WITH SBT

using avrohugger and avro4s

- avro4s
- avrohugger

SCALA TIME!

(live Sample)

LET'S CHECK THE ENCODING ON DISK

first, 248 Bytes of schema

lenght	sing	value	bytes	value
0001001	0	12	43687269 73746961 6E	Christian
0000011	0	06	55686C	Uhl

lastly 16 Byte i don't understand

SO HOW DO WRITER'S AND READER'S SCHEMA GO TOGETHER?

- they need to be *compatible*, but not equal
- resolution rules are in the Avro specification
- adding or removing only of fields with default values

HOW DOES DATA AND SCHEMA FIND TOGETHER?

1. You include it in the payload (as in the sample)
2. You versionize it, store it yourself and join it later (typical database application)
3. Roll your schema registry and do Avro RPC

WHAT BENEFITS DO WE GET FROM THAT?

1. Support for dynamically generated schemas (Protobuf and Thrift want to be hand-crafted)
2. Simpler interoperability with dynamically typed languages

AND THE DOWNSIDES

1. Protocol overhead or runtime dependency, pick a poison
2. Need to verify schema changes are compatible

KRYO

THE 'ODD' ONE OF OUR LITTLE LIST

- Object graph serialization framework for the JVM
- No schema evolution
- Blazing fast JVM-to-JVM communication
- good candidate for live cluster communication (Akka e.g.)

Source

JAVA SAMPLE

```
...
import com.esotericsoftware.kryo.Kryo;
import com.esotericsoftware.kryo.io.Output;
// serializing
Kryo kryo = new Kryo();
AcmeMessage message = buildAcmeMessage(); // some domain object
Output out = new Output(response.getOutputStream())
kryo.writeObject(out, myObject);
// deserializing
Input in = new Input(request.getInputStream());
AcmeMessage message = kryo.readObject(in, AcmeMessage.class);
```

USAGE WITH SBT

using twitter chill

- chill

SCALA TIME!

(live Sample)

LET'S CHECK THE ENCODING ON DISK

16 bytes, maximum density

field	type(?)	value (last byte starts with 1)	actual
01	01	4368 72697374 6961EE	Christian
02	01	5568 EC	Uhl

KRYO SUMMARY

- no schema
- therefore no schema evolution
- Good for message serialization within running instances
- you do not want to persist these serialized values

BONUS FRIEND: SIMPLE BINARY ENCODING

HIGH FREQENCY OPTIMIZED SERIALIZATION

SBE is an OSI layer 6 presentation for encoding and decoding binary application messages for low-latency financial applications. This repository contains the reference implementations in Java, C++, Golang, and C#.

Source

HIGH FREQUENCY OPTIMIZED SERIALIZATION

- crazily fast
- from Real Logic
- integrates well with the Aeron messaging system
- supports schema evolution

WHY IS IT NOT IN THIS LIST?

- Integration not so simple
- ease of use vs performance
- I cannot dissect the serialized bytes :)

SUMMARY

SUMMARY

Framework	Notes
Protobuf	😀 integration, 😀 concepts, 😫 2>3 version change
Thrift	😀 concepts, 🤓 bigger framework, 😫 lacking integration
Avro	😀 integration, 😀 for big files, 🤭 embedded schema concept
Kryo	😍 speed, 😍 simplicity, 😢 no evolvability, 😢 not for persisting

Caution:

`required` and schema evolution don't mix very well

RELEVANT LINKS

- Effective Java
- Desinging Data Intensive Applications (Everything I said in this talk is explained here, too)
- Schema evolution in Avro, Protocol Buffers and Thrift

QUESTIONS?

My twitter is @chrisuhl

Examples, slides and everything else:

https://github.com/christianuhlcc/protocol-shootout

I work for Matmatch building a material search engine: We're cloud native and release 5 times a day to prod with a team of 5 - Ask me offline if you want to now more

PICTURES:

- buring car
- caution