Protocol Buffers: Marshalling

Vojtěch Horký Petr Tůma

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1 Technology Overview

Technology Overview

Goals

Provide platform independent structured data serialization framework.

Features

- Platform independent data description language.
- Serialization code generation for multiple languages (C++, Java, Python, Go, Ruby, JavaScript, Objective C, C# ...).
- Binary transport format with compact data representation.
- Textual transport using JSON.

... http://developers.google.com/protocol-buffers

Examples To Play With ...

```
> git clone http://github.com/d-iii-s/teaching-introduction-middleware.git
```

C

```
> cd teaching-introduction-middleware/src/protocol-buffers-basic-usage/c
> cat README.md
```

Java

```
> cd teaching-introduction-middleware/src/protocol-buffers-basic-usage/java
> cat README.md
```

Python

```
> cd teaching-introduction-middleware/src/protocol-buffers-basic-usage/python
> cat README.md
```

Message Specification Example

```
syntax = "proto3";

package example;

message AnExampleMessage {
    uint32 some_integer = 1;
    sint32 another_integer = 2;
    string some_string = 8;
    repeated string some_more_strings = 11;
}

message MoreExampleMessages {
    repeated AnExampleMessage messages = 1;
}
```

2 Assignment Part I

Assignment

Server

Implement a server that will provide information on current time.

- The server should accept a spec of what fields to return.
- Fields should be standard YYYY-MM-DD HH:MM:SS.

Client

Implement a client that will query server time:

- Pick a random combination of fields.
- Query information on current time.
- Print the time.

Interoperability

Implement compatible clients and servers in two languages.

3 Message Encoding

Message Encoding

Goals

Compact structure with support for field removal and addition.

Features

- Sequence of field key value pairs.
- Key is field index and type indication.
  - One of variable integer, explicit length, fixed length.

    - Not enough to tell the exact field type !
  - Primitive repeated fields packed.
  - Total length not included !

Variable Length Encoding

Goals

Support integers clustered around zero more efficiently.

Features

- Integer stored as variable number of 7 bit values.
- High bit set to zero for last byte.
- Little endian byte order.
- Signed variant.

4 Message Specification

Primitive Field Types

Integer Types

(s)fixed(32|64) Integers with fixed length encoding.
(u)int(32|64) Integers with variable length encoding.
sint(32|64) Integers with sign optimized variable length encoding.

Floating Point Types

float IEEE 754 32 bit float.
double IEEE 754 64 bit float.

Additional Primitive Types

bool Boolean.
bytes Arbitrary sequence of bytes.
string Arbitrary sequence of UTF-8 characters.

More Field Types

Oneof Type

```
message AnExampleMessage {
    oneof some_oneof_field {
        int32 some_integer = 1;
        string some_string = 2;
    }
}
```

Enum Type

```
enum AnEnum {
    INITIAL = 0;
    RED = 1;
    BLUE = 2;
    GREEN = 3;
    WHATEVER = 8;
}
```

More Field Types

Any Type

```
import "google/protobuf/any.proto";
message AnExampleMessage {
    repeated google.protobuf.Any whatever = 8;
}
```

Map Type

```
message AnExampleMessage {
    map<int32, string> keywords = 8;
}
```

5 Message Manipulation

C++ Message Basics

Construction

```
AnExampleMessage message;
AnExampleMessage message (another_message);
message.CopyFrom (another_message);
```

Singular Fields

```
cout << message.some_integer ();
message.set_some_integer (1234);
```

Repeated Fields

```
int size = messages.messages_size ();
const AnExampleMessage &message = messages.messages (1234);
AnExampleMessage *message = messages.mutable_messages (1234);
AnExampleMessage *message = messages.add_messages ();
```

C++ Message Serialization

Byte Array

```
char buffer [BUFFER_SIZE];
message.SerializeToArray (buffer, sizeof (buffer));
message.ParseFromArray (buffer, sizeof (buffer));
```

Standard Stream

```
message.SerializeToOstream (&stream);
message.ParseFromIstream (&stream);
```

Java Message Basics

Construction

```
AnExampleMessage.Builder messageBuilder;
messageBuilder = AnExampleMessage.newBuilder ();
messageBuilder = AnExampleMessage.newBuilder (another_message);
AnExampleMessage message = messageBulder.build ();
```

Singular Fields

```
System.out.println (message.getSomeInteger ());
messageBuilder.setSomeInteger (1234);
```

Repeated Fields

```
int size = messages.getMessagesCount ();
AnExampleMessage message = messages.getMessages (1234);
List<AnExampleMessage> messageList = messages.getMessagesList ();
messagesBuilder.addMessages (messageBuilder);
messagesBuilder.addMessages (message);
```

Java Message Serialization

Byte Array

```
byte [] buffer = message.toByteArray ();
try {
    AnExampleMessage message = AnExampleMessage.parseFrom (buffer);
} catch (InvalidProtocolBufferException e) {
    System.out.println (e);
}
```

Standard Stream

```
message.writeTo (stream);
AnExampleMessage message = AnExampleMessage.parseFrom (stream);
```

Python Message Basics

Construction

```
message = AnExampleMessage ()
message.CopyFrom (another_message)
```

Singular Fields

```
print (message.some_integer)
message.some_integer = 1234
```

Repeated Fields

```
size = len (messages.messages)
message = messages.messages [1234]
message = messages.messages.add ()
```

Python Message Serialization

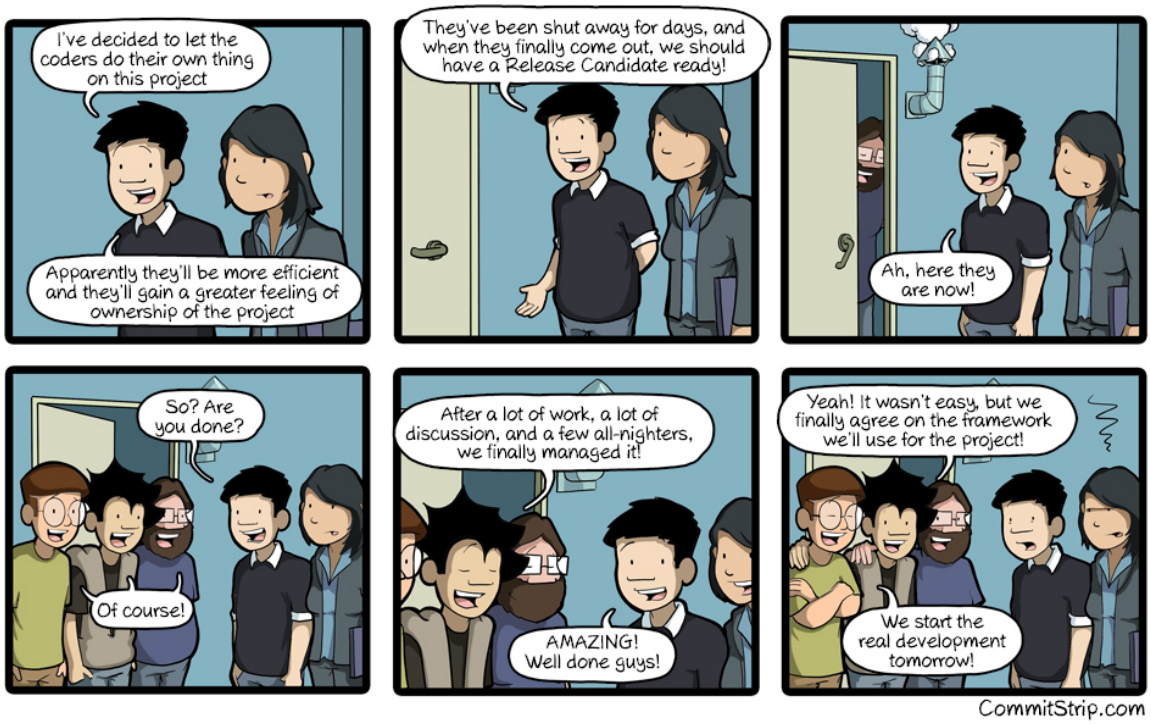
Byte Array

```
buffer = message.SerializeToString ()
message.ParseFromString (buffer)
message = AnExampleMessage.FromString (buffer)
```

Standard Stream

```
file.write (message.SerializeToString ())
message.ParseFromString (file.read ())
AnExampleMessage.FromString (file.read ())
```

Code Now ...



http://www.commitstrip.com/en/2017/03/16/when-we-leave-coders-to-do-their-own-thing

Show Your Code ...

Query Host Name

```
> hostname
u1-22
```

Run Screen Sharing

```
> x11vnc -viewonly
```

6 Assignment Part II

Assignment

Performance

Measure the performance of your implementation.

Experiment Design

Stick to the following, or provide arguments for why not:

- Random field mix, each field with probability 1/2.
- Measure at least two minutes long traffic.

- Report average invocation throughput.
- No printing during measurement.
- Compare with past assignments.

Submission

GitLab

Use your personal GitLab repository under `https://gitlab.mff.cuni.cz/teaching/nswi163/2022`.

Requirements

- Use the assignment subdirectory.
- Write brief report in `SOLUTION.md`.
- Include build scripts with instructions.
- Do not commit binaries or temporary build artifacts.
- Tag your solution with `task-02` and push the tag.