Protocol Buffers: Marshalling
Introduction to Middleware

Vojtěch Horký    Petr Tůma

Department of Distributed and Dependable Systems
Faculty of Mathematics and Physics
Charles University

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Outline

1. Technology Overview
2. Assignment Part I
3. Message Encoding
4. Message Specification
5. Message Manipulation
6. Assignment Part II
# 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;
}
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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.
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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.
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### 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

denum AnEnum {
  INITIAL = 0;
  RED = 1;
  BLUE = 2;
  GREEN = 3;
  WHATEVER = 8;
}
More Field Types

Any Type

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

Map Type

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

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

**Standard Stream**

```cpp
message.SerializeToOstream (&stream);
message.ParseFromIstream (&stream);
```
Java Message Basics

Construction

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

Singular Fields

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

Repeated Fields

```java
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**

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

**Standard Stream**

```java
message.writeTo (stream);
AnExampleMessage message = AnExampleMessage.parseFrom (stream);
```
Python Message Basics

Construction

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

Singular Fields

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

Repeated Fields

```python
size = len(messages.messages)
message = messages.messages [1234]
message = messages.messages.add ()
```
Python Message Serialization

**Byte Array**

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

**Standard Stream**

```python
file.write (message.SerializeToString ())
message.ParseFromStream (file.read ())
AnExampleMessage.FromString (file.read ())
```
I’ve decided to let the coders do their own thing on this project.

Apparently they’ll be more efficient and they’ll gain a greater feeling of ownership of the project.

They’ve been shut away for days, and when they finally come out, we should have a Release Candidate ready.

Ah, here they are now!

So? Are you done?

After a lot of work, a lot of discussion, and a few all-nighters, we finally managed it!

AMAZING! Well done guys!

Yeah! It wasn’t easy, but we finally agree on the framework we’ll use for the project!

We start the real development tomorrow!

Show Your Code ...

Query Host Name

> hostname
u1-22

Run Screen Sharing

> x11vnc -viewonly
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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


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.