Protobuf

tutorialspoint

SIMPLY EASY LEARNING

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Overview

Protocol Buffers is a library from Google. It provides efficient and language-independent ways to serialize the data. It supports serialization and deserialization from languages like Java, Python, Go, Dart, etc. It is one of the most popular serialization libraries used across industries by various companies.

The major use-case for Google Protocol Buffers is the serialization and deserialization of data which is simple and fast. Serialization and Deserialization becomes a very important piece in microservices/distributed environment where lot of data is transferred across services. That is why, it becomes a very useful library in developing applications which require high scalability and performance.

Audience

This tutorial deep dives into various components that make Google Protocol Buffers a very useful library. It is directed towards software professionals who want to develop highly scalable and performant applications. Post this tutorial, you would have intermediate knowledge of Protocol Buffers and its usage.

Prerequisite

To learn from this tutorial, you need to have a good hold over Java or Python and a basic knowledge of data structure is preferable.

1. Protobuf – Introduction

Before we jump into Protocol Buffer, let us go over a brief background of Serialization which is what Protocol Buffer does.

What is Serialization and Deserialization?

Serialization is the process of converting an object (of any language) into bytes and storing them in persistent memory system. This memory system could be a file on the disk, messaging queue or a database. The major intention with serialization of object is that we can reuse the data and recreate the object on same or different machine. In deserialization, we convert the stored bytes back to an object.

Why do we need Serialization and Deserialization?

While there are a few other use-cases, the most basic and important one is that it provides a way to transfer object data over a network to a different service/machine etc. and then to recreate object for its further use. Transferring object data via API, database or messaging queue requires the object to be converted into bytes so that it can be sent over a network. And this is where serialization becomes important.

In microservice architecture, the application is broken down into small services and these services communicate with each other via messaging queue and APIs. And all of this communication happens over a network which requires frequent conversion of object to bytes and back to objects. So, serialization and deserialization becomes very critical aspects when it comes to distributed environment.

Why Google Protobuf?

Google Protobuf performs the serialization and deserialization of the objects to bytes which can be transferred over the network. But there are some other libraries and mechanisms to transfer data as well.

So, what makes Google Protobuf special? Here are some of its important features:

- **Language independent**: Multiple languages have protobuf library, few famous ones being Java, Python, Go, etc. So, a Java object can be serialized into bytes from a Java program and can be deserialized to a a Python object.

- **Efficient Data Compaction**: In microservice environment, given that multiple communications take place over a network, it is critical that the data that we are sending is as succinct as possible. We need to avoid any superfluous information to ensure that the data is quickly transferred. Google Protobuf has that as one of the focus areas.

- **Efficient serialization and deserialization**: In microservice environment, given that multiple communications take place over a network, it is critical how fast can we serialize and deserialize. Google Protobuf ensures that it is as quick as possible in serializing and deserializing the data.

- **Simple to use**: Protobuf library auto-generates serialization code (as we will see in the upcoming chapters), has a versioning scheme to ensure that the creator of data and the user of data can have separate versions of the serialization definition, etc.

Protobuf vs Others (XML/JSON/Java serialization)

Let's take a look how other ways to transfer data over a network stack up against Protobuf

Feature	Protobuf	JSON	XML
Language independent	Yes	Yes	Yes
Serialized data size	Least of three	Less than XML	Highest among the three
Human Readable	No, as it uses separate encoding schema	Yes, as it uses text based format	Yes, as it uses text based format
Serialization speed	Fastest among the three	Faster than XML	Slowest among the three
Data type support	Richer than other two. Supports complex data types like Any, one of etc.	Supports basic data types	Supports basic data types
Support for evolving schema	Yes	No	No

2. Protobuf – Basic App

Let us now use Google Protocol Buffer and see how it works with a simple Greeting app. In this example, we will create a simple application which would do the following:

- **Greeting the Writer**:
  - Take greeting and username from the user
  - Store the above information in a file in the disk

- **Greeting Reader**:
  - Reads the same file which we stored in the above file
  - Convert that data into an object and print the data

Protocol Buffer Definition file

The protocol buffer "definition file" contains the schema definition of the data we want to serialize. The data is stored in a human readable file with the extension "**.proto**".

Let us store the following data in "**greeting.proto**" and we will use this in our first application.

```
syntax = "proto3";


package tutorial;


option java_package = "com.tutorialspoint.greeting";


message Greet {
  string greeting = 1;
  string username = 2;
}
```

Now, let us take a closer look at the data and see what each line of code does in the above code block.

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

The "**syntax**" here represents what version of Protobuf we are using. So, we are using the latest version 3 and the schema thus can use all the syntax which is valid for version 3.

```
package tutorial;
```

The **package** here is used for conflict resolution if, say, we have multiple classes/members with same name.

```
option java_package = "com.tutorialspoint.greeting";
```

This argument is specific to Java, i.e., the package where the code from the ".proto" file will be auto-generated.

```
message Greet
```

Name of the base class for the object which would be created/recreated.

```
string greeting = 1;

string username = 2;
```

These are the attributes of the **Greet** class along with the data type and the position of the tag in the schema. If a new tag is to be added, it should have "3" as the position. Note that this position integer is important to ensure that the actual data is compact and there is scope of schema evolution.

Protocol Buffer Code Generation

Now that we have defined, let us install the "proto" binary which we will use to auto-generate the code for the above **Greet** class. The binaries can be found at "https://github.com/protocolbuffers/protobuf/releases/".

Choose the correct binary based on the OS. We will install proto binary on Windows but the steps are not very different for Linux.

Once installed, ensure that you are able to access it via command line:

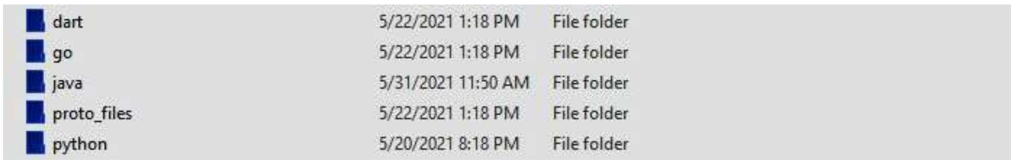
```
protoc --version

libprotoc 3.15.6
```

It confirms that Protobuf is correctly installed. Now let us move to creating the **Greeting** app described above for Java.

Project Structure

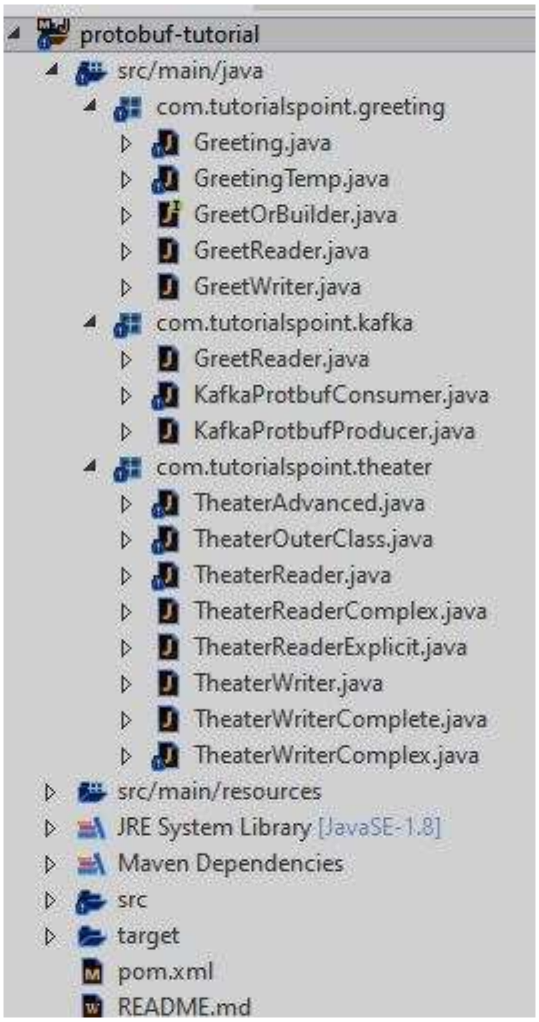
Here is the overall project structure that we would have:

Code related to individual languages go to their respective directories. And we have a separate directory to store our "proto" files.



dart	5/22/2021 1:18 PM	File folder
go	5/22/2021 1:18 PM	File folder
java	5/31/2021 11:50 AM	File folder
proto_files	5/22/2021 1:18 PM	File folder
python	5/20/2021 8:18 PM	File folder

And here is the project structure that we would be having for Java:



```
protobuf-tutorial
  src/main/java
    com.tutorialspoint.greeting
      Greeting.java
      GreetingTemp.java
      GreetOrBuilder.java
      GreetReader.java
      GreetWriter.java
    com.tutorialspoint.kafka
      GreetReader.java
      KafkaProtbufConsumer.java
      KafkaProtbufProducer.java
    com.tutorialspoint.theater
      TheaterAdvanced.java
      TheaterOuterClass.java
      TheaterReader.java
      TheaterReaderComplex.java
      TheaterReaderExplicit.java
      TheaterWriter.java
      TheaterWriterComplete.java
      TheaterWriterComplex.java
  src/main/resources
  JRE System Library [JavaSE-1.8]
  Maven Dependencies
  src
  target
  pom.xml
  README.md
```

Greeting App in Java

Now that we have installed **protoc**, we can auto-generate the code from the proto files using **protoc**. Let us first create a Java project though.

Following is the Maven configuration that we will use for our Java project. Note that it contains the required library for **Protobuf** as well.

```
<?xml version="1.0" encoding="UTF-8"?>

<project xmlns="http://maven.apache.org/POM/4.0.0"

   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

   xsi:schemaLocation="http://maven.apache.org/POM/4.0.0
http://maven.apache.org/xsd/maven-4.0.0.xsd">
```

```
    <modelVersion>4.0.0</modelVersion>
    <groupId>com.tutorials.point</groupId>
    <artifactId>protobuf-tutorial</artifactId>
    <version>1.0</version>
    <packaging>jar</packaging>

    <properties>
        <maven.compiler.source>1.8</maven.compiler.source>
        <maven.compiler.target>1.8</maven.compiler.target>
    </properties>

    <dependencies>
        <!--
https://mvnrepository.com/artifact/com.google.protobuf/protobuf-
java -->
        <dependency>
            <groupId>com.google.protobuf</groupId>
            <artifactId>protobuf-java</artifactId>
            <version>3.15.8</version>
        </dependency>

    </dependencies>

    <build>
        <plugins>
            <plugin>
                <groupId>org.apache.maven.plugins</groupId>
                <artifactId>maven-shade-plugin</artifactId>
                <version>3.2.4</version>
                <configuration>
```

```
                    <!--Put your configurations here-->
                </configuration>
                <executions>
                    <execution>
                        <phase>package</phase>
                        <goals>
                            <goal>shade</goal>
                        </goals>
                    </execution>
                </executions>
            </plugin>
        </plugins>
    </build>
</project>
```

All of our code would be present under **src/main/java**.

With the project structure out of the way, let us generate the code for the **Greet** class:

```
protoc  --java_out=java/src/main/java proto_files/greeting.proto
```

Post execution of the command, you will notice two auto-generated classes.

- **Greeting.java**
- **GreetOrBuilder.java**

These two classes would help us with serialization and deserialization of the **Greet** object.

Now, let us write the **writer** of the data, which will take the **username** and the **greeting** as its inputs:

```
package com.tutorialspoint.greeting;


import java.io.FileOutputStream;
import java.io.IOException;
import com.tutorialspoint.greeting.Greeting.Greet;


public class GreetWriter{
   public static void main(String[] args) throws IOException {
       Greet greeting = Greet.newBuilder()
               .setGreeting(args[0])
               .setUsername(args[1])
               .build();


       String filename = "greeting_protobuf_output";
       System.out.println("Saving greeting to file: " + filename);


       try(FileOutputStream output = new
FileOutputStream(filename)){
           greeting.writeTo(output);
       }


       System.out.println("Saved greeting with following data to
disk: \n" + greeting);
   }
}
```

The **writer** simply takes CLI arguments, creates the **Greet** object, serializes it and then dumps it to a file.

Now let us write a **reader** which will read the file:

```
package com.tutorialspoint.greeting;


import java.io.FileInputStream;
import java.io.IOException;
import com.tutorialspoint.greeting.Greeting.Greet;


public class GreetReader{
   public static void main(String[] args) throws IOException {


      Greet.Builder greetBuilder = Greet.newBuilder();


      String filename = "greeting_protobuf_output";
      System.out.println("Reading from file " + filename);


      try(FileInputStream input = new
FileInputStream(filename)) {
          Greet greet = greetBuilder.mergeFrom(input).build();
          System.out.println("Greeting: " + greet.getGreeting() + "\n" +
                          "Username: " + greet.getUsername());
      }
   }
}
```

The **reader** simply reads from the same file, deserializes it, and prints the data about the greeting.

Now that we have set up the **reader** and the **writer**, let us compile the project.

```
mvn clean install
```

And now, let us first execute the **writer**.

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.greeting.GreetWriter Hello John


Saving greeting to file:
greeting_protobuf_output
```

```
Saved greeting with following data to disk:

greeting: Hello

username: John
```

And then, let us execute the reader

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.greeting.GreetReader


Reading from file greeting_protobuf_output

Greeting: Hello

Username: John
```

So, as we see the data that was serialized by the **writer** and saved to the file, that exact data is correctly deserialized by the **reader** and printed accordingly.

Greeting App in Python

Let us now write the same example as a Python project:

We will need to install **protobuf pip package** before we proceed.

```
pip install protobuf
```

All of our code would be present under "**google-protobuf/python**".

With the project structure out of the way, let us generate the code for **Greet** class:

```
protoc  --python_out=python proto_files/greeting.proto
```

Post execution of this command, you will notice an auto-generated class " *** proto_files/greeting_pb2.py** " under the Python directory. This class would help us with serialization and deserialization of the **Greet** object.

Now, let us write the **writer** of the data, which will take the **username** and the **greeting** as its input:

```
from .proto_files import greeting_pb2


import sys

```

```
greet = greeting_pb2.Greet()
greet.username = sys.argv[1]
greet.greeting = sys.argv[2]

filename = "greeting_protobuf_output";
print("Saving to file: " + filename)

f = open(filename, "wb")
f.write(greet.SerializeToString())
f.close()

print("Saved following greeting to disk: \n" + str(greet))
```

The **writer** simply takes CLI arguments, creates the **Greet** object, serializes it, and then dumps it to a file.

Now let us create a **reader** which will read the file:

```
from proto_files import greeting_pb2

greet = greeting_pb2.Greet()

filename = "greeting_protobuf_output";
print("Reading from file: " + filename)

f = open(filename, "rb")
greet.ParseFromString(f.read())
f.close()

print("Read greeting from disk: \n" + str(greet))
```

The **reader** simply reads from the same file, deserializes it, and prints the data about the greeting.

Now, let us first execute the **writer**.

```
python greetWriter.py Hola Jane


Saving to file: greeting_protobuf_output

Saved following greeting to disk:

greeting: "Hola"

username: "Jane"
```

And then, let us execute the **reader**.

```
python greetReader.py


Reading from file: greeting_protobuf_output

Read greeting from disk:

greeting: "Hola"

username: "Jane"
```

So, as we see, the data that was serialized by the **writer** and saved to a file. Next, the same data is correctly deserialized by the **reader** and printed accordingly.

3. Protobuf – Constructs

Let us now look at a few basic data structures and data types which Google Protobuf provides. We will look at these data structures using an example of a Movie theater.

Note that for this structure while we will be using Java code, using them in Python code should also be equally simple and possible.

In the next few chapters, we will discuss the following Protobuf data types one by one:

- Protobuf Class/Member
- Protobuf Strings
- Protobuf Numbers
- Protobuf Boolean
- Protobuf Enum
- Protobuf List/Repeated
- Protobuf Map
- Protobuf Nested Class

4. Protobuf – Class/Member

The very basic building block of Protobuf is the **member** attribute. This translates to a **class** in the languages that we use, for example, Java, Python, etc.

Following is the syntax that we need to have to instruct Protobuf that we will be creating instances of a given class:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {


}
```

We will save the above in "**theater.proto**" and we will use this when we explore other data structures.

The "**syntax**" here represents what version of Protobuf are we using. So, we are using the latest version 3 and the schema thus can use all the syntax which is valid for version 3.

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

The package here is used for conflict resolution, if, say, we have multiple class/message with the same name.

```
package tutorial;
```

This argument is specific to Java, i.e., the package where the code from the "**.proto**" file will be auto-generated.

```
option java_package = "com.tutorialspoint.greeting";
```

Now that we are done with the prerequisites, the last item here is:

```
message Theater
```

This is nothing but the **class name** of the base class for the object which would be created/recreated. Note that it is useless in its current shape, as it does not have any other attributes. But we will be more adding attributes as we move along.

A single proto file can also have multiple classes/messages. For example, if we want, we can add a **Visitors** message/class as well in the same file. Protobuf would ensure to create two separate and independent classes for the same. For example:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
}


message Visitor {


}
```

To use Protobuf, we will now have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

Well, that is it! The above command should create the required files and now we can use it in our Java code:

```
Theater theater = Theater.newBuilder().build()


Visitor visitor = Visitor.newBuilder().build()
```

At this stage, it is not very useful, as we have not added any attributes to the members/classed. Let us do that when we look at **strings**.

5. Protobuf – Strings

Protobuf strings translate to a string in the languages that we use, for example, Java, Python, etc. Continuing on the **theater** example, following is the syntax that we need to have to instruct Protobuf that we will be creating a **string**:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 1;
  string address = 2;
}
```

Now our **class/message** contains two **string** attributes. Each of them also has a position which is what Protobuf uses while serialization and deserialization. Each attribute of a member needs to have a unique **position** attribute.

To use Protobuf, we will now have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Java code. First let's create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileOutputStream;
import java.io.IOException;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;


public class TheaterWriter{
   public static void main(String[] args) throws IOException {
       Theater theater = Theater.newBuilder()
               .setName("Silver Screener")
               .setAddress("212, Maple Street, LA, California")
               .build();


       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);


       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }


       System.out.println("Saved theater information with
following data to disk: \n" + theater);
   }
}
```

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;


import com.tutorialspoint.greeting.Greeting.Greet;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{
   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";
       System.out.println("Reading from file " + filename);


       try(FileInputStream input = new FileInputStream(filename)) {
            Theater theater = theaterBuilder.mergeFrom(input).build();
            System.out.println(theater);
        }
   }
}
```

Now, post compilation, let us execute the **writer** first:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
name: "Silver Screener"
address: "212, Maple Street, LA, California"
```

Now, let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader
```

```
Reading from file theater_protobuf_output

name: "Silver Screener"

address: "212, Maple Street, LA, California"
```

So, as we see, we are able to read the serialized strings by deserializing the binary data to the **Theater** object. Let us now look at **numbers** in the next chapter.

6. Protobuf – Numbers

Numbers include protobuf types like **int32**, **int64**, **float**, **double**, which are basic building blocks of Protobuf. It translates to **int**, **long float**, **double**, respectively, in the languages that we use, for example, Java, Python, etc.

Continuing with our **theater** example, following is the syntax that we need to have to instruct Protobuf that we will be creating **numbers**:

```
syntax = "proto3";

package theater;

option java_package = "com.tutorialspoint.theater";

message Theater {
  int32 total_capcity = 3;
  int64 mobile = 4;
  float base_ticket_price = 5;
}
```

Now our **class/message** contains **numerical** attributes. Each of them also has a **position** which is what Protobuf uses while serialization and deserialization. Each attribute of a **member** needs to have a unique number assigned.

To use Protobuf, we will now have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command will create the required files and now we can use it in our Java code. First, let's create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;

```

```
import java.io.FileOutputStream;
import java.io.IOException;

import com.tutorialspoint.theater.TheaterOuterClass.Theater;

public class TheaterWriter{
   public static void main(String[] args) throws IOException {
       Theater theater = Theater.newBuilder()
               .setTotalCapcity(320)
               .setMobile(98234567189L)
               .setBaseTicketPrice(22.45f)
               .build();

       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: "
+ filename);

       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }

       System.out.println("Saved theater information with
following data to disk: \n" + theater);
   }
}
```

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;

import java.io.FileInputStream;
import java.io.FileOutputStream;

import java.io.IOException;


import com.tutorialspoint.greeting.Greeting.Greet;

import com.tutorialspoint.theater.TheaterOuterClass.Theater;

import com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{

   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";

        System.out.println("Reading from file " + filename);


        try(FileInputStream input = new
FileInputStream(filename)) {

            Theater theater =
theaterBuilder.mergeFrom(input).build();

            System.out.println(theater.getBaseTicketPrice());

            System.out.println(theater);

        }

   }

}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output

Saved theater information with following data to disk:
```

```
total_capcity: 320

mobile: 98234567189

base_ticket_price: 22.45
```

Now, let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output

22.45

total_capcity: 320

mobile: 98234567189

base_ticket_price: 22.45
```

So, as we see, we are able to read the serialized **int**, **float**, and **long** by deserializing the binary data to **Theater** object. In the next chapter, we will look at the Boolean type.

7. Protobuf – Boolean

The "bool" data type is one of the basic building blocks of Protobuf. It translates to Boolean in the languages that we use, for example, Java, Python, etc.

Continuing with the **theater** example, following is the syntax that we need to have to instruct Protobuf that we will be creating a Boolean attribute:

```
syntax = "proto3";

package theater;

option java_package = "com.tutorialspoint.theater";

message Theater {
  bool drive_in = 6;
}
```

Now our **message** class contains a Boolean attribute. It also has a **position** which is what Protobuf uses while serialization and deserialization. Each attribute of a member needs to have a unique number assigned.

To use Protobuf, we will now have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command will create the required files and now we can use it in our Java code. First let's create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;

import java.io.FileOutputStream;
import java.io.IOException;

import com.tutorialspoint.theater.TheaterOuterClass.Theater;
```

```
public class TheaterWriter{
   public static void main(String[] args) throws IOException {
       Theater theater = Theater.newBuilder()
               .setTotalCapcity(320)
               .setMobile(98234567189L)
               .setBaseTicketPrice(22.45f)
               .build();

       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);

       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }

       System.out.println("Saved theater information with
following data to disk: \n" + theater);
   }
}
```

Next, we will have a **reader** to read the theater information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;


import com.tutorialspoint.greeting.Greeting.Greet;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
```

```
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{
   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";
        System.out.println("Reading from file " + filename);


        try(FileInputStream input = new
FileInputStream(filename)) {
            Theater theater =
theaterBuilder.mergeFrom(input).build();
            System.out.println(theater.getBaseTicketPrice());
            System.out.println(theater);
        }
   }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
drive_in: true
```

Now, let us execute the reader to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader
```

```

Reading from file theater_protobuf_output
drive_in: true
```

So, as we see, we are able to read the serialized Boolean by deserializing the binary data to **Theater** object.

8. Protobuf – Enum

enum is one of the composite datatypes of Protobuf. It translates to an **enum** in the languages that we use, for example, Java.

Continuing with our **theater** example, following is the syntax that we need to have to instruct Protobuf that we will be creating an enum:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  enum PAYMENT_SYSTEM{
        CASH = 0;
        CREDIT_CARD = 1;
        DEBIT_CARD = 2;
        APP = 3;
   }
   PAYMENT_SYSTEM payment = 7;
}
```

Now our **message** class contains an Enum for payment. Each of them also has a position which is what Protobuf uses while serialization and deserialization. Each attribute of a **member** needs to have a unique number assigned.

We define the **enum** and use it below as the data type along with "payment" attribute. Note that although we have defined **enum** inside the **message** class, it can also reside outside of it.

To use Protobuf, we will now have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Java code. First, we will create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileOutputStream;
import java.io.IOException;


import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.PAYMENT_SYSTEM;


public class TheaterWriter{
   public static void main(String[] args) throws IOException {
       Theater theater = Theater.newBuilder()
               .setPayment(PAYMENT_SYSTEM.CREDIT_CARD)
               .build();


       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);


       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }


       System.out.println("Saved theater information with
following data to disk: \n" + theater);
   }
}
```

Next, we have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;

import java.io.FileOutputStream;

import java.io.IOException;


import com.tutorialspoint.greeting.Greeting.Greet;

import com.tutorialspoint.theater.TheaterOuterClass.Theater;

import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{

   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";

        System.out.println("Reading from file " + filename);


        try(FileInputStream input = new
FileInputStream(filename)) {

            Theater theater =
theaterBuilder.mergeFrom(input).build();

            System.out.println(theater.getBaseTicketPrice());

            System.out.println(theater);

        }

   }

}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output

Saved theater information with following data to disk:

payment: CREDIT_CARD
```

Now, let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output

payment: CREDIT_CARD
```

So, as we see, we are able to read the serialized **enum** by deserializing the binary data to **Theater** object. In the next chapter, we will take a look at Protobuf **lists**.

9. Protobuf – List/Repeated

Lists are one of the composite datatypes of Protobuf. Protobuf translates this to a **java.util.list** interface in Java.

Continuing with our **theater** example, following is the syntax that we need to have to instruct Protobuf that we will be creating a **list**:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  repeated string snacks = 8;
}
```

Now our **message** class contains a **list** for snacks. Note that although we have a string list, we can as well have number, Boolean, custom data type list.

To use Protobuf, we will now have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Java code. First, we will have a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;


import java.util.List;
import java.io.FileOutputStream;
import java.io.IOException;
import java.util.ArrayList;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;


public class TheaterWriter{
   public static void main(String[] args) throws IOException {


       List<String> snacks = new ArrayList<>();
       snacks.add("Popcorn");
       snacks.add("Coke");
       snacks.add("Chips");
       snacks.add("Soda");


       Theater theater = Theater.newBuilder()
               .addAllSnacks(snacks)
               .build();


       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);


       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }


       System.out.println("Saved theater information with
following data to disk: \n" + theater);


   }
}
```

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;
```

```
import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;


import com.tutorialspoint.greeting.Greeting.Greet;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{
   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";
       System.out.println("Reading from file " + filename);


       try(FileInputStream input = new
FileInputStream(filename)) {
             Theater theater = theaterBuilder.mergeFrom(input).build();
             System.out.println(theater);
        }
   }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
```

```
snacks: "Popcorn"

snacks: "Coke"

snacks: "Chips"

snacks: "Soda"
```

Now, let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output

snacks: "Popcorn"

snacks: "Coke"

snacks: "Chips"

snacks: "Soda"
```

So, as we see, we are able to read the serialized **list** by deserializing the binary data to **Theater** object. In the next chapter, we will look at the **map** data type of Protobuf.

10. Protobuf – Map

Map is one of the composite datatypes of Protobuf. Protobuf translates this to a **java.util.Map** interface in Java.

Continuing with our **theater** example, following is the syntax that we need to have to instruct Protobuf that we will be creating a **map**:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  map<string, int32> movieTicketPrice = 9;
}
```

Now our **class/message** contains a map of movie and their ticket price. Note that although we have "**string -> int**" map, we can as well have number, Boolean, and custom data types. However, note that we cannot have a nested map.

To use Protobuf, we will now have to use the **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command will create the required files and now we can use it in our Java code. First, we will create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;


import java.util.List;
import java.util.Map;
import java.io.FileOutputStream;
import java.io.IOException;
import java.util.ArrayList;
import java.util.HashMap;

import com.tutorialspoint.theater.TheaterOuterClass.Theater;

public class TheaterWriter{
   public static void main(String[] args) throws IOException {

       Map<String, Integer> ticketPrice = new HashMap<>();

       ticketPrice.put("Avengers Endgame", 700);
       ticketPrice.put("Captain America", 200);
       ticketPrice.put("Wonder Woman 1984", 400);

       Theater theater = Theater.newBuilder()
               .putAllMovieTicketPrice(ticketPrice)
               .build();

       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);

       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }

       System.out.println("Saved theater information with
following data to disk: \n" + theater);

   }
}
```

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;


import com.tutorialspoint.greeting.Greeting.Greet;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{
   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";
        System.out.println("Reading from file " + filename);


        try(FileInputStream input = new
FileInputStream(filename)) {
            Theater theater =
theaterBuilder.mergeFrom(input).build();
            System.out.println(theater);
        }
   }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
```

```
movieTicketPrice {
  key: "Avengers Endgame"
  value: 700
}
movieTicketPrice {
  key: "Captain America"
  value: 200
}
movieTicketPrice {
  key: "Wonder Woman 1984"
  value: 400
}
```

Now, let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output
movieTicketPrice {
  key: "Avengers Endgame"
  value: 700
}
movieTicketPrice {
  key: "Captain America"
  value: 200
}
movieTicketPrice {
  key: "Wonder Woman 1984"
  value: 400
}
```

So, as we see, we are able to read the serialized map by deserializing the binary data to **Theater** object. In the next chapter, we will see how to create a nested class in Protobuf.

11. Protobuf – Nested Class

Here, we will see how to create a nested class. Protobuf translates this to a nested Java class.

Continuing with the **theater** example, following is the syntax that we need to have to instruct Protobuf that we will be creating a nested class:

```
syntax = "proto3";

package theater;

option java_package = "com.tutorialspoint.theater";

message Theater {
  TheaterOwner owner = 10;
}

message TheaterOwner{
    string name = 1;
    string address = 2;
}
```

Now our **class/message** contains a nested class, i.e., information about the owner of the theater.

To use Protobuf, we will now have to use the **protoc** binary to create the required classes from this "**.proto**" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Java code. First, let's create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;
```

```
import java.io.FileOutputStream;
import java.io.IOException;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.TheaterOwner;


public class TheaterWriter{
   public static void main(String[] args) throws IOException {


       TheaterOwner owner = TheaterOwner.newBuilder()
               .setName("Anthony Gonsalves")
               .setAddress("513, St Paul Street, West Coast, California")
               .build();


       Theater theater = Theater.newBuilder()
               .setOwner(owner)
               .build();


       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);


       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }


System.out.println("Saved theater information with following
data to disk: \n" + theater);
   }
}
```

Next, we have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;


import com.tutorialspoint.greeting.Greeting.Greet;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{
   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";
       System.out.println("Reading from file " + filename);


       try(FileInputStream input = new
FileInputStream(filename)) {
            Theater theater = theaterBuilder.mergeFrom(input).build();
            System.out.println(theater);
        }
   }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
```

```
owner {
  name: "Anthony Gonsalves"
  address: "513, St Paul Street, West Coast, California"
}
```

Now, let us execute the reader to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output
owner {
  name: "Anthony Gonsalves"
  address: "513, St Paul Street, West Coast, California"
}
```

So, as we see, we are able to read the serialized nested class data by deserializing the binary data to **Theater** object.

12. Protobuf – Optionality and Defaults

While we looked at various data types and how to use them. What happens if we do not specify the values while serialization? Google Protobuf 2 supported "required" and "optional" tag which helped in figuring out if the serialization/deserialization should fail if the required parsing logic is unavailable. But these tags are not available in the latest version. The failing part needs to be handled by respective code.

Let us look at the default values of the data types:

Data Type	Default value
Int32 / Int64	0
Float/double	0.0
String	Empty string
Boolean	False
Enum	First Enum item, that is the one with "index=0"
Repeated type	Empty list
Map	Empty Map
Nested Class	null

So, if one does not specify the data for these data types, then they would take the above default values. Now, let's continue with our **theater** example to demonstrate how it works.

In this example, we will let all the fields default. The only field which would be specified would be the name of the theater.

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 1;
  string address = 2;

  int32 total_capcity = 3;
  int64 mobile = 4;
  float base_ticket_price = 5;

  bool drive_in = 6;

  enum PAYMENT_SYSTEM{
        CASH = 0;
        CREDIT_CARD = 1;
        DEBIT_CARD = 2;
        APP = 3;
  }

  PAYMENT_SYSTEM payment = 7;

  repeated string snacks = 8;

  map<string, int32> movieTicketPrice = 9;

  TheaterOwner owner = 10;

}

message TheaterOwner{
    string name = 1;
    string address = 2;
}
```

Now our **class/message** contains multiple attributes. To use Protobuf, we will have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Java code. First, let's create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileOutputStream;
import java.io.IOException;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;


public class TheaterWriter{
   public static void main(String[] args) throws IOException {


       Theater theater = Theater.newBuilder()
               .setName("SilverScreen")
               .build();


       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);


       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }


       System.out.println("Saved theater information with
following data to disk: \n" + theater);


   }
}
```

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;

import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;
import java.util.Map;

import com.google.protobuf.DescriptorProtos.FileDescriptorProto;
import com.google.protobuf.Descriptors.FieldDescriptor;
import com.google.protobuf.Descriptors.FileDescriptor;
import com.tutorialspoint.greeting.Greeting.Greet;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;

public class TheaterReaderExplicit{
   public static void main(String[] args) throws IOException {

       Builder theaterBuilder = Theater.newBuilder();

       String filename = "theater_protobuf_output";
       System.out.println("Reading from file " + filename);

       try(FileInputStream input = new
FileInputStream(filename)) {
            Theater theater =
theaterBuilder.mergeFrom(input).build();
            System.out.println(
                    "Name:" + theater.getName() + "\n" +
                    "Address:" + theater.getAddress() + "\n" +
                    "Drive_In:" + theater.getDriveIn() + "\n" +
                    "Total Capacity:" +
theater.getTotalCapcity() + "\n" +
                    "Base Ticket Prices: " +
theater.getBaseTicketPrice() + "\n" +
                    "Owner: " + theater.getOwner() + "\n" +
                    "Snacks: " + theater.getSnacksList() + "\n" +
                    "Payment: " + theater.getPayment()
            );

            //Map<FieldDescriptor, Object> f = theater.getAllFields();

            System.out.println("List of fields explicitly specified: "
                    + theater.getAllFields());
        }
    }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
name: "SilverScreen"
```

Now, let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output
Name:SilverScreen
Address:
Drive_In:false
Total Capacity:0
```

```
Base Ticket Prices: 0.0

Owner:

Snacks: []

Payment: CASH

List of fields explicitly specified:
{theater.Theater.name=SilverScreen}
```

So, as we see, all the values defaulted accordingly apart from **name** which we have explicitly specified as seen in the bottommost line.

13. Protobuf – Language Independence

Till now, we have been using Java to serialize and deserialize the Movie Theater data. However, one of the key features that Google Protobuf provides is "language independence". In this chapter, we will see how to serialize using Java and deserialize using Python.

```
Sample Proto file


syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 1;
  string address = 2;

  int32 total_capcity = 3;
  int64 mobile = 4;
  float base_ticket_price = 5;

  bool drive_in = 6;

  enum PAYMENT_SYSTEM{
        CASH = 0;
        CREDIT_CARD = 1;
        DEBIT_CARD = 2;
        APP = 3;
  }

  PAYMENT_SYSTEM payment = 7;

  repeated string snacks = 8;

  map<string, int32> movieTicketPrice = 9;

  TheaterOwner owner = 10;

}

message TheaterOwner{
    string name = 1;
    string address = 2;
}
```

Serialization using Java

To use Protobuf with Java, we will now have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Java code. First, we will create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;

import java.io.FileOutputStream;
import java.io.IOException;
import java.util.ArrayList;
import java.util.HashMap;
import java.util.List;
import java.util.Map;

import com.tutorialspoint.theater.TheaterOuterClass.Theater;
```

```
import
com.tutorialspoint.theater.TheaterOuterClass.TheaterOwner;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.PAYMENT_SYS
TEM;


public class TheaterWriterComplete{
   public static void main(String[] args) throws IOException {


       TheaterOwner owner = TheaterOwner.newBuilder()
            .setName("Anthony Gonsalves")
            .setAddress("513, St Paul Street, West Coast,
California")
            .build();


       List<String> snacks = new ArrayList<>();
           snacks.add("Popcorn");
           snacks.add("Coke");
           snacks.add("Chips");
           snacks.add("Soda");


        Map<String, Integer> ticketPrice = new HashMap<>();
           ticketPrice.put("Avengers Endgame", 700);
           ticketPrice.put("Captain America", 200);
           ticketPrice.put("Wonder Woman 1984", 400);



       Theater theater = Theater.newBuilder()
               .setName("Silver Screener")
               .setAddress("212, Maple Street, LA, California")
               .setDriveIn(true)
               .setTotalCapcity(320)
                 .setMobile(98234567189L)
```

```
                  .setBaseTicketPrice(22.45f)
                  .setPayment(PAYMENT_SYSTEM.CREDIT_CARD)
                  .putAllMovieTicketPrice(ticketPrice)
                  .addAllSnacks(snacks)
                  .setOwner(owner)
                .build();

       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);

       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }

       System.out.println("Saved theater information with
following data to disk: \n" + theater);
   }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
name: "Silver Screener"
address: "212, Maple Street, LA, California"
total_capcity: 320
mobile: 98234567189
base_ticket_price: 22.45
drive_in: true
payment: CREDIT_CARD
```

```
snacks: "Popcorn"
snacks: "Coke"
snacks: "Chips"
snacks: "Soda"
movieTicketPrice {
  key: "Avengers Endgame"
  value: 700
}
movieTicketPrice {
  key: "Captain America"
  value: 200
}
movieTicketPrice {
  key: "Wonder Woman 1984"
  value: 400
}
owner {
  name: "Anthony Gonsalves"
  address: "513, St Paul Street, West Coast, California"
}
```

Deserialization using Python

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;
import java.util.Map;


import com.google.protobuf.DescriptorProtos.FileDescriptorProto;
import com.google.protobuf.Descriptors.FieldDescriptor;
import com.google.protobuf.Descriptors.FileDescriptor;
import com.tutorialspoint.greeting.Greeting.Greet;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReaderExplicit{
   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";
       System.out.println("Reading from file " + filename);


       try(FileInputStream input = new
FileInputStream(filename)) {
            Theater theater =
theaterBuilder.mergeFrom(input).build();
            System.out.println(
                    "Name:" + theater.getName() + "\n" +
                    "Address:" + theater.getAddress() + "\n" +
                    "Drive_In:" + theater.getDriveIn() + "\n" +
                    "Total Capacity:" +
theater.getTotalCapcity() + "\n" +
                    "Base Ticket Prices: " +
theater.getBaseTicketPrice() + "\n" +
                    "Owner: " + theater.getOwner() + "\n" +
                    "Snacks: " + theater.getSnacksList() + "\n" +
                    "Payment: " + theater.getPayment()
            );


            //Map<FieldDescriptor, Object> f = theater.getAllFields();


            System.out.println("List of fields explicitly specified: "
                        + theater.getAllFields());
            }
        }
}
```

Output:

```
Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
name: "SilverScreen"
```

To use Protobuf with Python, we will now have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --python_out=python proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Python code. Now, let us write a Python **reader**:

```
from proto_files import theater_pb2
from pathlib import Path


path = Path()


filename =
str(path.parent.absolute().parent.joinpath("java").joinpath("the
ater_protobuf_output"));
print("Reading from file: " + filename)


theater = theater_pb2.Theater()


f = open(filename, "rb")
theater.ParseFromString(f.read())
f.close()


print("Read greeting from disk: \n" + str(theater))
```

We read the **theater_protobuf_output** file which is generated in the Java directory. Now, let us execute the code:

```
python theaterReader.py


Reading from file: google-protobuf\java\theater_protobuf_output
Read greeting from disk:
name: "Silver Screener"
address: "212, Maple Street, LA, California"
total_capcity: 320
mobile: 98234567189
base_ticket_price: 22.45
drive_in: true
payment: CREDIT_CARD
snacks: "Popcorn"
snacks: "Coke"
snacks: "Chips"
snacks: "Soda"
movieTicketPrice {
  key: "Avengers Endgame"
  value: 700
}
movieTicketPrice {
  key: "Captain America"
  value: 200
}
movieTicketPrice {
  key: "Wonder Woman 1984"
  value: 400
}
owner {
  name: "Anthony Gonsalves"
  address: "513, St Paul Street, West Coast, California"
}
```

So, as we see, all the values which were written by the Java client were correctly deserialized and read by our Python client which effectively means Protobuf is language independent.

14. Protobuf – Compound Data Types

There are two more compound data types which may be useful for complicated use cases. They are "**OneOf**" and "**Any**". In this chapter, we will see how to use these two data types of Protobuf.

OneOf

We pass a few parameters to this **OneOf** data type and Protobuf ensures that only one of them is set. If we set one of them and try to set the other one, the first attribute gets reset. Let's us understand this via an example.

Continuing with our **theater** example, say, we have an API which is used to fetch the count of available employees. The value returned from this API is then set to **'count'** tag in the following file. But if that API errors out, we can't really 'count', instead we attach the error log.

Ideally, we will always have one of them set, i.e., either the call is successful and we get the count OR the count calculation fails and we get the error message.

Following is the syntax that we need to have to instruct Protobuf that we will be creating an **OneOf** attribute:

```
syntax = "proto3";

package theater;

option java_package = "com.tutorialspoint.theater";

message Theater {
  string name = 1;
  string address = 2;

  repeated google.protobuf.Any peopleInside = 3;

  oneof availableEmployees{
        int32 count = 4;
        string errorLog = 5;
  }
}
```

Now our **class/message** contains an **OneOf** attribute, i.e., information about the available employees.

To use Protobuf, we will have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java
proto_files\theater_advanced.proto
```

The above command should create the required files and now we can use it in our Java code. First, we will create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;


import java.util.List;
import java.io.FileOutputStream;
import java.io.IOException;
import java.util.ArrayList;


import com.google.protobuf.Any;
import com.tutorialspoint.theater.TheaterAdvanced.Employee;
import com.tutorialspoint.theater.TheaterAdvanced.Viewer;
import com.tutorialspoint.theater.TheaterAdvanced.Theater;


public class TheaterWriterComplex{
   public static void main(String[] args) throws IOException {


       List<Any> people = new ArrayList<>();

people.add(Any.pack(Employee.newBuilder().setName("John").build(
)));
people.add(Any.pack(Viewer.newBuilder().setName("Jane").setAge(3
0).build()));

people.add(Any.pack(Employee.newBuilder().setName("Simon").build
()));

people.add(Any.pack(Viewer.newBuilder().setName("Janice").setAge
(25).build()));


       Theater theater = Theater.newBuilder()
               .setName("SilverScreen")
               .addAllPeopleInside(people)
               .build();


       String filename = "theater_protobuf_output_silver";
       System.out.println("Saving theater information to file: " +
filename);


       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }


       System.out.println("Saved theater information with
following data to disk: \n" + theater);
   }
}
```

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;
import java.io.IOException;
import com.google.protobuf.Any;
import com.tutorialspoint.theater.TheaterAdvanced.Theater;
```

```
import
com.tutorialspoint.theater.TheaterAdvanced.Theater.AvailableEmpl
oyeesCase;
import
com.tutorialspoint.theater.TheaterAdvanced.Theater.Builder;
import com.tutorialspoint.theater.TheaterAdvanced.Viewer;
import com.tutorialspoint.theater.TheaterAdvanced.Employee;


public class TheaterReaderComplex{
   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output_silver";
       System.out.println("Reading from file " + filename);


       try(FileInputStream input = new FileInputStream(filename)) {
            Theater theater = theaterBuilder.mergeFrom(input).build();
            System.out.println("Name:" + theater.getName() + "\n");


            for (Any anyPeople : theater.getPeopleInsideList()) {
                if(anyPeople.is(Employee.class)) {
                    Employee employee = anyPeople.unpack(Employee.class);
                    System.out.println("Employee:" + employee + "\n");
                }


                if(anyPeople.is(Viewer.class)) {
                    Viewer viewer =
anyPeople.unpack(Viewer.class);
                    System.out.println("Viewer:" + viewer + "\n");
                }
            }
        }
   }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file:
theater_protobuf_output_silver
Saved theater information with following data to disk:
name: "SilverScreen"
peopleInside {
  type_url: "type.googleapis.com/theater.Employee"
  value: "\n\004John"
}
peopleInside {
  type_url: "type.googleapis.com/theater.Viewer"
  value: "\n\004Jane\020\036"
}
peopleInside {
  type_url: "type.googleapis.com/theater.Employee"
  value: "\n\005Simon"
}
peopleInside {
  type_url: "type.googleapis.com/theater.Viewer"
  value: "\n\006Janice\020\031"
}
```

Now, let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output_silver
Name:SilverScreen
```

```
Employee:name: "John"


Viewer:name: "Jane"
age: 30


Employee:name: "Simon"


Viewer:name: "Janice"
age: 25
```

So, as we see, in the list, we are able to figure out the **Any** type and find the respective underlying datatype employee/viewer. Let us now look at **defaults** and **AnyOf**.

Any

The next data type that can be of use for complicated uses cases is **Any**. We can pass any type/message/class to this data type and Protobuf would not complain. Let us understand this via an example.

Continuing with the **theater** example, say, we want to track people inside the theater. Some of them could be **employees** and others could be **viewers**. But ultimately they are people, so we will pass them in a single list which would contain both the types.

Following is the syntax that we need to have to instruct Protobuf that we will be creating a list:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


import "google/protobuf/any.proto";


message Theater {
  string name = 1;
  string address = 2;

  repeated google.protobuf.Any peopleInside = 3;
}

message Employee{
    string name = 1;
    string address = 2;
}

message Viewer{
    string name = 1;
    int32 age = 2;
    string sex = 3;
}
```

Now our **class/message** contains an **Any** attribute **'peopleInside'** list along with **Viewer** and **Employee** class, i.e., information about the people inside theater. Let us see this in action.

To use Protobuf, we will now have to use **protoc** binary to create the required classes from this ".proto" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java
proto_files\theater_advanced.proto
```

The above command should create the required files and now we can use it in our Java code. First, we will create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;

import java.util.List;
import java.io.FileOutputStream;
import java.io.IOException;
import java.util.ArrayList;
import com.google.protobuf.Any;
import com.tutorialspoint.theater.TheaterAdvanced.Employee;
import com.tutorialspoint.theater.TheaterAdvanced.Viewer;
import com.tutorialspoint.theater.TheaterAdvanced.Theater;


public class TheaterWriter{
   public static void main(String[] args) throws IOException {


       List<Any> people = new ArrayList<>();

people.add(Any.pack(Employee.newBuilder().setName("John").build(
)));
          people.add(Any.pack(Viewer.newBuilder().setName("Jane").setAg
e(30).build()));

people.add(Any.pack(Employee.newBuilder().setName("Simon").build
()));
          people.add(Any.pack(Viewer.newBuilder().setName("Janice").setAge
(25).build()));


       Theater theater = Theater.newBuilder()
               .setName("SilverScreen")
               .addAllPeopleInside(people)
               .build();


       String filename = "theater_protobuf_output_silver";
       System.out.println("Saving theater information to file: " +
filename);


       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }
       System.out.println("Saved theater information with
following data to disk: \n" + theater);


   }
}
```

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;
import java.io.IOException;
import com.google.protobuf.Any;
import com.tutorialspoint.theater.TheaterAdvanced.Theater;
import
com.tutorialspoint.theater.TheaterAdvanced.Theater.AvailableEmpl
oyeesCase;
import
com.tutorialspoint.theater.TheaterAdvanced.Theater.Builder;
import com.tutorialspoint.theater.TheaterAdvanced.Viewer;
import com.tutorialspoint.theater.TheaterAdvanced.Employee;


public class TheaterReaderComplex{
   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output_silver";
       System.out.println("Reading from file " + filename);


        try(FileInputStream input = new
FileInputStream(filename)) {
```

```
            Theater theater = 
theaterBuilder.mergeFrom(input).build();


            System.out.println("Name:" + theater.getName() + "\n");


            for (Any anyPeople : theater.getPeopleInsideList()) {
                if(anyPeople.is(Employee.class)) {
                    Employee employee = 
anyPeople.unpack(Employee.class);
                    System.out.println("Employee:" + employee + "\n");
                }


                if(anyPeople.is(Viewer.class)) {
                    Viewer viewer = anyPeople.unpack(Viewer.class);
                    System.out.println("Viewer:" + viewer + "\n");
                }
            }
        }
    }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar 
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: 
theater_protobuf_output_silver
Saved theater information with following data to disk:
name: "SilverScreen"
peopleInside {
  type_url: "type.googleapis.com/theater.Employee"
  value: "\n\004John"
}
peopleInside {
  type_url: "type.googleapis.com/theater.Viewer"
  value: "\n\004Jane\020\036"
}
peopleInside {
  type_url: "type.googleapis.com/theater.Employee"
  value: "\n\005Simon"
}
peopleInside {
  type_url: "type.googleapis.com/theater.Viewer"
  value: "\n\006Janice\020\031"
}
```

Note: There are two points to note:

1. In case of **Any**, Protobuf packs/serializes the contents inside any tag to bytes and then stores it as **'value'**. Basically, that allows us to send any message type with this **'Any'** tag.

2. We also see "**type.googleapis.com/theater.Viewer**" and "**type.googleapis.com/theater.Employee**". This is used by Protobuf to save the type of object along with the data as the type of data in the **Any** data type can vary.

Now let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output_silver
Name:SilverScreen


Employee:name: "John"


Viewer:name: "Jane"
age: 30
```

```


Employee:name: "Simon"


Viewer:name: "Janice"
age: 25
```

So, as we see, our **reader** code is successfully able to differentiate between **Employee** and the **Viewer**, even though they come in the same array.

15. Protobuf – Command Line Usage

Protobuf serializes the data and stores it in a binary format. While this may not be a problem if we are dealing simply with **strings**, because ultimately Protobuf uses UTF-8. So, any text that it stores would be human readable if you are using a UTF-8 enabled reader. However, things like **int32**, **Boolean**, **list**, **maps** are encoded using specific techniques to reduce space consumption.

That is why, at times, encoding/decoding a message via simple command line utility is useful for testing purposes. Let us see this in action:

Suppose we use the following simple "**greeting_cli.proto**":

```
syntax = "proto3";


package tutorial;


option java_package = "com.tutorialspoint.greeting";


message Greet {
  string greeting = 1;
  string username = 2;
  int32 age = 3;
}
```

And we create a message in **cli_greeting_message**:

```
greeting: "Yo"
username : "John"
age : 50
```

Now, let us encode this message using Protobuf CLI tool:

```
cat  .\cli_greeting_msg.proto |  protoc  --encode=tutorial.Greet
.\greeting_cli.proto > encoded_greeting
```

If we look at what is inside this file or **cat** this file:

```
cat .\encoded_greeting


☻Yo↕♦John↑2
```

You will notice some weird characters apart from "**Yo**" and "**John**". That is because these encoding may not be a valid unicode/UTF-8 encoding. UTF-8 is what is used, generally speaking, at most of the places. And this is used for **string** in case of Protobuf, but **ints**, **maps**, **Boolean**, **list** have separate formats. Plus, this file also contains a metadata of the data.

That is why, we need a decoder/deserializer to read this data. Let us use that.

```
cat .\encoded_greeting | protoc --decode=tutorial.Greet
.\greeting_cli.proto


greeting: "Yo"

username : "John"

age : 50
```

So, as we see, we are able to get the data back which was serialized and looked weird in the file.

16. Protobuf – Rules to Update Definition

Assume you came out with the definition of the **proto** file that you will use in the production environment. There will obviously be times in future when this definition would have to change. In that case, it is essential that the changes we make adhere to certain rules so that the changes are backwards compatible. Let us see this in action with a few do's and dont's.

Add a new field in the **writer**, while the **reader** retains the older version of code.

Suppose, you decide to add a new field. Ideally, to have the new field to be added, we will have to update the **writer** and the **reader** simultaneously. However, in a large-scale deployment, this is not possible. There will be cases where the **writer** has been updated, but the **reader** is yet to be updated with the new field. This is where the above situation occurs. Let us see that in action.

Continuing with our **theater** example, say, we just have a single tag which is **'name'** in our **proto** file. Following is the syntax that we need to have to instruct Protobuf:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 1;
}
```

To use Protobuf, we will now have to use the **protoc** binary to create the required classes from this "**.proto**" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Java code. First, we will create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;


package com.tutorialspoint.theater;


import java.io.FileOutputStream;
import java.io.IOException;


import com.tutorialspoint.theater.TheaterOuterClass.Theater;


public class TheaterWriter{
   public static void main(String[] args) throws IOException {
       Theater theater = Theater.newBuilder()
               .setName("Silver Screener")
               .build();


       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);


       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }


       System.out.println("Saved theater information with
following data to disk: \n" + theater);
   }
}
```

Next, we will have a **reader** to read the theater information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;


import com.google.protobuf.ProtocolStringList;
import com.tutorialspoint.greeting.Greeting.Greet;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{
   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";
        System.out.println("Reading from file " + filename);


        try(FileInputStream input = new
FileInputStream(filename)) {
            Theater theater =
theaterBuilder.mergeFrom(input).build();
            System.out.println(theater);
            System.out.println("Unknwon fields: " +
theater.getUnknownFields());
        }
   }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
name: "Silver Screener"
```

Now let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output
name: "Silver Screener"
```

Unknown Fields

We just wrote a simple string as per our Protobuf definition and the **reader** was able to read the string. And we also saw that there were no unknown fields that the reader was not aware of.

But now, let us suppose we want add a new string **'address'** to our Protobuf definition. Now, it will look like this:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 1;
  string address = 2;
}
```

We will also update our **writer** and add an **address** field:

```
Theater theater = Theater.newBuilder()
        .setName("Silver Screener")
        .setAddress("212, Maple Street, LA, California")
        .build();
```

Before compiling, rename the JAR from the previous compilation to **protobuf-tutorial-old-1.0.jar**. And then compile.

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output

Saved theater information with following data to disk:

name: "Silver Screener"

address: "212, Maple Street, LA, California"
```

Now let us execute the **reader** to read from the same file but from the older JAR:

```
java -cp .\target\protobuf-tutorial-old-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output

Reading from file theater_protobuf_output

name: "Silver Screener"

2: "212, Maple Street, LA, California"


Unknown fields: 2: "212, Maple Street, LA, California"
```

As you can see from the last line of the output, the old **reader** is unaware of the **address** field which was added by the new **writer**. It just shows how a combination of "new writer - old reader" functions.

Deleting a Field

Suppose, you decide to delete an existing field. Ideally, for the deleted field to have an effect immediately, we will have to update the **writer** and the **reader** simultaneously. However, in a large-scale deployment, this is not possible. There will be cases where the **writer** has been updated, but the **reader** is yet to be updated. In such a case, the **reader** will still attempt to read the deleted field. Let us see that in action.

Continuing with the **theater** example, say, we just have two tags in our **proto** file. Following is the syntax that we need to have to instruct Protobuf:

```
syntax = "proto3";

```

```
package theater;

option java_package = "com.tutorialspoint.theater";

message Theater {
  string name = 1;
  string address = 2;
}
```

To use Protobuf we will now have to use the **protoc** binary to create the required classes from this "**.proto**" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Java code. First, we will create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;

package com.tutorialspoint.theater;

import java.io.FileOutputStream;
import java.io.IOException;

import com.tutorialspoint.theater.TheaterOuterClass.Theater;

public class TheaterWriter{
   public static void main(String[] args) throws IOException {
       Theater theater = Theater.newBuilder()
               .setName("Silver Screener")
               .setAddress("212, Maple Street, LA, California")
               .build();

       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);
```

```
       try(FileOutputStream output = new
FileOutputStream(filename)){

           theater.writeTo(output);

       }


       System.out.println("Saved theater information with
following data to disk: \n" + theater);

   }

}
```

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;

import java.io.FileOutputStream;

import java.io.IOException;


import com.google.protobuf.ProtocolStringList;

import com.tutorialspoint.greeting.Greeting.Greet;

import com.tutorialspoint.theater.TheaterOuterClass.Theater;

import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{

   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";

        System.out.println("Reading from file " + filename);


        try(FileInputStream input = new FileInputStream(filename))
{
```

```
            Theater theater = 
theaterBuilder.mergeFrom(input).build();
            System.out.println(theater);
            System.out.println("Unknwon fields: " + 
theater.getUnknownFields());
        }
   }
}
```

Now, post compilation, let us execute the writer first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar 
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
name: "Silver Screener"
address: "212, Maple Street, LA, California"
```

Now let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar 
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output
name: "Silver Screener"
address: "212, Maple Street, LA, California"
```

So, nothing new here, we just wrote a simple **string** as per our Protobuf definition and the **reader** was able to read the **string**.

But now, let us suppose we want to delete the string **'address'** from our Protobuf definition. So, the definition would look like this:

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

```
package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 1;
}
```

We will also update our **writer** as follows:

```
Theater theater = Theater.newBuilder()
        .setName("Silver Screener")
        .build();
```

Before compiling, rename the JAR from the previous compilation to **protobuf-tutorial-old-1.0.jar**. And then compile.

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
name: "Silver Screener"
```

Now let us execute the reader to read from the same file but from the older JAR:

```
java -cp .\target\protobuf-tutorial-old-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output
Reading from file theater_protobuf_output
name: "Silver Screener"
address:
```

As you can see from the last line of the output, the old reader defaults to the value of "address". It shows how a combination of "new writer - old reader" functions.

Avoid Reusing Serial Number of the Field

There may be cases where, by mistake, we update the "serial number" of a field. This can be problematic, as the serial number is very critical for Protobuf to understand and deserialize the data. And some old **reader** may be relying on this serial number to deserialize the data. So, it is recommended that you:

- Do not change serial number of field
- Do not reuse serial number of deleted field.

Let us see that in action by interchanging the field tags.

Continuing with the **theater** example, let's assume we just have two tags in our **proto** file. Following is the syntax that we need to have to instruct Protobuf:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 1;
  string address = 2;
}
```

To use Protobuf, we will now have to use the **protoc** binary to create the required classes from this "**.proto**" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Java code. First, we will create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;


package com.tutorialspoint.theater;


import java.io.FileOutputStream;
import java.io.IOException;


import com.tutorialspoint.theater.TheaterOuterClass.Theater;


public class TheaterWriter{
   public static void main(String[] args) throws IOException {
       Theater theater = Theater.newBuilder()
               .setName("Silver Screener")
                .setAddress("212, Maple Street, LA, California")
               .build();


       String filename = "theater_protobuf_output";
       System.out.println("Saving theater information to file: " +
filename);


       try(FileOutputStream output = new
FileOutputStream(filename)){
           theater.writeTo(output);
       }


       System.out.println("Saved theater information with
following data to disk: \n" + theater);
   }
}
```

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;


import com.google.protobuf.ProtocolStringList;
import com.tutorialspoint.greeting.Greeting.Greet;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{
   public static void main(String[] args) throws IOException {
       Builder theaterBuilder = Theater.newBuilder();
       String filename = "theater_protobuf_output";
         System.out.println("Reading from file " + filename);


        try(FileInputStream input = new
FileInputStream(filename)) {
            Theater theater =
theaterBuilder.mergeFrom(input).build();
            System.out.println(theater);
            System.out.println("Unknwon fields: " +
theater.getUnknownFields());
        }
   }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
name: "Silver Screener"
address: "212, Maple Street, LA, California"
```

Next, let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output
```

```
name: "Silver Screener"
address: "212, Maple Street, LA, California"
```

Here, we just wrote simple strings as per our Protobuf definition and the **reader** was able to read the string. But now, let us interchange the serial number in our Protobuf definition and to make it like this:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 2;
  string address = 1;
}
```

Before compiling, rename the JAR from previous compilation to **protobuf-tutorial-old-1.0.jar**. And then compile.

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
address: "212, Maple Street, LA, California"
name: "Silver Screener"
```

Now let us execute the **reader** to read from the same file but from the older JAR:

```
java -cp .\target\protobuf-tutorial-old-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output
name: "212, Maple Street, LA, California"
```

```
address: "Silver Screener"
```

As you can see from the output, the old **reader** interchanged the **address** and the **name**. It shows that updating the serial number along with a combination of "new writer-old reader" does not function as expected.

More importantly, here we had two strings, which is why we get to see the data. If we had used different data types, for example, **int32**, **Boolean**, **map**, etc., Protobuf would have given up and treated that as an unknown field.

So, it is imperative to not change the serial number of a field or reuse the serial number of a deleted field.

Changing the Field Type

There may be cases where we need to update the **type** of an **attribute/field**. Protobuf has certain compatibility rules for this. Not all the types can be converted to other types. Few basic ones to be aware of:

- **string** and **bytes** are compatible if the bytes are UTF-8. This is because, **strings** are anyways encoded/decoded as UTF-8 by Protobuf.

- **enum** is compatible with **int32** and **int64** in terms of the value, however, the client may not deserialize this as expected.

- **int32**, **int64** (**unsigned** also) along with **bool** are compatible and thus can be interchanged. Excessive characters may get truncated similar to how **casting** works in languages.

But we need to be very careful when changing **types**. Let us see that in action with an incorrect example of converting **int64** to **int32**.

Continuing with the **theater** example, suppose we just have two tags in our **proto** file. Following is the syntax that we need to have to instruct Protobuf:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 1;
  int64 total_capacity = 2;
}
```

To use Protobuf, we will now have to use the **protoc** binary to create the required classes from this "**.proto**" file. Let us see how to do that:

```
protoc  --java_out=java/src/main/java proto_files\theater.proto
```

The above command should create the required files and now we can use it in our Java code. First, we will create a **writer** to write the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileOutputStream;
import java.io.IOException;


import com.tutorialspoint.theater.TheaterOuterClass.Theater;


public class TheaterWriter{
   public static void main(String[] args) throws IOException {
       Theater theater = Theater.newBuilder()
               .setName("Silver Screener")
               .setTotalCapacity(2300000000L)
               .build();


       String filename = "theater_protobuf_output";
         System.out.println("Saving theater information to file: " + filename);


       try(FileOutputStream output = new FileOutputStream(filename)){
           theater.writeTo(output);
       }


       System.out.println("Saved theater information with following data to disk: \n" + theater);
   }
}
```

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Saving theater information to file: theater_protobuf_output
Saved theater information with following data to disk:
name: "Silver Screener"
total_capacity: 2300000000
```

Let us suppose, we use a different version of **proto** file for the **reader**:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 1;
  int64 total_capacity = 2;
}
```

Next, we will have a **reader** to read the **theater** information:

```
package com.tutorialspoint.theater;


import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.io.IOException;


import com.google.protobuf.ProtocolStringList;
import com.tutorialspoint.greeting.Greeting.Greet;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
```

```
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.Builder;


public class TheaterReader{
   public static void main(String[] args) throws IOException {


       Builder theaterBuilder = Theater.newBuilder();


       String filename = "theater_protobuf_output";
        System.out.println("Reading from file " + filename);


        try(FileInputStream input = new
FileInputStream(filename)) {
            Theater theater =
theaterBuilder.mergeFrom(input).build();
            System.out.println(theater);
            System.out.println("Unknwon fields: " +
theater.getUnknownFields());
        }
   }
}
```

Now let us execute the **reader** to read from the same file:

```
java -cp .\target\protobuf-tutorial-old-1.0.jar
com.tutorialspoint.theater.TheaterReader


Reading from file theater_protobuf_output
name: "Silver Screener"
address: "212, Maple Street, LA, California"
```

So, nothing new here, we just wrote simple **strings** as per our Protobuf definition and the **reader** was able to read the string. But now, let us interchange the serial number in our Protobuf definition and make it like this:

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

```
package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 2;
  int32 total_capacity = 2;
}
```

Before compiling, rename the JAR from previous compilation to **protobuf-tutorial-old-1.0.jar**. And then compile.

Now, post compilation, let us execute the **writer** first:

```
> java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.theater.TheaterWriter


Reading from file theater_protobuf_output
address: "Silver Screener"
total_capcity: -1994967296
```

As you can see from the output, the old **reader** converted the number from **int64**, however, the given **int32** does not have enough space to contain the data, it wrapped around to negative number. This wrapping is Java specific and is not related to Protobuf.

So, we need to upgrade to **int64** from **int32** instead of other way around. If we still want to convert from **int64** to **int32**, we need to ensure that the values can be actually held in 31 bits (1 bit for sign bit).

17. Protobuf – Integration with Kafka

We have covered quite a lot of examples of Protobuf and its data types. In this chapter, let us take another example and see how Protobuf integrates with a Schema Registry used by Kafka. Let us first understand what a "schema registry" is.

Schema Registry

Kafka is one of the widely used messaging queues. It is used to apply the publisher-subscriber model at scale. More information about Kafka can be found here: https://www.tutorialspoint.com/apache_kafka/index.htm

However, at the basic level, a Kafka **producer** is supposed to send a message, i.e., a piece of information which the Kafka **consumer** can read. And this sending and consuming of message is where we need a schema. It is especially required in large-scale organization where there are multiple teams reading/writing to Kafka topic. Kafka provides a way to store this schema in a *schema registry* which are then created/consumed when the producer/consumer creates/consumes the message.

There are two major benefits of maintaining a schema:

- **Compatibility**: In larger organizations, it is necessary that the team producing the message does not break the downstream tools which consume these messages. Schema registry ensures that changes are backwards compatible.

- **Efficient encoding**: Sending in a field name, its type with every message is space and compute inefficient. With schemas in place, we do not need to send this information with each message.

The schema registry supports **Avro**, **Google Protobuf** and **JSON** Schema as the schema language. The schema in these languages can be stored in the schema registry. For this tutorial, we would require Kafka setup and Schema registry setup.

For installation of Kafka, you can check the following links:

- https://www.tutorialspoint.com/apache_kafka/apache_kafka_installation_steps.htm

- https://docs.confluent.io/platform/current/installation/installing_cp/deb-ubuntu.html#systemd-ubuntu-debian-install

Once you have Kafka installed, you can then setup the Schema Registry by updating the **/etc/schema-registry/schema-registry.properties** file.

```
# where should schema registry listen on
listeners=http://0.0.0.0:8081


# Schema registry uses Kafka beneath it, so we need to tell
where are the Kafka brokers available
kafkastore.bootstrap.servers=PLAINTEXT://hostname:9092,SSL://hos
tname2:9092
```

Once done, you can then run:

```
sudo systemctl start confluent-schema-registry
```

With the setup out of the way, let us start using Google Protobuf along with the Schema Registry.

Kafka Producer with Protobuf Schema

Let us continue with our **theater** example. We will use the following Protobuf schema:

```
syntax = "proto3";


package theater;


option java_package = "com.tutorialspoint.theater";


message Theater {
  string name = 1;
  string address = 2;

  int32 total_capcity = 3;
  int64 mobile = 4;
  float base_ticket_price = 5;
  bool drive_in = 6;

  enum PAYMENT_SYSTEM{
        CASH = 0;
        CREDIT_CARD = 1;
        DEBIT_CARD = 2;
        APP = 3;
  }

  PAYMENT_SYSTEM payment = 7;

  repeated string snacks = 8;

  map<string, int32> movieTicketPrice = 9;

}
```

Now, let us create a simple Kafka **writer** which would write the message encoded in this format to the Kafka topic. But for doing that, first, we need to add a few dependencies to our Maven POM:

- Kafka Client to use Kafka producer and consumer
- Kafka Protobuf serializer to serialize and deserialize the message
- **Slf4j** simple to ensure we get logs from Kafka

```
    <dependency>
        <groupId>org.apache.kafka</groupId>
        <artifactId>kafka-clients</artifactId>
        <version>2.5.0</version>
    </dependency>


    <!-- https://mvnrepository.com/artifact/io.confluent/kafka-
protobuf-serializer -->
    <dependency>
```

```
        <groupId>io.confluent</groupId>
        <artifactId>kafka-protobuf-serializer</artifactId>
        <version>5.5.1</version>
    </dependency>

    <!-- https://mvnrepository.com/artifact/org.slf4j/slf4j-
simple -->
    <dependency>
        <groupId>org.slf4j</groupId>
        <artifactId>slf4j-simple</artifactId>
        <version>1.7.30</version>
    </dependency>
```

Once this is done, let us now create a Kafka **producer**. This producer will create and send a message which will contain the **theater** object.

```
package com.tutorialspoint.kafka;
import java.util.ArrayList;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import java.util.Properties;
import org.apache.kafka.clients.producer.Producer;
import org.apache.kafka.clients.producer.KafkaProducer;

import org.apache.kafka.clients.producer.ProducerRecord;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.PAYMENT_SYS
TEM;

public class KafkaProtbufProducer {

   public static void main(String[] args) throws Exception{
      String topicName = "testy1";

      Properties props = new Properties();

      props.put("bootstrap.servers", "localhost:9092");
      props.put("clientid", "foo");
      props.put("key.serializer",

"org.apache.kafka.common.serialization.StringSerializer");

      props.put("value.serializer",

"io.confluent.kafka.serializers.protobuf.KafkaProtobufSerializer
");
      props.put("schema.registry.url", "http://localhost:8081");
      props.put("auto.register.schemas", "true");

      Producer<String, Theater> producer = new
KafkaProducer<>(props);

      producer.send(new ProducerRecord<String, Theater>
          (topicName, "SilverScreen", getTheater())).get();

      System.out.println("Sent to Kafka: \n" + getTheater());
      producer.flush();
      producer.close();
   }

   public static Theater getTheater() {

       List<String> snacks = new ArrayList<>();
           snacks.add("Popcorn");
           snacks.add("Coke");
```

```
            snacks.add("Chips");
            snacks.add("Soda");

        Map<String, Integer> ticketPrice = new HashMap<>();
            ticketPrice.put("Avengers Endgame", 700);
            ticketPrice.put("Captain America", 200);
            ticketPrice.put("Wonder Woman 1984", 400);



        Theater theater = Theater.newBuilder()
                .setName("Silver Screener")
                .setAddress("212, Maple Street, LA, California")
                .setDriveIn(true)
                .setTotalCapacity(320)
                .setMobile(98234567189L)
                .setBaseTicketPrice(22.45f)
                .setPayment(PAYMENT_SYSTEM.CREDIT_CARD)
                .putAllMovieTicketPrice(ticketPrice)
                .addAllSnacks(snacks)
                .build();

        return theater;


    }
}
```

Here is a list of a few points that we need to be aware of:

- We need to pass the Schema Registry URL to the Producer.
- We also need to pass the correct Protobuf Serializer which is specific to the Schema Registry.
- Schema registry would automatically store the schema of the **theater** object when we are done sending.
- Lastly, we created a **theater** object from our auto-generated Java code and that is what we will be sending.

Let us now compile and execute the code:

```
mvn clean install ; java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.kafka.KafkaProtbufProducer
```

We will get to see the following output:

```
[main] INFO org.apache.kafka.common.utils.AppInfoParser - Kafka
version: 2.5.0

[main] INFO org.apache.kafka.common.utils.AppInfoParser - Kafka
commitId: 66563e712b0b9f84

[main] INFO org.apache.kafka.common.utils.AppInfoParser - Kafka
startTimeMs: 1621692205607

[kafka-producer-network-thread | producer-1] INFO
org.apache.kafka.clients.Metadata - [Producer clientId=producer-
1] Cluster ID: 7kwQVXjYSz--bE47MiXmjw
```

Sent to Kafka:

```
name: "Silver Screener"
address: "212, Maple Street, LA, California"
total_capacity: 320
mobile: 98234567189
base_ticket_price: 22.45
drive_in: true
payment: CREDIT_CARD
snacks: "Popcorn"
snacks: "Coke"
snacks: "Chips"
snacks: "Soda"
movieTicketPrice {
  key: "Avengers Endgame"
  value: 700
}
movieTicketPrice {
  key: "Captain America"
  value: 200
}
movieTicketPrice {
  key: "Wonder Woman 1984"
  value: 400
}


[main] INFO org.apache.kafka.clients.producer.KafkaProducer -
[Producer clientId=producer-1] Closing the Kafka producer with
timeoutMillis = 9223372036854775807 ms.
```

It means that our message has been sent.

Now, let us confirm that the schema has been stored in the Schema Registry.

```
curl  -X GET http://localhost:8081/subjects | jq
```

And the output which is displayed is "**topicName**" + "**key/value**"

```
[
  "testy1-value"
]
```

We can also see the schema which is stored by the registry:

```
curl  -X GET http://localhost:8081/schemas/ids/1 | jq


{
  "schemaType": "PROTOBUF",
  "schema": "syntax = \"proto3\";\npackage theater;\n\noption
java_package = \"com.tutorialspoint.theater\";\n\nmessage
Theater {\n  string name = 1;\n  string address = 2;\n  int64
total_capacity = 3;\n  int64 mobile = 4;\n  float
base_ticket_price = 5;\n  bool drive_in = 6;\n
.theater.Theater.PAYMENT_SYSTEM payment = 7;\n  repeated string
snacks = 8;\n  repeated .theater.Theater.MovieTicketPriceEntry
movieTicketPrice = 9;\n\n  message MovieTicketPriceEntry {\n
option map_entry = true;\n  \n    string key = 1;\n    int32
value = 2;\n  }\n  enum PAYMENT_SYSTEM {\n    CASH = 0;\n
CREDIT_CARD = 1;\n    DEBIT_CARD = 2;\n    APP = 3;\n  }\n}\n"
}
```

Kafka Consumer with Protobuf Schema

Let us now create a Kafka **consumer**. This consumer will consume the message which contains the **theater** object.

```
package com.tutorialspoint.kafka;
import java.util.ArrayList;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import java.util.Properties;
import org.apache.kafka.clients.producer.Producer;
import org.apache.kafka.clients.producer.KafkaProducer;

import org.apache.kafka.clients.producer.ProducerRecord;
import com.tutorialspoint.theater.TheaterOuterClass.Theater;
import
com.tutorialspoint.theater.TheaterOuterClass.Theater.PAYMENT_SYS
TEM;

public class KafkaProtbufProducer {

   public static void main(String[] args) throws Exception{

      String topicName = "testy1";

      Properties props = new Properties();

      props.put("bootstrap.servers", "localhost:9092");
      props.put("clientid", "foo");
      props.put("key.serializer",

"org.apache.kafka.common.serialization.StringSerializer");

      props.put("value.serializer",
"io.confluent.kafka.serializers.protobuf.KafkaProtobufSerializer
");
      props.put("schema.registry.url", "http://localhost:8081");
      props.put("auto.register.schemas", "true");

      Producer<String, Theater> producer = new
KafkaProducer<>(props);

      producer.send(new ProducerRecord<String, Theater>
          (topicName, "SilverScreen", getTheater())).get();

      System.out.println("Sent to Kafka: \n" + getTheater());
      producer.flush();
      producer.close();
   }

   public static Theater getTheater() {

       List<String> snacks = new ArrayList<>();
           snacks.add("Popcorn");
           snacks.add("Coke");
           snacks.add("Chips");
           snacks.add("Soda");

       Map<String, Integer> ticketPrice = new HashMap<>();
           ticketPrice.put("Avengers Endgame", 700);
           ticketPrice.put("Captain America", 200);
           ticketPrice.put("Wonder Woman 1984", 400);


       Theater theater = Theater.newBuilder()
               .setName("Silver Screener")
```

```
                .setAddress("212, Maple Street, LA, California")
                .setDriveIn(true)
                .setTotalCapacity(320)
                .setMobile(98234567189L)
                .setBaseTicketPrice(22.45f)
                .setPayment(PAYMENT_SYSTEM.CREDIT_CARD)
                .putAllMovieTicketPrice(ticketPrice)
                .addAllSnacks(snacks)
                .build();

        return theater;

    }
}
```

Here is a list of points that we need to be aware of:

- We need to pass the Schema Registry URL to the Consumer.
- We also need to pass the correct Protobuf Deserializer which is specific to the Schema Registry.
- The Schema Registry would automatically read the stored schema of the **theater** object when we are done consuming.
- Lastly, we created a **theater** object from our auto-generated Java code and that is what we will be sending.

Let us now compile and execute the code:

```
mvn clean install ; java -cp .\target\protobuf-tutorial-1.0.jar
com.tutorialspoint.kafka.KafkaProtbufConsumer


offset = 0, key = SilverScreen, value = May 22, 2021 7:50:15 PM
com.google.protobuf.TextFormat$Printer$MapEntryAdapter compareTo
May 22, 2021 7:50:15 PM
com.google.protobuf.TextFormat$Printer$MapEntryAdapter compareTo


name: "Silver Screener"
```

```
address: "212, Maple Street, LA, California"
total_capacity: 320
mobile: 98234567189
base_ticket_price: 22.45
drive_in: true
payment: CREDIT_CARD
snacks: "Popcorn"
snacks: "Coke"
snacks: "Chips"
snacks: "Soda"
movieTicketPrice {
  key: "Captain America"
  value: 200
}
movieTicketPrice {
  key: "Wonder Woman 1984"
  value: 400
}
movieTicketPrice {
  key: "Avengers Endgame"
  value: 700
}
```

So, as we can see, the message which was written into Kafka was correctly consumed by the Consumer. Plus, the Registry stored the schema which can also be accessed by a REST API.

18. Protobuf – In Other Languages

We have been using Protobuf in Java and Python. But there are multiple languages it supports including C++, C#, Kotlin, Dart, Go, etc. The basic stuff mostly remains the same, i.e., writing a **proto** schema, generating the source code via **protoc** binary which our code can use. Let us write a basic example for **Go** and **Dart** as part of this section.

We will use the following **proto** file:

```
syntax = "proto3";


package tutorial;


message Greet {
    string greeting = 1;
    string username = 2;
}
```

Using Google Protobuf in Go Lang

To use the above Protobuf file, we will first have to generate the code for the **Greet** class in **Go** language. For that, we need to do the following:

Install the **Go Protobuf plugin** (**protoc-gen-go**) which is a prerequisite for the **protoc** file which we have been using:

```
go install google.golang.org/protobuf/cmd/protoc-gen-go
```

Then, run the **protoc** with the provided "**.proto**" file and we will instruct it to generate the code under the "**go**" directory.

```
protoc  --go_out=go proto_files/greeting.proto
```

Post execution of the above command, you will notice an auto-generated class: "**greeting.pb.go**". This class would help us with the serialization and deserialization of the **Greet** object.

Now, let us create the **writer** of the data, which will take the **username** and **greeting** as its input:

```
import "fmt"
import "io/ioutil"

func main() {
    greet := Greeting{}
    greet.username = "John"
    greet.greeting = "Hello"

    out, err := proto.Marshal(greet)

    ioutil.WriteFile("greeting_go_out", out , 0644)

    fmt.Println("Saved greeting with following data to disk:")
    fmt.Println(p)
}
```

Now let us create the **reader** which will read the file:

```
import "fmt"
import "io/ioutil"

func main() {
    in, err := ioutil.ReadFile("greeting_go_out")

    greet := &pb.Greet{}
    proto.Unmarshal(in, greet)

    fmt.Println("Reading from file greeting_protobuf_output:")
    fmt.Println(greet)
}
```

The **reader** simply reads from the same file, deserializes it, and prints the data about the greeting.

Now that we have setup the **reader** and the **writer**, let us compile the project.

Next, let us first execute the **writer**:

```
go run greeting_writer.go


Saved greeting with following data to disk:
{greeting: Hello, username: John}
```

Then, let us execute the **reader**:

```
go run greeting_reader.go


Reading from file greeting_protobuf_output
{greeting: Hello, username: John}
```

So, as we can see, the data that was serialized by the **writer** and saved to the file, that exact data is correctly deserialized by the **reader** and printed accordingly.

Using Google Protobuf in Dart

To use the above Protobuf file, we will first have to install and generate the code for the **Greet** class in Dart language. For that, we need to do the following:

Install the **Dart Protobuf plugin** (**protoc-gen-go**) which is the prerequisite for the **protoc** file which we have been using.

```
https://github.com/dart-
lang/protobuf/tree/master/protoc_plugin#how-to-build-and-use
```

Then, run the **protoc** with the provided "**.proto**" file and we will instruct it to generate the code under the "**dart**" directory.

```
protoc  --go_out=dart proto_files/greeting.proto
```

Post execution of the above command, you will notice an auto-generated class: "**greeting.pb.dart**". This class would help us with the serialization and deserialization of the **Greet** object.

Now, let us create the **writer** of the data, which will take the **username** and **greeting** as its input:

```
import 'dart:io';

import 'dart/greeting.pb.dart';

main(List arguments) {

  Greeting greet = Greeting();
  greet.greeting = "Hello";
  greet.username = "John";

  File file = File("greeting_go_out");

  print("Saved greeting with following data to disk:")
  file.writeAsBytes(greet.writeToBuffer());
  print(greet)
}
```

Next, let us create a **reader** which will read the file:

```
import 'dart:io';

import 'dart/greeting.pb.dart';

main(List arguments) {

  File file = File("greeting_go_out");

  print("Reading from file greeting_protobuf_output:")
  Greeting greet = Greeting.fromBuffer(file.readAsBytesSync());
  print(greet)
}
```

The **reader** simply reads from the same file, deserializes it, and prints the data about the **greeting**.

Now that we have setup the **reader** and the **writer**, let us compile the project.

Next, let us first execute the **writer**:

```
dart run greeting_writer.dart


Saved greeting with following data to disk:
greeting: Hello
username: John
```

And then, let us execute the **reader**.

```
dart run greeting_reader.dart


Reading from file greeting_protobuf_output
greeting: Hello
username: John
```

So, as we can see, the data that was serialized by the **writer** and saved to the file, that exact data is correctly deserialized by the reader and printed accordingly.