

RProtoBuf: An R API for Protocol Buffers

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Abstract

Protocol Buffers is a software project by Google that is used extensively internally and also released under an Open Source license. It provides a way of encoding structured data in an efficient yet extensible format. Google formally supports APIs for C++, Java and Python.

This vignette describes version 0.2.5 of the `RProtoBuf` package which brings support for protocol buffer messages to R.

1 Protocol Buffers

Protocol buffers are a language-neutral, platform-neutral, extensible way of serializing structured data for use in communications protocols, data storage, and more.

Protocol Buffers offer key features such as an efficient data interchange format that is both language- and operating system-agnostic yet uses a lightweight and highly performant encoding, object serialization and de-serialization as well data and configuration management. Protocol buffers are also forward compatible: updates to the `proto` files do not break programs built against the previous specification.

While benchmarks are not available, Google states on the project page that in comparison to XML, protocol buffers are at the same time *simpler*, between three to ten times *smaller*, between twenty and one hundred times *faster*, as well as less ambiguous and easier to program.

The protocol buffers code is released under an open-source (BSD) license. The protocol buffer project (<http://code.google.com/p/protobuf/>) contains a C++ library and a set of runtime libraries and compilers for C++, Java and Python.

With these languages, the workflow follows standard practice of so-called Interface Description Languages (IDL) (c.f. [Wikipedia on IDL](#)). This consists of compiling a protocol buffer description file (ending in `.proto`) into language specific classes that can be used to create, read, write and manipulate protocol buffer messages. In other words, given the 'proto' description file, code is automatically generated for the chosen target language(s). The project page contains a tutorial for each of these officially supported languages: <http://code.google.com/apis/protocolbuffers/docs/tutorials.html>

Besides the officially supported C++, Java and Python implementations, several projects have been created to support protocol buffers for many languages. The list of known languages to support protocol buffers is compiled as part of the project page: <http://code.google.com/p/protobuf/wiki/ThirdPartyAddOns>

The protocol buffer project page contains a comprehensive description of the language: <http://code.google.com/apis/protocolbuffers/docs/proto.html>

2 Dynamic use: Protocol Buffers and R

This section describes how to use the R API to create and manipulate protocol buffer messages in R, and how to read and write the binary *payload* of the messages to files and arbitrary binary R connections.

2.1 Importing proto files

In contrast to the other languages (Java, C++, Python) that are officially supported by Google, the implementation used by the `RProtoBuf` package does not rely on the `protoc` compiler (with the exception of the two functions discussed in the previous section). This means that no initial step of statically compiling the proto file into C++ code that is then accessed by R code is necessary. Instead, `proto` files are parsed and processed *at runtime* by the `protobuf` C++ library—which is much more appropriate for a dynamic language.

The `readProtoFiles` function allows importing `proto` files in several ways.

```
R> args( readProtoFiles )  
function (files, dir, package = "RProtoBuf", pattern = "\\..proto$",  
  lib.loc = NULL)  
NULL
```

Using the `file` argument, one can specify one or several file paths that ought to be `proto` files.

```
R> proto.dir <- system.file( "proto", package = "RProtoBuf" )  
R> proto.file <- file.path( proto.dir, "addressbook.proto" )
```

```
R> readProtoFiles( proto.file )
```

With the `dir` argument, which is ignored if the `file` is supplied, all files matching the `.proto` extension will be imported.

```
R> dir( proto.dir, pattern = "\\..proto$", full.names = TRUE )  
[1] "/usr/local/lib/R/site-library/RProtoBuf/proto/addressbook.proto"  
[2] "/usr/local/lib/R/site-library/RProtoBuf/proto/helloworld.proto"
```

```
R> readProtoFiles( dir = proto.dir )
```

Finally, with the `package` argument (ignored if `file` or `dir` is supplied), the function will import all `.proto` files that are located in the `proto` sub-directory of the given package. A typical use for this argument is in the `.onLoad` function of a package.

```
R> readProtoFiles( package = "RProtoBuf" )
```

Once the proto files are imported, all message descriptors are available in the R search path in the `RProtoBuf:DescriptorPool` special environment. The underlying mechanism used here is described in more detail in section~5.

```
R> ls( "RProtoBuf:DescriptorPool" )
[1] "rprotobuf.HelloWorldRequest"  "rprotobuf.HelloWorldResponse"
[3] "tutorial.AddressBook"         "tutorial.Person"
```

2.2 Creating a message

The objects contained in the special environment are descriptors for their associated message types. Descriptors will be discussed in detail in another part of this document, but for the purpose of this section, descriptors are just used with the `new` function to create messages.

```
R> p <- new( tutorial.Person, name = "Romain", id = 1 )
```

2.3 Access and modify fields of a message

Once the message created, its fields can be queried and modified using the dollar operator of R, making protocol buffer messages seem like lists.

```
R> p$name
[1] "Romain"
R> p$id
[1] 1
R> p$email <- "francoisromain@free.fr"
```

However, as opposed to R lists, no partial matching is performed and the name must be given entirely.

The `[[` operator can also be used to query and set fields of a messages, supplying either their name or their tag number :

```
R> p[["name"]] <- "Romain Francois"
R> p[[ 2 ]] <- 3
R> p[[ "email" ]]
[1] "francoisromain@free.fr"
```

2.4 Display messages

For debugging purposes, protocol buffer messages implement the `as.character` method:

```
R> writeLines( as.character( p ) )
name: "Romain Francois"
id: 3
email: "francoisromain@free.fr"
```

2.5 Serializing messages

However, the main focus of protocol buffer messages is efficiency. Therefore, messages are transported as a sequence of bytes. The `serialize` method is implemented for protocol buffer messages to serialize a message into the sequence of bytes (raw vector in R speech) that represents the message.

```
R> serialize( p, NULL )
[1] 0a 0f 52 6f 6d 61 69 6e 20 46 72 61 6e 63 6f 69 73 10 03 1a
[21] 16 66 72 61 6e 63 6f 69 73 72 6f 6d 61 69 6e 40 66 72 65 65
[41] 2e 66 72
```

The same method can also be used to serialize messages to files :

```
R> tf1 <- tempfile()
R> tf1
[1] "/tmp/Rtmpez2AVz/file3b6268822056"
R> serialize( p, tf1 )
R> readBin( tf1, raw(0), 500 )
[1] 0a 0f 52 6f 6d 61 69 6e 20 46 72 61 6e 63 6f 69 73 10 03 1a
[21] 16 66 72 61 6e 63 6f 69 73 72 6f 6d 61 69 6e 40 66 72 65 65
[41] 2e 66 72
```

Or to arbitrary binary connections:

```
R> tf2 <- tempfile()
R> con <- file( tf2, open = "wb" )
R> serialize( p, con )
R> close( con )
R> readBin( tf2, raw(0), 500 )
[1] 0a 0f 52 6f 6d 61 69 6e 20 46 72 61 6e 63 6f 69 73 10 03 1a
[21] 16 66 72 61 6e 63 6f 69 73 72 6f 6d 61 69 6e 40 66 72 65 65
[41] 2e 66 72
```

`serialize` can also be used in a more traditional object oriented fashion using the dollar operator :

```
R> # serialize to a file
R> p$serialize( tf1 )
R> # serialize to a binary connection
R> con <- file( tf2, open = "wb" )
R> p$serialize( con )
R> close( con )
```

2.6 Parsing messages

The `RProtoBuf` package defines the `read` function to read messages from files, raw vector (the message payload) and arbitrary binary connections.

```
R> args( read )
function (descriptor, input)
NULL
```

The binary representation of the message (often called the payload) does not contain information that can be used to dynamically infer the message type, so we have to provide this information to the `read` function in the form of a descriptor :

```
R> message <- read( tutorial.Person, tf1 )
R> writeLines( as.character( message ) )
name: "Romain Francois"
id: 3
email: "francoisromain@free.fr"
```

The input argument of `read` can also be a binary readable R connection, such as a binary file connection:

```
R> con <- file( tf2, open = "rb" )
R> message <- read( tutorial.Person, con )
R> close( con )
R> writeLines( as.character( message ) )
name: "Romain Francois"
id: 3
email: "francoisromain@free.fr"
```

Finally, the payload of the message can be used :

```
R> # reading the raw vector payload of the message
R> payload <- readBin( tf1, raw(0), 5000 )
R> message <- read( tutorial.Person, payload )
```

read can also be used as a pseudo method of the descriptor object :

```
R> # reading from a file
R> message <- tutorial.Person$read( tf1 )
R> # reading from a binary connection
R> con <- file( tf2, open = "rb" )
R> message <- tutorial.Person$read( con )
R> close( con )
R> # read from the payload
R> message <- tutorial.Person$read( payload )
```

3 Classes, Methods and Pseudo Methods

The RProtoBuf package uses the S4 system to store information about descriptors and messages, but the information stored in the R object is very minimal and mainly consists of an external pointer to a C++ variable that is managed by the `proto` C++ library.

```
R> str( p )
Formal class 'Message' [package "RProtoBuf"] with 2 slots
  ..@ pointer:<externalptr>
  ..@ type    : chr "tutorial.Person"
```

Using the S4 system allows the RProtoBuf package to dispatch methods that are not generic in the S3 sense, such as `new` and `serialize`.

The RProtoBuf package combines the *R typical* dispatch of the form `method(object, arguments)` and the more traditional object oriented notation `object$method(arguments)`.

3.1 messages

Messages are represented in R using the `Message` S4 class. The class contains the slots `pointer` and `type` as described on the table~1 :

Although the RProtoBuf package uses the S4 system, the `@` operator is very rarely used. Fields of the message are retrieved or modified using the `$` or `[[` operators as seen on the previous section, and pseudo-methods can also be called using the `$` operator. The table~2 describes the methods defined for the `Message` class :

| slot | description |
|---------|--|
| pointer | external pointer to the <code>Message</code> object of the C++ proto library. Documentation for the <code>Message</code> class is available from the protocol buffer project page: http://code.google.com/apis/protocolbuffers/docs/reference/cpp/google.protobuf.message.html#Message |
| type | fully qualified path of the message. For example a <code>Person</code> message has its <code>type</code> slot set to <code>tutorial.Person</code> |

Table 1: Description of slots for the `Message` S4 class

3.1.1 Retrieve fields

The `$` and `[[` operators allow extraction of a field data.

```
R> message <- new( tutorial.Person,
+   name = "foo", email = "foo@bar.com", id = 2,
+   phone = list(
+     new( tutorial.Person.PhoneNumber, number = "+33(0)...",
+     type = "HOME" ),
+     new( tutorial.Person.PhoneNumber, number = "+33(0)###",
+     type = "MOBILE" )
+   ) )
R> message$name
[1] "foo"
R> message$email
[1] "foo@bar.com"
R> message[[ "phone" ]]
[[1]]
[1] " message of type 'tutorial.Person.PhoneNumber' "

[[2]]
[1] " message of type 'tutorial.Person.PhoneNumber' "
R> # using the tag number
R> message[[ 2 ]]
[1] 2
```

Neither `$` nor `[[` support partial matching of names. The `$` is also used to call methods on the message, and the `[[` operator can use the tag number of the field.

The table~3 details correspondance between the field type and the type of data that is retrieved by `$` and `[[`.

| method | section | description |
|-----------------------------|------------------------|--|
| <code>has</code> | 3.1.3 | Indicates if a message has a given field. |
| <code>clone</code> | 3.1.4 | Creates a clone of the message |
| <code>isInitialized</code> | 3.1.5 | Indicates if a message has all its required fields set |
| <code>serialize</code> | 3.1.6 | serialize a message to a file or a binary connection or retrieve the message payload as a raw vector |
| <code>clear</code> | 3.1.7 | Clear one or several fields of a message, or the entire message |
| <code>size</code> | 3.1.8 | The number of elements in a message field |
| <code>bytesize</code> | 3.1.9 | The number of bytes the message would take once serialized |
| <code>swap</code> | 3.1.10 | swap elements of a repeated field of a message |
| <code>set</code> | 3.1.11 | set elements of a repeated field |
| <code>fetch</code> | 3.1.12 | fetch elements of a repeated field |
| <code>add</code> | | add elements to a repeated field |
| <code>str</code> | 3.1.14 | the R structure of the message |
| <code>as.character</code> | 3.1.15 | character representation of a message |
| <code>toString</code> | 3.1.16 | character representation of a message (same as <code>as.character</code>) |
| <code>update</code> | 3.1.18 | updates several fields of a message at once |
| <code>descriptor</code> | 3.1.19 | get the descriptor of the message type of this message |
| <code>fileDescriptor</code> | 3.1.20 | get the file descriptor of this message's descriptor |

Table 2: Description of slots for the `Message` S4 class

3.1.2 Modify fields

The `$<-` and `[[<-` operators are implemented for `Message` objects to set the value of a field. The R data is coerced to match the type of the message field.

```
R> message <- new( tutorial.Person,
+   name = "foo", id = 2 )
R> message$email <- "foo@bar.com"
R> message[[ "id" ]] <- 2
R> message[[ 1 ]] <- "foobar"
R> writeLines( message$as.character() )
name: "foobar"
id: 2
email: "foo@bar.com"
```

The table~4 describes the R types that are allowed in the right hand side depending on the target type of the field.

| field type | R type (non repeated) | R type (repeated) |
|------------|-----------------------------------|--|
| double | double vector | double vector |
| float | double vector | double vector |
| int32 | integer vector | integer vector |
| int64 | integer vector | integer vector |
| uint32 | integer vector | integer vector |
| uint64 | integer vector | integer vector |
| sint32 | integer vector | integer vector |
| sint64 | integer vector | integer vector |
| fixed32 | integer vector | integer vector |
| fixed64 | integer vector | integer vector |
| sfixed32 | integer vector | integer vector |
| sfixed64 | integer vector | integer vector |
| bool | logical vector | logical vector |
| string | character vector | character vector |
| bytes | character vector | character vector |
| enum | integer vector | integer vector |
| message | S4 object of class Message | list of S4 objects of class Message |

Table 3: Correspondance between field type and R type retrieved by the extractors.

3.1.3 Message\$has method

The **has** method indicates if a field of a message is set. For repeated fields, the field is considered set if there is at least on object in the array. For non-repeated fields, the field is considered set if it has been initialized.

The **has** method is a thin wrapper around the **HasField** and **FieldSize** methods of the `google::protobuf::Reflection` C++ class.

```
R> message <- new( tutorial.Person, name = "foo" )
R> message$has( "name" )
[1] TRUE
R> message$has( "id" )
[1] FALSE
R> message$has( "phone" )
[1] FALSE
```

3.1.4 Message\$clone method

The **clone** function creates a new message that is a clone of the message. This function is a wrapper around the methods **New** and **CopyFrom** of the `google::protobuf::Message` C++ class.

| internal type | allowed R types |
|--|---|
| double, float | integer, raw, double, logical |
| int32, int64, uint32, uint64, sint32, sint64, fixed32, fixed64, sfixed32, sfixed64 | integer, raw, double, logical |
| bool | integer, raw, double, logical |
| bytes, string | character |
| enum | integer, double, raw, character |
| message, group | S4, of class <code>Message</code> of the appropriate message type, or a list of S4 objects of class <code>Message</code> of the appropriate message type. |

Table 4: Allowed R types depending on internal field types.

```
R> m1 <- new( tutorial.Person, name = "foo" )
R> m2 <- m1$clone( )
R> m2$email <- "foo@bar.com"
R> writeLines( as.character( m1 ) )
name: "foo"
R> writeLines( as.character( m2 ) )
name: "foo"
email: "foo@bar.com"
```

3.1.5 Message\$isInitialized method

The `isInitialized` method quickly checks if all required fields have values set. This is a thin wrapper around the `IsInitialized` method of the `google::protobuf::Message` C++ class.

```
R> message <- new( tutorial.Person, name = "foo" )
R> message$isInitialized()
[1] FALSE
R> message$id <- 2
R> message$isInitialized()
[1] TRUE
```

3.1.6 Message\$serialize method

The `serialize` method can be used to serialize the message as a sequence of bytes into a file or a binary connection.

```
R> message <- new( tutorial.Person, name = "foo", email = "foo@bar.com",
id = 2 )
```

```

R> tf1 <- tempfile( )
R> tf1
[1] "/tmp/Rtmpez2AVz/file3b6262426eea"
R> message$serialize( tf1 )
R> tf2 <- tempfile( )
R> tf2
[1] "/tmp/Rtmpez2AVz/file3b6225483483"
R> con <- file( tf2, open = "wb" )
R> message$serialize( con )
R> close( con )

```

The files file3b6262426eea and file3b6225483483 both contain the message payload as a sequence of bytes. The `readBin` function can be used to read the files as a raw vector in R:

```

R> readBin( tf1, raw(0), 500 )
[1] 0a 03 66 6f 6f 10 02 1a 0b 66 6f 6f 40 62 61 72 2e 63 6f 6d
R> readBin( tf2, raw(0), 500 )
[1] 0a 03 66 6f 6f 10 02 1a 0b 66 6f 6f 40 62 61 72 2e 63 6f 6d

```

The `serialize` method can also be used to directly retrieve the payload of the message as a raw vector:

```

R> message$serialize(NULL)
[1] 0a 03 66 6f 6f 10 02 1a 0b 66 6f 6f 40 62 61 72 2e 63 6f 6d

```

3.1.7 Message\$clear method

The `clear` method can be used to clear all fields of a message when used with no argument, or a given field.

```

R> message <- new( tutorial.Person, name = "foo", email = "foo@bar.com",
id = 2 )
R> writeLines( as.character( message ) )
name: "foo"
id: 2
email: "foo@bar.com"
R> message$clear()
R> writeLines( as.character( message ) )

R> message <- new( tutorial.Person, name = "foo", email = "foo@bar.com",
id = 2 )
R> message$clear( "id" )

```

```
R> writeLines( as.character( message ) )
name: "foo"
email: "foo@bar.com"
```

The `clear` method is a thin wrapper around the `Clear` method of the `google::protobuf::Message` C++ class.

3.1.8 Message\$size method

The `size` method is used to query the number of objects in a repeated field of a message :

```
R> message <- new( tutorial.Person, name = "foo",
+               phone = list(
+                 new( tutorial.Person.PhoneNumber, number = "+33(0)...",
+                 type = "HOME" ),
+                 new( tutorial.Person.PhoneNumber, number = "+33(0)###",
+                 type = "MOBILE" )
+               ) )
R> message$size( "phone" )
[1] 2
R> size( message, "phone" )
[1] 2
```

The `size` method is a thin wrapper around the `FieldSize` method of the `google::protobuf::Reflection` C++ class.

3.1.9 Message\$bytesize method

The `bytesize` method retrieves the number of bytes the message would take once serialized. This is a thin wrapper around the `ByteSize` method of the `google::protobuf::Message` C++ class.

```
R> message <- new( tutorial.Person, name = "foo", email = "foo@bar.com",
+               id = 2 )
R> message$bytesize()
[1] 20
R> bytesize( message )
[1] 20
R> length( message$serialize( NULL ) )
[1] 20
```

3.1.10 Message\$swap method

The `swap` method can be used to swap elements of a repeated field.

```
R> message <- new( tutorial.Person, name = "foo",
+               phone = list(
+                 new( tutorial.Person.PhoneNumber, number = "+33(0)...",
+                   type = "HOME" ),
+                 new( tutorial.Person.PhoneNumber, number = "+33(0)###",
+                   type = "MOBILE" )
+               ) )
R> message$swap( "phone", 1, 2 )
R> writeLines( as.character( message$phone[[1]] ) )
number: "+33(0)###"
type: MOBILE
R> writeLines( as.character( message$phone[[2]] ) )
number: "+33(0)..."
type: HOME
R> swap( message, "phone", 1, 2 )
R> writeLines( as.character( message$phone[[1]] ) )
number: "+33(0)..."
type: HOME
R> writeLines( as.character( message$phone[[2]] ) )
number: "+33(0)###"
type: MOBILE
```

3.1.11 Message\$set method

The `set` method can be used to set values of a repeated field.

```
R> message <- new( tutorial.Person, name = "foo",
+               phone = list(
+                 new( tutorial.Person.PhoneNumber, number = "+33(0)...",
+                   type = "HOME" ),
+                 new( tutorial.Person.PhoneNumber, number = "+33(0)###",
+                   type = "MOBILE" )
+               ) )
R> number <- new( tutorial.Person.PhoneNumber,
+               number = "+33(0)--", type = "WORK" )
R> message$set( "phone", 1, number )
R> writeLines( as.character( message ) )
```

```

name: "foo"
phone {
  number: "+33(0)--"
  type: WORK
}
phone {
  number: "+33(0)###"
  type: MOBILE
}

```

3.1.12 Message\$fetch method

The `fetch` method can be used to set values of a repeated field.

```

R> message <- new( tutorial.Person, name = "foo",
+               phone = list(
+                 new( tutorial.Person.PhoneNumber, number = "+33(0)...",
+                 type = "HOME" ),
+                 new( tutorial.Person.PhoneNumber, number = "+33(0)###",
+                 type = "MOBILE" )
+               ) )
R> message$fetch( "phone", 1 )
[[1]]
[1] " message of type 'tutorial.Person.PhoneNumber' "

```

3.1.13 Message\$add method

The `add` method can be used to add values to a repeated field.

```

R> message <- new( tutorial.Person, name = "foo")
R> phone <- new( tutorial.Person.PhoneNumber,
+               number = "+33(0)...", type = "HOME" )
R> message$add( "phone", phone )
R> writeLines( message$toString() )
name: "foo"
phone {
  number: "+33(0)..."
  type: HOME
}

```

3.1.14 Message\$str method

The `str` method gives the R structure of the message. This is rarely useful.

```
R> message <- new( tutorial.Person, name = "foo", email = "foo@bar.com",
id = 2 )
R> message$str()
Formal class 'Message' [package "RProtoBuf"] with 2 slots
  ..@ pointer:<externalptr>
  ..@ type   : chr "tutorial.Person"
R> str( message )
Formal class 'Message' [package "RProtoBuf"] with 2 slots
  ..@ pointer:<externalptr>
  ..@ type   : chr "tutorial.Person"
```

3.1.15 Message\$as.character method

The `as.character` method gives the debug string of the message.

```
R> message <- new( tutorial.Person, name = "foo", email = "foo@bar.com",
id = 2 )
R> writeLines( message$as.character() )
name: "foo"
id: 2
email: "foo@bar.com"
R> writeLines( as.character( message ) )
name: "foo"
id: 2
email: "foo@bar.com"
```

3.1.16 Message\$toString method

`toString` currently is an alias to the `as.character` function.

```
R> message <- new( tutorial.Person, name = "foo", email = "foo@bar.com",
id = 2 )
R> writeLines( message$toString() )
name: "foo"
id: 2
email: "foo@bar.com"
R> writeLines( toString( message ) )
name: "foo"
```

```
id: 2
email: "foo@bar.com"
```

3.1.17 Message\$as.list method

The `as.list` method converts the message to an named R list

```
R> message <- new( tutorial.Person, name = "foo", email = "foo@bar.com",
id = 2 )
R> as.list( message )
$name
[1] "foo"

$id
[1] 2

$email
[1] "foo@bar.com"

$phone
list()
```

The names of the list are the names of the declared fields of the message type, and the content is the same as can be extracted with the `$` operator described in section [3.1.1](#).

3.1.18 Message\$update method

The `update` method can be used to update several fields of a message at once.

```
R> message <- new( tutorial.Person )
R> update( message,
+         name = "foo",
+         id = 2,
+         email = "foo@bar.com" )
[1] " message of type 'tutorial.Person' "
R> writeLines( message$as.character() )
name: "foo"
id: 2
email: "foo@bar.com"
```


3.1.19 Message\$descriptor method

The `descriptor` method retrieves the descriptor of a message. See section~3.2 for more information about message type descriptors.

```
R> message <- new( tutorial.Person )
R> message$descriptor()
[1] "descriptor for type 'tutorial.Person' "
R> descriptor( message )
[1] "descriptor for type 'tutorial.Person' "
```

3.1.20 Message\$fileDescriptor method

The `fileDescriptor` method retrieves the file descriptor of the descriptor associated with a message. See section~3.5 for more information about file descriptors.

```
R> message <- new( tutorial.Person )
R> message$fileDescriptor()
[1] "file descriptor"
R> fileDescriptor( message )
[1] "file descriptor"
```

3.2 message descriptors

Message descriptors are represented in R with the *Descriptor* S4 class. The class contains the slots `pointer` and `type` :

| slot | description |
|----------------------|--|
| <code>pointer</code> | external pointer to the <code>Descriptor</code> object of the C++ proto library. Documentation for the <code>Descriptor</code> class is available from the protocol buffer project page: http://code.google.com/apis/protocolbuffers/docs/reference/cpp/google.protobuf.descriptor.html#Descriptor |
| <code>type</code> | fully qualified path of the message type. |

Table 5: Description of slots for the `Descriptor` S4 class

Similarly to messages, the `$` operator can be used to extract information from the descriptor, or invoke pseudo-methods.

3.2.1 Extracting descriptors

The `$` operator, when used on a descriptor object retrieves descriptors that are contained in the descriptor.

This can be a field descriptor (see section~3.3), an enum descriptor (see section~3.4) or a descriptor for a nested type

```
R> # field descriptor
R> tutorial.Person$email
[1] "descriptor for field 'email' of type 'tutorial.Person' "
R> # enum descriptor
R> tutorial.Person$PhoneNumber
[1] "descriptor for enum 'PhoneNumber' of type 'tutorial.Person' "
R> # nested type descriptor
R> tutorial.Person$PhoneNumber
[1] "descriptor for type 'tutorial.Person.PhoneNumber' "
R> # same as
R> tutorial.Person.PhoneNumber
[1] "descriptor for type 'tutorial.Person.PhoneNumber' "
```

3.2.2 The new method

The `new` method creates a prototype of a message described by the descriptor.

```
R> tutorial.Person$new( )
[1] " message of type 'tutorial.Person' "
R> new( tutorial.Person )
[1] " message of type 'tutorial.Person' "
```

Passing additional arguments to the method allows to directly set the fields of the message at construction time.

```
R> tutorial.Person$new( email = "foo@bar.com" )
[1] " message of type 'tutorial.Person' "
R> # same as
R> update( tutorial.Person$new( ), email = "foo@bar.com" )
[1] " message of type 'tutorial.Person' "
```

3.2.3 The read method

The `read` method is used to read a message from a file or a binary connection.

```

R> # start by serializing a message
R> message <- new( tutorial.Person.PhoneNumber,
+               type = "HOME", number = "+33(0)...." )
R> tf <- tempfile()
R> serialize( message, tf )
R> # now read back the message
R> m <- tutorial.Person.PhoneNumber$read( tf )
R> writeLines( as.character( m ) )
number: "+33(0)...."
type: HOME
R> m <- read( tutorial.Person.PhoneNumber, tf )
R> writeLines( as.character( m ) )
number: "+33(0)...."
type: HOME

```

3.2.4 The toString method

3.2.5 The as.character method

3.2.6 The fileDescriptor method

3.2.7 The name method

The `name` method can be used to retrieve the name of the message type associated with the descriptor.

```

R> # simple name
R> tutorial.Person$name()
[1] "Person"
R> # name including scope
R> tutorial.Person$name(full = TRUE)
[1] "tutorial.Person"

```

3.3 field descriptors

The class *FieldDescriptor* represents field descriptor in R. This is a wrapper S4 class around the `google::protobuf::FieldDescriptor` C++ class.

3.3.1 as.character

The `as.character` method brings the debug string of the field descriptor.

| slot | description |
|-----------|---|
| pointer | External pointer to the <code>FieldDescriptor</code> C++ variable |
| name | simple name of the field |
| full_name | fully qualified name of the field |
| type | name of the message type where the field is declared |

Table 6: Description of slots for the `FieldDescriptor` S4 class

```
R> writeLines( as.character( tutorial.Person$PhoneNumber ) )
message PhoneNumber {
  required string number = 1;
  optional .tutorial.Person.PhoneType type = 2 [default = HOME];
}
```

3.3.2 toString

`toString` is an alias of `as.character`.

```
R> writeLines( tutorial.Person.PhoneNumber$toString() )
message PhoneNumber {
  required string number = 1;
  optional .tutorial.Person.PhoneType type = 2 [default = HOME];
}
```

3.3.3 name

TODO

3.4 enum descriptors

The class *EnumDescriptor* is an R wrapper class around the C++ class `google::protobuf::EnumDescriptor`.

| slot | description |
|-----------|--|
| pointer | External pointer to the <code>EnumDescriptor</code> C++ variable |
| name | simple name of the enum |
| full_name | fully qualified name of the enum |
| type | name of the message type where the enum is declared |

Table 7: Description of slots for the `EnumDescriptor` S4 class

3.4.1 as.list

The `as.list` method creates a named R integer vector that captures the values of the enum and their names.

```
R> as.list( tutorial.Person$PhoneType )
MOBILE    HOME    WORK
      0      1      2
```

3.4.2 as.character

The `as.character` method brings the debug string of the enum type.

```
R> writeLines( as.character( tutorial.Person$PhoneType ) )
enum PhoneType {
  MOBILE = 0;
  HOME = 1;
  WORK = 2;
}
```

3.5 file descriptors

TODO: add content

3.6 service descriptors

TODO: add content

3.7 method descriptors

TODO: add content

4 Utilities

4.1 coercing objects to messages

The `asMessage` function uses the standard coercion mechanism of the `as` method, and so can be used as a shorthand :

```
R> # coerce a message type descriptor to a message
R> # asMessage( tutorial.Person )
R>
R> # coerce a enum descriptor
```

```

R> asMessage( tutorial.Person.PhoneType )
[1] " message of type 'google.protobuf.EnumDescriptorProto' "
R> # coerce a field descriptor
R> asMessage( tutorial.Person$email )
[1] " message of type 'google.protobuf.FieldDescriptorProto' "
R> # coerce a file descriptor
R> asMessage( fileDescriptor( tutorial.Person ) )
[1] " message of type 'google.protobuf.FileDescriptorProto' "

```

4.2 completion

The RProtoBuf package implements the `.DollarNames` S3 generic function (defined in the `utils` package) for all classes.

Completion possibilities include pseudo method names for all classes, plus :

- field names for messages
- field names, enum types, nested types for message type descriptors
- names for enum descriptors

4.3 with and within

The S3 generic `with` function is implemented for class `Message`, allowing to evaluate an R expression in an environment that allows to retrieve and set fields of a message simply using their names.

```

R> message <- new( tutorial.Person, email = "foo@bar.com" )
R> with( message, {
+       # set the id field
+       id <- 2
+
+       # set the name field from the email field
+       name <- gsub( "[@]", " ", email )
+
+       sprintf( "%d [%s] : %s", id, email, name )
+ } )
[1] "2 [foo@bar.com] : foo bar.com"

```

The difference between `with` and `within` is the value that is returned. For `with` returns the result of the R expression, for `within` the message is returned. In both cases, the message is modified because RProtoBuf works by reference.

4.4 identical

The `identical` method is implemented to compare two messages.

```
R> m1 <- new( tutorial.Person, email = "foo@bar.com", id = 2 )
R> m2 <- update( new( tutorial.Person) , email = "foo@bar.com", id = 2 )
R> identical( m1, m2 )
[1] TRUE
```

The `==` operator can be used as an alias to `identical`.

```
R> m1 == m2
[1] TRUE
R> m1 != m2
[1] FALSE
```

Alternatively, the `all.equal` function can be used, allowing a tolerance when comparing float or double values.

4.5 merge

`merge` can be used to merge two messages of the same type.

```
R> m1 <- new( tutorial.Person, name = "foobar" )
R> m2 <- new( tutorial.Person, email = "foo@bar.com" )
R> m3 <- merge( m1, m2 )
R> writeLines( as.character( m3 ) )
name: "foobar"
email: "foo@bar.com"
```

4.6 P

The `P` function is an alternative way to retrieve a message descriptor using its type name. It is not often used because of the lookup mechanism described in section [5](#).

```
R> P("tutorial.Person")
[1] "descriptor for type 'tutorial.Person' "
R> new( P("tutorial.Person") )
[1] " message of type 'tutorial.Person' "
R> tutorial.Person
[1] "descriptor for type 'tutorial.Person' "
R> new( tutorial.Person )
[1] " message of type 'tutorial.Person' "
```

5 Descriptor lookup

The `RProtoBuf` package uses the user defined tables framework that is defined as part of the `RObjectTables` package available from the OmegaHat project.

The feature allows `RProtoBuf` to install the special environment `RProtoBuf:DescriptorPool` in the R search path. The environment is special in that, instead of being associated with a static hash table, it is dynamically queried by R as part of R's usual variable lookup. In other words, it means that when the R interpreter looks for a binding to a symbol (foo) in its search path, it asks to our package if it knows the binding "foo", this is then implemented by the `RProtoBuf` package by calling an internal method of the `protobuf` C++ library.

6 Plans for future releases

Saptarshi Guha wrote another package that deals with integration of protocol buffer messages with R, taking a different angle : serializing any R object as a message, based on a single catch-all `proto` file. We plan to integrate this functionality into `RProtoBuf`. Saptarshi's package is available at <http://ml.stat.purdue.edu/rhipec/doc/html/ProtoBuffers.html>

Protocol buffers have a mechanism for remote procedure calls (rpc) that is not yet used by `RProtoBuf`, but we may one day take advantage of this by writing a protocol buffer message R server, and client code as well, probably based on the functionality of the `Rserve` package.

7 Acknowledgments

Some of the design of the package is based on the design of the `rJava` package by Simon Urbanek (dispatch on new, S4 class structures using external pointers, etc ...). We'd like to thank Simon for his indirect involvement on `RProtoBuf`.

The user defined table mechanism, implemented by Duncan Temple Lang for the purpose of the `RObjectTables` package allowed the dynamic symbol lookup (see section 5). Many thanks to Duncan for this amazing feature.