

RProtoBuf: An R API for Protocol Buffers

Dirk Eddelbuettel^a, Romain François^b, and Murray Stokely^c

^a<http://dirk.eddelbuettel.com>; ^b<https://romain.rbind.io/>; ^c<https://stokely.org>

This version was compiled on February 7, 2020

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 the `RProtoBuf` package which brings support for Protocol Buffer messages to R.

Contents

1	Protocol Buffers	3
2	Basic use: Protocol Buffers and R	3
2.1	Importing proto files dynamically	3
2.2	Creating a message	4
2.3	Access and modify fields of a message	4
2.4	Display messages	5
2.5	Serializing messages	5
2.6	Parsing messages	6
2.7	Classes, Methods and Pseudo Methods	7
2.8	Messages	7
2.8.1	Retrieve fields	7
2.8.2	Modify fields	8
2.8.3	Message\$has method	9
2.8.4	Message\$clone method	10
2.8.5	Message\$isInitialized method	10
2.8.6	Message\$serialize method	10
2.8.7	Message\$clear method	11
2.8.8	Message\$size method	11
2.8.9	Message\$bytesize method	12
2.8.10	Message\$swap method	12
2.8.11	Message\$set method	13
2.8.12	Message\$fetch method	13
2.8.13	Message\$setExtension method	13
2.8.14	Message\$getExtension method	14
2.8.15	Message\$add method	14
2.8.16	Message\$str method	14
2.8.17	Message\$as.character method	14
2.8.18	Message\$toString method	15
2.8.19	Message\$as.list method	15
2.8.20	Message\$update method	15
2.8.21	Message\$descriptor method	16
2.8.22	Message\$fileDescriptor method	16
2.9	Message descriptors	16
2.9.1	Extracting descriptors	16
2.9.2	The new method	17
2.9.3	The read method	18
2.9.4	The readASCII method	18
2.9.5	The toString method	18
2.9.6	The as.character method	18
2.9.7	The as.list method	20
2.9.8	The asMessage method	20

2.9.9	The fileDescriptor method	20
2.9.10	The name method	20
2.9.11	The containing_type method	21
2.9.12	The field_count method	21
2.9.13	The field method	21
2.9.14	The nested_type_count method	21
2.9.15	The nested_type method	21
2.9.16	The enum_type_count method	21
2.9.17	The enum_type method	22
2.10	Field descriptors}	22
2.10.1	The as.character method	22
2.10.2	The toString method	22
2.10.3	The asMessage method	23
2.10.4	The name method	23
2.10.5	The fileDescriptor method	23
2.10.6	The containing_type method	23
2.10.7	The is_extension method	24
2.10.8	The number method	24
2.10.9	The type method	24
2.10.10	The cpp_type method	24
2.10.11	The label method	25
2.10.12	The is_repeated method	25
2.10.13	The is_required method	25
2.10.14	The is_optional method	25
2.10.15	The has_default_value method	26
2.10.16	The default_value method	26
2.10.17	The message_type method	26
2.10.18	The enum_type method	26
2.11	Enum descriptors	27
2.11.1	Extracting descriptors	27
2.11.2	The as.list method	27
2.11.3	The as.character method	28
2.11.4	The toString method	28
2.11.5	The asMessage method	28
2.11.6	The name method	28
2.11.7	The fileDescriptor method	28
2.11.8	The containing_type method	29
2.11.9	The length method	29
2.11.10	The has method	29
2.11.11	The value_count method	29
2.11.12	The value method	30
2.12	Enum value descriptors	30
2.12.1	The number method	30
2.12.2	The name method	30
2.12.3	The enum_type method	31
2.12.4	The as.character method	31
2.12.5	The toString method	31
2.12.6	The asMessage method	31
2.13	File descriptors	31
2.13.1	The as.character method	32
2.13.2	The toString method	33
2.13.3	The asMessage method	33
2.13.4	The as.list method	35
2.13.5	The name method	35
2.13.6	The package method	36
2.14	Service descriptors	36

2.14.1 The method descriptors method	36
3 Utilities	36
3.1 Ccoercing objects to messages	36
3.2 Completion	37
3.3 with and within	37
3.4 merge	38
3.5 P	38
4 Advanced Features	38
4.1 Extensions	38
4.2 Descriptor lookup	39
4.3 64-bit integer issues	39
4.4 Deprecated Feature: Protocol Buffer Groups	39
5 Other approaches	39
6 Plans for future releases	40
7 Acknowledgements	40

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. Basic 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 dynamically. 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.

```
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.

```
pdir <- system.file("proto", package = "RProtoBuf")  
pfile <- file.path(pdir, "addressbook.proto")  
readProtoFiles(pfile)
```

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

```
dir(pdir, pattern = "\\\\.proto$", full.names = TRUE)  
readProtoFiles(dir = pdir)
```

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.

```
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~4.2.

```
ls("RProtoBuf:DescriptorPool")
```

```
# [1] "rexp.CMPLX"           "rexp.REXP"  
# [3] "rexp.STRING"          "rprotobuf.HelloWorldRequest"  
# [5] "rprotobuf.HelloWorldResponse" "tutorial.AddressBook"  
# [7] "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.

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

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

```
p$name
```

```
# [1] "Romain"
```

```
p$id
```

```
# [1] 1
```

```
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 message, supplying either their name or their tag number :

```
p[["name"]] <- "Romain Francois"
p[[ 2 ]] <- 3
p[[ "email" ]]
```

```
# [1] "francoisromain@free.fr"
```

Protocol buffers include a 64-bit integer type, but R lacks native 64-bit integer support. A workaround is available and described in [Section~4.3](#) for working with large integer values.

2.4. Display messages. Protocol buffer messages and descriptors implement `show` methods that provide basic information about the message :

```
p
```

```
# message of type 'tutorial.Person' with 3 fields set
```

For additional information, such as for debugging purposes, the `as.character` method provides a more complete ASCII representation of the contents of a message.

```
cat(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.

```
serialize( p, NULL )
```

```
# [1] 0a 0f 52 6f 6d 61 69 6e 20 46 72 61 6e 63 6f 69 73 10 03 1a 16 66 72 61 6e 63 6f 69
# [29] 73 72 6f 6d 61 69 6e 40 66 72 65 65 2e 66 72
```

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

```
tf1 <- tempfile()
tf1
```

```
# [1] "/tmp/RtmpRBfpcs/file31743d74b662"
```

```
serialize( p, tf1 )
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 16 66 72 61 6e 63 6f 69
# [29] 73 72 6f 6d 61 69 6e 40 66 72 65 65 2e 66 72
```

Or to arbitrary binary connections:

```
tf2 <- tempfile()
con <- file(tf2, open = "wb")
serialize(p, con)
close(con)
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 16 66 72 61 6e 63 6f 69
# [29] 73 72 6f 6d 61 69 6e 40 66 72 65 65 2e 66 72
```

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

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

```
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 :

```
message <- read(tutorial.Person, tf1)
cat(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:

```
con <- file(tf2, open = "rb")
message <- read(tutorial.Person, con)
close(con)
cat(as.character(message))
```

```
# name: "Romain Francois"
# id: 3
# email: "francoisromain@free.fr"
```

Finally, the payload of the message can be used :

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

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

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

2.7. 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.

```
str(p)
```

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)`.

2.8. 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.

slot	description
pointer	external pointer to the Message object of the C++ proto library. Documentation for the Message 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 Person message has its type slot set to tutorial.Person

Table 1. Description of slots for the Message S4 class

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. Table~2 describes the methods defined for the Message class :

2.8.1. Retrieve fields. The \$ and [[operators allow extraction of a field data.

```
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")
  )
)
message$name
```

method	section	description
has	2.8.3	Indicates if a message has a given field.
clone	2.8.4	Creates a clone of the message
isInitialized	2.8.5	Indicates if a message has all its required fields set
serialize	2.8.6	serialize a message to a file or a binary connection or retrieve the message payload as a raw vector
clear	2.8.7	Clear one or several fields of a message, or the entire message
size	2.8.8	The number of elements in a message field
byteSize	2.8.9	The number of bytes the message would take once serialized
swap	2.8.10	swap elements of a repeated field of a message
set	2.8.11	set elements of a repeated field
fetch	2.8.12	fetch elements of a repeated field
setExtension	2.8.13	set an extension of a message
getExtension	2.8.14	get the value of an extension of a message
add	2.8.15	add elements to a repeated field
str	2.8.16	the R structure of the message
as.character	2.8.17	character representation of a message
toString	2.8.18	character representation of a message (same as as.character)
as.list	2.8.19	converts message to a named R list
update	2.8.20	updates several fields of a message at once
descriptor	2.8.21	get the descriptor of the message type of this message
fileDescriptor	2.8.22	get the file descriptor of this message's descriptor

Table 2. Description of methods for the Message S4 class

```
# [1] "foo"
```

```
message$email
```

```
# [1] "foo@bar.com"
```

```
message[["phone"]]
```

```
# [[1]]
# message of type 'tutorial.Person.PhoneNumber' with 2 fields set
#
# [[2]]
# message of type 'tutorial.Person.PhoneNumber' with 2 fields set
```

```
# using the tag number
message[[2]] # id
```

```
# [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.

Table~3 details correspondence between the field type and the type of data that is retrieved by \$ and [[.

2.8.2. 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.

```
message <- new(tutorial.Person, name = "foo", id = 2)
message$email <- "foo@bar.com"
message[["id"]] <- 42
```


field type	R type (non repeated)	R type (repeated)
double	double vector	double vector
float	double vector	double vector
uint32	double vector	double vector
fixed32	double vector	double vector
int32	integer vector	integer vector
sint32	integer vector	integer vector
sfixed32	integer vector	integer vector
int64	integer or character vector ¹	integer or character vector
uint64	integer or character vector	integer or character vector
sint64	integer or character vector	integer or character vector
fixed64	integer or character vector	integer or character vector
sfixed64	integer or character vector	integer or character 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. Correspondence between field type and R type retrieved by the extractors. 1. R lacks native 64-bit integers, so the `RProtoBuf.int64AsString` option is available to return large integers as characters to avoid losing precision. This option is described in Section 4.3. R also lacks an unsigned integer type.

```
message[[1]] <- "foobar"
cat(message$as.character())
```

```
# name: "foobar"
# id: 42
# email: "foo@bar.com"
```

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

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, character
bool	integer, raw, double, logical
bytes, string	character
enum	integer, double, raw, character
message, group	S4, of class Message of the appropriate message type, or a list of S4 objects of class Message of the appropriate message type.

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

2.8.3. `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.

```
message <- new(tutorial.Person, name = "foo")
message$has("name")
```

```
# [1] TRUE
```

```
message$has("id")
```

```
# [1] FALSE
```

```
message$has("phone")
```

```
# [1] FALSE
```

2.8.4. 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.

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

```
# name: "foo"
```

```
cat(as.character(m2))
```

```
# name: "foo"
# email: "foo@bar.com"
```

2.8.5. 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.

```
message <- new(tutorial.Person, name = "foo")
message$isInitialized()
```

```
# [1] FALSE
```

```
message$id <- 2
message$isInitialized()
```

```
# [1] TRUE
```

2.8.6. 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.

```
message <- new(tutorial.Person, name = "foo", email = "foo@bar.com", id = 2)
tf1 <- tempfile()
tf1
```

```
# [1] "/tmp/RtmpRBfpcs/file317419c2144f"
```

```
message$serialize(tf1)

tf2 <- tempfile()
tf2
```

```
# [1] "/tmp/RtmpRBfpcs/file31746f1b8c63"
```

```
con <- file(tf2, open = "wb")
message$serialize(con)
close(con)
```

The (temporary) files `tf1` and `tf2` 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:

```
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
```

```
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:

```
message$serialize(NULL)
```

```
# [1] 0a 03 66 6f 6f 10 02 1a 0b 66 6f 6f 40 62 61 72 2e 63 6f 6d
```

2.8.7. `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.

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

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

```
message$clear()
cat(as.character(message))

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

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

```
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")
                          ))
message$size("phone")
```

```
# [1] 2
```

```
size( message, "phone")
```

```
# [1] 2
```

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

2.8.9. 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.

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

```
# [1] 20
```

```
bytesize(message)
```

```
# [1] 20
```

```
length(message$serialize(NULL))
```

```
# [1] 20
```

2.8.10. Message\$swap method. The swap method can be used to swap elements of a repeated field.

```
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" )))
message$swap("phone", 1, 2)
cat(as.character(message$phone[[1]]))
```

```
# number: "+33(0)###"
# type: MOBILE
```

```
cat(as.character(message$phone[[2]]))
```

```
# number: "+33(0)..."
# type: HOME
```

```
swap(message, "phone", 1, 2)
cat(as.character(message$phone[[1]]))
```

```
# number: "+33(0)..."
# type: HOME
```

```
cat(as.character(message$phone[[2]]))
```

```
# number: "+33(0)###"
# type: MOBILE
```

2.8.11. Message\$set method. The set method can be used to set values of a repeated field.

```
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")))
number <- new(tutorial.Person.PhoneNumber, number = "+33(0)---", type = "WORK")
message$set("phone", 1, number)
cat(as.character( message))
```

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

2.8.12. Message\$fetch method. The fetch method can be used to get values of a repeated field.

```
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" )))
message$fetch("phone", 1)
```

```
# [[1]]
# message of type 'tutorial.Person.PhoneNumber' with 2 fields set
```

2.8.13. Message\$setExtension method. The setExtension method can be used to set an extension field of the Message.

```

if (!exists("protobuf_unittest.TestAllTypes", "RProtoBuf:DescriptorPool")) {
  unittest.proto.file <- system.file("tinytest", "data", "unittest.proto",
                                     package="RProtoBuf")
  readProtoFiles(file=unittest.proto.file)
}

## Test setting a singular extensions.
test <- new(protobuf_unittest.TestAllExtensions)
test$setExtension(protobuf_unittest.optional_int32_extension, as.integer(1))

```

2.8.14. Message\$getExtension method. The getExtension method can be used to get values of an extension.

```
test$getExtension(protobuf_unittest.optional_int32_extension)
```

```
# [1] 1
```

2.8.15. Message\$add method. The add method can be used to add values to a repeated field.

```

message <- new(tutorial.Person, name = "foo")
phone <- new(tutorial.Person.PhoneNumber, number = "+33(0)...", type = "HOME")
message$add("phone", phone)
cat(message$toString())

```

```

# name: "foo"
# phone {
#   number: "+33(0)..."
#   type: HOME
# }

```

2.8.16. Message\$str method. The str method gives the R structure of the message. This is rarely useful.

```

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

```

```

# Formal class 'Message' [package "RProtoBuf"] with 2 slots
# ..@ pointer:<externalptr>
# ..@ type : chr "tutorial.Person"

```

```
str(message)
```

```

# Formal class 'Message' [package "RProtoBuf"] with 2 slots
# ..@ pointer:<externalptr>
# ..@ type : chr "tutorial.Person"

```

2.8.17. Message\$as.character method. The as.character method gives the debug string of the message.

```

message <- new(tutorial.Person, name = "foo", email = "foo@bar.com", id = 2)
cat(message$as.character())

```

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

```
cat(as.character(message))
```

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

2.8.18. Message\$toString method. toString currently is an alias to the as.character function.

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

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

```
cat(toString( message))
```

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

2.8.19. Message\$as.list method. The as.list method converts the message to a named R list.

```
message <- new(tutorial.Person, name = "foo", email = "foo@bar.com", id = 2)
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~2.8.1.

2.8.20. Message\$update method. The update method can be used to update several fields of a message at once.

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

```
# message of type 'tutorial.Person' with 3 fields set
```

```
cat(message$as.character())
```

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

2.8.21. Message\$descriptor method. The descriptor method retrieves the descriptor of a message. See section~2.9 for more information about message type descriptors.

```
message <- new(tutorial.Person)
message$descriptor()
```

```
# descriptor for type 'tutorial.Person'
```

```
descriptor(message)
```

```
# descriptor for type 'tutorial.Person'
```

2.8.22. Message\$fileDescriptor method. The fileDescriptor method retrieves the file descriptor of the descriptor associated with a message. See section~2.13 for more information about file descriptors.

```
message <- new(tutorial.Person)
message$fileDescriptor()
```

```
# file descriptor for package tutorial (addressbook.proto)
```

```
fileDescriptor(message)
```

```
# file descriptor for package tutorial (addressbook.proto)
```

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

slot	description
pointer	external pointer to the Descriptor object of the C++ proto library. Documentation for the Descriptor class is available from the protocol buffer project page: http://code.google.com/apis/protocolbuffers/docs/reference/cpp/google.protobuf.descriptor.html#Descriptor
type	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. Table~6 describes the methods defined for the Descriptor class :

2.9.1. 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~2.10), an enum descriptor (see section~2.11) or a descriptor for a nested type

Method	Section	Description
<code>new</code>	2.9.2	Creates a prototype of a message described by this descriptor.
<code>read</code>	2.9.3	Reads a message from a file or binary connection.
<code>readASCII</code>	2.9.4	Read a message in ASCII format from a file or text connection.
<code>name</code>	2.9.10	Retrieve the name of the message type associated with this descriptor.
<code>as.character</code>	2.9.6	character representation of a descriptor
<code>toString</code>	2.9.5	character representation of a descriptor (same as <code>as.character</code>)
<code>as.list</code>	2.9.7	return a named list of the field, enum, and nested descriptors included in this descriptor.
<code>asMessage</code>	2.9.8	return DescriptorProto message.
<code>fileDescriptor</code>	2.9.9	Retrieve the file descriptor of this descriptor.
<code>containing_type</code>	2.9.11	Retrieve the descriptor describing the message type containing this descriptor.
<code>field_count</code>	2.9.12	Return the number of fields in this descriptor.
<code>field</code>	2.9.13	Return the descriptor for the specified field in this descriptor.
<code>nested_type_count</code>	2.9.14	The number of nested types in this descriptor.
<code>nested_type</code>	2.9.15	Return the descriptor for the specified nested type in this descriptor.
<code>enum_type_count</code>	2.9.16	The number of enum types in this descriptor.
<code>enum_type</code>	2.9.17	Return the descriptor for the specified enum type in this descriptor.

Table 6. Description of methods for the Descriptor S4 class

```
# field descriptor
tutorial.Person$email
```

```
# descriptor for field 'email' of type 'tutorial.Person'
```

```
# enum descriptor
tutorial.Person$PhoneType
```

```
# descriptor for enum 'PhoneType' with 3 values
```

```
# nested type descriptor
tutorial.Person$PhoneNumber
```

```
# descriptor for type 'tutorial.Person.PhoneNumber'
```

```
# same as
tutorial.Person.PhoneNumber
```

```
# descriptor for type 'tutorial.Person.PhoneNumber'
```

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

```
tutorial.Person$new()
```

```
# message of type 'tutorial.Person' with 0 fields set
```

```
new(tutorial.Person)
```

```
# message of type 'tutorial.Person' with 0 fields set
```

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

```
tutorial.Person$new(email = "foo@bar.com")
```

```
# message of type 'tutorial.Person' with 1 field set
```

```
# same as  
update(tutorial.Person$new(), email = "foo@bar.com")
```

```
# message of type 'tutorial.Person' with 1 field set
```

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

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

```
# number: "+33(0)..."  
# type: HOME
```

```
m <- read( tutorial.Person.PhoneNumber, tf)  
cat(as.character(m))
```

```
# number: "+33(0)..."  
# type: HOME
```

2.9.4. The readASCII method. The readASCII method is used to read a message from a text file or a character vector.

```
# start by generating the ASCII representation of a message  
text <- as.character(new(tutorial.Person, id=1, name="Murray"))  
text
```

```
# [1] "name: \"Murray\"\\nid: 1\\n"
```

```
# Then read the ascii representation in as a new message object.  
msg <- tutorial.Person$readASCII(text)
```

2.9.5. The toString method. toString currently is an alias to the as.character function.

2.9.6. The as.character method. as.character prints the text representation of the descriptor as it would be specified in the .proto file.

```
desc <- tutorial.Person
cat(desc$toString())
```

```
# message Person {
#   message PhoneNumber {
#     required string number = 1;
#     optional .tutorial.Person.PhoneType type = 2 [default = HOME];
#   }
#   enum PhoneType {
#     MOBILE = 0;
#     HOME = 1;
#     WORK = 2;
#   }
#   required string name = 1;
#   required int32 id = 2;
#   optional string email = 3;
#   repeated .tutorial.Person.PhoneNumber phone = 4;
#   extensions 100 to 199;
# }
```

```
cat(toString(desc))
```

```
# message Person {
#   message PhoneNumber {
#     required string number = 1;
#     optional .tutorial.Person.PhoneType type = 2 [default = HOME];
#   }
#   enum PhoneType {
#     MOBILE = 0;
#     HOME = 1;
#     WORK = 2;
#   }
#   required string name = 1;
#   required int32 id = 2;
#   optional string email = 3;
#   repeated .tutorial.Person.PhoneNumber phone = 4;
#   extensions 100 to 199;
# }
```

```
cat(as.character(tutorial.Person))
```

```
# message Person {
#   message PhoneNumber {
#     required string number = 1;
#     optional .tutorial.Person.PhoneType type = 2 [default = HOME];
#   }
#   enum PhoneType {
#     MOBILE = 0;
#     HOME = 1;
#     WORK = 2;
#   }
#   required string name = 1;
#   required int32 id = 2;
```

```
# optional string email = 3;
# repeated .tutorial.Person.PhoneNumber phone = 4;
# extensions 100 to 199;
# }
```

2.9.7. The `as.list` method. The `as.list` method returns a named list of the field, enum, and nested descriptors included in this descriptor.

```
tutorial.Person$as.list()
```

```
# $name
# descriptor for field 'name' of type 'tutorial.Person'
#
# $id
# descriptor for field 'id' of type 'tutorial.Person'
#
# $email
# descriptor for field 'email' of type 'tutorial.Person'
#
# $phone
# descriptor for field 'phone' of type 'tutorial.Person'
#
# $PhoneNumber
# descriptor for type 'tutorial.Person.PhoneNumber'
#
# $PhoneType
# descriptor for enum 'PhoneType' with 3 values
```

2.9.8. The `asMessage` method. The `asMessage` method returns a message of type `google.protobuf.DescriptorProto` of the Descriptor.

```
tutorial.Person$asMessage()
```

```
# message of type 'google.protobuf.DescriptorProto' with 5 fields set
```

2.9.9. The `fileDescriptor` method. The `fileDescriptor` method retrieves the file descriptor of the descriptor. See section~2.13 for more information about file descriptors.

```
desc <- tutorial.Person
desc$fileDescriptor()
```

```
# file descriptor for package tutorial (addressbook.proto)
```

```
fileDescriptor(desc)
```

```
# file descriptor for package tutorial (addressbook.proto)
```

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

```
# simple name
tutorial.Person$name()
```

```
# [1] "Person"
```

```
# name including scope
tutorial.Person$name(full = TRUE)
```

```
# [1] "tutorial.Person"
```

2.9.11. The `containing_type` method. The `containing_type` method retrieves the descriptor describing the message type containing this descriptor.

```
tutorial.Person$containing_type()
```

```
# NULL
```

```
tutorial.Person$PhoneNumber$containing_type()
```

```
# descriptor for type 'tutorial.Person'
```

2.9.12. The `field_count` method. The `field_count` method retrieves the number of fields in this descriptor.

```
tutorial.Person$field_count()
```

```
# [1] 4
```

2.9.13. The `field` method. The `field` method returns the descriptor for the specified field in this descriptor.

```
tutorial.Person$field(1)
```

```
# descriptor for field 'name' of type 'tutorial.Person'
```

2.9.14. The `nested_type_count` method. The `nested_type_count` method returns the number of nested types in this descriptor.

```
tutorial.Person$nested_type_count()
```

```
# [1] 1
```

2.9.15. The `nested_type` method. The `nested_type` method returns the descriptor for the specified nested type in this descriptor.

```
tutorial.Person$nested_type(1)
```

```
# descriptor for type 'tutorial.Person.PhoneNumber'
```

2.9.16. The `enum_type_count` method. The `enum_type_count` method returns the number of enum types in this descriptor.

```
tutorial.Person$enum_type_count()
```

```
# [1] 1
```

2.9.17. The `enum_type` method. The `enum_type` method returns the descriptor for the specified enum type in this descriptor.

```
tutorial.Person$enum_type(1)
```

```
# descriptor for enum 'PhoneType' with 3 values
```

2.10. Field descriptors. The class *FieldDescriptor* represents field descriptor in R. This is a wrapper S4 class around the `google::protobuf::FieldDescriptor` C++ class. Table~8 describes the methods defined for the *FieldDescriptor* class.

slot	description
pointer	External pointer to the <i>FieldDescriptor</i> 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 7. Description of slots for the *FieldDescriptor* S4 class

method	section	description
<code>as.character</code>	2.10.1	character representation of a descriptor
<code>toString</code>	2.10.2	character representation of a descriptor (same as <code>as.character</code>)
<code>asMessage</code>	2.10.3	return <i>FieldDescriptorProto</i> message.
<code>name</code>	2.10.4	Return the name of the field descriptor.
<code>fileDescriptor</code>	2.10.5	Return the <i>fileDescriptor</i> where this field is defined.
<code>containing_type</code>	2.10.6	Return the containing descriptor of this field.
<code>is_extension</code>	2.10.7	Return TRUE if this field is an extension.
<code>number</code>	2.10.8	Gets the declared tag number of the field.
<code>type</code>	2.10.9	Gets the type of the field.
<code>cpp_type</code>	2.10.10	Gets the C++ type of the field.
<code>label</code>	2.10.11	Gets the label of a field (optional, required, or repeated).
<code>is_repeated</code>	2.10.12	Return TRUE if this field is repeated.
<code>is_required</code>	2.10.13	Return TRUE if this field is required.
<code>is_optional</code>	2.10.14	Return TRUE if this field is optional.
<code>has_default_value</code>	2.10.15	Return TRUE if this field has a default value.
<code>default_value</code>	2.10.16	Return the default value.
<code>message_type</code>	2.10.17	Return the message type if this is a message type field.
<code>enum_type</code>	2.10.18	Return the enum type if this is an enum type field.

Table 8. Description of methods for the *FieldDescriptor* S4 class

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

```
cat(as.character(tutorial.Person$PhoneNumber))
```

```
# message PhoneNumber {  
#   required string number = 1;  
#   optional .tutorial.Person.PhoneType type = 2 [default = HOME];  
# }
```

2.10.2. The `toString` method. `toString` is an alias of `as.character`.

```
cat(tutorial.Person.PhoneNumber$toString())
```

```
# message PhoneNumber {  
#   required string number = 1;  
#   optional .tutorial.Person.PhoneType type = 2 [default = HOME];  
# }
```

2.10.3. The `asMessage` method. The `asMessage` method returns a message of type `google.protobuf.FieldDescriptorProto` of the `FieldDescriptor`.

```
tutorial.Person$id$asMessage()
```

```
# message of type 'google.protobuf.FieldDescriptorProto' with 4 fields set
```

```
cat(as.character(tutorial.Person$id$asMessage()))
```

```
# name: "id"  
# number: 2  
# label: LABEL_REQUIRED  
# type: TYPE_INT32
```

2.10.4. The `name` method. The `name` method can be used to retrieve the name of the field descriptor.

```
# simple name.  
name(tutorial.Person$id)
```

```
# [1] "id"
```

```
# name including scope.  
name(tutorial.Person$id, full=TRUE)
```

```
# [1] "tutorial.Person.id"
```

2.10.5. The `fileDescriptor` method. The `fileDescriptor` method can be used to retrieve the file descriptor of the field descriptor.

```
fileDescriptor(tutorial.Person$id)
```

```
# file descriptor for package tutorial (addressbook.proto)
```

```
tutorial.Person$id$fileDescriptor()
```

```
# file descriptor for package tutorial (addressbook.proto)
```

2.10.6. The `containing_type` method. The `containing_type` method can be used to retrieve the descriptor for the message type that contains this descriptor.

```
containing_type(tutorial.Person$id)
```

```
# descriptor for type 'tutorial.Person'
```

```
tutorial.Person$id$containing_type()
```

```
# descriptor for type 'tutorial.Person'
```

2.10.7. The *is_extension* method. The `is_extension` method returns TRUE if this field is an extension.

```
is_extension( tutorial.Person$id )
```

```
# [1] FALSE
```

```
tutorial.Person$id$is_extension()
```

```
# [1] FALSE
```

2.10.8. The *number* method. The `number` method returns the declared tag number of this field.

```
number( tutorial.Person$id )
```

```
# [1] 2
```

```
tutorial.Person$id$number()
```

```
# [1] 2
```

2.10.9. The *type* method. The `type` method can be used to retrieve the type of the field descriptor.

```
type( tutorial.Person$id )
```

```
# [1] 5
```

```
tutorial.Person$id$type()
```

```
# [1] 5
```

2.10.10. The *cpp_type* method. The `cpp_type` method can be used to retrieve the C++ type of the field descriptor.

```
cpp_type( tutorial.Person$id )
```



```
# [1] 1
```

```
tutorial.Person$id$cpp_type()
```

```
# [1] 1
```

2.10.11. The *label* method. Gets the label of a field (optional, required, or repeated). The `label` method returns the label of a field (optional, required, or repeated). By default it returns a number value, but the optional `as.string` argument can be provided to return a human readable string representation.

```
label(tutorial.Person$id)
```

```
# [1] 2
```

```
label(tutorial.Person$id, TRUE)
```

```
# [1] "LABEL_REQUIRED"
```

```
tutorial.Person$id$label(TRUE)
```

```
# [1] "LABEL_REQUIRED"
```

2.10.12. The *is_repeated* method. The `is_repeated` method returns TRUE if this field is repeated.

```
is_repeated( tutorial.Person$id )
```

```
# [1] FALSE
```

```
tutorial.Person$id$is_repeated()
```

```
# [1] FALSE
```

2.10.13. The *is_required* method. The `is_required` method returns TRUE if this field is required.

```
is_required( tutorial.Person$id )
```

```
# [1] TRUE
```

```
tutorial.Person$id$is_required()
```

```
# [1] TRUE
```

2.10.14. The *is_optional* method. The `is_optional` method returns TRUE if this field is optional.

```
is_optional(tutorial.Person$id)
```

```
# [1] FALSE
```

```
tutorial.Person$id$is_optional()
```

```
# [1] FALSE
```

2.10.15. The `has_default_value` method. The `has_default_value` method returns TRUE if this field has a default value.

```
has_default_value(tutorial.Person$PhoneNumber$type)
```

```
# [1] TRUE
```

```
has_default_value(tutorial.Person$PhoneNumber$number)
```

```
# [1] FALSE
```

2.10.16. The `default_value` method. The `default_value` method returns the default value of a field.

```
default_value(tutorial.Person$PhoneNumber$type)
```

```
# [1] 1
```

```
default_value(tutorial.Person$PhoneNumber$number)
```

```
# [1] ""
```

2.10.17. The `message_type` method. The `message_type` method returns the message type if this is a message type field.

```
message_type(tutorial.Person$phone)
```

```
# descriptor for type 'tutorial.Person.PhoneNumber'
```

```
tutorial.Person$phone$message_type()
```

```
# descriptor for type 'tutorial.Person.PhoneNumber'
```

2.10.18. The `enum_type` method. The `enum_type` method returns the enum type if this is an enum type field.

```
enum_type(tutorial.Person$PhoneNumber$type)
```

```
# descriptor for enum 'PhoneType' with 3 values
```

2.11. Enum descriptors. The class *EnumDescriptor* is an R wrapper class around the C++ class `google::protobuf::EnumDescriptor`. Table~10 describes the methods defined for the *EnumDescriptor* class.

slot	description
pointer	External pointer to the <i>EnumDescriptor</i> 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 9. Description of slots for the *EnumDescriptor* S4 class

method	section	description
<code>as.list</code>	2.11.2	return a named integer vector with the values of the enum and their names.
<code>as.character</code>	2.11.3	character representation of a descriptor
<code>toString</code>	2.11.4	character representation of a descriptor (same as <code>as.character</code>)
<code>asMessage</code>	2.11.5	return <i>EnumDescriptorProto</i> message.
<code>name</code>	2.11.6	Return the name of the enum descriptor.
<code>fileDescriptor</code>	2.11.7	Return the <i>fileDescriptor</i> where this field is defined.
<code>containing_type</code>	2.11.8	Return the containing descriptor of this field.
<code>length</code>	2.11.9	Return the number of constants in this enum.
<code>has</code>	2.11.10	Return TRUE if this enum contains the specified named constant string.
<code>value_count</code>	2.11.11	Return the number of constants in this enum (same as <code>length</code>).
<code>value</code>	2.11.12	Return the <i>EnumValueDescriptor</i> of an enum value of specified index, name, or number.

Table 10. Description of methods for the *EnumDescriptor* S4 class

2.11.1. Extracting descriptors. The `$` operator, when used on a *EnumDescriptor* object retrieves *EnumValueDescriptors* that are contained in the descriptor.

```
tutorial.Person$PhoneType$WORK
```

```
# [1] 2
```

```
name(tutorial.Person$PhoneType$value(number=2))
```

```
# [1] "WORK"
```

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

```
as.list(tutorial.Person$PhoneType)
```

```
# $MOBILE
# [1] 0
#
# $HOME
# [1] 1
#
# $WORK
# [1] 2
```

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

```
cat(as.character(tutorial.Person$PhoneType ))
```

```
# enum PhoneType {  
#   MOBILE = 0;  
#   HOME = 1;  
#   WORK = 2;  
# }
```

2.11.4. The `toString` method. The `toString` method gives the debug string of the enum type.

```
{ toStringMethod3} cat(toString(tutorial.Person$PhoneType))
```

2.11.5. The `asMessage` method. The `asMessage` method returns a message of type `google.protobuf.EnumDescriptorProto` of the `EnumDescriptor`.

```
tutorial.Person$PhoneType$asMessage()
```

```
# message of type 'google.protobuf.EnumDescriptorProto' with 2 fields set
```

```
cat(as.character(tutorial.Person$PhoneType$asMessage()))
```

```
# name: "PhoneType"  
# value {  
#   name: "MOBILE"  
#   number: 0  
# }  
# value {  
#   name: "HOME"  
#   number: 1  
# }  
# value {  
#   name: "WORK"  
#   number: 2  
# }
```

2.11.6. The `name` method. The `name` method can be used to retrieve the name of the enum descriptor.

```
# simple name.  
name( tutorial.Person$PhoneType )
```

```
# [1] "PhoneType"
```

```
# name including scope.  
name( tutorial.Person$PhoneType, full=TRUE )
```

```
# [1] "tutorial.Person.PhoneType"
```

2.11.7. The `fileDescriptor` method. The `fileDescriptor` method can be used to retrieve the file descriptor of the enum descriptor.

```
fileDescriptor(tutorial.Person$PhoneType)
```

```
# file descriptor for package tutorial (addressbook.proto)
```

```
tutorial.Person$PhoneType$fileDescriptor()
```

```
# file descriptor for package tutorial (addressbook.proto)
```

2.11.8. The *containing_type* method. The `containing_type` method can be used to retrieve the descriptor for the message type that contains this enum descriptor.

```
tutorial.Person$PhoneType$containing_type()
```

```
# descriptor for type 'tutorial.Person'
```

2.11.9. The *length* method. The `length` method returns the number of constants in this enum.

```
length(tutorial.Person$PhoneType)
```

```
# [1] 3
```

```
tutorial.Person$PhoneType$length()
```

```
# [1] 3
```

2.11.10. The *has* method. The `has` method returns TRUE if this enum contains the specified named constant string.

```
tutorial.Person$PhoneType$has("WORK")
```

```
# [1] TRUE
```

```
tutorial.Person$PhoneType$has("nonexistent")
```

```
# [1] FALSE
```

2.11.11. The *value_count* method. The `value_count` method returns the number of constants in this enum.

```
value_count(tutorial.Person$PhoneType)
```

```
# [1] 3
```

```
tutorial.Person$PhoneType$value_count()
```

```
# [1] 3
```

2.11.12. The value method. The value method extracts an EnumValueDescriptor. Exactly one argument of ‘index’, ‘number’, or ‘name’ must be specified to identify which constant is desired.

```
tutorial.Person$PhoneType$value(1)
```

```
# enum value descriptor tutorial.Person.MOBILE
```

```
tutorial.Person$PhoneType$value(name="HOME")
```

```
# enum value descriptor tutorial.Person.HOME
```

```
tutorial.Person$PhoneType$value(number=1)
```

```
# enum value descriptor tutorial.Person.HOME
```

2.12. Enum value descriptors. The class *EnumValueDescriptor* is an R wrapper class around the C++ class `google::protobuf::EnumValueDescriptor`. Table~12 describes the methods defined for the *EnumValueDescriptor* class.

slot	description
pointer	External pointer to the EnumValueDescriptor C++ variable
name	simple name of the enum value
full_name	fully qualified name of the enum value

Table 11. Description of slots for the EnumValueDescriptor S4 class

method	section	description
number	2.12.1	return the number of this EnumValueDescriptor.
name	2.12.2	Return the name of the enum value descriptor.
enum_type	2.12.3	return the EnumDescriptor type of this EnumValueDescriptor.
as.character	2.12.4	character representation of a descriptor.
toString	2.12.5	character representation of a descriptor (same as as.character).
asMessage	2.12.6	return EnumValueDescriptorProto message.

Table 12. Description of methods for the EnumValueDescriptor S4 class

2.12.1. The number method. The number method can be used to retrieve the number of the enum value descriptor.

```
number(tutorial.Person$PhoneType$value(number=2))
```

```
# [1] 2
```

2.12.2. The name method. The name method can be used to retrieve the name of the enum value descriptor.

```
# simple name.  
name(tutorial.Person$PhoneType$value(number=2))
```

```
# [1] "WORK"
```

```
# name including scope.  
name(tutorial.Person$PhoneType$value(number=2), full=TRUE)
```

```
# [1] "tutorial.Person.WORK"
```

2.12.3. The `enum_type` method. The `enum_type` method can be used to retrieve the `EnumDescriptor` of the enum value descriptor.

```
enum_type(tutorial.Person$PhoneType$value(number=2))
```

```
# descriptor for enum 'PhoneType' with 3 values
```

2.12.4. The `as.character` method. The `as.character` method gives the debug string of the enum value type.

```
cat(as.character(tutorial.Person$PhoneType$value(number=2)))
```

```
# WORK = 2;
```

2.12.5. The `toString` method. The `toString` method gives the debug string of the enum value type.

```
cat(toString(tutorial.Person$PhoneType$value(number=2)))
```

```
# WORK = 2;
```

2.12.6. The `asMessage` method. The `asMessage` method returns a message of type `google.protobuf.EnumValueDescriptorProto` of the `EnumValueDescriptor`.

```
tutorial.Person$PhoneType$value(number=2)$asMessage()
```

```
# message of type 'google.protobuf.EnumValueDescriptorProto' with 2 fields set
```

```
cat(as.character(tutorial.Person$PhoneType$value(number=2)$asMessage()))
```

```
# name: "WORK"  
# number: 2
```

2.13. File descriptors. File descriptors describe a whole .proto file and are represented in R with the `FileDescriptor` S4 class. The class contains the slots pointer, filename, and package :

Similarly to messages, the `$` operator can be used to extract fields from the file descriptor (in this case, types defined in the file), or invoke pseudo-methods. Table~14 describes the methods defined for the `FileDescriptor` class.

```
f <- tutorial.Person$fileDescriptor()  
f
```

slot	description
pointer	external pointer to the FileDescriptor object of the C++ proto library. Documentation for the FileDescriptor class is available from the protocol buffer project page: http://developers.google.com/protocol-buffers/docs/reference/cpp/google.protobuf.descriptor.html#FileDescriptor
filename	fully qualified pathname of the .proto file.
package	package name defined in this .proto file.

Table 13. Description of slots for the FileDescriptor S4 class

```
# file descriptor for package tutorial (addressbook.proto)
```

```
f$Person
```

```
# descriptor for type 'tutorial.Person'
```

method	section	description
name	2.13.5	Return the filename for this FileDescriptorProto.
package	2.13.6	Return the file-level package name specified in this FileDescriptorProto.
as.character	2.13.1	character representation of a descriptor.
toString	2.13.2	character representation of a descriptor (same as as.character).
asMessage	2.13.3	return FileDescriptorProto message.
as.list	2.13.4	return named list of descriptors defined in this file descriptor.

Table 14. Description of methods for the FileDescriptor S4 class

2.13.1. The as.character method. The as.character method gives the debug string of the file descriptor.

```
cat(as.character(fileDescriptor(tutorial.Person)))
```

```
# syntax = "proto2";
#
# package tutorial;
#
# option java_package = "com.example.tutorial";
# option java_outer_classname = "AddressBookProtos";
#
# message Person {
#   message PhoneNumber {
#     required string number = 1;
#     optional .tutorial.Person.PhoneType type = 2 [default = HOME];
#   }
#   enum PhoneType {
#     MOBILE = 0;
#     HOME = 1;
#     WORK = 2;
#   }
#   required string name = 1;
#   required int32 id = 2;
#   optional string email = 3;
#   repeated .tutorial.Person.PhoneNumber phone = 4;
#   extensions 100 to 199;
# }
#
# message AddressBook {
```



```
#   repeated .tutorial.Person person = 1;
# }
#
# service EchoService {
#   rpc Echo(.tutorial.Person) returns (.tutorial.Person);
# }
```

2.13.2. The `toString` method. `toString` is an alias of `as.character`.

```
cat(fileDescriptor(tutorial.Person)$toString())
```

```
# syntax = "proto2";
#
# package tutorial;
#
# option java_package = "com.example.tutorial";
# option java_outer_classname = "AddressBookProtos";
#
# message Person {
#   message PhoneNumber {
#     required string number = 1;
#     optional .tutorial.Person.PhoneType type = 2 [default = HOME];
#   }
#   enum PhoneType {
#     MOBILE = 0;
#     HOME = 1;
#     WORK = 2;
#   }
#   required string name = 1;
#   required int32 id = 2;
#   optional string email = 3;
#   repeated .tutorial.Person.PhoneNumber phone = 4;
#   extensions 100 to 199;
# }
#
# message AddressBook {
#   repeated .tutorial.Person person = 1;
# }
#
# service EchoService {
#   rpc Echo(.tutorial.Person) returns (.tutorial.Person);
# }
```

2.13.3. The `asMessage` method. The `asMessage` method returns a protocol buffer message representation of the file descriptor.

```
asMessage(tutorial.Person$fileDescriptor())
```

```
# message of type 'google.protobuf.FileDescriptorProto' with 5 fields set
```

```
cat(as.character(asMessage(tutorial.Person$fileDescriptor())))
```

```

# name: "addressbook.proto"
# package: "tutorial"
# message_type {
#   name: "Person"
#   field {
#     name: "name"
#     number: 1
#     label: LABEL_REQUIRED
#     type: TYPE_STRING
#   }
#   field {
#     name: "id"
#     number: 2
#     label: LABEL_REQUIRED
#     type: TYPE_INT32
#   }
#   field {
#     name: "email"
#     number: 3
#     label: LABEL_OPTIONAL
#     type: TYPE_STRING
#   }
#   field {
#     name: "phone"
#     number: 4
#     label: LABEL_REPEATED
#     type: TYPE_MESSAGE
#     type_name: ".tutorial.Person.PhoneNumber"
#   }
#   nested_type {
#     name: "PhoneNumber"
#     field {
#       name: "number"
#       number: 1
#       label: LABEL_REQUIRED
#       type: TYPE_STRING
#     }
#     field {
#       name: "type"
#       number: 2
#       label: LABEL_OPTIONAL
#       type: TYPE_ENUM
#       type_name: ".tutorial.Person.PhoneType"
#       default_value: "HOME"
#     }
#   }
#   enum_type {
#     name: "PhoneType"
#     value {
#       name: "MOBILE"
#       number: 0
#     }
#     value {
#       name: "HOME"
#       number: 1
#     }
#   }
# }

```

```
#     }
#     value {
#       name: "WORK"
#       number: 2
#     }
#   }
#   extension_range {
#     start: 100
#     end: 200
#   }
# }
# message_type {
#   name: "AddressBook"
#   field {
#     name: "person"
#     number: 1
#     label: LABEL_REPEATED
#     type: TYPE_MESSAGE
#     type_name: ".tutorial.Person"
#   }
# }
# service {
#   name: "EchoService"
#   method {
#     name: "Echo"
#     input_type: ".tutorial.Person"
#     output_type: ".tutorial.Person"
#   }
# }
# options {
#   java_package: "com.example.tutorial"
#   java_outer_classname: "AddressBookProtos"
# }
```

2.13.4. The `as.list` method. The `as.list` method creates a named R list that contains the descriptors defined in this file descriptor.

```
as.list(tutorial.Person$fileDescriptor())
```

```
# $Person
# descriptor for type 'tutorial.Person'
#
# $AddressBook
# descriptor for type 'tutorial.AddressBook'
#
# $EchoService
```

2.13.5. The `name` method. The `name` method can be used to retrieve the file name associated with the file descriptor. The optional boolean argument can be specified if full pathnames are desired.

```
name(tutorial.Person$fileDescriptor())
```

```
# [1] "addressbook.proto"
```

```
tutorial.Person$fileDescriptor()$name(TRUE)
```

```
# [1] "addressbook.proto"
```

2.13.6. The package method. The package method can be used to retrieve the package scope associated with this file descriptor.

```
tutorial.Person$fileDescriptor()$package()
```

```
# [1] "tutorial"
```

2.14. Service descriptors. Not fully implemented. Needs to be connected to a concrete RPC implementation. The Google Protocol Buffers C++ open-source library does not include an RPC implementation, but this can be connected easily to others.

2.14.1. The method descriptors method. Not fully implemented. Needs to be connected to a concrete RPC implementation. The Google Protocol Buffers C++ open-source library does not include an RPC implementation, but this can be connected easily to others. Now that Google **gRPC** is released, this is an obvious possibility. Contributions would be most welcome.

3. Utilities

3.1. Coercing objects to messages. The `asMessage` function uses the standard coercion mechanism of the `as` method, and so can be used as a shorthand :

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

```
# message of type 'google.protobuf.DescriptorProto' with 5 fields set
```

```
# coerce a enum descriptor  
asMessage(tutorial.Person.PhoneType)
```

```
# message of type 'google.protobuf.EnumDescriptorProto' with 2 fields set
```

```
# coerce a field descriptor  
asMessage(tutorial.Person$email)
```

```
# message of type 'google.protobuf.FieldDescriptorProto' with 4 fields set
```

```
# coerce a file descriptor  
asMessage(fileDescriptor(tutorial.Person))
```

```
# message of type 'google.protobuf.FileDescriptorProto' with 5 fields set
```

3.2. 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
- names for top-level extensions
- message names for file descriptors

In the unlikely event that there is a user-defined field of exactly the same name as one of the pseudo methods, the user-defined field shall take precedence for completion purposes by design, since the method name can always be invoked directly.

3.3. 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 within message <- new(tutorial.Person, email = "foo### The com" method 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 )

})
```

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

```
## identical
```

The `\texttt{identical}` method is implemented to compare two messages.

```
```r
m1 <- new(tutorial.Person, email = "foo@bar.com", id = 2)
m2 <- update(new(tutorial.Person) , email = "foo@bar.com", id = 2)
identical(m1, m2)
```

```
[1] TRUE
```

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

```
m1 == m2
```

```
[1] TRUE
```

```
m1 != m2
```

```
[1] FALSE
```

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

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

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

```
name: "foobar"
email: "foo@bar.com"
```

**3.5. `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~4.2.

```
P("tutorial.Person")
```

```
descriptor for type 'tutorial.Person'
```

```
new(P("tutorial.Person"))
```

```
message of type 'tutorial.Person' with 0 fields set
```

```
but we can do this instead
tutorial.Person
```

```
descriptor for type 'tutorial.Person'
```

```
new(tutorial.Person)
```

```
message of type 'tutorial.Person' with 0 fields set
```

## 4. Advanced Features

**4.1. Extensions.** Extensions allow you to declare a range of field numbers in a message that are available for extension types. This allows others to declare new fields for a given message type possibly in their own `.proto` files without having to edit the original file. See <https://developers.google.com/protocol-buffers/docs/proto#extensions>.

Notice that the last line of the `Person` message schema in `addressbook.proto` is the following line :

```
extensions 100 to 199;
```

This specifies that other users in other `.proto` files can use tag numbers between 100 and 199 for extension types of this message.

**4.2. 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.

**4.3. 64-bit integer issues.** R does not have native 64-bit integer support. Instead, R treats large integers as doubles which have limited precision. For example, it loses the ability to distinguish some distinct integers:

```
2^53 == (2^53 + 1)
```

```
[1] TRUE
```

Protocol Buffers are frequently used to pass data between different systems, however, and most other systems these days have support for 64-bit integers. To work around this, RProtoBuf allows users to get and set 64-bit integer types by treating them as characters when running on a platform with a 64-bit long long type available.

If we try to set an int64 field in R to double values, we lose precision:

**4.4. Deprecated Feature: Protocol Buffer Groups.** Groups are a deprecated feature that offered another way to nest information in message definitions. For example, the TestAllTypes message type in `unittest.proto` includes an OptionalGroup type:

```
optional group OptionalGroup = 16 {
 optional int32 a = 17;
}
```

And although the feature is deprecated, it can be used with RProtoBuf:

```
test <- new(protobuf_unittest.TestAllTypes)
test$optionalgroup$a <- 3
test$optionalgroup$a
```

```
[1] 3
```

```
cat(as.character(test))
```

```
OptionalGroup {
a: 3
}
```

Note that groups simply combine a nested message type and a field into a single declaration. The field type is OptionalGroup in this example, and the field name is converted to lower-case 'optionalgroup' so as not to conflict with the type name.

Note that groups simply combine a nested message type and a field into a single declaration. The field type is OptionalGroup in this example, and the field name is converted to lower-case 'optionalgroup' so as not to conflict with the type name.

## 5. Other approaches

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. Saptarshi's package is available at <http://ml.stat.purdue.edu/rhipe/doc/html/ProtoBuffers.html>.

Jeroen Ooms took a similar approach influenced by Saptarshi in his RProtoBufUtils package. Unlike Saptarshi's package, RProtoBufUtils depends on RProtoBuf for underlying message operations. This package is available at <https://github.com/jeroenooms/RProtoBufUtils>.

## 6. Plans for future releases

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. Now that Google `gRPC` is released, this is an obvious possibility. Contributions would be most welcome.

Extensions have been implemented in RProtoBuf and have been extensively used and tested, but they are not currently described in this vignette. Additional examples and documentation are needed for extensions.

## 7. Acknowledgements

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 would 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~4.2). Many thanks to Duncan for this amazing feature.