RProtoBuf: Protocol Buffers for R

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Outline

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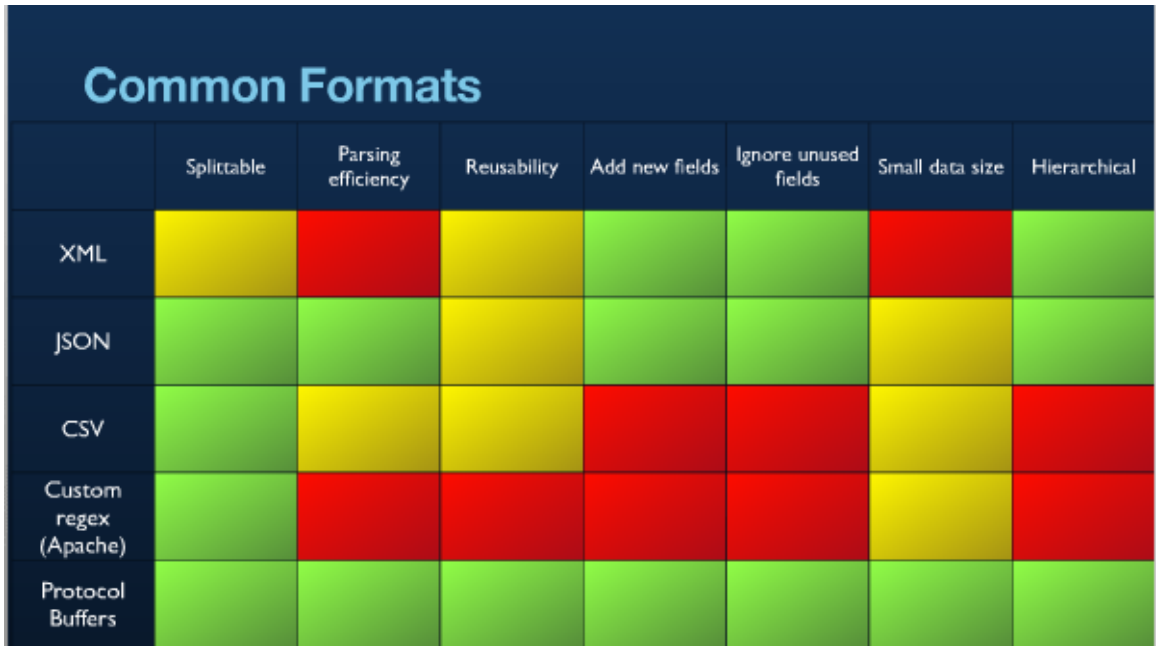
Brief Description

- Google's Protocol Buffers are a flexible, efficient, automated mechanism for serializing structured data—think XML, but smaller, faster, and simpler.
- Users define the data structures in a `proto` file, and then use special generated source code. Code is forwards- and backwards-compatible to `proto` changes.
- This permits to easily write and read structured data to and from a variety of data streams, and using a variety of officially supported languages— Java, C++, or Python.
- Or one can use third-party implementations for languages such as C#, Perl, Ruby, Haskell, and now R via the **RProtoBuf** package.

Features



Source: http://http://www.slideshare.net/kevinweil/protocol-buffers-and-hadoop-at-twitter

Protocol Buffers compare favourably against a number of competing data / messaging formats.

Example `proto` file from Tutorial

```
package tutorial;
message Person {
 required string name = 1;
 required int32 id = 2;          // Unique ID number for person.
 optional string email = 3;
 enum PhoneType {
   MOBILE = 0; HOME = 1; WORK = 2;
 }
 message PhoneNumber {
   required string number = 1;
   optional PhoneType type = 2 [default = HOME];
 }
 repeated PhoneNumber phone = 4;
}
// Our address book file is just one of these.
message AddressBook {
  repeated Person person = 1;
}
```

Example C++ usage

```
#include "addressbook.pb.h"
using namespace std;

// Iterates though all people in the AddressBook
// and prints info about them.
void ListPeople(const tutorial::AddressBook&
address_book) {
  for (int i=0; i < address_book.person_size(); i++) {
    const tutorial::Person& person =
        address_book.person(i);

    cout << "Person ID: " << person.id() << endl;
    cout << "  Name: " << person.name() << endl;
    if (person.has_email()) {
      cout << "  E-mail address: "
           << person.email() << endl;
    }
```

Example C++ usage (cont.)

```
    for (int j = 0; j < person.phone_size(); j++) {
      const tutorial::Person::PhoneNumber
         &phone_number = person.phone(j);

      switch (phone_number.type()) {
        case tutorial::Person::MOBILE:
          cout << "  Mobile phone #: ";
          break;
        case tutorial::Person::HOME:
          cout << "  Home phone #: ";
          break;
        case tutorial::Person::WORK:
          cout << "  Work phone #: ";
          break;
      }
      cout << phone_number.number() << endl;
    }
  }
}
```

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- The **RProtoBuf** package implements R bindings to the C++ protobuf library from Google.
- **RProtoBuf** uses features of the protocol buffer library to support creation, manipulation, parsing and serialization of protocol buffers messages.
- Taking advantage of facilities in the **Rcpp** package, **RProtoBuf** uses S4 classes and external pointers to expose objects that look and feel like standard R lists, yet are managed by the underlying C++ library.
- These objects also conform to the language-agnostic definition of the message type allowing access to their content from other supported languages.

Addressbook example from R

See `demo(addressbook)`

```
> # load the package
> require( RProtoBuf )
> # read the proto file
> readProtoFiles( files="addressbook.proto" )
> # create a prototype with a call to new
> # on the descriptor for the Person type,
> romain <- new( tutorial.Person )
> # then update the message
> romain <- update( romain ,
+     email = "romain@r-enthusiasts.com",
+     id = 1, name = "Romain Francois",
+     phone = new(tutorial.Person.PhoneNumber,
+       number = "+33(0)...", type = "MOBILE"))
```

Addressbook example from R (cont)

```
> # directly supply parameters to the ctor
> dirk <- new( tutorial.Person,
+     email = "edd@debian.org",
+     id = 2, name = "Dirk Eddelbuettel" )
> # update the phone repeated field with list
> dirk$phone <- list(
+   new( tutorial.Person.PhoneNumber,
+         number = "+01...", type = "MOBILE" ),
+   new( tutorial.Person.PhoneNumber ,
+         number = "+01...", type = "HOME" ) )
```

Addressbook example from R (cont)

```
> # build the address book
> book <- new( tutorial.AddressBook,
+              person = list( romain, dirk ) )
> # debug content - this is not wire content
> writeLines( as.character( book ) )
> # the serialized message,
> # see also the io demo
> serialize( book, NULL )
```

Example `proto` file for Financial Data

```
// Namespace
package TradeData;

// A simple Fill, ie a completed trade
message Fill {
   required double timestamp = 1;
   required string symbol = 2;
   required double price = 3;
   required int32 size = 4;
}

// A sequence of Fills
message Trades {
   repeated Fill fill = 1;
}
```

See `inst/examples/HighFrequencyFinance/` in the **RProtoBuf** package.

Example C++ data creator

```
int main(int argc, char **argv) {
  const char* pbfile = "trades.pb";
  const int N = 1000;
  set_seed(123, 456);
  double tstamp = 1277973000;      // 2010-07-01 08:30:00
  double tprice = 100.0;           // gotta start somewhere
  char sym[] = "ABC";
  TradeData::Trades tr;
  for (int i=0; i<N; i++) {
    TradeData::Fill *fill = tr.add_fill();
    tstamp += runif(0.000, 0.100);
    tprice += round(rt(5) * 0.01 * 100)/100;
    int tsize = 100 + round(runif(0,9))*100;
    fill->set_timestamp(tstamp);
    fill->set_price(tprice);
    fill->set_symbol(sym);
    fill->set_size(tsize);
  }
  std::fstream output(pbfile, std::ios::out | std::ios::binary);
  if (!tr.SerializeToOstream(&output)) {
      std::cerr << "Failed to write data." << std::endl;
      return -1;
  }
  return 0;
}
```

See `inst/examples/HighFrequencyFinance/protoCreate.cpp`

Extensibility

We could add this to the `proto` file:

```
enum exchType {
  NYSE = 0; NASDAQ = 1; ARCS = 2; BATS = 3;
}
optional exchType exchange = 5 [default = NYSE];
```

If you want your new buffers to be backwards-compatible, and your old buffers to be forward-compatible [...]:

- *you must not change the tag [...] of any existing fields.*
- *you must not add or delete any required fields.*
- *you may delete optional or repeated fields.*
- *you may add new optional or repeated fields but you must use fresh tag numbers [...]*

See `http://code.google.com/apis/protocolbuffers/docs/cpptutorial.html`

Example R reader: Simple

```
> basicUse <- function(verbose=TRUE) {
+   readProtoFiles("TradeData.proto")
+   x <- read( TradeData.Trades, "trades.pb")
+   xl <- as.list(x)
+   df <- do.call(rbind,
+                 lapply(as.list(xl$fill),
+                        function(.)
+                        as.data.frame(as.list(.))))
+   df[,1] <- as.POSIXct(df[,1], origin="1970-01-01")
+   if (verbose) print(summary(df))
+   invisible(df)
+ }
```

See `inst/examples/HighFrequencyFinance/loadInR.r`

Example R reader: Smarter

```
> betterUse <- function(verbose=TRUE,
+                       file="trades.pb") {
+   readProtoFiles("TradeData.proto")
+   x <- read( TradeData.Trades, "trades.pb")
+   xl <- lapply( x$fill, as.list )
+
+   df <- data.frame(timestamp= as.POSIXct(sapply(xl,
+                       "[[", "timestamp" ),
+                       origin="1970-01-01"),
+                    symbol = sapply(xl,"[[","symbol"),
+                    price  = sapply(xl,"[[","price"),
+                    size   = sapply(xl,"[[","size"))
+   if (verbose) print(summary(df))
+   invisible(df)
+ }
```

See `inst/examples/HighFrequencyFinance/loadInR.r`

Example R reader: Manual via Rcpp

```
> compiled <- function(verbose=FALSE,
+                      file="trades.pb") {
+
+     stopifnot(file.exists(file))
+
+     df <- .Call("pbload", file);
+
+     if (verbose) print(summary(df))
+
+     invisible(df)
+ }
```

See `inst/examples/HighFrequencyFinance/loadInR.r`

Example R reader: C++ support

```
extern "C" SEXP pbload(SEXP b) {
  std::string pbfile = Rcpp::as<std::string>(b);
  TradeData::Trades tr;
  std::fstream fs(pbfile.c_str(), std::ios::in | std::ios::binary);
  if (!tr.ParseFromIstream(&fs)) {
    std::cerr << "Trouble parsing..." << std::cout;
    return R_NilValue;
  }
  int n = tr.fill_size();
  Rcpp::DatetimeVector timestamp(n);
  Rcpp::CharacterVector tsym(n);
  Rcpp::NumericVector tprice(n);
  Rcpp::IntegerVector tsize(n);
  for (int i=0; i<n; i++) {
    const TradeData::Fill &fill = tr.fill(i);
    timestamp[i] = fill.timestamp();
    tsym[i]      = fill.symbol();
    tprice[i]    = fill.price();
    tsize[i]     = fill.size();
  }
  return Rcpp::DataFrame::create(Rcpp::Named("times")  = timestamp,
                                 Rcpp::Named("symbol") = tsym,
                                 Rcpp::Named("price")  = tprice,
                                 Rcpp::Named("size")   = tsize);
}
```

See `inst/examples/HighFrequencyFinance/protoModule.cpp`

Timing comparison

Running the script `loadInR.r` from the aforementioned examples directory in the **RProtoBuf** package:

Version	Elapsed Time	Relative
Compiled	0.006	1.0000
betterUse	0.138	23.0000
basicUse	4.606	767.6667

Times are total in seconds from on three replications each on relatively recent server, using the **rbenchmark** package.

Outline

Summary

- We have introduced the Google *Protocol Buffers* library as a means to generating efficient data interfacing code: fast, auto-generated and extensible.
- We illustrated its use via our nascent **RProtoBuf** package.
- **RProtoBuf** brings autogenerated accessors to R—which may however not be the fastest access.
- The **Rcpp** package makes it easy to *manually* add Protocol Buffers capabilities to our R analyses.

Outlook

- Goal: Use the new *Modules* feature in **Rcpp** to get at (almost) auto-generated yet very efficient (C++-based) access from R.
- Second Goal: Add networking capabilities, maybe via R's built-in http server.