Rcpp Workshop
Part II: Rcpp Details

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Outline

1. Main Rcpp Classes
   - RObject
   - IntegerVector
   - NumericVector
   - GenericVector
   - DataFrame
   - Function
   - Environments
   - S4

RObject

The `RObject` class is the basic class behind the **Rcpp** API.

It provides a thin wrapper around a `SEXP` object—this is sometimes called a *proxy object* as we do not copy the R object.

`RObject` manages the life cycle, the object is protected from garbage collection while in scope—so *you* do not have to do memory management.

`RObject` defines several member functions common to all objects (*e.g.*, `isS4()`, `attributeNames`, ...); derived classes then define specific member functions.

Overview of classes: Comparison

Rcpp class	R `typeof`
`Integer(Vector|Matrix)`	`integer` vectors and matrices
`Numeric(Vector|Matrix)`	`numeric` ...
`Logical(Vector|Matrix)`	`logical` ...
`Character(Vector|Matrix)`	`character` ...
`Raw(Vector|Matrix)`	`raw` ...
`Complex(Vector|Matrix)`	`complex` ...
`List`	`list` (aka generic vectors) ...
`Expression(Vector|Matrix)`	`expression` ...
`Environment`	`environment`
`Function`	`function`
`XPtr`	`externalptr`
`Language`	`language`
`S4`	`S4`
...	...

Overview of key vector / matrix classes

`IntegerVector` vectors of type `integer`

`NumericVector` vectors of type `numeric`

`RawVector` vectors of type `raw`

`LogicalVector` vectors of type `logical`

`CharacterVector` vectors of type `character`

`GenericVector` generic vectors implementing `list` types

Common core functions for Vectors and Matrices

Key operations for all vectors, styled after STL operations:

`operator()`	access elements via `()`
`operator[]`	access elements via `[]`
`length()`	also aliased to `size()`
`fill(u)`	fills vector with value of `u`
`begin()`	pointer to beginning of vector, for iterators
`end()`	pointer to one past end of vector
`push_back(x)`	insert x at end, grows vector
`push_front(x)`	insert x at beginning, grows vector
`insert(i, x)`	insert x at position i, grows vector
`erase(i)`	remove element at position i, shrinks vector

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A first example

`examples/part2/intVecEx1.cpp`

A simpler version of `prod()` for integer vectors:

```
#include <Rcpp.h>

// [[Rcpp::export]]
int intVec1a(Rcpp::IntegerVector vec) {
    int prod = 1;
    for (int i=0; i<vec.size(); i++) {
        prod *= vec[i];
    }
    return prod;
}
```

which we can compile by loading it with `sourceCpp()`.

We can also use a standard C++ type (`std::vector<int>`), and a non-loop computation. More on that later...

A first example

examples/part2/intVecEx1.R

To discuss the example, we reimplement it using `cxxfunction()` from the **inline** package:

```
library(inline)

src <- '
    Rcpp::IntegerVector vec(vx);
    int prod = 1;
    for (int i=0; i<vec.size(); i++) {
        prod *= vec[i];
    }
    return Rcpp::wrap(prod);
'
fun <- cxxfunction(signature(vx="integer"),
                   src, plugin="Rcpp")
fun(1L:10L)
```

Passing data from from R

examples/part2/intVecEx1.R

We instantiate the `IntegerVector` object with the `SEXP` received from R :

```
library(inline)

src <- '
    Rcpp::IntegerVector vec(vx);
    int prod = 1;
    for (int i=0; i<vec.size(); i++) {
        prod *= vec[i];
    }
    return Rcpp::wrap(prod);
'
fun <- cxxfunction(signature(vx="integer"),
                   src, plugin="Rcpp")
fun(1L:10L)
```

Objects tell us their size

examples/part2/intVecEx1.R

The loop counter can use the information from the `IntegerVector` itself:

```
library(inline)

src <- '
    Rcpp::IntegerVector vec(vx);
    int prod = 1;
    for (int i=0; i<vec.size(); i++) {
        prod *= vec[i];
    }
    return Rcpp::wrap(prod);
'
fun <- cxxfunction(signature(vx="integer"),
                   src, plugin="Rcpp")
fun(1L:10L)
```

Element access

examples/part2/intVecEx1.R

We simply access elements by index (but note that the range is over $0 \ldots N-1$ as is standard for C and C++):

```
library(inline)

src <- '
    Rcpp::IntegerVector vec(vx);
    int prod = 1;
    for (int i=0; i<vec.size(); i++) {
        prod *= vec[i];
    }
    return Rcpp::wrap(prod);
'
fun <- cxxfunction(signature(vx="integer"),
                   src, plugin="Rcpp")
fun(1L:10L)
```

Returning results

examples/part2/intVecEx1.R

We return the scalar `int` by using the `wrap` helper:

```
library(inline)

src <- '
    Rcpp::IntegerVector vec(vx);
    int prod = 1;
    for (int i=0; i<vec.size(); i++) {
        prod *= vec[i];
    }
    return Rcpp::wrap(prod);
'
fun <- cxxfunction(signature(vx="integer"),
                   src, plugin="Rcpp")
fun(1L:10L)
```

An STL variant

`examples/part2/intVecEx2.R`

As an alternative, the Standard Template Library also allows us a loop-less variant similar in spirit to vectorised R expressions:

```
library(inline)

src <- '
  Rcpp::IntegerVector vec(vx);
  int prod = std::accumulate(vec.begin(), vec.end(),
                             1, std::multiplies<int>());
  return Rcpp::wrap(prod);
'
fun <- cxxfunction(signature(vx="integer"),
                   src, plugin="Rcpp")
fun(1L:10L)
```

An STL variant

`examples/part2/intVecEx2.cpp`

The shortest, most-functional and pure C++ version:

```
#include <Rcpp.h>

// [[Rcpp::export]]
int intVec2b(std::vector<int> vec) {
    int prod = std::accumulate(vec.begin(),
                               vec.end(),
                               1,
                               std::multiplies<int>());
    return prod;
}
```

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A first example

examples/part2/numVecEx1.R

`NumericVector` is very similar to `IntegerVector`.

Here is an example generalizing sum of squares by supplying an exponentiation argument:

```
src <- '
  Rcpp::NumericVector vec(vx);
  double p = Rcpp::as<double>(dd);
  double sum = 0.0;
  for (int i=0; i<vec.size(); i++) {
    sum += pow(vec[i], p);
  }
  return Rcpp::wrap(sum); '
fun <- cxxfunction(signature(vx="numeric",
                             dd="numeric"),
                   src, plugin="Rcpp")
fun(1:4,2)
fun(1:4,2.2)
```

A second example

Remember to `clone`: `examples/part2/numVecEx2.R`

```
R> src <- '
+   NumericVector x1(xs);
+   NumericVector x2(Rcpp::clone(xs));
+   x1[0] = 22;
+   x2[1] = 44;
+   return(DataFrame::create(Named("orig", xs),
+                            Named("x1", x1),
+                            Named("x2", x2)));'
R> fun <- cxxfunction(signature(xs="numeric"),
+                     body=src, plugin="Rcpp")
R> fun(seq(1.0, 3.0, by=1.0))
  orig x1 x2
1   22 22  1
2    2  2 44
3    3  3  3
R>
```

A second example: continued

So why is the second case different? `examples/part2/numVecEx2.R`

Understanding why these two examples perform differently is important:

```
R> fun(seq(1.0, 3.0, by=1.0))
  orig x1 x2
1   22 22  1
2    2  2 44
3    3  3  3
R> fun(1L:3L)
  orig x1 x2
1    1 22  1
2    2  2 44
3    3  3  3
R>
```

Constructor overview

For `NumericVector` and other vectors deriving from `RObject`

```
SEXP x;
NumericVector y( x ); // from a SEXP

// cloning (deep copy)
NumericVector z = clone<NumericVector>( y );

// of a given size (all elements set to 0.0)
NumericVector y( 10 );

// ... specifying the value
NumericVector y( 10, 2.0 );

// with given elements
NumericVector y = NumericVector::create( 1.0, 2.0 );
```

Matrices

examples/part2/numMatEx1.R

`NumericMatrix` is a specialisation of `NumericVector` which uses a dimension attribute:

```
src <- '
  Rcpp::NumericVector mat =
         Rcpp::clone<Rcpp::NumericMatrix>(mx);
  std::transform(mat.begin(), mat.end(),
                 mat.begin(), ::sqrt);
  return mat; '
fun <- cxxfunction(signature(mx="numeric"), src,
                   plugin="Rcpp")
orig <- matrix(1:9, 3, 3)
fun(orig)
```

Matrices: RcppArmadillo for math

`examples/part2/numMatEx3.R`

However, **Armadillo** is an excellent C++ choice for linear algebra, and **RcppArmadillo** makes this very easy to use:

```
src <- '
  arma::mat m1 = Rcpp::as<arma::mat>(mx);
  arma::mat m2 = m1 + m1;
  arma::mat m3 = m1 * 2;
  return Rcpp::List::create(m1, m2, m3); '
fun <- cxxfunction(signature(mx="numeric"), src,
                   plugin="RcppArmadillo")
mat <- matrix(1:9, 3, 3)
fun(mat)
```

Matrices: RcppArmadillo for math

examples/part2/numMatEx3.cpp

Of course, we can also use Rcpp Attributes:

```
// [[Rcpp::depends(RcppArmadillo)]]
#include <RcppArmadillo.h>

// [[Rcpp::export]]
Rcpp::List armafun(arma::mat m1) {
    arma::mat m2 = m1 + m1;
    arma::mat m3 = m1 * 2;
    return Rcpp::List::create(m1, m2);
}

/*** R
mat <- matrix(1:9, 3, 3)
armafun(mat)
*/
```

RcppArmadillo will be featured more this afternoon.

Other vector types

`LogicalVector` is very similar to `IntegerVector` as it represent the two possible values of a logical, or boolean, type. These values—True and False—can also be mapped to one and zero (or even a more general 'not zero' and zero).

The class `CharacterVector` can be used for vectors of R character vectors (“strings”).

The class `RawVector` can be used for vectors of raw strings.

`Named` can be used to assign named elements in a vector, similar to the R construct `a <- c(foo=3.14, bar=42)` letting us set attribute names (example below); `"_"` is a shortcut alternative we will see in a few examples.

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GenericVector class (aka List) to receive values

We can use the `List` type to receive parameters from R . This is an example from the **RcppExamples** package:

```
RcppExport SEXP newRcppParamsExample(SEXP params) {

  Rcpp::List rparam(params);   // Get parameters in params.
  std::string method = Rcpp::as<std::string>(rparam["method"]);
  double tolerance   = Rcpp::as<double>(rparam["tolerance"]);
  int    maxIter     = Rcpp::as<int>(rparam["maxIter"]);
  [...]
```

A `List` is initialized from a `SEXP`; elements are looked up by name as in R .

Lists can be nested too, and may contain other `SEXP` types too.

GenericVector class (aka List) to return values

We can also use the `List` type to send results from R . This is an example from the **RcppExamples** package:

```
return Rcpp::List::create(Rcpp::Named("method", method),
                          Rcpp::Named("tolerance", tolerance),
                          Rcpp::Named("maxIter", maxIter),
                          Rcpp::Named("startDate", startDate),
                          Rcpp::Named("params", params));
```

This uses the `create` method to assemble a `List` object. We use `Named` to pair each element (which can be anything wrap'able to `SEXP`) with a name.

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DataFrame class

examples/part2/dataFrameEx1.R

The `DataFrame` class be used to receive and return values. On input, we can extract columns from a data frame; row-wise access is not possible.

```
src <- '
  Rcpp::IntegerVector v =
                Rcpp::IntegerVector::create(1,2,3);
  std::vector<std::string> s(3);
  s[0] = "a";
  s[1] = "b";
  s[2] = "c";
  return Rcpp::DataFrame::create(Rcpp::Named("a")=v,
                                 Rcpp::Named("b")=s);
'
fun <- cxxfunction(signature(), src, plugin="Rcpp")
fun()
```

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Function: First example

`examples/part2/functionEx1.R`

Functions are another types of `SEXP` object we can represent:

```
src <- '
   Function s(x) ;
   return s( y, Named("decreasing", true));'
fun <- cxxfunction(signature(x="function",
                             y="ANY"),
                   src, plugin="Rcpp")
fun(sort, sample(1:5, 10, TRUE))
fun(sort, sample(LETTERS[1:5], 10, TRUE))
```

The R function `sort` is used to instantiate a C++ object `s`—which we feed the second argument as well as another R expression created on the spot as `decreasing=TRUE`.

Function: Second example

examples/part2/functionEx1.R

We can use the `Function` class to access R functions:

```
src <- '
  Rcpp::Function rt("rt");
  return rt(5, 3);
'
fun <- cxxfunction(signature(),
                   src, plugin="Rcpp")
set.seed(42)
fun()
```

The R function `rt()` is access directly and used to instantiate a C++ object of the same name—which we get draw five random variable with three degrees of freedom.

While convenient, there is overhead—so we prefer functions available with 'Rcpp sugar' (discussed later).

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Environments

examples/part2/environmentEx1.R

The `Environment` class helps us access R environments.

```
src <- '
    Rcpp::Environment stats("package:stats");
    Rcpp::Function rnorm = stats["rnorm"];
    return rnorm(10, Rcpp::Named("sd", 100.0));
'

fun <- cxxfunction(signature(),
                   src, plugin="Rcpp")
fun()
```

The environment of the (base) package **stats** is instantiated, and we access the `rnorm()` function from it. This is an alternative to accessing build-in functions. (But note that there is also overhead in calling R functions this way.)

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S4

examples/part2/S4ex1.R

`S4` classes can also be created, or altered, at the C++ level.

```
src <- '
  S4 foo(x) ;
  foo.slot(".Data") = "bar" ;
  return(foo);
'
fun <- cxxfunction(signature(x="any"), src,
                   plugin="Rcpp")
setClass( "S4ex", contains = "character",
          representation( x = "numeric" ) )
x <- new( "S4ex", "bla", x = 10 )
fun(x)
str(fun(x))
```

Outline

2 Extending Rcpp via `as` and `wrap`

- Introduction
- Extending wrap
- Extending as
- Example

`as()` and `wrap()`

`as()` and `wrap()` are key components of the R and C++ data interchange.

They are declared as

```
// conversion from R to C++
template <typename T>
T as( SEXP m_sexp) throw(not_compatible);

// conversion from C++ to R
template <typename T>
SEXP wrap(const T& object);
```

as and wrap usage example

examples/part2/asAndWrapEx1.R

```
code <- '
  // we get a list from R
  Rcpp::List input(inp);
  // pull std::vector<double> from R list
  // via an implicit call to Rcpp::as
  std::vector<double> x = input["x"] ;
  // return an R list
  // via an implicit call to Rcpp::wrap
  return Rcpp::List::create(
    Rcpp::Named("front", x.front()),
    Rcpp::Named("back", x.back())
  );
'

fun <- cxxfunction(signature(inp = "list"),
                   code, plugin = "Rcpp")
input <- list(x = seq(1, 10, by = 0.5))
fun(input)
```

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2 Extending Rcpp via `as` and `wrap`
- Introduction
- Extending wrap
- Extending as
- Example

Extending wrap: Intrusively

We can declare a new conversion to `SEXP` operator for class `Foo` in a header `Foo.h` *before* the header `Rcpp.h` is included.

```
#include <RcppCommon.h>

class Foo {
    public:
        Foo();

        // this operator enables implicit Rcpp::wrap
        operator SEXP();
}

#include <Rcpp.h>
```

The definition can follow in a regular `Foo.cpp` file.

Extending wrap: Non-Intrusively

If we cannot modify the class of the code for which we need a wrapper, but still want automatic conversion we can use a template specialization for `wrap`:

```
#include <RcppCommon.h>

// third party library that declares class Bar
#include <foobar.h>

// declaring the specialization
namespace Rcpp {
    template <> SEXP wrap( const Bar& );
}

// this must appear after the specialization,
// otherwise the specialization will not be seen by Rcpp types
#include <Rcpp.h>
```

Extending wrap: Partial specialization

We can also declare a partial specialization as the compiler will pick the appropriate overloading:

```
#include <RcppCommon.h>

// third party library that declares template class Bling<T>
#include <foobar.h>

// declaring the partial specialization
namespace Rcpp {
    namespace traits {

        template <typename T> SEXP wrap( const Bling<T>& ) ;

    }
}

// this must appear after the specialization,
// otherwise the specialization will not be seen by Rcpp types
#include <Rcpp.h>
```

Outline

2. Extending Rcpp via `as` and `wrap`
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   - Example

Extending as: Intrusively

Just like for `wrap`, we can provide an intrusive conversion by declaring a new constructor from `SEXP` for class `Foo` *before* the header `Rcpp.h` is included:

```
#include <RcppCommon.h>

class Foo{
    public:
        Foo() ;

        // this constructor enables implicit Rcpp::as
        Foo(SEXP) ;
}

#include <Rcpp.h>
```

Extending as: Non-Intrusively

We can also use a full specialization of `as` in a non-intrusive manner:

```
#include <RcppCommon.h>

// third party library that declares class Bar
#include <foobar.h>

// declaring the specialization
namespace Rcpp {
    template <> Bar as( SEXP ) throw(not_compatible) ;
}

// this must appear after the specialization,
// otherwise the specialization will not be seen by Rcpp types
#include <Rcpp.h>
```

Extending as: Partial specialization

`Rcpp::as` does not allow partial specialization. We can specialize `Rcpp::traits::Exporter`.
Partial specialization of class templayes is allowed; we can do

```
#include <RcppCommon.h>
// third party library that declares template class Bling<T>
#include <foobar.h>

// declaring the partial specialization
namespace Rcpp {
  namespace traits {
     template <typename T> class Exporter< Bling<T> >;
  }
}
// this must appear after the specialization,
// otherwise the specialization will not be seen by Rcpp types
#include <Rcpp.h>
```

Requirements for the `Exporter< Bling<T> >` class are that it should have a constructor taking a `SEXP`, and it should have a methods called `get` that returns a `Bling<T>` instance.

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The RcppBDT package wraps Boost Date_Time

A simple use case of Rcpp modules

Here, `as` and `wrap` simply convert between a `Date` representation from R and one from Boost:

```
// define template specialisations for as and wrap
namespace Rcpp {
    template <> boost::gregorian::date as( SEXP dtsexp ) {
        Rcpp::Date dt(dtsexp);
        return boost::gregorian::date(dt.getYear(), dt.getMonth(), dt.getDay());
    }

    template <> SEXP wrap(const boost::gregorian::date &d) {
        boost::gregorian::date::ymd_type ymd = d.year_month_day();      // to y/m/d struct
        return Rcpp::wrap(Rcpp::Date( ymd.year, ymd.month, ymd.day ));
    }
}
```

The header file provides both declaration and implementation: a simple conversion between two representations.

The RcppBDT package wraps Boost Date_Time

Example usage of `as` and `wrap`

Two converters provide a simple usage example:

```
// thanks to wrap() template above
Rcpp::Date date_toDate(boost::gregorian::date *d) {
    return Rcpp::wrap(*d);
}

// thanks to as
void date_fromDate(boost::gregorian::date *d, SEXP dt) {
    *d = Rcpp::as<boost::gregorian::date>(dt);
}
```

There are more examples in the (short) package sources.

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3. Using Rcpp in your package
   - Overview
   - Call
   - C++ files
   - R file
   - DESCRIPTION and NAMESPACE
   - Makevars and Makevars.win

Creating a package with Rcpp

R provides a very useful helper function to create packages: `package.skeleton()`.

Our function `Rcpp.package.skeleton()` wraps / extends this to create a framework for a user package. It also supports Modules and Attributes.

The next few slides will show its usage.

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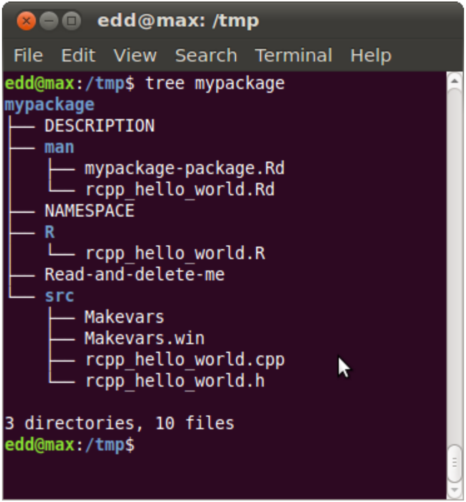
Calling `Rcpp.package.skeleton()`

```
R> Rcpp.package.skeleton( "mypackage" )
Creating directories ...
Creating DESCRIPTION ...
Creating NAMESPACE ...
Creating Read-and-delete-me ...
Saving functions and data ...
Making help files ...
Done.
Further steps are described in './mypackage/Read-and-delete-me'.

Adding Rcpp settings
 >> added Depends: Rcpp
 >> added LinkingTo: Rcpp
 >> added useDynLib directive to NAMESPACE
 >> added Makevars file with Rcpp settings
 >> added Makevars.win file with Rcpp settings
 >> added example header file using Rcpp classes
 >> added example src file using Rcpp classes
 >> added example R file calling the C++ example
 >> added Rd file for rcpp_hello_world
```

`Rcpp.package.skeleton` creates a file tree



```
edd@max:/tmp$ tree mypackage
mypackage
├── DESCRIPTION
├── man
│   ├── mypackage-package.Rd
│   └── rcpp_hello_world.Rd
├── NAMESPACE
├── R
│   └── rcpp_hello_world.R
├── Read-and-delete-me
└── src
    ├── Makevars
    ├── Makevars.win
    ├── rcpp_hello_world.cpp
    └── rcpp_hello_world.h

3 directories, 10 files
edd@max:/tmp$
```

We will discuss the individual files in the next few slides.

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The C++ header file

```
#ifndef _mypackage_RCPP_HELLO_WORLD_H
#define _mypackage_RCPP_HELLO_WORLD_H

#include <Rcpp.h>

/*
 * note : RcppExport is an alias to `extern "C"` defined by Rcpp.
 *
 * It gives C calling convention to the rcpp_hello_world function so that
 * it can be called from .Call in R. Otherwise, the C++ compiler mangles the
 * name of the function and .Call can't find it.
 *
 * It is only useful to use RcppExport when the function is intended to be called
 * by .Call. See http://thread.gmane.org/gmane.comp.lang.r.rcpp/649/focus=672
 * on Rcpp-devel for a misuse of RcppExport
 */
RcppExport SEXP rcpp_hello_world() ;

#endif
```

The C++ source file

```
#include "rcpp_hello_world.h"

SEXP rcpp_hello_world(){
  using namespace Rcpp ;

  CharacterVector x = CharacterVector::create( "foo", "bar" )  ;
  NumericVector y   = NumericVector::create( 0.0, 1.0 ) ;
  List z            = List::create( x, y ) ;

  return z ;
}
```

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The R file

The R file makes one call to the one C++ function:

```
rcpp_hello_world <- function(){
    .Call( "rcpp_hello_world",
           PACKAGE = "mypackage" )
}
```

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    - Makevars and Makevars.win

The DESCRIPTION file

This declares the dependency of your package on **Rcpp**.

```
Package: mypackage
Type: Package
Title: What the package does (short line)
Version: 1.0
Date: 2011-04-19
Author: Who wrote it
Maintainer: Who to complain to <yourfault@somewhere.net>
Description: More about what it does (maybe more than one line)
License: What Licence is it under ?
LazyLoad: yes
Depends: Rcpp (>= 0.9.4)
LinkingTo: Rcpp
```

The NAMESPACE file

Here we use a regular expression to export all symbols.

```
useDynLib(mypackage)
exportPattern("^[[:alpha:]]+")
```

Outline

3. Using Rcpp in your package
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    - DESCRIPTION and NAMESPACE
    - Makevars and Makevars.win

The standard Makevars file

```
## Use the R_HOME indirection to support installations of multiple R version
PKG_LIBS = `$(R_HOME)/bin/Rscript -e "Rcpp:::LdFlags()"`

## As an alternative, one can also add this code in a file 'configure'
##
##    PKG_LIBS=`${R_HOME}/bin/Rscript -e "Rcpp:::LdFlags()"`
##
##    sed -e "s|@PKG_LIBS@|${PKG_LIBS}|" \
##        src/Makevars.in > src/Makevars
##
## which together with the following file 'src/Makevars.in'
##
##    PKG_LIBS = @PKG_LIBS@
##
## can be used to create src/Makevars dynamically. This scheme is more
## powerful and can be expanded to also check for and link with other
## libraries.  It should be complemented by a file 'cleanup'
##
##    rm src/Makevars
##
## which removes the autogenerated file src/Makevars.
##
## Of course, autoconf can also be used to write configure files. This is
## done by a number of packages, but recommended only for more advanced users
## comfortable with autoconf and its related tools.
```

The Windows `Makevars.win` file

On Windows we have to also reflect 32- and 64-bit builds in the call to `Rscript`:

```
## Use the R_HOME indirection to support installations of multiple R version
PKG_LIBS = \
   $(shell "${R_HOME}/bin${R_ARCH_BIN}/Rscript.exe" \
           -e "Rcpp::LdFlags()")
```

Installation and Usage

```
edd@max:/tmp$ R CMD INSTALL mypackage
* installing to library ’/usr/local/lib/R/site-library’
* installing *source* package ’mypackage’ ...
** libs
g++ -I/usr/share/R/include [....]
g++ -shared -o mypackage.so [....]
installing to /usr/local/lib/R/site-library/mypackage/libs
** R
** preparing package for lazy loading
** help
*** installing help indices
** building package indices ...
** testing if installed package can be loaded

* DONE (mypackage)
edd@max:/tmp$ Rscript -e ’library(mypackage); rcpp_hello_world()’
Loading required package: Rcpp
Loading required package: methods
[[1]]
[1] "foo" "bar"

[[2]]
[1] 0 1

edd@max:/tmp$
```