

# Foreign Language Interfaces

Valerie Obenchain

Fred Hutchinson Cancer Research Center

17-18 February, 2011

# Overview

- ▶ Motivation
- ▶ Interface functions
- ▶ Compile and load dynamic libraries
- ▶ Using `.C()`
- ▶ Register native routines

# Motivation

- ▶ Areas where the R implementation is suboptimal :
  - ▶ sliding window algorithms
  - ▶ calculations that are difficult to vectorize
- ▶ Implement third party algorithms or libraries (e.g., GSL, BOOST, BGL, SAMtools, affxparser)

# Interface Functions

The following functions provide a standard interface to compiled code that has been linked into *R*:

- ▶ .C
- ▶ .Call
- ▶ .Fortran

# Advantages of .Call() vs .C()

- ▶ Less copying
- ▶ Memory allocation in C
- ▶ Pass and receive R objects instead of primitive types
- ▶ Access to the attributes of the vectors (i.e., names)
- ▶ Ability to handle missing values easily

# C code

- ▶ Compiled code should not return anything except through the arguments
- ▶ C functions should be of type void

```
/* composite_linkage_disequilibrium.c */

void composite_linkage_disequilibrium(
    unsigned char *snp, /* matrix indiv x snp */
    int *n_ind,         /* # individuals */
    int *n_snp,         /* # snps */
    int *width,         /* adjacent snp window */
    double *delta)      /* result */
{
    ...
}
```

# Compile and load dynamic libraries : *R* Session

- ▶ A shared object can be created with  
R CMD SHLIB `composite_linkage_disequilibrium.c`.
- ▶ From within an *R* session the shared object can be loaded with `dyn.load`. The functions in the compiled code are now available for use in the *R* session.  
> `dyn.load("composite_linkage_disequilibrium.so")`

# Compile and load dynamic libraries : *R* Package

- ▶ Load with `useDynLib(mypkg)` in the `NAMESPACE`
- ▶ Other instructions can be put in `.onLoad` and `.onUnload` functions in a `zzz.R` file.



## Using .C()

- ▶ The first argument is a character string of the C function name. The remainder of the arguments are *R* objects to be passed to the C function.
- ▶ Arguments should be coerced to the *R* storage mode that corresponds to the data type defined in the C code

```
## Create sample data
snps <- matrix(sample((1:3), replace=TRUE, 400),
               nrow=10, ncol=4)

width <- 3
delta <- rep.int(0, (ncol(snps)-width)*width)
out <- .C("composite_linkage_disequilibrium",
        snp = as.raw(snps),
        n_ind = as.integer(nrow(snps)),
        n_snp = as.integer(ncol(snps)),
        width = as.integer(width),
        delta = as.double(delta))
```

# Register Native Routines

Motivation :

- ▶ Platform-independent mechanism for finding routines in shared objects
- ▶ Information about a native routine made available within *R*

Steps :

- ▶ Create an initialization file called `R_init_mypkg.c`
- ▶ Create an array describing the function with `R_CMethodDef`
- ▶ Register the function with `R_registerRoutines`

# Register Native Routines

- ▶ Create an array describing the C routine with R\_CMethodDef:

```
typedef struct {  
    const char *name; DL_FUNC fun; int numArgs;  
    R_NativePrimitiveArgType *types;  
    R_NativeArgStyle          *styles;  
} R_CMethodDef;
```

- ▶ R types and corresponding type identifiers :

```
`numeric'    `REALSXP'  
`integer'    `INTSXP'  
`logical'    `LGLSXP'  
`character'  `STRSXP'  
`raw'        `RAWSXP'
```

# Register Native Routines

- ▶ Given the original C function

```
void composite_linkage_disequilibrium(  
    unsigned char *snp,  
    int *n_ind,  
    int *n_snp,  
    int *width,  
    double *delta)
```

- ▶ We create the R\_CMethodDef array in R\_init\_mypkg.c

```
R_CMethodDef cMethods[] = {  
    {"composite_linkage_disequilibrium",  
     (DL_FUNC) &composite_linkage_disequilibrium, 5,  
     {RAWSXP, INTSXP, INTSXP, INTSXP, REALSXP}  
    },  
    {NULL, NULL, 0}  
};
```

# Initialization Function

- ▶ The initialization file contains the R\_CMethodDef array and the R\_registerRoutines function wrapped in the R\_init\_mypkg function.

```
void R_init_mypkg(DllInfo *info)
{
    /* Create the R_CMethodDef array */
    R_CMethodDef cMethods[] = {
        {"composite_linkage_disequilibrium",
         (DL_FUNC) &composite_linkage_disequilibrium,
         5, {RAWSXP, INTSXP, INTSXP, INTSXP, REALSXP}
        },
        {NULL, NULL, 0}
    };

    /* Register the routine */
    R_registerRoutines(info, cMethods,
                      NULL, NULL, NULL);
}
```

# Resources

- ▶ Writing *R* Extensions Manual  
Section 5: System and Foreign Language Interfaces  
<http://www.r-project.org/>

# Wrap Up

- ▶ C code belongs in src directory of package
  - ▶ function type void
  - ▶ return results through arguments
- ▶ By including `useDynLib(mypkg)` in the `NAMESPACE` the R CMD INSTALL process compiles and links the C code into shared object
- ▶ Call C routine using `.C` interface using correct data types
- ▶ Register C method with R in the `R_init_mypkg.c` file
  - ▶ `R_CMethodDef` defines the C function
  - ▶ `R_registerMethods` registers routine we defined with `R_CMethodDef`
  - ▶ `R_CMethodDef` and `R_registerMethods` belong in `R_init_mypkg` function