GraalVM FastR

Mixed interactive debugging of R and native code with FastR and Visual Studio Code

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Agenda

• Quick Intro to GraalVM
• FastR Overview
• Debugging Native Code Examples
• Conclusion
• Q&A
Top 5 Things To Do With GraalVM

1. High-performance modern Java (just-in-time mode)
2. Low-footprint, fast-startup Java (ahead-of-time mode)
3. Combine JavaScript, Java, Ruby, Python and R
4. Run native languages (e.g. C, Fortran) via LLVM
5. Tools that work across all languages (debugger, profiler ...)

• To learn the Top 10 Things, visit a comprehensive article by Chris Seaton on https://medium.com/graalvm/graalvm-ten-things-12d9111f307d
What’s FastR?

• An R implementation running on GraalVM
• Mature, but still in the experimental stage
• Goals
  – Efficient
  – Polyglot
  – Compatible
    • https://www.graalvm.org/docs/reference-manual/compatibility/
  – Embeddable
• Licence: GPLv3
GraalVM Debugger

• GraalVM supports debugging of guest language applications
• Implements ChromeDev Tools protocol
• GraalVM applications can be debugged using, e.g.:
  • Chrome Developer Tools
  • Visual Studio Code
Native Code Debugging Examples - Prerequisites

• GraalVM installed
• FastR installed in GraalVM
• Visual Studio Code installed
• VSC R Plugin installed
• Debugging examples cloned from GitHub
• The examples folder added to VSC workspace
• Visit fastr-mixed-debug in https://github.com/graalvm/examples repository for detailed information
Example 1: Debugging Simple Native Code

• Agenda
  • How to debug a **simple R and C code** using FastR and GraalVM debugger
  • How to use **Visual Studio Code** and the **R plugin** to debug the code
  • How to use FastR’s **LLVM backend** to debug native code
  • How **FastR objects** are displayed when debugging **native code**
  • [https://youtu.be/xc9mS09B7Fk](https://youtu.be/xc9mS09B7Fk)
# Debugging Simple Native Code

### lapplyNative.c

```c
#include <R.h>
#include <Rdefines.h>

SEXP lapplyNative(SEXP list, SEXP fn, SEXP rho) {
    int n = length(list);
    SEXP R_fcall, ans;

    R_fcall = PROTECT(lang2(fn, R_NilValue));
    ans = PROTECT(allocVector(VECSXP, n));
    for(int i = 0; i < n; i++) {
        SETCAR(R_fcall, VECTOR_ELT(list, i));
        SET_VECTOR_ELТ(ans, i, eval(R_fcall, rho));
    }
    setAttrib(ans, R_NamesSymbol,
              getAttrib(list, R_NamesSymbol));
    UNPROTECT(2);
    return ans;
}
```

### lapplyNative.R

```r
lapplyNative <- function (x, fun, env = new.env()) {
    .Call("lapplyNative", x, fun, env)
}
```

### Source:

Debugger Activation in FastR

- Launch FastR with this additional argument
  - `--inspect` — activates the GraalVM debugger
Enable LLVM Debugging in FastR

- To debug native code, FastR must be instructed to use the LLVM version of shared libraries
  - The LLVM bitcode is bundled with a shared library during compilation
  - Native code is compiled by the GraalVM LLVM toolchain (clang)
  - The LLVM bitcode is interpreted just as another GraalVM language
- Use these LLVM-related additional arguments
  - `--R.BackEndLLVM` — to instruct FastR to use the LLVM version of libs
  - `--R.DebugLLVMLibs` — to enable debugging of the LLVM bitcode
Attaching Visual Studio Code to GraalVM Debugger

bash-3.2$ R --inspect --inspect.Suspend=false --R.BackEndLLVM --R.DebugLLVMLibs
Debugger listening on port 9229.
To start debugging, open the following URL in Chrome:

chrome-devtools://devtools/bundled/js_app.html?ws=127.0.0.1:9229/1fbc7af8-2f50632a8171

Note: The URL can be copied and pasted to Chrome to start debugging in DevTools
Debugging in Visual Studio Code

• Locate `lapplyNative.R` in VSC Explorer and toggle a breakpoint in the `lapplyNative` function

• Execute `lapplyNative` again
Debugging in Visual Studio Code

• Locate `lapplyNative.c`, toggle a breakpoint and press F5
Example 2: A Package With Rcpp Code

• Agenda
  • Debugging a package containing Rcpp code
  • Stepping into and debugging Rcpp functions

• Prerequisites
  • Rcpp 1.0.0 installed from the unpacked source tarball
    • R CMD INSTALL package-sources/Rcpp
  • The gibbs sampler example installed
    • R CMD INSTALL ./gibbs
    • http://adv-r.had.co.nz/Rcpp.html#rcpp-package by Hadley Wickham
Debugging Rcpp Code

- Launch FastR in debug mode
- Load the gibbs package and execute `gibbs_cpp(100, 10)`

```r
> library(gibbs)
> gibbs_cpp(10, 10)
   [,1]     [,2]
[1,] 0.4922806 0.9848679
[2,] 0.3332298 0.7986238
[3,] 0.1811279 2.3413093
[4,] 0.2363802 2.0305358
[5,] 0.6196257 0.8939006
[6,] 0.4226072 0.8424776
[7,] 0.4207100 0.2881861
[8,] 0.5958476 0.6877602
[9,] 0.3973855 1.0024997
[10,] 0.9245635 0.8350409
```
Debugging Rcpp Code (cont.)

• Switch to VSC and attach to the GraalVM debugger

• Locate gibbs/src/gibbs.cpp and toggle a breakpoint

Source: http://adv-r.had.co.nz/Rcpp.html#rcpp-package
Debugging Rcpp Code (cont.)

• Step into the \texttt{rgamma} Rcpp function (F11)
Conclusion

- FastR as part of GraalVM provides an advanced support for **mixed debugging** of **native** and **R** code
- **Visual Studio Code** provides a comfortable debugger UI that can be used in tandem with **FastR/GraalVM**

**TODO**
- Completeness of LLVM implementation
- Displaying “nativized” R objects (esp. Rcpp ones)
- A better source-paths management for packages installed from CRAN
Run Programs Faster Anywhere

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Website
http://www.graalvm.org/

Github Repository
https://github.com/oracle/graal
https://github.com/oracle/fastr
https://github.com/graalvm/examples

Stay Tuned
graalvm-announce@oss.oracle.com

Other Links

FastR overview:
https://medium.com/graalvm/faster-r-with-fastr-4b8db0e0dceb

GraalVM compatibility (can be used to check the status of a package):
http://www.graalvm.org/docs/reference-manual/compatibility/