Intro to Parallel Random Number Generation with RevoScaleR

Posted on June 6, 2013 by **Joseph Rickert** in Uncategorized | 0 Comments

by Joseph Rickert

Random number generation is fundamental to doing computational statistics. As you might expect, R is very rich in random number resources. The R base code provides several high quality random number generators including: Wichmann-Hill, Marsaglia-Multicarry, Super-Duper, Mersenne-Twister, Knuth-TAOCP-2002 and L'Ecuyer-CMRG. (See Random for details.) And, there are at least three packages, rspring, rlecuyer, and rstream for generating independent streams of random numbers in parallel. Independent streams are essential for parallel computations because even though small numbers of random draws done on different processors might show little correlation, as the the number of random draws approaches a significant fraction of the period length of the random number generator there are sure to be significant correlations among two or more streams.

High quality, independent, parallel random number streams are essential for doing statistical analyses with data sets having billions of observations. Random sampling, bootstrapping and ensemble techniques require generating independent random number streams in distributed environments. The RevoScaleR package in Revolution R Enterprise 6.2 handles this task by providing access to several of the parallel random number generators included in Intel's MKL Vector Statistical Library. RevoScaleR lets users select from among the following VSL random number generators:

- MCG31m1 – a 32-bit multiplicative congruential generator: fast and good for testing but the period length is not sufficient for working with big data
- R250 – a generalized feedback shift register generator: used commonly in physics applications but fails a number of tests.
- MRG32k3a – a combined multiple recursive generator: meets modern requirements for modern random number generators and is optimized for Intel architectures
- MCG59 – a 59 bit multiplicative congruential generator: implemented in the Numerical Algorithms Group, but quirky
- MT19937 – A Merseene Twiister with period length 2^19937

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- MT2203 – This set of 6024 random number generators provides mutual independence of the random number streams. It has a period length of 2^2203 and is the default generator for RevoScaleR's rxRngNewStream package
- SFMT19937 – is a Single Instruction Multiple Data Merseene Twister with a period length of (2^199370) – 1
- SOBOL – a quasi-random number generator
- NIEDERREITER – quasi-random number generator with excellent asymptotic properties

The following code shows how easily two independent random number streams can be generated with RevoScaleR's rxExec function. rxExec acts much like R's apply family of functions, but in a parallel or distributed computing environment. The first line tells the code underlying the RevoScaleR's parallel infrastructure to use 2 parallel workers. The second line "rxSetComputeContext("localpar)" instructs rxExec to use my laptop as the "compute" context. (If I had access to a cluster, either a Microsoft HPC cluster or a Linux LFS cluster this line of code would be a little more elaborate, but it would be the only line of code that would have to change to use a different, more powerful compute context.) The call to rxExec in line in line 20 instructs each core on my laptop generate a random number stream. The rest of the code performs some simple tests on resulting random number streams.

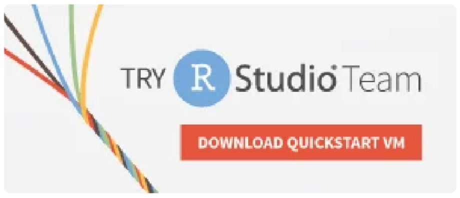
```
# Code for Random Numbers Blog Post
# Joseph Rickert
# Revolution Analytics
# June 2013
library(ggplot2)            # For plotting
#
#--------------------------------------------------------------------------
# Using the vectorized random number generators
# See the Intel Math Kernel Library, Vector Statistical Library Notes.
# http://software.intel.com/sites/products/documentation/doclib/mkl_sa/11/vslr
# for an explanation of the various random number generators
rkind = c("MCG31", "R250", "MRG32K3A", "MCG59", "MT19937", "MT2203", "SFMT1993

rxOptions(numCoresToUse=2)            # 2 cores on my Dell XPS, i7 laptop
rxSetComputeContext("localpar")           # Set the compute context to local
N <- 10000                  # Length of random number stream
# Generate random number stream
ranNums <- rxExec(runif, n = rxElemArg(c(N, N)), RNGkind = rkind[6])

ranNumsDF <- data.frame(ranNums)        # put the nmbers in a data frame
names(ranNumsDF) <- c("stream.1","stream.2")
length(unique(ranNumsDF$stream.1))
length(unique(ranNumsDF$stream.2))

cor(ranNumsDF)                    # Look at the correlation of the two streams
                         # See how the random numbers cover the plan
# If we were generating numbers from the Reals, then the
# differences of the sorted numbers we generate should be unique
uniqueDif <- function(x){
    # Function suggested by john.angell@csueastbay.edu
    x = sort(x)
    xu <- x[2:N] - x[1:N-1]
    len <- list(length(xu),length(unique(xu)))
    return(len)
    }
uniqueDif(ranNumsDF$stream.1)
uniqueDif(ranNumsDF$stream.2)
# Look at a scatter plot of the random number streams
ggplot(ranNumsDF, aes(x=stream.1, y=stream.2)) +
    geom_point(shape=1,colour="red") +     # Use hollow circles
    geom_smooth() +             # Add a loess smoothed fit curve with confidence
    ggtitle("Two Random Number Streams with Loess Estimator")
```

Both streams contain 10,000 unique numbers. The correlation matrix shows very little correlation between the two streams.



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```
           stream.1    stream.2
stream.1 1.000000000 0.002468557
stream.2 0.002468557 1.000000000
```

The unique difference test, which was brought to my attention by John Angell of Cal State East Bay, is very interesting. If we were actually dealing with random Real numbers then we would expect the differences between adjacent numbers in a sorted list to be unique. However, even with high quality random number generators we must live with the reality of finite precision arithmetic.

```
uniqueDif(ranNumsDF$stream.1)
#[[1]]
#[1] 9999
#
#[[2]]
#[1] 9952
```

Finally, a scatter plot shows good coverage of the plane.

But, if you really want to put random number generators through their paces look at the diehard site and have a go at the tests in the RDieHarder package.

This post presents just the very basics. In future posts, I hope to show some parallel random number applications and results from running them on clusters.

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