Fast automatic indexing with data.table

R/Finance, Chicago

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H_2O.ai
Machine Intelligence

Yesterday

Thomas to me:

“dplyr has completely killed off data.table”

I've tilted this presentation to address this.

1964

U.S. Supreme Court Justice Stewart :

“I can't define it but I know it when I see it.” **(paraphrased)**

data.table users know they need data.table

https://github.com/Rdatatable/data.table/wiki

fast **aggregation** of large data; e.g. 100GB in RAM (see benchmarks on up to two billion rows)

fast **ordered joins**; e.g. rolling forwards, backwards, nearest and limited staleness

fast **overlapping range joins**; e.g. GenomicRanges

fast add/modify/delete of columns **by reference** by group using no copies at all

cells may themselves contain vectors/objects/functions; i.e. **columns of type list**

fast and friendly file reader: **fread**

+ research into production (e.g. daily or intra-day) with no code changes
+ or might in future
+ brief syntax to prevent code bloat; e.g. do anything in j
+ optimization of combined [where, select|update, by]

```
> DT    # 1.5GB
         id val
1e+00: BAR   5
2e+00: FOO   1
3e+00: REW   4
4e+00: NUR   5
5e+00: AMW   3
   ---
1e+08: QNP   1
1e+08: HXB   2
1e+08: FOO   1
1e+08: CYY   2
1e+08: VKG   1
```

```
> DT[id=="FOO",]
        id val
   1: OSK   1
   2: OSK   3
  ---
5813: OSK   5
5814: OSK   1

   user  system elapsed
  1.928   0.064   1.991

> DT[id=="BAR",]

   user  system elapsed
  0.000   0.000   0.001

> DT[id %in% c("FOO","BAR"),]

   user  system elapsed
  0.000   0.000   0.001
```

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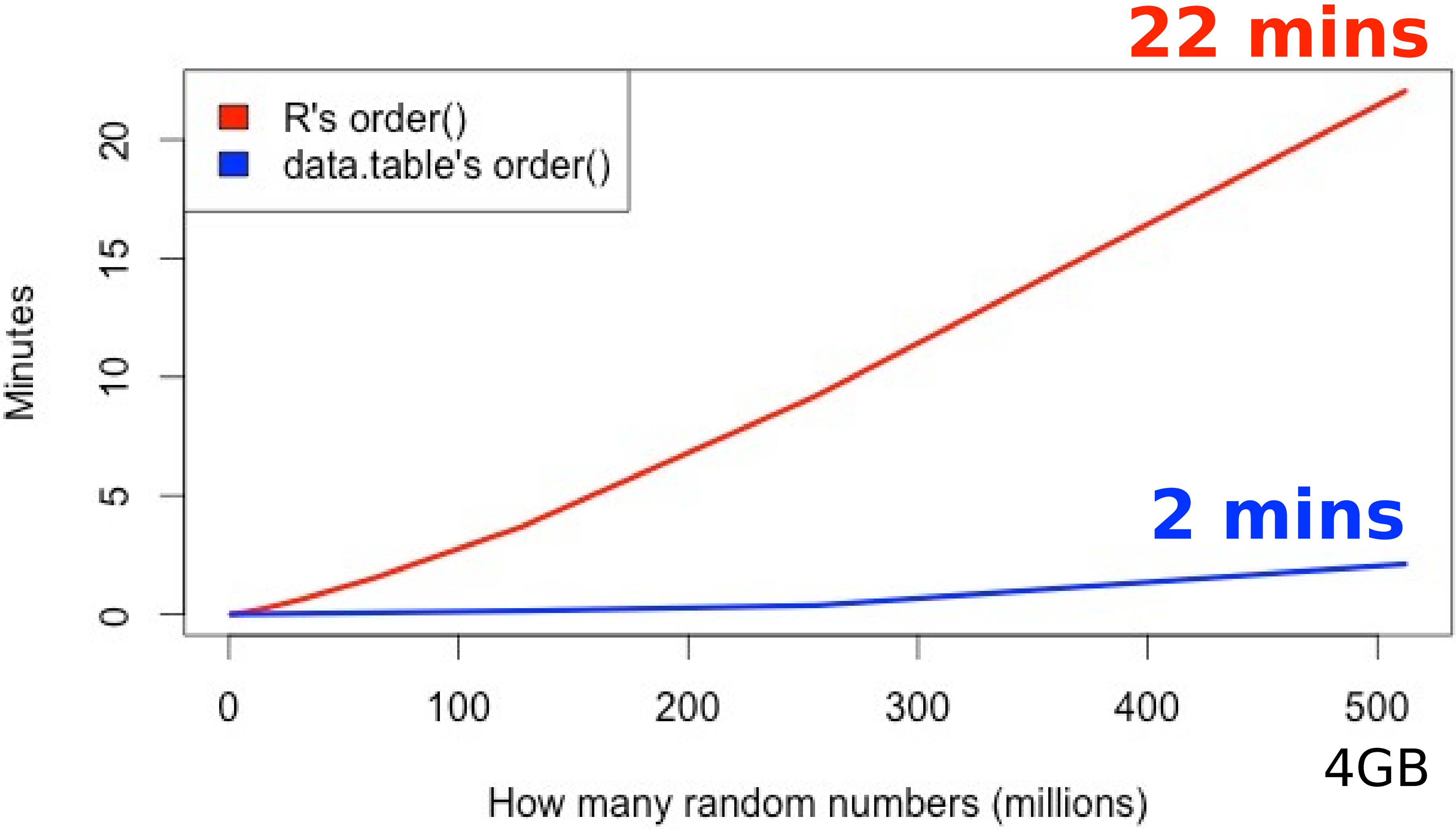
```
> options(datatable.verbose=TRUE)
> DT[id=="FOO",]
creating new index 'id'
forder took 1.932 sec
Starting bmerge ...done in 0.00 secs

> DT[id=="BAR",]
using existing index 'id'
Starting bmerge ...done in 0.00 secs
```

```
> DF %>% filter(id=="FOO")
   user  system elapsed
  1.952   0.020   1.970
> DF %>% filter(id=="FOO")
   user  system elapsed
  1.940   0.012   1.949


> DF[DF$id=="FOO", ]
   user  system elapsed
  2.244   0.124   2.367
> DF[DF$id=="FOO", ]
   user  system elapsed
  2.260   0.112   2.369
```

```
> DT %>% filter(id=="FOO")  # v0.3.0.2
                            # Oct 2014
using existing index 'id'
Starting bmerge ...done in 0 secs
   user  system elapsed
  0.000   0.000   0.001

> DT %>% filter(id=="FOO")  # v0.4.0
                            # Jan 2015
  user  system elapsed
  1.952   0.020   1.982
```



22 mins

2 mins

4GB

MacBook Pro 2.8GHz Intel Core i7 16GB
R 3.1.3 data.table 1.9.4

References

Terdiman, 2000

http://codercorner.com/RadixSortRevisited.htm

Herf, 2001

http://stereopsis.com/radix.html

Arun Srinivasan implemented forder() in data.table entirely in C for integer, character and double

Matt Dowle changed from LSD (backwards) to MSD (forwards)

Pros

- Index storage is small and fixed: nrow * 4|8 bytes
- No collisions in hash table (no hash table)
- Building new indexes may be able to reuse existing indexes
- Rolling joins and overlapping range joins

Cons

- Insert and delete of rows requires memmove
- Binary search vs direct hash table lookup (note though collisions)

H2O

Machine learning e.g. Deep Learning (GBM)

In-memory, parallel and distributed

1. Data >> 250GB needle-in-haystack e.g. fraud

2. Data < 250GB compute intensive, in parallel on 1000 cores

3. Data < 250GB but where feature engineering > 250GB

Speed for production

Open source on GitHub, liberal Apache license

Install H2O

```
$ sudo add-apt-repository -y ppa:webupd8team/java
$ sudo apt-get update
$ sudo apt-get -y install oracle-java8-installer
$ sudo apt-get -y install oracle-java8-set-default
$ java -version

$ R
> install.packages(“h2o”)
```

Start H2O

```
> require(h2o)

> h2oServer <- h2o.init()

H2O is not running yet, starting it now...

Successfully connected to http://127.0.0.1:54321

R is connected to H2O cluster:

    H2O cluster uptime:         1 sec 397 ms

    H2O cluster version:        2.8.4.4

    H2O cluster total nodes:    1

    H2O cluster total memory:   26.67 GB

    H2O cluster total cores:    32
```

h2o.importFile

- 23GB .csv, 9 columns, 500e6 rows

```
> system.time(DF <- h2o.importFile(h2oServer, path
= "/dev/shm/test.csv"))
```

```
   user  system elapsed
  0.775   0.058  50.559
```

```
> head(DF)
    id1   id2         id3 id4 id5  id6 v1 v2      v3
1 id076 id035 id0000003459  20  80 8969  4  3 43.1525
2 id062 id023 id0000002848  99  49 7520  5  2 86.9519
3 id001 id052 id0000007074  89  16 8183  1  3 19.6696
```

```
h2o.importFile                            # 50 sec

require(data.table)
fread("/dev/shm/test.csv")                # 290 sec

require(readr)
read_csv(“/dev/shm/test.csv”)             # 720 sec
```

Why not 30x?

- Maybe IO bound but this test.csv was on ramdisk /dev/shm
- H2O compresses the data in RAM
- Profiles the data while reading e.g. min and max per column, for later efficiency gains.

Thank you

https://github.com/Rdatatable/data.table/wiki

http://h2o.ai/product