THE #RDATATABLE PACKAGE

+ new developments in v1.9.7

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SEP 3'16, BUDAPEST

@ARUN_SRINIV

WHO AM I?

- Bioinformatician / Comp. Biologist
- data.table user, co-developer since late 2013
- Previous: Data scientist @Open Analytics
- Future: Lead engineer @investment mgmt. firm

MOST UNDERRATED PACKAGE

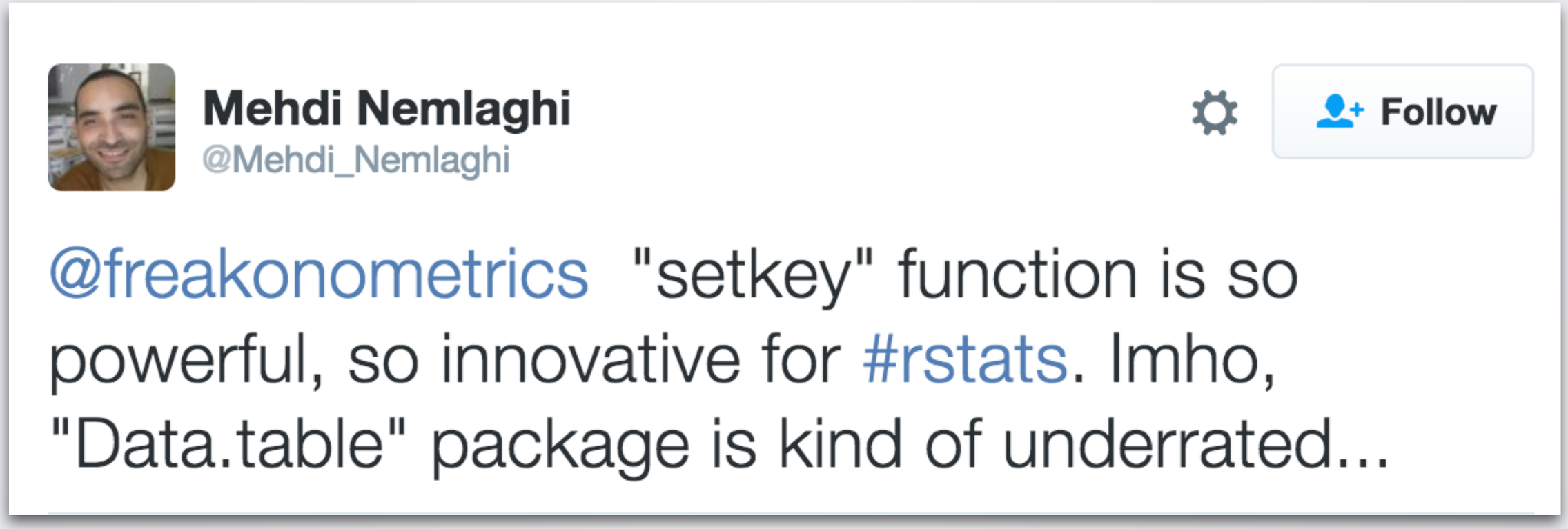
Conor Nash
@conornash

Follow

Data.table is the most underrated R package. It has saved me *days* in waiting for analyses to complete.

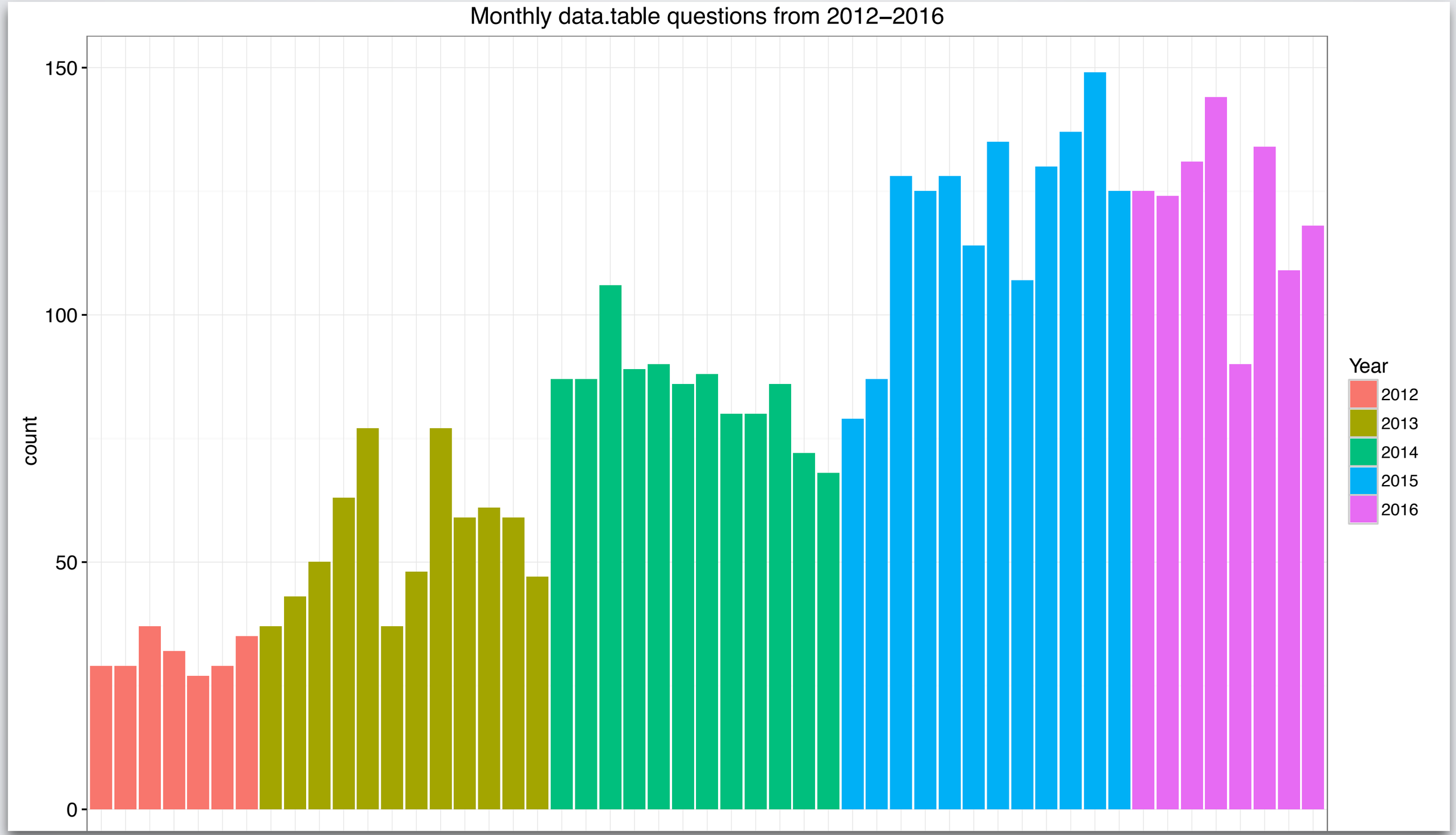
August 2016

MOST UNDERRATED PACKAGE



May 2015

- Homepage: http://r-datatable.com
- Since 2006 on CRAN, >30 releases so far
- >5500 unit tests, ~89% coverage (using covr)
- >260 packages import/depend/suggest data.table
  - ~12.6 packages per month since Sep'15
- 8th most starred R package on Github (METACRAN)
- >4400 Q on StackOverflow. 3rd amongst R packages


Monthly data.table questions from 2012–2016
150
100
50
0
count
Year
2012
2013
2014
2015
2016

POWERFUL

Alexander Flyax
@aflyax

Follow

somebody should just write a version of #Rstat's data.table for #python. end of story. nothing as powerful exists at the moment.

(With no intent on fuelling language wars)

GREAT SADNESS

Jim Savage
@khakieconomist

Follow

With great sadness I was forced to start using data.table today.

DATA.TABLE DATA.TABLE DATA.TABLE

Joey Reid
@JoeyPReid

Follow

data.table
data.table
data.table
data.table
ggplot2
rstan
knitr

#7FavPackages

TALK OVERVIEW

- data.table's philosophy
  - concise + straightforward code
  - fast + memory efficient
- New features and improvements in v1.9.7
  - fwrite, conditional joins, parallel sort & other optimisations

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DATA FRAMES

- are columnar data structures

X

	id	val
1	b	4
2	a	2
3	a	3
4	c	1
5	c	5
6	b	6

2 column data.frame

DATA FRAMES

- are columnar data structures
  - 2D — rows and columns

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- subset rows — X[X$id != “a”,]

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  - 2D — rows and columns
- subset rows — X[X$id != “a”,]
- select columns — X[, “val”]
- subset rows & select columns — X[X$id != “a”, “val”]
- that’s pretty much it…

X

	id	val
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1. HOW TO COMPUTE ON COLUMNS?

DF

	id	code	valA	valB
1	1	abc	0.1	11
2	1	abc	0.6	7
3	1	abd	1.5	5
4	2	apq	0.9	10
5	2	apq	0.3	13

For code != “abd”,
get sum(valA)

1.9

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```
sum(DF[DF$code != “abd”, “valA”])
```

1.9

2. GROUPED AGGREGATE

DF

	id	code	valA	valB
1	1	abc	0.1	11
2	1	abc	0.6	7
3	1	abd	1.5	5
4	2	apq	0.9	10
5	2	apq	0.3	13

For code != “abd”,
get sum(valA) and sum(valB)
for each id

	id	valA	valB
1	1	0.7	18
2	2	1.2	23

2. GROUPED AGGREGATE

DF

	id	code	valA	valB
1	1	abc	0.1	11
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```
aggregate(cbind(valA, valB) ~ id,
          DF[DF$code != "abd", ],
          sum)
```

	id	valA	valB
1	1	0.7	18
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3. SIMPLE UPDATE

DF

	id	code	valA	valB
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For code == “abd”,
update valA
with NA

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3. SIMPLE UPDATE

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4	2	apq	0.9	10
5	2	apq	0.3	13

```
DF[DF$code == "abd", "valA"] <- NA
```

CAN WE BE MORE CONSISTENT?

```
sum(DF[DF$code != “abd”, “valA”])
```

How to get *sum* of both *valA* and *valB*?
Or *sum* of *valA* and *valB* combined?

```
aggregate(cbind(valA, valB) ~ id,
          DF[DF$code != “abd”, ],
          sum)
```

New function. Formula interface.
Unwanted columns are subsetted.
How to get sum(valA) and mean(valB)?

```
DF[DF$code == “abd”, “valA”] <- NA
```

Entire expression is now to the left
of the “<-“ operator

ENHANCED DATA FRAMES

- Three main enhancements:
  1. Allow column names to be seen as variables within [...]
  2. Since they're variables, we can do computations on them directly, i.e, within [...]
  3. Additional argument by

DATA TABLES

- are columnar data structures as well

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2 column data.table

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DATA TABLES

- are columnar data structures as well
  - 2D — rows and columns
- subset rows — X[id != “a”,]
- select columns — X[, val]

X

	id	val
1:	b	4
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DATA TABLES

- are columnar data structures as well
  - 2D — rows and columns
- subset rows — X[id != “a”,]
- select columns — X[, val]
- *compute on* columns — X[, mean(val)]

X

	id	val
1:	b	4
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3:	a	3
4:	c	1
5:	c	5
6:	b	6

mean
3.5

DATA TABLES

- are columnar data structures as well
  - 2D — rows and columns
- subset rows — X[id != “a”,]
- select columns — X[, val]
- *compute on* columns — X[, mean(val)]
- subset rows & select / *compute on* columns — X[id != “a”, mean(val)]

X

	id	val
1:	b	4
2:	a	2
3:	a	3
4:	c	1
5:	c	5
6:	b	6

mean
4.0

DATA TABLES

- are columnar data structures as well
  - 2D — rows and columns
- subset rows — X[id != “a”,]
- select columns — X[, val]
- *compute on* columns — X[, mean(val)]
- subset rows & select / *compute on* columns — X[id != “a”, mean(val)]
- *virtual* 3rd dimension — group by

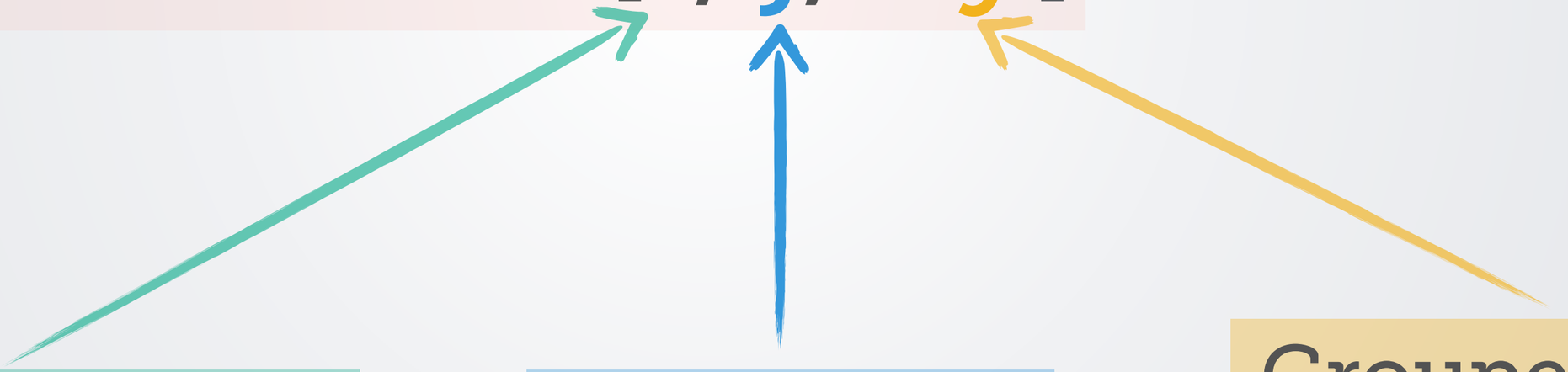
X

	id	val
1:	b	4
2:	a	2
3:	a	3
4:	c	1
5:	c	5
6:	b	6

DATA TABLES

- think in terms of basic units — rows, columns and groups
- data.table syntax provides *placeholder* for each of them

General form: DT[i, j, by]



On which rows

What to do?

Grouped by what?

EQUIVALENT DATA TABLE CODE

```
sum(DF[DF$code != “abd”, “valA”])
```

```
DT[code != “abd”, sum(valA)]
```

```
aggregate(cbind(valA, valB) ~ id,
          DF[DF$code != “abd”, ],
          sum)
```

```
DT[code != “abd”,
   .(sum(valA), sum(valB)),
   by = id]
```

```
DF[DF$code == “abd”, “valA”] <- NA
```

```
DT[code == “abd”, valA := NA]
```

TWO TABLES

A

	id	code	valA	valB
1:	1	abc	0.1	11
2:	1	abc	0.6	7
3:	1	abd	1.5	5
4:	2	apq	0.9	10
5:	2	apq	0.3	13

B

	id	code	mul
1:	1	abd	2.0
2:	2	apq	0.5
3:	3	abc	1.7

Update valA with valA*mul while matching on id, code

TWO TABLES

A

	id	code	valA	valB
1:	1	abc	0.1	11
2:	1	abc	0.6	7
3:	1	abd	1.5	5
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5:	2	apq	0.3	13

B

	id	code	mul
1:	1	abd	2.0
2:	2	apq	0.5
3:	3	abc	1.7

Update valA with valA*mul while matching on id, code

```
A[B, on = .(id, code),
    valA := valA * mul]
```

on which rows?
what to do?

TWO TABLES

A

	id	code	valA	valB
1:	1	abc	0.1	11
2:	1	abc	0.6	7
3:	1	abd	3.0	5
4:	2	apq	0.45	10
5:	2	apq	0.15	13

B

	id	code	mul
1:	1	abd	2.0
2:	2	apq	0.5
3:	3	abc	1.7

Update valA with valA*mul while matching on id, code

```
A[B, on = .(id, code),
    valA := valA * mul]
```

on which rows?
what to do?

TALK OVERVIEW

- data.table's philosophy
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  - fwrite, conditional joins, parallel sort & other optimisations

FWRITE - PARALLEL FILE WRITER

		Laptop SSD 4core/16gb 10m rows		Server 32core/256gb 100m rows		
		Time Sec	Size GB	RamDisk Time	HDD Time	Size GB
`fwrite(DT,"fwrite.csv")`	csv	2	0.8	9	61	7.5
`write_feather(DT, "feather.bin")`	bin	5	1.0	27	75	9.1
`save(DT,file="save1.Rdata",compress=F)`	bin	11	1.2	90	137	12.0
`save(DT,file="save2.Rdata",compress=T)`	bin	70	0.4	647	679	2.8
`write.csv(DT,"write.csv.csv",**)`	csv	63	0.8	749	824	7.3
`readr::write_csv(DT,"write_csv.csv")`	csv	132	0.8	1997	1571	7.3

[**] row.names=F,quote=F

SOURCE: http://blog.h2o.ai/2016/04/fast-csv-writing-for-r/

FSORT - PARALLEL SORT

length	size in RAM	threads	base R	v1.9.7
500m	3.8GB	8	65s	3.9s
1b	7.6GB	32	140m	3.5s
10b	76GB	32	25m	48s

SOURCE: https://www.r-project.org/dsc/2016/slides/ParallelSort.pdf

PARALLEL ROW SUBSETS

DT[sample(.N, .N/2)] 200e6 rows, 4 cols~4.6GB	
v1.9.6	20.0s
v1.9.7 (C, parallelised)	3.6s (16 threads)
	run time

%BETWEEN%

x %between% c(2000, 20000) length(x) = 500e6, int, ~1.9GB		
v1.9.6	15.7s	7.2GB
v1.9.7 (C, parallelised)	1.1s (4 threads)	3.8GB
	run time	peak memory

MEDIAN

1e6 rows, 61 columns, ~460MB
10,000 unique groups

```
7  # v1.9.6, CRAN version
8  ans1 <- dt[, lapply(.SD, median), by=x]
9  #    user  system elapsed
10 #  19.610   0.229  19.917
11
12 # v1.9.7, devel
13 # median is internally optimised
14 ans2 <- dt[, lapply(.SD, median), by=x]
15 #    user  system elapsed
16 #   1.195   0.007   1.207
17
18 # = 16.5x speedup.
```

CONDITIONAL OPERATIONS

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	id	code	valA	valB
1:	1	abc	0.1	11
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B

	id	begin	end
1:	1	0.1	0.9
2:	2	0.6	0.8

Update valB with NA while matching on id, valA > begin, valA < end

CONDITIONAL OPERATIONS

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	id	code	valA	valB
1:	1	abc	0.1	11
2:	1	abc	0.6	NA
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	id	begin	end
1:	1	0.1	0.9
2:	2	0.6	0.8

Update valB with NA while matching on id, valA > begin, valA < end

```
A[B, on = .(id, valA>begin, valA<end),
    valB := NA]
```

SUMMARY AND FUTURE DIRECTIONS

- data.table allows for *concise* and *straightforward* code, and is *fast* and *memory efficient*
- More efforts towards parallelisation in future
- File backed data.tables would be great feature to have soon, #1336
- Give data.table a go :-)

Thank you for
your attention!

Questions?