

Introduction to rsolr

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1 Introduction

The `rsolr` package provides an idiomatic (R-like) and extensible interface between R and Solr, a search engine and database. Like an onion, the interface consists of several layers, along a gradient of abstraction, so that simple problems are solved simply, while more complex problems may require some peeling and perhaps tears. The interface is idiomatic, syntactically but also in terms of *intent*. While Solr provides a search-oriented interface, we recognize it as a document-oriented database. While not entirely schemaless, its schema is extremely flexible, which makes Solr an effective database for prototyping and adhoc analysis. R is designed for manipulating data, so `rsolr` maps common R data manipulation verbs to the Solr database and its (limited) support for analytics. In other words, `rsolr` is for analysis, not

search, which has presented some fun challenges in design. Hopefully it is useful — we had not tried it until writing this document.

We have interfaced with all of the Solr features that are relevant to data analysis, with the aim of implementing many of the fundamental data munging operations. Those operations are listed in the table below, along with how we have mapped those operations to existing and well-known functions in the base R API, with some important extensions. When called on `rsolr` data structures, those functions should behave analogously to the existing implementations for `data.frame`. Note that more complex operations, such as joining and reshaping tables, are best left to more sophisticated frameworks, and we encourage others to implement our extended base R API on top of such systems. After all, Solr is a search engine. Give it a break.

Operation	R function
Filtering	<code>subset</code>
Transformation	<code>transform</code>
Sorting	<code>sort</code>
Aggregation	<code>aggregate</code>

2 Demonstration: `nycflights13`

2.1 The Dataset

As part demonstration and part proof of concept, we will attempt to follow the introductory workflow from the `dplyr` vignette. The dataset describes all of the airline flights departing New York City in 2013. It is provided by the `nycflights13` package, so please see its documentation for more details.

```
library(nycflights13)
dim(flights)

## [1] 336776    19

head(flights)

## # A tibble: 6 x 19
##   year month   day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##   <int> <int> <int> <int>         <int>         <int>     <dbl>     <int>         <int>
## 1  2013     1     1     517           515             2         830           819
## 2  2013     1     1     533           529             4         850           830
## 3  2013     1     1     542           540             2         923           850
```

```
## 4 2013      1      1      544          545          -1      1004          1022
## 5 2013      1      1      554          600          -6       812           837
## 6 2013      1      1      554          558          -4       740           728
## # i 11 more variables: arr_delay <dbl>, carrier <chr>, flight <int>,
## #   tailnum <chr>, origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>,
## #   hour <dbl>, minute <dbl>, time_hour <dtm>
```

2.2 Populating a Solr core

The first step is getting the data into a Solr *core*, which is what Solr calls a database. This involves writing a schema in XML, installing and configuring Solr, launching the server, and populating the core with the actual data. Our expectation is that most use cases of `rsolr` will involve accessing an existing, centrally deployed, usually read-only Solr instance, so those are typically not major concerns. However, to conveniently demonstrate the software, we need to violate all of those assumptions. Luckily, we have managed to embed an example Solr installation within `rsolr`. We also provide a mechanism for autogenerating a Solr schema from a `data.frame`. This could be useful in practice for producing a template schema that can be tweaked and deployed in shared Solr installations. Taken together, the process turns out to not be very intimidating.

We begin by generating the schema and starting the demo Solr instance. Note that this instance is really only meant for demonstrations. You should not abuse it like the people abused the poor built-in R HTTP daemon.

```
library(rsolr)

## Loading required package: BiocGenerics
## Loading required package: generics
##
## Attaching package: 'generics'
## The following objects are masked from 'package:base':
##
##   as.difftime, as.factor, as.ordered, intersect, is.element,
##   setdiff,
##   setequal, union
##
## Attaching package: 'BiocGenerics'
```

```

## The following objects are masked from 'package:stats':
##
##   IQR, mad, sd, var, xtabs
## The following objects are masked from 'package:base':
##
##   anyDuplicated, aperm, append, as.data.frame, basename, cbind,
##   colnames, dirname, do.call, duplicated, eval, evalq, Filter,
Find,
##   get, grep, grepl, is.unsorted, lapply, Map, mapply, match,
mget,
##   order, paste, pmax, pmax.int, pmin, pmin.int, Position, rank,
##   rbind, Reduce, rownames, sapply, saveRDS, table, tapply,
unique,
##   unsplit, which.max, which.min
##
## Attaching package: 'rsolr'
## The following object is masked from 'package:stats':
##
##   ftable
## The following object is masked from 'package:base':
##
##   grouping

schema <- deriveSolrSchema(flights)
solr <- TestSolr(schema)

## Starting Solr...
## Use options(verbose=TRUE) to diagnose any problems.
## Solr not found
## Solr installation not found, installing...
## Solr started at: http://localhost:8983/solr/flights

```

Next, we need to populate the core with our data. This requires a way to interact with the core from R. `rsolr` provides direct access to cores, as well as two high-level interfaces that represent a dataset derived from a core (rather than the core itself). The two interfaces each correspond to a particular shape of data. `SolrList` behaves like a list, while `SolrFrame` behaves like a table (data frame). `SolrList` is useful for when the data are ragged, as is often the case for data stored in Solr. The Solr schema is so dynamic that we could trivially define a schema with a virtually infinite

number of fields, and each document could have its own unique set of fields. However, since our data are tabular, we will use *SolrFrame* for this exercise.

```
sr <- SolrFrame(solr$uri)
```

Finally, we load our data into the Solr dataset:

```
sr[] <- flights
```

This takes a while, since Solr has to generate all sorts of indices, etc.

As *SolrFrame* behaves much like a base R data frame, we can retrieve the dimensions and look at the head of the dataset:

```
dim(sr)
## [1] 336776    19

head(sr)
## DocDataFrame (6x19)
##   year month day dep_time sched_dep_time dep_delay arr_time sched_arr_time
## 1 2013     1  1     517           515         2      830           819
## 2 2013     1  1     533           529         4      850           830
## 3 2013     1  1     542           540         2      923           850
## 4 2013     1  1     544           545        -1     1004          1022
## 5 2013     1  1     554           600        -6      812           837
## 6 2013     1  1     554           558        -4      740           728
##   arr_delay carrier flight tailnum origin dest air_time distance hour minute
## 1         11      UA   1545 N14228   EWR  IAH     227     1400     5     15
## 2         20      UA   1714 N24211   LGA  IAH     227     1416     5     29
## 3         33      AA   1141 N619AA   JFK  MIA     160     1089     5     40
## 4        -18      B6    725 N804JB   JFK  BQN     183     1576     5     45
## 5        -25      DL    461 N668DN   LGA  ATL     116      762     6      0
## 6         12      UA   1696 N39463   EWR  ORD     150      719     5     58
##
##           time_hour
## 1 2013-01-01 10:00:00
## 2 2013-01-01 10:00:00
## 3 2013-01-01 10:00:00
## 4 2013-01-01 10:00:00
## 5 2013-01-01 11:00:00
## 6 2013-01-01 10:00:00
```

Comparing the output above the that of the earlier call to `head(flights)` reveals that the data are virtually identical. As Solr is just a search engine (on steroids), a significant amount of engineering was required to achieve that result.

2.3 Restricting by row

The simplest operation is filtering the data, i.e., restricting it to a subset of interest. Even a search engine should be good at that. Below, we use `subset` to restrict to the flights to those departing on January 1 (2013).

```
subset(sr, month == 1 & day == 1)

## 'flights' (ndoc:842, nfield:19)
##   year month day dep_time sched_dep_time dep_delay arr_time sched_arr_time
## 1 2013     1  1     517           515           2      830           819
## 2 2013     1  1     533           529           4      850           830
## 3 2013     1  1     542           540           2      923           850
## 4 2013     1  1     544           545          -1     1004          1022
## 5 2013     1  1     554           600          -6      812           837
## ...     ...     ...     ...           ...           ...     ...           ...
## 838 2013     1  1    2356          2359          -3      425           437
## 839 2013     1  1    <NA>          1630         <NA>    <NA>          1815
## 840 2013     1  1    <NA>          1935         <NA>    <NA>          2240
## 841 2013     1  1    <NA>          1500         <NA>    <NA>          1825
## 842 2013     1  1    <NA>           600         <NA>    <NA>           901
##   arr_delay carrier flight tailnum origin dest air_time distance hour minute
## 1         11      UA   1545 N14228  EWR  IAH     227     1400     5     15
## 2         20      UA   1714 N24211  LGA  IAH     227     1416     5     29
## 3         33      AA   1141 N619AA  JFK  MIA     160     1089     5     40
## 4        -18      B6    725 N804JB  JFK  BQN     183     1576     5     45
## 5        -25      DL    461 N668DN  LGA  ATL     116       762     6      0
## ...     ...     ...     ...     ...     ...     ...     ...     ...     ...
## 838        -12      B6    727 N588JB  JFK  BQN     186     1576    23     59
## 839    <NA>      EV   4308 N18120  EWR  RDU    <NA>       416    16     30
## 840    <NA>      AA    791 N3EHAA  LGA  DFW    <NA>     1389    19     35
## 841    <NA>      AA   1925 N3EVAA  LGA  MIA    <NA>     1096    15      0
## 842    <NA>      B6    125 N618JB  JFK  FLL    <NA>     1069     6      0
##                                     time_hour
## 1 2013-01-01 10:00:00
```

```

## 2 2013-01-01 10:00:00
## 3 2013-01-01 10:00:00
## 4 2013-01-01 10:00:00
## 5 2013-01-01 11:00:00
## ...
## 838 2013-01-02 04:00:00
## 839 2013-01-01 21:00:00
## 840 2013-01-02 00:00:00
## 841 2013-01-01 20:00:00
## 842 2013-01-01 11:00:00

```

Note how the records at the bottom contain missing values. Solr does not provide any facilities for missing value representation, but we mimic it by excluding those fields from those documents.

We can also extract ranges of data using the canonical `window()` function:

```

window(sr, start=1L, end=10L)

## DocDataFrame (10x19)
##   year month day dep_time sched_dep_time dep_delay arr_time sched_arr_time
## 1 2013     1  1     517           515           2      830           819
## 2 2013     1  1     533           529           4      850           830
## 3 2013     1  1     542           540           2      923           850
## 4 2013     1  1     544           545          -1     1004          1022
## 5 2013     1  1     554           600          -6      812           837
## 6 2013     1  1     554           558          -4      740           728
## 7 2013     1  1     555           600          -5      913           854
## 8 2013     1  1     557           600          -3      709           723
## 9 2013     1  1     557           600          -3      838           846
## 10 2013     1  1     558           600          -2      753           745
##   arr_delay carrier flight tailnum origin dest air_time distance hour minute
## 1         11      UA   1545  N14228  EWR  IAH     227     1400    5     15
## 2         20      UA   1714  N24211  LGA  IAH     227     1416    5     29
## 3         33      AA   1141  N619AA  JFK  MIA     160     1089    5     40
## 4        -18      B6    725  N804JB  JFK  BQN     183     1576    5     45
## 5        -25      DL    461  N668DN  LGA  ATL     116      762    6      0
## 6         12      UA   1696  N39463  EWR  ORD     150      719    5     58
## 7         19      B6    507  N516JB  EWR  FLL     158     1065    6      0
## 8        -14      EV   5708  N829AS  LGA  IAD      53      229    6      0

```

```

## 9      -8      B6      79 N593JB      JFK MCO      140      944      6      0
## 10     8      AA      301 N3ALAA      LGA ORD      138      733      6      0
##
##           time_hour
## 1 2013-01-01 10:00:00
## 2 2013-01-01 10:00:00
## 3 2013-01-01 10:00:00
## 4 2013-01-01 10:00:00
## 5 2013-01-01 11:00:00
## 6 2013-01-01 10:00:00
## 7 2013-01-01 11:00:00
## 8 2013-01-01 11:00:00
## 9 2013-01-01 11:00:00
## 10 2013-01-01 11:00:00

```

Or, as we have already seen, the more convenient:

```

head(sr, 10L)

## DocDataFrame (10x19)
##   year month day dep_time sched_dep_time dep_delay arr_time sched_arr_time
## 1 2013     1  1     517           515         2      830           819
## 2 2013     1  1     533           529         4      850           830
## 3 2013     1  1     542           540         2      923           850
## 4 2013     1  1     544           545        -1     1004          1022
## 5 2013     1  1     554           600        -6      812           837
## 6 2013     1  1     554           558        -4      740           728
## 7 2013     1  1     555           600        -5      913           854
## 8 2013     1  1     557           600        -3      709           723
## 9 2013     1  1     557           600        -3      838           846
## 10 2013     1  1     558           600        -2      753           745
##   arr_delay carrier flight tailnum origin dest air_time distance hour minute
## 1         11      UA   1545 N14228  EWR  IAH     227     1400    5     15
## 2         20      UA   1714 N24211  LGA  IAH     227     1416    5     29
## 3         33      AA   1141 N619AA  JFK  MIA     160     1089    5     40
## 4        -18      B6    725 N804JB  JFK  BQN     183     1576    5     45
## 5        -25      DL    461 N668DN  LGA  ATL     116      762    6      0
## 6         12      UA   1696 N39463  EWR  ORD     150      719    5     58
## 7         19      B6    507 N516JB  EWR  FLL     158     1065    6      0
## 8        -14      EV   5708 N829AS  LGA  IAD      53      229    6      0
## 9         -8      B6     79 N593JB  JFK  MCO     140      944    6      0

```

```

## 10      8      AA      301 N3ALAA      LGA  ORD      138      733      6      0
##           time_hour
## 1 2013-01-01 10:00:00
## 2 2013-01-01 10:00:00
## 3 2013-01-01 10:00:00
## 4 2013-01-01 10:00:00
## 5 2013-01-01 11:00:00
## 6 2013-01-01 10:00:00
## 7 2013-01-01 11:00:00
## 8 2013-01-01 11:00:00
## 9 2013-01-01 11:00:00
## 10 2013-01-01 11:00:00

```

We could also call : to generate a contiguous sequence:

```

sr[1:10,]

## 'flights' (ndoc:10, nfield:19)
##   year month day dep_time sched_dep_time dep_delay arr_time sched_arr_time
## 1 2013     1   1     517         515           2     830           819
## 2 2013     1   1     533         529           4     850           830
## 3 2013     1   1     542         540           2     923           850
## 4 2013     1   1     544         545          -1    1004          1022
## 5 2013     1   1     554         600          -6     812           837
## 6 2013     1   1     554         558          -4     740           728
## 7 2013     1   1     555         600          -5     913           854
## 8 2013     1   1     557         600          -3     709           723
## 9 2013     1   1     557         600          -3     838           846
## 10 2013     1   1     558         600          -2     753           745
##   arr_delay carrier flight tailnum origin dest air_time distance hour minute
## 1         11      UA   1545 N14228  EWR  IAH     227      1400     5     15
## 2         20      UA   1714 N24211  LGA  IAH     227      1416     5     29
## 3         33      AA   1141 N619AA  JFK  MIA     160      1089     5     40
## 4        -18      B6    725 N804JB  JFK  BQN     183      1576     5     45
## 5        -25      DL    461 N668DN  LGA  ATL     116       762     6      0
## 6         12      UA   1696 N39463  EWR  ORD     150       719     5     58
## 7         19      B6    507 N516JB  EWR  FLL     158      1065     6      0
## 8        -14      EV   5708 N829AS  LGA  IAD      53       229     6      0
## 9         -8      B6     79 N593JB  JFK  MCO     140       944     6      0
## 10         8      AA   301 N3ALAA  LGA  ORD     138       733     6      0

```

```
##           time_hour
##  1 2013-01-01 10:00:00
##  2 2013-01-01 10:00:00
##  3 2013-01-01 10:00:00
##  4 2013-01-01 10:00:00
##  5 2013-01-01 11:00:00
##  6 2013-01-01 10:00:00
##  7 2013-01-01 11:00:00
##  8 2013-01-01 11:00:00
##  9 2013-01-01 11:00:00
## 10 2013-01-01 11:00:00
```

Unfortunately, it is generally infeasible to randomly access Solr records by index, because numeric indexing is a foreign concept to a search engine. Solr does however support retrieval by a key that has a unique value for each document. These data lack such a key, but it is easy to add one and indicate as such to `deriveSolrSchema()`.

2.4 Sorting

To sort the data, we just call `sort()` and describe the order by passing a formula via the `by` argument. For example, we sort by year, breaking ties with month, then day:

```
sort(sr, by = ~ year + month + day)

## 'flights' (ndoc:336776, nfield:19)
##      year month day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##  1 2013     1   1     517           515           2         830           819
##  2 2013     1   1     533           529           4         850           830
##  3 2013     1   1     542           540           2         923           850
##  4 2013     1   1     544           545           -1        1004          1022
##  5 2013     1   1     554           600           -6         812           837
##  ...     ...   ...   ...           ...           ...         ...           ...
## 336772 2013    12  31      <NA>           705           <NA>      <NA>           931
## 336773 2013    12  31      <NA>           825           <NA>      <NA>          1029
## 336774 2013    12  31      <NA>          1615           <NA>      <NA>          1800
## 336775 2013    12  31      <NA>           600           <NA>      <NA>           735
## 336776 2013    12  31      <NA>           830           <NA>      <NA>          1154
##      arr_delay carrier flight tailnum origin dest air_time distance hour
```

```

##      1      11      UA      1545      N14228      EWR      IAH      227      1400      5
##      2      20      UA      1714      N24211      LGA      IAH      227      1416      5
##      3      33      AA      1141      N619AA      JFK      MIA      160      1089      5
##      4     -18      B6       725      N804JB      JFK      BQN      183      1576      5
##      5     -25      DL       461      N668DN      LGA      ATL      116       762      6
##      ...     ...     ...     ...     ...     ...     ...     ...     ...
## 336772 <NA>      UA      1729      <NA>      EWR      DEN      <NA>      1605      7
## 336773 <NA>      US      1831      <NA>      JFK      CLT      <NA>       541      8
## 336774 <NA>      MQ      3301      N844MQ      LGA      RDU      <NA>       431     16
## 336775 <NA>      UA       219      <NA>      EWR      ORD      <NA>       719      6
## 336776 <NA>      UA       443      <NA>      JFK      LAX      <NA>      2475      8
##      minute      time_hour
##      1      15 2013-01-01 10:00:00
##      2      29 2013-01-01 10:00:00
##      3      40 2013-01-01 10:00:00
##      4      45 2013-01-01 10:00:00
##      5       0 2013-01-01 11:00:00
##      ...     ...     ...
## 336772      5 2013-12-31 12:00:00
## 336773     25 2013-12-31 13:00:00
## 336774     15 2013-12-31 21:00:00
## 336775      0 2013-12-31 11:00:00
## 336776     30 2013-12-31 13:00:00

```

To sort in decreasing order, just pass `decreasing=TRUE` as usual:

```

sort(sr, by = ~ arr_delay, decreasing=TRUE)

## 'flights' (ndoc:336776, nfield:19)
##      year month day dep_time sched_dep_time dep_delay arr_time sched_arr_time
##      1 2013     1   9      641           900         1301      1242           1530
##      2 2013     6  15     1432          1935         1137      1607           2120
##      3 2013     1  10     1121          1635         1126      1239           1810
##      4 2013     9  20     1139          1845         1014      1457           2210
##      5 2013     7  22     845           1600         1005      1044           1815
##      ...     ...     ...     ...           ...           ...           ...           ...
## 336772 2013     5   4     1816          1820           -4       2017           2131
## 336773 2013     5   2     1947          1949           -2       2209           2324
## 336774 2013     5   6     1826          1830           -4       2045           2200
## 336775 2013     5  20     719           735          -16       951           1110

```

```
## 336776 2013      5  7      1715              1729      -14      1944              2110
##      arr_delay carrier flight tailnum origin dest air_time distance hour
##      1      1272      HA      51  N384HA      JFK  HNL      640      4983      9
##      2      1127      MQ      3535  N504MQ      JFK  CMH      74      483      19
##      3      1109      MQ      3695  N517MQ      EWR  ORD      111      719      16
##      4      1007      AA      177   N338AA      JFK  SFO      354      2586      18
##      5      989      MQ      3075  N665MQ      JFK  CVG      96      589      16
##      ...      ...      ...      ...      ...      ...      ...      ...      ...
## 336772      -74      AS      7    N551AS      EWR  SEA      281      2402      18
## 336773      -75      UA      612  N851UA      EWR  LAX      300      2454      19
## 336774      -75      AA      269  N3KCAA      JFK  SEA      289      2422      18
## 336775      -79      VX      11   N840VA      JFK  SFO      316      2586      7
## 336776      -86      VX      193  N843VA      EWR  SFO      315      2565      17
##      minute              time_hour
##      1      0 2013-01-09 14:00:00
##      2      35 2013-06-15 23:00:00
##      3      35 2013-01-10 21:00:00
##      4      45 2013-09-20 22:00:00
##      5      0 2013-07-22 20:00:00
##      ...      ...              ...
## 336772      20 2013-05-04 22:00:00
## 336773      49 2013-05-02 23:00:00
## 336774      30 2013-05-06 22:00:00
## 336775      35 2013-05-20 11:00:00
## 336776      29 2013-05-07 21:00:00
```

2.5 Restricting by field

Just as we can use `subset` to restrict by row, we can also use it to restrict by column:

```
subset(sr, select=c(year, month, day))

## 'flights' (ndoc:336776, nfield:3)
##      year month day
##      1 2013      1  1
##      2 2013      1  1
##      3 2013      1  1
##      4 2013      1  1
```

```
##      5 2013      1  1
##      ... ...      ... ...
## 336772 2013      9 30
## 336773 2013      9 30
## 336774 2013      9 30
## 336775 2013      9 30
## 336776 2013      9 30
```

The `select` argument is analogous to that of `subset.data.frame`: it is evaluated to set of field names to which the dataset is restricted. The above example is static, so it is equivalent to:

```
sr[c("year", "month", "day")]

## 'flights' (ndoc:336776, nfield:3)
##      year month day
##      1 2013      1  1
##      2 2013      1  1
##      3 2013      1  1
##      4 2013      1  1
##      5 2013      1  1
##      ... ...      ... ...
## 336772 2013      9 30
## 336773 2013      9 30
## 336774 2013      9 30
## 336775 2013      9 30
## 336776 2013      9 30
```

But with `subset` we can also specify dynamic expressions, including ranges:

```
subset(sr, select=year:day)

## 'flights' (ndoc:336776, nfield:3)
##      year month day
##      1 2013      1  1
##      2 2013      1  1
##      3 2013      1  1
##      4 2013      1  1
##      5 2013      1  1
```

```
##      ...      ...      ...      ...
## 336772 2013      9      30
## 336773 2013      9      30
## 336774 2013      9      30
## 336775 2013      9      30
## 336776 2013      9      30
```

And exclusion:

```
subset(sr, select==(year:day))

## 'flights' (ndoc:336776, nfield:16)
##      dep_time sched_dep_time dep_delay arr_time sched_arr_time arr_delay
##      1      517      515      2      830      819      11
##      2      533      529      4      850      830      20
##      3      542      540      2      923      850      33
##      4      544      545     -1     1004     1022     -18
##      5      554      600     -6      812      837     -25
##      ...      ...      ...      ...      ...      ...      ...
## 336772 <NA>      1455     <NA>     <NA>     1634     <NA>
## 336773 <NA>      2200     <NA>     <NA>     2312     <NA>
## 336774 <NA>      1210     <NA>     <NA>     1330     <NA>
## 336775 <NA>      1159     <NA>     <NA>     1344     <NA>
## 336776 <NA>      840      <NA>     <NA>     1020     <NA>
##      carrier flight tailnum origin dest air_time distance hour minute
##      1      UA   1545  N14228  EWR  IAH    227    1400    5    15
##      2      UA   1714  N24211  LGA  IAH    227    1416    5    29
##      3      AA   1141  N619AA  JFK  MIA    160    1089    5    40
##      4      B6    725  N804JB  JFK  BQN    183    1576    5    45
##      5      DL    461  N668DN  LGA  ATL    116    762    6     0
##      ...      ...      ...      ...      ...      ...      ...      ...
## 336772 9E   3393  <NA>   JFK  DCA    <NA>    213    14    55
## 336773 9E   3525  <NA>   LGA  SYR    <NA>    198    22     0
## 336774 MQ   3461  N535MQ  LGA  BNA    <NA>    764    12    10
## 336775 MQ   3572  N511MQ  LGA  CLE    <NA>    419    11    59
## 336776 MQ   3531  N839MQ  LGA  RDU    <NA>    431     8    40
##      time_hour
##      1 2013-01-01 10:00:00
##      2 2013-01-01 10:00:00
##      3 2013-01-01 10:00:00
```

```
##      4 2013-01-01 10:00:00
##      5 2013-01-01 11:00:00
##      ...
## 336772 2013-09-30 18:00:00
## 336773 2013-10-01 02:00:00
## 336774 2013-09-30 16:00:00
## 336775 2013-09-30 15:00:00
## 336776 2013-09-30 12:00:00
```

Solr also has native support for globs:

```
sr[c("arr_*", "dep_*")]

## 'flights' (ndoc:336776, nfield:4)
##      arr_time arr_delay dep_time dep_delay
##      1      830         11      517         2
##      2      850         20      533         4
##      3      923         33      542         2
##      4     1004        -18      544        -1
##      5      812        -25      554        -6
##      ...      ...      ...      ...      ...
## 336772 <NA>      <NA>      <NA>      <NA>
## 336773 <NA>      <NA>      <NA>      <NA>
## 336774 <NA>      <NA>      <NA>      <NA>
## 336775 <NA>      <NA>      <NA>      <NA>
## 336776 <NA>      <NA>      <NA>      <NA>
```

While we are dealing with fields, we should mention that renaming is also (in principle) possible:

```
### FIXME: broken in current Solr CSV writer
### rename(sr, tail_num = "tailnum")
```

2.6 Transformation

To compute new columns from existing ones, we can, as usual, call the `transform` function:

```

sr2 <- transform(sr,
  gain = arr_delay - dep_delay,
  speed = distance / air_time * 60)
sr2[c("gain", "speed")]

## 'flights' (ndoc:336776, nfield:1)
##      gain
##    1     9
##    2    16
##    3    31
##    4   -17
##    5   -19
##    ...  ...
## 336772 <NA>
## 336773 <NA>
## 336774 <NA>
## 336775 <NA>
## 336776 <NA>

```

2.6.1 Advanced note

The `transform` function essentially quotes and evaluates its arguments in the given frame, and then adds the results as columns in the return value. Direct evaluation affords more flexibility, such as constructing a table with only the newly computed columns. By default, evaluation is completely eager — each referenced column is downloaded in its entirety. But we can make the computation lazier by calling `defer` prior to the evaluation via `with`:

```

with(defer(sr), data.frame(gain = head(arr_delay - dep_delay),
  speed = head(distance / air_time * 60)))

##      gain      speed
## 1      9 370.0440
## 2     16 374.2731
## 3     31 408.3750
## 4    -17 516.7213
## 5    -19 394.1379
## 6     16 287.6000

```

Note that this approach, even though it is partially deferred, is potentially less efficient than `transform` two reasons:

1. It makes two requests to the database, one for each column,
2. The two result columns are downloaded eagerly, since the result must be a `data.frame` (and thus practicalities required us to take the `head` of each promised column prior to constructing the data frame).

We can work around the second limitation by using a more general form of data frame, the *DataFrame* object from *S4Vectors*:

```
with(defer(sr),
      S4Vectors::DataFrame(gain = arr_delay - dep_delay,
                          speed = distance / air_time * 60))

## DataFrame with 336776 rows and 2 columns
##           gain           speed
##   <SolrFunctionPromise> <SolrFunctionPromise>
## 1             9           370.04404
## 2            16           374.27313
## 3            31           408.375
## 4           -17           516.7213
## 5           -19           394.13794
## ...           ...             ...
## 336772         NA             NA
## 336773         NA             NA
## 336774         NA             NA
## 336775         NA             NA
## 336776         NA             NA
```

Note that we did not need to take the `head` of the individual columns, since *DataFrame* does not require the data to be stored in-memory as a base R vector.

2.7 Summarization

Data summarization is about reducing large, complex data to smaller, simpler data that we can understand.

A common type of summarization is aggregation, which is typically defined as a three step process:

1. Split the data into groups, usually by the the interaction of some factor set,
2. Summarize each group to a single value,
3. Combine the summaries.

Solr natively supports the following types of data aggregation:

- `mean`,
- `min`, `max`,
- `median`, `quantile`,
- `var`, `sd`,
- `sum`,
- `count` (`table`),
- counting of unique values (for which we introduce `nunique`).

The `rsolr` package combines and modifies these operations to support high-level summaries corresponding to the R functions `any`, `all`, `range`, `weighted.mean`, `IQR`, `mad`, etc.

A prerequisite of aggregation is finding the distinct field combinations that correspond to each correspond to a group. Those combinations themselves constitute a useful summary, and we can retrieve them with `unique`:

```
unique(sr["tailnum"])  
  
## DocDataFrame (4044x1)  
##      tailnum  
##    1 D942DN  
##    2 NOEGMQ  
##    3 N10156  
##    4 N102UW  
##    5 N103US  
##   ...     ...  
## 4040 N998AT  
## 4041 N998DL  
## 4042 N999DN
```

```
## 4043 N9EAMQ
## 4044 <NA>

unique(sr[c("origin", "tailnum")])

## DocDataFrame (7944x2)
##      origin tailnum
##    1    EWR  NOEGMQ
##    2    EWR  N10156
##    3    EWR  N102UW
##    4    EWR  N103US
##    5    EWR  N104UW
##   ...    ...    ...
## 7940   LGA  N998AT
## 7941   LGA  N998DL
## 7942   LGA  N999DN
## 7943   LGA  N9EAMQ
## 7944   LGA   <NA>
```

Solr also supports extracting the top or bottom N documents, after ranking by some field, optionally by group.

The convenient, top-level function for aggregating data is `aggregate`. To compute a global aggregation, we just specify the computation as an expression (via a named argument, mimicking `transform`):

```
aggregate(sr, delay = mean(dep_delay, na.rm=TRUE))

##      delay
## 1 12.63907
```

It is also possible to specify a function (as the `FUN` argument), which would be passed the entire frame.

As with `stats::aggregate`, we can pass a grouping as a formula:

```
delay <- aggregate(~ tailnum, sr,
                   count = TRUE,
                   dist = mean(distance, na.rm=TRUE),
                   delay = mean(arr_delay, na.rm=TRUE))
delay <- subset(delay, count > 20 & dist < 2000)
```

The special `count` argument is a convenience for the common case of computing the number of documents in each group.

Here is an example of using `nunique` and `ndoc`:

```
head(aggregate(~ dest, sr,
               nplanes = nunique(tailnum),
               nflights = ndoc(tailnum)))

##   dest nplanes nflights
## 1 ABQ     108     254
## 2 ACK      58     265
## 3 ALB     172     439
## 4 ANC       6       8
## 5 ATL    1180    17215
## 6 AUS     993    2439
```

There is limited support for dynamic expressions in the aggregation formula. At a minimum, the expression should evaluate to logical. For example, we can condition on whether the distance is more than 1000 miles.

```
head(aggregate(~ I(distance > 1000) + tailnum, sr,
               delay = mean(arr_delay, na.rm=TRUE)))

##   I(distance > 1000) tailnum    delay
## 1                FALSE D942DN 31.500000
## 2                FALSE NOEGMQ  8.986755
## 3                FALSE N10156 13.701149
## 4                FALSE N102UW  2.937500
## 5                FALSE N103US -6.934783
## 6                FALSE N104UW  1.804348
```

It also works for values naturally coercible to logical, such as using the modulus to identify odd numbers. For clarity, we label the variable using `transform` prior to aggregating.

```
head(aggregate(~ odd + tailnum, transform(sr, odd = distance %% 2),
               delay = mean(arr_delay, na.rm=TRUE)))

##   odd tailnum    delay
## 1 FALSE D942DN 31.500000
```

```
## 2 FALSE NOEGMQ 8.589520
## 3 FALSE N10156 7.797753
## 4 FALSE N102UW 19.000000
## 5 FALSE N103US -7.285714
## 6 FALSE N104UW 20.700000
```

Aggregate and subset in the same command, as with `data.frame`:

```
head(aggregate(~ tailnum, sr,
               subset = distance > 500,
               delay = mean(arr_delay, na.rm=TRUE)))

##   tailnum      delay
## 1 D942DN 31.500000
## 2 NOEGMQ  8.919580
## 3 N10156 12.009174
## 4 N102UW  2.937500
## 5 N103US -6.934783
## 6 N104UW  1.804348
```

Aggregate the entire dataset:

```
aggregate(sr, delay = mean(arr_delay, na.rm=TRUE))

##      delay
## 1 6.895377
```

3 Cleaning up

Having finished our demonstration, we kill our Solr server:

```
solr$kill()
```