Scaling a recommender system across large data volumes

## Building a recommendation engine in presence of large data volume

E-commerce businesses can suggest new products to their customers. How do they choose the products to recommend? The companies collect data about the purchases of their customers. Starting from the history of purchases, they can identify items that have been purchased by the same customers and customers that purchased the same items. Given a new customer, the company can recommend him/her items similar to the ones that he/she purchased already, or items that have been purchased by similar customers. There are also other data sources like personal information, descriptions of the items, ratings, reviews. Large companies like Amazon and eBay already built sophisticated recommendation engines tailored to their environment.

What if a smaller company wants to build a smaller recommendation engine from scratch? Even if the complexity is not the same as huge companies, the volume of data to process may still be large. In this article, we see how to build simple recommender systems that can be scaled across large data volumes. To show the concepts avoiding unnecessary complications, in this article we are using the information about purchases only. Due to the complexity of the problem and to the variety of contexts, this article describes it from a generic high-level perspective.

## Choosing the environment

In this article, the technology that we use is SQL Server 2016 with R Services. The reason is that we can store large SQL tables and process them using advanced analytics techniques provided by R.

The use-case consists in recommending movies to the users. Given a set of movies and users, the table describes what movies each user has watched. To avoid further complications, the table doesn’t include user ratings. Its structure is:

* A row for each movie
* A column for each user
* Cells equal to 1 if the user watched the movie and to 0 otherwise

The data has already been imported into SQL 2016 into a table called *movies*. To analyse the data, we use the R environment and we define a SQL table object called sql\_movies that allows us to access the SQL table. The function creating the object is *RxSqlServerData* and it needs a connection string for the database and the name of the table. We also define another SQL table object, called sql\_clust\_users, referring to a table that doesn't exist yet. We'll create and use this table from R.

connection\_string <- "Driver=SQL Server;Server=.;Database=movies;Uid=usernam;password"  
  
sql\_movies <- RxSqlServerData(connectionString = connection\_string,  
 table = "movies")  
  
sql\_clust\_users <- RxSqlServerData(connectionString = connection\_string,  
 table = "sql\_clust\_users")

Let's have a quick look at the data.

dim(sql\_movies)

## [1] 11503 865

rxGetVarInfo(sql\_movies)[1:4]

## $MovieId  
## Type: integer, Low/High: (91, 3630218)  
##   
## $U9928  
## Type: numeric, Low/High: (0.0000, 1.0000)  
##   
## $U15152  
## Type: numeric, Low/High: (0.0000, 1.0000)  
##   
## $U7850  
## Type: numeric, Low/High: (0.0000, 1.0000)

head(sql\_movies)[, 1:8]

## MovieId U9928 U15152 U7850 U9065 U8166 U5251 U10249  
## 1 368688 0 0 1 0 0 0 0  
## 2 368709 0 0 0 0 0 0 0  
## 3 368794 0 0 0 0 0 0 0  
## 4 368891 0 0 0 0 1 0 0  
## 5 368909 0 0 1 0 0 0 0  
## 6 368933 0 0 0 0 0 0 0

The table has 865 columns. The first column contains the Movie ID and each other column corresponds to a user. The values in the *user* columns are equal to 1 if the user watched the movie and to 0 otherwise.

To build a recommendation engine, we can use the R package *recommenderlab*. However, this package need all the data to be stored into the RAM, so it can deal with relatively small data volumes only. Therefore, dealing with a large dataset, we need to transform it first to reduce its volume. In this example, the data volume is not really huge. However, the solution is designed in such a way that it's applicable on a larger data volume.

## Reducing the data volume

To produce a small table, we can either reduce the number of rows or the number of columns. In this chapter we are reducing both.

A common challenge is that there are many users, i.e. columns. A solution consists in identifying small groups of similar users and to define a new table having a column for each group of users. The steps are

1. Define a formula describing what columns we are dealing with. We include all the columns apart from the first
2. Measure the similarity between users using the function rxCor
3. Starting from the similarity, define a matrix containing the distance between the users
4. Starting from the distance matrix, identify groups of users applying hierarchical clustering
5. Define a new table which columns correspond to the clusters. The value of each column is equal to one if at least one user of the cluster watched the movie

The new table contains a row for each movie and a column for each group of users.

This is the related code to detect 100 clusters of users.

# define the formula  
cols\_movies <- names(sql\_movies)[-1]  
string\_users <- paste(cols\_movies, collapse = " + ")  
formula\_users <- formula(paste("~", string\_users))  
  
# build the hierachical clustering model  
cor\_users <- rxCor(formula\_users, sql\_movies,  
 rowsPerRead = 5e02)

## Rows Read: 11503, Total Rows Processed: 11503, Total Chunk Time: 2.931 seconds   
## Computation time: 6.034 seconds.

dist\_users <- as.dist(1 - abs(cor\_users))  
model\_hc <- hclust(dist\_users, method = "complete")  
which\_cluster <- cutree(model\_hc, k = 100)  
var\_clusters <- sort(unique(which\_cluster))  
  
# group the users into clusters  
clusterCols <- function(list\_in) {  
   
 # define a field for each cluster  
 list\_out <- lapply(var\_clusters, function(this\_cluster) {  
 these\_cols <- names(which\_cluster[which\_cluster == this\_cluster])  
 df\_cols <- data.frame(list\_in[these\_cols])  
 rowSums(df\_cols) > 0  
 })  
   
 names(list\_out) <- paste0("clust", var\_clusters)  
 # for each movie, count the number of clusers having watched it  
 df\_views <- data.frame(list\_out)  
 list\_out$n\_views <- rowSums(df\_views)  
   
 # add the movie ID  
 list\_out$MovieId <- list\_in$MovieId  
   
 list\_out  
}  
  
rxDataStep(  
 inData = sql\_movies,  
 outFile = sql\_clust\_users,  
 overwrite = TRUE,  
 transformFunc = clusterCols,  
 transformObjects = list(var\_clusters = var\_clusters,  
 which\_cluster = which\_cluster))

## Warning in rxLinkTransformComponents(transforms = transforms, transformFunc = transformFunc, :   
## There are 'transformObjects' that have the same name as an  
## object in the evaluation environment, which could cause  
## misleading results. Try renaming the following objects in the  
## 'transformObjects' list: 'var\_clusters', 'which\_cluster'.

## Rows Read: 11503, Total Rows Processed: 11503, Total Chunk Time: 1.418 seconds

dim(sql\_clust\_users)

## [1] 11503 102

The other approach to decrease the size is to reduce the number of rows. Applying a clustering algorithm, we can identify groups of similar items and define a table with a row for each group of items. For this purpose, we can use the function *rxKmeans*.

The starting point is sql\_clust\_users and the steps are

1. Build a formula defining the variables to base the clustering on
2. Identify 20 clusters of movies using rxKmeans
3. Extract the centers of the clusters. They contain averages that in this context express the percentage of users that watched each movie
4. Starting from the centers, define the table *df\_movies* which values are 1 if the value is above 0.1 and 0 otherwise

This is the related code.

cols\_km <- names(sql\_clust\_users)  
feat\_km <- paste(cols\_km, collapse = " + ")  
formula\_km <- formula(paste("~", feat\_km))  
model\_km <- rxKmeans(formula\_km, sql\_clust\_users,  
 numClusters = 20,  
 reportProgress = 0)  
df\_movies <- ifelse(model\_km$centers[, -1] > 0.1, 1, 0)  
df\_movies[1:10, 1:6]

## clust1 clust2 clust3 clust4 clust5 clust6  
## 1 1 0 0 1 1 1  
## 2 0 0 0 0 1 0  
## 3 1 0 1 1 1 1  
## 4 0 0 0 0 0 0  
## 5 0 0 0 0 1 1  
## 6 1 0 0 1 0 1  
## 7 1 0 0 1 1 1  
## 8 0 0 0 1 1 1  
## 9 0 0 0 0 1 1  
## 10 1 0 0 1 1 1

The table *df\_movies* is small-sized and it contains a column for each cluster of users and a row for each cluster of movies. The value of each cell is equal to 1 if the related cluster of users watched at least a given percentage of the related cluster of movies, and 0 otherwise.

## Building the engine

In the previous step we produced a small table stored in the R environment. Starting from that, we can build a recommender system using the package *recommenderlab*.

The steps are

1. Starting from *df\_movies*, build, test and validate a recommendation engine. There are a few options in the recommenderlab package, so test and evaluate a few of them, and pick the best-performing
2. Given a new user, measure the distance between each cluster center and he/she. Then, identify the closest center and associate the user to the related cluster
3. Identify the cluster of movies to recommend to the cluster related to the new user
4. Out of the recommended cluster of movies, choose one or more movies to recommend to the user

## Conclusions

Using the approach described by this article, it's possible to apply a recommender system on a large data volume.

To extend this solution, it's possible to use a matrix containing user ratings instead of just 0s a 1s. Also, the recommender system can include some information about the users and/or movies. For each cluster of movies or users, it's possible to summarise the related information and to include it into the recommender systems.