Bench-Ranking:

Towards prescriptive analysis of big graph processing: the case of SparkSQL

The 14th LDBC TUC Meeting

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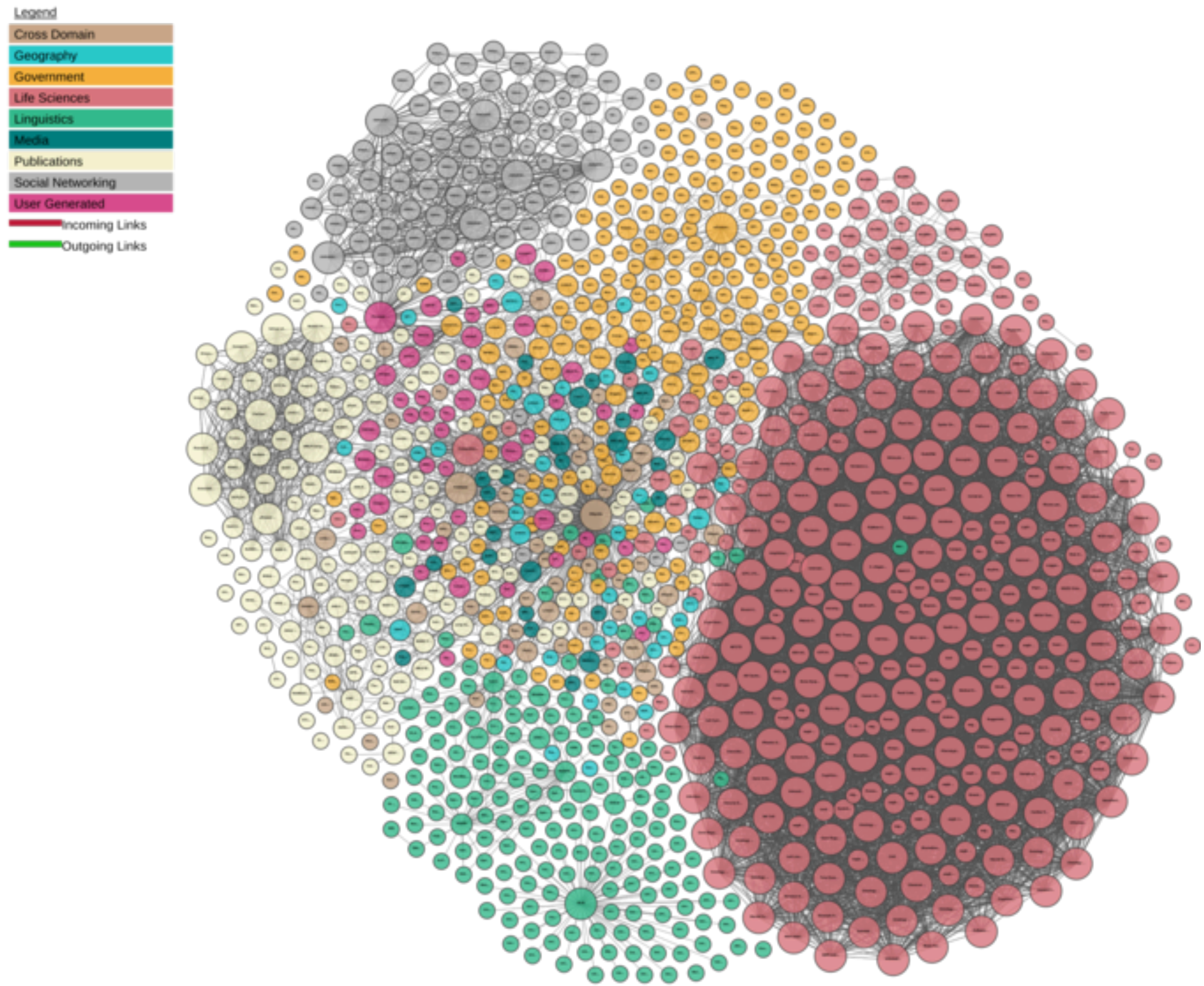
RDF data is exploding…



The Linked Open Data Cloud: https://lod-cloud.net/


DO YOU THINK THAT'S A
Graph YOU ARE QUERYING?

Native Vs. Non-native (Relational) RDF Proc.

Native Triple Stores

- Centralized
- E.g, Jena, RDF3X,..

VS.

Big Relational Systems

- Not tailored for RDF Processing.
- E.g, Apache Spark, Hive, Impala.

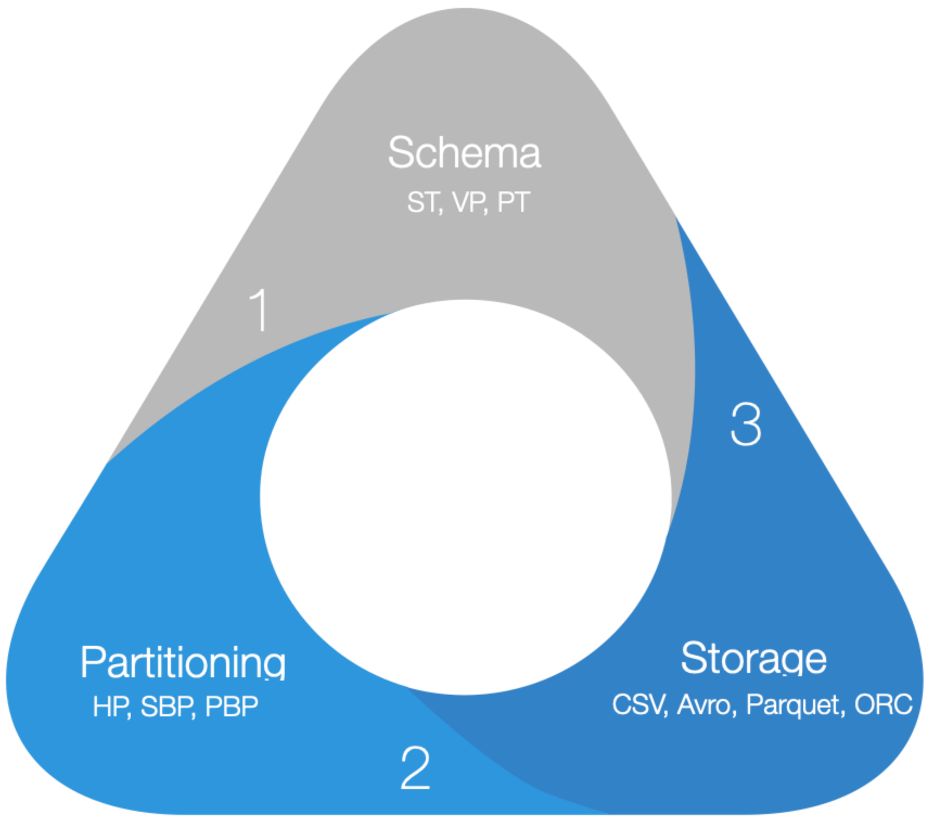
The Datafloq Open Source Landscape 2.0
Data Analysis & Platforms
HPCC Systems
Storm
Hadoop
Dremel
hadoop Map Reduce
Apache Spark
HD
Apache Drill
SAMOA
IKANOW | BRILLIANT DECISIONS
Hortonworks
Databases / Data warehousing
bigdata
INFOBRIGHT
Cassandra
4store
H2
GlobalsDB
SQLite
InfiniDB
riak
Infinispan
HYPERTABLE
MariaDB
Drizzle
RethinkDB
terrastore
HIVE
Firebird
ORACLE BERKELEY DB
HyperSQL
monetdb
In-Memory Computing
GridGain
IN-MEMORY COMPUTING
hazelcast
TERRACOTTA
NMemory
GORA
Business Intelligence
ERP BI Solutions
Open Source Business Intelligence Solutions for ERP
openi.org
Open Intelligence
talend
open data solutions
Jaspersoft
Palo
Open Source Business Intelligence
spagobi
pentaho
jedox.
BIRT
Data Mining
orange
rapidminer
KNIME
Data Analytics Made Easy
mahout
WEKA
KEEL
togaware
SPMF
Big Data search
Lucene
Apache Solr
elasticsearch.
Multivalue database
Rocket
U2
REVELATION SOFTWARE
Open QM
Ladybridge Systems
northgate
Reality
jBASE INTERNATIONAL
FREEDOM. OPENNESS. POWER.
ScarletDME
Programming
R
julia
Data aggregation
sqoop
FLUME
chukwa
KeyValue
AEROSPIKE
leveldb
redis
Chordless Beta
Tokyo Cabinet
MEMCACHED
SCALIEN
Project Voldemort
A distributed database.
hamsterdb
RAPTORDB
FairCom
STSDB
DATABASE & VIRTUAL FILE SYSTEM
HyperDex
OpenLDAP
IQLECT
ioremap.net
STORAGE AND BEYOND
Scalaris
Document Store
Raven DB
mongoDB
COUCHBASE
CLUSTERPOINT
Tokutek
RaptorDB
EJDB
djondb
JasDB
sisodb
Apache CouchDB relax
SchemafreeDB
Graph databases
Gephi
makes graphs handy
Gremlin
GraphBuilder
FRANZ INC.
*Sparksee
InfiniteGraph
Powered by Objectivity
INFOGRID
HYPERGRAPHDB
Neo4j
the graph database
FlockDB
GraphBase
BrightstarDB
Operational
VOLTDB
SMART DATA FAST.
Social
Apache Kafka
A high-throughput distributed messaging system.
ThinkUp
Corona
Multidimensional
FIS
SciDB
rasdaman
raster data manager
Object databases
db4objects
NEOPPOD
Distributed Transactional NoSQL for the Cloud
ZOPE
mobject
precision data management
Magma
Picolisp
siaqodb
RAMER D
PERSEVERE
EyeDB
STARCOUNTER
Sterling
NDatabase
C# Lightweight Object Database
Multimodel
ArangoDB
alchemydatabase
XML Databses
existdb
BASE X
Qizx
sedna
LIQUIBASE
Grid Solutions
GIGASPACES
Galaxy
Created by: www.Datafloq.com

Let’s take (Apache Spark-SQL) as example

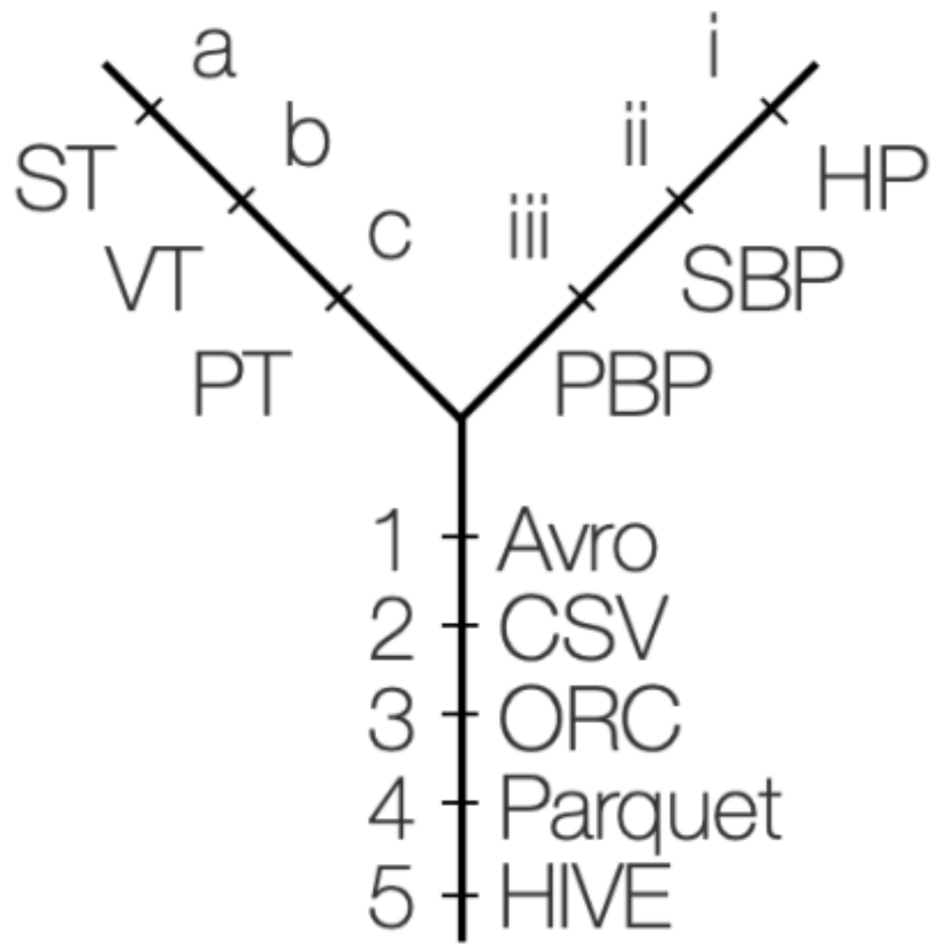
01
Schema
- Single Statement Table (ST)
- Vertically Partitioned Tables (VT)
- Property Tables (PT)

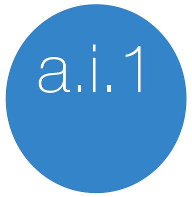
02
Partitioning
- Horizontal Partitioning (HP)
- Subject-based Partitioning (SBP)
- Predicate-based Partitioning(PBP)

03
Storage Formats
- Row-oriented (Avro, CSV).
- Columnar-oriented (ORC, Parquet).



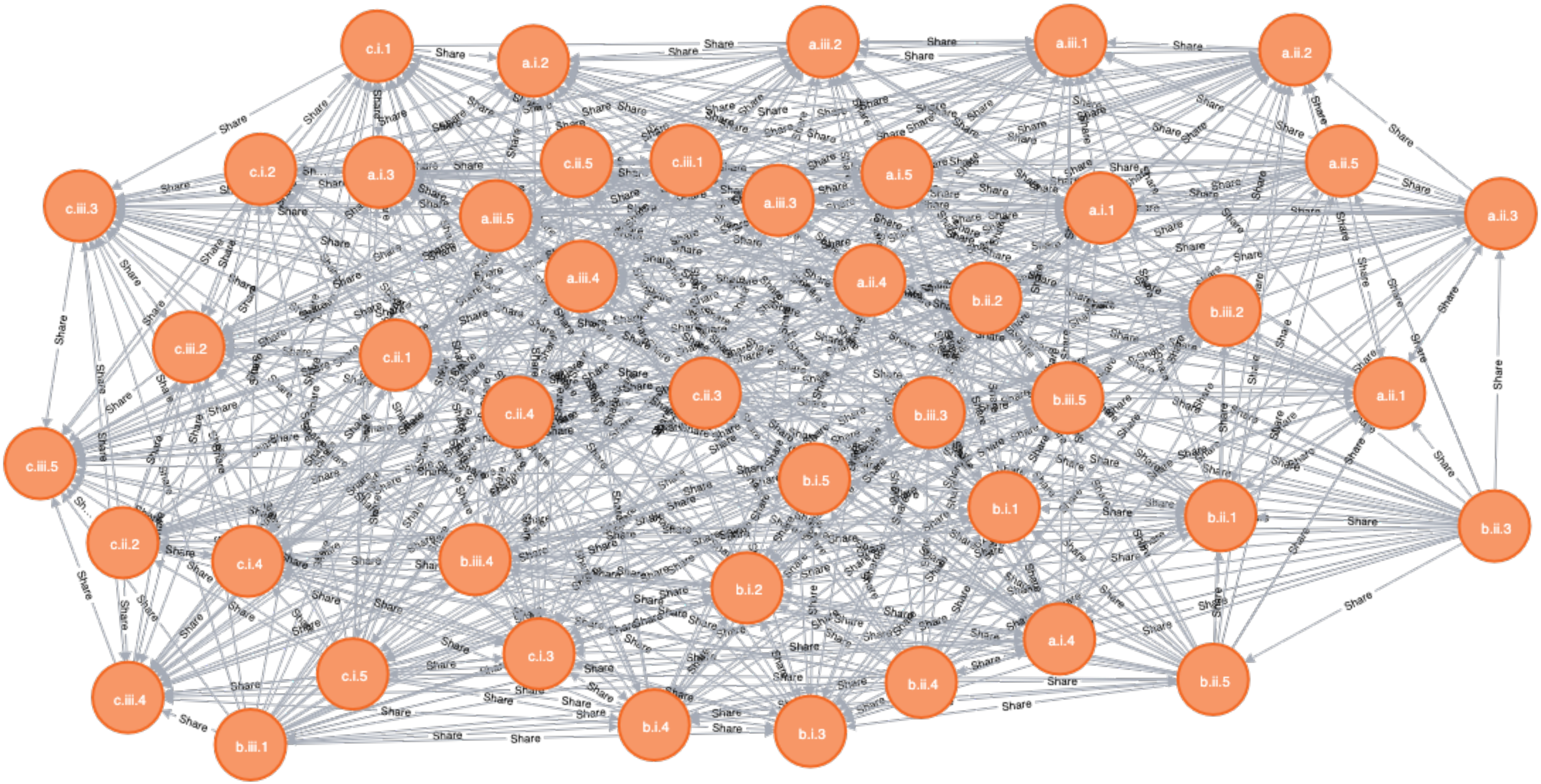
Experimental Solution Space





== ST.HP.Avro

Experimental Solution Space



Which configuration combination the best to choose ?!

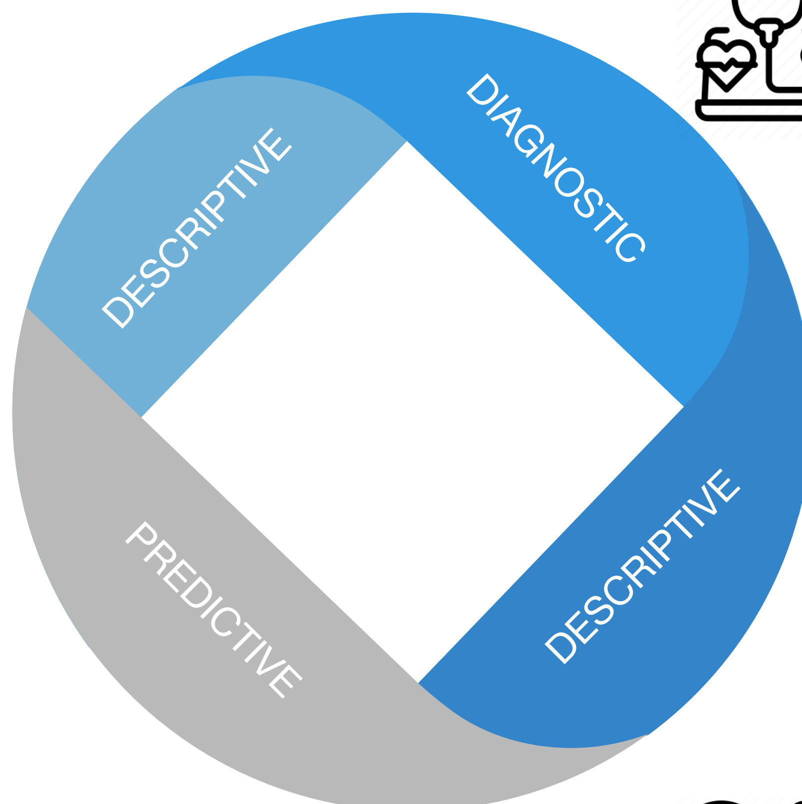
The 4 Levels of Analysis

01 Descriptive Analysis

- - Describe results (Which dimension was better).
- By how much.

02 Diagnostic Analysis

- Try to describe why it happened
- using the Domain knowledge.



03 Predictive Analysis

- Predict what will happen?!
- Applying ML and other stat.

04 Prescriptive Analysis

- What should be done?
  - E.g. what is the best conf

The 4 levels of Data Analytics: https://koopingshung.com/blog/four-levels-of-analytics-data-science-descriptive-diagnostic/

Bench-Ranking

01

Looking at the descriptive analysis is not enough!

- looking at a lot of performance data might be overwhelming.
- Sometimes, **Contradicting results**.

02

Dimensions Trade-offs

There are always clear trade-offs between these dimensions.

03

Selecting Best Combination

Selecting the best configuration combination out of this complex solution space is not an easy task.

04

Bench-Ranking: Simple Yet Accurate

Bench-ranking criteria provide an accurate yet simple way that supports the practitioners in this task even in the existence of dimensions' trade-offs.

05

Firsts Steps of BD Ranking: Saleem et.al

Saleem et al. Proposed a ranking criteria for ranking 7 approaches for Partitioning RDF graphs.

An Empirical Evaluation of RDF Graph Partitioning Techniques: https://svn.aksw.org/papers/2018/EKAW_Graph_Partitioning/public.pdf

Individual Ranking Criteria

- For each dimension, we rank how the alternatives of this dimension are ranked.
- Example of Rank Scores.

$$R = \sum_{r=1}^{d} \frac{O_{dim}(r) * (d - r)}{Q(d-1)}, 0 < R \leq 1$$

Schema Rank Scores (for HP and Avro)

HP/ Avro	**1st**	**2nd**	**3rd**	***Rank(R)***
ST	1	3	7	0.23
VT	6	4	1	0.73
PT	4	4	3	0.55

Partiton. Rank Scores (for ST and Avro)

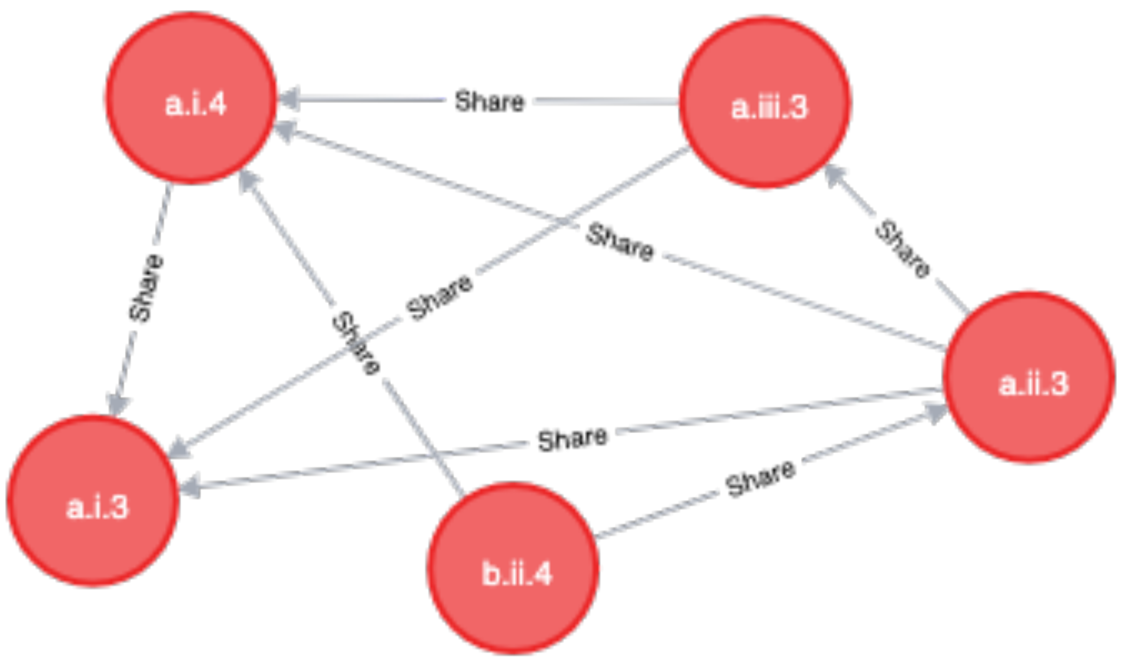
ST/ Avro	**1st**	**2nd**	**3rd**	***Rank(R)***
HP	2	6	3	0.45
SBP	8	3	0	0.86
PBP	1	2	8	0.18

Storage Rank Scores (for ST and HP)

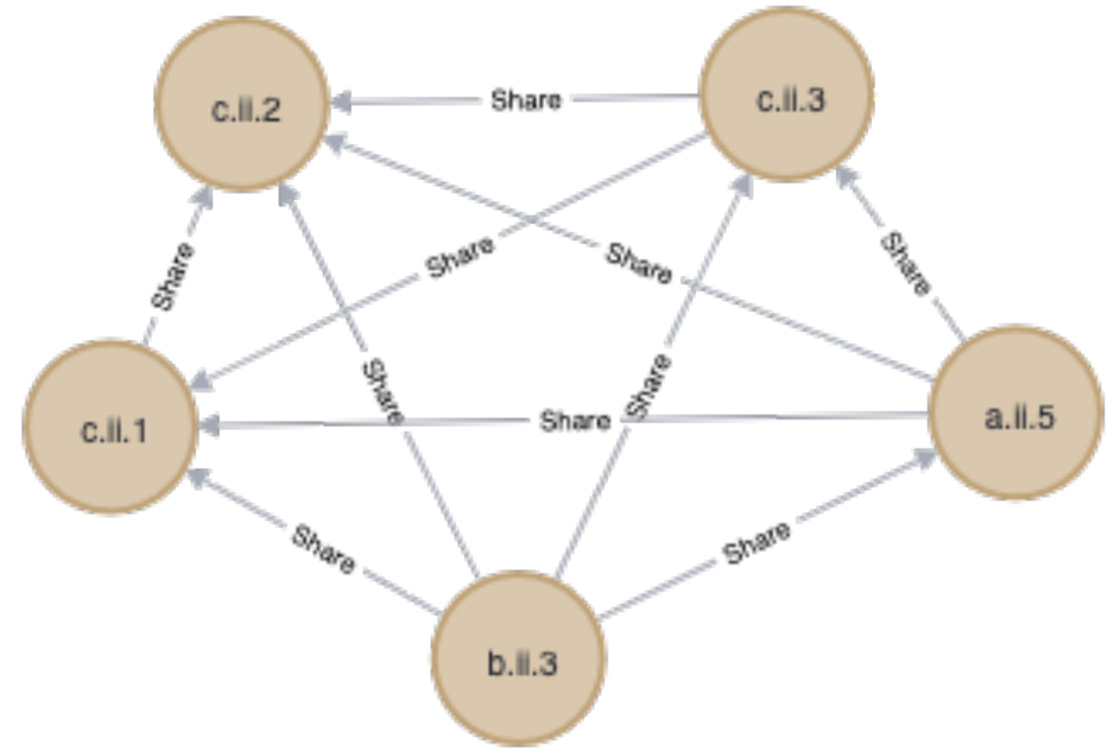
ST/ HP	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Rank (R)**
Avro	0	0	1	10	0	0.27
CSV	0	0	0	0	11	0.00
ORC	4	6	1	0	0	0.82
Parquet	2	3	5	1	0	0.64
Hive	5	2	4	0	0	0.77

An Empirical Evaluation of RDF Graph Partitioning Techniques: https://svn.aksw.org/papers/2018/EKAW_Graph_Partitioning/public.pdf

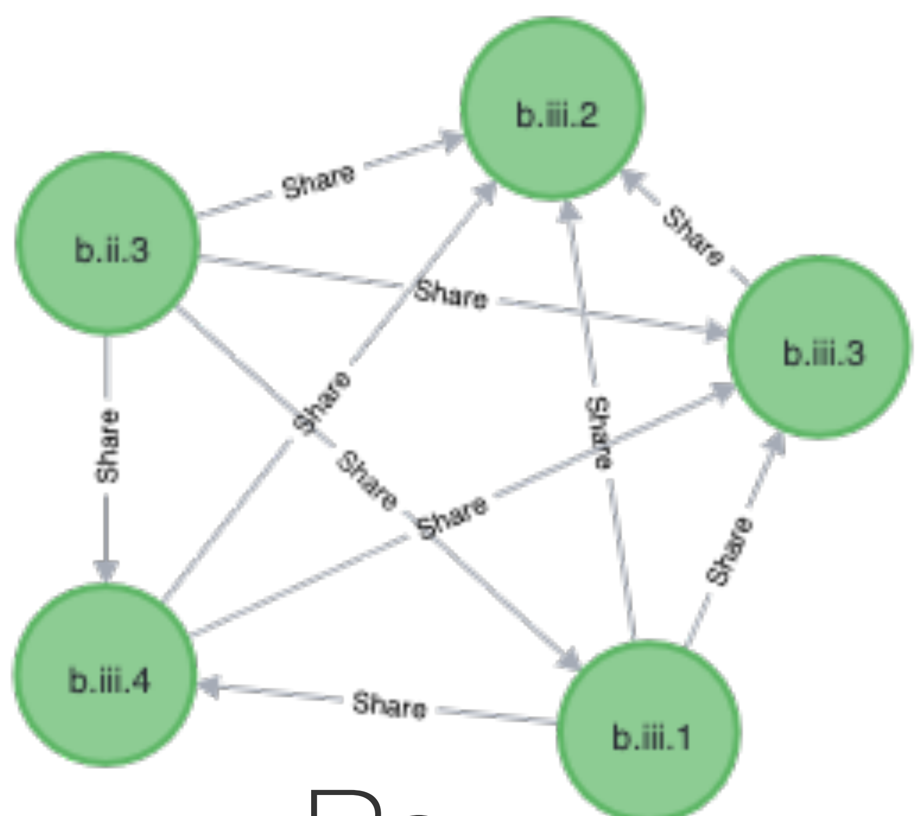
Ranking towards each dimension (Rf, Rp, Rs)



Rf

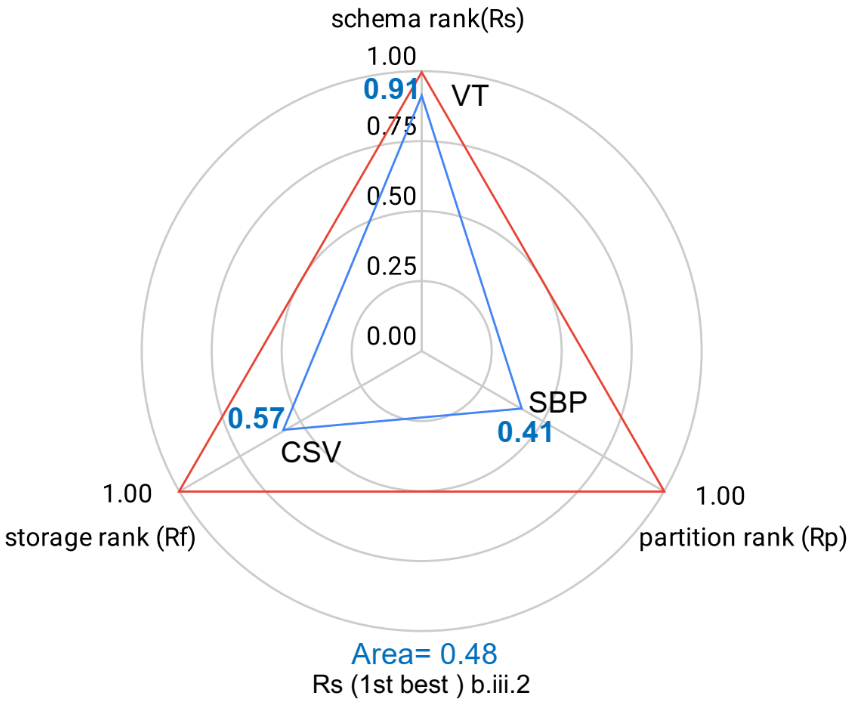


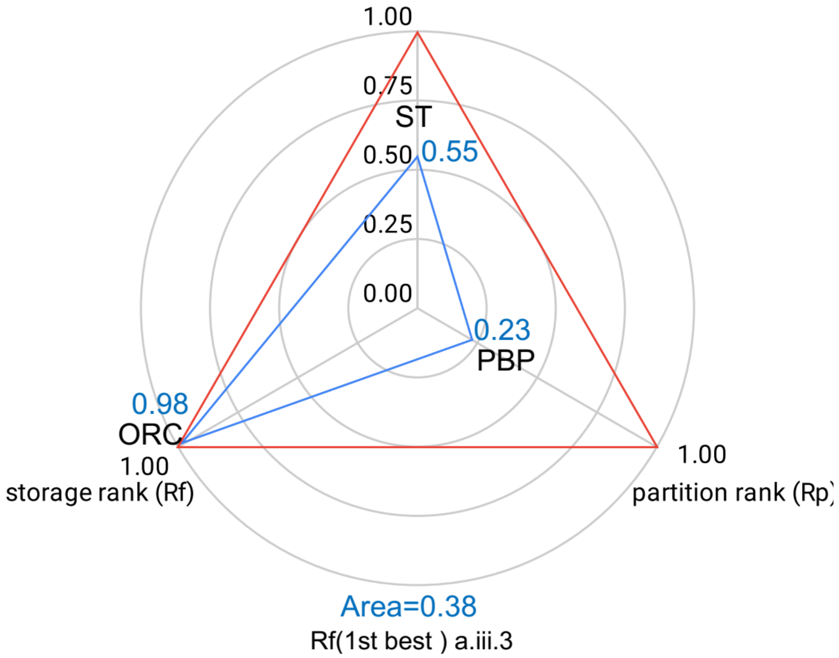
Rp

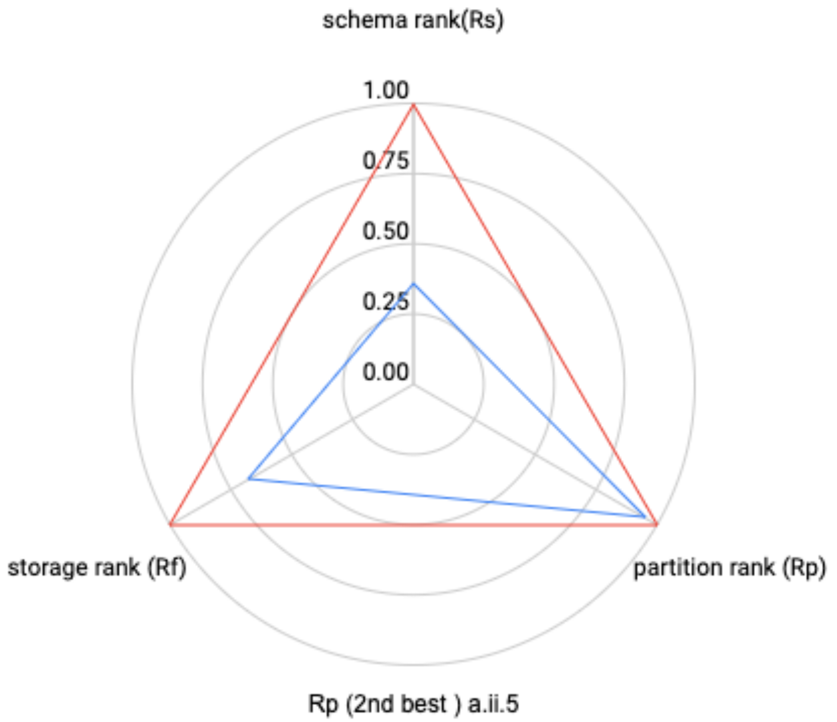


Rs

Individual ranking Limitations







Rank_Schema (Rs) Rank_Format (Rf) Rank_Partition. (Rp)

Ranking Criteria Goodness Metrics

1 Conformance

Conformance with the actual query rankings

2 Coherence

How Coherent the ranking across different dataset scales.

1- Ranking Goodness

- A ranking criterion “**good**” if it does not suggest a low-performing configuration.
- We are interested to be the best at any particular query as long as we are never the worst.
- The ranking criterion is confident if it’s top ranked configurations are not actually performing bad.

$$A(\mathcal{R}^k) = 1 - \sum_{i=0}^{Q}\sum_{j=0}^{k}\frac{\bar{A}(i,j)}{Q*k}, \quad \bar{A}(i,j) = \begin{cases} 1 & \mathcal{R}^k[j] \in \mathcal{Q}i_h^i \\ 0 & otherwise \end{cases}$$

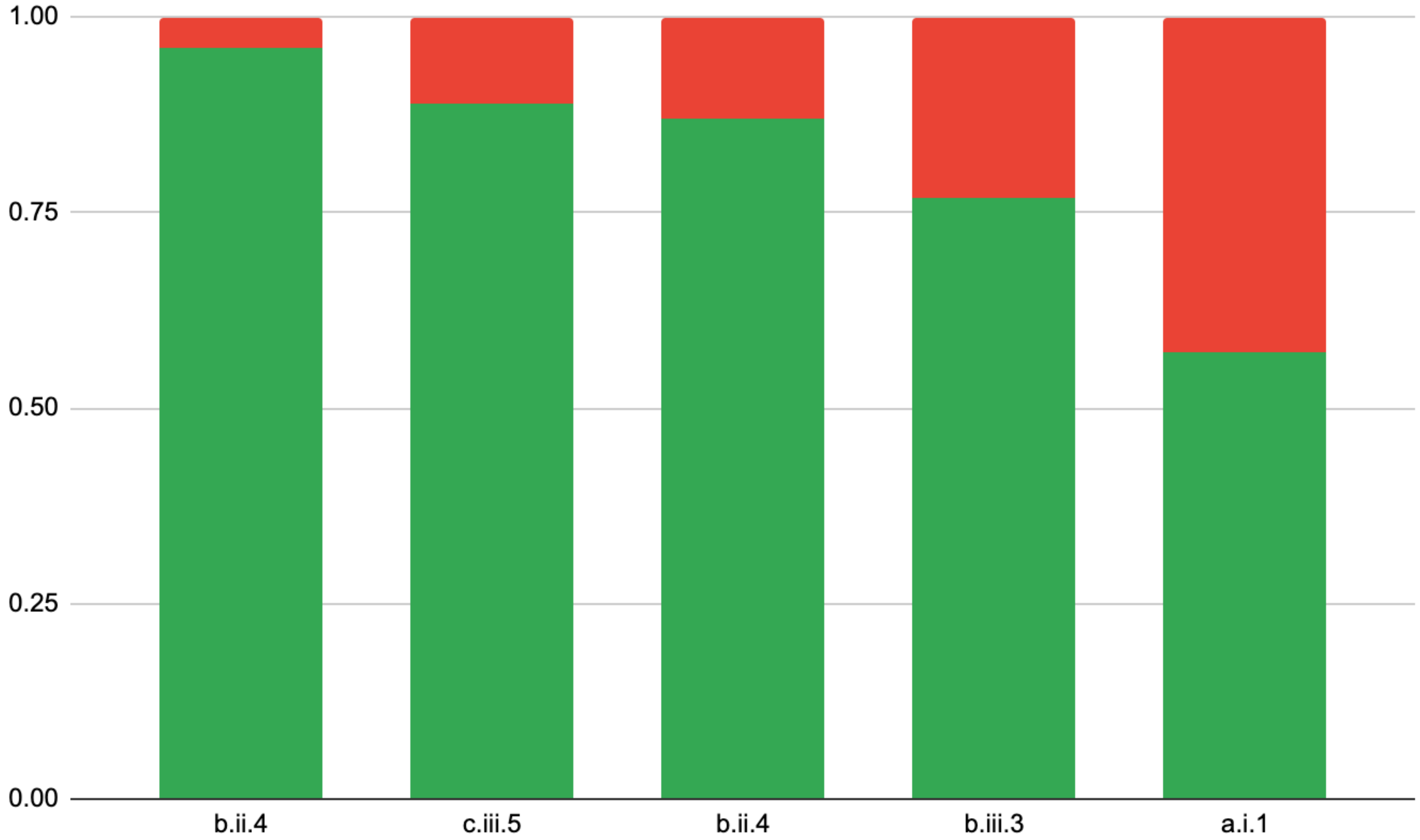
Conf

500M	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
a.i.1	35	40	37	43	41	34	19	36	22	25	32
a.i.2	45	45	45	45	45	45	30	45	30	36	40
..	..	..	..	..	..	..	..	..	..	..	..
c.iii.5	41	42	39	37	38	28	31	2	31	43	43

Ranks

Confs. Query Ranking

Goodness example



Ranking by Storage (Rf)

2- Ranking Coherence

- We opt for **Kendall index**, which counts the number of pairwise disagreements between two rank sets
- The larger the distance, the more dissimilar the rank sets are.

$$K(\mathcal{R}1, \mathcal{R}2) = \sum_{\{i,j\} \in P} \frac{\bar{K}_{i,j}(\mathcal{R}1, \mathcal{R}2)}{|\, P \,|}$$

$$\bar{K}_{i,j}(\mathcal{R}1, \mathcal{R}2) = \begin{cases} 0 & \mathcal{R}1[r_i^1] = \mathcal{R}2[r_i^2] = i \ \wedge \mathcal{R}1[r_j^1] = \mathcal{R}2[r_j^2] = j \ \wedge \\ & r_i^1 - r_j^1 = r_i^2 - r_j^2 \\ 1 & \text{otherwise} \end{cases}$$

Kendall rank correlation coefficient: https://en.wikipedia.org/wiki/Kendall_rank_correlation_coefficient

100M

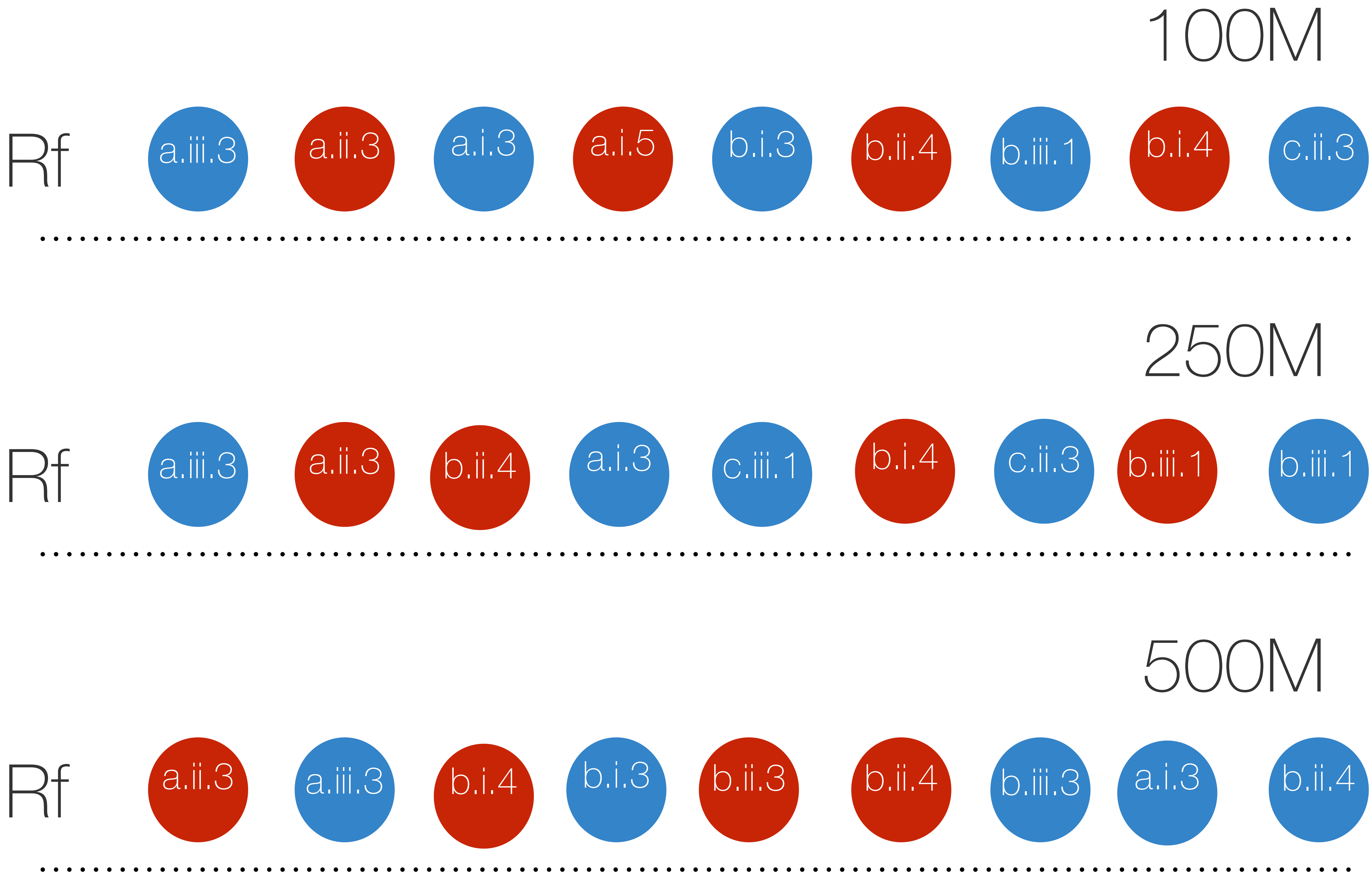
Rf a.iii.3 a.ii.3 a.i.3 a.i.5 b.i.3 b.ii.4 b.iii.1 b.i.4 c.ii.3

100M

Rp a.ii.3 a.ii.5 a.ii.4 b.ii.5 b.ii.1 a.ii.1 b.ii.4 c.ii.4 b.ii.3

100M

Rs b.iii.2 b.iii.1 b.iii.4 b.iii.5 b.ii.2 b.i.2 b.iii.3 b.ii.1 b.ii.4

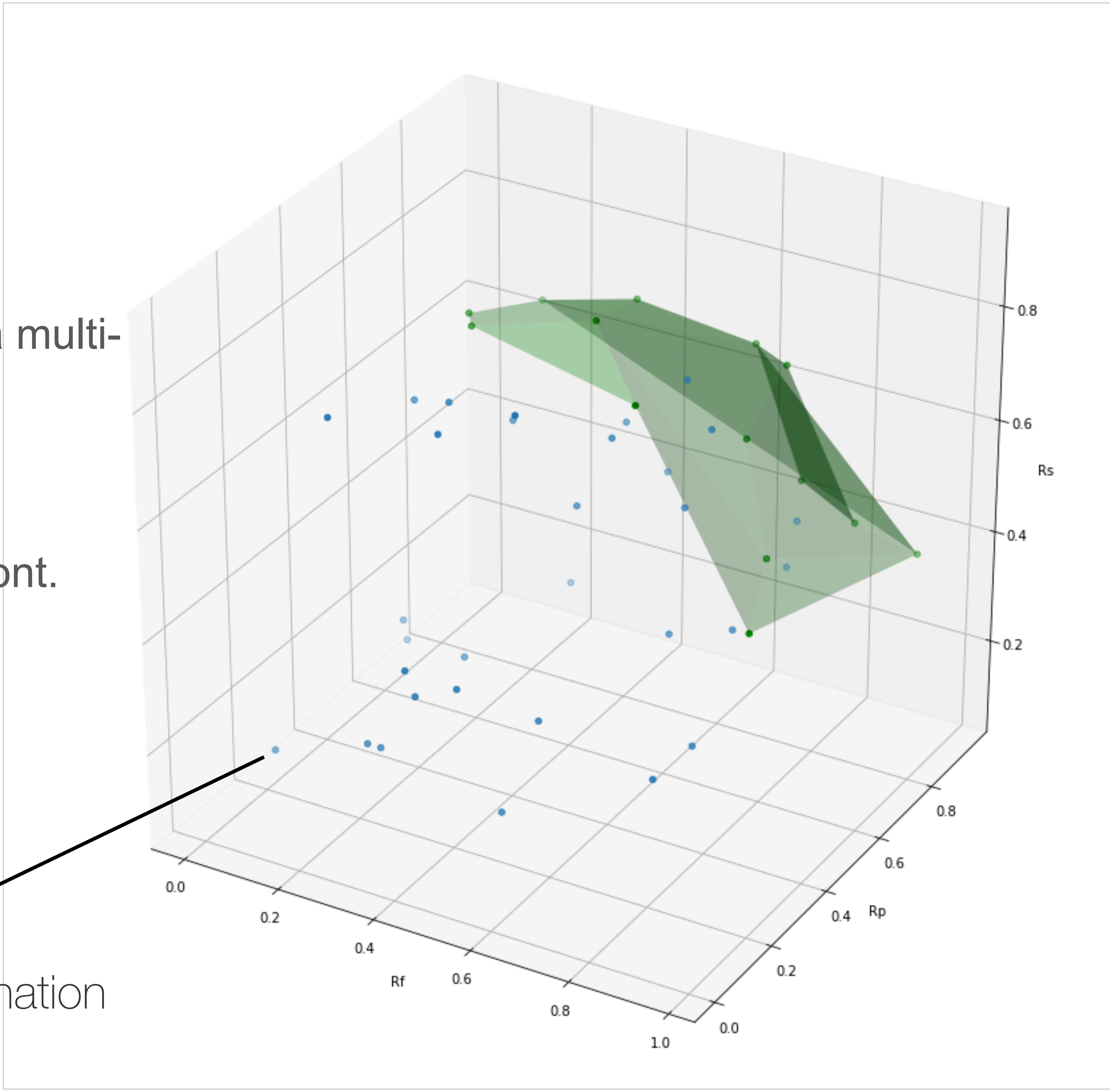

100M
Rf
a.iii.3 a.ii.3 a.i.3 a.i.5 b.i.3 b.ii.4 b.iii.1 b.i.4 c.ii.3
250M
Rf
a.iii.3 a.ii.3 b.ii.4 a.i.3 c.iii.1 b.i.4 c.ii.3 b.iii.1 b.iii.1
500M
Rf
a.ii.3 a.iii.3 b.i.4 b.i.3 b.ii.3 b.ii.4 b.iii.3 a.i.3 b.ii.4

Experiments showed that Individual ranking criteria have:

- High coherence.
- Low conformance.

Bench-Ranking as a multi-Objective Optimiz. Problem

- We look at the Bench-ranking as a multi-objective problem.
- We aim to maximize the three dimensions altogether.
- We opt for the standard Pareto Front. algorithm (NSGA2).



An item of configuration combination

e.g, a.i.4

A fast and elitist multiobjective genetic algorithm: NSGA-II: https://ieeexplore.ieee.org/document/996017

Conclusions

BD Prescriptive Analysis

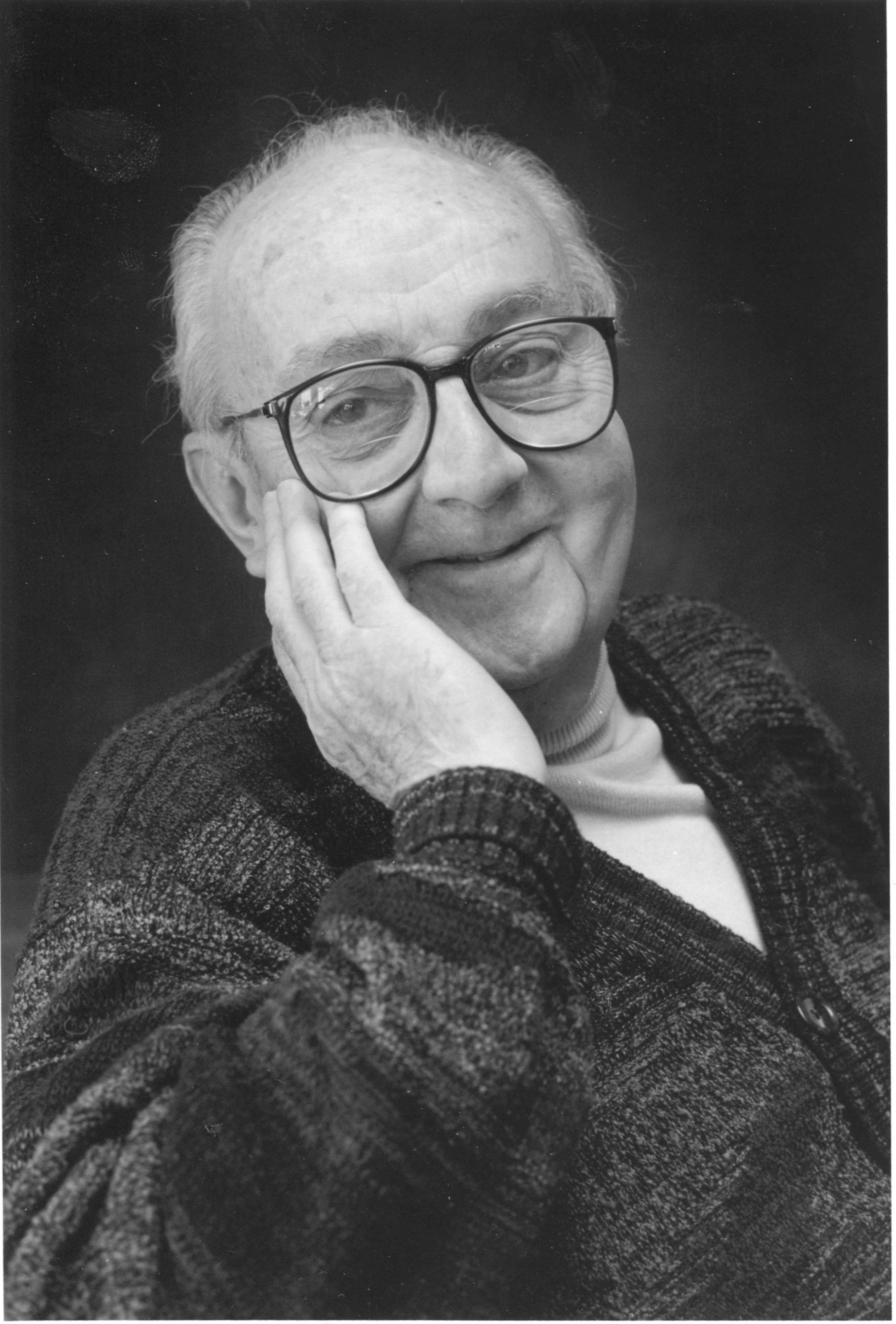
There is still gap in BD Prescriptive analysis.

Case study

We worked the case study of Processing RDF graphs in the realm of Relational world (Apache Spark).

Bench-Ranking

Simple Yet accurate, in the cases of Selecting the best configuration combination out of this complex solution



"All the ~~models~~ rankings are wrong but some of them are useful!" ~~George Box~~ **Ragab**