Schema Discovery in Large Web Data Sources

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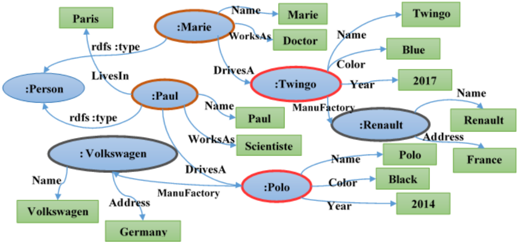
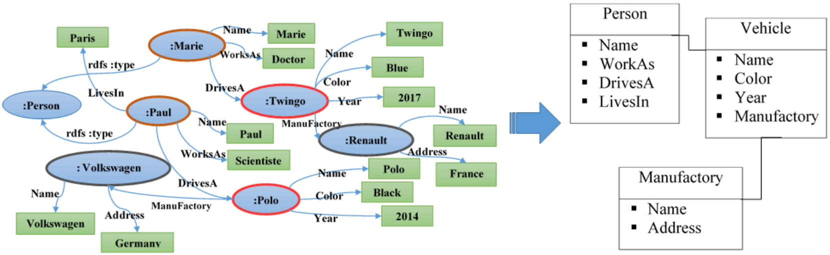
Context: Semantic Web Data

- Increasing number of datasets published in languages proposed by the W3C (RDF(s)/OWL)
    - Represented by triples $< S, P, V >$
    - Contain the data and the schema
- Difficult exploitation of these datasets
    - Incomplete or missing schema
    - Data do not always follow the schema



Our Goal: Toward a Scalable Schema Discovery Approach

- Our goal is to automatically discover the underlying schema given an RDF dataset
- Descriptive schema for the entities within a dataset
- Ensuring the scalability of our approach
  - Implement our proposal using a big data technology

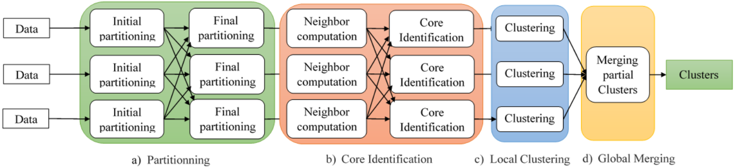


General Principle

- Grouping similar entities into clusters
- Similar entities are those having common properties
  - Evaluated using Jaccard Index: $J(e_i, e_j) = \frac{|e_i \cap e_j|}{|e_i \cup e_j|}$
  - ϵ similarity threshold
- A cluster represents a class in the descriptive schema
- SC-DBSCAN, Density-Based clustering algorithm inspired by DBSCAN
  - Scalable schema discovery approach
  - Implemented using Spark
  - Provides the same results as the sequential DBSCAN

Overview of Our Approach (SC-DBSCAN)

- Partitioning the data
- Identifying the cores
- Computing the partial clusters
- Merging the partial clusters



- The entities are distributed over the calculating nodes according to the properties
- Partitions
  - A partition $part_{p_x}$ is a subset containing entities described by the property p_x
- The question is how to assign entities to partitions ?

Data Partitioning

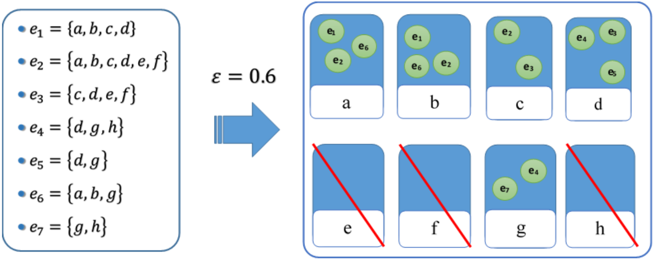
Entity assignment

- Naive assignment
  - Basically, assign an entity e to a partition $part_{p_x}$ if e is described by p_x
  - This assignment ensures that all similar entities are compared
  - Many meaningless comparisons
- Optimized assignment
  - Assign the entities to a minimum number of partitions ensuring all similar entities are compared
  - Reduce the number of partitions
  - Reduce the number of entities in each partition
  - Skip more meaningless comparisons

Data Partitioning

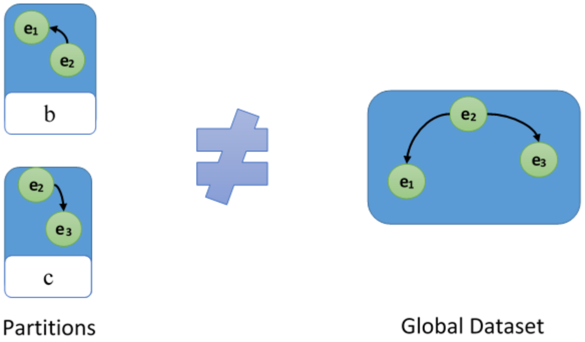
Optimized assignment

- An entity e_j is similar to e_i if they share at least $|e_i| * \epsilon$ properties
  - $\frac{|e_i \cap e_j|}{|e_i \cup e_j|} \geqslant \epsilon \iff |e_i \cap e_j| \geqslant |e_i \cup e_j| * \epsilon$
  - $|e_i \cup e_j| \times \epsilon \geqslant |e_i| * \epsilon \implies |e_i \cap e_j| \geqslant |e_i| * \epsilon$
- Dissimilarity threshold $k_{e_i} = |e_i| - (\lceil |e_i| * \epsilon \rceil) + 1$
- Assigning an entity e_i to k_{e_i} chosen partitions
  - Reduces the duplication
  - Ensures comparing e_i with all its neighbors

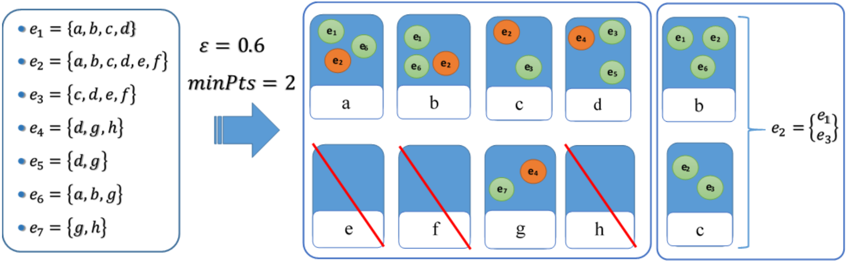


Core Identification

- An entity is a *core entity* if the number of entities in its ϵ-neighborhood is greater than *minPts*.
  - *minPts* density threshold
  - ϵ similarity threshold
- The neighborhood of an entity may span across several partitions

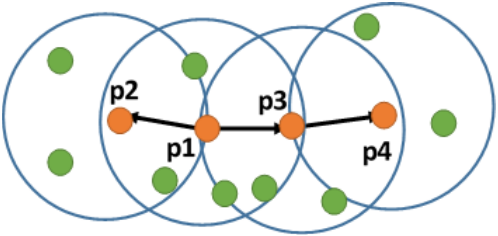


- Neighborhood computation
  - The neighbors of each entity in each partition are computed in parallel
  - Merge for each entity the lists of its neighbors
- The entities having a number of neighbors greater than *minPts* are cores



Partial Clustering

- For each core entity e
  - A cluster C that contains e and its neighbors is created
  - Recursively the neighbors of the cores in C are added to C



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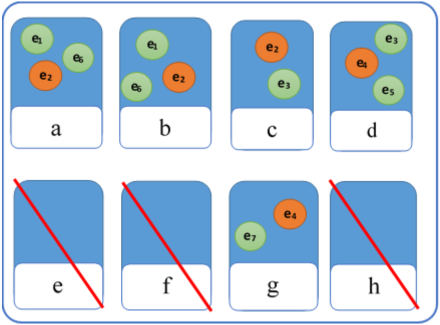

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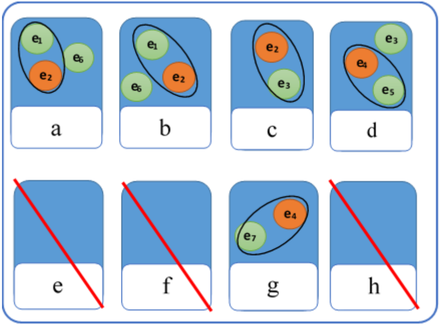
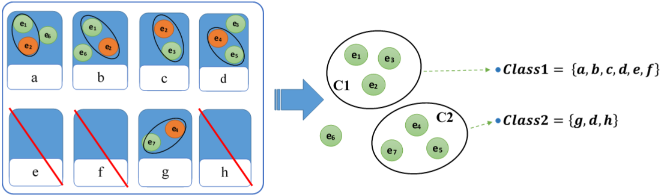


Merging Partial Clusters

- The partial clusters having a core entity in their intersection are merged
- Each resulting cluster represents a class of the descriptive schema

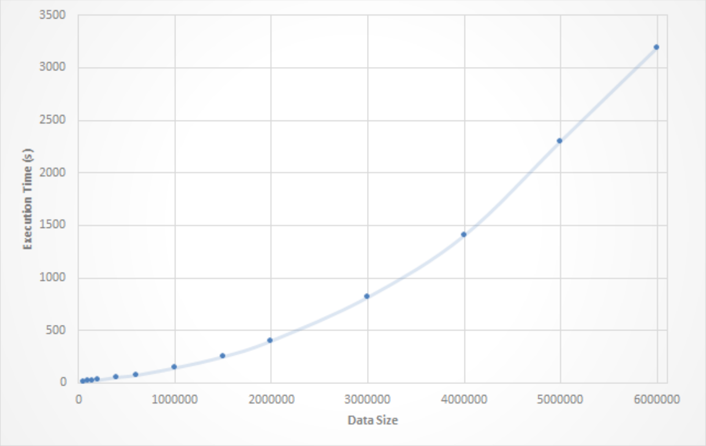


Evaluating our Approach

- Scalability of the clustering
  - Execution time
  - Using synthetic datasets [IBM Quest Synthetic Data Generator]
- Environment
  - Ubuntu Linux, Apache Spark 2.0
  - Scala
  - 5 nodes (1 master and 4 slaves), 30 GB of RAM and 12 Core CPU

Scalability of the Clustering

- Evaluating the similarity using Jaccard Index
- Parameters: $\epsilon = 0.8$, $minPts = 3$



Existing Approaches for Discovering the Structure of a Dataset

- Schema discovery using clustering algorithms
  - Cluster similar entities into classes that form the schema
  - Do not scale-up [K. K-Menouer, Z.Kedad, TLKDS 2016, K.Christodoulou et al., TLKDS 2013]
- Schema discovery for big data
  - Grouping entities having the same type declaration and propose a descriptive schema [M.Baazizi et al., EDBT 2017, D.Ruiz et al., ER 2015]
  - Not suitable when the schema is incomplete or missing
- Scalable versions of DBSCAN
  - Duplicating the whole datasets in all the calculating nodes is too costly [M.Patwary et al., SC 2012]
  - Some approaches are probabilistic and do not provide the same result as DBSCAN [G. Luo et al., BDCloud 2016, I. Savvas et al., WETICE 2016, A. Lulli et al., VLDB 2016]
  - Because of the high dimensionality of web data, the algorithms that require to order the data or partitioning the data using methods such as BSP are not efficient [D. Han et al., IPDPS 2016, Y. HE et al., IPDPS 2013]

Conclusion

- Contribution towards the scalability of schema discovery
  - Extracting a descriptive schema in large RDF datasets
  - Facilitating RDF datasets exploitation
- SC-DBSCAN: a novel distributed clustering algorithm
  - Implemented using big data technology
  - Providing the same clustering result as DBSCAN
- Key ideas of SC-DBSCAN
  - Partitioning according to properties
  - Parallelize the clustering

Future Works

- Perform more experiments on SC-DBSCAN
  - Number of properties describing the data
  - The size of the entities
  - Use Spark clusters of different configurations
- Study the evolution issues
  - Update the schema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dakujem vám
ありがとう
ngiyabonga
dziękuję
merci
thank
you
baie dankie
धन्यवाद
molte grazie
suksema
danke
gracias
obrigada
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Quality Evaluation

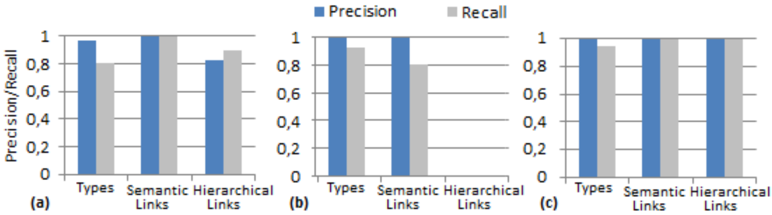

Figure: Evaluation of Schema Discovery in Conference (a) BNF (b) and DBpedia (c).