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RECORD LINKAGE AND PPRL with Clustering of Matches

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AGENDA

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- Record Linkage with Clustering
  - FAMER Tool
- Privacy-Preserving Record Linkage (PPRL)
  - PRIMAT Tool
- Summary

RECORD LINKAGE WORKFLOW

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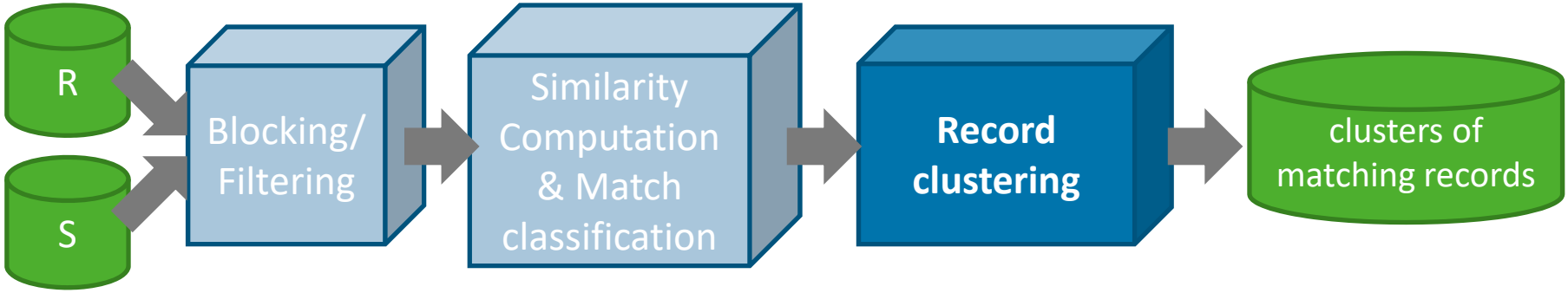

- input: 1, 2 or n data sources
- clustering can improve match quality
  - additional matches
  - removal of wrong matches
- compact representation of matches
  - cluster with k records corresponds to k(k-1)/2 match pairs
  - e.g. 10 elements instead of 45 match pairs

FAMER TOOL

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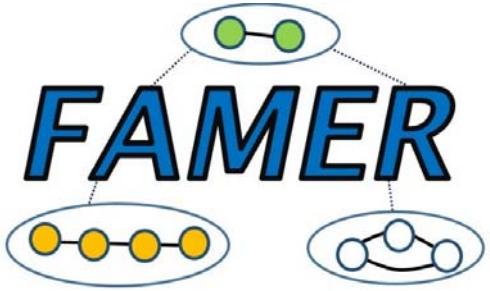
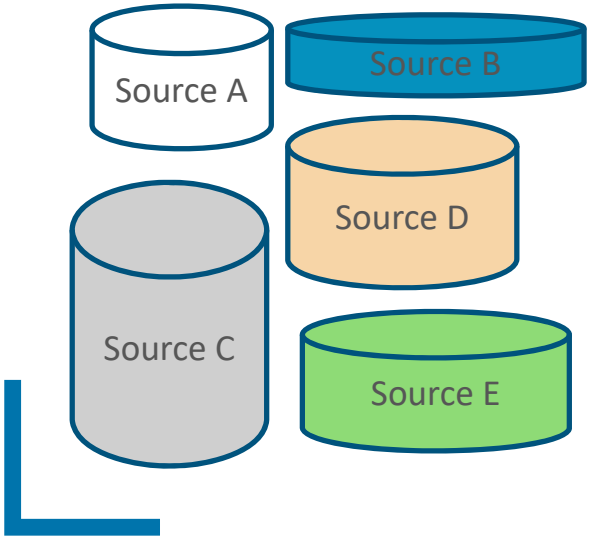


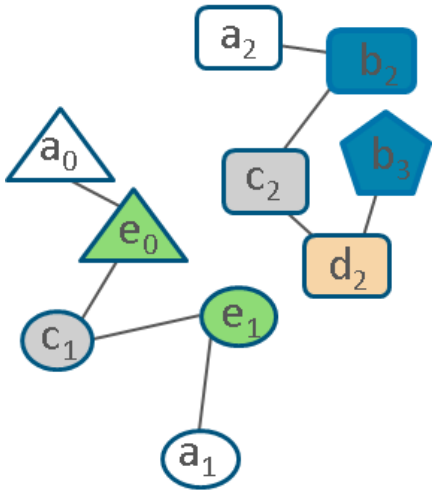
FAst **M**ulti-source **E**ntity **R**esolution System

- scalable linking & clustering for many sources

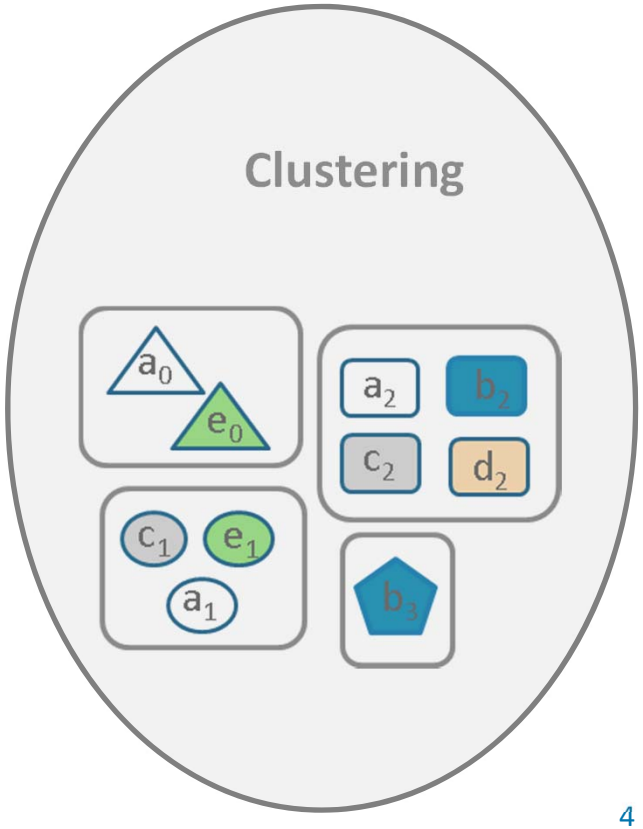
Input



Linking: Similarity Graph



Clustering



FAMER OVERVIEW

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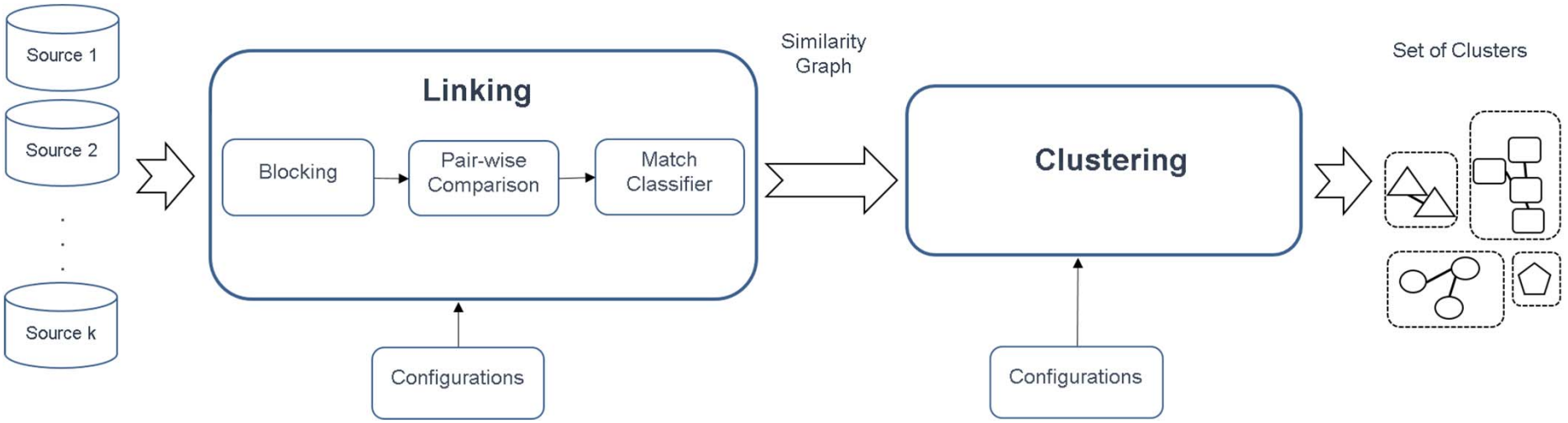

FAMER OVERVIEW

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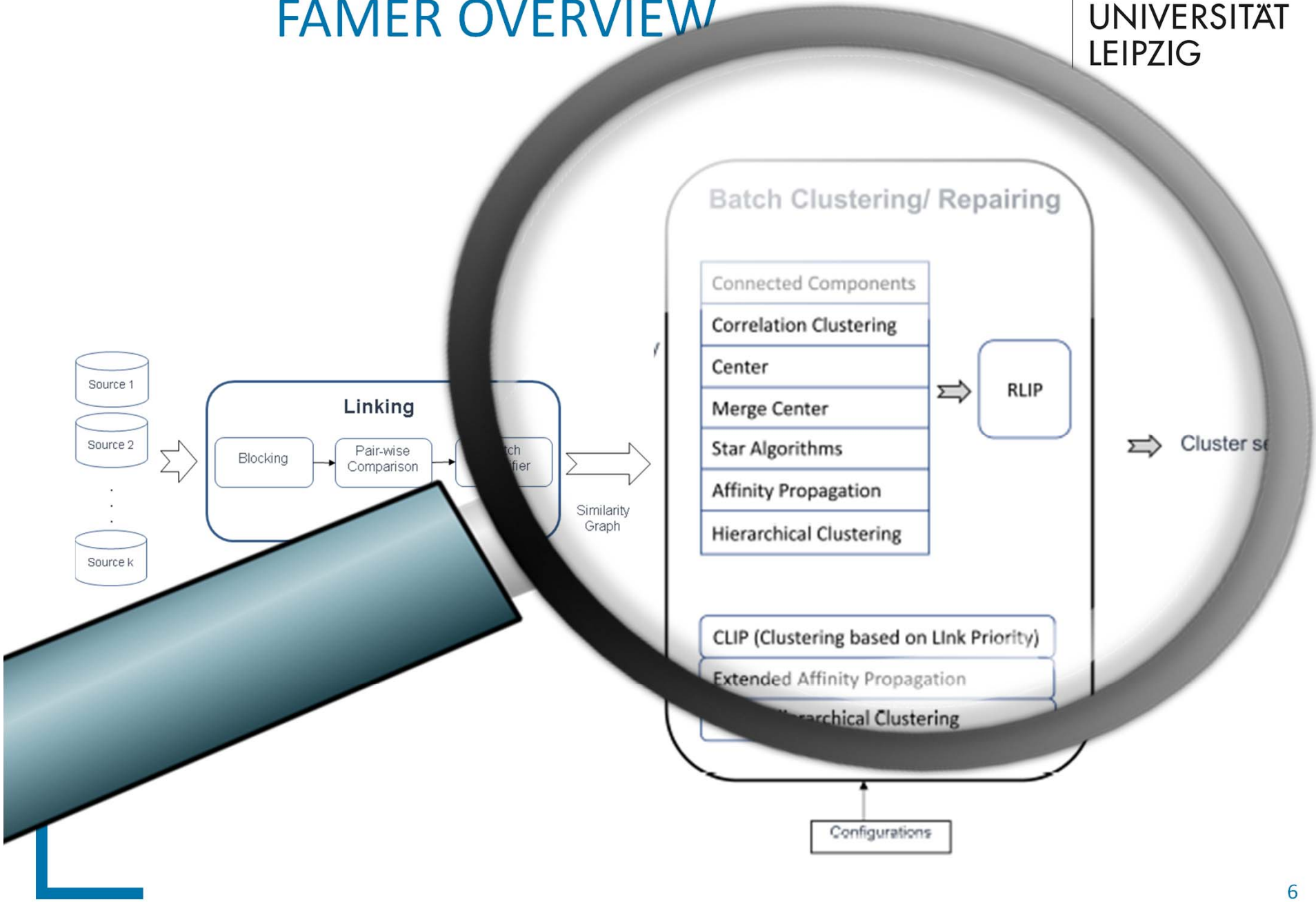

INCREMENTAL MATCHING & CLUSTERING

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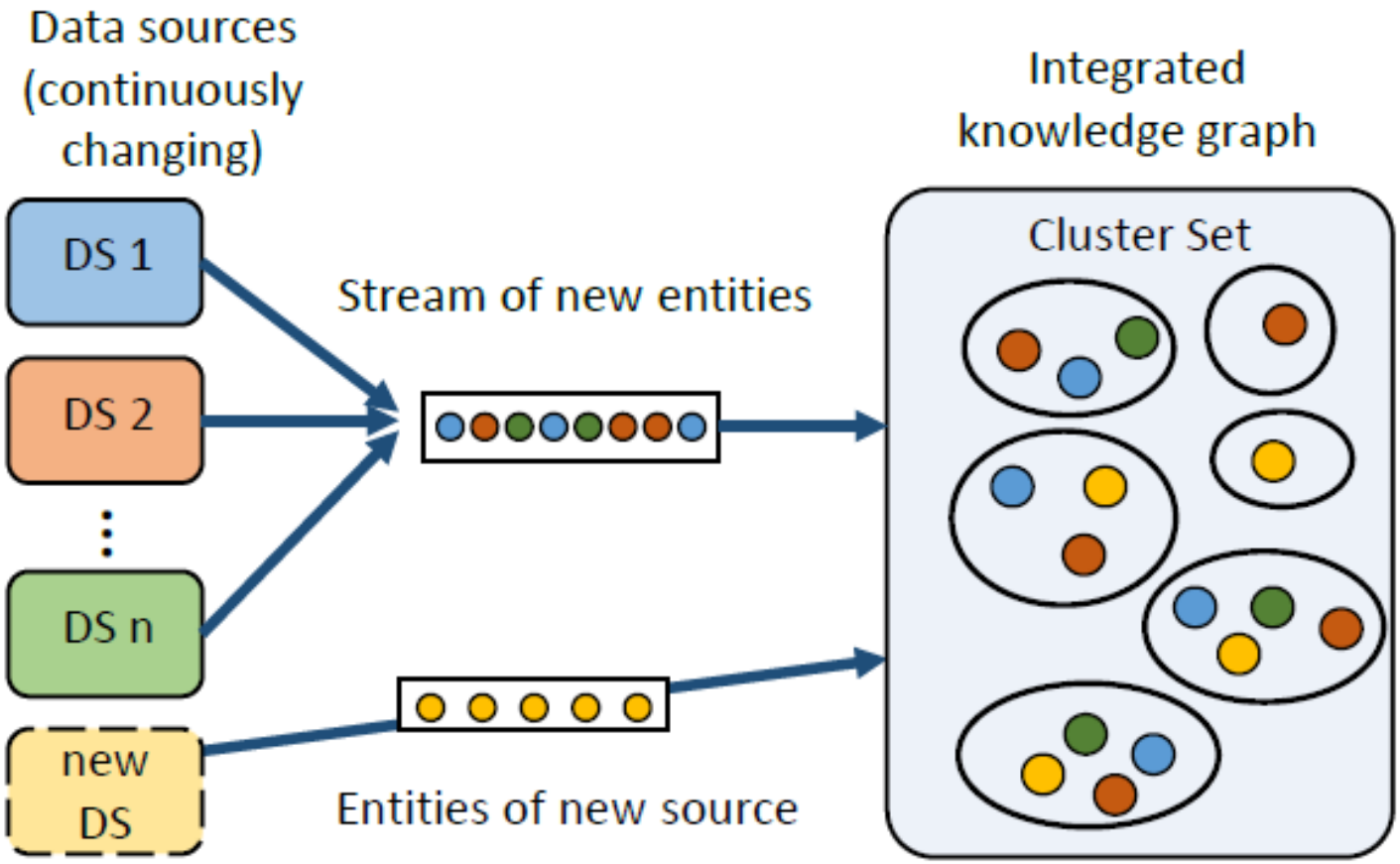

AGENDA

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- Record Linkage mit Clustering
  - FAMER Tool
- Privacy-Preserving Record Linkage (PPRL)
  - PRIMAT Tool
- Zusammenfassung

PPRL REQUIREMENTS

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- high degree of privacy
  - no forwarding of unencoded quasi-identifiers to other institutions
  - minimal attack risk, e.g. no forwarding of person data to multiple sites or no central storage of (encoded) patient lists
- High performance and scalability
  - Many institutions, many persons/patients
- high match quality on encoded data
  - robustness against data errors/deviations, e.g. changed last name
  - support for match groups (clusters), not only match pairs
- dynamic PPRL: support for additional patients/ institutions
- flexible usability in different projects / scenarios
  - possible need to allow re-identification of patiens, e.g. for recruitment in new clinical study
- suitable tool support
  - flexible configurability, support for different usage forms
  - ease of use

BATCH VS. INCREMENTAL MATCHING

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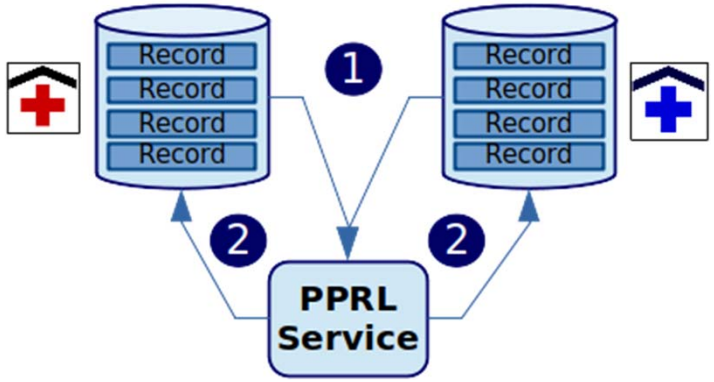
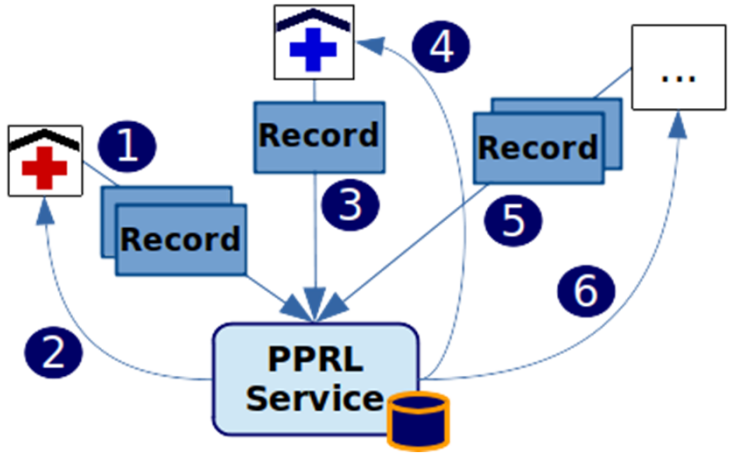
- **Batch Matching**
  - linkage on fixed set of data
  - no storage of data and match resulzts at linkage unit
  - re-computation needed for changed data



- **Incremental Matching**
  - encoded person records and matches are stored in database
  - incremental matching for new records
  - faster compared to complete re-computation



PRIMAT TOOLBOX

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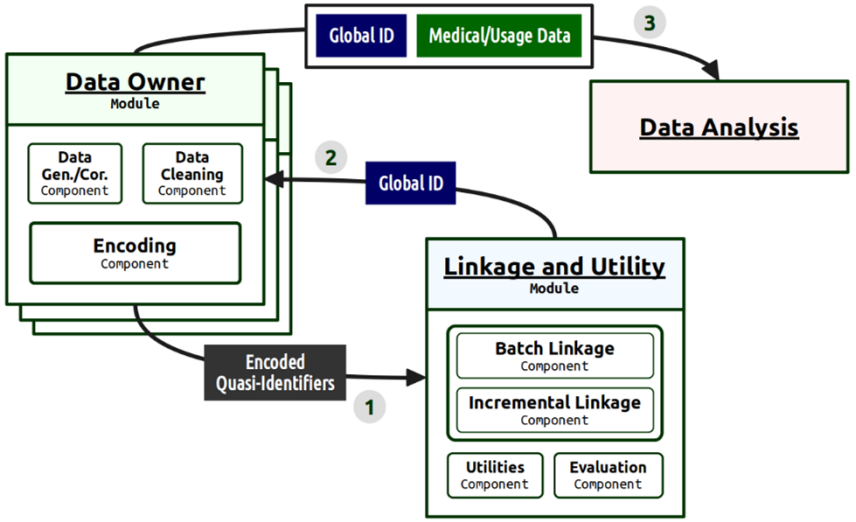
- **Pri**vate **Ma**tching **T**oolbox (Uni Leipzig)
- open-source PPRL-Tool for entire PPRL process
  - components for data owner and Linkage Unit
  - batch or incremental matching
- flexible configuration and execution of PPRL workflows
- high performance by blocking and parallel matching

PRIMAT
Private Matching Toolbox



Franke, M.; Sehili, Z.; Rahm, E.: *PRIMAT: A Toolbox for Fast Privacy-preserving Matching*. PVLDB 2019

COMPARISON OF PPRL TOOLS

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	Mainzelliste (Lablans et. al.)	PRIMAT (U Leipzig)
Open source	✔	✔
data cleaning	(✔)	✔
Flexible encodings (Bloom Filter)	field-level Bloom Filter	✔
Hardening support	✗	✔
private blocking (with LSH)	✔	✔
Parallel matching	✗	(✔)
Match grouping / clustering	without transitivity	✔
Central or decentralized linkage	central	central
Batch + incremental Matching	Incremental	(✔)

CLUSTERING IN MAINZELLISTE

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- Mainzelliste tool used in many projects in Germany
- Cluster is represented by oldest (first) record
- new record is assigned to cluster with highest similarity (above threshold)
- inserts are processed one record at a time (slow, results can depend on order of inserts)
- **Problems:**
  - poor qualiy of cluster representant (first record) can reduce match quality
  - fixed cluster representant cannot deal with changes in address, name etc.
  - joint insertion of multiple records or entire sources can improve performance and quality

CLUSTERING MAINZELLISTE PROBLEM SCENARIO

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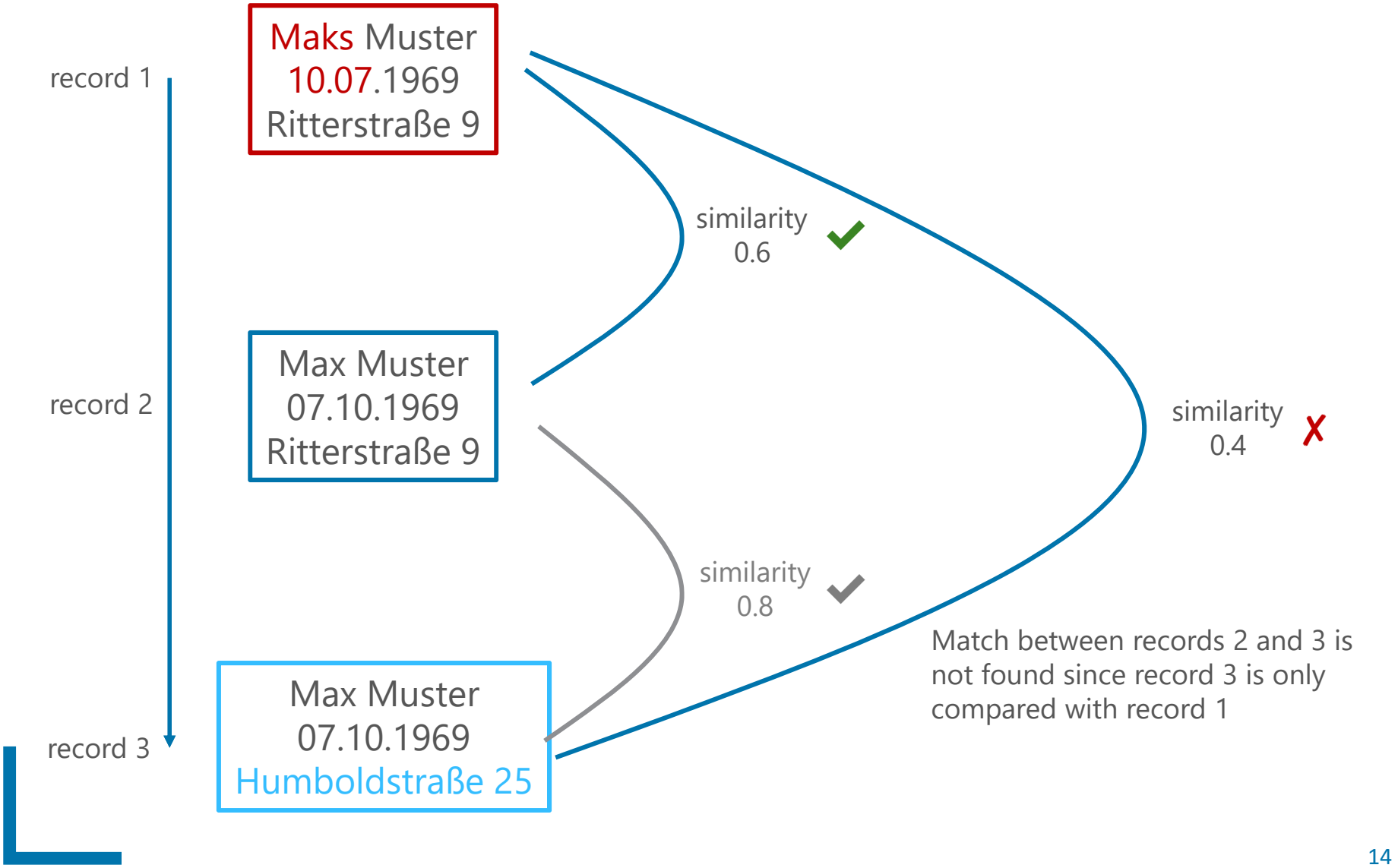

CLUSTERING MAINZELLISTE PROBLEM II

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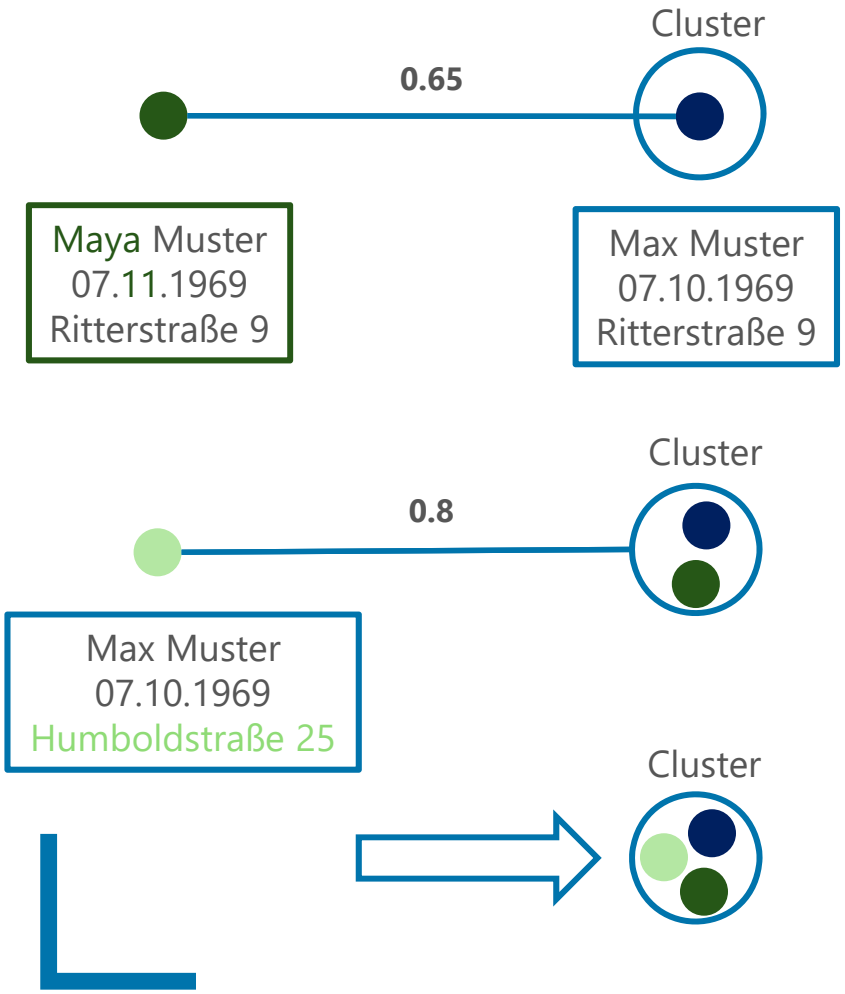
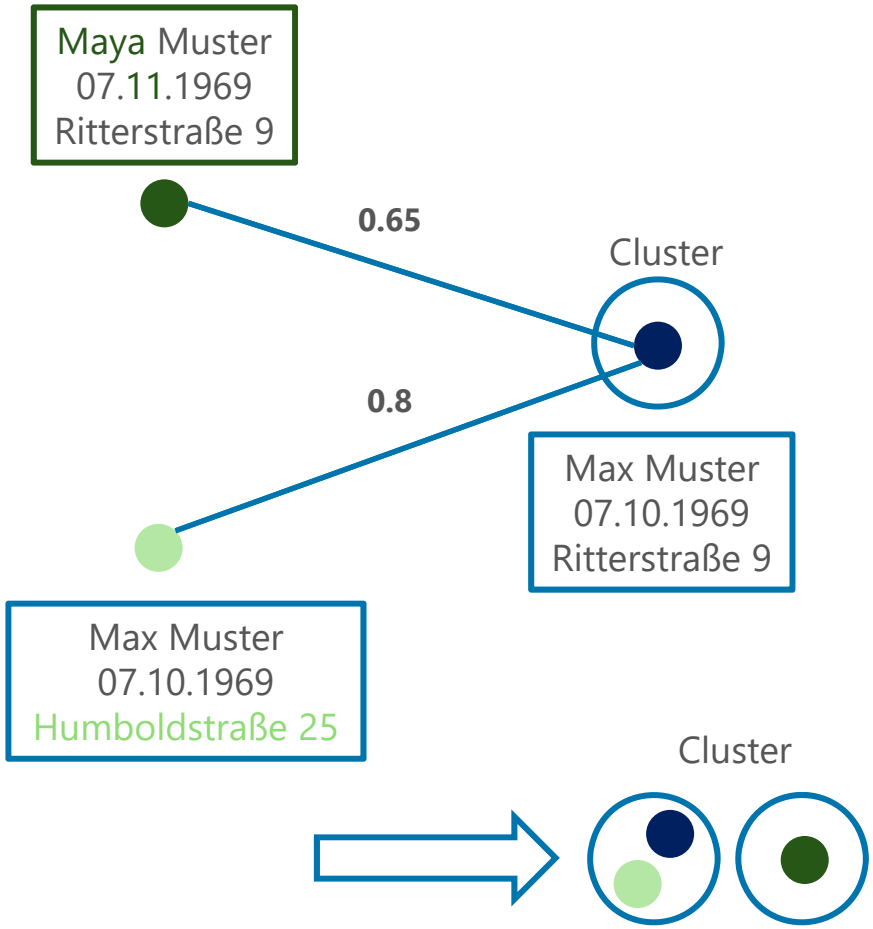
record-wise matching



joint consideration of multiple records

From duplicate-free source



CLUSTERING EXTENSIONS

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- Record for sources whether they are duplicate-free
  - optimized cluster assignment (per cluster at most one record of duplicate-free source)
- Comparison with all cluster members or only 1 representant
  - trade-off between quality and scalability
- Dynamic selection of cluster representant
  - youngest (newest) record
  - record with highest average similarity to all other cluster members
  - ‚virtual' cluster representant by aggregating cluster members, e.g. with Counting Bloom Filter

COUNTING-BLOOM-FILTER AS DYNAMIC CLUSTER REPRESENTANT

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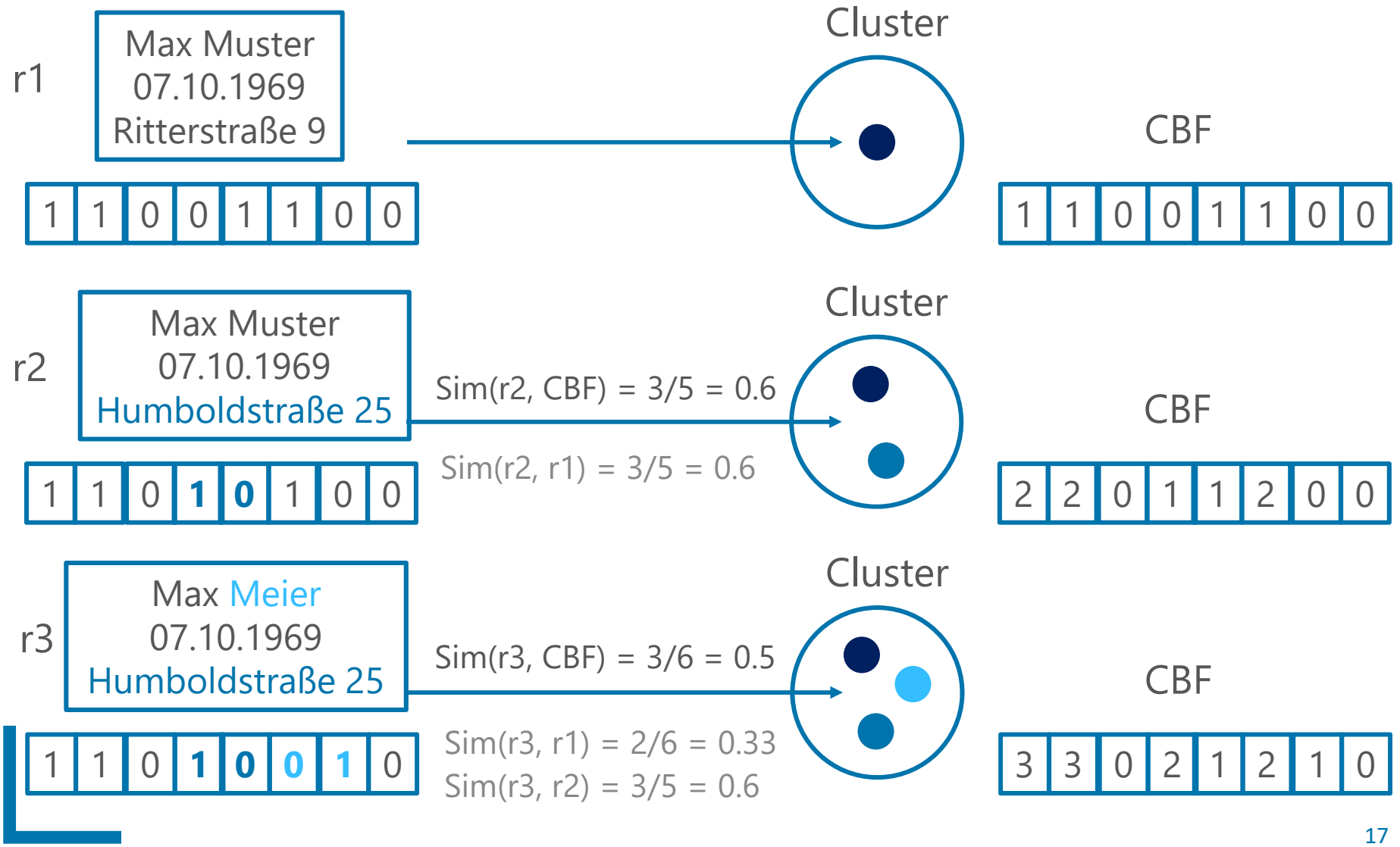

SUMMARY

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- Record Linkage: pipeline with blocking, matching and clustering
- PPRL: many, partiallly project-specific requirements
- flexible configurability needed
  - batch and/or incremental matching
  - preprocessing, encoding, blocking, matching, clustering
- current PPRL tools provide no or insufficient support for clustering
  - need grows with more data sources and more possible duplicates
- PRIMAT: configurable toolbox with high flexibility and performance

REFERENCES RECORD LKINKAGE

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