Metadata Management for Data Integration in Medical Sciences
- Experiences from the LIFE Study -

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LIFE
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Data in Medical Sciences

- Clinical Care
  - Patients with dedicated problems in health
  - Many unstructured data, e.g., anamneses, findings, discharge reports, images
  - Structured data captured or derived from unstructured data: diagnoses, procedures etc. → goal: mostly billing
- Medical reserach projects
  - Recruited patients/probands
  - Determining a specific scientific goal
  - Mostly structured data + complex types (genetic data, images, …)

LIFE Research Center

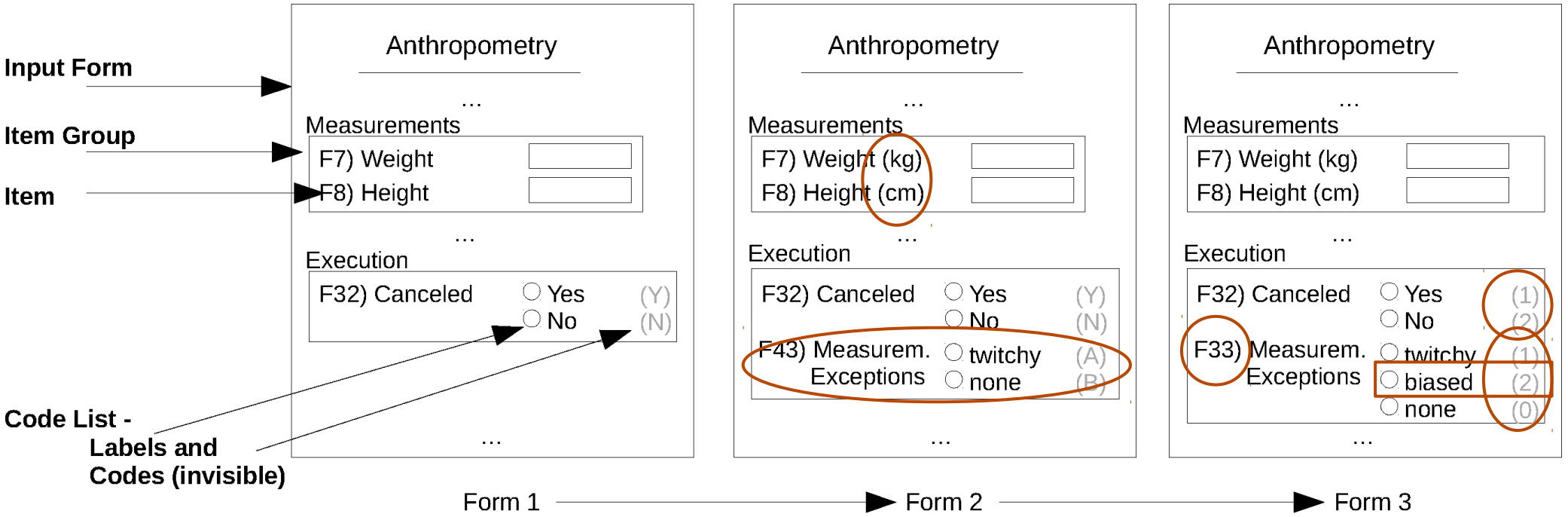
- Center at the Medical Faculty, Univ. of Leipzig
- Goal: Prevalences, risk factors and development of common civilization diseases
- Different epidemiological studies
  - Two population based cohorts (inhabitants of Leipzig)
  - Three disease specific cohorts
- Complex data capturing processes by multiple hospitals and ambulances
  - Mostly structured data capturing
  - Complex data, e.g., omics data

Multiple Input Forms (10/'16)

Assessment Type	# Assess-ments	avg(|Input Forms| / Assessment|)	|Items|	Avg(|Items| / |Assessment|)
Interview	317	3	18,980	59.9
Questionnaire	217	2	16,740	77.1
Physical Examination	78	2.5	10,606	136
Laboratory	114	1.5	2,110	18.5
. . .	. . .	...	. . .	
Total	> 850	2.4 > 1,700	> 51,000	66.7 (8 - 844)

- Evolution of input forms within a single input system
- Multiple input systems: Online ~, paper based data capturing, spreadsheets, desktop databases, ...

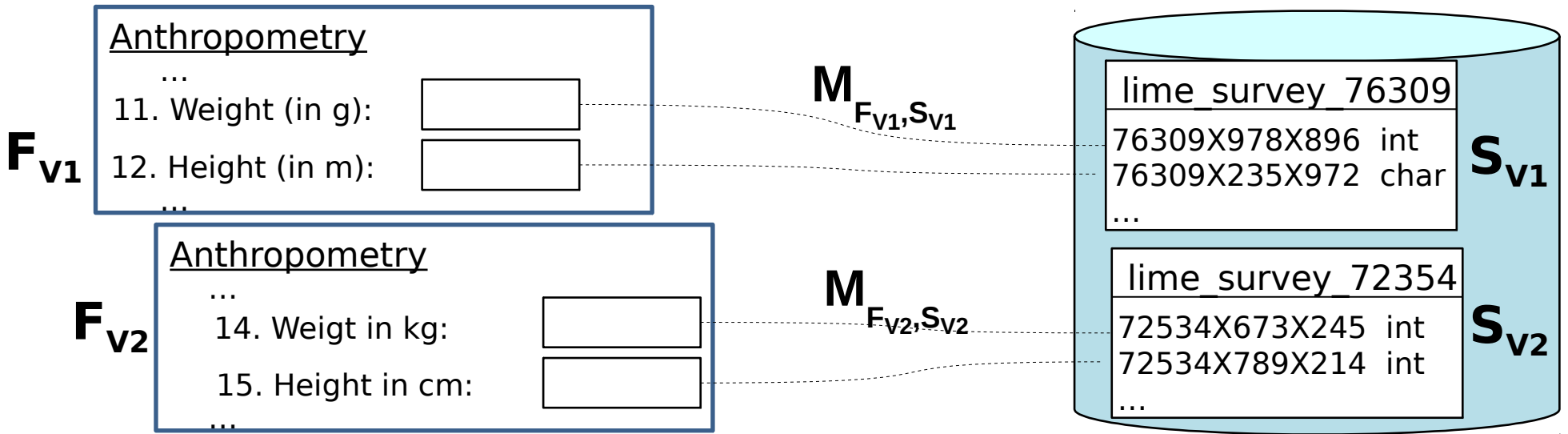
Evolution of Input Forms: Example



Änderungen

Evolution of Input Forms

- Problem: How form modifications can be managed with implications on data integration and later data analyses ?
- Two alternatives
  - Single evolving input form (per input system)
  - Multiple input forms: New form whenever a relevant modification need to be implemented

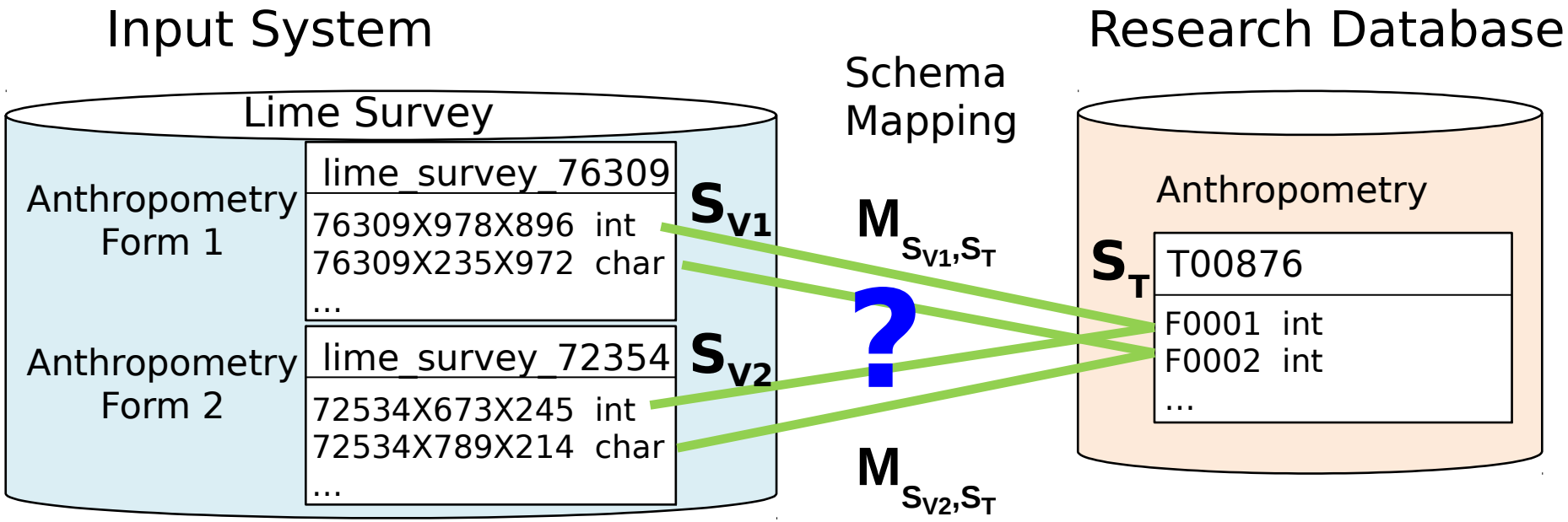


Requirements

- Data capturing and analysis in parallel
- Large set of analysis projects (> 350, Jan. 2017)
- Consider data provenance
- Harmonization of schemas according to evolution of input forms and multiple input systems
  - Study Items (questions, parameters)
  - Code lists (coding of answers)
- Efficiency
  - Automatic data transfer & transformations
  - Dynamic extension of target schema (research database)
- Further requirements: „Data descriptions“ used in analysis, Metadata for query generation, reporting, curation ...

Problem: Integration of Input Forms

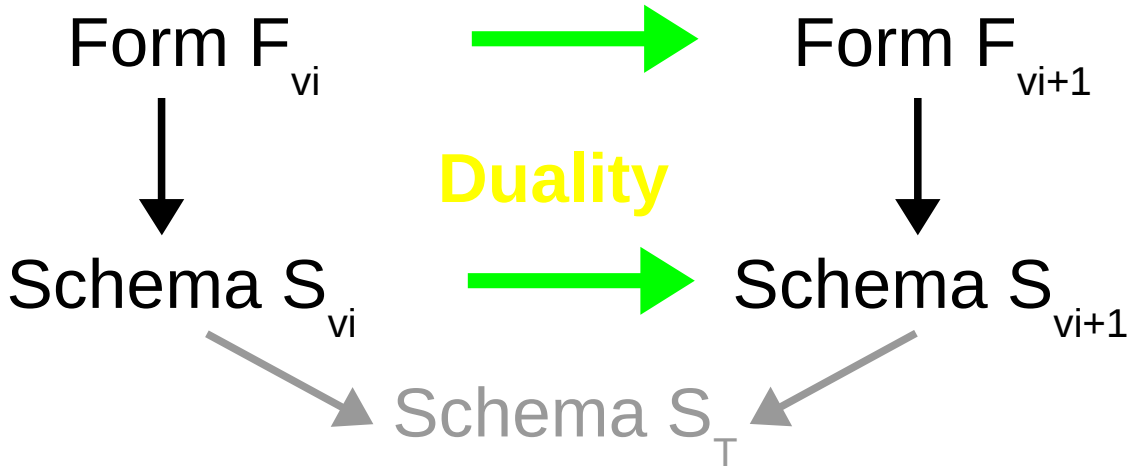
- Harmonization of study items
- Schema examples



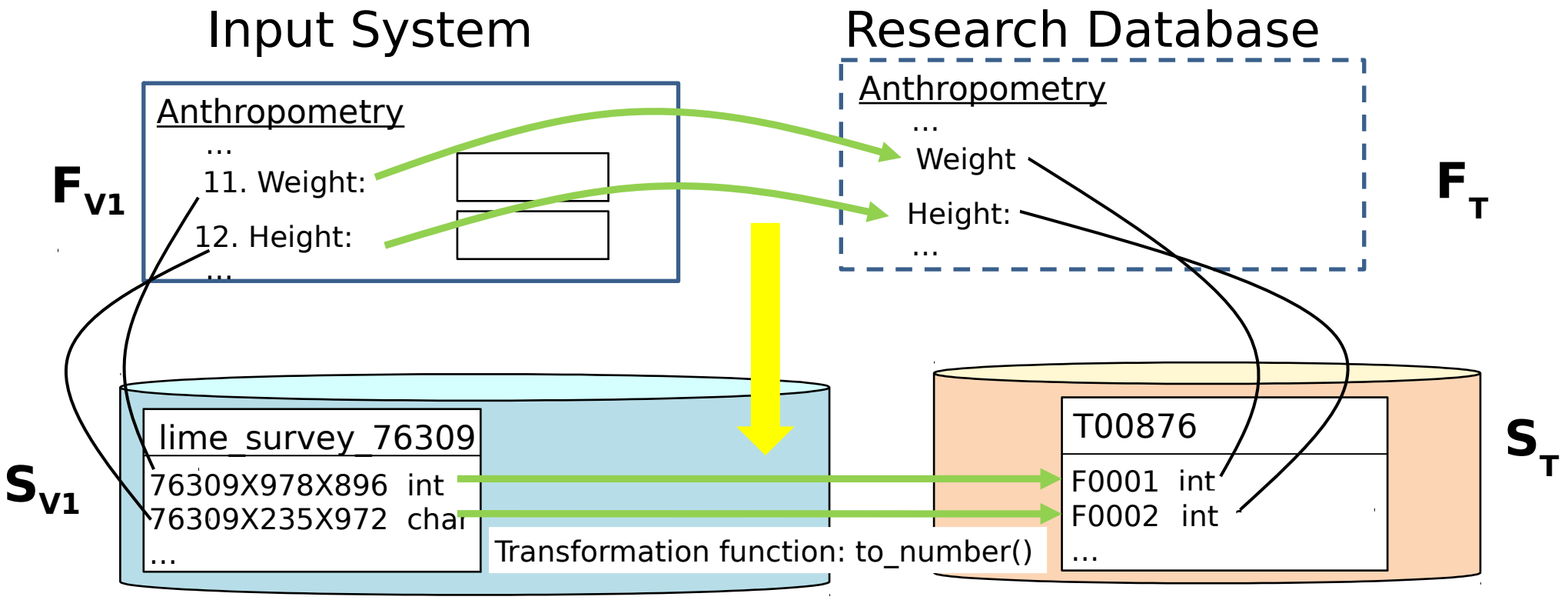
No application of matching techniques on schema level
– mostly names of schema elements are technically induced

Mapping based Approach

- Two step realization
  1) Extension of target schema T for each new assessment – first version (first input form)
  2) Mapping all further forms (vi > 1) to the succeeding form and reuse existing schema mappings M
- Central Idea: Transforming schema mapping problem into form mapping problem

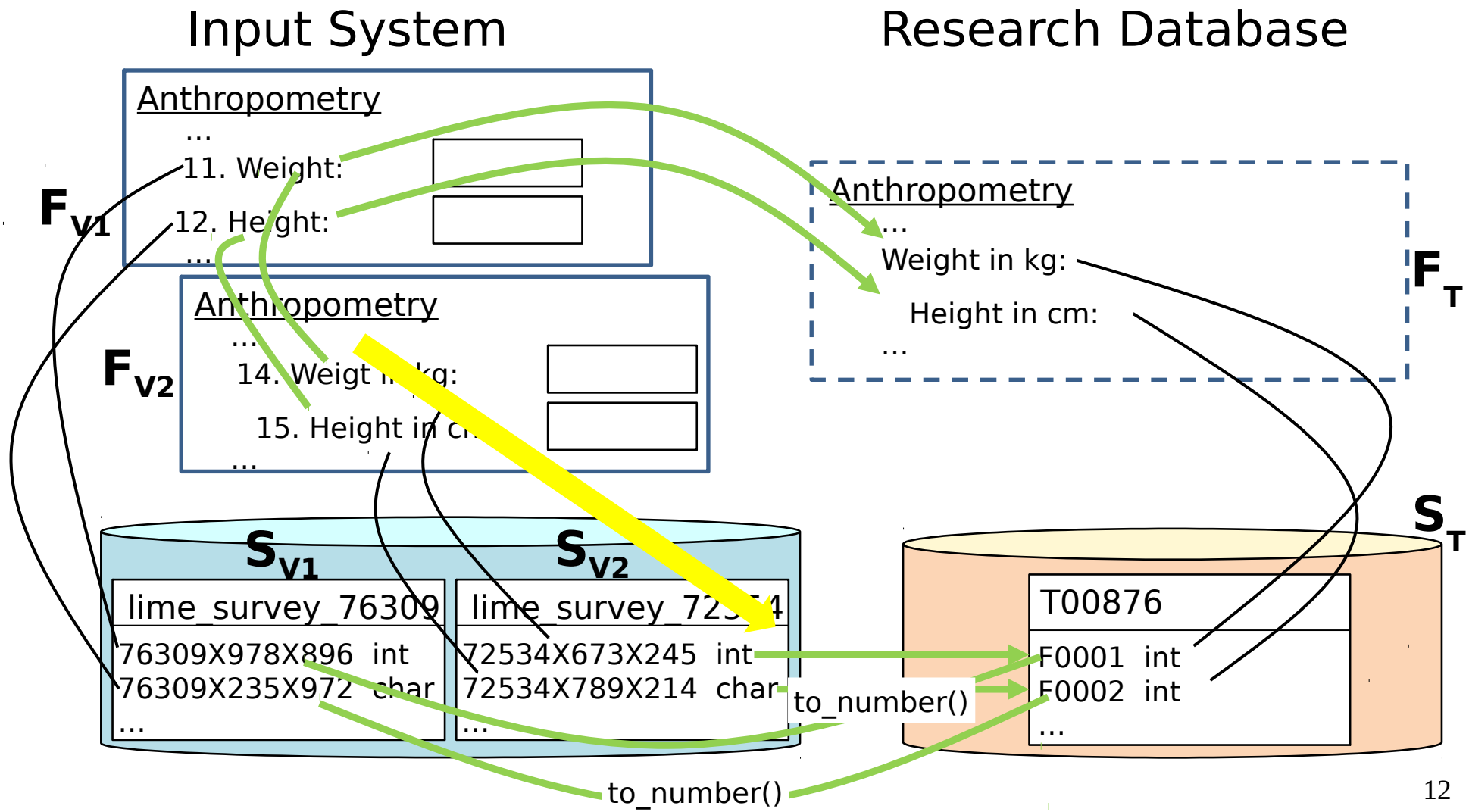


Step 1: Mapping of first Form Version



Derive schema mapping M_{S_{V1},S_T} by mapping composition

Step 2: Mapping of Form Version > 1



Form Matching

- Match process taking item description into account: Question, parameter name
- Different matcher calculating similarity between two items, e.g.,
  - String based similarity: n-gram, Levenshtein, …
  - Set based similarity: Jaccard, ...

Blocking

- Basic Idea: Reducing the number of item – item comparisons without loosing quality
- Different blocking strategies
- **In LIFE**
  - Recurring item groups, e.g., questions according to each drug (medication)
  - Item groups typically unmodified in succeeding forms
- Block → item group (block key → group name)
  - Comparing items of two dedicated blocks belonging to succeeding input forms having the same block key

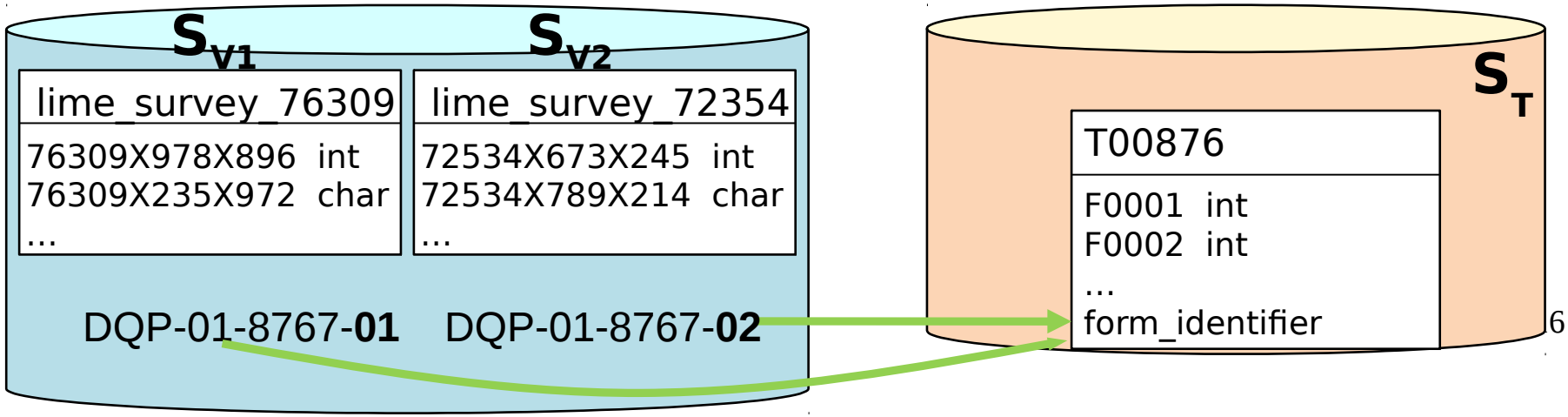
Data Type Mappings

- Mapping data types when extracting data from source system and store them into a target DB
  - Different DBMS specific data types, e.g., TEXT (MySQL), VARCHAR2, LONG (ORACLE)
  - Implementation: **type [length|precision[, scale]]** e.g., VARCHAR2 (20), INT(1), DECIMAL(5, 3)
- Building data type patterns
- Map data type patterns of sources to target DB

Source Data Type Pattern (MySQL)	Target Data Type Pattern (ORACLE)
VARCHAR(<LENGTH>)	**VARCHAR2(<LENGTH>)**
TEXT	**CLOB**

Data Provenance

- Multiple input forms per assessment
- Key question in LIFE: What data have been produced by which input system – by which input form F_x?
- Idea:
  - Associate an identifier for each form in MD
  - Represent form identifier in target table as instance



Evaluation

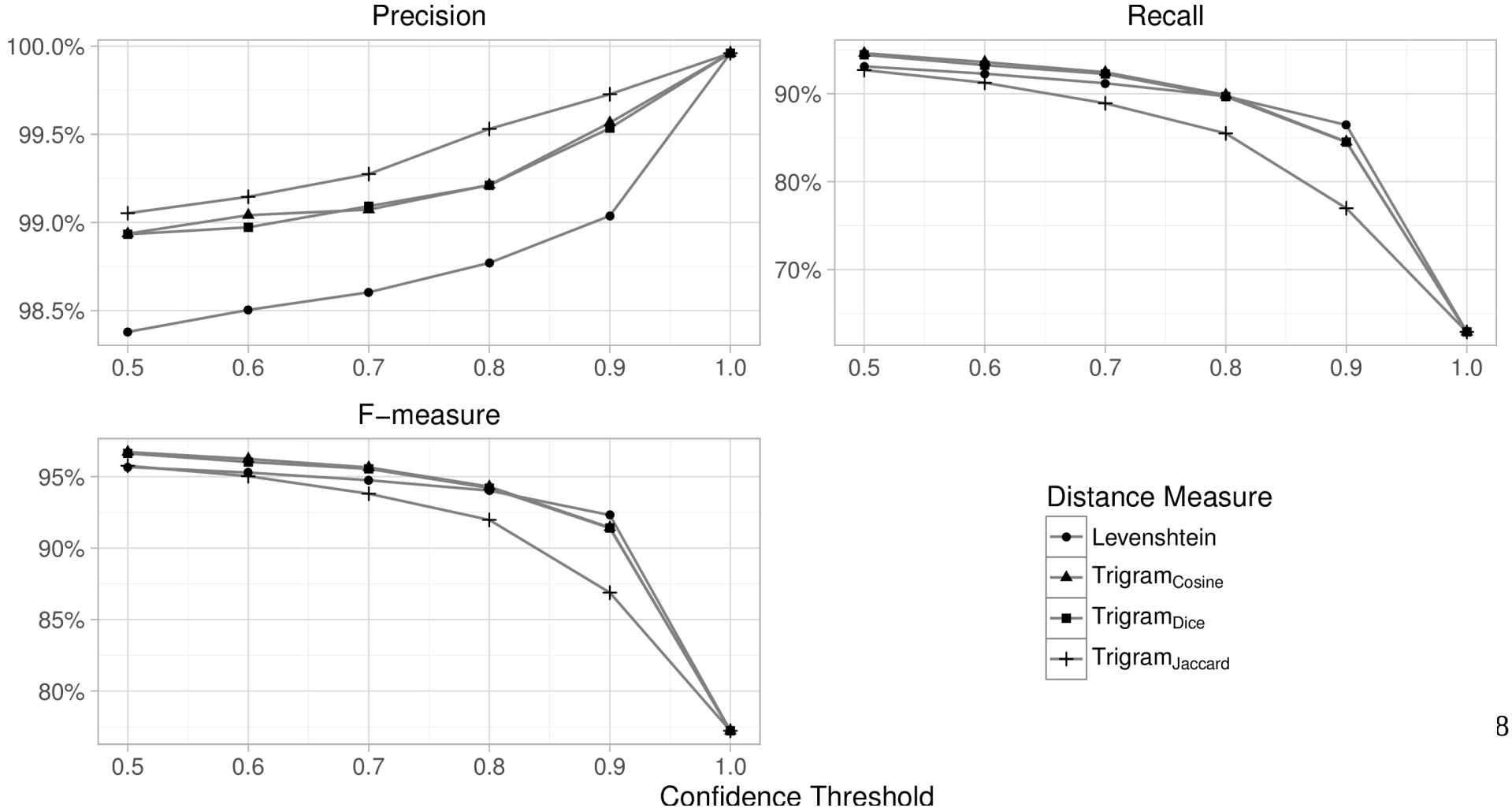
- Set up
  - Use all checked mappings as gold standard
  - Map all input forms per assessment in chronologic order
  - Evaluate match quality – no user adaptations of descriptions, aliasing etc.

|Mappings|	|Assessments|	avg (|Items per Assessment|)	min - max(|Items per Assessment|)
1	528	47.5	6 - 789
2	138	78.9	6 - 844
3	62	59.7	9 - 279
4	37	101.9	19 - 637
5	31	73.6	16 - 463
6	22	74.6	19 - 411
7	22	58.9	17 - 425
8	12	83.6	20 - 467
9	2	65.6	27 - 197
10	1	102.9	83 - 119

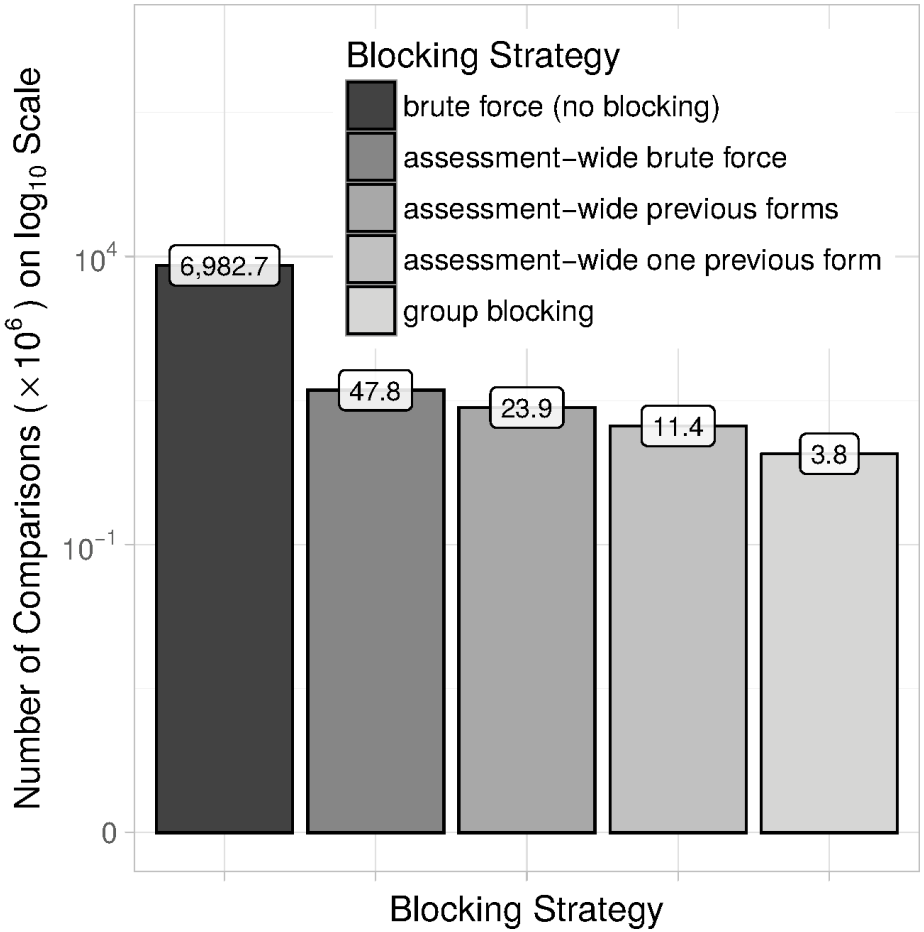
1,166 forms
327 assessments

Evaluation Results: Quality

- Trigram-Jaccard (string) with best precision but worsest recall
- Trigram-Dice with best F-Measure for nearly every threshold



Evaluation Results: Blocking



- Different blocking strategies
- Brute force = vector of all items
- Most reduction when blocking based on item groups
- Reduction factor 1,838

- No significant loss of quality when blocking mode is used

Metadata Repository

- Sometimes called data dictionary
- Central collection of
  - Sources MD
  - Assessments and input forms, code lists, data types
  - Mappings on different levels
- Used for
  - Extraction, transformation & loading
  - Query generation
  - Reporting
  - Curation (in close connection with R)

Conclusions

- LIFE: Epidemiological study with large set assessments
  - Evolving input forms (multiple forms per assessment)
  - Different input systems
- Need for harmonization
- Matching input forms → derive schema mappings
  - Automatic generation
  - Manual check & adaptation (if necessary)
- Scientific evaluation
- Running in production mode for 5y

Thank You