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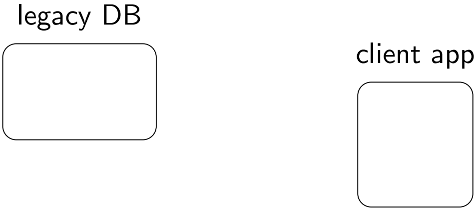

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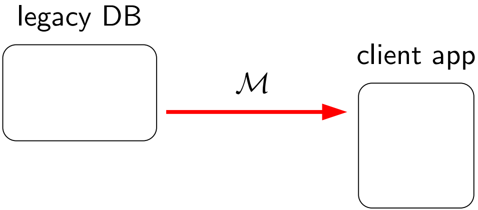

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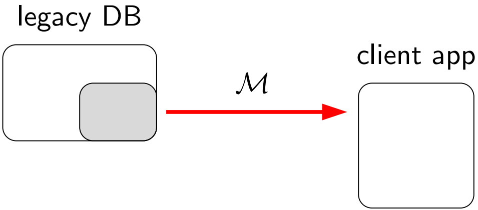

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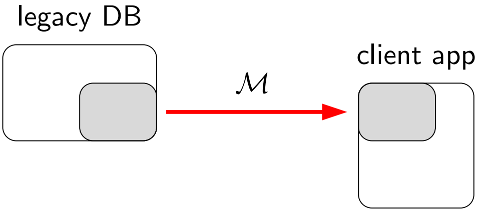

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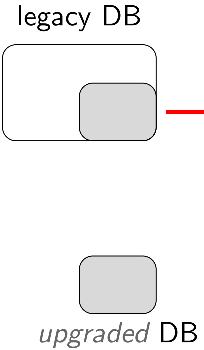

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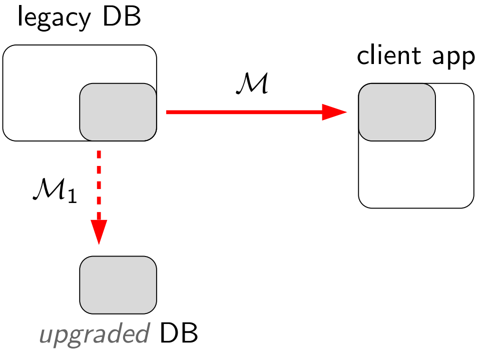

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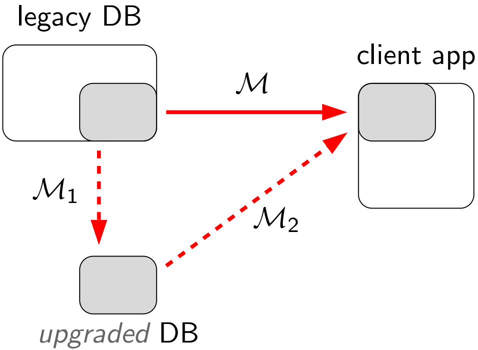

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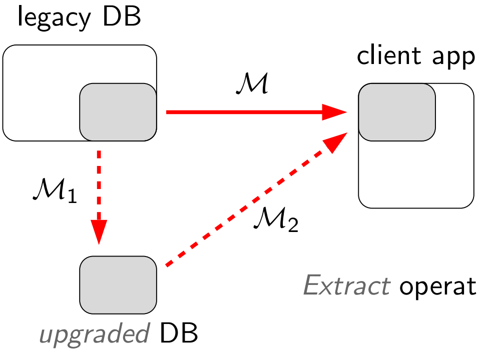

Extract operation

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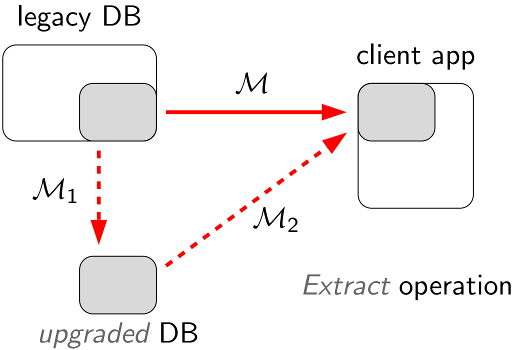

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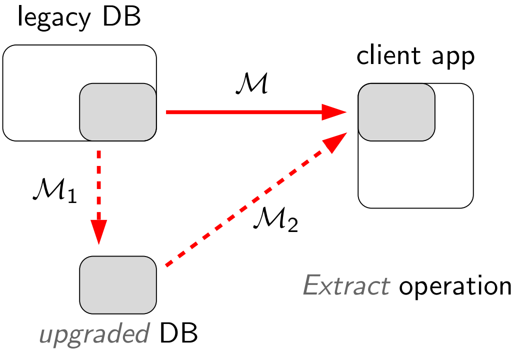

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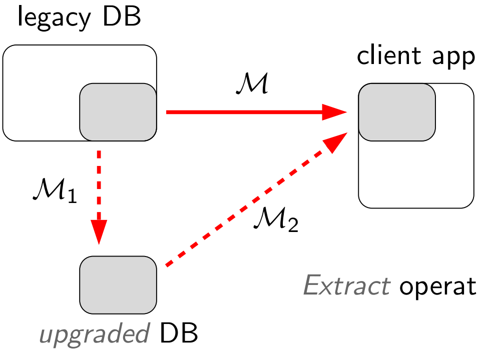

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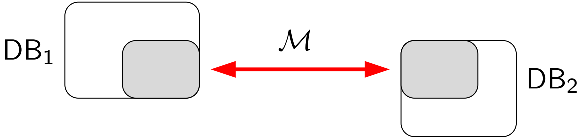

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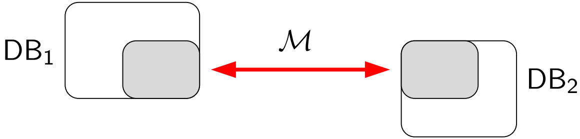

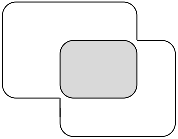

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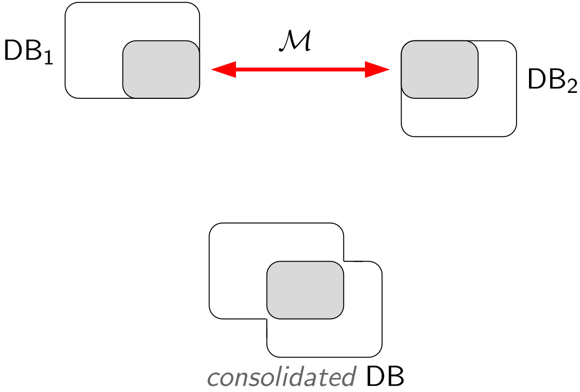

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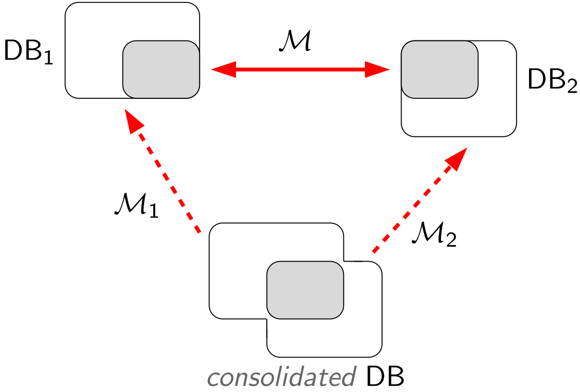

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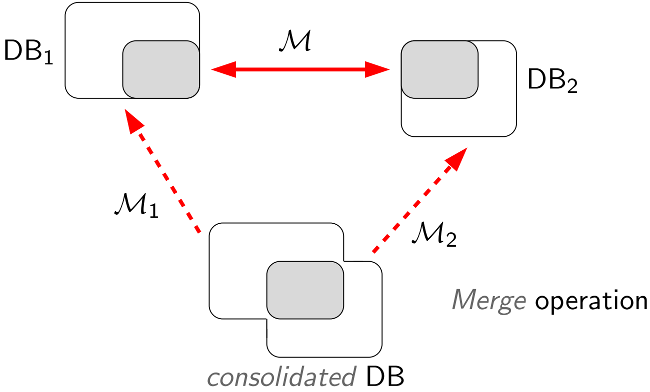

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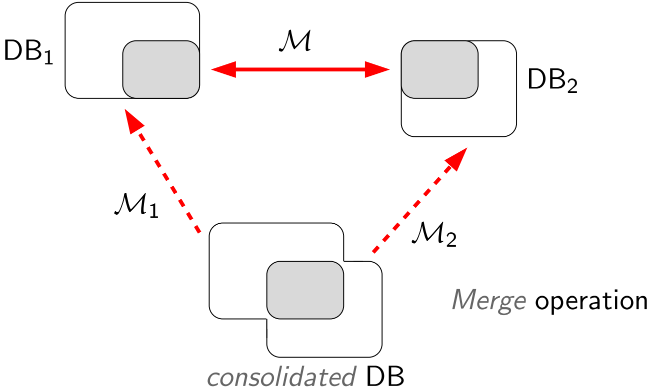

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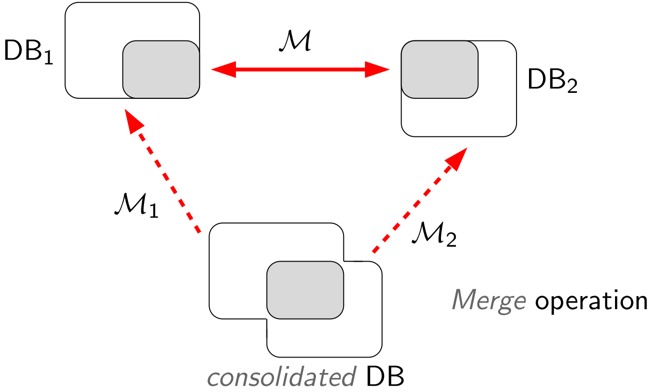

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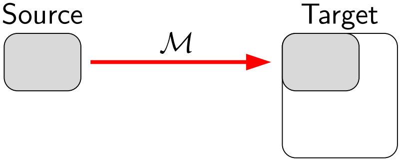

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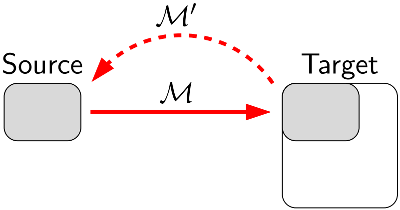

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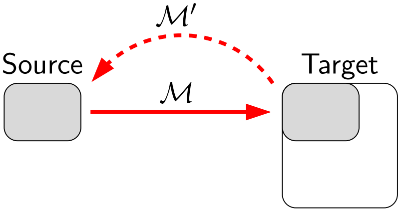

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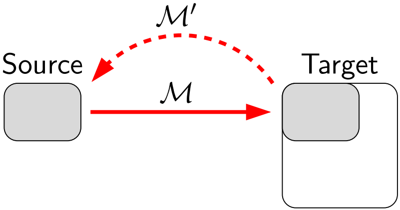

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Invertibility for $\mathcal{M}$ should coincide with no loss of information.

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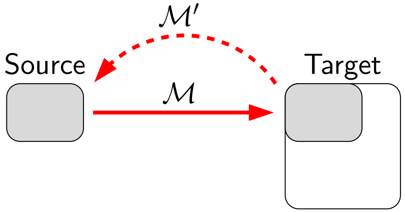

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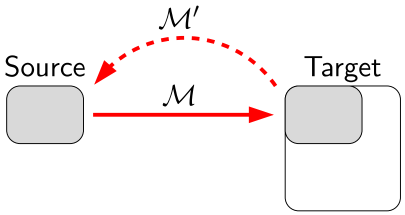

Inverse operation

Although fundamental, the notions of *information* and *redundancy* have received little attention in the schema mapping context.

Foundations of Schema Mapping Management

Marcelo Arenas, Jorge Pérez, Juan L. Reutter, Cristian Riveros

PUC Chile, U. Edinburgh, U. Oxford

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1. *Information* and *redundancy* in schema mappings
   - general formalization
   - characterizations and algorithmic issues
2. Applications of the notions:
   - schema evolution problem
   - *Extract*, *Merge* and *Inverse* operators

Outline

A bit of notation...

A *mapping* $\mathcal{M}$ is a set of pairs (I, J) with

- I a source instance and J a target instance
  (J is called a *solution* for I under $\mathcal{M}$).

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- $\mathbf{L}_1$**-to-**$\mathbf{L}_2$ dependency: $\varphi_{\mathbf{S}}(\bar{x}) \in \mathbf{L}_1$ and $\psi_{\mathbf{T}}(\bar{x}) \in \mathbf{L}_2$.
- **CQ-to-CQ** $=$ st-tgds.
- we are also interested in $\mathbf{CQ}^{\neq}$**-to-CQ** and **FO-to-CQ**.

Source information transferred by a mapping: Intuition

Source: $\{$Emp(**name**, **lives_in**, **works_in**) $\}$
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$\mathcal{M}_1$ and $\mathcal{M}_3$ are *incomparable*.

Source information transfered by a mapping: Formalization

Assume that $\mathcal{M}_1$ and $\mathcal{M}_2$ share the source schema.

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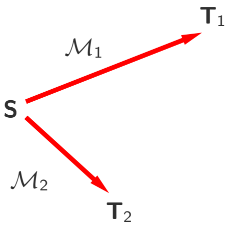

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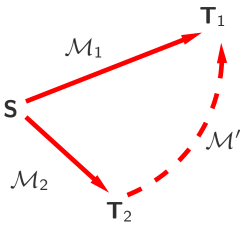

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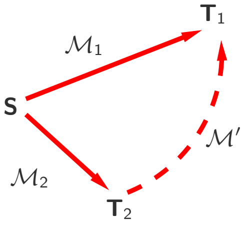

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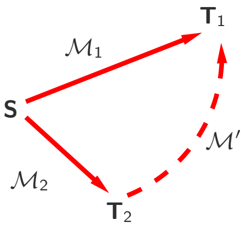

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 & \mathbf{T}_1 \\
\mathbf{S} \arrow[ur, "\mathcal{M}_1"] \arrow[dr, "\mathcal{M}_2"'] & \\
 & \mathbf{T}_2 \arrow[uu, dashed, bend right, "\mathcal{M}'"']
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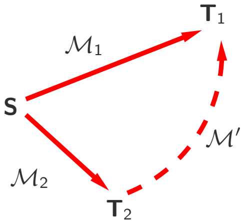

$$\begin{aligned}
\mathcal{M}_1: &\quad \mathrm{Emp}(x,y,z) \rightarrow \exists u\ \mathrm{Person}(u,x) \\
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\end{aligned}$$

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Theorem

The order $\preceq_{\mathrm{S}}$ is the strictest *relation that satisfies (C1-C4).*

Towards deciding $\preceq_{\mathrm{S}}$: target rewritability

Certain answers

Mapping $\mathcal{M}$, target query $Q_{\mathbf{T}}$, source instance I:

$$\underline{\mathsf{certain}}_{\mathcal{M}}(Q_{\mathbf{T}}, I) = \bigcap_{(I,J) \in \mathcal{M}} Q_{\mathbf{T}}(J)$$

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- Intuitively: if $Q_\mathbf{S}$ is target rewritable under $\mathcal{M}$, then $\mathcal{M}$ *transfers all the source data* retrieved by $Q_\mathbf{S}$.

Source information transferred by a mapping can be characterized in terms of queries.

Theorem

Let $\mathcal{M}_1$ *and* $\mathcal{M}_2$ *be specified by* **FO-to-CQ**, *then:*

$$\mathcal{M}_1 \preceq_{\mathrm{S}} \mathcal{M}_2 \text{ if and only if}$$

every source query *that is target rewritable under* $\mathcal{M}_1$
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- The characterization is particular for **FO-to-CQ**. For example, it does not work for **CQ-to-UCQ**.

Deciding $\preceq_{\mathrm{S}}$

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For mappings specified by **FO-to-CQ**:

testing $\mathcal{M}_1 \preceq_{\mathrm{S}} \mathcal{M}_2$ *is* undecidable

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Theorem

For mappings specified by **CQ$^{\neq}$-to-CQ**

$$\textit{testing } \mathcal{M}_1 \preceq_{\mathrm{S}} \mathcal{M}_2 \textit{ is } \text{decidable}$$

Proof idea

For **CQ$^{\neq}$-to-CQ** mappings, we prove that:

- checking target rewritability for **UCQ$^{\neq}$** is decidable,
- only a finite number of queries in **UCQ$^{\neq}$** need to be checked to determine if $\mathcal{M}_1 \preceq_{\mathrm{S}} \mathcal{M}_2$.

Application: Invertibility can be characterized using $\preceq_{\mathrm{S}}$.

Let $\overline{\mathsf{Id}}$ be a mapping specified by a set of *copying*
(rules of the form $R(\bar{x}) \rightarrow \hat{R}(\bar{x})$ with R a source relation).

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Corollary [FN09]

Testing invertibility for **CQ$^{\neq}$-to-CQ** mappings is decidable.

Covering target information: the *dual* definition

Assume that $\mathcal{M}_1$ and $\mathcal{M}_2$ share the target schema.

Definition

$\mathcal{M}_2$ is *more (or equally) target-informative* than $\mathcal{M}_1$, denoted by

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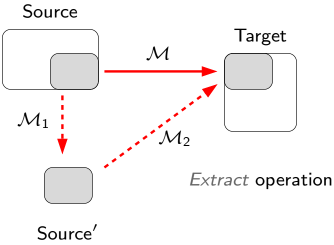
Application 2: formalization of *Extract* (first attempt)



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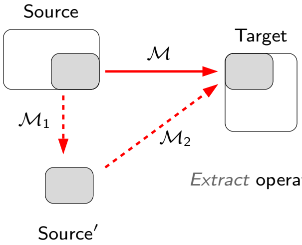

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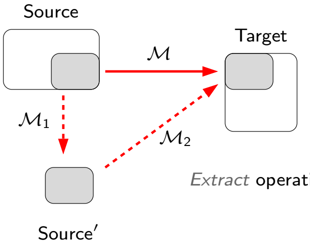

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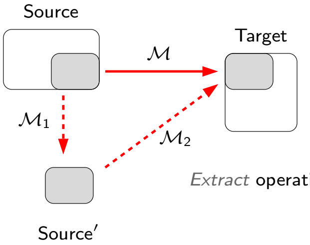

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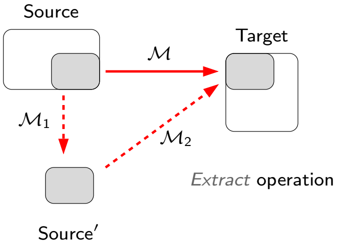

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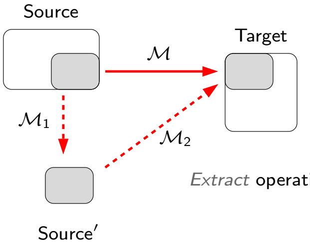

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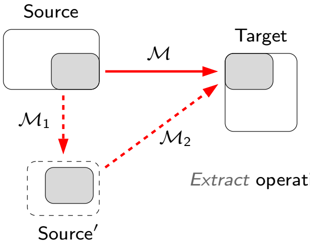

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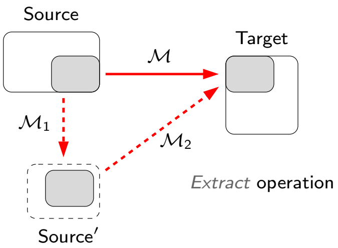

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¿How do we ensure the *optimality* of the new source schema?

Outline

Target redundancy in mappings: Intuition

Source: $\{$Emp(**name**, **lives_in**, **works_in**) $\}$

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Target redundancy in mappings: Intuition

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- $\mathcal{M}_1$ is *target redundant*:
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Notice that $\mathcal{M}_1$ and $\mathcal{M}_2$ are *equally source-informative*, $\mathcal{M}_1 \equiv_{\mathrm{S}} \mathcal{M}_2$

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$\mathcal{M}$ is *target redundant* if there is an instance $J^\star \in \text{range}(\mathcal{M})$ such that the mapping

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$J^\star$:

ENames:

name
Juan
Cristian

WorksIn:

name	place
Juan	Santiago

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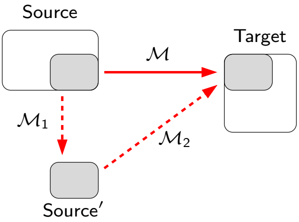
- *$\mathcal{M}$ is target redundant iff there is a target instance that is not a universal solution under $\mathcal{M}$* (onto mapping [FN09]).
- *$\mathcal{M}$ is source redundant iff there are two source instances with the same space of solutions under $\mathcal{M}$* (unique solutions *property* [F06]).

Application 2: formalization of *Extract*



$(\mathcal{M}_1, \mathcal{M}_2)$ is an *extract* of $\mathcal{M}$ iff:

(E1) $\mathcal{M}_1 \equiv_{\mathrm{S}} \mathcal{M}$

(E2) $\mathcal{M}_2 \equiv_{\mathrm{T}} \mathcal{M}$

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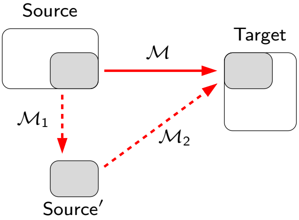

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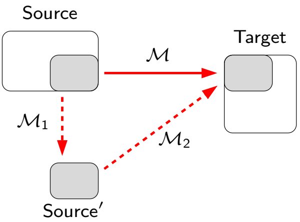

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For mappings specified by **FO-to-CQ** *an extract* always exists.

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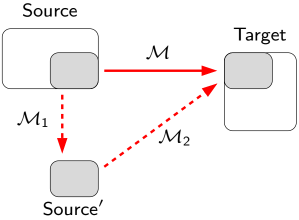

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Theorem

For mappings specified by **FO-to-CQ** *an extract always exists.*

In the paper: an algorithm to compute an extract.

Information and redundancy are fundamental notions for schema mappings

In our work:

- we provide a formalization for both notions
- we study algorithmic issues, and natural characterizations
- we use these notions to re-study some schema mapping operators (schema evolution, extract, merge, inverse).

Foundations of Schema Mapping Management

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Outline