Schema Equivalence and Optimization

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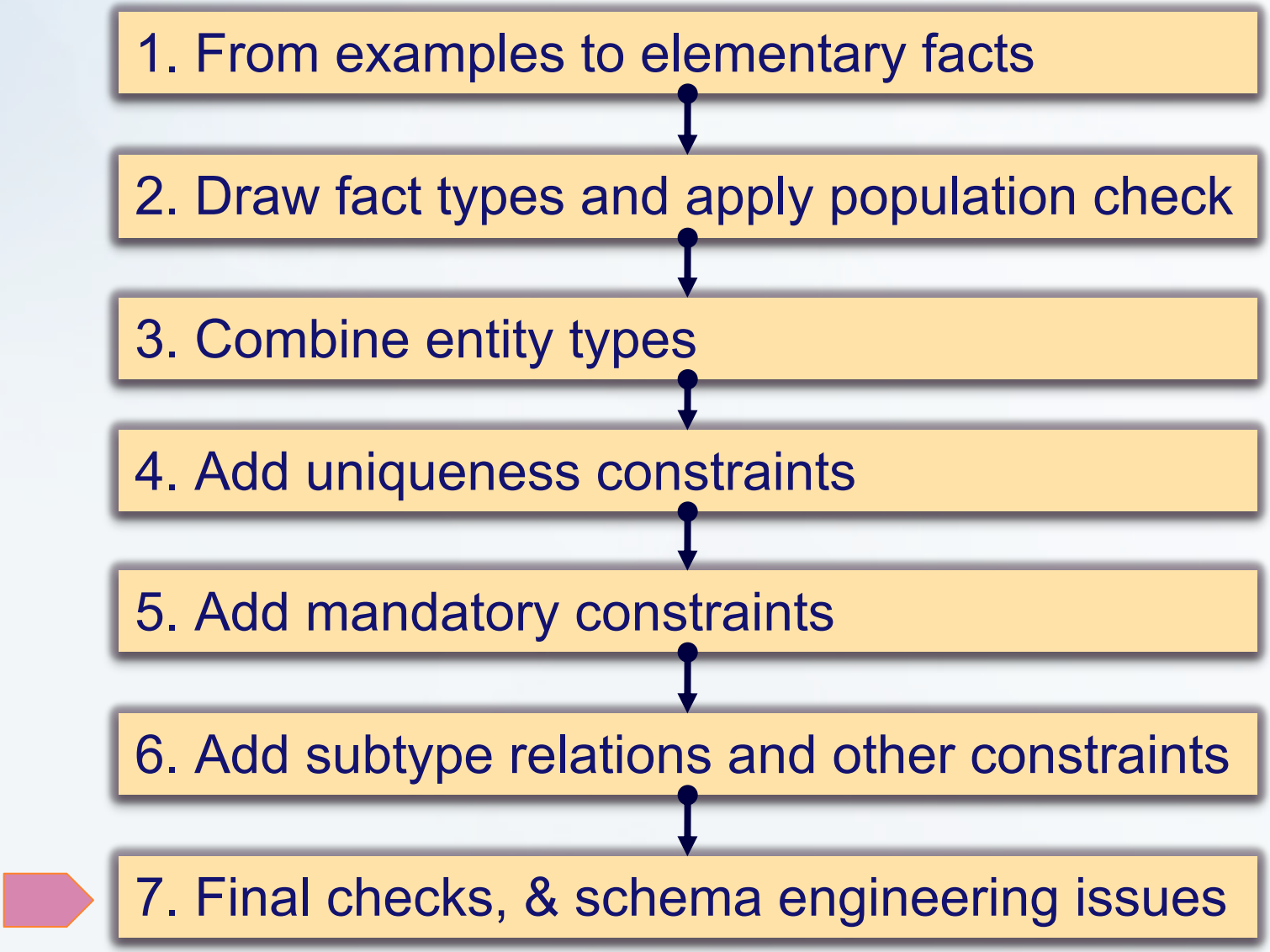
Some diagrams in this lecture are based on [1]

Keywords: Schema, Schema Engineering, constraints, Schema Equivalence, Schema Optimization,
constraints, Cardinality, multiplicity, Rules, Business Rules, Business logic derivation rules, integrity constraints

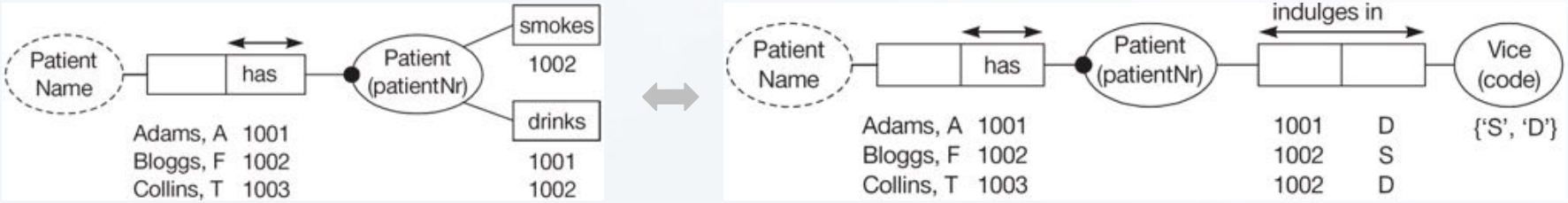
Conceptual Schema Design Steps



Schema Equivalence and Optimization

Based on [1]

- It is not surprising that people often come up with different ways (i.e., different conceptual models) of describing the same reality.
- Two conceptual schemas are equivalent if and only if whatever UoD state can be modeled in one can also be modeled in the other.
- What is the difference between these two schemes:



➢ The act of reshaping two equivalent schemes like this is said to be a **conceptual schema transformation**.

Schema Equivalence and Optimization

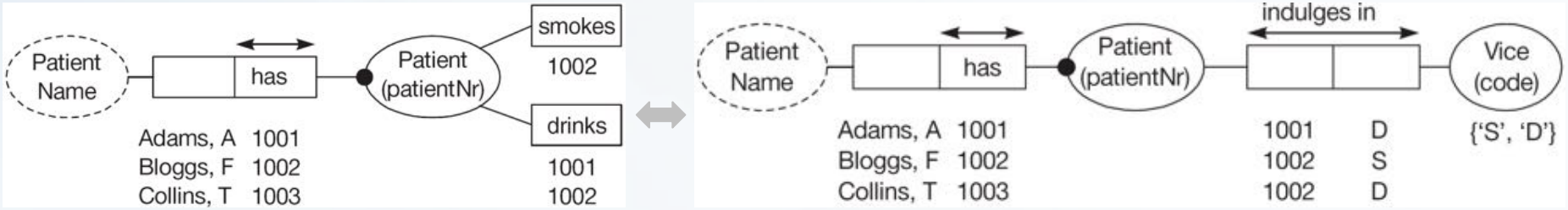
- **Skills** of schema transformations helps you to see what different design choices are possible.
- Moreover, if two independently developed schemas are to be either fully or partly integrated, we often need to resolve the differences in the ways that each schema models common UoD features.
- To do this, we need to know whether one representation can be transformed into the other, and if so, how.
- Another use of conceptual schema transformations is to reshape the original conceptual schema into one that maps directly to a more **efficient** implementation, or to more conceptually **elegant** schema.
- This process is known as **conceptual schema optimization**.

➔There are two class of schema transformations:
Predicate Specialization, and **Predicate Generalization**

Predicate Specialization and Generalization

Based on [1]

If two or more predicates may be thought of as special cases of a more general predicate, then we may replace them by the more general predicate, so long as the original distinction can be preserved in some way.

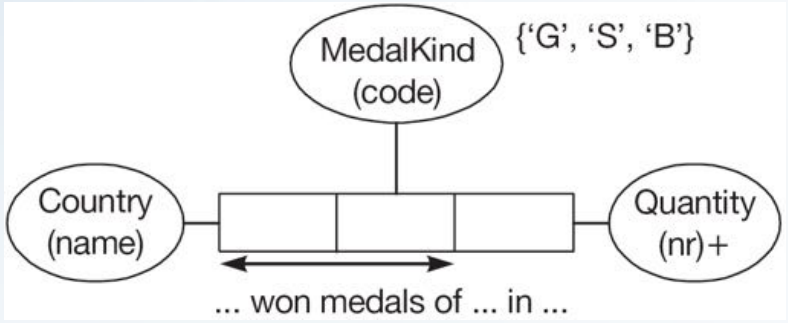


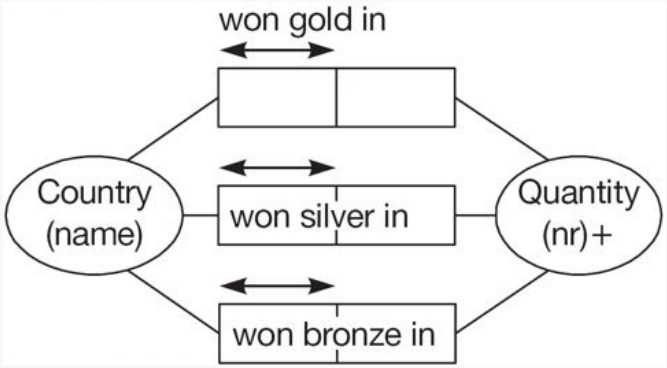
We generalize smoking and drinking into indulging in a vice, where vice has two specific cases. If we transform in the opposite direction, we specialize indulging in a vice into two predicates, one for each case.

Predicate Specialization and Generalization

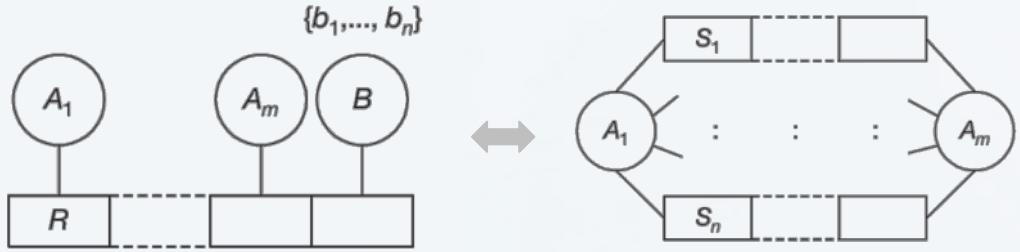
Based on [1]

If two or more predicates may be thought of as special cases of a more general predicate, then we may replace them by the more general predicate, so long as the original distinction can be preserved in some way.





Because there are exactly three kinds of medals, the ternary may be specialized into three binaries, one for each medal kind,



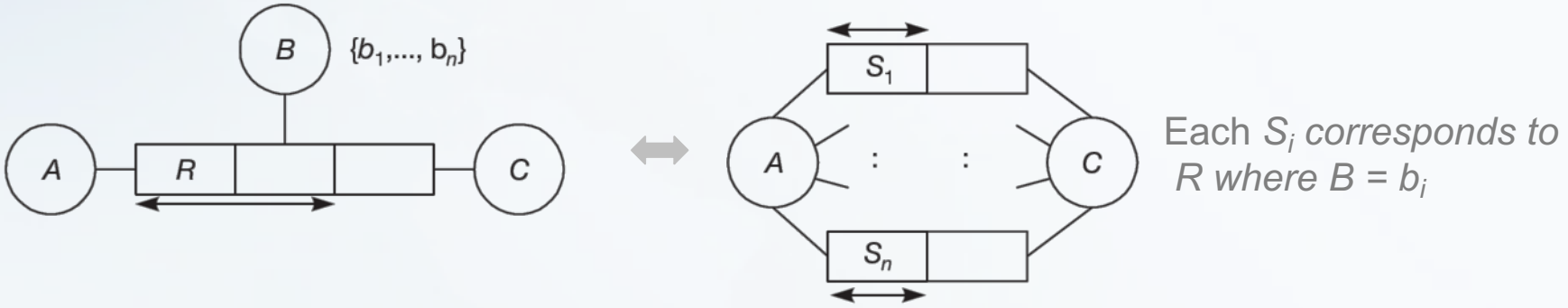
Where $m \geq 1$, and each S_i corresponds to R where $B = b_i$

Theory: *R may be specialized into $S_1..S_n$ by absorbing B.*

Predicate Specialization and Generalization

Based on [1]

The previous theorem always holds, but any constraint added to one of the schemas must be translated into an equivalent, additional constraint on the other schema.



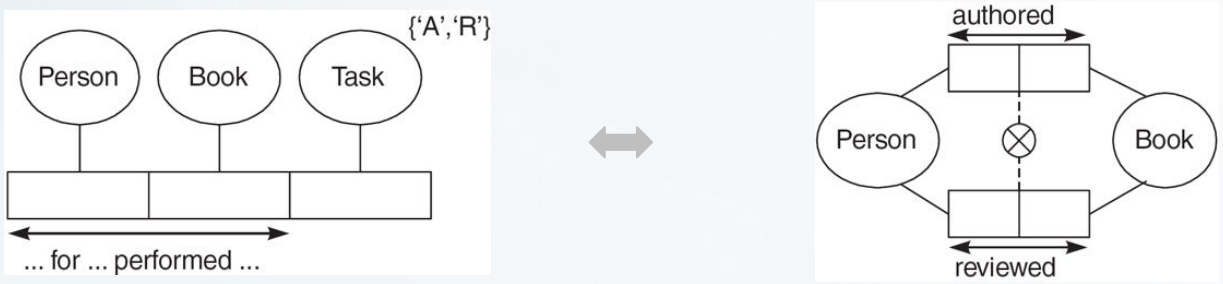
The UC on the left is equivalent to the UCs on the right.

- **If a UC in R spans a combination of B's role and other roles, a UC spans the specialization of these other roles in S_1,..,S_n, and conversely.**

Predicate Specialization and Generalization

Based on [1]

The UC on the left is equivalent to the exclusion constraint on the right.



The UC on the left is equivalent to the exclusion constraint on the right.

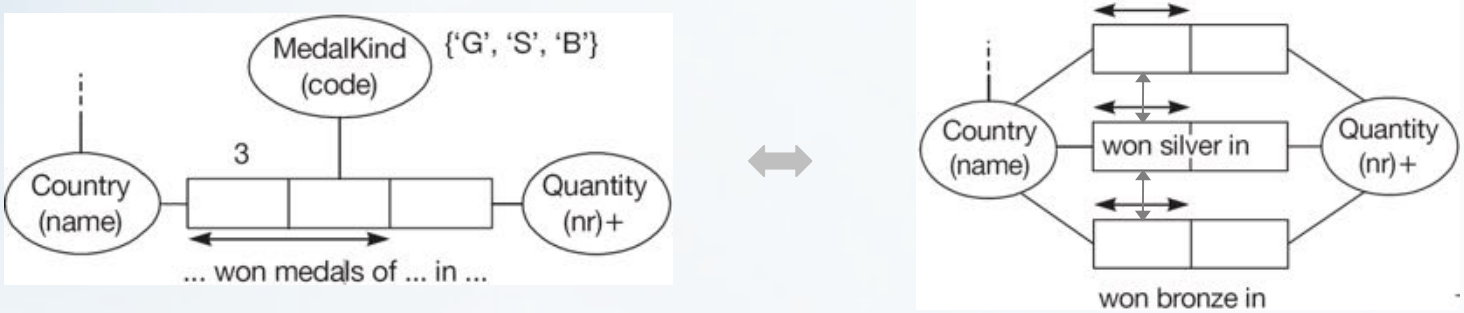
Where $m \geq 1$, and each S_i corresponds to R where $B = b_i$

The UC on the left is equivalent to the exclusion constraint on the right.

➢ **If a UC spans all roles of *R* except for *B*'s role, then S_1 .. S_n are mutually *exclusive, and* conversely.**

Predicate Specialization and Generalization

Based on [1]



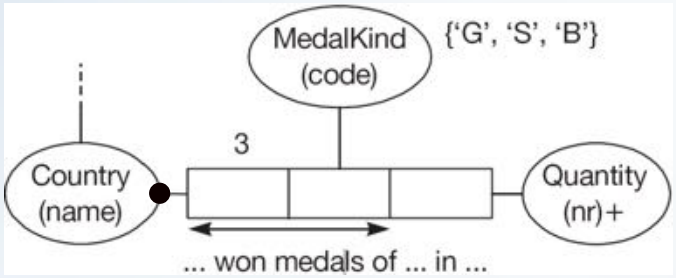
if any medal results are recorded for a country, all three medal results (gold, silver, and bronze) are required. To express, we add an *equality constraint between the medal winning roles played by Country.*

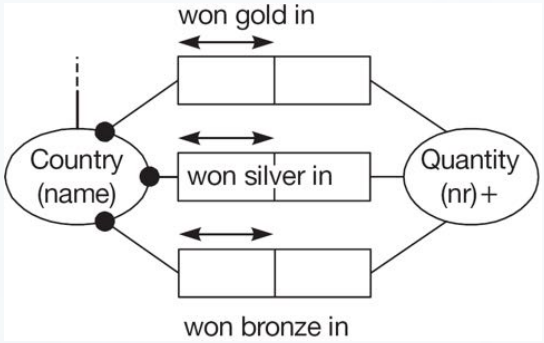
- ***If R is a ternary with a UC spanning just B's role and one other role, then adding a frequency constraint of n to this other role is equivalent to adding an equality constraint over the specialized versions of that role.***

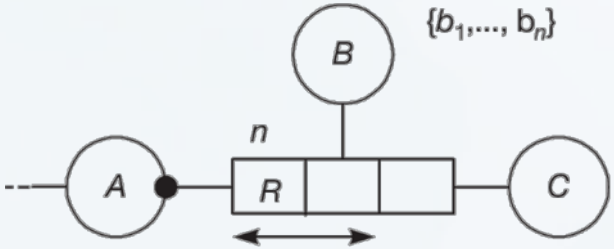
Predicate Specialization and Generalization

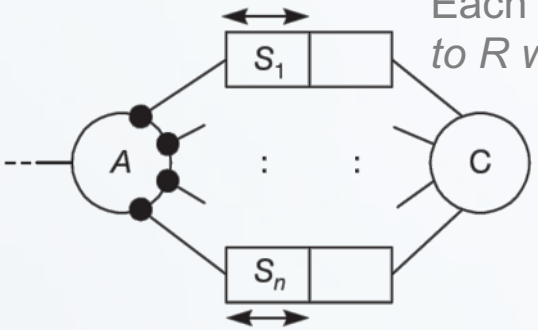
Based on [1]

The impact of adding mandatory role and frequency constraints.







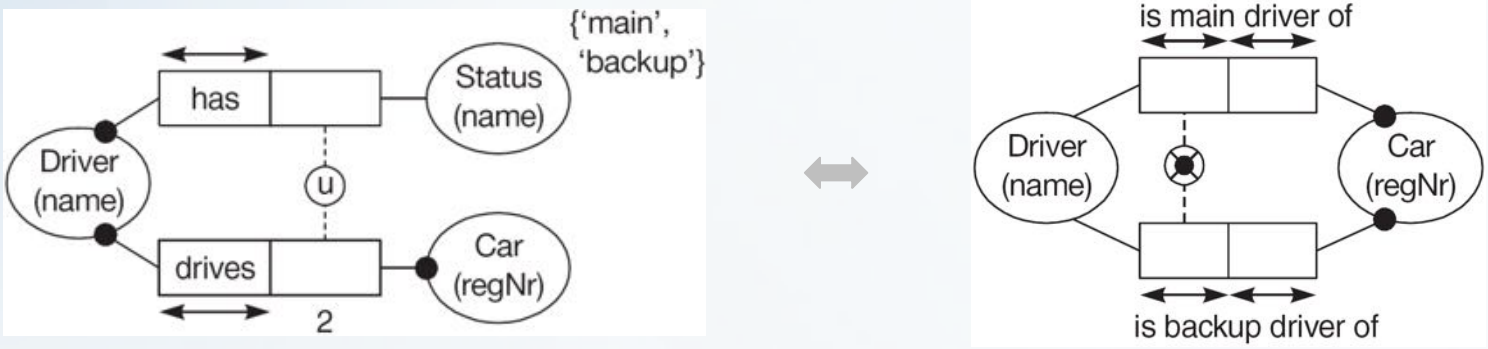


Each *S corresponds to R where B = b_i*

- ***If A's role (or role disjunction) in R is mandatory, then the disjunction of its specialized roles is mandatory, and conversely ($1 \leq i \leq m$).***
- ***If R is a ternary with a UC spanning just B's role and one other role, then adding a mandatory role constraint and frequency constraint of n (the number of possible values for B) to this other role is equivalent to making each specialized version of that role mandatory.***

Other Cases and Examples

Based on [1]

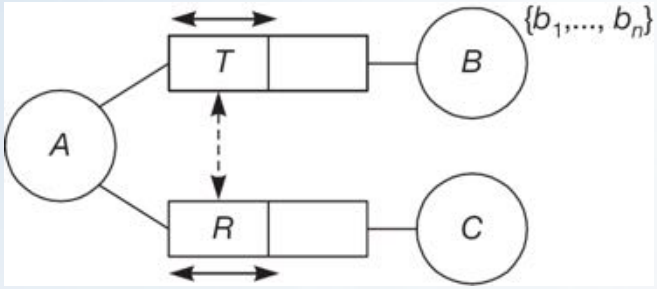


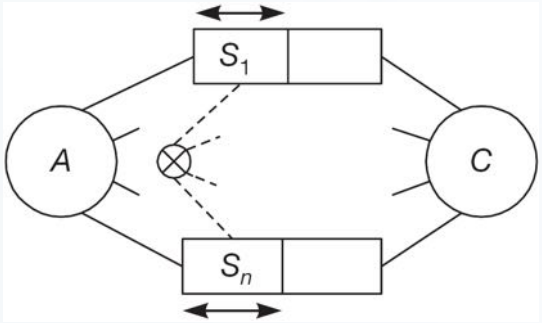
Each car in the rally has two drivers (a main driver and a backup driver), and each person drives exactly one car.

The drives predicate is specialized by absorbing Status.

Other Cases and Examples

Based on [1]





Each S_i corresponds to R where T is restricted to $B = b_i$

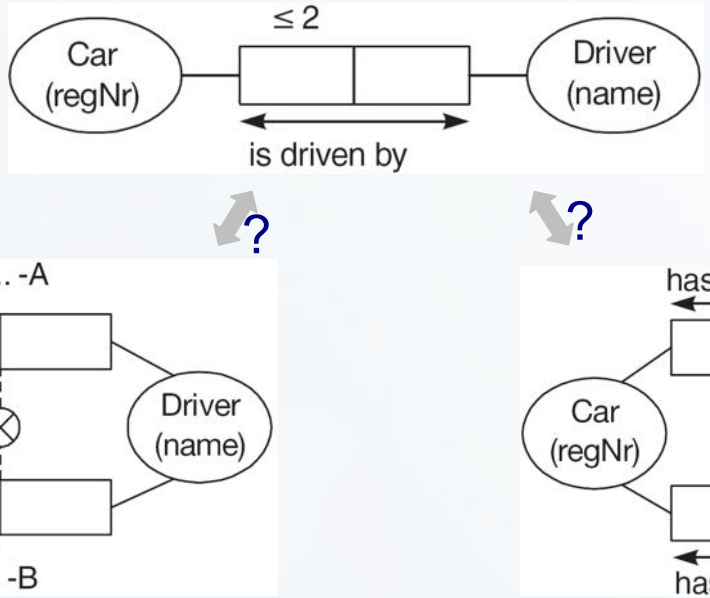
Theory: ***R may be specialized into S_1..S_n by absorbing B.***

- **Corollary 1: If s roles are mandatory in the left-hand schema, the disjunction of s roles in the right-hand schema is mandatory, and conversely.**
- **Corollary 2: If an external UC spans the roles of and in the left-hand schema, then a UC applies to each of s roles in the right-hand schema, and conversely.**
- **Corollary 3: If s role in the left-hand schema is mandatory, then each of s roles in the right-hand schema is mandatory, and conversely.**
- **Corollary 4: An equality constraint over s roles in the RHS is equivalent to a frequency constraint of on s role in the left-hand schema; this constraint is strengthened to if a UC exists on each of s roles in the right-hand schema.**

Other Cases and Examples

Based on [1]

Can the predicate be specialized?

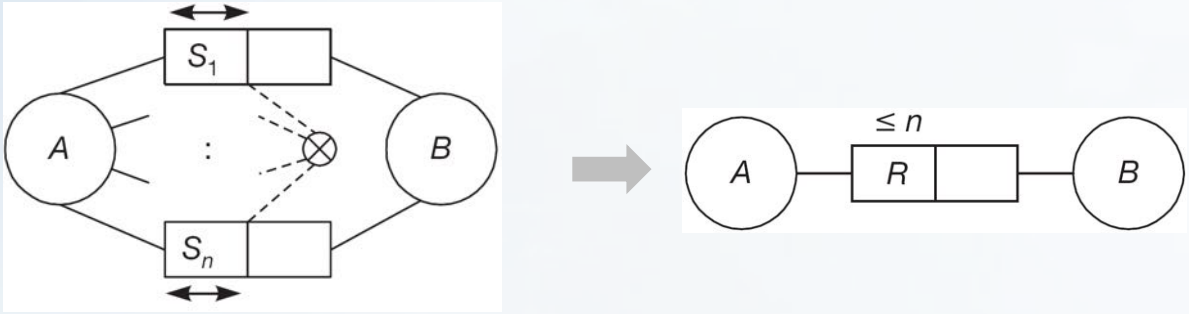


- Transforming from the original schema to one of those strengthens the schema by adding information.
- Transforming in the opposite direction weakens the schema by losing information.

➢ Any such transformations that add or lose information should be the result of conscious decisions that are acceptable to the client (for which the business domain is being modeled).

Other Cases and Examples

Based on [1]



Each S_i *corresponds to one instance of R*

Theory: The left-hand schema implies the right-hand schema.

Corollary 1:If an equality constraint applies over s roles in the left-hand schema, then the frequency constraint in the right-hand schema is strengthened to , and conversely.

Corollary 2: Adding a UC to role in the right-hand schema is equivalent in the left-hand schema to adding UCs to s roles (making the S 1:1) and strengthening the exclusion constraint to an exclusion constraint over s roles.

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