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Patterns for Mapping Conceptual Models to Logical Models and to Relational Schemas

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Key Topics

- Mapping to Tables
- Multiplicity Mapping Rules
- Link Tables
- Mapping Generalizations
- Managing Normal Forms

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Summary of Mapping Rules

- Each entity becomes a table (relation)
- Associations, aggregations, and composition are treated as relationships without any distinction
- 1:1 relationships:
  - optionally merge attributes or treat as 1:N
- 1:N relationships:
  - add the primary key from the "one" as a foreign key attribute to the "many"
- M:N relationships:
  - create an association or junction table with rows as pairs of primary keys from both relations
- Generalization relationships are represented as a single table with a type attribute or a set of tables with common primary keys

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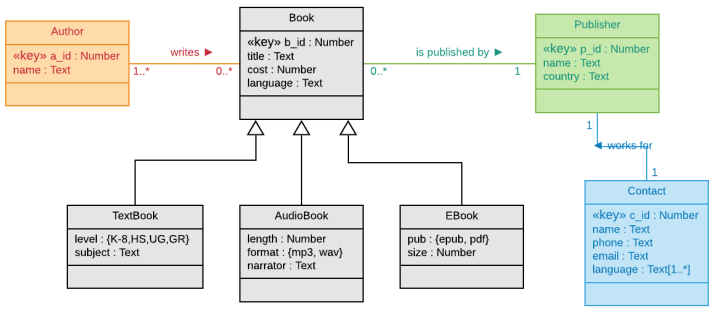
Mapping a Conceptual Model in UML

- UML Class Diagram representing a conceptual model for a publishing domain
- Contains associations with 1:1, 1:N, and N:M multiplicities plus generalization and multi-valued attribute
- Note that aggregation and composition relationships are mapped like associations



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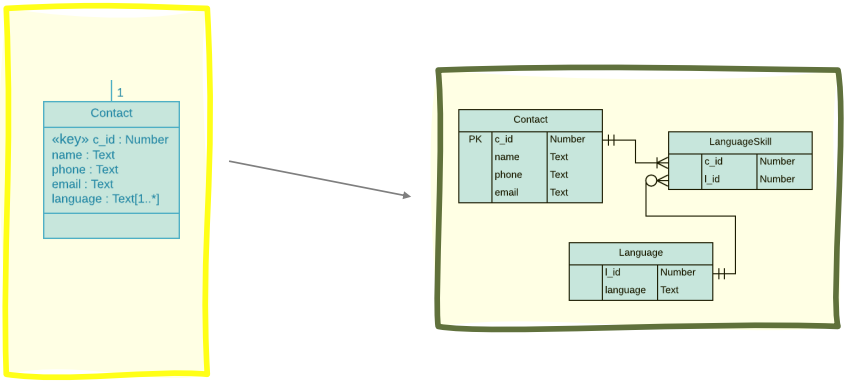
Mapping a Multi-Valued Attribute

- Create a table containing all possible values of the multi-valued attribute's domain
- Create a link table with the primary keys of each table
- Resulting table is in at least 1NF



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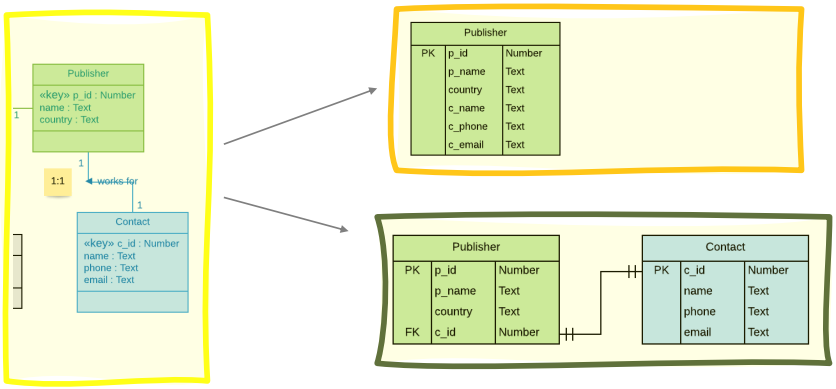
Mapping a 1:1 Association or Aggregation

1. Merge the two entities into a single table, although that precludes changing the multiplicity later and because it violates 3NF and leads to poor design it should be avoided
2. Create two tables with a foreign key in the dominant entity



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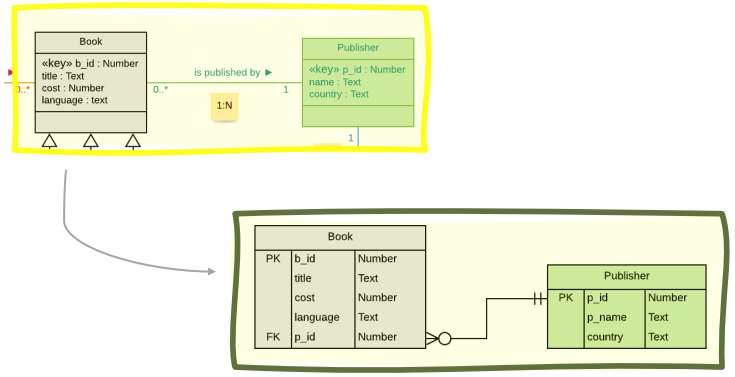
Mapping a 1:N Association or Aggregation

- Create a table for each entity
- Add the primary key of the entity on the side of the "1" in the relationship as a foreign key on the entity on the side of the "N"
- The resulting relational schema is in 3NF if the two tables are each in at least 3NF



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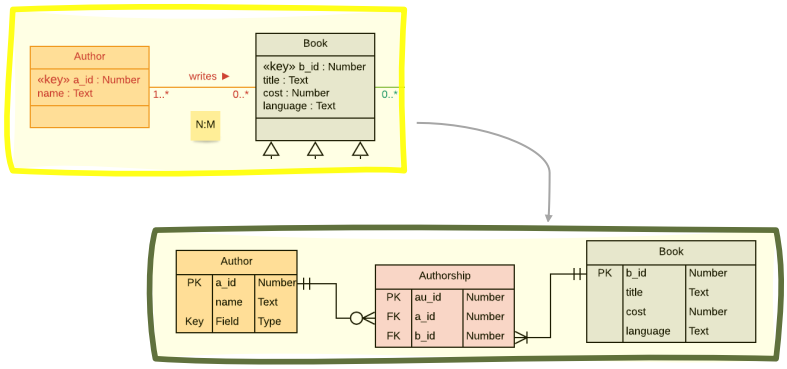
Mapping a N:M Association or Aggregation

- Create a table for each entity
- Create a new table containing the primary keys of each of the entities as foreign keys
- Introduce a surrogate key as a primary key for the new table
- The resulting relational schema is in 3NF if the two tables are each in at least 3NF



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Mapping Generalizations

- Generalization (type or inheritance) hierarchies representing taxonomies in a conceptual model cannot be represented directly in a relational model.
- There are two approaches for representation:
  1. Collapsed Superclass
  2. Shared-Key Class Set

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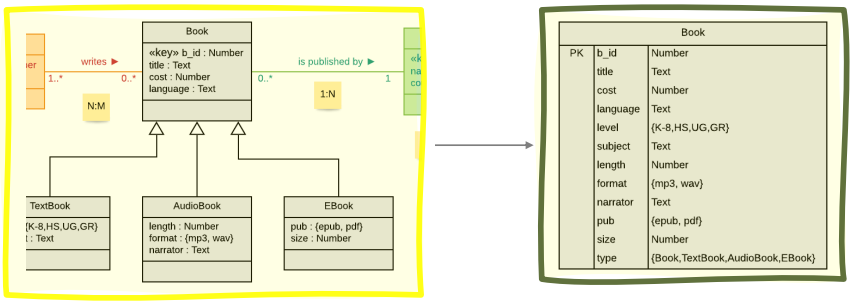
Mapping Generalization: *Collapsed Superclass*

- Create a single class with superclass name containing the attributes of the superclass and all subclasses
- Add a new categorical attribute called "type" with a domain that is the set of all classes, excluding the superclass if it is abstract
- A row is an instance of the superclass or one of the subclasses; all attributes not belonging to that type of entity are *null*
- This approach results in a sparse table with many *null* values



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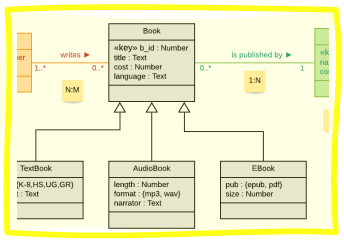
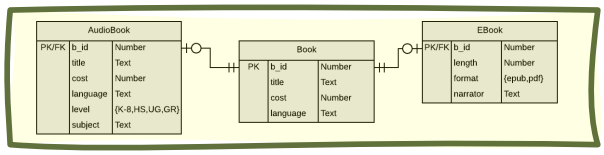
Mapping Generalization: *Shared-Key Class Set*

- Create a table for each subclass class and for the superclass
- Use the primary key of the superclass as the primary key of each subclass
- The primary key of the subclass is also a foreign key linking to the superclass creating 1:1 relationships between the tables
- An instance of a subclass is therefore split over at least two tables
- If the superclass is concrete then the relationships to the subclasses are optional, otherwise concrete





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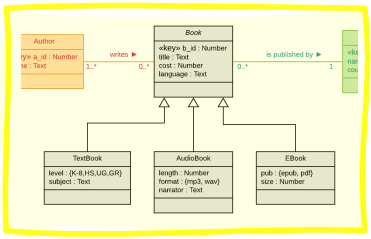
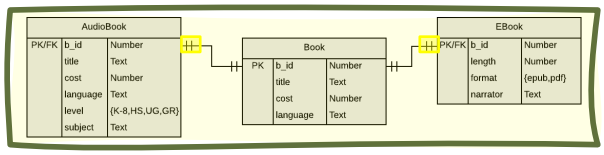
Mapping Generalization: *Abstract Superclass*

- Implement the same as the in the Shared-Key Class Set patter except that for every primary key in the superclass table there must be a corresponding primary key in at least one subclass table
- If the hierarchy is disjoint, then the same primary key cannot appear in sibling nodes





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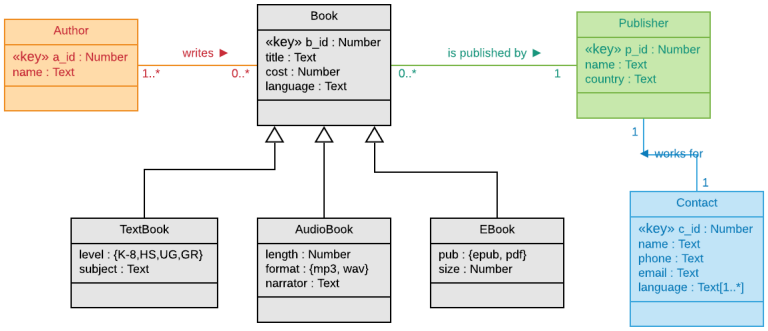
Full UML Conceptual Model



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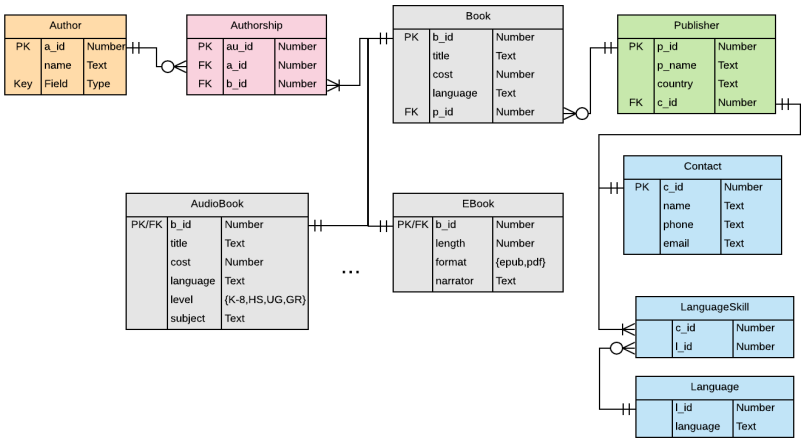
Full ERD Logical Model



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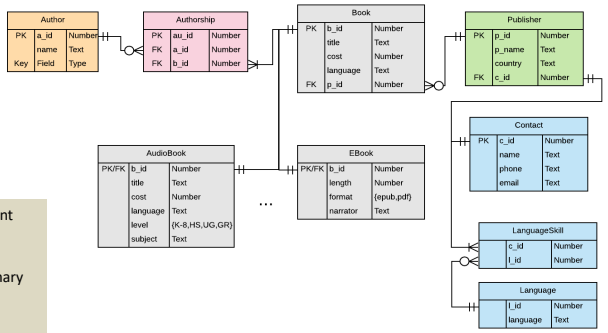
Some Issues with Model



- What if a book is sold in different formats, *e.g.*, on Kindle and paperback?
- Would ISBN make a better primary key as it is a natural key?
- What about hardcover vs paperback?
- What about books without an author, *e.g.*, the Bible?
- What about country in publisher? Doesn't that violate a normal form?

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Sample Relation Instances

Author

a_id	a_name
843	Smith, Adam
763	Kant, Emmanuel
921	Hegel, Georg
420	Descartes, Rene

Authorship

au_id	a_id	b_id
109	763	221
110	843	222
111	921	223
112	921	224

Book

b_id	b_title	cost	p_id
221	Critique of Reason	48.99	303
222	Wealth of Nations	29.00	303
223	Science of Logic	9.99	394
224	Philosophy of Right	4.99	394

EBook

b_id	length	format
221	2387	epub
222	823	pdf
223	458	epub
224	1097	epub

Publisher

p_id	p_name	country	c_id
321	Pearson	India	332
332	Elsevier	UK	321
303	Random House	US	303
394	Putnam	US	394

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Some columns are renamed from attributes in order to make them unique, and thus simplify foreign key naming.
This is not strictly necessary, but convenient. Some tables have non-relevant columns omitted for brevity.

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Common Constraints

- Common constraints:
  - Non-null values for attributes
  - Lower bound of 1 on multiplicity, *e.g.*, 1..*
  - Specific upper bound on multiplicity, *e.g.*, 1..5
  - Referential integrity of foreign keys
  - Deletion of classes from multiple tables in a generalization hierarchy

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Enforcing Constraints

- During table creation:
  - `NOT NULL` on attributes or foreign keys
  - `ON DELETE CASCADE` to force deletion of dependent entities
  - user defined constraints and domains
- As business logic:
  - use `BEFORE` triggers to enforce multiplicity constraints
  - Transactions via application code or stored procedures

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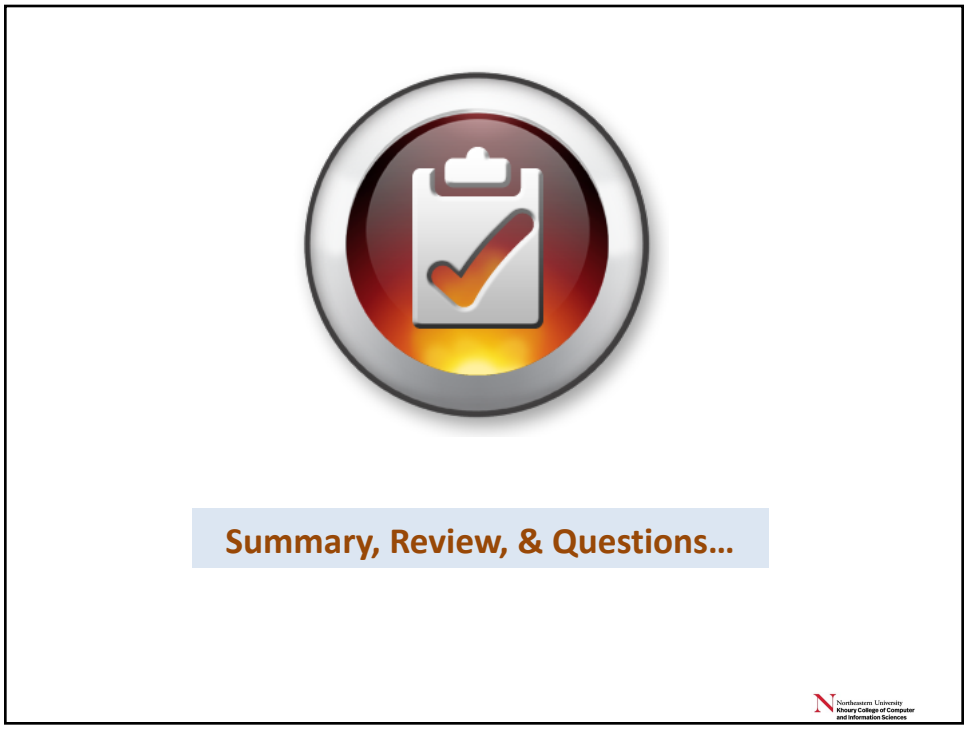
Summary, Review, & Questions…
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