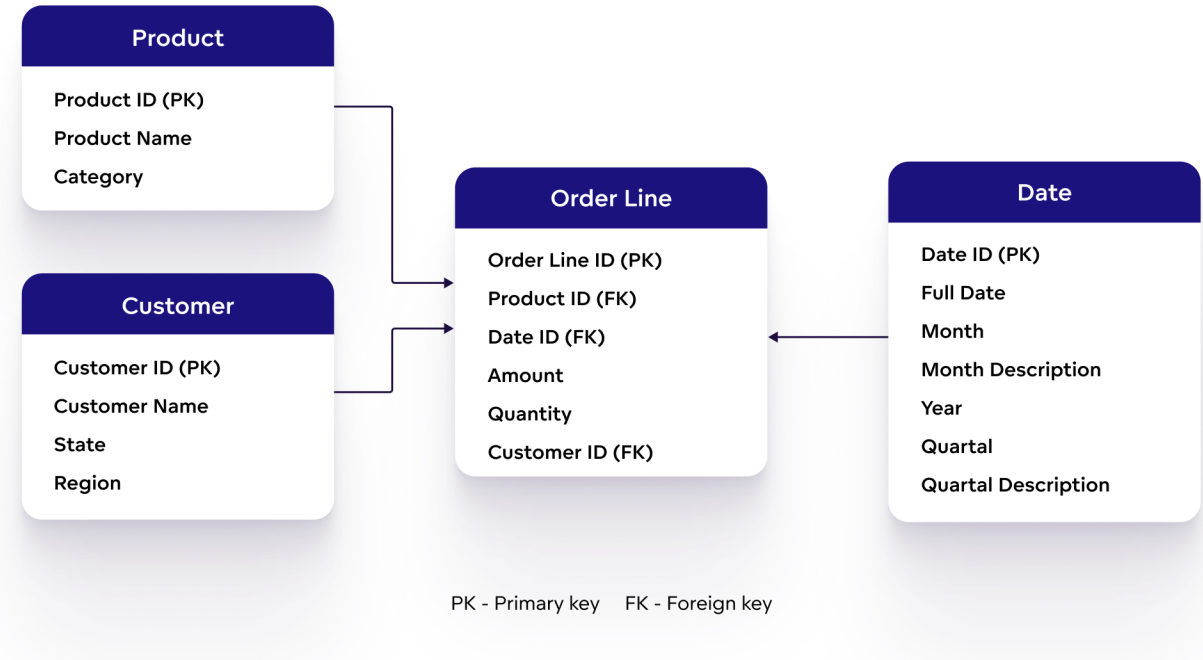


The relational model

Data Model

- A *data model* is representation of *data elements* and the relationships between them based on real-world objects
 - For example when modeling a simple online store, data element representing customer is related to a data element representing an order
- Data elements document real-world which means that the data model represents reality



Components of a data model

- A data model consists of three components:
 - i. *Structural part*: a set of rules according to which databases can be constructed
 - ii. *Integrity part*: a set of integrity constraints to ensure database integrity
 - iii. *Manipulative part*: a set of operations that are allowed on the data

The relational model

- When all data model's data is logically structured within *relations*, the model is a *relational model*
- These relations are informally referred to as *tables*
- The data is perceived by the users as tables
- Relation has named *attributes* (informally called *columns*)
- Attributes have a set of allowable values, which is referred to as the attribute's *domain*
 - For example "person" relation's "age" attribute could be an integer value larger or equal to zero
- The actual data is in relations's *tuples* (informally called *rows*)

The diagram illustrates a database table structure with the following components and annotations:

- relation name:** An arrow points from the label "relation name" to the word **COURSE**.
- attributes:** An arrow points from the label "attributes" to the header row of the table.
- attribute names:** An arrow points from the label "attribute names" to the **code** header cell.
- tuples:** Three arrows point from the label "tuples" to the three data rows of the table.

code	name	credits
swd1tf001	Introduction to Software Engineering	5
swd4tf002	Programming (Java)	5
swd4tf003	Data Management and Databases	5

Properties of relations

- Each relation has a name that is distinct from all other relation names
- Each attribute has a distinct name
- Each tuple's cell contains exactly one value
- Values of an attribute are all from the same domain
- The order of attributes has no significance
- There are no duplicate tuples
- The order of tuples has no significance

Integrity constraints

- The quality of the data directly determines the quality of the whole database
- Therefore preventing entry of incorrect data is one of the most important functions of a DBMS
- *Integrity constraints* are rules used to control the legal database states
- If the database satisfies all the integrity constraints specified on the database schema, it is in a legal state

Domain integrity

- A *domain constraint* specifies the set of allowable values for an attribute
 - For example valid grade marks are integers between 0 and 5
- Domain constraints enforce *domain integrity*

Entity Integrity

- A *superkey* is an attribute or group of attributes that uniquely identifies each tuple of a relation
- Relation can have multiple superkeys
 - In the "course" relation the "code" attribute, and group of "code" and "name" attributes are superkeys
 - What other superkeys does the "course" relation have?

code	name	credits
swd1tf001	Introduction to Software Engineering	5
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Entity Integrity

- A *candidate key* is a superkey that satisfies the property of *minimality*
 - Minimality is satisfied if an attribute can't be removed from the group of attributes without breaking the uniqueness property
 - In the "course" relation the group of "code" and "name" attributes doesn't satisfy minimality, so it isn't a candidate key
 - What other candidate keys does the "course" relation have?

code	name	credits
swd1tf001	Introduction to Software Engineering	5
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Entity Integrity

- From the set of candidate keys for the relation, *exactly one* candidate key is chosen to be the *primary key*
- The other candidate keys become *alternate keys*
- Each tuple has a value for the primary key, *it can't be missing*
- Primary key's value *should not change*
 - For example person's name or phone number might sound tempting options for a primary key but are actually subject to change
- *Primary key constraint* prevents duplicate tuples to exist for the relation
- Primary key constraints enforce *entity integrity*

Surrogate keys

- If there is initially no candidate key for a relation, then we cannot determine a *natural* primary key
- For example a relation for email messages:

from	to	title	body
kalle.ilves@haaga-helia.fi	john.doe@gmail.com	Greeting	Hello John!
john.doe@gmail.com	kalle.ilves@haaga-helia.fi	Response	Hello Kalle!

Surrogate keys

- We have to take care of the situation by including an extra attribute in the relation to act as the primary key
- For example a "messageid" column that holds a unique number for each tuple:

messageid	from	to	title	body
1	kalle.ilves@haaga-helia.fi	john.doe@gmail.com	Greeting	Hello John!
2	john.doe@gmail.com	kalle.ilves@haaga-helia.fi	Response	Hello Kalle!

Surrogate keys

- Such primary key is called a *surrogate key*
- Surrogate key has no relationship to the real-world meaning of the data held in a tuple
- Surrogate keys are quite common and a natural key is often replaced with a surrogate key
- Surrogate keys are commonly generated by the DBMS once a tuple is inserted
- Automatically incremented numbers and randomly generated values like UUID are common surrogate key values

Choosing a primary key

- Let's consider a suitable primary key in the following cases:
 - Is "course" relation's "name" attribute a good option for a primary key? Why or why not?
 - Person's contacts are stored in relation which has attributes "address" and "name" (home address and name of a contact). What would be suitable primary key for this relation and why?

Referential Integrity

- *Foreign key* is a attribute or group attributes whose values are required to match those of the primary key of the referenced relation
- There can be several foreign keys in a relation
- Foreign-to-primary-key matching is the "glue" which holds the database together
- *Foreign key constraint* prevents foreign key not being matched by a primary key in the referenced relation
- Foreign key constraints enforce *referential integrity*

Primary key
constraint

empno	empname	deptno
20	Mark	10
18	Sue	10
49	Frank	20
31	Mary	20

Foreign key
constraint

Primary key
constraint

deptno	deptname	budget
10	Sales	50000
20	Marketing	250000

Employee (Referencing relation)

Department (Referenced relation)

Not null constraint

- *Null* is a marker for a missing attribute value
- Null is not the same as e.g. blanks or zero. Null represents absence of a value
- The *not null constraint* is a restriction placed on an attribute
- It enforces the condition that, in that attribute, every tuple of data must contain a value
- For example it would make sense that in the "employee" relation, the "deptno" attribute has a not null constraint, meaning that every employee belongs to a department

Database manipulation

- A *manipulation mechanism* is among the most important parts of a data model
- A manipulation mechanism allows the data to be retrieved and updated
- SQL is the standard database language for relational databases. With SQL we can:
 - Create the database and relation structures
 - Perform insertion, modification, and deletion of data from the relations
 - Perform database queries
- Instead of using formal terms of relations, attributes, and tuples, the terms *tables*, *columns*, and *rows* are used in the SQL standard

SQL

- An SQL query is a single statement in which you describe what you want from the database
- The query operates on tables and builds a result table from one or more tables in the database
- Here's an example of an SQL query:

```
SELECT code, name, credits  
FROM course  
WHERE name = 'Data Management and Databases';
```

Summary

- A *data model* consists of three components: the *structural part*, the *integrity part* and the *manipulative part*
- In the *relational model*, all data is logically structured within relations that have attributes and tuples
- *Integrity constraints* are rules which make sure that the database is in a legal state
- *Domain constraint* specifies the set of allowable values for an attribute
- *Primary key constraint* prevents duplicate tuples to exist for the relation
- *Foreign key constraint* prevents foreign key not being matched by a primary key in the referenced relation