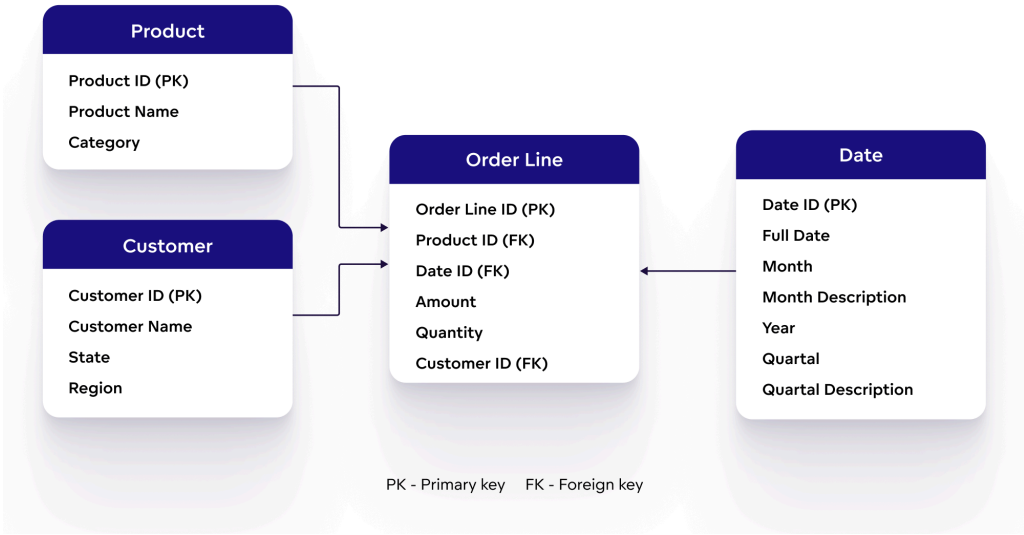
The relational model

- The learning objectives for this week are:
  - Knowing what is a *data model*
  - Knowing what is the *relational data model*
  - Knowing the core terminology of the relational model
  - Knowing what are the properties of database *relations*
  - Knowing what are *domain integrity*, *entity integrity*, and *referential integrity* rules
  - Knowing how to identify *candidate keys*, *primary keys*, *alternate keys*, and *foreign keys*

Data Model

- A *data model* is an abstract representation of *data elements* and the relationships between them based on real-world objects
    - In case of a simple online store, data element representing customer consists of data elements such as customer's name and region
- Data elements document real-world which means that the data model represents reality

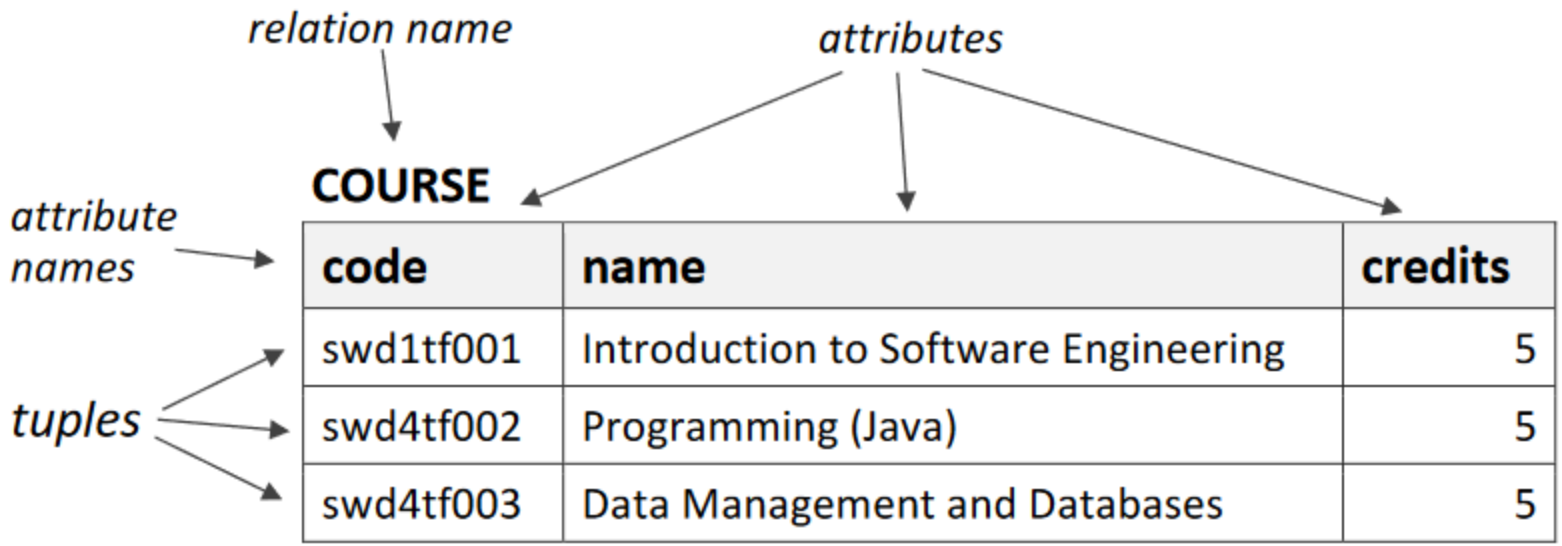


Components of a data model

- 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*)


relation name
attributes
COURSE
attribute names
tuples
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 of a relation 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
swd4tf002	Programming (Java)	5
swd4tf003	Data Management and Databases	5

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 satify 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
swd4tf002	Programming (Java)	5
swd4tf003	Data Management and Databases	5

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 actully 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

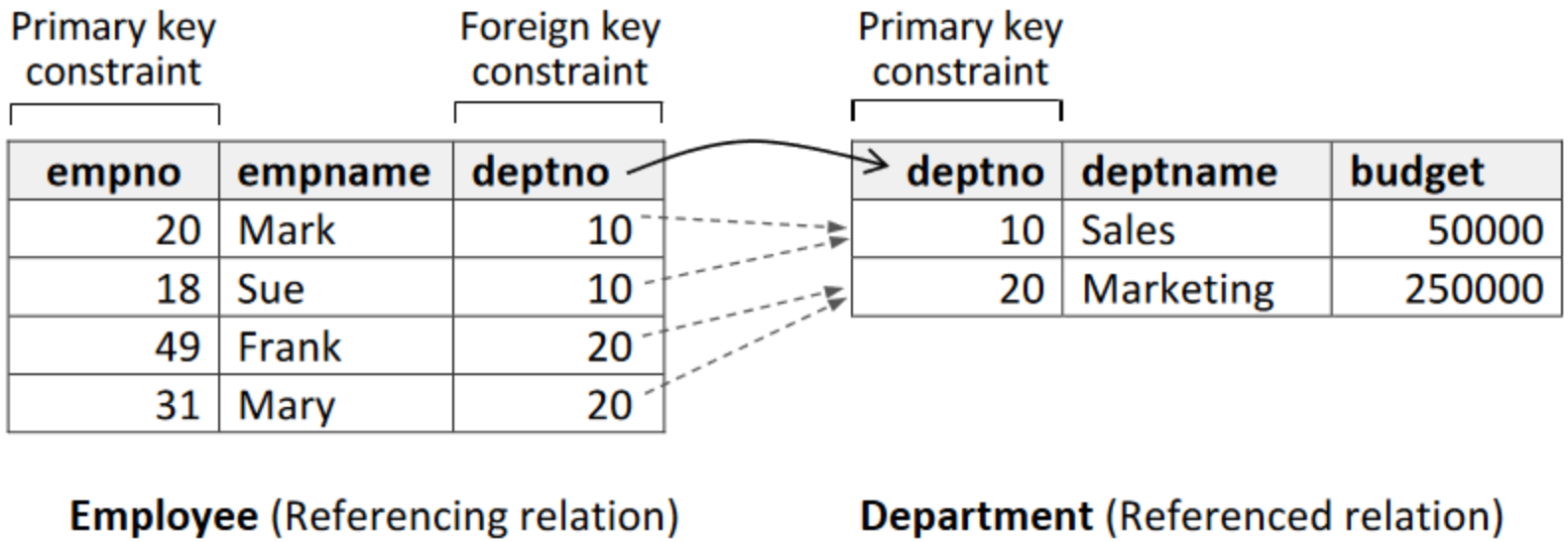
- Such primary key is called a *surrogate key*
- Surrogate key has no relationship to the real-world meaning of the data held in a tuple
- Surrogate keys are quite common and a natural key is often replaced with a surrogate key
- Surrogate keys are commonly generated by the DBMS once a tuple is inserted
- 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 primery 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
Foreign key constraint
Primary key constraint
empno
empname
deptno
20
Mark
10
18
Sue
10
49
Frank
20
31
Mary
20
deptno
deptname
budget
10
Sales
50000
20
Marketing
250000
Employee (Referencing relation)
Department (Referenced relation)

Example of primary and foreign keys

- Let's have a look at the exercise 5 in the first week's intro assignment
- *What are the primary keys for each table?*
- *What are the foreign keys for each table?*

TEAM

teamno	team name
9	Hawks
7	Tigers
5	Sharks

ARTIST

artistno	given name	family name
a15	Katy	Perry
a3	Ariana	Grande
a16	Bruno	Mars
a20	Johnny	Smith
a7	Lady	Gaga
a12	Alicia	Keys

TEAM_ARTIST

teamno	artistno
9	a3
7	a7
7	a16
9	a7
7	a12

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
- *SQL* is the standard database language for relational databases
- *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