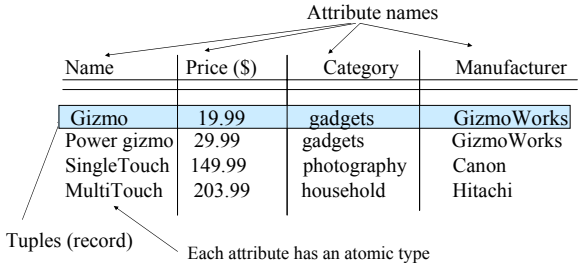
Relational Data Model

- a data model in which all data is modelled as relations (tables)
  - a way of looking at data
- a prescription for a way of
  - representing data
  - manipulating data (relational algebra)
  - representing integrity constraints

A Relation

A relation contains a SET of tuples

PARTS(Name: String; Price: Real; Category: String; Manufacturer: String)



Integrity

- restrictions on data defined by users
  - on individual tables
    - age > 18; salary < 100k
  - on more than one table
    - *if* budget < 10M *then* salary < 50k
- implicit in the data model

Integrity Constraints (ICs)

- IC: condition that *must be* true for *any* instance of the database
  - e.g., *domain constraints*
    - Each attribute has values taken from a *domain*. ICs are specified when schema is defined.

Primary and foreign keys

E_id	E_name	Dept_id	Salary
E1	Smith	D1	40K
E2	John	D1	42K
E3	Stella	D2	30K
E4	Art	D3	35K

foreign

primary

Dept_id	Dept_name	Budget
D1	Marketing	10M
D2	Development	12M
D3	Research	5M

More Integrity Constraints

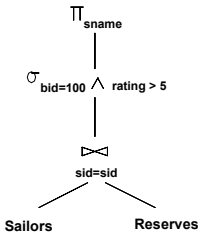
- *Key constraints*: each tuple must be distinct. A key is a subset of fields that uniquely identifies a tuple (*superkey*), and for which no subset of the key has this property.
- *Referential integrity constraints*: a field in one relation may refer to a tuple in another relation by including its key (*foreign key*). The referenced tuple must exist in the other relation for the database instance to be valid.
- Typically, a relation may have several *candidate* keys one of which is chosen as the *primary* key.

Relational Operations

- *Selection* (σ) Selects a subset of rows from relation.
- *Projection* (Π) Deletes unwanted columns from relation.
- *Join* (⋈) Allows us to combine two relations.
- *Set-difference* (-) Tuples in reln. 1, but not in reln. 2.
- *Union* (∪) Tuples in reln. 1 and in reln. 2.
- *Aggregation* (SUM, MIN, etc.) and GROUP BY

Example

```
SELECT  S.sname
FROM  Reserves R, Sailors S
WHERE  R.sid=S.sid AND
   R.bid=100 AND S.rating>5
```



Equality Joins With One Join Column

```
SELECT  *
FROM    Reserves R, Sailors S
WHERE  R.sid=S.sid
```

- In algebra: R ⋈ S.
- Most frequently used operation; very costly operation.

Join Example

sid	sname	rating	age
22	dustin	7	45.0
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

sid	bid	day	rname
31	101	10/11/96	lubber
58	103	11/12/96	dustin

Join Example

sid	sname	rating	age
22	dustin	7	45.0
28	yuppy	9	35.0
31	lubber	8	55.5
44	guppy	5	35.0
58	rusty	10	35.0

sid	bid	day	rname
31	101	10/11/96	lubber
58	103	11/12/96	dustin

sid	sname	rating	age	bid	day	rname
31	lubber	8	55.5	101	10/11/96	lubber
58	rusty	10	35.0	103	11/12/96	dustin

Simple Nested Loops Join

- For each tuple in the outer relation R, we scan the entire inner relation S.

```
foreach tuple r in R do
        foreach tuple s in S do
                if r.sid == s.sid then add <r, s> to result
```