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## *Chapter 5*

# Database Systems

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# The nature of geographic data

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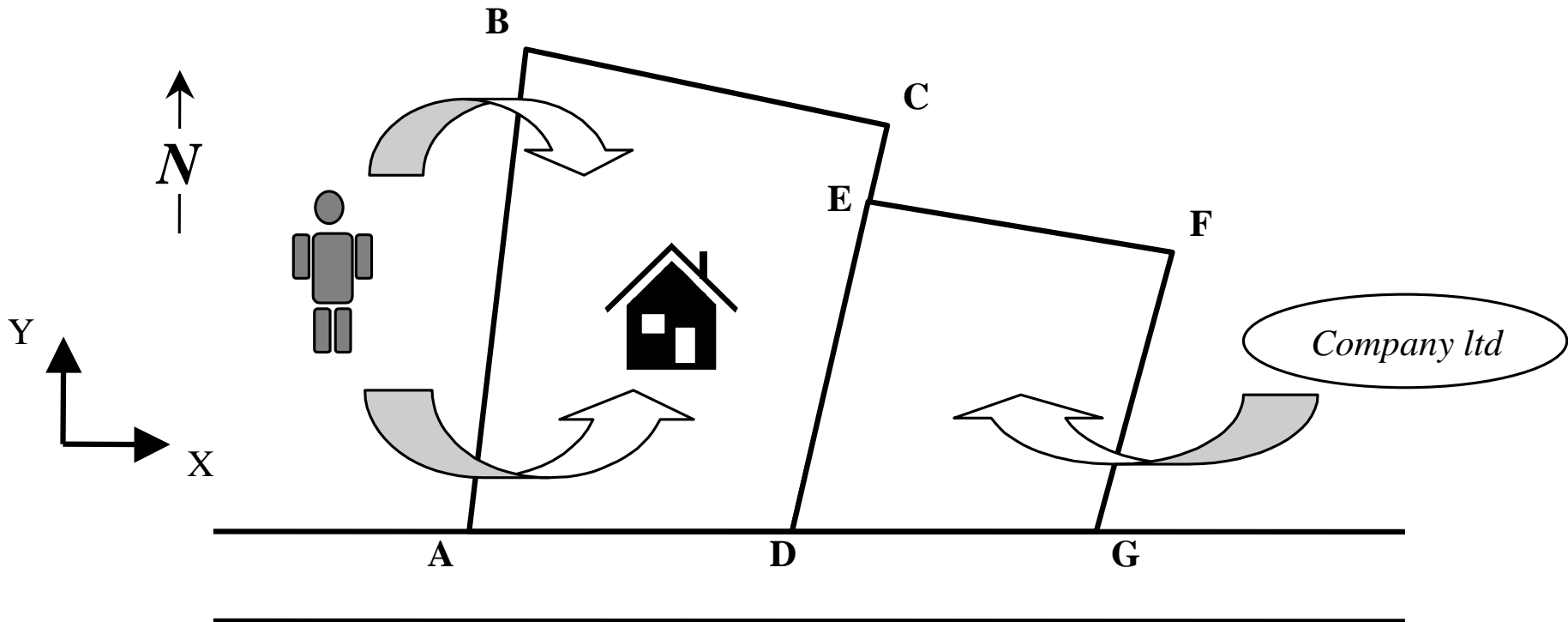
- Reality ...
  - is very complex
  - to describe it ...
    - split into small units (entities)
  - consists of **entities**
    - distinct and interrelated
- Entity ...
  - a unit or object with ...
    - physical or conceptual existence

# The nature of geographic data

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- **Entities and their relationships**

– example ...

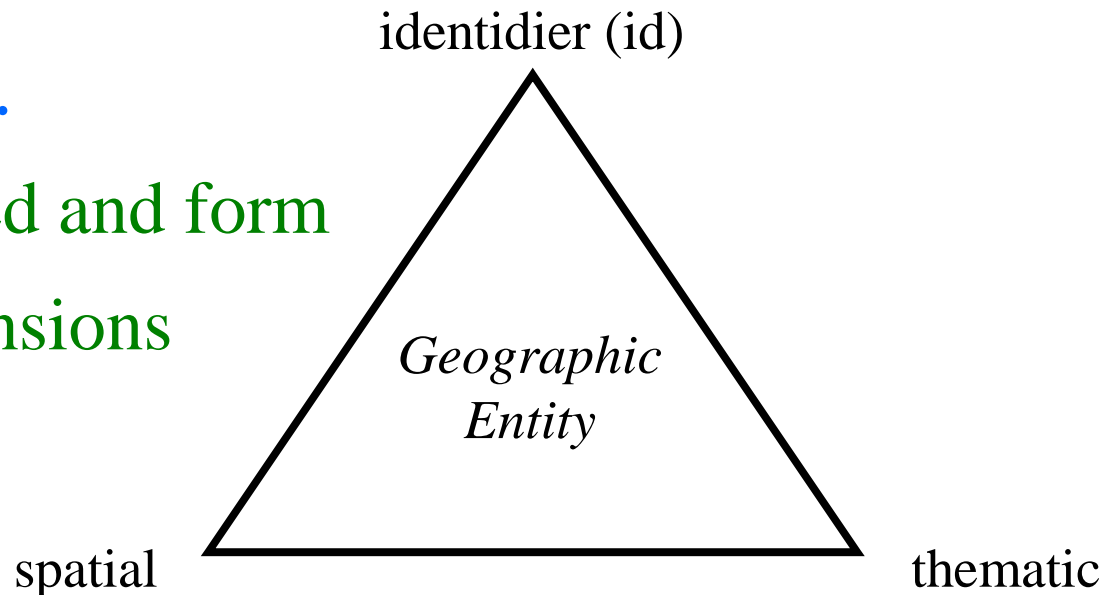


# The nature of geographic data

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- An entity (or relationship) is described by...
  - a set of **properties (attributes)**
    - e.g., a house has an address, date of construction, number of rooms, etc.

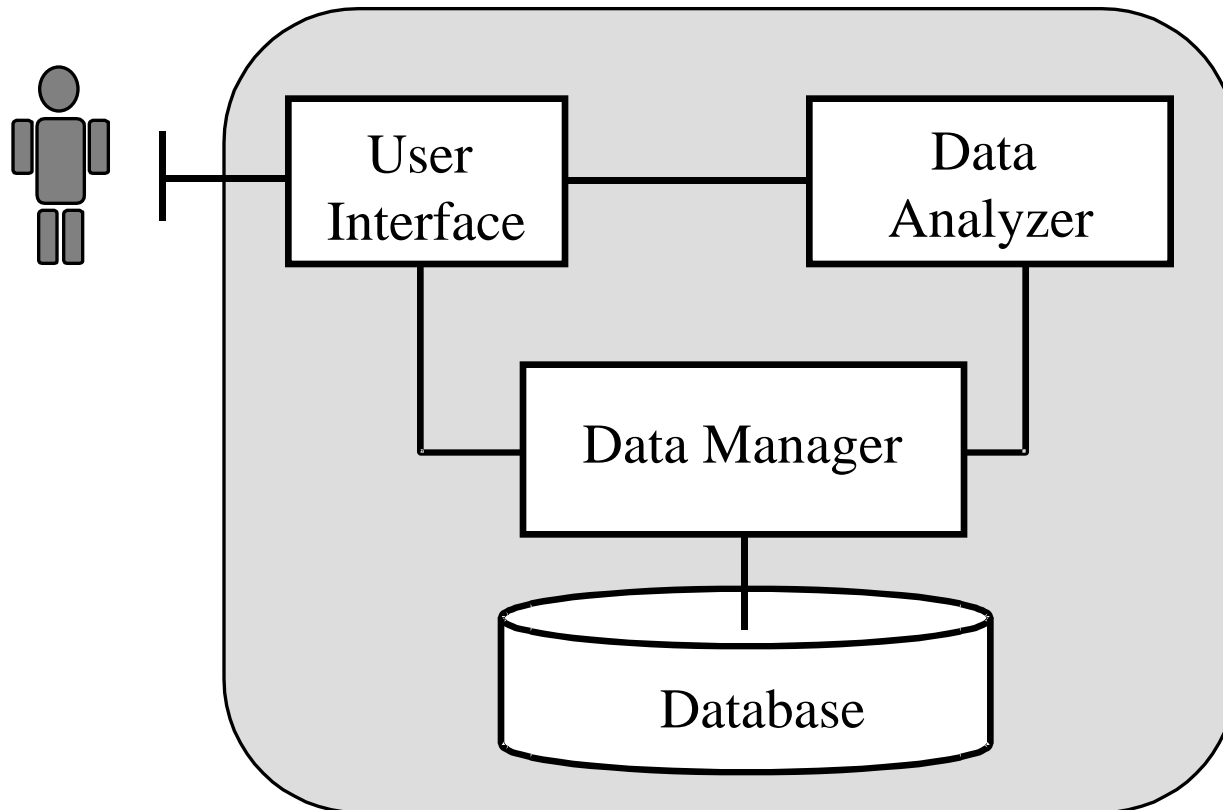
- Properties ...
  - are classified and form entity dimensions



# Information Systems

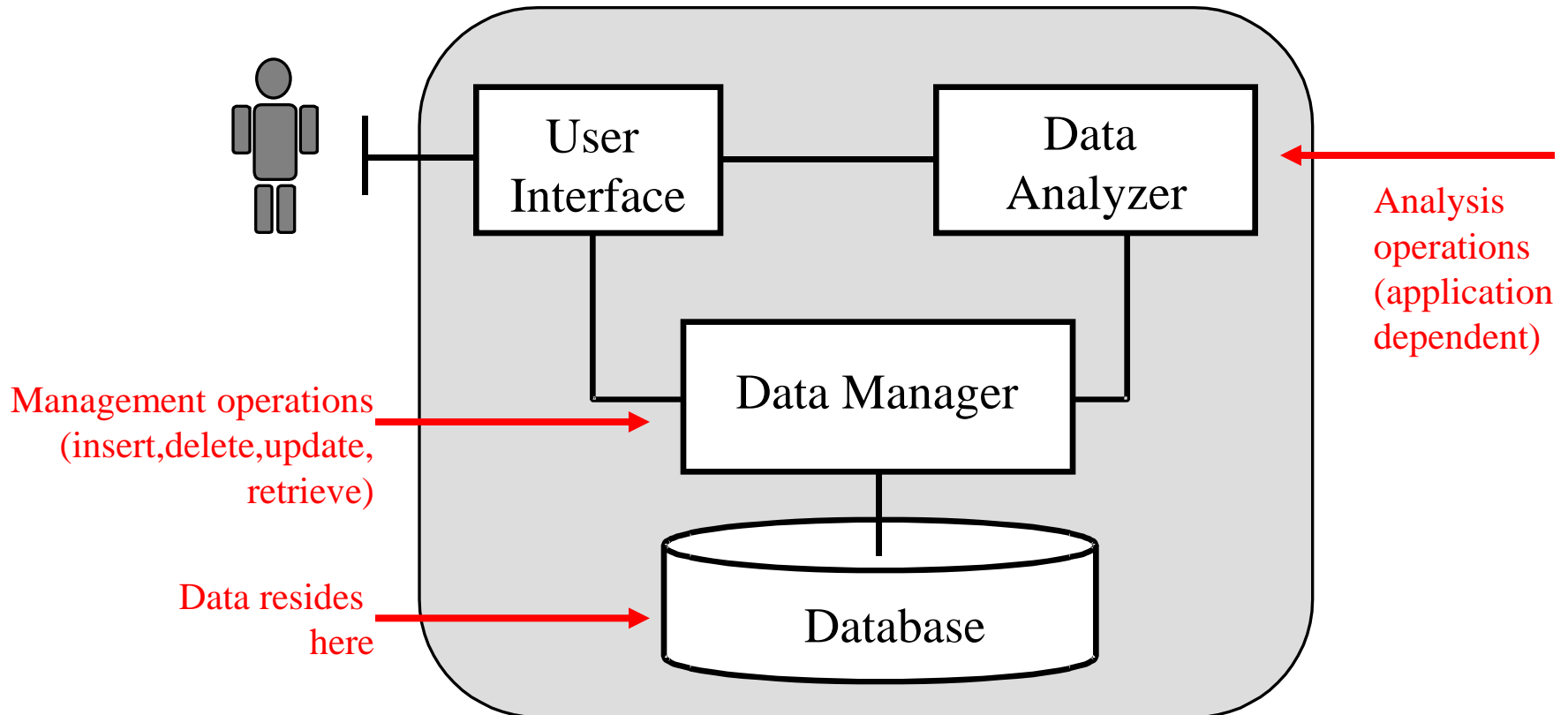
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- Architecture (simplified)



# Information Systems

- Architecture (simplified)



# Database Systems

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- **Database**
  - a collection of **related data**
- An example database
  - names, telephone numbers and addresses of an organizer
- Database properties
  - represents some aspect of the world (mini-world)
  - a logically coherent collection of data (no random assortment of data)
  - designed, built and populated with data for specific purpose (users and applications)

# Database Systems

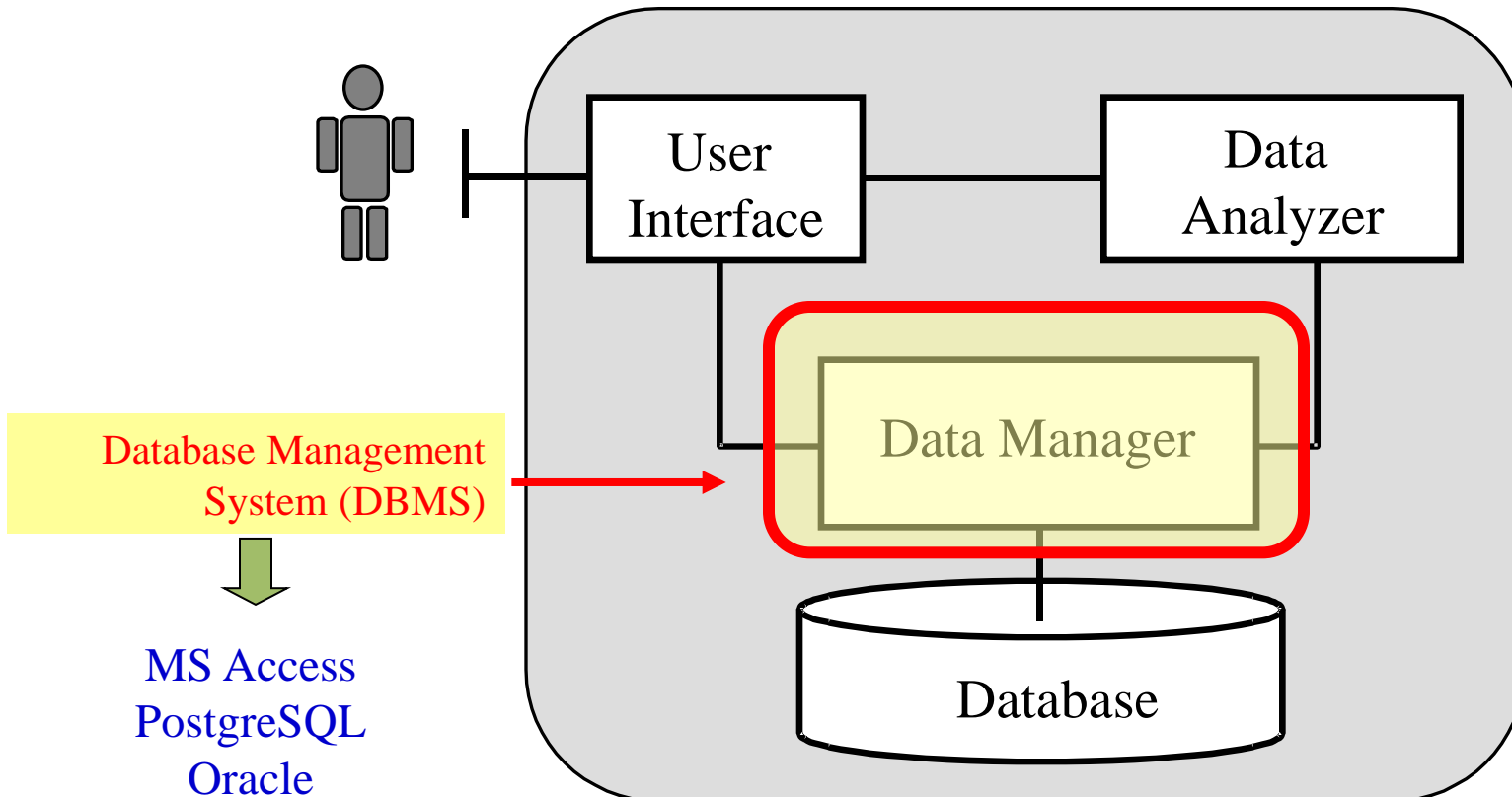
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- A database can be created / maintained ...
  - either **manually** (e.g., traditional notary offices)
  - or may be **computerized** (e.g., cadastral database)
- A Database Management System (**DBMS**)
  - a collection of programs to define, construct and manipulate a database
- A **Database System**
  - Database + DBMS



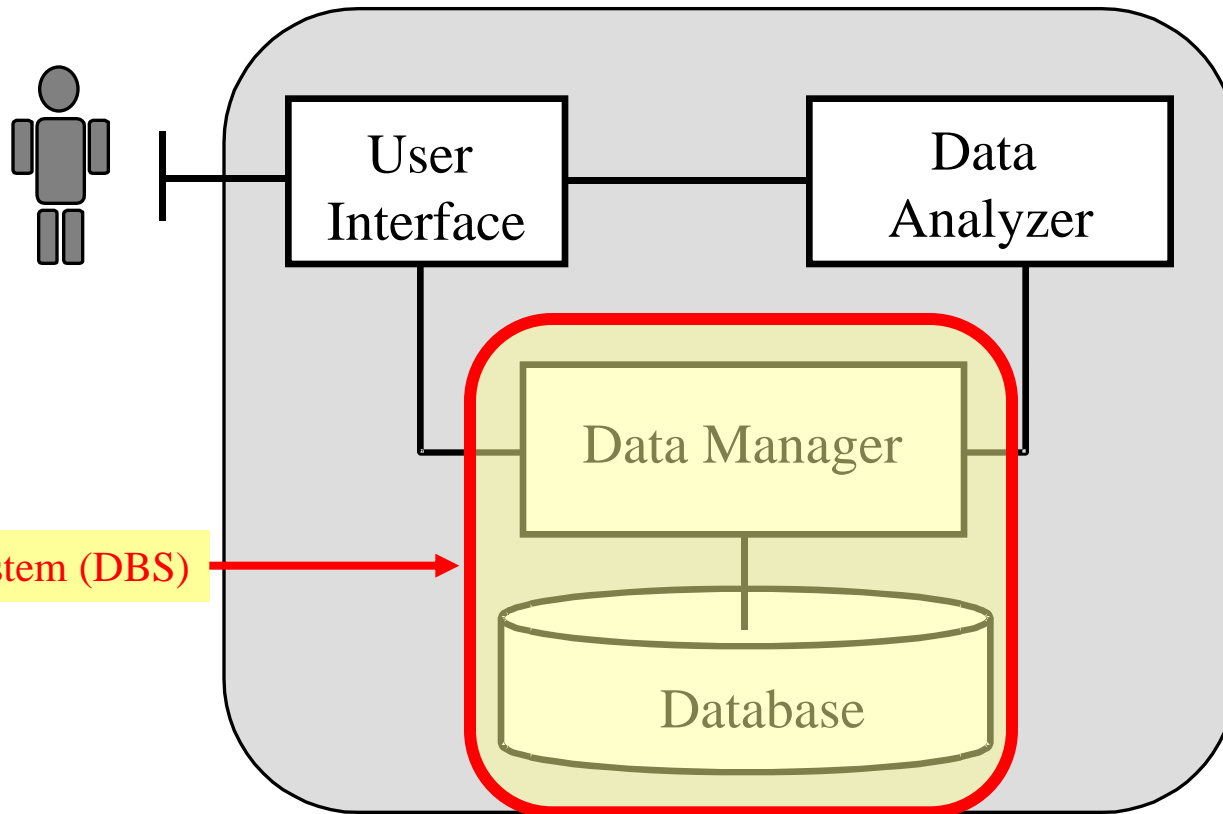
# Information Systems

- Architecture (simplified)



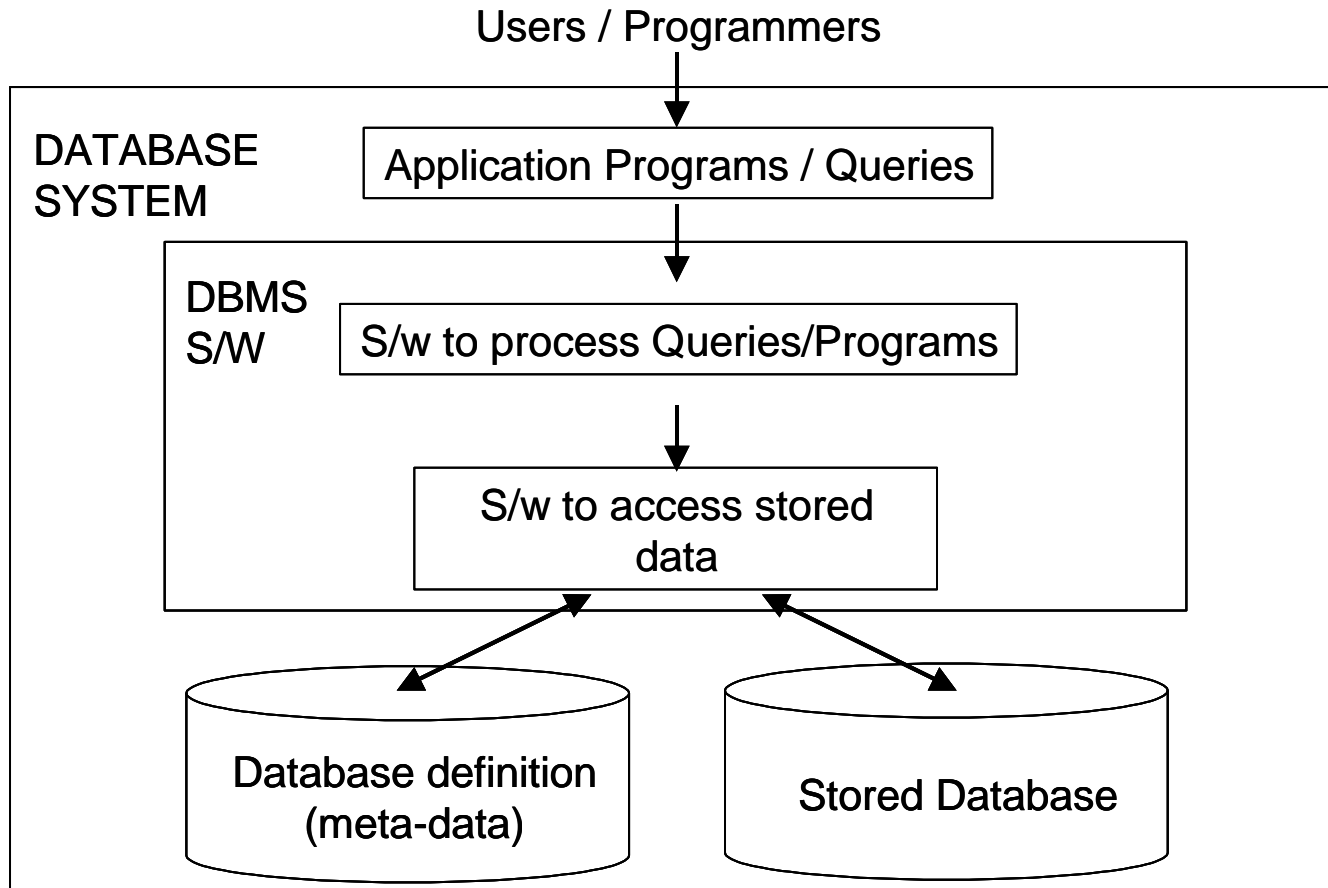
# Information Systems

- Architecture (simplified)



# Database Systems

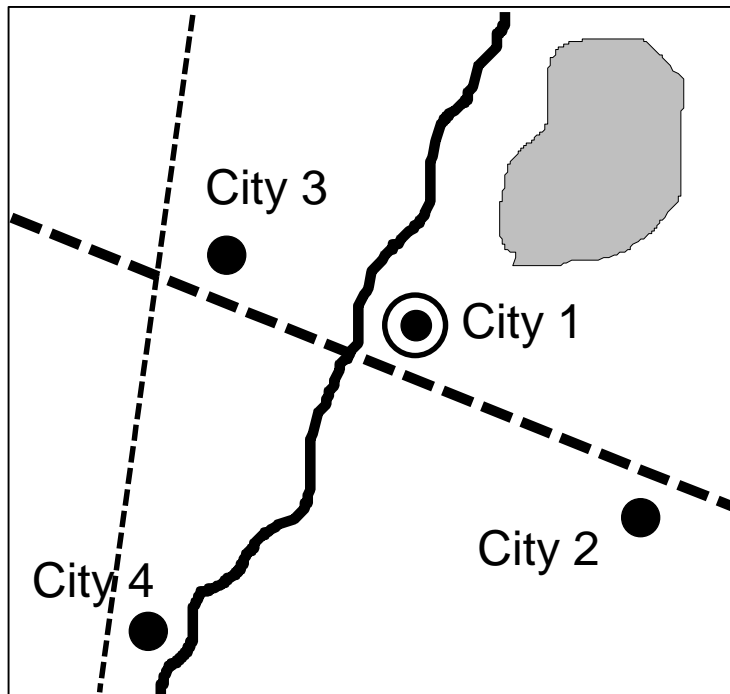
- A Database System Architecture



# Database Systems

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- The traditional **map** is an analog **database**



## Geographic entities:

Cities (points)

$(x, y)$

Roads/Rivers (lines)

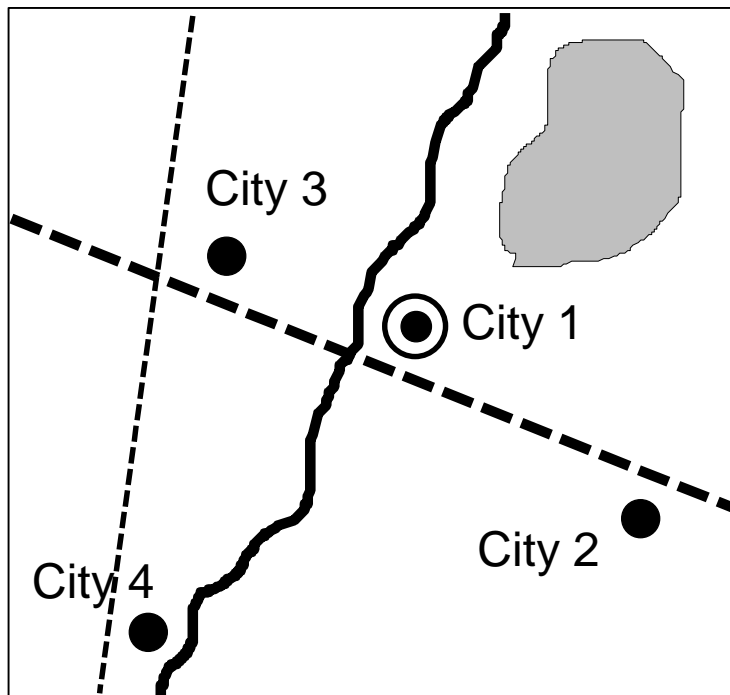
$(x_1, y_1, x_2, y_2, \dots, x_n, y_n)$

Lakes (regions)

$(x_1, y_1, x_2, y_2, \dots, x_n, y_n, x_1, y_1)$

# Database Systems

- The traditional map is an analog database



Entity properties (attributes)

(geometry/symbology/text)

Relationships

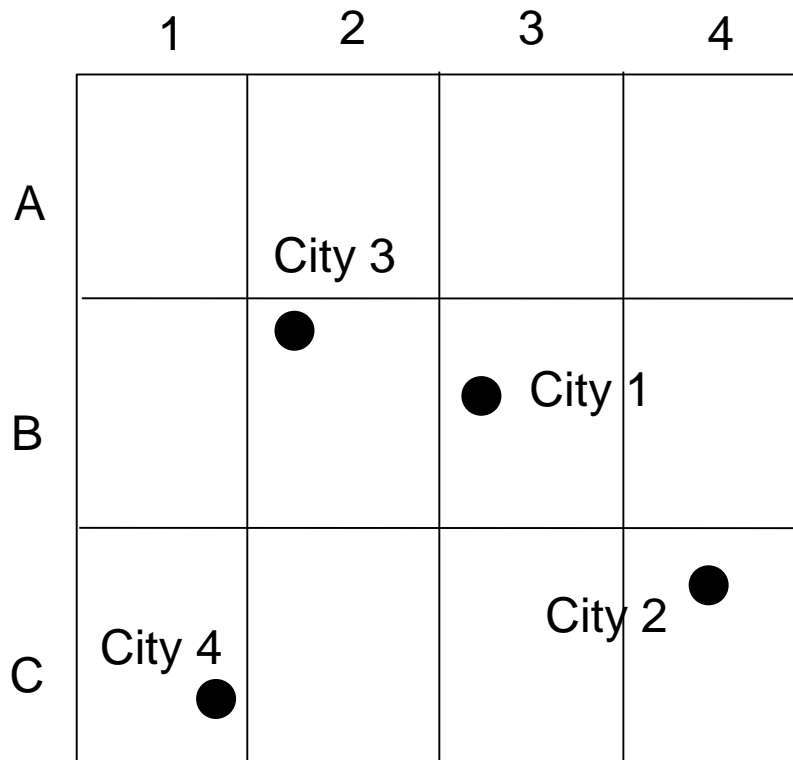
(e.g., cities by the river)

LEGEND			
.....	national road	●	city
.....	provincial road	⊙	capital
—	river	■	lake

# Database Systems

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- The traditional map is an analog database



## Indices ...

mechanisms provided to facilitated search

Index	
City	Cell
1	B3
2	C4
3	B2
4	C1

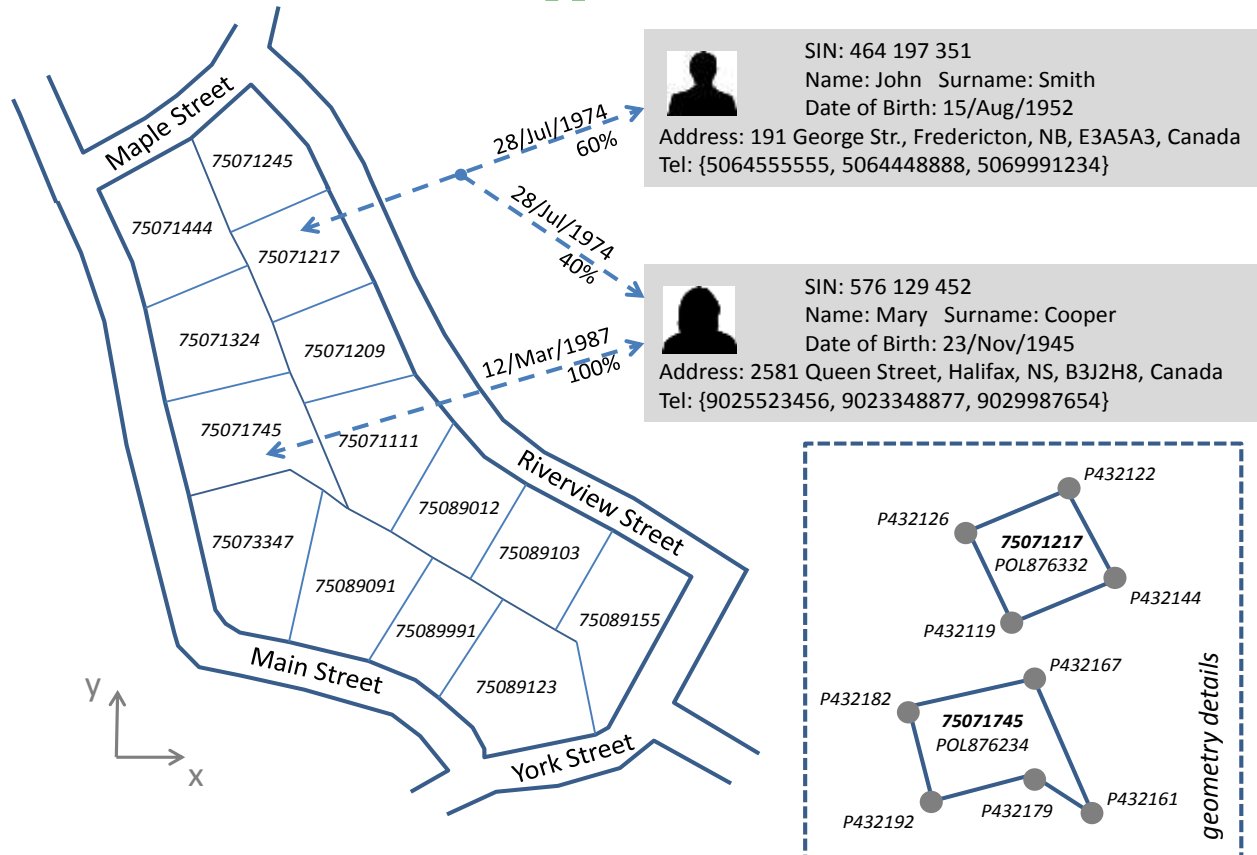
# Database Management Systems

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- A general purpose s/w system that facilitates
  - the **definition** of a database
    - specify data types, structures and constraints of data
  - the **construction** of a database
    - populate the database / store the actual data
  - the **manipulation** of a database
    - retrieve data, update data or generate reports from data

# Database Management Systems

- An example ...
  - The mini-world (cadastral application)





# Database Management Systems

- An example ...
  - The mini-world in six files...

**OWNERS**

SIN	SURNAME	NAME	DoB	STREET	No	CITY	PROV	ZIP	COUNTRY
464197351	SMITH	JOHN	08/15/1952	GEORGE	191	FREDERICTON	NB	E3A5A3	CANADA
576129452	COOPER	MARY	11/23/1945	QUEEN	2581	HALIFAX	NS	B3J2H8	CANADA
...	...	...	...	...	...	...	...	...	...

**TELEPHONES**

OWNER	NUMBER
464197351	5064555555
464197351	5064448888
464197351	5069991234
576129452	9025523456
576129452	9023348877
576129452	9029987654
...	...

**TITLES**

PARCEL	OWNER	PERCENTAGE	PURCHASE_DATE
75071217	464197351	60%	07/28/1974
75071217	576129452	40%	07/28/1974
75071745	576129452	100%	03/12/1987
...	...	...	...

**POLYGONS**

PLID	AREA	PERIMETER
POL876332	1.235	142
POL876234	1.440	169
...	...	...

**PARCELS**

ID	USE	BUILT_FACTOR	ADDRESS	POLYGON
75071217	HOUSING	1.40	542 RIVERVIEW STREET, FREDERICTON	POL876332
75071745	PARKING	1.20	323 MAIN STREET, FREDERICTON	POL876234
...	...	...	...	...

**POINTS**

PTID	X	Y	Z	POLYGON	ORDER
P432122	45678.34	8938.89	34.20	POL876332	1
P432144	45705.56	8879.67	32.85	POL876332	2
P432119	45621.12	8845.87	31.97	POL876332	3
P432126	45592.56	8910.91	32.88	POL876332	4
P432167	45650.33	8813.12	30.71	POL876234	1
P432161	45692.11	8726.44	28.12	POL876234	2
P432179	45653.98	8749.92	28.65	POL876234	3
P432192	45550.19	8730.51	27.92	POL876234	4
P432182	45539.87	8802.01	29.33	POL876234	5
...	...	...	...	...	...

# Database Management Systems

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- An example...
  - six database files...
    - each file accommodates records of the same type
      - e.g., owners' file: information about the owners
  - **definition** of the database
    - define the files and the structure of their records
      - e.g., each titles file record consists of the parcel id, the proprietor id, percentage and the date of ownership
    - definition of data types and constraints
      - e.g., percentage of ownership is an integer number in the interval [0,100]

# Database Management Systems

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- An example...
  - **construction** of the database
    - populate the database / store the actual data
      - e.g., owners data are stored in owners file
    - records in different files may be related
      - e.g., each record in titles file is related with one record in owners' file and one record in parcels file
  - the **manipulation** of a database
    - includes search queries and updates
      - e.g., “find all parcels owned by John Smith”, or “modify Mary Cooper’s address to 75 Maple Str.”
      - all expressed in a systems language

# DBMS – Basic Concepts

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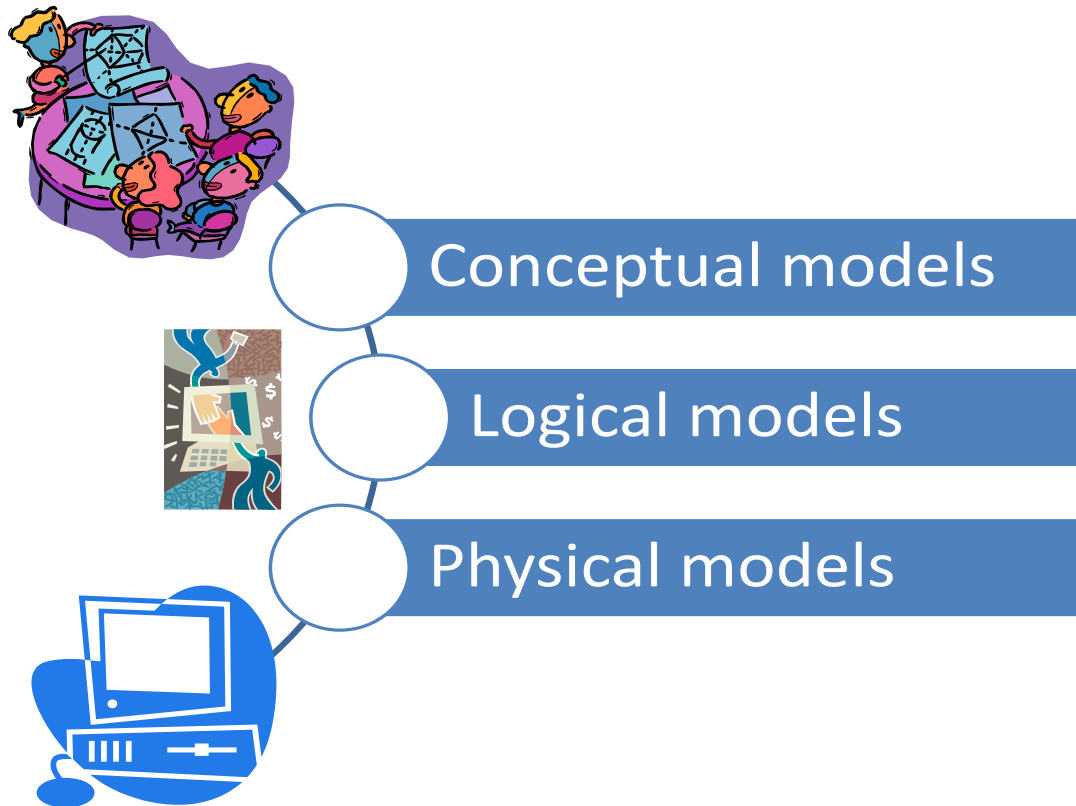
- **Data Model**

- A collection of concepts that can be used to describe **the structure of a database**
  - data types
  - relationships
  - constraints (that should hold on the data)
- Most data models also include ...
  - A set of **basic operations** for ...
    - retrievals and updates on the database

# DBMS – Basic Concepts

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- Categories of **Data Models** ...



# DBMS – Basic Concepts

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- Categories of **Data Models** ...
  - according to the types of concepts they use
    - conceptual data models (high level)
      - close to the way humans perceive data
    - physical data models (low level)
      - how data are stored in the computer
    - representational data models (medium level)
      - may be understood by end users but not too far from the way data is organized within the computer

# DBMS – Basic Concepts

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- **Schemas and Instances**

- Important distinction between...

- The description of the database and the database itself

- Database schema ...

- description of the database

- specified during database design and is not expected to change frequently

## OWNERS

<b>SIN</b>	<b>SURNAME</b>	<b>NAME</b>	<b>DoB</b>	<b>STREET</b>	<b>No</b>	<b>CITY</b>	<b>PROV</b>	<b>ZIP</b>	<b>COUNTRY</b>
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## TITLES

<b>PARCEL</b>	<b>OWNER</b>	<b>PERCENTAGE</b>	<b>PURCHASE_DATE</b>
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## PARCELS

<b>ID</b>	<b>USE</b>	<b>BUILT_FACTOR</b>	<b>ADDRESS</b>	<b>POLYGON</b>
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# DBMS – Basic Concepts

- **Schemas and Instances**

- Database state (instance)...

- The data in the database at a particular moment in time
- A snapshot of the database
- In a dynamic database it changes very often

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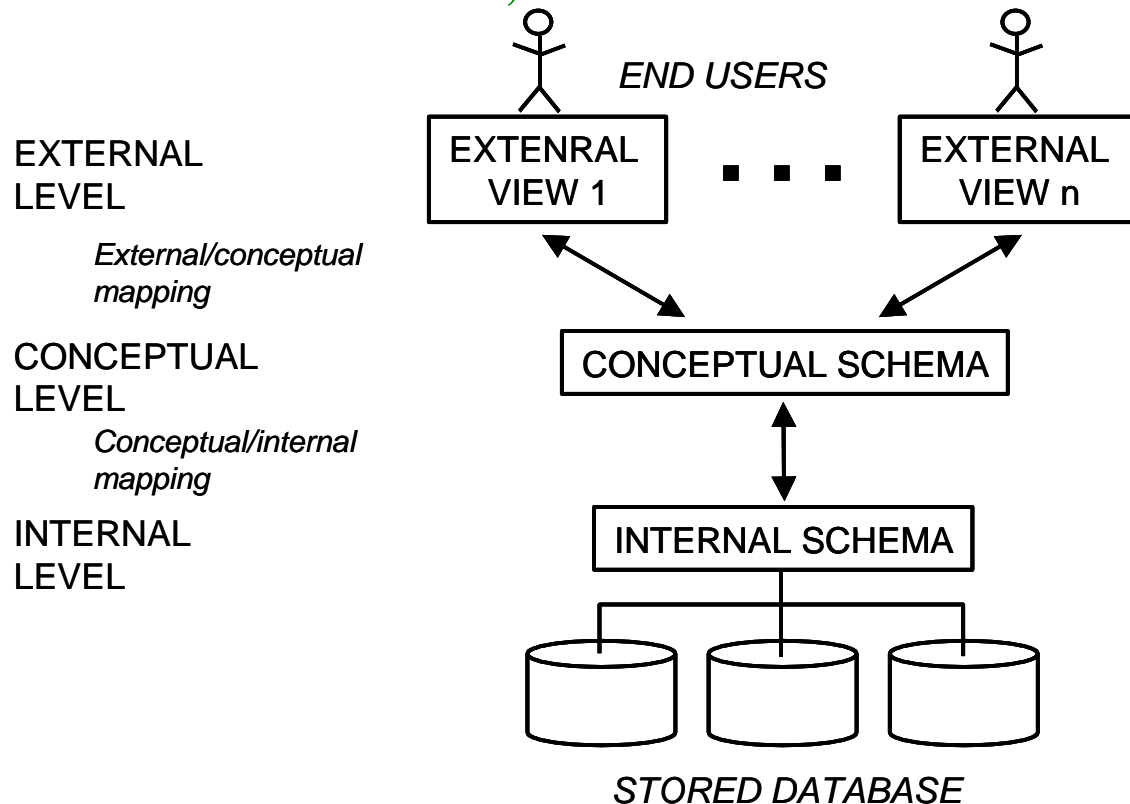
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...	...	...	...	...



# DBMS – Basic Concepts

- DBMS Architecture

- Based on ANSI/SPARC, 1970.



# DBMS – Basic Concepts

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- DBMS Languages
  - Data definition language (DDL)
  - Storage definition language (SDL)
  - Data manipulation language (DML)
  - View definition language (VDL)
- DBMS Interfaces
  - Menu-based interfaces for browsing
  - Forms-based interfaces
  - Graphical user interfaces
  - Natural language interfaces
  - Interfaces for parametric users
  - Interfaces for the DBA

# DBMS – Basic Concepts

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- DBMS Categories
  - Based on the **data model** adopted
    - Hierarchical DBMS
    - Network DBMS
    - **Relational DBMS**
    - Object-Oriented DBMS
    - Object-Relational DBMS

# DBMS – Basic Concepts

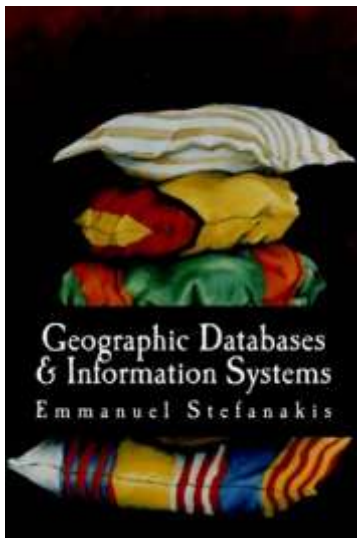
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- DBMS Categories
  - Based on the **number of users**
    - Single-user DBMS
    - Multi-user DBMS
  - Based on the **number of sites** where data resides
    - Centralized DBMS
    - Distributed DBMS

# Database System Development

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- Seven steps ...
  - Definition of users/application requirements
  - **System design**
  - System implementation
  - Import data into the system
  - System evaluation
  - System operation (life-cycle begins)
  - System maintenance



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