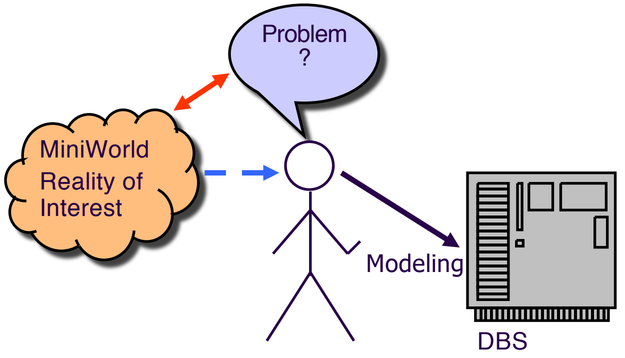
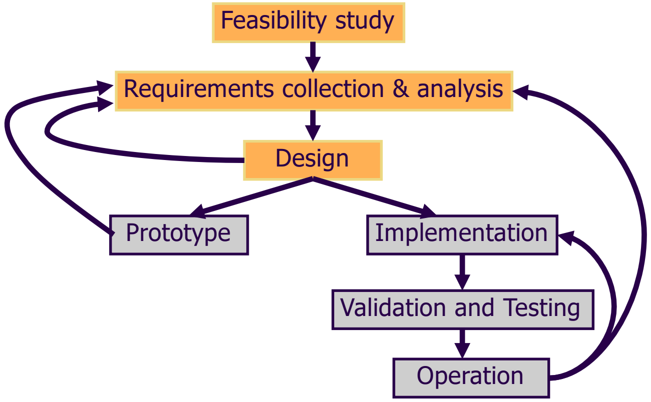
# Conceptual Database Design & ER-Model

- ER-Model
- ER-Diagrams
- EER Model & Diagrams

# Database System Design/Data Modeling



# Database System Life Cycle



# Design

- ❑ Functional Design
- ❑ Database Design

## Functional Design

- High-level specification of Transactions
  - DBMS-independent
  - Even diagrams, UML
- Application program design
  - DBMS-specific (db Schema together with DML)
  - Language and environment-specific

## Database Design

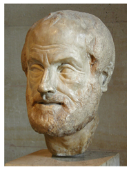
- Database design is the activity of specifying the schema of a database in a given data model
- Three categories:
  - Conceptual database design
  - Logical database design
  - Physical database design

## Database Design

- Conceptual database design
  - An abstract but complete description of the DB
  - Implementation independent (*semantic clarity*)
  - E.g., conceptual model: E-R Model, UML
- Logical database design
  - The conceptual database schema
  - Formal schema in an *implementation* data model
  - E.g., Relational, O-O, O-R, Network, hierarchical
- Physical database design
  - Internal schema: Internal storage organization of objects, implementing the conceptual model

## Aristotle (Greek: Ἀριστοτέλης Aristotélēs)

384 BC – 322 BC



- The first to create a comprehensive system of philosophy, encompassing morality and aesthetics, logic and science, politics and metaphysics.
- Taxonomy [Physica: physical sciences]
  - living things
  - their relationships
  - prototype or exemplar

## Entity-Relationship Model (P. Chen, 1976)

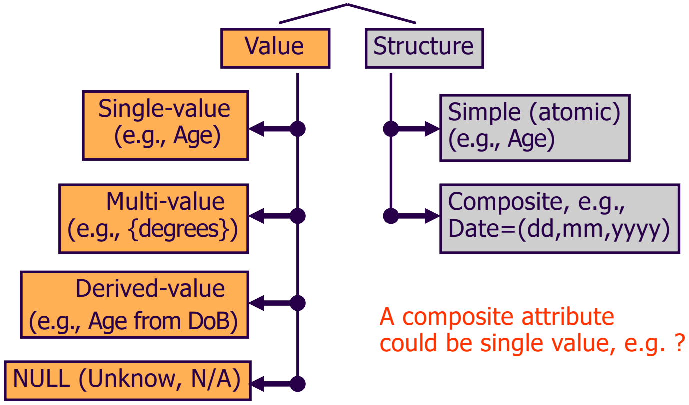
Two Semantics primitives

- Entities
  - Objects with physical existence, e.g., Peter, Mary, Peter's house, etc.
  - Objects with conceptual existence, e.g., University, Course, Account, etc.
- Relationships
  - Associations between two or more entities e.g., Peter *married* Mary, Mary *studies* Physics, etc.

## Attributes

- Entities are characterized by their attributes
  - Peter has an age,
  - Mary's car has a color
- Relationships may also have attributes
  - Peter married Mary on Jan 7

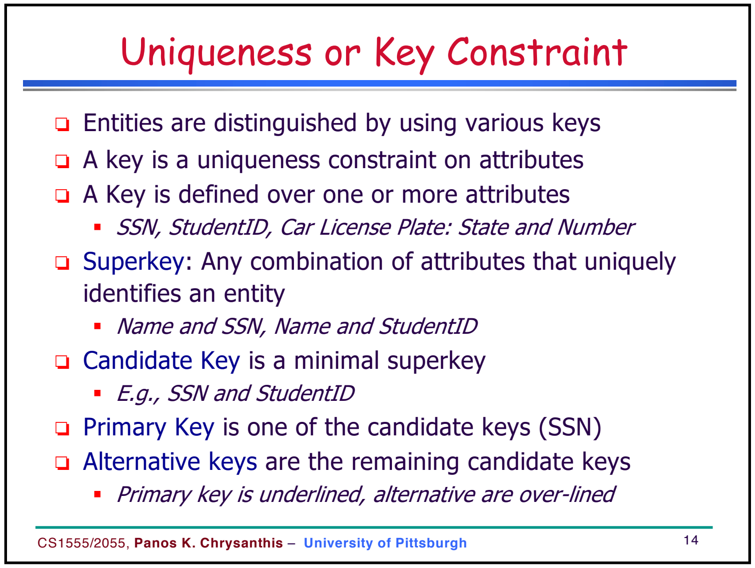
## Attribute Classification


Value
Structure
Single-value (e.g., Age)
Multi-value (e.g., {degrees})
Derived-value (e.g., Age from DoB)
NULL (Unknow, N/A)
Simple (atomic) (e.g., Age)
Composite, e.g., Date=(dd,mm,yyyy)

A composite attribute could be single value, e.g. ?

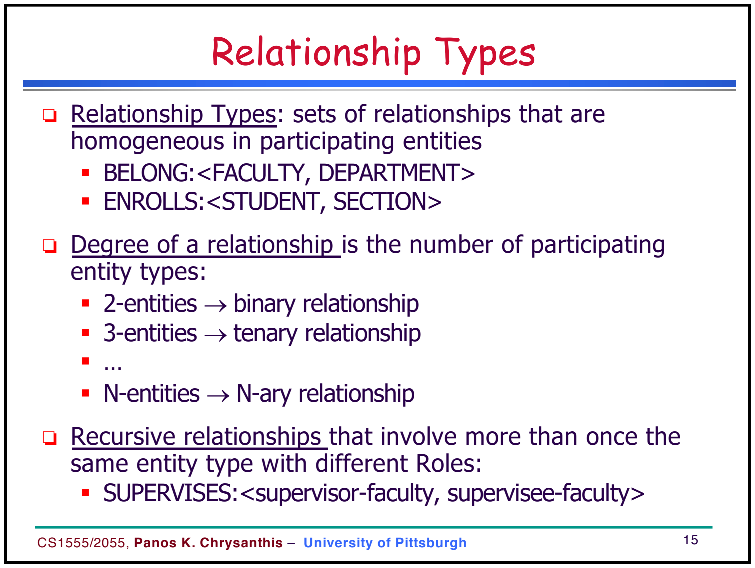
## Entity Types

- All similar (same attributes) entities are grouped into sets, an entity type
- Entity type schema specifies the common structure:
  - type name
  - entity attributes (Domain, value set)
  - constraints on entities
- E.g.,
  FACULTY: Name(FN,LM,MI), DoB, SSN, {Degree}, Rank
  - FN:String(15), LN: String(15), SSN: String(9), etc.
  - DoB: DD/MM/YYYY
  - Degree: {BS,MS,PhD}
  - Rank: {Lecturer, Assistant, Associate, Full}



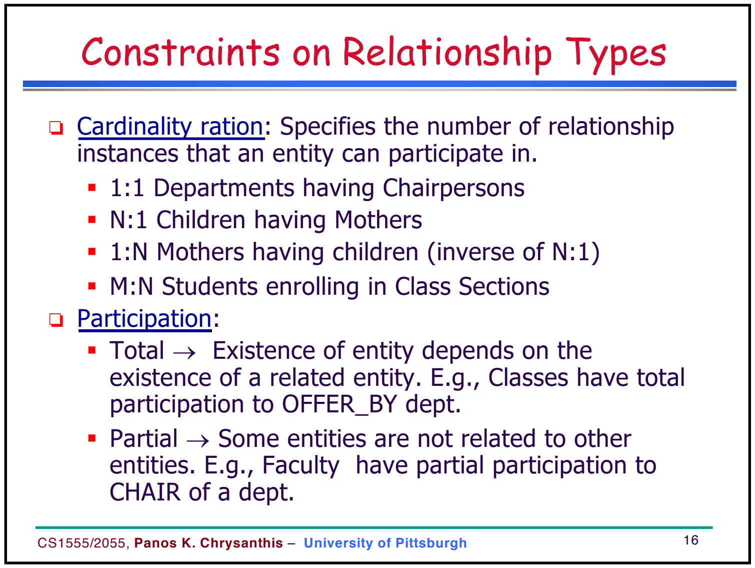
## Uniqueness or Key Constraint

- Entities are distinguished by using various keys
- A key is a uniqueness constraint on attributes
- A Key is defined over one or more attributes
  - *SSN, StudentID, Car License Plate: State and Number*
- Superkey: Any combination of attributes that uniquely identifies an entity
  - *Name and SSN, Name and StudentID*
- Candidate Key is a minimal superkey
  - *E.g., SSN and StudentID*
- Primary Key is one of the candidate keys (SSN)
- Alternative keys are the remaining candidate keys
  - *Primary key is underlined, alternative are over-lined*



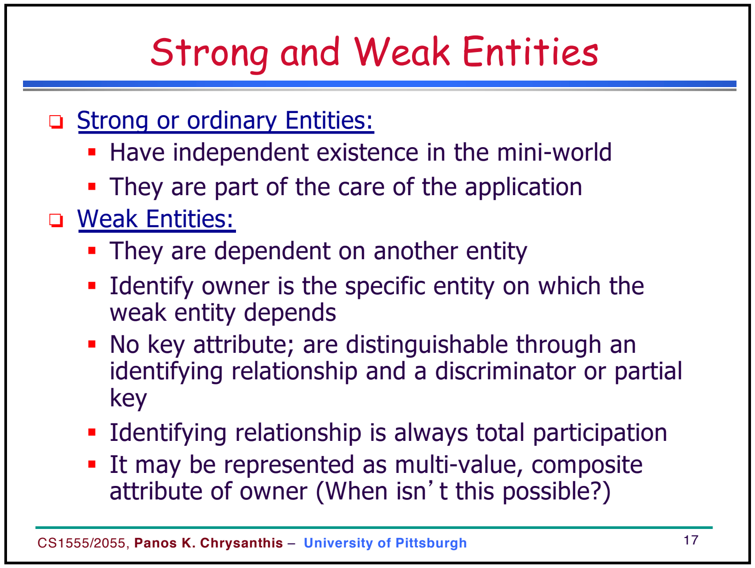
## Relationship Types

- Relationship Types: sets of relationships that are homogeneous in participating entities
  - BELONG:<FACULTY, DEPARTMENT>
  - ENROLLS:<STUDENT, SECTION>
- Degree of a relationship is the number of participating entity types:
  - 2-entities → binary relationship
  - 3-entities → tenary relationship
  - …
  - N-entities → N-ary relationship
- Recursive relationships that involve more than once the same entity type with different Roles:
  - SUPERVISES:<supervisor-faculty, supervisee-faculty>



## Constraints on Relationship Types

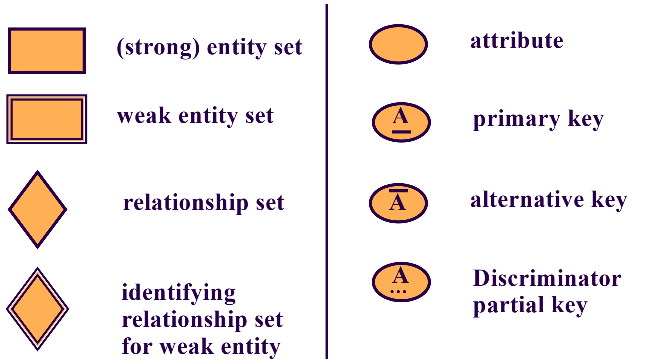
- Cardinality ration: Specifies the number of relationship instances that an entity can participate in.
  - 1:1 Departments having Chairpersons
  - N:1 Children having Mothers
  - 1:N Mothers having children (inverse of N:1)
  - M:N Students enrolling in Class Sections
- Participation:
  - Total → Existence of entity depends on the existence of a related entity. E.g., Classes have total participation to OFFER_BY dept.
  - Partial → Some entities are not related to other entities. E.g., Faculty have partial participation to CHAIR of a dept.



## Strong and Weak Entities

- Strong or ordinary Entities:
  - Have independent existence in the mini-world
  - They are part of the care of the application
- Weak Entities:
  - They are dependent on another entity
  - Identify owner is the specific entity on which the weak entity depends
  - No key attribute; are distinguishable through an identifying relationship and a discriminator or partial key
  - Identifying relationship is always total participation
  - It may be represented as multi-value, composite attribute of owner (When isn't this possible?)

# ER-Diagrams



(strong) entity set

weak entity set

relationship set

identifying relationship set for weak entity

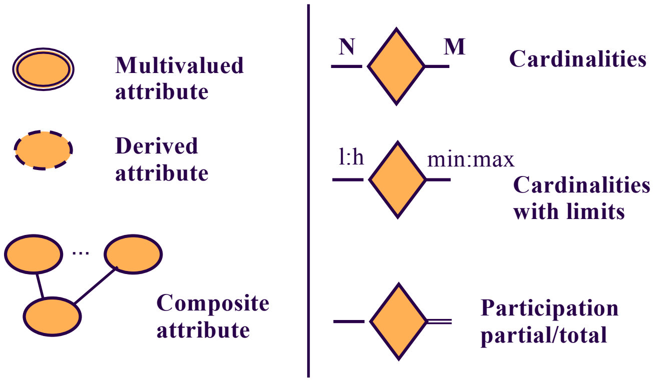
attribute

primary key

alternative key

Discriminator partial key

# ER Diagrams…



Multivalued attribute

Derived attribute

Composite attribute

Cardinalities

Cardinalities with limits

Participation partial/total

# Case Study: Library Database System

- Library organized into sections, like art, children, computing, science, etc. Each section has name and a number and its headed by a head librarian
- Each book title belongs to a section and has a title, authors, ISBN, call number, year and publisher
- For each copy of the book keep track the current borrower, the due date and the librarian who charged it out.
- Members have membership number, a driver's license, an address, a phone number and birthday
- Members can have up to 5 borrowed books and can put a hold request on a book.
- Librarians have a name, ssn, address, phone

# Observation

- nouns -> entity types/sets
- verbs -> relationship types