DATABASE MANAGEMENT SYSTEMS (IT 2040)

LECTURE 01- INTRODUCTION TO DBMS AND DATABASE DESIGN PROCESS

LECTURE CONTENT

- Introduction to databases, DBMS and their benefits
- Database design process
- Requirement analysis
- Conceptual modelling using EER diagrams
- Design traps

LEARNING OUTCOMES

- Explain what is a database and a DBMS.
- Identify situations where using a database would be beneficial.
- Explain the database design process.
- Draw a EER diagram for a given scenario.

DATABASE DESIGN PROCESS

- There are six main phases of the process to develop a database
  - Requirement collection and analysis — What are the data you should store, relationships and quarries.
  - Conceptual database design — Where you can show the requirements u have collected in a picture(ER Diagram)
  - Logical database design
  - Schema refinement (Normalize) — If we have problems in ER(Redundant data), we can do refine data
  - Physical database design — Create tables, import data, create quarries.
  - Security design

REQUIREMENT COLLECTION AND ANALYSIS

- The purpose of the phase is to collect and analyze the expectations of the users & the intended uses of the database.
- The process would include interviewing clients and analyzing documents such as files used to record data and reports to be generated.
- At the end of the requirement collection, the database developer should identify any unclear or incomplete requirements, redundant information and eliminate them.

eg :-

If we gonna create a system for a Hospital,
Interview Medical staff(Nurse, Doctors, Lab Staff), patients and workers.
Analyze documents like registries, patient cards, lab report .etc.

REQUIREMENT ANALYSIS (CONTD.)

- Aspects to consider include
  - What data is to be stored in the database?
  - What applications are to be built?
  - What operations have to be performed?

CONCEPTUAL DATABASE DESIGN

(Basically the concept of the database we are going to use)

- The result of the requirement analysis step is a concisely written set of users' requirements.
- Once, this step is completed, the next step is to create a **conceptual database schema** for the database, using a high-level conceptual data model.
- This step is called **conceptual database design**.
- **Entity-Relationship (ER) model** is a high-level conceptual data model.

ER MODEL - ENTITIES & ATTRIBUTES

- You already know these !

Check Handout

  - Check the handout for the definitions and examples for entities, different types of attributes and keys.
- Select an important entity in a context you are familiar. Add simple attributes, a multivalued attribute, a composite attribute and a key to the entity you identified.
  - Try not to use the attributes shown in the handouts.
- Exchange what you have drawn with your peer. What have they written?

ER MODEL - BINARY RELATIONSHIPS

- You already know these too !

Check Handout

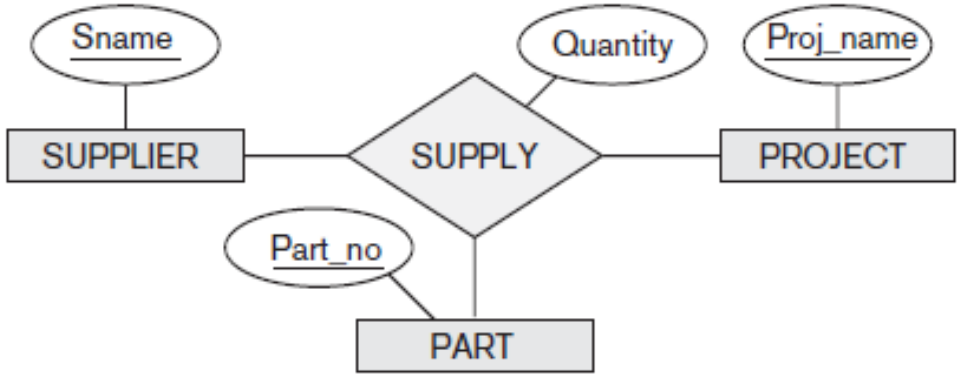
  - Check the handout for the definitions and examples for different cardinalities in binary relationships such as 1:1, 1:N and M:N
  - Now draw examples for each cardinality ratio above associated with binary relationships.
  - Exchange what you have drawn with your peer. What has he/she drawn?

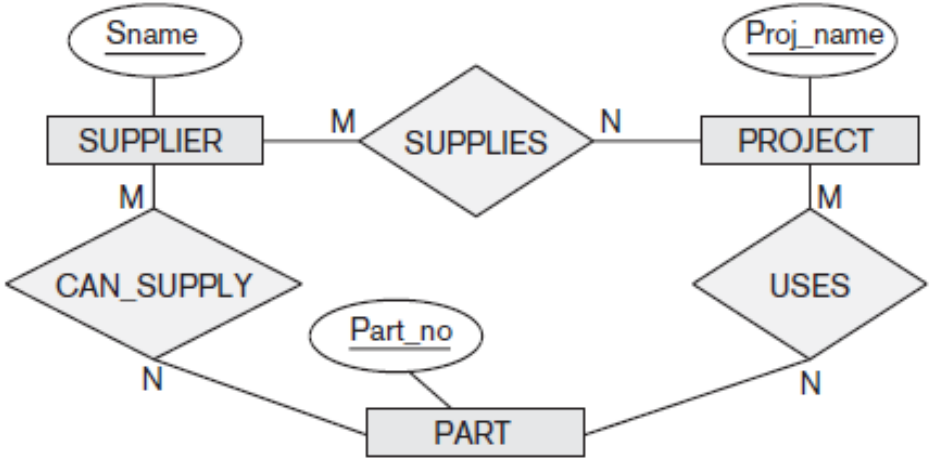
ER MODEL - WEAK ENTITIES

- Weak entities are entities that cannot be uniquely identified alone in a domain.
- Following restrictions must hold with relevance to weak entities
  - The owner entity set and the weak entity set must participate in a one-to-many relationship set (one owner entity is associated with one or more weak entities, but each weak entity has a single owner). This relationship set is called the **identifying relationship set** of the weak entity set.
  - The weak entity set must have total participation in the identifying relationship set.
- Can you think of an weak entity in a domain you know?

ER MODEL - TERNARY RELATIONSHIPS

- A ternary relationship is when three entities participate in the relationship.
- When to use ternary vs binary?





- Ternary relationships could be used when there is a common attribute that needs all three entities together, (ex: quantity)
- Include the ternary relationship *plus* one or more of the binary relationships, if they represent different meanings and if all are needed

SUPPLIER SUPPLY PART for a PROJECT

SUPPLIER SUPPLIES PROJECTS
SUPPLIER CAN_SUPPLY PARTS that USES for PROJECTS

ACTIVITY

- ENTITIES

- Draw an ER diagram for the scenario below.
  - A Library is organized into several sections such as fiction, children and technology. Each section has a name and a number(unique) and its headed by a head librarian.
  - Each book belong to a section and has a title, authors, ISBN, year and a publisher.
  - A book may have several copies. Each copy is identified by an access number.
  - For each copy borrowed, current borrower and due date should be tracked.
  - Members have a membership number(unique), an address and a phone number.
  - Members can borrow 5 books and could put hold request on a book
  - Librarian has a name, id number(unique), phone and an address.

EER MODEL

Enhanced ER Model

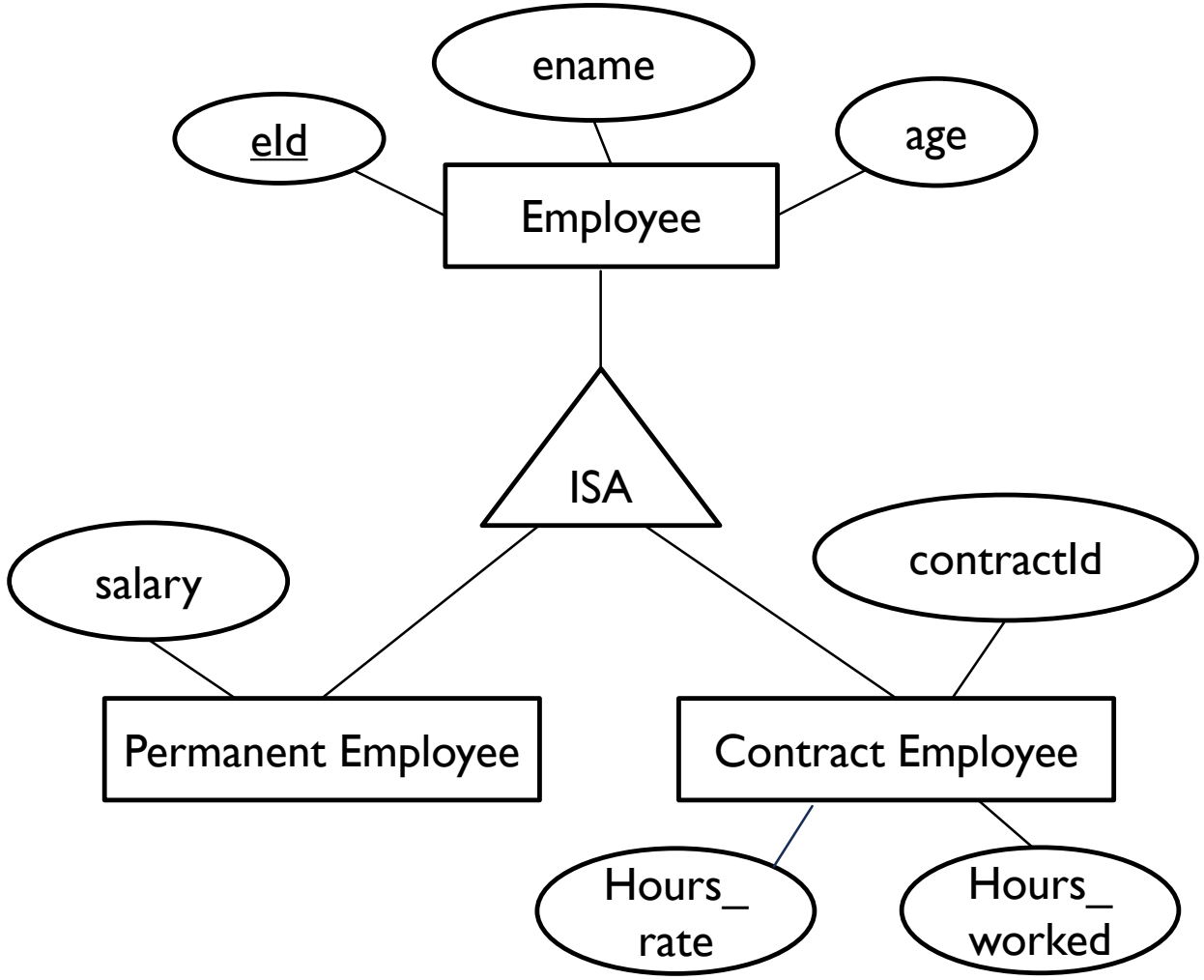
- ER model we discussed so far has been enhanced by adding several new concepts leading to the development of the EER model.
- An important extension included in the EER model is the specialization and generalization concepts.
  - Specialization is the process of defining a set of subclasses of an entity type.
    - Employee & permanent employee
  - Generalization is the process of identifying commonalities between entity types and grouping them as super-classes.

EER MODEL - ISA RELATIONSHIPS

- In many cases an entity type has numerous subgroupings or subtypes of its entities that are meaningful and need to be represented explicitly because of their significance to the database application.
  - Ex: the entities that are members of the EMPLOYEE entity type may be distinguished further into contract employees and permanent employees
- Such subtypes could be represented in EER diagrams using 'ISA' relationships

EER MODEL - ISA RELATIONSHIPS (CONTD.)

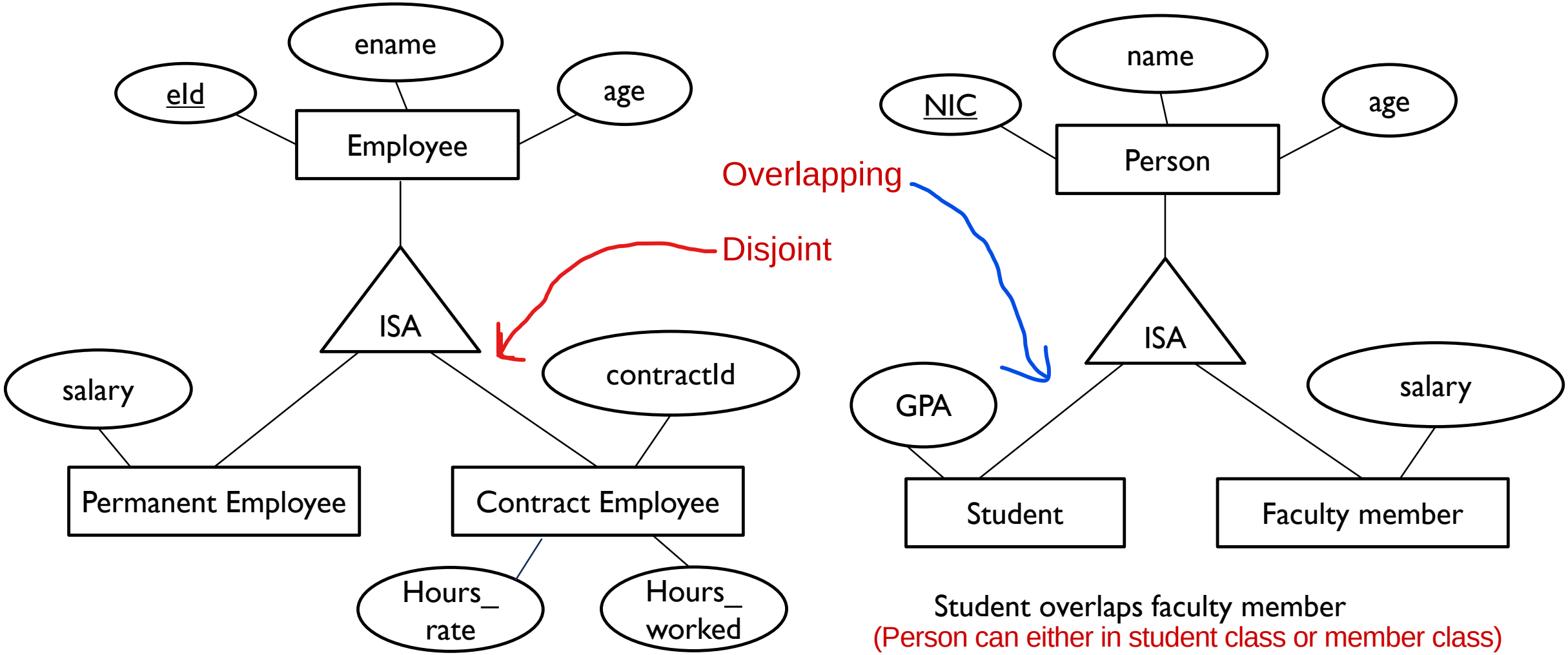
- Note that the subclasses may have their own attributes and relationships.
- Every entity in the subclass is also an employee entity and have all the have all of the attributes of Employees entity.
- Thus, attributes of the permanent employee include all attributes of employee entity and those of permanent employee.



OVERLAPPING CONSTRAINT

- **Overlapping constraint** determine whether two subclasses are allowed to contain the same entity.
  - For example can an employee E be a permanent employee and a contract employee? Probably not. Therefore, the permanent employee subclass and the contract employee subclass are disjoint.
  - Can a person P in a university environment be a student and a faculty member at the same time. If it is so, we denote this by writing student overlaps faculty member. In absence on such a statement we assume that the sub classes are disjoint.

OVERLAPPING CONSTRAINT (CONTD.)

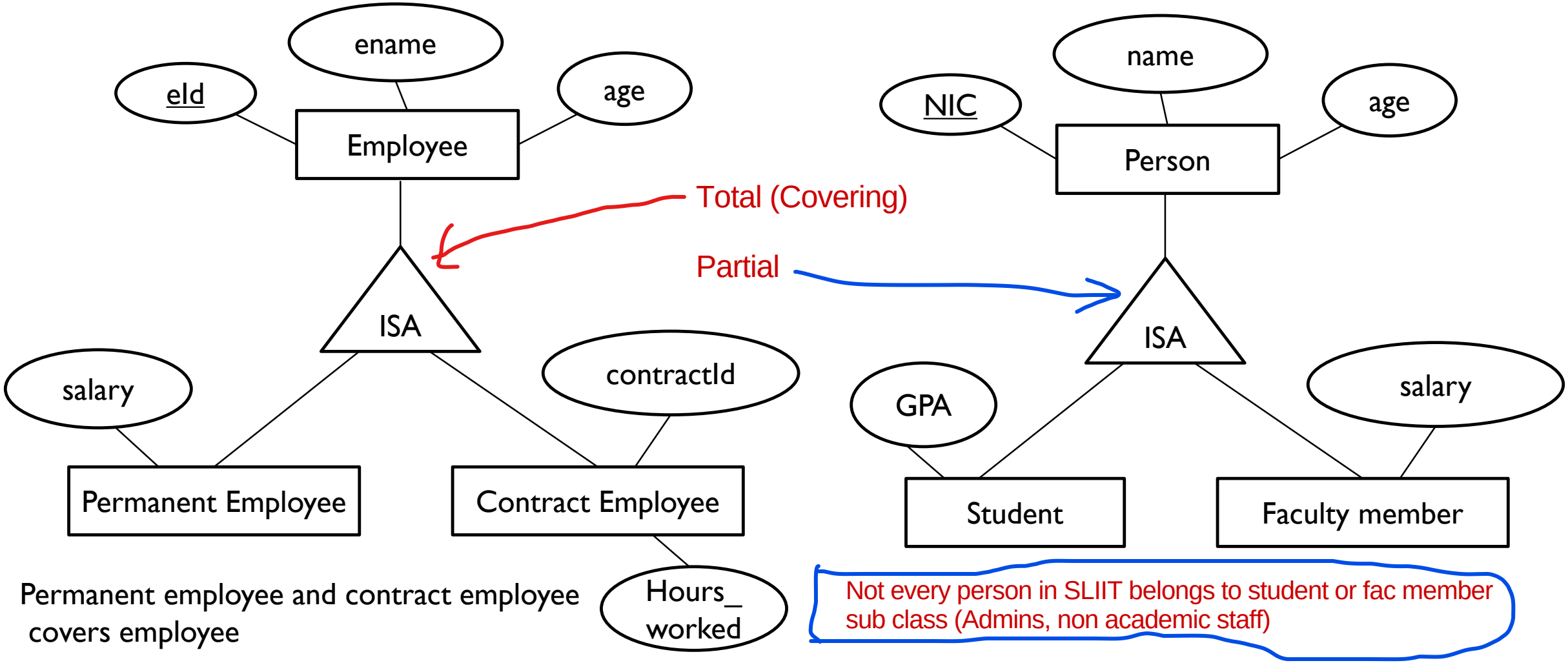


Student overlaps faculty member
(Person can either in student class or member class)

COVERING CONSTRAINT

- **Covering constraints** determine whether the entities in the subclasses collectively include all entities in the super class.
  - For example, does every employee entity e, belong to one of its subclasses (i.e. permanent employee or contract employee)? If so we denote this by writing permanent employee and contract employee covers employee.
  - Does every person p in a university environment belong to either student sub class or the faculty member sub class? Probably not. Therefore, there is no covering constraint associated with the hierarchy.
- Existence of a covering constraint is also know as having a total specialization.
- Absence of a covering constraint in a class hierarchy is known as partial specialization.

COVERING CONSTRAINT (CONTD.)

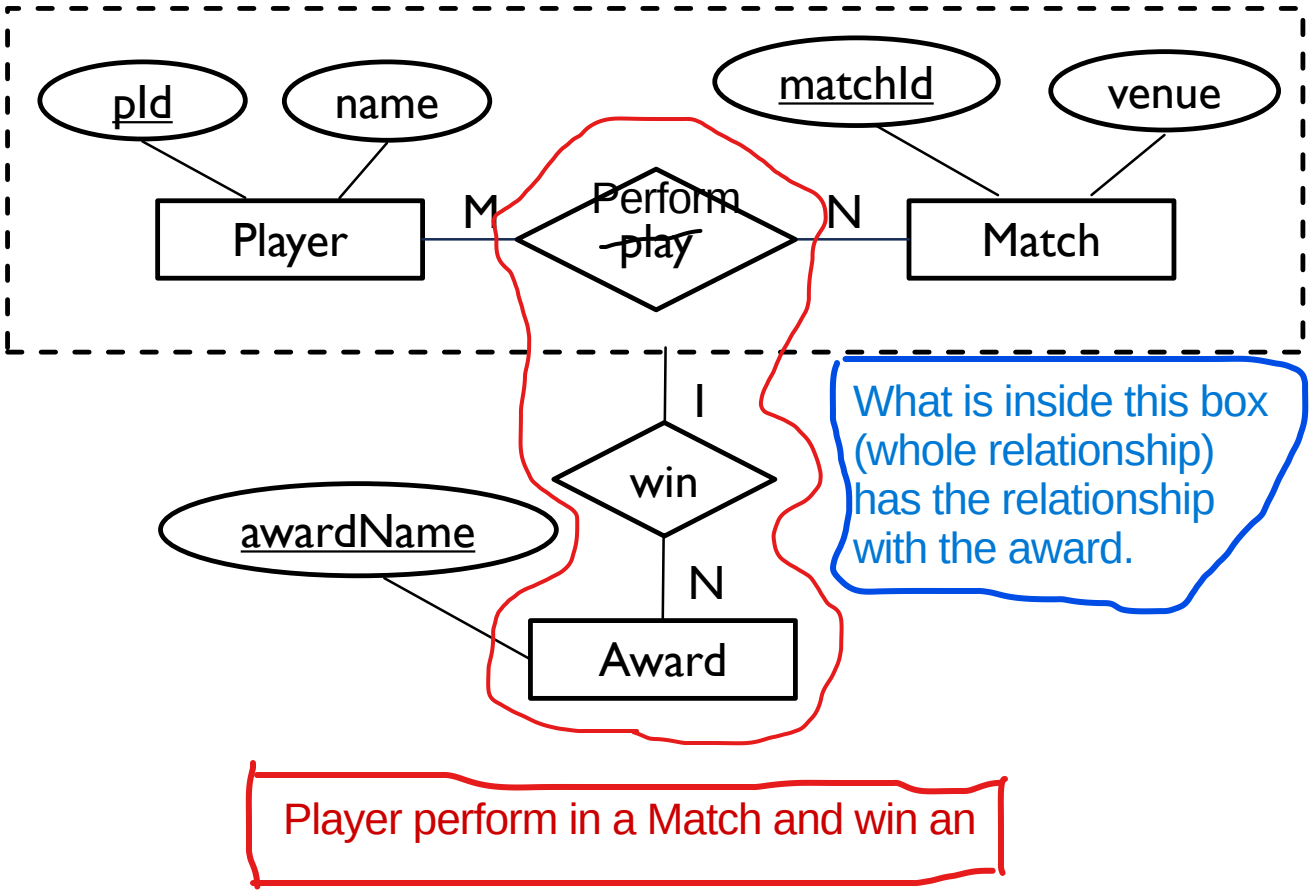


ACTIVITY

- In a blank paper draw two ISA relationships, one which is having a covering constraint and another which is having a overlapping constraint.
- Exchange what you have drawn with your peer. What have they drawn?
- Have you understood the concepts properly?

EER MODEL - AGGREGATION

- **Aggregation** allows us to indicate that a relationship as a above which is between a relationship set that participates in another relationship set.
- For example, a cricket players play in cricket matches. When he plays a match for his performance he may win awards.
- Note that, the difference between ternary and aggregation is that aggregation contain two independent relationships whereas in ternary relationship there is one.



ACTIVITY

- Can you think of an aggregation relationship in a domain familiar to you?
- Exchange what you have drawn with your peer. What have they drawn?
- Have you understood the concepts properly?

ACTIVITY

- Draw an E-ER diagram for the following requirements.
  - Students contain an id (unique), name and an address.
  - There are academic semesters containing an *semester id* (unique), *semester* and *year*.
  - There are courses offered during academic semesters. A course has a *number* (unique), *name* and *credits*.
  - Students make payments. A payment has *receipt number* (unique), *amount* and *date*.
  - Payments can be classified into Tuition (semester payment), Examination and other (Library fine, Printouts).
  - A Tuition payment is made for an academic semester
  - For other payments description should be stored
  - Students register for courses offered during a particular semester. The registered date must be stored in the database.

DESIGN TRAPS

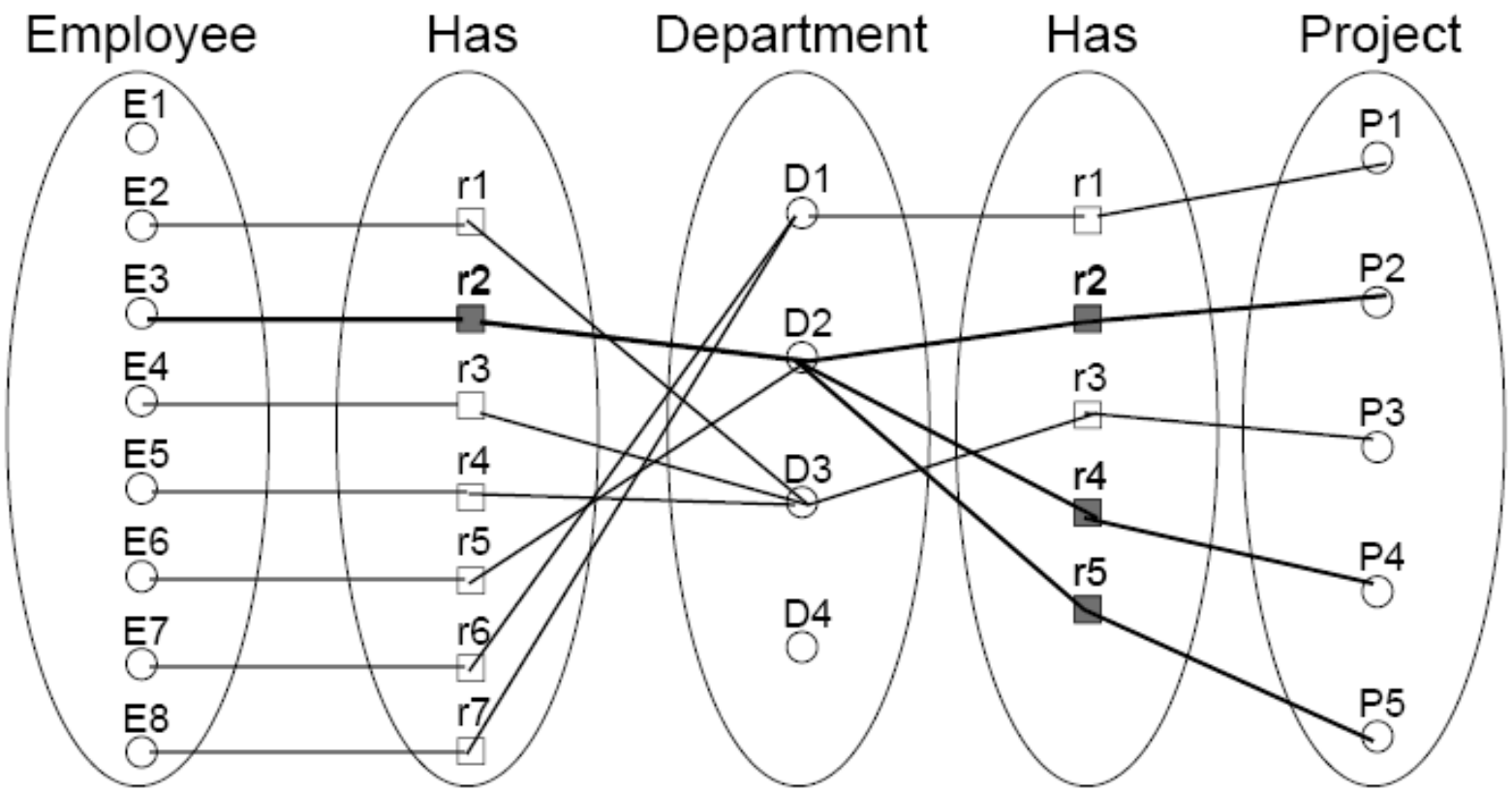
- There are several different "modeling traps" (called *connection traps*) that you can fall into when designing your ER model.
- Two connection traps that we will look at are:
  - Fan traps
  - Chasm traps

FAN TRAP

- A ***fan trap*** is when a model represents a relationship between entity types, but the pathway between certain entity instances is ambiguous.
  - Often occurs when two or more one-to-many relationships fan out (come from) the same entity type.
- Example: A department has multiple employees, a department has multiple projects, and each project has multiple employees.

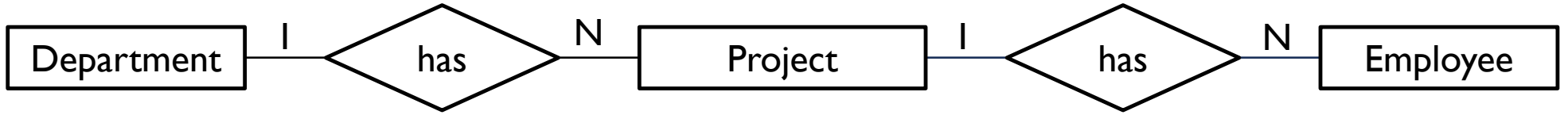
FAN TRAP (CONTD.)

- Which projects does employee E3 work on?



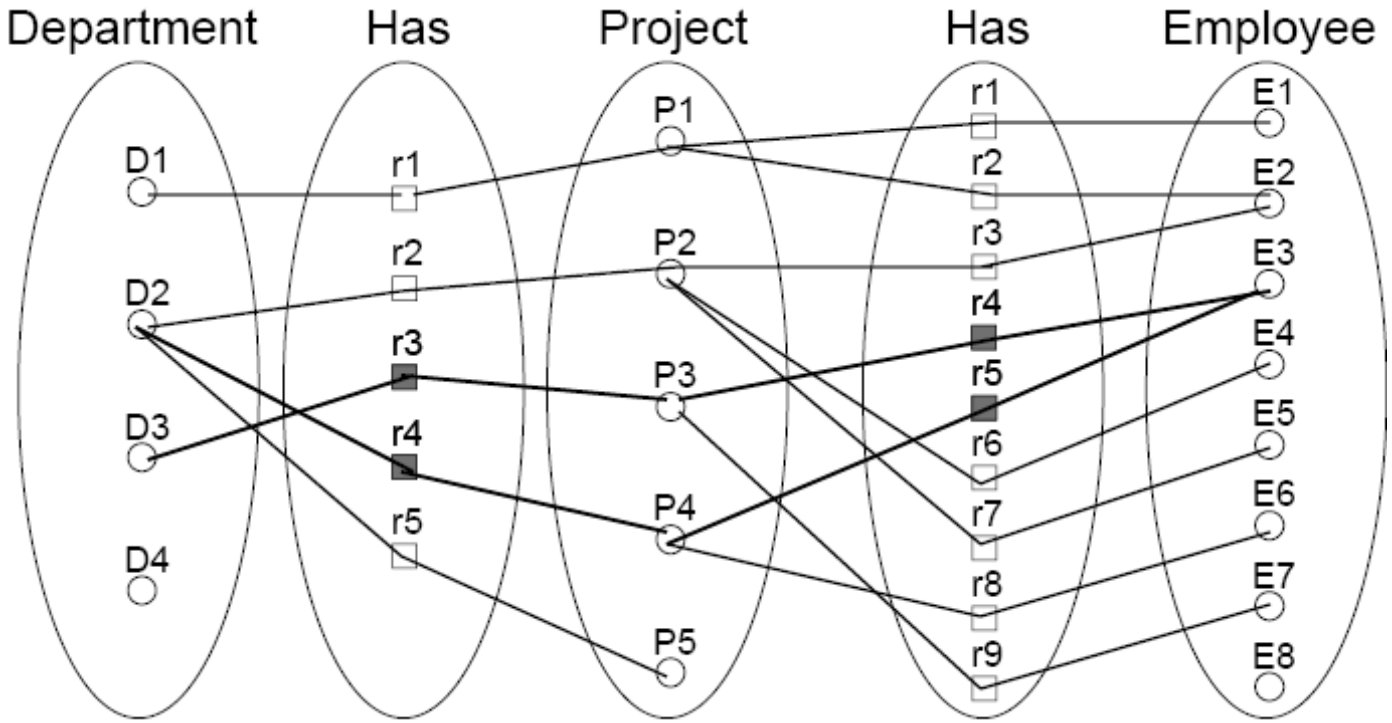
CHASM TRAP

- A ***chasm trap*** occurs when a model suggests that a relationship between entity types should be present, but the relationship does not actually exist. (*missing* relationship)
  - May occur when there is a path of optional relationships between entities.
- Example: A department has multiple employees, a department has multiple projects, and each project has multiple employees.



CHASM TRAP (CONTD.)

- Which department is employee E8 in?
- What are the employees of department D4?



WHAT YOU HAVE TO DO BY NEXT WEEK

- Try out the self-test questions on the course web.
- Try out tutorial and bring the answers to the class.
- Answer the questions at the end of chapter 2 of Database Management Systems by Ramakrishnan & Gehrke

DATABASE MANAGEMENT SYSTEMS (IT 2040)

LECTURE 02- ER AND EER TO RELATIONAL MODEL MAPPING

LECTURE CONTENT

- Logical database design
- Relational model and its components
- ER to relational mapping

LEARNING OUTCOMES

- Explain the process of logical database design
- Explain relational model and its components
- Convert a complex ER model to the relational model

LOGICAL DATABASE DESIGN

- Once we finished the step of conceptual database design we next select a DBMS to implement our database design.
- We then convert the conceptual database design into a database schema in the data model of the chosen DBMS.
- Before 1970 most database systems were based on two older data models namely, hierarchical model and network model.
- Leading DBMS products nowadays are based on the relational model which introduced by Codd in 1970.

THE RELATIONAL MODEL

- The major advantage of relational model is its simplicity in data representation.
- A relational database is a collection of relations with distinct relation names.
- The main construct representing data in the relational model is the relation.
- A relation consists of a relational schema and a relational instance.

THE RELATIONAL MODEL (CONTD.)

- The relational schema describes the columns for a relation.
  - Ex: Students(*sid:* string, *name:* string, *login:* string, *age:* integer, *gpa:* real)
  - The schema species the relation's name, the name of each **field** and the **domain** of each field.
- An **instance** of a relation is a set of **tuples**, also called **records**, in which each tuple has the same number of fields as the relation schema.
  - A relation instance can be thought of as a *table* in which each tuple is a *row*, and all rows have the same number of fields.

sid	*name*	*login*	*age*	*gpa*
53831	Madayan	madayan@music	11	1.8
53832	Guldu	guldu@music	12	2.0
53688	Smith	smith@ee	18	3.2
53650	Smith	smith@math	19	3.8

INTEGRITY CONSTRAINTS

- An integrity constraints (IC) is a condition specified on a database schema and restricts the data that could be stored in an instance of the database.
- If a database instance satisfies all the integrity constraints specified on the database schema, it is a **legal** instance.
- There are several types of integrity constraints
  - Domain constraints
  - Referential integrity constraints
  - Key constraints
  - Other constraints

INTEGRITY CONSTRAINTS (CONTD.)

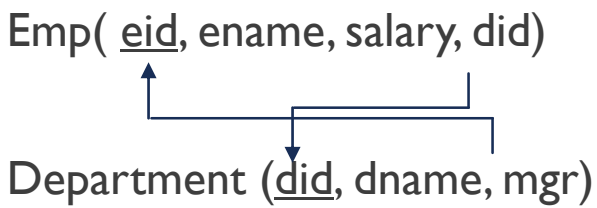
- Domain Constraint
  - Domain constraint specifies that the values that appear in a column must be drawn from the domain associated with that column.
  - Relational database provides data types to specify valid domains.
- Key Constraint
  - The minimal set of attributes that uniquely identify a tuple is called the **key** of a relation
  - A set of fields that uniquely identifies a tuple according to a key constraint is called a candidate key for the relation; we often abbreviate this to just key.
  - One of the candidate keys is designated as the primary key.

INTEGRITY CONSTRAINTS (CONTD.)

- Referential integrity Constraint
  - The referential integrity constraint is specified between two relations and is used to maintain the consistency among tuples in the two relations.
  - Informally, the referential integrity constraint states that a tuple in one relation that refers to another relation must refer to an existing tuple in that relation.
  - Foreign keys enforce referential integrity constraints
  - Foreign key attributes in R1 referring to R2 have the following rules:
    - The FK attributes in R_1 have the *same domain(s)* as the primary key attributes if R_2
    - The value of FK in tuple t_1 in R_1 must reference an *existing* PK value in tuple t_2 of R_2
  - We can diagrammatically display the foreign keys by drawing an arrow from the foreign key to the primary key

INTEGRITY CONSTRAINTS (CONTD.)

- Other constraints
  - **Table Constraints** (constraints within tables)
    - Example : Balance of the account should be greater than 0
    - In SQL, CHECK constraint can be used
  - **Assertions** (constraints between multiple tables)
    - For example: consider the following schema



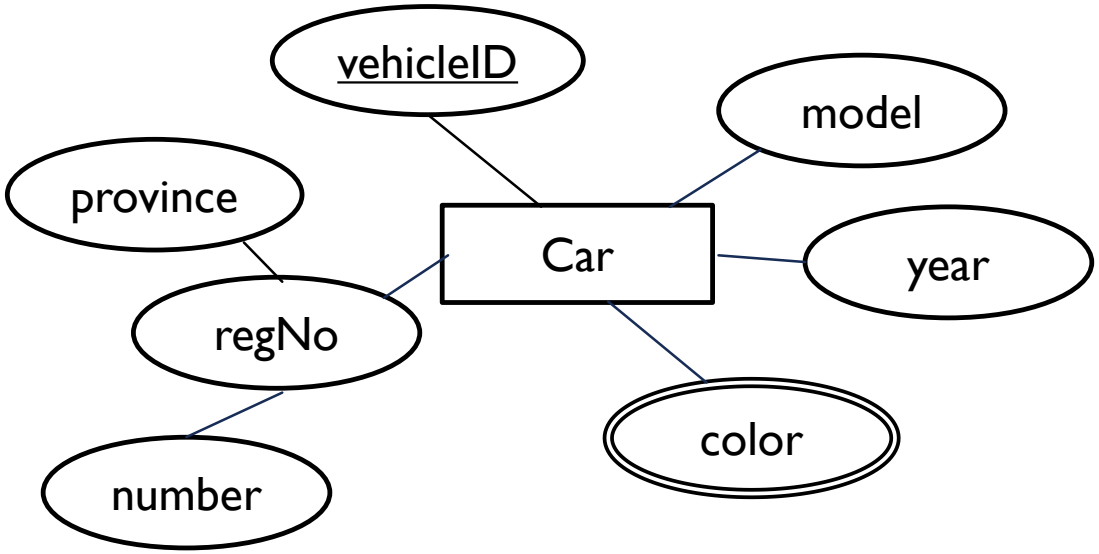
    - Suppose that an employee's salary should not exceed his/her manager's salary
    - Such constraints can be using specific language features such as triggers and assertions

ACTIVITY

- In two minutes summarize the integrity constraints discussed in today's lecture on a blank paper.
- Exchange what you have written with your peer and correct the answer.
- Have you understood each constraint well?

MAPPING ENTITIES AND ATTRIBUTES

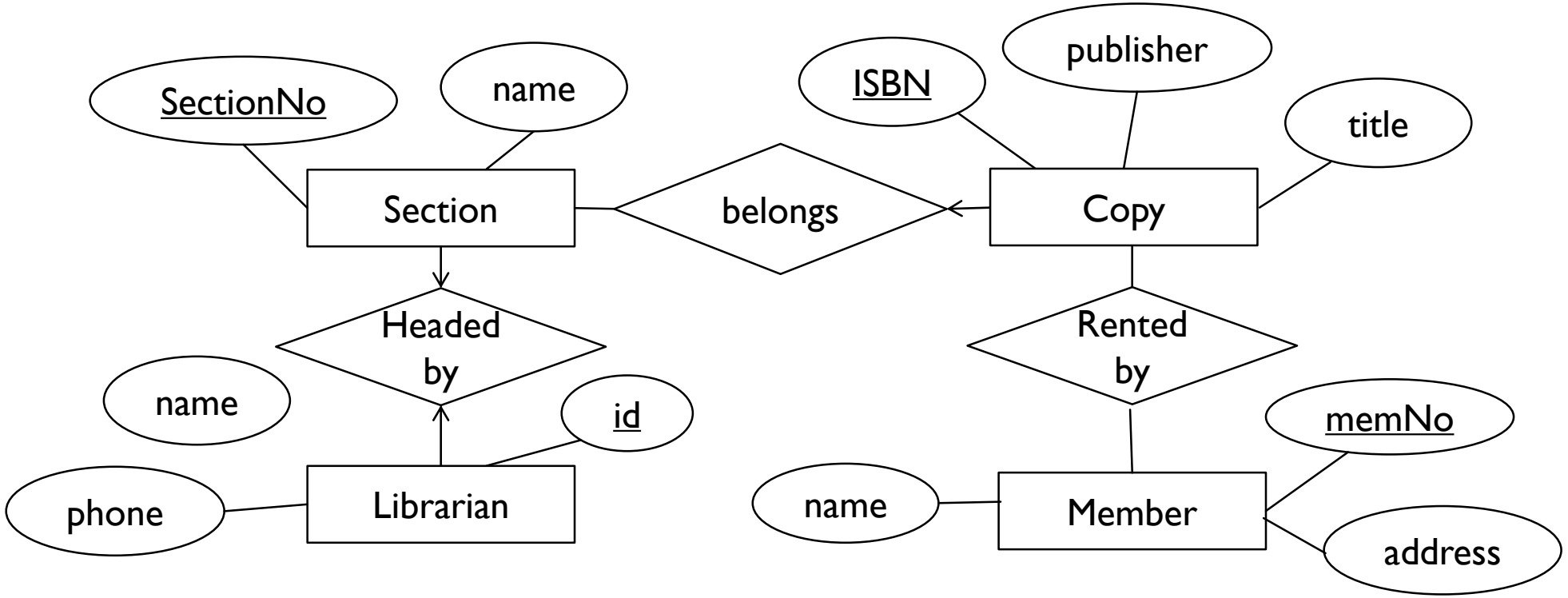
- Go through page 1 of the handout 2.
- Map the entity below to relational model.



- Compare what you have written with your peer.

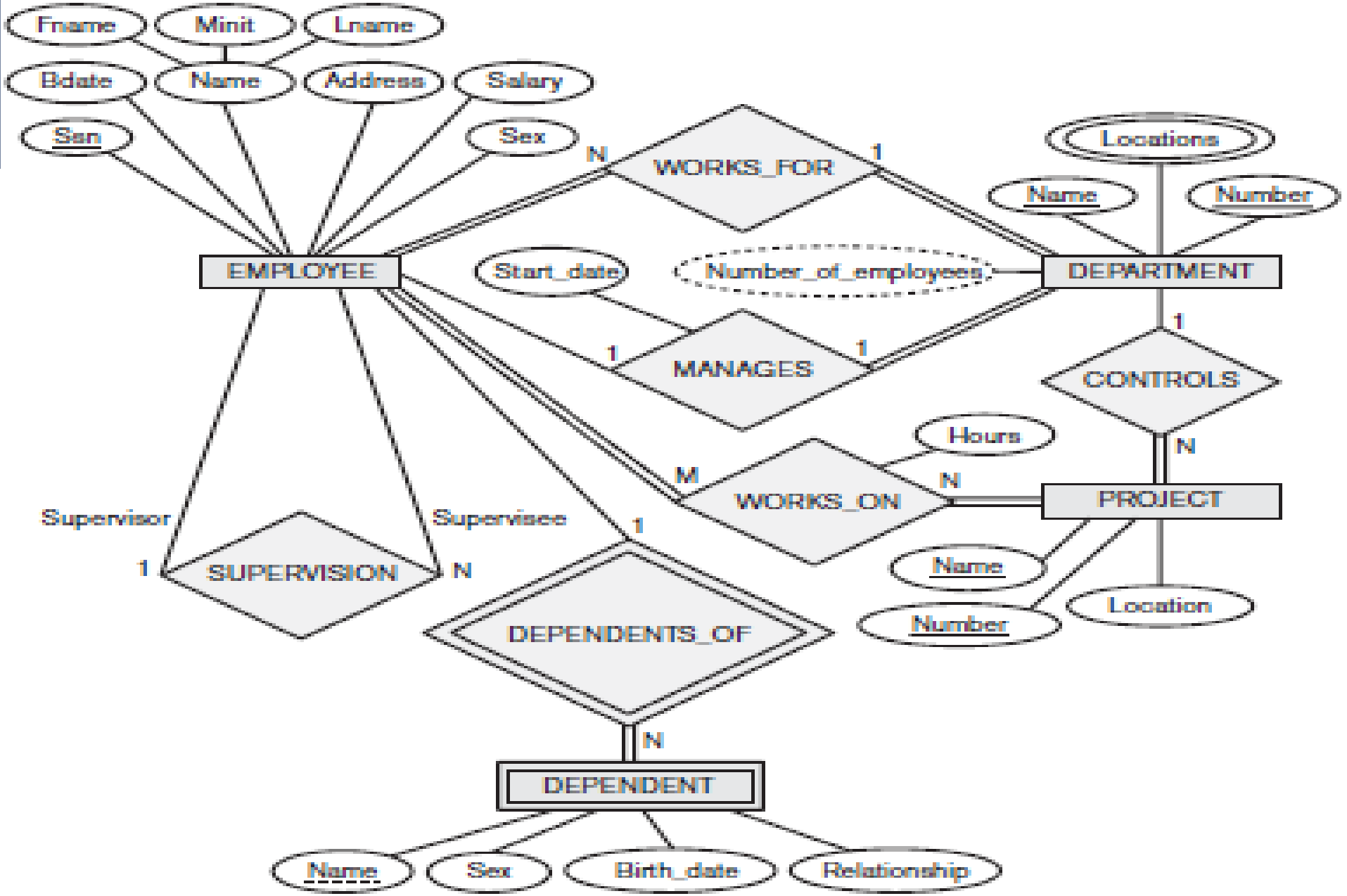
MAPPING BINARY RELATIONSHIPS

- Go through page 1 of the handout 2.
- Now lets map the following ER diagram to relational model



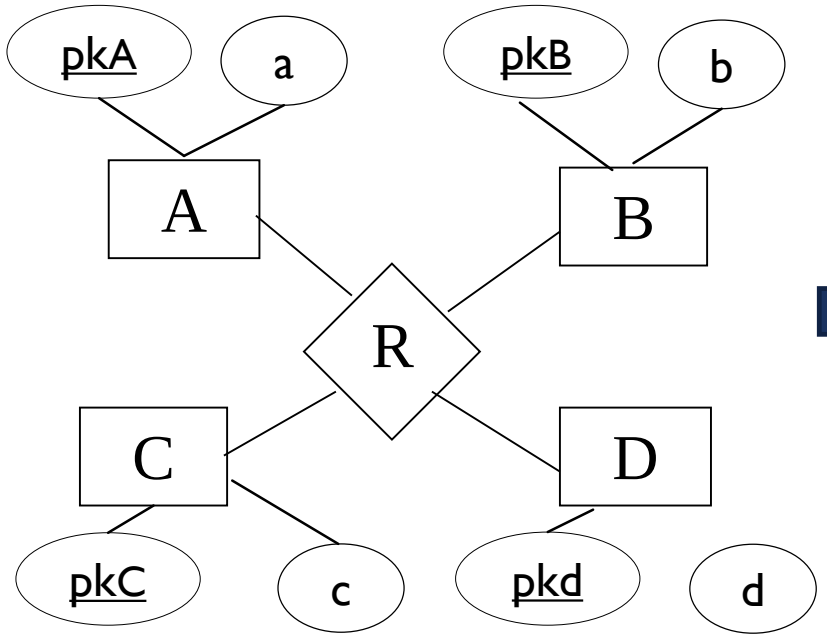
ACTIVITY

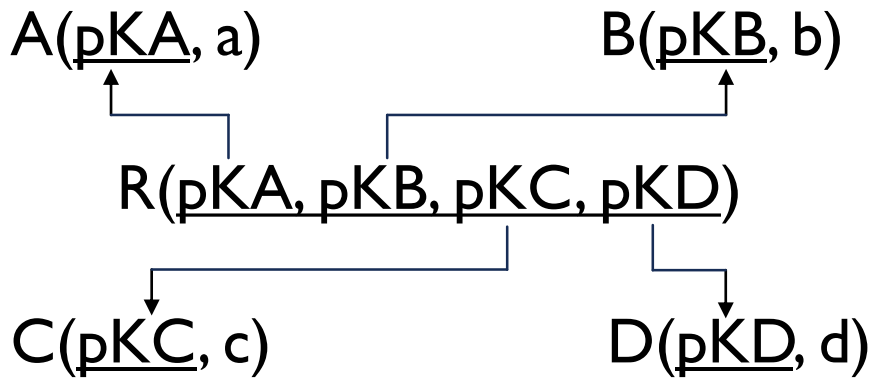
- Map the ER diagram to relational model



MAPPING N-ARY RELATIONSHIPS

- N-ary relationship is mapped in to a "Relationship" relation and foreign keys



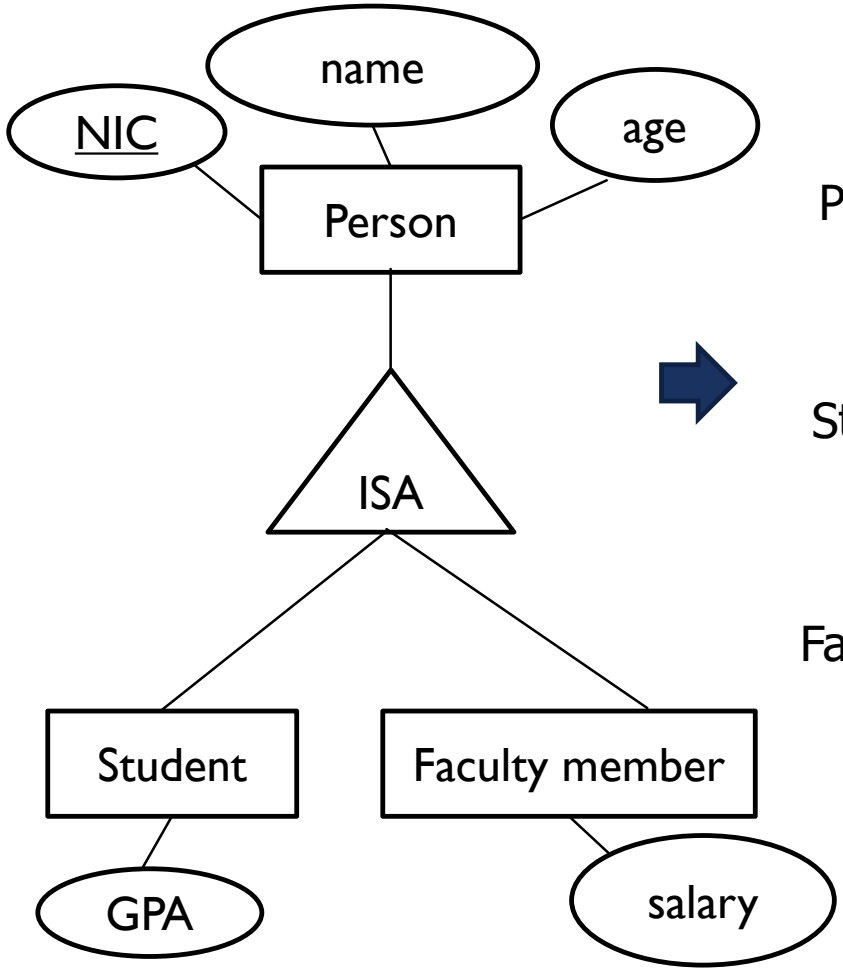


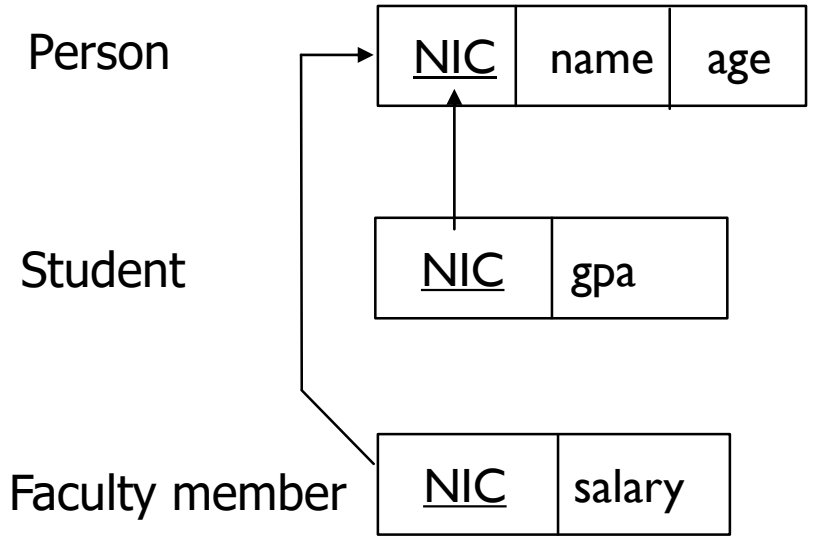
MAPPING ISA-RELATIONSHIPS

- There are four different options for mapping ISA relationships.
  - Multi-relation options : option 1 & option 2
  - Single-relation options : option 3 & option 4
- Each option is suitable for specific situations.

ISA MAPPING – OPTION 1

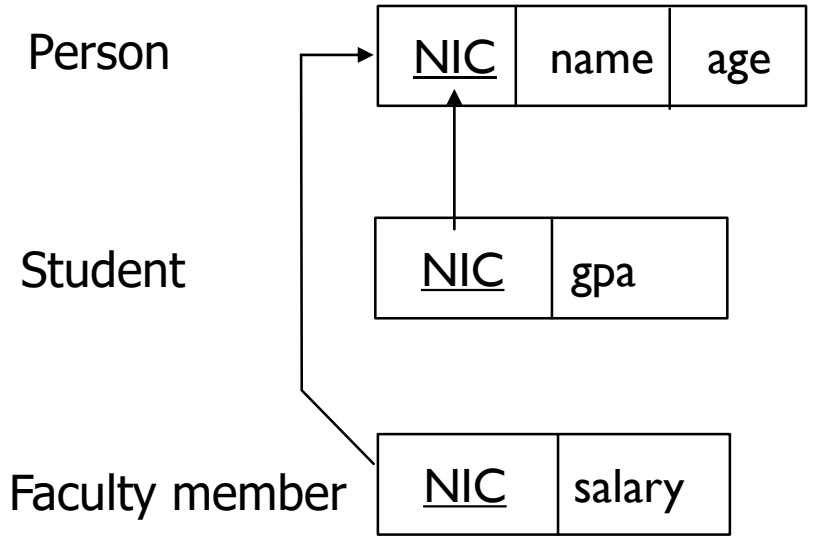
- Create a relation for the superclass with its attributes. Primary key of the superclass becomes the primary key of the relation.
- Create separate relations for the sub classes with their attributes. Primary key of the superclass is also primary key of each subclass. They are also foreign keys referring to the primary key of the relation created for the super class.
- **Option 1 works for all constraints disjoint, overlapping, total and partial**





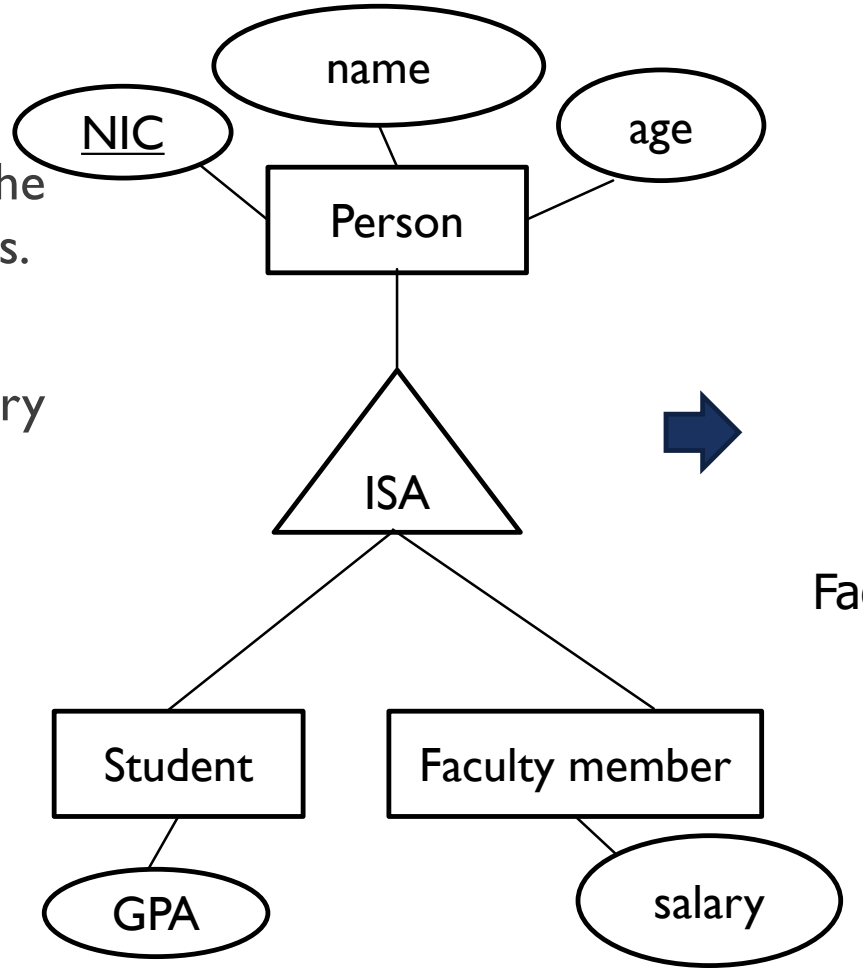
ISA MAPPING – OPTION 1 (CONTD.)

- Now think how you would store information of following people
  - A person who is not a student or a faculty member(i.e when the ISA relationship is parial)
  - A person who is a student but not a faculty member (i.e disjoint)
  - A person who is both a student and a faculty member (i.e: overlapping classes)



ISA MAPPING – OPTION 2

- Create separate relations for all the subclasses with their own attributes and the attributes of the superclass.
- Primary key of the superclass becomes primary key of the subclasses.
- **The ISA relationship must be total (i.e. subclasses must cover the super class)**

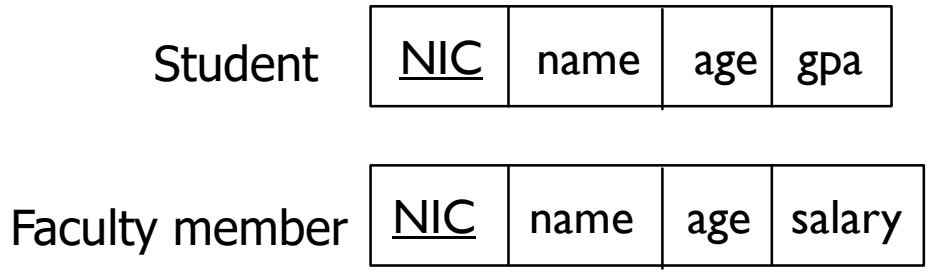


Student	NIC	name	age	gpa

Faculty member	NIC	name	age	salary

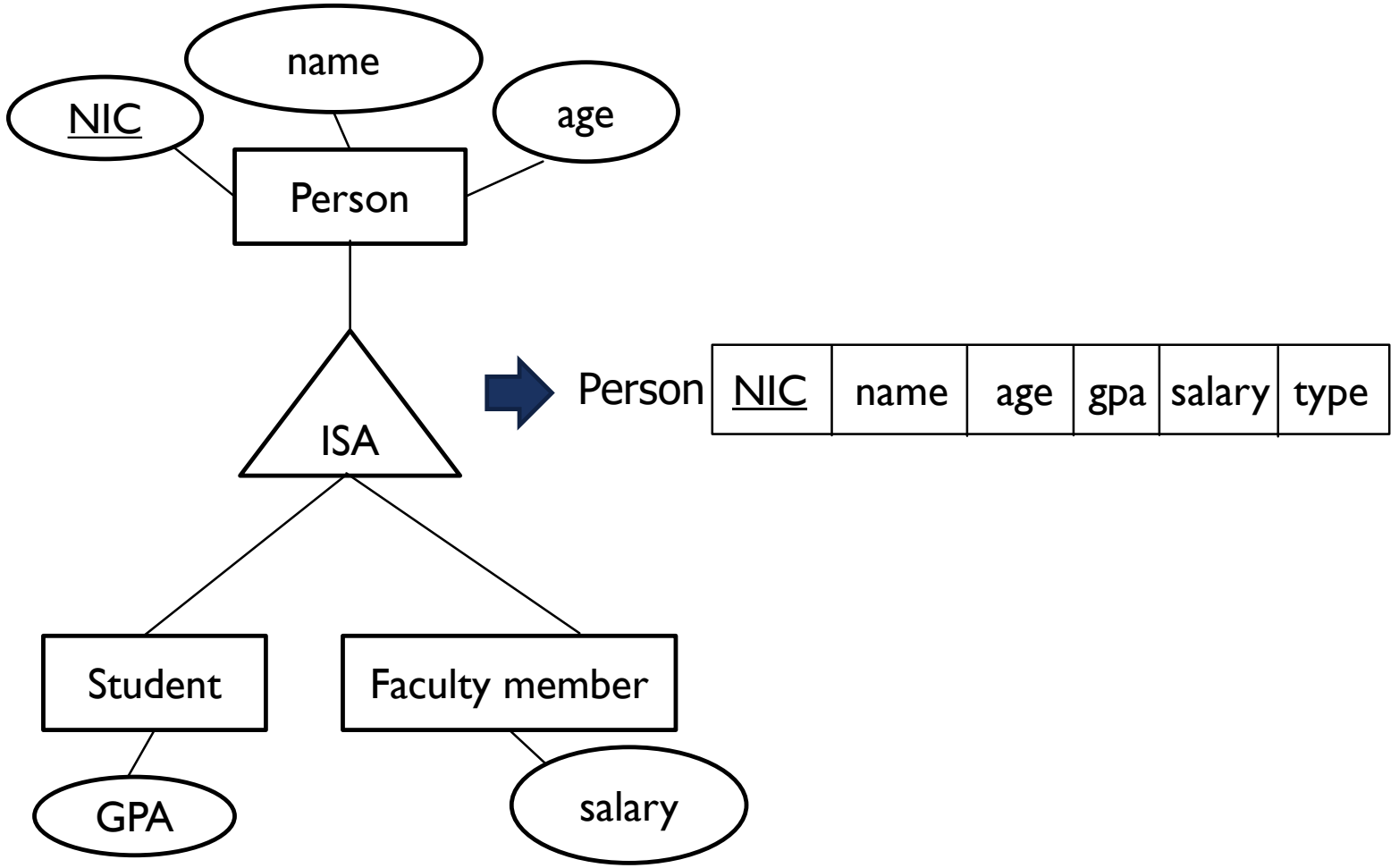
ISA MAPPING – OPTION 2 (CONTD.)

- Now think how you would store information of following people
  - A person who is not a student or a faculty member(i.e when the ISA relationship is parial)
  - A person who is a student but not a faculty member (i.e disjoint)
  - A person who is both a student and a faculty member (i.e: overlapping classes)



ISA MAPPING – OPTION 3

- Create a single relation including attributes of the superclass as well as attributes of all sub classes.
- Include an attribute named type for specifying which subclass the entity belongs if any.
- Primary key of the superclass becomes primary key of the relation.
- The specialization/generalization relationship must be **disjoint**
- Good if subclasses have **few attributes**



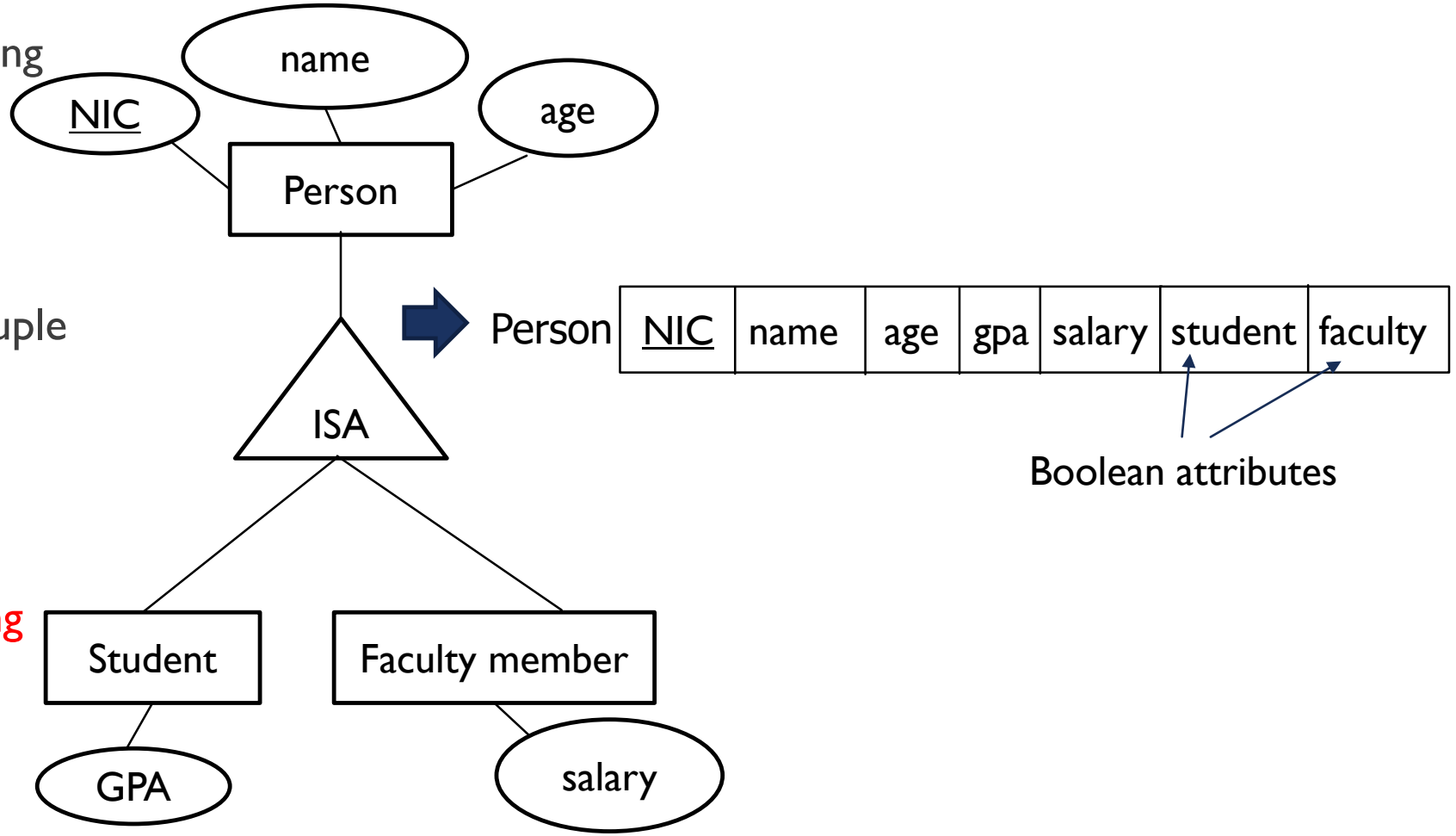
ISA MAPPING – OPTION 3 (CONTD.)

Person	NIC	name	age	gpa	salary	type

- Now think how you would store information of following people
  - A person who is not a student or a faculty member(i.e when the ISA relationship is parial)
  - A person who is a student but not a faculty member (i.e disjoint)
  - A person who is both a student and a faculty member (i.e: overlapping classes)

ISA MAPPING – OPTION 4

- Create a single relation including attributes of the superclass as well as attributes of all sub classes.
- Include a Boolean attribute to indicate which subclass each tuple belongs to
- Primary key of the superclass becomes primary key of the relation.
- This relation allows overlapping constraints for specialization/generalization relationship



ISA MAPPING – OPTION 4 (CONTD.)

Person	NIC	name	age	gpa	salary	student	faculty

- Now think how you would store information of following people
  - A person who is not a student or a faculty member(i.e when the ISA relationship is parial)
  - A person who is a student but not a faculty member (i.e disjoint)
  - A person who is both a student and a faculty member (i.e: overlapping classes)

ACTIVITY

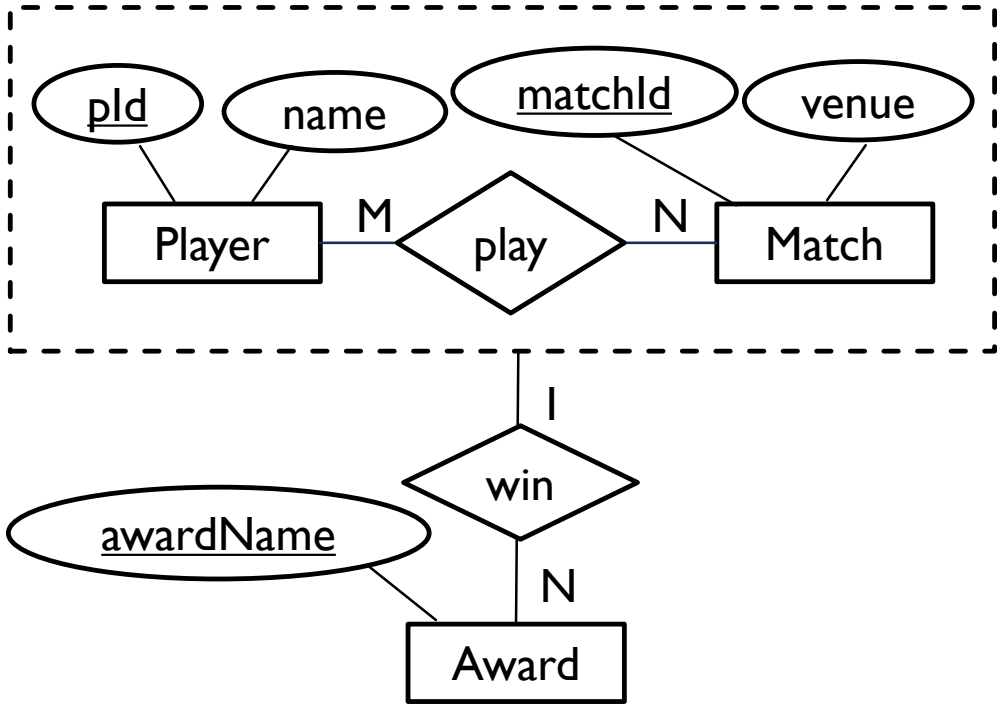
- Fill the table below indicating the which constraints work with which option.

	Overlapping	Disjoint	Total	Partial
Option 1				
Option 2				
Option 3				
Option 4				

MAPPING AGGREGATION RELATIONSHIPS

- Aggregation mapping could be performed in two steps.
  - Step 1: First map the aggregation relationship R.
  - Step 2 :To map relationship set involving aggregation of R, treat the aggregation like an entity set whose primary key is the primary key of the table for R

MAPPING AGGREGATION RELATIONSHIPS (CONTD.)



- Step 1: First map the aggregation relationship R.

  Player (<u>pId</u>, name)

  Match (<u>matchId</u>, venue)

  Play (<u>pId, matchId</u>)

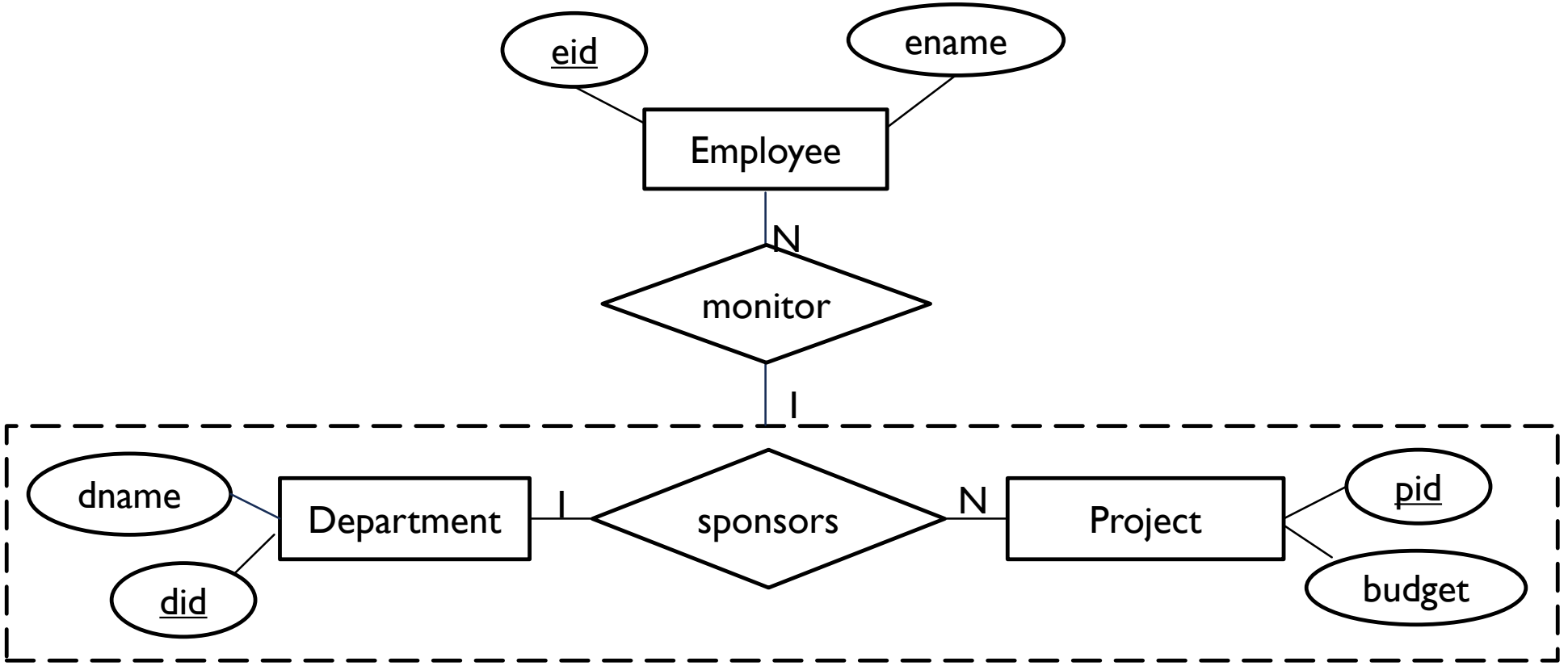
- Step 2 : To map relationship set involving aggregation of R, treat the aggregation like an entity set whose primary key is the primary key of the table for R.

Table for aggregation is 'Play'. Thus, the relationship win should be mapped considering 1:N relationship between play (primary key : pId,matchId) and award,

Award (<u>awardName, pId, matchId</u>)

MAPPING AGGREGATION RELATIONSHIPS (CONTD.)

- Map the following EER diagram to relational model.



WHAT YOU HAVE TO DO BY NEXT WEEK

- Try out the self-test questions on the course web.
- Complete the tutorial.
- Complete the lab sheet

SLIIT

Discover Your Future

Database management systems (IT 2040)

Lecture 03 - schema refinement

Lecture content

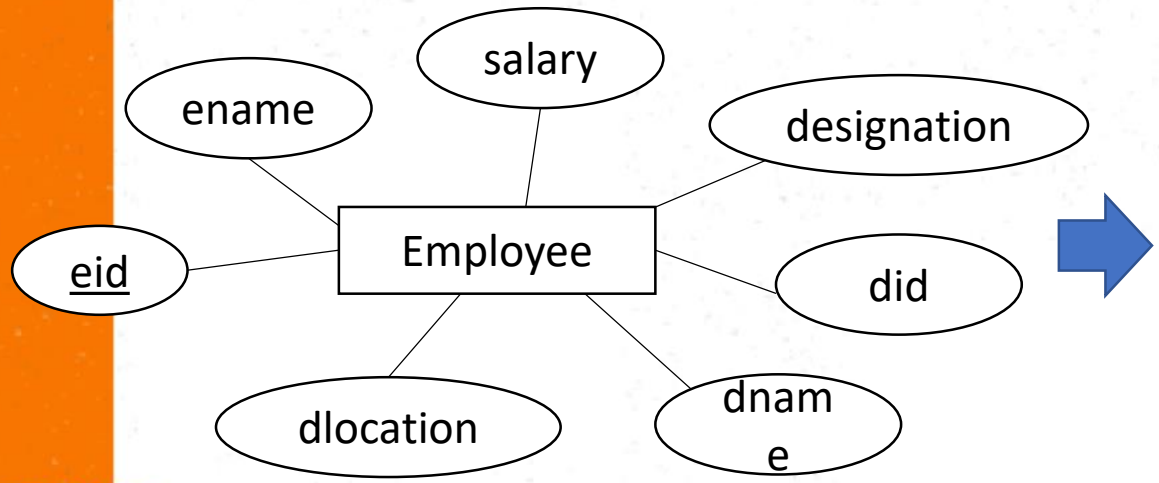
- Why schema refinement?
- Properties of good decomposition
- Functional dependencies
- Computing keys of relations
- Normalization and normal forms

Learning outcomes

- Explain the pitfalls of incorrect grouping of attributes in relations.
- Explain the properties of a good decomposition.
- Compute keys from a given set of FDs in a relation
- Normalize a given schema to BCNF.

Why schema refinement?

- The relations resulted through the logical database design may not be very good if your conceptual database design is not good.
- For example, what is wrong with the following schema resulted through mapping of an ER diagram



Employee

eid	ename	designation	salary	did	dname	location

Why schema refinement? (contd.)

- Schemas such as in the previous slide lead to several anomalies while inserting, updating and deleting and wasting of space due to redundancies of data.
- Can you spot where data are duplicated and issues may cause during insert/update & delete?

eid	Ename	Designation	Salary	did	dname	location
1000	Ajith	Lecturer	60000	1	Academic	malabe
1001	Sunil	Executive	45000	3	Maintenance	Kandy
1002	Kamal	Lecturer	75000	1	Academic	malabe
1003	Piyumi	Manager	50000	2	Admin	metro
1004	Roshan	Lecturer	35000	1	Academic	malabe
1005	Nuwan	Lecturer	80000	1	Academic	malabe
1006	Jayamini	Assistant	25000	2	Admin	metro
1007	Nishani	Lecturer	42000	1	Academic	malabe
1008	Amal	Assistant	28000	4	ITSD	Matara

Why schema refinement? (contd.)

- Insertion Anomaly
  - Inserting a new employee to the emp table
    - Department information is repeated (ensure that correct department information is inserted).
  - Inserting a department with no employees
    - Impossible since eid cannot be null
- Deletion Anomaly
  - Deleting the last employee from the department will lead to loosing information about the department
- Update Anomaly
  - Updating the department's location needs to be done for all employees working for that department

Why schema refinement? (CONTd.)

- To solve the issues discussed previously, we should decompose the relations to smaller relations.
- For example, we can decompose the emp relation discussed previously into two relations as below to overcome the issues of redundancies and anomalies.

eid	Ename	Designation	Salary	did
1000	Ajith	Lecturer	60000	1
1001	Sunil	Executive	45000	3
1002	Kamal	Lecturer	75000	1
1003	Piyumi	Manager	50000	2
1004	Roshan	Lecturer	35000	1
1005	Nuwan	Lecturer	80000	1
1006	Jayamini	Assistant	25000	2
1007	Nishani	Lecturer	42000	1
1008	Amal	Assistant	28000	4

did	dname	location
1	Academic	malabe
2	Admin	metro
3	Maintenance	Kandy
4	ITSD	Matara

Why schema refinement? (CONTd.)

- Random decompositions however, may introduce new problems.
- Two properties that could be looked up to ensure that the relations resulted from decomposition are good are as follows:
  - Loss-less join property
  - Dependency preserving property

Why schema refinement? (CONTd.)

- Loss-less join property : the property enables recovery of original relation from a set of smaller relations resulted through decomposition.
  - For example, suppose S is decomposed in to R1and R2. When we join R1 and R2 do we get S? if so, we say the decomposition is loss-less.

S

S	P	D
S1	P1	D1
S2	P2	D2
S3	P1	D3

R_1

S	P
S1	P1
S2	P2
S3	P1

R_2

P	D
P1	D1
P2	D2
P1	D3

- Dependency preserving property : enables to enforce any constraint on the original relation simply enforcing some constraints on each of the smaller relation.

Schema refinement

- Schema refinement can be considered a systematic process for analyzing a relational schema with the aim of minimizing redundancies and minimizing insertion, deletion and update anomalies.
- The process performs a series of tests called normal form tests to check whether the schemas meet certain conditions, and those relations that are unsatisfactory are decomposed in to smaller relation.
- Normalization is based on functional dependencies

Functional dependency in general terms

- Functional dependency is a relationship that exists when one attribute uniquely determine another attribute.
- For example: Suppose we have a student table with attributes: id name, age.
  - Here id attribute uniquely identifies the name attribute of student table because if we know the student id we can tell the student name associated with it.
  - This is known as functional dependency and can be written as id->name or in words we can say name is functionally dependent on id.
- Redundancies in relations are based on functional dependencies

Functional dependencies

- Mathematical definition of functional dependency (FD) :
  - A functional dependency, denoted by X→ Y, where X and Y are sets of attributes in relation R, specifies the following constraint:
    - Let t_1 and t_2 be tuples of relation R for any given instance

    Whenever $t_1[X] = t_2[X]$ then $t_1[Y] = t_2[Y]$

    where $t_i[X]$ represents the values for X in tuple t_i

Activity

- Consider a person entity. With respect to attributes you know a person holds write three functional dependencies that can exist in a person table.
- Exchange what you have written with your peers.
- What have they written?

Keys and FDs

- A key constraint is a special case of a FD where the attributes in the key play the role of X and the set of all attributes play the role of Y.
- Normalization process analyzes schemas based on keys and on the functional dependencies among their attributes.
- Thus, to start normalization it is essential to find keys of a given relation.
- Attribute closure of an attribute set X, denoted by X+ can be defined as set of all attributes which can be functionally determined from it.
- If X+ = all attributes, then X is a key.

Attribute closure could be computed using Armstrong Axioms.

X, Y, Z are sets of attributes:

Reflexivity: If $X \subseteq Y$, then $Y \rightarrow X$
Augmentation: If $X \rightarrow Y$, then $XZ \rightarrow YZ$ for any Z
Transitivity: If $X \rightarrow Y$ and $Y \rightarrow Z$, then $X \rightarrow Z$

Couple of additional rules (that follow from Armstrong Axioms):

Union: If $X \rightarrow Y$ and $X \rightarrow Z$, then $X \rightarrow YZ$
Decomposition: If $X \rightarrow YZ$, then $X \rightarrow Y$ and $X \rightarrow Z$

COMPUTING keys (Contd.)

- Consider a relation R (A, B, C, D), with the following set of functional dependencies over R:
  - F = { A → B, B → C, B → D}

A → A (reflexivity rule)
A → B (given)
A → B and B → C then A → C (transitivity)
A → B and B → D then A → D (transitivity)

A → ABCD (Union rule) , [A]+={ABCD}

B+= {BCD} , C+ = {C} , D+={D}
Therefore A is the key

ACTIVITY

- Consider a relation R (A, B, C, D, E), with the following set of functional dependencies over R:
- {A → B, A → C, CD → E, B → D, E → A}
- Compute the keys for relation R.

Revisit to some definitions

- Superkey: Set of attributes S in relation R such that no two distinct tuples t_1 and t_2 will have $t_1[S] = t_2[S]$
- Key: A key is a superkey with the additional property that removal of any attributes from the key will not satisfy the key condition
- Candidate Key: Each key of a relation is called a candidate key
- Primary Key: A candidate key is chosen to be the primary key
- Prime Attribute: an attribute which is a member of a candidate key
- Nonprime Attribute: An attribute which is not prime

Normal forms

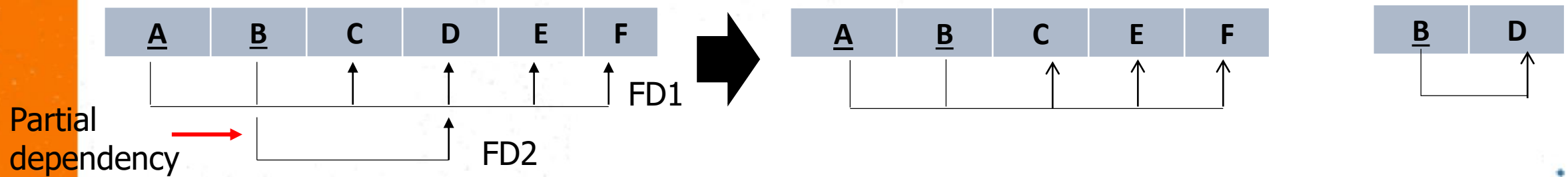
- Normal forms refers to a series of tests performed on relational schemas to improve their goodness.
- We discuss four normal forms namely,
  - 1st Normal Form
  - 2nd Normal Form
  - 3rd Normal Form
  - Boyce Codd Normal Form
- Test for each normal form is performed in a top-down fashion.
- The Normal form of a relation refers to the highest normal form condition it meets.

1st normal form

- A relation R is in first normal form (1NF) if domains of all attributes in the relation are *atomic* (simple & indivisible).
- 1NF is now considered to be part of the formal definition of a relation in the relational model since it allows only atomic values and disallows multivalued attributes and composite attributes.

2nd Normal form

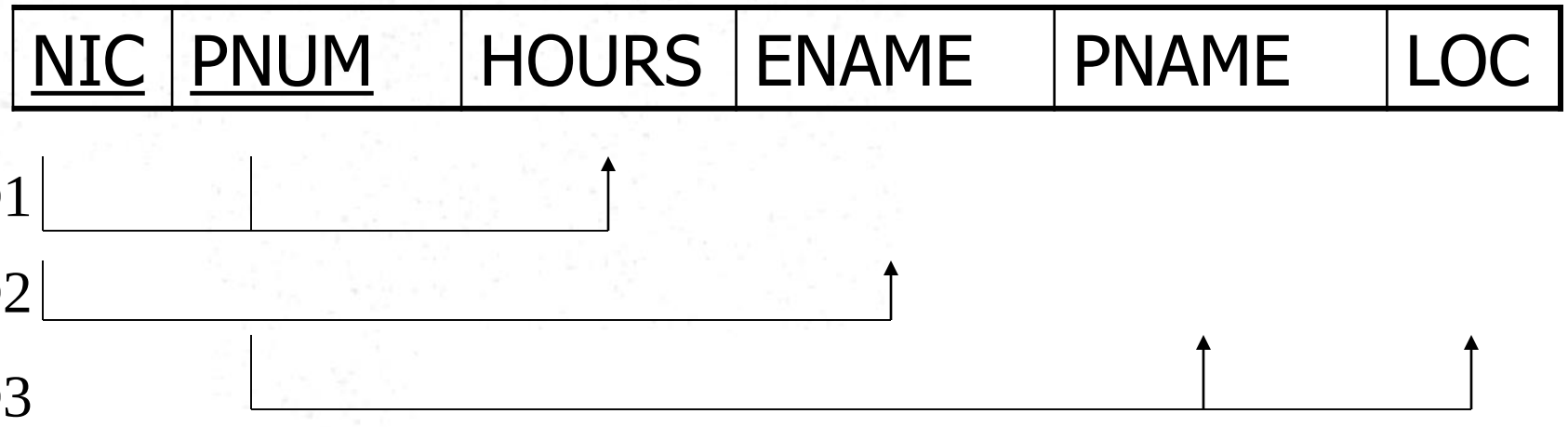
- A relation R is in second normal form (2NF) if every nonprime attribute A in R is not partially dependent on any key of R.
- Second normal form (2NF) is based on the concept of full functional dependency.
  - A functional dependency X →Y is a full functional dependency if removal of any attribute A from X means that the dependency does not hold any more.
  - For example, in a relation R (ABCDE) where AB -> {ABCDE}, if A-> C , A->C is a partial dependency (not fully functional dependent)
- To normalize the relation to 2NF decomposition is performed as follows.



ACTIVTY

- What normal form the relation in the slide is? If the relation is not in 2NF normalize the relation to 2NF.

EMP_PROJ



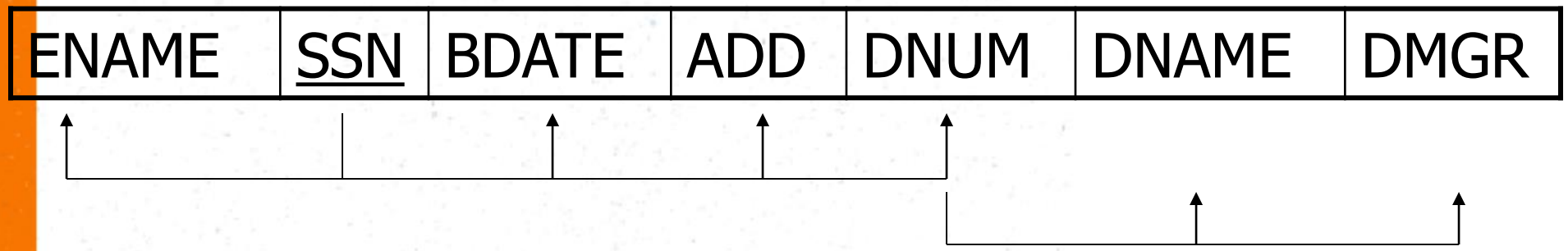
3rd Normal Form

- A relation R is in 3rd normal form (3NF) if every
  - R is in 2NF, and no nonprime attribute is transitively dependent on any key
- Third normal form is based on the concept of transitive dependency.
  - A functional dependency X →Y in a relational schema R is a transitive dependency if there is a set of non-prime attributes Z where both X →Z and Z →Y hold.
- To normalize the relation to 2NF decomposition is performed as follows.

activity

- What normal form the relation in the slide is? If the relation is not in 3NF normalize the relation to 3NF.

EMP_DEPT



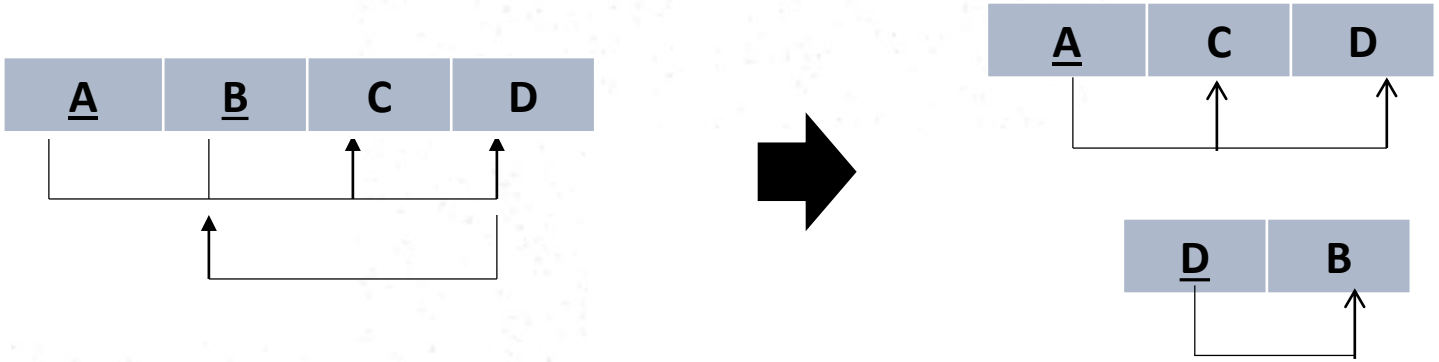
FD1

Boyce-Codd Normal Form

- A relation schema is in Boyce-Codd Normal Form
  - If every nontrivial functional dependency X→A hold in R, then X is a superkey of R

Decomposition into BCNF:

- Consider relation R with FDs F. If X → Y violates BCNF, decompose R

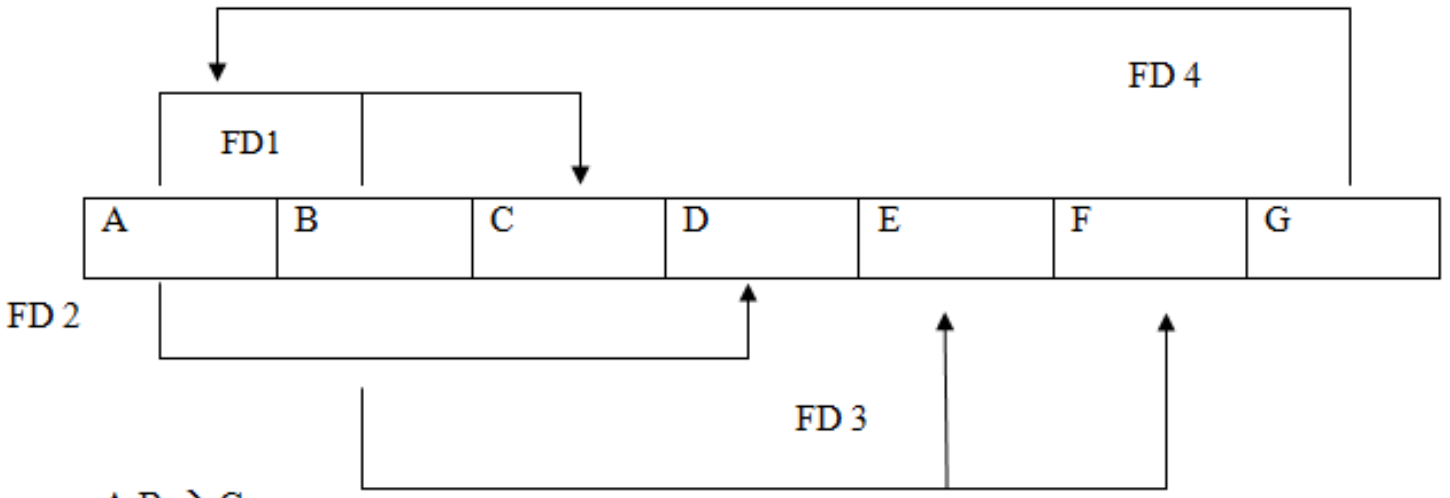


activity

- Consider the following relational schema for R:

  R(A, B,C,D,E,F,G)

- AB is the primary key in the relation.



A B → C

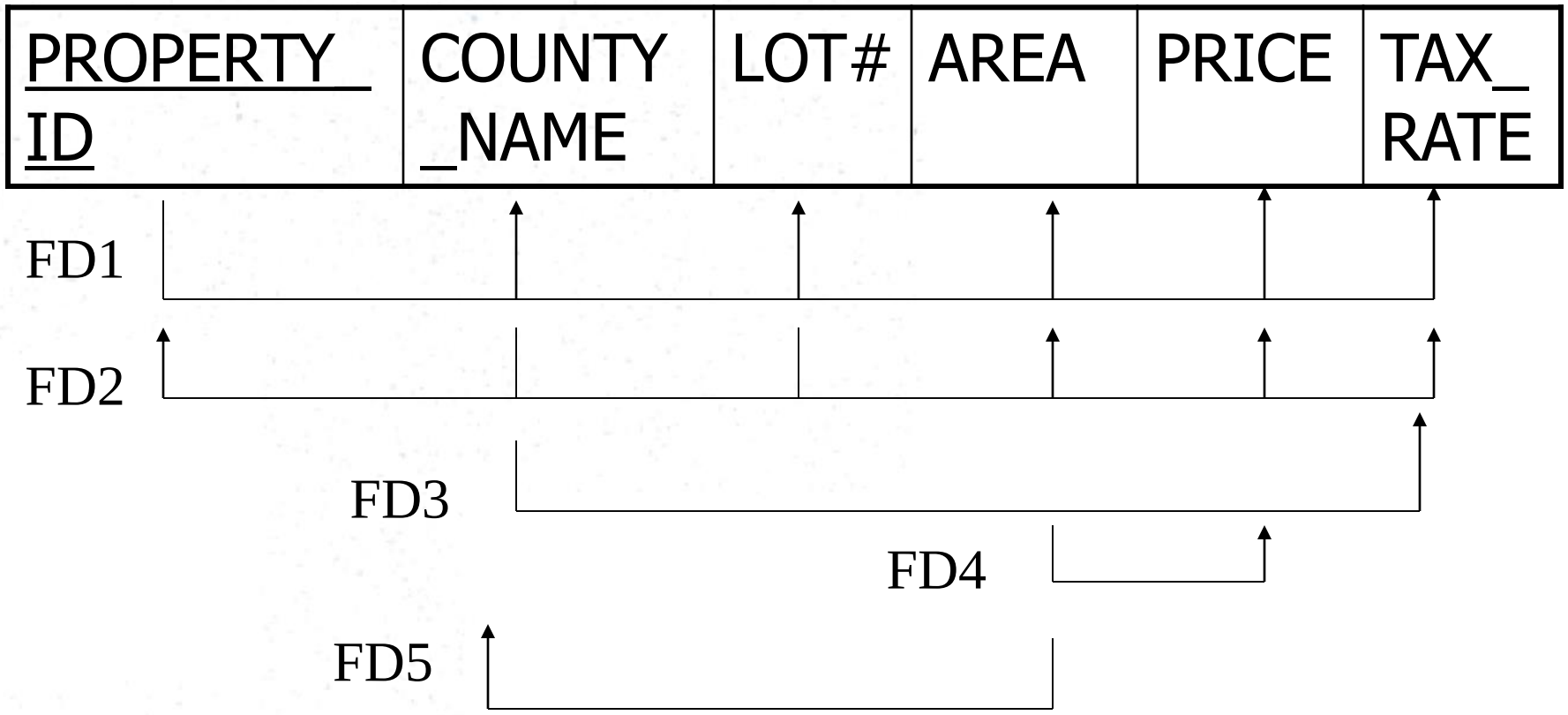
A → D

B → E F

G → A

- What normal form is the relation in?
- If R is not in BCNF, convert it to BCNF.

activity


PROPERTY_ID
COUNTY_NAME
LOT#
AREA
PRICE
TAX_RATE
FD1
FD2
FD3
FD4
FD5

What you have to do by next week

- Try out the self-test questions on the course web.
- Complete the tutorial.
- Read Chapter

SLIIT

Discover Your Future

Database Management Systems

Lecture 4 - SQL

Lecture content

- Introduction to SQL
- Data definition language
- Data manipulation language

Lecture content

- At the end of this lecture students should be able to
  - Write syntactically correct SQL statements to create and modify relations in a RDBMS
  - Write syntactically correct SQL statements to answer user defined queries in a RDBMS

SQL

- SQL Initially called SEQUEL (for Structured English QUEry Language)
- It was developed for an experimental relational database system called System R
- A joint effort between ANSI (American National Standard Institute) and ISO (International Standards Organization) led to a standard version of SQL in 1986 (SQL1, SQL-86, etc.)
- Major revisions have been proposed and SQL2 (also called SQL-92) has subsequently been developed

Relational Model Vs. SQL

- Terminology

Relational Model	SQL
Relation	Table
Attribute	Column
Tuple	Row

SQL: Review (contd.)

SQL is a comprehensive database language:

- Data Definition Language (DDL)
- Data Manipulation Language (DML)
- Facilities for security & authorization
- Facilities for transaction processing
- Facilities for embedding SQL in general purpose languages (Embedded SQL)
- …

Data Definition Language (DDL)

- DDL is the subset of SQL that supports the creation, deletion and modifications for tables and views.
- Constraints can be defined on the tables

Constraint	Purpose
Not Null	Ensure that column doesn't have null values
Unique	Ensure that column doesn't have duplicate values
Primary key	Defines the primary key
Foreign key	Defines a foreign key
Default	Defines a default value for a column (When no values are given)
Check	Validates data in a column

Creating a Table - Example

```
CREATE TABLE STUDENT
(
   studentId INTEGER PRIMARY KEY,
   sName VARCHAR (30) NOT NULL,
   nic CHAR(10) UNIQUE,
   gpa FLOAT,
   progId VARCHAR(10) DEFAULT 'IT',
   CONSTRAINT student_prog_fk FOREIGN KEY (progId)   REFERENCES
            programs(id) ON DELETE SET DEFAULT ON UPDATE CASCADE,
   CONSTRAINT gpa_ck CHECK (gpa<= 4.0 )
)
```

Modifications to Tables

- ALTER commands – to alter the definition of the object
  - Ex : Adding a new column to a table
    - **ALTER TABLE** student **ADD** age **INT**
  - Ex : Adding a new constraint to a column
    - **ALTER TABLE** student **ADD CONSTRAINT** chk_age **CHECK** (age > 18)
  - Ex : removing a column from a table
    - **ALTER TABLE** student **DROP COLUMN** age
- DROP commands – for dropping objects
  - Ex: Deleting a table
    - **DROP TABLE** Employee

Data Manipulation Language (DML)

- DML is the subset of SQL that allows users to write statements to insert, delete, modify and display rows.
  - Inserting a row
    - **INSERT INTO** student **VALUES (**1000, 'Amal', '123456789V', 3.2, 'BM'**)**
    - **INSERT INTO** student**(**studentId, sName, nic**) VALUES (**1001, 'Nimali', '234567890V'**)**

StudentID	SName	nic	gpa	progId
1000	Amal	123456789V	3.2	BM
1001	Nimali	234567890V	Null	IT

Data Manipulation Language (DML)(Contd.)

- Deleting a row
  - **DELETE** student **WHERE** studentId=1000
- Updating a row
  - **UPDATE** student
    SET gpa=2.8
    WHERE studentId=1001

Select clause

- Select clause in SQL is the basic statement for retrieving information from a database
- Basic form

SELECT <attributes>

FROM <one or more relations>

WHERE <conditions>

- Ex : display ids of all students whose gpa is above 3.0
  - Select StudentId from student where gpa> 3.0

Clauses and operators used with SELECT

- LIKE operator
- IS [NOT] NULL operator
- DISTINCT operators
- BETWEEN operator
- ORDER BY clause
- Joins (inner & outer)
- Nested query (IN/SOME/ANY, ALL), [NOT] EXISTS
- Aggregate functions
- GROUP BY – HAVING clauses

LIKE operator

- Used for matching patterns
- Syntax : <string> LIKE <pattern>
  - <pattern> may contain two special symbols:
    - % = any sequence of characters
    - _ = any single character

Student

StudentID	Name	gpa	progId
1000	Amal	3.2	BM
1001	Nimali	Null	IT
1002	Aruni	3.0	SE
1003	Surani	2.5	IT

- Ex : Find students whose name starts with a 'A'
  - Select Name From student where Name Like 'A%'

Name
Amal
Aruni

IS [NOT] NULL operator

- IS NULL :Used to check whether attribute value is null
- Ex : Find studentIDs of the students who have not completed a semester yet.
  - Select studentId

    From student

    Where gpa IS NULL

StudentID
1001
1004

Student

StudentID	Name	gpa	progId
1000	Amal	3.2	BM
1001	Nimali	Null	IT
1002	Aruni	3.0	SE
1003	Surani	2.5	IT
1004	Imali	Null	BM

DISTINCT operator

- In a table, a column may contain many duplicate values.
- Duplicates in results can be eliminated using DISTINCT operator
- Ex :

```
Select progId
From student
```

ProgId
BM
IT
SE
IT
BM

Student

StudentID	Name	gpa	progId
1000	Amal	3.2	BM
1001	Nimali	Null	IT
1002	Aruni	3.0	SE
1003	Surani	2.5	IT
1004	Imali	Null	BM

```
Select DISTINCT progId
From student
```

ProgId
BM
IT
SE

BETWEEN operator

- Used to check whether attribute value is within a range
- Ex :Find the students who will be obtaining a first class (3.7<=gpa<=4.0)

```
Select studentID
From student
Where gpa between 3.7 and 4.00
```

Student

StudentID	Name	gpa	progId
1000	Amal	3.2	BM
1001	Nimali	Null	IT
1002	Aruni	3.8	SE
1003	Surani	2.5	IT
1004	Imali	4.0	BM

StudentID
1002
1004

ORDER BY Clause

- Used to order results based on a given field
- Ordering is ascending (ASC), unless you specify the DESC keyword
- Ex : display the student names and gpa's in the ascending order of gpa's.

```
Select Name, gpa
From student
Order by gpa
```

Name	gpa
Surani	2.5
Nimali	2.8
Amal	3.2
Aruni	3.8
Imali	4.0

Student

StudentID	Name	gpa	progId
1000	Amal	3.2	BM
1001	Nimali	2.8	IT
1002	Aruni	3.8	SE
1003	Surani	2.5	IT
1004	Imali	4.0	BM

[INNER] Join

- Joins two tables based on a certain condition
- Ex : Find the names of students who follow programs offered by SLIIT

```
Select s.Name
From student s, program p
where s.pid=p.ProgId and offerBy='SLIIT'
                Or
Select s.Name
From student s INNER JOIN program p on s.pid=p.progId
Where offerBy='SLIIT'
```

Student

SID	Name	gpa	pid
1000	Amal	3.2	BM
1001	Nimali	2.8	IT
1002	Aruni	3.8	SE
1003	Surani	2.5	IT

Program

progId	years	Offer By
BM	3	Curtin
IT	4	SLIIT
SE	3	SHU

Name
Nimali
Surani

LEFT OUTER JOIN

- Returns all rows from the table on the left hand side of join, with the matching rows in the table on the right hand side of the join.
- The result is NULL in the right side when there is no match.
  - Ex : For all the students display the name and the offering institute

```
Select s.Name, p.offerBy
From student s LEFT OUTER JOIN program p
                on s.pid=p.progId
```

Student

SID	Name	gpa	pid
1000	Amal	3.2	BM
1001	Nimali	2.8	IT
1002	Aruni	3.8	SE
1003	Surani	2.5	IT

Program

progId	years	Offer By
BM	3	Curtin
IT	4	SLIIT

Name	offerBy
Amal	Curtin
Nimali	SLIIT
Aruni	NULL
Surani	SLIIT

RIGHT OUTER JOIN

- Returns all rows from the table on the right hand side of join, with the matching rows in the table on the left hand side of the join.
- The result is NULL in the left side when there is no match.
  - Ex : For all the programs display the offering institute and names of the students following

```
Select s.Name, p.offerBy
From student s RIGHT OUTER JOIN program p on
s.pid=p.progId
```

Student

SID	Name	gpa	pid
1000	Amal	3.2	BM
1001	Nimali	2.8	IT
1002	Aruni	3.8	NULL
1003	Surani	2.5	IT

Program

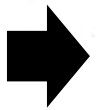
progId	years	Offer By
BM	3	Curtin
IT	4	SLIIT
SE	3	SHU

Name	offerBy
Amal	Curtin
Nimali	SLIIT
Surani	SLIIT
NULL	SHU

IN operator

- Used to check whether attribute value matches any value within a value list
- Ex : Find the students who has obtained a ‘A’.

```
Select s.Name
From Student s
Where s.SID IN ( Select SID
                 from Grades
                 Where Grade=‘A’)
```



Student

SID	Name	gpa
1000	Amal	3.2
1001	Nimali	2.8
1002	Aruni	3.8

Grades

SID	cid	Grade
1000	IT102	A
1000	IT100	B
1001	IT102	A
1002	IT102	C
1002	IT200	C

Name
Amal
Nimali

EXISTS operator

- Used to check if subquery returns any rows
- Ex : Find the students who has obtained a ‘A’.

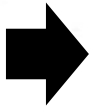
```
Select s.Name
From Student s
Where EXISTS ( Select *
               from grades g
               Where g.SID=s.SID and
               g.Grade='A')
```

Student

SID	Name	gpa
1000	Amal	3.2
1001	Nimali	2.8
1002	Aruni	3.8

Grades

SID	cid	Grade
1000	IT102	A
1000	IT100	B
1001	IT102	A
1002	IT102	C
1002	IT200	C



Name
Amal
Nimali

Comparison operators with SOME, ANY & ALL

- Comparison operators such as =, <>, > ,>= ,< and <= could be modified using operators SOME, ANY and ALL.
  - SOME and ANY : used to compare a value to a list or subquery. Return true if at least one of the comparison evaluates as true.
  - ALL : used to compare a value to a list or subquery. If all of the comparisons evaluate to true then the result of the ALL expression will be true. Otherwise the result will be false

ANY and SOME operators

- Ex : Find BM students who has gpa greater than any of the IT students.

```
Select s.Name
From student s
Where s.progID='BM' and
        s.gpa > ANY (
                select s1.gpa
                from student s1 where
                s1.progId='IT')
```

Student

StudentID	Name	Gpa	progId
1000	Amal	3.2	BM
1001	Nimali	2.8	IT
1002	Aruni	3.8	SE
1003	Surani	2.5	BM
1004	Imali	4.0	IT

Name
Amal

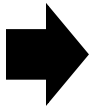
ALL operator

- Ex : Find IT students who has gpa greater than all the BM students.

```
Select s.Name
From student s
Where s.progID='IT' and
        s.gpa > ALL (
                select s1.gpa
                from student s1 where
                s1.progId='BM')
```

Student

StudentID	Name	gpa	progId
1000	Amal	3.2	BM
1001	Nimali	2.8	IT
1002	Aruni	3.8	SE
1003	Surani	2.5	BM
1004	Imali	4.0	IT



Name
Imali

Aggregation

- An aggregate function summarizes the results of an expression over a number of rows, returning a single value.
- Some of the commonly used aggregate functions are SUM, COUNT, AVG, MIN and MAX

Aggregation (Contd.)

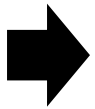
- Ex : Find the average, minimum, maximum gpa of students

Student

StudentID	Name	gpa	progId
1000	Amal	3.2	BM
1001	Nimali	2.8	IT
1002	Aruni	3.8	SE
1003	Surani	2.5	BM
1004	Imali	4.0	IT

Select AVG(gpa), MIN(gpa), MAX(gpa)

From student



AVG(gpa)	MIN(gpa)	MAX(gpa)
3.26	2.5	4.0

Grouping (GROUP BY Clause)

- Groups the data in tables and produces a single summary row for each group.
- Grouping is done based on a values in a given field
- When using group by
  - Each item in the SELECT list must be single valued per group.
  - SELECT clause may only contain Columns names, aggregate function, constants or an expression involving combinations of the above.
  - All column names in SELECT list must appear in the GROUP BY clause unless the name is used only in the aggregate function.

Grouping (Contd.)

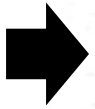
- Ex: Count the number of students who has followed each module.

Student

SID	CID	Grade
1000	DBII	A
1000	SEI	B
1001	DBII	A
1002	DBII	C
1002	SPD	C

SID	CID	Grade
1000	DBII	A
1001	DBII	A
1002	DBII	C
1000	SEI	B
1002	SPD	C

```
Select CID, Count(SID)
From Student
Group by CID
```

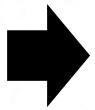


CID	Count (SID)
DBII	3
SEI	1
SPD	1

HAVING Clause

- Used to apply conditions on the groupings
- Ex: Find courses which is followed by more than two students

```
Select CID, Count(SID)
From course
Group by CID
Having count(SID)>2
```



CID	Count (SID)
DBII	3

Student

SID	CID	Grade
1000	DBII	A
1000	SEI	B
1001	DBII	A
1002	DBII	C
1002	SPD	C

SID	CID	Grade
1000	DBII	A
1001	DBII	A
1002	DBII	C
1000	SEI	B
1002	SPD	C

SQL: Review (contd.)

Summary of SQL Queries…

```
SELECT <attribute-list>
FROM   <table-list>
[WHERE   <condition>]
[GROUP BY      <group attribute(s)>]
[HAVING  <group condition>]
[ORDER   BY    <attribute list>];
```

What you have to do by next week

- Try out the self-test questions on the course web.
- Complete the tutorial.

SLIIT

Discover Your Future

Database management systems (IT 2040)

Lecture 05 – database programming

Lecture content

- Views
- SQL extensions (specifically T-SQL)
- Functions & Procedures
- Triggers

Learning outcomes

- At the end of this lecture, students should be able to
  - Identify situations where views, functions, stored procedures and triggers are applicable.
  - Write syntactically correct sql statements to create functions, procedures and triggers on RDBMS to cater user requirements.

Views

- A **view** is a virtual table which is derived from other tables which are called **base tables** or **defining tables.**
- A view does not necessarily exist in a physical form.
- In SQL, CREATE VIEW statement is used to define views.
- Syntax :

```
CREATE VIEW <view_name> AS
SELECT <column_name(s)>
FROM <table_name>
WHERE <condition>
```

Views (contd.)

- emp (eid, ename, age, salary) ,dept (did, dname, budget,mangerId), works (eid, did, pct_time)

- Create a view named dept_info that contains name of the department, budget and manager's name

```
CREATE VIEW dept_info(dname,budget,manager)
AS
SELECT d.dname, d.budget, e.ename
FROM emp e, dept d
WHERE e.eid=d.managerId
```

Exercise 1

- Create a view named emp_info which contains eid, name, salary and total percentage of time.

  emp (eid, ename, age, salary)

  dept (did, dname, budget,mangerId)

  works (eid, did, pct_time)

Querying and Deleting a view

- Querying a view can be done similar to a table.
  - Ex : SELECT * FROM dept_info
  - Ex : SELECT dname FROM dep_info WHERE budget> 500,000

- Dropping a view
  - Ex : DROP VIEW dept_info

Updating Views (Contd.)

- Updating a view can be ambiguous…
  - Views containing aggregate functions are not updateable
  - Ex :

```
UPDATE emp_info
SET  tot_pct= 90
WHERE eid = 1000
```

**This is not possible

Updating Views (Contd.)

- Views containing a join can be ambiguous

A	B
b	1

B	C
1	d
1	e

A	B	C
b	1	d
b	1	e

UPDATE V1
SET A = a
WHERE C = e

- Thus, in many DBMSs, views are updateable only if they are defined on a single base table.

Why Views ?

- Advantages
  - **Security :** Each user can be given permission to access the database only through a small set of views that contain the specific data the user is authorized to see, thus restricting the user's access to stored data
  - **Query Simplicity :** A view can draw data from several different tables and present it as a single table, turning multi-table queries into single-table queries against the view.
- Disadvantages
  - **Performance :** Views create the appearance of a table, but the DBMS must still translate queries against the view into queries against the underlying source tables. If the view is defined by a complex, multi-table query then simple queries on the views may take considerable time
  - **Update restrictions**

Programming in T-SQL

- Similar to a programming language, certain extensions have been made in SQL to program simple server-side logic.
- Some of the statements include:
  - Variables
  - Selection conditions
    - IF (…)… ELSE …
  - Looping
    - WHILE (…)

T-SQL: Variables

- A Transact-SQL local variable is an object that can hold a single data value of a specific type.
- Variables in scripts are typically used:
  - As a counter either to count the number of times a loop is performed or to control how many times the loop is performed
  - To hold a data value to be tested by a control-of-flow statement
  - To save a data value to be returned by a stored procedure return code.

T-SQL: Variables (Contd.)

- The DECLARE statement initializes a Transact-SQL variable.
  - Syntax: DECLARE @<variable name> <data type>
  - Ex: DECLARE @DName VARCHAR(20)
  - The created variable will be holding a null value

- To assign a value to a variable, use the SET statement.
  - Syntax : SET @<variable name> =<value>
  - SET @DName = 'SESD'

T-SQL: Variables (Contd.)

- The declared variables could be used in scripts
- Ex :
  - SELECT budget
    FROM Dept
    WHERE dname = @DName

  - DECLARE @empId INT
    SELECT @empId = MAX(eid)
    FROM emp

T-SQL: IF statement

- Imposes conditions on the execution of a Transact-SQL statement.
- Ex:

```
IF (SELECT count(eid) FROM emp) > 1000
BEGIN
    PRINT 'Inside the IF statement'
    PRINT 'There are lesser than 1000 employees '
END
ELSE
    PRINT 'There are more than 1000 emloyees ! '
```

T-SQL: WHILE statement

- Sets a condition for the repeated execution of an SQL statement or statement block.
- The statements are executed repeatedly as long as the specified condition is true.
- The execution of statements in the WHILE loop can be controlled from inside the loop with the BREAK and CONTINUE keywords.

T-SQL: WHILE statement (contd.)

- BREAK
  - Causes an exit from the innermost WHILE loop. Any statements appearing after the END keyword, marking the end of the loop, are executed.

- CONTINUE
  - Causes the WHILE loop to restart, ignoring any statements after the CONTINUE keyword.

T-SQL: WHILE statement(contd.)

- Ex :

```
WHILE @count<=100
BEGIN
        INSERT INTO Employees VALUES(@count,CONCAT('Employee',@count))
        SET @count=@count+1
END
```

Stored Functions/Procedures

- Business logic is maintained in database tier for data intensive operations
  - E.g. Calculating all interest earned in bank accounts

- In SQL Server 2005, Stored Procedure/ Functions can be written in
  - T-SQL (we will study only this)
  - Any .NET Language

Stored Functions/Procedures (Contd.)

- Syntax of a function

```
CREATE FUNCTION <function name> (parameters)
RETURNS <return type>
<function body>
```

- Parameter mode of parameters for functions is IN which parameters allow the calling code to pass values into the procedure

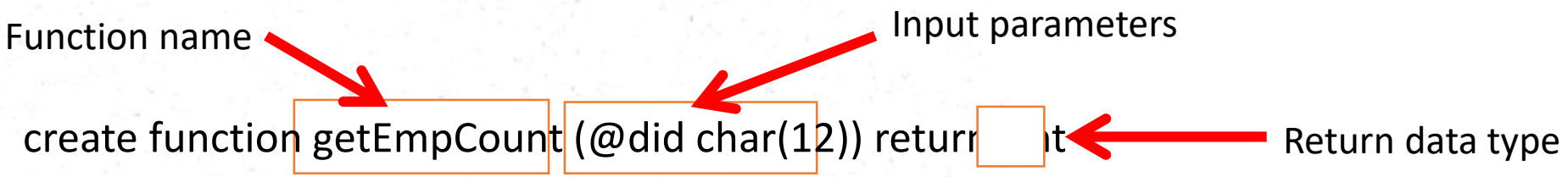
- Syntax of a procedure

```
CREATE PROCEDURE <procedure name> (parameters)
<proedure body>
```

- Each parameter to a procedure should have a data type and a parameter mode (IN or OUT).
  - IN: This is the default mode. IN parameters allow the calling code to pass values into the procedure
  - OUT: OUT parameters allow the procedure to pass values back to the calling code

Functions

- Ex : Create a function that returns the number of employees in a given department.




```
create function getEmpCount (@did char(12)) returns int
as
begin
        declare @ecount int
        select @ecount=count(*)
        from works w
        where w.did=@did
        return @ecount
end
```

Functions (Contd.)

- Calling the function created previously

```
declare @result int
exec @result=get_empCount 'Admin'
print @result
```

Exercise 2

- Create a function to return the total percentage of time a person works given the employee id.

Stored Procedures

- Ex : Create a procedure to give a salary increment to all the employee by a given percentage from their existing salary

```
CREATE PROCEDURE increaseSalary (@pct float)
as
begin
   Update emp
   Set salary=salary+salary * (pct/100)
end;
```

Stored Procedures (Contd.)

- Calling the procedure

```
exec increaseSalary 10
```

Stored Procedures (Contd.)

- Ex 2: create a procedure that outputs statistics of salary (min, max) for a given department.

```
create procedure get_stats(@did varchar(12),@maxm real output,@minm real
output)
as
begin
      select @maxm=max(e.salary),@minm=min(e.salary)          from dept d, works
      w, emp e
      where d.did=w.did and w.eid=e.eid and d.did=@did
end
```

Stored Procedures (Contd.)

- Calling the procedure

```
declare @max int,@min int
exec get_stats 'Admin', @max output,@min output
print @max
print @min
```

Exercise 3

- Create a procedure that outputs the name of the manager and his salary in a given department.

Triggers

- Triggers are useful in enforcing business rules and data integrity.
- They are more powerful than general constraints.
- For example,
  - The employees salary is always less than his/her manager's salary

T-SQL: Triggers

- A trigger is a special type of stored procedure that automatically takes effect when the data in a specified table is modified.
- A trigger is invoked in response to a
  - DDL statement (CREATE, ALTER etc.) or
  - DML statement (INSERT, UPDATE, or DELETE statement). ‘

T-SQL: Trigger syntax

- We will learn DML triggers…
- Syntax :

```
CREATE TRIGGER trigger_name
ON { table | view }
{
   { { FOR | AFTER | INSTEAD OF }
         { [ INSERT ] [ , ] [ UPDATE ] [ , ]
           [DELETE ] }
      AS
          sql_statement [ ...n ]
      }
  }
```

T-SQL: Trigger syntax (Contd.)

- FOR|AFTER
  - AFTER specifies that the DML trigger is fired only when all operations specified in the triggering SQL statement have executed successfully.
  - AFTER is the default when FOR is the only keyword specified.
  - AFTER triggers cannot be defined on views.

- INSTEAD OF
  - Specifies that the trigger is executed *instead of* the triggering SQL statement, thus overriding the actions of the triggering statements.
  - Specifies At most, one INSTEAD OF trigger per INSERT, UPDATE, or DELETE statement can be defined on a table or view.

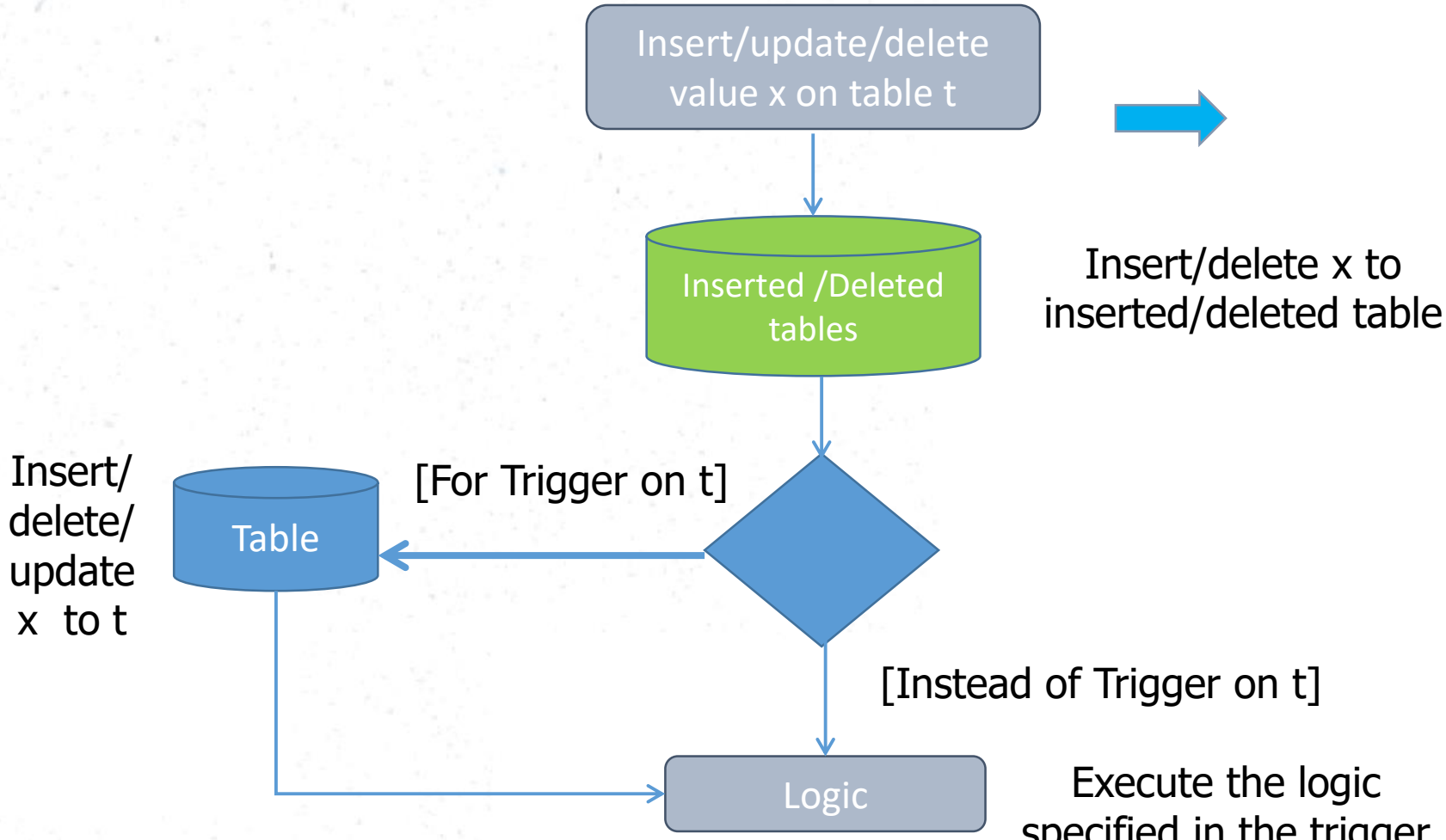
T-SQL: Trigger syntax (Contd.)

- [DELETE] [,] [INSERT] [,] [UPDATE]
  - Are keywords that specify which data modification statements, when attempted against this table or view, activate the trigger. At least one option must be specified.

Triggers : inserted/deleted tables

- When a trigger is executed SQL Server creates two virtual tables called INSERTED and DELETED.
- The **deleted** table stores copies of the affected rows during DELETE and UPDATE statements
- The **inserted** table stores copies of the affected rows during INSERT and UPDATE statements
  - For example when inserting a record to a table, SQL Server creates a virtual table call INSERTED and loads data into the inserted table then executes the trigger statements and writes the related data pages.
- The format of the inserted and deleted tables is the same as the format of the table on which the trigger is defined
- Each column in the inserted and deleted tables maps directly to a column in the base table

Triggers : How do they work?



T-SQL: Triggers(contd.)

- Example 1:
  - Consider tables below
    - Account (accountNo, custId, branch, balance)
    - AccountAudit (accountNo, balance, date)
  - Create a trigger to track all inserts/updates done to the balance field of an Account table at a bank in the AccountAudit table

T-SQL: Triggers (contd.)

```
Create trigger account_audit_trigg
On Account
For Insert, update
As
Begin
    Declare @ano int
    Declare @balance float

    Select @ano=accountNo,@balance=balance from inserted
    Insert into accountAudit(@ano,@balance,getdate())
end
```

T-SQL: Triggers (contd.)

- Example 2:
  - Consider following tables :
    - Emp(eid ,ename, age, salary)
    - Works (eid, did, pct-time)
    - Dept(did, budget, managerid)
  - Create a trigger to ensure that an employee doesn't work in more than 2 departments

Exercise 4

- Consider the following table
  - Transaction(tid, accountNo, type,amount,date)
    - Type may contain ‘credit’ or ‘debit’
- Assuming that the bank’s maximum withdrawal limit per day is 40000, write a trigger to ensure that no customer withdraws more than the given limit.

Exercise 5

- Consider the tables given below
  - Employee(nic, name, salary, dno)
  - Dept (dno, dname, mgrNic)
- Create a trigger to ensure that no employee has a salary greater than his/her manager.

Summary

- Views
- Transaction Basics
- T-SQL extensions
- Stored Procedures
- Triggers

DATABASE MANAGEMENT SYSTEMS (IT 2040)

LECTURE 06 – JAVA DATABASE CONNECTIVITY

LECTURE CONTENT

- JDBC

LEARNING OUTCOMES

- At the end of this lecture students would be able to
  - Write a command line program in java to access different databases

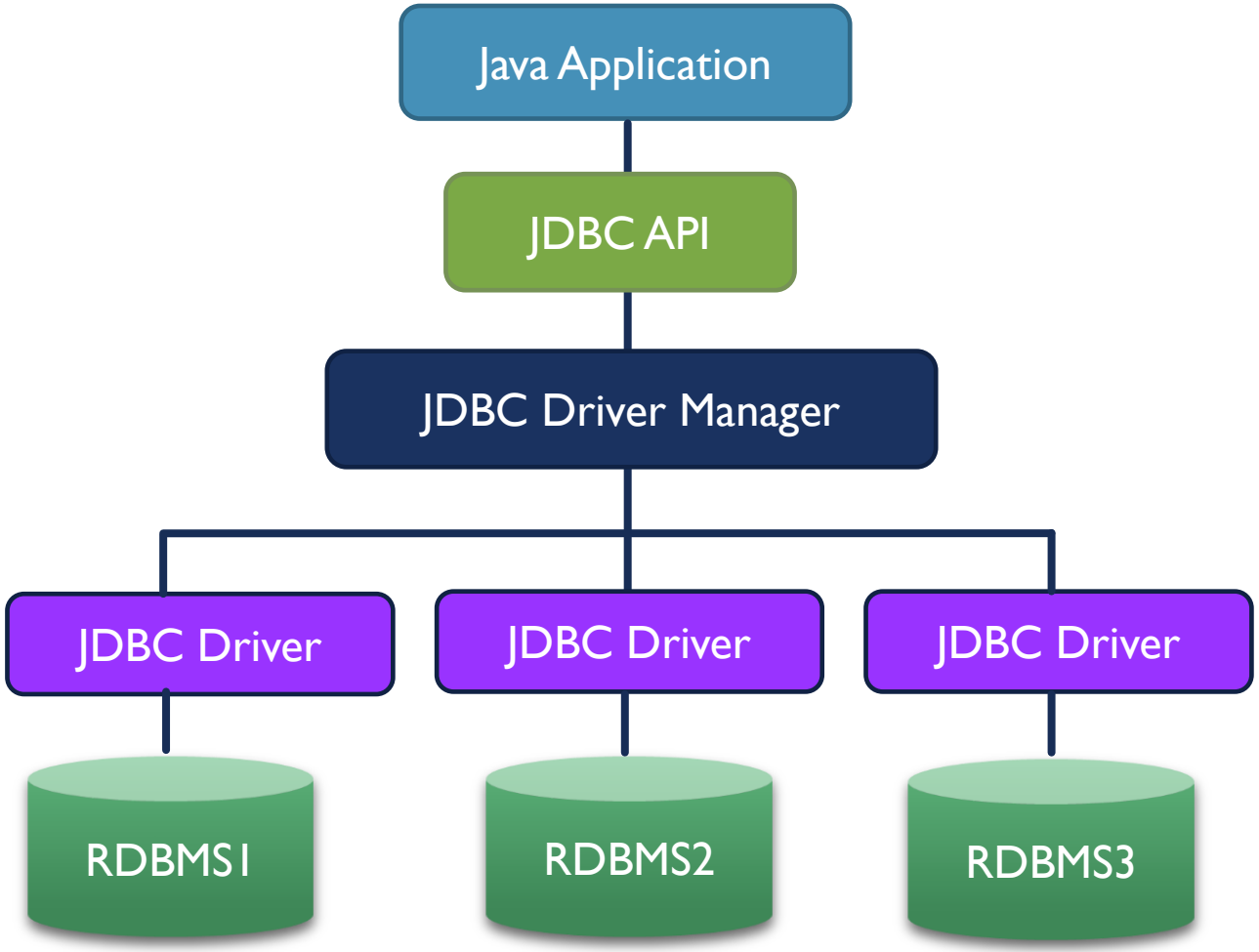
INTRODUCTION

- SQL is the standard common language used for storing in and obtaining information from relational databases.
- Even though SQL was standardized, still different applications was needed to be developed to access different DBMSs.
- A common way for an application to access a relational database was highly desirable.

JDBC

- Java Database Connectivity (JDBC) is an application program interface (API) specification for connecting programs written in Java to the data in popular databases.
- The application program interface lets you to connect to a database, to interact with that database via SQL and retrieve results from the database that could be used within a java application.

JDBC ARCHITECTURE



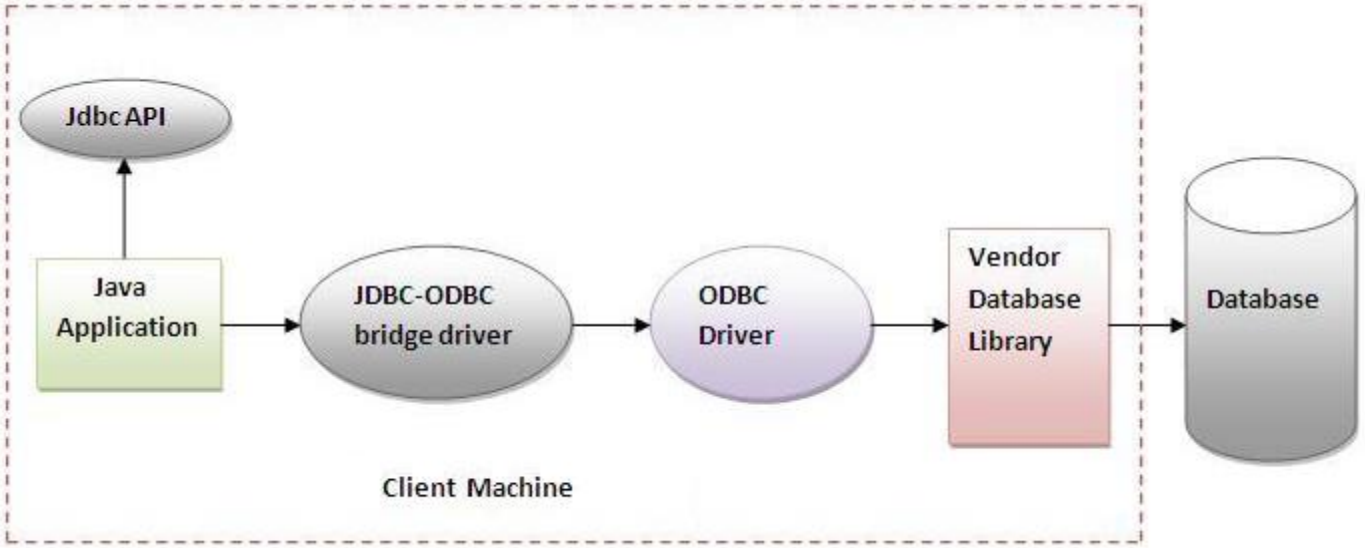
- The JDBC API provides the application-to-JDBC Manager connection.
- The JDBC driver manager supports the JDBC Manager-to-Driver Connection. It manages a list of database drivers. Matches connection requests from the java application with the proper database driver.
- JDBC Driver handles the communications with the database server.

TYPES OF JDBC DRIVERS

- JDBC driver implementations vary because of the wide variety of operating systems and hardware platforms in which Java operates. Sun has divided the implementation in to four categories which are :
  - Type 1: JDBC-ODBC Bridge Driver
  - Type 2: Native API Driver
  - Type 3: Network Pure Java Driver
  - Type 4: Thin Driver(100% Pure Java Driver)

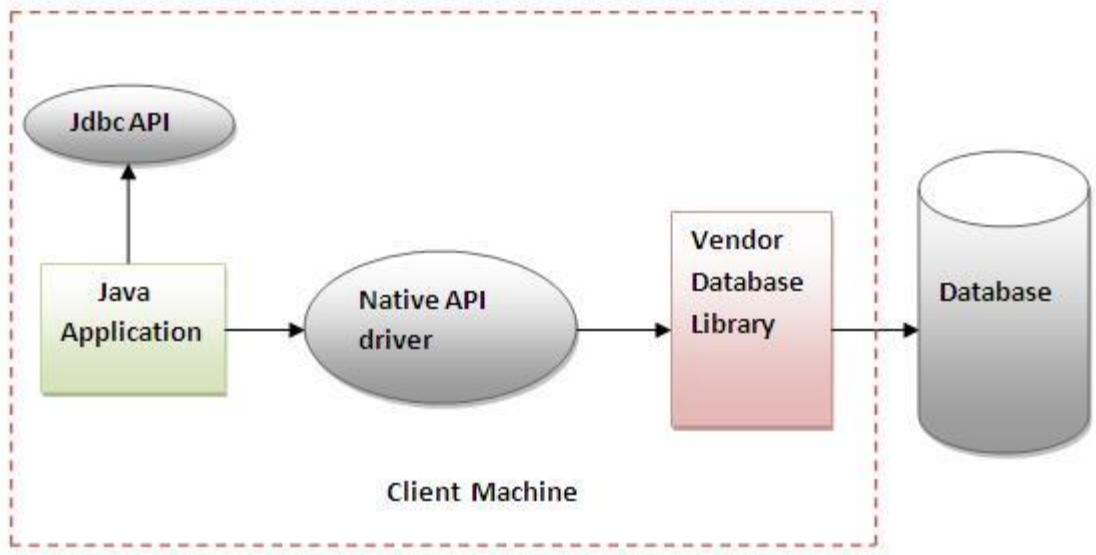
JDBC-ODBC BRIDGE DRIVER

- The JDBC-ODBC bridge driver uses ODBC driver installed in a client machine to connect to the database.
- The JDBC-ODBC bridge driver converts JDBC method calls into the ODBC function calls.



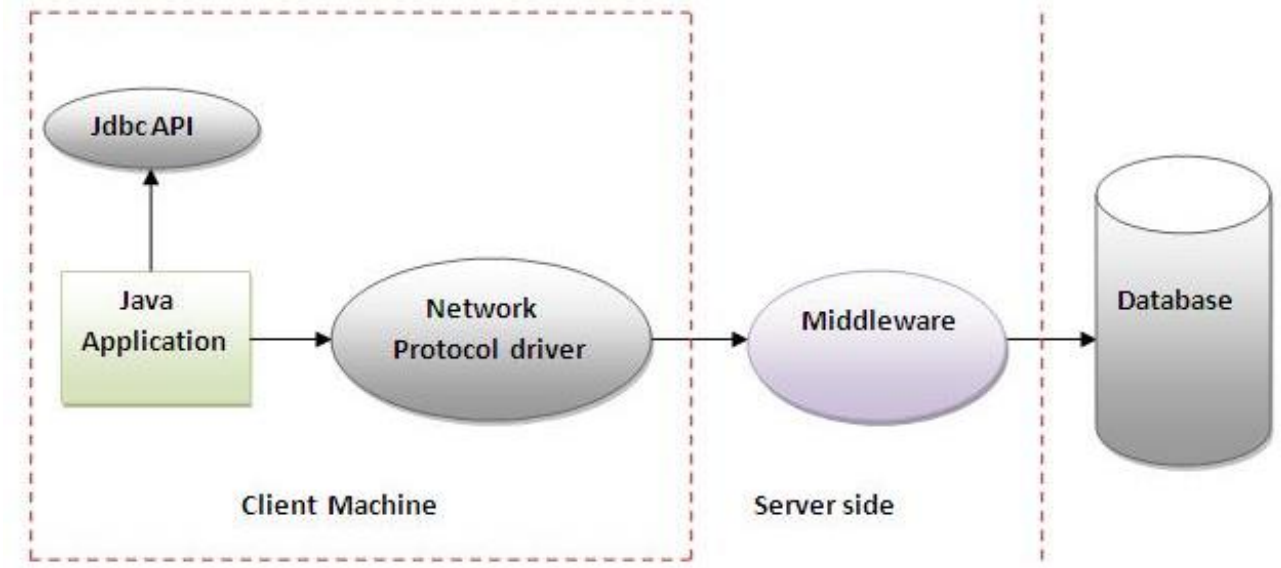
NATIVE API DRIVER

- In a Type 2 driver, JDBC API calls are converted into native C/C++ API calls, which are unique to the database a specific database, such as IBM, Informix, Oracle or Sybase.
- These drivers are typically provided by the database vendors and used in the same manner as the JDBC-ODBC Bridge.
- The vendor-specific driver must be installed on each client machine.



NETWORK PURE JAVA DRIVER

- In a Type 3 driver, a three-tier approach is used to access databases.
- The JDBC clients translate JDBC calls in to middleware vendor's protocol which in return is then translated by the middleware application server into the call format required by the DBMS, and forwarded to the database server.



THIN DRIVER(100% PURE JAVA DRIVER)

- Written entirely in Java
- Converts JDBC calls into packets that are sent over the network in the proprietary format
- used by the specific database.
- This is the highest performance driver available for the database and is usually provided by the vendor itself.

CREATING A JDBC APPLICATION

- **Import the packages**: Import the packages containing the JDBC classes needed for database programming. Most often, using *import java.sql.** will suffice.
- **Load the driverRegister the JDBC driver**: Initialize a driver in order to open a communication channel with the database.
- **Open a connection**: Create a Connection object, which represents a physical connection with the database.
- **Execute a query**: Using an object of type Statement for building and submitting an SQL statement to the database.
- **Extract data from result set**: retrieve the data from the result set.
- **Clean up the environment**: Closing all database resources versus relying on the JVM's garbage collection.

STEP 1 : IMPORT THE PACKAGES

- In this step the packages containing the JDBC classes needed for database programming are imported.
- The Java.sql package contains the entire JDBC API that sends SQL statements to relational databases and retrieves the results of executing those SQL statements.
- Some commonly used interfaces in the package are as follows.
  - The Driver interface represents a specific JDBC implementation for a particular database system.
  - Connection represents a connection to a database.
  - The Statement, PreparedStatement, and CallableStatement interfaces support the execution of various kinds of SQL statements.
  - ResultSet is a set of results returned by the database in response to a SQL query.

STEP 2: REGISTERING DATABASE DRIVERS

- In order to use a driver, it should be registered in the program.
- The most common approach to register a driver is to use Java's **Class.forName()** method, to dynamically load the driver's class file into memory, which automatically registers it.
  - Ex : Class.forName("sun.jdbc.odbc.JdbcOdbcDriver").newInstance();

STEP 3 : OPEN A CONNECTION

- After the driver is loaded to the memory a connection to the database could be established using the **DriverManager.getConnection()** method.
- There are three parameters to the method which are URL of the database, user name and the password.
  - Ex:
    - String url = “jdbc:odbc:dbConn”
    - Connection c = DriverManager.getConnection(url,“user",“password");
- This connection should be closed later using Connection.close()

STEP 4 : EXECUTING QUERIES

- Once a connection is obtained we can interact with the database. The JDBC *Statement*, *CallableStatement*, and *PreparedStatement* interfaces define the methods and properties that enable you to send SQL commands and receive data from your database.
- A summary of statements is available below :

Interface	Recommended use
Statement	Useful when static SQL statements are used at runtime. The Statement interface cannot accept parameters.
PreparedStatement	Suitable when SQL statements are used many times. The PreparedStatement interface accepts input parameters at runtime
CallableStatement	Used to access the database stored procedures. The CallableStatement interface can also accept runtime input parameters.

STEP 4 : EXECUTING QUERIES – STATEMENT OBJECT

- Once you've created a Statement object, you can then use it to execute an SQL statement with one of its three execute methods.
  - boolean execute (String SQL): Returns a boolean value of true if a ResultSet object can be retrieved; otherwise, it returns false.
  - int executeUpdate (String SQL): Returns the number of rows affected by the execution of the SQL statement. Use this method to execute SQL statements for which you expect to get a number of rows affected
    - Ex: int rowsUpd = st.executeUpdate("INSERT INTO Customers (cid, cname) VALUES '123A', 'Sampath')");
  - ResultSet executeQuery (String SQL): Returns a ResultSet object. Use this method when you expect to get a result set, as you would with a SELECT statement.
    - Ex: ResultSet s = st.executeQuery("SELECT cname FROM Customers");

STEP 4 : EXECUTING QUERIES – PREPARED STATEMENTS

- This statement gives you the flexibility of supplying arguments dynamically
- All parameters in JDBC are represented by the **?** symbol, which is known as the parameter marker. You must supply values for every parameter before executing the SQL statement.
- The **setXXX()** methods bind values to the parameters, where **XXX** represents the Java data type of the value you wish to bind to the input parameter.
- All of the Statement object's methods for interacting with the database (a) execute(), (b) executeQuery(), and (c) executeUpdate() also work with the PreparedStatement object.
    - Ex:

```
String sql = "UPDATE Employees set age=? WHERE id=?";
PreparedStatement pstmt = conn.prepareStatement(sql);
stmt.setInt(1, 35); // This would set age
stmt.setInt(2, 102); // This would set ID
int rows = stmt.executeUpdate();
```

STEP 4 : EXECUTING QUERIES – CALLABLE STATEMENTS

- Following steps are used in calling a procedure within a java program
- Firstly, we must prepare a CallableStatement object
  - CallableStatement cStmt = conn.prepareCall("exec getEmpName ?, ?");
- Bind parameters
  - stmt.setInt(1, 102);
- Register output parameters if any
  - stmt.registerOutParameter(2, java.sql.Types.VARCHAR);
- Execute the stored procedure
  - stmt.execute();
- Get any output parameters if any
  - String empName = stmt.getString(2);

STEP 5 : EXTRACT DATA FROM THE RESULT SET

- The SQL statements that read data from a database query, return the data in a result set.
- The java.sql.ResultSet interface represents the result set of a database query.
- A ResultSet object maintains a cursor that points to the current row in the result set.
- The next() method moves the cursor to the next row, and because it returns false when there are no more rows in the ResultSet object, it can be used in a while loop to iterate through the result set.
- There is a get method for each of the possible data types There is a get method for each of the possible data types. Get method could be called by providing the column index or column name
- Ex:
  - rs = stmt.executeQuery("SELECT cname, salary FROM Customer");

```
while (rs.next())
{
    String name = rs.getString(1);
    float salary = rs.getFloat(2);
}
```

SQL EXCEPTIONS

- JDBC Exception handling is very similar to the Java Excpetion handling but for JDBC, the most common exception you'll deal with is java.sql.SQLException.
- When an exception occurs, an object of type SQLException will be passed to the catch clause.
- The passed SQLException object has the following methods available for retrieving additional information about the exception:
  - A string describing the error: getMessage()
  - An integer error code that is specific to each vendor: getErrorCode()

A SAMPLE PROGRAM

```
String url="jdbc:odbc:dsn";
String query="select ProductID,ProductName,UnitPrice from Products";
try{
Class.forName("sun.jdbc.odbc.JdbcOdbcDriver").newInstance();
Connection con=DriverManager.getConnection(url);
Statement s=con.createStatement();
ResultSet res=s.executeQuery(query);
System.out.println("Product ID \t Product Name \t\t\t Unit Price");
        while(res.next())
        {
                int pID=res.getInt(1);
                String pName=res.getString(2);
                float price=res.getFloat(3);
                System.out.println(pID+"\t"+pName+"\t\t"+price);
        }
        con.close();
}
```

SLIIT

Discover Your Future

Database management systems (IT 2040)

Lecture 07 – Database Utilities

SLIIT
FACULTY OF COMPUTING

Lecture content

- Transferring data between different sources
- Backup and restore of data
- Jobs and job schedules
- Database maintenance plans

Learning outcomes

- At the end of this week, students should be able to
  - Transfer data between a data source and a database
  - Create jobs in SQL server
  - Develop a simple database maintenance plan

Database utilities

- Once the database is developed, you may need to perform several tasks on the created tables and stored data.
- SQL server provides many types of utilities for performing commonly used tasks.
- These include,
  - Data Transferring
  - Creating and managing jobs
  - Backup tools & etc.

data transferring

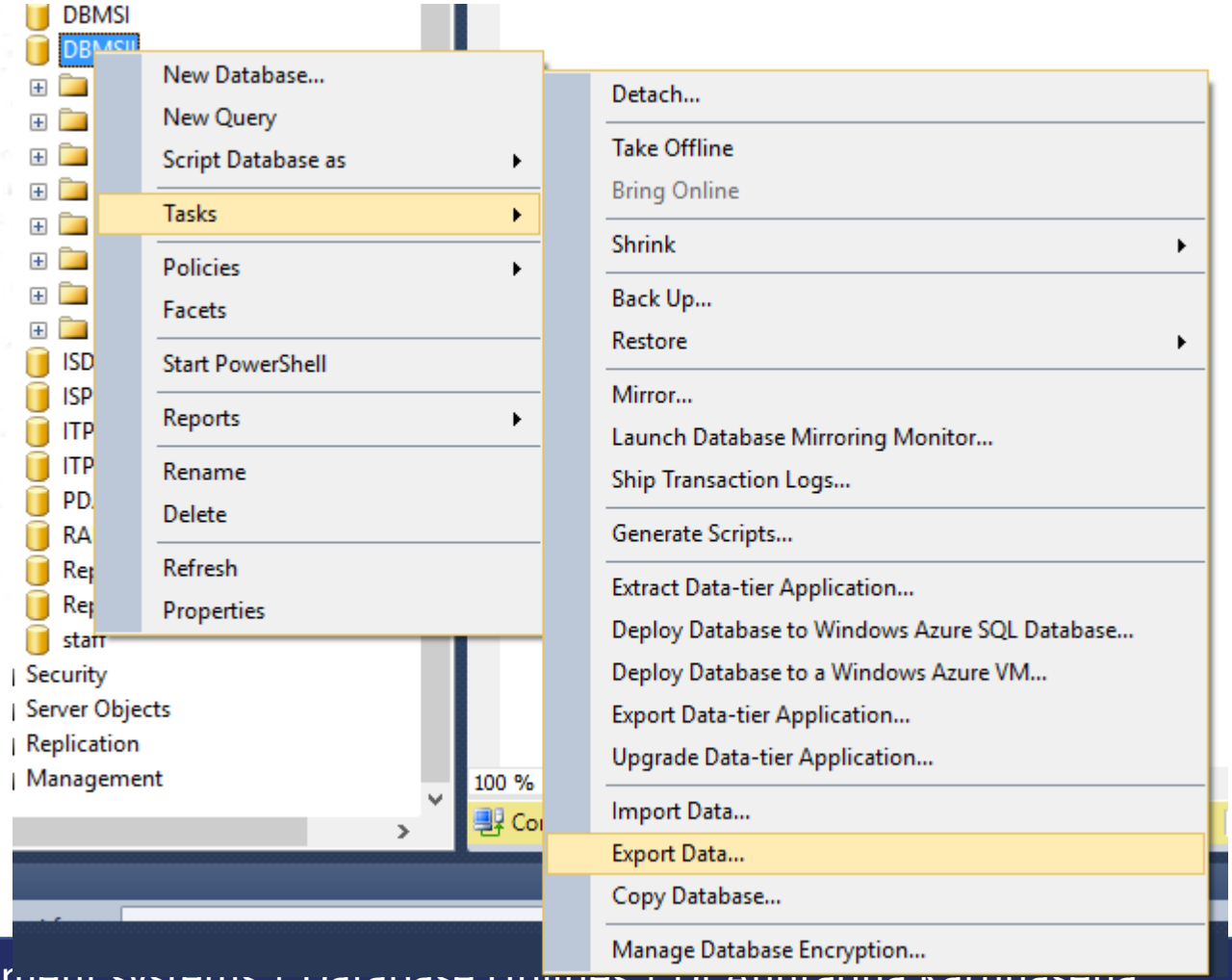
- Some times it is required for transferring data between two sources such as between tables and servers.
- SQL server offers a number of options to facilitate the above as follows :
  - SQL Server Integration Services (SSIS)
  - Using the SQL Server Import and Export Wizard
  - Using BCP to Import and Export Data
  - BULK INSERT
  - SELECT INTO command

SQL sever import and export wizard

- The SQL sever import and export wizard provides a quick way to move data and perform very light transformations of data.
- The wizard is available in all editions of SQL Server except the Local Database edition and Express.
- Next few slides of the lecture shows how data in an Excell file could be exported to a SQL server table in 5 steps.

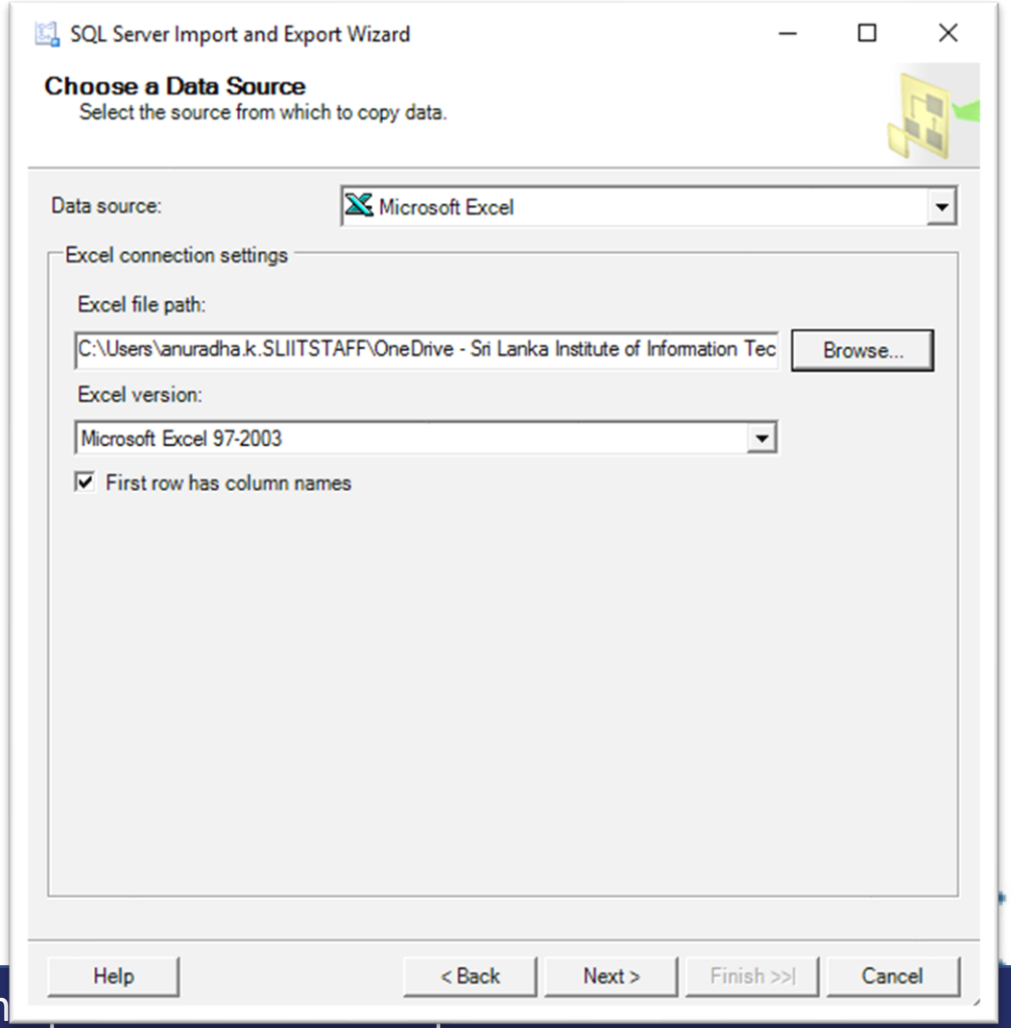
Step 1 – Exporting data from an excel file

- Log in to the SQL sever
- Right click on a database name and select export data sub menu from the task menu.
- Click Next in the welcome screen which appears.



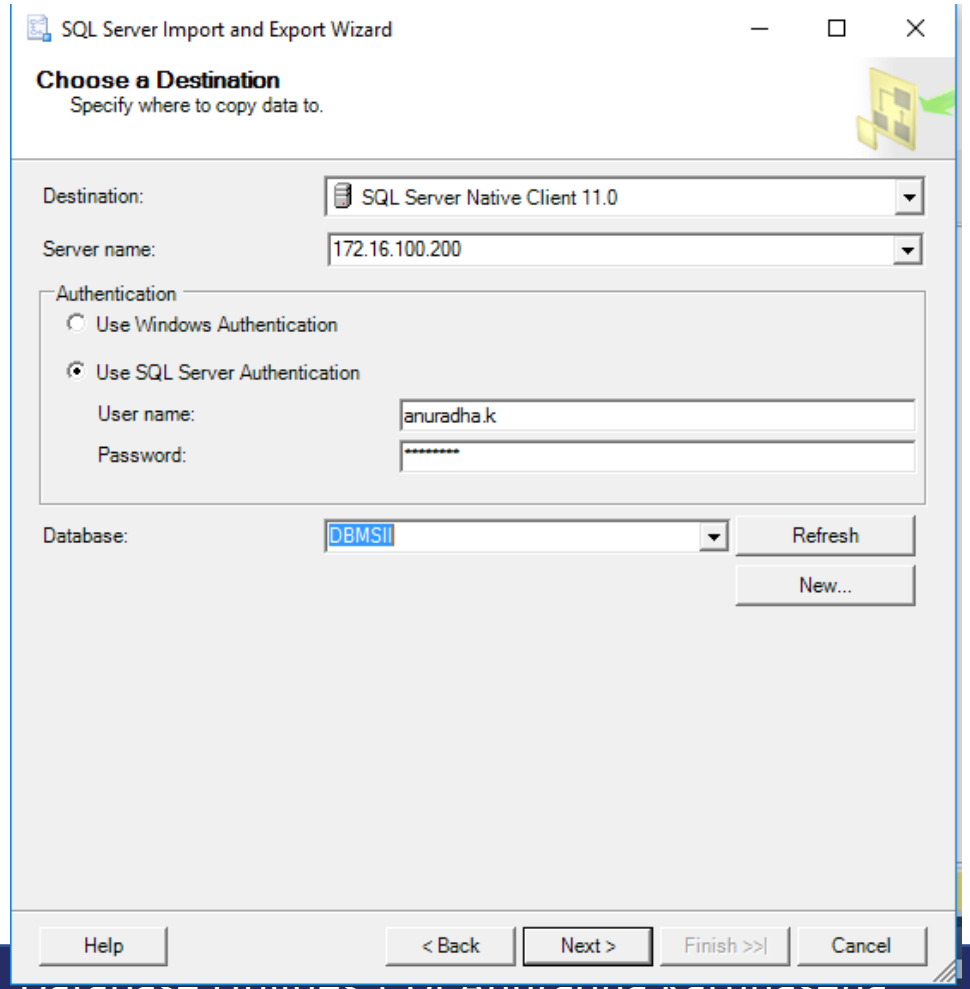
Step 2 – Exporting data from an excel file

- On the next screen select the data source.
- In this scenario the data source is an excel file.
- Browse and select the location of the file.
- Tick the check box on the bottom of the screen if the column names are in the first row of the file.
- Click Next.



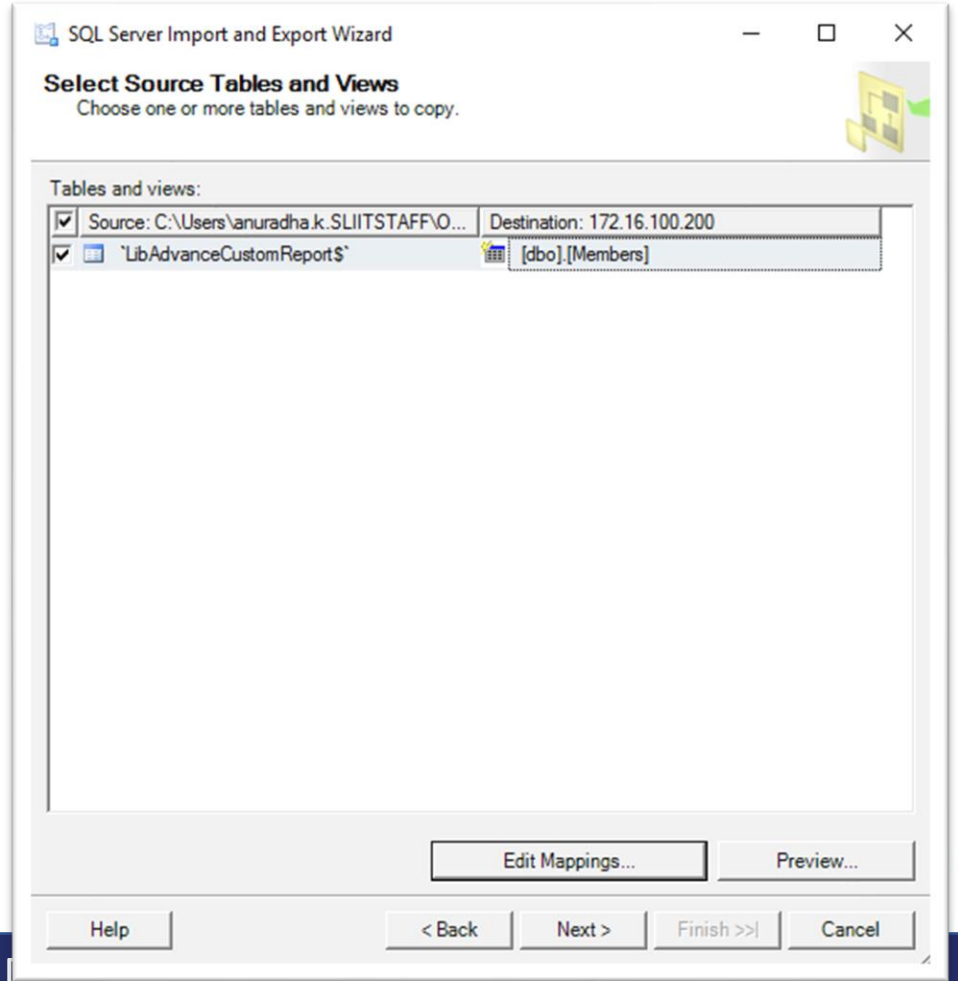
Step 3 – Exporting data from an excel file

- Select the destination for the exported data.
- In this case the destination is the SQL sever database.
- Provide the server name, authentication information and the name of the target database in this screen.
- On the next, select whether all data from a file should be copied or specific data should be drawn through querying.
- In this case all data from the file should be copied.



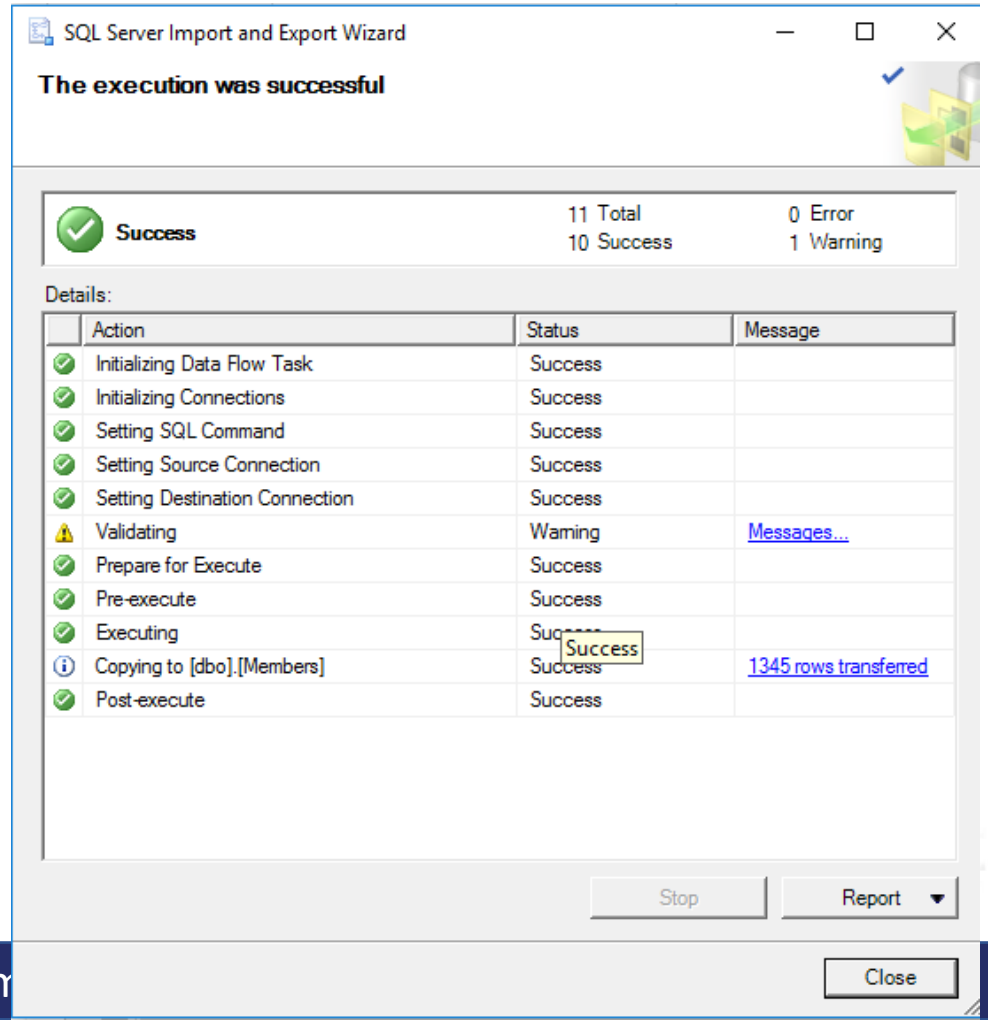
Step 4 – Exporting data from an excel file

- In this screen mapping between the source and destination could be done.
- Change the destination name (i.e. target table name) if it is required.
- Select edit mapping to provide more information on the mapping between the source and the destination
  - Ex: data types of the source table
- Click Next



Step 5 – Exporting data from an excel file

- Click finish to complete the migration on the next screen.
- Outcome of the data migration process would be displayed as shown on the screen.



BCP command

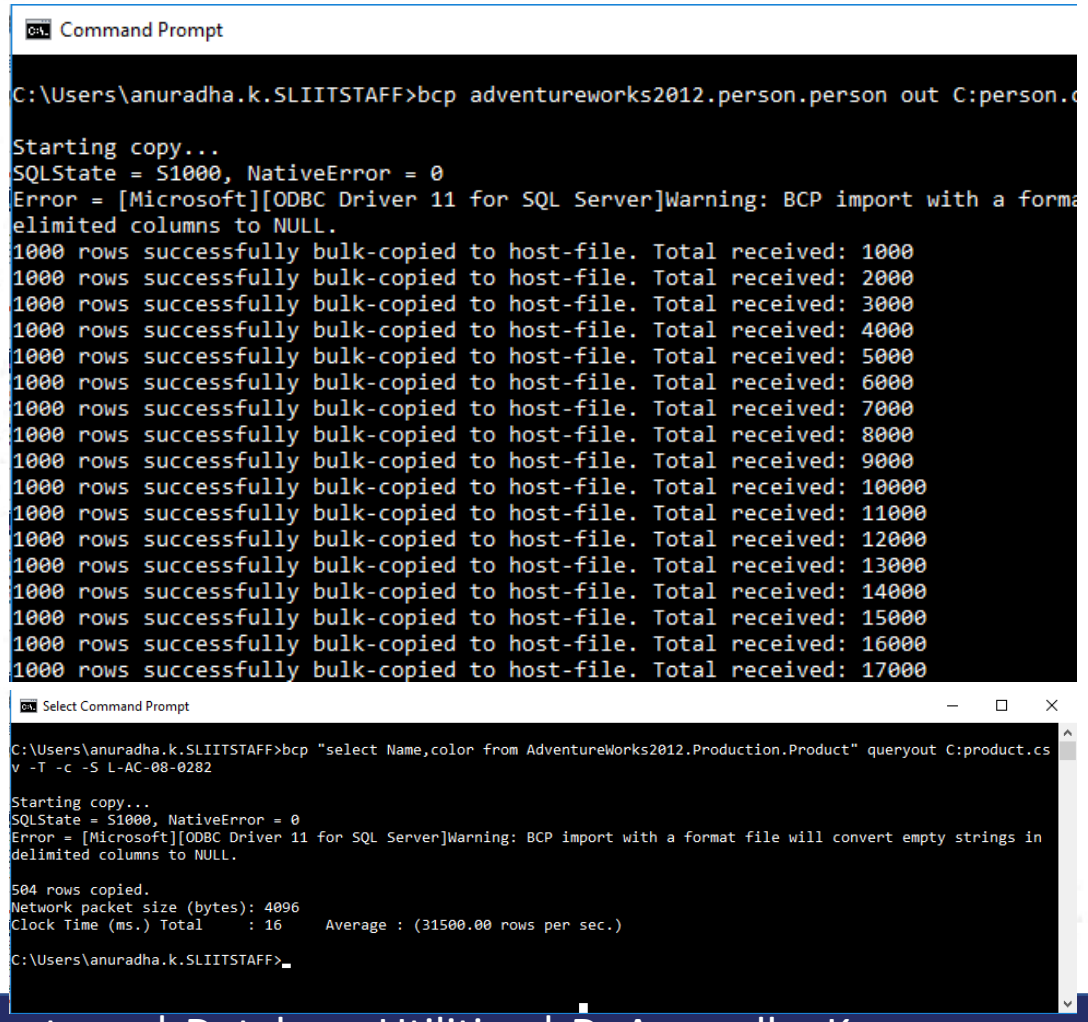
- BCP is a powerful command line utility that enables us to transfer large number of records between a SQL instance and a data file using a special file format.
- This tool is installed by default with SQL Server.
- With BCP the data migrated can be a table or a SQL query result.
- Type BCP command on the command line to obtain the options that could be used with the command.

BCP command (Contd.)

- Format of the BCP command is as follows
  - bcp {table|view|"query"} {out|queryout|in|format} {data_file|nul} {[optional_argument]...}
  - Table|view|query represents the source of the data
  - out|queryout|in|format determines the command's mode (direction)
    - Ex: **out option** exports data from a table or view into a data file.
    - Ex: queriyout option exports data retrieved through a query into a data file.
  - *data_file*|nul is the full path of the data file or, when a data file should not be specified, the **nul** value.

BCP Command – Examples

- Copying data from a table to a file
  - bcp adventureworks2012.person.person out C:person.csv -T -c -S L-AC-08-0282
  - -c argument is used to perform operations using a character type.
  - -T is used to connect using a Trusted connection (Windows Authentication).
  - -S is used to specify the SQL Server name.
- Exporting data from a SQL Server Query to a file.
  - bcp "select Name,color from AdventureWorks2012.Production.Product" queryout C:product.csv -T -c -S L-AC-08-0282



Bulk insert command

- BULK INSERT loads data from a data file into a table.
- This functionality is similar to that provided by the **in** option of the **bcp** command; however, the data file is read by the SQL Server process.
- Example :

```
BULK INSERT emp2 from "D:\emps.csv"
WITH (
FIELDTERMINATOR = ',',
ROWTERMINATOR = '\n'
)
SELECT * FROM emp2
```

SELECT INTO COMMAND

- SELECT INTO statement copies data from one table to another
- Tables can be on the same SQL Server or linked SQL servers or on different types of servers using distributed queries
- SELECT INTO operates just like Bulk Insert except it can’t read from an external file
- SELECT INTO can also create the destination table automatically before copying the data
- Example :
  - select * into emps from emp2

Securing data with backups

- Backing up your SQL Server databases, protects you from potentially catastrophic data loss.
- With valid backups of a database, you can recover your data from many failures, such as:
  - User errors, for example, dropping a table by mistake.
  - Hardware failures, for example, a damaged disk drive or permanent loss of a server.
  - Natural disasters.

Backup and Restore of databases

- The SQL Server backup and restore component provides an essential safeguard for protecting critical data stored in your SQL Server databases.
- To minimize the risk of catastrophic data loss, you need to back up your databases to preserve modifications to your data on a regular basis.
- A well-planned backup and restore strategy helps protect databases against data loss caused by a variety of failures.

Types of backups

- Full Backups : Full database backup takes a copy of the entire database including the part of the transaction log file.
- Differential Backups : Differential database backup includes only extents which were changed since the last full database backup.
- Transaction Log Backups :Transaction log backup captures all the transaction log records that have been written after the last full database backup or last transaction log backup.

Demo

JOBs in SQL server

- A job is a specified series of operations performed sequentially
- Use jobs to define an administrative task that can be run one or more times and monitored for success or failure. A job can run on one local server or on multiple remote servers.
- A job can perform a wide range of activities and can run repetitive or schedulable tasks
- Automatically notify users of job status

Running jobs in sql server

- Jobs can run in several ways:
  - According to one or more schedules.
  - In response to one or more alerts.
  - By executing the sp_start_job stored procedure.
- Jobs can be created by users in several roles including sysadmin user role
- A created job can be edited by only its owners or members of sysadmin role.

Schedules

- A *schedule* specifies when a job runs. More than one job can run on the same schedule, and more than one schedule can apply to the same job. A schedule can define the following conditions for the time when a job runs:
  - Whenever SQL Server Agent starts. (SQL server agent is the component of SQL sever responsible for automation)
  - Whenever CPU utilization of the computer is at a level you have defined as idle.
  - One time, at a specific date and time.
  - On a recurring schedule.

Demo

Maintenance Plans

- A database maintenance plan is a set of specific, proactive tasks that need to be performed regularly on **databases** to ensure their adequate performance and availability.
- Maintenance Plan Wizard and Designer is to cover those critical database maintenance tasks that, as a bare minimum, should be applied to all databases, to ensure *adequate* performance and availability.

Core maintenance plan tasks

- Backup Databases
- Verify the Integrity of Database
- Maintain a Database's Indexes
- Remove Older Data from msdb
- Remove Old Backups

Demo

Thank you!

DATABASE MANAGEMENT SYSTEMS (IT 2040)

LECTURE 08 – DATABASE SECURITY

LEARNING OUTCOMES

- At the end of the lecture, the students should be able to:
  - Explain the three important aspects of security
  - Identify different roles and permissions in SQL server at server and database level
  - Implement a security policy of a given database using access control mechanisms in SQL server

LECTURE CONTENT

- Aspects of database security
- Access control mechanisms
- Roles, Users and Permissions in SQL server

DATABASE SECURITY

- The data stored in a DBMS is often vital to the business interests of the organization and is regarded as a corporate asset.
- In addition to protecting the intrinsic value of the data, corporations must consider ways to ensure privacy and to control access to data that must not be revealed to certain groups of users for various reason.

ASPECTS OF DATABASE SECURITY

- There are three main objectives to consider while designing a secure database application:
  - **Secrecy**: Information should not be disclosed to unauthorized users.
    - For example, a student should not be allowed to examine other students' grades.
  - **Integrity**: Only authorized users should be allowed to modify data.
    - For example, students may be allowed to see their grades, yet not allowed to modify them.
  - **Availability**: Authorized users should not be denied access.
    - For example, an instructor who wishes to change a grade should be allowed to do so.

SECURITY POLICY & ACCESS CONTROLS

- To achieve the objectives in the previous slide, a clear and consistent security policy should be developed
- A security policy specifies who is authorized to do what.
- Most users need to access only a small part of the database to carry out their tasks.
- Allowing users unrestricted access to all the data can be undesirable.
- Two main mechanisms at the DBMS level to control access to data
  - Discretionary access control
  - Mandatory access control

DISCRETIONARY ACCESS CONTROL

- Discretionary access control is based on the concept of access rights, or privileges, and mechanisms for giving users such privileges.
- A privilege allows a user to access some data object in a certain manner (e.g., to read or to modify).
- A user who creates a database object such as a table or a view automatically gets all applicable privileges on that object.
- The DBMS subsequently keeps track of how these privileges are granted to other users and ensures that at all times only users with the necessary privileges can access an object.

SECURITY IN SQL SERVER

- A SQL Server instance contains a hierarchical collection of entities, starting with the server.
- Each server contains multiple databases, and each database contains a collection of securable objects.
- The SQL Server security framework manages access to securable entities through authentication and authorization
  - Authentication : verifying the identities of users trying to connect to a SQL Server instance
  - Authorization : determines which data resources that authorized users can access and what actions they can take.

SECURITY IN SQL SERVER (CONTD.)

- Authentication and authorization are achieved in SQL Server through a combination of security principals, securable, and permissions.
- Together, these three component types provide a structure for authenticating and authorizing SQL Server users.
- You must grant each principal the appropriate permissions it needs on specific securables to enable users to access SQL Server resources.

PRINCIPALS, SECURABLE AND PERMISSIONS

- **Principals :** Individuals, groups, or processes granted access to the SQL Server instance, either at the server level or database level.
  - Server-level principals include logins and server roles.
  - Database-level principals include users and database roles.
- **Securable:** Objects that make up the server and database environment. The objects can be broken into three hierarchical levels:
  - Server-level securables include such objects as databases and availability groups.
  - Database-level securables include such objects as schemas and full-text catalogs.
  - Schema-level securables include such objects as tables, views, functions, and stored procedures.
- **Permissions:** The types of access permitted to principals on specific securables. You can grant or deny permissions to securables at the server, database, or schema level.

STEPS TO PROVIDE USERS WITH ACCESS TO SQL SERVER RESOURCES

1. At the server level, create a login for each user that should be able to log into SQL Server.
   - create Windows authentication logins that are associated with Windows user or group accounts,
   - create SQL Server authentication logins that are specific to that instance of SQL Server.
2. Create user-defined server roles if the fixed server roles do not meet your configuration requirements.
3. Assign logins to the appropriate server roles (either fixed or user-defined).
4. For each applicable server-level securable, grant or deny permissions to the logins and server roles.

STEPS TO PROVIDE USERS WITH ACCESS TO SQL SERVER RESOURCES (CONTD.)

5. At the database level, create a database user for each login.
   - A database user can be associated with only one server login.
6. Create user-defined database roles if the fixed database roles do not meet your configuration requirements.
7. Assign users to the appropriate database roles (either fixed or user-defined).
8. For each applicable database-level or schema-level securable, grant or deny permissions to the database users and roles.

SCENARIO

- A software company is assigned to create a software system for a super market.
- The project manager responsible to develop the system assigns the task of creating the databases related to the projects (inventory database, payroll database) to a senior DBA (Kamal)
- The senior DBA creates the databases and all logins for the users
- The senior dba then assigns a junior DBA (Namali & Janaka) to look after each database.
- The junior DBA designs the database and assigns the task of creating tables to a database developer (Sahan)
- The junior DBA also assigns the task of entering data to some data entry operators (Amali and Mihiran)

CREATING A LOGIN USING WINDOWS AUTHENTICATION

- A login is an individual user account for logging into the SQL Server instance.
- Syntax

```
CREATE LOGIN [domain_name\login_name]
FROM WINDOWS
[ WITH DEFAULT_DATABASE = database_name
| DEFAULT_LANGUAGE = language_name ];
```

- Example

```
CREATE LOGIN [win10b\winuser01] FROM WINDOWS
WITH DEFAULT_DATABASE = master, DEFAULT_LANGUAGE = us_english;
```

CREATING A LOGIN USING SQL SERVER

- Syntax

```
CREATE LOGIN [Login Name] -- This is the User that you use for login
WITH PASSWORD = 'provide_password' MUST_CHANGE,
CHECK_EXPIRATION = ON,  CHECK_POLICY = ON,  DEFAULT_DATABASE = [Database Name],
DEFAULT_LANGUAGE = [Language Name];-- This is Optional
```

- Example

```
CREATE LOGIN sqluser01
WITH PASSWORD = 'tempPW@56789'
MUST_CHANGE, CHECK_EXPIRATION = ON,
DEFAULT_DATABASE = master, DEFAULT_LANGUAGE = us_english;
```

CREATING AND ASSIGNING SERVER ROLES

- With sever roles logins could be grouped together in order to more easily manage server-level permissions.
- SQL Server supports fixed server roles and user-defined server roles.
- With fixed server roles logins could be assigned, but permissions cannot be changed.
- For user-defined roles logins can be assigned and permission can be changed

ADDING LOGINS TO FIXED SEVER ROLES

- Assigning logins to sever roles
  - Syntax : ALTER SERVER ROLE server_role_name ADD MEMBER login
  - Server role names :

Role	Description
Sysadmin	Members of the **sysadmin** fixed server role can perform any activity in the server.
dbcreator	Members of the **dbcreator** fixed server role can create, alter, drop, and restore any database.
securityadmin	Members of the securityadmin fixed server role manage logins and their properties. They can GRANT, DENY, and REVOKE server-level permissions.

  - Ex : ALTER SERVER ROLE diskadmin ADD MEMBER Ted

CREATING USER-DEFINED SERVER ROLES AND PERMISSIONS

- Creating a user defined sever role and assigning permissions
  - Syntax for creating a server role: CREATE SERVER ROLE role_name
    - Ex: CREATE SERVER ROLE devops;
- Syntax for granting permissions : GRANT permission TO grantee_principal [WITH GRANT OPTION]
  - Permission Examples :
    - CREATE ANY DATABASE — Create a database on the server.
    - ALTER ANY DATABASE — Create, alter, or drop any login in the instance.
    - ALTER ANY LOGIN — Modify any login.
    - SHUTDOWN — Shut down the server.
  - Ex: GRANT ALTER ANY DATABASE TO devops;

REVISIT TO SCENARIO

- Senior DBA, Junior DBA, Database Developer and Data entry operator should have logins.
- According to the scenario, Senior dba also should be able to create databases and logins.
- Therefore two methods could be used to create logins
  - All logins could be created by the project manager
  - Project manager could create the login of Senior DBA and Senior DBA could create the other logins. (we will use this approach)

REVISIT TO SCENARIO (CONTD.)

- First create the login for the senior DBA using windows authentication of SQL server authentication as follows:
- Windows authentication

```
CREATE LOGIN PC2\kamal
FROM WINDOWS WITH DEFAULT_DATABASE = Master
```

- SQL server authentication

```
CREATE LOGIN Kamal
WITH PASSWORD = 'kamal@123', DEFAULT_DATABASE = Master
```

REVISIT TO SCENARIO (CONTD.)

- Now let's give permission to the senior DBA to create databases and logins.
- This could be done using pre-defined sever roles or user defined server roles as follows
- Using pre-defined server roles

  alter server role dbcreator add member kamal

  alter server role securityadmin add member kamal
- Using user-defined server role

  create server role seniordba

  grant create any database,alter any login to seniordba

  alter server role seniordba add member kamal

DATABASE USERS

- Logins are created at the server level, while users are created at the database level.
- In other words, a login allows to connect to the SQL Server service and permissions inside the database are granted to the database users, not the logins.
- The logins will be assigned to server roles (for example, *serveradmin*)
- The database users will be assigned to roles within that database
- Syntax : CREATE USER user_name FOR LOGIN login_name
  - user_name : The name of the database user that you wish to create.
  - login_name : The Login used to connect to the SQL Server instance

REVISIT TO SCENARIO

- Senior DBA can now create the databases and create a logins for the junior DBAs who are in-charge of the databases
- Create the login first

  CREATE LOGIN namali

  WITH PASSWORD = 'namali@123', DEFAULT_DATABASE = Inventory
- The senior DBA can also create all the other logins for the other roles here
- Now let's create the user for the login so that the user can be given permission at the database level

  Create user namali for login namali

CREATING DATABASE ROLES

- A database role is a group of users that share a common set of database-level permissions.
- As with server roles, SQL Server supports both fixed and user-defined database roles.
- To set up a user-defined database role, you must create the role, grant permissions to the role, and add members to the role (or add members and then grant permissions).

ASSIGNING USERS TO FIXED DATABASE ROLES

- Some examples of database roles are as follows:

Role	Description
db_owner	Members of the **db_owner** fixed database role can perform all configuration and maintenance activities on the database, and can also drop the database in SQL Server.
db_securityadmin	Members of the **db_securityadmin** fixed database role can modify role membership for custom roles only and manage permissions.
db_accessadmin	Members of the **db_accessadmin** fixed database role can add or remove access to the database
db_ddladmin	Members of the **db_ddladmin** fixed database role can run any Data Definition Language (DDL) command in a database.

- Syntax for windows authentication :ALTER ROLE db_datawriter ADD MEMBER <domain\username>
- Syntax for SQL authentication :ALTER ROLE db_datawriter ADD MEMBER <username>;

REVISIT TO SCENARIO

- The junior DBAs are expected to manage the databases.
- Therefore they could be assigned with the db_owner role by the senior DBA as follows :

```
use inventoryDB

alter role db_owner add member namali

alter role db_securityadmin add member namali

alter role db_accessadmin add member namali
```

ASSIGNING USERS TO USER DEFINED DATABASE ROLES

- Creating a user defined role
  - Syntax : CREATE ROLE <role_name>
  - Example : CREATE ROLE student
- Assigning login to the role
  - Syntax : ALTER ROLE <role_name> ADD MEMBER <username>
  - Example : ALTER ROLE student ADD MEMBER Brady

PERMISSIONS

- Every SQL Server securable has associated permissions that can be granted to user.
- At the database level they are assigned to database users and database roles.
- Some permissions are as follows :

Role	Description
ALTER	Grants or denies the ability to alter the existing database.
CREATE TABLE	Grants or denies the ability to create a table.
INSERT	Grants or denies the ability to issue the INSERT command against all applicable objects within the database.
EXECUTE	Grants or denies the ability to issue the EXECUTE command against all applicable objects within the database.
REFERENCES	The REFERENCES permission on a table is needed to create a FOREIGN KEY constraint

CREATING AND REMOVING PERMISSIONS

- Creating and removing permissions could be done using GRANT, DENY and REVOKE
  - **GRANT** – Grants permissions on a securable to a principal.
  - **DENY** – Denies a permission to a principal.
  - **REVOKE** – Removes a previously granted or denied permission.

GRANTING PERMISSIONS

- Granting permissions to a role/user
  - Ex: GRANT SELECT TO GrantSelectRole
  - Ex: GRANT SELECT, INSERT, UPDATE, DELETE, REFERENCES, EXECUTE ON Northwind TO sqluser01;
- Denying permissions to a role/user
  - Ex: DENY SELECT TO DenyTest
- Revoking permissions assigned to a user
  - Ex: REVOKE SELECT TO GrantSelectRole;

REVISIT TO SCENARIO

- The database developers need to create tables which would probably have foreign keys
- Lets create a role names database developer for this

```
create role databaseDev

grant create table,  alter, references on inventoryDB to databaseDev

alter role databaseDev add member Sahan
```

- Similarly create another role with select and insert for the data Entry operators

VIEWS AND SECURITY

- Views can be used to present necessary information (or a summary), while hiding details in underlying relation(s).
- Creator of view has a privilege on the view if (s)he has the privilege on all underlying tables.
- Together with GRANT/REVOKE commands, views are a very powerful access control tool

Thank you!