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Analisis dan Perancangan Sistem

Data Modeling and Analysis using ERD

Fakultas Ekonomi & Bisnis
School of Economics & Business
Telkom University

Learning Objectives

REMINDING Concept of Data Modelling & ERD Symbols

- **Entities** : What? Types?
- **Attributes** : Domain? Data types? Identification?
- **Relationships** : Cardinality? Degree? Foreign key? Generalization?

UNDERSTANDING Constructing and Analyzing Data Models

- Entity discovery
- The context data model
- The key-based data model
- Generalized hierarchies
- Fully attributed data model
- Analyzing data model : good or not?

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Source: System Analysis & Design, Whitten & Bentley 6th ed

ERD Exercise (1) – ArtBase Galleries

- ArtBase, that builds a product for art galleries. The core of this product is a database with a schema that captures all the information that galleries need to maintain.
- Galleries keep information about artists, their names (which are unique), birthplaces, ages, and style of art. For each piece of artwork, the artist, the year it was made, its unique title, its type of art (e.g., painting, lithograph, sculpture, photograph), and its price must be stored. Pieces of artwork are also classified into groups of various kinds, for example, portraits, still life, works by Picasso, or works of the 19th century; a given piece may belong to more than one group.
- Each group is identified by a name (like those just given) that describes the group. Finally, galleries keep information about customers. For each customer, galleries keep that person's unique name, address, total amount of dollars spent in the gallery (very important!), and the artists and groups of art that the customer tends to like.
- Draw the ER diagram for the database.

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Data Modeling

Data modeling – a technique for organizing and documenting a system's data. Sometimes called *database modeling*.

Entity relationship diagram (ERD) – a data model utilizing several notations to depict data in terms of the entities and relationships described by that data.

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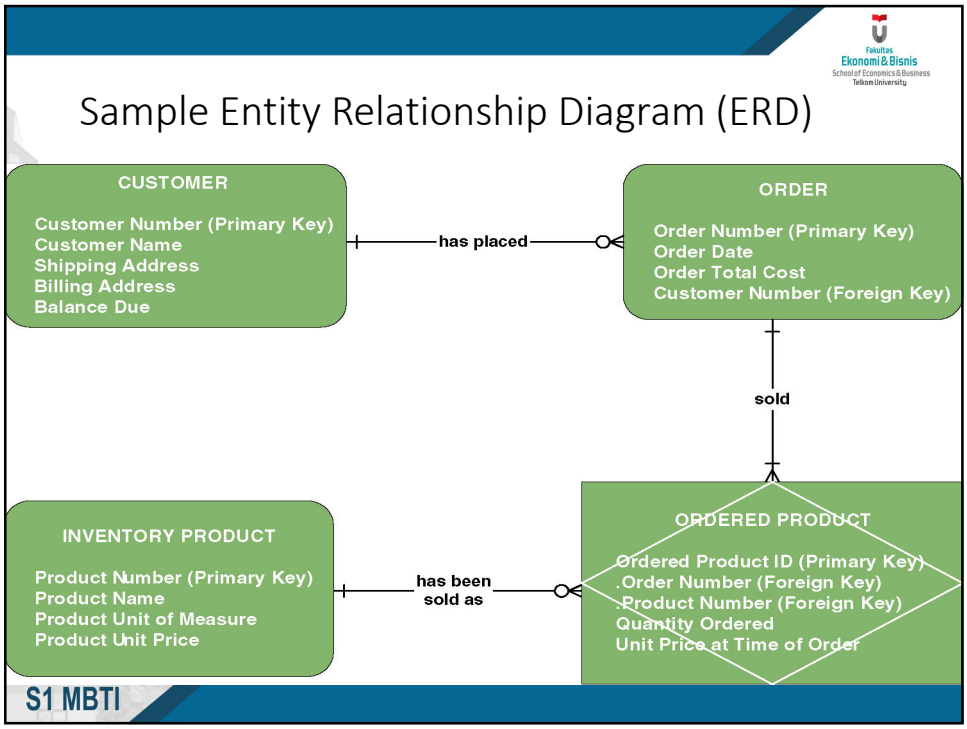
Sample Entity Relationship Diagram (ERD)
CUSTOMER
Customer Number (Primary Key)
Customer Name
Shipping Address
Billing Address
Balance Due
has placed
ORDER
Order Number (Primary Key)
Order Date
Order Total Cost
Customer Number (Foreign Key)
sold
INVENTORY PRODUCT
Product Number (Primary Key)
Product Name
Product Unit of Measure
Product Unit Price
has been sold as
ORDERED PRODUCT
Ordered Product ID (Primary Key)
.Order Number (Foreign Key)
.Product Number (Foreign Key)
Quantity Ordered
Unit Price at Time of Order
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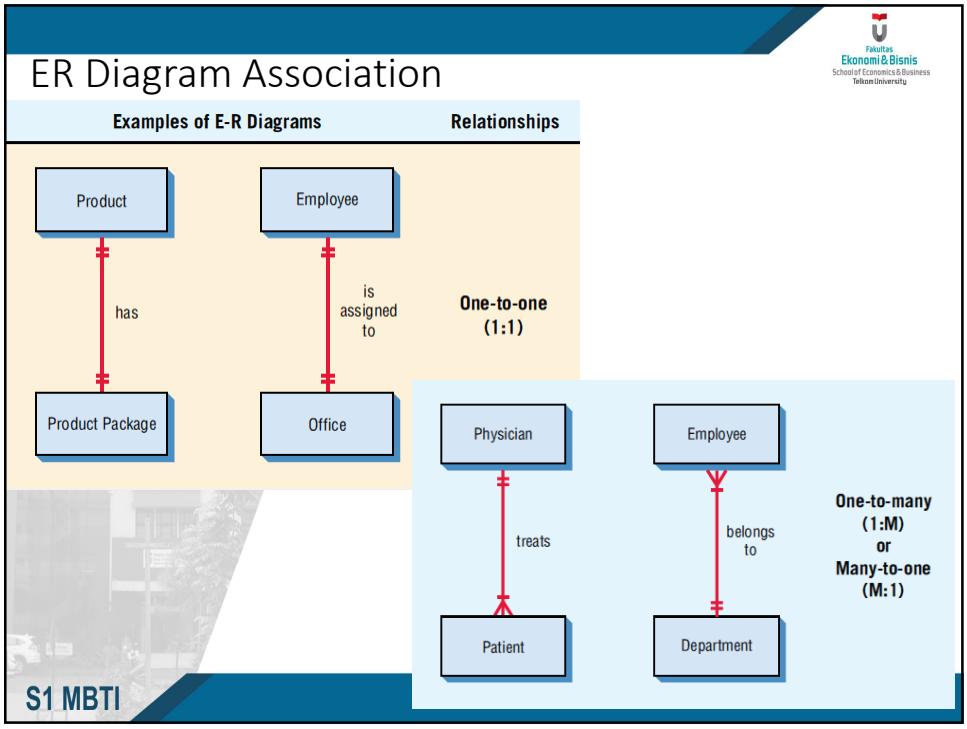
ER Diagram Association
Examples of E-R Diagrams
Relationships
Product
has
Product Package
Employee
is assigned to
Office
One-to-one (1:1)
Physician
treats
Patient
Employee
belongs to
Department
One-to-many (1:M) or Many-to-one (M:1)
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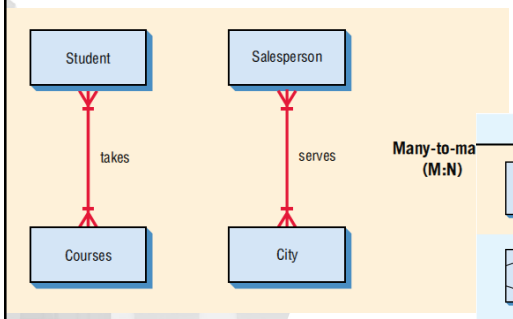
ER Diagram Association



Symbol	Official Explanation	What It Really Means
	Entity	A class of persons, places, or things
	Associative entity	Used to join two entities
	Attributive entity	Used for repeating groups
	To 1 relationship	Exactly one
	To many relationship	One or more
	To 0 or 1 relationship	Only zero or one
	To 0 or more relationship	Can be zero, one, or more
	To more than 1 relationship	Greater than one

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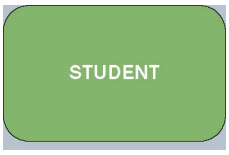
Data Modeling Concepts: Entity

Entity – a class of persons, places, objects, events, or concepts about which we need to capture and store data.

- Named by a singular noun
  - Persons: agency, contractor, customer, department, division, employee, instructor, student, supplier.
  - Places: sales region, building, room, branch office, campus.
  - Objects: book, machine, part, product, raw material, software license, software package, tool, vehicle model, vehicle.
  - Events: application, award, cancellation, class, flight, invoice, order, registration, renewal, requisition, reservation, sale, trip.
  - Concepts: account, block of time, bond, course, fund, qualification, stock.



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Data Modeling Concepts: Entity

Entity instance – a single occurrence of an entity.

entity

instance

Student ID	Last Name	First Name
2144	Arnold	Betty
3122	Taylor	John
3843	Simmons	Lisa
9844	Macy	Bill
2837	Leath	Heather
2293	Wrench	Tim

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Data Modeling Concepts: Attributes

Attribute – a descriptive property or characteristic of an entity. Synonyms include *element*, *property*, and *field*.

- Just as a physical student can have attributes, such as hair color, height, etc., a data entity has data attributes

Compound attribute – an attribute that consists of other attributes. Synonyms in different data modeling languages are numerous: concatenated attribute, composite attribute, and data structure.

STUDENT

Name
.Last Name
.First Name
.Middle Initial
Address
.Street Address
.City
.State or Province
.Country
.Postal Code
Phone Number
.Area Code
.Exchange Number
.Number Within Exchange
Date of Birth
Gender
Race
Major
Grade Point Average

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Data Modeling Concepts: Data Type

Data type – a property of an attribute that identifies what type of data can be stored in that attribute.

Representative Logical Data Types for Attributes	
Logical Data Type	**Logical Business Meaning**
NUMBER	Any number, real or integer.
TEXT	A string of characters, inclusive of numbers. When numbers are included in a TEXT attribute, it means that we do not expect to perform arithmetic or comparisons with those numbers.
MEMO	Same as TEXT but of an indeterminate size. Some business systems require the ability to attach potentially lengthy notes to a give database record.
DATE	Any date in any format.
TIME	Any time in any format.
YES/NO	An attribute that can assume only one of these two values.
VALUE SET	A finite set of values. In most cases, a coding scheme would be established (e.g., FR=Freshman, SO=Sophomore, JR=Junior, SR=Senior).
IMAGE	Any picture or image.

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Data Modeling Concepts: Domains

Domain – a property of an attribute that defines what values an attribute can legitimately take on.

Representative Logical Domains for Logical Data Types		
Data Type	**Domain**	**Examples**
NUMBER	For integers, specify the range. For real numbers, specify the range and precision.	{10-99} {1.000-799.999}
TEXT	Maximum size of attribute. Actual values are usually infinite; however, users may specify certain narrative restrictions.	Text(30)
DATE	Variation on the MMDDYYYY format.	MMDDYYYY MMYYYY
TIME	For AM/PM times: HHMMT For military (24-hour times): HHMM	HHMMT HHMM
YES/NO	{YES, NO}	{YES, NO} {ON, OFF}
VALUE SET	{value#1, value#2,…value#n} {table of codes and meanings}	{M=Male F=Female}

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Data Modeling Concepts: Default Value

Default value – the value that will be recorded if a value is not specified by the user.

Permissible Default Values for Attributes		
Default Value	**Interpretation**	**Examples**
A legal value from the domain	For an instance of the attribute, if the user does not specify a value, then use this value.	0 1.00
NONE or NULL	For an instance of the attribute, if the user does not specify a value, then leave it blank.	NONE NULL
Required or NOT NULL	For an instance of the attribute, require that the user enter a legal value from the domain. (This is used when no value in the domain is common enough to be a default but some value must be entered.)	REQUIRED NOT NULL

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Data Modeling Concepts: Identification

Key – an attribute, or a group of attributes, that assumes a unique value for each entity instance. It is sometimes called an *identifier*.

Concatenated key - a group of attributes that uniquely identifies an instance of an entity. Synonyms include *composite key* and *compound key*.

Candidate key – one of a number of keys that may serve as the primary key of an entity. Also called a *candidate identifier*.

Primary key – a candidate key that will most commonly be used to uniquely identify a single entity instance.

Alternate key – a candidate key that is not selected to become the primary key is called an alternate key. A synonym is secondary key.

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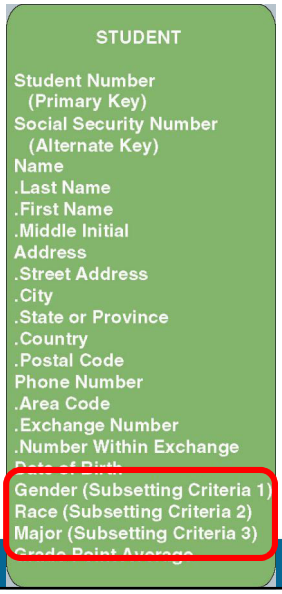
Data Modeling Concepts: Subsetting Criteria

Subsetting criteria – an attribute(s) whose finite values divide all entity instances into useful subsets. Sometimes called inversion entry.



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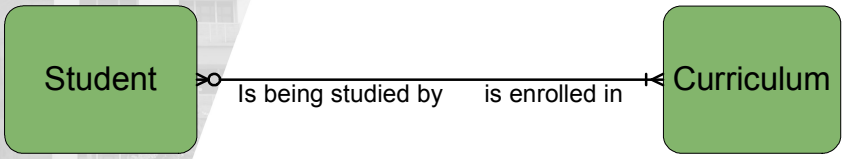
Data Modeling Concepts: Relationships

Relationship – a natural business association that exists between one or more entities.

The relationship may represent an event that links the entities or merely a logical affinity that exists between the entities.



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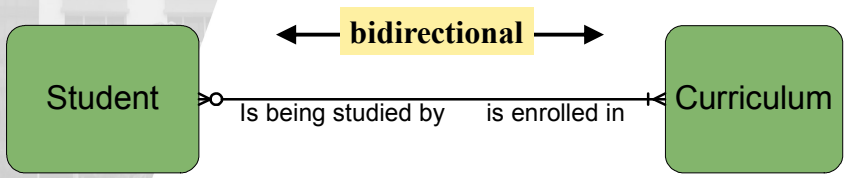
Data Modeling Concepts: Cardinality

Cardinality – the minimum and maximum number of occurrences of one entity that may be related to a single occurrence of the other entity.

Because all relationships are bidirectional, cardinality must be defined in both directions for every relationship.



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Cardinality Notations

Cardinality Interpretation	Minimum Instances	Maximum Instances	Graphic Notation
Exactly one (one and only one)	1	1	– or –
Zero or one	0	1	
One or more	1	many (>1)	
Zero, one, or more	0	many (>1)	
More than one	>1	>1	

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Data Modeling Concepts: Degree

Degree – the number of entities that participate in the relationship.

- A relationship between two entities is called a *binary relationship*.
- A relationship between different instances of the same entity is called a *recursive relationship*.
- A relationship between three entities is called a *3-ary* or *ternary relationship*.

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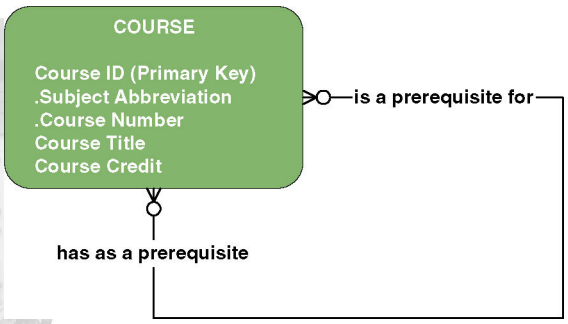
Data Modeling Concepts: Recursive Relationship



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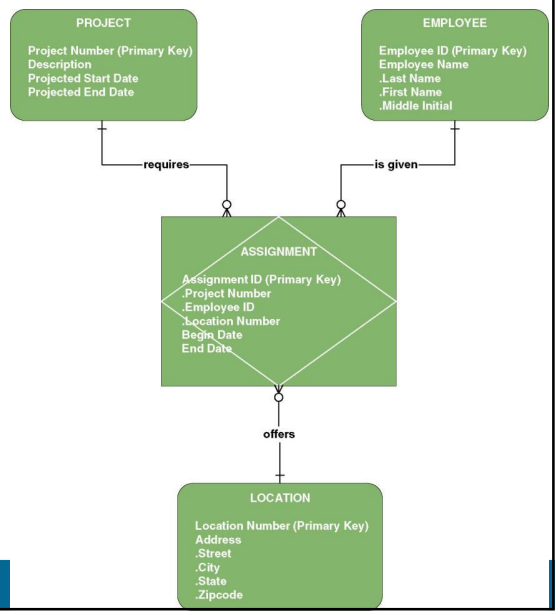
Data Modeling Concepts: Degree

Relationships may exist between more than two entities and are called *N-ary* relationships.

The example ERD depicts a *ternary relationship*.



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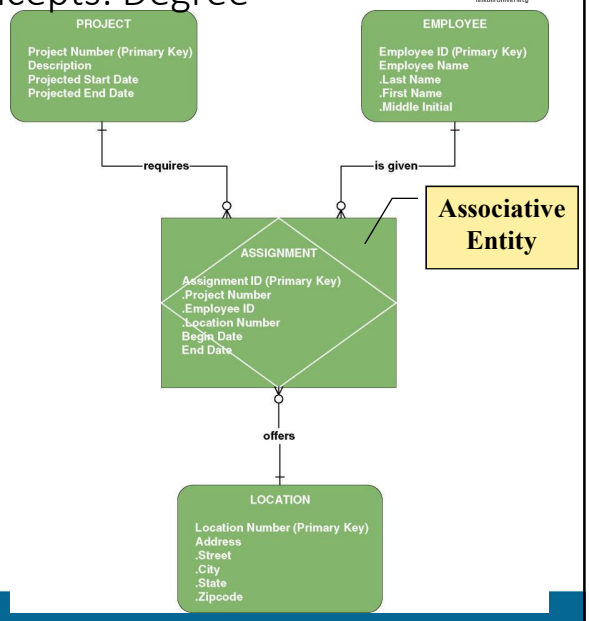
Data Modeling Concepts: Degree

Associative entity – an entity that inherits its primary key from more than one other entity (called parents).

Each part of that concatenated key points to one and only one instance of each of the connecting entities.



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Data Modeling Concepts: Foreign Keys

Foreign key – a primary key of an entity that is used in another entity to identify instances of a relationship.

- A foreign key is a primary key of one entity that is contributed to (duplicated in) another entity to identify instances of a relationship.
- A foreign key always matches the primary key in the another entity
- A foreign key may or may not be unique (generally not)
- The entity with the foreign key is called the child.
- The entity with the matching primary key is called the parent.

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Data Modeling Concepts: Foreign Keys

Primary Key

Student ID	Last Name	First Name	Dorm
2144	Arnold	Betty	Smith
3122	Taylor	John	Jones
3843	Simmons	Lisa	Smith
9844	Macy	Bill	
2837	Leath	Heather	Smith
2293	Wrench	Tim	Jones

Primary Key

Dorm	Residence Director
Smith	Andrea Fernandez
Jones	Daniel Abidjan

Foreign Key Duplicated from primary key of Major entity (not unique)

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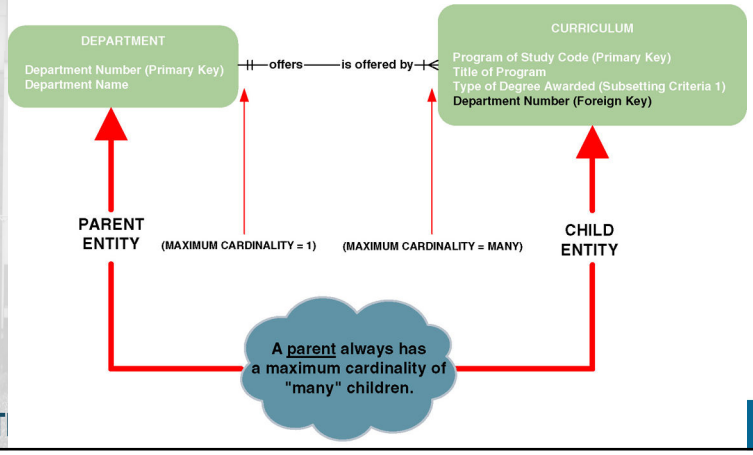
Data Modeling Concepts: Nonidentifying Relationships

Nonidentifying relationship – a relationship in which each participating entity has its own independent primary key

- Primary key attributes are not shared.
- The entities are called *strong* entities



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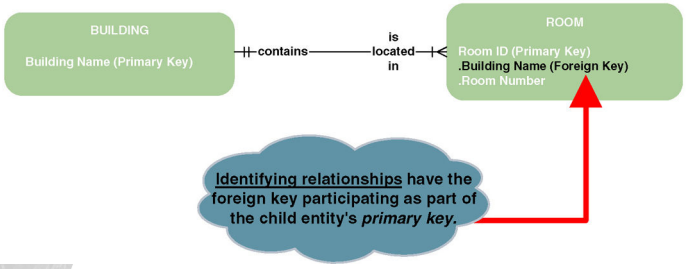
Data Modeling Concepts: Identifying Relationships

Identifying relationship – a relationship in which the parent entity' key is also part of the primary key of the child entity.

- The child entity is called a *weak* entity.



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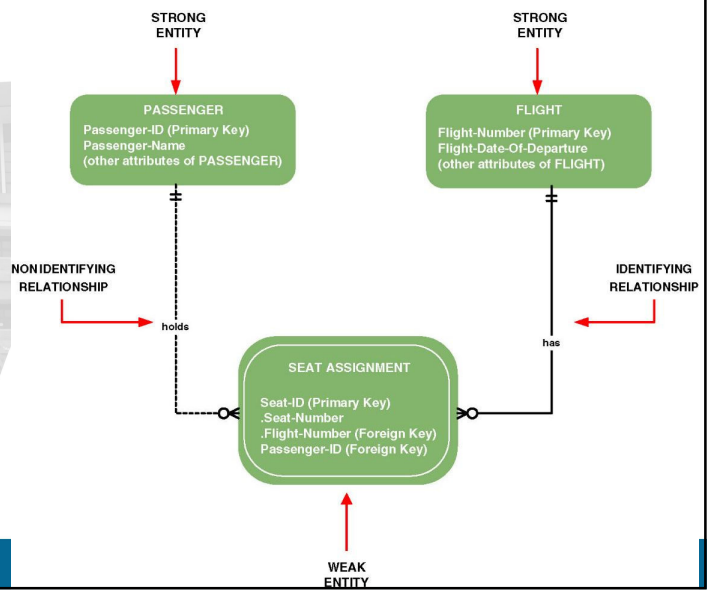
Data Modeling Concepts: Sample CASE Tool Notations



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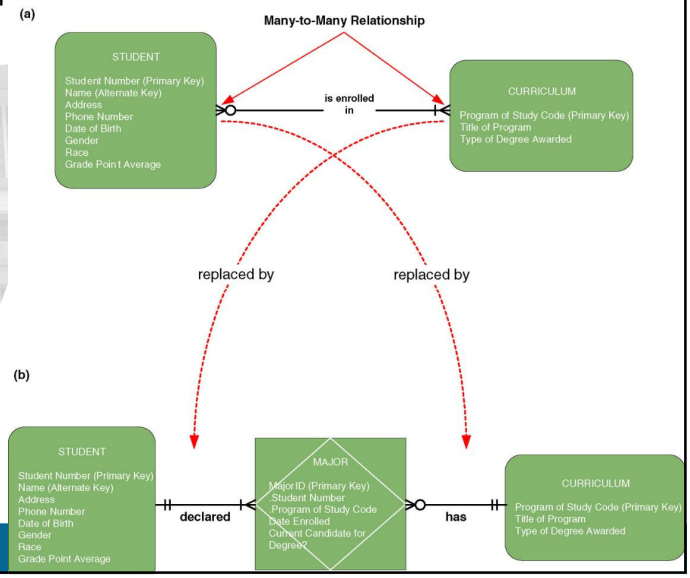
Data Modeling Concepts: Nonspecific Relationships

Nonspecific relationship – a relationship where many instances of an entity are associated with many instances of another entity. Also called *many-to-many relationship*.

Nonspecific relationships must be resolved. Most nonspecific relationships can be resolved by introducing an associative entity.



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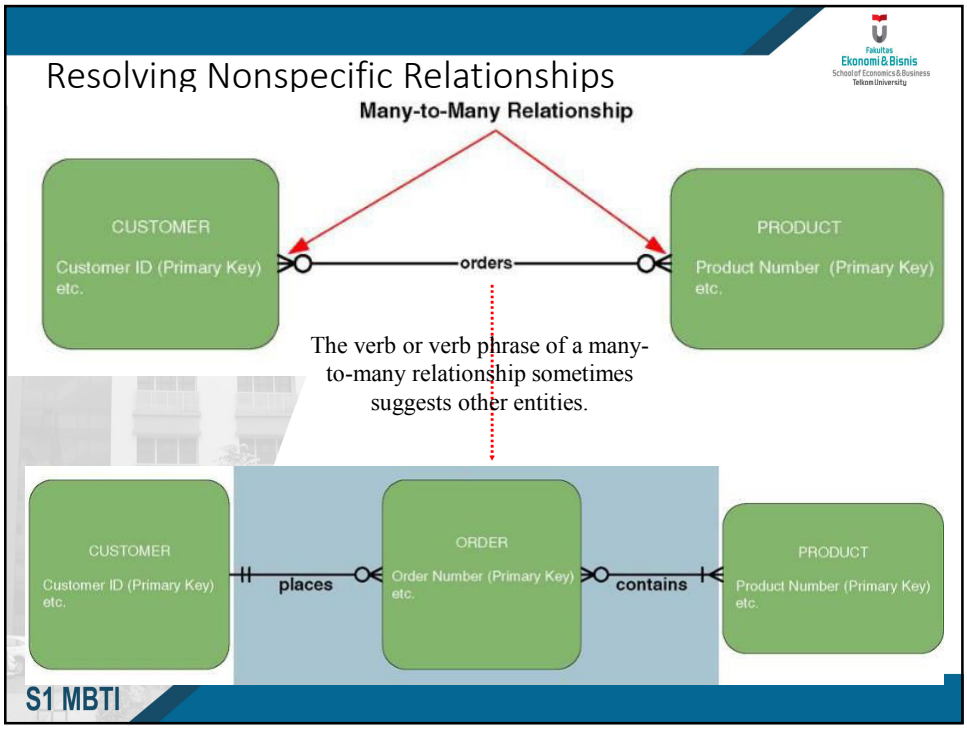
Resolving Nonspecific Relationships
Many-to-Many Relationship
CUSTOMER
Customer ID (Primary Key)
etc.
orders
PRODUCT
Product Number (Primary Key)
etc.
The verb or verb phrase of a many-to-many relationship sometimes suggests other entities.
CUSTOMER
Customer ID (Primary Key)
etc.
places
ORDER
Order Number (Primary Key)
etc.
contains
PRODUCT
Product Number (Primary Key)
etc.
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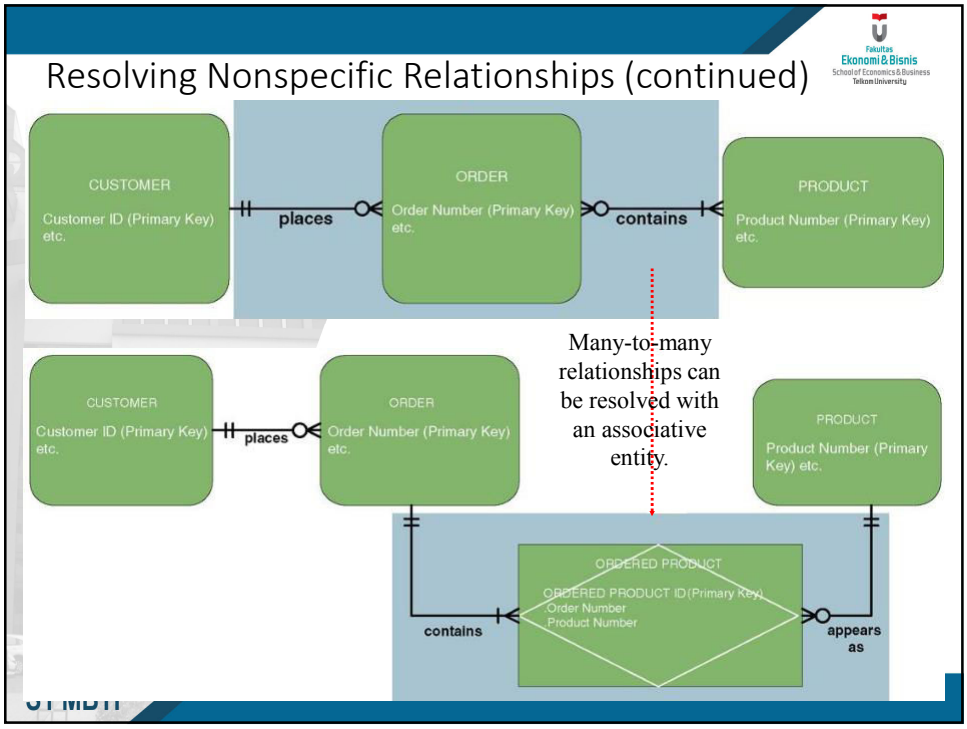
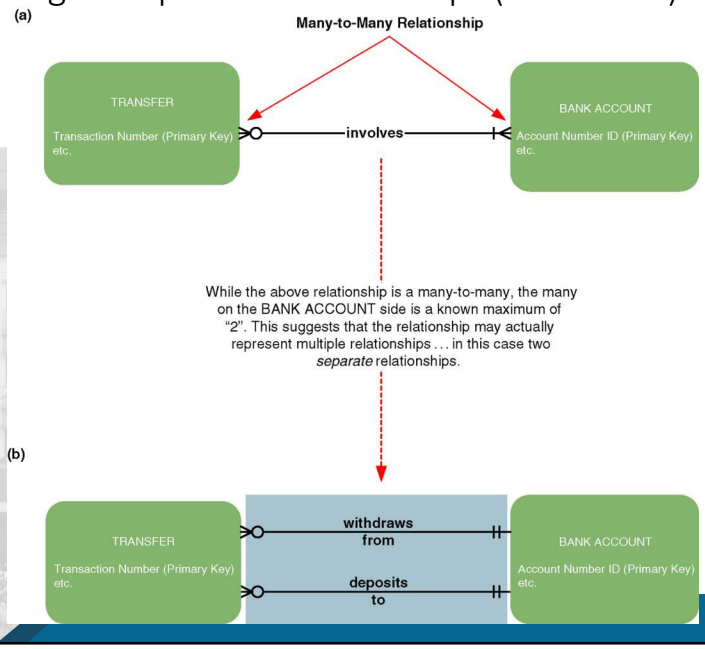

Resolving Nonspecific Relationships (continued)
CUSTOMER
Customer ID (Primary Key)
etc.
places
ORDER
Order Number (Primary Key)
etc.
contains
PRODUCT
Product Number (Primary Key)
etc.
Many-to-many relationships can be resolved with an associative entity.
CUSTOMER
Customer ID (Primary Key)
etc.
places
ORDER
Order Number (Primary Key)
etc.
PRODUCT
Product Number (Primary Key) etc.
ORDERED PRODUCT
ORDERED PRODUCT ID (Primary Key)
Order Number
Product Number
contains
appears as

Resolving Nonspecific Relationships (continued)



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Data Modeling Concepts: Generalization

Generalization – a concept wherein the attributes that are common to several types of an entity are grouped into their own entity.

Supertype – an entity whose instances store attributes that are common to one or more entity subtypes.

Subtype – an entity whose instances may inherit common attributes from its entity supertype

And then add other attributes that are unique to the subtype.

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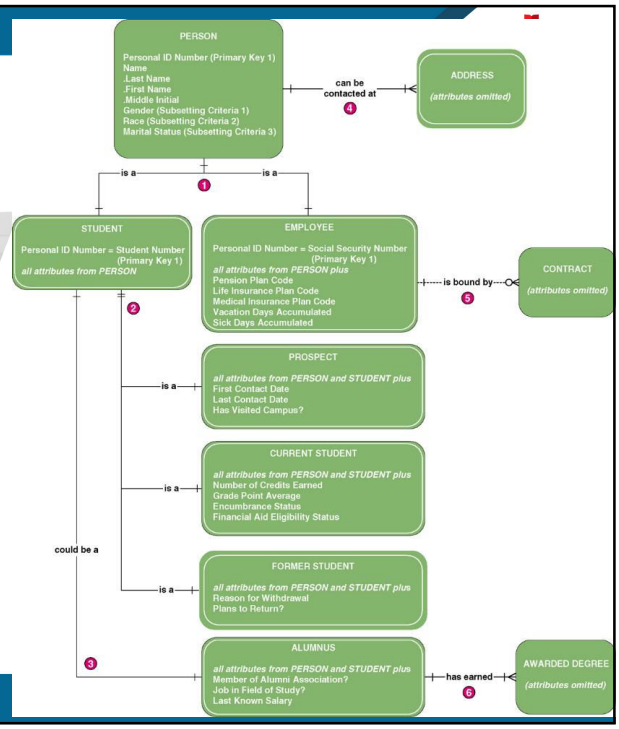
Generalization Hierarchy



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The Process of Logical Data Modeling

- Strategic Data Modeling
  - Many organizations select IS development projects based on strategic plans.
    - Includes vision and architecture for information systems
    - Identifies and prioritizes develop projects
    - Includes enterprise data model as starting point for projects
- Data Modeling during Systems Analysis
  - Data model for a single information system is called an application data model.
  - Context data model includes only entities and relationships.
- **Looking Ahead to Systems Design**
  - The logical data model will be transformed into a physical data model (called a database schema) for the chosen DBMS

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Logical Model Development Stages

1. Context Data model
   - To establish project scope
2. Key-base data model
   - Eliminate nonspecific relationships
   - Add associative entities
   - Include primary and alternate keys
   - Precise cardinalities
3. Fully attributed data model
   - All remaining attributes
   - Subsetting criteria
4. Normalized data model

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Entity Discovery – Interview or JAD

Purpose	Candidate Questions (see Table 8-4 in text for a more complete list)
Discover system entities	What are the subjects of the business?
Discover entity keys	What unique characteristic (or characteristics) distinguishes an instance of each subject from other instances of the same subject?
Discover entity subsetting criteria	Are there any characteristics of a subject that divide all instances of the subject into useful subsets?
Discover attributes and domains	What characteristics describe each subject?
Discover security and control needs	Are there any restrictions on who can see or use the data?
Discover data timing needs	How often does the data change?
Discover generalization hierarchies	Are all instances of each subject the same?
Discover relationships?	What events occur that imply associations between subjects?
Discover cardinalities	Is each business activity or event handled the same way, or are there special circumstances?

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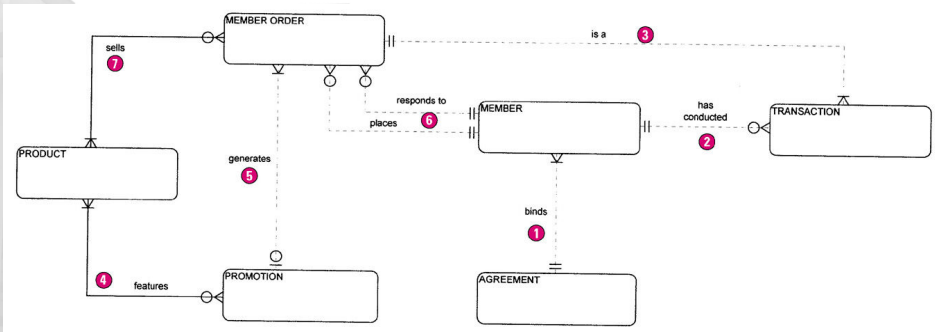
Entity Discovery for SoundStage

Entity Name	Business Definition
Agreement	A contract whereby a member agrees to purchase a certain number of products within a certain time. After fulfilling that agreement, the member becomes eligible for bonus credits that are redeemable for free or discounted products.
Member	An active member of one or more clubs. Note: A target system objective is to re-enroll inactive members as opposed to deleting them.
Member order	An order generated for a member as part of a monthly promotion, or an order initiated by a member. Note: The current system only supports orders generated from promotions; however, customer initiated orders have been given a high priority as an added option in the proposed system.
Transaction	A business event to which the Member Services System must respond.
Product	An inventoried product available for promotion and sale to members. Note: System improvement objectives include (1) compatibility with new bar code system being developed for the warehouse, and (2) adaptability to a rapidly changing mix of products.
Promotion	A monthly or quarterly event whereby special product offerings are made available to members.

The Context Data Model



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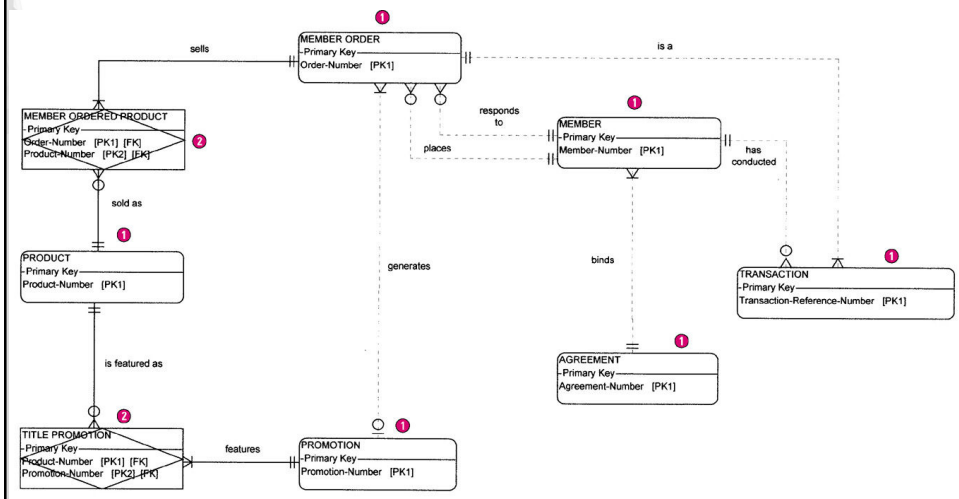
The Key-based Data Model



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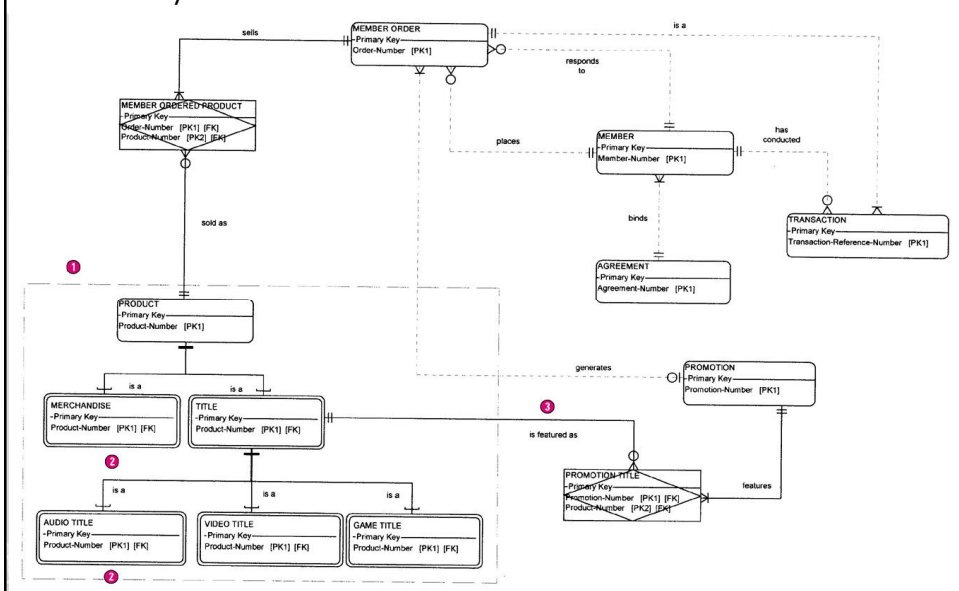
The Key-based Data Model With Generalization



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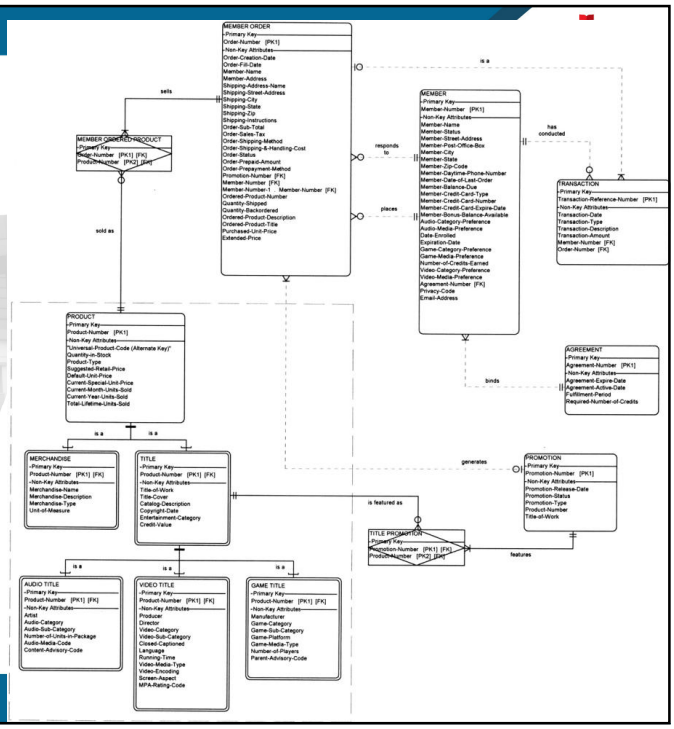
The Fully-Attributed Data Model



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What is a Good Data Model?

- A good data model is simple.
  - Data attributes that describe any given entity should describe only that entity.
  - Each attribute of an entity instance can have only one value.
- A good data model is essentially nonredundant.
  - Each data attribute, other than foreign keys, describes at most one entity.
  - Look for the same attribute recorded more than once under different names.
- A good data model should be flexible and adaptable to future needs.

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Data Analysis & Normalization

Data analysis – a technique used to improve a data model for implementation as a database.

Goal is a simple, nonredundant, flexible, and adaptable database.

Normalization – a data analysis technique that organizes data into groups to form nonredundant, stable, flexible, and adaptive entities.

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Normalization: 1NF, 2NF, 3NF

First normal form (1NF) – an entity whose attributes have no more than one value for a single instance of that entity

- Any attributes that can have multiple values actually describe a separate entity, possibly an entity and relationship.

Second normal form (2NF) – an entity whose nonprimary-key attributes are dependent on the full primary key.

- Any nonkey attributes that are dependent on only part of the primary key should be moved to any entity where that partial key is actually the full key. This may require creating a new entity and relationship on the model.

Third normal form (3NF) – an entity whose nonprimary-key attributes are not dependent on any other non-primary key attributes.

- Any nonkey attributes that are dependent on other nonkey attributes must be moved or deleted. Again, new entities and relationships may have to be added to the data model.

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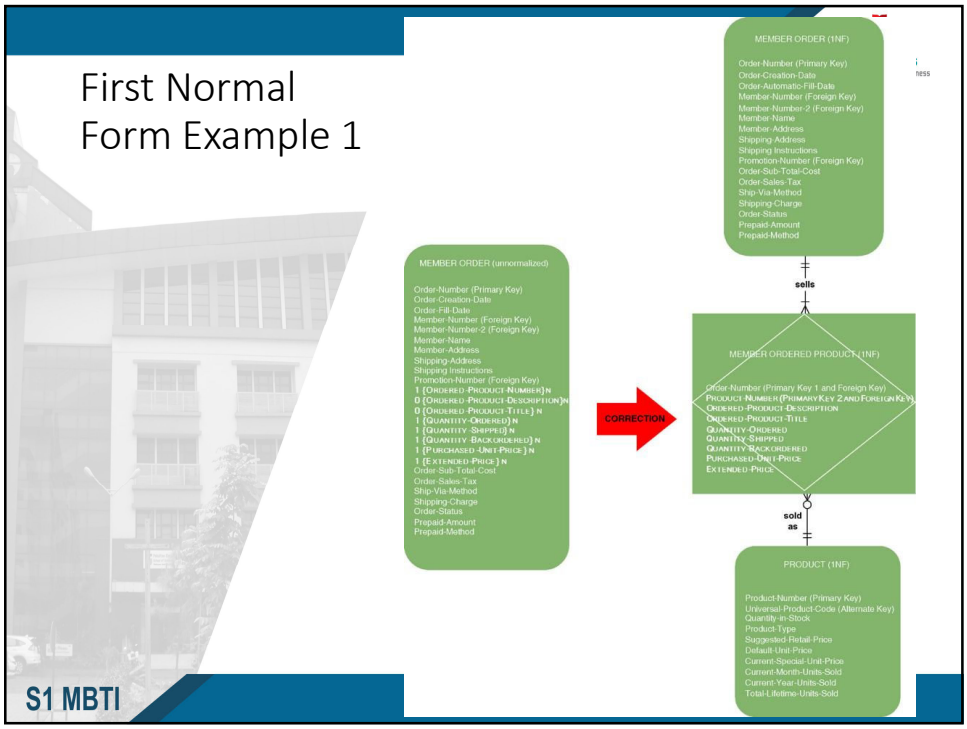
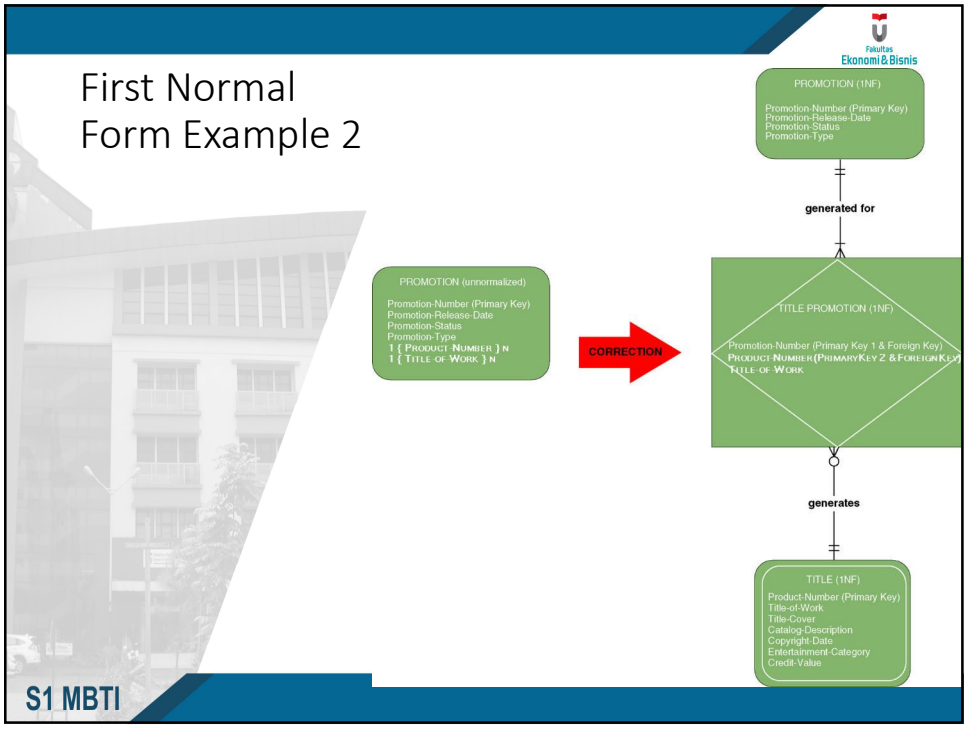
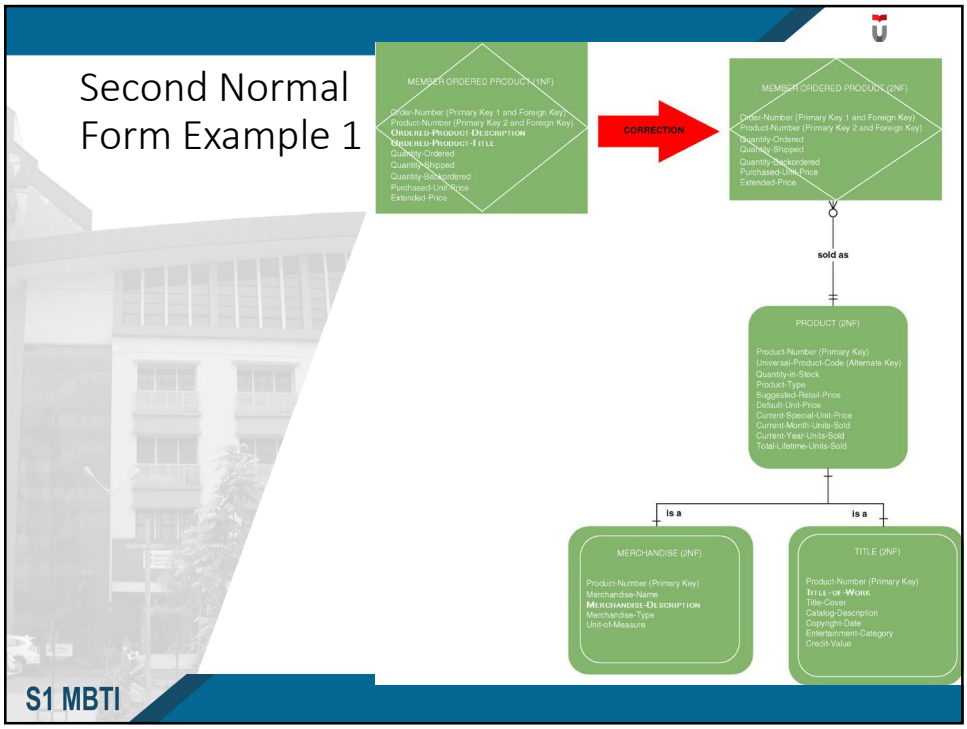
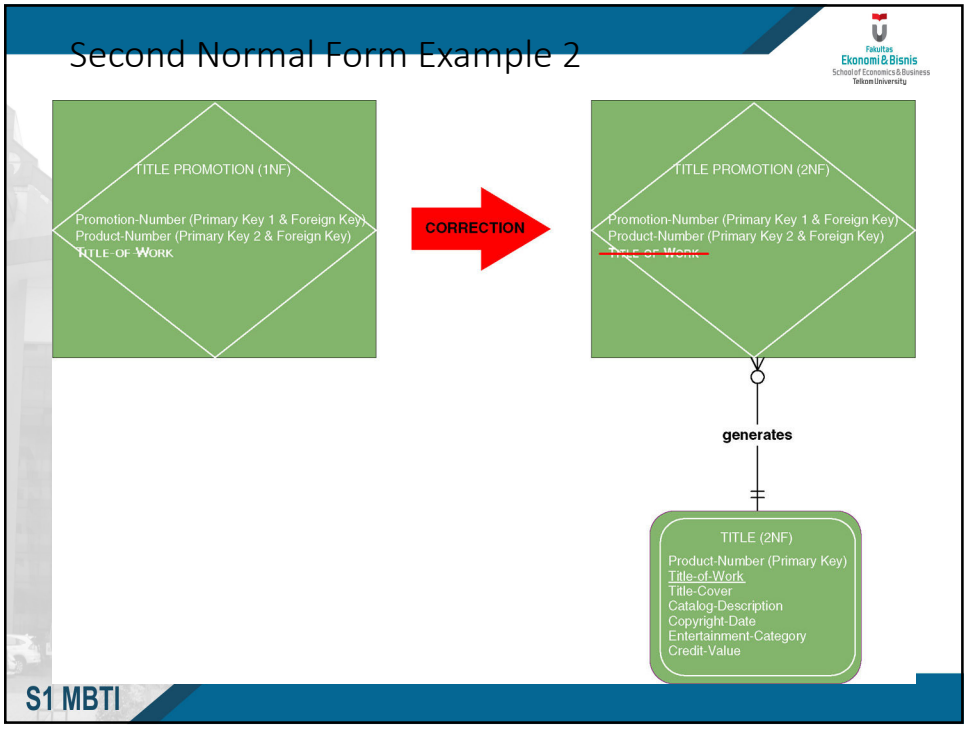

First Normal Form Example 1
MEMBER ORDER (1NF)
Order-Number (Primary Key)
Order-Creation-Date
Order-Automatic-Fill-Date
Member-Number (Foreign Key)
Member-Number-2 (Foreign Key)
Member-Name
Member-Address
Shipping-Address
Shipping-Instructions
Promotion-Number (Foreign Key)
Order-Sub-Total-Cost
Order-Sales-Tax
Ship-Via-Method
Shipping-Charge
Order-Status
Prepaid-Amount
Prepaid-Method
sells
MEMBER ORDER (unnormalized)
Order-Number (Primary Key)
Order-Creation-Date
Order-Fill-Date
Member-Number (Foreign Key)
Member-Number-2 (Foreign Key)
Member-Name
Member-Address
Shipping-Address
Shipping-Instructions
Promotion-Number (Foreign Key)
1 {Ordered-Product-Number} N
0 {Ordered-Product-Description} N
0 {Ordered-Product-Title} N
1 {Quantity-Ordered} N
1 {Quantity-Shipped} N
1 {Quantity-Backordered} N
1 {Purchased-Unit-Price} N
1 {Extended-Price} N
Order-Sub-Total-Cost
Order-Sales-Tax
Ship-Via-Method
Shipping-Charge
Order-Status
Prepaid-Amount
Prepaid-Method
CORRECTION
MEMBER ORDERED PRODUCT (1NF)
Order-Number (Primary Key 1 and Foreign Key)
Product-Number (Primary Key 2 and Foreign Key)
Ordered-Product-Description
Ordered-Product-Title
Quantity-Ordered
Quantity-Shipped
Quantity-Backordered
Purchased-Unit-Price
Extended-Price
sold as
PRODUCT (1NF)
Product-Number (Primary Key)
Universal-Product-Code (Alternate Key)
Quantity-in-Stock
Product-Type
Suggested-Retail-Price
Default-Unit-Price
Current-Special-Unit-Price
Current-Month-Units-Sold
Current-Year-Units-Sold
Total-Lifetime-Units-Sold
S1 MBTI

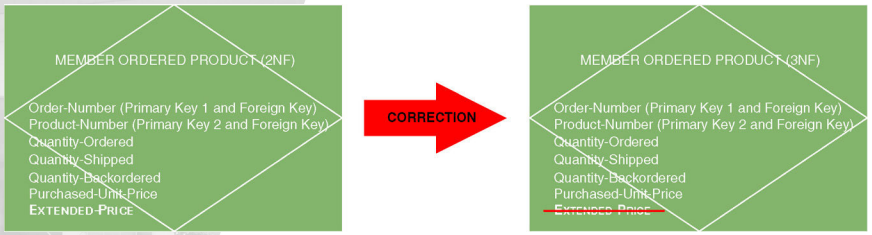

First Normal Form Example 2
Fakultas Ekonomi & Bisnis
PROMOTION (1NF)
Promotion-Number (Primary Key)
Promotion-Release-Date
Promotion-Status
Promotion-Type
generated for
PROMOTION (unnormalized)
Promotion-Number (Primary Key)
Promotion-Release-Date
Promotion-Status
Promotion-Type
1 { Product-Number } N
1 { Title-of-Work } N
CORRECTION
TITLE PROMOTION (1NF)
Promotion-Number (Primary Key 1 & Foreign Key)
Product-Number (Primary Key 2 & Foreign Key)
Title-of-Work
generates
TITLE (1NF)
Product-Number (Primary Key)
Title-of-Work
Title-Cover
Catalog-Description
Copyright-Date
Entertainment-Category
Credit-Value
S1 MBTI


Second Normal Form Example 1
MEMBER ORDERED PRODUCT (1NF)
Order-Number (Primary Key 1 and Foreign Key)
Product-Number (Primary Key 2 and Foreign Key)
Ordered-Product-Description
Ordered-Product-Title
Quantity-Ordered
Quantity-Shipped
Quantity-Backordered
Purchased-Unit-Price
Extended-Price
CORRECTION
MEMBER ORDERED PRODUCT (2NF)
Order-Number (Primary Key 1 and Foreign Key)
Product-Number (Primary Key 2 and Foreign Key)
Quantity-Ordered
Quantity-Shipped
Quantity-Backordered
Purchased-Unit-Price
Extended-Price
sold as
PRODUCT (2NF)
Product-Number (Primary Key)
Universal-Product-Code (Alternate Key)
Quantity-in-Stock
Product-Type
Suggested-Retail-Price
Default-Unit-Price
Current-Special-Unit-Price
Current-Month-Units-Sold
Current-Year-Units-Sold
Total-Lifetime-Units-Sold
is a
is a
MERCHANDISE (2NF)
Product-Number (Primary Key)
Merchandise-Name
Merchandise-Description
Merchandise-Type
Unit-of-Measure
TITLE (2NF)
Product-Number (Primary Key)
Title-of-Work
Title-Cover
Catalog-Description
Copyright-Date
Entertainment-Category
Credit-Value
S1 MBTI


Second Normal Form Example 2
Fakultas
Ekonomi & Bisnis
School of Economics & Business
Telkom University
TITLE PROMOTION (1NF)
Promotion-Number (Primary Key 1 & Foreign Key)
Product-Number (Primary Key 2 & Foreign Key)
Title-of-Work
CORRECTION
TITLE PROMOTION (2NF)
Promotion-Number (Primary Key 1 & Foreign Key)
Product-Number (Primary Key 2 & Foreign Key)
Title-of-Work
generates
TITLE (2NF)
Product-Number (Primary Key)
Title-of-Work
Title-Cover
Catalog-Description
Copyright-Date
Entertainment-Category
Credit-Value
S1 MBTI

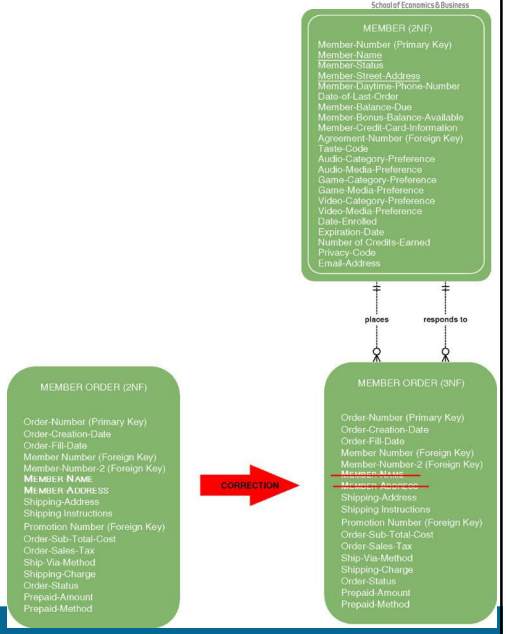
Third Normal Form Example 1

Derived attribute – an attribute whose value can be calculated from other attributes or derived from the values of other attributes.



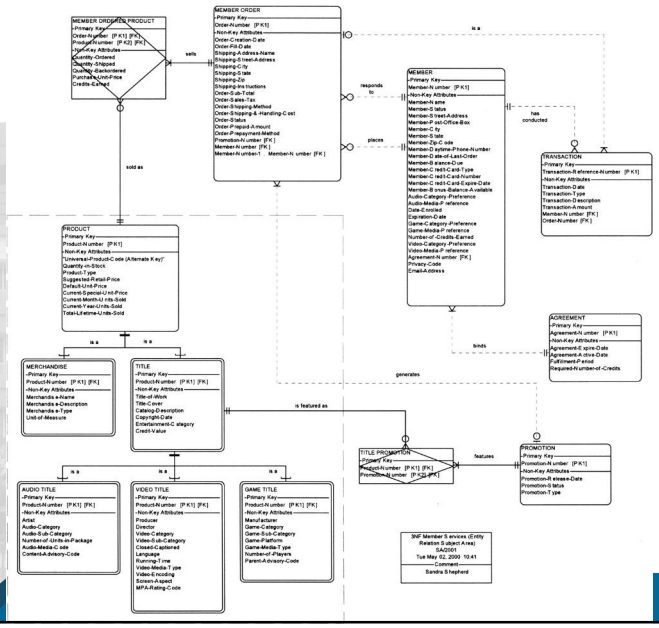
S1 MBTI

Third Normal Form Example 2



S1 MBTI

SoundStage 3NF Data Model



S1 MBTI

LATIHAN

- Klinik “Sehat Selalu” ingin mengembangkan sebuah sistem *database* untuk mengelola pasien yang berobat di klinik tersebut dengan ketentuan sebagai berikut.
- Pasien yang berobat di klinik tsb akan dicatat nama, alamat, no_telp, pekerjaan dan diberikan ID pasien. Klinik telah bekerja sama dengan sejumlah asuransi kesehatan seperti prudential, bpjs, dan sebagainya, sehingga pasien yang datang dapat berobat sebagai pasien umum (tanpa asuransi) atau pasien asuransi. Satu orang pasien bisa memiliki lebih dari satu asuransi. Sedangkan pasien umum akan diminta nama penanggungnya (biasanya nama kepala keluarga) untuk dituliskan di kuitansi pembayaran.
- Setiap Dokter di klinik tersebut dicatat NIP, nama, no_telp dan jenis spesialisasinya seperti spesialis anak, spesialis bedah, dan sebagainya. Dokter yang telah berkeluarga juga akan dicatat data anggota keluarganya (nama, hubungan, usia) agar bisa diberikan diskon 50% jika berobat di klinik tsb.
- Setiap kali datang berobat, sistem akan mencatat tanggal berobat, biaya pengobatan, serta dokter yang menangani pasien tersebut. Satu pasien dapat berobat ke satu dokter atau lebih. Satu dokter bisa mengobati lebih dari satu pasien.

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