Information Systems Planning and the Database Design Process

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I 257: Database Management

Lecture Outline

- Review
  - Database Terms
  - Database Types
- Database Life Cycle
- Information Systems Planning
- Information Systems Architecture
- Information Engineering
- Database Design

Announcements

- Yiming office hours:
  - Thursdays 11-12 in the CoLab (or by arrangement
- My office hours:
  - Tue, Thu 2-3 in 207B South Hall or by arrangement

Lecture Outline

- Review
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  - Database Types
- Database Life Cycle
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- Database Design

Terms and Concepts

- Database activities:
  - ***Create***
    - Add new data to the database
  - ***Read***
    - Read current data from the database
  - ***Update***
    - Update or modify current database data
  - ***Delete***
    - Remove current data from the database

Terms and Concepts

- ***Enterprise***
  - Organization
- ***Entity***
  - Person, Place, Thing, Event, Concept...
- ***Attributes***
  - Data elements (facts) about some entity
  - Also sometimes called fields or items or domains
- ***Data values***
  - instances of a particular attribute for a particular entity

Terms and Concepts

- ***Records***
  - The set of values for all attributes of a particular entity
  - AKA "tuples" or "rows" in relational DBMS
- ***File***
  - Collection of records
  - AKA "Relation" or "Table" in relational DBMS

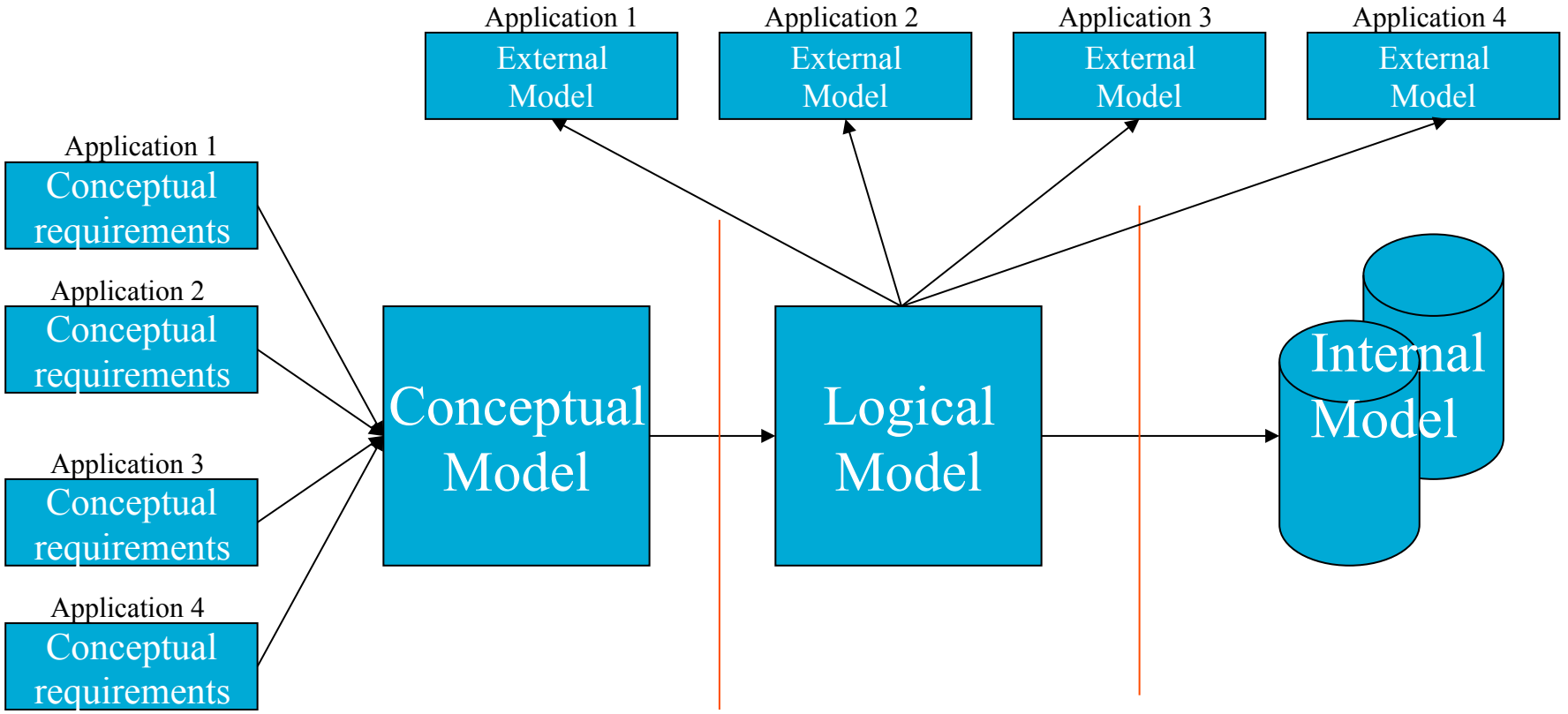
Terms and Concepts

- ***Key***
  - an attribute or set of attributes used to identify or locate records in a file
- ***Primary Key***
  - an attribute or set of attributes that *uniquely* identifies each record in a file

Terms and Concepts

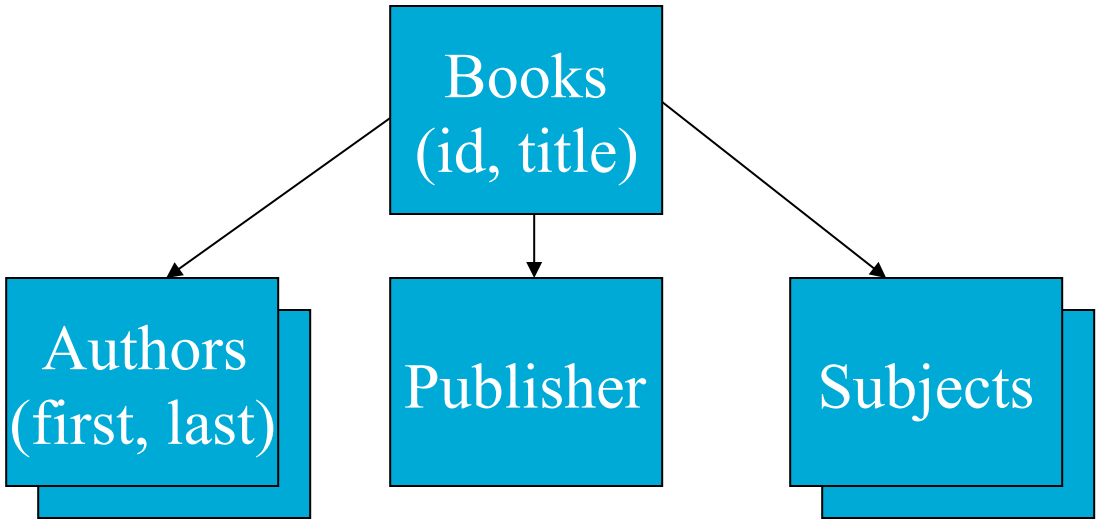
- ***Models***
  - (1) Levels or views of the Database
    - Conceptual, logical, physical
  - (2) DBMS types
    - Relational, Hierarchic, Network, Object-Oriented, Object-Relational

Models (1)


Application 1
External Model
Application 2
External Model
Application 3
External Model
Application 4
External Model
Application 1
Conceptual requirements
Application 2
Conceptual requirements
Application 3
Conceptual requirements
Application 4
Conceptual requirements
Conceptual Model
Logical Model
Internal Model

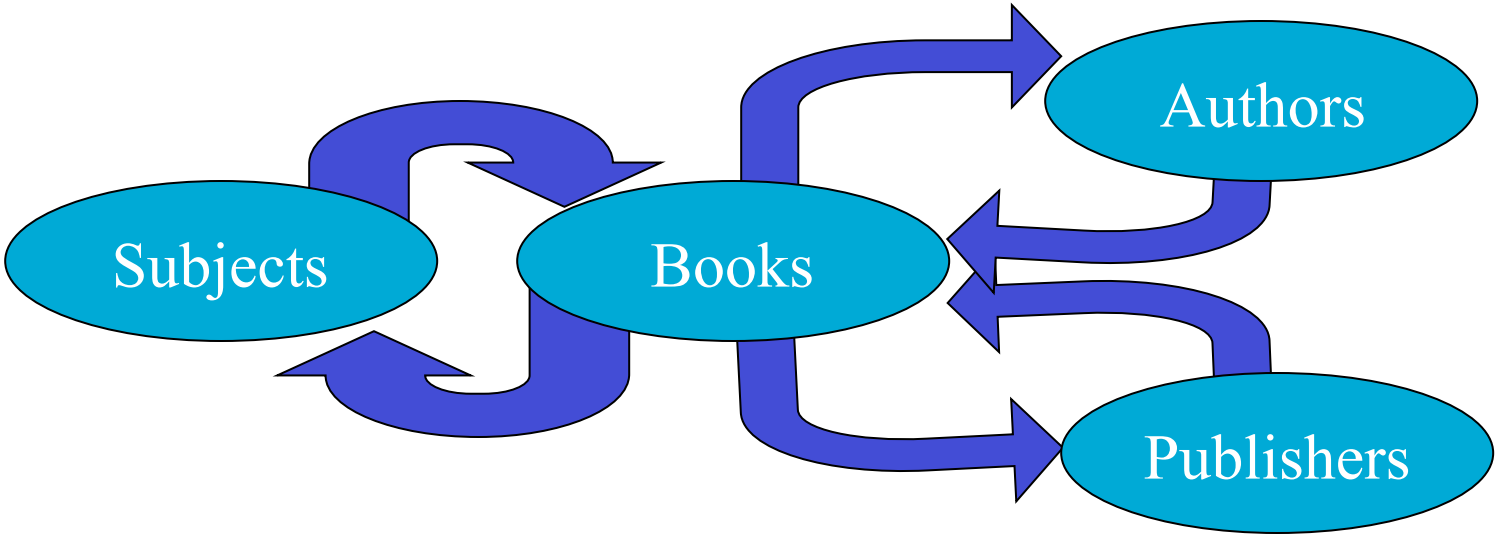
Data Models(2): History

- Hierarchical Model (1960's and 1970's)
  - Similar to data structures in programming languages.



Data Models(2): History

- Network Model (1970's)
  - Provides for single entries of data and navigational "links" through chains of data.



Data Models(2): History

- Relational Model (1980's)
  - Provides a conceptually simple model for data as relations (typically considered "tables") with all data visible.

Book ID	Title	pubid	Author id
1	Introductio	2	1
2	The history	4	2
3	New stuff a	3	3
4	Another tit	2	4
5	And yet m	1	5

pubid	pubname
1	Harper
2	Addison
3	Oxford
4	Que

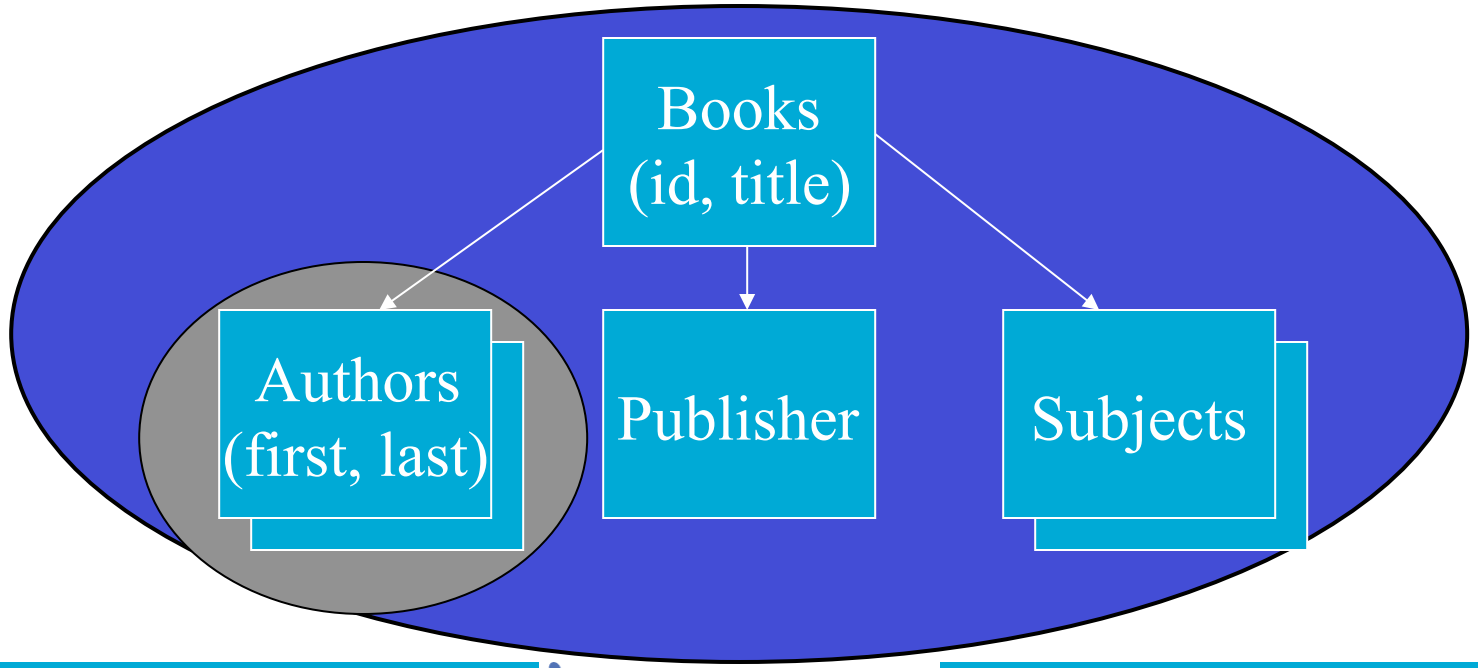
Authorid	Author nan
1	Smith
2	Wynar
3	Jones
4	Duncan
5	Applegate

Book ID	Subid
1	2
2	1
3	3
4	2
4	3

Subid	Subject
1	cataloging
2	history
3	stuff

Data Models(2): History

- Object Oriented Data Model (1990's)
  - Encapsulates data and operations as "Objects"



Data Models(2): History

- Object-Relational Model (1990's)
  - Combines the well-known properties of the Relational Model with such OO features as:
    - User-defined datatypes
    - User-defined functions
    - Inheritance and sub-classing

NoSQL Databases

- Started as a reaction to the overhead in more conventional SQL DBMS
- Usually very simple key/value search operations
- Usually very fast, with low storage overhead, but often lack security, consistency and other features of RDBMS
- May use distributed parallel processing (grid/cloud, e.g. MongoDB + Hadoop)
- Semantic Web “TripleStores” are one type

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- **Database Life Cycle**
- Information Systems Planning
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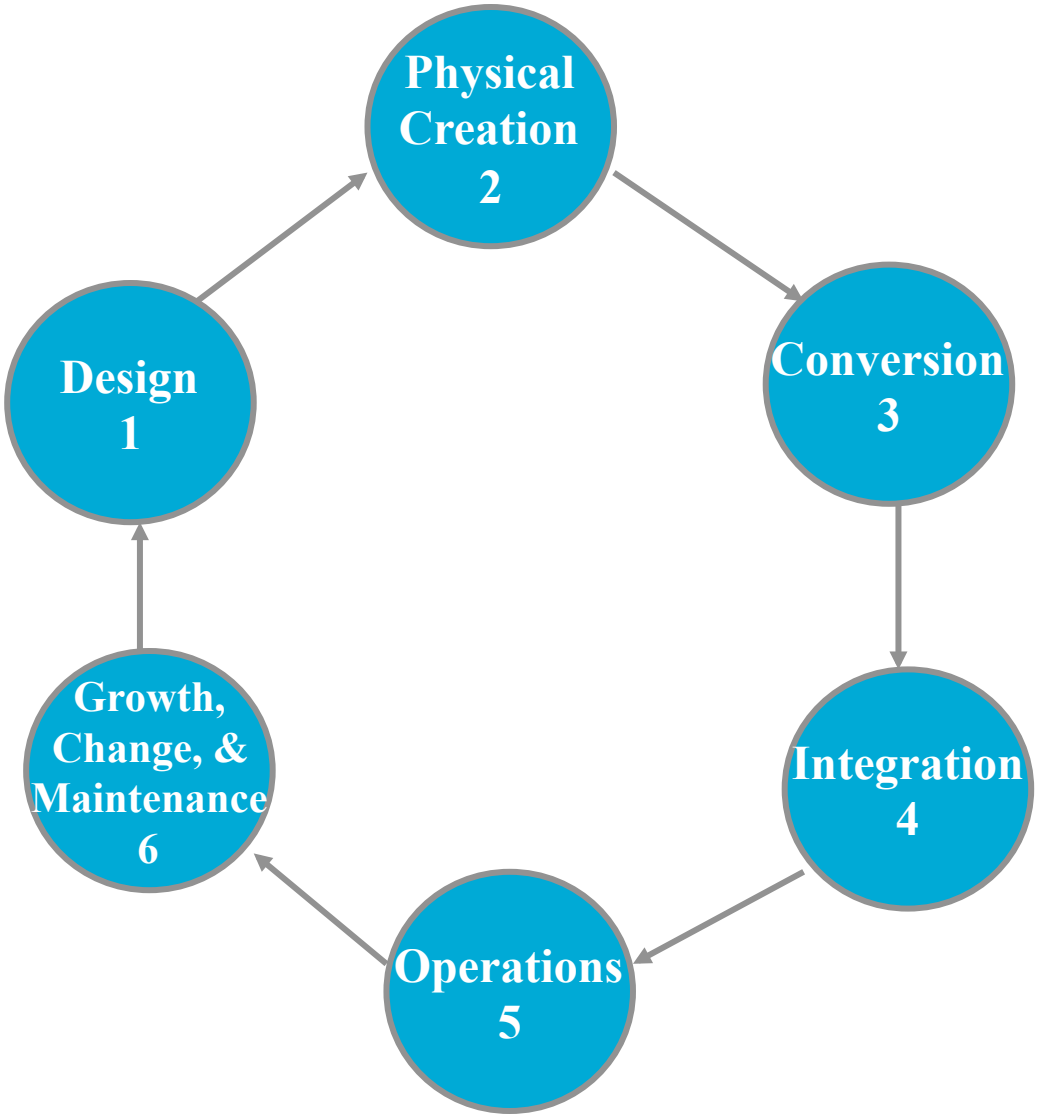
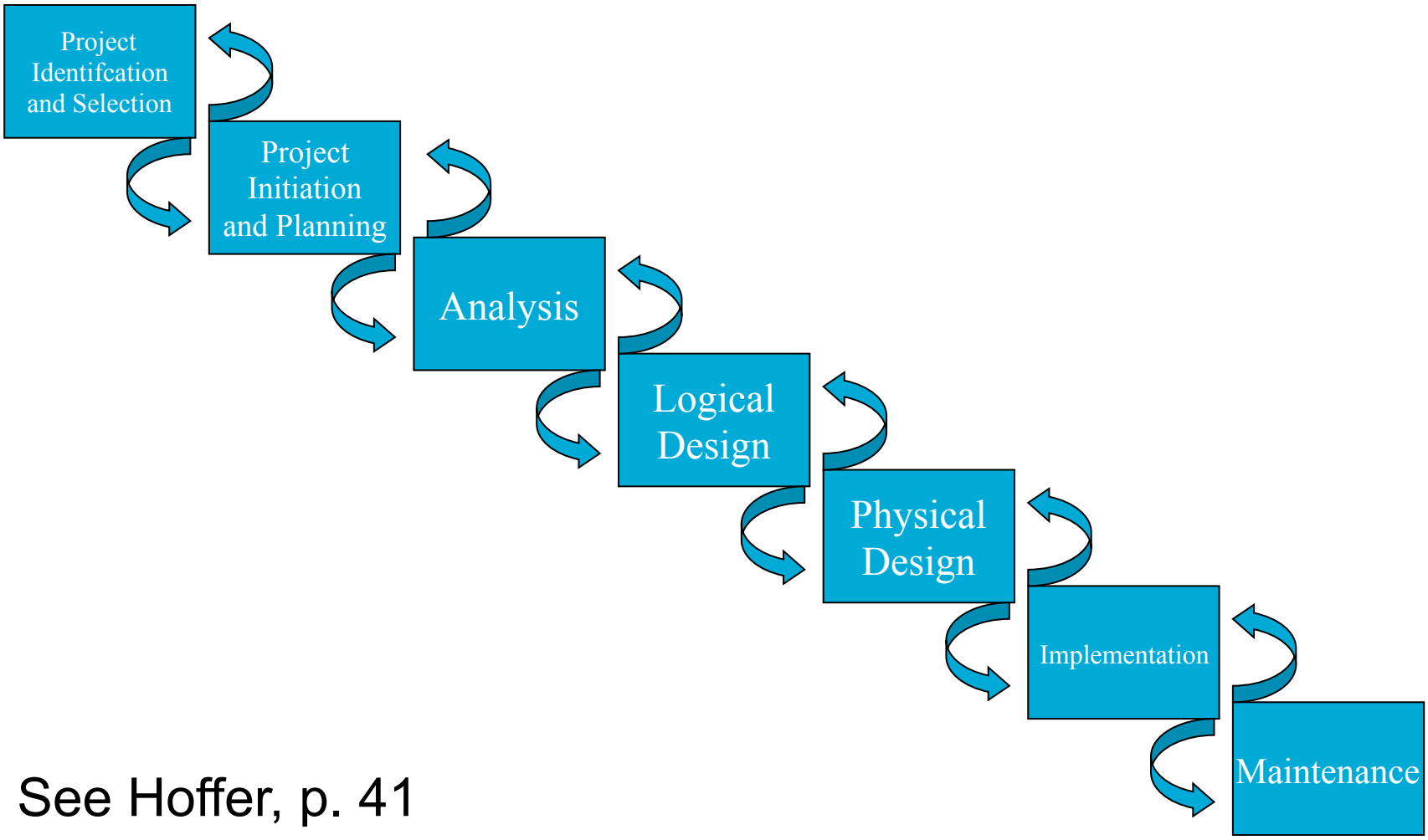
Database System Life Cycle



The "Cascade" View



See Hoffer, p. 41

1. Design

- Determination of the needs of the organization
- Development of the Conceptual Model of the database
  - Typically using Entity-Relationship diagramming techniques
- Construction of a Data Dictionary
- Development of the Logical Model

2. Physical Creation

- Development of the Physical Model of the Database
  - data formats and types
  - determination of indexes, etc.
- Load a prototype database and test
- Determine and implement security, privacy and access controls
- Determine and implement integrity constraints

3. Conversion

- Convert existing data sets and applications to use the new database
  - May need programs, conversion utilities to convert old data to new formats.

4. Integration

- Overlaps with Phase 3
- Integration of converted applications and new applications into the new database

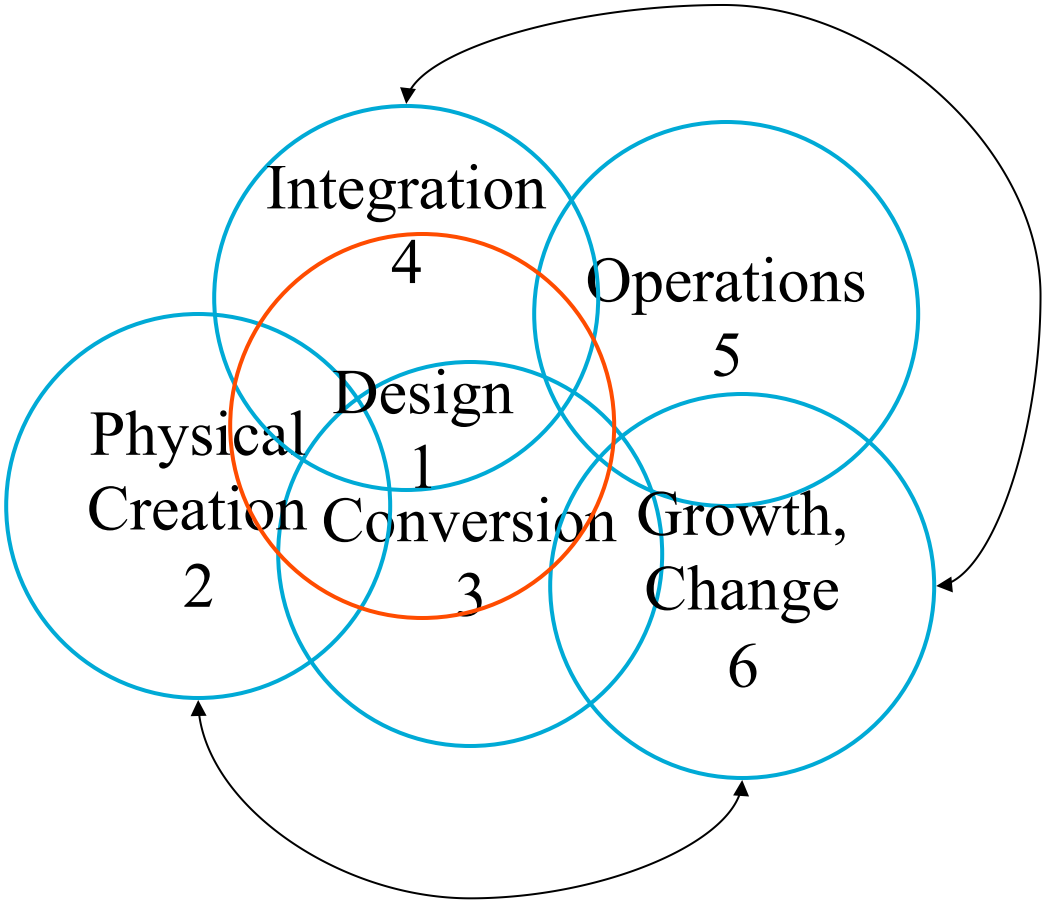
5. Operations

- All applications run full-scale
- Privacy, security, access control must be in place.
- Recovery and Backup procedures must be established and used

6. Growth, Change & Maintenance

- Change is a way of life
  - Applications, data requirements, reports, etc. will all change as new needs and requirements are found
  - The Database and applications and will need to be modified to meet the needs of changes

Another View of the Life Cycle



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Information Systems Planning

- Scope of IS is now the entire organization
- Sometimes called “enterprise-wide” computing or “Information Architecture”
- Problem: isolated groups in an organization start their own databases and it becomes impossible to find out who has what information, where there are overlaps, and to assess the accuracy of the information

Information Systems Planning

- To support enterprise-wide computing, there must be enterprise-wide information planning
- One framework for thinking about and planning for enterprise-wide computing is an *Information Systems Architecture* or ISA
- Most organizations do ***NOT*** have such an architecture

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Information Systems Architecture

- An ISA is a "*conceptual blueprint or plan that expresses the desired future structure for information systems in an organization*"
- It provides a "*context within which managers throughout the organization can make consistent decisions concerning their information systems*"
  - Quotes from McFadden (Modern Database Management, 4th edition), Ch. 3

Information Systems Architecture

- Benefits of ISA:
  - "Provides a basis for strategic planning of IS
  - Provides a basis for communicating with top management and a context for budget decisions concerning IS
  - Provides a unifying concept for the various stakeholders in information systems.
  - Communicates the overall direction for information technology and a context for decisions in this area
  - Helps achieve information integration when systems are distributed (increasing important in a global economy)
  - Provides a basis for evaluating technology options (for example, downsizing and distributed processing)"
    - Quotes from McFadden (Modern Database Management, 4th edition), Ch. 3

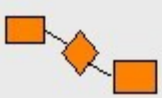
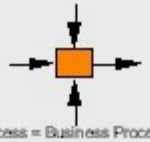
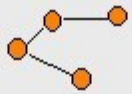
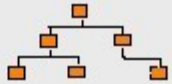
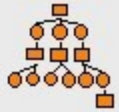
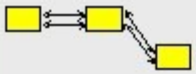
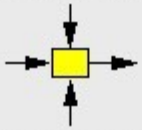
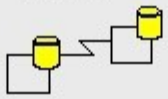
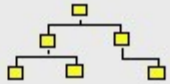
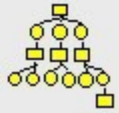
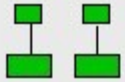
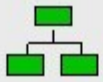
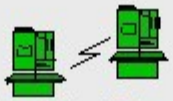
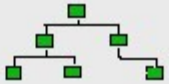
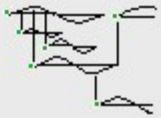
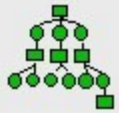
Information Systems Architecture

- Zachman ISA Framework components
  - Data
    - The "**What**" of the information system
  - Process
    - The "**How**" of the information system
  - Network
    - The "**Where**" of the information system
  - People
    - **Who** performs processes and are the source and receiver of data and information.
  - Events and Points in time
    - **When** processes are performed
  - Reasons
    - **Why**: For events and rules that govern processing

Information Systems Architecture

- Six roles or perspectives of the Data, Process and Network components
  - Business scope (Owner)
  - Business model (Architect)
  - Information systems model (Designer)
  - Technology model (Builder)
  - Technology definition (Contractor)
  - Information system (User)

Zachman Framework

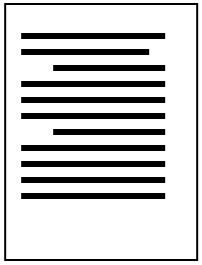
abstractions / perspectives	DATA *What*	FUNCTION *How*	NETWORK *Where*	PEOPLE *Who*	TIME *When*	MOTIVATION *Why*
SCOPE *Planner* contextual	List of Things - *Important to the Business*  Entity = Class of Business Thing	List of Processes - *the Business Performs*  Function = Class of Business Process	List of Locations - *in which the Business Operates*  Node = Major Business Location	List of Organizations - *Important to the Business*  People = Class of People and Major Organizations	List of Events - *Significant to the Business*  Time = Major Business Event	List of Business Goals and Strategies  Ends/Means=Major Business Goal/Critical Success Factor
ENTERPRISE MODEL *Owner* conceptual	e.g., Semantic Model  Entity = Business Entity Rel. = Business Relationship	e.g., Business Process Model  Process = Business Process I/O = Business Resources	e.g., Logistics Network  Node = Business Location Link = Business Linkage	e.g., Work Flow Model  People = Organization Unit Work = Work Product	e.g., Master Schedule  Time = Business Event Cycle = Business Cycle	e.g., Business Plan  End = Business Objective Means = Business Strategy
SYSTEM MODEL *Designer* logical	e.g., Logical Data Model  Entity = Data Entity Rel. = Data Relationship	e.g., Application Architecture  Process = Application Function I/O = User Views	e.g., Distributed System Architecture  Node = IS Function Link = Line Characteristics	e.g., Human Interface Architecture  People = Role Work = Deliverable	e.g., Processing Structure  Time = System Event Cycle = Processing Cycle	e.g., Business Rule Model  End = Structural Assertion Means = Action Assertion
TECHNOLOGY CONSTRAINED MODEL *Builder* physical	e.g., Physical Data Model  Entity = Tables/Segments/etc. Rel. = Key/Pointer/etc.	e.g., System Design  Process= Computer Function I/O =Data Elements/Sets	e.g., Technical Architecture  Node = Hardware/System Software Link = Line Specifications	e.g., Presentation Architecture  People = User Work = Screen/Device Format	e.g., Control Structure  Time = Execute Cycle = Component Cycle	e.g., Rule Design  End = Condition Means = Action
DETAILED REPRESEN-TATIONS *Subcontractor* out-of-context	e.g. Data Definition  Entity = Field Rel. = Address	e.g. Program  Process= Language Statement I/O = Control Block	e.g. Network Architecture  Node = Addresses Link = Protocols	e.g. Security Architecture  People = Identity Work = Job	e.g. Timing Definition  Time = Interrupt Cycle = Machine Cycle	e.g. Rule Specification  End = Sub-condition Means = Step
FUNCTIONING ENTERPRISE	DATA Implementation	FUNCTION Implementation	NETWORK Implementation	ORGANIZATION Implementation	SCHEDULE Implementation	STRATEGY Implementation

John A. Zachman, Zachman International

Information Systems Architecture

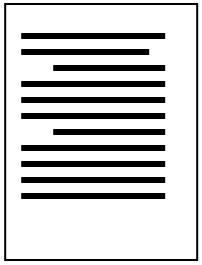
Data

List of entities important to the business



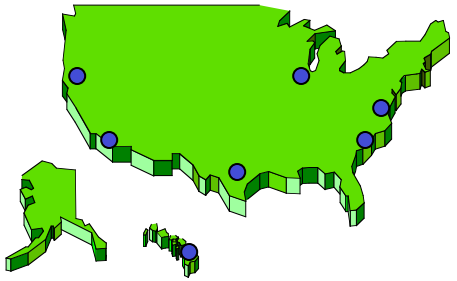
Process

List of processes or functions that the business performs



Network

List of locations in which the business operates



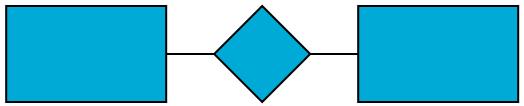
1. Enterprise Scope

(Owner)

Information Systems Architecture

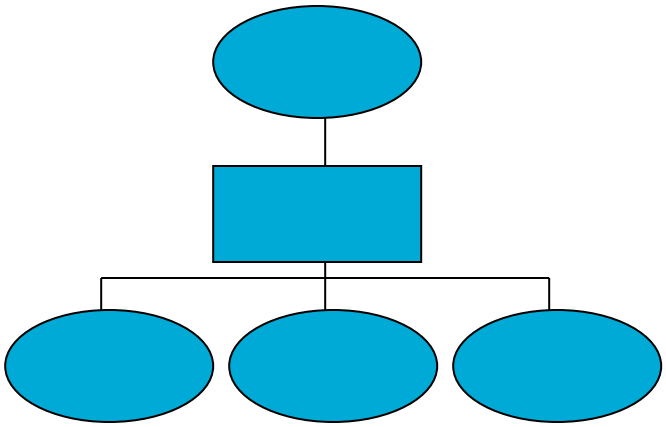
Data

Business entities and their relationships



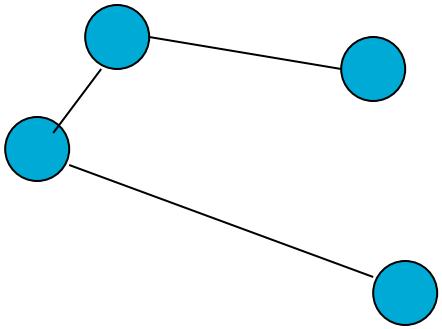
Process

Function and process decomposition



Network

Communications links between business locations

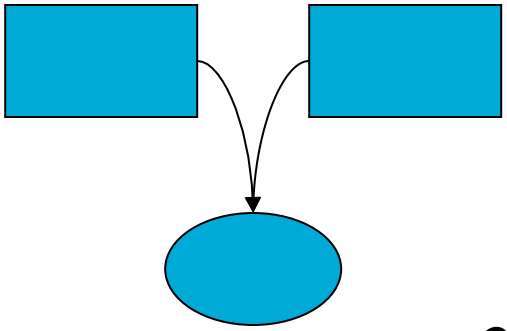


2. Enterprise Model (Architect)

Information Systems Architecture

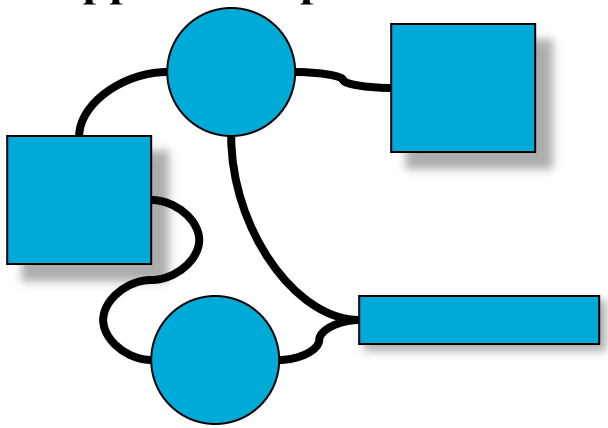
Data

Model of the business data and their relationships (ERD in Database design)



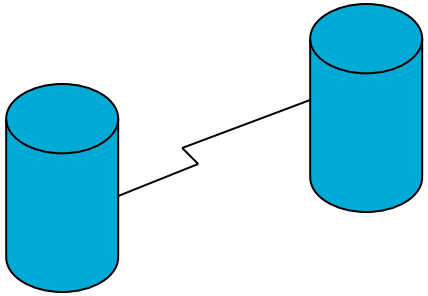
Process

Flows between application processes



Network

Distribution Network

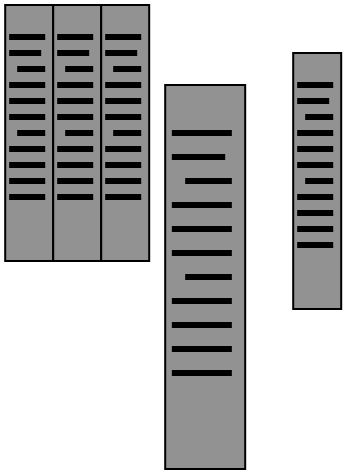


3. Information System Model (Designer)

Information Systems Architecture

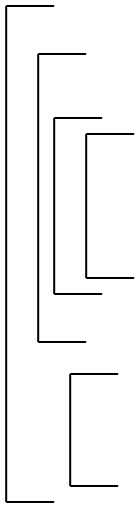
Data

Database Design (logical)



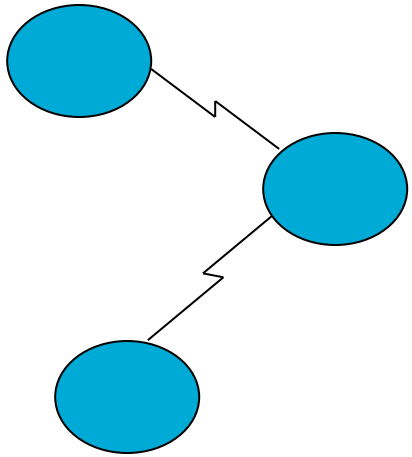
Process

Process specifications



Network

Database Design

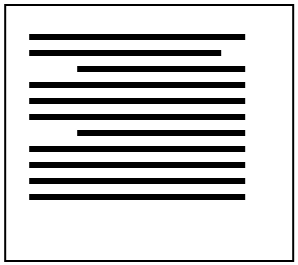


4. Technology Constrained Model
(Builder)

Information Systems Architecture

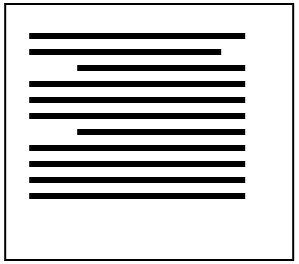
Data

Database Schema and subschema definition



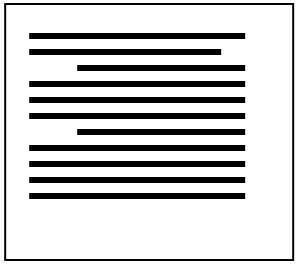
Process

Program Code and control blocks



Network

Configuration definition/ Network Architecture



5. Technology Definition/ Detailed Representations

(Contractor)

Information Systems Architecture

Data	Process	Network
Implemented Database and information	Implemented Application Programs	Current System Configuration

6. Functioning Enterprise

(User)

Lecture Outline

- Review
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- Database Design

Information Engineering

- A formal methodology that is used to create and maintain information systems
- Starts with the Business Model and works in a Top-Down fashion to build supporting data models and process models for that business model

Information Engineering

Planning

Analysis

1. Identify Strategic Planning Factors
   a. Goals
   b. Critical Success Factors
   c. Problem Areas
2. Identify Corporate Planning Objects
   a. Org. Units
   b. Locations
   c. Business Functions
   d. Entity types
3. Develop Enterprise Model
   a. Function decomposition
   b. Entity-Relationship Diagram
   c. Planning Matrices

Design

1. Develop Conceptual Model (detailed E-R Diagram)
2. Develop Process Models (data flow diagrams)

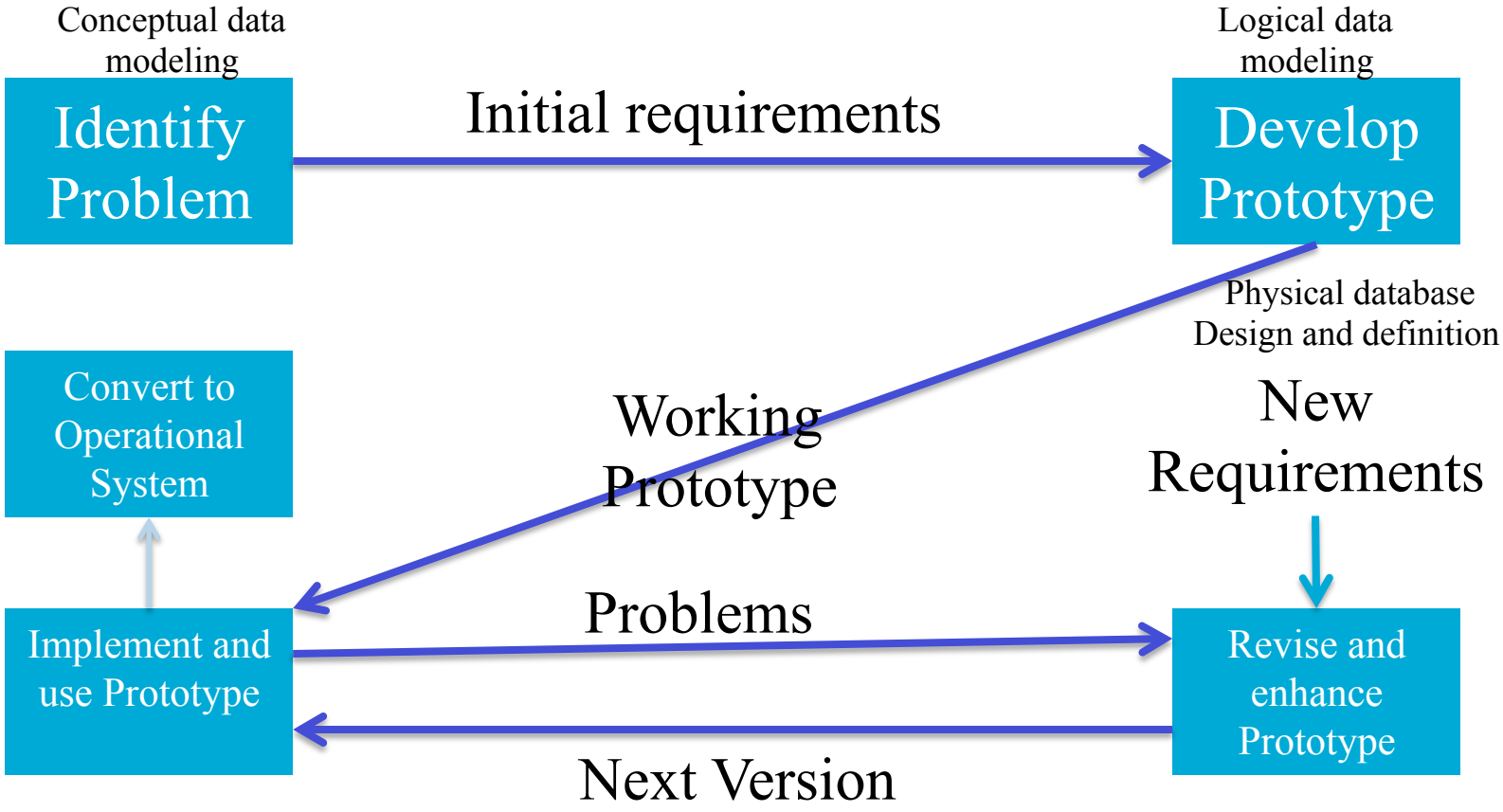
Implementation

1. Design Databases (normalized relations)
2. Design Processes
   a. Action Diagrams
   b. User Interfaces: menus, screens, reports

1. Build database definitions (tables, indexes, etc.)
2. Generate Applications (program code, control blocks, etc.)

Rapid Application Development

- One more recent, and very popular, development methods is RAD Prototyping



Lecture Outline

- Review
  - Database Life Cycle
- Information Systems Planning
- Information Systems Architecture
- Information Engineering
- Database Design

Lecture Outline

- Review
  - Database Terms
  - Database Types
- Database Life Cycle
- Information Systems Planning
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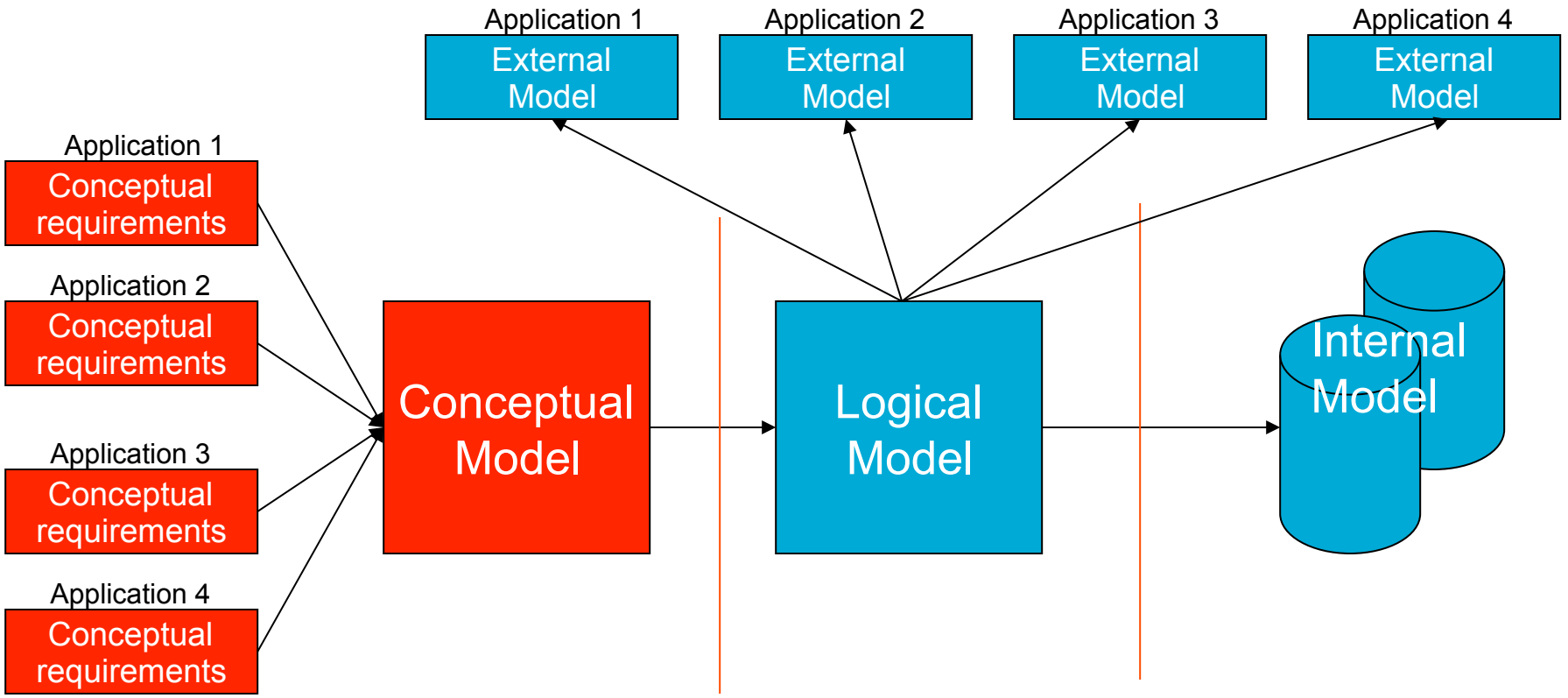
Database Design Process



Stages in Database Design

1. Requirements formulation and analysis
2. Conceptual Design -- Conceptual Model
3. Implementation Design -- Logical Model
4. Physical Design --Physical Model

Database Design Process

- Requirements formulation and analysis
  - Purpose: Identify and describe the data that are used by the organization
  - Results: Metadata identified, Data Dictionary, Conceptual Model-- ER diagram

Database Design Process

- Requirements Formulation and analysis
  - Systems Analysis Process
    - Examine all of the information sources used in existing applications
    - Identify the characteristics of each data element
      - numeric
      - text
      - date/time
      - etc.
    - Examine the tasks carried out using the information
    - Examine results or reports created using the information

Database Design Process

- Conceptual Model
  - Merge the collective needs of all applications
  - Determine what ***Entities*** are being used
    - Some object about which information is to maintained
  - What are the ***Attributes*** of those entities?
    - Properties or characteristics of the entity
    - What attributes uniquely identify the entity
  - What are the ***Relationships*** between entities
    - How the entities interact with each other?

Database Design Process

- Logical Model
  - How is each entity and relationship represented in the Data Model of the DBMS
    - Hierarchic?
    - Network?
    - Relational?
    - Object-Oriented?

Database Design Process

- Physical (AKA Internal) Model
  - Choices of index file structure
  - Choices of data storage formats
  - Choices of disk layout

Database Design Process

- External Model
  - User views of the integrated database
  - Making the old (or updated) applications work with the new database design

Developing a Conceptual Model

- Overall view of the database that integrates all the needed information discovered during the requirements analysis.
- Elements of the Conceptual Model are represented by diagrams, *Entity-Relationship or ER Diagrams*, that show the meanings and relationships of those elements independent of any particular database systems or implementation details.

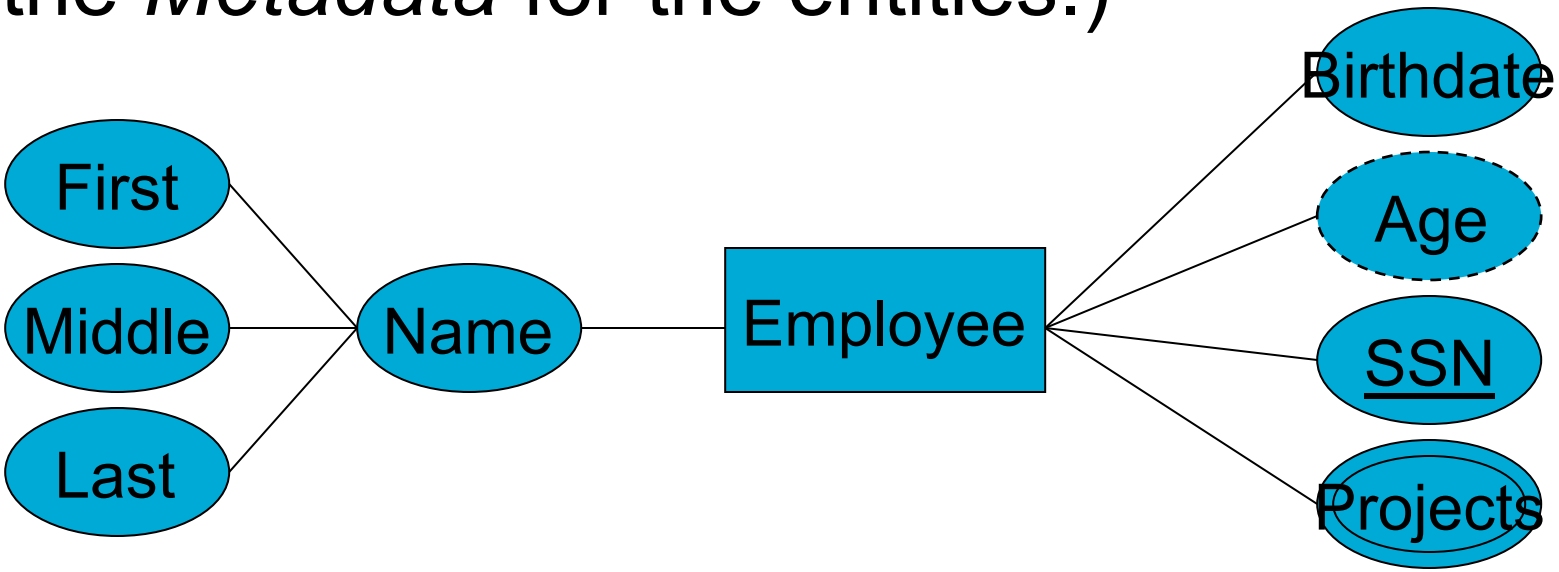
Entity

- An Entity is an object in the real world (or even imaginary worlds) about which we want or need to maintain information
  - Persons (e.g.: customers in a business, employees, authors)
  - Things (e.g.: purchase orders, meetings, parts, companies)

Employee

Attributes

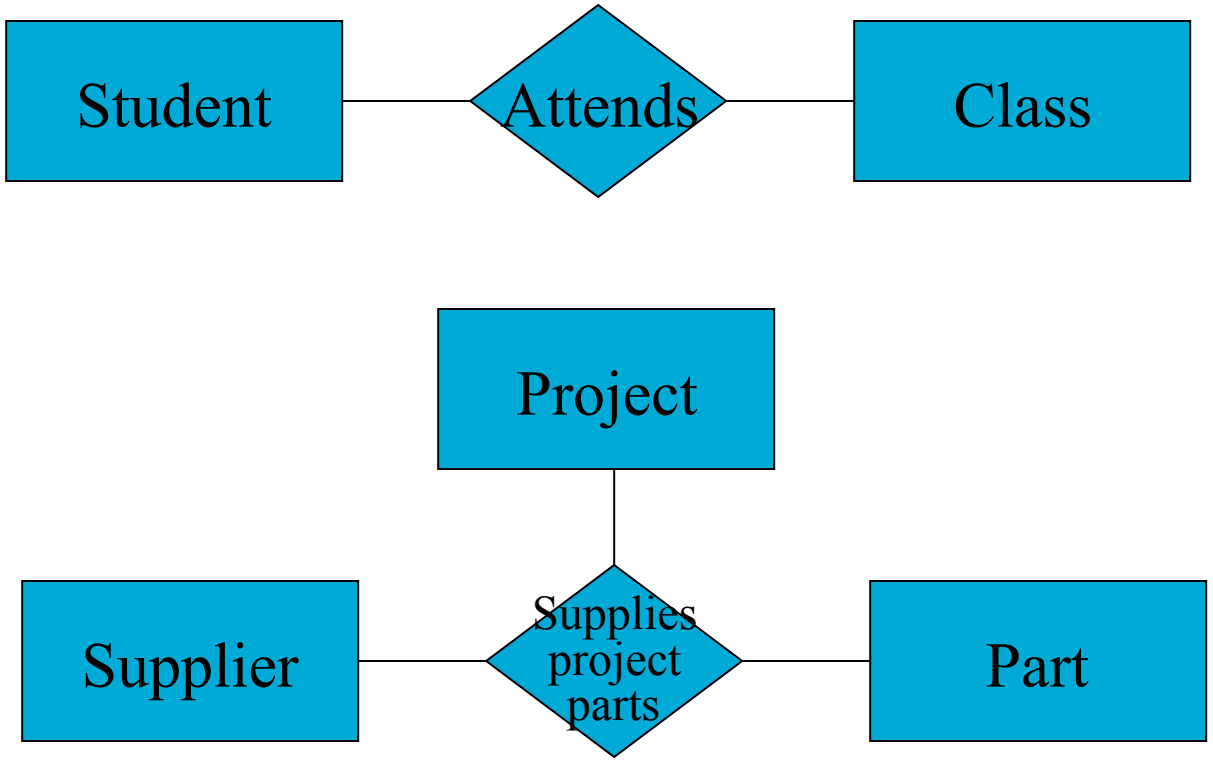
- Attributes are the significant properties or characteristics of an entity that help identify it and provide the information needed to interact with it or use it. (This is the *Metadata* for the entities.)



Relationships

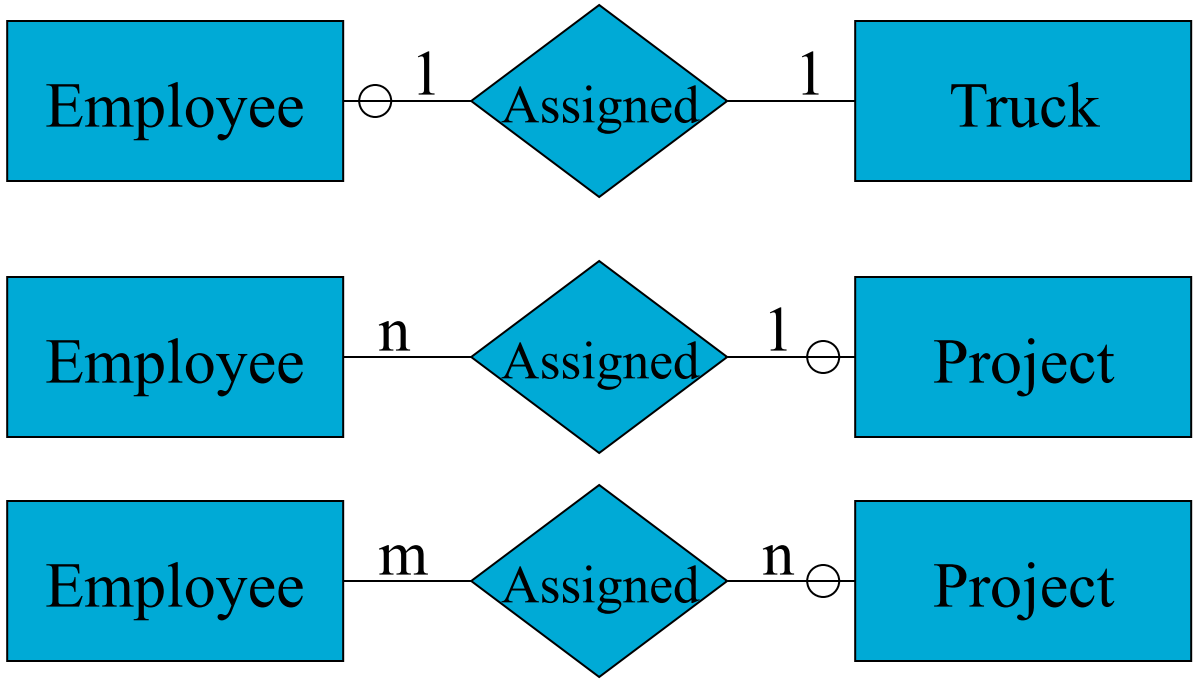
- Relationships are the associations between entities. They can involve one or more entities and belong to particular relationship types

Relationships



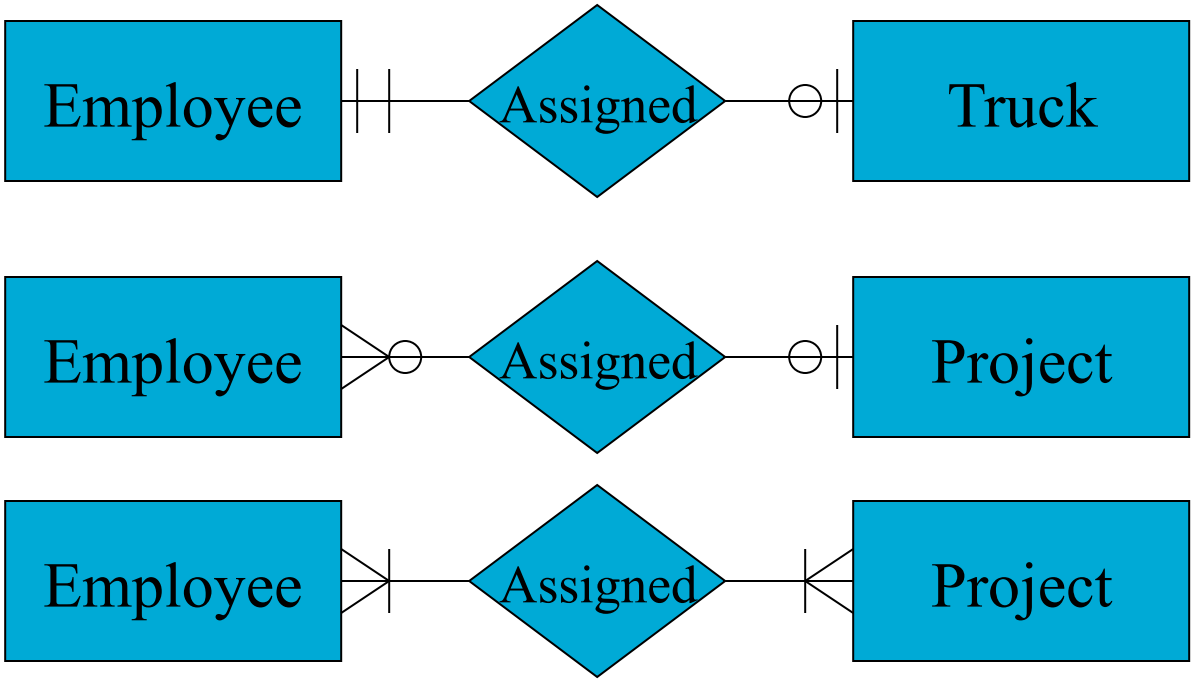
Types of Relationships

- Concerned only with *cardinality* of relationship



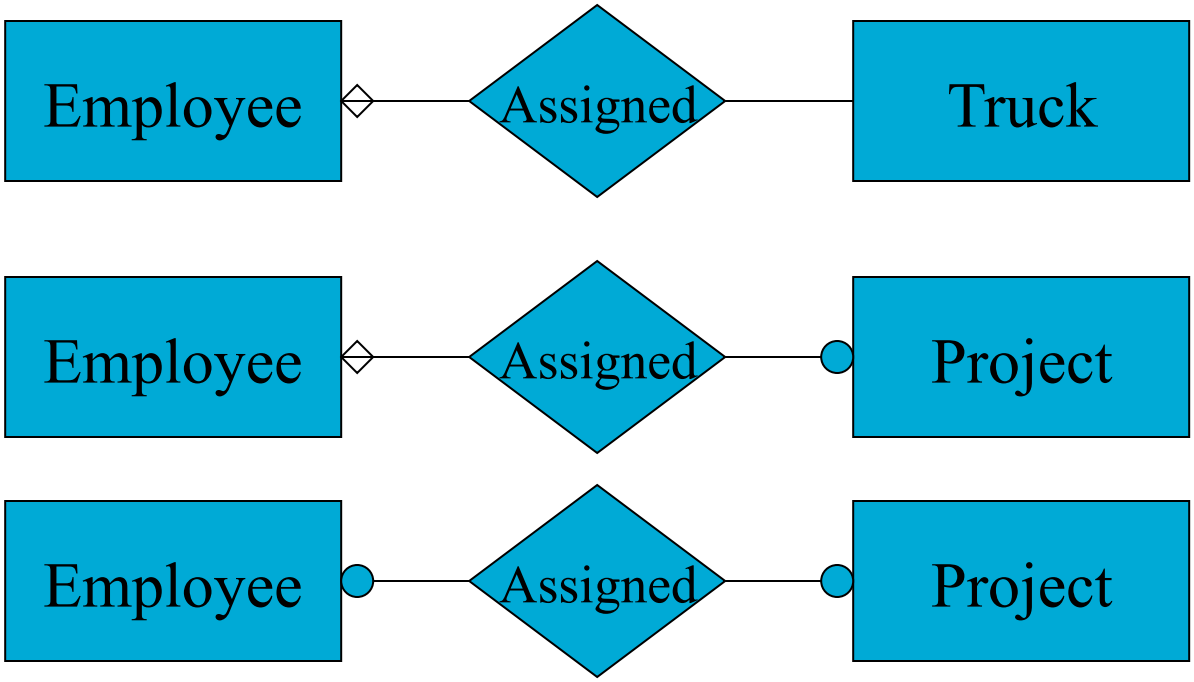
Chen ER notation

Other Notations



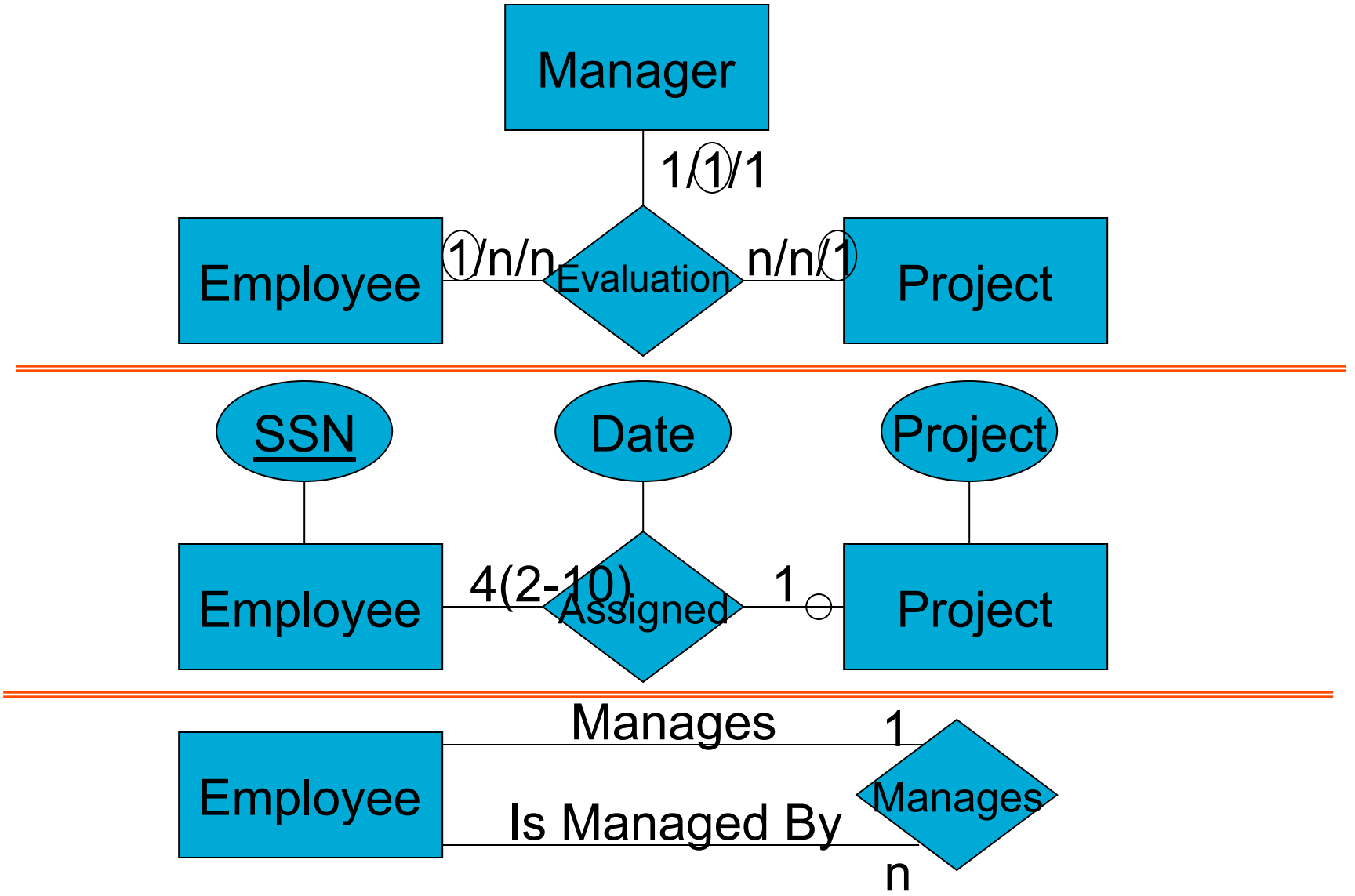
"Crow's Foot"

Other Notations



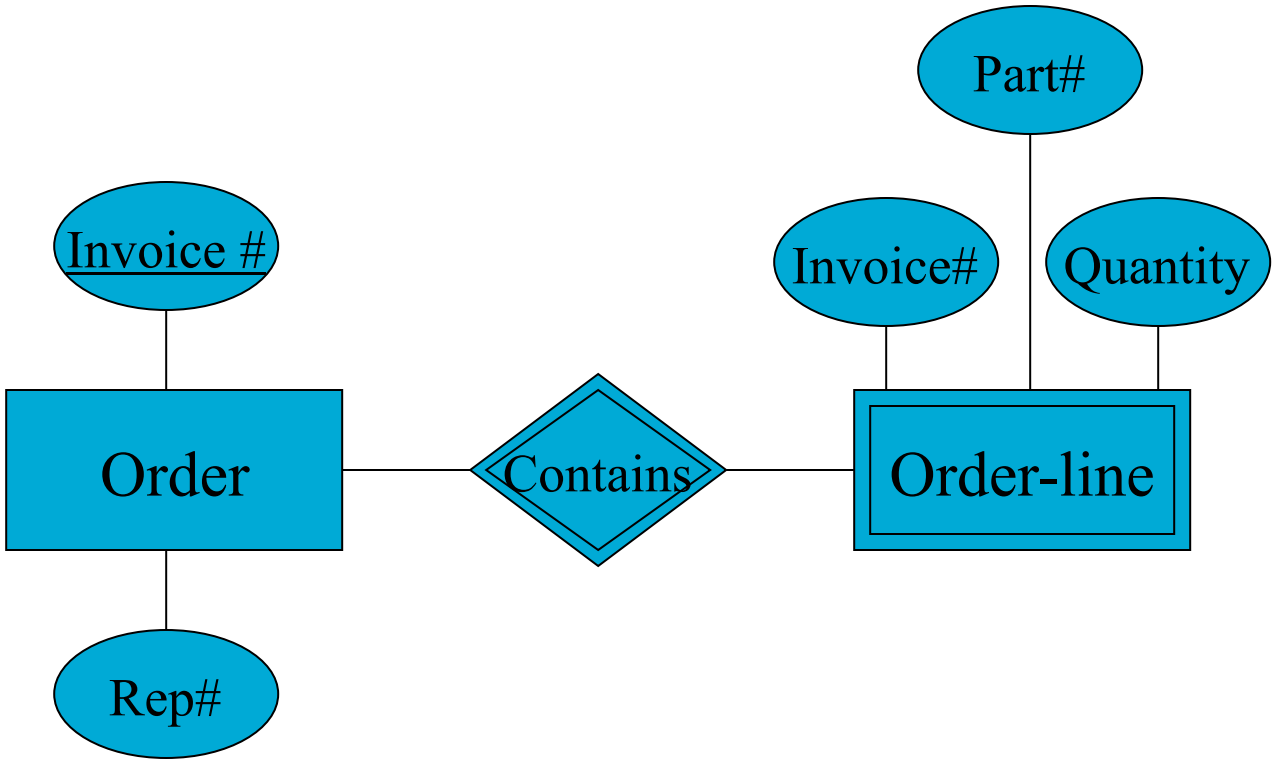
IDEFIX Notation

More Complex Relationships

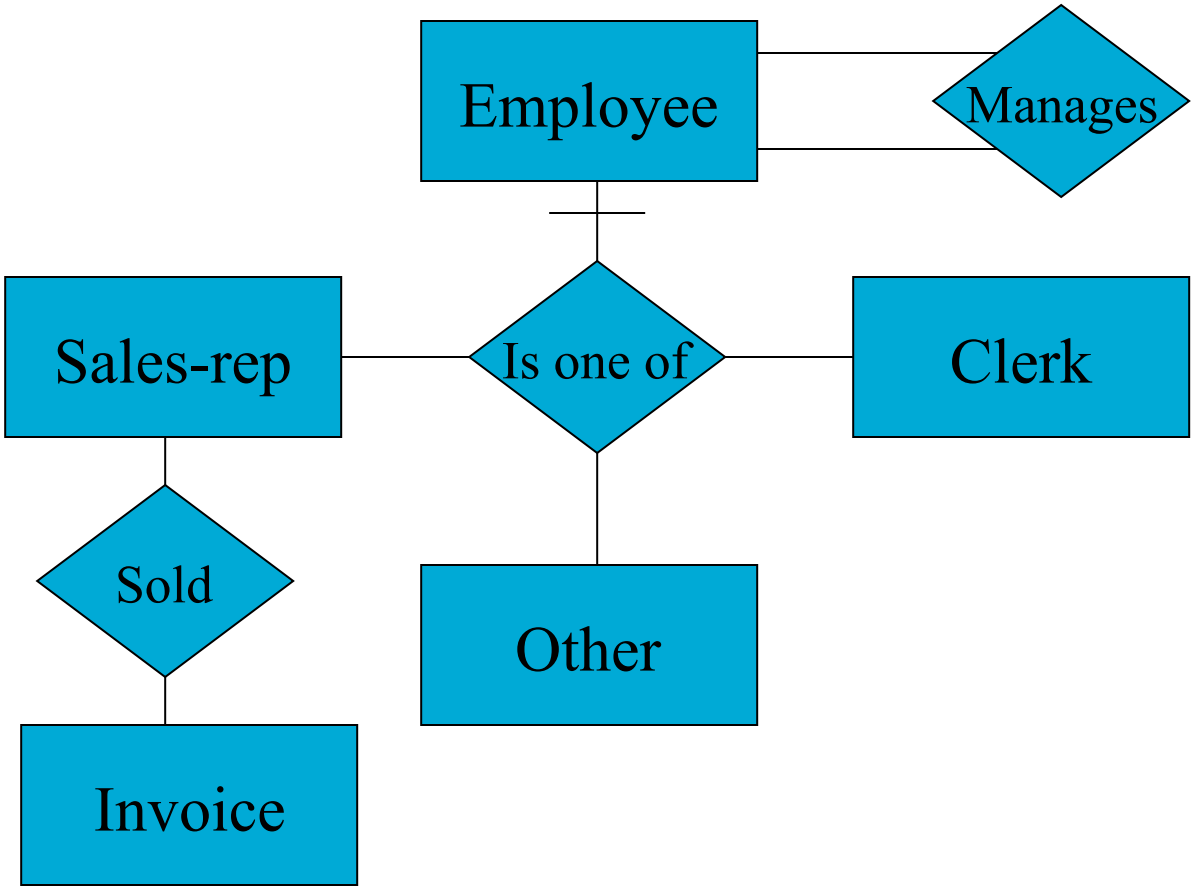


Weak Entities

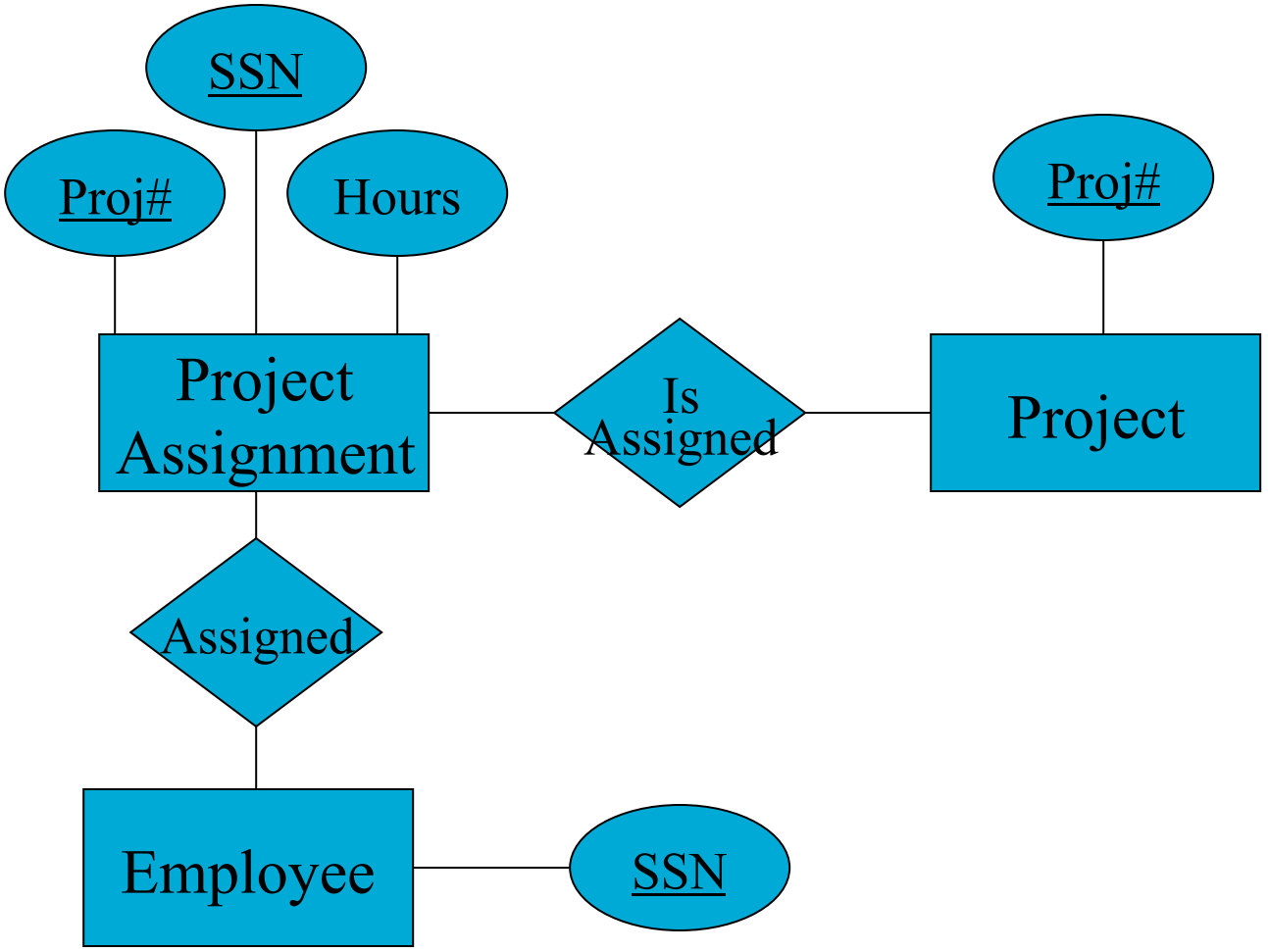
- Owe existence entirely to another entity



Supertype and Subtype Entities



Many to Many Relationships



Next Time

- THURSDAY:
  - More on ER modelling
  - Designing the Conceptual Model for the Diveshop Database
  - Assignment 1
  - Using MySQL for Assignment 1