

CMSC 424 – Database design  
Lecture 4:  
Relational Model  
ER to Relational model

Book: Chap. 2 and 6

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# Administrative issues

- Oracle accounts
- SQL homework next week

# Summary

- Entity-relationship Model
  - Intuitive diagram-based representation of domain knowledge, data properties etc...
  - Two key concepts:
    - Entities
    - Relationships
  - We also looked at:
    - Relationship cardinalities
    - Keys
    - Weak entity sets
    - ...

# Summary

- Details unimportant
  - Key idea: We can represent many data properties and constraints conceptually using this
- Read Chapter 6
  - Assignment will require you to do this anyway !

# Relational Data Model

Introduced by Ted Codd (late 60's – early 70's)

- *Before = “Network Data Model” (Cobol as DDL, DML)*
- *Very contentious: Database Wars (Charlie Bachman vs. Mike Stonebraker)*

Relational data model contributes:

- *Separation of logical, physical data models (data independence)*
- *Declarative query languages*
- *Formal semantics*
- *Query optimization (key to commercial success)*

1<sup>st</sup> prototypes:

- *Ingres → CA*
- *Postgres → Illustra → Informix → IBM*
- *System R → Oracle, DB2*

# Why Called Relations?

## Mathematical relations

*Given sets:  $R = \{1, 2, 3\}$ ,  $S = \{3, 4\}$*

- $R \times S = \{ (1, 3), (1, 4), (2, 3), (2, 4), (3, 3), (3, 4) \}$
- *A **relation** on  $R, S$  is any subset ( $\subseteq$ ) of  $R \times S$  (e.g:  $\{ (1, 4), (3, 4) \}$ )*

## Database relations

*Given attribute domains*

*Branches =  $\{ \text{Downtown, Brighton, ...} \}$*

*Accounts =  $\{ A-101, A-201, A-217, ... \}$*

*Balances =  $\mathbb{R}$*

*Account  $\subseteq$  Branches  $\times$  Accounts  $\times$  Balances*

*$\{ (\text{Downtown}, A-101, 500),$   
 $(\text{Brighton}, A-201, 900),$   
 $(\text{Brighton}, A-217, 500) \}$*

# Relations

Account =

bname	acct_no	balance
Downtown	A-101	500
Brighton	A-201	900
Brighton	A-217	500

*Considered equivalent to...*

$\{ (Downtown, A-101, 500),$   
 $(Brighton, A-201, 900),$   
 $(Brighton, A-217, 500) \}$

*Relational database semantics defined in terms of  
mathematical relations*

# Terms and Definitions

1. Tables = Relations
2. Columns = Attributes
3. Rows = Tuples
4. Relation Schema (or Schema)
  1. A list of attributes and their domains
  2. We will require the domains to be atomic
  3. E.g. **account**(account-number, branch-name, balance)
5. Relation Instance
  1. A particular instantiation of a relation with actual values
  2. Will change with time

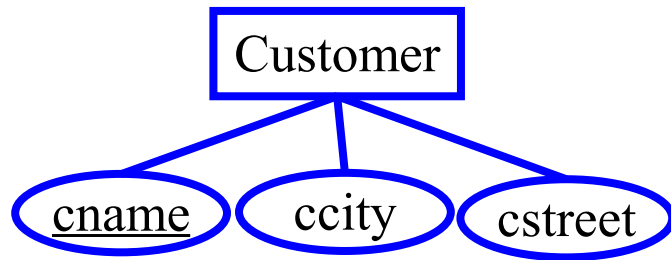


# So...

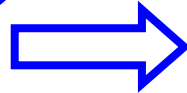
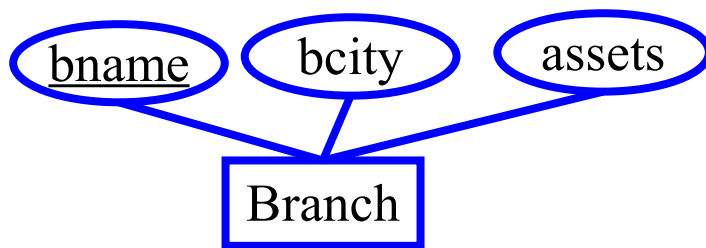
- That's the basic relational model
- That's it ?
  - What about the constraints ?
  - How do we represent one-to-one vs many-to-one relationships ?
  - Many of those constraints get embedded in the schema
    - Especially relationship cardinality constraints
- Others are explicitly represented using other constructs

# E/R Diagrams → Relations

Convert entity sets into a relational schema with the same set of attributes



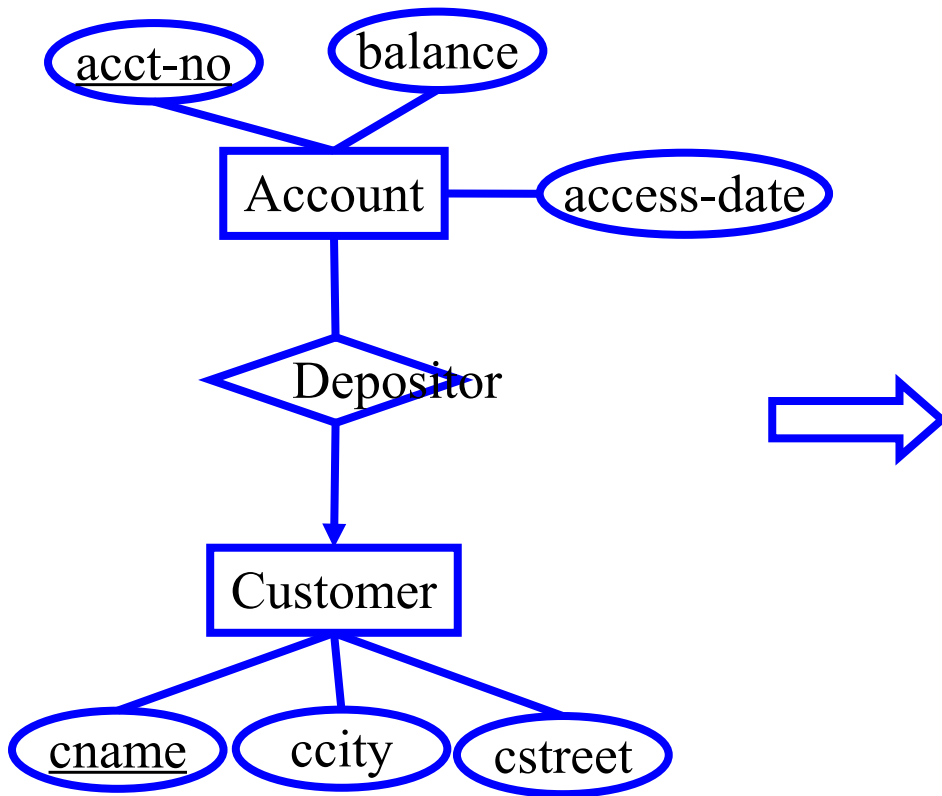
Customer\_Schema(cname, ccity, cstreet)



Branch\_Schema(bname, bcity, assets)

# E/R Diagrams → Relations

Say One-to-Many Relationship from Customer to Account  
→ Many accounts per customer



*Account\_Schema(acct-no, balance,  
cname, access-date)*

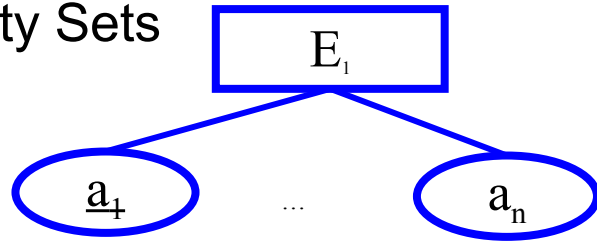
*Customer\_Schema(cname, ccity, cstreet)*

# E/R Diagrams → Relations

E/R

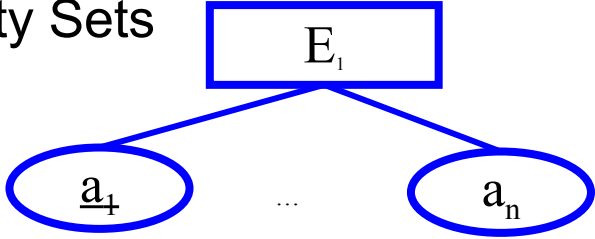
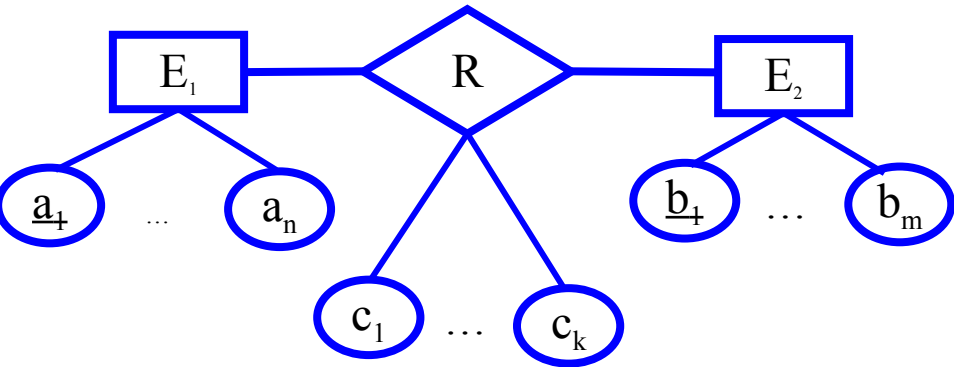
Relational Schema

Entity Sets



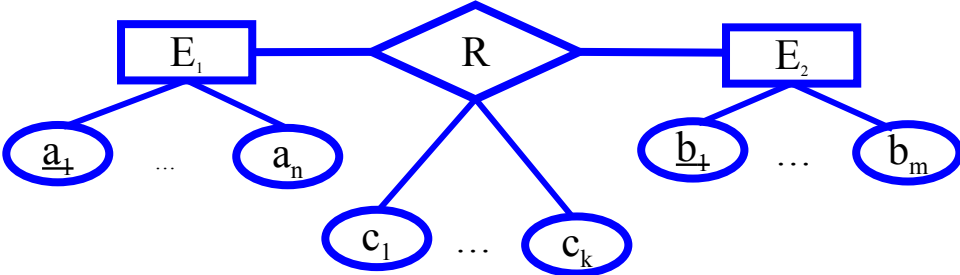

$$E = (\underline{a_1}, \dots, a_n)$$

# E/R Diagrams → Relations

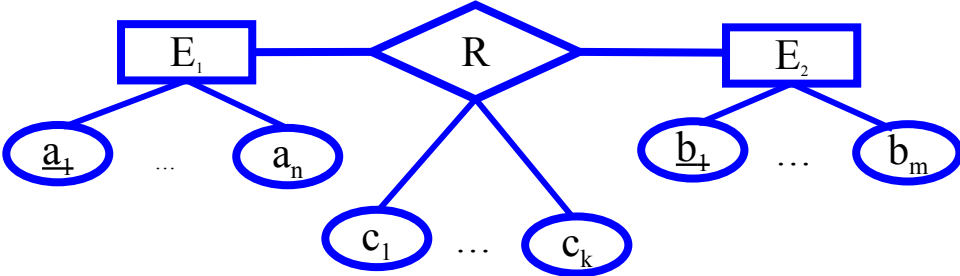


E/R	Relational Schema
<p>Entity Sets</p>  <p>The diagram shows a rectangular box labeled <math>E_1</math> at the top. Two lines extend downwards from the box to two ovals. The left oval contains <math>\underline{a_1}</math> and the right oval contains <math>a_n</math>. Ellipses are placed between the two ovals.</p>	$E = (\underline{a_1}, \dots, a_n)$
<p>Relationship Sets</p>  <p>The diagram shows a diamond-shaped box labeled <math>R</math> in the center. Two lines extend horizontally from the diamond to two rectangular boxes labeled <math>E_1</math> on the left and <math>E_2</math> on the right. From <math>E_1</math>, two lines extend downwards to two ovals containing <math>\underline{a_1}</math> and <math>a_n</math>. From <math>E_2</math>, two lines extend downwards to two ovals containing <math>\underline{b_1}</math> and <math>b_m</math>. From the bottom vertex of the diamond <math>R</math>, two lines extend downwards to two ovals containing <math>c_1</math> and <math>c_k</math>. Ellipses are placed between the ovals for <math>a_1</math> and <math>a_n</math>, between the ovals for <math>b_1</math> and <math>b_m</math>, and between the ovals for <math>c_1</math> and <math>c_k</math>.</p>	$R = (\underline{a_1}, \underline{b_1}, c_1, \dots, c_k)$ <p><math>a_1</math>: <math>E_1</math>'s key <math>b_1</math>: <math>E_2</math>'s key <math>c_1, \dots, c_k</math>: attributes of <math>R</math></p>

*Not the whole story for Relationship Sets ...*

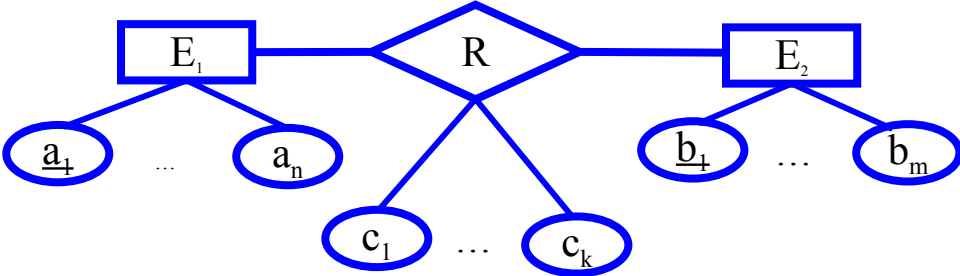



# E/R Diagrams $\rightarrow$ Relations

Relationship Cardinality	Relational Schema
	
<p><math>n:m</math></p> 	$E_1 = (\underline{a}_1, \dots, a_n)$ $E_2 = (\underline{b}_1, \dots, b_m)$ $R = (\underline{a}_1, \underline{b}_1, c_1, \dots, c_n)$

# E/R Diagrams $\rightarrow$ Relations

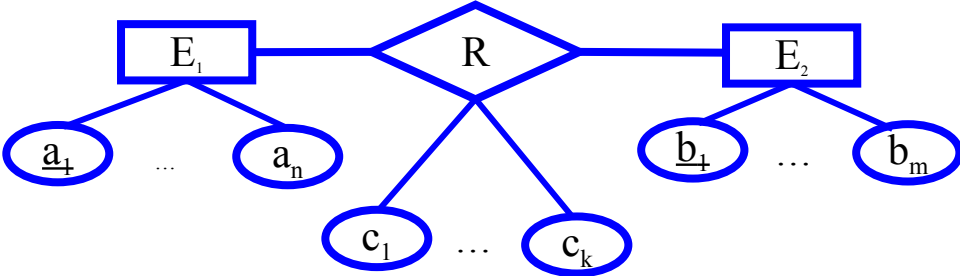




Relationship Cardinality	Relational Schema
	
<p>n:m</p> 	$E_1 = (\underline{a}_1, \dots, a_n)$ $E_2 = (\underline{b}_1, \dots, b_m)$ $R = (\underline{a}_1, \underline{b}_1, c_1, \dots, c_n)$
<p>n:1</p> 	$E_1 = (\underline{a}_1, \dots, a_n, b_1, c_1, \dots, c_n)$ $E_2 = (\underline{b}_1, \dots, b_m)$

# E/R Diagrams → Relations

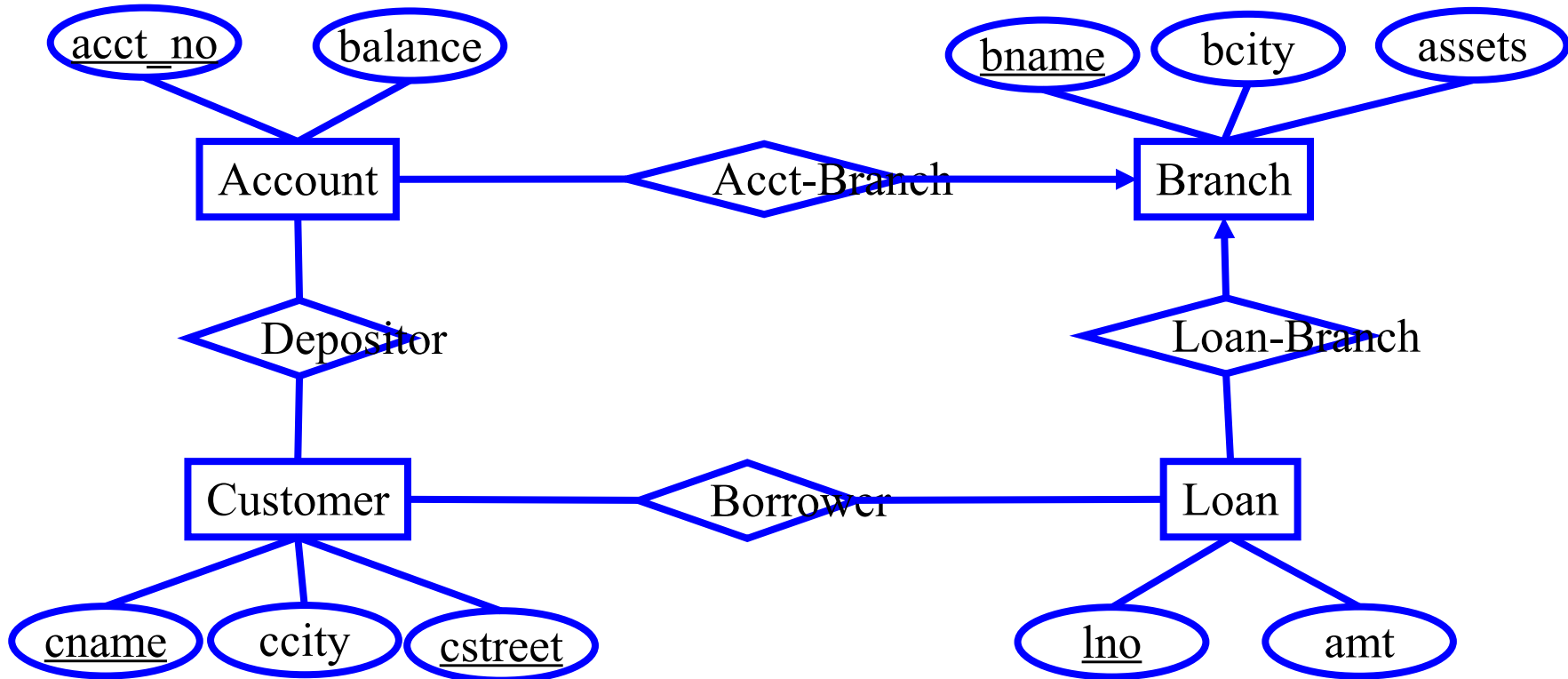
Relationship Cardinality	Relational Schema
	
<p>n:m</p> 	$E_1 = (\underline{a}_1, \dots, a_n)$ $E_2 = (\underline{b}_1, \dots, b_m)$ $R = (\underline{a}_1, \underline{b}_1, c_1, \dots, c_n)$
<p>n:1</p> 	$E_1 = (\underline{a}_1, \dots, a_n, b_1, c_1, \dots, c_n)$ $E_2 = (\underline{b}_1, \dots, b_m)$
<p>1:n</p> 	$E_1 = (\underline{a}_1, \dots, a_n)$ $E_2 = (\underline{b}_1, \dots, b_m, a_1, c_1, \dots, c_n)$



# E/R Diagrams → Relations

Relationship Cardinality	Relational Schema
	
<p>n:m</p> 	$E_1 = (\underline{a}_1, \dots, a_n)$ $E_2 = (\underline{b}_1, \dots, b_m)$ $R = (\underline{a}_1, \underline{b}_1, c_1, \dots, c_n)$
<p>n:1</p> 	$E_1 = (\underline{a}_1, \dots, a_n, b_1, c_1, \dots, c_n)$ $E_2 = (\underline{b}_1, \dots, b_m)$
<p>1:n</p> 	$E_1 = (\underline{a}_1, \dots, a_n)$ $E_2 = (\underline{b}_1, \dots, b_m, a_1, c_1, \dots, c_n)$
<p>1:1</p> 	<p>Treat as n:1 or 1:n</p>

# Translating E/R Diagrams to Relations



Q. How many tables does this get translated into?

A. 6 (account, branch, customer, loan, depositor, borrower)

# Bank Database

Account		
<u>bname</u>	<u>acct_no</u>	balance
Downtown	A-101	500
Mianus	A-215	700
Perry	A-102	400
R.H.	A-305	350
Brighton	A-201	900
Redwood	A-222	700
Brighton	A-217	750

Depositor	
<u>cname</u>	<u>acct_no</u>
Johnson	A-101
Smith	A-215
Hayes	A-102
Turner	A-305
Johnson	A-201
Jones	A-217
Lindsay	A-222

Customer		
<u>cname</u>	<u>cstreet</u>	<u>ccity</u>
Jones	Main	Harrison
Smith	North	Rye
Hayes	Main	Harrison
Curry	North	Rye
Lindsay	Park	Pittsfield
Turner	Putnam	Stanford
Williams	Nassau	Princeton
Adams	Spring	Pittsfield
Johnson	Alma	Palo Alto
Glenn	Sand Hill	Woodside
Brooks	Senator	Brooklyn
Green	Walnut	Stanford

Branch		
<u>bname</u>	<u>bcity</u>	assets
Downtown	Brooklyn	9M
Redwood	Palo Alto	2.1M
Perry	Horseneck	1.7M
Mianus	Horseneck	0.4M
R.H.	Horseneck	8M
Pownel	Bennington	0.3M
N. Town	Rye	3.7M
Brighton	Brooklyn	7.1M

Borrower	
<u>cname</u>	<u>lno</u>
Jones	L-17
Smith	L-23
Hayes	L-15
Jackson	L-14
Curry	L-93
Smith	L-11
Williams	L-17
Adams	L-16

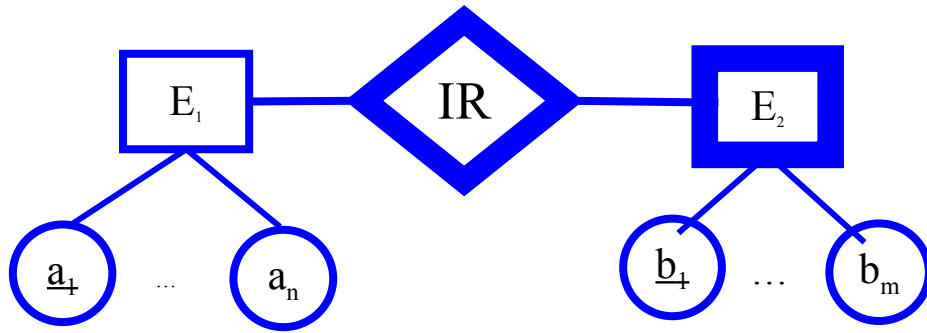
Loan		
<u>bname</u>	<u>lno</u>	amt
Downtown	L-17	1000
Redwood	L-23	2000
Perry	L-15	1500
Downtown	L-14	1500
Mianus	L-93	500
R.H.	L-11	900
Perry	L-16	1300

# E/R Diagrams & Relations

E/R

Relational Schema

*Weak Entity Sets*



$$E_1 = (\underline{a_1}, \dots, a_n)$$

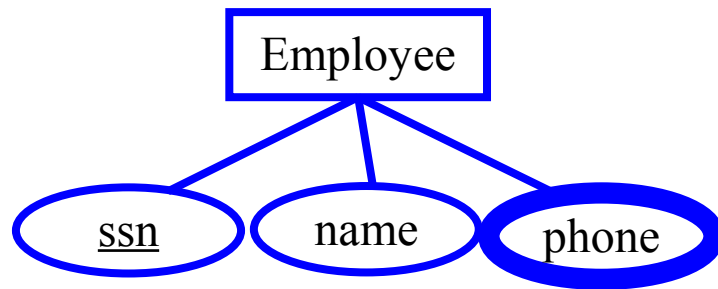
$$E_2 = (\underline{a_1}, \underline{b_1}, \dots, b_m)$$

# E/R Diagrams & Relations

E/R

Relational Schema

*Multivalued Attributes*



Emp = (ssn, name)

Emp-Phones = (ssn, phone)

ssn	name
001	Smith
...	...

Emp

ssn	phone
001	4-1234
001	4-5678
...	...

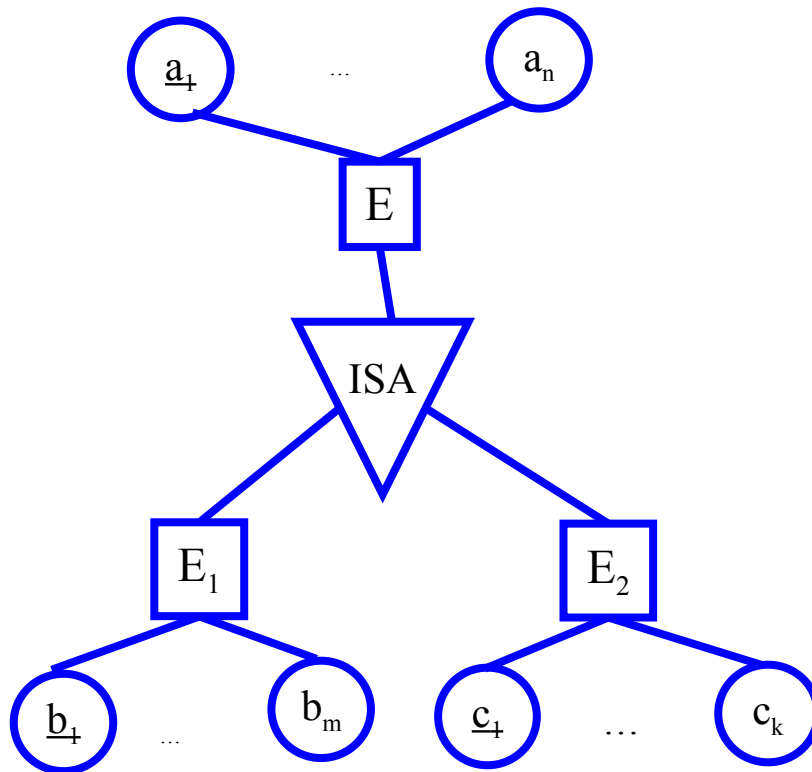
Emp-Phones

# E/R Diagrams & Relations

E/R

Relational Schema

*Subclasses*



Method 1:

$$E = (\underline{a}_1, \dots, a_n)$$

$$E_1 = (\underline{a}_1, b_1, \dots, b_m)$$

$$E_2 = (\underline{a}_1, c_1, \dots, c_k)$$