

Database Design: SQL (cont.), Conceptual Model (cont.), UML and The Logical Model University of California, Berkeley School of Information IS 257: Database Management

Announcements



- Questions about reading/ assignments?
- Question(s) asked in class
- Chapter 6 & 7 Concepts Reinforced
- Lecture
- Lab Assignment Ideas and Introductions

Relation Algebra Divide



- There is a relational operator that directly gives us this result. The operator is division, written R ÷ S.
- Unfortunately, there is no direct way to express division in SQL
- https://www.inf.usi.ch/faculty/soule/ teaching/2016-fall/db/division.pdf

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Subquery Naming



- Query works in Postgres
- SELECT * FROM diveshop.divecust where customer_no in (SELECT customer_no from diveshop.diveords where destination='Fiji')

Chapter 6 & 7 Concept Review



- Data Integrity Controls
- Row Value & Aggregates
- Joins
- Query Design and Tips

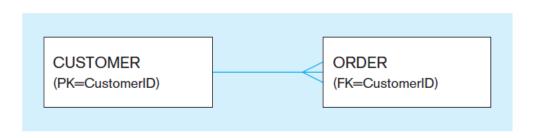
Data Integrity Controls



- Referential integrity—constraint that ensures that foreign key values of a table must match primary key values of a related table in 1:M relationships
- Restricting:
 - Deletes of primary records
 - -Updates of primary records
 - Inserts of dependent records

Figure 6-7 Ensuring data integrity through updates P. 256





Restricted Update: A customer ID can only be deleted if it is not found in ORDER table.

CREATE TABLE CustomerT

(CustomerID CustomerName INTEGER DEFAULT '999' VARCHAR(40) NOT NULL, NOT NULL.

. . .

CONSTRAINT Customer_PK PRIMARY KEY (CustomerID), ON UPDATE RESTRICT);

Cascaded Update: Changing a customer ID in the CUSTOMER table will result in that value changing in the ORDER table to match.

... ON UPDATE CASCADE);

Set Null Update: When a customer ID is changed, any customer ID in the ORDER table that matches the old customer ID is set to NULL.

... ON UPDATE SET NULL);

Set Default Update: When a customer ID is changed, any customer ID in the ORDER tables that matches the old customer ID is set to a predefined default value.

... ON UPDATE SET DEFAULT);

Relational integrity is enforced via the primary-key to foreign-key match

Issues about row value & aggregates



- SQL cannot return both a row value (such as Product_ID) and a set value (such as COUNT/AVG/SUM of a group);
 - users must run two separate queries, one that returns row info and one that returns set info
- 1. SELECT S_ID FROM STUDENT Row
- 2. SELECT AVG(GPA) FROM STUDENT Set
- 3. SELECT S_ID, AVG(GPA) FROM STUDENT row & set

Processing Multiple Tables



- Join—a relational operation that causes two or more tables with a common domain to be combined into a single table or view
- Equi-join—a join in which the joining condition is based on equality between values in the common columns; common columns appear redundantly in the result table
- Natural join—an equi-join in which one of the duplicate columns is eliminated in the result table

The common columns in joined tables are usually the primary key of the dominant table and the foreign key of the dependent table in 1:M relationships

Processing Multiple Tables-Joins

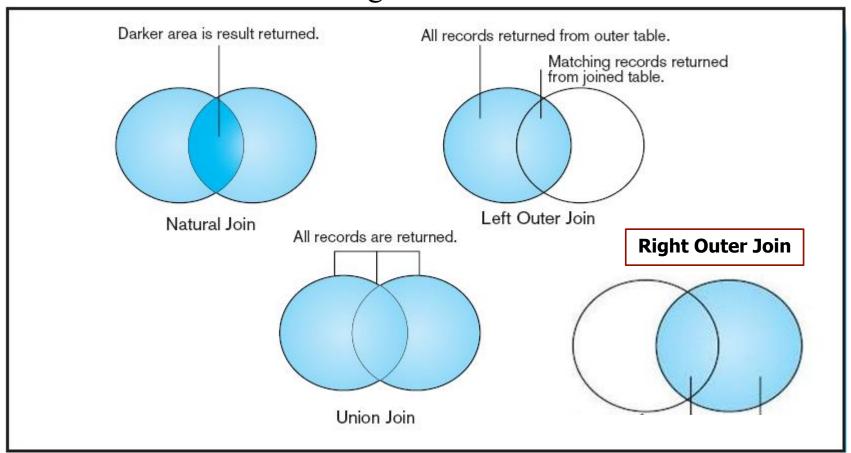


- Outer join—a join in which
 - rows that do not have matching values in common columns are nonetheless included in the result table
 - (as opposed to *inner* join, in which rows must have matching values in order to appear in the result table)
- Union join—includes all columns from each table in the join, and an instance for each row of each table

Visualization of different join types with results returned in shaded area



Figure 7.2



"Golden Rules" of Outer join



- × Rule 1:
- **×** OUTER JOIN can only join 2 tables
 - +*IF* attempt to join more than two tables in outer join, unexpected outcomes would result.
- × Rule 2:
- Do NOT abuse outer join: UNLESS you truly want ALL rows from one table (including unmatched rows), should you use outer join

Tips for Developing Queries



- Be familiar with the data model (entities and relationships)
- Understand the desired results
- CUSTOMER_t

 Customer_ID

 Customer_Name
 Customer_Address
 Customer_City
 Customer_State
 Postal_Code

 ORDER_t

 Order_ID

 Order_Date

 Customer_ID
- Know the attributes desired in result
- Identify the entities that contain desired attributes
- Review ERD
- Construct a WHERE equality for each table join
- Fine tune with GROUP BY and HAVING clauses if needed
- Consider the effect on unusual data

Query Efficiency Considerations



- Instead of SELECT *, identify the specific attributes in the SELECT clause; this helps reduce network traffic of result set
- Limit the number of subqueries; try to make everything done in a single query if possible
- If data is to be used many times, make a separate query and store its results rather than performing the query repeatedly

Guidelines for Better Query Design



- Use compatible data types for fields and literals
- Write simple queries
- Break complex queries into multiple simple parts
- Don't nest one query inside another query
- Don't combine a query with itself (if possible avoid self-joins)

Guidelines for Better Query Design



- Create temporary tables for groups of queries
- Combine update operations
- Retrieve only the data you need
- Don't have the DBMS sort without an index
- Learn!
- Consider the total query processing time for ad hoc queries

Lecture Outline



- Review (and continuation)
 - Database Design, Conceptual Model
- Assignment 2 Personal Database Conceptual Design
- Object-Oriented Modeling in UML
- The Logical Model

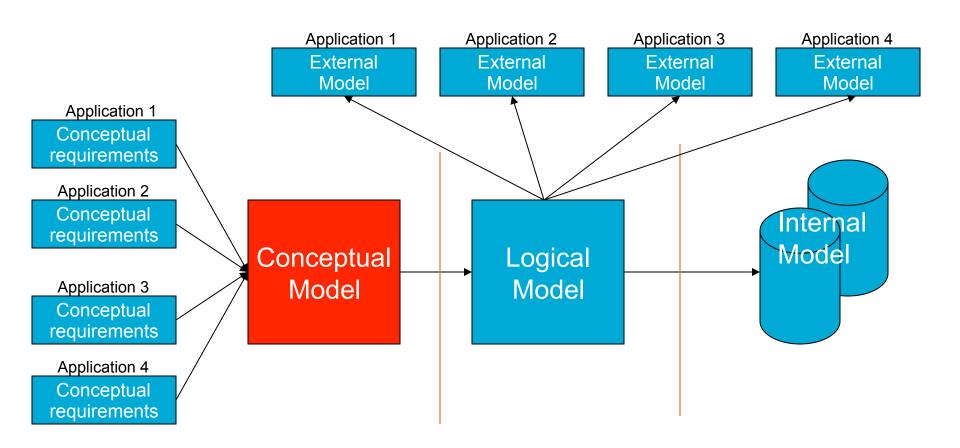
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Database Design Process





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.
- Can also be represented using other modeling tools (such as UML – more later)

Developing a Conceptual Model



 Building the Conceptual Model for the Diveshop database

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Developing a Conceptual Model



- We will look at a small business -- a diveshop that offers diving adventure vacations
- Assume that we have done interviews with the business and found out the following information about the forms used and types of information kept in files and used for business operations...

Entities

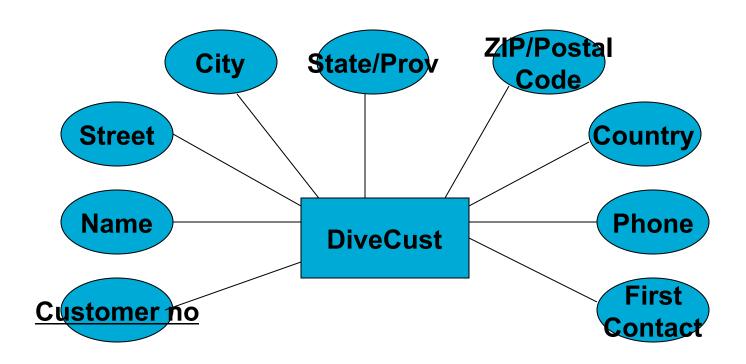


- Customer
- Dive Order
- Line item
- Shipping information
- Dive Equipment/ Stock/Inventory
- Dive Locations

- Dive Sites
- Sea Life
- Shipwrecks

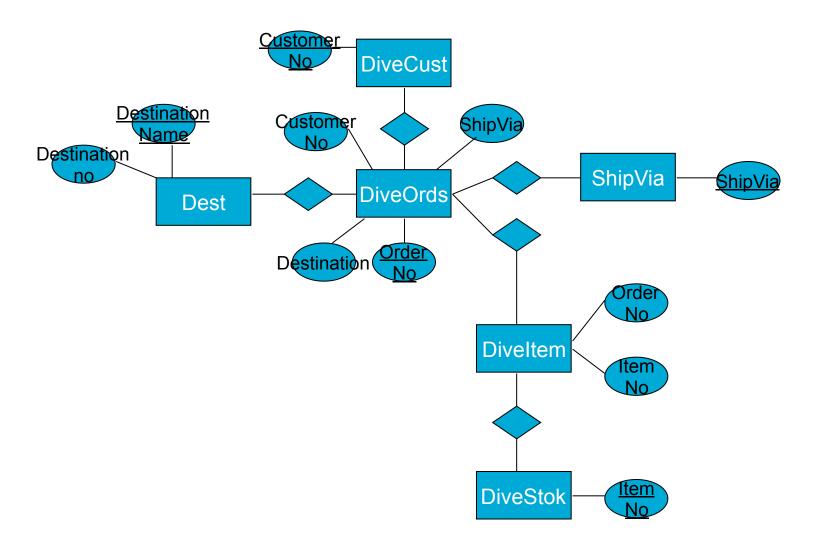
Diveshop Entities: DIVECUST





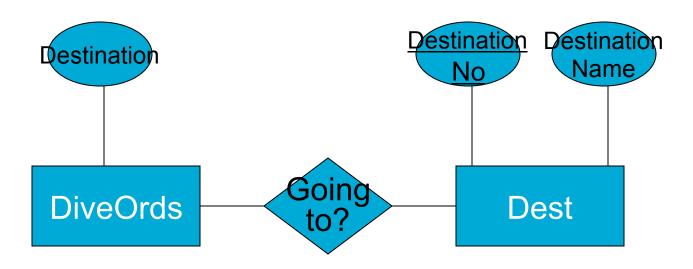
Ordering: Full ER





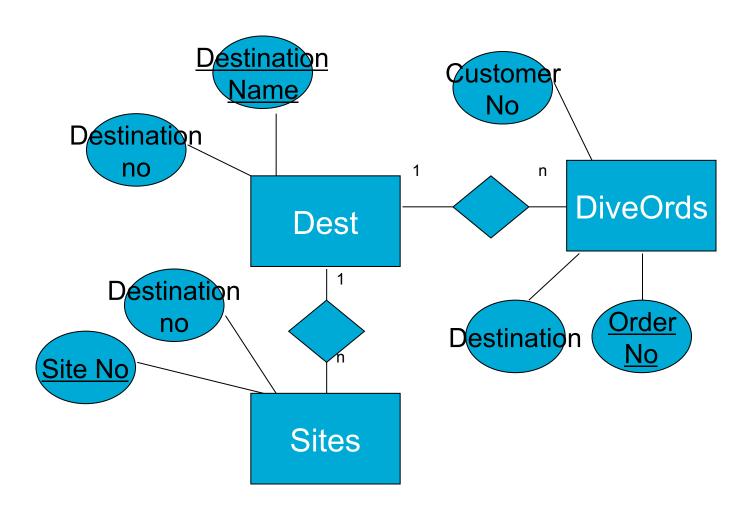
Location/Site Selection





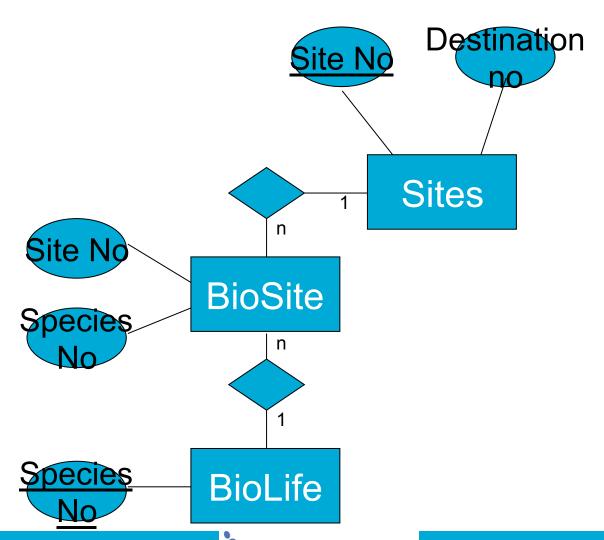
Destination/ Sites





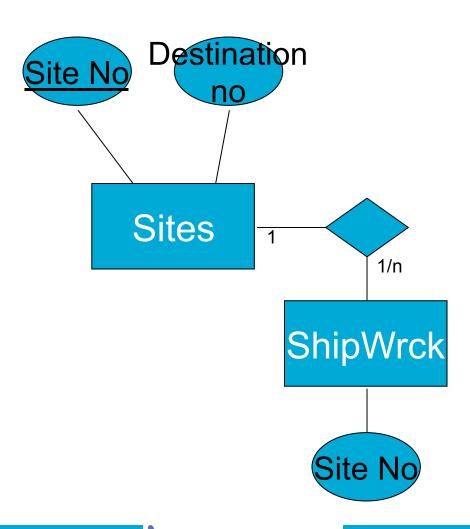
Sites and Sea Life 2





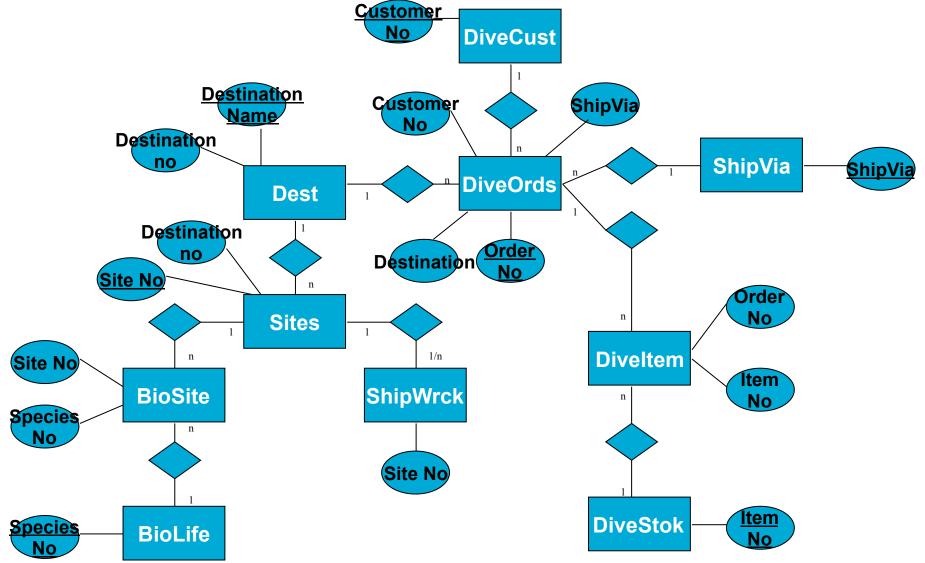
Sites and Shipwrecks





DiveShop ER Diagram





Another ERD Example (Crows Foot)



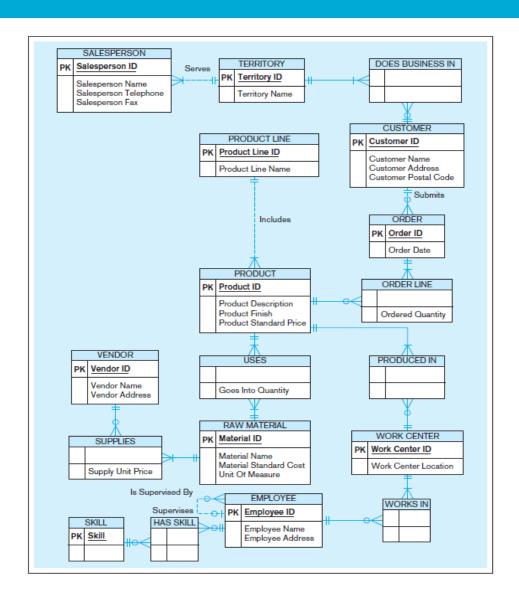


Figure 2-22
Data model for Pine
Valley Furniture
Company in
Microsoft Visio
notation

Different modeling software tools may have different notation for the same constructs.

Online references of E-R diagram



A concise but fairly complete E-R model quick reference:

– http://creately.com/blog/diagrams/er-diagramstutorial/

E-R diagram elements (Chen and crow's foot), with examples

http://www.conceptdraw.com/solution-park/ diagramming-ERD

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Assignment 2b



- Due Friday March 14th
- Personal Database Project Design
- Note: decide groups by February 27th
- The following information should be turned in for the preliminary design of your personal database project.
- 1. A written description of the data you will be using for the database, and what uses you might expect the database to have. (2-4 pages)
- 2. A preliminary data dictionary for the entities and attributes and format of the data elements of the database. You should have at least 5 entities with some logical connections between them. The data dictionary consists of all of the attributes that you have identified for each entity, along with indication of whether the attribute is a primary key (or part of a primary key), and what format the data will be (e.g.: text, decimal number, integer, etc.)
- 3. Produce an entity-relationship diagram of the database *OR* a UML diagram.
 - These will be preliminary design specifications, so do not feel that you must follow everything that you describe here in the final database design.
 - The report should be in PDF format

Assignment 2b – ERD Development



Steps of ERD development (logic flow)

- 1. Identify/define entity types
- 2. Identify/define attributes for each entity type
- 3. Identify/define relationships
- State business rules (that contains meaning of cardinality – "for each instance in A, 1 (or M) instances of B can be related)
- 5. Based on the above, draw the ER diagram

Tools for ER (and UML) diagrams



- Microsoft Visio has a UML-like set of diagramming templates for databases
- For Macs OmniGraffle has UML or spreadsheet templates that can be used for ER diagrams
- DrawlO, Gliffy, Lucidchard
- More sophisticated (and open source) CASE tools are available such as:
 - MySQLWorkbench (for MySQL only)
 - DBDesigner (optimized for MySQL databases)
- Many other drawing packages have ERD available (sometimes as add-ons)

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Object-Oriented Modeling



- Becoming increasingly important as
 - Object-Oriented and Object-Relational DBMS continue to proliferate
 - Databases become more complex and have more complex relationships than are easily captured in ER or EER diagrams

 (Most UML examples based on McFadden, "Modern Database Management", 5th edition)

Object Benefits



- Encapsulate both data and behavior
- Object-oriented modeling methods can be used for both database design and process design
 - Real-World applications have more than just the data in the database they also involve the processes, calculations, etc performed on that data to get real tasks done
 - OOM can be used for more challenging and complex problems

Unified Modeling Language (UML)



- Combined three competing methods
- Can be used for graphically depicting
 - Software designs and interaction
 - Database
 - Processes

CLASS



- A class is a named description of a set of objects that share the same attributes, operations, relationships, and semantics.
 - An object is an instance of a class that encapsulates state and behavior.
 - These objects can represent real-world things or conceptual things.
 - An attribute is a named property of a class that describes a range of values that instances of that class might hold.
 - An operation is a named specification of a service that can be requested from any of a class's objects to affect behavior in some way or to return a value without affecting behavior

UML Relationships



- An relationship is a connection between or among model elements.
- The UML defines four basic kinds of relationships:
 - Association
 - Dependency
 - Generalization
 - Realization

UML Diagrams



- The UML defines nine types of diagrams:
 - activity diagram
 - class diagram
 - Describes the data and some behavioral (operations) of a system
 - collaboration diagram
 - component diagram
 - deployment diagram
 - object diagram
 - sequence diagram
 - statechart diagram
 - use case diagram

Class Diagrams



 A class diagram is a diagram that shows a set of classes, interfaces, and/or collaborations and the relationships among these elements.

UML Class Diagram



DIVEORDS

Order No

Customer No

Sale Date

Shipvia

PaymentMethod

CCNumber

No of People

Depart Date

Return Date

Destination

Vacation Cost

CalcTotalInvoice()
CalcEquipment()

Class Name

List of Attributes

List of operations

Object Diagrams



307:DIVORDS

Order No = 307

Customer No = 1480

Sale Date = 9/1/99

Ship Via = UPS

PaymentMethod = Visa

CCNumber = 12345 678 90

CCExpDate = 1/1/01

No of People = 2

Depart Date = 11/8/00

Return Date = 11/15/00

Destination = Fiji

Vacation Cost = 10000

Differences from Entities in ER



- Entities can be represented by Class diagrams
- But Classes of objects also have additional operations associated with them

Operations



- Three basic types for database
 - Constructor
 - Query
 - Update

Associations



- An association is a relationship that describes a set of links between or among objects.
- An association can have a name that describes the nature of this relationship.
 You can put a triangle next to this name to indicate the direction in which the name should be read.

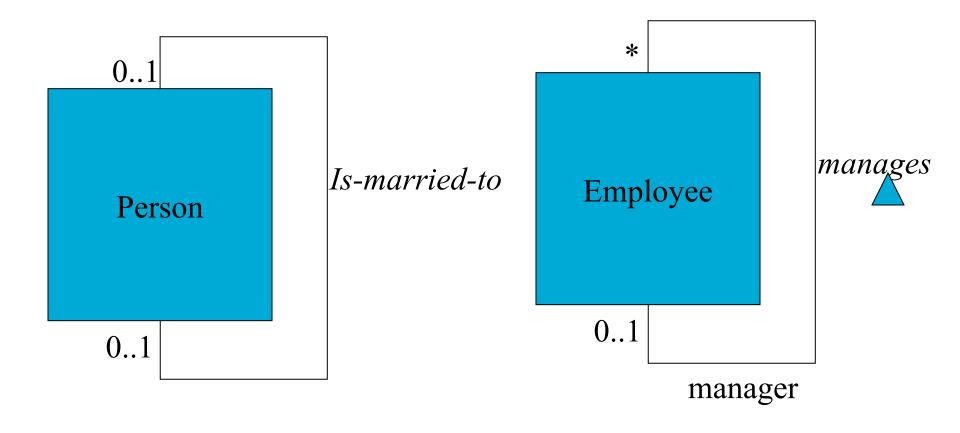
Associations



- An association contains an ordered list of association ends.
 - An association with exactly two association ends is called a binary association
 - An association with more than two ends is called an n-ary association.

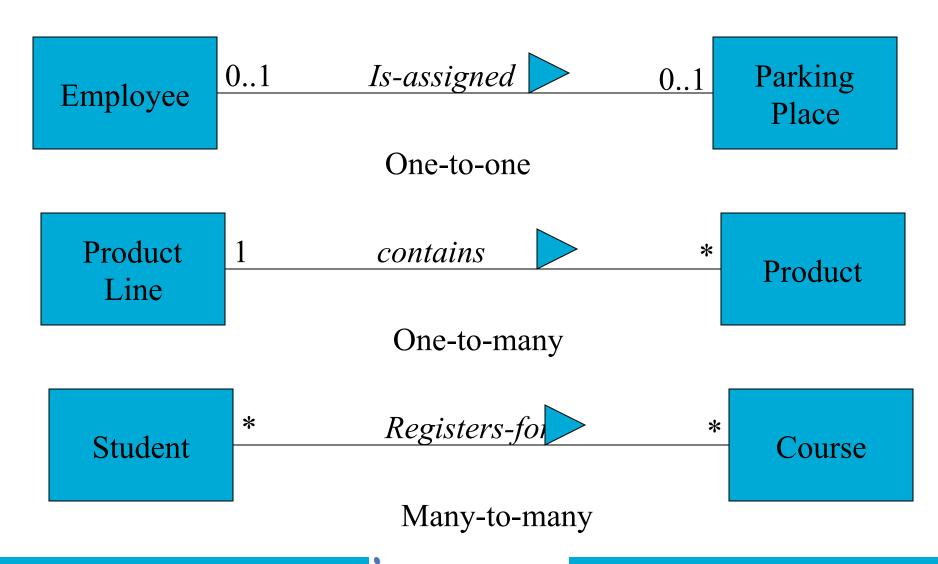
Associations: Unary relationships





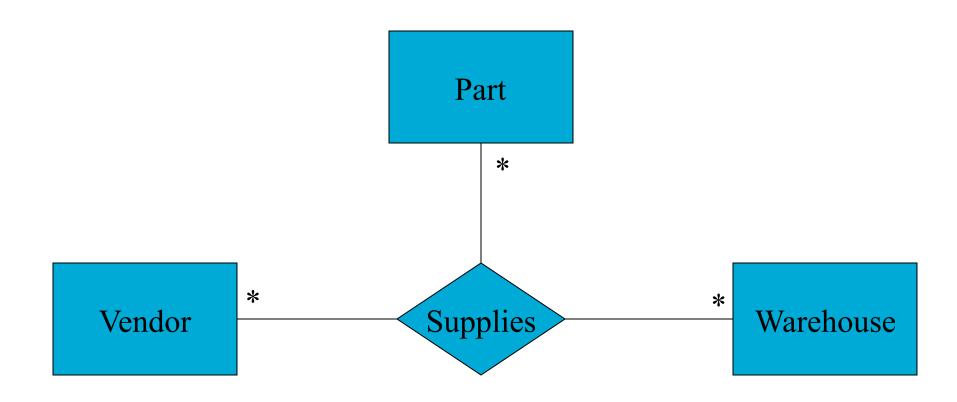
Associations: Binary Relationship





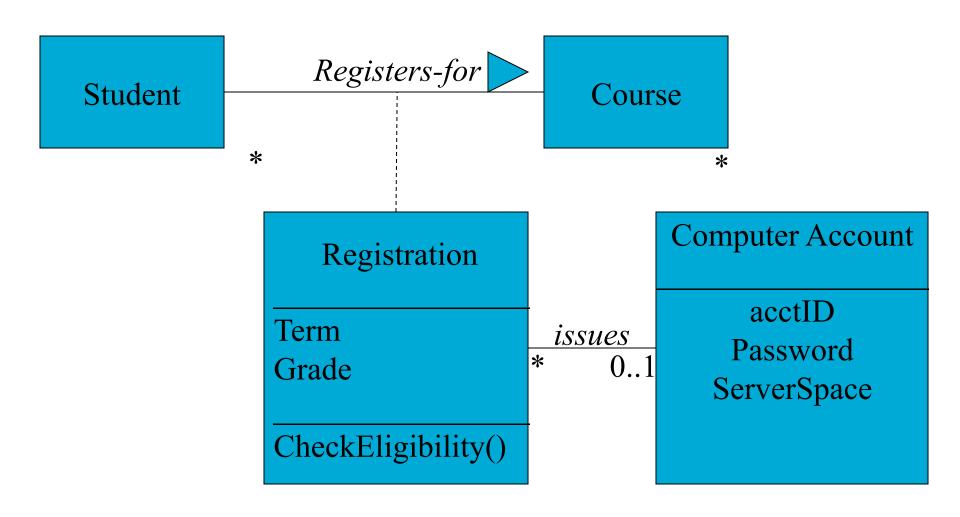
Associations: Ternary Relationships





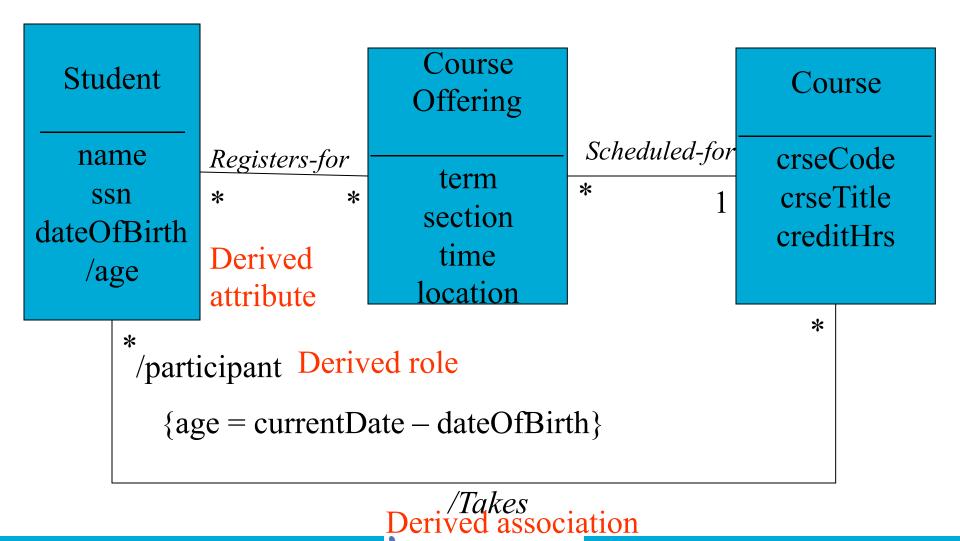
Association Classes





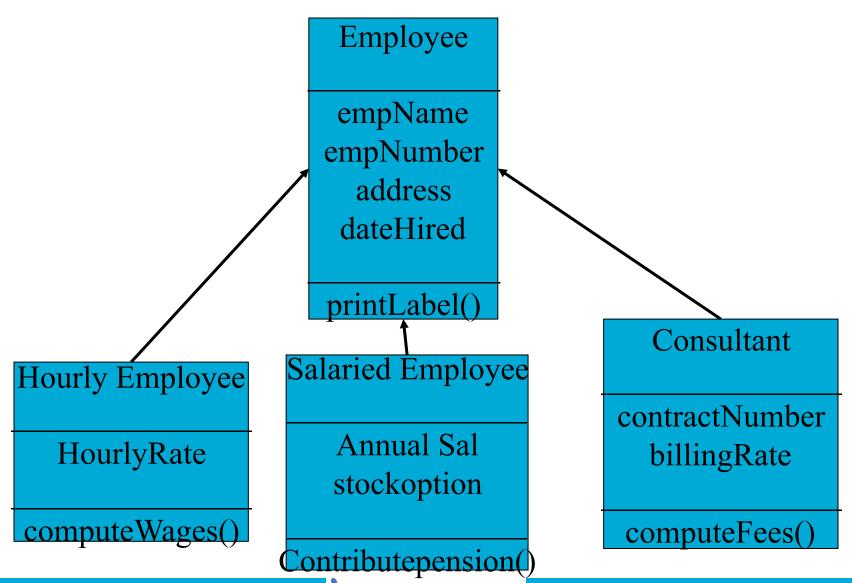
Derived Attributes, Associations, and Roles





Generalization





Other Diagramming methods



- SOM (Semantic Object Model)
- Object Definition Language (ODL)
 - Not really diagramming
- Access relationships display
- Hybrids

Application of SOM to Diveshop



```
DIVECUST
Name 1.1
Address
  Street
  City<sub>1.1</sub>
   StateProvince
   ZIPPostalCode
   Country ...
Phone ...
FirstContact ...
DIVEORDS
```

DIVEORDS



DIVEORDS

OrderNo SaleDate

DIVECUST

SHIPVIA

DESTINATION

DIVEITEM

PaymentMethod CCNumber CCExpDate NoOfPeople DepartDate ReturnDate VacationCost

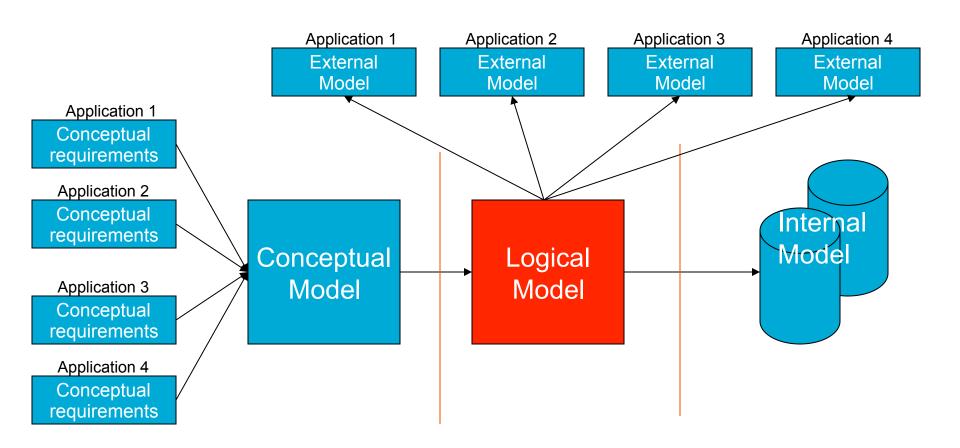
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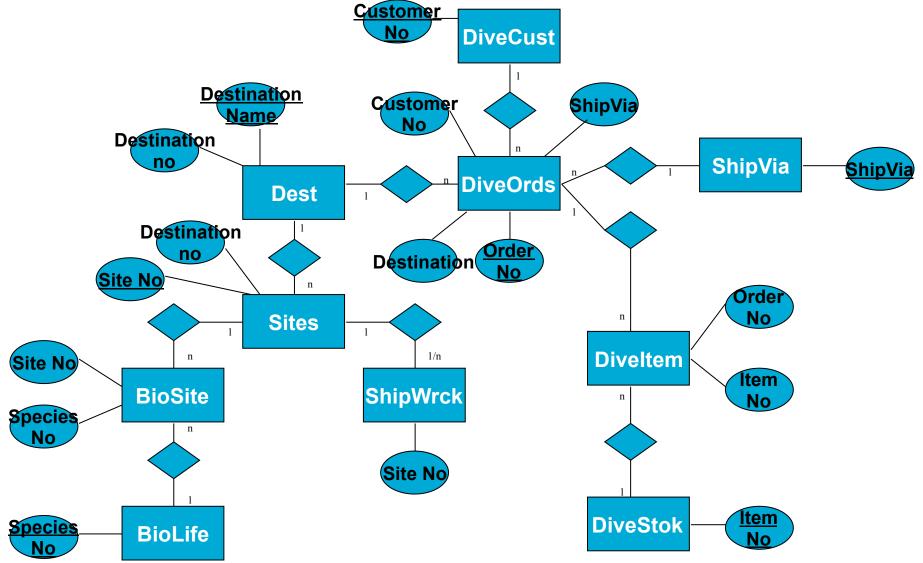
Logical Model: Mapping to a Relational Model



- Each entity in the ER Diagram becomes a relation.
- A properly normalized ER diagram will indicate where intersection relations for many-to-many mappings are needed.
- Relationships are indicated by common columns (or domains) in tables that are related.
- We will examine the tables for the Diveshop derived from the ER diagram

DiveShop ER Diagram





Customer = DIVECUST



Customer	Name	Street	City	State/Prov	Zip/Postal	Country	Phone	First Conta
1480	Louis Jazd	2501 O'Co	New Orlea	LA	60332	U.S.A.	(902) 555-{	1/29/95
1481	Barbara W	6344 W. F	San Franc	CA	95031	U.S.A.	(415) 555-4	2/2/93
1909	Stephen B	559 N.E. 1	Indianapoli	IN	46241	U.S.A.	(317) 555-3	1/5/93
1913	Phillip Dav	123 First S	Berkeley	CA	94704	U.S.A.	(415) 555-(3/9/98
1969	David Burg	320 Montg	Seattle	WA	98105	U.S.A.	(206) 555-7	3/12/99
2001	Mary Riou	1701 Gate	Pueblo	CO	81002	U.S.A.	(719) 555-2	3/15/97
2306	Kim Lopez	14134 Not	Honolulu	HI	96826	U.S.A.	(808) 555-{	1/29/99
2589	Hiram Mar	7233 Mill F	San Franc	CA	94123	U.S.A.	(415) 555-(2/18/99
3154	Tanya Kule	505 S. Flo	New York	NY	10032	U.S.A.	(212) 555-(1/30/99
3333	Charles Se	110 East F	Miller	SD	57362	U.S.A.	(613) 555-4	3/16/98
3684	Lowell Lutz	915 E. Fes	Dallas	TX	75043	U.S.A.	(214) 555-2	2/15/99
4158	Keith Luca	56 South E	Chicago	IL	60542	U.S.A.	(312) 555-4	3/17/98
4175	Karen Ng	2134 Elmh	Klamath F	OR	97603	U.S.A.	(503) 555-4	3/20/99

Dive Order = DIVEORDS



Order No	Customer N	Sale Date	Ship Via	PaymentMe	CcNumber	CcExpDate	No Of Peopl	Depart Date	Return Date	Destination	VacationCos
307	1480	9/1/99	UPS	Visa	12345 678 9	1/1/01	2	11/8/00	11/15/00	Fiji	10000
310	1481	9/1/99	FedEx	Check			1	4/4/00	4/18/00	Santa Barba	6000
313	1909	9/1/99	Walk In	Visa	456456456	9/11/00	4	6/27/00	7/11/00	Cozumel	8000
314	1913	9/1/99	FedEx	Check			3	2/7/00	2/14/00	Monterey	6000
317	1969	9/1/99	FedEx	AmEx	432432432	12/31/02	4	5/9/00	5/16/00	Fiji	20000
320	2001	9/1/99	Walk In	Cash			1	10/10/00	10/17/00	Santa Barba	3000
321	2306	9/1/99	Emery	Master Card	1112223334	8/12/00	1	3/15/00	4/12/00	New Jersey	8000
325	2589	9/1/99	Emery	AmEx	332332332	12/10/99	1	3/15/00	4/12/00	New Jersey	8000
326	3333	9/1/99	FedEx	Money Orde	er		2	2/10/00	2/17/00	Monterey	4000
327	3684	9/1/99	DHL	Master Card	122122321	11/9/99	4	3/10/00	3/23/00	Florida	24000
329	4158	9/1/99	Walk In	Cash			1	5/4/00	5/15/00	Cozumel	1571
330	4175	9/1/99	FedEx	Check			2	7/3/00	7/10/00	Florida	6000
331	5510	9/1/99	FedEx	Money Orde	er		6	6/20/00	6/30/00	Santa Barba	36000
333	5926	9/1/99	DHL	Discover	123123123	12/21/00	2	6/10/00	6/17/00	Fiji	10000

Line item = DIVEITEM



Order No	Item No	Rental/Sal	Qty	Line Note	
307	90010	Rental	4		
307	90020	Rental	1	This is our	most popul
307	90021	Rental	1		
307	90030	Rental	2	These are	our best se
307	90051	Rental	2		
310	90011	Rental	1		
310	90045	Rental	1		
310	90059	Rental	1	A good we	ight belt for
310	90074	Rental	1		
310	90078	Rental	1		
313	90127	Sale	1	Holds 10 c	ubic feet of
314	90072	Rental	3		
314	90094	Rental	3		
314	90100	Rental	3		

Shipping information = SHIPVIA



Ship Via	Ship Cost
DHL	8
Emery	11
FedEx	12
UPS	10
US Mail	6

Dive Equipment Stock= DIVESTOK



Item No	Description	Equipment	On Hand	Reorder Po	Cost	Sale Price	Rental Pric
90010	Shotgun 2	Snorkel	12	2	\$18.00	\$30.00	\$2.00
90011	Shotgun 2	Snorkel	12	2	\$18.00	\$30.00	\$2.00
90012	Shotgun 2	Snorkel	11	2	\$18.00	\$30.00	\$2.00
90020	Tri-Vent Ma	Mask	14	2	\$62.50	\$100.00	\$5.00
90021	Tri-Vent Ma	Mask	10	2	\$62.50	\$100.00	\$5.00
90022	Tri-Vent Ma	Mask	14	2	\$62.50	\$100.00	\$7.00
90023	Quad Visio	Mask	11	2	\$48.25	\$80.00	\$7.00
90024	Quad Visio	Mask	13	2	\$48.25	\$80.00	\$7.00
90025	Quad Visio	Mask	10	2	\$48.25	\$80.00	\$10.00
90030	Sea Wing	Fins	12	2	\$60.00	\$100.00	\$12.00
90031	Sea Wing	Fins	11	2	\$60.00	\$100.00	\$12.00
90032	Sea Wing	Fins	12	2	\$60.00	\$100.00	\$12.00
90033	Jet Fin - B	Fins	14	2	\$30.00	\$60.00	\$10.00
90040	D350 Seco	Regulator	11	1	\$162.50	\$270.00	\$20.00
90041	G250 Seco	Regulator	13	1	\$144.50	\$240.00	\$20.00

Dive Locations = DEST



Destination	Destination	Avg Temp	Avg Temp Sp	oring Ten Sp	ring TenS	Summer Tes	Summer TeFa	ll Temp (F	all Temp (W	inter Ten W	inter Ter Accomoda	Night Life	Body of W	Travel Cost
1	Cozumel	78	25.556	76	24.444	84	28.889	78	25.556	74	23.333Cheap	Sleepy	Caribbean	1000
2	Great Barrie	80	26.667	76	24.444	84	28.889	78	25.556	76	24.444Moderate	Pleasant	Coral Sea	5000
3	Monterey	60	15.556	62	16.667	64	17.778	64	17.778	58	14.444Expensive	Wild	Pacific	2000
4	Santa Barb	75	23.889	73	22.777	78	25.556	72	22.222	70	21.111Expensive	Wild	Pacific	3000
5	Florida	77	25	75	23.889	85	29.444	78	25.556	70	21.111Moderate	Pleasant	Caribbean	3000
6	Fiji	75	23.889	76	24.444	80	26.667	74	23.333	70	21.111Expensive	Sleepy	South Paci	5000
7	New Jersey	57	13.889	57	13.89	60	15.556	58	14.444	53	11.667Expensive	Pleasant	Atlantic	2000

Dive Sites = SITE



Site No	Destination	Site Name	Site Highligh S	it Distan [Distanc	Depth (Depth (m)	Visibility (f1	Visibility (m Current	Skill Level
1001	1	Palancar Reef	Reef	10	16.09	100	30.48	150	45.72Strong	Intermediat
1002	1	Santa Rosa Reef	Reef	8	12.87	80	24.384	150	45.72Strong	Intermediat
1003	1	Chancanab Reef	Reef	4	6.437	60	18.288	100	30.48Mild	Beginning
1004	. 1	Punta Sur	Reef	13	20.92	120	36.576	175	53.34Strong	Advanced
1005	1	Yocab Reef	Reef	6	9.656	50	15.24	100	30.48Mild	Beginning
2001	2	Heron Island	Reef	50	80.47	90	27.432	150	45.72Mild	Intermediat
2002	2	Cod Hole	Fish	45	72.42	50	15.24	150	45.72Mild	Beginning
2003	2	Butterfly Bay	Caves	20	32.19	70	21.336	70	21.336None	Advanced
2004	. 2	Wheeler Reef	Marine Life	30	48.28	50	15.24	125	38.1 Mild	Beginning
2005	2	Watanabe	Marine Life	130	209.2	150	45.72	200	60.96None	Intermediat
3001	3	Point Lobos	Marine Life	3	4.828	60	18.288	75	22.86None	Beginning
3002	3	Macabee Beach	Marine Life	0.1	0.161	40	12.192	40	12.192None	Beginning
3003	3	Pinnacles	Pinnacle	1	1.609	60	18.288	50	15.24Mild	Beginning
3004	. 3	Monastery Beach	Marine Life	3	4.828	50	15.24	40	12.192Surge	Beginning

Sea Life = BIOLIFE



Species No	Category	Common Name	Species Name	Length (c	Length (i	Notes	Graphic
90020	Triggerfish	Clown Triggerfish	Ballistoides conspicillu	50	19.685		
90030	Snapper	Red Emperor	Lutjanus sebae	60	23.622		
90050	Wrasse		Cheilinus undulatus	229	90.157		
90070	Angelfish	Blue Angelfish	Pomacanthus nauarch	30	11.811		
90080	Cod	Lunartail Rockcod	Variola louti	80	31.496		
90090	Scorpionfish	Firefish	Pterois volitans	38	14.961		
90100	Butterflyfish	Ornate Butterflyfish	Chaetodon Ornatissin	19	7.4803		
90110	Shark	Swell Shark	Cephaloscyllium ventr	102	40.157		
90120	Ray	Bat Ray	Myliobatis californica	56	22.047		
90130	Eel		Gymnothorax mordax	150	59.055		
90140	Cod	Lingcod	Ophiodon elongatus	150	59.055		

BIOSITE -- linking relation



Species	No	Site	No
	9001	0	200
	9001	0	2002
	9001	0	2003
	9001	0	2004
	9001	0	200
	9001	0	600
	9001	0	6003
	9001	0	6004
	9001	0	600
	9002	0	200
	9002	0	2002

Shipwrecks = SHIPWRK



Ship Name	Site No	Category	Type	Interest	Tonnage	Length	Length (n	Beam	(Beam (m)	Cause	Date Sunk	Con	Passer	Survivo	Conditio
Delaware	7007	Commercial	Steam Frei	Treasure	1646	252	76.809	6 37	11.277	6Fire			66	66	Broken
F.S.Loop	4004	Commercial	Steam Sch	Machinery	794	193	58.826	4 39	11.887	2Deliberate	1/1/4	7	0		Scattere
Gosford	4001	Commercial	Barque Rig	Fixture	2250	280	85.34	42	12.801	6Fire					Intact
Great Isaac	7002	Commercial	Seagoing ⁷	Fixture	1117	185	56.388	37	11.277	6Collision	4/16/4	7	27	27	Intact
Lizzie D	7001	Commercial	Tug/Rumr	Treasure	122	84	25.603	2 21	6.400	8Unknown	10/19/2	2	8	0	Intact
Mohawk	7004	l Passenger	Ocean Line	Treasure	8140	402	122.529	6 54	16.459	2Collision	1/25/3	5	163	118	Scattere
R.P. Resor	7006	Commercial	l Oil Tanker	Treasure	7450	435	132.58	3 66.8	20.3606	4Military	2/28/4	2	50	2	Broken
Star of Scotl	4002	Passenger	British Q-B	Treasure	1250	263	80.162	4 35	10.66	8Weather	1/22/4	2	5	4	Broken
Tolten	7008	Commercial	Freighter	Fixture	1858	280	85.34	43	13.106	4Military	3/13/4	2	28	1	Intact
USS Moody	4006	Military	WWI Destro	Treasure	1308	314	95.707	2 31	9.448	8Deliberate	1/1/3	3	0		Intact
1/51:554	4000	D	I Ma	T	111	100	40 4005	h 20	7024	OF:	10/17/0	^	2 L	2.5	1

Mapping to Other Models



- Hierarchical
 - Need to make decisions about access paths
- Network
 - Need to pre-specify all of the links and sets
- Object-Oriented
 - What are the objects, datatypes, their methods and the access points for them
- Object-Relational
 - Same as relational, but what new datatypes might be needed or useful (more on OR later)

Next Lecture



- Normalization and the relational model
- Implementing DBs in MySQL