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INFO90002

Database Systems & Information Modelling

Week 5

Physical Database Design



- Physical database design
 - Estimating usage
 - Data types
 - Indexing
 - De-normalisation
- Aims of physical design
 - Translate the logical description of data into the technical specifications for storing and retrieving data on disk
 - Create a design for storing data that will provide good performance and insure database integrity, recoverability and security

Inputs

- Normalised data model
- Attribute definitions
- Volume estimates
- Response time expectations
- Data security needs
- Backup/recovery needs
- Integrity expectations
- DBMS used

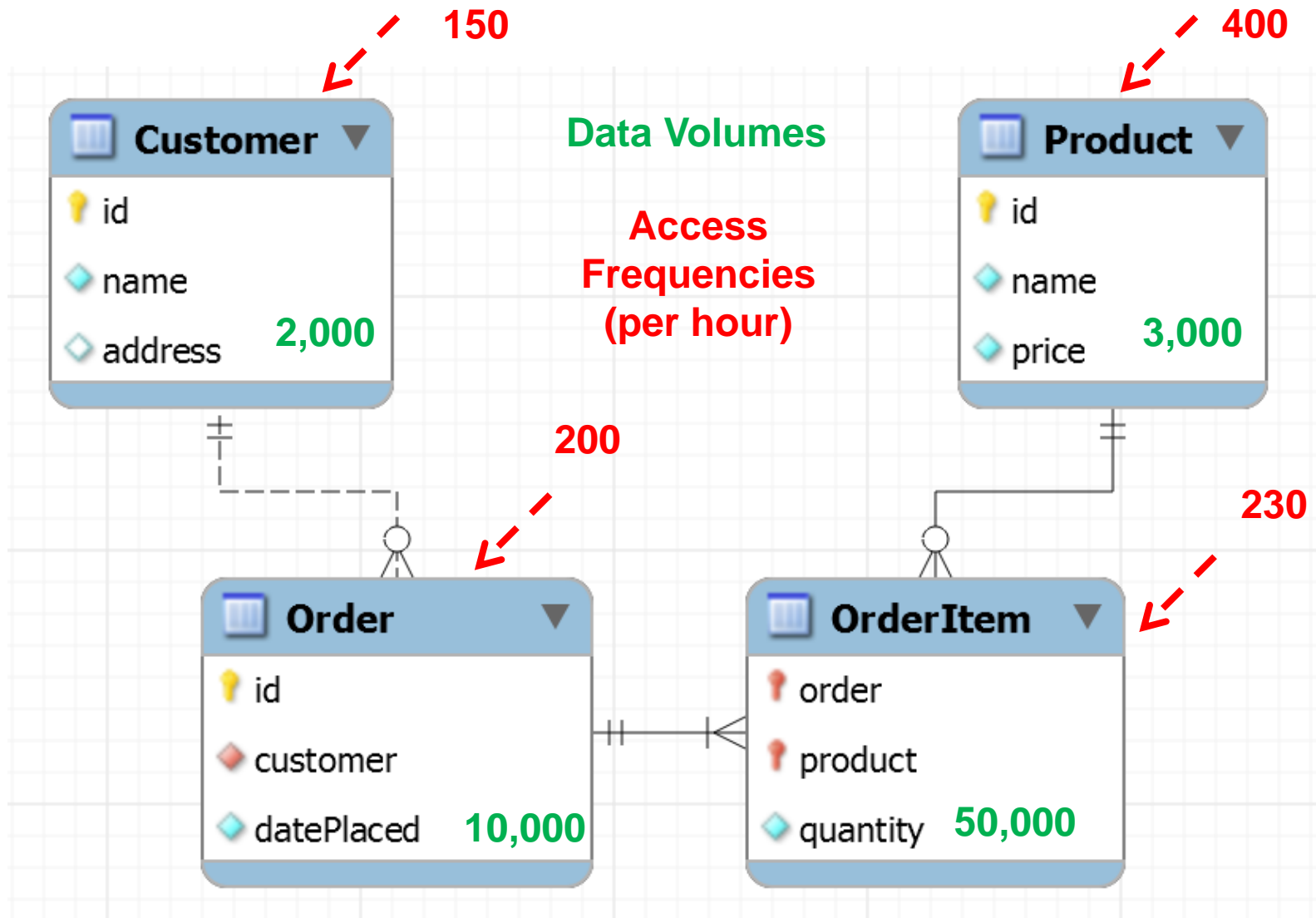


leads to

Decisions

- Attribute data types
- Physical record descriptions (doesn't always match logical design)
- File organisations
- Indexes
- Query optimisation

Estimating Usage





- Column: smallest unit of data in database
- Data types help DBMS to store and use information efficiently
- You should choose data types that:
 - enforce data integrity (quality)
 - can represent all possible values
 - support all required data manipulations
 - minimize storage space
 - maximize performance (e.g. fixed or variable length)
- The major data types are:
 - text or character
 - number
 - dates and time

- **CHAR(M):** A fixed-length string that is always right-padded with spaces to the specified length when stored on disc. The range of M is 1 to 255.
- **CHAR:** Synonym for CHAR(1).
- **VARCHAR(M):** A variable-length string. Only the characters inserted are stored – no padding. The range of M is 1 to 65535 characters.
- **BLOB, TEXT:** A binary or text object with a maximum length of 65535 (2^{16}) bytes (blob) or characters (text). Not stored inline with row data.
- **LOB, LONGTEXT:** A BLOB or TEXT column with a maximum length of 4,294,967,295 ($2^{32} - 1$) characters.
- **ENUM** ('value1', 'value2', ...) up to 65,535 members.

- Integers

- **TINYINT**: Signed (-128 to 127), Unsigned (0 to 255)
- **BIT, BOOL**: synonyms for TINYINT
- **SMALLINT**:
Signed (-32,768 to 32,767), Unsigned (0 to 65,535 – 64k)
- **MEDIUMINT**:
Signed (-8388608 to 8388607), Unsigned (0 to 16777215 –16M)
- **INT / INTEGER**:
Signed (-2,147,483,648 to 2,147,483,647),
Unsigned (0 to 4,294,967,295 – 4G or 2^{32})
- **BIGINT**:
Signed (-9223372036854775808 to 9223372036854775807),
Unsigned (0 to 18,446,744,073,709,551,615 - 2^{64})
- **Don't** use the “(M)” number for integers

- Real numbers (fractions)
 - **FLOAT**: single-precision floating point, allowable values: - 3.402823466E+38 to -1.175494351E-38, 0, and 1.175494351E-38 to 3.402823466E+38.
 - **DOUBLE / REAL**: double-precision, allowable values: - 1.7976931348623157E+308 to -2.2250738585072014E-308, 0, and 2.2250738585072014E-308 to 1.7976931348623157E+308.
 - optional M = number of digits stored, D = number of decimals.
 - Float and Double are often used for scientific data.
 - **DECIMAL[(M[,D])]**: fixed-point type. Good for money values.
 - M = precision (number of digits stored), D = number of decimals

- **DATE** 1000-01-01 to 9999-12-31
- **TIME** -838:59:59 to 838:59:59
(time of day or elapsed time)
- **DATETIME** 1000-01-01 00:00:00 to
9999-12-31 23:59:59
- **TIMESTAMP** 1970-01-01 00:00:00 - ~ 2037
Stored in UTC, converted to local
- **YEAR** 1901 to 2155

How is DATETIME different to TIMESTAMP?

- TIMESTAMP is for automatically adding “now” to a row
- DATETIME is for referring to a time in the real world
- since version 5.6.4, both can store fractions of a second

- Index – a separate file that contains pointers to table rows, to allow fast retrieval
- Similar to an index in a book

Index		
<i>Song No.</i>	<i>Title</i>	<i>Page No.</i>
127	Ace In The Hole	37
119	After The Ball	34
94	After You've Gone	27
35	A Good Man Is Hard To Find	13
11	Ain't She Sweet?	7
4	Ain't We Got Fun?	5
134	Alabama Bound	39
54	Alexander's Ragtime Band	17
132	All By Myself	38
84	All Of Me	25
109	Always	31
80	Angry	24
108	Anytime	31
1	April Showers	5
135	Avalon	40
53	Baby Face	17
177	Back In Your Own Back Yard	50
128	Ballin' The Jack	36
63	Beer Barrel Polka	19
183	Bill Bailey	52
123	Button Up Your Overcoat	35
103	Bye Bye Blackbird	29
26	Bye Bye Blues	11
100	By The Light Of The Silvery Moon	29
113	Carolina Moon	32
18	Carolina In The Morning	9
96	Cecelia	28
130	Coney Island Babe	38
114	Cruising Down The River	32
73	Cuddle Up A Little Closer	20
47	Daisy Bell—(Bicycle Built For Two)	15
141	Darkness On The Delta	41
50	Dark Town Strutters Ball	16
74	Dearie	23
69	Deep In The Heart Of Texas	21

- You choose which columns to index
- PKs and FKs are automatically indexed
- Nominate columns to index when creating tables

Index Name	Type	Index Columns		
PRIMARY	PRIMARY	Column	#	Order
fk_Forum_Moderator...	INDEX	<input type="checkbox"/> Id		ASC
fk_Forum_Moderator...	INDEX	<input checked="" type="checkbox"/> Topic	1	ASC
topicIndex	INDEX	<input type="checkbox"/> WhenCreated		ASC
		<input type="checkbox"/> CreatedBy		ASC
		<input type="checkbox"/> WhenClosed		ASC
		<input type="checkbox"/> ClosedBy		ASC

```
CREATE TABLE IF NOT EXISTS `UniChat`.`Forum` (  
  `Id` INT NOT NULL,  
  `Topic` VARCHAR(100) NULL,  
  `WhenCreated` TIMESTAMP NULL,  
  `CreatedBy` INT NULL,  
  `WhenClosed` TIMESTAMP NULL,  
  `ClosedBy` INT NULL,  
  PRIMARY KEY (`Id`),  
  INDEX `fk_Forum_Moderator1_idx` (`CreatedBy` ASC),  
  INDEX `fk_Forum_Moderator2_idx` (`ClosedBy` ASC),  
  INDEX `topicIndex` (`Topic` ASC),  
  CONSTRAINT `fk_Forum_Moderator1`  
    FOREIGN KEY (`CreatedBy`)  
    REFERENCES `UniChat`.`Lecturer` (`Id`)  
    ON DELETE NO ACTION  
    ON UPDATE NO ACTION,  
  CONSTRAINT `fk_Forum_Moderator2`  
    FOREIGN KEY (`ClosedBy`)  
    REFERENCES `UniChat`.`Lecturer` (`Id`)  
    ON DELETE NO ACTION  
    ON UPDATE NO ACTION)  
ENGINE = InnoDB;
```

When to use Indexes

- use on larger tables
- on columns which are frequently in WHERE clauses
- or in ORDER BY and GROUP BY clauses
- if column has >100 distinct values but not if <30 values

Id	Title	Classification	ReleaseYear	Genre	CostWholesale	PricePerView
1	Titanic	PG	1999	1	5.02	0.67
2	The Lord of the Ring...	PG	2004	2	1.31	0.58
3	Pirates of the Carib...	PG	2006	2	1.49	1.40
4	Harry Potter and the...	PG	2002	3	3.50	0.75
5	Pirates of the Carib...	PG	2007	2	3.06	1.04
6	Harry Potter and the...	PG	2007	4	4.78	1.47
7	Star Wars: Episode I...	PG	2001	5	4.71	0.72
8	The Lord of the Ring...	PG	2003	3	9.23	0.67
9	Jurassic Park	PG	2001	6	2.02	0.72
10	Harry Potter and the...	PG	2006	4	2.41	1.09
11	Spider-Man 3	PG	2007	2	6.00	0.79

Im 2 x



- Limit the use of indexes for *volatile* databases
 - Why?
 - "Volatile" = data are frequently changed
 - When table data are changed
(e.g. by inserts, deletes, updates)
indexes need to be updated

- Normalisation
 - removes data redundancy
 - solves Insert, Update and Delete anomalies
 - makes it easier to maintain information in a consistent state
- However
 - it leads to more tables in the database
 - typically these need to be joined during Selects, which is expensive to do
 - sometimes we decide to 'de-normalize'

Denormalization example: Look-up table

PRODUCT File

Product_No	Description	Finish	...
B100	Chair	C	
B120	Desk	A	
M128	Table	C	
T100	Bookcase	B	
...	

FINISH Look-up Table

Code	Value
A	Birch
B	Maple
C	Oak

Lookup table saves space and improves data consistency, but costs an additional read to obtain actual value

- You might want to de-normalise if
 - database speeds are unacceptable
 - there are going to be very few INSERTs, UPDATEs, or DELETEs
 - there are going to be lots of SELECTs that involve the joining of tables
- Examples
 - one-to-one relationship
 - many-to-many relationship with attributes
 - reference data / lookup table
(1:N relationship where data on 1-side not used in any other relationship)



Normalized relations:

STUDENT

<u>Student_ID</u>	Campus_Address
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APPLICATION

<u>Application_ID</u>	Application_Date	Qualifications	<u>Student_ID</u>
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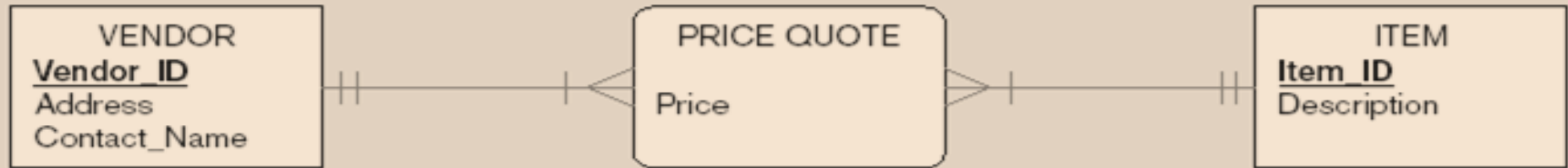
Denormalized relation:

STUDENT

<u>Student_ID</u>	Campus_Address	Application_Date	Qualifications
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and Application_Date and Qualifications may be null

Many-to-Many with non-key attributes



Normalized relations:

VENDOR

<u>Vendor_ID</u>	Address	Contact_Name
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ITEM

<u>Item_ID</u>	Description
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PRICE QUOTE

<u>Vendor_ID</u>	<u>Item_ID</u>	Price
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Extra Table
Access

Denormalized relations:

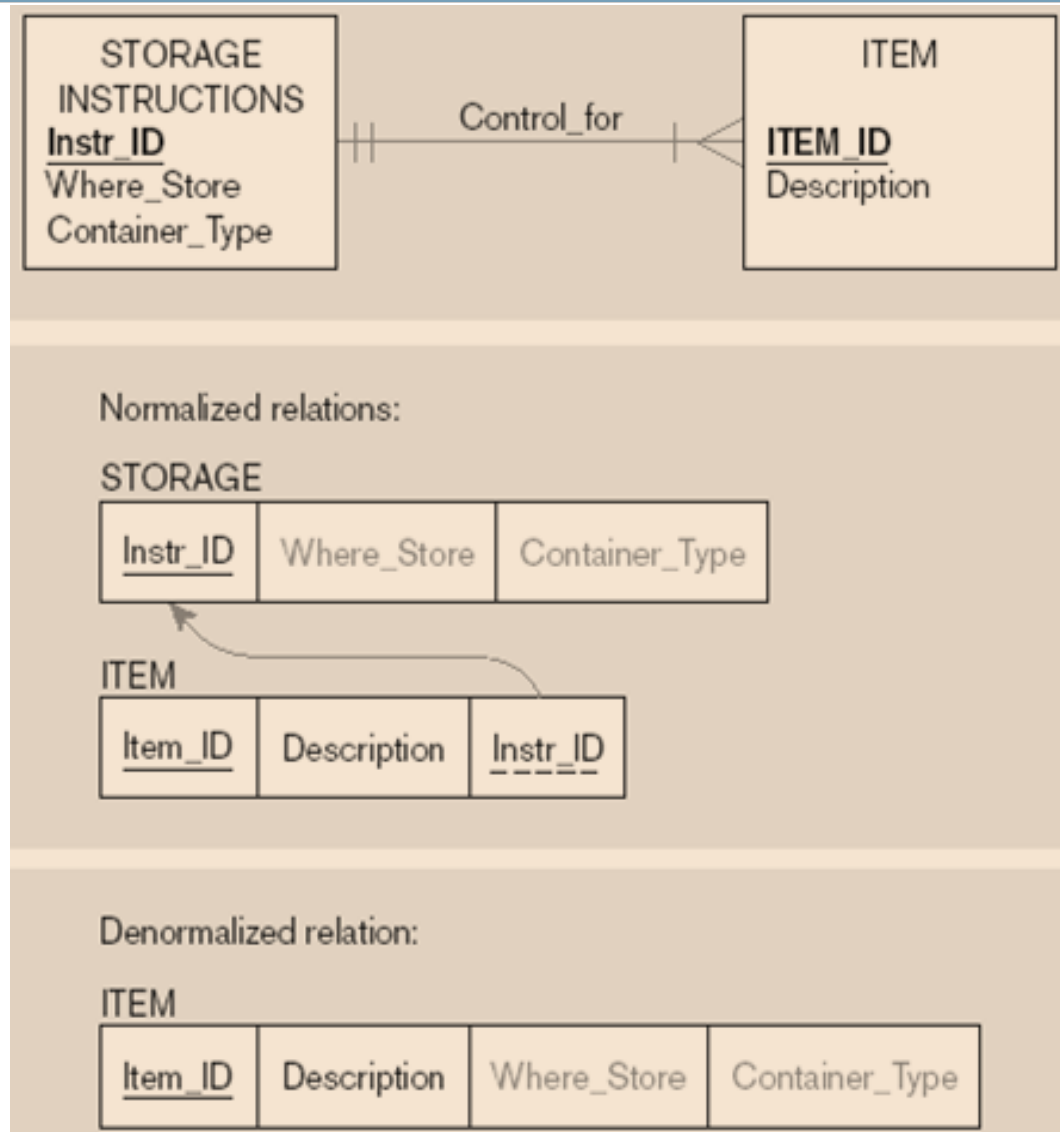
VENDOR

<u>Vendor_ID</u>	Address	Contact_Name
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ITEM QUOTE

<u>Vendor_ID</u>	<u>Item_ID</u>	Description	Price
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Same Item – Many Descriptions



extra table
access
required

data duplication

- Next week we finish learning about data modelling and SQL.
- After that we begin the second half of the subject.
- In week 7 we explore how databases are embedded within larger applications, in particular, web apps