Introduction to SQL

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A little bit of about our group and me

- Research Computing services, visit http://rcs.bu.edu for more info
  - Consulting
  - Training
  - Visualization
  - Optimization
- Experience:
  - Database programming
  - Software development

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Tutorial Outlines

- What is SQL
- SQL History
- Terminology By Examples
- SQL Syntax By Examples
- SQL Category
- Small yet worth noting points
- Tutorial sample db overview
- Schema of the sample db
- Data of the sample db
- Hands on Tutorial Setup

What is SQL (‘Structured Query Language’)?

- SQL stands for ‘Structured Query Language’
- SQL is domain-specific language, NOT a general programming language
  - SQL is specialized to handle ‘structured data’ that follows relational model – data that incorporates relations among entities and variables.
  - Used to interact with relational databases to manage data: create, populate, modify, or destroy data. Also can manage data access

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SQL is a standard language

- Nevertheless, SQL is a ‘language’. It has its language specification – a set of language elements, rules (grammar) and syntax
- Rigid and structural – have both advantages and disadvantages
  - Since the underlying data model is structural, SQL is very ‘structural’ too - requiring rigid predefined *schema* as compared with those of ‘noSQL’
  - Syntax and grammar is also strict
- SQL specific features – triggers, stored procedures

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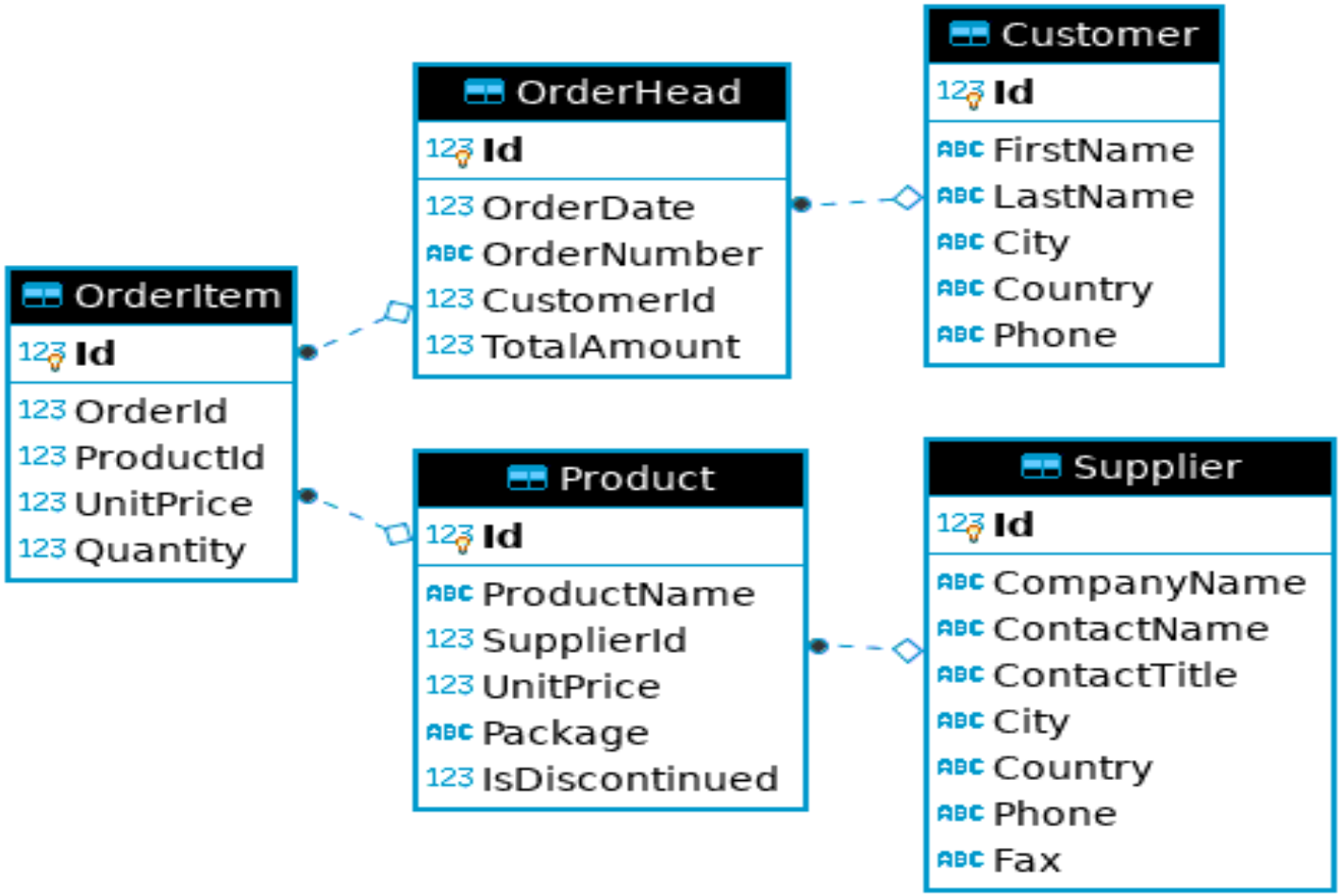
History of SQL

- First developed in 1970s by two scientists at IBM following a theory of ‘relational algebra’ by Edgar F. Codd, who was also an IBM scientist.
- First commercial implementation of SQL-based RDBMS was Oracle’s V2.
- First adopted by ANSI in 1986, and ISO in 1987 as standard.
- The latest version of the SQL standard is from 2016. There have been very many versions in between.
- Though standardized, this does not necessarily mean SQL code can be migrated between different RDBMS seamlessly (Why?)

Terminology - Structure

- Database
- Table
- Column
- Row
- Relation
- Primary key
- Foreign key

Take *sample_ecomm.db* as an Example - schema



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Customer

Id	FirstName	LastName	City	Country	Phone
1	Maria	Anders	Berlin	Germany	030-0074321
2	Ana	Trujillo	México D.F.	Mexico	(5); 555-4729
3	Antonio	Moreno	México D.F.	Mexico	(5); 555-3932
4	Thomas	Hardy	London	UK	(171); 555-7788
5	Christina	Berglund	Luleå	Sweden	0921-12 34 65

Terminology - SQL Language Elements

- Clause
- Statement
- Query
- Function
- Stored Procedure
- Predicate
- Expression
- Keyword
- Identifier

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A SQL Example From Wikipedia

Let's take the following SQL UPDATE statement as an example:

```
UPDATE country
SET population=population+1
WHERE name='USA'
```

A chart showing several of the SQL language elements that compose a single statement
(source: https://wikimedia.org/api/rest_v1/media/math/render/svg/b83ad563285f7b0ebb325226d91f25ca0bffa7cd)

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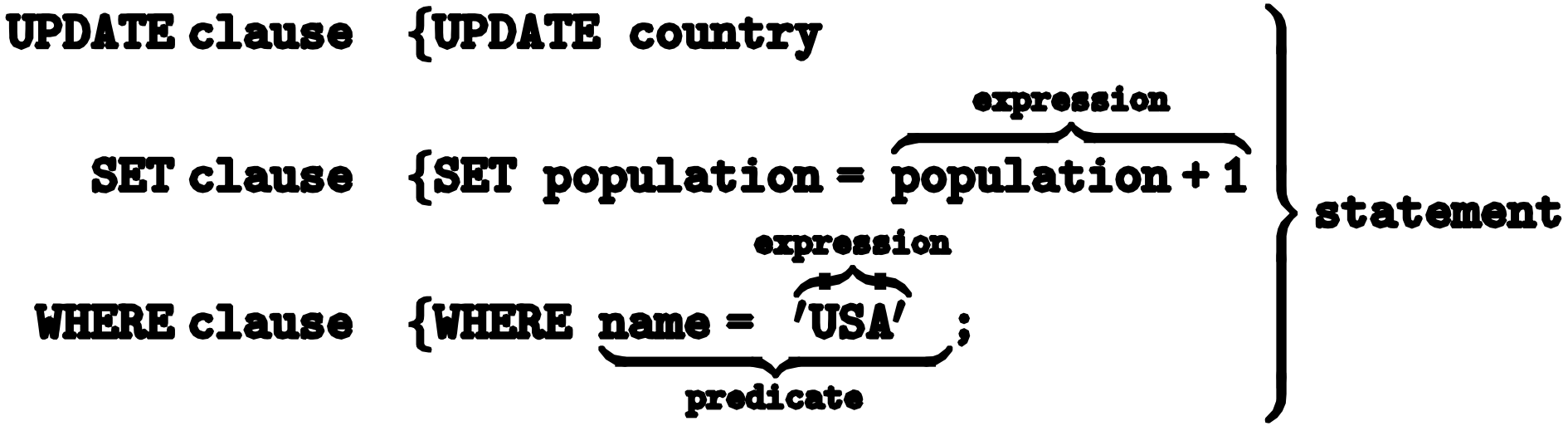
A SQL Example From Wikipedia



A chart showing several of the SQL language elements that compose a single statement
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Our Own Query Example

```
SELECT FirstName, LastName  -- SELECT clause
FROM Customer  -- FROM clause
WHERE Id=1 – WHERE Clause
```

Clean way:

```
SELECT FirstName, LastName FROM Customer WHERE Id=1
```

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Complete Query Statement Syntax – Order Matters !

Clause	Priority	Required?	Covered In Tutorial?
SELECT <*columns*>	5.	Mandatory	✓
FROM <*table*>	1.	Mandatory	✓
WHERE <*predicate on rows*>	2.	Optional	✓
GROUP BY <*columns*>	3.	Optional	✓
HAVING <*predicate on groups*>	4.	Optional, work with GROUP BY	
ORDER BY <*columns*>	6.	Optional	✓
OFFSET	7.	Optional	
FETCH FIRST	8.	Optional	

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SQL Category

1. Data Query Language (DQL) - used to query data
2. Data Manipulation Language (DML) – used to create/modify/destroy data
3. Data Definition Language (DDL) – used to define database schema
4. Data Control Language (DCL) – used for security and access control

Most Important SQL Statements

- **SELECT** - extracts data from a database (DQL)
- **UPDATE** - updates data in a database (DML)
- **DELETE** - deletes data from a database (DML)
- **INSERT** - inserts new data into a database (DML)
- **CREATE DATABASE** - creates a new database (DDL)
- **CREATE TABLE** - creates a new table (DDL)
- **DROP TABLE** - deletes a table (DDL)

Attention Please !

1. SQL keywords and table/column names are **NOT case sensitive**: ‘select’ and ‘SELECT’ are the same
2. values stored in a table can be **case-sensitive** – depending on configuration
3. Usually single quotes (‘’) or double quotes (“”) don’t matter, but could be configured otherwise
4. Semicolon ‘;’ is the standard way to separate SQL statements. It can be required in some DBMS. So always end each statement with a ‘;’ even after a single statement
5. Comments can be used to make SQL more readable. Usually ‘--’ for single line comment, and ‘/*’ and ’*/’ for multiline comments. Add ‘--’ at the beginning to indicate a comment line
6. Use alias to make query clear to understand. “AS” keyword can be omitted sometimes.

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Standard is NOT STANDARD!!

Standard is NOT STANDARD – none of SQL standard is fully implemented by all vendors. Pay attention to the differences that each vendor's implementation has from the SQL 'standard'

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In this Tutorial

- We will use upper-case only in all keywords
- We will use double quotes “” to indicate strings
- We will end each SQL statement with a ‘;’

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Keywords Used in this Tutorial

- INNER JOIN
- SELECT
- *
- FROM
- ORDER BY
- ASC
- DESC
- AND
- OR
- NOT
- WHERE
- LIMIT
- DISTINCT
- AS
- GROUP BY
- ON
- !=
- INSERT
- UPDATE
- DELETE
- CREATE
- TABLE
- LIKE
- %
- INTO
- VALUES
- DROP
- NULL

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Functions Used in this Tutorial

Aggregation Function:

- COUNT()
- MIN()
- MAX()
- AVG()
- SUM()

String Function:

- REPLACE()

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Hands On Demo

Basic	SELECT + WHERE
Aggregation	SELECT + GROUP BY
JOIN	SELECT + JOIN
WRITE Queries	INSERT/UPDATE/DELETE

Read Only

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Tutorial Tools and Files Overview

DB GUI : DB Browser for SQLite

- sufficient yet simple/clean interface for demo purpose
- SQLite engine is already embedded in this tool

Sample DB: sample_ecomm.db

- a simple example e-commerce db. We will explore it a bit more …

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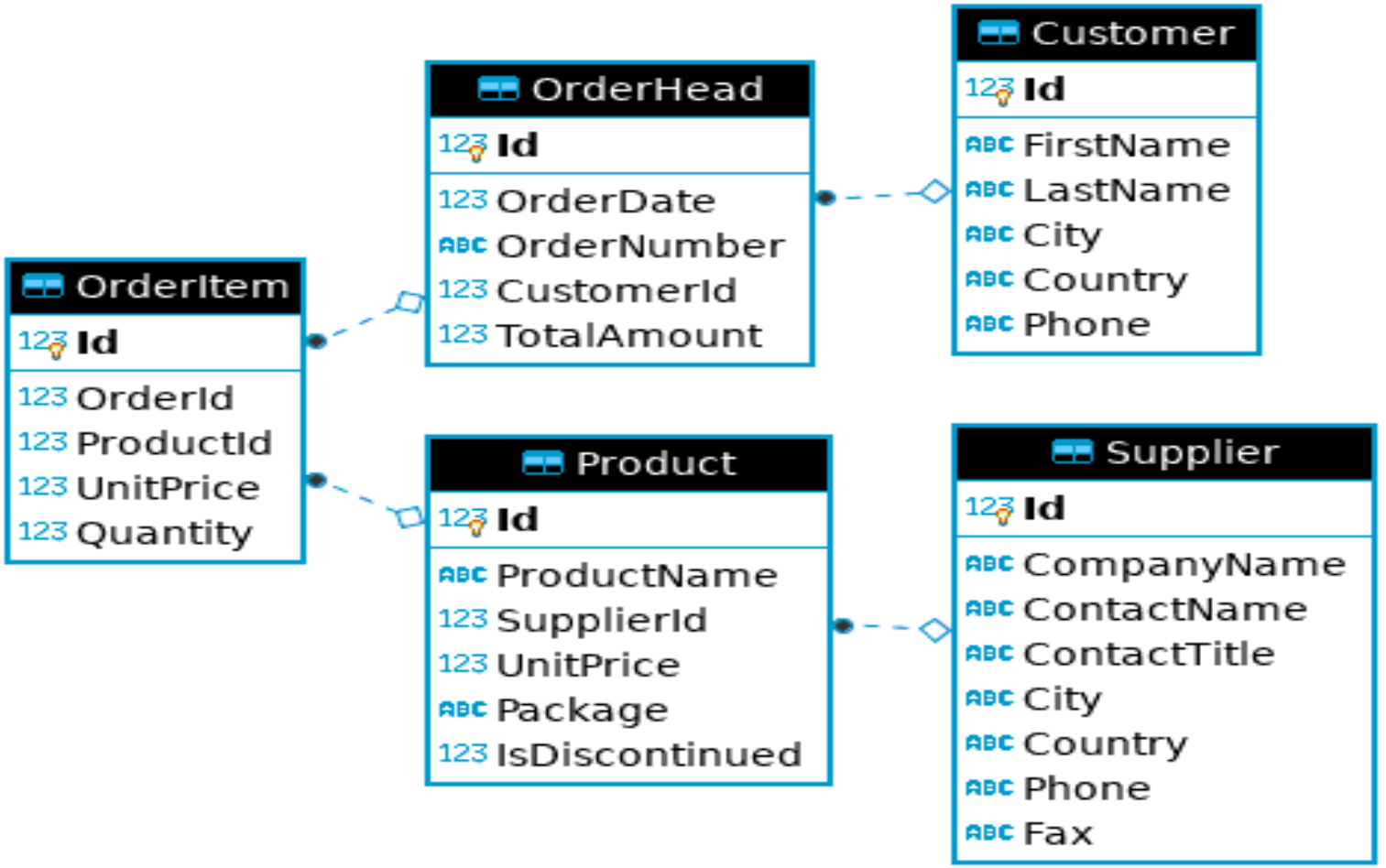
sample_ecomm.db E-R Diagram



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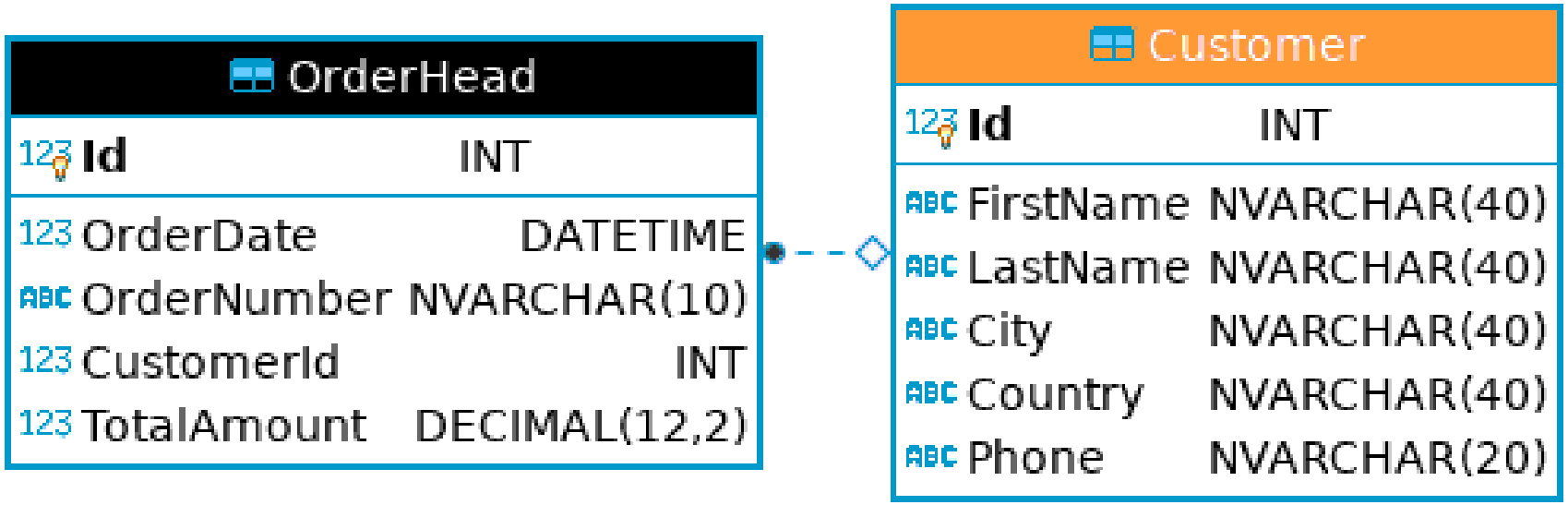
Look Into Individual Table – Customer



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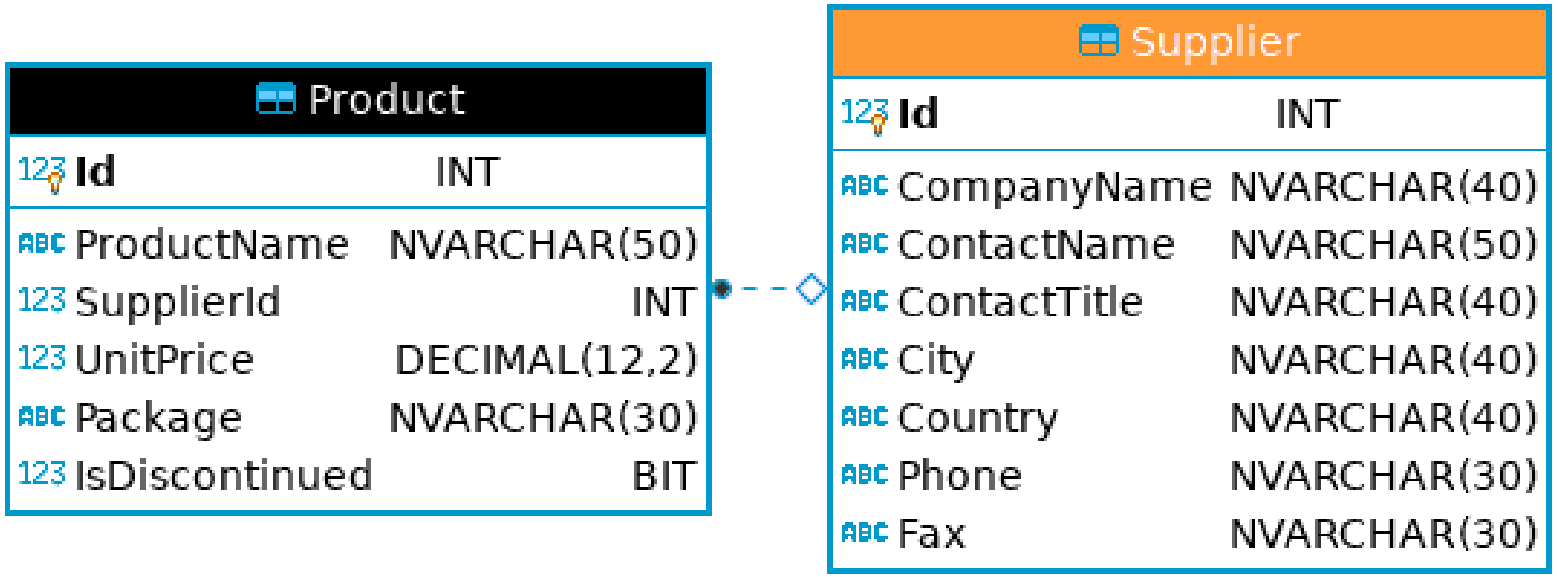
Look Into Individual Table – Supplier



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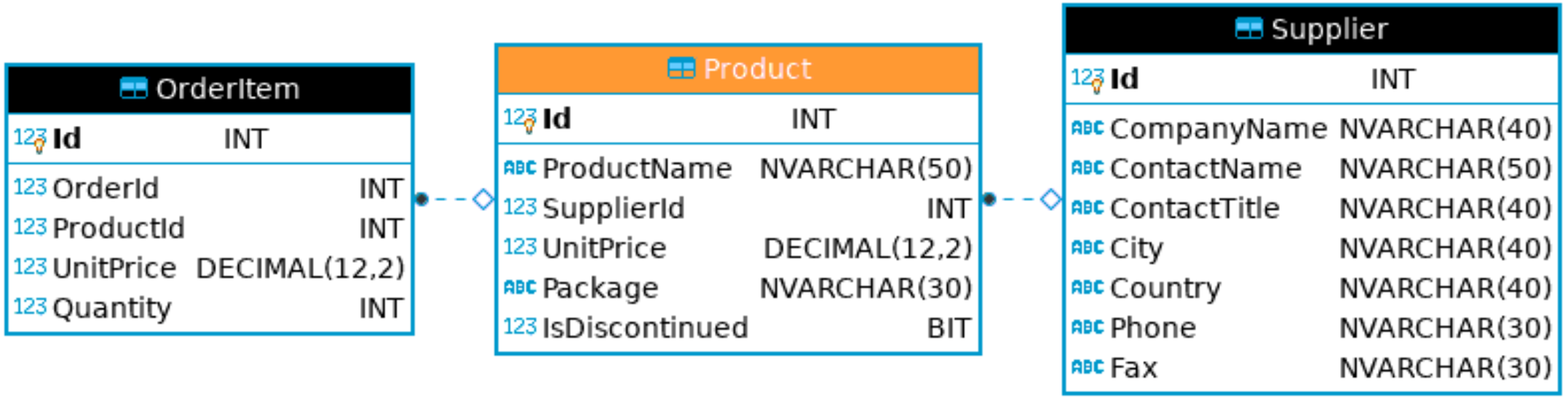
Look Into Individual Table – Product



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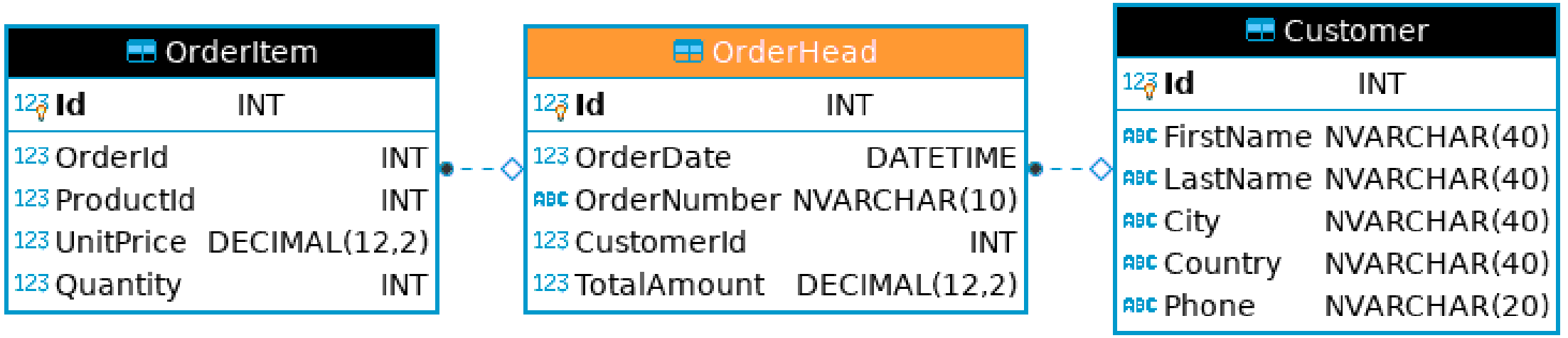
Look Into Individual Table – OrderHead



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Look Into Individual Table – OrderItem

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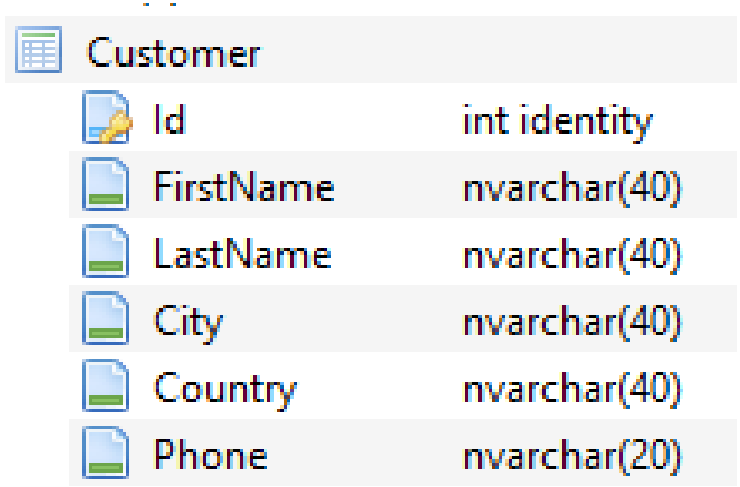
Customer - data view and schema view



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4	Thomas	Hardy	London	UK	(171); 555-7788
5	Christina	Berglund	Luleå	Sweden	0921-12 34 65

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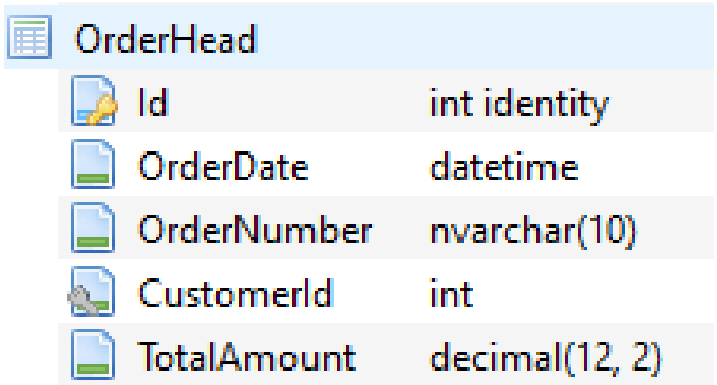
OrderHead - *data view and schema view*



Id	OrderDate	OrderNumber	CustomerId	TotalAmount
1	Jul 4 2012 12:00:00:000AM	542378	85	440
2	Jul 5 2012 12:00:00:000AM	542379	79	1863.4
3	Jul 8 2012 12:00:00:000AM	542380	34	1813
4	Jul 8 2012 12:00:00:000AM	542381	84	670.8
5	Jul 9 2012 12:00:00:000AM	542382	76	3730

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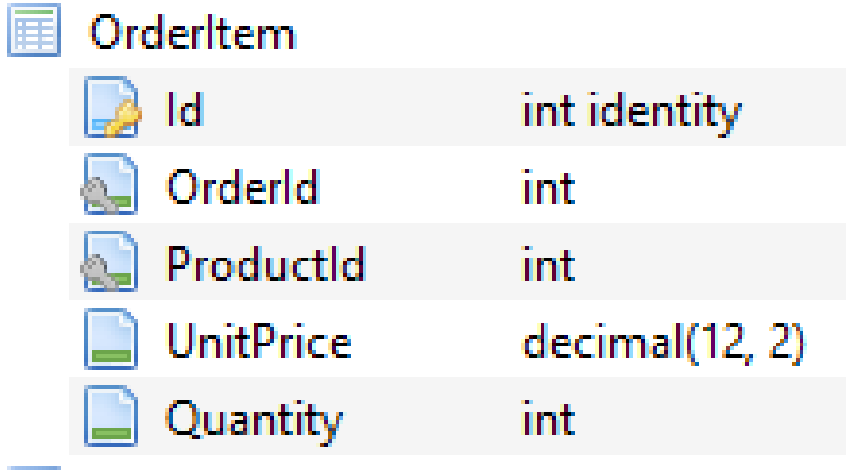
OrderItem - *data view and schema view*



Id	OrderId	ProductId	UnitPrice	Quantity
1	1	11	14	12
2	1	42	9.8	10
3	1	72	34.8	5
4	2	14	18.6	9
5	2	51	42.4	40

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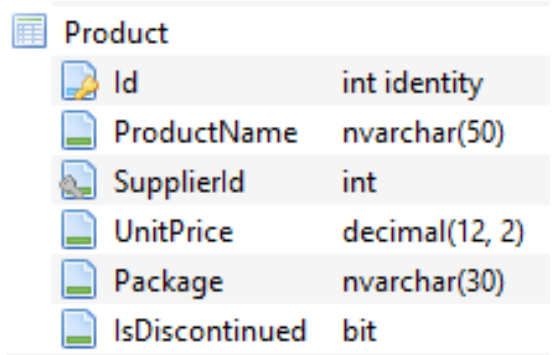
Product - *data view and schema view*



Id	ProductName	SupplierId	UnitPrice	Package	IsDiscontinued
1	Chai	1	18	10 boxes x 20 bags	0
2	Chang	1	19	24 - 12 oz bottles	0
3	Aniseed Syrup	1	10	12 - 550 ml bottles	0
4	Chef Anton's Cajun Seasoning	2	22	48 - 6 oz jars	0
5	Chef Anton's Gumbo Mix	2	21.35	36 boxes	1

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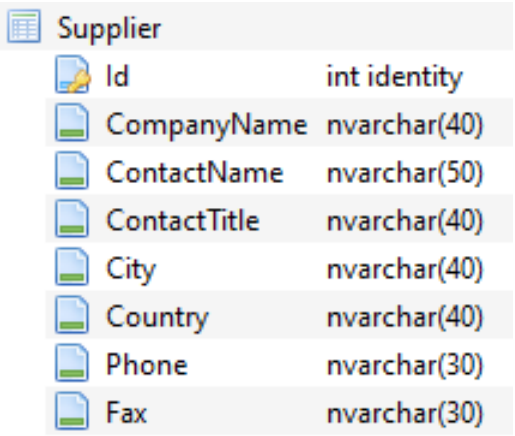
Supplier - *data view and schema view*



Id	CompanyName	ContactName	**ContactTitle**	City	Country	Phone	Fax
24	G'day, Mate	Wendy Mackenzie	*NULL*	Sydney	Australia	(02); 555-5914	(02); 555-4873
25	Ma Maison	Jean-Guy Lauzon	*NULL*	Montréal	Canada	(514); 555-9022	*NULL*
26	Pasta Buttini s.r.l.	Giovanni Giudici	*NULL*	Salerno	Italy	(089); 6547665	(089); 6547667
27	Escargots Nouveaux	Marie Delamare	*NULL*	Montceau	France	85.57.00.07	*NULL*
28	Gai pâturage	Eliane Noz	*NULL*	Annecy	France	38.76.98.06	38.76.98.58

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Tutorial Setup

All the tutorial files can be accessed from:
http://rcs.bu.edu/examples/db/tutorials/intro_to_SQL/

You can download all the tutorial materials as one single package, then unzip it:
http://rcs.bu.edu/examples/db/tutorials/intro_to_SQL/intro_to_SQL.zip

This presentation: presentation/intro2SQL.pdf

DB Browser software tool: tutfiles/software/

Tutorial Sample DB: tutfiles/db/sample_ecomm.db

Demo SQL script: tutfiles/sql/ecomm_demo.sql

Python code snipet: codesnippet/sample_ecomm_python.py

R code snipet: codesnippet/sample_ecomm_Rexample.R

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Some Extra Info

The following pages are some extra information you may be interested in

Point #1: GUI tool is not the only way!

A GUI tool like DB Browser is not the only way to access databases!

There could be many other ways! The following are the two ways:

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SQLite Programming Interface - Python

```
[yshen16@scc-wi2 codesnippet]$ module load python3/3.8.10
[yshen16@scc-wi2 codesnippet]$ ipython
Python 3.8.10 (default, May  3 2021, 17:15:02)
Type 'copyright', 'credits' or 'license' for more information
IPython 7.23.0 -- An enhanced Interactive Python. Type '?' for help.

In [1]: import sqlite3
   ...: ecomm = sqlite3.connect('../db/sample_ecomm.db')
   ...: c = ecomm.cursor()
   ...: id = ('10',)
   ...: c.execute('SELECT * FROM customer WHERE id=?', id)
   ...: print(c.fetchone())
   ...: ecomm.close()
(10, 'Elizabeth', 'Lincoln', 'Tsawassen', 'Canada', '(604); 555-4729')

In [2]: exit()
[yshen16@scc-wi2 codesnippet]$
```

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SQLite Programming Interface - Python

- Just run as normal python script:

```
[yshen16@scc-wi2 codesnippet]$ python sample_ecomm_python.py
(10, 'Elizabeth', 'Lincoln', 'Tsawassen', 'Canada', '(604); 555-4729')
[yshen16@scc-wi2 codesnippet]$
```

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SQLite Programming Interface - R

```
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> #load library
> library(RSQLite)
>
> # create connection
> ecomm <- dbConnect(RSQLite::SQLite(), "sample_ecomm.db")
>
> # query data
> result <- dbGetQuery(ecomm, "SELECT * FROM customer WHERE id=?", params=c(10))
> result
  Id FirstName LastName      City Country           Phone
1 10 Elizabeth  Lincoln Tsawassen  Canada (604); 555-4729
>
> # disconnect db
> dbDisconnect(ecomm)
> q()
```

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Point #2: How to Choose Database Tool

- 1. understand the differences among Database Management Systems (DBMSs)
- 2. Analyze Data
  - a. writing DB/reading DB
  - b. frequency
  - c. application domain (real time/transactional) ?
- 3. Budget and Cost
  - a. initial cost
  - b. maintainence

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Useful Resources:

- This tutorial materials:
  http://rcs.bu.edu/examples/db/tutorials/intro2SQL/
- W3Schools SQL tutorial: https://www.w3schools.com/sql/
- Online cheat sheets:
  https://www.sqltutorial.org/sql-cheat-sheet/
  https://intellipaat.com/mediaFiles/2019/02/SQL-Commands-Cheat-Sheet.pdf
- How to use DB Browser:
  https://datacarpentry.org/sql-socialsci/02-db-browser/index.html

Thank You !!

Please don’t forget to spend some time to give me some feedback at

http://rcs.bu.edu/eval

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