Database Technologies
PG-DAC

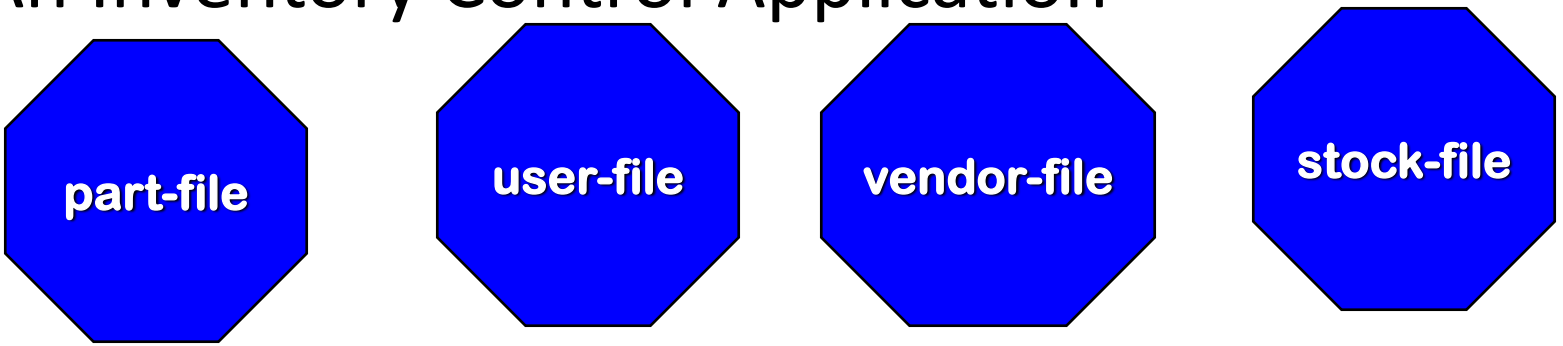
Content

- Introduction to DBMS
- Basic Database Terminology
- Types of DBMS
  - Relational
  - Object Relational
- Introduction to MySQL, MySQL Clients (Monitor, Shell, Workbench)

Conventional Systems

First .....

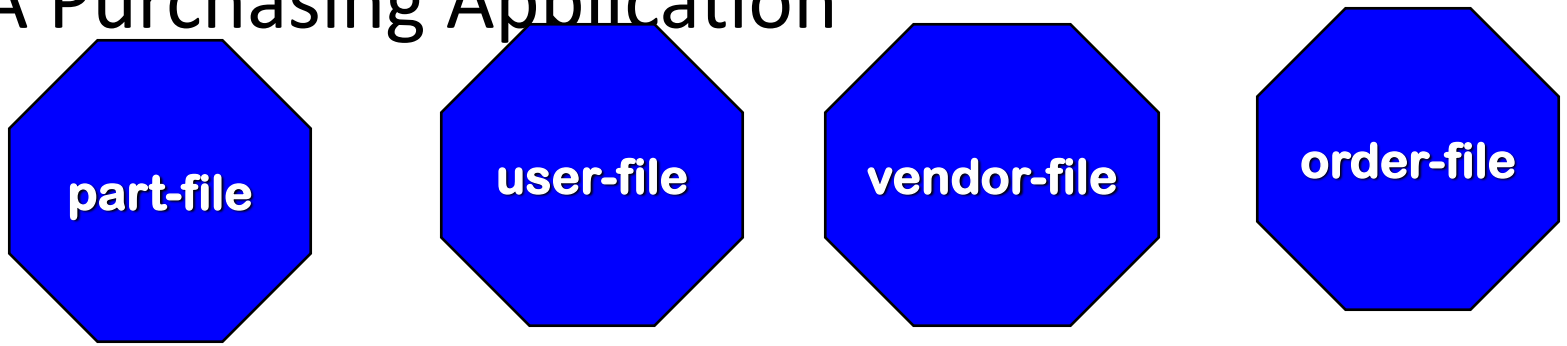
An Inventory Control Application



Conventional Systems

Then .....

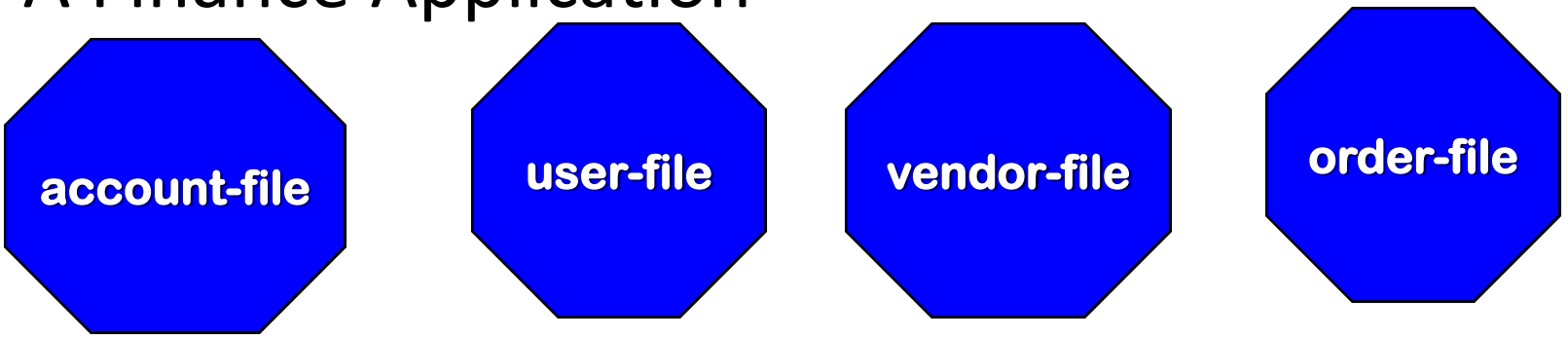
A Purchasing Application



Conventional Systems

and then .....

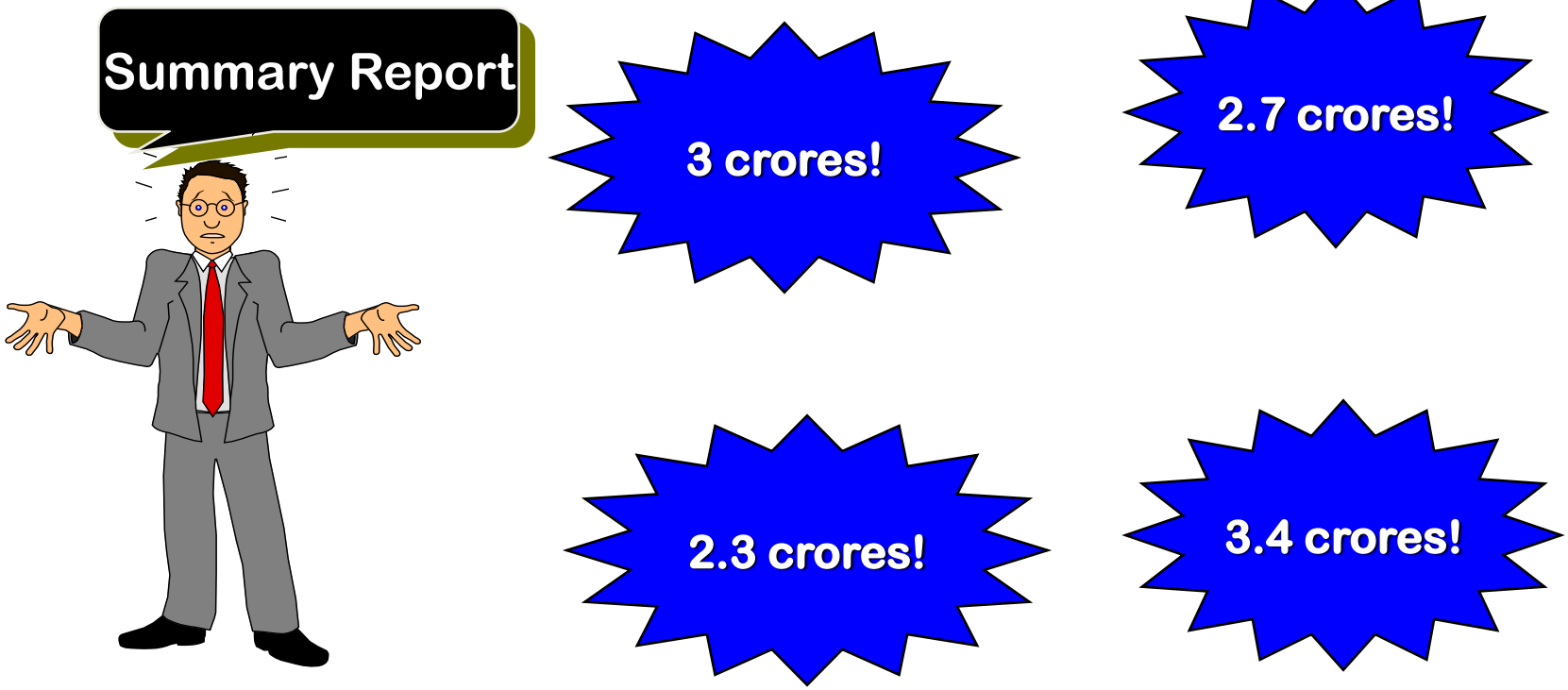
A Finance Application



Conventional Systems

and Now ……

The Information Seeker!



Problems

- Data Redundancy
- No consistency
- No integrity
  - maintaining and assuring the accuracy
- Concurrency related problems
  - Note: OS concurrency never handled database concurrency implementations
- Security – Not everyone should be allowed to access all the data at all the time

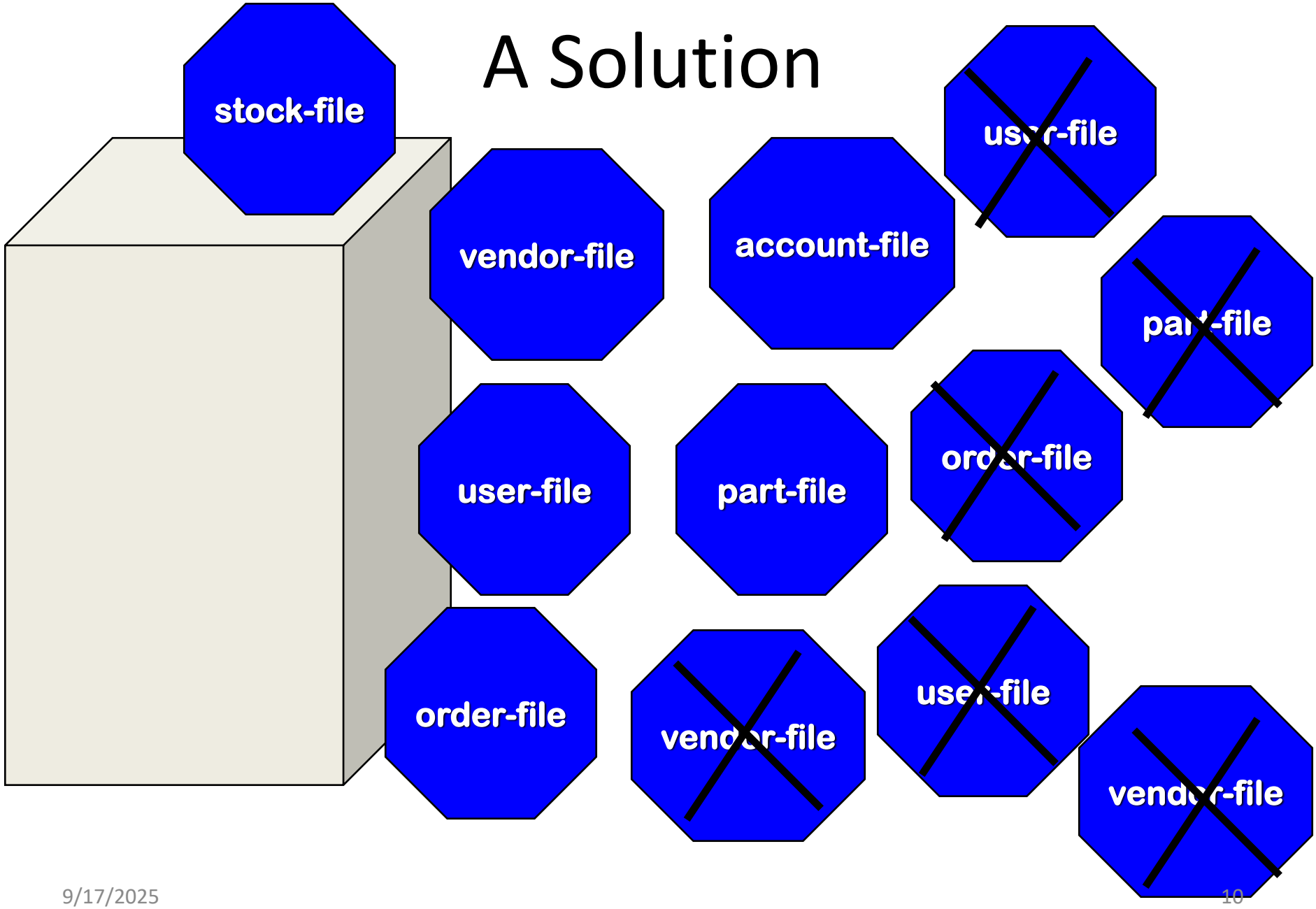
The Causes?

- No sharing
- Data isolation
- Diffused responsibilities
- Poor coordination
- Disorganized developments
- Data redundancy
- Weak integrity

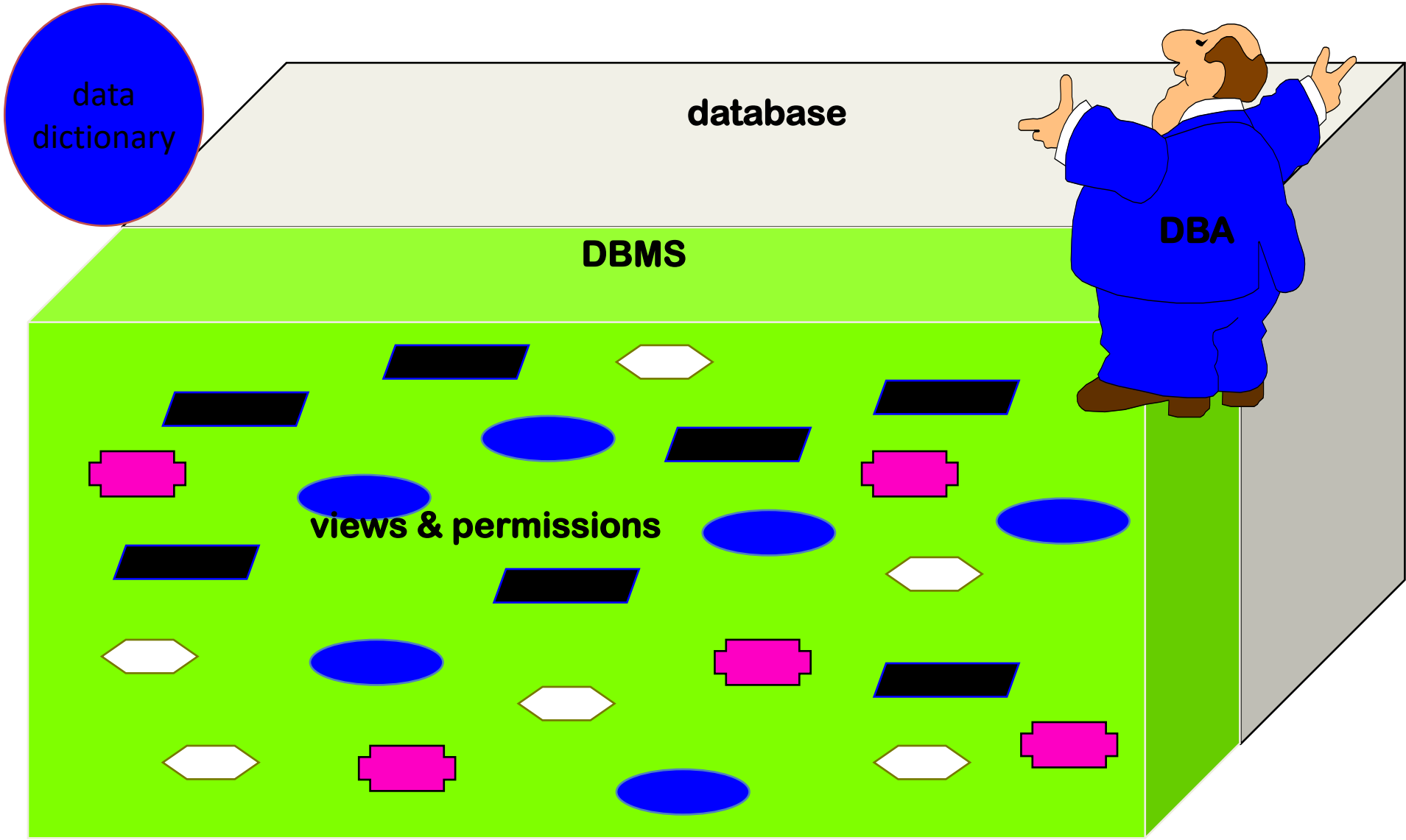
Problems with File systems

- Problems with file processing systems
  - Limited data sharing
  - Poor enforcement of standards
  - Inconsistent data
  - Inflexibility – everything dependent on programs
  - Even simple tasks required extensive programming
  - Security feature practically nil
  - Complex system administration
  - Excessive program maintenance

A Solution


stock-file
vendor-file
account-file
user-file
part-file
user-file
part-file
order-file
order-file
vendor-file
user-file
vendor-file

A Solution



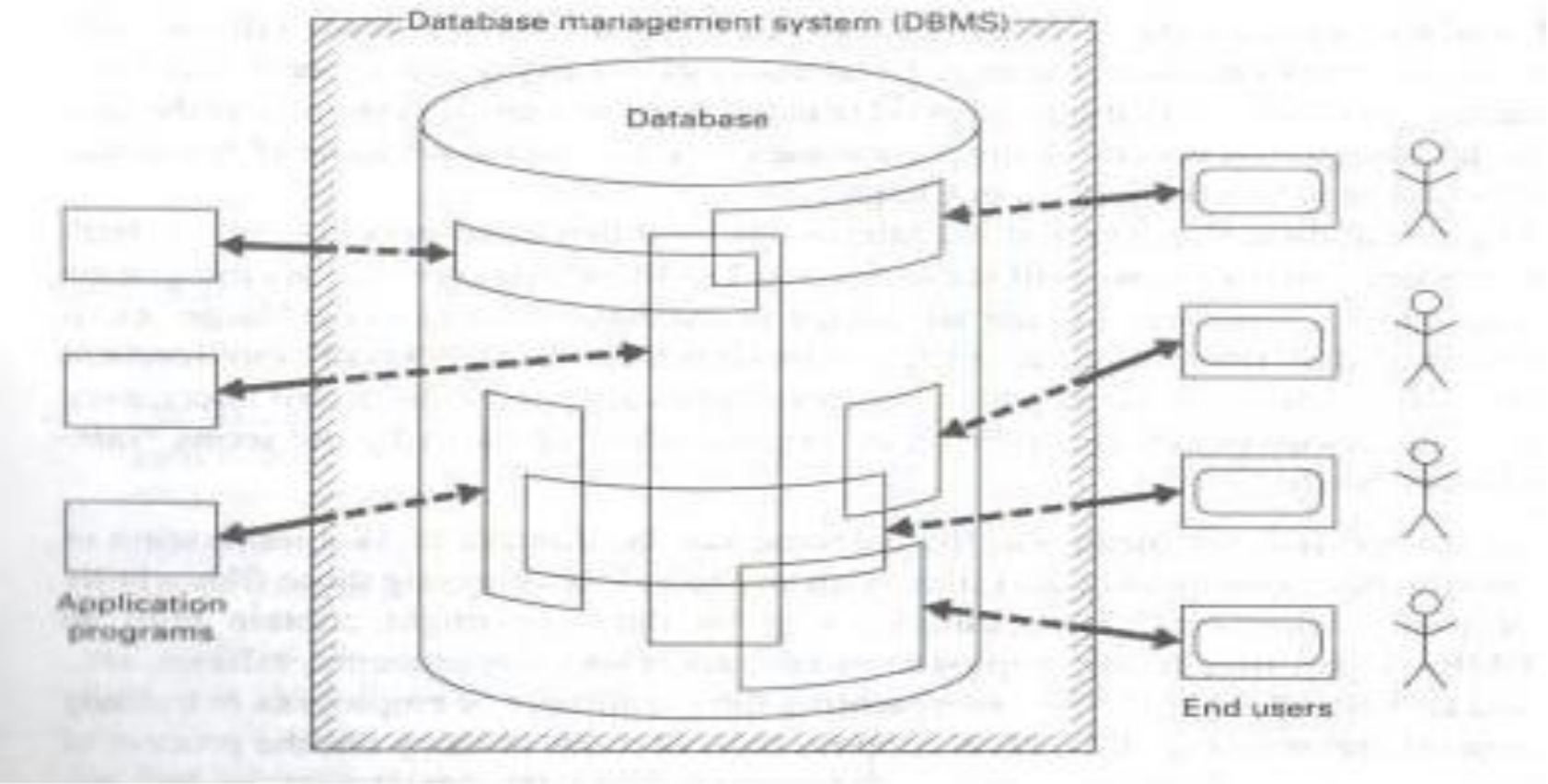
Data, Information, Database

- Data –raw facts
- Information- Result of processing raw data to reveal meaning
- Data is building blocks of information
- Information produced by processing raw data
- Accurate, timely, relevant information is the key to good decision making
- A database is a collection of information that is organized so that it can easily be accessed, managed, and updated.

Introduction to DBMS

- A database management system (DBMS) is system software for creating and managing databases.
- The DBMS provides users and programmers with a systematic way to create, retrieve, update and manage data.

Introduction to DBMS

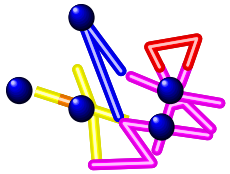


Architecture for a DBMS

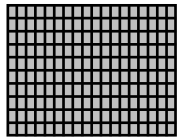
- External view
  - Content of the database as seen by a particular external user defined by external schema
- Conceptual view
  - Abstract view of the physical level defined by conceptual schema
- Internal view
  - Low level representation of the entire database defined by internal schema

Types of databases

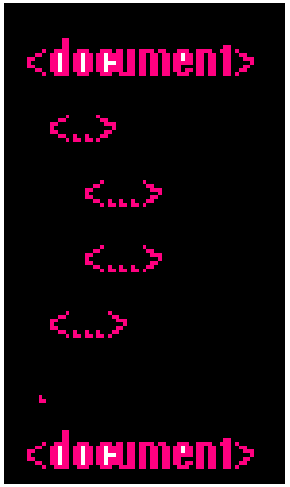
Hierarchical databases



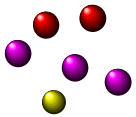
Network databases



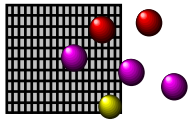
Relational databases



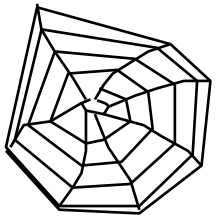
Document-oriented databases



Object databases

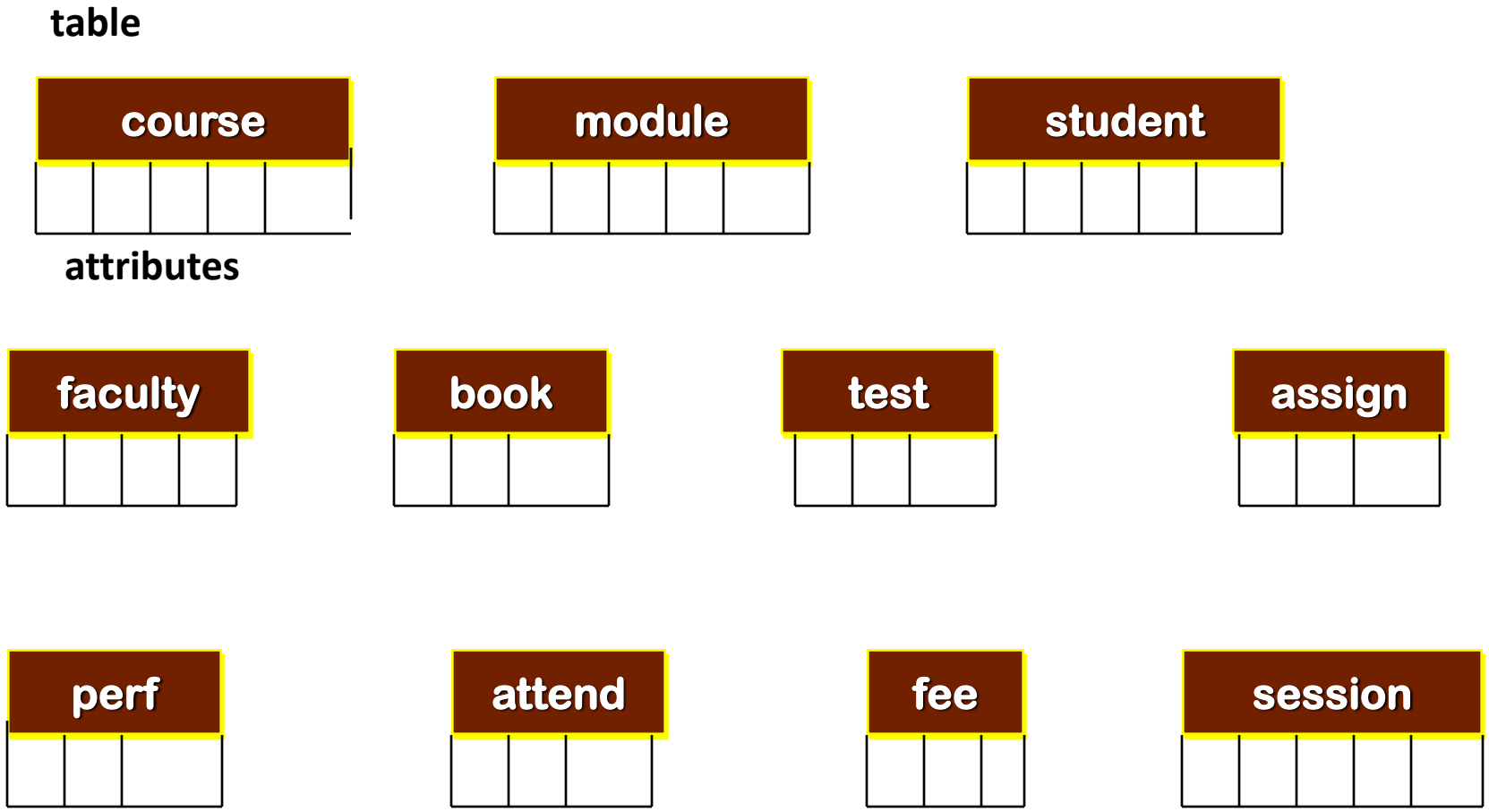


Object-relational databases



Enterprise databases

Relational Model



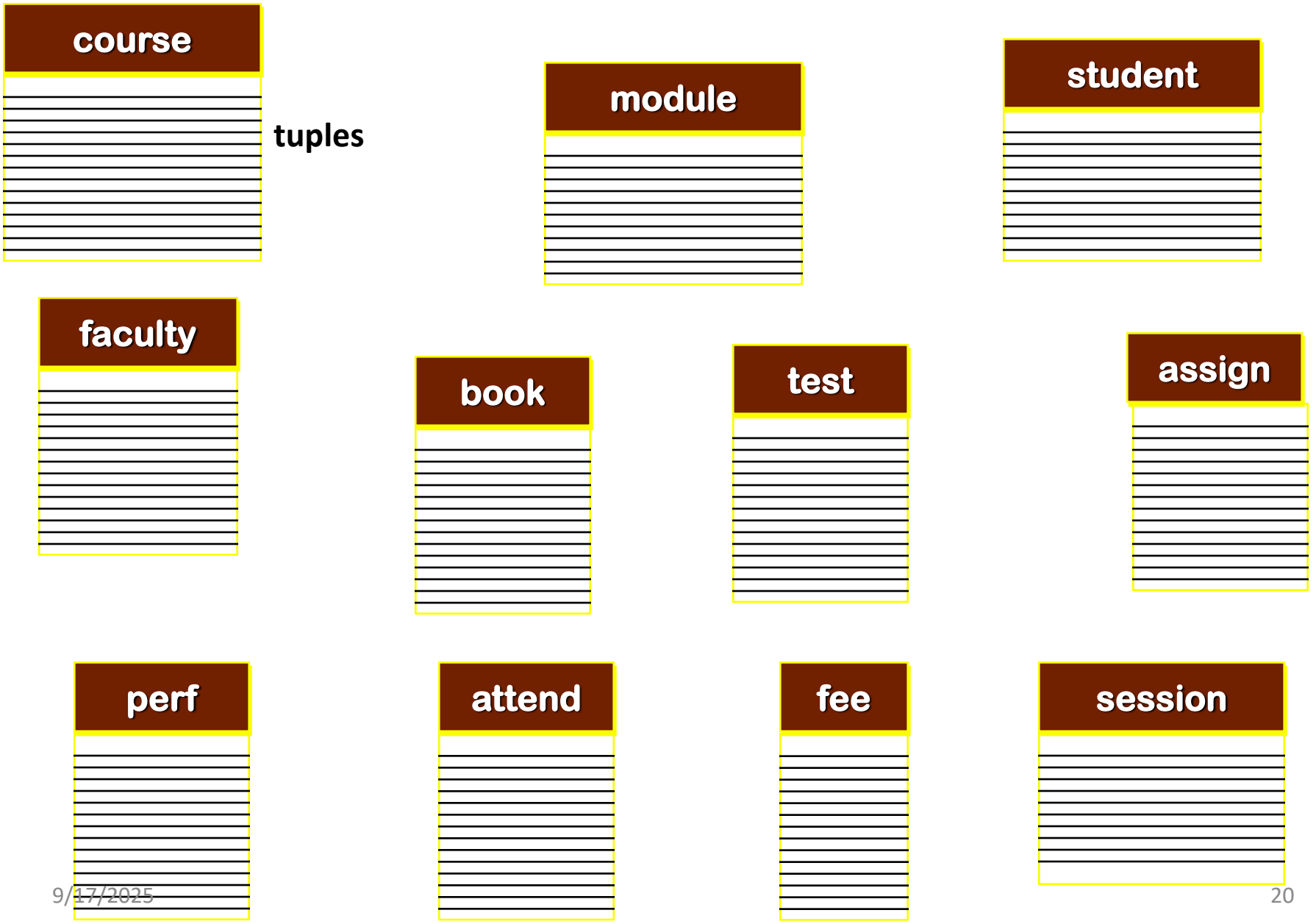
Relational model

- A DBMS is said to be a Relational DBMS(RDBMS) if the database relationships are treated in the form of a table.
- Three keys on relational DBMS
  - Relation
  - Domain
  - Attributes.
- A number of RDBMSs are available, some popular examples are Oracle, MySQL, Sybase, Ingress, Informix, Microsoft SQL Server, and Microsoft Access.

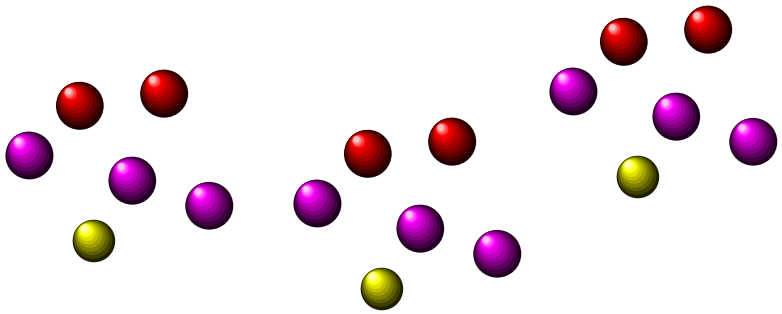
Relational model (contd)

- Properties of Relational Tables:
  - Values Are Atomic
  - Each Row is Unique
  - Column Values Are of the Same Kind
  - The Sequence of Columns is Insignificant
  - The Sequence of Rows is Insignificant
  - Each Column Has a Unique Name

Relational Database



Object-Oriented Model

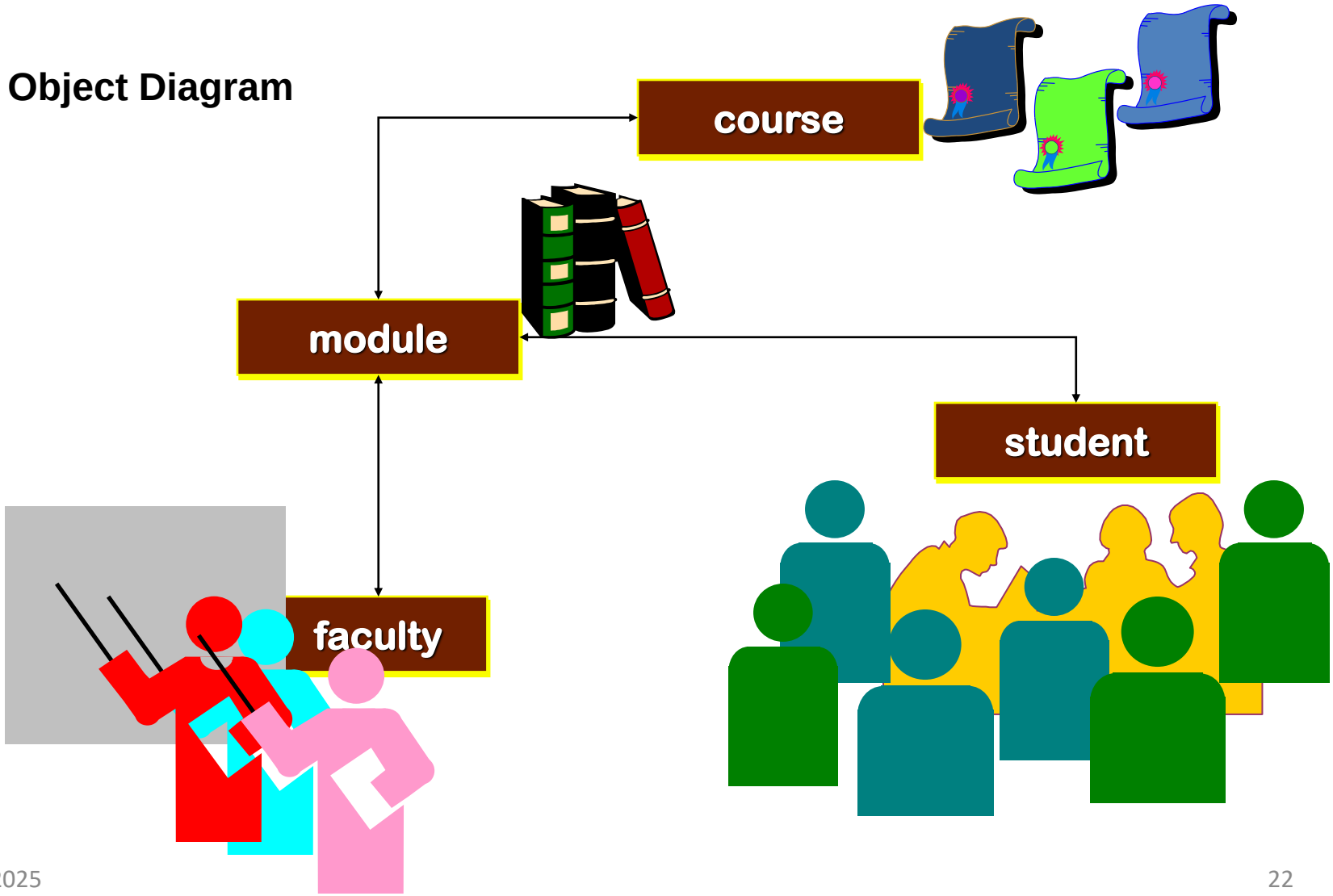


object
databases

attributes
methods

messages

Object Model



Object-Oriented Model

- New user defined data types.
- Complex data types
- Object references and methods
- New capabilities like encapsulation, inheritance etc. for databases.
- Intuitive and Natural Model

What is Object Oriented Database? (OODB)

- A database system that incorporates all the important object-oriented concepts
- Some additional features
- Unique Object identifiers
- Persistent object handling
- Designer can specify the structure of objects and their behavior (methods)
- Better interaction with object-oriented languages such as Java and C++
- Definition of complex and user-defined types
- Encapsulation of operations and user-defined methods

- Queries look very similar in SQL and OQL, sometimes they are the same
- In fact, the results they give are very different Query returns
- Foundation for several OO database management systems – ORACLE8, DB2, etc

OQL	SQL
Object	Tuple
Collection of objects	Table

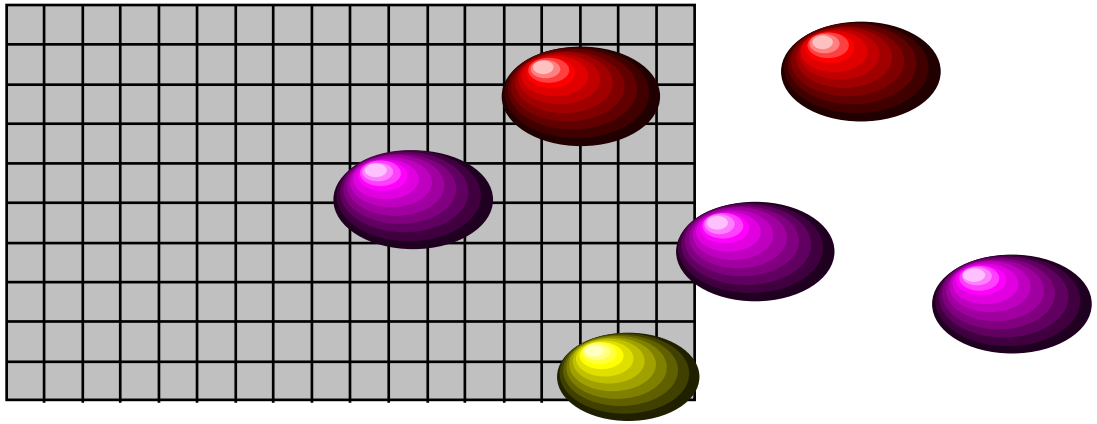
Benefits of OODBMS

- Object database is a good choice for three factors: business need, high performance, and complex data.
- With ODBMS, lesser code is required compared to RDBMS.
  - If using Java or C++ -- no need to translate into a database sub-language such as SQL, ODBC, or JDBC.
  - The data structure that you can imagine in Java or C++ can be stored directly without translation in an ODBMS.
- ODBMS give better performance than an RDBMS.
  - The data is read off the disk, it is already in the format that Java or C++ uses (OO). No translation is needed.

Shortcomings OODBMS

- Object databases are not as popular as RDBMS.
- Not many programming language support object databases.
- RDBMS have SQL as a standard query language. Object databases do not have a standard.
- Object databases are difficult to learn for non-programmers.

Object-Relational Model



object-relational databases

Object-Relational Model

- Combination of
  - OO features - Complex objects, Functions, Inheritance, Overloading

    And
  - Relations features - Tables, Views, Transactions, Recovery, Indexing, Optimization, SQL queries
- Data is still stored in tables
- SQL3 (‘object-oriented’ SQL) is the language for data definition, manipulation, and query.

Object-Relational Model

- Extend the relational data model by including object orientation and constructs to deal with added data types
- Allow attributes of tuples to have complex types, including non-atomic values such as nested relations
- Preserve relational foundations, in particular the declarative access to data, while extending modeling power
- PostgreSQL is the most popular pure ORDBMS.

Stonebraker's Application Matrix

	No Query	Query
Complex Data	OODBMS	ORDBMS
Simple Data	File System	RDBMS

Stonebraker's view: Most applications will move to the upper right.

Conclusion

- Data: Known facts that can be recorded and have implicit meaning
- Database: Collection of interrelated data
- DBMS: A computerized data/record keeping system for managing data

Introduction to MySQL

- Open Source SQL based database management system developed, distributed, and supported by Oracle Corporation.
- The MySQL software is Dual Licensed.
  - Users can choose to use the MySQL software as an Open Source product under the terms of the GNU General Public License
  - Or can purchase a standard commercial license from Oracle
- MySQL Database Server is very fast, reliable, scalable, and easy to use.

MySQL 8.0 Command Line Client

```
(base) surabhi@surabhi-seng:~$ sudo mysql
[sudo] password for surabhi:
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 14
Server version: 8.0.26-0ubuntu0.20.04.2 (Ubuntu)

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affiliates. Other names may be trademarks of their respective
owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement

mysql> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| mysql              |
| performance_schema |
| sys                |
+--------------------+
4 rows in set (0.00 sec)

mysql>
```
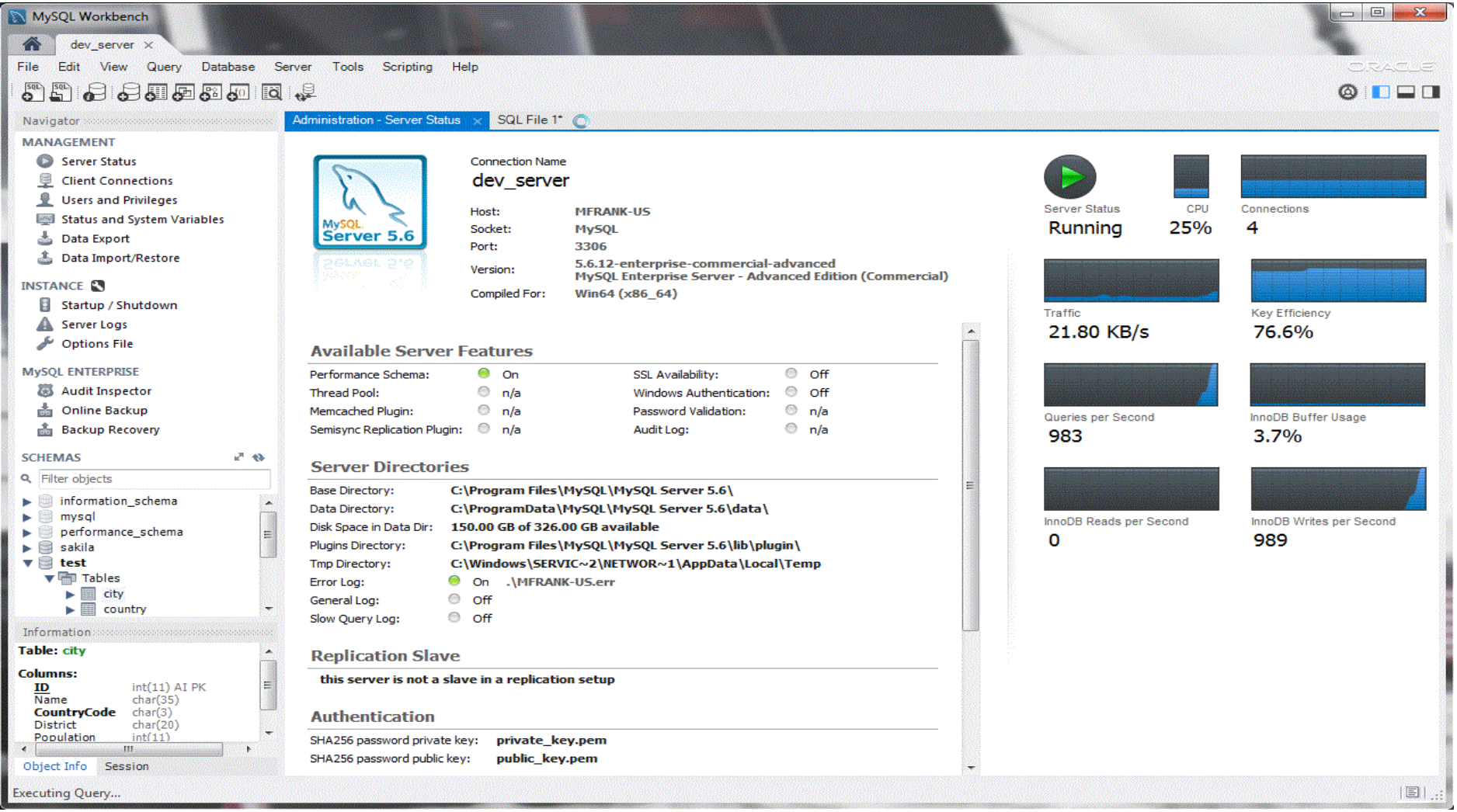
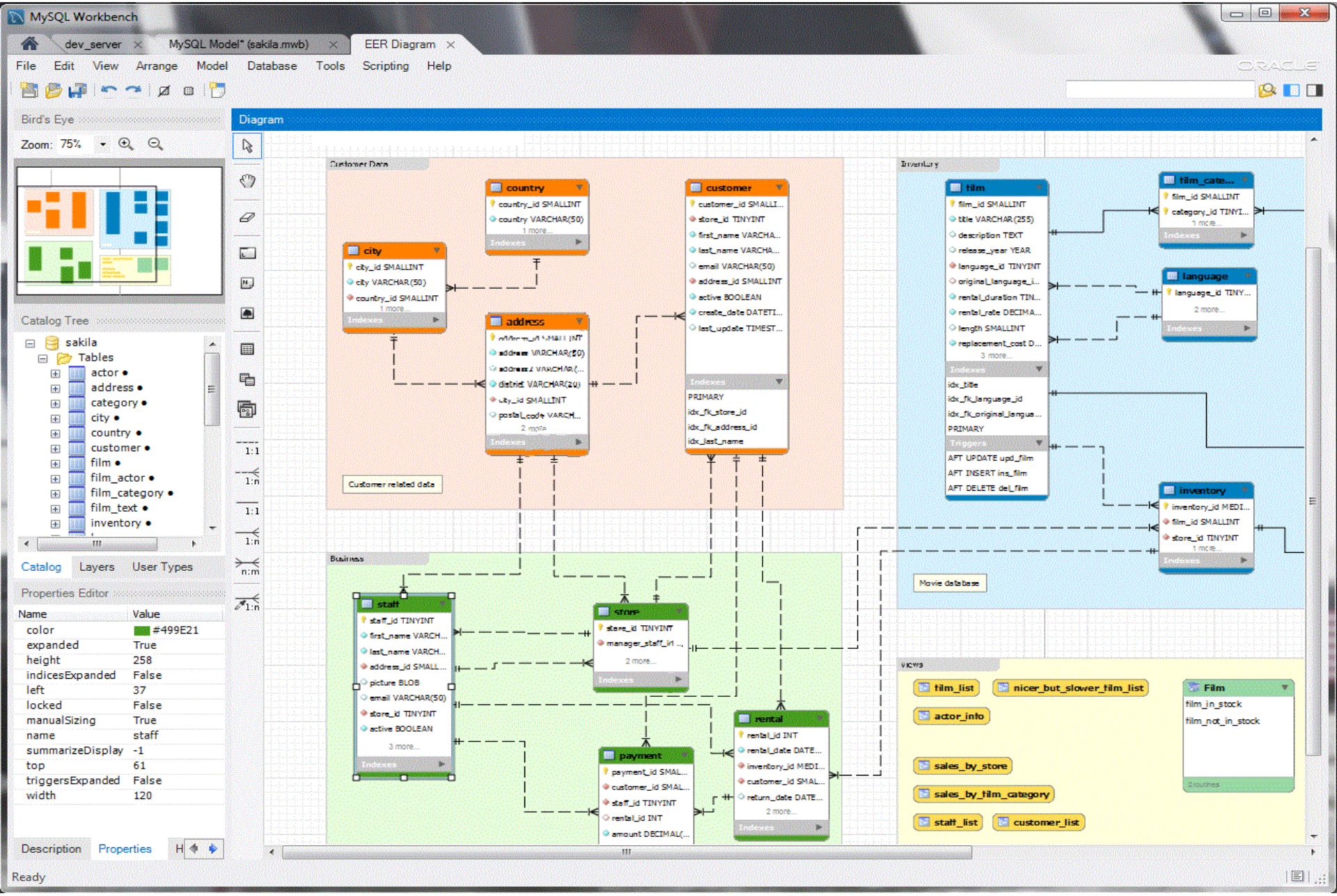

MySQL Workbench

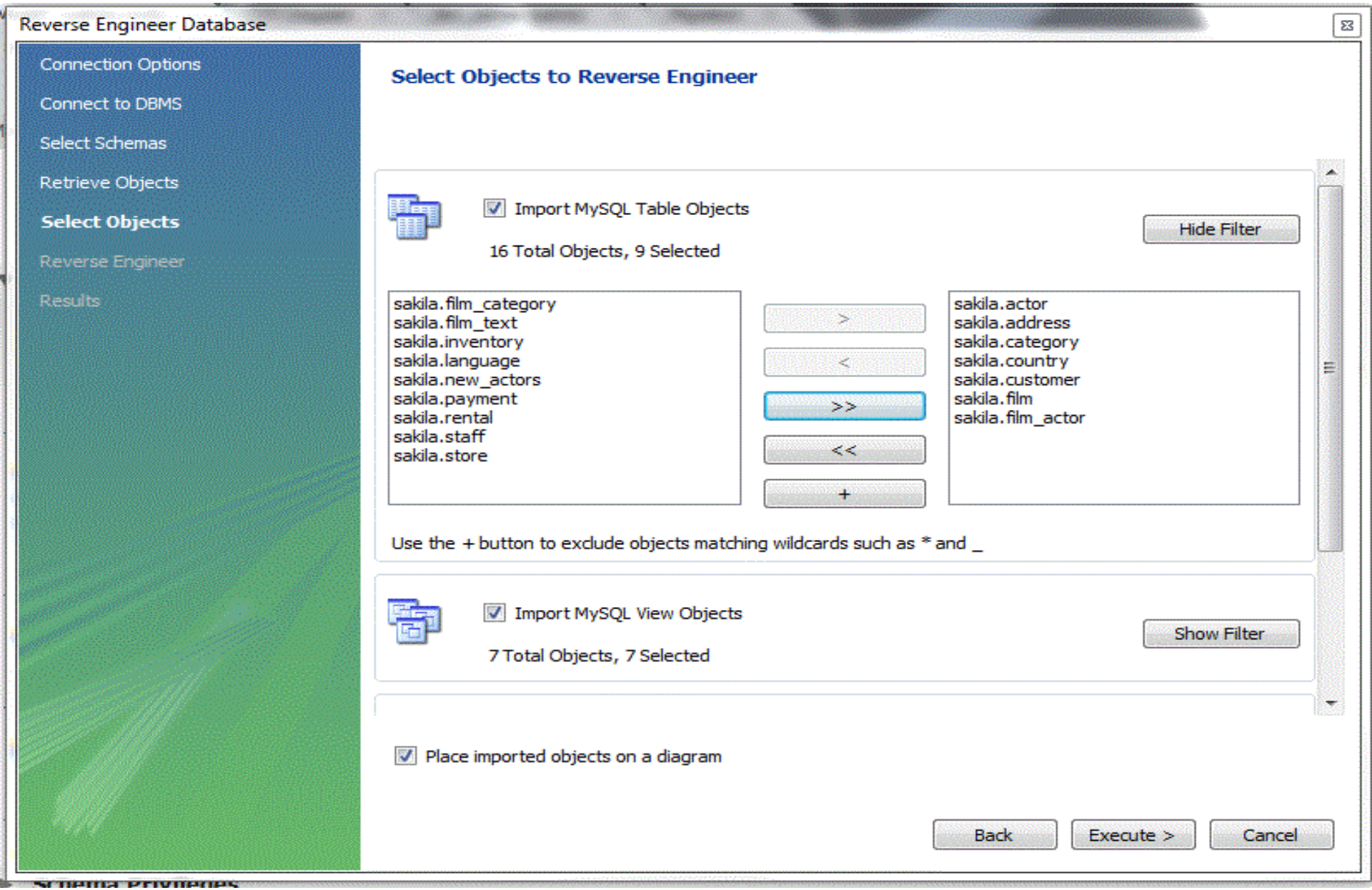


MySQL Workbench

Design

- MySQL Workbench enables a DBA, developer, or data architect to visually design, model, generate, and manage databases.
- It includes everything a data modeler needs for creating complex ER models, forward and reverse engineering,

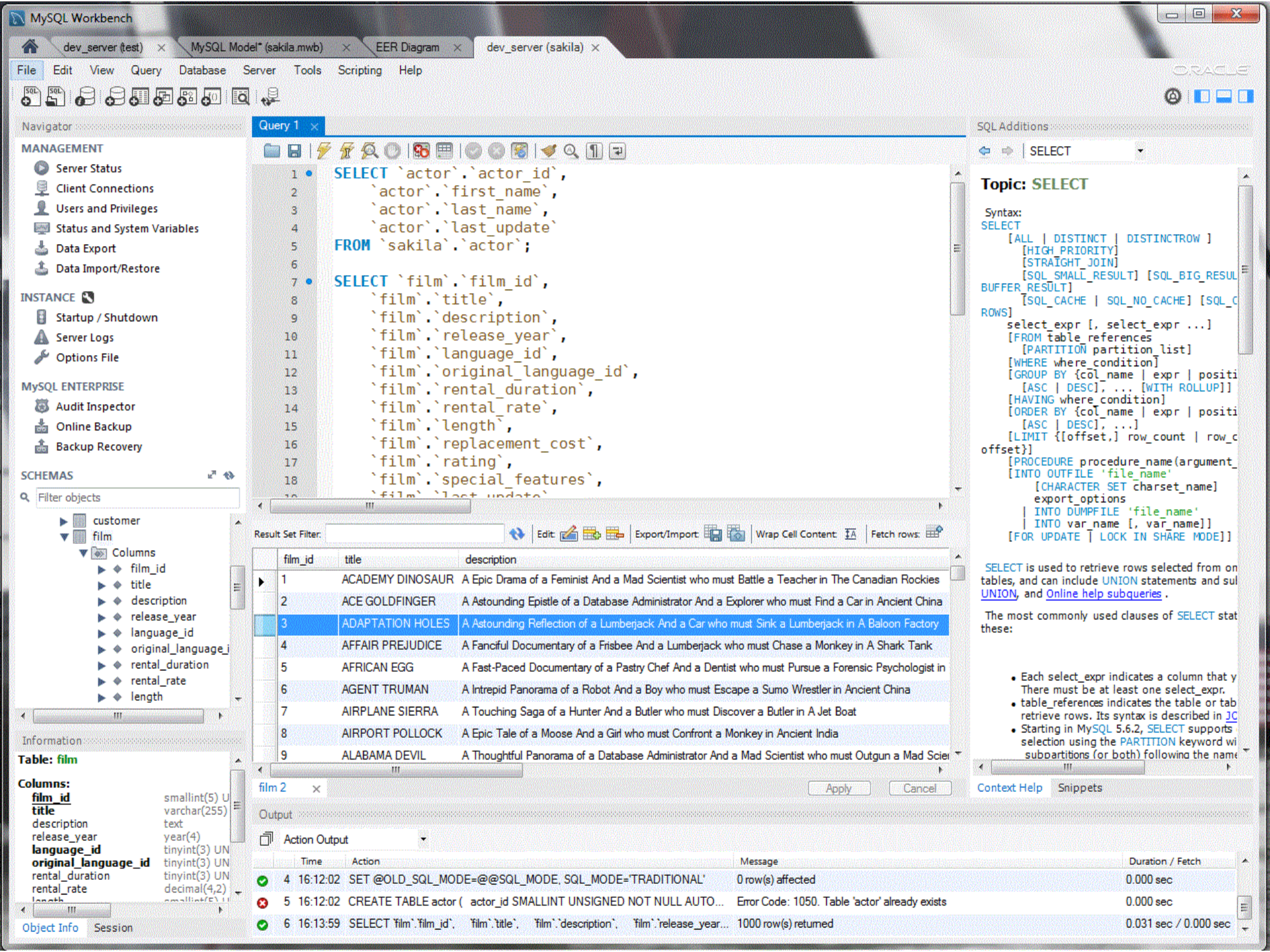

MySQL Workbench
dev_server
MySQL Model* (sakila.mwb)
EER Diagram
File Edit View Arrange Model Database Tools Scripting Help
Bird's Eye
Zoom: 75%
Catalog Tree
sakila
Tables
actor
address
category
city
country
customer
film
film_actor
film_category
film_text
inventory
Catalog Layers User Types
Properties Editor
Name Value
color #499E21
expanded True
height 258
indicesExpanded False
left 37
locked False
manualSizing True
name staff
summarizeDisplay -1
top 61
triggersExpanded False
width 120
Description Properties
Diagram
Customer Data
country
country_id SMALLINT
country VARCHAR(50)
city
city_id SMALLINT
city VARCHAR(50)
country_id SMALLINT
address
customer
customer_id SMALLI...
store_id TINYINT
first_name VARCHA...
last_name VARCHA...
email VARCHAR(50)
address_id SMALLINT
active BOOLEAN
create_date DATETI...
last_update TIMEST...
PRIMARY
idx_fk_store_id
idx_fk_address_id
idx_last_name
Customer related data
Inventory
film
film_id SMALLINT
title VARCHAR(255)
description TEXT
release_year YEAR
language_id TINYINT
length SMALLINT
idx_title
idx_fk_language_id
PRIMARY
AFT UPDATE upd_film
AFT INSERT ins_film
AFT DELETE del_film
film_cate...
film_id SMALLINT
category_id TINYI...
language
language_id TINY...
inventory
inventory_id MEDI...
film_id SMALLINT
store_id TINYINT
Movie database
Business
staff
staff_id TINYINT
first_name VARCH...
last_name VARCH...
address_id SMALL...
picture BLOB
email VARCHAR(50)
store_id TINYINT
active BOOLEAN
store
store_id TINYINT
manager_staff_id ...
payment
payment_id SMAL...
customer_id SMAL...
staff_id TINYINT
rental_id INT
amount DECIMAL(...
rental
rental_id INT
rental_date DATE...
inventory_id MEDI...
customer_id SMAL...
return_date DATE...
Views
film_list
nicer_but_slower_film_list
actor_info
sales_by_store
sales_by_film_category
staff_list
customer_list
Film
film_in_stock
film_not_in_stock
Ready

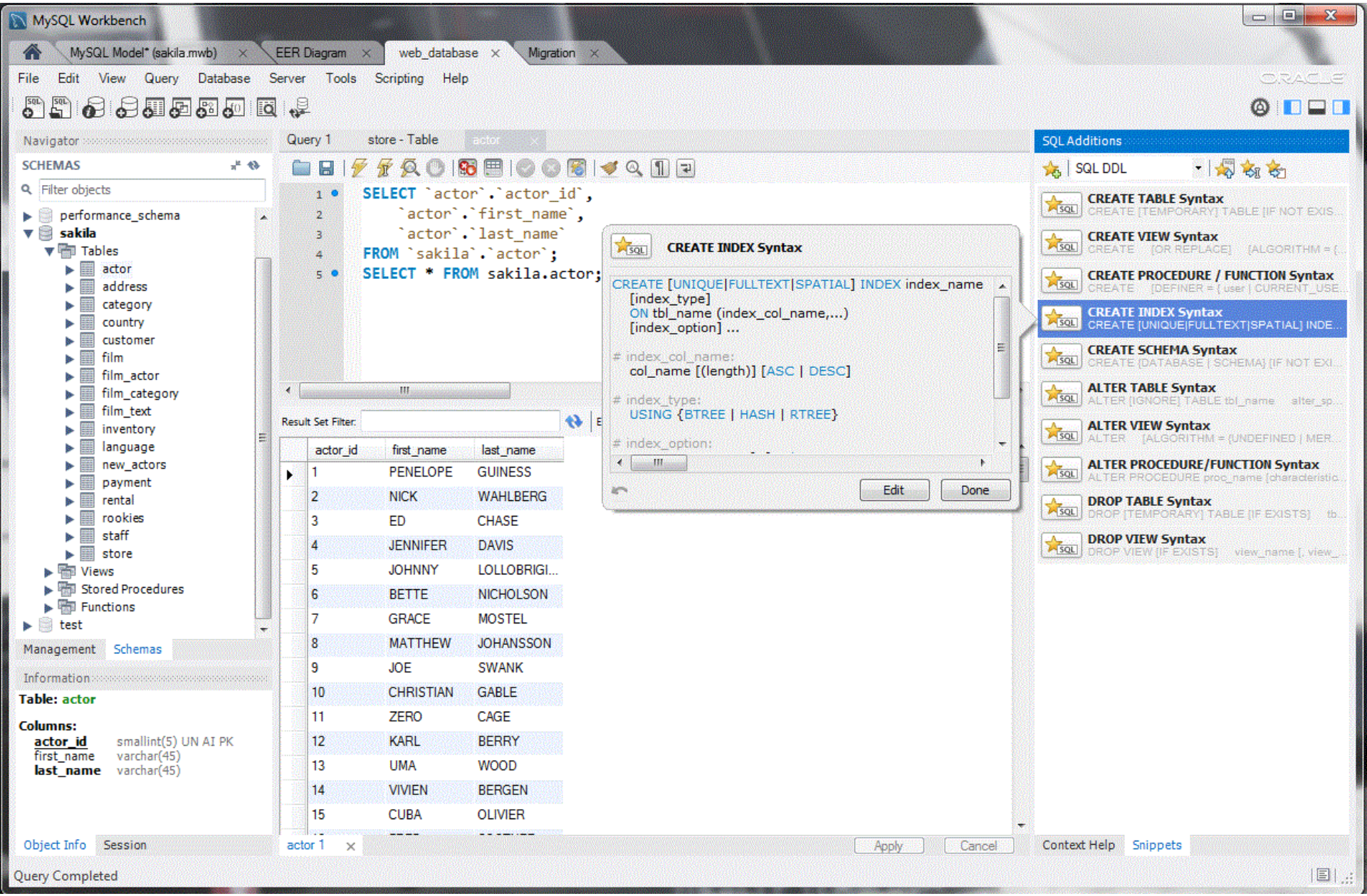

Reverse Engineer Database
Connection Options
Connect to DBMS
Select Schemas
Retrieve Objects
Select Objects
Reverse Engineer
Results
Select Objects to Reverse Engineer
Import MySQL Table Objects
16 Total Objects, 9 Selected
Hide Filter
sakila.film_category
sakila.film_text
sakila.inventory
sakila.language
sakila.new_actors
sakila.payment
sakila.rental
sakila.staff
sakila.store
>
<
>>
<<
+
sakila.actor
sakila.address
sakila.category
sakila.country
sakila.customer
sakila.film
sakila.film_actor
Use the + button to exclude objects matching wildcards such as * and _
Import MySQL View Objects
7 Total Objects, 7 Selected
Show Filter
Place imported objects on a diagram
Back
Execute >
Cancel

MySQL Workbench

Develop

- MySQL Workbench delivers visual tools for creating, executing, and optimizing SQL queries.
- The SQL Editor provides color syntax highlighting, auto-complete, reuse of SQL snippets, and execution history of SQL.
- The Database Connections Panel enables developers to easily manage standard database connections
- The Object Browser provides instant access to database schema and objects.


MySQL Workbench
dev_server (test)
MySQL Model* (sakila.mwb)
EER Diagram
dev_server (sakila)
File Edit View Query Database Server Tools Scripting Help
Navigator
MANAGEMENT
Server Status
Client Connections
Users and Privileges
Status and System Variables
Data Export
Data Import/Restore
INSTANCE
Startup / Shutdown
Server Logs
Options File
MySQL ENTERPRISE
Audit Inspector
Online Backup
Backup Recovery
SCHEMAS
Filter objects
customer
film
Columns
film_id
title
description
release_year
language_id
original_language_i
rental_duration
rental_rate
length
Information
Table: film
Columns:
film_id smallint(5) U
title varchar(255)
description text
release_year year(4)
language_id tinyint(3) UN
original_language_id tinyint(3) UN
rental_duration tinyint(3) UN
rental_rate decimal(4,2)
Object Info
Session
Query 1
1 SELECT `actor`.`actor_id`,
2 `actor`.`first_name`,
3 `actor`.`last_name`,
4 `actor`.`last_update`
5 FROM `sakila`.`actor`;
6
7 SELECT `film`.`film_id`,
8 `film`.`title`,
9 `film`.`description`,
10 `film`.`release_year`,
11 `film`.`language_id`,
12 `film`.`original_language_id`,
13 `film`.`rental_duration`,
14 `film`.`rental_rate`,
15 `film`.`length`,
16 `film`.`replacement_cost`,
17 `film`.`rating`,
18 `film`.`special_features`,
Result Set Filter:
Edit:
Export/Import:
Wrap Cell Content:
Fetch rows:
film_id title description
1 ACADEMY DINOSAUR A Epic Drama of a Feminist And a Mad Scientist who must Battle a Teacher in The Canadian Rockies
2 ACE GOLDFINGER A Astounding Epistle of a Database Administrator And a Explorer who must Find a Car in Ancient China
3 ADAPTATION HOLES A Astounding Reflection of a Lumberjack And a Car who must Sink a Lumberjack in A Baloon Factory
4 AFFAIR PREJUDICE A Fanciful Documentary of a Frisbee And a Lumberjack who must Chase a Monkey in A Shark Tank
5 AFRICAN EGG A Fast-Paced Documentary of a Pastry Chef And a Dentist who must Pursue a Forensic Psychologist in
6 AGENT TRUMAN A Intrepid Panorama of a Robot And a Boy who must Escape a Sumo Wrestler in Ancient China
7 AIRPLANE SIERRA A Touching Saga of a Hunter And a Butler who must Discover a Butler in A Jet Boat
8 AIRPORT POLLOCK A Epic Tale of a Moose And a Girl who must Confront a Monkey in Ancient India
9 ALABAMA DEVIL A Thoughtful Panorama of a Database Administrator And a Mad Scientist who must Outgun a Mad Scie
film 2
Apply
Cancel
SQL Additions
SELECT
Topic: SELECT
Syntax:
SELECT
[ALL | DISTINCT | DISTINCTROW]
[HIGH_PRIORITY]
[STRAIGHT_JOIN]
[SQL_SMALL_RESULT] [SQL_BIG_RESUL
BUFFER_RESULT]
[SQL_CACHE | SQL_NO_CACHE] [SQL_C
ROWS]
select_expr [, select_expr ...]
[FROM table_references
[PARTITION partition_list]
[WHERE where_condition]
[GROUP BY {col_name | expr | positi
[ASC | DESC], ... [WITH ROLLUP]]
[HAVING where_condition]
[ORDER BY {col_name | expr | positi
[ASC | DESC], ...]
[LIMIT {[offset,] row_count | row_c
offset}]
[PROCEDURE procedure_name(argument_
[INTO OUTFILE 'file_name'
[CHARACTER SET charset_name]
export_options
| INTO DUMPFILE 'file_name'
| INTO var_name [, var_name]]
[FOR UPDATE | LOCK IN SHARE MODE]]
SELECT is used to retrieve rows selected from on
tables, and can include UNION statements and sul
UNION, and Online help subqueries .
The most commonly used clauses of SELECT stat
these:
Each select_expr indicates a column that y
There must be at least one select_expr.
table_references indicates the table or tab
retrieve rows. Its syntax is described in JC
Starting in MySQL 5.6.2, SELECT supports
selection using the PARTITION keyword wi
subpartitions (or both) following the name
Context Help
Snippets
Output
Action Output
Time Action Message Duration / Fetch
4 16:12:02 SET @OLD_SQL_MODE=@@SQL_MODE, SQL_MODE='TRADITIONAL' 0 row(s) affected 0.000 sec
5 16:12:02 CREATE TABLE actor (actor_id SMALLINT UNSIGNED NOT NULL AUTO... Error Code: 1050. Table 'actor' already exists 0.000 sec
6 16:13:59 SELECT `film`.`film_id`, `film`.`title`, `film`.`description`, `film`.`release_year`... 1000 row(s) returned 0.031 sec / 0.000 sec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web_database
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performance_schema
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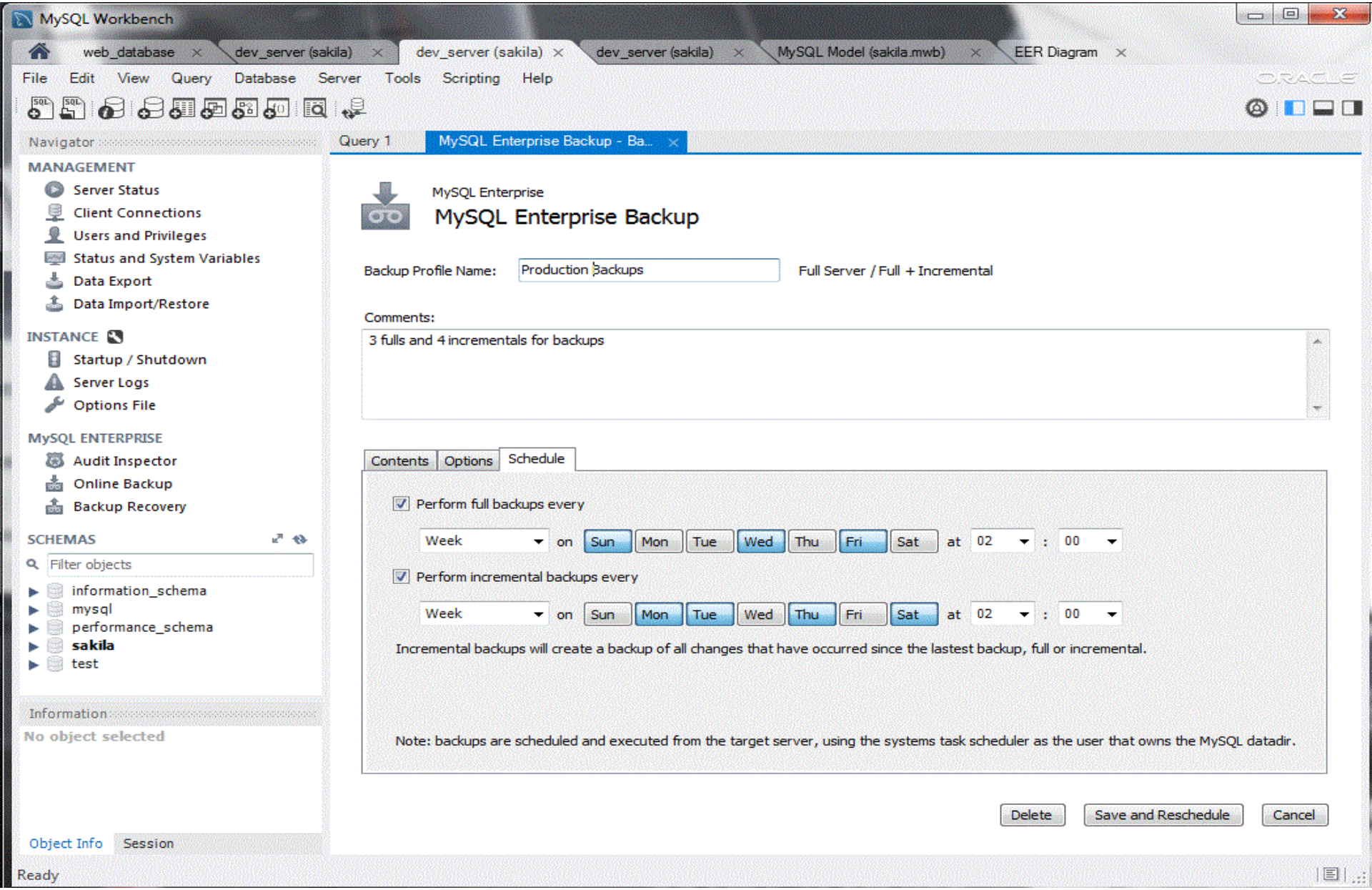
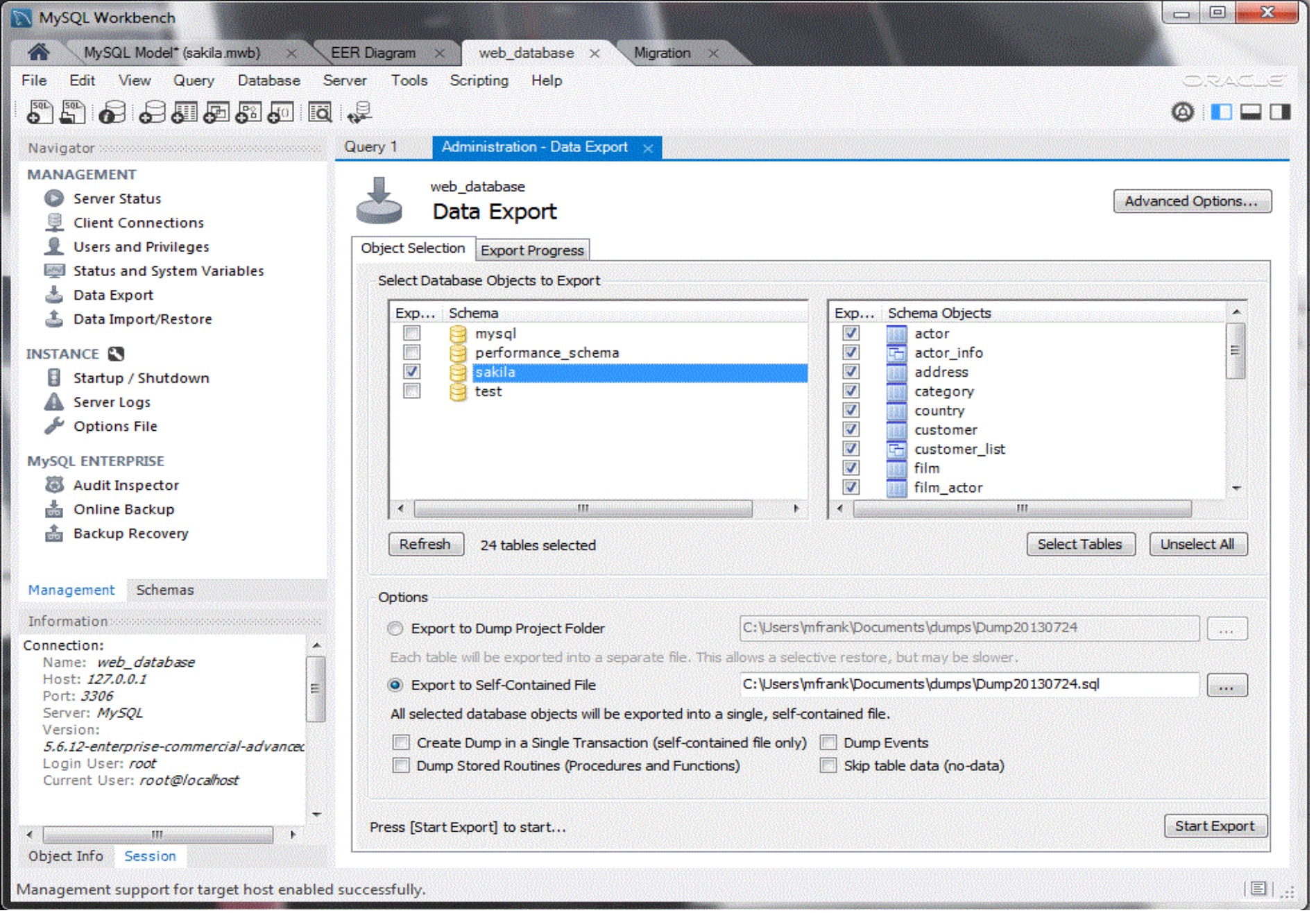
Tables
actor
address
category
country
customer
film
film_actor
film_category
film_text
inventory
language
new_actors
payment
rental
rookies
staff
store
Views
Stored Procedures
Functions
test
Management Schemas
Information
Table: actor
Columns:
actor_id smallint(5) UN AI PK
first_name varchar(45)
last_name varchar(45)
Object Info Session
Query 1
store - Table
actor
SELECT `actor`.`actor_id`,
`actor`.`first_name`,
`actor`.`last_name`
FROM `sakila`.`actor`;
SELECT * FROM sakila.actor;
Result Set Filter:
actor_id first_name last_name
1 PENELOPE GUINESS
2 NICK WAHLBERG
3 ED CHASE
4 JENNIFER DAVIS
5 JOHNNY LOLLOBRIGI...
6 BETTE NICHOLSON
7 GRACE MOSTEL
8 MATTHEW JOHANSSON
9 JOE SWANK
10 CHRISTIAN GABLE
11 ZERO CAGE
12 KARL BERRY
13 UMA WOOD
14 VIVIEN BERGEN
15 CUBA OLIVIER
actor 1
Apply
Cancel
CREATE INDEX Syntax
CREATE [UNIQUE|FULLTEXT|SPATIAL] INDEX index_name
[index_type]
ON tbl_name (index_col_name,...)
[index_option] ...
index_col_name:
col_name [(length)] [ASC | DESC]
index_type:
USING {BTREE | HASH | RTREE}
index_option:
Edit
Done
SQL Additions
SQL DDL
CREATE TABLE Syntax
CREATE VIEW Syntax
CREATE PROCEDURE / FUNCTION Syntax
CREATE INDEX Syntax
CREATE SCHEMA Syntax
ALTER TABLE Syntax
ALTER VIEW Syntax
ALTER PROCEDURE/FUNCTION Syntax
DROP TABLE Syntax
DROP VIEW Syntax
Context Help Snippets
Query Completed

MySQL Workbench

Administer

- MySQL Workbench provides a visual console to easily administer MySQL environments and gain better visibility into databases.
- Developers and DBAs can use the visual tools for configuring servers, administering users, performing backup and recovery, inspecting audit data, and viewing database health.


MySQL Workbench
web_database
dev_server (sakila)
dev_server (sakila)
dev_server (sakila)
MySQL Model (sakila.mwb)
EER Diagram
File Edit View Query Database Server Tools Scripting Help
Navigator
MANAGEMENT
Server Status
Client Connections
Users and Privileges
Status and System Variables
Data Export
Data Import/Restore
INSTANCE
Startup / Shutdown
Server Logs
Options File
MySQL ENTERPRISE
Audit Inspector
Online Backup
Backup Recovery
SCHEMAS
Filter objects
information_schema
mysql
performance_schema
sakila
test
Information
No object selected
Object Info
Session
Query 1
MySQL Enterprise Backup - Ba...
MySQL Enterprise
MySQL Enterprise Backup
Backup Profile Name:
Production Backups
Full Server / Full + Incremental
Comments:
3 fulls and 4 incrementals for backups
Contents
Options
Schedule
Perform full backups every
Week
on
Sun
Mon
Tue
Wed
Thu
Fri
Sat
at
02
00
Perform incremental backups every
Week
on
Sun
Mon
Tue
Wed
Thu
Fri
Sat
at
02
00
Incremental backups will create a backup of all changes that have occurred since the lastest backup, full or incremental.
Note: backups are scheduled and executed from the target server, using the systems task scheduler as the user that owns the MySQL datadir.
Delete
Save and Reschedule
Cancel
Ready


MySQL Workbench
MySQL Model* (sakila.mwb)
EER Diagram
web_database
Migration
File Edit View Query Database Server Tools Scripting Help
Navigator
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Options File
MySQL ENTERPRISE
Audit Inspector
Online Backup
Backup Recovery
Management Schemas
Information
Connection:
Name: web_database
Host: 127.0.0.1
Port: 3306
Server: MySQL
Version:
5.6.12-enterprise-commercial-advanced
Login User: root
Current User: root@localhost
Object Info Session
Query 1
Administration - Data Export
web_database
Data Export
Advanced Options...
Object Selection
Export Progress
Select Database Objects to Export
Exp... Schema
mysql
performance_schema
sakila
test
Exp... Schema Objects
actor
actor_info
address
category
country
customer
customer_list
film
film_actor
Refresh
24 tables selected
Select Tables
Unselect All
Options
Export to Dump Project Folder
C:\Users\mfrank\Documents\dumps\Dump20130724
Each table will be exported into a separate file. This allows a selective restore, but may be slower.
Export to Self-Contained File
C:\Users\mfrank\Documents\dumps\Dump20130724.sql
All selected database objects will be exported into a single, self-contained file.
Create Dump in a Single Transaction (self-contained file only)
Dump Events
Dump Stored Routines (Procedures and Functions)
Skip table data (no-data)
Press [Start Export] to start...
Start Export
Management support for target host enabled successfully.

MySQL Workbench

- **Database Migration**
  - MySQL Workbench now provides a complete, easy to use solution for migrating Microsoft SQL Server, Microsoft Access, Sybase ASE, PostreSQL, and other RDBMS tables, objects and data to MySQL.
- Migration also supports migrating from earlier versions of MySQL to the latest releases.

- References

- "*An Introduction to Database Systems*", **C. J. Date**, Sixth Edition
- "*Database System Concepts*", **Avi Silberschatz, Henry F. Korth, S. Sudarshan**
- http://www.cse.iitb.ac.in/~sudarsha/db-book/slide-dir/
- "*Fundamentals of Database Systems*", **Ramez Elmasri, Shamkant B. avathe**
- "*Database Management Systems*", **Raghu Ramakrishan**
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- *MySQL manuals*
- *https://downloads.mysql.com/docs/refman-8.0-en.pdf*