Security and Privacy

Lecture 13

Outline

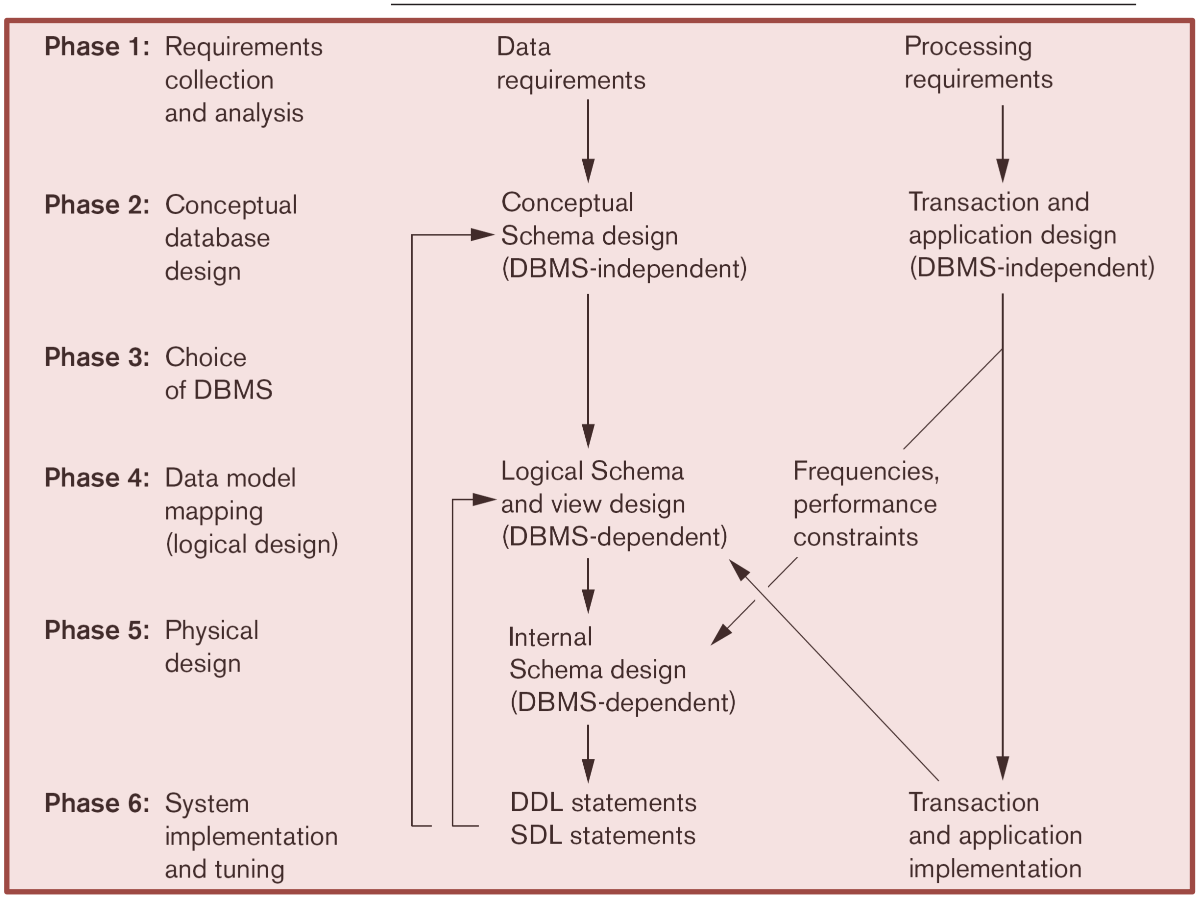
- Context
- Access Control
  - Discretionary, Mandatory
  - Least Privilege, Separate Privileges
  - Strong password policies, 2FA
- Attacks
  - SQL Injection
  - DoS (limit password length!)
  - Brute force password attempts (iCloud)
  - Internal vs. External (80% internal via Oracle)
  - Separate server, updates, audit logs
- Inference Control
- Encryption
  - Symmetric, Asymmetric, Hashing – tricky to get right!
  - Whole Database (and backups!), Communication
  - Sensitive Data (salting)

Database Design and Implementation Process

Figure 10.1
Phases of database design and implementation for large databases.

Data content, structure, and constraints

Database applications



Phase 1: Requirements collection and analysis

Data requirements

Processing requirements

Phase 2: Conceptual database design

Conceptual Schema design (DBMS-independent)

Transaction and application design (DBMS-independent)

Phase 3: Choice of DBMS

Phase 4: Data model mapping (logical design)

Logical Schema and view design (DBMS-dependent)

Frequencies, performance constraints

Phase 5: Physical design

Internal Schema design (DBMS-dependent)

Phase 6: System implementation and tuning

DDL statements
SDL statements

Transaction and application implementation

Guidelines

- Security as first-class citizen
  - *Early on security was an add-on, now it is everything.*
- Security via depth
  - *Don't assume a firewall will save you*
- Design for failure
  - *What happens after a breach occurs?*
- Secure the weakest link
  - *Anything but the crypto!*
- Obscurity is not security
  - *Keys in binary stand out like sore thumbs*
  - *Stored procedures are not a cure for access control*

Authentication Policies

- Passwords
  - Enforce minimum length/complexity
    - Also maximum (more later w.r.t. DoS)
  - Require updates
  - Goal: make guessing/cracking difficult
    - Cross-service

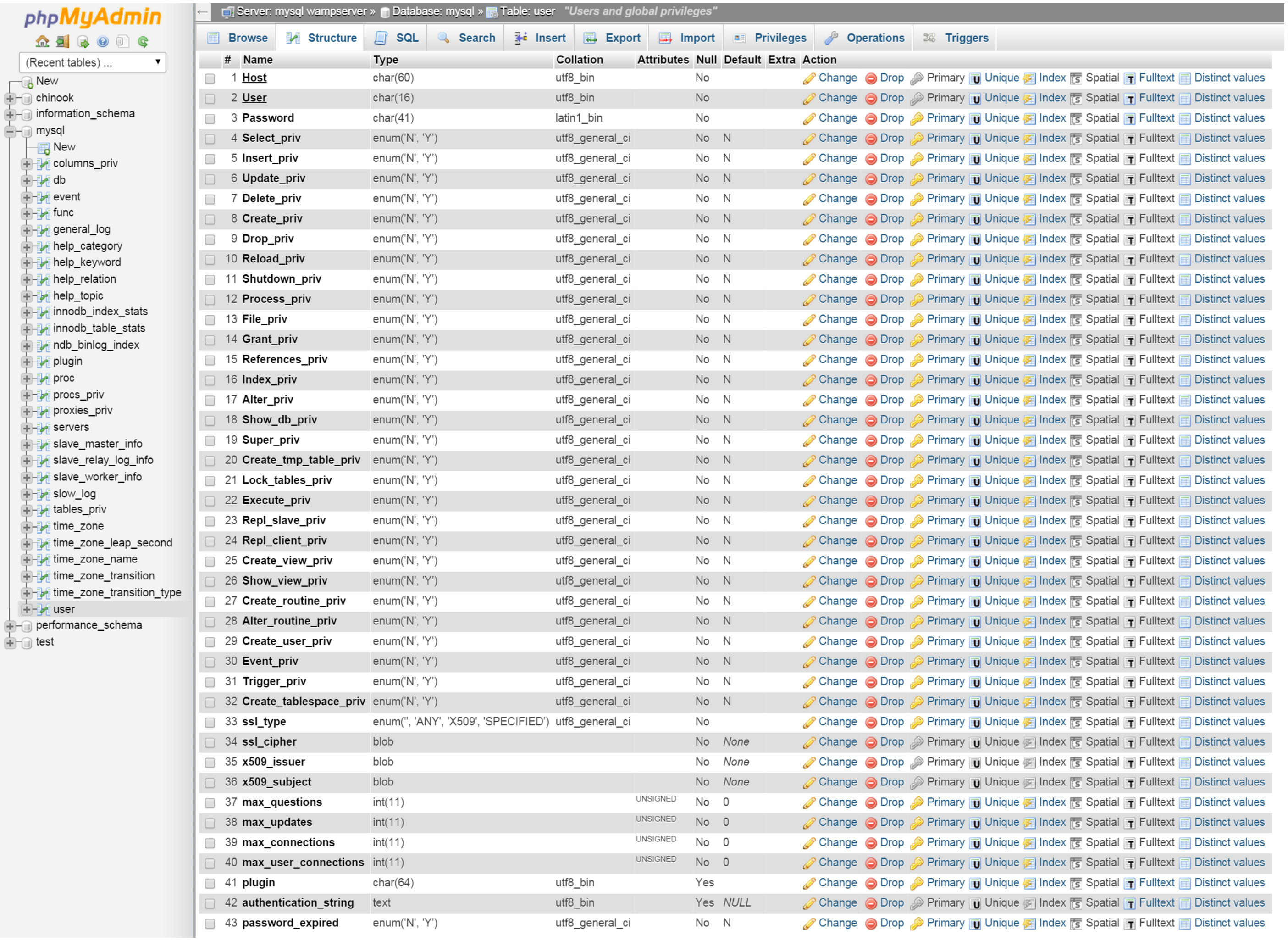
- Attempts
  - Enforce limits to avoid brute force (iCloud)

- 2 Factor Authentication (2FA)
  - Often infeasible
  - Implementation may weaken
    - e.g. Social engineering

Discretionary Access Control

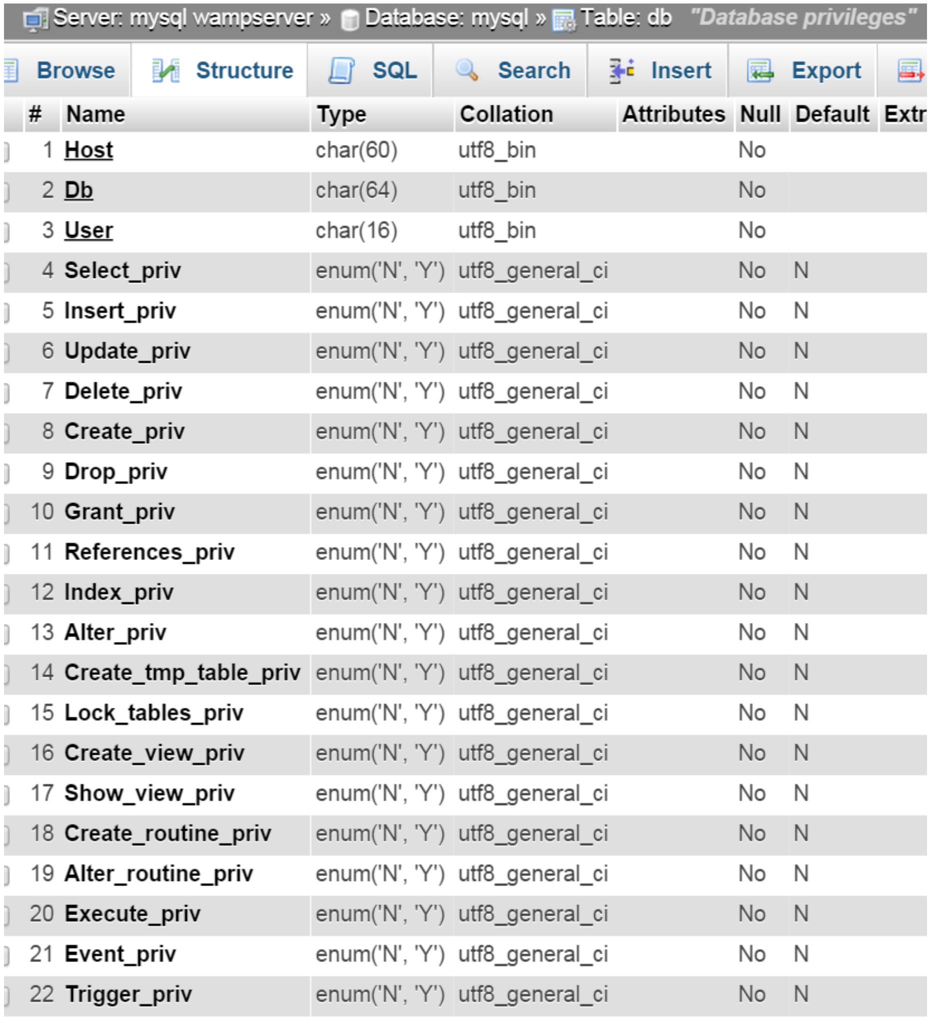
- Users **grant/revoke** privileges to other users
  - Starts with root/superuser/dba
  - with **`GRANT OPTION`**
- Privileges typically apply at multiple levels
  - Global, database, table, column
- Access matrix model
  - Users x Objects
- Fairly universal

MySQL (user)



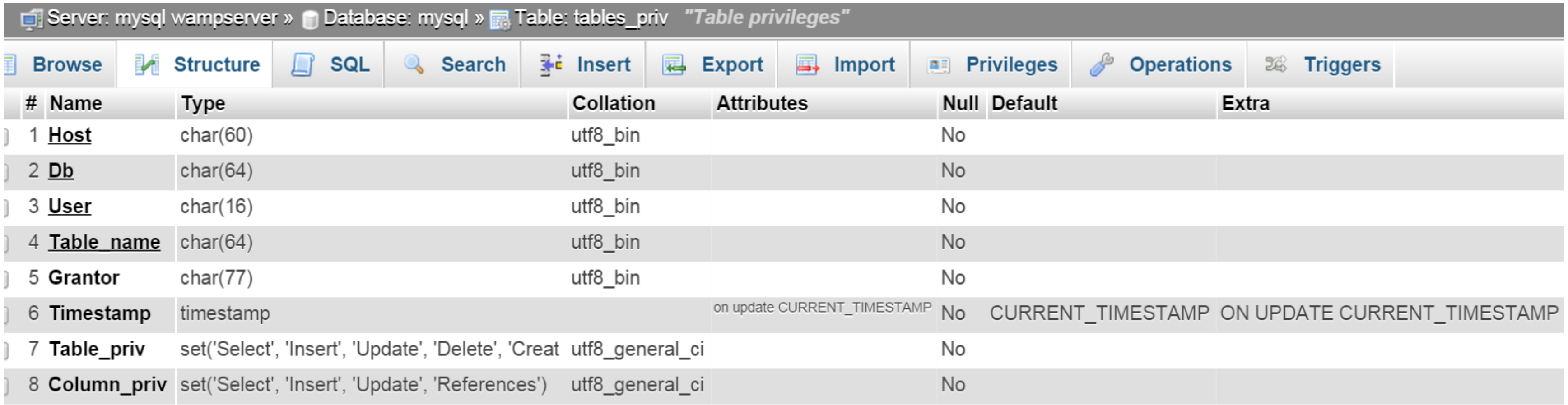
#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	Host	char(60)	utf8_bin		No			Change Drop Primary Unique Index Spatial Fulltext Distinct values
2	User	char(16)	utf8_bin		No			Change Drop Primary Unique Index Spatial Fulltext Distinct values
3	Password	char(41)	latin1_bin		No			Change Drop Primary Unique Index Spatial Fulltext Distinct values
4	Select_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
5	Insert_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
6	Update_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
7	Delete_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
8	Create_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
9	Drop_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
10	Reload_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
11	Shutdown_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
12	Process_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
13	File_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
14	Grant_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
15	References_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
16	Index_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
17	Alter_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
18	Show_db_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
19	Super_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
20	Create_tmp_table_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
21	Lock_tables_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
22	Execute_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
23	Repl_slave_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
24	Repl_client_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
25	Create_view_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
26	Show_view_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
27	Create_routine_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
28	Alter_routine_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
29	Create_user_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
30	Event_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
31	Trigger_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
32	Create_tablespace_priv	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values
33	ssl_type	enum('', 'ANY', 'X509', 'SPECIFIED')	utf8_general_ci		No			Change Drop Primary Unique Index Spatial Fulltext Distinct values
34	ssl_cipher	blob			No	*None*		Change Drop Primary Unique Index Spatial Fulltext Distinct values
35	x509_issuer	blob			No	*None*		Change Drop Primary Unique Index Spatial Fulltext Distinct values
36	x509_subject	blob			No	*None*		Change Drop Primary Unique Index Spatial Fulltext Distinct values
37	max_questions	int(11)		UNSIGNED	No	0		Change Drop Primary Unique Index Spatial Fulltext Distinct values
38	max_updates	int(11)		UNSIGNED	No	0		Change Drop Primary Unique Index Spatial Fulltext Distinct values
39	max_connections	int(11)		UNSIGNED	No	0		Change Drop Primary Unique Index Spatial Fulltext Distinct values
40	max_user_connections	int(11)		UNSIGNED	No	0		Change Drop Primary Unique Index Spatial Fulltext Distinct values
41	plugin	char(64)	utf8_bin		Yes			Change Drop Primary Unique Index Spatial Fulltext Distinct values
42	authentication_string	text	utf8_bin		Yes	*NULL*		Change Drop Primary Unique Index Spatial Fulltext Distinct values
43	password_expired	enum('N', 'Y')	utf8_general_ci		No	N		Change Drop Primary Unique Index Spatial Fulltext Distinct values

MySQL (db)


Server: mysql wampserver » Database: mysql » Table: db "Database privileges"
Browse
Structure
SQL
Search
Insert
Export

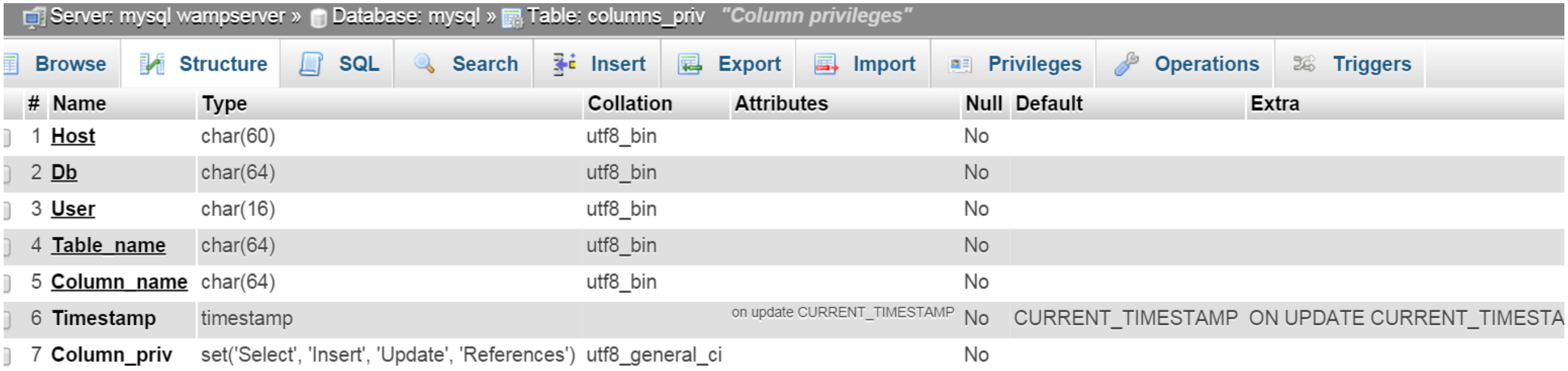
#	Name	Type	Collation	Attributes	Null	Default	Extr
1	Host	char(60)	utf8_bin		No		
2	Db	char(64)	utf8_bin		No		
3	User	char(16)	utf8_bin		No		
4	Select_priv	enum('N', 'Y')	utf8_general_ci		No	N	
5	Insert_priv	enum('N', 'Y')	utf8_general_ci		No	N	
6	Update_priv	enum('N', 'Y')	utf8_general_ci		No	N	
7	Delete_priv	enum('N', 'Y')	utf8_general_ci		No	N	
8	Create_priv	enum('N', 'Y')	utf8_general_ci		No	N	
9	Drop_priv	enum('N', 'Y')	utf8_general_ci		No	N	
10	Grant_priv	enum('N', 'Y')	utf8_general_ci		No	N	
11	References_priv	enum('N', 'Y')	utf8_general_ci		No	N	
12	Index_priv	enum('N', 'Y')	utf8_general_ci		No	N	
13	Alter_priv	enum('N', 'Y')	utf8_general_ci		No	N	
14	Create_tmp_table_priv	enum('N', 'Y')	utf8_general_ci		No	N	
15	Lock_tables_priv	enum('N', 'Y')	utf8_general_ci		No	N	
16	Create_view_priv	enum('N', 'Y')	utf8_general_ci		No	N	
17	Show_view_priv	enum('N', 'Y')	utf8_general_ci		No	N	
18	Create_routine_priv	enum('N', 'Y')	utf8_general_ci		No	N	
19	Alter_routine_priv	enum('N', 'Y')	utf8_general_ci		No	N	
20	Execute_priv	enum('N', 'Y')	utf8_general_ci		No	N	
21	Event_priv	enum('N', 'Y')	utf8_general_ci		No	N	
22	Trigger_priv	enum('N', 'Y')	utf8_general_ci		No	N	

MySQL (tables_priv)


Server: mysql wampserver » Database: mysql » Table: tables_priv "Table privileges"
Browse
Structure
SQL
Search
Insert
Export
Import
Privileges
Operations
Triggers

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	Host	char(60)	utf8_bin		No		
2	Db	char(64)	utf8_bin		No		
3	User	char(16)	utf8_bin		No		
4	Table_name	char(64)	utf8_bin		No		
5	Grantor	char(77)	utf8_bin		No		
6	Timestamp	timestamp		on update CURRENT_TIMESTAMP	No	CURRENT_TIMESTAMP	ON UPDATE CURRENT_TIMESTAMP
7	Table_priv	set('Select', 'Insert', 'Update', 'Delete', 'Creat	utf8_general_ci		No		
8	Column_priv	set('Select', 'Insert', 'Update', 'References')	utf8_general_ci		No		

MySQL (columns_priv)


Server: mysql wampserver » Database: mysql » Table: columns_priv "Column privileges"
Browse
Structure
SQL
Search
Insert
Export
Import
Privileges
Operations
Triggers

#	Name	Type	Collation	Attributes	Null	Default	Extra
1	Host	char(60)	utf8_bin		No		
2	Db	char(64)	utf8_bin		No		
3	User	char(16)	utf8_bin		No		
4	Table_name	char(64)	utf8_bin		No		
5	Column_name	char(64)	utf8_bin		No		
6	Timestamp	timestamp		on update CURRENT_TIMESTAMP	No	CURRENT_TIMESTAMP	ON UPDATE CURRENT_TIMESTA
7	Column_priv	set('Select', 'Insert', 'Update', 'References')	utf8_general_ci		No		

Mandatory Access Control

- Objects are classified with security levels
- Users are afforded security clearance
- Government model, not typically supported

Privilege Policies

- Principle of least privilege
- Privilege separation
  - Multiple users, each with least privilege
- Abuse
  - Unauthorized
    - Mitigate escalation attacks
  - Authorized
    - Teachers changing grades
    - Firing a DBA

SQL Injection

SQL manipulation for nefarious purpose

Method

- String manipulation
  - Parameters, function calls
- Code injection (e.g. buffer overflow)

Goals

- Fingerprinting
  - Learn about service via version, configuration
- DoS
- Bypass authentication/privilege escalation
- Remote execution

Protection

- Parameterized statements
- Filter input
- Limit use of custom functions

Denial of Service (DoS)

Any exposed interface:

- Failed login
  - Lock out users
  - Resource utilization via long password verification
- Complex queries

Mitigation

- Resource limits
- Patching
- Monitoring

Issues

- Protect against internal attacks
  - Oracle: up to 80% of data loss
- Isolate DBMS
  - Separate machine, VM
- Regular patching policies
- Audit logs

Inferential Security

- Relevant when offering parameterized access to aggregate data
  - But must protect sensitive individual data!
- Prior knowledge and/or clever exploration might yield queries that reveal private information
  - Find "average" salary of <insert conditions that identify single individual>
- Techniques
  - Minimum result set size threshold
  - Added noise
  - Group partitioning

Encryption

- Symmetric
  - Single key encrypts/decrypts
- Asymmetric
  - 2 Keys: public encryption, private decryption
- Hashing
  - No decryption
- Encryption theory is solid, implementation is tricky
  - High-quality randomness
  - Bug-free code

Basics

- Encrypt database files
  - Including backups!
  - Native or 3rd-party wrapper
  - Can be difficult to implement while being resilient to restarts, high-performance

- Encrypt application communication

Sensitive Data

- When dealing with sensitive data, always consider how it needs to be used
- If only verification (e.g. password), hash
- If usage, encrypt
  - – Ideally segment usage (e.g. CC entry vs. processing = public/private + last 4 as string)

Password Salting

- Salt = additional input prepended to hashed value
  - Ideally 1 salt per sensitive value
  - Stored text = salt, hash(salt + sensitive value)
    - Possibly several hashes
- Increases complexity of usefully processing bulk data
  - Re-use within service, across services
  - Rainbow tables