Security and Privacy

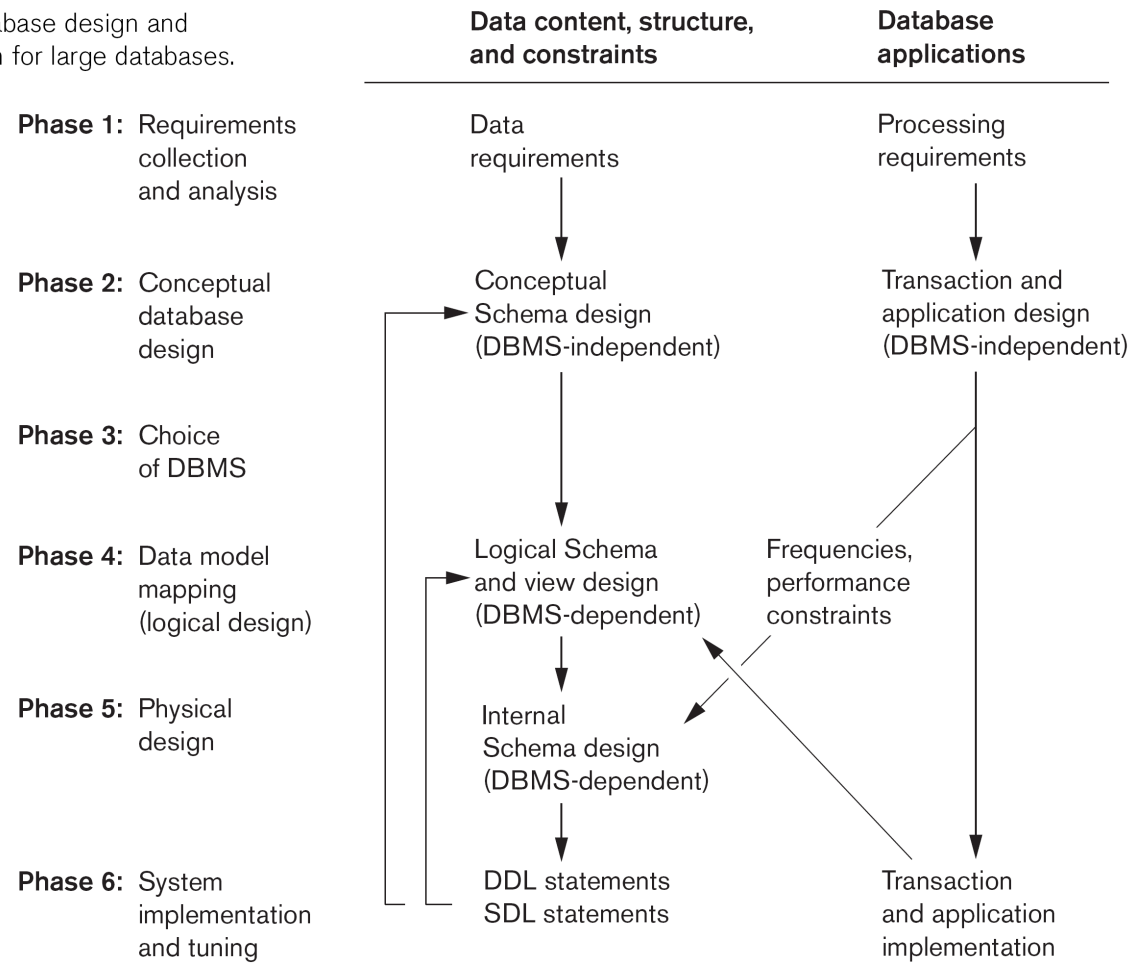
Lecture 11

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.



Guidelines

- Security as first-class citizen
- 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*

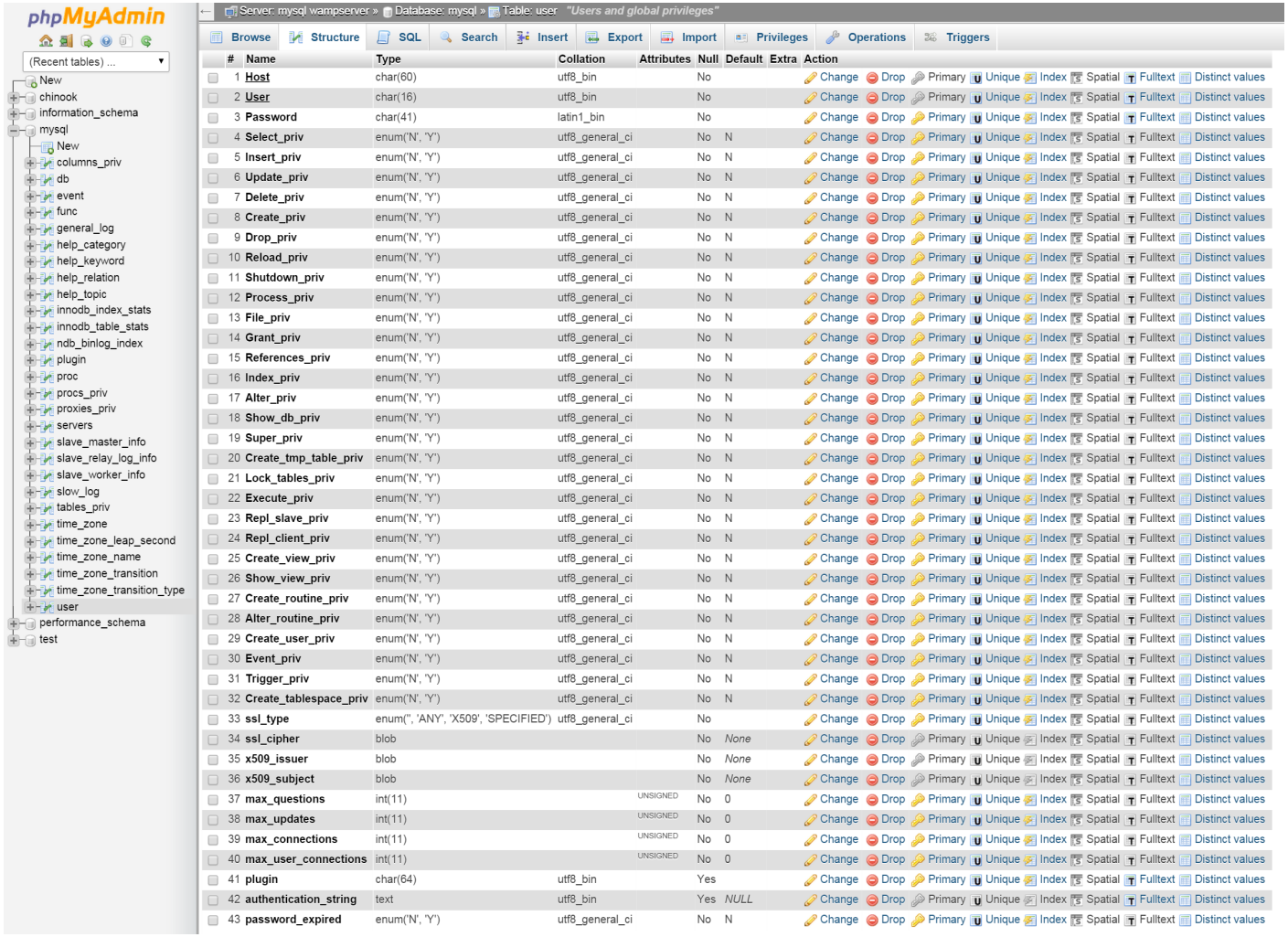
Authentication Policies

- 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

Discretionary Access Control

- Users **grant/revoke** privileges to other users
  - Starts with root/superuser/dba
  - with/without **`GRANT OPTION`**
- Privileges typically apply at multiple levels
  - Global, database, table, column
- Access matrix model
  - Users x Objects
- Fairly universal

MySQL (user)


phpMyAdmin
(Recent tables) ...
New
chinook
information_schema
mysql
New
columns_priv
db
event
func
general_log
help_category
help_keyword
help_relation
help_topic
innodb_index_stats
innodb_table_stats
ndb_binlog_index
plugin
proc
procs_priv
proxies_priv
servers
slave_master_info
slave_relay_log_info
slave_worker_info
slow_log
tables_priv
time_zone
time_zone_leap_second
time_zone_name
time_zone_transition
time_zone_transition_type
user
performance_schema
test
Server: mysql wampserver » Database: mysql » Table: user "Users and global privileges"
Browse Structure SQL Search Insert Export Import Privileges Operations Triggers
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
- 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
- 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

- Some services offer parameterized 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
- 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 hash/sensitive value
  - Stored text = salt + hash(salt . sensitive value)

- Increases complexity of usefully processing bulk data
  - Re-use within service, across services
  - Rainbow tables