Intro to Backend Development

Lecture 3 · Relational Databases

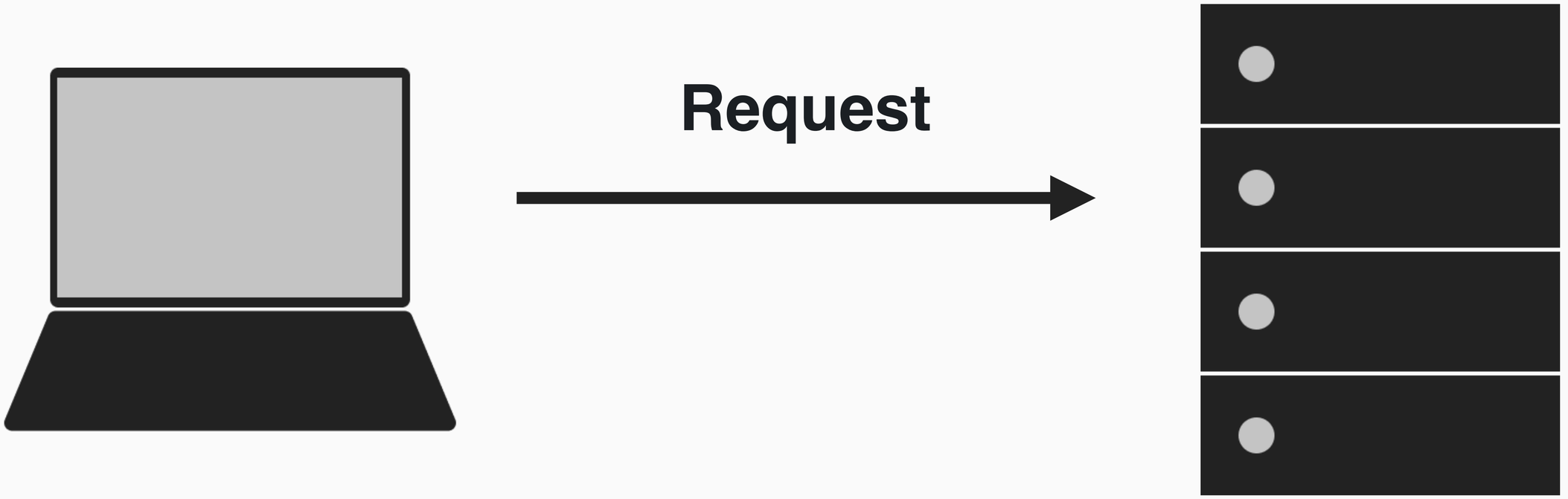
Kidus Zegeye
Tony Matchev

Announcements

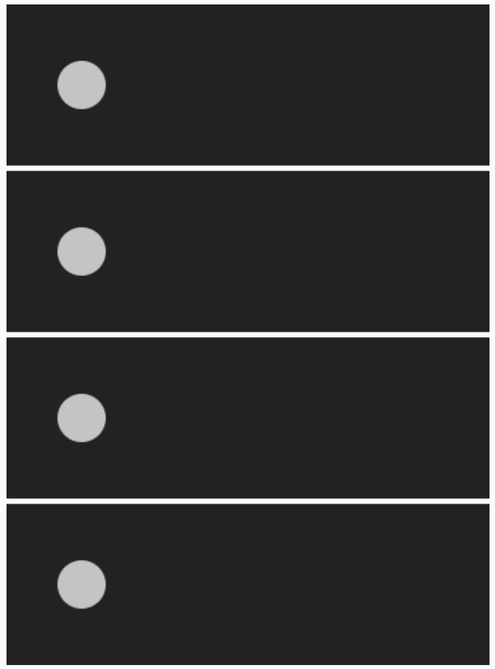
Announcements

- PA2 is due **this Wednesday (10/25)**

Review


Request
Client
Server

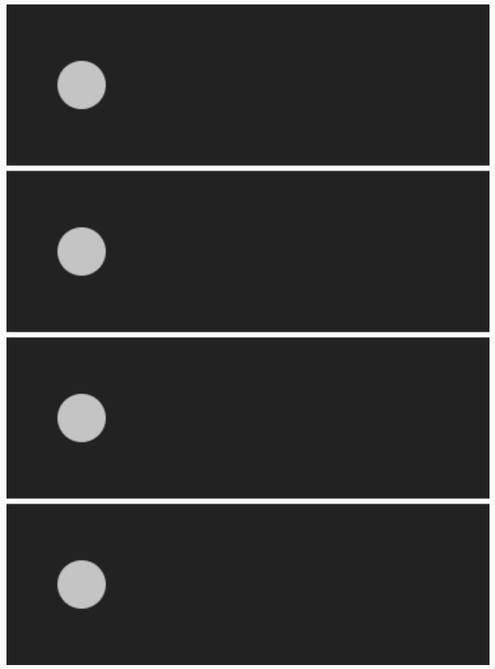
Request



Server

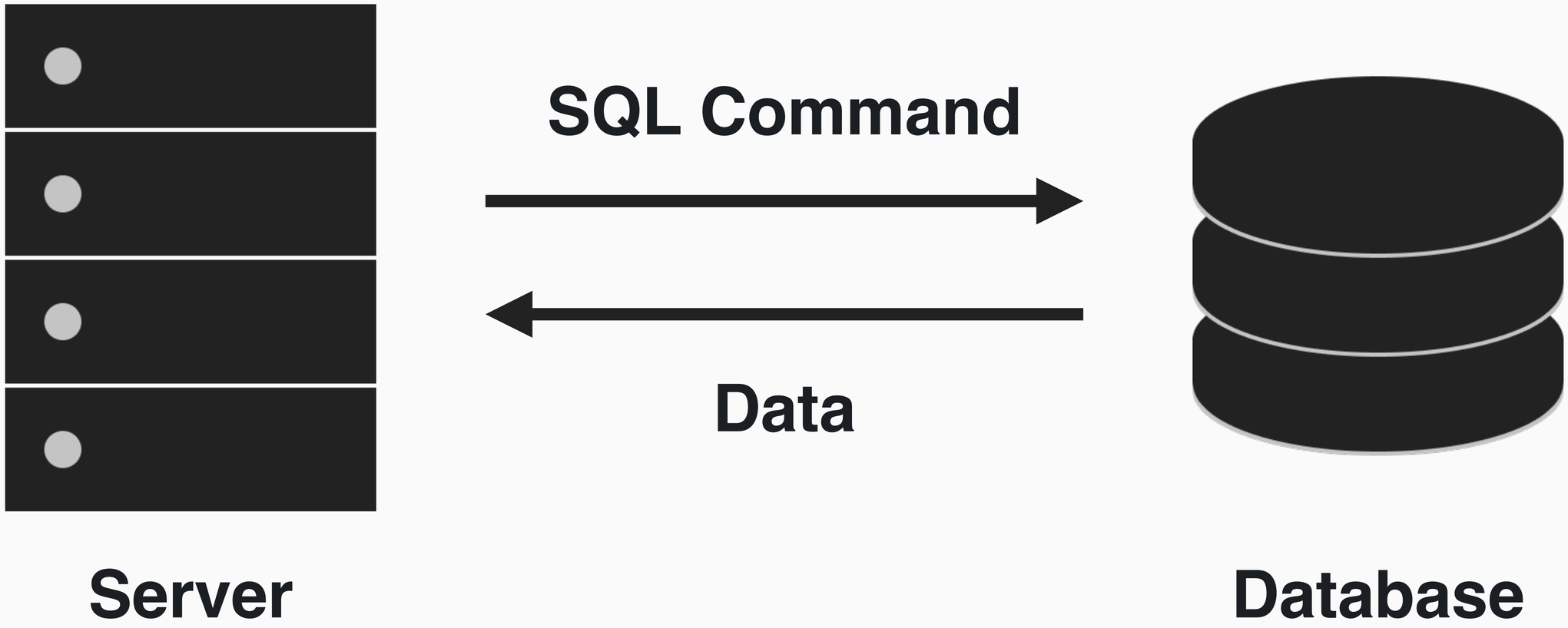
- Route triggered
- Data operation
- Return response

Request

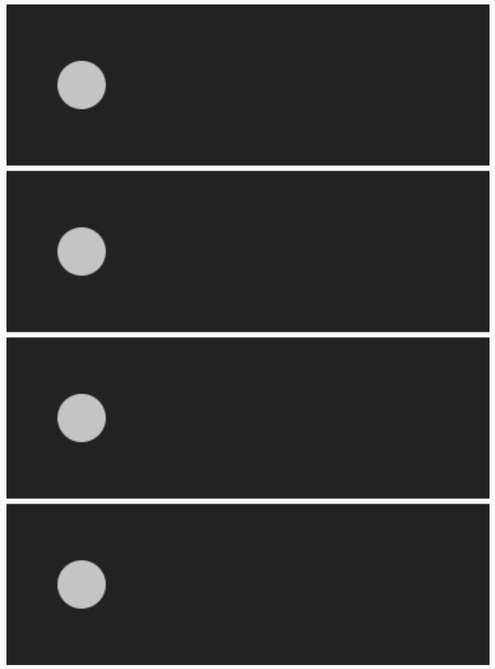


Server

- Route triggered
- Data operation
- Return response

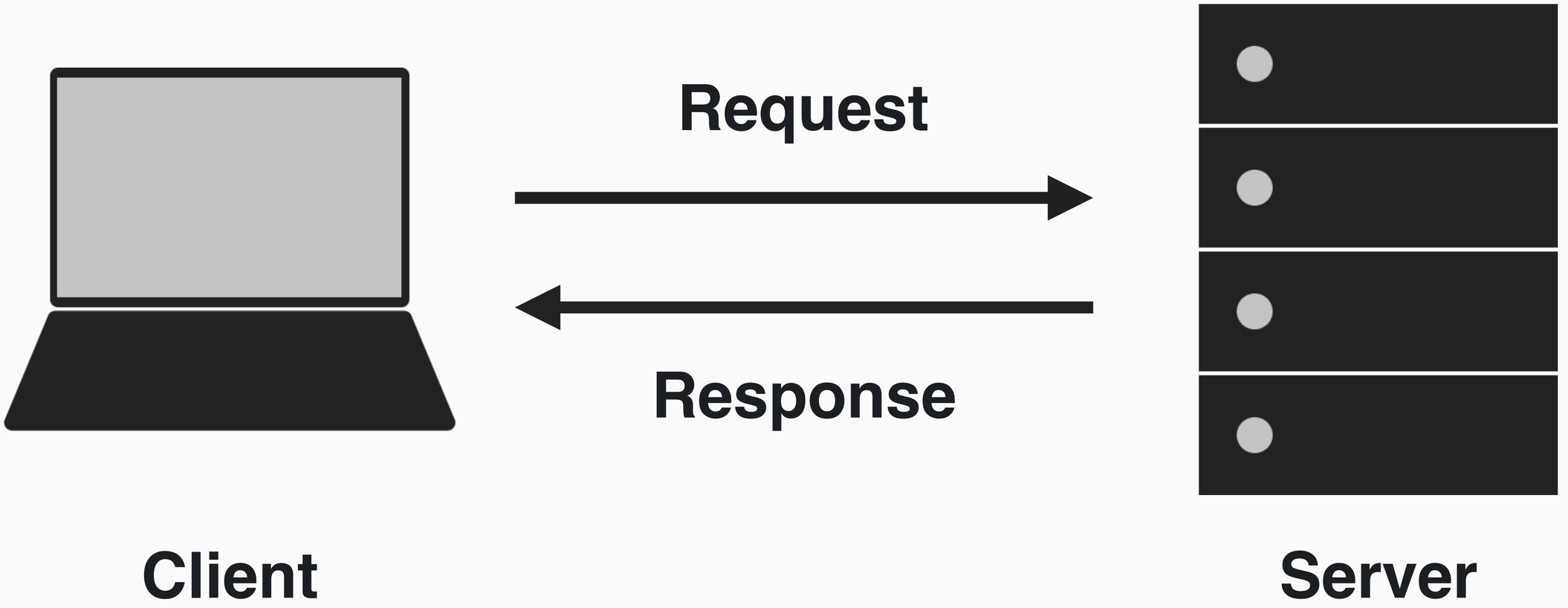

SQL Command
Data
Server
Database

Request



Server

Route triggered
Data operation
Return response


Request
Response
Client
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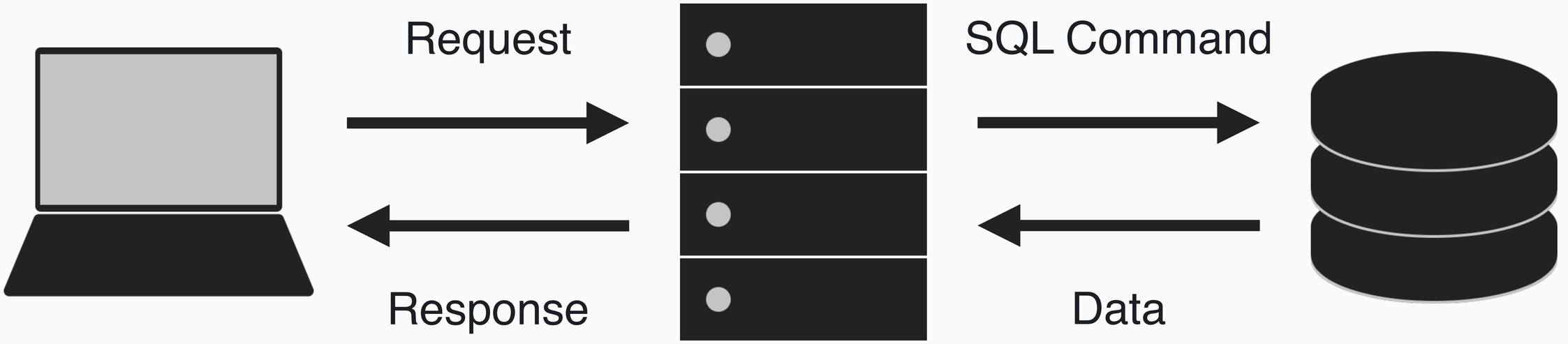
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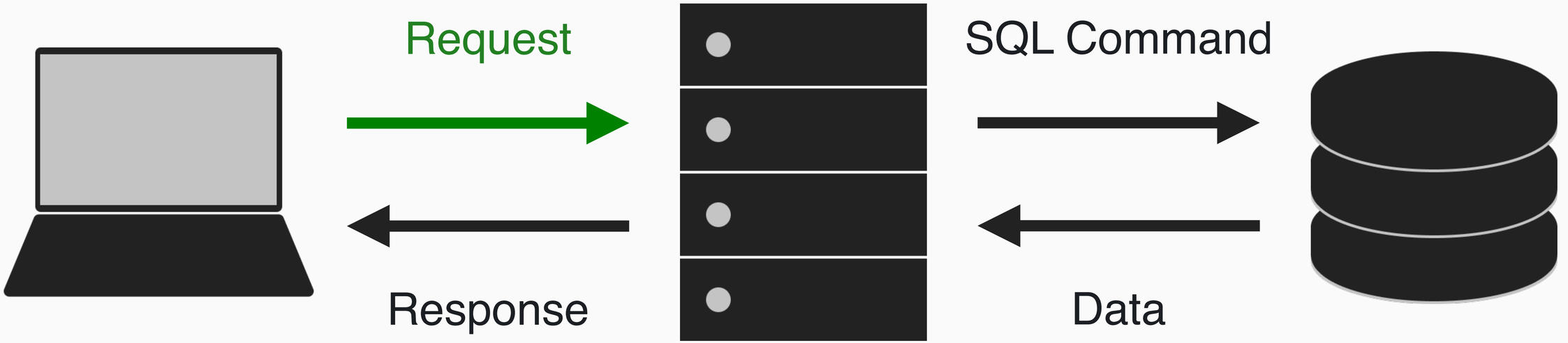
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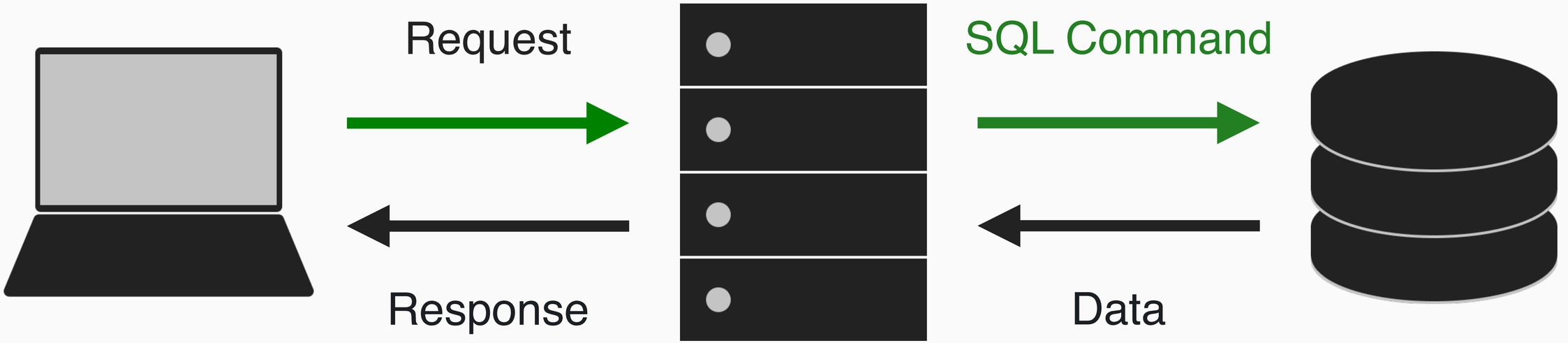
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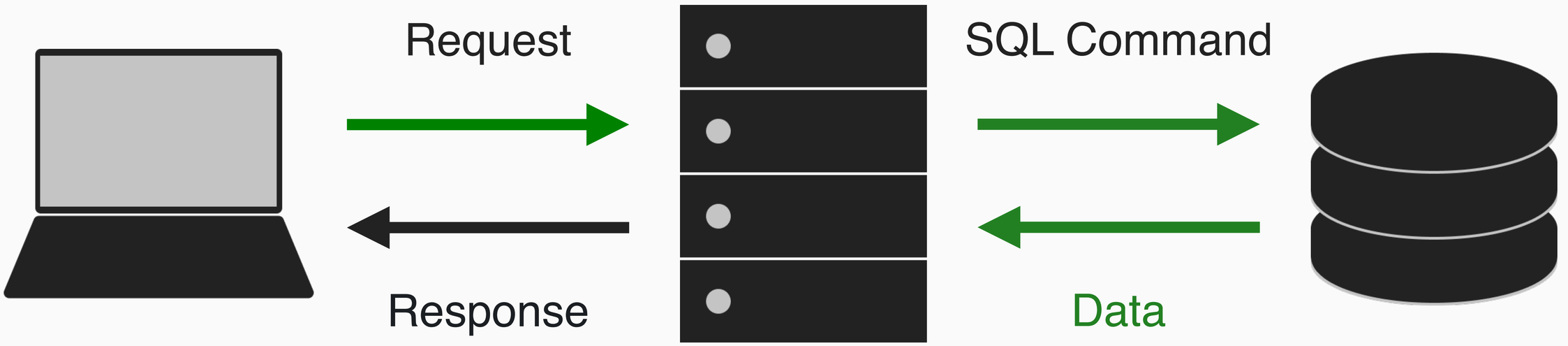
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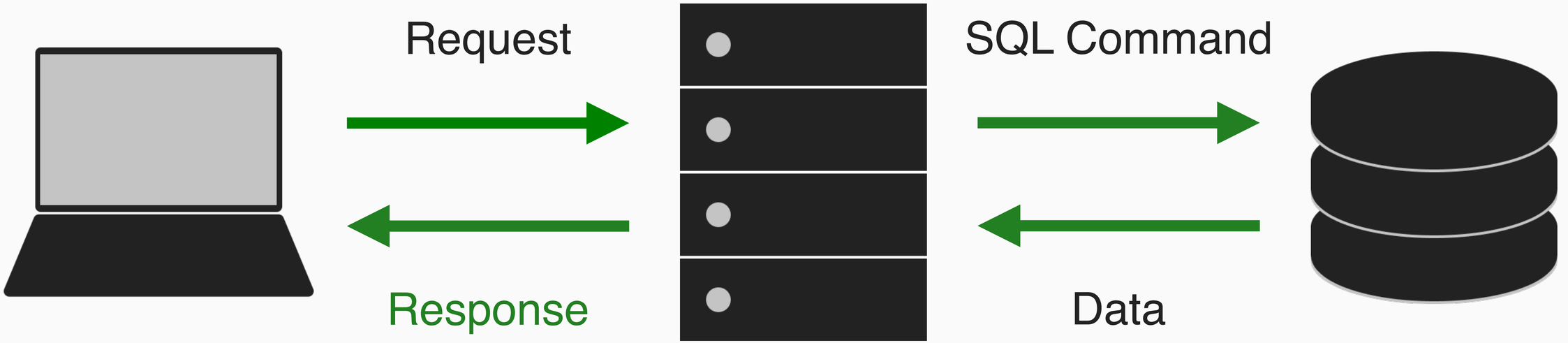
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SQL Command
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Database

Single Table Database

- Tables structure information into rows and columns
- Columns represent a field with a defined type
- Rows represent a collection of column values
- Query and manipulate data with SQL

Course Overview

1. Routes
2. Databases
3. Relational Databases
4. Abstractions
5. Containerization & DevOps
6. Deployment & Services
7. Hack Challenge & Authentication
8. Images & OAuth

Course Overview

1. Routes
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4. Abstractions
5. Containerization & DevOps
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7. Hack Challenge & Authentication
8. Images & OAuth

Questions?

Relational Databases

Overview

- Allows relationships between data
- Which comments belong to which post?
- Which users are friends?
- Which transactions relate to which senders and receivers?

id	name
1	“Jessica”
2	“Shungo”

User Table

id	text	user_id
1	“Shohei Ohtani is the coolest person ever ⚾”	2
2	“I love TikTok!”	1

Post Table

id	name
1	“Jessica”
2	“Shungo”

User Table

id	text	user_id
1	“Shohei Ohtani is the coolest person ever ⚾”	2
2	“I love TikTok!”	1

Post Table

id	name
1	“Jessica”
2	“Shungo”

User Table

id	text	user_id
1	“Shohei Ohtani is the coolest person ever ⚾”	2
2	“I love TikTok!”	1

Post Table

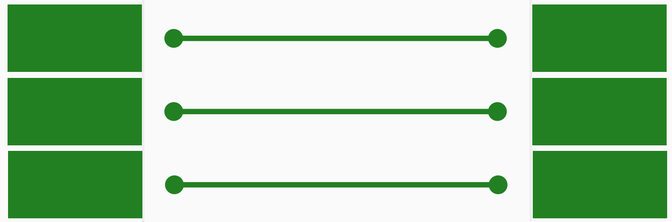
Foreign Keys

- Column in one table that uniquely identifies a specific row
- Also called a “secondary key”
- user_id field in Post Table refers to the id belonging to a user row
- Foreign Key column = relationship

Relationship Types

1. One-to-One
2. One-to-Many
3. Many-to-Many

One-to-One



- Row *x* in table A refers to **one** row *y* in table B
- Row *y* in table B refers to **one** row *x* in table A
- Example: students and netid's
  - Each student has only **one** netid
  - Each netid belongs to only **one** student

User Table

id	name
10	“Shungo”
20	“Jessica”

NetID Table

id	netid	user_id
30	“jzs27”	20
40	“sn685”	10

User Table

id	name
10	“Shungo”
20	“Jessica”

NetID Table

id	netid	user_id
30	“jzs27”	20
40	“sn685”	10

User Table

id	name
10	“Shungo”
20	“Jessica”

NetID Table

id	netid	user_id
30	“jzs27”	20
40	“sn685”	10

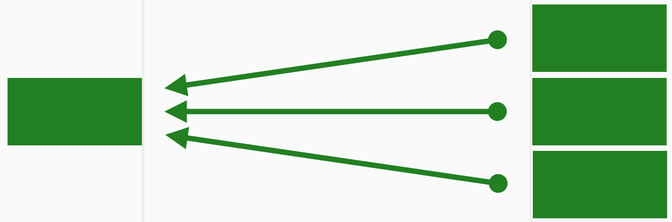
```
CREATE TABLE user (
  id   INTEGER PRIMARY KEY AUTOINCREMENT,
  name TEXT NOT NULL
);

CREATE TABLE netid (
  id      INTEGER PRIMARY KEY AUTOINCREMENT,
  netid   TEXT NOT NULL,
  user_id INTEGER UNIQUE,
  FOREIGN KEY user_id REFERENCES user(id)
);
```

```
INSERT INTO user (name)
     VALUES (“Jessica”);
```

```
INSERT INTO netid (netid, user_id)
     VALUES (“jzs27”, 1);
```

One-to-Many



- Row *x* in table A refers to **many** rows *y1, y2, …* in table B
- Row *y* in table B refers to **one** row *x* in table A
- Example: baseball teams and players
  - Each team can have **many** players
  - Each player belongs to only **one** team

Album Table

id	team_name
10	“IGOR”
20	“4:44”

Song Table

id	name	team_id
30	“EARFQUAKE”	10
40	“I THINK”	10
50	“4:44”	20
60	“Moonlight”	20

Album Table

id	team_name
10	“IGOR”
20	“4:44”

Song Table

id	name	team_id
30	“EARFQUAKE”	10
40	“I THINK”	10
50	“4:44”	20
60	“Moonlight”	20

Album Table

id	team_name
10	“IGOR”
20	“4:44”

Song Table

id	name	team_id
30	“EARFQUAKE”	10
40	“I THINK”	10
50	“4:44”	20
60	“Moonlight”	20

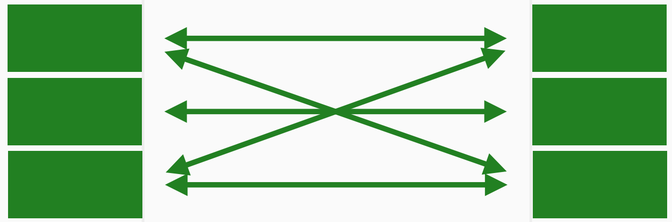
```
CREATE TABLE album (
  id   INTEGER PRIMARY KEY AUTOINCREMENT,
  name TEXT NOT NULL
);

CREATE TABLE song (
  id        INTEGER PRIMARY KEY AUTOINCREMENT,
  name      TEXT NOT NULL,
  album_id  INTEGER NOT NULL,
  FOREIGN KEY album_id REFERENCES album(id)
);
```

```
INSERT INTO song (name, album_id)
     VALUES (“EARFQUAKE”, 10);


SELECT *
  FROM song
 WHERE album_id = 10;
```

Many-to-Many



- Row *x* in table A refers to **many** rows *y1, y2, …* in table B
- Row *y* in table B refers to **many** rows *x1, x2, …* in table A
- Example: students and courses
  - Each student can be in **many** courses
  - Each course can have **many** students

Implementation

- Three potential choices, two are not ideal:
  1. Multiple columns to store more foreign keys
  2. Single column to store a list of id’s
  3. Join / association table

Student Table

id	netid	course1	course2	course3
1	“sn685”	1110	1998	2110
2	“jzs27”	1110	2110	2800

Student Table

id	netid	course1	course2	course3
1	“sn685”	1110	1998	2110
2	“jzs27”	1110	2110	2800

What happens if a student wants more than 3 courses?

Student Table

id	netid	course1	course2	course3		
1	“sn685”	1110	1998	2110		
2	“jzs27”	1110	2110	2800		
3	“gg387”	1110	1998	2110	2800	3110

Student Table

id	netid	course1	course2	course3	course4	course5
1	“sn685”	1110	1998	2110	*null*	*null*
2	“jzs27”	1110	2110	2800	*null*	*null*
3	“gg387”	1110	1998	2110	2800	3110

Student Table

id	netid	course1	course2	course3	course4	course5
1	“sn685”	1110	1998	2110	*null*	*null*
2	“jzs27”	1110	2110	2800	*null*	*null*
3	“gg387”	1110	1998	2110	2800	3110
4	“rm834”	4810	*null*	*null*	*null*	*null*

Student Table

id	netid	courses
1	“sn685”	1110, 1998
2	“jzs27”	1110

Course Table

id	title	students
1110	“CS1110”	1, 2
1998	“CS1998”	1

Student Table

id	netid	courses
1	“sn685”	1110, 1998
2	“jzs27”	1110

Course Table

id	title	students
1110	“CS1110”	1, 2
1998	“CS1998”	1

Student Table

id	netid	courses
1	“sn685”	1110, 1998
2	“jzs27”	1110

Course Table

id	title	students
1110	“CS1110”	1, 2
1998	“CS1998”	1

Student Table

id	netid	courses
1	“sn685”	1110, 1998
2	“jzs27”	1110
3	“gg387”	1110, 1998

Course Table

id	title	students
1110	“CS1110”	1, 2
1998	“CS1998”	1

Student Table

id	netid	courses
1	“sn685”	1110, 1998
2	“jzs27”	1110
3	“gg387”	1110, 1998

Course Table

id	title	students
1110	“CS1110”	1, 2
1998	“CS1998”	1

Student Table

id	netid	courses
1	“sn685”	1110, 1998
2	“jzs27”	1110
3	“gg387”	1110, 1998

Course Table

id	title	students
1110	“CS1110”	1, 2, 3
1998	“CS1998”	1, 3

Student Table

id	netid	courses
1	“sn685”	1110, 1998
2	“jzs27”	1110

Course Table

id	title	students
1110	“CS1110"	1, 2
1998	“CS1998”	1

Student Table

id	netid	courses
1	“sn685”	1110, 1998
2	“jzs27”	1110

Course Table

id	title	students
1110	“CS1110”	1, 2
1998	“CS1998”	1

Student Table

id	netid
1	“sn685”
2	“jzs27”

Join / Association Table

student_id	course_id
1	1110
1	1998
2	1110

Course Table

id	title
1110	“CS1110”
1998	“CS1998”

Student Table

id	netid
1	“sn685”
2	“jzs27”

Join / Association Table

student_id	course_id
1	1110
1	1998
2	1110

Course Table

id	title
1110	“CS1110”
1998	“CS1998”

Student Table

id	netid
1	“sn685”
2	“jzs27”

Join / Association Table

student_id	course_id
1	1110
1	1998
2	1110

Course Table

id	title
1110	“CS1110”
1998	“CS1998”

Student Table

id	netid
1	“sn685”
2	“jzs27”

Join / Association Table

student_id	course_id
1	1110
1	1998
2	1110

Course Table

id	title
1110	“CS1110”
1998	“CS1998”

Student Table

id	netid
1	“sn685”
2	“jzs27”

Join / Association Table

student_id	course_id
1	1110
1	1998
2	1110

Course Table

id	title
1110	“CS1110”
1998	“CS1998”

Student Table

id	netid
1	“sn685”
2	“jzs27”

Join / Association Table

student_id	course_id
1	1110
1	1998
2	1110

Course Table

id	title
1110	“CS1110”
1998	“CS1998”

Student Table

id	netid
1	“sn685”
2	“jzs27”

Join / Association Table

student_id	course_id
1	1110
1	1998
2	1110

Course Table

id	title
1110	“CS1110”
1998	“CS1998”

Student Table

id	netid
1	“sn685”
2	“jzs27”

Join / Association Table

student_id	course_id
1	1110
1	1998
2	1110

Course Table

id	title
1110	“CS1110”
1998	“CS1998”

Student Table

id	netid
1	“sn685”
2	“jzs27”

Join / Association Table

student_id	course_id
1	1110
1	1998
2	1110
2	1998

Course Table

id	title
1110	“CS1110”
1998	“CS1998”

```
CREATE TABLE student (
   id    INTEGER PRIMARY KEY AUTOINCREMENT,
   netid TEXT NOT NULL
);

CREATE TABLE course (
   id    INTEGER PRIMARY KEY AUTOINCREMENT,
   title TEXT NOT NULL
);
```

```
CREATE TABLE join (
   id          INTEGER PRIMARY KEY AUTOINCREMENT,
   course_id   INTEGER NOT NULL,
   student_id INTEGER NOT NULL,
   FOREIGN KEY course_id REFERENCES course(id)
   FOREIGN KEY student_id REFERENCES student(id)
);
```

Demo