Transactions for web developers

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“Transaction management tools are often made to seem like a **black art**.”

Christophe Pettus (2011)
Life with Object-Relational Mappers

Today's talk

Framework

sqlite3 psycopg2

Interface

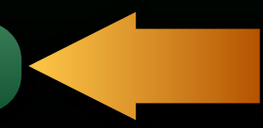
Database

SQL-92

Framework

Interface

Database



Definition

"An **SQL-transaction** (sometimes simply called a "transaction") is a sequence of executions of SQL-statements that is **atomic** with respect to recovery."

Source: http://www.sqlite.org/atomiccommit.html

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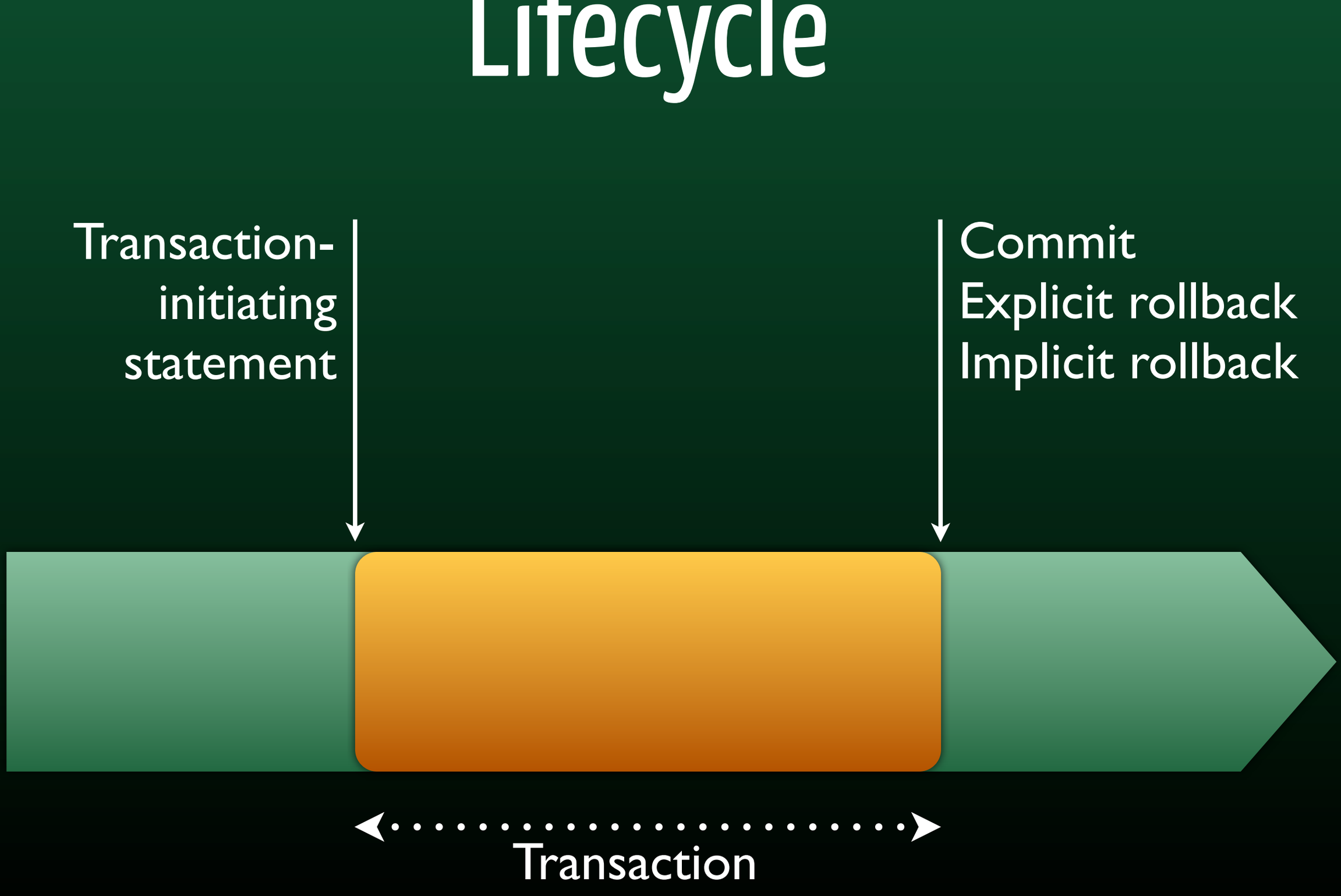
Example

```
BEGIN;

UPDATE  cars
   SET  status = 'available'
 WHERE  id = 1;

UPDATE  rentals
   SET  end = CURRENT_TIMESTAMP
 WHERE  car_id = 1 AND end IS NULL;

COMMIT;
```

Lifecycle

Transaction-initiating statement

Commit
Explicit rollback
Implicit rollback



Isolation levels

At this level,	these phenomena **cannot** happen:
READ UNCOMMITTED	-
READ COMMITTED	dirty read read a row that is never committed
REPEATABLE READ	non repeatable read read different values for the same row
SERIALIZABLE (default)	phantom read read different rows for the same query

SERIALIZABLE also guarantees that transactions are serializable.

Statements

- COMMIT
- ROLLBACK

(advanced)

- SET TRANSACTION ...
- SET CONSTRAINTS ...

SQL:1999

Framework

Interface

Database

Savepoints

becomes either

after

SAVEPOINT S3;

or

RELEASE SAVEPOINT S2;

or

ROLLBACK TO SAVEPOINT S2;

Explicit transaction start

```
START TRANSACTION;

UPDATE  cars
   SET  status = 'available'
 WHERE  id = 1;

UPDATE  rentals
   SET  end = CURRENT_TIMESTAMP
 WHERE  car_id = 1 AND end IS NULL;

COMMIT;
```

Statements

- SAVEPOINT <svpt>
- RELEASE SAVEPOINT <svpt>
- ROLLBACK TO SAVEPOINT <svpt>

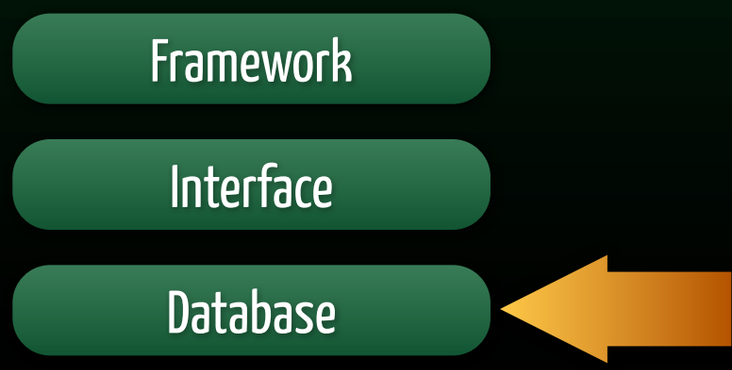
(advanced)

- START TRANSACTION ...

Key learnings

- Statements always run in a transaction.
- Transactions are opened automatically.
- Transactions are advanced technology.

An interlude about PostgreSQL



The dreaded PostgreSQL error:

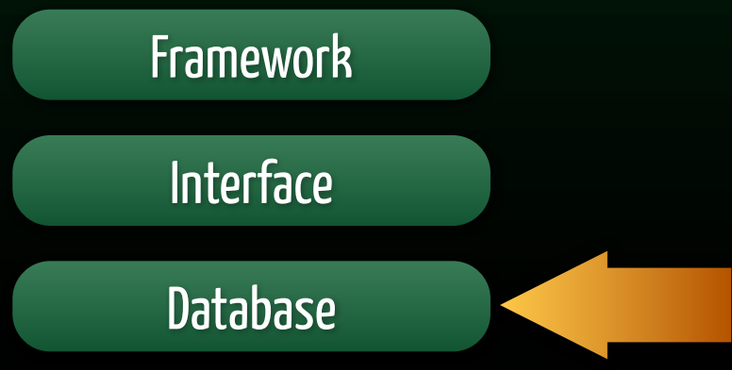
current transaction is aborted,
commands ignored until end of transaction block

What it actually means:

a previous statement failed,
the application must perform a rollback

Any “auto-recovery” scheme breaks transactional integrity!

Autocommit



What does it mean?

- Commit implicitly after each statement.
- Wrap each statement in its own transaction.
- Just execute my query KTHXBYE!

- Most databases default to autocommit.

Transactions in autocommit

START TRANSACTION
BEGIN *(alias)*

COMMIT
ROLLBACK

Auto-commit ON

Auto-commit OFF

Auto-commit ON

Transaction

Autocommit in PostgreSQL

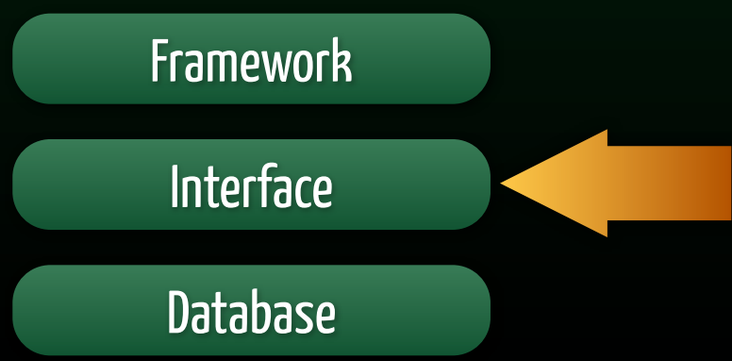
- The server always uses autocommit.
- Client libraries can emulate standard behavior by inserting implicit BEGIN statements.
  - In psql: \set autocommit off

Autocommit in SQLite

- Transaction semantics are tightly related to the implementation of atomic commit.
- SQLite automatically starts a transaction before all statements except SELECT.
- It automatically commits such transactions as soon as all statements finish executing.
- Transactions are always serializable.

Python

client libraries



DB API 2.0 - PEP 249

- Connection
  - Performs commits and rollbacks
- Cursor
  - Executes queries
  - Fetches results

Transactions in PEP 249

- "If the database supports an auto-commit feature, this must be initially off."
- "An interface method may be provided to turn it back on."
- "Closing a connection without committing the changes first will cause an implicit rollback to be performed."

Example

```
>>> from psycopg2 import connect
>>> cnx = connect(...); cur = cnx.cursor()

>>> cur.execute("INSERT INTO cars "
...              "VALUES (1, 'available');")


>>> cnx = connect(...); cur = cnx.cursor()

>>> cur.execute("SELECT * FROM cars;")
>>> cur.fetchall()
[]
```

Example

```
>>> from psycopg2 import connect
>>> cnx = connect(...); cur = cnx.cursor()

>>> cur.execute("INSERT INTO cars "
...                 "VALUES (1, 'available');")
>>> cnx.commit()

>>> cnx = connect(...); cur = cnx.cursor()

>>> cur.execute("SELECT * FROM cars;")
>>> cur.fetchall()
[(1, 'available')]
```

Transactions in psycopg2

- psycopg2 tracks the transaction state.
- It inserts a BEGIN before each statement, unless there's already a transaction in progress.
  - Even before SELECT statements.
  - "Idle in transaction".
- cnx.autocommit = True disables this behavior.

Transactions in sqlite3

- sqlite3 tracks the transaction state.
- It parses statements to insert BEGIN or COMMIT:
  - SELECT: —
  - INSERT, UPDATE, DELETE, REPLACE: BEGIN
  - Any other statement: COMMIT
- cnx.isolation_level = None disables this behavior.
  - This is totally unrelated to the isolation level!

Transactions in sqlite3

- sqlite3 tracks the transaction state.
- It parses statements to insert BEGIN or COMMIT:
  - SELECT: —
  - INSERT, UPDATE, DELETE, REPLACE: BEGIN
  - Any other statement: COMMIT
    - Broken by design.
    - “SAVEPOINT foo” triggers a commit!

Key learnings

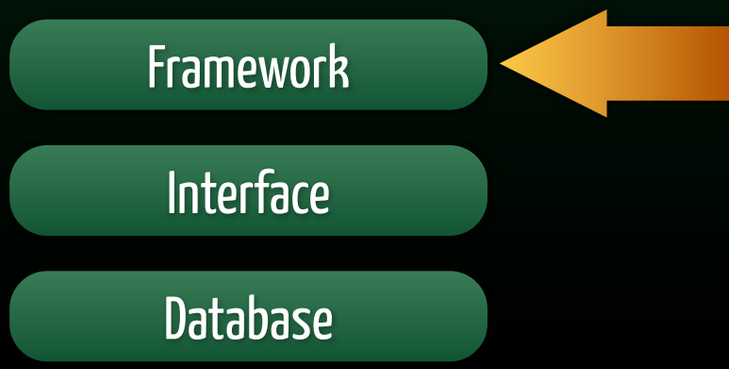
- The DB API requires the same transactional behavior as the SQL standard.

- Client libraries for databases that always autocommit have to emulate this behavior.

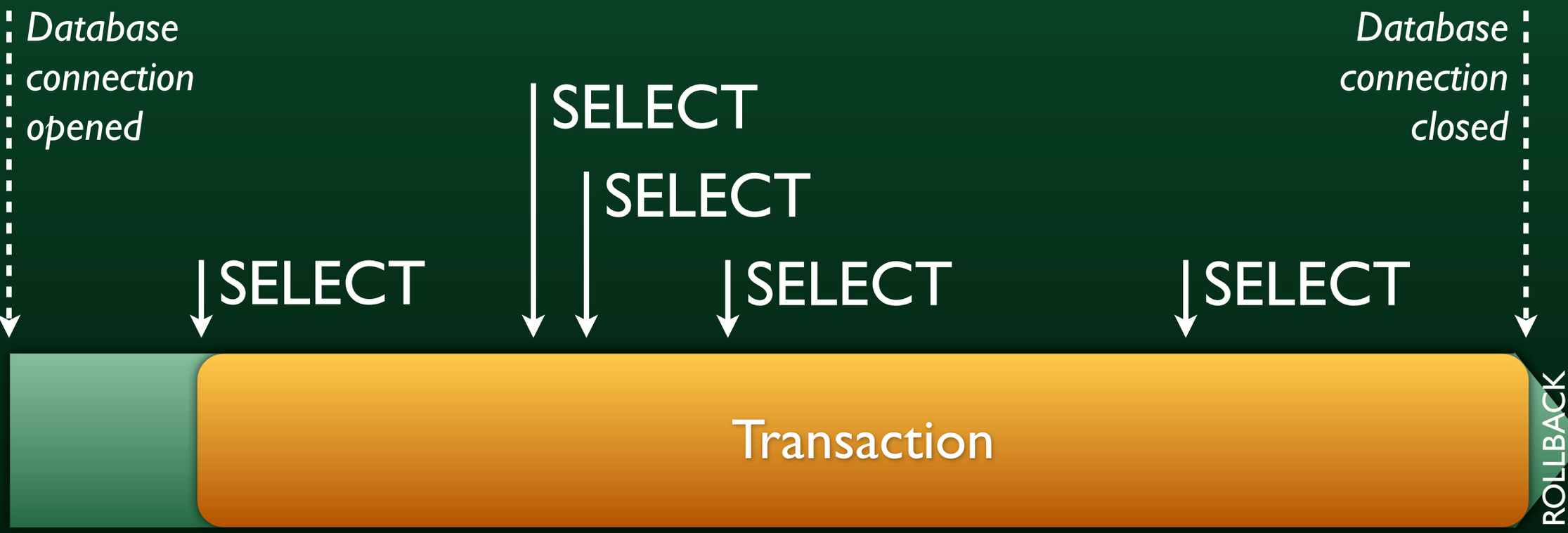
- But you can turn it off and use autocommit.

Problems in

Django ≤ 1.5

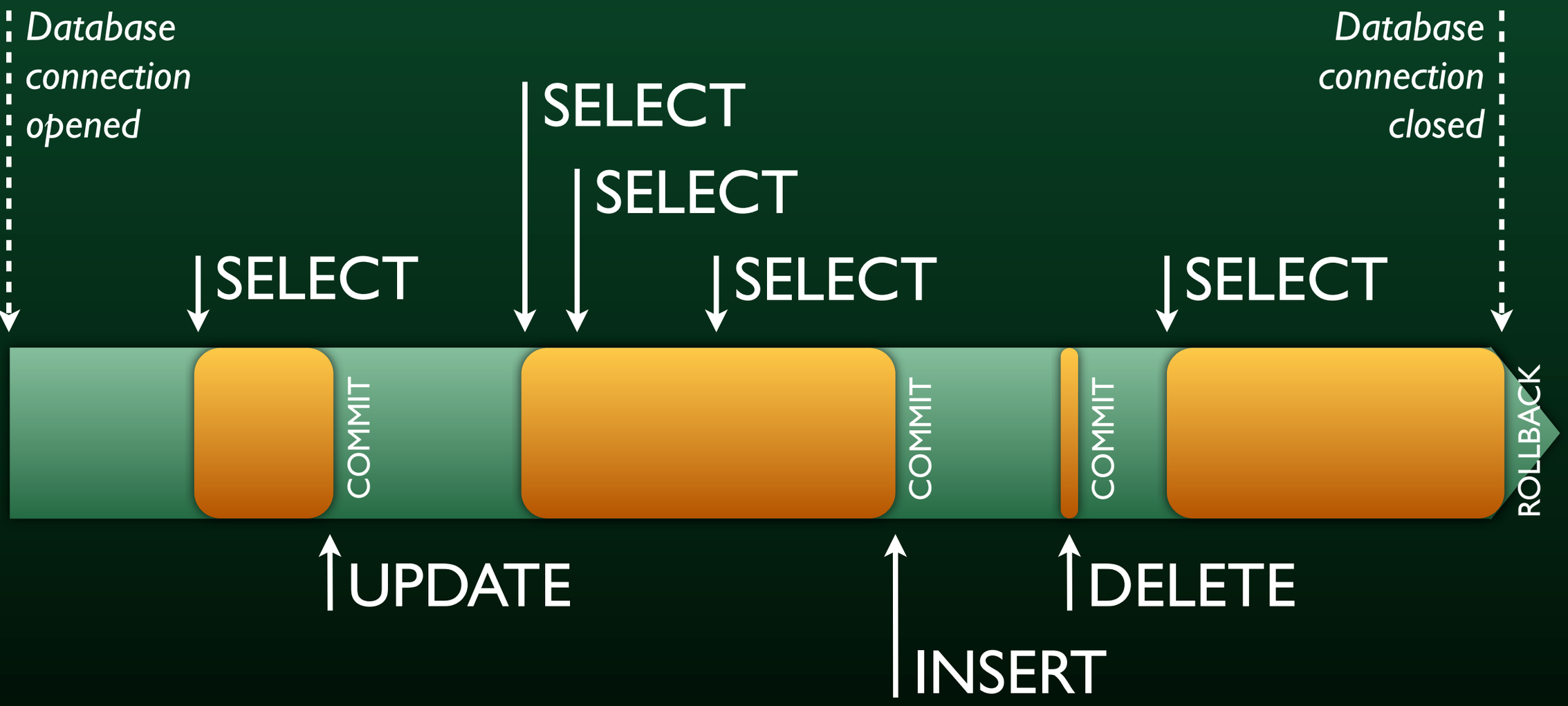


Default behavior (≤ 1.5)



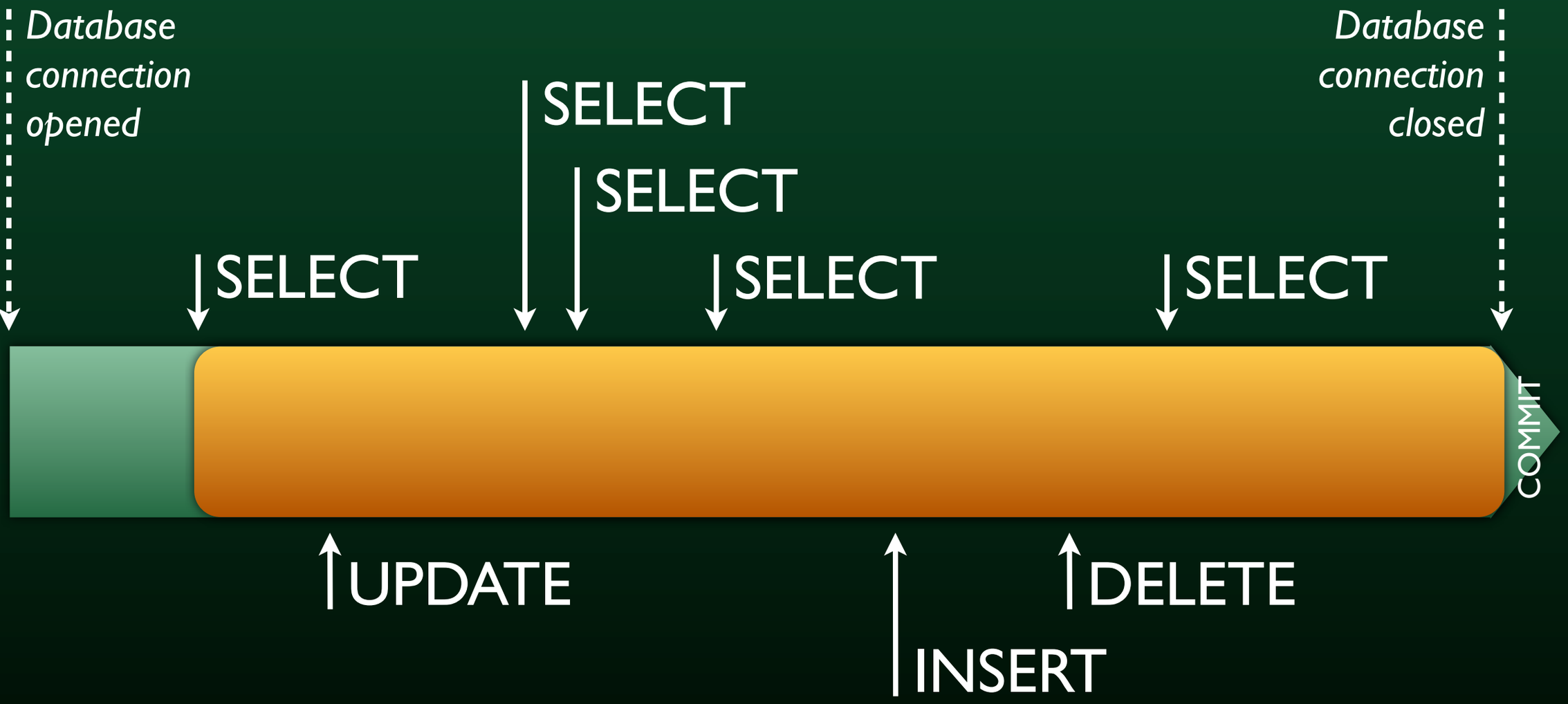
Django runs with an open transaction.

Default behavior (≤ 1.5)



Django "auto-commits" in save(), delete(), update() and bulk_create().

Transaction middleware



One HTTP request ≈ one transaction. Commit on success, roll back on exception.

Only for the default database! **May or may not apply to middleware!**

High-level APIs

```
from django.db import transaction

with transaction.autocommit():
    # Like Django's default behavior.

with transaction.commit_on_success():
    # Like the transaction middleware.

with transaction.commit_manually():
    # Don't use it.
```

Low-level APIs

```
from django.db import transaction

transaction.commit()
transaction.rollback()


sid = transaction.savepoint()

transaction.savepoint_commit(sid)
transaction.savepoint_rollback(sid)
```

How do they interact with Django's transaction management?

Behind the scenes

- Django maintains a stack of transaction management states:
  - "Auto" (False): the ORM commits every change.
  - "Managed" (True): Django doesn't commit.
- Django maintains a "dirty" flag:
  - Set automatically by the ORM after writes.
  - Must be set manually after raw SQL writes.

Nesting doesn't work well

```
from django.db import transaction

from music.models import Guitar

guitars = (Guitar.objects
                 .filter(brand="Fender"))

with transaction.commit_on_success():
    guitars.update(brand="Gibson")
    with transaction.autocommit():
        # Raises IntegrityError.
        guitars.compute_ratings()
```

Is the brand change saved?

Nesting doesn't work well

```
from django.db import transaction

from music.models import Guitar

guitars = (Guitar.objects
                 .filter(brand="Fender"))

with transaction.commit_on_success():
    guitars.update(brand="Gibson")
    with transaction.commit_manually():
        # Raises IntegrityError.
        guitars.compute_ratings()
```

Is the brand change saved?

Key learnings

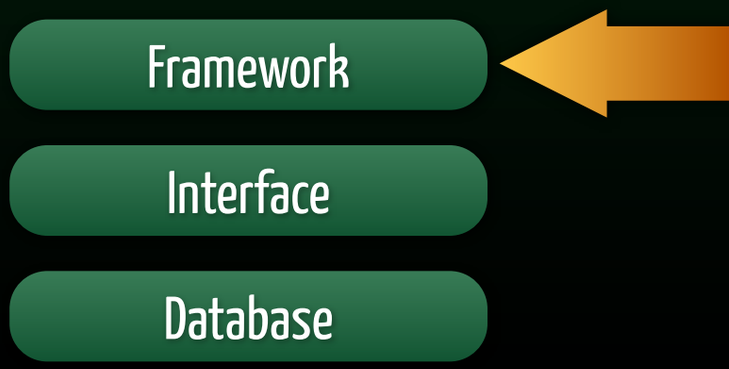
- If you never understood transaction management in Django ≤ 1.5, that's fine.

- The transaction middleware is a reasonable idea.

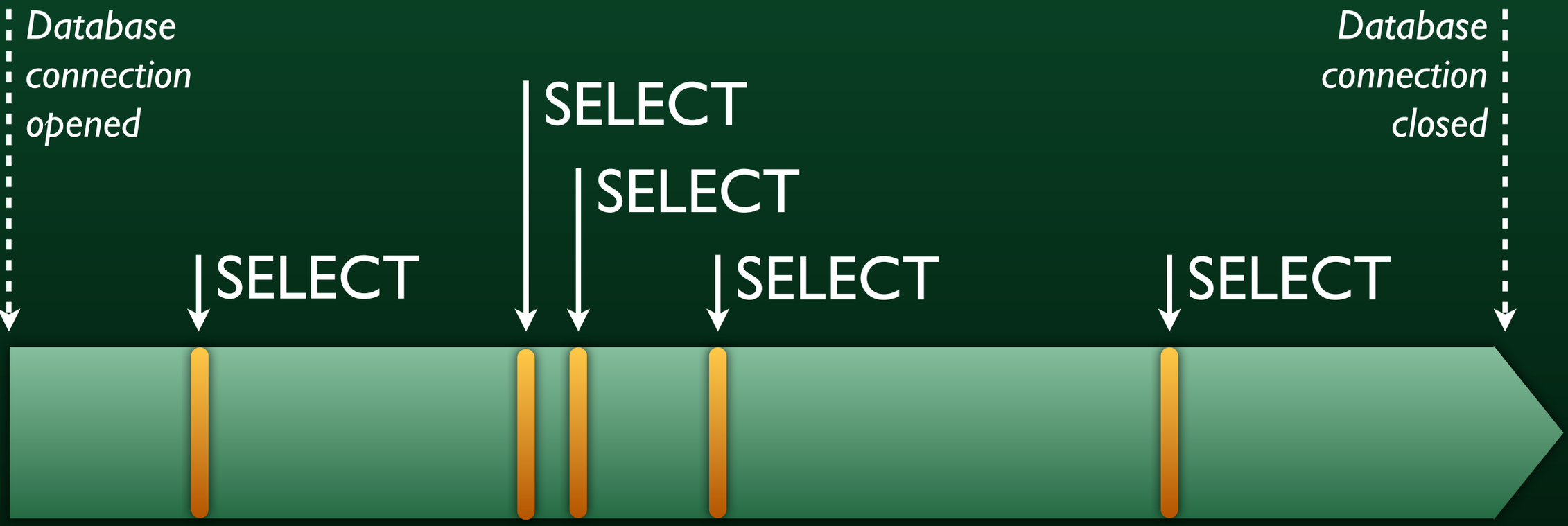
- The decorators / context managers don't work well, especially when they're nested.

Solution in

Django ≥ 1.6

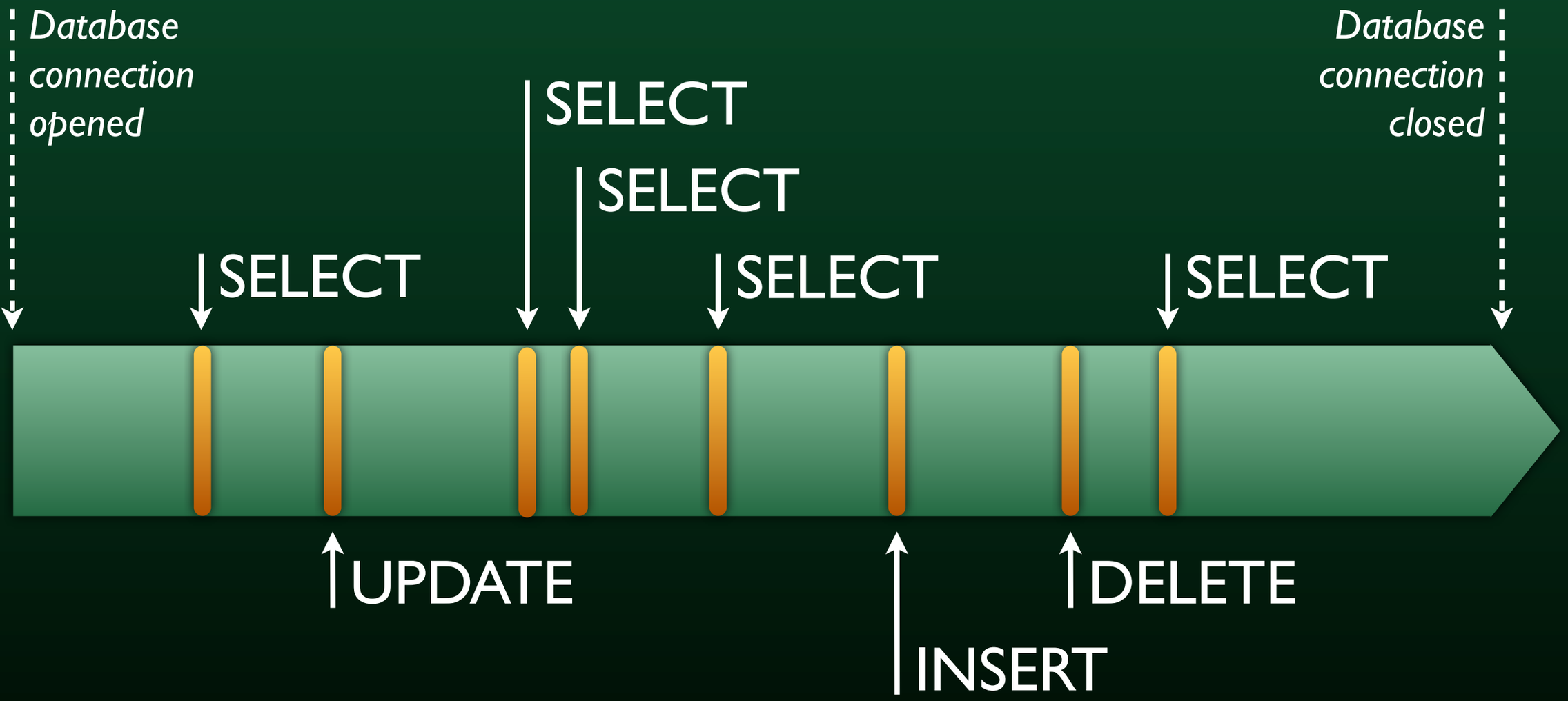


Default behavior (≥ 1.6)



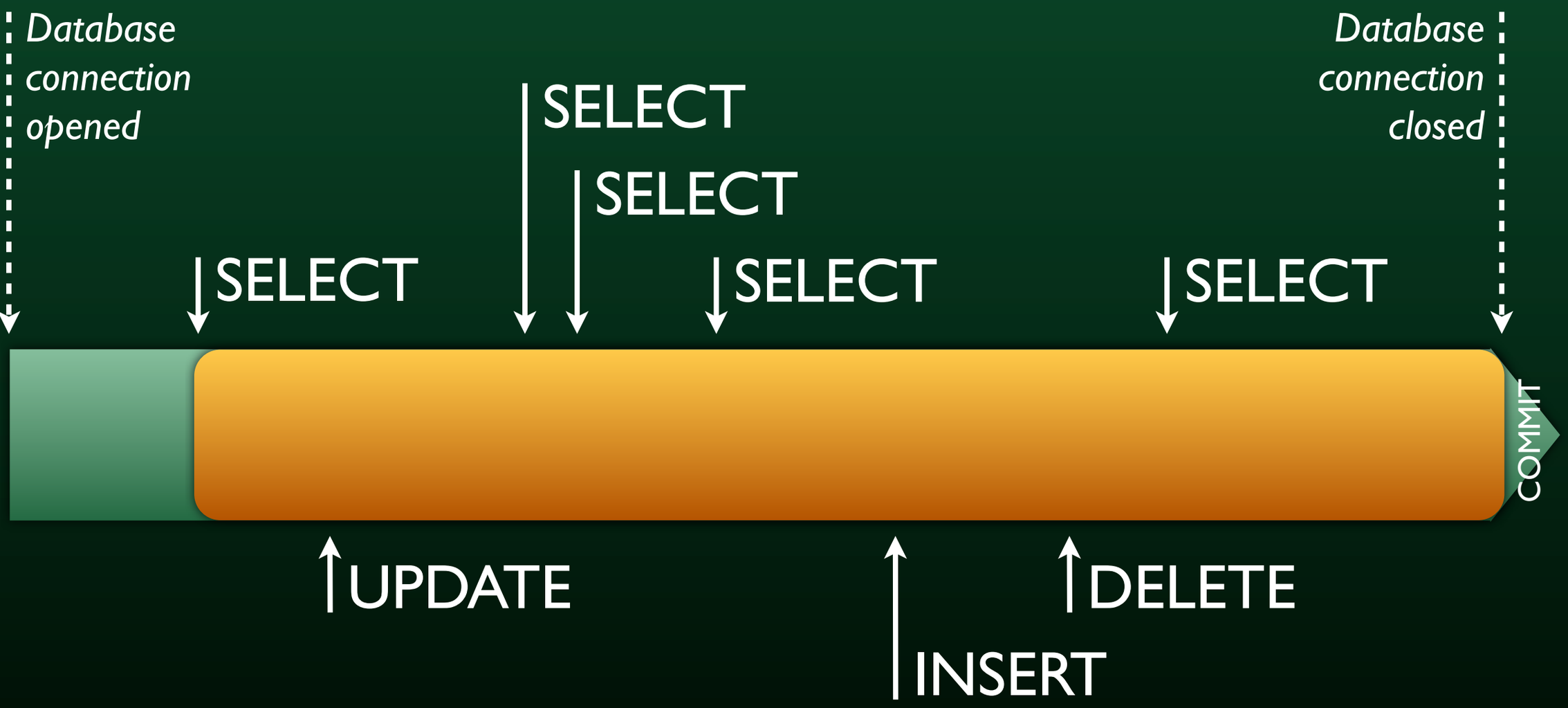
Django ≥ 1.6 uses database-level autocommit.

Default behavior (≥ 1.6)



Django ≥ 1.6 uses database-level autocommit.

ATOMIC_REQUESTS



One HTTP request = one transaction. Commit on success, roll back on exception.

Per database. **Only for the view function.**

High-level API: atomic

- Usable as a decorator or as a context manager.
- Commits on success, rolls back on exceptions.

- Can be nested without any restrictions.
  - Concept stolen from xact.
- Guarantees atomicity.
  - *"Don't Give Users Guns Aimed At Feet"* principle.

Error recovery with atomic

```
from django.db import IntegrityError
from django.db import transaction

@transaction.atomic()
def meddle_with_guitars(guitars)
    guitars.update(brand="Gibson")

    try:
        with transaction.atomic():
            guitars.compute_ratings()
    except IntegrityError:
            guitars.check_consistency()

    guitars.check_inventory()
```

Low-level APIs

- Still there in case you're sufficiently masochistic to to implement your own transaction management.

- There aren't many sane ways to combine them.

Key learnings

- If you don't understand transaction management in Django ≥ 1.6, read the documentation!

- ATOMIC_REQUESTS is still a reasonable idea.

- Use the atomic decorator / context manager whenever you need atomicity.

Thank you!

Questions?

https://docs.djangoproject.com/en/dev/topics/db/transactions/