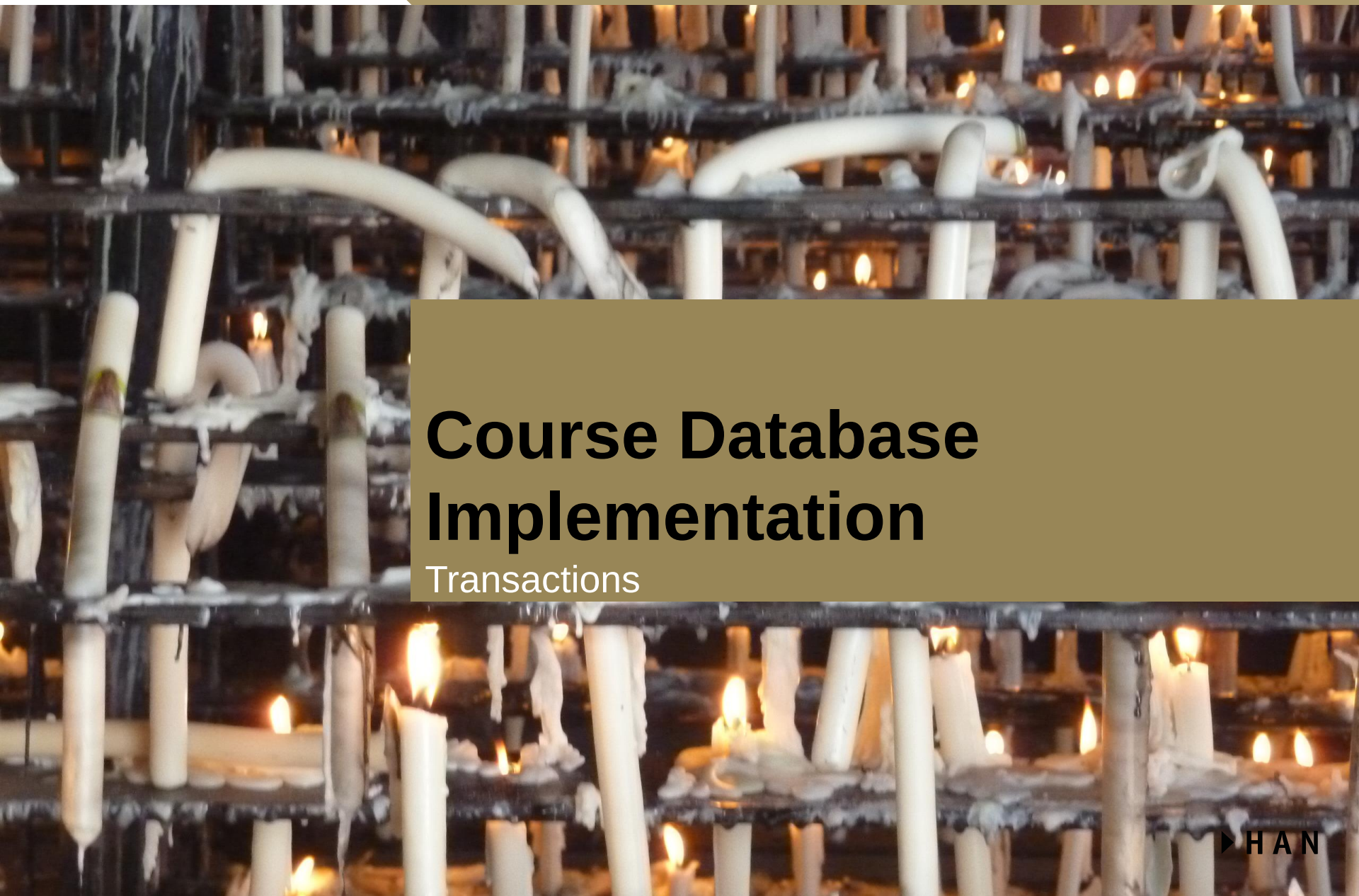
ICA | INFORMATICA COMMUNICATIE ACADEMIE

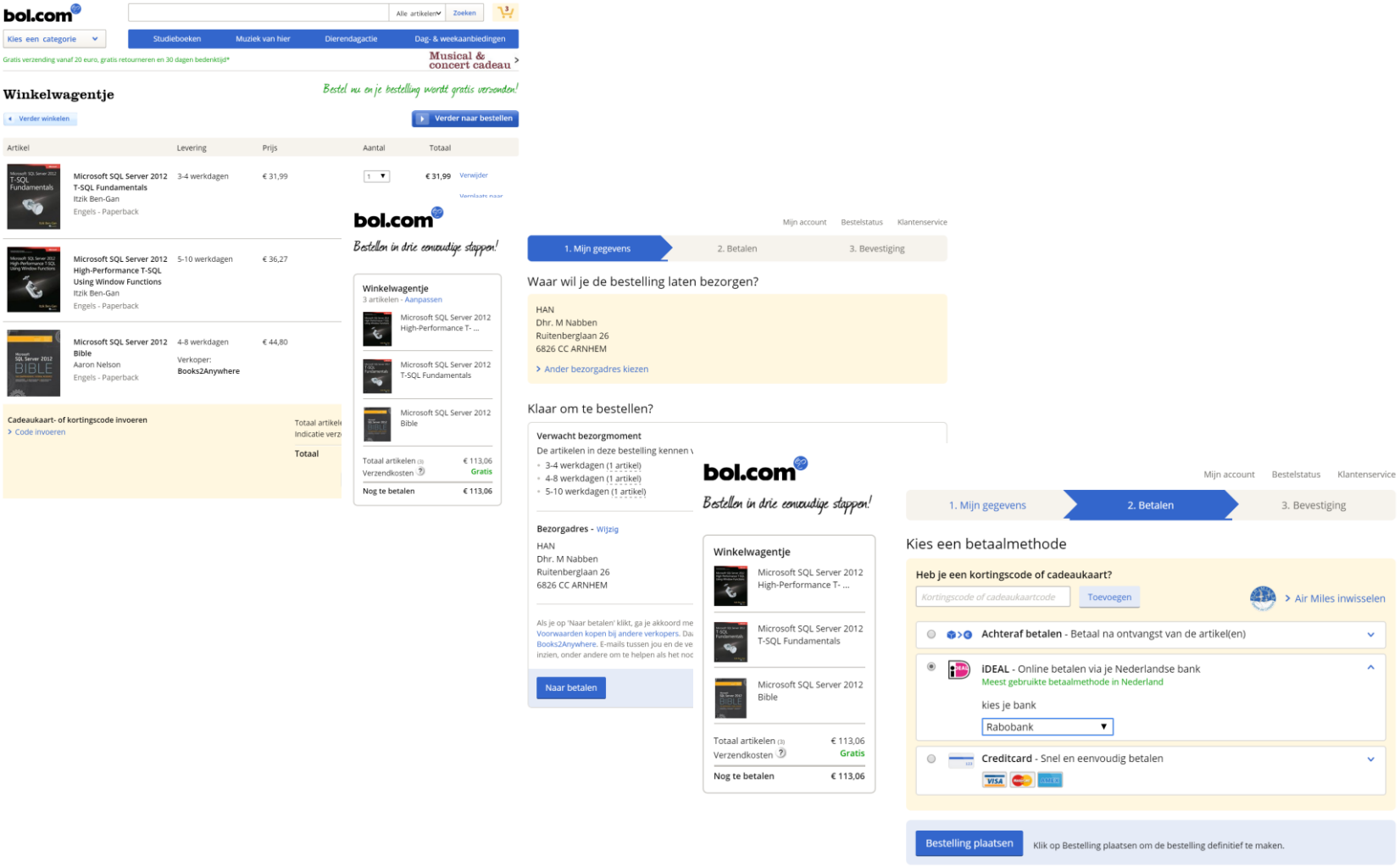


Course Database Implementation

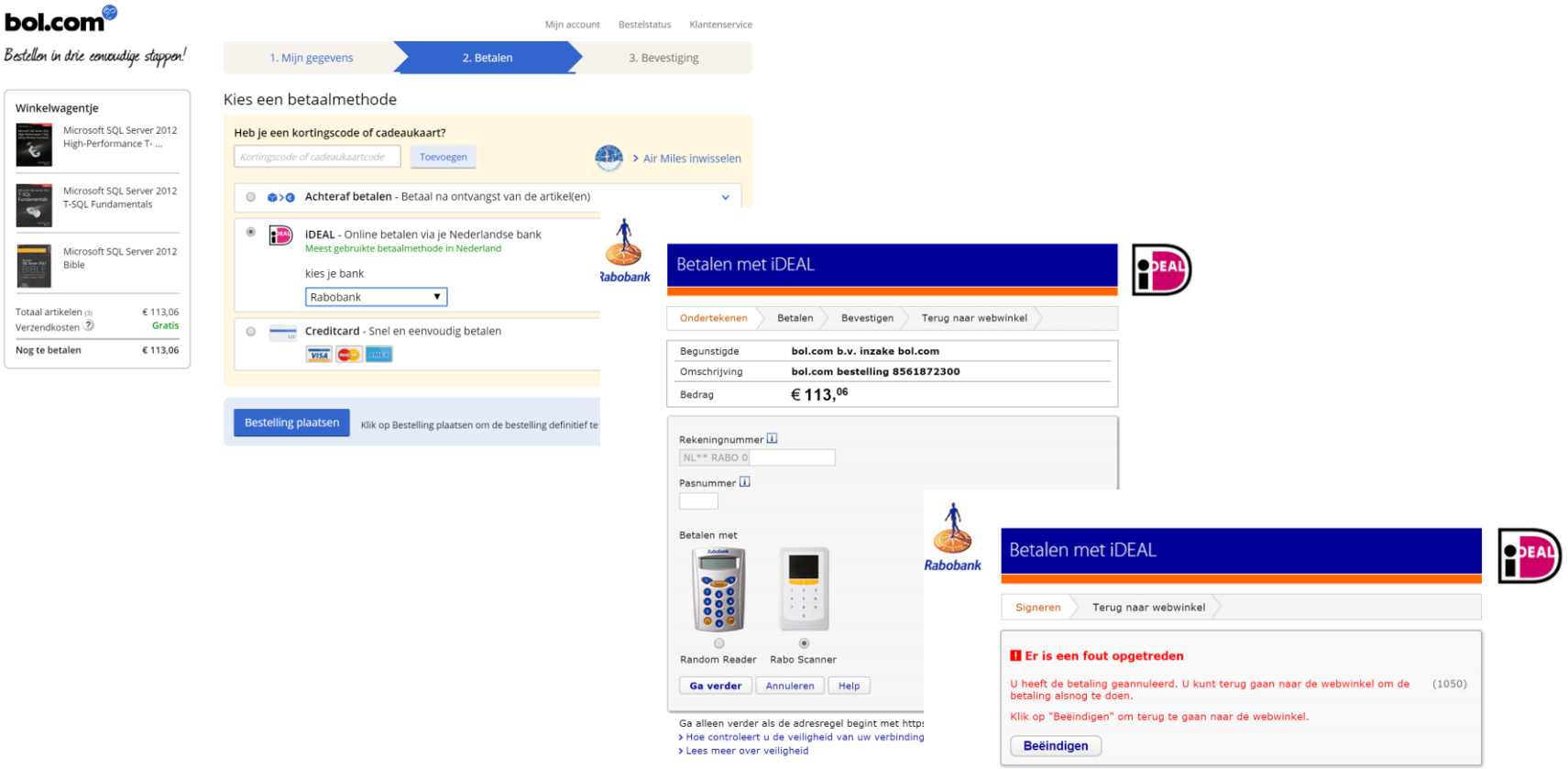
Transactions

HAN

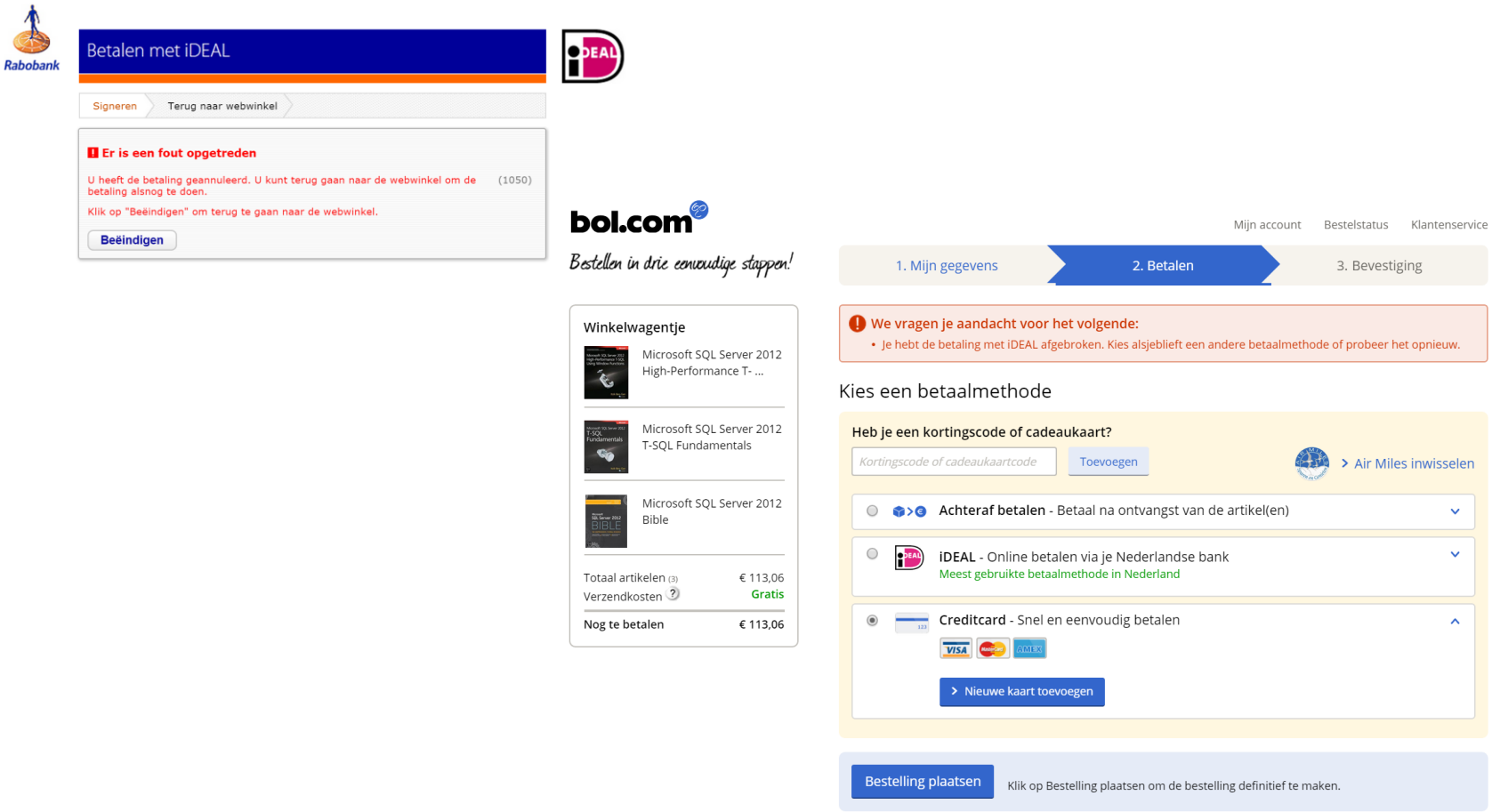
Order with BOL.COM



Payment by IDEAL



Confirmation of BOL.COM



Order process 1-3

- **Add articles to shopping basket**
  - BOL.COM >> ADDTOBASKET
- **Place order in basket**
  - BOL.COM >> PLACEORDER
- **Pay order**
  - BOL.COM >> PAYORDER
    - IDEAL >> PAYORDER …
      - *RABOBANK >> PAYORDER*
      - *RABOBANK >> CONFIRMPAYMENT*
    - IDEAL >> CONFIRMPAYMENT
  - BOL.COM >> CONFIRMPAYMENT
- **Receive confirmation order**
  - BOL.COM >> SENDCONFIRMATION
- **Receive articles**

CRUCIAL TRANSACTION

Order process 2-3

- **Add articles to shopping basket**
  - BOL.COM >> ADDTOBASKET
- **Place order in basket**
  - **BOL.COM >> PLACEORDER**
- **Pay order**
  - **BOL.COM >> PAYORDER**
    - **IDEAL >> PAYORDER …**
      - *RABOBANK >> PAYORDER* **<< ERROR**
      - *RABOBANK >> CONFIRMPAYMENT*
    - IDEAL >> CONFIRMPAYMENT
  - BOL.COM >> CONFIRMPAYMENT
- **Receive confirmation order**
  - BOL.COM >> SENDCONFIRMATION
- **Receive articles**

NESTED TRANSACTIONS

Order process 3-3

- **Add articles to shopping basket**
  - BOL.COM >> ADDTOBASKET
- **Place order in basket**
  - **BOL.COM >> PLACEORDER**
- **Pay order**
  - **BOL.COM >> PAYORDER**
    - **IDEAL >> PAYORDER …**
      - *RABOBANK >> PAYORDER* **<< ERROR**
      - *RABOBANK >> CONFIRMPAYMENT*
    - IDEAL >> CONFIRMPAYMENT
  - BOL.COM >> CONFIRMPAYMENT
- **Receive confirmation order**
  - BOL.COM >> SENDCONFIRMATION
- **Receive articles**

NESTED TRANSACTIONS

CANCEL

Example transactions

```
CREATE TABLE checkings (
    account VARCHAR(10) CONSTRAINT pk_checkings PRIMARY KEY,
    Balance INT NOT NULL
)

CREATE TABLE savings (
    account VARCHAR(10) CONSTRAINT pk_savings PRIMARY KEY,
    Balance INT NOT NULL
)

INSERT checkings (account, balance) VALUES ('Sally', 5000)

INSERT savings (account, balance) VALUES ('Sally', 2000)
```

Why do we need Transactions?

Bank transfer:

```
BEGIN TRANSACTION
                UPDATE checkings
                SET balance = balance - 1000
                WHERE account = 'Sally'

                UPDATE savings
                SET balance = balance + 1000
                WHERE account = 'Sally'
COMMIT TRANSACTION
```

These statements must *both* execute, or *none* of them

Transaction management may (!) help you

Try out

```
BEGIN TRANSACTION

UPDATE checkings
SET balance = balance - 1000
WHERE account = 'Sally'

SELECT ch.balance + sav.balance AS [Total Balance]
FROM checkings ch INNER JOIN savings sav
       ON ch.account = sav.account
WHERE ch.account = 'Sally'

/*
now break the connection without committing
and execute the SELECT statement again
*/
```

Transaction

Set of database operations

- to be completed at one time
- as though they were a single, **atomic operation**

A transaction must either be

- ***wholly* committed**
  - making the changes durable
- or **rolled back**
  - any changes must be undone

Commands are database vendor specific!

Transactions in SQL Server

Transactions are managed at the connection level by the Recovery Manager

Three modes:

- **Autocommit**
  - **Default**
- **Explicit transaction management**
  - **For executing two or more SQL-statements in a transaction**
- **Implicit transaction management**
  - **For ANSI-compatibility**

Autocommit mode

Default mode in SQL Server

EVERY T-SQL-statement is committed or rolled back when it completes

INSERT, UPDATE, DELETE, CREATE, etc.

- **UPDATE titles**
  SET price = price * 1.05
- **ALL rows will be committed or NO rows at all! (including execution of triggers)**
- **THROW in Trigger causes a Rollback (RAISERROR doesn't !!)**

Explicit Transactions

Programmer uses specific instructions:

- BEGIN TRANSACTION
- COMMIT TRANSACTION
- ROLLBACK TRANSACTION

- SAVE TRANSACTION savepoint_name
- ROLLBACK TRANSACTION savepoint_name

```
BEGIN TRANSACTION
    INSERT orders …

    UPDATE inventory
      SET   …
COMMIT TRANSACTION, or ROLLBACK TRANSACTION
```

'Nested' Transactions

Transactions can be ‘nested’

- Usually occurs when stored procedures or triggers with `BEGIN TRAN - COMMIT TRAN` statements invoke one another

-
```
BEGIN TRAN
  …
      BEGIN TRAN
      …
      COMMIT TRAN
  …
COMMIT TRAN
```

Only the outermost `BEGIN-COMMIT` statement pair applies!!

But `ROLLBACK TRAN` rolls back ALL changes up to first BEGIN TRAN.

@@TRANCOUNT

Tells how many `BEGIN TRAN` commands have been executed without being committed

When no open transactions exist: `@@TRANCOUNT is 0`

`BEGIN TRAN`: `@@TRANCOUNT += 1`

`COMMIT TRAN`: `@@TRANCOUNT -= 1`

`ROLLBACK TRAN`: `@@TRANCOUNT := 0`

`SAVE TRAN savepoint_name`: *no effect* on `@@TRANCOUNT`

`ROLLBACK TRAN savepoint_name`: *no effect* on `@@TRANCOUNT`

Implicit Transactions

Command:

```
SET IMPLICIT_TRANSACTIONS ON
```

Result:

SQL Server then automatically starts a transaction when it first executes:

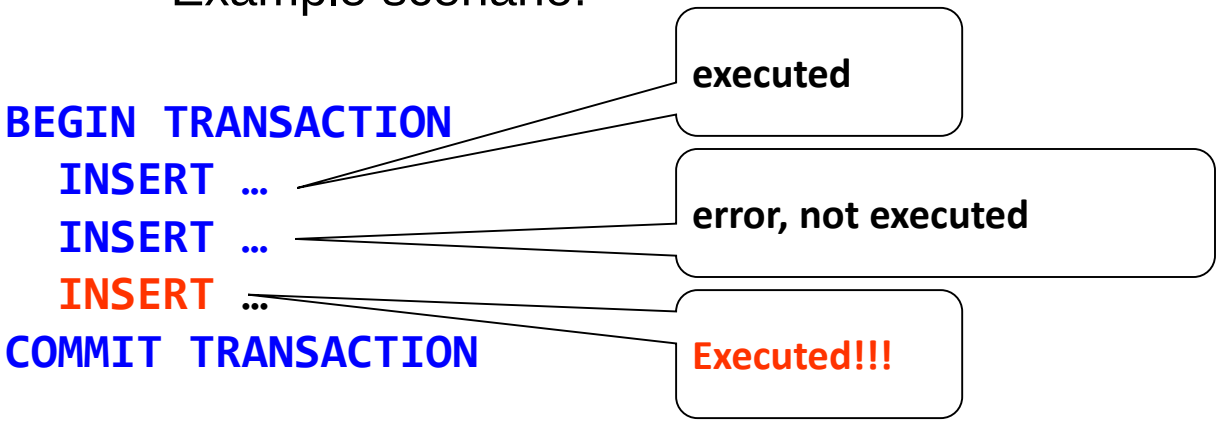
- `DELETE, INSERT, SELECT, UPDATE, CREATE, DROP, ALTER`, etc.
- transaction remains in effect until a `COMMIT` or `ROLLBACK` is issued

For compatibility with Oracle, DB2, …

Error handling inside transactions

Transaction management does not handle errors!

- Example scenario:



Violates the Atomic property

EXCEPTION HANDLING is REQUIRED !!!

Without exception handling

```
CREATE TABLE test (
    col INT CONSTRAINT PK_TEST PRIMARY KEY
)
GO

BEGIN TRAN
    INSERT test (col) VALUES (1)
    INSERT test (col) VALUES (1)
    INSERT test (col) VALUES (2)
COMMIT TRAN

-- Messages? Exercise 1
```

Is this exception handling?

```
BEGIN TRAN
    DECLARE @err int
    INSERT test (col) VALUES (1)
    SET @err = @@ERROR
    IF @err <> 0 ROLLBACK TRAN

    INSERT test (col) VALUES (1)
    SET @err = @@ERROR
    IF @err <> 0 ROLLBACK TRAN

    INSERT test (col) VALUES (2)
    SET @err = @@ERROR
    IF @err <> 0 ROLLBACK TRAN
COMMIT TRAN

-- Messages? Exercise 2
```

Exception handling with TRY/CATCH

```
BEGIN TRY
    BEGIN TRAN
        INSERT test (col) VALUES (1)
        INSERT test (col) VALUES (1)
        INSERT test (col) VALUES (2)
    COMMIT TRAN
END TRY
BEGIN CATCH
    ROLLBACK TRAN
END CATCH

-- Messages? Exercise 3
```

But when it's a nested transaction?

```
BEGIN TRAN
    BEGIN TRY
        BEGIN TRAN
        INSERT test (col) VALUES (1)
        INSERT test (col) VALUES (1)
        INSERT test (col) VALUES (2)
        COMMIT TRAN
    END TRY
    BEGIN CATCH
        ROLLBACK TRAN
    END CATCH
COMMIT TRAN

-- Messages? Exercise 4
```

Now as a stored proc…

```
CREATE PROC tranTest
AS
BEGIN
    BEGIN TRY
        BEGIN TRAN
        INSERT test (col) VALUES (1)
        INSERT test (col) VALUES (1)
        INSERT test (col) VALUES (2)
        COMMIT TRAN
    END TRY
    BEGIN CATCH
        ROLLBACK TRAN
    END CATCH
END
GO
BEGIN TRAN -- suppose the call is inside a transaction:
    EXEC tranTest
COMMIT TRAN -- Messages? Exercise 5
```

Solution? Exercise 6

Make a generally usable template for transaction management in a stored procedure.

***Explanation*:**

Stored procedures may need to use explicit transaction management.

Of course TRY/CATCH is used for exception handling.

But the sp itself may be called from another transaction, what can be checked in the sp.

In this case it is preferred that the sp itself does not execute a BEGIN TRAN, but instead a SAVE TRAN: the sp can do a rollback to the savepoint, but leave the actual rollback or commit to the *calling transaction*.

Exception handling in transactions

Guidelines for stored procedures

Commit as many transactions as you begin

Don't rollback a transaction unless @@TRANCOUNT was zero when the sp started

- Better not to rollback at all
- Protects you from the situation where a sp is executed in another transaction
- The stored procedure must signal the **caller** that is has failed

Transaction Log

```
CREATE DATABASE dbTest
```

Results in creation of two files:

```
dbTest.mdf          -- the database
dbTest_log.ldf      -- the transaction log
```

Data changes do NOT go initially to the database itself

Changes are first written serially to the Transaction Log

Transaction Log

Write-ahead log

- on the database level
- so **ONE** log for all users of the database

The log is changed in cache, and is only *flushed* to disk at a COMMIT

SQL Server uses the log to recover data in case of

- a system failure
- a transaction cancellation request

Data Modification

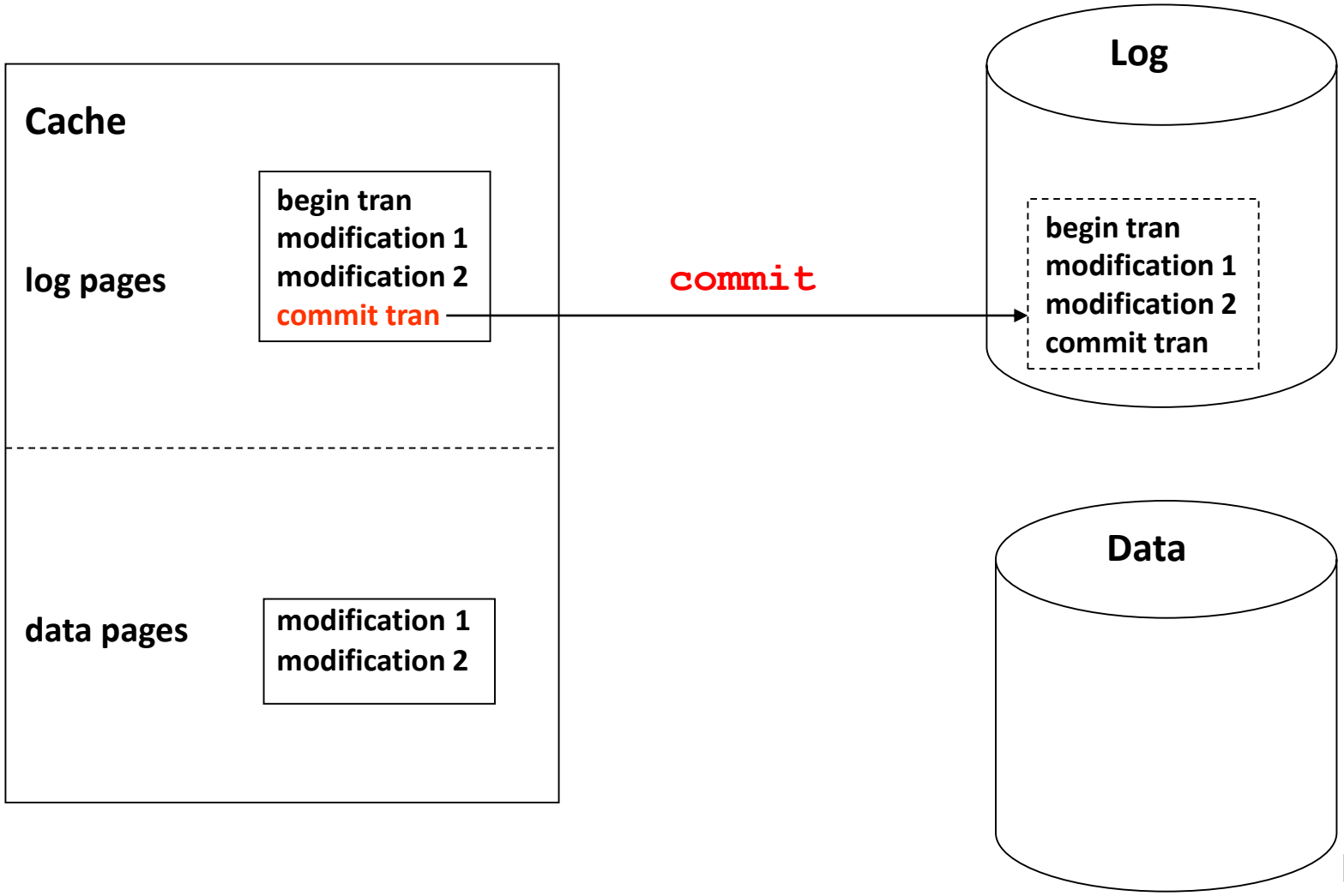
SQL Server caches modifications in buffers for a period of time to optimize disk writes:

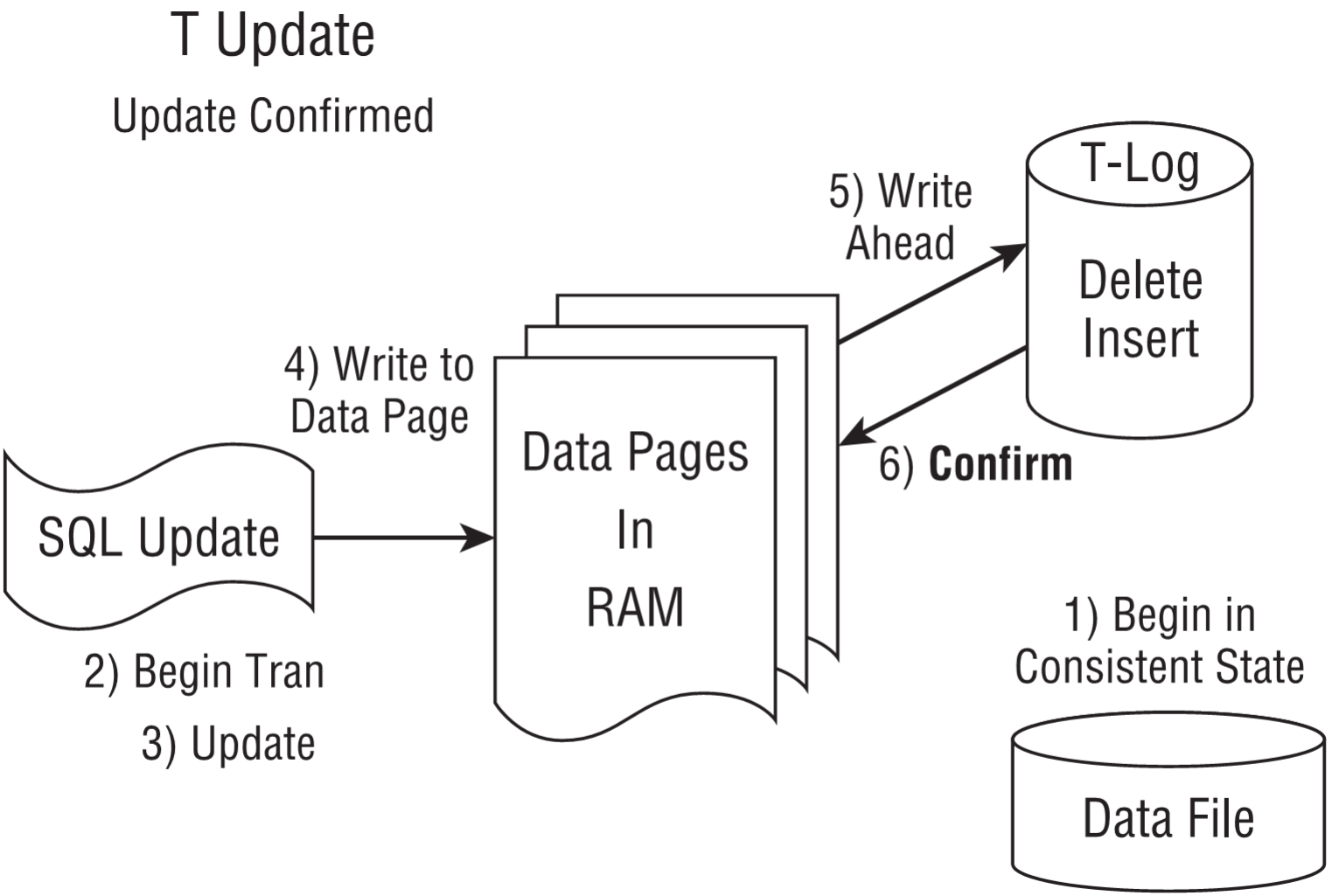
- `BEGIN TRANSACTION` written in log (log cache)
- Modification in log (log cache)
- Modification of the data (data cache)
- `COMMIT TRANSACTION` in log (log cache)

The `COMMIT` forces a 'Flush' of dirty log pages to disk

- *Dirty pages*: Log pages or data pages that have been modified, but are not yet been written to disk
- Log pages are written to disk *before* data pages are written to disk

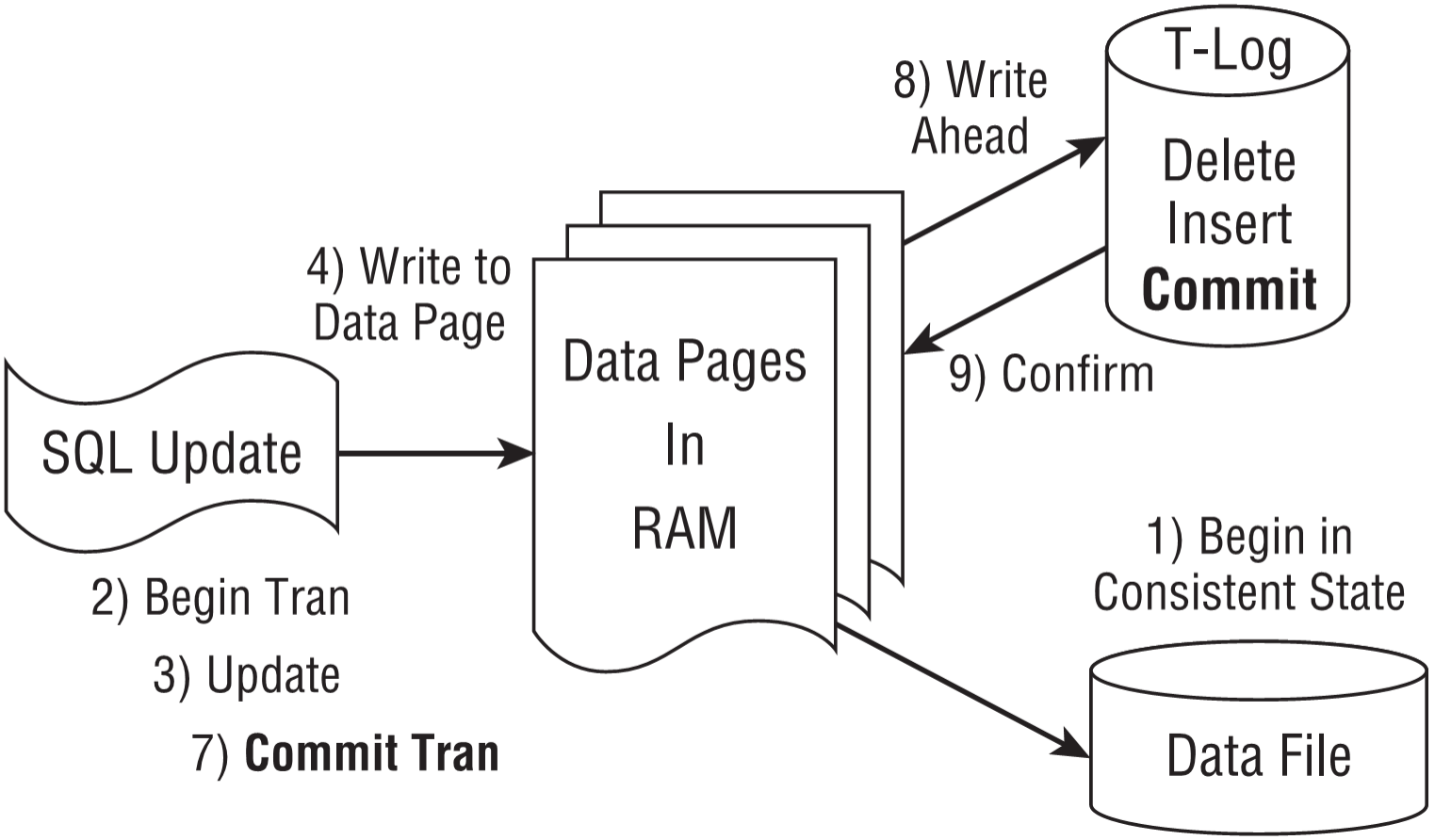
The Commit Process



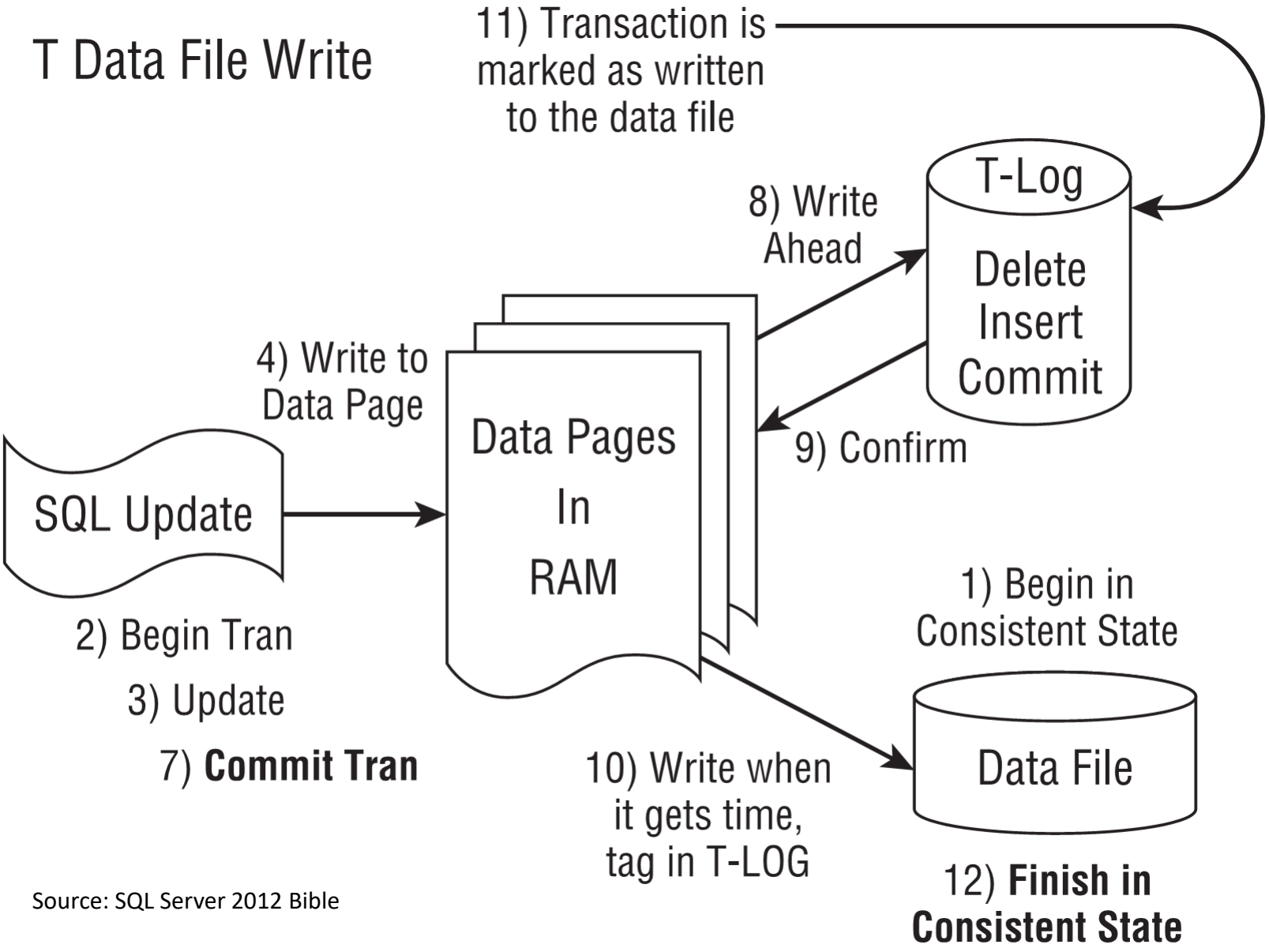


Source: SQL Server 2012 Bible

T Commit



Source: SQL Server 2012 Bible



Source: SQL Server 2012 Bible

Checkpoint

periodic synchronization between database and log

- **ALL** dirty data pages are written from cache to disk
- log pages are written at COMMIT or ROLLBACK
- checkpoint is also being logged

reduces the time and resources needed to recover

- otherwise the log would fill up

checkpoint is issued by:

- DBO with the command **CHECKPOINT**
- Server when the *recovery interval* is elapsed

Recovery

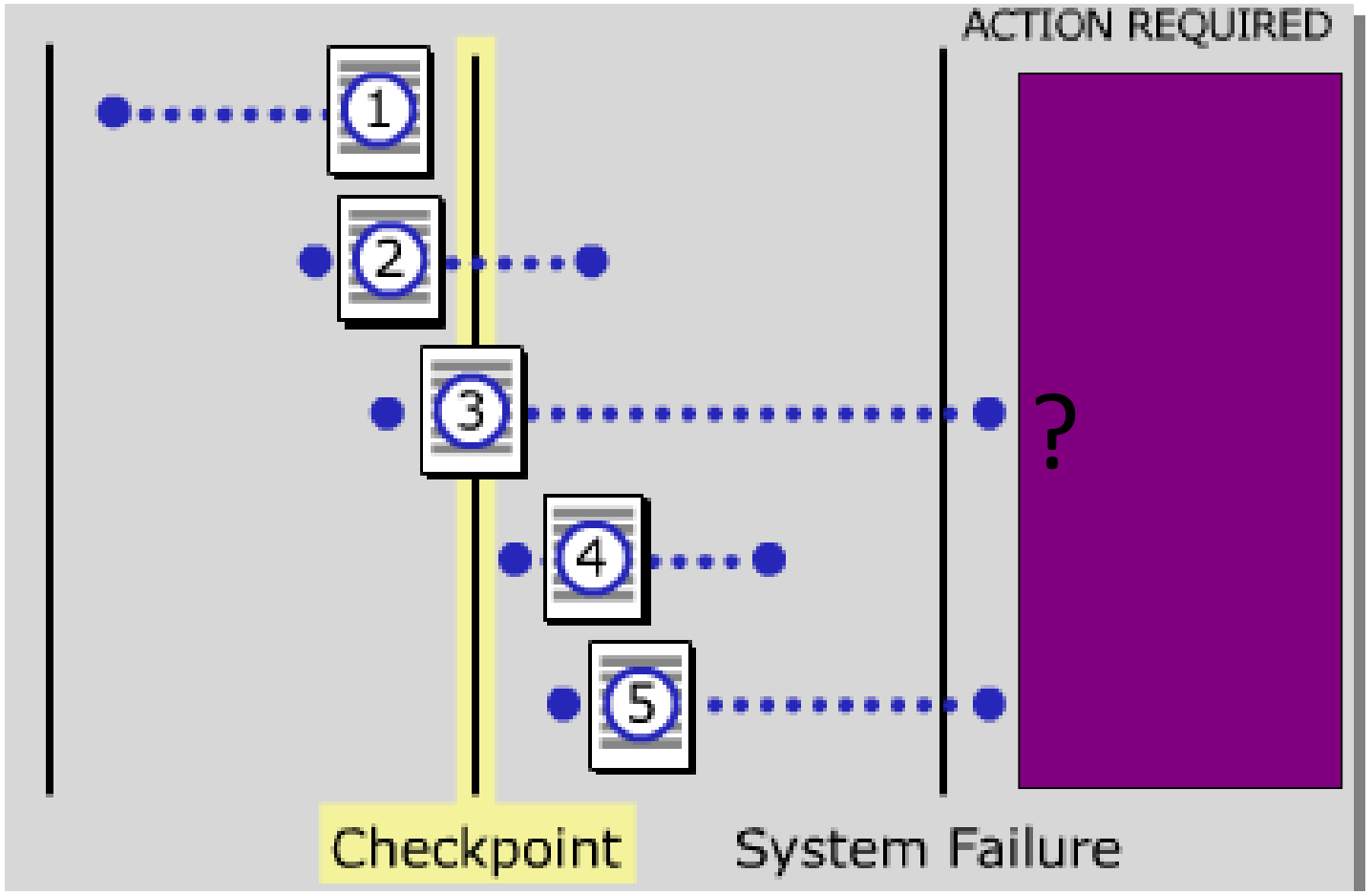
At recovery time the server examines the log on disk

Committed transactions which are not yet written to disk are written to disk (roll forward)

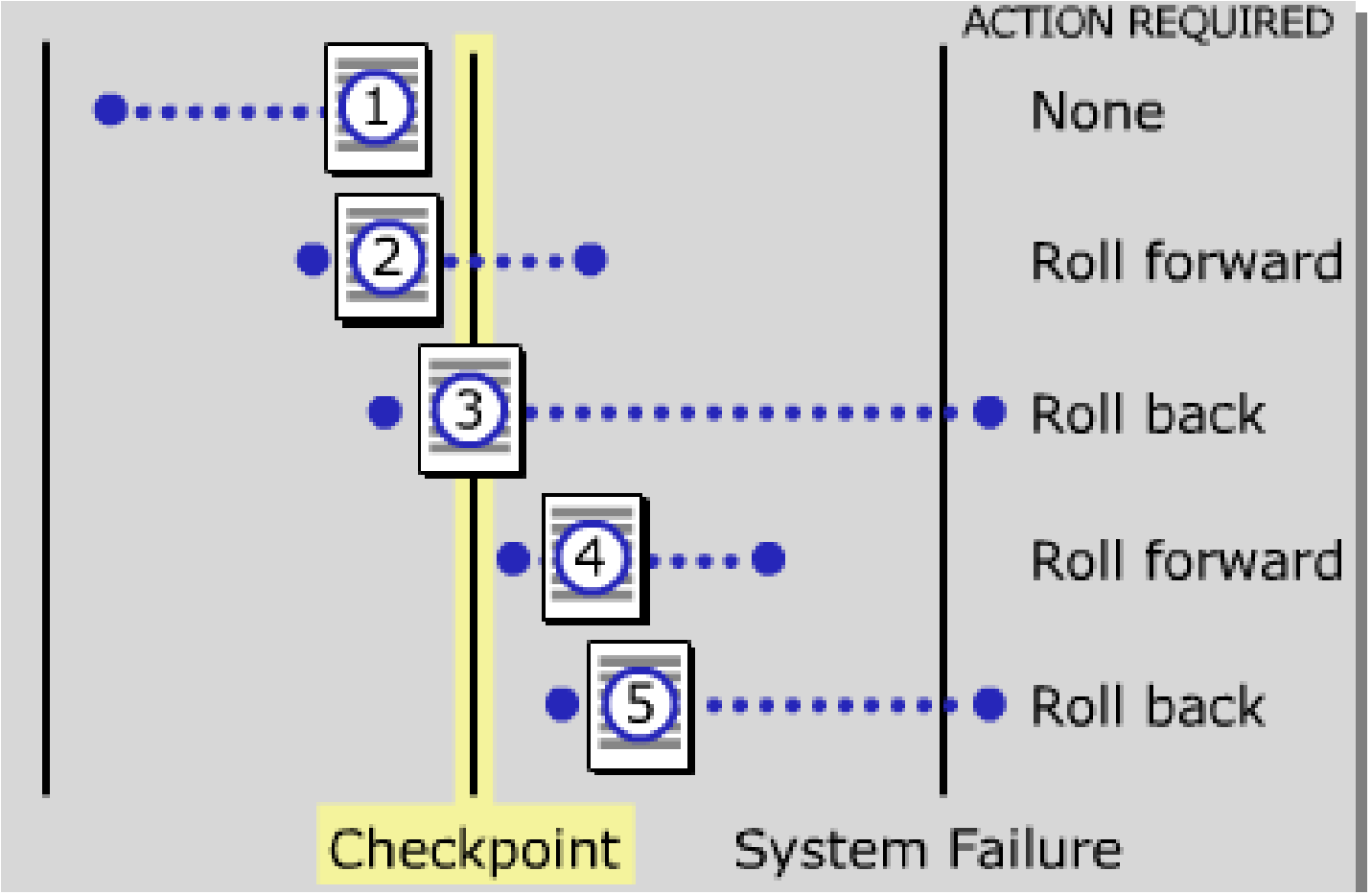
- Server looks for *checkpoints* recorded in the log

Uncommitted transactions are rolled back

Failure



Recovery


ACTION REQUIRED
1
None
2
Roll forward
3
Roll back
4
Roll forward
5
Roll back
Checkpoint
System Failure

Recovery Actions

1. **No action**
   - committed: log pages were flushed to log disk
   - before the checkpoint: log and database were synchronized
2. **Roll forward**
   - committed: log pages were flushed to log disk
   - after the checkpoint: not all modifications are on data disk
3. **Roll back**
   - not committed, and unknown where a commit was intended to be
   - started before the checkpoint, so some modifications may be on data disk. some modifications after the checkpoint may be on log disk due to commits of other processes
4. **Roll forward**
   - committed: log pages were flushed to log disk
   - after the checkpoint: none of the modifications are on data disk
5. **Roll back**
   - not committed, and unknown where a commit was intended to be
   - started after the checkpoint, so some modifications may be on log disk due to commits of other processes

ACID Properties of Transactions

Atomicity

- A transaction is an atomic unit of processing, **all or nothing**
- Responsibility of the recovery manager to ensure completion
- Recovery happens every time at start-up

Consistency

- The transaction must take the database from one consistent state to another
- Responsibility of the database programmers

ACID Properties of Transactions

Isolation

- A transaction should **not** make its updates **visible** to other transactions **until it is committed**
- Enforced by the concurrency control method imposed by the programmers

Durability

- Once a transaction changes the database and the changes are committed, these changes must never be lost because of subsequent failure
- Responsibility of the recovery manager