Databases 2

1 Transactional Systems

In this lecture

- Introduction to the concept of *transaction*
- *Properties* of a transaction
- Modules of the DBMS responsible of guaranteeing such properties

1 Transactional Systems

Definition of Transaction

- An elementary, atomic unit of work performed by an application
- Each transaction is encapsulated within two commands:
  - `begin transaction` (bot)
  - `end transaction` (eot)
- Within a transaction, **one** of the commands below is executed (exactly **once**):
  - `commit-work` (commit)
  - `rollback-work` (abort)
- **Transactional System** (OLTP): a system that supports the execution of transactions on behalf of concurrent applications

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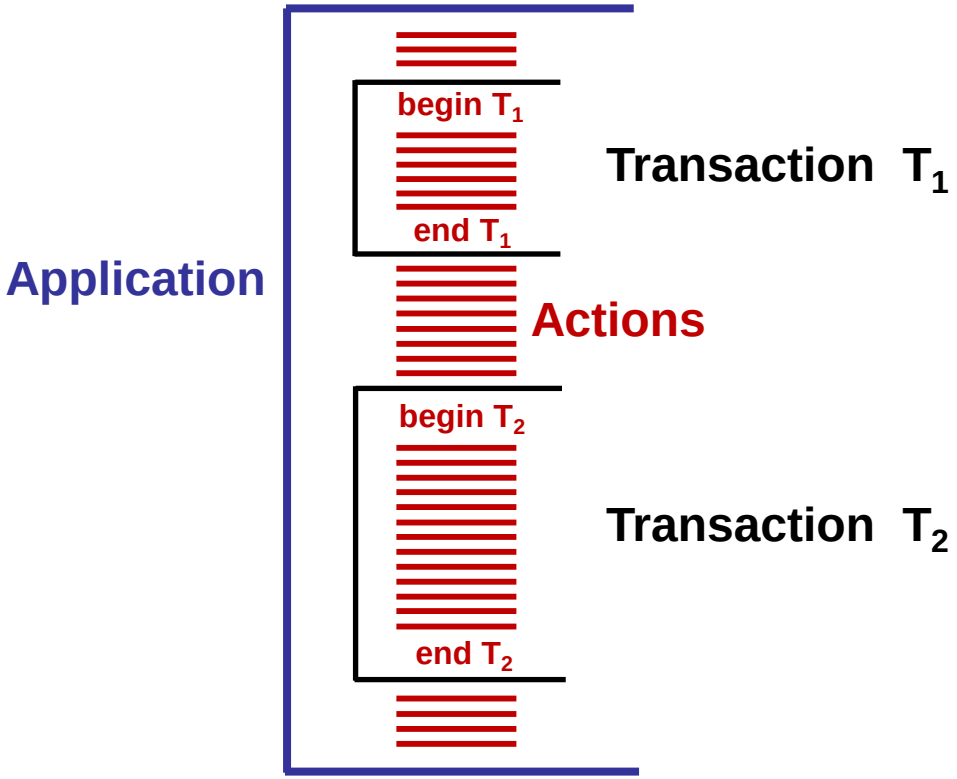
Difference between Application and Transaction



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Transactions: an example

```
begin transaction;
update Account
   set Balance = Balance + 10 where AccNum = 12202;
update Account
   set Balance = Balance – 10 where AccNum = 42177;
commit-work;
end transaction;
```

Transactions: an example with alternatives

```
begin transaction;
update Account
   set Balance = Balance + 10 where AccNum = 12202;
update Account
   set Balance = Balance – 10 where AccNum = 42177;
select Balance into A from Account
   where AccNum = 42177;
if ( A >= 0 ) then commit-work
              else rollback-work;
end transaction;
```

Well-formed Transactions

begin transaction

code for data manipulation (reads and writes on DB)

commit-work / rollback-work

possibly more code, but no data manipulation

end transaction

ACID Properties of Transactions

- A transaction is a unit of work enjoying the following properties:
  - Atomicity
  - Consistency
  - Isolation
  - Durability

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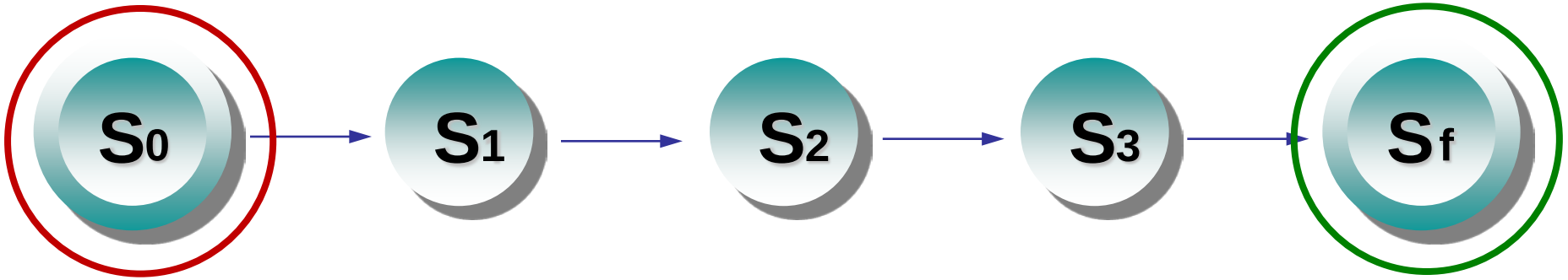
Atomicity

- A transaction is an atomic unit of execution, it can't be divided
  - Either all the operations in the transaction are executed or none is executed



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Atomicity

- In the case of the bank transfer, the execution of a single update statement would be disastrous
- The instant in which COMMIT is executed marks the atomic and indivisible instant in which the transaction ends successfully:
  - An error before should cause the rollback of the work performed
  - An error afterwards should not alter the effect of the transaction

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Atomicity

- The ROLLBACK of the work performed can be caused
  - By a ROLLBACK statement
  - By the DBMS, for example for the violation of integrity constraints or for concurrency management

- In case of a rollback, the work performed must be undone, bringing the database to the state it had before the start of the transaction

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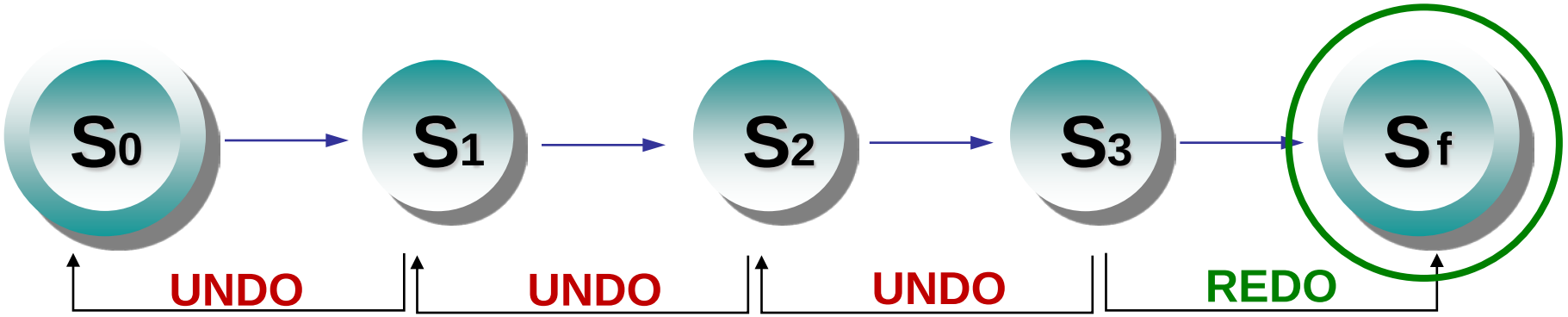
Atomicity

- Possible behaviours:
  1. commit-work: **SUCCESS**
  2. rollback-work or fault before commit-work: **UNDO**
  3. fault after commit-work: **REDO**



Consistency

- A transaction must satisfy the DB integrity constraints

- Consequence:
  - **if** the initial state S_0 is consistent
  - **then** the final state S_f is also consistent

This is not necessarily true for the intermediate states S_i

Consistency - EXAMPLES

- A table can’t contain two rows with the same value for a column declared as a primary key
- The sum of the balances of every couple of accounts must remain the same
  - If Balance(a)+Balance(b)=Costant before the transaction then Balance(a)+Balance(b)=Costant after the transaction
  - This type of constraint can be temporarily violated during the execution of the transaction, but must be satisfied at the end

Isolation

- The execution of a transaction must be independent from the concurrent execution of other transactions
- In particular, the concurrent execution of a number of transaction must produce the same result as the execution of the same transactions in a sequence
- E.g., the concurrent execution of T1 and T2 must produce the same results that can be obtained by executing one of these sequences
  - T1,T2
  - T2,T1

Durability

- The effect of a transaction that has successfully committed will last "**forever**"
  - Independently of any system fault
  - Sounds obvious… but every DBMS manipulates data in *main memory*

Transaction Properties and related mechanisms

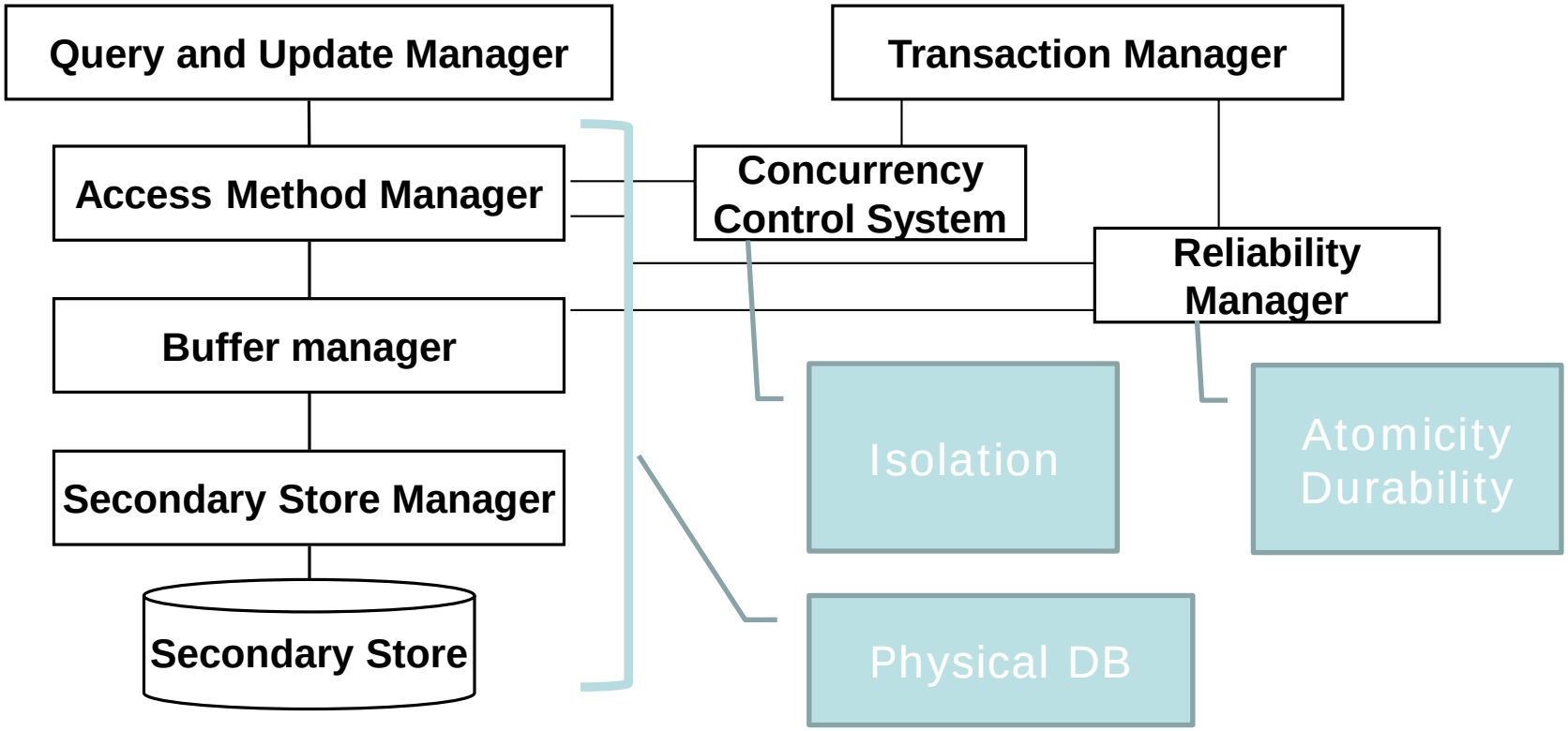
- **A**tomicity
  - Abort-rollback-restart, Commit protocols
- **C**onsistency
  - Integrity checking of the DBMS
- **I**solation
  - Concurrency control
- **D**urability
  - Recovery management

ACID properties

Transactions and DBMS modules

- Atomicity and Durability
  - Reliability Manager
- Isolation
  - Concurrency Control System
- Consistency
  - Integrity Control System at query execution time (with the support of the DDL compiler)

Logical Architecture of a DBMS



Next Topics...

- Concurrency Control (Isolation)
  - Theory
  - DBMS adopted method
- Reliability Control (Atomicity and Durability)
  - Commit protocols and 2PC
  - Logging and recovery on a single DBMS