FIT: A Distributed Database Performance Tradeoff

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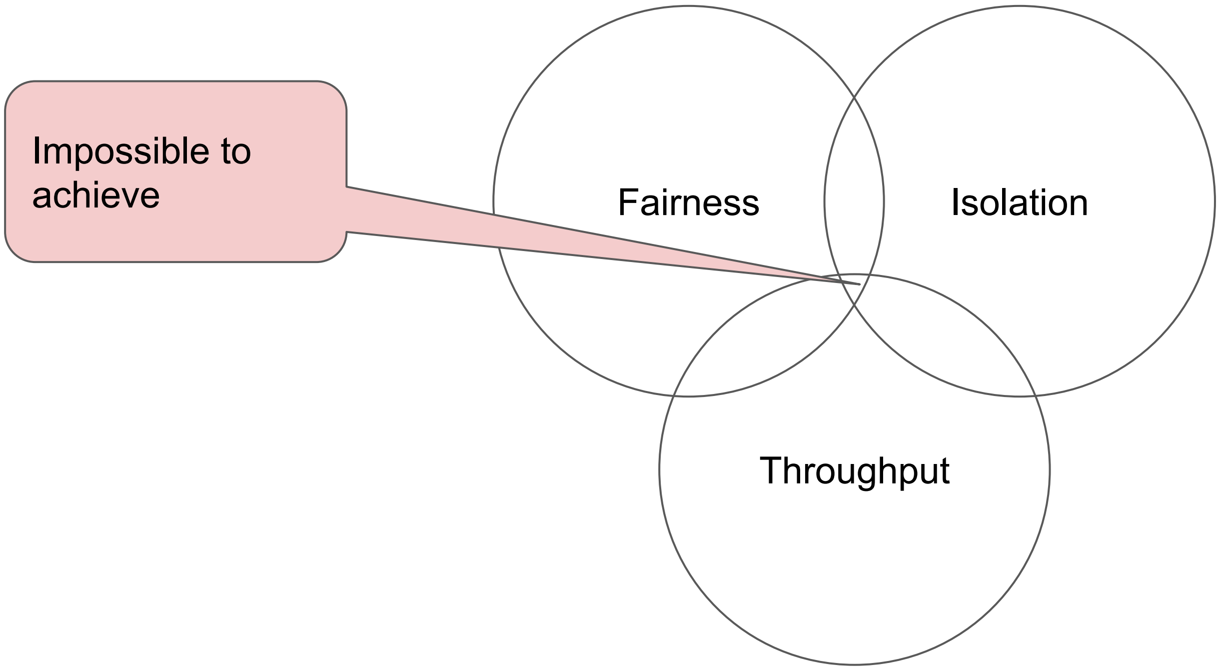
Desirable features in Distributed Databases



- It is impossible to have it all. Only two out of the three are achievable simultaneously.
- CAP was proposed by Eric Brewer (a distributed systems researcher) and does apply perfectly to distributed database systems

Assumptions and Definitions

- Sharded data (partitioned): data is distributed across multiple partitions
- Distributed transactions have **read-sets** and **write-sets** from multiple partitions.
- Transactions must either COMMIT or ABORT
  - ABORTS can be **logic-induced** or **system-induced**
- **Logic-induced** aborts by transaction logic based on application semantics.
  - Abort a balance transfer if source balance will be negative.
- **System-induced** aborts by transactional system
  - e.g. in order to avoid deadlocks

Safety, Liveness and Atomicity

A database is required to satisfy the following properties, when processing distributed transactions:

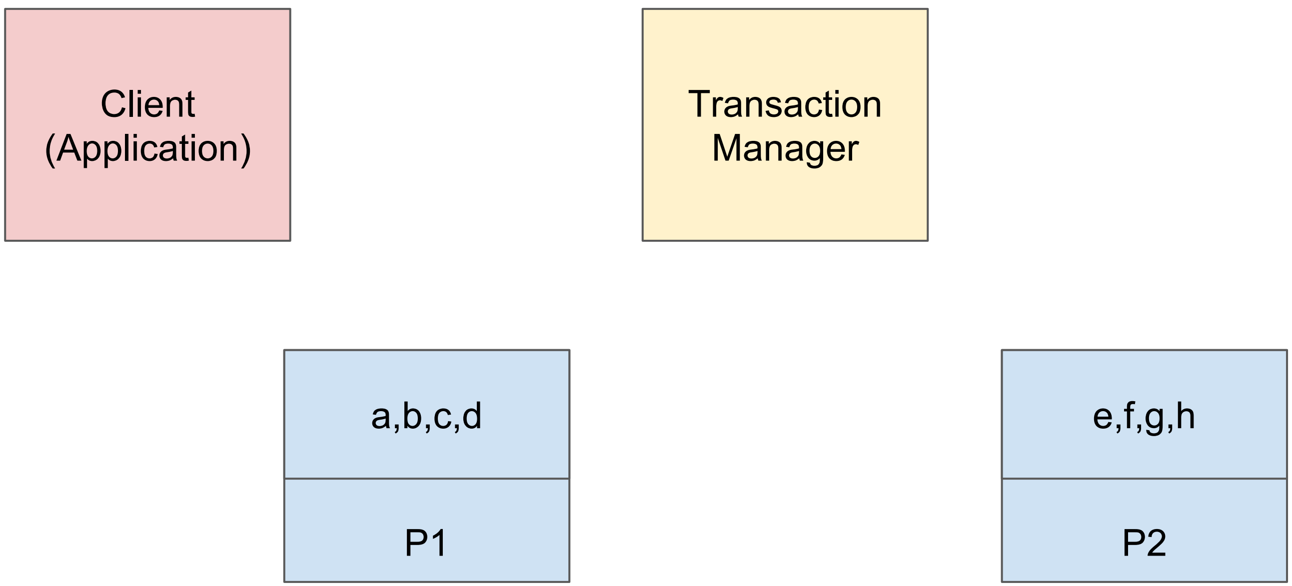
- **Safety**: a transaction is allowed to commit if all partitions can commit, otherwise it must abort

- **Liveness**: when a transaction is aborted by the system, and retried, it must eventually commit.

- **Atomicity**: **All** updates of a transaction must be reflected in the database state if it is **committed**, and **none** are reflected if it is **aborted**

Distributed transactions

- Transactions involving data that reside on multiple nodes are called **distributed transactions**



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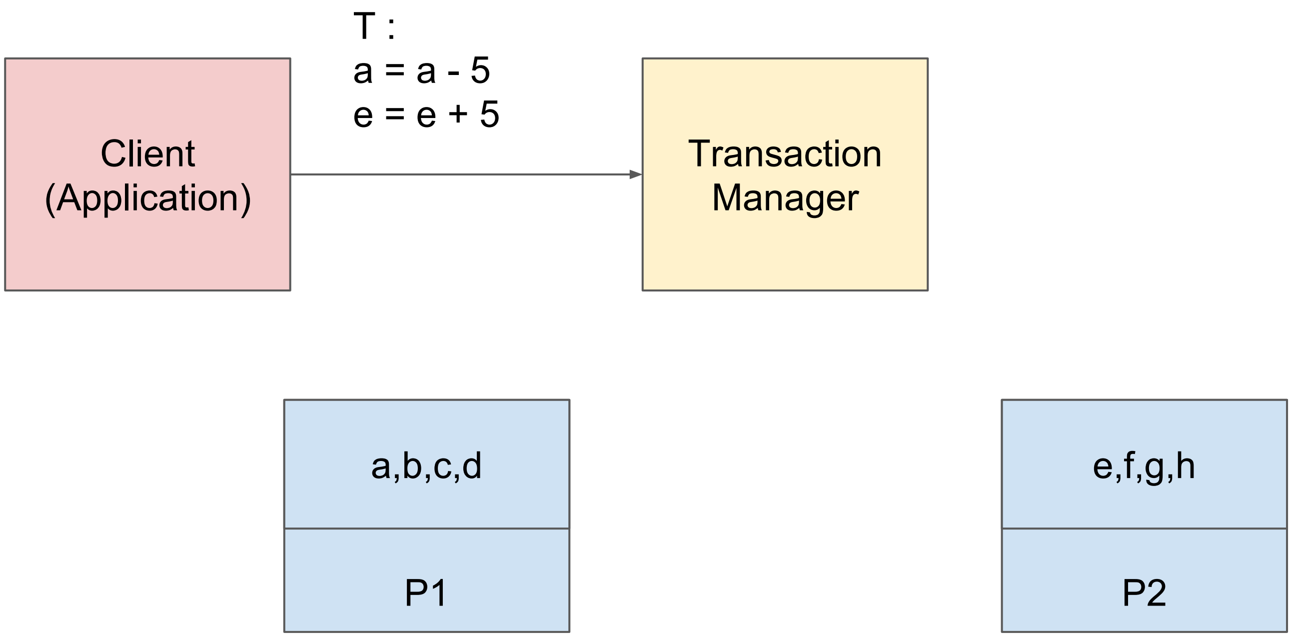

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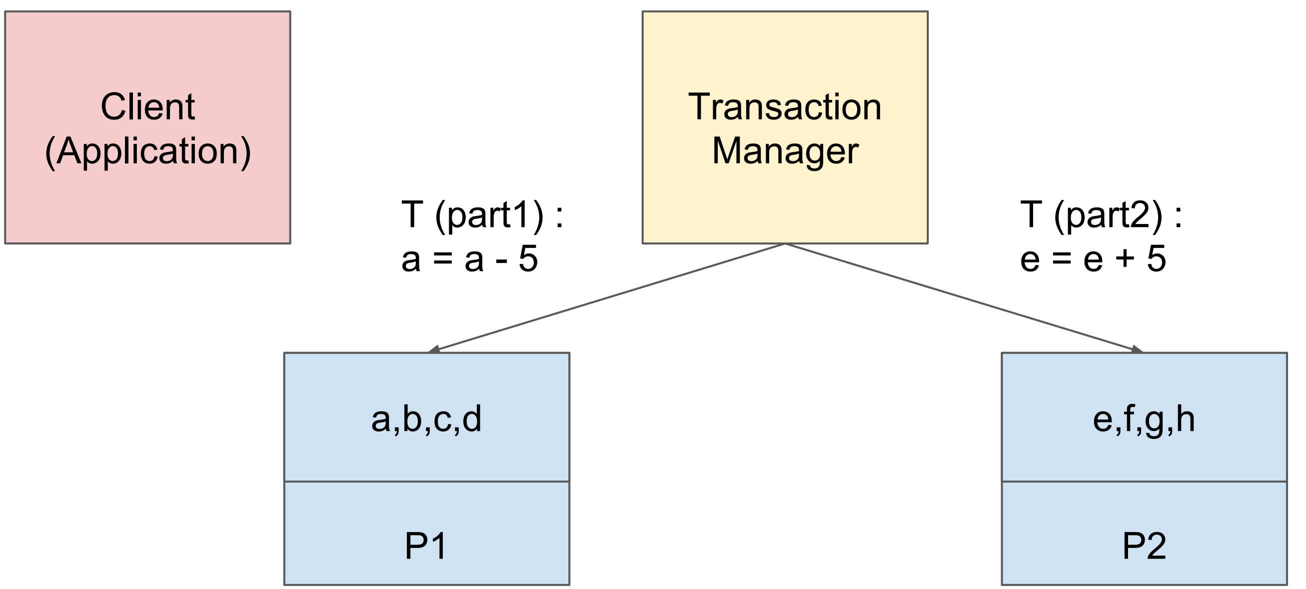

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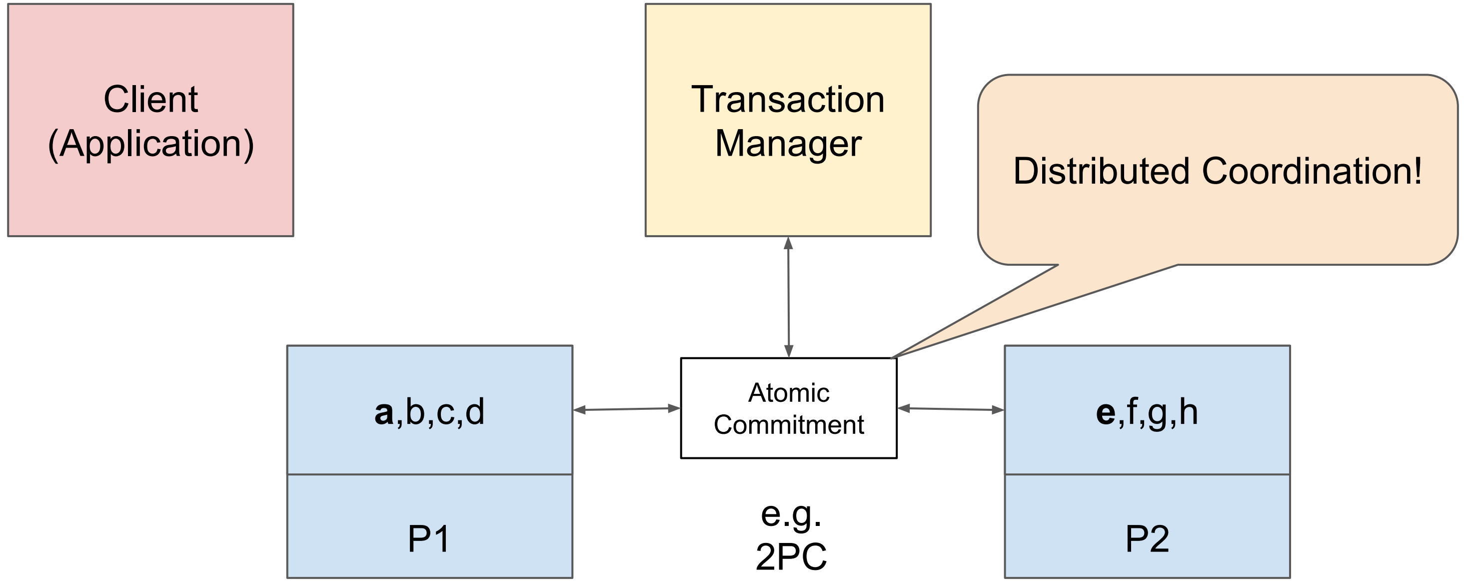

Fairness

- When to block a transaction from continuing its execution?
  - Blocking due to a concurrency control mechanism to ensure isolation and consistency (reason #1)
  - Blocking to improve throughput
    - e.g batching operations or log records
- When it is unfair to block a transaction from progressing?
  - For any reason other concurrency control
- Examples of unfairness:
  - Group Commit: batches log records write operations delays some transactions
  - Lazy transaction evaluation: batches transactions that have spatial locality

Synchronization Independence

- Transactions do not block each other even when they are conflicting
- Synchronization independence implies weak isolation

FIT Tradeoff

- Coordination among conflicting transactions has a cost.
- If the system pays this cost **during** executing the transaction, it is considered **fair**.
    - Conflicting transactions and non-conflicting transactions are treated equally as they all start **ASAP**
- If the system pays this cost, before (or after) transaction execution, it is considered **unfair**.
- Intuitively, stronger isolation implies lower throughput.
    - Conflicting transactions are blocked from making meaningful progress due to synchronization and distributed coordination overhead.
- In general, most systems sacrifice fairness to obtain strong isolation and high throughput.

FIT in action

System	Fairness	Isolation	Throughput
G-Store	✗	✓	✓
Calvin	✗	✓	✓
Google Spanner	✓	✓	✗
Cassandra	✓	✗	✓
RAMP	✓	✗	✓
Silo	✗	✓	✓
Doppel	✗	✓	✓

Paper Criticism and Research Questions

- Why **fairness** is a desirable feature? Why do we need to guarantee **fairness**? Isn't **liveness** enough?
- How to formally characterize **fairness**? If we bound the **unfairness**, does that make us fair?

Thank You