State Machine and Business Rules

Purpose: Defines the rigorous logic governing the lifecycle of core business entities. These rules enforce data integrity and prevent operational chaos (e.g., selling tickets for a departed bus).

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1. Trip (Schedule) Lifecycle

Owner: Company Service

A "Trip" represents a specific instance of a route (e.g., Kigali -> Huye at 08:00 AM on 25th Dec).

1.1 State Definitions

State	Description	Sales Status
DRAFT	Created but not yet visible to public.	Closed
PUBLISHED	Live on the system.	**OPEN**
BOARDING	Bus is at the platform loading passengers.	**OPEN** (Last minute)
DEPARTED	Bus has left the terminal.	**CLOSED**
COMPLETED	Bus arrived at destination.	Closed
CANCELLED	Trip aborted (Weather, Breakdown).	Closed

1.2 Transition Rules

From	To	Trigger / Actor	Condition
`DRAFT`	`PUBLISHED`	Scheduler (Admin)	Bus and Driver must be confirmed.
`PUBLISHED`	`BOARDING`	Time Auto-trigger OR Driver	30 mins before dep time.
`BOARDING`	`DEPARTED`	Driver (App)	"Start Trip" button pressed.
`DEPARTED`	`COMPLETED`	Driver (App)	"End Trip" button pressed.

From	To	Trigger / Actor	Condition
`PUBLISHED`	`CANCELLED`	Supervisor	Must trigger Refund flow.
`DEPARTED`	`CANCELLED`	**BLOCKED**	Cannot cancel a moving bus (Use "Breakdown" flow instead).

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2. Ticket Lifecycle

Owner: Ticketing Service

A "Ticket" represents the right to occupy a specific seat.

2.1 State Definitions

State	Description
LOCKED	Temporarily held while user attempts payment (TTL: 5-10 mins).
BOOKED	Payment confirmed. Ticket is valid.
USED	Passenger has successfully boarded.
EXPIRED	User failed to pay within the lock time. Seat released.
CANCELLED	User requested refund or Trip was cancelled.

2.2 Transition Rules

From	To	Trigger	Consistency Check
(Null)	`LOCKED`	Customer/Agent	**Strict:** Redis Mutex Lock on `seat_id`. Atomic check.
`LOCKED`	`BOOKED`	Payment Webhook	Verify `payment_status == SUCCESS`.
`LOCKED`	`EXPIRED`	System Cron / TTL	If time > 10 mins and no payment.
`BOOKED`	`USED`	Driver App	Scan QR Code. Bus must not be `COMPLETED`.
`USED`	`BOOKED`	**BLOCKED**	Cannot "un-use" a ticket (prevents fraud).
`BOOKED`	`CANCELLED`	Customer	Only if Trip status is `PUBLISHED` (not `DEPARTED`).

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3. Payment Lifecycle

Owner: Payment Service

3.1 State Definitions

State	Description
PENDING	Initial state. Waiting for user to enter PIN (Mobile Money) or approve.
SUCCESS	Provider confirmed receipt of funds.
FAILED	Provider rejected (Insufficient funds, timeout).
REFUNDED	Money returned to user.

3.2 Transition Rules

- **Idempotency:** A Payment ID can strictly transition to `SUCCESS` or `FAILED` **only once**. Subsequent webhooks for the same ID are ignored.

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4. Operational Invariants (The "Golden Rules")

These rules are enforced by code constraints and database constraints.

1. **The Physics of Time:** A ticket cannot be sold for a Trip in state `DEPARTED`, `COMPLETED`, or `CANCELLED`.
2. **The Physics of Space:** `Tickets Sold` <= `Bus Capacity`. The system prevents "Standing Room" sales unless explicitly configured.
3. **One Butt, One Seat:** A specific seat (e.g., "A1") cannot have two active `BOOKED` tickets for the same Trip ID. Uniqueness Constraint in Database.
4. **Driver License:** A driver cannot be assigned to a trip if their backend status is `SUSPENDED` or `EXPIRED_LICENSE`.
5. **Vehicle Availability:** A bus cannot be assigned to two overlapping trips. (e.g., Trip A ends at 10:00, Trip B starts at 09:00 with the same bus -> **REJECTED**).

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5. Conflict Resolution Strategy

- **Online vs Offline Sales:**

    - Scenario: Online user buys Seat 4. Simultaneously, Offline POS (no internet) sells Seat 4.
    - Resolution: When POS syncs, the server rejects the Offline sale.
    - Action: Agent must issue a refund or move passenger to another seat. **Server is Authority.**
- **Race Conditions:**
    - Scenario: Two online users click "Buy" on Seat 5 at the exact same millisecond.
    - Resolution: Redis `SETNX` (Set if Not Exists) is used. The first request wins the lock. The second request receives `409 Conflict` ("Seat taken").