4. Checkpoints

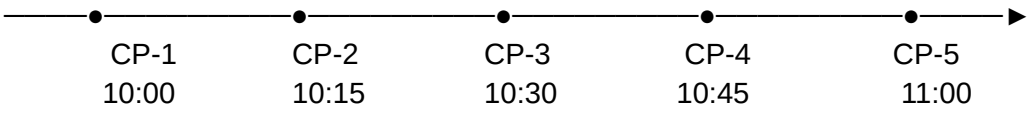
4.1 Checkpoint Overview

A **checkpoint** is a point in the transaction log where:

- All committed transactions' changes are written to disk
- A record of active transactions is maintained
- Dirty pages in memory are flushed to disk

4.2 Checkpoint Timeline

Timeline:



4.3 Checkpoint Information Structure

```
CREATE TABLE checkpoint_info (
    checkpoint_id VARCHAR(10) PRIMARY KEY,
    timestamp TIMESTAMP,
    lsn BIGINT,                    -- Log Sequence Number at checkpoint
    active_transactions TEXT,      -- JSON array of active transaction IDs
    dirty_pages TEXT,              -- JSON array of dirty page IDs
    buffer_pool_status VARCHAR(20) -- FLUSHED, PARTIAL, etc.
);
```

4.4 Sample Checkpoint Data

Checkpoint CP-3 Details:

```
{
  "checkpoint_id": "CP-3",
  "timestamp": "2024-08-04T10:30:15Z",
  "lsn": 45230,
  "active_transactions": ["T5", "T7", "T9"],
  "dirty_pages": ["Page_101", "Page_205", "Page_340"],
  "buffer_pool_status": "FLUSHED",
  "transaction_details": {
    "T5": {
      "start_lsn": 44100,
      "operation": "UPDATE accounts SET balance = balance - 200 WHERE id = 5"
    },
    "T7": {
      "start_lsn": 44800,
```

```
      "operation": "SELECT * FROM accounts WHERE id IN (1,2) FOR UPDATE"
    },
    "T9": {
      "start_lsn": 45000,
      "operation": "INSERT INTO audit_log VALUES (...)"
    }
  }
}
```


4.5 Checkpoint Creation Process

```
-- Checkpoint Creation SQL
BEGIN CHECKPOINT CP-4;

-- Step 1: Flush all dirty pages to disk
FLUSH DIRTY_PAGES;

-- Step 2: Record active transactions
INSERT INTO checkpoint_info (
    checkpoint_id,
    timestamp,
    lsn,
    active_transactions,
    dirty_pages,
```