Real-Time Databases
Real-Time Systems Design (CS 6414)

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Overview

- Conventional and real-time database differs on
  - characteristics of stored data
  - timing constraints on database operations
  - performance goals
- Example applications
  - Process control
  - Internet Service Management
  - Spacecraft Control System
  - Network Management System
- Concurrency control protocols - ACID properties
  - Atomicity
  - Consistency
  - Isolation
  - Durability

Real-time Databases - three issues

- Temporal Data or Perishable Data
  - Data whose validity lost after prespecified time interval elapses
  - Temperature sensor data sampled every 100 msec, old values archived
  - New stock market price quotations, previous ones obselete
  - Aircraft computes current position and path deviation every few msec
- Timing constraints on database operations
  - Real-time tasks assume deterministic execution time
  - Real-time database transacation execution time unpredictable
  - Transactions require many records and disk accesses
- Performance metric
  - Transaction response time
  - Transactional database - #transacations completed per unit time
  - Optimize average response time for non-real-time applications
  - Real-time database - #transacations missing deadlines per unit time

Real-time database Design issues

- Data access in secondary memory make transactions miss deadline
- Impossible to predict transacation response time due to protocols for
  - concurrency control, commit and recovery
- Roll backs - cascading effects introducting unpredictable delay
- Use of databases impractical in hard real-time applications
- Use of an in-memory database can solve identified problems
- In real-time applications - set of transactions are known before hand
- Transactions fixed - use same amount and types of data each time
- Effective resource usage plans - deterministic transacation executions

Characteristics of Temporal Data

- Temporal Consistency
  - Requires actual states of environment and database be very close
  - Closeness remains within limits required by application
- Two main requirements
  - Absolute Validity - consistency between environment and its reflection
  - Relative Consistency - among data used to derive new data
- How to Respresent Data Items in a Real-Time Database?
  - Data item *d*:(value,avi,timestamp)
  - Three components
    - *d_value* - value recorded for *d*
    - *d_avi* - absolute validity interval for *d*
    - *d_timestamp* - time when *d* was measured
  - Example *d*=(120 ,5 msec, 100 msec)
    - data item with value 120
    - recorded at 100 msec
    - with an absolute validity interval of 5 msec

Relative Consistency Set

- A set of data items is used to derive a new data
- Derived data correctness - relative consistency of data items
- Anti-missile sys - new missile position from curr velocity & position
- Incorrect to use earlier sampled position with current velocity
- Relative consistency - contemporary data items to derive new data
- R - Relative consistency set
- R_avi - R associated with relative validity interval (rvi)
- Condition for Absolute Validity
  - *d* is absolutely valid, if (*Current time - d_timestamp* $\leq$ *d_avi*)
- Condition for Relative Consistency
  - *d* is relatively consistent, if (*d_timestamp - d_timestamp'* $\leq$ *R_rvi*)

Concurrency Control in Real-Time Databases

- Locking-based concurrency control
- 2PL leads to deadlocks
- T1: Lock d1, Lock d2, Unlock d2, Unlock d1
  T2: Lock d2, Lock d1, Unlock d1, Unlock d2
- 2PL-WP
- 2PL-HP
- PCP
  - Read, Absolute, Read-Write Ceilings
  - Transaction requesting data object granted same
  - iff priority of requesting data object $>$ read-write celing of all

Optimistic Concurrency Control Protocols

- Forward OCC
- OCC Broadcast Commit
- Speculative Concurrency Control
- Comparision of Concurrency Control Protocols

Thank you