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Concurrency: Sharing Volatile Files

<table>
<thead>
<tr>
<th>Item</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarn</td>
<td>A</td>
</tr>
<tr>
<td>String</td>
<td>A</td>
</tr>
<tr>
<td>Ball</td>
<td>B</td>
</tr>
<tr>
<td>Sandal</td>
<td>C</td>
</tr>
</tbody>
</table>

Transaction S:
Change type A to B

Transaction T:
Change type A to C

Acceptable outcomes (serial or *serializable*):
- Yarn C | Yarn C
- String B | String C

Unacceptable outcomes (unserializable):
- Yarn B | Yarn C
- String C | String B

(For instance, there might be a consistency constraint that Yarn and String have the same type.)

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Concurrency: Two-Phase Locking

Never lock after starting to unlock!

(Phase 1: lock. Phase 2: unlock)

Apply rule to each transaction independently of other transactions.

Deadlock is possible.
Concurrency and File Structures

$B^+$-trees

Insert $K$, concurrently read $I$

1. 2PL

```
insert    read
lock 2    lock 2
lock 0    lock 3
write 0   unlock 3
write 3   unlock 2
write 2   unlock 2
```

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Concurrency and B-trees

2. “Lock Conversion” variant of “Lock Coupling”

\begin{align*}
\text{insert} & \quad \text{read} \\
r\text{Lock} & \quad r\text{Lock} 2 \\
r\text{Lock} & \quad r\text{Lock} 0 \\
& \quad \text{unlock} 0 \\
& \quad \text{unlock} 2 \\
w\text{Lock} & \quad 0 \\
w\text{Lock} & \quad 2 \\
& \quad \text{write} 0 \\
& \quad \text{unlock} 0 \\
& \quad \text{write} 2 \\
& \quad \text{write} 3 \\
& \quad \text{unlock} 2 \\
\end{align*}

Lock coupling: don’t unlock node before locking children!


Lock conversion: change rLock to wLock if needed!

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Concurrency and B-trees

3. Using Links

Hold at most 1 lock (no deadlock) and modify search procedure.

\[
\begin{align*}
\text{insert} & \quad \text{read} \\
\text{rLock} 2 & \quad \text{rLock} 2 \\
\text{unlock} 2 & \quad \text{unlock} 2 \quad \text{write} 3 \\
\text{wLock} 0 & \\
\text{write} 0 & \\
\text{unlock} 0 & \\
& \quad \text{rLock} 0 \\
\text{wLock} 2 & \quad \text{rLock} 3 \\
\text{write} 2 & \\
\text{unlock} 2 & \\
\end{align*}
\]

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Concurrency: Other Dynamic Files

1. Order-Preserving
   - Can all use links in similar ways.
   - E.g., tries (next).
   - E.g., dynamic multipaging: need $d$ links.

2. Linear Hashing
   - If no overflows, only 1 block involved.
   - If overflow chain order-preserving, has links already.
     - Normally overflow chain adds to end: no problem.
     - Current-split pointer may have changed: search semantics must check addresses given by both hash functions.
Concurrency: Tries

Counts stored separately for dynamic tries: must lock at least the trailing counts of a level. This reduces concurrency.

E.g. read 10101100 (transaction 1) and concurrently write 01011010 (transaction 2):

```
  r1 1010       #4
  w2 0101       #4 → #5
  w2 1010
  r1 1100       not found!
```

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• B-trees can support read/write concurrency by advancing the read page if a write happens to have messed it up.
• Tries do not have enough redundancy to check for a mess.
• So add redundancy: on each page, store the lowest and highest prefix from parent to this page.

- Two writes can lock each other out of the whole trie.
- B-trees have the same problem because root may be split.