UNIVERSITÄT DES SAARLANDES
Fachrichtung 6.2 – Informatik
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5. Übung zur Vorlesung *Transaktionsorientierte Informationssysteme* im Sommersemester 2000

5.1. Investigate what kind of deadlocks can arise in a layered system with layered 2PL, and how they can be detected and eliminated. Under what conditions is it sufficient that each layer tests only for "local" deadlocks caused by lock waits of one layer only? Under what conditions is it necessary to consider lock waits of all layers "globally" to detect all deadlocks?

5.2. Discuss the pros and cons of the selective layered 2PL. As an example, consider query-, record-, and page-level operations along the lines of Figure 7.5. Does it have performance advantages to have all three levels involved in locking rather than only two? If locking should be limited to two levels, are there arguments on which levels should be chosen?

5.3. Trace the lock requests, conflict tests, lock acquisitions, and lock releases for the execution of the schedule in Figure 7.6 under the general object-model 2PL with a SS2PL variant. How would the example execution change if the append operations were dropped and t_2's decrement operation were replaced by an *incr(a)* operation that commutes with other increments? How would the execution change if t_2 started first and t_1 were spawned after all of t_2's operations but before the commit of t_2?

5.4. Develop pseudocode for a restricted version of the object-model 2PL, where a generalized form of 2-level schedules is considered with some transactions bypassing the object level L_1 and invoking L_0 operations directly. This setting is, for example, of interest in the context of federated information systems, where global transactions access a variety of databases through a federation layer, using commutativity-based 2PL for high-level operations exported by the underlying databases, but local transactions are still allowed to access a database directly. Such an architecture is sometimes called a federation of` *"autonomous"* databases.

5.5. Apply the following hybrid protocols to the schedule of Figure 7.3 in a selective way so that only two levels are involved in concurrency control:

a) the forward-oriented optimistic concurrency control (FOCC, see Chapter 4) at the page level, and strong 2PL at the record level,

b) the forward-oriented optimistic concurrency control at the page level, and strong 2PL at the query level,

c) the hybrid multiversion protocol ROMV (see Chapter 5) at the page level, and strong 2PL at the record level,

d) the hybrid multiversion protocol ROMV at the page level, and strong 2PL at the query level.

Sketch the resulting executions.

5.6. Prove the correctness of the 2PL protocol for 2-level schedules with deferred lock conflict testing based on return-value commutativity sketched in Section 7.6.

5.7. Trace the intermediate states of the escrow data structure (i.e., the infimum and supremum values) for the counter object *x* in the example execution of Figure 7.8.

5.8. Consider two counter objects *x* and *y*, with initial values *x=100* and *y=50*. Both counters have zero as a lower bound and no upper bound. Apply the Escrow locking method to the following schedule of three transactions one of which aborts:

$decr_1(x,60)\ incr_2(x,20)\ incr_1(x,10)\ decr_3(x,50)\ decr_2(y,60)\ incr_2(x,20)\ a_2\ decr_1(y,10)\ c_1\ c_3$

5.9. Escrow operations can be further generalized into conditional increment and decrement operations where the conditions may be stronger than the actual resource quantity needed, taking the form:

```
conditional_decr (x, ε, Δ):
  if x ≥ ε then x := x - Δ fi;
```

and an analogous `conditional_incr` operation. For the `conditional_decr`, the value of the ε parameter would be larger than or equal to the operation's Δ value, and the situation would be the other way round for the `conditional_incr` operation. In addition to such operation-specific conditions, the global invariants for `x.low` and `x.high` must be satisfied at all times, too. Discuss the notions of general and return-value commutativity for these generalized Escrow operations.