M.Sc. Nico Schäfer / M.Sc. Angjela Davitkova



Exercise 11: Handout 21.01.2020, Due 27.01.2020 16:00 MEZ https://dbis.cs.uni-kl.de

### Question 1: Schedules - RC, ACA, Strict

(1 P.)

For the following schedules, decide in which of the classes RC, ACA, or ST they are.

Required submission: Class for each schedule; Reasoning for class;

# Question 2: 2-Phase-Locking and Waits-for-Graph (1 P.)

a) Given the following schedules:

$$\begin{array}{rcl} s_1 & = & w_4(a) \; r_2(c) \; r_3(a) \; r_3(c) \; c_3 \; r_2(a) \; r_4(c) \; c_4 \; w_2(a) \; c_2 \\ s_2 & = & w_1(b) \; r_2(c) \; w_3(a) \; w_2(b) \; r_1(a) \; r_3(b) \; c_1 \; c_3 \; w_2(a) \; c_2 \end{array}$$

Create a 2PL history for both schedules and note the Waits-for-Graph (WfG) every time it changes. If you encounter a deadlock, abort the transaction that caused the deadlock (No deadlock prevention strategy).

Required submission: 2PL histories; WfGs after every change;

b) Specify a 2PL history and WfG (up until a deadlock) involving four transactions  $t_1, t_2, t_3$ , and  $t_4$ , such that the strategies **most cycles** and **most edges** cause the same transaction to be aborted as the strategy **youngest**. Assume that the strategies are applied as soon as the deadlock is detected.

Required submission: 2PL history; WfG



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### Question 3: Deadlock prevention

(1 P.)

Implement a scheduler, which creates a (SS)2PL schedule, using the deadlock prevention strategies waitdie, wound-wait and immediate restart.

Test your program with the given schedule. It has to print the output schedule for each of the prevention strategies and indicate when a transaction has to wait.

$$s := w_1(x) \ r_2(x) \ w_3(y) \ r_1(y) \ r_3(z) \ w_1(x) \ c_1 \ w_2(y) \ c_2 \ w_3(y) \ c_3$$

You can use the template provided in OLAT, which implements an internal representation of a history and all required operations.

Required submission: Source code; Output after executing the code;

### **Question 4: Intention Locks**

(1 P.)

Additionally to read and write locks we now consider "intention locks". With the following query, an application could indicate that the returned tuples will soon be updated:

SELECT \* FROM parts WHERE p\_partkey = 1234 FOR UPDATE;

- a) Describe which additional rules could be implemented given these new locks. Give a possible compatibility matrix, including the known and the new locks.
  - Notation read with update intention:  $\tilde{r}_i(x)$ ; Intention lock:  $il_i(x)$ .
  - Required submission: Rule(s); Compatibility matrix;
- b) Give a possible output history for the following schedule:

$$s = r_3(y) \ r_1(x) \ \tilde{r}_3(x) \ r_1(y) \ \tilde{r}_2(y) \ r_4(x) \ r_4(z) \ a_4 \ c_1 \ w_3(x) \ w_2(y) \ c_2 \ c_3$$

Required submission: History



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## Question 5: Timestamp-Based Approaches

(1 P.)

$$\begin{split} s_1 &= w_1(x) \ w_2(x) \ r_2(x) \ r_1(x) \\ s_2 &= r_1(y) \ r_2(y) \ r_1(x) \ w_2(y) \ w_3(x) \ w_1(x) \ r_1(x) \end{split}$$

Describe how a timestamp ordering (TO) based scheduler would execute the operations. Complete the following tables. Note the used rule in the "Comment" column. The max-r and max-w columns contain the value of max-q-scheduled for the given object. One row contains the entry after applying the rule. You may assume  $ts(t_1) < ts(t_2)$ . Do not restart aborted transactions.

Required submission: Filled out tables

 $s_1$ :

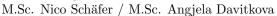
Operation	$\max -r(\mathbf{x})$	$\max$ - $w(x)$	Comment
$BOT_1$	$-\infty$	$-\infty$	$ts(t_1) = 1$
$BOT_2$	$-\infty$	$-\infty$	$ts(t_2) = 2$

 $s_2$  without Thomas' write rule:

Operation	$\max -r(\mathbf{x})$	$\max$ - $w(x)$	$\max -r(y)$	$\max$ - $w(y)$	Comment
$BOT_1$	$-\infty$	$-\infty$	$-\infty$	$-\infty$	$ts(t_1) = 1$
$BOT_2$	$-\infty$	$-\infty$	$-\infty$	$-\infty$	$ts(t_2) = 2$
$BOT_3$	$-\infty$	$-\infty$	$-\infty$	$-\infty$	$ts(t_3) = 3$

## Database Systems WS 2019/20

Prof. Dr.-Ing. Sebastian Michel





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#### $s_2$ with Thomas' write rule:

Operation	$\max -r(\mathbf{x})$	$\max$ - $w(x)$	$\max -r(y)$	$\max$ - $w(y)$	Comment
$BOT_1$	$-\infty$	$-\infty$	$-\infty$	$-\infty$	$ts(t_1) = 1$
$BOT_2$	$-\infty$	$-\infty$	$-\infty$	$-\infty$	$ts(t_2) = 2$
$BOT_3$	$-\infty$	$-\infty$	$-\infty$	$-\infty$	$ts(t_3) = 3$