Quiz Sheet No. 4 for *Architecture and Implementation of Database Systems*
Prof. Rudolf Bayer, Ph. D.
Institut für Informatik
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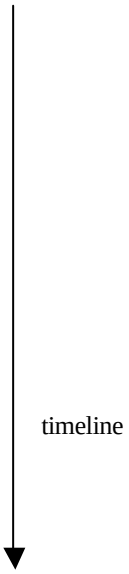
Exercises for **Chapter 5.2.4: Cache/Safe Method**

1. Reconsider schedule H2 of Exercise 2c) of Quiz Sheet No. 3:

t_1	t_2	t_3	
r(u)			1
	r(z)		2
r(y)			3
	r(u)		4
	r(y)		5
w(y)			6
	w(z)		7
	ct		8
r(z)			9
w(z)			10
		r(z)	11
		r(y)	12
w(u)			13
ct			14
		r(u)	15
		w(u)	16
		ct	17



a) Determine the different states of the database, the cache and the safe along the timeline from timestamp 1 to 13 using the following schema. For each step fill in the appropriate objects. Indicate R- and A-locks on objects u, y, z using this notation: $obj(C)_A^R$, where
   - *obj* is the respective object,
   - *C* is an *ordered* list of all transactions (use indices 1, 2, 3 for t_1, t_2, t_3) that have changed the object in the past (on commit),
   - *R* is a list of all transactions that hold an R-lock on the object, and
   - *A* is a list of all transactions that hold an A-lock on it

Example: $z(3,1)_3^{1,2}$ indicates, on the one hand, that object z has been altered first by transaction t_3 and then by t_1, and on the other hand, that currently transactions t_1 and t_2 hold R-locks on z, while t_3 holds an A-lock. Assume that old versions of objects are removed from the cache when a committing transaction writes their new versions into the database.

Schema:

	DB	Cache	Safe
0	u, y, z		
1	u, y, z	u^1	
2	…	…	…
…			
13			

Answer:

	DB	Cache	Safe
0	u, y, z		
1	u, y, z	u^1	
2	u, y, z	u^1, z^2	
3	u, y, z	u^1, z^2, y^1	
4	u, y, z	$u^{1,2}, z^2, y^1$	
5	u, y, z	$u^{1,2}, z^2, y^{1,2}$	
6	u, y, z	$u^{1,2}, z^2, y_1^2$	
7	u, y, z	$u^{1,2}, z_2, y_1^2$	
8	u, y, z(2)	u^1, y_1, z(2)	z(2)
9	u, y, z(2)	$u^1, y_1, z(2)^1$	z(2)
10	u, y, z(2)	$u^1, y_1, z(2)_1$	z(2)
11	u, y, z(2)	$u^1, y_1, z(2)_1^3$	z(2)
12	u, y, z(2)	$u^1, y_1^3, z(2)_1^3$	z(2)
13	u, y, z(2)	$u_1, y_1^3, z(2)_1^3$	z(2)

b) Show that in timestamps 14 to 17 a deadlock occurs between transactions t_1 and t_3.

Answer:

	DB	Cache	Safe
14	u, y, z(2)	$t_1 \rightarrow t_3$ [z(2) and y]	z(2)
15	u, y, z(2)	$u_1^3, y_1^3, z(2)_1^3$	z(2)
16	u, y, z(2)	$u_3, y_1^3, z(2)_1^3$	z(2)
17	u, y, z(2)	$t_3 \rightarrow t_1$ [u]	z(2)

$\Rightarrow$ t_1 waits for t_3 to release its R-locks on z(2) and y,
t_3 waits for t_1 to release its A-lock on u

$\Rightarrow$ deadlock

c) Complete the Cache/Safe listing of exercise 1a) assuming that t_3 does *not* set R-locks on objects z and y (at timestamps 11 and 12).

Answer:

	DB	**Cache**	**Safe**
13	u, y, z(2)	u_1 , y_1 , $z(2)_1$	z(2)
14	u(1), y(1), z(2,1)	y(1), $z(2,1)$, $u(1)$	z(2), y(1), z(2,1), u(1)
15	u(1), y(1), z(2,1)	y(1), $z(2,1)$, $u(1)^3$	z(2), y(1), z(2,1), u(1)
16	u(1), y(1), z(2,1)	y(1), $z(2,1)$, $u(1)_3$	z(2), y(1), z(2,1), u(1)
17	u(1,3), y(1), z(2,1)	y(1), $z(2,1)$, $u(1,3)$	z(2), y(1), z(2,1), u(1,3)