German International University in Cairo
Informatics and Computer Science
Dr. Eng. Amal Yassien
Ahmed Ramadan
Nourhan Ahmed

Database Programming, Winter 2025
Practice Assignment 8

Exercise 8-1 Recovery Manager
Undo Logging

For each of the sequences of log records representing the actions of one transaction T, tell all the sequences of events that are legal according to the rules of undo logging. The events of interest are:

1. Writing the blocks containing database elements to disk
2. Writing the blocks containing the update and commit records of the log

You may assume that log records are written to disk in the order shown; i.e., it is not possible to write one log record to disk while a previous record is not written to disk.

a) <Start T>; <T, A, 10>; <T, B, 20>; <Commit T>;

Solution:

Log record \to disk	***A* to disk**	***B* to disk**
$< START\ T >$	No	No
$< T, A, 10 >$	No	No
$< T, B, 20 >$	Yes	No
	Yes	Yes
$< COMMIT\ T >$	No	No

b) Start T>; <T, A, 10>; <T, B, 20>; <T, C, 30>; <Commit T>;

Solution:

Log record \to disk	***A* to disk**	***B* to disk**	***C* to disk**
$< START\ T >$	No	No	No
$< T, A, 10 >$	No	No	No
$< T, B, 20 >$	Yes	No	No
$< T, C, 30 >$	Yes	Yes	No
	Yes	Yes	Yes
$< COMMIT\ T >$	No	No	No

Exercise 8-2 Recovery Manager
Undo Logging

The following is a sequence of undo-log records written by two transactions T and U:

$$
\begin{gathered}
< START\ T >; \\
< T, A, 10 >; \\
< START\ U >; \\
< U, B, 20 >; \\
< T, C, 30 >; \\
< U, D, 40 >; \\
< COMMIT\ U >; \\
< T, E, 50 >; \\
< COMMIT\ T >;
\end{gathered}
$$

Describe the action of the recovery manager, including changes to both disk and the log, if there is a crash and the last log record to appear on disk is:

a) <Start U>

Solution:

T is undone and the value of A on the hard disk is 10.

b) <Commit U>

Solution:

Transaction U won't be undone. However, Transaction T is undone and the value of A on the hard disk becomes 10 and the value of C on the hard disk becomes 30.

c) <T, E, 50>

Solution:

Transaction U won't be undone. However, Transaction T is undone and the value of A on the hard disk becomes 10, the value of C on the hard disk becomes 30, and the value of E becomes 50.

d) <Commit T>

Solution:

Both T and U won't be undone

Exercise 8-3 Recovery Manager
Undo Logging

For each of the situations described in Exercise 8-2, which values written by T and U must appear on disk? And which values might appear on disk?

a) <Start U>

Solution:

T must: might: A

U must: might:

b) <Commit U>

Solution:

T must: might: A, C

U must: B, D might:

c) <T, E, 50>

Solution:

T must: might: A, C, E

U must: B, D might:

d) <Commit T>

Solution:

T must: A, C, E might:

U must: B, D might:

Exercise 8-4 Undo Logging
Checkpoints

Consider the following sequence of log records:

$$< START\ S >;$$

$$< S, A, 60 >;$$

$$< COMMIT\ S >;$$

$$< START\ T >;$$

$$< T, A, 10 >;$$

$$< START\ U >;$$

$$< U, B, 20 >;$$

$$< T, C, 30 >;$$

$$< START\ V >;$$

$$< U, D, 40 >;$$

$$< V, F, 70 >;$$

$$< COMMIT\ U >;$$

$$< T, E, 50 >;$$

$$< COMMIT\ T >;$$

$$< V, B, 80 >;$$

$$< COMMIT\ V >;$$

Suppose we add checkpoints to the log file where exactly will they be allocated?

Solution:

$< START\ S >;$

$< S, A, 60 >;$

$< COMMIT\ S >;$

$< CKPT >;$

$< START\ T >;$

$< T, A, 10 >;$

$< START\ U >;$

$< U, B, 20 >;$

$< T, C, 30 >;$

$< START\ V >;$

$< U, D, 40 >;$

$< V, F, 70 >;$

$< COMMIT\ U >;$

$< T, E, 50 >;$

$< COMMIT\ T >;$

$< V, B, 80 >;$

$< COMMIT\ V >;$

$< CKPT >;$

Exercise 8-5 Undo Logging
Checkpoints

Now for the log file you have after solving Exercise 8-4. For each of the following possible point at which a crash could occur, how far back in the log the recovery manager must look to find all possible incomplete transactions?

a) <S, A, 60>

Solution:

Go back to the beginning of the file

b) <T, A, 10>

Solution:

Go back to the checkpoint

c) <U, B, 20>

Solution:

Go back to the checkpoint

d) <T, E, 50>

Solution:

Go back to the checkpoint

e) <V, B, 80>

Solution:

Go back to the checkpoint

Exercise 8-6 Recovery Manager
Redo Logging

For each of the sequences of log records representing the actions of one transaction T, tell all the sequences of events that are legal according to the rules of redo logging. The events of interest are:

1. Writing the blocks containing database elements to disk
2. Writing the blocks containing the update and commit records of the log

You may assume that log records are written to disk in the order shown; i.e., it is not possible to write one log record to disk while a previous record is not written to disk.

a) <Start T>; <T, A, 10>; <T, B, 20>; <Commit T>;

Solution:

Log record \to disk	A to disk	B to disk
$< START\ T >$	No	No
$< T, A, 10 >$	No	No
$< T, B, 20 >$	No	No
	No	No
$< COMMIT\ T >$	Yes	Yes

b) Start T>; <T, A, 10>; <T, B, 20>; <T, C, 30>; <Commit T>;

Solution:

Log record \to disk	A to disk	B to disk	C to disk
$< START\ T >$	No	No	No
$< T, A, 10 >$	No	No	No
$< T, B, 20 >$	No	No	No
$< T, C, 30 >$	No	No	No
	No	No	No
$< COMMIT\ T >$	Yes	Yes	Yes

Exercise 8-7 Recovery Manager
Redo Logging

The following is a sequence of redo-log records written by two transactions T and U:

$$
\begin{gathered}
< START\ T >; \\
< T, A, 10 >; \\
< START\ U >; \\
< U, B, 20 >; \\
< T, C, 30 >; \\
< U, D, 40 >; \\
< COMMIT\ U >; \\
< T, E, 50 >; \\
< COMMIT\ T >;
\end{gathered}
$$

Describe the action of the recovery manager, including changes to both disk and the log, if there is a crash and the last log record to appear on disk is:

a) <Start U>

Solution:

Abort T.

b) <Commit U>

Solution:

Abort T and Redo U.

c) <T, E, 50>

Solution:

Abort T and Redo U.

d) <Commit T>

Solution:

Redo T and Redo U.

Exercise 8-8 Recovery Manager
Redo Logging

For each of the situations described in Exercise 8-7, which values written by T and U must appear on disk? And which values might appear on disk?

a) <Start U>

Solution:

T must: might:

U must: might:

b) <Commit U>

Solution:

T must: might:

U must: might: B, D

c) <T, E, 50>

Solution:

T must: might:

U must: might: B, D

d) <Commit T>

Solution:

T must: might: A, C, E

U must: might: B, D

Exercise 8-9 Redo Logging
Checkpoints

For the following sequence of log records, begin a non-quiescent checkpoint after < START U >

$< START\ S >;$

$< S, A, 60 >;$

$< COMMIT\ S >;$

$< START\ T >;$

$< T, A, 10 >;$

$< START\ U >;$

$< U, B, 20 >;$

$< T, C, 30 >;$

$< START\ V >;$

$< U, D, 40 >;$

$< V, F, 70 >;$

$< COMMIT\ U >;$

$< T, E, 50 >;$

$< COMMIT\ T >;$

$< V, B, 80 >;$

$< COMMIT\ V >;$

Solution:

$< START\ S >;$
$< S, A, 60 >;$
$< COMMIT\ S >;$
$< START\ T >;$
$< T, A, 10 >;$
$< START\ U >;$
$< STARTCKPT\ (T, U) >;$
$< U, B, 20 >;$
$< T, C, 30 >;$
$< START\ V >;$
$< U, D, 40 >;$
$< V, F, 70 >;$
$< COMMIT\ U >;$
$< T, E, 50 >;$
$< COMMIT\ T >;$
$< END\ CKPT >;$
$< V, B, 80 >;$

Exercise 8-10 Recovery Manager
Undo/Redo Logging

The following is a sequence of undo/redo log records written by two transactions T and U:

$$
\begin{aligned}
&< START\ T >;\\
&< T, A, 10, 11 >;\\
&< START\ U >;\\
&< U, B, 20, 21 >;\\
&< T, C, 30, 31 >;\\
&< U, D, 40, 41 >;\\
&< COMMIT\ U >;\\
&< T, E, 50, 51 >;\\
&< COMMIT\ T >;
\end{aligned}
$$

Describe the action of the recovery manager, including changes to both disk and the log, if there is a crash and the last log record to appear on disk is:

a) <Start U>

Solution:

Undo T.

b) <Commit U>

Solution:

Undo T and Redo U.

c) <T, E, 50>

Solution:

Undo T and Redo U.

d) <Commit T>

Solution:

Redo T and Redo U.

Exercise 8-11 Undo/Redo Logging
Checkpoints

For the following sequence of Undo/Redo log records, a non-quiescent check-pointing has occurred. Answer the questions below.

<START T_1>
<$T_1, A, 4, 5$>
<START T_2>
<COMMIT T_1>
<$T_2, B, 9, 10$>
<START CKPT (T_2)>
<$T_2, C, 14, 15$>
<START T_3>
<$T_3, D, 19, 20$>
<END CKPT>
<COMMIT T_2>
<COMMIT T_3>

1. Describe the actions done during the check-pointing process.

   Solution:

   Flush A and B to disk.

2. Describe the actions of the recovery manager if a crash occurs:

   a. At the end of this sequence of events

      Solution:

      Redo: T2 & T3. However when we redo T2, we do not need to look above the start checkpoint; as we know that T2's changed prior to the start of the checkpoint were flushed to disk during the checkpoint.

   b. Just before the <commit T3> record

      Solution:

      Redo T2 by setting C to 15 on disk. We will not have to set B to 10 since we already know that is has been done during the checkpoint. Also, we undo T3 by setting D back to 19.

3. How would your answer to part 2-b. change, if T3 had been active at the start of the checkpoint.

   Solution:

   Since the crash occurred before T3 committed, so we still Redo T2 by changing C only. However, when we undo T3 we have to look above the start checkpoint; to find any actions done by T3 that may have reached the disk and need to be undone.