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| **HOMEWORK 6** | **Transaction Processing** |
| **Due Wed, Nov 11 at 11:30 pm** | **Objectives: Introduction to Transaction Processing Concepts** |

**20.16.** Add the operation commit at the end of each of the transactions *T*1 and *T*2 in Figure 20.2, and then list all possible schedules for the modified transactions. Determine which of the schedules are recoverable, which are cascadeless, and which are strict.

(5+3)! / (5! \* 3!) = 8\*7\*6\*5\*4\*3\*2\*1/ 5\*4\*3\*2\*1\*3\*2\*1 = 56.

You don’t need to list all 56 possible schedules; only list 2 strict, 2 recoverable, 2 non-recoverable, and 2 cascadeless schedules.

Below are the 56 possible schedules, and the type of each schedule:

S 1 : r 1 (X); w 1 (X); r 1 (Y); w 1 (Y); C 1 ; r 2 (X); w 2 (X); C 2 ; strict

S 21 : r 1 (X); r 2 (X); w 1 (X); r 1 (Y); w 1 (Y); C 1 ; w 2 (X); C 2 ; strict

S 2 : r 1 (X); w 1 (X); r 1 (Y); w 1 (Y); r 2 (X); C 1 ; w 2 (X); C 2 ; recoverable

S 3 : r 1 (X); w 1 (X); r 1 (Y); w 1 (Y); r 2 (X); w 2 (X); C 1 ; C 2 ; recoverable

S 9 : r 1 (X); w 1 (X); r 1 (Y); r 2 (X); w 2 (X); w 1 (Y); C 2 ; C 1 ; non-recoverable

S 10 : r 1 (X); w 1 (X); r 1 (Y); r 2 (X); w 2 (X); C 2 ; w 1 (Y); C 1 ; non-recoverable

S 22 : r 1 (X); r 2 (X); w 1 (X); r 1 (Y); w 1 (Y); w 2 (X); C 1 ; C 2 ; cascadeless

S 23 : r 1 (X); r 2 (X); w 1 (X); r 1 (Y); w 1 (Y); w 2 (X); C 2 ; C 1 ; cascadeless

**20.17.** List all possible schedules for transactions *T*1 and *T*2 in Figure 20.2, and determine which are conflict serializable (correct) and which are not.

Below are the 15 possible schedules, and the type of each schedule:

S 1 : r 1 (X); w 1 (X); r 1 (Y); w 1 (Y); r 2 (X); w 2 (X); serial (and hence also serializable)

S 2 : r 1 (X); w 1 (X); r 1 (Y); r 2 (X); w 1 (Y); w 2 (X); (conflict) serializable

S 3 : r 1 (X); w 1 (X); r 1 (Y); r 2 (X); w 2 (X); w 1 (Y); (conflict) serializable

S 4 : r 1 (X); w 1 (X); r 2 (X); r 1 (Y); w 1 (Y); w 2 (X); (conflict) serializable

S 5 : r 1 (X); w 1 (X); r 2 (X); r 1 (Y); w 2 (X); w 1 (Y); (conflict) serializable

S 6 : r 1 (X); w 1 (X); r 2 (X); w 2 (X); r 1 (Y); w 1 (Y); (conflict) serializable

S 7 : r 1 (X); r 2 (X); w 1 (X); r 1 (Y); w 1 (Y); w 2 (X); not (conflict) serializable

S 8 : r 1 (X); r 2 (X); w 1 (X); r 1 (Y); w 2 (X); w 1 (Y); not (conflict) serializable

S 9 : r 1 (X); r 2 (X); w 1 (X); w 2 (X); r 1 (Y); w 1 (Y); not (conflict) serializable

S 10 : r 1 (X); r 2 (X); w 2 (X); w 1 (X); r 1 (Y); w 1 (Y); not (conflict) serializable

S 11 : r 2 (X); r 1 (X); w 1 (X); r 1 (Y); w 1 (Y); w 2 (X); not (conflict) serializable

S 12 : r 2 (X); r 1 (X); w 1 (X); r 1 (Y); w 2 (X); w 1 (Y); not (conflict) serializable

S 13 : r 2 (X); r 1 (X); w 1 (X); w 2 (X); r 1 (Y); w 1 (Y); not (conflict) serializable

S 14 : r 2 (X); r 1 (X); w 2 (X); w 1 (X); r 1 (Y); w 1 (Y); not (conflict) serializable

S 15 : r 2 (X); w 2 (X); r 1 (X); w 1 (X); r 1 (Y); w 1 (Y); serial (and hence also serializable)

**20.23.** Consider the three transactions *T*1, *T*2, and *T*3, and the schedules *S*1 and *S*2 given below.

Draw the serializability (precedence) graphs for *S*1 and *S*2, and state whether each schedule is serializable or not. If a schedule is serializable, write down the equivalent serial schedule(s).

*T*1: *r*1 (*X*); *r*1 (*Z*); *w*1 (*X*);

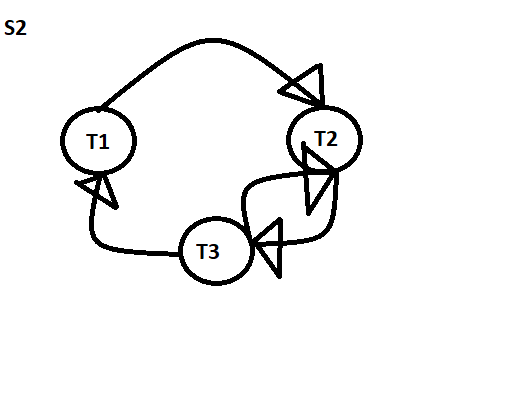
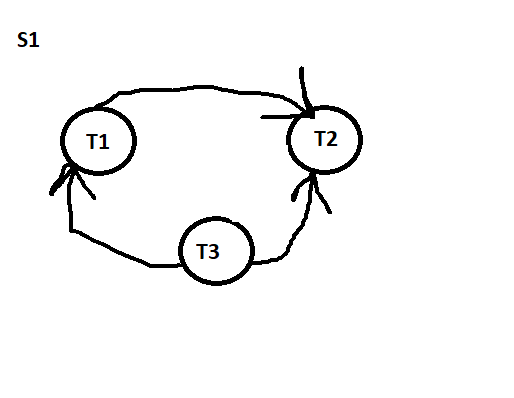
*T*2: *r*2 (*Z*); *r*2 (*Y*); *w*2 (*Z*); *w*2 (*Y*);

*T*3: *r*3 (*X*); *r*3 (*Y*); *w*3 (*Y*);

*S*1: *r*1 (*X*); *r*2 (*Z*); *r*1 (*Z*); *r*3 (*X*); *r*3 (*Y*); *w*1 (*X*); *w*3 (*Y*); *r*2 (*Y*); *w*2 (*Z*); *w*2 (*Y*);

*S*2: *r*1 (*X*); *r*2 (*Z*); *r*3 (*X*); *r*1 (*Z*); *r*2 (*Y*); *r*3 (*Y*); *w*1 (*X*); *w*2 (*Z*); *w*3 (*Y*); *w*2 (*Y*);

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| 20.23 |  |  |  | S1 |  |  |  | S2 |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| T1 | T2 | T3 |  | T1 | T2 | T3 |  | T1 | T2 | T3 |
| R(x) | R(z) | R(x) |  | R(x) |  |  |  | R(x) |  |  |
| R(z) | R(y) | R(y) |  |  | R(z) |  |  |  | R(z) |  |
| W(x) | W(z) | W(y) |  | R(z) |  |  |  |  |  | R(x) |
|  | W(y) |  |  |  |  | R(x) |  | R(z) |  |  |
|  |  |  |  |  |  | R(y) |  |  | R(y) |  |
|  |  |  |  | W(x) |  |  |  |  |  | R(y) |
|  |  |  |  |  |  | W(y) |  | W(x) |  |  |
|  |  |  |  |  | R(y) |  |  |  | W(z) |  |
|  |  |  |  |  | W(z) |  |  |  |  | W(y) |
|  |  |  |  |  | W(y) |  |  |  | W(y) |  |



S1is conflict serializable because there is NOT a cycle.

S2 is NOT conflict serializable because there is a cycle.

**20.24.** Consider schedules *S*3, *S*4, and *S*5 below. Determine whether each schedule is strict, cascadeless, recoverable, or nonrecoverable. (Determine the strictest recoverability condition that each schedule satisfies.)

*S*3: *r*1 (*X*); *r*2 (*Z*); *r*1 (*Z*); *r*3 (*X*); *r*3 (*Y*); *w*1 (*X*); *c*1; *w*3 (*Y*); *c*3; *r*2 (*Y*); *w*2 (*Z*); *w*2 (*Y*); *c*2;

*S*4: *r*1 (*X*); *r*2 (*Z*); *r*1 (*Z*); *r*3 (*X*); *r*3 (*Y*); *w*1 (*X*); *w*3 (*Y*); *r*2 (*Y*); *w*2 (*Z*); *w*2 (*Y*); *c*1; *c*2; *c*3;

*S*5: *r*1 (*X*); *r*2 (*Z*); *r*3 (*X*); *r*1 (*Z*); *r*2 (*Y*); *r*3 (*Y*); *w*1 (*X*); *c*1; *w*2 (*Z*); *w*3 (*Y*); *w*2 (*Y*); *c*3; *c*2;

***Answer:***

**Strict schedule**: A schedule is strict if it satisfies the following conditions:

1. Tj reads a data item X ***after*** Ti has written to X and Ti is terminated (aborted or

committed)

2. Tj writes a data item X ***after*** Ti has written to X and Ti is terminated (aborted or

committed)

**Schedule S3 is not strict** because T3 reads X (r3(X)) ***before*** T1 has written to X (w1(X))

but T3 commits ***after*** T1. In a strict schedule T3 must read X ***after*** C1.

**Schedule S4 is not strict** because T3 reads X (r3(X)) ***before*** T1 has written to X (w1(X))

but T3 commits ***after*** T1. In a strict schedule T3 must read X ***after*** C1.

**Schedule S5 is not strict** because T3 reads X (r3(X)) ***before*** T1 has written to X (w1(X))

but T3 commits ***after*** T1. In a strict schedule T3 must read X ***after*** C1.

**Cascadeless schedule**: A schedule is cascadeless if the following condition is satisfied:

Tj reads X only ***after*** Ti has written to X and terminated (aborted or committed).

Schedule S3 is ***not cascadeless*** because T3 reads X (r3(X)) before T1 commits.

Schedule S4 is ***not cascadeless*** because T3 reads X (r3(X)) before T1 commits.

Schedule S5 is ***not cascadeless*** because T3 reads X (r3(X)) ***before*** T1 commits or T2 reads

Y (r2(Y)) ***before*** T3 commits.

**NOTE**: According to the definition of cascadeless schedules S3, S4, and S4 are not

cascadeless. However, T3 is not affected if T1 is rolled back in any of the schedules, that is,

T3 does not have to roll back if T1 is rolled back. The problem occurs because these

schedules are not serializable.

**Recoverable schedule**: A schedule is recoverable if the following condition is satisfied:

Tj commits after Ti if Tj has read any data item written by Ti.

NOTE: Ci > Cj means Ci happens ***before*** Cj. Ai denotes abort Ti. To test if a schedule is

recoverable one has to include abort operations. Thus in testing the recoverability abort

operations will have to used in place of commit one at a time. Also the strictest condition is

where a transaction neither reads nor writes to a data item, which was written to by a

transaction that has not committed yet.

If A1>C3>C2, then S3 is ***recoverable*** because rolling back of T1 does not affect T2 and

T3. If C1>A3>C2. S3 is ***not recoverable*** because T2 read the value of Y (r2(Y)) ***after***

T3 wrote X (w3(Y)) and T2 committed but T3 rolled back. Thus, T2 used non- existent

value of Y. If C1>C3>A3, then S3 is ***recoverable*** because roll back of T2 does not

affect T1 and T3. Strictest condition of S3 is C3>C2.

If A1>C2>C3, then S4 is ***recoverable*** because roll back of T1 does not affect T2 and

T3. If C1>A2>C3, then S4 is ***recoverable*** because the roll back of T2 will restore the

value of Y that was read and written to by T3 (w3(Y)). It will not affect T1. If

C1>C2>A3, then S4 is ***not recoverable*** because T3 will restore the value of Y which was

not read by T2. Strictest condition of S4 is C3>C2, but it is not satisfied by S4.

If A1>C3>C2, then S5 is ***recoverable*** because neither T2 nor T3 writes to X, which is

written by T1. If C1>A3>C2, then S5 is ***not recoverable*** because T3 will restore the

value of Y, which was not read by T2. Thus, T2 committed with a non-existent value of

Y. If C1>C3>A2, then S5 is ***recoverable*** because it will restore the value of Y to the

value, which was read by T3. Thus, T3 committed with the right value of Y. Strictest

condition of S3 is C3>C2, but it is not satisfied by S5.