Homework 8 - Concurrency - Solutions

Reminders - IMPORTANT:

- Like all homeworks, it has to be done individually.
- Please typeset your answers.
- Please submit your answers in hard copy, in class, 1:30pm, on Tue 4/23/2013
- As before, for ease of grading, please solve each of the questions on a separate page, and type
  - the homework number (i.e., 'HW8')
  - your name and
  - your andrew ID

  on each of the answer pages.

Reminders - FYI:

- Weight: 5% of homework grade, as announced.
- The points of this homework add up to 100.
- Explanations: Optional, unless explicitly asked. If you do give explanations, they will be used to your benefit, for partial credit.
- Rough time estimates: 2-4 hours.
Consider the Schedule A given below in Table 1. R(·) and W(·) stand for 'Read' and 'Write', respectively. Ignore the lock T1:S(Y), for the moment.

Table 1: Schedule A, with 4 transactions.

<table>
<thead>
<tr>
<th>T1</th>
<th>S(Y)</th>
<th>E(Y)</th>
<th>T2</th>
<th>X(X)</th>
<th>W(X)</th>
<th>U(X)</th>
<th>T3</th>
<th>S(X)</th>
<th>R(X)</th>
<th>X(Z)</th>
<th>W(Z)</th>
<th>U(X)</th>
<th>U(Z)</th>
<th>T4</th>
<th>U(X)</th>
<th>U(Z)</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
</tr>
</tbody>
</table>

(a) [2 points] Is the schedule serial?   ○ Yes  √ No

(b) [5 points] Which of the following dependency graphs (a-d) of Figure 1 corresponds to the schedule?
   ○ Figure 1a  √  Figure 1b  ○ Figure 1c  ○ Figure 1d

Figure 1: Potential dependency graphs for Schedule A.

(c) [2 points] Is Schedule A conflict serializable?   √ Yes  ○ No

(d) [3 points] If not, briefly explain why. If it is conflict serializable, what is the conflict equivalent serial schedule?

Solution: Schedule A is conflict serializable, because the dependency graph does not contain any cycle. The equivalent serial schedule is T2-T1-T4-T3.

(e) [1 point] Is the schedule allowed by 2PL?   √ Yes  ○ No

(f) [7 points] If not, briefly explain why. If yes, fill in Table 1 with the lock/unlock requests that could have happened.

- Make sure that the 2PL protocol is obeyed, by all.
- Use S(·) for shared lock, X(·) for exclusive lock and U(·) to unlock. We already put the lock T1:S(Y) (in bold), as an example.

Solution: See Table 1.

Grading info: 0.5 point per lock/unlock.

Homework 8 continues...
Question 2: Serializability 2 ............................... [20 points]

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Consider Schedule B given below in Table 2.

<table>
<thead>
<tr>
<th>time</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td></td>
<td></td>
<td>R(X)</td>
<td>R(Y)</td>
<td>W(X)</td>
<td></td>
<td>W(X)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>T2</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>R(Y)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>T3</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>W(Y)</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Table 2: Schedule B.

(a) [2 points] Is the schedule serial?  ○ Yes  √ No

(b) [5 points] In Figure 2, which of the dependency graphs (a-d) corresponds to the schedule?  ○ Figure 2a  ○ Figure 2b  ○ Figure 2c  √ Figure 2d

![Figure 2: Potential dependency graphs for Schedule 2.](image)

(c) [2 points] Is Schedule B conflict serializable?  ○ Yes  √ No

(d) [3 points] If not, briefly explain why. If it is conflict serializable, what is the conflict equivalent serial schedule?

Solution: The dependency graph contains a cycle.

(e) [1 point] Is the schedule allowed by 2PL?  ○ Yes  √ No

(f) [7 points] If not, briefly explain why. If yes, fill in Table 2 with the lock/unlock requests that could have happened. Use S(·) for shared lock, X(·) for exclusive lock and U(·) to unlock.

Solution: It can not possibly be generated by 2PL, since it is not serializable.
Question 3: Deadlock Detection .......................... [20 points]

The first questions refer to Schedule 1 of Table 3, and the last ones refer to Schedule 2 of Table 4.

<table>
<thead>
<tr>
<th>time</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>S(A)</td>
<td></td>
<td>S(B)</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td></td>
<td>X(A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T3</td>
<td></td>
<td></td>
<td></td>
<td>X(B)</td>
</tr>
</tbody>
</table>

Table 3: Schedule 1 - Deadlock Detection.

<table>
<thead>
<tr>
<th>time</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>T4</td>
<td>S(D)</td>
<td></td>
<td>S(F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T5</td>
<td></td>
<td>X(D)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T6</td>
<td></td>
<td></td>
<td>X(F)</td>
<td>X(D)</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Schedule 2 - Deadlock Detection.

(a) [2 points] For Schedule 1, assuming no other transactions, mention which lock request will be granted (g) or blocked (b) by the lock manager.

Solution: g, b, g, b

(b) [5 points] Give the wait-for graph for Schedule 1.

Solution: See Figure 3

Grading info: wrong direction of arrow: -0.5, wrong arrow: -1, missing arrow: -2

Figure 3: Solution

(c) [3 points] For Schedule 1, indicate whether there will be a deadlock or not at the end of this sequence, and give a 1-sentence explanation.

Solution: There will not be a deadlock. The wait-for graph is cycle-free.

(d) [2 points] For Schedule 2, which lock request will be granted (g), and which will be blocked (b) by the lock manager.

Solution: g,b,g,b,b

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Question 3 continues...
(e) [5 points] Give the wait-for graph for Schedule 2.

Solution: See Figure 4

Grading info: wrong direction of arrow: -0.5, wrong arrow: -1, missing arrow: -2

![Wait-for graph](image)

Figure 4: Solution

(f) [3 points] For Schedule 2, indicate whether there will be a deadlock or not at the end of this sequence, and give a 1-sentence explanation.

Solution: There will be a deadlock, since there is a cycle in the wait-for graph.

Homework 8 continues...
Question 4: B+ tree Locking ........................................... [20 points]

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Figure 5: B+ tree Locking. The image is taken from the textbook; Fig. 17.5, p. 563.

Use the non-conservative crabbing algorithm, Bayer-Schkolnick, to lock the B+ tree. The algorithm is described in slide 54 of the lecture notes #22, as well as in p. 564 of the textbook. For each of the following transactions give the sequence of lock/unlock requests. For example, use S(A) / X(A) / U(A) if the transaction requests a shared lock / exclusive lock / unlock on A respectively.

Grading info: For Shared instead of Exclusive lock: -0.5pt
Grading info: For Exclusive instead of Shared lock: -0.5pt
Grading info: For not unlocking: -0.5pt
Grading info: For completely missing a lock: -1pt

(a) [5 points] Search for the data entry 25*.

Solution: S(A), S(C), U(A), S(F), U(C), S(M), U(F), U(M)

(b) [5 points] Insert the data entry 39*.

Solution: S(A), S(C), U(A), S(G), X(O), X(G), X(C), U(C), U(G), U(O).
Grading info: Possible error: not getting exclusive lock on G (-1 pt) or C (-1 pt).
Grading info: They are required because O and G are both full.

(c) [5 points] Insert the data entry 59*.

(c) [5 points] Insert the data entry 59*.
(d) [5 points] Delete the data entry 13*.

Solution: S(A), S(B), U(A), S(E), U(B), X(K), U(E), U(K)
Question 5: Hierarchical Locking ........................ [20 points]  
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Consider a Database (D) consisting of two tables, Employees (E) and Gym (G).
- Employees spans 500 pages, namely E1-E500, while
- Gym spans 1000 pages, i.e., G1-G1000.

Moreover, each page contains 200 records. For example, the 1st record of the first page of Employees is noted as E1:1, the 2nd record as E2:2 etc. Similarly, the 100th record of the 200th page of Gym is noted as G200:100.

We use multiple-granularity locking, with S, X, IS, IX, and SIX locks, and four levels of granularity: (a) the database-level, (b) the table-level, (c) the page-level and (d) the record-level.

For each of the following operations, give the sequence of lock requests that must be generated by a transaction that wants to carry out these operations. For example, write IS(E)/IS(G) for Intention Shared lock on Employees/Gym respectively. You do not need to give the sequence of unlocking.

Grading info: Also acceptable: S lock on table
Grading info: Also acceptable: IS lock on table, S lock on record, S lock on another record;
Grading info: escalation S-lock on table
Grading info: If Shared lock instead of Exclusive lock (or vice versa): -1pt

(a) [4 points] Read all records on all pages of Employees.

Solution: IS(D), S(E)

(b) [4 points] Read all the records of Gym, and capitalize all initial letters of every gym name, if they are not already capital. That is, Light weights is updated to Light Weights, but Skibo will be left unchanged.

Solution: IS(D), IX(D), SIX(G)

Grading info: Also acceptable: IX(D), SIX(G)

(c) [4 points] Read the record G15:4.

Solution: IS(D), IS(G), IS(G15), S(G15:4)

(d) [4 points] Update the first record from each and every page of Employees.

Solution: IX(D), X(E)

Grading info: Also acceptable with escalation: IX(D), IX(E), X(E1), X(E2), X(E)

(e) [4 points] Read all the records from E400:198 to E402:2.

Question 5 continues...
Solution: IS(D), IS(E), IS(E400), S(E401), IS(E402), S(E400:198), S(E400:199), S(E400:200), S(E402:1), S(E402:2)

Grading info: Also acceptable: IS(D), IS(E), S(E400), S(E401), S(E402)