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.
Question 1: Serializability 1 .......................... [20 points]
[*** SUBMIT ON SEPARATE PAGE ***]

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.

|    | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| T1 | S(Y) | R(Y) |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| T2 |     | W(X) |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| T3 |     |     | R(X) |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| T4 |     |     |     | R(Z) |     |     |     |     |     |     |     |     | W(Y) |     |     |     |     |     |     |     |     |

Table 1: Schedule A, with 4 transactions.

(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.](image)

(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?

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(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.

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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>R(X)</td>
<td>R(Y)</td>
<td>W(X)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>W(X)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td></td>
<td></td>
<td></td>
<td>R(Y)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>W(Y)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<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.

(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?

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(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.

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Question 3: Deadlock Detection ......................... [20 points]

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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>X(B)</td>
<td></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

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

(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.

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

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

(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.

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

[*** SUBMIT ON SEPARATE PAGE ***]

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.

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

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

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

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

Figure 3: B+ tree Locking. The image is taken from the textbook; Fig. 17.5, p. 563.

Homework 8 continues...
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.

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


(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.


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


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


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


End of Homework 8