Database Systems - Homework 4

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1

1.1

```
for all tuples s in S:
    for all tuples  a in A:
        if a.artistID == A.ID and A.genre == 'Jazz' and
                s.releaseDate>=TO_DATE('2023/00/00','YYYY/MM/DD'):
            output(a.ID, s.ID)
```

Let B_A be the number of blocks in A, B_S the number of blocks in S and n_S the number of tuples in S.
As seen in the lectures the IO cost for this is $O(B_A + n_S \cdot B_S) = O(10^4 + 10^7)$

1.2

i. IO cost $O(1)$. By going through the tree and and finding the lexicographically largest element with the constraint that `artistID=236363`, then getting the block which contains it - and extracting that element from that block.

ii. Let n_S be the number of rows that refer to this artirst, from the year 2023 onwards. Thus the IO complexity is $O(n_S)$.
After going to the index and finding the largest leaf with $artistID = 236363$, we can generate the set of outputs (while outputing the `s.id` for each tuple) in decending order by iterating over the leaves which have a year after 2023.
Note that the specific ordering is not required by the implementation is more efficient this way.

1.3

Iterate over each element from the set of artits, if the artist's genre is Jazz - output all of his songs which are from after 2023 - by searching through the tree in lexicographic order - in the same way as in ii. (Denote this alg with `alg12`), and finally we project the tuples on `A.ID` and `S.ID`.

```
for all tuples a in A:
    if a.genre == 'Jazz':
        //run alg from 1.2 ii running on a
        T := alg12(a)
        for t in T:
            output(a.id, t.id)
```

2

2.1

i. First we show the scheduling is not *view serializable* and thus it is not *conflict serializable* - thanks to the theorem seen in lectures which states that conflict serializability implies view serializability.

   First we note that in any serial scheduling which is equivalent to the given scheduling, T_3 has be come after T_2 since T_3 and T_2 refer to the same variable y.
   Thus the scheduling options remaining are:

   (a) $T_1 \to T_2 \to T_3$.
   This scheduling is not equivalent since in the original schedule - T_1 reads y written by T_2 and in this one it reads the initial value of y.

   (b) $T_2 \to T_3 \to T_1$
   Not equivalent since in the original the final value of x is written by T_2 while in this schedule it is written by T_1.

   (c) $T_2 \to T_1 \to T_3$
   Not equivalent due to exact the same reason as $T_2 \to T_3 \to T_1$.

ii. Denote the following serialization:

$$S' = R_2(z), R_2(y), W_2(x), W_3(z), W_4(z), R_4(y), R_1(z)$$

   The operations are equivalent: $S =_C S'$, since each pair of operations in conflict in S appear in the same relative order in S'.
   For example the conflicting operations $R_2(z), W_3(z)$, are in the ordering $R_2(z) \to ... \to W_3(z)$ both in the original and new schedule.

   Thus S is *conflict serializable* by def.
   Thus from the theorem seen in lecture - S is also *view serializable*.

iii. Denote the provided schedule as S.
   Note that T_2 is has to appear last in any serial scheduling which is equivalent to the one provided, since all transactions write to y, while $W_2(y)$ happends after both $W_1(y)$ (meaning T_2 must be after T_1) and $W_2(y)$ is after $W_3(y)$ (meaning T_2 must be after T_3).
   Thus we are left with two options:

(a) $T_1 \rightarrow T_3 \rightarrow T_2$

(b) $T_3 \rightarrow T_1 \rightarrow T_2$

b is not *view equivalent* to S since S, T_1 reads y's initial value, while in b - T_1 reads the value written to y in T_3.
a is *view equivalent* to S by def. and thus S is *view serializable*.
So far we have found that a is the only possbile equivalent serialization of S. Since in S: $W_3(y) \rightarrow \cdots \rightarrow W_1(y)$, and in a: $W_1(y) \rightarrow \cdots \rightarrow W_3(y)$, thus a is not *conflict equivalent* to S.
This means there is no *conflict equivalent* serialization for S.
Hence S is not *conflict serializable*.

2.2

i. $R_{L_1}(x), R_1(x), R_{L_2}(y), R_2(y), R_1(x), R_{U_1}(x), R_{L_2}(x), R_2(x), R_2(y), R_{U_2}(x), R_{U_2}(y)$

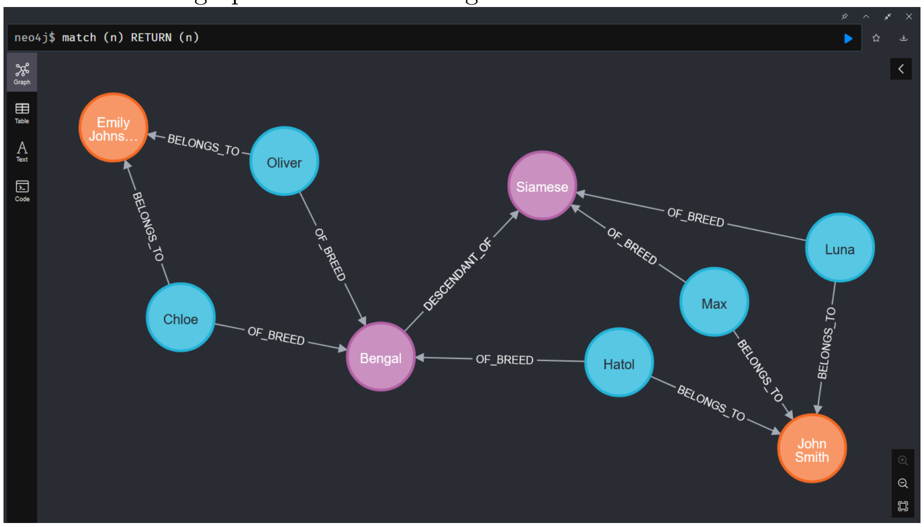
ii. $W_2(x), W_1(x), W_2(x), R_2(y)$

3

For the purpose of providing an example for each solution we have provided in this question we have created an example database and added a few kittens to it, and ran the solution queries on each of them.
The following code creates the content of our databse:

```
CREATE (b1:Breed {name: 'Siamese', origin: 'Thailand', lifespan: '12-15 years'})
CREATE (b2:Breed {name: 'Bengal', origin: 'United States', lifespan: '12-16 years'})
CREATE (b2)-[:DESCENDANT_OF]->(b1)

CREATE (o1:Owner {name: 'John Smith', address: '123 Main St'})
CREATE (o2:Owner {name: 'Emily Johnson', address: '456 Elm St'})

CREATE (c1:Cat {name: 'Max', age: 3, gender: 'Male'})
CREATE (c2:Cat {name: 'Luna', age: 2, gender: 'Female'})
CREATE (c3:Cat {name: 'Oliver', age: 4, gender: 'Male'})
CREATE (c4:Cat {name: 'Chloe', age: 1, gender: 'Female'})
CREATE (c5:Cat {name: 'Hatol', age:7, gender: 'Male'})

CREATE (c1)-[:BELONGS_TO {relationship_length: 2}]->(o1)
CREATE (c2)-[:BELONGS_TO {relationship_length: 1}]->(o1)
CREATE (c3)-[:BELONGS_TO {relationship_length: 1}]->(o2)
CREATE (c4)-[:BELONGS_TO {relationship_length: 1}]->(o2)
CREATE (c5)-[:BELONGS_TO {relationship_length: 3}]->(o1)

CREATE (c1)-[:OF_BREED]->(b1)
CREATE (c2)-[:OF_BREED]->(b1)
CREATE (c3)-[:OF_BREED]->(b2)
CREATE (c4)-[:OF_BREED]->(b2)
CREATE (c5)-[:OF_BREED]->(b2)
```

Here is how the graph looks after adding the kittens:

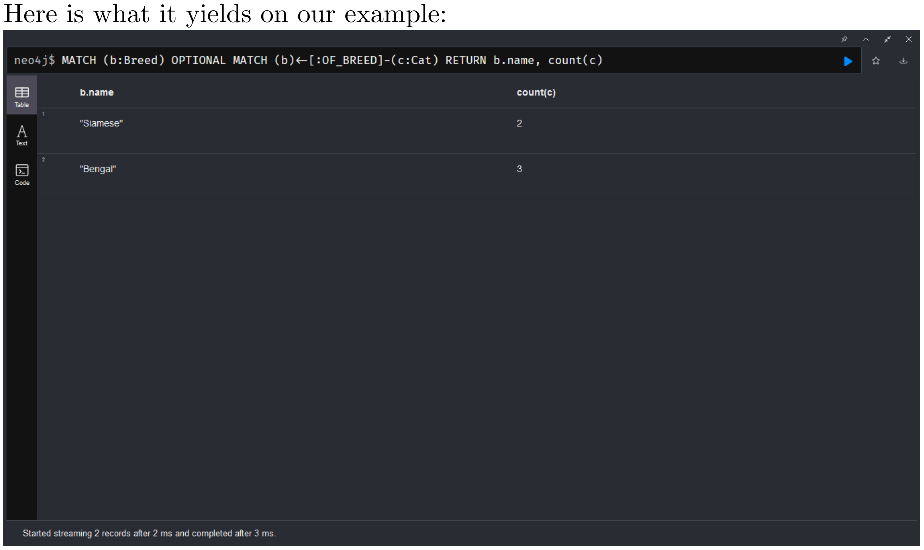


3.1

The query can be solved by:

```
MATCH (b:Breed)
OPTIONAL MATCH (b)<-[:OF_BREED]-(c:Cat)
RETURN b.name, count(c)
```

Here is what it yields on our example:



b.name	count(c)
"Siamese"	2
"Bengal"	3

Running this on our example yields:

b.name	count(c)
"Siamese"	2
"Bengal"	3

3.2

This question is solved by the query:

```
MATCH (o:Owner)<-[:BELONGS_TO]-(c:Cat)-[:OF_BREED]->(b:Breed)
WITH o, collect(DISTINCT b) AS breeds
WHERE size(breeds) = 1
RETURN o.name
```

Running this on our example yields:

b.name	count(DISTINCT c)
"Siamese"	5
"Bengal"	3

3.3

This question is solved by the query:

```
MATCH (b:Breed)
OPTIONAL MATCH (b)<-[:DESCENDANT_OF*0..]-(:Breed)-[:OF_BREED]-(c)
RETURN b.name, count(DISTINCT c)
```

Running this on our example yields:

o.name
"Emily Johnson"

3.4

This question is solved by the query:

```
MATCH (b:Breed)
OPTIONAL MATCH (b)<-[:OF_BREED]-(c:Cat)
RETURN b.name, count(c)
```

Running this on our example yields:

o.name
"John Smith"