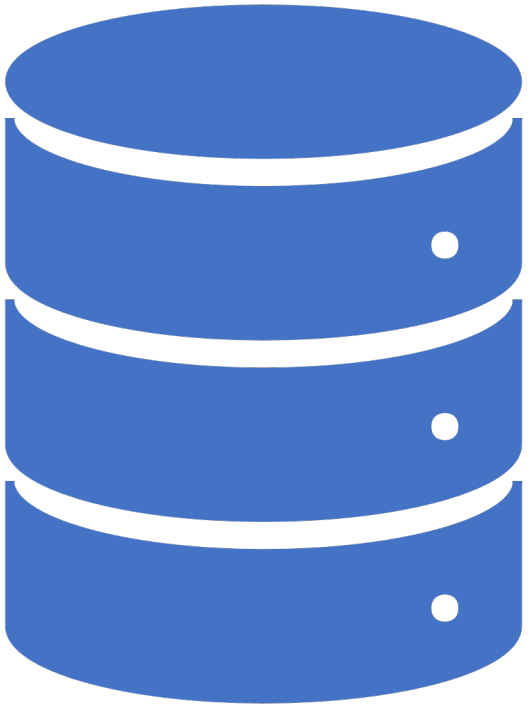


Lecture 13

DATABASES
Written Exam - Problems

Database Exam

- Written Exam – 50% >=5
- Practical Test – 25% >=5
- Lab Activity – 25%

- **Written Exam**
  - 14 questions - multiple choice questions (3 questions as in Seminar 6 – Part I) (0.5 points / question) (= 7 **points**)
    - 4 possible answers – 1 correct answer
  - 2 questions with open (short) answers (0.5 point / question) (= **1 point**)
    - (theory, *query - description*, *relational algebra*, functional dependencies, …)
  - 1 question with open answer (1 point / question) (= 1 **point**)
    - (*queries*, relational algebra, indexes/B-trees, …)
  - (+ **1 point default**)

- Duration: **1 hour 40 minutes**

Written Exam – multiple choice questions

Choose the correct answer for the following multiple choice questions. Each question has just one correct answer.

1. For a SELECT query
a. due to the concepual evaluation strategy, the clause ORDER BY is evaluated before the clause WHERE
b. the HAVING clause should contain row-level qualification conditions
c. the SELECT clause cannot contain arithmetic expressions
d. DISTINCT eliminates the duplicates from the result set

Answer: d

2. In the relational algebra, the natural join operator $R_1 * R_2$
a. returns 2 relation instances
b. returns a relation that contains all the attributes from R_1 and R_2, with the common attributes apearing only once
c. returns a relation that contains the attributes from R_1 that don't appear in R_2
d. returns a relation that contains the attributes from R_2 that don't apear in R_1

Answer: b

Written Exam – multiple choice questions

Choose the correct answer for the following multiple choice questions. Each question has just one correct answer.

3. In the ANSI-SPARC architecture relative to a database system, a database can have
a. several conceptual structures
b. several physical structures
c. several external structures
d. only one external structure

Answer: c

4. Consider the relational schema S[A, B, C, D, E] with none repeatable attributes and none candidate keys. The primary key is {A}. The set of the functional dependencies that holds is {A→D, C→A, D→E}
a. S is not 1NF
b. S is 2NF
c. S is BCNF
d. S is 1NF

Answer: d (1NF: yes; 2NF, BCNF: no)

Written Exam – multiple choice questions

Choose the correct answer for the following multiple choice questions. Each question has just one correct answer.

5. In a B-tree of order 6
a. a non-terminal node has at most 6 subtrees
b. a non-terminal node has at least 5 subtrees
c. terminal nodes can be on different levels
d. a non-root node has at most 5 subtrees
Answer: a (non-terminal, non-root node – at most 6, at least 4 subtrees (between 2 and 5 values))

6. Let a, b, c be subsets of attributes in a relational schema. If a→b and b→c then from the transitivity follows
a. c→b
b. a→c
c. b→a
d. c→a
Answer: b

Written Exam – multiple choice questions

Choose the correct answer for the following multiple choice questions. Each question has just one correct answer.

7. Consider the table Management[Mid, ManagerId, EmployerId, DiscussionTime] from SQL Server. The table Management has 100.000 records and 2 indexes: a unique clustered index on Mid and a non-clustered index on ManagerId. Consider also the following query

```
SELECT Mid, ManagerId, DiscussionTime
FROM Management
WHERE ManagerId=10
```

If the execution plan contains an *Index Seek (NonClustered), it also contains:*

a. an *Index Scan (NonClustered)*
b. a *Key Lookup (Clustered)*
c. a *Clustered Index Scan*
d. an *Unique Index*

Answer: b

Written Exam – multiple choice questions

Choose the correct answer for the following multiple choice questions. Each question has just one correct answer.

8. A secondary index:
a. can contain duplicates
b. cannot contain duplicates
c. cannot be created
d. the search key include the primary key
Answer: a

9. In the relational algebra, the cross-product operator $R_1 \times R_2$
a. returns a relation whose schema contains all the attributes from R_1 followed by all the attributes from R_2
b. returns a relation whose schema contains only the attributes from R_1 that are not in R_2
c. returns 3 relation instances
d. does not allow the combination of two relations
Answer: a

Written Exam – multiple choice questions

Choose the correct answer for the following multiple choice questions. Each question has just one correct answer.

10. Consider the following relation R[A1, A2, X, Y, Z, V, W] with the instance given below.
Consider also the queries:

	A1	A2	X	Y	Z	V	W
1	11	11	x1	y1	z1	10	4
2	11	12	x	y1	z2	8	4
3	11	13	x2	y	z1	NULL	4
4	12	11	x3	y3	z	NULL	20
5	12	13	x2	y	z3	NULL	20

Q1: SELECT * FROM R r1 LEFT JOIN R r2 ON r1.A1=r2.A2
Q2: SELECT DISTINCT * FROM R r1 INNER JOIN R r2 ON r1.A1=r2.A2

The cardinality of the answer set of Qi is denoted by |Qi|, where i=1,2.
Which is the result of |Q1|-|Q2|?

a. 4
b. 0
c. 6
d. 5

Answer: b (8-8=0)

Written Exam – multiple choice questions

Choose the correct answer for the following multiple choice questions. Each question has just one correct answer.

11. Consider the following relation R[A1, A2, X, Y, Z, V, W] with the instance given below.

Consider also the queries:

```
Q1: SELECT A1, X, COUNT(DISTINCT Y)
     FROM R
    GROUP BY A1, X
    HAVING MIN(V)>5
```

```
Q2: SELECT A1, X, COUNT(Y)
    FROM R
    GROUP BY A1, X
    HAVING MAX(W)>0
```

	A1	A2	X	Y	Z	V	W
1	11	11	x1	y1	z1	10	4
2	11	12	x	y1	z2	8	4
3	11	13	x2	y	z1	NULL	4
4	12	11	x3	y3	z	NULL	20
5	12	13	x2	y	z3	NULL	20

The cardinality of the answer set of Qi is denoted by |Qi|, where i=1,2.

Which is the result of |Q2|-|Q1|?

a. 5
b. 2
c. 3
d. -3

Answer: c (5-2)

Written Exam – multiple choice questions

Choose the correct answer for the following multiple choice questions. Each question has just one correct answer.

12. Consider the following relation R[A1, A2, X, Y, Z, V, W] with the instance given below.
Consider also the queries:

Q1: SELECT * FROM R r1 RIGHT OUTER JOIN R r2 ON r1.A1=r2.A1
WHERE r1.Z LIKE '%1*'

Q2: SELECT DISTINCT * FROM R r1 RIGHT OUTER JOIN R r2 ON r1.A2=r2.A2
WHERE r1.Y LIKE '%1*'

Q3: SELECT * FROM R r1 RIGHT OUTER JOIN R r2 ON r1.A1=r2.A2
WHERE r1.X LIKE '%1*'

	A1	A2	X	Y	Z	V	W
1	11	11	x1	y1	z1	10	4
2	11	12	x	y1	z2	8	4
3	11	13	x2	y	z1	NULL	4
4	12	11	x3	y3	z	NULL	20
5	12	13	x2	y	z3	NULL	20

Which of the following answers is not correct?

a. The cardinality of the answer set of Q2 is 0.
b. The cardinality of the answer set of Q1 and Q3 is the same.
c. The cardinality of the answer set of Q1 is 2.
d. The cardinality of the answer set of Q3 and Q2 is the same.

Answer: c (Q1, Q2, Q3 return 0 rows)

Written Exam – multiple choice questions

Choose the correct answer for the following multiple choice questions. Each question has just one correct answer.

13. Consider the following relation R[A1, A2, X, Y, Z, V, W] with the instance given below.
Regarding the functional dependencies of R and the instance:

	A1	A2	X	Y	Z	V	W
1	11	11	x1	y1	z1	10	4
2	11	12	x	y1	z2	8	4
3	11	13	x2	y	z1	NULL	4
4	12	11	x3	y3	z	NULL	20
5	12	13	x2	y	z3	NULL	20

a. At least one of the following dependencies is not satisfied by the instance: {X}→{Y}, {A1, A2}→{X, Y}, {A1}→{X}.
b. The functional dependency {A1}→{W} is not satisfied by the instance.
c. The functional dependencies {A2}→{V} and {X}→{Z} are satisfied by the instance.
d. At least one of the following dependencies is satisfied by the instance: {A2}→{Z}, {Z}→{X}, {W, Z}→{A2}

Answer: a ({A1}→{X})

Written Exam – multiple choice questions

14. Consider the following SQL queries created on the relations A[x, y, z] and B[z, t, v]

    Q1: SELECT y, t FROM A INNER JOIN B ON A.z=B.z

    Q2: SELECT y, t FROM A, B WHERE A.z=B.z

a. Q1 and Q2 provide different result sets.
b. Q1 and Q2 provide the same result set.
c. Q1 provide a result set that is included in the result set of Q2.
d. Q2 provide a result set that is included in the result set of Q1.

Answer: b

15. Consider the following SQL queries created on the relations A[x, y, z] and B[z, t, v]

    Q1: SELECT y, t FROM A INNER JOIN B ON A.z=B.z

    Q2: SELECT y, t FROM A, B WHERE A.z=B.z ORDER BY t

a. Q1 and Q2 provide different result sets.
b. Q1 and Q2 provide the same result set.
c. Q1 provide a result set that is included in the result set of Q2.
d. Q2 provide a result set that is included in the result set of Q1.

Answer: b

Written Exam – multiple choice questions

16. Consider the following SQL queries created on the relations A[x, y, z] and B[z, t, v]

    Q1: SELECT DISTINCT y, t FROM A INNER JOIN B ON A.z=B.z

    Q2: SELECT y, t FROM A, B WHERE A.z=B.z

a. Q1 and Q2 provide different result sets.
b. Q1 and Q2 provide the same result set.
c. Q1 provide a result set that is included in the result set of Q2.
d. Q2 provide a result set that is included in the result set of Q1.

Answer: c

17. Consider the following SQL queries created on the relations A[x, y, z] and B[z, t, v]

    Q1: SELECT y, t FROM A INNER JOIN B ON A.z=B.z

    Q2: SELECT t, y FROM A, B WHERE A.z=B.z

a. Q1 and Q2 provide different result sets.
b. Q1 and Q2 provide the same result set.
c. Q1 provide a result set that is included in the result set of Q2.
d. Q2 provide a result set that is included in the result set of Q1.

Answer: a

Written Exam – open questions

Answer the following questions / solve the following problems.

1. Rewrite the following CREATE TABLE statement such that the restriction is enforced: one A entity can be associated with one or more B entities, and one B entity can be associated with at most one A entity. Don't add other SQL statements.

```
CREATE TABLE A (
        Aid INT PRIMARY KEY,
        FieldA1 VARCHAR(50)
)
CREATE TABLE B (
        Bid INT PRIMARY KEY,
        FieldB1 DATETIME
)
```

Solution:

```
CREATE TABLE B (
        Bid INT PRIMARY KEY,
        FieldB1 DATETIME,
        Aid INT FOREIGN KEY REFERENCES A(Aid) )
```

Written Exam – open questions

Answer the following questions / solve the following problems.

2. Write the following relational algebra expression as a SQL query.

$$\pi_{\{FieldA1,\, FieldA2,\, FieldB1\}}\left(\left(\pi_{\{Aid,\, FieldA1,\, FieldA2\}}\left(\sigma_{FieldA3=50}(A)\right)\right) \otimes_{Aid=BAid} \left(\pi_{\{Bid,\, FieldB1,BAid\}}\left(\sigma_{FieldB2>10}(B)\right)\right)\right)$$

Solution:

```
SELECT FieldA1, FieldA2, FieldB1
FROM (SELECT Aid, FieldA1, FieldA2 FROM A WHERE FieldA3=50) AA
INNER JOIN (SELECT Bid, FieldB1, BAid FROM B WHERE FieldB2>10) BB ON AA.Aid=BB.BAid
```

Consider the following relational schema A[Aid, B, C, D, E, F, G], where Aid is the primary key, with the next instance

	Aid	B	C	D	E	F	G
1	1	10	20	5	20	2	1
2	2	11	5	1	20	5	2
3	3	10	10	7	10	5	3
4	4	20	20	6	20	2	4
5	5	20	10	2	20	5	9
6	6	30	5	1	20	5	1

Written Exam – open questions

Answer the following questions / solve the following problems.

3. What is the result set returned by the following query? Write the tuples' values and the name of the columns.

```
SELECT a1.Aid, a1.B+a2.B adding, a1.B*a2.D multiplication
FROM A a1 RIGHT JOIN A a2 ON a1.Aid=a2.Aid
WHERE a1.B>ANY(SELECT C FROM A WHERE C<6)
```

A[Aid, B, C, D, E, F, G]

	Aid	B	C	D	E	F	G
1	1	10	20	5	20	2	1
2	2	11	5	1	20	5	2
3	3	10	10	7	10	5	3
4	4	20	20	6	20	2	4
5	5	20	10	2	20	5	9
6	6	30	5	1	20	5	1

Solution:

	Aid	adding	multiplication
1	1	20	50
2	2	22	11
3	3	20	70
4	4	40	120
5	5	40	40
6	6	60	30

Written Exam – open questions

Answer the following questions / solve the following problems.

4. What is the result set returned by the following query? Write the tuples' values and the name of the columns.

```
SELECT A.*
FROM (SELECT a1.Aid, a2.C, a3.E FROM A a1  INNER JOIN A a2 ON a1.Aid=a2.Aid
INNER JOIN A a3 ON a2.Aid=a3.Aid
WHERE a1.G<5)AA LEFT JOIN A ON A.Aid=AA.Aid
```

A[Aid, B, C, D, E, F, G]

	Aid	B	C	D	E	F	G
1	1	10	20	5	20	2	1
2	2	11	5	1	20	5	2
3	3	10	10	7	10	5	3
4	4	20	20	6	20	2	4
5	5	20	10	2	20	5	9
6	6	30	5	1	20	5	1

Solution:

	Aid	B	C	D	E	F	G
1	1	10	20	5	20	2	1
2	2	11	5	1	20	5	2
3	3	10	10	7	10	5	3
4	4	20	20	6	20	2	4
5	6	30	5	1	20	5	1

Written Exam – open questions

Answer the following questions / solve the following problems.

5. Evaluate the expression that follows. π does not eliminate the duplicates. What is the cardinality of Y?

$$X = \sigma_{F<5}(A)$$
$$Y = \pi_{\{X.Aid, A.E\}}(X \otimes_{X.G=A.G} A)$$

A[<u>Aid</u>, B, C, D, E, F, G]

	Aid	B	C	D	E	F	G
1	1	10	20	5	20	2	1
2	2	11	5	1	20	5	2
3	3	10	10	7	10	5	3
4	4	20	20	6	20	2	4
5	5	20	10	2	20	5	9
6	6	30	5	1	20	5	1

Solution:

X= SELECT * FROM A WHERE F<5

	Aid	B	C	D	E	F	G
1	1	10	20	5	20	2	1
2	4	20	20	6	20	2	4

Y= SELECT a1.Aid, a2.E FROM
(SELECT * FROM A WHERE F<5) a1 INNER JOIN A a2 ON a1.G=a2.G

	Aid	E
1	1	20
2	4	20
3	1	20

Written Exam – open questions

Answer the following questions / solve the following problems.

6. Consider the following relation Student[Sid, Name, Email, Age, Grade], where Sid is primary key, with the next legal instance

a. Give an example of an attribute (group of attributes) that cannot be a candidate key.

b. Can be deduced if an attribute (group of attributes) can be a candidate key?

Solution:

a. Name, Age are not candidate keys (the same value appears more than once) (Grade is not a good example for this instance, even if multiple students can have the same grade)

b. A candidate key cannot be determined from only one instance of the relation. Even if the instance is legal, it is not enough; a candidate key must be respected by all the legal instances of a relation.

Sid	Name	Email	Age	Grade
27	Adrian	adrian@scs.ubbcluj.ro	19	9
28	Paul	paul@scs.ubbcluj.ro	20	8
29	Mary	mary@scs.ubbcluj.ro	21	10
25	Kelly	kelly@scs.ubbcluj.ro	22	7.75
31	John	john@scs.ubbcluj.ro	18	5.5
30	Paul	paul2@scs.ubbcluj.ro	20	7
32	Susan	susan@scs.ubbcluj.ro	19	9.5

Written Exam – open questions

Answer the following questions / solve the following problems.

7. Consider the following relational structure to store information about travelling
- Traveller[Tid, Name, Dob] – Tid is the primary key
- Place[Pid, PName, Country, Area] – Pid is the primary key
- Trip[TravellerId, PlaceId, Budget, TripDate] – (TravellerId, PlaceId) is the primary key; TravellerId and PlaceId reference the records from Traveller and Place

Write SQL queries for the next requirements:

a. Display the name of the places in which the area is greater than 150 ha (acres) and less than 250 ha (acres).

```
SELECT PName FROM Place
WHERE Area>150 AND Area<250
```

or

```
SELECT Pname FROM Place
WHERE Area BETWEEN 151 AND 249
```

b. Display the name of the places in which the area is greater than 250 ha or it is less than 500 ha.

```
SELECT PName FROM Place
WHERE Area>150 OR Area<250
```

Written Exam – open questions

Answer the following questions / solve the following problems.

7. Consider the following relational structure to store information about travelling
- Traveller[Tid, Name, Dob] – Tid is the primary key
- Place[Pid, PName, Country, Area] – Pid is the primary key
- Trip[TravellerId, PlaceId, Budget, TripDate] – (TravellerId, PlaceId) is the primary key; TravellerId and PlaceId reference the records from Traveller and Place

Write SQL queries for the next requirements:

c. Display the name of the travellers and the country in which they have a planned trip if the name of the place starts with *D* and the budget is greater than 500$.

```
SELECT Name, Country
FROM Traveller INNER JOIN Trip ON Traveller.Tid=Trip.TravellerId
                    INNER JOIN Place ON Place.Pid=Trip.PlaceId
WHERE Pname LIKE  'D*' AND Budget>500
```

Written Exam – open questions

Answer the following questions / solve the following problems.

7. Consider the following relational structure to store information about travelling
- Traveller[Tid, Name, Dob] – Tid is the primary key
- Place[Pid, PName, Country, Area] – Pid is the primary key
- Trip[TravellerId, PlaceId, Budget, TripDate] – (TravellerId, PlaceId) is the primary key; TravellerId and PlaceId reference the records from Traveller and Place

Write SQL queries for the next requirements:

d. Display the name of the travellers that had a trip in the same place and date.

```
SELECT DISTINCT Name
FROM Traveller T INNER JOIN Trip Tr1 ON T.Tid=Tr1.TravellerId
                 INNER JOIN Trip Tr2 ON T.Tid=Tr2.TravellerId
WHERE Tr1.PlaceId=Tr2.PlaceId AND Tr1.TripDate=Tr2.TripDate
```

Written Exam – open questions

Answer the following questions / solve the following problems.

7. Consider the following relational structure to store information about travelling
- Traveller[Tid, Name, Dob] – Tid is the primary key
- Place[Pid, PName, Country, Area] – Pid is the primary key
- Trip[TravellerId, PlaceId, Budget, TripDate] – (TravellerId, PlaceId) is the primary key; TravellerId and PlaceId reference the records from Traveller and Place

Write SQL queries for the next requirements:

e. Display the name of the travellers that had a trip in the same place and in different dates.

```
SELECT DISTINCT Name
FROM Traveller T INNER JOIN Trip Tr1 ON T.Tid=Tr1.TravellerId
                 INNER JOIN Trip Tr2 ON T.Tid=Tr2.TravellerId
WHERE Tr1.PlaceId=Tr2.PlaceId AND Tr1.TripDate<>Tr2.TripDate
```

Written Exam – open questions

Answer the following questions / solve the following problems.

7. Consider the following relational structure to store information about travelling
- Traveller[Tid, Name, Dob] – Tid is the primary key
- Place[Pid, PName, Country, Area] – Pid is the primary key
- Trip[TravellerId, PlaceId, Budget, TripDate] – (TravellerId, PlaceId) is the primary key; TravellerId and PlaceId reference the records from Traveller and Place

Write SQL queries for the next requirements:

f. Display pairs of two different travellers that had a trip in the same place and in different dates.

```
SELECT T1.Name, T2.Name
FROM Traveller T1, Traveller T2
        INNER JOIN Trip Tr1 ON T1.Tid=Tr1.TravellerId
        INNER JOIN Place P1 ON P1.Pid=Tr1.PlaceID
        INNER JOIN Trip Tr2 ON T2.Tid=Tr2.TravellerId
        INNER JOIN Place P2 ON P2.Pid=Tr2.PlaceID
WHERE Tr1.PlaceId=Tr2.PlaceId AND Tr1.TripDate<>Tr2.TripDate AND T1.Tid<>T2.Tid
```

Written Exam – open questions

Answer the following questions / solve the following problems.

8. Consider the following relational structure to store information about the students and their attend classes
   - Student[Sid, Name, Surname, Age] – Sid is the primary key
   - Class[Cid, Floor, Side, NoOfPlaces] – Cid is the primary key
   - Attend[Sid, Cid, AttendDate, NoOfStudents] – (Sid, Cid) is the primary key; Sid and Cid reference the records from Student and Class

Explain what return each query:

a. $\pi_{Name}\left(\pi_{Sid}\left(\left(\sigma_{Age>20}(Student)\right)\otimes Attend\right)\otimes\left(\sigma_{Floor=2}(Class)\right)\right)$

Display the name of the students that attend the classes from the 2nd floor and have the age >20.

b. $\pi_{Name}\left(\pi_{Sid}\left(\sigma_{Age>20}(Student)\otimes Attend\otimes\sigma_{Floor=2}(Class)\right)\right)$

The query does not return anything, because the last projection cannot be realized, the field *Name* does not exist (in *Class*) (only the field *Sid* was projected on the previous step and it is the only field returned.

Written Exam – open questions

Answer the following questions / solve the following problems.

8. Consider the following relational structure to store information about the students and their attend classes
   - Student[Sid, Name, Surname, Age] – Sid is the primary key
   - Class[Cid, Floor, Side, NoOfPlaces] – Cid is the primary key
   - Attend[Sid, Cid, AttendDate, NoOfStudents] – (Sid, Cid) is the primary key; Sid and Cid reference the records from Student and Class

Explain what return each query:

c. $\pi_{Name}\left(\pi_{Sid}\left(\left(\sigma_{Age>20}(Student)\right)\otimes Attend\right)\otimes\left(\sigma_{Floor=2}(Class)\right)\right)\cap\pi_{Name}\left(\pi_{Sid}\left(\left(\sigma_{Age<21}(Student)\right)\otimes Attend\right)\otimes\left(\sigma_{Floor=2}(Class)\right)\right)$

Display the name of the students that attend the classes from the 2nd floor and have the age >20 and <21.

d. $\pi_{Name}\left(\pi_{Sid}\left(\left(\sigma_{Age>20}(Student)\right)\otimes Attend\right)\otimes\left(\sigma_{Floor=2}(Class)\right)\right)\cup\pi_{Name}\left(\pi_{Sid}\left(\left(\sigma_{Age<21}(Student)\right)\otimes Attend\right)\otimes\left(\sigma_{Floor=2}(Class)\right)\right)$

Display the name of the students that attend the classes from the 2nd floor or have the age >20 or <21.

Written Exam – open questions

Answer the following questions / solve the following problems.

8. Consider the following relational structure to store information about the students and their attend classes
   - Student[Sid, Name, Surname, Age] – Sid is the primary key
   - Class[Cid, Floor, Side, NoOfPlaces] – Cid is the primary key
   - Attend[Sid, Cid, AttendDate, NoOfStudents] – (Sid, Cid) is the primary key; Sid and Cid reference the records from Student and Class

Explain what return each query:

e. $(\pi_{Sid,Cid}Attend) \,/\, \pi_{Cid}Class$

Display the student identifiers that attend all the classes.

(R1/R2 contains all the tuples x such that for each of the tuple from R2 there is a xy tuple in R1)

f. $\rho(R_1, Attend), \rho(R_2, Attend)$

$$\pi_{R_1.Cid}(\sigma_{R_1.Cid=R_2.Cid \wedge R_1.Sid<>R_2.Sid}(R_1 \times R_2))$$

Display the students that attend at least 2 classes.

Written Exam – open questions

Answer the following questions / solve the following problems.

9. To record the books from a library, the following information is required:

BookNo, ISBN, Section, SerialNo, SampleNo, Title, Author

Each book sample (SampleNo) has associated an unique book number (BookNo) used to manage the rentail of the books. This number is attached to a book as a code bar with no specified remark.

ISBN is an unique code associated to an edition of the book (the same value for all the books from an edition).

Each book is part of a section. In a section there are different books with different serial numbers. (1, 2, 3, … for each section). If there are multiple books identical, there are numbered different (by using SampleNo).

Which of the following functional dependencies are fulfil? Explain why.

a. $BookNo \longrightarrow ISBN, Section, SerialNo, SampleNo$

Yes, each book has an unique number (BookNo); BookNo is key

b. $ISBN \longrightarrow BookNo$

No, there can be multiple identical books (that will have the same ISBN, but different values for BookNo)

c. $ISBN \longrightarrow Section, SerialNo$

Yes, this constraint keeps the consistency of storing the books in the library

Written Exam – open questions

Answer the following questions / solve the following problems.

10. Consider the following 3 tuples of the legal instance of the relation R[X, Y, Z]

(1, 2, 3)
(4, 2, 3)
(5, 3, 3)

1) Which of the following functional dependencies is not fulfilled by R?
a. X→Y b. YZ→X c. Y→Z
Answer: b is not fulfilled. (1, 2, 3) and (4, 2, 3): different values for X but the same values for YZ

2) Identify a functional dependency that is satisfied by R.
Answer: No. A functional dependency is fulfilled by a relation if it is fulfilled by all the instances (legal, allowed) of the relation. (not enough just an instance)

Written Exam – open questions

Answer the following questions / solve the following problems.

11. Consider the relation R[X, Y, Z, T, V] with the set of functional dependencies
F={XY→ZTV, XZ→YTV, Y→Z, Z→Y, Z→T, Y→V}

a. Find all the keys of R
b. Determine a minimal cover of F
c. Is R in BCNF? Why?
d. Can R be decomposed? Are the functional dependencies kept?
e. Is R in 3NF? Why?
f. Determine a 3NF decomposition of R.

a. For F={XY→ZTV, XZ→YTV, Y→Z, Z→Y, Z→T, Y→V}:

$$X^+ = X; Y^+ = YZVT$$

X cannot be deduced from other attributes, and so X is part of the key

$$XY^+ = XYZTV\ candidate\ key; XZ^+ = XZYTV\ candidate\ key$$
$$XT^+ = XT;\ XV^+ = XV;\ XTV^+ = XTV$$

Written Exam – open questions

Answer the following questions / solve the following problems.

11. Consider the relation R[X, Y, Z, T, V] with the set of functional dependencies
F={XY→ZTV, XZ→YTV, Y→Z, Z→Y, Z→T, Y→V}
b. Determine a minimal cover of F

Definition: A ***minimal cover*** for the set ***F*** of functional dependencies is a set ***G*** of functional dependencies for which

1. Each functional dependency from G has the form $\alpha \rightarrow A$
2. For each functional dependency $\alpha \rightarrow A$ from G, α does not have redundant attributes
3. There are no redundancy functional dependencies in G
4. G and F are equivalent

To calculate the minimal cover for the set **F**:

1. Use the decomposition to obtain functional dependencies with one attribute in the right side
2. Remove the redundant attributes
3. Remove the redundant functional dependencies.

A minimal cover for F is {Y→Z, Z→Y, Z→T, Y→V}

Written Exam – open questions

Answer the following questions / solve the following problems.

11. Consider the relation R[X, Y, Z, T, V] with the set of functional dependencies
F={XY→ZTV, XZ→YTV, Y→Z, Z→Y, Z→T, Y→V}
c. Is R in BCNF? Why?

Definition: A relation that satisfies the functional dependencies F is in the ***Boyce-Codd normal form*** (***BCNF***) if for all $\alpha \rightarrow A$ from F^+

- $A \in \alpha$ (the trivial functional dependency)
- α contains a key of the relation R (α is a superkey)

F={XY→ZTV, XZ→YTV, Y→Z, Z→Y, Z→T, Y→V}

- Candidate keys: XY and XZ
- R is not in BCNF because there exist at least one functional dependency (e.g. Y→Z) that is not trivial and the left side does not represent a superkey (does not include a key)

Written Exam – open questions

Answer the following questions / solve the following problems.

11. Consider the relation R[X, Y, Z, T, V] with the set of functional dependencies
F={XY→ZTV, XZ→YTV, Y→Z, Z→Y, Z→T, Y→V}
d. Can R be decomposed? Are the functional dependencies kept?

Definition: Let R a relation with the set F of functional dependencies. If $\alpha \rightarrow A$ does not respect the definition of BCNF, R can be decomposed in R-A and αA.

Y→Z does not respect BCNF, so R can be decomposed in **{XY**TV**}, {Y**Z**}**
Y→T does not respect BCNF, so R can be decomposed in **{XY**T**}, {Y**Z**}, {Y**V**}**

The decomposition **{XY**T**}, {Y**Z**}, {Y**V**}** is in BCNF, but does not keep the dependencies (e.g. Z→T is not respected because Z and T are part of different relations)

Written Exam – open questions

Answer the following questions / solve the following problems.

11. Consider the relation R[X, Y, Z, T, V] with the set of functional dependencies
F={XY→ZTV, XZ→YTV, Y→Z, Z→Y, Z→T, Y→V}
e. Is R in 3NF? Why?

Definition: A relation *R* that satisfies the set of the functional dependencies *F* is in the ***third normal form*** (***3NF***) if for all $\alpha \rightarrow A$ from F^+

- $A \in \alpha$ (trivial functional dependency), or,
- α contains a key of *R* (α is a superkey), or,
- *A* is a prime attribute

R is not in 3NF because there exist at least one functional dependency (e.g. Z→T) that is not trivial, the left side is not a superkey and $T \not\subset XY$ or $T \not\subset XZ$

Written Exam – open questions

Answer the following questions / solve the following problems.

11. Consider the relation R[X, Y, Z, T, V] with the set of functional dependencies
F={XY→ZTV, XZ→YTV, Y→Z, Z→Y, Z→T, Y→V}
f. Determine a 3NF decomposition of R.

Input: Relation R with the set of functional dependencies F that is a minimal cover
Output: A 3NF decomposition of R lossless join that keep the functional dependencies,
Initialize $D = \emptyset$
Reunion used to combine all the functional dependencies from F in a single functional dependency set that has the same attribute in the left side

for each functional dependency $\alpha \rightarrow \beta$ from F – the relation $\alpha\beta$ is inserted in the set D
in D is inserted δ, where δ is a candidate key of R
the redundant relations from D are removed - remove each R_i from D if $R_i \subseteq R_j$ where R_j is from D

Return D

Written Exam – open questions

Answer the following questions / solve the following problems.

11. Consider the relation R[X, Y, Z, T, V] with the set of functional dependencies
F={XY→ZTV, XZ→YTV, Y→Z, Z→Y, Z→T, Y→V}
f. Determine a 3NF decomposition of R.

{Y→Z, Z→Y, Z→T, Y→V} is the minimal cover
XY, XZ candidate keys

- Reunion to combine (the same configuration in the left side): {Y→ZV, Z→YT}
- Decomposition of R
  - **{Y**, Z, V**}** and **{Z**, Y, T**} –** generated from the functional dependencies
  - **{X,Y}** and {**X**,Z} – generated from the key
- This decomposition is final because there are no redundant relations.

Written Exam – open questions

Answer the following questions / solve the following problems.

12. Consider a hard disk with the sector dimension equal with 512 bytes, 2000 tracks per part, 50 sectors per track, 5 double disks and the average of the search time is 10msec.

a. Which is the capacity of a track (in bytes)? Which is the capacity of each surface? Which is the capacity of a disk?

Bytes / track = bytes / sector*sector /track = 512*50=25Kb

bytes/surface = bytes/track * track/surface = 25 *Kb* * 2000 = = 50000 *Kb*

bytes/disk = bytes/surface*surfaces = 50.000*Kb* * 2*5 = = 500000 *Kb*

b. How many cylinders has the hard disk?

Number of cylinders= number of tracks on each disk – 2000

c. 256 bytes is a valid dimension for a block? What about 2048 or 51200?

The dimension of a block is multiple of a sector (only 2048 and 51200 are valid)

d. If the disks rotate with 5400rpm, which is the maximum delay?

Delay of maximum rotation = the need time to perform a rotation

e. Which is the transfer speed if a track can be transferred in a single revolution movement?

25Kb / 0,011=2250 bytes per sec

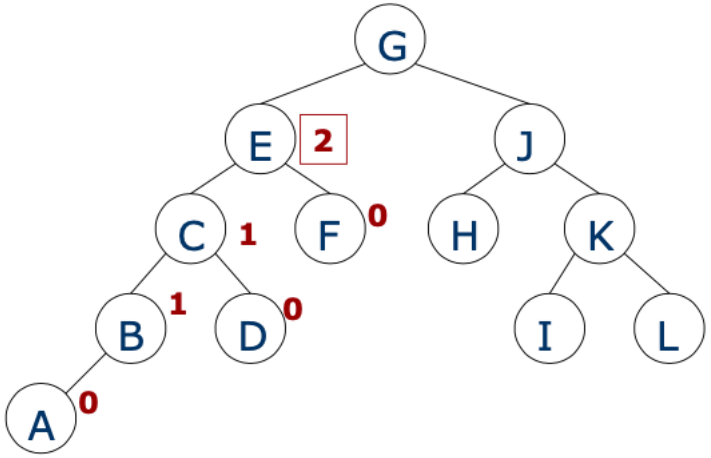
Written Exam – open questions

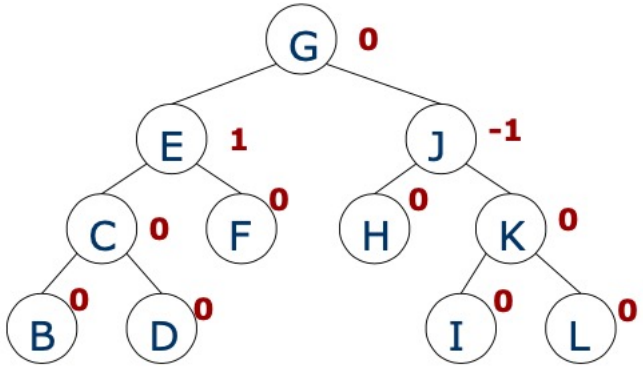
Answer the following questions / solve the following problems.

13. Consider the following binary (balanced) tree. Describe the operations that should be realized such that the binary tree remain balanced after inserting *A*.

Balanced tree = for each node the difference between the height of their subtrees is 0, 1 or -1.

Solution:





- E node becomes the right child of C
- D node becomes the left child of E

Written Exam – open questions

Answer the following questions / solve the following problems.

13. Consider the following binary (balanced) tree. Describe the operations that should be realized such that the binary tree remain balanced after inserting *A*.

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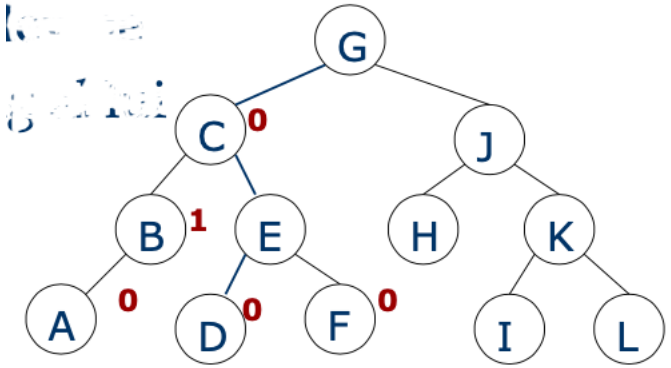
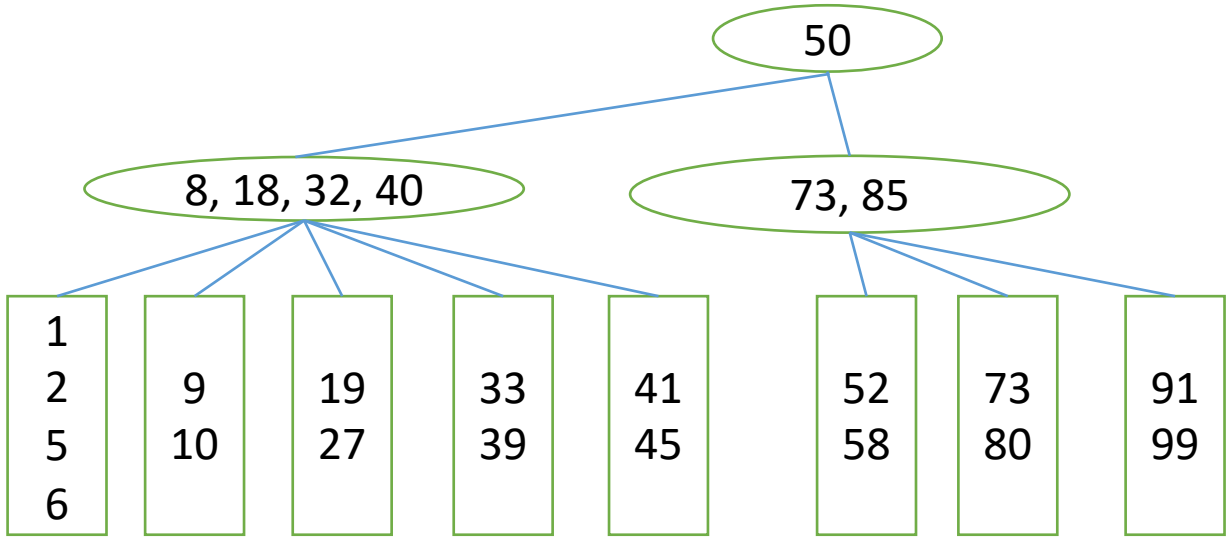


- E node becomes the right child of C
- D node becomes the left child of E
- C node becomes the left child of G

Written Exam – open questions

Answer the following questions / solve the following problems.

14. Consider the following B-tree of order 5.

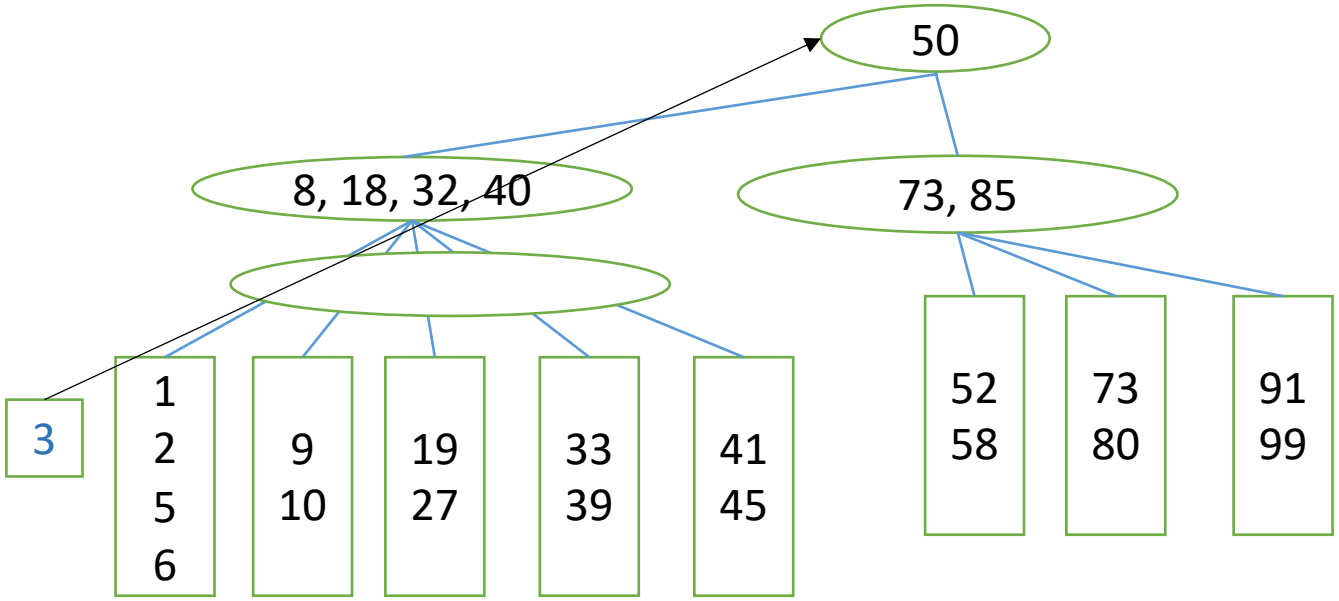


a. Determine the B-tree that result after inserting value 3.
b. Determine the B-tree that result after removing the value 8 from the initial B-tree (use redistribution).
c. Determine the B-tree that result after removing the value 8 from the initial B-tree (use concatenation).

Written Exam – open questions

Answer the following questions / solve the following problems.

14. Consider the following B-tree of order 5.
   a. Determine the B-tree that result after inserting value 3.



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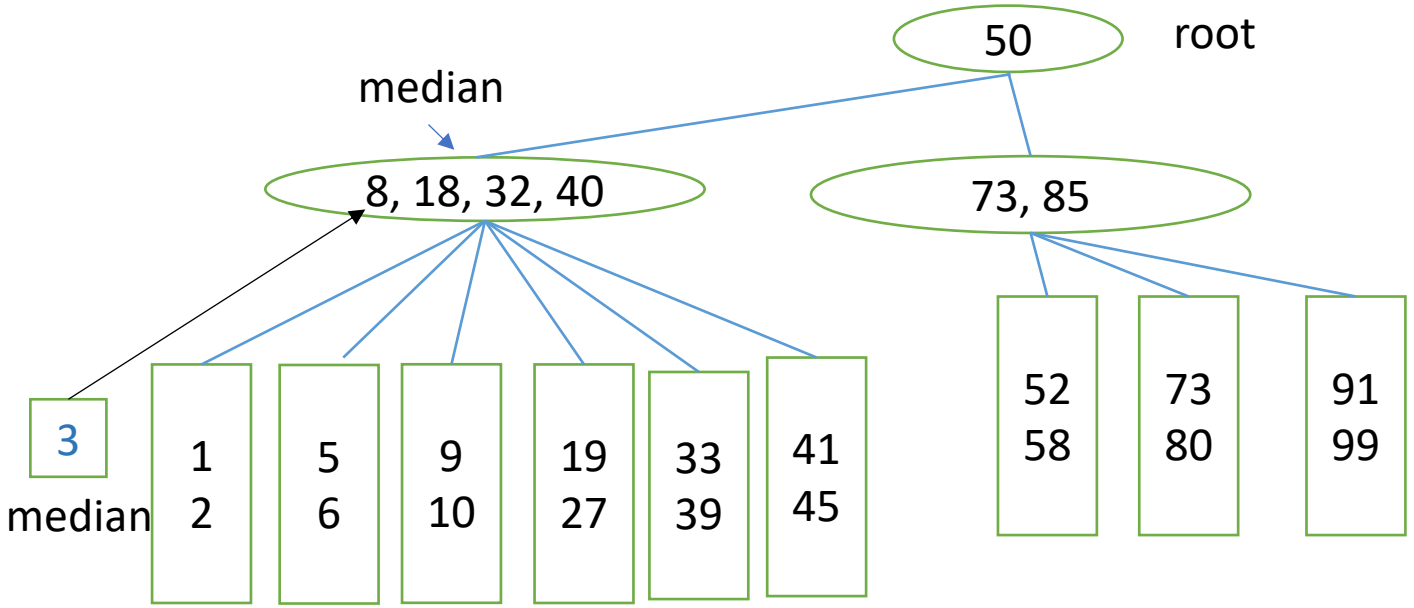

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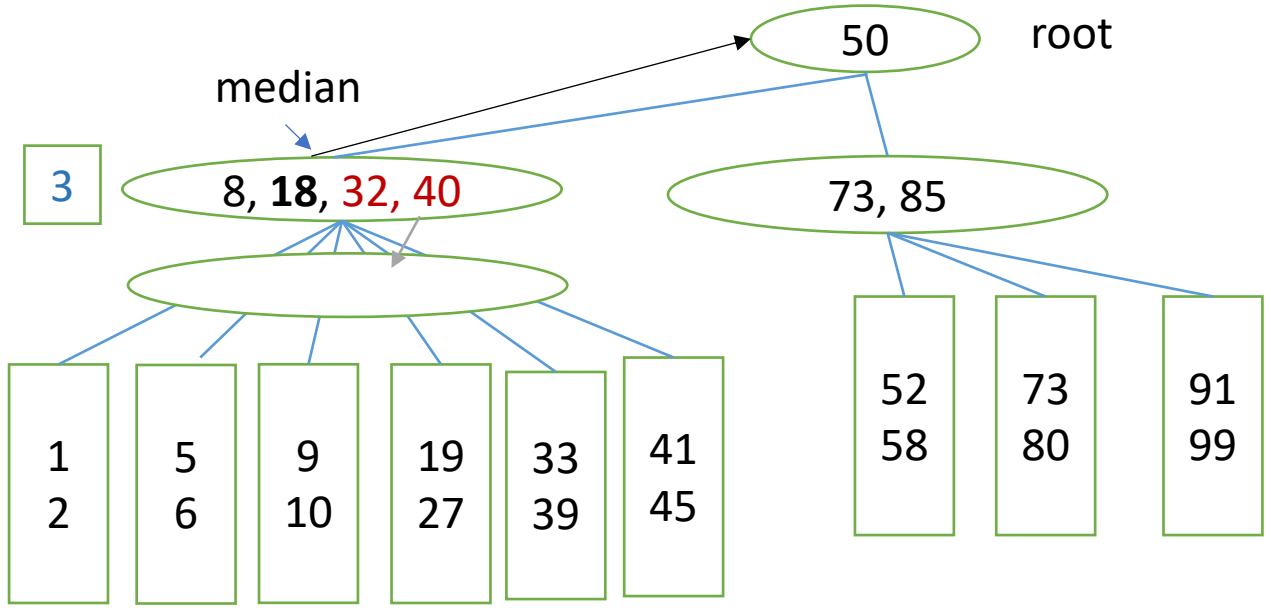

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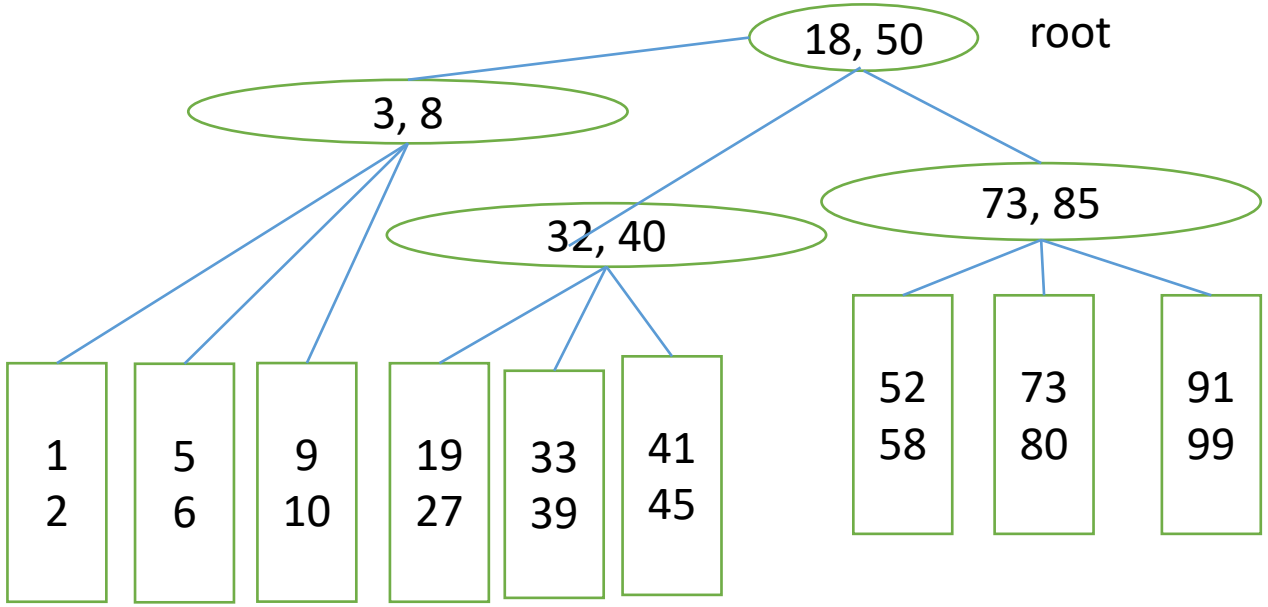

Written Exam – open questions

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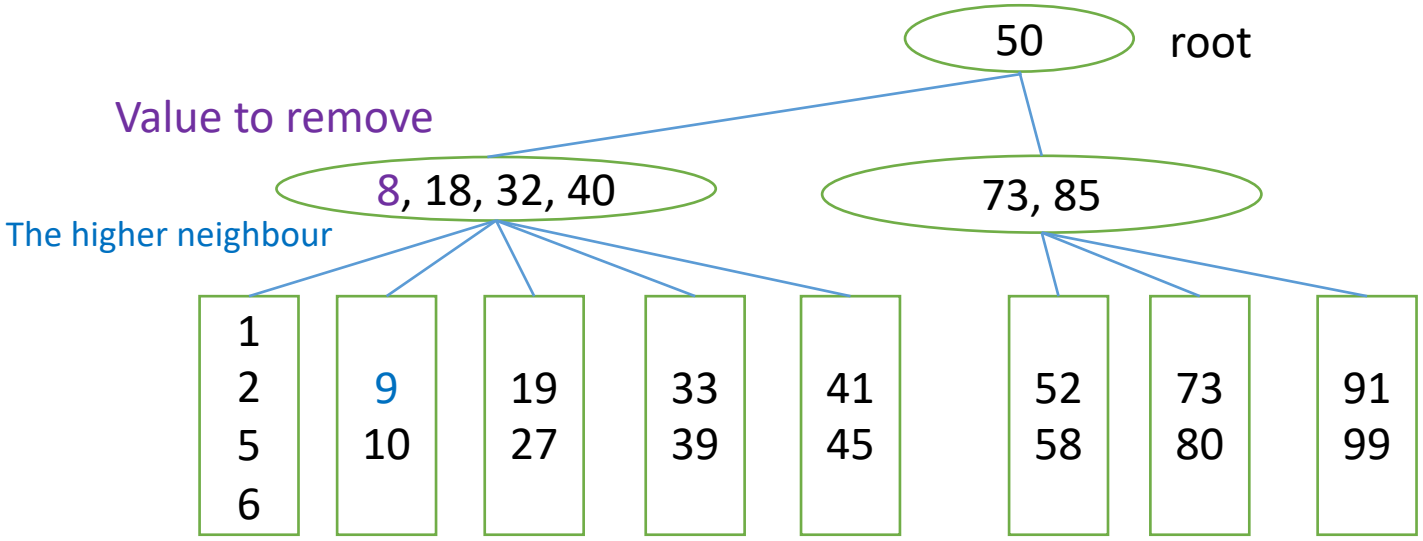
14. Consider the following B-tree of order 5.

b. Determine the B-tree that result after removing the value 8 from the initial B-tree (use redistribution).



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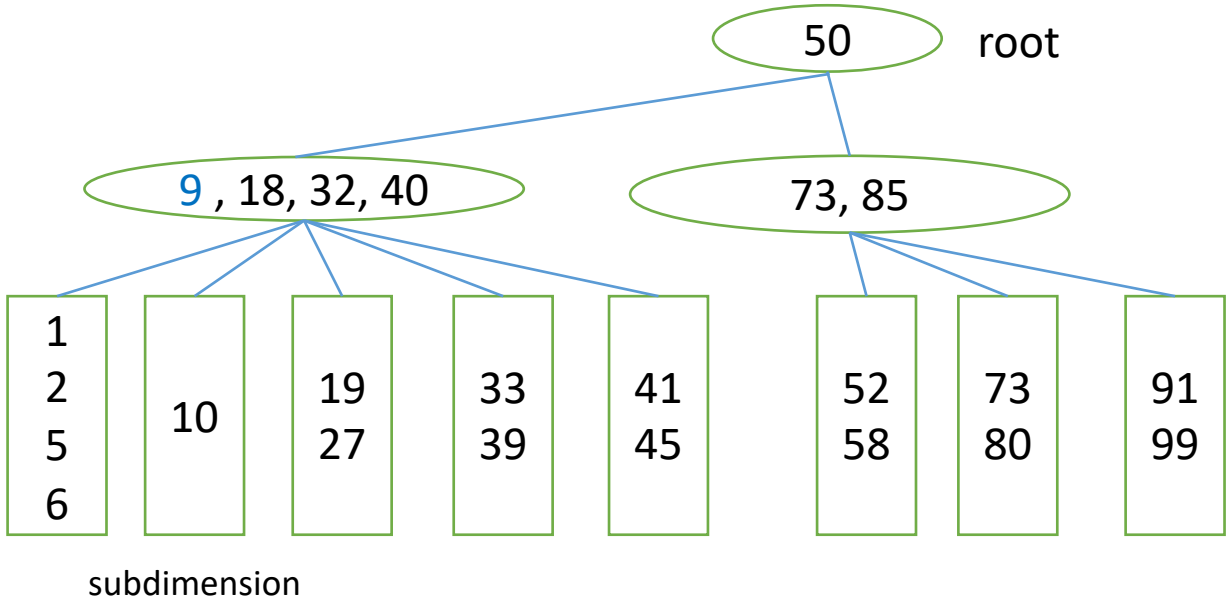

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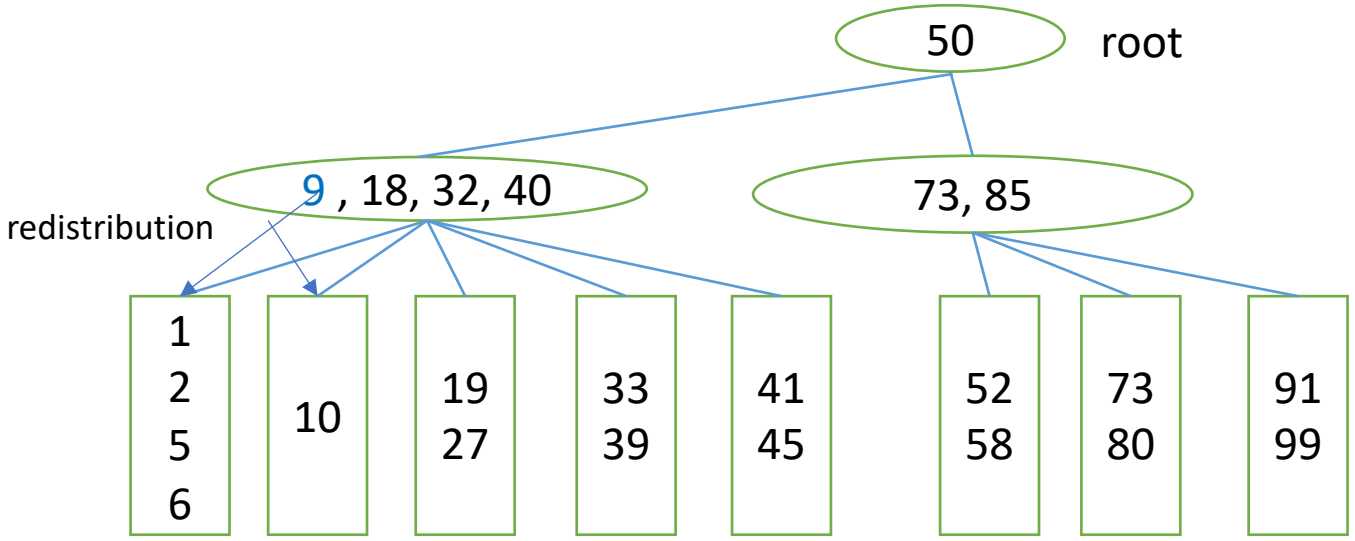

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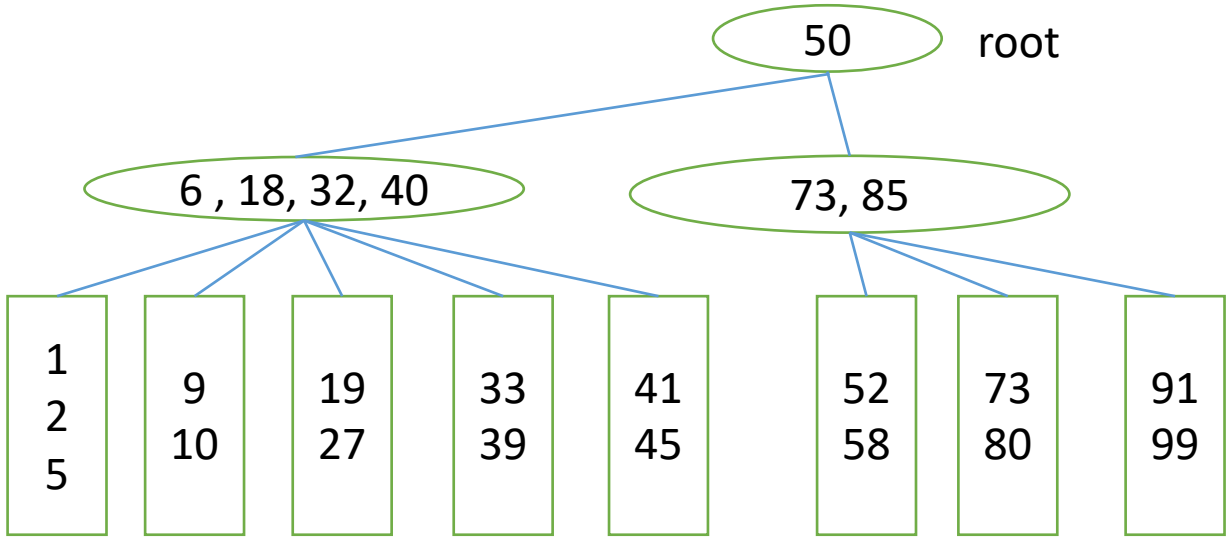

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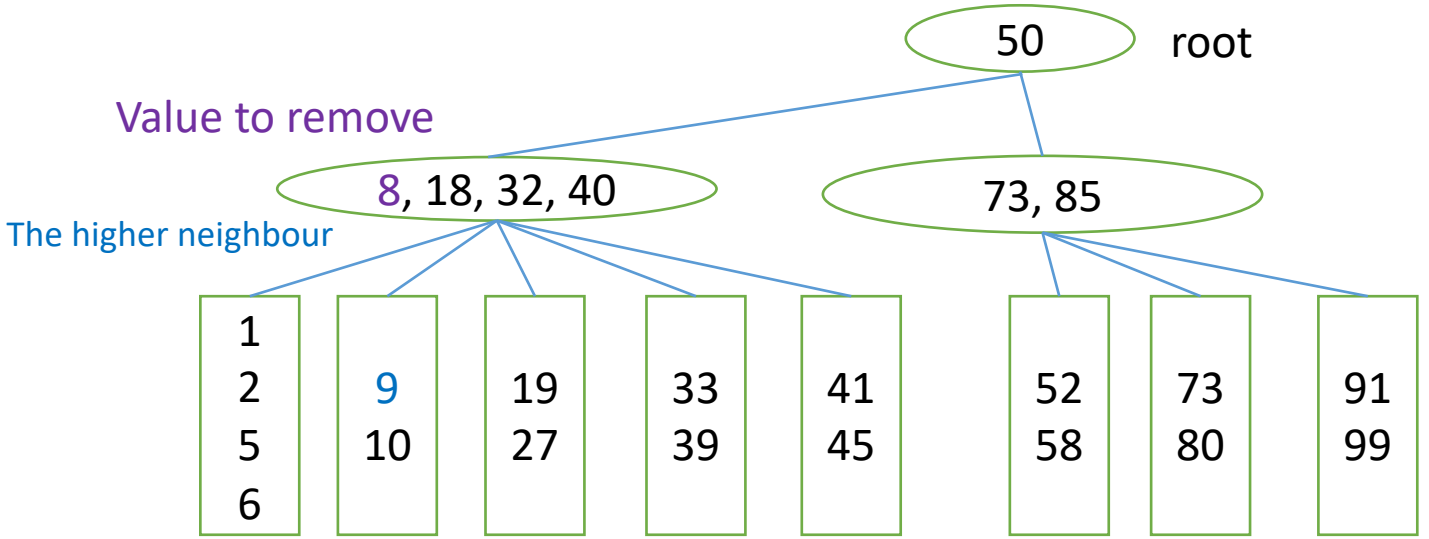
14. Consider the following B-tree of order 5.

c. Determine the B-tree that result after removing the value 8 from the initial B-tree (use concatenation).



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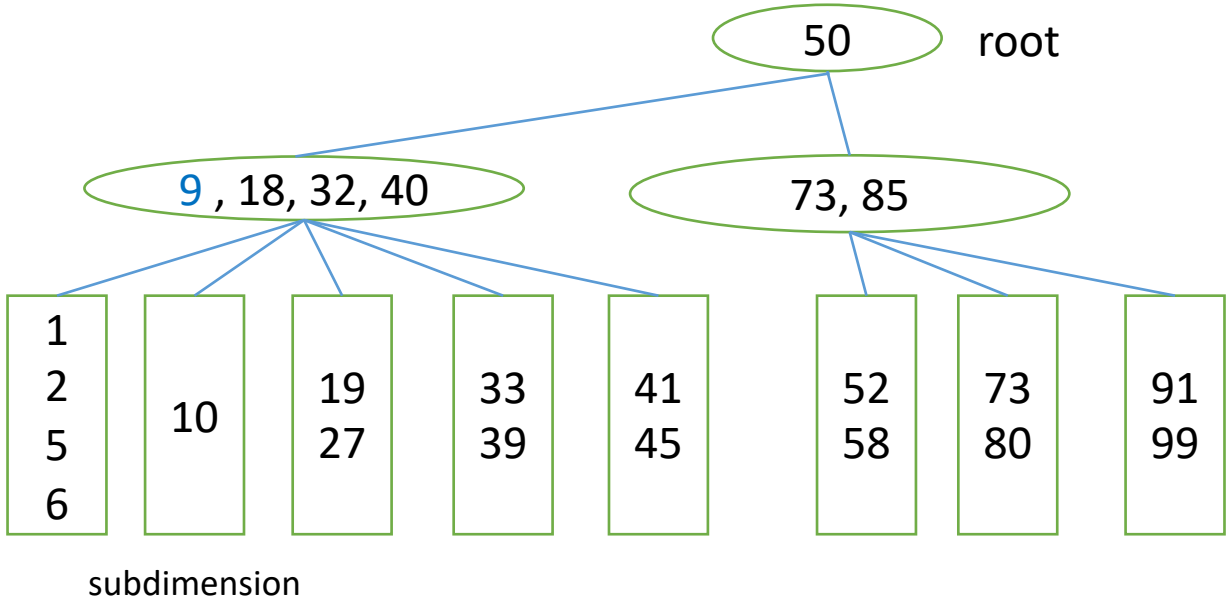

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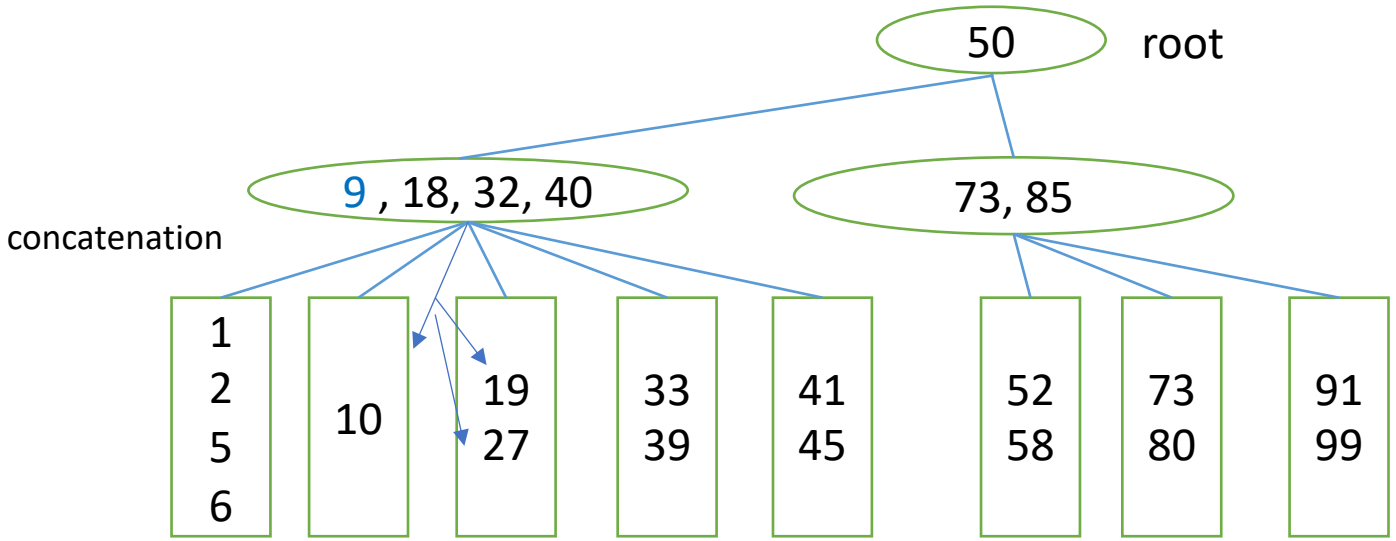

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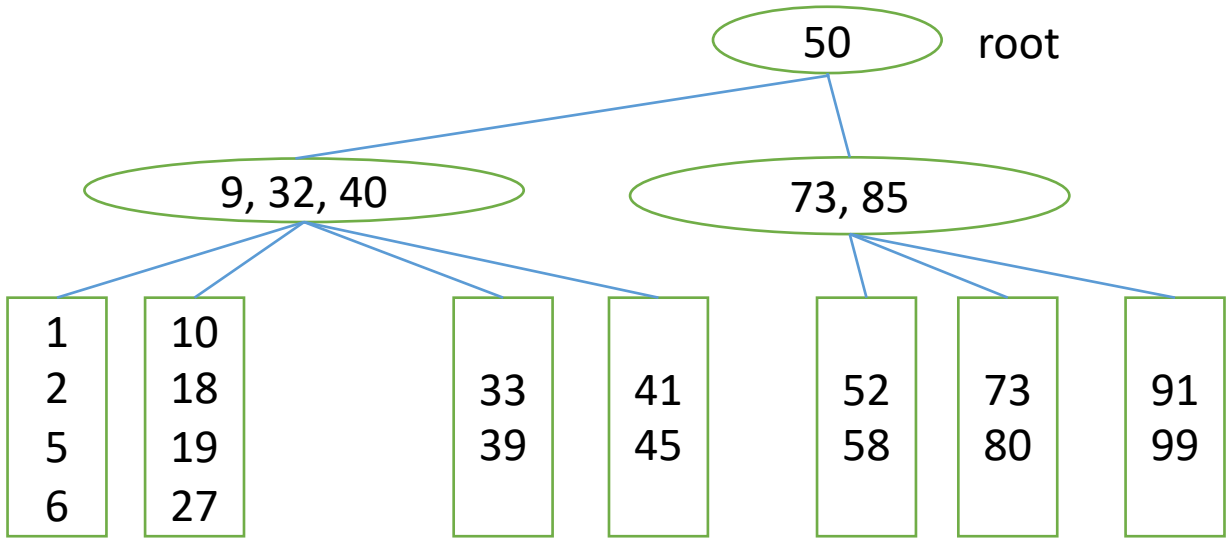

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