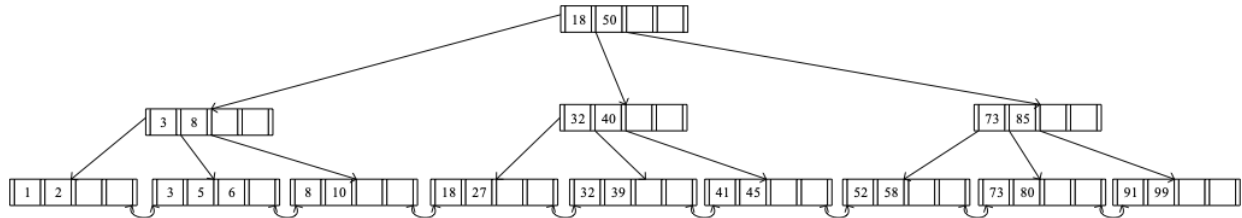
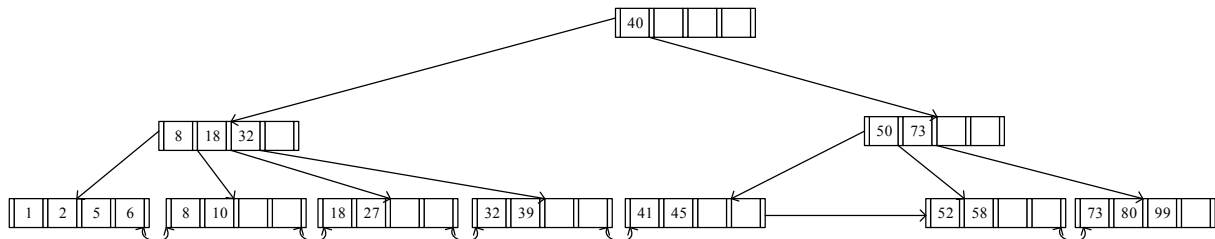


## Q1

- 1) **82** additional records could be added to this tree without changing its height.
- 2) As followed:



- 3) As followed:



## Q2

As the question said, in order to find out which approach is the cheapest, we don't need to consider the approach of accessing the sorted file for R directly since using index to access data will be cheaper than accessing it directly in most situations. Also, those approaches where hash indexes are used need to be removed because hash-based indexes are best for equality selections, cannot support range searches.

So we only need to consider the approaches that use a clustered B+ tree index on attributes R.a or R.b or (R.a, R.b).

First, a clustered B+ tree index on attribute R.b, it's useless since R.a is the candidate key, according to this approach, we need to search all indexes and pick the appropriate R.a. This is still expensive.

Consider using a clustered B+ tree on attributes (R.a, R.b) and using a clustered B+ tree on attributes R.a, according to the question, the the index contain all columns required to answer the query, so we don't need to access the data records in the file,

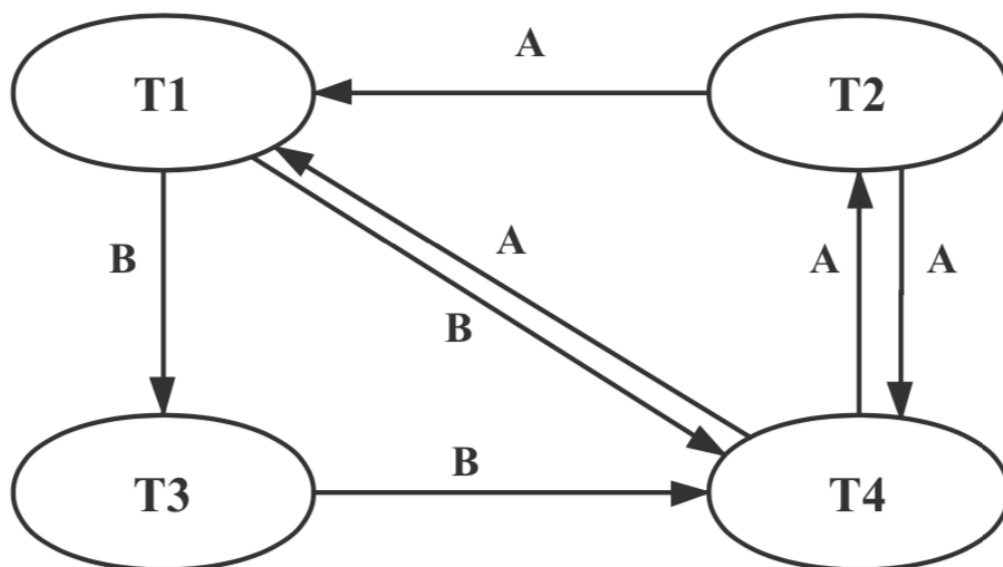
So using a clustered B+ tree on attributes R.a is cheaper than using a clustered B+ tree on attributes (R.a, R.b) because we don't need to organised second time by R.b, we only need organised once by R.a.

In conclusion, using a clustered B+ tree on attributes R.a is the most likely to be the cheapest.

Q3

- 1 ) T1: undo  
T4: undo

- 2 ) The precedence graph shows below:



No, the graph has cycle so this is not transaction schedule conflict serialisable.

3)

The schedule which causes deadlock shows below:

Time	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12
T1					R(A)		R(B)		W(B)		W(A)	
T2	R(A)			W(A)								
T3		R(B)	W(B)									
T4						R(B)		R(A)		W(A)		W(B)

4)

The schedule which does not cause deadlock shows below:

Time	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12
T1					R(A)	R(B)	W(B)	W(A)				
T2	R(A)	W(A)										
T3			R(B)	W(B)								
T4									R(B)	W(B)	R(A)	W(A)