Database Systems: The Complete Book

▼❑Chapter 17

▼❑Section 1

▼❑1

- ❑a Yes
- ❑b No
- ❑c Yes

▼❑2

- ❑a Read(A, t)
  Read(b, u)
  t = t + u
  Write(A, t)
  u = t + u
  Write(B, u)
  Output(B)
  crash here ok
  Output(A)
- ❑b Read(A, t)
  Read(B, u)
  u = + u
  Write(B, u)
  Output(B)
  crash here ok
  t = t + u
  Write(A)
  Output(A)
- ❑c Read(A, t)
  Read(B, u)
  t = u + 1
  Write(A)
  u = t + 1
  Write(B)
  Output(B)
  crash here ok
  Output(A)

▼❑Section 2

▼❑1

Step	Action	t	u	M-A	M-B	D-A	D-B	Log
1								Start T
2	Read(A, t)	5		5		5	10	
3	Read(B, u)	5	10	5	10	5	10	
4	t = t + u	15	10	5	10	5	10	
5	Write(A, t)	15	10	15	10	5	10	T, A, 5
6	u = t + u	15	25	15	10	5	10	
7	Write(B, u)	15	25	15	25	5	10	T, B, 10
8	Output(B)	15	25	15	25	15	10	
9	Output(A)	15	25	15	25	15	25	
10		15	25	15	25	15	25	Commit T
11	Flush Log	15	25	15	25	15	25	

- ❑a

Step	Action	t	u	M-A	M-B	D-A	D-B	Log
1								Start T
2	Read(A, t)	5		5		5	10	
3	Read(B, u)	5	10	5	10	5	10	
4	u = t + u	5	15	5	10	5	10	
5	Write(B, u)	5	15	5	15	5	10	
6	Output(B)	5	15	5	15	5	15	T, B, 10
7	t = t + u	20	15	5	15	5	15	
8	Write(A)	20	15	20	15	5	15	
9	Output(A)	20	15	20	15	20	15	T, A, 5
10		20	15	20	15	20	15	Commit T
11	Flush Log	20	15	20	15	20	15	

- ❑b

Step	Action	t	u	M-A	M-B	D-A	D-B	Log
1								Start T
2	Read(A, t)	5		5		5	10	
3	Read(B, u)	5	10	5	10	5	10	
4	t = u + 1	11	10	5	10	5	10	
5	Write(A)	11	10	11	10	5	10	T, A, 5
6	u = t + 1	11	12	11	10	5	10	
7	Write(B)	11	12	11	12	5	10	T, B, 10
8	Output(B)	11	12	11	12	5	12	
9	Output(A)	11	12	11	12	11	12	
10		11	12	11	12	11	12	Commit T
11	Flush Log	11	12	11	12	11	12	

- ❑c

▼❑2

Log record to disk	A to disk	B to disk
Start T	No	No
T, A, 10	No	No
T, B, 20	Yes	No
	Yes	Yes
Commit T	No	No

- ❑a

Log record to disk	A to disk	B to disk	C to disk
Start T	No	No	No
T, A, 10	No	No	No
T, B, 20	Yes	No	No
T, C, 30	Yes	Yes	No
	Yes	Yes	Yes
	Yes	Yes	Yes
Commit	No	No	No

- ❑b

- ❑3 n!

▼❑4

- ❑a T is undone.
- ❑b U is not undone.
  T is undone.
- ❑c U is not undone.
  T is undone.
- ❑d Nothing is undone.

▼❑5

▼❑a

▼❑T

- ❑must: { }
- ❑might: {A}

▼❑U

- ❑must: { }
- ❑might: { }

▼❑b

▼❑T

- ❑must: { }
- ❑might: {A, C}

▼❑U

- ❑must: {B, D}
- ❑might: { }

▼❑c

▼❑T

- ❑must: { }
- ❑might: {A, C, E}

▼❑U

- ❑must: {B, D}
- ❑might: { }

▼❑d

▼❑T

- ❑must: all

▼❑U

- ❑must: all

- ❑6 If a crash occurs before <U, D, 40>, A is recoverable for transaction T. If a cash occurs after, A is recoverable for transaction U. Logging does not preserve atomicity.

▼❑7

- ❑a

	Transaction T	Transaction U	Transaction V	Checkpoints	failure occurs here:
<S, A, 60>					S undone
				<START CKPT(S)>	S undone
<COMMIT S>					S undone
				<END CKPT>	nothing undone
	<START T>				nothing undone
	<T, A, 10>				T undone
		<START U>			T undone
		<U, B, 20>			T,U undone
	<T, C, 30>				T,U undone
			<START V>		T,U undone
		<U, D, 40>			T,U undone
			<V, F, 70>		T,U,V undone
		<COMMIT U>			T,U,V undone
	<T, E, 50>				T,U,V undone
	<COMMIT T>				T,U,V undone
			<V, B, 80>		T,U,V undone
			<COMMIT V>		T,U,V undone

- ❑b

	Transaction T	Transaction U	Transaction V	Checkpoints	failure occurs here:
<S, A, 60>					S undone
<COMMIT S>					S undone
	<START T>				S undone
	<T, A, 10>				T undone
				<START CKPT(T)>	T undone
		<START U>			T undone
		<U, B, 20>			T,U undone
	<T, C, 30>				T,U undone
			<START V>		T,U undone
		<U, D, 40>			T,U,V undone
			<V, F, 70>		T,U,V undone
		<COMMIT U>			T,U,V undone
	<T, E, 50>				T,U,V undone
	<COMMIT T>				T,U,V undone
				<END CKPT>	U,V undone
			<V, B, 80>		U,V undone
			<COMMIT V>		U,V undone

- ❑c

	Transaction T	Transaction U	Transaction V	Checkpoints	failure occurs here:
<S, A, 60>					S
<COMMIT S>					S
	<START T>				S
	<T, A, 10>				S,T
		<START U>			S,T
		<U, B, 20>			S,T,U
				<START CKPT(T, U)>	T,U
	<T, C, 30>				T,U
			<START V>		T,U
		<U, D, 40>			T,U
			<V, F, 70>		T,U,V
		<COMMIT U>			T,U,V
	<T, E, 50>				T,U,V
	<COMMIT T>				T,U,V
				<END CKPT>	V
			<V, B, 80>		V
			<COMMIT V>		V

- ❑d

	Transaction T	Transaction U	Transaction V	Checkpoints	failure occurs here:
<S, A, 60>					S
<COMMIT S>					S
	<START T>				S
	<T, A, 10>				S,T
		<START U>			S,T
		<U, B, 20>			S,T,U
	<T, C, 30>				S,T,U
			<START V>		S,T,U
		<U, D, 40>			S,T,U
				<START CKPT(T, U, V)>	T,U
			<V, F, 70>		T,U,V
		<COMMIT U>			T,U,V
	<T, E, 50>				T,U,V
	<COMMIT T>				T,U,V
			<V, B, 80>		T,U,V
			<COMMIT V>		T,U,V
				<END CKPT>	nothing undone

- ❑e

	Transaction T	Transaction U	Transaction V	Checkpoints	failure occurs here:
<S, A, 60>					S
<COMMIT S>					S
	<START T>				S
	<T, A, 10>				S,T
		<START U>			S,T
		<U, B, 20>			S,T,U
	<T, C, 30>				S,T,U
			<START V>		S,T,U
		<U, D, 40>			S,T,U
			<V, F, 70>		S,T,U,V
		<COMMIT U>			S,T,U,V
	<T, E, 50>				S,T,U,V
				<START CKPT(T, V)>	T,V
	<COMMIT T>				T,V
			<V, B, 80>		T,V
			<COMMIT V>		T,V
				<END CKPT>	nothing undone

▼❑Section 3

▼❑1

Step	Action	t	u	M-A	M-B	D-A	D-B	Log
1								Start T
2	Read(A, t)	5		5		5	10	
3	Read(B, u)	5	10	5	10	5	10	
4	t = t + u	15	10	5	10	5	10	
5	Write(A, t)	15	10	15	10	5	10	T, A, 15
6	u = t + u	15	25	15	10	5	10	
7	Write(B, u)	15	25	15	25	5	10	T, B, 25
8		15	25	15	25	5	10	Commit
9	Flush Log	15	25	15	25	5	10	
10	Output(A)	15	25	15	25	15	10	
11	Output(B)	15	25	15	25	15	25	

- ❑a

Step	Action	t	u	M-A	M-B	D-A	D-B	Log
1								Start T
2	Read(A, t)	5		5		5	10	
3	Read(B, u)	5	10	5	10	5	10	
4	u = t + u	5	15	5	10	5	10	
5	Write(B, u)	5	15	5	15	5	10	T, B, 15
6	t = t + u	20	15	5	15	5	10	
7	Write(A)	20	15	20	15	5	10	T, A, 20
8		20	15	20	15	5	10	Commit
9	Flush Log	20	15	20	15	5	10	
10	Output(A)	20	15	20	15	20	10	
11	Output(B)	20	15	20	15	20	15	

- ❑b

Step	Action	t	u	M-A	M-B	D-A	D-B	Log
1								Start T
2	Read(A, t)	5		5		5	10	
3	Read(B, u)	5	10	5	10	5	10	
4	t = u + 1	11	10	5	10	5	10	
5	Write(A)	11	10	11	10	5	10	T, A, 11
6	u = t + 1	11	12	11	10	5	10	
7	Write(B)	11	12	11	12	5	10	T, B, 12
8		11	12	11	12	5	10	Commit
9	Flush Log	11	12	11	12	5	10	
10	Output(A)	11	12	11	12	11	10	
11	Output(B)	11	12	11	12	11	12	

- ❑c

▼❑2

Log record to disk	A to disk	B to disk
Start T	No	No
T, A, 10	No	No
T, B, 20	No	No
Commit T	No	No
	Yes	Yes

- ❑a

- ❑b Same as 17.3.2a

▼❑3

- ❑a Write: Abort T
- ❑b Write: Abort T
  Redo: U, B, 20
  Redo: U, D, 40
- ❑c Same as 17.3.3b
- ❑d Redo: T, A, 10
  Redo: U, B, 20
  Redo: T, C, 30
  Redo: U, D, 40
  Redo: T, E, 50

▼❑4

▼❑a

▼❑T

- ❑must: { }
- ❑might { }

▼❑U

- ❑must: { }
- ❑might { }

▼❑b

▼❑T

- ❑must: { }
- ❑might: { }

▼❑U

- ❑must: { }
- ❑might: {B, D}

▼❑c

▼❑T

- ❑must: { }
- ❑might { }

▼❑U

- ❑must: { }
- ❑might: {B, D}

▼❑d

▼❑T

- ❑must: { }

- ❑might: {A, C}

▼❑U

- ❑must: { }
- ❑might: {B, D}

▼❑5

- ❑a

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<S, A, 60>						before END CKPT: redo nothing
				<START CKPT(S)>		after END CKPT: redo S writes
<COMMIT S>					ok here	
				<END CKPT>	ok here	
	<START T>				ok here	
	<T, A, 10>				ok here	
		<START U>			ok here	
		<U, B, 20>			ok here	
	<T, C, 30>				ok here	
			<START V>		ok here	
		<U, D, 40>			ok here	
			<V, F, 70>		ok here	
		<COMMIT U>			ok here	
	<T, E, 50>				ok here	
	<COMMIT T>				ok here	
			<V, B, 80>		ok here	
			<COMMIT V>		ok here	

- ❑b

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<S, A, 60>						
<COMMIT S>						
	<START T>					
	<T, A, 10>					
		<START U>				
		<U, B, 20>				
				<START CKPT(T)>		
		<START U>			ok here	before END CKPT: redo S writes
		<U, B, 20>			ok here	after END CKPT: redo T writes
	<T, C, 30>				ok here	
			<START V>		ok here	
		<U, D, 40>			ok here	
			<V, F, 70>		ok here	
		<COMMIT U>			ok here	
	<T, E, 50>				ok here	
	<COMMIT T>				ok here	
				<END CKPT>	ok here	
			<V, B, 80>		ok here	
			<COMMIT V>		ok here	

- ❑c

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<S, A, 60>						
<COMMIT S>						
	<START T>					
	<T, A, 10>					
		<START U>				
		<U, B, 20>				
				<START CKPT(T, U)>		
	<T, C, 30>				ok here	before END CKPT: redo S writes
			<START V>		ok here	after END CKPT: redo T,U writes
		<U, D, 40>			ok here	
			<V, F, 70>		ok here	
		<COMMIT U>			ok here	
	<T, E, 50>				ok here	
	<COMMIT T>				ok here	
				<END CKPT>	ok here	
			<V, B, 80>		ok here	
			<COMMIT V>		ok here	

- ❑d

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<S, A, 60>						
<COMMIT S>						
	<START T>					
	<T, A, 10>					
		<START U>				
		<U, B, 20>				
	<T, C, 30>					
			<START V>			
		<U, D, 40>				
				<START CKPT(T, U, V)>		
			<V, F, 70>		ok here	before END CKPT: redo S writes
		<COMMIT U>			ok here	after END CKPT: redo T, U, V writes
	<T, E, 50>				ok here	
	<COMMIT T>				ok here	
			<V, B, 80>		ok here	
			<COMMIT V>		ok here	
				<END CKPT>	ok here	

- ❑e

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<S, A, 60>						
<COMMIT S>						
	<START T>					
	<T, A, 10>					
		<START U>				
		<U, B, 20>				
	<T, C, 30>					
			<START V>			
		<U, D, 40>				
			<V, F, 70>			
		<COMMIT U>				
	<T, E, 50>					
				<START CKPT(T, V)>		
	<COMMIT T>				ok here	before END CKPT: redo S,U writes
			<V, B, 80>		ok here	after END CKPT: redo T,V writes
			<COMMIT V>		ok here	
				<END CKPT>	ok here	

▼❑Section 4

▼❑1

- ❑a

Step	Action	t	u	M-A	M-B	D-A	D-B	Log
1								Start T
2	Read(A, t)	5		5		5	10	
3	Read(B, u)	5	10	5	10	5	10	
4	t = t + u	15	10	5	10	5	10	
5	Write(A, t)	15	10	15	10	5	10	T, A, 5, 15
6	u = t + u	15	25	15	10	5	10	
7	Write(B, u)	15	25	15	25	5	10	T, B, 10, 25
8		15	25	15	25	5	10	Commit
9	Flush Log	15	25	15	25	5	10	
10	Output(A)	15	25	15	25	15	10	
11	Output(B)	15	25	15	25	15	25	

- ❑b

Step	Action	t	u	M-A	M-B	D-A	D-B	Log
1								Start T
2	Read(A, t)	5		5		5	10	
3	Read(B, u)	5	10	5	10	5	10	
4	u = t + u	5	15	5	10	5	10	
5	Write(B, u)	5	15	5	15	5	10	T, B, 10, 15
6	t = t + u	20	15	5	15	5	10	
7	Write(A)	20	15	20	15	5	10	T, A, 5, 20
8		20	15	20	15	5	10	Commit
9	Flush Log	20	15	20	15	5	10	
10	Output(A)	20	15	20	15	20	10	
11	Output(B)	20	15	20	15	20	15	

Step	Action	t	u	M-A	M-B	D-A	D-B	Log
1								Start T
2	Read(A, t)	5		5		5	10	
3	Read(B, u)	5	10	5	10	5	10	
4	t = u + 1	11	10	5	10	5	10	
5	Write(A)	11	10	11	10	5	10	T, A, 5, 11
6	u = t + 1	11	12	11	10	5	10	
7	Write(B)	11	12	11	12	5	10	T, B, 10, 12
8		11	12	11	12	5	10	Commit
9	Flush Log	11	12	11	12	5	10	
10	Output(A)	11	12	11	12	11	10	
11	Output(B)	11	12	11	12	11	12	

- ❑c

- ❑2 Same as 17.2.2

▼❑3

▼❑a

- ❑T undone

▼❑b

▼❑U redone

- ❑Write: B, 21
- ❑Write: D, 41

- ❑T undone

- ❑c Same as 17.4.3b
- ❑d Both T and U redone

- ❑4 Same as 17.2.5

▼❑5

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<S, A, 60>						undo S
				<START CKPT(S)>		redo S
<COMMIT S>					ok here	
				<END CKPT>	ok here	
	<START T>				ok here	
	<T, A, 10>				ok here	
		<START U>			ok here	
		<U, B, 20>			ok here	
	<T, C, 30>				ok here	
			<START V>		ok here	
		<U, D, 40>			ok here	
			<V, F, 70>		ok here	
		<COMMIT U>			ok here	
	<T, E, 50>				ok here	
	<COMMIT T>				ok here	
			<V, B, 80>		ok here	
			<COMMIT V>		ok here	

- ❑a

- ❑b

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<S, A, 60>						
<COMMIT S>						
	<START T>					
	<T, A, 10>					
				<START CKPT(T)>		
		<START U>			ok here	merge of G and J
		<U, B, 20>			ok here	
	<T, C, 30>				ok here	
			<START V>		ok here	
		<U, D, 40>			ok here	
			<V, F, 70>		ok here	
		<COMMIT U>			ok here	
	<T, E, 50>				ok here	
	<COMMIT T>				ok here	
				<END CKPT>	ok here	
			<V, B, 80>		ok here	
			<COMMIT V>		ok here	

- ❑c

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<S, A, 60>						
<COMMIT S>						
	<START T>					
	<T, A, 10>					
		<START U>				
		<U, B, 20>				
				<START CKPT(T, U)>		
	<T, C, 30>				ok here	merge of G and J
			<START V>		ok here	
		<U, D, 40>			ok here	
			<V, F, 70>		ok here	
		<COMMIT U>			ok here	
	<T, E, 50>				ok here	
	<COMMIT T>				ok here	
				<END CKPT>	ok here	
			<V, B, 80>		ok here	
			<COMMIT V>		ok here	

- ❑d

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<S, A, 60>						
<COMMIT S>						
	<START T>					
	<T, A, 10>					
		<START U>				
		<U, B, 20>				
	<T, C, 30>					
			<START V>			
		<U, D, 40>				
				<START CKPT(T, U, V)>		
			<V, F, 70>		ok here	merge of G and J
		<COMMIT U>			ok here	
	<T, E, 50>				ok here	
	<COMMIT T>				ok here	
			<V, B, 80>		ok here	
			<COMMIT V>		ok here	
				<END CKPT>	ok here	

- ❑e

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<S, A, 60>						
<COMMIT S>						
	<START T>					
	<T, A, 10>					
		<START U>				
		<U, B, 20>				
	<T, C, 30>					
			<START V>			
		<U, D, 40>				
			<V, F, 70>			
		<COMMIT U>				
	<T, E, 50>					
				<START CKPT(T, V)>		
	<COMMIT T>					merge of G and J
			<V, B, 80>			
			<COMMIT V>			
				<END CKPT>		