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 + uWrite(A, t) u = t + uWrite(B, u) Output(B) crash here ok Output(A) • □b Read(A, t) Read(B, u) u = + uWrite(B, u) Output(B) crash here ok t = t + uWrite(A) Output(A) • □c Read(A, t) Read(B, u) t = u + 1Write(A) u = t + 1Write(B) Output(B) crash here ok Output(A) **▼**□Section 2

▼□1

Step	Action	t	u	M-A	М-В	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	М-В	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	М-В	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

	Transaction T	Transaction U	Transaction V	Checkpoints	failure occurs here:
<s, 60="" a,=""></s,>					S undone
				<start ckpt(s)=""></start>	S undone
<commit s=""></commit>					S undone
				<end ckpt=""></end>	nothing undone
	<start t=""></start>				nothing undone
	<t, 10="" a,=""></t,>				T undone
		<start u=""></start>			T undone
		<u, 20="" b,=""></u,>			T,U undone
	<t, 30="" c,=""></t,>				T,U undone
			<start v=""></start>		T,U undone
		<u, 40="" d,=""></u,>			T,U undone
			<v, 70="" f,=""></v,>		T,U,V undone
		<commit u=""></commit>			T,U,V undone
	<t, 50="" e,=""></t,>				T,U,V undone
	<commit t=""></commit>				T,U,V undone
			<v, 80="" b,=""></v,>		T,U,V undone
			<commit v=""></commit>		T,U,V undone
	Transaction T	Transaction II	Transaction V	Checknointe	failure occure here:

• □a

	Transaction T	Transaction U	Transaction V	Checkpoints	failure occurs here:
<s, 60="" a,=""></s,>					S undone
<commit s:<="" td=""><td>></td><td></td><td></td><td></td><td>S undone</td></commit>	>				S undone
	<start t=""></start>				S undone
	<t, 10="" a,=""></t,>				T undone
				<start ckpt(t)=""></start>	T undone
		<start u=""></start>			T undone
		<u, 20="" b,=""></u,>			T,U undone
	<t, 30="" c,=""></t,>				T,U undone
			<start v=""></start>		T,U undone
		<u, 40="" d,=""></u,>			T,U,V undone
			<v, 70="" f,=""></v,>		T,U,V undone
		<commit u=""></commit>			T,U,V undone
	<t, 50="" e,=""></t,>				T,U,V undone
	<commit t=""></commit>				T,U,V undone
				<end ckpt=""></end>	U,V undone
			<v, 80="" b,=""></v,>		U,V undone
			<commit v=""></commit>		U,V undone

	Transaction T	Transaction U	Transaction V	Checkpoints	failure occurs here:
<s, 60="" a,=""></s,>					S
<commit s:<="" td=""><td></td><td></td><td></td><td></td><td>S</td></commit>					S
	<start t=""></start>				S
	<t, 10="" a,=""></t,>				S,T
		<start u=""></start>			S,T
		<u, 20="" b,=""></u,>			S,T,U
				<start ckpt(t,="" u)=""></start>	T,U
	<t, 30="" c,=""></t,>				T,U
			<start v=""></start>		T,U
		<u, 40="" d,=""></u,>			T,U
			<v, 70="" f,=""></v,>		T,U,V
		<commit u=""></commit>			T,U,V
	<t, 50="" e,=""></t,>				T,U,V
	<commit t=""></commit>				T,U,V
				<end ckpt=""></end>	V
			<v, 80="" b,=""></v,>		V
⊒c			<commit v=""></commit>		V
	Transaction T	Transaction U	Transaction V	Checknoints	failure occurs here:
<s, 60="" a,=""></s,>	Transaction 1	Transaction o	Transaction v	Checkpoints	S
<commit s<="" td=""><td>></td><td></td><td></td><td></td><td>S</td></commit>	>				S
COMMIT 5	<start t=""></start>				S
	<t, 10="" a,=""></t,>				S,T
	<1, A, 102	<start u=""></start>			S,T
		<u, 20="" b,=""></u,>			S,T,U
	<t, 30="" c,=""></t,>	(0, 0, 202			S,T,U
	<1, C, 30>		<start v=""></start>		S,T,U
		<u, 40="" d,=""></u,>	ADIAICI V		S,T,U
		(U, D, 40)		<start ckpt(t,="" u,="" v)=""></start>	
			<v, 70="" f,=""></v,>	START CRFT(1, 0, V)>	T,U,V
		<commit u=""></commit>	~0,1,702		T,U,V
	<t, 50="" e,=""></t,>	COMMIT 02			T,U,V
	<commit t=""></commit>				T,U,V
	400MM1117		<v, 80="" b,=""></v,>		T,U,V
			<commit v=""></commit>		T,U,V
⊒d			COMMIT V	<end ckpt=""></end>	nothing undone
- 4					
0 1 60	Transaction T	Transaction U	Transaction V	Checkpoints	failure occurs here:
<s, 60="" a,=""></s,>					S
<commit s<="" td=""><td></td><td></td><td></td><td></td><td>S</td></commit>					S
	<start t=""></start>				S
	<t, 10="" a,=""></t,>	074074			S,T
		<start u=""></start>			S,T
	W 0 00	<u, 20="" b,=""></u,>			S,T,U
	<t, 30="" c,=""></t,>		OW4.0W.4		S,T,U
			<start v=""></start>		S,T,U
		<u, 40="" d,=""></u,>			S,T,U
			<v, 70="" f,=""></v,>		S,T,U,V
		<commit u=""></commit>	1		S,T,U,V
	<t, 50="" e,=""></t,>				S,T,U,V
				<start ckpt(t,="" v)=""></start>	T,V
	<commit t=""></commit>				T,V
			<v, 80="" b,=""></v,>		T,V
⊒e			<commit v=""></commit>		T,V
				<end ckpt=""></end>	nothing undone

▼□Section 3



Step	Action	t	u	M-A	М-В	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	М-В	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	М-В	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

	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<s, 60="" a,=""></s,>						before END CKPT: redo nothing
				<start ckpt(s)=""></start>		after END CKPT: redo S writes
<commit s<="" td=""><td>></td><td></td><td></td><td>-END CHOT-</td><td>ok here</td><td></td></commit>	>			-END CHOT-	ok here	
	<start t=""></start>	-		<end ckpt=""></end>	ok here ok here	
	<t, 10="" a,=""></t,>	Į.			ok here	
	41, A, 102	<start u=""></start>			ok here	
		<u, 20="" b,=""></u,>			ok here	
	<t, 30="" c,=""></t,>			İ	ok here	
			<start v=""></start>		ok here	
		<u, 40="" d,=""></u,>			ok here	
			<v, 70="" f,=""></v,>		ok here	
		<commit u=""></commit>			ok here	
	<t, 50="" e,=""></t,>				ok here	
	<commit t=""></commit>		AV D 00-	-	ok here	_
⊒а ———			<v, 80="" b,=""> <commit v=""></commit></v,>		ok here ok here	
⊿ a		J				
	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<s, 60="" a,=""></s,>						
<commit s<="" td=""><td></td><td></td><td></td><td></td><td></td><td></td></commit>						
	<start t=""></start>	-			-	
	<t, 10="" a,=""></t,>	-		<start ckpt(t)=""></start>		
		<start u=""></start>		, some on t(t)	ok here	before END CKPT: redo S writes
		<u, 20="" b,=""></u,>			ok here	after END CKPT: redo T writes
	<t, 30="" c,=""></t,>	,,			ok here	
			<start v=""></start>		ok here	
		<u, 40="" d,=""></u,>			ok here	
			<v, 70="" f,=""></v,>		ok here	
		<commit u=""></commit>			ok here	
	<t, 50="" e,=""></t,>				ok here	
	<commit t=""></commit>			L-END CHOT	ok here	
			4)(P. 905	<end ckpt=""></end>	ok here	
⊒b			<v, 80="" b,=""></v,>		ok here ok here	
- 0						
	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
<s, 60="" a,=""></s,>	-					
<commit s:<="" td=""><td>START T></td><td></td><td></td><td></td><td></td><td></td></commit>	START T>					
	<starl 12<="" td=""><td></td><td></td><td></td><td></td><td></td></starl>					
	~T A 10>					
	<t, 10="" a,=""></t,>	<start ii=""></start>				
	<t, 10="" a,=""></t,>	<start u=""></start>				
	<t, 10="" a,=""></t,>	<start u=""> <u, 20="" b,=""></u,></start>		<start ckpt(t,="" u)=""></start>		
				<start ckpt(t,="" u)=""></start>	ok here	before END CKPT: redo S writes
	<t, 10="" a,=""></t,>		<start v=""></start>	<start ckpt(t,="" u)=""></start>	ok here	before END CKPT: redo S writes after END CKPT: redo T,U writes
				<start ckpt(t,="" u)=""></start>	ok here ok here	
		<u, 20="" b,=""></u,>	<start v=""></start>	<start ckpt(t,="" u)=""></start>	ok here ok here ok here	
	<t, 30="" c,=""></t,>	<u, 20="" b,=""></u,>		<start ckpt(t,="" u)=""></start>	ok here ok here ok here ok here	
	<t, 30="" c,=""></t,>	<u, 20="" b,=""></u,>		<start ckpt(t,="" u)=""></start>	ok here ok here ok here ok here ok here	
	<t, 30="" c,=""></t,>	<u, 20="" b,=""></u,>			ok here ok here ok here ok here ok here ok here	
	<t, 30="" c,=""></t,>	<u, 20="" b,=""></u,>	<v, 70="" f,=""></v,>	<start ckpt(t,="" u)=""></start>	ok here	
10	<t, 30="" c,=""></t,>	<u, 20="" b,=""></u,>	<v, 70="" f,=""></v,>		ok here	
	<t, 30="" c,=""></t,>	<u, 20="" b,=""></u,>	<v, 70="" f,=""></v,>		ok here	
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""></commit></t,></t,>	<u, 20="" b,=""></u,>	<v, 70="" f,=""></v,>		ok here	
	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""></commit></t,></t,>	<u, 20="" b,=""></u,>	<v, 70="" f,=""></v,>		ok here	
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> > <start t=""></start></commit></t,></t,>	<u, 20="" b,=""></u,>	<v, 70="" f,=""></v,>		ok here	
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""></commit></u,></u,>	<v, 70="" f,=""></v,>		ok here	
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> > <start t=""></start></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""> <start u=""></start></commit></u,></u,>	<v, 70="" f,=""></v,>		ok here	
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> >> <start t=""> <t, 10="" a,=""></t,></start></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""></commit></u,></u,>	<v, 70="" f,=""></v,>		ok here	
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> > <start t=""></start></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""> <start u=""></start></commit></u,></u,>	<v, 70="" f,=""> <v, 80="" b,=""> <commit v=""></commit></v,></v,>		ok here	
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> >> <start t=""> <t, 10="" a,=""></t,></start></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""> <start u=""> <u, 20="" b,=""></u,></start></commit></u,></u,>	<v, 70="" f,=""></v,>		ok here	
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> >> <start t=""> <t, 10="" a,=""></t,></start></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""> <start u=""></start></commit></u,></u,>	<v, 70="" f,=""> <v, 80="" b,=""> <commit v=""></commit></v,></v,>	<end ckpt=""></end>	ok here	
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> >> <start t=""> <t, 10="" a,=""></t,></start></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""> <start u=""> <u, 20="" b,=""></u,></start></commit></u,></u,>	<v, 70="" f,=""> <v, 80="" b,=""> <commit v=""> <start v=""></start></commit></v,></v,>		ok here ok here ok here ok here ok here ok here ok here ok here ok here	after END CKPT: redo T,U writes
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> >> <start t=""> <t, 10="" a,=""></t,></start></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""> <start u=""> <u, 20="" b,=""> <u, 40="" d,=""></u,></u,></start></commit></u,></u,>	<v, 70="" f,=""> <v, 80="" b,=""> <commit v=""></commit></v,></v,>	<end ckpt=""></end>	ok here	after END CKPT: redo T,U writes
	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> <start t=""> <t, 10="" a,=""> <t, 30="" c,=""></t,></t,></start></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""> <start u=""> <u, 20="" b,=""></u,></start></commit></u,></u,>	<v, 70="" f,=""> <v, 80="" b,=""> <commit v=""> <start v=""></start></commit></v,></v,>	<end ckpt=""></end>	ok here	after END CKPT: redo T,U writes
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> <start t=""> <t, 10="" a,=""> <t, 30="" c,=""></t,></t,></start></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""> <start u=""> <u, 20="" b,=""> <u, 40="" d,=""></u,></u,></start></commit></u,></u,>	<v, 70="" f,=""> <v, 80="" b,=""> <commit v=""> <start v=""></start></commit></v,></v,>	<end ckpt=""></end>	ok here	after END CKPT: redo T,U writes
<s, 60="" a,=""></s,>	<t, 30="" c,=""> <t, 50="" e,=""> <commit t=""> <start t=""> <t, 10="" a,=""> <t, 30="" c,=""></t,></t,></start></commit></t,></t,>	<u, 20="" b,=""> <u, 40="" d,=""> <commit u=""> <start u=""> <u, 20="" b,=""> <u, 40="" d,=""></u,></u,></start></commit></u,></u,>	<v, 70="" f,=""> <v, 80="" b,=""> <commit v=""> <start v=""></start></commit></v,></v,>	<end ckpt=""></end>	ok here	after END CKPT: redo T,U writes
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	Transaction T	Transaction U	Transaction V	Checkpoints	i	ii
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• □e

▼□Section 4

▼□1

Step	Action	t	u	M-A	М-В	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	

• □a

Step	Action	t	u	M-A	М-В	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	

• □b

Step	Action	t	u	M-A	М-В	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
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