

Chapter 3

Isolation: Examples

Example 1

Miniworld

Inventory database of a wine dealer:

White wines	
<i>article</i>	<i>stock</i>
Gutedel	12
Riesling	34
Silvaner	2
Weißburgunder	11
Müller Thurgau	100

Sales transaction

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1. Sales transaction with inventory update (R: Riesling)

step

1	read(R)
2	update(R)
3	write(R)

Ignored in the R/W model: Local action

Transaction in the R/W model: $t = r(R) w(R)$

2. Two sales persons: *Miller* and *Smith*.
3. Database: **page \approx tuple.**

Lost Update

time	Miller	Smith	db value	comment
1	read(R)		34	
2		read(R)	34	
3	update(R)		34	Miller sells 1 box
4		update(R)	34	Smith sells 2 boxes
5	write(R)		33	34-1
6		write(R)	32	34-2

Mr. Miller's update has been lost (**lost update**).

White wines	
<i>article</i>	<i>stock</i>
Gutedel	12
Riesling	34
Silvaner	2
Weißburgunder	11
Müller Thurgau	100



White wines	
<i>article</i>	<i>stock</i>
Gutedel	12
Riesling	32
Silvaner	2
Weißburgunder	11
Müller Thurgau	100

Schema: $r_1(R)$ $r_2(R)$ $w_1(R)$ $w_2(R)$

Dirty Read (1)

time	Miller	Smith	db value	comment
1	read(R)		34	
2	update(R)		34	Miller sells 1 box
3	write(R)		33	34-1
4		read(R)	33	Smith reads the changed value
5		update(R)	33	Smith sells 2 boxes
6	abort		34	Miller cancels his sale
7		write(R)	31	33-2

Never became valid!

Cancelation ignored.

White wines	
<i>article</i>	<i>stock</i>
Gutedel	12
Riesling	34
Silvaner	2
Weißburgunder	11
Müller Thurgau	100



White wines	
<i>article</i>	<i>stock</i>
Gutedel	12
Riesling	31
Silvaner	2
Weißburgunder	11
Müller Thurgau	100

Schema: $r_1(R)$ $w_1(R)$ $r_2(R)$ a_1 $w_2(R)$

Dirty Read (2)

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- **Dirty read:** Read a value after it was changed by a second transaction but before its validity could be guaranteed.
- Occurs whenever a transaction reads a value changed by a second transaction before that one committed.

Inconsistent Read (1)

Compute the sum total of wines on stock.

Correct a mixup in stock registration.

time	Miller	Smith
1	sum:=0	
2	read(Gutedel)	
3	sum:=12	
4	read(Riesling)	read(Müller-Th.)
5	sum:=12+34	Müller-Th.:= Müller-Th.-10
6	read(Silvaner)	write(Müller-Th.)
7	sum:= 46+2	read(Gutedel)
8	read(Weißb.)	Gutedel:=Gutedel+10
9	sum:= 48+11	write(Gutedel)
10	read(Müller-Th.)	
11	sum:= 59+90	

Inconsistent Read (2)

time	Miller	Smith
1	sum:=0	
2	read(Gutedel)	
3	sum:=12	
4	read(Riesling)	read(Müller-Th.)
5	sum:=12+34	Müller-Th.:= Müller-Th.-10
6	read(Silvaner)	write(Müller-Th.)
7	sum:= 46+2	read(Gutedel)
8	read(Weißb.)	Gutedel:=Gutedel+10
9	sum:= 48+11	write(Gutedel)
10	read(Müller-Th.)	
11	sum:= 59+90	

White wines <i>persistent</i>		White wines <i>transient</i>		White wines <i>persistent</i>	
article	stock	article	stock	article	stock
Gutedel	12	Gutedel	12	Gutedel	22
Riesling	34	Riesling	34	Riesling	34
Silvaner	2	Silvaner	2	Silvaner	2
Weißburgunder	11	Weißburgunder	11	Weißburgunder	11
Müller Thurgau	100	Müller Thurgau	90	Müller Thurgau	90

Inconsistent Read (3)

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- **inconsistent read**: Read of states that are valid at different times \Rightarrow inconsistent view of the database.
- In the example: resulting count incorrect (missed 10 bottles).
- **Schema:**

$r_1(G)$ $r_1(R)$ $r_2(M)$ $r_1(S)$ $w_2(M)$ $r_2(G)$ $r_1(W)$ $w_2(G)$ c_2 $r_1(M)$ c_1

Threats to the global consistency

- Interaction of reads and writes :
 - ◆ Two concurrent read-only transactions have no mutual impact, since in the read/write model the only interactions possible between transactions are via database writes.
 - ◆ If a read transaction competes with a write transaction, the write transaction remains unaffected and hence the database consistent. On the other hand, the write transaction may have an effect on the read transaction.
 - ◆ Two concurrent write transactions may affect each other, and the database may become inconsistent.

Example 2

Scenario

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- Relations:
 - ◆ TICKET (ticketNo, name) **T**
 - ◆ BOOKING (flightNo, ticketNo, seatCode, date) **B**
- Transactions:
 - ◆ t_1 : Check the consistency of passenger list und bookings,
 - ◆ t_2 : Rebook a passenger group,
 - ◆ t_3 : Cancel a booking.
- Simplification:
 - ◆ Relations fit on a single page.

Transaction t_1

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- Print number of tickets sold for 12 August 2000 plus the list of the associated passengers:

```
select   count (distinct ticketNo)
from     BOOKING
where    date = 12-AUG-00;
```

read BOOKING

print number of tickets;

```
select   name
from     TICKET
where    ticketNo in
          (select ticketNo
           from   BOOKING
           where date = 12-AUG-00);
```

read TICKET

BOOKING already read

print passenger list;

commit;

r/w model for t_1 : $r_1(B)$ $r_1(T)$ c_1 .

Transaction t_2

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- Rebook passengers in row 19 from LH500 on 12 August 2000 to 11 August 2000 and mark ticket number:

```
update TICKET
set    ticketNo = ticketNo + 100000      read TICKET
where  ticketNo in
      (select ticketNo
       from  BOOKING                    read BOOKING
       where date = 12-AUG-00 and flightNo = "LH500"
       and   (seatCode = "19D" or seatCode = "19E"
              or seatCode = "19G" ));    write TICKET

update BOOKING                          BOOKING already read
set    date = 11-AUG-00, ticketNo = ticketNo + 100000
where  date = 12-AUG-00 and flightNo = "LH500"
and    (seatCode = "19D" or seatCode = "19E" or seatCode = "19G");    write BOOKING
```

Note that the first write depends on the two reads.

commit,

r/w model for t_2 : $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 .

Transaction t_3

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- Cancel the ticket with number 7216087338:

```
delete   from TICKET
where    ticketNo = 7216087338;
delete   from BOOKING
where    ticketNo = 7216087338;
commit;
```

read TICKET

write TICKET
read BOOKING

write BOOKING

r/w model for t_3 : $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 .

Inconsistent Read (1)

```
select count (distinct ticketNo)
from BOOKING
where date = 12-AUG-00;
```

$r_1(B)$

Print number of tickets;

```
update TICKET
set ticketNo = ticketNo + 100000
where ticketNo in
(select ticketNo
from BOOKING
where date = 12-AUG-00 and flightNo = "LH500"
and (seatCode = "19D" or seatCode = "19E" or seatCode = "19G" ));
```

$r_2(T)$

$r_2(B)$

```
update BOOKING
set date = 11-AUG-00, ticketNo = ticketNo + 100000
where date = 12-AUG-00 and flugNr = "LH500"
and (seatCode = "19D" or seatCode = "19E" or seatCode = "19G");
```

$w_2(T)$

$w_2(B)$

commit;

```
select name
from TICKET
where ticketNo in
(select ticketNo
from BOOKING
where date = 12-AUG-00);
```

$r_1(T)$

print passenger list;

commit;

S1: $r_1(B)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_1(T)$ c_1

read-write interaction by interrupting the reader

Inconsistent Read (2)

$r_1(B)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_1(T)$ c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216087338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

Inconsistent Read (3)

$r_1(B)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_1(T)$ c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216087338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216083970</u>	<u>19G</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216080817</u>	<u>19E</u>	<u>12-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

Output t_1 : number of tickets = 3.

Inconsistent Read (4)

$r_1(B)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_1(T)$ c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216087338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216083970</u>	<u>19G</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216080817</u>	<u>19E</u>	<u>12-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 reads BOOKING and selects.

Inconsistent Read (5)

$r_1(B)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_1(T)$ c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	<u>7216087338</u>	<u>Kuhn_Mrs_E</u>
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	<u>7216083970</u>	<u>Bender_Mr_P</u>
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	<u>7216080817</u>	<u>Weinand_Mr_C</u>
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216083970</u>	<u>19G</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216080817</u>	<u>19E</u>	<u>12-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 reads TICKET and selects.

Inconsistent Read (6)

$r_1(B)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_1(T)$ c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216 <u>1</u> 87338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 updates and writes TICKET.

Inconsistent Read (7)

$r_1(B)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_1(T)$ c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216 <u>1</u> 87338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216 <u>1</u> 87338	19D	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 83970	19G	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 80817	19E	<u>11-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 updates and writes BOOKING.

Inconsistent Read (8)

$r_1(B)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_1(T)$ c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216 <u>1</u> 87338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216 <u>1</u> 87338	19D	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 83970	19G	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 80817	19E	<u>11-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

Output t_1 : empty passenger list.

No problem

```
update  TICKET       $r_2(T)$ 
set     ticketNo = ticketNo + 100000
where  ticketNo in
      (select  ticketNo
       from    BOOKING       $r_2(B)$ 
       where   date = 12-AUG-00      and flightNo = "LH500"
       and     (seatCode = "19D" or seatCode = "19E,, or seatCode = "19G" ));
```

S2: $r_2(B)$ $r_2(T)$ $r_1(B)$ $r_1(T)$ c_1 $w_2(T)$ $w_2(B)$ c_2

```
select  count (distinct ticketNo)
from    BOOKING       $r_1(B)$ 
where   date = 12-AUG-00;
```

print number of tickets;

```
select  name
from    TICKET       $r_1(T)$ 
where   ticketNo in
      (select  ticketNo
       from    BOOKING
       where   date = 12-AUG-00);
```

print passenger list;

commit;

```
update  BOOKING       $w_2(T)$ 
set     date = 11-AUG-00, ticketNo
where  date = 12-AUG-00      and flightNo = "LH500"
and     (seatCode = "19D" or seatCode = "19E,, or seatCode = "19G");
```

commit;

read-write interaction by
interrupting the writer

No problem, because t_1 reads a database state that was not yet changed. Tough luck for t_1 that it is no longer valid shortly afterwards.

$w_2(B)$

Dirty Read (1)

```

update  TICKET      r2(T)
set     ticketNo = ticketNo + 100000
where  ticketNo in
(select ticketNo
from   BOOKING    r2(B)
where  date = 12-AUG-00 and flightNo = "LH500"
and    (seatCode = "19D" or seatCode = "19E,, or seatCode = "19G" ));
    
```

S3: r₂(B) r₂(T) w₂(T) r₁(B) r₁(T) c₁ w₂(B) c₂

```

select  count (distinct ticketNo)
from    BOOKING
where   date = 12-AUG-00;
print number of tickets;

select  name
from    TICKET      r1(T)
where   ticketNo in
        (select ticketNo
         from   BOOKING
         where  date = 12-AUG-00);
print passenger list;
commit;
    
```

read-write interaction by interrupting the writer

Effect on t₁ as in S1.

```

update  BOOKING
set     date = 11-AUG-00, ticketNo = ticketNo + 100000
where  date = 12-AUG-00 and flightNo = "LH500"
and    (seatCode = "19D" or seatCode = "19E,, or seatCode = "19G");
commit;
    
```

w₂(B)

Dirty Read (2)

$r_2(B)$ $r_2(T)$ $w_2(T)$ $r_1(B)$ $r_1(T)$ $w_2(B)$ c_2 c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216087338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

Dirty Read (3)

$r_2(B)$ $r_2(T)$ $w_2(T)$ $r_1(B)$ $r_1(T)$ $w_2(B)$ c_2 c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216087338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216083970</u>	<u>19G</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216080817</u>	<u>19E</u>	<u>12-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 reads BOOKING and selects.

Dirty Read (4)

$r_2(B)$ $r_2(T)$ $w_2(T)$ $r_1(B)$ $r_1(T)$ $w_2(B)$ c_2 c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	<u>7216087338</u>	<u>Kuhn_Mrs_E</u>
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	<u>7216083970</u>	<u>Bender_Mr_P</u>
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	<u>7216080817</u>	<u>Weinand_Mr_C</u>
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216083970</u>	<u>19G</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216080817</u>	<u>19E</u>	<u>12-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 reads TICKET and selects.

Dirty Read (5)

$r_2(B)$ $r_2(T)$ $w_2(T)$ $r_1(B)$ $r_1(T)$ $w_2(B)$ c_2 c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216 <u>1</u> 87338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 updates and writes TICKET.

Dirty Read (6)

$r_2(B)$ $r_2(T)$ $w_2(T)$ $r_1(B)$ $r_1(T)$ $w_2(B)$ c_2 c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216 <u>1</u> 87338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216083970</u>	<u>19G</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216080817</u>	<u>19E</u>	<u>12-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

Output t_1 : number of tickets = 3.

Dirty Read (7)

$r_2(B)$ $r_2(T)$ $w_2(T)$ $r_1(B)$ $r_1(T)$ $w_2(B)$ c_2 c_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216 <u>1</u> 87338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

Output t_1 : empty passenger list.

Dirty Read (8)

$r_2(B)$ $r_2(T)$ $w_2(T)$ $r_1(B)$ $r_1(T)$ $w_2(B)$ C_2 C_1

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216 <u>1</u> 87338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216 <u>1</u> 87338	19D	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 83970	19G	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 80817	19E	<u>11-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 updates and writes BOOKING.

Dirty Read (9)

- „dirty read“ leaves open whether the transient state is consistent or not.
- Take schedule
S4: $r_2(B) r_2(T) w_2(T) w_2(B) r_1(B) r_1(T) c_2 c_1$.
- $r_1(B) r_1(T)$ has a consistent output despite dirty read.
- Still dangerous! Take abort of T_2 :
S4: $r_2(B) r_2(T) w_2(T) w_2(B) r_1(B) r_1(T) a_2 c_1$.
- Because t_2 leaves no trace t_1 reads a state that never existed!

Inconsistent + Dirty Read (1)

```
delete
where
from TICKET  $r_3(T)$ 
ticketNo = 7216087338;  $w_3(T)$ 
```

```
update
set
where
TICKET  $r_2(T)$ 
ticketNo = ticketNo + 100000
ticketNo in
(select
from
where
and
BOOKING  $r_2(B)$ 
date = 12-AUG-00 and flightNo = "LH500"
(seatCode = "19D" or seatCode = "19E,, or seatCode = "19G" ));  $w_2(T)$ 

update
set
where
and
BOOKING
date = 11-AUG-00, ticketNo = ticketNo + 100000
date = 12-AUG-00 and flightNo = "LH500"
(seatCode = "19D" or seatCode = "19E,, or seatCode = "19G");  $w_2(B)$ 

commit;
```

```
delete
where
commit;
from BOOKING  $r_3(B)$ 
ticketNo = 7216087338;  $w_3(B)$ 
```

writer-writer interaction by interrupting one of the writers

S5: $r_3(T)$ $w_3(T)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_3(B)$ $w_3(B)$ c_3

Inconsistent + Dirty Read (2)

$r_3(T)$ $w_3(T)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_3(B)$ $w_3(B)$ c_3

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216087338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

Inconsistent + Dirty Read (3)

$r_3(T)$ $w_3(T)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_3(B)$ $w_3(B)$ c_3

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	<u>7216087338</u>	<u>Kuhn_Mrs_E</u>
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_3 reads TICKET and selects.

Inconsistent + Dirty Read (4)

$r_3(T)$ $w_3(T)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_3(B)$ $w_3(B)$ c_3

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00		
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_3 writes TICKET.

Inconsistent + Dirty Read (5)

$r_3(T)$ $w_3(T)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_3(B)$ $w_3(B)$ c_3

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00		
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216083970</u>	<u>19G</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216080817</u>	<u>19E</u>	<u>12-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 reads BOOKING and selects.

Inconsistent + Dirty Read (6)

$r_3(T)$ $w_3(T)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_3(B)$ $w_3(B)$ c_3

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00		
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	<u>7216083970</u>	<u>Bender_Mr_P</u>
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	<u>7216080817</u>	<u>Weinand_Mr_C</u>
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216083970</u>	<u>19G</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216080817</u>	<u>19E</u>	<u>12-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 reads TICKET and selects.

Inconsistent + Dirty Read (7)

$r_3(T)$ $w_3(T)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_3(B)$ $w_3(B)$ c_3

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00		
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 writes TICKET.

Inconsistent + Dirty Read (8)

$r_3(T)$ $w_3(T)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_3(B)$ $w_3(B)$ c_3

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00		
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216 <u>1</u> 87338	19D	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 83970	19G	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 80817	19E	<u>11-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 writes BOOKING .

Inconsistent + Dirty Read (9)

$r_3(T)$ $w_3(T)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_3(B)$ $w_3(B)$ c_3

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00		
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216 <u>1</u> 87338	19D	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 83970	19G	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 80817	19E	<u>11-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_3 reads BOOKING .

Inconsistent + Dirty Read (10)

$r_3(T)$ $w_3(T)$ $r_2(B)$ $r_2(T)$ $w_2(T)$ $w_2(B)$ c_2 $r_3(B)$ $w_3(B)$ c_3

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00		
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216 <u>1</u> 87338	19D	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 83970	19G	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 80817	19E	<u>11-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_3 writes BOOKING .

Lost Update (1)

```
update  TICKET
set     ticketNo = ticketNo + 100000
where   ticketNo in
        (select ticketNo
         from   BOOKING
         where  date = 12-AUG-00      and flightNo = "LH500"
         and   (seatCode = "19D" or seatCode = "19E,, or seatCode = "19G" ));
```

```
delete  from TICKET
where   ticketNo = 7216087338;

delete  from BOOKING
where   ticketNo = 7216087338;

commit;
```

```
update  BOOKING
set     date = 11-AUG-00, ticketNo = ticketNo + 100000
where   date = 12-AUG-00      and flightNo = "LH500"
and     (seatCode = "19D" or seatCode = "19E,, or seatCode = "19G");

commit;
```

S6: $r_2(B)$ $r_2(T)$ $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 $w_2(T)$ $w_2(B)$ c_2

**writer-writer interaction by
interrupting one of the writers**

Lost Update (2)

$r_2(B)$ $r_2(T)$ $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 $w_2(T)$ $w_2(B)$ c_2

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216087338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

Lost Update (3)

$r_2(B)$ $r_2(T)$ $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 $w_2(T)$ $w_2(B)$ c_2

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216087338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216083970</u>	<u>19G</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216080817</u>	<u>19E</u>	<u>12-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 reads BOOKING and selects.

Lost Update (4)

$r_2(B)$ $r_2(T)$ $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 $w_2(T)$ $w_2(B)$ c_2

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	<u>7216087338</u>	<u>Kuhn_Mrs_E</u>
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	<u>7216083970</u>	<u>Bender_Mr_P</u>
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	<u>7216080817</u>	<u>Weinand_Mr_C</u>
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216083970</u>	<u>19G</u>	<u>12-AUG-00</u>		
<u>LH500</u>	<u>7216080817</u>	<u>19E</u>	<u>12-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 reads TICKET and selects.

Lost Update (5)

$r_2(B)$ $r_2(T)$ $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 $w_2(T)$ $w_2(B)$ c_2

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	<u>7216087338</u>	<u>Kuhn_Mrs_E</u>
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_3 reads TICKET and selects.

Lost Update (6)

$r_2(B)$ $r_2(T)$ $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 $w_2(T)$ $w_2(B)$ c_2

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00		
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216087338	19D	12-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_3 writes TICKET.

Lost Update (7)

$r_2(B)$ $r_2(T)$ $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 $w_2(T)$ $w_2(B)$ c_2

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00		
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
<u>LH500</u>	<u>7216087338</u>	<u>19D</u>	<u>12-AUG-00</u>		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_3 reads BOOKING and selects.

Lost Update (8)

$r_2(B)$ $r_2(T)$ $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 $w_2(T)$ $w_2(B)$ c_2

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00		
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216083970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216080817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_3 writes BOOKING.

Lost Update (9)

$r_2(B)$ $r_2(T)$ $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 $w_2(T)$ $w_2(B)$ c_2

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216 <u>1</u> 87338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216083970	19G	12-AUG-00		
LH500	7216080817	19E	12-AUG-00		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 writes TICKET.

Lost Update (10)

$r_2(B)$ $r_2(T)$ $r_3(T)$ $w_3(T)$ $r_3(B)$ $w_3(B)$ c_3 $w_2(T)$ $w_2(B)$ c_2

flightNo	ticketNo	seatCode	date	ticketNo	name
LH711	7216083495	02B	26-AUG-00	7216 <u>1</u> 87338	Kuhn_Mrs_E
LH3724	7216084316	08A	29-SEP-00	7216084065	Pulkowski_Mr_S
LH3651	7216084316	14F	03-OCT-00	7216082757	Witte_Mr_R
LH408	7216088131	04D	04-SEP-00	7216084316	Krakowski_Mrs_P
LH403	7216088131	05D	08-SEP-00	7216084317	Posselt_Mr_D
LH208	7216088131	07C	09-SEP-00	7216083495	Gimbel_Mr_M
LH2419	7216083969	02E	01-SEP-00	7216083971	Muelle_Mrs_J
LH4080	7216084728	10K	07-AUG-00	7216 <u>1</u> 83970	Bender_Mr_P
LH4171	7216084728	07A	11-AUG-00	7216080815	Lockemann_Mr_P
LH191	7216084728	01K	11-AUG-00	7216080816	Simpson_Mr_B
LH208	7216084069	05D	01-AUG-00	7216 <u>1</u> 80817	Weinand_Mr_C
LH3724	7216088132	07E	14-AUG-00		
LH458	7216080815	81K	03-SEP-00		
LH710	7216082757	34D	10-SEP-00		
LH400	7216084317	05G	21-JUL-00		
LH401	7216084317	05D	05-AUG-00		
LH500	7216 <u>1</u> 87338	19D	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 83970	19G	<u>11-AUG-00</u>		
LH500	7216 <u>1</u> 80817	19E	<u>11-AUG-00</u>		
LH778	7216083911	83K	05-AUG-00		
LH6390	7216083911	82A	06-AUG-00		

t_2 writes BOOKING.

Lost Update (11)

- Note: Neither t_2 nor t_3 include „inconsistent read“ or „dirty read“. „lost update“ is an independent phenomenon!

Example 3

OLTP Example: Debit/Credit

57

```
void main ( ) {
    EXEC SQL BEGIN DECLARE SECTION
        int b /*balance*/, a /*accountid*/, amount;
    EXEC SQL END DECLARE SECTION;
    /* read user input */
    scanf ("%d %d", &a, &amount);
    /* read account balance */
    EXEC SQL Select Balance into :b From Account
        Where Account_Id = :a;
    /* add amount (positive for debit, negative for credit) */
    b = b + amount;
    /* write account balance back into database */
    EXEC SQL Update Account
        Set Balance = :b Where Account_Id = :a;
    EXEC SQL Commit Work;
}
```

OLTP Example: Concurrent Executions

P1	Time	P2
Select Balance Into :b ₁ From Account Where Account_Id = :a	1	
		Select Balance Into :b ₂ From Account Where Account_Id = :a
	2	
b1 = b1-50	3	
	4	b ₂ = b ₂ +100
Update Account Set Balance = :b ₁ Where Account_Id = :a	5	
	6	Update Account Set Balance = :b ₂ Where Account_Id = :a