

Figure 15.1 The lossless join testing algorithm. (a) Applying the algorithm to test the decomposition of EMP_PROJ into EMP_PROJ1 and EMP_LOCS. (b) Another decomposition of EMP_PROJ. (c) Applying the algorithm to the decomposition in Figure 15.1(b).

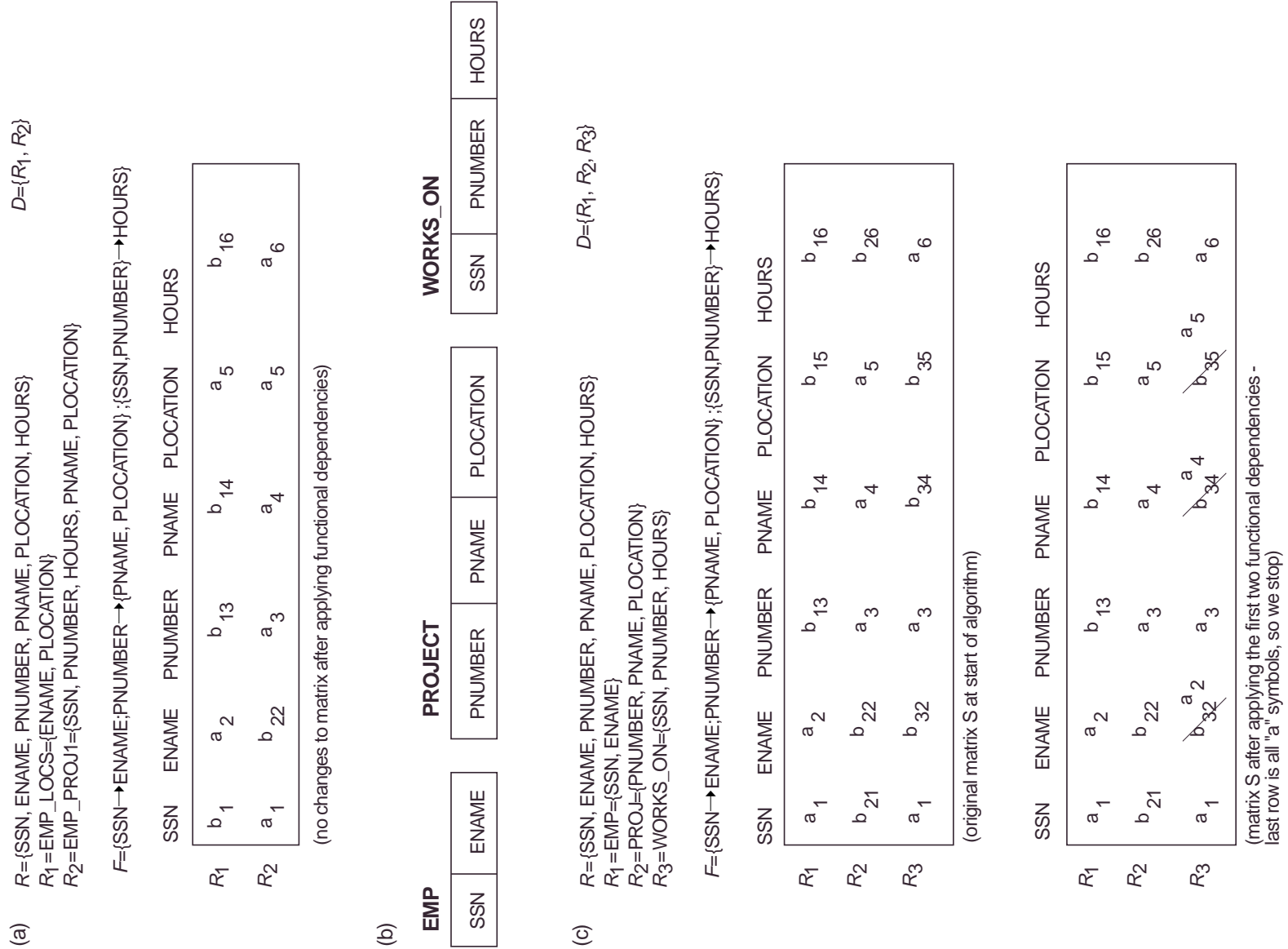


Figure 15.2 Illustrating null value join issues. (a) A database with nulls for some join attributes. (b) Result of applying NATURAL JOIN to the EMPLOYEE and DEPARTMENT relations. (c) Result of applying OUTER JOIN to EMPLOYEE and DEPARTMENT.

EMPLOYEE						
ENAME	SSN	BDATE	ADDRESS	DNUM		
Smith, John B.	123456789	1965-01-09	731 Fondren, Houston, TX	5		
Wong, Franklin T.	333445555	1955-12-08	638 Voss, Houston, TX	5		
Zelaya, Alicia J.	999887777	1968-07-19	3321 Castle, Spring, TX	4		
Wallace, Jennifer S.	987654321	1941-06-20	291 Berry, Bellaire, TX	4		
Narayan, Ramesh K.	666884444	1962-09-15	975 Fire Oak, Humble, TX	5		
English, Joyce A.	453453453	1972-07-31	5631 Rice, Houston, TX	5		
Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX	4		
Borg, James E.	888665555	1937-11-10	450 Stone, Houston, TX	4		
Berger, Anders C.	999775555	1965-04-26	6530 Braes, Bellaire, TX	1	null	null
Benitez, Carlos M.	888664444	1963-01-09	7654 Beech, Houston, TX	1	null	null

DEPARTMENT		
DNAME	DNUM	DMGRSSN
Research	5	333445555
Administration	4	987654321
Headquarters	1	888665555

ENAME	SSN	BDATE	ADDRESS	DNUM	DNAME	DMGRSSN
Smith, John B.	123456789	1965-01-09	731 Fondren, Houston, TX	5	Research	333445555
Wong, Franklin T.	333445555	1955-12-08	638 Voss, Houston, TX	5	Research	333445555
Zelaya, Alicia J.	999887777	1968-07-19	3321 Castle, Spring, TX	4	Administration	987654321
Wallace, Jennifer S.	987654321	1941-06-20	291 Berry, Bellaire, TX	4	Administration	987654321
Narayan, Ramesh K.	666884444	1962-09-15	975 Fire Oak, Humble, TX	5	Research	333445555
English, Joyce A.	453453453	1972-07-31	5631 Rice, Houston, TX	5	Research	333445555
Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX	4	Administration	987654321
Borg, James E.	888665555	1937-11-10	450 Stone, Houston, TX	1	Headquarters	888665555

ENAME	SSN	BDATE	ADDRESS	DNUM	DNAME	DMGRSSN
Smith, John B.	123456789	1965-01-09	731 Fondren, Houston, TX	5	Research	333445555
Wong, Franklin T.	333445555	1955-12-08	638 Voss, Houston, TX	5	Research	333445555
Zelaya, Alicia J.	999887777	1968-07-19	3321 Castle, Spring, TX	4	Administration	987654321
Wallace, Jennifer S.	987654321	1941-06-20	291 Berry, Bellaire, TX	4	Administration	987654321
Narayan, Ramesh K.	666884444	1962-09-15	975 Fire Oak, Humble, TX	5	Research	333445555
English, Joyce A.	453453453	1972-07-31	5631 Rice, Houston, TX	5	Research	333445555
Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX	4	Administration	987654321
Borg, James E.	888665555	1937-11-10	450 Stone, Houston, TX	1	Headquarters	888665555
				1	Headquarters	888665555
				1	Headquarters	888665555

Figure 15.3 The “dangling tuple” problem. (a) The relation EMPLOYEE_1 (includes all attributes of EMPLOYEE except DNUMBER). (b) The relation EMPLOYEE_2 (includes DNUMBER attribute with null values). (c) The relation EMPLOYEE_3 (includes DNUMBER attribute but does not include tuples for which DNUMBER has null values).

(a) **EMPLOYEE_1**

ENAME	<u>SSN</u>	BDATE	ADDRESS
Smith, John B.	123456789	1965-01-09	731 Fondren, Houston, TX
Wong, Franklin T.	333445555	1955-12-08	638 Voss, Houston, TX
Zelaya, Alicia J.	999887777	1968-07-19	3321 Castle, Spring, TX
Wallace, Jennifer S.	987654321	1941-06-20	291 Berry, Bellaire, TX
Narayan, Ramesh K.	666884444	1962-09-15	975 Fire Oak, Humble, TX
English, Joyce A.	453453453	1972-07-31	5631 Rice, Houston, TX
Jabbar, Ahmad V.	987987987	1969-03-29	980 Dallas, Houston, TX
Borg, James E.	888665555	1937-11-10	450 Stone, Houston, TX
Berger, Anders C.	999775555	1965-04-26	6530 Braes, Bellaire, TX
Benitez, Carlos M.	888664444	1963-01-09	7654 Beech, Houston, TX

(b) **EMPLOYEE_2**

<u>SSN</u>	DNUM
123456789	5
333445555	5
999887777	4
987654321	4
666884444	5
453453453	5
987987987	4
888665555	1
999775555	null
888664444	null

(c) **EMPLOYEE_3**

<u>SSN</u>	DNUM
123456789	5
333445555	5
999887777	4
987654321	4
666884444	5
453453453	5
987987987	4
888665555	1

Figure 15.4 Fourth and fifth normal form. (a) The EMP relation with two MVDS: $ENAME \twoheadrightarrow PNAME$ and $ENAME \twoheadrightarrow DNAME$. (b) Decomposing EMP into two relations in 4NF. (c) The relation SUPPLY with no MVDS satisfies 4NF but does not satisfy 5NF if the $JD(R1, R2, R3)$ holds. (d) Decomposing SUPPLY into three 5NF relations.

(a)

EMP		
<u>ENAME</u>	PNAME	<u>DNAME</u>
Smith	X	John
Smith	Y	Anna
Smith	X	Anna
Smith	Y	John

(b)

EMP_PROJECTS		
<u>ENAME</u>	PNAME	
Smith	X	
Smith	Y	

EMP_DEPENDENTS		
<u>ENAME</u>	DNAME	
Smith	John	
Smith	Anna	

(c)

SUPPLY		
<u>SNAME</u>	PARTNAME	<u>PROJNAME</u>
Smith	Bolt	ProjX
Smith	Nut	ProjY
Adamsky	Bolt	ProjY
Walton	Nut	ProjZ
Adamsky	Nail	ProjX
Adamsky	Bolt	ProjX
Smith	Bolt	ProjY

(d)

R1		
<u>SNAME</u>	PARTNAME	
Smith	Bolt	
Smith	Nut	
Adamsky	Bolt	
Walton	Nut	
Adamsky	Nail	

R2		
<u>SNAME</u>	PROJNAME	
Smith	ProjX	
Smith	ProjY	
Adamsky	ProjY	
Walton	ProjZ	
Adamsky	ProjX	

R3		
PARTNAME	PROJNAME	
Bolt	ProjX	
Nut	ProjY	
Bolt	ProjY	
Nut	ProjZ	
Nail	ProjX	

Figure 15.5 Benefits of 4NF. (a) The EMP relation with some additional tuples. (b) Projecting EMP on EMP_PROJECTS and EMP_DEPENDENTS.

(a) **EMP**

<u>ENAME</u>	<u>PNAME</u>	<u>DNAME</u>
Smith	X	John
Smith	Y	Anna
Smith	X	Anna
Smith	Y	John
Brown	W	Jim
Brown	X	Jim
Brown	Y	Jim
Brown	Z	Jim
Brown	W	Joan
Brown	X	Joan
Brown	Y	Joan
Brown	Z	Joan
Brown	W	Bob
Brown	X	Bob
Brown	Y	Bob
Brown	Z	Bob

(b) **EMP_PROJECTS**

<u>ENAME</u>	<u>PNAME</u>
Smith	X
Smith	Y
Brown	W
Brown	X
Brown	Y
Brown	Z

EMP_DEPENDENTS

<u>ENAME</u>	<u>DNAME</u>
Smith	Anna
Smith	John
Brown	Jim
Brown	Joan
Brown	Bob

Figure 15.6 Templates for common types of dependencies. (a) Template for the functional dependency $X \rightarrow Y$. (b) Template for the multivalued dependency $X \twoheadrightarrow Y$. (c) Template for the inclusion dependency $R.X < S.Y$.

(a)	$R = \{ A, B, C, D \}$		
hypothesis	$\begin{array}{ccc} a_1 & b_1 & c_1 \\ a_1 & b_1 & c_2 \end{array}$ <hr style="width: 50%; margin-left: 0;"/>	$X = \{ A, B \}$	$Y = \{ C, D \}$
conclusion	$c_1 = c_2$ and $d_1 = d_2$		
(b)	$R = \{ A, B, C, D \}$		
hypothesis	$\begin{array}{cccc} a_1 & b_1 & c_1 & d_1 \\ a_1 & b_1 & c_2 & d_2 \end{array}$ <hr style="width: 50%; margin-left: 0;"/>	$X = \{ A, B \}$	$Y = \{ C \}$
conclusion	$\begin{array}{cccc} a_1 & b_1 & c_2 & d_1 \\ a_1 & b_1 & c_1 & d_2 \end{array}$		
(c)	$R = \{ A, B, C, D \}$	$S = \{ E, F, G \}$	
hypothesis	$\begin{array}{cccc} a_1 & b_1 & c_1 & d_1 \end{array}$ <hr style="width: 50%; margin-left: 0;"/>		$X = \{ C, D \}$
conclusion			$Y = \{ E, F \}$
		c_1	d_1 g

Figure 15.7 Templates for the constraint that an employee's salary must be less than the supervisor's salary.

EMPLOYEE = { NAME , SSN , ... , SALARY , SUPERVISORSSN }

	a	b	c	d
hypothesis	e	d	f	g
conclusion	<hr/>			
	c < f			