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ECS165 HW2

1a)
A+ = {A}
B+ = {B,C}
C+ = {C}
D+ = {D}
E+ = {E}
AB+ = {A,B,C,D,E} <- key
AC+ = {A,C,D,E}
AD+ = {A,D}
AE+ = {A,D,E}
BC+ = {B,C}
BD+ = {B,D}
BE+ = {A,B,C,D,E} <- key
CD+ = {C,D}
CE+ = {C,E}
DE+ = {D,E}
ABC+ = ABD+ = ABE+ = {A,B,C,D,E} <- superkey
ACD+ = {A,C,D,E}
ACE+ = {A,C,D,E}
ADE+ = {A,D,E}
BCD+ = {B,C,D}
BCE+ = BDE+ = {A,B,C,D,E} <- superkey
CDE+ = {C,D,E}
ABCD+ = {A,B,C,D,E} <- superkey
ABCE+ = {A,B,C,D,E}<- superkey
ACDE+ = {A,C,D,E}
BCDE+ = {A,B,C,D,E}<- superkey
ABCDE+ = {A,B,C,D,E} <- superkey

Keys of R are AB, BE

1b)
check FD's (closure without each left hand side attributes, checking if follow)

AC+ = {A,C}   so AC->E doesn't follow the rest
AE+ = {A,E}   so AE->D doesn't follow the rest
B+ = {B}   so B->C doesn't follow the rest
BE+ = {B,E,C}   so BE->A doesn't follow the rest

check attributes:

C+ = {C}   C in AC
A+ = {A}   A in AC
E+ = {E}   E in AE
A+ = {A}   A in AE
E+ = {E}   E in BE
B+ = {B,C}   B in BE

Therefore, the original set of FD's:
<u>AC->E</u>
<u>AE->D</u>
<u>B->C</u>
<u>BE->A</u>
is a minimal basis for the FD's.

1c)
BCNF violations follow from the FD's:
AC->E
AE->D
B->C
AC->D
BD->C
ACD->E
ACE->D

Their left-hand-side attributes are not superkeys. (keys: AB, BE)

1d)
Choose AC to be X
Then X+ = AC+ = {A,C,D,E}

R1(A,C,D,E)
{
~~AC->D~~ (deleted b/c it follows)
AC->E
AE->D <- violation
~~ACD->E~~ (deleted b/c it follows)
~~ACE->D~~ (deleted b/c it follows)
}
key:
AC+ = {A,C,D,E}
AE+ = {A,D,E}
R1's key: AC

R2(A,B,C)
{
B->C <- violation
}
key:
AB+ = {A,B,C}
R2's key: AB

BCNF violation in R1, further decompose R1:
Choose AE to be X,
Then X+ = AE+ = {A,D,E}

R3(A,D,E)
{
AE->D
}
key:
AE+ = {A,D,E}
R3's key: AE

R4(A,C,E)
{
AC->E
}
key:
AC+ = {A,C,E}
R4's key: AC

BCNF violation in R2, further decompose R2:
Choose B to be X,
Then X+ = B+ = {B,C}

R5(B,C)
{
B->C
}
key:
B+ = {B,C}
R5's key: B

R6(A,B)
{
}
key:
AB+ = {A,B}
R5's key: AB

Therefore the BCNF decomposition:
R3(A,D,E)
R4(A,C,E)
R5(B,C)
R6(A,B)
with FD's:
AE->D
AC->E
B->C

1e)
3NF violations that follow from FD’s:
AE->D
B->C
AC->D
BD->C
ACE->D

Left hand sides are not superkeys and right hand sides are not primes.

1f)
Find minimal basis:
from part b):
AC->E
AE->D
B->C
BE->A
Create relations with schemas:
R1(A,C,E)   AC-> E   key: AC
R2(A,D,E)   AE->D   key: AE
R3(B,C)   B->C   key: B
R4(A,B,E)   <- ABE is a superkey   BE->A   key:BE

So 3NF decomposition is:
R1(A,C,E)
R2(A,D,E)
R3(B,C)
R4(A,B,E)
with FDs:
AC-> E
AE->D
B->C
BE->A

1g)
List of all MVD's that follow FD's:
B->->C <-violation
AB->->C
AB->->D
AB->->E
AC->->D <-violation
AC->->E <-violation
AE->->D <-violation
BD->->C <-violation
BE->->A
BE->->C
BE->->D
ABC->->D
ABC->->E
ABD->->C
ABD->->E
ACD->->E <-violation
ACE->->D <-violation
BCE->->A
BDE->->A
BDE->->C
B->->ADE <-violation
AB->->DE
AB->->CE
AB->->CD
AC->->BE <-violation
AC->->BD <-violation
AE->->BC <-violation
BD->->AE <-violation
BE->->CD
BE->->AD
BE->->AC
ACD->->B <-violation
ACE->->B <-violation

Therefore, 4NF violations:
B->->C
AC->->D
AC->->E
AE->->D
BD->->C
ACD->->E
ACE->->D
B->->ADE
AC->->BE
AC->->BD
AE->->BC
BD->->AE
ACD->->B
ACE->->B

1h)
Choose AC->E to be the 4NF violation,
R1(A,C,E)
{
AC->E
AC->->E
}
key: AC

R2(A,B,C,D)
{
~~ABC->D~~ (deleted for minimal basis)
~~ABD->C~~ (deleted for minimal basis)
~~AB->D~~ (deleted for minimal basis)
AB->C
AC->D
BD->C
B->->C <- violation
AB->->C
AB->->D
AC->->D <- violation
BD->->C <- violation
}
key: AB

4NF violation in R2, further decomposition of R2:
Choose B->C
R3(B,C)
{
B->C
B->->C
}
key: B

R4(A,B,D)
{
AB->D
AB->->D
}
key: AB
Therefore, 4NF decomposition:
R1(A,C,E)
R3(B,C)
R4(A,B,D)
FDs and MVDs:
AC->E
B->C
AB->D
AC->->E
B->->C
AB->->D

1i)
S(A,B,C) = π R(A,B,C,D,E)
B->C
~~AB->C~~ (follow from the rest)
B->->C
~~AB->->C~~ (trivial)
B->->A

2a)
Use chase test to prove: CH->R holds in Courses.

C	T	H	R	S	G
c	t1	h	r1	s1	g1
c	t2	h	r2	s2	g2

apply C->T

C	T	H	R	S	G
c	t1	h	r1	s1	g1
c	t1	h	r2	s2	g2

apply HT->R

C	T	H	R	S	G
c	t1	h	r1	s1	g1
c	t1	h	r1	s2	g2

The R column agrees.
<u>Therefore, CH->R holds.</u>

2b)
Use chase test to prove: CHR->G holds in Courses.

C	T	H	R	S	G
c	t1	h	r	s1	g1
c	t2	h	r	s2	g2

apply C->T

C	T	H	R	S	G
c	t1	h	r	s1	g1
c	t1	h	r	s2	g2

The only FD and MVD associated with G are:
CS->G
CS->->G
Since elements in columns C+S do not agree, no further changes for column G.
Column G will never agree.
Therefore, <u>CHR->G does not hold in Courses.</u>

2c)

C+ = {C,T}
T+ = {T}
H+ = {H}
R+ = {R}
S+ = {S}
G+ = {G}
CT+ = {C,T}
CH+ = {C,T,H,R}
CR+ = {C,T,R}
CS+ = {C,S,G}
CG+ = {C,G}
TH+ = {C,T,H,R}
TR+ = {T,R}
TS+ = {T,S}
TG+ ={T,G}
HR+ = {C,H,R}
HS+ = {C,T,H,R,S,G} <-key
HG+ = {H,G}
RS+ = {R,S}
RG+ = {R,G}
SG+ = {S,G}
CTH+ ={C,T,H,R}

CTR+ = {C,T,R}
CTS+ = {C,T,S,G}
CTG+ = {C,T,G}
CHR+ = {C,T,H,R}
CHS+ = {C,T,H,R,S,G} <- superkey
CHG+ = {C,T,H,R,G}
CRS+ = {C,T,R,S,G}
CRG+ = {C,T,R,G}
CSG+ = {C,T,S,G}
THR+ = {T,H,R}
THS+ = {T,H,R,S}
THG+ = {T,H,R,G}
TRS+ = {T,R,S}
TRG+ = {T,R,G}
TSG+ = {T,S,G}
HRS+ = {C,T,H,R,S,G} <-superkey
HRG+ = {C,T,H,R,G}
HSG+ = {H,S,G}
RSG+ = {R,S,G}
…………..

Key for Courses: HS

R1(C,T,H)
{
C->T
TH->D
}
key: TH

R2(C,H,R,G)
{
CH->R
CHG->R(deleted, follow others)
HRG->C
}
key: CHG,HRG

R3(C,H,S)
{
HS->C
}
key: HS

So relations and FDs to run chase test for lossless join:
R1(C,T,H) R2(C,H,R,G) R3(C,H,S)
C->T, TH->C, CH->R, HRG->C, HS->C

C	T	H	R	S	G
c	t	h	r1	s1	g1
c	t2	h	r	s2	g
c	t3	h	r3	s	g3

Since attribute G is not on the right hand side of any FDs, it is not possible to have G column marked with all lowercase letters.
Therefore, R1, R2, R3 decomposition doesn't have a lossless join.

2d)
Find minimal basis:
FD's (check if any follows from the rest):
C+ = {C}
HR+ = {H,R}
HT+ = {H,T}
HS+ ={H,S}
CS+ = {C,T,S}
attributes (check FD with any attribute removed from lhs still follows the rest)
H+ = {H} R+ ={R}   in HR
H+ = {H} T+ = {T}   in HT
H+ = {H} S+ = {S}   in HS
C+ = {C,T} S+ = {S}   in CS

Therefore, the original set of FDs is a minimal basis:
C->T
HR->C
HT->R
HS->R <- schema with superkey
CS->G
Create relations with schemas:
R1(C,T)   C->T   key: C
R2(C,H,R)   CH->R, HR->C   key: CH, HR
R3(T,H,R)   TH->R   key: TH
R4(H,R,S)   HS->R   key: HS
R5(C,S,G)   CS->G   key: CS

Therefore, 3NF decomposition:
R1(C,T)
R2(C,H,R)
R3(T,H,R)
R4(H,R,S)
R5(C,S,G)
with FDs:
C->T
CH->R
HR->C
TH->R
HS->R
CS->G

2e)
Find relations that are not in BCNF:

R1(C,T) C->T key: C
R2(C,H,R) CH->R, HR->C key: CH, HR
R3(T,H,R) TH->R key: TH
R4(H,R,S) HS->R key: HS
R5(C,S,G) CS->G key: CS

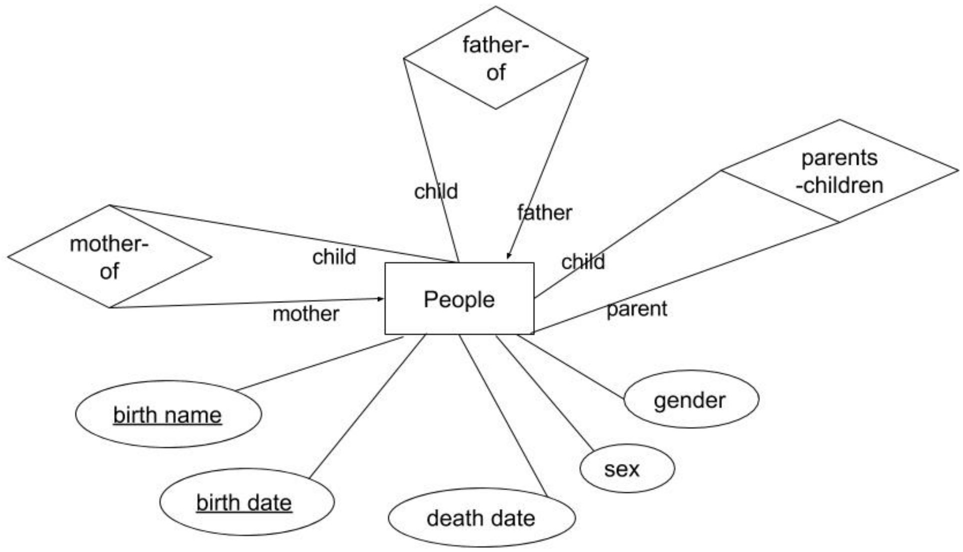
Because among all the FDs, the left hand sides are all superkeys,
<u>all the relations are in BCNF</u>

2f)
Find relations that are not in 4NF:

R1(C,T)   C->->T   trivial
R2(C,H,R)   CH->->R, HR->->C   trivial
R3(T,H,R)   TH->->R   trivial
R4(H,R,S)   HS->->R   trivial
R5(C,S,G)   CS->->G   trivial

Because all the MVDs follow from the FDs are trivial MVDs, there are no non-trivial MVDs. Hence, there are not violations.
All relations are in 4NF.

3)



Note:
A person only has one mother and one father
A right-end arrow on the line “mother” from relation “mother-of” to entity “People”;
a lower-end arrow on the line “father” from relation “father-of” to entity “People”.
Birth name + birth date is the key.