DASC 5333 Database Systems for Data Science
CSCI 4333 Design of Database Systems
Spring 2024
Suggested Solution to Homework #7

[1] For example:

1	Account(Username, Password)
Candidate Keys	[1] Username
Foreign Keys	
Nullable Attributes	
Non-nullable Attributes	Username, Password
Notes	Account(Username, Password)
Normalization Analysis	[FD]: [1] Username -> Password [Highest NF]: BCNF
2	TRMember(TRMemberId, LName, FName, ScreenName, StartTime, EMail, ReferrerTRMemberId, Username)
Candidate Keys	[1] TRMemberId, [2] ScreenName
Foreign Keys	[1] ReferrerTRMemberId references TRMember(TRMemberId), [2] Username references Account(Username)
Nullable Attributes	TRRefererMemberId, EMail
Non-nullable Attributes	TRMemberId, LName, FName, ScreenName, StartTime
Notes	
Normalization Analysis	[FD]: [1] TRMemberId -> LName, FName, ScreenName, StartTime, EMail, ReferrerTRMemberId, Username; [2] ScreenName -> TRMemberId [Highest NF]: BCNF
3	Team(TeamId, TName, Description, Since, OwnerTRMemberId)
Candidate Keys	[1] TeamId
Foreign Keys	[1] OwnerTRMemberId references TRMember(TRMemberId)
Nullable Attributes	Description
Non-nullable Attributes	TeamId, TName, Since, OwnerTRMemberId
Notes	
Normalization Analysis	[FD]: [1] TeamId -> Description, Since, OwnerTRMemberId [Highest NF]: BCNF
4	TeamManager(ManagerId, TRMemberId, TeamId)
Candidate Keys	[1] ManagerId, [2] TRMemberId, TeamId
Foreign Keys	[1] TRMemberId references TRMember(TRMemberId), [2] TeamId references Team(TeamId)
Nullable Attributes	
Non-nullable Attributes	ManagerId, TRMemberId, TeamId
Notes	[1] ManagerId is created as a surrogate primary key.
Normalization Analysis	[FD]: [1] ManagerId -> TRMemberId, TeamId; [2] TRMemberId, TeamId -> ManagerId [Highest NF]: BCNF
5	TeamMember(TMId, TRMemberId, TeamId, JointTime)
Candidate Keys	[1] TMId, [2] TRMemberId, TeamId, JointTime

Foreign Keys	[1] TRMemberId references TRMember(TRMemberId), [2] TeamId references Team(TeamId)
Nullable Attributes	
Non-nullable Attributes	TMId, TRMemberId, TeamId, JointTime
Notes	[1] TMId is created as a surrogate primary key.
Normalization Analysis	[FD]: TMId -> TRMemberId, TeamId, JointTime; [2] TRMemberId, TeamId, JointTime -> TMId [Highest NF]: BCNF
6	RoleLevel(RLNum, Definition)
Candidate Keys	[1] RLNum
Foreign Keys	
Nullable Attributes	
Non-nullable Attributes	RLNum, Definition
Notes	
Normalization Analysis	[FD]: [1] RLNum -> Definition [Highest NF]: BCNF
7	Role(RoleId, RLNum)
Candidate Keys	[1] RoleId
Foreign Keys	[1] RLNum references RoleLevel(RLNum)
Nullable Attributes	
Non-nullable Attributes	
Notes	[1] RoleId is created as a surrogate primary key. [2] We used three relations to implement the three classes Role, UserDefinedRole and StandardRole. It is possible to use only one relation.
Normalization Analysis	[FD]: [1] RoleId -> RLNum [Highest NF]: BCNF
8	TeamSpecificRole(TSRId, TSRName, Description, CTime, RoleId, ManagerId)
Candidate Keys	[1] TSRId, [2] RoleId
Foreign Keys	[1] RoleId references Role(RoleId), [2] ManagerId references TeamManager(ManagerId)
Nullable Attributes	Description
Non-nullable Attributes	TSRId, TSRName, CTime, RoleId, ManagerId
Notes	[1] TSRId is created as a surrogate primary key.
Normalization Analysis	[FD]: [1] TSRId -> TSRName, Description, CTime, RoleId, ManagerId; [2] RoleId -> TSRId [Highest NF]: BCNF
9	StandardRole(SRId, SRName, RoleId)
Candidate Keys	[1] SRId, [2] SRName, [3] RoleId
Foreign Keys	[1] RoleId references Role(RoleId)
Nullable Attributes	
Non-nullable Attributes	SRId, SRName, RoleId
Notes	[1] SRId is created as a surrogate primary key.
Normalization Analysis	[FD]: [1] SRId -> SRName, RoleId; [2] SRName -> SRId; [3] RoleId -> SRId [Highest NF]: BCNF
10	TeamMemberRole(TMRId, TMId, RoleId)
Candidate Keys	[1] TMRId, [2] TMId, RoleId

Foreign Keys	[1] TMId references TeamMember(TMId), [2] RoleId references Role(RoleId)
Nullable Attributes	
Non-nullable Attributes	TMRId, TMId, RoleId
Notes	[1] TMRId is created as a surrogate primary key.
Normalization Analysis	[FD]: [1] TMRId -> TMId, RoleId; [2] TMId, RoleId -> TMRId [Highest NF]: BCNF
11	ProjectStatus(PSId, PSName, Description)
Candidate Keys	[1] PSId
Foreign Keys	
Nullable Attributes	Description
Non-nullable Attributes	PSId, PSName
Notes	[1] PSId is created as a surrogate primary key.
Normalization Analysis	[FD]: [1] PSId -> PSName, Description [Highest NF]: BCNF
12	Project(ProjectId, PName, Description, ExpCompTime, ActCompTime, CurrentStatusId, ParentProjectId, TeamId, CreatorManagerId, AssigneeTMId)
Candidate Keys	[1] ProjectId
Foreign Keys	[1] CurrentStatusId references Status(StatusId), [2] CreatorManagerId references Manger(ManagerId), [3] AssigneeTMId references TeamMember(TMId), [4] ParentProjectId references Project(ProjectId), [5] TeamId references Team(TeamId)
Nullable Attributes	ParentProjectId, AssigneeTMId
Non-nullable Attributes	ProjectId, PName, Description, ExpCompTime, ActCompTime, TeamId, CreatorManagerId, CurrentStatusId
Notes	
Normalization Analysis	[FD]: [1] ProjectId -> PName, Description, ExpCompTime, ActCompTime, CurrentStatusId, ParentProjectId, TeamId, CreatorManagerId, AssigneeTMId [Highest NF]: BCNF
13	Status(StatusId, ProjectId, PSId, PSTime)
Candidate Keys	[1] StatusId, [2] ProjectId, PSId, PSTime
Foreign Keys	[1] ProjectId references Project(ProjectId), [2] PSId references ProjectStatus(PSid)
Nullable Attributes	
Non-nullable Attributes	Status, ProjectId, PSId, PSTime
Notes	
Normalization Analysis	[FD]: [1] StatusId -> ProjectId, PSId, PSTime; [2] ProjectId, PSId, PSTime -> StatusId [Highest NF]: BCNF

[2] Proof of F = {A->B, CD->E, AC->D, E->F} |- AC-> F.

[1] AC-> D (given)
[2] CD-> E (given)
[3] ACC-> E (pseudo-transitivity on [1] and [2])
[4] AC -> E (simplification of [3]

[5] E->F (given)
[5] AC -> F (transitivity on [4] and [5])

[3]

[a] R(A,B,C,D) {B->C, C->DA}
CK:[1] B
Highest NF: 2NF
Reason: C-> DA violates 3NF since C is not a superkey, and D and A are non-prime.
Canonical Cover (optional): {B->C, C->DA}

[b] R(A,B,C,D) {B->C, BC->DA}
CK:[1] B
Highest NF: BCNF
Reason: The LHS of all non-trivial FS are superkeys.
Canonical Cover (optional): {B->ACD}

[c] R(A,B,C,D) {B->C, A->C, AC->D}
CK: [1] AB
Highest NF: 1NF
Reason: B->C, A->C and A->D all violate 2NF as the LHS are a proper subset of a CK (AB) and the RHS are non-prime
Canonical Cover (optional): {B->C, A->CD}

[d] R(A,B,C,D) {B->C, C->AB, AB->D}
CK:[1] B, [2] C
Highest NF: BCNF
Reason: The LHS of all non-trivial FS are superkeys.
Canonical Cover (optional): {B->C, C->ABD}

[4] For F = {RS->PQ, QR->S, S->P, U->ST, STU->R, Q->U}

(a)

P+=P
Q+= PQRSTU
R+ = R
S+ = SP
T+ = T
U+ = PQRSTU

(b) CK: [1] Q, [2] RS and [3] U.

(c) Prime: Q,R,S,U; non-prime: P,T

(d) Canonical Cover: there are many, for examples, {RS-> Q, Q->RSTU, S-> P, U->Q}

(e) Highest NF: 1NF. S->P violates the 2NF.

(f) The decomposition into R1(Q,R,S,T,U) {RS-> Q, Q->RSTU, U->Q} and R2(P,S) {S-> P} are lossless and FD preserving. R1 and R2 are in BCNF. Further decomposition of R1(Q,R,S,T,U) is also acceptable but not desirable.

[5] For Tutor(TutorId, TLName, TFName, StudentId, SLName, SFName, SubjectId, SubjectName, StartDate, Level).

[a] Functional Dependencies:

TutorId -> TLName, TFName
StudentId -> SLName, SFName
SubjectId -> SubjectName
SubjectName -> SubjectId
TutorId, StudentId, SubjectId, Level -> StartDate

[b] The CKs are

1. TutorId, StudentId, SubjectId, Level
2. TutorId, StudentId, SubjectName, Level

[c] Thus, the highest normal form is 1NF as TutorId -> TLName, TFName violates 2NF, for example.

[d] Decomposition:

Tutor(TutorId, TLName, TFName) {TutorId -> TLName, TFName}; BCNF
Student(StudentId, SLName, SFName) {StudentId -> SLName, SFName}; BCNF
Subject(SubjectId, SubjectName) {SubjectId -> SubjectName, SubjectName -> SubjectId}; BCNF
TutorAssignement(TutorId, StudentId, SubjectId, Level, StartDate) {TutorId, StudentId, SubjectId, Level -> StartDate}; BCNF

[6] Minimum: 9, e.g., ACDE is the other candidate key. The 9 SK accordingly: AB, ABC, ABD, ABE, ABCD, ABCE, ABDE, ABCDE and ACDE

Maximum: 20, e.g., C is the other candidate key. The 20 SK accordingly: AB, ABC, ABD, ABE, ABCD, ABCE, ABDE, ABCDE, C, CA, CB, CD, CE, CAD, CAE, CBD, CBE, CDE, CADE, and CBDE.

Thus, the number of SK: {20,24}