

# Normalization

## Company (**CompanyID**, Cname, Location)

Company  $C(CIDCnL)$  - Functional Dependencies (FDs)  $\{CID \rightarrow Cn, CID \rightarrow L\}$

(a) List all candidate keys for Company.

- $CIDCnL$  - all attributes are always a superkey
- $CIDL$  - can get attribute  $Cn$  through  $CID \rightarrow Cn$
- $CIDCn$  - can get attribute  $L$  through  $CID \rightarrow L$
- $CID$  - can get attribute  $Cn$  through  $CID \rightarrow Cn$ , and then get attribute  $L$  through  $CID \rightarrow L$
- Therefore the candidate key is:  $CID$ .

(b) Is Company in 3NF?

- $CID \rightarrow Cn$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? Yes it is a candidate key.
  - (c) Is the right side a prime attribute? No.
- $CID \rightarrow L$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? Yes it is a candidate key.
  - (c) Is the right side a prime attribute? No.

(c) Therefore Company relation is in 3NF

## Department (**DepartmentID**, Dname, FK: CID)

Department  $D(DIDCnCID)$  - FDs  $\{DID \rightarrow Dn, CID \rightarrow DID\}$

(a) List all candidate keys for Department.

- $DIDCnCID$  - all attributes are always a superkey
- $DIDCID$  - can get attribute  $Dn$  through  $DID \rightarrow Dn$
- $DnCID$  - can get attribute  $DID$  through  $CID \rightarrow DID$
- Therefore the candidate keys are:  $DIDCID$  and  $DnCID$ .

(b) Is Department in 3NF?

- $DIDCID \rightarrow Dn$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key -  $DnCID$ .
- $CID \rightarrow DID$ 
  - (a) Is the right side a member of the left side? No.

- (b) Is the left side a super key? No.
- (c) Is the right side a prime attribute? Yes it is part of the candidate keys - *DIDCID*.

(c) Therefore Department is in 3NF.

**Employee (EmployeeID, Fname, Minit, Lname, FK: CID, FK: DID)**

Employee *E*(*EIDFnMLnCIDDDID*) - FDs {*EID* → *Fn*, *EID* → *M*, *EID* → *Ln*, *FnLn* → *EID*, *CIDDDID* → *EID*}

(a) List all candidate keys for Employee.

- *EIDFnMLnCIDDDID* - all attributes are always a superkey
- *EIDMLnCIDDDID* - can get attribute *Fn* through *EID* → *Fn*
- *EIDFnLnCIDDDID* - can get attribute *M* through *EID* → *M*
- *EIDFnMCIDDDID* - can get attribute *Ln* through *EID* → *Ln*
- *FnMLnCIDDDID* - can get attribute *EID* through *FnLn* → *EID*
- *FnMLnCIDDDID* - can get attribute *EID* through *CIDDDID* → *EID*
- *EIDCIDDDID* - can get attribute *Fn* through *EID* → *Fn*, then can get attribute *M* through *EID* → *M*, and then can get attribute *Ln* through *EID* → *Ln*
- Candidate keys for Employee are: *EIDCIDDDID* and *FnMLnCIDDDID*.

(b) Is Employee in 3NF?

- *EID* → *Fn*
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key: *FnMLnCIDDDID*.
- *EID* → *M*
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key: *FnMLnCIDDDID*.
- *EID* → *Ln*
  - (a) Is the right side a member of the left side? No
  - (b) Is the left side a super key? No
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key: *FnMLnCIDDDID*
- *FnLn* → *EID*
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.

(c) Is the right side a prime attribute? Yes it is part of the candidate key:  
*EIDCIDDID*.

- *CIDDID*  $\rightarrow$  *EID*

(a) Is the right side a member of the left side? No.

(b) Is the left side a super key? No.

(c) Is the right side a prime attribute? Yes it is part of the candidate key:  
*EIDCIDDID*.

(c) Therefore Employee is in 3NF.

### **Performance (PerformanceID, SpeedTests, FK: EID)**

Performance *Pe(PIDStEID)* - FDs  $\{PID \rightarrow St, EID \rightarrow PID\}$

(a) List all the candidate keys for Performance.

- *PIDStEID* - all attributes are always a super key
- *PIDEID* - can get attribute *St* through  $PID \rightarrow St$
- *StEID* - can get attribute *PID* through  $EID \rightarrow PID$
- The candidate keys for Performance are: *PIDEID*, *StEID*.

(b) Is Performance in 3NF?

-  $PID \rightarrow St$

(a) Is the right side a member of the left side? No.

(b) Is the left side a super key? No.

(c) Is the right side a prime attribute? Yes it is part of the candidate key:  
*StEID*.

-  $EID \rightarrow PID$

(a) Is the right side a member of the left side? No.

(b) Is the left side a super key? No.

(c) Is the right side a prime attribute? Yes it is part of the candidate key:  
*PIDEID*.

(c) Therefore Performance is in 3NF.

### **Payout (PaystubID, Paystub, Ptotal, Dtotal, FK: EID)**

Payout *Pa(PaEIDPsPtDtEID)* - FDs  $\{PaEID \rightarrow Pt, PaEID \rightarrow Dt, PtDt \rightarrow Ps\}$

(a) List all the candidate keys for Payout.

- *PaEIDPsPtDtEID* - all attributes are always a super key
- *PaEIDPsDtEID* - can get attribute *Pt* through  $PaEID \rightarrow Pt$
- *PaEIDPsPtEID* - can get attribute *Dt* through  $PaEID \rightarrow Dt$
- *PaEIDPtDtEID* - can get attribute *Ps* through  $PtDt \rightarrow Ps$

- $PaEIDPsEID$ - can get attribute  $Pt$  through  $PaEID \rightarrow Pt$ , and then get attribute  $Dt$  through  $PaEID \rightarrow Dt$
- The candidate keys for Payout are:  $PaEIDPtDtEID$ ,  $PaEIDPsEID$ .

(b) Is Payout in 3NF?

- $PaEID \rightarrow Pt$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  $PaEIDPtDtEID$ .
- $PaEID \rightarrow Dt$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? Yes it is a candidate key.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  $PaEIDPtDtEID$ .
- $PtDt \rightarrow Ps$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  $PaEIDPsEID$ .

(c) Therefore Payout is in 3NF.

**Salary (SalaryID, baseSalary, Bonus, FK: EID, FK: PID)**

Salary  $S(SIDBsBoEIDPID)$  - FDs  $\{SID \rightarrow Bs, SID \rightarrow Bo, EIDPID \rightarrow SID\}$

(a) List all candidate keys for Salary.

- $SIDBsBoEIDPID$  - all attributes are always a super key
- $SIDBoEIDPID$  - can get attribute  $Bs$  through  $SID \rightarrow Bs$
- $SIDBsEIDPID$ - can get attribute  $Bo$  through  $SID \rightarrow Bo$
- $BsBoEIDPID$  - can get attribute  $SID$  through  $EIDPID \rightarrow SID$
- $SIDEIDPID$  - can get attribute  $Bs$  through  $SID \rightarrow Bs$ , and then get attribute  $Bo$  through  $SID \rightarrow Bo$
- The candidate key for Salary is  $BsBoEIDPID$ ,  $SIDEIDPID$ .

(b) Is Salary in 3NF?

- $SID \rightarrow Bs$ 
  - (a) Is the right side a member of the left side? No
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  $BsBoEIDPID$ .

- $SID \rightarrow Bo$ 
  - (a) Is the right side a member of the left side? No
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $BsBoEIDPID$ .
- $EIDPID \rightarrow SID$ 
  - (a) Is the right side a member of the left side? No
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $SIDEIDPID$ .

(c) Therefore Salary is in 3NF.

**Leave (leaveID, leavePay, fromDate, toDate, FK: EID, FK: PID)**

Leave  $L(LIDLpFdTdEIDPID)$  - FDs  $\{LID \rightarrow Lp, LID \rightarrow Fd, LID \rightarrow Td, EIDPID \rightarrow LID\}$

(a) List all candidate keys for Leave.

- $LIDLpFdTdEIDPID$  - all attributes are always a super key
- $LIDFdTdEIDPID$  - can get attribute  $Lp$  through  $LID \rightarrow Lp$
- $LIDLpTdEIDPID$  - can get attribute  $Fd$  through  $LID \rightarrow Fd$
- $LIDLpFdEIDPID$  - can get attribute  $Td$  through  $LID \rightarrow Td$
- $LpFdTdEIDPID$  - can get attribute  $LID$  through  $EIDPID \rightarrow LID$
- $LIDEIDPID$  - can get attribute  $Lp$  through  $LID \rightarrow Lp$ , then get attribute  $Fd$  through  $LID \rightarrow Fd$ , and then get attribute  $Td$  through  $LID \rightarrow Td$
- The candidate keys in Leave are:  $LpFdTdEIDPID, LIDEIDPID$ .

(b) Is Leave in 3NF?

- $LID \rightarrow Lp$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $LpFdTdEIDPID$ .
- $LID \rightarrow Fd$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $LpFdTdEIDPID$ .
- $LID \rightarrow Td$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.

(c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $LpFdTdEIDPID$ .

-  $EIDPID \rightarrow LID$

(a) Is the right side a member of the left side? No.

(b) Is the left side a super key? No.

(c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $LIDEIDPID$ .

(c) Therefore Leave is in 3NF

**Tax (TaxID, StateTax, FederalTax, FK: CID, FK: CID, FK: PID)**

Tax  $T(TIDSxFxCIDEIDPID)$  - FDs  $\{TID \rightarrow Sx, TID \rightarrow Fx, CID \rightarrow Sx, EIDPID \rightarrow TID\}$  (Found online that state tax changes can have an affect on federal tax)

(a) List all the candidate keys for Tax.

- $TIDSxFxCIDEIDPID$ - all attributes are always a super key
- $TIDFxIDEIDPID$  - can get attribute  $Sx$  through  $TID \rightarrow Sx$
- $TIDSxIDEIDPID$  - can get attribute  $Fx$  through  $TID \rightarrow Fx$
- $TIDFxIDEIDPID$  - can get attribute  $Sx$  through  $CID \rightarrow Sx$
- $SxFxCIDEIDPID$  - can get attribute  $TID$  through  $EIDPID \rightarrow TID$
- $TIDCIDEIDPID$  - can get attribute  $Sx$  through  $TID \rightarrow Sx$ , and then get attribute  $Fx$  through  $TID \rightarrow Fx$
- The candidate keys for Tax are:  $SxFxCIDEIDPID$ ,  $TIDFxIDEIDPID$ ,  $TIDCIDEIDPID$ .

(b) Is Tax 3NF?

-  $TID \rightarrow Sx$

(a) Is the right side a member of the left side? No.

(b) Is the left side a super key? No.

(c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $SxFxCIDEIDPID$ .

-  $TID \rightarrow Fx$

(a) Is the right side a member of the left side? No.

(b) Is the left side a super key? No.

(c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $SxFxCIDEIDPID$ ,  $TIDFxIDEIDPID$ .

-  $CID \rightarrow Sx$

(a) Is the right side a member of the left side? No.

(b) Is the left side a super key? No.

(c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $SxFxCIDEIDPID$ .

- $EIDPID \rightarrow TID$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $TIDCIDEIDPID, TIDFxCIDEIDPID$ .

(c) Therefore Tax is in 3NF.

### **Attendance (AttendanceID, Absences, Tardies, FK: EID, FK: PID)**

Attendance  $A(AIDA bTaEIDPID)$  - FDs  $\{AID \rightarrow Ab, AID \rightarrow Ta, EIDPID \rightarrow AID\}$

- (a) List all the candidate keys for Attendance.
  - $AIDA bTaEIDPID$ - all attributes will always be a super key
  - $AIDTaEIDPID$  - can get attribute  $Ab$  through  $AID \rightarrow Ab$
  - $AIDA bEIDPID$  - can get attribute  $Ta$  through  $AID \rightarrow Ta$
  - $AIDEIDPID$  - can get attribute  $Ab$  through  $AID \rightarrow Ab$ , and then get attribute  $Ta$  through  $AID \rightarrow Ta$
  - $AbTaEIDPID$  - can get attribute  $AID$  through  $EIDPID \rightarrow EIDPID$
  - The candidate keys for Attendance are:  $AIDEIDPID, AbTaEIDPID$ .

(b) Is Attendance in 3NF?

- $AID \rightarrow Ab$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $AbTaEIDPID$ .
- $AID \rightarrow Ta$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $AbTaEIDPID$ .
- $EIDPID \rightarrow AID$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is part of the candidate key:  
 $AIDEIDPID$ .

(c) Therefore Attendance is in 3NF.

### **Benefits (BenefitsID, Retirement, Insurance, FK: EID, FK: PID)**

Benefits  $B(BIDRIEIDPID)$  - FDs  $\{BID \rightarrow R, BID \rightarrow I, EIDPID \rightarrow BID\}$

(a) List all the candidate keys for Benefits.

- $BIDRIEIDPID$  - all attributes will always be a super key
- $BIDIEIDPID$  - can get attribute  $R$  through  $BID \rightarrow R$
- $BIDREIDPID$  - can get attribute  $I$  through  $BID \rightarrow I$
- $RIEIDPID$  - can get attribute  $BID$  through  $EIDPID \rightarrow BID$
- $BIDEIDPID$  - can get attribute  $R$  through  $BID \rightarrow R$ , and then get attribute  $I$  through  $BID \rightarrow I$
- The candidate key for Benefits is:  $RIEIDPID, BIDEIDPID$ .

(b) Is Benefits in 3NF?

- $BID \rightarrow R$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is a part of the candidate key:  $RIEIDPID$ .
- $BID \rightarrow I$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is a part of the candidate key:  $RIEIDPID$ .
- $EIDPID \rightarrow BID$ 
  - (a) Is the right side a member of the left side? No.
  - (b) Is the left side a super key? No.
  - (c) Is the right side a prime attribute? Yes it is a part of the candidate key:  $BIDEIDPID$ .

(c) Therefore Benefits is in 3NF.