Metoda dekompozicije

Metoda dekompozicije

- Jedna od metoda normalizacije
- Zasnovana je na pstupnom razvijanju šeme relacije (U,C) dok se ne dobije skup šema relacija u željenoj normalnoj formi (BCNF)
- (U, F) dekomponujemo na skup šema relacija $S = \{(R_i, F_i) | i = 1, \dots, n\}$ koje su u BCNF
- Neke funkcionalne zavisnosti iz polaznog skupa mogu biti izgubljene

Izbor f.z. za dekompoziciju

Kriterijum P1

- Uvodi se uslov koji garantuje da se pri dekompoziciji neće izgubiti neka f.z. ali ne garantuje da će se dobiti skup šema relacija u BCNF
- $Y \to A$ tako da važi $(A \nsubseteq Y) \wedge (R \nsubseteq Y^+) \wedge (F^+ = \left(F_{|Y(R \backslash A)} \cup F_{|YA}\right)^+)$

Kriterijum P2

- $Y \to A$ tako da važi $(A \nsubseteq Y) \wedge (AY \subset R) \wedge (F^+ = \left(F_{|Y(R \backslash A)} \cup F_{|YA}\right)^+)$

Izbor f.z. za dekompoziciju

Kriterijum P3

- netrivijalna funkcija koja nije posledica zavisnosti ključa. Ovaj uslov obezbeđuje dolazak u BCNF
- $Y \rightarrow A$ tako da važi $(A \not\subseteq Y) \wedge (R \not\subseteq Y^{+})$

Završne napomene

- Redosled kriterijuma : P1, P2 pa ako ne mogu ova dva tek onda po P3
- Ne treba dekomponovati na osnovu trivijalnih f.z.
- Na početku se ne izabira f.z. koja sa leve strane sadrži ključ.

Spojivost bez gubitaka

Teorema o spojivosti bez gubitaka

- Ova teorema uvodi potreban i dovoljan uslov koji treba da bude zadovoljen da bi skup šema relacija predstavljao dekompoziciju sa spojem bez gubitaka s obzirom na skup funkcionalnih zavisnosti.
- **Neka je $S = \{(R_1, F_1), (R_2, F_2)\}$ jedna dekompozicija šeme univerzalne relacije (U, F), gde je $U = R_1 \cup R_2$. S je dekompozicija sa spojem bez gubitaka s obzirom na F akko važi:**

$$R_1 \cap R_2 \rightarrow R_1 \setminus R_2 \in F^+ \text{ ili } R_1 \cap R_2 \rightarrow R_2 \setminus R_1 \in F^+$$

Spojivost bez gubitaka

- Posledica ove teoreme je da $R_1 \cap R_2$ sadrži ključ bilo šeme relacije (R_1, F_1), bilo (R_2, F_2).

$$\left.\begin{array}{r} R_1 \cap R_2 \to\ R_1 \backslash R_2 \\ R_1 \cap R_2 \subseteq\ R_1 \cap R_2 \end{array}\right\} \xRightarrow{proš.} R_1 \cap R_2 \to (R_1 \backslash R_2) \cup (R_1 \cap R_2)$$

$$\Rightarrow R_1 \cap R_2 \to R_1 \in F^+$$

- Analogno druga

$$\left.\begin{array}{c} R_1 \cap R_2 \to\ R_1 \in F^+ \\ R_2 \subseteq\ R_2 \end{array}\right\} \xRightarrow{proš.} R_2 \to R_1 R_2 \in F^+$$

R_2 sadrži ključ šeme univerzalne relacije

Primer 1

- $U = \{A, B, C\}$
- $F = \{AB \rightarrow C, C \rightarrow B\}$

Primer 1

Ključ univerzalne šeme relacije

- $\left.\begin{matrix}(AB)^{+}=ABC\\(AC)^{+}=ACB\end{matrix}\right\} \Rightarrow \boldsymbol{K} = \{\boldsymbol{AB}, \boldsymbol{AC}\}$

Primer 1

Dekompozicija

Po P1

$\boldsymbol{AB} \to \boldsymbol{C} : C \nsubseteq AB, (AB)^+ = ABC \supseteq ABC = U$ – ne odgovara
$\boldsymbol{C} \to \boldsymbol{B} : B \subseteq C, C^+ = CB \nsupseteq ABC,$
$F_{|AC} = \{\}\ F_{|BC} = \{C \to B\} \Rightarrow F^+ \neq \{C \to B\}^+$

Po P2

$\boldsymbol{AB} \to \boldsymbol{C} : ABC \not\subset ABC$ – ne odgovara
$\boldsymbol{C} \to \boldsymbol{B} : CB \subset ABC, F^+ = \{C \to B\}^+$ – ne odgovara

Po P3

$\boldsymbol{AB} \to \boldsymbol{C} : C \nsubseteq AB\ \wedge ABC \subseteq ABC$ – ne odgovara
$\boldsymbol{C} \to \boldsymbol{B} : B \nsubseteq C\ \wedge ABC \nsubseteq C^+ = CB$ – odgovara

Primer 1

$$(\{A, B, C\}, \{AB \rightarrow C, C \rightarrow B\})$$

$$\boldsymbol{C \rightarrow B}$$

Ali smo izgubili $AB \rightarrow C$

$$(\{B, C\}, \{C \rightarrow B\})$$

BCNF

$$(\{A, C\}, \{\})$$

BCNF

Primer 1

- $S = \{(\{B, C\}, \{C \rightarrow B\}), (\{A, C\}, \{\}\ )\}$
- $S = \{N_1(\{C, B\}, \{C\}), N_2(\{A, C\}, \{AC\})\}$

- Referencijalni integriteti:

  $N_2\ [C] \subseteq N_1[C]$

Primer 2

- $U = \{A, B, C, D, E, F, G\}$
- $F = \{A \rightarrow B, C \rightarrow D, D \rightarrow C, E \rightarrow F,$
  $E \rightarrow C, E \rightarrow D, AC \rightarrow G, AC \rightarrow E\}$
- Metodom dekompozicije izgenerisati šemu baze podataka (S, I)

Primer 2

Ključ univerzalne šeme relacije

- $\boldsymbol{K = \{AC, AD, AE\}}$

Primer 2

Dekompozicija

- $\boldsymbol{A} \rightarrow \boldsymbol{B} : B \nsubseteq A, A_F^+ = AB \nsupseteq U$
  $F_{|AB} = \{A \rightarrow B\}, F_{|A(U \setminus B)} = F \setminus \{A \rightarrow B\},$
  $F^+ = \left(F_{|AB} \cup F_{|A(U \setminus B)}\right)^+$
  - zadovoljava P1

Primer 2

$$\begin{tikzcd}
(U, F) \arrow[d] \arrow[dr, "\mathbf{P1} : \boldsymbol{A \to B}"] & \\
(\{A, B\}, \{A \to B\}) & (\{A, C, D, E, F, G\}, \{C \to D, D \to C, E \to F, E \to C, E \to D, AC \to G, AC \to E\})
\end{tikzcd}$$

Primer 2

- $\boldsymbol{E} \rightarrow \boldsymbol{F} : F \nsubseteq E, E_{F_1}^{+} = EFCD \nsupseteq R_1$
  $F_{1_{|EF}} = \{E \rightarrow F\}, F_{1_{|E(R_1 \setminus F)}} = F_1 \setminus \{E \rightarrow F\}$
  - zadovoljava P1

Primer 2

$(\{A, C, D, E, F, G\}, \{C \to D, D \to C, E \to F,$
$E \to C, E \to D, AC \to G, AC \to E\})$

$\mathbf{P1}: \boldsymbol{E \to F}$

$(\{E, F\}, \{E \to F\})$

$(\{A, C, D, E, G\}, \{C \to D, D \to C, E \to C,$
$E \to D, AC \to G, AC \to E\})$

Primer 2

- $\boldsymbol{C \rightarrow D}$ **:** $D \nsubseteq C, C_{F_2}^{+} = CD \nsupseteq R_2$

  $F_{2_{|CD}} = \{C \rightarrow D, D \rightarrow C\},$

  $F_{2_{|C(R_2 \setminus D)}} = \{E \rightarrow C, AC \rightarrow G, AC \rightarrow E\}$

  $\left.\begin{matrix} E \rightarrow C \\ C \rightarrow D \end{matrix}\right\} \overset{A_3}{\Rightarrow} E \rightarrow D$

  – zadovoljava P1

Primer 2

$$
\begin{tikzcd}
(\{A,C,D,E,G\},\{C \to D, D \to C, E \to C, E \to D, AC \to G, AC \to E\}) \arrow[d] \arrow[dr, "\mathbf{P1}:\ \boldsymbol{C \to D}"] & \\
(\{C,D\},\{C \to D, D \to C\}) & (\{A,C,E,G\},\{E \to C, AC \to G, AC \to E\})
\end{tikzcd}
$$

Primer 2

- $\boldsymbol{E} \rightarrow \boldsymbol{C} : C \nsubseteq E, E_{F_3}^{+} = EC \nsupseteq R_3$
  $F_{3_{|EC}} = \{E \rightarrow C\}, F_{3_{|E(R_3 \setminus C)}} = \{\}$
  - ne zadovoljava P1,P2
- $\boldsymbol{AC} \rightarrow \boldsymbol{G} : G \nsubseteq AC, (AC)_{F_3}^{+} = ACGE = R_3, ACG \subset R_3$
  $F_{3_{|ACG}} = \{AC \rightarrow G\}, F_{3_{|AC(R_3 \setminus G)}} = \{E \rightarrow C, AC \rightarrow E\} -$
  - zadovoljava P2
- $\boldsymbol{AC} \rightarrow \boldsymbol{E} : E \nsubseteq AC, (AC)_{F_3}^{+} = ACEG = R_3, ACE \subset R_3$
  $F_{3_{|ACE}} = \{AC \rightarrow E, E \rightarrow C\}, F_{3_{|AC(R_3 \setminus E)}} = \{AC \rightarrow G\}$
  - zadovoljava P2

Primer 2

$$\begin{tikzcd}
(\{A, C, E, G\}, \{ E \rightarrow C, AC \rightarrow G, AC \rightarrow E\}) \arrow[d] \arrow[dr, "\mathbf{P2:}\ \boldsymbol{AC \rightarrow G}"] & \\
(\{A, C, G\}, \{AC \rightarrow G\}) & (\{A, C, E\}, \{E \rightarrow C, AC \rightarrow E\})
\end{tikzcd}$$

Primer 2

- $\boldsymbol{E} \rightarrow \boldsymbol{C} : C \nsubseteq E, E_{F_4}^{+} = EC \nsupseteq R_4$
  $F_{4_{|EC}} = \{E \rightarrow C\}, F_{4_{|EA}} = \{\}$
  - zadovoljava samo P3
- $\boldsymbol{AC} \rightarrow \boldsymbol{E} : E \nsubseteq AC, (AC)_{F_4}^{+} = ACE = R_4, ACE \not\subset R_4$
  - ne zadovoljava nijedno pravilo

Primer 2

$$
\begin{tikzcd}
& (\{A, C, E\}, \{E \rightarrow C, AC \rightarrow E\}) \arrow[dl] \arrow[dr, "\mathbf{P3}\,:\ \boldsymbol{E \rightarrow C}"] & \\
(\{E, C\}, \{E \rightarrow C\}) & & (\{A, E\}, \{\})
\end{tikzcd}
$$

- Izgubljena je f.z. $AC \longrightarrow E$
- Sve šeme relacija su u BCNF

Primer 2

- $S = \left\{ \begin{matrix} (\{A,B\},\{A \rightarrow B\}), (\{E,F\},\{E \rightarrow F\}), \\ (\{C,D\},\{C \rightarrow D, D \rightarrow C\}),\ (\{A,C,G\},\{AC \rightarrow G\}), \\ (\{E,C\},\{E \rightarrow C\}), (\{A,E\},\{\}) \end{matrix} \right\}$
- $S = \left\{ \begin{matrix} N_1(\{A,B\},\{A\}), N_2(\{E,F\},\{E\}), N_3(\{C,D\},\{C,D\}), \\ N_4(\{A,C,G\},\{AC\}),\ N_5(\{E,C\},\{E\}), N_6(\{A,E\},\{AE\}) \end{matrix} \right\}$
- N1,N2,N3,N4,N5,N6 - BCNF
- Spojivost koja garantuje da će skup šema i dalje biti u BCNF

  $\boldsymbol{bcnf}(R_i, F_i) \wedge \boldsymbol{bcnf}(R_j, F_j) \wedge K_i \cap K_j \neq \emptyset \Rightarrow \boldsymbol{bcnf}(R_k, F_k)$
- Spajanjem (R_i, F_i) i (R_j, F_j) uz uslov $K_i \cap K_j \neq \emptyset$ dobija se (R_k, F_k), za koju važi $R_k = R_i \cup R_j$, $F_k = F|_{R_i \cup R_j}$ i $K_k = K_i \cup K_j$
- N2 i N5 su u BCNF, imaju zajednički ključ pa u spojive, nastaje $N_2' = (\{E,F,C\},\{E\})$

Primer 2

- $S = \left\{ \begin{array}{c} (\{A, B\}, \{A \to B\}), (\{E, C, F\}, \{E \to F, E \to C\}), \\ (\{C, D\}, \{C \to D, D \to C\}),\ (\{A, C, G\}, \{AC \to G\}), \\ (\{A, E\}, \{\}) \end{array} \right\}$
- $S = \left\{ \begin{array}{c} N_1(\{A, B\}, \{A\}), N_2'(\{E, F, C\}, \{E\}), N_3(\{C, D\}, \{C, D\}), \\ N_4(\{A, C, G\}, \{AC\}), N_6(\{A, E\}, \{AE\}) \end{array} \right\}$
- N_1, N_2', N_3, N_4, N_6 – BCNF
- **Spojivost na osnovu ekvivalentnih ključeva**
- $(K_i)_F^+ = (K_j)_F^+$ - šeme relacija se (R_i, F_i),(R_j, F_j) se spajaju u jednu šemu relacije
- $(AC)^+ = ACBDGEF = (AE)^+$ – spajamo N_4 i N_6
- $N_4' = (\{A, C, G, E\}, \{AC, AE\})$

Primer 2

- $S = \left\{ \begin{matrix} (\{A,B\},\{A \to B\}), (\{E,C,F\},\{E \to F, E \to C\}), \\ (\{C,D\},\{C \to D, D \to C\}), \\ (\{A,C,G,E\},\{AC \to G, AC \to E, E \to C\}) \end{matrix} \right\}$
- $S = \left\{ \begin{matrix} N_1(\{A,B\},\{A\}), N_2'(\{E,F,C\},\{E\}), N_3(\{C,D\},\{C,D\}), \\ N_4'(\{A,C,G,E\},\{AC,AE\}) \end{matrix} \right\}$
- N1, N2’ i N3 – BCNF; N4’ – 3NF
- Spajanjem nadoknadjena izgubljena f.z. $AC \to E$

Primer 2

- Da li je obezbeđen spoj bez gubitaka informacija?
  - N_4'sadrži ključ šeme univerzalne relacije AC, AE
- Da nije bilo tako morali bi smo dodati šemu relacije u S koja sadrži ključ čeme univerzalne relacije.
- Referencijalni integriteti:
  - $N_4'[A] \subseteq N_1[A]$
  - $N_4'[C] \subseteq N_3[C]$
  - $N_4'[E] \subseteq N_2'[E]$
  - $N_2'[C] \subseteq N_3[C]$

Primer 3

- $U = \{A, B, C, D, E, F\}$
- $F = \{AB \rightarrow C, AB \rightarrow D, CD \rightarrow E, C \rightarrow A, D \rightarrow B, B \rightarrow F\}$
- Metodom dekompozicije izgenerisati šemu baze podataka (S, I)

Primer 3

Ključ univerzalne šeme relacije

- $(ABCDEF)^{+} = U$
- $(ABCDE)^{+} = ABCDEF$
- $(ABCD)^{+} = ABCDEF$
- $(ABC)^{+} = ABCDEF$
- $(AB)^{+} = ABCDEF$
  - $A^{+} = A$
  - $B^{+} = BF$
- $C \to A : (BC)^{+} = BCADEF = U$
  - $C^{+} = CA \neq U$
- $D \to B : (AD)^{+} = ADBFCE = U$
  - $D^{+} = DBF \neq U$
- $(CD)^{+} = ADBFCE = U$

- $\boldsymbol{K = \{AB, BC, AD, CD\}}$

Primer 3

Dekompozicija

- $\boldsymbol{AB \rightarrow C, AB \rightarrow D, CD \rightarrow E}$ sadrže ključ sa leve strane pa najpre pokušavamo dekompoziciju po ostalim f.z. iz F.
- $\boldsymbol{C \rightarrow A, D \rightarrow B}$ ne zadovoljava P1 – dokazati!
- $\boldsymbol{B \rightarrow F}$: $F \notin B, B^{+} = BF \not\supseteq U$
  $F_{|BF} = \{B \rightarrow F\}$
  $F_{|ABCDE} = F \setminus \{B \rightarrow F\}$
  - zadovoljava P1

Primer 3

$$
\begin{tikzcd}
(U, F) \arrow[d] \arrow[dr, "\mathbf{P1}: \boldsymbol{B \rightarrow F}"] & \\
(\{B, F\}, \{B \rightarrow F\}) & (\{A, B, C, D, E\}, \{AB \rightarrow C, AB \rightarrow D, CD \rightarrow E, C \rightarrow A, D \rightarrow B\})
\end{tikzcd}
$$

Primer 3

- Nijedna f.z. ne zadovoljava P1 – dokazati!
- Zatim proveravamo $\boldsymbol{C} \rightarrow \boldsymbol{A}, \boldsymbol{D} \rightarrow \boldsymbol{B}$ po P2 – dokazati da ne zadovoljava!
- $\boldsymbol{AB} \rightarrow \boldsymbol{C}, \boldsymbol{AB} \rightarrow \boldsymbol{D} -$ proveriti da li zadovoljava P2
- $\boldsymbol{CD} \rightarrow \boldsymbol{E} : E \notin CD, (CD)^{+} = CDEAB = R_1$, pa ne zadovoljava P1, $CDE \subset R_1$
  $F_{1_{|CDE}} = \{CD \rightarrow E\}$
  $F_{1_{|ABCD}} = F_1 \backslash \{CD \rightarrow E\}$
  - zadovoljava P2

Primer 3

$$
\begin{tikzcd}
(\{A, B, C, D, E\}, \{AB \rightarrow C, AB \rightarrow D, CD \rightarrow E, C \rightarrow A, D \rightarrow B\}) \arrow[d] \arrow[dr, "\mathbf{P2}: \boldsymbol{CD \rightarrow E}"] & \\
(\{C, D, E\}, \{CD \rightarrow E\}) & (\{A, B, C, D\}, \{AB \rightarrow C, AB \rightarrow D, C \rightarrow A, D \rightarrow B\})
\end{tikzcd}
$$

Primer 3

- Nijedna f.z. ne zadovoljava P1 – dokazati!
- $\boldsymbol{AB} \rightarrow \boldsymbol{C}: C \notin AB, (AB)^{+} = ABCD = R_2, ABC \subset R_2$
  $F_{2_{|ABC}} = \{AB \rightarrow C, C \rightarrow A\}$
  $F_{1_{|ABD}} = \{AB \rightarrow D, D \rightarrow B\}$
  – zadovoljava P2

Primer 3

$$(\{A, B, C, D\}, \{AB \to C, AB \to D, C \to A, D \to B\})$$

$$\mathbf{P2}: \boldsymbol{AB \to C}$$

$$(\{A, B, C\}, \{AB \to C, C \to A\}) \qquad (\{A, B, D\}, \{AB \to D, D \to B\})$$

Možemo dalje dekomponovati obe šeme

Dokazati da $C \to A$ i $D \to B$ jedino zadovoljavaju P3, ostale ne.

Primer 3

$(\{A, B, C\}, \{AB \to C, C \to A\})$ $(\{A, B, D\}, \{AB \to D, D \to B\})$

$\mathbf{P3}: \boldsymbol{C \to A}$ $\mathbf{P3}: \boldsymbol{D \to B}$

$(\{A, C\}, \{C \to A\})$ $(\{C, B\}, \{\})$ $(\{B, D\}, \{D \to B\})$ $(\{A, D\}, \{\})$

izgubljene su f.z. $AB \to C, AB \to D$

Primer 3

- $S = \{N_1(\{A, C\}, \{C\}), N_2(\{B, C\}, \{BC\}),$ $N_3(\{B, D\}, \{D\}), N_4(\{A, D\}, \{AD\}),$ $N_5(\{C, D, E\}, \{CD\}), N_6(\{B, F\}, \{B\})\}$
- $(BC)^+ = BCAFDE = (AD)^+ = (CD)^+$ – spajamo N_2, N_4 i N_5
- N_2' = $(\{B, C, D, E, A\}, \{BC, AD, CD\})$

Primer 3

- $S = \{N_1(\{A, C\}, \{C\}), N_2' (\{B, C, D, E, A\}, \{BC, AD, CD\})$
  $N_3(\{B, D\}, \{D\}), N_4(\{B, F\}, \{B\})\}$
- Očuvan je spoj bez gubitaka jer se ključ šeme univerzalne relacije nalazi u šemama relacija N_2, N_4 ,N_5
- $I = \{N_2'[C] \subseteq N_1[C],$
  $N_2'[D] \subseteq N_3[D],$
  $N_2'[B] \subseteq N_4[B],$
  $N_3[B] \subseteq N_4[B]\}$

Primer 4

- $U = \{A, B, C, D, E, F, G\}$
- $F = \{A \to B, AC \to D, B \to D, C \to F, CD \to E, AC \to G,$
  $EF \to G\}$
- Metodom dekompozicije izgenerisati šemu baze podataka (S, I)

Primer 4

Ključ univerzalne šeme relacije

- A, C se moraju nalaziti u ključu
- $(AC)^+ = ACBDFEG$

  $A^+ = ABD$

  $C^+ = CF$
- $\boldsymbol{K = \{AC\}}$

Primer 4

Redukcija levih strana

- $AC \rightarrow D : A^{+} = ABD$ – redukuje se na $A \rightarrow D$
- $CD \rightarrow E : C^{+} = CF, D^{+} = D$ – ne može se redukovati
- $AC \rightarrow G : A^{+} = ABD, C^{+} = CF$ – ne može se redukovati
- $EF \rightarrow G : E^{+} = E, F^{+} = F$ – ne može se redukovati
- $\boldsymbol{F_1 = \{A \rightarrow B, A \rightarrow D, B \rightarrow D, C \rightarrow F, CD \rightarrow E, AC \rightarrow G, EF \rightarrow G\}}$

Primer 4

Neredundantni pokrivač

- $A \to B : B \notin A^+_{F_1 \setminus \{A \to B\}} = AD$
- $A \to D : D \in A^+_{F_1 \setminus \{A \to D\}} = ABD$ – suvišna
- $B \to D : D \notin B^+_{F_1 \setminus \{B \to D\}} = B$
- $C \to F : F \notin C^+_{F_1 \setminus \{C \to F\}} = C$
- $CD \to E : E \notin (CD)^+_{F_1 \setminus \{CD \to E\}} = CDF$
- $AC \to G : G \in (AC)^+_{F_1 \setminus \{AC \to G\}} = ACBDEFG$ – suvišna
- $EF \to G : G \notin (CD)^+_{F_1 \setminus \{EF \to G\}} = EF$
- **Kanonički pokrivač**

$$\boldsymbol{G = \{A \to B, B \to D, C \to F, CD \to E, EF \to G\}}$$

Primer 4

Dekompozicija

- $\boldsymbol{EF} \rightarrow \boldsymbol{G}$ **:** $G \notin EF, (EF)^{+} = EFG \nsupseteq U$
  $G_{|EF} = \{EF \rightarrow G\}$
  $G_{|U \backslash \{G\}} = G \backslash \{EF \rightarrow G\}$

Primer 4

$$
\begin{tikzcd}
(U, G) \arrow[d] \arrow[dr, "\mathbf{P1}: \boldsymbol{EF \to G}"] & \\
(\{E, F, G\}, \{EF \to G\}) & (\{A, B, C, D, E, F\}, \{A \to B, B \to D, C \to F, CD \to E\})
\end{tikzcd}
$$

Primer 4

- $\boldsymbol{C} \rightarrow \boldsymbol{F}: F \notin CF, (C)^{+} = CF \not\supseteq R_1$
  $G_{1_{|EF}} = \{C \rightarrow F\}$
  $G_{1_{|ABCDE}} = G_1 \backslash \{C \rightarrow F\}$

Primer 4

$$(\{A, B, C, D, E, F\}, \{A \rightarrow B, B \rightarrow D, C \rightarrow F, CD \rightarrow E\})$$

$$\mathbf{P1}: \boldsymbol{C \rightarrow F}$$

$$(\{C, F\}, \{C \rightarrow F\}) \quad (\{A, B, C, D, E\}, \{A \rightarrow B, B \rightarrow D, CD \rightarrow E\})$$

Primer 4

- $\boldsymbol{CD \to E}$ **:** $E \notin CD, (CD)^+ = CDE \not\supseteq R_2$
  $G_{2_{|CDE}} = \{CD \to E\}$
  $G_{2_{|ABCD}} = \{A \to B, B \to D\}$

Primer 4

$$
\begin{tikzcd}
(\{A, B, C, D, E\}, \{A \to B, B \to D, CD \to E\}) \arrow[d] \arrow[dr, "\mathbf{P1}: \boldsymbol{CD} \to \boldsymbol{E}"] & \\
(\{C, D, E\}, \{CD \to E\}) & (\{A, B, C, D\}, \{A \to B, B \to D\})
\end{tikzcd}
$$

Primer 4

- $\boldsymbol{B} \to \boldsymbol{D}: D \notin B, B^+ = BD \not\supseteq R_3$
  $G_{3_{|BD}} = \{B \to D\}$
  $G_{3_{|ABC}} = \{A \to B\}$

Primer 4

$$\begin{tikzcd}
(\{A, B, C, D\}, \{A \to B, B \to D\}) \arrow[d] \arrow[dr, "\mathbf{P1}: \boldsymbol{B \to D}"] & \\
(\{B, D\}, \{B \to D\}) & (\{A, B, C\}, \{A \to B\})
\end{tikzcd}$$

Primer 4

- $(\{A, B, C\}, \{A \rightarrow B\})$ nije u BCNF pa dekomponujemo dalje (ključ je AC)
- $\boldsymbol{A \rightarrow B} : B \notin A, A^+ = AB \not\supseteq R_4$
  $G_{4_{|AB}} = \{A \rightarrow B\}$
  $G_{3_{|AC}} = \{\}$

Primer 4

$$
\begin{tikzcd}
(\{A, B, C\}, \{A \rightarrow B\}) \arrow[d] \arrow[drr, "\mathbf{P1}\text{: } \boldsymbol{A \rightarrow B}"] & & \\
(\{A, B\}, \{A \rightarrow B\}) & & (\{A, C\}, \{\})
\end{tikzcd}
$$

Primer 4

- $S = \{N_1(\{A, B\}, \{A\}), N_2(\{A, C\}, \{AC\}),$
  $N_3(\{B, D\}, \{B\}), N_4(\{C, D, E\}, \{CD\}),$
  $N_5(\{C, F\}, \{C\}), N_6(\{E, F, G\}, \{EF\})\}$
- Očuvan je spoj bez gubitaka jer se ključ šeme univerzalne relacije nalazi u šemI N_2
- $I = \{N_2[A] \subseteq N_1[A],$
  $N_2[C] \subseteq N_5[C],$
  $N_1[C] \subseteq N_5[C],$
  $N_4[C] \subseteq N_5[C]\}$

Primer 5

- $U = \{A, B, C, D, E, F, G, H\}$
- $F = \{ABC \rightarrow D, ABC \rightarrow E, AG \rightarrow H, A \rightarrow G, G \rightarrow B, H \rightarrow A, H \rightarrow E, AC \rightarrow H\}$
- Metodom dekompozicije izgenerisati šemu baze podataka (S, I)

Primer 5

Ključ univerzalne šeme relacije

- $\boldsymbol{K = \{ACF\}}$

Primer 5

Redukcija levih strana

- $ABC \to D : A^+ = AGBHE, B^+ = B, C^+ = C,$
  $(AB)^+ = ABGHE, (AC)^+ = ACGBDEH$
  – redukuje se na $AC \to D$
- $ABC \to E$ – redukuje se na $A \to E$
- $AG \to H$ – redukuje se na $A \to H$
- $AC \to H$ – redukuje se na $A \to H$
- $\boldsymbol{F_1 = \{AC \to D, A \to E, A \to H, A \to G, G \to B, H \to A,}$
  $\boldsymbol{H \to E\}}$

Primer 5

Neredundantni pokrivač

- $AC \to D : D \notin (AC)^{+}_{F_1 \setminus \{AC \to D\}} = ACEHGB$
- $A \to E : E \in A^{+}_{F_1 \setminus \{A \to E\}} = AHGBE$ – suvišna
- $A \to H : H \notin A^{+}_{F_1 \setminus \{A \to H\}} = AGB$
- $A \to G : G \notin A^{+}_{F_1 \setminus \{A \to G\}} = AHE$
- $G \to B : B \notin G^{+}_{F_1 \setminus \{G \to B\}} = G$
- $H \to A : A \in H^{+}_{F_1 \setminus \{H \to A\}} = HE$
- $H \to E : E \notin H^{+}_{F_1 \setminus \{H \to E\}} = HAGB$
- **Kanonički pokrivač**

  $$\boldsymbol{G = \{AC \to D, A \to H, A \to G, G \to B, H \to A, H \to E\}}$$

Primer 5

Dekompozicija

$$
\begin{tikzcd}
(U, G) \arrow[d] \arrow[dr, "\mathbf{P1}: \boldsymbol{G \rightarrow B}"] & \\
(\{G, B\}, \{G \rightarrow B\}) & (\{A, C, D, E, F, G, H\}, \{AC \rightarrow D, A \rightarrow H, A \rightarrow G, H \rightarrow A, H \rightarrow E\})
\end{tikzcd}
$$

Primer 5

$$(\{A, C, D, E, F, G, H\}, \{AC \to D, A \to H, A \to G, H \to A, H \to E\})$$

$$\mathbf{P1}: \boldsymbol{H \to E}$$

$$(\{H, E\}, \{H \to E\})$$

$$(\{A, C, D, F, G, H\}, \{AC \to D, A \to H, A \to G, H \to A\})$$

Primer 5

$$(\{A, C, D, F, G, H\}, \{AC \to D, A \to H, A \to G, H \to A\})$$

$$\mathbf{P1}: \boldsymbol{A \to G}$$

$$(\{A, G\}, \{A \to G\}) \quad (\{A, C, D, F, H\}, \{AC \to D, A \to H, H \to A\})$$

Primer 5

$$
\begin{tikzcd}
(\{A, C, D, F, H\}, \{AC \to D, A \to H, H \to A\}) \arrow[d] \arrow[dr, "\mathbf{P1}: \boldsymbol{AC \to D}"] & \\
(\{A, C, D\}, \{AC \to D\}) & (\{A, C, F, H\}, \{A \to H, H \to A\})
\end{tikzcd}
$$

Primer 5

$$
\begin{tikzcd}
(\{A, C, F, H\}, \{A \to H, H \to A\}) \arrow[d] \arrow[dr, "\mathbf{P1}: \boldsymbol{A \to H}"] & \\
(\{A, H\}, \{A \to H, H \to A\}) & (\{A, C, F\}, \{\})
\end{tikzcd}
$$

Primer 5

- $S = \{N_1(\{A, C, F\}, \{ACF\}), N_2(\{A, H\}, \{A, H\}),$
  $N_3(\{A, C, D\}, \{AC\}), N_4(\{A, G\}, \{A\}),$
  $N_5(\{H, E\}, \{H\}), N_6(\{G, B\}, \{G\})\}$
- Očuvan je spoj bez gubitaka jer se ključ šeme univerzalne relacije nalazi u šemI N_1

$$\left.\begin{array}{l} (AH)^+_{F_2 \cup F_4 \cup F_5} = AHGE \\ (AG)^+_{F_2 \cup F_4 \cup F_5} = AGHE \\ (HE)^+_{F_2 \cup F_4 \cup F_5} = HEAG \end{array}\right\} spajamo\ N_2, N_4\ i\ N_5\ u\ (\{A, E, G, H\}, \{A, H\})$$

Primer 5

- Sada imamo:
- $U = \{A, B, C, D, E, F, G, H\}$
- $F = \{ABC \to D, ABC \to E, AG \to H, A \to G, G \to B, H \to A, H \to E, AC \to H\}$
- $N_1(\{A, E, G, H\}, \{A, H\})$ - $AG \to H, A \to G, H \to A, H \to E$
- $N_2(\{A, C, F\}, \{ACF\})$ - BCNF
- $N_3(\{A, C, D, H\}, \{AC\})$ - $AC \to H, H \to A$ – 3NF
- $N_4(\{B, G\}, \{G\})$ – BCNF

Primer 5

- Dekomponujemo N_1

$$\begin{tikzcd}
(\{A, E, G, H\}, \{AG \to H, A \to G, H \to A, H \to E\}) \arrow[d] \arrow[dr, "\boldsymbol{AG \to H}"] & \\
(\{A, G, H\}, \{AG \to H, H \to A\}) & (\{A, E, G\}, \{A \to G\})
\end{tikzcd}$$

Primer 5

$$
\begin{tikzcd}
(\{A,G,H\},\{AG \to H, H \to A\}) \arrow[d] \arrow[drr, "\boldsymbol{H \to A}"] & & \\
(\{A,H\},\{H \to A\}) & & (\{H,G\},\{\})
\end{tikzcd}
$$

Primer 5

- Dekomponujemo N_3

$$\begin{tikzcd}
(\{A, C, D, H\}, \{AC \to H, H \to A\}) \arrow[d] \arrow[dr, "\boldsymbol{H \to A}"] & \\
(\{A, H\}, \{H \to A\}) & (\{C, D, H\}, \{\})
\end{tikzcd}$$