

Solutions to Homework #1 - Section 2

Relational Algebra

2.1 Retrieve the names of all borrowers who do not have any books checked out.

$$\text{CardNoSet} \leftarrow \Pi_{\text{CardNo}} (\text{BORROWER}) - \Pi_{\text{CardNo}} (\text{BOOK_LOANS})$$

$$\text{Result} \leftarrow \Pi_{\text{Name}} (\text{CardNoSet} \bowtie \text{BORROWER})$$

2.2 How many copies of the book titled *How to Avoid Publicity* are owned by the library branch whose name is 'Charles Village'?

$$\text{CVillageID} \leftarrow \Pi_{\text{BranchID}} (\sigma_{\text{BranchName}='CharlesVillage'} (\text{LIBRARY_BRANCH}))$$

$$\text{BookHowTo} \leftarrow \Pi_{\text{BookID}} (\sigma_{\text{Title}='HowtoAvoidPublicity'} (\text{BOOK}))$$

$$\text{Result} \leftarrow \Pi_{\text{NumCopies}} (\text{CVillageID} \bowtie \text{BOOK_COPIES} \bowtie \text{BookHowTo})$$

2.3 List the card numbers and names of all borrowers who have checked out every book in the Charles Village branch at least once.

$$\text{CV_LIBRARY} \leftarrow \Pi_{(\text{BranchID})} (\sigma_{(\text{BranchName}='CharlesVillage')} (\text{LIBRARY_BRANCH}))$$

$$\text{BOOKS_IN_CV} \leftarrow \Pi_{(\text{BookID})} (\text{BOOK_COPIES} \bowtie_{\text{BOOK_COPIES.BranchID}=\text{CV_LIBRARY.BranchID}} \text{CV_LIBRARY})$$

$$\text{BORROWED_ALL} \leftarrow \Pi_{(\text{CardNo}, \text{BookID})} (\text{BOOK_LOANS}) \div \text{BOOKS_IN_CV}$$

$$\text{Result} \leftarrow \Pi_{(\text{Name}, \text{BORROWER.CardNo})} (\text{BORROWED_ALL} \bowtie_{\text{BORROWED_ALL.CardNo}=\text{BORROWER.CardNo}} \text{BORROWER})$$

2.4 List the title and publisher of every book that has never been borrowed by someone living in Towson

$$\text{BorrowedByTowson} \leftarrow \Pi_{\text{BookID}} ((\sigma_{\text{City}='Towson'} (\text{Borrower})) \bowtie \text{Book_Loans})$$

$$\text{Result} \leftarrow \Pi_{\text{Title}, \text{PublisherName}} (\text{Book} - \text{BorrowedByTowson})$$

2.5 List the card numbers and names of all borrowers who have checked out the same book more than once.

$$\text{Result} \leftarrow \Pi_{\text{A.CardNo}, \text{Name}} (((\sigma_{\text{A.BookID}=\text{B.BookID} \wedge \text{A.CardNo}=\text{B.CardNo} \wedge \text{A.DateOut} \neq \text{B.DateOut}} (\rho_{\text{A}} (\text{Book_Loans}) \bowtie \rho_{\text{B}} \text{Book_Loans}))) \bowtie_{\text{A.CardNo}=\text{CardNo}} \text{Borrower})$$

2.6 List all branches that do not have any copies of 'How to Avoid Publicity'.

$$\text{Copies} \leftarrow \Pi_{\text{BranchID}, \text{NumCopies}} (\sigma_{\text{Title}='HowToAvoidPublicity'} (\text{Book_Copies}) \bowtie \text{Book})$$

$$\text{Result} \leftarrow \Pi_{\text{BranchName}} (\sigma_{\text{NumCopies}=0} (\text{Library_Branch}) \bowtie \text{Copies})$$

2.7 For each book authored (or coauthored) by 'Paris Hilton', retrieve the title and the number of copies owned by the library branch whose name is 'Towson South'.

$$\text{TowsonSouthID} \leftarrow \Pi_{\text{BranchID}} (\sigma_{\text{BranchName}='TowsonSouth'} (\text{LIBRARY_BRANCH}))$$

$$\text{BookOfHilton} \leftarrow \Pi_{\text{BookID}} (\sigma_{\text{AuthorName}='ParisHilton'} (\text{BOOK_AUTHORS}))$$

$$\text{Result} \leftarrow \Pi_{\text{Title}, \text{NumCopies}} (\text{BookOfHilton} \bowtie \text{BOOK_COPIES} \bowtie \text{TowsonSouthID} \bowtie \text{BOOK})$$

2.8 List the name of every book that Ben Bernanke has borrowed more than once.

$BensLoans \leftarrow \sigma_{Name="BenBernake"}(Book_Loans \bowtie Borrower)$

$MoreThanOnce \leftarrow \Pi_{BookID}(\sigma_{b1.BranchID \neq b2.BranchID \vee b1.DateOut \neq b2.DateOut \vee b1.DateDue \neq b2.DateDue}(\rho_{b1}(BensLoans) \bowtie \rho_{b2}(BensLoans)))$

$Result \leftarrow \Pi_{Title}(MoreThanOnce \bowtie Book)$

2.9 List the name of every book that Ben Bernanke has borrowed exactly once.

$Result \leftarrow \Pi_{Title}((\Pi_{BookID}(BensLoans) - MoreThanOnce) \bowtie Book)$

2.10 For each book that is loaned out from the 'Charles Village' branch and whose Due Date is today, retrieve the book title, the book author, the publisher's address, the borrower's name, and the borrower's address.

$CVillageID \leftarrow \Pi_{BranchID}(\sigma_{BranchName="CharlesVillage"}(LIBRARY_BRANCH))$

$DueCVillage \leftarrow \Pi_{BookID, CardNo}(\sigma_{DateDue=10-20-11}(CVillageID \bowtie BOOK_LOANS))$

$BookDetail \leftarrow BOOK \bowtie_{PublisherName=Name} PUBLISHER \bowtie BOOK_AUTHORS$

$BookInfo \leftarrow \Pi_{BookID, Title, AuthorName, PCity, Country}(BookDetail)$

$CardInfo \leftarrow \Pi_{CardNo, Name, Address}(BORROWER)$

$DetailedResult \leftarrow DueCVillage \bowtie BookDetail \bowtie CardInfo$

$Result \leftarrow \Pi_{Title, AuthorName, City, Country, Name, Address}(DetailedResult)$

2.11 List the name and addresses of branches who have more copies of the book 'Dishwashing for Dummies' than copies of 'Brave New World'. (You can assume only one publisher/author/BID for both of these books).

$CopiesI \leftarrow \sigma_{Title="DishwashingforDummies"}(Book \bowtie Book_Copies)$

$CopiesII \leftarrow \sigma_{Title="BraveNewWorld"}(Book \bowtie Book_Copies)$

$Result \leftarrow \Pi_{BranchName}(\sigma_{CopiesI.NumCopies > CopiesII.NumCopies}(CopiesI \bowtie_{BookID, BranchID} CopiesII) \bowtie Library_Branch)$

2.12 Print the name of the branch in the database with the most copies of the book "How to Avoid Publicity" (relative to other branches in the database). If there is a tie, list all branches in the tie. You should not use aggregate operators such as Max or Sum.

$Publicity_Book \leftarrow \Pi_{(BookID)}(\sigma_{Title='HowtoAvoidPublicity'}(Book))$

$BRANCH_I \leftarrow \Pi_{(BranchID, NumCopies)}$

$Publicity_Book \bowtie_{Publicity_Book.BookID=BOOK_COPIES.BookID} Book_Copies$

$BRANCH_II \leftarrow \Pi_{(BranchID, NumCopies)}$

$Publicity_Book \bowtie_{Publicity_Book.BookID=BOOK_COPIES.BookID} Book_Copies$

$LIBS_WITH_MOST_COPIES \leftarrow$

$(Publicity_Book \bowtie_{Publicity_Book.BookID=BOOK_COPIES.BookID} Book_Copies) - \sigma_{(BRANCH_I.NumCopies < BRANCH_II.NumCopies)}$

$RESULT \leftarrow \Pi_{(BranchName)}$

$LIBRARY_BRANCH \bowtie_{LIBRARY_BRANCH.BranchID=LIBS_WITH_MOST_COPIES.BranchID} LIBS_WITH_MOST_COPIES$

2.13 List the title and publisher of all books in the database with more than one author.

$$RESULT \leftarrow \Pi_{(Title, Publisher Name)}(\sigma_{A.Author \neq B.Author}(\rho A(Book \bowtie Book_Authors) \bowtie_{A.BookID=B.BookID} \rho B(Book \bowtie Book_Authors))))$$

2.14 List the addresses and cities of all libraries that carry books from 'Bob Jones University Press'.

$$RESULT \leftarrow \Pi_{(LIBRARY_BRANCH.Address, LIBRARY_BRANCH.City)}(\sigma_{Publisher Name='Bob Jones University Press' \wedge NumCopies \neq 0}((Book \bowtie_{Book.BookID=Book_Copies.BookID} Book_Copies) \bowtie_{Book_Copies.BranchID=Library_Branch.BranchID} (Library_Branch))))$$

2.15 List the addresses and cities of all libraries that do not have any books from 'Bob Jones University Press'

$$RESULT \leftarrow \Pi_{Address, City}(Library_Branch) - ResultFrom2.14$$

2.16 List the titles and publishers of every book available in the Charles Village branch but not in the Towson South branch.

$$cvBooks \leftarrow \Pi_{BookID}(\sigma_{BranchName='CharlesVillage' \wedge NumCopies \neq 0}(Library_Branch \bowtie Book_Copies))$$

$$tsBooks \leftarrow \Pi_{BookID}(\sigma_{BranchName='TowsonSouth' \wedge NumCopies \neq 0}(Library_Branch \bowtie Book_Copies))$$

$$Result \leftarrow \Pi_{Title, Publisher Name}((cvBooks - tsBooks) \bowtie Book)$$

2.17 List the names, addresses and card numbers of the borrowers who have not yet borrowed any book.

$$Result \leftarrow \Pi_{Name, Address, CardNo}(\Pi_{CardNo}(Borrower) - \Pi_{CardNo}(Book_Loans)) \bowtie Borrower$$

2.18 List the name, address and card number of the borrowers who have not yet borrowed a book from a library branch in the same city where they live.

$$sameCity \leftarrow \Pi_{CardNo, BranchID}(Borrower \bowtie Library_Branch)$$

$$borrowedSameCity \leftarrow sameCity \cap \Pi_{CardNo, BranchID}(Book_Loans)$$

$$Result \leftarrow \Pi_{Name, Address, CardNo}(\Pi_{CardNo}(Borrower) - \Pi_{CardNo}(borrowedSameCity)) \bowtie Borrower$$

2.19 List the name, address and card number of the borrowers who have borrowed at least one book from every branch in the library system

$$Result \leftarrow \Pi_{Name, Address, CardNo}(Book_Loans \bowtie Borrower) \div \Pi_{BranchID}(Library_Branch)$$

2.20 How many copies of the book titled it My Judicial Experience are owned by each library branch (give branch name and total copies)?

$$BookMJE \leftarrow \Pi_{BookID}(\sigma_{Title='MyJudicialExperience'}(BOOK))$$

$$NumMJE \leftarrow \Pi_{BranchID, NumCopies}(BookMJE \bowtie BOOK_COPIES)$$

$$Result \leftarrow \Pi_{BranchName, NumCopies}(NumMJE \bowtie LIBRARY_BRANCH)$$

2.21 List the title and publisher of all books in the database with more than two authors.

$$Result \leftarrow \Pi_{Title, Publisher Name}(Book \bowtie \Pi_{BookID}(\sigma_{b1.BookID=b2.BookID \wedge b1.AuthorName \neq b2.AuthorName}(\rho_{b1}(Book_Authors) \bowtie \rho_{b2}(Book_Authors))))$$

2.22 Restricted to the authors and borrowers included in the database, list the names of authors who have not borrowed a book written by someone with the same name as themselves.

$$Borrowed \leftarrow \Pi_{AuthorName}(Book_Authors \bowtie_{AuthorName=Name} Borrower \bowtie Book_Loans)$$

$$Result \leftarrow \Pi_{AuthorName}(Book_Authors - Borrowed)$$

2.23 List the card numbers and names of all borrowers who have checked out every book in some branch at least once.

$$borrowerBranch \leftarrow \Pi_{BranchID,CardNo,Name}(Borrower \bowtie Library_Branch)$$

$$borrowerBranchLoaned \leftarrow \Pi_{BookID,BranchID,CardNo,Name}(Book_Loans \bowtie Borrower)$$

$$borrowerBranchHas \leftarrow \Pi_{BookID,BranchID,CardNo,Name}(borrowerBranch \bowtie_{NumCopies \neq 0} Book_Copies)$$

$$Result \leftarrow \Pi_{CardNo,Name}(borrowerBranch - \Pi_{BranchID,CardNo,Name}(borrowerBranchHas - borrowerBranchLoaned))$$

2.24 List the title and publisher of every book that has never been borrowed by someone living in Towson but has been borrowed by someone living in Baltimore.

$$notTowson \leftarrow \Pi_{BookID}(\sigma_{City='Towson'}(Book_Loans \bowtie Borrower))$$

$$baltimore \leftarrow \Pi_{BookID}(\sigma_{City='Baltimore'}(Book_Loans \bowtie Borrower))$$

$$Results \leftarrow \Pi_{Title,PublisherName}((notTowson \cap baltimore) \bowtie Book)$$

2.25 Retrieve the names of all books that have 1 or more copies in every library branch in the database.

$$Results \leftarrow \Pi_{Title}((\sigma_{NumCopies \neq 0}(Book_Copies) \div \Pi_{BranchID}(Library_Branch)) \bowtie Book)$$

2.26 See 2.22

Relational Calculus

2.1 Retrieve the names of all borrowers who do not have any books checked out

$$\{t \mid \exists b \in BORROWER(\\ t[Name] = b[Name] \\ \wedge \neg \exists l \in BOOK_LOANS(\\ l[CardNo] = b[CardNo]))\}$$

2.2 How many copies of the book titled *How to Avoid Publicity* are owned by the library branch whose name is 'Charles Village'?

$$\{t \mid \exists c \in BOOK_COPIES(\\ t[NumCopies] = c[NumCopies] \\ \wedge \exists l \in LIBRARY_BRANCH(\\ l[BranchName] = "CharlesVillage" \wedge l[BranchID] = c[BranchID] \\ \wedge \exists b \in BOOK(\\ b[Title] = "HowtoAvoidPublicity" \wedge b[BookID] = c[BookID]))))\}$$

2.10 For each book that is loaned out from the 'Charles Village' branch and whose DueDate is today, retrieve the book title, the book author, the publisher's address, the borrower's name and the borrower's address.

$$\{t \mid \exists lb \in LIBRARY_BRANCH(\\ lb[BranchName] = "CharlesVillage" \\ \wedge \exists bl \in BOOK_LOANS(\\ bl[DueDate] = 10 - 20 - 11 \\ \wedge \exists bk \in BOOK(\\ bk[BookID] = bl[BookID] \wedge t[Title] = bk[Title] \\ \wedge \exists pr \in PUBLISHER(\\ pr[Name] = bk[PublisherName] \wedge t[PublisherCity] = pr[City] \wedge t[PublisherCountry] = \\ pr[Country] \\ \wedge \exists ba \in BOOK_AUTHORS(\\ ba[BookID] = bl[BookID] \wedge t[Author] = ba[AuthorName] \\ \wedge \exists br \in BORROWER(\\ br[CardNo] = bl[CardNo] \wedge t[Name] = br[Name] \wedge t[BorrowerAddress] = br[Address]))))))))\}$$

2.19 How many copies of the book titled *My Judicial Experience* are owned by each library branch (give branch name and total copies)?

$$\{t \mid \exists b \in BOOK(\\ b[Title] = "MyJudicialExperience" \\ \wedge \exists c \in BOOK_COPIES(\\ c[BookID] = b[BookID] \wedge t[NumCopies] = c[NumCopies] \\ \wedge \exists l \in LIBRARY_BRANCH(\\ t[BranchName] = l[BranchName] \wedge c[BranchID] = l[BranchID]))))\}$$