University of Toronto
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Part 1: Queries

1. Find the manufacturers who make an item whose type is a descendant of apparel in the subcategory hierarchy/ies. Report the manufacturer ID, name, address, and phone number.

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2. Lets say a singleton order is one that includes exactly one item. Find all gold customers who have made at least one singleton order in 2016. Report their CID, and the date and time when they made their first and their last singleton order that year.

   $NotSingleton(T1.OID) := \Pi_{T1.OID}\sigma_{T1.OID=T2.OID \wedge T1.IID <> T2.IID}(\rho_{T1}(LineItem) \times \rho_{T2}(LineItem))$

   $notSingle2016(Order.OID) := \Pi_{Order.OID}\sigma_{NotSingleton.OID=Order.OID \wedge when.year=2016}((NotSingleton) \times (Order))$

   $Order2016(Order.OID) := \Pi_{Order.OID}\sigma_{when.year=2016}(Order)$

   $Single2016(OID) = Order2016 - notSingle2016$

   $GoldSingle2016(Customer.CID, Single2016.OID, Order.when) := \Pi_{Customer.CID, Single2016.OID, Order.when}\sigma_{Order.OID=Single2016.OID \wedge Order.CID=Customer.CID \wedge membership="gold" \wedge}(Order \times Single2016 \times Customer)$

   $NotFirst(T1.CID, T1.OID, T1.when) :=$
   $\Pi_{T1.CID}\, T1.OID, \sigma_{T1.OID=T2.OID \wedge T1.when > T2.when}(\rho_{T1}(GoldSingle2016) \times \rho_{T2}(GoldSingle2016))$

   $NotLast(T1.CID, T1.OID, T1.when) :=$
   $\Pi_{T1.CID}, T1.OID\sigma_{T1.OID=T2.OID \wedge T1.when < T2.when}(\rho_{T1}(GoldSingle2016) \times \rho_{T2}(GoldSingle2016))$

   $First(CID, OID, when) := GoldSingle2016 - NotFirst$

   $Last(CID, OID, when) := GoldSingle2016 - NotLast$

   $Answer(First.CID, First.when, Last.when) := \Pi_{First.CID, First.when, Last.when}\sigma_{First.CID=Last.CID}(First \times Last)$

3. Suppose we consider two orders to be identical if they contain exactly the same items (ignoring quantity). Find all pairs of customers who have made identical orders on the same day. Report each customers CID and OID for the order that was identical. A pair could have multiple identical orders

on the same day. If so, report them all.

$AllParies(T1.OID, T2.OID) := \Pi_{T1.OID, T2.OID}\sigma_{T1.OID \neq T2.OID}(\rho_{T1}(Order) \times \rho_{T2}(Order))$

$SameItem(T1.OID, T2.OID, T1.IID) := \Pi_{T1.OID, T2.OID, T1.IID}\sigma_{T1.OID \neq T2.OID \wedge T1.IID = T2.IID}$
$(\rho_{T1}(LineItem) \times \rho_{T2}(LineItem))$

$ShouldHaveBeen(T1.OID, T2.OID, T1.IID) := \Pi_{T1.OID, T2.OID, T1.IID}\sigma_{T1.OID \neq T2.OID}$
$(\rho_{T1}(LineItem) \times \rho_{T2}(LineItem))$

$WereNotAlways(OID1, OID2, IID)) := ShouldHaveBeen - SameItem$

$ItenticalOrderPair := AllParies - \Pi_{OID1, OID2}WereNotAlways$

$CustomerPair(CID1, OID1, CID2, OID2)) :=$
$\Pi_{T1.CID1, T1.OID1, T2.CID, T2.OID}\sigma_{T1.OID = ItenticalOrderPair.OID1 \wedge T2.OID = ItenticalOrderPair.OID2}(\rho_{T1}(Order) \times$
$\rho_{T2}(Order))$

4. Find all customers who have a silver membership, have placed at least two orders in 2014, fewer than 2 orders in 2015, and no orders at all in 2016. Report the CID.

$Silver(Customer.CID) := \Pi_{Customer.CID}\sigma_{membership="silver"}(Customer)$

$Silver2016(Customer.CID) := \Pi_{Customer.CID}\sigma_{Customer.CID = Order.CID \wedge membership="silver" \wedge when.year=2016}$
$(Customer \times Order)$

$Silver2015(Customer.CID, Order.CID) :=$
$\Pi_{Customer.CID}, \sigma_{Customer.CID = Order.CID \wedge membership="silver" \wedge when.year=2015}$
$(Customer \times Order)$

$Silver2015More2(T1.CID) := \Pi_{T1.CID}\sigma_{T1.CID = T2.CID \wedge T1.OID \neq T2.OID}(\rho_{T1}(Silver2015) \times \rho_{T2}(Silver2015))$

$Silver2014(Customer.CID, Order.CID) :=$
$\Pi_{Customer.CID}, \sigma_{Customer.CID = Order.CID \wedge membership="silver" \wedge when.year=2014}(Customer \times Order)$

$Silver2014More2(T1.CID) := \Pi_{T1.CID}\sigma_{T1.CID = T2.CID \wedge T1.OID \neq T2.OID}(\rho_{T1}(Silver2014) \times \rho_{T2}(Silver2014))$

$Answer(CID) := (Silver - Silver2016 - Silver2015More2) \cup Silver2014More2$

5. Lets say the top cost on any order is the cost of the most expensive item. (There could be several items tied for that top cost.) Among all the orders a customer places in a year, lets say their skimpiest order is the one whose top cost is the lowest. (There could be several orders tied for skimpiest.) For each customer who has ever placed an order, find their skimpiest order. If several orders for that customer are tied for skimpiest, report them all. Report the customer ID, order ID, and the orders top cost.

$OrderCost(OID, IID, Price) := \Pi_{LineItem.OID, LineItem.IID, Item.Price}\sigma_{LineItem.IID = Item.IID}(LineItem \times$
$Item)$

$NotTopCost := (OID, IID, Price)\Pi_{T1.OID, T1.IID, T1.Price}\sigma_{T1.OID = T2.OID \wedge T1.Price < T2.Price}$
$(\rho_{T2}(OrderCost) \times \rho_{T2}(OrderCost))$

$TopCost(OID, IID, Price) := OrderCost - NotTopCost$

$OrderTop(OID, CID, Price) := \Pi_{Order.OID,Order.CID,Price}\sigma_{Order.OID=TopCost.OID}(Order \times TopCost)$

$NotSkimpiest(OID, CID, Price) := \Pi_{T1.OID,T1.CID,Price}\sigma_{T1.CID=T2.CID \wedge T1.Price>T2.Price}(\rho_{T1}(OrderTop) \times \rho_{T2}(OrderTop))$

$Skimpiest := OrderTop - NotSkimpiest$

6. Find every order that includes at least one item for which reviewers unanimously gave it a rating of 0 and at least one item for which reviewers unanimously gave it a rating of 5. Report the customer ID, customers last name and first name, order ID, and when the order was placed.

$NotSameRating(CID1, IID1) := \Pi_{T1.CID}, T1.IID\sigma_{T1.IID=T2.IID \wedge T1.rating<>T2.rating}(\rho_{T1}(Review) \times \rho_{T2}(Review))$

$FiveRating(CID, IID) := \Pi_{CID,IID}\sigma_{rating=5}(Review)$

$ZeroRating(CID, IID) := \Pi_{CID,IID}\sigma_{rating=0}(Review)$

$AllZeroRating(CID, IID) := ZeroRating - (ZeroRating \cap NotSameRating)$

$AllFiveRating(CID, IID) := FiveRating - (FiveRating \cap NotSameRating)$

$OrderZero(OID) := \Pi_{OID}\sigma_{AllZeroRating.IID=LineItem.IID}(AllZeroRating \times LineItem)$

$OrderFive(OID) := \Pi_{OID}\sigma_{AllFiveRating.IID=LineItem.IID}(AllFiveRating \times LineItem)$

$FinalOrder(OID) := OrderZero \cup OrderFive$

$Answer(Order.CID, lastName, firstName, Order.OID, Order.when) := \Pi_{Order.CID,lastName,firstName,Order.OID,Order.when}\sigma_{Finalorder.OID=Order.OID \wedge Order.IID=Customer.IID}(FinalOrder \times Order \times Customer)$

7. Find all pairs of customers c1 and c2 such that: c2 has reviewed at least one item, and c1 assessed every review of c2 as helpful.

$ReadID(reader) = \Pi_{reader}(Helpfulness)AllParies(CID1, CID2) = \Pi_{Review.CID,ReadID.CID}((Review) \times ReadID)$

$AllReviewHelpful(c2, c1, item) = \Pi_{reviewer,reader,item}\sigma_{helpful="yes"}(Helpfulness)ShouldHaveBeen(c1, c2, item) = \Pi_{reader,Review.CID,Review.IID}((Review) \times (ReadID))$

$WereNotAlways(c1, c2, item) = ShouldHaveBeen - AllReviewHelpfulAnswer(c1, c2) = AllParies - \Pi_{c1,c2}WereNotAlways$

8. For every item that has been ordered, find the last customer to order it. Report the item ID and the customer ID of the customer who ordered it last.

$Lineitemtime(LineItem.OID, LineItem.IID, Order.when) := \Pi_{LineItem.OID,LineItem.IIDOrder.when}\sigma_{LineItem.OID=Order.OID}((LineItem) \bowtie (Order))$

$NotLastOrder(T1.OID, T2.IID) :=$
$\Pi_{T2.OID,T2.IID}\sigma_{(T1.IID=T2.IID)\wedge(T1.when.date<T2.when.date)}(\rho_{T1}(Lineitemtime) \times \rho_{T2}(Lineitemtime))$

$LastOrder(OID) := (\Pi_{OID,IID}LineItem) - (NotLastOrder)$

$LastOrderWithCID(NotLastOrder.IID, Order.CID) :=$
$\Pi_{NotLastOrder.CID,Order.OID}(sigma_{NotLastOrder.OID=Order.OID})(LastOrder \times Order)$

9. Find all the customers who have given a review that at most one reader assessed as helpful. For each of these customers, find every review that had more yes (helpful) assessments than no assessments. Report the customer ID, item ID, and item price.

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10. Find all customers who have given at least three reviews, and for whom the rating they give has always gone down over time from review to review. Report the customer ID, last name, and email address, and the item ID for the last item they reviewed.

    $DecreaseRating(CID, IID) := \Pi_{T1.CID,T3.IID}$
    $\sigma_{T1.When<T2.When<T3.When\wedge T1.Rating>T2.Rating>T3.rating\wedge T1.CID=T2.CID=T3.CID}(\rho_{T1}(Review)\times$
    $\rho_{T2}(Review) \times \rho_{T3}(Review))$

    $Answer(CID, LastName, mail, IID) := \Pi_{Customer.CID,LastName,Email,IID}$
    $\sigma_{DecreaseRating.CID=Customer.CID}(DecreaseRating \times Customer)$

11. A top-level category is one that is not a subcategory of anything else. Find all customers who have reviewed an item in each top-level category. Report just the customer ID.

    $Topcategory(type) := (\Pi_{type}Item) - (\Pi_{a}Subcategory)$

    $ItemTopCategory(IID) := \Pi_{IID}\sigma_{item.type=Topcategory.type}(Item \times Topcategory)$

    $CustomerTopCategoryPair(CID, IID) := \Pi_{Review.CID,Review.IID}\sigma_{Review.IID=ItemTopCategory.IID}$
    $(ItemTopCategory \times Review)$

    $ShouldHaveBeen(CID, IID) = \Pi_{Review.CID,ItemTopCategory.IID}((Review)\times(ItemTopCategory))$

    $WereNotAlways(CID, item) = ShouldHaveBeen - CustomerTopCategoryPair$

    $ReviewInTop(CID) = \Pi_{CID}\sigma_{item=ItemTopCategory.IID}(Review \times ItemTopCategory)$

    $Answer(CID) = \Pi_{CID}ReviewInTop - \Pi_{CID}WereNotAlways$

12. Find the orders with at least one item, and for which every item on the order had a type that was either book or a direct a subcategory of book. Report the order ID.

    $OrderBook(OID, IID) := \Pi_{CID,IID}\sigma_{LineItem.IID=Item.IID \wedge (type='book' \vee (a='book' \wedge type='book'))}$
    $(LineItem \bowtie Item)$

    $OrderNotAllBook(OID) := \Pi_{LineItem.OID}\sigma_{LineItem.OID=OrderBook.OID \wedge LineItem.IID \neq OrderBook.IID}$
    $(OrderBook \bowtie LineItem)$

    $BookOrder(OID) = LineItem - OrderNotAllBook$

13. Find the orders with more than three items, and for which at least half of the items have a category that is not book. Report the order ID, customer ID, and the credit that they used.

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Part 2: Additional Integrity Constraints

1. A customer who reviews an item must have ordered that item.

    $BuyItem(CID, IID) := \Pi_{order.CID,LineItem.IID}\sigma_{order.OID=LineItem.OID}(Order \bowtie LineItem)$

    $\Pi_{CID}review = \Pi_{CID}BuyItem \wedge \Pi_{IID}Review - \Pi_{IID}BuyItem) = \emptyset$

2. Orders made by gold members have no limit on the items that can be included. However, orders made by silver members must include at least one item costing over 50 dollars, and orders made by non-members cannot include any items costing under 50 dollars.

    $AllOrderFifty(OID, CID) := \Pi order.OID, order.CID$
    $\sigma_{order.OID=LineItem.OID \wedge order.CID=customer.CID \wedge customer.membership="none" \wedge LineItem.IID=Item.IID \wedge Item.Price<50}$
    $(Order \bowtie Customer \bowtie LineItem \bowtie Item) = \emptyset$

    $AllOrderO50(OID, CID) := \Pi_{Order.OID,Order.CID}\sigma_{order.OID=LineItem.OID \wedge LineItem.IID=Item.IID \wedge Price>50}$
    $(Order \times LineItem \times Item)$

    $OrderSilver(OID, CID) := \Pi_{order.OID,order.CID}\sigma_{order.CID=customer.CID \wedge membership="Silver"}(Order \times Customer)$

    $OrderSilver - AllOrder50 = \emptyset$