**Assignment 1: Sabina Shin, Eric Chen**

**Part 1: Queries**

1.

- Find the lastest volunteer(s) in Staff.

Latest\_volunteer (SID, firstname):=

Π*SID, firstname* Staff - Π*a.SID, a.firstname* (σ*a.date < b.date ⋀ a.type = “volunteer” ⋀ b.type = “volunteer”* (ρ*a* Staff x ρ*b* Staff))

- Get the objects that the newest volunteer(s) catalogued

Supergroup (SID, firstname, description, type, date):=

Π*SID, firstname, description, type, date* (Latest\_volunteer ⋈*Latest\_volunteer.SID = Object.who* Object)

- Find the latest object(s) catalogued by the latest volunteer(s).

Latest\_object (SID, firstname, description, type, date):=

Π*SID, firstname, description, type, date* Supergroup - Π*c.SID, c.firstname, c.description, c.type, c.type, c.date* (σ*c.date < d.date ⋀ c.SID = d.SID* (ρ*c* Supergroup x ρ*d* Supergroup))

Result (SID, firstname, description, type, date):= Latest\_object

2.

- Detailed information of each catalogued objects

DonatedObjects (DID, CN, value, category):=

Π*DID, CN, value, category* (Donation ⋈ Contains ⋈ Object ⋈*Object.type = SecondaryTerm.secondary* SecondaryTerm)

- Everyone who should have donated to every Chenhall category

Full\_list (DID, category):= ΠDID DonatedObjects x Chenhall

- Donor(s) who did not donate to every Chenhall category.

Missing (DID):= Π*DID* (Full\_list - Π*DID, category* DonatedObjects)

- Donor(s) that donated to every Chenhall category.

Broad\_donor (DID):= Π*DID* DonatedObjects- Missing

- Value of all objects donated by these donor(s) who donated in every Chenhall category

Result (DID, CN, value):= Π*DID, CN, value* (Broad\_donor ⋈ DonatedObjects)

Most\_valuable (DID, value):=

Π*DID, value* Result - Π*a.DID, a.value* (σ*a.DID = b.DID ⋀ a.value < b.value* (ρ*a* Result x ρ*b* Result))

Least\_valuable (DID, value):=

Π*DID, value* Result - Π*c.DID, c.value* (σ*c.DID = d.DID ⋀ c.value > d.value* (ρ*c* Result x ρ*d* Result))

Solution (DID, MostValuable, LeastValuable):=

Π*a.DID, a.value, b.value* σ*a.DID = b.DID* (ρ*a* Most\_valuable x ρ*b* Least\_valuable )

3.

- Detailed information about the objects in the donation

Supergroup (NID, CN, height, width):= Π*NID, CN, height, width* (Object ⋈ Contains)

- Remove the tallest object in each donation

Tallest\_removed (NID, CN, height, width):=

Π*a.NID, a.CN, a.height, a.width* (σ*a.NID = b.NID ⋀ a.CN ≠ b.CN ⋀ a.height < b.height* (ρ*a* supergroup x ρ*b* supergroup))

- Remove the shortest object in each donation

Shortest\_removed (NID, CN, height, width):=

Π*c.NID, c.CN, c.height, c.width* (σ*c.NID = d.NID ⋀ c.CN ≠ d.CN ⋀ c.height > d.height* (ρ*c* Tallest\_removed x ρ*d* Tallest\_removed ))

- Find the then tallest object in each donation, which would be the second tallest due to removing the tallest beforehand.

- Second tallest object in the donation

Second\_tallest (NID, CN, height, width):=

Shortest\_removed - Π*e.NID, e.CN, e.height, e.width* (σ*e.NID = f.NID ⋀ e.height < f.height* (ρ*e* Shortest\_removed x ρ*f* Shortest\_removed ))

Result (NID, CN, height, width):= Second\_tallest

4.

- Get more detailed information on individual object catalogued

Catalogued (NID, CN, SID):= Π*NID, CN, SID* (Contains ⋈ Object)

- Donation catalogued by multiple staff

MultipleStaff (NID):=

Π*T1.NID* σ*T1.NID = T2.NID ⋀ T1.CN ≠ T2.CN ⋀ T1.SID ≠ T2.SID* (ρ*T1* Catalogued x ρ*T2* Catalogued )

- Donation catalogued entirely by one person

OneStaff (NID, CN, SID):= Catalogued - Catalogued ⋈ MultipleStaff

- Get all the existing tags staff added

OneStaffTag (NID, CN, SID, phrase):= OneStaff ⋈ Tag

- Same tag was used for at least 2 objects in a donation

SameTag (NID, CN, SID, phrase):=

Π*T1.NID, T1.CN, T1.SID, T1.phrase* σ*T1.NID = T2.NID ⋀ T1.CN ≠ T2.CN ⋀ T1.phrase = T2.phrase* (ρ*T1* OneStaffTag x ρ*T2* OneStaffTag)

- Same tags used for at least 2 objects in a donation used in other donation by the same employee

OtherTags (NID, CN, SID, phrase):=

Π*s.NID, s.CN, s.SID, s.phrase* σ *s.phrase=t.phrase ⋀ t.CN=o.CN ⋀ s.SID=o.who ⋀ s.CN≠ o.CN* (ρ*s* SameTag x ρ*t* Tag x ρ*o* Object)

- Same tags used for at least 2 objects in a donation not used in other donation by the same employee

NotInOtherDonations (NID, SID):= Π*NID, SID* SameTag - Π*NID, SID* OtherTags

Solution (NID, DID, SID):= Π*NID, DID, SID* NotInOtherDonations ⋈ Donation

5.

- Find all volunteers from Staff.

Volunteers (SID):= Π*SID* (σ*type = “volunteer”* Staff)

- All catalogued objects up to and including in 2016

AllCatalogued (NID, SID, date):=

Π*NID, SID, date* σ*date.year ≤ 2016* (Object ⋈*Object.who = Volunteers.SID* Volunteers ⋈ Contains)

- Volunteers who have catalogued objects from at least two different donations

TwoDiffDonations (SID, date):=

Π*T1.SID, T1.date* σ*T1.NID ≠ T2.NID ⋀ T1.SID = T2.SID ⋀ T1.date.year = T2.date.year* (ρ*T1* AllCatalogued x ρ*T2* AllCatalogued)

- Every year until and including 2016

AllYear (date):= Π*date* σ*date.year ≤ 2016*  Object

- Volunteers should have catalogued each year

ShouldHave (SID, date):= AllYear x Volunteers

- Volunteers who has not always catalogued each year

WasNotAlways (SID, date):= ShouldHave - TwoDiffDonations

- Volunteers who have catalogued at least two different donations every year up to and including in 2016

EveryYearUntil2016 (SID):= Π*SID, date*  AllCatalogued - WasNotAlways

- Volunteers who have catalogued after 2016

CataloguedAfter2016 (SID):= Π*who* σ*date.year > 2016*  Object

- Volunteers who have catalogued at least two different donations every year up to and including in 2016 but have catalogued nothing since

SolutionSID (SID):= EveryYearUntil2016 - CataloguedAfter2016

Solution (SID, email):= Π*SID, email*  SolutionSID ⋈ Staff

6.

- Combine Object, SecondaryTerm, PrimaryTerm, and Contains tables.

Supergroup (CN, Category, who, NID):=

Π*CN, Category, who, NID* (Object ⋈*object.type = SecondaryTerm.secondary* SecondaryTerm ⋈ PrimaryTerm ⋈ Contains)

- Find “inconsistent donations” with objects from different categories.

InconsistentNID (NID):=

Π*a.NID* (σ*a.NID = b.NID ⋀ a.category ≠ b.category* (ρa Supergroup x ρb Supergroup))

- Removing “inconsistent donations” to get “consistent” ones we want.

Consistent (CN, Category, who, NID):=

Supergroup - Π*CN, Category, who, Supergroup.NID* (σ*InconsistentNID.NID = Supergroup.NID* (InconsistentNID x Supergroup))

- More than one person catalogued “consistent donations”

Result (NID, SID):=

Π*a.NID, a.who* (σ*a.NID = b.NID ⋀ a.CN ≠ b.CN ⋀ a.who ≠ b.who* (ρ*a* Consistent x ρ*b* Consistent))

7.

- Cannot be expressed

8.

- All objects with donation number

DonatedObject(NID, CN, SID):= Π*NID, CN, SID* (Object ⋈ Donation)

- One staff catalogued the every object in a donation

CatalogueDonation (NID, SID):=

Π*NID, SID* DonatedObject - Π*T1.NID, T1.SID*(σ*T1.NID = T2.NID ⋀ T1.CN ≠ T2.CN ⋀ T1.SID ≠ T2.SID* (ρ*T1* DonatedObject x ρ*T2* DonatedObject))

- Staff who have two or more times catalogued every object in a donation

CataloguedDonationTwice(NID, SID) :=

Π*NID, SID* DonatedObject - Π*T1.NID, T1.SID*(σ*T1.NID ≠ T2.NID ⋀ T1.SID = T2.SID* (ρ*T1* CatalogueDonation x ρ*T2* CatalogueDonation))

- At least one tag in a donation

TaggedDonation(NID, who) :=

Π*NID, who* (CataloguedDonationTwice ⋈ Contains ⋈ Object ⋈ Tag)

- No tag in a donation

NoTaggedDonation(NID, who) :=

CataloguedDonationTwice - TaggedDonation ⋈ CataloguedDonationTwice

Solution(who) := Π*who* NoTaggedDonation

9.

- Combine Object, Staff, and Contains tables.

Supergroup (SID, email, NID):=

Π*who, email, NID* (Object ⋈*Object.who = Staff.SID* Staff ⋈ Contains)

- Pairs of staff who catalogued together for the same donation

CataloguedTogether (NID, SID):=

Π*T1.NID, T1.SID* (σ*T1.NID = T1.NID ⋀ T1.SID ≠ T1.SID* (ρ*T1* Supergroup x ρ*T2* Supergroup))

- Staff who has catalogued with other people

CataloguedOther (NID1, NID2, SID):=

Π*T1.NID, T2.NID, T1.SID* (σ*T1.NID ≠ T1.NID ⋀ T1.SID = T1.SID* (ρ*T1* CataloguedTogether x ρ*T2* Supergroup))

- Staff who has only catalogued with only one person

CatOnlyTogether (NID, SID):=

CataloguedTogether - Π*NID1, SID* CataloguedOther - Π*NID2, SID* CataloguedOther

- Pairs of staff that only catalogued together

Together (SID1, SID2):=

Π*T1.SID, T2.SID* σ*T1.NID = T2.NID ⋀ T1.SID < T2.SID* (ρ*T1* CatOnlyTogether x ρ*T2* CatOnlyTogether)

Solution (SID1, email1, SID2, email2):=

Π*SID1, T1.email, SID2, T2.email* (Together ⋈*Together.SID1=T1.SID* ρ*T1* SuperGroup ⋈*Together.SID2=T2.SID* ρ*T2* SuperGroup)

10.

- Find all primary that has a secondary in SecondaryTerm.

HasSecondary (primary):= Π*primary* SecondaryTerm

- Find all category that has a primary from previous filter.

HasPrimary (category):= Π*category* (HasSecondary ⋈ PrimaryTerm)

- Find all Chenhall category that were not in the previous filter (incomplete).

NotComplete (category):= Chenhall - HasPrimary

**Part 2: Additional Integrity Constraints**

1.

- Secondary term is primary term

SecondaryIsPrimary (\*):= Π*secondary* SecondaryTerm ∩ Π*primary* PrimaryTerm

- Secondary term is a Chenhall category

SecondaryIsChenhall (\*):= Π*secondary* SecondaryTerm ∩ Π*category* Chenhall

- Primary term is a Chenhall category

PrimaryIsChenhall (\*):= Π*primary* PrimaryTerm ∩ Π*category* Chenhall

SecondaryIsPrimary ∪ SecondaryIsChenhall ∪ PrimaryIsChenhall = ∅

2.

- Cannot be expressed

3.

- Find all objects catalogued before 2018.

Before2018 (CN, phrase):= Π*CN, phrase* (σ*date.year < 2018* (Object ⋈ Tag))

- Objects with more than 3 tags

AtleastThree (CN):=

Π*a.CN* (σ*a.CN=b.CN=c.CN ∧ a.phrase ≠ b.phrase ≠ c.phrase* (ρ*a* Before2018 x ρ*b* Before2018 x ρ*c* Before2018))

- Objects with more than 4 tags

AtleastFour (CN):=

Π*d.CN* (σ*d.CN=e.CN=f.CN=g.CN ∧ d.phrase ≠ e.phrase ≠ f.phrase ≠ g.phrase* (ρ*d* Before2018 x ρ*e* Before2018 x ρ*f* Before2018 x ρ*g* Before2018))

- Object with exactly 3 tags

ExactThree (CN):= AtleastFour - AtleastThree

Π*CN* Before2018 - ExactThree= ∅

4.

- Combine Object, SecondaryTerm, PrimaryTerm tables.

Supergroup (CN, type, category):=

Π*type, category* (Staff ⋈*Staff.SID = Object.who* Object ⋈ SecondaryTerm ⋈ PrimaryTerm)

- Temp staff catalogued

Temp (SID):= Π*SID*  σ*type=’temp’*  Supergroup

- Other category catalogued by not a permanent staff

OtherCat (SID):= Π*SID*  σ*category ≠ ‘personal artifacts’ ∧ category ≠ ‘architectural’ ∧ type ≠ ‘permanent’*  Supergroup

TempStaff ∪ OtherCat = ∅