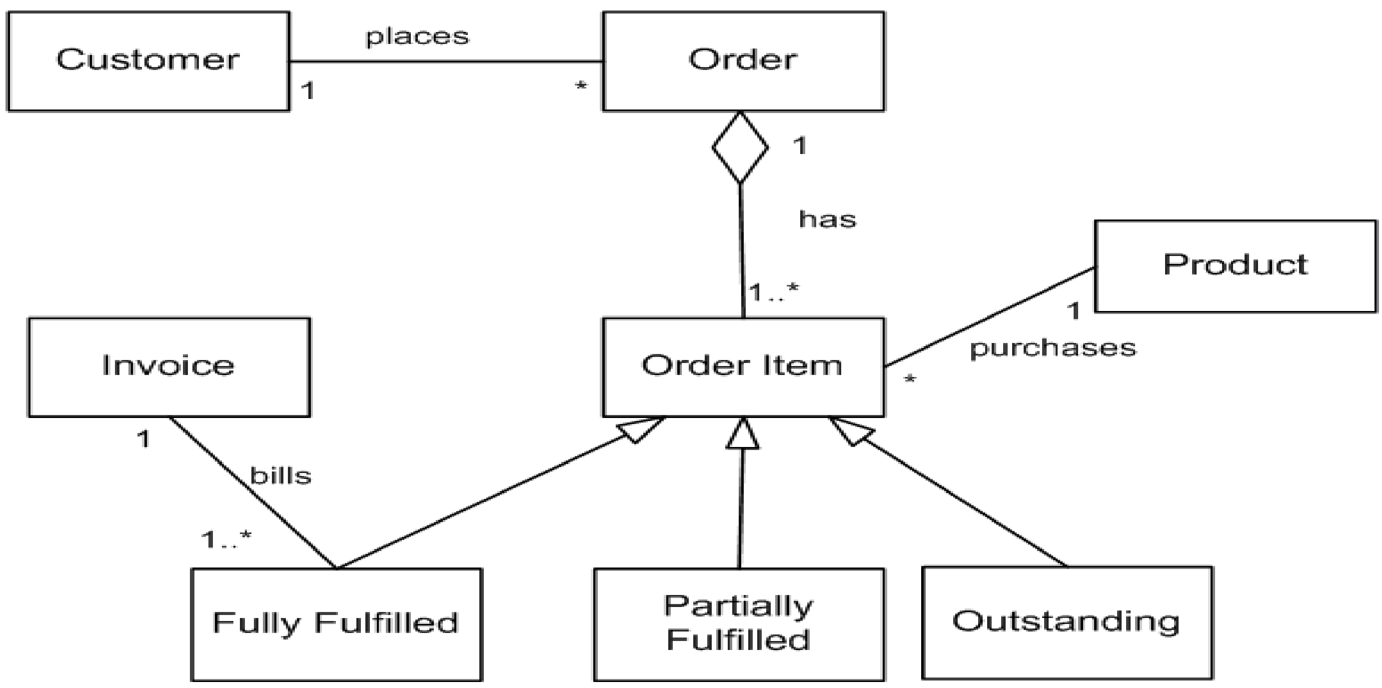
EE4001/IM2001 Software Engineering
Tutorial 4 and sample Answer

Q1 Draw a class diagram to model the following structural properties in the Order Processing System in a company:
Customers place orders with the company to purchase products that are sold by the company. A customer may have none or multiple orders placed. Each order is always placed by one customer. It may have single or multiple order items. Each item is to purchase one product. An order item could be fully fulfilled, partially fulfilled or outstanding (completely unfulfilled). Periodically, an invoice is raised to bill the customer for the order items that have been fully fulfilled.

Q1 Answer



2. **A Diagnostic Test on the Basic OO Concepts:** Based on the class diagram shown in Figure 1 and 2, state the correctness of the following statements and justify your answers:

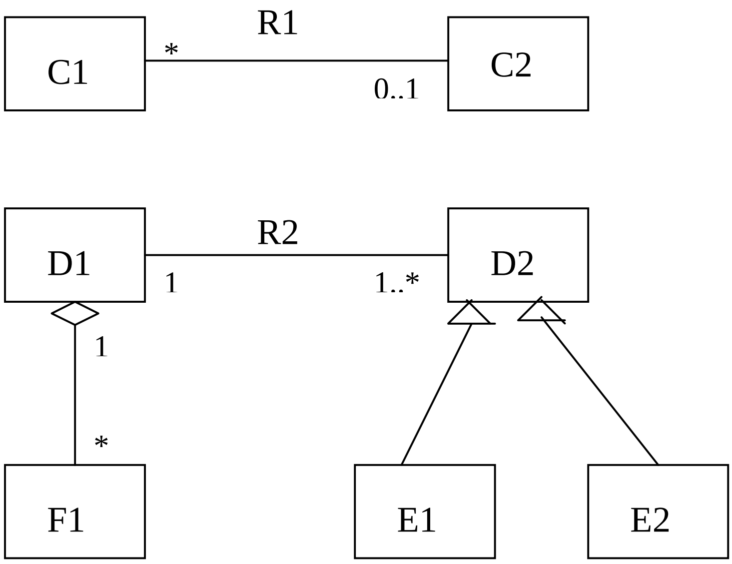


Figure 1. A class diagram

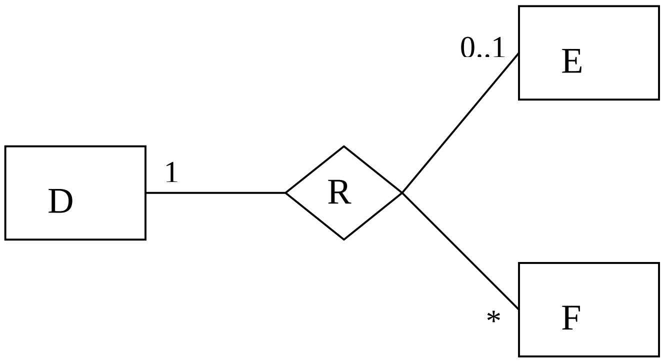


Figure 2. A class diagram

Q2 Answer

(i) In R1, each C1 object is associated with at most one C2 object.
Answer (i): Correct. This is because the multiplicity at C2 end is “0..1”.

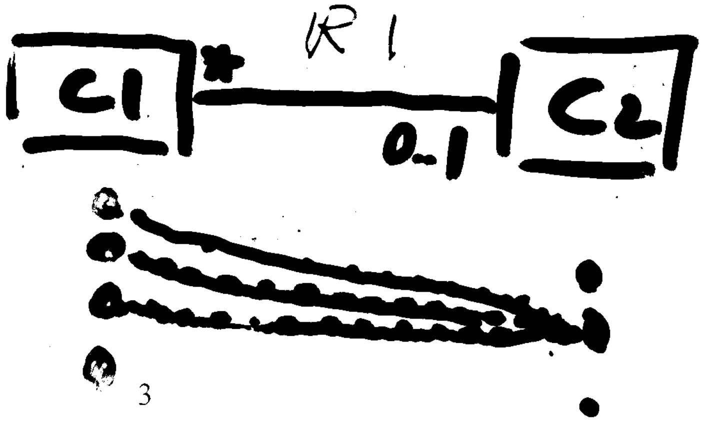
(ii) In R1, different C1 instances may associate to the same C2 instance.
Answer (ii): Correct. Since the multiplicity at C1 end is “*”, a C2 instance may associate to multiple C1 instances. As such, different C1 instances may associate to the same C2 instance.

(iii) Each instance of R1 associates a C1 object ~~to~~ with a C2 object.
Answer (iii): Correct. This is because the association R1 is a binary association that associates class C1 and class C2.

(iv) Some instances of F1 may not be part-of any D1 instance.
Answer (iv): Incorrect. In the aggregation between D1 and F1, the multiplicity at D1 end is “1”. As such, each instance of F1 must be a part of exactly one D1 instance.

(v) Each instance of E1 is an instance of D2.
Answer (v): Correct. Since E1 is a subclass of D2, each instance of E1 must also be an instance of D2.

(vi) Each instance of D2 is an instance of E1 or E2.
Answer (vi): Incorrect. In general, an instance of a super-class needs not be an instance of any of its sub-class. As such, this statement is wrong.



(vii) We can add multiplicity notations to the generalization between D2, E1 and E2.

Answer (vii): Incorrect. Since generalization is for structuring classes, it does not refer to different instances of the classes involved. As such, multiplicity notations cannot be applied to generalization.

(viii) Each instance of E1 associates with one instance of D1 under the association R2.

Answer (viii): Correct. Each instance of E1 is an instance of D2 as E1 is a subclass of D2. As an instance of D2, it always associates with an instance of D1 under the association R2.

(ix) When the sets of instances of D, E and F are {d1, d2}, {e1} and {f1, f2} respectively, {(d1, e1, f1), (d2, e1, f2)} is a possible set of R instances.

Answer (ix): Correct. This because every instance in the latter set associates one object from each associated class and the set satisfies all the multiplicities defined in R as follows:

a) For the multiplicity at D end "1": There are two combinations of E and F objects: e1 and f1; e1 and f2. The first combination associates with one D object d1. The second combination also associates with one D object d2. Hence, each combination associates with one D instance.

b) For the multiplicity at E end "0..1": There are four combinations of D and F objects: d1 and f1; d1 and f2; d2 and f1; d2 and f2. The first and last combination associates with one E object each. Both the second and third combinations associate with zero E's object.

c) For the multiplicity and F end "*": There are two combination of D and E objects: d1 and e1; d2 and e1. Both combinations associates with one F object.

(x) When the sets of instances of D, E and F are {d1, d2}, {e1, e2} and {f1, f2} respectively, {(d2, e1, f1), (d2, e1, f2), (d2, e2, f1), (d1, e2, f2)} is a possible set of R instances

Answer (ix): Incorrect. This is because the combination d2, f1 of instances of D and F associates with two instances of E, e1 and e2. This violates the multiplicity of T at E end = "0..1".

3. In Figure 3, if B has 1000 instances, what is the number of A instances?

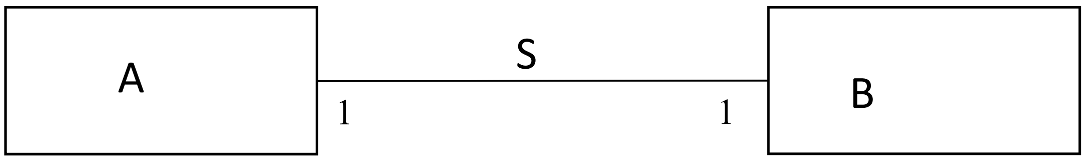


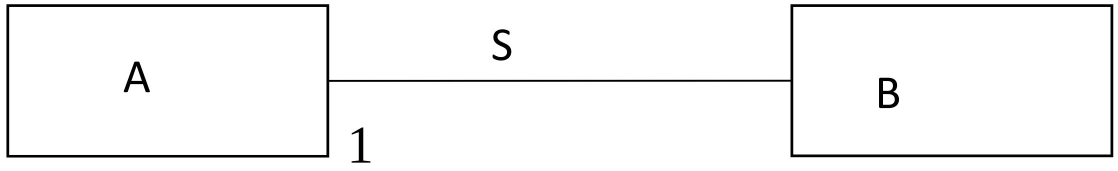
Figure 3. A class diagram

Answer:

Multiplicity at A end = "1"
⇒Each instance of B associates with one instance of A
⇒Each instance of B is in exactly one instance of S
⇒Total no of S instances = no of B instances = 1000

Multiplicity at B end = "1"
⇒Each instance of A associates with one instance of B
⇒Each instance of A is in exactly one instance of S
⇒Total no of A instances = no of S instances = 1000

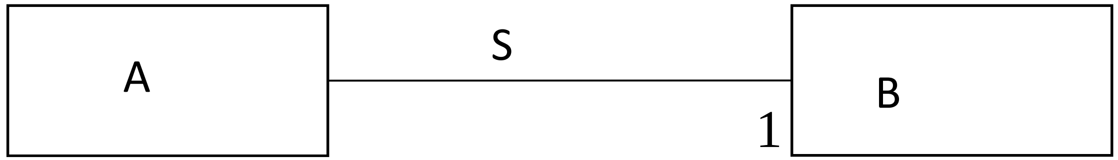
Illustration of Multiplicity at A end (1)



<u>B instances</u>		<u>S instances</u>
b1	→	(a1, b1)
b2	→	(a2, b2)
b3	→	(a3, b3)
	. . . .	
bn	→	(an, bn)

Tot No of S instances = tot No of B instances = 1000

Illustration of Multiplicity at A end (1)



<u>A instances</u> <u>S instances</u>

a1 → (a1, b1)

a2 → (a2, b2)

a3 → (a3, b3)

.
.
.
.

an → (an, bn)

Tot No of S instances = tot No of A instances = 1000

4. In Figure 4, if B has 9000 insances, what is the number of A instances?

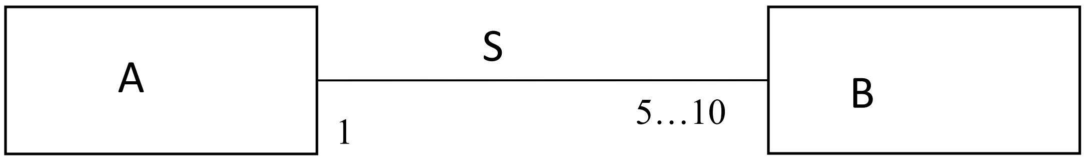


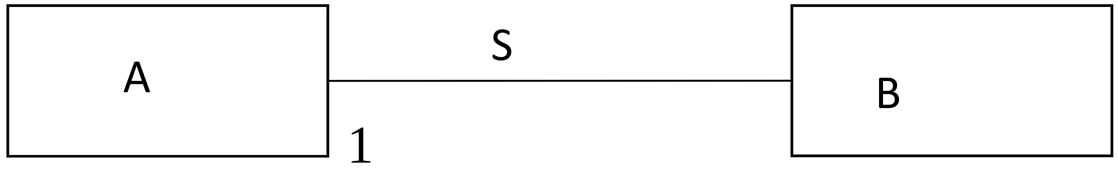
Figure 4. A class diagram

Answer:

Multiplicity at A end = “1”
⇒Each instance of B associates with one instance of A
⇒Each instance of B is in exactly one instance of S
⇒Total no of S instances = no of B instances = 9000

Multiplicity at B end = “5..10”
⇒Each instance of A associates with 5 to 10 instances of B
⇒Each instance of A is in 5 to 10 instances of S
⇒ 5 * no of A instances ≤ Total no of S instances ≤ 10* no of A instances
⇒ 5 * no of A instances ≤ 9000 ≤ 10* no of A instances
⇒ no of A instances ≤ 1800 and no of A instances ≥ 900
⇒ 900 ≤ no of A instances ≤ 1800

Illustration of Multiplicity at A end (1)



<u>B instances</u> | <u>S instances</u>

b1 → (a1, b1)

b2 → (a2, b2)

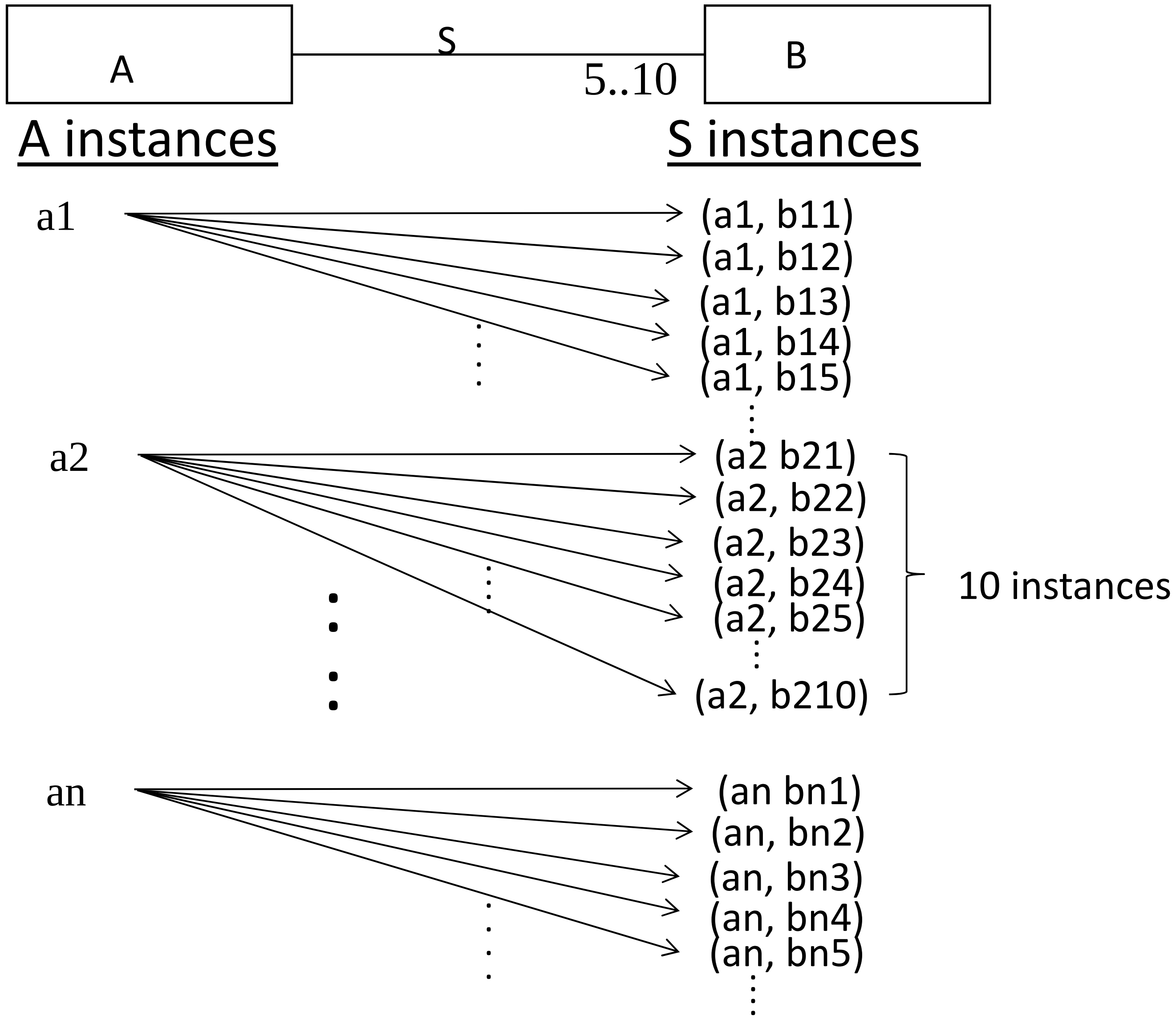
b3 → (a3, b3)

.
.
.
.

bn → (an, bn)

Tot No of S instances = tot No of B instances = 9000

Illustration of Multiplicity at B end (5…10)



Tot No of S instances $\geq$ 5* Tot no of A instances

Tot No of S instances$\leq$ 10* tot No of A instances

5. In Figure 5,

(i) If Y has 1000 instances, what is the minimum number of X instances?

(ii) If X has 3000 instances, what are the maximum numbers of Y and Z instances?

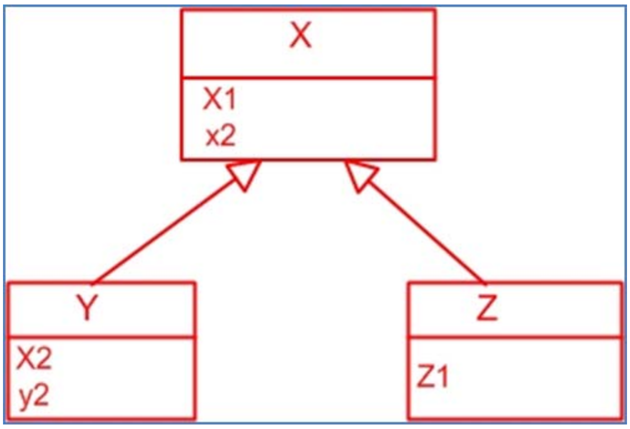


Figure 5. A generalization

(i) If Y has 1000 instances:

Y has 1000 instances

$\Rightarrow$No of X instances $\geq$ 1000 (this is because every Y instance is a X instance)

Hence, the minimum number of X instances is 1000

(ii) If X has 3000 instances:

X has 3000 instances

$\Rightarrow$No of Y instances $\leq$ 3000, No of Z instances $\leq$ 3000 (this is because every Y or Z instance is a X instance)

Hence, the maximum numbers of Y and Z instances are both 3000.

6. In the class diagram shown in Figure 6, let the number of instances of G1, G2, G3 and G4 be m, n, p and q (all greater than zero) respectively. Prove that n ≥ 2*m and m ≥ p.

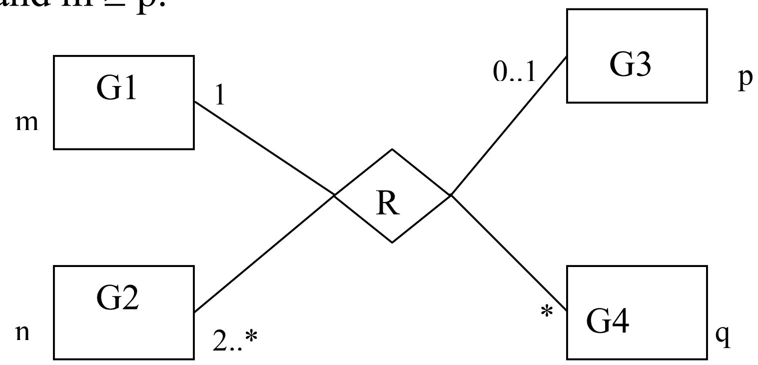


Figure 6. A class diagram

<u>Q4 Answer:</u>

Since the multiplicity at G1 end is 1, each combination of G2, G3, and G4 objects must associate to exactly one G1 instance. As there are altogether n*p*q combinations of G2, G3 and G4 objects, the number of R instances must be n*p*q. (that is, $|R| = npq$)

Since the multiplicity at G2 end is 2 or more, each combination of G1, G3, and G4 objects must associate to 2 or more G2 instances. As there are altogether m*p*q combinations of G1, G3 and G4 objects, the number of R instances must be greater or equal to 2*m*p*q. That is, $|R| \geq 2mpq$.

Therefore, we have n*p*q ≥ 2*m*p*q.

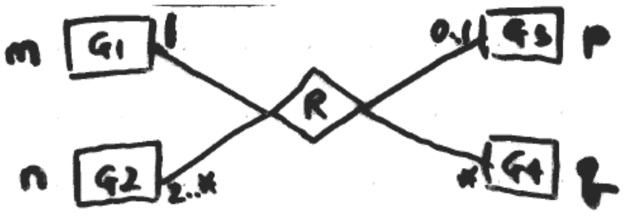
Since the multiplicity at G3 end is 0 or 1, each combination of G1, G2, and G4 objects can associate at most one G3 instance. As there are altogether m*n*q combinations of G1, G2 and G4 objects, the number of R instances must be less than or equal to m*n*q. That is, $|R| \leq mnq$.

Therefore, we have n*p*q ≤ m*n*q.

As such:

$$2*m*p*q \leq n*p*q \leq m*n*q$$
$$\Rightarrow\ n \geq 2*m \text{ and } m \geq p$$

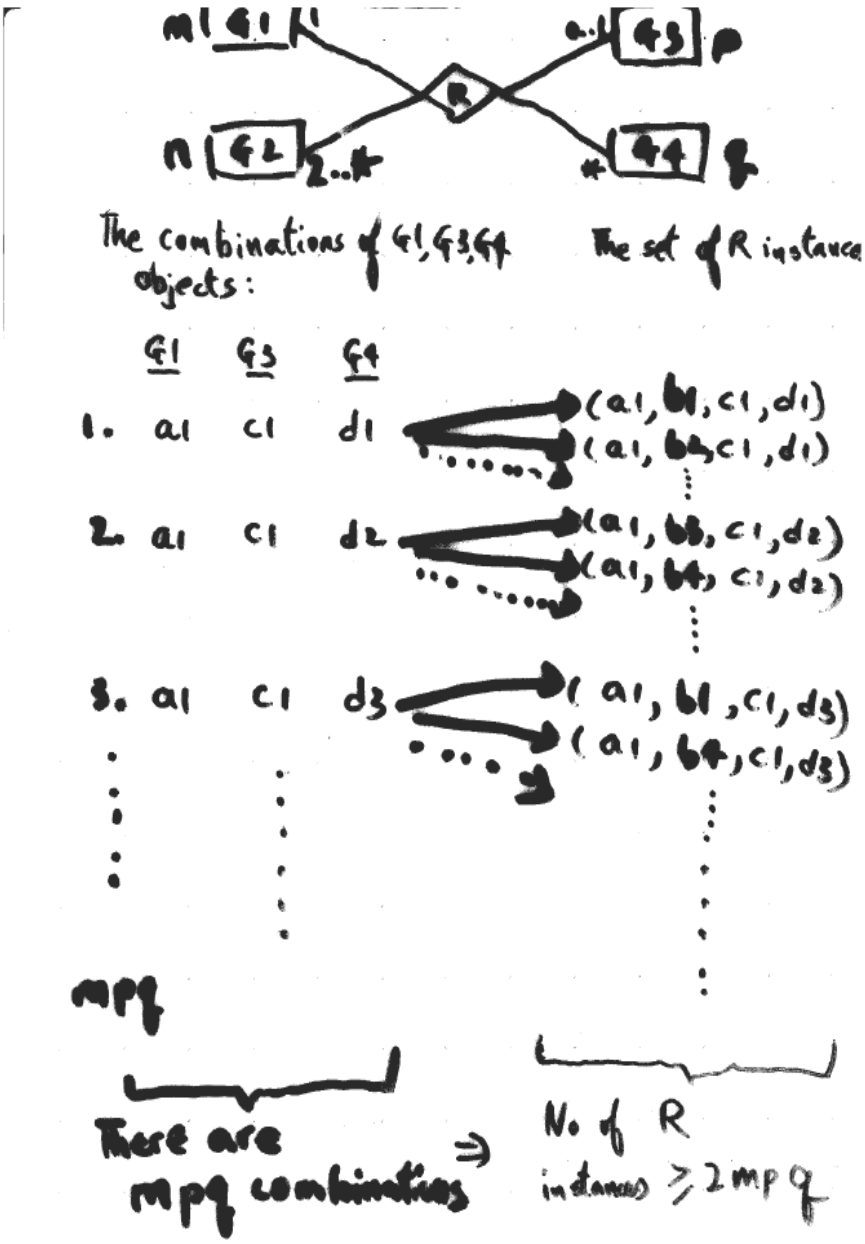
I) The correspondence between (combinations of G2, G3 and G4 instances one from each class) and R instances that is derived from the multiplicity at G1 end and the derivation of equality (1)



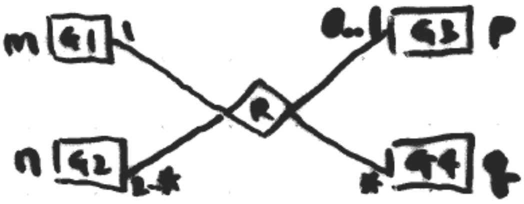
The combinations of G2,G3,G4 objects					The set of R instances
	G2	G3	G4		~~(a1, b1, c1, d1)~~
1.	b1	c1	d1	→	(a1, b1, c1, d1)
2.	b1	c1	d2	→	(a2, b1, c1, d2)
3.	b1	c1	d3	→	(a3, b1, c1, d3)
⋮		⋮			⋮
	b1	c2	d1	→	(a2, b1, c2, d1)
⋮		⋮			⋮
npq					

There are npq combinations ⇒ No of R instances = npq

II) The correspondence between (combinations of G1, G3 and G4 instances one from each class) and R instances that is derived from the multiplicity at G2 end and the derivation of inequality (2)



III) The correspondence between (combinations of G1, G2 and G4 instances one from each class) and R instances that is derived from the multiplicity at G3 end and the derivation of inequality (3).



The combinations of G1, G2, G4 objects

The set of R instances

	G1	G2	G4		
1.	a1	b1	d1	$\longrightarrow$	(a1, b1, c1, d1)
2.	a1	b1	d2		
3.	a1	b1	d3	$\longrightarrow$	(a1, b1, c3, d3)
4.	a1	b1	d4		
5.	a1	b1	d5	$\longrightarrow$	(a1, b1, c3, d5)
⋮		⋮			⋮
mnq					

There are mnq combinations $\Rightarrow$ No of R instances $\leq$ mnq