

1)

E: Universe will exist

H: World end in a heat death

B: There was big bang

X: Universe is expanding

A: Universe is accelerated

a)

1) The universe will either simply exist as it is or end in heat death. $E \vee H$ 2) If there was no big bang, then the universe simply existed. $\neg B \rightarrow E$ 3) The universe had a big bang (B) if and only if it is expanding (X) $B \leftrightarrow X$

4) If the universe is both expanding and accelerated then it will end in a heat death.

$$X \wedge A \rightarrow H$$

b)

contrapositive of $\neg B \rightarrow E$ is $\neg E \rightarrow B$ contrapositive of $B \leftrightarrow X$ is $\neg X \leftrightarrow \neg B$ since both are equivalentcontrapositive of $X \wedge A \rightarrow H$

is

$$\neg H \rightarrow \neg (X \wedge A)$$

$$\neg H \rightarrow \neg X \vee \neg A$$

→ if universe simply doesn't exist then there was big bang.

→ if universe doesn't end in a heat death then it is not expanding nor accelerated.

c) Inferences that can be made:-

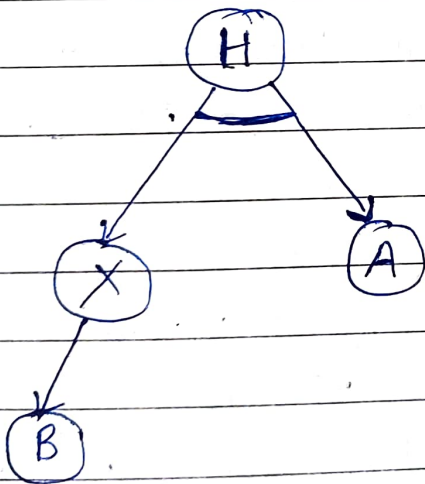
- If the universe is expanding (X) then there was a big bang. $B \leftrightarrow X$
- If the universe is expanding and accelerated, then it will end in a heat death.

Inferences that cannot be made directly

- We cannot infer whether the universe will simply exist as it is or end in a heat death without additional info. E v H doesn't provide direct implication.
- We cannot infer whether there was big bang or not.
- We cannot infer whether the universe is expanding or not.

d) AND-OR Graph

Goal:- universe end in heat death (H)

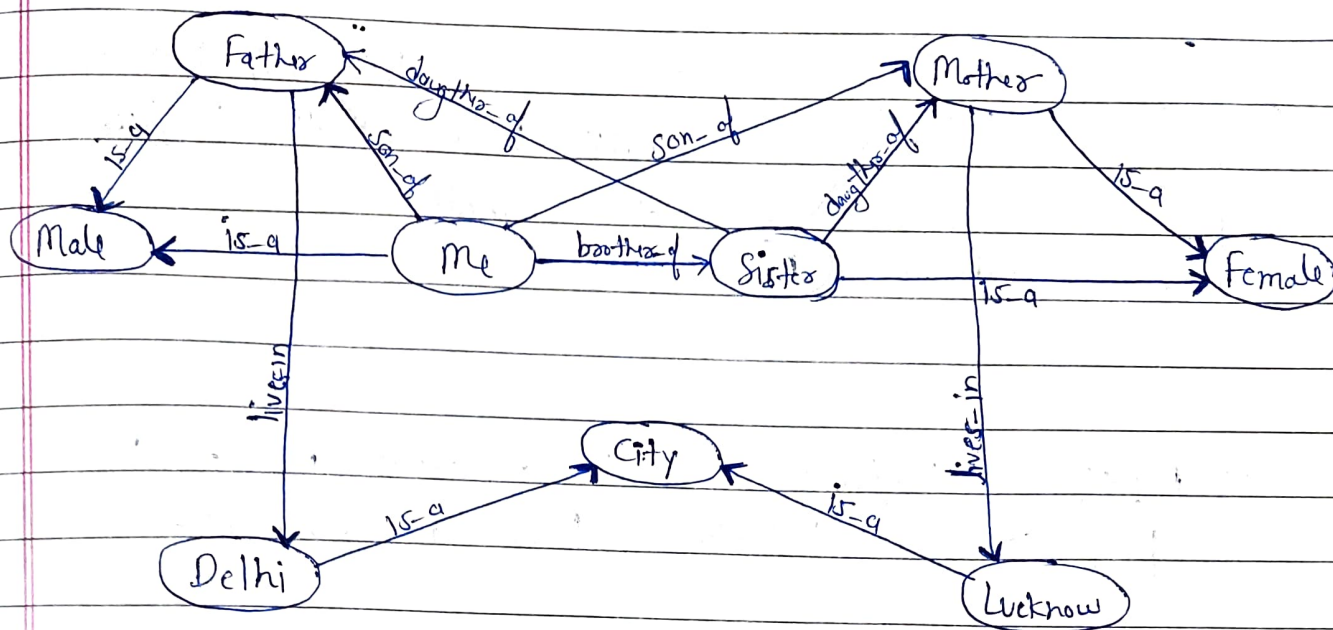


X: universe is expanding

A: universe is accelerating

B: There was big bang

2)

Semantic Graph

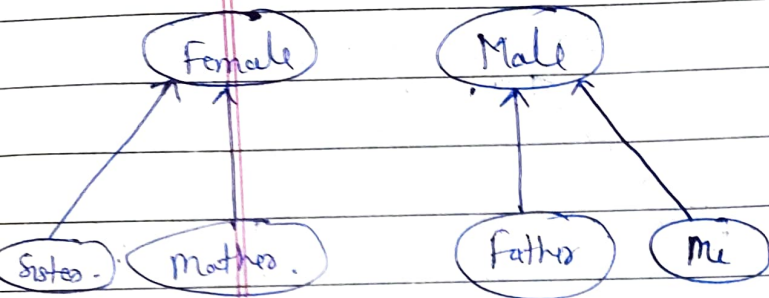
blu, me, my father, mother and sister.

→ Knowledge Base

- I am a male.
- I am son of my father and mother.
- I am brother of my sister.
- My sister is daughter of my father and mother.
- My father is a male.
- My sister and mother are female.
- My father stays in Delhi.
- My Mother stays in Lucknow.
- Delhi and Lucknow are cities.

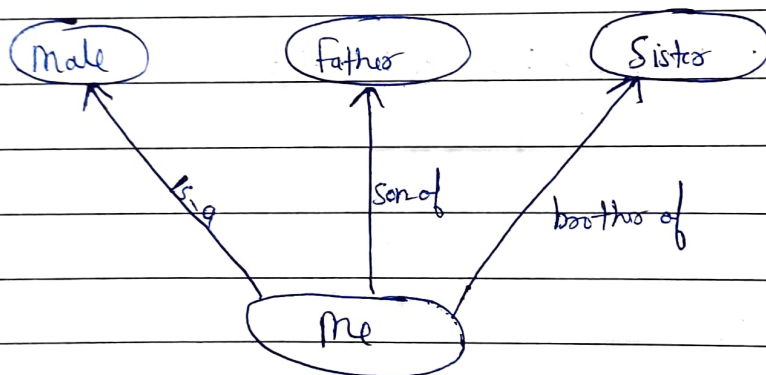
Inheritance is to inherit properties and behaviours from an existing object. The key idea is that an inherited object has properties of parent object.

In the above semantic graph.



This means that My father will have all the properties of a male.

→ Multiple Inheritance :- When an object inherits the properties and behaviors from multiple objects.



3)

Unit Resolution

unit resolution rule takes a clause - disjunction of literals - and a literal and produces a new clause.

Proof by resolution rule,

$$\frac{l_1 \vee l_2 \vee \dots \vee l_k, m_1 \vee m_2 \vee \dots \vee m_n}{l_1 \vee l_2 \vee \dots \vee l_k \vee m_1 \vee m_2 \vee \dots \vee m_n}$$

where l_1 & l_2 are complementary literals.

- Soundness :- A proof system is sound if it never derives false conclusion from true premises.

The soundness of the resolution rule can be seen easily by considering the literal l_1 that is complementary to literal m_1 in the other clause. If l_1 is true, then m_1 is false, and hence

$m_1 \vee m_2 \vee \dots \vee m_n$ must be true, because $m_1 \vee m_2 \vee \dots \vee m_n$ is given. If l_1 is false, then $l_1 \vee l_2 \vee \dots \vee l_k$ must be true because $l_1 \vee l_2 \vee \dots \vee l_k$ is given. Now l_1 is either true or false, so one or other of these conclusion holds - exactly as the resolution rule states.

- Completeness :- A proof is complete if, given any valid statement it can eventually derive that statement using its inference rules. If a set of sentences is unsatisfiable, then resolution will always be able to derive a contradiction.

Our goal therefore is to prove the following:

If S is an unsatisfiable set of clauses, then the application of a finite number of resolution steps to S will yield a contradiction.

Any set of sentences S is representable in clausal form



Assume S is unsatisfiable, and in clausal form



← Herbrand's theorem

Some set S' of ground instances is unsatisfiable.



← Ground resolution theorem

Resolution can find a contradiction in S'



← Lifting lemma.

There is a resolution proof for the contradiction in S' .