Entailments: 1

Is there a company whose CEO loves Jane?

$\exists x$ [Company(x) $\wedge$ Loves(ceoOf(x),jane)] ??

Suppose $\mathfrak{I}$ |= KB.

Then $\mathfrak{I}$ |= Rich(john), Man(john),

and $\mathfrak{I}$ |= $\forall y$[Rich(y) $\wedge$ Man(y) $\supset$ Loves(y,jane)]

so $\mathfrak{I}$ |= Loves(john,jane).

Also $\mathfrak{I}$ |= john = ceoOf(fic),

so $\mathfrak{I}$ |= Loves(ceoOf(fic),jane).

Finally $\mathfrak{I}$ |= Company(faultyInsuranceCorp),

and $\mathfrak{I}$ |= fic = faultyInsuranceCorp,

so $\mathfrak{I}$ |= Company(fic).

Thus, $\mathfrak{I}$ |= Company(fic) $\wedge$ Loves(ceoOf(fic),jane),

and so

$\mathfrak{I}$ |= $\exists x$ [Company(x) $\wedge$ Loves(ceoOf(x),jane)].

Can extract identity of company from this proof

Entailments: 2

If no man is blackmailing John, then is he being blackmailed by somebody he loves?

$\forall x[\text{Man}(x) \supset \neg\text{Blackmails}(x,\text{john})] \supset$
$\exists y[\text{Loves}(\text{john},y) \wedge \text{Blackmails}(y,\text{john})]$??

Note: KB |= ($\alpha \supset \beta$) iff KB $\cup \{\alpha\}$ |= β

Let: $\mathfrak{I}$ |= KB $\cup \{\forall x[\text{Man}(x) \supset \neg\text{Blackmails}(x,\text{john})]\}$

Show: $\mathfrak{I}$ |= $\exists y[\text{Loves}(\text{john},y) \wedge \text{Blackmails}(y,\text{john})$

Have: $\exists x[\text{Adult}(x) \wedge \text{Blackmails}(x,\text{john})]$ and $\forall x[\text{Adult}(x) \supset \text{Man}(x) \vee \text{Woman}(x)]$
so $\exists x[\text{Woman}(x) \wedge \text{Blackmails}(x,\text{john})]$.

Then: $\forall y[\text{Rich}(y) \wedge \text{Man}(y) \supset \text{Loves}(y,\text{jane})]$ and $\text{Rich}(\text{john}) \wedge \text{Man}(\text{john})$
so $\text{Loves}(\text{john},\text{jane})$!

But: $\forall y[\text{Woman}(y) \wedge y \neq \text{jane} \supset \text{Loves}(y,\text{john})]$
and $\forall x \forall y[\text{Loves}(x,y) \supset \neg\text{Blackmails}(x,y)]$
so $\forall y[\text{Woman}(y) \wedge y \neq \text{jane} \supset \neg\text{Blackmails}(y,\text{john})]$ and $\text{Blackmails}(\text{jane},\text{john})$!!

Finally: $\text{Loves}(\text{john},\text{jane}) \wedge \text{Blackmails}(\text{jane},\text{john})$
so: $\exists y[\text{Loves}(\text{john},y) \wedge \text{Blackmails}(y,\text{john})]$

What individuals?

Sometimes useful to reduce n-ary predicates to 1-place predicates and 1-place functions

- involves reifying properties: new individuals
- typical of description logics / frame languages (later)

Flexibility in terms of arity:

Purchases(john,sears,bike) or
Purchases(john,sears,bike,feb14) or
Purchases(john,sears,bike,feb14,$100)

Instead: introduce purchase objects

Purchase(p) $\wedge$ agent(p)=john $\wedge$ obj(p)=bike $\wedge$ source(p)=sears $\wedge$ ...

allows purchase to be described at various levels of detail

Complex relationships: MarriedTo(x,y) vs. ReMarriedTo(x,y) vs. ...

Instead define marital status in terms of existence of marriage and divorce events.

Marriage(m) $\wedge$ husband(m)=x $\wedge$ wife(m)=y $\wedge$ date(m)=... $\wedge$...

Abstract individuals

Also need individuals for numbers, dates, times, addresses, etc.

objects about which we ask wh-questions

Quantities as individuals

age(suzy) = 14

age-in-years(suzy) = 14
age-in-months(suzy) = 168

perhaps better to have an object for “the age of Suzy”, whose value in years is 14

years(age(suzy)) = 14

months(x) = 12*years(x)

centimeters(x) = 100*meters(x)

Similarly with locations and times

instead of

time(m)="Jan 5 2006 4:47:03EST"

can use

time(m)=t $\wedge$ year(t)=2006 $\wedge$ ...

Other sorts of facts

Statistical / probabilistic facts

- Half of the companies are located on the East Side.
- Most of the employees are restless.
- Almost none of the employees are completely trustworthy,

Default / prototypical facts

- Company presidents typically have secretaries intercepting their phone calls.
- Cars have four wheels.
- Companies generally do not allow employees that work together to be married.

Intentional facts

- John believes that Henry is trying to blackmail him.
- Jane does not want Jim to think that she loves John.

Others ...