# Elements of Situation Calculus

Nils J. Nilsson

Intelligenza Artificiale – Ed. Apogeo

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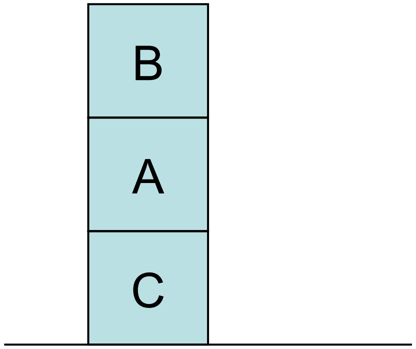
# States




On(B,A)
On(A,C)
On(C,Floor)
Free(B)
Free(Floor)

Goal: ∃x On(x,B)

S0 =
On(B,A) ∧ Su(A,C) ∧ On(C,Floor) ∧ Free(B) ∧ Free(Floor)

<u>States reification</u>

We consider abstract entities, in this case states, as objects of the world we are considering

On(B,A,S0) ∧ On(A,C,S0) ∧ On(C,Floor,S0) ∧ Free(B,S0) ∧ Free(Floor,S0)

On, Free : **Fluents**. Predicates changing from a situation to another one

∀ x,y,s On(x,y,s) ∧ ¬(y = Floor) ⇒ ¬Free(y,s)
∀ s Free(Floor,s)

# Representing Actions and Effects

- Reify actions: actions can be denoted with constants, variables, functional expressions.
  - In the blocks worls, actions are functions over blocks: `move(A,B,Floor)`
- Introduce the function `do`. This function relates states and actions with other states
  - `do(a,s)` respresents the state reached starting from `s` performig `a`
- Represent the effects of actions by formulas.

PRECONDITIONS $\Rightarrow$ EFFECT

**Postive Effect Axiom**

$\forall$ x,y,s On(x,y,s) $\wedge$ Free(x,s) $\wedge$ Free(z,s) $\wedge$ $\neg$(x=z) $\Rightarrow$
On(x,z,do(move(x,y,z),s))

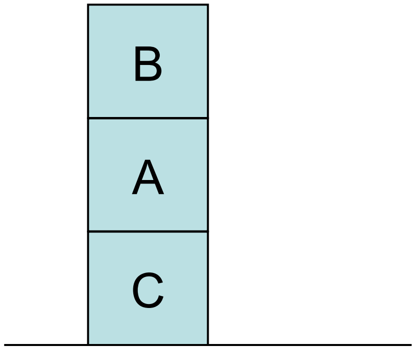
**Negative Effect Axiom**

$\forall$ x,y,s On(x,y,s) $\wedge$ Free(x,s) $\wedge$ Free(z,s) $\wedge$ $\neg$(x=z) $\Rightarrow$
$\neg$On(x,y,do(move(x,y,z),s))

$\forall$ x,y,s On(x,y,s) $\wedge$ Free(x,s) $\wedge$ Free(z,s) $\wedge$ $\neg$(x=z) $\wedge$ $\neg$(y=z) $\Rightarrow$
Free(y,do(move(x,y,z),s))

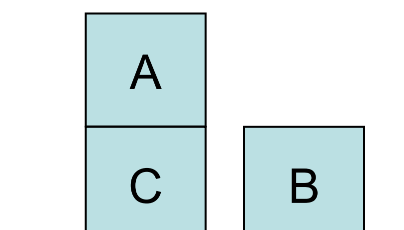
$\forall$ x,y,s On(x,y,s) $\wedge$ Free(x,s) $\wedge$ Free(z,s) $\wedge$ $\neg$(x=z) $\wedge$ $\neg$(x=Floor) $\Rightarrow$
$\neg$Free(z,do(move(x,y,z),s))

# Use Effect Axioms in the Blocks World




```
On(B,A,S0)
On(A,C,S0)
On(C,Floor,S0)
Free(B,S0)
Free(Pav,S0)
```

```
S0
move(B,A,Floor)
S1 = do(move(B,A,Floor),S0)
```




```
On(A,Floor,do(move(B,A,Floor),S0))
¬On(B,A,do(move(B,A,Floor),S0))
Free(A,do(move(B,A,Floor),S0))

On(A,C,do(move(B,A,Floor),S0))
On(C,Floor,do(move(B,A,Floor),S0))
Free(B,do(move(B,A,Floor),S0))

Free(Floor,S0)
```
**It is true for all the states!**

OBS: Formulas in Situation Calculus ARE STATELESS.

Even if we are in S1, formulas resulting true in S0 continue to be true.

# The Frame Problem

- Not all the infornation related to state `S1 = do(sposta(B,A,Pav))` can be inferred from the Effect Axioms
- Some facts true before an action (C on the floor, B is free) continue to be true also in the state following the «move» action.
- Actions have local effects
- Many fluents remains unchanged
- We need a pair of «*frame axioms*» – *positive frame axiom* and *negative frame axiom* – for each pair **<action,Fluent>** [**may we derive them automatically?**]

  **<move,On>**

  $On(x,y,s) \wedge \neg(x=u) \Rightarrow On(x,y,do(move(u,v,z),s))$

  $\neg On(x,y,s) \wedge (\neg(x=u) \vee \neg(y=a)) \Rightarrow \neg On(x,y,do(move(u,v,z),s))$

  **<move,Free>**

  $Free(u,s) \wedge \neg(x=z) \Rightarrow Free(u,do(move(x,y,z),s))$

  $\neg Free(u,s) \wedge \neg(u=y) \Rightarrow \neg Free(u,do(move(x,y,z),s))$

- From the positive frame axiom for **<move,Free>** we may infer `Free(B,do(move(B,A,Floor),S))`