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Modular Basic Action Theories

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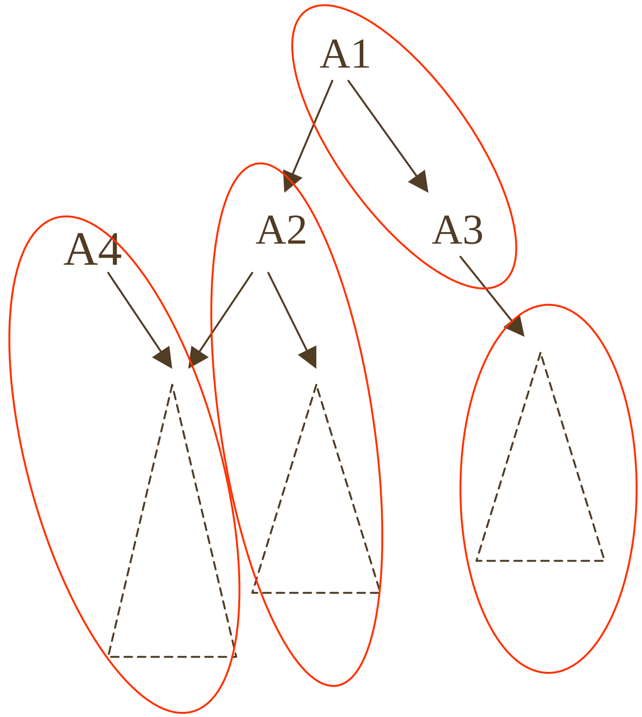
Outline

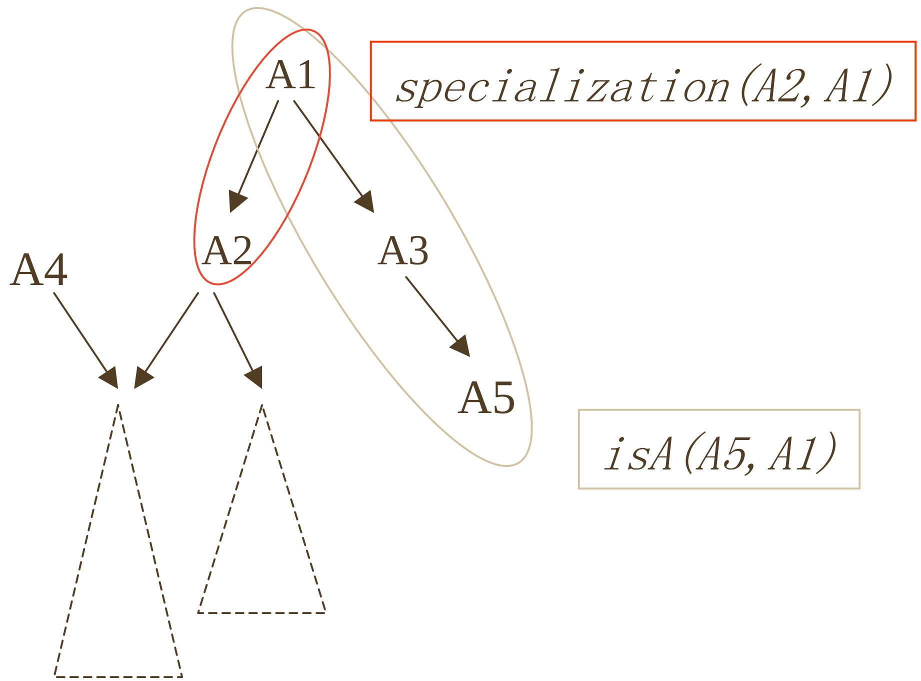
- Motivation
- Action Hierarchy
- Modular Basic Action Theories (BATs)
- The Correctness

Motivation

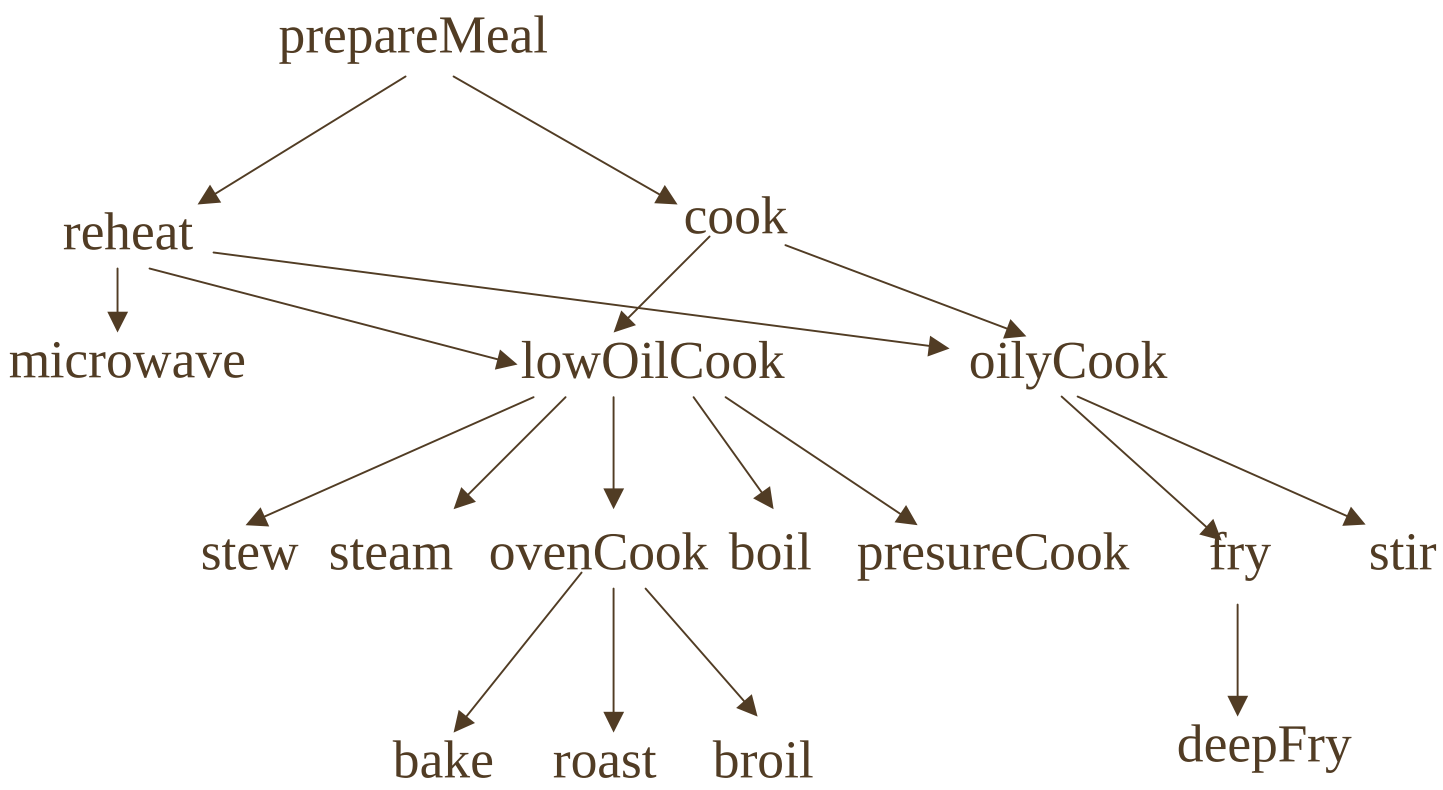


Action Hierarchy

- Acyclic
- Antisymmetric
- Multiple inheritance



A Cooking Example



Examples of Action Hierarchy Axioms

- Examples of direct specializations:

specialization(reheat(x), prepareMeal(x)). specialization(cook(x), prepareMeal(x)).

specialization(microwave(x), reheat(x)). specialization(lowOilcook(x), reheat(x)).

specialization(oilyCook(x), reheat(x)). specialization(lowOilcook(x), cook(x)).

specialization(oilyCook(x), cook(x)). specialization(stew(x), lowOilCook(x)).

… …

specialization(deepFry(x), fry(x)).

- Examples of isA:

isA(cook(x), cook(x)).

isA(deepFry(x), fry(x)).

… …

isA(deepFry(x), prepareMeal(x)).

Modular BAT Representation

- Precondition Axioms:

$$Poss(a,s) \equiv \exists x(\ isA(a, reheat(x)) \wedge food(x) \wedge cooked(x,s)\ ) \vee$$
$$\exists x(\ isA(a, cook(x)) \wedge food(x) \wedge \neg\ cooked(x,s)\ ) \vee$$
$$\exists x\ (a = prepareMeal(x) \wedge food(x)\ ).$$

- Successor State axioms:

$$cooked(x,do(a,s)) \equiv isA(a, cook(x)) \vee$$
$$cooked(x,s).$$

$$mealReady(x,do(a,s)) \equiv isA(a, prepareMeal(x)) \vee$$
$$mealReady(x,s).$$

Comparison: Reiter's BAT Representation

- Precondition Axioms:

  $Poss(deepFry(x),s) \equiv food(x)$. $Poss(fry(x),s) \equiv food(x)$. … …

  $Poss(prepareMeal(x),s) \equiv food(x)$. $Poss(reheat(x),s) \equiv food(x) \wedge cooked(x)$.

  $Poss(reheat(x),s) \equiv food(x) \wedge \neg cooked(x)$.

- Successor State axioms:

$$cooked(x,do(a,s)) \equiv a = cook(x) \vee a = lowOilCook(x) \vee a = oilyOilCook(x) \vee a = steam(x) \vee a = boil(x) \vee a = stew(x) \vee a = broil(x) \vee a = bake(x) \vee a = ovenCook(x) \vee a = roast(x) \vee a = presureCook(x) \vee a = fry(x) \vee a = deepFry(x) \vee a = stir(x) \vee cooked(x,s).$$

$$mealReady(x,do(a,s)) \equiv a = prepareMeal(x) \vee a = reheat(x) \vee a = cook(x) \vee a = microwave(x) \vee a = lowOilCook(x) \vee a = oilyOilCook(x) \vee a = steam(x) \vee a = boil(x) \vee a = stew(x) \vee a = broil(x) \vee a = bake(x) \vee a = ovenCook(x) \vee a = roast(x) \vee a = presureCook(x) \vee a = fry(x) \vee a = deepFry(x) \vee a = stir(x) \vee mealReady(x,s).$$

Correctness of the New BATs

- A modular BAT $D^H = D_0 \cup D_{ap}^H \cup D_{ss}^H \cup D_{una} \cup \Sigma \cup H$
  1. D_0 – the (usual) initial theory
  2. D_{ap}^H – the modular precondition axioms
  3. D_{ss}^H – the modular successor state axioms
  4. D_{una} – the (usual) unique name axioms for actions
  5. Σ – the (usual) foundational axioms
  6. H – the specialization axioms and the definition of isA
- Theorem: For any modular BAT D^H there exists an equivalent D of Reiter's BAT format, where equivalence means that for any FO regressable sentence W, $D^H \models W$ iff $D \models W$.
- Although the formal definition of isA is second-order, the reasoning in D^H can be reduced to a FOL reasoning only.
- A regression theorem similar to Reiter's regression theorem is proved.

The End

Thank you!