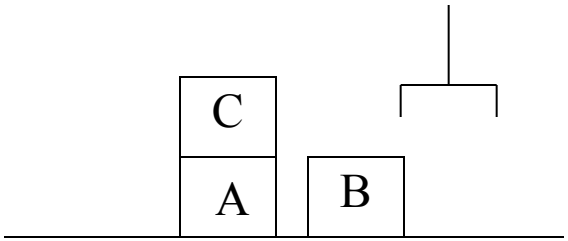
Planning problem: Given an **initial state** and **goal specification**,
find a sequence/set of operators that transform initial state to a state that satisfies goal specification

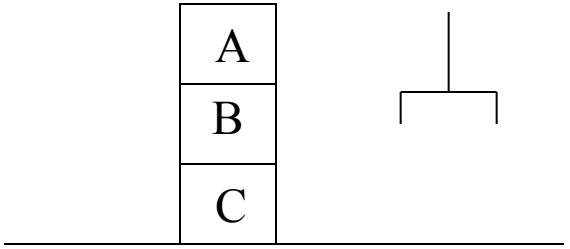
Initial State



CLEAR(B)
ON(C,A)
CLEAR(C)
ONTABLE(A)
ONTABLE(B)
HANDEMPTY

Goal Specification

ON(B,C) and ON(A,B)



Example state that satisfies goal spec

Representation of operators: A PREcondition list, an ADD list, a DELETE list, or as a single effects list

pickup(?x): PRE: ONTABLE(?x), CLEAR(?x), HANDEMPTY
DEL: ONTABLE(?x), CLEAR(?x), HANDEMPTY
ADD: HOLDING(?x)
or (EFFECTS: HOLDING(?x), ~ONTABLE(?x), ~CLEAR(?x), ~HANDEMPTY)

putdown(?x): PRE: HOLDING(?x)
DEL: HOLDING(?x)
ADD: ONTABLE(?x), CLEAR(?x), HANDEMPTY

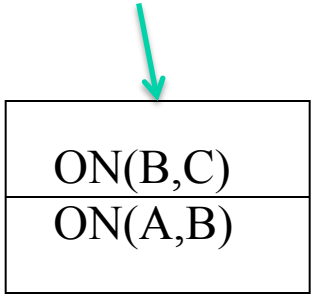
stack(?x, ?y): PRE: HOLDING(?x), CLEAR(?y)
DEL: HOLDING(?x), CLEAR(?y)
ADD: HANDEMPTY, ON(?x, ?y), CLEAR(?x)

unstack(?x, ?y): PRE: HANDEMPTY, CLEAR(?x), ON(?x,?y)
DEL: HANDEMPTY, CLEAR(?x), ON(?x,?y)
ADD: HOLDING(?x), CLEAR(?y)

OP(S[t1]) = S[t1] – DEL(OP) + ADD(OP) = S[t2], where PRE(OP) is a subset of S[t1]

Most classical planning systems perform search that is informed by the goal state (e,g., Strips, Tweak from first planning talk and reading). Regression planners (10.2.2 of Russell and Norvig) are even more goal-directed, and compute a set of possible prior states by "regressing" through action operator definitions (formula for g' on p. 374).

Goal state of planner, and start state of regression planner



stack(B,C) will achieve ON(B,C)
stack(A,B) will achieve ON(A,B)

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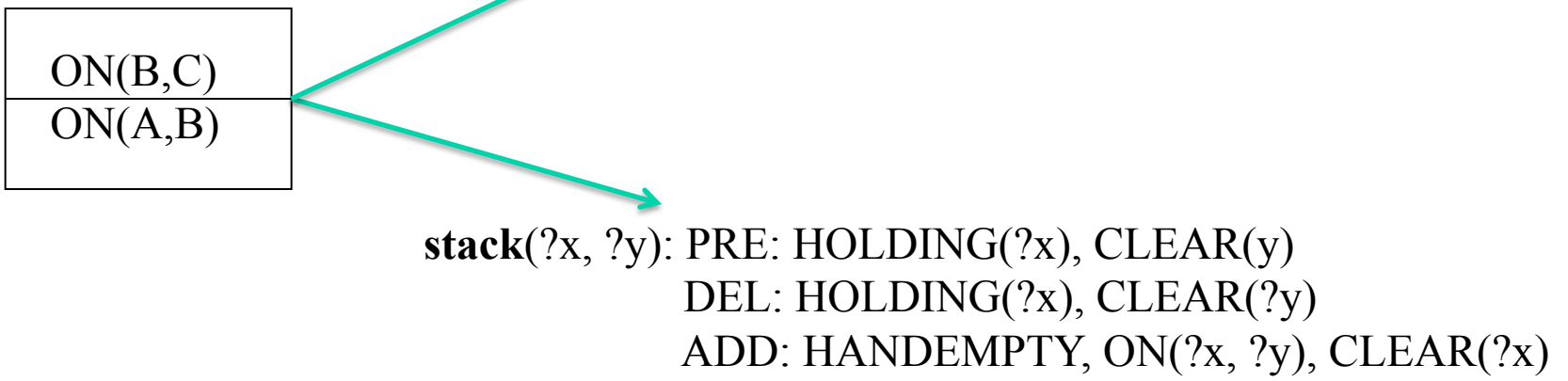

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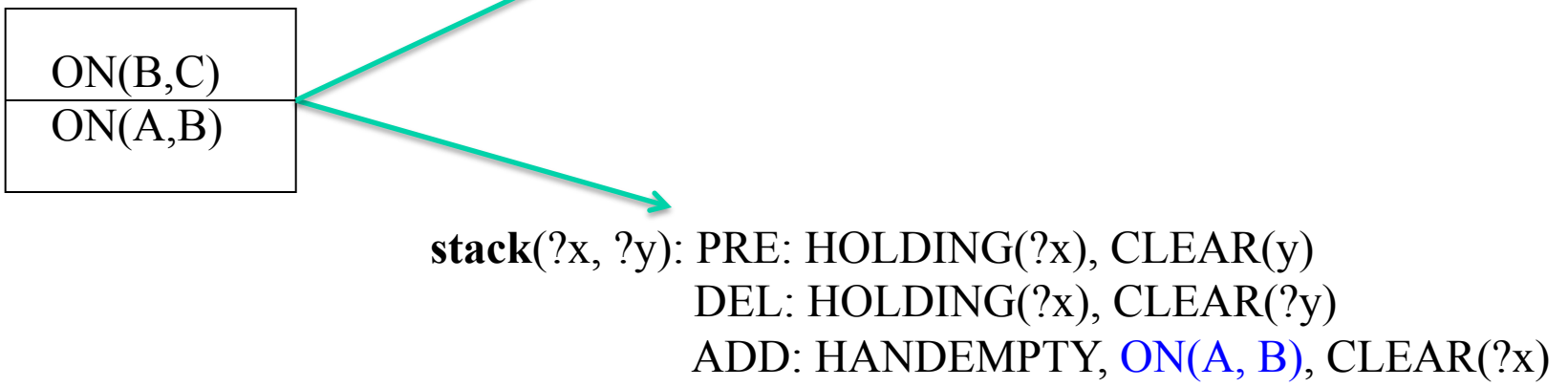

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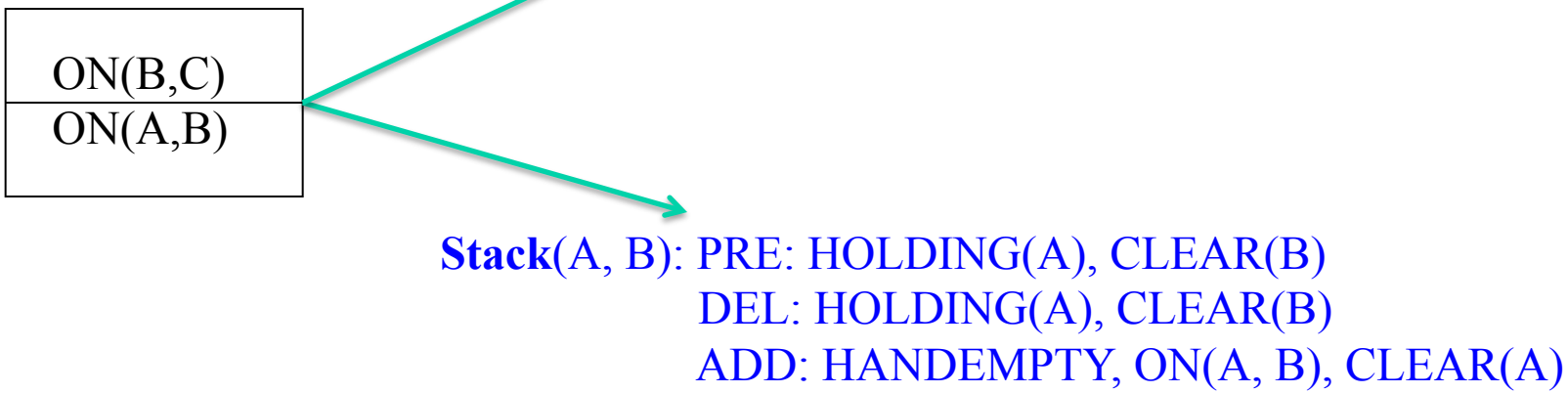
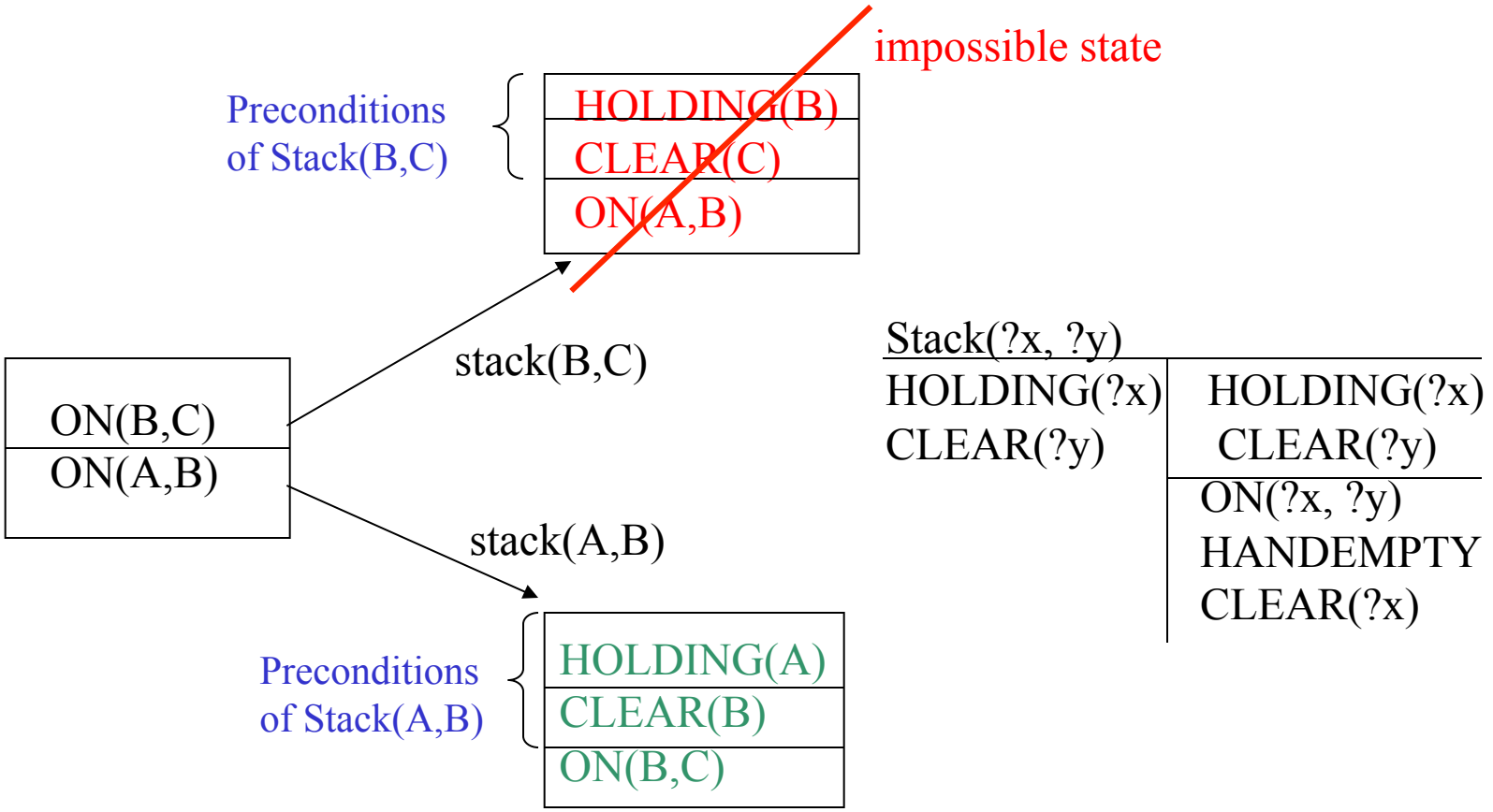


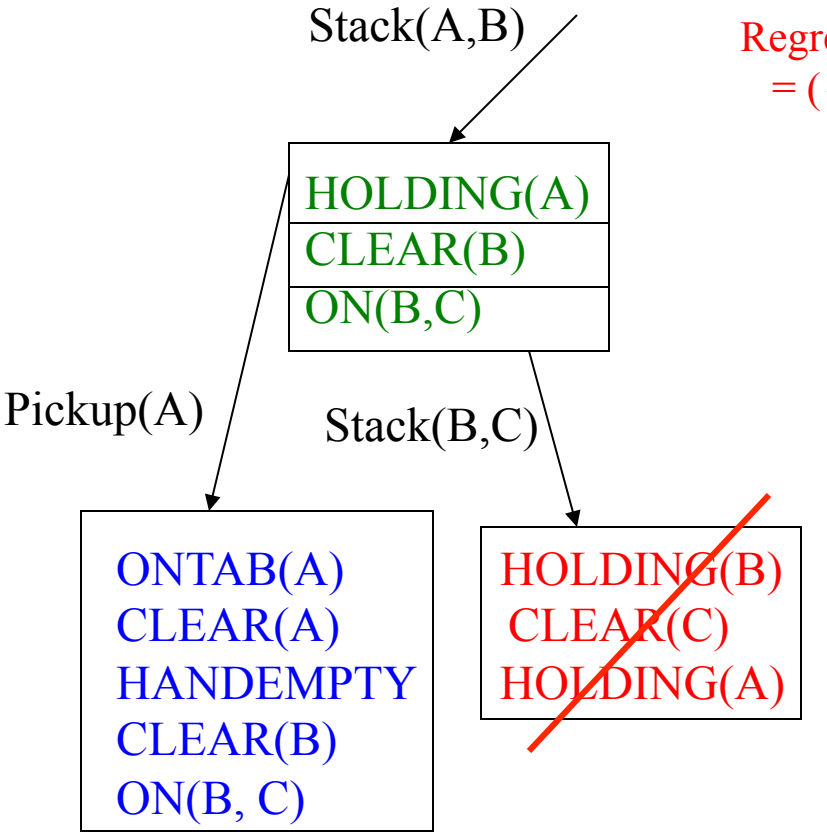
$$g' = \text{Regress}(g, op) = (g - \text{ADD}(op)) \cup \text{PRE}(op)$$

Most classical planning systems perform search that is informed by the goal state (e,g., Strips, Tweak from first planning talk and reading). Regression planners are even more goal-directed, and compute a set of possible prior states by "regressing" through action operator definitions.

Regress({ON(B,C), ON(A,B)}, stack(B,C))
= ({ON(B,C), ON(A,B)} – {ON(B,C), HANDEMPTY, CLEAR(B)}) U {HOLDING(B), CLEAR(C)}
= {ON(A,B), HOLDING(B). CLEAR(C)}



Regress({ON(B,C), ON(A,B)}, stack(A, B))
= ({ON(B,C), ON(A,B)} – {ON(A,B), HANDEMPTY, CLEAR(A)}) U {HOLDING(A), CLEAR(B)}
= {ON(B,C), HOLDING(A), CLEAR(B)}

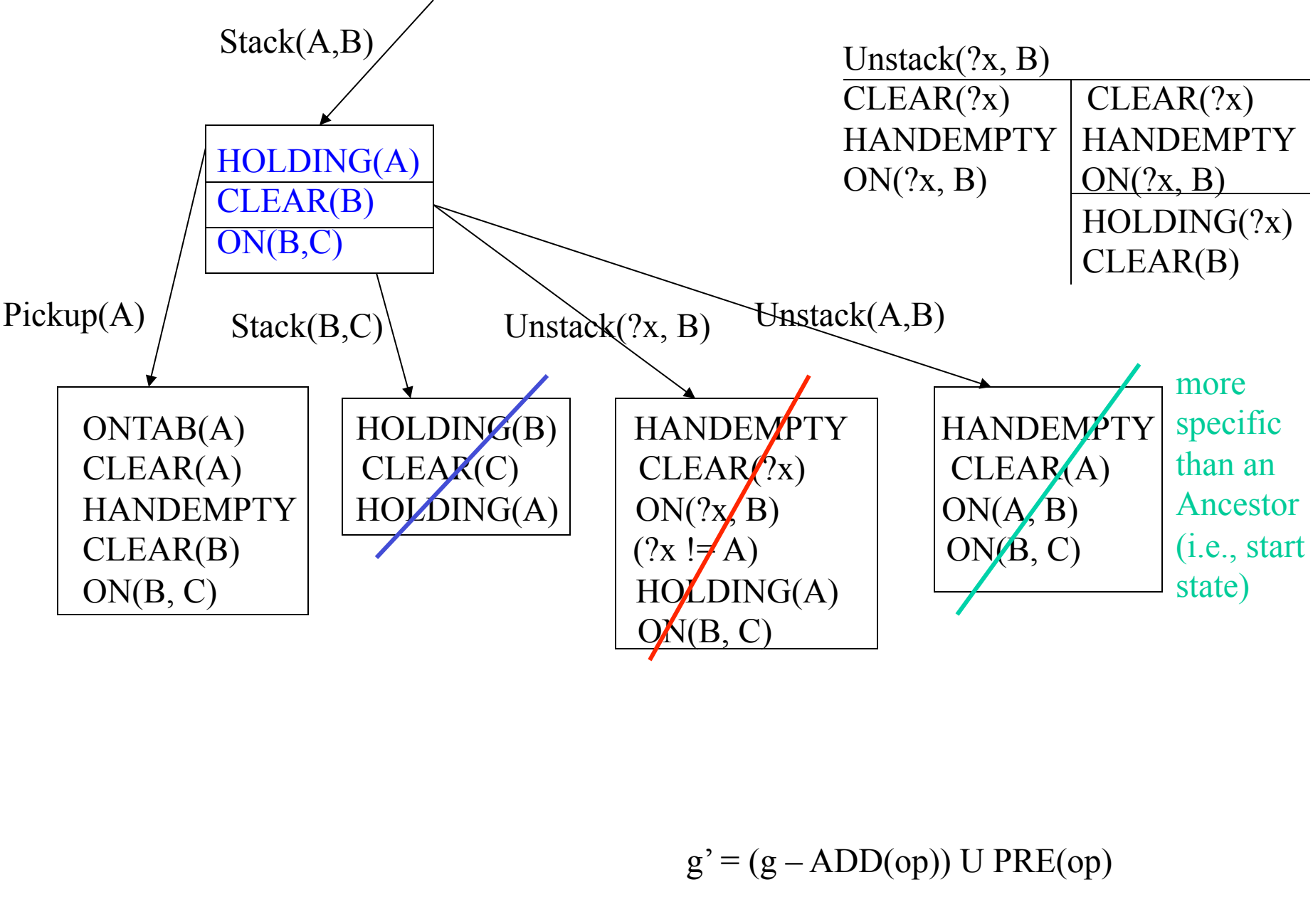


Regress({HOLDING(A), CLEAR(B), ON(B,C)}, Stack(B,C))
= ({HOLDING(A), CLEAR(B), ON(B,C)}
- {ON(B,C), HANDEMPTY, CLEAR(B)})
U {HOLDING(B), CLEAR(C)}

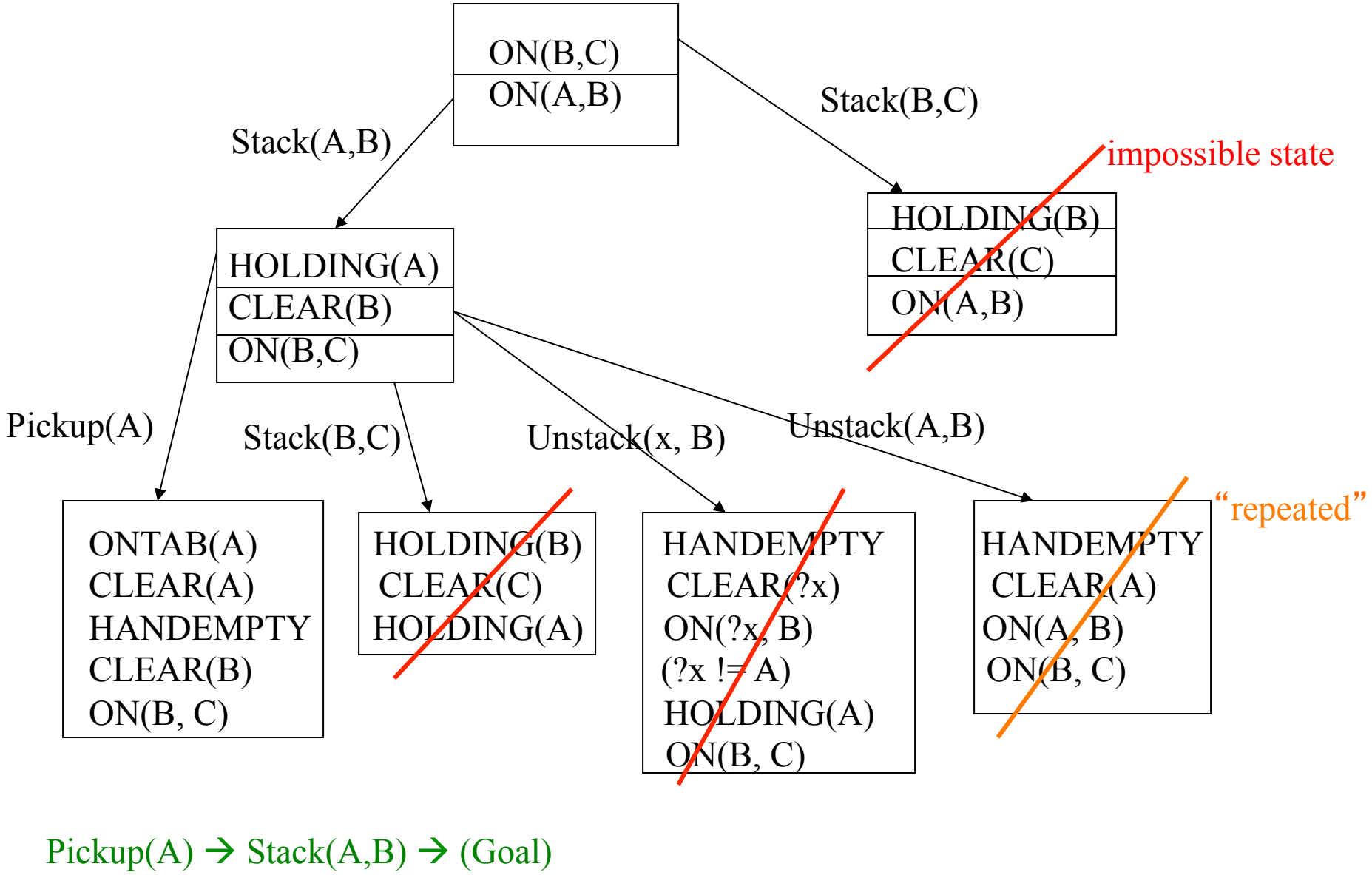
Stack(?x, ?y)	
HOLDING(?x)	HOLDING(?x)
CLEAR(?y)	CLEAR(?y)
	ON(?x, ?y)
	HANDEMPTY
	CLEAR(?x)

Regress({HOLDING(A), CLEAR(B), ON(B,C)}, Pickup(A))
= ({HOLDING(A), CLEAR(B), ON(B,C)}
- {HOLDING(A)})
U {ONTAB(A), CLEAR(A), HANDEMPTY}

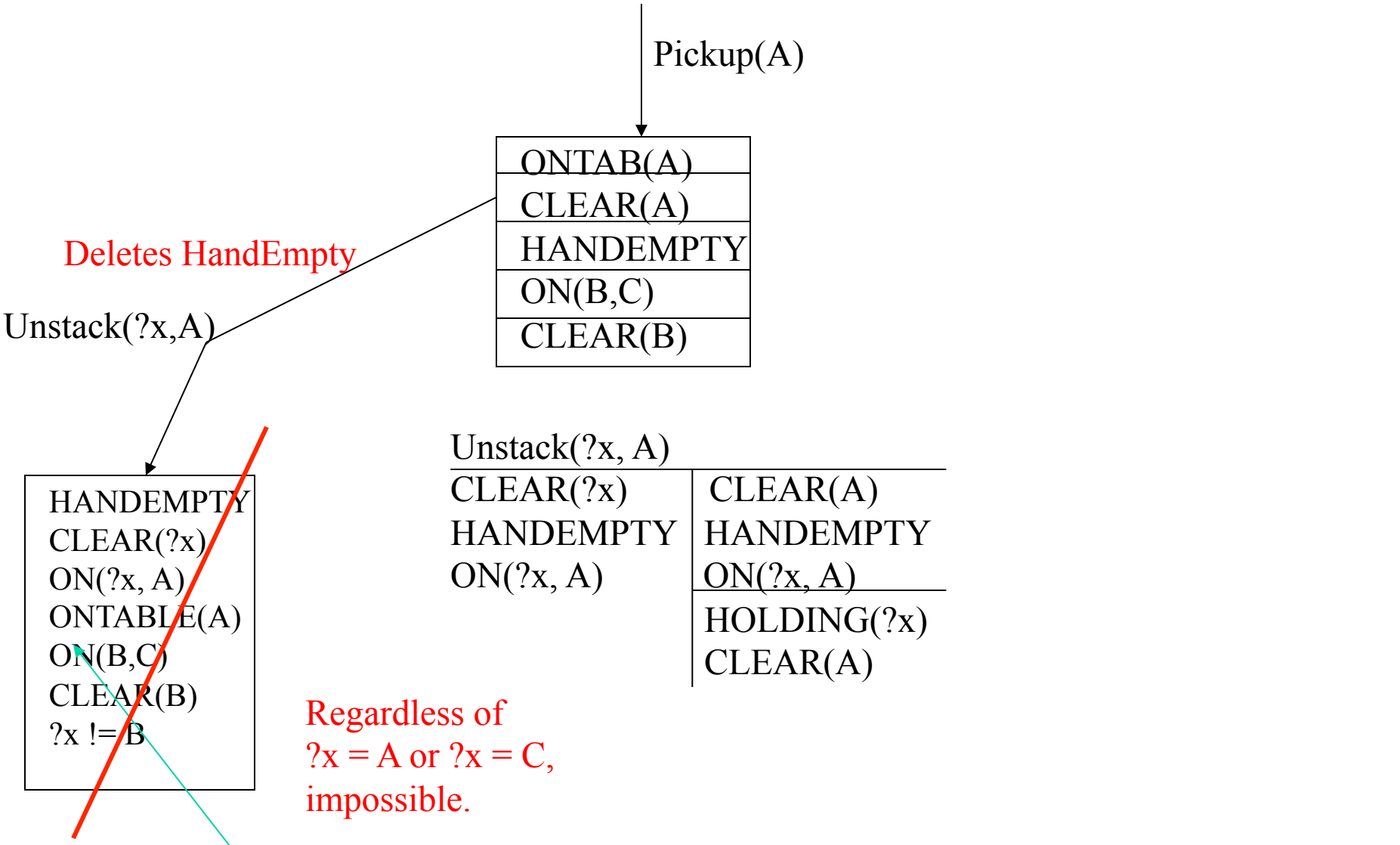
Pickup(?x)	
ONTAB(?x)	ONTAB(?x)
CLEAR(?x)	CLEAR(?x)
HANDEMPTY	HANDEMPTY
	HOLDING(?x)



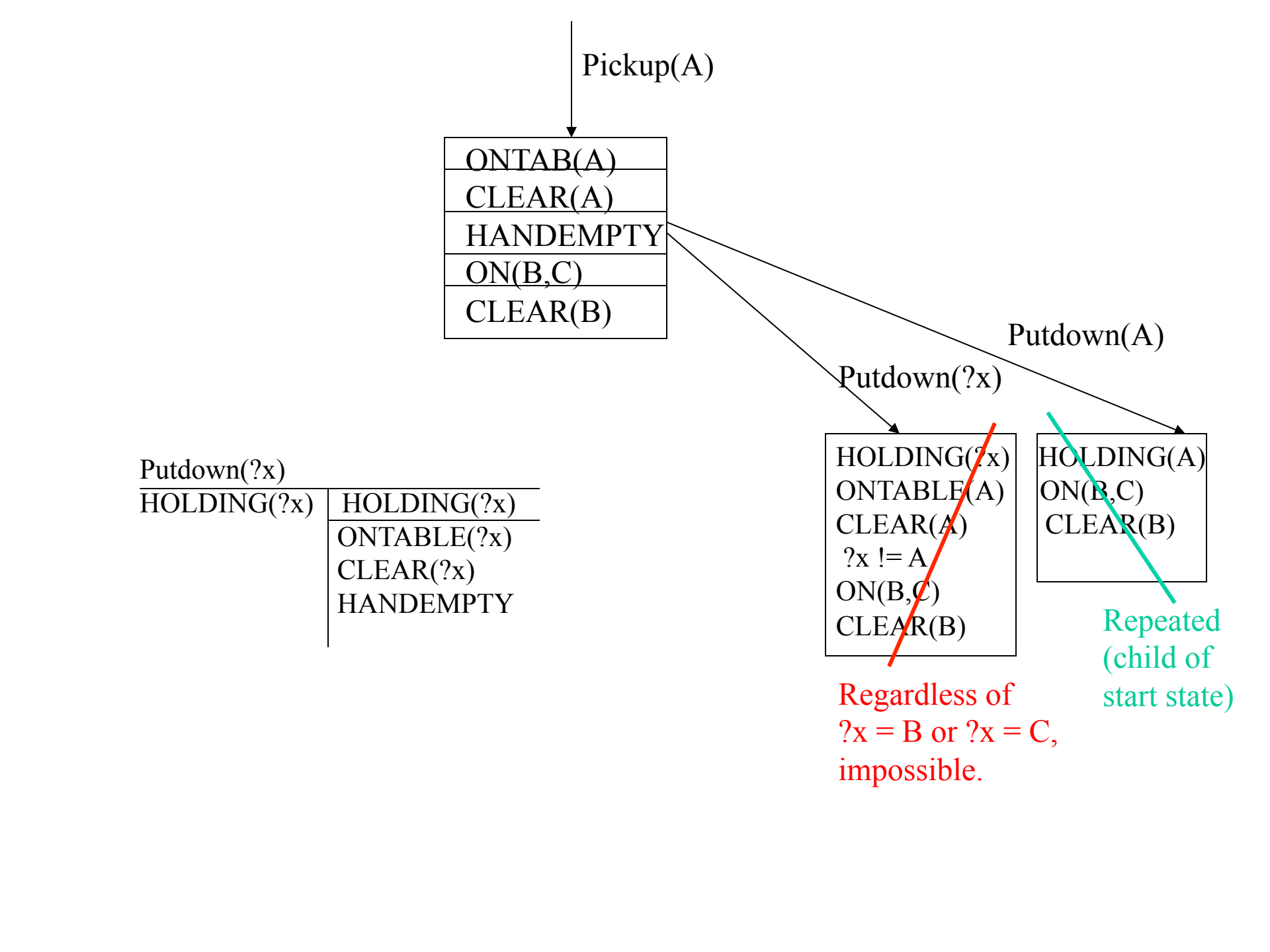
g' = (g – ADD(op)) U PRE(op)

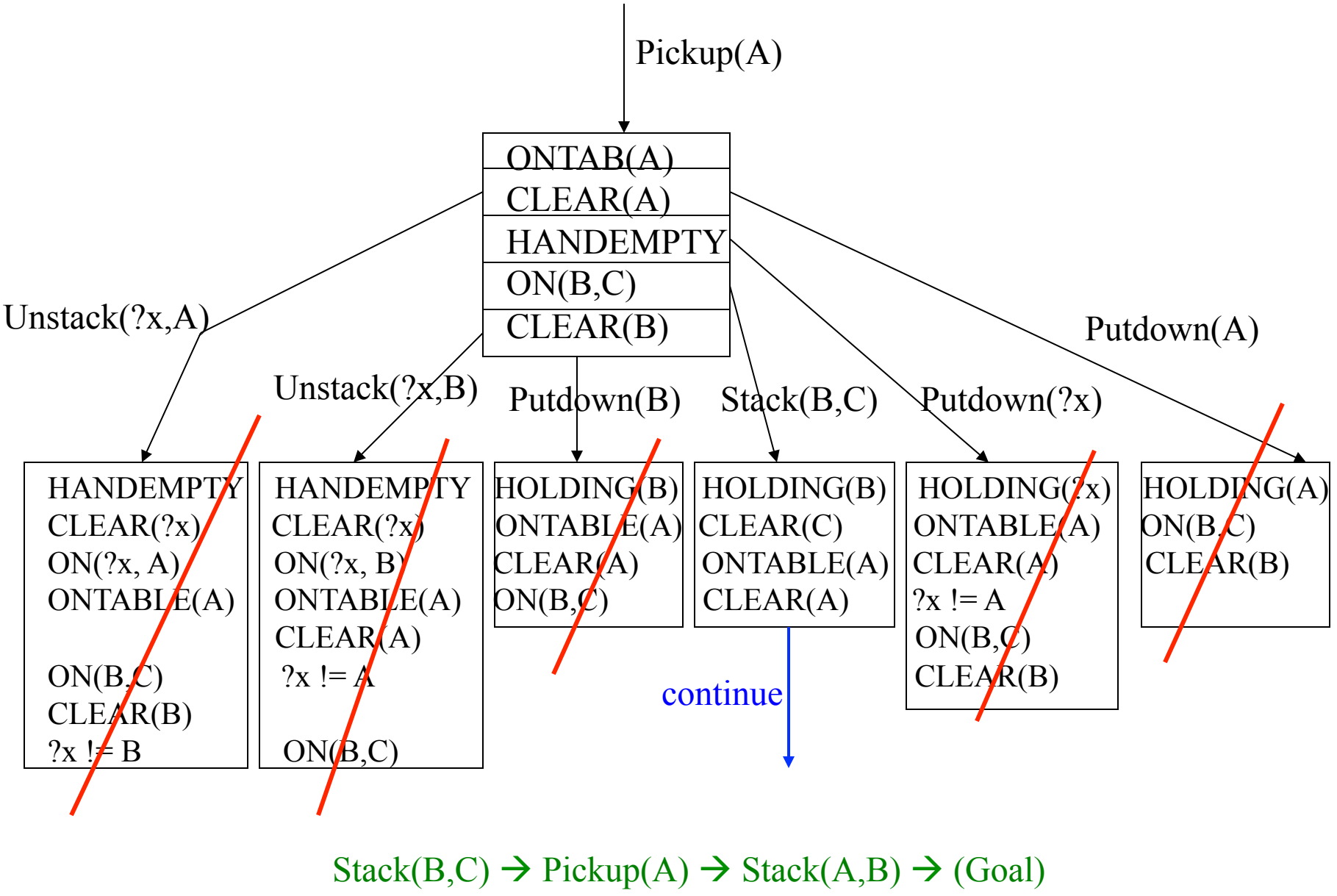


Pickup(A) → Stack(A,B) → (Goal)

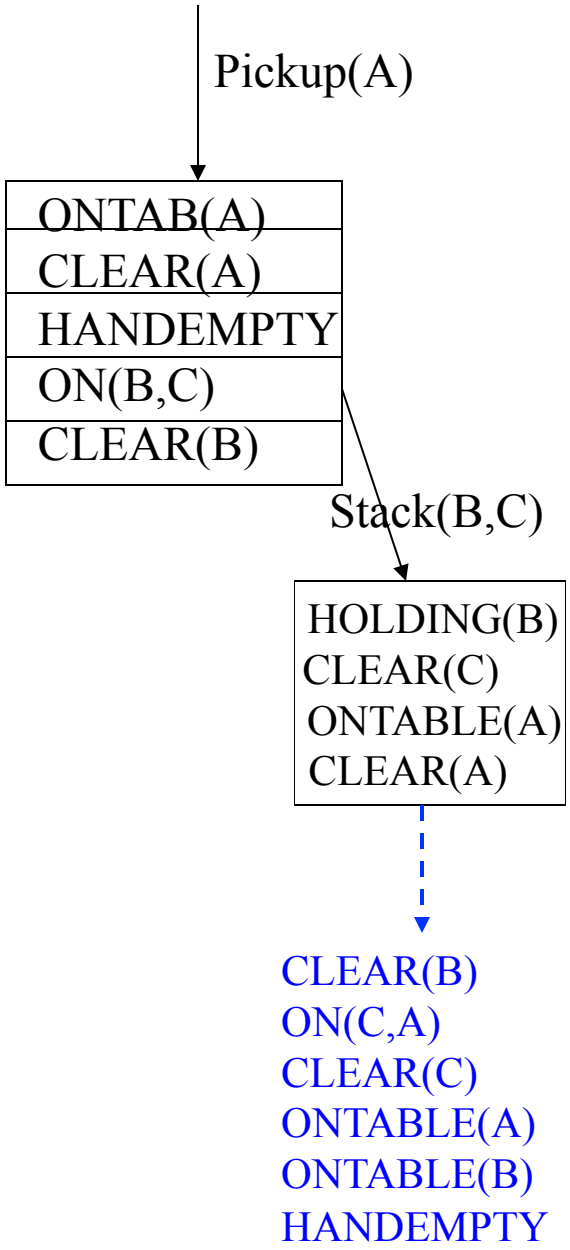


Regress(({ONTAB(A),CLEAR(A),HANDEMPTY,ON(B,C),CLEAR(B, Unstack(?x, A))}
- {HOLDING(?x), CLEAR(A) where ?x != B}
U {CLEAR(?x), HANDEMPTY, ON(?x, A)}


Pickup(A)
ONTAB(A)
CLEAR(A)
HANDEMPTY
ON(B,C)
CLEAR(B)
Putdown(A)
Putdown(?x)
HOLDING(?x)
ONTABLE(A)
CLEAR(A)
?x != A
ON(B,C)
CLEAR(B)
HOLDING(A)
ON(B,C)
CLEAR(B)
Repeated (child of start state)
Regardless of ?x = B or ?x = C, impossible.
Putdown(?x)
HOLDING(?x)
HOLDING(?x)
ONTABLE(?x)
CLEAR(?x)
HANDEMPTY



Stack(B,C) → Pickup(A) → Stack(A,B) → (Goal)



Unstack(C) → Putdown(C) → Pickup(B) → Stack(B,C) → Pickup(A) → Stack(A,B) → (Goal)