Correcting Hierarchical Plans by Action Deletion

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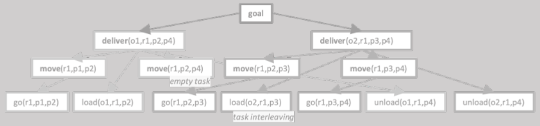


HTN grammar model

T → T1...Tk [C]

where C are decomposition constraints:

Ti < Tj: ordering of tasks

before(p,U): a precondition constraint

between(U,p,V): a prevailing constraint

Verification problem

Given an action sequence, is it a valid HTN plan?

- causally consistent (executable)
- proper structure

What if the plan is invalid?

How to correct a plan to become valid?

Possible correction steps:

- adding actions (planning, undecidable)
- deleting actions (NP-hard)
- action swapping (delete and add)
- attribute change (delete and add)

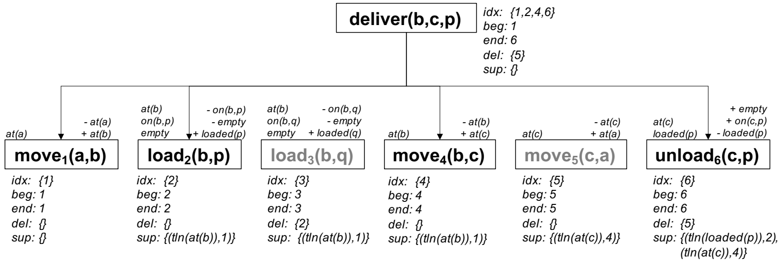
What is the minimal number of actions to be deleted from the action sequence to obtain a valid HTN plan?

Parsing-based approach

Step 1: if action precondition is violated, find a support action (and delete all intermediate threats)

timeline	Init	move$_1$(a,b)	load$_2$(b,p)	load$_3$(b,q)	move$_4$(b,c)	move$_5$(c,a)	unload$_6$(c,p)
empty	0		-2	-3			+6
loaded(p)			+2				-6
loaded(q)				+3			
on(b,p)	0		-2				
on(c,p)							+6
on(b,q)	0			-3			
at(a)	0	-1				+5	
at(b)		+1			-4		
at(c)					+4	-5	

Step 2: build valid decomposition structures via parsing (violated conditions are corrected by finding support actions and deleting threats)



deliver(b,c,p)
idx: {1,2,4,6}
beg: 1
end: 6
del: {5}
sup: {}

at(a)
- at(a)
+ at(b)
move$_1$(a,b)
idx: {1}
beg: 1
end: 1
del: {}
sup: {}

at(b)
on(b,p)
empty
- on(b,p)
- empty
+ loaded(p)
load$_2$(b,p)
idx: {2}
beg: 2
end: 2
del: {}
sup: {(tln(at(b)),1)}

at(b)
on(b,q)
empty
- on(b,q)
- empty
+ loaded(q)
load$_3$(b,q)
idx: {3}
beg: 3
end: 3
del: {2}
sup: {(tln(at(b)),1)}

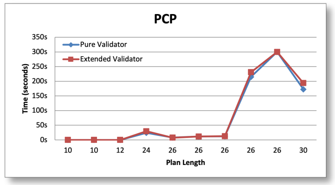
at(b)
- at(b)
+ at(c)
move$_4$(b,c)
idx: {4}
beg: 4
end: 4
del: {}
sup: {(tln(at(b)),1)}

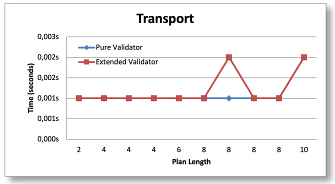
at(c)
- at(c)
+ at(a)
move$_5$(c,a)
idx: {5}
beg: 5
end: 5
del: {}
sup: {(tln(at(c)),4)}

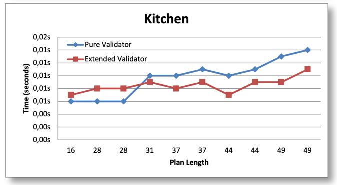
at(c)
loaded(p)
+ empty
+ on(c,p)
- loaded(p)
unload$_6$(c,p)
idx: {6}
beg: 6
end: 6
del: {5}
sup: {(tln(loaded(p)),2),
(tln(at(c)),4)}

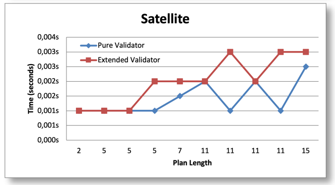
Step 3: find a task that requires no additional support and has the largest number of actions

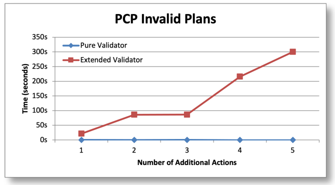
Empirical evaluation

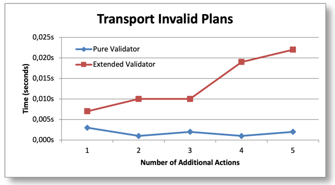


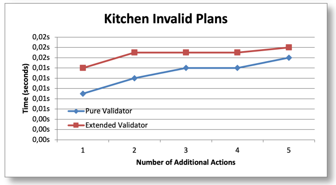


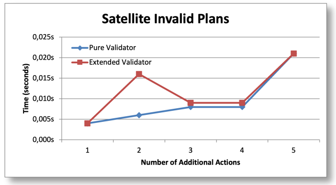












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