

# From Byrd Box to Debug Boxes: HTN Introduction and Application in



DECIMA™



STUDIOS GUERRILLA

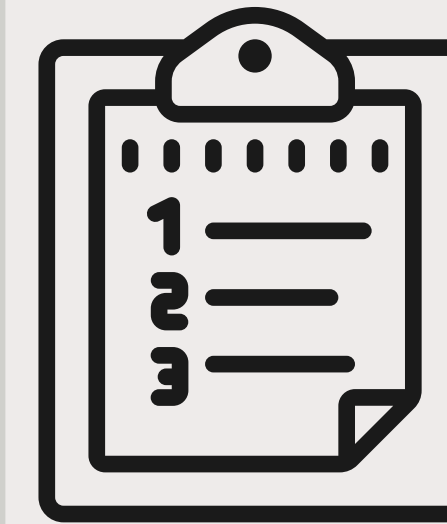
world state



hierarchical  
task network



plan



initial  
abstract  
task



# From Byrd Box to Debug Boxes: HTN Introduction and Application in



DECIMA™

Tim Johan Verweij  
Principal AI Programmer  
Guerrilla



Robert Morcus

First HTN planner

Hylke Kleve

HTN translator

Ricardo Desmedt

HTN language extension  
for VS Code



DECIMA



HTN planning in







# ORIGINS & HISTORY



```
for (const Enemy* enemy = enemies.begin(); enemy != enemies.end(); enemy++)  
    for (const Weapon* weapon = weapons.begin(); weapon != weapons.end(); weapon++)  
        if (weapon->IsEffectiveAgainst(enemy))
```

## JSHOP2

```
(enemy ?e)  
(weapon ?w)  
(call is_effective_against ?w ?e)
```



# DECIMA'S HTN VS BEHAVIOR TREES

- Reason about future state
- Separation selection & execution
- Local variables and task parameters
- Flexible world state & powerful queries



# FACTS & QUERIES

(`in_fridge` milk)

▶ failure

(`in_fridge` cheese)

(`in_fridge` eggs)

(`in_fridge` bike\_keys)

(`in_fridge` ?item)

▶ success, ?item = cheese

▶ success, ?item = eggs

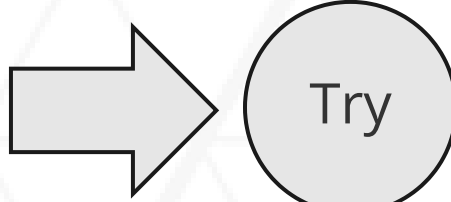
▶ success, ?item = bike\_keys

▶ failure

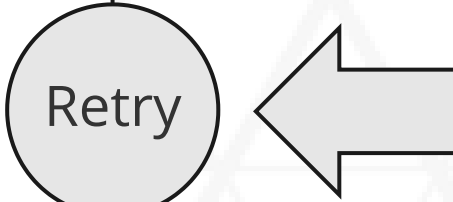
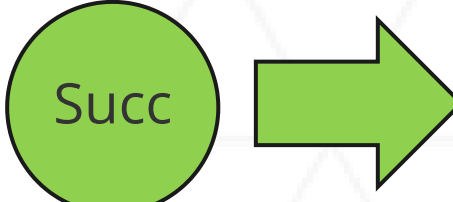
# HTN TRANSLATOR



# Condition

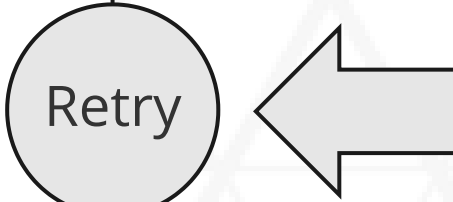
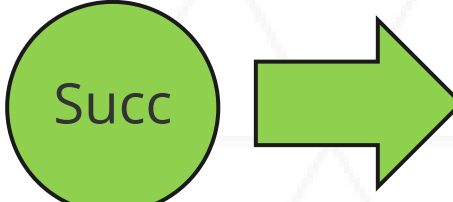
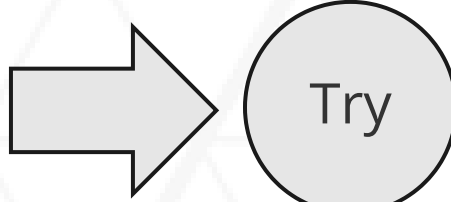


Byrd Box Model  
Procedure Box Model



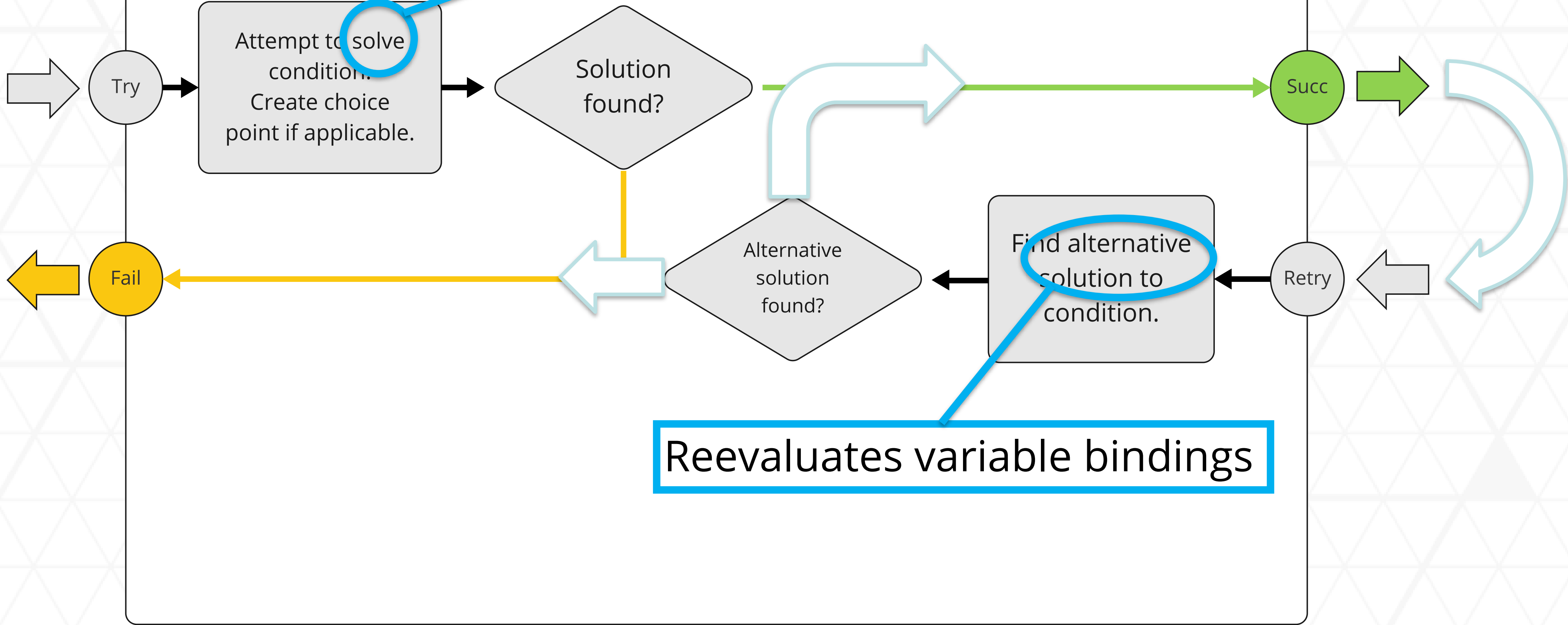
# Condition

`(in_fridge ?item)`



# Condition

**Binds variables**



# CONJUNCTION: AND

(**in\_fridge** cheese)

(**in\_fridge** eggs)

(**in\_fridge** bike\_keys)

(**allergic\_to** jeff eggs)

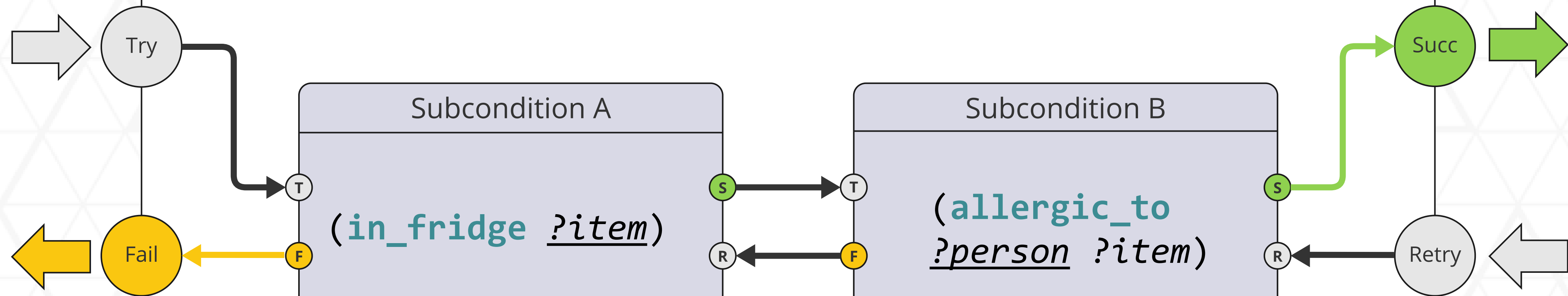
(**allergic\_to** mary silly\_jokes)

# CONJUNCTION: AND

```
(and
  (in_fridge ?item)
  (allergic_to ?person ?item)
)
```

- ▶ success, *?item* = eggs, *?person* = jeff
- ▶ failure

# AND

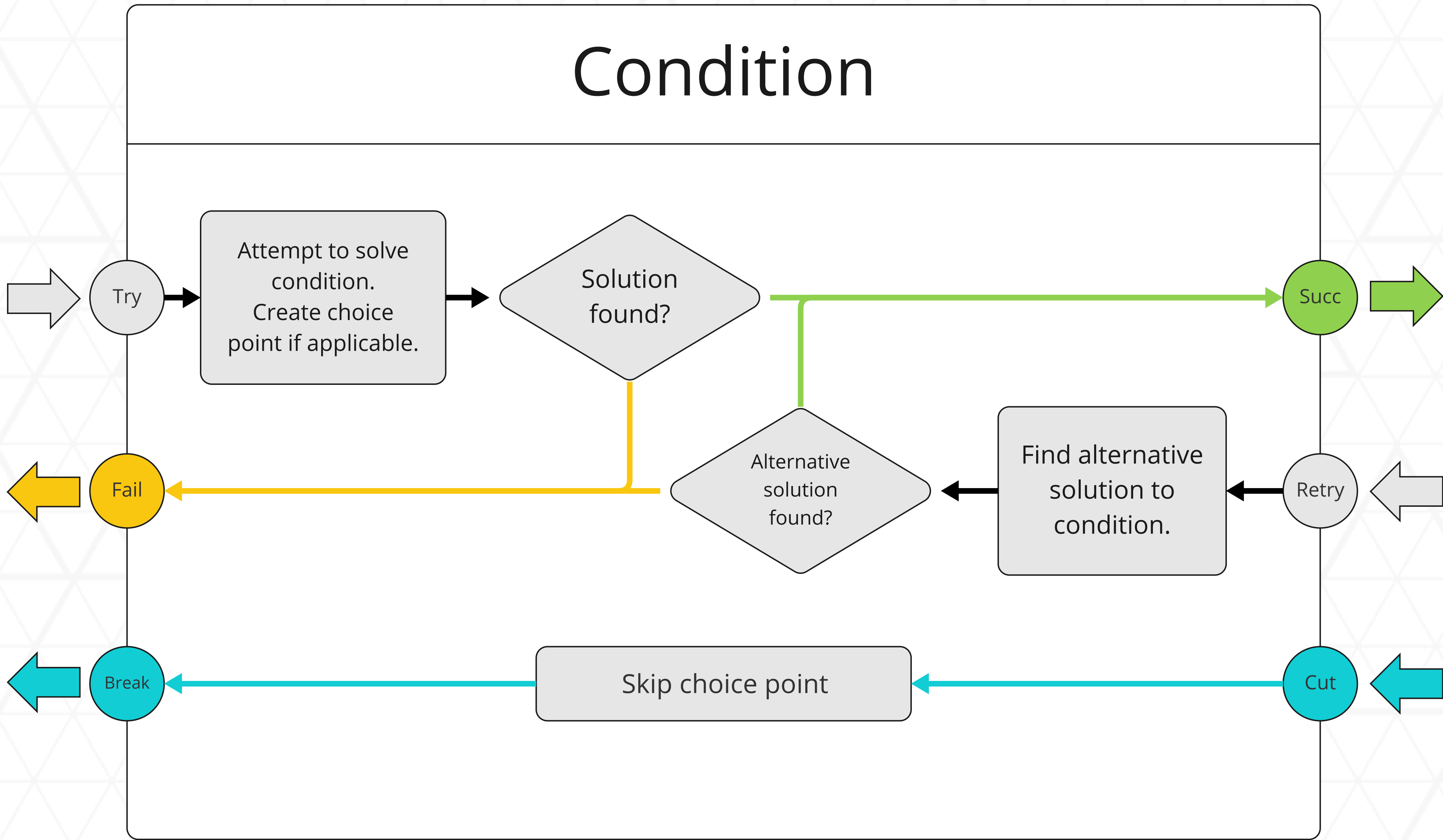


# NEGATION: NOT

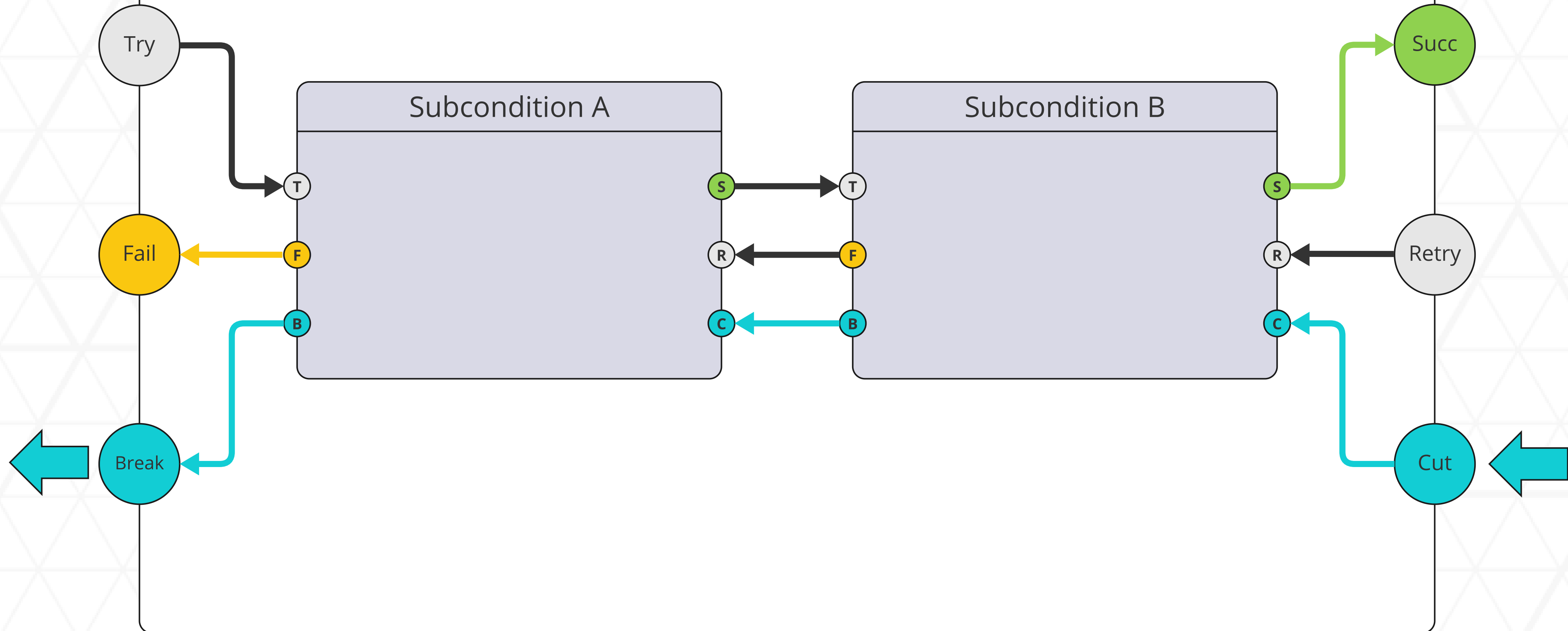
```
(and  
  (in_fridge ?item)  
  (not (allergic_to ?person ?item))  
)
```

- ▶ success, ?item = cheese
- ▶ success, ?item = bike\_keys
- ▶ failure

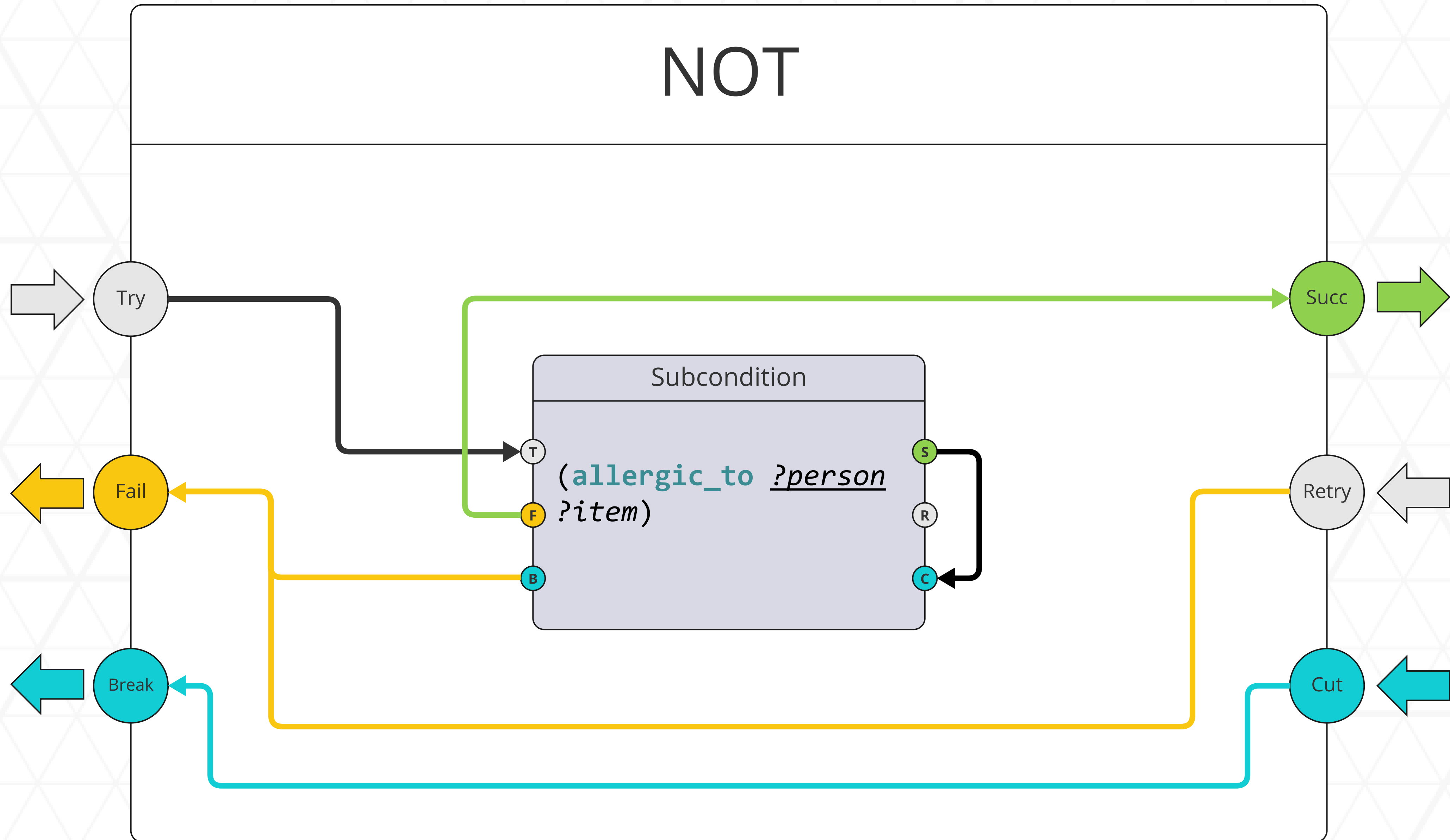
# Condition



# AND

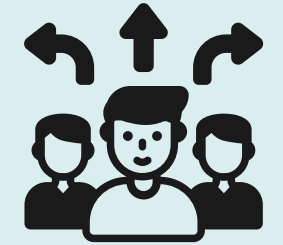


# NOT





world state

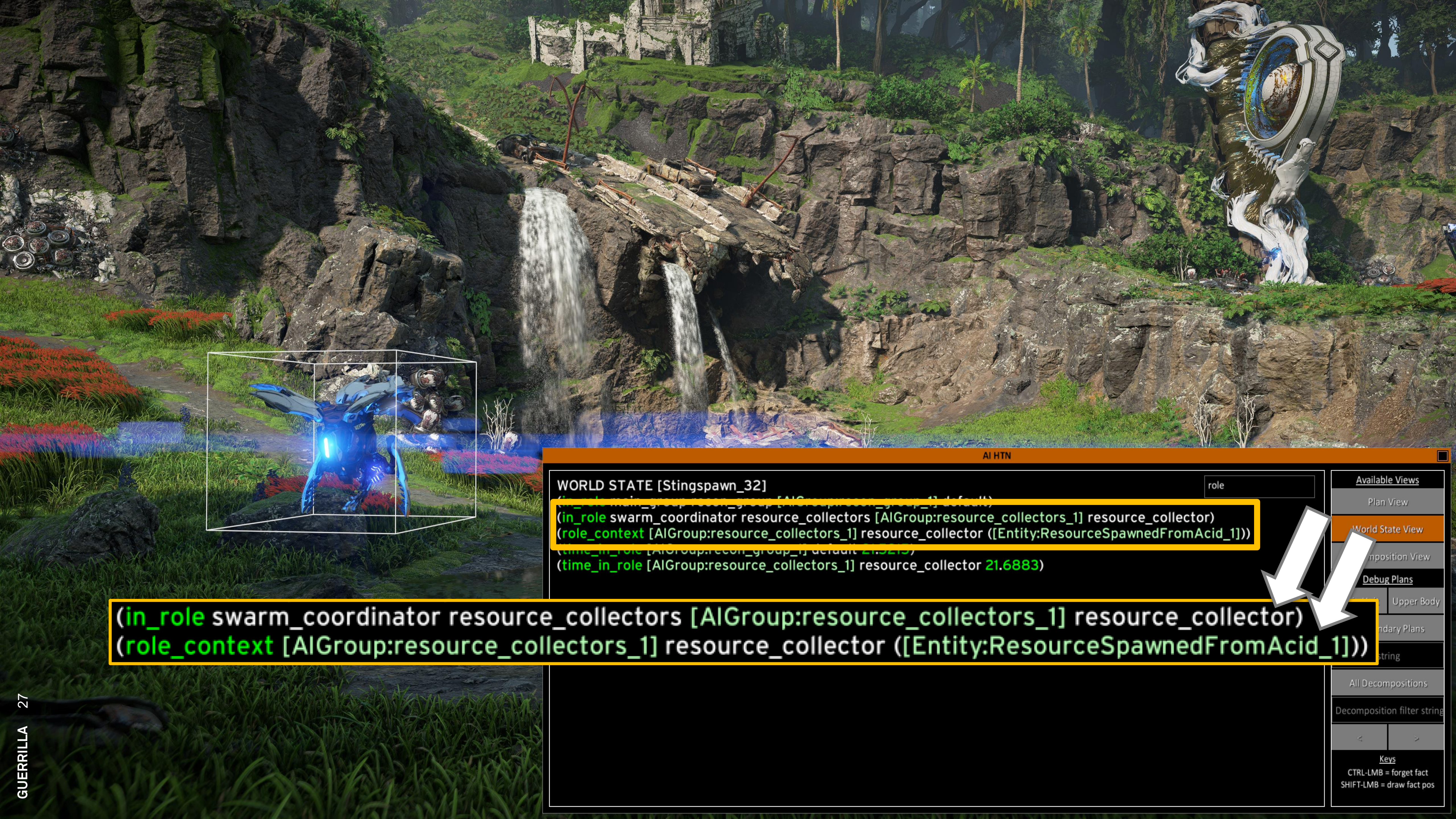


plan



Behave!





AI HTN

WORLD STATE [Stingspawn\_32]

role

(in\_role swarm\_coordinator resource\_collectors [AIGroup:resource\_collectors\_1] resource\_collector)  
(role\_context [AIGroup:resource\_collectors\_1] resource\_collector ([Entity:ResourceSpawnedFromAcid\_1]))  
(time\_in\_role [AIGroup:recon\_group\_1] default 21.5215)  
(time\_in\_role [AIGroup:resource\_collectors\_1] resource\_collector 21.6883)

(in\_role swarm\_coordinator resource\_collectors [AIGroup:resource\_collectors\_1] resource\_collector)  
(role\_context [AIGroup:resource\_collectors\_1] resource\_collector ([Entity:ResourceSpawnedFromAcid\_1]))

Available Views

- Plan View
- World State View
- Composition View
- Debug Plans
- Upper Body
- Boundary Plans
- string
- All Decompositions
- Decomposition filter string
- Keys
- CTRL-LMB = forget fact
- SHIFT-LMB = draw fact pos



```
(:method (behave)
  ( branch_combat
    (enemy ?enemy)
    (
      (do_combat_behavior ?enemy)
    )
  )

  ( branch_idle
    (not (enemy ?enemy))
    (
      (do_idle_behavior)
    )
  )
)
```

```

(:method (do_idle_behavior)
  ( branch_move_to_grab_resource
    (and
      (in_role swarm_coordinator resource_collectors ?group resource_collector)
      (role_context ?group resource_collector ?resource)
    )
    ( move_to_grab_resource ?resource )
  )
)

( branch_follow_swarm_leader
  (and
    (in_group swarm_coordinator stingspawn_swarm ?swarm_group)
    (other_member ?swarm_group leader ?leader)
  )
  ( follow_swarm_leader ?leader )
)
)
)

```

```
(:method (move_to_grab_resource ?inp_resource) ←
  (
    branch_move_to_grab_resource
    (not (has_grabbed_entity ?inp_resource))
  )
  (
    (!begin_plan move_to_grab_resource ?inp_resource)
    (hover_to_resource ?inp_resource) →
    (grab_resource ?inp_resource)
    (!end_plan)
  )
)
)
```



AI HTN

Upper Body    Main Unit

Fail Plan

Draw Position

Available Views

Plan View

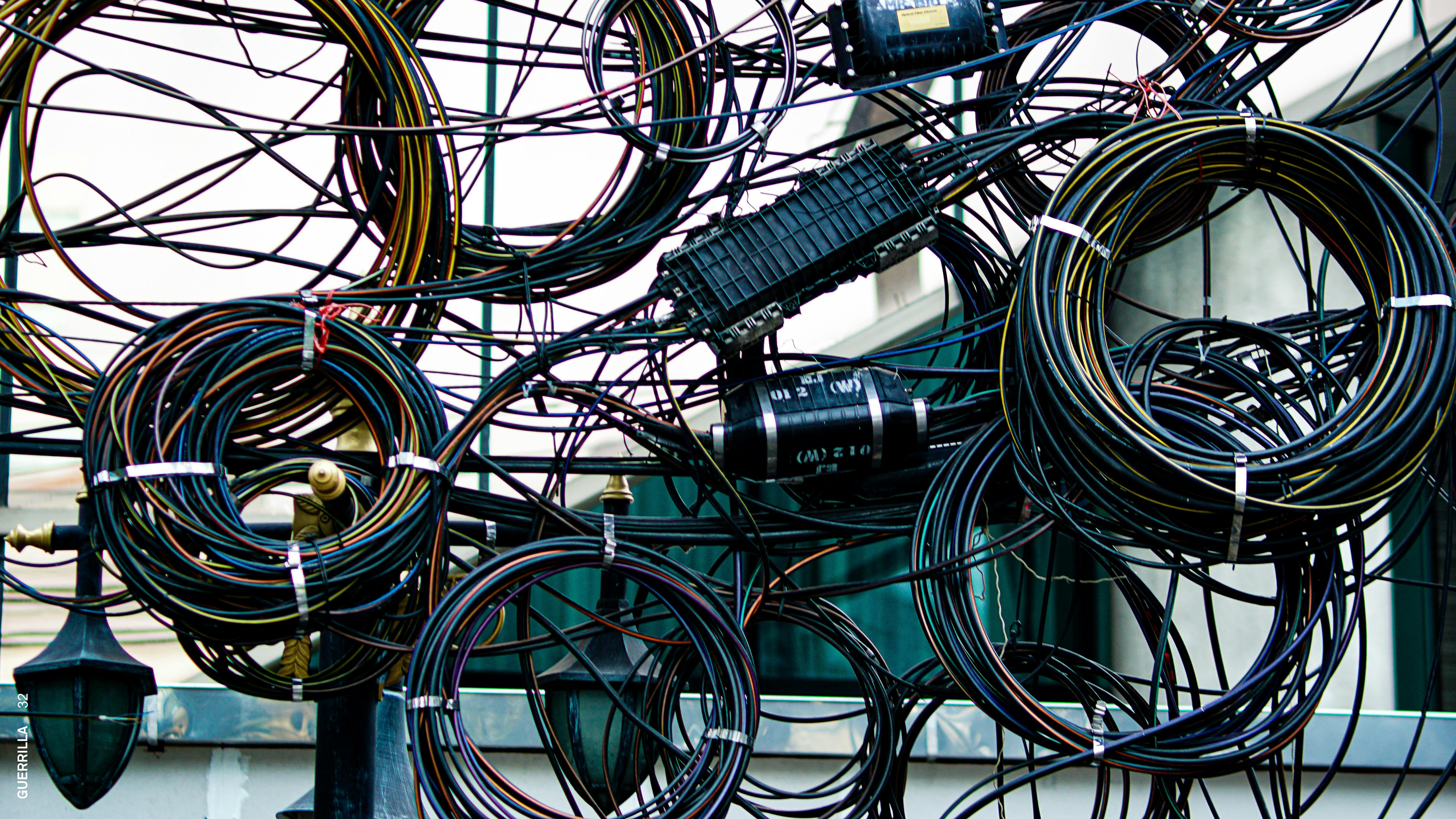
World State View

INDIVIDUAL MAIN PLAN [Stingspawn\_32]

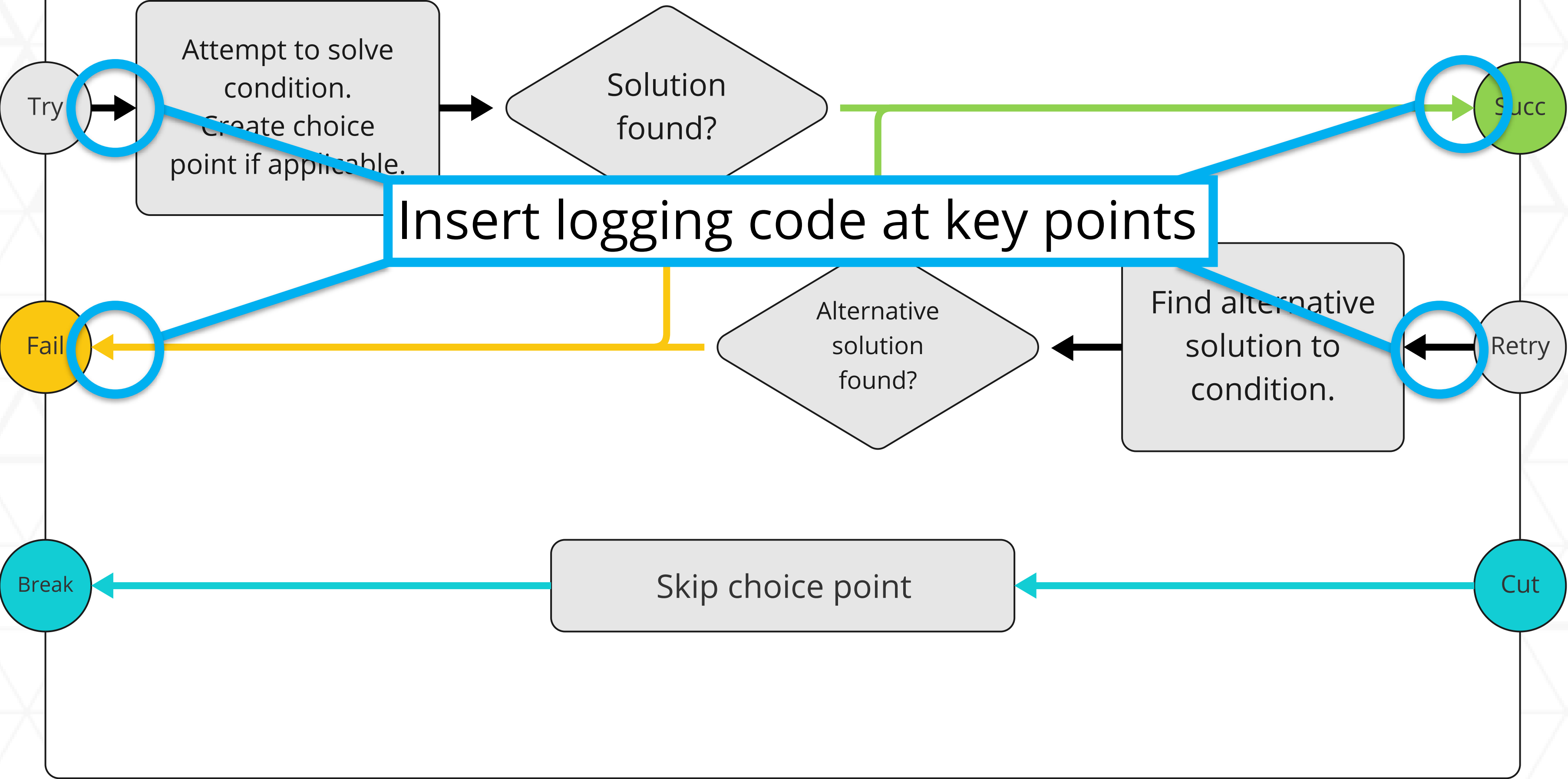
ACTIVE PLAN (continued from previous update)

(!begin\_plan move\_to\_grab\_resource [Entity:ResourceSpawnedFromAcid\_1] (800.47 -4313.31 323.39))

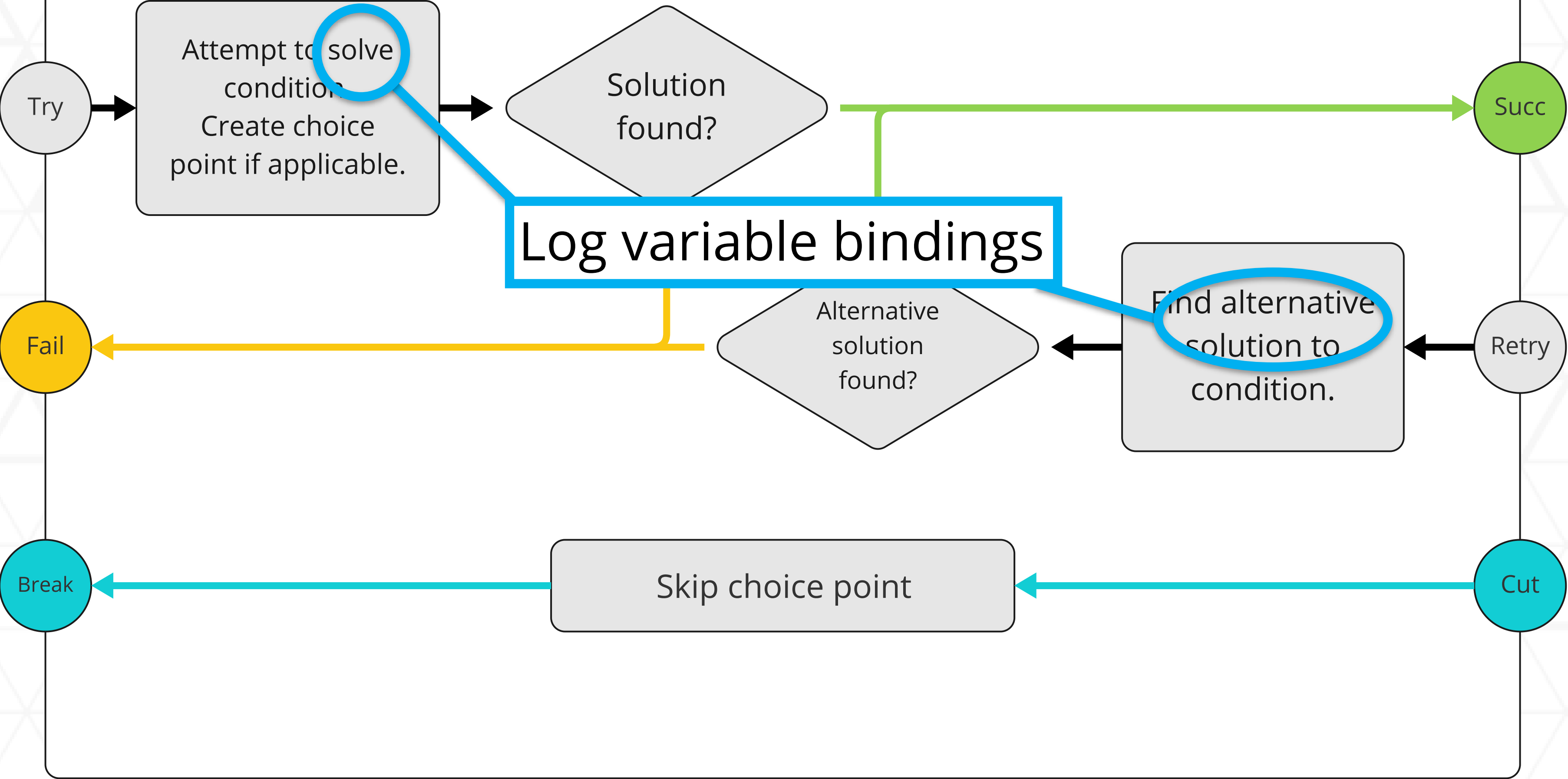
```
(!begin_plan move_to_grab_resource [Entity:ResourceSpawnedFromAcid_1] (800.47 -4313.31 323.39))
(!hover_segment_following_terrain ((800.75 -4312.75 325.75) (800.75 -4312.25 325.75) (800.75 -4311.75 325.75))
(!select_weapon grab_resource)
(!face_towards [Entity:ResourceSpawnedFromAcid_1])
(!plan_scoped_remember - grabbing_resource [Entity:ResourceSpawnedFromAcid_1])
(!scavenge [Entity:ResourceSpawnedFromAcid_1])
(!delayed_solve (mark_resource_unreachable_if_grab_fails [Entity:ResourceSpawnedFromAcid_1]))
(!end_plan)
```



# Condition

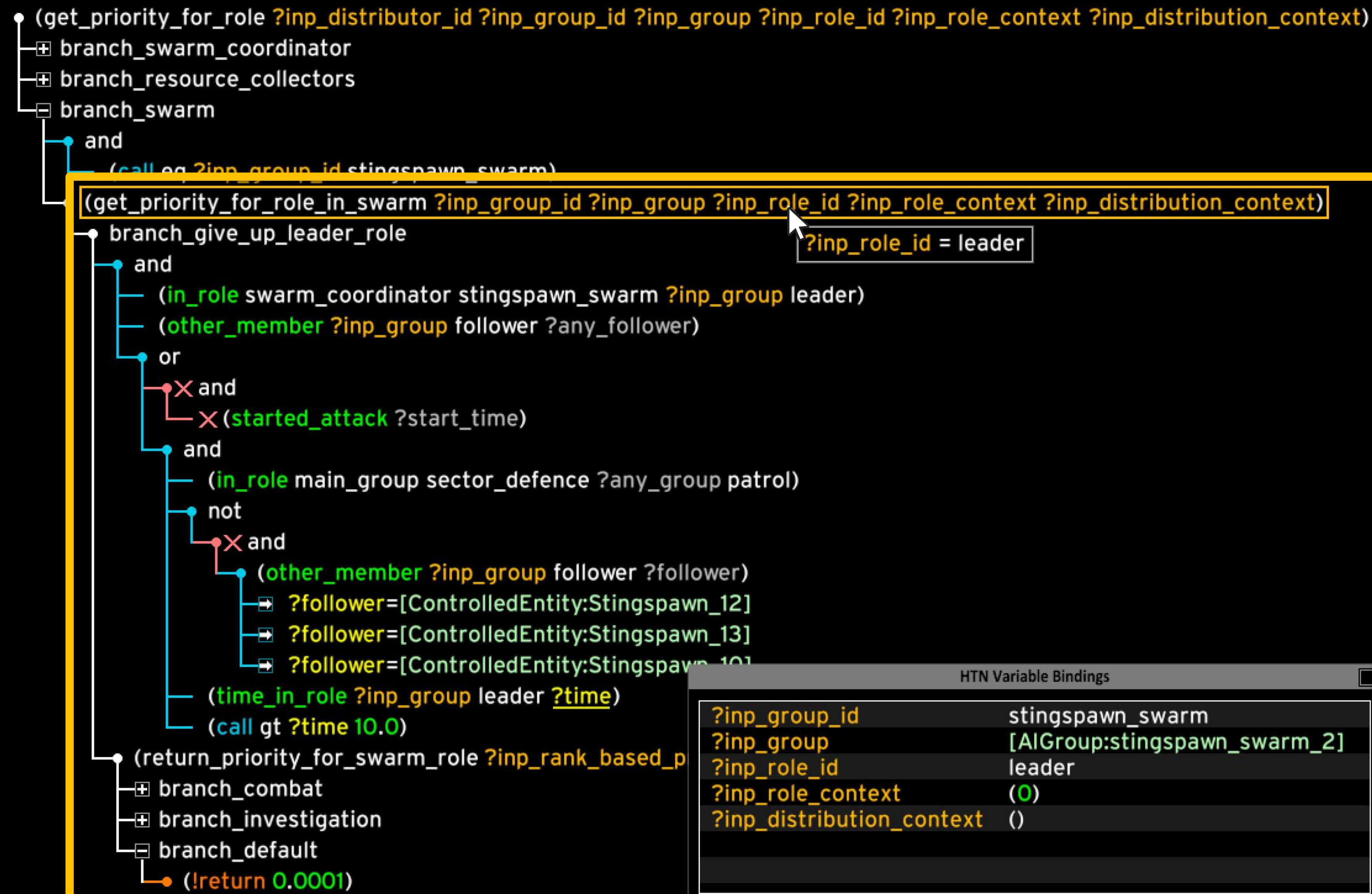


# Condition





```
(not
  (and
    (other_member ?inp_group follower ?follower)
    (= ?distance (call get_distance_to_entity ?follower))
    (call gt ?distance 3.0)
  )
)
```



?inp\_role\_id = leader

HTN Variable Bindings

?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()

(get\_priority\_for\_role\_in\_swarm ?inp\_group\_id ?inp\_group ?inp\_role\_id ?inp\_role\_context ?inp\_distribution\_context)

?inp\_role\_id = leader

branch\_give\_up\_leader\_role

and  
(in\_role swarm\_coordinator stingspawn\_swarm ?inp\_group leader)

(other\_member ?inp\_group follower ?any\_follower)

or

~~and  
(started\_attack ?start\_time)~~

and  
(in\_role main\_group sector\_defence ?any\_group patrol)

not

~~and  
(other\_member ?inp\_group follower ?follower)  
?follower=[ControlledEntity:Stingspawn\_12]  
?follower=[ControlledEntity:Stingspawn\_13]  
?follower=[ControlledEntity:Stingspawn\_10]~~

(time\_in\_role ?inp\_group leader ?time)

(call gt ?time 10.0)

(return\_priority\_for\_swarm\_role ?inp\_rank\_based\_p

+ branch\_combat

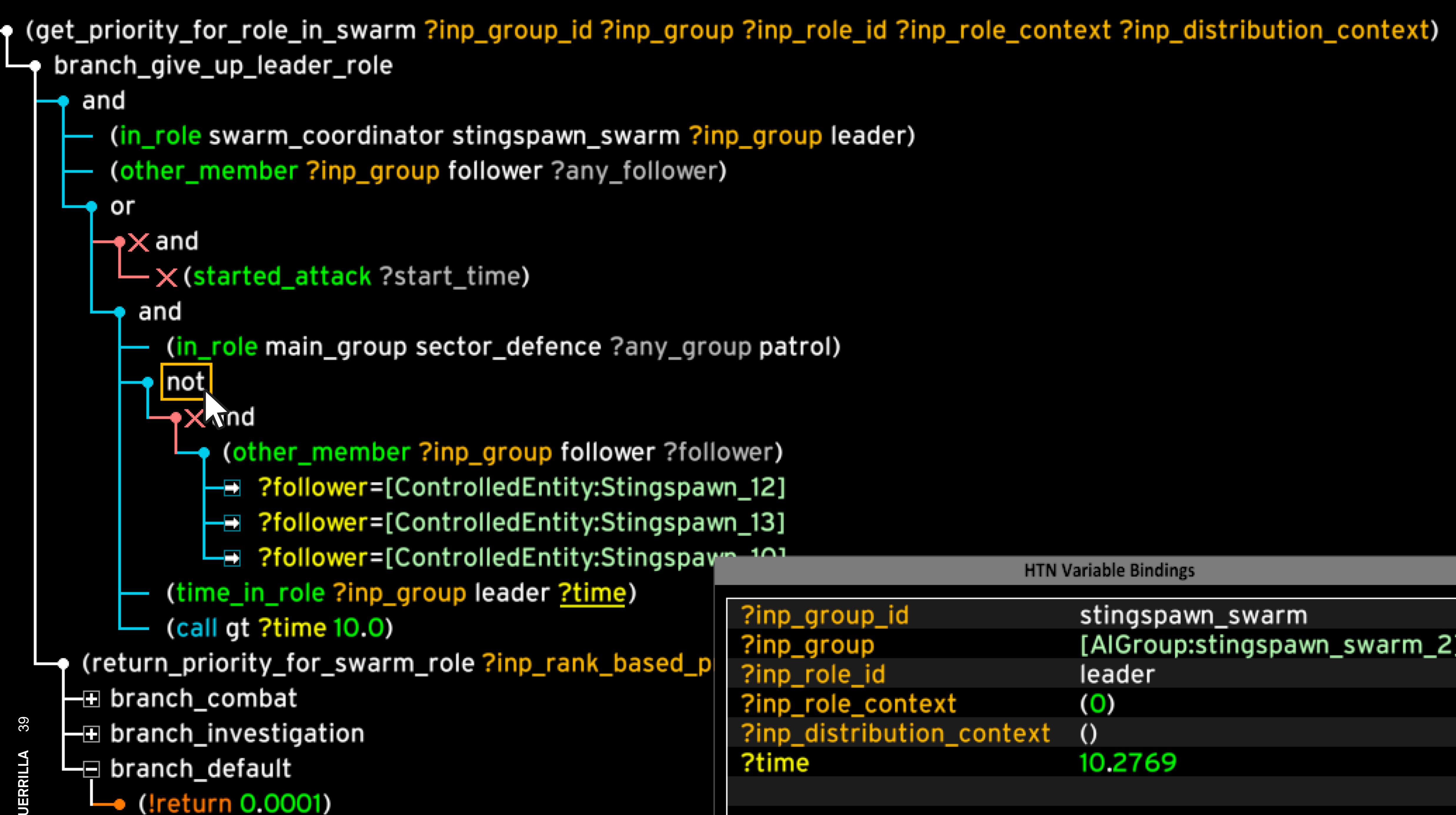
+ branch\_investigation

- branch\_default

!return 0.0001

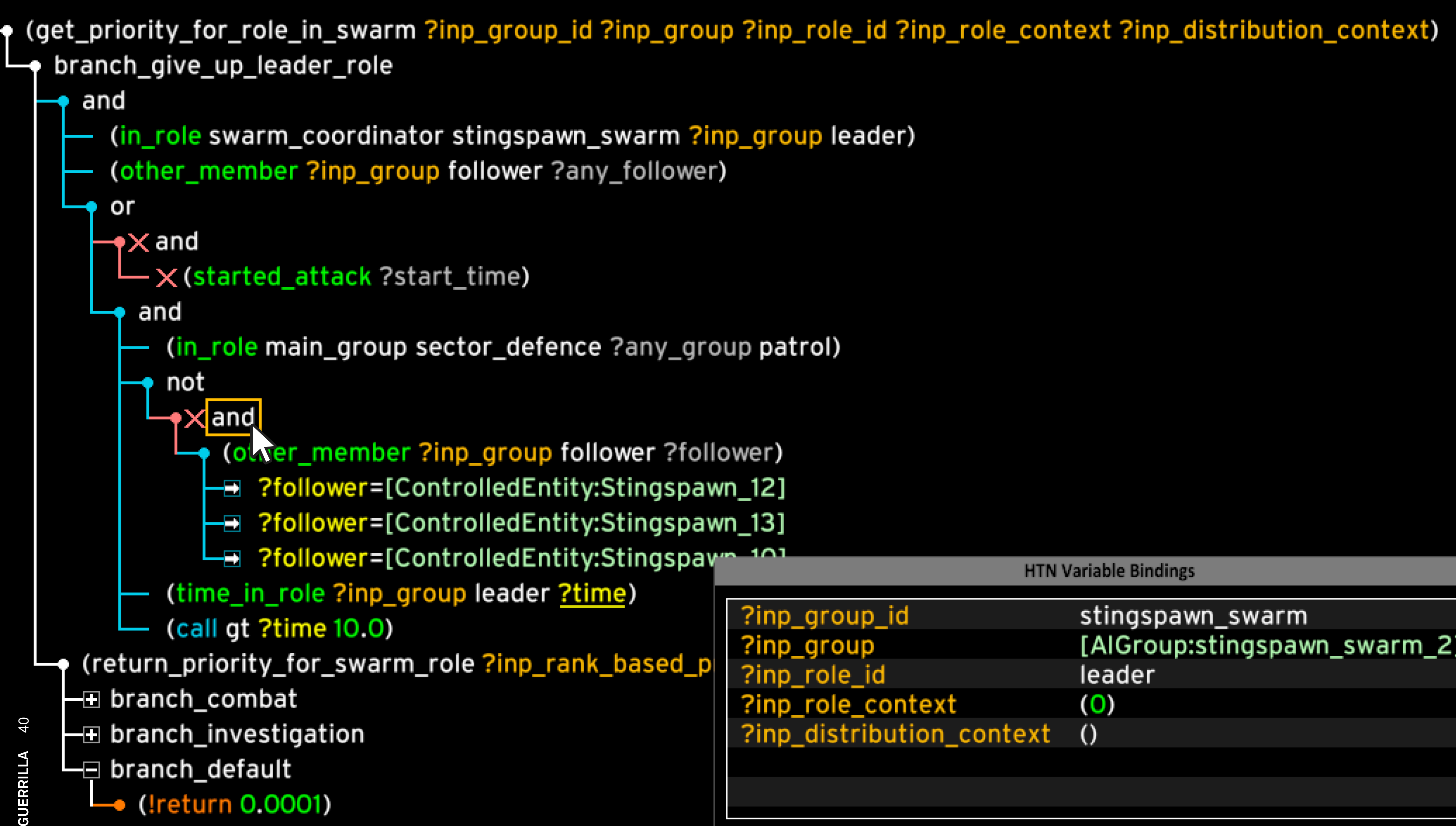
HTN Variable Bindings

?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()



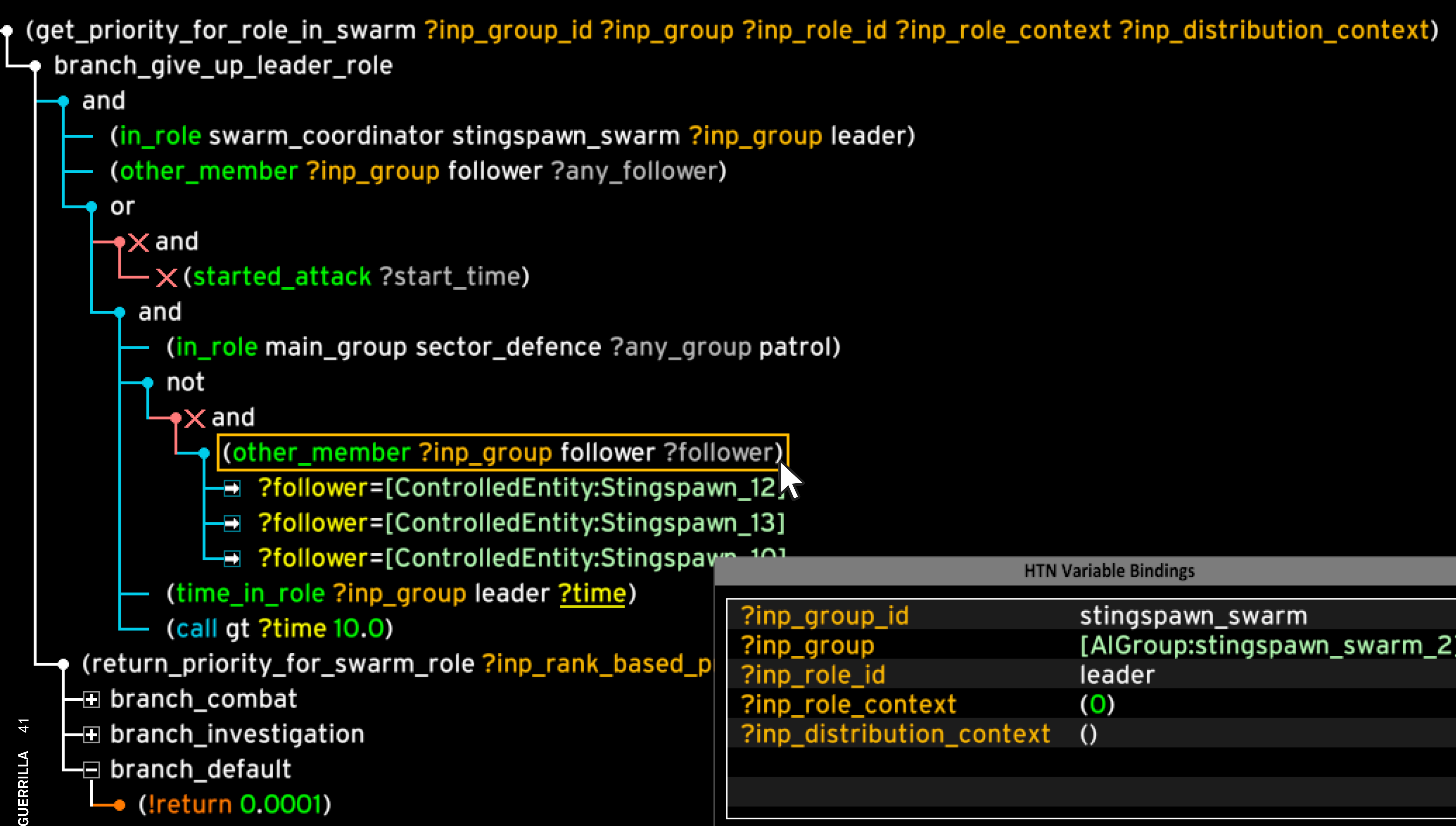
HTN Variable Bindings

?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?time	10.2769



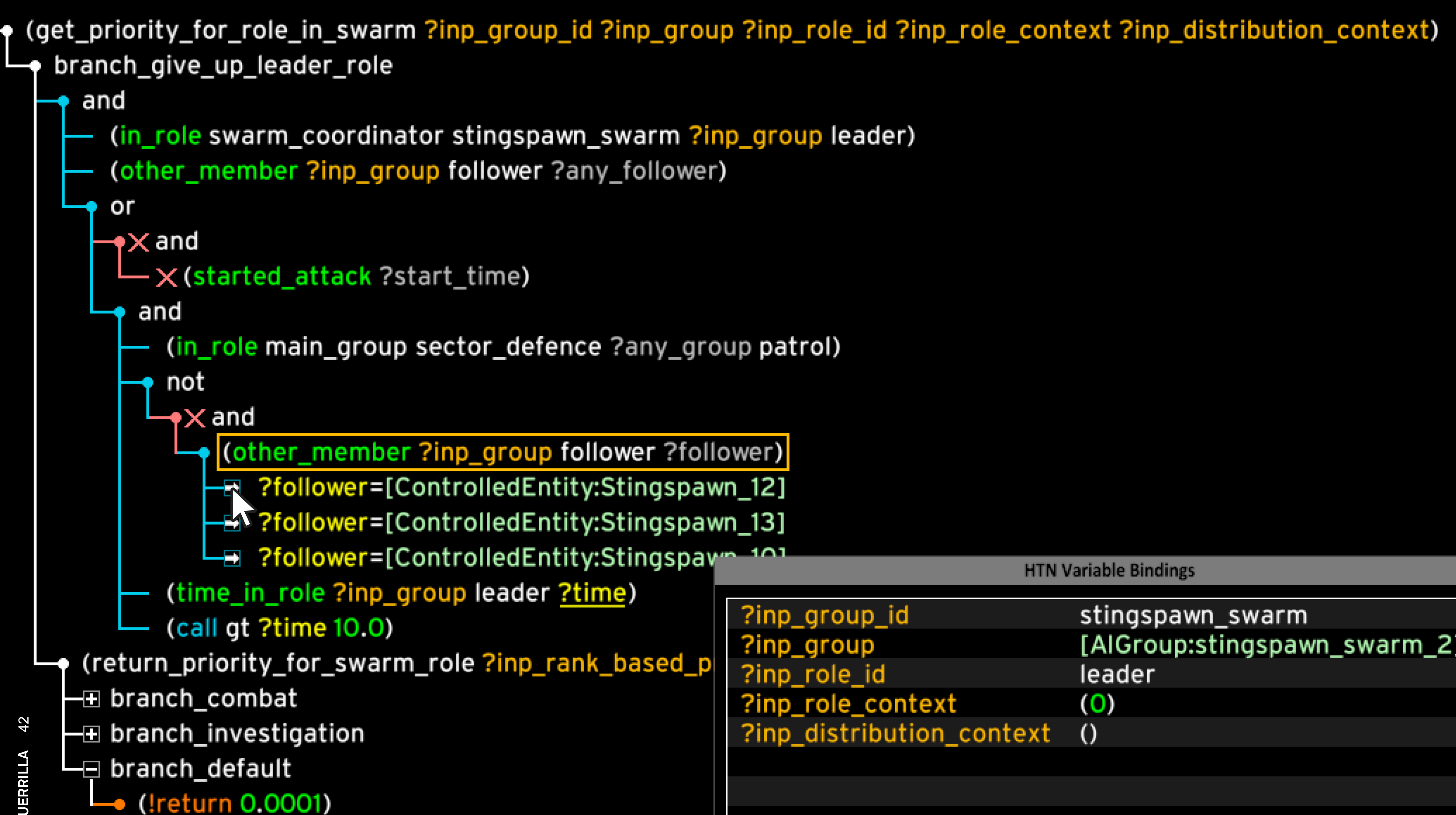
HTN Variable Bindings

?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()



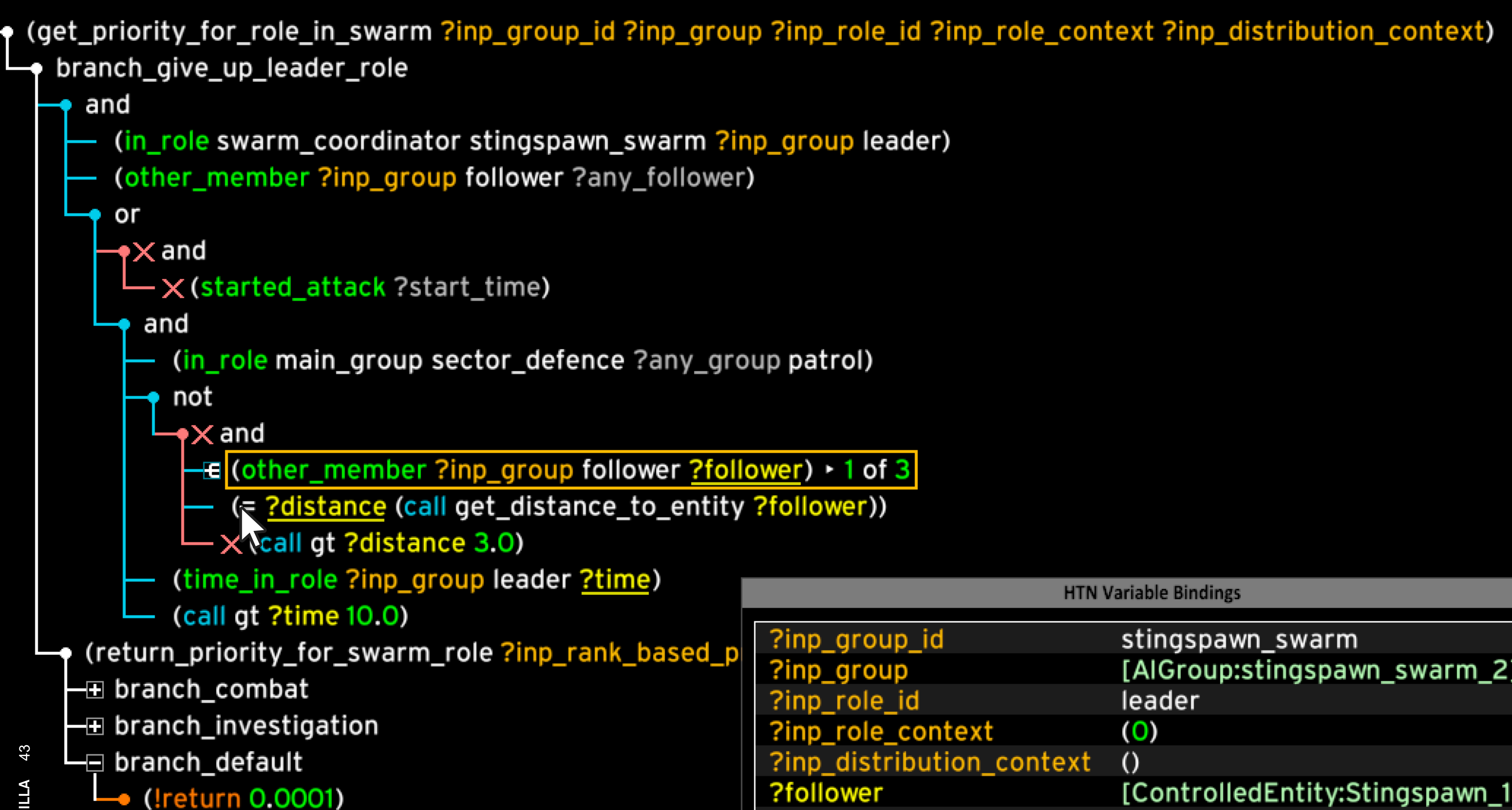
HTN Variable Bindings

?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()

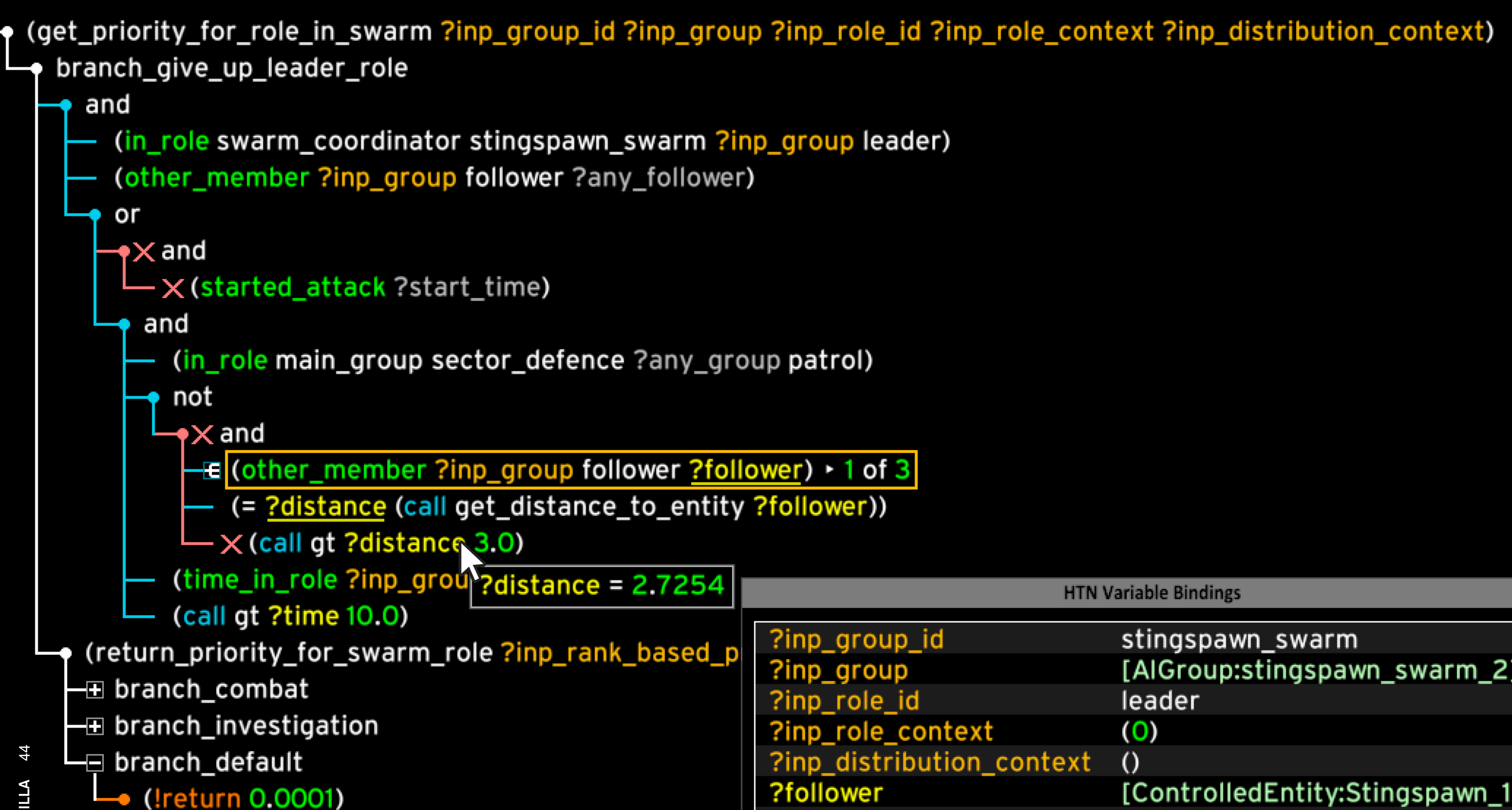


HTN Variable Bindings

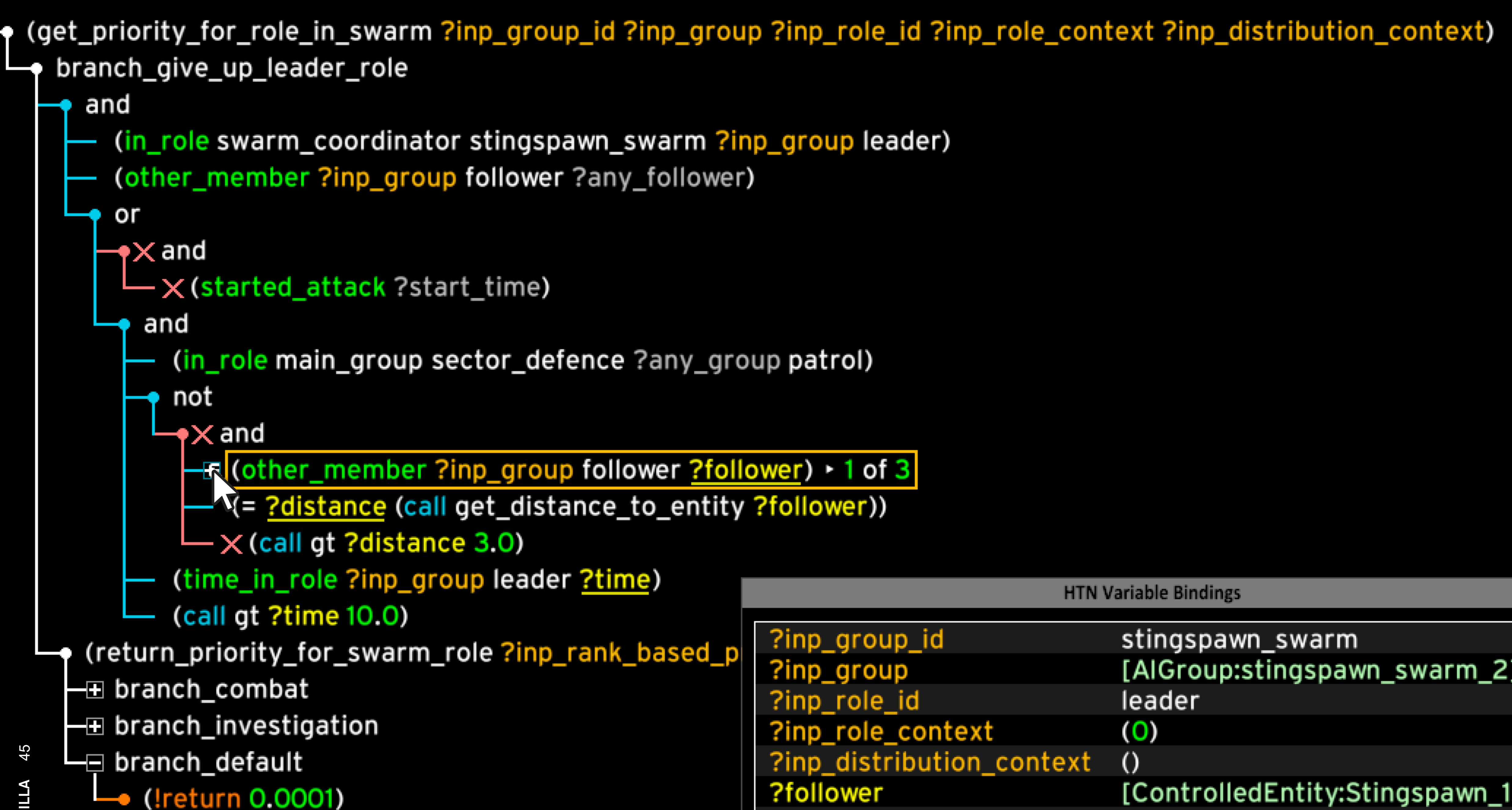
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()



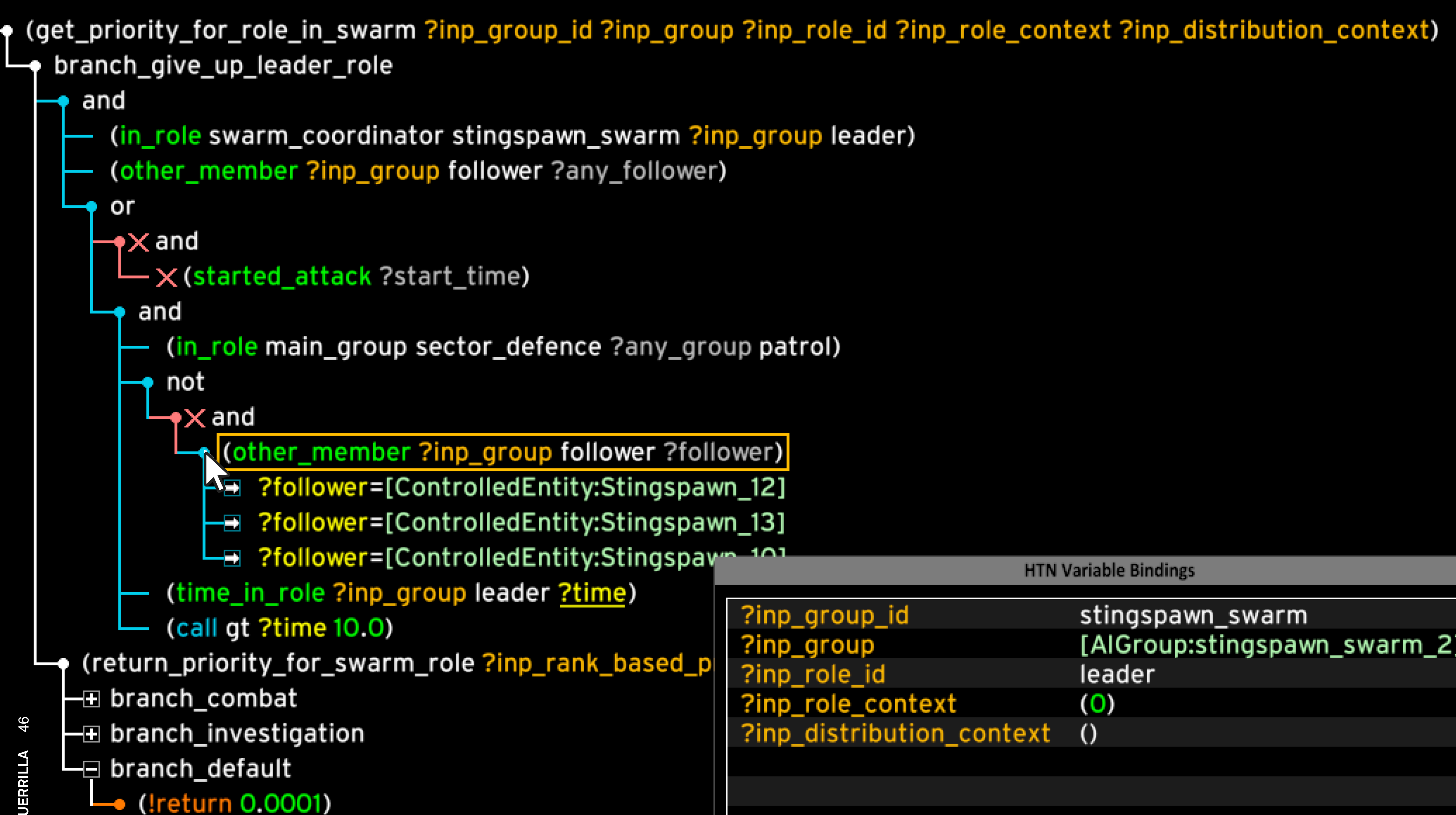
HTN Variable Bindings	
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?follower	[ControlledEntity:Stingspawn_12]
?distance	2.7254



HTN Variable Bindings	
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?follower	[ControlledEntity:Stingspawn_12]
?distance	2.7254

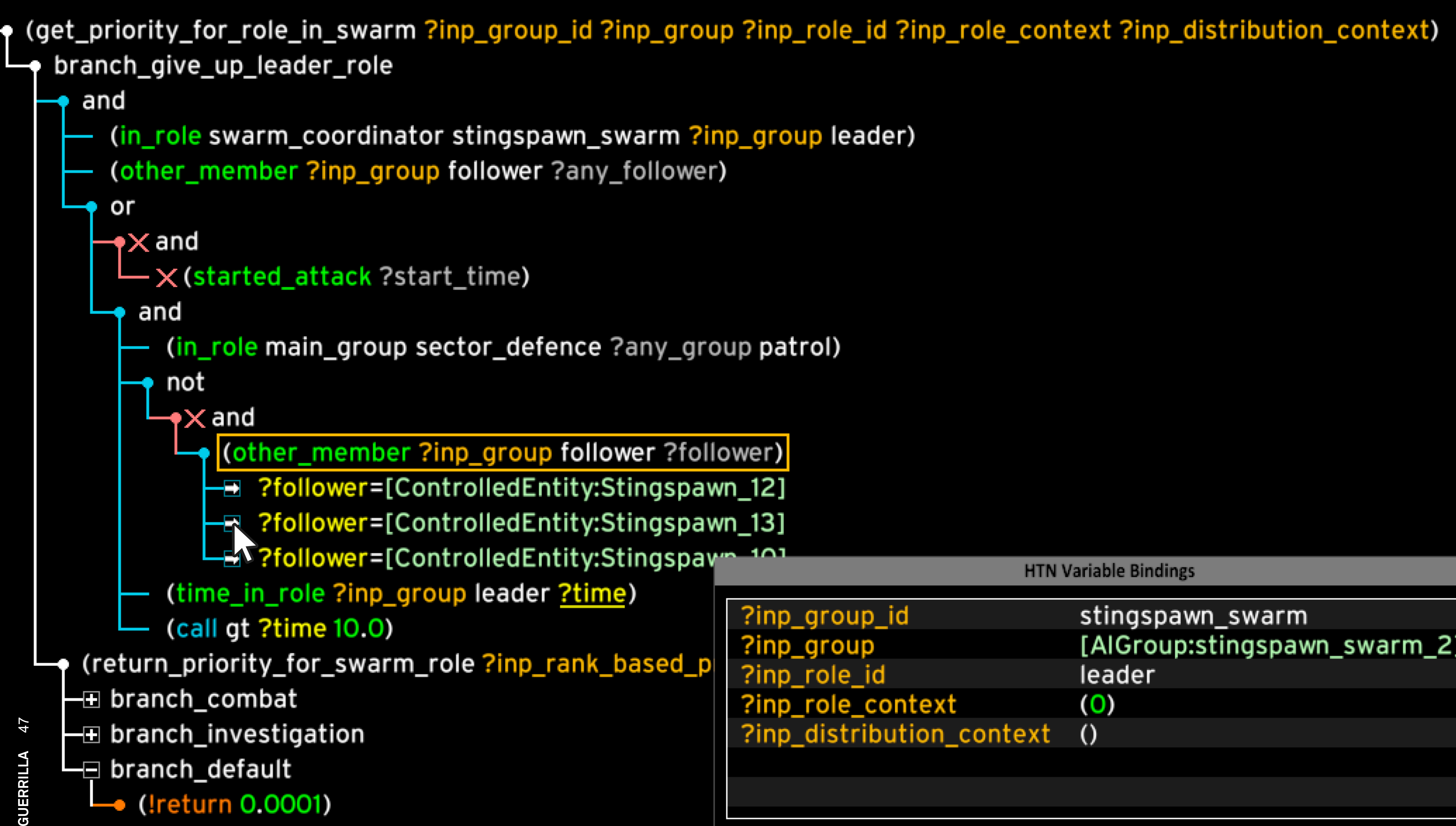


HTN Variable Bindings	
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?follower	[ControlledEntity:Stingspawn_12]
?distance	2.7254



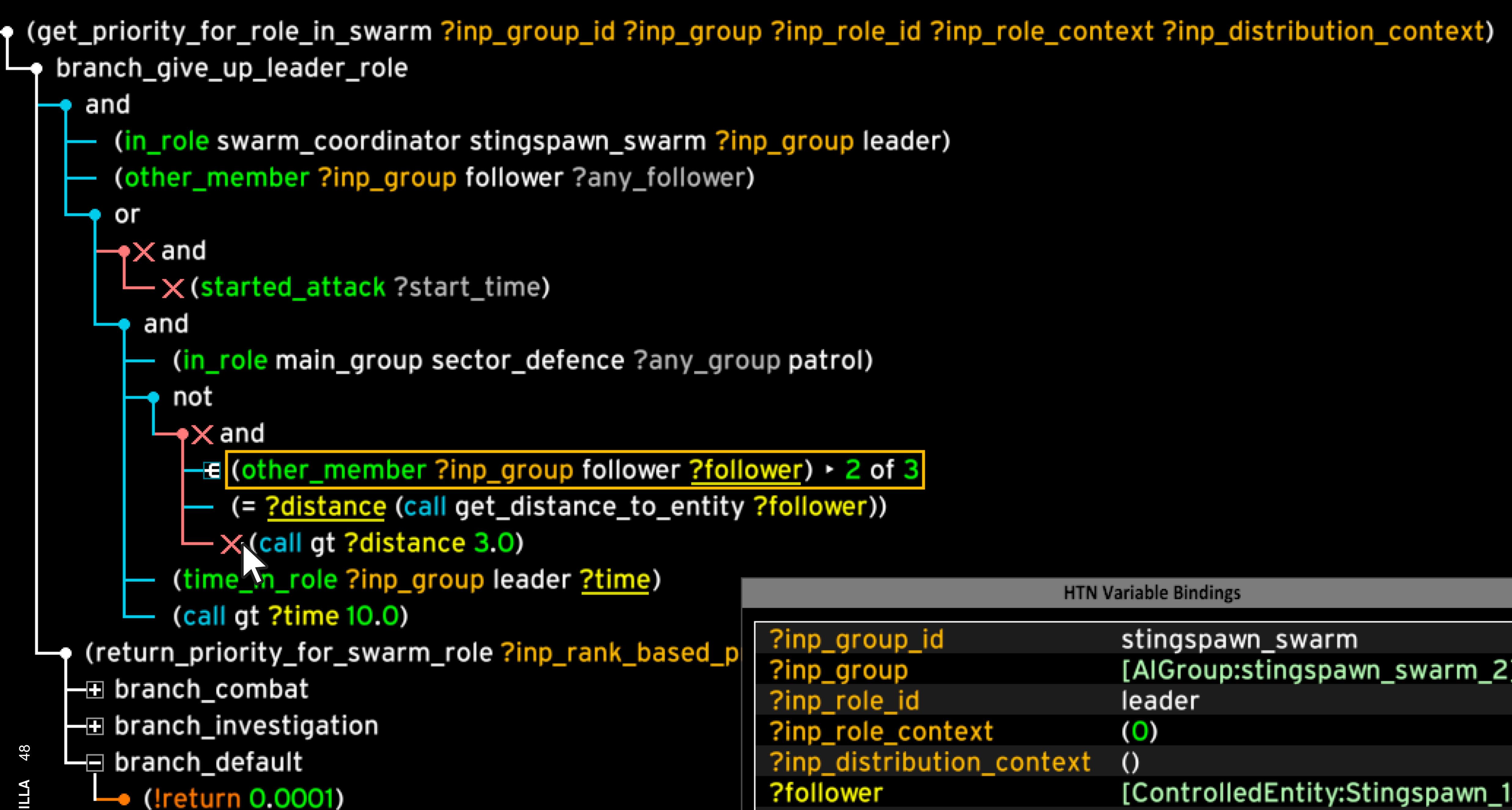
HTN Variable Bindings

?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()

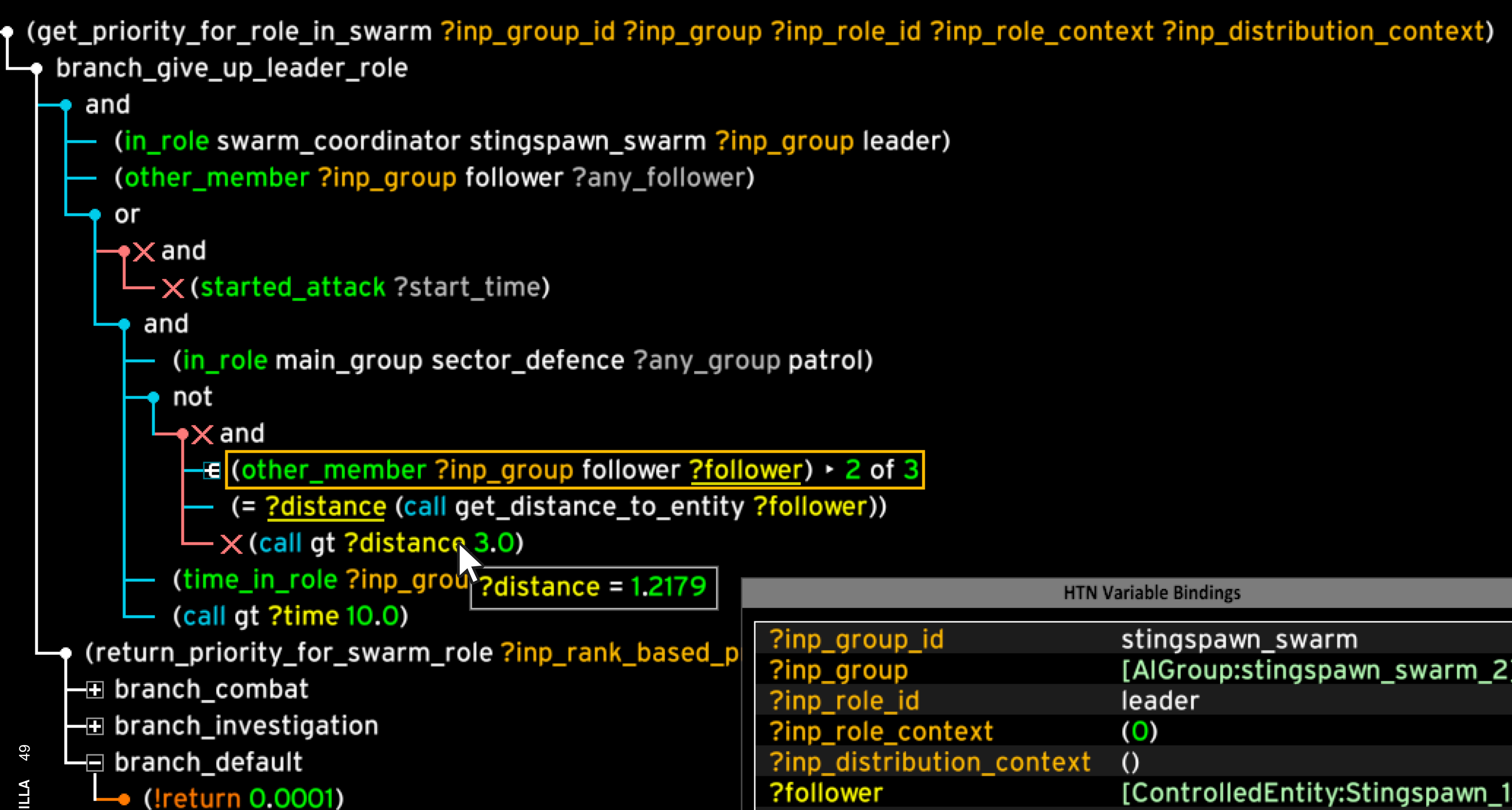


HTN Variable Bindings

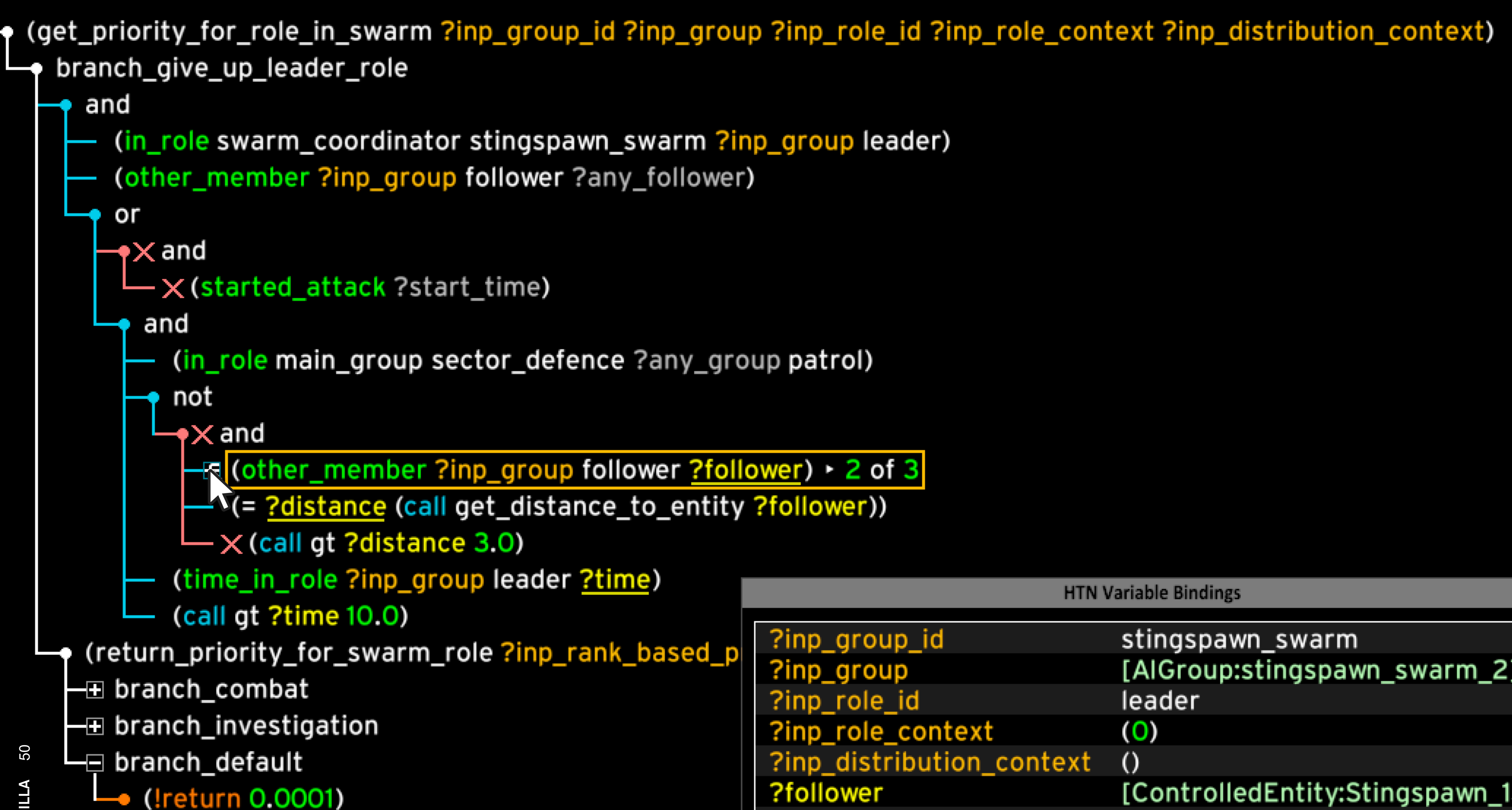
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()



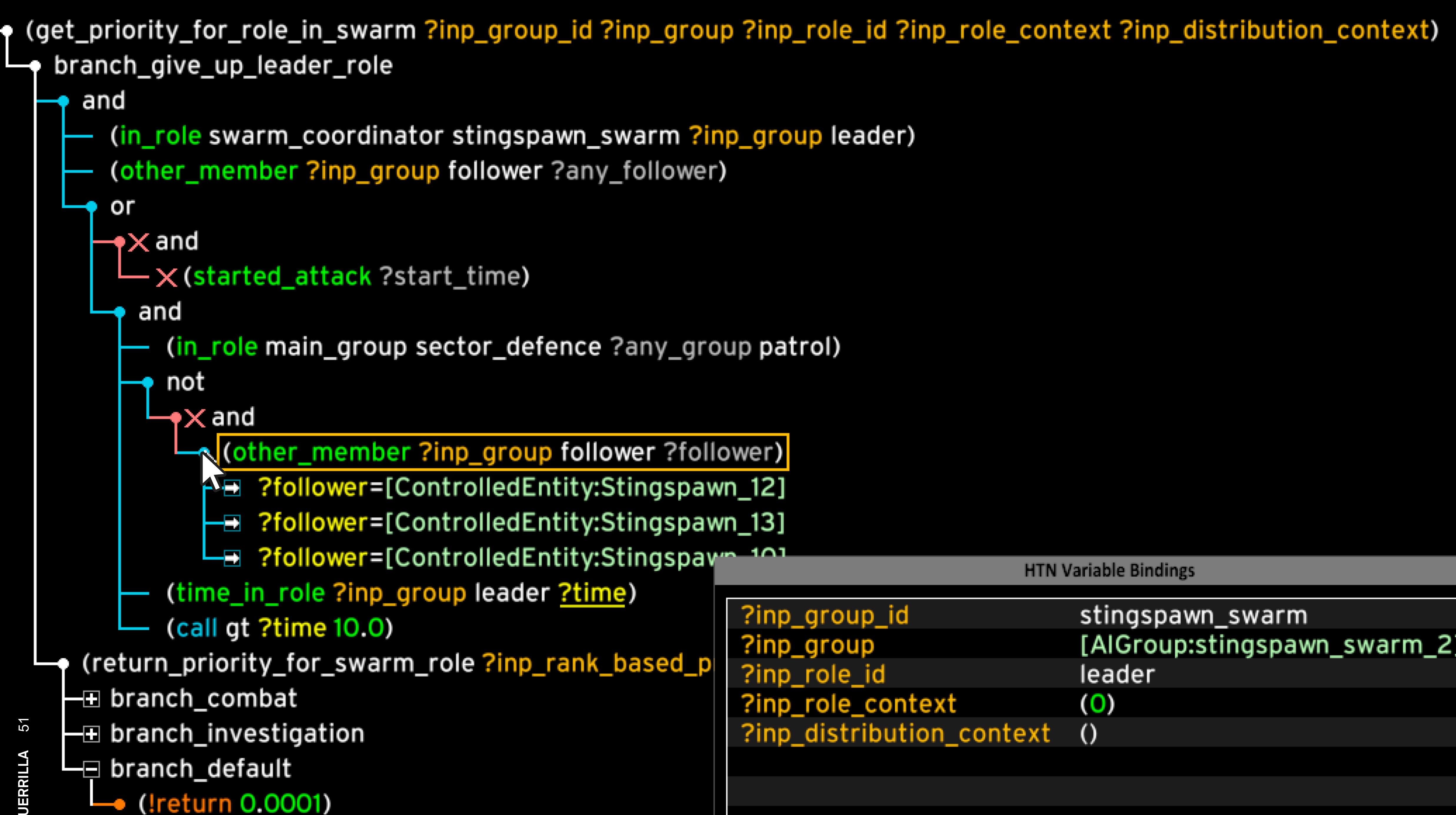
HTN Variable Bindings	
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?follower	[ControlledEntity:Stingspawn_13]
?distance	1.2179



HTN Variable Bindings	
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?follower	[ControlledEntity:Stingspawn_13]
?distance	1.2179

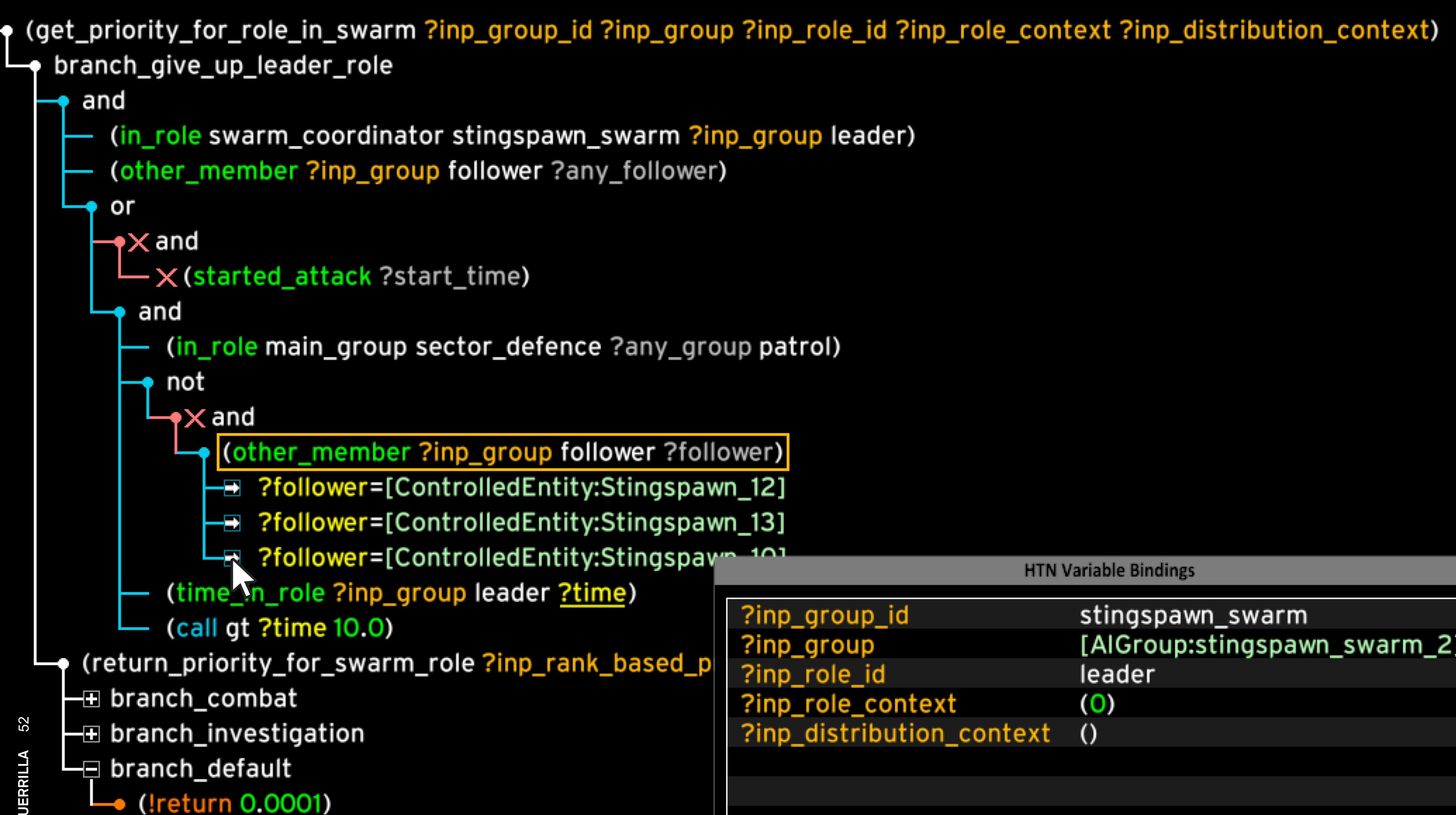


HTN Variable Bindings	
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?follower	[ControlledEntity:Stingspawn_13]
?distance	1.2179



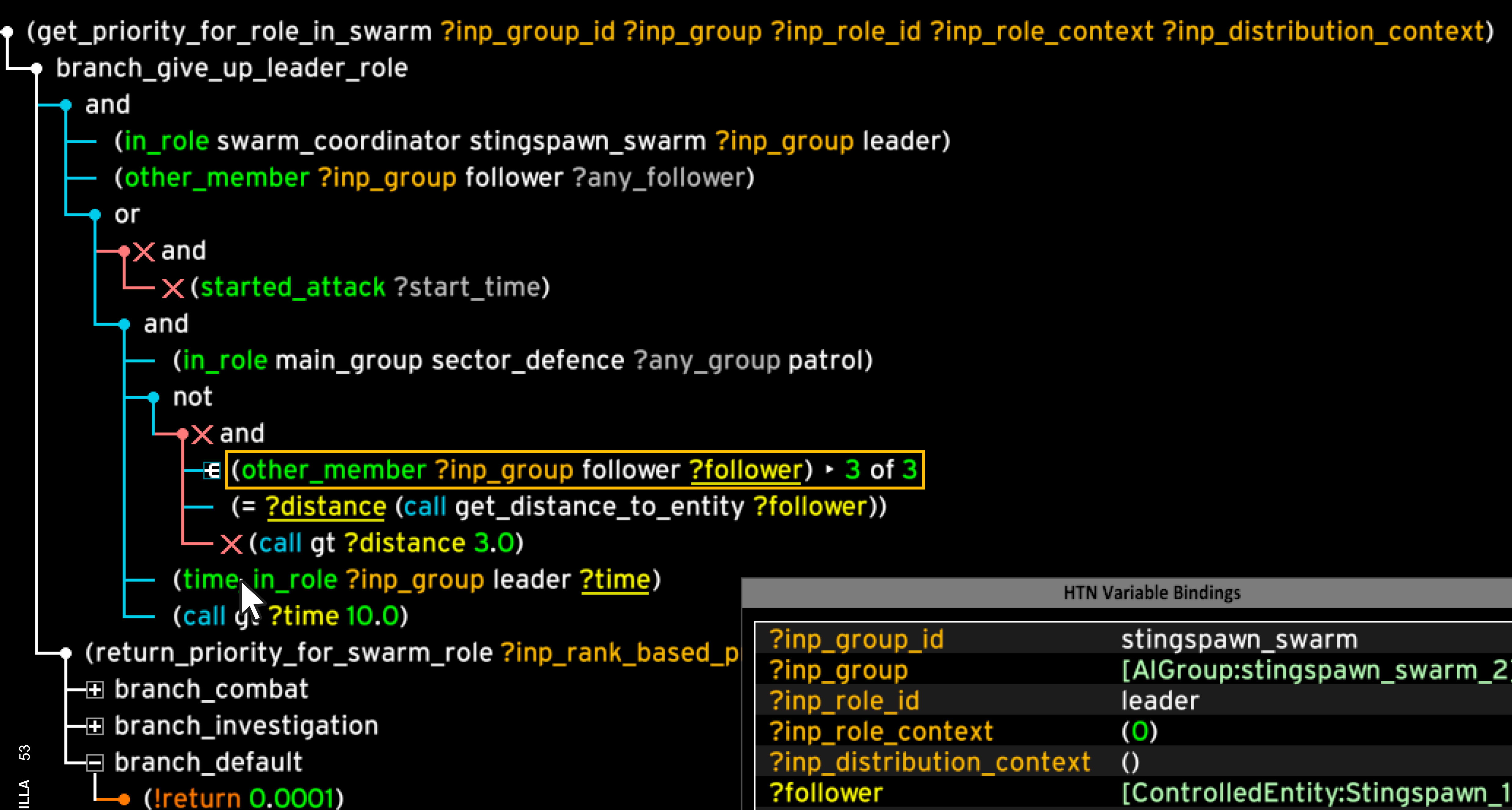
HTN Variable Bindings

?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()

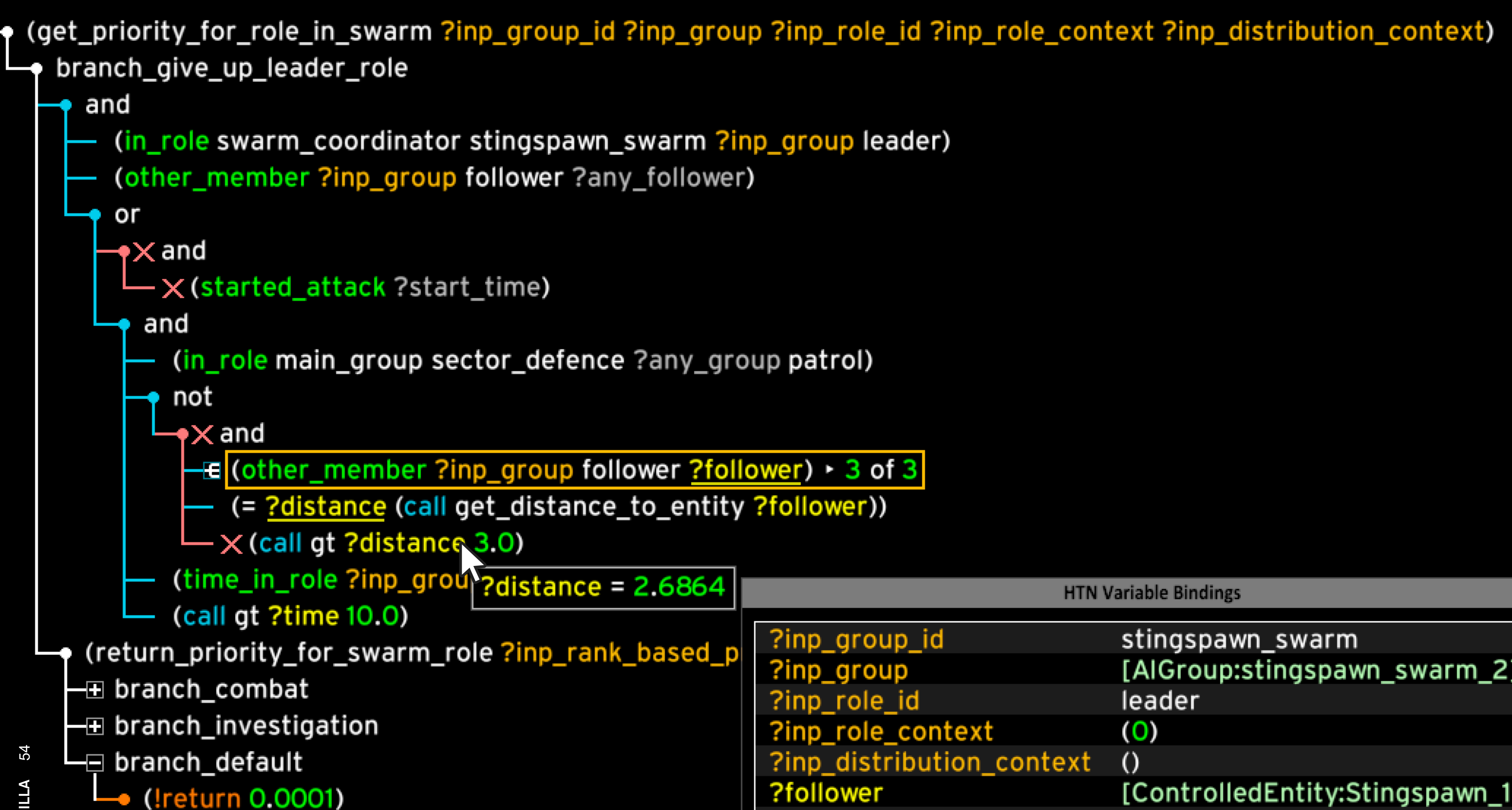


HTN Variable Bindings

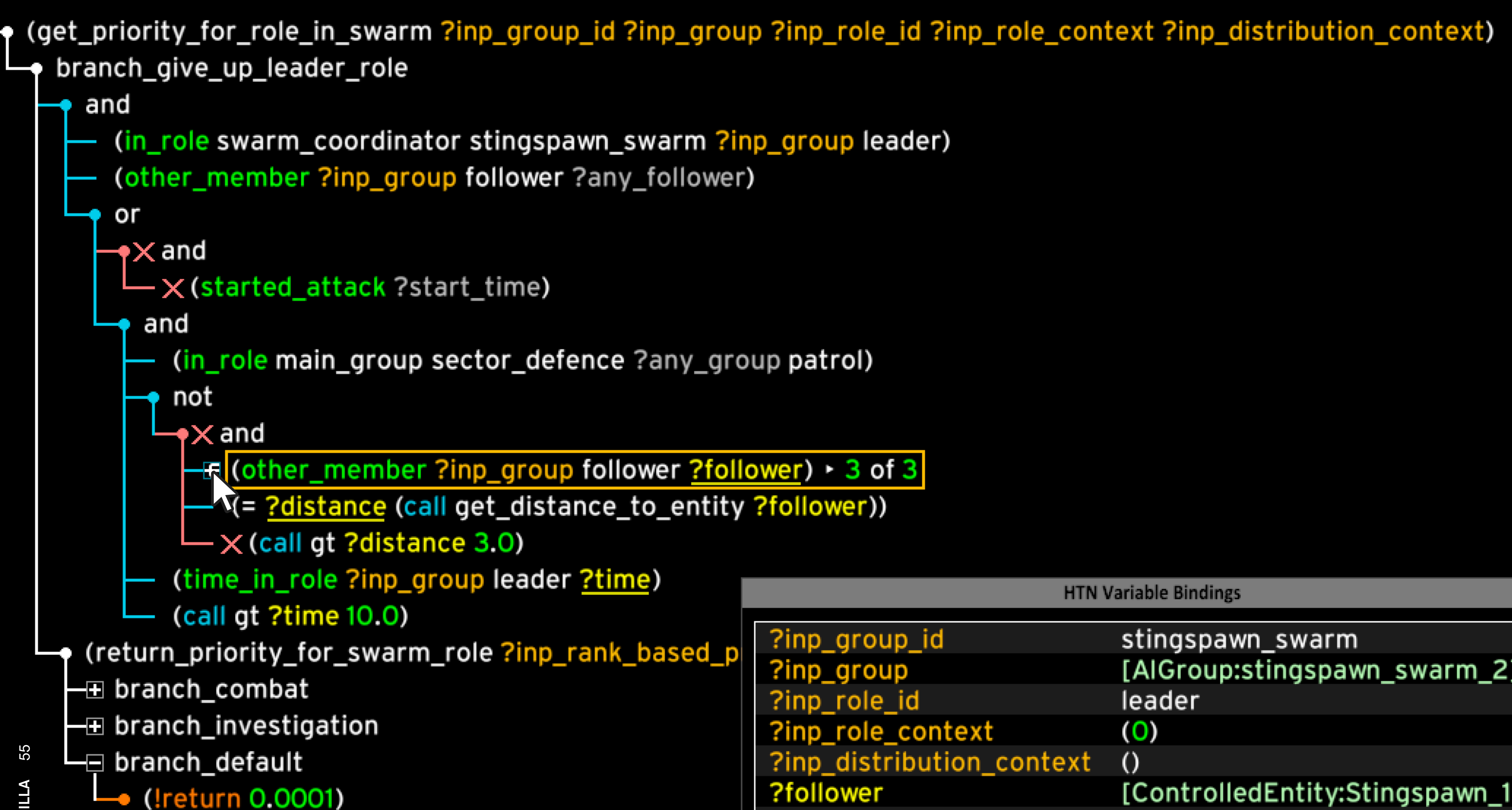
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()



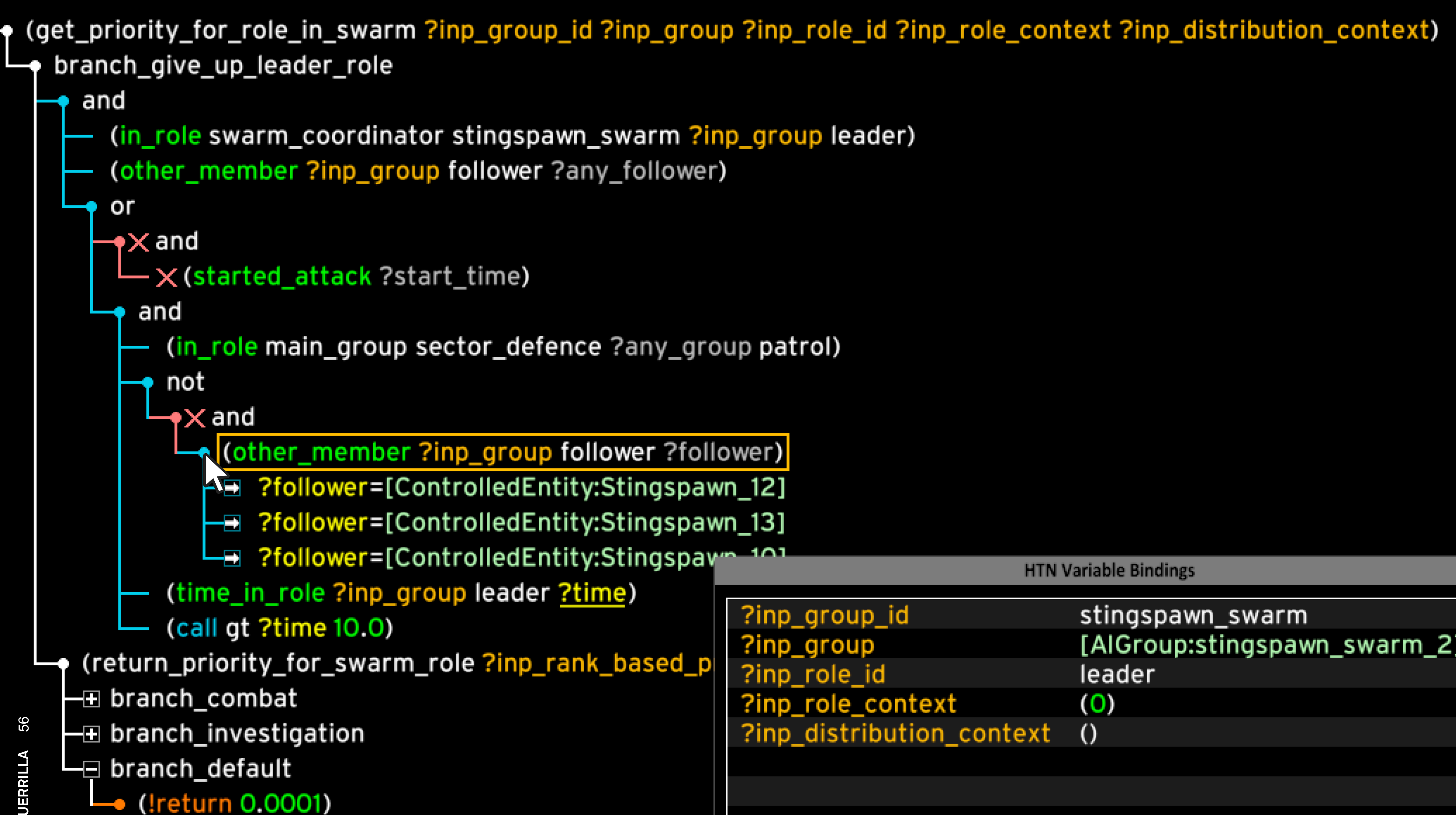
HTN Variable Bindings	
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?follower	[ControlledEntity:Stingspawn_10]
?distance	2.6864



HTN Variable Bindings	
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?follower	[ControlledEntity:Stingspawn_10]
?distance	2.6864

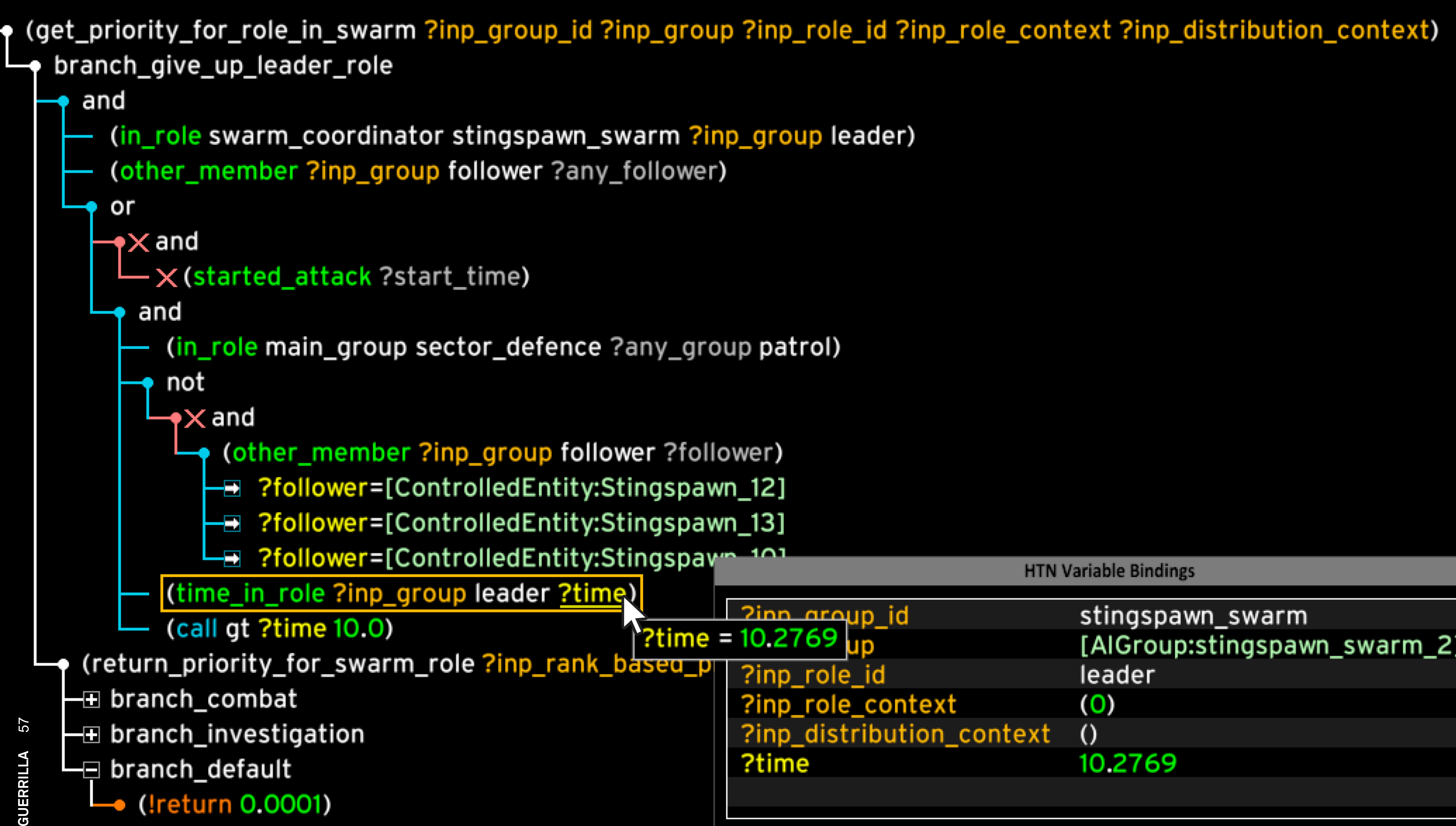


HTN Variable Bindings	
?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?follower	[ControlledEntity:Stingspawn_10]
?distance	2.6864



HTN Variable Bindings

?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()

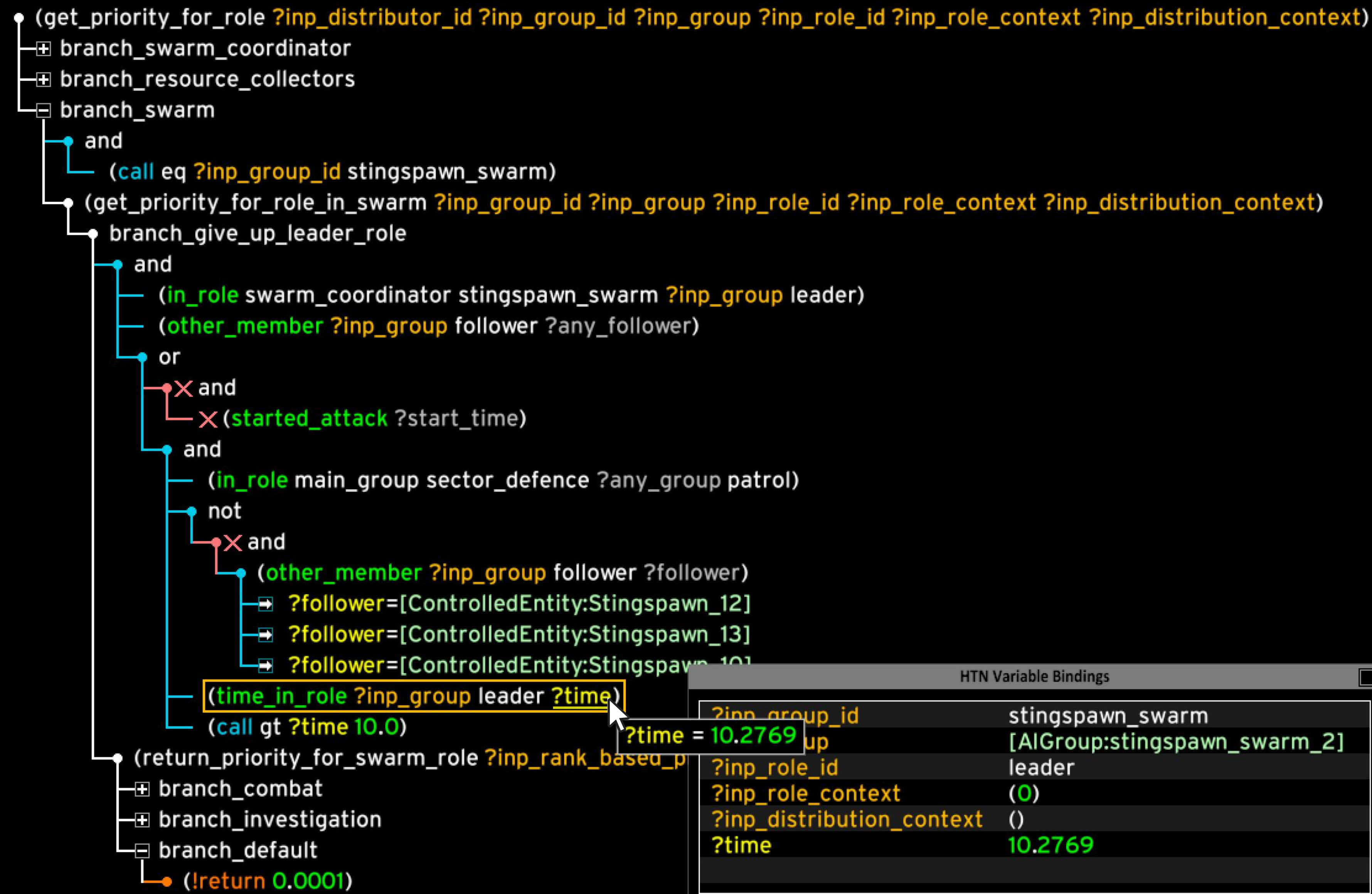


HTN Variable Bindings

?inp_group_id	stingspawn_swarm
?inp_group	[AIGroup:stingspawn_swarm_2]
?inp_role_id	leader
?inp_role_context	(0)
?inp_distribution_context	()
?time	10.2769



Decomposition View



HTN Variable Bindings

?inp_group_id	stingspawn_swarm
?inp_role_id	up
?inp_role_context	[AIGroup:stingspawn_swarm_2]
?inp_distribution_context	( )
?time	10.2769



THANK YOU

# From Byrd Box to Debug Boxes: HTN Introduction and Application in



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