



Local Plan Execution and Repair in a Hierarchical Structure of Sub-Teams of Heterogeneous Autonomous Vehicles

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retour sur innovation

1- Context

- A Multi-Agent Context
- Issue
- HTN (Hierarchical Task Network)

2 – HSST (Hierarchical Structure of Sub-Teams)

- Construction of the HSST
- Algorithm & example

3 – Plan execution preparation

- Plan distribution and adaptation
- Architecture examples

4 – Local supervision

- Local repair in a hierarchical plan structure
- Consistency issues

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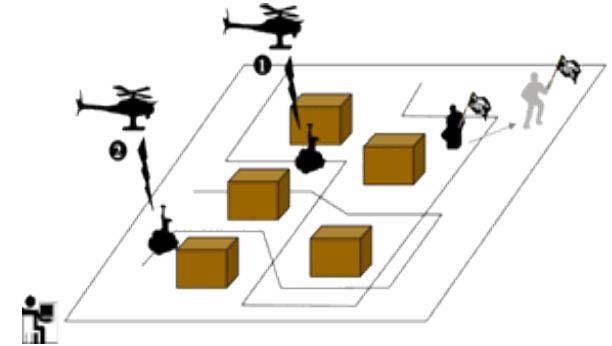
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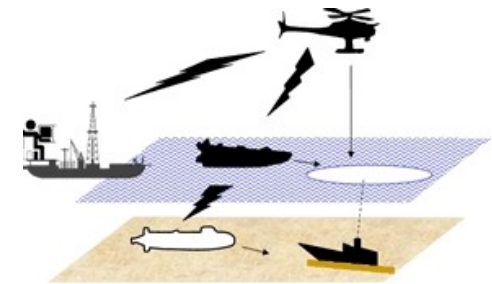
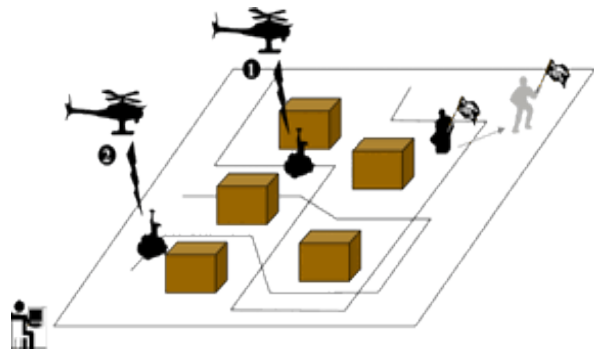
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Context ➤ A Multi-Agent Context

- ♦ Multi-robot
- ♦ Heterogeneous
- ♦ Individual autonomy
- ♦ Communication restrictions
- ♦ Dynamic environment => disruptive events
- ♦ Distributed system

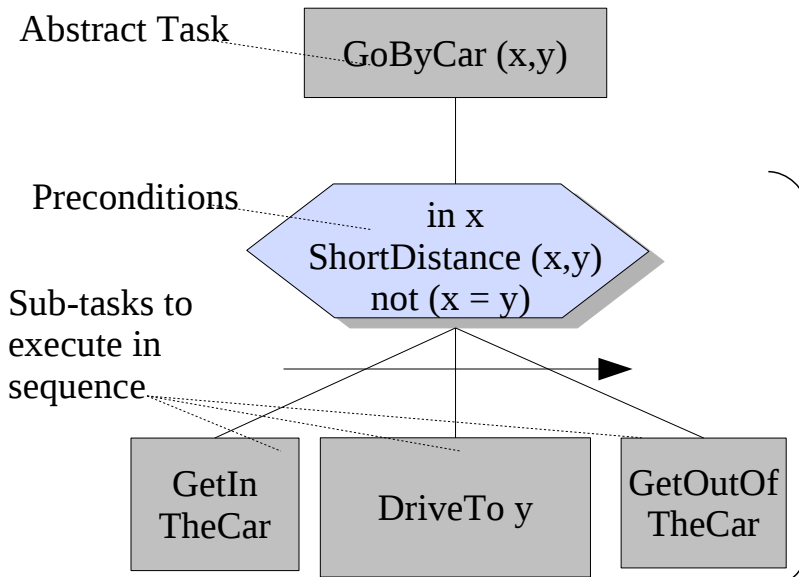




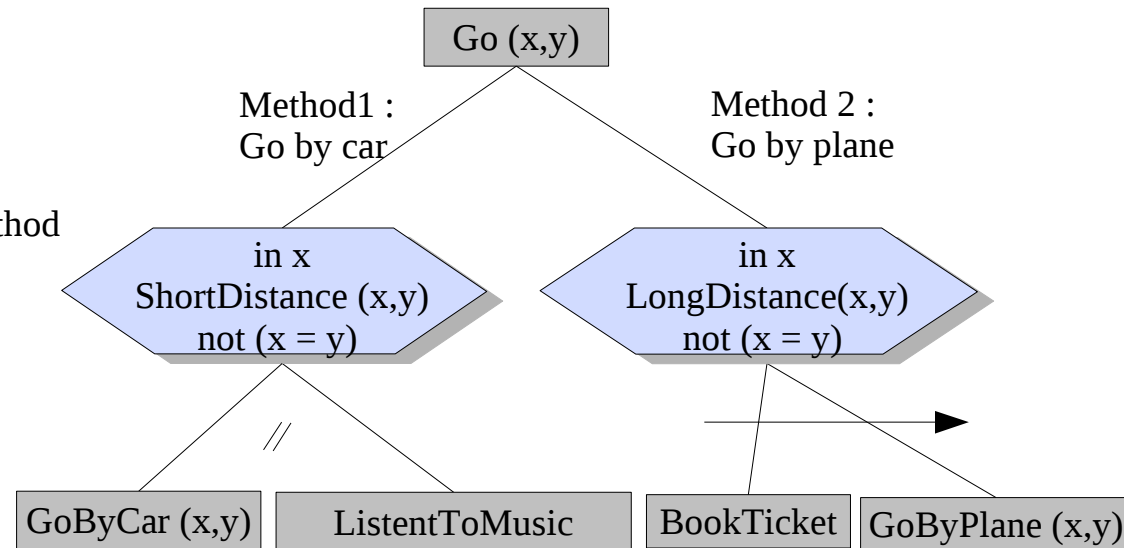
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HTN Formalism [EHN94]

A sequential method



Many methods



> Possible recursivity and parallelism

[EHN94]: Erol, K.; Hendler, J.; and Nau, D. 1994. HTN planning: complexity and expressivity. In AAAI

➤ HSST (Hierarchical Structure of Sub-Teams)

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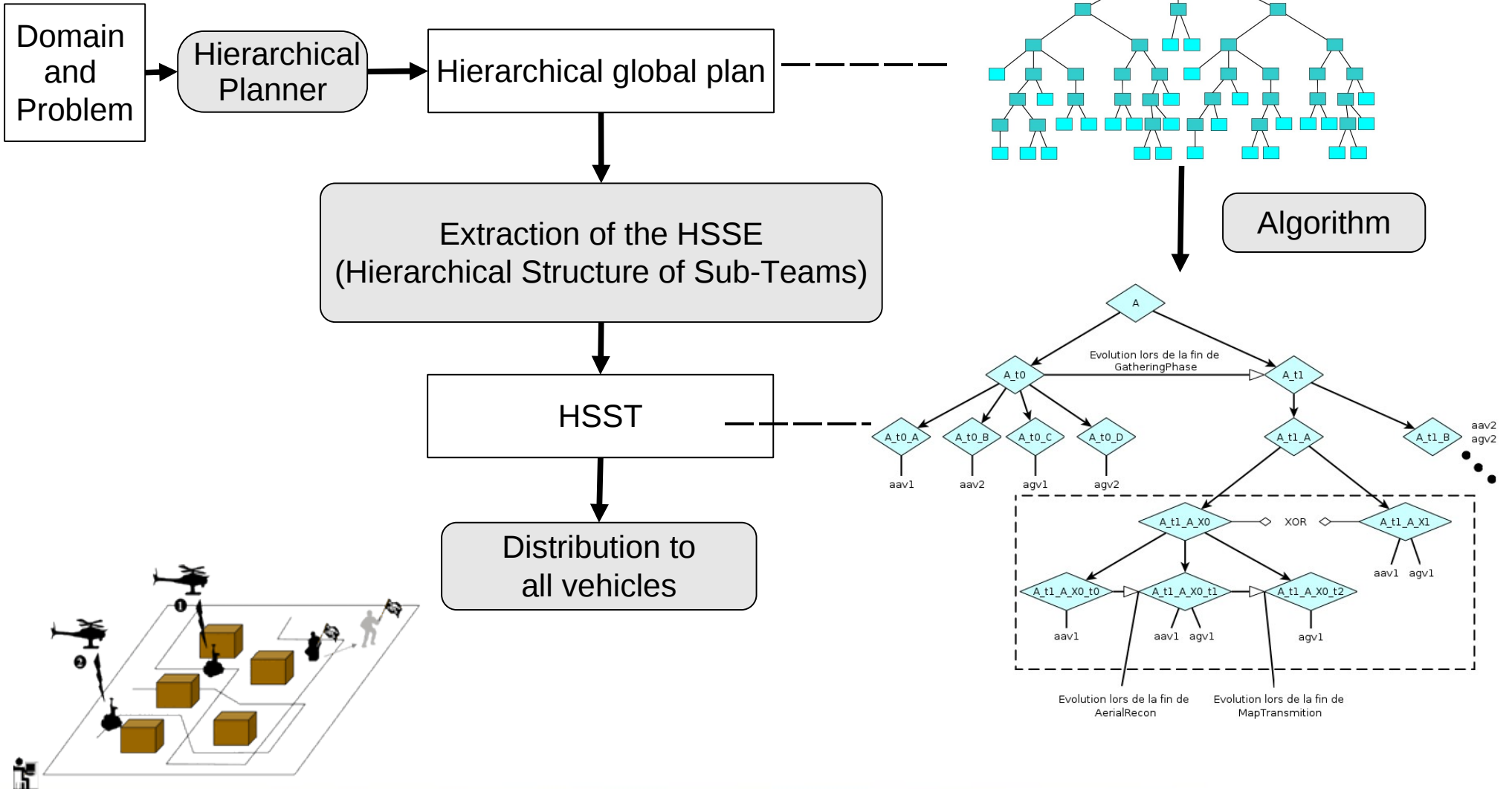
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HSST ➤ Construction of the Hierarchical Structure of Sub-Teams



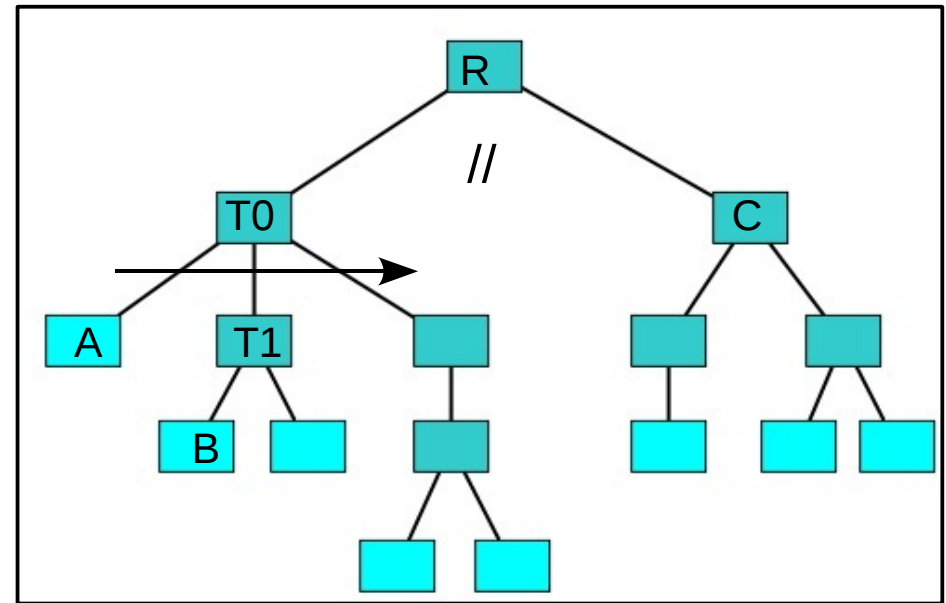
Algorithm 1 *Extract*(T)

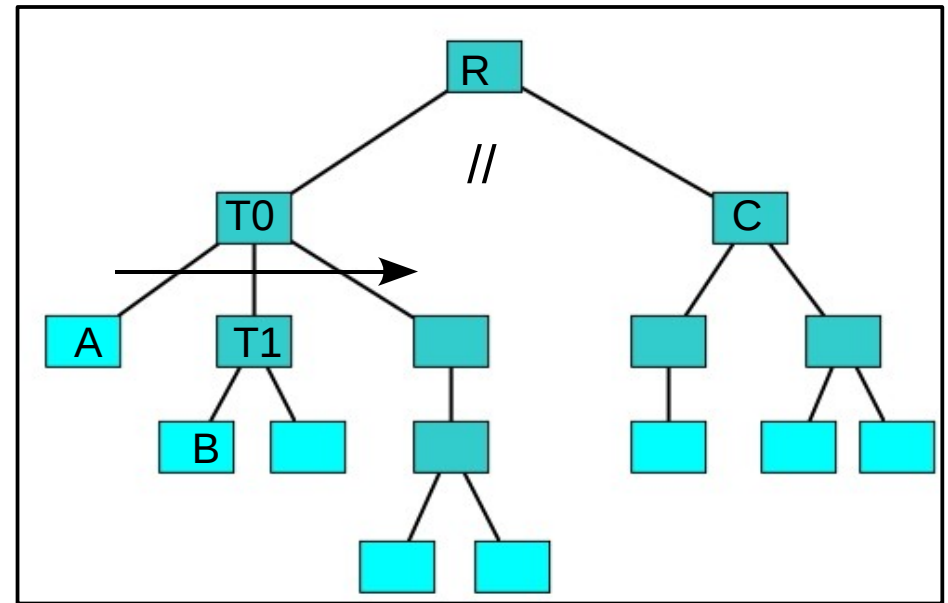
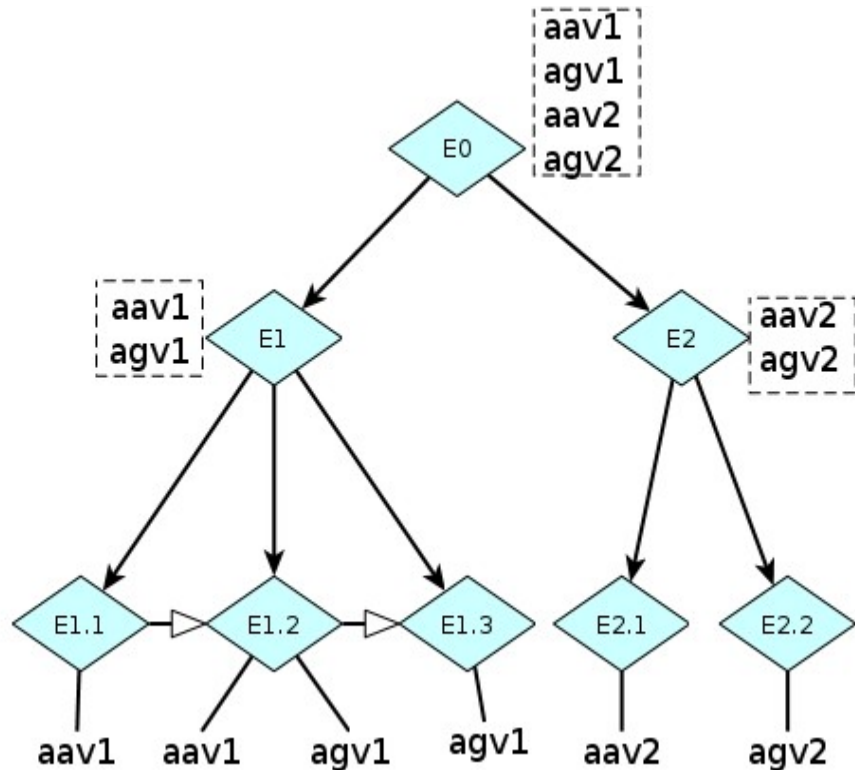
Require: T : a HTN task

```

1:  $A = \emptyset$ 
2: if  $T$  elementary then
3:   return Agents( $T$ )
4: end if
5: for all  $T_i \in \text{children}(T)$  do
6:    $A_i = \text{Extract}(T_i)$ 
7:   if  $T$  sequential then
8:      $\text{link}(A, A_i, \text{sequence})$ 
9:   else if  $T$  parallel then
10:     $\text{link}(A, A_i, \text{parallel})$ 
11:   else if  $T$  multi-method then
12:     $\text{link}(A, A_i, \text{xor})$ 
13:   end if
14: end for
15: return  $A$ 

```





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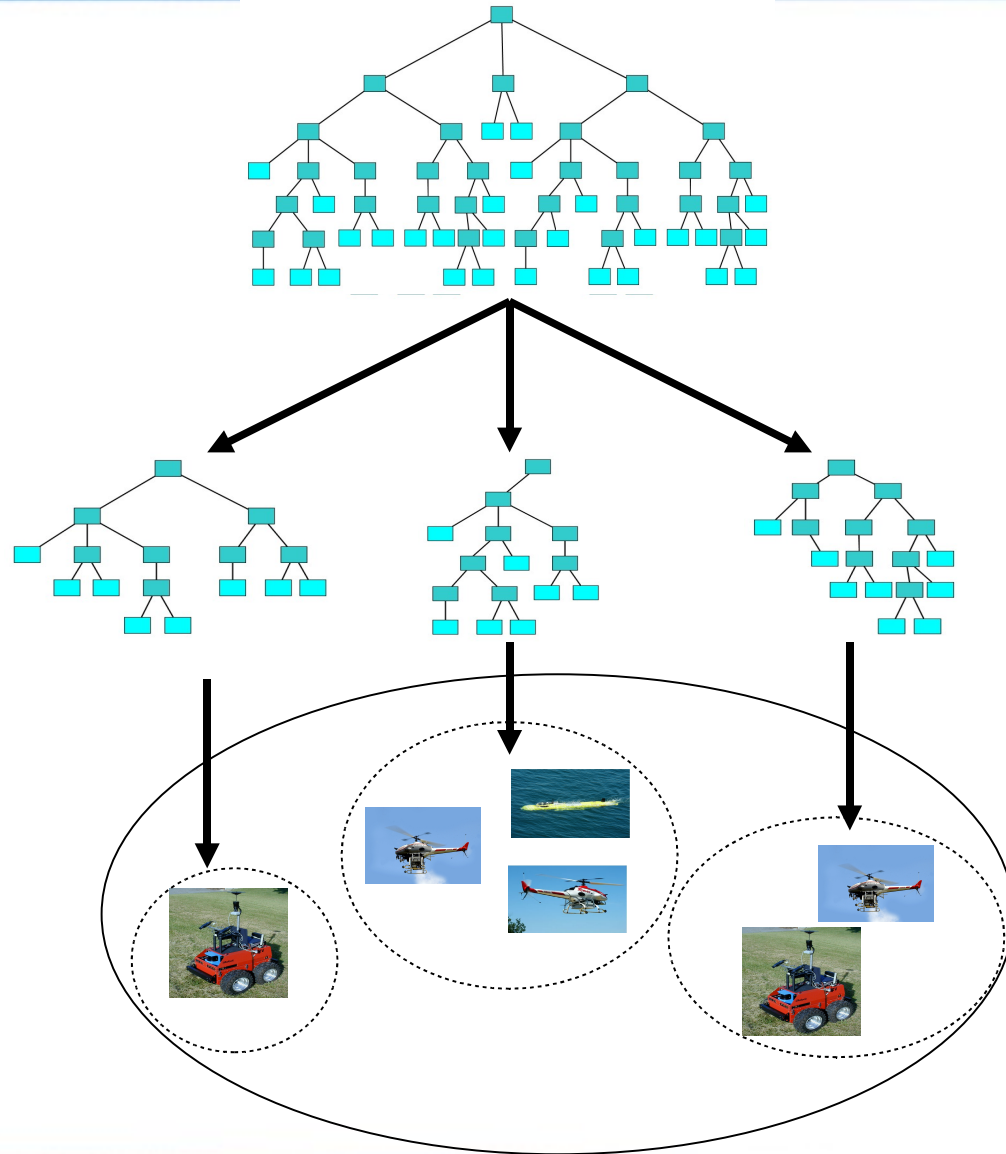
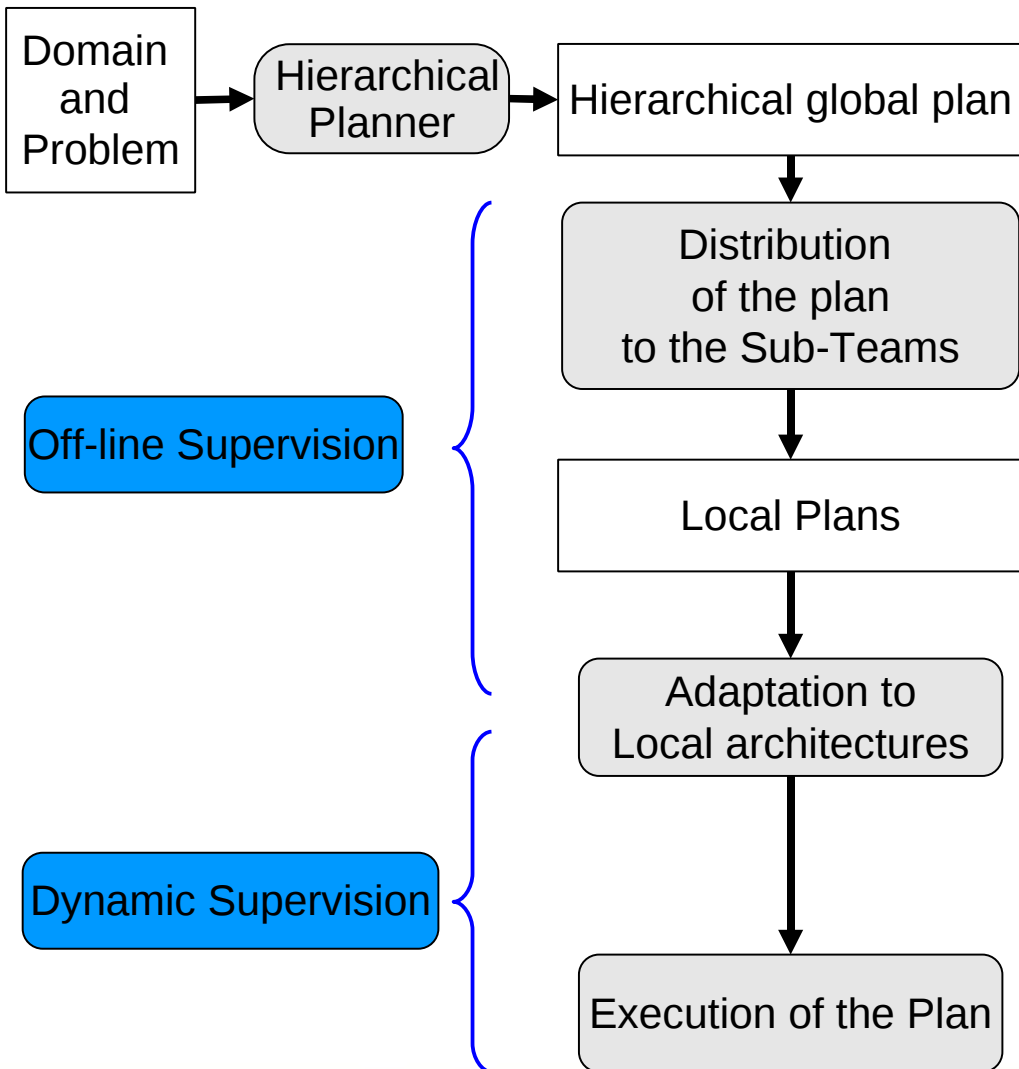
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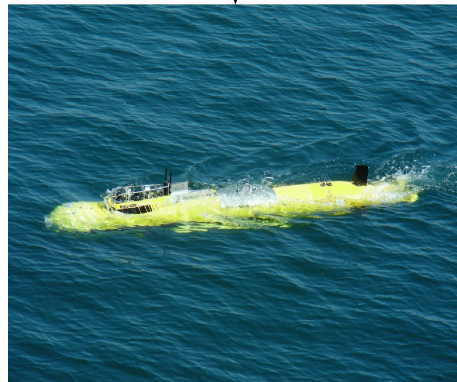
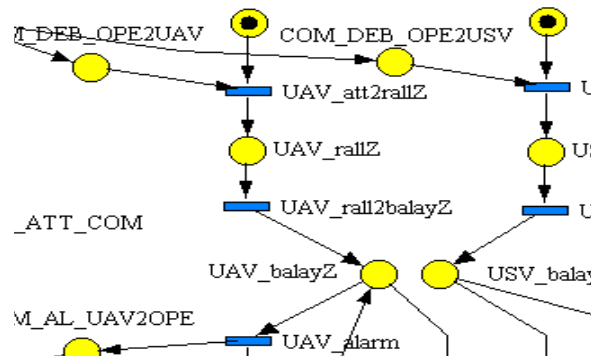
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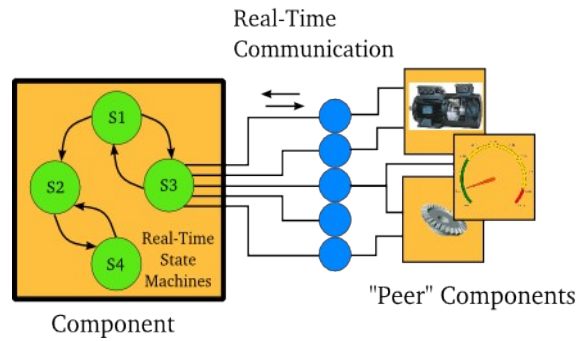
Plan Execution Preparation ➤ Plan Distribution and Adaptation



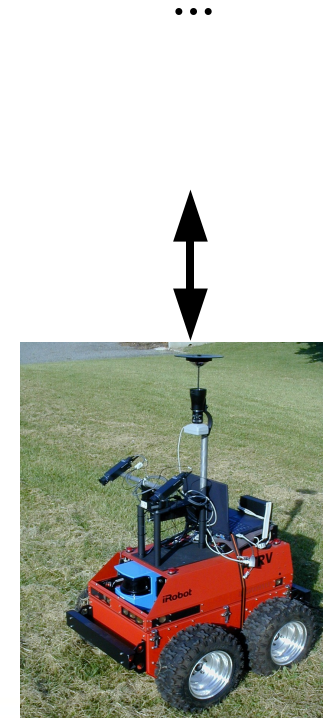
ProCoSA : Petri Nets



Orocos : State Machines



Open PRS and other architectures



➤ Local supervision

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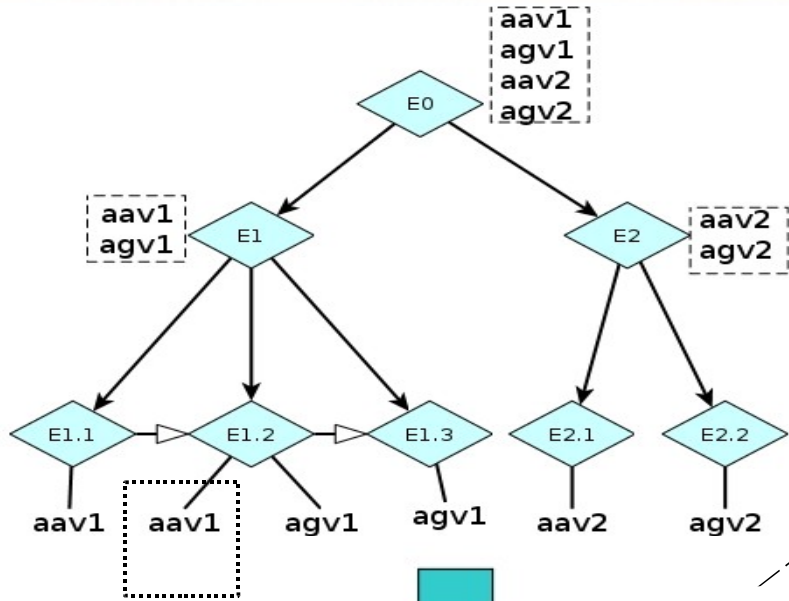
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Local Supervision ➤ Local Repair in a Hierarchical Plan Structure

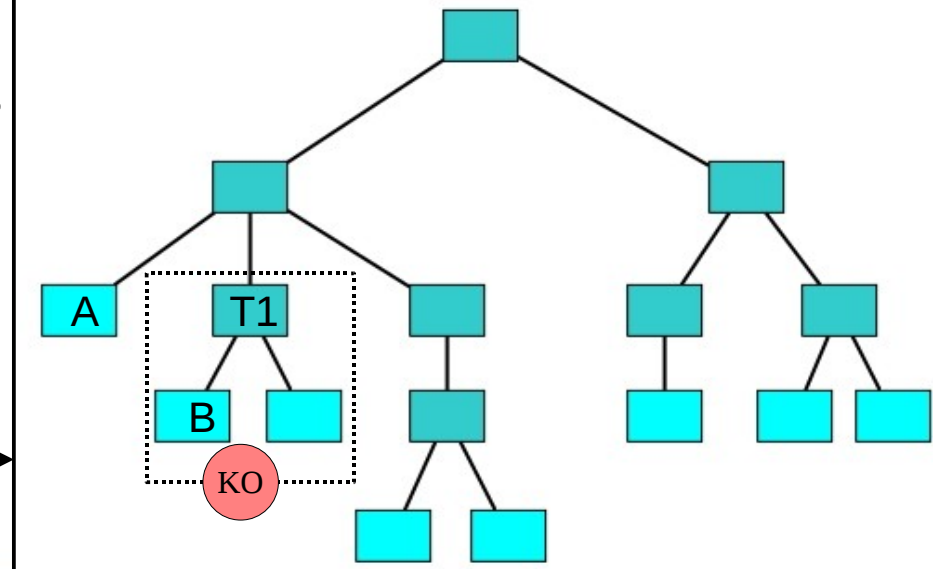
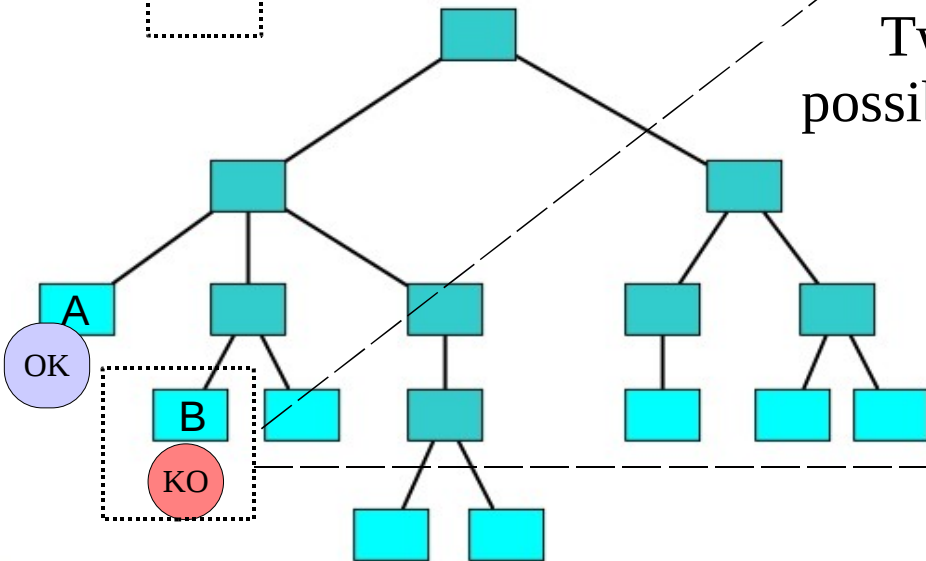


A plan repair as local as possible

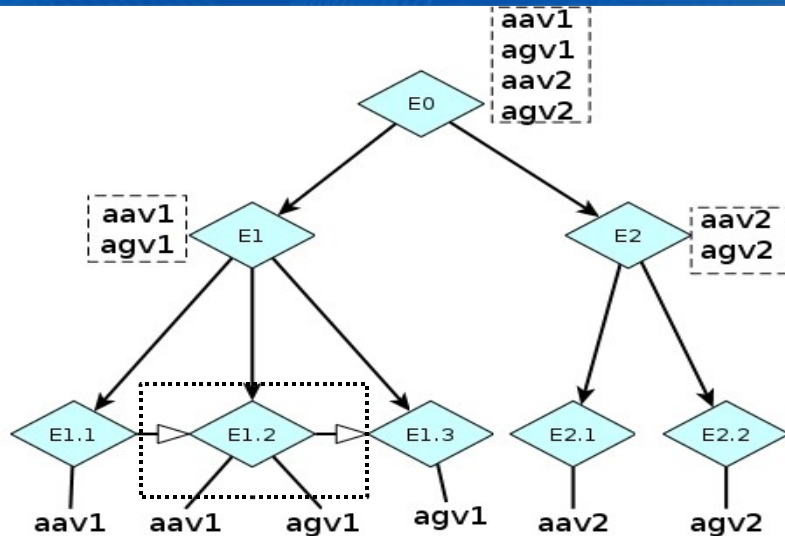
Local repair found
Task B => Task B'

No local repair : go up in the plan hierarchy

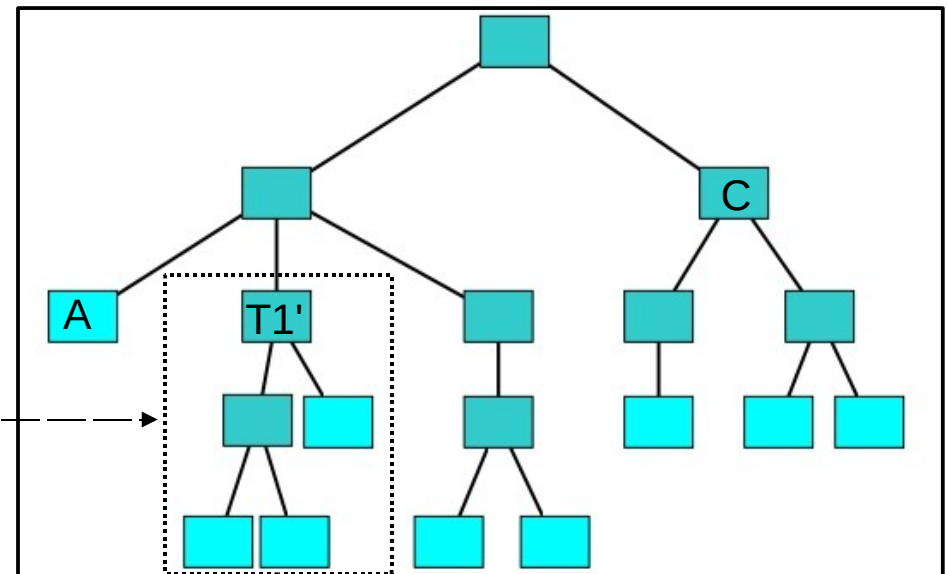
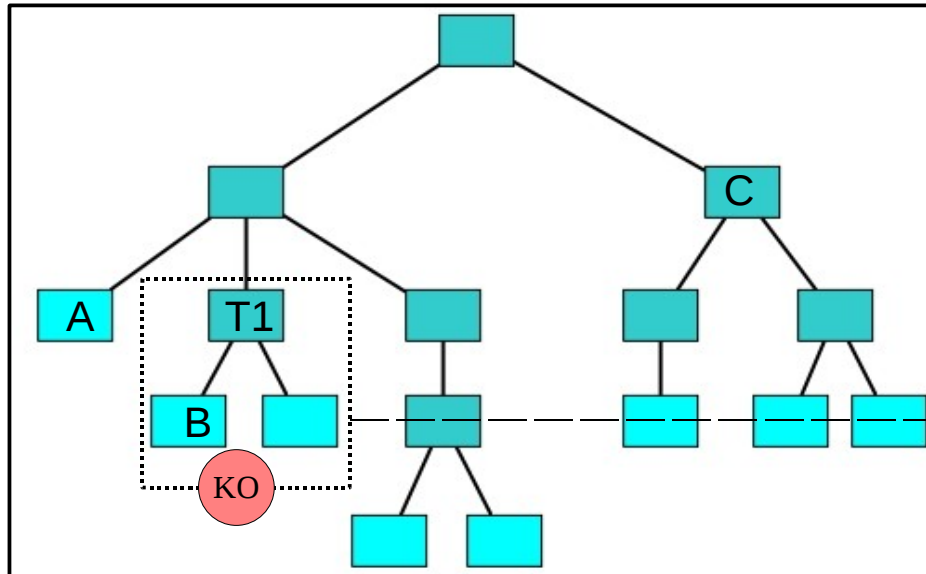
Two possibilities



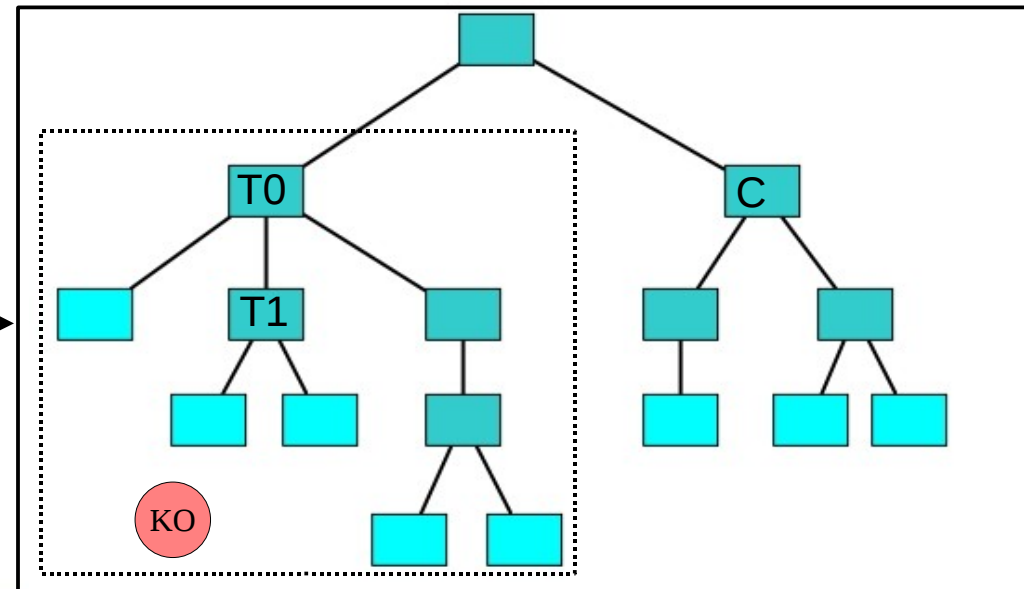
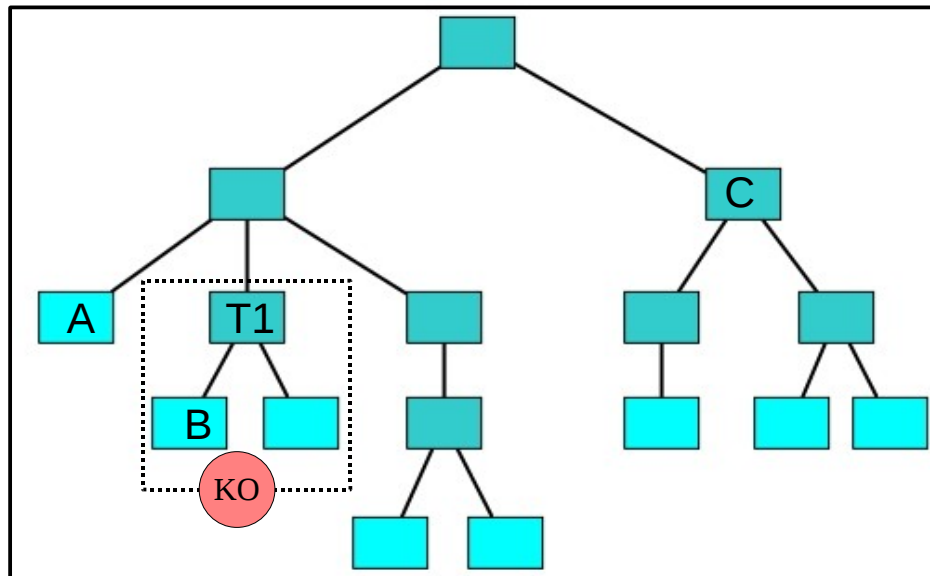
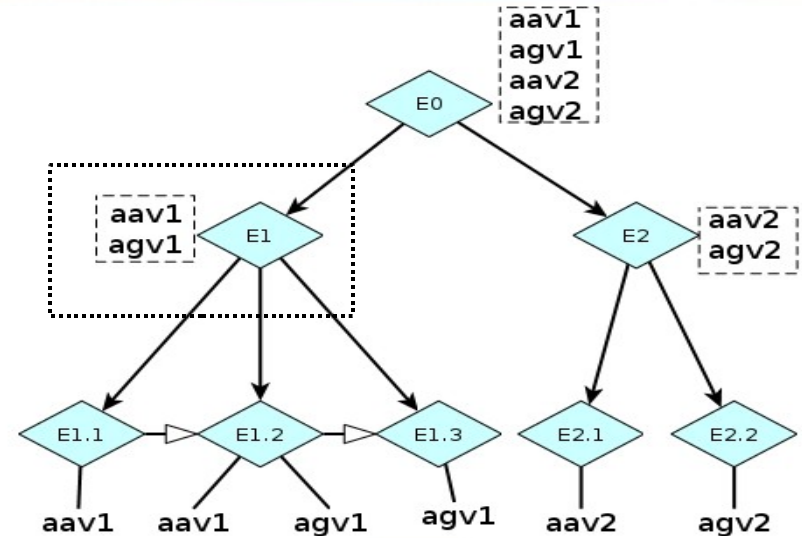
Local Supervision ➤ Local Repair in a Hierarchical Plan Structure



1st case - An alternative partial plan is found : T1 => T1'



2nd case : No solution found
 => Go up in the plan hierarchy
 etc...

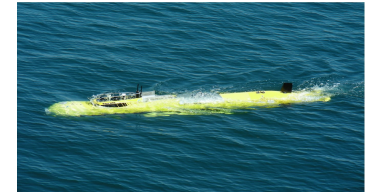
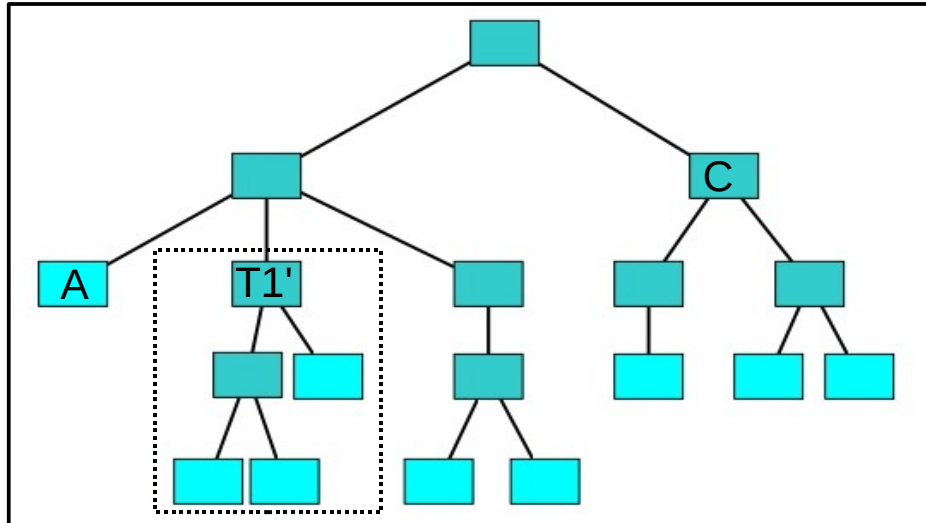


Local Supervision ➤ Consistency issues

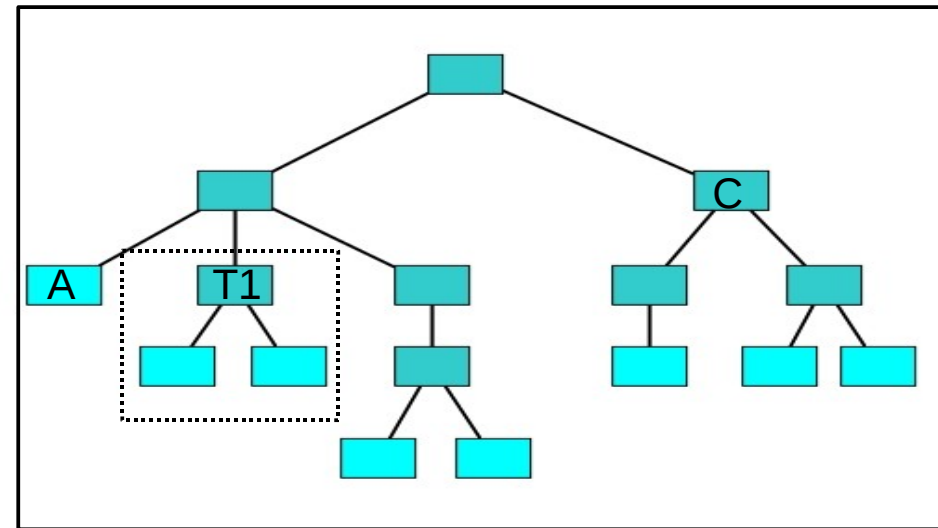
- Repair done at a local level : a new usable plan is available
- But what about consistency issues in the team ?



After repairing,
new current plan :



Other vehicles' current plans :



Conclusion ➤ Futher work

- On the way :

➤ Implementation of the local Execution Manager

- * Basic structure completed
- * Adaptation for specific formalism
- * Interface with local architectures

➤ HSST efficiency : run many simulations with different:

- * Types of hierarchies in the team
- * Amounts of disturbing events
- * Numbers of vehicles
- * Communication restrictions

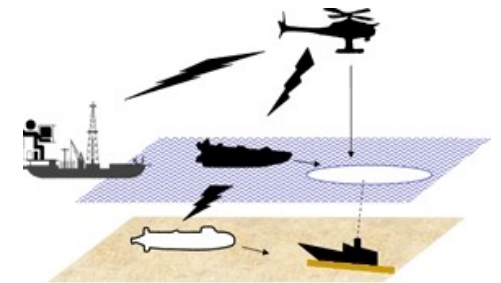
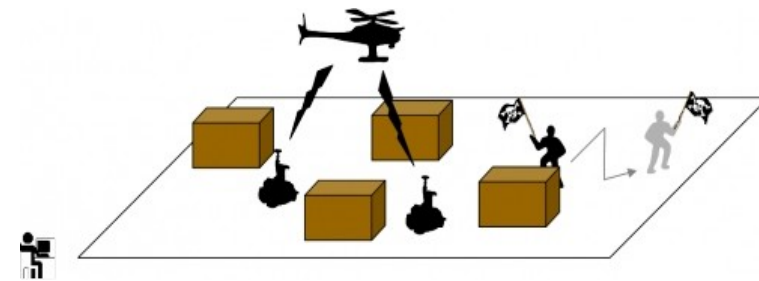
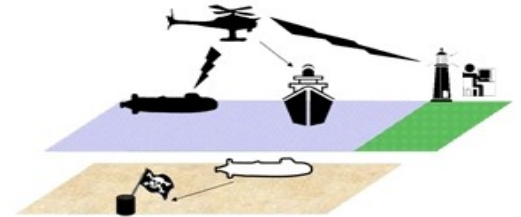
and comparison with existing multi-robot architectures...

- Future issues :

➤ Consistency issue

- * Environment Information Sharing
- * Plan Sharing

➤ Tests: simulations and experiments on the field



Thank you for your attention !

Any questions ?

?

Annex ➤ Central Role of the Local Supervisor

