Local Replanning in a Team of Cooperative Agents

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ABSTRACT

This thesis aims at formalising the relationship between the team plan and individual agents' plans and the replanning process through the use of Petri nets.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*multiagent systems*; D.2.2 [**Software Engineering**]: Design Tools and Techniques—*Petri nets*

Keywords

Hierarchical Petri nets, object Petri nets, replanning, teamwork

The general framework is a mission specified in terms of objectives: agents are operated in order to carry out the mission and they are hierarchically organised in a team. This thesis aims at formalising the relationship between the team plan and individual agents' plans and the replanning process through the use of Petri nets (PN) [3]. The *objective* of the mission is decomposed into a hierarchy of goals that must be carried out. *Recipes* [4] give courses of actions for achieving the *elementary goals* (leaves in the hierarchy). Several recipes may exist for the same elementary goal. Agents' resources are modelled by coloured Petri nets [5]. A Petri net models the execution control [1] (fig. 1).

Thanks to constraint programming the team plan is initially designed as an organised subset of recipes, represented as a coloured Petri net. The set of token colours is the set of agents. Each reachable marking corresponds to an organisation of the team, *i.e.* a distribution of agents that realises the activities associated to the marked places. The team plan bears some typical structures that can be identified as modifications of the team organisation. The **reduction** [2] provides a methodology for transforming the team plan into a hierarchical Petri net reflecting the team organisation for each activity. Hence each reachable marking corresponds to an *agenticity hierarchy* (fig. 2) of the whole team, whose leaves are elementary agents and whose nodes are subteams, *i.e.* composite agents. The *agenticity* corresponds to the depth of an agent relative to a given (sub)team. Then the team plan is **projected** [2] on the agents in order to execute the relevant actions. At the occurrence of an unforeseen event a replanning step is triggered: a reaction is deployed in the form of a contingency plan while the system goes under diagnosis. When the failure is located the plan is repaired as locally as possible in trying to solve the problem at the lowest level in the agenticity hierarchy: the failing recipe is replaced by another recipe or subset of recipes that realise the same goal. If this fails other parts of the initial plan are involved in the repair in ascending the agenticity hierarchy. Once the new plan is elaborated an adjusting step is required to ensure a smooth switching between the contingency plan and normal execution of the new plan.

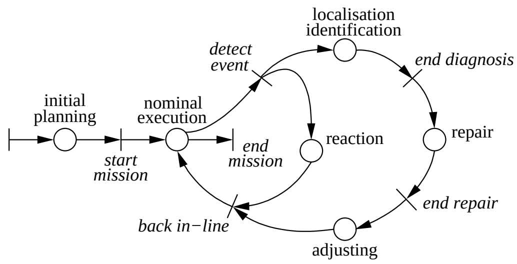

Figure 1: Execution control Petri net

In the context of teams of robots, this approach may help in dynamically responding to an unforeseen event, such as a failure or an external action, at a relevant level. Current and future works concern the development of EΛAIA, a Petri net-based decision architecture for local replanning within the team. Experiments are prepared in order to validate the principles with a team of *PeKee* robots at Supaero. The envisioned applications concern the implementation of cooperative robots for missions ranging from search & rescue operations to military UAV/UCAV team operation.

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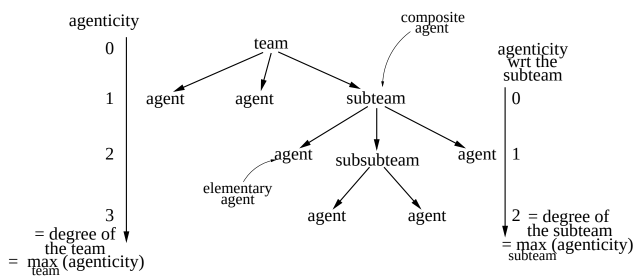

Figure 2: Hierarchy of agenticity