Dealing with incompatibilities among goals
(Extended Abstract)

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ABSTRACT

An intelligent agent may in general pursue multiple goals at the same time, which leads to arise some conflict among them. In this paper, we focus on these conflicts or incompatibilities among goals. Our approach is based on the model of Castelfranchi and Paglieri, in which, three forms of incompatibility and the criteria for selection of goals are defined. We characterise computationally the different forms of incompatibility (terminal, instrumental and superfluity) and propose a way, based on abstract argumentation theory, for selecting those goals that will continue to be pursued.

Keywords

goals conflict, abstract argumentation, goals selection

1. AGENTS

In this work, an agent consists of a belief base $\mathcal{B}$, a set of goals $\mathcal{G}$, and a plan library $\mathcal{P}$[1]. Let $\mathcal{L}$ be the logical language used to represent such goals, beliefs and plans, and $\wedge$,$\vee$ and $\neg$ denote the logical connectives conjunction, disjunction and negation.

Each plan has the following form: $pl_i = e : \psi \leftarrow P, [\mathcal{R}_{req}]$ encoding a plan-body program P for handling an event-goal e when the context condition ψ is believed to hold. Consider that plans may include calls to other plans in their plan-bodies. Finally, the resource requirements list $\mathcal{R}_{req}$ is composed of a list of pairs (res_i, n), where $n > 0$ represents the necessary amount of resource res_i to perform the plan.

Finally, the agent is equipped with the following functions:
- $\texttt{GOAL} : \mathcal{P} \rightarrow \mathcal{G}$ returns the event-goal e of a given plan,
- $\texttt{CONTEXT} : \mathcal{P} \rightarrow 2^{\mathcal{L}}$ returns the elements of the context of a given plan,
- $\texttt{AVAILABLE\_RES} : \mathcal{R} \rightarrow \mathbb{R}$ returns the available quantity of a given resource of the agent,
- $\texttt{NEED\_RES} : \mathcal{G} \times \mathcal{R} \rightarrow \mathbb{R}$ returns the amount of a given resource that a goal needs.

[1]We assume that agents have a library of programmer-provided plans.

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Next section presents the formalization of the three forms of incompatibility, defined by Castelfranchi and Paglieri [2], and Section 3 is devoted to our proposal for dealing with incompatible goals. Our proposal returns a set of non-conflicting goals the agent can continue to pursue.

2. FORMS OF INCOMPATIBILITY

1. Terminal incompatibility: It happens when two or more goals cannot be pursued in the same world at the same time. For example, a cleaner agent cannot pick up garbage and be repaired at the same time.

In order to identify this kind of incompatibility, the relevant plans of currently pursued goals have to be evaluated, let us call them $\mathcal{P}_{rel}$. Notice that plans of a same goal are not compared among them.

Definition *1.* **(Terminal incompatibility)** Let g_i and g_j be two goals, and $pl_k, pl_l \in \mathcal{P}_{rel}$ be two relevant plans, one for each goal respectively. Goals g_i and g_j have terminal incompatibility when $\exists b_i \in \texttt{CONTEXT}(pl_k) | b_i = \neg b_j$, where $b_j \in \texttt{CONTEXT}(pl_l)$.

2. Instrumental incompatibility: It is related to the necessary resources that goals need to be achieved. Thus, the quantity of resources of an agent can be enough for achieving a goal, nevertheless, when two or more goals need the same resources, it is possible that some conflicts arise.

Definition *2.* **(Instrumental incompatibility)** Let $\{g_i, g_j, ..., g_k\}$ be goals in $\mathcal{G}$ that need the same resource res_m. There is instrumental incompatibility among them when $(\sum_{x=i,j,...,k} \texttt{NEED\_RES}(g_x, res_m)) > \texttt{AVAILABLE\_RES}(res_m)$

3. Superfluity: It occurs when two or more goals are means to the same end. In order to identify it, the plan-bodies of the plans of the agent have to be evaluated.

Definition *3.* **(Superfluity)** Let g_i, g_j and g_k be pursued goals, and pl_r, pl_s and pl_t be their respective relevant plans. Goals g_j and g_k have superfluous incompatibility when:
- Both pl_s and pl_t are part of the plan-body P of pl_r. According to the structure of P only one must be called. However, both $g_j = \texttt{GOAL}(pl_s)$ and $g_k = \texttt{GOAL}(pl_t)$ are being currently pursued. In this case, goals g_j and g_k have superfluous incompatibility.

- Plan pl_r activates twice a goal that is part of its plan-body P, but with different parameters. Thus, both goals g_{j1} and g_{j2} are being pursued at the same time, and therefore they are incompatible. For example, a buyer agent is performing a plan to buy a TV and it activates the goal $pay\_with(TV, x)$, firstly with $x = dollar$ and then with $x = euro$.

3. EVALUATING INCOMPATIBLE GOALS

In this section, we present a framework for solving incompatibilities based on abstract argumentation theory [3]. More precisely given a set of incompatible goals, we are going to use abstract argumentation theory for deciding which of them will continue to be pursued.

Definition *4.* **(Incompatible goals framework)** It is a triple $\mathcal{GF} = \langle \mathcal{G}_{inc}, \mathcal{R}_{inc}, \texttt{WORTH} \rangle$, where: (i) $\mathcal{G}_{inc}$ is a set of goals, which have at least one form of incompatibility, (ii) $\mathcal{R}_{inc} \subseteq \mathcal{G}_{inc} \times \mathcal{G}_{inc}$ is a symmetric binary relation of incompatibility. A goal $g_i \in \mathcal{G}_{inc}$ is incompatible with another goal $g_j \in \mathcal{G}_{inc}$ if $(g_i, g_j) \in \mathcal{R}_{inc}$. Notice that $(g_j, g_i) \in \mathcal{R}_{inc}$ since incompatibility is a symmetric relation, and (iii) $\texttt{WORTH} : \mathcal{G} \rightarrow \eta$ (for $\eta \in [0, 1]$ and $\eta \in \mathbb{R}$) is a function that returns a value for every goal in $\mathcal{G}$, where 0 is the minimum value a goal may have and 1 the maximum one.

Example *1.* Let $\mathcal{S}_{inc} = \{\{g_1, g_2\}, \{g_2, g_4\}, \{g_3, g_4\}, \{g_1, g_5, g_6, g_7\}, \{g_2, g_8\}\}$ be a set of sets of incompatible goals, hence $\mathcal{G}_{inc} = \{g_1, g_2, g_3, g_4, g_5, g_6, g_7, g_8\}$. This can be translated into a $\mathcal{GF}$ represented by the directed graph of Figure 1(a), where nodes represent the goals and edges the incompatible relation between goals. Numbers next to the nodes represent the value returned by function WORTH for each goal.

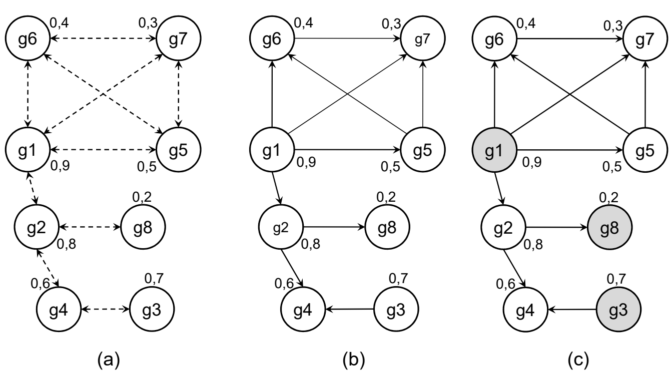

Figure 1: (a) Graph representation of the incompatibility relations, represented by dashed lines. (b) Continues lines represent the defeat relation among goals. (c) Grey filled nodes represent the grounded extension and hence the acceptable goals.

We will use the value of each goal to break the symmetry, if possible, in order to decide which attacks succeed as defeats.

Definition *5.* **(Defeat)** Given an attack relation (g_i, g_j), goal g_i defeats goal g_j when $\texttt{WORTH}(g_i) > \texttt{WORTH}(g_j)$.

Figure 1(b) shows the resultant graph taking into account the defeat relation. Notice that all attacks only have one direction.

So far, we have presented the representation of goals incompatibility, the next step is to identify which of these goals will continue to be pursued, to which end we will use the concept of semantics.

In abstract argumentation theory several semantics of **acceptability** were defined [3]. These produce none, one or several acceptable sets of arguments, called extensions, which contain a set of consistent arguments. In our case, semantics will be used to produce a set of non-conflicting goals. We also aim to obtain a set of the most valuable non-conflicting goals, which is guaranteed since a goal only defeats another one if it has a greater value.

The role of the semantics is to define which goals will be considered acceptable, in our case, which goals are compatible. In this work, we propose the use of grounded semantics [3] because it always exist and it is unique for every $\mathcal{GF}$. In the case that the grounded extension is an empty set, we suggest to use the preferred extension.

Definition *6.* **(Acceptable goal)** A goal g_i is considered acceptable iff $g_i \in \mathcal{E}$ such that $\mathcal{E}$ is a preferred or a grounded extension.

Example *2.* In order to calculate the semantics for Example 1 we will use ConArg [1], a computational tool for modeling and solving argumentation frameworks.

Figure 1(c) shows the resultant grounded extension $\mathcal{E} = \{g_1, g_3, g_8\}$, which means that such goals are considered acceptable or consistent ones, and will continue to be pursued. Notice that although g_2 is more valuable than g_8, it is no considered acceptable, this is due to g_1, whose value is the greatest one, and since g_1 defeats g_2, it cannot be considered part of the grounded extension.

4. CONCLUSIONS AND FUTURE WORK

This work presents the formalization and identification of three forms of incompatibility among goals. We noticed that the problem of selecting a set of goals from a larger set of incompatible ones can be compared to the problem of calculating an extension in abstract argumentation. Therefore, we have adapted concepts of abstract argumentation to our problem. In this adaptation, it was also considered the notion of defeat, since each goal has a different value for the agent.

We used the grounded semantics to obtain the set of compatible goals. We want to study what and how other semantics can be applied in this problem. We also will work on comparing this approach with others that deal with conflicting goals. Finally, this work does not deal with already adopted goals, it will be for sure another interesting direction of our future research.

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