Solving distributed and dynamic constraints using an emotional metaphor: Application to the timetabling problem.

Pierre De Loor, Pierre Chevaillier

To cite this version:


HAL Id: hal-00609025
https://hal.archives-ouvertes.fr/hal-00609025
Submitted on 17 Jul 2011

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Solving Distributed and Dynamic Constraints Using an Emotional Metaphor: Application to the Timetabling Problem

P. De Loor* P. Chevaillier†

March 17, 2003

Key words: Distributed and Dynamic Problem, Software agent, Metaphorical Assumption, Emotion, Human Behavior Model.

Abstract

This paper presents a method and its implementation for solving distributed and dynamic constraints satisfaction problem. In order to improve adaptability and performance, our algorithm is based on agents with autonomous behaviors guided by metaphorical assumptions. Our approach can be distinguished by the following points: The metaphor turns on sociological and emotional criterias without negotiation and memorisation. It tries to copy collective and affective human’s behavior during a complex decision making. The agent’s model include the notions of affective power, intruder and public mood perception. We have applied this method successfully to the timetabling problem. This paper show formalisation, implementation and first results of this work.

1 Introduction

Our objective is to develop adaptive algorithms for solving distributed and dynamic problem. Recently, some techniques has been developed to solve such king of problem. They are based on distributed operationnal research techniques [13] or with multi-agent paradigm [2], [8]. This two classes of approaches start from different models, mechanism and point of view.

- The firts kind of approaches allow a systematic research. Variables control some constraints and communicate their values with the others. Some Values can be refused depending on the constraints. Some algorithms record the refusals. Consequently, in return for time and memories, this approaches are generales and completes []. However, they present some draw-back : for complex problems, as allocation or scheduling, the modelisation of the constraints are a hard stage which imply the definition of numbered variables and constraints []. To optimize performances of such algorithms, some heuristics are used (which do not keep completeness properties). They are based on quantitative criterias whithout particular semantic. However, including qualitative criterias, relative to the problem, seem important to improve the performance of the search.

- The second kind of approaches are based of complex autonomous agent including decision and negociation mechanisms. Usually, they are guided by metaphoric assumption like in [11] (auction) or [1] (social insects). The main advantage is relative to the modelisation of the problem by the way of flexible data structures and implicit constraints rather than by a simple set of data and mathematical constraints. However, the backtracking is generally not explicit or forbidden.

2 principe

Our approach is clearly agent oriented. It can be distinguished by the following points: the metaphorical assumption guiding the behavior of the agents turns on sociological and emotional criterias [5]: It tries to copy collective and affective human’s behavior during a complex decision making. Each agent (representing a human) owns some goals, skills and a variable which mean it’s cognitive power. This variable evolves depending on the perception of differs messages: requests, denial, proposal, cancellation (see figure 1). The more important point is that the cognitive power of an agent is altered by messages concerning the agent itself but also by other messages (but with a different strength). Then, each agent perceive the “public mood” of the global system. It is endowed with a self-perception of his part. For example, it can perceive him as an intruder. When it’s affective power pass over an emotive threshold, the agent throw a t : it cancel his commitment (towards other agents) and his affective power is reset. The evolution’s rule of the

*Laboratory of Software Engineering, École Nationale d’Ingénieurs de Brest F-29608 Brest cedex – France, deloor@enib.fr
†Laboratory of Software Engineering, École Nationale d’Ingénieurs de Brest F-29608 Brest cedex – France, chevailler@enib.fr
Solving Distributed and Dynamic Constraints Using an Emotional Metaphor: Application to the Timetabling Problem

Affective power avoid cycle during the problem solving because it’s not always the same agent who throw a fit but rather the next more intruder agent. This algorithm can be compared to the dynamical hierarchie introduced by [4] but, in our case, this hierarchie is defining for agents by a high level metaphor rather than purely mathematical considerations. Finally, our approaches is dedicated to dynamical’s environments. In such environment, variables and constraints can be added or retracted at any time during the search of a solution. The algorithm adapts himself to the current situation. In order to do that, we use two considerations:

- agents don’t know the global problem and the set of constraints representing it.
- agent’s are unaware of the set (and the number) of the others agents involving in the problem.

In this way, adding agents or constraints implies neither a global restarting of the algorithm nor a modification of it’s current mechanisms or structures. Nous prfrons parler de recherche de solution par simulation “anytime”, plutot que de résolution de contraintes.

政协

$: A^A$ is the set of skills. (symbolic declarations).
- $R^A_g$ is the set of requested goals.
- $P^A_g$ is the set of personal goals.

3.1.2 Goal’s model
A Goal $g$ is a 3-uplet $< P^g, S^g, A^g, V^g >$:
- $P^g$ is a first order predicate which express the goal. This symbolic expression is relative to the problem.
- $S^g$ is a skill required to achieve or improve the goal (solving $P^g$).
- $A^g$ is a solution to achieve or improve the goal. A solution is a data structure depending of the problem (and can be partial).
- $V^g$ is a boolean meaning the value of $P^g$.

3.1.3 Message’s model
A message $M$ is a 3-uplet $< T^M, E^M, G^M >$:
- $T^M \in \{\text{request}, \text{proposal}, \text{cancellation}, \text{refusal}\}$ is the message’s type.
- $E^M$ is an Agent : the emitter of the message.
- $G^M$ is a goal : the topic of the message.

3.2 Agent’s behavior
Figure 2 summarizes the agent’s cyclic behavior. Each message processing depends of it’s nature. The cognitive power is affected according to the message or the result of the processing. It acts upon the reaction of the agent as a broadcasting of some messages.

---

3 Algorithm

3.1 Models

3.1.1 Emotional agent’s model
An emotional agent $A$ is formalized by an 8-uplet:

$$< \psi^A, \alpha^A_s, \alpha^A_c, \rho^A, \gamma^A, S^A_s, R^A_g, P^A_g >$$

- $\psi^A \in [0,1]$ is a real meaning the cognitive power.
- $\alpha^A_s \in [0,1]$ is a real meaning the self-sensitivity rate.
- $\alpha^A_c \in [0,1]$ is a real meaning the collective-sensitivity rate.
- $\rho^A \in [0,1]$ is a real meaning the requirement threshold.
- $\gamma^A \in [0,1]$ is a real meaning the crisis threshold ($\gamma^A > \rho^A$).
3.2.1 default behavior

The default behavior of an agent $A$ is executed as long as no message is received:

\[
\forall \text{ goal } g \in P_g^A \\
\text{if } (V_g^g == false) \quad \psi^A = \psi^A + \alpha_s^A \ast (1 - \psi^A)
\]

\[
\text{if } (\psi^A > \rho^A) \text{ (requirement)} \quad \forall \text{ goal } g \in P_g^A \\
\text{if } (V_g^g == false) \quad \text{broadcasting the message } <' request', A, g > \\
\psi^A = \psi^A - (\alpha_s^A \ast \psi^A)
\]

\[
\text{if } (\psi^A > \gamma^A) \text{ (crisis)} \quad \forall \text{ goal } g \in R_g^A \\
\text{broadcasting the message } <' cancellation', A, g > \\
R_g^A = \phi \\
\psi^A = 0
\]

\[
\psi^A = \psi^A - f(\alpha_s^A, \psi^A) \text{ (default relaxation)}
\]

Summary: each unreached personal goal increases the cognitive power in proportion to the agent’s self-sensitiveness rate ($\alpha_s^A$). If the cognitive power exceeds the requirement threshold, requests concerning personal goals are sending. In this case, the cognitive power decreases. Such mechanism avoids complex acknowledgments with some answering messages. Indeed, it’s the cognitive power which regulate the flow of requests. In fact, some policies can be use. For example, the request can depend on a probability depending on the cognitive power and the requirement threshold. Only one request for one goal should be broadcasted at one time than requests for all goals. The influence of the police on the performance of the algorithm must be studied. When the cognitive power exceeds the crisis threshold, the agent cancels all its commitments towards others agents. In order to do that, it broadcast cancellation’s messages relative to all the goal included in it’s set of requested goals. In this case, the cognitive power is reseted. Therefore, if other agents have a high cognitive power, they should enter in the crisis before the previous one. This mechanism can be seen as a local backtrack which goes among the more awkward agents. This backtrack is based on psychological issues and introduce a dynamic hierarchie of intruder. To finish, $f$ is a positive function meaning the natural trend to decrising the cognitive power when no problem occurs. (The definition of this function will be discibing later). It is basically used to evaluate the convergence’s algorithm: when each agent’s cognitive power decreases, a solution is founded.

3.2.2 messages processing

- processing a message <' request', $A'$, $g$ >

if ($A \neq A'$) \land (S^g \notin S^{A'})
\[
\psi^A = \psi^A + \alpha_c^A \ast (1 - \psi^A) \text{ (public mood)}
\]
else
solving($P_g^g$)
if $P_g^g$ is soluble with a solution $s$
\[
A^g = s \\
V_g^g = true \\
R_g^A = R_g^A \cup g \\
\text{broadcasting the message } <' proposal', A, g > \\
\psi^A = \psi^A - (\alpha_c^A \ast \psi^A)
\]

summary: if the agent has the skill, it attempts to solve the goal with a solving method depending of the problem. The success of this method return a solution in abstract solution’s goal form (see 3.1.2 and the exemple).

- processing a message <' proposal', $A'$, $g$ >

if ($A \neq A'$) \land (\exists g' \in P_g^A | P_g^g == P_g^g) \}
analyse($A^g$)
if ($A^g$ is acceptable)
\[
A^g = A^g' \\
V_g^g' = true \\
\psi^A = \psi^A - (\alpha_s^A \ast \psi^A)
\]
else
\[
\text{broadcasting the message } <' refusal', A, g > \\
\psi^A = \psi^A - (\alpha_c^A \ast \psi^A) \text{ (public mood)}
\]

Summary: an agent $A$ is concerned by a proposal if this one is the result of a request from $A$. Nevertheless, the affective power at an agent is decreased even if it is not concerned by the proposal. It is a part of the perception of the “public mood”. Before accepting the proposal, the agent must analyse it with a problem dependent method.

- processing a message <' refusal', $A$, $g$ >

if ($A \neq A'$) \land (\exists g' \in R_g^A | P_g^g == P_g^g) \}
\[
\psi^A = \psi^A + (\alpha_s^A \ast \psi^A) \\
R_g^A = R_g^A - g' \\
\text{else} \\
\psi^A = \psi^A + (\alpha_c^A \ast \psi^A) \text{ (public mood)}
\]

- processing a message <' cancellation', $A$, $g$ >

if (\exists g' \in P_g^A | P_g^g == P_g^g) \}
\[
\psi^A = \psi^A - (\alpha_s^A \ast \psi^A) \\
V_g' = false \\
\text{else} \\
\psi^A = \psi^A - (\alpha_c^A \ast \psi^A) \text{ (public mood)}
\]
3.2.3 Informal justification

The cognitive power depends on the agents’ perception and action. In practical term, perception is the reception of broadcasted messages (figure 1). Actions are the research of a solution for a requested goal.

• positives informations : it decreases the cognitive power, and can be devided as following :
  
  – le : l’agent a riusse d un (ou des) but(s), personnel ou requis.
  
  – la dcharge de responsabilit : l’agent fait une re-
    quête car il ne peut riusse d un but personnel. Dans ce cas, il se repose sur la communaut.
    Precisons que contrairement certains protocoles
    de type contract net protocol, l’agent n’opre cette
    dcharge que pour ses buts personnels et non sur
    des buts requis.
  
  – le succs coopratif : un agent lui a fait une propo-
    sition qui permet de riusse d un de ses buts per-
    sonnels.
  
  – la crise : l’agent annule toutes les solutions qu’il
    avait auparavant proposees. La crise est un vne-
    ment particulier qui va provoquer la remise zro
    de la charge cognitive de l’agent et provoquer
    une remise en question de la solution en cours
    de recherche.

• les informations ngatives : elles augmentent la charge
  cognitive d’un agent. Elles peuvent tre decomposes de
  la faon suivante :

  – les requites : toute requete est un signe que
    “quelque chose n’est pas riu au sein du systme
    multi-agents” et va augmenter la charge cogni-
    tive. Si l’agent peut rpondre cette requete, le
    succs personnel conscutif (voir les informations
    positives) diminue la charge cognitive. S’il n’est
    pas comptent pour rpondre cette requete, il ne
    fait rien. S’il est comptent mais qu’il ne peut
    riusse le probleme il la requete, il en riusse un
    chec personnel.

– les checs personnels : l’agent est incapable de
  riusse d un probleme, qu’il lui soit propre ou pos
  par un autre agent.

– les refus : l’agent peroit les refus diffus par les
  autres agents. Il distingue les refus le concernant
  directement (amnulant une proposition qu’il a faite) et qui accrossent davantage sa charge cog-
  nitive que les refus ne le concernant pas. Cepen-
  dant le fait qu’elle croisse refite la perception de
  la “mauvaise ambiance” grale au sein du systme
  multi-agents. Cette proposition part de la con-
  statation que la communication indirecte peut
  tre un mecanisme fondamental lors de la rsolu-
  tion de problmes [6].

4 Implementation

5 Application to the timetabling problem

We applie algorithme au probleme de la giration des em-
ploy des temps ruit difficile [12]. Notre solution se diffren-
cie de celles proposes classiquement [9], [7] par le fait
que la recherche est distribue, compltement asynchrone
et adaptative. Par contre,contrairement [7] nous ne pro-
posons pas pour l’instant de dmarche d’optimisation qui
fait l’objet de nos recherches actuelles. L’article montr-
era la formalisation de l’algorithme et les rsultats obtenus
sur cet exemple implement l’aide du langage oTis [3].
Elaboration d’un langage plus formel de ces changent en
broadcast un peu comme propos par [10]
5.1 Results

This section will describe the result we obtain. It can include graphical representing the convergence time relative to the problem complexity.

Figure 5: TimeTable Class.

6 conclusion and futur work

References


approaches to propositional satisfiability. In *IJCAI*,
