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A Policy-Oriented Reputation BDI Model

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Abstract. Computational trust and reputation models have been recognized as one of the key technologies required to design and implement agent systems. These models manage and aggregate the information needed by agents to efficiently perform partner selection in uncertain situations. In this paper, by taking advantage of the non-monotonic knowledge representation and reasoning mechanisms of defeasible logic, a reputation-Oriented Agent model is proposed, which is capable of accepting policy guidance, the real-time rule modifications, and handling the run-time rule conflicts. This agent is both autonomous and controllable, and is able to cooperate with other Agents via contracts in an open and dynamic environment.

Introduction

In the increasing demand of shared resource and coordinated services under distributed environme -nt Agent becomes increasingly hot research. Because it has characteristics of reactivity, autonomy and sociality, Agent has been generally considered to be a key technology which is support for large-scale, open and distributed information systems to achieve dynamic service integration and collaboration [1]. But the traditional BDI logic-based Agent still has some shortcomings in the process of architecture and logical reasoning Firstly, the unpredictable and uncontrollable Agent behaviors: Agent autonomy and collaboration opacity cause that the Agent behaviors cannot be reliably predicted and controlled by the system [2]. Secondly, lack of reliability evaluation of Agent behaviors and individuals: Traditional BDI logical models haven't evaluated the reliability of Agent behaviors and individuals and referred to the impact of social other Agents. So Agent's collaborative cooperation might fail. Thirdly, lack of conflict management mechanism in traditional model.

According to the shortcomings, in this paper, by taking advantage of the non-monotonic knowledge representation and reasoning mechanisms of defeasible logic, a reputation-Oriented Agent model is proposed, which is capable of accepting policy guidance, the real-time rule modifications, and handling the run-time rule conflicts. We call this model PR-BDI model, which can, under the guidance of the policy, fully consider the reliability evaluation of other Agents to carry out regular dynamic changes and has effective mechanism flexibly adapting to these changes.

Policy-oriented reputation model in BDI Agent

Policy

Policy specification is a concept family, including norms, obligations, convention, rules, etc.Usual -ly it refers to the external constraints abided by each agent considering the target in the MAS, decision making and behavior[2]. From the Virtual Organization Individual Agent perspective, article argues that each agent are subject to two different sources of policy-oriented, that is, different parties accordi -ng to policy formulation will be further subdivided into two policies, organizational policies and indiv -idual-level policy level by the corresponding policy framework of the issued and implemented, as sho -wn in **Fig. 1**:

Organizational-level policy is seen as a virtual organization, or the agreement between the various

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business entities, the accepted norms of the industry's formalization, including organizational planning and system supervising, the delegation of responsibilities, punish, etc. It is a means of the synergy betw -een the virtual organization and agent. Generally speaking, it is a division of responsibilities focusing on roles. Individual-level policy is seen as a foreign strategy of an individual legal entity or individual preferences for the realization of the restraint and control of agent behavior by individual companies. Individual-level policy is established by the individual legal institution which the agent belongs to, reflecting the individual interests of individual firms.

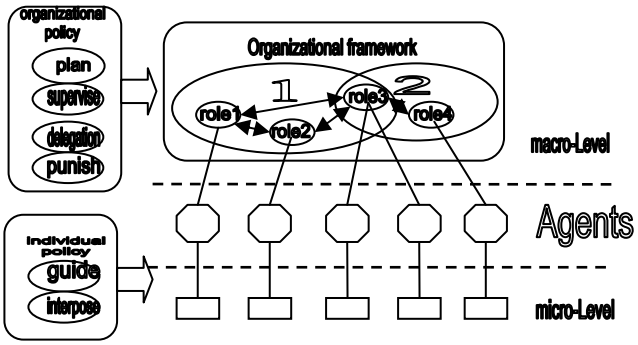

Fig. 1 Schematic diagram of two-tier policy

PR-BDI System Architecture

The PR-BDI Agent Model discussed in this article is quite different from the past BDI Agent Model. It not only integrates the possibility of the cognitive reputation model into the cognitive BDI Agent, but also introduces the idea the regulation and control policy. Let the agent complete the expected task of the organizations and individuals under the influence of the dual model of the policy and reputation. The architecture of PR-BDI model is shown in **Fig 2**

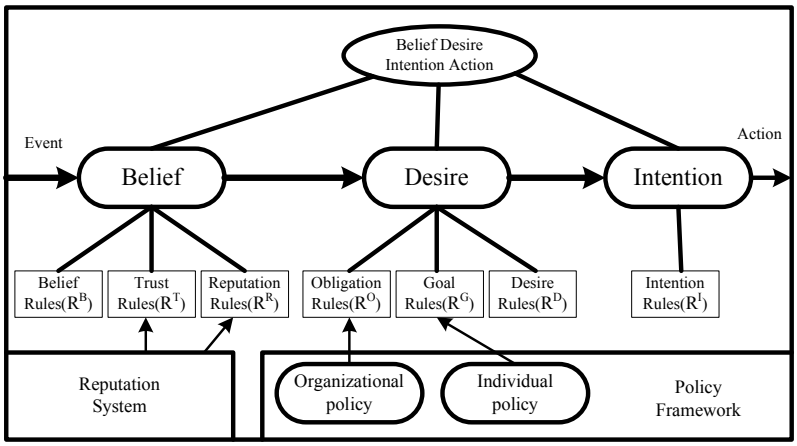

Fig 2:PR-BDI Agent System Architecture

Logic Framework

In this paper we use extend defeasible logic, which contains three elements: Literals, Rules and superiority relation(details of defeasible logic show in [3,4,5]). We gave the definition of the Language as follow.

Definition 1 (Language) Let Prop={p,q,…} be a set of propositional atoms, £={t|0<t≤1}is the set of credible value,if t2>t1 stand for credibility t2 is larger than t1,Mod={ BEL,TRU,REP，DES,GOL,OBL,INT } be the set of modal operators, and Lab={r_1,r_2,…} be a set of labels. The sets below are the smallest sets closed under the following rules:

Literals

Lit = Prop ∪ {¬p|p ∈ Prop},we use ψ, ψ_1,ψ_2,....,ψn or a,b,c,g,e...donate literals; If ψ is a literal, ~ ψ denotes the complementary literal (if ψ is a positive literal p then ~ ψ is ¬p; and if ψ is ¬p, then ~ ψ is p);

Credible Literals

TruLit={l:t| l∈Lit,t∈£}

If l is literal, and t∈£ is credible value, then l:t is credible literal

Modal literals

ModLit = {Xψ,¬Xψ | ψ∈TruLit, X ∈ Mod} we useφ, φ_1, . . . ,φ_n to donate literals;

rules

Rule = {r : $\varphi_1:t_1, \ldots, \varphi n:tn \Rightarrow X\ \psi:t$ | r ∈ Lab, $\{\varphi_1:t_1, \ldots, \varphi_n:t_n\} \subseteq$ ModLit,
ψ ∈Lit,X ∈ Mod∪ {Θ},t>(t1|……tn)}

$R^X[\psi:t] = \{\varphi_1:t_1, \ldots, \varphi_n:t_n \rightarrow X\ \psi:t` | \{\varphi 1:t1, \ldots, \varphi n:tn\} \subseteq$ Lit ∪ ModLit, ψ:t`∈ Lit, X ∈ Mod ∪ {Θ},t`>=t }

$R^X[\sim\psi:t] = \{\varphi_1:t_1, \ldots, \varphi_n:t_n \rightarrow X \sim\psi:t` | \{\varphi_1:t_1, \ldots, \varphi_n:t_n\} \subseteq$ Lit ∪ ModLit, ~ψ:t`∈ Lit, X ∈ Mod∪ {Θ}, t`>=t }

superiority relation

$S \subseteq R^X \times R^X$

S is a binary relation over R, superiority relations are asymmetrical, non-cyclic, we use the symbol > to indicate the superiority relations between the two rules.

Definition 2 (Framework)A PR-BDI Model in Agent Organization can be defined as the following tuples: M=<£, F, Θ,R^B,R^T,R^R,R^D,R^G ,R^O,R^I ,S>, in which:

- £=(t|0<t≤1) the set of credible value
- F denotes the set of fact
- Θ={B,T,R,D,G,O,I} denotes the set of the internal state properties of a model, be made up of modal literals
- R^B,R^T,R^R,R^O,R^G,R^D,R^I: denotes the rules of agent belief, trust, reputation, obligation, goal, desire, intention
- S denotes the superiority relations;deal with conflict between the rules

Belief Generation

Definition 2. PR-BDI model M=<£, F, Θ,R^B,R^T,R^R,R^D,R^G ,R^O,R^I ,S> The belief formula ψ is true, if and only if I ├+ Δψ, or I ├+ ∂ψ. they means respectively that ψ is definitely provable and defeasibly provable. Because of adding credible literals， the strict rules was definition to defeasible rules witch credible values is 1.Then beliefs generated unify by defeasible method. Belidef geaeration rules $R^{BEL}= R^B \cup R^T \cup R^R$,and we think that $S(R^B)>S(R^T)>S(R^R)$,R^T<1and R^R<1.

Definition 3 The reasoning rules of belief generation by defeasible way

The reasoning rules of $\pm\partial^{BEL}$q :

$+\partial^{BEL}$: if P(i + 1) = $+\partial_{BEL}$ *ψ：t* then

(1) ∃ r ∈ R^{BEL} [*ψ:t*] , ∀*BELa:*t_1 ， *c:*t_2 ∈ A(r):
$+\partial^{BEL}$a:t_3∈P(1...i), t_3>= t_1 and
+∂c:t_4∈P(1...i), t_4>=t_2 and

(2) ∀s ∈ R^{BEL}[~ *ψ:t*]， $R^{BEL}=R^T \cup R^P \cup R^B$

(2.1) ∃*BEL*a :t_5∈ A(s) : $-\partial^{BEL}$a:t_6 ∈P(1...i) or $+\partial^{BEL}$a:t_6 ∈P(1...i) ,t_6<t_5 or
∃c:t_7 ∈ A(s) : −∂c :t_8∈P(1...i), or +∂c :t_8∈P(1...i),t_8<t_7 or

(2.2)∃u ∈ R^{BEL} [*ψ:t*], ∀BELa： t_9,c :t_{10}∈ A(u):
$+\partial^{BEL}$a:t_{11},+∂c:t_{12}∈P(1...i),t_{11}<t_9 , t_{12}>=t_{10} and u >s

$-\partial^{BEL}$: if P(i + 1) = $-\partial^{BEL}$ *ψ:t* ,then either

(1)∀r ∈ R^{BEL} [*ψ:t*],
∃BELa :t_1∈ A(r) : $-\partial^{BEL}$a :t_2∈P(1...i) or $+\partial^{BEL}$a:t_3 ∈P(1...i) ,t_3<t_1 or
∃c:t4 ∈ A(r) : −∂c:t_5∈P(1...i),or−∂c:t_5∈P(1...i),t_5<t_4 or

(2) ∃s ∈ R^{BEL} [~ *ψ:t*], R=$R^T \cup R^P \cup R^B$
(2.1)∀BELa： t_6,c :t_7∈ A(s):+ ∂^{BEL}a:t_8, +∂c:t_9∈P(1...i),t_8>=t_6, t_9>=t_7 and

(2. 2)$\forall t \in R^{BEL}$ [ψ:t]

$\exists$BELa:$t_{10} \in A(t)$: $-\partial^{BEL}$a:$t_{11} \in P(1...i)$ or $+\partial^{BEL}$a:$t_{11} \in P(1...i), t_{11} >= t_{10}$ or

$\exists$c:$t_{12} \in A(t)$: $-\partial$c :$t_{13} \in P(1...i)$, or $+\partial$c :$t_{13} \in P(1...i), t_{13} >= t_{12}$ or t $\succ$ s

To show that BEL q is defeasibly provable we have two choices: (1) We show that q is already definitely provable; or (2) we need to argue using the defeasible part of D as well. For the second case, we need to consider possible "attacks", i.e., reasoning chains in support of ~q. To be more specific: to prove q defeasibly we must show that ~q is not definitely provable. It is that all the rules which has head of ~q either can not be satisfied (2.1)or were defeated by rules who have higher priority(2.2).The reasoning rules of $-\partial$ is complement of $+\partial$.Detail of explain was omitted. The process of defeasibly provable embody the way of conflict resolution which the rules with higher priority can defeat rules which is conflict with them.

Desire Generation

Definition 4 PR-BDI model M=<£, F, Θ,R^B,R^T,R^R,R^D,R^G ,R^O,R^I ,S> The desire formula ψ is true, if and only if I ├ + $\partial\psi$. they means respectively that ψ is definitely provable and defeasibly provable. Desire geaeration rules $R^{DES}= R^O \cup R^G \cup R^D$.Generally speaking, the priority of organization policy is higher than individual policy and the priority of individual policy is higher than their desire. we think that $S(R^O)>S(R^G)>S(R^D)$. The reasoning rules of the generation of desire and belief are similar, we do not explain it in detail here.

Intention Generation

Definition 5.PR-BDI model M=<£, F, Θ,R^B,R^T,R^R,R^D,R^G ,R^O,R^I ,S> The intention formula ψ is true, if and only if I ├ + $\partial\psi$. they means respectively that ψ is definitely provable and defeasibly provable. Desire geaeration rules $R^{INT}= R^I$. The reasoning rules of the generation of intention and belief are similar. We do not explain it in detail here.

Putting the model to work

In this section we analyze the reasoning processes performed of model by an example of buy and sell wine. For simplicity, we only analyzed mental reasoning process between one shopper and three suppliers. The three suppliers are supplier a, supplier b and supplier c. **Table 1**. Related with symbols and their significance.

Table 1 related symbols and their significance

symbols	significance
LowTime(d_i:t_j)	supplier d_i has limit deliver time， probability t_j
WellQua(d_i:q_j)	supplier d_i has well quality , probability q_j
LowPrice(d_i:p_j)	supplier d_i has Low price， probability p_j
Trust(d_i:u_j)	Agent direct trust for supplier d_i, Trust worthiness u_j
Reputation(d_i:r_j)	reputation worthiness of supplier d_i is r_j
Choice(d_i:p_j)	choose supplier d_i probability p_j
Event(d_i:p_j)	Event happened on supplier d_i, probability p_j
Refuse(d_i:p_j)	Refuse supplier d_i， probability p_j
Punish(d_i:p_j)	Punish supplier di， probability p_j
Use(d_i:p_i)	Use supplier d_i probability p_j
Update(d_i:p_i)	Update direct trust value of supplier d_i
Avg(p1,p2…)	Average of credibility value p1,p2…
LessThan (pi,pj)	Average of credibility value pi,pj less than 0.5

shopper Agent model:M=<£, F, Θ,R^B,R^T,R^R,R^D,R^G ,R^O,R^I ,S>, all part of M as follow:

£={p|0<p<=1}

F={LowTime(a:0.8),WellQua(a:0.6),LowPrice(a:0.7),Trust(a:0.5), Reputaion(a:0.4),LowTime(b:0.7),WellQua(b:0.8),LowPrice(b:0.6), Trust(b:0.5) ,Reputaion(b:0.7), Event(b:1), LowTime(c:0.5) ,WellQua(c:0.7), LowPrice(c:0.7) ,Trust(c:0.5) ,Reputaion(c:0.7) }

Θ is Agent internal state , as shown in Table 2;

RBEL= RB ∪ RT ∪ RR ={ b1:Event(di:1) ⇒BEL Punish(di:1);

b2: Trust(di:uj),Reputaion(di:rj),LessThan(uj,rj) ⇒BEL Refuse(di:1)}

RDES= RD ∪ RO ∪ RG ={d1: Punish(di:pj) ⇒DES ¬ Choice(di:pj);
d2: Refuse(di:1) ⇒DES ¬Choice(di:1);

d3:LowTime(di:tj),WellQua(di:qj),LowPrice(di:pj)⇒DESChoice(di:g(x);

g(x) is denotes credibility value calculation，in this paper we use Avg(tj,qj,pj)

d4: Punish(di:pj) ⇒DESUpdate(di:-0.2);

d5: Refuse(di:1) ⇒DES Update(di:-0.1);}

RINT={i1: Choice(di:pj) ⇒INT Use(di:pj), Update(di:+0.1)}

S={d1>d2>d3>d4>d5}

Table 2 Agent model reasoning result

BEL	DES	INT
M $\vdash+\partial_{BEL}$LowTime(a:0.8)M $\vdash+\partial_{BEL}$WellQua(a:0.6) M $\vdash+\partial_{BEL}$LowPrice(a:0.7)M $\vdash+\partial_{BEL}$LowTime(b:0.7) M $\vdash+\partial_{BEL}$WellQua(b:0.8)M $\vdash+\partial_{BEL}$ LowPrice(b:0.6) M $\vdash+\partial_{BEL}$LowTime(c:0.5)M $\vdash+\partial_{BEL}$ WellQua(c:0.7) M $\vdash+\partial_{BEL}$ LowPrice(c:0.7)M $\vdash+\partial_{OBL}$ ¬Choice(d_3) M $\vdash+\partial_{BEL}$ Punish(b:1)M $\vdash+\partial_{OBL}$ Refuse(a:1)	M $\vdash+\partial_{DES}$ Choice(c:0.7); M $\vdash+\partial_{DES}$ ¬Choice(a:1); M $\vdash+\partial_{DES}$¬ Choice(b:1); M $\vdash+\partial_{DES}$Update(a:0.1); M $\vdash+\partial_{DES}$Update(b:0.2);	M $\vdash+\partial_{INT}$ Use(c:0.7); M $\vdash+\partial_{DES}$Update(c:0.1)

The generation process of desire is not only reflects the traditional reasoning but also take the influence of direct trust and reputation. In the generation process of desire, we have considered the influence which made by organizational and individual policy, and it deal well with the conflict between organizational benefits and individual benefits. According to individual benefits, or considering profits, Agent should have chose supplier b, but because b is being punished by organization and organization stipulate that other corporation can not choose supplier b, Agent will give up b because its reasoning mechanism can follow the organizational policy. In the end, because chose supplier c, we need to revise the direct trust and it also tally with actual situation.

Conclusions

In this paper, we have presented a possible integration of a cognitive reputation model in a BDI agent architecture. We use organizational and individual policy to constraints on and guide the Agent's behavior. This method can make Agent have autonomy and keep Agent to be controlled and predictable. We give the belief of agent probabilistic semantics by using extensionally defeasible logic.

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