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Towards Consistency-Based Reliability Assessment

(Extended Abstract)

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1. MOTIVATION

Merging information provided by several sources is an important issue and merging techniques have been extensively studied. When the reliability of the sources is not known, one can apply merging techniques such as majority or arbitration merging or distance-based merging for solving conflicts between information. At the opposite, if the reliability of the sources is known, either represented in a quantitative or in a qualitative way, then it can be used to manage contradictions: information provided by a source is generally weakened or ignored if it contradicts information provided by a more reliable source [1, 4, 6]. Assessing the reliability of information sources is thus crucial. The present paper addresses this key question. We adopt a qualitative point of view for reliability representation by assuming that the relative reliability of information sources is represented by a total preorder. This works considers that we have no information about the sources and in particular, we do not know if they are correct (i.e. they provide true information) or not. We focus on a preliminary stage of observation and assessment of sources. We claim that during that stage the key issue is a consistency analysis of information provided by sources, whether it is the consistency of single reports or consistency w.r.t trusted knowledge or the consistency of different reports together. We adopt an axiomatic approach: first we give some postulates which characterize what this reliability preorder should be, then we define a generic operator for building this preorder in agreement with the postulates.

2. PRELIMINARIES

Let $A$ be a finite set of agents; let $L$ be a propositional logic defined over the finite set of propositional letters and propositional constants $\top$ and $\bot$. An interpretation $m$ is a mapping from the set of formulas of $L$ to the set of truth values $\{0, 1\}$ so that $m(\top) = 1$ and $m(\bot) = 0$. Interpretation $m$ is a model of formula $F$ iff $m(F) = 1$. The set of $F$ models is denoted $M(F)$. Tautologies are formulas which are interpreted by 1 in any interpretation. We write $\models F$ when $F$ is a tautology. Consistent formulas are interpreted by 1 in at least one interpretation. A formula is consistent iff it has one model.

Let $\preceq$ be a total preorder on $A$ representing the relative reliability of agents: $a \preceq b$ stands for $b$ is at least as reliable as $a$. $a = b$ stands for $a \preceq b$ and $b \preceq a$. $GT(a, \preceq) = \{x \in A \setminus \{a\} : a \preceq x\}$ is the set of agents which are as least as reliable as $a$. Let $a \in A, \preceq_1$ be a total preorder on $A$ and $\preceq_2$ a total preorder on $A \setminus \{a\}; \preceq_1$ is compatible with $\preceq_2$ iff $\forall x \forall y \ x \preceq_1 y \Rightarrow x \preceq_2 y$.

A communication set on $A$, $\Psi$, is a set of pairs $< a, \varphi >$ where $a \in A$ and $\varphi$ is a formula reported by $a$. We define $Ag(\Psi) = \{a \in A, \exists \varphi \ a < \varphi > \in \Psi\}, \Psi_a = \{< a, \varphi > | < a, \varphi > \in \Psi\}$ and $\Psi(C) = \bigcup_{a \in C} \Psi_a$, if $C$ is a set of agents. Finally we define $Report(\Psi) = \bigwedge_{\forall a, \varphi > \in \Psi} \varphi$ if $\Psi \neq \emptyset$ and by $\top$ otherwise.

Let $\Psi$ and $\Psi'$ be two communication sets on $A$. $\Psi$ and $\Psi'$ are equivalent (denoted $\Psi \equiv \Psi'$) iff $\forall a \in A \Rightarrow Report(\Psi_a) \leftrightarrow Report(\Psi'_a)$. $\Psi$ and $\Psi'$ are weakly equivalent (denoted $\Psi \sim \Psi'$) iff $\forall a \in A, \exists b \in A, \exists c \in A \Rightarrow Report(\Psi_a) \leftrightarrow Report(\Psi'_a)$ and $\Rightarrow Report(\Psi'_a) \leftrightarrow Report(\Psi_a)$. Consistency of communication sets is evaluated with respect to some integrity constraint $IC$, which is a consistent formula of $L$. $IC$ has to be viewed as information taken for granted or certain. Let $\Psi$ be a communication set on $A$. $\Psi$ is IC-contradictory iff $Report(\Psi) \land IC$ is inconsistent; otherwise $\Psi$ is IC-consistent. $\Psi$ is minimal IC-contradictory iff $\Psi$ is IC-contradictory and no strict subset of $\Psi$ is IC-contradictory. The set of minimal IC-contradictory subsets of $\Psi$ is denoted $\Psi \downarrow IC$.

$A^+ = \bigcup_{\Psi \in \Psi \downarrow IC} Ag(F)$ is the set of agents which have reported a piece of information which belongs to some minimal IC-contradictory communication set. Notice that $A^+ \neq \emptyset$ iff $\Psi$ is IC-contradictory.

Finally consider $C \subseteq A$, $C$ is IC-conflicting iff $Report(\Psi(C)) \land IC$ is inconsistent. $C$ is minimal IC-conflicting iff it is IC-conflicting and no strict subset of $C$ is IC-conflicting.
3. RELIABILITY ASSESSMENT

Given a set of agents $A$ and an integrity constraint $IC$ and communication set $Ψ$, the total preorder representing the relative reliability of the agents is characterized by the following relation $\prec^T$.

DEFINITION 2. Consider a set of agents $A$ and a communication set $Ψ$. $\prec^T$ is the total preorder on $A$.

$\prec^T$ is the total preorder on $A$.

4. A GENERIC OPERATOR

We start by introducing a measure to quantify the inconsistency of a report. We prove that this generic operator agrees with the postulates.

DEFINITION 3. The consistent report is defined by:

$X \sim Y \iff X \triangleright Y \cup Y \triangleright X$.

5. CONCLUSION

The work proposes to assess the relative reliability of agents in a setting where the agents are considered to be partially reliable. The proposed method allows for the evaluation of the relative reliability of each agent based on the consistency of their reports.

Theorem 1. $\prec^T$ LT operator satisfies properties $PLP_T$.

Theorem 2. The function $\tilde{C}$ obviously induces a total preorder among agents. This preorder does not satisfy $PT$. This is why we propose the following general operator for ranking agents, $\triangleright^T$.

$\triangleright^T$ is defined by:

$\triangleright^T = \tilde{C}(\psi) \ni \psi \in IC(\Psi)$.

REFERENCES

