MITRA: A Meta-Model for Information Flow in Trust and Reputation Architectures

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Abstract

We propose MITRA, a meta-model for the information flow in (computational) trust and reputation architectures. On an abstract level, MITRA describes the information flow as it is inherent in prominent trust and reputation models from the literature. We use MITRA to provide a structured comparison of these models. This makes it possible to get a clear overview of the complex research area. Furthermore, by doing so, we identify interesting new approaches for trust and reputation modeling that so far have not been investigated.

Keywords: Computational Trust, Reputation Systems, Meta Model.

1 Introduction

Open and decentralized systems are vulnerable to buggy or malicious agents. To make these systems robust against malfunction, agents need the ability to assess the reliability and attitudes of other agents in order to choose trustworthy interaction partners. To this end, a multitude of trust and reputation models have been and still are being proposed in the literature. In short, each such model generally defines all or some of the three following processes: how evidence about the trustworthiness of an agent is gathered, how this evidence is combined into a final assessment, and how this final assessment is used in decision-making.

Currently, it is difficult to get an overview of what has been done in the area, and what needs to be done. The main reasons for this are: that the proposed trust and reputation models use no common terminology; that
they are not compatible in their basic structure; and that their respective contributions are evaluated against different metrics. While not considering the last point in this article, the first two questions motivate the introduction of an abstract model that allows researchers to organize their models in a unified way.

To this end, we propose MITRA, a meta-model for the information flow in computational trust and reputation architectures. MITRA formalizes and organizes the flow of information inside and between agents. More precisely, it describes the top-level processes to gather evidence, and to combine it with information exchanged with other agents. MITRA makes use of four simple concepts of information processing, namely the observation, the evaluation, the fusion and the filtering of information, and abstracts away from numerical computations. Although being an abstract model, MITRA captures important concepts used by existing trust and reputation models. This way, MITRA provides a big-picture of the trust and reputation domain and paves the way for a structured survey of the domain.

The model is useful for the community in at least four respects. First, it serves as a terminological and structural framework to describe new models. Secondly, it provides a means for researchers to classify and compare existing approaches in this domain. In addition to this, MITRA helps to identify new approaches to model trust and reputation, as we will show in this article. Finally, it helps newcomers to get a concise overview on the structure of computational models of trust and reputation.

The remainder of the article is organized as follows. In Sect. 2 we introduce basic concepts of trust and reputation modeling. We describe the MITRA model in Sect. 3. Following this, in Sect. 4 we use MITRA to classify existing models and identify what has not yet been done in the research field of trust and reputation. Finally, we review related work in Sect. 5 and we draw conclusions in Sect. 6.

2 Basic Concepts

In this section, we describe basic concepts and notations that are used in this article.

2.1 Trust Beliefs/Intentions/Acts and Reputation

Following [MC01], we distinguish three concepts that are often confused in the literature: the trust belief, the trust intention and the trust act. In the same spirit as for the BDI architecture [Rao96], raw observations are at first evaluated and then used to form trust beliefs, which in turn, are used to build trust intentions. Finally, these intentions can be used as one criterion in the decision-making process, eventually leading to a trust or distrust act. Figure 1 provides a schematic view of the trust information chain.
A basic trust belief, which we denote with $tb^\theta_\Gamma$, reflects the view of an individual agent $\theta$ on the trustworthiness of the agents $\Gamma$. In the common case, the set of agents $\Gamma$ contains only one agent. However, trust beliefs can also reflect how an agent $\theta$ thinks about a group of agents (see also [Hal02, FC08]); the agents belonging to the group $\Gamma$ have to be similar in some regard and so, experiences with any of them may to some extent be evidence for the trustworthiness of the group as a whole. For example, consider several agents being employed by a certain company; in such a situation, the agents can be judged in their roles as employees of this company, and their characteristics can be “generalized” to other agents in the same company [FC08].

There is a second type of trust beliefs, which is also called “reputation”: a collective assessment of a group of agents about other agents [MFT+08]. Here, the corresponding trust beliefs are the estimate by an individual of what could be such a shared opinion of a group of agents $\Theta$ about other agents $\Gamma$. We denote this collective trust believe by $tb^{\Gamma}_{\Theta}$.

Each trust belief is relating to a certain context, for which it is valid. The context includes a particular task, and the environmental conditions, under which the trustee is believed (or not) to successfully carry out this task on behalf of the trustor. We will discuss this concept of context in more detail later. Now, for given trustor(s) $\Theta$, trustee(s) $\Gamma$ and a certain context, there can only be one unique trust belief. This makes sure that the trustor cannot believe that trustee(s) $\Gamma$ are at the same time trustworthy and untrustworthy concerning a context. Nevertheless, the various kinds of trust beliefs can still be contradictory. For example, an agent can believe that the agents that belong to a certain group are usually untrustworthy, but that a specific agent in this group is well known and believed to be trustworthy. The reasoning about how to deal with such situations is typically what occurs in another process, that does not fall into the scope of this paper.

While trust beliefs are solely estimates about the trustworthiness of other agents, the process of forming trust intentions incorporates also strategic
considerations or characteristics of the trustee. For example, although a trustee believes another agent to be trustworthy, he might still be very pessimistic about relying on this agent. When forming trust intentions, an agent actually transforms trust beliefs, which are based on the past behavior of other agents, into its own intended future behavior towards them. This typically corresponds to computing the “shadow of the future” \cite{Axe84}.

Trust intentions of an agent \(\alpha\) towards an agent \(\gamma\), derived from sets of trust beliefs, are denoted by \(t^\gamma_\alpha\).

### 2.2 Acquisition of Evidence

Two types of information exist that can be used as input for a trust reasoning process. An agent can make direct observations about and evaluations of the behavior of other agents, and it can also receive messages from other agents that contain observations, evaluations or trust beliefs.

#### 2.2.1 Direct Observations and Evaluations

A trust belief about an agent \(\gamma\) is derived from information that provides evidence for \(\gamma\)’s trustworthiness. We call such evidence an *evaluation* (see Fig. 1). An evaluation is a subjective interpretation of a set of direct observations about \(\gamma\)’s behavior towards some other agent \(\delta\). In other words, the process of evaluation decides whether the observations are evidence for trustworthiness of \(\gamma\). We write \(\text{eval}^ {\langle \delta, \gamma \rangle} \alpha\) to denote an evaluation that is done by agent \(\alpha\) concerning the behavior of agent \(\gamma\) towards agent \(\delta\). Analogously, the direct observations made by \(\alpha\) on an interaction between \(\gamma\) and \(\delta\) are denoted by \(\text{obs}^ {\langle \delta, \gamma \rangle} \alpha\).

#### 2.2.2 Communicated Evidence

Besides directly acquired information, an agent can use information received by messages from other agents. We introduce the notation \((x)^{\beta} \theta, ..., \beta\) for a message \(x\) that is sent by agent \(\beta\) to agent \(\alpha\) through a path of transmitters \(\beta\) (direct sender to \(\alpha\)), \(\theta\) (initial sender). We call such a message *communicated evidence*. To ensure the correctness of the indicated path, either the final receiver can assess the correctness of this chain of transmitters (e.g., by spot-checking agents on the path and asking them whether they have sent the message as is), or mechanisms are put in place to prove that the message has indeed taken the indicated path and which intermediary has made which modifications (by means of cryptography, e.g., public-key infrastructure and signing).

Direct observations that an agent makes on its own can only be incorrect if the sensors with which the observations were made are faulty. Communicated evidence additionally can be wrong when the sender is dishonest or incompetent.
2.3 Context and Uncertainty

Each observation, evaluation, trust belief or trust intention is in general only valuable if two pieces of information are attached to it:

1. the context to which the information applies;
2. a measure of uncertainty of the information itself.

The concept of context is a vital part for evidence-based trust reasoning. [MC96] give the example that “one would trust one’s doctor to diagnose and treat one’s illness, but would generally not trust the doctor to fly one on a commercial airplane”. If some direct observations are made in a certain context, then this context should be annotated also to the evaluations (and the trust beliefs and trust intentions) that are based on these observations. As a result, context annotations should be propagated through the information chain shown in Fig. [1].

A measure of uncertainty is needed to express how uncertain a piece of information is believed to be. This is especially important when a trust model incorporates communicated evidence that may be biased or wrong. Similarly to the context information, uncertainty should be propagated through the whole information chain.

3 The Meta-Model

In this section we present MITRA, illustrated in Fig. [2]. This meta-model organizes the different ways of how the information chain of Fig. [1] can be realized in an agent α’s trust model. The agent can send all pieces of information that occur in this information chain (the square boxes in the Figure) to other agents; for the sake of clarity, we did not illustrate such actions in Fig. [2].

On the top level, MITRA divides the trust modeling process into four consecutive sub-processes:

1. observation;
2. evaluation;
3. fusion;
4. decision-making.

Let us first exemplify these sub-processes from the perspective of an agent α, which reasons about its trust in an agent γ. In the observation process, agent α tries to collect any form of evidence it can get to assess γ’s trustworthiness. Agent α judges the direct observations (either its own or the communicated ones) about γ’s behavior in the evaluation process. In the
Figure 2: Structure of MITRA for an agent $\alpha$. For the sake of clarity what is not shown in this illustration: agent $\alpha$ can decide to send any piece of information occurring in the illustration to other agents.

In the fusion process, $\alpha$ can use its own evaluations, and the filtered evaluations received from other agents, to form its trust beliefs about $\gamma$ and an image of other agents' trust beliefs about $\gamma$. Finally, in the decision-making process, $\alpha$ builds its trust intentions and applies them in the respective situations.
Below, we describe each sub-process in greater detail and then have a closer look at the issue of context-sensitivity.

3.1 Observation

During observation, agent $\alpha$ uses its sensors to capture information about other agents and the environment. In network settings for instance, sensors could be network cards, that can receive or overhear packets from the network. In the general case, the process of direct observation is subjective, since different agents may use sensors that differ in certain respects, for instance in quality.

As mentioned earlier, information can result from direct observation of the environment or be received as communicated evidence. For an observation $\text{obs}_\alpha^{(\delta,\gamma)}$, $\alpha$ may be the same agent as $\delta$; in this case, $\alpha$ observes its own interaction with some other agent $\gamma$, otherwise $\alpha$ is observing the interactions of other agents.

Because communicated evidence is received from other agents, $\alpha$ needs to filter the information. Communicated evidence might be incorrect for different reasons [CP02, BS08]. First, the communicator can intentionally provide wrong information, i.e., lie. For instance, the communicator might want to increase its own reputation or the reputation of an acquaintance; this is usually called “misleading propaganda”. It can also try to decrease the reputation of another competing agent, which is usually called “defamation”. Secondly, the communicator can provide information that is not wrong but leads the receiver intentionally to wrong conclusions. For instance, it can hide information, give partial information or give out-of-context information. Finally, the communicator can unwittingly communicate untrue facts. Note that agent $\beta$, the last agent who sent the information, needs not to be the originator of the information [CP02], and therefore might alter the information if it is not signed. The credibility filter should take all these aspects into account and filter the information according to how much the sources of this information are intended to be trusted, more precisely, whether they are decided to be trusted. In Figure 2 this is indicated by the “influence”-arrows from “making decisions” to the credibility filters, which exactly try to filter out information that does not seem to be credible.

3.2 Evaluation

During the process of evaluation, an agent evaluates sets of direct observations about the behavior of other agents. Such an evaluation estimates whether the set of observations provides evidence for the agent in question being trustworthy or untrustworthy. At this stage, it is not yet decided whether an agent is actually believed to be trustworthy or not; sets of observations are only examined for their significance in respect to an agent’s trust-
worthiness. In many models, this is done by comparing the actual behavior of an agent to what its behavior was expected to be like. This expected behavior can, for instance, be determined by formal contracts [Sab02] or social norms [COTZ00, VM10]. Various representations are used to describe evaluations: binary (e.g., [SS02]), more fine-grained discrete (e.g., \{-1, 0, +1\} in eBay [eBa09]), or continuous assessments (e.g., [Sab02, HJS04, VM10]).

As the sets of norms and established (implicit) contracts can be subjective, an evaluation can be subjective too. Therefore, different agents might contradictorily interpret the same observations as evidence for trustworthy and untrustworthy behavior. This is evident in the case of eBay [eBa09] where each human does the evaluation along his own criteria. As a consequence, an agent can try to emulate how other agents would evaluate observations, to eventually emulate their trust beliefs. Therefore, MITRA contains two different ways of evaluation (see Fig. 2): using \(\alpha\)'s criteria, which results in evaluations \(\text{eval}^{(\delta, \gamma)}_{\alpha}\); and the way \(\alpha\) thinks \(\theta\) would do the evaluation, which results in \(\text{eval}^{(\delta, \gamma)}_{\theta}\).

For evaluation, it can be vital to know about the causality behind what happened. Indeed, if the causal relationships are not clear to the evaluating agent, it can wrongly evaluate a failure to be evidence for untrustworthiness, although it is actually an excusable failure – or vice versa [CF00, SE07].

3.3 Fusion

In a third step, the different evaluations are fused into trust beliefs. Trust beliefs can be formed based on evaluations of individual agents or groups of agents, and can be about individuals or groups. Figure 2 shows that an agent \(\alpha\) can fuse evaluations to get its own trust beliefs \(\text{tb}^{\Gamma}_{\alpha}\); or to emulate the trust modeling of another agent \(\theta\), in order to estimate this agent’s \(\theta\)'s trust beliefs \(\text{tb}^{\Gamma}_{\theta}\). In any case, if \(\alpha\) uses evaluations \(\text{eval}^{(\cdot, \cdot)}_{\beta}\) received from another agent \(\beta\), it first needs to filter out the “incompatible” subjectivity inherent in the evaluations: For evaluation, \(\beta\) may have applied criteria that \(\alpha\) does not agree with, or – when \(\alpha\) is emulating the trust beliefs of \(\theta\) – where \(\alpha\) thinks that \(\theta\) would not agree with. In the figure, the check for the match of the applied criteria, and the potential adjustment of the evaluations, is named subjectivity filtering.

The emulation of another agent \(\theta\)'s trust beliefs is for instance needed when forming reputation, i.e., trust beliefs that a certain group of agents \(\Theta\) (with \(\theta \in \Theta\)) would associate to a given trustee. For this, also trust beliefs received from other agents can be incorporated. A subjectivity filter should not be applied to these received trust beliefs, because reputation reflects the subjectivity of different agents. Still, a credibility filter is applied to avoid a biased reputation estimate.

Furthermore, if an agent forms trust beliefs based on interactions where itself was not involved, it has to account for the relation between the inter-
acting agents. Assume, an agent $\alpha$ receives from another agent the evaluation $\text{eval}_{\theta}^{(\delta,\gamma)}$, where all four agents $\alpha, \theta, \delta, \gamma$ are distinct agents. If $\alpha$ wants to reason about $\delta$’s trustworthiness towards itself, then it first needs to apply a personality filter. Here, information is filtered out that contains no evidence for the behavior of $\delta$ towards $\alpha$, because it is specific for interactions between $\delta$ and $\gamma$. For example, imagine that the evaluation is about the behavior of a mother ($\delta$) towards her child ($\gamma$), and she behaved very trustworthy. Then this behavior does not say much about how the mother will behave towards another unrelated person (e.g., $\alpha$). This shows that trustworthiness is directed, and that this direction has to be taken into account in trust reasoning.

Whenever fusing sets of evaluations or trust beliefs into a single trust belief, it is particularly important to account for the “correlated evidence” problem [Pea88]. This problem arises when different evaluations or trust beliefs are based on the same observed interactions of agents. In other words, the evidence expressed by the evaluations/trust beliefs “overlaps”. If the reasoning agent is not aware of this overlapping, certain parts of the evidence will wrongly be amplified and the resulting trust belief be biased.

Many different approaches for fusing evaluations into trust beliefs (e.g., [WS07, TPJL06a, RRRJ07]), and trust beliefs into community models (e.g., [KSGM03, SFR99]) have been proposed in the literature. Most importantly, each trust belief should incorporate the two properties mentioned in Sect. 2.3: the uncertainty, i.e., how strong the belief is, and in which context(s) it applies.

### 3.4 Decision-Making

The last component in MITRA is the decision-making process, which consists of two steps:

1. fix trust intentions based on trust beliefs;

2. apply the trust intentions to make the final decision to act (or not) in trust.

In the first step, a set of individual and/or collective trust beliefs are used to derive one or several trust intentions for different contexts. Trust beliefs can, for instance, be aggregated into trust intentions by simply averaging over them, or by taking the most “pessimistic” or “optimistic” trust belief, etc. But also, it is possible to ignore available negative trust beliefs about another agent $\gamma$, and to decide to act in trust with $\gamma$ in order to give this agent the opportunity to rethink its behavior [FC04]. This “advance” in trust, which can in some cases be forgiveness, accounts for the dynamics of trust such as “trust begets trust” [BE89].
A trust intention $t_{i\alpha}^\gamma$ has to reflect two things: in which situations $\alpha$ actually intends to act in trust with $\gamma$ (context), and how strong the intention is (uncertainty). Trust intentions with these two properties can be used in decision-making in the same way as other criteria. Although many trust and reputation models from the literature do not separate the derivation of trust intentions from the process of decision-making, we strongly argue for a separation of the two processes. The reason is that the derivation of trust intentions is specific to trust research, while a trust intention plays in decision making the role of a context-sensitive criterion in the same way as many other criteria (like availability of a potential partner). This problem is however studied in depth in a research area called Multiple Criteria Decision Making (MCDM) [Kal06] and is not specific to trust.

### 3.5 Context in MITRA

In general, everything that can impact the behavior of a trustee and is not part of the trustee itself, is said to belong to the context [Dey00]. The more of the available context information is considered by a trust and reputation model, the better the final decision can be. We propose to arrange the different facets of context into five classes:

1. time (points in time or time intervals);
2. external conditions:
   - (a) physical conditions,
   - (b) laws/norms,
   - (c) other agents nearby;
3. type of the delegated task;
4. contract;
5. information source.

The information source is the one that provides the information, on which the reasoning is based, e.g., a sensor or another agent. This context facet is a special case, because it is not linked to a trustee’s behavior. It is important though, since it allows an agent to have several trust beliefs about the same trustee, based on different information sources.

Two different contexts can be distinguished: the one in which the information was taken, and the one in which a decision is made (decision context). To fuse information that comes from different contexts, or use it in decision-making for different contexts, an agent needs to know how similar the different contexts are. In the literature, many ways for representing context information, and similarities between contexts, have been proposed.
[KR03] represent context relations in form of a weighted directed graph. [SY07] use ontologies and a set of rules to represent context information. In a more general way, [RP07] represent context information as points in a multi-dimensional space, where each dimension represents one characteristic of the context (e.g., the point in time, the dollar exchange rate, etc.). The distance between two points in the context space, which is determined by some distance metric, states the similarity of the two contexts. These approaches have in common that an agent was given some similarity metric about different contexts in advance. MITRA does not assume that, and so, if the similarity metric cannot be known in advance, an agent needs to learn the metric.

At which stage information that belongs to different contexts is eventually fused, is up to the concrete model. However, since during this fusion process some information is lost, it should be done as late as possible in the information chain. As a consequence, that principle should generally be used when processing information.

4 Organizing Existing Models

In this section, we exemplify how existing trust and reputation (T&R) models can be classified by means of MITRA. The approach we take here is to investigate which types of data are used in the considered trust models. For a small selection of trust models, this is shown in tables 1 and 2. Table 1 lists types of data that belong to the observation process. Table 2 lists the remaining data types, i.e., those in the evaluation, fusion and decision-making processes. A check-mark indicates whether a trust model accounts for the respective kind of data. Still, not every model accounts for the context and uncertainty of the processed information.

Additionally to this classification approach, T&R models can also be described by specifying:

1. which filters are applied,
2. where uncertainty is considered, and
3. which facets of context are accounted for at which stage.

Since the focus of this article lies on the meta model MITRA itself, we leave it to future work to provide an extensive and comprehensive classification using MITRA. However, as it can already be seen in the resulting tables, a clear picture emerges of what has been done (columns with check-marks) and what needs to be done in the T&R modeling domain – for example, there is no model with no empty columns, i.e., that uses all available types of information. Furthermore, the column eval$^{(δ,γ)}_{θ}$ is always empty. None of
### Table 1: Classification with MITRA (Observation).

| Observation | \( \text{obs}^{<\delta,\gamma>}_\alpha \) | \( \text{eval}^{(\delta,\gamma)}_\alpha[\beta,...] \) | \( \text{tb}^{\Gamma}_\alpha[\beta,...] \) | \( \text{tb}^{\Theta}_\alpha[\beta,...] \) |
|-------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Marsh [Mar94] | ✓ | ✓ | | |
| Schillo et al. [SFR99] | ✓ | ✓ | | |
| Histos [ZMP99] | ✓ | ✓ | | |
| Sporas [ZMP99] | ✓ | ✓ | | |
| Beta-Rep. System [JI02] | ✓ | ✓ | ✓ | ✓ |
| Sen and Sajja [SS02] | ✓ | ✓ | | |
| Eigentrust [KSG03] | ✓ | ✓ | | |
| Regret [SM03] | ✓ | ✓ | ✓ | |
| Secure [CGS+03] | ✓ | ✓ | ✓ | ✓ |
| Wang and Vassileva [WV03] | ✓ | ✓ | | |
| Peertrust [XL04] | ✓ | ✓ | | |
| Capra and Musolesi [CM06] | ✓ | ✓ | | |
| Travos [TPJL06b] | ✓ | ✓ | | |
| Reece et al. [RRRJ07] | ✓ | ✓ | | |
| Şensoy and Yolum [SY07] | ✓ | ✓ | | |
| Wang and Singh [WS07] | ✓ | ✓ | ✓ | ✓ |
| Falcone and Castelfranchi [FC08] | ✓ | ✓ | ✓ | |
| Liar [VM10] | ✓ | ✓ | ✓ | ✓ |
| Vogiatzis et al. [VMC10] | ✓ | ✓ | ✓ | |

*a* implicitly

*b* only considering the case of \( |\Gamma| = 1 \)

*c* submitted to a central rating center

*d* provided by a central rating center
Table 2: Classification with MITRA (Evaluation, Fusion, Decision-Making).

|                             | Evaluation $\text{eval}^{(\delta,\gamma)}$ | Fusion $\text{tb}^\Gamma$ | Decision-Making $\text{ti}^\gamma$ |
|-----------------------------|--------------------------------------------|-----------------------------|-------------------------------------|
| Marsh [Mar94]               | ✓                                          | ✓                           | ✓                                   |
| Schillo et al. [SFR99]      | ✓                                          | ✓                           | ✓                                   |
| Histos [ZMP99]              | ✓                                          | ✓                           | ✓                                   |
| Sporas [ZMP99]              | ✓                                          | ✓                           | ✓                                   |
| Beta-Rep. System [JJ02]     | ✓                                          | ✓                           | ✓ab                                 |
| Sen and Sajia [SS02]        | ✓                                          | ✓                           | ✓a                                  |
| EigenTrust [KSG03]          | ✓                                          | ✓                           | ✓a                                  |
| Regret [SM03]               | ✓                                          | ✓                           | ✓a                                  |
| Secure [CGS+03]             | ✓                                          | ✓                           | ✓                                   |
| Wang and Vassileva [VV03]   | ✓                                          | ✓                           | ✓                                   |
| PeerTrust [XJ04]            | ✓                                          | ✓                           | ✓                                   |
| Capra and Musolesi [CM06]   | ✓                                          | ✓                           | ✓                                   |
| Travos [TPJL06b]            | ✓                                          | ✓                           | ✓                                   |
| Reece et al. [RRRJ07]       | ✓                                          | ✓                           | ✓                                   |
| Şensoy and Yolum [SY07]     | ✓                                          | ✓                           | ✓                                   |
| Wang and Singh [WS07]       | ✓                                          | ✓                           | ✓                                   |
| Falcone and Castelfranchi [FC08] | ✓             | ✓                           | ✓                                   |
| Liar [VM10]                 | ✓                                          | ✓                           | ✓a                                  |
| Vogiatzis et al. [VMC10]    | ✓                                          | ✓                           | ✓                                   |

*a*only considering the case of $|\Gamma| = 1$

*b*computation performed by central rating center
the here considered trust model[1] uses the intermediate step of simulating the evaluation of another agent to eventually form a collective trust belief (reputation). However, we believe that this is something what humans do regularly; for example in form of questions like “What would my mother think about his behavior?” or “How would my best friend judge this agent’s behavior?”. This issue deserves more attention as it makes it possible to evaluate the behavior of other agents in cases where an own opinion on their behavior is lacking.

5 Related Work

Numerous survey or overview papers on trust and reputation models have been published. Many works start with a basic classification and then enumerate and describe existing models [SMS05, AG07, JIB07, RHJ04, MHM02]. Opposed to that, we tried in our work to use a rigorous methodology for the organization of the state of the art: extract the core structure of prominent trust and reputation models, in order to get clear and simple differentiation criteria for the models of the literature.

[KBR05] proposed a generic trust model that integrates several existing trust models. They show how to map each of these models to their model. However, they focus on the fusion of evaluations, whereas we examined the overall structure of trust and reputation modeling.

[CS05] define a functional ontology of reputation, that is used in different systems [VCSB07, NBSV08] in order to help agents using different trust and reputation models inter-operate. These approaches try to cope with a situation where different models exist, whereas we try to propose a unified meta-model of trust and reputation.

6 Conclusion

In this article, we presented MITRA, a meta-model for trust and reputation. The model structures many essential concepts found in the literature on evidence-based T&R models. The simple and generic structure of MITRA makes it suitable both for experts to organize their models in a common way, and for newcomers to easily enter the domain. Although there is the possibility that a specific T&R model does not comply with MITRA, the fact that the latter was derived from the study of many existing models argues for its comprehensiveness, and we believe that its modularity should make it simple to modify in order to encompass new elements.

Finally, by using MITRA, we classified existing T&R models from the literature. This classification revealed which kinds of information are com-

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1To our knowledge there is no such trust model in the literature.
monly used by these models, and which kinds of information are often ne-
glected. In this way, we found that none of the considered models actually
tries to emulate another agent’s evaluation of a trustee; this emulation would
make it possible to form the reputation of an agent in a new way.

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