

An Integrated trust and reputation model for open multi-agent systems

A paper by Trung Dong Huynh, Nicholas R. Jennings & Nigel R. Shadbolt (2006)

Jaspreet Singh & Daniël Stekelenburg



Overview

1. Terminology
2. The FIRE Model
3. Results
4. Conclusions



.. an open MAS?

“...systems in which agents can freely join and leave at any time and where the agents are owned by various stakeholders with different aims and objectives.”



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“...systems in which agents can freely join and leave at any time and where the agents are owned by various stakeholders with different aims and objectives.”

This causes some uncertainties:

1. Agents tend to be self-interested and may be unreliable
2. No agent can know everything about the environment
3. No central authority can control everything



Sources of trust/reputation

Source	Type
Direct experience	Interaction trust
Witness experience	Witness reputation
Role-bases rules	Role-based trust
Third-party references	Certified reputation



Uses all four sources of information

Works, based on the following assumptions:

- ▶ Agents are willing to share their experiences with others (as witnesses or as referees)
- ▶ Agents are honest in exchanging information with one another.



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- ▶ Agents are honest in exchanging information with one another.

So... we do not consider the problem of lying and inaccuracy.



How to quantify trust/reputation? - The old way

Just take the average of all the ratings.



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Just take the average of all the ratings.

However... these ratings are not equally relevant:

- ▶ Older ratings might not be as relevant as new ones
- ▶ Some ratings are more credible than other depending on the source

So in what other way can we quantify trust?



How to quantify trust? - The FIRE way

Every rating is a tuple $r = (a, b, c, i, v)$.

Where a and b are the agents participating in transaction i .
Value $v \in [-1, +1]$ is the rating given by agent a to agent b regarding regarding topic c (e.g. quality, honesty).

These ratings are stored in the agent's local database.



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Since ratings become outdated over time, an agent only stores the latest H transactions it gave to other agents.



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This gives us:

$$\mathcal{T}_K(a, b, c) = \frac{\sum_{r_i \in \mathcal{R}_K(a, b, c)} \omega_K(r_i) \cdot v_i}{\sum_{r_i \in \mathcal{R}_K(a, b, c)} \omega_K(r_i)} \quad (1)$$

- ▶ $\mathcal{T}_K(a, b, c)$ is the trust value of agent a towards agent b on topic c , regarding K .
- ▶ $\mathcal{R}_K(a, b, c)$ are the ratings collected on K .
- ▶ $\mathcal{T}_K(a, b, c) \in [-1, +1]$



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- ▶ We now have a trust value \mathcal{T}_K
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- ▶ We now have a trust value \mathcal{T}_K
- ▶ How reliable is \mathcal{T}_K ?
- ▶ We need a value to express how reliable the calculated trust value \mathcal{T}_K is!



How to express reliability?

- ▶ We know how to calculate how reliable each individual rating is: ω_K
- ▶ We use this to express:
 - ▶ Rating reliability ρ_{RK} : The total reliability of the individual ratings.
 - ▶ Deviation reliability ρ_{DK} : The higher the variance in the ratings is, the more volatile the agent is likely to fulfilling its agreements.



How to express reliability? - Rating reliability

- The total reliability of the individual ratings. → The sum of reliability of the individual ratings.

$$\rho_{RK}(a, b, c) = 1 - \exp\left(-\gamma_K\left(\sum_{r_i \in \mathcal{R}_K(a, b, c)} \omega_K(r_i)\right)\right) \quad (2)$$

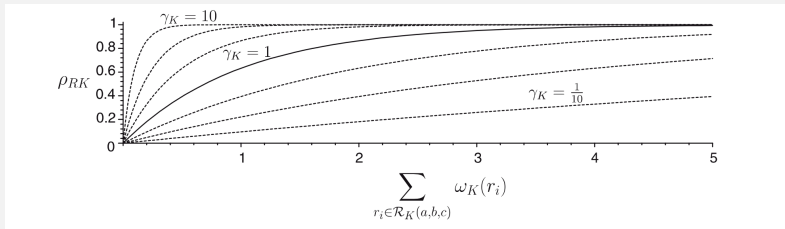


Figure 1: Rating reliability function [Faculty of Science
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How to express reliability? - Deviation reliability

- ▶ The higher the variability in the ratings is, the more volatile the agent is likely to fulfilling its agreements.
- ▶ → The higher the variability the lower the deviation reliability is.

$$\rho_{DK}(a, b, c) = 1 - \frac{1}{2} \cdot \frac{\sum_{r_i \in \mathcal{R}_K(a, b, c)} \omega_K(r_i) \cdot |v_i - \mathcal{T}_K(a, b, c)|}{\sum_{r_i \in \mathcal{R}_K(a, b, c)} \omega_K(r_i)} \quad (3)$$



How to express reliability?

- ▶ Now we know how to calculate both the rating reliability ρ_{RK} and deviation reliability ρ_{DK} .
- ▶ We combine both values and get a single value for the reliability of \mathcal{T} :

$$\rho_K(a, b, c) = \rho_{RK}(a, b, c) \cdot \rho_{DK}(a, b, c) \quad (4)$$



Interaction trust

- ▶ Is built from the direct experiences of an agent and models the direct interactions between two agents.
- ▶ The reliability $\omega_I(r_i)$ of a single interaction is determined by its recency:

$$\omega_I(r_i) = \exp\left(-\frac{\Delta t(r_i)}{\lambda}\right) \quad (5)$$

- ▶ $\Delta t(r_i)$ is the difference in time between now and the time when r_i was recorded.
- ▶ λ is the recency scaling factor.



Interaction trust

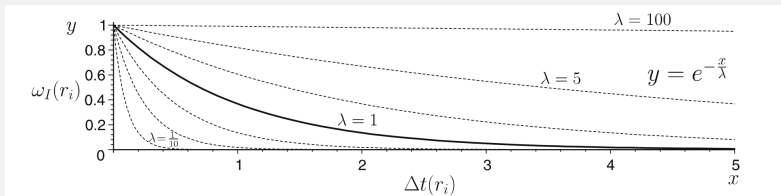


Figure 2: Behavior of the weight function $\omega_I(r_i)$.



Role-based trust



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Witness reputation



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Certified reputation



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Putting it all together



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Summary



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