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

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

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Overview

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

.. an open MAS?

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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

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

How to quantify trust/reputation? - The old way

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Since ratings become outdated over time, an agent only stores the latest H transactions it gave to other agents.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

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

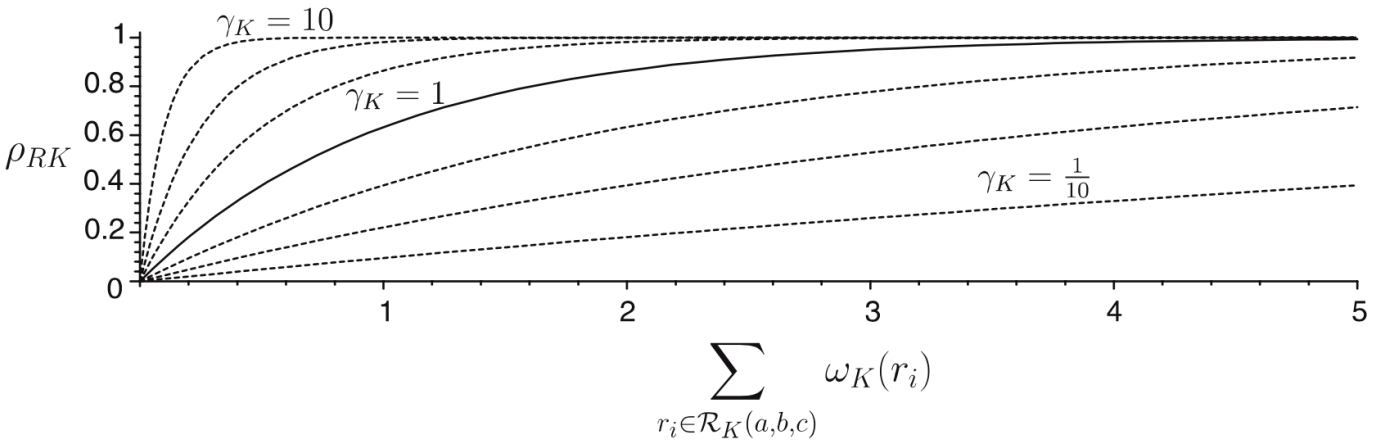

Figure 1: Rating reliability function

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.
- $\rightarrow$ 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 $\mathcal{T}$:

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

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:

$$\omega_I(r_i) = exp\Big(- \frac{\Delta t(r_i)}{\lambda} \Big) \tag{5}$$

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

Interaction trust

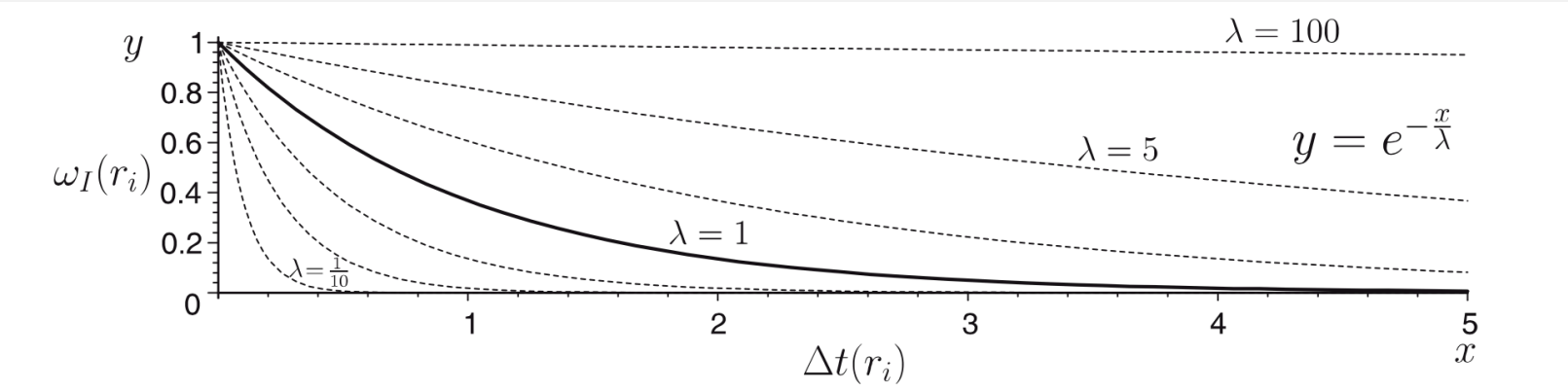

Figure 2: Behavior of the weight function $\omega_I(r_i)$.

Role-based trust

- Models trust resulting from role-based relations.
- For example: provider-consumer relationship.
- The reliability $\omega_R(r_i)$ of a single interaction is determined by a set of rules:

$$rule = (role_a, role_b, c, e, v) \tag{6}$$

  - v is the expected performance.
  - e is the amount of influence this rule has on the total value.

- $\omega_R(r_i) = e_i$

Witness reputation

- Is built on observations on the agents behavior by other agents.
- Need to find other agents that have interacted with b.
- This might be problematic in large environment:
  - Limited resources available;
  - Need to find these witnesses in reasonable time.
- Once all the ratings have been collected, the weight is determined by $\omega_W(ri) = omega_W(ri)$.

Witness reputation

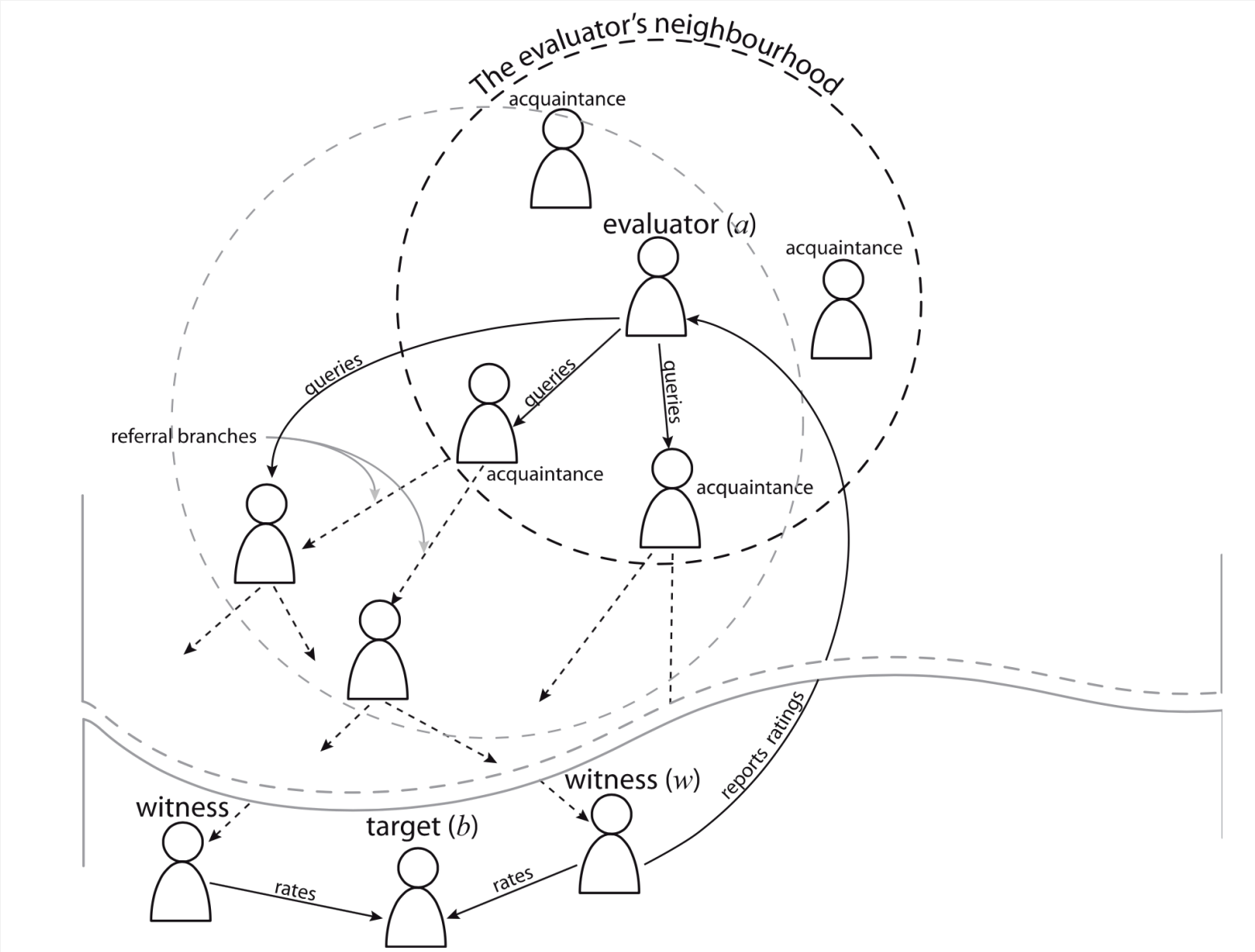

Figure 3: How to find witnesses

Certified reputation

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Putting it all together

Summary