Mobile Adventure

Reputation based computational models of trust in P2P networks

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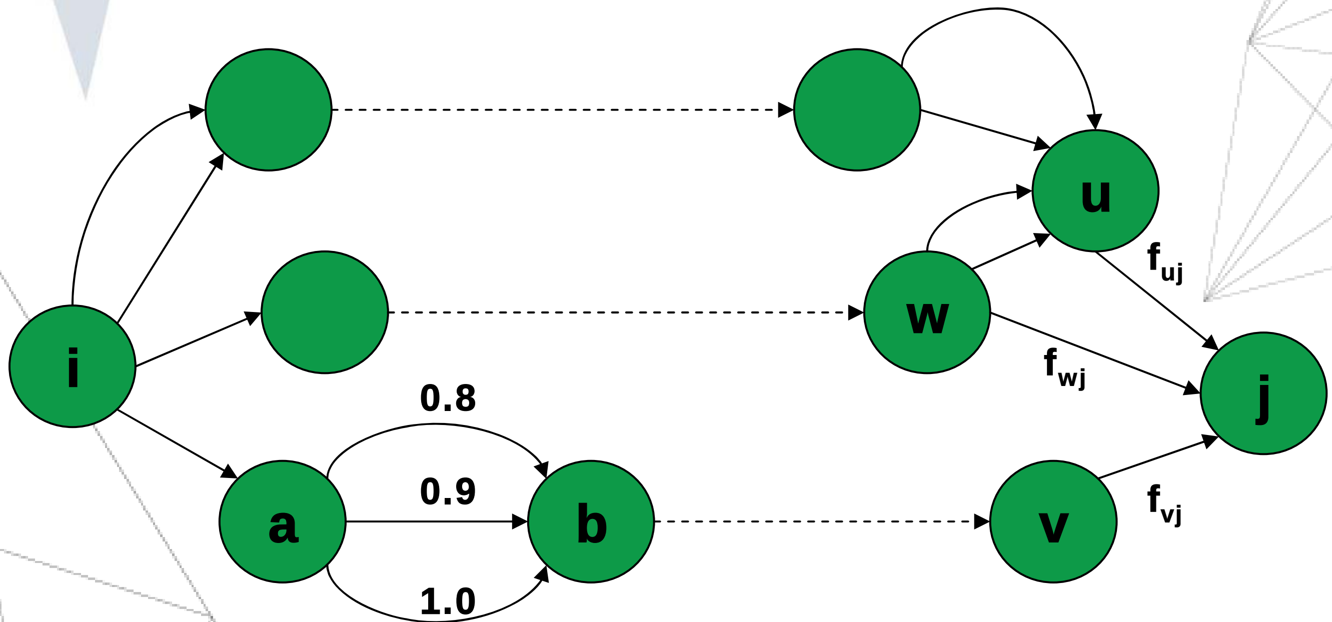
Outline

- Problem statement
- Example solutions
- Problems with current solutions
- Design principles
- Discussion

Reputation Systems

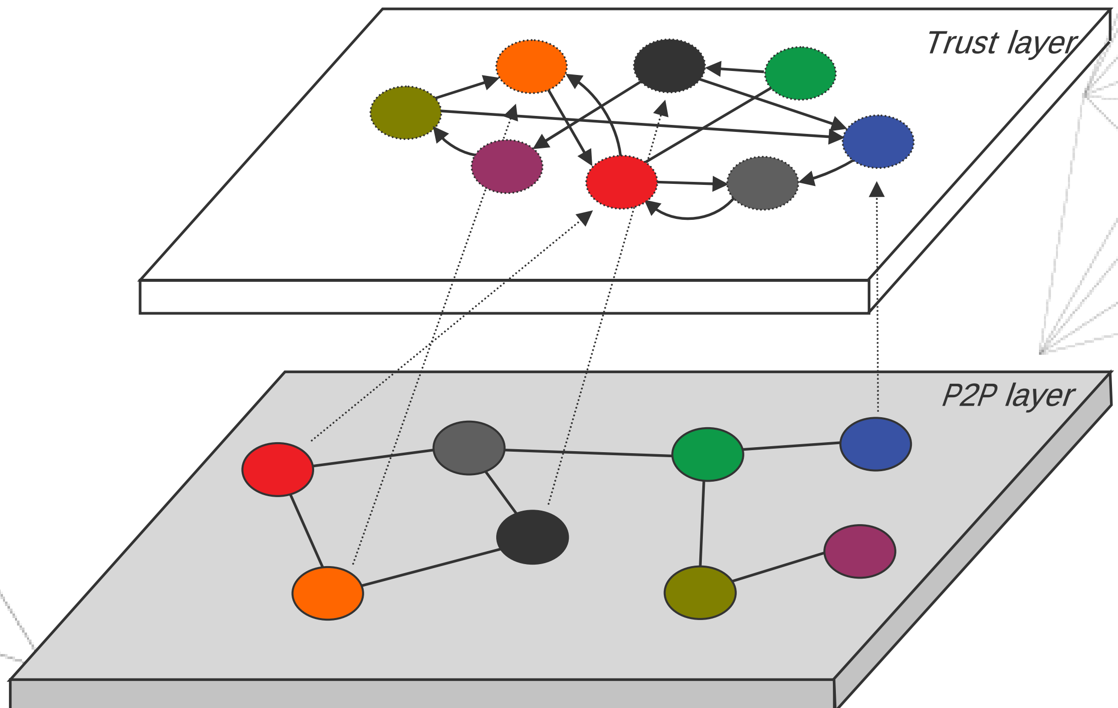
- Problem: Reputation based trust management
  - Define:
    - A form of feedback to be taken from interacting agents about their partners' trustworthiness
    - A strategy to aggregate the available feedback
  - Output:
    - An estimate of the trustworthiness of the agents to encourage trustworthy behavior in the society
- Underlying Assumptions
  - Bilateral interactions with a globally known set of outcomes
  - Service provider and consumer
  - Consumer's feedback on the provider's trustworthiness

Example



$$t_j = \frac{f_{uj} \times t_u + f_{vj} \times t_v + f_{wj} \times t_w}{t_u + t_v + t_w}$$

Storing feedback in the underlying P2P network



- Use peer IDs as keys and store feedback in the underlying DHT, indexing it by the target peers' keys

Implementation costs

- Exploring formed trust graphs incurs a too high communication overhead in a large P2P network
- "All paths" aggregations are usually exponential
  - Equivalent to the trust matrix power computation only if "along the path" and "across paths" operations satisfy certain conditions (Google's PageRank)
- Lesser overhead if the environment is a structured P2P network but using all available information still not acceptable
- Use only local portions of the available feedback

Behavior - Performance

- Most of works do no make any assumptions w.r.t. the underlying behavior
  - Unclear model semantics
  - For evaluations, a usual assumption is probabilistic behavior, e.g. some peers honest and some cheat with specific probabilities
- Probabilistic behavior does not fit many settings
  - Consider other forms of behavior - help from social sciences to characterize human behavior
  - Rational and bounded rational

Behavior - Inconsistency

- The underlying P2P networks are normally assumed to operate perfectly
- Different types (or parameters) of the behavior in the trust and P2P layer - inconsistent models

Design principles

1. Analytic characterization of the underlying behavior describing agents' goals, maybe their innate properties, their reaction to a reputation change etc.
2. Computationally efficient algorithm to aggregate opinions about any particular agent and make trust scores to be used when interacting with the concerned agent.
3. For dynamic behavior the aggregation algorithm has to provide quick convergence of the system toward the trustworthy behavior in the considered society.

Example - Probabilistic behavior

- Based on maximum likelihood estimation (MLE)
- Model “Honest – dishonest peers”
  - Binary outcomes of the interactions
  - Innate probabilities of performing honestly and lying when reporting to others: θ_k , l_k
- Algorithm
  - Probability of report y_k from peer k on peer j (l – probability that it was flipped):

$$P[Y_k = y_k] = \begin{cases} l \cdot (1-\theta_j) + (1-l)\cdot\theta_j & \text{if } y_k = 1 \\ l\cdot\theta_j + (1-l)\cdot(1-\theta_j) & \text{if } y_k = 0 \end{cases}$$

  - Determine l by checking reports on own performances
  - Collect all reports $y_1, y_2, \ldots, y_n$ on peer j and determine θ_j that maximizes:

$$L(\theta_j) = P[Y_1 = y_1]P[Y_2 = y_2]\cdots P[Y_n = y_n]$$

MLE - Main Properties

- Probabilistic behavior assumption made explicit
  - Well known probabilistic estimation techniques on an appropriately defined model
- Trust semantics
  - Probability distributions over the set of possible behaviors as the output
- Performance comparable to that of "all paths" solutions
- Low implementation overhead!
  - Only a small fraction of the available information used
  - Communication costs to retrieve reports of the witnesses
- Consistent models: probabilistic assumptions present in all system aspects

Rational behavior

- Clear analytic characterization – utility maximization
- Inherently dynamic
- Game-theoretic framework
  - Bayesian games – modeling uncertainties
  - Repeated games – modeling repeated interactions
- Analytic design
  - Clear link between feedback aggregation strategies and resulting (equilibrium) behavior
- Complicated for decentralized settings!
  - Decentralized implementation makes the underlying game too complex
  - Ex.: Feedback aggregation implies maintaining a window of K random reports; peers themselves must do this, but they can behave strategically

Anything in-between?

- Reciprocation as a possible behavior class
  - ‘You scratch my back and I’ll scratch yours’
  - Tit-for-tat in Prisoner’s Dilemma
- Very close to how humans behave; many empirical confirmations
- Works also indirectly:
  - “I scratch your back because you scratched someone else’s back”
  - Reputation becomes important
- Reciprocation should be easier to consider in the mechanism implementation