Trust in Multiagent Systems

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Working together

- Finding the right service provider from a set of providers
- Yellow-pages
  - Lookup based on service criteria
  - May not always exist
  - May return many results
- Example?

Reputation

- Someone's reputation is a general opinion about that party
- By definition centralized
- Sometimes partially probed by asking others
- Computed by reputation agency
  - Authenticates users
  - Records, aggregates, and reveals ratings (e.g., amazon.com)
  - Provides the conceptual schema for
    - How to capture ratings (typically a number and text)
    - How to aggregate them
    - How to decay them over time

Problems with explicit aggregation

- Context and understanding: The contexts of usage may not be in agreement.
- Privacy: The parties providing their ratings are stating publicly (or to the reputation agency) what they may only wish to reveal in private.
- Trust: The parties using the ratings don’t necessarily know where the ratings come from.

Confidence vs. trust

Luhmann’s distinction:

- Hope: Wish it will come true (no basis).
- Confidence: Think it will come true (based on evidence).
- Trust: Commit to action with partly uncertain consequences.

Computational trust

1. Send request to SPx
2. Receive a service
3. Evaluate the service
4. Update the model of SPx based on evidence

Local trust

- Based on personal evidence
- Using prior interactions
- Try all others on your own
- Too costly if:
  - There are too many service providers
  - Service providers enter and leave

Institutional trust

- Organizations monitor members' actions
- Ensure a quality of service
- Centralized reputation systems
- Challenges:
  - Privacy: Raters may not want to reveal true ratings in public
  - Trust: Users of ratings don't necessarily know where the ratings come from

Social trust

- Based on evidence from others
- Information sources should be trustworthy
- Ask those you trust yourself
- Challenges:
    - Context: The contexts of usage may be unspecified
    - Satisfaction criteria: The expectations of the raters may be significantly different

Beta-Reputation System (Jøsang and Ismail, 2002)

- Collect ratings from others
- Agent counts the positive and negative ratings
- Uses a beta distribution to predict the reputation
- Assume most ratings are fair

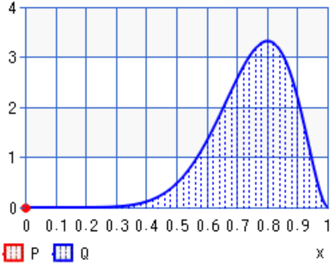
Beta-Reputation System

Estimate the probability of events

- The beta-family of probability density functions is a continuous family, indexed by α and β
- Beta Density Function is used for binary events
- Count the past occurrences and decide based on frequency
- Let *r* be observed occurrences of *x* (successful transactions) and s be the observed occurrences of $\bar{x}$ (unsuccessful transactions)
- Set $\alpha = r + 1$ and $\beta = s + 1$

Beta-Reputation System

- The probability expectation value of the beta distribution is:
  $E(p) = \alpha/(\alpha + \beta)$
- Example:
  - 8 positive transactions, 2 negative
  - α = 9; β= 3
  - E(p) = 9/12 =0.75 (Most likely frequency of the outcome)



Example

- Agent *A* has collected feedback about agent *B* over time and represents this as $(10, 8)$, where 10 is the positive feedback and 8 is the negative feedback. Calculate *B*'s reputation rating by *A*.

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- The expected value for *B* to provide satisfactory service is: 11/20 $= 0.55$. The reputation rating is (0.55-0.5)*2=0.1.

Beta-Reputation System

- Transactions are not always binary
- Consider the extent of satisfaction (r,s), where r is how satisfied and s is how dissatisfied
- Calculate T's reputation function by agent X (p_T^X)
- Collective amount of positive and negative feedback (r_T^X, s_T^X)
  $E(p_T^X) = (r_T^X + 1)/(r_T^X + s_T^X + 2)$
- Reputation function yields a result between [0,1], where 0.5 is neutral
- Scale to give a result between [-1,1]

$$Rep(r_T^X, s_T^X) = (E(p_T^X) - 0.5) * 2$$

Combining feedback

- Combine equally from everyone
  - $r_T^{X,Y} = r_T^X + r_T^Y$
  - $s_T^{X,Y} = s_T^X + s_T^Y$
- Discount based on how much you trust; e.g., both Y and Z have opinion about T, if X trusts Y more than Z, then Y's opinion should count more.
- Using belief theory: $w_Y^X = (b_Y^X, d_Y^X, u_Y^X)$: X's opinion about Y for belief, disbelief, uncertainty.
- Mapping experience to belief values
  - $b = r/(r + s + 2)$
  - $d = s/(r + s + 2)$
  - $u = 2/(r + s + 2)$
- Discounted reputation (r, s) = (2*b/u, 2*d/u)

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- $w_B^A = (b_B^A, d_B^A, u_B^A)$
- $b_B^A = 10/(8+10+2)$, $d_B^A = 8/(8+10+2)$, $u_B^A = 2/(8+10+2)$
- $w_B^A = (0.5, 0.4, 0.1)$

Calculating beliefs

- Given X's opinion of Y ($w_Y^X = (b_Y^X, d_Y^X, u_Y^X)$) and Y's opinion of T ($w_T^Y = (b_T^Y, d_T^Y, u_T^Y)$), how much X should trust T? ($w_T^{X:Y} = (b_T^{X:Y}, d_T^{X:Y}, u_T^{X:Y})$)
- Combining beliefs
  - Belief: $b_T^{X:Y}$ = $b_Y^X * b_T^Y$
  - Disbelief: $d_T^{X:Y}$ = $b_Y^X * d_T^Y$
  - Uncertainty: $u_T^{X:Y}$ = $d_Y^X + u_Y^X + b_Y^X * u_T^Y$

Example

- Agent *A* needs to find the reputation of agent *C* but it has not interacted with agent *C* before. However, agent *B* has interacted with agent *C*. *B*'s opinion of *C* is $\omega_C^B = (0.7, 0.2, 0.1)$. Assuming *A* does not have any other information about *C*, calculate *C*'s reputation rating by *A*. Make sure you first calculate *A*'s opinion of *B* and take that into account.

Example

- Agent A needs to find the reputation of agent C but it has not interacted with agent C before. However, agent B has interacted with agent C. B's opinion of C is $\omega_C^B = (0.7, 0.2, 0.1)$. Assuming A does not have any other information about C, calculate C's reputation rating by A. Make sure you first calculate A's opinion of B and take that into account.
- A's opinion of B, based on $(10, 8)$ is $(10/20, 8/20, 2/20)$, yielding $(0.5, 0.4, 0.1)$. Then, A's opinion of C though B is discounted as: $(0.5 * 0.7, 0.5 * 0.2, 0.4 + 0.1 + 0.5 * 0.1)$, yielding $(0.35, 0.1, 0.55)$. Converting this to $(r, s) = (2 * b/u, 2 * d/u)$ yields: $(1.27, 0.36)$. The expected value is 2.27/3.63=0.625. The reputation rating is: $(0.625 - 0.5)$*2=0.25.

Forgetting

- The recent interactions should count for more.
  - Introduce an age and multiply evidence to age the older ones
  - Need to keep track of the time-stamp
- $r_T^Q = \sum_{i=1}^n r_{T,i}^Q$ and $s_T^Q = \sum_{i=1}^n s_{T,i}^Q$
- Add forgetting factor based on *i*
- $r_{T,\lambda}^Q = \sum_{i=1}^n r_{T,i}^Q * \lambda^{(n-i)}$ and $s_{T,\lambda}^Q = \sum_{i=1}^n s_{T,i}^Q * \lambda^{(n-i)}$, where $0 \leq \lambda \leq 1$

Challenges

- What if there are untruthful agents?
- Which agents do you ask?
- Could evaluation of a service differ for a person?
- How could the context be captured?