# A Tunable Mechanism for Identifying Trusted Nodes in Large Scale Distributed Networks

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## Motivation

- **Increasing importance of user contributions in online services**
  - Online social networks
  - Collaborative filtering
  - Content sharing
  - Crowdsourcing
  - Peer-to-Peer systems

facebook amazon.de Dropbox microWorkers work & earn or offer a micro job BitTorrent YouTube Epinions

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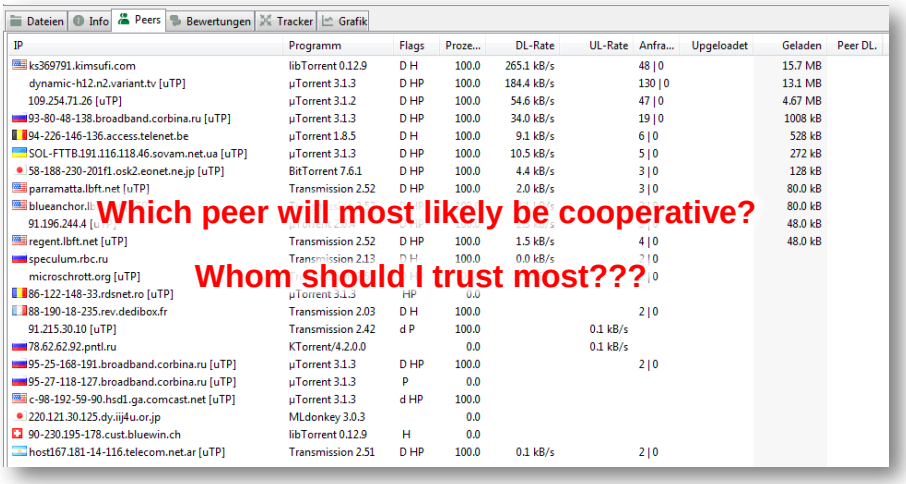
# Motivation




**Which peer will most likely be cooperative?**

**Whom should I trust most???**



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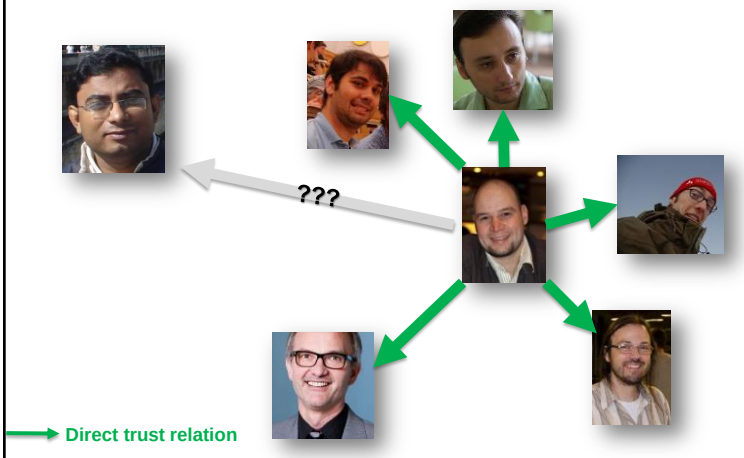
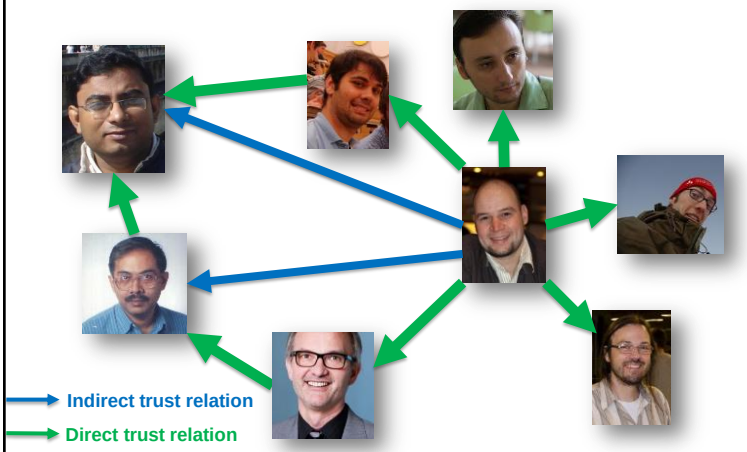
# Trust relationships

**Assumption: Users keep track of trusted contacts**



# Trust propagation

**We assume a transitive notion of trust!**




S. D. Kamvar et al.: **The EigenTrust Algorithm for Reputation Management in P2P Networks**, WWW 2003





# Global Reputation?

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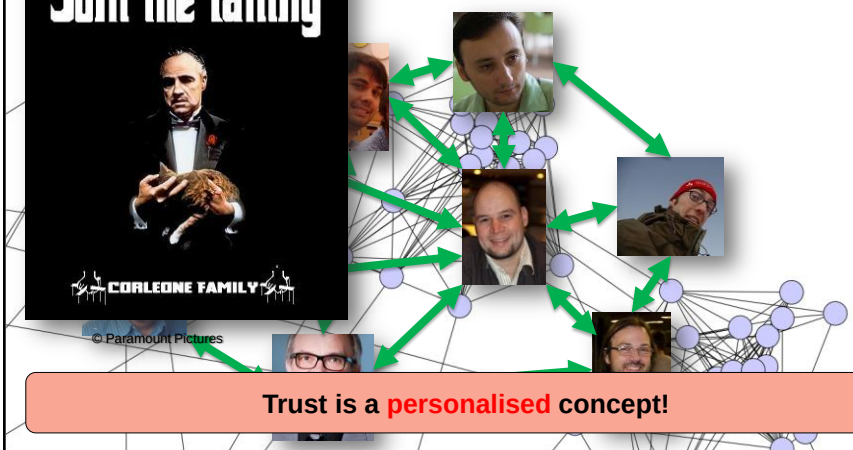


**Trust is a personalised concept!**

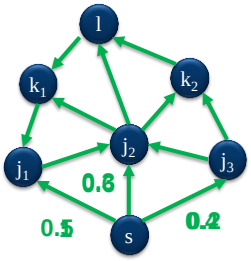
# TrustWebRank

- Network-theoretic approach to personalised, transitive trust [1]
- Assume direct trust matrix $T_{ij} \in [0,1]$
- Normalization of direct trust

$$S_{ij} = \frac{T_{ij}}{\sum_{k \in N(s)} T_{ik}}$$

- (Indirect) trust between $s$ and $l$

$$\tilde{T}_{sl} = S_{sl} + \beta \sum_{j \in N(s)} S_{sj} \tilde{T}_{jl}$$




- Personalised trust measure
- Distributed implementation proposed in [2]

**Exhaustive computation of matrix $\tilde{T}$ is expensive!**

[1] F. E. Walter, S. Battiston, F. Schweitzer: **Personalised and dynamic trust in social networks**. ACM RecSys 2009
[2] V. Carchiolo et al.: **A distributed algorithm for personalized trust evaluation in social networks.** Intelligent Distributed Computing IV, 2010



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# Research goals …

- **Efficiently identify small number of most trusted nodes …**
  **… without exhaustive calculation of trust matrix**
- **Simple and practicable protocol …**
  **… easy to apply in Peer-to-Peer topologies**
- **Tunable mechanism …**
  **… that allows trade-off between accuracy and efficiency**

**Sample from the probability distribution which TWR computes!**

**Perform a biased random walk via trust links and count node visits!**

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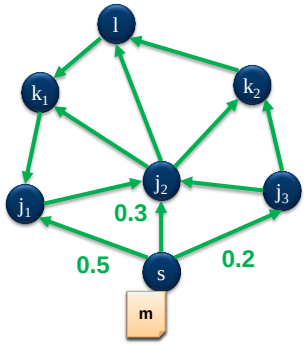
# Sampling indirect trust by random walks …

- **Node $s$ starts random walker**
- **Potential restart after each step …**
  - with prob. $\gamma$ ➔ continue walk
  - with prob. $1-\gamma$ ➔ restart at node $s$
- **Maximum of $W$ restarts**
- **Record visited nodes**
- **Example …**

**Visits:** | $j_1$ | $j_2$ | l | $k_1$ | $j_3$ | $k_2$ | l | $j_1$ | $j_2$ | $k_2$ | l |




**Number of visits of node $l$ is an estimate for $\tilde{T}_{sl}$**



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# A probabilistic protocol

Random walker with W restarts

W+1 dying random walkers

| $j_1$ | $j_2$ | l | $k_1$ | $j_3$ | $k_2$ | l | $j_1$ | $j_2$ | $k_2$ | l |

Node ***s*** has received all died messages m[]

$$visits := \bigcup_i m[i].path$$

$$\tilde{T}_{sv} := \frac{visits.count(v)}{visits.length}$$

Node ***i*** receives message ***msg***:

$msg.visits.add(i)$

$p_j := \gamma \frac{T_{ij}}{\sum T_{ij}}$

*with probability* $p_j$ *do*

$msg.hops := msg.hops + 1$

*send msg to neighbor j*

*with probability* $(1 - \sum p_j)$ *do*

$msg.dead := true$

*send msg to msg.source*

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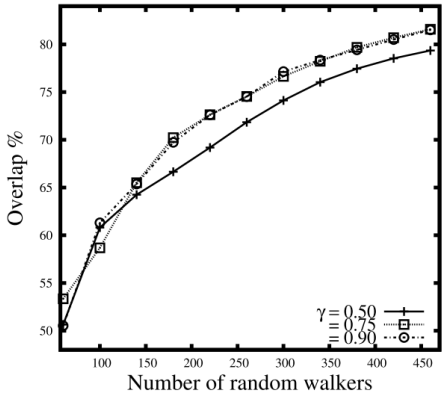
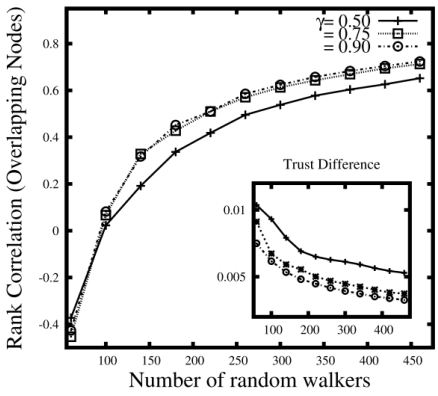
# Experimental Evaluation

**Q: How well do we recover the most trusted nodes?**




$$\frac{|T_{TWR} \cap T_{RWT}|}{|T_{TWR}|}$$

*Erdös-Rényi network*



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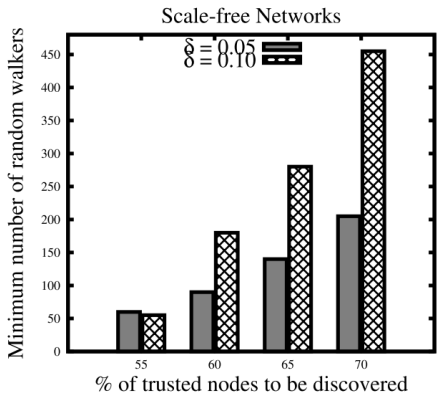
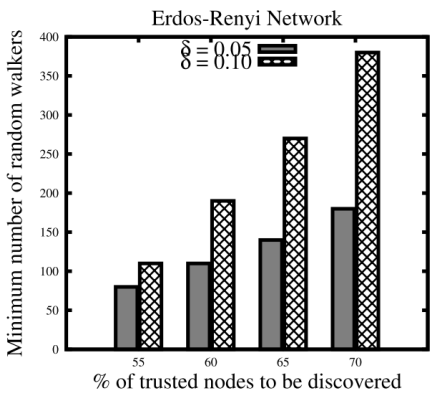
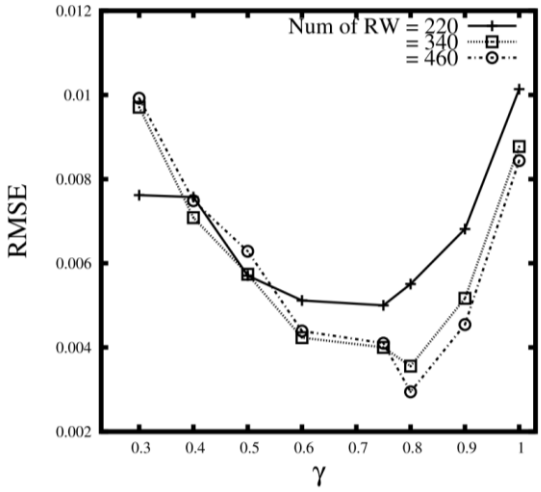
# Minimum number of walkers

**Q: How many walkers are needed to detect most trusted nodes?**



# The role of restarts …




*Scale-free network*



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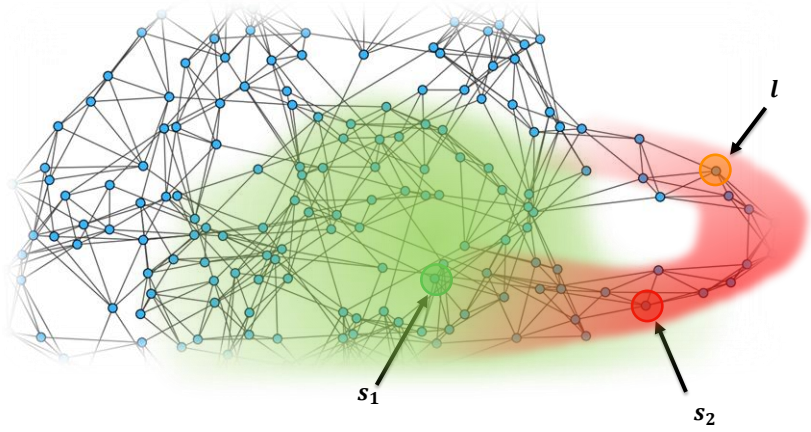
# The role of restarts …

$$Trust(s_1, l) <> Trust\ (s_2, l)$$

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# Conclusion and future steps …

- **Proposed random walk algorithm …**

  … captures the same notion of **personalized trust** like TrustWebRank
  … correctly **identifies most trusted nodes**
  … is **more efficient than TrustWebRank** implementations
  … can be tuned for a **trade-off between efficiency and precision**
  … is **simple** and suitable for P2P applications

- **Current work**
  - Evaluation based on empirical (clustered) trust networks
  - Scalability analysis
  - Extension to other trust propagation schemes



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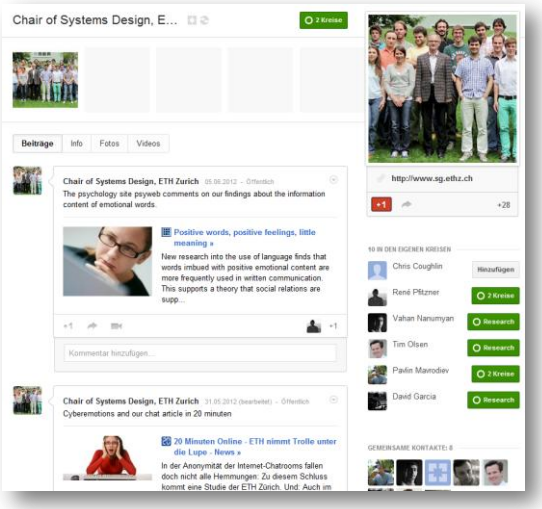


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