

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

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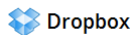


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Motivation

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



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Motivation

IP	Programm	Flags	Proze...	DL-Rate	UL-Rate	Anfra...	Upge-loadet	Geladen	Peer DL
ks369791.kimsufi.com	libTorrent 0.12.9	D H	100.0	265.1 kB/s		48 0		15.7 MB	
dynamic-h12.n2.vanant.tv [uTP]	µTorrent 3.1.3	D HP	100.0	184.4 kB/s		130 0		13.1 MB	
109.254.71.26 [uTP]	µTorrent 3.1.2	D HP	100.0	54.6 kB/s		47 0		4.67 MB	
93-80-48-138.broadband.corbina.ru [uTP]	µTorrent 3.1.3	D HP	100.0	34.0 kB/s		19 0		1008 kB	
94-226-146-136.access.telenet.be	µTorrent 1.8.5	D H	100.0	9.1 kB/s		6 0		528 kB	
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parramatta.lbft.net [uTP]	Transmission 2.52	D HP	100.0	2.0 kB/s		3 0		80.0 kB	
blueanchor.li	Transmission 2.52	D HP	100.0	1.5 kB/s		4 0		80.0 kB	
91.196.244.4 [uTP]	Transmission 2.13	D HP	100.0	0.0 kB/s		2 0		48.0 kB	
regent.lbft.net [uTP]	Transmission 2.13	D HP	100.0	0.0 kB/s		2 0		48.0 kB	
speculum.rbc.ru	Transmission 2.13	D HP	100.0	0.0 kB/s		2 0		48.0 kB	
microschrott.org [uTP]	µTorrent 3.1.3	HP	0.0						
86-122-148-33.rdsnet.ro [uTP]	µTorrent 3.1.3	D H	100.0			2 0			
88-190-18-235.rev.dedibox.fr	Transmission 2.03	D H	100.0						
91.215.30.10 [uTP]	Transmission 2.42	d P	100.0		0.1 kB/s				
78.62.62.92.pntl.ru	KTorrent/4.2.0.0		0.0		0.1 kB/s				
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95-27-118-127.broadband.corbina.ru [uTP]	µTorrent 3.1.3	P	0.0						
c-98-192-59-90.hsd1.ga.comcast.net [uTP]	µTorrent 3.1.3	d HP	100.0						
220.121.30.125.dy.jij4u.or.jp	MLdonkey 3.0.3		0.0						
90-230.195-178.cust.bluewin.ch	libTorrent 0.12.9	H	0.0						
host167.181-14-116.telecom.net.ar [uTP]	Transmission 2.51	D HP	100.0	0.1 kB/s		2 0			

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

Direct trust relation

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Trust propagation

We assume a transitive notion of trust!

→ Indirect trust relation
→ Direct trust relation

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

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Global Reputation?

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Trust is a personalised concept!

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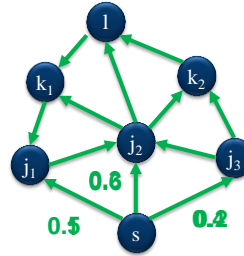
TrustWebRank

- 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

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!

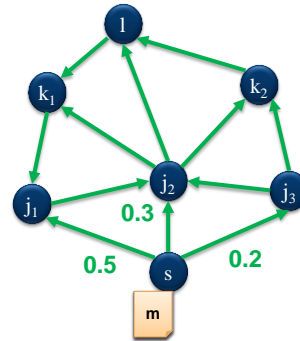
Perform a biased random walk via trust links and count node visits!

Sampling indirect trust by random walks ...

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

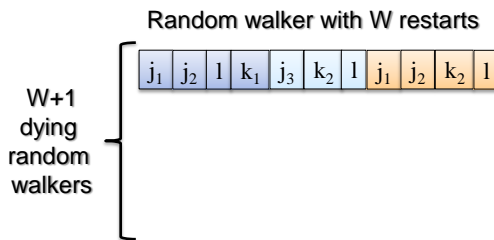
Visits:

j ₁	j ₂	l	k ₁	j ₃	k ₂	l	j ₁	j ₂	k ₂	l
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Number of visits of node l is an estimate for \tilde{T}_{sl}

A probabilistic protocol



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?

Overlap %

Number of random walkers

$\gamma = 0.50$ (solid line, +)
 $\gamma = 0.75$ (dashed line, x)
 $\gamma = 0.90$ (dotted line, o)

Rank Correlation (Overlapping Nodes)

Number of random walkers

$\gamma = 0.50$ (solid line, +)
 $\gamma = 0.75$ (dashed line, x)
 $\gamma = 0.90$ (dotted line, o)

Trust Difference

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

Erdős-Rényi network

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Minimum number of walkers

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

Scale-free Networks

Minimum number of random walkers

% of trusted nodes to be discovered

$\delta = 0.05$ (solid bars)
 $\delta = 0.10$ (cross-hatched bars)

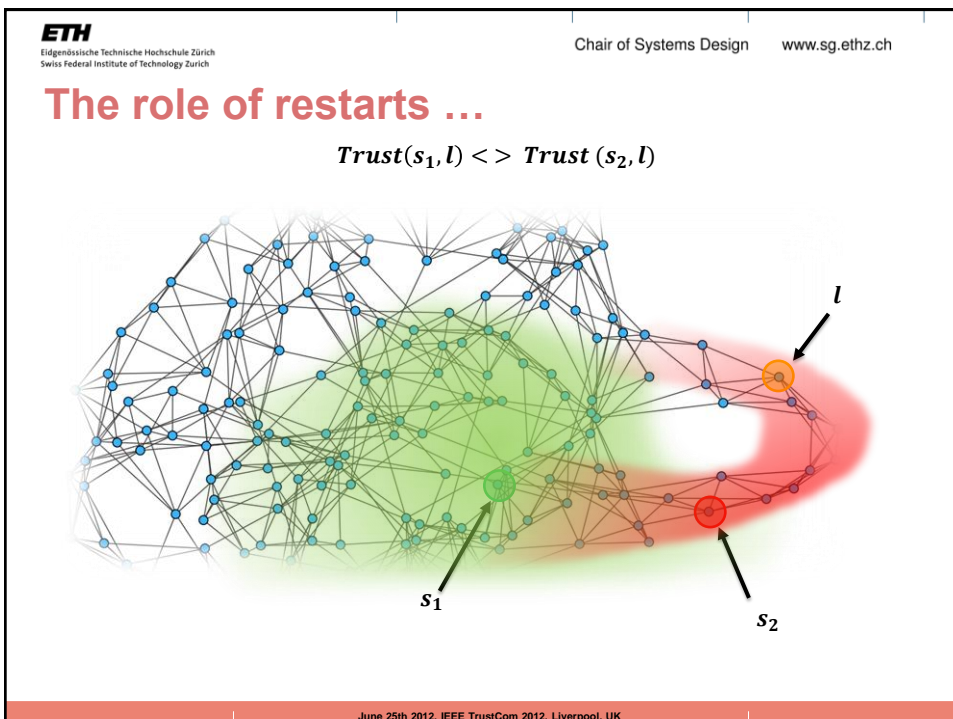
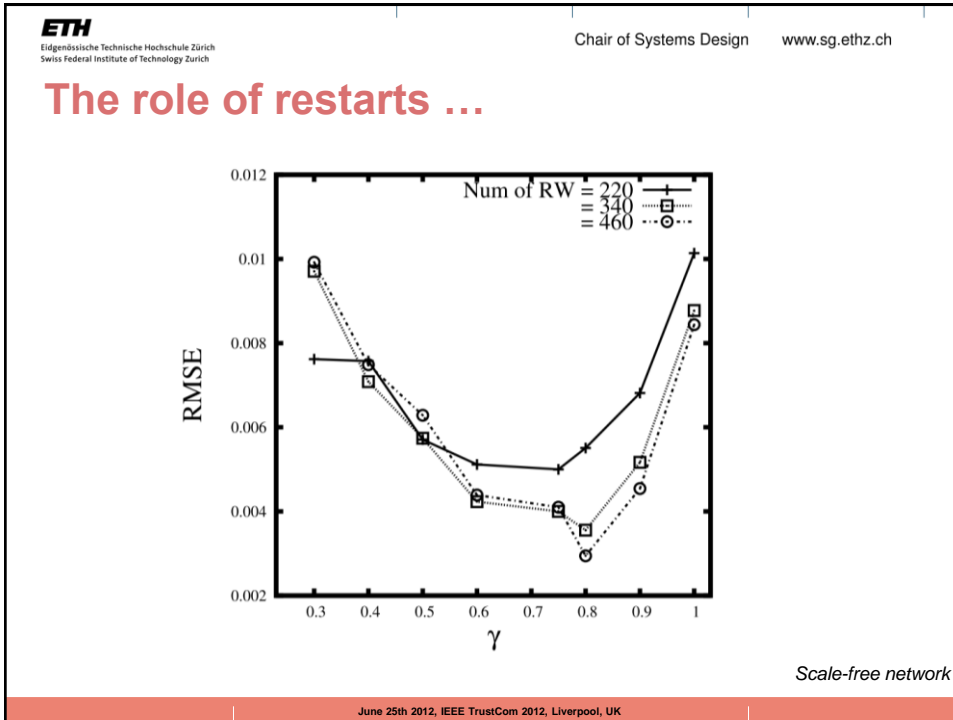
Erdos-Rényi Network


Minimum number of random walkers

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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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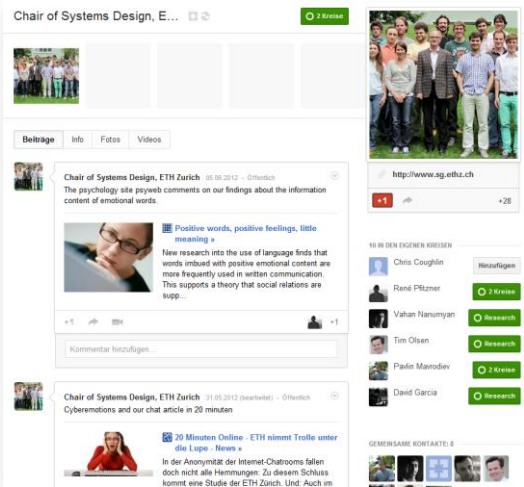


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