The Impact of Competence and Benevolence in a Computational Model of Trust

Ameneh Deljoo, Tom van Engers, Leon Gommand and Cees de Laat

University of Amsterdam

a.deljoo@uva.nl

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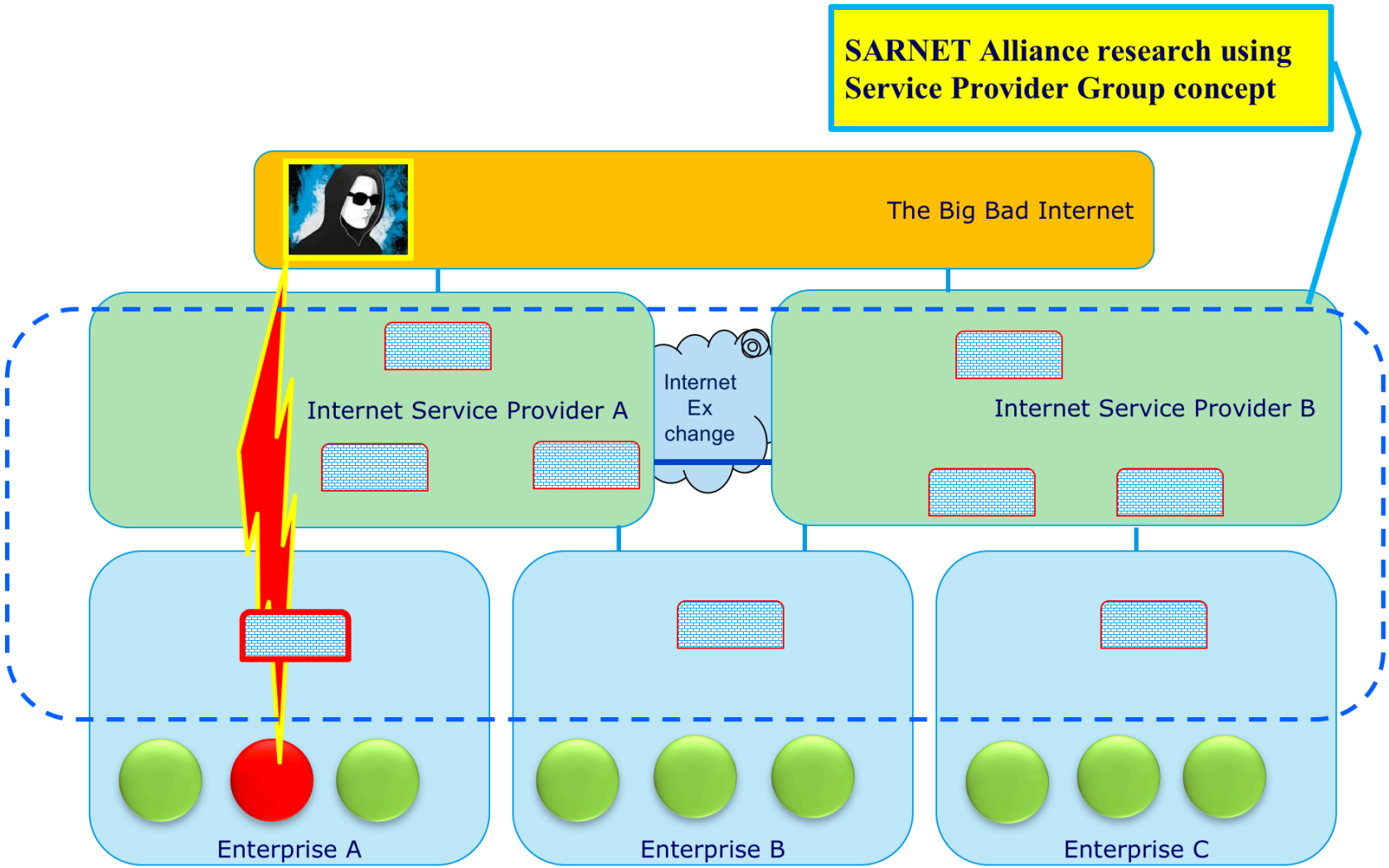
SARNET Alliance Project



Motivation

- Social Networks evolve over time.
- The conditions in the past are not exactly the same as they are now.
- The estimation of trustworthiness is predominant to assess trust between each peer in such network.
- Collaboration with the right partners to work on joint tasks is essential.
- Sharing with these partners that may be competitors in other aspects requires organizing Trust.

Goal

Define a Social Computational Trust Model

- Consider **trustworthiness dimensions** (Benevolence and Competence)
- Consider different **stages** of relationships between each pair (trustee and trustor)
- Estimate trustworthiness in a **dynamic way** by taking into consideration the **situation** and the **development** of the relationship.
- Use the available **evidence** to the trustee by considering different situations to estimate the trustee's benevolence and competence.
- Use an Agent-Based Model

Trust

Inter-organizational trust: as the **expectation** held by one firm that another will not exploit its **vulnerabilities** when faced with the **opportunity** to do so.

- demonstrate **competence** relate to the **potential ability** of the evaluated entity to do a given task,
- act accordingly to fulfill the **commitments** even when acting on them is not in self-interest and accept the consequences, and
- **do good** and act out of kindness even if unforeseen contingencies arise.

Trustworiness' Factors

- Competence
- Integrity
- Benevolence

Hypothesis

The extraction of **benevolence-competence** based information from the set of **evidence** on the **trustee** under evaluation and its use in adequate **stages of the relationship** between truster and trustee shows that trustee's trust- worthiness **improves** by increasing the number of **interactions** between trustor and trustee.

Notation

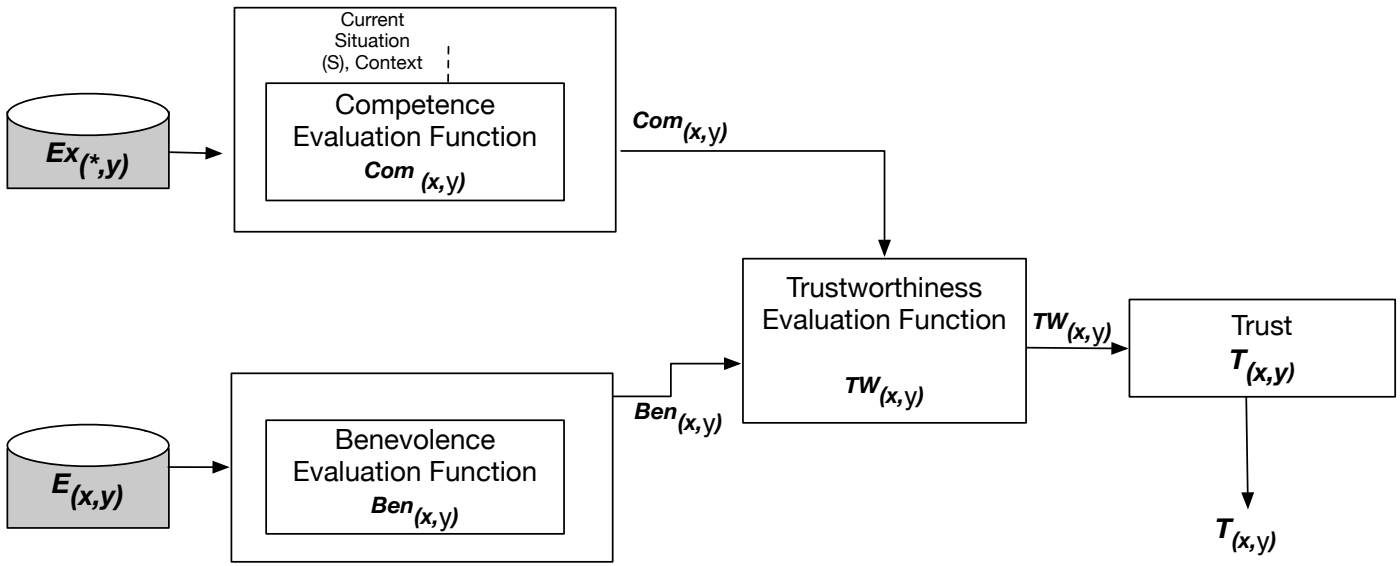
Table: Basic Notation

Description	Representation	Value Range
Agent	x,y	
All the situations	S	
Situations	$\alpha, \beta \in S$	
Society of Agents	$x, y \in A$	
All the situations	S	
Tasks	t	
Context	$D^1 = d_1, d_2, ...d_8$	
d_8	FD, FDD, V	1, 0.5,0
Trust x on y in the situation S	$Tx(y, S)$	[0,1]
All the available evidence on y	$E(*, y)$	[0,1]
All the available direct evidence on y	$E(x, y)$	[0,1]

[1]

- d_1 = trustor, d_2= trustee
- d_3 = time, d_4= location, d_5= task, d_6= complexity, d_7= deadline

Social Computational Trust Model



Trustworthiness Function: Benevolence

- $Benevolence_{(x,y)} \in [0, 1]$

$$Ben_{(x,y)} = \frac{1}{|S^a|} \sum_{E_{(x,y)}} (val(E_{(x,y)})). \quad (1)$$

[a] Where S is the set of situations, in which x has interactions with y.

Trustworthiness Function: Competence

$Competence_{(x,y)} \in [0, 1]$

- There is no evidence available from the trustee.

$$Risk = \frac{Cost \times (1 - Pr^a)}{benefit \times Pr}, \tag{2}$$

- Situation β: there are some evidence but not for the considered context.

$$Com = \frac{1}{|N|} \sum_{\beta \in N} (val(E_{*,y}) \times \widehat{T}_x(y, \beta)^b), \tag{3}$$

$\widehat{T}_x(y, \beta) = 1 \,/\, |N| \sum_{\beta \in N} T_{(x,y)}$.

- Situation α: there is related evidence about the agent in this context.

$$Com = \frac{1}{|N|} \sum_{\alpha \in N} (val(E_{*,y})), \tag{4}$$

[a] where Pr is the probability of performing the task by the given trustee.

[b] where $\widehat{T}_x(y, \beta)$ denotes the basic trust and β is the set of all situations.

Calculate Trustworthiness Algorithm

Algorithm 1 Calculate $TW_{(x,y)}$

Require: $E_{(*,y)}$: the set of all evidence about trustee y.
Require: $N_{ben} = 2$: minimum interaction between trustee and trustor.
Ensure: $E_{(x,y)} \notin E_{(*,y)}$

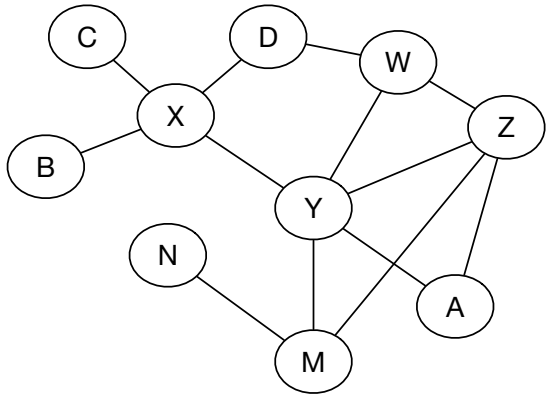
$N_{(x,y)} \leftarrow |E_{(x,y)}|$
$Ben_{(x,y)} \leftarrow F(Ben_{(x,y)})$
$Com_{(x,y)} \leftarrow F(Com_{(x,y)})$
$TW_{(x,y)} = Com_{(x,y)} + Ben_{(x,y)}$
return $TW_{(x,y)}$

Simulation Setup

- Agent-Based Simulation (Jadex tool)
- Collaborative Network
- Estimate trustworthiness of different members

Assumptions:

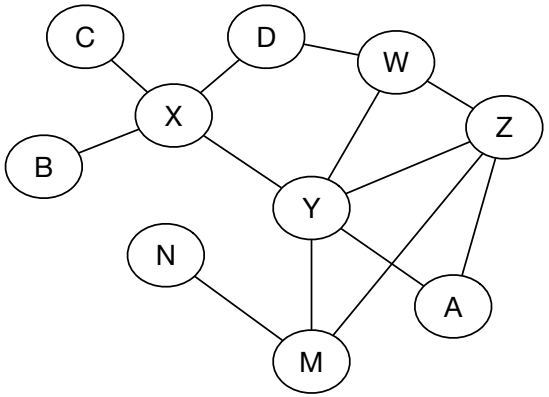
- Only one task being negotiated,
- Agents are honest,
- There is no conflict on the evidence, and
- Message are encrypted.



Simulation Setup Cont.

Task: Mitigate an attack (e.g. DDOS)
Situations

- S_1: provides a specific number of samples within 24 hours,
- S_2: provides a specific type of resource (e.g. allocating resources),
- S_3: blocks a link, and
- S_4: monitors a specific traffic.



Result

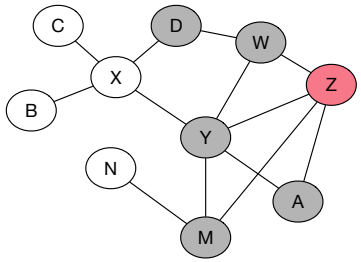
Table: $Ben_{(x,y)}$ evaluation for the number of rounds

No. of rounds →	20	50	100
$Ben_{(x,y)}$	*0.22*	0.31	**0.86**
SD^2	*0.113*	0.105	**0.081**
M	*0.762*	0.777	**0.810**

[2] including mean M and standard deviation SD.

Simulation Setup Cont.

Table: Agent x asks different Agents' opinion about agent z in the four situations



Situation $\rightarrow$	s_1	s_2	s_3
Y	FDD	FD	FDD
M	FDD	FD	FDD
W	FDD	FD	FDD
D	FDD	FD	FDD
A	FDD	FD	FDD

Result Cont.

Table: Competence evaluation for agents a, z and y and the number of rounds

No. of rounds $\rightarrow$	20	50	100
$Com_{(x,a)}$	*0.21*	0.40	**0.65**
$Com_{(x,z)}$	*0.28*	0.43	**0.88**
$Com_{(x,y)}$	*0.18*	0.33	**0.54**
SD_a	*0.059*	0.051	**0.048**
SD_z	*0.068*	0.058	**0.042**
SD_y	*0.081*	0.066	**0.041**
M_a	*0.927*	0.938	**0.941**
M_z	*0.910*	0.927	**0.947**
M_y	*0.917*	0.936	**0.962**

Conclusion and Future Work

Conlusion

- The benevolence and competence of trustees are increased as the number of interaction increases.
- We have proved that the trustworthiness estimation grew with the increasing number of interactions between any trustor-trustee pair.
- Trustor and trustee's behaviors evolve based on different stages of existing relationships between them.

Future Work

- Integrity based trustworthiness.
- Evaluate our framework against the badmouthing attacks and non-compliant members.
- Evidential reasoning in the case of conflicting on evidence.

The End

Ameneh Deljoo
a.deljoo@uva.nl