Social Computational Trust Model (SCTM): A Framework to Facilitate the Selection of Partners

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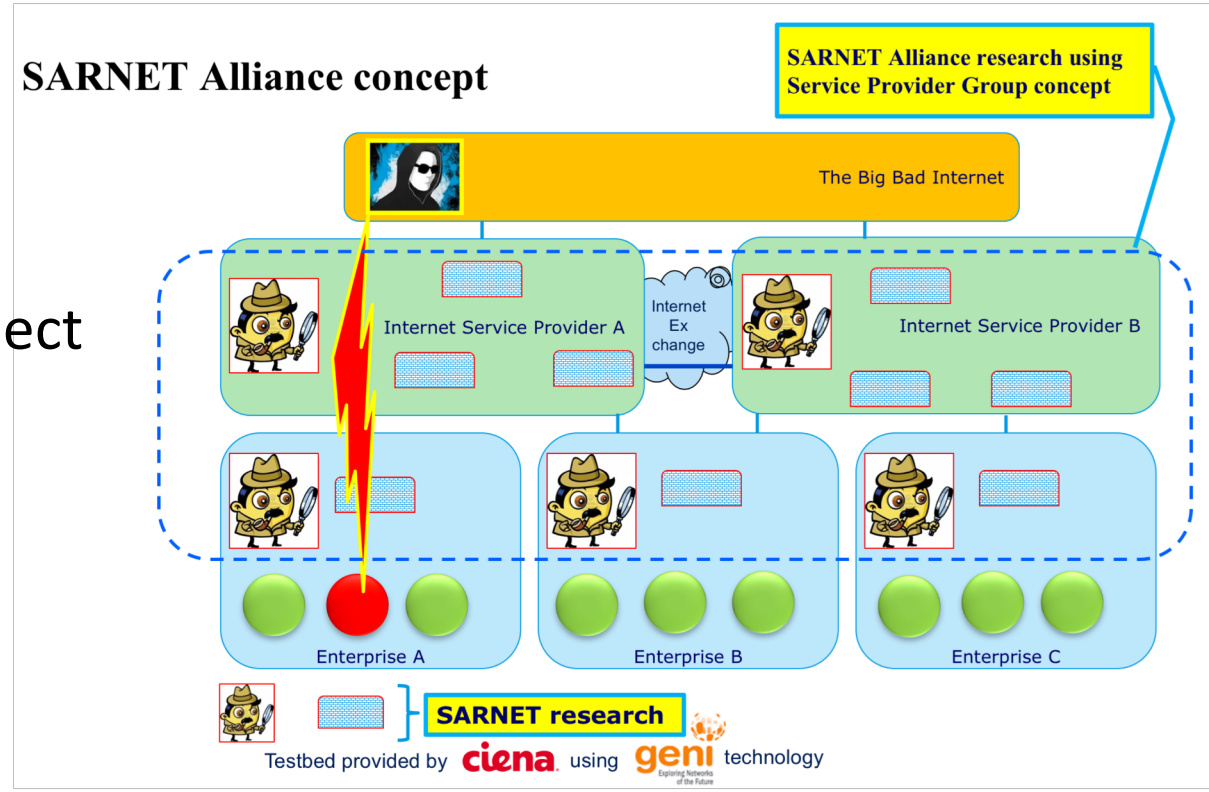
Motivation

- Network of organizations evolve over time and become more complex,
- Find a “right” partner is a challenging task

We need to:

- Define a more **sophisticated** and **computationally executable** method to select the “**right**" partner for **sharing data** and **intelligence**.



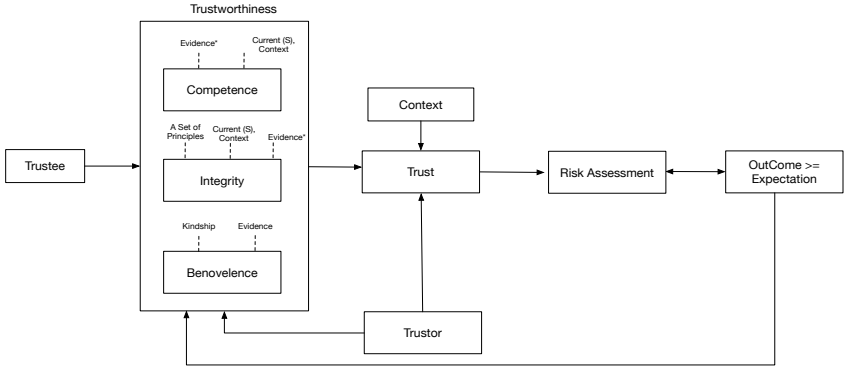
Contributions

- **The Social Computational Trust Model (SCTM)** represents social trust and its components, which are important for evaluating the partners.

- **Risk assessment** through the SCTM model. The SCTM facilitates risk-based partner selection to select the **“right"** partner to collaborate in joint tasks.

Trust and its Antecedents

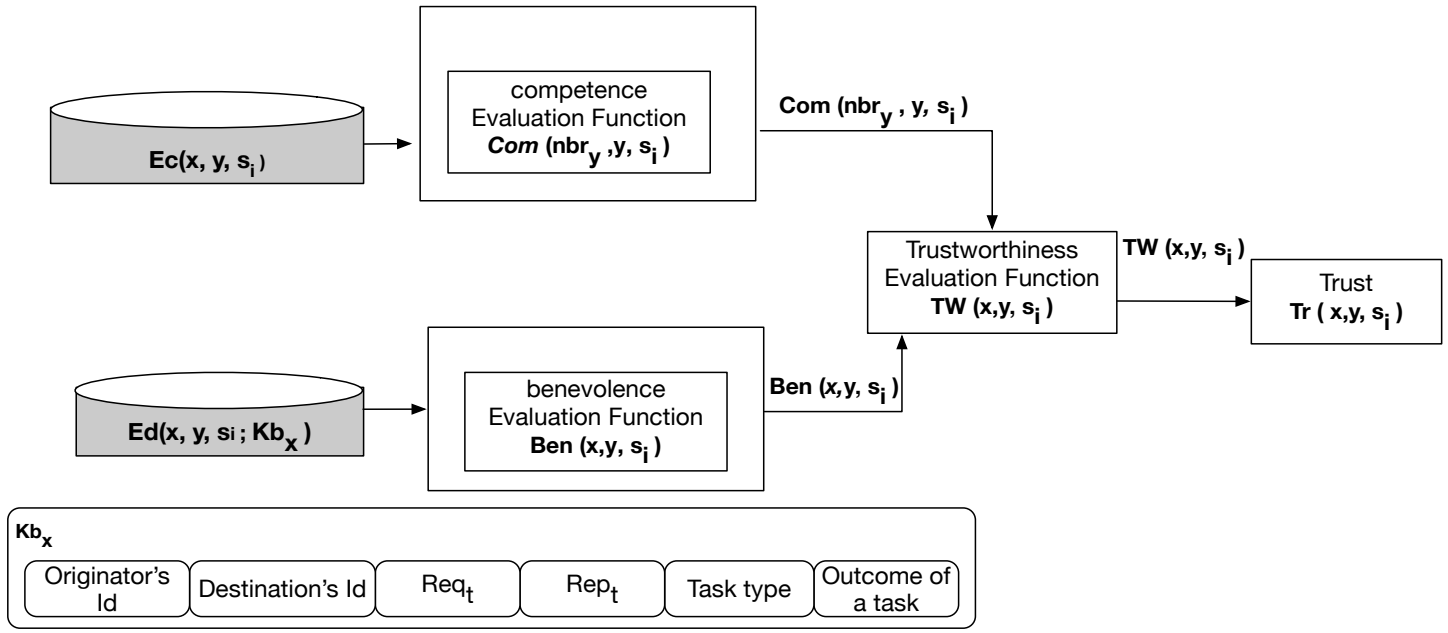
- "x" expects "y" to do task (τ) and "y" will not exploit vulnerabilities of "x" when "y" faced with the opportunity to do so. Therefore, "y":
  - Has the **potential ability** to perform a given task (competence),
  - **Adheres** to a set of **rules** agreed upon and acts accordingly to **fulfill the commitments** (integrity), and
  - **Acts** and does **good** even if unexpected contingencies arise (benevolence).



Adopted from Mayer et al. (1995) ``An Integrative Model of Organizational Trust''

Social Computational Trust Model (SCTM)

- Identify two distinctive trustworthiness factors (Benevolence and Competence)
- Evaluate Trust in a dynamic way
- Gather the direct and indirect evidence on a trustee
- Update Trust value



[1] Integrity has been considered as a part of Benevolence function.

Notation

Description	Representation	Value Range
Agent	x,y	
Society of Agents (trustor, trustee)	$x, y \in A$	
Knowledge based of trustor x	Kb_x	
Set of Situations	$S = \{s_1, s_2, ..s_n\}$	
Tasks	τ	
Sub-tasks	$\tau_{s1}, ...\tau_{sn}$	
Context	$D = \{d_1, d_2, ...d_8\}$[1]	
d_8	$\{Fd, Fdd, V\}$	1, 0.5, 0
All the direct evidence on y in the situation s_i	$Ed(x, y, s_i; Kb_x)$	
All the available evidence on y from y's neighbors in the situation s_i	$Ec(nbr_y, y, s_i)$	
Trustee's trustworthiness toward trustor x in the situation s_i	$TW(x, y; s_i)$	[0,1]
Trust x on y in the situation s_i	$Tr(x, y; s_i)$	[0,1]

[1]Dimensions are: d1 = trustor, d2= trustee , d3 = time, d4= location, d5= task, d6=complexity, d7= deadline, d8= Outcome

Dimensions

In order to define the situations that lead to an agreement between a trustor and a trustee:

- d_1 = trustor,
- d_2= trustee ,
- d_3 = time,
- d_4= location,
- d_5= task,
- d_6=complexity,
- d_7= deadline,
- d_8= Outcome
- Three different outcome of tasks
  - $Fd(Fullfil\ duty)$
  - $Fdd(Fullfil\ duty\ with\ delay)$
  - $V(Violate)$

$$\text{val}\,(d_8) = \begin{cases} 1\,, & if\ d_8 = Fd \\ 0.5\,, & if\ d_8 = Fdd \\ 0\,, & if\ d_8 = V \end{cases}$$

Calculate the Outcome

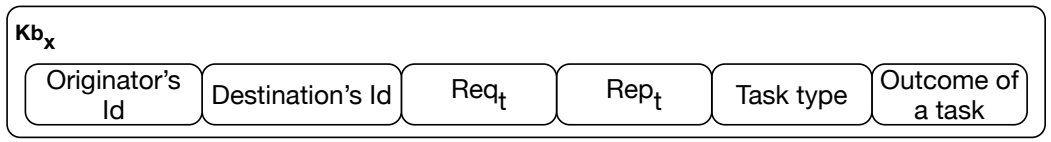
- d_8= Outcome
- Three different outcome of tasks

$$Fd(Fullfil\ duty)$$
$$Fdd(Fullfil\ duty\ with\ delay)$$
$$V(Violate)$$

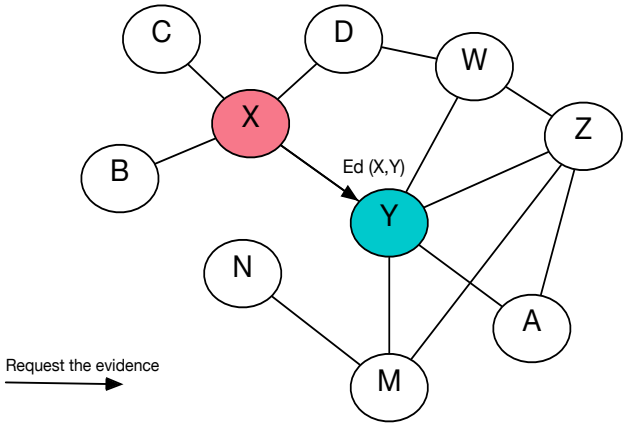
$$\text{val}\ (d_8) = \begin{cases} 1\ , & if\ d_8 = Fd \\ 0.5\ , & if\ d_8 = Fdd \\ 0\ , & if\ d_8 = V \end{cases}$$

Algorithm 1 Calculate the Outcome Based on the Task's Deadline.

Require: $Time_w$: time window.
Require: Req_t: request time.
Require: Rep_t: report time.
$d_7 = Rep_t - Req_t$
if $d_7 <= Time_w$ **then**
$d_8 = Fd$
else if $d_7 > Time_w$ **then**
$d_8 = Fdd$
else if $d_7 = 0$ **then**
$d_8 = V$
end if
return d_8



Evidence Gathering: Direct evidence



❖A trustor looks at its Kb to collect the evidence on a trustee based on past interactions.

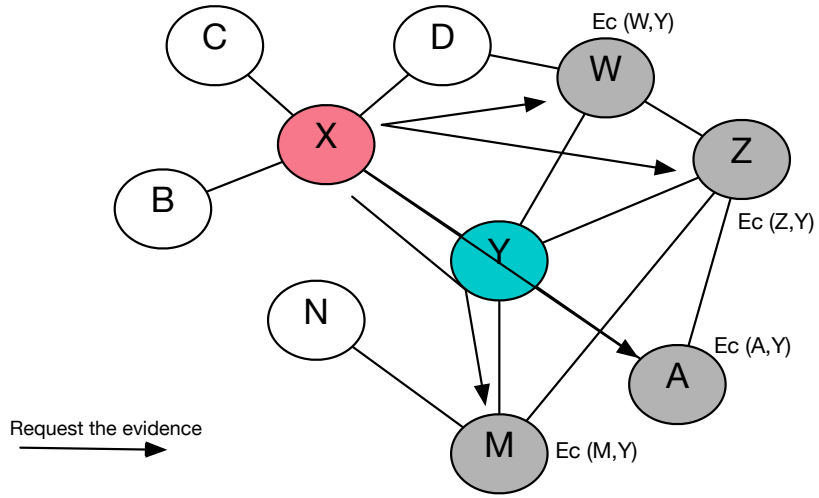
$$val_d(.) \longrightarrow [0,1]$$

$$Ed(x, y, s_i; kb_x) = \{d_8(\text{x, y},s_i) \in kb_x\}$$

$$val_d(Ed(x, y, s_i; kb_x)) = \frac{1}{N_x}\sum_{d_8(x,y,s_i)\in Ed(x,y,s_i;\, kb_x)} val(d_8(\text{x, y},s_i))$$

$$\text{val}\,(d_8) = \begin{cases} 1\,, & if\ d_8 = Fd \\ 0.5\,, & if\ d_8 = Fdd \\ 0\,, & if\ d_8 = V \end{cases} \quad , N_x = number\ of\ enrties\ in\ the\ Kb's$$

Evidence Gathering: Indirect evidence



❖A trustor asks a trustee's direct neighbors to send him their evidence on a given trustee.

$$val_c(.) \longrightarrow [0,1]$$

$$Ec\,(nbr_y, y, s_i) = \{\, Ed(u, y, s_i, kb_u) \mid u \in nbr_y \}$$

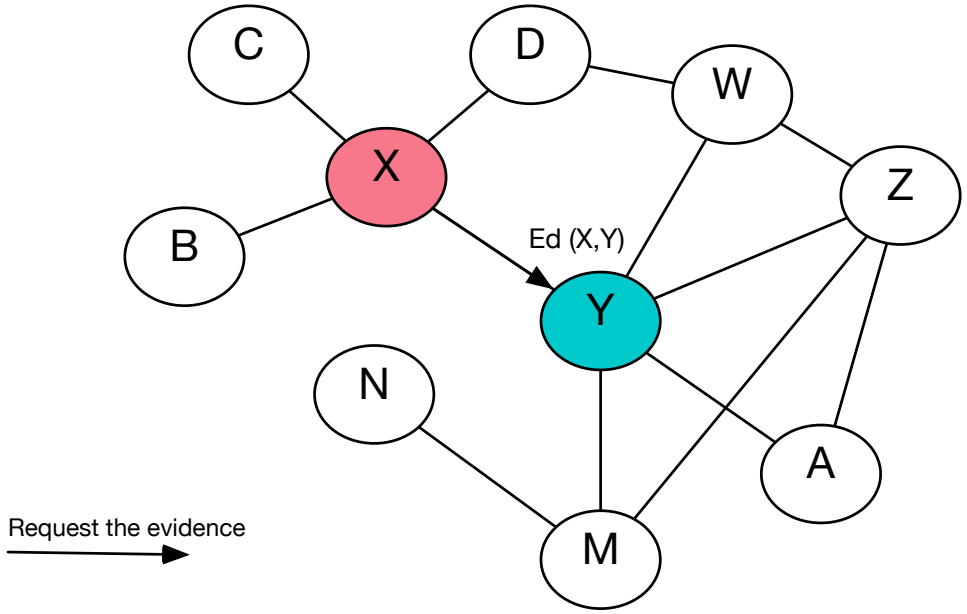
$$val_c(Ec(x, y, s_i)) = \frac{1}{N_{nbr}} \sum_{Ed(u,y,s_i;\, kb_x) \in Ec(nbr_y, y,\, s_i)} val_d(Ed\,(u, y, s_i; kb_u))$$

$N_{nbr} = number\ of\ neighbors\ that\ contribute\ to\ the\ val_c$

Benevolence Function

❖Based on the **direct** interactions between $trustor\ x\ and\ trustee\ y$ in the situation s_i.

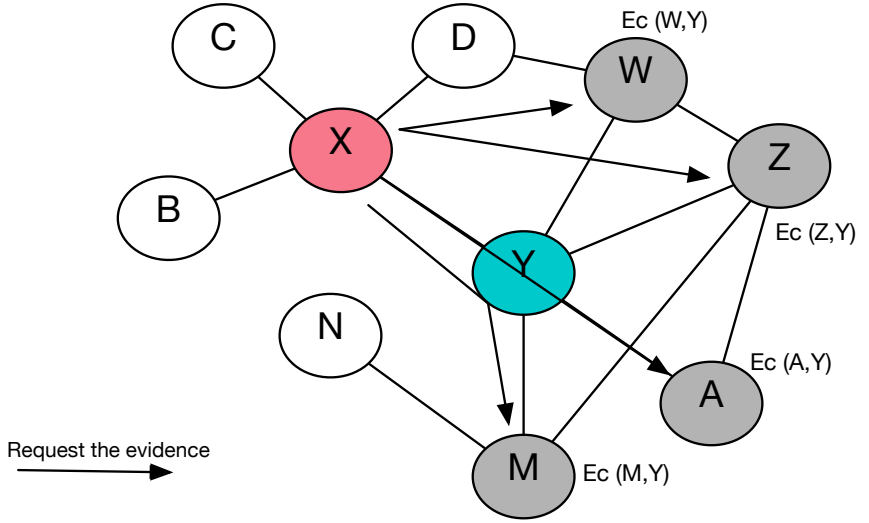
$$Ben(x, y, s_i) = val_d(Ed(x, y, s_i, kb_x))$$



Competence Function

❖Evaluate based on the **all available** evidence on Trustee (e.g. y,z)

$$Com\left(nbr_y, y, s_i\right) = val_c\left(Ec\left(nbr'_y, y, s_i\right)\right), nbr'_y = nbr_y \backslash \{x\}$$



Deljoo, Ameneh, et al. "The Impact of Competence and Benevolence in a Computational Model of Trust." IFIP International Conference on Trust Management. Springer, Cham, 2018.

Estimating Trust[1] based on Competence and Benevolence functions

$$Tw(x, y, s_i) = \frac{1}{2}(Com(nbr_y, y, s_i) + Ben(x, y, s_i))$$

$$Tr(x, y, s_i) = Tw(x, y, s_i)$$

[1] Integrity has been considered as a part of Benevolence function.

Risk Estimation

Risk Estimation

Interaction Risk $(R_i(x, y, s_i))$ in the Alliance Consists of:

- Relational Risk $\left(R_r(x, y, s_i)\right)$: The **probability** and **consequence** of **not having** a successful cooperation.
- Performance Risk $(R_p(x, y, s_i))$: The **probability** and **consequences** that alliance **objectives** are not **realized** despite **satisfactory cooperation** among the partner.

Propositions

Proposition1

Benevolent[1] behavior of partners **increases trust** and **reduces** former perceived **relational risk** in the alliance.

$$R_r(x, y, s_i) \propto (1 - Ben(x, y, s_i))$$

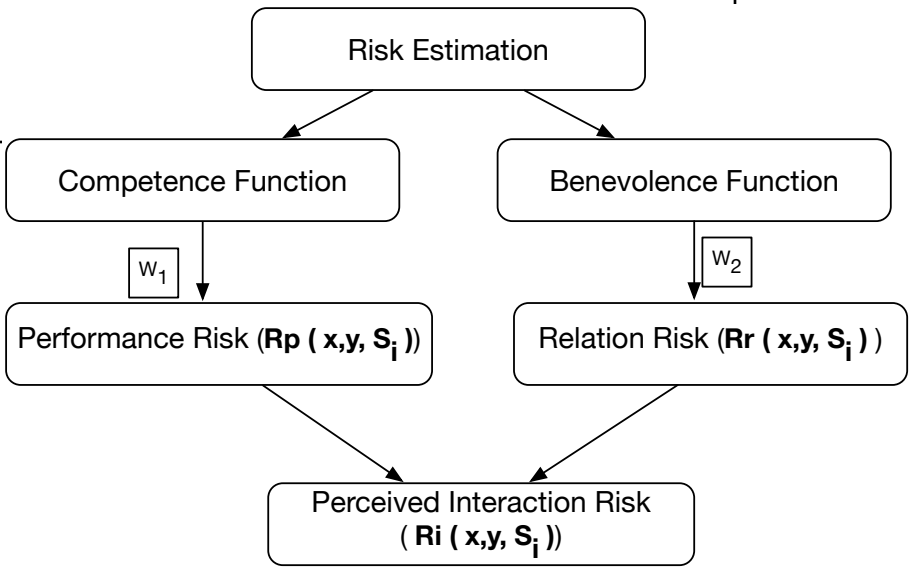
Proposition 2

The **perceived performance risk** will be **reduced** if the competence of the given member is **high**.

$$R_p(x, y, s_i) \propto \left(1 - Com\left(nbr_y, y, s_i\right)\right)$$

[1]Some of the scholars consider faith and good intentions instead of benevolence.

Interaction risk



Interaction Risk is given by:

$$R_i(x, y, s_i) = R_r(x, y, s_i) + R_p(x, y, s_i)$$

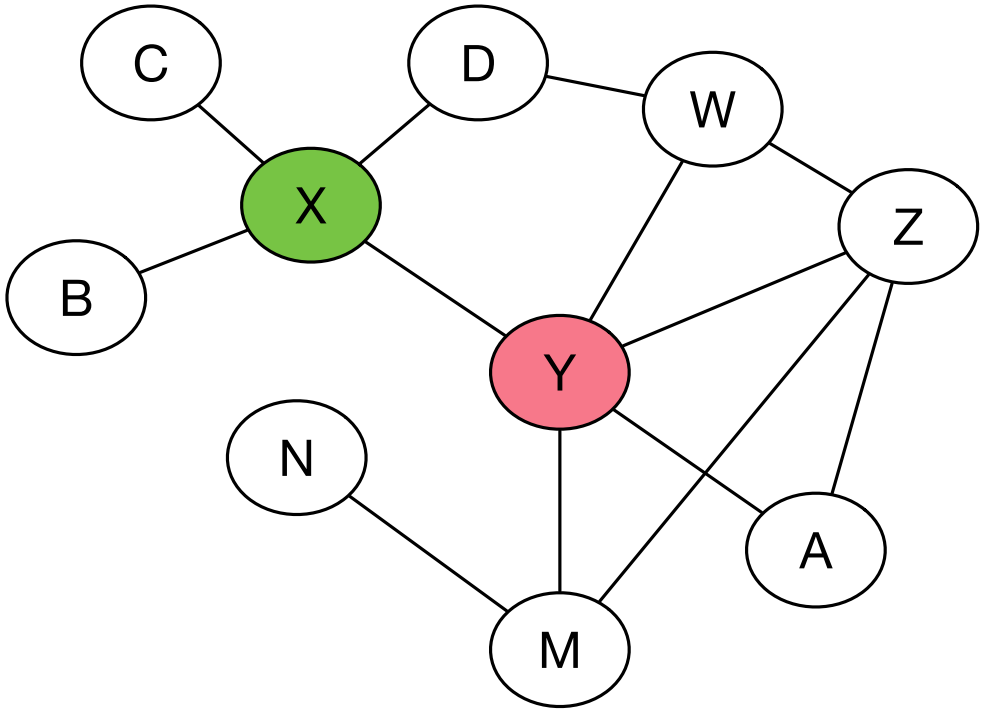
$$R_i(x, y, s_i) = w_1(1 - Com(x, y; s_i)) + w_2\big(1 - Ben(x, y; s_i)\big)$$

$$R_i(x, y, s_i) = \alpha\Big(1 - Com\big(nbr_y, y, s_i\big)\Big) + (1 - \alpha)\big(1 - Ben(x, y, s_i)\big), \qquad 0 \le \alpha \le 1$$

$w_1 = \alpha$, $w_2 = 1 - \alpha$

T. Das, B.-S. Teng, Risk types and inter-rm alliance structures, Journal of management studies 33 (6) (1996) 827{843.

Case Study



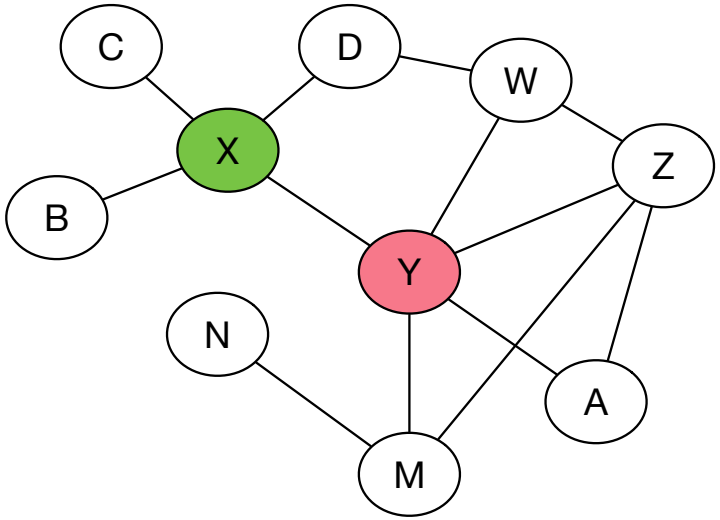
A Collaborative Network

Simulation settings and their illustrations

Parameters	Values	Illustrations
A	Fixed	Number of nodes in the network
τ	Fixed	Type of task (defend and mitigate the attack)
N_x	6	Number of entries in the Kbs
$t_{request}$	Initiate the simulation	Request time
t_{report}	Receive the feedback on the request	Report time
Δt_w	10 s	Time window
α	0.3	Weight factor
S	4	number of situations
τ_s	4	number of sub-tasks

Scenario

Domain “N” wants to choose ideal domains for collaboration in order to **mitigate and defend against a certain attack.**



Task (τ): Mitigate and defend against a certain attack.

Sub-tasks:

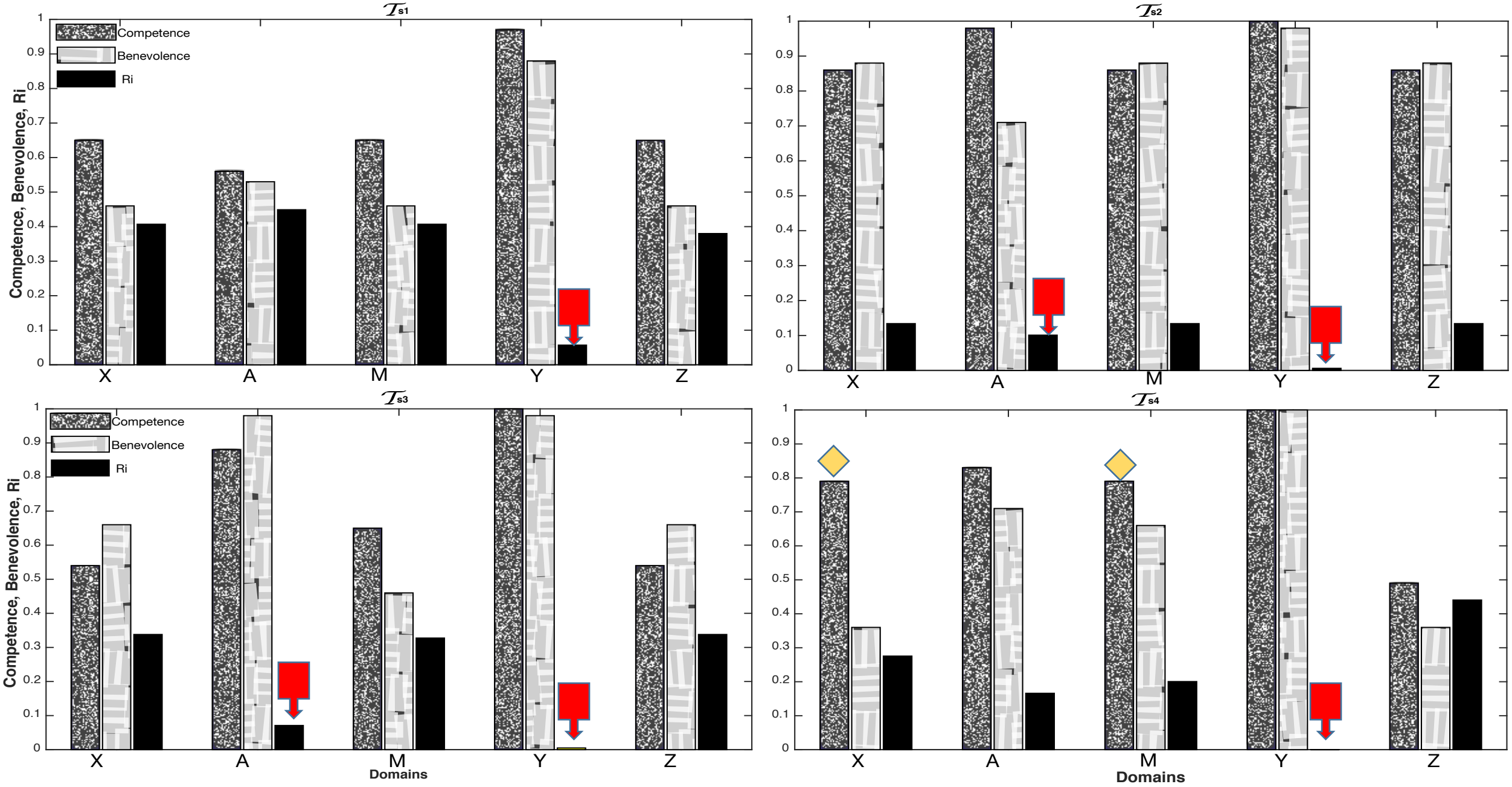
- τ_{s1}: provide resources within a certain time window,
- τ_{s2}: monitor a certain traffic,
- τ_{s3}: block a certain link,
- τ_{s4}: implement a certain counter measurement.

Selecting a “right” partner algorithm

Algorithm 2 Selecting a “right” partner (trustee) to collaborate on performing a task. Input: benevolence, competence and $Ri(x, y, s_i)$

1: Employ the benevolence (see Section 3.3) and the competence (see Section 3.4) functions to calculate the competence and benevolence for all the members.
2: Identify the first trust discriminator for each task to assign the weight to each factor.
3: Use the value of the benevolence and competence to evaluate the interaction risk for each member (see Section 5).
4: Recommend a domain for each task such that its estimated interaction risk $Ri(x, y, s_i)$ is minimal.
5: **if** two members have the same $Ri(x, y, s_i)$ **then**
6: Select a member with the maximum benevolence value.
7: **end if**
8: **return** Selected member(s)

Result

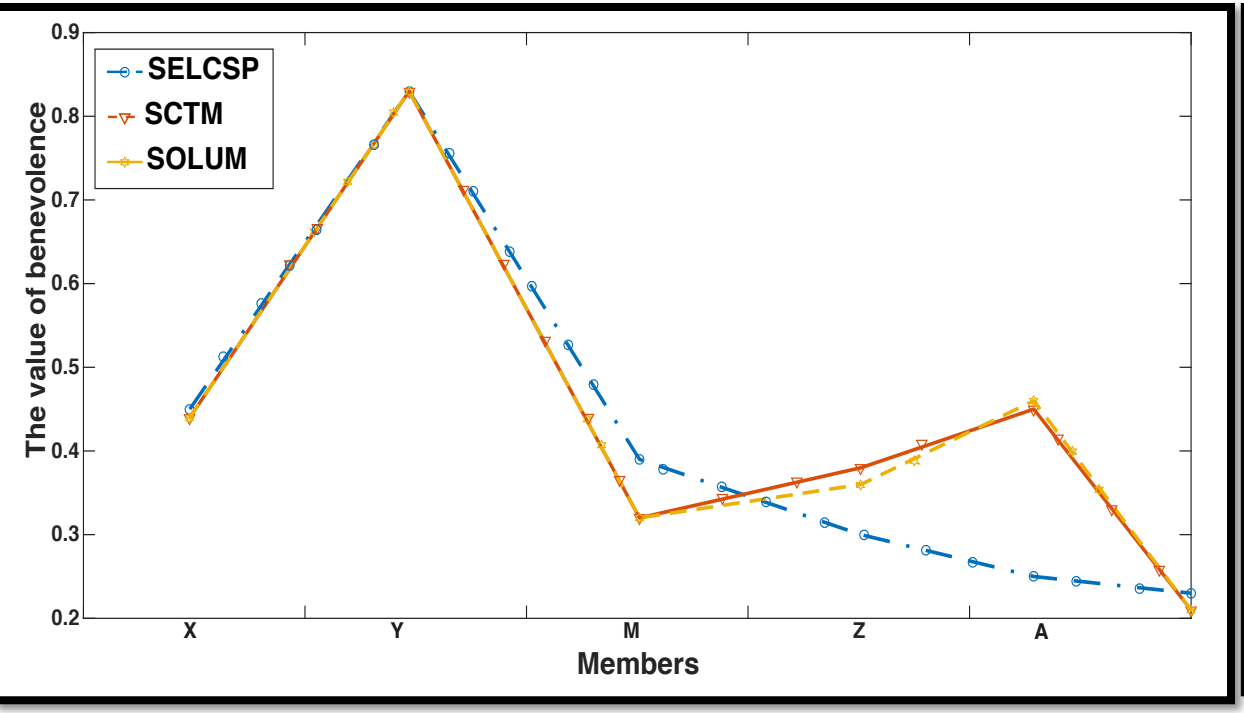

$\mathcal{T}_{s1}$
$\mathcal{T}_{s2}$
$\mathcal{T}_{s3}$
$\mathcal{T}_{s4}$
Competence
Benevolence
Ri
Competence, Benevolence, Ri
X
A
M
Y
Z
Domains

Evaluation

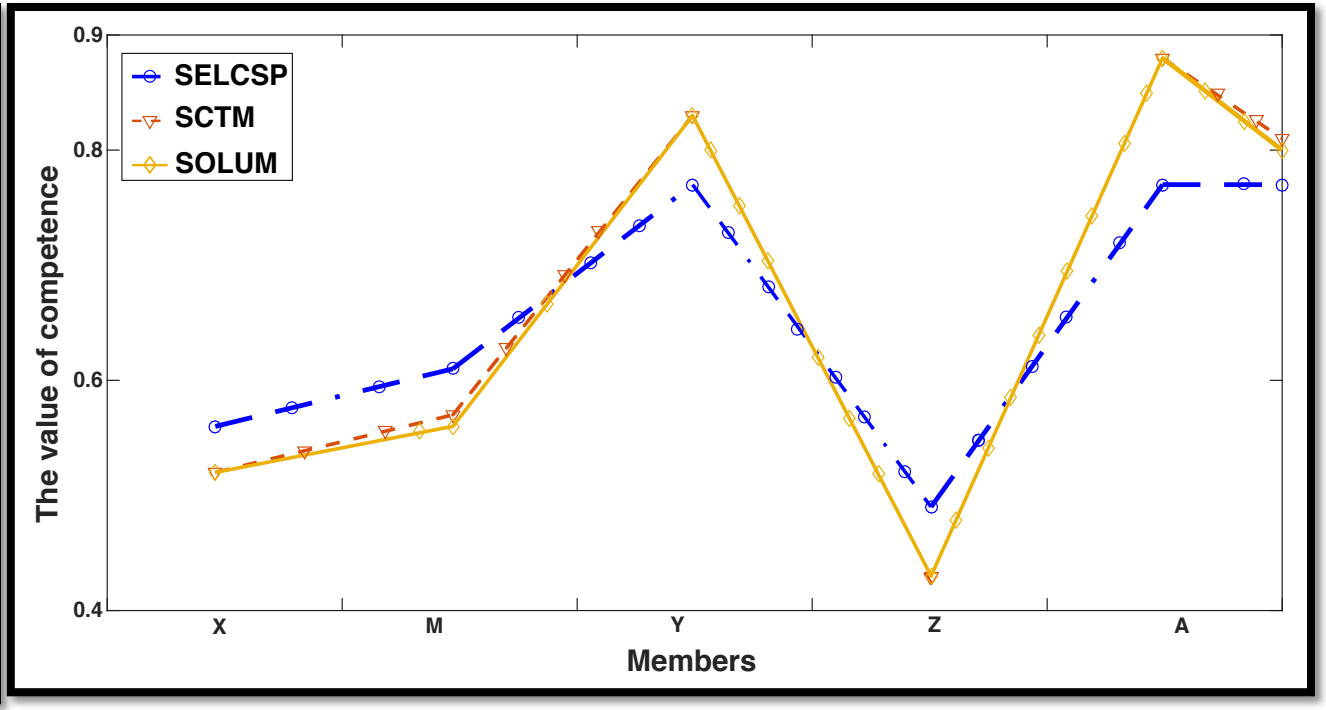
- Epinion[1] dataset a popular product review site.
  - Each user gives a trust value (–1 to 1) on other users.
  - And gives feedback ratings (1 to 5) on entities/items.
- V = 1, Fdd = 2 and Fd = 3; 4; 5.
- Select five items from the dataset and evaluate benevolence and competence of each item.
- SELCSP Algorithm and SOLUM Algorithm.

[1]http://www.trustlet.org/epinions.html

Evaluation Result



The value of benevolence for three different algorithms



The value of competence for three different algorithms

Conclusion

- To **evaluate** the **trustworthiness** of a trustee the **direct** and **indirect** evidence on the given trustee were taken into account.
- The **trust** value is computed by **two** trust factors, namely **competence** and **benevolence**.
- **Benevolence** is computed from **direct** evidence between a trustee and a trustor
- **Competence** is assessed on the base of the **received feedback** from the other alliance members (a trustee's direct neighbors).
- We are able to collect a **variety of evidence** on a trustee by introducing **eight dimensions** for each context.

Conclusion

- The **interaction risk** estimated through the **SCTM** by combining **benevolence** and **competence**.
- The **weighting factors** used to determine different weights to define the main trust factors in different trusting scenarios.
- We have shown that the **stability** of the alliance is **dependent** on the value of **benevolence** that led to a **lower interaction risk**.
- We demonstrated that the SCTM is able to obtain **comparable results** to the other trust models that we evaluated.

Thank you.

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