Context-aware Trust Evaluation Functions for Dynamic Reconfigurable Systems

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General

• Work conducted in terms of the ITEA/Trust4All project
• Joint work with Telematica Instituut (The Netherlands)
• Work in progress

• Observation: Contextual information often has influence on trust
• Research subject: How to take context into account in trustworthiness evaluation?
Outline

- Terminology
- Motivation and point of departure
- Example
- Trustworthiness evaluation
- Ongoing and future work

Trust4All Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Explanation</th>
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</thead>
<tbody>
<tr>
<td>Trust</td>
<td>Subjective unidirectional relationship between the trustor and the trustee.</td>
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<tr>
<td>Trustor</td>
<td>The subject of the trust relationship.</td>
</tr>
<tr>
<td>Trustee</td>
<td>The object of the trust relationship.</td>
</tr>
<tr>
<td>Trustworthiness</td>
<td>The degree of which the trustor considers the trustee as trustworthy, preferably expressible with a (numerical) value.</td>
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<tr>
<td>Trustworthiness evaluation</td>
<td>The process executed by the trustor in order to determine the trustworthiness of the trustee.</td>
</tr>
<tr>
<td>Quality attributes</td>
<td>Attributes of the trustee, which are “mandatory” for executing the trustworthiness evaluation, typically maintain more static values than the context attributes.</td>
</tr>
<tr>
<td>Context attributes</td>
<td>&quot;Optional&quot; attributes used for tuning the trustworthiness evaluation process.</td>
</tr>
<tr>
<td>Trust scope</td>
<td>An instrument used case by case for dividing trustee’s attributes into quality attributes and context attributes.</td>
</tr>
<tr>
<td>Reputation</td>
<td>Trustor’s opinion on the trustee, based on past experiences.</td>
</tr>
<tr>
<td>Recommendation</td>
<td>Reputation of the trustee in the eye of someone else than the trustor, but transmitted to the trustor.</td>
</tr>
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Motivation and Point of Departure

- Degree of trust varies based on the situational details
  - Take this into account in trustworthiness determination process

- Trust scope \( \sigma \)
  - Trust evaluation is performed given some \( \sigma \)
  - "goal" of the trustor
  - Set of Attributes (A)
    - Quality Attributes (Q)
    - Context Attributes (C)
  - Context-insensitive trust evaluation utilizes only Qs
  - Context-aware trust evaluation tunes this with Cs
  - Division into Cs and Qs depends on the current \( \sigma \)

![Diagram of trust relationships and attributes](image_url)

Example: Game Component Download

<table>
<thead>
<tr>
<th>Player / Game Application</th>
<th>Composition</th>
<th>Game Manager (GM)</th>
<th>Game Scenario (GS)</th>
<th>GM Provider</th>
<th>GS Provider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trustor</td>
<td>Trustee</td>
<td>Trustee</td>
<td>Trustee</td>
<td>Trustee</td>
<td>Trustee</td>
</tr>
</tbody>
</table>

- Quality Attributes
  - Game type / category
  - CPU usage (estimated)
  - Memory usage (estimated)
  - Interdependencies
- Context Attributes
  - Network status
  - Site availability
  - Device status
  - Location (player)
  - Activity (player)
  - User profile

![Diagram of game component download process](image_url)
Context-aware Trustworthiness Evaluation

- Trustworthiness defined as a value in $[0,1]$
- Functions $\text{inc}(t,w)$ and $\text{dec}(t,w)$ for increasing and decreasing the initial trustworthiness based on the available contextual information
  - value for each context attribute $c$ is first assigned with a binary predicate $p$
  - each context attribute is then weighted with $w$, $w$ in $[0,\infty[$
    - 0 meaning "no importance"
  - assigning is order-insensitive
  - $\text{inc}(\text{dec}(t,w),w)=t$
  - $\text{dec}(\text{inc}(t,w),w)=t$
- Implementing the functions for example as
  \[
  \begin{align*}
  \text{inc}(t,w) &= \sqrt{t} \\
  \text{dec}(t,w) &= t^{-2}
  \end{align*}
  \]

Context-aware Trustworthiness Evaluation
– Reputation and Recommendations

- In addition to the context attributes ($C$), the context-aware trust function ($\text{ctrust}$) takes into account the quality attributes ($Q$), reputation ($r$), and recommendations ($R$) within a certain scope $\sigma$ at a certain time $i$
  \[
  \text{ctrust}^i_s(Q) = \text{ctrust}^i_s(Q, C', r', R')
  \]
  - for the sake of simplicity, we assume here that $Q$ does not change over time
- Reputation is considered via past "compatible" contexts in which trustworthiness evaluation has taken place
  - compatibility defined in terms of the the contexts, in which the predicates ($p$) deliver similar results as the current one
  - if many to choose from, apply the most recent one (or do avg on them)
- Recommendations can be context-related, too
  - "When the device has little processing power available, this component performs better than others"
  - "He is a regular navigator in good weather conditions, but performs exceptionally well in storm or at night"
Context-aware Trustworthiness Evaluation
– Formalizing the Compatibility of Contexts

• Given two context data $c$ and $c'$ of type $a_k$, are single compatible iff they satisfy the same predicate

$$c \equiv c' \iff p_k(c) = p_k(c')$$

• The composed compatibility between two context (data sets) $C, C'$, is expressed in terms of weighted summation of the compatibility grades of the single context attributes

$$d(C, C') = \sum_{i=1}^{\infty} \frac{w_i \cdot (c_i \approx c_i')}{W}$$

Ongoing and Future Work

1. Consider coping with indirect and incomplete information, for example in cases:
   a) Trustee is unknown to the trustor across contexts \rightarrow consider reputations of entities similar enough with the trustee
   b) Trustee unknown in the current context \rightarrow consider the reputation of the trustee in contexts similar to the one currently at hand
      • can be combined with a)
      • presupposes that the context is accessible
   c) Recommender is unknown to the trustor \rightarrow consider links connecting the trustor with the recommender
      • social links, professional systems, etc.
Ongoing and Future Work (contd.)

2. Consider other function families for trustworthiness evaluation
   - They can be selected (as plug-ins) by trustors to personalize their trust evaluation functions

\[
y = 2wx(x - \sqrt{2}) \quad w \in [0, \sqrt{2}]
\]
rotated anticlockwise by \(\pi/4\)

\[
dec_w(v) = \frac{(v + v')}{2}
\]
\[
inc_w(v) = \frac{(v + \sqrt{v})}{2}
\]

\[
\begin{align*}
\text{(A)} & \quad \text{\hspace{1cm} \hspace{1cm} (B)} \\
\end{align*}
\]

\[
dec_w(v) = (v + w) \quad w \in [0,1]
\]
\[
inc_w(v) = (v - w) \quad w \in [0,1]
\]

Thank You!

- Questions?

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