Managing Conflicting Resource-based Requirements in Systems of Systems

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Managing Conflicting Resource-based Requirements in Systems of Systems

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Example of an SoS
Feed Me Feed Me Me (Bennaceur et al, 2016)
• **Conflicting requirements** - a common problem present in all types of systems.

• Conflicts will arise within each component system and also across the SoS as a whole due to unexpected interactions.
Resource-based Conflicting Requirements

• Resources
  – Calories;
  – Insulin;
  – Food;
  – Electricity;
  – Budget.

• Focus on Requirements Satisfaction
  – Relaxing requirements to manage conflicts.
• **AM_R5** - AnalyseMe SHALL suggest a <meal plan> with <total calories> AS CLOSE AS POSSIBLE TO <ideal calories level> AND <total insulin> AS CLOSE AS POSSIBLE TO <ideal insulin>.

• **HH_R2** - HomeHub SHALL <prevent food consumption> AS EARLY AS POSSIBLE AFTER <food resource> is AS CLOSE AS POSSIBLE TO <20%> of the <total home food resource>.
Framework Overview

Conflict Diagnosis

SoS-1

Ontology

CSs

SoS-1 Req.

StC

Req.

Ontology

Conflict Manager

Overlap Detection

CS-1

Conflict Identification

StC

Req. Map

Knowledge

Conflict Diagnosis

SoS-N

Ontology

CSs

SoS-1 Req.

StC

Req.

Ontology

Conflict Resolution

StC

Req-N

CS-N
Conflict Identification

Assertions Monitor

Overlap Detection
- Basic Search
  - Assertions Monitor
  - Engine Search
- Inference Search
  - Behavior Inference Engine Search

Conflicting Requirements Mapping

Conflict Diagnosis

Requirements Interaction Features
- Basis
- Degree
- Direction
- Likelihood

Conflict Resolution
- Utility Function
- Resolution Method List

ENTITIES (CSs, Webservices, SoSs)
• **HH_R2** - HomeHub SHALL <prevent food consumption> AS EARLY AS POSSIBLE AFTER <food resource> is AS CLOSE AS POSSIBLE TO <20%> of the <total home food resource>.

• **RELAX Grammar Expression:**
  – SHALL (AS EARLY AS POSSIBLE AFTER q p)
    • q is (AS CLOSE AS POSSIBLE TO a b)
      – a is 20% x <total home food resource>
      – b is <food resource>
    • p is <prevent food consumption>

• **Formal FBTL expression:**
  – AGX>q p
  – q = AF(Δ(b) − a ∈ S)
• **Assertions Engine Search**
  • The assertions related to the same resource have overlapping elements, they might be:
    • Complementary (Disjoint), Mutually Exclusive, Subset, Cooperative, Opposite and Irrelevant;

• **Behavior Inference Search**
  • Inferences over the statechart and the RELAX requirement using ontology matching functions.
• The requirement related to the violated assertion;
  – HH_R2
    • As an example, consider requirement HH_R2 with the actual value for <food resource> as 16 and that 20% of <total home food resource> is 20.

• The requirements related with the overlapped assertions;
  – AM_R5;
    • Inference search:
      – AnalyseMe <meal plan> contains elements that indicates the consumption of <food resource>.
Conflict Diagnosis

• **Basis feature** is the food resource, the HomeHub and the AnalyseMe system and the list of the identified conflicting requirements;

• **Degree feature** represents the requirement satisfaction level
  – Food resource should be $\geq 20$, however it is 16.

• **Direction feature** is positive (the food resource usage is higher than the expected);

• **Likelihood feature** is based on historical data of past conflict resolution associated with the involved requirements.
Resolu/on	Method	List
(Robinson et al., 2003)

- Relaxation
- Refinement
- Abandonment
- Compromise
- Postponement
- Restructuring
- Reenforcement
- Replanning
- Helping Hand
- Sacrifice

Configurable Utility Function considering:

- Global X Local
  - Priorities
- Requirement Satisfaction Degree
- Resource Usage
  - Individual and/or Overall
Consider the example:

1. **Relaxation** over the food resource limit level from 20% to 15%;
2. **Replanning** using an alternative goal of AnalyseMe and generate a Meal Plan to consume less from food resource;
3. **Helping Hand** using a smart city level component and invoking a shopping list from a supermarket to increase the food level;

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### Resolution Method List (Robinson *et al.*, 2003)

<table>
<thead>
<tr>
<th>Method</th>
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<tbody>
<tr>
<td>Relaxation</td>
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<tr>
<td>Refinement</td>
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</tr>
<tr>
<td><strong>Sacrifice</strong></td>
</tr>
</tbody>
</table>
Initial Evaluation

• Exploring the effect of different conflict resolution methods on the utilization of the resources managed by the SoS.

  – Two Simulated Scenarios of FmFm;
  – Use of 3 Resolution Methods:
    • Abandonment;
    • Relaxation;
    • Refinement.
Initial Evaluation

Abandonment

Refinement

Relaxation
Future Work

• Investigate and implement the diagnosis and resolution steps (e.g.: expand the utility function);
• Full implementation of the framework;
• Evaluation of the framework using realistic domains/case studies;
Thank you.

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