Managing Conflicting Resource-based Requirements in Systems of Systems


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Version: Version of Record
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Example of an SoS
Feed Me Feed Me (Bennaceur et al, 2016)
Feed Me Feed Me - FmFm

Create Family Meals
Improve Family Budget
Avoid Food Waste

System of Systems

AnalyseMe
HomeHub
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

SoS-1
- CSs
- CS Req.
- StC
- Ontology

SoS-N
- CSs
- CS Req.
- StC
- Ontology

Conflict Manager
- Conflict Identification
  - Overlap Detection
  - Conflict Req. Map
- Knowledge

Conflict Diagnosis
Conflict Resolution

StC
- Ontology
- Req-N
CS-1

StC
- Ontology
- Req-N
CS-N
Conflict Identification

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

Conflict Diagnosis

- Requirements Interaction Features
  - (Basis, Degree, Direction, Likelihood)

Conflict Resolution

- Utility Function
- Resolution Method List

ENTITIES (CSs, Webservices, SoSs)

Probes

Violation detected in the Requirement Re regarding the Resource R
• **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:**
  – AG X>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>`.
• **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.
Conflicting Resolution

Configurable Utility Function considering:
- Global X Local
  - Priorities
- Requirement Satisfaction Degree
- Resource Usage
  - Individual and/or Overall

Resolution Method List (Robinson et al., 2003)
- Relaxation
- Refinement
- Abandonment
- Compromise
- Postponement
- Restructuring
- Reenforcement
- Replanning
- Helping Hand
- Sacrifice

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Considering 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;

### 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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• 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

Energy vs. Calories vs. Insulin vs. Budget over time.

Refinement

Energy vs. Calories vs. Insulin vs. Budget over time.

Relaxation

Energy vs. Calories vs. Insulin vs. Budget over time.
• 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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