Managing Conflicting Resource-based Requirements in Systems of Systems

Conference or Workshop Item

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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)
Feed Me Feed Me - FmFm

Create Family Meals

Improve Family Budget

Avoid Food Waste

System of Systems

AnalyseMe

HomeHub

AWASE - 2017
New System, Same Old Problem...

• 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.
Requirements Description: Structured RELAX

• **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
- Ontology
- Conflict Identification
  - Overlap Detection
  - Conflict Req. Map

StC

SoS-N
- Ontology
- Conflict Diagnosis
- Conflict Resolution

StC

Conflict Manager

CS-1
- Ontology
- Req-N

CS-N
- Ontology
- Req-N
Conflict Identification

- Assertions Monitor
- Overlap Detection
  - Basic Search
    - Assertions 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.

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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.
Conflict 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)

<table>
<thead>
<tr>
<th>Method</th>
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<tbody>
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<td>Refinement</td>
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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)

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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.
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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