Managing Conflicting Resource-based Requirements in Systems of Systems

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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

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• 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>`. 
Conflict Identification

- Assertions Monitor
  - Violation detected in the Requirement $Re$ regarding the Resource $R$

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.
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.
Conflic 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)

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<thead>
<tr>
<th>Method</th>
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<tbody>
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<tr>
<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;

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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.
Initial Evaluation

Abandonment

Refinement

Relaxation

Graphs showing changes in energy, calories, insulin, and budget over time.
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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