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## Managing Conflicting Resource-based Requirements in Systems of Systems

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# Managing Conflicting Resource-based Requirements in Systems of Systems

Thiago Viana, Andrea Zisman and Arosha Bandara

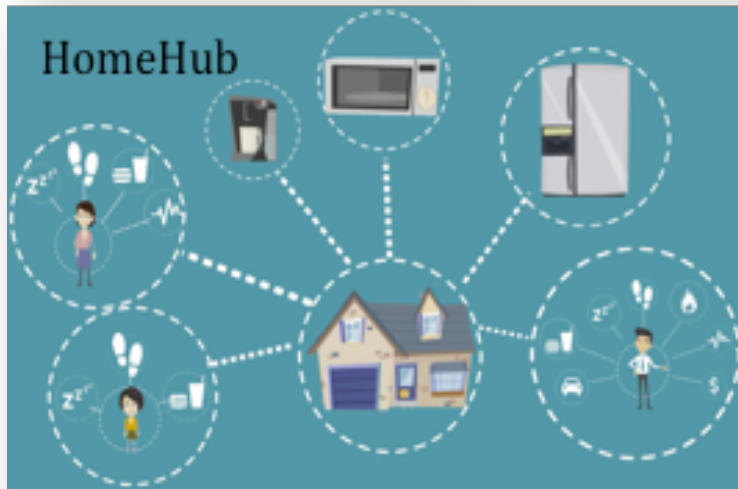
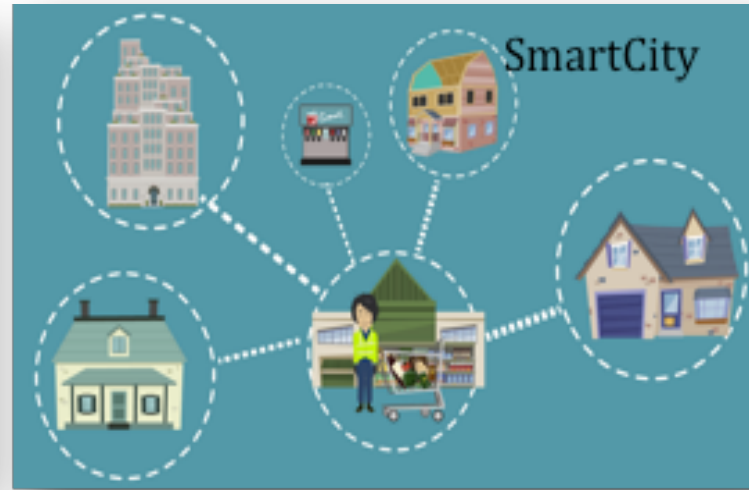
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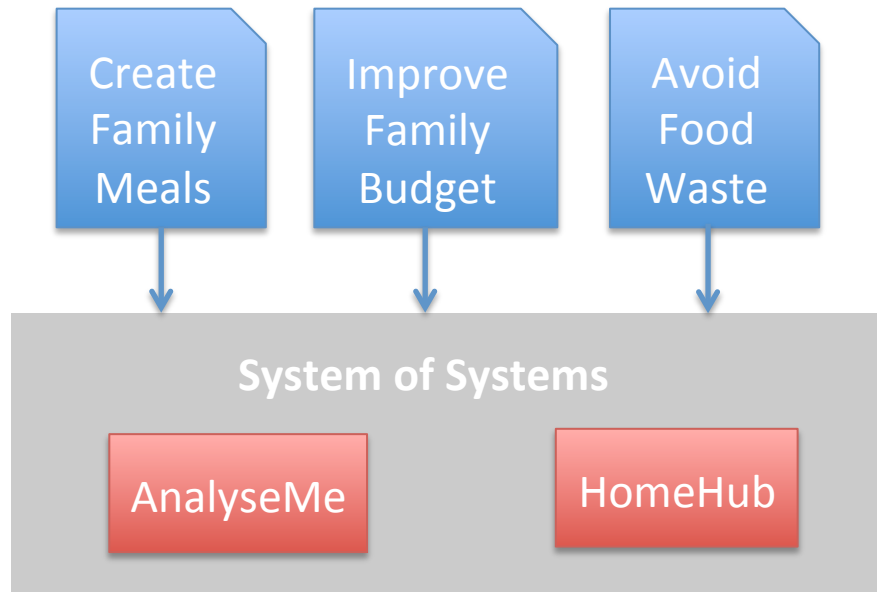
Adaptive Security and Privacy (ASAP) research programme

# Example of an SoS

## Feed Me Feed Me (Bennaceur *et al*, 2016)



# Feed Me Feed Me - FmFm



## 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.

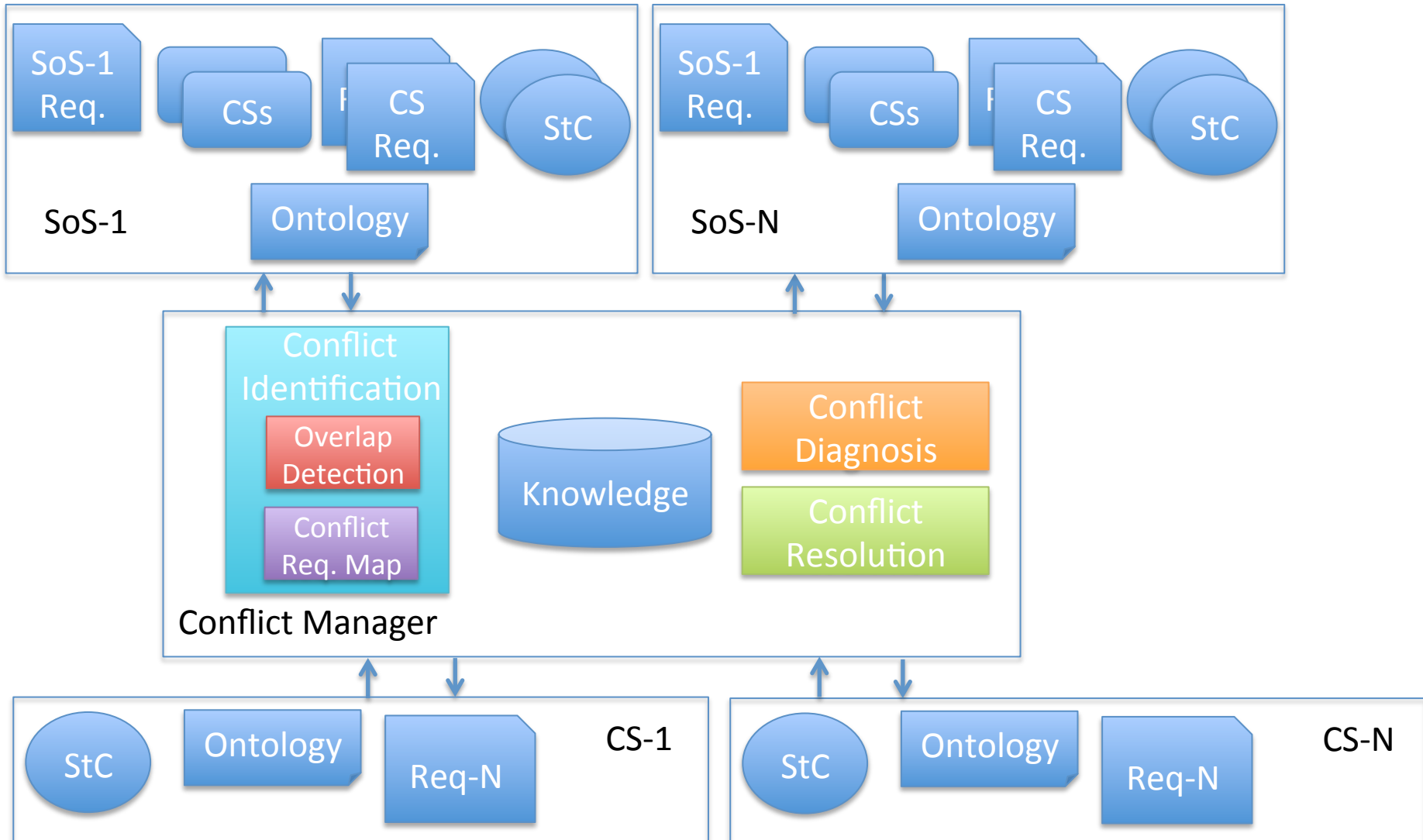
# Resource-based Conflicting Requirements

- **Resources**
  - Calories;
  - Insulin;
  - Food;
  - Electricity;
  - Budget.
- **Focus on Requirements Satisfaction**
  - Relaxing requirements to manage conflicts.

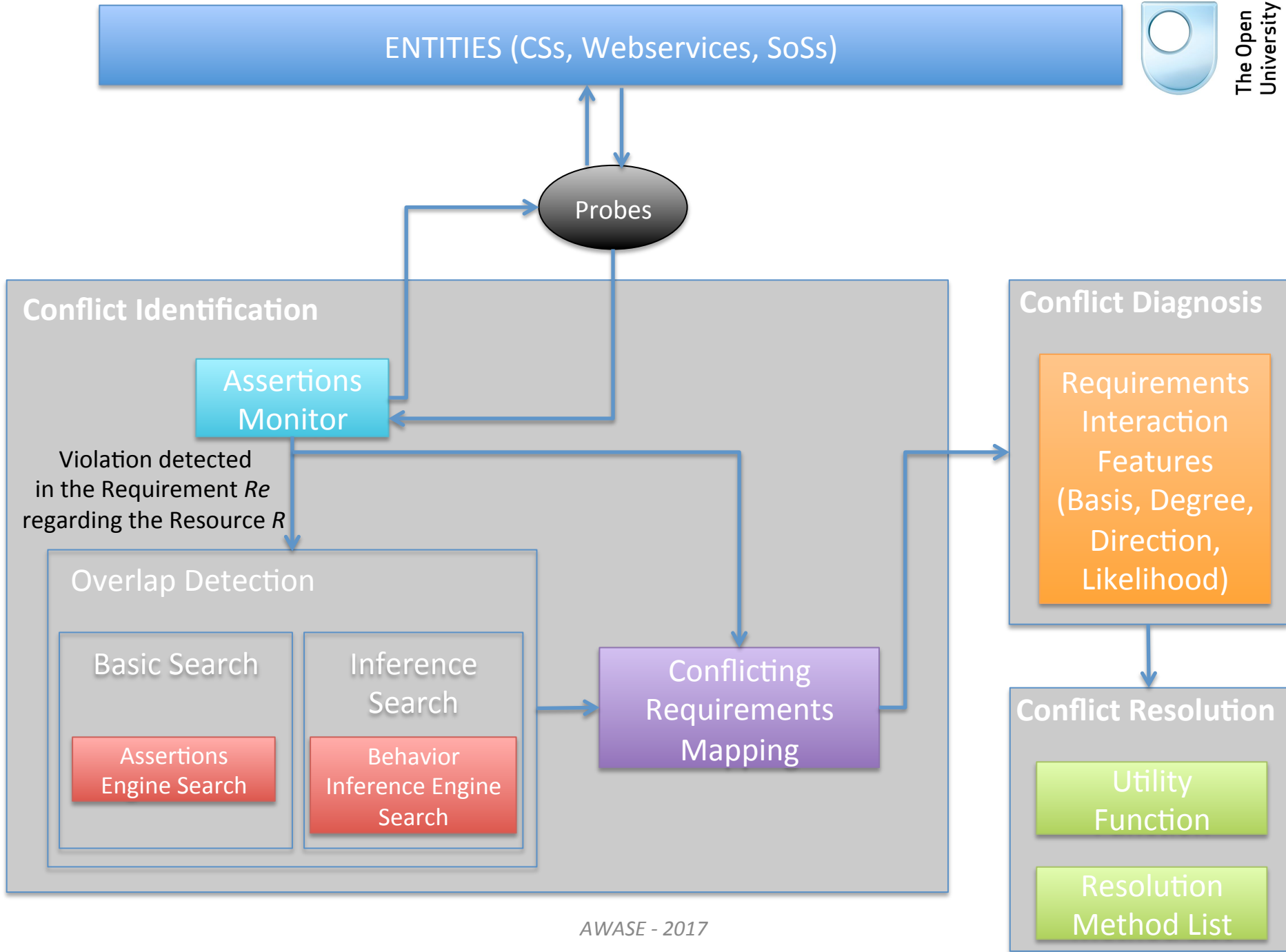
# Requirements Description: Structured RELAX

- **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







# Assertions Monitor

- **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:**
  - $AGX>q p$
  - $q = AF(\Delta(b) - a \in S)$



# Overlap Detection

- **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.



# Conflicting Requirements Mapping

- 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.





# 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)

Relaxation

Refinement

Abandonment

Compromise

Postponement

Restructuring

Reenforcement

Replanning

Helping Hand

Sacrifice

# Conflict Resolution

## 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)

Relaxation

Refinement

Abandonment

Compromise

Postponement

Restructuring

Reinforcement

Replanning

Helping Hand

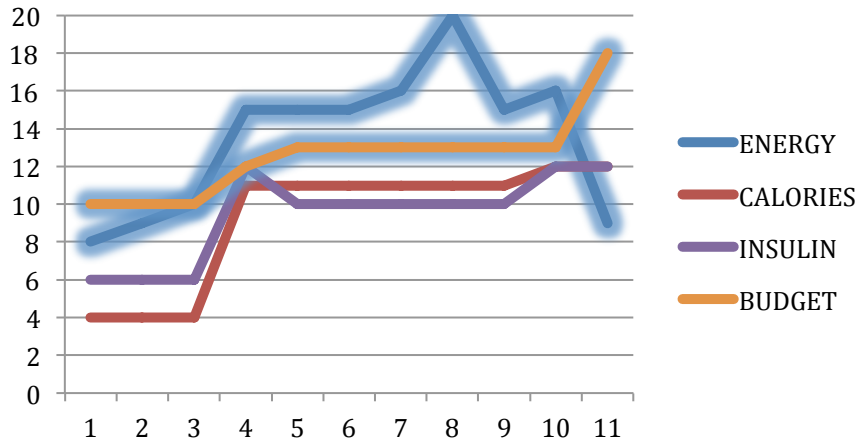
Sacrifice

# Initial Evaluation

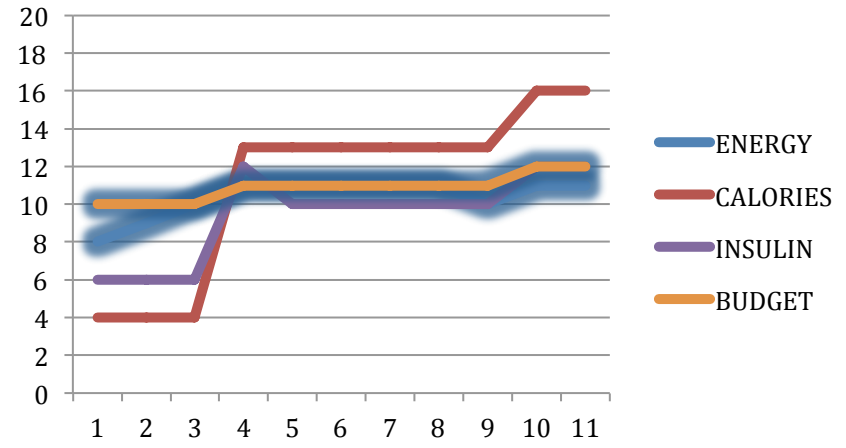
- Exploring the effect of different conflict resolution methods on the utilization of the resources managed by the SoS.
  - Two Simulated Scenarios of FmFm;
  - Use of 3 Resolution Methods:
    - Abandonment;
    - Relaxation;
    - Refinement.



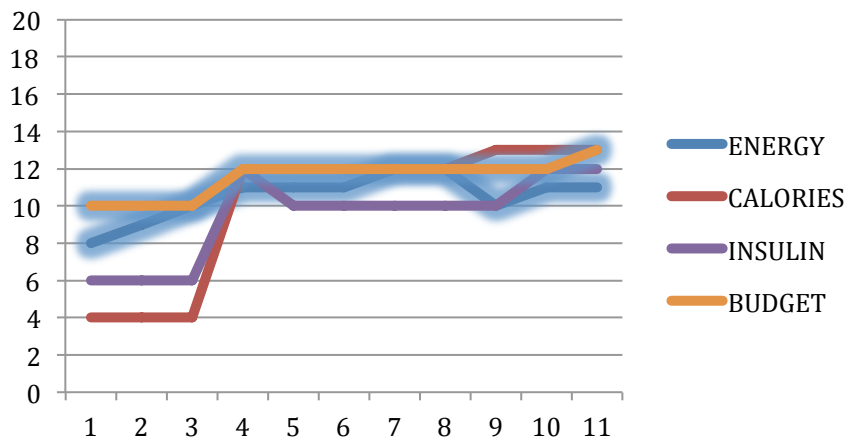
# Initial Evaluation



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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