Engineering Adaptive Requirements

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Premise

- **Self-adaptive systems** can configure and reconfigure themselves, augment their functionality, continually optimize themselves, protect themselves, and recover themselves, while keeping most of their complexity hidden from the user and administrator *"Dagstuhl RoadMap 08"*

- Research focus on Design-time to Run-time adaptation
  - **RAINBOW** *[Garlan 04 et al.]*
  - **Self-Managed Systems: An Architecture Challenge** *[J. Kramer 07 et al.]*

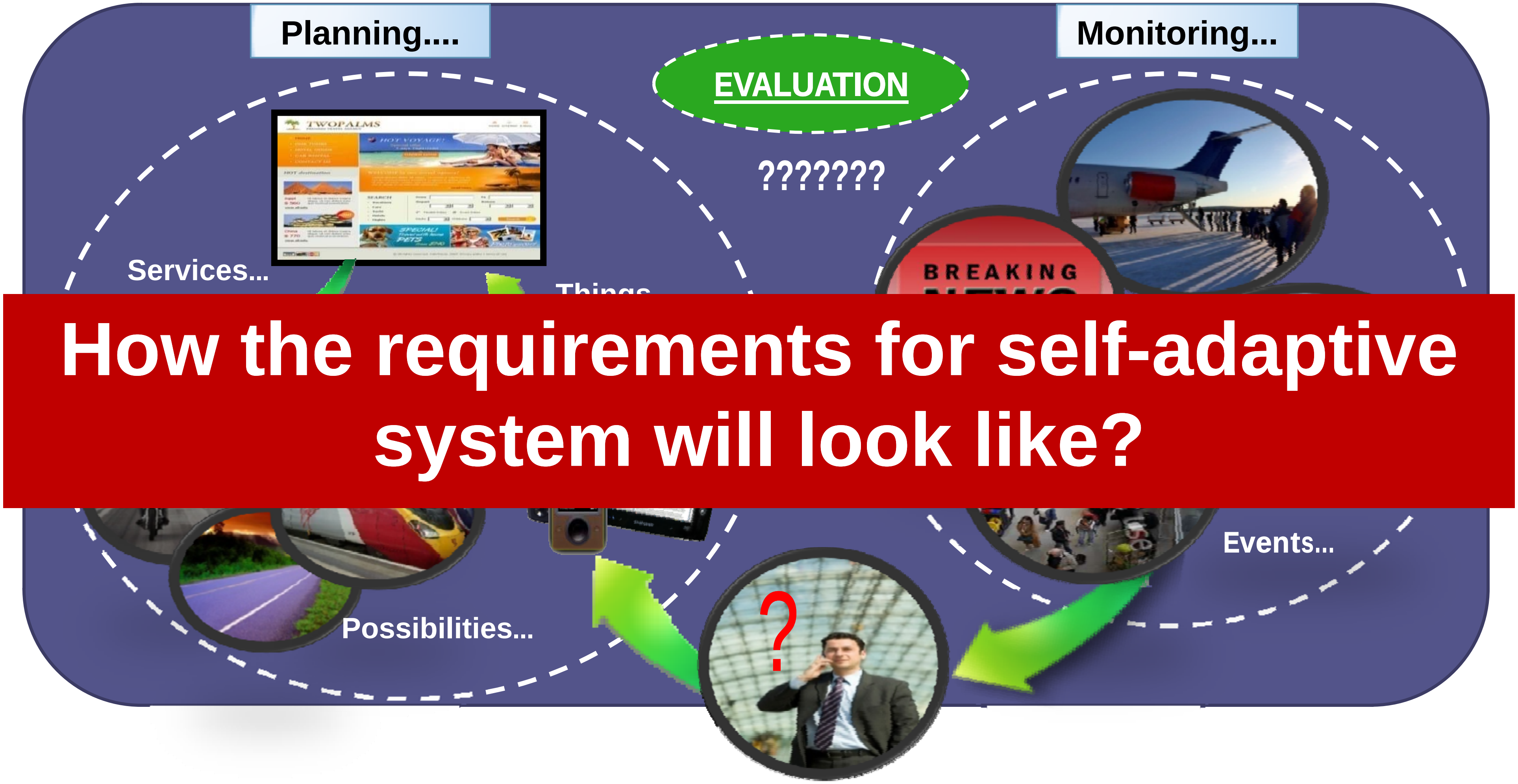
- Less attention on Requirements engineering for self-adaptive software systems *"Dagstuhl RoadMap 08, Betty Cheng et al."*

Setting up the Stage

- Introduction
  - *Example Scenario*
  - *Research Objectives*
- Research Baseline
- Adaptive Requirements
  - *Characterizing Adaptive Requirements*
- Capturing Adaptive Requirements
  - *Steps for Eliciting Adaptive Requirements*
  - *Specification of Adaptive Requirements*
- Conclusion & Future Work

Introduction

- Example Scenario ***(Travel Companion)***



How the requirements for self-adaptive system will look like?

User Goal: To enjoy Convenient & Comfortable Travel.

Introduction

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- Example Scenario *(Travel Comp.):*
  - To help clarifying how the analyst can capture variability and flexibility that identify requirements for self-adaptive system

✓ **Planning:** Travel booking (involving the user)
✓ **Monitoring:** Booking, User Context, Assets, Events
✓ **Evaluating:** Decide about Change, Some Uncertain Event
✓ **Adapting:** Enact adaptation with the chosen behavior

Research Objectives

- ***First*** objective is to support the system analyst to elicit requirements for self-adaptive systems at requirements-time
  - What are the requirements for self-adaptive system?
  - How to support analyst to elicit and specify them?

✓

- ***Second*** is to make software able to reason on requirements at run-time in order to enable a goal-oriented adaptation
  - How to make requirements as live artifact enabling the software to reason on for adaptation?

There is a need to make explicit the variability in the requirements for self-adaptive systems

We call them Adaptive Requirements!

Research Baseline

- Goal Oriented Requirements Engineering “GORE”
  - High Variability Design *[Penserini 07 et al.]*
  - Goal Oriented development of SAS *[Morandini 08 et al.]*
  - Automatic Software Configuration *[Liaskos 05 et al.]*
- Knowledge Representation “Ontologies”
  - Redefining the core RE ontology *[Jureta 08 et al.]*
  - GOORE: Goal-Oriented and Ontology Driven Requirements Elicitation Method *[Shibaoka 06 et al.]*
- Variability design approaches
  - Problem frame extension to (monitor and switching) reason on problem variants *[Salifu 07 et al.]*
- Natural Language to Specify requirements for adaptive systems
  - Using Modal Verbs *[Whittle 08 et al.]*

Adaptive Requirement Characterization

- Adaptive Requirements:
  - By adaptive requirements, we mean that a requirement encompasses the notion of variability and flexibility in it, while elaborating either a functional or quality aspects of the software system.

- To make explicit the variability, we consider:
  - Uncertainty in **time**
  - Variability in user Context (**Profile**, **location** and **Resource**)
  - Variants of behavior **(Monitoring Parameters)** based on **domain assumptions**
  - Alternatives " **OR** " predefined before execution / exploiting **user' assets**

- An Example:
  - **[Req¹]:** A user friendly confirmation message after the booking should be communicated to the user's email using a proper format.
  - Here we have 4 functional & 1 Non functional requirement:
    - **[FRs]:** Book a ticket, Send confirmation message, Message communication to email, set format representation of message
    - **[NFR]:** User friendly Message

Adaptive Requirement Characterization

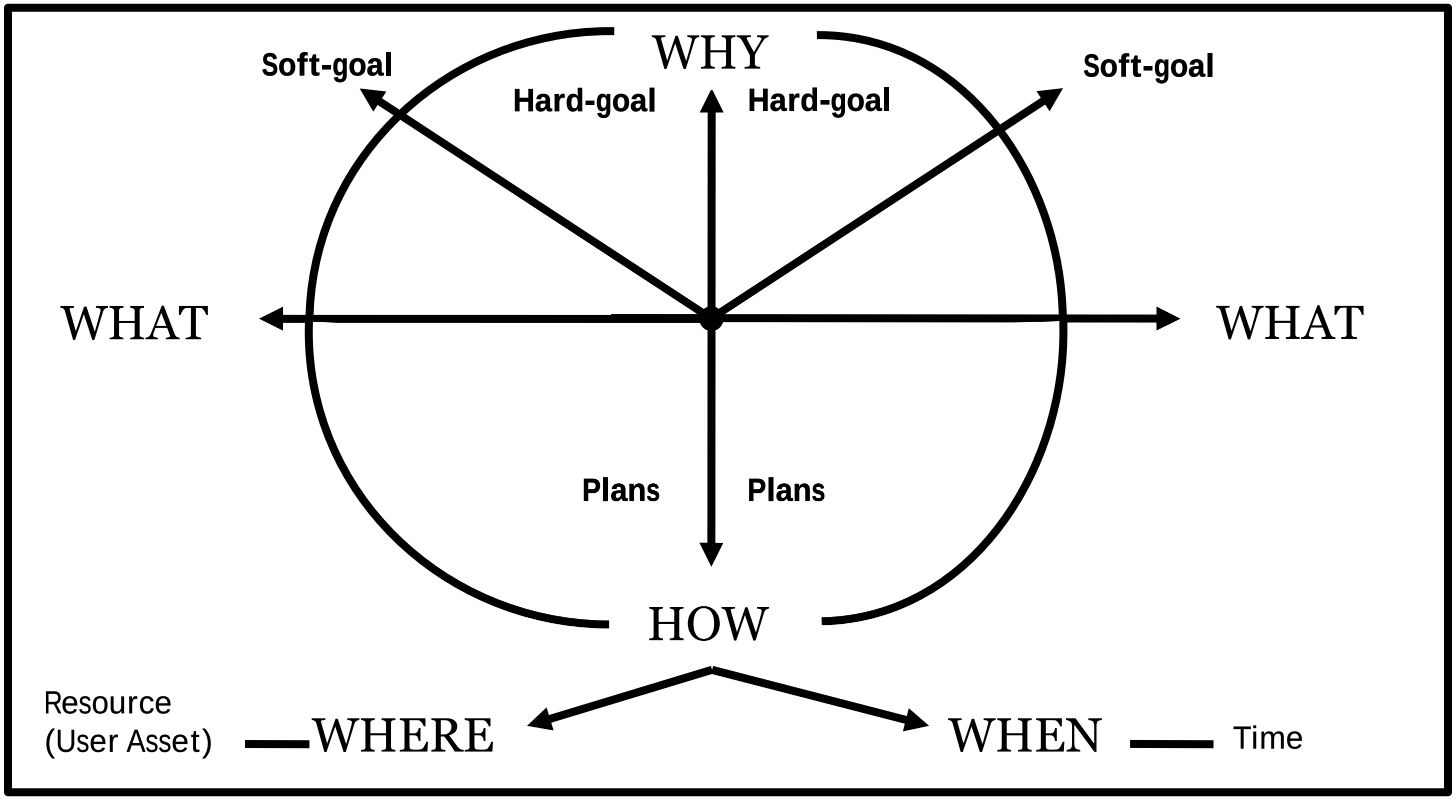
- Adaptive Requirement Analysis:
  - **[ReqAR[1]]:** A confirmation message for booking is generated **as soon** the booking is processed, and required to **possibly** communicate the message to the user **eventually** on his current device (e.g. PDA/Laptop) by **seamlessly** observing (monitor) the user's context (**Profile**, **Location**, **Device**), run-time events and QoS attributes **until** the message is delivered in a **correct format** (by scaling it, size, etc) and with personalized representation (e.g. SMS, Email) to his current device i.e. PDA **or** a different way of notification is applied i.e. exploiting his personal **assets** (e.g. Contact List)

[Followed approach from Whittle 08 et al.]

- At Run-time (e.g. cases):
  - Message was delivered; the user's device battery went down (so the message could not be confirmed as delivered)
  - The software again employs other alternatives at run-time using **user's contact info asset**, either sending an email to her secretary or any colleague; or notifying her family/friends

Dimensions of Adaptive Requirements

- ***Why*** the user wants this; ***Why*** in this way?
- ***What*** the system should do?
- Possibly ***How*** (well) should it do?
- ***What*** requirements may lead also to answer questions about ***Where*** and ***When*** aspects?



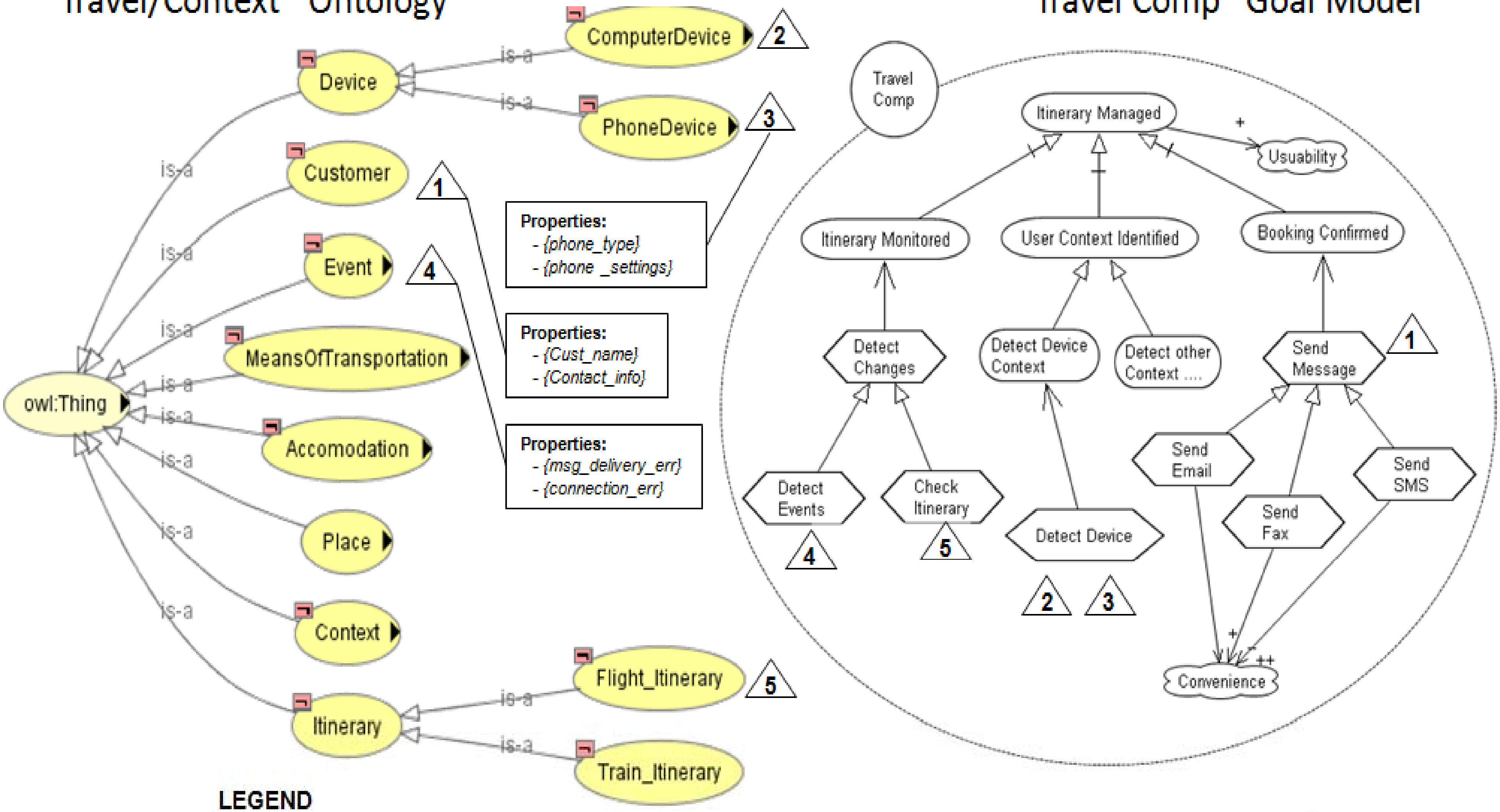
Capturing Adaptive Requirements

- Analysis (Steps) Guidelines:

1. Analyze domain concepts and assumptions
   - **Outcome**: Ontology
2. Analyze stakeholder’s intensions, dependency and variability in goals
   - **Outcome**: Goal model
3. Link domain assumptions/concept properties to goals/plans
   - **Outcome**: Link properties
4. Develop a specification which encompasses the notion of variability
   - **Outcome**: Adaptive Policy / Plan Sepcs. **(A live Artifact)**

“Travel/Context” Ontology

“Travel Comp” Goal Model

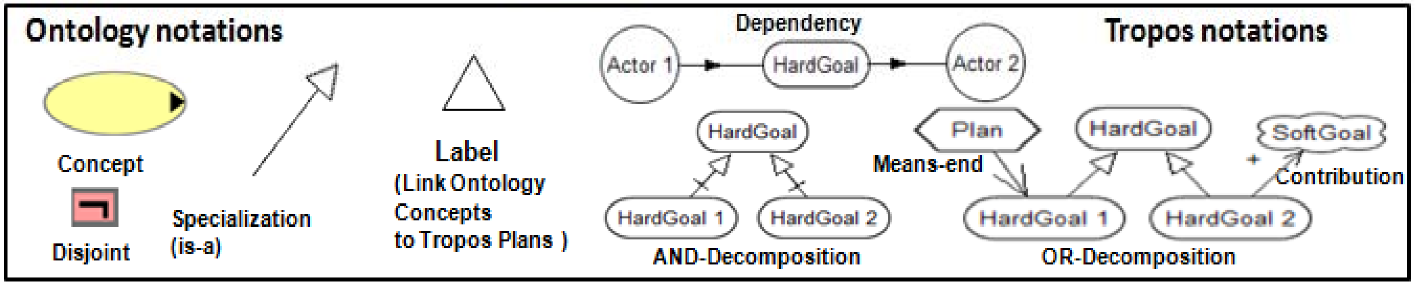


Properties:
- *{phone_type}*
- *{phone _settings}*

Properties:
- *{Cust_name}*
- *{Contact_info}*

Properties:
- *{msg_delivery_err}*
- *{connection_err}*

LEGEND



Capturing Adaptive Requirements

- Plan Specification **(Example Template)**:

```
Plan Model(<SendMessage>) to accomplish Goal (BookingConfirmed)
begin procedure Plan Model(<SendMessage>)
   do triggerGoals (UserContextIdentified,ItineraryMonitored)
       begin
             for Goal (UserContextIdentified)
                   do executePlan <DetectDevice>; //@param: phone type, phone setting
                   return; //@result: device
       end;
      begin
             for Goal (ItineraryMonitored)
                    do executePlan <DetectChanges>; //@param: msg delivery err, conn err
                   return;//@result: eventMessage
       end;
  decision = decision on AltP lans(device, eventMessage);
     case decision:
          - Select case:<SendSMS>; //if device = PDA, eventMessage = null
          - Select case:<SendEmail>; //if device = Laptop, eventMessage = null
          - default case: <SendFax>; //if device = null, eventMessage = null
      If not [decision]
      then lookupContact; //@param: cust name, contact info
             alt decision = decision on AltP lans(cust name, contact info);
      case alt decision:
          - Select case: <SendEmail>; //contact info
          - default case: <SendFax> //contact info
end procedure;
```

Why and What…

How (Using Plans)

Where (User's Context … Device/Resource)

Using Ontology
(@param: Link properties)

Alternatives "OR"

When (Until) without compromising goal

Conclusions

- Proposed an integrated approach using ***Ontologies*** and ***Goal-oriented modeling*** to better support the analysis of variability, a key step towards understanding adaptive requirements for self-adaptive software systems

- Defined & Characterized Adaptive Requirements

- Presented an Example to justify adaptive requirements along ***Why***, ***What***, ***How***, ***When*** and ***Where*** dimensions

Future Work

- Consolidate our analysis, especially with real scenarios, and to define a step by step analysis process.
- Investigating a suitable technique to specify Adaptive requirements to keep requirements ***"ALIVE"***
- Demonstrating the role of these requirements artifacts *(goal models plus ontology)* to enable adaptation at run-time.

Thank you !!

We cannot undo things.... So we adapt....

Can we have softwares, which can...?