Run-time Resolution of Uncertainty

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Abstract

Requirements awareness should help optimize requirements satisfaction when factors that were uncertain at design time are resolved at runtime. We use the notion of claims to model assumptions that cannot be verified with confidence at design time. By monitoring claims at runtime, their veracity can be tested. If falsified, the effect of claim negation can be propagated to the system's goal model and an alternative means of goal realization selected automatically, allowing the dynamic adaptation of the system to the prevailing environmental context.

Keywords-self adaptive systems; requirements models; goals;

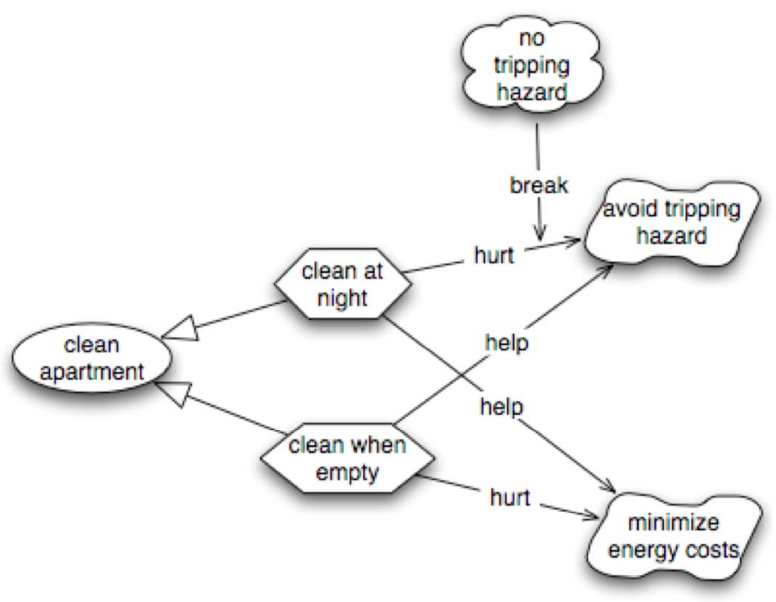
Introduction

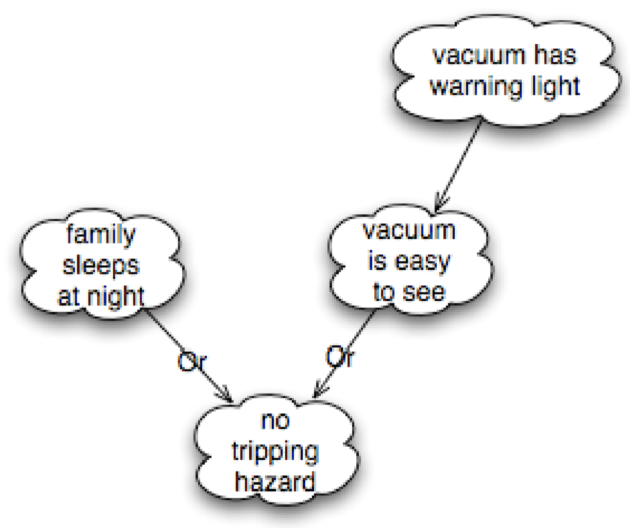
We argue that requirements models for self-adaptive systems should be runtime entities that can be reasoned over in order to understand the extent to which they are being satisfied and to support adaptation decisions. The goal of the work described here was to investigate the feasibility of maintaining requirements models at runtime and their utility for guiding principled adaptations to contexts unanticipated at design time.

ReAssuRE (Recording of Assumptions in Requirements Engineering)

REAssuRE augments i* Strategic Rationale (SR) models with *claims* (from the NFR framework). Claims record the rationale for a choice of goal realization strategy when the selection is based on imperfect information.

Example: Consider **a robot vacuum cleaner for domestic apartments**. The vacuum cleaner has a goal to clean the apartment *clean apartment* and two softgoals; to avoid causing a danger to people within the house *avoid tripping hazard* and to be economical to run *minimize energy costs*. The vacuum cleaner goal *clean apartment* can be satisfied by two different realization strategies. It can *clean at night* or when the apartment is empty.





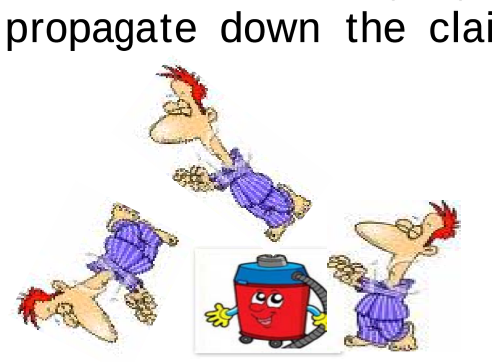
The choice of best strategy appears unclear but the analyst wishes to prioritize the *minimize energy costs* over the *avoid tripping hazard* softgoal. The analyst uses a claim, *no tripping hazard*, to *break* the *hurt* contribution link from the *clean at night* task to the *avoid tripping hazard* softgoal.

The *break*-ing claim nullifies the contribution link to which it is attached: it nullifies the negative impact that night cleaning was presumed to have on tripping hazard avoidance.

However, the *tripping hazard* claim is an assertion in which the analyst has some doubt; it is based on an assumption that at night, the apartment residents will be asleep and therefore in no danger of tripping over the vacuum cleaner. The analyst hopes that this is so in order to exploit night-time cleaning to promote energy saving. The claim acts as a marker for uncertainty.

A claim may be derived from another claim. Claim derivation can be represented explicitly in a claim refinement model. The claim refinement model that shows that the *no tripping hazard* claim is derived from three other claims: *family sleeps at night*, *vacuum is easy to see* and *vacuum has warning light*, arranged in a hierarchy. Falsity of any claim will propagate down the claim refinement model to the bottom-level claim.

But how valid are the contributing claims? We should monitor the no tripping hazard claim (perhaps via a shock sensor on the vacuum cleaner).

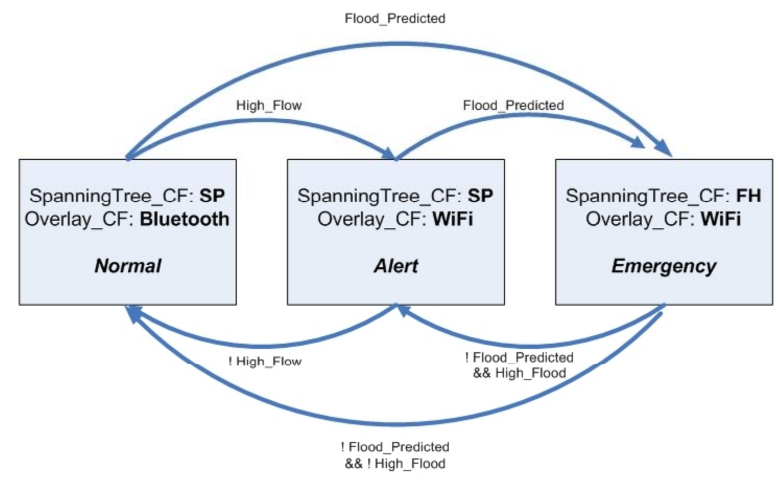


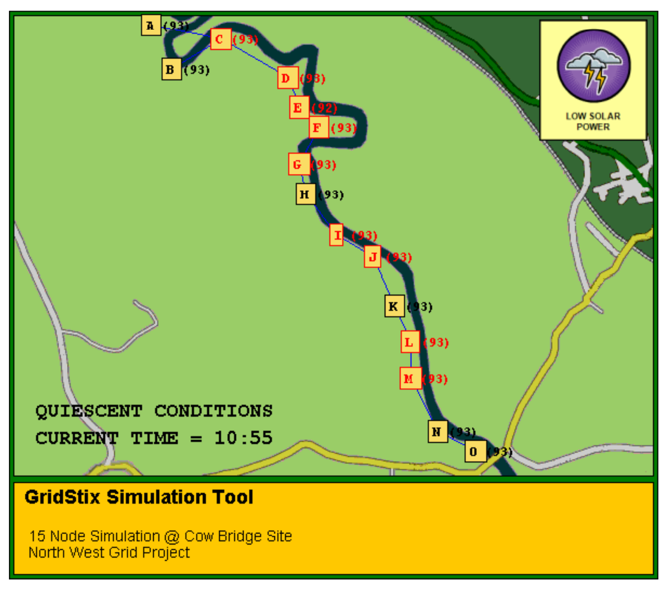
Because we restrict the use of claims to selection between alternative goal realization strategies the effect of claim falsification is easily processed, and the goal models updated, at run-time. Thus uncertainty resolution and corrective adaptation can be performed automatically without human intervention, provided:

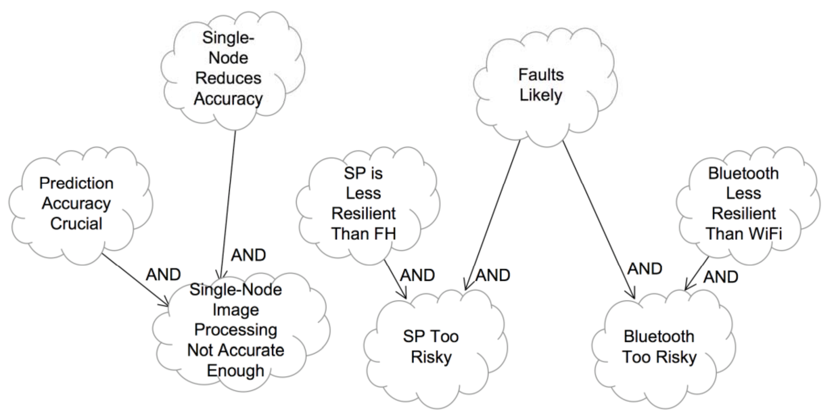
- The claims are monitorable
- An alternate goal realization strategy has been defined

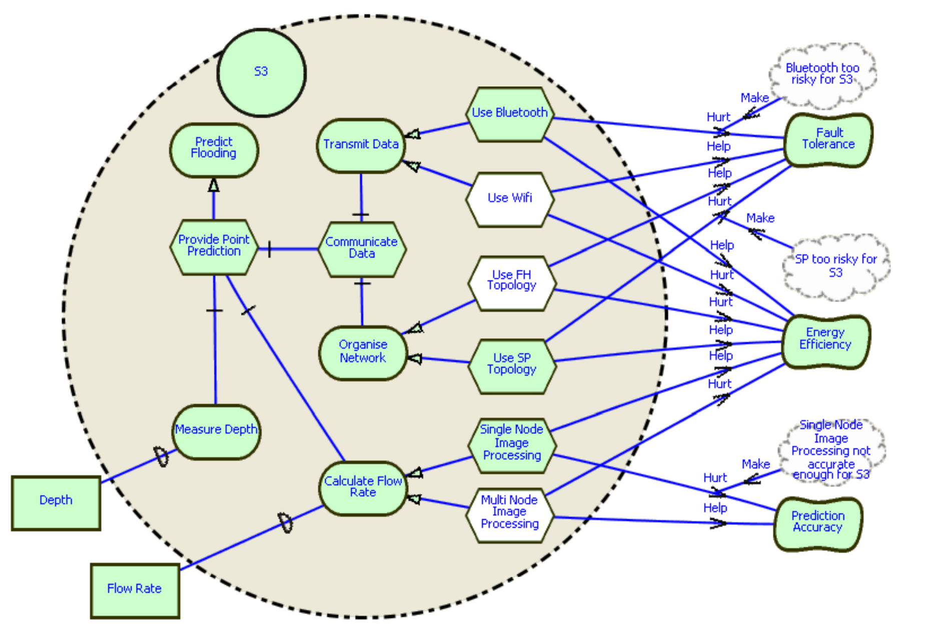
GridStix

We have applied REAssuRE to GridStix, an experimental flood warning system that was deployed on the River Ribble in England. GridStix adapts its behaviour dynamically as the river it monitors changes state.









Effectively, there is a trade-off between *Fault Tolerance* and *Energy Efficiency*. The analyst wants to promote fault tolerance and uses claims to "force" the selection of the *FH/WiFi* configuration. But in so doing the analyst is also making explicit that they are making assumptions: that in practice, the *WiFi/FH* configuration will deliver the greatest resilience.

Thus the system is able to monitor the validity of these assumptions and adapt if they prove false.

In experiments using the GridStix simulator, the system remained operating with sufficient battery power for longer using claim monitoring than without. Demonstrating that the claims were shown not to hold under all circumstances, allowing the system to prioritize energy efficiency, and keeping the system operating for longer.

CONCLUSIONS

Combined with goal models, claims allow assumptions whose truth can't be resolved at design time to be made explicit. Furthermore, by combining claims with monitoring and a self adaptive capability, uncertainty can be resolved at run-time and adapted to dynamically.

Related Publications

[1]- *Towards Requirements Aware Systems: Run-time Resolution of Design-time Assumptions,* Kristopher Welsh, Pete Sawyer, Nelly Bencomo, ASE 2011, Kansas, USA, 2011

[2]- *Requirements-Aware Systems A research agenda for RE for self-adaptive systems,* Pete Sawyer, *Nelly Bencomo*, Jon Whittle, Emmanuel Letier, Anthony Finkelstein, International Requirements Engineering Conference, RE 2010, Sydney, Australia, September, 2010

[3]- *Requirements Reflection: Requirements as Runtime Entities, Nelly Bencomo*, Jon Whittle, Pete Sawyer, Anthony Finkelstein, and Emmanuel Letier, ICSE 2010, Track on New Ideas and Emerging Results (NIER), Cape Town, South Africa, 2010

[4]- *A Goal-Based Modeling Approach to Develop Requirements for Adaptive Systems with Environmental Uncertainty,* Betty H.C. Cheng, Pete Sawyer, *Nelly Bencomo*, and Jon Whittle, MODELS 2009, Colorado, USA, 2009

[5]- **Genie: Supporting the Model Driven Development of Reflective, Component-based Adaptive Systems**, Nelly Bencomo, Paul Grace, Carlos Flores, Danny Hughes, and Gordon Blair , Formal Research Demonstrations, ICSE 2008, Leipzig, Germany,, 2008

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