The Logic of Requirements

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Over the past 40 years there has been tremendous progress in formally characterizing the reasoning required for some intellectual task and studying efficient algorithms for its automation. Examples of tasks for which such characterizations have been proposed include planning, diagnosis and learning in AI, but also model checking in Automated Reasoning and Formal Methods. Multicriteria decision-making and game theory are other examples from outside Computer Science.

There are difficulties in attempting to do the same with requirements. Firstly, we need to understand better the fundamental nature of requirements. Secondly, we need to establish that reasoning with a collection of requirements (the problem) to determine a specification (the solution) is amenable to formalization, rather than it being context-dependent and therefore not characterizable by a set of formal rules. The thrust of this position statement is precisely to sketch the elements of such a formalization.

Let's begin with the nature of requirements. For much of the history of Requirements Engineering (RE), requirements were treated as *functions* and *qualities* that the system-to-be must possess (called respectively functional and non-functional requirements). Only in the last 15 years has this perception changed with the rise of goal-oriented techniques. In goal-oriented RE, requirements are goals the stakeholders have that must be fulfilled by the system-to-be. This change has had a tremendous impact on how requirements are modeled and analyzed. [Zave97] characterizes the nature of requirements in terms of stakeholder goals R, domain knowledge K and specification (of the system-to-be) S such that

$$K, S \vdash R$$

, stating that one can infer (in some logical theory) R from K and S. This is an interesting characterization because it explains what is the requirements problem (a pair K and R) and what does it mean for a specification S to be a solution to a given requirements problem. However, the "|-" relation is not defined formally. Moreover, this account leaves aside non-functional requirements, known to be a very important element of the requirements puzzle.

In our recent work [Jureta08], we have adopted the position that requirements include domain assumptions D (comparable to K above), stakeholder goals G, qualities Q, and preferences P. Domain assumptions are things that are taken for granted in producing the system-to-be, such as "Stores are closed on Sundays" or "There are enough rooms for requested meetings". Goals are desired states of the world, such as "Meeting scheduled" or "Fulfill every book request". Qualities are constraints on the actions that fulfill a given goal. For instance, "Meeting scheduling will be done in $\leq$ 1 day". Finally, preferences are nice-to-have properties, such as "Prefer morning meetings", "Prefer book to be sent to my home".

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The requirements problem can now be re-formulated as follows: Given D, G, Q, P find a specification S such that if D is true, G is fulfilled, Q is satisfied; moreover, there is no other specification S' such that given D, G, Q are satisfied and moreover, S' satisfies at least all the preferences that S satisfies. In other words, the requirements problem amounts to an optimal planning problem with preferences defining the criteria for optimality.

On the basis of the above, we are working towards a concrete characterization of requirements reasoning, consisting of a formal modeling language for representing domain assumptions, goals, qualities and preferences, also algorithms for determining a specification S, given D, G, Q, P.

References

[Jureta08] Jureta, I., Mylopoulos, J. and Faulkner, S., "Revisiting the core ontology and problem in requirements engineering", Proceedings 16th International IEEE Conference on Requirements Engineering, Barcelona, September 2008.

[Zave97] Zave, P., and M. Jackson, M., "Four dark corners of requirements engineering", *ACM Transactions on Software Engineering and Methodology 6(1)*, 1997.