Towards a Property Based Requirements Theory: System Requirements Structured as a Semilattice

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Abstract.

Requirements engineering has, at least, three dimensions: (1) a logistical dimension dealing with requirements management, requirement databases and tools, (2) a methodological aspect dealing with issues such as "*how to elicit requirements?*", "*how to analyze and how to validate requirements?*" and (3) an epistemological dimension which deals with questions such as "*what is a well-formed requirement?*", "*what type of relationships link requirements together and with other design artifacts?*".

This paper does not deal with the two first aspects of the requirement engineering process but actually with the third since the epistemological aspect is the more neglected.

Usually, the requirement definition process is based on a rather lax definition of the requirement, notion called text-based requirement or TBR according to the AP233. The implementation and management costs of these requirements remain very high and this is partially due to the theoretical shortage of TBR. So, in this paper we outline a property-based requirement (PBR) theory. The ultimate motivation for our PBR theory is a reduction of design specification costs thanks to an improvement of epistemological foundations of requirement engineering.

After introducing the mathematical notion of semilattice with its both equivalent definitions (semilattice as poset and as algebraic structure), we express the ontological and epistemological assumptions on which our theory is built.

Then, we propose a definition of well-formed (wf-) requirements based on the concept of property or PBR that are strictly distinguished from expectations. We give some illustrations of wf-requirements, and then we focus on the relationships which structure a set of requirements assigned to a system. To be meaningful, such wf-requirements should reference objects and properties defined in one or more ontologies (scientific or technological bodies of knowledge), otherwise, they are meaningless.

We introduce two binary relationships; the first one is an operator called "conjunction" that allows the requirement composition (this operator embeds a set of

requirements into an algebraic structure of semilattice), the second one is an order relationship called “stringency” relationship that allows the requirement comparison (this operator embeds a set of requirements into an order structure of semilattice connected to the previous algebraic semilattice). So, we state that a finite set of wf-requirements can be embedded in a structure of semilattice. We can then define a system specification as the maximum element of this finite semilattice.

We define a requirement model of a given system as the network including all the expectations and wf-requirements related to this system linked together through two very unlike categories of requirement relationships: “*de dicto*” and “*de re*” relationships. “*De dicto*” relationships are linguistic dependencies used to allow these statements readable and easier to manage. They link expectations together or expectations with wf-requirements. “*De re*” relationships among requirements are extra-linguistic dependencies among material properties refereed by these requirements statements. “*De re*” dependencies among requirements denote material laws that bind properties involved in these requirements. Engineering (in)equations stand for “d*e re*” dependencies.

We highlight two types of “*de re*” relationship among wf-requirements. The first one is the well known “derivation” relationship that links together a “parent” requirement with its “child” requirements during the system design process. We introduce a second “*de re*” relationship that we call “coupling” relationship. Wf-requirements are coupled when the change of one of them collides with others (due to material dependencies between supporting properties). Requirement conflicts are symptoms of unmanaged requirement coupling that reduce the system solution set to the empty set.

To conclude, we claim that our PBR theory belongs to the same paradigm as the model-based design (MBD) approaches whereas TBR belongs to the same field as empirical design approaches. On the one hand, future work should be dedicated to develop this membership to the MBD paradigm and on the other hand, connections of the requirement models with ontologies that support them should be made explicit.