Defining Interactions and Interfaces in Engineering Design

This PhD thesis focuses on the understanding and definition of interactions and interfaces during the architectural decomposition of complex, multi-technological products. The Interaction and Interface Framework developed in this PhD project contribute to the field of engineering design research.

Developing complex, multi-technological products involves the joint effort of multiple engineering disciplines in order to arrive at an end product, which satisfies its requirements. A major challenge is however the fact that bringing together engineers from different technical backgrounds means that they have different conceptual viewpoints on the product and use different ‘technical languages’ to communicate. Some terms like an interface, is used frequently in engineering however with no commonly declared meaning and is thus subject to much interpretation across engineering disciplines. It is well-known that most problems arise at the interfaces during product development, which is why there is a need for a rigorous and multi-disciplinary treatment of the concept of interfaces as well as interactions.

On the basis of a two-year case study at a medical device manufacturer, the role of interactions and interfaces in product family development has been investigated. The case study showed that for this particular case, interaction and interface descriptions represents the rationales needed to reuse documentation across multiple product variants. The interaction and interface descriptions thus become documents of legal matter and must therefore be unambiguously and completely described.

Following this observation, a comprehensive and systematic literature review has been performed in order to investigate the definition and perception of an interface. The review resulted in a classification revealing 13 dominant perceptions of what an interface is from an academic perspective including the observation of an apparent confusion between the terms interaction and interface. In addition, a case example of a solenoid valve was examined in order to reason out the likely causes of problems occurring at interfaces. The case example showed that interfaces that reside at the boundary between engineering disciplines are vulnerable to misinterpretation and rework.

Based on this understanding, this thesis presents a first principles, physics-based Interaction and Interface Framework, which provides a ‘common language’ across any engineering discipline for describing and communicating about interactions and interfaces in engineering design. The framework contains classifications of three key terms; interaction, interaction mechanism, and interface. Due to the first principles, physics-based approach to deriving the framework, it has been possible to arrive at a classification of interaction mechanism, which is mutually exclusive (no overlap) and collectively exhaustive (no gaps). This contribution changes the existing paradigm of reasoning about interactions and allows for an unambiguous architectural decomposition of a product.

The framework further proposes an 8-step architecting approach explicitly articulating how to systematically apply the framework top-down thus enabling complete and unambiguous descriptions of interactions and interfaces throughout the system. A tool called an Interaction Specification Wheel (ISW) is introduced to support consistency in writing requirements and specifications. All of the contributions have been evaluated in an initial test, which indicated a positive effect on their ability to capture interactions and unambiguously specify them. Further research is needed to obtain statistical significance. Future research may investigate how to incorporate the framework into practice and further evaluate the high level effects. This will most likely require two or more case studies in real-life projects.

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