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Methodological Support for Building Cohesion among Software Artifacts to Help Understanding Emergent Software Behavior

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1. Introduction

This research endeavor aims to facilitate the understanding of emergent software behavior based on software knowledge artifacts that are inter-operable, structured, measurable, and traceable to the real-world needs and constraints. We define a software knowledge artifact as a semantically-meaningful, structured and machine understandable representation that characterizes certain software behavior.

To focus research efforts in this direction, the Onto-ActRE framework [2] aggregates artifacts from diverse sources at different levels of abstraction based on goal, scenario, and viewpoint modeling notions in a unifying ontological knowledge engineering process. The resulting hierarchical Problem Domain Ontology (PDO) [4] provides the definition of a common language to promote reasoning that spans over artifacts from diverse modeling philosophies in different RE process stages using well-defined semantics for their structure and interoperability.

Therefore, leveraging the potential for analytical requirements analysis within the Onto-ActRE framework, individual artifacts finally become valuable knowledge when they establish 'links' with each other from various aspects/dimensions driven by the goals of analysis. Based on this fundamental theory, we introduce Multi-Dimensional Link Analysis (MDLA) as a methodological support for building cohesion among software knowledge artifacts which may utilize diverse semantics or become available in different RE stages but are essential to understand emergent software behavior.

To produce reliable pieces of valuable knowledge using MDLA, the links among diverse artifacts are determined based on metrics and measures that serve as indicators for immediate impact, global effects, and propagative nature related to software behavior. For example "physical" links are discovered based on data-driven metrics such as ontological distance or keyword based similarity; "analogical" links are discovered based on structural metrics such as graph similarity; and finally "semantic" links are discovered based on theory-driven metrics concerning the complementary nature of goals, scenarios, and viewpoints, and their relationships with requirements. Such well-defined links drive the creation of potential neighborhoods of cohesive artifacts in collaboration with a subject matter expert. These neighborhoods are called Metric Pools within the MDLA methodology. A hierarchical PDO also facilitates the creation of metric pools at different levels of abstractions.

Within a metric pool, we use Formal Concept Analysis (FCA) [1] to group artifacts which share links among them, and organize such groupings into a lattice of concepts, which are linked through generalization/specialization relationships. The groupings of cohesive artifacts at different levels of abstraction in a FCA lattice convey measures for determining the groupings that have the largest impact (subsumption of other groupings) within a metric pool. Such measures can play a critical role in determining the global/propagative nature of artifacts and their importance in understanding software behavior. FCA can also help to determine trends across related metric pools and identify significant patterns of interactions among goal, scenario, and viewpoints based artifacts in the Onto-ActRE framework.

Our approach has been applied to automate the Department of Defense Information Technology Security Certification and Accreditation Process (DITSCAP) with promising preliminary results in its initial stages [3].

2. References

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