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A General Algorithm for Assessing Product Architecture Performance Considering Architecture Extension in Cyber Manufacturing

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Abstract

In modern manufacturing, the product architecture design options are usually restricted to those that can be produced with 100% confidence using those proven technologies to satisfy the existing customer requirement. As a result, the inefficiencies of architecture design are considerable due to such limitations. This issue is of particular interests in cyber manufacturing when exploring the tradeoff between generality and feasibility in product design and manufacturing. It can be expected that the improvement and extension of the existing product architecture may be required to meet new customer requirement when new technologies become available. An effective system performance assessment algorithm is necessary to facilitate the extension of existing product architecture. Though there has been a lot of research on architecture assessment, there is no well-defined model for level by level architecture assessment considering architecture extension. In this paper, we propose a general architecture assessment model considering the integration of additional functionality requirements and performance metrics to evaluate the architecture performance along its value pathway to meet stakeholder's requirements. A numerical case study focusing on a hypothetical auto cooling system is used to validate the effectiveness of the proposed model.

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Keywords: Extended architecture; Architecture assessment; Renewable Sources; Automobile cooling system; multiple fuzzy model.

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1. Introduction

Defining a complete architecture and establishing an appropriate relationship network among all functional parameters of a certain product play a critical role in resolving system fuzziness for building a successful product architecture. The architecture building aiming at value creation usually begins from the need or functional requirements of the stakeholders. Since value is benefit at cost [1], it is important to balance the system complexity and performance capabilities of the product architecture.

The required system capabilities to achieve the given goal are called key performance attributes (KPAs). To fulfill those KPAs, the solution specific function, or the top functionality that is used to build the architecture, is decomposed into lower level functionalities. By recursively applying the function goal reasoning, all higher-level functions can be decomposed down to the manageable granulation. The highest level functional parameters in the decomposition are called measure of effectiveness (MOEs). MOEs are determined by the relationships to and performance of the immediate lower level functional parameters which are defined as measure of performance (MOPs). Those MOPs are the resultant of other even lower level functional parameters called technical performance measures (TPMs).

With the rapid advancement of technologies in recent years, the architectures of today's products have become inherently complex. It usually consists of highly interrelated, interconnected, or interwoven entities. In addition, due to the trend of seeking the best value of product and bettering life at minimum cost with maximum satisfaction, this complex architecture needs to be changed or extended all the time to find new competitive advantages in rapidly changing market.

The architecture extension can be realized either by adding new functional requirements to the existing architecture or introducing new metrics to measure additional performance of the architecture. On one hand, to achieve new functional requirements, the additional functions need to be divided down to the manageable granulation like existing architecture. Then, it is required to correlate newly developed functional parameters with all other existing ones at each level of the architecture. The performance of the extended system depends on the effect of internal correlation among all functional parameters in the extended architecture. On the other hand, when new performance metric is needed, the introduction of new metric for each functional parameter at each level along its value pathway can measure the system capability of new architecture.

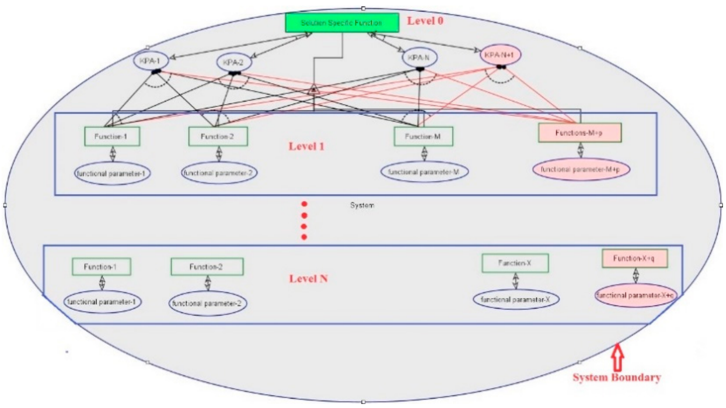

Fig. 1. Extended architecture generation

The Fig. 1 is an illustration of a generalized representation of extended architecture. To evaluate the solution specific function shown in Fig. 1, the architecture is assessed at its boundary using n different KPAs. The architecture is further extended by an additional functional requirement, which is denoted as KPA n+1. To fulfill the requirement of this additional KPA, p new functions are introduced at the lower level, i.e., Level-1, of the architecture. All new functions are then kept being decomposed until level N. With each function, there is also a corresponding functional parameter at each level of the architecture. Their interrelationship at different levels will determine the whole system capability at the boundary of the system.

Although extension of existing architecture in product design is increasingly important in today's competitive world, research that can be used to guide such an extension and assess the performance of post-extension has been less focused. Most existing literature in architecture modeling for design is focused on the assessment of top level