

Engineering Design Performance (Extended Abstract)

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A reader may be slightly puzzled by the title. Indeed, it might say either what performance in engineering design is, or how to engineer design performance. We mean both. Research we are going to report about aims at developing a rigorous engineering methodology for reaching optimal performance in the processes of engineering design. The methodology and the software tool are based on a fine-grained model of performance and its environment. The domain we specifically focus on for validation, evaluation and further exploitation is engineering design in microelectronics and integrated circuits. However, the models presented in this talk are more generic and may be applied in various industrial sectors or academic disciplines.

Our research in formalizing design performance has solid industrial motivation. In the sector of microelectronic and integrated circuits design this motivation can be demonstrated using a system law formulated by Gordon Moore [1]. One of its important corollaries says that the number of components on a chip doubles roughly every 10 to 24 months. It is known in the sector that doubling the number of components crammed onto a silicon chip causes approximately the order of magnitude increase in engineering design effort [2]. In contrast, the productivity of engineering design environments (electronic design automation tools, technologies, methodologies, skills), although increasing, grows substantially slower. Since time to market frame remains roughly constant, the only way to fit this window is hiring more designers and blowing up the budgets. Given a fixed design environment, ensuring that an engineering design process is performed in an optimal way may bring serious benefits, lowering the mentioned gap between design productivity growth and the increase in chip complexity. Engineering design performance should be measured in a way keeping the process on the most optimal possible trajectory.

Today's performance measurement and management practices are based mostly on strategic level benchmarking – finding a place of a company among the others on the industry sector bench. The prevailing methodology is the use of balanced scorecards [3]. Such a benchmarking provides reasonably sound indications of what is good or bad in terms of performance at a strategic management level. However, it does not fully satisfy industrial demand. Krause [4] has analyzed the following weaknesses of the contemporary business performance management (PM) approaches pointing to them as to the reasons of dissatisfaction in industry: (i) strategic PM approaches are driven by “lagging”¹ but not “leading” metrics; (ii) resulting PM methodologies and

¹ The quotes are retained from the source [4].

systems tend to be static²; (iii) there is a significant “abstraction” gap between strategic PM approaches and available knowledge acquisition and representation methodologies; (iv) PM is traditionally based on rigid organizational structuring but not on desired properties of the required business processes; (v) the “metrics” are not transparent, are vague and do not clearly reveal the method of measurement and the sources of data. Our experience backed up by the opinion of [5] suggests adding: (vi) the role of a human designer and his pro-active collaboration in a design team is almost neglected; (vii) existing frameworks do not allow revealing the reasons of the weaknesses of a design system.

Answering “why” questions requires a sort of a paradigm shift in modeling and assessing a design system and performed design processes. In addition to building and measuring high-level heuristic performance characteristics we need to acquire and use a deeper knowledge about the processes, their environment, and their performers to make the assessments more justified. These bits of knowledge should cover engineering design processes and their support by technical, human, and organizational components comprising the aspects of design complexity, designers’ competencies and abilities, concurrency and iteration of design tasks, dependencies, interfaces and collaboration effects at required level of detail. A negative consequence of taking this complex way in performance assessment and management is that the volume and the complexity of data to be processed are far too high to perform such an analysis by hand before the changes pass the point of no return. Therefore, a methodology and an intelligent software tool capable to partially automate such analyses are required. Once they are available, they become important factors ensuring better, closer to optimal, performance demonstrated by a design system. The objective of PSI³ project is to develop such a methodology and a tool capable to discover the hidden reasons for the weaknesses of a design system and accounting for the pro-activity of human designers and the stochastic character of the external and internal influences.

In this talk we focus on the presentation of the theoretical framework of PSI. We first give a high-level sketch of the main ideas, concepts, and approaches forming our framework. These are: an Engineering Design Process, a Design System as the environment of an Engineering Design Process, a Performance Management Process and its environment, external and internal events, and Time. As far as process model is central to PSI, we continue with presenting our state-based approach to model an Engineering Design Process as a transformation process of developing a Design Artifact in its representations and transiting from an initial state, through the sequence of intermediate states, to its target state. We assume that such a process is dynamic because a decision to choose the next step on the path is taken at each state by assigning an action to a designer and providing the required resources and tools. We continue with highlighting the complexities induced by the changing character of design specifications and requirements by introducing the notion of a process state which is sensitive to the Design Artifact requirements. Accounting for this sensitivity allows us to propose a rich typology of design actions which properly reflect the specificities of the domain of microelectronic engineering design. Some examples of different types of actions are: creation actions, further elaboration actions, verification actions,

² ... and linear [6].

³ Performance Simulation Initiative (PSI) is the R&D project of Cadence Design Systems, GmbH.

de-bugging actions, refinement actions, cessation actions. Next, we proceed with explaining and specifying the model of an Actor – a designer, a manager, who may play different roles in the process, and the model of a design team which is a part of a design system. The model of an actor and a design team, as a self-regulating proactive social system, is based on intelligent software agents. Like people in a human design team, these agents may have different beliefs about the peers and about their environments as well as different individual behaviors. However, individual agents, as the members of a design team collaborate in an Engineering Design Process and seek for the most possible achievable coherence in their goals by reaching agreements. We conclude by briefly presenting the concept of PSI Performance Measurement and Management Methodology and by outlining the issues which are still in our research agenda.

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