[[1]](#footnote-1)

**Autonomous Generative Design of Process Structures via Discrete-Event Systems**

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*Abstract*— **In this paper we introduce a method for the automatic generation and computer experimentation of process structures. Process structures are Discrete-Event Systems with a dynamically changing structure that is defined by a collection of resources (or processes) that are networked by interrelated processes and ubiquitous in high-level, abstract, distributed, adaptive and complex systems, yet remain time dependant; such as supply networks, transport or logistics systems and manufacturing systems. In this work a given ‘process structure’ represented as a permutation that is checked for logical feasibility for completion of a hierarchically decomposed goal that is represented as time intervals, then constructed automatically as a forward model or simulation that uncertainty quantification regarding process durations and context switching of utilised resources. In this way, the design of such systems is outsourced to the computer - all feasible possible configurations and their performance is discovered autonomously. A simple example system shows how this approach is applied. We claim this is the basis for a powerful tool in high-level informed design of these types of systems that have hitherto avoided autonomous description or have been previously designed using time consuming manually defined programs.**

***Index terms***— ***generative design, generative models, discrete event systems, job-shop scheduling, event calculus, mathematical logic, metaprogramming***

# INTRODUCTION

The fields of engineering and computing have synergistically supported one another in providing tools to enhance humanities ability to shape our world. Various forms of ‘Electronic Design Automation’ (EDA), including optimisation of hypotheticals in the broadest sense under the context of *Model Driven Engineering* (MDE), have allowed engineering tasks to be presented in appropriate mathematical structures to be utilised by computer programs. As a result of the ability of the computer to inform design decisions, the computer becomes a part of the engineer’s cognitive process allowing the engineer to sit at a higher level of abstraction – typically defining the constraints and goals of the system. It is inevitable this trend will continue, EDA being one of the most established software disciplines to utilise design automation. In a more broader-still context, *Generative Design* has emerged as software process in which a program assists in the design of a wide range of mediums including sound, images, animations and products. In this work we want to show how Discrete-Event Systems that can be generalised as a ‘process structure’ and modelled using event calculus and non-deterministic processing time intervals can also be generated autonomously using a functional-style programming approach. The program itself is inspired by the metaprogramming capabilities of the *LISt Processing* (LISP) programming language but written in MATLAB.

DES express phenomena that can only be described through two distal model theoretic viewpoints; on the one hand, by considering their logical structure encoding (a computer-science theoretical approach, in which analogies to *Cellular Automata* (CA), *Markov Logic Networks* (MLN) message passing networks, or even the representation of a Chess board, in which the places are *processors*) or on the other, through statistical modelling of the dynamic evolution of the system, which draws somewhat predictably most heavily from the fields of a simulation, computer programming and statistics. The former is related to the state space definition as a *disjoint sum*, as opposed to the Cartesian product, that removes the necessity to declare variables not required as simply undefined. There have been little to no attempts to unify these two aspects of the DES field in a coherent framework, despite the fact that they are inextricably linked – the *structure*, or *processor array* viewpoint allows us to consider a ‘space’ of possible structural DES configurations and establish how they relate to one another when actualised through simulation and statistical uncertainty propagation. As shown in this paper, the statistical information indicates that the logical structure has a dramatic and fundamental effect on the system dynamics and thus has many important applications in many real-world system. An accessible approach to explore this configuration space is an important and new concept in the discrete or combinatorial optimisation of many highly commercially valuable systems, including supply chains, logistical system and manufacturing systems to be brought into the fold of EDA.

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a. Sample of a Table footnote. (Table footnote)

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Appendix

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