Formal Methods for Complex Workflow Management in Industry 4.0

Spyros Reveliotis

School of Industrial & Systems Engineering
Georgia Institute of Technology

Abstract

Some primary strategic objectives for modern corporations are the support of ever increasing levels of customization for the offered products and services, with a simultaneous reduction of the production lead times and the operational costs. The current advent of Industry 4.0 seeks to address these requirements by taking advantage of the extensive capabilities of sensing, communication, and computation that are provided by the modern information technology and the proliferation of this technology in the current industrial settings. These capabilities enable a very comprehensive and detailed view of the real-time status of the underlying operations, and the dissemination of the corresponding information to any stakeholder of this production process. They also facilitate, in principle, the effective control of this production process through well-informed and timely decisions. However, in reality, this decision making process can be challenged by extensive levels of representational and computational complexity that results from the extensive levels of flexibility, concurrency and automation (or even autonomy) that are aspired for the targeted operations.

This talk will overview the results of a research program that has sought to address the aforementioned challenges through the formal abstraction of the operations that take place in the considered environments into a resource allocation system (RAS), and the employment of this abstraction for the formulation and the systematic investigation of a number of optimal control problems that will guarantee the integrity and the efficiency of these operations. Besides providing the necessary qualitative insights regarding the nature of optimality in the underlying decision-making process and the factors that determine this optimality, the availability of the aforementioned RAS models and formulations also enable a systematic and very effective management of the inherent trade-off between the computational tractability of the decision-making process involved and the operational efficiency of the derived solutions. Finally, an additional important feature of the presented models and methods is that they are applicable not only in the context of the industrial processes that are typically targeted by Industry 4.0, but also in any other application context that concerns the management of complex sequential resource allocation. Some characteristic examples of such application contexts are the workflows that take place in modern health care systems; the internet-enabled workflow concerning the “backend” operations taking place in certain service areas like logistics, banking, and insurance claiming; and the traffic coordination in (automated) transport systems where the traffic evolves in a constricted medium represented by the links of a “guidepath network”.