Enabling Personalized Pharmaceutical Production through Co-Simulation and Digital Twins

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Abstract:

The pharmaceutical industry is undergoing transformations driven by the emergence of Advanced Therapy Medicinal Products (ATMPs), which are highly personalized treatments based on gene, cell, and tissue engineering. While these therapies offer unprecedented clinical potential, they challenge traditional manufacturing paradigms that rely on rigid, large-scale batch production with limited flexibility.

At the core of this transformation lies the convergence of co-simulation and digital twins, which will enable pharmaceutical production systems to become virtualizable, explorable, and reconfigurable before manufacturers physically realize them. This will allow the industry to transition from reactive, trial-and-error processes to predictive, adaptive, and continuously optimized systems.

This talk will present how digital twins and integrated simulation environments can transform pharmaceutical manufacturing into a flexible, plug-and-produce ecosystem where quality is designed, simulated, and assured from the inception, when requirements are being acquired and the architecture being define.

The talk will also cover the ultimate developments on Virtual Certification, where simulation, data, and digital evidence become mandatory artifacts in regulatory processes, reducing time-to-market while increasing confidence and transparency.

Last, it is expected that this talk will encourage the computer science community to understand the key role of software engineering in shaping the future of pharmaceutical production and, ultimately, medicine, and also the need for professionals who can engineer a new class of cyber-physical systems in which simulation is not just a tool but the foundation of innovation.

Dr. Pablo Antonino is the Head of the Virtual Engineering department at Fraunhofer IESE in Kaiserslautern, Germany. He earned his PhD in Computer Science from TU Kaiserslautern and brings extensive experience in the design, evaluation and integration of dependable embedded systems across diverse domains, including automotive, avionics, agricultural and construction machinery and the pharmaceutical industry. Under his leadership, the Virtual Engineering department develops the FERAL platform, which enables the creation of lightweight digital twins of embedded assets and simulation-based virtual prototypes, as well as the application of the Eclipse BaSyx middleware in the pharmaceutical domain. These initiatives contribute to advancing Physical AI — the convergence of physical systems, simulation models, and real-time digital twins to drive prediction, optimization, and continuous validation of complex systems. A further focus of his work lies in continuous engineering, combining simulation-based virtual validation, digital twins, and architecture-centric monitoring to shorten development cycles and enable systems to continuously adapt to change.

