Simulation-based Learning-aided Adaptation of Complex System of Systems

Vinay Kulkarni[1]

[1] Tata Consultancy Services Research, India
vinay.vkulkarni@tcs.com

Abstract Digital technologies like IoT, AI, Cloud, and advances in computing, and connectivity are blurring the operational boundaries of traditional enterprises. These digital forces are shaping Business 4.0 where enterprises are dynamic ecosystems that need to continually adapt to changes that cannot be deduced in order to stay relevant.

Typically, enterprises rely on use of precise analytical techniques, or models based on past data to arrive at suitable adaptive response. However, with both approaches turning out to be somewhat ineffective, enterprises have to rely on human expertise for adaptation, which, in turn, puts limits on agility and scaling at speed.

The critical questions that remain therefore are: How can a complex system of systems survive in an increasingly dynamic environment? How best can such systems be resilient in the face of constant change? What is the right strategy for adaptation as opposed to a reactive, time-triggered tactical response?

The talk presents a simulation-based, data-driven learning-aided approach to decision-making in the face of uncertainty. It outlines homegrown technology that is based on proven ideas from Modelling Simulation, Control Theory, and Artificial Intelligence, and builds upon further to be able to use these in an integrated manner.

At the core of the approach is the concept of Digital Twin – a virtual, hi-fidelity, machine processable representation of a system or reality that is amenable to quantitative and qualitative analysis. Subject Matter Experts can use Digital Twin as "in silico" experimentation and intervention validation aid. Bringing in Reinforcement Learning (RL) reduces the analysis and synthesis burden on human experts. Architectures such as Model Reference Adaptive Control integrate Digital Twin, RL agent, and system to support dynamic adaptation. Real life use cases from Information-only, Cyber-physical and Societal space will be presented to illustrate utility and efficacy of the approach and supporting technology.

Keywords digital twin, modeling simulation, actor based modeling, reinforcement learning, adaptation architectures, decision making, uncertainty

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