

# Trilogy of Innovations for Achieving High-Performance Cyber-Physical Factory

Prof. George Q. Huang

*Department of Industrial and Systems Engineering,  
The Hong Kong Polytechnic University, Hong Kong, P. R. China*

**Abstract.** The talk is about our first attempt to propose and develop an Industry 4.0 intelligent factory following a formal computer architecture and operating system. By so doing, computer hardware and software techniques can be adapted for high-performance factory production management. The breakthrough is achieved through a trilogy of innovations: (1) digitizing a factory with smart IoT devices into a “factory computer” (iFactory); (2) innovating iFactory visibility and traceability (VT) to enable “look around” techniques just as used in the “Out of Order Execution (OoOE)” algorithm by CPUs (Central Processing Units); and (3) developing novel models for iFactory shopfloor operations management. In the iFactory architecture, value-adding units (such as machine tools for changing forms or properties, and forklifts for changing locations of parts / products) are digitized to become intelligent processors. The computational powers, in both hardware and software forms, of digital twins of manufacturing resources (e.g. machines, human operators, materials, tools, storage spaces, etc.) are used to construct the iFactory CPU around the processor. Their IoT devices / sensors collect real-time process and operation data, and update the iFactory CPU memory at a timed heartbeat rate. With every such heartbeat, the CPU carries out its operational decisions for the processor to execute. The iFactory architecture provides new opportunities to explore and study factory uncertainties through cyber-physical visibility and spatial-temporal traceability, and to develop brand-new data-driven decision models for factory operations planning, scheduling and execution. iFactory demonstrates a new approach to implement Industry 4.0 smart manufacturing systems for high performance, responsiveness and resilience.

**George Q. Huang** is Chair Professor of Smart Manufacturing at Department of Industrial and Systems Engineering, The Hong Kong Polytechnic University. He gained BEng and PhD in Mechanical Engineering from Southeast University (China) and Cardiff University (UK) respectively. He has conducted research projects in areas of Smart Manufacturing, Logistics, and Construction Systems Analytics through IoT-enabled Cyber-Physical Internet with substantial government and industrial grants exceeding HK\$120M. He collaborated closely with industries through joint projects and start-up companies. He has published extensively and his works have been widely cited by research communities. He serves as associate editors and editorial members for several international journals. He is Chartered Engineer (CEng), Fellow of ASME, CILT, HKIE, IET, and IISE.