Industry 4.0 Integration of Legacy CNC Machines Enabled by Blockchains and Machine Learning

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*Abstract*—Pervasive digitalization and the increase in computing capabilities of CNC manufacturing machines are progressively enabling them to fit into the emerging landscape of Industry 4.0 and Cyber Physical Systems. However, there remains a significant population of legacy CNC machines on shopfloors all around the world, that cannot harness the boons of connectivity and predictive analytics. In this paper, the authors present through applied use cases, how legacy CNC machines can be made Industry 4.0 compliant. Through the integration of edge devices and communication protocols like MTConnect, the authors present the design and implementation of server based infrastructures that are able to stream real time data from CNC machines to the cloud and third party software. The provenance of such data is of paramount importance in ensuring integrity of manufacturing nodes on shared cloud manufacturing infrastructures. The authors present the implementation of a blockchain based cloud manufacturing supply chain connecting these CNC machines that ensures tamperproof data provenance through distributed consensus. Finally, the authors also present how deployed Machine Learning algorithms on the cloud infrastructure can provide real time predictive analytics for the connected legacy CNC machines.

Keywords—MTConnect, machine learning, predictive analytics, blockchain, cloud manufacturing.

# Introduction

The presence of networked architectures [ref] and increasing developments within the domains of Cyber Physical Systems [ref] and Digital Twins [ref], has led to the evolution of highly efficient and scalable systems and processes. Such developments have also led to a paradigm shift in how product manufacturing takes place today. Conventional manufacturing processes are increasingly transforming into Cloud Manufacturing processes wherein resources from several different service providers can be deployed on a cloud infrastructure for end users to consume. These paradigms have imposed new requirements on the overall capabilities of manufacturing machines and manufacturing supply chains.

One of the fundamental requirements of cloud manufacturing is that manufacturing nodes like Computer and Numerically Controlled (CNC) machines should have the ability to be able to seamlessly communicate with, stream data to and respond to queries and actions sent from software based cloud infrastructures. In view of this requirement, state of the art CNC machines are increasingly being equipped with complex hardware and decision making software with unparalleled computational capabilities. There are contemporary, high fidelity CNC machine nodes today that are able to autonomously suggest best part orientations, make corrective actions when errors are encountered and are able to remotely communicate with operators for active user intervention. This has all become possible due to the implementation of intricate decision making enabled by computer coded software logic running on computationally intensive hardware. However, a significant portion of CNC machines on shop floors today are legacy manufacturing nodes

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