VISVESVARAYA TECHNOLOGICAL UNIVERSITY “JNANA SANGAMA”, BELAGAVI – 590 018



TECHNICAL SEMINAR ON

“Edge , Fog and Cloud Computing Framework for Flexible Production”

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Edge, Fog and Cloud Computing Framework for flexible Production 2024-2025

# INTRODUCTION

Industry 4. 0 is the current innovation wave , and it can bring huge value to any field. Among all of them manufacturing can get the highest benefit. Connectivity is one of the main characteristics of the 4th industrial Revolution. This is new possibility of data sharing can bring huge value in the manufacturing lines as information. can be collected anywhere and be visible from anywhere. Moreover, the system is monitored in real time and it is possible to know the exact state of machines and components and maintenance teams can intervene as soon as required with precision. With an improved Statistical Process Control (SPC) [2], [3], [4], it is even possible to act before the failure occurs, with a predictive maintenance [5], avoiding disruption and damage spread [6]. The impacts of this kind of adoption are reductions in costs and downtimes. In fact, with precise interventions, it is possible to restore the system in less time. Another key benefit of I4.0 is the possibility for the system to self-adapt and adjust to the real conditions. As the variability of the requested output increases, the system must be able to face all the required changes. Customers are getting more and more demanding, and the mass customization becomes a necessity for many companies [7]. To achieve that, production must be flexible. Flexibility is indeed one of the main characteristics of I4.0 [8] and can make companies able to face the current fluctuations in markets. New technologies can in fact enable the system to switch from one batch to another, even if they are very different from each other. Advanced robotics are provided with devices to change tools quickly and automatically based on the desired outcome. The ability to switch from a production to another is very important to meet the needs of the market, but also to face problems that could occurs, like delays, missing spare parts [9]. As Manufacturing systems are very complex, with thousands of variables correlated to each other, it becomes fundamental to adopt systems able to collect data in real time and perform calculations, which can be sometimes time consuming [7]. This issue increases in severity when the data flow gets bigger and bigger, up to becoming Big Data [10]. In that case, the latency of system can become a very severe limitation to the exploitation of data, whose main value comes from the real time production [11]. In a time-evolving system, timing can be crucial to act with effectiveness.

# ABSTRACT

Industry 4.0 (I4.0) offers tremendous potential benefits across various sectors. Manufacturing can derive the greatest value from it. However, the rate of adoption remains low due to barriers such as management commitment, lack of knowledge, and costs. Simple solutions that require minimal investment and carry low risk are the best way to introduce I4.0 into companies. The shared data flow generated by sensors and the Industrial Internet of Things (IIoT) can provide valuable insights thanks to new connectivity between systems. This deeper knowledge enables the creation of highly flexible production systems capable of meeting customer demands and achieving mass customization. However, a key point too little addressed yet is that the intensity of data flow can lead to latency and data loss issues, resulting in a system unable to meet the real requirements as answers are provided too late. To address this challenge, the authors propose a framework based on the integration of Edge, Fog, and Cloud Computing, aimed at extracting maximum value from data by analysing it both locally and centrally. This approach reduces latency in production systems, enhances flexibility, and enables predictive maintenance. The result is an architectural framework that integrates Edge, Fog, and Cloud Computing to improve the flexibility of a multi-product manufacturing system. The implementation of I4.0 in existing Industry 3.0 plants facilitates flexible production capable of meeting mass customization requirements and achieving high resilience.

**OBJECTIVES**

Edge, Fog, and Cloud computing are essential frameworks for modern applications, particularly in IoT, AI, and industrial automation. Edge computing processes data closer to the source, reducing transmission delays and enabling real-time processing. It enhances security, improves bandwidth efficiency, and is useful for applications like autonomous vehicles and healthcare systems. Fog computing acts as an intermediary between edge and cloud, supporting large-scale IoT networks by filtering and processing data before sending it to the cloud. It optimizes bandwidth and is ideal for smart cities and network management. Cloud computing provides centralized infrastructure for scalable data storage and processing, supporting big data, AI, and enterprise applications. A hybrid approach leveraging all three enhances performance, security, and cost efficiency, making it suitable for smart manufacturing and autonomous systems.

**CONCLUSION**

Industry 4.0, with data share and connectivity, can provide great value in companies. The knowledge about the system can be strongly improved and this will bring new opportunities for enhancing competitiveness in a fast changing world. The data flow, however, requires strong systems to be collected and correctly analyzed. A centralized system cannot in fact manage Big Data. To solve this problem, decentralization is the key. With Edge, Fog and Cloud Computing it is possible to analyze data close to the source and aggregate the results of the first evaluations. With a reduction of response times (-86.7%), fault frequency (-30%), downtimes (-25%), energy consumption (17.6%), setups (-40%) and improved product variability (+50%), the system becomes a lot more flexible. Then, it is possible to conclude that Industry 4.0, and in particular Edge, Fog and Cloud Computing are pivotal for reaching a true flexible production. Future works will extend this framework to Artificial Intelligence [57] and its cognitive capabilities [58] and Digital twin [59], taking into consideration different sectors, like healthcare [60], [61] and energy [62], applied in different activities, from warehouse [63], [64] to supply chain, and focusing also on resilience, sustainability [65], [66] and safety [67]. To successfully reach these goals, it is mandatory for researchers to ensure cybersecurity in an effective way, taking advantage of the ability of this system to isolate infected blocks. Moreover, studies associated to the company size to the need of edge and fog computing should be addressed, providing clearer definition of these 2 technologies. Different kinds of analysis and simulations should be studied to face system stochasticity [68], [69].