Group Report Template

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***Abstract*—The rapid adoption of Industry 4.0 technologies has transformed traditional automotive manufacturing into intelligent and automated production systems. However, many existing car manufacturing systems are constrained by legacy architectures that limit responsiveness, performance transparency when handling complex customized orders. Most related work, which primarily addresses functional and structural aspects of Industry 4.0 architectures, this study focuses on early-stage performance measurement as a core architectural concern. This project presents a software architecture for an Industry 4.0 enabled automated car manufacturing system designed to support fast and flexible processing of customer-specific vehicle configurations. The proposed architecture contains a client-facing web application for order customization. A prototype implementation was developed to validate the architectural design, and experimental evaluations were conducted to measure performance characteristics during the architecture development phase. The results show that the proposed architecture is able to meet the required performance targets under stable operating conditions. The system processes messages with very low delay, continues to operate reliably when orders are created continuously, and allows the scheduler to handle incoming orders fast enough to stay within the defined limits. Overall, these results show that using automated and repeatable performance testing early in the design of Industry 4.0 software architectures is a practical and effective approach.**

***Index Terms*—Industry 4.0, Smart Manufacturing, Software Architecture Evaluation, Formal Verification and Validation, Performance Measurement.**

I. Introduction and Motivation

The structure of the paper is as follows. Section II outlines the research question and the research approach. Section III describes similar work in the field and how our contribution fits the field. Section IV presents a production reconfiguration use case. The use case serves as input to specify a reconfigurability QA requirement in Section V. Section **??** introduces the proposed reconfigurable middleware software architecture design. Section VIII evaluates the proposed middleware on realistic equipment in the I4.0 lab and analyzes the results against the stated QA requirement.

II. Problem and Approach

Problem.

Research questions:

1)
2)

Approach. The following steps are taken to answer this paper's research questions:

1)

III. Related work

This Section addresses existing contributions by examining xxx in the I4.0 domain. In total, x papers are investigated.

In [1], experiences are elaborated on a three-layer architecture of a reconfigurable smart factory for drug packing in healthcare I4.0.

The paper [2] proposes an ontology agent-based architecture for inferring new configurations to adapt to changes in manufacturing requirements and/or environment.

In [3], [4] an architecture for a reconfigurable production system is specified. Two objectives for reconfiguration and how they can be reached are described.

Several papers [5]–[7] describe reconfigurable manufacturing systems that are cost-effective and responsive to market changes.

All contributions provide valuable knowledge about reconfiguration but lack a study of the software architecture perspective that specifies a quantifiable reconfigurability architectural requirement, a software architecture that adopts the architectural requirements, and evaluates the architectural requirement.

IV. Use Case

This Section introduces the use cases.

V. Quality Attribute Scenario

This Section introduces the specified x QASes. The QASes are developed based on the use case.

VI. Design and Analysis Modelling

Design and analysis modelling.

VII. Formal verification and validation

Formal verification and validation of system(s).

VIII. Evaluation

This Section describes the evaluation of the proposed design. Section VIII-A introduces the design of the experiment to evaluate the system. Section VIII-B identifies the measurements in the system for the experiment. Section VIII-C describes the pilot test used to compute the number of replication in the actual evaluation. Section VIII-D presents the analysis of the results from the experiment.

A. Experiment design

B. Measurements

C. Pilot test

D. Analysis

IX. Conclusion

Conclusion of the report, discussion and relevant future work.

A. Discussion

B. Future work

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Contributions

Name	Contribution