A Knowledge Graph-based Approach for the Quality Management of Bosch Products

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1. Introduction

For electronic products at Bosch, internal defects are a type of anomaly that may happen and cause severe degradation in the electronic product quality. Normally, the data for analyzing internal defects in the Surface-Mount Technology (SMT) area is heterogeneous and disconnected. Different semantic interpretations of data are also present. This leads to various disconnected data silos (as engineered, as supplied, as produced) along the product lifecycle that cause not only huge but also repeated efforts for data clarification, collection, cleaning, and analysis. Despite the existing efforts to tackle these problems at Bosch [1], still a concrete solution that can be used world-wide for the semantic integration in SMT is missing. To address the above challenges, we introduce a Knowledge Graph (KG)-based approach that provides a data-driven solution to make all data transparent, semantically-enriched, and easy to access along the entire electronic product lifecycle from engineering to supply to production.

2. KG-based approach for SMT cost reduction

Fig. 1 shows the proposed architecture for SMT cost reduction using KGs. The architecture consists of four layers, from bottom to up. **Data Source Layer.** At this layer, heterogeneous data sources have been identified and selected for answering business questions. An innovative feature of this layer is the reuse of graph data from another Bosch project called Line Information System [2]. The reuse of KG data follows the principles of Data Mesh concept where data is distributed among several Mesh nodes and centrally governed & shared throughout these nodes [3]. **Mapping Layer.** This layer aims to map data fields in data sources to the classes and relationships in ontologies so that isolated data silos are semantically linked and integrated together. **Knowledge Graph Layer.** At this layer, a group of ontologies are either reused or developed for data ingestion. Together with the ingested data, a unified KG is constructed. In total, the KG contains 16 classes, 54 properties, and around 8 million triples. **Application Layer.** The constructed KG serves as a unified and cleaned center of data exposing API for

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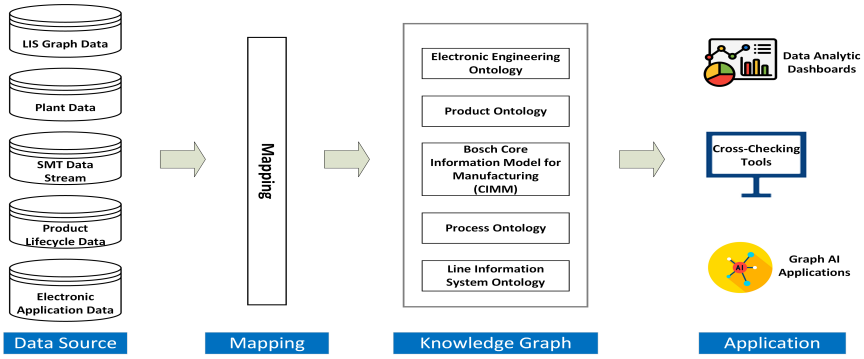

Figure 1: The proposed KG-based architecture for SMT cost reduction.

developing applications. Based on the KG, graph-based AI algorithms, e.g., subgraph mining, graph neural networks, are easy to be deployed for failure analysis and prediction during the design and production phases of electronic components.

3. Lessons learned

Traditional approaches for identifying internal defects of electronic products are quite laborious and time-consuming. Now thanks to KG, this process has been shortened from three months to three minutes. This is all because the heterogeneous data sources have been semantically enriched, integrated, and standardized so that new insights can be derived from the data to support cost reduction tasks. By the use of our KG-based approach, we improve the efficiency of data analysis by 70% also for effort reduction and save around 200k EUR per year across Bosch factories. Lessons that are learned from this project can be generalized to a wider range of KG-based projects, e.g., it is recommended to follow the best practices for developing ontologies; KG is a suitable solution for mitigating Semantic Interoperability Conflicts (SICs) [4] that are evident across multiple databases. As of future work, we aim to further develop Neural-symbolic AI solutions on top of the KG to predict potential product defects.

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