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Semantically Connected Semiconductor Supply Chains

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SC3

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Publishable Executive Summary

This deliverable refers to the demonstrators for the SC^3 projects. The content of this report covers in particular specification, development and implementation of the demonstrators proposed by SC^3 consortium members one year after the project was initiated.

Six demonstrators have been discussed in this report. The first one, (1) **Digital Reference development**, refers to the progress made on SC^3 project so far with focus on the Digital Reference – upper ontology for semiconductor and semiconductor supply chains domain. The second one,(2) **Knowledge graph pricing model use case**, demonstrates practical application of semantic data integration and its benefits. The third one, (3) **Digital Reference-based approach for complex semiconductor industry-wide problems**, is an example for more complex application of semantic web technologies for the tasks requiring data integration from multiple heterogenous sources. In the fourth demonstrator, (4) **collaborative ontology development platform** is presented. This is an innovative, user-oriented framework for ontologies development and visualization developed to bridge the gap between knowledge engineers and domain experts. The fifth demonstrator, (5) **Blockchain solution for the collaborative development of the Digital Reference**, shows a prototype model of collaborative workflow for ontologies' development. Also, in this demonstrator blockchain solution for ontologies' development and its current application for the Digital Reference update process is discussed. The sixth demonstrator, (6) **Requirements gathering and use case delimitation**, presents a use case of generic data model as a digital twin for the production line for dynamic simulation and high degree of forecast accuracy.

For each of the demonstrators its specifications have been described as well as a current state of development and possibilities of the future implementation.

Table of contents

List of tables

1. Introduction

SC^3 is a project with the aim to take the Supply Chain Management of production in Europe to a new level. Based on the Internet of Things and linking the real with the digital world, it will push a close interaction to a smooth and transparent collaboration making even highly complex supply chains resilient, flexible and agile. This project focuses on merging a Digital Reference platform including its ontology with a Generic Data Model. In other words, SC3 intends to create a common language for total collaboration between humans and machines and all partners involved.

Important part of any project is to share its vision with a possibly broad auditorium as well as to demonstrate its goals' realization to the relevant authorities. Demonstrators can serve both those purposes. In this report three demonstrators have been proposed and discussed, with the aim to present progress made by SC^3 consortium members so far. The first demonstrator, Digital Reference development, refers to the progress made on SC^3 project with focus on the Digital Reference – upper ontology for semiconductor and semiconductor supply chains domain. Demonstrators number 2 and 3, Knowledge graph pricing model use case and Digital Reference-based approach for complex semiconductor industry-wide problems, demonstrate practical application of semantic data integration and its benefits. The fourth demonstrator, Collaborative ontology development platform demonstrator, presents innovative framework for ontologies development and visualization. In the next demonstrator, number 5, a prototype platform for ontology changing by multiple users and a blockchain solution for ontology development have been demonstrated. Demonstrator 6, Requirements gathering and use case delimitation, includes generic data model use case. For each of the demonstrators its specifications have been described as well as a current state of development and possibilities of the future implementation.

The initial goal of the SC^3 demonstrators is to present them during consortium review meeting. However, as they also show practical benefits of semantic technologies application, they might be reused in the future to promote the Digital Reference as a domain standard and as possible solution for other domains.

2. Demonstrators specifications

2.1 Digital Reference development

Work Package:

WP5

Demonstrator:

Video

Length:

4 min

Purpose:

The main goal of this demonstrator is to present progress made on the Digital Reference development in frames of SC^3 project so far. The Digital Reference has been introduced as a quasi-standard for digitalization in the domain of semiconductor supply chains in frames of Productive 4.0 project. Further development of the Digital Reference and its connection to other domains are goals of the SC^3 project.

Specification:

In this demonstrator evolution of the Digital Reference since the beginning of the SC^3 project has been discussed. First of all, short history of the Digital Reference has been presented with reference to the Productive 4.0 project. Here the Digital Reference as an enabler for semiconductor supply chains digitalization and as a digital analogue of a human brain has been mentioned.

Moreover, evolution of the Digital Reference has been discussed. The key achievements are:

- Thanks to application of naming conventions and ontology best practices linguistic layer of the Digital Reference is more consistent now, which means also better readable for the users,
- Structural improvements to the Digital Reference have been made (fiscal year time perspective, connections between disconnected entities have been added),
- CO2 ontology has been integrated to the Digital Reference as a significant extension of the scope of the ontology and possible future connection to the automotive industry,
- Regular update process with blockchain as the first step into direction collaborative ontologies development.

Additionally, Digital Reference has not only been developed further, but has also been introduced to other funded project, since application of semantic technologies may improve results achieved within the projects. Thus, short description of possible application of the Digital Reference in different areas and participants' experience of using the Digital Reference has been included in the last part of this demonstrator.

2.2 Knowledge graph pricing model use case

Work Package:

WP5

Demonstrator:

Video

Length:

17 min

Purpose:

This demonstrator presents how Digital Reference can help to solve important business problems. The main goal is to show that companies can actually benefit from applying solutions based on semantic technologies.

Specification:

At Infineon Technologies multiple researches have been conducted that prove effectiveness of semantic technologies application for the business use cases. For some problems, especially heterogeneous data-related, best solutions could be found thanks to semantic approach. For this demonstrator we want to focus on one chosen example. We propose to demonstrate use case of knowledge graph-based pricing model for semiconductors supply chains.

Semiconductor supply chains are strongly affected by the bullwhip effect, i.e., increasing demand fluctuation. Thus, in a competitive market, semiconductor manufacturers seek to optimize capacity utilization, deliver with shorter lead times than the agreed contractual times and guarantee customer satisfaction and loyalty. Firms exploit faster delivery by resorting to revenue management ideas such as dynamic pricing. However, this potentially affects relationships with customers.

Knowledge graph pricing model is a semantic lead time-based pricing approach allowing tailored revenue generation according to customers' profile thus reducing the risk of harming relationships. Via Digital Reference, upper ontology for the whole semiconductor domain, information about orders can be easily compared with customers' profile and data about customers' order behavior. Using a pricing algorithm, implemented as a SPARQL query, a premium price can be assigned to each customer based on their order behavior and changes in the order lead time. In this way, semantic data integration enables customer profiling aware lead time-based pricing.

This demonstrator contains problem statement, demonstration of semantic approach with help of the Digital Reference presents benefits for the company.

2.3 Digital Reference-based approach for complex semiconductor industry-wide problems

Work Package:

WP 5

Demonstrator:

Video

Length:

7 min

Purpose:

With support of semantic web technologies even complex problems can be solved in a fast and effective way. This can refer to the big industry-wide problems like global semiconductor chip shortage. This demonstrator proves that with help of the Digital Reference a knowledge-based solution can be find.

Specification:

First of all, short description of the global chip shortage is provided, including causes and consequences. Bearing in mind, that global character of this crisis requires cooperation of multiple partners and information exchange between them, it has been concluded that knowledge-based solution is needed.

Next, list of important points and questions about semiconductor industry is presented. The idea is that if all the semiconductor companies worldwide would answer those questions providing appropriate data, knowledge gathered in this way would be sufficient enough to find solution to the global chip shortage problem e.g. via knowledge-based strategic decision making.

However, it is difficult to coordinate process of gathering data from so many sources. Luckily, Digital Reference can serve as a framework for data integration. Mapping of data to the Digital Reference and obtaining results (answers) is a unified and standardized process. Digital Reference is also sufficiently developed to facilitate the process. In the next part of the demonstrator particular parts of the Digital reference have been presented. It has been demonstrated that with help of the Digital Reference all the questions asked before can be asked.

This demonstrator proves that Digital Reference can enable solving industry-wide current problems, but we also are convinced that it can support decision-making process in case of the future challenges.

2.4 Collaborative ontology development. Bridging the gap between knowledge engineers and knowledge experts

Work Package:

WP 4

Demonstrator:

Video, additionally presentation available

Length:

8 min

Purpose:

This demonstrator presents a collaborative ontology development and visualization platform. Such a platform is currently being developed by SC^3 consortium members. It will enable intuitive and user-oriented customization and metamorphosis of ontologies. Tools available so far did not provide such features, thus this demonstrator will present an innovative approach proposed as part of SC^3 project.

Specification:

A video demonstration provides introduction to the platform. First, motivation and limitations currently related to collaborative ontology development are explained. The main goal for the platform is to provide user-oriented ontology development possibilities. It means that it should

be intuitive and allow experienced knowledge engineers, novice ontologists and domain experts not familiar with semantic web technologies equally.

Then, functionalities of the platform implemented so far have been presented with the focus on practical application aspects. Currently, with help of the platform ontologies can be represented in text, widget, graph or hybrid mode. Moreover, customization is possible to some extent. Colors of entities can be changed as well as font size.

2.5 Blockchain solution for the collaborative development of the Digital Reference

Work Package:

WP 5

Demonstrator:

Video

Length:

10 min

Purpose:

Collaborative development of ontologies requires cooperation of multiple participants and means that ontology is subject to regular change. Thus, on the one hand, it is important to provide a technical possibility for effective cooperation, on the other hand, the whole process should be transparent and safe, which means that other participants should have right to authorize canes and all versions of ontology should be easily trackable. In this demonstrator we present a prototype platform for collaborative changing of ontologies and authorization of changes. Moreover, we present how the update process of the Digital Reference established by SC^3 consortium is designed and how blockchain hashes generation is used to allow tracking of changes made and secure the whole process. Solutions presented in this demonstrator will be in the future integrated with the platform presented in demonstrator 4.

Specification:

In this demonstration video first, the problem is described. Then a current Digital Reference update process has been presented followed by the demonstration of a prototype platform. This platform allows multiple user to propose changes to the Digital Reference, all the users actively take part in the process. The platform is based on distributed ledger technology concept, which has been explained afterwards. Also, platform architecture is discussed in this demonstrator. Then, practical application is presented. Finally, it is demonstrated how a blockchain hash for the newest version of the Digital Reference are generated each time.

2.6 Requirements gathering and use case delimitation

Work Package:

WP 2

Demonstrator:

Presentation

Purpose:

One of the goals for SC^3 is data comparison and mapping between Digital Reference and generic data model. This demonstrator focuses on the generic data model and shows its application in the industry for production simulation.

Specification:
Generic data model serves as a digital twin for production lines. It is a high-fidelity model that provides a high degree of forecast accuracy, enabling proactive fab production control - avoiding issues rather than reacting to issues observed when they happen. This presentation gives an overview on the data model-supported simulation process.

3. Demonstrators development and implementation

3.1 Development

3.1.1.1 Demonstrator 1 (Digital Reference development)

This demonstrator has been created by IFAG, resources were partially available.

3.1.1.2 Demonstrator 2 (Knowledge graph pricing model use case)

This demonstrator has been created by IFAG, this demonstrator is based on the previously published paper *KnowGraph-PM: A Knowledge Graph Based Pricing Model for Semiconductor Supply Chains* [1].

3.1.1.3 Demonstrator 3 (Digital Reference-based approach for complex semiconductor industry-wide problems)

This demonstrator has been created by IFAG.

3.1.1.4 Demonstrator 4 (Collaborative ontology development. Bridging the gap between knowledge engineers and knowledge experts)

This demonstrator has been created by TIB. Demonstrated platform will be further developed and used for ontology development.

3.1.1.5 Demonstrator 5 (Blockchain solution for the collaborative development of the Digital Reference)

This demonstrator has been created by IFAG. As the next step, demonstrated functionalities will be integrated with the platform presented in demonstrator 4.

3.1.1.6 Requirements gathering and use case delimitation

This demonstrator has been created by BOSCH.

3.2 Implementation

All demonstrators have been presented during the SC^3 review meeting on 17th November 2021. All demonstrators can be also used for the promotion and dissemination of the project.

4. Conclusion

Demonstrators proposed and described in this report show progress made on the project's objectives, with focus on the further development of the Digital Reference, ontologies development and practical application of the Digital Reference, generic data model and semantic web technologies. Thanks to this, everyone interested in the project can obtain up-to-date and practical information about its vision, goals and realization.

5. References

1. Nour Ramzy, Sören Auer, Javad Chamanara, Hans Ehm, *KnowGraph-PM: A Knowledge Graph Based Pricing Model for Semiconductor Supply Chains*
https://rd.springer.com/chapter/10.1007/978-3-030-79474-3_5

6. Appendix

6.1 Abbreviations

Table 1: Abbreviations

Abbreviation	Meaning
PCA	Project Consortium Agreement
PGA	Project Grant Agreement
SC3	Semantically Connected Semiconductor Supply Chains
IFAG	Infineon Technologies AG
TIB	Technosphere Informationsbibliothek