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Publishable Executive Summary

This deliverable (D6.1A) refers to the yearly report on stakeholders' engagement activities of SC3 project for the first year. In this context, this report presents the results of the workshops and webinars done throughout the first year of the project.
The conducted webinars and workshops addressed the gathering of additional requirements provided by participants as well as the presentation of the project objects and software architecture in order to increase the awareness for the project.

This deliverable is structured as follows:

- Chapter 1 provides an introduction that addresses the general aspects of Semantic Web technologies in the context of semiconductor and supply chain domains and related challenges in order to provide the applied terminology and definitions for this deliverable.
- Chapter 2 addresses stakeholder engagement in the context of the SC3 project and describes stakeholder needs and requirements: (i) for a standardized vocabulary describing the domain and the commonly known and existing data documentation and models (ii) for platform functionalities (iii) for demonstrators.
- Chapter 3 provides a conclusion summarizing the obtained needs and requirements.

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1. Introduction

The semiconductor industry is characterized by complex supply chain structures. Thus, it requires mechanisms to define, describe, and adjust its underlying processes in such a way that supply chains become highly resilient and agile. Furthermore, communication between supply chain partners needs to be fast for appropriate planning, decision-making and execution.

Semantic Web technologies receive growing attention in industrial and academic contexts and provide knowledge representations that are understood by humans and machines alike. Taxonomies, vocabularies, and ontologies serve this purpose by providing a formal, machine-readable representation of domain knowledge. However, the larger and more interlinked such semantically enriched knowledge representations become, the more challenging it is for humans to explore and comprehend them.
The SC3 project propose to apply Semantic Web technologies for defining supply chain processes in the form of ontologies related to this domain. In particular, the project proposes the extension and standardization of the *Digital Reference ontology* that has been developed in the H2020/ECSEL Productive 4.0 (https://productive40.eu/) context.

A fundamental aspect of Semantic Web is creating and communicating conceptualizations of information and data in certain domains. Related to this, ontology development thrives through communication and common agreement. However, through the increased attention of Semantic Web in academic and industrial context, ontology development becomes more prominent across different user groups including ontology engineers, domain experts and various stakeholders. Thus, approaches that are customizable and user-oriented are required to engage all stakeholders and facilitate communication, understanding and the common agreement for semantically enriched representation of data, information, processes and knowledge.

The SC3 project addresses this challenges in the ontology development by a collaborative ontology development platform that will facilitates communication, common agreement, trust and validation. To this end, the conducted workshops and webinars presented a customizable approach that uses hybrid modes of operations in order to address the different requirements and needs of different user groups.

2. Stakeholder Engagement

The SC3 project relies on enabling a collaboration of industrial as well as academic stakeholders. Therefore, it is important to engage stakeholders from the very beginning of the project. Stakeholder engagement not only addresses the needs and requirements for creating a high-quality standardized ontology for the semiconductor domain but also addresses users' needs and requirements for a collaborative ontology development platform. Nowadays, ontology development process is done in joint efforts of domain experts and knowledge engineers.

2.1 Awareness building on SC3

The successful realization and adoption of Semantic Web technologies in the semiconductor domain and related supply chains relies on the increased awareness of stakeholders for the benefits and opportunities and its applications. While Semantic Web technologies have been successfully adopted in Business-to-Customer (B2C) environments, the SC3 project addresses the adoption of Semantic Web in Business-to-Business (B2B) environments.

As the project has an extrovert outlook, involving domain stakeholders from the beginning, to maximize the efficiency of communication initiatives, the awareness building activities consisted of several presentations with a particular attention paid to industrial and academic community. The Table 1 summarizes the different meetings that have been held and does not include meetings between project partners.

Meeting	Location	Audience	Date
Introduction to SC^3	Gardanne	• Academic (EMSE) • 25 participants	01.02.2021
Half-day seminar on advances in the Semiconductor Manufacturing domain	Online	• Industrial and Academic (IMT-EMSE / STM) • 53 participants	16.02.2021
Discussions on the development of an Ontology of Semiconductor Manufacturing Metrology and Risk Management	Online	• Industrial (STM) • 5 participants	10.08.2021
Discussions on the ontology development methodology	Online	• Industrial (STM) • 5 participants	03.09.2021

Table 1: SC3 Meetings

Furthermore, in order to increase the awareness of the SC3 project partners have participated in the *DORIC-MM Workshop* co-located with the *European Semantic Web Conference* (ESWC, https://2021.eswc-conferences.org/) organized by *Onto Commons* (Ontology-Driven Data Documentation For Industry Commons, https://ontocommons.eu/). Also, a presentation has been accepted in a special session at the *IEEE CASE 2021 conference* (https://case2021.sciencesconf.org/). The aim of this presentation is to increase the awareness for the project, provide an overview of the platform functionalities for customizable visualizations and different modes of operations to engage various user groups. The Q&A session after the presentation did not provide additional user requirements, however the customizable visualization approach was positively remarked.

Additionally, workshops and webinars are announced via e-mail, mailing lists, twitter and could be found on the Eventbrite system, which was used for the participant registrations and distribution of the meeting links. We conducted workshops and webinars for obtaining stakeholders' needs and requirements. The target audience of this workshops and webinars are academic and industrial stakeholders. Furthermore, in order to increase the awareness of the project, the project partners participated in the DORIC-MM workshop and presented the overview of the platform functionalities at IEEE CASE 2021 as described in Chapter 2.1. The focus on engagement was the user requirements for the platform realization that are provided in section 2.3.2. In these events we presented the proposed solutions for the platform realization which resulted in positive feedback and discussions for additional requirements. Due to the COVID-19 pandemic all workshops and webinars have been held virtually. In all events participants included academic and industrial stakeholders. In the following Table 2, we list the webinars and workshops with additional details.

Meeting Title	Type and Location	Participants	Date
Introduction to the project objectives	Webinar	15	17.02. 2021
Collaborative ontology development platform	Workshop	15	24.03. 2021
Bring ontologies to a larger audience	Webinar	11	06.05.2021
Standardization aspects	Workshop	11	18.06.2021
Introduction to hybrid modes of operations	Webinar	12	04.08.2021

Table 2: Table of Webinars and Workshops

In addition, FTK worked on an ontology for demand fulfillment activities in semiconductor supply chains. For this, FTK researchers discussed the proposed ontology with domain experts from Infineon and Bosch. A condensed version of the proposed ontology is published in [4]. Moreover, a description of the full ontology including a corresponding owl-file is publicly available using the link that is provided in [5].

2.2 Stakeholder needs and requirements

The modeling of ontologies is frequently done collaboratively in joint efforts of knowledge engineers and domain experts. On the one hand, domain experts, providing the conceptualization of domain knowledge, are typically not familiar with semantic formalism and conceptual modeling techniques. They often find it hard to follow logical notations in OWL representations. On the other hand, knowledge engineers, providing the necessary know-how for ontology modeling and logical notations in OWL, usually lack the domain's expertise to create ontologies of sufficient quality. Therefore, different stakeholders have different needs requirements. The next sections will elaborate on the creation of domain ontologies, the capturing user requirements, and their implication to our demonstrators.

2.2.1 A standardized vocabulary describing the domain

In order to create ontologies representing a standard vocabulary of the semiconductor manufacturing domain, the most important data sets as well as existing taxonomies, ontologies and other data models have to be identified. Some of them have been identified and are listed in the project proposal. With the Digital Reference (DR) developed in H2020/ECSEL Productive4.0, solid foundations are available ranging from vocabularies, to UML Semiconductor *Generic Data Model* (GDM) as well as several datasets. However, as many sub-ontologies are being developed, additional relevant resources will be identified and used. Finally, several meetings were organized to identify, define and collect the required datasets from the various stakeholders in order to compare them.

The Digital Reference provides a standardized vocabulary that has been developed in the H2020/ECSEL Productive 4.0 project. However, specific topics such as demand fulfillment or order management are not always fully addressed and need additional extensions and refinements. This is also true for the automation of specific decision-making activities that can be supported by ontologies. In the SC3 project, we are interested in reducing these gaps by proposing several subontologies of the Digital Reference. More specifically, we work on the following subontologies:

1. ontology for demand fulfillment and order management activities
2. ontology on metrology processes and risk management
3. ontology for planning activities in semiconductor supply chains.

2.2.2 Requirements and needs for platform functionalities

The requirements of for the platform functionalities are defined in the project proposal. However, as stated before, gathering additional requirements and feedback from participants of the workshops and webinars provides additional opportunities for improved functionalities of the system, allowing for engaging different stakeholders more directly.

2.2.2.1 General requirements for the data infrastructure

The general requirements for the platform functionalities are derived from the representation format of semantically enriched structures in Semantic Web contexts. In particular, ontologies, vocabularies and taxonomies are textual representations of the domain knowledge. These textual representations of the domain knowledge describe its conceptualizations and their relations using the Resource Description Framework (RDF) in different serialization formats such as Turtle, XML, or Manchester Syntax.

Due to the aspect that nowadays domain experts, knowledge engineers and other stakeholders work across different devices the collaborative ontology development platform needs to be realized in a web application fashion. Web applications do not require any installation processes (which often require administrative rights on a system and that are not guaranteed to be available for all users) and are ready-to-use. However, to ensure validation, tracking of changes, communication between different users, and different access rights, user authentication and authorization are required. To this end the platform envisions a single-sign-on mechanism for identification of users and their corresponding rights for reading, writing, and suggesting changes for the ontologies provided in the platform.

Over the last years numerous ontologies have been developed for different domains. These ontologies are typically hosted under different domains (URLs) or are provided as artifacts on platforms such as GitHub. This decentralized distribution of ontologies on the web makes it difficult to discover existing ontologies for a specific use case. Furthermore, extensions or modifications are typically difficult to integrate.

Thus, the collaborative ontology development platform envisions providing access to ontologies using an ontology repository. This repository provides indexing and archiving functionalities. Considering the different user rights, the indexing functionality lists all available ontologies in the repository with their names and additional human readable descriptions. Depending on the publication status of ontologies (i.e., public or private) users can request different access rights to ontologies. In the case of public ontologies all users have read rights and can inspect the content of the ontology in the platform. The archiving functionality holds the content (i.e., the textual representation of the ontology).

Thus, indexing and archiving functionalities are conceptually separated, whereas the indexing database provides only meta information of the ontology, while the archiving database holds the content of the ontology. Ontologies are integrated into this repository using upload functionalities. Therefore, new ontologies for the domain knowledge of the semiconductor and related supply chains can be uploaded in to the system, providing a central repository for related ontologies and facilitate the discovery and reuse of existing ontologies in the system.

For a successful realization of the platform, user management is essential. The access to the content of ontologies requires the identification of a user and the corresponding rights for the archiving database. Since ontologies thrive through common agreement changes and updates to ontologies require additional rights. Thus, the platform envisions all changes to be addressed in two steps. The first step addresses the desired modification of a user. These modifications are in fact in the first stage suggestions. These suggestions can then be validated by the governing authority of an ontology and be accepted or rejected. Accepted changes are then integrated into the database and a Blockchain version is created to ensure validation, trust and versioning of the ontology. The envisioned communication functionalities provide additional information for the accepted or rejected changes and facilitate communication between different stakeholders to find a common agreement on the machine-readable conceptualization for processes or the domain knowledge. This requirement is also reflected in the deliverable D1.3 Quality assurance and risk management, which states the need for update and versioning mechanism for maintaining the Digital Reference ontology.

The deliverable D7.7 Data management plan emphasizes additionally on the platform functionalities to provide the ontologies in open and FAIR (Findable Accessible Interoperable and Reusable) manner. The indexing functionality of the platform addresses the findability aspect, where it provides the name and a human readable description of the ontology. Accessibility is addressed by the platform and the granularity of rights. Interoperability is governed by the general conceptualization how ontologies are created (machine-readable representations of domain knowledge). Reusability is envisioned to be addressed by the platform in the form of the Ontology Lookup Service (OLS) and auto-complete functionalities. Thus, the conceptualizations of existing ontologies that are publically available or belong to a governing authority can be directly reused during the modeling process of ontologies.

While ontologies provide semantics for their underlying conceptualizations, it is essential to recognize that ontologies are designed by humans. Thus, in order to facilitate a common design paradigm naming conventions are necessary. Naming conventions provide a better understanding and increase the communication about the content of ontologies from a user perspective. Furthermore, they facilitate integration, reusability and combinability of ontologies and decrease inconsistencies in the development process. To this end a naming convention has been created.

2.2.2.2 User Requirements

The objective of the SC3 project is to enable a collaboration of industrial as well as academic stakeholders. As reported in deliverable D7.7 - Data management plan, the framework provides a collaborative ontology development approach to be used by academic and industrial stakeholders. Thus, these different user groups have different requirements and needs for platform functionalities. The workshops and webinars addressed academic and industrial stakeholder to obtain additional user requirements and needs for a successful realization of the platforms that acts as key enabler for creating ontologies of high quality.

The general aspect of Semantic Web is that the machine-readable conceptualizations for domain knowledge are represented in textual formats with different serializations. Thus, the platform requires the supporting of different ontology serialization formats such as Turtle or Manchester Syntax.
From a user perspective the platform should allow for uploading ontologies in different serialization formats. Related to this, the OWL-API, which is the backbone of Protégé provides such functionality and is employed before an ontology is integrated into the database. Furthermore, the OWL-API provides basic validation mechanism for ontologies, i.e., parse-able (correct syntax) and identification of additionally imported ontologies. This pre-initialization validation mechanism ensures that only valid ontologies are integrated into the system. Furthermore, these validation mechanisms can be used to validate suggested updates. Thus, these validation mechanisms address the user requirements for high quality ontologies for the domain. The naming conventions additionally contribute the quality of ontologies.

During the first workshop, we obtained additional feedback from the participants using an interactive poll system (Mentimeter). The first poll inquired the feedback about the used tools for ontology development, see Figure 1. The second poll addressed the challenges in ontology development, see Figure 2. As indicated in Figure 1, users use a variety of ontology development tools. These results are grounded in the aspect that users have different experiences with tools and expectations for system functionalities for specific use cases.

These results are used for the development of a hybrid mode of operation paradigm for the collaborative ontology development platform. We identified that form and widget-based interaction methods as provided by Protégé are mostly used. To a certain extent these widget based tools hide the complexity for the ontology development and provide restrictions on where and what values can be edited; however, still provide the full formalizations for OWL ontologies. WebVOWL Editor is an ontology visualization tool that additionally provides visual editing features. In particular, users new to ontology modeling can inspect the network-like structure in the form of node-link diagram visualizations and can create conceptual elements or interlink them directly in the graph. However, WebVOWL editor is designed for small ontologies and supports only a subset of OWL constructs. Nevertheless, for novice user this mode of operation provides reasonable interaction mechanism for understanding the content and also provides interactions for extensions of ontologies.

Generally, since ontologies are distributed in textual representation, these can in principle be created using a simple text editor. While text-based editing can be error-prone and difficult to understand for large ontologies, it is still the representation method for machines; and some users (i.e., knowledge engineers) prefer to use text-based editing for creating complex OWL constructs such as cardinality restrictions. Thus, text-based editing represents a mode of operation for experts that supports all formalizations of OWL ontologies.

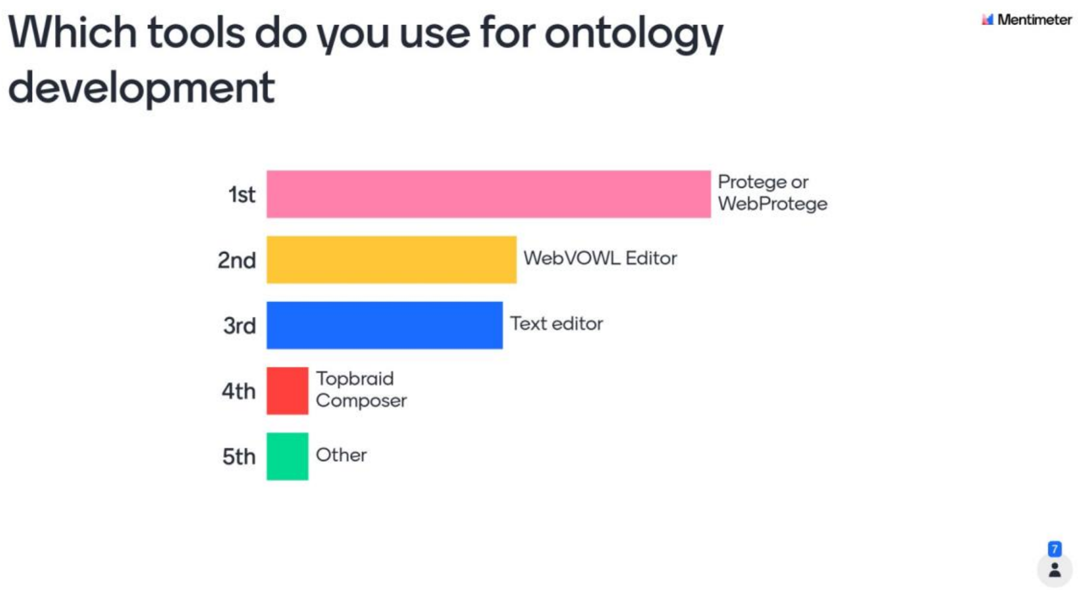

Figure 1: Poll results for used ontology development tools

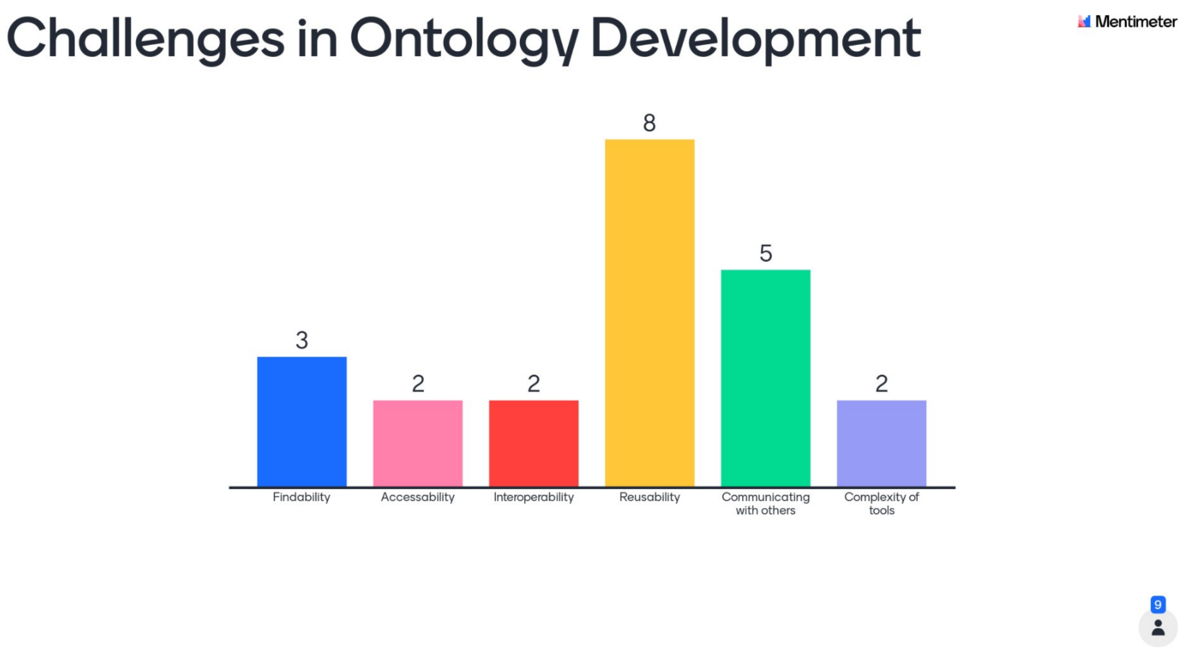

Figure 2: Poll Results for challenges in ontology development

With these considerations we identified three modes of operations for three different user groups. The first group of users addresses the experts in knowledge engineering which require the full OWL formalization features to create and refine ontologies, ensuring high-quality and machine-actionability. The second group addresses intermediate users in the context of knowledge engineering. In particular, this group includes experts who prefer a widget-based mode of operation and domain experts who have prior experience in ontology development using Protégé. The third group addresses users without any prior experience in ontology modeling. For this user group, the visual modeling paradigm provides the reduction for the complexity of OWL formalizations and allows them to edit the content directly in the visual representation. Furthermore, we propose a combination of all modes of operation in a hybrid approach that allows users to inspect a conceptual element of an ontology simultaneously in all representations.

The different modes of operation provide an additional benefit, namely the facilitation for communication between different user groups. Since the content of the ontology provides the foundation, the modes of operation provide different views and interaction methods for the ontology development. Thus, different user groups can communicate with other user groups on a level that reflects their preferred representations.

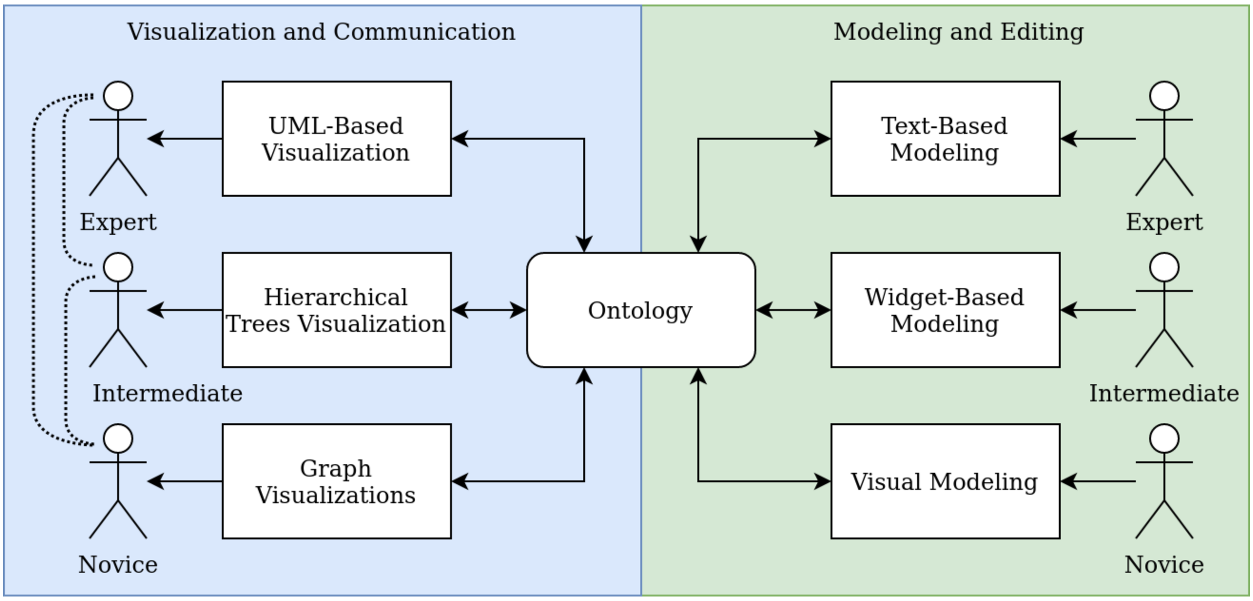

Figure 3: Representation for the different user groups and the corresponding modes of operations.

Visualizations provide an abstraction of information that reinforces human cognition and facilitate understanding of complex data through its visual representations. Thus, visualizations offer a good starting point for exploration with an additional cognitive support for the understanding of provided information. In Semantic Web contexts various visualization methods and tools are available. The applied methods range from indented trees and chord diagrams to treemaps and Euler diagrams. Suitable visualizations, however, are highly dependent on individual use cases and targeted user groups. Therefore, an additional requirement for the collaborative ontology platform is the customizable visual representation of ontologies as described in task T4.2 of work package 4 in the project proposal.

The *Graph Visualization Meta Ontology* (GizMO) [1] provides such customization features for node-link diagram visualizations. The main characteristic of visual representation in the form of node-link diagrams addresses the visual appearance and spatial position of elements. In the GizMO conceptualization visual appearance is described by a notation, while the spatial position assignment is described by views.

As illustrated in Figure 4, the Digital Reference ontology consists of sub ontologies that address different conceptualizations for the semiconductor domain and related supply chains. Currently the Digital Reference ontology contains more than 800 classes and over 700 properties describing different concepts on one ontology. As human cognitive capacities are limited, visualizing the full ontology results in cognitive- and information-overload. Thus, users require mechanism for handling the cognitive complexity for the presented information.

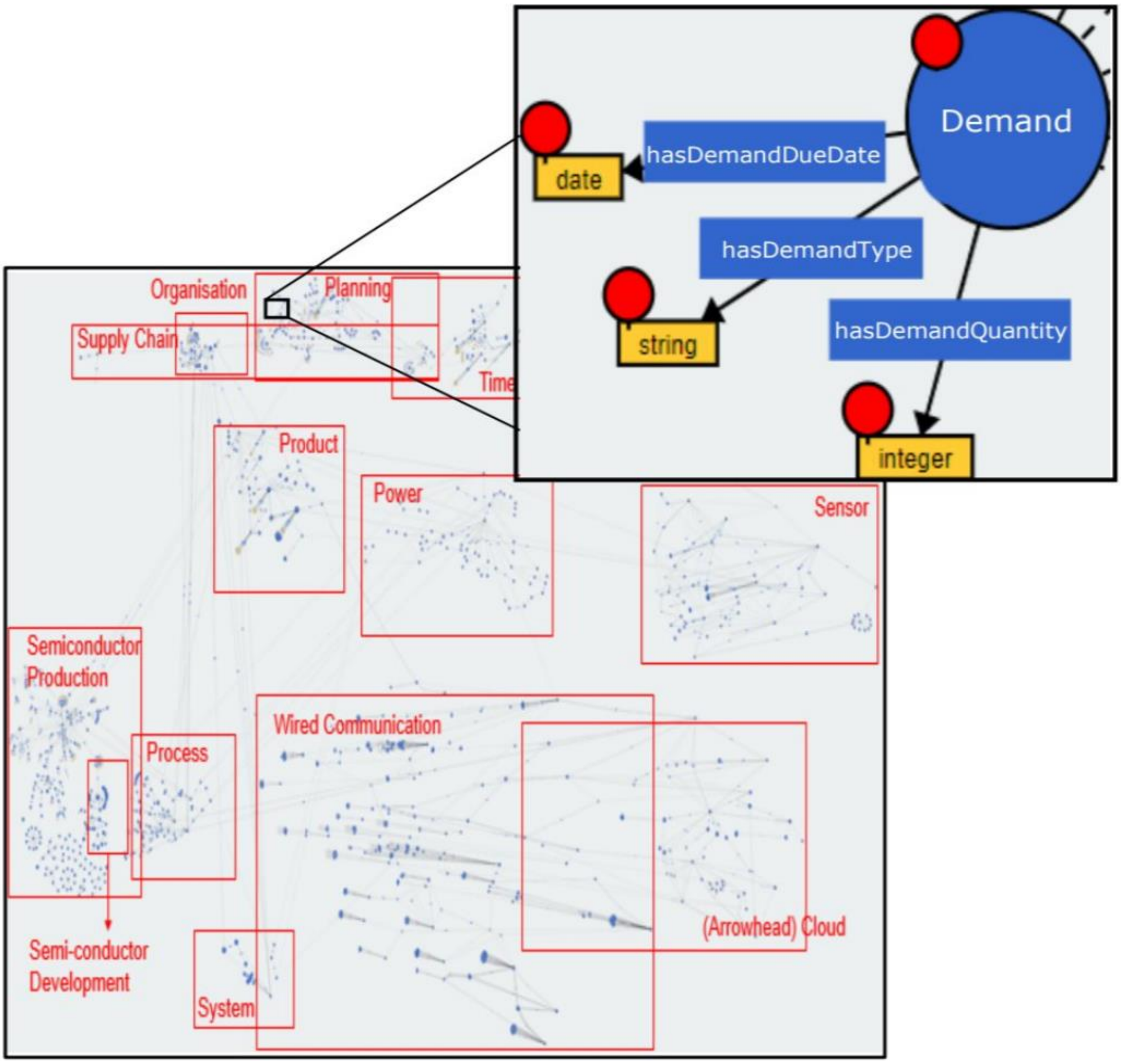

Figure 4: DR ontology visualisation

In order to address these challenges in information mediation, the platform envisions through the use of GizMO (i.e., its conceptualizations for views) to enable users to create different views on the ontology. In particular search and filtering mechanisms shall allow the users to inspect only relevant information that serves a specific information need. These created views for specific use cases should be accessible and reusable. To this end, the platform envisions to attach these views as metadata to the ontology and provide them as selections in the user interface. This meta information will facilitate the inspection of different aspects of the ontology that can be provided by all users that have at least reading access rights.

Furthermore, users require additional navigation support to explore related and close-by conceptualizations. Thus, the platform envisions the use of the Semantic Zooming approach for ontology graphs [2]. This approach allows for reducing the displayed information by using collapse and expanding mechanism on nodes (corresponding to classes of the ontology) and links (corresponding to properties of the ontology). Using this approach, users can obtain an overview on a certain area in the graph visualization and drill further down to obtain more information.

While GizMO provides customizable visual appearance of rendering elements (defined in notations), it additionally provides customization for individual nodes and links. Thus, users can change the visual appearance for specific elements in the visual representation. For example, using these customizations concepts can be grouped and highlighted by colors.

2.2.2.3 Bringing Ontologies to Larger Audiences

The development of high quality ontologies is a challenging task. It involves domain experts, who provide the expertise in the domain, and knowledge engineers who provide the necessary knowhow for creating semantically enriched representations of knowledge using OWL formalizations. Different users have to understand different aspects of the conceptualizations in order to find a common agreement or extend and modify ontologies. A webinar has been held that addresses how to increase the understanding for the content of ontologies.

The main question of this webinar investigated how to bring the domain knowledge to the users. As mentioned before, ontology development thrives through communication and common agreement on the semantical representation of the domain knowledge.

However, with the growing size and complexity of ontologies, it will be difficult to engage large audiences due to the sheer amount of information. Although the platform envisions functionalities for handling cognitive load (e.g., navigation, exploration and different views features), it still requires users' efforts to understand and explore how conceptualizations are semantically defined and how they relate. As described in deliverable D7.7 – Data management plan, documentations of ontologies will provide human readable descriptions for the conceptualization of ontologies. However, such long documentations allow users to inspect specific and detailed information about concepts that are of interest for the user (known search-term aspect). Thus, to increase understanding of different aspects of the ontology, which might be not yet known to the user, a gamification approach was discussed in the webinar.

This gamification approach is inspired by the app "Quiz Duell". Here users can test their common knowledge in a competitive environment against other users. Players play against each other (one vs one), and are presented with the same multiple-choice questions about different knowledge area. At the end of the round, the player with the most correct answers wins and gains points. The idea of the "OntoQuiz" approach has multiple advantages. The nature of such "casual" gaming does not expect much effort or time from the players. Furthermore, the questions should be reasonably easy/complex to provide an answer quickly. Thus, the questions only provide small chunks of information to the user. Furthermore, users can test their knowledge in a competitive environment against other users and get rewards for correct answers.

The conceptualization of this gamification approach envisions that users play competitive against each other in a round based manner. A round has 10 multiple choice questions for a certain knowledge area of the Digital Reference ontology (e.g., sub ontologies and their conceptualization). After the round the winner is determined and gets additional points. In case of a tie, users still receive a portion of points for the correct answers. Additionally, a high-score system provides users information how they rank against other users. Thus, the gained points in a tie scenario continue to motivate users to increase their rankings. Furthermore, such an application provides us with feedback on the quality of the ontology.

Using the questions and the provided answers by the players we can observe how well users understand the current conceptualization of the domain knowledge. Additionally, we can inspect the concepts that have frequently wrong answers in the game, in order to validate if the conceptualization in the ontology is correct. An envisioned feature of such application is the opportunity for users to provide additional feedback to questions and results. For example, users could disagree on the answers provided by the system and provide additional feedback for such disagreement. Using the provided feedback, the corresponding conceptualization can be investigated for further improvement using the suggestion mechanisms of the collaborative ontology development platform.

2.2.2.4 Standardization Requirements

The SC3 project intends to create a common language for total collaboration between humans and machines and all partners involved. Thus, one of the goals of the SC3 project is to create a standard vocabulary for the semiconductor domain and related supply chains.

Standardization is the process of implementing and developing technical standards based on the consensus of different parties that include firms, users, interest groups, standards organizations and governments [https://en.wikipedia.org/wiki/Standardization]. The *International Organization for Standardization* (ISO) [https://www.iso.org/developing-standards.html] reports that “from first proposal to final publication, developing a standard usually takes about 3 years.” Furthermore, updating a standard takes also about 3 years. Thus, in the corresponding workshop we presented these challenges and pose the question how to make this process faster in the context of the SC3 project. Furthermore, in this workshop we identified that there are two aspects considering ontologies and standards.

The first aspect reflects on the numerous existing standards in various domains. However, these standards are typically provided as documents. Additionally existing standards have different formats and data models. While from the perspective of open and FAIR data these existing standards are Findable and Accessible, they are not always Interoperable or Reusable. Thus, existing standards require the transformation towards machine-readable representations using Semantic Web technologies to facilitate their interoperability and their reuse. From the perspective of the platform functionalities, it should provide an iterative process to create ontologies from standards. The envisioned suggestions and communication features provide such iterative process for collaborative ontology development. The different modes of operation allow us to engage different stakeholders with varying backgrounds and ontology modeling skills. Furthermore, the envisioned use of Blockchain technologies fosters versioning and the history of made changes to the developed ontology.

The second aspect reflects on the creation of a standard for ontologies. As mentioned before, creating a standard involves different parties and requires efforts and time, which could be to slow in fast pace environment. Considering the common agreement and the high quality ontologies “quasi-standards” allows to reduce the required time before the machine-readable conceptualizations can be directly applied in the domain. Nevertheless, “quasi-standards” also require documentation in human natural text that describes the different conceptualizations, how they relate, and how to use them. While the suggestions for updates in the ontology and the common agreement of accepting or rejecting this changes addresses the updates in the ontology and its content, documentations are typically provided as separated documents. Thus, synchronization between the updates in the ontology might get lost or create with a delay. In order to overcome these challenges, the platform envisions the use of automatic documentation generation tools, such as WIDOCO [3]. Such automatic documentation generation ensures that the content of the ontology and its documentation are synchronized.

2.2.3 **Requirements and needs for demonstrators**

Demonstrators should support the assessment of the proposed ontologies and ontology modeling tools in several situations. Such situations may for instance, specific planning processes in semiconductor supply chains. Functional and technical requirements are differentiated. The following functional requirements are identified for demonstrators:

1. The demonstrators should be designed for complex-enough situations to really show the advantage of using ontologies compared to more conventional approaches to represent and use data in application systems.
2. The provided ontologies should be detailed, i.e., expressive, enough to allow for a rich and meaning communication in specific situations in a certain company.
3. The ontologies should be used by domain experts with a computer science or industrial engineering background to solve specific decision support problems.
4. The proposed ontologies should be applied in different semiconductor companies. Therefore, the same demonstrator has to be assessed by different companies.
5. The demonstrators should check whether it is possible to merge different ontologies for a concrete application scenario from a functional point of view.

Moreover, several technical requirements can be also identified:

1. Accessing the ontology in concrete application scenarios should be fast enough.
2. The demonstrators should check whether it is possible to merge different ontologies for a concrete application scenario from a technical point of view.
3. It should be possible to use the proposed ontologies in different application systems in semiconductor companies without much additional deployment effort.

3. Conclusion

In alignment with the project proposal, workshops and webinars have been conducted to engage stakeholder from the very beginning of the project. The objective of the workshops and webinars aim to increase the awareness of the project, as well as gather users' needs, requirements and additional feedback (i) for a standardized vocabulary describing the domain and the commonly known and existing data documentation and models (ii) for platform functionalities and (iii) for demonstrators.

The semiconductor domain and related supply chains require high quality ontologies which provide machine-readable representations of the domain knowledge for information processing. However, various user groups are nowadays involved in the design of such semantically enriched formats. Ontology development is often done in joint efforts of knowledge engineers, domain experts and other stakeholders. Furthermore, ontology development thrives through common agreement and communication. Thus, documentations of the ontology should be created in automatic manner to provide human readable descriptions for the concepts of the ontologies and how to use them.

The general requirements for a collaborative ontology development platform, serving as a key enabler for collaboration and the design of high quality ontologies, are provided in the project proposal. However, for a successful realization and adoption of Semantic Web technologies in B2B environments additional users' needs and requirements are gathered. These additional requirements and user needs refine the platform functionalities. The workshops and webinars proposed solutions for the corresponding challenges, whereas the participants feedback was positive and resulted in discussions.

A general observation reflects that in the development process of ontologies various user groups are involved. These user groups have different skills, backgrounds, expectations, and needs for a collaborative ontology development platform. Therefore, different modes of operations are envisioned to be realized in the platform. Here we identified three user groups: i) Experts (Knowledge engineers), ii) Intermediate (Domain experts with prior experience with ontology modeling) and iii) Novice (Users without prior experience).

For each user group the platform shall provide dedicated user interfaces that serve their skills and needs. Additionally, with growing size and complexity of ontologies, their content becomes difficult to comprehend due to information overload. Thus, the platform requires search filter and exploration functionalities. Visualizations provide an abstract representation for the content of the ontology. However, visualizations are highly dependent on the use case and the targeted user groups. Numerous ontology visualization methods and tools have been developed in the last years. Thus, in order to address and reflect users' previous experiences with other visualization methods and tools customizations for the visual appearance are required.

Through the use of GizMO, the platform provides such customizations on two levels, i.e., the visual notation level, which defines how OWL constructs are depicted, and on glyph level, where the visual appearance of individual glyphs can be adjusted. These glyph modifications, allow for example to visually group elements of the ontology using different colors.

The content of ontologies typically does not address its visual representations thus such customizations would be non-persistent. However GizMO's conceptualizations of views which allows to save the spatial position of elements and their additional glyph modifications allows for saving and sharing such user generated views on the ontology.

During the SC³ process, particular attention was paid to industry and academia stakeholders by organizing several meetings to raise public awareness of the project. As a positive result of these activities, STMicroelectronics expressed his interest regarding the development of a sub-ontology of Metrology Processes and Risk Management in Semiconductor Manufacturing. In addition, STMicroelectronics can provide the necessary datasets for the related use cases.

Regarding the stakeholder needs and requirements for a standardized vocabulary describing the domain, the most significant datasets, as well as current taxonomies, ontologies, and other data models, have been identified in order to develop a standard language for the semiconductor manufacturing domain. There are strong foundations available, ranging from vocabularies to the UML Semiconductor generic data model (GDM). Finally, several meetings between project partners took place to identify, specify and collect the data sets needed for comparison.

4. References

[1] Wiens, Vitalis, Steffen Lohmann, and Sören Auer. "GizMO--A Customizable Representation Model for Graph-Based Visualizations of Ontologies." In Proceedings of the 10th International Conference on Knowledge Capture, pp. 163-170. 2019.

[2] Wiens, Vitalis, Steffen Lohmann, and Sören Auer. "Semantic zooming for ontology graph visualizations." In Proceedings of the Knowledge Capture Conference, pp. 1-8. 2017.

[3] Garijo, Daniel. "WIDOCO: a wizard for documenting ontologies." In International Semantic Web Conference, pp. 94-102. Springer, Cham, 2017.

[4] Herding, Raphael, Lars Mönch, and Hans Ehm. "Design and Application of an Ontology for Demand Fulfillment in Semiconductor Supply Chains." In Proceedings of the 2021 Winter Simulation Conference.

[5] Herding, Raphael, and Lars Mönch. "Description of the Demand Fulfillment Ontology and Related OWL-File". https://p2schedgen.fernuni-hagen.de/index.php?id=demand_fulfillment_ontology&L=1. Last accessed September, 17th, 2021.

5. Appendix

Abbreviations

Abbreviation	Meaning
SC3	Semantically Connected Semiconductor Supply Chains
B2C	Business-to-Customer
B2B	Business-to-Business
IEEE	Institute of Electrical and Electronics Engineers
CASE	International Conference on Automation Science and Engineering
ESWC	European Semantic Web Conference
RDF	Resource Description Framework
XML	Extensible Markup Language
URL	Uniform Resource Locator
OWL	Web Ontology Language
API	Application Programming Interface
GizMO	Graph Visualization Meta Ontology
FAIR	Findable Accessible Interoperable and Reusable
OLS	Ontology Lookup Service
ISO	International Organization for Standardization
WIDOCO	WIzard for DOCumenting Ontologies