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Implementing Cross-Domain Linking of Service Information in the Aviation Security Sector

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Abstract. This paper explores the implementation of Semantic Correlation Rules in the field of Technical Communication to integrate information sources within an industry domain specializing in X-ray devices for the aviation security sector. The research partner company aims to provide linked service information from multiple content sources to supply users delivered via search portals and by a service bulletin. To address this, a standardized ontology was developed, consolidating metadata from two types of Content Management Systems. The integration process was accomplished using knowledge graph technology, targeted queries, and API calls from delivery environments, establishing connectivity between the systems.

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1. INTRODUCTION

In recent years, semantic modelling has gained ground in technical communication (TC) and thus also in the cross-domain linking of technical content that originates from different sources. Content management is a fundamental component of TC departments focusing efficient content creation and topic-based document provisioning. On the other hand, end users and their information needs are increasingly becoming the focus of content delivery. This necessitates the strategic implementation of metadata and the use and share of information in knowledge graphs to optimize information retrieval.

This research explores the implementation of Semantic Correlation Rules (SCR) [1] to integrate information sources within the aviation security industry. The aim of the research project was to provide a linking service for information delivered from multiple content sources. More specifically, information users should be supported by structured user documentation within Content Delivery Portals (CDP) with a comprehensive service bulletin system as a separate domain representative.

The SCR technology applied in this work enables dynamic, context-sensitive information delivery and offers a scalable solution for cross-domain access to service information. The transformation and integration of different data sources aims to improve information management across multiple sectors and systems and provides methods to structure, connect, and exchange data. Based on the participating organization's use cases, we identify and link relevant information from multiple data sources to provide a comprehensive service bulletin.

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2. SUBJECT OF RESEARCH

The industrial research partner manages multiple content sources, with each department operating a distinct system that contains different service information and meta data structures which, however, complement each other. To demonstrate the functionality of SCR, we developed an ontology based on the metadata of the two systems: Cosima, the Component Content Management System (CCMS) [2] and Drupal, the Web Content Management System (WCMS). Furthermore, SCR processes are designed based on use cases that enable bidirectional content exchange between Cosima and Drupal. The designated content delivery portal is TopicPilot.

The stakeholder is a manufacturer of X-ray devices used in the security sector, including the aviation industry as well as urban security, defense, ports and borders. Proper operation and continuous maintenance of these devices is crucial. Therefore, it is essential for users to always have access to all relevant information. Given the vast amount of data, an efficient linking of relevant and required information is also necessary to ensure the appropriate operation of the devices.

3. METHOD

3.1 Transforming metadata from two systems into an ontology

The ontology development process was initiated by gathering metadata from Drupal and the CCMS, two distinct and widely used services for corporate information management. The metadata was then systematically organized into classes and instances, while parent-child relationships were established to reflect hierarchical dependencies. These relational definitions were guided by the company's use cases to capture interdependencies between entities (e.g., service technicians, developers, help desks), forming the conceptual basis for SCRs.

For the data obtained from the Drupal WCMS, the information was provided as an Excel spreadsheet, easily exportable to an XML (Extensible Markup Language) file. To prepare this data for integration into the ontology, we conducted an in-depth analysis to determine its representation within the ontology. Based on this analysis, we developed an XSLT (Extensible Stylesheet Language Transformations) script to convert the XML data into an RDF (Resource Description Framework) format, ensuring semantic interoperability. The data from the Cosima system was processed using a standardized XSLT script, as described in [7]. At this stage, a substantial amount of well-structured data has been compiled, providing a foundation for the subsequent development of SCRs.

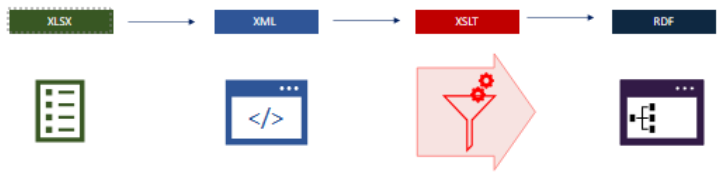

FIGURE 1. Steps in transforming the XSLX File into a base-ontology in RDF/OWL Format.

3.2 Developing Semantic Correlation Rules

Throughout the project, SCRs were developed to represent semantic correlations between datasets, ensuring that relevant metadata was dynamically linked and consistently delivered. These rules provide a formalism for correlating objects beyond the standard linking mechanisms used in content management systems. Each SCR consists of an InRule, which specifies a primary selection event (e.g., a search query), and at least one OutRule, which determines the selection of secondary objects related to the retrieved primary object. SCRs are based on use cases that ensure

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related topics are suggested whenever a user accesses a topic, whether within one system or across both systems [1]. An example of an InRule in the aviation security sector would be: When a user searches for a safety check, the system should also display the relevant operating and display elements, along with the locations of the emergency stop switches.

Metadata was identified using a combination of IDs (Identifier) and a custom namespace to generate IRIs (Internationalized Resource Identifier). The ontology was further refined to support complex correlations, utilizing key data properties to enhance the management of semantic correlations. After modeling the domain ontology by defining the metadata and their relations, the In- and OutRules were defined using SPARQL, a query language for the semantic web. These rules can be implemented in a graph database such as GraphDB, where SPARQL is used to model SCRs by querying from and inserting into triple data stores, based on the standard SCR modeling pattern described in [3].

3.3 PI-Classification & SIM Core

The next step involves further classification to correctly process data in the API (Application Programming Interface). This includes manual mapping via subclasses to identify the source of requests, such as whether they originate from Drupal or Cosima. The classification process assigns extra classes through subclass relations, where "domain" indicates the responsible party for metadata management, and "environment" specifies the software system calling the SCR-API. Additionally, the extended Product-Information (PI) classification [4], [5], [6] covers characteristics, such as Product Class, Information Class, or Variant Management, allowing for multi-assignment, as further explained in [7].

3.4 Building the ontology

The ontology is built from four key components: two metadata.rdf files, SCR (which includes both RDF and a script), and SIM-Core [7]. These components together provide the necessary data structures, semantic rules, and logic required to model the domain effectively. The various metadata.rdf encapsulate metadata from their respective systems (in this case Drupal and Cosima), while SCR defines the semantic correlation rules, and SIM-Core adds the structural elements and processing scripts. The integration of these components enables the construction of a comprehensive and complex ontology that supports dynamic metadata linking and accurate data processing across systems. Fig. 2 shows a section of the ontology, more precisely one InRule that points to two OutRules. The OutRules both refer to the class in which the product extrinsic metadata (green & purple bubble) is located in each system. This ensures that later, when selecting a topic for one specific product, in the other system, the topic will be selected for the exact same product.

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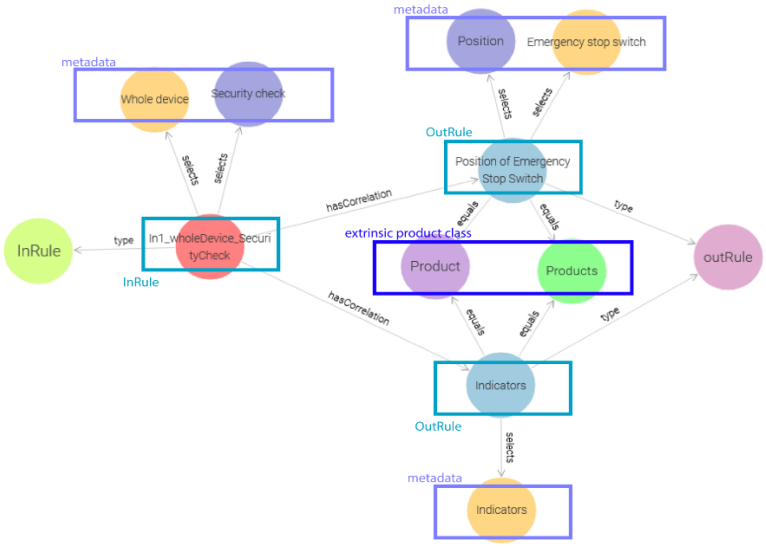

FIGURE 2. Image detail of the ontology: InRule1 (red) pointing to two OutRules (light blue) which access the "Product Class" in both systems.

4. Representation/Results

Due to the limited scope of the research project, the implementation of SCRs is based on use cases regarding two of the multiple Content Management Systems (CMS). This represents a demonstration of the linking process for other systems. Currently, the integration between the two CMS used for demonstration is only implemented from TopicPilot to Drupal, but it is technically feasible to enable bidirectional integration. In the following, we are demonstrating the technical feasibility and the functionality of the SCRs.

4.1 Rule Functionality Testing, Server & API

To test if each InRule has the correct relation to its correlating OutRule(s) and if the sever is responding to the query, Postman was used to simulate a request to a SCR-API described in [4]. As seen in Fig. 3 it was simulated that a topic in the Frontend is selected, containing the two metadata "Whole Device" (Product Class) and "Security check" (which is a task and therefore Information-Class). In this case these are defined as "selects" in an InRule.


```
{
    "selects": [
        {"id": "http://www.smithsdetection.de#6b4fef053d809a90c0a8b216188f6f98", "label": "Whole
            Device"},
        {"id": "http://www.smithsdetection.de#6df797f0074aad16c0a8b2161a671c3d", "label": "Security
            Check"}

    ]
}
```


FIGURE 3. Requesting two metadata by IRI in Postman.

By sending the request to the server, the query returns the corresponding OutRules that are correlated to the InRule with the exact selects. The SCR-API was implemented in a way, that upon request (selection of metadata) delivers a correctly generated link to the topics that contains the metadata selected by each correlated OutRule, as shown in Fig.4. The generated link leads to the correlated content which was previously defined in the use cases.

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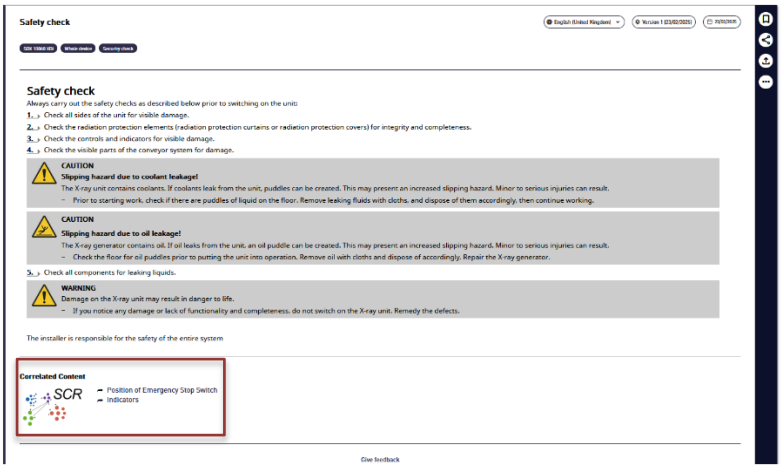
FIGURE 4. Resulting Link List out of the Request made in Figure 3.

The links were later labeled with their respective metadata labels to make them readable (i.e. “Position of Emergency Stop Switch”) and an API was developed, as detailed in [8]. The CDP (TopicPilot) implemented the API call on their side, so that correlated content can be directly accessed from the frontend at the end of a topic, if it is tagged with the specific metadata selected by an InRule (see Fig 5.).



a)



b)

FIGURE 5. The resulting links that are suggested under “Correlated Content” in the frontend (a), here: TopicPilot, when selecting an article with the metadata defined in an InRule. The target address for the link to “Indicators” showing the secondary topics in the CDP (b).

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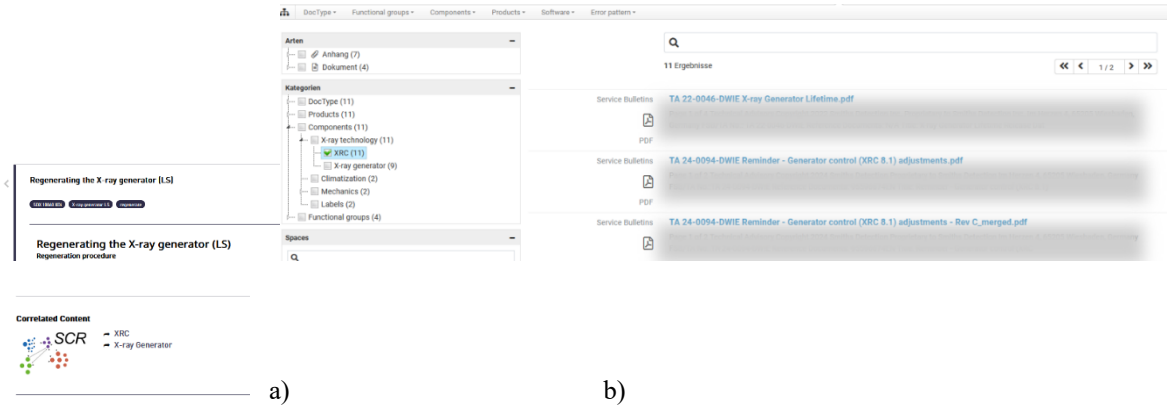

FIGURE 6. Result links beneath topic carrying correlations (a) leading to metadata and content selection in Drupal (b)

After creating an ontology out of all metadata, it is not relevant if the correlated content is located in one or the other domain, since it is connected by a centralized graph, resp. the SCR-API. As shown in Fig. 6 it is therefore also possible that the correlated content is located inside a different domain, in this case Drupal. The links can still be generated and suggested at the bottom of each relevant page.

It would also be possible to suggest and access content in and from Drupal or other CMS if their providers include the API call in their user interface, resp. the client software. To show the functionality in the backend, a "fictional" use case was developed, selecting a topic with metadata, that was coming out of one domain (Drupal), but a correlated OutRule that selected metadata in the other domain (CDP), as shown in Fig. 7.

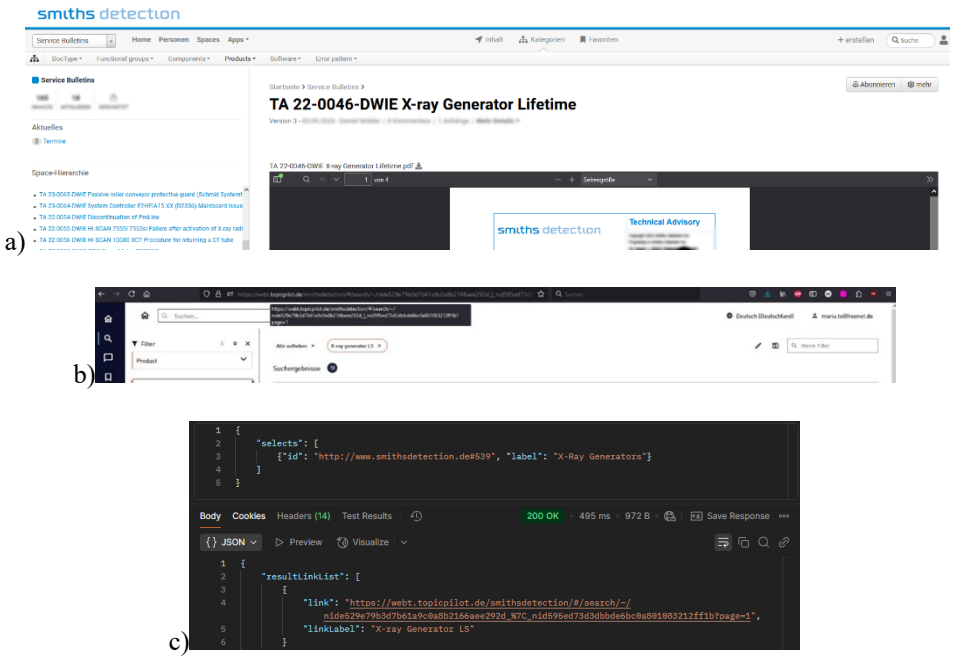

FIGURE 7. Selection of metadata from Drupal (a), this leads to a result ink (b) and topic search and selection by metadata in Cosima (c).

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5 Key findings and challenges

Even though the current Drupal instance does not yet support the API call, it is technically straightforward to integrate the SCR-based links in the future with a corresponding API call. To illustrate its feasibility, we developed a hypothetical use case that pointed from Drupal to Cosima and used Postman to verify that the generated links function correctly. Given that additional systems are planned to be integrated into the ontology in the future, this approach can also be used to validate the functionality of the SCR for other systems. The backend is operational, with system providers needing only to implement the interface to enable interaction.

Context-based rules, such as the equals relationship, can be integrated to consider the product context of a content selection event. In our project, the equals relationship was intended to ensure that the requested product is also reflected in the output. However, since we are working with two different domains, there is a need for a semantic mapping which was not completed in the project described. The mapping can be done in the SIM and then processed as so-called DynaRules of the extended 1.2 version of the SCR definition. Similar processes have already been implemented in previous research projects [9], [10].

6. Outlook

This work represents a significant first step toward comprehensive Semantic Information Management, integrating all systems used by the stakeholder. So far, an ontology has been developed that captures metadata from the Drupal and Cosima systems. The existing SCRs are based on use cases that utilize information from these two systems. In the future, the ontology can be progressively expanded to include metadata from all other systems employed by the stakeholder. Additionally, further use cases and corresponding SCR developments are planned to enable a more holistic and flexible application of the ontology, i.e. the Semantic Information Model (SIM).

When providing information, access control is essential. This serves not only to prevent unauthorized access in cases where sensitive data is involved but also to regulate the distribution of information. This allows for the prioritization of highly relevant information over less relevant data, thereby improving the user experience in information retrieval. For instance, correlation rules can be established based on user roles to tailor access and presentation of information accordingly.

The current ontology integrates multiple metadata concepts; however, semantic information management also offers the potential to maintain a unified metadata model within a centralized graph and data governance. In this scenario, the ontology would consist of a single consolidated metadata concept. Such a centralized approach simplifies maintenance by preventing for example inconsistencies, like terminological redundancies and inexactness.

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