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HOCHSCHULE FÜR ANGEWANDTE WISSENSCHAFTEN MÜNCHEN

Bachelor Thesis for the Course of Study Technical Writing/ Technical Communication

Opportunities and Limitations of Ontologies in the Context of a Unified Content Strategy

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Abstract

This thesis discusses the question of how ontologies can be used for the implementation of a unified content strategy (UCS), highlighting possible benefits and challenges.

So far, the literature and case studies have shown that the implementation of a UCS comes with several benefits, such as consistency and reduced cost, due to the high reusability of content. The metadata models used to implement a UCS were mainly based on taxonomies, which can only depict hierarchical dependencies.

With the growing need for interoperability and personalization, a development referred to as content 4.0, this thesis examines whether ontologies can support a UCS and how. Since the creation of an ontology takes a substantial amount of time and resources, reusing existing ontologies is preferred to creating a new one. The thesis examines iiRDS, a content delivery standard which also comprises an ontology for technical communication, and discusses its use for the implementation of a UCS. However, to classify content originating from other departments, iiRDS needs to be extended. Using the example of workplace learning content, the thesis discusses how iiRDS can be extended by creating the iiRDS Learning domain.

The thesis comprises two parts. The first part looks at 15 research questions to introduce terms and technologies concerning the implementation of a UCS. Based on literature discussions and case studies, the requirements of a UCS, ontologies, and workplace learning are collected. In the second part, a new iiRDS Learning domain is created to meet these requirements, following Uschold and King's method. The method lacks a conceptualization phase, so this deficit was mitigated by incorporating engineering practices described by Feilmayr and Wöß, which also focus on reuse.

The thesis finds that ontologies provide a powerful tool to model metadata, ensure their consistency, and deliver content based on personal preferences. The possibilities of effectively using iiRDS for a UCS are tied to the software that can process iiRDS packages, i.e. the iiRDS consumer. At the time of writing, the only off-the-shelf iiRDS consumers are content delivery portals. Other applications, such as chatbots, are still in the early stages of development. Since learning management systems cannot process iiRDS packages, the usefulness for classifying e-learning courses is questionable. For static media, such as workbooks, the iiRDS Learning domain provides sufficient metadata.

Die Bachelorarbeit behandelt die Frage, wie Ontologien für die Umsetzung der integrierten Technikkommunikation (Unified Content Strategy, folgend mit UCS abgekürzt) genutzt werden können, und zeigt mögliche Vorteile und Herausforderungen auf. Wie die Literatur und einige Fallstudien belegen, bringt die Einführung einer UCS mehrere Vorteile mit sich, wie eine hohe Wiederverwendbarkeit von Inhalten, verbesserte Konsistenz und geringere Kosten. In der Literatur werden häufig Taxonomien zur Erstellung eines Metadatenmodells für die UCS eingesetzt. Jedoch können diese nur hierarchische Abhängigkeiten abbilden.

Angesichts des wachsenden Bedarfs an Vernetzung und Personalisierung, subsumiert unter dem Begriff Content 4.0, untersucht die Arbeit, ob und wie Ontologien eine UCS unterstützen können. Da die Erstellung einer Ontologie einen erheblichen Zeit- und Ressourcenaufwand erfordert, ist es ratsam bereits bestehende Ontologien zu nutzen und erweitern. Daher untersucht die Bachelorarbeit den „intelligent information request and delivery standard“ (iiRDS), der auch eine Ontologie für die technische Kommunikation umfasst, und diskutiert seine Verwendung für die Implementierung einer UCS. Um Inhalte aus verschiedenen publizierenden Abteilungen zur klassifizieren, muss iiRDS erweitert werden. Am Beispiel von Lerninhalten wird in der Arbeit diskutiert, wie iiRDS durch eine iiRDS-Learning-Domäne erweitert werden kann.

Im ersten Teil der Bachelorarbeit werden 15 Forschungsfragen bearbeitet, um Begriffe und Technologien zur Implementierung eines UCS einzuführen. Mittels Literatur und Fallstudien werden die Anforderungen einer UCS, Ontologien und betrieblicher Bildung erörtert. Im zweiten Teil wird eine iiRDS-Learning-Domäne nach der der Methode von Uschold und King erstellt, um den Anforderungen gerecht zu werden. Da die Methode keine Konzeptphase vorsieht, wurde sie um von Feilmayr und Wöß beschriebene Praktiken erweitert. Dadurch wurde zudem der Aspekt der Wiederverwendung berücksichtigt.

Die Bachelorarbeit kommt zu dem Ergebnis, dass Ontologien ein leistungsfähiges Werkzeug zur Modellierung von Metadaten, zur Gewährleistung ihrer Konsistenz und zur Bereitstellung von Inhalten auf der Grundlage persönlicher Präferenzen bietet. Die Möglichkeiten der effektiven Nutzung von iiRDS für eine UCS sind an die Software gebunden, die iiRDS-Pakete verarbeiten kann, d.h. die iiRDS consumer. Zum Erstellungszeitpunkt dieser Arbeit sind die einzigen käuflichen iiRDS consumer sogenannte Content Delivery Portale. Andere iiRDS-fähige Anwendungen, wie z.B. Chatbots, befinden sich noch in den Kinderschuhen. Da Lernmanagementsysteme iiRDS-Pakete nicht verarbeiten können, ist der Nutzen für die Klassifizierung von E-Learning Inhalten fraglich. Für statische Medien, wie z. B. Arbeitsmittel, stellt die iiRDS-Learning-Domäne ausreichend Metadaten zur Verfügung.

Statutory Declaration - Erklärung i. S. des § 35 Abs. 7 RaPO

I hereby formally declare that I have written the submitted bachelor theses independently. I did not use any outside support except for the quoted literature and other sources mentioned in the paper. I clearly marked and separately listed all of the literature and all of the other sources I employed to produce this academic work, either literally or in content. I am aware that the violation of this regulation will lead to failure of the thesis.

Ich erkläre, dass ich die vorliegende Bachelorarbeit selbständig verfasst, noch nicht anderweitig für Prüfungszwecke vorgelegt, keine anderen als die angegebenen Quellen oder Hilfsmittel benützt sowie wörtliche und sinngemäße Zitate als solche gekennzeichnet habe.

Tina Lüdtke

München, 06. Oktober 2020

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List of Abbreviations

Abbreviation	Explanation
ADL	Advanced Distributed Learning
AICC	Aviation Industry Computer-based Training Committee
API	Application Programming Interface
BBC	British Broadcasting Corporation
CDP	Content Delivery Portal
cf.	Latin “conferre”: confer to
cmi5	Computer-managed instruction
CMS	Content Management System
HTML	Hypertext Markup Language
ibid.	Latin “ibidem”: in the same place; indicates that the preceding source is cited again
i.e.	Latin “id est”: that is; namely
IEEE	Institute of Electrical and Electronics Engineers
iiRDS	Intelligent Information Request and Delivery Standard
IRI	International Resource Identifier
LMS	Learning Management System
LOM	Learning Object Metadata
OWL	Web Ontology Language
PAS	Publicly Available Specification
PDF	Portable Document Format
RDF	Resource Description Framework
RQ	Research Question
SCORM	Shareable Content Object Reference Model
SPARQL	SPARQL Protocol and RDF Query Language (recursive acronym)
UCS	Unified Content Strategy
xAPI	Experience API
XML	Extensible Markup Language

1 Introduction

The smartphone is man's best friend. Users steadily spend more time on their smartphones, as Armstrong revealed in a survey from 2012 and 2016[1]. While the usage time steadily increases, it is useful to know the frequency of usage and what users do on their screens.

A survey conducted by Coop Italia in 2019 asked 1000 Italians, how many hours in a normal day they could resist without using their smartphone. 18 % of Italians stated they could not go without their phone for less than one hour, whereas 19 % lasted one to two hours, and 28 % between three to six hours. Only 35 % of the participants could last without their phone for six hours or longer.[2]

TNS Infratest and Google interviewed 802 Italians about their typical weekly smartphone activities in 2018, revealing that the most important task was using search engines (71 %). An activity relevant to this thesis was "Look for product information," which 32 % of Italians do every week.[3] The numbers looked similar across other European countries, ranging from 21 % in Belgium to 45 % in Spain.[4] That means users spend a respectable amount of time consuming content from organizations.

1.1 Problem Definition

These statistics show that smartphones play a significant role in organizations, as their customers use them to retrieve product information. However, there is a gap between the ideal format for small devices and what many organizations currently publish. Göttel identified this format gap, stating that while technical communicators author and edit information on a modular basis, they publish information products in rigid structures[5] that might not even get frequently updated. These information products are not only unsuitable for smartphones, but the content also does not consider the user's context and, therefore, cannot be personalized. Consequently, the user experience does not live up to the user's expectation of a personalized experience.[6]

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[1] Armstrong, "Smartphone Addiction Tightens Its Global Grip."
[2] cf. Coop Italia, "In a Normal Day, How Many Hours Can You Resist without Using Your Smartphone?"
[3] TNS Infratest and Google, "What Online Activities Do People Do on Their Smartphones at Least Weekly?"
[4] cf. Statista, "Smartphone Market in Europe."
[5] cf. Göttel, "iiRDS Als Austausch- und Bereitstellungsmechanismus für zukünftige Dokumente."
[6] cf. Fritz, "Was ist intelligente Information?"

Research Gap

The concept of a unified content strategy (UCS) was created by Rockley and Cooper and addresses editorial shortcomings such as inconsistencies, device-adequate content delivery, and personalization[7]. The technological foundation for a UCS is a unified metadata model, which enables reuse and ensures consistency. The case studies discussed in the literature have built their metadata model based on taxonomies, which are useful to describe hierarchical dependencies.

With the advent of industry 4.0, interoperability and connectivity take the center stage for value creation. This change also concerns content, as Gollner describes that content 4.0 is characterized by many formats, created by many owners, published in many channels and by many publishers[8]. Ontologies can unify data inputs from heterogeneous sources to make them interoperable, which is similar to the approach of a UCS. However, there is little to no research concerning how ontologies can aid in establishing a UCS. The thesis examines how ontologies, especially the intelligent information Request and Delivery Standard (iiRDS), can be used to establish a UCS, focusing on personalized content delivery.

Relevance of the Research

This thesis contributes to the discussion of how content needs to be delivered in the future, leveraging iiRDS to support a UCS. The findings suggest that while iiRDS' metadata model is focused on technical communication, it needs to be expanded to be relevant for other departments that create customer-facing content as well. In terms of publishing, iiRDS grants flexibility and possibilities for personalization, however the actual value gain of using iiRDS depends on the available outlets, i.e. iiRDS consumers.

Personal Motivation

My motivation for writing this thesis is to explore how organizations can react to challenges in content delivery. The goals of a unified content strategy and ontologies are alike: Unifying content across the organization by establishing a general metadata model. Therefore, I chose to investigate if ontologies can be the foundation to establish a UCS.

1.2 Research Objectives

The central question of this thesis is: How can **ontologies** be used for the **implementation** of a **unified content strategy**? This question is broken down into three subject areas.

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[7] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. p. 13
[8] cf. Gollner, "Content 4.0 - The Content Philosopher."

Subject area 1: Unified content strategy

This subject area is covered in chapter 2 and will review literature on content strategy, especially the concept of a unified content strategy. The following research questions will provide a more detailed view of the subject area:

> **RQ 1.1:** What is a unified content strategy?
>
> **RQ 1.2:** When is a unified content strategy useful?
>
> **RQ 1.3**: How can a unified content strategy be implemented?
>
> **RQ 1.4:** What are common challenges when implementing a unified content strategy?

Subject area 2: Ontologies

Chapter 3 discusses ontologies, reviewing literature to illustrate the use cases and limitations of ontologies. The following research questions will aid in answering the initial thesis:

> **RQ 2.1:** What are ontologies?
>
> **RQ 2.2:** When are ontologies useful?
>
> **RQ 2.3:** How can ontologies be used for personalized content delivery?
>
> **RQ 2.4:** What are the limitations of ontologies?
>
> **RQ 2.5** How can an ontology be used for a unified content strategy?

Subject area 3: Implementation

The third subject area explores how iiRDS can be used in a UCS. The research questions 3.1-3.5 are solved based on literature discussions and own analyzation. RQ 3.6 will be discussed in chapter 4.4 where iiRDS is compared against the Learning Object Metadata (LOM) standard. Chapter 5 proposes an iiRDS vocabulary for learning content which is based on the comparison.

> **RQ 3.1:** What are common standards for metadata and ontologies in the communication sector?
>
> **RQ 3.2:** What is iiRDS?
>
> **RQ 3.3:** How can iiRDS be used to implement a unified content strategy?
>
> **RQ 3.4:** Which communication channels are practical for content delivery with iiRDS?

RQ 3.5: What are existing metadata standards for training?

RQ 3.6: What metadata would an iiRDS domain for training need to classify learning objects?

1.3 Scope of the Thesis

The thesis focuses on organizational communication, as most organizations face the challenge of unifying dispersed information sources. The focus lies on the technology needed to implement a unified content strategy, especially regarding digital content delivery. As a practical demonstration, metadata for learning content, which is closely related to technical communication, will be examined.

The challenges of change management and people management are not part of this thesis but they are relevant to implement a UCS. The thesis will not explain the ontological engineering process in detail. Gómez-Pérez et al.[9] cover the ontological engineering methods in depth. Philosophical and ethical implications of information architecture, ontologies and internet studies are also not covered, as Luciano Floridi discusses these topics in his book "The Onlife Manifesto - Being Human in a Hyperconnected Era". Expert systems, which are designed to make decisions based on ontologies and inference rules, are also excluded as they do not contribute to finding an answer to the thesis.

[9] cf. Gómez-Pérez, Fernández-López, and Corcho, *Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web*.

2 Unified Content Strategy

This chapter introduces terms and concepts relevant in the context of a UCS, explaining the benefits of a UCS and how to establish a UCS in an organization. The last section discusses the challenges of implementing a UCS, summarizing the requirements of a UCS.

2.1 Definitions

Content

In the sense the web industry uses the term content it subsumes all different kinds of media that convey meaningful information.[10] Drewer and Ziegler define content as all objects maintained in a content management system (CMS) used for the publication of information products.[11] The focus of this thesis lies on publishing information products across digital outlets, therefore, Drewer and Ziegler's definition, will be applied.

The thesis is centered around customer-facing content, as it is rather complex. Customer-facing content deals with[12]:

- Many different messages
- For diverse target audiences
- In multiple file formats and media
- Created by various departments of an organization

The variety of existing and future content needs to be planned and managed. This is where content strategy comes into play.

Content Strategy

To understand the term content strategy and its implications, three definitions are reviewed:

I. Redish defines content strategy as thinking strategically about content. Content is regarded as a part of the business plan and needs to be aligned with an organization's goals.[13]

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[10] cf. Merriam-Webster Inc., "Definition of Content"; cf. Kissane, *The Elements of Content Strategy*. p. 1

[11] Drewer and Ziegler, *Technische Dokumentation: Eine Einführung in die übersetzungsgerechte Texterstellung und in das Content-Management*. p. 295

[12] Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. p. 4

[13] Redish, *Letting Go of the Words: Writing Web Content That Works*. p. 37

II. Halvorson provides more detail, stating, "Content strategy plans for the creation, publication and governance of useful, usable content."[14]

III. Bailie defines content strategy as “a repeatable system that governs the management of content throughout the entire lifecycle."[15]

The first definition emphasizes the relationship between business and content, which is not explicitly stated in the other two definitions. Halvorson and Bailie agree that content needs to be managed following the content lifecycle. While Halvorson does not explain governance in her definition, Bailie describes governance as deciding on how content is created, collected, managed, published, and curated. According to Bailie, a content strategy needs to be repeatable, meaning it is an ongoing process to handle content[16].

Based on these definitions, the term content strategy subsumes responsibilities and rules for creating, distributing, and governing content with the content lifecycle. Content strategy needs to support business goals and provide useful information.

Unified Content Strategy

As we now know what a content strategy is, let us discuss what makes a content strategy *unified*. Rockley and Cooper coined the term unified content strategy, and they give the following definition:

> "A unified content strategy brings together the planning and design for all customer-facing content to ensure a seamless customer experience from first contact through purchase, usage, and support."[17]

This goal can only be achieved with an unobstructed information flow across all departments involved in content creation. The authors describe this as “breaking down the silos.” To establish a seamless customer experience and consistent content, there needs to be a single source of truth and rules for structuring information.[18] Style guides and terminology ensure consistency on word and sentence level. Chapter 2.3 explains the measures to design and implement a UCS.

In contrast to the definition of content strategy, Rockley and Cooper state explicitly that content must be assembled on-demand to meet customer needs[19]. To deliver content dynamically, it needs to be intelligent.

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14 Halvorson, “Understanding the Discipline of Web Content Strategy.”
15 Bailie, “What’s the Buzz about Content Strategy?”
16 cf. ibid.
17 Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. p. 4
18 cf. ibid. p. 10
19 cf. ibid.

Intelligent Content

Rockley and Cooper define intelligent content as follows:

> "Intelligent content is content that is structurally rich and semantically categorized, and is therefore automatically discoverable, reusable, reconfigurable, and adaptable."[20]

The purpose of intelligent content is to support users in finding information that answers their questions quickly. The "intelligence" of content is based on the metadata that describes it. The higher the semantic expressiveness of metadata, the easier it is discoverable[21].

Content Delivery and Content Delivery Portals

Content delivery is an umbrella term for applications and methods for delivering content related to the situation, context, and target audience[22]. The art of content delivery lies in choosing the appropriate communication channels to reach the audience when they need content. Traditionally, metadata are used during the content creation phase but are not needed after publishing. However, content delivery means publishing metadata and content together to improve the findability and usability of information products. A current application is a content delivery portal (CDP).[23]

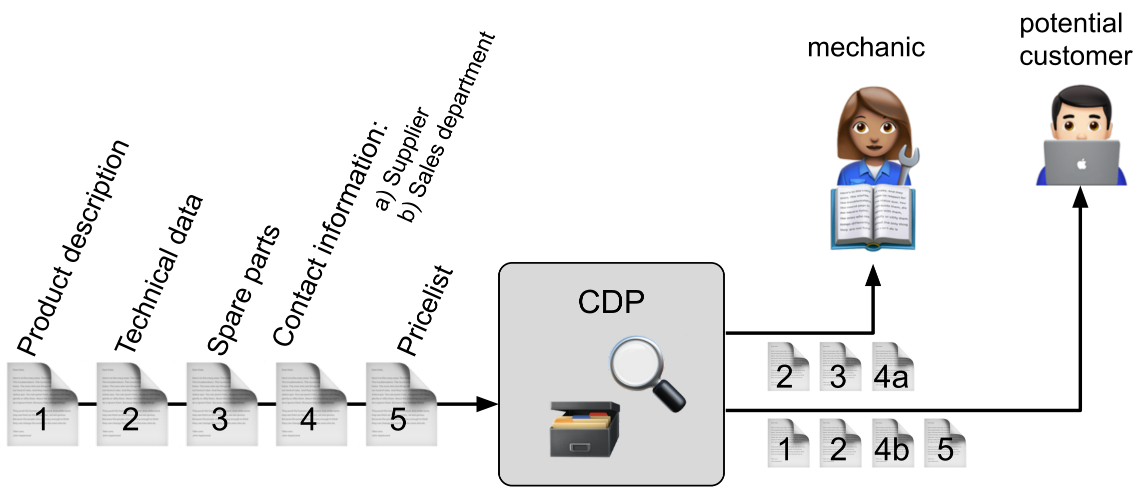

Fig. 1: Content aggregation and delivery with a CDP

Ziegler and Beier define a CDP as "a web-based platform to provide modular, aggregated, or document-based information for audiences using content-related search mechanisms".[24] CDPs unite content from many sources. Based on the assigned metadata, the user

[20] Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy.* p. 29
[21] cf. Kreutzer and Parson, "Intelligente Lieferung."
[22] cf. Steurer, "Dynamische Information und ihre Bereitstellung."
[23] cf. Parson, "Das Datenmodell der technischen Dokumentation in iiRDS."
[24] Ziegler and Beier, "Alles muss raus."

retrieves the piece of information that is relevant to their task. Metadata is also used to narrow down search results, making a standardized metadata model even more important.[25] Fig. 1: above illustrates how a CDP works.

2.2 Use Cases and Benefits of a Unified Content Strategy

This chapter lays out why organizations should consider organizing their work according to a UCS. Thinking about content in a strategic way means acknowledging that content is an asset that has to be managed. Managing content is different and more nuanced than managing data, thus requiring a carefully thought out strategy. A content strategy allows measuring key figures throughout the content lifecycle.[26] Organizations and readers alike benefit from a UCS[27].

Structure

Authoring content in a standardized, structured way is the basis for a successful UCS. Structured content is also semantically rich, which enables information reuse[28] and flexible formatting[29]. Structured content frees the writer's mental capacity, allowing them to focus on the subject, thus enhancing the content creation process[30]. Structures help writers to stay concise and write with purpose[31]. Since content follows a standardized structure, predictability, and therefore, consistency is improved[32].

Consistency and Quality Improvements

While structures sequence information chunks, style guides define rules on the sentence and word level. Style guides are essential for creating usable, consistent content that appears unified.[33] Stylistic and architectural structures reduce the reader's cognitive load[34]. Readers can skim through consistent texts more easily, skipping parts they already know.

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[25] cf. Ziegler and Beier, "Alles muss raus."
[26] cf. Bailie, "What's the Buzz about Content Strategy?"
[27] cf. Kissane, *The Elements of Content Strategy*. p. 18
[28] cf. Halvorson, "Understanding the Discipline of Web Content Strategy."
[29] Ziegler, "Metadaten für intelligenten Content."
[30] Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. pp. 17, 22
[31] Redish, *Letting Go of the Words: Writing Web Content That Works*. p. 37
[32] Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. p. 22
[33] cf. Rockley and Cooper. p. 208
[34] cf. Kissane, *The Elements of Content Strategy*. p. 10; cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. pp. 11, 12

Consistency leads to better customer experience, increases brand strength and the customers' trust in the organization. [35]

Multichannel and Omnichannel Publishing

"Digital publishing is [...] no longer just a desirable capability; it's a matter of survival."[36] Rockley and Cooper highlight that digital publications are a critical asset for organizations. The competitive advantage shifted from *if* there is content online to *how* well content reaches the audience. In a UCS, content creators of different departments work towards aligning communication across channels[37]. There are two prevalent paradigms: multichannel and omnichannel publishing, which are elaborated in the following paragraphs.

The term "multichannel" originated from retail and marketing, meaning to sell a product via more than one distribution channel, without any overlap between the separate channels.[38] For content that means to distribute information products across different outlets, offline and online. Structured content that is stored independently of layout, enables publishing content to multiple channels.[39] Style sheets and transformations that are based on semantic metadata give content a different look, depending on the publication channel, such as a website, an app, or a PDF[40]. Since content and layout are separated, it is possible to add future channels with XML, allowing organizations to adapt to the ever-changing business world[41].

Traditionally, marketing departments in a multichannel setting operate in silos, where each channel has its own goals, budgets, and marketing activities, resulting in different messages for each channel. Multichannel marketing assumes that customers go through a typical sales funnel, leading to impersonal customer journeys. The result is that customers have to put in effort to move across channels. However, the reality of consumer behavior looks more like this: Customers use multiple touchpoints and retail channels before purchasing a product, sometimes simultaneously. The use of mobile devices and social media has increased, leading to a different customer journey for each individual.[42]

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[35] cf. Redish, *Letting Go of the Words: Writing Web Content That Works*. pp. 5, 6, 37
[36] Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. p. 41
[37] cf. Kissane, *The Elements of Content Strategy*. p. 1
[38] cf. Verhoef, Kannan, and Inman, "From Multi-Channel Retailing to Omni-Channel Retailing. Introduction to the Special Issue on Multi-Channel Retailing."
[39] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. p. 26
[40] cf. Ziegler, "Metadaten für intelligenten Content."
[41] cf. Rockley and Gollner, "An Intelligent Content Strategy for the Enterprise."
[42] cf. Barry and Shawn, "Planning and Implementing an Effective Omnichannel Marketing Program."

Retail and marketing scientists refer to this new trend as *omnichannel*. Böckenholt et al. define omnichannel management as “using and connecting all available communication and retail channels, so that the retailer and customer alike can use the channels. The customer is at the center of the strategy, being in control of the purchasing process, and having full control over data integration and transparency.”[43] The borders between different channels start to disappear[44], which makes it easy for consumers to “hop within a given transaction among retail stores, computer [sic!], smartphones, tablets, in-store kiosk [sic!] and social media sites.”[45] For example, Apple showcases its devices with the product details on the screens, encouraging customers to research further information online[46].

For omnichannel marketing to be successful, organizations have to make the customer experience as smooth and seamless as possible. Marketing messages need to be uniform across channels, leaving room for individual customer journeys.[47] Two of the benefits associated with omnichannel marketing are improved trust and increased customer loyalty[48].

The characteristics and goals of omnichannel marketing show many parallels to the communication approach of a UCS. Coining the term omnichannel to content delivery, I define omnichannel publishing as delivering unified messages that originate from a single source of truth and are available in the reader’s preferred channel.

It takes a well-designed content strategy to reap the discussed benefits. The next chapter covers the steps toward a UCS.

Cost Efficiency

The transition to a UCS can pay off for multiple reasons. Writers create content in a single source of truth and reuse it as necessary. Modifications have to be done only once and are synchronized automatically, depending on the reuse strategy.[49] By reducing manual work, content creators have more time to create actual value[50], increasing the content's

[43] Böckenholt, Mehn, and Westermann, *Konzepte und Strategien für Omnichannel-Exzellenz: Innovatives Retail-Marketing mit mehrdimensionalen Vertriebs-und Kommunikationskanälen*. p. 12
[44] Verhoef, Kannan, and Inman, “From Multi-Channel Retailing to Omni-Channel Retailing. Introduction to the Special Issue on Multi-Channel Retailing.”
[45] Barry and Shawn, “Planning and Implementing an Effective Omnichannel Marketing Program.” p. 600
[46] cf. Verhoef, Kannan, and Inman, “From Multi-Channel Retailing to Omni-Channel Retailing. Introduction to the Special Issue on Multi-Channel Retailing.”
[47] cf. Barry and Shawn, “Planning and Implementing an Effective Omnichannel Marketing Program.”
[48] cf. Cao and Li, “The Impact of Cross-Channel Integration on Retailers’ Sales Growth.”
[49] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. pp. 11, 154, 155
[50] cf. ibid. p. 11

effectiveness[51]. Reuse also lowers translation costs because only new content is translated. Choosing to work with a translation memory system further reduces cost while improving the quality of translated content.[52]

2.3 Implementing a Unified Content Strategy

Designing and establishing a UCS fills books on its own. A content strategy is concerned with creating usable content (content design) and the processes and structures involved in content creation and delivery (systems design). The editorial part of a content strategy defines target audiences, voice and tone, and messages that support business goals. By knowing the audience and their context, it is possible to create a well-rounded experience. To ensure consistency and integrity of content over time, the structure and metadata need to be standardized. Designing processes for content creation and governance ensure that the content strategy is steadily carried out. [53]

This chapter provides an overview of the steps to design and implement a UCS. Kissane groups the activities for developing a UCS into evaluation, design, and execution.[54]

2.3.1 Evaluation

Before designing a UCS, it is essential to analyze whom to write for, examine the business goals and the current content, as well as its creation process.

The target audience

The first step to finding out what content to create is investigating who the target audience is. A common practice is to create one or more personas, which contain the audience's characteristics and skills. The persona should not be based on assumptions but data. Useful data points are surveys, customer feedback, data collected on webpages, such as search logs, and colleagues from marketing, and customer service.[55]

After creating personas, content strategists look at the situations in which information is being used to create user scenarios. Anameier structures user scenarios like this[56]:

1. Describe the scenario. Who does what, and in which context?

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[51] Kissane, *The Elements of Content Strategy*. p. 1
[52] cf. Drewer and Ziegler, *Technische Dokumentation: Eine Einführung in die übersetzungsgerechte Texterstellung und in das Content-Management*. p. 99
[53] cf. Halvorson, “New Thinking: Brain Traffic’s Content Strategy Quad.”
[54] cf. Kissane, *The Elements of Content Strategy*. p. 40
[55] cf. Redish, *Letting Go of the Words: Writing Web Content That Works*. pp. 21-32
[56] cf. Anameier, “Want to Create Great Content? Know Your Context.”

2. Likely state of mind. Depending on the emotions, the audience might have a short attention span, for example, when an error needs to be solved quickly, and they feel stressed already.
3. Content needed. Summarize in short what content the audience needs.
4. Likelihood of this scenario. This criterion defines how important the information is and, therefore, how prominent its place should be.

After assessing the customer needs, content strategists examine the business goals to align the two.

Business goals

The purpose of a content strategy is to support the overall business strategy and business goals.[57] Rockley and Cooper suggest identifying the organization's dangers, opportunities, and strengths by interviewing key people. The content strategy takes these factors into account to avoid dangers and make use of the strengths and opportunities. A UCS can only achieve communicative goals.[58] To measure the effectiveness of the UCS, Kissane suggests defining success metrics.[59] Once the business goals are clear, it is time to check how the current content supports users and business goals.

Content Audit

There are two ways of performing a content audit: qualitative and quantitative. A quantitative audit is also called content inventory. It provides an overview of an organizations' content.[60] Kissane suggests organizing the overview in a spreadsheet that lists the title, format, location, type of content, and responsible person.[61]

A qualitative audit aims to assess the quality of the content and find opportunities for reuse. The content strategists look at representative content samples and analyze their structure, tone, and usefulness.[62]

These audits reveal how well current content meets strategic goals and whether they are on target with the organization's messages. They also show if the content is organized well for site visitors and answers their questions. Based on the audits, content strategists decide

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57 cf. Redish, *Letting Go of the Words: Writing Web Content That Works*. p. 39
58 cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. pp. 81, 82
59 cf. Kissane, *The Elements of Content Strategy*. p. 50
60 cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. p. 101
61 cf. cf. Kissane, *The Elements of Content Strategy*. p. 52
62 cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. pp. 101 – 103

if content has to be deleted, moved, combined or separated, or edited. They also might identify gaps for which new content must be created.[63]

The Content Creation Process

To implement a UCS, content creation must follow a standardized process. Typically, content lives through a life cycle, just like products do. Figure 2[64] depicts the four phases of the content life cycle.

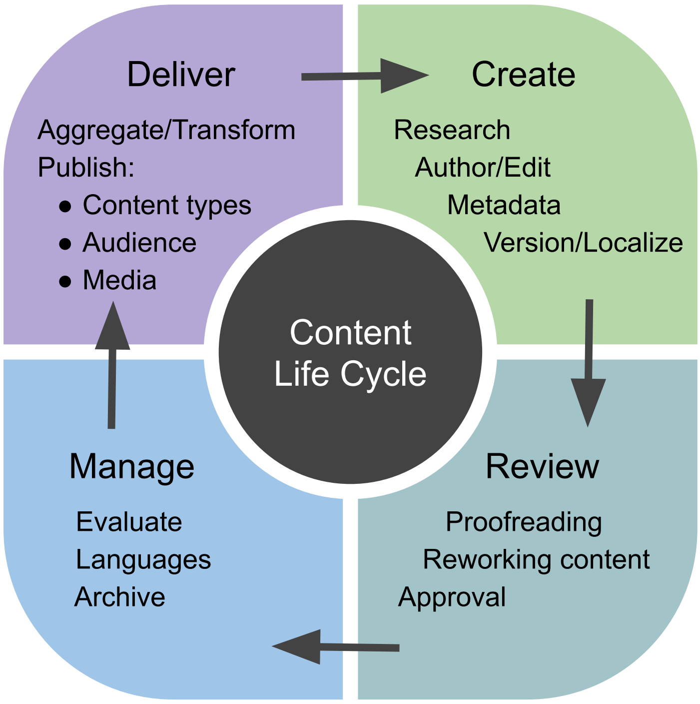

Fig. 2: The content life cycle

Since the workflows across an organization differ, Rockley and Cooper propose to interview key players to understand current processes and dependencies and to identify deficits. Typical players are Authors, Editors, Reviewers, and Translators, but also Instructors and departments concerned with product development and marketing.[65] Once it is clear how all departments work, content strategists design a new, collaborative workflow that is aligned with the content life cycle.

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[63] cf. Redish, *Letting Go of the Words: Writing Web Content That Works*. pp. 43, 44

[64] Adapted from Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. p. 89; Drewer and Ziegler, *Technische Dokumentation: Eine Einführung in die übersetzungsgerechte Texterstellung und in das Content-Management*. p. 300

[65] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. p. 90

2.3.2 Design

In the design phase, content strategists create the blueprint for content structure, metadata, and creation processes.

Creating a Vision

Developing a vision of the UCS and introducing new concepts is vital to gain the stakeholders' support[66]. The vision should contain different user scenarios for different stages in a typical user journey, and an overview of the channels content will be delivered. One approach is to map the customer journey with the content in a content matrix.[67]

Content Models

The purpose of content is to bridge the gap between the audience and business requirements[68]. Therefore, the content structure has to meet the user's needs and support business goals[69]. A content model defines standardized building blocks and their sequence.

Rockley and Cooper propose to create content models on two levels: The information product level and the component level. A component is a piece of self-contained information, resembling a topic. Standardizing information products means to define the structure in which components appear in an information product. Components are standardized by defining which purpose they serve and what they need to contain.[70] One example is that a component called "task" always lists prerequisites, describes the needed steps, and indicates the result.

A survey by Straub and Ziegler in 2019 revealed that 35,7 % of technical writing departments do not use standardized content models, meaning that standardization is still a common issue. The majority of technical writing departments (68 %) use custom structures to standardize their information products. There are also open-source standards, such as the Darwin Information Typing Architecture (DITA). Since the last survey in 2014, the use of DITA doubled and is now used by almost 10 % of respondents. [71] DITAs latest version provides a metadata model for technical communication, and learning and training content.[72]

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[66] cf. Kissane, *The Elements of Content Strategy.* p. 57
[67]cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy.* pp. 119-121
[68]cf. Halvorson, "Understanding the Discipline of Web Content Strategy."
[69] cf. Kissane, *The Elements of Content Strategy.* p. 58
[70] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy.* pp. 139-142
[71] cf. Straub and Ziegler, *Effizientes Informationsmanagement durch komponentenbasierte Content-Management-Systeme (CCMS).* p.47
[72] cf. OASIS DITA Technical Committee, "1.1 About the DITA Specification: All-Inclusive Edition."

Standardization on a component level is practiced by fewer organizations than on the information product level. The most prominent method is functional design (33,2 %) followed by simplified English (8,4 %) and Information Mapping (7,9 %). The survey was carried out in the German-speaking area, and functional design was developed by two German Professors. In other parts of the world, the numbers on standardization and used methods are probably different.[73]

Functional design standardizes on information product and component level as well but also takes sentence-level and word-level into account. The method was initially developed for technical documentation but is also applicable for other kinds of standardized content, as it can be adapted to meet the organization's needs.[74] Regardless of the chosen method, the content model needs to support reuse.

Reuse Strategy

Since one of the goals of a UCS is to reduce redundant work, a reuse strategy is essential for efficient work. The type of reuse depends on the business goals, on the authors, and on what the tools support[75]. Generally, there are three types of reuse, which can be applied manually or automatically[76]:

- *Identical reuse* means the content is reused without a change, which is helpful when creating a new information product from existing content. It can be applied to different levels of granularity:
  - *Section-based reuse* references a section.
  - *Component-based reuse* references an entire component.
  - *Fragment-based reuse* only references a part of a component, such as a paragraph.
- *Conditional reuse* allows creating variants of components, which enables greater flexibility in the publishing process. Content, which is not needed in the final information product, is filtered out.
- *Variable reuse* pursues the same goal as conditional reuse but on the sentence and word level. Variables have different values, depending on the publication scenario. This is a common approach for handling product names.

Another critical part of the reuse strategy is determining who has the right to modify content and how modifications affect already reused content. The two approaches are *locked reuse*

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[73] cf. Straub and Ziegler, *Effizientes Informationsmanagement durch komponentenbasierte Content-Management-Systeme (CCMS).* p. 48
[74] cf. Schmeling, "Informationsverarbeitung mit Funktionsdesign."
[75] cf. Rockley and Gollner, "An Intelligent Content Strategy for the Enterprise."
[76] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy.* pp. 156-160

and *derivative reuse.* Locked reuse means that nobody can change a reused fragment. Since not all content can be reused directly, derivative reuse allows making changes to the reused component.[77]

Workflow

In the evaluation phase, the current state of the content creation process was assessed. The content strategist identified where processes contain unnecessary complexity and redundant steps. Based on the findings, content strategists design a new workflow that defines players, tasks, and processes. The goal is to support the content creation workflow with tools that automate recurring tasks, such as reminders for reviews. Since workflow design is not the focus of this thesis, please refer to Rockley and Cooper chapter 14 for more information.[78]

Metadata

Metadata plays a prominent role because it is the basis for structured content, precise content delivery, reuse, and automated workflows. Ultimately, metadata is the foundation of a UCS. As Rockley and Cooper have put it: "It's more than just data about data; it's the encoded knowledge of your organization."[79]

Technical communicators are familiar with standardized metadata. 37,4 % of technical writers use metadata defined by their CMS, while 36,5 % have a custom concept for metadata. Open metadata standards are less common, with 2,6 % of CMS users applying iiRDS. The percentage seems low, but most likely reflects the early adopters, as the standard was released in 2018, and the survey was conducted in 2019. 14 % of technical writing departments that use a CMS are applying using PI-Class[80].

Drewer and Ziegler developed the PI-Class method to define metadata for products (P) and information (I) [81]. The two spheres are further distinguished between intrinsic and extrinsic metadata, totaling four different combinations[82]:

- *Intrinsic product* metadata describe the components a product is made of. They often follow a hierarchy, such as bicycle -> lights -> tail light.

[77] cf. Rockley and Cooper. pp. 155, 156
[78] cf. ibid. pp. 166-170
[79] Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. p. 204
[80] cf. Straub and Ziegler, *Effizientes Informationsmanagement durch komponentenbasierte Content-Management-Systeme (CCMS)*. p. 49
[81] cf. Institute for Information and Content Management, “PI Classification.”
[82] cf. Drewer and Ziegler, *Technische Dokumentation: Eine Einführung in die übersetzungsgerechte Texterstellung und in das Content-Management*. pp. 368-371

- *Intrinsic information* metadata characterize the components that make up an information product. Other characteristics that describe the content itself, such as the language or data format, are also intrinsic information metadata.
- *Extrinsic product* metadata identifies products, for example, manufacturer information, name, and features. Using extrinsic product metadata allows filtering content for product information.
- *Extrinsic information* metadata are relevant for content delivery, as they describe which components are published in which information product. Additional extrinsic information metadata are, for example, the target audience, publication formats.

There is a fifth category of metadata (functional metadata) that relates to the content life cycle and information sphere to support the administrative side of content management.

Style Guides

Style guides ensure that content creators follow stylistic conventions, making content user-centric and concise. These conventions specify what and how to write within the defined content model, such as the voice and tone of the content. If there is more than one audience, it is possible to create another style guide to converse with the audience appropriately[83]. A useful style guide also contains positive and negative examples[84].

2.3.3 Execution

The organization needs a set of new and modified roles to execute the designed content strategy. Since the thesis omits managerial implications of a UCS, please refer to Rockley and Cooper chapter 18 for more information.[85] Apart from people, a governance strategy and technology support a sound UCS.

Governance

Governance means deciding whether rules and processes are kept in place or need modifications because of new business requirements. Content governance means to keep the content in order by creating, reviewing, curating, and removing content.[86] A governance

[83] cf. Redish, *Letting Go of the Words: Writing Web Content That Works*. p. 38
[84] cf. Kissane, *The Elements of Content Strategy*. p. 61
[85] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy*. pp. 251-261
[86] cf. Redish*, Letting Go of the Words: Writing Web Content That Works*. p.39; cf. Bailie, “What’s the Buzz about Content Strategy?”

board's objective is to spot business threats or opportunities and evolve the UCS[87]. Earley suggests a governance board with a maximum of ten people, organized in three layers[88]:

1. Strategic: A steering committee is responsible for long-term decisions regarding content. The committee should comprise of a user advocate and people with knowledge about business requirements, the technological landscape, and information architecture.
2. Tactical: The tactical level is governed best by people involved in the day-to-day business.
3. Advisory: Advisors only consume content and give input sporadically. Such players can be subject matter experts and user experience designers.

Technology

Technology plays a crucial role in sustaining the processes of a UCS. XML-based tools are useful for content creation and governance, because of their versatility. Since taxonomies are often used to classify content, the thesis investigates how ontologies can be used to distribute personalized content, starting in chapter 3.

2.4 Challenges and Limitations of a Unified Content Strategy

Rockley and Cooper highlight that while a UCS identifies issues within the organization, it can only tackle problems revolving around content and its creation. Organizational issues, such as work culture, deserve attention, but cannot be solved with a UCS.[89] This chapter presents common challenges during the evaluation and design phase of a UCS.

Determining the Needs of the Target Audience

Most organizations most likely have done user research for marketing purposes, which content strategists can use. Sometimes the target audience and their needs cannot be determined easily when there is not enough data, which the following example illustrates.

Dawkins from the Western Sydney University examined if a content strategy can be established for the creation of learning material. While Dawkins identified that optimizing content through a content strategy might reduce failure rates, it remains unclear how to optimize content because there is no data on students' needs. The University conducted a small scale study to gain insights on the students' weekly engagement. However, there were

[87] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy.* p. 247
[88] cf. Earley, “Developing a Content Maintenance and Governance Strategy.”
[89] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy.* p. 85

issues regarding the study design because the learning management system (LMS) did not support user data collection. A workaround solution was able to collect data but with questionable quality, due to and missing benchmarks for conversion and engagement rates in higher education and a file type restriction. Without appropriate and diverse data points, the problem of not knowing the audience's needs persists. [90]

Social Acceptance

Rockley and Cooper highlight that change management is indispensable for implementing a UCS. Stakeholders will only cooperate when they have a precise understanding of the vision, changes in roles, and workflow. A common issue is switching to new software, which the following example describes. To enable structured authoring and multi- or omnichannel publishing, the creation tools have to support XML and the organizations' metadata model. When content creators are unfamiliar with structured authoring, they might be reluctant to change. Change management and user-friendly tools help with facilitating the shift to structured authoring.[91]

Unstructured Content

When designing a UCS, unstructured content deserves special attention, as new metadata models need to be created. A case study by Rockley and Gollner showed great potential for structured content and reuse in a traditionally unstructured department: marketing. The core messages were turned into components, which could be adapted to the different target audiences with derivative reuse. The marketers feared that structures would limit their creativity. However, working with standardized styles made the content creation process more efficient, as layout and design were automated.[92]

Level of Granularity in the Metadata Model

As discussed in chapter 0, there are different approaches to modeling content in terms of granularity. Consequently, the degree of standardization determines the granularity of reuse[93].

While modeling content in information products and components (or topics) creates structures that are sufficient for publishing, content is not classified on sentence- or word-level. Ley highlights that this causes the problem of a topic black box. Semantic information is lost

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[90] cf. Dawkins, “Content Strategy: A Lesson from the Industry for University Learning Analytics.”
[91] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy.* pp. 231, 232, 264
[92] cf. Rockley and Gollner, “An Intelligent Content Strategy for the Enterprise.”
[93] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy.* p. 141

when the structure inside a topic consists of paragraphs and lists, instead of descriptive tags, such as step or prerequisite. Only with a high level of semantic richness, dynamic content delivery becomes possible, thus improving customer experience [94]. Creating content models using the functional design approach solves this problem.

Sometimes reuse is not possible, namely when the quality of the content worsens because of the reuse. For example, one component can contain the same message for two different target audiences, but they each require a different voice and tone. In this case, it makes more sense to write two topics accommodating the needs of the audience. The same principle applies to reuse on sentence-level. If a sentence does not fit into the destination topic, thus creating confusion, it should not be reused. Rockley and Cooper advise that the content quality and appropriateness for a target audience is more important than reusability.[95]

Merging Existing Metadata Models

Since the metadata model is the technical core of a UCS, a particular challenge arises when there are multiple taxonomies in an organization, which have to be combined. Fran Alexander published a paper on such a project at the BBC. The project focused on improving the findability of content and the preciseness of search results in the content archive. The problem was that only content experts could find what they needed precisely because the content is classified with a variety of taxonomies and classification schemes. Therefore, Alexander focused her efforts on unifying the metadata on 16 taxonomies with two major classification schemes. Since it was not possible or practical to create one taxonomy to fit all classification needs, the existing taxonomies were linked by carrying out crosswalks on a structural level, thus appearing unified in the search portal. The crosswalk is a method used to find structural equivalents. The taxonomies were not mapped on a semantic level, as it poses further challenges, such as mapping homonyms and synonyms, errors in source data, and a lack of specialist knowledge. Alexander concludes that the project was successful in improving findability, but the metadata should be organized in an ontology.[96]

[94] cf. Ley, "Informationen erhalten Bedeutung."
[95] cf. Rockley and Cooper, *Managing Enterprise Content. A Unified Content Strategy.* pp. 162, 163
[96] cf. Alexander, "Building Bridges: Linking Diverse Classification Schemes as Part of a Technology Change Project."

2.5 Summary: Requirements of a Unified Content Strategy

This chapter introduced the concept of a UCS and how to implement one, discussing the benefits and some challenges. To design and implement a UCS, the used technological setup needs to meet the following requirements:

- **Consistency**: The technology of choice must allow using content models to ensure consistent messages.
- **Reusability**: There needs to be a single source of truth storing modular content components that are fit for reuse.
- **Personalization**: Each component covers one use case or situation to deliver content precisely based on an elaborate metadata model.
- **Channel-independence**: The content needs to be stored in a way that is adaptable to different output channels.

The following chapter discusses ontologies and analyzes if they can meet the requirements of a UCS.

3 Ontologies

The goal of a UCS is to create a unified metadata model for content, to ensure consistency across the organization. Ontologies are a technological means to unify data from multiple sources, making an investigation of the application for a UCS worthwhile. The following chapters introduce semantic networks and ontologies, discuss their application, and highlight challenges regarding the creation of an ontology. Since the creation of an ontology from scratch consumes a lot of time and resources, ontology reuse is preferred[97]. The ontology of the content delivery standard iiRDS is introduced and will be examined whether it can support the implementation of a UCS.

3.1 Definitions

This section introduces metadata constructs of different levels of formality and semantic expressiveness. Figure 3[98] gives an overview of how formalized and elaborate knowledge can be represented.

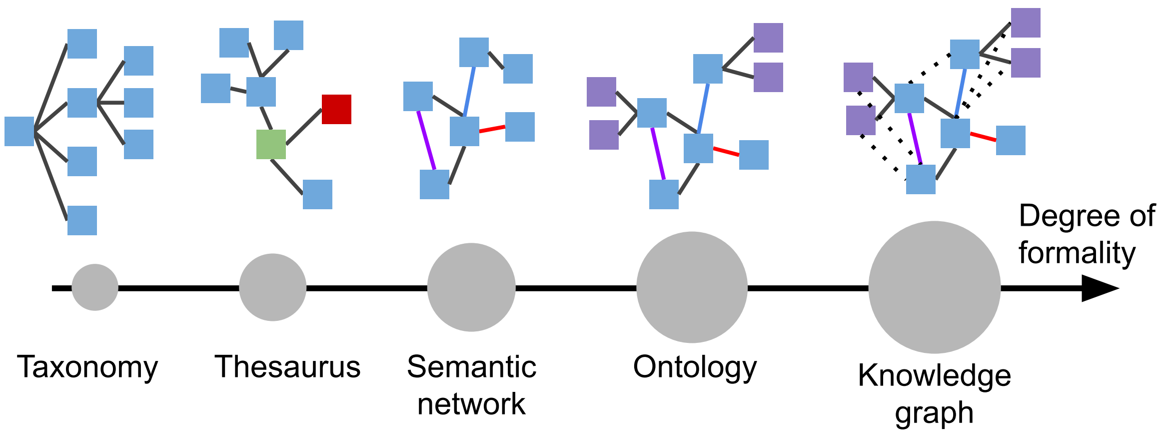

Fig. 3: Metadata constructs depending on the degree of formality

Taxonomy

A taxonomy is a system to classify objects in a hierarchical order using classes and superclasses. Taxonomies describe "is-a" relationships; for example, a dog is a mammal, making the dog a subclass of mammals. Ideally, objects are assigned to a class unambiguously, meaning that there are no cross-connections to other classes, leading to a tree structure.[99]

[97] cf. Feilmayr and Wöß, “An Analysis of Ontologies and Their Success Factors for Application to Business.”
[98] Created by the author
[99] cf. Ley, “Informationen erhalten Bedeutung”; cf. Hedden, “Taxonomies and Controlled Vocabularies Best Practices for Metadata”; cf. Feilmayr and Wöß, “An Analysis of Ontologies and Their Success Factors for Application to Business.”

Organizations often use taxonomies to classify content, indicating which category, such as product information or language, is appropriate for the content. A prominent use case is a faceted search, where users can filter information based on the taxonomy.[100]

Thesaurus

A thesaurus is a word network that defines terms and its concepts, aiming to structure a language. Terms are related to one another as synonyms, homonyms, or broader/narrower relationships[101]. As the relations in a thesaurus are limited to linguistic phenomena, thesauri are not feasible to represent knowledge, because they lack logic-based relations[102]. Although thesauri form hierarchical relationships, the overall structure resembles more of a network, making them rudimental semantic networks[103].

Hedden distinguishes between dictionary thesauri (word networks) and thesauri used for content retrieval. The difference between the two is that dictionary thesauri provide alternative terms depending on a specific context. A content retrieval thesaurus aims to serve many usage contexts and is, therefore, more structured.[104] Content retrieval thesauri improve information retrieval by grouping several terms into a concept[105].

Semantic network

The term semantic network is an umbrella term for structures that link objects together using relations. Semantic networks aim to reflect the real world so that humans and machines can interpret the data. The objects in the semantic network, also called concepts or classes, represent beings or ideas, such as persons, products, and even content. Objects can have attributes, also called properties, which specify an object. The relation expresses how objects relate to each other; for example, a tire is part of a car. The car and the tire are both objects, connected with the "is part of" relation.[106] Taxonomies and thesauri can serve as a basis when creating a semantic network, as cross-connecting classes to form a network is the next step to increase semantic expressiveness[107].

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[100] cf. Reußner, *Classification of Technical Documentation*. p. 11
[101] cf. Hedden, “Taxonomies and Controlled Vocabularies Best Practices for Metadata.”
[102] cf. Grimm et al., “Ontologies and the Semantic Web.” p. 524
[103] cf. Stuckenschmidt, *Ontologien: Konzepte, Technologien und Anwendungen*. p. 244
[104] cf. Hedden, “Taxonomies and Controlled Vocabularies Best Practices for Metadata.”
[105] cf. Stuckenschmidt, *Ontologien: Konzepte, Technologien und Anwendungen*. p. 250
[106] cf. Reichenberger, *Kompendium semantische Netze: Konzepte, Technologie, Modellierung*. pp. 4, 5
[107] cf. ibid. p. 14

Ontology

Originally the term derived from philosophy where the discipline of ontology aims to explain all beings systematically[108]. In computer science, an ontology is a type of semantic network. The computer scientist Studer, who had researched ontologies for more than 20 years, defines an ontology as "a formal, explicit specification of a shared conceptualisation."[109]

Formal means that the ontology is written in a structured way, such as a knowledge representation language, to make the information machine-readable. *Explicit* describes that the concepts (knowledge) and their constraints are machine-interpretable. *Shared* refers to the consensus about concepts within a community. The term *conceptualization* means the representation of a concept or being in the real-world in an abstract model.[110]

Grimm et al. add to Studer's definition that the scope of an ontology is limited to a domain of interest. This facilitates the creation of ontologies, as it allows focusing on modeling the details of the domain.[111] Another benefit is that well-modeled ontologies are reusable for other application contexts of the same domain[112].

Feilmayr and Wöß refine Studer's definition further, adding the characteristic of "high semantic expressiveness" required for the increasing complexity of conceptual models[113]. This semantic expressiveness is achieved through relations and axioms, portraying real-world concepts as precisely as possible. In short, the goal of an ontology is to make a domain explicit by capturing its entities and their relationships.

Types of Ontologies

There are different types of ontologies, not all of which are restricted to domain knowledge. Upper ontologies, also called top-level ontologies, describe generic concepts that can be applied domain-independent. They lean more towards the philosophical roots of explaining every being or concept in the world. The idea behind such general ontologies is that there are relevant concepts regardless of the domain, which can help verify domain-specific

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[108] Gómez-Pérez, Fernández-López, and Corcho, *Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web*. p. 6
[109] Studer, Benjamins, and Fensel, "Knowledge Engineering: Principles and Methods." p. 184
[110] cf. Grimm et al., "Ontologies and the Semantic Web" pp. 510, 511; cf. Studer, Benjamins, and Fensel, "Knowledge Engineering: Principles and Methods."
[111] Grimm et al., "Ontologies and the Semantic Web." pp. 510, 511
[112] cf. Ley, "Informationen erhalten Bedeutung."
[113] Feilmayr and Wöß, "An Analysis of Ontologies and Their Success Factors for Application to Business."

ontologies.[114] One example is the suggested upper merged ontology (SUMO), one of the largest publicly available ontologies, containing about 25,000 terms and 80,000 axioms[115].

In addition to domain and upper ontologies, there are also task and application ontologies. Task ontologies specialize terms in the upper ontology, providing a vocabulary for generic tasks. Application ontologies have a very narrow scope, as they specify domain and task ontologies to serve a specific application.[116]

Another possible distinction is between lightweight or heavyweight ontologies, for which the criterion is the degree of formality[117]. Lightweight ontologies form relations between concepts, modeling a domain. For instance, taxonomies and thesauri fall on the side of lightweight ontologies. Heavyweight ontologies add constraints and axioms, in order to clarify the meaning of the terms.[118] Because of their extensive axioms, heavyweight ontologies can be used for reasoning, i.e. to validate an existing ontology and infer new knowledge based on logic[119].

Knowledge Graph

Google introduced the term knowledge in 2012 to describe the use of semantic technologies to improve its search engine[120]. The term also gained popularity among practitioners and scientists, leading to a synonymous use to the term ontology. Ehrlinger and Wöß conducted a literature review to settle the difference between ontologies and knowledge graphs. The authors concluded that knowledge graphs consist of an ontology, but also contain a reasoning engine to derive new information from the ontology.[121] Following this definition, knowledge graphs are a synonym for heavyweight ontologies.

3.2 Use Cases and Benefits of Ontologies

This chapter looks at the use cases of data integration and information retrieval, as these are needed to support a unified content strategy. Ontologies can aid in delivering content precisely, as they are used to integrate data into a standardized (meta-) data model, and

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114 cf. Reichenberger, *Kompendium semantische Netze: Konzepte, Technologie, Modellierung. p 80*; cf. Grimm et al., “Ontologies and the Semantic Web.” p. 523

115 cf. Pease, “The Suggested Upper Merged Ontology (SUMO) - Ontology Portal.”

116 cf.Gómez-Pérez, Fernández-López, and Corcho, *Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web*. pp. 26-34

117 cf. Grimm et al., “Ontologies and the Semantic Web.” p. 539

118 cf. Gómez-Pérez, Fernández-López, and Corcho, *Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web*. p. 8

119 cf. Grimm et al., “Ontologies and the Semantic Web.” pp. 516, 517

120 cf. Singhal, “Introducing the Knowledge Graph: Things, Not Strings.”

121 cf. Ehrlinger and Wöß, “Towards a Definition of Knowledge Graphs.”

facilitate information retrieval. The chapter also explores how ontologies can provide personalized information.

3.2.1 Data Integration

Organizations often store data in several data models and classification systems (structured data), or store data without a structure (unstructured data), which complicates information retrieval[122]. The integration of data from multiple sources enables reuse, interoperability, and search. Grimm et al. distinguish two methods[123] to integrate data, the Query-Driven Information Integration approach, see figure 4[124], and the Linked Open Data approach. While the linked data approach models data using semantic web standards to ensure interoperability, this approach is not further discussed, as the thesis focuses on organizations that want to implement ontologies on top of their existing infrastructure.

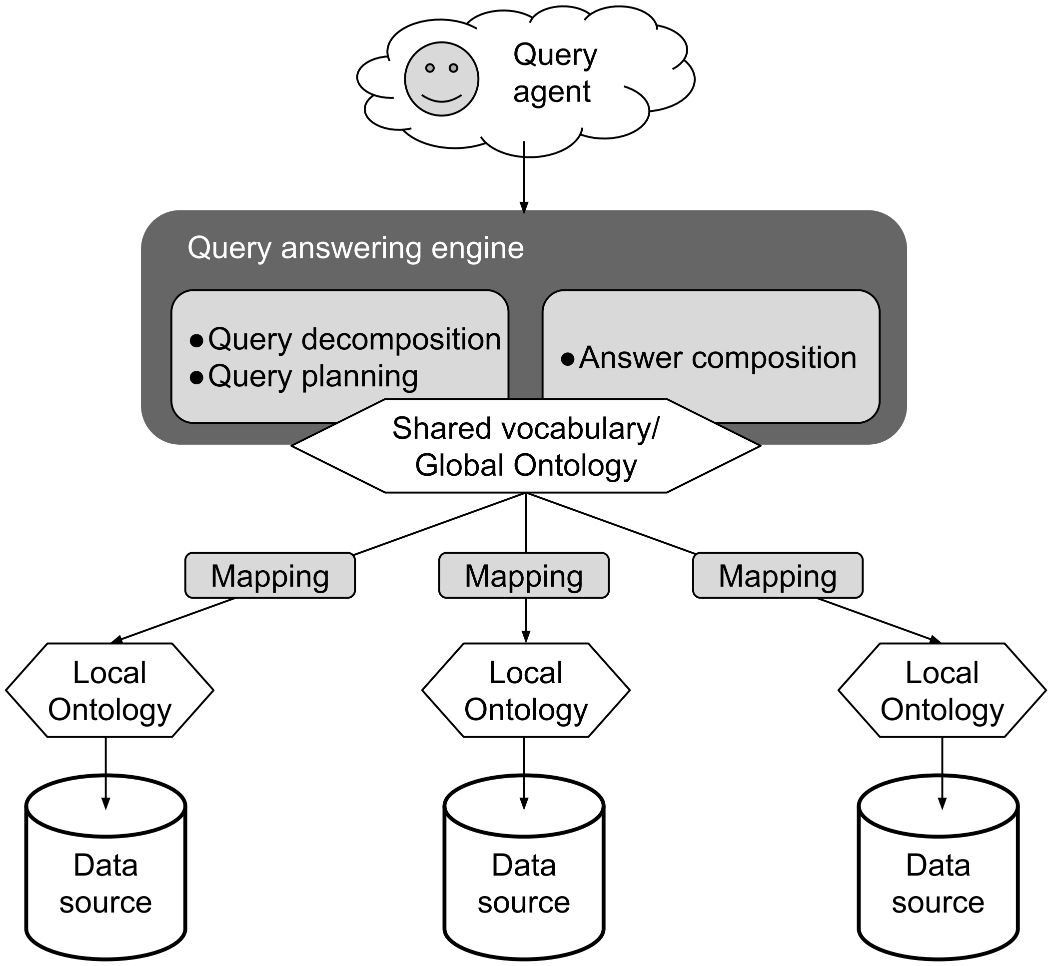

Fig. 4: Architecture for interoperability using ontologies

[122] cf. Reichenberger, *Kompendium semantische Netze: Konzepte, Technologie, Modellierung*. p. 16
[123] cf. Grimm et al., "Ontologies and the Semantic Web." pp. 547-549
[124] Adapted from Grimm et al., "Ontologies and the Semantic Web." p. 548

Query-Driven Information Integration means to query several data sources and retrieve and aggregate results using one interface. This approach is suitable for settings, where infrastructure has not been designed for interoperability. The technical approach is to create one ontology for each data source which represents the local data structures. A second, global ontology connects all local ontologies and is used in the query application.

Since not all data sources provide structured data, the integration of unstructured data plays an important part to fulfil the users' information needs. Information extraction algorithms can extract metadata from unstructured text-based documents and integrate the metadata within the local ontology. When unstructured data is represented in the ontology, the interface can aggregate informal and formal information sources, enhancing the findability and usefulness of information.[125]

Stuckenschmidt identifies three benefits of using ontologies to integrate several data sources[126]:

I. A neutral data model can accommodate and unify existing data sources. In the Query-Driven Information Integration approach, the global ontology unifies the underlying ontologies.

II. Conceptual knowledge and implicit presumptions are made explicit in an ontology. Explicit facts and definitions contribute to the comparability of objects, enabling a sophisticated use of axioms.

III. Based on explicit models a reasoning algorithm can check the data model's consistency and validity using logic-based inference axioms.

When data models are unified and data is semantically enriched through ontologies, new usage scenarios, such as semantic search are possible.

3.2.2 Semantic Search

The term semantic search encompasses two kinds of search: The first is searching within a semantic network and getting objects from the network as results; the second notion is using semantic networks to enhance full-text search. Enhanced full-text search is based on traditional information retrieval mechanisms and the search in a semantic network.[127] The following section discusses the enhancement of full-text search, followed by an introduction into personalized content delivery.

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[125] cf. Reichenberger, *Kompendium semantische Netze: Konzepte, Technologie, Modellierung.* p. 91; cf. Ley, "Informationen erhalten Bedeutung."
[126] cf. Stuckenschmidt, *Ontologien: Konzepte, Technologien und Anwendungen.* pp. 220-229
[127] cf. Reichenberger, *Kompendium semantische Netze: Konzepte, Technologie, Modellierung.* p. 205

Traditional information retrieval relies on comparing a search term with resources in a given answer space. To calculate the relevance of potential results, search algorithms use the TF-IDF approach. TF stands for term frequency. This part of the algorithm measures how often the search term(s) appear in an information source. IDF stands for inverse document frequency and marks how relevant a term is in the context of other potential documents. The relevance of a document increases when the term appears often (high term frequency) in one document but does rarely occur in other documents of the answer space.[128]

Since the TF-IDF algorithm is word-based, synonyms and homonyms can distort the search results[129]. Semantic networks can resolve this problem by taking the context of the terms into account when information is stored as objects[130].

Grimm et al. describe the semantic search process as shown in figure 5[131] and identify five use cases for ontologies to support the search process[132].

The first step of a semantic search is to formulate a query, for example, search terms or a SPARQL query. In the second step, the query is transformed into a representation used for further computation. Then, the information retrieval system determines the similarity between the query and the information items based on their descriptions. In the last step, the results are collected and presented to the query agent. If the information need was not satisfied, the agent can reformulate the query.[133]

Ontologies can support the search process at every step, starting with supporting the query formulation. Since ontologies are context-aware, the system can refine the initial query (1) with context information.

If a query was ambiguous and needs to be reformulated (2), ontologies can provide a vocabulary to refine the query or resolve the ambiguity through reasoning mechanisms. When a query was too vague it can be refined by expanding the query based on similar concepts.

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[128] cf. Stuckenschmidt, *Ontologien: Konzepte, Technologien und Anwendungen*. pp. 234-239

[129] cf. Stuckenschmidt, *Ontologien: Konzepte, Technologien und Anwendungen*. pp. 242-243

[130] cf. Haase, Tran, and Studer, "Semantic Search - Using Graph-Structured Semantic Models for Supporting the Search Process."

[131] Adapted from Grimm et al., "Ontologies and the Semantic Web." p. 543

[132] cf. ibid. pp. 542-545

[133] cf. Stegmaier, *Unified Retrieval in Distributed and Heterogeneous Multimedia Information Systems*. p. 13; cf. Grimm et al., "Ontologies and the Semantic Web." pp. 542-546

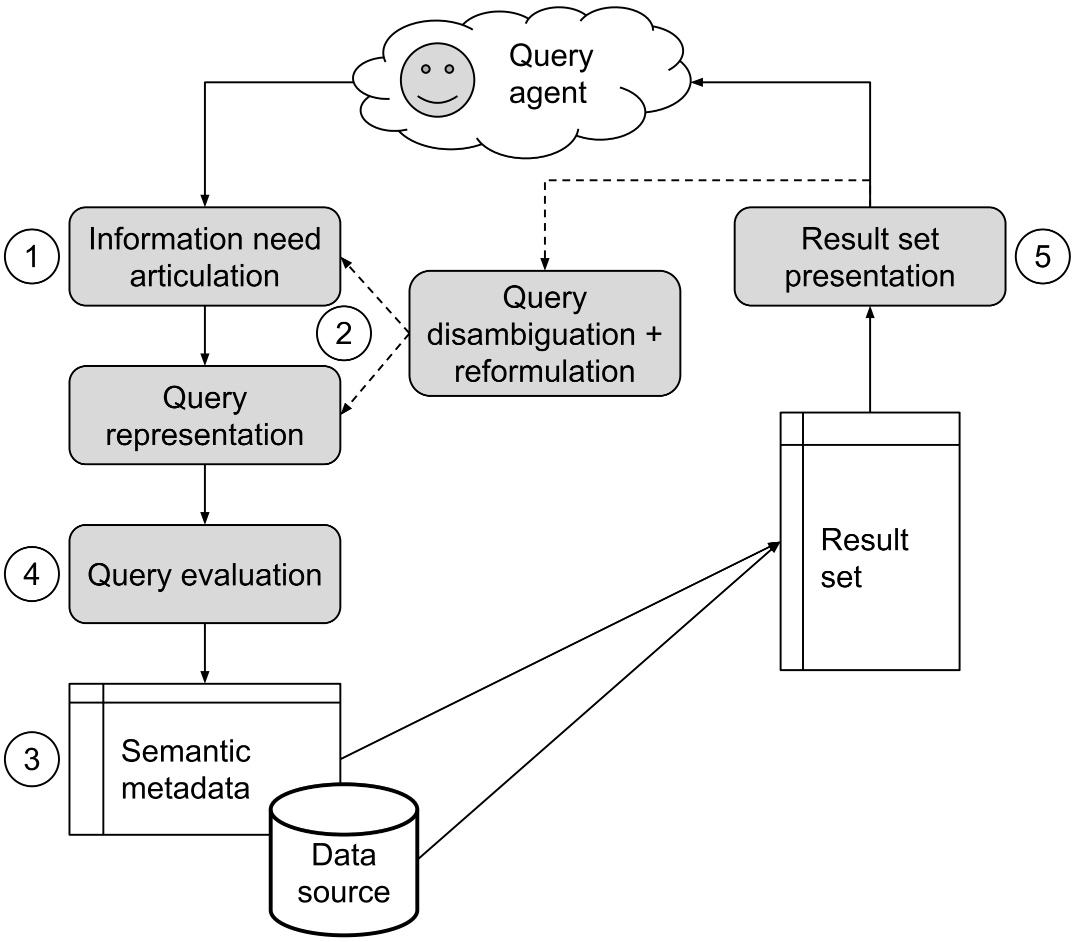

Fig. 5: Semantic search process

To retrieve information based on knowledge, the information sources need to have semantic metadata (3), stored as an ontology. The benefit of semantic metadata is that it describes sources regardless of their format, meaning that non-textual information is also retrievable. Standardized metadata, as discussed in section 3.2.1, can put sources into the same context, facilitating the similarity analysis.

Knowledge-based information retrieval (4) matches the query term against semantic metadata to determine information source(s) with a high probability to fulfill the information need. Metadata stored in an ontology enables inferring the relevance for the search using reasoning mechanisms.

When the system has calculated results, ontologies are used for post-processing (5). The search results are ranked and ordered, or visualized, for example, as a network, from which a user can select the most useful sources. So far, the relevance is determined by the similarity between the query term(s) and the available metadata. Section 3.3.3 discusses how the search process can be adjusted to deliver personalized results.

3.3 Frameworks for Metadata and Ontologies in the Communication Sector

The idea of interconnecting data sources, so that digital personal assistants merge them into meaningful information to serve their users, is not new. Tim Berners-Lee, the founding father of the web, has proposed this vision which he calls the Semantic Web. To realize this vision, ontologies and metadata are vital, as they are key to making machines genuinely understand documents and data.[134]

Ever since the internet gained popularity, discoverability and findability became more important. In 1995 a group of 50 people discussed how to tackle these issues and proposed a standardized metadata set comprising 15 elements, known as the Dublin Core[135]. Because the Dublin Core metadata set is not domain-specific, it is now widely used for all kinds of digital documents. The Dublin Core has influenced many ontologies since it is represented in the Resource Description Framework (RDF). [136]

RDF is a markup language, which can represent knowledge machine-readable as a graph. RDF Schema is used to provide a scaffolding for RDF statements. To retrieve data from an RDF graph, the SPARQL Protocol and RDF Query Language were invented. These three technologies are used to realize Semantic Web applications. iiRDS is based on RDF and provides a framework for unifying information from various sources for technical communication resources. The next sections introduce to presented technologies.

3.3.1 Resource Description Framework (RDF)

The Resource Description Framework (RDF) is a markup language to describe resources. A resource can be anything from a person to an idea, concept, or physical object. Each resource has an International Resource Identifier (IRI), making it addressable and unique, allowing the formation of ontologies.[137] RDF stores data in triples to describe resources, see figure 6.**Error! Reference source not found.**A triple has a sentence-like structure containing a subject, predicate, and object. [138]

[134] cf. Berners-Lee, Hendler, and Lassila, "The Semantic Web."
[135] cf. Dublin Core Metadata Initiative, "DCMI History."
[136] cf. DCMI Usage Board, "DCMI Metadata Terms."
[137] Schreiber and Raimond, "RDF 1.1 Primer."
[138] cf. ibid.

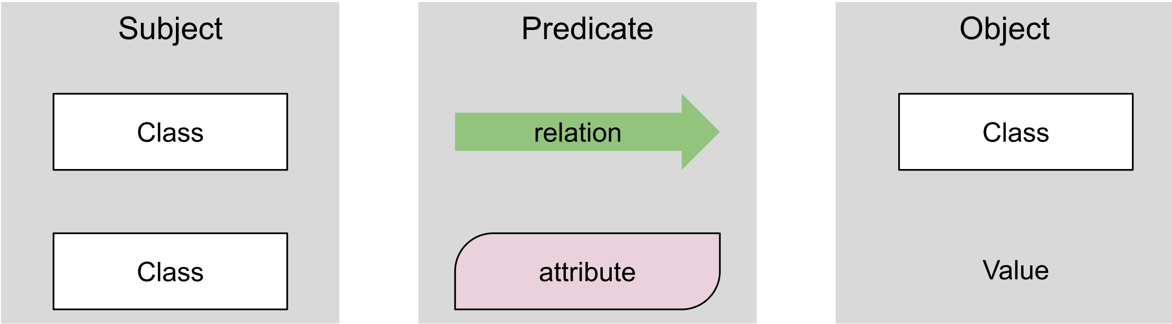

Fig. 6: Triples in RDF

There are two types of data in RDF: classes and properties. Classes are valid in the subject and the object position of a triple. Properties go in the predicate position. A property can either be a relation or an attribute. Relations connect two classes and describe in which way they are related. Attributes describe a class further by assigning a value to it.[139]

It is also possible to visualize triples as a graph, see figure 7Fig. 7: [140].

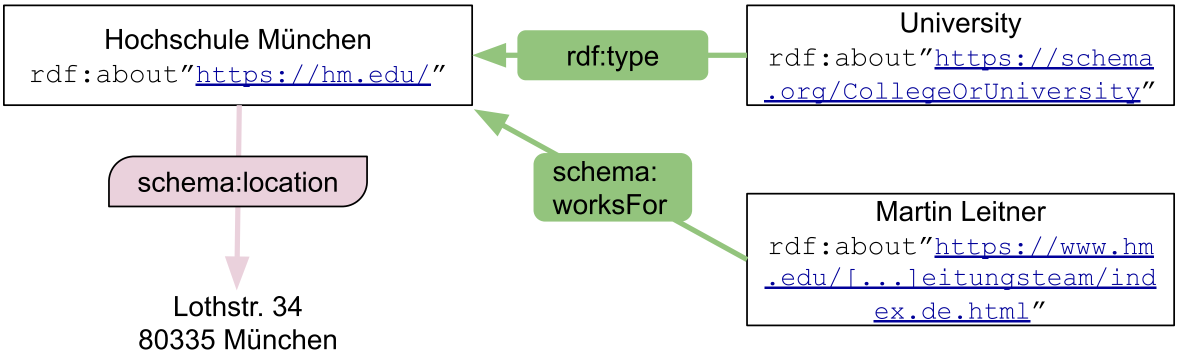

Fig. 7: RDF triples represented as a graph

The subject and object become nodes, and the predicate becomes an arc. The property `rdf:about` adds an IRI to each class. In this case, the IRIs are URLs, but an IRI could also be an email address or IP address[141]. The properties in Fig. 7: are named `schema:worksFor` or `rdf:type.` It is a more readable way of assigning an IRI. The prefix states from which vocabulary the property originates, for example, `schema:` resembles the schema.org vocabulary. The suffix designates the actual property used from that vocabulary. The property `rdf:type` creates an instance of a class, in this case, the class `Hochschule München` is an instance of the class `University`.

An RDF vocabulary provides the semantic context to describe IRIs and other semantic characteristics of RDF data. Creating new RDF graphs becomes more efficient with

139 cf. Pool Party Semantic Suite, "2.8 Anatomy of an Ontology."
140 Created by the author.
141 cf. Nuding, "Standards im Umfeld Industrie 4.0."

vocabularies as they were built to be reused. Whenever there is a need for a new vocabulary, it can be created with the RDF Schema language, explained in the following section.

RDF versus XML

Both XML and RDF are used to describe resources through metadata, but how are they different? XML is useful for creating and standardizing document structures, which is why it is used as the underlying technology in many CMSs[142]. An XML document follows a tree-structure. The order of the tags matters to build the correct association in the writer's or reader's mind. However, a machine cannot make sense of the order without a schema that defines the valid elements and their sequence in an XML file.[143] Even with a schema, XML does not express information about how the tags are related[144].

RDF uses relations to express the connections between the tags, resembling a network structure. Since the sequencing does not matter, RDF allows greater flexibility in content modeling[145]. Furthermore, each RDF tag has an explicit definition, so that the meaning of a tag is unambiguous.

Use Cases and Benefits of RDF

The purpose of RDF is to link data together so that they form a network of knowledge. The goal is to make data exchangeable between different applications, primarily on the web. RDF can also be used in a corporate setting to interlink datasets and query them using a query language, such as SPARQL. RDF is one technical approach to realize an unrestricted information flow, which is useful when breaking down information silos. Other use cases of RDF include, for example, improving SEO on websites, and content aggregation through linked data[146].

One of the benefits of RDF is that it can be easily expanded, for example, by adding a new vocabulary. RDF enables merging information from multiple sources while still being coherent because each resource has an IRI. A reasoner can validate the logic of the triples, using a set of logic-based rules. It is even possible to generate new statements that are true, as long as the existing statements are true.[147]

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142 cf. Straub and Ziegler, *Effizientes Informationsmanagement durch komponentenbasierte Content-Management-Systeme (CCMS)*. p. 47
143 cf. Berners-Lee, "Why the RDF Model Is Different from the XML Model."
144 cf. Hitzler et al., *Semantic Web: Grundlagen*. p. 30
145 cf. Schubert, "RDF Is Not XML – RDF Serialization and iiRDS Metadata."
146 Linked data is following relational links and aggregating data about these nodes.
147 cf. Schreiber and Raimond, "RDF 1.1 Primer."

3.3.2 RDF Schema

RDF is used to form statements about resources. However, without a schema, it is unknown which classes and properties exist and how to form valid statements.

> “Schemas exist to provide the necessary semantics to enable the correct interpretation of instance data and to facilitate consistency between multiple data publishers. It is important that schemas are error free. They are a reference point for both machines and human data modellers and it is arguable which of those is the more pedantic.”[148]

RDF Schema is a semantic extension of RDF and provides a data modeling vocabulary that defines classes, properties, and (hierarchical) relations. In general, classes group different types of resources together.[149]

Properties describe the relation between a subject and an object, such as instantiation, attribution, and subsumption. RDF Schema allows restricting the usage of properties by using domain and range relations. The domain and range mechanism limits which classes can go into the subject or the object position of a triple. The domain restricts which classes are valid in the subject position. The range defines valid classes in the object position of the triple. Looking back to the example presented in Fig. 7: 7, the property `worksFor` can be restricted see Fig. 8:

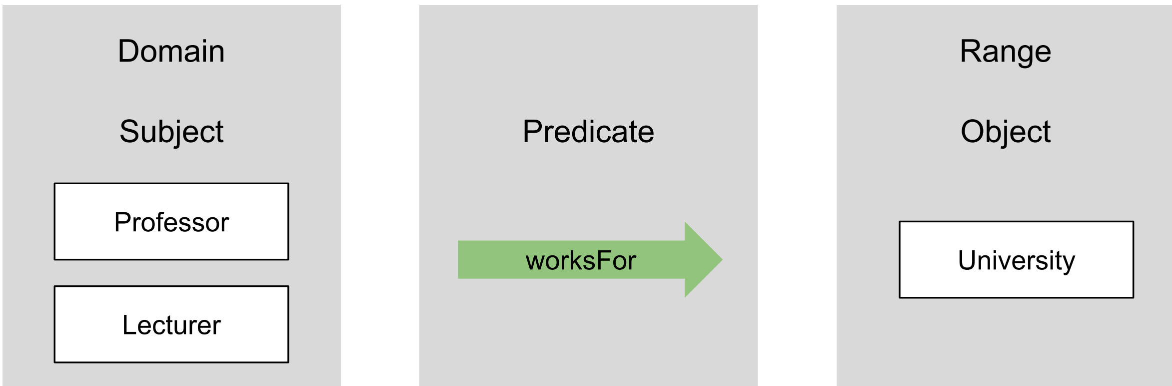

Fig. 8: Domain and range mechanism in RDF Schema

The classes `Professor` and `Lecturer` are the domain of `worksFor`, whereas the range is the class `University`. RDF Schema allows for flexibility in domain and range relations. Oftentimes one class in the domain is restricted in its range, modeling a 1 to 1 relation. RDF Schema also allows filling only the subject or the object position or defining multiple classes as a domain or range. This example defines two possible classes for the domain[150].

[148] Archer, Loutas, and Goedertier, *Cookbook for Translating Relational Data Models to RDF Schemas*. p. 6

[149] cf. Brickley and Guha, “RDF Schema 1.1.”

[150] cf. Schreiber and Raimond, “RDF 1.1 Primer.”

However, RDF Schema does not specify relations to model negations or excluding classes, making it a lightweight ontology language[151].

In short, an RDF Schema is used to create a new domain vocabulary. The principles discussed in this chapter are vital for understanding iiRDS, which provides a vocabulary for RDF Schema.

3.3.3 SPARQL Protocol and RDF Query Language

SPARQL (SPARQL Protocol and RDF Query Language) comprises of a set of specifications regarding querying and manipulating RDF graphs. This section explains the basics of the SPARQL query language in order to discuss how to retrieve personalized results from an RDF graph.

SPARQL allows evaluating several data sources simultaneously with a single query. The syntax is similar to SQL. A simple SPARQL query contains three elements: `PREFIX`, `SELECT`, and `WHERE`. The `PREFIX` determines the namespace so that instead of an IRI the system can resolve prefixes. `SELECT` defines what the query returns, and `WHERE` states where a query should run. [152] The following example query returns all employees that work for Hochschule München:

```
PREFIX schema: http://schema.org/
SELECT ?employee
WHERE {?employee schema:worksFor <https://hm.edu>}
```

Inside the curly brackets, the query is formulated as one or more triples, called a basic graph pattern. The subject, predicate, or object can be replaced by variables. The result is displayed as a table, where the columns represent the variables and the rows contain the results. SPARQL provides the option to rank and filter the results so that for example only employees from the department of Technical Writing and Communication are displayed.[153]

Results can also be displayed as RDF statements instead of tables. SPARQL can use the retrieved RDF statements and transform them according to a template. This allows to convert RDF statements from one ontology into another. [154] For example, if the Hochschule München and the Technical University of Munich were to join forces, SPARQL could replace the object `https://hm.edu` with `https://tum.de`.

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[151] cf. Grimm et al., “Ontologies and the Semantic Web.” p. 520
[152] cf. Hitzler et al., *Semantic Web: Grundlagen.* p. 203; Harris and Seaborne, “SPARQL 1.1 Query Language.”
[153] cf. Harris and Seaborne, “SPARQL 1.1 Query Language.”
[154] cf. Nuding, “Standards im Umfeld Industrie 4.0.”

Since SPARQL allows retrieving and manipulating query results, it is a suitable tool for personalizing information retrieval. The next section explains why there is a need for personalization and presents a possible solution.

Personalized Content Delivery

Abel emphasizes that personalization is becoming the norm, causing customers to subconsciously expect to consume personalized content. The author challenges technical communicators to close the gap between the content produced and the content required by customers.[155] However, user-centric information is only one part of the equation. Users do also need to be able to retrieve information based on their context and preferences.

Many search engines retrieve documents based on consensus relevancy, meaning that the same query always results in the same answers. The algorithms calculate results based on the usefulness for most people but do not take personal preferences into account. [156]

One approach to personalize information retrieval is based on user profiles. Banouar and Raghay propose an algorithm to identify and store user preferences. Based on these preferences, the initial SPARQL query can be enhanced by adding triples to the basic graph pattern. The degree of personalization is controlled by limiting how many preferences need to be satisfied simultaneously.[157] Manipulating the SPARQL query means to personalize information retrieval in the second step of the process, see Fig. 5: .

Another approach is to manipulate the ranking of the results (step 5 in Fig. 5:) meaning that the page rank reflects the personal relevance. However, most algorithms for personalized page rank are computing extensive, which translates into increased costs.[158]

3.3.4 iiRDS

Since no metadata vocabulary sufficiently fulfilled the needs in the technical communication industry, the tekom Germany working group "Information 4.0" initiated the creation of iiRDS[159], which is short for the intelligent information request and delivery standard. Created in 2018, the current version (1.0.1) was released in 2019. The purpose of the standard is to

[155] cf. Abel, “It’s Time We Start Personalizing Technical Documentation Experiences.”
[156] cf. Banouar and Raghay, “Enriching SPARQL Queries by User Preferences for Results Adaptation.”
[157] cf. Banouar and Raghay.
[158] cf. Gallo, Lissandrini, and Velegrakis, “Personalized Page Rank on Knowledge Graphs: Particle Filtering Is All You Need!”
[159] cf. Gesellschaft für Technische Kommunikation – tekom Deutschland e. V., “iiRDS - A Short Introduction.”

make information exchangeable between systems and manufacturers as well as to deliver information according to the needs of the user.[160]

The iiRDS standard specifies a package format (`.iirds`) and a vocabulary as an RDF Schema. The metadata model of iiRDS focuses on user assistance information for products, such as documentation and servicing information. An iiRDS package contains content and an RDF file that stores information about the content. iiRDS supports content in many different file formats and levels of granularity, such as XML or HTML topics, but also monolithic PDF files. Metadata is the reason why users can find content that is relevant to their current situation. Depending on their device and the technical limitations, content is displayed differently and adapts to the device. Metadata provides the needed context, making information intelligent.[161]

The prerequisites to working with iiRDS are an iiRDS generator and an iiRDS consumer, which is software that can create and process iiRDS packages. Chapter 3.4.2 discusses the publishing workflow of iiRDS. The metadata model is introduced first.

The iiRDS Metadata Model in a Nutshell

The iiRDS metadata model was created using the theoretical foundations of the PI-Class, discussed in chapter 0. Apart from information (I) metadata, iiRDS defines functional metadata, which supports content delivery scenarios.[162] As product (P) metadata vary for every organization, they have to be added using docking points, explained in chapter 3.4.1.

As the iiRDS vocabulary is an RDF Schema, it also contains a set of classes and relations. Attributes are called properties, and instances of classes are referred to as objects. iiRDS reuses existing standards as vCard and Dublin Core, where it is appropriate.

The main classes in iiRDS are[163]:

1. Administrative Metadata: Metadata used to identify entities, describe the lifecycle status of information units, and parties involved.
2. Directory node: Nodes for creating navigation structures.
3. Documentation metadata: Contains product metadata and functional metadata.
4. Information object: Class for an information unit in a different language or version.
5. Information type: Defines the type of information, such as a topic type.
6. Information unit: Class for metadata about a piece of information.

[160] cf. iiRDS Consortium, “Tekom iiRDS Standard Version 1.0.1.”
[161] cf. ibid.
[162] cf. Parson, “Das Datenmodell der technischen Dokumentation in iiRDS.”
[163] cf. iiRDS Consortium, “Tekom iiRDS Standard Version 1.0.1.”

7. Rendition: Defines the format of the content.
8. Selector: Points to a resource or a range or fragment in a resource.

These classes were defined in the iiRDS core vocabulary to provide very general metadata for technical communication. Since some industries require more specific metadata, the iiRDS Consortium added new domains for machinery and the software industry.[164]

The class `Information Unit` is the central class in iiRDS, describing the actual content. Information units contain subclasses to cover different levels of granularity, such as `package`, `document`, `topic`, and `fragment`. A package refers to a whole iiRDS package (biggest unit), while a fragment is a part of a topic (most granular unit).[165]

Most relations connect an information unit to another class, adding further metadata to an information unit. For example, the class `Information Subject` (a subclass of `Information Type`) states the general idea of what an information unit is about. Information units are not to be confused with information objects, which are versions of an information unit, such as a language variant.[166] In the iiRDS Learning domain, the classes `Documentation Metadata`, `Information Type`, and `Information Unit` will be used to extend the core vocabulary.

3.4 iiRDS for a Unified Content Strategy

iiRDS is promising for implementing a UCS because it shares the same principles like the concept of a UCS proposed by Rockley and Cooper. The purpose of iiRDS is to deliver content dynamically depending on the following factors[167]:

- The target audience: Information matches the user's roles and skills.
- The context: Topics are delivered based on previous steps and system information.
- The product: Information matches the product variant or configuration in use.
- The product life cycle: Information according to the current life cycle of the product.
- The device: Content adapts to the device and its technical capabilities.
- Finding information: iiRDS improves search because of its semantic richness.
- The flexibility of the metadata model: iiRDS can be extended to adapt to new products or projects.

[164] cf. ibid.
[165] cf. Parson, "Das Datenmodell der technischen Dokumentation in iiRDS." pp. 33, 34
[166] cf. iiRDS Consortium, "Tekom iiRDS Standard Version 1.0.1."
[167] cf. Parson, "Das Datenmodell der technischen Dokumentation in iiRDS." pp. 30, 31

iiRDS is a domain for technical communication. Other departments that publish customer-facing content, such as marketing or technical training, have different needs which a metadata model has to reflect. Extending iiRDS to cover a whole organization would be interesting but exceeds the scope of this bachelor thesis. Therefore, the thesis focuses on educational content in the sense of workplace learning, investigating if it makes sense to extend iiRDS to fulfill the needs described in chapter 2.5. The next section explains the technical background on how iiRDS can be extended.

3.4.1 Extending iiRDS

iiRDS allows two different ways of extending the metadata model to promote flexibility:

1. Proprietary extension (custom vocabulary): iiRDS can be extended with a custom vocabulary for organization-specific instances, classes, and properties, such as product metadata. iiRDS provides docking points where organizations can add in their metadata model using an iiRDS generator. The custom vocabulary must comply with iiRDS so that iiRDS consumers can process them. iiRDS consumers can use the custom metadata to present information matching the set parameters, for example filtering by products.[168]

2. iiRDS domain extensions: Domain extensions contain additional classes and instances for specific domains. All classes and instances of an iiRDS domain are registered in a dedicated sub-namespace of the iiRDS core namespace, making them part of the standard iiRDS. So far, there is a domain for machinery and software.[169]

3.4.2 Publishing Workflow of iiRDS

To publish content using iiRDS, it takes an authoring system, an iiRDS generator, and an iiRDS consumer, as Fig. 9: 9[170] illustrates.

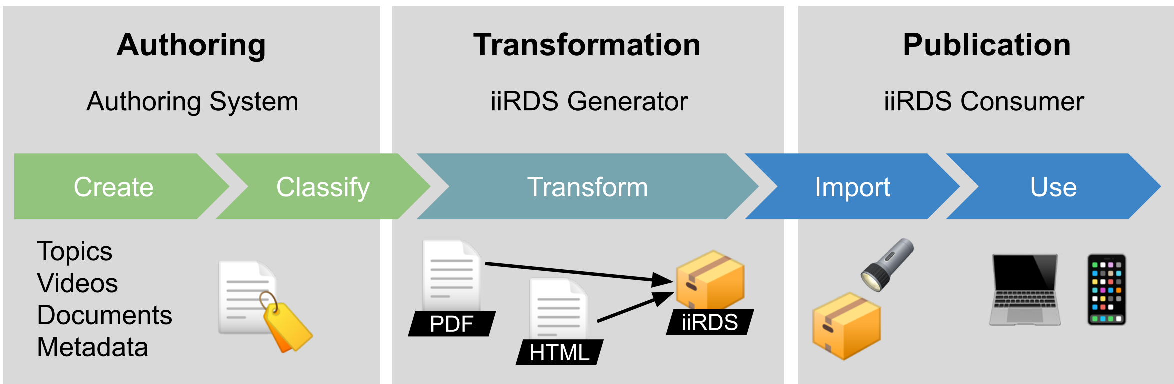

Fig. 9: Publishing content with iiRDS

[168] cf. iiRDS Consortium, "Tekom iiRDS Standard Version 1.0.1."
[169] cf. ibid.
[170] Adapted from Kreutzer and Parson, "Intelligente Lieferung."

1. Authoring: To publish content with iiRDS, it has to be created with an authoring system first. Kreutzer and Parson advise that writing in a topic-based approach makes it easier to transform the content into iiRDS packages later.[171] The topic-based approach allows distributing content that matches exactly one question or use case[172].

Classifying content with the PI-Class facilitates the transformation further. iiRDS standardizes only delivery and not content creation, so the correct transformation is critical.[173]

2. Transformation: An iiRDS generator transforms content into iiRDS packages. The authoring system can be an iiRDS generator if it is capable of packaging content into an iiRDS package. If the CMS does not support iiRDS, there are third-party tools available for the transformation. The transformation process comprises three steps:

1. Content is compiled into the desired target format(s).
2. The assigned metadata is converted into an RDF file that complies with iiRDS.
3. Content and metadata are packaged into iiRDS packages.[174]

3. Publication: The packages have to be stored in a location where an iiRDS consumer can access them. An iiRDS consumer is a software that can process iiRDS packages, for example, a CDP[175]. After importing an iiRDS package into a CDP, the content and metadata are indexed to retrieve information quickly. Some CDPs also support iiRDS metadata as facets, so users can narrow down search results.[176]

3.4.3 Pros and Cons of Using iiRDS

Every organization has to decide for themself if the switch to iiRDS makes sense. This section summarizes the benefits of iiRDS and examines weak spots, raising awareness for difficulties that arise in the context of a UCS.

Precise Information Retrieval

The advantage of delivering content via iiRDS lies in its flexibility, which this chapter described at the beginning. Information can be aggregated and delivered independently of the organization that created it, facilitating supplier documentation integration[177]. Depending on

[171] cf. Kreutzer and Parson, “Intelligente Lieferung.”
[172] cf. Fritz, “Was ist intelligente Information?”
[173] cf. Kreutzer and Parson, “Intelligente Lieferung.”
[174] cf. Kreutzer and Parson.
[175] cf. iiRDS Consortium, “Tekom iiRDS Standard Version 1.0.1.”
[176] cf. Kreutzer and Parson, “Intelligente Lieferung.”
[177] cf. Gutknecht and Ley, “Informationen bedarfsgerecht verpackt.”

the industry, up to a thousand suppliers are involved in building and documenting a machine[178].

Because iiRDS enriches its packages with abundant standardized metadata, users can search and filter for the exact information they need, independent from the original metadata model[179]. In that sense, iiRDS adds to the value of a product when users quickly find personalized content. Intelligent information becomes part of the value proposition.[180]

In more advanced content delivery scenarios, the content delivery portal could notify their users in case of an error and present the corresponding help topics. Furthermore, functional metadata can support planning corrective measures, for example, to determine the amount of time needed for a repair. [181] The iiRDS consumer simply adds up the durations of all task topics, when they are tagged with the metadatum `Planning Time`.

Synonyms

iiRDS does a good job of standardizing information and functional metadata, but things get more complicated in the product sphere. On the one hand, it makes sense to provide docking points for product metadata, because every organization uses its own terms for their products and components. As long as there are no suppliers involved, the only challenge is to stay consistent within the organization. Problems arise when the supplier uses a different name for the same physical object[182]. These synonyms need to be unified in the product ontology, requiring cross-organizational collaboration.

The Information Model

There are also some weaknesses concerning the possibilities of using the information model. If resources are mentioned in the text but not represented in the metadata belonging to the text, semantic information is lost. Therefore, the level of semantic detail decreases, making it unclear for iiRDS consumers what other information a topic contains. A similar problem occurs when an event should trigger a reaction. It is possible to model such relations in iiRDS, but it is useless when event information is only available in the text. When authoring content, metadata needs to be assigned on a sentence level, to improve content delivery and enable more sophisticated content delivery scenarios.[183]

[178] cf. Göttel, “iiRDS als Austausch- und Bereitstellungsmechanismus für zukünftige Dokumente.”
[179] cf. Gutknecht and Ley, “Informationen bedarfsgerecht verpackt.”; cf. Göttel, “iiRDS als Austausch- und Bereitstellungsmechanismus für zukünftige Dokumente.”
[180] cf. Kreutzer and Parson, “Intelligente Lieferung.”
[181] cf. Gutknecht and Ley, “Informationen bedarfsgerecht verpackt.”
[182] cf. ibid.
[183] cf. ibid.

As described in section 3.4.2, the transformation process converts the assigned metadata into the RDF format. Therefore, the existing metadata model has to be mapped to the structure of iiRDS. If the content is not classified or mapped thoroughly, semantic data is lost.[184] In the end, metadata about content and physical objects have to be stored in the ontology to unlock the full potential of the metadata model.[185]

Publication scenarios

Multichannel publishing, as discussed in chapter 2.2, is useful to generate multiple outputs from one information source. Which publication scenarios can iiRDS support? The complexity of a content delivery scenario depends on the iiRDS consumer since only they are capable of processing iiRDS packages. The following three industry projects illustrate the current possibilities.

I. iiBot: Tcworld and Endress+Hauser have presented a proof of concept chatbot called iiBot at the tekom Jahrestagung/tcworld Conference in 2019. The iiBot delivers content matching the context and machine setup of the user, facilitating pull communication. The iiBot in its current state is not ready for the real world, as it only supports two use cases.[186]

II. Supplier documentation: Integrating supplier documentation is a task technical writers in the machine construction industry are familiar with. The problem is that legacy supplier documentation is often stored in monolithic, unstructured documents, mostly in PDF format. Oevermann and Kreutzer demonstrate enriching unstructured data with metadata using AI and computational linguistics to make them iiRDS ready. After the PDFs are classified automatically, a technical writer should review them, and add metadata as needed. The classified PDFs are then transformed into iiRDS packages and uploaded to the CDP, where customers can easily find the supplier documentation.[187]

III. Siemens SIKiiRDS: To make Siemens ready for publishing with iiRDS, they have built an iiRDS generator called SIKiiRDS, which allows transferring information from the CMS to a CDP. The challenges are mapping the existing metadata to iiRDS and the automatic generation of iiRDS metadata using computational linguistics. Although the project covered the generation of iiRDS metadata, the report suggests future content delivery

[184] cf. Gutknecht and Ley, "Informationen bedarfsgerecht verpackt."
[185] cf. Fabricius, "Information statt nur XML erzeugen: Wie Topicerstellung und ontologische Modellierung zusammenhängen."
[186] cf. Hallwachs, "Die Erfolgsgeschichte geht weiter."
[187] cf. Oevermann and Kreutzer, "Best Practice Example: SmartFactory Industry 4.0: Integrating Supplier Documentation."

scenarios. The vision is to transform structured, as well as unstructured content into iiRDS packages. The iiRDS packages are retrieved through many channels using an API, such as a spare parts shop, as help content in diagnosis software or a smart factory.[188]

Summary

iiRDS' strength lies in the precise and personalized delivery of aggregated content. The main shortcomings of synonyms and lost semantic metadata can be overcome with careful authoring, which is why, in my opinion, the benefits outweigh the challenges. As the examples II and III demonstrate, organizations can transition to iiRDS already, when mapping the organization-specific metadata model to the iiRDS ontology. Present documents can be enriched with semantic metadata automatically, meaning that unstructured content can be integrated into a CDP, for example, without worsening the search results.

iiRDS is not a magical solution that solves all publishing issues in an organization. The vocabulary in iiRDS has a strong focus on documentation, which means that publications from other departments, such as marketing, are not adequately represented in the ontology. In order to support a UCS, iiRDS needs further extensions to classify other customer-facing content accordingly.

The actual value gain depends on the iiRDS consumer and whether the input is structured or unstructured data. Unstructured data can cause costs when retrofitted with metadata. As there are not many off-the-shelf iiRDS consumers, organizations may have to develop their own software.

However, once the metadata model fits the whole organization, and there are resources for creating custom iiRDS consumers, various possibilities arise. Publishing content with iiRDS packages adds one or more channels, depending on the available iiRDS consumers. As of today, iiRDS is limited in its delivery channels, but the technical concept supports the vision of omnichannel publishing.

3.5 Challenges and Limitations of Ontologies

Ontologies are a powerful tool to make knowledge machine-processable and machine-interpretable, yet there are some pitfalls when creating an ontology. This chapter discusses the challenges and limitations of ontologies and concludes with a discussion on when to use ontologies.

[188] cf. Hoffmann, Erfle, and Reuther, "SIKiiRDS: The Siemens Digital Industries Pilot Project."

The Modeling Process

Modeling an ontology is a team effort that requires a lot of time[189], energy, and resources, and tools to support the ontological engineering process are sparse. Feilmayr and Wöß have identified that needed time could be shortened by ontology reuse, as most organizations face similar challenges. When existing frameworks need little customization, less time is spent on ontological engineering.

Another issue is finding consensus within the stakeholders involved on modeling decisions. One example is the degree of explicitness of the modeled knowledge, where the literature also has conflicting ideas. Reichenberger suggests that as much knowledge as possible should be inferred[190], whereas Stuckenschmidt proposes to model relations explicitly when they are already apparent to save computing capabilities[191]. Inferring knowledge grants more flexibility, but consumes more resources, having a direct impact on the cost of running the ontology.

Another issue during the creation is when the ontology is built for the problems of an organization at the time of creation. Building an ontology without future developments in mind can lead to structures that are not extendable to future use cases.[192]

Another challenge arises when there are already multiple data models that an ontology should unify. An ontology models information on two levels: The structural level and the semantic level. Structural conflicts occur when equivalent objects from two or more sources consist of different data structures and data types. Semantic conflicts form when two objects look alike but should be interpreted differently, for example when two objects contain a temperature, but one in degree Celsius and the other in degree Fahrenheit. To avoid inconsistencies and skewed search results, the ontology needs to be modeled carefully.[193]

Structured versus Unstructured Data

Merging different sources of structured data is a complicated task but will not lead to complete representation of an organizations' resources. Especially content is often available in unstructured documents, meaning that the information is not semantically tagged. Prominent examples are PDFs, PowerPoint presentations, and e-mails. Information in rigid structures complicates information retrieval, as search is only possible on word-level. However,

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[189] cf. Ley, "Informationen erhalten Bedeutung."
[190] cf. Reichenberger, *Kompendium semantische Netze: Konzepte, Technologie, Modellierung*. p. 10
[191] cf. Stuckenschmidt, *Ontologien: Konzepte, Technologien und Anwendungen*. p. 227
[192] cf. Feilmayr and Wöß, "An Analysis of Ontologies and Their Success Factors for Application to Business."
[193] cf. Stuckenschmidt, *Ontologien: Konzepte, Technologien und Anwendungen*. pp. 211-220

for elaborate content delivery context information in the form of semantic networks is needed.[194]

Retrofitting unstructured content with semantic metadata can either be done manually or automatically using natural language processing algorithms. In most scenarios, manual classification is not feasible due to the mass of unstructured documents. Oevermann provides in-depth information on automated semantic classification.[195] In either case, retrofitting semantic metadata causes costs, so organizations have to evaluate which resources should be retrofitted. After implementing a UCS, this issue should only be relevant for legacy documents, as content is structured and semantically rich in a UCS.

While linguistic analytics is an effective method to classify text, other assets like pictures, videos, or interactive materials, such as e-learning courses, need manual labor to retrofit accurate metadata. Therefore, it is best to assign metadata during content creation.

Information Retrieval and Natural Language

As discussed in section 3.2.2 semantic search is a major use case of ontologies. The quality and preciseness of the search results depend on the preciseness of the chosen query method. The chapter looked at personalizing search results by manipulating a SPARQL query, which is a dedicated query language for RDF and has the highest possible preciseness. However, the average user is probably not familiar with SPARQL, which makes it an inconvenient search mode. The most simple form of search, which is also the most convenient, is a keyword-based search. A system querying ontologies based on keywords needs algorithms that derive the correct context to display useful search results. This disconnect between usability and preciseness is one of the reasons why semantic search is not as widely used as it could be.[196]

Natural language is another obstacle for precise information retrieval. Since natural language is diverse, homonyms and synonyms can skew search results[197]. A principle used for writing user-centered content is also useful for modeling ontologies: Use the vocabulary of the audience[198]. If the vocabulary differs between the audience and the organization, the

194 cf. Oevermann, "Informationen werden Intelligent – Ein Überblick."
195 cf. Oevermann, "Optimierung des semantischen Informationszugriffs auf technische Dokumentation." pp. 87-107
196 cf. ibid p. 25
197 cf. Reichenberger, *Kompendium semantische Netze: Konzepte, Technologie, Modellierung*. p. 5
198 cf. Redish, *Letting Go of the Words: Writing Web Content That Works*. p. 8

synonyms need to be aligned with the model[199]. A mechanism to resolve synonyms is using the `sameAs` relation to connect multiple concepts.

Data Integration across Multiple Organizations

As mentioned in section 3.4.3 the integration of third party content is relevant for some organizations. In such a scenario, redundancies and inconsistencies can occur, especially when there are no agreements on who has data sovereignty. Therefore, the switch to an ontology should also be aligned with suppliers to ensure a seamless user experience.

Business Case for Ontologies

Ontologies are a powerful tool when it comes to unifying data sources, information retrieval, and content delivery. This section discusses when the implementation of an ontology is justified. Ultimately, when a taxonomy suffices, building an ontology is a waste of resources.[200] Feilmayr and Wöß have analyzed factors that determine which kind of semantic network or model fulfills the demands of increasing complexity, the requirement for sharing, and semantic expressiveness, see figure 10[201].

Requirement of sharing: The need for an ontology becomes more likely when information should be shared outside of an organization. Ontologies are the most sophisticated approach to sharing and reusing concepts between different organizations.

Complexity: The complexity increases with the number of objects relevant to a use case. Ontologies are useful for managing a massive amount of data, also called a data lake, potentially saving resources and cost.

Semantic Expressiveness: When existing modules are modeled with a high semantic expressiveness, it becomes easier to model more complex models, and the cost of ontological engineering decreases.

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[199] cf. Massion, “Kontextgerechte Informationen: Die neue Herausforderung in der technischen Kommunikation”; cf. Reichenberger, *Kompendium semantische Netze: Konzepte, Technologie, Modellierung*. pp. 92, 204

[200] cf. Feilmayr and Wöß, “An Analysis of Ontologies and Their Success Factors for Application to Business.”

[201] from ibid p. 15

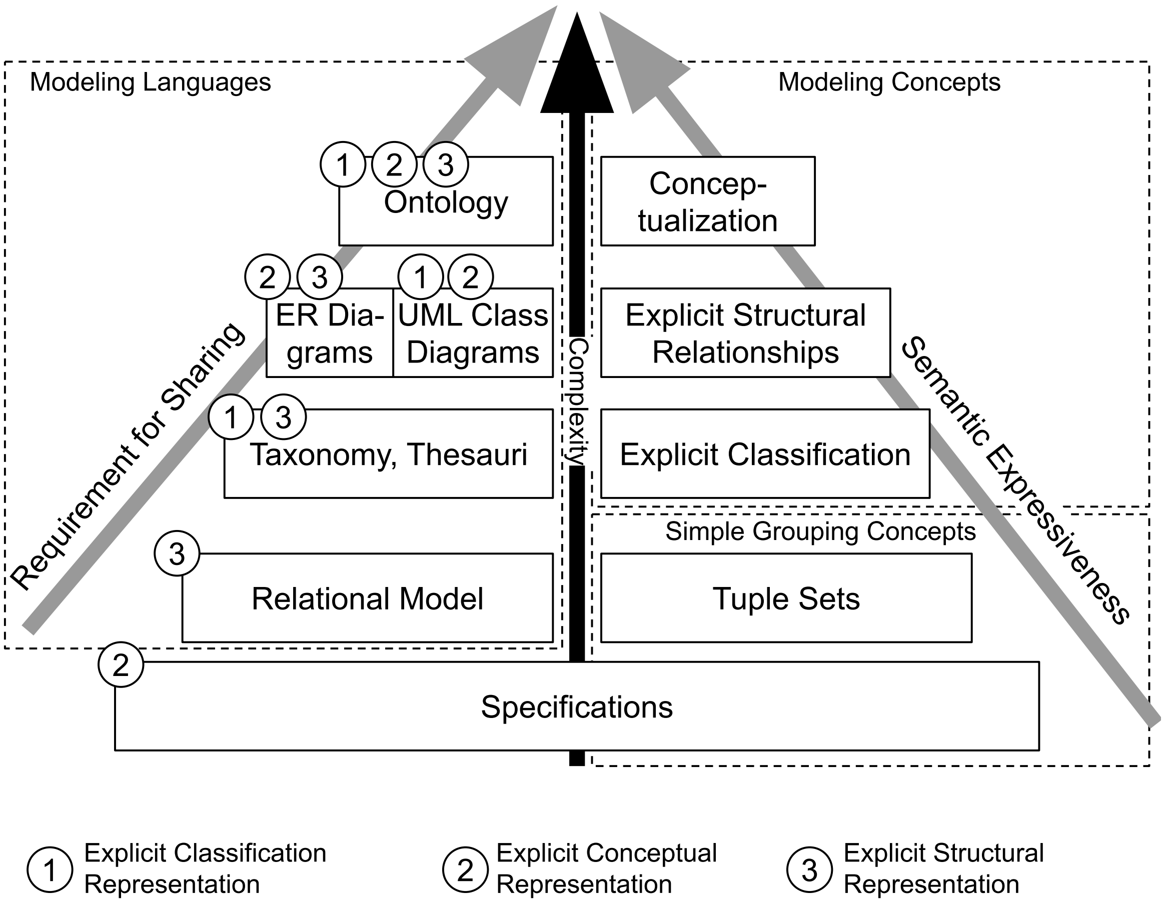

Fig. 10: Different types of semantic networks depending on the degree of sharing, complexity, and semantic expressiveness.

The pillars sharing and expressiveness correspond to each other, meaning that when there is no need for sharing, the efforts of creating a highly expressiveness semantic network is obsolete.[202]

The following chapter summarizes the requirements of a useful ontology and analyzes whether ontologies are useful to establish a UCS.

3.6 Summary: Ontologies in the Context of a Unified Content Strategy

The beginning of chapter 3 covered use cases of ontologies and explained the underlying technology, making them a strong candidate to create a metadata model used in a UCS. To create a useful, scalable ontology, it needs to meet the following requirements:

- **Explicitness**: The ontology has to make domain knowledge machine-readable and -interpretable.

[202] From Feilmayr and Wöß, "An Analysis of Ontologies and Their Success Factors for Application to Business."

- **Reusability**: The ontology must allow for interoperability to enable reuse and, therefore, consistency.
- **Expansion**: The ontology must be adaptable and expandable to represent changing circumstances, such as new projects.
- **Semantic richness**: The ontology needs to describe content in detail for precise information retrieval.
- **Inference**: Axioms are needed to validate triples and infer new statements

Chapter 2.3 discussed the steps to establishing a UCS in three phases: evaluation, design, and execution. Ontologies can aid in establishing and carrying out a UCS in all three phases.

Evaluation

During the evaluation phase, content strategists perform a content inventory to map out the current content landscape. Ontologies can support this process, as they can represent information as a network. Reichenberger describes a case study of a newspaper editing department that turned their existing keyword catalog into a semantic network using clustering algorithms. The content could now be depicted as a graph, where the authors could quickly spot which topics are covered a lot, and where information is still needed.[203]

Design

The goal of a UCS is to unify content from multiple sources both structurally (metadata model) and stylistic (style guides). One prominent use case of ontologies is unifying multiple data sources, as discussed in section 3.2.1. Ontologies provide the possibility to establish context between different existing structures, which reduces restructuring legacy content.

Another use case of ontologies is to serve as a single source of truth for content. When all departments use and update the ontology, the information flows freely, enhances collaboration, and removes redundancies[204]. Therefore, ontologies support the need for consistency, which is a major principle in a unified content strategy. Consistency and validity checks are supported when the organization uses a rather heavyweight ontology with axioms and a reasoning algorithm.

Execution

[203] cf. Reichenberger, *Kompendium semantische Netze: Konzepte, Technologie, Modellierung*. pp. 97, 98

[204] cf. Fabricius, “Information statt nur XML erzeugen: Wie Topicerstellung und ontologische Modellierung zusammenhängen.”

A UCS demands that content must fit the user's needs precisely. As discussed in section 3.3.3, personalized information retrieval is possible with user-profiles and the RDF querying language SPARQL[205]. Since only a few individuals are familiar with querying ontologies, the average user should use a regular keyword-based search, which is then translated into a SPARQL query. and (inference mechanism) can live up to the demand for personalized content.

In the context of semantic search, ontologies are useful for representing the search results as a graph instead of a list. However, Ziegler questions the usefulness of displaying the ontology to the user and emphasizes their value for interconnecting multiple data sources[206]. Whether an ontology should be used for post-processing search results depends on the individual case. A network view might be useful for explorative navigation when the user does not know what to search for.

Up until now, the thesis has covered the creation of a UCS and discussed how ontologies can support a UCS. iiRDS was identified as a promising candidate for the implementation of a UCS, as it covers technical communication and allows for expansion. A UCS aims to unify content from many departments in an organization, such as sales, marketing, or learning and development. Since it would go beyond scope to discuss the needs and metadata adaptations for all possible departments, the thesis focuses on learning and development. The following chapters look at the integration of learning metadata into the UCS by comparing the Learning Objects Metadata (LOM) standard with iiRDS.

[205] cf. Banouar and Raghay, “Enriching SPARQL Queries by User Preferences for Results Adaptation.”
[206] cf. Ziegler, “Metadaten für intelligenten Content.”

4 Workplace Learning

This chapter introduces the needs of organizational, online learning content, and compares LOM to iiRDS to identify gaps in iiRDS. Chapter 5 then proposes how iiRDS could be adapted to classify learning content.

4.1 Introduction to Workplace Learning

Definition

The Institute for Education Sciences defines workplace learning as follows[207]:

> "Processes or outcomes associated with the work-related learning experiences of individuals or groups within their work environment. May include, but is not limited to, self-directed learning, experiential learning, on-the-job training, staff development programs, informal and nonformal education. Related activities may occur off-site."

While this definition is focused on learners and how they fulfill learning objectives, the related term "corporate education" [208] focuses on an organization providing means of education. The following discussions will be centered around the term workplace learning.

Functions and Trends

For organizations, workplace learning contributes to increased performance and payoffs. The individual profits from workplace learning as they can acquire or update skills, furthering career development, and satisfaction.[209] There is also a social aspect of workplace learning, as it promotes team cohesion and identification with the organization[210].

In a quali-quantitative survey, Caporarello et al. interviewed 91 employees on their future desired workplace learning experience. Since the participants learned mainly on the job (informal), they wished for more formal class-based learning and a guided learning journey. They also expect learning processes to be digitally supported, leaving room for personalization.[211] A report by Mimeo Inc. and Challenger Inc. supports the need for

[207] Institute of Education Sciences, "ERIC - Thesaurus - Workplace Learning."
[208] cf. Institute of Education Sciences, "ERIC - Thesaurus - Corporate Education."
[209] cf. Caporarello et al., "How Do We Learn Today and How Will We Learn in the Future Within Organizations? Digitally-Enhanced and Personalized Learning Win."
[210] cf. Kerres, *Mediendidaktik: Konzeption und Entwicklung digitaler Lernangebote*. p. 339
[211] cf. Caporarello et al., "How Do We Learn Today and How Will We Learn in the Future Within Organizations? Digitally-Enhanced and Personalized Learning Win."

personalization, as 35 % of interviewed trainers plan to work on custom learning paths in the next two years[212].

Methods

The Publicly Available Specification (PAS) 1032-1 describes the process of creating e-learning content. The process consists of seven phases with several steps per phase, starting with research and requirements engineering, followed by the conceptualization and creation of e-learning content. The last steps cover implementation and evaluation.[213] The content lifecycle, see Fig. 2: and the process model of PAS 1032-1 largely correspond to each other, while the PAS process model covers the individual phases more granularly. The second part of that specification is the PAS 1032-2 which describes a metadata model according to the creation process described in PAS 1032-1. However, the PAS 1032-2 has been withdrawn, and thus, will not be further discussed.

When it comes to the creation of e-learning content, blended learning is an effective concept for workplace learning[214] and can meet the requirements of learners. Blended learning merges face-to-face and self-paced online learning. Kerres proposes to model expository e-learnings used in blended learning scenarios according to the 3-2-1 model[215]:

- The first element (3 of 3-2-1) describes the three essential and obligatory items: learning objectives, learning material, and assignments, such as exercises. The learning objectives describe the expected outcome of the learning process and help learners identify relevant learning resources. The learning material presents new information, and the assignments support the understanding of the learning material.
- The second element (2) is optional for e-learning arrangements. It consists of opportunities for communication and collaboration. Depending on the learning objective, it might be useful to integrate this element, for example when a debate about a controversial topic supports the learning process. This element can take place online or face to face.
- The last element (1) consists of tests, and is also optional, as learners might be averse against periodic tests. Tests are graded and ensure that the learners have acquired the skills or knowledge given by the learning objectives.

212 cf. Mimeo.com Inc. and Challenger Inc., *State of Learning and Development 2020*. p. 16
213 cf. DIN Deutsches Institut für Normung e. V., "PAS 1032-1:2004."
214 cf. Kerres, *Mediendidaktik: Konzeption und Entwicklung digitaler Lernangebote*. p. 93
215 cf. ibid. pp. 336-338

Requirements for Workplace Learning Metadata

Based on the discussions, metadata for workplace learning must cover the following criteria:

- **Processes**: The metadata needs to assign the learning content to a phase in the content lifecycle to avoid providing outdated material. Furthermore, the content needs to be classified corresponding to the 3-2-1 model.
- **Personalization**: The metadata must classify learning material with a focus on personalization.[216]
- **Reusability**: Since the creation of e-learning content is a considerable cost factor, the content must be reusable.[217]
- **Rights**: When content from other organizations is reused the metadata needs to express the usage rights.[218]

4.2 Existing Standards in the Learning Industry

The purpose of standards is to promote compatibility across systems and processes. In the educational field, standards are beneficial for creators of learning material, as well as learners. Creators can easily publish learning material to learning platforms that adhere to standards. Learners benefit from standardized navigation, thus improving usability. Standards cover different education field processes, such as the creation of learning material, search and retrieval of learning material, creation of courses, quality management, and data exchange between LMSs.[219]

4.2.1 Shareable Content Object Reference Model (SCORM)

One widely used and well-known standard for creators of e-learning material is the shareable content object reference model (SCORM). The current version is SCORM 2004 4th edition and was published in 2009 by the Advanced Distributed Learning (ADL) Initiative. A primary principle of SCORM is that learning information has to be self-contained. The standard consists of three parts:

- Content aggregation model
- Sequencing and navigation
- Run-time environment

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[216] cf. Caporarello et al., “How Do We Learn Today and How Will We Learn in the Future Within Organizations? Digitally-Enhanced and Personalized Learning Win.”
[217] cf. Kerres, *Mediendidaktik: Konzeption und Entwicklung digitaler Lernangebote*. p. 473
[218] cf. ibid. p. 281
[219] cf. Niegemann, *Kompendium multimediales Lernen*. pp. 603-607

The content aggregation model describes how to build reusable content objects and larger formations like courses. Content objects are packed into SCORM packages so that LMSs supporting the standard can process them, thus ensuring portability. SCORM also provides rules for sequencing and navigation to deliver content in a predefined order. They allow for tracking the learner's progress through an LMS. The SCORM run-time environment ensures interoperability by defining requirements for data exchange for LMSs.[220] The metadata model to classify content is the Learning Object Metadata (LOM), which is discussed in the next section.

As SCORM is soon to be outdated, as the ADL is working on a follow-up standard called cmi5[221]. Together with the Experience API (xAPI), it is possible to track learners' progress across platforms. xAPI takes other means of learning into account, such as e-books, providing a holistic view of skills learners develop.[222]

4.2.2 Learning Object Metadata (LOM)

The IEEE published the LOM standard in 2002. A learning object is an entity used for learning, education, and training, regardless of digital or non-digital use. The goal is to make learning objects interoperable while providing strong semantic richness. Furthermore, the defined metadata shall support learners, instructors, or software in the search, evaluation, acquisition, and use of learning objects.[223] Alongside the standard, the IEEE released a document on the implementation of LOM with XML schema in 2005 and updated it in April 2020[224], meaning that it still has relevance today.

Metadata in LOM

The LOM base schema consists of nine categories[225]:

1. General: Information about learning objects as a whole.
2. Lifecycle: Describes the state and editors of a learning object.
3. Meta-Metadata: Information about the metadata instance.
4. Technical: Technical requirements and characteristics of the learning object.
5. Educational: Describes educational and pedagogic characteristics.

[220]cf. Advanced Distributed Learning (ADL), "SCORM®."
[221] cf. Advanced Distributed Learning (ADL), "An Introduction to cmi5: Next-Generation of e-Learning Interoperability."
[222] cf. Advanced Distributed Learning (ADL), "xAPI Background & History."
[223] cf. IEEE, "IEEE Standard for Learning Object Metadata."
[224] cf. IEEE, "IEEE Standard for Learning Technology--Extensible Markup Language (XML) Schema Definition Language Binding for Learning Object Metadata."
[225] cf. IEEE, "IEEE Standard for Learning Object Metadata." p. 3

6. Rights: Information about intellectual property and conditions for use.
7. Relation: Information about relationships between learning objects.
8. Annotation: Enables comments for learning objects.
9. Classification: Describes the learning object in relation to a classification system.

The educational metadata is the most relevant category for this thesis, as iiRDS provides classes for general information, lifecycle, rights, and annotations. The table below shows an extract of the IEEE LOM standard's educational metadata in its revised version (2011), which is compared to the iiRDS standard. The columns **Nr.** and **Name** refer to the metadata contained in the category. The column **Explanation** specifies the purpose of the metadata. The column **Datatype** assigns one of the five possible datatypes in LOM:

- LangString
- CharacterString
- DateTime
- Duration
- Vocabulary

The column **Value Space** defines the set of allowed values in the form of predefined values, such as vocabularies[226].

Tab. 1: Extract from the metadata in category 5. Educational

Nr.	**Name**	**Explanation**	**Datatype**	**Value Space**
5.1	Interactivity Type	Predominant mode of learning supported by this learning object. "Active" learning (e.g., learning by doing) is supported by content that directly induces productive action by the learner. An active learning object prompts the learner for semantically meaningful input or for some other kind of productive action or decision, not necessarily performed within the learning object's framework. Active documents include simulations, questionnaires, and exercises. "Expositive" learning (e.g., passive learning) occurs when the learner's job mainly consists of absorbing the	Vocabulary (State)	active expositive mixed

[226] See ibid pp. 3, 5.

		content exposed to him (generally through text, images or sound). An expositive learning object displays information but does not prompt the learner for any semantically meaningful input. Expositive documents include essays, video clips, all kinds of graphical material, and hypertext documents. When a learning object blends the active and expositive interactivity types, then its interactivity type is "mixed." [...]		
5.2	Learning Resource Type	Specific kind of learning object. The most prominent kind shall be first. [...]	Vocabulary (State)	exercise simulation questionnaire diagram figure graph index slide table narrative text exam experiment problem statement self assessment lecture
5.3	Interactivity Level	The degree of interactivity characterizing this learning object. Interactivity in this context refers to the degree to which the learner can influence the aspect or behavior of the learning object. [...]	Vocabulary (Enumerated)	very low low medium high very high
5.4	Semantic Density	The degree of conciseness of a learning object. The semantic density of a learning object may be estimated in terms of its size, span, or [...] duration.	Vocabulary (Enumerated)	very low low medium high very high

		The semantic density of a learning object is independent of its difficulty. It is best illustrated with examples of expositive material, although it can be used with active resources as well. [...]		
5.5	Intended End User Role	Principal user(s) for which this learning object was designed, most prominent first. NOTES […] 2— In order to describe the intended end user role through the skills the user is intended to master, or the tasks he or she is intended to be able to accomplish, the category 9:Classification can be used.	Vocabulary (State)	teacher author learner manager
5.6	Context	The principal environment within which the learning and use of this learning object is intended to take place. NOTE— Suggested good practice is to use one of the values of the value space and to use an additional instance of this data element for further refinement, as in (`“LOMv1.0,” “higher education”`) and (`“http://www.ond.vlaanderen.be/onderwijs- invlaanderen/Default.htm,” “kandidatuursonderwijs”`)	Vocabulary (State)	school higher education training other
5.7	Typical Age Range	Age of the typical intended user. This data element shall refer to developmental age, if that would be different from chronological age. NOTES 1— The age of the learner is important for finding learning objects, especially for school age learners and their teachers. [...] 2— Alternative schemes for what this data element tries to cover (such as various reading age or	LangString	-

		reading level schemes, IQ's or developmental age measures) should be represented through the 9:Classification category.		
5.8	Difficulty	How hard it is to work with or through this learning object for the typical intended target audience. NOTE—The “typical target audience” can be characterized by data elements 5.6:Educational.Context and 5.7:Educational.Typical-AgeRange.	Vocabulary (Enumerated)	very easy easy medium difficult very difficult
5.9	Typical Learning Time	Approximate or typical time it takes to work with or through this learning object for the typical intended target audience. [...]	Duration	-

Source: IEEE LOM specification and IEEE LOM corrigendum (extract)[227]

Metadata section `9.1 Purpose` provides additional values in its vocabulary that are useful to determine a learning object's purpose.

Tab. 2: Extract from the metadata in category 9. Classification

Nr.	Name	Explanation	Datatype	Value Space
9.1	Purpose	The purpose of classifying this learning object	Vocabulary (State)	discipline idea prerequisite educational objective accessibility restrictions educational level skill level security level competency

Source: IEEE LOM specification and IEEE LOM corrigendum [228]

The LOM metadata model will serve as the source for the iiRDS Learning domain. The values `security level` and `accessibility restrictions` will not be discussed

[227] IEEE, “IEEE Standard for Learning Object Metadata - Corrigendum 1: Corrigenda for 1484.12.1 LOM (Learning Object Metadata)”; IEEE, “IEEE Standard for Learning Object Metadata.” pp. 15-19
[228] IEEE, “IEEE Standard for Learning Object Metadata - Corrigendum 1: Corrigenda for 1484.12.1 LOM (Learning Object Metadata)”; IEEE, “IEEE Standard for Learning Object Metadata.” p. 21

because they would affect the iiRDS standard in its entirety. The iiRDS Consortium could discuss adding these metadata in the next iteration of the standard.

4.3 Methodology

There are several methods for ontological engineering, following paradigms known from software engineering. In order to extend iiRDS, this thesis leans on Uschold and King's approach to ontological engineering[229]. Uschold and King's method was the first ontological engineering method, resembling a traditional waterfall approach[230]. The downside of this method is that before the actual coding happens, there is no conceptualization phase[231]. To mitigate this deficit, some steps from the ontological engineering process proposed by Feilmayr and Wöß were incorporated during the building phase[232]. Another advantage is, that the custom process now supports reuse, which is not included in Uschold and King's method. Fig. 11: shows the final engineering process.

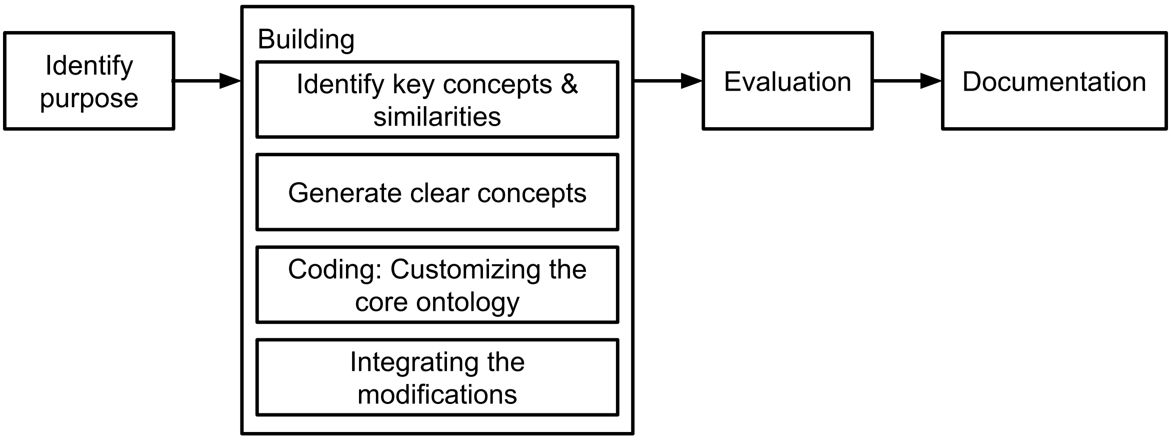

Fig. 11: Ontological engineering process used in this thesis.

I. Identify the purpose and scope[233]: The purpose of the iiRDS Learning domain is to classify learning content using the iiRDS framework.

II. Building the ontology:

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[229] cf. Gómez-Pérez, Fernández-López, and Corcho, *Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web*. p. 115
[230] cf. Feilmayr and Wöß, "An Analysis of Ontologies and Their Success Factors for Application to Business."
[231] cf. Gómez-Pérez, Fernández-López, and Corcho, *Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web*. p. 119
[232] cf. Feilmayr and Wöß, "An Analysis of Ontologies and Their Success Factors for Application to Business." p. 20
[233] cf. Gómez-Pérez, Fernández-López, and Corcho, *Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web*. p. 116

1. The first step to reuse engineering is to recognize similarities[234]. The LOM standard is compared to iiRDS to find equivalents and spot deficits of iiRDS to classify learning content. Following the middle-out strategy, new terms are identified and specified as needed.[235]
2. Conceptualization: Before coding, the metadata are modeled into a concept, providing a less formal overview[236], see Fig. 12: .
3. Coding: By defining additional metadata for learning content in iiRDS, the iiRDS core vocabulary is extended. Since the thesis focuses on conceptual work, there is no RDF file containing the metadata model. Instead, a specification of the iiRDS Learning domain is provided in the appendix.
4. Integration of modifications: This step cannot be done within the bachelor thesis, as the focus is the conceptual work and due to the lack of a strategic partner. To actually use the new vocabulary, it needs to be registered in the proposed namespace, which is for the iiRDS Consortium to decide.

III. Evaluation: A code example is used to evaluate whether the metadata model can be applied to an actual topic, discussed in chapter 5.6. The full code example is located in the appendix.

IV. Documentation: The full iiRDS Learning domain specification follows the structure of the iiRDS core specification and is located in the appendix. Chapter 5 explains the design decisions and purpose of these classes.

4.4 Comparison Between iiRDS and LOM

The educational metadata in LOM describe the people involved on the one hand and classifies the actual learning content and their qualities on the other hand. Following this structure, this chapter investigates how iiRDS classifies learning information, identifying possible gaps.

Similarities

In general, LOM and iiRDS provide metadata for handling content, such as status values and content lifecycle management. Most metadata have direct equivalents. For example,

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[234] cf. Feilmayr and Wöß, "An Analysis of Ontologies and Their Success Factors for Application to Business." p. 20

[235] cf. Gómez-Pérez, Fernández-López, and Corcho, *Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web*. p. 118

[236] cf. Feilmayr and Wöß, "An Analysis of Ontologies and Their Success Factors for Application to Business." p. 20; cf. Gómez-Pérez, Fernández-López, and Corcho, *Ontological Engineering: With Examples from the Areas of Knowledge Management, e-Commerce and the Semantic Web*. p. 119

the class `Administrative Metadata` in iiRDS provides similar classification options as the LOM class `2. Lifecycle`. The class `1.8 Aggregation Level` in LOM is expressed through the different levels of granularity in the iiRDS class `Information unit`. Using the iiRDS Software domain, it is possible to assign metadata equivalent to category `4. Technical`.

People

The category `5.5 Intended End User Role` in LOM describes people involved in creating and consuming learning content. The vocabulary includes authors, managers, teachers, and learners. iiRDS provides an `Author` object already, but no manager. Since managers and their exact role descriptions vary from organization to organization, they should not be added to the iiRDS standard. Organizations can add roles using a proprietary vocabulary, as discussed in section 3.4.1.

iiRDS holds an object of the class `Party role` called `Customer`. The customer is "an individual or an organization that purchased or consumes the referenced iiRDS domain entity."[237] The customer could resemble a learner, but the definition is so broad that it is hard to determine the actual individual consuming the learning content. The notion of customer suggests that the content is consumed by external customers because of the term "purchased". However, learners can also be internal customers, for example, mechanics in a machinery production site. To make the iiRDS metadata model more explicit, a new class for learners is needed.

The object `teacher` also does not exist in iiRDS. Since the term "teacher" is associated with institutional learning, the term "instructor" might fit better in a workplace learning environment.

Different Types of Learning Content

LOM holds many values for classifying learning content in category `5.2 Learning Resource Type`. In contrast, iiRDS suggests that one single topic type, namely `Learning`, is sufficient for learning content. This makes distinguishing different types of learning content impossible. Subsequently, it becomes difficult for content creators to determine which content is suitable for an exercise, for example, without looking at the actual content.

However, iiRDS could express the values from LOM `5.2 Learning Resource Type`, since they resemble common types of fragments:

[237] iiRDS Consortium, "Tekom iiRDS Standard Version 1.0.1."

- problem statement
- narrative text
- figure
- graph
- table
- diagram

The remaining values in the `5.2 Learning Resource Type` vocabulary are:

- questionnaire, self assessment: Can be modeled with the iiRDS topic type `Form`.
- index: Can be built using the iiRDS directory node mechanism.
- slide: Resembles a kind of a rendition, so it does not need to be modeled.

The remaining values in the `5.2 Learning Resource Type` have no equivalent in iiRDS and shall serve as input for modeling the iiRDS Learning Domain:

- exercise
- simulation
- exam
- experiment
- lecture

Metadata about Learning Content

Most metadata in category `5. Educational` deals with properties of learning content, for example, the difficulty. Since two categories refer to the interactivity, having a similar meaning, the iiRDS Learning domain merges the two categories into the class `Interactivity level`. The semantic density is a concept, which iiRDS lacks. The categories `5.8 Difficulty` and `5.9 Typical Learning Time` are essential for the thorough classification, as well. While iiRDS has no metadatum to express difficulty, there is a class called `Planning time` to estimate how long tasks take. However, no subclass was suitable for learning content, which chapter 5.2 explains in greater detail.

Category `9.1 Purpose` provides further classification options. The LOM value `educational level` resembles the iiRDS class `Qualification`. The `skill level` has a direct equivalent in iiRDS. The value `educational objective` is missing in iiRDS.

Obsolete LOM Categories

Some of the metadata in LOM become superfluous when transferring them into iiRDS, as LOM is a taxonomy and iiRDS is an ontology.

Category `9. Classification` allows adding a custom classification system, but in iiRDS, docking points are used to add custom metadata. Therefore, all metadata, except for `9.1 Purpose`, are irrelevant for the metadata model in iiRDS because the standard offers a classification system already. Categories `3. Meta-Metadata`, and `7. Relation` become obsolete, as RDF already provides mechanisms for dealing with meta-metadata and relations.

In LOM, the metadatum `5.7 Typical Age Range` indicates which age content is suitable for. This is useful when dealing with children in different developmental stages. Since iiRDS is used in a professional area, learning content is most likely aiming at adults. Since the iiRDS class `Qualification` and its subclasses provide a better differentiation of the target audience, the attribute for age range was neglected.

Another LOM metadatum that does not need representation in iiRDS is `5.6 Context`. The context of learning topics tagged with iiRDS would always be in a setting of workplace learning. A report on workplace learning states that learning and development departments play an important role in covering organizations' legal obligations[238]. Therefore, it makes sense to classify a course as mandatory, whenever regulations demand compliance.

Summary

The most important difference between LOM and iiRDS stems from their intended fields of use. iiRDS does not provide an in-depth classification of learning content, as it was designed for and by technical communicators. iiRDS provides a topic type called `Learning` but other than that, there are no ways to further classify learning content. The LOM metadata categories `5. Educational` and `9.1 Purpose` provide some ideas of how iiRDS can be extended. The iiRDS Learning domain will be based on the shortcomings discussed in this chapter.

238 cf. Mimeo.com Inc. and Challenger Inc., "State of Learning and Development 2020." p. 28

5 Metadata Model of the iiRDS Learning Domain

Based on the previous findings discussed in chapters 2.5, 3.6, and 4.4, this chapter presents the metadata of the iiRDS Learning domain. The discussed thoughts resemble step II of the ontological engineering process, explained in chapter 4.3.

5.1 Overview

As reuse is an important factor for ontological engineering, existing learning vocabularies were researched on the Linked Open Vocabularies (LOV) database. There was only one relevant result, namely the implementation of LOM as an OWL ontology by Rajabi from the University of Alcalá.[239] However, this is not an official binding specified by the IEEE. Furthermore, it is unclear if the ontology is used actively because, according to LOV, the ontology was used in zero datasets.[240] Checking the ontology with the ontology pitfall scanner (OOPS!)[241] revealed some errors, of which ten are critical.

IEEE had started working on an RDF binding standard for LOM in 2002, but the project has been halted[242], so IEEE has never released an official document for LOM metadata expressed through RDF. Since there is no official RDF binding definition for LOM, this chapter defines metadata within the iiRDS standard to classify learning content.

As discussed in chapter 3.4.1, iiRDS can be extended by creating vocabularies (domains) or by using the docking points. For this thesis, the docking points are not sufficient to create an in-depth model for classifying learning content, because new classes can only be subclasses of existing classes. Therefore, a new domain called Learning (iiRDSLrn) extends the iiRDS core vocabulary.

The following sections explain which elements complement the iiRDS core vocabulary. For the full iiRDS Learning domain specification, please refer to the appendix. The IRIs are a proposal for possible identifiers and not registered.

239 cf. Rajabi, "LOM Ontology."
240 cf. Ontology Engineering Group, "Learning Object Metadata Ontology."
241 cf. Poveda-Villalón, Gómez-Pérez, and Suárez-Figueroa, "OOPS! (OntOlogy Pitfall Scanner!): An On-Line Tool for Ontology Evaluation."
242 cf. Nilsson, "IEEE Learning Object Metadata RDF Binding."

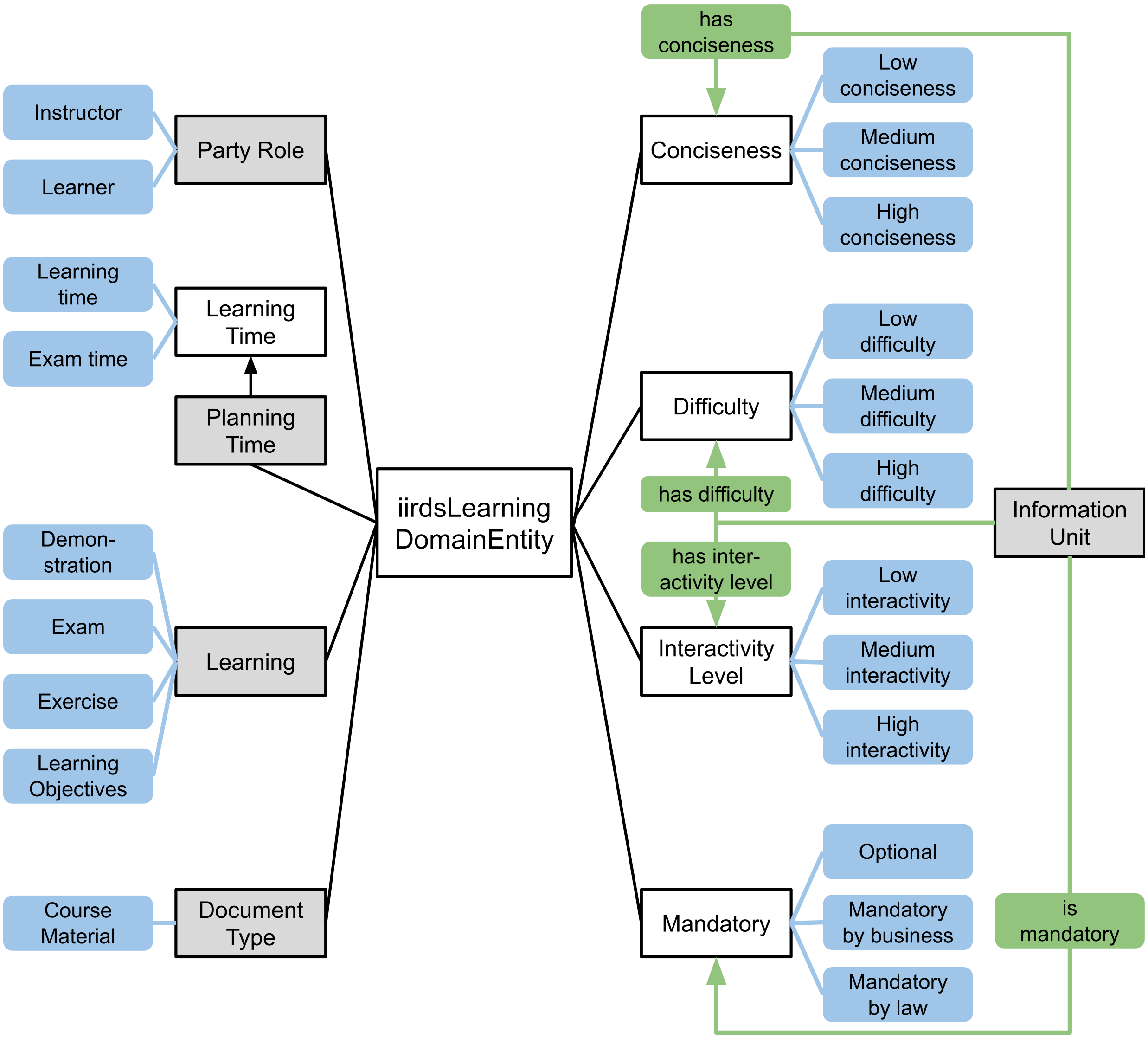

Fig. 12: Mind map of the iiRDS Learning domain

The mind map in Fig. 12: shows all metadata included in the iiRDS Learning domain. Objects that already exist in the iiRDS core vocabulary were omitted, except for classes extended by this domain. Metadata from the iiRDS core vocabulary are in a gray box. White boxes are new classes specified by the iiRDS Learning domain. The blue boxes contain objects, whereas the green boxes represent new relations. The following sections explain the thoughts and decisions behind the metadata of the iiRDS Learning domain.

5.2 Classes

The iiRDS Learning domain introduces six new classes.

1. iirdsLrn:iirdsLearningDomainEntity: The class `Domain entity` is the parent class for all other classes and binds objects to the iiRDS Learning domain.

2. iirdsLrn:LearningTime: The class `Learning time` is a subclass of the iiRDS core class `Planning time`. The iiRDS Learning domain introduces a new class for learning time because the existing class `Working time` is used for working tasks, which usually add to the organizations' value creation. Employees or contractors could be paid for their work according to the given working time.

Learning, on the other hand, is relevant to employees, but also customers of an organization. Complex products, such as machinery, require additional knowledge, which can be obtained by attending training. Creating the class `Learning time` makes it possible to have instances for different kinds of learning time, such as exams.

3. iirdsLrn:Conciseness: The class `Conciseness` is based on the LOM category `5.4 Semantic density`. However, the metadatum is called conciseness in iiRDS, because it is more obvious than semantic density. The metadatum describes how compact information is depicted. This helps creators of learning content determine which content is more appropriate for their target audience. For example, an introductory course to mechanical engineering for welding trainees requires much explanation because they are most likely not familiar with the concepts. In this setting, an instructor chooses content with low conciseness. As the trainees advance, they become more familiar with mathematical notations and technical terms, thus the content can become more concise.

Originally in LOM, the semantic density has five levels, ranging from very low to very high. However, there is no detailed description of the difference between a very low or a low semantic density. Consequently, the content might be classified differently, depending on who created it. In the iiRDS Learning domain, the values are consolidated to low, medium, and high.

4. iirdsLrn:Difficulty: The class `Difficulty` is based on the LOM category `5.8 Difficulty`. Originally LOM proposed five difficulty levels, ranging from very easy to very hard. Every creator of learning content might judge differently, whether a learning topic is very easy or easy. Therefore, the iiRDS Learning domain simplifies the difficulty levels to low, medium, and high. To indicate the level of difficulty, the corresponding object is assigned to a learning topic.

5. iirdsLrn:InteractivityLevel: The class `Interactivity level` merges the LOM categories `5.1 Interactivity type` and 5.3 `Interactivity level` to avoid having nonsense combinations of metadata. The meaning of combining an expositive learning method with a very high interactivity level or vice versa is questionable. Furthermore, the levels of interactivity in iiRDS are consolidated to three levels, which are defined as objects of the class `Interactivity level`.

6. iirdsLrn:Mandatory: The class `Mandatory` derives from the LOM category `5.6 Context`. In the LOM standard, the context specifies the setting a training takes place in. As iiRDS is suitable for technical communication in a professional setting, learning topics would always appear as a part of workplace learning. What is special about workplace learning is that some lessons are mandatory in order to use a product, perform specific tasks, or gain a new qualification. A simple example is a web-based training on anti-corruption practices, which many organizations require as a part of their onboarding process. Regulations can also be a reason why employees have to participate in a training. One example is that regulations require that only certified electricians are allowed to work on tasks that involve high-voltage currents. To declare if an information unit is mandatory, use the relation is-mandatory and the corresponding objects.

5.3 Properties

The iiRDS Learning Domain does not introduce new properties. This section explains the thought process behind this decision.

In the first iteration, the model proposed `conciseness`, `difficulty`, `interactivity` and `mandatory` as properties of the class `Learning`. The relation `has-topic-type` connects the topic type `Demonstration` to the demonstration. The `Demonstration` object was specified with the attributes, see the following markup example.

```
<iirds:Topic rdf:about="IRI">
<iirds:has-topic-type rdf:about="http://iirds.tekom.de/iirds/do-
main/learning#Demonstration">
    <iirdsLrn:Demonstration>
       <iirdsLrn:conciseness>medium</iirdsLrn:conciseness>
       <iirdsLrn:difficulty>easy</iirdsLrn:difficulty>
       <iirdsLrn:interactivity>low</iirdsLrn:interactivity>
       <iirdsLrn:mandatory>optional</iirdsLrn:mandatory>
    </iirdsLrn:Demonstration>
</iirds:has-topic-type>
</iirds:Topic>
```

This is valid iiRDS markup but does not work as intended. Since the `Demonstration` object does not have an IRI, the values stay the same for each `Demonstration` topic within the iiRDS package. That means another topic of the type `Demonstration` would have the same level of `conciseness`, `difficulty`, and `interactivity`.

After coming to this conclusion, the next approach modeled these properties belonging to the class `Information Unit`. In this scenario, every information unit could use the properties, making it possible to assign them to fragments, and documents as well. The downside is that properties have no fixed vocabulary because of their datatype (literal). That implicates that if a content creator is not familiar with the values for the property `difficulty`, for example, they could declare a resource with the value `easy` or `low`, depending on their preference.

Looking at the definition of ontology, a major criterium is that ontologies make knowledge explicit[243]. Therefore, the most explicit modeling solution was to create classes instead of properties. The classes resemble a metadatum and the objects resemble one value out of a value space (all objects of the class). Using relations and the domain and range mechanism, it is possible to define a set of valid "values", thus ensuring consistency in classifying learning content.

5.4 Relations

The iiRDS Learning domain proposes four new relations to classify information units. The domain is always the information unit. The Learning vocabulary introduces the classes `Conciseness`, `Difficulty`, `Interactivity`, and `Mandatory` for the range. The objects of the classes represent the possible values, see Fig. 12: .

Tab. 3: Overview of the relations defined in the iiRDS Learning domain

Subject	**Predicate**	**Object**
iirds:informationUnit	iirdsLrn:has-conciseness	iirdsLrn:Conciseness
iirds:informationUnit	iirdsLrn:has-difficulty	iirdsLrn:Difficulty
iirds:informationUnit	iirdsLrn:has-interactivity-level	iirdsLrn:InteractivityLevel
iirds:informationUnit	iirdsLrn:is-mandatory	iirdsLrn:Mandatory

Source: Created by the author

For the remaining metadata in the iiRDS Learning domain, there no new relations needed to be defined. The new topic types `Demonstration`, `Exam`, `Exercise`, and `Learning Objectives` are subclasses of `Learning`, which is part of the iiRDS core vocabulary. Therefore, the existing relation `has-topic-type` is also valid for the newly defined topic types.

243 cf. Grimm et al., "Ontologies and the Semantic Web." p. 539

The class `Learning time` is a subclass of `Planning time` and can be assigned to a topic using the existing relation `has-planning-time.`

5.5 Objects

This section provides an overview of the objects in the iiRDS Learning domain.

1. Objects of the type iirds:Learning: The objects `Demonstration`, `Exam`, and `Exercise` were added based on the values from LOM `5.2 Learning Resource Type`. As discussed in section 4.4, iiRDS does not specify what kind of learning material the topic contains. Creators of learning content profit from the new metadata as they can model courses according to the 3-2-1 model, see chapter 4.1.

The objects `Learning objective`, `Demonstration`,and `Exercise` represent the first element of the 3-2-1 model. The object `Learning objective` is based on `9.1. Educational objective` and states the goals of a lesson or course. The object `Demonstration` is used for learning material, which explains how processes or objects work, combining the LOM values “experiment” and “simulation”. Learning materials, which are not demonstrations, can be classified using existing topic types. The object `Exercise` is used for assignments to enhance the learning process. The object `Exam` is used for tests, resembling the last element of the 3-2-1 model.

2. Objects of the type iirds:PartyRole: The objects `Learner` and `Instructor` were added based on `LOM 5.5 Intended End User Role`. These two new objects provide rudimentary means of communication (second element of the 3-2-1 model), as the objects can be annotated with contact information. In more complex content delivery scenarios, the objects could also aid in creating user profiles for personalization, which is discussed in further detail in chapter 5.7.

3. An Object of the type iirds:DocumentType: A new document type called `Course material` was added based on the value `lecture` from LOM category `5.2 Learning Resource Type`. This document type collects all constituents of a course, such as learning objectives, learning materials, assignments, and tests.

4. Objects of the type iirds:PlanningTime: The object `Generic learning time` allows estimating how long it takes to work through a learning topic. When adding the values of all topics contained in a course, it is possible to estimate how long it takes to gain a new qualification. The object `Exam time` is used to define a time limit for tests, which should not be exceeded. Based on these time estimations, accounting departments can estimate how much it will cost to train workers or customers.

5. Objects of the type iirdsLrn:Conciseness: To model a controlled vocabulary, the following objects are "values" for the class `Conciseness`. The size, duration, or span of the learning material determines the level of conciseness. The objects were simplified, as explained in chapter 5.2, providing three levels of conciseness with examples:

- Low conciseness: An uncut recording of a lecture. (45 min)
- Medium conciseness: A recorded lecture with bookmarks to skip familiar sections.
- High conciseness: An explanatory video (15 min) condensing the knowledge of the lecture, supported by infographics or simulations.

6. Objects of the type iirdsLrn:Difficulty: Just like for the class `Conciseness`, the objects of the class `Difficulty` represent fixed possibilities to classify a learning topic's degree of difficulty. The degree of difficulty depends on the intended target audience and their previous experience and knowledge. An information unit can have one of the three levels:

- Low difficulty: The learner can work through the learning topic easily.
- Medium difficulty: The learner has to reflect on the learning topic but is able to work through it.
- High difficulty: The learner has to reflect and might need additional help to work through the learning topic.

7. Objects of the type iirdsLrn:InteractivityLevel: To create fixed values for the levels of interactivity, Each level of interactivity is an object of its own to model a controlled vocabulary for the class `Interactivity Level`.

- Low interactivity: Expositive (passive) learning content, requiring only the learner's attention.
- Medium interactivity: Learning topics mixing active and expositive learning content.
- High interactivity: Active learning content, requiring the learner to contribute to the lecture or assignment.

8. Objects of the type iirdsLrn:Mandatory: The objects of the class `Mandatory` express, whether an information unit is mandated by law or organizational policies. If a learning topic is not mandatory, it is optional. Since it is good ontological engineering practice to design as explicitly as possible, the object `Optional` was created, although a learning topic could also be optional if it has no relation to the class `Mandatory`.

5.6 Classification Example

This example shows how a resource can be classified using the iiRDS Learning domain. To focus on the domain metadata, the example uses metadata from the iiRDS core vocabulary sparingly. Figure 13[244] depicts the example as a conceptual model. The complete RDF markup can be found in the appendix.

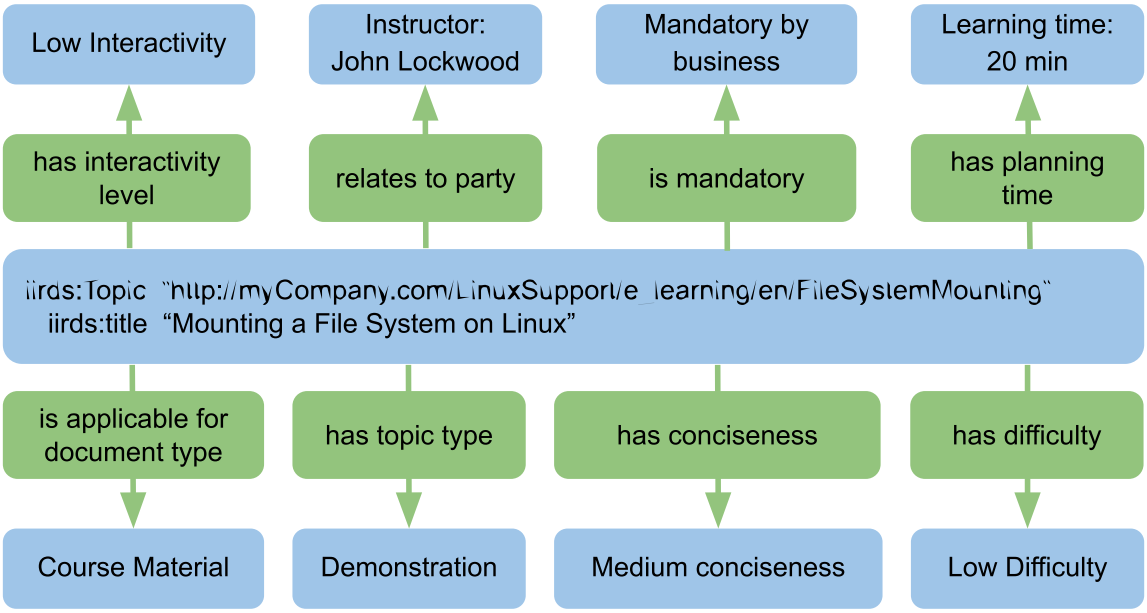

Fig. 13: Simplified portrayal of the metadata.rdf file in an iiRDS package.

The topic is about how to mount a file system on Linux. The topic inherits metadata from other classes using relations. For this example, let us assume that the topic contains a video that explains what to do and the underlying concepts at each step.

The topic has the topic type `Demonstration` and can be collected in a document type called `Course Material`. Because learners only have to pay attention, the topic has a low interactivity level. The relation `relates to party` links an instructor to the information unit, so that learners can ask questions in person, or via email. Since the topic uses abbreviations, the conciseness is medium. The organization requires each new system administration trainee to take this lesson, which makes it mandatory. For this audience, the difficulty is low, since they are familiar with basic IT concepts. A typical learner can work through this topic in 20 minutes, indicated by the `Learning time` object.

[244] Created by the author.

5.7 Discussion

This chapter reviews how iiRDS can support a UCS based on the requirements presented in chapters 2.5, 3.6, and 4.1. discusses further ideas on extending iiRDS and challenges related to content creation and content delivery.

Channel-independence, Consistency, and Inference

Since iiRDS stores metadata separately from the content and stylesheets, the requirement of channel-independence is met. Since the workflow of iiRDS foresees that the content is authored and annotated in a structured way, iiRDS does not mandate a specific content model. Organizations are free to create content models that meet their needs. When the actual iiRDS packages should be created, the metadata model needs to be mapped precisely to the structures in iiRDS. Since the mapping process is based on rules, there should be no inconsistencies.

Since iiRDS is based on RDF, a rather lightweight ontology, there are no predefined axioms for validation of the metadata model. If a consistency check on the ontological level is desired, organizations need to formulate axioms themselves. However, RDF Schema limits the extent to which axioms can be formulated, as RDF Schema does not allow negations and excluding classes[245].

Personalization

The requirement of personalization plays a major role in the realization of a UCS but is also relevant for workplace learning metadata. Ontologies themself, together with a query language support personalization. iiRDS by itself can only provide granular packages and metadata, therefore the degree of personalization is dependent on the architecture of the information retrieval engine.

The objects `Learner` and `Instructor` are useful for creating profiles for content personalization. Learners might want to get different learning content based on their skill level or qualification, which are already existing classes in iiRDS. Instructors might want to see additional information in a list of search results, such as the level of interactivity to find appropriate material for their courses.

245 cf. Grimm et al., “Ontologies and the Semantic Web.” p. 520

Reusability

The requirement for reusability is found in all three areas, for multiple reasons. Reuse promotes consistency, lowers cost, and is the key to interoperability. iiRDS meets the need for reusability, as the standard is independent of a specific organization.

Explicitness, Expansion, and Semantic Richness

Since iiRDS is based on RDF, which is a lightweight ontology, these requirements are met by the nature of iiRDS. iiRDS itself is expandable by creating new domains or adding ontologies at docking points.

Processes and Rights

Two requirements stemming from workplace learning are supporting processes and rights management. Since the process of creating e-learning applications is similar to the content lifecycle, information about the content's lifecycle can be annotated using the iiRDS classes `Content Lifecycle Status` and `Content Lifecycle Status Value`. To represent the 3-2-1 model, used for created e-learning and blended learning courses, respective objects were added to the iiRDS Learning domain.

The proper declaration of copyright information is important for Instructors, as they might rely on third party content to make a matter clearer. The attribute `rights` in the iiRDS core helps classifying copyright information.

Further Ideas on Extending iiRDS

With this initial version, it is possible to classify learning content. For future iterations of this domain, learning events could be added. With the iiRDS class `Event` it is possible to deliver content specific to an event happening in a technical system, such as an error or malfunction.[246] These events could also be used to enhance the learning experience, for example, to improve exercises. When a learner does not answer a question correctly, a learning event called *incorrect* is triggered. Additional information on why the answer was wrong could be displayed. Exams could also be enriched with events, such as *passed*. Based on the passed exams, an employee obtains a new qualification, allowing them to perform new tasks or displaying new learning content.

The problem is that iiRDS was designed to deliver content, but not to manipulate nodes. Therefore, a reasoning mechanism has to infer that an employee has a new qualification, based on the passed exams. Another issue when working with events is that the class is a

[246] cf. iiRDS Consortium, "Tekom iiRDS Standard Version 1.0.1."

docking point for proprietary metadata, allowing each organization to create their own events[247]. This can lead to inconsistencies when sharing the content with stakeholders outside of the organization, hindering interoperability.

Challenges Related to Content Creation

Depending on the tools content creators use, exporting content into an iiRDS package might be difficult. 62 % of internal trainers use e-learning creation software[248]. One popular tool to create e-learning courses and exams is Adobe Captivate. Captivate supports the export to the file formats SWF and HTML5 with the standards SCORM, AICC, and xAPI.[249]

Since iiRDS supports the classification of HTML5, it is possible to manually create RDF files describing these resources. However, time constraints are the number one challenge technical trainers face in their everyday work.[250] Manually assigning metadata is a tedious task, even with a limited metadata set. In order to save time, e-learning tools need to assign metadata automatically during content creation.[251] E-learning tools need to be able to export content and metadata into iiRDS packages, making them iiRDS generators.

Challenges Related to Content Delivery

Since iiRDS can not manipulate nodes, it is questionable if classifying interactive media, such as e-learning is useful. For static media, iiRDS is a good fit, since it was designed for technical documentation. Workplace learning also relies heavily on handbooks/manuals (79 %), job aids (64 %), and workbooks (56 %), as a survey conducted by Mimeo Inc. and Challenger Inc. revealed. Sales Trainers distribute their learning material using LMSs (56 %), email (46 %), shared drives (42 %), and content management applications (28 %).The most relevant channels for internal trainers are virtual learning delivery systems (78 %), LMSs (65 %), and company intranets (58 %).[252]

Since LMSs play a vital role in sharing learning material internally and externally, the use of iiRDS to classify learning content opens further questions. The answers to these questions depend on each organization.

I. Which channel delivers which types of learning material?

[247] cf. Gutknecht and Ley, “Informationen bedarfsgerecht verpackt.”
[248] cf. Mimeo.com Inc. and Challenger Inc., “State of Learning and Development 2020.” p. 30
[249] cf. Adobe, “Upload an Adobe Captivate Project to a Learning Management System.”
[250] cf. Mimeo.com Inc. and Challenger Inc., “State of Learning and Development 2020.” p. 26
[251] cf. Niegemann, *Kompendium multimediales Lernen*. p. 610
[252] cf. Mimeo.com Inc. and Challenger Inc., “State of Learning and Development 2020.” pp. 19, 28, 30

Handbooks and workbooks which should be consumed in a predefined order could be published to an LMS or an iiRDS consumer, which are mainly CDPs. If there are no interaction points, where the learner can manipulate the learning material, a CDP would suffice. The downside of using CDPs for learning material is, that it cannot track the learner's progress.

II. Is iiRDS useful in combination with an LMS?

    So far, no LMS supports iiRDS, but the question arises if LMSs should be iiRDS consumers in the future. The cmi5 standard has quite similar goals as iiRDS. Cmi5 enables learners to track their learning journey across organizations, methodologies, technology platforms, and activities. Cmi5 uses xAPI to specify data formats, transport, and storage.[253] Since cmi5 and xAPI focus on learning content and have respective committees to develop the standards further, it is questionable if the integration of iiRDS into an LMS makes sense.

III. If LMSs could process iiRDS packages, where does the sequencing and navigation of learning content happen?

    If a handbook were delivered in a CDP, the topics were sequenced using the iiRDS' directory nodes. However, if an LMS could use iiRDS packages, should the course structure be built in iiRDS or the LMS? If iiRDS should provide the structure, the iiRDS Learning domain must define additional directory node types for learning content. Since iiRDS currently supports linear structures, delivering content based on decision trees is not possible[254].

The interaction between iiRDS and other standards is a complex matter, which the thesis cannot discuss in its entirety. The questions above provide ideas to start a discussion in the iiRDS Consortium, which needs to decide whether the adoption of an iiRDS Learning domain is in the interest of the project, and how iiRDS should interact with existing standards.

[253] cf. Advanced Distributed Learning (ADL), "An Introduction to cmi5: Next-Generation of e-Learning Interoperability."

[254] cf. Nuding, "Das Topic-Wirrwar ordnen."

6 Conclusion

The range of digital information services is increasing, ranging from consumer applications such as smart home and industry 4.0. It is expected that information and content will be a fixed component of many organizations' value proposition.[255] Interoperability becomes more important as content is created, used, published, and managed by multiple stakeholders. Seen from this angle, the thesis analyses the question "How can ontologies be used for the implementation of a unified content strategy?"

The thesis showed that ontologies are a powerful tool to establish a UCS. Ontologies provide the means to establish consistency, reuse, and personalization, which are key requirements of a UCS. With extensive axioms, the data model can be validated, ensuring consistency, and based on logic, new knowledge can be inferred. Ontologies can aid in all three phases of creating a UCS, see chapter 3.6.

Since creating an ontology requires many resources, reusing existing ontologies makes the transition to an ontology more affordable. The iiRDS framework was analyzed to determine its usefulness to serve as a foundation for implementing a UCS. Since the ontology of iiRDS is based on RDF, all aspects from the previous paragraph apply, except for the heavy use of axioms. However, there are two major hurdles which complicate using iiRDS for a UCS:

I. **The integration of iiRDS with tools**: Since the standard was released in 2018, the tools that support the publishing workflow of iiRDS are sparse.[256] The same applies to software that can process iiRDS packages. As section 3.4.3 discussed, iiRDS supports the vision of omnichannel publishing but the currently available off-the-shelf solutions are very limited.
II. **The iiRDS vocabulary**: The purpose of iiRDS is to classify technical communication resources. To classify content from other departments, such as marketing or learning and development, the vocabulary needs to be extended. The thesis demonstrated what an expansion for workplace learning metadata could look like. The use of iiRDS for learning content is questionable since LMSs do not support iiRDS and the lack of tracking of the learner's progress. Metadata models developed by dedicated committees, such as the ADL, might be more suitable. With xAPI learner's progress can be tracked

[255] cf. Ziegler, "Man muss auch austeilen können."
[256] cf. Ley, "Informationen erhalten Bedeutung."

across online and offline media. The ADL even provides an open-source ontology[257] to classify learning content.

Ontologies could be a key technology in customer relationship management and personalized marketing as well. A McKinsey report from 2019 states that “personalization will be the prime driver of marketing success within five years.”[258] Ontologies could be used to manage customer profiles in even more depth and deliver marketing information across the most successful channels for each customer. To achieve personalized omnichannel content delivery, teams need to be cross-functional, focusing on specific customer journeys. [259] Therefore, marketers will benefit from a UCS centered around an ontology as well.

Reviewing all these developments, the use of ontologies and semantic networks will be inevitable to achieve personalized content delivery, one of the cornerstones of a UCS. However, it is more useful for each department to create or reuse an ontology. An overarching ontology can connect and unify the single ontologies for precise, personalized content delivery.

257 cf. Advanced Distributed Learning (ADL), “GitHub - Adlnet/Xapi-Ontology: xAPI Statement Data Model Represented as RDF Classes and Properties.”
258 Boudet et al., “The Future of Personalization-and How to Get Ready for It.”
259 cf. ibid.

Appendix

A.1 iiRDS Learning Domain Specification

A1.1 Class definitions

iirdsLrn:Conciseness

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#Conciseness
Type of Term:	http://www.w3.org/2000/01/rdf-schema#Class
Label:	Conciseness
Subclass Of:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Indicates how concise the learning topic is.
Description:	Not intended to be used directly. Use the instances instead.
IRI:	*OPTIONAL*

iirdsLrn:Difficulty

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#Difficulty
Type of Term:	http://www.w3.org/2000/01/rdf-schema#Class
Label:	Difficulty
Subclass Of:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Indicates how difficult the learning topic is.
Description:	Not intended to be used directly. Use the instances instead.
IRI:	*OPTIONAL*

iirdsLrn:InteractivityLevel

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#InteractivityLevel
Type of Term:	http://www.w3.org/2000/01/rdf-schema#Class
Label:	Interactivity level
Subclass Of:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Indicates the degree of interactivity of a learning topic.
Description:	Not intended to be used directly. Use the instances instead.
IRI:	*OPTIONAL*

iirdsLrn:iirdsLearningDomainEntity

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#iirdsLearningDomainEntity
Type of Term:	http://www.w3.org/2000/01/rdf-schema#Class
Label:	iirdsLearningDomainEntity
Subclass Of:	iirds:iirdsDomainEntity
Definition:	Entity of the learning domain.

iirdsLrn:LearningTime

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#LearningTime
Type of Term:	http://www.w3.org/2000/01/rdf-schema#Class
Label:	Learning time
Subclass Of:	iirds:PlanningTime, iirdsLrn:iirdsLearningDomainEntity

Definition:	Type of planning time: Period of time *REQUIRED* to work through a learning topic.
IRI:	*OPTIONAL*

iirdsLrn:Mandatory

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#Mandatory
Type of Term:	http://www.w3.org/2000/01/rdf-schema#Class
Label:	Mandatory
Subclass Of:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Indicates if a learning topic is required by law or business standards in order to perform a task or gain a qualification or certificate.
Description:	Not intended to be used directly. Use the instances instead.
IRI:	*OPTIONAL*

A1.2 Property definitions

N/A

A1.3 Relations

iirdsLrn:iirdsLearningRelationConcept

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#iirdsLearningRelationConcept
Type of Term:	http://www.w3.org/1999/02/22-rdf-syntax-ns#Property
Label:	iirdsLearningRelationConcept
Has Domain:	iirds:iirdsLearningDomainEntity
Has Range:	iirds:iirdsLearningDomainEntity

Definition:	Base class for all relations in the iiRDS Learning domain.
Description:	Not intended to be used directly.

iirds:has-conciseness

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#has-conciseness
Type of Term:	http://www.w3.org/1999/02/22-rdf-syntax-ns#Property
Label:	has conciseness
Subproperty Of:	iirdsLrn:iirdsLearningRelationConcept
Has Domain:	iirds:InformationUnit
Has Range:	iirdsLrn:Conciseness
Definition:	References the conciseness of an information unit.

iirds:has-difficulty

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#has-difficulty
Type of Term:	http://www.w3.org/1999/02/22-rdf-syntax-ns#Property
Label:	has difficulty
Subproperty Of:	iirdsLrn:iirdsLearningRelationConcept
Has Domain:	iirds:InformationUnit
Has Range:	iirdsLrn:Difficulty
Definition:	References the difficulty of an information unit.

iirds:has-interactivity-level

Term	Description

URI:	http://iirds.tekom.de/iirds/domain/learning#has-interactivity-level
Type of Term:	http://www.w3.org/1999/02/22-rdf-syntax-ns#Property
Label:	has interactivity level
Subproperty Of:	iirdsLrn:iirdsLearningRelationConcept
Has Domain:	iirds:InformationUnit
Has Range:	iirdsLrn:InteractivityLevel
Definition:	References the interactivity level of an information unit.

iirds:is-mandatory

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#is-mandatory
Type of Term:	http://www.w3.org/1999/02/22-rdf-syntax-ns#Property
Label:	is mandatory
Subproperty Of:	iirdsLrn:iirdsLearningRelationConcept
Has Domain:	iirds:InformationUnit
Has Range:	iirdsLrn:Mandatory
Definition:	References whether an information unit is mandatory.

A1.4 Object definitions

iirdsLrn:ConcisenessLow

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#ConcisenessLow
Type of Term:	iirdsLrn:Conciseness
Label:	Low conciseness

Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the class Conciseness that indicates how concise the learning topic is.
Description:	The conciseness of a learning object *MAY* be estimated in terms of its size, span, or duration. Examples: An unedited video of a lecture that is 45 min long. A text about mechanical engineering, in which every technical term is explained.

iirdsLrn:ConcisenessMedium

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#ConcisenessMedium
Type of Term:	iirdsLrn:Conciseness
Label:	Medium conciseness
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the class Conciseness that indicates how concise the learning topic is.
Description:	The conciseness of a learning object *MAY* be estimated in terms of its size, span, or duration. Examples: A video of a lecture that has been enriched with markers to skip chapters. Textual representation of a mathematical theorem.

iirdsLrn:ConcisenessHigh

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#ConcisenessHigh
Type of Term:	iirdsLrn:Conciseness
Label:	High conciseness
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the class Conciseness that indicates how concise the learning topic is.

Description:	The conciseness of a learning object *MAY* be estimated in terms of its size, span, or duration. Examples: A short, explanatory video showing a simulation with great detail. A symbolic representation of a circuit.

iirdsLrn:CourseMaterial

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#CourseMaterial
Type of Term:	iirds:DocumentType
Label:	Course material
Type:	iiirdsLrn:iirdsLearningDomainEntity
Definition:	Collection of topics which are used in a course.
Description:	The object training *MAY* comprise learning objectives, exams, demonstrations, exercises and generic learning content.

iirdsLrn:Demonstration

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#Demonstration
Type of Term:	iirds:Learning
Label:	Demonstration
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	A demonstration shows how a process, or an object works.
Description:	Demonstrations *MAY* comprise experiments, simulations, screencasts and utility films.

iirdsLrn:DifficultyLow

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#DifficultyLow

Type of Term:	iirdsLrn:Difficulty
Label:	Low difficulty
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the class Difficulty that indicates how difficult the learning topic is.
Description:	The learner can work through the learning topic easily.

iirdsLrn:DifficultyMedium

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#DifficultyMedium
Type of Term:	iirdsLrn:Difficulty
Label:	Medium difficulty
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the class Difficulty that indicates how difficult the learning topic is.
Description:	The learner has to reflect on the learning topic but is able to work through it.

iirdsLrn:DifficultyHigh

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#DifficultyHigh
Type of Term:	iirdsLrn:Difficulty
Label:	High difficulty
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the class Difficulty that indicates how difficult the learning topic is.
Description:	The learner has to reflect and might need additional help to work through the learning topic.

iirdsLrn:Exam

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#Exam
Type of Term:	http://www.w3.org/2000/01/rdf-schema#Class
Label:	Exam
Subclass Of:	iirds:Learning, iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the topic type learning for exams.
Description:	Exams *MAY* comprise multiple-choice questions, graded work assignments and assessments.

iirdsLrn:ExamTime

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#ExamTime
Type of Term:	iirdsLrn:LearningTime
Label:	Exam time
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Sets a time limit for an exam.
duration	PT0M
Description:	The LearningTime class is a parent class for periods of time *REQUIRED* to work through a learning topic.

iirdsLrn:Exercise

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#Exercise
Type of Term:	http://www.w3.org/2000/01/rdf-schema#Class

Label:	Exercise
Subclass Of:	iirds:Learning, iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the topic type Learning that is used to classify exercises.
Description:	Exercises are assignments that learners solve to better understand learning topics.

iirdsLrn:GenericLearningTime

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#GenericLearningTime
Type of Term:	iirdsLrn:LearningTime
Label:	Learning time
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Generic instance of the LearningTime class.
duration	PT0M
Description:	The LearningTime class is a parent class for periods of time *REQUIRED* to work through a learning topic.

iirdsLrn:Instructor

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#Instructor
Type of Term:	iirds:PartyRole
Label:	Instructor
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the PartyRole class describing the role of an actor related to an iiRDS domain entity.
Description:	An instructor is an individual who presents learning topics to learners, answers questions and is responsible for conducting exams.

iirdsLrn:InteractivityLow

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#InteractivityLow
Type of Term:	iirdsLrn:InteractivityLevel
Label:	Low interactivity
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Indicates how interactive the learning topic is.
Description:	The interactivity of a learning object is low when the learner has to absorb the presented content and has few options of activity.

iirdsLrn:InteractivityMedium

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#InteractivityMedium
Type of Term:	iirdsLrn:InteractivityLevel
Label:	Medium interactivity
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Indicates how interactive the learning topic is.
Description:	The interactivity of a learning object is medium when passive and active elements are mixed.

iirdsLrn:InteractivityHigh

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#InteractivityHigh
Type of Term:	iirdsLrn:InteractivityLevel
Label:	High interactivity

Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Indicates how interactive the learning topic is.
Description:	The interactivity of a learning object is high when the learner has to actively participate in a lecture or solve assignments.

iirdsLrn:Learner

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#Learner
Type of Term:	iirds:PartyRole
Label:	Learner
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the PartyRole class describing the role of an actor related to an iiRDS domain entity.
Description:	A learner is an individual who consumes learning topics in order to learn something.

iirdsLrn:LearningObjectives

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#LearningObjectives
Type of Term:	iirds:Learning
Label:	Learning Objectives
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the topic type Learning that is used to classify learning objectives.
Description:	Learning objectives state the goals of a learning topic. They can serve as guidelines for designing exams.

iirdsLrn:MandatoryBusiness

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#MandatoryBusiness
Type of Term:	iirdsLrn:Mandatory
Label:	Mandatory by business
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the class Mandatory that is used to classify learning topics as mandatory based on business standards.
Description:	Example: Every employee of an organization has to do a course on phishing and IT security.

iirdsLrn:MandatoryLaw

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#MandatoryLaw
Type of Term:	iirdsLrn:Mandatory
Label:	Mandatory by law
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the class Mandatory that is used to classify learning topics as mandatory by law.
Description:	Example: Every electrician has to know about handling high-voltage current.

iirdsLrn:Optional

Term	Description
URI:	http://iirds.tekom.de/iirds/domain/learning#Optional
Type of Term:	iirdsLrn:Mandatory

Label:	Optional
Type:	iirdsLrn:iirdsLearningDomainEntity
Definition:	Instance of the class Mandatory that is used to classify learning topics as optional.
Description:	Example: Case studies to illustrate a topic.

A.2 Classification Example

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!--Import the vocabularies.-->
<rdf:RDF
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:iirds="http://iirds.tekom.de/iirds#"
   xmlns:iirdsLrn="http://iirds.tekom.de/iirds/domain/learning#">

<iirds:Topic rdf:about="http://example.org/LinuxSupport/e_learn-
ing/en/FileSystemMounting">
<iirds:title>Mounting a File System on Linux</iirds:title>
<!-- Add further metadata, such as date of creation, language, rendi-
tion, information subject, product lifecycle phase, copyright etc. -->
<!--Learning Metadata -->
<iirds:is-applicable-for-document-type
rdf:rsource="http://iirds.tekom.de/iirds/domain/learning#CourseMate-
rial"/> <!-- This learning topic can be used for a course. -->

<iirds:has-topic-type rdf:about="http://iirds.tekom.de/iirds/do-
main/learning#Demonstration"/> <!-- Assign topic type -->

<iirdsLrn:has-conciseness rdf:resource="http://iirds.tekom.de/iirds/do-
main/learning#ConcisenessMedium"/> <!-- Assign the level of conciseness
using an IRI. -->

<iirdsLrn:has-difficulty rdf:resource="http://iirds.tekom.de/iirds/do-
main/learning#DifficultyLow"/> <!-- Assign the level of difficulty using
an IRI. -->

<iirdsLrn:has-interactivity-level
rdf:resource="http://iirds.tekom.de/iirds/domain/learning#Interactiv-
ityLevelLow"/> <!-- Assign the level of interactivity using an IRI. -->

<iirdsLrn:is-mandatory rdf:datatype="http://iirds.tekom.de/iirds/do-
main/learning#MandatoryBusiness"/> <!-- Indicates that the learning
topic is mandatory. -->

<iirds:relates-to-party>
      <iirds:Party rdf:about="http://example.org/instructors/JohnLock-
      wood">
            <iirds:has-party-role rdf:re-
            source="http://iirds.tekom.de/iirds/domain/learning#Instruc-
            tor"/> <!--Adding contact details using the vCard vocabulary
            could provide learners with contact information. -->
       </iirds:Party>
```

```
</iirds:relates-to-party>

<iirds:has-planning-time>
   <iirdsLrn:GenericLearningTime>
            <iirds:duration
            rdf:datatype="http://www.w3.org/2001/XMLSchema#duration">
            PT20M</iirds:duration> <!--It takes 20 minutes to work
            through the learning topic-->
   </iirdsLrn:GenericLearningTime>
</iirds:has-planning-time>

</iirds:Topic>
</rdf:RDF>
```

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