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Chapter 7

How Can Linked Open Data Ontologies be Customized for Digitally Archiving Cultural Routes?

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Introduction

Culture is a multi-faceted and dynamic concept, ever evolving as people interact, create, and adapt to changing circumstances (Stepin, 2003). An amalgamation of aspects that formulates the identity of a society or a social group, embracing distinct spiritual, material, intellectual and emotional features (UNESCO, 1983). This widens the scope of human experience around the globe with a deeper appreciation of various constructive elements of society (Erbaş, 2013).

Culture often overlaps with cultural heritage (Brumann, 2015), referred to as various artefacts, a group of buildings, sites, and museums that possess diverse values including symbolic, historic, artistic, ethnological, or anthropological, scientific, and social significance (UNESCO & UIS, 2009). Cultural heritage includes both tangible and intangible works that have been passed on to the upcoming generations, as a result of evolving expression of creativity representing societies. These can be in the form of languages, rites, beliefs, literature, works of art, historic places and monuments, archives, and libraries. It reflects a society's identity through its creations, practices, and values, whereas culture is an umbrella term that represents the entire way of living of a society and can often be used interchangeably in some cases (Brumann, 2015). However, understanding the nuances of related terms can help initiate precise conversations to better appreciate the richness and diversity of human cultures.

Culture clubbed with cultural heritage explores the tangible and enduring expression of society shaping our collective identity and linking the past, present and future generations (Musteață, 2020). Reflecting on society's unique identity, the richness and diversity of these very elements are under threat (Russo & Giusti, 2019). The aftermath of the ongoing thoughtlessness, urbanisation, industrialisation, armed conflicts, foreign occupations and climate change have intensified the loss of cultural heritage (Fatorić & Seekamp, 2017; Seyedashrafi et al. 2021; UNESCO, 1983). As a result of such consequences, there is a disconnection from the past, leading to outcomes such as the loss of one's sense of belonging within society (Messias et al., 2020). Thus, there is a need to preserve and appreciate the culture's heritage, enabling the people of society to affirm, promote and protect their cultural identity.

There is a growing demand for the digitization of cultural heritage data, which is further intensified due to the pandemic (Çelebi Karakök, 2023). Thus, the amount of digitized cultural heritage data has grown rapidly, which requires a framework for inventory management, through metadata creation for compliance with the FAIR (Findable, Accessible, Interoperable, and Reusable) guiding principles. The Linked Open Data for Libraries Archives and Museums (LODLAM) Ontologies provide GLAM (Galleries, Libraries, Archives, and Museums) institutions with a uniform metadata schema to create a digital multi-layered and structured inventory system (Liu et al., 2023).

As stated by ICOMOS, Cultural routes are humanity's common cultural heritage, which should be protected through collaborative efforts (ICOMOS, 2008). They are transnational in nature, which demands international efforts for collaborative research, assessment, protection, preservation, conservation, use, and management. Therefore, cultural routes pose a new dimension to the ontological frameworks as a catalyst to promote the dialogue of cultural heritage for international cooperation, world peace, and sustainable tourism (Borin &

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Donato, 2023). As a concept it is backed by a vision of unified cultural heritage, protecting the overarching theme of these individual assets by incorporating them into a larger picture representing the identity of an entire region. This approach to cultural heritage will facilitate the archival of diverse perceptions of the same route held by different cultures and nations. This study scrutinizes different data standards and applications that are built upon these ontologies. The results hint at the shortcomings and possibilities of existing frameworks and conclude with developing an integrated approach that can be enabled to customize ontologies for digitally archiving cultural routes and historic roads.

Methodology

This research adopts a secondary approach for analysing the Linked Open Data (LOD) ontologies and their compliance with the digital knowledge organisation tools for cultural heritage. The study emphasises the Cultural routes context and concludes with an integrated approach that can be enabled to digitally archive cultural routes. More specifically the article is divided into three parts. The first section is dedicated to developing an extensive understanding of cultural routes through the various definitions that have surfaced over time. It gives an overview of how the concept has emerged in the constantly evolving and quickly expanding field of cultural heritage (Suarze-Inclan & Rosa, 2005). The second part of the study investigates two tools for digitally archiving cultural Heritage i.e., Dive into Heritage and Arches Heritage Inventory and Management system. By reviewing these tools, the authors build on the knowledge of their core concepts and web architecture. The third part of the study corresponds to the former sections by incorporating the distinct features of cultural routes and examining the limitations of existing ontologies (specifically CIDOC CRM) for mapping cultural route data. Thus, concluding the article by building on an approach to enable customizations of linked open data ontologies for digitally archiving cultural routes. The framework leverages the strengths of the CIDOC CRM ontology by building upon its established ecosystem thereby promoting collaboration and data exchange within the cultural heritage community.

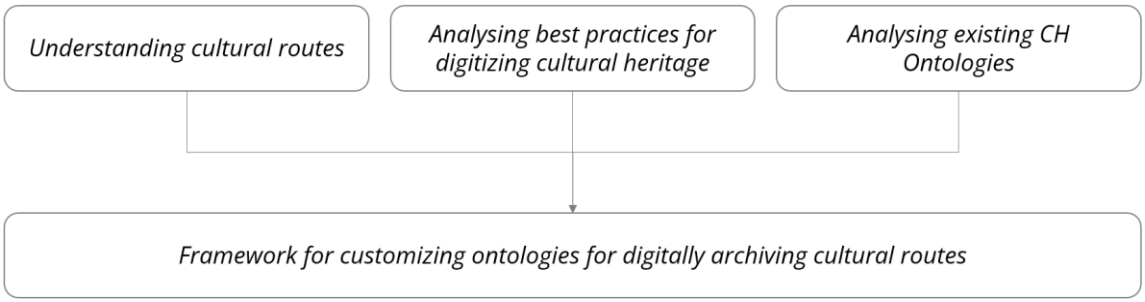

Figure 1. Structure of the Study (Source: Author)

Defining Cultural Routes

Cultural Route as a concept enables society to explore cultural heritage beyond historic reality into a modern idea that is depicted through a multidimensional perspective (Suarze-Inclan & Rosa, 2005). A continuously evolving concept, first discussed in the report titled Routes as part of our Cultural Heritage, one of the proceedings of UNESCO's Convention on the Protection of the World's Cultural and Natural Heritage conducted in 1994 in Madrid, Spain. Defined cultural route as "A heritage route composed of tangible elements of which the cultural significance comes from exchanges and a multi-dimensional dialogue across countries or regions, and that illustrate the interaction of movement, along the route, in space and time (UNESCO, 1994)."

Figure 2. Timeline representing the evolution of Cultural Route as a Concept (Source: Author)

The term heritage route was used to represent the concept, thus setting context by identifying the main features as well as giving a new perspective to cultural heritage (Suarze-Inclan & Rosa, 2005). The second definition was given in 2001 under the proceedings of the International Congress of the ICOMOS CIIC (ICCR) which was held in Navarra Spain. Here the discussion of intangible associations was initiated with a greater emphasis on the related values and non-physical elements. The definition is stated as "A set of values where the whole is greater than the sum of its parts, and through which it gains its meaning. Dynamic channels of exchange that go beyond physical paths and is characterised by the movement and exchange, intangible heritage, and connections across space and time (ICOMOS, 2001)."

The third definition of Cultural Route was defined in 2003, following the ICCR meeting of experts in Madrid, Spain. Here the concept was perceived as "A land, water, mixed or other type of route, which is physically determined and characterized by having its own specific and historic dynamics and functionality, showing interactive movements of people as well as multi-dimensional, continuous and reciprocal exchanges of goods, ideas, knowledge and values within or between countries and regions over significant periods of time, and thereby generating a cross-fertilisation of the cultures in space and time, which is reflected both in its tangible and intangible heritage (Durusoy, 2014)."

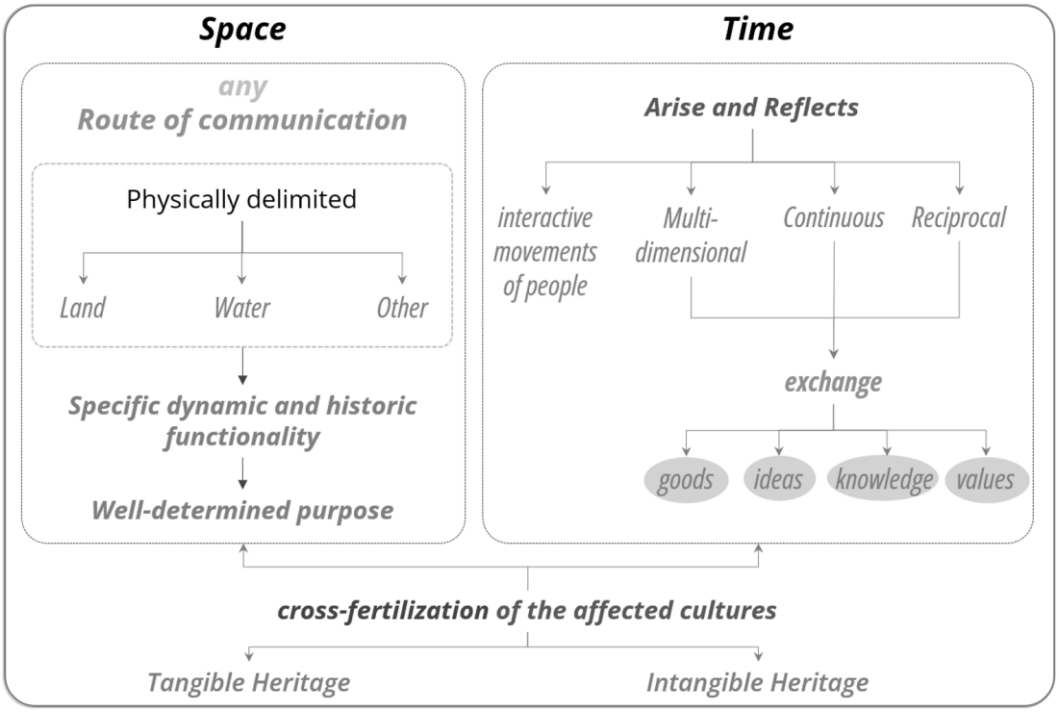

Figure 3. Visual representation of the Cultural Route Concept (Source: Author)

This explains the cultural route as a medium of cross-fertilisation among cultures considering tangible elements and intangible values. The concept of routes links these components given its significance for a particular society at a specific point in history. In addition, UNESCO's efforts to recognise the cultural routes delivered a qualitative change to the concept of cultural heritage (Srichandan et al. 2021). The importance of the concept is evident in its inclusion in the World Heritage Sites category. To Provide more clarity on the subject, ICOMOS adopted a Charter on cultural routes in 2008. It constructs an approach for the documentation, preservation, and promotion of cultural routes. The charter defines the concept as "Any route of communication, be it land, water, or some other type, which is physically delimited and is also characterized by having its own specific dynamic and historic functionality to serve a specific and well-determined purpose, which must fulfil the following conditions: (i) It must arise from and reflect interactive movements of people as well as multi-dimensional, continuous, and reciprocal exchanges of goods, ideas, knowledge and values between peoples, countries, regions or continents over significant periods of time; (ii) It must arise from and reflect interactive movements of people as well as multi-dimensional, continuous, and reciprocal exchanges of goods, ideas, knowledge and values between peoples, countries, regions or continents over significant periods of time; (iii) It must have integrated into a dynamic system the historic relations and cultural properties associated with its existence (ICOMOS, 2008)."

As observed by the authors there are three components to this definition, depicted in Figure 3. The first two components represent the dimensions of space and time, whereas the third aspect considers the cross-fertilization of the affected cultures within these dimensions. Incorporating these elements, forms the concept

of cultural routes, as an integrated dynamic system that makes it a part of another bigger system that is constantly evolving and adapting.

Classifying Cultural Routes

Cultural Routes have been classified into six major categories under the ICOMOS Charter on Cultural Routes (ICOMOS, 2008). These categories represent the dimensions of space and time as well as the cross-fertilization of the affected cultures that establishes the concept itself. Their classifications offer a fascinating lens to understand these dynamic pathways (Masini et al. 2024). By territorial scope, they can range from local trails showcasing regional traditions to vast intercontinental journeys that connect civilizations (Berti et al., 2015). Culturally, they might focus on a specific region's heritage or bridge geographically distinct areas that have historically influenced each other's values and practices. Their goals are equally diverse, serving social functions that foster community, economic purposes that stimulate trade, political aims that connect power centres, or purely cultural objectives that celebrate artistic expression and shared narratives.

Furthermore, the dimension of time adds another layer. Some routes represent the remnants of the past eras, silent testaments to earlier ways of life. Others remain vibrant arteries, constantly evolving as new social, economic, and political forces shape their use. This multifaceted approach to classification allows us to appreciate the incredible richness and diversity that cultural routes symbolise.

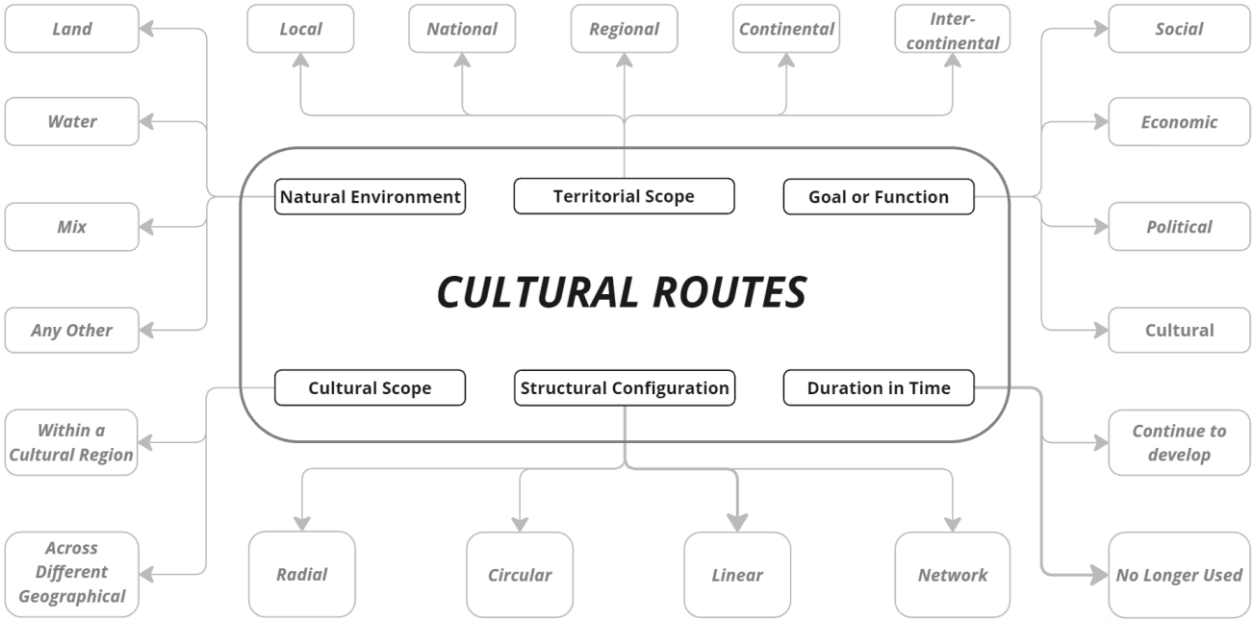

Figure 4. Classification of Cultural Routes (Source: ICOMOS, 2008; Visualised by Author)

Tools for Digitizing Cultural Heritage

Dive into Heritage

UNESCO, in collaboration with the Kingdom of Saudi Arabia, launched this project to bridge the gap between identifying, introducing, and protecting cultural and natural heritage, encompassing both tangible and intangible aspects. The pilot phase (2022-2024) focuses on the Arab States region, with plans for future expansion (UNESCO, 2023). The project aims to create a digital platform for exploring, educating, safeguarding, and virtually reconstructing cultural and natural heritage. This platform is intended to engage diverse users with heritage through incorporating various types of digital data. To achieve this, the project will develop custom standards for the platform and data (Vileikis et al. 2023). These standards will ensure several key aspects: meeting the requirements of stakeholders, maintaining data quality and accuracy, and supporting interoperability across different domains.

Arches Heritage Inventory and Management System

Arches Heritage Inventory and Management System is an open-source web-based geospatially enabled information system to help inventory and manage immovable cultural heritage (Carlisle et al. 2014). The Getty Conservation Institute and the World Monuments Fund (WMF) collaborated on this project. To develop a system that fulfils the inventory requirements of the heritage field without requiring organizations to create individually to meet very similar needs and, prompting long-term preservation and interoperability of datasets.

It was developed following a standards-based approach. The two main components of arches were the Conceptual Reference Model (CRM) and the Core Data Standards (CDS).

i) Core Data Standards (CDS)

It was developed as an international standard for archaeological and architectural heritage inventory and management. It is a collaboration between the Archaeological Sites Working Group established by the International Committee of Documentation (CIDOC) and the Archaeology Documentation Group of the Council of Europe (Carlisle et al., 2014).

In the year 1993, the European Plan for Archaeology was released. The creation of CDS for the documentation of archaeological sites and monuments was one of the plan's objectives. These standards were intended to supplement the council's Core Data Index (CDI) for the historic buildings and monuments of the architectural heritage. Later on, the Council became aware of the CIDOC working group and adopted their data standards with minor adjustments reflecting the Council's small-scale geographical focus.

In the later 2000s, the need for revision of the data standards arose, bringing the insights contribution from the International Committee of Architectural Photogrammetry (CIPA – Heritage Documentation). CIPA is one of the oldest scientific committees of ICOMOS, jointly founded in 1968 with ISPRS (International Society of Photogrammetry and Remote Sensing). It exhibits twin responsibilities of keeping up with technology and ensuring its usefulness for cultural heritage conservation, education, and dissemination (CIPA, 2024). In 2014, the most recent version of CDS (V04) was released, which was developed with inputs from CIPA.

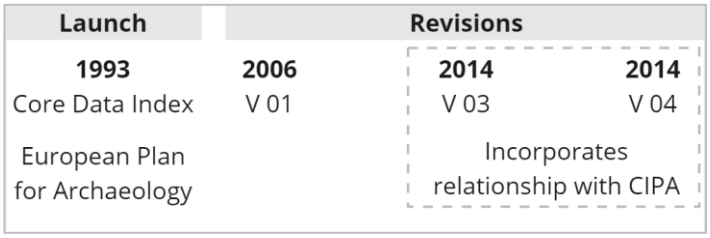

Figure 5. Timeline showing the development of Core Data Standards (CDS) (Source: Author)

CDS was used as a starting step for developing the data structure of arches by defining the data fields in the generic version of the system. The development of Data structure through CDS helps arches to identify the type of data users will be recording, therefore, defining the data fields. Later, the data fields can be mapped to entity classes within CIDOC CRM.

ii) Conceptual Reference Model (CRM)

It was developed by the International Committee of Documentation (CIDOC) of the International Committee of Museums (ICOM). A conceptual framework for describing cultural heritage information and the relationship between entities (Liu et al., 2023). It was first launched in 1999, under the European Plan for Archology, later in 2000 accepted by the International Standards Organization (ISO) as a working draft, for which a special group was formed and it was officially accepted in 2006 as an official ISO Standard information and Documentation, A reference ontology for the interchange of cultural Heritage Information (ISO, 2023).

Figure 6. Timeline showing the development of the Core Reference Model (CRM) (Source: Author)

In Arches, CRM provides the semantic framework to the specified entities i.e. data fields, to help manage the inventories. It provides the definition, a formal structure, and a common semantic framework for mapping the information.

iii) Open Geospatial Consortium (OGC)

The open geospatial consortium is an international community of geospatial experts, dedicated to making location information Findable, Accessible, Interoperable, and Reusable (FAIR) (Consortium, 2023). It provides royalty-free, publicly available, open geospatial standards. In arches, it is used to maintain the interoperability of spatial data between various GIS (Geographic Information System) Applications. It leverages GeoJSON. A widely used open format for representing geographic data, enabling seamless integration with other geospatial information systems.

iv) Other Standards

In addition to its focus on semantic standards, the Arches platform implements a robust set of technological standards. Ranging from JSON-LD for data exchange, REST-API for system communication, and the Library of Congress EDTF for flexible date representation. Furthermore, the platform adheres to the International Image Interoperability Framework (IIIF) for image sharing and is actively working towards implementing the latest W3C Accessibility Guidelines (Arches, 2023). This standard-based approach enables collaboration and efficient data exchange.

The Architecture of Arches

Arches is a geospatially aware system that can access and interpret spatial information. It is specifically designed to present heritage information that has a geographical component. The platform provides customizable definitions of cultural heritage information. It manages controlled vocabularies, to accommodate the data standards defined under different jurisdictions (Shown in Figure 7). Therefore, makes the system customizable according to the specific needs and objectives of the implementing organizations. It is also equipped with search, reporting, and user management capabilities. Providing easy browsing through the data sets.

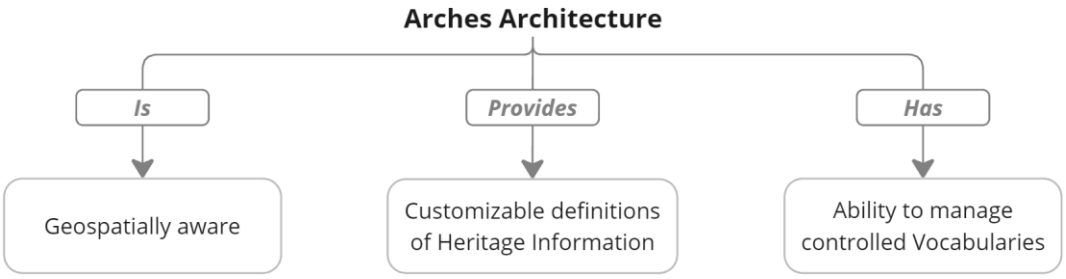

Figure 7. Flow diagram showing the architecture of the Arches Platform (Source: Author)

Arches consist of two components, the arches server, and data management packages (as shown in Figure 8). The arches server is made up of a core system that provides administration and essential services for managing cultural heritage information. It has the ability to implement different data management packages, that follow data standards as defined by their jurisdictions. The initial model developed by Arches has adopted the core data standards package.

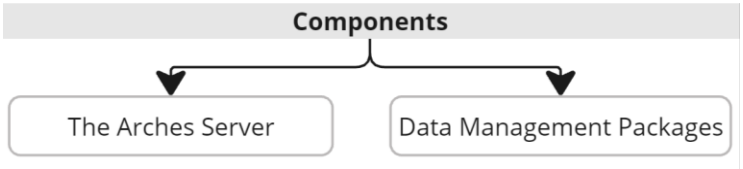

Figure 8. Breakdown of arches platform (Source: Author)

The Organizations implementing arches can customize the server to their specific needs and develop a model that is based on the data package, available in their jurisdiction. Other examples of data management packages are the United States National Register of Historic Places standards, created under the national programme to preserve America's historical and archaeological resources. Based on these types of standards, the arches server can be customized to meet the specific needs of particular jurisdictions.

Data Interpretation

Network science as a discipline, studies and analyses massive datasets and their interdependent relationships providing the underlying wiring diagram of the system (Schneider & Mühlhaus, 2019). The data collected through the servers can be interpreted and analysed through network visualization tools utilizing network science algorithms. They help in analysing the system as a whole and understanding the relationships and

interdependence of various subsystems. Arches utilizes the "Gephi" software package for visualizing the relationships between the data as specified in the CIDOC CRM. Gephi is an open-source network exploration and manipulation tool that utilizes real-time 3d rendering, to interpret large data sets (i.e. over 20,000 nodes) (Bastian et al. 2009). Gephi algorithm works on a multi-core processing model, that enables users to perform multiple tasks at similar times. It uses a specialized "force-directed algorithm" that offers real-time graph customizations.

The output file of Gephi is simple, machine-readable, and ready for import into the Arches server. It is in the form of nodes and edges. The nodes represent the data elements, and the edges represent the relationship between these elements.

Ontologies

Depending on the domain, the "ontology" word can differ in its meaning. To get a better understanding, we can consider two perspectives. The first discusses Ontology as a discipline of philosophy, that deals with the nature and structure of "reality." It was defined by Aristotle as the science of "being qua being," i.e., the study of attributes that belong to things because of their very nature (Guarino et al. 2009). It studies the nature and structure of things, without considering external factors including their physical existence. Whereas experimental sciences seek to model and understand reality from a certain approach. The second perspective is the computer science domain, which discusses ontology as a structured blueprint for organising information (Thomas et al. 2018). Computer scientists focus on a specific type of information object and study their structure and how it functions within a computer system. In the context of Artificial Intelligence (AI), the concept of physical existence can be represented pragmatically. In AI, what exists is defined as what can be represented within the system. Therefore, in this case, existence is not about physical or metaphysical reality but about the ability to model or symbolize entities and their relationships within the AI's framework (Russel & Norvig, 2012). Formal ontologies were introduced in computer science to describe common conceptualisation behind multiple schemata, and not to become a synonym of schemata (Guarino et al., 2009).

There are four main types of categorisations for ontologies, ranging from generalized to performing specific tasks. Each category is suited to different levels of detail as can be seen in Figure 9 (Haller & Polleres, 2020). Upper ontologies provide very basic categories like "object" or "action". Mid-level ontologies delve deeper into broader domains like space or society, offering some relevant concepts. For cultural routes, a domain ontology is ideal as it focuses specifically on a particular domain of cultural routes. Also building upon an existing mid-level ontology like CIDOC CRM and adding concepts relevant to cultural routes, such as pilgrimage activities or themed locations would be beneficial to utilize the ecosystem of an existing well-established ontology. Finally, use-case ontologies target specific tasks, like managing pilgrimage routes by a specific organization.

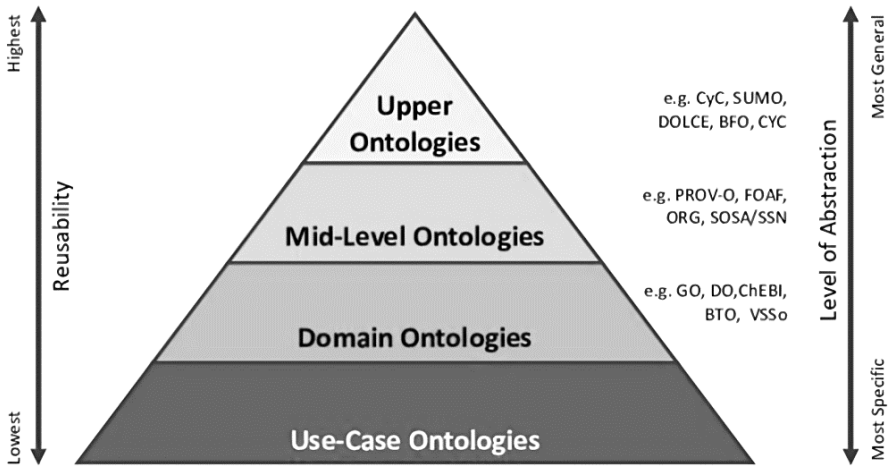

Figure 9. Abstraction of Ontologies; Source: (Haller & Polleres, 2020)

Limitations of CIDOC CRM in Digitizing Cultural Routes

As Cultural Routes are complex and dynamic systems that weave together the tangible and the intangible elements in space and time (Dominioni, 2020), they possess unique features as well as challenges while digitally archiving using existing frameworks. This section of the research delves into identifying various limitations of the existing CIDOC CRM ontology, which restricts in digitizing the cultural route narratives. The further discussion is divided into four categories that represent the shortcomings of the existing ontology. These categories will be further used as a baseline for the customization framework.

- ***Networked Structure***

CIDOC CRM provides a comprehensive framework for representing individual entities and their relationships. However, cultural routes are complex and intricate networks of places, activities, and communities. Therefore, digitising the route as a whole, rather than its individual sections comprising an inventory of all the assets along the route, is crucial. This will help in archiving various perceptions of the same route as per different cultures and nations.

- ***Thematic Focus***

The existing ontology struggles to capture the overarching theme of the cultural route. These themes such as Pilgrimage, Trade, Artistic exchange, etc are essential to depict the core purpose and significance. In some cases, a route can also possess more than one theme. The ability to capture these overall themes will enable the framework to digitally archive the essence and driving force behind the route's existence.

- ***Spatio-temporal Scope***

While existing ontologies provide a basic framework for archiving the dimensions of space and time, they might not fully capture the intricate spatiotemporal relationships and characteristics of cultural routes. These routes often traverse vast areas, and their significance evolves over time (ICOMOS Australia, 2023). Existing ontologies may struggle to capture the territorial extent of the route and its relationship with its historical development. These territorial scopes are also subject to change over time, expanding or contracting based on the route's influence.

- ***Intangible Heritage***

Cultural Routes are dominated by their intangible elements. This dominance highlights the need to establish a connection between the tangible and intangible elements. However, the existing ontology lacks a framework to capture the rituals traditions, stories and knowledge passed down through generations that give the route its significance.

Discussion

While existing ontologies like CIDOC CRM offer a strong foundation for representing cultural heritage, they do not fully capture the unique characteristics of cultural routes. The customization approach leverages the strengths of CIDOC CRM while addressing its limitations for cultural routes. It utilizes the core classes and properties of CIDOC CRM as a solid foundation. Upon this base, the framework introduces sub-classes and properties specifically designed to capture the unique characteristics of cultural routes. These new additions play a crucial role by establishing connections between existing and newly introduced elements, ensuring a comprehensive framework.

As previously discussed, the framework focuses on four key aspects of cultural routes that were identified as limitations: Networked Structure, Thematic Focus, Spatiotemporal Scope, and Intangible Heritage (as shown in Figure 10).

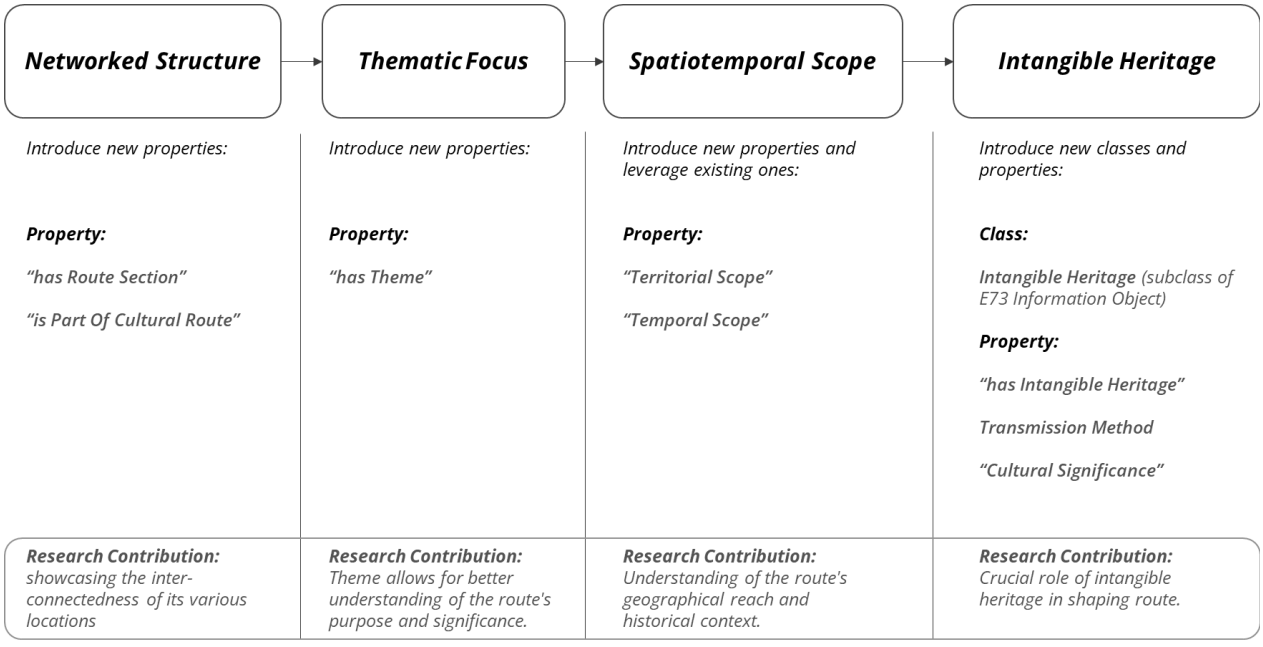

Figure 10. CIDOC CRM Customization Framework for Cultural Routes (Source: Author)

To represent the networked structure of cultural routes, new properties can be introduced. A "Has Route Section" property links the "Cultural Route" class to individual sections along the route, and the property "Is Part of Cultural Route" does vice versa. This approach allows for mapping the route as a network, capturing the interconnectedness of its various locations.

Thematic focus defines the route's purpose which can be pilgrimage, trade, etc, and is addressed by introducing a "Has Theme" property. This property links the "Cultural Route" class to a concept describing the overarching theme. This fosters a deeper understanding of the route's significance.

The spatiotemporal scope necessitates new properties and leveraging existing ones. The "Territorial Scope" property describes the route's geographic reach, potentially linking to existing location classes. Another property "Temporal Scope" describes the historical period(s) associated with the route. Additionally, existing properties like "P194 is located in" can link route sections to the broader territories they traverse. These elements provide a clear picture of the route's geographical reach and historical context.

Finally, addressing intangible heritage is crucial. A new "Intangible Heritage" subclass of "E73 – Information object" emphasizes the importance of these elements. "Has Intangible Heritage" property connects the "Cultural Route" class to the "Intangible Heritage" class. Likewise, the "Transmission Method" and "Cultural Significance" properties capture how intangible knowledge is transmitted and its importance to the route. It also acknowledges the crucial role of intangible heritage in shaping the cultural significance of the route.

This approach ensures a more comprehensive representation, encompassing both the physical locations, objects, and activities (tangible) alongside the cultural traditions, narratives, and experiences (intangible) that define these routes. Furthermore, by building upon CIDOC CRM, the framework promotes interoperability, allowing seamless integration with existing cultural heritage information systems. This standardization facilitates efficient data exchange and collaboration within the community. By incorporating existing vocabularies related to cultural heritage or specific regions, descriptions become richer and more consistent across projects. Documenting the mapping decisions between the ontology and these vocabularies ensures clarity and simplifies future maintenance. Additionally, employing formal knowledge representation methods and adhering to scientific principles during development guarantees a rigorous and well-grounded ontology.

However, the success of this framework lies in collaboration with cultural heritage experts like archaeologists, historians, and route specialists. Their input is crucial for ensuring the ontology's relevance and accuracy. In addition, implementing a validation process and continuously refining the ontology based on feedback and emerging knowledge is essential for its long-term effectiveness.

Following this comprehensive framework and considering these practices, can ensure a future-proof ontology for digitally archiving cultural routes. Since knowledge is constantly expanding, the framework for representation should also evolve. Therefore, timely revisions are crucial. This will not only ensure the preservation of these unique pathways for generations to come but also unlock new avenues for research, analysis, and a deeper appreciation for the rich tapestry of human experience they represent.

Conclusion

Existing ontologies provide a strong foundation for mapping cultural heritage. However, this research highlights the need for customizations to the existing ontological framework to digitally archive cultural routes. The proposed framework in this study addresses four key aspects of cultural routes: (i) networked structure, (ii) thematic focus, (iii) spatiotemporal scope, and (iv) intangible heritage. This integrated approach leverages CIDOC CRM's strengths while incorporating new elements to capture their unique features. By fostering an understanding of these routes as dynamic pathways, continuously evolving and expanding in space and time. This research paves the way for future development, with potential areas for exploration including user-generated content and multilingual support. By continuing to refine and expand ontologies through community involvement, formalization, and validation, we can ensure the effective preservation of cultural routes for future generations.

Acknowledgement

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Conflict of Interests

The author declares no conflict of interest.

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