Covering the Semantic Space of Tourism – An Approach based on Modularized Ontologies

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ABSTRACT
Personalized online tourism services play a crucial role for tourists. In order to deliver adequate information, a semantic matching between tourism services and user context is needed. In the phase of trip planning, the essential user context comprises primarily user preferences and interests, while during the trip location and time context are added. While being on the move, unexpected events might force tourists to completely reschedule their travel plan and look for alternatives. In order to facilitate semantic matching between alternative touristic sites and user context, a specific vocabulary for the tourism domain, user type, time and location is needed. We demonstrate in this paper that existing tourism ontologies can hardly fulfill this goal as they mainly focus on domain concepts. The goal of this paper is to provide an alternative approach for covering the semantic space of tourism through the integration of modularized ontologies, such as user, W3C Time or W3C Geo, that center around a core domain ontology for the tourism sector.

Categories and Subject Descriptors
H.3 [**Information Storage and Retrieval**]: Information Search and Retrieval

Keywords
modularized tourism ontology, user profiling, semantic matching, ontology development, e-tourism

1. INTRODUCTION
Travel and tourism is commonly known as an information-intensive domain where online information plays a crucial role for the whole life-cycle of a journey, covering the *pre-trip*, *on-trip* and *post-trip phase*. During the last couple of years, the emergence of ontologies led to fundamental enhancement of web-based travelling and information systems towards semantic technologies. An *ontology* is a specification of a conceptualization [18] and provides a description of the domain of interest. The application of ontologies has the potential to cope with a number of challenging requirements related to the tourism sector. Firstly, having a common semantic base compensates the *interoperability problem* [15] that comes along with the integration of heterogeneous data sources. Secondly, an ontology provides a formal basis which is the prerequisite for *formal rule statement creation* and *inferential analysis* in the tourism domain [9]. Thirdly, an ontology provides enhanced possibilities for *information search* and for *automatic discovery*, *negotiation* and *adaptation/ personalization* of tourism services [8].

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Personalization plays an important role in e-tourism as tourists expect to get access to information about tourism objects (e.g., hotels, flights or important points of interest) as well as services (e.g., search for suitable hotels, receipt of flight notifications or weather forecast) that is tailored to their current context. For the given purpose, user context is conceived as defined by Dey and Abowd [11] as "*any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.*"

In the course of *trip-planning*, the profile of a tourist, including *interest* and *preferences*, has to be captured and formalized in order to provide personalized information about destinations, hotel offers or activities that may be consumed at the destination.

During the trip, tourists act in a highly mobile environment and require travel-related information that is tailored to their location [19]. While being mobile, it is further crucial for tourists to receive *up-to-date* information, as travel-related information is obviously subject to dynamic changes. Attractions can be temporarily closed, restaurants can change their special offers on a weekly basis, and open-air concerts can be cancelled due to bad weather conditions. These unexpected events might force tourists to completely reschedule their trip plan and look for alternatives.

In order to cope with unexpected situations, tourism services have to be *context-aware* [33]. Hence, they require to store and process contextual data in a machine processable form. A number of *context modeling approaches* [1] exist that differ from each other with respect to the data structures used for the representation and exchange of contextual information.

Ontology based models are a promising approach for modeling contextual tourism information because of their relatively high expressiveness and reasoning capabilities in order to infer additional higher level concepts by automatic classification [26]. By reasoning over service/user profiles and the actual context of the user, personalized services and information can be provided based on *matching techniques* between prospect *tourist demands* and *service offerings*.

The following example explains how three semantic sources can be aligned in order to relate certain types of attractions to the preferences and interests of tourists. These interests can be aggregated to describe certain *tourist types* such as an *art lover*.

Using this approach, the semantic mapping can take place on a *more abstract level*, i.e., between tourist objects and tourist types.

A geographical knowledge base of the city of Vienna might contain the statements:

```
austrian_theatre_museum a geo:Site;
isLocatedIn vienna.
```

A destination management organisation might have defined the additional statement:

```
austrian_theatre_museum isAttractiveFor [a
Person, hasAge > 10, interestedIn Art].
```

The official Vienna tourism board might have developed a tourism ontology including following statements:

```
ArtLover a Person, interestedIn some Art.

CulturalAttraction ≡ isAttractiveFor some
ArtLover.
```

Based on these concept definitions and by leveraging the pertinent information from the other semantic sources, it is possible to infer that the Austrian theatre museum is a cultural attraction for tourists currently staying in Vienna, who are interested in arts.

In order to facilitate *semantic matching* between tourism objects and user context, a specific *vocabulary* for the (tourism) *domain*, *user type*, *time* and *location* is needed. As we will discuss in this paper, existing tourism ontologies can hardly fulfill this goal as they focus on the domain concepts, thereby neglecting essential vocabularies, like user context or location.

The goal of this paper is to provide an alternative approach for covering the *semantic space of tourism* through the integration of *modularized ontologies*, that center around a *core domain ontology* for the tourism sector. Based on the evaluation of existing tourism ontologies (cf. Section 2), we developed a **c**ore **D**omain **O**ntology for **T**ravel and **T**ourism (**cDott**), which is outlined in Section 3. In Section 4, we further show the integration of other ontologies, such as the W3C Time [39] and the W3C Geo [38] ontology, that are relevant for modeling user context information. In addition, we demonstrate interesting concepts of the cDOTT vocabulary, such as classifying travelers into tourist types and match them to appropriate activities (e.g., bungee jumping). Section 5 summarizes the lessons learned and concludes the paper with future work.

2. RELATED WORK

Recently, there is a proliferation of ontologies (Harmonise [15], an OWL Ontology for E-Tourism [4], ebSemantics [13], DERI OnTour [10], EON Traveling ontology [14]) that have been developed in the area of e-tourism either by industry, academia or within collaborative projects. We analyzed various relevant tourism ontologies, which are described below. According to our evaluation, they show following shortcomings:

- Their vocabulary covers only a limited set of tourism concepts, due to a restricted application scope.
- They hardly integrate existing, domain-independent ontologies, that already define commonly used concepts such as time, currency or geo-location.
- They often contain a diversified mix of concepts, thus making ontology mediation and (automatic) exchange of data a difficult task.

The QALL-ME Ontology. QALL-ME [30] is an EU-funded project that aims at establishing a shared infrastructure for multilingual and multimodal question answering in the tourism domain. Thereby, it allows users to pose natural questions in different languages using a variety of input devices and returns a list of answers in the most appropriate modality. The QALL-ME ontology provides a conceptualized description of several aspects of the tourism domain, including *tourism destinations*, *tourism sites*, *tourism events* and *transportation*. It contains 122 classes and 107 properties that indicate the relationships among the classes. QALL-ME is encoded in the ontology language OWL-DL.

The Harmonise Ontology. The Harmonise [5] ontology, initially developed within the Harmonise project, is now the central element within the HarmoNET (Harmonisation Network for the Exchange of Travel and Tourism Information) that aims to create an international network for harmonization and data exchange in the tourism industry. The ontology focuses on two sub-domains of the tourism domain, namely events (e.g., conferences, sport) and accommodation (private rooms, hotels, guesthouses), modeled in the language RDFS. Members of this network can share data by mapping their specific data model to the Harmonise ontology, which acts as the central data model of the network. The mapping proceeds at the site of each individual member, since there is a proprietary mapping between the member's legacy system and the Harmonise ontology.

The Hi-Touch Ontology. The Hi-Touch ontology [27] was developed during the IST/CRAFT European Program Hi-Touch, which aimed at establishing Semantic Web methodologies and tools for intra-European sustainable tourism. The goal was to formalize knowledge on travelers' expectations and to propose customized tourism products. The ontology was mainly developed by Mondeca[1] and is encoded in the ontology language OWL. The ontology classifies tourist objects, which are linked together in a network by semantic relationships. The semantic network is provided by a Topic Map. The top-level classes of the Hi-Touch ontology are *documents* (any kind of documentation about a tourism product), *objects* (the tourism objects themselves) and *publication* (a document created from the results of a query, e.g., a PDF document). The tourism objects can be further indexed by keywords using the thesaurus on tourism and leisure activities by the World Tourism Organisation [41]. This standard terminology ensures the consistency of the tourism resources categorization managed on distributed databases and enables semantic query functionalities.

Further ontologies. The *DERI e-Tourism ontology* [10] was developed by STI Innsbruck. The ontology focuses on the description of accommodations and infrastructure and enables a user, who queries a tourism portal to find a package of relevant accommodations and infrastructure. The *Travel Agent Game in Agentcities* (TAGA) [36] is an agent framework for simulating the global travel market on the Web. The TAGA ontology defines travel concepts such as *itineraries*, *customers*, *travel services*, and *service reservations* as well as different types of *auctions*. The *GETESS* (German Text Exploitation and Search System) [34]

[1] http://www.mondeca.com

project focused on retrieving information from touristic websites. This information is semantically interpreted and can be queried by the user through natural language processing techniques. The *EON Travelling Ontology* [14] was developed by the Institut National de l'Audiovisuel in France. It describes tourism concepts that are divided into *temporal entities* (e.g., reservations) and *spatial entities*, which further comprise *dynamic artefacts* (e.g., means of transportation) as well as *static artefacts* which comprise *town sights* or *lodging facilities*.

3. A MODULAR STRUCTURE OF ONTOLOGIES COVERING THE SEMANTIC SPACE OF TOURISM

Due to the heterogeneity of the tourism sector, the process of developing and maintaining a *single tourism ontology* that covers the whole tourism market, including geographical-, temporal-, and user-related information would be very tedious [5] and would require an agreement on a shared vocabulary between the different tourism organizations. Hence, in order to cover the semantic space of the tourism domain and to facilitate interoperability between the different tourism services, a bundle of ontologies may be required. However, these ontologies are not disconnected, but should be integrated around a *core domain ontology*, as proposed by the methodology in [35]. In detail, the core ontology should contain the common vocabulary of the tourism sector and can be *extended by other ontologies* in a modular way, such as ontologies for modeling time, location or user context.

In this light, there is an urgent need for developing a core ontology, which adheres to a strict teleological orientation. With respect to the tourism domain, a core domain ontology needs to describe travel-related information, which is typically provided by tourist services in order to satisfy the information needs of tourists in all phases of a journey, on a conceptual level. The main concepts to be defined are *tourism objects* (i.e., attraction, food&service, accommodation, transportation and infrastructure), *tourism events* (e.g., music festival) as well as *tourism destinations* (e.g., national park or lake region) [32]. New concepts can be added through the integration of peripheral ontologies, including a *time pattern ontology* (e.g., in order to model recurring events), a *user ontology* (e.g., to model personal data, preferences or travel budget available) or an *e-commerce ontology* (e.g., to model service offerings). In case of conflicts, the concepts involved need to be modified in order to ensure compatibility with the core vocabulary. The integration of other ontologies enables concept expansion and reasoning. This approach leads to a *loose coupling* of ontologies, while retaining *flexibility* and *extensibility*. The benefit of this methodology is the ability to leverage existing concepts and enrich tourism objects with semantic annotations using controlled vocabularies, thereby assigning new semantic roles to tourism objects.

3.1 Mosaic-Ontology-Model

The modular structure of integrating different modular ontologies around the core domain ontology is explained by the proposed Mosaic-Ontology-Model. Figure 1 depicts the linkage between cDOTT and other pertinent ontologies. cDOTT is symbolized through the mosaic block in the center of Figure 1.

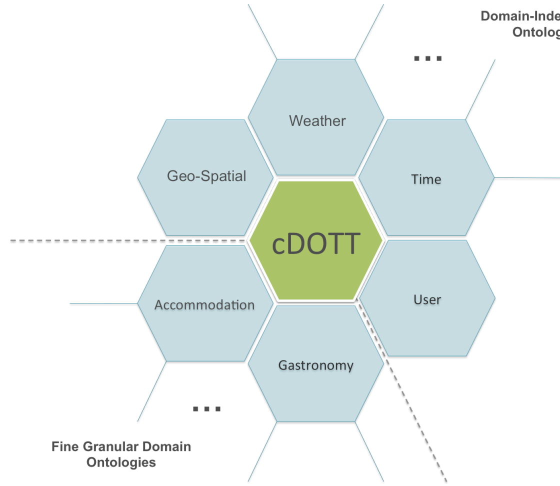

Figure 1. The Mosaic-Ontology-Model Depicting the Integration of Modularized Ontologies

Thereby, cDOTT acts as the core domain ontology and covers the relevant tourism vocabulary. As shown in the model, cDOTT co-exists with other, modularized ontologies that are located around the inner domain ontology. On the one hand, these comprise *domain-independent ontologies* such as a time ontology (e.g., for modeling opening-hours), a weather ontology (e.g., for modeling weather-dependent activities), a geo-spatial ontology (e.g., for establishing a model of tourism destinations), a user-ontology (e.g., for modeling tourists preferences and interests, which are further aggregated to tourist types) and a currency ontology (e.g., for modeling price types). On the other hand, more *fine-grained domain ontologies* such as a gastronomy-, hotel-, transport- or event-ontology can be imported that focus on describing a sub-part of the tourism domain. The selection of these ontologies can be tailored to the purpose of usage. This enables the integration of concepts in a flexible way, thus facilitating the merging of instances from different knowledge bases.

3.2 Ontology Classification

The ontologies in the Mosaic-Ontology-Model can be described according to their level of genericity (cf. Figure 2), using the *classification model* developed in [20].

Top-Level (upper-level) *ontologies* describe general concepts. Ontologies on this level are domain or problem

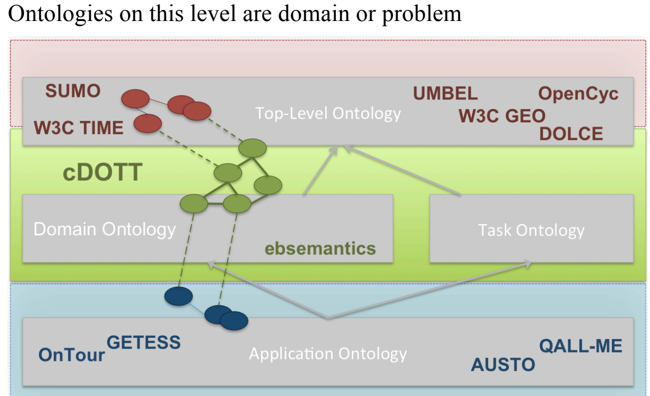

Figure 2. Types of Ontologies and Classification of cDOTT

independent. Several top-level ontologies are available, such as UMBEL[2], SUMO[3], OpenCyc[4], W3C Geo or W3C Time. A domain ontology describes the vocabulary related to a generic domain. Thereby, the concepts introduced in the top-level ontologies are further specialized. Task ontologies describe a generic task or activity, such as the process of booking a package tour, including flight and rental car. Application ontologies are a combination of both, domain and task ontologies. The concepts of an application ontology correspond to roles played by domain objects while performing a certain activity. An example would be an ontology to assist tourists in planning a complete travel solution. As depicted in Figure 2, cDOTT is a domain ontology that contains tourism concepts on a higher-abstract level. In addition, it is related to concepts in upper-level ontologies, achieving the linkage of lower-level and upper-level ontologies.

4. MAIN CONCEPTS OF cDOTT

This section discusses the main concepts of cDOTT related to contextual information such as location, time and tourist types.

cDOTT was developed based on the methods proposed by Uschold & King [6] and Noy & McGuinness [29]. Applying reasoners on top of the ontology following three questions should be answered:

- Which kind of tourist type can be assigned to a user based on his interests and preferences?
- How can tourism objects such as events, attractions or important landmarks be mapped to certain types?
- While staying at a destination, which activities can tourists perform based on given contextual constraints such as current time, available travel budget and opening hours?

cDOTT is based on the published Harmonise ontology [15] as well as on the EON Traveling ontology [14], while including relevant terms from additional ontologies. The ontologies were investigated with respect to their level of maturity, because each of them has been developed under a slightly different purpose. According to this fact, there is only a small overlap of concepts and one has to cope with different naming and distinctive granularity of concepts. In order to counteract these obstacles, cDOTT is defined on a more abstract level, so that existing, more fine-grained tourism ontologies such as the QALL-ME [30] or the DERI OnTour ontology [10] can be easily integrated. On the other hand, cDOTT has a bigger coverage of relevant tourism concepts than the evaluated tourism ontologies.

In order to allow for ontological reasoning over a broad set of data, cDOTT was partly aligned to concepts of the upper-level ontology UMBEL, a lightweight, subject concept reference structure for the Web. In addition, concepts of other upper-level ontologies were integrated, including the W3C Geo & Time-, the FOAF[5]-, a currency[6]- and a country[7] ontology.

In the current version cDOTT contains 578 classes, 75 object properties and 27 data properties. Some concepts are borrowed from existing ontologies such as the EON traveling ontology.

[2] http://www.umbel.org/
[3] http://www.ontologyportal.org/
[4] http://www.cyc.com/cyc/opencyc/overview
[5] http://xmlns.com/foaf/0.1/
[6] http://www.daml.ecs.soton.ac.uk/ont/currency.owl
[7] http://www.bpiresearch.com/BPMO/2004/03/03/cdl/Countries

According to Figure 3, the *Entity* class is one of the top-level classes and comprises the classes *SpatialEntity*, *Spatial-TemporalEntity* and *TemporalEntity*, depending on whether they have a spatial or temporal extension or even a combination of both. *GeographicalRegions* and *Artefacts* are kinds of *SpatialEntities*. *GeographicalRegions* are explained in Subsection 4.3. *Artefacts* can either have a geostationary or changing location. The latter comprises for example the concept *MeansOfTransport*. Means of transportation can be further classified into *InterUrbanMOT*, such as trains connecting destinations or into *UrbanOnlyMOT*, such as *CityBus*, *Under-ground* or *Tramway*. *NonGeostationaryArtefacts* can be further divided into *DependentGeostationaryArtefacts* and *IndependentGeostationaryArtefacts*.

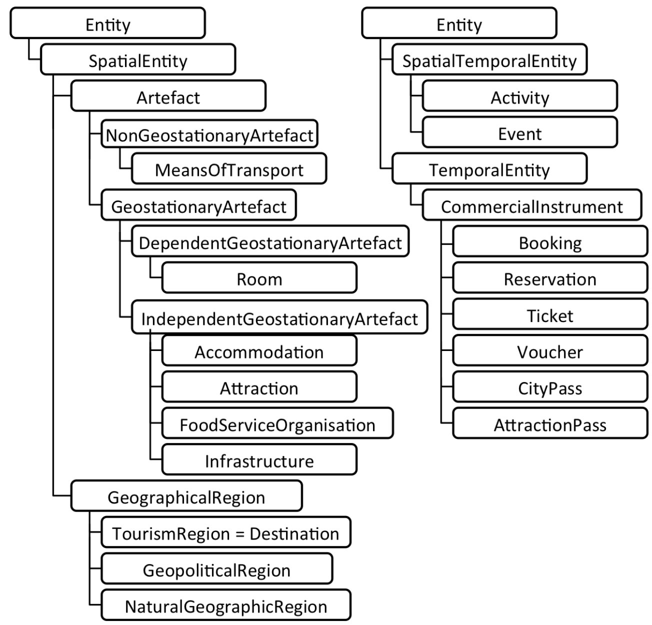

Figure 3. Hierarchical Structure of cDOTT

DependentGeostationaryArtefacts are for example GuestRooms (DoubleRoom, Single-Room or Suite), which are enclosed by another Artefact. *IndependentGeostationaryArtefacts*, that are important for the tourism domain, are *Accommodation*, Attraction, *FoodServiceOrganisation* and *Infrastructure*.

SpatialTemporalEntities have both a temporal and spatial context. They comprise *Activities,* which might be performed at a certain destination and *Events,* which refer to an occurrence with a specific content at a specific location within a certain time period [30]. *Reservations*, *Bookings* or any kind of *Tickets* are *TemporalEntities* as they are valid for a certain time period.

As tourists seek to get personalized travel information that is tailored to their context, their preferences and needs have to be semantically matched to the tourism concepts of cDOTT.

Vogt & Fesenmaier [37] propose a model of information needs of tourists forming a categorization of different types of needs, including functional, hedonic as well as aesthetic needs. Such needs, wants, behavior and expectations of tourists can be further classified into tourist types. Gibson & Yiannakis propose in [17] a set of 15 different tourist types such as *action seeker, active sport tourist* or *independent mass tourist*. Tourists typically engage in a variety of these types, whereby types differ from each other with respect to a different set of interest. As described in [17], the interests of the *thrill seeker* can be described in terms of statements such as "*interested in risky, exhilarating activities which provide emotional highs for the participant*". This description can be modeled in a *tourist-type* ontology. Berger et al. investigated in [2] whether tourist's preferences can be derived from tourism-related photographs in order to facilitate the process of user profile creation.

4.1 Modeling Service / Activity / Tourist Type Relations

Figure 4 depicts the relations between the concepts *service*, *activity* and *tourist type* of cDOTT. Tourism organizations aim at generating profit by offering services that satisfy tourist needs. For example, an adventure company situated in Austria might offer services related to adventure activities, including a *bungee jumping service* offered at the national park *Kalkalpen*, which is a *tourist destination*. Tourists, who visit this destination during their trip, want to know which activities they can perform according to their preferences. If they are assigned to the tourist type *thrill seeker*, the *bungee jumping service* might be suggested to them. The reason for this recommendation is twofold. Firstly, the *bungee jumping service* is related to the activity *bungee jumping*. Secondly, the interest profile of the *thrill seeker* tourist matches the *bungee jumping* activity as both are related to extreme sports.

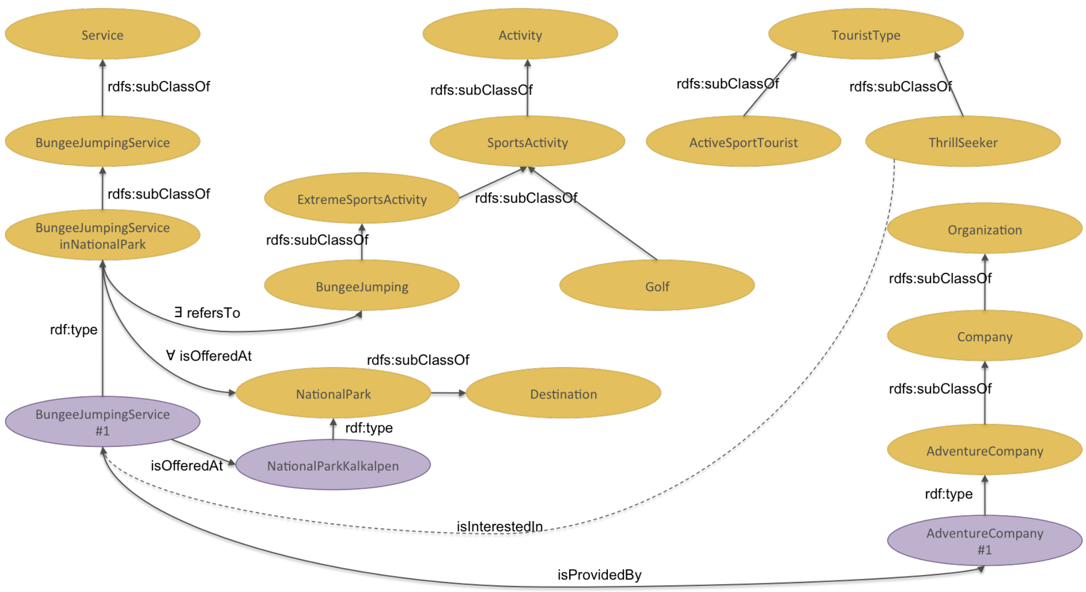

Figure 4. Modeling the Concepts Service, Activity and Tourist Type

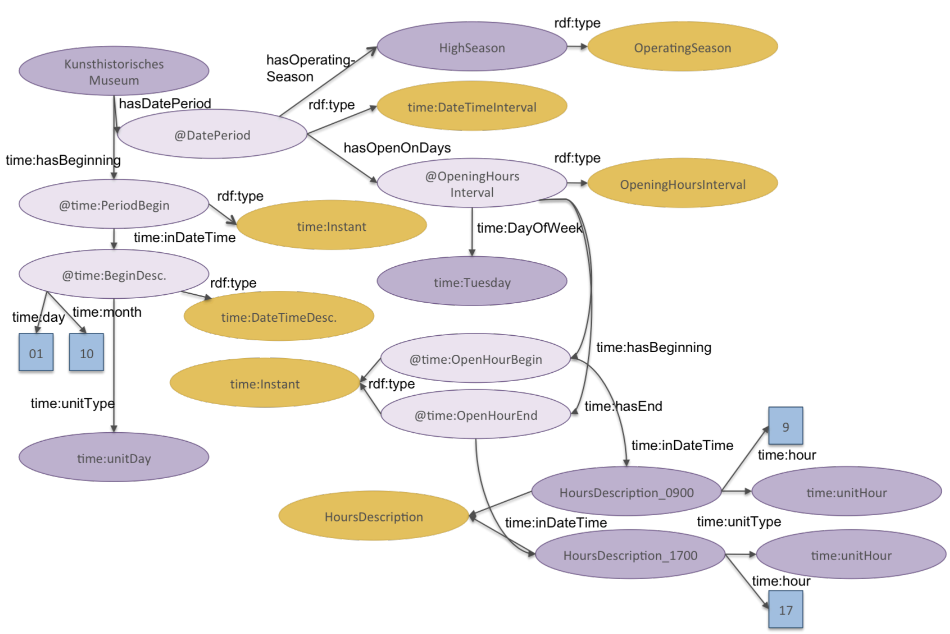

Figure 5. An Example of Modeling the Opening-Hours of a Museum

4.2 Modeling Opening Hours of Tourism Objects

For tourists it is essential to know the opening-hours of tourist objects such as a museum in order to schedule the planned visit. We integrated the W3C time ontology in order to model temporal concepts. This ontology provides a vocabulary for expressing date/time instants, intervals and durations. We used this ontology to describe operating seasons (e.g., high, medium or low season), opening hours as well as opening days of tourism objects. Figure 5 shows the temporal concepts for the national museum *Kunsthistorisches Museum* of Austria. During the high season it opens every Tuesday from 09:00 a.m. to 05:00 p.m. To express this fact, the museum is linked to an instance of type *DateTimeInterval* (*hasDatePeriod*). This instance is further linked to an *OpeningHoursInterval* (*hasOpenOnDays)*. This interval includes both the opening days (*time:Monday, time:Tuesday*, etc.) as well as the opening times, which are of type *time:instant*. An opening time instance is of type *time:unitHour* and linked to a specific XML integer value through the property *time:hour*.

4.3 Defining a Geospatial Model

During a journey tourists usually move from one place to another in order to visit points of interest. These places are located within a *geographical region*, which can be represented as a *tourism region*, a *geopolitical region* or a *geographic natural region* (cf. Figure 6).

Geopolitical Regions. The geopolitical model is based on the regional taxonomy defined by the Open Directory Project[8]. A *Country* must contain at least one *AdministrativeArea*. An *AdministrativeArea* may be a province or a second level administrative area of a province such as a county or department, which allows flexible modeling of sub divisions of an *AdministrativeArea*. *Localities* are populated places or areas with buildings and include *Cities*, *Towns* or *Villages*. Cities and larger towns can be further subdivided into districts. A *District* is a part of a city, e.g., the city of Vienna is divided into 23 districts.

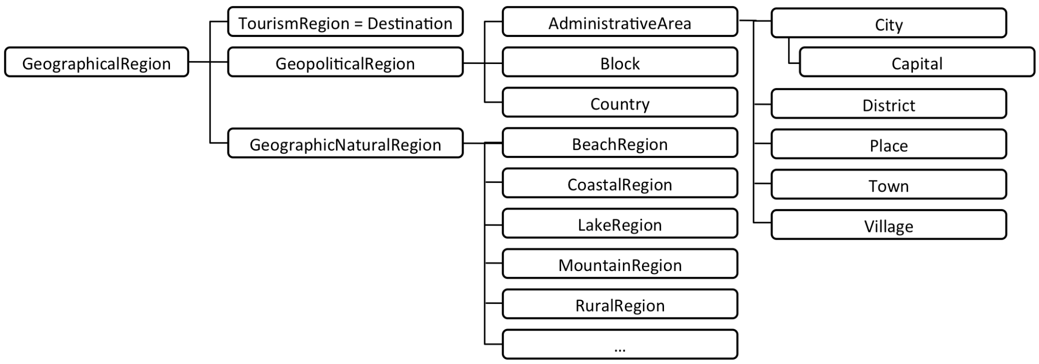

Figure 6. Defining a Geospatial Model

Tourism & GeographicNatural Regions. The class *TourismRegion* is equivalent to a *Destination* and defines those geographical regions that are able to attract a number of visitors by offering a bundle of products, services or natural resources [3]. A *Destination* may contain sub-destinations and may be located within different *GeopoliticalRegions*. An example of modeling geographical- and tourism regions of *Austria* is shown in Figure 7. The central element is the *NationalParkKalkalpen*, which is characterized as both a *TourismRegion* (destination) and a *MountainRegion*. *Ennstal* as well as *Steyrtal* are sub-destinations of the *NationalParkKalkalpen*. *Großraming* is a village (a subclass of locality), which is located in *Ennstal*. The tourism

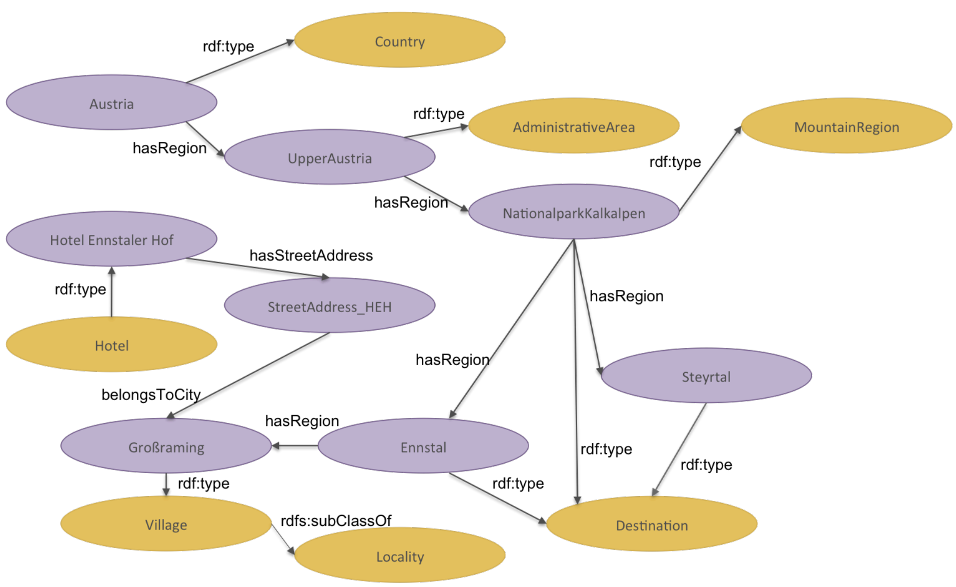

Figure 7. A Geographical Model of Großraming

object *Hotel Ennstaler Hof* – a three star rated hotel – is located in *Großraming*. In addition, the national park belongs to the Austrian province *Upper Austria*, which is an instance of the class *AdministrativeArea*.

5. LESSONS LEARNED

In this Section, we briefly summarize the results of the evaluation of existing tourism ontologies and discuss the experiences we gained during the development of cDOTT.

Semantic Matching between Tourism Objects and Tourist Types. Existing tourism ontologies neglect to model user preferences, which are fundamental to provide personalized information about tourism objects. In the tourism domain, these user preferences can be aggregated to a set of tourist types. We successfully demonstrated how to relate user preferences and domain knowledge by mapping tourist types to tourism objects on a conceptual level.

Temporal Context of Tourism Objects. Information about tourism objects is of little value without a valid temporal description. Receiving up-to-date information about events, opening-hours of points of interest, or delays of means of transportation is essential for tourists in order to have a successful trip. Existing tourism ontologies rather neglect temporal information. Some of them create proprietary concepts to model time or date periods. We demonstrated the successful integration of the upper-level W3C time ontology, which provides a variety of temporal concepts. Modeling even simple temporal statements can be cumbersome and often results in creating complex, nested structures. Moreover, common tourism time patterns such as recurrent events, e.g., yearly festivals, are not supported by this time ontology.

Location Context of Tourism Objects. Information needs in the tourism domain are typically assigned to a geographical context. Current ontologies rather use a simple geospatial model. We proved that applying a geographic model of different kinds of regions can lead to more appropriate search results than just taking into account the environment of the tourist.

Boolean Values and the Open World Assumption (OWA). Organizations tend to store their data in relational databases, thereby following a closed world assumption. This means that if something cannot be found in these databases, it is assumed to be absent and therefore false. As the uplifting of existing resources to an ontological level is a very labor-intensive process, using Boolean values in ontologies is still a common way, although it is regarded as a bad style. Following example does not model the intended semantics:

```
CafeSacher live-music ‘true’
```

Does this mean that there is live music? Every day or at certain recurrent days? How do we get information about the band? What, if the boolean value is missing at all? In this case, a database would infer that the café Sacher does not offer live-music. However, the OWA assumes incomplete information by default, which means that a fact can be true even if it is not present in the knowledge base. Something is false only if it can be proved to contradict other information in the ontology.

[8] http://www.dmoz.org

In the near future, we will work on the integration of further ontologies in order to extend the vocabulary of cDOTT. One important task will be the development of a time-pattern ontology in order to model recurring events (e.g., a music series takes place biweekly every Monday) as the standard W3C Time ontology lacks this feature. Another task will be the evaluation of existing e-commerce ontologies (e.g., the GoodRelations Ontology [21]) in order to describe tourism-related services, such as bungee jumping for a specific price to a certain user group at a certain location and time. Further research will also target the exploitation of cDOTT for selected tourism scenarios, such as semantic (Web) information extraction or context-aware reactive trip planning.

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