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What is that place for?

The role of affordances in gazetteer integration

by

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Declaration of Authorship

I, Germán Carrillo, declare that this thesis titled, "What is that place for? The role of affordances in gazetteer integration" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
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- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
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ABBREVIATIONS

AI	**A**rtificial **I**ntelligence
ETS	**E**xtreme **T**agging **S**ystems
FOAF	**F**riend **O**f **A** **F**riend
HCI	**H**uman-**C**omputer **I**nteraction
HTML	**H**yper**T**ext **M**arkup **L**anguage
HTTP	**H**yper**T**ext **T**ransfer **P**rotocol
INSPIRE	**IN**frastructure for **SP**atial **I**nfo**R**mation in **E**urope
ISO	**I**nternational **O**rganization for **S**tandardization
JSON	**J**ava**S**cript **O**bject **N**otation
KOS	**K**nowledge **O**rganization **S**ystems
NFL	**N**ational **F**ootball **L**eague
LOD	**L**inked **O**pen **D**ata
OGC	**O**pen **G**eospatial **C**onsortium
OWL	**W**eb **O**ntology **L**anguage
POI	**P**lace **O**f **I**nterest
RDF	**R**esource **D**escription **F**ramework
SPARQL	**S**PARQL **P**rotocol **A**nd **R**DF **Q**uery **L**anguage
SQL	**S**tructured **Q**uery **L**anguage
TGN	**T**hesaurus of **G**eographic **N**ames
URI	**U**niform **R**esource **I**dentifier
XML	E**X**tensible **M**arkup **L**anguage
W3C	**W**orld **W**ide **W**eb **C**onsortium

To my family…

1

INTRODUCTION

Gazetteers are a key component of georeferenced information systems (Keßler et al., 2009). They translate everyday language (in the form of placenames) into precise location instances (represented by georeferenced shapes) (Goodchild, 1999; Hill, 2009). Since the information they contain is mostly local, there is a recognized need for establishing ways of integrating gazetteers (Hill, 2009).

The most basic gazetteer model is the triple: placename, footprint, and feature type (Hill, 2000). A single place can have multiple instances of any element of such a triple. However, that place representation, and extensions based on it, has proven to be insufficient for place disambiguation (Hastings, 2008). Places simply do not fit into a single feature type since they may hold multiple and even versatile functions. A broader account of place is therefore required (Scheider and Janowicz, 2010).

Places have a strong social component. They are social constructs whose importance stems from their functional meaning (Heft, 1996). They allow humans to perform social activities due to both, the properties of the place and the characteristics and capabilities of humans. This reciprocal nature might be captured by the notion of affordances, introduced by J. Gibson in the realm of ecological psychology. Affordances are what the environment offers the animal, they relate and depend on both (Gibson, 1986).

Places afford specific activities to humans (Heft, 2007). Affordances of places, unlike physical affordances, might not be directly perceived by humans. This is due to the fact that places are not objects, but more complex structures; thus we need to switch the scale for studying them. Social experiences and conventions play a role in advertising affordances of places.

This thesis aims to answer two research questions: 1) How can gazetteers deal with affordances of places?, and 2) What is the role of affordances in gazetteer integration?

The use case corresponds to bicycle touring. A cyclist undertakes an international tour, requiring different kinds of accommodation at various towns, cities, and countries along the way. His challenge is to find places to stay accounting for local feature types. Linked Open Data serves as framework for the use case and SPARQL queries help solve the cyclist requirements based on affordances of places included in local gazetteers.

The remainder of this document is structured as follows. In Chapter 2 the research questions as well as the methodological approach are stated; in Chapter 3, the state of the art in affordance-based gazetteers is presented, followed by the analysis, modeling, and implementation of an affordance-based gazetteer in Chapter 4; the development of the use case can be found in Chapter 5 and a general discussion of the results of the thesis are given in Chapter 6. Finally, conclusions are drawn for summing up the thesis.

2

RESEARCH QUESTIONS AND METHODOLOGY

Despite the acknowledged advantages that affordances bring to models of place (Janowicz et al., 2012; Jordan et al., 1998; Scheider and Janowicz, 2010), gazetteer research has not been interested in them yet (see Section 3.2.1). This thesis intends to broaden our understanding on affordances in the context of place information retrieval and seeks to identify caveats and challenges in their inclusion. Both single and distributed gazetteers will be taken into account, which leads to the following research questions:

Research Question 1. How can gazetteers deal with affordances of places?

The first research question entails a thorough literature review on affordances, place models, and gazetteers. Analyzing different views on affordances is fundamental to understand how they can help place models to include crucial aspects of place that so far have been overlooked in information systems. The expected outcome is a gazetteer model including affordances of places (see Chapter 4).

In concrete, based on a comprehensive literature review, which is a must to get an understanding of the topic, we intend to extract the main characteristics of affordances in order to select a suitable way of representing them in gazetteers in the context of place information retrieval. Special attention will be taken regarding questions like: What are affordances? What are the affordances of places? What of those affordances of places are relevant for gazetteers? Next, a number of requirements that an affordance-based gazetteer should meet will be extracted from the literature as well as from our own analysis. These requirements cover relevant classes and relationships between classes, as well as queries that an affordance-based gazetteer would add to conventional gazetteers. From the requirements, a model will be designed and implemented as a vocabulary in Linked Open Data, which will be shared online as a resource for others to evaluate and extend this work.

Research Question 2. What is the role of affordances in gazetteer integration?

The second research question aims to evaluate through a use case how affordances can help integrate gazetteer information. We intend to evaluate gazetteer integration

through the implementation of four scenarios occurred in a touring cyclist's journey. Every scenario occurs in a different country, which gives the use case a colorful bunch of situations and troubles that an affordance-based gazetteer will sort out (see Chapter 5).

The vocabulary elaborated as outcome of the first part of the thesis will be taken as a basis for implementing the use case. We intend to select real scenarios that involve relevant information provided by affordances to solve a problem occurred during a touring cyclist's journey. For example, we will account for affordances of places that help distinguish them among others. We will try to select scenarios in different countries to simulate local gazetteers. The data will be collected from the Internet reflecting faithfully local feature typing schemes, placenames, and affordances of places. The data will be then structured as Linked Open Data and uploaded to a triple store, from which it is possible to perform SPARQL queries. At the end, we will evaluate how the affordance-based gazetteer answers the cyclist requests and how standard the procedure is for solving each scenario (remember that they occur in different countries), which could give us a hint on the appropriateness of the affordance-based approach over conventional gazetteers.

3

STATE OF THE ART IN AFFORDANCE-BASED GAZETTEERS

3.1 Gazetteers

Gazetteers are a key component of georeferenced information systems (Keßler et al., 2009). They provide a mechanism to translate daily language (in the form of placenames) into precise location instances (represented by georeferenced shapes) (Goodchild, 1999; Hill, 2009). This is known as indirect georeferencing (Hill and Zheng, 1999) and constitutes the core of a large number of applications that involve geographic information nowadays.

In the context of digital information retrieval, a gazetteer is a triple composed of a placename, a footprint, and a feature type. These are known as the three core elements of a gazetteer (Hill, 2000). Variations of the same component must be supported. In fact, it is very common to have multiple placenames, footprints, and categories referring to the same place. This situation is more evident when searching for a place in several distributed gazetteers.

For instance, an environmental community might refer to Colombian forests as *Dry forests*, *Andean forests*, and *Cloud forests*, among others, whereas for a global geographic dataset, these might be described only as forests. If members of the environmental community search on the global dataset they will face problems since the feature types used in it are not specific enough for their purposes.

3.1.1 Gazetteer models and gazetteer interoperability

The three core elements are rarely implemented in isolation and a number of new elements are included when modelling gazetteer data, e.g., time, data source, and relationships, such as *part-of* or *capital-of*, among others (Hill, 2009). The selection of the gazetteer elements is up to authorities or communities and may be driven by the project objectives. For instance, historic gazetteers would definitely use time, but its inclusion in other gazetteers has been rather optional.

Gazetteer data is better described and maintained by local communities or authorities (Janowicz and Keßler, 2008), which leads to the need of establishing ways of communicating and searching between them (Hill, 2009). There have been attempts to standardize and guide gazetteer development through specifications of gazetteer models (e.g., the *Spatial referencing by geographic identifiers*[1] by ISO, the *Gazetteer Service - Application Profile of the Web Feature Service Best Practice*[2] by OGC, and the *INSPIRE Data Specification on Geographical Names - Guidelines*[3] by INSPIRE) as well as through higher-level models called protocols (e.g., the *Alexandria Digital Library Gazetteer Protocol*[4]), intended to be much more global, and thereby, flexible.

The following are interoperability use cases for distributed gazetteers (Goodchild and Hill, 2006): harvesting (aggregation of gazetteer data), lookup (finding a place by name), reverse lookup (finding places and feature types located at certain coordinates), geoparsing (identifying placenames in texts and locating their corresponding shapes), ontology-based reasoning (inferencing over place relationships), and conflation (Hastings, 2008) (the combination of diverse place representations into a single instance).

Interoperability between distributed gazetteers has been a research topic over the last decades (Goodchild, 1999). The three core components of gazetteers lead to interoperability issues in gazetteer integration, though it is the feature type that imposes more challenges because they are created with a wide variety of purposes, thematic scopes, and spatial scales (Janowicz and Keßler, 2008).

3.1.2 Dealing with feature types

Besides unstructured feature type lists, thesauri have been employed for establishing relationships (namely, hierarchy, equivalence, and associative ones (Hodge, 2000)) between feature types (Hill and Zheng, 1999), and in general, between gazetteer instances (see the Getty Thesaurus of Geographic Names[5] (TGN)). A more sophisticated approach in the context of Knowledge Organization Systems (KOS) is given by ontologies. An ontology is defined by Gruber (1993) as "an explicit specification of a conceptualization." Ontologies have been proposed and recommended for feature types (Janowicz and Keßler, 2008) because they enable dealing with more complex relationships, rules, and axioms (Hodge, 2000) in order to support semantic reasoning such as subsumption and similarity (Janowicz and Keßler, 2008).

[1] Standard ISO 19112.
[2] Available online at: https://portal.opengeospatial.org/files/?artifact_id=46964
[3] Available online at: http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_GN_v3.0.1.pdf
[4] See http://www.alexandria.ucsb.edu/gazetteer/protocol/specification.html
[5] http://www.getty.edu/research/tools/vocabularies/tgn/about.html

The aforementioned approaches not only improve interoperability between gazetteers, but also help end users in the process of information retrieval. For instance, the TGN makes use of relationships between places and types of places for displaying links and paths, and thus, eases navigation through records. The feature type ontology (Janowicz and Keßler, 2008) is used in a semantics-based interface that suggests related feature types to users (Janowicz et al., 2009).

Moreover, defining universal categories of places is hampered by cultural and language diversity. The necessity of being flexible with the definition of categories has been recognized by (Hill, 2009; Janée, 2006; Janowicz, 2012), who state that categories of places, and in general, of gazetteer models, could be driven by use cases, thus allowing people to come up with their own definitions depending on their purpose and embedded in a particular context. Janowicz et al. (2012) point out that pursuing standardization might be tougher than semantic translation, matching, or alignment. Modern approaches even account for problematic or contradictory views in the so called Microtheories, which leverage local conceptualizations (Duce and Janowicz, 2010; Janowicz, 2009, 2012).

3.1.3 Difficulties in modeling place

Places are social concepts that help people communicate location. They are used in everyday social interaction in a number of ways due to their versatile (and therefore, ambiguous) conceptualizations (Bennett and Agarwal, 2007; Jordan et al., 1998; Santos and Chaves, 2006). Their dynamic (Kauppinen et al., 2008; Mostern and Johnson, 2008) and imprecise (Montello et al., 2003; Santos and Chaves, 2006) nature implies several challenges for them to be included in digital KOS and applications. Some approaches even deal with combinations of KOS while pursuing models of place (Tanasescu and Domingue, 2008). It is remarkably difficult to establish a minimum set of properties to identify places (Janowicz, 2009), although their complexity is rarely taken into account in digital applications and lots of their meaningful aspects are usually overlooked (Scheider and Janowicz, 2010).

3.2 Affordances

The notion of affordances was first stated by Gibson (1986, p.127) (emphasis in original):

> The *affordances* of the environment are what if *offers* the animal, what it *provides* or *furnishes*, either for good or ill. The verb to *afford* is found in the dictionary, but the noun *affordance* is not. I have made it up. I mean by it

> something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment.

The environment, for Gibson, represents the surroundings of the animals, where they perceive and behave. Perception and behavior are the foundations of the concept, introduced in the realm of ecological psychology.

Affordances are relational in nature, according to Gibson (1986, p.129):

> [A]n affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer.

An attempt to express affordances quantitatively was carried out, among others, by (Warren, 1984). He described the affordance of climbability, provided by stairs, through a relation between leg length and riser height. It turned out that 0.88 is a critical ratio for human beings to perceive the stair as climbable. Climbability is an affordance people directly perceives and thus, there is no need for any prior experience or explicit instructions (like those given by (Cortázar, 1962)) in order act upon it.

Other views on affordances as well as their use in the context of place modelling are reviewed in the remaining of this chapter.

3.2.1 Gazetteers and affordances

To the best of our knowledge there are no gazetteer models involving affordances up to now. While affordances have been included in feature type definitions (see section 3.2.4), they have not been used for describing place instances in gazetteers.

Perhaps the most similar approach is given by web applications for tourism that classify places according to the functions they offer (e.g., places to eat, to stay, and to shop) and present a variety of activities that can be performed at places (e.g., things to do and things to see). These web applications are built upon Places of Interest (POIs). Both gazetteers and POIs are considered simplistic digital models of place (Scheider and Janowicz, 2010).

3.2.1.1 Places (or points) of interest

POIs are locations of places, products, or services used as reference points, identified by name, and distinguished by types.[6] POIs are usually associated to human activities and place functionality. However, the inclusion of activities is not mandatory in POI models nor is their view on place functionality made explicit. This can be seen from the broad definition of POIs given by the World Wide Web Consortium (W3C),[7] which states that a POI "is a location about which information is available."

POIs have a flexible and lightweight model supporting folksonomies[8] and also more formal structures for feature types. The W3C acknowledges the fact that a place is not constrained to belong to a single category, and leaves the possibility open for them to belong to a list of categories. In this regard, Scheider et al. (2011) propose to represent POIs not as a list of categories but as a list of affordances offered by its parts (e.g., chairs, tables, and the like).

On the other hand, a series of encounters among scholars in the realm of Geographic Information Science have been taking place regularly during the last years. One of the results of such encounters, known as *GeoVoCamps*,[9] is the first version of an affordance-driven POI pattern.[10] The pattern constitutes a solid foundation for this thesis and will be adapted to, extended, and implemented in the context of gazetteers.

3.2.2 Places and affordances

Despite their passive role in gazetteer research, affordances have been considered in establishing the notion of place for a long time and are nowadays recognized as a promising research topic in the context of Geographic Information Science (Janowicz et al., 2012).

Non-reductionists accounts of place acknowledge affordances (and the potential actions and activities they create) can help capture better the notion of place (Jordan et al., 1998; Scheider and Janowicz, 2010). Places have been compared to affordances at a different scale (Heft, 2007), have been seen as collections of affordances (Alazzawi et al., 2010; Heft, 2007; Scheider et al., 2011), and have been described as homogeneous affordance fields (Tanasescu and Domingue, 2008).

[6] Adapted from the OGC Glossary: http://www.opengeospatial.org/ogc/glossary/p

[7] See *Points of Interest Core*: http://www.w3.org/2010/POI/documents/Core/core-20111216.html

[8] "[F]olksonomies are simply the set of terms that a group of users tagged content with [...]." (Mathes, 2004, p.4)

[9] See http://vocamp.org/wiki/GeoVoCampSB2012

[10] The pattern (version 1, February 2012) is available at: http://geog.ucsb.edu/~jano/POIpattern.png

Places have functional significance for humans (Heft, 1996). Such functions are the core of certain feature type definitions (Alazzawi et al., 2010; Kuhn, 2005, 2007; Rugg et al., 1997). A distinction has been made between affordances that help define a feature type and the affordances that such feature type may possess, i.e., feature types have optional affordances (Hart et al., 2004).

3.2.2.1 Behavior

Places, as social constructs, frame appropriate behavior imposing social constraints to activities that however might be physically possible (Harrison and Dourish, 1996; Raubal and Moratz, 2008). We act according to the intrinsic meaning of places (Goffman, 1959). Even adjacent places may afford different behavior. That is the case of Wendover, Utah, and West Wendover, Nevada, in the United States of America. Due in part to laws, customs and economical activities are not only different but opposite in both cities.[11]

Goffman (1959) considers places as regions where human beings realize theatric performances, which are framed by the function of the place. He defines *front region* as the place where the performance is given and *back region* as the place where the actors of the performance can be hidden, preparing themselves and other elements of the performance while relying on not being disturbed members of the audience.

3.2.3 Affordances of places

Gibson (1986) gives some hints on affordances of places. As he deals with animals and their environment, for him, places afford to find food or danger (not all affordances are good for the observer), to refuge from predators, and to conceal oneself from other observers. For Scheider and Janowicz (2010) places afford containment and movement, whereas for Heft (2007) places afford specific activities for an individual or group.

Gibson lacks social considerations when presenting affordances of places, which have been distinguished from other kinds of affordances and have been said to be usually social-institutional affordances (Scheider and Janowicz, 2010). Humans modify their environment bearing in mind intended or specified affordances, according to social needs and practice (Hammond, 2010).

[11] See https://fronterasblog.wordpress.com/2012/12/04/en-este-local-se-juega-pero-solo-hasta-la-raya

3.2.4 Affordances and semantics

Affordances play a role in categorization (Kuhn, 2007; Ortmann and Kuhn, 2010), indeed, they lead to categories that are closer to our understanding (Janowicz and Raubal, 2007; Kuhn, 2001) because they are acquired by perception rather by cognition.

It has been stated that affordances can improve interoperability (Kuhn, 2007; Ortmann and Kuhn, 2010) and, moreover, that models of place (and by extension, gazetteers) must include them (Jordan et al., 1998; Scheider and Janowicz, 2010). In a broader sense, affordances have been proposed to enrich ontologies of geographic domains (Kuhn, 2001). Approaches such as data mining have been employed for extracting and identifying types of services and activities present in feature type definitions in order to support the development of place ontologies (Alazzawi et al., 2012).

The national mapping agency of Great Britain, Ordnance Survey, employed affordances as one of the main relationships for developing a topographic ontology (Hart et al., 2004). Additionally, they developed an ontology for buildings and places[12] relying on the relation *has purpose*.

Ontologies are useful because they specify conceptualizations and thus, provide a means for reducing complex expressions to primitive ones. The problem is then how to relate primitive expressions to qualities that lie outside of such a formal specification (a problem known as *grounding*) (Scheider et al., 2009). Affordances have been claimed to be suitable for such a task (Kuhn, 2001; Scheider and Janowicz, 2010). Nonetheless, they are difficult to model due to their relational nature. Generic ontological approaches propose to deal with affordances as qualities that lead to actions (Ortmann and Kuhn, 2010) and, moreover, as referential qualities (Ortmann and Daniel, 2011). Affordances, as observable qualities, could lead to consensus easier than object classifications, thus improving interoperability (Ortmann and Kuhn, 2010).

Affordances represent another level of abstraction to disambiguate feature types (Kuhn, 2007; Scheider et al., 2011) and therefore, could enable transformations between multiple conceptualizations (Kuhn, 2007). They can also play a role in similarity measurements (Janowicz and Raubal, 2007): if two places afford the same they may be referred to as being similar, even if their feature types do not match (Jordan et al., 1998; Rugg et al., 1997). For instance, in (Scheider and Kuhn, 2010) the authors formalize a theory of channel networks and apply it to road networks by using an affordance-based definition of junction satisfied by both. This does not mean that feature types are to be replaced, but that affordances can complement them for more meaningful information retrieval (Kuhn, 2001; Scheider et al., 2011).

[12] See http://www.ordnancesurvey.co.uk/oswebsite/ontology/v1/BuildingsAndPlaces.htm

3.2.5 Difficulties with affordances

Affordances do not account for cognitive and social processes (Janowicz and Raubal, 2007) and have been recognized to be incomplete for comprising the notion of place in isolation. To overcome this they have been used with Extreme Tagging Systems (ETS) for providing richer, though less formal place descriptions (Tanasescu and Domingue, 2008).

How to describe and account for agent-centered (cultural and affective) views of affordances is still an open matter (Heft, 2007; Jordan et al., 1998). Agent individuation is required from an ecological perspective, since the agent capabilities and characteristics may turn affordances into obstacles (Heft, 2007; Jordan et al., 1998; Ortmann and Kuhn, 2010). Nonetheless, as acknowledged by Ortmann and Michels (2011), Gibson's environment is shared by animals of the same species, i.e., affordances are shared by animals with similar capabilities (Gibson, 1986).

Moreover, the concept of affordance is difficult to grasp. There is no sharp border on what should be considered an affordance and what should not (Jones, 2003). Such concept has evolved over the decades and has been used in several realms such as Human-Computer Interaction (HCI), Artificial Intelligence (AI), Design, Psychology, Philosophy, and Education.

Furthermore, it may become problematic to establish what kind of affordances should place models take into account (Jordan et al., 1998; Tanasescu and Domingue, 2008) as there might be countless affordances in the environment (Ortmann and Kuhn, 2010). How to combine and how to describe relationships between affordances is also an open issue (Janowicz and Raubal, 2007).

Affordances are said to be independent from (usage) conventions (Norman, 1999), a distinction not always easy to make, which has led to misusing the term (Norman, 1999; Tanasescu and Domingue, 2008; Turner, 2005). To overcome this issue, several kinds of affordances have been defined for extending Gibson's original insight (Norman, 1999; Raubal, 2001; Raubal and Moratz, 2008; Turner, 2005). For example, Raubal (2001) describes physical, social-institutional, and mental affordances.

The difference between the various kinds of affordances mostly stems from whether they involve direct perception, whether they are considered as properties, and whether they are relational in nature (Hammond, 2010).

3.2.6 Relationships between affordances

A point that merits special attention is the existence of several levels of action afforded by objects, places, as well as by other persons and animals (as Gibson pointed out, behavior affords behavior); in other words, there are levels of affordances (Gaver, 1991; Gibson, 1986; Janowicz and Raubal, 2007; Jordan et al., 1998; Sen, 2008). Jordan et al. (1998) cite authors that have dealt with affordances at low level (image schemata) or at small (in sizes relative to the human body) and large scales of space (for the task of wayfinding).

Moreover, Jordan et al. (1998) apply a means-end hierarchy from Rasmussen (1986) in order to represent the environment. The hierarchy is composed by levels of action for agents in the context of a given task. The authors use a subset of the hierarchy (namely, the *Why*, *What*, and *How* (Vicente and Rasmussen, 1990)) to illustrate different actions a afforded by a restaurant.

Janowicz and Raubal (2007) briefly introduce sub-affordances as the result of granularity levels and leave the question on connections between affordances open. In this regard, Gaver (1991) mentions that affordances are sequential in time and nested in space and elaborates further the idea in the context of technology affordances, whereas Sen (2008) points out the correspondence between sequential affordances and sequential actions, as well as the correspondence between nested affordances and nested actions. An example of an ordering of afforded actions for a specific domain is given by Kuhn (2001).

Finally, Kuhn (2001) borrows some tenants from activity theory to account for a hierarchy of activities, actions, and operations, whereas Ortmann and Michels (2011) describe different levels of activities by introducing agent-specific *Activity Umwelten*[13] and *Compound Activity Umwelten*. The *Activity Umwelten* of an agent can be structured in a mereological (i.e., part of) hierarchy.

[13] Defined as a human environment composed by all the surrounding objects that afford an activity.

4

TOWARDS AN AFFORDANCE-BASED GAZETTEER

Throughout this chapter, we conceive and implement an affordance-based gazetteer in order to endow place models with broader and richer context descriptions to facilitate retrieval.

When we refer to places we include both geographic and artificial places. Places have a name and according to (Gibson, 1986; Smith and Mark, 2003), it is difficult and perhaps misleading to treat places differentially since, on the one hand, geographic places like Mount Everest are also products of social beliefs and, on the other hand, even artificial places can be seen as part of the environment.

However, we recognize that places like marshes will not likely benefit from an affordance-based approach to gazetteers, but other geographic places like mountains certainly could (e.g., a mountain could afford hiking to humans).

4.1 Types or instances

According to literature (Alazzawi et al., 2012; Hart et al., 2004; Scheider and Kuhn, 2010), the role of affordances in digital place models (such as gazetteers) is mostly to help describe feature types with functional aspects of places to provide richer context. Our view on affordances corresponds rather to a different role: affordances can help us understand the versatile functional meaning of place instances. In that sense, we are not focused on ontologies of places at the class level but on a more vivid representation of place instances.

Furthermore, we follow the current trend of favoring bottom-up approaches over top-down ones for dealing with feature types (see the rationale in Subsection 3.1.2) and recognize the use of affordances for feature types as a way to preserve the inadequacy of solely attending authoritative precepts for understanding places. In this regard, we think that a bottom-up approach based on functional meanings (affordances) of places

for specific user communities (or groups) and embedded in particular contexts such as tourism, can improve our understanding of places.

4.1.1 Types

Affordances provide another level of abstraction (Scheider et al., 2011) that can help transform between multiple conceptualizations (Kuhn, 2007). A more explicit account of categories as constructs shaped by functional meaning, could indeed help describe them better (Hart et al., 2004).

(Rugg et al., 1997) mention that in order to describe what a road is we need more than static attributes or relationships, we also need to include operations that are critical properties of roads (e.g., vehicular traffic handling). (Scheider et al., 2011, p.26) illustrate this fact by showing that one can distinguish "supermarkets from restaurants by asserting that they allow to buy food, but not to eat it there."

However, we have identified some caveats when dealing with affordances of feature types. These caveats by no means exclude others that might be found while doing a more complete research focused on types, and are presented here just as arguments of why we consider affordances can be best exploited at the instance level.

Countless optional affordances

It is difficult to describe entity types with affordances (Sen, 2008) as their realizations (instances) can gain or lose affordances depending on situational aspects. There may be a large number of optional affordances for describing a feature type (Hart et al., 2004, p5) unless one wants to model "typical affordances" of feature types (Alazzawi et al., 2012) and thus, discard particular interpretations of and interactions with the environment.

Taking rivers as example, we could say that they afford to go rafting, to swim, to go canoing and boating, to fish, to view, to collect gold, and so on. But that is clearly not valid for all rivers, and therefore describing rivers through affordances would overestimate some rivers (if including optional affordances) or underestimate others (if modeling typical affordances).

Another example is the feature type *bar*, normally used for alcohol consumption, but in Mediterranean countries even open for breakfast. A project with a global scope (such as OpenStreetMap) relying on feature types, can merely document the issue instead of accounting for it in the data structure.[14]

[14]See the notes on *bar* in the OpenStreetMap project `http://wiki.openstreetmap.org/wiki/Tag:amenity=bar`

Multi-functional places

There are places that encapsulate multiple place functions. For instance, a gas station could have a restaurant, bathrooms, grocery store, and perhaps an ATM. While there is no category for these kind of multi-functional places, the main place can be better described by using affordances and thus include this information, that would be otherwise hidden, for improving place information retrieval.

Another example is given by Scheider et al. (2011), who point out that, depending on people's intentions, a restaurant can be used as café, as a place to find a restroom, or as a place to get WiFi access. Again, it would be difficult to attach a feature type that encompasses such functional variety.

Cultural diversity

It is certainly different to describe what is happening in the world and what is supposed to happen. For example, rivers are used in some countries to wash clothes, but such a functionality of rivers will not be found in any national mapping agency's object catalog. Feature types homogenize views about places and can hardly deal with their particularities.

The wide variety of activities that could be found at certain places is a good motivation for studying and understanding cultural expressions instead of overlooking them. In that sense, an affordance-based gazetteer can help describe how people actually act upon their environment, rather than just reflect what object catalogs may suggest about it.

4.1.2 Instances

Gibson (1986, p.134) himself provides a view on types of objects. He mentions that affordances are perceived on objects without the need of classifications (we expose our thoughts on perception of place affordances in Section 4.2).

Moreover, applying Gibson's insights to places, we could say that if we know what a place affords to us, what it can be used for, we can call it whatever we please. In his book, Gibson refers in this way to graspable detached objects, but the analogy with places seems to be valid.

Affordances span across types and thus help discriminate place instances by enhancing their descriptions with functional aspects. However, we acknowledge that affordances

are not to replace feature types but rather to complement them (Kuhn, 2001; Scheider et al., 2011), since types convey meaningful and shared conceptualizations of places and, furthermore, humans use them extensively to communicate about places.

In summary, even though feature types can be enhanced with affordances, this thesis is rather focused on affordances for describing place instances. By doing so, we envision that such bottom-up approach can even improve our understanding on feature types by finding patterns of affordance occurrences.

4.2 Affordances and activities

The framework of this thesis is gazetteer modeling and therefore our view on affordances is bound to a digital representation of place for information retrieval. A strict notion of affordances is replaced by a loose approach that allows us to analyze their role in gazetteer modeling and integration.

Notice that, at this point, we are tackling the problem of selecting kinds of affordances that can be included in gazetteers (see Subsection 3.2.5). There are countless affordances in the environment (Ortmann and Kuhn, 2010), but we need to focused on those that are meaningful in the context of place information retrieval.

Consequently, we account for affordances whose participants are human beings (rather than animals) and places (rather than the environment). By doing so, we discard what things that are not places (e.g., doors, chairs, or other parts of places in isolation) afford to humans as well as what places afford to other agents.

Places are not single objects, but much more complex structures, therefore, we need to switch the scale for studying them: from objects that afford single actions to humans, we switch to more complex objects that allow humans to rest, to find protection from climate and other phenomena, and for interacting with other humans. Due to the nature of place, this work extends broader views on affordances such as social-institutional affordances (Raubal, 2001; Raubal and Moratz, 2008). We adhere to (Scheider and Janowicz, 2010) in that affordances of places are different from other kinds of affordances, as well as to Heft (2007) in that places afford specific activities to individuals or groups.

Affordances of places are higher-level affordances in the sense that they are not single actions (e.g., to grasp, to push, to jump, and the like). Instead, since places are made up of objects and represent complex structures for humans, affordances of places are also complex, they are human activities composed of single actions.

We therefore do not fully adopt the proposal of Scheider et al. (2011) to describe POIs through a list of affordances offered by its parts (e.g., chairs, tables, and the like) but take advantage of object aggregation used by (Jordan et al., 1998, p.6) to argue that gazetteers must account for human activities offered by places as a whole. That is, we consider places as constituted by physical elements as well as by social and economic aspects. It is the place (with its arrangement of physical elements, human interactions, and economic intentions) that affords to eat and not the chair and the table.

As a consecuence, gazetteers will represent place and not its parts (see (Jordan et al., 1998, p.6)), which still fits in the view of gazetteers as digital dictionaries of places.

The notion of affordances as activities has its roots in the hierarchical view of affordances and actions (see Subsection 4.5.2). Human activities are on top of such hierarchies, i.e., they are still affordances, they are indeed higher-level ones: they have a strong relational nature (they relate and depend on both places and humans) and they describe well what places offer humans. However, we need to make some distinctions between affordances of places (i.e., activities) and affordances (as originally conceived) regarding perception.

4.2.1 On perception

As we have stated before in this section, we take a loose approach to affordances. The characteristic of affordances that most has to be reconsidered with respect to its original view is perception. It is not that we discard perception in order to take affordances as human activities, but rather that we have to ask ourselves how affordances of places (i.e., activities) are perceived by human beings.

We claim that humans employ conventions and symbols to advertise affordances of places. These symbols and conventions have been arbitrarily chosen in a way that humans can learn and communicate functional meanings encapsulated by places, i.e., cognition plays a role for conveying what a place is for. In this regard, we cannot talk about affordances of places as directly perceivable (see (Gibson, 1986, p.138) on *Gestalt*), but as sometimes covered affordances that have to be revealed via symbols and conventions.

The use of symbols and conventions is needed because of the strong social component of places. That a lake affords to fish is subject to regulations from local environmental authorities. That a restaurant affords to eat might depend on advance bookings or opening hours. These are crucial aspects that shape potential activities at places.

Additionally, it might be the case that a place cannot be explored from the outside or that a human cannot understand what its functions are. In this case humans need to be

told about the usage conventions that the place has been endowed with in the frame of local behavior.

4.2.2 Delimiting activities

Even considering hierarchies of operations-actions-activities (see (Kuhn, 2001)) or accounting for activities at the level of agents instead of organs (like in Ortmann and Michels (2011)), delimiting human activities for affordance-based gazetteers is a challenging task. That is because a large number of verbs might be associated to human activities.

To start establishing a set of activities that could be included in an affordance-based gazetteer, we need to focus on the audience and contributors of gazetteers. According to (Keßler et al., 2009), in the next generation of gazetteer infrastructure, non-experts and machines take over from experts as the gazetteer audience. Contributors are no longer established authorities but user communities.

Having said that, an affordance-based gazetteer should include activities that are relevant for user communities, i.e., activities that are likely to be searched by non-experts in order to find suitable places for performing certain activity. This still involves a wide range of activities, from daily (such as eating) to eccentric or touristic ones (such as going bungee jumping).

On the other hand, we can take Goffman's *front* and *back* regions of places (see Subsubsection 3.2.2.1) to discard activities in support of the function of places, i.e., ignore those activities that occur in the back region. This is based on the following hypothesis: only those activities framed by the front region can represent interest for user communities searching for places in gazetteers.

For example, a restaurant can be a place to eat (for customers) or to cook (for some of the workers), and both help describe what happens at the restaurant (e.g., cooks prepare food that customers eat), but it is not likely, at least at a first glance, that people would search for places to cook to obtain restaurants. Instead, they could search for the activity *Learn to Cook* if they are actually interested in a cooking school. This is because complex social interactions and prerequisites need to be met (e.g., to be hired and to count with the ability to cook) before performing the activity *Cook* at the restaurant.

Despite having presented ways of selecting activities, we acknowledge that the aforementioned criteria might be insufficient to delimit them and therefore suggest to follow a bottom-up approach in order to find patterns of activities and ways of naming and

relate them. In this regard, we prefer to remain flexible rather than forcing gazetteer users and contributors to use a subset of activities that could be easily exceeded.

4.3 Requirements for an affordance-based gazetteer

4.3.1 Classes and relationships

The literature review on affordances is the basis of the following series of requirements that an affordance-based gazetteer should meet. We consider that accounting for user groups, prerequisites, constraints (either spatial, temporal, economic, or social), and hierarchies of activities, as well as broadening the relationship place-time in terms of functionality, is a must if we want the gazetteer to be truly based on affordances.

User groups

Places might afford different activities to different people. As we have seen, affordances depend on both environment and animal, or, in this case, place and human being.

Depending on people's abilities, characteristics, and interests, places can be seen as appealing or unappealing; but places (at least those created or modified by humans) are also built accounting for people's expectations and requirements. This duality is well expressed by affordances and, by extension, by activities.

This could partially support the idea of allowing communities to explain their own view on places and feature types (i.e., bottom-up approaches like microtheories (Duce and Janowicz, 2010)), thus enriching digital representations of places while capturing some of their essential traits.

For instance, a flea market affords both selling and buying. It would depend on the user group to take the affordance that best applies to its intentions.

Temporal constraints

Affordances of places are valid and can be acted upon only at certain temporal intervals. This might be due to social constraints like opening hours or to dynamic or physical aspects like seasons.

An example of the latter is given by Rugg et al. (1997) when they mention that in Maine, United States of America, people can stand on and cross frozen lakes and rivers. Those lakes and rivers' affordances are not present at other times of the year.

An interesting issue to consider is related to temporal places like markets (that might exist one or two days of the week), where the validity of affordances coincides with the place lifetime (the place delimited by the market only exists on market days).

Other seasonal markets like German Christmas markets seem to present both behaviors. They exist during Christmas and most of their affordances are only valid at certain opening hours.

On the other hand, as Alazzawi et al. (2012) point out, the temporal dimension is crucial for understanding the functional meaning of places since they may afford different activities at different times.

Finally, it is important to account for named periods, which might be imprecise in terms of dates (nobody knows when exactly the lake will be frozen).

Social constraints

Laws, traditions, customs, and conventions, among others, represent social constraints for acting upon affordances of places. They may restrict user groups, particular areas, techniques, or other concepts related to the activities. Because of the vast variety of social constraints, the model should consider them in a generic way.

Spatial Constraints

Performing an activity at a place might be spatially constrained. For instance, while one could say that a river affords fishing, chances are that such an activity is only allowed (or even possible at all) at some area of the river rather than on its entire extension. This might be due to law or to physical impediments. The former can be modeled by connecting the spatial constraint with a social constraint, whereas we leave the latter implicit in the description of the place, i.e., the fact that people cannot fish at some parts of the river corresponds to the lack of properties of the river for affording the activity.

Economic constraints

Places that are modified by humans (and, sometimes, also those not intervened) are usually subject of representing revenue for the owner or administrator. Those places afford activities that have economic constraints for being performed.

However, the wide variety of business models built around activities involves countless elements that could be economically exploited. These elements include bookings, permissions, tickets, memberships, equipment, food, and other payments. Accounting for all of them generically would be desirable to avoid making the model too complex, which would affect its adoption by communities worldwide.

Needless to say, besides presenting the motives of payment, providing a means to specify prices, currencies, payment methods, and the like, is also required.

Prerequisites

Constraints that represent activities themselves are better described as prerequisites. Both prerequisites and activities might be performed at different places, usually nearby ones.

For instance, there is a famous church on a mountain's peak in Bogotá, Colombia. The mountain is called *Monserrate* and has other touristic attractions like restaurants, viewpoints, and a small marketplace. There are three ways of climbing it: By taking the stone stairs (which can take 40 to 60 minutes), by cable railway, or by funicular. The activity *go to mass* afforded by that church entails climbing the mountain *Monserrate*, i.e., to climb the mountain is a prerequisite for going to the mass.

Activity hierarchy

Even though establishing hierarchies of activities is out of scope for this thesis, the model must account for them in a way that searches for generic (parent) activities could discover also specific (children) ones. For instance, the activity *Eat Pizza* is more specific than *Eat*, so a search for *Eat* could also return results only tagged as *Eat Pizza* (such a discovery should be based on relationships between the activities rather than on the eventual appearance of the verb *Eat*).

4.3.2 Further requirements

Place-Activity-Place

There are activities that a place affords humans that somehow involve other places. For example, a viewpoint allows humans to survey a city or a valley and and some bridges allow humans to fish a river. Including this relationship in the model could help discover associated places (places that participate in other places' affordances), which could go beyond a nearness relationship by adding functional meaning.

Similarly, an interesting issue in place representations is how to model places contained within other places. For instance, a public square can hold a temporal market that affords to buy fruits. The decision whether one should add the affordance *Buy Fruits* to both the market and the public square might depend on complex considerations like place identity.

Since the number of ways in which activities might involve other places is certainly unknown, we suggest adding a description (as plain text) of their realizations in the model.

Other special cases are administrative entities like cities, which contain a number of places within their boundaries. A simple aggregation of the activities afforded by the places inside could be replaced by remarkable affordances of the city.

For instance, the city of Mendoza, Argentina, is recognized as the international capital of wine,[15] which suggest the suitability of describing the city with activities such as *Drink Wine*. Another example is the city of Münster, known as the Germany's bicycle capital. Both infrastructure and culture invite people to ride a bicycle. Therefore, it would be appropriate to use the activity *Ride Bicycle* as an affordance of Münster.

Parts of places affording meaningful lower-level activities

If we consider all the objects that aggregated constitute a place, the affordances of places are no longer only activities but also lower-level activities like actions and operations. For instance, entrances of a large botanic garden (affording to enter or to access) could complement the representation of the place and might improve other applications built on top of gazetteers, such as journey planners.

[15] In fact, there is a saying: *the one who came to Mendoza and did not drink wine, what he came for?* In Spanish: *El que vino a Mendoza y no tomó vino, a qué vino?* Taken from http://www.crazyguyonabike.com/doc/page/?o=1&page_id=307848&v=Mb

At this point, we consider that accounting for such affordances could hamper our view on affordances of places as it could bring further levels of complexity to the model. Nonetheless, we think it is worth documenting that in order to propose it as further work.

4.3.3 Queries

At least four new types of queries must be supported by an affordance-based gazetteer.

In the following listings, the queries are written in Structured Query Language (SQL) for the sake of making explicit how activities and other gazetteer components are involved in each query. Terms in brackets represent parameters given by the user to help constrain the query. The *Within* function filters footprints that are contained within an area given by its second parameter.

Query 1. Retrieve places of certain feature type that afford a given activity.
Example: Select the rivers to fish in Germany.
Returns: Places of one type (e.g., rivers).

Listing 1: (Query 1) Retrieve places of certain feature type that afford a given activity.

```
SELECT PlaceId
FROM Gazetteer
WHERE FeatureType == "FeatureType"
   AND Activity == "Activity"
   AND Within(Footprint, Germany);
```

Query 2. Retrieve places that afford a given activity.
Example: Where can I swim in this city?
Returns: Places of multiple types.

Listing 2: (Query 2) Retrieve places that afford a given activity.

```
SELECT PlaceId
FROM Gazetteer
WHERE Activity == "Activity"
   AND Within(Footprint, Muenster);
```

Query 3. Retrieve feature types of places that afford a given activity.
Example: What kind of places allow me to swim in this country?
Returns: List of feature types.

Listing 3: (Query 3) Retrieve feature types of places that afford a given activity.

```
SELECT DISTINCT FeatureType
FROM Gazetteer
WHERE Activity == "Activity"
```

```
   AND Within(Footprint, Germany);
```

Query 4. Retrieve activities afforded by a place.
Example: What can I do in this place?
Returns: List of activities.

Listing 4: (Query 4) Retrieve activities afforded by a place.

```
SELECT Activity
FROM Gazetteer
WHERE PlaceId == "PlaceId";
```

Query 4a. Retrieve activities afforded by places in a given area.
Example: What can I do in this area?
Returns: List of activities.

Listing 5: (Query 4a) Retrieve activities afforded by places in a given area.

```
SELECT Activity
FROM Gazetteer
WHERE Within(Footprint, Germany);
```

Query 4b. Retrieve activities afforded by places of certain feature type.
Example: What can I do in this kind of places?
Returns: List of activities.

Listing 6: (Query 4b) Retrieve activities afforded by places of certain feature type.

```
SELECT Activity
FROM Gazetteer
WHERE FeatureType == "FeatureType";
```

The query 4b represents a bottom-up approach to affordances describing feature types.

Queries in a gazetteer can be more complex than these four. For instance, one could perform queries based on spatial relationships between footprints (such as adjacency or nearness), and based on user groups; the latter enabled by an affordance-based view.

4.4 Implementation

The implementation consists of following a series of steps in order to publish a vocabulary in Linked Open Data (LOD) that will be taken as reference for the use case. Such a vocabulary encompasses all the considerations extracted from the analysis of the literature.

4.4.1 The framework: Linked Open Data

According to Bizer et al. (2009, p.1), Linked Data is "a set of best practices for publishing and connecting structured data on the Web." These best practices are also called *Linked Data principles* and can be summarized as follows:[16]

1. Use URIs as names for things;
2. Use HTTP URIs so that people can look up those names;
3. When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL);
4. Include links to other URIs. so that they can discover more things.

When this set of principles includes a fifth one that refers to sharing the data under open licenses, the best practices are called Linked Open Data.

LOD provides a suitable framework for authoritative sources and communities to publish gazetteer data, enabling interoperability in a broad sense: data encoding, data access (protocols), queries (through SPARQL), data formats (JSON, XML), feature typing schemes (semantic reference systems), footprints (spatial references system), and time reference systems.

For the aforementioned reasons, some gazetteer projects have been implemented in LOD or are being migrated to it gradually. For instance, the GeoNames geographical database[17] and the Ordnance Survey Linked Data.[18]

Furthermore, LOD favors the proliferation of ontologies and vocabularies to tackle heterogeneity (Van Harmelen, 2011), which is in line with the aforementioned microtheories or micro-ontologies (Janowicz et al., 2012).

4.4.2 Workflow

For publishing the vocabulary, we follow the document *Best Practices for Publishing Linked Data*,[19] by the W3C. In the remaining of this chapter, we explain how every step mentioned in such a document is applied to the current work.

[16] Taken from the online document available at: http://www.w3.org/DesignIssues/LinkedData.html
[17] See details at http://www.geonames.org/ontology/documentation.html
[18] See http://data.ordnancesurvey.co.uk/.html
[19] Available online at: https://dvcs.w3.org/hg/gld/raw-file/default/bp/index.html

Step 1: Identify. This step corresponds to identifying data sets that could be reused by someone due to their relevance for certain communities. The fact of undertaking the work on this thesis implies such identification. However, literature review on affordances, gazetteers, and place modeling helps confirm the interest in an affordance-based gazetteer.

Step 2: Model. The objects (classes) and relationships between objects that constitute the model are detailed in Section 4.5. Nonetheless, some adjustments were required while working in the context of LOD. For example, the class `TemporalConstraint` was considered a blank node since it does not represent an object itself (i.e., it does not require an identifier), but rather serves as a generic concept that encompasses other specific objects such as seasons and opening hours (that, indeed, require identifiers).

Step 3: Name. This step deals with naming objects of the vocabulary using Uniform Resource Identifier (URIs). Since the vocabulary is to be published locally, it is only necessary to define a path that could host the objects and properties of the vocabulary. The path chosen is `/gazetteer/affgaz.rdf` Thus, the URI of an object like `Place` is `http://localhost/gazetteer/affgaz.rdf#Place`

Step 4: Standard vocabularies. In this step, concepts like `Offering`, `Group`, or `Time Interval`, are specified better by aligning them to other vocabularies. The purpose of this alignment is to link the vocabulary with others already existent and well spread, and thus contribute to data integration at a large scale in LOD.

In order to discover LOD vocabularies, the following search engines were employed: Swoogle,[20] SWSE,[21] Sindice,[22] Watson,[23] Falcons,[24] and LOV.[25]

Step 5: Consistent representation. This step is not fully applicable to this work as it deals with persistence of the chosen URIs. The vocabulary is rather published here for the sake of a local implementation.

Step 6: Description. Descriptions of objects and properties are included in the vocabulary in a way that it is not only aimed at machines but also to humans. This is achieved by adding triples for properties such as `label`, `prefLabel`, `altLabel`, and `comment` that help humans understand the different conceptualizations included in the model.

[20] `http://swoogle.umbc.edu`
[21] `http://swse.deri.org`
[22] `http://sindice.com`
[23] `http://watson.kmi.open.ac.uk`
[24] `http://ws.nju.edu.cn/falcons/objectsearch/index.jsp`
[25] `http://lov.okfn.org/dataset/lov/`

However, for an implementation on the Internet or on a production environment, besides describing objects and properties, an HTML page could be created for explaining the vocabulary scope and purpose in a human readable format.

Step 7: Convert. The chosen format for the representation of the model in LOD is *Turtle*, due to its simplicity and readability.

Step 8: Specify an appropriate license. Following other vocabularies' policies, the license of the affordance-based gazetteer vocabulary was selected from the framework Creative Commons. The license of the vocabulary is *Attribution-ShareAlike 3.0 Unported* (CC BY-SA 3.0),[26] permitting to share and adapt the work attributing it properly and redistributing it under the same license.

Step 9: Announce. This step is not applicable to the current work for the same reason given in the Step 5.

Step 10: Social contract. This step neither applies to the current work, for the aforementioned reason.

The result of this series of steps is a document containing triples in format *Turtle*, describing the model discussed and elaborated throughout this chapter. Such a document (called the RDF serialization) was locally published through a Web server to produce a starting point for the use case and can be found in both the Appendix A and the Internet.[27]

4.5 Affordance-based gazetteer vocabulary

The design of the vocabulary was carried out based on the requirements stated in Section 4.3. The implementation phase has been summarized in Section 4.4. In the current section, we describe both classes and relationships between classes as well as the rationale behind their inclusion in the vocabulary.

Figure 1 shows the classes and relationships that constitute the vocabulary. It serves as a reference for observing relationships between classes described in the remainder of this section.

[26] Available online at: http://creativecommons.org/licenses/by-sa/3.0/

[27] The vocabulary can be accessed online at: http://ifgibox.de/g_carr02/thesis/affgaz_vocabulary.ttl

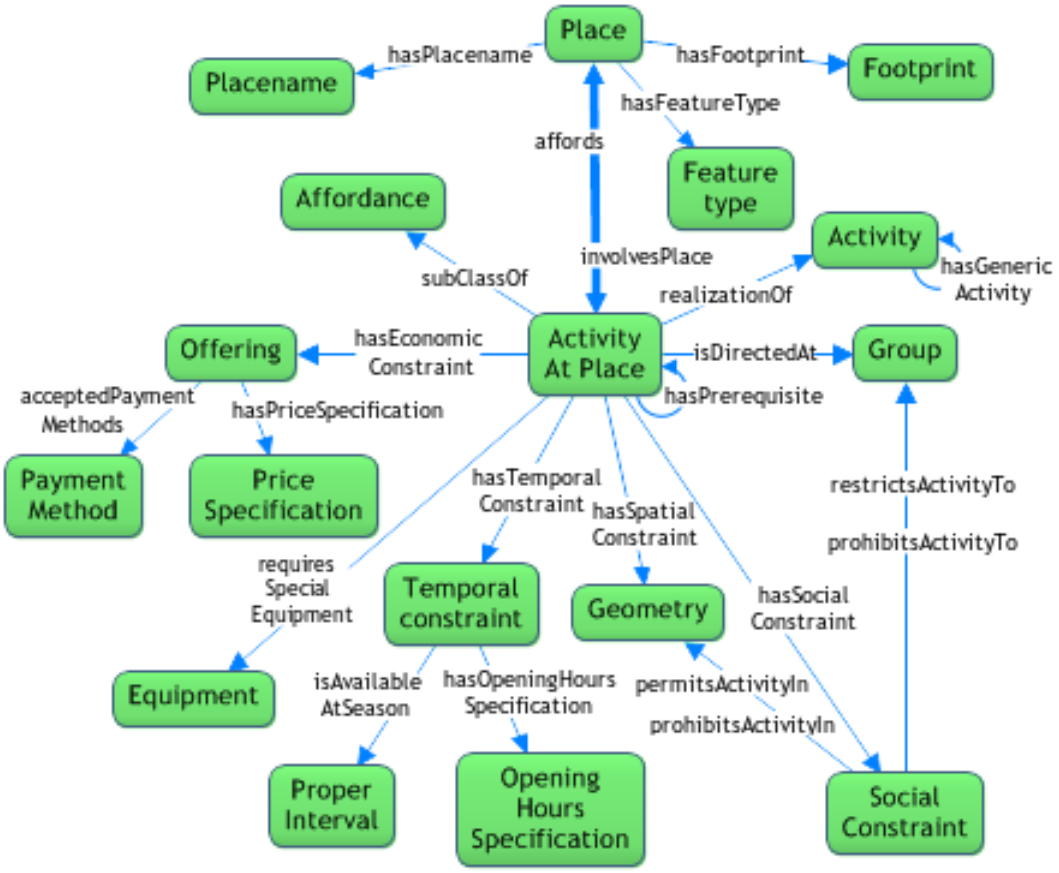

FIGURE 1: Affordance-based gazetteer vocabulary. Green boxes represent objects (classes or concepts) in the vocabulary, whereas arrows represent predicates (or relationships).

4.5.1 Classes

Place. The core object of a gazetteer is `Place`. We have defined the class `Place` in the vocabulary that inherits from the class `Thing`, taken from the *OWL 2 Schema vocabulary*.[28] The class `Place` is related to the core elements of gazetteers (see Section 3.1) as well as to a new class called `ActivityAtPlace`.

Placename. This class corresponds to the name given to a place. It can be used multiple times to describe the same place.

FeatureType. This class corresponds to the feature type with which a place has been categorized by an authority or a community. We do not intend to model feature types in this vocabulary, therefore we define it as a literal instead of defining it as a class that belongs to vocabularies of feature typing schemes.

[28] Available online at: `http://www.w3.org/2002/07/owl`

Footprint. We define the class `Footprint` that corresponds to the same class in the *Topography Ontology*[29] by Ordnance Survey.

We consider the class `Footprint` as a subclass of the class `Feature` (i.e., a `Footprint` is a `Feature`), defined by the vocabulary introduced by the *GeoSPARQL standard*[30] by the OGC. Therefore, the footprint may have multiple shapes or geometries. We employ the class `Geometry` provided by GeoSPARQL to specify the shape of the footprint. The relationship between a `Footprint` and a `Geometry` is called `hasGeometry`, also borrowed from GeoSPARQL.

Affordance. We use the class `Affordance`[31] provided by the DBpedia project,[32] which in turn extracts the concept from Wikipedia.[33]

Activity. We define `Activity` as a class that corresponds to English verbs. This correspondence is made explicit by linking `Activity` to the class `VerbSynset` (that refers to English verbs) defined by the *WordNet ontology 2.0*.[34]

To account for hierarchies of activities, we define the relationship between children and parent activities as `hasGenericActivity` (e.g., the activity `Lunch` has a generic or parent activity `Eat`).

Even though we use English verbs for representing activities, the verbs could be mapped to gerunds or other variations for broadening the scope of queries and improve retrieval (as mentioned by (Kuhn, 2001)).

ActivityAtPlace. This class is the core of the affordance-based gazetteer approach. In the affordance-based gazetteer vocabulary we distinguish between activities (i.e., instances of the class `Activity`) and realizations of activities that occur at a place (i.e., instances of the class `ActivityAtPlace`). Every single place affords activities to humans and even if the activity afforded by two places is the same (e.g., accommodation places afford the activity `Stay`), we need to account for its instances to establish other meaningful properties and constraints only present at each place. The relationship between `ActivityAtPlace` and `Activity` is therefore `realizationOf`.

We define the class `ActivityAtPlace` as an affordance (or an action possibility) that relates and depends on places and humans. Therefore, `ActivityAtPlace` is a subclass of `Affordance` (though we could have used `SocialAffordance` to be more specific)

[29] Available online at: http://www.ordnancesurvey.co.uk/ontology/Topography/v0.1/Topography.owl
[30] Available online at: http://www.opengeospatial.org/standards/geosparql
[31] See the definition of the concept Affordance at: http://dbpedia.org/page/Affordance
[32] See http://dbpedia.org/About
[33] See http://wikipedia.org
[34] Available online at: http://www.w3.org/2006/03/wn/wn20/schemas/wnfull.rdfs

in the vocabulary and a `Place` affords instances of the class `ActivityAtPlace`. The `ActivityAtPlace` might be constrained socially, spatially, temporally, or economically, and might involve other places (see the property `involvesPlace`). Two instances of `ActivityAtPlace` can be related with each other (see the predicate `hasPrerequisite`). Additionally, every instance of `ActivityAtPlace` is directed at one group of people, though it can be directed at several groups.

Group. We use the concept of `Group` defined in the vocabulary *Friend of a Friend* (foaf).[35] We do so because the `Group` is a collection of agents (that in the case of foaf are persons, organizations, or groups), which lets us to be flexible at what groups should be employed in the affordance-based gazetteer. In this regard, we do not specify groups, but let the main concept specified for contributors of gazetteers to choose or define their own groups. As examples of groups we can mention sportsmen, tourists, and disabled people, among others.

Notice that we use groups and not individuals to model affordances because affordances are shared by animals with similar capabilities Gibson (1986); Ortmann and Michels (2011). Therefore, we expect that the groups of humans are selected in a way that they involve humans of similar capabilities.

Geometry (Spatial constraint). We use the class `Geometry` provided by GeoSPARQL to represent spatial constraints of instances of `ActivityAtPlace`. For example, a river can be said to afford to fish, however, it might be that there are only certain parts of the river where it is possible to fish. Those specific parts where humans can fish the river can be described by using instances of the class `Geometry` (either points, lines, or polygons). Multiple instances of `Geometry` can represent spatial constraints of the same instance of `ActivityAtPlace`. On the other hand, it is expected that the `Geometry` that delimits the spatial constraint is contained within the `Footprint` of the `Place`.

SocialConstraint. We define `SocialConstriant` as any constraint imposed to an activity (or, in vocabulary terms, to an `ActivityAtPlace`) by society. We deliberately let the `SocialConstraint` flexible (we define it as a generic class of the *OWL 2 Schema vocabulary*), so that it can be used by contributors of gazetteers in a wide range of ways. Instances of the class `SocialConstraint` might be constraints given by laws, culture, religion, conventions, habits, and so on, and can affect groups (restrict or prohibit activities to groups) or determine spatial constraints (e.g., a given law can establish areas where it is possible to fish a river).

TemporalConstraint. This class corresponds to constraints of instances of the class `ActivityAtPlace` given by time intervals, i.e., it specifies time intervals within which

[35] `Availableonlineat:http://xmlns.com/foaf/spec/`

activities can be performed at places. We distinguish between two types of temporal constraints, namely, opening hours (see the class `OpeningHoursSpecification`) and seasons (see the class `ProperInterval`). These two types express temporal constraints by their own and can occur both for the same instance of the class `ActivityAtPlace`, so the class `TemporalConstraint` is considered a blank node since it is not meaningful enough to require a name (i.e., a URI). Nonetheless, the class serves as a generic term for such kind of constraints.

OpeningHoursSpecification. We take the class `OpeningHoursSpecification` from the *GoodRelations vocabulary*[36] to specify opening hours where a given activity is afforded by a place. That is, we do not specify opening hours for a `Place` but for an `ActivityAtPlace`, which allows us to establish at what hours an activity can be performed at a place. This is relevant because there are places that behave differently according to the hour of the day, e.g., a place can be a restaurant (i.e., it affords to lunch) at noon but a bar (i.e., it affords to drink alcohol or dance) at night.

ProperInterval (Seasons). We use the class `ProperInterval` from the *Time Ontology*[37] to represent seasons. We mean by seasons those time intervals that are not opening hours, mainly intervals that span days, months, years, and the like.

Offering (Economic constraint). We take the class `Offering` from the *GoodRelations vocabulary* to represent economic constraints of a given `ActivityAtPlace`. `Offering` is a flexible class that can refer to tickets, rooms (in the context of accommodation places), permissions, or any other type of payment that has to be done in order to perform an activity.

PaymentMethod. This class is defined in the *GoodRelations vocabulary* and is intended to represent the payment methods that can be used to acquire or pay an `Offering`.

PriceSpecification. This class is defined in the *GoodRelations vocabulary* and can be used to specify several aspects of the `Offering` related to price, namely, currency, units, and price per unit.

Equipment. We take the `Equipment` class from DBpedia to account for special equipment required to perform activities. We include this class merely for reference and do not study exhaustively its implications or other possible associations (e.g., with the class `Offering`) to avoid increasing the complexity of the vocabulary.

[36] http://www.heppnetz.de/ontologies/goodrelations/v1
[37] See http://www.w3.org/TR/owl-time/

4.5.2 Relationships

hasPlacename. Relates a `Place` and a `Placename`. A place can have multiple placenames and a placename can belong to different places.

hasFootprint. Relates a `Place` and a `Footprint`. A place can have multiple footprints and footprints that belong to different places can overlap one another.

hasFeatureType. Relates a `Place` and a `FeatureType`. A place can have multiple feature types and a feature type can belong to different places.

affords. Relates a `Place` with an `ActivityAtPlace`. This is the main relationship added by the affordance-based gazetteer approach since it helps to describe places with their affordances (or human activities, as explained in Section 4.2).

realizationOf. Relates an `ActivityAtPlace` and an `Activity`. Every `ActivityAtPlace` is directly related to an `Activity` and can be related to other (parent) `Activities` implicitly.

hasGenericActivity. Relates a children `Activity` with a parent `Activity`. This relationship enables the gazetteer to deal with hierarchies of activities to return children activities when parent ones are searched (an assumed expected behavior).

involvesPlace. Relates an `Activity` and a `Place` (not to be confused with the relationship `affordedBy`, which would be the inverse predicate of `affords`). The relationship `involvesPlace` helps specify that an `Activity` afforded by a `Place` involves other places. For instance, a viewpoint (which is a `Place`) may afford to survey (an `Activity`) a valley (another `Place`); we would say then that the `Activity Survey` involves the place represented by the valley.

hasPrerequisite. Relates an `ActivityAtPlace` with another `ActivityAtPlace`. It is intended to model prerequisites, i.e., instances of `ActivityAtPlace` that need to be performed before another instance of `ActivityAtPlace` can be performed (see Prerequisites for an example).

isDirectedAt. Relates an `ActivityAtPlace` with a `Group`. Every `ActivityAtPlace` must be at least directed at a `Group`.

hasSpatialConstraint. Relates an `ActivityAtPlace` with a `Geometry`. Several instances of `Geometry` might be related to the same `ActivityAtPlace`.

hasSocialConstraint. Relates an `ActivityAtPlace` with a `SocialConstraint`. Several instances of `SocialConstraint` might be related to the same `ActivityAtPlace`.

restrictsActivityTo. Relates a `SocialConstraint` and a `Group`. It is intended to specify the only groups that can perform an activity due to social constraints.

prohibitsActivityTo. Relates a `SocialConstraint` and a `Group`. It is intended to specify the groups that cannot perform an activity due to social constraints.

permitsActivityIn. Relates a `SocialConstraint` and a `Geometry` (spatial constraint). It is intended to specify the areas where an activity can be performed due to social constraints.

prohibitsActivityIn. Relates a `SocialConstraint` and a `Geometry` (spatial constraint). It is intended to specify the areas where an activity cannot be performed due to social constraints.

hasTemporalConstraint. Relates an instance of `ActivityAtPlace` with the blank node `TemporalConstraint`.

isAvailableAtSeason. Relates the blank node `TemporalConstraint` with an instance of `ProperInterval` to specify the availability of an activity at certain season.

hasOpeningHoursSpecification. Relates the blank node `TemporalConstraint` with an instance of `OpeningHoursSpecification`. It is borrowed from the *GoodRelations vocabulary* and serves to specify the opening hours in that a place affords a given activity.

hasEconomicConstraint. Relates an `ActivityAtPlace` with an `Offering` (economic constraint). There might be several `Offerings` for the same `ActivityAtPlace`, like in the case of an accommodation place that affords to stay and provides guests with various options depending on budget and facilities included.

acceptedPaymentMethods. Relates an `Offering` and a `PaymentMethod`. It is borrowed from the *GoodRelations vocabulary*.

hasPriceSpecification. Relates an `Offering` and a `PriceSpecification`. It is borrowed from the *GoodRelations vocabulary*.

requiresSpecialEquipment. Relates an `ActivityAtPlace` with an `Equipment`.

It can be noticed that several LOD vocabularies have been used in the affordance-based gazetteer vocabulary. Namely, *Time Ontology*, foaf, DBpedia, WordNet, GeoSPARQL, the *Topography Ontology*, and GoodRelations. These vocabularies are well established ones and by linking the vocabulary presented in this section to them we are leveraging the reuse of the classes they define, as recommended by the LOD principles.

Concerning GoodRelations, some associations can be established between it and the affordance-based gazetteer vocabulary. For instance, GoodRelations also accounts for

places. It does so through a class `Location` that has a name, a category, a pair of coordinates (Latitude-Longitude), and opening hours. An `Offering` has accepted payment methods and price specification and is available at a `Location`. It seems feasible to establish some ways of collecting affordance-based gazetteer data from data structured in GoodRelations, procedure known as *harvesting*. We leave this as further work since some reasoning between offerings and activities has to be made before, which might not be an easy task.

4.5.3 Requirements revisited

The requirements stated in Section 4.3 have been taken as a basis for elaborating the affordance-based gazetteer vocabulary. Table 1 shows the relationships and classes that have been considered to meet each requirement. Again, Figure 1 can be taken as reference for observing the vocabulary as a whole.

TABLE 1: Relationships and classes used to meet the requirements of the affordance-based gazetteer model.

Requirement	Classes	Relationships
User groups	`Group`	`directedAt`
Temporal constraints	`TemporalConstraint` (Blank node), `ProperInterval`, `OpeningHoursSpecification`	`hasTemporalConstraint`, `isAvailableAtSeason`, `hasOpeningHoursSpecification`
Social constraints	`SocialConstraint`	`hasSocialConstraint`, `restrictsActivityTo`, `prohibitsActivityTo`, `permitsActivityIn`, `prohibitsActivityIn`
Spatial constraints	`Geometry`	`hasSpatialConstraint`
Economic constraints	`Offering`, `PaymentMethod`, `PriceSpecification`	`hasEconomicConstraint`, `acceptedPaymentMethods`, `hasPriceSpecification`
Prerequisites	`ActivityAtPlace`	`hasPrerequisite`
Activity hierarchy	`Activity`	`hasGenericActivity`
Place-Activity-Place	`Place`, `ActivityAtPlace`	`involvesPlace`

5

USE CASE: BICYCLE TOURING

5.1 Characterization

The use case corresponds to bicycle touring and is based on a real story documented in an online touring diary[38] that can be summarized in the following description.

Sebastian, a Colombian cyclist, undertakes an international tour requiring different kinds of accommodation at various towns, cities, and countries. Despite the fact of having roughly planned stages, the tour is subject to adjustments along the way. His challenge is to find places to stay accounting for local feature types. He has access to an off-line affordance-based gazetteer from his mobile phone, that he can use to search for places.

Bicycle touring is an activity that comprises both cycling and tourism. There are different kinds or tours, depending on the budget, duration, and length, among other factors. It is also a matter of taste whether to stick to a plan or to be flexible with the stages. Moreover, touring cyclists can face unexpected situations that lead them to change and adjust their original plans. They can extend their stages if they feel strong enough and there are optimal conditions (e.g., weather, state of the road, some company, and so forth). Depending on the budget, they can expect to stay at hotels (and related types of accommodation places) or to camp. Eventually, they could stay at cyclists houses (where they stay for free) or at familiar houses.

Sebastian's diary, like any other detailed diary of a touring cyclist, is a good source of activities that might be performed at several towns, cities, and countries, as well as a reference for understanding differences among types of places to stay.

Sebastian undertook an expedition tour across South America in the second half of 2012. His budget was limited, a factor that played a prominent role in his decisions. When searching for accommodation, he favored cheap places over luxurious and expensive hotels. However, he decided to make his best trying to stay in towns, avoiding camping in abandoned fields or constructions, which are alternative ways of saving money, but might involve security risks.

[38] Available in Spanish at: http://www.crazyguyonabike.com/doc/10785

Touring cyclists have their own sources of information when searching for accommodation places. They can lookup at specialized websites (e.g., *Warmshowers* and *POIDB*), hostage services (e.g., *Lonely Planet* and *Trip Advisor*), generic mapping services (e.g., *OpenStreetMap* and *Google Earth*), or at local touristic websites[39] and yellow pages. They could also be advised by other touring cyclists or by locals.

An implementation of the affordance-based gazetteer vocabulary in Linked Open Data serves as framework for the use case. SPARQL queries help solve the cyclist requirements based on affordances of places included in local gazetteers. The underlying hypothesis is that an affordance-based gazetteer may facilitate place lookups by involving relevant context information in the form of activities. Beyond place types, bicycle tourists are regularly interested in activities performed at places as well as in how much those activities cost.

5.2 Four scenarios

There is a wide variety of situations in which a touring cyclist can be involved while traveling. From Sebastian's diary we have selected a subset of relevant scenarios that help us illustrate the appropriateness of affordance-based gazetteers for place information retrieval.

The four scenarios are entirely based on Sebastian's experiences during his journey, i.e., the situations are real. For reference, we include the days when Sebastian mentions such situations in his diary. Accommodation offerings were collected from the Internet and from directories of touristic services. When needed, data about location, activities, communities, prices, and the like, was made up for the sake of illustration.

Both the vocabulary and the data used to implement each scenario have been published online[40] in *Turtle* format. For reference, the scenario 1 has 256 triples, the scenario 2 has 708 triples, the scenario 3 has 429 triples, and the scenario 4 has 303 triples.

5.2.1 Scenario 1: A restaurant that permits to camp in Colombia (Day 10)

The road Mocoa-Sibundoy, in Colombia, is a tough but worthy route for touring cyclists. It is a narrow road called the *Trampoline of Death* because of the cliffs. The road is about 80 km long and due to the mountains and to the lack of proper road surface, it is usually covered in two stages.

[39] See for example http://www.bolivia.travel/activities_en.aspx
[40] They are available at: http://ifgibox.de/g_carr02/thesis/

While searching for places to stay Sebastian would normally enter the terms *Hostel*, *Hotel*, *Inn*, and the like. However, besides abandoned houses along the way, there are no hotels or similar places to stay near the road. Surprisingly, a restaurant offers campsites for free and that is exactly the information Sebastian would like to obtain from a gazetteer.

Figure 2 illustrates the structure of a sample place included in the scenario 1. The place shown is the restaurant *Buenos Aires* (represented by the box named *RBA*), which affords two activities (in orange): `Eat` and `Camp`. In general, arrows represent relationships between data, which has two representations: literals (yellow boxes) or objects (boxes of colors other than yellow). The arrows are not labeled for the sake of readability, however, Figure 1 can be used as reference for the relationships. Blue arrows represent conventional relationships between gazetteer components, i.e., the place *RBA* has feature type *Restaurant*, has placename *Buenos Aires*, and has footprint *RBAFootprint*. Colors in other arrows, as well as in other boxes, are merely to indicate associations, for instance, green arrows represent the relationship *affords* between a place and a realization of an activity, whereas orange arrows represent relationships between activities.

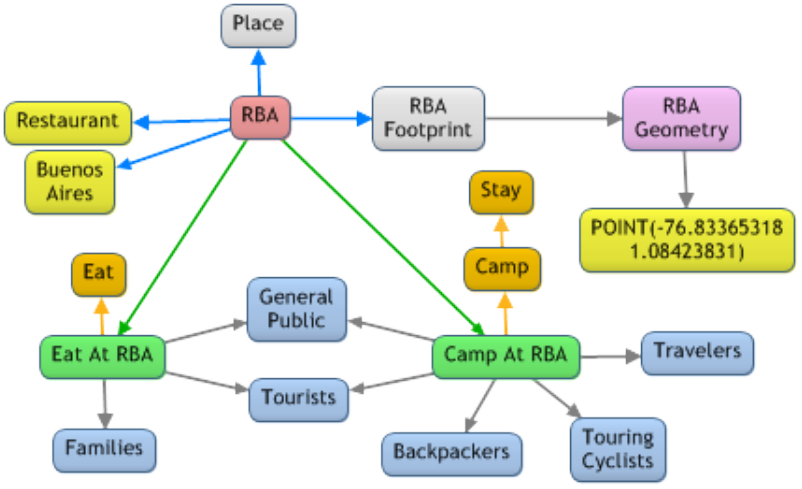

FIGURE 2: Sample place included in the scenario 1: Restaurant *Buenos Aires*. The box named RBA represents the place itself, from where relationships such as *hasPlacename*, *hasFeatureType*, *hasFootprint* (all these three in blue), and *affords* (in green) are defined. Activities are represented by orange boxes, their realizations by green boxes, and the user groups by blue boxes.

An overview of the data, including places, placenames, feature types, and activities is shown in Figure 3. Again, blue arrows are conventional gazetteer relationships, green arrows represent the relationship *affords*, pink boxes are instances of places, whose feature types and placenames are represented by yellow boxes (both are literals). Finally, green boxes are realizations of activities.

By executing the SPARQL query given in Listing 7, the gazetteer is able to return places that afford to stay ignoring feature types. This allows Sebastian to obtain a hotel, an

inn, and a restaurant. It can be noticed from the same listing that the activity `Camp` is not explicitly searched, but it is returned by looking at its relationship with the activity `Stay` through the predicate `hasGenericActivity` (see lines 17-21). Table The results of this query are presented in Table 2.

FIGURE 3: Places (pink boxes), placenames (yellow boxes), feature types (yellow boxes), and realizations of the activities (green boxes) in the scenario 1.

LISTING 7: SPARQL query for the scenario 1. Obtaining places to stay near the road Mocoa-Sibundoy.

```
1  PREFIX affgaz: <http://localhost/gazetteer/affgaz.rdf#>
2  PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
3  PREFIX geo: <http://www.opengis.net/ont/geosparql#>
4
5  SELECT DISTINCT
6  (concat("(", ?type, ") ", ?pName) as ?Place) ?Activity ?Geometry
7  WHERE {
8     ?p a affgaz:Place ;
9     affgaz:hasPlacename ?pName ;
10    affgaz:hasFeatureType ?type ;
11    affgaz:hasFootprint ?footprint ;
12    affgaz:affords ?aff .
13    ?footprint geo:hasGeometry ?geom .
14    ?geom geo:asWKT ?Geometry .
15    ?aff affgaz:realizationOf ?act .
16    ?act skos:prefLabel ?Activity .
17    OPTIONAL {
18      ?act affgaz:hasGenericActivity ?genAct .
19      ?genAct skos:prefLabel ?genActivity .
20    }
21    FILTER (?Activity = "Stay"@en || ?genActivity = "Stay"@en)
22 }
```

Once the three places are drawn over a background map, Sebastian can realize his only option is to camp at the restaurant. A filter by proximity could also be employed to filter out the hotel and the inn, as they are farther away of the middle of the road.

TABLE 2: Results of the SPARQL query shown in Listing 7. Three places would allow Sebastian to stay; a restaurant among them.

Place	Activity	Geometry
(Inn) La Orquidea	Stay	POINT(-76.891894 1.187039)
(Hotel) San Diego	Stay	POINT(-76.921259 1.204725)
(Restaurant) Buenos Aires	Camp	POINT(-76.83365318 1.08423831)

5.2.2 Scenario 2: Accommodation in Bolivia (Days 106-107)

Even though there is a clear main activity afforded by accommodation places, there are features that make them remarkably diverse. Accommodation places can be difficult to categorize and it is likely to find problems with terminology. For instance, the word *motel* is a type of accommodation for motorists in the United States of America, but it is almost a taboo in some Latin American countries since it refers to a kind of accommodation related to extramarital encounters. Furthermore, the terminology used for accommodation places might not be shared among countries, and even among countries with a common language. Depending on culture and language, accommodation places can be named in a wide variety of ways and the same name might mean different things.

Taking Bolivia's regulation on the matter[41] as example, there are nine types of places for touristic accommodation. One of them is focused on sportsmen and other communities, and has four subtypes. Not to mention that some of those types have their own categories, according to the facilities and services offered. To make things more difficult, an official directory of touristic services[42] in Bolivia lists types of accommodation not included in the aforementioned regulation.

Sebastian looks for a place to stay when arriving in Potosí, Bolivia. He is not aware of local or specialized feature types, but intends to get accommodation at a good price.

To avoid using particular feature types Sebastian could search for the activity `Stay` and, additionally, he could make use of user groups and prices as filters to discriminate the results. In that sense, the gazetteer search would emulate what tourist cyclists usually do when arriving in towns: ask locals or other touring cyclists for accommodation places that are suitable for their activity (i.e., just one or two nights of accommodation, cheap prices, perhaps enough space, and the like).

[41] Estado Plurinacional de Bolivia, Ministerio de culturas, Viceministerio de Turismo. *Reglamento Ley de Promoción y Desarrollo de la Actividad Turística en Bolivia*, chapter 2. 2001. Available at http://www.viceturismo.minculturas.gob.bo/images/stories/normativas/rhospedaje.pdf

[42] Estado Plurinacional de Bolivia. Directorio de Prestadores de Servicios Turísticos, pp.101–126. 2012. Available at https://docs.google.com/open?id=0B39YZtTKDcSANHBKUm94Nk5SUXM

It should be noticed here that user groups are essential for truly accounting for affordances in gazetteer modeling, which makes them also meaningful for discovering and retrieving place information in new ways.

Figure 4 shows a subset of the data related to a sample place included in the scenario 2. The place is the hotel *Cima Argentum*represented by the pink box named *HCA*. Different colors are used to associate different concepts and relationships. For instance, green boxes represent realizations of activities, purple boxes are offerings associated to those realizations of activities, and blue boxes are user groups.

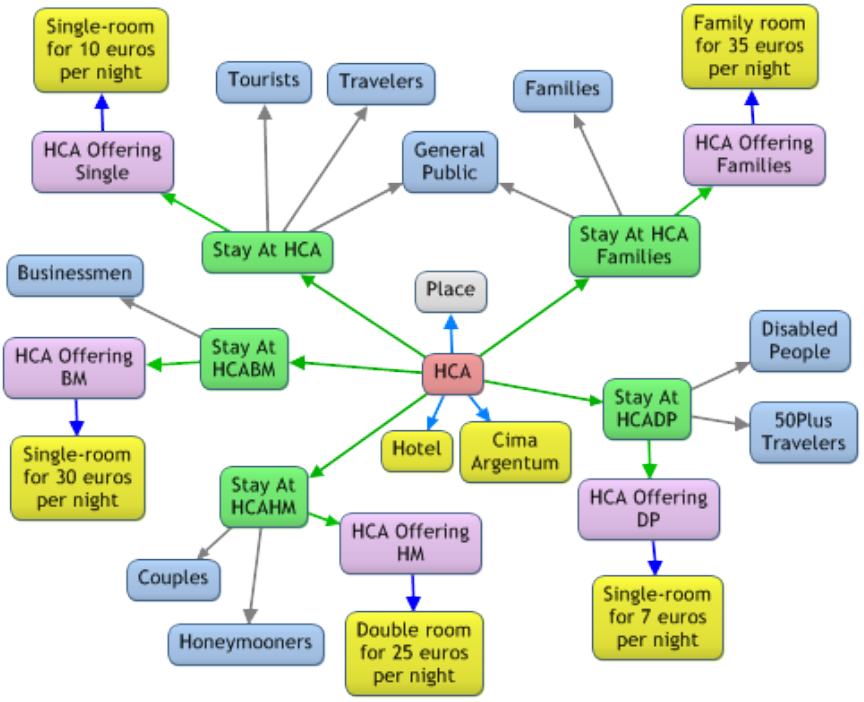

FIGURE 4: Sample place included in the scenario 2: Hotel *Cima Argentum*. The box named *HCA* represents the place itself. Realizations of activities are represented by green boxes, user groups by blue boxes, and offerings by purple ones.

For the sake of clarity, the linked open data used in this example is limited to the activity `Stay`, discarding other activities afforded by accommodation places. The SPARQL query presented in Listing 8 retrieves accommodation offerings directed at touring cyclists (see line 21) and orders them by price (see line 31). The results are shown in Table 3.

LISTING 8: SPARQL query for the scenario 2. Obtaining places to stay directed at touring cyclists and ordered by price.

```
1  PREFIX data: <http://localhost/gazetteer/scenario2/>
2  PREFIX affgaz: <http://localhost/gazetteer/affgaz.rdf#>
3  PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
4  PREFIX gr: <http://purl.org/goodrelations/v1#>
5  PREFIX geo: <http://www.opengis.net/ont/geosparql#>
6
7  SELECT DISTINCT
8  (CONCAT("(", ?type, ") ", ?pName ) as ?Place) ?Offering
9  (CONCAT(?curValue," ",?currency,"/",?units ) as ?Price)
10 ?Geometry
11 WHERE {
```

```
12      ?p a affgaz:Place ;
13      affgaz:hasPlacename ?pName ;
14      affgaz:hasFeatureType ?type ;
15      affgaz:hasFootprint ?footprint ;
16      affgaz:affords ?aff .
17      ?footprint geo:hasGeometry ?geom .
18      ?geom geo:asWKT ?Geometry .
19      ?aff affgaz:realizationOf ?act .
20      ?act skos:prefLabel ?Activity .
21      ?aff affgaz:isDirectedAt data:TouringCyclists .
22      ?aff affgaz:hasEconomicConstraint ?ecoConstraint .
23      ?ecoConstraint gr:name ?Offering .
24      ?ecoConstraint affgaz:hasPriceSpecification ?blank .
25      ?blank gr:hasCurrencyValue ?curValue .
26      ?blank gr:hasCurrency ?currency .
27      ?blank gr:hasUnitOfMeasurement ?units .
28      FILTER (?Activity = "Stay"@en)
29      FILTER( lang(?type) IN ("en"))
30  }
31  ORDER BY ?curValue
```

TABLE 3: Results of the SPARQL query in Listing 8. Accommodation offerings directed at touring cyclists ordered by price.

Place	Offering	Price	Geometry
(Bed and Breakfast) Hospedaje María José	Single room for 2.5 euros per night	2.5 EUR/DAY	POINT(-65.755228 -19.588898)
(Inn) Tupac Katari	Single room for 2.5 euros per night	2.5 EUR/DAY	POINT(-65.750172 -19.594761)
(Bed and Breakfast) Porco Santa Rosa	Single room for 3 euros per night	3 EUR/DAY	POINT(-65.765614 -19.577633)
(Guest House) Mi Tupiza Bella	Single room for 3 euros per night	3 EUR/DAY	POINT(-65.747638 -19.588363)
(Inn) La Estrella	Single room for 3 euros per night	3 EUR/DAY	POINT(-65.755180 -19.577466)
(Boarding House) Copacabana	Shared-room for 4 euros per night	4 EUR/DAY	POINT(-65.75452 -19.584865)
(Guest House) The Koalas Den	Single room for 5 euros per night	5 EUR/DAY	POINT(-65.755963 -19.589101)
(Hostel) La Casona	Shared-room for 5 euros per night	5 EUR/DAY	POINT(-65.752927 -19.590445)
(Boarding House) Tarija	Shared-room for 5 euros per night	5 EUR/DAY	POINT(-65.755738 -19.584168)

On the other hand, as mentioned while describing new queries for gazetteers in Chapter 4 (see query 3), Sebastian could also retrieve the accommodation types used in Bolivia for reference. That could give him a hint before doing the search to be aware of local feature types and, probably, of their definitions.

Figure 5 presents an overview of places, placenames, and feature types included in the scenario 2. Places are represented by pink boxes, whereas their feature types and placenames (both being literals) are shown in yellow. Blue arrows point to feature types, whereas gray arrows point to placenames.

Listing 9 shows a query for retrieving feature types of places to stay. The results of such a query are given in Table 4.

Listing 9: SPARQL query for the scenario 2. Obtaining feature types of places to stay in Potosí.

```
PREFIX data: <http://localhost/gazetteer/scenario2/>
PREFIX affgaz: <http://localhost/gazetteer/affgaz.rdf#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>

SELECT DISTINCT
?Type
WHERE {
   ?p a affgaz:Place ;
   affgaz:hasFeatureType ?Type ;
   affgaz:affords ?aff .
   ?aff affgaz:realizationOf ?act .
   ?act skos:prefLabel ?Activity .
   FILTER (?Activity = "Stay"@en)
   FILTER( lang(?Type) IN ("en"))
}
```

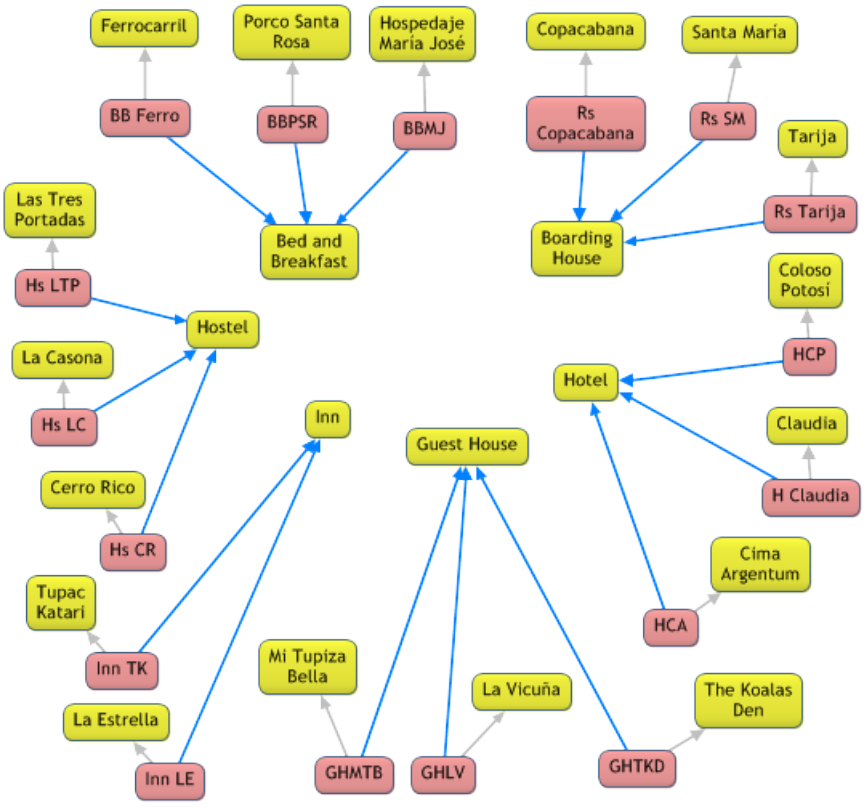

Figure 5: Overview of places, placenames, and feature types included in the scenario 2. Places are represented by pink boxes. Both placenames and feature types are literals and are represented by yellow boxes. Blue arrows point to feature types.

Table 4: Results of the SPARQL query in Listing 9. Feature types of places to stay.

Type
Inn
Guest House
Bed and Breakfast
Boarding House
Hostel
Hotel

5.2.3 Scenario 3: Play tejo in Chile (Day 198)

Prices are not an exclusive criterion when touring cyclists select places to stay. Being aware of other activities afforded by a place may also play a prominent role as those activities could fit into the touring cyclist intentions or preferences. The affordances of accommodation places are related to features and facilities that constitute the place; some of them might make it unique even among places sharing a common feature type (see Figure 6).

For instance, Sebastian found by chance that it is possible to play *tejo*[43] at one of the accommodation places in Bahía Murta, Chile. While that might be irrelevant for most people, the *tejo* happens to be an autochthonous Colombian sport; thus Sebastian, who comes from Colombia, was certainly surprised by having the opportunity of playing it abroad and learning the variations of such sport in other countries. Information about different activities that people can perform at places, even being rare activities, can ease the selection of places.

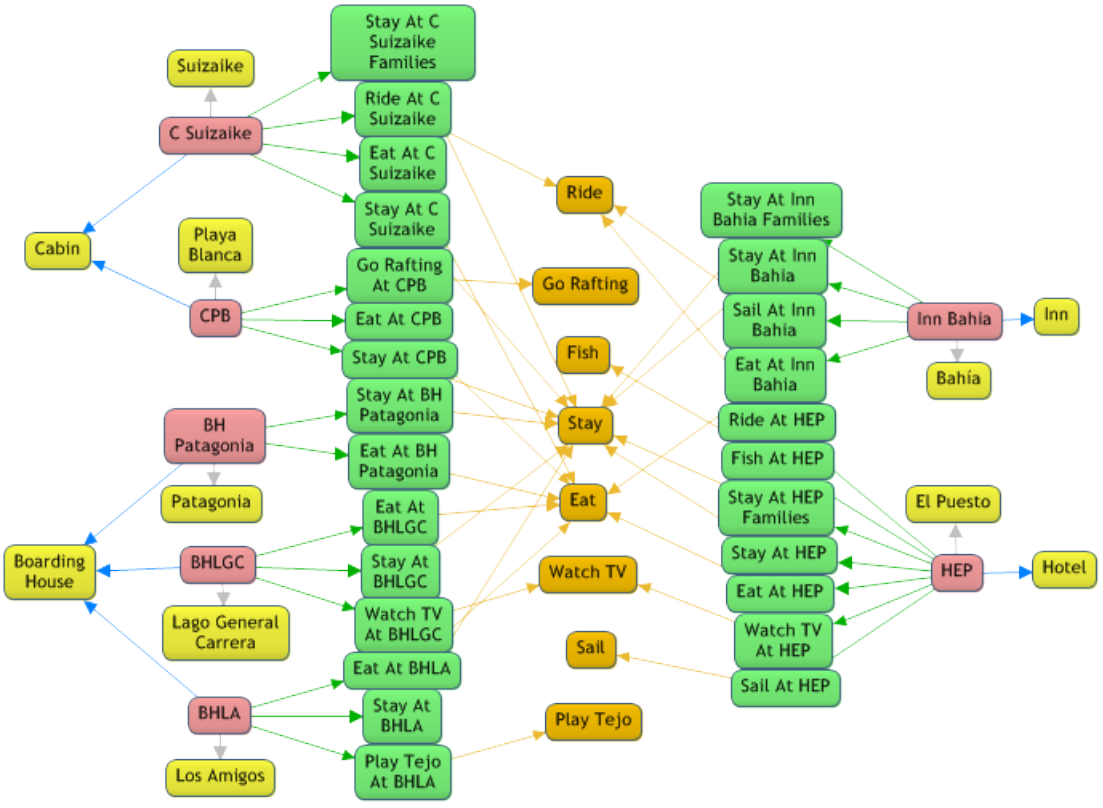

FIGURE 6: Overview of the data included in the scenario 3. Places are represented by pink boxes, activities are represented by orange boxes, and their realizations by green boxes. Feature types and placenames are represented by yellow boxes (because both are literals). The former can be distinguished from the latter since they are connected to places by blue arrows.

[43] See a brief description of *tejo* at http://suite101.com/article/traditional-sports-colombian-tejo-a140526

Figure 7 shows a sample place included in the scenario 3, namely, the boarding house *Los Amigos*. Besides illustrating different activities afforded by the place, the figure also shows the implementation of sequential activities, i.e., activities that can only be performed if another activity is performed before. The latter activity is called a *prerequisite* in the vocabulary and the relationship between both activities is expressed by the predicate `hasPrerequisite` (represented by a red arrow in the figure).

By executing the query presented in Listing 10, a gazetteer could show Sebastian places that afford touring cyclists to stay in Bahía Murta (see Table 5).

Listing 10: SPARQL query for the scenario 3. Obtaining places to stay directed at touring cyclists.

```
PREFIX data: <http://localhost/gazetteer/scenario3/>
PREFIX affgaz: <http://localhost/gazetteer/affgaz.rdf#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>

SELECT DISTINCT
(CONCAT("(", ?type, ") ", ?pName ) as ?Place)
WHERE {
   ?p a affgaz:Place ;
   affgaz:hasPlacename ?pName ;
   affgaz:hasFeatureType ?type ;
   affgaz:affords ?aff .
   ?aff affgaz:realizationOf ?act .
   ?act skos:prefLabel ?Activity .
   ?aff affgaz:isDirectedAt data:TouringCyclists .
   FILTER( ?Activity = "Stay"@en )
   FILTER( lang(?type) IN ("en") )
}
```

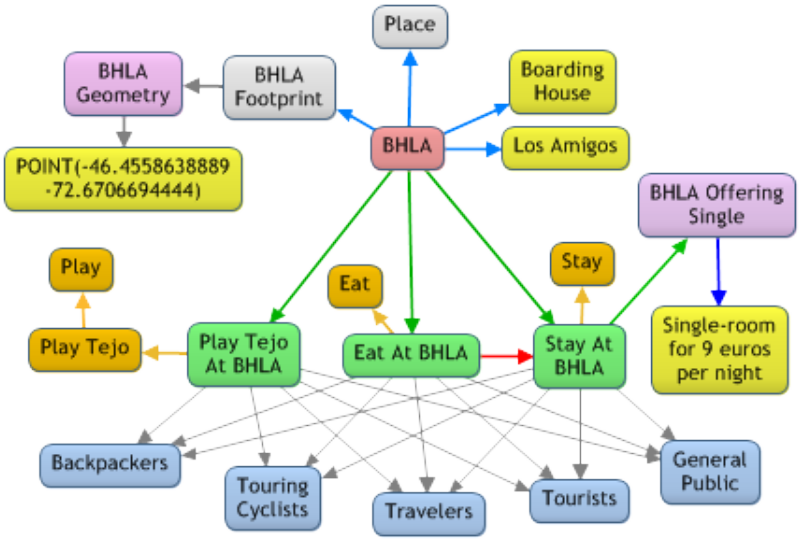

Figure 7: Sample place included in the scenario 3: Boarding house *Los Amigos*. Activities are represented by orange boxes, their realizations by green boxes, and user groups by blue boxes. The red arrow represents the predicate `hasPrerequiste`, indicating that the activity `Eat` is only possible if the activity `Stay` is performed before.

TABLE 5: Results of the SPARQL query in Listing 10. Places that afford touring cyclists to stay in Bahía Murta, Chile.

Place
(Boarding House) Los Amigos
(Boarding House) Patagonia
(Boarding House) Lago General Carrera

After that, an application built on top of the gazetteer could offer Sebastian to explore activities afforded by such places, so that he can evaluate differences between places and make better decisions. The Listing 11 shows the query required to obtain activities afforded by the three places listed in Table 5. The result is shown in Table 6, from which Sebastian can notice that the place *Los Amigos* allows him to play *tejo*.

LISTING 11: SPARQL query for the scenario 3. Obtaining activities afforded by places to stay in Bahía Murta.

```
PREFIX data: <http://localhost/gazetteer/scenario3/>
PREFIX affgaz: <http://localhost/gazetteer/affgaz.rdf#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>

SELECT DISTINCT
?Place
(GROUP_CONCAT(DISTINCT ?Activity; SEPARATOR=", ") AS ?Activities)
?Geometry
WHERE {
   ?p a affgaz:Place ;
   affgaz:hasPlacename ?pName ;
   affgaz:hasFeatureType ?type ;
   affgaz:hasFootprint ?footprint ;
   affgaz:affords ?aff .
   ?footprint geo:hasGeometry ?geom .
   ?geom geo:asWKT ?Geometry .
   ?aff affgaz:realizationOf ?act .
   ?act skos:prefLabel ?Activity .
   OPTIONAL {
     ?act affgaz:hasGenericActivity ?genAct .
     ?genAct skos:prefLabel ?genActivity .
   }
   FILTER (?pName IN ("Patagonia"@es, "Los Amigos"@es,
      "Lago General Carrera"@es))
   FILTER( lang(?type) IN ("en") && lang(?Activity ) IN ("en"))
   BIND (CONCAT("(", ?type, ") ", ?pName ) as ?Place)
}
GROUP BY ?Place ?Geometry
```

TABLE 6: Results of the SPARQL query in Listing 11. Activities afforded by places to stay.

Place	Activities	Geometry
(Boarding House) Los Amigos	Play tejo, Eat, Stay	POINT(-46.4558639 -72.6706694)
(Boarding House) Patagonia	Eat, Stay	POINT(-46.4602333 -72.6714556)
(Boarding House) Lago General Carrera	Watch TV, Eat, Stay	POINT(-72.6740611 -46.4555472)

5.2.4 Scenario 4: Dormis to watch football on TV in Argentina (Day 223)

This scenario involves the aforementioned three scenarios: it deals with places affording activities that are not expected because of their official feature type, with integration of

feature typing schemes, and also with richer representation of places for improving decision making.

When arriving to Tolhuin, Argentina, Sebastian is aware of a National Football League (NFL)[44] game that will take place at night. Since he is a football fan, he intends to watch it on TV. In Tolhuin, a bakery offers accommodation for cyclists for free, but Sebastian knows that the environment to be found there is probably communal and he intends to watch the game with some privacy, even if he has to pay more than he normally does during his journey.

As in the scenario 2, Sebastian does not know about local types for accommodation places. The Figure 8 presents an overview of places and activities included in the scenario 4. Places are represented by pink boxes, feature types and placenames by yellow boxes (they both are literals in the vocabulary), and realizations of activities by green boxes.

By executing the SPARQL query shown in Listing 12, Sebastian is able to find places to stay in Tolhuin (including the bakery) as well as the activities afforded by those places. The results of such query are listed in Table 7.

FIGURE 8: Overview of the data included in the scenario 4. Places are represented by pink boxes, the realizations of activities by green ones, and the feature types as well as the placenames, being literals, are represented by yellow boxes.

[44]The main football league in the United States of America.

Listing 12: SPARQL query for the scenario 4. Obtaining activities afforded by places to stay.

```
PREFIX data: <http://localhost/gazetteer/scenario4/>
PREFIX affgaz: <http://localhost/gazetteer/affgaz.rdf#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>

SELECT DISTINCT
?Place
(GROUP_CONCAT(DISTINCT ?Activity; SEPARATOR=", ") AS ?Activities)
?Geometry
WHERE {
   ?p a affgaz:Place ;
   affgaz:hasPlacename ?pName ;
   affgaz:hasFeatureType ?type ;
   affgaz:hasFootprint ?footprint ;
   affgaz:affords ?aff .
   ?footprint geo:hasGeometry ?geom .
   ?geom geo:asWKT ?Geometry .
   ?aff affgaz:realizationOf ?act .
   ?act skos:prefLabel ?Activity .
   {SELECT ?subPName
       WHERE{
          ?subP a affgaz:Place ;
          affgaz:hasPlacename ?subPName ;
          affgaz:affords ?subAff .
          ?subAff affgaz:realizationOf ?subAct .
          ?subAct skos:prefLabel ?subActivity .
          OPTIONAL {
             ?subAct affgaz:hasGenericActivity ?subGenAct .
             ?subGenAct skos:prefLabel ?subGenActivity .
          }
          FILTER(?subActivity = "Stay"@en ||
             ?subGenActivity = "Stay"@en)
       }
   }
   FILTER(lang(?Activity) IN ("en"))
   FILTER(lang(?type) IN ("en"))
   FILTER(?pName IN (?subPName))
   BIND (CONCAT("(", ?type, ") ", ?pName ) as ?Place)
}
GROUP BY ?Place ?Geometry
```

Table 7: Results of the SPARQL query in Listing 12. Activities afforded by places to stay in Tolhuin, Argentina.

Place	Activities	Geometry
(Dormis) De Paso	Watch TV, Stay	POINT(-67.19264 -54.514406)
(Lodging House) Rutalsur	Watch TV, Eat, Stay	POINT(-67.198344 -54.522478)
(Campground) Hain	Camp	POINT(-67.228947 -54.508227)
(Hotel) Hain del Lago Khami	Watch TV, Eat, Stay	POINT(-67.222584 -54.519263)
(Inn) La Posada de los Ramírez	Eat, Stay	POINT(-67.194357 -54.506832)
(Bakery) La Unión	Stay, Buy bread, Eat bread	POINT(-67.197542 -54.510069)

But the activity `Watch TV` could be performed in communal areas or in private rooms, depending on the accommodation place. These aspects of the activity can be modeled through the `SocialConstraint` (see Figure 9) concept and, thus, help add more context to the digital representation of the place in a gazetteer.

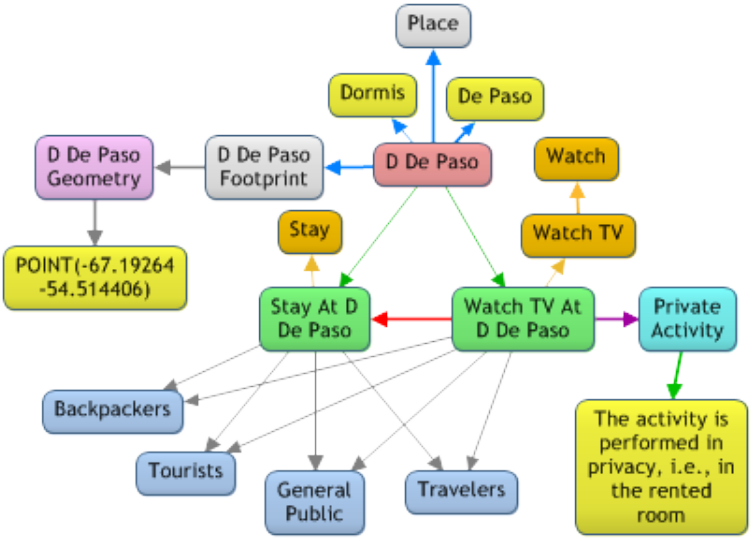

FIGURE 9: Sample place included in the scenario 4: Dormis *De Paso*. The box named *D De Paso* represents the place itself. Activities are represented by orange boxes, their realizations by green boxes, and user groups by blue boxes. The cyan box represents a social constraint that indicates privacy. The red arrow indicates that the activity `Stay` is a prerequisite of the activity `Watch TV`.

A detailed view on other characteristics of the activity `Watch TV` at the three places that afford it (see Table 7), provides remarks about social constraints of the activity. Those constraints restrict the ways Sebastian can perform the activity `Watch TV` and give him hints on the environment to be found there. The Listing 13 shows a query for retrieving social constraints associated to the aforementioned activity. The results are presented in Table 8, from where Sebastian could pick the place that better fits his expectations. As the hotel remains ambiguous in this regard, a look to the prices could help him decide between the hotel (60 euros per day) and the dormis (6 euros per day).

LISTING 13: SPARQL query 1.

```
PREFIX data: <http://localhost/gazetteer/scenario4/>
PREFIX affgaz: <http://localhost/gazetteer/affgaz.rdf#>
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>

SELECT DISTINCT
?Place ?Activity ?SocialConstraint
WHERE {
   ?p a affgaz:Place ;
   affgaz:hasPlacename ?pName ;
   affgaz:hasFeatureType ?type ;
   affgaz:affords ?aff .
   ?aff affgaz:realizationOf ?act .
   ?act skos:prefLabel ?Activity .
   OPTIONAL {
      ?aff affgaz:hasSocialConstraint ?socCon .
      ?socCon rdfs:comment ?SocialConstraint .
   }
   FILTER(?Activity = "Watch TV"@en )
   FILTER(lang(?type) IN ("en"))
   BIND (CONCAT("(", ?type, ") ", ?pName ) as ?Place)
}
```

TABLE 8: Results of the SPARQL query in Listing 13. Social constraints of the activity `Watch TV`.

Place	Activity	Social Constraint
(Dormis) De Paso	Watch TV	The activity is performed in privacy, i.e., in the rented room
(Lodging House) Rutalsur	Watch TV	The activity is performed in a shared environment
(Hotel) Hain del Lago Khami	Watch TV	

5.3 Discussion

Throughout the Section 5.2 the affordance-based gazetteer vocabulary built in Chapter 4 was employed as a framework for implementing local gazetteers that meet the main requirements of touring cyclists when looking for places to stay.

The data included in the four scenarios were collected from several sources in the Internet (mainly names of places to stay, feature types, and their locations). When needed, some data concerning activities, user groups, prices, and the like, were made up to complete the requirements of each scenario. The data were then structured in triples and encoded in *Turtle* format. Finally, the triple store *Parliament*[45] was used to load the data and perform SPARQL queries on them.

Concerning gazetteer integration, even though the four scenarios presented occurred in four countries, it was possible for Sebastian to search for places to stay following a common procedure and taking advantage of a subset of the vocabulary. Namely, he made use of the following parts of the vocabulary, not present in conventional gazetteers that only rely on feature types:

- **Activities:** They serve to characterize places with their functional meanings and were used to abstract feature types in order to discover commonalities and differential aspects of places to stay.
- **Realization of activities:** They are the core of the affordance-based gazetteer approach. Through their relationships with other concepts, it was possible to give more context to the accommodation places, making it easier to find the most suitable places to stay in each scenario.
- **Generic activities**: They were used to discover more specific activities that still meet the requirements of a given query.
- **User groups:** They were used for filtering out accommodation offerings that are directed at user groups other than touring cyclists. This is relevant because each

[45] See `http://parliament.semwebcentral.org`

user group has its own requirements, interests, and expectations, which are implicitly encapsulated on the instances of the class.

- **Economic constraints (offerings):** They are relevant for establishing costs of a given activity and were used as a means of differentiating similar offerings by looking at their prices.
- **Social constraints:** They help provide more context to the activities afforded by places regarding social aspects. In the scenario 4, they were used to specify lower-level affordances such as privacy.

Other objects (e.g., `OpeningHours`) and predicates (e.g., `hasPrerequisite`) of the vocabulary were also included in the data for reference, though they were not exploited in any scenario.

We can summarize each scenario in separate and identify their bottom line as follows (bear in mind that we are accounting for affordances as activities, as explained in Section 4.2):

Scenario 1: Affordances span across feature types.
This scenario shows how activities can be employed for discovering unexpected functions of places. We refer to these functions as unexpected because of the feature types (e.g., a restaurant that affords to camp), thus, the scenario serves to evidence some troubles that arise when merely accounting for feature types in digital representation of places.

Scenario 2: Affordances help integrate feature typing schemes.
This scenario shows how activities help integrate specialized or local feature types, in a way that it is possible to retrieve the data sought by exploiting their commonalities. In this scenario, a local feature typing scheme for accommodation places (that at first sight is unknown for non-locals) is no longer an obstacle but an opportunity for the touring cyclist to find places to stay. Through the employment of user groups, differential characteristics of places to stay are revealed, what constitutes a new way for discovering and retrieving gazetteer data. Economic constraints, in the form of prices, were used to further distinguish between offerings.

Scenario 3: Affordances enrich the digital representation of place.
Activities contribute to distinguish places that share feature types but are somehow different. It seems to be naive to expect that feature types can encapsulate and express the very diverse nature of places. In this scenario, several opportunities for action at places to stay were presented to the touring cyclist as a way of differentiating similar

offerings. By chance, the touring cyclist found one of such activities certainly appealing, what led him to choose a place over others.

Scenario 4: Lower-level affordances play a role describing higher-level ones. In Section 4.2, we have deliberately preferred high-level affordances (i.e., activities) over low-level ones (i.e., actions, operations) for modeling places in gazetteers. However, it turns out that the latter ones might help describe the former ones, i.e., the description of an activity might be enhanced by making explicit other aspects provided by places. In this scenario, the activity `Watch TV` has been further specified by means of the social constraint `Privacy`, which can be seen as an affordance itself provided by a place to stay. It can be noticed here that the affordance `Privacy` is indeed related to one of the affordances of places given by (Gibson, 1986, p.136), namely, to conceal oneself from other observers. Privacy was decisive for the touring cyclist to select a place to stay, as it met his requirements for watching TV.

Concerning the queries mentioned in Subsection 4.3.3, the four scenarios show the applicability of three out of four of those queries. The scenario 1 uses the query 2 for retrieving places that afford to stay. The scenario 2 uses the same query for the same purpose and also uses the query 3 for retrieving a list of feature types of places that afford to stay. The scenario 3 uses the query 4 to explore the different activities afforded by a place. Finally, the scenario 4 uses the query 2 (for the purpose already mentioned) as well as the query 4, for obtaining activities afforded by a place. The query 1 was not used in any scenario.

In summary, affordances play a role in gazetteer integration by providing another level of abstraction for place disambiguation. Namely, they serve to capture commonalities between places with different feature types (see scenarios 1, 2, and 4) as well to specify distinguishing aspects of places that share feature types (see scenario 3 and at some extent scenario 4).

6

RESULTS AND DISCUSSION

This thesis has served to conceive a gazetteer model based on affordances as well as to evaluate through a use case how such a model helps integrate distributed gazetteers.

We have tackled the challenge of including affordances of places into gazetteers with the purpose of improving digital representations of places in a way that they embrace more explicitly functional and social aspects. Our work is focused on instances of places rather than on feature types, which has been already addressed by other authors (Alazzawi et al., 2012; Hart et al., 2004; Scheider and Kuhn, 2010). We think that affordances can improve our understanding of feature types and not the other way around.

Our approach to affordances has been loose because places demand special considerations that were not originally embedded into such a concept. The social component plays a strong role for understanding places and is therefore relevant for studying affordances of places. The implications that places bring to the strict notion of affordances have been made explicit where possible in this work, in order to facilitate their distinction and association.

Moreover, we have dealt with affordances in the more graspable form of human activities. The validity of such an account stems from hierarchical views of affordances and actions, introduced and explored by some scholars, as well as from acknowledging that places are not merely human-size objects, but more complex structures that need to be studied from a wider perspective.

In this regard, activities fit in both contexts: regarding affordances, they can be seen as higher-level ones (i.e., they are composed of other lower-level affordances afforded by parts of places as well as of conventions and social habits), and regarding gazetteers, they can feasibly be adopted by digital models of places as they are experienced by humans in general and can be understood by non-experts, which is critical for their extended usage (by both contributors and gazetteer users).

Nonetheless, a selection of activities that a gazetteer should include is far from being an easy task. We have made our best at establishing initial guidelines that could roughly indicate a subset of meaningful activities in the context of place information retrieval.

However, we consider bottom-up approaches and interdisciplinary work can be more appropriate for achieving a better understanding of models of activities.

A series of requirements inspired by the literature review constitute the foundations for coming up with an affordance-based gazetteer model that has been implemented as a Linked Open Data vocabulary.

On the other hand, the vocabulary has been employed as a framework for the use case. The affordance-based gazetteer has sorted out specific challenges of four scenarios experienced by a touring cyclist while looking for places to stay. The scenarios have occurred in four different countries of South America and despite the fact of having dealt with problems with local and specialized feature types for accommodation places, affordances have been suitable for the task of place information retrieval in a seamlessly way.

The results of the use case have been summarized as follows: 1) affordances span across feature types, 2) affordances help integrate feature typing schemes, 3) affordances enrich the digital representation of place, and, 4) lower-level affordances play a role describing higher-level ones.

Affordances have proven to be of help for exploiting commonalities between feature types as well as for specifying distinguishing aspects of places that share feature types. This is a relevant achievement for gazetteer integration because feature types have been recognized as problematic due to their specialized and local nature. Affordances open new scopes and challenges for gazetteers while making them more usable to non-experts.

7

CONCLUSIONS

7.1 Conclusions

How can gazetteers deal with affordances of places? The first research question has been addressed in Chapter 4. Gazetteers can deal with affordances through human activities, which, in the context of place information retrieval, are still action possibilities.

What is the role of affordances in gazetteer integration? The second research question has been tackled in Chapter 5 based on the analysis given in Chapter 4. The role of affordances in gazetteer integration is twofold: first, they can help describe feature types, and second, they can enrich instances of places with functional meaning.

When dealing with instances of places, affordances can exploit commonalities between feature types as well as specify distinguishing aspects of places with common feature types. Affordances can take over from feature types in gazetteer searches, which might help solve inherent problems of searches based on feature types, namely, their specialized and local nature.

However, as acknowledged by some scholars (Kuhn, 2001; Scheider et al., 2011), it does not mean that feature types are no longer required, but rather that affordances can complement them. Feature types serve to communicate abstract characteristics of places, which is useful for humans to communicate location.

7.2 Summary of contributions

This thesis has made the following contributions to our understanding of affordances in gazetteer modeling:

- The role of affordances in gazetteer integration has been explored and identified. Affordances have proven to be of help for exploiting commonalities between feature types as well as for specifying distinguishing aspects of places that share feature types.

- A loose approach to affordances in the context of place information retrieval has led us to employ the more graspable concept of human activities.
- An affordance-based gazetteer vocabulary has been implemented in Linked Open Data and can be accessed online.[46]
- Affordances can be employed for describing both feature types and instances of places. The former has been addressed already by other scholars, whereas this thesis has been focused on the latter.
- Four queries that an affordance-based gazetteer must support have been identified and illustrated.
- An initial attempt for establishing guidelines to delimit activities for affordance-based gazetteers has been made.

7.3 Future research

Future research goes in the direction of applying bottom-up approaches for coming up with descriptions of feature types based on affordances of place instances as well as for comparing such descriptions with current feature typing schemes.

Moreover, bottom-up approaches could also be employed for delimiting activities that an affordance-based gazetteer should take into account. Such an approach could reveal hierarchies of activities (i.e., parent-children relationships) in order to apply reasoning based on similarity and relationships between activities.

On the other hand, as stated at the end of Subsection 4.5.2, some research is needed in order to harvest data structured according to vocabularies like GoodRelations. Such a vocabulary implicitly accounts for gazetteer data, but associations between offerings (included there) and activities (of the affordance-based gazetteer vocabulary) need to be made.

Finally, future research could tackle the affordances of parts of places, such as tables, chairs, doors, and the like, to evaluate if the benefits they bring to place information retrieval exceed the level of complexity in their modeling. For example, it might be the case that such an approach can leverage applications built on top of journey planners, providing them with locations, activities, prerequisites, opening times, entrances, and the like.

[46] Both vocabulary and data are available at: http://ifgibox.de/g_carr02/thesis/

A

AFFORDANCE-BASED GAZETTEER VOCABULARY

```
############################################################
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix skos: <http://www.w3.org/2004/02/skos/core#> .
@prefix time: <http://www.w3.org/2006/time#> .
@prefix geo: <http://www.opengis.net/ont/geosparql#> .
@prefix gr: <http://purl.org/goodrelations/v1#> .
@prefix os: <http://www.ordnancesurvey.co.uk/ontology/Topography/v0.1/
    Topography.owl#> .
@prefix owl:  <http://www.w3.org/2002/07/owl#> .
@prefix dbpedia: <http://dbpedia.org/resource#> .
@prefix wn20schema: <http://www.w3.org/2006/03/wn/wn20/schema/> .
@prefix affgaz: <http://localhost/gazetteer/affgaz.rdf#> .

# Classes
affgaz:Place
   skos:prefLabel "Place"@en ;
   rdfs:comment "A geographical place"@en ;
   affgaz:hasPlacename affgaz:Placename ;
   affgaz:hasFootprint affgaz:Footprint ;
   affgaz:hasFeatureType affgaz:FeatureType ;
   affgaz:affords affgaz:ActivityAtPlace ;
   rdfs:subClassOf owl:Thing .

affgaz:Placename
   skos:prefLabel "Placename"@en , "Place name"@en, "Geographic name"@en ;
   skos:altLabel "Toponym"@en ;
   rdfs:comment "The name by which a geographical place is known (Wordnet)"@en ;
   rdfs:subClassOf foaf:name .

affgaz:Footprint
   owl:sameAs os:Footprint ;
   rdfs:comment "Georeferenced coordinate representation of a place
        (Hill, 1999)"@en ;
   geo:hasGeometry geo:Geometry ;
   rdfs:subClassOf geo:Feature .

affgaz:FeatureType
   a owl:Class ;
   rdfs:label "Feature type"@en ;
   rdfs:comment "A category to which a geographical place belongs"@en .

affgaz:ActivityAtPlace
   a owl:Class ;
   skos:prefLabel "Activity at place"@en ;
   rdfs:comment "An activity at place is a realization of an activity. It
        relates a place and a human as an affordance (a place affords an
        'activity at place', which is in turn directed at a group of people). An
        activity at place might be constrained socially, spatially, temporally,
        or economically, and might involve other places (see the property
        involvesPlace)."@en ;
   affgaz:hasPrerequisite affgaz:ActivityAtPlace ;
   affgaz:involvesPlace affgaz:Place ;
   affgaz:realizationOf affgaz:Activity ;
   affgaz:isDirectedAt foaf:Group ;
   affgaz:hasSocialConstraint affgaz:SocialConstraint ;
   affgaz:hasSpatialConstraint geo:Geometry ;
   affgaz:hasTemporalConstraint _:TemporalConstraint ;
   affgaz:hasEconomicConstraint gr:Offering ;
   affgaz:requiresSpecialEquipment dbpedia:Equipment ;
   rdfs:subClassOf dbpedia:Affordance .

affgaz:Activity
   a owl:Class ;
   skos:prefLabel "Activity"@en ;
```

```
   rdfs:comment "Any specific behavior (Wordnet)"@en ;
   affgaz:hasGenericActivity affgaz:Activity ;
   owl:sameAs wn20schema:VerbSynset .

affgaz:SocialConstraint
   a owl:Class ;
   skos:prefLabel "Social constraint" ;
   rdfs:comment "Any constraint imposed to an activity by society"@en ;
   affgaz:permitsActivityIn geo:Geometry ;
   affgaz:prohibitsActivityIn geo:Geometry ;
   affgaz:restrictsActivityTo foaf:Group ;
   affgaz:prohibitsActivityTo foaf:Group .

# Blank node
_:TemporalConstraint
   a owl:Class ;
   rdfs:label "Temporal constraint"@en ;
   rdfs:comment "Defines a time interval within which an activity can be
        performed"@en ;
   affgaz:isAvailableAtSeason time:ProperInterval ;
   gr:hasOpeningHoursSpecification gr:OpeningHoursSpecification .

# Properties
affgaz:hasPlacename
   a rdf:Property ;
   rdfs:label "Has place name"@en ;
   rdfs:domain affgaz:Place ;
   rdfs:range affgaz:Placename .

affgaz:hasFootprint
   a rdf:Property ;
   rdfs:label "Has footprint"@en ;
   owl:sameAs os:hasFootprint ;
   rdfs:domain affgaz:Place ;
   rdfs:range affgaz:Footprint .

affgaz:hasFeatureType
   a rdf:Property ;
   rdfs:label "Has feature type"@en ;
   rdfs:domain affgaz:Place ;
   rdfs:range affgaz:FeatureType .

affgaz:affords
   a rdf:Property ;
   rdfs:label "Affords"@en ;
   rdfs:domain affgaz:Place ;
   rdfs:range affgaz:ActivityAtPlace .

affgaz:involvesPlace
   a rdf:Property ;
   rdfs:label "Involves place"@en ;
   rdfs:comment "The activity involves a place different from which affords
        it"@en ;
   rdfs:domain affgaz:ActivityAtPlace ;
   rdfs:range affgaz:Place .

affgaz:hasPrerequisite
   a rdf:Property ;
   rdfs:label "Has prerequisite"@en ;
   rdfs:comment "The activity can be performed only after performing another
        activity"@en ;
   rdfs:domain affgaz:ActivityAtPlace ;
   rdfs:range affgaz:ActivityAtPlace .

affgaz:isDirectedAt
   a rdf:Property ;
   rdfs:label "Is directed at"@en ;
   rdfs:comment "The activity is directed at a particular user group"@en ;
   rdfs:domain affgaz:ActivityAtPlace ;
   rdfs:range foaf:Group .

affgaz:hasTemporalConstraint
   a rdf:Property ;
   rdfs:label "Has temporal constraint"@en ;
   rdfs:comment "The activity can be performed during certain time interval"@en ;
   rdfs:domain affgaz:ActivityAtPlace ;
   rdfs:range _:TemporalConstraint .

affgaz:hasSpatialConstraint
   a rdf:Property ;
   rdfs:label "Has spatial constraint"@en ;
   rdfs:comment "The activity is constrained spatially"@en ;
   rdfs:domain affgaz:ActivityAtPlace ;
   rdfs:range geo:Geometry .
```

```
affgaz:hasSocialConstraint
   a rdf:Property ;
   rdfs:label "Has social constraint"@en ;
   rdfs:comment "The activity is constrained socially"@en ;
   rdfs:domain affgaz:ActivityAtPlace ;
   rdfs:range owl:Class .

affgaz:hasEconomicConstraint
   a rdf:Property ;
   rdfs:label "Has economic constraint"@en ;
   rdfs:comment "The activity requires the user to pay"@en ;
   rdfs:domain affgaz:ActivityAtPlace ;
   rdfs:range gr:Offering .

affgaz:permitsActivityIn
   a rdf:Property ;
   rdfs:label "Permits activity in"@en ;
   rdfs:domain owl:Class ;
   rdfs:range geo:Geometry .

affgaz:prohibitsActivityIn
   a rdf:Property ;
   rdfs:label "Prohibits activity in"@en ;
   rdfs:domain owl:Class ;
   rdfs:range geo:Geometry .

affgaz:restrictsActivityTo
   a rdf:Property ;
   rdfs:label "Restricts activity to"@en ;
   rdfs:domain owl:Class ;
   rdfs:range foaf:Group .

affgaz:prohibitsActivityTo
   a rdf:Property ;
   rdfs:label "Prohibits activity to"@en ;
   rdfs:domain owl:Class ;
   rdfs:range foaf:Group .

affgaz:requiresSpecialEquipment
   a rdf:Property ;
   rdfs:label "Requires special equipment"@en ;
   rdfs:comment "The activity requires special equipment to be performed"@en ;
   rdfs:domain affgaz:ActivityAtPlace ;
   rdfs:range dbpedia:Equipment .

affgaz:isAvailableAtSeason
   a rdf:Property ;
   rdfs:label "Is available at season"@en ;
   rdfs:comment "The activity can be performed during a particular season"@en ;
   rdfs:domain _:TemporalConstraint ;
   rdfs:range time:ProperInterval .

affgaz:hasGenericActivity
   a rdf:Property ;
   rdfs:label "Has generic activity"@en ;
   rdfs:comment "The activity is related to a broader (parent) activity"@en ;
   rdfs:domain  affgaz:Activity ;
   rdfs:range affgaz:Activity .

############################################################
# From the GoodRelations Vocabulary
# (http://www.heppnetz.de/ontologies/goodrelations/v1):

affgaz:Offering
   skos:prefLabel "Offering"@en ;
   owl:sameAs gr:Offering ;
   gr:hasPriceSpecification gr:PriceSpecification ;
   gr:acceptedPaymentMethod gr:PaymentMethod .

affgaz:hasPriceSpecification
    a owl:ObjectProperty ;
   owl:sameAs gr:hasPriceSpecification ;
   rdfs:label "has price specification (0..*)"@en;
   rdfs:range gr:PriceSpecification.

affgaz:acceptedPaymentMethods
    a owl:ObjectProperty;
   owl:sameAs gr:acceptedPaymentMethods ;
   rdfs:label "accepted payment methods (0..*)"@en;
   rdfs:range gr:PaymentMethod.

############################################################
```

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