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A Semantic Wiki Based on Spatial Hypertext

Carlos Solis
(Lero, the Irish Software Engineering Research Centre, University of Limerick
Limerick, Ireland
carlos.solis@lero.ie)

Nour Ali
(Lero, the Irish Software Engineering Research Centre, University of Limerick
Limerick, Ireland
nour.ali@lero.ie)

Abstract: Spatial Hypertext Wiki (ShyWiki) is a wiki which represents knowledge using notes that are spatially distributed in wiki pages and have visual characteristics such as colour, size, or font type. The use of spatial and visual characteristics in wikis is important to improve human comprehension, creation and organization of knowledge. Another important capability in wikis is to allow machines to process knowledge. Wikis that formally structure knowledge for this purpose are called semantic wikis. This paper describes how ShyWiki can make use of spatial hypertext in order to be a semantic wiki. ShyWiki can represent knowledge at different levels of formality. Users of ShyWiki can annotate the content and represent semantic relations without being experts of semantic web data description languages. The spatial hypertext features make it suitable for users to represent unstructured knowledge and implicit graphic relations among concepts. In addition, semantic web and spatial hypertext features are combined to represent structured knowledge. The semantic web features of ShyWiki improve navigation and publish the wiki knowledge as RDF resources, including the implicit relations that are analyzed using a spatial parser.

Keywords: Semantic Wiki, Spatial Hypertext, ShyWiki, Semantic Web
Categories: H.5.3, H.5.4

1 Introduction

A wiki is a web based system that allows users to collaborate in a shared information space and incrementally create hyperlinked web pages [Leuf, 01]. Wikis are based on the principles of ease of use, continuous improvement through incremental content creation, open structure for editing and evolution, and supporting a structure that can be organized according to the needs of the community [Cunningham, 06]. These characteristics make wikis a popular solution for knowledge management [Wagner, 05]. Wikis permit knowledge management tasks such as capturing, searching, and sharing knowledge to be performed in an open, collaborative and distributed way [Weiss, 05].

The Semantic Web is an approach along with a set of standard technologies (RDF, OWL, RDFS, etc) that provides semantics to the web in order to allow it to be machine readable [Berners-Lee, 01], [Shadbolt, 06]. Semantic Web allows machines to access web hypermedia content by enriching it with typed conceptual graph

structures. The semantics is expressed as annotations and metadata that can be controlled by an ontology. In this way, agents would be able to reason about the web content using semantic data. In addition, navigation, personalization, and search facilities are expected to be enhanced using the semantic web. A semantic wiki uses semantic web technologies to formalize knowledge which can include content (annotations and properties), hyperlinks (hyperlink types), and wiki pages (metadata and concept types).

One of the most important design principles that wikis have to satisfy is that they should have low access barriers [Cunningham, 06]. If this principle is applied to semantic wikis, then users must be able to use a semantic wiki without previous knowledge about the use of the interface or about the semantic web [Schaffert, 08]. This is difficult to achieve in the case of semantic wikis because users have to be experts in using a web data description language as well as defining ontologies. This tradeoff between usability and semantic expressiveness has also been pointed out in [Völkel, 06]. For defining machine readable knowledge, users need more formal ways to express knowledge structures. However, formality is harmful for most users [Shipman, 99]. Therefore, formality must be hidden and isolated from semantic wiki users.

In most semantic wikis, users have to explicitly interconnect wiki pages by using typed hyperlinks. This is not an intuitive task to be performed by users who are not experts in semantic wikis because they need to identify concepts and the relations among them [Shipman, 99]. Spatial Hypertext is an approach for encouraging users to externalize their knowledge by allowing them to create hypertext that is spatially organized instead of making them articulate explicit relations between two objects. Spatially organized content has several advantages over explicit related objects. It is easier to be navigated, better presented, and is more expressive because it represents implicit relations that cannot be expressed using hyperlinks.

However, Spatial Hypertext has not been previously used for defining ontologies or in the semantic web or wikis. In this work, we show how semantic wikis can benefit from using Spatial Hypertext concepts. We do so, by focusing on a wiki which is based on Spatial Hypertext called the Spatial Hypertext Wiki (ShyWiki). In ShyWiki, knowledge is contained in notes, which are spatially distributed in wiki pages and have visual characteristics such as colour, size, or font type that can be modified. Spatial and visual characteristics are used to improve human comprehension, creation and organization of knowledge. Previously, the Spatial Hypertext Model of ShyWiki has been presented in [Solis, 08], and a demo of the prototype was shown in [Solis08a]. We have also presented the knowledge management capabilities of ShyWiki in [Solis, 10] by supporting the knowledge conversions of Nonaka's Knowledge Creation Spiral [Nonaka, 95]. In addition, we have presented how ShyWiki can be used for eliciting requirements when users are globally distributed [Solis, 10a].

In this paper, Semantic Spatial Hypertext Wiki is presented as an enrichment to ShyWiki with semantic web capabilities for supporting the collaborative and incremental formalization of knowledge. The knowledge that can be defined in ShyWiki includes unstructured, structured, and machine accessible knowledge represented in Resource Description Framework (RDF).

ShyWiki's spatial hypertext features allow users to annotate content and express implicit relations among wiki concepts. This aids users to gradually formalize knowledge. Users that are not experts in semantic wikis can define knowledge relations implicitly by using spatial and visual characteristics. The implicit relations among notes can be automatically transformed into explicit by using a spatial parser. ShyWiki's semantic web characteristics allow content to be structured, and wiki pages and hyperlinks to be typed. In addition, the wiki knowledge is published as RDF data, which allows automated agents to contribute to the wiki knowledge using web services.

This paper is structured as follows: Section 2 presents the background which ShyWiki is based on: Spatial Hypertext and related work to semantic wikis. Section 3 gives an overview of ShyWiki. Section 4 presents the semantic spatial hypertext wiki, which includes the representation of implicit structures and their recognition by means of the spatial parser that make them explicit, the representation of structured knowledge by means of annotations, typed hyperlinks, and concept types or templates, and the publication of linked data in a parallel RDF wiki that can be manipulated by external agents using web services. Finally, section 5 gives the conclusions and future work.

2 Background and Related Work

In this section, we present the related work about spatial hypertext and semantic wikis.

2.1 Spatial Hypertext

Spatial hypertext [Marshall, 95] is a kind of hypermedia that is based on using visual and spatial characteristics to define relations among hypertext elements. Spatial hypertext emerged as a solution for the navigation problem [Bernstein, 91], where users get lost in the hyperspace of a large hypertext network. A way to solve this problem is by showing the relations among hypertext documents. Map based navigation shows the relations among hypertext documents using a graph where the documents are the nodes and the hyperlinks are the arrows connecting the nodes [Puntambekar, 03]. Instead in spatial hypertext, the arrows are removed and the relations are implicitly represented by using spatial proximity and colour clues.

Elements of a spatial hypertext document are as post-it or bibliographic notes. Users can handle and move the notes in a document, or change their properties such as their colour, size or location. In spatial hypertext, hyperlinks may become implicit because they are indirectly expressed by means of visual and spatial relations (for instance, notes can form lists, stacks, composites and heaps [Shipman, 95]). In addition, notes can be organized using several combinations of visual and spatial characteristics (background colour, border colour, border thickness, font types, adornments, positions, proximity to notes, etc.). Collections of notes can also be created by inserting notes inside others.

Experiences have reported that spatial hypertext usage is suitable for domains with complex structures, collaborative tasks, and where there is no difference between

readers and authors [Marshall, 95]. These characteristics make spatial hypertext an excellent candidate for being used in a wiki.

Several spatial hypertext systems have been developed. In the following, some are described:

- VIKI [Marshall, 94] is one of the first spatial hypertext systems, and focuses on the emergent structure of hypertext documents.
- VKB [Shipman, 01] is a descendant of VIKI with improved and additional presentation features such as navigable history and global links.
- WARP [Francisco-Revilla, 04] is a Web-based dynamic spatial hypertext system that is based on applets and JavaScript. Its most remarkable feature is an interactive user interface.
- TinderBox [Bernstein, 03] is a standalone application that can generate HTML documents for the Web. It has a personal content assistant for visualizing, analyzing, and sharing notes.

The previous spatial hypertext applications do not provide a collaborative web interface such as the one provided by wikis, and have not been applied to the semantic web. The later implies that knowledge is not published in the web with semantics e.g. in RDF data and the expressiveness of spatial hypertext such as the implicit relations cannot be available to agents. In this work, we show that spatial hypertext can be used in the semantic web.

2.2 Semantic Wikis

Semantic wikis are tools that provide semantic web knowledge description languages for defining semantics to the content of wikis. Semantic wikis are an effort for allowing end users to collaboratively create semantic web information in an easy way.

According to Millard et al. [Millard, 08], the basic characteristics that make a wiki semantic are:

- **Concepts.** A wiki page represents a concept in a knowledge graph. The content of a wiki page represents the set of properties and annotations of a concept.
- **First class types.** The types of concepts are defined using wiki pages. Relations can be first class types which are also represented in wiki pages.
- **Annotations**. Annotations indicate the semantics of the content. Annotations are part of the content of the wiki pages.
- **Typed hyperlinks**. A hyperlink to another wiki page is an association between concepts represented by the connected wiki pages, and it is a semantic relation that has a type.

Some semantic wikis have focused on the creation of semantic annotations and ontologies from the content in a wiki. This approach for supporting semantic wikis is called *Wikitology* [Klein, 05]. Examples of wikis that follow this approach are:

- Platypus [Tazzoli, 04] is one of the first semantic wikis. It allows users to edit a metadata page for each wiki page, and to create annotations in RDF. In Platypus, the edition of RDF and data is performed in different editors.

- SHAWN [Aumueller, 05] is a wiki similar to Platypus. It allows defining RDF metadata for each wiki page and the metadata is not embedded in the wiki content.

Instead of having two editors as in Platypus, other semantic wikis allow semantic annotations to be embedded in the content of wiki pages. Since using RDF is a hard task for common wiki users, several wikis use specific wiki mark-up syntax to define semantic annotations as well as use WYSIWYG editors to avoid users from editing RDF directly. The wiki engine translates automatically the semantic annotations into RDF. Examples of this kind of wikis are:

- Rhizome [Souzis, 05] uses a wiki mark-up language called ZML that allows users to represent semantic properties in the wiki content.
- SemperWiki [Oren, 06] is a personal semantic wiki that permits annotating the wiki content using embedded RDF.
- Semantic MediaWiki [Völkel, 06] extends the popular MediaWiki with typed links, concept types and properties. In addition, it provides wiki page templates. The semantic properties are specified using the wiki mark-up language.
- KawaWiki [Kawamoto, 06] is a wiki which provides a set of predefined RDF templates that are specified by experts. Users can fill the missing properties and relations using web forms to define wiki pages.
- WikSar [Aumueller, 05a] allows user to embed semantic statements in wiki content using an easy to use notation. In addition WikSar provides a graphic interface to visualize the Wikitology graph and for navigating in the wiki.

Other semantic wikis have focused on building and managing ontologies, which are used to guide the structure of the wiki hypertext. These wikis are similar to an easy to use collaborative knowledge base. Among these wikis are:

- OntoWiki [Hepp, 06] is a collaborative ontology editor and knowledge base. OntoWiki is oriented to the management and building of ontologies rather than building hypertext content.
- In SweetWiki [Buffa, 06] the creation of concept types is based on social tagging and folksonomies. The creation of the wiki content is guided by the ontology. It also has a reasoner and a WYSIWYG editor for defining annotations and ontologies.
- IkeWiki [Schaffert, 06] is based on MediaWiki. IkeWiki has a WYSIWYG editor for updating the wiki pages content and the RDF annotations. IkeWiki allows users to create ontologies, and its annotation editor can use the ontology.

These wikis are able to represent unstructured and structured knowledge using typed wiki pages and hyperlinks. The initial semantic wikis used embedded RDF for the creation of semantic annotations. Embedded RDF can hardly be used by non expert users. The most recent semantic wikis are using WYSIWYG editors in order to aid users in creating annotations and categories of objects.

None of the available semantic wikis uses spatial hypertext for the definition of semantic annotations, and they lack support for expressing implicit relations among concepts. In this case, ShyWiki is an appropriate candidate for defining semantic information and expressing implicit relations among concepts using spatial hypertext.

3 Overview of ShyWiki

ShyWiki [Solis, 08] is a wiki which uses spatial hypertext for representing its content. In ShyWiki, each page is a hypermedia document that is identified by its name and is composed by a set of notes (see Figure 1). The notes can contain text, images, and hyperlinks, or a combination of them. The content of the wiki pages is spatially organized: notes may be placed in different regions of the page, or moved around. Notes can also have different sizes and colours. Composite notes can be created by dropping notes inside others.

ShyWiki provides the basic operations to create or modify wiki pages. In the edition mode, a user can perform several actions on wiki pages such as creating new wiki pages by navigating through a hyperlink, and on notes such as creating, content editing, moving, grouping, or transcluding notes. Transcluding a note is including a note defined in another wiki page by reference. In addition, templates can be created and instantiated. A template is a wiki page which includes predefined notes. New wiki pages can be created by instantiating templates. In this way, the notes defined in a template are automatically created in the new wiki page.

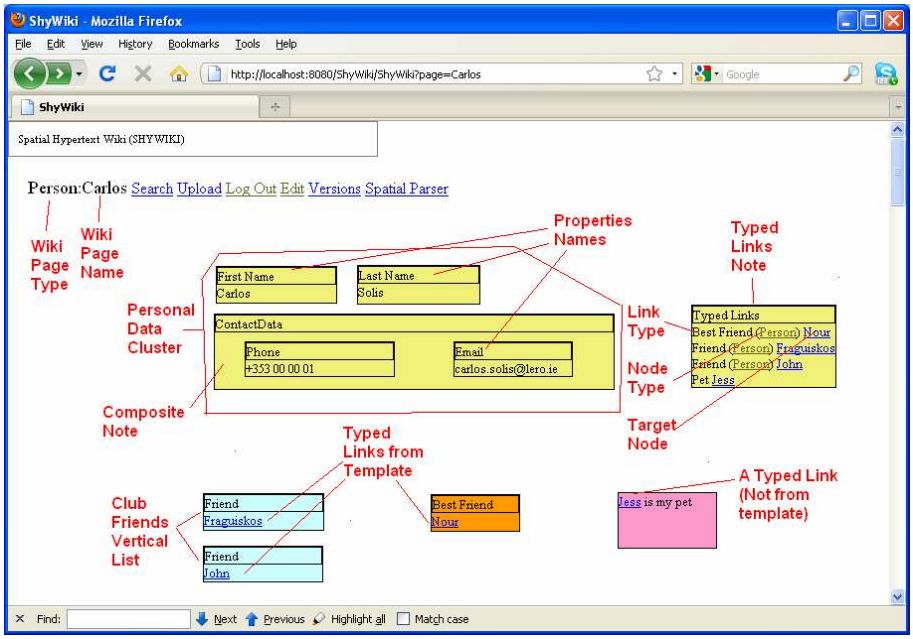

Figure 1: A ShyWiki Page

4 The Semantic Spatial Hypertext Wiki

Semantic wikis give support to structured knowledge and its publishing. Structured knowledge is defined in terms of concepts, properties, annotations, types of concepts and relations (see section 2.2). Publishing knowledge implies using a semantic web standard [Millard, 08]. These characteristics are supported in ShyWiki. Semantic

ShyWiki is a kind of semantic wiki which uses the wiki content to create a *Wikitology*. The *Wikitology* does not guide or constrain the creation of the wiki hypertext. In addition, the use of spatial hypertext allows ShyWiki to avoid the use of RDF annotations. The hypertext structures built using spatial hypertext by users can be translated into RDF automatically by the ShyWiki engine (see Figure 2).

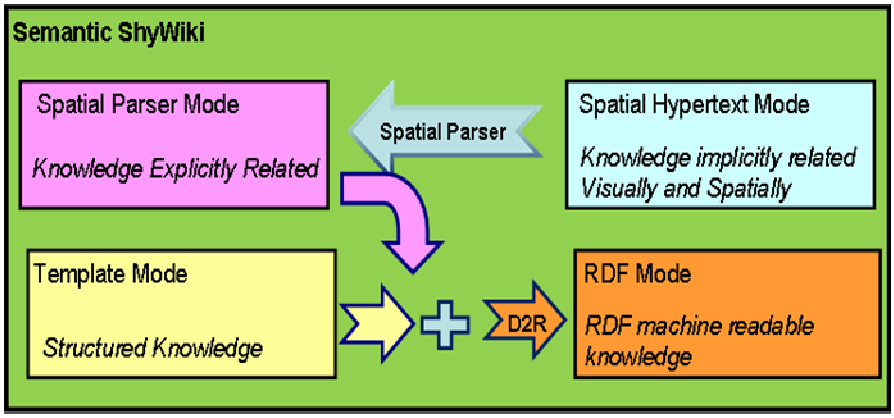

Figure 2: Different Modes of Semantic ShyWiki

In addition to the traditional semantic wiki characteristics, ShyWiki gives support to the implicit semantic behind visual and spatial organization of concepts, which is made explicit using a spatial parser (see Figure 2). The generated explicit knowledge as well as the structured knowledge, defined by users using templates, are transformed to RDF machine readable knowledge. In the following, we explain in detail how the semantic wiki characteristics are supported in ShyWiki.

4.1 Representing Implicit Relations and the Spatial Parser

In ShyWiki, it is possible to capture implicit relations among notes in a wiki page using visual and spatial properties. Logic and cardinality relations can be expressed using visual and spatial properties [Francisco-Revilla, 05].

The following logic relations can be expressed graphically in ShyWiki: the disjoint relation is represented by notes which are not in contact with each other. In Figure 3 *Gabriel Garcia* and *Cervantes* notes have a disjoint relation. The intersection relation between two notes is represented when one note is partially over the other. In Figure 3, there is an intersection relation between the *Hamlet* and *Readers Reviews* notes. The part of relation is represented when a note is inside another. For example in Figure 3, *Act 1* note is part of *Hamlet* note. The connection relation is represented by the perimeter of a note touching the perimeter of another but without any overlapping between the notes' areas. In Figure 3, *Act 1* has a connection relation with *Act 2*.

Users do not have to explicitly think in terms of logic relations when they are spatially organizing the hypertext. This does not represent a cognitive overhead to the users.

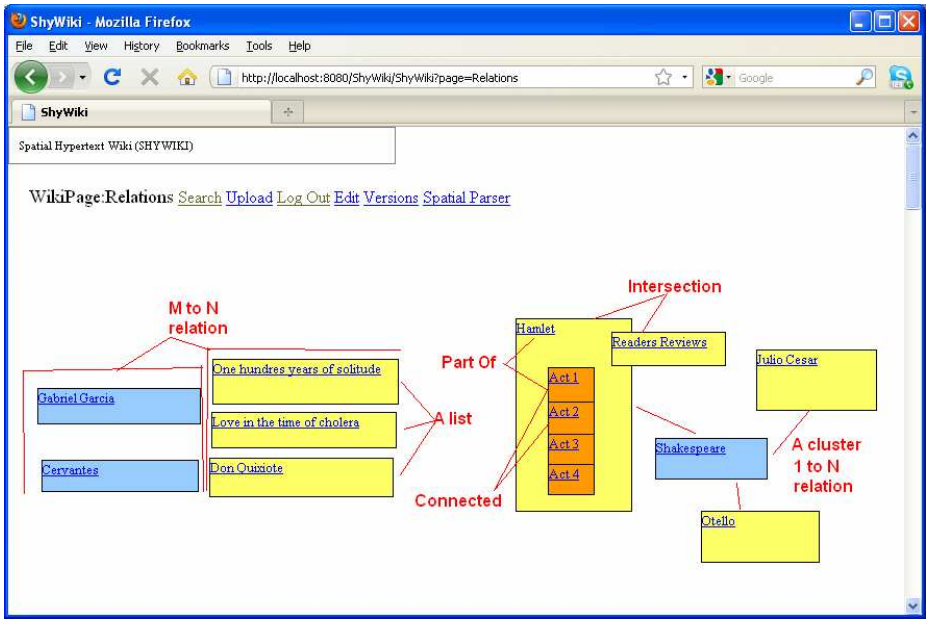

Figure 3: Implicit relations represented in a wiki page

In ShyWiki, users can represent clusters and vertical and horizontal lists using spatial proximity, and it is possible to represent implicit relations with different cardinalities: one to one, one to n, and m to n. A group of elements which are near each other define a cluster. For example in Figure 3, *Shakespeare, Hamlet, Otello,* and *Julio Cesar* notes form a cluster. In addition, there is a one to n relation between *Shakespeare* note and the others. The elements in a cluster can also form structures as lists and stacks. In Figure 3, there are two vertical lists one is integrated by *Gabriel Garcia* and *Cervantes* notes, and the other by *One hundred years of solitude*, *Love in the time of cholera* and *Don Quixiote*, and they form a m to n relation with the elements of the other list.

ShyWiki can identify several emergent hypertext structures using a spatial parser, which is a program that recognizes implicit relations represented through spatially organized structures and makes them explicit in order to allow machines to interpret them [Marshall, 94].

ShyWiki's spatial parser is based on the spatial parser implementation described in [Igarashi, 95], which takes into account spatial attributes. ShyWiki's spatial parser can recognize three spatial structures: clusters, vertical lists, and horizontal lists.

The spatial parser creates labelled graphs to identify spatial relations. A graph is created as follows: For each note-i the parser creates a vertex, and for each note-x that is near to note-i, it creates an edge between note-i and note-x. In addition, each edge is labelled as a vertical list, a horizontal list or a cluster type. An edge is typed as vertical or horizontal list, if the distance is less than list-distance and the notes are vertically or horizontally aligned. If the edge is neither a vertical nor a horizontal list

and the distance is less than the cluster-distance, then the edge is labelled as a cluster type. Once the graphs are created, the parser analyzes if a graph has the same edge labels. If a graph contains lists and cluster types, then the implicit structure is identified as a cluster. If a graph contains only list edges of the same type, then the graph is identified as a list. If a graph contains vertical and horizontal list edges, then several vertical and horizontal lists are identified.

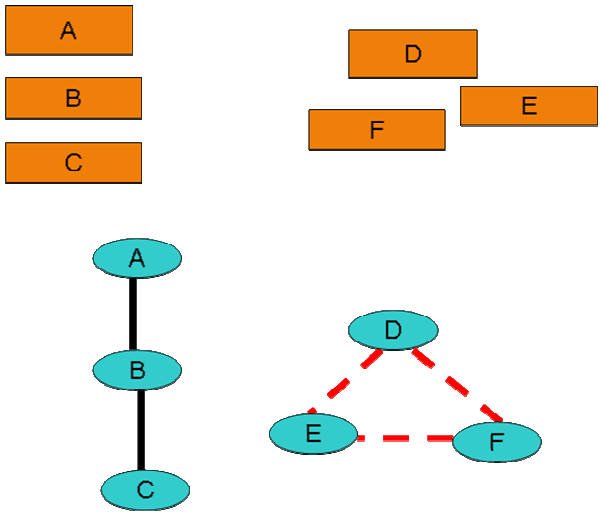

Figure 4: Representation in the spatial parser

Figure 4 presents the representation of a vertical list and a cluster in the spatial parser. Note A is near and vertically aligned with B. Therefore, the parser adds a vertex for each note and connects them with a vertical list edge. The same situation happens for note B and C. Therefore, the spatial parser recognizes that there is a vertical list integrated by A, B, and C notes. Since notes D, E and F are near each other but are not aligned, the spatial parser adds an edge for each note and connects them using the cluster edge. From the graph representations, the spatial parser recognizes that there is a vertical list and a cluster.

To work with the spatial parser, users have to use the spatial parser mode of ShyWiki. The spatial parser mode presents a drop down list of the identified spatial structures. If the user selects an item from the list, then the wiki page only shows notes that form part of the structure. In this way, users can observe a single implicit structure recognized by the spatial parser. Users can give a name to any recognized structure, and indicate if it will be published in the RDF wiki (see section 4.3). In this way, the implicit visual structures become explicit and are readable by machines. For example, the spatial parser recognizes in the wiki page shown in Figure 1 that *Phone* and *Email* are *PartsOf Contact Data*, and recognizes the *Club Friends* structure as a vertical list, and *Personal Data* as a cluster.

4.2 Representing Structured Knowledge

This section presents how structured knowledge is represented in ShyWiki. ShyWiki supports the characteristics that Millard *et.al.* [Millard, 08] defined and were discussed in section 2.2. In the following, we explain how these are supported in ShyWiki:

Concepts. ShyWiki can be viewed as a graph knowledge structure, where the nodes are wiki pages, and the hyperlinks are associations (relations) between concepts. Therefore, a ShyWiki page is a concept. In Figure 1, the concept shown is called *Carlos* which is the name of the wiki page.

Annotations. In ShyWiki, any note in a wiki page can be optionally named. A named note is a property of the concept represented by a wiki page. A named note is also a semantic annotation of the content, and serves to describe it. In Figure 1, the concept *Carlos* has the attributes *First Name, Last Name, Contact Data, Phone and Email*.

Typed Hyperlinks. Hyperlinks represent associations between wiki pages. ShyWiki hyperlinks can be typed or not. The type of a relation can be indicated by means of a label in the wiki mark-up language by using the following notation: *[[target wiki page | label]]*.

For improving the navigation mode and for making users aware of the typed hyperlinks that a wiki page has, each wiki page can include a special kind of note called *Typed-Hyperlinks* (see Figure 1). The *Typed-Hyperlinks* note displays for each typed hyperlink, the label of the hyperlink, the target wiki page and its type (if any) are shown.

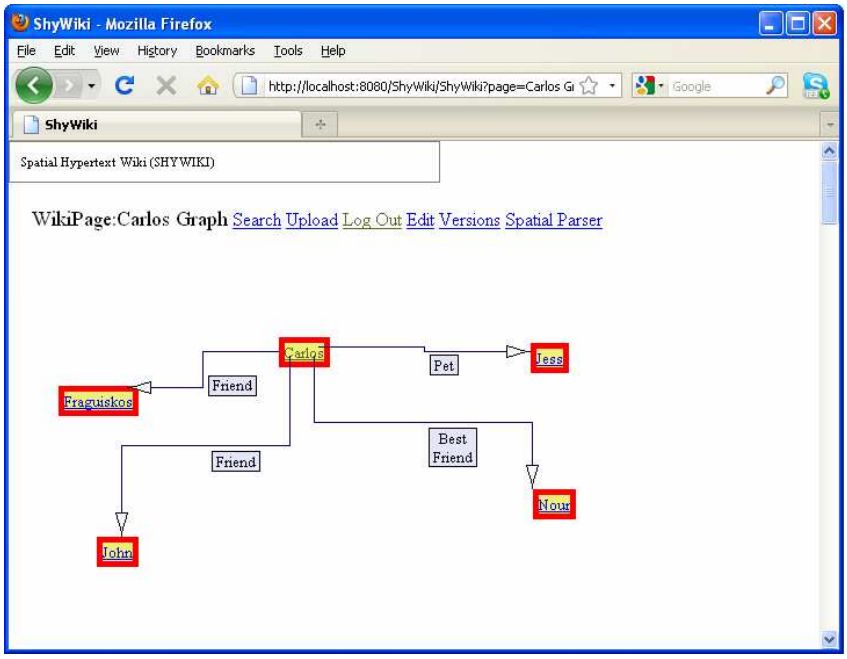

Figure 5: Visualization of a Map consisting of MapNotes and typed hyperlinks

ShyWiki provides explicit visual representation of relations represented by the typed hyperlinks. ShyWiki has a special kind of note called *MapNote*, which is used to explicitly draw labelled hyperlinks between two concepts (wiki pages). For instance, Figure 1 has a note with the text *Jess is my pet,* where the hyperlink in the word *Jess* was labelled as *Pet* and is defined in the wiki mark up language as*: [Jess|Pet]].* A wiki page can have a *MapNote* of any concept in ShyWiki. For example, in Figure 5, *Carlos* and *Jess* map notes have been added. As a result, ShyWiki draws the *Pet* label and an arrow between *Carlos* and *Jess MapNotes.*

First Class Types. In ShyWiki, concept types are supported through templates. A ShyWiki template is an abstraction that represents a set of concepts which share common properties and relations. Templates permit structured knowledge definitions to be reused. A template has a unique template name.

In ShyWiki, properties and relations are defined in the following way: A property is defined by a content note with a name. If the note has some content, this content becomes the default value of the property in the instances. Relations are defined by a named note that contains a typed hyperlink. The content of the note must include a hyperlink to another template (a drop down list of templates is presented to the user, see Figure 6), and the name of the relation is the same as the name of the note. Users have the options to define relations that relate one or many elements, and to define a default spatial distribution for the elements in one to many relations as vertical or horizontal lists.

Figure 6 shows that the user has defined a template called *Person*. It is composed of 7 notes. Each note is defined by giving it a name, a colour and optionally indicating if it represents an association. When a note represents a property, then only the name and colour have to be defined. In Figure 6, the notes *First Name, Last Name*, *Contact Data, Phone and Email* are properties, and the notes *BestFriend*, and *Friend* are relations.

Figure 6 also shows how the orange note (the note on the left bottom side) which corresponds to the *BestFriend* relation is defined. The note's name defines the name of the relation. Then, the associated element is selected from the template list which in this case is *Person.* The content of the note is then defined automatically by creating a typed hyperlink to a *Person* instance, which is labelled as *BestFriend*. The blue note (the note on the right bottom side) corresponds to the *Friend* relation. Its cardinality is 1 to N and it contains a hyperlink to a *Person*. In the template instances, the relations are defined with the help of the note editor which allows users to choose the associated instances using a drop down list, and creates the typed hyperlinks for them. In Figure 1, *Nour* is the best friend of *Carlos*, and *Fraguiskos* and *John* are friends of *Carlos*.

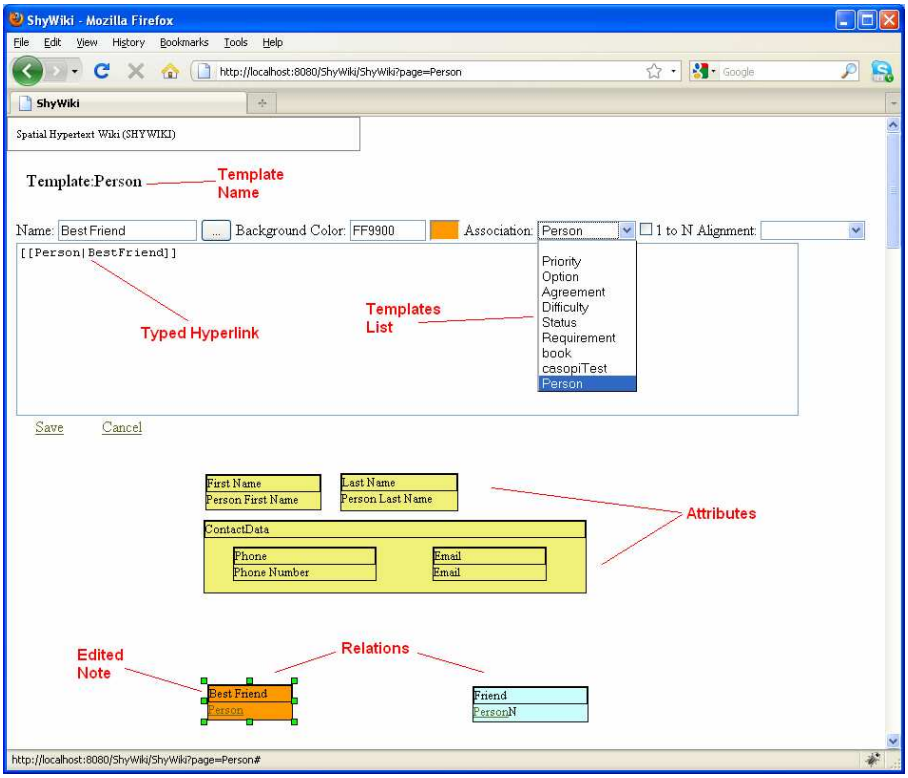

Figure 6: The Person template in edition mode

4.3 Machine Accessible Knowledge

The publication of ShyWiki content as an RDF graph is done using D2R server [Bizer, 03]. D2R is a tool for publishing linked data from relational databases, and also provides a SPARQL Protocol and RDF Query Language (SPARQL) query interface.

Each wiki page and note is published as a RDF resource. In this way, the metadata, annotations, typed hyperlinks, and implicit relations can be used by other applications. The agents that need to read the semantic content of a wiki page can access the RDF projection of the page by means of the link relation included in the HTML: <link rel = 'alternate' type = 'application/rdf+xml' href = 'http://localhost:2020/data/wikipage/546?output = rdfxml' title = 'This page in RDF'>.

The RDF resource that describes a wiki page includes the following: the name of the wiki page, its type if it is an instance of a template, the list of notes it contains, and its typed hyperlinks. The implicit relations of "intersection", "connect", and "part of" are also included in the RDF. The disjoint relation can be inferred using the list of notes and the intersections. Each note, the implicit relations, typed hyperlinks, and parsed structures are described in a different RDF resource.

The content of the wiki can be explored by agents that can navigate through the RDF wiki. In addition, the content of the wiki can be read or written by agents

because ShyWiki is a service oriented wiki [Solis, 08]. The ShyWiki web client interacts with the server using Asynchronous JavaScript and XML (AJAX) web services. These services can be used by other agents that are different than a web browser to interact with ShyWiki.

ShyWiki's web services allow external agents to write or read the content of the wiki pages, the following web services are available:

- createWikiPage. This web service creates an empty wiki page.
- readWikiPage. This web service returns the content of a wiki page in HTML, RDF or JSON formats.
- editWikiPage. This web service enables the use of the following web services in order to edit the content of a wiki page:
    - createNote. This web service is used to create a note in a wiki page. The web service receives as parameter the wiki page name, the note name, and the initial content text of the note.
    - changeNote. This web service is used to change the content or properties of a note. The web service receives as parameter the wiki page name, the note name, and the new content text of the note.
    - moveNote. This web service is used to change the position of a note. The web service receives as parameter the wiki page name, the note name, and the new position of the note.
    - deleteNote. This web service is used to delete a note. The web service receives as parameter the wiki page name and the note name
    - saveVersion. This web service creates a new version of the wiki page, and commits the changes performed. This web service is also used to cancel the edition of a wiki page.

Figure 7 shows the HTML view of the RDF resource of the wiki page *Carlos*. It indicates the name of the wiki page (Carlos), the version (19), and a list of notes that it contains. Each note and implicit relations are described in another RDF resource. Users of ShyWiki do not have to deal with RDF definitions. The projection to a machine readable format is automatically generated when the wiki pages are saved. Users only have to manipulate and add notes to create properties, or use templates and labeled links. The RDF ShyWiki is a parallel wiki for computers. In this way, users only work with ShyWiki without worrying about the semantic notation.

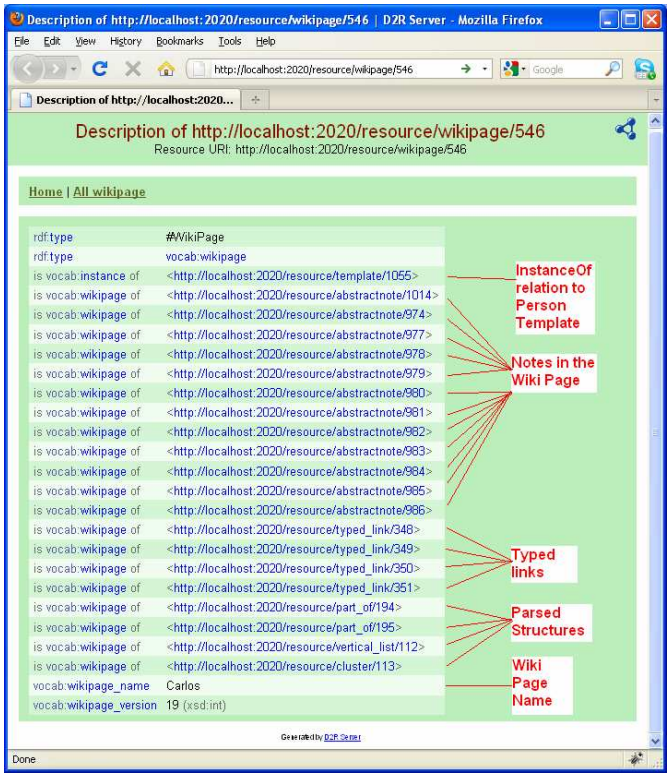

Figure 7: HTML view of the RDF resource Carlos wiki page

5 Conclusions and Future Work

The main contribution of this paper is that we have demonstrated that spatial hypertext provides an easy way for users to interact with semantic wikis and that the expressiveness of visual and spatial relations can be represented semantically e.g. in RDF. We have implemented these characteristics through our prototype Semantic Spatial Hypertext Wiki.

ShyWiki uses spatial hypertext to represent wiki pages content, which is formed of spatially organized notes. Spatial hypertext is a rich paradigm that permits ShyWiki to represent different types of knowledge. Unstructured knowledge is represented in the form of text and images contained inside notes. ShyWiki by means of spatial and visual properties can represent implicit relations among notes, which are recognized using a spatial parser, and published as RDF resources.

Similarly to other semantic wikis, ShyWiki can also represent structured knowledge. ShyWiki can have wiki page types that are used to define shared attributes and relations of a set of concepts. Any hyperlink can be typed, and ShyWiki can display graph relations by means of *MapNotes*. In addition, the attributes and typed relations of wiki pages are displayed in order to help users in their navigation.

The knowledge stored in the wiki can be unstructured in the form of implicit relations, or structured. Both can be transformed and published as RDF. This allows agents to manipulate the stored knowledge.

As future work, we plan to improve the spatial parser in order to detect cardinalities, and types associated to a relation by using note types and visual characteristics. The spatial parser presents challenges particularly in relation with its operation parameters such as the definition of constants that represent that two objects are near and the amount of alignment/misalignment permitted in order to decide if two notes have a cluster or a list edge connection. Another improvement is to take advantage that notes in ShyWiki can have types. The spatial parser needs to be exteneded in order to use note types to recognize relations of elements that have a type.

We are currently working on improving ShyWiki by giving better support to collaborative annotation and reducing information overload using superimposed information sets. In this way, notes can belong to different layers and users can hide or show them depending on their needs. Scalability can be also supported by providing layers because the information can be divided between them. In addition, we are planning to perform a user evaluation of the semantic features.

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