

## **A Semantic Spatial Hypertext Wiki**

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**Abstract:** Spatial Hypertext Wiki (ShyWiki) is a wiki which represents knowledge using notes that are spatially distributed in wiki pages and have some visual characteristics such as colour, size, or font type. Spatial and visual characteristics are important in a wiki 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 the semantic wiki capabilities of ShyWiki. 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 and incrementally create hyperlinked web pages [Leuf, 01]. Wikis have low technical barriers, a collaborative shared information space, and are a way for providing read and write access to hypertext documents. 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.

The Semantic Web allows machines to access web textual content by enriching it with typed conceptual graph structures and standard data formats. Navigation, personalization, and search are expected to be enhanced using the semantic web [Berners-Lee, 01]. A semantic wiki uses semantic web technologies to formalize knowledge which can include content, hyperlinks, and wiki pages.

One of the most important design principles that wikis have to satisfy is that they should have low access barriers [Cunningham, 06]. 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 and in the use of ontologies. This tradeoff between usability and semantic expressiveness has also been pointed out in [Völkel, 06]. To define 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. However, people who are not experts in semantic wikis find it difficult to identify concepts and relations among them [Shipman, 99]. A way for encouraging users to formalize knowledge is by allowing them to create hypertext that is spatially organized instead of making them articulate explicit relations between two objects. Content that is spatially organized provides easier its navigation, better its presentation, and represents implicit relations that cannot be expressed using hyperlinks.

The Spatial Hypertext Wiki (ShyWiki) is a wiki which represents knowledge using notes, which are spatially distributed in wiki pages and have some visual characteristics such as colour, size, or font type. Spatial and visual characteristics are used to improve human comprehension, creation and organization of knowledge. In previous work, the Spatial Hypertext Model of ShyWiki has been presented in [Solis, 08]. In [Solis, 10], we presented the knowledge management capabilities of ShyWiki by supporting the knowledge conversions in the Knowledge Creation Spiral of Nonaka [Nonaka, 95].

In this paper, ShyWiki is presented as a semantic Spatial Hypertext Wiki, for supporting the collaborative and incremental formalization of knowledge. The knowledge that can be defined in ShyWiki includes unstructured, structured, and RDF machine accessible knowledge. ShyWiki's spatial hypertext features allow users to annotate the 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 are made explicit automatically 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 related work to semantic wikis. Section 3 presents the semantic spatial hypertext wiki, which includes an overview of ShyWiki, the representation of implicit structures and structured knowledge, and the publication of data in RDF. Finally, section 4 gives the conclusions and future work.

## 2 Related Work

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 of a concept.
- **First class types.** The types of the concepts are also defined using wiki pages. Relations can be first class types, and 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. Others have focused on building ontologies, which are used to guide the structure of the wiki hypertext. In the following, examples of semantic wikis are given:

- Platypus [Tazzoli, 04] is one of the first semantic wikis. It allows users to edit a meta-data page for each wiki page, and to create annotations in RDF.
- Semantic MediaWiki [Völkel, 06] extends the popular MediaWiki with typed links, concept types and properties. In addition, it provides wiki page templates.
- 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 another semantic wiki that permits to annotate the wiki content using embedded RDF.
- OntoWiki [Hepp, 06] is a collaborative ontology editor and knowledge base. OntoWiki is oriented to the management and building of ontologies rather than in building hypertext content.
- 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.
- 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.

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 The Semantic Spatial Hypertext Wiki

ShyWiki [Solis, 08] is a wiki which uses spatial hypertext for representing its content. Spatial hypertext [Marshall, 95] is based on using visual and spatial characteristics of hypertext elements for defining the relations among them. The elements of a spatial hypertext document are viewed as notes that are classified through visual clues, or spatial positions that allow users to define implicit relations. For example, related elements can be represented by sharing the same visual and spatial characteristics: colours, borders, font types, position, proximity, geometric relations, etc.

In ShyWiki, each page is a hypermedia document that is identified by its name and is composed of 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 link, 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.

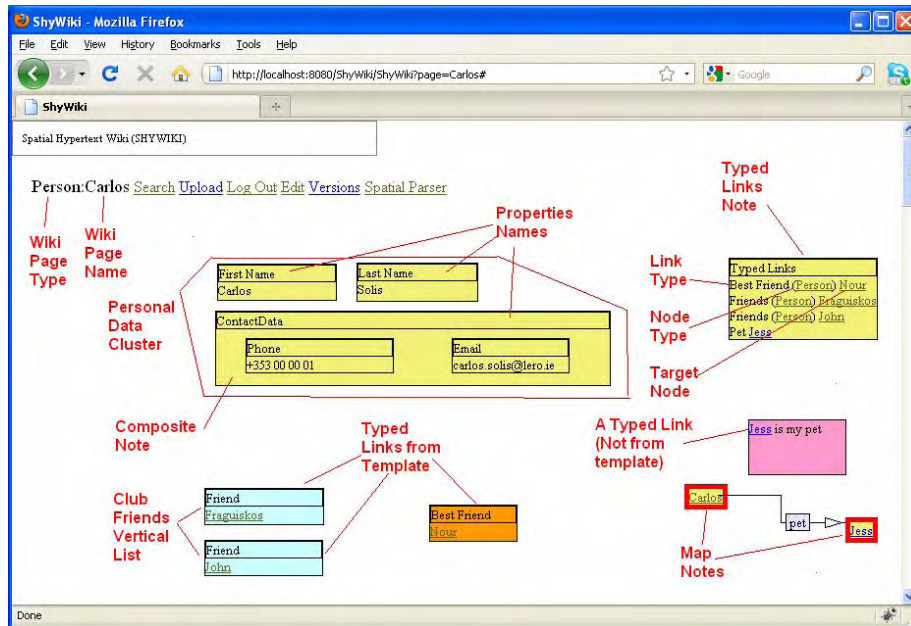


Figure 1: A ShyWiki Page

Semantic wikis give support to structured knowledge and its publishing. Structured knowledge is defined in terms of concepts, properties, and types of concepts and relations. Publishing knowledge implies using a semantic web standard [Millard, 08]. These characteristics are supported in 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. In the following, we explain how the semantic wiki characteristics are supported in ShyWiki.

### 3.1 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: disjoint (notes not touching each other), intersection (a note partially over another), part of (a note inside another), and connection (a note touching the border of another). Users do not have to explicitly think in terms of logic relations when they are organizing the hypertext spatially. This does not represent a cognitive overhead to the users.

A group of elements which are near each other define a cluster. The elements in a cluster can also form structures as lists and stacks. 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 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.

To work with the spatial parser, users have to enter to 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 3.3). 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.

### 3.2 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. In the following, these are explained:

**Concepts.** ShyWiki can be seen 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 ]]`.

ShyWiki provides explicit visual representation of relations. In the navigation mode, each ShyWiki page automatically presents a note called *Typed Links* (see Figure 1). This note summarizes the set of typed links defined in the wiki page. For each typed link, the label of the link, the target wiki page and its type are shown. Figure 1 has a note with the text *Jess is my pet*, where the hyperlink in the word *Jess* is labelled as *Pet* and defined in the wiki mark up language as: `[Jess/Pet]`. In addition, ShyWiki has a special kind of note called *MapNote*, which is used to explicitly draw labelled hyperlinks between two concepts (wiki pages). A wiki page can have a *MapNote* of any concept in ShyWiki. For example, in Figure 1, *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 link to another template (a drop down list of templates is presented to the user, see Figure 2), 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.

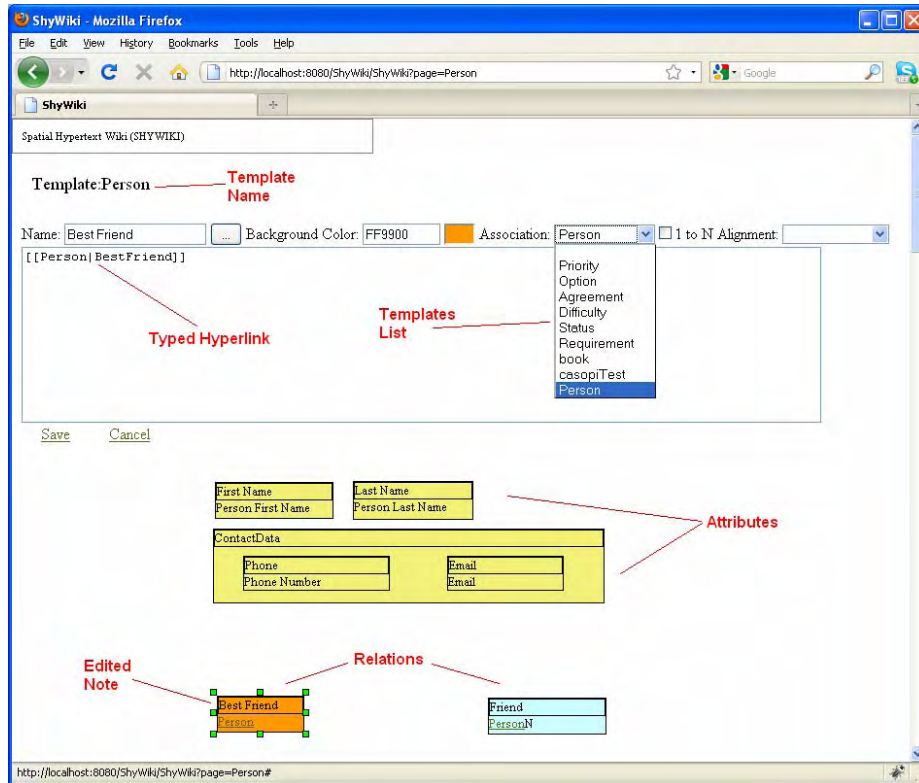


Figure 2: The Person template in edition mode

Figure 2 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 2, the notes *First Name*, *Last Name*, *Contact Data*, *Phone* and *Email* are properties, and the notes *BestFriend*, and *Friend* are relations. Figure 2 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 labeled 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*.

### 3.3 Machine Accessible Knowledge

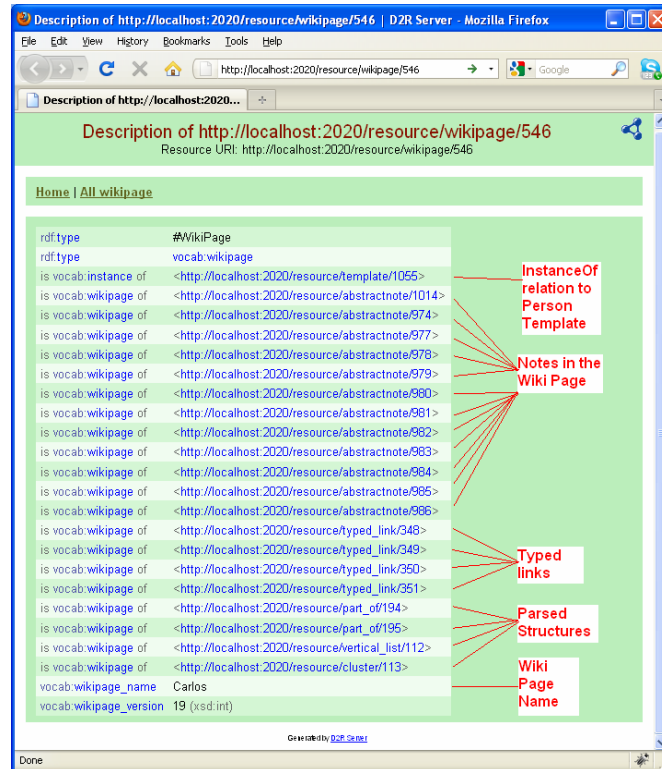


Figure 3: HTML view of the RDF resource Carlos wiki page

The publication of ShyWiki content as an RDF graph is done using D2R server [Bizer, 03]. D2R is a tool for publishing data which is stored as an RDF graph in relational databases, and also provides a SPARQL query interface. All the wiki pages and notes are published as RDF resources. 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/wikipedia/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 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.



Figure 3 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.

## 4 Conclusions and Future Work

This paper has presented the characteristics of a Semantic Spatial Hypertext Wiki (ShyWiki). 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.

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. 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. In addition, we are planning to perform a user evaluation of the semantic features.

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