National Ontology Infrastructure Service ONKI

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Abstract. This paper presents the national level cross-domain ontology and ontology service infrastructure ONKI used in Finland. The novelty of ONKI is based on two ideas. First, the core ontologies are developed collaboratively by experts transforming thesauri into mutually aligned lightweight ontologies, based on a large top ontology that is extended by various domain specific ontologies. Second, the National Ontology Service ONKI has been implemented for publishing ontologies cost-efficiently as ready to use services. ONKI provides legacy and other applications with ready to use functionalities for using ontologies on the HTML level by Ajax and semantic widgets. ONKI has been used in various applications for creating mash-up applications in a way analogous to using Google Maps, but in our case external applications are mashed-up with ontology support for indexing and information retrieval.

1 A National Ontology Infrastructure

An ambitious goal of the National Semantic Web Ontology project (2003–2010)[1] [1] is to develop a semantic web ontology infrastructure on a national level in Finland. The consortium behind the initiative—39 companies and public organizations—represents a wide spectrum of functions of the society, including libraries, health organizations, cultural institutions, government, media, and education. The ontology infrastructure consists of the following components:

1. *Cross-domain ontology system KOKO.* A system of collaborative developed, mutually aligned, cross-domain ontologies has been developed.
2. *National Ontology Service ONKI.* ONKI[2] enables ontology development and publishing, content indexing, and information retrieval through public web and mash-up services [2] .
3. *Tools for metadata creation.* A bottleneck limiting proliferation of the semantic web is production of metadata. For this purpose, semiautomatic content annotation tools utilizing KOKO and ONKI have been developed.

[1] Our work is funded by the National Funding Agency for Technology and Innovation (Tekes) and a consortium of 38 companies and public organizations. http://www.seco.tkk.fi/projects/finnonto/, http://www.seco.tkk.fi/projects/sw20/

[2] http://www.yso.fi/

The ontology infrastructure is based on international domain independent recommendations and best practices of W3C, especially RDF, SKOS, and OWL. The ontologies have been developed from existing national thesauri [3] and vocabularies encompassing different application domains. There are also international ontologies mapped with the framework. The framework has been evaluated by implementing a number of practical semantic portal applications in the domains of eCulture (MuseumFinland [4] and CultureSampo [5]), eHealth (HealthFinland [6], eGovernment [7], eLearning [8], and eCommerce [9]. The National Ontology Service is operational on the web at *http://www.yso.fi/* and is now being used in several applications outside of the FinnONTO project itself.

In the following, the idea of creating collaboratively a system of mutually aligned ontologies is first elaborated. After this, the ONKI Ontology Service system is introduced and generic tools related to the infrastructure are presented.

2 Collaborative System of Mutually Aligned Ontologies

ONKI ontologies can be divided into four main categories: KOKO system of class ontologies, instance ontologies extending KOKO, and SKOS vocabularies. In addition, the service includes a number of international ontologies with their own structure, mapped with KOKO.

KOKO system of Class Ontologies. In the FinnONTO approach, the ontologies are developed in a distributed fashion by collaborating expert groups of different fields. During this work, the ontologies are mapped together to form a large national collaborative ontology KOKO, encompassing all domains. KOKO includes an upper ontology YSO (20 600 concepts), museum ontology MAO (6800 concepts), agriforestry ontology AFO (5500 concepts), applied art ontology TAO (2600 concepts), a photography ontology VALO (1900 concepts), and the SUO geo-ontology containing some 700 geo-concept from the GNS Name Server and the Finnish PNR Register of the National Land Survey of Finland. The KOKO ontologies have been aligned with YSO pairwise, and in some cases with each other.

A major goal of collaborative ontology development is to create the ontologies proactively as interoperable as possible, and avoid need for tedious later alignments. At the same time, a lot of duplicate work can be avoided, since work done in structuring one ontology can be reused in related ontologies. According to our experience, a lot of work has been saved by reusing the work done with the top ontology YSO in this way. Most of the ONKI ontologies were created from existing thesauri used in Finland. The idea of transforming thesauri into ontologies was also suggested in [10] and by the SKOS initiative[3]. However, we stress that although a syntactic transformation into SKOS can be useful, it is not enough from a semantic viewpoint. The fundamental problem with a traditional thesaurus [3], is that its semantic relations have been constructed mainly to help the indexer in finding indexing terms, and for understanding the relations implicit human knowledge is needed. Unless the meaning of the semantic relations

[3] http://www.w3.org/2004/02/skos/

of a thesaurus is made more explicit and accurate for the computer to interpret, the SKOS version is equally confusing to the computer as the original thesaurus, even if semantic web standards are used for representing it. The method is explained in more detail in [11]. If deeper ontologization cannot be done for one or another reason, a SKOS version can be useful as it is. For this reason ONKI service contains several SKOS vocabularies, too.

Instance Ontologies. KOKO ontology classes can be populated with instances from various sources. In ONKI this has been done for places, persons and organisations: 1) There is an isntance ontology based on SUO and the geographical place registry of 800 000 places in Finland. In addition, a spatio-temporal ontology of Finnish counties 1865–2007 [12] has been created. Our ontology of persons and organizations is based on the Universal List of Artists Names (ULAN)[4]. This ontology will be populated with more Finnish persons and organizations from national sources.

International Ontologies. Ontologized international vocabularies include: 1) the Inconclass[5], 2) the Universal List of Artists Names (ULAN), 3) Medical Subject Headings (MeSH), 4) the European Multilingual Thesaurus on Health Promotion (HP Multi) 4) and Integrated Public Sector Vocabulary (IPSV).

SKOS Vocabularies. A growing number of SKOS vocabularies are now available with tens of thousands of published terms: General Finnish Thesaurus (YSA), Thesaurus for Music Terms (MUSA), Thesaurus for Shipping Terms and Thesaurus for Govermental Terms.

3 National Ontology Service ONKI

The Semantic Web is based on using shared ontologies for enabling semantically disambiguated data exchange between distributed systems. This requires, from the ontology publisher's viewpoint, tools for publishing ontologies on the web to ensure the availability and acceptance of the ontologies. From the ontology end-user's viewpoint, support services are needed for utilizing ontologies easily and cost-effectively in the users' own systems that are typically legacy systems without ontology support. ONKI addresses both problems at the same time.

ONKI *Services.* The ONKI service site divided into three sections: 1) **Published ontologies** contains ready-to-use ontologies with related ontology services. 2) **Development section** contains ontology mappings in the KOKO framework for ontology development use. 3) **Your ONKI** is a service section where clients' own ontologies and vocabularies, external to KOKO, can be published.

ONKI implements three ontology browsers, by which needed ontology concepts can be searched for, their meaning disambiguated and relations with other concepts determined: 1) ONKI SKOS [2] is used for SKOS vocabularies and lightweight ontologies. 2) ONKI Geo [13] for geographical ontologies with a map

[4] http://www.getty.edu/research/conducting_research/vocabularies/ulan/
[5] http://www.iconclass.nl

mash-up interface. 3) ONKI People is used for ontologies of persons, organizations, and similar instance registries.

ONKI provides services to three user groups: 1) ontology developers, 2) content indexes, and 3) information searchers.

Services for Ontology Developers. For ontology developers, the ONKI site is a meeting point for collaboration and publishing ontologies. The services are provided at the Development section. In this section each ontology development project is presented with mappings in the KOKO framework (typically mapping with YSO) that can be viewed with the ONKI SKOS Browser. This is useful for e.g. viewing the joined subsumption hierarchies when developing the mapped ontologies with Protégé[6] or other ontology editors. Links to Wiki documentation as well as research underlying the ontology work are provided. Version management and ontology change propagation between interlinked ontologies are underway; this is currently done manually. The Your ONKI section provides ontology developers an ontology publishing channel as a national living laboratory service. Ontologies and vocabularies represented in standard SKOS and simple RDFS/OWL format can be sent to the service and will by published as ready to use services for indexers and information searchers. The publication process is very effective: only little configuration of the server is needed. Source code versions of the ontologies are available for downloading if allowed by the ontology owner. Open source publishing with Creative Commons licenses is encouraged.

Services for Indexers. To support indexing work, ONKI provides the following centralized services for each published ontology:

1. ONKI Selector Widget. A major contribution of ONKI is to provide the end users with a Selector Widget. It is an input field device that can be created on any HTML page at the client side with two lines of Javascript code. The widget is used for creating "mash-up" applications in a way related to Google Maps and Ads. The widget provides all centralized ontology browser functionalities, i.e., concept finding, semantic disambiguation, and concept fetching, in external applications as centralized ontology services.
2. ONKI Selector Widget Generator. With this online service, the code for selector widget can be generated interactively by the setting widget parameters.
3. ONKI Web Service. Ontology services are available also as traditional Web Services[7] using WSDL and SOAP.
4. ONKI Web Service Generator. With this online facility, the code for ONKI Web Services can be generated interactively.

A major innovation of the ONKI service is the ONKI Selector Widget illustrated in Figure 1. The widget enables the user, e.g. a content annotator, to find correct ontological concepts to describe the content to be annotated. The user is provided with searching and browsing capabilities to aid this task.

[6] http://protege.stanford.edu
[7] http://www.w3.org/TR/ws-arch/

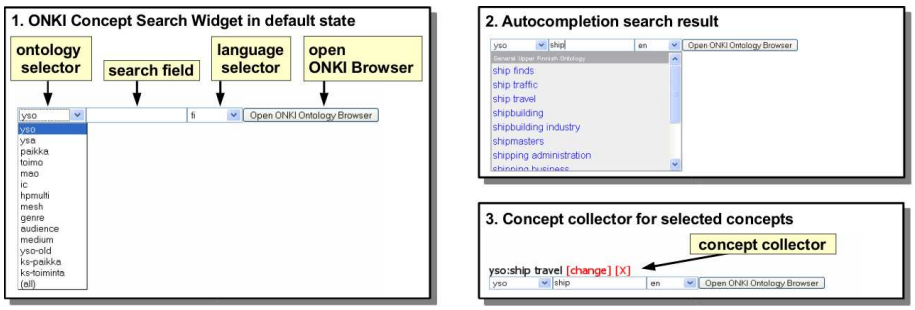

Fig. 1. ONKI Selector Widget.

When the correct concept is found, its URI and label can be fetched to the target application. In addition to annotating content, the web widget can be used for supporting other tasks where ontological concepts need to be searched and fetched, such as content searching. Part 1 of Figure 1 shows the default functionality of the widget. The ontology selector defines the target ontology from all available ONKI ontologies. It is also possible to use all ontologies simultaneously as the search target. The search field implements an autocompletion string search on the ontological concepts. The search can be restricted to labels with a specific language code by using the language selector. Finally, the "Open ONKI Browser" button is used for opening the ontology specific ONKI Browser of the currently selected ontology. The widget supports concept fetching to the target application by either selecting the concept from the autocompletion search or by using the ONKI Browser. In future, the ONKI Selector will provide contextual information in the search results which has been demonstrated in IRMA [14].

Services for Information Searchers. The widget mechanism (and web services) can be used in information search for query constructions. For example, replacing the query input field with a widget query allows terms or URIs using semantic autocompletion to be found. This has been applied e.g. in the eViikki application[8] for finding scientific literature related to agriforestry. This can be useful even if the search engine is not ontology-based, because query phrase finding is in many cases a non-trivial task. Another use case on ONKI services in information retrieval is query expansion. An example of this is an add-on application created on top of the existing Kantapuu.fi service for finding artifacts and photos in a museum. Here the contents have been indexed using thesauri that have been ontologized as a part of the KOKO ontology. When the user types in a query word, semantic autocompletion of the widget makes suggestions and after selecting a concept, a boolean query based on it and the concept hierarchy with related terms can be constructed. For example, when searching for "axes" all materials indexed using subtypes of axes can be retrieved without knowing the names of these types.

[8] http://www-db.helsinki.fi/eviikki/eviikkihaku.html

4 Tools for Metadata Creation

The ONKI framework also includes a set of generic tools for utilizing ontologies and the ONKI Services in metadata creation: 1) By using the contextual concept selector widget IRMA [14], the mapping structure of multiple ontologies can be utilized when searching for concepts. For example, the Iconclass ontology has been mapped with KOKO. When a concept is found in one ontology, related concepts in the other ontology can be suggested in the widget. 2) The browser based metadata editor SAHA [15, 16] takes as input a metadatata schema whose element values may be attached to ontologies using range contraints. The result is a ready-to-use metadata editor, connected to ONKI with appropriate widgets. SAHA is in use in e.g. the semantic portals CultureSampo[9] [17] and HealthFinland[10] [6]. 3) The information extraction tool POKA[11] extracts concepts from text. It is used e.g. as an add-on in SAHA for semiautomatic annotation [18]. 4) The semantic content validator VERA[12] validates RDF data against a given metadata schema. The tools have been applied e.g. in the CultureSampo portal.

5 Discussion

ONKI aims to build an open source ontology infrastructure and service that consists of a set of mutually aligned ontologies from different application domains, maintained and owned by diverse organizations and consortiums. The core of the system is a horizontal top ontology, related vertical domain ontologies extending its class hierarchy in different directions and application domains. This approach contributes to earlier work on creating ontology infrastructures that has focused either on work on developing domain independent standards on the international level (e.g. W3C activities), for developing single global ontologies, such as the Open Directory Project[13] or OpenCyc[14], or for developing ontologies within a particular application domain (e.g., SNOMED CT[15] in medicine and Getty Vocabularies[16] in cultural heritage). In contrast, FinnONTO tries to establish a comprehensive cross-domain ontology infrastructure, based on independent but mutually aligned ontologies. The experiment is conducted on a national level with a serious effort of actually starting to use ontologies in a larger scale. For example, the National Library of Finland is committed to use the ONKI service for publishing their thesauri, including Finland's most widely used thesaurus YSA. To support this, a MARCXML-SKOS content pipeline has been established from the National Library's thesaurus database to ONKI for publishing daily the latest versions of National Library's thesauri.

[9] http://www.kulttuurisampo.fi/
[10] http://www.tervesuomi.fi/
[11] http://www.seco.tkk.fi/tools/poka/
[12] http://www.seco.tkk.fi/tools/vera/
[13] http://dmoz.org/
[14] http://www.opencyc.org/
[15] http://www.ihtsdo.org/
[16] http://www.getty.edu/research/conducting_research/vocabularies/

The resulting ontology library is maintained as a centralized ONKI service providing support for 1) collaborative ontology creation, publishing and maintenance, 2) content indexing, and 3) information searching. The ontology services can be used in external legacy and other applications as ready-to-use functionalities. The new idea here is to support mash-up usage of ontologies in a way similar to Google Maps and other similar services. Our approach of providing an integrable autocompletion widget for external systems is the same as in [19].

The ONKI system supports syntactically, structurally and semantically heterogeneous content. RDF based content representations such as RDF Schema, SKOS and OWL can be easily published by the ONKI-SKOS server. SKOS generators for especially thesauri presentation formats such as MARCXML, various database schemas and text files has been implemented. Also multilingual content is supported. ONKI has been built for and tested with real world data consisting of ontologies, well-known thesauri and registers. The geographical ontology SUO contains over 800 000 places in Finland, which is published using the ONKI Geo server. ONKI SKOS server have contained up to 200 000 concepts from Wordnet, but typically the size of published ontologies and thesauri has turned out to be only tens of thousands concept, e.g., YSO contains 20 600 concepts. The ONKI services have been tested in various ways: the ONKI Selector as part of the SAHA editor in creating content for e.g. HealthFinland and CultureSampo and by external parties in their indexing and search applications. The ONKI Browser has been tested by expert users from e.g. the National Library of Finland.

To conclude, this full scale national ontology infrastructure ONKI is novel and has not been done before. There are currently over 50 organizations from different domains testing the ONKI system and using it in pilot applications. The National Library's commitment to ONKI means that a substantial part of public and private organizations in Finland begin to use ONKI – and most promisingly also the KOKO ontology – for indexing and search, but also for publishing and accessing their ontologies and thesauri – and to join the Semantic Web.

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Instructions for testing the ONKI system

1. Getting an overview of the ONKI ontologies and services

Start testing the ONKI service by going to: *http://www.yso.fi/*

The home page contains the published versions of the ontologies and thesauri. The page is divided in three tabs: 1) **Published**[17] - ready-to-use ontologies, 2) **Development** - KOKO member ontologies, 3) **Your ONKI** - for your own uploaded ontologies and thesauri. Each ontology is presented shortly to get an overview of the available ontologies.

To get an overview of a specific ontology, e.g. the **KOKO Ontology**, choose the **ONKI Browser** function for browsing and making searches to the selected ontology. If the ontology suits your needs, you can integrate it to your system by using the **ONKI Selector** or **ONKI Web Service** functions. Both are helper pages that help you in getting started with respective interfaces to the ONKI system. Ontologies can be published also as downloadable files. Check e.g. the **Audience Ontology** and select **Download**. For more information about the ontology, each ontology is linked to the relevant **Wiki** page. To provide feedback on a specific ontology, select **Feedback**.

To upload your own ontology, select **Upload** from the top menu bar. The upload process contains a moderation phase to ensure that the material and the license terms are suitable for publishing. Also, if the ontology is not presented in SKOS, some manual configuration work is needed to control how the ontology is displayed in ONKI SKOS Browser, which is the default ONKI version for publishing ontologies.

2. Use case: ONKI Selector in annotating museum content

Joe is a museum curator working at the National Museum of Finland. His job covers annotating items of the museum collections. Joe uses the web based museum cataloguing software, into which the ONKI Selector Widget has been integrated, which is located at: *http://www.yso.fi/joe*

At the moment Joe is examining a toy car and wants to fill the **dc:subject** field with relevant concepts. He first selects the **KOKO** ontology from the first dropdown menu.

Since Joe observes that the item is a plaything, he starts to **write a string "plaything"** into the search field. As he types the search string, the ONKI Selector dynamically performs queries to the ONKI service and returns the concepts whose labels match the string. Joe **selects the concept "playthings"**, and the concept is moved on top of the search field as an indication that it is selected.

Joe thinks that concept "playthings" is perhaps too general to describe the item by itself, so Joe **types string "cars"** into the search field. Joe **selects the concept "cars"** but still wants to make the annotation more accurate. He therefore **clicks on the selected concept "cars"** which opens the ONKI Ontology

[17] Please try yourself all things that are **bolded**.

Browser. Joe observes the concept hierarchy of the "cars" concept and notices, that it has a subconcept lorries which, in Joe's opinion, describes the item more accurately than "cars". By **selecting the "lorries" concept** and **pressing the "Fetch Concept!" button** the concept "lorries" is transferred into the museum annotation form replacing the previously selected concept "cars".

Joe continues by filling the other fields in the same fashion (please try on your own). Finally, when he is satisfied with the annotation, he saves his work and goes for a cup of coffee.

3. Content Creation tools

Home pages for the content creation tools, part of the FinnONTO infrastructure, with some demonstrations are available as follows:

- Browser-based metadata editor SAHA: http://www.seco.tkk.fi/services/saha/
- Information extraction tool POKA: http://www.seco.tkk.fi/tools/poka/
- Semantic content validator Vera: http://www.seco.tkk.fi/tools/vera/

4. Reference systems Using ONKI

eViikki The ONKI Selector Widget has been integrated into the Viikki Science Library[18] reference database system eViikki[19]. eViikki is a search interface for the library's collections, which consists of scientific literature on agriforestry. The ONKI Selector is used for populating the "keywords" field of the search form of eViikki. The fetched concept labels are used in the information retrieval task. Query expansion is not performed currently.

The search form with the ONKI Selector is available only in Finnish (the ONKI Selector is integrated into the field "Sanasto"), but the Finnish form can be compared to the English search form without the ONKI Selector Widget[20] to see how the addition of the ONKI Selector enhances the system.

Tilkut The web laboratory Owela[21] of the VTT Technical Research Centre of Finland has implemented a service for collecting and sharing text and image clips from the Web[22]. In the service one can organize the clips into folders and tag them with different categories. The ONKI Selector can be used for tagging the clips. After registering to the service, one can access a page which is used for adding a new clip to the service and tagging it with labels of ontological concepts or free text[23]. In the "Folder" section of the page all the input fields are utilizing the ONKI Selector's autocompletion functionality. The recommended way of using the Tilkut service is to utilize the Firefox browser's add-on.

[18] http://www.tiedekirjasto.helsinki.fi/english/
[19] http://www-db.helsinki.fi/eviikki/eviikkihaku.html
[20] http://www-db.helsinki.fi/eviikki/Welcome_eng.html
[21] http://owela.vtt.fi/
[22] http://owela.vtt.fi/tilkut
[23] http://owela.vtt.fi/tilkut/blogclip.jspx

Kantapuu.fi Kantapuu.fi[24] is a web user interface for browsing and searching for collections of Finnish museums of forestry. The collection items are annotated with terms from General Finnish Thesaurus YSA, Thesaurus for Museum Domain MASA and Agriforest Thesaurus. Kantapuu.fi search page is a web form into which query strings are typed as free text. The query strings can be placed into specific fields, e.g. "keywords", "place of use" or "time of use". We have created a demonstration page containing a web form with ONKI Selector which can be used for selecting query terms to be used in the Kantapuu.fi search[25]. The ONKI Selector is used for finding terms from vocabularies of the ONKI service. The used vocabularies are the same as those used in the annotation process of the items, or actually their ontologized versions. To find suitable query terms user can utilize the autocompletion search functionality or the ONKI Browser. Thus, the user does not need to be familiar with the vocabularies used in the annotations of the items, as in the case of free text search. The ONKI Selector performs query expansion on the subconcepts of the selected query terms. So, for example a query term "animals" would return items annotated with term "cats". When the desired query terms are selected, the actual search to the Kantapuu.fi system can be executed by pressing the "Submit Query" button. At the moment the search functions only in Finnish. Future work includes implementing support for cross-language search.

HealthFinland & CultureSampo The ONKI Selector in combination with SAHA and POKA has been used in metadata creation processes for the semantic web portals HealthFinland and CultureSampo.

[24] http://www.kantapuu.fi/
[25] http://www.yso.fi/onki/yso/app/annotation/lusto-demo.html