



Elements of a National Semantic Web Infrastructure

Case Study Finland on the Semantic Web

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<http://www.seco.hut.fi/>



Outline of Talk



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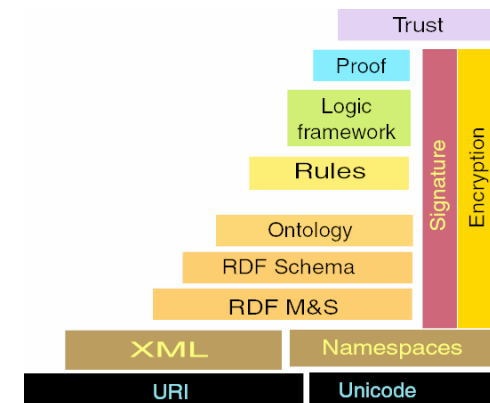
- The semantic web is coming
- A content infrastructure on the web is needed for it
- What should be done about it?
 - The vision of a national FinnONTO-project 2003-2007
 - Goal and results
 - » Standards
 - » Ontologies
 - » Ontology services
 - » Tools
 - » Applications: semantic web at work

Perspectives of the Semantic Web



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- **Content perspective:** A new metadata layer on the web describing its contents in terms of shared vocabularies, i.e. ontologies
 - » Web as a global database system
- **Application perspective:** Machine understandable web
 - » The meaning (semantics) of contents accessible to machines
 - » Enables
 - Intelligent web services
 - Semantic interoperability
- **Technological perspective:** Next technological layers above XML
 - » W3C standards: RDF, OWL etc.



WHAT IS NEW?



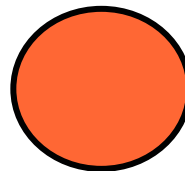
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PROGRAMMING

Object-oriented
modeling

ARTIFICIAL
INTELLIGENCE

Knowledge representation
Logic based semantics
Ontologies



XML, RDF(S), OWL,...

WWW-TECHNOLOGIES



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A Climpse of RDF(S)



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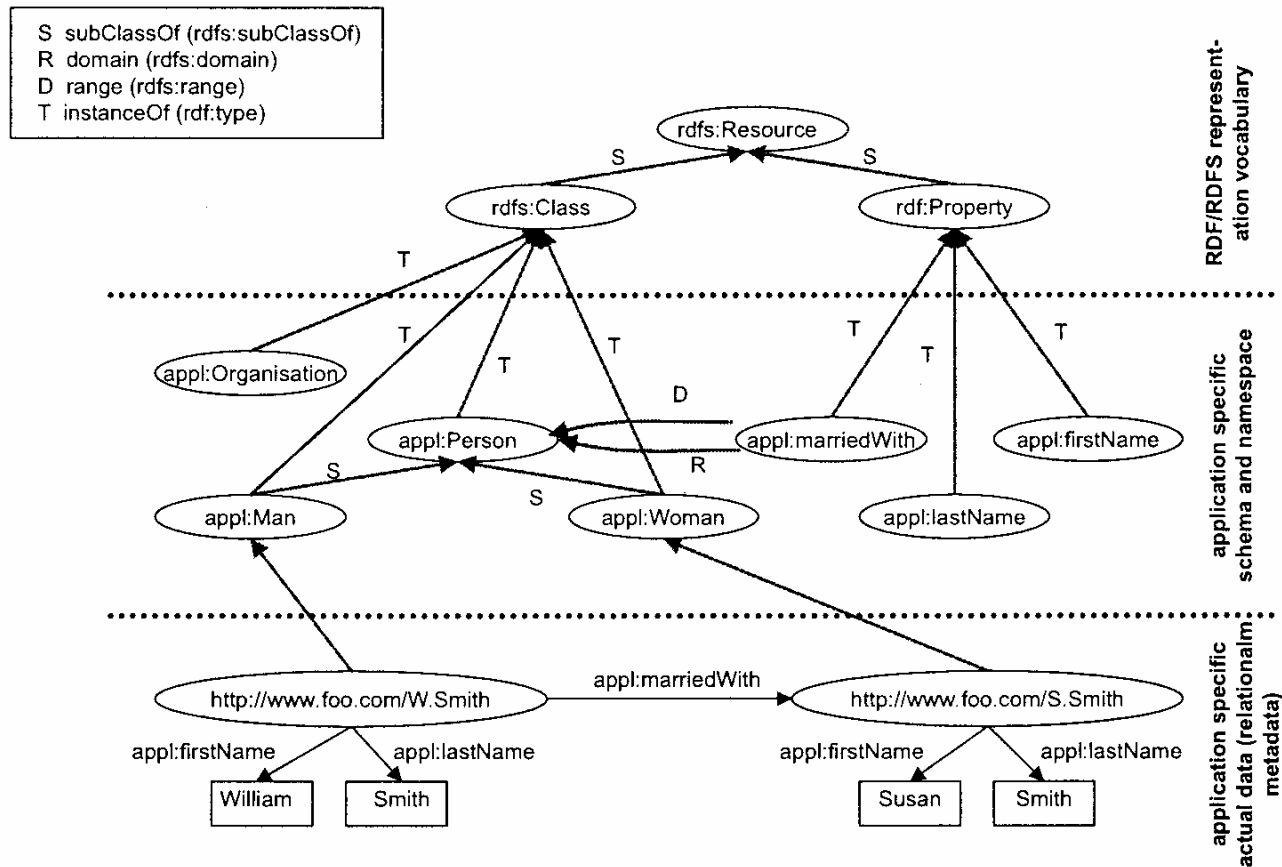


Figure 3.4. An RDF-Schema Example

A National Problem



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- Semantic Web = next generation/layer of the Web
 - Ontologies = "silver bullet" of the Semantic Web
 - Finnish ontologies did not exist
 - Something should be done about it!
-
- A solution approach:
The National Finnish Semantic Web
Ontology Project FinnONTO (2003-2007)



- Semantic Web needs a **content infrastructure**
 - Like traffic needs roads
 - Like energy service needs powerlines, power plants, standards, ...
 - Like mobile phones need GSM or 3G-networks

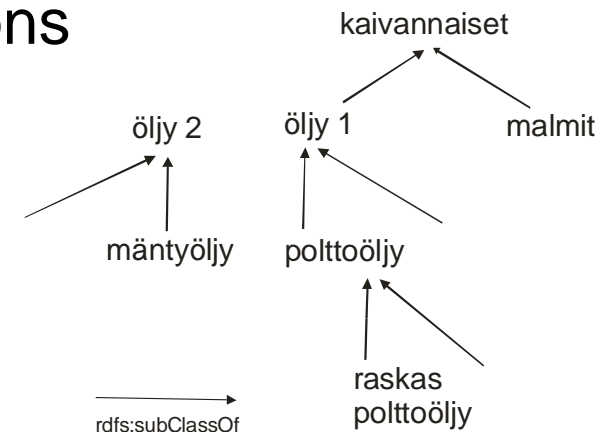


FinnONTO Solution Approach



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- Major infrastructure components
 - **Ontologies** to be shared
 - **Ontology services** for utilizing ontologies
 - **Standards** to make things interoperable
 - » **E.g. metadata standards**
 - **Tools** to help in creating applications



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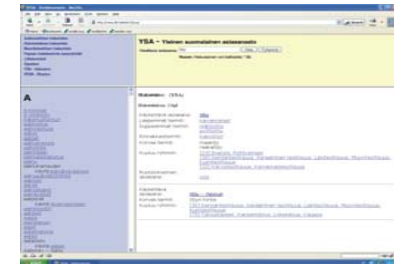
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The Way to Go



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- Start a national multi-domain ontologization process
 - Making contents of different domain interoperable
 - Thesauri -> ontologies
 - » Human usage -> human/machine usage
 - Key ontologies should be open source and maintained publicly
 - » Wide acceptance and usage
- Business applications can be built effectively upon a solid infrastructure



FinnONTO project organization



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- Universities as research partners
 - Helsinki University of Technology (TKK)
 - » Lab. of Media Technology and Lab. of Cartography & Geoinformatics
 - University of Helsinki (UH)
 - » Department of Computer Science and Dept. of General Linguistics
 - University of Tampere
 - » Department of information sciences
- Directed and 80-90% of the research done by the Semantic Computing Research Group
 - TKK and UH

Industrial & public organization consortium



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- 2003-2004
 - 14 funding organizations
- 2004-2005
 - 16 funding organizations
- 2005-2006
 - 30 funding organizations
- 2006-2007:
 - 37 funding organizations
- Current budget 0,8M€ / year (Tekes 80%)



KANSALLISKIRJASTO



Kansanterveyslaitos
Folkhälsoinstitutet
National Public Health Institute



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Viikin tiedekirjasto



MAANMITTAUSLAITOS

m-cult



SUOMALAISEN KIRJALLISUUDEN SEURA

SUOMEN MAATALOUSHUSEO SARKA



TEKNILLINEN KORKEAKOULU
Viestintätekniikka

Suomen valokuvataiteen museo
Finlands fotografiska museum
The Finnish Museum of Photography



Valtiovarainministeriö
Finansministeriet Ministry of Finance



TEKNILLINEN KORKEAKOULU
Viestintätekniikka



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TEKNILLINEN KORKEAKOULU
Kartografia ja geoinformatiikka



Antikvaria-ryhmä



VALTION TAIDEMUSEO



SanomaWSOY



HELSINGIN KAUPUNGINKIRJASTO
HELSINGFORS STADSBIBLIOTEK
HELSINKI CITY LIBRARY



Goals



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- **1. Ontology development** open source
 - General Finnish Ontology based on the national YSA thesaurus (23,000 concepts)
 - Various vertical ontologies based on YSO
- **2. ONKI ontology services**
 - Content indexing using ontology web services
 - Ontology-based information retrieval
 - Collaborative ontology development
- **3. Pilot applications & tools**
 - Eating our own dog food

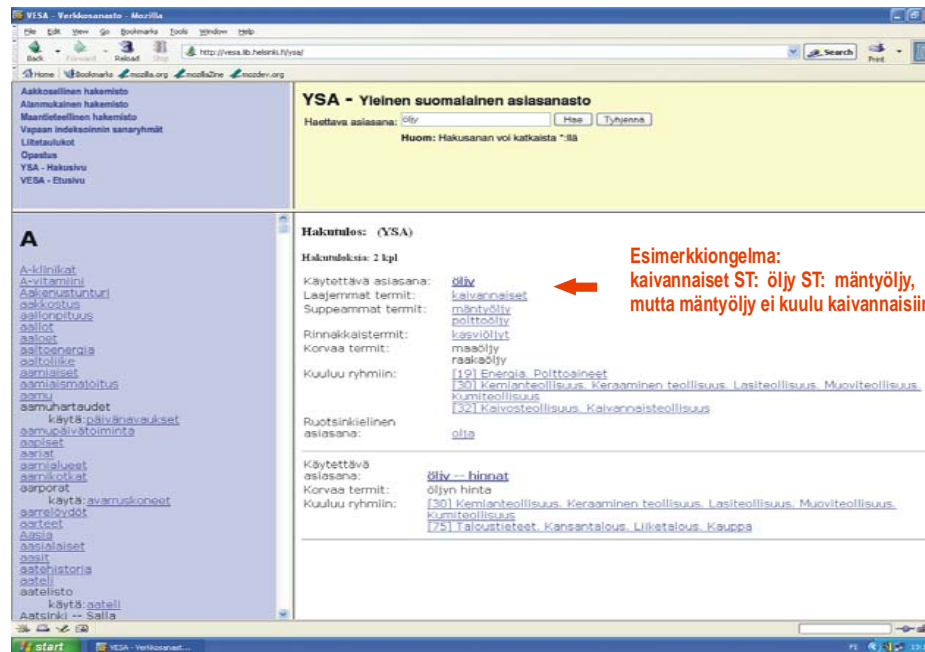
1. Ontology development



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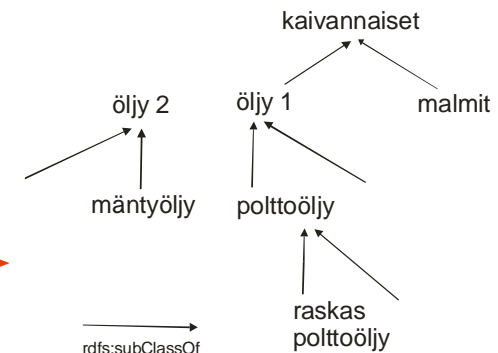
- Motto: Thesauri -> Ontologies!

YSA



Esimerkkiongelmia:
kaivannaiset ST: öljy ST: mäntyöljy,
mutta mäntyöljy ei kuulu kaivannaisiin!

YSO



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Why Thesauri are Not Enough but Ontologies are needed?



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- Example from the YSA-thesaurus:

Solar system

BT

Comet

BT

Halley's
comet



Solar system Celestial body

partOf

subClassOf

Comet

type

Halley's comet

- The machine is confused:

- Is Halley's comet an individual or a class of them, such as Comet?
- Can there be many Halley's comets or only one?
- Is Comet a kind of Solar system or a part of a solar system. Is it a part as a concept or are all individual comets a part of some solar system?
- What does "part of" mean: real part of, contained in, member of, made of, connected to.
- Do comets have properties of solar systems (e.g. own planets) based on BT
- Searching "Solars systems" would retrieve comets although comets are not solar systems
- ...

A Key Point of Ontologies: Using URIs, not Keywords!



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- Each concept will have a **globally unique URI** (across all domains)
 - URI = Universal Resource Identifier
 - » URL web addresses are a special case of URIs
 - A keyword is not enough for indexing the meaning:
 - » E.g. "Nokia":
 - = "Nokia" as a company?
 - = "Nokia" as a city in Finland?
 - = "Nokia" a character in a F.E. Sillanpää's novel?
 - = "Nokia" as an animal?
 - » E.g. "Pyhäjärvi" as a location
 - There 49 Pyhäjärvi lakes, villages etc. in Finland
- The URIs are **globally shared** among users



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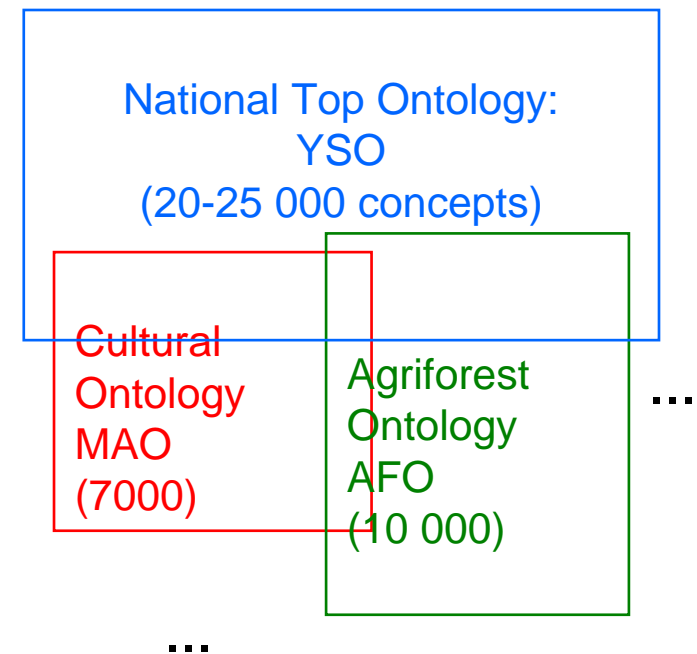
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Idea: Horizontal top ontology + vertical domain ontologies



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- Top ontology YSO as semantic glue
- Merges overlapping domain ontologies
 - Cultural ontology MAO
 - Place ontology SUO
 - Time-place ontology SAPO
 - Actor ontology TOIMO
 - Event & Process ontology TAO
 - Photography ontology VALO
 - Agriforest ontology AFO
 - Ontology of Finnish History HISTO
 - ...
- Alinging other classification systems and top ontologies
 - » HKLJ + YSO (library domain)
 - » ICONCLASS + YSO (fine arts domain)
 - » MeSH + YSO (medical domain)



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Metadata standards



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- Ontology structures
- Cultural content types
- Health promotion information and services
- Spatial metadata
 - With a national working group
- Learning objects
 - With FinnMeta group
- ...



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2. Ontology Services & User Groups

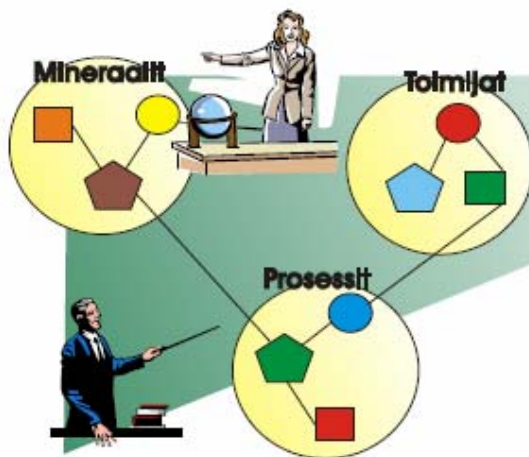


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1. Ontology Developers

- Collaborative development of interdependent ontologies
- Versioning and support for updates



2. Information Searchers

- Support concept-based search
- Keyword disambiguation
- Finding the right search concepts

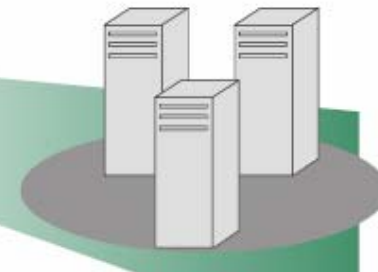


Nokia:
company or city?



2. Information Indexers

- Support indexing concept finding
- Keyword disambiguation
- Support indexing patterns



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ONKI Ontology Service Demonstration



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- Sharing ontologies on the web when indexing content
- Demonstration
 - Indexing with concepts (meaning), not with keywords
 - Finding the right indexing annotation concept
 - Retrieving the corresponding URI automatically to an external application
 - (Komulainen, Hyvönen, Valo, DC 2005)

ONKI-annotation use-cases - Windows Internet Explorer

http://www.yso.fi/ontki/ysso/annotation/

Google AMERISTEP OUTHOUSE Go

Nordic Outdoors ONKI-

1. Open the
2. Search the
3. Copy-paste

- More feasible v
 - For each i
 - autocomp
 - When iter
 - Typing er
- The integration e

Step 1 (Fetch URI to

- In this example,
- Click "Find"-butt
- Browse in the co
- When the conce
- Now the selected

Step 2 (Fetch URI a

- Search concept
- When fetching y

Step 3 (Find URI's w

- Try typing some
- Select the conce

OnKi-Selain : Ontologiakirjasto-selain - Windows Internet Explorer

http://www.yso.fi/ontki/ysso/?page=hierarchy&class=http%3A%2F%2Fyso.fi%2FYSO%23toiminta&lang=fi&aFormName=f

Google

OnKi-Selain : Ontologiakirjasto-selain

OnKi-Selain

Yleinen Suomalainen Ontologia YSO

Haku | Hierarkia | Hakemisto | Tietoa Onkista | Palaute | Kieli Suomi

Käsittehierarkia

:ysso-käsitteet
:muuttuva
:prosessit
:tapahtumat
:toiminta
:havainnointi ja aist...
:hoito
:kognitio
:kulutus ja käyttö
:liikkuminen ja liiku...
:mentaalinen toiminta
:muutos
:muuttaminen
:oleminen
:omistus ja omistukse...
:luominen
:vuorovaikutus

:toiminta <http://yso.fi/YSO#toiminta> **[Kaikki aliluokat]**

rdfs:Laajempi käsite
rdfs:Kuvaus

:Asiasana
:Asiasana
:Rinnakkainen käsite
rdf:Tyyppi
rdf:Tyyppi
:ysaGroup

:prosessit
YSAn mukaan: toiminta esim. filmatisointi, vaihto ja sen suorat aliluokat (ei epäsuorat!), kaukopuhelut, reduktio (historian ja filosofian reduktio mahd. erikseen), tietoliikenne, vastaanotto
toiminta
verksamhet
:toimintaan_liittyvä_rooli
owl:Class
:YSOconcept
ysa-groups:Group-00

Nouda käsite

Internet 100%

2. Demo

Collection Cataloging System view

Item description:

Leather boots found from Helsinki area at 18th century

Item type: [Step 1]

Item type (jalkineet): [Step 1]

Item found from:

Item found from: [Step 2]

Item's describing URI's

Search [Step 3]

Item's describing URI's

Search w/ rdfs:range [Step 3]

Find

Find

Find

ONKI-annotation use-cases - Windows Internet Explorer

http://www.yso.fi/ontki/ysa/annotation/

Google AMERISTEP OUTHOUSE Go 15 blocked Check AutoLink AutoFill Send to AMERISTEP OUTHOUSE Settings

Nordic Outdoors ONKI-annotation use-cases http://www.seco.tkk.fi/publi...

- **More feasible** way of doing this is by hooking software to OnkiBrowser:
 1. For each field there is a "Find"-button for finding concepts from Ontology repository and buttons for fetching them back to your cataloging app. In this example there is also an autocompletion concept find-utility attached to field *FFFF*. Just try typing something to this field for seeing it in action.
 2. When Items are indexed with URI's, one can use efficient multi-faceted search engines to explore collections, such as [Museosuumi](#).
 3. Typing errors are history, mechanism forces you to use right vocabulary and guides you to find the right concepts.
- The integration explained here is quite easy and straightforward to implement.

- **Step 1 (Fetch URI to field *Item Type*)**
 - In this example, this field represents the items type. For example, is it a book, helmet, knife or perhaps boots?
 - Click "Find"-button associated to field *Item Type*. This opens up OnkiBrowser in a new window.
 - Browse in the concept-hierarchy on the left-hand side of the screen or search them by keyword. Try finding 'KengÄä' from the repository
 - When the concept you were looking for is found, click the "fetch concept"-button on the OnkiBrowser.
 - Now the selected URI is transferred to your application.
- **Step 2 (Fetch URI and label to field *Found from*)**
 - Search concept just like in Step 1
 - When fetching you can see that also the label of the concept is imported.
- **Step 3 (Find URI's with autocompletion to field *Describing URI's*)**
 - Try typing something to field *search*
 - Select the concepts of your choice by clicking the concept

2. Demo

Collection Cataloging System view

Item description: Leather boots found from Helsinki area at 18th century

Item type: [Step 1] Find

Item type (jalkineet): [Step 1] Find

Item found from: Find

Item found from: [Step 2] Find

Item's describing URI's

Search [Step 3] :nahk

Item's describing URI's

Search w/ rdfs:range [Step 3]

- :nahkalyt
- :nahkateollisuus
- :nahkatuotteet
- :merinahkakalipikonna
- :nahka
- :nahkajäkälät
- :nahkavaatteet
- :nahkainen
- :nahkiaisikalat
- :piikkinahkaiset
- :pikkunahkainen
- :tekonahka

12 käsitettä, 0.175 s [Sulje](#)

start 4 O... IB... 3 I... d:\... Pr... 2 J... 3 N... 2 M... Do... Mic... 2 M... 96% Internet 100% 20:03

Try ONKI Yourself



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- Versions of new ONKI with
 - Various multi-lingual ontologies
 - Connected to "legacy cataloging system" demo
 - Two lines of JavaScript is needed for an Ajax mash-up!
 - <http://www.seco.tkk.fi/services/onki/>



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3. Pilot Applications



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- eCulture
 - MuseumFinland – Finnish Museums on the Semantic Web (2004)
 - CultureSampo – Finnish Culture on the Semantic Web (2005, 2006, 2007)
- eHealth
 - Semantic prototype of national citizens' health promotion portal Tervesuomi.fi (2007)
- eLearning
 - Orava – Semantic video & learning object portal (2004)
 - Opintie – General learning object portal (2007)
- eGovernment
 - Semantic citizen's Suomi.fi portal (2005)
- Tools
- Other topics

"MuseumFinland—Finnish Museums on the Semantic Web"



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- Ideas
 - Global seamless view to heterogeneous collections
 - Semantic search + browsing
 - Common publication channel for museums
- (Inter)nationally awarded application
 - Semantic Web Challenge Award 2004 (2. prize)
 - Nordic Digital Excellence in Museums 2004 (nominee)
 - Prime Minister's Innovation Acknowledgement

<http://www.museosuomi.fi>



[Google Maps + MuseumFinland](#)

(Hyvönen et al., JWS 2005)

"CultureSampo – Finnish Culture on the Semantic web"



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- Generalizing MuseumFinland to cross-domain cultural content
- Modeling cultural context, events, and processes for enhanced intelligence
- Deep event-based semantic annotations
- New interface ideas: semantic autocompletion, maps, time lines, visualizing semantic structures
- New search ideas: searching and explaining links, meta-search
- Successive prototypes

– 2005, 2006, 2007

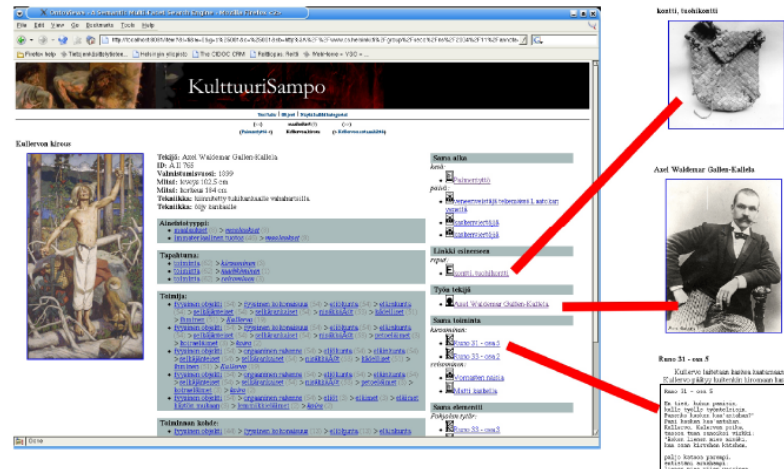
(Junnila et al., FAIS 2006)

(Hyvönen et al., FAIS 2006)

(Kauppinen et al., FAIS 2006)



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TerveSuomi.fi ("HealthyFinland.fi")

The citizen's semantic health promotion portal



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- Aggregates content produced by different Finnish health organizations
- Provides information through user-centric views
- Recommends related material of interest
- (Holi et al., ASWC 2006)
- (Suominen et al., ESWC 2007)
- (Hyvönen et al., ISWC 2007)

The screenshot shows the TerveSuomi.fi website interface. At the top, there's a search bar and navigation links like HOME, NEWS, INDEX A-Z, SITEMAP, FEEDBACK, and HELP. The main content area is titled 'Smoking' and features a sidebar with a table of contents for various health topics. The main text area contains an article about smoking cessation, including statistics and links to related resources. A search results section at the bottom shows a list of search results with filters for Type, Publisher, Year, and Audience.

Topic	Count
Nutrition & Food	230
Exercise	178
Weight control	142
Sexuality	124
Family & Children	132
Addiction & Intoxicants	252
Alcohol	56
Smoking	98
Health effects	34
How to quit	23
Smoking in Finland	17
Law & regulations	19
Drugs	43
Other addictions	38
Catastrophes & Epidemics	96
Mental health	88
Violence & Crises	112
Diseases & Symptoms	79
Health services	153
Environment	132
Health at work	84



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Orava: Video clip & learning object portal



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- Semantic search & browsing
 - » 2200 videos, Learning Object Metadata (LOM)
- Semantic autocompletion
- Inter-portal semantic linking
 - » Linked with MuseumFinland

<http://www.museosuomi.fi/orava>

Orava
Opetusvideoiden haku- ja suositellukone

Tervetuloa Orava-portaaliin!

Orava tarjoaa helpon tavan selata Yle:n Kieppi-portaalin aineistoa yksinkertaisen käyttöliittymänsä kautta.

Aloita valitsemalla sinua kiinnostava kategoria vasemmasta laidasta sijaitsevista vaihtoehdoista, jolloin sivun keskiosaan tulee näkyviin linkejä videoiden kohdesivuille.

Voit tarkentaa hakua valitsemalla vasemmasta laidasta lisää kategorioita tai tutkia jotakin mielenkiintoista videota lähemmin napsauttamalla hakutuloksesta videon linkkiä.

Hakuehdon poistaminen tapahtuu napsauttamalla uudelleen valittua kategoriaa, joka on esitetty korostettuna.

Tarkempia ohjeita löytyy oikean yläkulman ohje-linkkiä napsauttamalla.

Portaaliin on tehnyt Helsingin yliopiston tietojenkäsittelytieteen laitoksen ohjelmistotuotantoprojekti-kurssille ryhmä **Orava**.

Suosituimmat kohteet
Kuva mielessä: katseen kulku
Supisuomea: Helsinki on Suomen pääkaupunki

Viimeksi katsotut kohteet
Kuva mielessä: katseen kulku
Supisuomea: Helsinki on Suomen pääkaupunki
Kansalaisen ABC: Tietoyhteiskunta, uusi työelämä, sql-kieli ohjelmoinnin pohjana
Televisio: henkilö, Esa-Pekka Tiitinen
Opinkino: pääjuttu, Opetushallitus

(Känsälä & Hyvönen, ASWC 2006 WS)



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Semantic Suomi.fi portal



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- Providing alternative views to eGov link library content
- Aggregating relevant content automatically from different



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(Sidoroff & Hyvönen, ISWC 2005 WS)



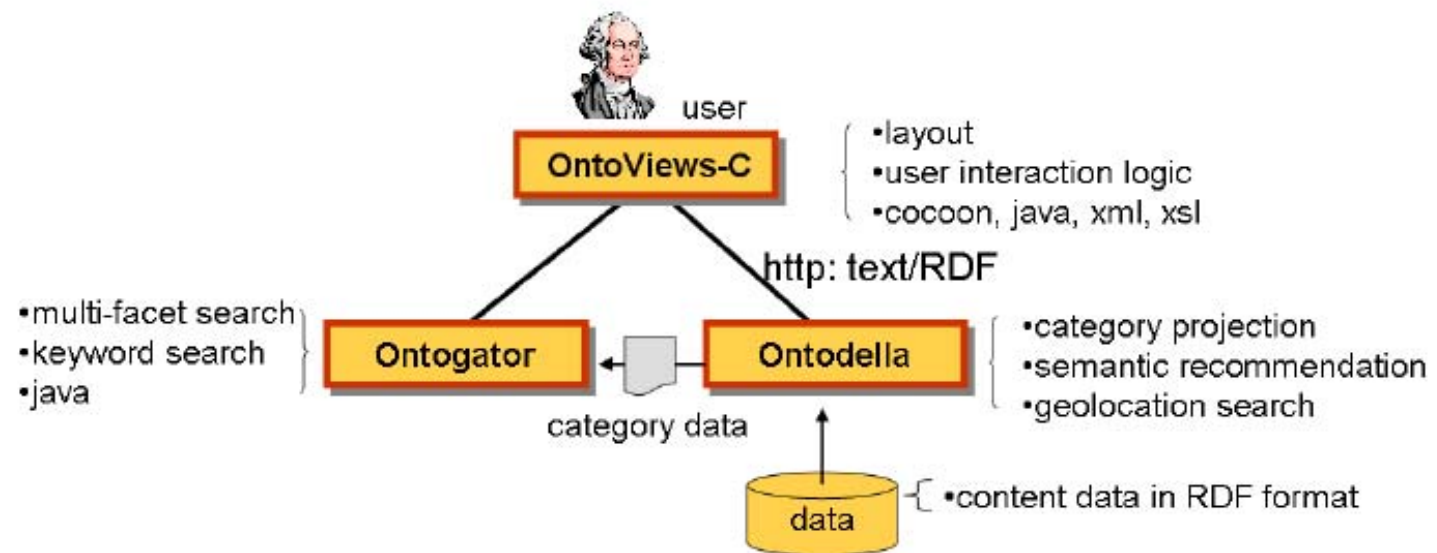
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OntoViews Framework



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- Ontogator + Ontodella + Apache Cocoon
- (Makelä, Hyvönen, Viljanen, ISWC 2004)
(Mäkelä, Hyvönen, Saarela, ISWC 2006)
(Viljanen; Hyvönen, Käsä, DEXA WS, 2006)



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Semantic Faceted Search Engine ONTOGATOR



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- Integrates view-based search paradigm with semantic web
 - Ontologies and reasoning
- Used to build 8 different systems
- Scales up to millions of search items and hundreds of thousands of categories
- (Mäkelä, Hyvönen, Saarela, ISWC 2006)



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Semantic Recommendation Server ONTODELLA



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- For creating semantic recommendations between resources
- Provides
 - logic-based services for projecting facets
 - logic-based recommendations with explanations
- (Viljanen, Hyvönen, Känslä, DEXA 2006 WS)



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Annotation tool SAHA



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- Adapts to different annotation schemas
- Support distributed annotation work and ontology population
- Easy to use with a web browser

The screenshot shows the SAHA - Annotation Editor web interface. The browser window title is "SAHA - Annotaatieditori - Mozilla Firefox". The address bar shows the URL "http://localhost:8888/saha/saha.2040532c53636c83668960106172116a76292848". The interface has a blue header bar with the text "SAHA - Annotation Editor Version 2.3 - Semantic Computing Research Group".



On the left, there is a sidebar with the following content:

- Annotation**
- Document: <http://www.seco.tkk.fi>
- Class: Article
- Close
- Cancel
- Remove annotation

The main content area has several sections:

- Title**: A name given to the resource. Below it is a text input field containing "Semantic Computing Research Group" and a "Remove" button. A red box labeled "Literal property value" points to this field.
- Document abstract**: A summary of the content of the resource. Below it is a text input field.
- Creator**: An entity responsible for making the resource available. Below it is a text input field. A red box labeled "Field to add a literal value for property" points to this field.
- Property's label and description (rdfs:comment)**: A text input field. A red box labeled "Autocompletion search-field for an object property" points to this field.

At the bottom of the main content area, there is a red dashed box containing the following content:

- 
- Semantic Computing Research Group (SeCo)**
- Making computers and the web more intelligent and interoperable!
- [print this page!](#)
- HOME PAGE**
- MISSION**
- NEWS**
- PEOPLE**
- PARTNERS**
- SeCo welcomes you!**
- The Semantic Computing Research Group (SeCo) researches machine-processable semantics related to, e.g., the Semantic Web. We are located at the [Helsinki University of Technology \(TKK\)](#).
- Our research is [focused](#) on semantic media technologies, such as the Semantic Web and intelligent web services. In addition to research and publications, we also create prototype...
- Have you tasted the semantic web?**
- 

(Valkeapää, Hyvönen, ISWC 2006 WS)
(Valkeapää, Alm, Hyvönen, JUCS, 2007)



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Semi-automatic semantic annotation and authoring tool OPAS



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- Support help-desk question-answering (QA)
 - Annotating QA-pairs and helping authoring answers
- National "Ask the librarian" service as a case study

The screenshot shows the OPAS web application running in Mozilla Firefox. The browser address bar displays a URL: `http://wrk-4.seco.hut.fi:8090/opas_ul/Home,$DirectLink.direct?sp=Shitp%3A%2F%2Fyso.fi%2Fopas%23entry-5539`. The page title is "OPAS". Below the title, there is a navigation bar with links: "Tiedosto", "Muokkaa", "Näytä", "Siirry", "Kirjanmerkit", "Työkalut", and "Ohje". The main content area is titled "OPAS" and "Takaisin hakusivulle". Below this, there is a section "Kysymykseen vastaaminen" (Answering the question). The interface is divided into several sections: "Ohjeita" (Instructions) with a link "näytä ohjeet"; "Kysymys" (Question) containing the user's question: "Voisitko mahdollisesti kertoa Arto Paasilinnan elämästä ja sen tärkeimmät teokset. Minun pitäisi tehdä esitelmä"; "Etsi asiasanoja kysymyksestä" (Find keywords from the question); "Vastajan apurit" (Authoring components) with buttons "SAMANKALTAISIA VASTAUKSIA... NÄYTÄ", "VASTAAVIA HKLJ-KIRJASTOLUOKITUKSIA... NÄYTÄ", and "LINKKIKIRJASTON LINKIT... NÄYTÄ"; "OPPAAN LÖYTÄMÄT KÄSITTEET" (Concepts not found in the guide) with a table showing concepts like "teokset [kulttuuriset tuotokset]" and "esitelmät [puheet]"; "KYSYMYKSESTÄ TUNNISTETUT ERISNIMET" (Distinct names identified from the question) with a table showing names like "Arto Paasilinna"; and "VAPAASTI ASIASANAT" (Free keywords) with a link "lisää asiasana". Annotations with arrows point to various elements: "The user's question." points to the question text; "Checkbox to indicate that the concept is included as an annotation concept." points to a checkbox in the "OPPAAN LÖYTÄMÄT KÄSITTEET" table; "A button to specify a concept." points to a button in the "OPPAAN LÖYTÄMÄT KÄSITTEET" table; "Common noun concepts. In the brackets is the superclass of the concept." points to the bracketed text in the "OPPAAN LÖYTÄMÄT KÄSITTEET" table; "A person name found in the question." points to the name "Arto Paasilinna" in the "KYSYMYKSESTÄ TUNNISTETUT ERISNIMET" table; "The authoring components." points to the "Vastajan apurit" section; "Each button displays the corresponding authoring component." points to the buttons in the "Vastajan apurit" section; and "Link to add a free annotation concept." points to the "lisää asiasana" link in the "VAPAASTI ASIASANAT" section.

(Vehviläinen, Hyvönen, Alm,
ISWC 2006 WS)



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Using and visualizing historical geospatial information



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Figure 6: A searchable map interlinked with the semantic portal MuseumFinland.

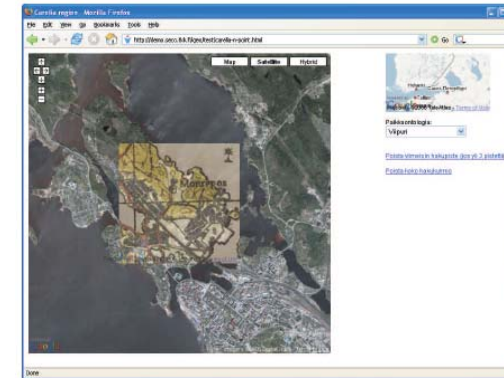
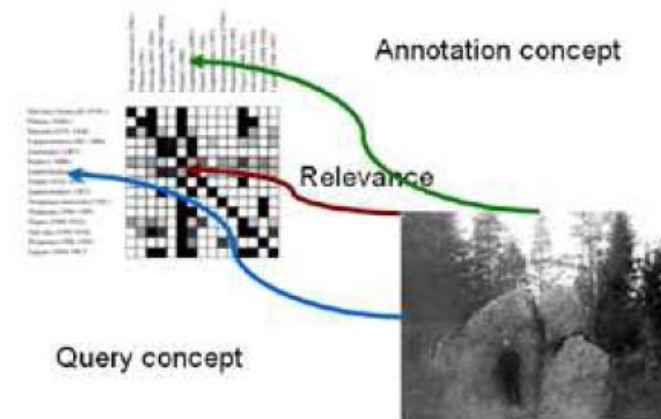


Figure 4: Using multiple maps simultaneously. A historical Karelian map depicting the park of Monrepos in Viipuri is shown semi-transparently on top of a modern satellite image provided by the Google Maps service.



Figure 5: Search results using the n-point search: Viipuri, Koivisto and Maksilahti are matched.



(Kauppinen et al., FAIS 2006)

Figure 3: Annotation and indexing concepts matched.

Other topics



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- Uncertainty in ontologies
 - Representing and reasoning with spatial uncertainty
 - » (Holi, Hyvönen, Springer 2006)
 - Fuzzy view-based search
 - » (Holi, Hyvönen, ASWC 2006)
- Representing and reasoning with historical geospatial changes
 - An ontological model of Finnish communes and counties
 - » (Kauppinen, Hyvönen, Springer 2006)
- Semantic autocompletion
 - » (Hyvönen, Makelä, ASWC 2006)
- Combining text- and ontology-based searching
- Automatic annotation using NLP



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What Next?



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- Semantic Web 2.0 – Intelligent Collaborative Services
 - Idea: synergy of Web 2.0 and Semantic Web
 - Based on FinnONTO infrastructure
 - 3 years, 39 funding organizations, 1M€/ year
 - 2008-2010, if funding application is approved



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Conclusions



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- Semantic web is coming
- An ontology-based infrastructure is needed for it
- Open infrastructure enables development of practical applications
- FinnONTO is an experiment of this on a national Finnish level
- Papers, software, ontologies, demos, and pilot systems available at:
 - <http://www.seco.tkk.fi/>

- Thank you
- Questions?



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