Wordnets and Ontologies

Aleš Horák, Karel Pala

Faculty of Informatics, Masaryk University
Botanická 68a, CZ-602 00 Brno, Czech Republic
E-mail: hales@fi.muni.cz, pala@fi.muni.cz
Web: http://deb.fi.muni.cz

KEG seminar, VŠE Praha

Outline

Main Features

- Lexical database
- Not ordered alphabetically
- Basic semantic relations
- Senses and sense discrimination
- Synonymy, antonymy
- Hypero/hyponymy
- Holonymy/meronymy
- Internal vs. external relations
- Four parts of speech – N, A, V, D
- Multilinguality – PWN, EWN, Balkanet

Starting Points I

- G. A. Miller – founder of psycholexicology, 1993
- Model of human lexical memory, associations
- Hierarchical organization of nouns in human memory
- Five Papers on Wordnet, Miller et al, 1993
  A canary can sing. $\times$ *A canary can fly.* $\times$ *A canary has skin.*
- Canary – *can sing* – *time* t_1 (answer: true)
- Bird – *can fly* – *time* t_2 (answer: true)
- Animal – *has skin* – *time* t_3, where $t_1 < t_2 < t_3$
- Generic information is not stored redundantly

Starting Points II

- Humans easily process anaphoric expressions
  He has a rifle, but this weapon has never been used.
- Alphabetic vs. hierarchical ordering entries in dictionaries, capturing semantic relations
- Hypero/hyponymy, siblings (*tree* vs. *pine, oak, beech, fir, spruce, lime tree*)
- Machine-readable dictionaries – problems with data organization
  alphabetic ordering separates pieces of information belonging naturally together: *dog, coyote, hyena*
- WordNet, thesauri, e.g. Roget vs. standard explanatory dictionaries

Princeton WordNet

- Net of words, English: WN v.1.5, 1.7, 2.0, ..., 3.0, total – 155287 synsets
- Nouns – 117798, verbs – 11529, adjectives – 21479, adverbs – 4481
- Synsets: [(List of synonyms), (POS), (Gloss), (Semantic Relations), ID], driver:1 (n), the operator of a motor vehicle, H/H, ID:ENG20-09277009-n
- Semantic relations: synonymy, hypero/hyponymy, antonymy, holo/meronymy (with inheritance), others
- Top Ontology, introduced in EWN – 63, BCs: 1053
- H/H trees have up to 13 levels with nouns, about 6 for verbs

Princeton WordNet II

- It is free and exists for all platforms, can be downloaded at the address: `http://wordnet.princeton.edu/wordnet/` or `http://nlp.fi.muni.cz/projekty/visdic/` (in XML format)
- Original Princeton browser allowing to export selected data for further processing can be downloaded from the Princeton address
- Standard database format – now XML format is used in VisDic and DEBVisDic (see above)
- PWN as such is not based on any corpus data, built introspectively, problems with sense discrimination, too fine-grained (splitting)

Top Hyperonyms in WordNet 1.5, I

- act, action, activity (činnost, aktivita), natural object (fyzický objekt)
- animal, fauna (zvíře, fauna), natural phenomenon (přírodní jev)
- artifact (výtvor, výrobek),person, human being (osoba, lidská bytost)
- attribute, property (atribut, vlastnost), plant, flora (rostlina, flora)
- body, corpus (tělo, těleso), possession (vlastnictví)
- motive (motiv)

Top Hyperonyms in WordNet 1.5, II

- cognition, knowledge (znalost, poznání), process (proces)
- communication (komunikace, sdělování), quantity, amount (kvantita, množství)
- event, happenning (událost), relation (vztah)
- feeling, emotion (pocit, emoce), shape (podoba, tvar)
- food (potrava, jídlo), state, condition (stav)
- group, collection (skupina, soubor), substance (substance, látka)
- location, place (umístění, místo), time (čas)

Synset Structure

- Synset is a basic unit but not atomic
- One or more synonyms
- Consists of the literals – they are atoms

```
smrtelník:1, člověk:1, duše:3, osoba:1
POS: n
ID: ENG20-00006026-n
BCS: 1
Domain:  biology
SUMO/MILO: = Human
-->> [hypernym] *[n] organismus:1, tvor:2, bytost:1
```

EuroWordNet 1 and 2

New features in comparison with PWN:

- multilinguality: 8 languages – En, It, Du, Sp, Ge, Fr, Esto, Cz, Interlingual Index (ILI)
- Top ontology (63 beginners), the set of Base Concepts (1053), example, now approx. 8000
- Internal Language Relations (ILR), semantic roles: Ag, Pat, Instr, Loc, Addr, Deriv,...
- browser and editor – Polaris 1.5 (licensed), can be obtained from ELDA/ELRA CD
- example: Top Ontology scheme (DEBVisDic)

BalkaNet Project (2001–2004)

For the six languages the following number of synsets has been obtained:

- Bulgarian – 21 444 synsets (S. Koeva, G. Totkov)
- Czech – 30 400 synsets (K. Pala, A. Horák)
- Greek – 18 313 synsets (D. Christodoulakis, S. Stamou)
- Romanian – 19680 synsets (D.Tufis and D. Cristea)
- Serbian – 8000 synsets (C. Krsteva, D. Vitas)
- Turkish – 14 626 synsets (K. Oflazer)

All BN WordNets are linked to PWN 2.0

Valency Frames in CzWn

- Valency frames with syntactic and semantic information (morphological cases and semantic roles)
- Different from ILRs introduced in EuroWordNet, EWN uses binary relations, Role_Agent : Agent_Involved, etc.
- Database VerbaLex – complex verb frames (see next slide for example)
- Translation equivalents (TE): universality of the valency frames (ILI)

Valency Frames II – VerbaLex Example

Princeton WordNet: dress:2, clothe:1, enclothe:1, garb:1, ...

VerbaLex Synset: oblékat:1$_{impf}$, obléknout:1$_{pf}$, ustrojit:1$_{pf}$, strojit:1$_{impf}$

=def: provide with clothes or put clothes on

=canbepassive: yes

=meaning: I

=class: dress-41.1.1

1. obléci:1, oblékat:1, obléknout:1

-frame: AG$\langle$person:1$\rangle^{obl}_{who1}$ VERB PAT$\langle$person:1$\rangle^{obl}_{to_whom3}$ ART$\langle$garment:1$\rangle^{obl}_{what4}$

-synonym: ustrojit:1, strojit:1

-example: *maminka oblékla dítěti kabát / the mother put a coat on her child*

-attr: use: prim, reflexivity=obj_dat, mustbeimperative=no

2. obléci:1, oblékat:1, obléknout:1, ustrojit:1, strojit:1

-frame: AG$\langle$person:1$\rangle^{obl}_{who1}$ VERB PAT$\langle$person:1$\rangle^{obl}_{whom4}$ ART$\langle$garment:1$\rangle^{obl}_{in+sth2}$

...

Valency Frames III

- The labels used consist of:
  - the general labels like Ag, Pat, Loc, Adr, etc., taken partly from EWN and partly similar to those from other inventories (VALLEX, Lopatková, Žabokrtský, 2002)
  - subcategorizing features (selected literals taken directly from the PWN 2.0, quite often from BCs)
  - through them we can access the individual lexical units when processing the sentences the occur in,
- The promising result: a multilingual dictionary of the verb frames is feasible, in fact, a small one exists.

Derivational Relations in CzWn

- Morphological module Ajka (Sedláček 2004) yields now automatically the word derivation nests (subnets), example: učit → uči**tel** → **-ka** → **-ský** → **-ství** → **-stvo**, uč-í → **-cí**/**vat** (they are derivations from učit, to teach)
- uč-e → **n** → **-í** → **-ý** → **-ec**, uč-e → **b** → **n**/**a** → **ice**, uč → **ba**
- Prefixation: **od** – učit (finish teaching, cure sb of sth), **vy** – učit (train sb in sth), **za** – učit (give sb initial training), not implemented yet
- Prefixation causes problems with TE (povyskočit – jump up a little, there's no lexicalized TE in English)
- Linking the word forms in a free text with literals in synsets – the tool SAFT

Domains and SUMO/MILO Ontology

- All Balkanet WNs have been enriched with the domain information, originally from PWN 1.6 (by Istituto Trentino di Culture, not free)
- linking to SUMO labels for: 17 453 adjectives, 3 101 adverbs, 65 636 nouns, 11 793 verbs
- Both domain and SUMO/MILO information has been implemented in VisDic and DEBVisDic, demo

POS: n ID: ENG20-02599023- BCS: 2
Synonyms: airplane:1, aeroplane:1, plane:1
Definition: an aircraft that has a fixed wing and is powered by propellers or jets
Usage: the flight was delayed due to trouble with the airplane
Domain: transport
SUMO/MILO: = Airplane

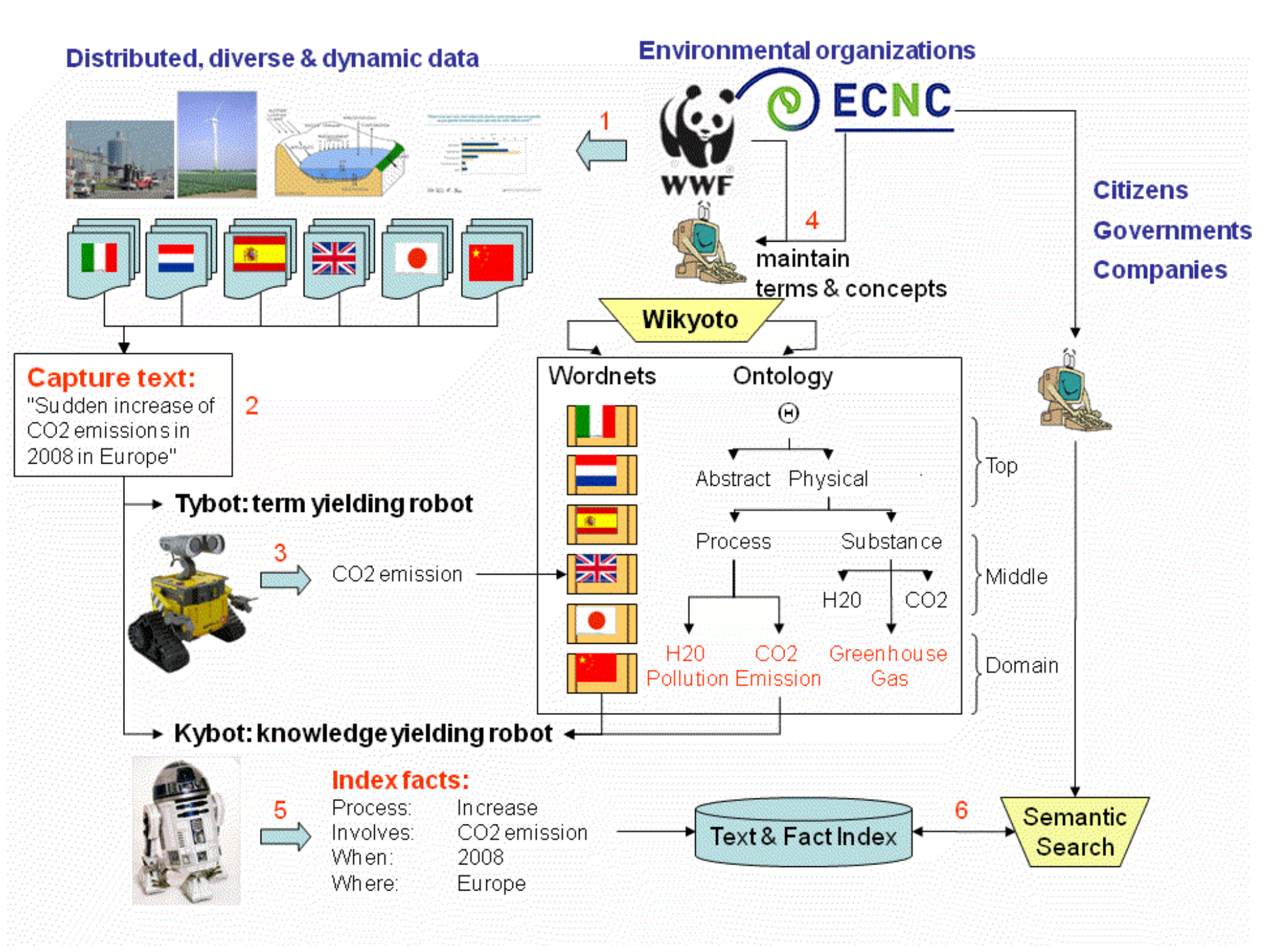
Outline

The KYOTO Project

- Project acronym – KYOTO, `www.kyoto-project.eu`
- Project full title
  Knowledge Yielding Ontologies for Transition-based Organization
- EU Programme
  FP7 ICT, Digital libraries and Content
  March 1 2008 – February 28 2011
- Coordinator – Piek Vossen, Vrije Universiteit, Amsterdam
  11 project partners
- Task –
  - to allow people in communities to define the meaning of their words and terms in a shared Wiki platform
  - one shared ontology adapted by concept users
  - the ontology is linked to multiple national language wordnets
  - the ontology is understood by computer

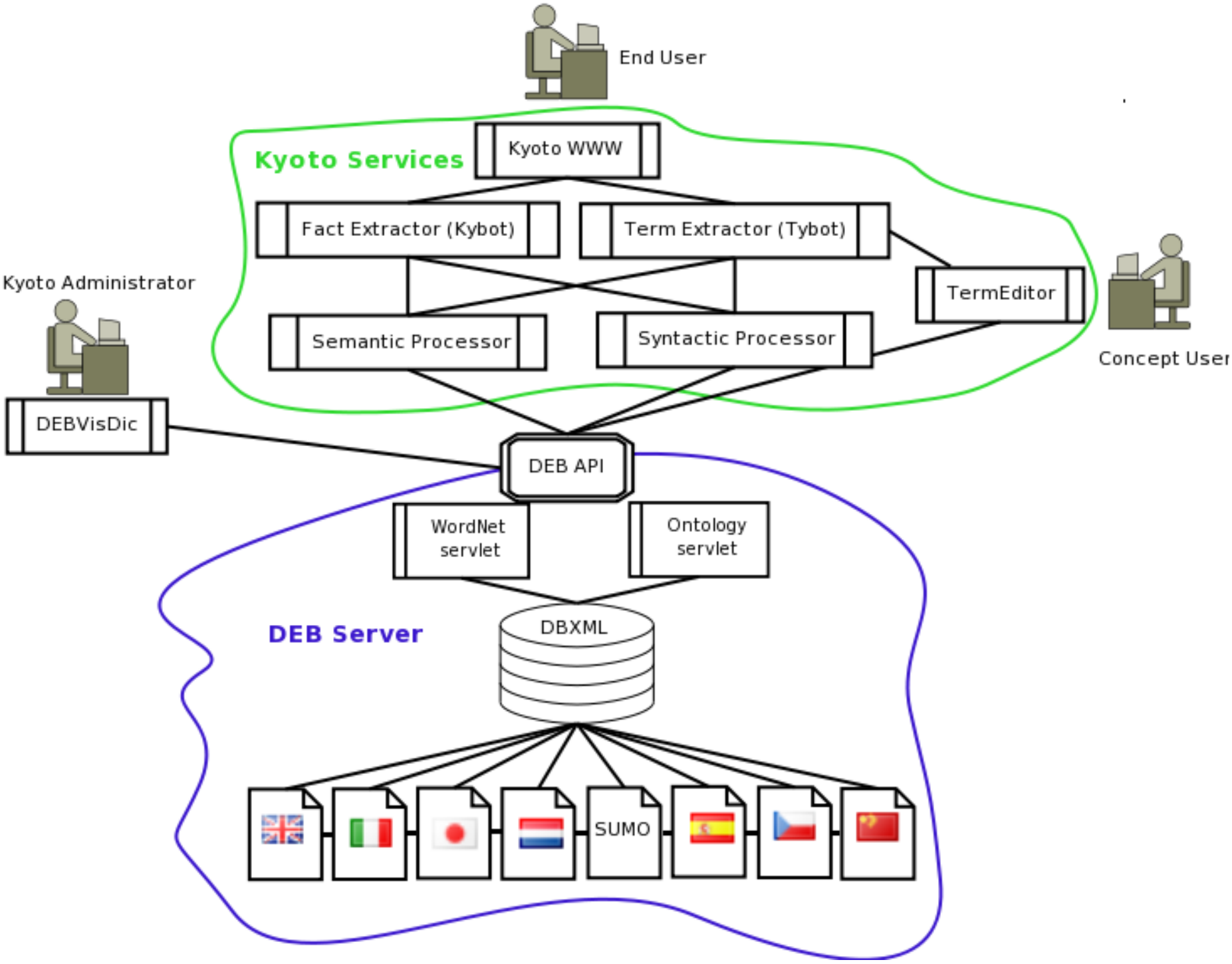
The KYOTO System Cycle

1. people from a domain specify the locations of sources of knowledge
2. texts are collected from the sources; linguistic structure representation is generated
3. term yielding robots extract terms and semantic relations
4. wiki-environment allows the domain people to maintain the terms and concepts in a domain ontology
5. knowledge yielding robots use the terms and knowledge to detect facts
6. the facts are indexed and accessed through semantic search


Distributed, diverse & dynamic data
Environmental organizations
ECNC
WWF
1
4
maintain
terms & concepts
Citizens
Governments
Companies
Wikyoto
Wordnets
Ontology
Abstract
Physical
Process
Substance
H20
CO2
H20
Pollution
CO2
Emission
Greenhouse
Gas
Top
Middle
Domain
Capture text:
"Sudden increase of CO2 emissions in 2008 in Europe"
2
Tybot: term yielding robot
3
CO2 emission
Kybot: knowledge yielding robot
5
Index facts:
Process: Increase
Involves: CO2 emission
When: 2008
Where: Europe
Text & Fact Index
6
Semantic Search

The KYOTO Database

- built over the Dictionary Editor and Browser (DEB) development platform
- stores data in distributed XML databases
- accessed from applications through specialized Application Programming Interface (API) calls


End User
Kyoto Services
Kyoto WWW
Fact Extractor (Kybot)
Term Extractor (Tybot)
TermEditor
Semantic Processor
Syntactic Processor
Kyoto Administrator
Concept User
DEBVisDic
DEB API
WordNet servlet
Ontology servlet
DEB Server
DBXML
SUMO

Global WordNet Grid

- the idea first introduced at GWC 2006 in Korea by P.Vossen, A.Pease and Ch.Fellbaum (GWA)
- today:
  - more than 50 national wordnets
  - many of them not freely available due to licence restrictions
  - some are linked to the Princeton WordNet
- in the Global WordNet Grid:
  - multilingual database of WordNets linked to a common ontology
  - provides common subset of concepts/synsets in all languages
  - publicly accessible
  - maintained by GWA, software developed by Masaryk University on the DEB Platform

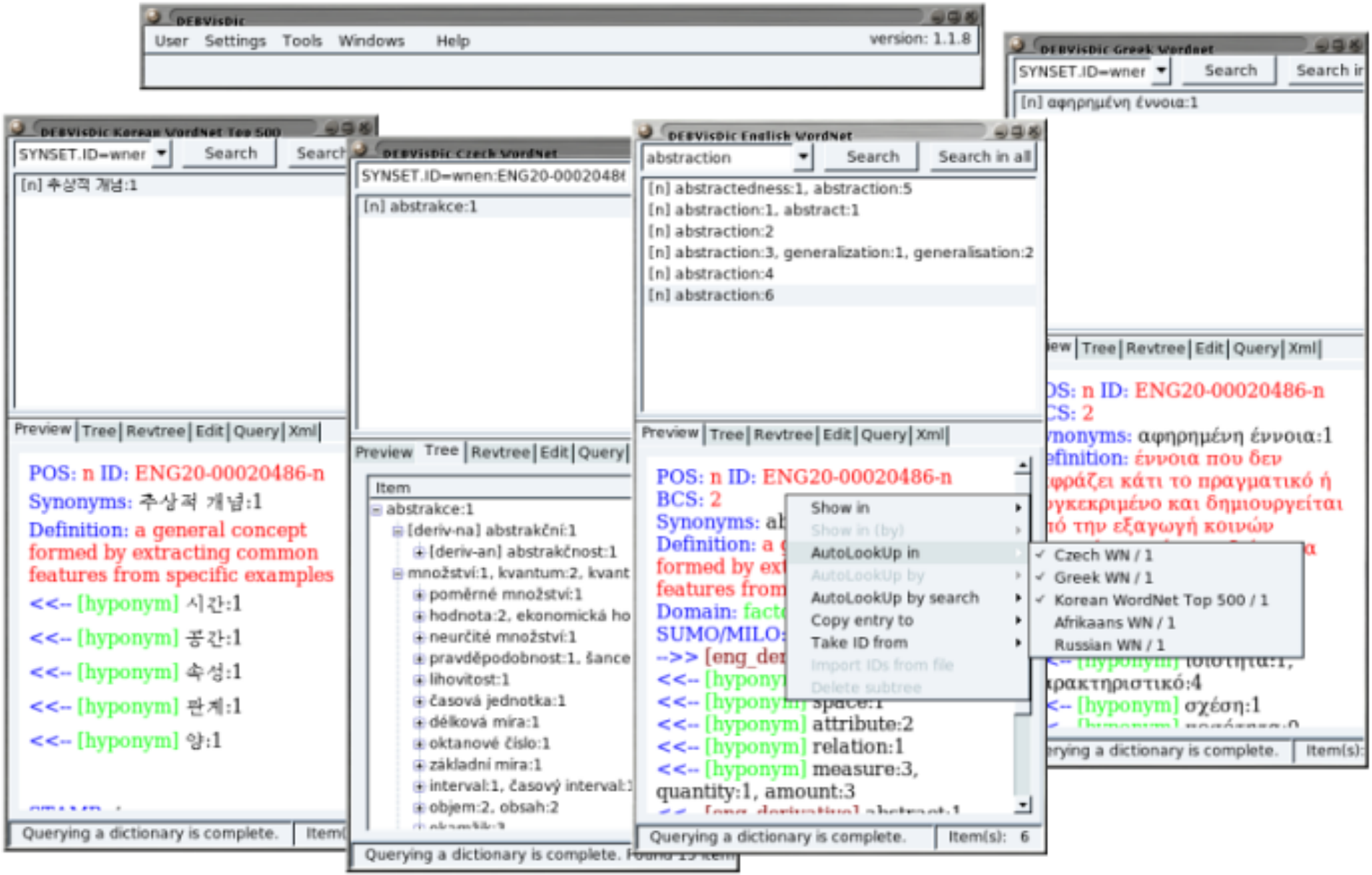
DEB Development Platform

DEB – Dictionary Editor and Browser

- platform for dictionary writing systems development
  - basically any XML data
  - strict client-server architecture
- server part
  - server side modules (servlets in Ruby)
  - database backend (Oracle Berkeley DB XML, Virtuoso, PostgreSQL)
- client part
  - simple functionality
  - graphical interfaces (Mozilla/Firefox extensions)
  - web interfaces
- freely available – `http://deb.fi.muni.cz`
  - 10 servers installed world-wide (Brno, Prague, Amsterdam-UvA, Amsterdam-VU, Poznan, Pretoria, Johannesburg, Budapest, Ljubljana, Bristol)
  - the Brno server – 632 users from 18 domains/countries

DEBVisDic

- its predecessor VisDic used in the EuroWordNet project
- all the main features for advanced WordNet browsing and editing
- Internet distributed architecture
- connection to other resources (e.g. morphological analyzer, dictionaries, Visual Browser, . . .)
- DEBVisDic is used for preparation of new Polish, Hungarian, Slovene, Dutch (Cornetto), Nepalese, Afrikaans, . . . WordNets


DEBVisDic
User Settings Tools Windows Help
version: 1.1.8
DEBVisDic Korean WordNet Top 500
SYNSET.ID=wner
Search
[n] 추상적 개념:1
Preview Tree Revtree Edit Query Xml
POS: n ID: ENG20-00020486-n
Synonyms: 추상적 개념:1
Definition: a general concept formed by extracting common features from specific examples
<<- [hyponym] 시간:1
<<- [hyponym] 공간:1
<<- [hyponym] 속성:1
<<- [hyponym] 관계:1
<<- [hyponym] 양:1
Querying a dictionary is complete.
DEBVisDic Czech WordNet
SYNSET.ID=wnen:ENG20-0002048
[n] abstrakce:1
Preview Tree Revtree Edit Query
Item
abstrakce:1
[deriv-na] abstrakční:1
[deriv-an] abstrakčnost:1
množství:1, kvantum:2, kvant
poměrné množství:1
hodnota:2, ekonomická ho
neurčité množství:1
pravděpodobnost:1, šance
lihovitost:1
časová jednotka:1
délková míra:1
oktanové číslo:1
základní míra:1
interval:1, časový interval:
objem:2, obsah:2
Querying a dictionary is complete.
DEBVisDic English WordNet
abstraction
Search
Search in all
[n] abstractedness:1, abstraction:5
[n] abstraction:1, abstract:1
[n] abstraction:2
[n] abstraction:3, generalization:1, generalisation:2
[n] abstraction:4
[n] abstraction:6
Preview Tree Revtree Edit Query Xml
POS: n ID: ENG20-00020486-n
BCS: 2
Synonyms: ab
Definition: a
formed by ext
features from
Domain: facte
SUMO/MILO:
-->> [eng_der
<<- [hyponym]
<<- [hyponym]
<<- [hyponym] attribute:2
<<- [hyponym] relation:1
<<- [hyponym] measure:3,
quantity:1, amount:3
Show in
Show in (by)
AutoLookUp in
AutoLookUp by
AutoLookUp by search
Copy entry to
Take ID from
Import IDs from file
Delete subtree
Czech WN / 1
Greek WN / 1
Korean WordNet Top 500 / 1
Afrikaans WN / 1
Russian WN / 1
Querying a dictionary is complete.
Item(s): 6
DEBVisDic Greek Wordnet
SYNSET.ID=wner
Search
Search ir
[n] αφηρημένη έννοια:1
Tree Revtree Edit Query Xml
OS: n ID: ENG20-00020486-n
CS: 2
nonyms: αφηρημένη έννοια:1
efinition: έννοια που δεν
φράζει κάτι το πραγματικό ή
γκεκριμένο και δημιουργείται
ό την εξαγωγή κοινών
ρακτηριστικό:4
<- [hyponym] σχέση:1
erying a dictionary is complete.
Item(s):

DEB WordNet Storage

a WordNet in the DB can be physically stored:

i) on the central server
   - traditional DEBVisDic setup
   - offers the best performance

ii) on a DEB server located at the WordNet owner's institution
   - the Central DB server has only the knowledge of which server to contact
   - all queries are dynamically resolved over the Internet
   - can be slower
   - the WordNet owner has full control over the displayed data and access permissions

iii) a mixed solution – some WordNets are stored on central server and some are stored on their respective owners' servers.

DEB WordNet Presentation

each WordNet in the DB can be presented to the DB users as:

a) simple HTML interface working in any web browser
   - using XSLT templates, several different views – from a terse view up to a detailed view
   - best for public anonymous access to the DB

b) using the full DEBVisDic application
   - needs to be installed
   - offers much more complex functionality than the web access
   - the possibility to edit the data (with the access rights)
   - the most advanced environment for working with WordNets

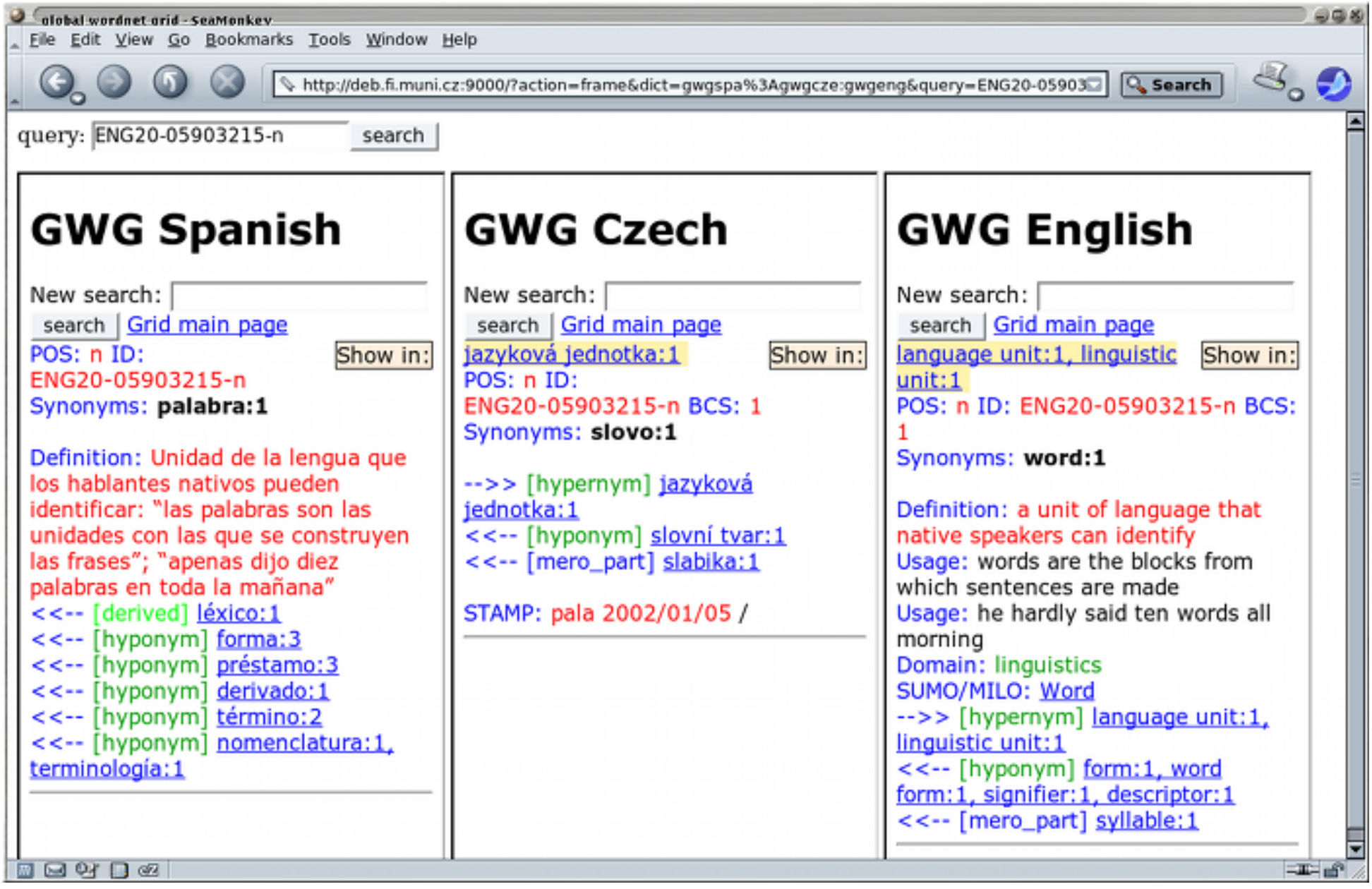
c) by means of the DEB API
   - any external application may query the server and receive WordNet entries (in XML or other form) for subsequent processing

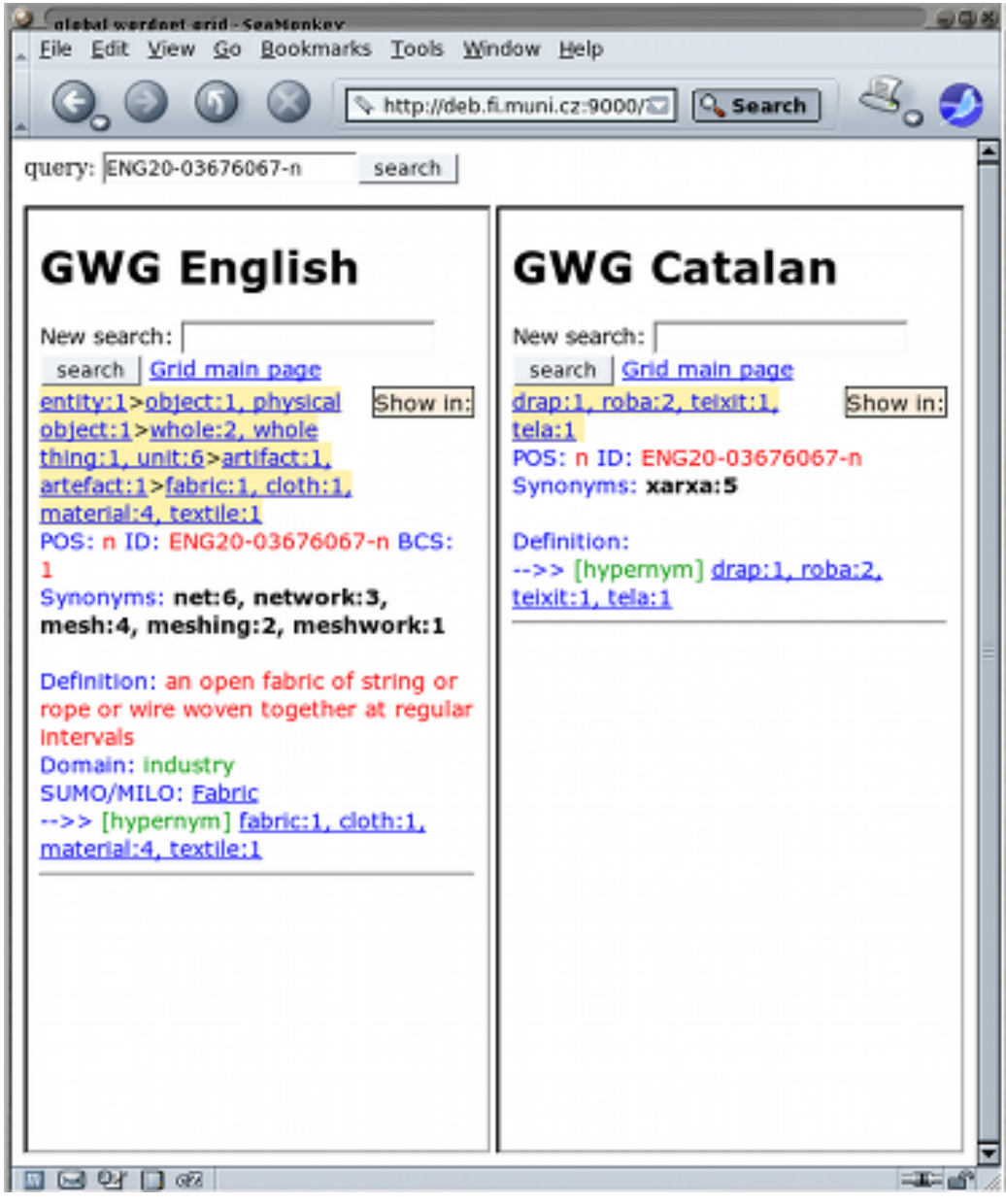
New DEB Features within the KYOTO Project

The DEBVisDic server API is documented on
http://deb.fi.muni.cz/doc.php

Latest additions to the DEBVisDic API:

i) Synset API Calls Granularity
ii) Synset Translation
iii) Links between Wordnets and Ontologies
iv) Importing Full Subtree
v) JSONP Support
vi) External WordNet Relations


global wordnet grid - SeaMonkey
File Edit View Go Bookmarks Tools Window Help
http://deb.fi.muni.cz:9000/?action=frame&dict=gwgspa%3Agwgcze:gwgeng&query=ENG20-05903
Search
query: ENG20-05903215-n search
GWG Spanish
New search:
search Grid main page
Show in:
POS: n ID: ENG20-05903215-n
Synonyms: palabra:1
Definition: Unidad de la lengua que los hablantes nativos pueden identificar: "las palabras son las unidades con las que se construyen las frases"; "apenas dijo diez palabras en toda la mañana"
<<-- [derived] léxico:1
<<-- [hyponym] forma:3
<<-- [hyponym] préstamo:3
<<-- [hyponym] derivado:1
<<-- [hyponym] término:2
<<-- [hyponym] nomenclatura:1, terminología:1
GWG Czech
New search:
search Grid main page
Show in:
jazyková jednotka:1
POS: n ID: ENG20-05903215-n BCS: 1
Synonyms: slovo:1
-->> [hypernym] jazyková jednotka:1
<<-- [hyponym] slovní tvar:1
<<-- [mero_part] slabika:1
STAMP: pala 2002/01/05 /
GWG English
New search:
search Grid main page
Show in:
language unit:1, linguistic unit:1
POS: n ID: ENG20-05903215-n BCS: 1
Synonyms: word:1
Definition: a unit of language that native speakers can identify
Usage: words are the blocks from which sentences are made
Usage: he hardly said ten words all morning
Domain: linguistics
SUMO/MILO: Word
-->> [hypernym] language unit:1, linguistic unit:1
<<-- [hyponym] form:1, word form:1, signifier:1, descriptor:1
<<-- [mero_part] syllable:1


global wordnet grid - SeaMonkey
File Edit View Go Bookmarks Tools Window Help
http://deb.fi.muni.cz:9000/
Search
query: ENG20-03676067-n search
GWG English
New search:
search Grid main page
entity:1>object:1, physical object:1>whole:2, whole thing:1, unit:6>artifact:1, artefact:1>fabric:1, cloth:1, material:4, textile:1
Show in:
POS: n ID: ENG20-03676067-n BCS: 1
Synonyms: net:6, network:3, mesh:4, meshing:2, meshwork:1
Definition: an open fabric of string or rope or wire woven together at regular intervals
Domain: industry
SUMO/MILO: Fabric
-->> [hypernym] fabric:1, cloth:1, material:4, textile:1
GWG Catalan
New search:
search Grid main page
drap:1, roba:2, teixit:1, tela:1
Show in:
POS: n ID: ENG20-03676067-n
Synonyms: xarxa:5
Definition:
-->> [hypernym] drap:1, roba:2, teixit:1, tela:1


Knowledge base Browser - Fabric - SeaMonkey
File Edit View Go Bookmarks Tools Window Help
http://sigma.on
Search
Sigma knowledge engineering environment [Home | Graph |]
Browsing Interface
KB: SUMO
Language: EnglishLanguage
KB Term: Fabric Show
English Word: Noun Show
Fabric(fabric)
Acrilan, Aertex, Bedford cord, Brussels carpet, Brussels lace, Canton crepe, Canton flannel, Courtelle, Dacron, Golden Fleece, Harris Tweed, Levant, Levant morocco, Mackinaw blanket, Orlon, Persian lamb, Russia leather, Terylene, Turkish towel, Ultrasuede, Valenciennes, Valenciennes lace, Velcro, Vivella, aba, acetate, acetate rayon, acrylic, adhesive bandage, afghan, alligator, alpaca, antimacassar, apishamore, astrakhan, bagging, baize, balbriggan, band, bandage, banding, banner, basket weave, bath linen, bath mat, bath towel, batik, batiste, beach towel, bearskin...
appearance as argument number 1
(disjoint Fabric StationaryArtifact)
Merge.kif 12150-12150
fabric is disjoint from stationary art
(documentation Fabric EnglishLanguage "Artifacts that are created by weaving together natural or synthetic fibers or by treating the skins of certain sorts of Animals. Note that this Class includes
Merge.kif 12151-12156
%3

English Wordnet 3

entity:1>physical entity:1>object:1, physical object:1>location:1>region:3>area:1, country:5>section:3>vicinity:1, locality:1, neighborhood:1, neighbourhood:1, neck of the woods:1>scenery:2
POS: n ID: eng-30-08646902-n
Synonyms: **landscape:1**

Definition: an expanse of scenery that can be seen in a single view
-->> [hypernym] scenery:2
-->> [eng_derivative] landscape architect:1, landscape gardener:1, landscaper:1, landscapist:2
-->> [eng_derivative] landscapist:1
<<-- [eng_derivative] landscape architect:1, landscape gardener:1, landscaper:1, landscapist:2
<<-- [eng_derivative] landscapist:1

---

support:1, back up:1>help:1, assist:1, aid:1>care:2, give care:1>attend:2, take care:3, look:6, see:14>tend:2>garden:1
POS: v ID: eng-30-01741221-v
Synonyms: **landscape:2**

Definition: do landscape gardening
Usage: My sons landscapes for corporations and earns a good living
-->> [hypernym] garden:1
-->> [verb_group] landscape:1
-->> [eng_derivative] landscaping:1, landscape gardening:1
-->> [eng_derivative] landscape architect:1, landscape gardener:1, landscaper:1, landscapist:2
-->> [category_domain] gardening:1, horticulture:1
<<-- [eng_derivative] landscaping:1, landscape gardening:1

GEMET Thesaurus

```
SELECT ?x ?conceptLabel
WHERE {
?x skos:prefLabel ?conceptLabel .
FILTER regex(?conceptLabel, "landscape", "i")
}
```

http://www.eionet.eu.int/gemet/concept/204	agricultural landscape
http://www.eionet.eu.int/gemet/concept/4455	intervention in nature and landscape
http://www.eionet.eu.int/gemet/concept/4648	landscape
http://www.eionet.eu.int/gemet/concept/4649	landscape after mining
http://www.eionet.eu.int/gemet/concept/4650	landscape alteration
http://www.eionet.eu.int/gemet/concept/4651	landscape architecture
http://www.eionet.eu.int/gemet/concept/4652	landscape component
http://www.eionet.eu.int/gemet/concept/4653	landscape conservation
http://www.eionet.eu.int/gemet/concept/4654	landscape conservation policy
http://www.eionet.eu.int/gemet/concept/4662	landscape consumption
http://www.eionet.eu.int/gemet/concept/4657	landscape ecology
http://www.eionet.eu.int/gemet/concept/4658	landscape management

Ontology OWN

New search: landscape
search

SubClassOf:
http://www.loa-cnr.it/ontologies/OWN/OWN.owl#LANDSCAPE_1
http://www.loa-cnr.it/ontologies/OWN/OWN.owl#PAINTING__PICTURE

EntityAnnotation:
http://www.loa-cnr.it/ontologies/OWN/OWN.owl#LANDSCAPE_1
a painting depicting an expanse of natural scenery

SubClassOf:
http://www.loa-cnr.it/ontologies/OWN/OWN.owl#LANDSCAPE_2
http://www.loa-cnr.it/ontologies/OWN/OWN.owl#SCENERY

EntityAnnotation:
http://www.loa-cnr.it/ontologies/OWN/OWN.owl#LANDSCAPE_2
an expanse of scenery that can be seen in a single view

SubClassOf:
http://www.loa-cnr.it/ontologies/OWN/OWN.owl#LANDSCAPE_ARCHITECTURE
http://www.loa-cnr.it/ontologies/OWN/OWN.owl#ARCHITECTURE_3

EntityAnnotation:
http://www.loa-cnr.it/ontologies

Conclusions

- extending CzWn is going on (slowly)
- CzWn can be presently accessed via DEBDict or DEBVisDic by everyone (`http://nlp.fi.muni.cz/declaration/`)
- The KYOTO database currently contains:
  - wordnets: Basque, English, Italian, Japanese, Dutch, Spanish, Chinese
  - ontologies: OWL KYOTO Central Ontology, SUMO and OWL-WN
  - thesauri: GEMET, SPECIES 2000, WWF Ecoregions, EUNIS
- DEB platform offers high modularity and configurability
- further functionality development within the KYOTO project

References

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- EuroWordNet, final report, CD ROM with data, 1999, www pages EWN, distributed by ELDA/ELRA
- P. Vossen et al., EuroWordNet, book published by Kluwer
- www pages of Global WordNet Association (GWA, P. Vossen, Ch. Fellbaum)
- www pages of Balkanet Project, Final report 2004
- Proceedings of the Second Global WordNet Conference, Brno, 20.-23.1.2004
- www pages – NLP Lab. FI MU in Brno, DEBVisDic page: `http://deb.fi.muni.cz/debvisdic`

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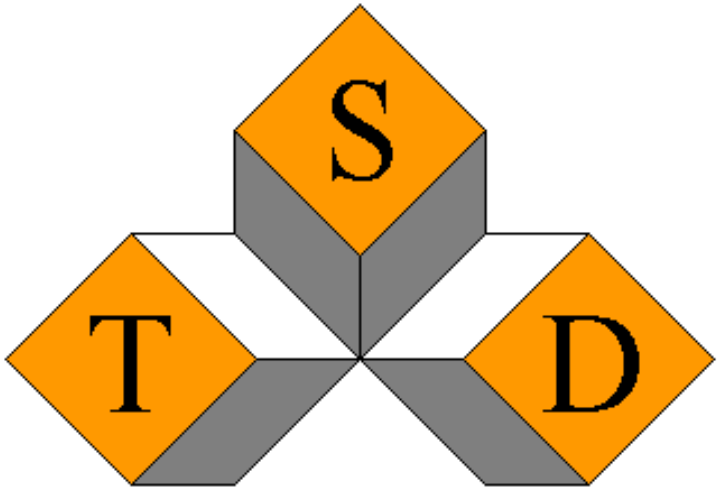

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March 2010 - submission of full papers

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