A Solid Foundation of Semantic Computing toward Web Intelligence

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Technical Committee on Semantic Computing

The Technical Committee on Semantic Computing (SC) addresses the derivation and matching of the semantics of computational content to that of naturally expressed user intentions in order to retrieve, manage, manipulate or even create content, where “content” may be anything including video, audio, text, software, hardware, network, process, etc.

This connection between content and the user intentions is made via (1) Semantic Analysis, converting it to machine processable descriptions (semantics); (2) Semantic Integration, which integrates information from multiple sources; (3) Semantic Applications, which utilize content and descriptions to solve problems which interprets users’ intentions expressed in natural language or other communicative intentions of users to create content via analysis and synthesis techniques.

The ultimate success of Semantic Computing requires new, synergized technologies be created in the areas of data and knowledge engineering, software engineering, computer systems and networks, pattern recognition, etc.

Founded in 2010, the mission of TCSEM is to establish a community for Semantic Computing.

Semantic Computing Gets Technical Committee

University of California Irvine professor Phillip C-Y Sheu, interim chair of the newly formed Technical Committee on Semantic Computing, is looking for volunteers for the Executive Committee. —Read more
SemTech 2010 is the world’s largest, most authoritative conference on semantic technology for enterprise computing professionals. It covers every major technology and application area you’ll need to know.

Semantic technologies are being used in lots of industries today. Sometimes they address problems that couldn’t be solved until semantics came along, and other times they are used because they are faster, cheaper and simpler than the alternatives. Here are some of the industrial application spaces you’ll hear about if you attend SemTech 2010:

**SEMANTICS IN HEALTHCARE**

Applications for electronic medical records, cost management and accounting, public health monitoring, and horizon scanning. Plus, what impact will semantics have in Health Reform? Sessions [here](http://semtch.org).

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**SPEAKERS**

**Semantic Tools for More Profitable Online Commerce**
Jay Myan
Jadestone
e

**From Relational Databases to the Semantic Web — New W3C Standards and Directions**
Harry R. Heflin,
University of Edinburgh
e

**Semantic Technology and Healthcare Reform: How to Decrease the Cost of Healthcare with Semantic Technologies**
Bill Wooldridge,
Blue Cross Blue Shield of Texas; Health Care Services Corp.

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**REGISTER NOW**

Semantifi Named Winner
SemTech Start-Up Competition

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**BREAKING NEWS**

Semantifi Named Winner
SemTech Start-Up Competition

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Semantic Computing

- Toward Semantic-level Content Utilization by computers, beyond its surface-level processing.

In many domains:
- natural language texts,
- image and video,
- audio and speech,
- semi-structured data,
- behavior of software and network,
- data and web mining, etc.

Applications:
- semantic annotation to contents,
- semantic computing of textual documents,
- semantic software engineering,
- semantic search engine,
- semantic multimedia services,
- context-aware devices and services,
- semantic GIS system,
- semantic interfaces,
- semantic trusted computers, etc.
Semantic Computing at present

- Increasing interests in many domains.
- Most technologies are partial and ad hoc at present.
- We need a solid foundation of semantic computing.

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- Natural language plays a major role to express and convey the semantic meaning. It should thus become the first focus and the core of the semantic computing.
- We need a common and universal language that computers and human can understand, to represent concept meaning at a certain level.
The aims of CDL are
1) to realize machine understandability of Web text contents, and
2) to overcome language barrier on the Web.
Major Differences from Semantic Web

Semantic Web

- Target of representation: Meta-data extracted from Web contents.
- Domain-dependent ontologies (which cause the difficulty of wide inter-boundary usage)
- RDF / OWL (description logic is hard for ordinary people to understand)

Semantic Computing based on CDL

- Target of representation: Semantic concepts expressed in texts.
- Universal vocabulary (+ additional specific vocabulary in a domain if necessary), and pre-defined relation set.
- CDL.nl (richer than RDF)

Tim Berners-Lee says that: “Data Web” or “Linked Data” is more adequate rather than “the Semantic Web”. (2007)

Main body:
Institute of Semantic Computing (ISeC) in Japan
Int’l Standardization Activity: W3C Common Web Language (CWL)-XG
Incubator Group Activity at W3C from Oct. 2006 to May 2008

Common Web Language Incubator Group Charter

The mission of the Common Web Language Incubator Group, part of the Incubator Activity, is to develop the CWL (Common Web Language), a common language for exchanging information through the web and also for enabling computers to process information semantically. A pilot model of CWL platform will also be developed on the web. The CWL is used to describe contents and meta-data of web pages written in natural languages. Then CWL will realize a language barrier free world in the web and will also enable computers to extract semantic information and knowledge from web pages accurately.

Join the Common Web Language Incubator Group.

End date: 15 October 2007
Confidentiality: Proceedings are public
Initial Chairs: Hiroshi Uchida (SeC)
Initiating Members:
- Institute of Semantic Computing (iSeC)
- National Institute of Advanced Industrial Science and Technology (AIST)
- Justsystem Corporation

Usual Meeting Schedule:
- Teleconferences: once a month
- Face-to-face: twice a year W3C10 Asia, AC Meeting (Tokyo) 28 Nov 2008 in Japan and May 2007 in Canada

Scope

An attempt to describe texts in the web in a common language is promoted in the Semantic Web Activity. The RDF/OWL is used as a basic description language and can be used to describe texts in web pages. However, RDF/OWL is originally designed to describe meta-data of resources, and at this moment, there is no standard set of properties and vocabulary to cover various web pages. There are some activities to provide common bases for describing information in the web such as the WordNet, NCTEDR Electronic Dictionary, for providing lexical bases, Conceptual Graphs for providing a representation basis. The CWL initiative is an activity quite different from those activities. The CWL will provide not only representation scheme but also a vocabulary with semantic background. It is an initiative to integrate existing and ongoing activities for providing a common description language with unambiguous grammar and enough amount of lexicons based on the CDL (Concept Description Language) scheme aiming at describing every kind of information understandable for computers.

The CWL has the following characteristics:

1. CWL is designed to be independent from any natural languages and shall enable users to develop conversion systems between CWL and
2nd Incubator Group at W3C from June 2008

Common Web Language Evaluation and Installation Incubator Group Charter

The mission of the Common Web Language Evaluation and Installation Incubator Group is to substantiate the CWL (Common Web Language) in actual web environment using the pilot model of the CWL platform. The CWL is a graphic language of semantic network with hyper node and is used to describe contents and meta-data of web pages in three different types of form such as UNL, CDL and RDF. The CWL platform allows people to input CWL using natural languages and display information written in CWL in natural languages. Using this CWL platform, the CWL will be evaluated from multilingualism, semantic computing and semantic web points of view. Based on these evaluation and feedback, the CWL and its platform will be bearable in actual use in the web.

Join the Common Web Language Evaluation and Installation Incubator Group.

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<thead>
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<th>End date</th>
<th>20 May 2009</th>
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<td>public</td>
</tr>
<tr>
<td>Initial Chairs</td>
<td>Hiroshi Uchida (SeC)</td>
</tr>
</tbody>
</table>

Initiating Members
- Institute of Semantic Computing (SeC)
- National Institute of Advanced Industrial Science and Technology (AIST)
- Kyoto University
- JetSystems Corporation

Usual Meeting Schedule
- Teleconferences: No teleconferences
- Face-to-face: 2 per year

Scope

The CWL is a graphic language of semantic network with hyper node, a node represents a concept, an arc represents a relation between nodes and a node can be annotated by attributes. This CWL can be expressed in three forms such as UNL, CDL and RDF. The same information in CWL can be described in each form but in different manner. The CWL unil is a language in UNL form, the CWL cdil is a language in CDL form, and the CWL rdf is a language in RDF form. Information in the web is basically expressed in natural languages. UNL is for multilingual activities, CDL is for semantic computing activity, RDF is for semantic web activities. Various information will be expressed in three types of representation, and applications based on those representations will be developed, and information will be utilized.
From Machine Translation

Pivot Language

Transfer method

English Japanese Chinese

UNL (Universal Networking Language)

CDL (Concept Description Language)

Minimal and sufficient relations have been chosen to represent the surface-level concept meaning of texts.

Standardization in W3C

CWL (Common Web Language)
CDL Representation

- Text example:
  “John reported to Alice that he bought a computer yesterday.”

- CDL graph notation:
CDL Representation

- **Text example:**
  “John reported to Alice that he bought a computer yesterday.”

- **CDL text notation:**

```plaintext
{#A01 Event tmp='past';
  {#B01 Event tmp='past';
    <#b01:buy;>
    <#b02:computer ral='def';>
    <#b03:yesterday;>
    [#b01 agt #John]
    [#b01 obj #b02]
    [#b01 tim #b03]
  }
  <#John:John;>
  <#Alice:Alice;>
  <#a01:report;>
  [#a01 agt #John]
  [#a01 gol #Alice]
  [#a01 obj #B01]
}
```

Orange: entity  
Blue: relation
# CDL (UNL) Relations – 44 labels

<table>
<thead>
<tr>
<th>Semantic Roles</th>
<th>Logical</th>
<th>Restrictive</th>
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<tbody>
<tr>
<td><strong>Intra-Event</strong></td>
<td><strong>Inter-Entity</strong></td>
<td><strong>Restrictive</strong></td>
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<tr>
<td>[Agent Relations]</td>
<td>[Instrument Relations]</td>
<td>[Logical Relations]</td>
</tr>
<tr>
<td>agt (agent)</td>
<td>ins (instrument)</td>
<td>and (conjunction)</td>
</tr>
<tr>
<td>cag (co-agent)</td>
<td>met (method, means)</td>
<td>fmt (range, from-to)</td>
</tr>
<tr>
<td>aoj (thing w/ attribute)</td>
<td>[State Relations]</td>
<td>orr (disjunction, alternative)</td>
</tr>
<tr>
<td>cao (co-thing w/ attribute)</td>
<td>src (source, initial state)</td>
<td>fmr (origin)</td>
</tr>
<tr>
<td>ptn (partner)</td>
<td>gol (goal, final state)</td>
<td>[Concept Relations]</td>
</tr>
<tr>
<td>[Object Relations]</td>
<td>via (interm. place or state)</td>
<td>mod (modification)</td>
</tr>
<tr>
<td>obj (affected thing)</td>
<td>[Time Relations]</td>
<td>[Cause Relations]</td>
</tr>
<tr>
<td>cob (affected co-thing)</td>
<td>tim (time)</td>
<td>qua (quantity)</td>
</tr>
<tr>
<td>opl (affected place)</td>
<td>tmf (initial time)</td>
<td>con (condition)</td>
</tr>
<tr>
<td>ben (beneficiary)</td>
<td>tmt (final time)</td>
<td>tto (destination)</td>
</tr>
<tr>
<td>[Place Relations]</td>
<td>dur (duration)</td>
<td>rsn (reason)</td>
</tr>
<tr>
<td>plc (place)</td>
<td>[Manner Relations]</td>
<td>[Sequence Relations]</td>
</tr>
<tr>
<td>plf (initial place)</td>
<td>man (manner)</td>
<td>coo (co-occurrence)</td>
</tr>
<tr>
<td>plt (final place)</td>
<td>bas (basis for a standard)</td>
<td>seq (sequence)</td>
</tr>
<tr>
<td>scn (scene)</td>
<td>Discourse</td>
<td></td>
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</tbody>
</table>
Semantic Role Labels in PropBank

The focus is on Predicate-Argument Structure.

- **Arg0** (prototypical agent)
- **Arg1** (prototypical patient)
- **Arg2** (indirect object/benefactive/instrument/attribute/end state)
- **Arg3** (start point/benefactive/instrument/attribute)
- **Arg4** (end point)
- **Arg5**
- **TMP** (time)
- **LOC** (location)
- **DIR** (direction)
- **MNR** (manner)
- **PRP** (purpose)
- **CAU** (cause)
- **MOD** (modal verb)
- **NEG** (negative marker)
- **ADV** (general-purpose modifier)
- **DIS** (discourse particle and clause)
- **PRD** (secondary predication)

These are defined wrt each word sense.

Ex) **buy::**
- **Arg0**: buyer
- **Arg1**: thing bought
- **Arg2**: seller (bought-from)
- **Arg3**: price paid
- **Arg4**: benefactive (bought-for)

This set is not sufficient for representing every concept expressed in natural language texts. It cannot be used for every language due to its language (English) dependency.
Rich Attributes in UNL and CDL

- Express subjectivity evaluation of the writer/speaker for the sentence.
  - Ex.) tense, aspect, mood, etc.

- Time with respect to writer
  @past @present @future

- Writer’s view on aspect of event
  @begin @complete @continue @custom
  @end @experience @progress @repeat @state

- Writer’s view of reference
  @generic @def @indef @not @ordinal

- Writer’s view of emphasis, focus and topic
  @emphasis @entry @qfocus @theme
  @title @topic

- Writer’s attitudes
  @affirmative @confirmation @exclamation
  @imperative @interrogative @invitation
  @politeness @respect @vocative

- Writer’s view of reference
  @generic @def @indef @not @ordinal

- Writer’s feeling and judgements
  @ability @get-benefit @give-benefit
  @conclusion @consequence @sufficient @grant
  @grant-not @although @discontented
  @expectation @wish
  @insistence @intention @want @will @need
  @obligation @obligation-not @should
  @unavoidable @certain @inevitable @may
  @possible @probable @rare @regret @unreal
  @admire @blame @contempt @regret
  @surprised @troublesome

- Describing logical characters and properties of concepts
  @transitive @symmetric @identifiable
  @disjoint

- Modifying attribute on aspect
  @just @soon @yet @not

- Attribute for convention
  @passive @pl @angle_bracket @brace
  @double_parenthesis @double_quote
  @parenthesis @single_quote @square_bracket
The defining method of one unique sense of a word in **UW** (Patent of UN Univ.)

- **Defining category**
  - swallow(icl>bird)  
    - the bird  
    - “One swallow does not make a summer”  
  - swallow(icl>action)  
    - the action of swallowing  
    - “at one swallow”  
  - swallow(icl>quantity)  
    - the quantity  
    - “take a swallow of water”

- **Defining possible case relations**
  - spring(agt>thing,obj>wood)  
    - bending or dividing something  
  - spring(agt>thing,obj>mine))  
    - blasting something  
  - spring(agt>thing,obj>person, src>prison))  
    - escaping (from) prison  
  - spring(agt>thing,gol>place)  
    - jumping up  
    - “to spring up”  
  - spring(agt>thing,gol>thing)  
    - jumping on  
    - “to spring on”  
  - spring(obj>liquid)  
    - gushing out  
    - “to spring out”
**Universal Word**

uw{(equ>Universal Word)}

**adjective concept{(icl>uw)}**

uw(aoj>thing{,and>uw,ben>thing,cao>thing,cnt>uw,cob>thing,con>uw,coo>uw,dur>period,man>how,obj>thing,or>uw(aoj>thing),plc>thing,plf>thing,plt>thing,rsn>uw(aoj>thing),rsn>do,icl>adjective concept})

Achaean{(icl>uw(aoj>thing{})
Afghan{(icl>uw(aoj>thing{})
African{(icl>uw(aoj>thing{})
African-American{(icl>uw(aoj>thing{})
Ainu{(icl>uw(aoj>thing{}}
Alaskan{(icl>uw(aoj>thing{}}
Albanian{(icl>uw(aoj>thing{}}
Aleutian{(icl>uw(aoj>thing{}}
Alexandrian{(icl>uw(aoj>thing{}}
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Altaic{(icl>uw(aoj>thing{}}
American{(icl>uw(aoj>thing{}}
Anglian{(icl>uw(aoj>thing{}}
Anglo-American{(icl>uw(aoj>thing{}}
Anglo-Catholic{(icl>uw(aoj>thing{}}
Anglo-French{(icl>uw(aoj>thing{}}
Anglo-Indian{(icl>uw(aoj>thing{}}
Anglo-Irish{(icl>uw(aoj>thing{}}
Anglo-Norman{(icl>uw(aoj>thing{}}
Arab{(icl>uw(aoj>thing{}}
Arab-Israeli{(icl>uw(aoj>thing{}}
Arabian{(icl>uw(aoj>thing{}}
Arabic{(icl>uw(aoj>thing{}}

40,000 lexicons are open to public.

The full vocabulary includes 200,000 lexicons as of 2007.
There are several choices for the deep semantic-level description depending on applications. On the other hand, a certain consensus has been made wrt “Concept Description” which is slightly below the surface level, through decades-long researches on NLP, machine translation and electric dictionaries.

Whereas a complete consensus has not been achieved yet regarding the Concept Description level and its description scheme, it is meaningful to set up a common concept description format as an international standard today.
Hierarchical Construction of Concept Representation in CDL

situation (discourse)

- temporal and causal relations, etc., and coreference

composite concept/event (complex sentence)

- agent-patient relation, phrasal relation, etc.

composite entity

- single event (single sentence) consisting of proposition and modality components

elementary thing/entity corresponding to disambiguated word sense

- predicate, case components, predicate-modification components, etc.
Approaches for Generating CDL Data

- Manual Coding & Editing
  - Even in this case, a graphical input editor is necessary.

- **Graphical Input & Editing** *(Hasida’s Semantic Authoring)*

- Some Manual Tagging to Text, then Conversion into CDL.

- Semi-automatic Conversion from Text (1)
  - Automatic and Manual Word Sense Disambiguation, then Conversion into CDL.

- Semi-automatic Conversion from Text (2)
  - Post editing of converted CDL data with a GUI.

- Full Automatic Conversion *(ultimate goal)*
Recognition of CDL Relations from dependency-analyzed text

Syntactic and Dependency-path features

Lexical features from WordNet, VerbNet and UNLKB.

Some labels of Connexor Machine Analyser:

- **ha** (prepositional phase attachment), **phr** (verb particle), **pcomp** (subject complement)

Performance for frequent 36 relations (out of 44)

Precision 87.3%  Recall 88.1%  F-value 87.1%
**Frequencies of CDL Relations**

- **Data sparseness:**
  - The whole number of relations: 13487
  - Relation type: 44
  - Average num per relation: 306.5

<table>
<thead>
<tr>
<th>nam</th>
<th>Mod</th>
<th>Obj</th>
<th>Aoj</th>
<th>And</th>
<th>Agt</th>
<th>Man</th>
<th>Plc</th>
<th>Gol</th>
<th>Tim</th>
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<td>Pof</td>
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<td>Or</td>
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<td>1</td>
<td>0</td>
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</tbody>
</table>
A Semi-automatic Conversion from NL Text to CDL

Natural Language Text

Syntactic and Dependency Parsing

Word Sense Disambiguation

Rule-based Translation (UNL server)

CDL Description

Automatic and Manual Selection

Check & Post Editing (GUI)
Semi-automatic Conversion from NL Texts to CDL

CWL Platform Interface
manual word sense disambiguation

Universal Words (Lexical Data)

Language Server for NL texts consisting of disambiguated word senses

The UNL System
CDL data
CWL Platform Interface (1)

CWL Platform

Menu
Home
Edit
Conversion(NL->CWL)
Conversion(CWL->NL)

Word Selection
Editor View

A computer is a machine that manipulates data according to a list of instructions.

Candidates

- manipulat "manipulate(icl>control(agt>thing, obj>thing))"
- manipulat "manipulate(icl>influence(agt>thing, obj>thing))"
- manipulat "manipulate(icl>thing, obj>thing)"
- manipulat "manipulate(icl>move(agt>thing, obj>thing))"
- manipulat "manipulate(icl>use(agt>thing, obj>thing))"
- manipulat "manipulate(icl>thing, gol>thing, obj>thing)"
- manipulat "manipulate(icl>thing, obj>thing, one>person)"

Editor for Word Sense Disambiguation
CWL Platform Interface Screenshots (2)
CWL Platform Interface (3)

Graph Representation
CDL Data Retrieval via CDQL
(an Extended SPARQL)

Query::
What did John report?

\[
\text{SELECT } * \ y \ *z \\
\text{WHERE } \{ \\
[\text{report} \ \text{agt} \ \text{John}] \\
[\text{report} \ \text{obj} \ ?x] \\
\{?x \ \text{Event; } *y, *z\} \\
\} \\
\]

result

*\(y = \{\#b1 \text{ buy; }\}
\{\#b2 \text{ computer; }\}
\{\#b3 \text{ yesterday; }\}\)

*\(z = [\#b1 \text{ agt John}]
[\#b1 \text{ obj } \#b2]
[\#b1 \text{ tim } \#b3]\)

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Semantic Retrieval through a Flexible Graph Matching

CDL data graph

query graph
Semantic Retrieval of CDL data

- **CDQL**: SQL-like query language for CDL data
Hierarchical Coding of UW for Efficient Semantic Retrieval

- Allow efficient controlled matching with the hyponyms, hypernyms and sibling words.
- 64 bytes (4 bits per layer) for 20,000 words; 128 bytes for 200,000 words.
Preliminary Result of Retrieval Speed Improvement
Summary

- Toward a solid foundation of Semantic Computing, I introduced CDL (Concept Description Language), which is expected to be a common platform of expressing the meaning of every concept corresponding to natural language text.
- CDL is computer Esperanto language that both humans and computers can understand.
- It will also contribute to overcome the language barrier on the Web and in the world.
- The current major issue of CDL is a way to convert natural language texts into CDL with a small effort.
Thank You