When Ontology meets e-Catalog.

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Preliminary (1)

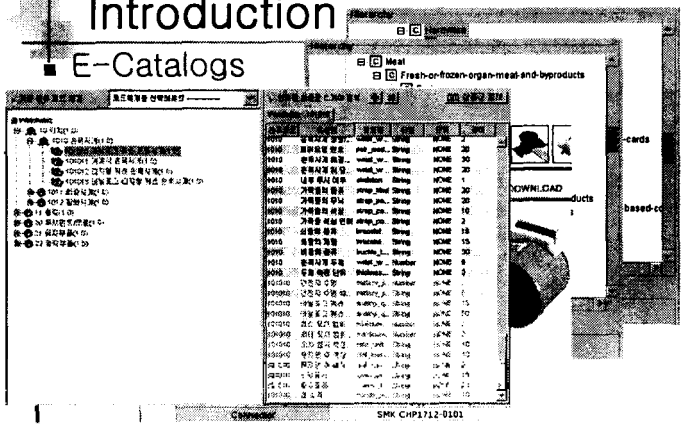
- Sounds the title intriguing to you, but suspicious about the content of our talk ?
  - Title: When Ontology meets e-Catalog.
  - Hot subjects :
    - Terms (or topics) such as Ontology, Semantic Web, and e-Catalogs have been on many people's lips recently.
    - However, we claim that the outcomes or contents of the majority of talks or workshops have touched the surface of the subjects. For examples,
      - Good for having Ontology ....
      - Go for Semantic Web ....
      - Probably Semantic Web being feasible for e-Commerce .....

Preliminary (2)

- Okay, definitely we agree on the direction.
  - What direction? : Applying the Semantic Web (more specifically Ontology and Inference) technology to e-Catalogs.
  - However, got to tell more on the followings:
    - Specifically what would be good doing so?
    - What would the appearance of such applications look like?
  - Okay, we will do the best on covering those issues. And how?

Introduction

- E-Catalogs



Introduction

- Intriguing Examples
  - Scenario 1: Find out all food-item classes which might cause *mad-cow* disease. (Food & Drug Administration)
    - Knowledge: Foods containing brain, tripe, or bone of cow, => mad-cow disease.
  - Scenario 2: Do not allow the following item to be exported. (Customs Service)
    - IBM product of which part contains DC spindle motor less than 0.1" diameter. Then a product may compose of product which contains a 0.05" DC spindle motor as its part.
  - Scenario 3: Might this item(class) be categorized under that item(class) ? (Public Procurement Service)
    - Or item A is same as item B?
    - Knowledge: A is subsumed by B if parts of A are also parts of B

Introduction

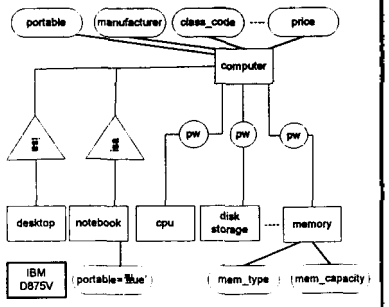
- Contents of the talk
  - Related domain
  - *Our e-Catalog model*
  - Semantic and property of each modeling construct
  - Applying example scenarios in our model
  - Implementing the scenarios in a Description Logic tool
  - Discussion & Conclusion

Related Domain

- Semantic Web
  - *"an extension of the current web in which information is given well-*defined meaning, better enabling computers and people to work in cooperation," By Tim Berners-Lee et al.
  - Semantics + Web = Semantic Web
  - XML(Extensible Markup Language) & RDF(Resource Description Framework)
- Ontology
  - "branch of metaphysics concerned with the nature and relations of being" from Webster.
  - taxonomic hierarchies of classes + (class definitions + subsumtion relations + ((any knowledge about the beings and the world))
  - OIL(Ontology Inference Layer), DAML-OIL, DAML-S, OWL(Web Ontology Language), OWL-S
- Description Logic
  - ALC, SHIQ(d)
  - DAML+OIL, OWL(OWL-S, DAML-S)
  - RACER, FaCT

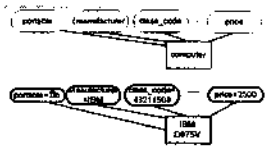
E-Catalog Model

- Foundational Model :
  - EER(Extended Entity Relationships) + Description Language
  - Basic Modeling Constructs
    - Class
    - Attribute
    - Object
    - ISA
    - Part-Whole



Class and Object

- Denotation

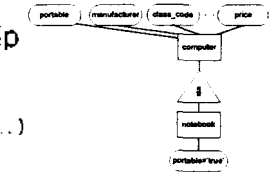


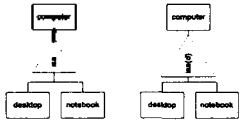
- Description Logic
  - Computer ⊆ ∀price.Integer ∩= 1price ∩ ∀class_code.Integer ∩= 1class_code ∩ ∀mf.String ∩= 1mf ∩ ∀portable.Bool ∩= 1portable
  - Integer, Real, String, and Bool are concrete domain attributes (predefined classes) and have concrete type expressions such as $\geq_d$, $\leq_d$, $>_d$, $<_d$, $\geq_d \cap \leq_d$, $=_d$.
  - We have a Top class corresponding to $\top$ in DL. $\top$ has the basic set of attributes which must appear in any catalog item. E.g: ECIF's Common Property Set for Catalog from GDAS.
  - Object is defined as Abox in DL.
    E.g.: desktop(IBMD875V), price(IBMD875V, 2000), class_code(IBMD875V, 43171803), mf(IBMD875V, "IBM")

ISA

- Super-sub class relationship
- Inheritance

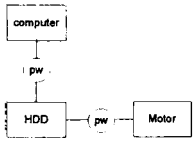
  notebook ⊆ computer ∩ ∀portable=$_{true}$
  ∩ (*∀attr.concretedomain ∩= 1attr ∩ ...*)
- Constraints on ISA
  - cover
    - computer ⊆ desktop ∪ notebook
  - disjoint
    - desktop⊆¬ notebook
  - More ..





PW

- Part-Whole
  - Rich Semantics : Mereology
    - Eg1: Computer *has* HDD, CPU, ...
    - Eg2: Beef stew *has* beef, garlic, onion, ...
  - *Properties associated with each semantic are different.*
    - Eg1: (transitive) Computer has HDD. HDD has motor. => Do you want to have motor appear as a part of computer?
  - Needs to clarify a "proper" set of part-whole relationships (in the domain of catalogs), and semantic and property of each pw relationship.

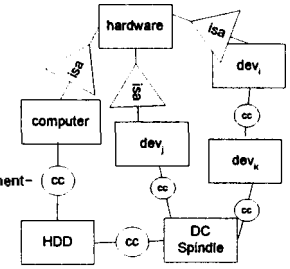


Properties of PW

- Transitive
  - x pw y, y pw z ⇒ x pw z.
- Inverse
  - x pw_1 y ⇒ y pw_2 x for $((pw_1^{-1})^{-1})=pw_2$
- Asymmetric
  - x pw y ⇒ ¬ (y pw x)
- Identical
  - x pw $l_1,l_2,...l_p$ & y pw $m_1,m_2,...m_q$ & $l_1=m_1,l_2=m_2,...l_p=m_q$ ⇒ x=y
- Atomic
  - Always exists N such that x_1 pw x_2, ..., x_i pw x_{i+1}, ... x_{N-1} pw x_N
- And more ...
- Note: Different pw relationships may have different sets of properties.

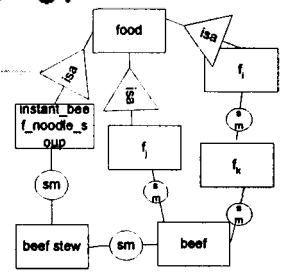
CC: component-of / composed-of

- In general, not transitive.
  - aggregate_part(integral)+ *functional*
  - component-of
  - component-of$_t$
- Inverse:
  - component-of^{-1} = composed-of
- Eg.:
  HDD ⊆ ∃component-of.computer, HDD ⊆ ∃component-of$_t$.computer
  DCSpindle ⊆ ∃component-of.HDD, DCSpindle ⊆ ∃component-of$_t$.HDD
  component-of ⊆ composed-of^{-1}, component-of$_t$ ⊆ composed-of$_t^{-1}$
  composed-of ⊆ component-of^{-1}, composed-of$_t$ ⊆ component-of$_t^{-1}$
  component-of$_t$ ∈ S*, composed-of$_t$ ∈ S*
- Query: Find hardwares which contains DC Spindle as its direct (or indirect) part.
  hardware ∩ ∃ composed-of.DCSpindle (or hardware ∩ ∃ composed-of$_t$.DCSpindle)



SM:substance-of / made-of

- In general, transitive.
  - substance-of ∈ S*, made-of ∈ S*
- Inverse:
  - substance-of^{-1} = made-of
  - made-of $^{-1}$ = substance-of
- Eg.:
  beef_stew ⊆ ∃made-of.beef (or beef ⊆ ∃substance-of.beef_stew), ibns(instant_beef_noodle_soup) ⊆ ∃made-of.beef_stew
  made-of ⊆ substance-of^{-1}, substance-of ⊆ made-of^{-1}
  made-of ∈ S*, substance-of ∈ S*
- Query: find all foods which contains beef as its ingredients.
  food ∩ ∃ made-of.beef

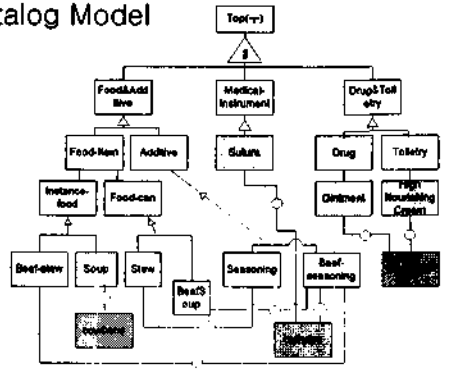


More PW Relationships

- The followings to be looked into:
  - Portion-of
    - mass-of^{-1}
    - portion-of ∈ S*
    - cheese_cake_slice *portion-of* cheese_cake
  - Member-of
    - collection-of^{-1}
    - tree *member-of* forest
  - Feature-of
    - activity-of^{-1}
    - paying *feature-of* shopping
  - Etc.
- Note: The variety of PW relationships should be considered in e-catalog domain.

Back to the Examples (1)

- E-Catalog Model



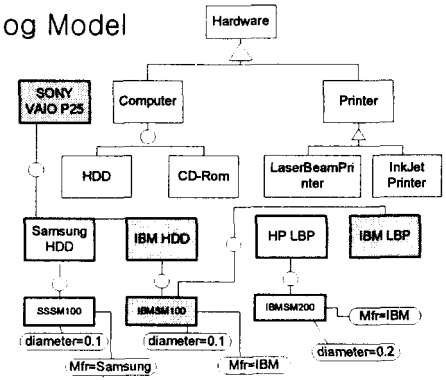
Back to the Examples (1)

- Description Logics-al Model

BSE ⊆ (Food&Additive ∩ (∃made-of.cowbrain ∪ ∃made-of.cowtripe ∪ ∃made-of.cowbone))
∪ (Drug&Toiletry ∩ (∃made-of.cowbrain ∪ ∃made-of.cowtripe ∪ ∃made-of.cowbone))
∪ (Medical-Instrument ∩ (∃made-of.cowbrain ∪ ∃made-of cowtripe ∪ ∃made-of cowbone))
Food-Item ∪ Additive ⊆ Food&Additive
Food-can ∪ Instance-Food ⊆ Food&Additive
Drug-Item ∪ Toiletry-Item ⊆ Drug&Toiletry
Soup ⊆ Instance-Food ∩ ∃made-of.cowbone
BeefSoup ⊆ Food-can ∩ ∃made-of.BeefSeasoning
Stew ⊆ Food-can ∩ ∃made-of.Seasoning
BeefStew ⊆ Instance-Food ∩ ∃made-of.BeefSeasoning
Seasoning ⊆ Additive
BeefSeasoning ⊆ Additive ∩ ∃made-of.cowtripe
HighNourisingCream ⊆ Toiletry-Item ∩ ∃made-of.cowbrain
Ointment ⊆ Drug-Item ∩ ∃made-of.cowbrain
Suture ⊆ Medical-Instrument ∩ ∃made-of.cowtripe

Back to the Examples (2)

- E-Catalog Model



Back to the Examples (2)

- Description Logics-al Model

SpindleMoter(≥0.1 SpindleMoterDiameter) ∪ ∃Compose-of.SpindleMoter (≥0.1SpindleMoterDiameter) ⊆ NoExport
HDD(SamsungHDD), HDD(IBMHDD)
SpindleMoter(SSSM100), SpindleMoter(IBMSM100), SpindleMoter(IBMSM200),
LaserBeamPrinter(HPLBP), LaserBeamPrinter(IBMLBP)
Computer ∪ Printer ⊆ Hardware
∃compose-of .HDD ∩ ∃compose-of .CD-Rom ⊆ Computer
LaserBeamPrinter ∪ InkJetPrinter ⊆ Printer
Product-of(Samsung) ∩ =0.1 SpindleMoterDiameter ⊆ SSSM100
Product-of(IBM) ∩ =0.1 SpindleMoterDiameter ⊆ IBMSM100
Product-of(IBM) ∩ =0.2 SpindleMoterDiameter ⊆ IBMSM200
HDD ∩ ∃compose-of. SSSM100 ⊆ SamsungHDD
HDD ∩ ∃compose-of. IBMSM100 ⊆ IBMHDD
∃compose-of. IBMHDD ⊆ SONYVAIOP25
Printer ∩ ∃compose-of. IBMSM100 ⊆ IBMLBP
Printer ∩ ∃compose-of. IBMSM200 ⊆ HPBP

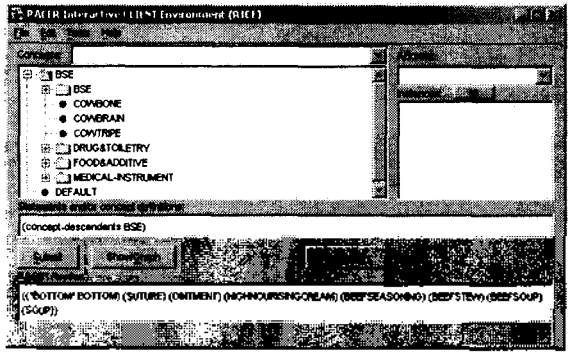
Practicability: Implementing the scenario (1)

- RACER
  - SHIQ (also known as ALCQHI$_{R^+}$: number restriction, role hierarchy, inverse role, transitive role)
  - Haarslev & Moller
- In RACER syntax

```
(in-knowledge-base BSE FDT)
(signature :atomic-concepts (Food&Additive Drug&Toiletry Medical-Instrument BSE cowbrain cowtripe cowbone Drug-Item Toiletry-Item
    Instance-Food Food-can Food-Item Additive HighNourisingCream Soup Stew Dressing Seasoning Ointment Suture hormon
    BeefSeasoning BeefSoup BeefStew)
:roles ((substance-of :transitive t :inverse made-of)))
(implies (or (and Food&Additive (some made-of cowbrain)) (and  Food&Additive (some made-of cowtripe)) (and  Food&Additive (some made-of
    cowbone))
(and Drug&Toiletry (some made-of cowbrain)) (and Drug&Toiletry (some made-of cowtripe)) (and Drug&Toiletry (some made-of cowbone))
(and Medical-Instrument  (some made-of cowbrain)) (and Medical-Instrument  (some made-of cowtripe)) (and  Medical-Instrument  (some
    made-of cowbone))) BSE)
(implies (or Food-Item Additive) Food&Additive)
(implies (or Food-can Instance-Food) Food&Additive)
(implies (or Drug-Item Toiletry-Item) Drug&Toiletry)
(implies Soup (and  Food&Additive (Some made-of cowbone)))
(implies BeefSoup (and Food-can (Some made-of BeefSeasoning)))
(implies Stew (and  Food-can (Some made-of seasoning)))
(implies BeefStew (and  Instance-Food (Some made-of Beefseasoning)))
(implies Seasoning Additive)
(implies BeefSeasoning (and Additive  (Some made-of cowtripe)))
(implies HighNourisingCream (and Toiletry-Item (Some made-of cowbrain)))
(implies Ointment (and Drug-Item (Some made-of cowbrain)))
(implies Suture (and Medical-Instrument (Some made-of cowtripe)))
```

Practicability: Implementing the scenario (1)

- Running ....



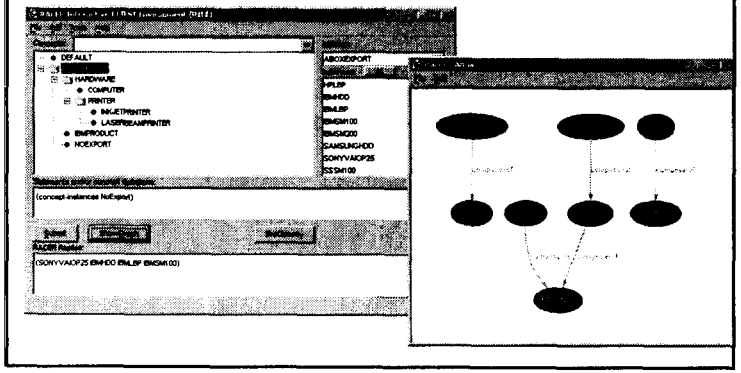
Practicability: Implementing the scenario (2)

- In RACER syntax

```
(in-knowledge-base TBOXEXPORT ABOXEXPORT)
(signature :atomic-concepts
 (Hardware Computer HDD CD-Rom Printer LaserBeamPrinter InkJetPrinter
SpindleMoter NoExport IBMProduct)
:roles ((compose-of :transitive t :inverse component-of) (Manufacture :inverse product-of) (has))
:individuals (SonyVAIOP25 SamsungHDD IBMHDD SSSM100 IBMSM100 IBMSM200 HPLBP IBMLBP)
:attributes ((real SpindleMoterDiameter ))
:objects(SSSM100size IBMSM100size IBMSM200size))
(implies (or LaserBeamPrinter InkJetPrinter) Printer)
(implies (or Printer Computer) Hardware)
(implies (or (and IBMProduct (<= SpindleMoterDiameter 0.1))
(some compose-of (and IBMProduct (<= SpindleMoterDiameter 0.1)))) NoExport)
(instance SamsungHDD HDD)
(related SamsungHDD SSSM100 compose-of )
(instance IBMHDD HDD)
(related IBMHDD IBMSM100 compose-of )
(instance SSSM100 SpindleMoter)
(constrained SSSM100 SSSM100size SpindleMoterDiameter)
(constraints (= SSSM100size 0.1))
(instance IBMSM100 SpindleMoter)
(instance IBMSM100 IBMProduct )
(constrained IBMSM100 IBMSM100size SpindleMoterDiameter)
(constraints (= IBMSM100size 0.1))
```

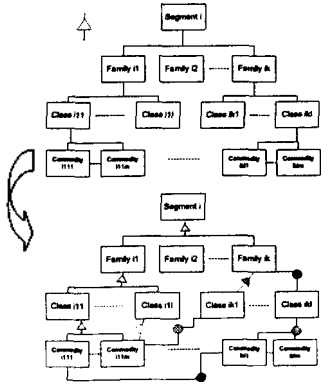
Practicability: Implementing the scenario (2)

- Running ....



Discussion

- What is the major reason for the troublesome of having UNSPSC ....
  - Mixed Uses of several Semantics
- *Reasoning complexity*
  - Tableau-based satisfiability algorithm : reasonably-practical
  - PSpace-complete – ExpTime-complete
- Integrate with other semantic catalog models ...



Conclusion

- Contribution
  - First *visible outlook* for *the conceptive ideology*:
    - Ontology + e-Catalog
    - Models and Queries
    - Verification for feasibility: Run the scenario using Racer
  - *Tasty* but yet *delusive*? (in the following sense of)
    - Naive (for the complex catalogs in the field)
    - Beyond the realistic (to putting into implementation)
    - These two are paradox each other.
- On-going works and future direction
  - Model Extensions
  - Related with
    - Description Logics
      - Language Capabilities
      - Reasoning Complexities
    - Practical e-Cataloging
      - Classification Schemes or so-called Code-based e-catalogs such as UNSPSC, HS. . .
    - Precise Model Semantics on Mereology.