Faceted Approach To Diverse Query Processing

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Introduction

- Classical libraries had systems that processed subjects or domains and built representations such as subject indices

  Example : Colon Classification System (CCS)
- The method of facetisation and synthesis in CCS brings contextual information -- so that it formed a semantic formalisation of the domain scope of the library collections
- The faceted schema can be applied in describing resources in web directories and annotating resources in digital libraries using SKOS/RDF representation to express DEPA strings, according to faceted theory by Ranganathan and DEPA facet analysis
- Current keyword-based querying methods does not use DEPA strings to represent web directories and annotating resources in digital libraries, so they seem inadequate to search over digital repositories organized according to CCS and similar faced-based classification systems

Introduction

- For answers to be relevant, a user must ask the appropriate query in order to retrieve the desired information and fulfill the information need (IN).
- The semantic ambiguity of querying languages:
  - Built upon natural language
  - The query length
- For keyword-based search a high number of keywords is necessary to the user to narrow down the search according to her information need
- The ambiguity of the query is somewhat mirrored in the relative relevance of search results
- The only solution is **query refinement by the user**

Introduction

- To resolve such ambiguity some authors advanced the notion of ‘context’ in web search
- In context-based solutions the user is often assumed to know how data and information are organized in the search domain
- This is often hard to happen in real world, distributed scenarios like the Web, due to large amounts of heterogeneous data organized in an unknown structure

The DEPA framework

- A formal framework to define a method for the extraction of DEPA facets from a user query.
- The facets are then used to refine the original query for search and retrieval purposes.
- The method is aimed to suggest the user a list of facets that the user would hardly be aware of by simply typing a keyword-based query into a search engine, without any query context.
- These automatically suggested new facets can be used by the user, for instance by clicking on one of the new facets, to narrow down the search space by expanding the original user query with the suggested facet

The Facets Analysis

- A conceptual analysis of the subject matter, or the topical content of a concept into distinct divisions that together constitute a semantic description of the concept.
- A *facet consists of a group of terms derived by taking* each term and defining it, per genus et differentiam, with respect for its parent class.
- Each domain is made of distinct divisions or facets that are groups of mutually exclusive concepts and many such facets together constitute a domain. (Ranganathan)
- The notion of such facetization has been extended to subject indexing by representing content as a string of fundamental categories DEPA (Discipline, Entity, Property and Action) that are conceptually equivalent to 'facets'. (Bhattacharya)

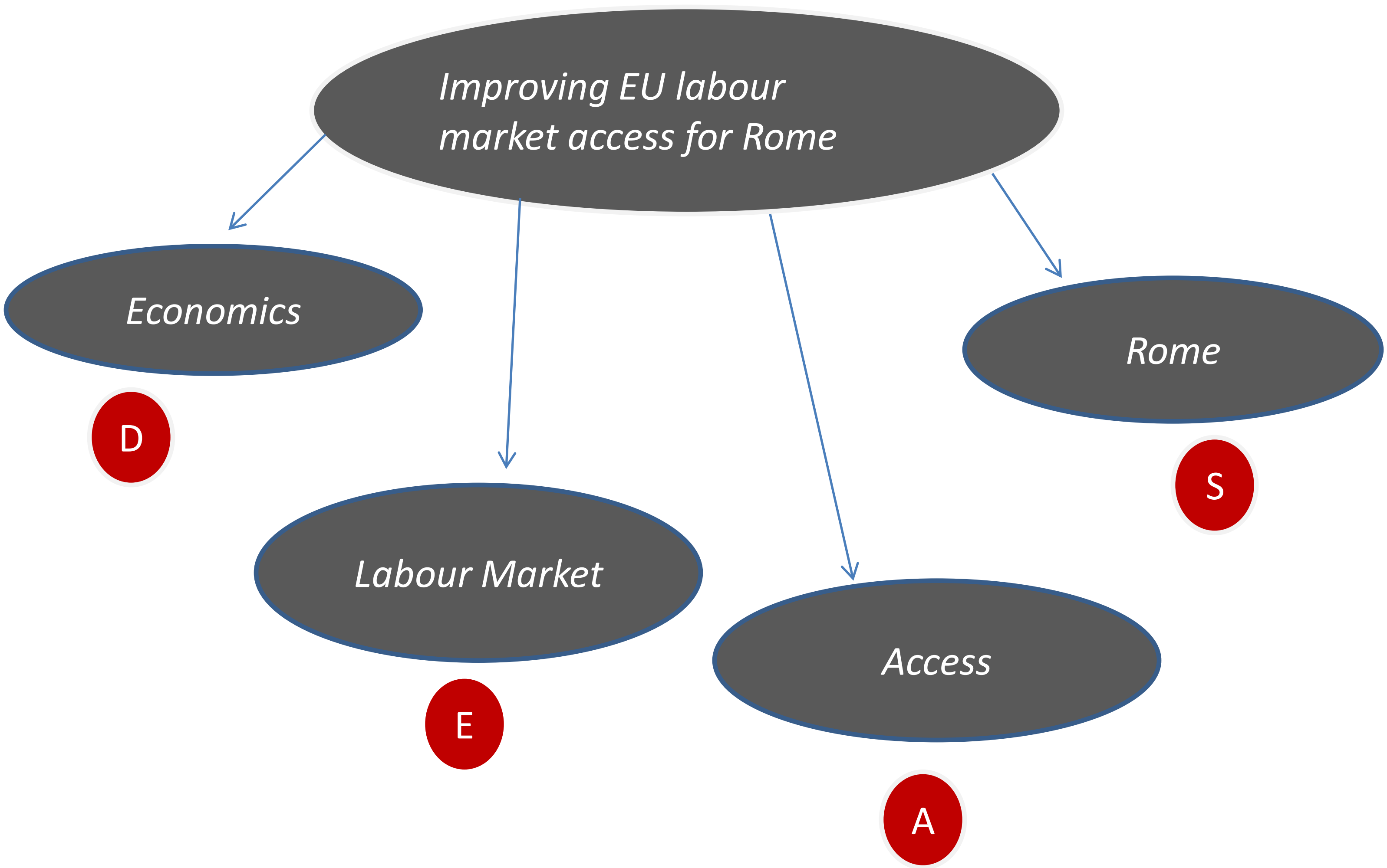
The Facets Repository

- These facets can be use to build the facet repository available to a user to refine a query
- The facets repository is organized around two main notions of the DEPA paradigm for facet analysis

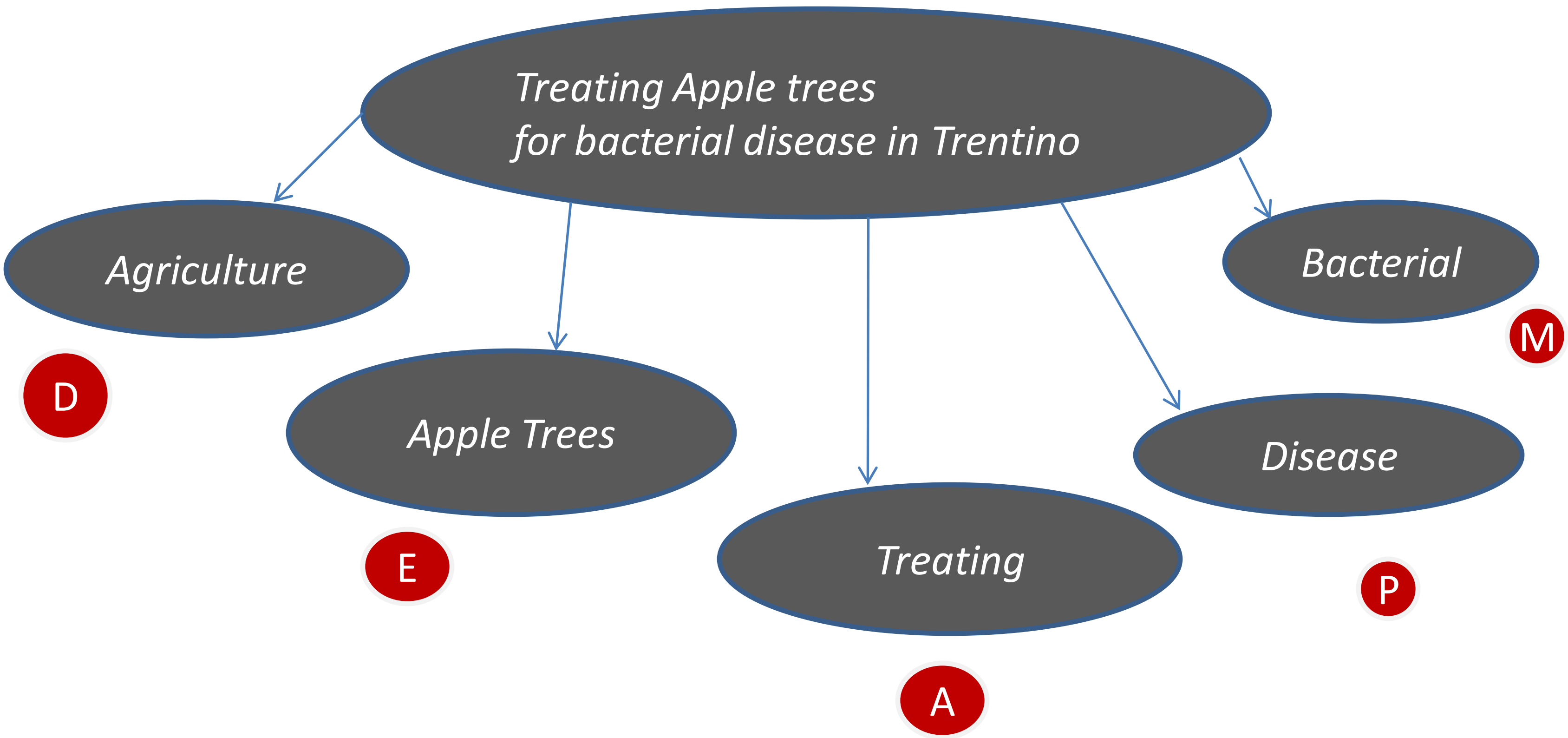
  subjects and facets

- A ***subject of a concept*** *is the* ***topical content of the concept -*** the concept's overall semantics, as defined by the combination of extensional and intensional semantics of the concept term
- The definition can be extended to a query, which in its simplest form can be thought of as a finite sequence of concept terms

Example1


Improving EU labour market access for Rome
Economics
D
Labour Market
E
Access
A
Rome
S

Example 2



Treating Apple trees
for bacterial disease in Trentino
Agriculture
Apple Trees
Treating
Disease
Bacterial
D
E
A
P
M

Facet Repository

- A *facet repository for a context C is the set*

$$FR(C) = \{\langle C : d, e, p, a \rangle \mid C \text{ has DEPA facets } d, e, p, a\}$$

  where ***C*** *is a concept description in description logic* ***ALC*** of a concept or subject of interest in context ***C****, and* ***d, e, p, a*** *are, respectively, a* ***Discipline, Entity, Property*** *and* ***Action*** **in DEPA** classification system
- Improving EU labour market access for Rome *is represented by a concept description* ***C1***
- *Treating Apple trees for bacterial disease in Trentino is represented by a concept description* ***C2*** *in a* ***context C***
- *The facet repository* ***FR(C)*** *contains:*

⟨C1 : Economics; LabourMarket; p; Access⟩ for p is unspecified, and

⟨C2 : Agriculture; AppleTrees;Disease; Treating⟩

Organization of documents

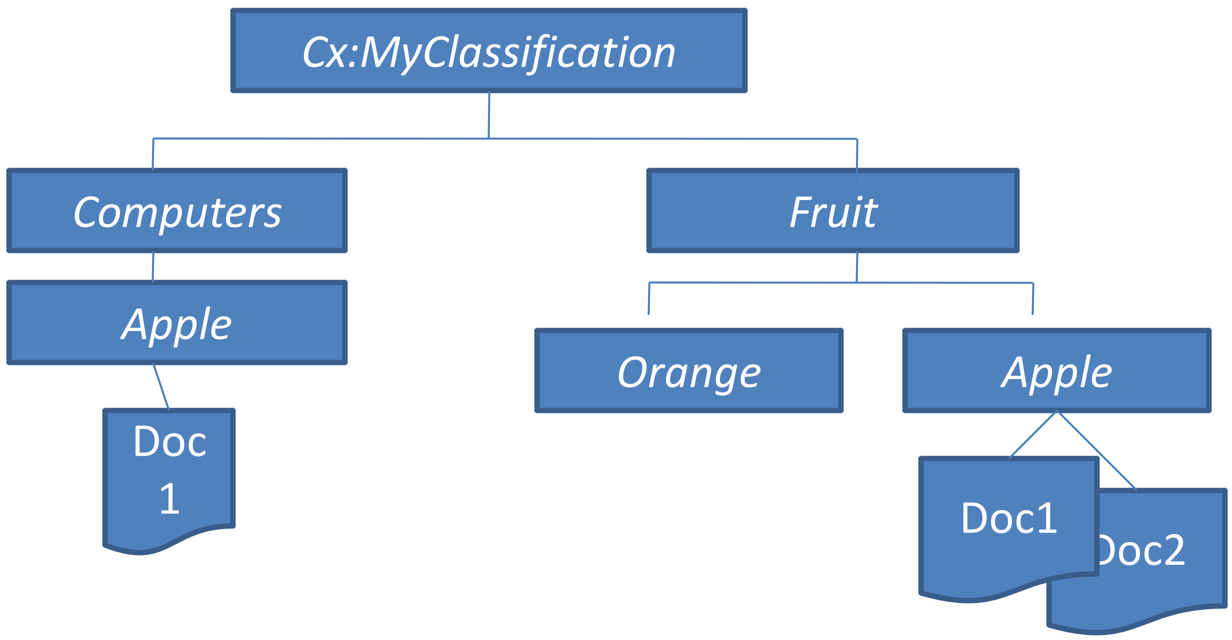
- Although our method can be adopted as integral part of digital libraries systems, both for describing the documents collection and for faceted querying over the collection or the web
- The method assists a *querying user in query refinement. As* the method in this specific application uses a textual collection of documents stored in the user's querying machine, we stipulate the following convention.
- **CONVENTION 1**. *We denote the set of available documents to a querying user by D. All available documents are textual, that is, they can be processed by text information retrieval techniques as the variant of a standard technique discussed in the previous Section*
- The domain *D of documents can be thought of as the* set of all documents the querying user has classified and stored in the querying machine

Focused Terms From Text

- Here facetization is used as a technique to combine extensional and intensional semantics of concepts viz. queries, or equivalently to disclose the subject of concepts and queries to the querying user, for the purpose of query refinement and search assistance
- We implement facetization in two related steps:
  1. we produce certain "focused terms" from documents organized in a Polyhierarchy
  2. From focused terms we produce new facets

Focused Terms From Text

- **CONVENTION 2**. *We assume that the querying user organizes documents in D by using a 'polyhierarchical classification', or polyhierarchy*
- A *polyhierarchical classification is a hierarchical classification* permitting some concept terms to be listed in multiple categories of a taxonomy, or branches of a hierarchy
- *Example* the concept term 'Apple'



Focused Terms From Text

- A subset of documents is organized in ‘contexts’, each context be organized into related sets of documents.
- A *context is a polyhier*archical classification composed by sets of documents, i.e., ‘nodes’ of the polyhierarchy, called *clusters, and a relation over the nodes* as defined by the polyhierarchy
- Typical relations are the binary relations of subsumption, part-of, is-a, among others relations.
- Each cluster in a given context has a name composed by a finite sequence of words from a representation language, often a natural langiage thereby betting that clusters are named by a human the querying user, who naturally applies her native language for clusters naming.

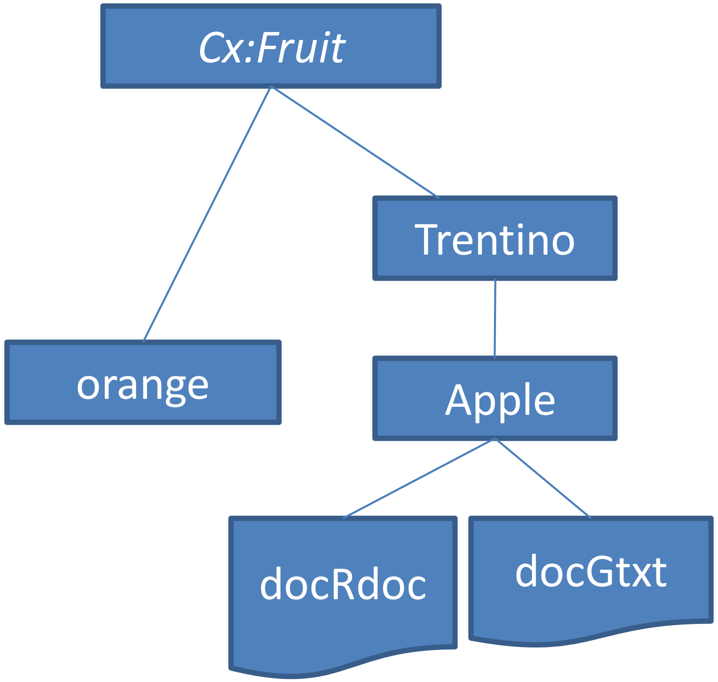
Focused Terms From Text

- A cluster's name in such representation language is referred to as *concept term. A concept is a concept term provided with a* semantics.
- Two kinds of semantics are provided to a concept term:
  - An extensional semantics, defined over the documents in the cluster named by the concept term
  - An intensional semantics, defined by the unique position of the concept term in a given 'focus'
- Contexts provide a way to define finite, ordered sequences of concept terms, each sequence called a *focus.*
- *A focus consists of an* ordered set of related concept terms, each concept term naming a cluster built upon the collection of documents in *D. Intuitively, a* focus is a path of concept terms corresponding to a path in a given context

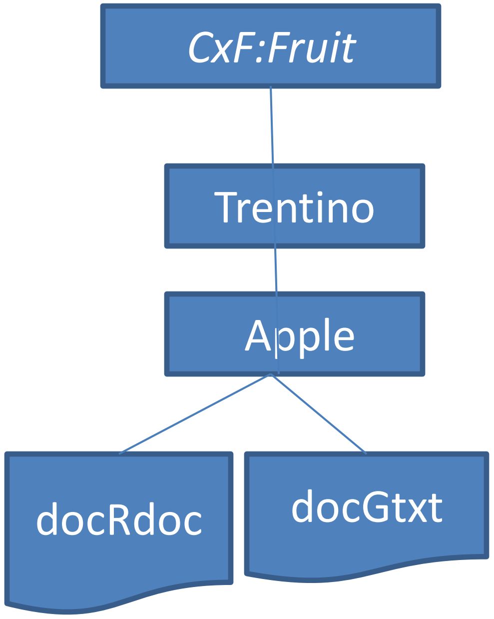
Example

Cx:Fruit>Trentino>Apple *to denote the* ***focus named 'Apple'*** **in the context** ***Cx*** *and* two documents in the cluster 'Apple': docRdoc and docGtxt

A context



A focus



Concept terms grounded in documents

- In this section, our goal is to automatically assign a 'label' to every cluster of a given context.
- Each cluster's label produced by Algorithm1 below is a finite, simple concatenation of terms with maximum 'weight', extracted by using Text (.)
- Let Text (.) be a text extraction function. (a standard keywords extraction function)
- Given a document *d, Text (d) listes all the keywords* in *d, precisely, the most frequent 'tokens'. Applied to a documentd, Text (.) produces a set Text (d) of terms (or 'keywords').*
- *Let d* be any document in *D. As terms are defined from documents, from* now on we write *k 2 Text (d) to denote a generic term retrieved by* using Text () *d.*
- *Given a document d, we rank a term k 2 Text (d)* by adapting IR standard TF/IDF ("Term Frequency / Inverse Document Frequency") method to deal with contexts and unique concept terms' *position, i.e., focus, within a context*

Concept terms grounded in documents

- For a given context *C we write 'C in C' in place of 'C in C' set of clusters' for every cluster C*
- Let querying user u organizing a context *C, cluster C in C, and term*

$k \in \mathsf{Text}(d)$ for a document $d \in \mathcal{D}$ be given.

- We define the *weight of k in C as follows*

$$\mathsf{W}_{\mathbf{u}}[k, C] = (\sum_{d \in C} \mathsf{TF}[k, d]) \cdot log \frac{Card(FC)}{\mathsf{doCK}_{\mathbf{u}}[k]}, \qquad (1)$$

- where TF[*k; d] is the total number of occurrences of k in d, so* that $\sum_{d \in C} \mathsf{TF}[k, d]$ is the total number of occurrences of *k in C; Card (FC) is the number of focuses in C with leaf C, and* doCKu[*k] is the total number of clusters in the set* $\mathcal{C} \setminus \{C' \mid C' \neq C \text{ is a cluster in a focus in } \mathcal{C} \text{ with leaf } C\}$ (2)

  which contain *k. Intuitively*

Concept terms grounded in documents

- *(1) says that, in order to represent the* extensional semantics of a focus, the importance of a retrieved term for a cluster, i.e., the value of Wu[*k;C],* *is inversely proportional* to the number of different focuses with *C as leaf which contain the* term
- The label of a cluster *C is the most representative term or sequence* of terms for the cluster.
- Now we want compute the label of all clusters of a given context. For doing this, we process all documents stored in each cluster by considering the position of each cluster in the context.
- To define the process formally, we rely on the following technical definition. Let context *C organize (a subset of)* documents in *D and cluster C in C be given we define :*

$$IR(\mathcal{D}, \mathcal{C}, C) = \{k \in \mathsf{Text}(d) \mid d \in C, C \text{ in } \mathcal{C}\}. \qquad (3)$$

- We expect that the label of cluster *C in (3) is the most representative* term or sequence of terms in IR (*D; C;C).*
- *The most representative* term among terms in IR (*D; C;C) is the term with the highest* weight among all terms in IR (*D; C;C) according to weighting* measure

  1. Formally, a term *k in IR (D; C;C) is the most representative* for the cluster *C in C, and we say that k is a label of C,*if Wu[*k',C] Wu[k,C] for all terms k' in IR (D, C,C). A sequence k1, k2,… kn of terms in IR (D, C,C) is a label of C if (a)* Wu[*ki,C] = Wu[k,C] for i = 1, 2, …n, and (b) k is a label of C.*
- LEMMA 1. *Every cluster C organized by a querying user u in a context C has a label if and only if C contains a document d such that Text (d) is nonempty*

- To compute a label of every nonempty cluster *C of a given context C, we exhibit an algorithm that produces the label lC of C*

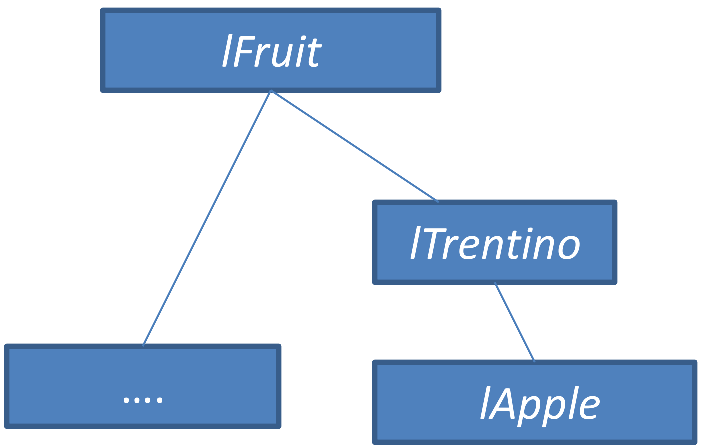
Algorithm 1. Set IR = IR (*D, C,C)*

Algorithm 1 Context-based cluster labeling.

Input: $\mathcal{C}, \mathcal{D} \neq \emptyset$
foreach C in $\mathcal{C}$ with $C \neq \emptyset$ **do**
  foreach $k \in IR\,(\mathcal{D}, \mathcal{C}, C)$ **do**
    compute $\mathsf{W}_{\mathbf{u}}[k, C]$ according to formula (1) **od**;
  compute $M = \{k \in IR \mid \forall k' \in IR, \mathsf{W}_{\mathbf{u}}[k', C] \leq \mathsf{W}_{\mathbf{u}}[k, C]\}$;
  Let n be the cardinality of M;
  Let $\{k_1, k_2, \ldots, k_n\}$ be the lexicographical ordering of M;
  Set $l_0 = \emptyset$; /* empty sequence */
  for $i = 1$ **to** $i = n$ **do**
    Pick $k_i \in M$;
    Set $l_i = l_{i-1} k_i$ **od** **od**; /* simple concatenation */
Define $l_C = l_n$
Return : set of labels $\{l_C \mid C \text{ in } \mathcal{C},\ C \neq \emptyset\}$.

Concept terms grounded in documents

- If *C≠ Ø then IR≠ Ø. 2. The label lC computed by* Algorithm 1 in not unique. In fact, *M in Algorithm 1 is assumed to* be ordered according to lexicographical ordering. Other orderings of the elements in *M are possible and, as a consequence, a different* label can be generated from each ordering
- Example



A focus as labeled by Algorithm 1

Focused terms

- Let a focus *F with* concept term *C as leaf be given. A focused term for F is any term* that appears in a label *lC of a cluster C in F. In symbols, the set* of focus terms for *F is*

$$FT(\mathcal{F}) = \{k \mid k \text{ appears in } l_C, C \in \mathcal{F}\}.$$

- A focused term for *C is any term that appears in lC. A focus term* for a concept term plays the role of a synonymous, or alias names, of the concept term. As we will see in Section 6, alias names are important to improve keyword-based querying.

Faceted Ontology Building

- The result of extracting terms from documents and “facetizing” the concepts of a polyhierarchical classification by using them produces a basic kind of faceted taxonomy, provided that

  (1) the extracted terms or, often, a proper subset of these, are matched with a predefined set of facets

  (2) the clusters in a focus are related to each other by a subsumption relation

- For a *faceted taxonomy* consists of:

  (a) a set of facets, where each facet consists of a predefined set of terms

  (b) a subsumption relation among the terms

- In this section we provide the formal framework we need to formalize the focused terms and labeled contexts we have produced by Algorithm 1 by shallowly assuming (2)2

Description Logics

- Description Logics (DLs) are a family of logic-based knowledge representation formalisms designed to represent and reason about the knowledge of an application domain in a structured and well-understood way
- Here we use a basic description logic, called *ALC, thereby betting that ALC provides us with an* efficient SAT solver to implement our facet engine
- *ALC is the smallest propositionally closed DL, and provides the* concept constructors

$$\neg C, C \sqcap D, C \sqcup D, \exists R.C, \forall R.C,$$

- And concept inclusion (or subsumption) $C \sqsubseteq D$ *and concept* equality $C \equiv D$ *where C, D are concept descriptions and R is a* named role
- A DL knowledge base (KB) consists of concept axioms (such as concept inclusion and concept equality axioms), role axioms (such as functional role axioms) and assertions of the form *C(a),R(a, b) where a and b are named individuals*

Description Logics

- A DL knowledge base (KB) consists of concept axioms (such as concept inclusion and concept equality axioms), role axioms (such as functional role axioms) and assertions of the form *C(a),R(a, b) where a and b are named individuals*
- Here we use a limited part of *ALC's expressive power;* in particular we do not use role axioms and assertions
- That in this approach clusters in a focus are related to each other by a subsumption relation follows from Convention 2 by observing that polyhierarchical classifications are often subsumption hierarchies
- Here we write concept descriptions in lower case, as concept description from now on are terms extracted by Algorithm 1 from documents as explained.

Description Logics

- Example 5

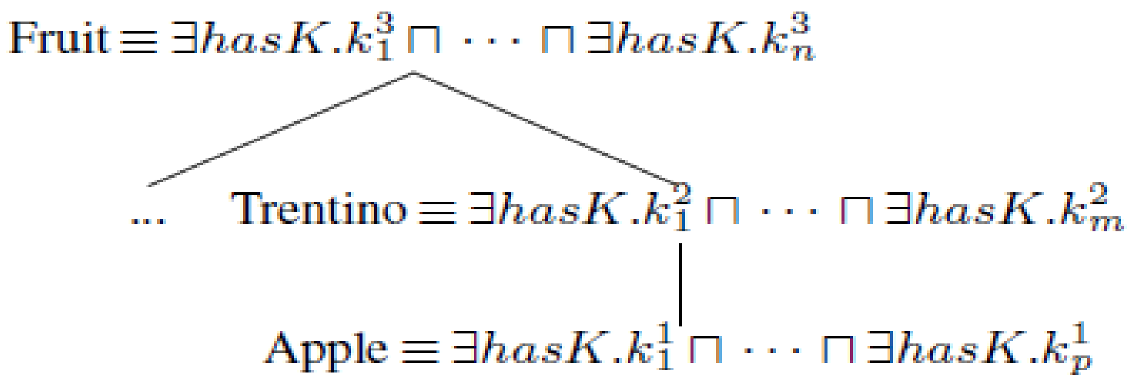


Figure 4: A labeled focus in $\mathcal{ALC}$.

- *Consider the labeled focus in the previous example , We can represent it within ALC by a set of equality axioms*

Description Logics

- *The concept descriptions k_i^j that appear in the tree refer to the focused terms extracted by Algorithm 1 for each concept in the focus; has K is a named role, which is intuitively interpreted as 'has keyword'*
- *For example $\exists hasK.k_1^3$ intuitively means that concept term 'Fruit' in focus* ***F:Fruit>Trentino>Apple*** *is extended with focused term (keyword) k_1^3.*
- *Each equality axiom that appears along the tree defines in ALC a concept term in F; the focus itself is formalized by the equality axiom:*

$$FocusApple \equiv \mathrm{Apple} \sqcap \exists \mathrm{R}.(\mathrm{Trentino} \sqcap \exists \mathrm{R}.\mathrm{Fruit}).$$

- *An ALC KB for this example is the set of the three equality axioms depicted along the tree plus the equality axiom that defines 'FocusApple' as the 'focus Apple', i.e., the focus F*

Formal Faceted Classifications

- The Algorithm 2 provides a way to build an *ALC faceted knowledge base, or faceted ontology,* for a given context.

  The algorithm works in two main steps

Step1

- It builds a knowledge base by adding *ALC equality axioms* that formally define the concept terms of an input context by using focused terms computed by Algorithm 1 over the same context .
- For matching purposes if strictly more or strictly less (but at least one) focused terms were computed for a concept term, then the algorithm adds to the knowledge base all the equality axioms defined over all possible combinations of four focused terms picked up, possibly with repetitions, from the computed terms

Formal Faceted Classifications

Step 2

- The algorithm adds to the knowledge base so obtained all *ALC equality axioms that formally define DEPA facets of every* concept as stored in the facet repository (see Section 2). These axioms have the form

$$C \equiv \exists FacetD.d \sqcap \exists FacetE.e \sqcap \exists FacetP.p \sqcap \exists FacetA.a,$$

- where *C represents a concept c available in the facet repository, FacetD, FacetE, FacetP , and FacetA are named roles rapresenting* the property of *c in terms of DEPA facet analysis paradigm.3*
- The intended interpretation of these named roles relates to the facet repository
- For example $\exists FacetD.f$ means that there is a concept in the facet repository with facet 'Discipline' be *f*

Formal Faceted Classifications

- The equality axiom means that there is a concept in the facet repository with facet 'Discipline' *d, 'Entity' e, 'Property' p, and 'Action' a, and that concept has name C.*
- *Hence, as per second step, Algorithm* 2 adds to the knowledge base all axioms of form as in, if and only if there is a concept (or a subject) with DEPA facets *d, e, p, a in the facet repository. We make the system insensitive to case* and punctuation in the facets *d, e, p, a by adding additional axioms* where variants of *d, e, p, a with the same meaning are used.*
- The ontology produced by Algorithm 2 a *formal faceted classification* (FFC)

Algorithm 2

Algorithm 2 Building a $\mathcal{ALC}$ faceted ontology $\mathcal{O}$.

Input: $\mathcal{C}, \mathcal{D} \neq \emptyset, FR(\mathcal{C})$
Set $\mathcal{O} = \emptyset$; /* $\mathcal{ALC}$ ontology to be built */
foreach C in $\mathcal{C}$ with $C \neq \emptyset$ **do**
    $l_C := \langle k_1 k_2 \cdots k_n \rangle$; /* l_C computed by Algorithm 1 */
    for $i = 1$ **to** $i = \binom{n}{4}$ **do**
        $\mathcal{O} := \mathcal{O} \cup \{C \equiv \exists hasK.k_{i1} \sqcap \cdots \sqcap \exists hasK.k_{i4}\}$ **od**;
    if $\langle C : d, e, p, a \rangle \in FR(\mathcal{C})$
        /* facets d, e, p, a for C in facet repository */
      then
          $\mathcal{O} := \mathcal{O} \cup \{\mathrm{C} \equiv \exists \mathrm{D}.d \sqcap \exists \mathrm{E}.e \sqcap \exists \mathrm{P}.p \sqcap \exists \mathrm{A}.a\}$;
          /* axiom of form in (4) added */
    fi **od**;
Return : $\mathcal{O}$.

Facet Engine

- Here we design within our framework a facet engine that computes the matching between the focused terms of a input context and the predefined set of facets stored in the facet repository for a number of concepts
- The facet engine looks at all keywords generated for each concept name in a focus for all focuses of the hierarchy, and browse through the focus from the root to the leaf to identify what keywords are DEPA facets stored in facet repository
- The facet engine’s main component is Algorithm 3

Algorithm 3

- Step 1. Input a concept description *C that represents a user's query*
- Step 2. Find and retrieve from the ontology built by Algorithm 2 all equality axioms that define *C in the ontology either by focused* terms or DEPA facets. If no axioms do exist, that is, *C is not defined* according to the knowledge stored in the ontology, the algorithm ends with no help to the user. This state means that the search engine cannot provide the user with help for query refinement by facets.
- Step 3. For all retrieved axioms and for each axiom of the form $C \doteq \exists hasK.k_1 \sqcap \cdots \sqcap \exists hasK.k_n$, where $l_C = k_1 ... k_n$ is the label computed by Algorithm 1, the algorithm runs the *ALC SAT* solver in order to match (focused) terms *ki in the axiom to all* DEPA facets for *C possibly stored in the facet repository*
- Step 4. For all successful matchings computed in Step 3, the retrieved DEPA facets are output and shown to the user

Algorithm 3

Algorithm 3 Query expansion with facets from focused terms.

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proc *QueryExpansion*
  Input: C, $\mathcal{O}$, $FR(\mathcal{C})$ /* C is meant to represent user query */
  Define Ω_K be the set of axioms in $\mathcal{O}$ of the form
  $C \equiv \exists hasK.k_1 \sqcap \cdots \sqcap \exists hasK.k_n$; /* $k_1 \ldots k_n = l_C$ */
  Define Ω_F be the set of axioms in $\mathcal{O}$ of the form
  $C \equiv \exists D.d \sqcap \exists E.e \sqcap \exists P.p \sqcap \exists A.a$;
   /* $\langle C : d, e, p, a \rangle$ is in $FR(\mathcal{C})$ */
  if $\Omega_K \vee \Omega_F = \emptyset$
   then exit /* no query exspansion provided */
   else
    $s := Card(\Omega_K)$; /* Ω_K cardinality is $s \geq 1$ */
    $t := Card(\Omega_F)$; /* Ω_F cardinality is $t \geq 1$ */
    $FacetSet(C) := \emptyset$; /* set of facets retrieved for C */
    for $j = 1$ **to** $j = s$ **do**
     $F_{00} := \emptyset$; /* different facets strings retrieved */
      /* by using a single axiom in Ω_K */
     for $l = 1$ **to** $l = t$ **do**
      for $i = 1$ **to** $i = \binom{n}{4}$ **do**
       if $\mathcal{O} \models \exists hasK.k_{i1} \sqcap \cdots \sqcap \exists hasK.k_{i4}\} \equiv$
        $\exists D.d \sqcap \exists E.e \sqcap \exists P.p \sqcap \exists A.a$
        /* focused terms and DEPA facets match */
        then
         $F_{li} := F_{li-1} \cup \{\langle C : d, e, p, a \rangle\}$
          /* $\langle C : d, e, p, a \rangle$ retrieved */
          /* depending on $k_{i1}, \ldots, k_{i4}$ */
       fi **od**
     od;
     $FacetSet(C)_j := FacetSet(C)_{j-1} \cup F_{li}$
      /* all DEPA strings for C in $FR(\mathcal{C})$ retrieved */
    od **fi**;
  Return : $FacetSet(C)_j$.

Query Processing

- After building the faceted ontology and defining the facet engine we are ready to use them to provide new facets to the user for query refinement.
- The user can make three kind of query:
  - keyword-based
  - by focus
  - on subject

Keyword-based querying

- The user types one or more keywords in the search box.
- Here the user does not know anything about the subject to search, or the user's knowledge on the query subject is not based on documents locally stored in the user querying machine, so that we can not use the ontology and facet engine we have advanced
- This is also a tyipical case of keyword-based querying by common search engines, where the keywords used in the query are listed without a specific ordering on the only basis of the user's information need
- Each keyword is mapped to zero or more concept terms in the context *C. We do that* using an exact string match of the keyword to the concept term or one of its alias names, namely, its focused terms
- If no concept term and its alias names match any keyword, no concept description is available to the facet engine, and as a consequence no facets for query refinement are shown to the user

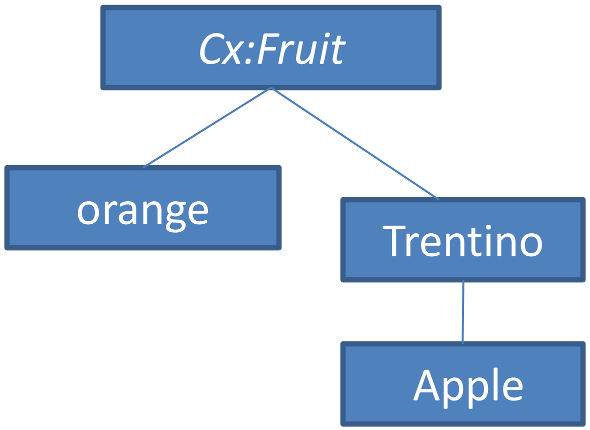
Keyword-based querying

- If one concept term or its alias names match some keywords, then the concept description *C of the concept term is generated and processed* by Algorithm 3 for query expansion.
- The facets that occur in the query expansion are shown to the user
- When selecting one of the new facets, the user will narrow down the search by expanding the original query with the suggested facet
- If multiple concept terms match some keywords, then the concept description of each term is generated and processed by Algorithm 3 for query expansion
- The facets that occur in the query expansion of every concept description are shown to the user. Alternatively, the user is given the option to refine their query to indicate which concept term, namely, keyword they meant the most

Querying-By-Focus

- Now suppose that the user knows at least something about the subject to search, and the user’s knowledge comes from documents stored and polyhierarchically organized in the user’s document collection.
- In this case, it would always be desiderable for the user to get better and better understanding of the hidden content of the query, as it is automatically generated by a suitable method, so as to discover new facets of the original query that the user was not aware of before

Querying-By-Focus



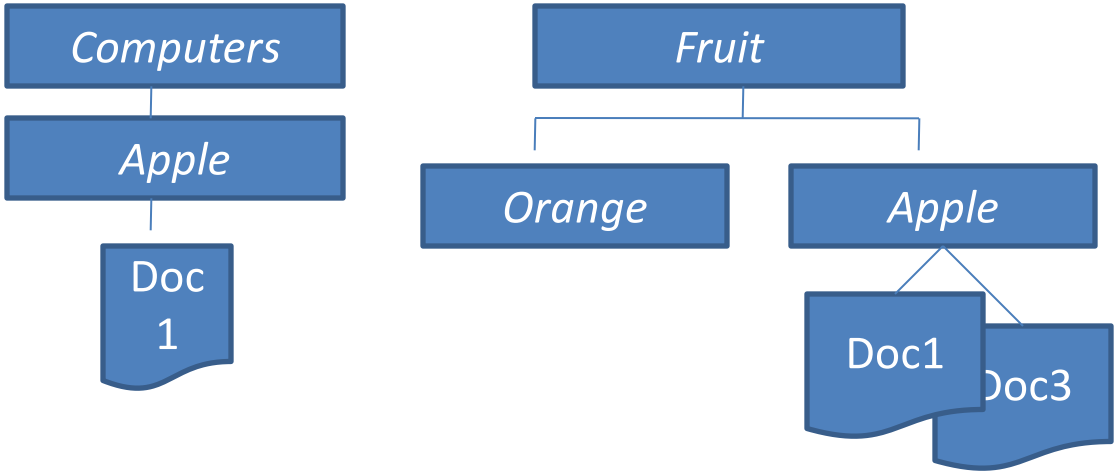
- For example, suppose the query is 'apple' as contextualized. The user clicks on a concept term in a context *C* , ie. the user selects a focus in *C.*
- *Alternatively, the user* types some keywords as in keyword-based querying, but in a specific order to mean a focus in *C.*
- For example, the user may click on (an appropriate graphic-version of) 'Apple' in context or either type keywords 'fruit', 'trentino', 'apple' *in this order, as to mean Cx:Fruit>Trentino>Apple*

Querying-By-Focus

- by selecting the facet ‘Fruit’ the user would narrow down the search space by excluding all subjects about Apple Computers and related subjects as search results
- by selecting facet ‘Trentino’ the user would be able to narrow down the search space by excluding all subjects about fruits that are not related to Trentino’s production of apples
- It follows that the keyword-based method and querying by focus are not equivalent for at least one reason, that is, in keyword-based querying the order of keywords does not matter, in querying by focus does
- The other main difference between these two querying methods arises looking at query processing.
- The difference is that concept terms in a focus are not ‘pure’ keywords; a concept term is represented by a *string of similar keywords as generated* by Algorithm 1
- Concept terms relate to documents in the user’s repository, while keywords are usually unrelated to the user’s documents.

Querying-By-Focus

- A query-by-focus is similar to a query by example, yet it is more specific.
- In querying by example, a sample document (*the example)* is selected by the user to refine the query. On the other hand, in querying by focus the *position of the sample document is also considered,* that is, the place the document is stored within the user's documentary repository
- Suppose that a user stores his documents according two different structures



Querying-By-Focus

- suppose the user selects the document named doc1 as the sample document.
- In classical querying by example, a relevant answer to the user would be any document about ‘apple’, as meant as either a fruit or a computer
- In contrast, using querying by focus the only relevant answers to the user would be documents from one of the two focus Fruit*>Apple and Computers>Apple*
- Here ,First, a concept description *C of the concept term that is the leaf of the focus is generated* and processed by Algorithm 3 for query expansion.
- The facets that occur in the query expansion are shown to the user.
- When selecting one of the new facets, the user will narrow down the search by expanding the original query with the suggested facet
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Querying-By-Focus

- The documents used for querying by focus are all and only the documents locally stored in the user's querying device, whatever the search objective is either to retrieve documents stored in the user's device or in the Web
- As a consequence, querying by focus clearly scales to the size of the web. To understand a bit further, recall that our method is about query refinement, it is not a query search method.
- We use standard methods and search engines to search; the difference is that the keywords we let the search engines to use are automatically generated by our facetization technique.

Querying-On-Subject

- ‘subject’ refers to the topical intent of a query
- In our faceted approach to representation of documents in collection *D, ‘subjects’ are broken down into distinct divisions,* the facets of subject
- A typical ‘query-on-subject’ is deemed to relate to a specific subject of a preexisting faceted classification.
- For example, a subject-based query is: ‘What are the documents on the effects of nitrogen fertilizers on rice plants?’
- The subject of the concept subsumed by this query is one of possibly many focuses, for example the following:

  Cx:rice plants>nitrogen fertilizers>effects. (5)
- This is a partial focus, in the sense that the discipline subsumed by the query as provided by the DEPA facet analysis is

  Cx: Agriculture>rice plants>nitrogen fertilizers>effects. (6)
- Another possible focus for the subject of query’s concept is the following:
  C’x:Agriculture> effects of nitrogen> fertilizers>rice plants. (7)

Querying-By-Focus

- A number of different but equivalent focuses could exists for a given subject-based query.
- The existance of a focus for this query as well as the focus form depend only upon the querying user's classification of documents
- By merging a subject to one or more focuses, by automatically transforming a query-on-subject to a query-by-focus, the method provides the user with assistance in query refinement. In fact, we compute the focuses generated from the query on subject, and for each focus we consider the concept description that represents the focus in *ALC ontology computed by Algorithm 2*
- Then we proceed as in the case of querying by focus and compute the query expansion of the focus according to knowledge stored in the ontology

Querying-By-Focus

- The retrieved facets are shown to the user. If multiple focuses are computed from the query’s subject, the user is given the option to refine the original query to indicate which focus they meant for the searched subject

Conclusion

- This paper presented a formal framework for a querying refinement method that enables the extraction of the diversity aspects, or facets, of a user query
- The method uses the general principles of facet analysis in the DEPA paradigm of facetization and the notion of ‘focus’, which is used to infer new facets from the user query
- The method provides a user with additional and essential contextual information, in form of new facets
- When selecting one of the new facets, the user can narrow down the search by expanding the original query with the suggested facets
- The proposed method of query refinement is based on diversity in querying and a multi-dimensionality of information
- Three methods of querying weree discussed: keyword-based, by focus, and on subject

Conclusion

- For each method, textual and structural dimensions were used to assist the user in query refining
- The textual dimension allowed us to generate the top-k most relevant terms for each concept of a given polyhierarchy of text and text-annotated documents
- The structural dimension of the polyhierarchy was used to match DEPA facets with the user query
- We have situated our framework within the smallest propositionally closed description logic *ALC, and we* have used *ALC's solver to implement the facet engine as the main* component of the method

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