Semantic indexing modelling of resources in personal and collective memories based on a P2P approach

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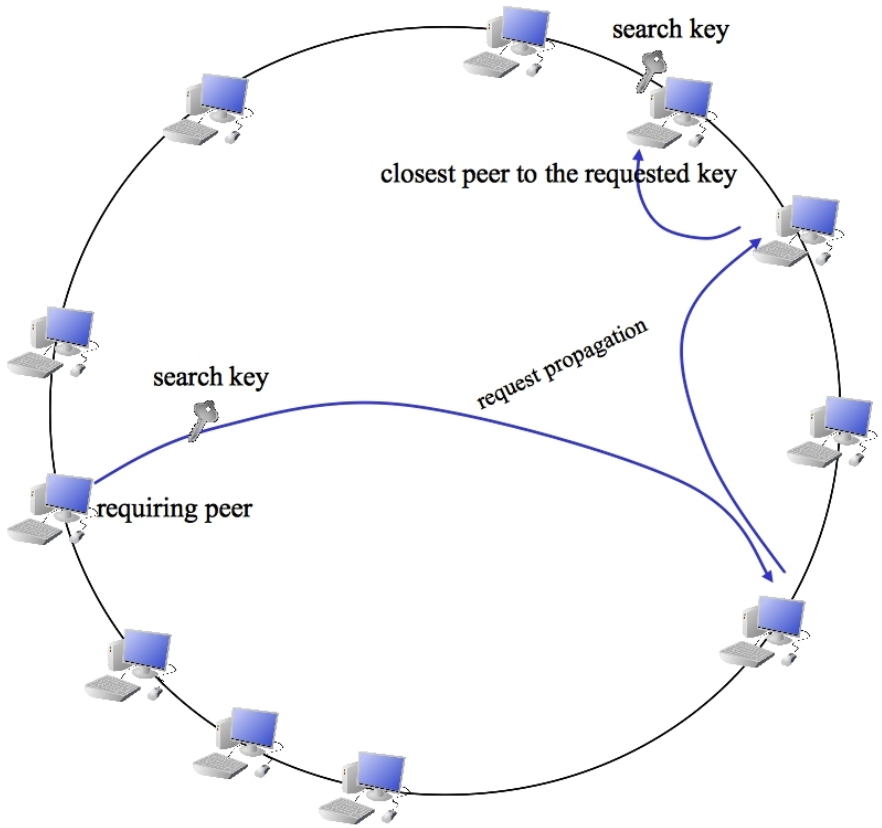
Outline

- Motivation
- Semantic Indexing
- Indexing Patterns
- Community of Users
- Conclusion
- Future Work

Motivation
Context

- Loose community of users
  - Private and shared resources.
  - Experts and general users.
- Resources of different types.
- Any nature of community
  - Possible focus on community of teachers and students.



Motivation
Issues

- How to manage publication and retrieval contexts?
  - How to match the description made during the retrieval context with a description made during the publication context?
- How to transform a user understandable description to machine understandable one?
  - How to create a formal description from the user input?
- How to make possible the life of a decentralized community?
  - How to manage a certain level of communication among members?
  - How to manage elements allowing the indexing of resources?

Motivation
Contribution

- How to manage publication and retrieval contexts?
  - Description extension.
  - The description is enlarged during publication to foresee different possible retrieval situations.
- How to transform a user understandable description to machine understandable one?
  - Model of Indexing Patterns.
- How to make possible the life of a decentralized community?
  - A distributed Semantic Wiki of the community and a distributed system of Notes.
  - A set of *Core resources* is managed for allowing the indexing.

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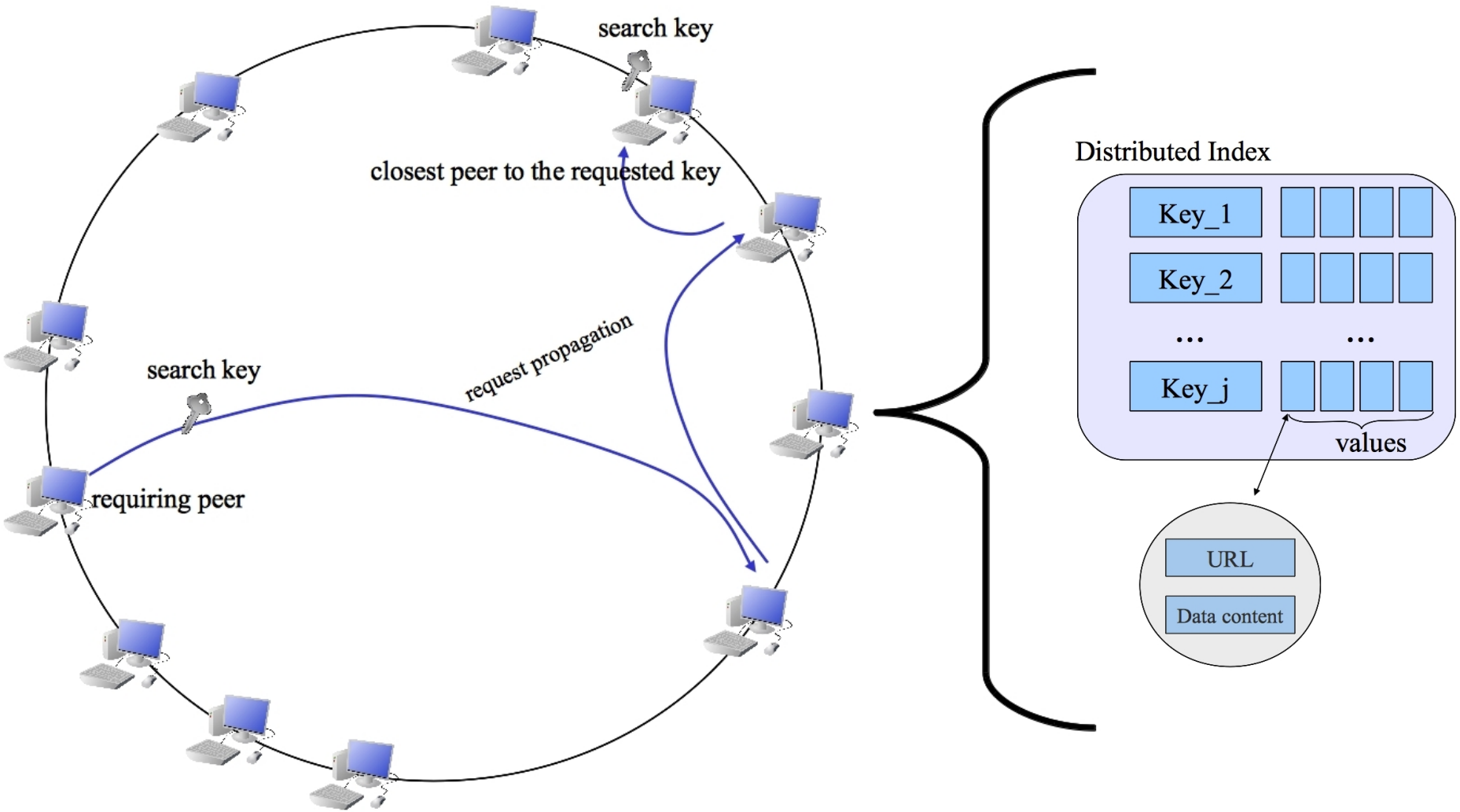
Semantic Indexing
A P2P system



Semantic Indexing
Indexing

- P2P networks require the Boolean indexing
  - We choose to adopt the same Boolean indexing also for the personal memory.
- Indexing is the process of creating or updating an index
  - Given a list of resources it is necessary to create their proper descriptions different from the only title.
- The only *title* of a resource does not give a meaning universally known
  - In traditional filesharing systems it is usually used the title or a set of keywords to identify a resource.
- We consider semantic descriptions built manually by users.

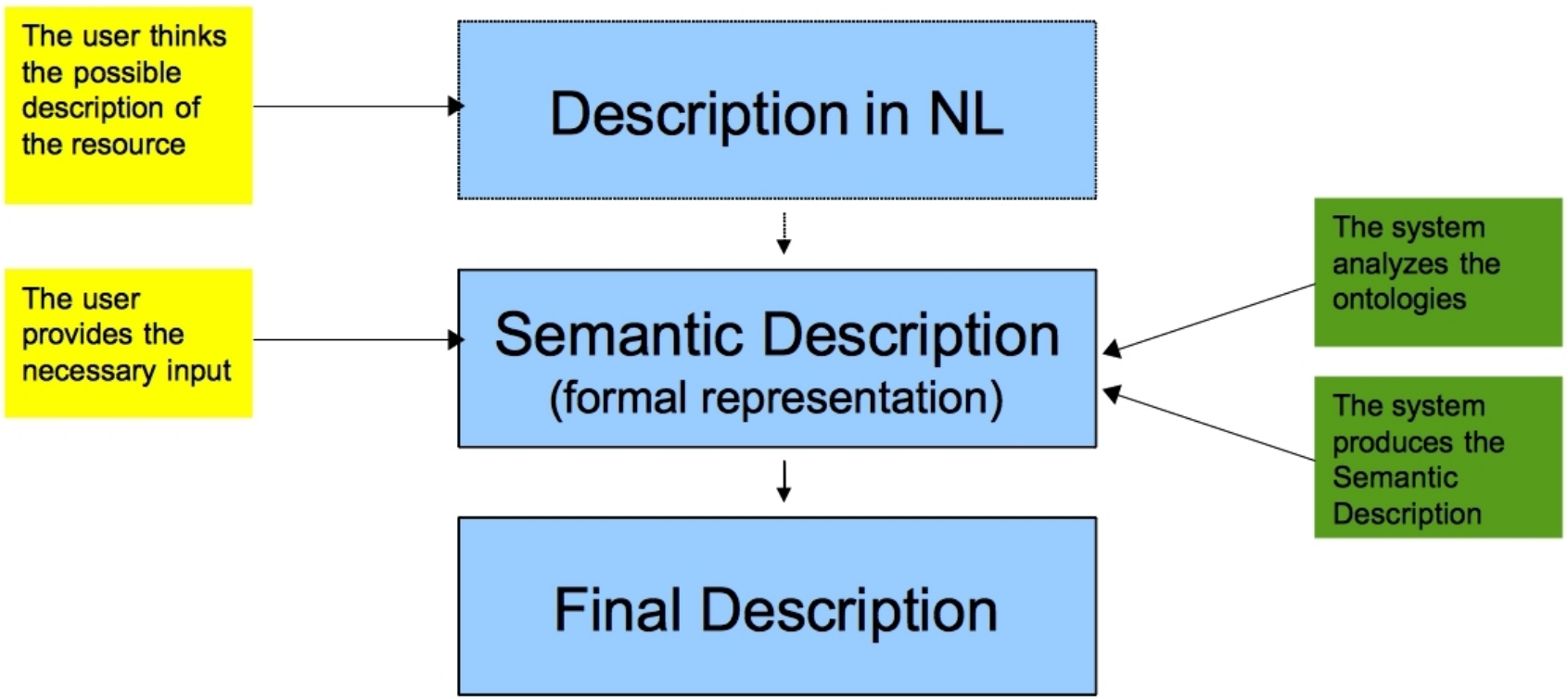
Semantic Indexing
Description and query

- A *description* is supplied during publication
- In a Boolean Index, for retrieving a resource it is required the same description
  - Exact matching between descriptions.
- A *query* is supplied during retrieval
  - It is equivalent to a description of a potential set of resources.

Semantic Indexing
Ontologies and Knowledge bases

- Expert community members are able to
  - Find the proper *ontologies*.
  - Build a population of an ontology grouping the most prominent individuals of the domain: knowledge base.
- Ontologies and knowledge bases are available within the community.
- *Open description*
  - Add keywords to the description.
  - Guidelines for preventing typing ambiguities.

Semantic Indexing
Semantic description



Semantic Indexing
Types of Descriptions

- Resource type
  - Address resources giving elements of description concerning the resource itself and not its content.
  - *Document written by Chomsky*.
- Content type
  - Address resources giving elements of description that concern their content.
  - *Document about Chomsky*.

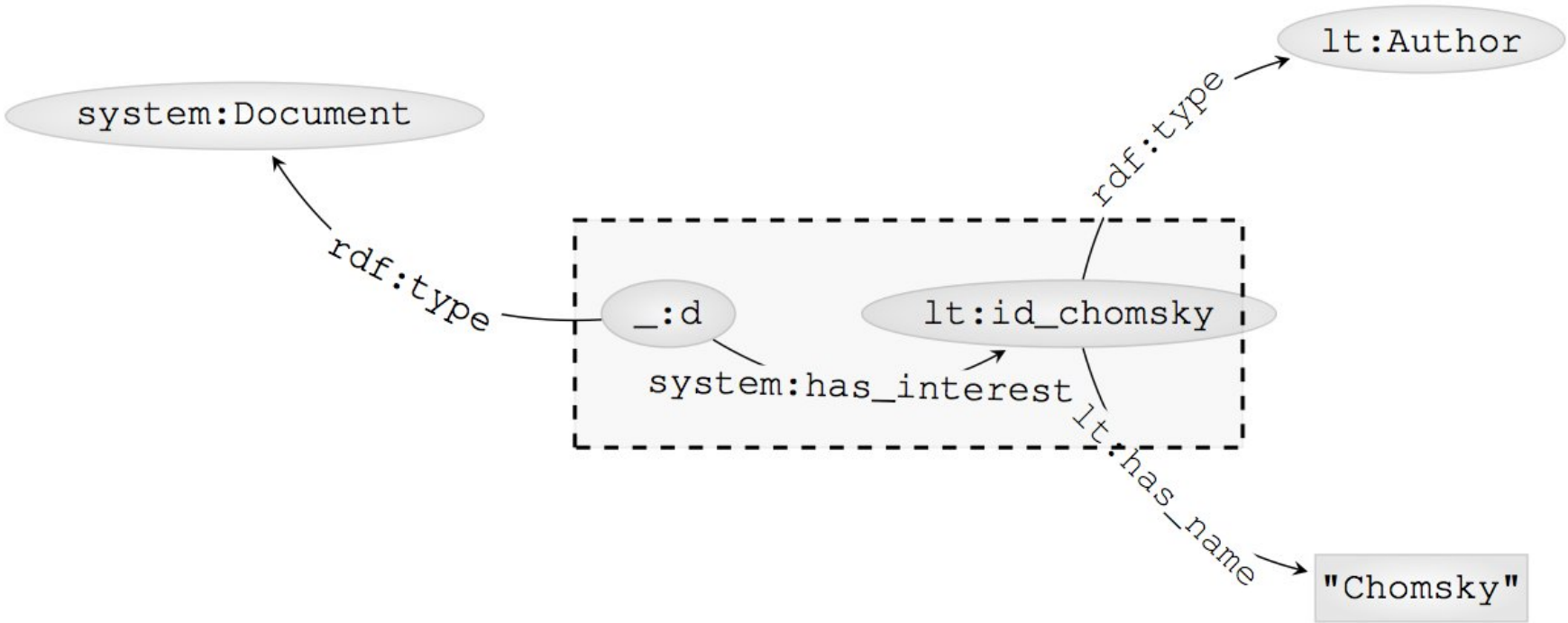
Semantic Indexing
Resource Type

- *Document written by Chomsky*.
- An ontology of domain is necessary. It should contain:
  - A concept that can represent the resource.
  - A concept that can represent an author.
  - A relation that binds the document to the author.
- The resource is considered as an instance of the concept that represents the resource itself.
- The system must show the concepts of the ontology that can represent the resource: *Entry Point*
  - The ontology provider has to declare what are the Entry Points.

Semantic Indexing
Content Type

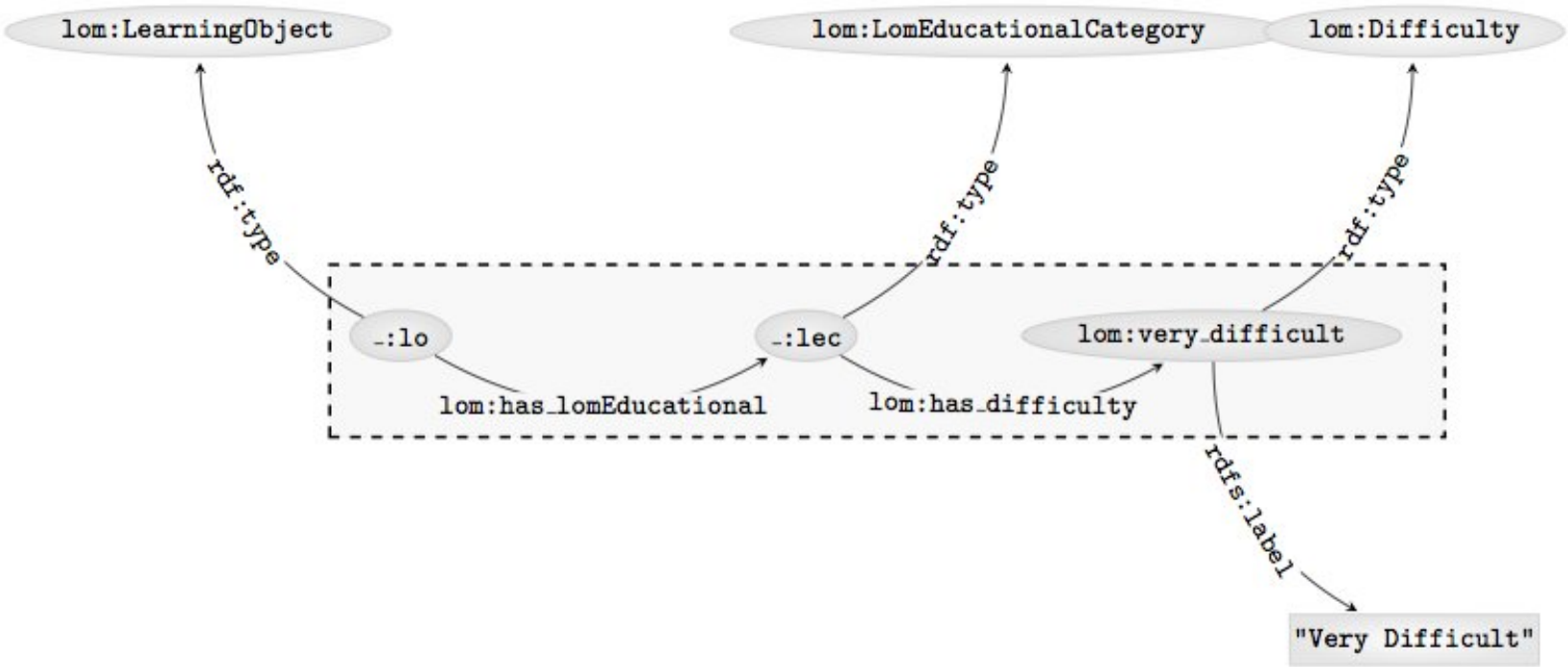
- *Document about Chomsky*
- An ontology that represents the resource and its content is necessary.
- We have defined the *System Ontology* that contains
  - The concept *system:Document* that represents the resource.
  - The property *system:hasInterest* that paraphrases *about*.
- It is necessary to have an ontology of domain for extracting the concept describing the content
  - It is necessary to represent the author *Chomsky*.

Semantic Indexing
Description Tree: Content Type



- The whole figure represents the *Formal Description*: it is an RDF Graph.
- The bordered part is used for the *Final Description*.

Semantic Indexing
Description Tree: Resource Type

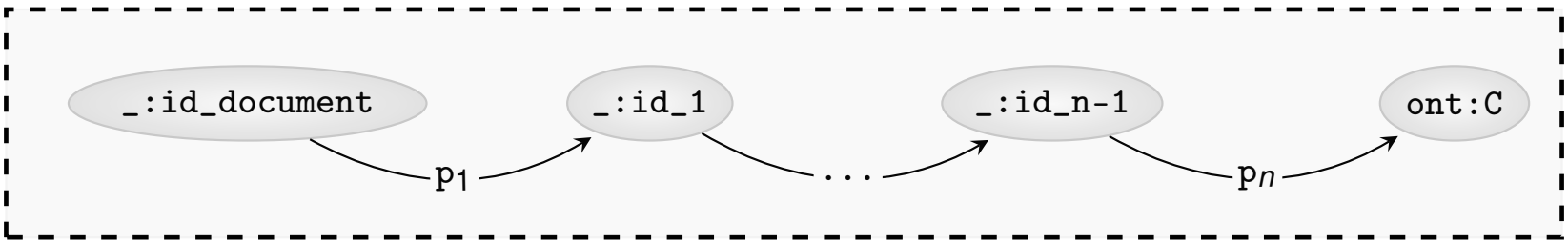


- The whole figure represents the *Formal Description*: it is an RDF Graph.
- The bordered part is used for the *Final Description*.

Semantic Indexing
Simple description

Definition

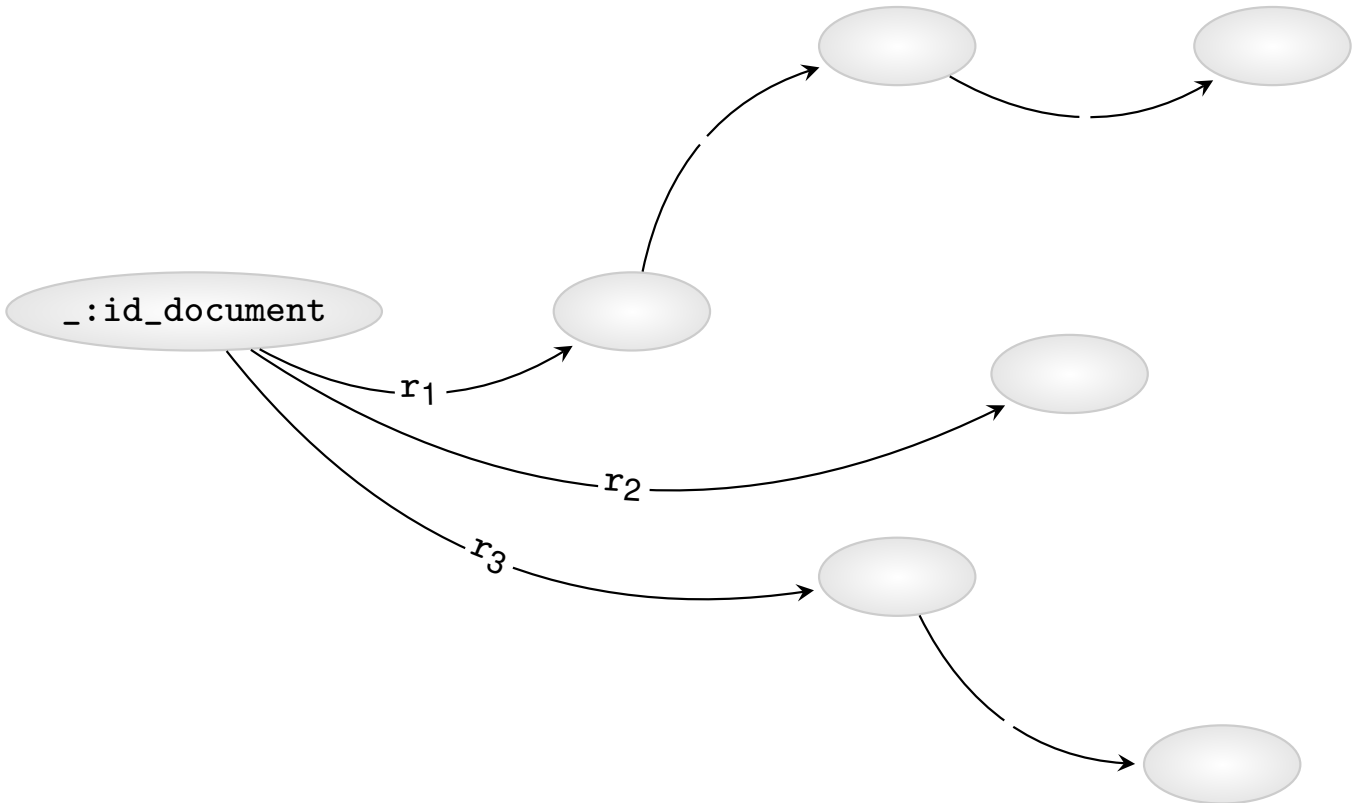
A Simple Description is a description where the root of the Description Tree has only one child.



- The general form of the part used for the *Final Description*.
- The *blank nodes* are virtual instances of concepts.
- The last node is a real individual of a concept defined in the ontology.

Semantic Indexing
Complex description: Description Tree

A Complex Description contains several paths. Each path starts from the root and relates a Simple Description *SDes* of the same document.



Semantic Indexing
Complex description: definition

Definition

A Complex Description is a Description Tree where the root has more than one child. The tree is the merging of n simple descriptions. A Complex Description $CDes$ is defined by the union of simple descriptions:

$$CDes = SDes_1 \vee SDes_2 \vee ... \vee SDes_n$$

Semantic Indexing
Complex description: publication and retrieval

- A resource $\mathscr{R}$ with ***n*** *SDes* is published *n* times, once with each *SDes*.
- A query with one of the ***n*** descriptions must answer positively with the resource $\mathscr{R}$.
- A query requesting for resources having a complex description is considered as a set of elementary queries (corresponding at a simple description). The result of the query is the intersection of the elementary query results.

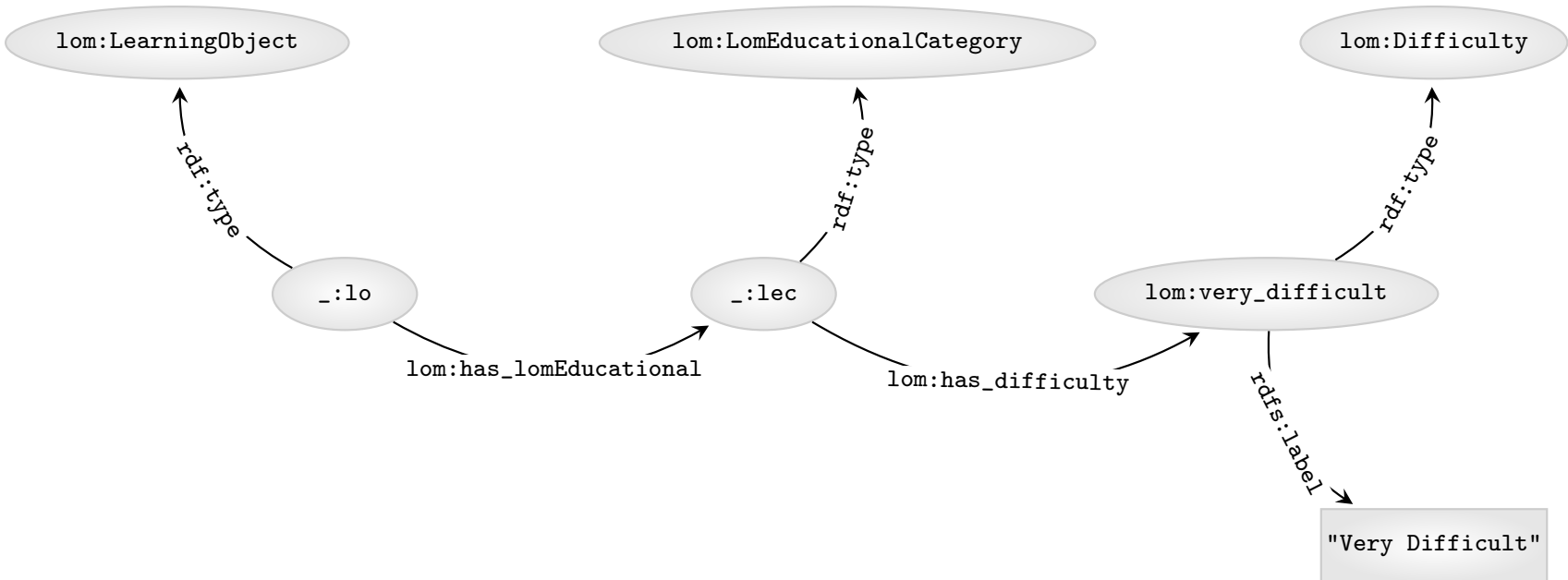
$$Result(Q_{CDes}) = \bigcap_{i=1,p} Result(Q_{SDes_i})$$

Semantic Indexing
Creation of keys

- A key used in the index is a representation of the semantic description of a resource and is written in a language based on RDF.
- The semantic description is an RDF graph (the *Description Tree*)
  - That contains blank nodes useless for indexing because they do not contain semantic information necessary for describing a resource.

Semantic Indexing
An example of Description Tree

Very difficult documents.



Semantic Indexing
A small knowledge base

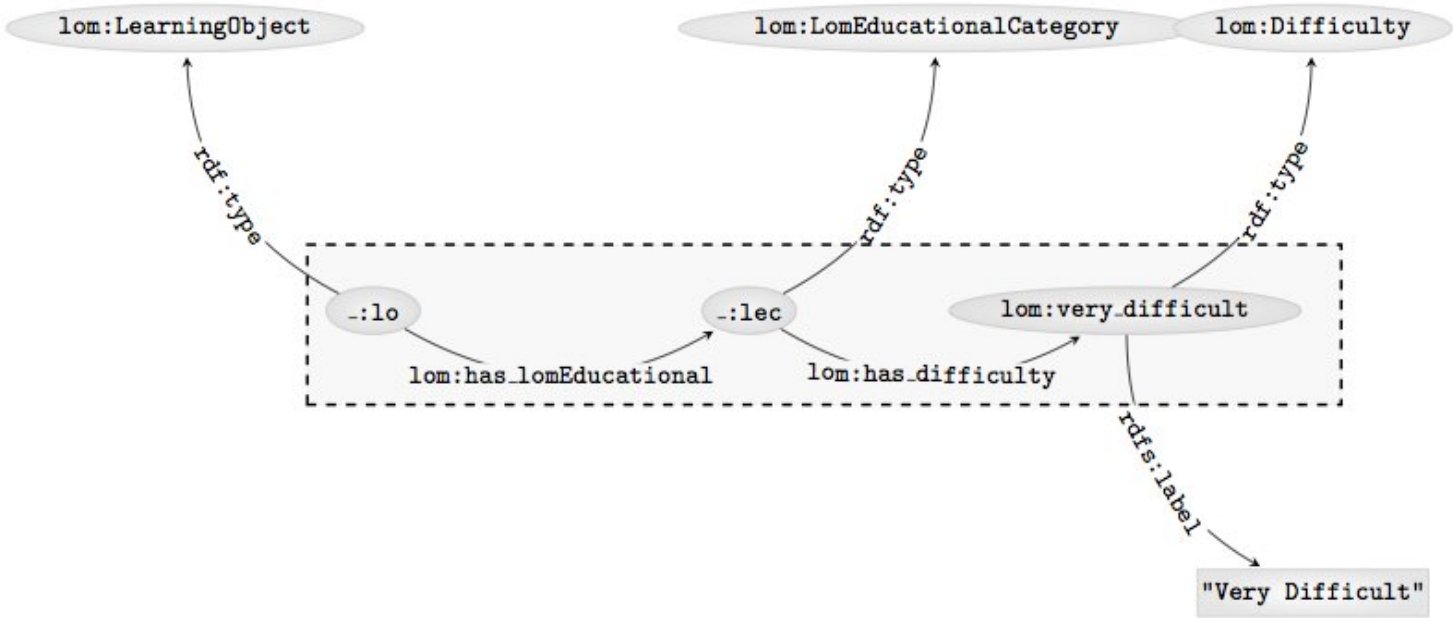
The description contains the following triples:

```
_:lo rdf:type lom:LearningObject .
_:lo lom:has_lomEducational :_lec .
_:lec rdf:type lom:LomEducationalCategory .
_:lec lom:has_difficulty lom:very_difficult .
```

The N3 notation synthesizes the description as follows:

```
[ a lom:LearningObject ] lom:has_lomEducational
[a lom:LomEducationalCategory ;
    lom:has_difficulty lom:very_difficult .]
```

Semantic Indexing
Format of the key



Key:
{rdf:type,lom:LearningObject}
{lom:has_lomEducational}
{lom:has_difficulty,lom:very_difficult}

Semantic Indexing
Keys extension

- Users should be able to find a resource with other characteristics than those exactly used for publishing
  - The System must also publish a resource with descriptions corresponding to these expected characteristics.
- The extension of keys produces a *Complex Description*
  - The *Simple Description* supplied by the resource provider is combined with others generated by the system.
  - The resource is published with each of them.

Semantic Indexing
Keys extension: subsumption

- *Documents about Stack.*
- The ontology *Theory of Languages* contains the concept *lt:Stack* and the super-concept: *lt:Data_Structure*.
- Any request of resources concerning Data Structure should also return resources concerning Stack.

Key_initial:
{rdf:type,system:Document}
{system:hasInterest, lt:Stack}

Key_extended:
{rdf:type,system:Document}
{system:hasInterest, lt:Data_Structure}

Semantic Indexing
Keys extension: facet

- *Very difficult documents*.
- A resource may be published with a specific difficulty level (lom:very_difficult).
- We consider also interesting to look for resources where the difficulty level has been defined.
- A request of resources where the difficulty level has been defined, should also return resources published with a specific difficulty level (instances of the concept lom:Difficulty).

Key_initial:
{rdf:type,lom:LearningObject}
{lom:has_lomEducational}
{lom:has_difficulty,lom:very_difficult}

Key_extended:
{rdf:type,lom:LearningObject}
{lom:has_lomEducational}
{lom:has_difficulty}

Semantic Indexing
Keys extension: category

- *Documents about Chomsky.*
- We consider that if the content of a resource is about a particular author, it is also about the concept of Author.

Key_initial:
{rdf:type,system:Document}
{system:hasInterest, lt:chomsky}

Key_extended:
{rdf:type,system:Document}
{system:hasInterest, lt:Author}

Semantic Indexing
Keys extension: keyword (I)

- *Documents about "Jeffrey D. Ullman".*
- The ontology *Theory of Languages* **does not contain** any individual of the concept *lt:Author* referring to the author *"Jeffrey D. Ullman"*
  - We considered the possibility for the System to create a virtual individual of the concept *lt:Author*
  - And let the user enter the string *"Jeffrey D. Ullman"* as value of its property *lt:hasName*

```
Key_initial:
  {rdf:type,system:Document}
  {system:hasInterest,lt:Author}
  {lt:hasName,"Jeffrey D. Ullman"^^xsd:string}
```

Semantic Indexing
Keys extension: keyword (II)

- A resource whose content is about a particular author, is also about the concept of Author (Category extension).

```
Key_extended:
  {rdf:type,system:Document}
  {system:hasInterest, lt:Author}
```

- A resource whose content is associated to a string, is also about a keyword (Keyword extension).

```
Key_extended:
  {rdf:type,system:Document}
  {system:hasKeyword,
          "Jeffrey D. Ullman"^^xsd:string}
```

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Indexing Patterns
Cases of indexing

		1 Step	2 Steps	Example	Extension
C.T.	N.V.	concept		*treating of Family.*	Subsumption
		property		*about the semantic density of a LO.*	Subsumption
		individual		*treating of Chomsky.*	Category
	V.	individual	property	*treating of Ullman.*	Keyword

		≥1 Step	>1 Step	Example	Extension
R.T.	N.V.	individual		*having a known contributor.*	Facet
	V.	individual	property	*having an unknown contributor.*	Facet + Keyword

		1 Step		Example	Extension
K.T.		string		*about Medieval Italy.*	

Legenda:

C.T.: *Content Type*
R.T.: *Resource Type*
K.T.: *Keyword Type*

V.: *Virtual*
N.V.: *Not Virtual*

Indexing Patterns
Objective

- An Indexing Pattern is a model of a case of indexing.
- An Indexing Pattern allows to follow a path within an ontology, defining a sequence of steps
  - At each step, the user interacts only with the necessary part of the ontology. The unnecessary parts are hidden.
- An Indexing Pattern is used
  - For presenting the ontologies to users in a friendly and easy-to-use way
    - Developers can provide a User Interface able to guide the user through the ontologies.
  - For creating the keys of indexing.

Indexing Patterns
Definition

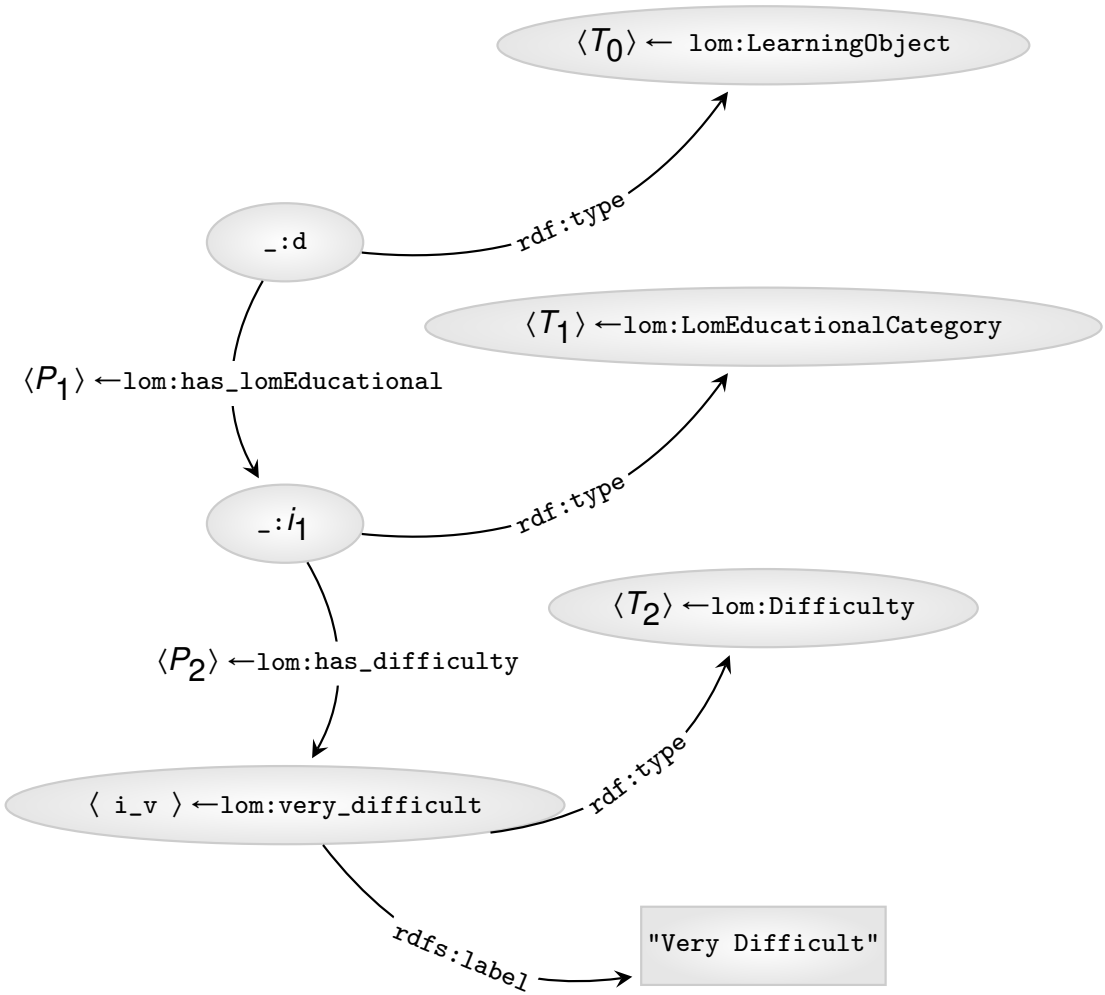
We call Indexing Pattern a triple
$\mathscr{IP} = (\mathscr{D}, \mathscr{P}, \mathscr{A})$ where:

- $\mathscr{D}$ is a *Description Template*, the generalized description of a resource. It contains some variables that are fixed during the steps followed by users for creating the description.
- $\mathscr{P}$ is a *User Process*, the sequence of steps necessary for determining the values of the variables. It is composed of a sequence of assignments involving either SPARQL queries, or other types of user inputs.
- $\mathscr{A}$ is an *Algorithm*, the sequence of computations used for creating the keys of indexing.

Indexing Patterns
Description Template: Iterative Pattern

$\mathscr{D}$

```
Individual: _:d
    Types: <T0>
loop (k=1,n)
    Facts: <Pk> _:ik
Individual: _:ik
    Types: <Tk>
end loop
  <i_v> ← _:in
  <V> ← <Tn>
```



Indexing Patterns
User process: Iterative Pattern

$\mathscr{P}$

$\mathcal{O} \leftarrow$ userOntologyChoice()

$T_0 \leftarrow$ user(entry_point($\mathcal{O}$))

$k \leftarrow 0$

i_v $\leftarrow$ null

repeat

  $k \leftarrow k{+}{+}$

  $S_k\langle T_{k-1}\rangle \leftarrow (\gamma\langle T_{k-1}\rangle, \{\mathcal{O}\},$ select ?p ?r)

    with $\gamma\langle T_{k-1}\rangle$= {

      ?p rdf:type owl:ObjectProperty .

      ?p rdfs:domain $\langle T_{k-1}\rangle$.

      ?p rdfs:range ?r . }

  $\langle p_k, T_k\rangle \leftarrow$ user(res($S_k\langle T_{k-1}\rangle$))

  $S_F\langle T_k\rangle \leftarrow (\gamma\langle T_k\rangle, \{\mathcal{O}\},$ select ?i)

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  if (res($S_F\langle T_k\rangle$)) $\neq \varnothing$

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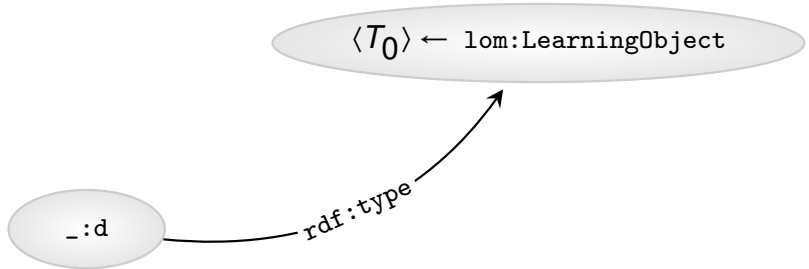

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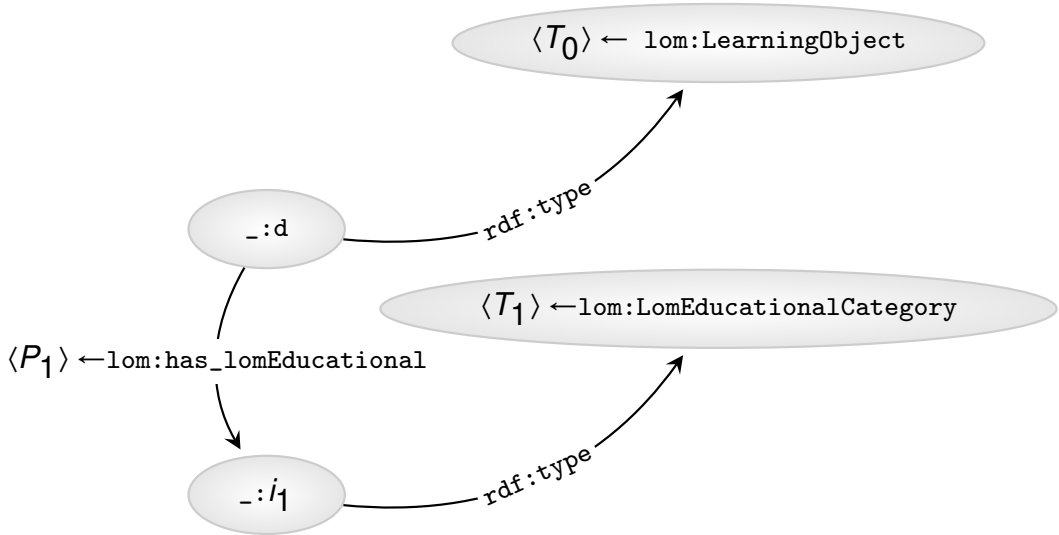

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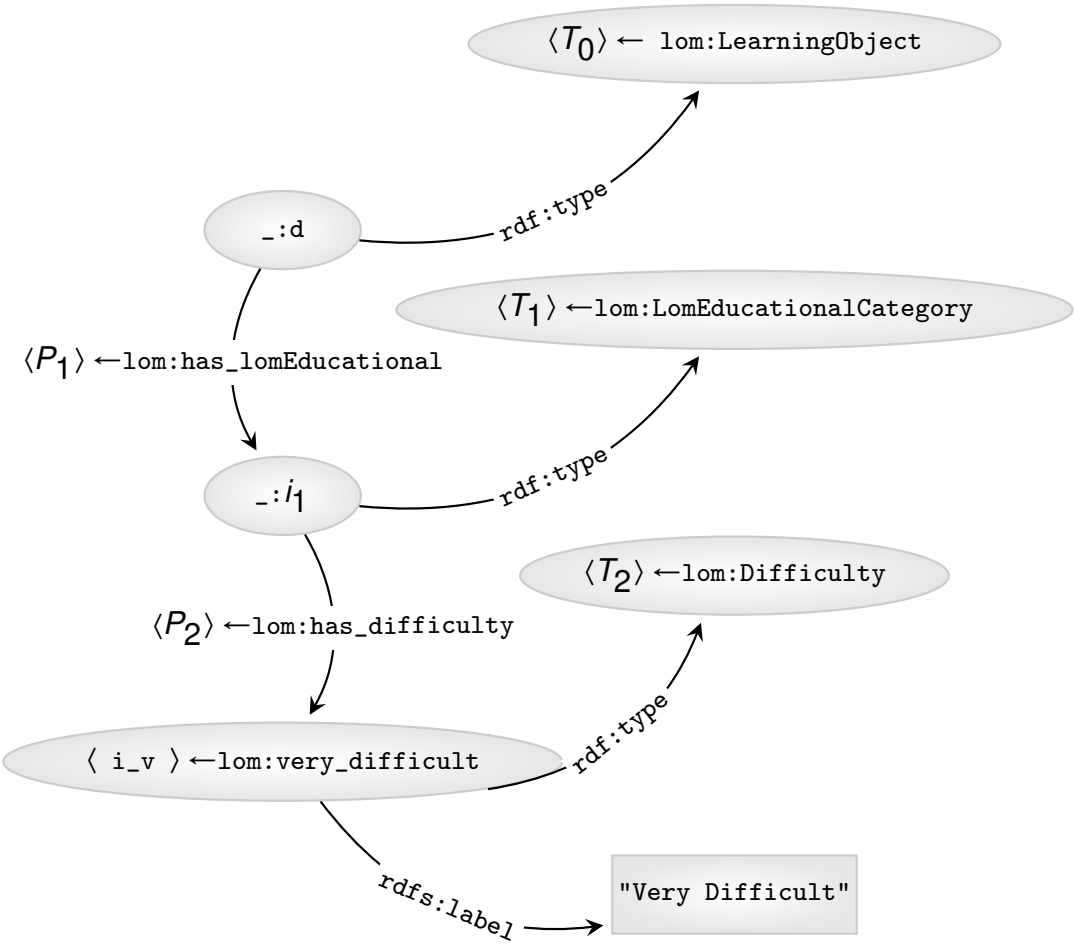

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Community of Users
Community and users

A Community is composed of users interested in collaborative activities

- *Expert users*: experts in the domain of interest of the community. They are in charge of the activities of providing the ontologies, their description and their publication.
- *Provider users*: they don't have an high level role. They usually publish and retrieve resources.
- *Consumer users*: they have a passive participation because they don't provide any contribution to the community. They just retrieve resources.

Community of Users
Community and resources

- Community resources
  - Documents
    - The resources shared by users through the Shared Memory.
  - Core resources
    - *Ontologies*: used for creating the keys of indexing.
    - *Notes*: free text provided by a user to include additional information in the System.
    - *Wiki*: a unique space of the System shared by all users.
    - Are published in the network with specific keys using the System Ontology.

Community of Users
Core resources: Ontologies

- Are published in the network by expert users with a small additional description:
  - a textual description concerning domain of the ontology;
  - the set of Entry Points.
- The publication is made thanks a key of indexing assigned automatically by the System.
- Are retrieved from the network when the user starts the system.

Community of Users
Core resources: Notes

- The use of Notes is considered of general purpose
  - The content of the Note may be any topic of interest for the user: messages for other users, memos, comments on certain resources, etc.
  - Notes are published using a keyword.
- Notes are published with a key assigned by the System.

Community of Users
Core resources: Wiki

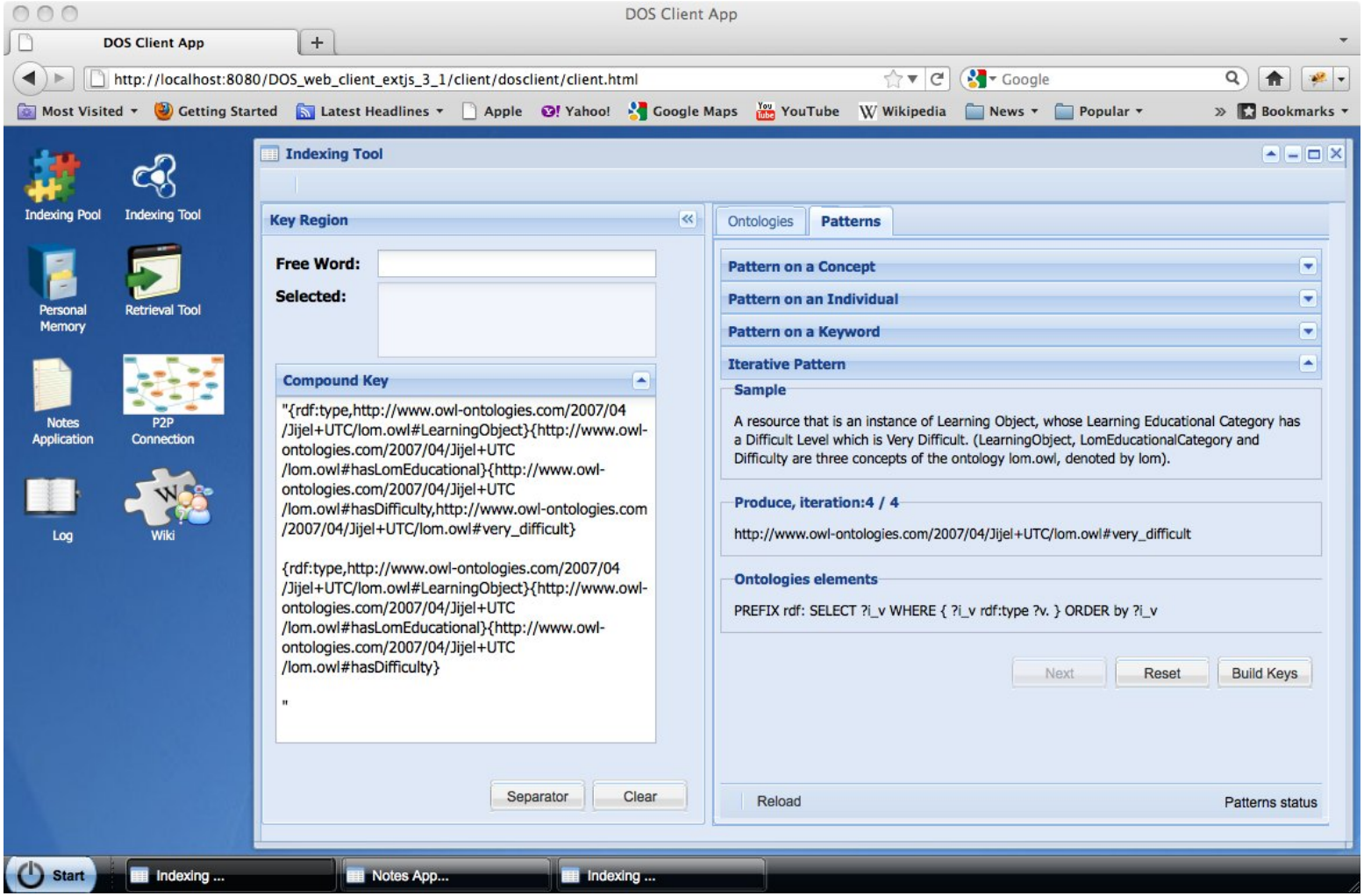
- The Wiki of the Community is composed of only one physical document containing several parts that may link to other resources, distributed in the network
  - Links are *Semantic*, refer to keys of indexing, are embedded in the HTML *link* tag.
- When a new community is created the System publishes the Wiki in the network from a template containing the skeleton with only the essential structure.

Community of Users
Community and tools

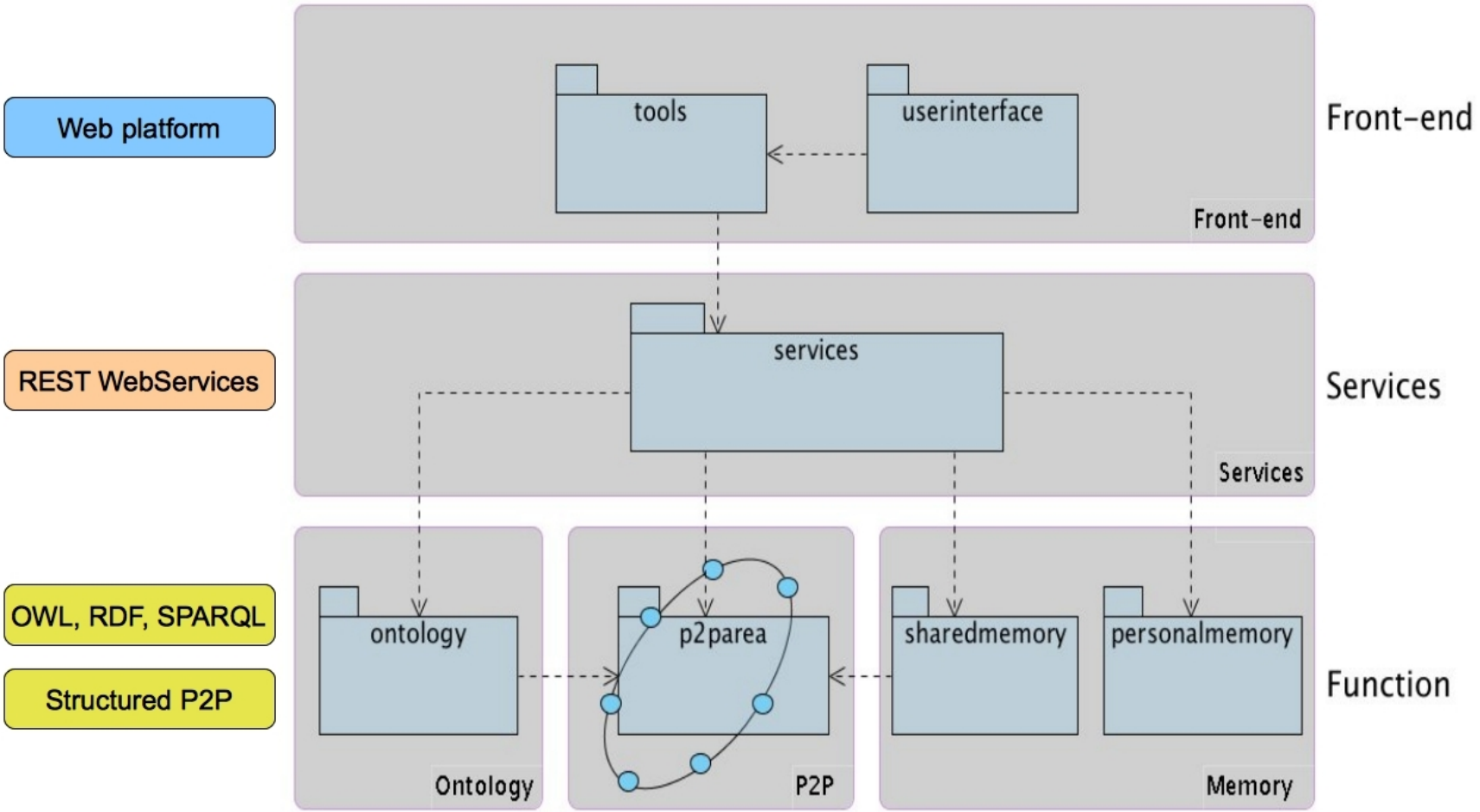
A Community is supported by a Web platform equipped with a set of tools

- *Indexing Tool*: is used for choosing the ontologies retrieved from the network and for creating the keys of indexing.
- *Indexing Pool*: is a temporary container of (key, resource) pairs. It allows users to select the resource they want to index and to associate the key of indexing built with the Indexing Tool.
- *Notes Editor*: is a tool that enables users to create personal notes that are associated to keys of indexing and published.
- *Retrieval Tool*: allows users to submit queries to the system. It retrieves results and displays them.

Community of Users
Web Platform



Community of Users
Architecture of a Peer



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Conclusion

- A model of Indexing Patterns
  - For transforming a user understandable description to a machine understandable one.
- Description extension mechanism
  - Form managing publication and retrieval contexts.
  - The description is enlarged during publication to foresee different possible retrieval situations.
- A Web platform
  - That makes feasible the life of a decentralized community.
  - Contains a set of *Core resources* for allowing the indexing.
  - Contains a distributed Semantic Wiki and a distributed system of Notes.

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Future Work

- Advanced navigation system for ontologies
  - A richer navigation system for ontologies for better organize the visual composition of represented data.
- Exchange with an external system.
  - It may query our system by creatin a semantic description of potential resources based on RDF
- Multilingual issues.
  - It concerns resources indexed on keywords or indexed on virtual individuals because the user has to add at least one string in order to describe this individual.
- Evaluation.
  - Experiments should prove that the system can really support a real community.

Publications (I)

- In proceedings
  - Moulin, C., Lai, C. *Ontologies based approach for semantic indexing in distributed environments*. KEOD 2009, International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, Madeira, 6 - 8 October 2009, Portugal. pp. 420-423.
  - Moulin, C., Lai, C. *Semantic indexing within a Semantic Desktop*. WWW/Internet 2009, Rome, 19 - 22 November 2009, Italy, pp. 149-152.
  - Moulin, C., Lai, C. *Indexing Patterns within a Distributed System*. In S. D. Fatos Xhafa, Santi Caballe, Ajith Abraham, ed., Second International Conference on Intelligent Networking and Collaborative Systems (INCOS 2010), Thessaloniki, 24 - 26 November 2010, Greece, pp. 206-213.
  - Moulin, C., Lai, C. *Reasoning in a distributed semantic indexing system*. 4th International Workshop on Distributed Agent-based Retrieval Tools, DART 2010. 18 - 19 June, Geneva, pp. 88-98.

Publications (II)

- Journal
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