DODO: A Mechanism Helping to Dynamically Construct Domain Ontologies for Services Integration

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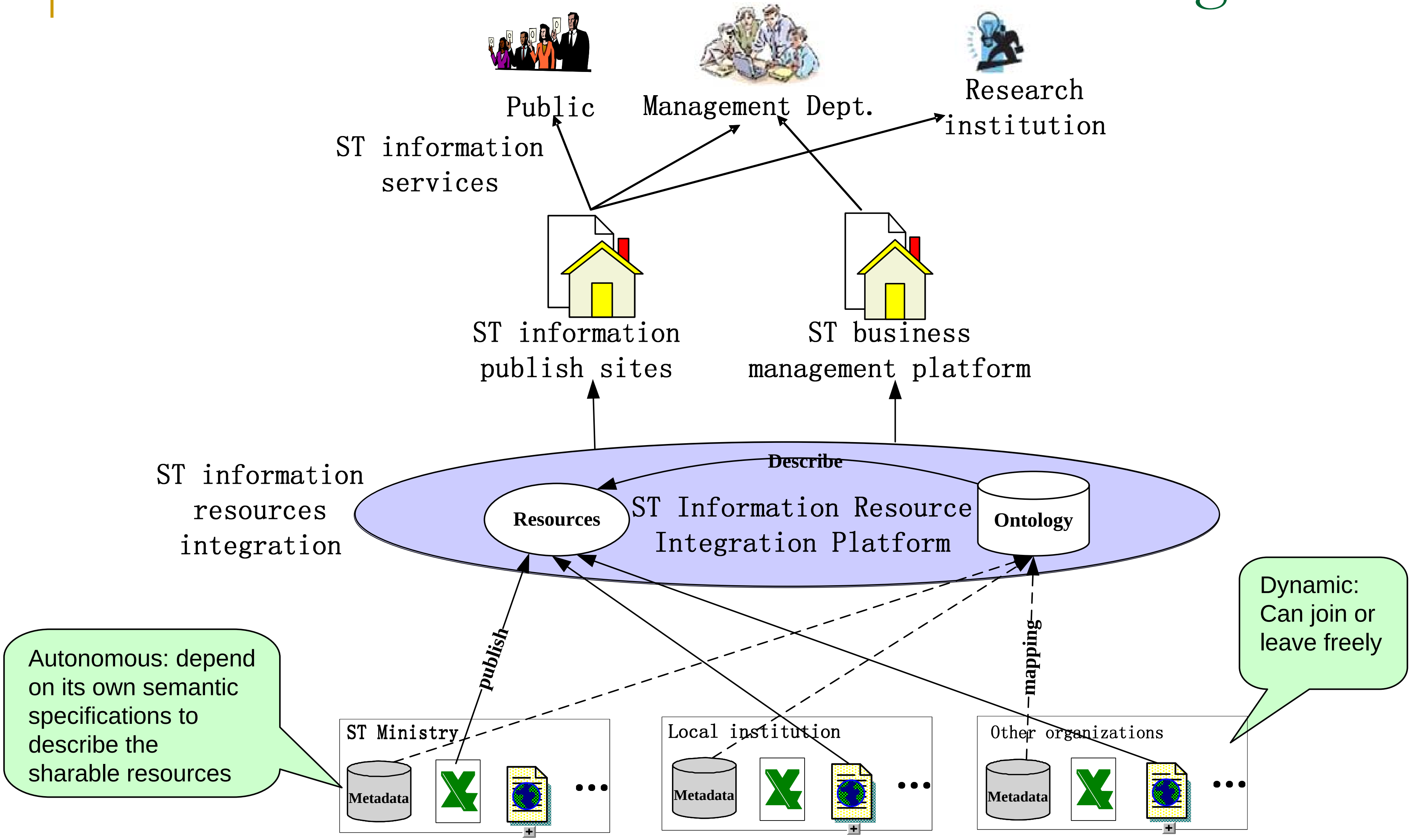
Outline

- Background and Challenges
- Related Works
- Rationale of the DODO Mechanism
- Application of the DODO Mechanism
- Conclusion

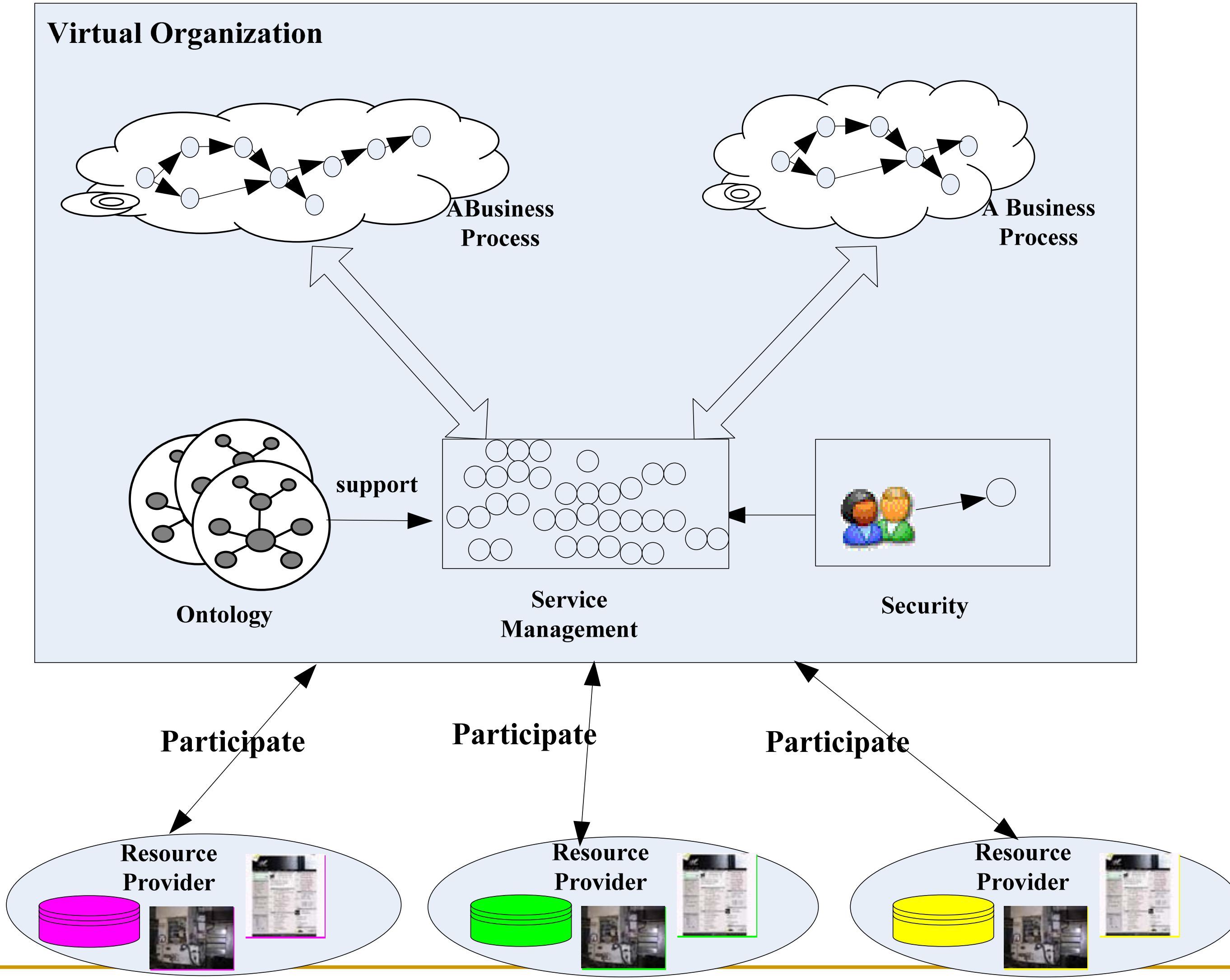
Background and Challenges

A scenario : ST* information resources integration



*ST : science and technology

Our solutions: virtual organization



The characteristics of a VO

- Goal driven: A VO is sponsored according to a business goal. The sponsor is called the owner.
- Dynamic: Each Resource provider can join or leave a VO freely.
- Autonomous: Each member of a VO is autonomous.
- Process-oriented: The services in a VO can be composed into business processes to satisfy users' requirements.

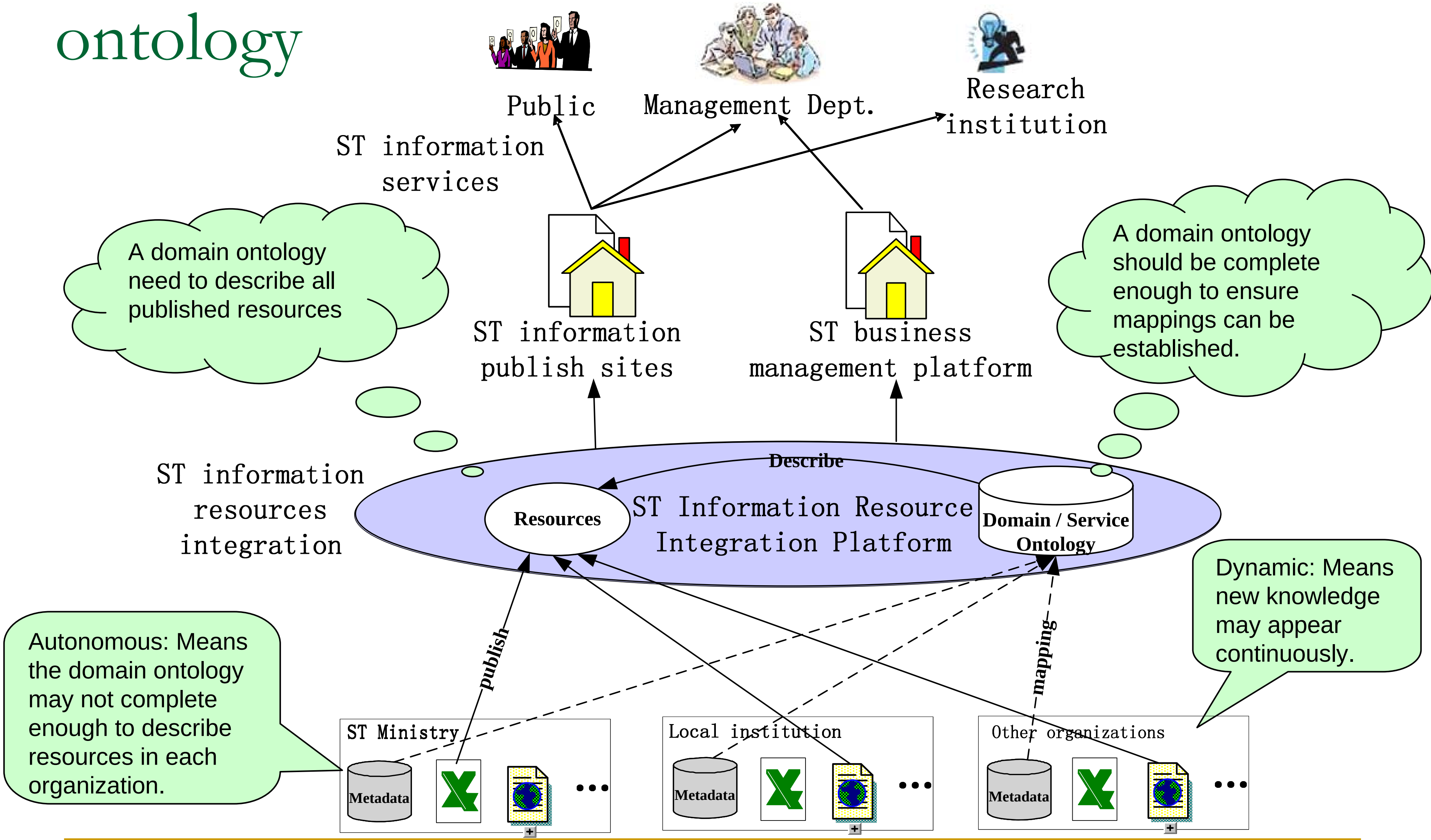
The functions of the ontology

- The ontology is mainly used to describe the services and their related resources. Only after adding semantic annotations to services, a VO can:
  - Help users to find their needed services exactly
  - Enable semi-automatic service composition

The semantic description of web services

- Describe the semantic web services depending on two kinds of ontologies:
  - A generic web service ontology: define what is a web service, such as owl-s
  - A domain ontology: describe the resources which related to the services

Back to the scenario : requirements for a domain ontology



ST : science and technology

Challenges for constructing a domain ontology in a VO

- The dynamics and autonomy of a VO plague the construction of a domain ontology
  - Cannot pre-construct a global ontology.
  - Cannot construct a stable ontology.
- Conclusion
  - A domain ontology in a VO should keep evolving.

Related Works

Traditional approaches

- Build-from-scratch approaches
  - Domain experts analyze the application domain and construct ontologies from scratch.
  - Enterprise Ontologies and skeletal methodology [7], TOVE ontology and evaluation methodology [8] as well as CHEMICAL and Methontology methodology [9].
- Build-by-integrating-others approaches
  - reusing other available ontologies to build a new ontology [11-12].
  - merging different ontologies about the same subject into a single one that “unifies” all of them [13-14].

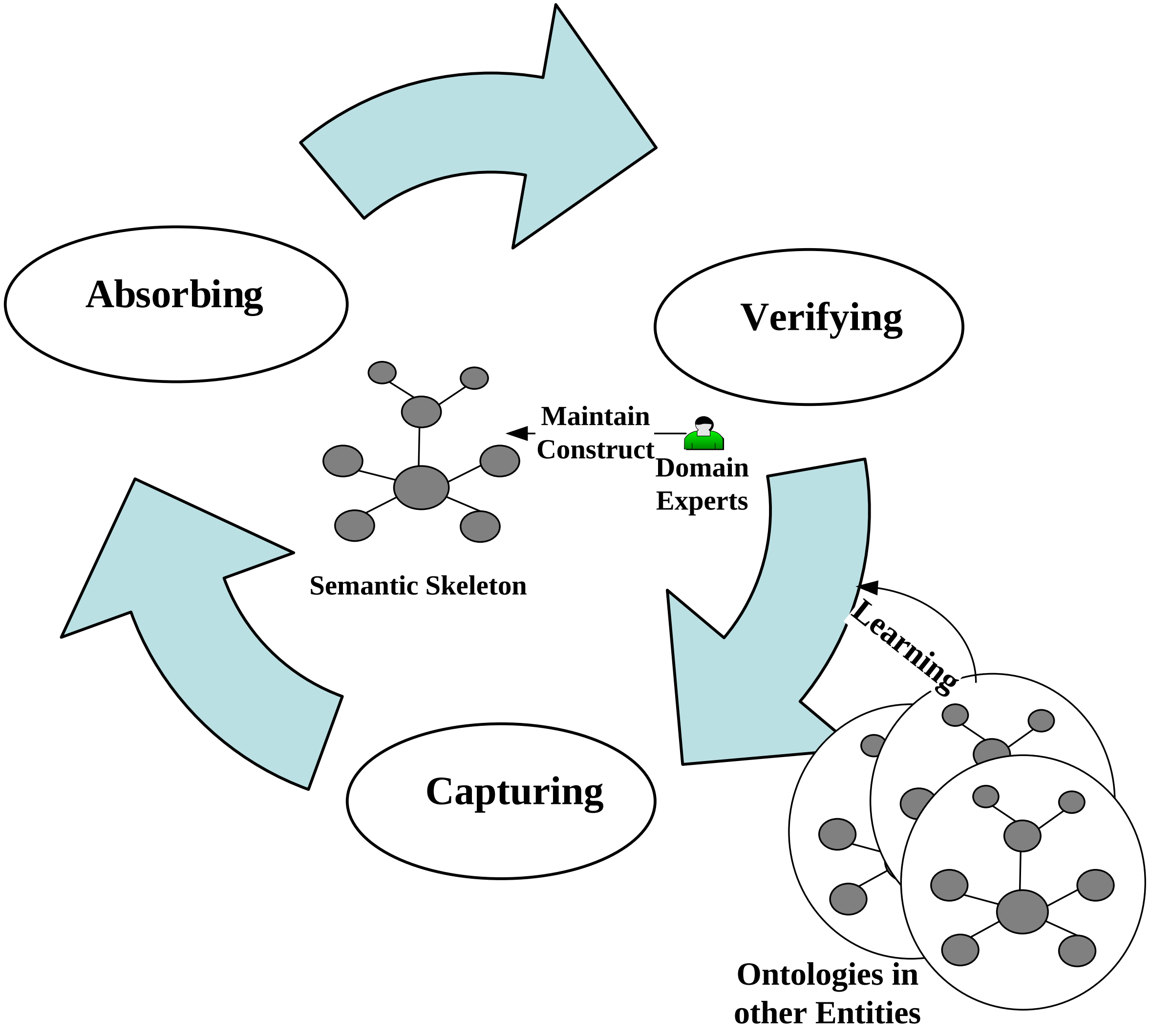
Analysis

- Build-from-scratch approaches are incapable
  - Construct ontologies beforehand and result in inflexible and hard-to-change ontologies.
- Build-by-integrating-others approaches are incapable
  - High cost and apt to lose original semantics heavily. [6]

Rationale of the DODO Mechanism

The process of constructing a domain ontology

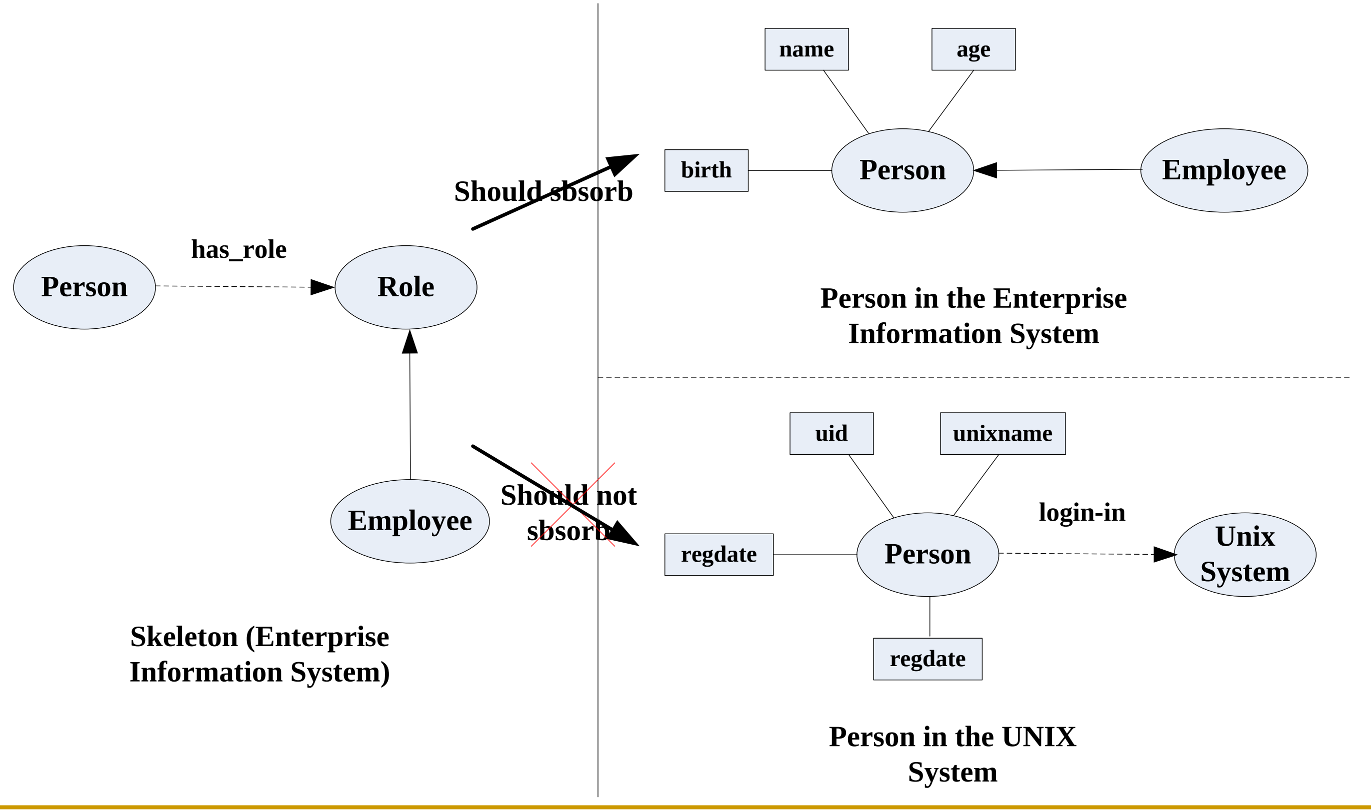
- DODO provides a dynamic iterative process for constructing a domain ontology.
  - Constructing the semantic skeleton
  - Capturing the knowledge
  - Absorbing the knowledge
  - Verifying the knowledge



Absorbing
Verifying
Capturing
Maintain
Construct
Domain
Experts
Semantic Skeleton
Learning
Ontologies in
other Entities

Step1: constructing the semantic skeleton

- Goal
  - To provide enough background knowledge to eliminate the possible ambiguities.



Definition of the semantic skeleton

- An semantic skeleton is a tuple S:= (C, P, Hc, Hp), where:
  - C: The set of key concepts of a given application domain.
  - P: The set of optional properties of a given application domain.
  - Hc: The hierarchy of predefined key concepts.
  - Hp: The hierarchy of predefined key properties.

Differences between semantic skeleton and ontology

- The semantic skeleton is much simpler
  - Doesn't have the complex constraints including data types.
  - Easy to construct.
- Semantic skeleton is incomplete
  - Important concepts
  - Important properties
- Semantic skeleton is steady
  - Changes to the semantic skeleton should be handled only by domain experts.

Step2 : Capturing the knowledge

- Goal
  - Capture new knowledge
  - Capture different knowledge
- Method
  - Matching the semantic descriptions of the published resources with current constructed ontology to find their similarities and differences.

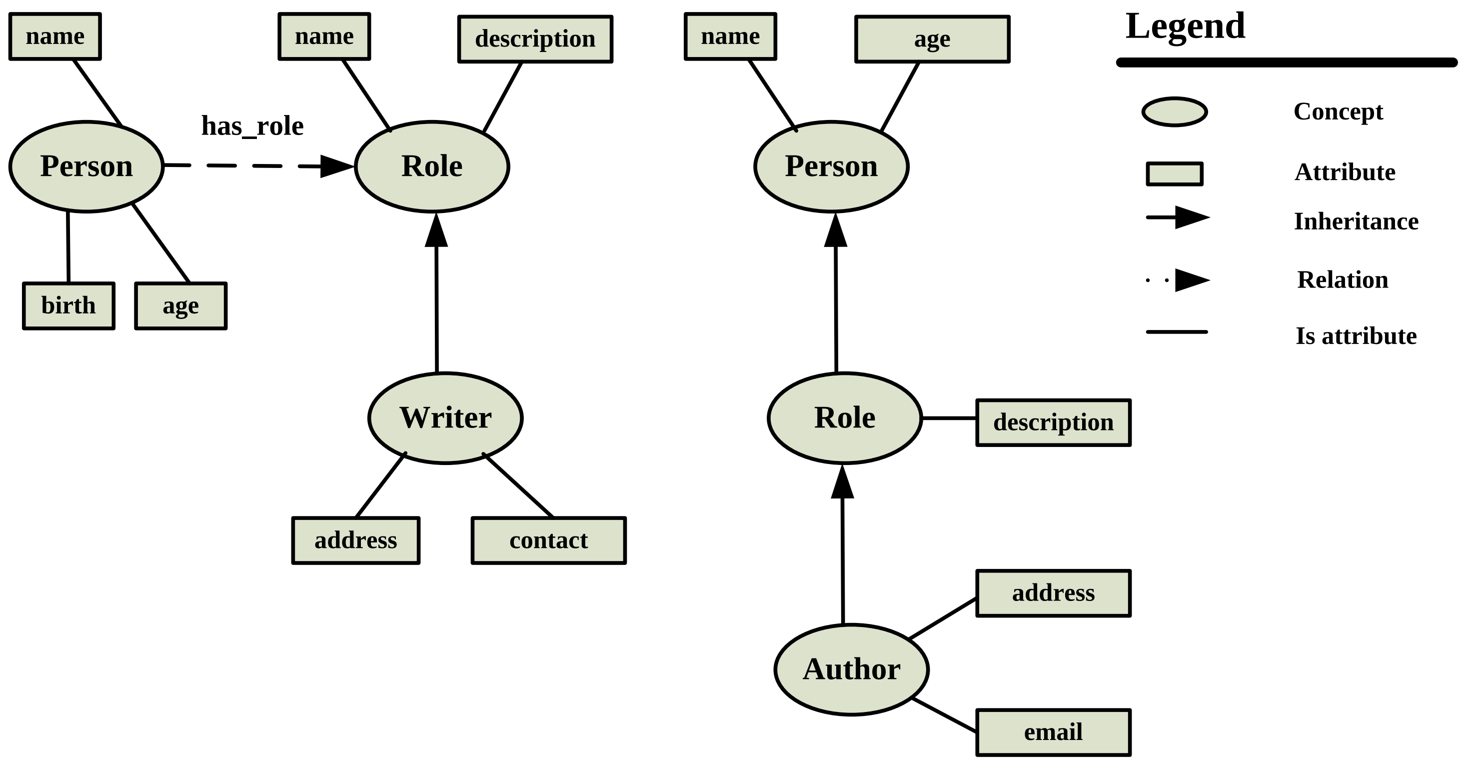
Matching algorithm

- H-Match algorithm [16-17]
  - Name Affinity :
    - To quantify the level of matching two concepts based on their names.
    - Refer to WordNet [15]
  - Structure affinity
    - To quantify the level of matching two concepts based on their attributes
    - Proportional to the number of similar attributes
  - Context affinity
    - To quantify the level of matching two concepts based on their contexts.
    - Proportional to the affinity of directly adjacent concepts
  - Global affinity: the linear combination of the above affinities

Matching results

- New knowledge
  - New concept
  - New attribute
  - New relation
- Update knowledge
  - Label change
  - Relation change
  - Domain change
  - Range change

An example



Constructing Ontology

Resource Provider A

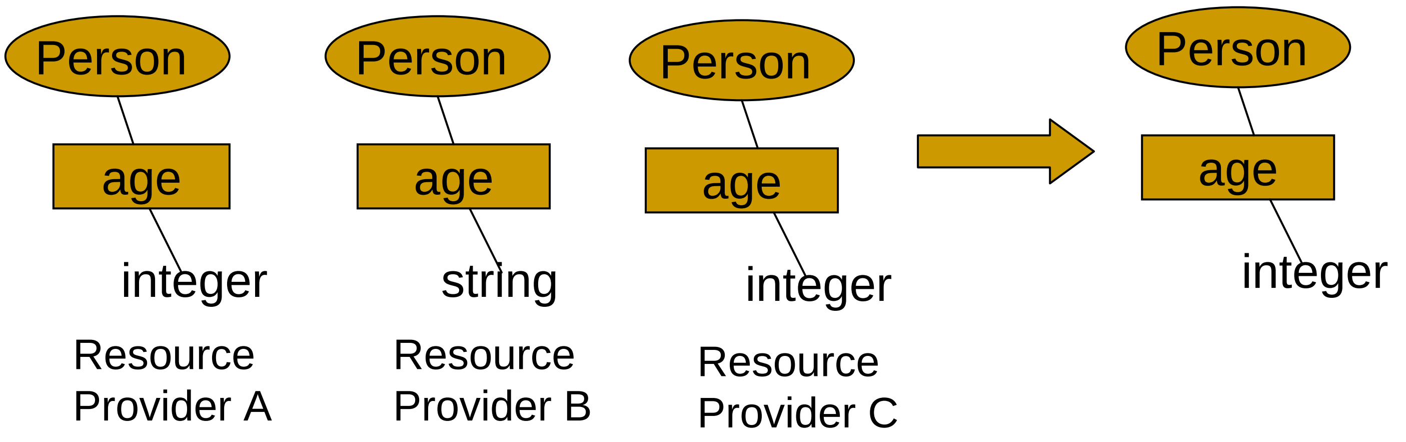
- Fragment of matching result
  - New attribute: Author.email
  - Label change: Writer->Author

Step3: Absorbing the knowledge

- Goal
  - To absorb captured knowledge under the supervising of the domain experts.
- Problems
  - What to absorb?
    - In the running of a VO, knowledge about even the same kind of resource may have multiple editions.
  - How to absorb?

The principle to absorb

- Consensus-driven principle: if a piece of knowledge is provided by most of resource providers, then it should be recommended in high priority.



The way to absorb

- Algorithm
  - For each kind of matching result, a sub-algorithm is developed to solve the ontology change problem.
  - Traverse all the matching result to implement the absorption.

Matching Result	Sub-algorithm
New concept	1 Try to find the super-concept in the current constructing ontology 2 If found, derive new concept from existed concepts 3 Otherwise, add a completely new concept
New attribute	1 add a completely new attribute
New relation	1 Try to find the super-relation in the current constructing ontology 2 If found, derive new concept from existed relations 3 Otherwise, add a completely new relation
Label change	1 remove the original label 2 add the new label
Relation change	1 remove the original relation 2 add the new relation
Domain change	1 remove the original domain 2 add the new domain
Range change	1 remove the original range 2 add the new range

Step4: Verifying the constructing ontology

- Consistency : means no contradictory conclusions can be drawn from valid input definitions.
- Completeness : means all that is supposed to be in the ontology is explicitly represented in it or can be inferred using other definitions.
- Non-redundancy : means that the constructed ontology should avoid the errors such as redefining expressions that were already explicitly defined or that can be inferred using other definitions.

Application

A real scenario

- Enterprise dynamic supplying chains
  - Goal : realizing resource sharing among a huge electronic manufacturing enterprise and its upriver and downriver partners
  - Scale : more than 20 enterprises and almost 100 kinds of resources are involved
  - Application
    - A VO is constructed to form the alliance among these organizations.
    - DODO mechanism is exploited to construct a flexible and scalable semantic support environment.

Conclusion

- DODO
  - Goal: Dynamically constructing a domain ontology for a VO
  - Characteristics
    - Runtime construction
      - The construction of ontology doesn’t need to be finished before the application.
      - Stresses the consummation of ontology in the runtime.
    - Lightweight
      - It avoids integrating two ontologies. On the contrary, it focus only on the semantic descriptions of sharable resources.

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