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Lösung

Übungsblatt 3
Ontologiebasiertes Wissensmanagement

Termin: 25. Juni 2001

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Aufgabe 1. Ontologiebasierte Wissensmanagement Systeme in Unternehmen

Forschung und Entwicklung

- Wissen
  - Projekt- und Produktwissen
- Aufgaben und Funktionen
  - Strukturierung des Wissens durch Konzepte der Ontologie
  - Einbindung externer Quellen (Patent DB) möglich
  - Ontologiebasierte Suchanfrage und Wissenseingabe
  - Gezielte aktuelle Wissensweiterleitung (Push) an betroffene Personen
  - Wissensaustausch mit Lieferanten
- Ziele
  - Keine Doppelentwicklungen und Doppelfehlentwicklungen

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Aufgabe 1. Ontologiebasierte Wissensmanagement Systeme in Unternehmen

Produktion und Qualitätsmanagement

- Wissen
  - Wissen über Vor-, Zwischen- und Endprodukte, Produktionsverfahren mit aktuellen Produktionsparametern und Messwerten und deren Zusammenhänge
- Aufgaben und Funktionen
  - Ontologiebasierte Anfragen
  - Ontologiebasierte Inferenzmaschine
- Ziele
  - Qualitätsmängel und Produktionsstops vermeiden
  - Produktionsvorbereitung optimieren
  - Auffinden von „Problemzonen“

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Aufgabe 1. Ontologiebasierte Wissensmanagement Systeme in Unternehmen

Dokumenten Management

- Wissen
  - Wissen über Inhalte, Autoren, Zusammenhänge
  - Wissen über Leser (Interessen, Aufgaben)
- Aufgaben und Funktionen
  - Ordne Dokumente in eine Struktur ein
  - Leite Relevante Dokumente an richtige Leser weiter
  - Ontologiebasierte Suchanfrage an Dokumentensammlung
- Ziele
  - Reduzierung der Recherche Zeit aller Mitarbeiter
  - Gezielte Versorgung der Mitarbeiter mit relevanten Dokumenten.

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Aufgabe 1. Ontologiebasierte Wissensmanagement Systeme in Unternehmen

Unterschiede zu herkömmlichen Systemen

- Personalisierbarkeit:
  - Verknüpfung einer System-Ontologie (Entwicklung, Produktion) mit der User-Ontologie ermöglicht genaue Wissensverteilung.
  - Visuelle interfaces können mit der Ontologie besser auf User zugeschnitten werden
- Komplexität, Verständlichkeit
  - Nach innen sehr komplex, nach außen durch einheitliche Sprache weniger komplex
- Funktionalität
  - Datenbanken, Datawarehouses, Stichwortverzeichnisse etc. bekommen durch das Zugrundelegen einer Ontologie einen wesentlich mächtigeren Wissensgehalt.

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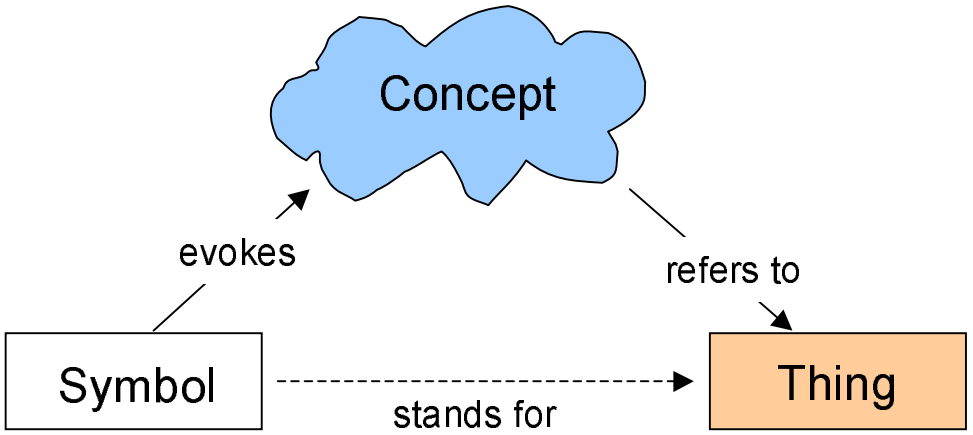
Aufgabe 2

Meaning treangle

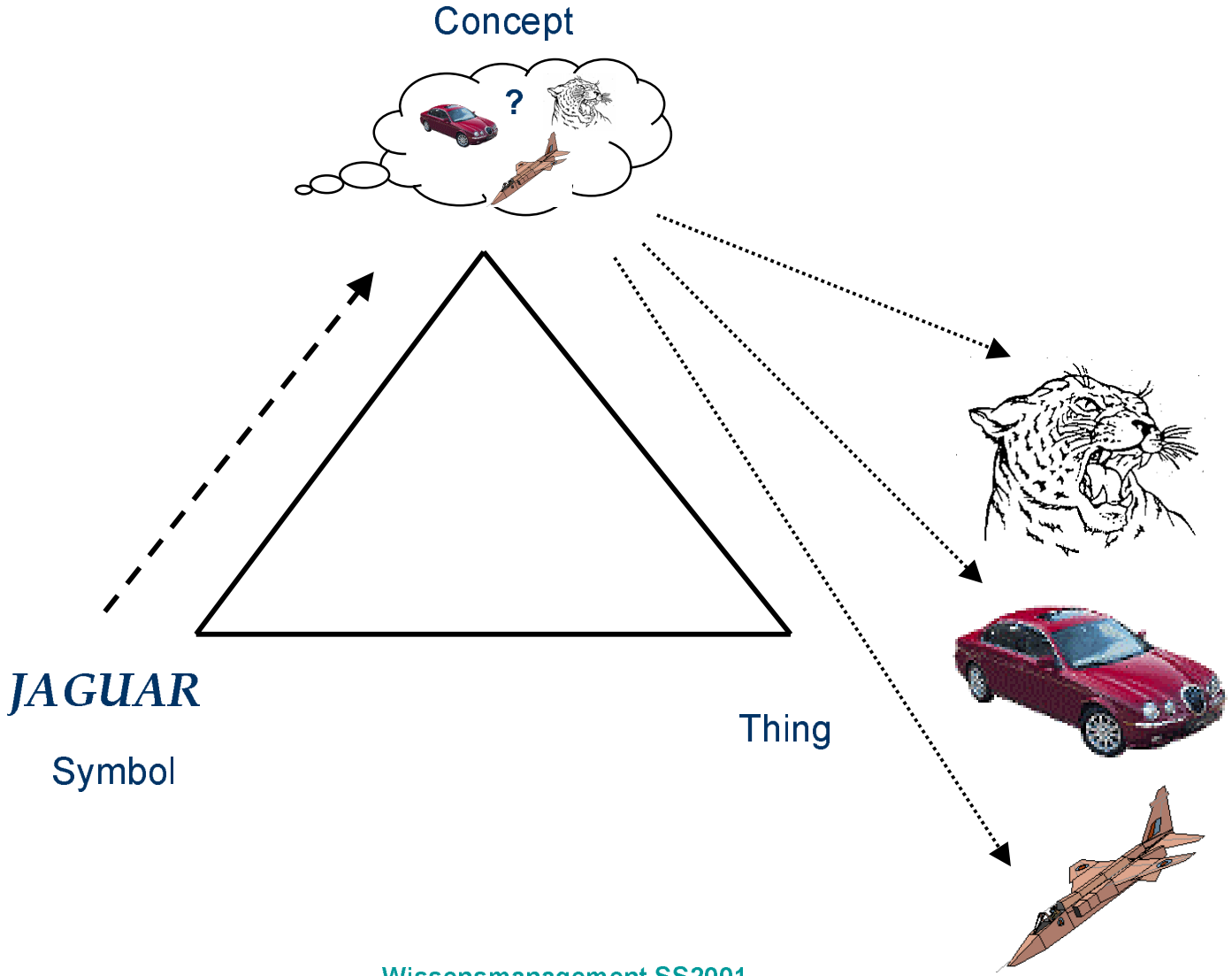
The general context of communication is described by the **meaning triangle**, that defines the interaction between

- symbols,
- concepts and
- things of the world:



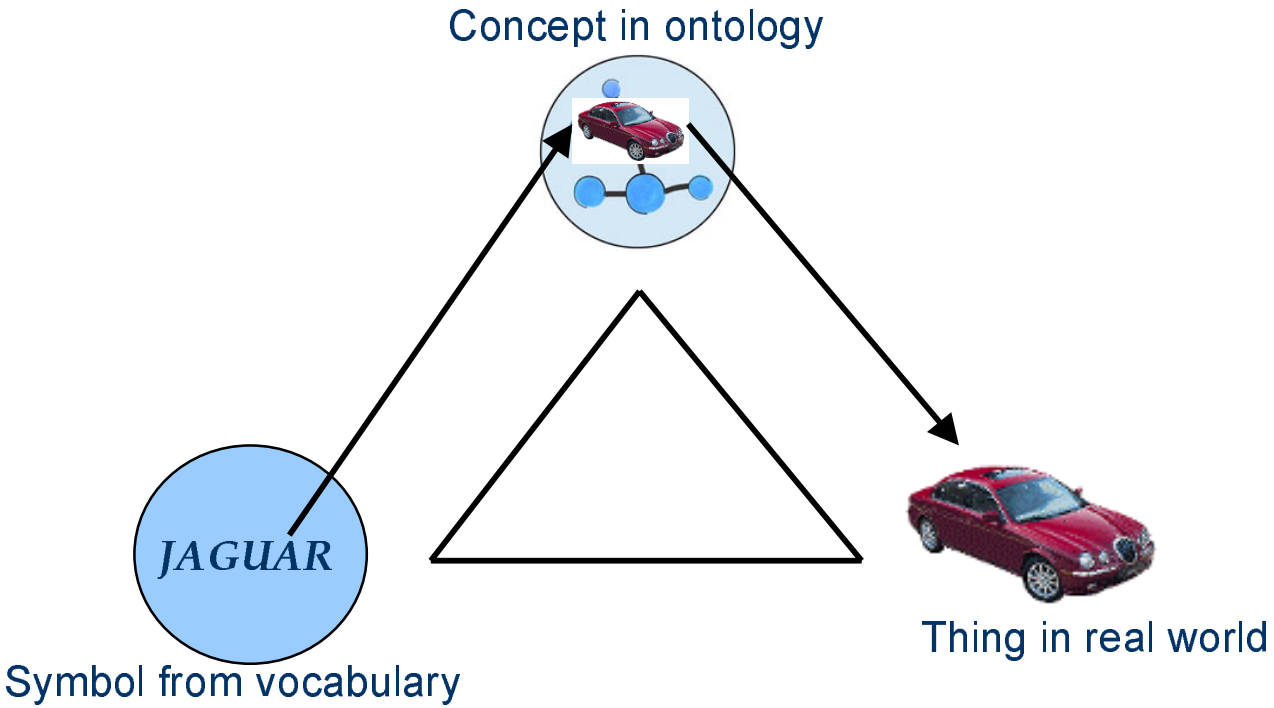
Aufgabe 2

Mapping from Symbols to Things in World



Aufgabe 2

The ontology reduces the number of mapping from **symbols** to **things** in real world



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Aufgabe 2

Communication - Vocabular

In a concrete domain there are two kind of symbols used for communication :

Abstract:

- domain-general terms
- exist in the same or similar meaning in all the state-of-affairs of the domain (in each instantination of the domain)
- they depict abstract terms of domain, not concrete in the sense of THAT ENTITY

Example: Person, Chair, Work

Concrete:

- specific for the given instantination of domain (they are not domain-general, but instantination-specific)
- they are CONCRETE in the sense that they could be refferd with: THAT ENTITY

Example: John, X, Y

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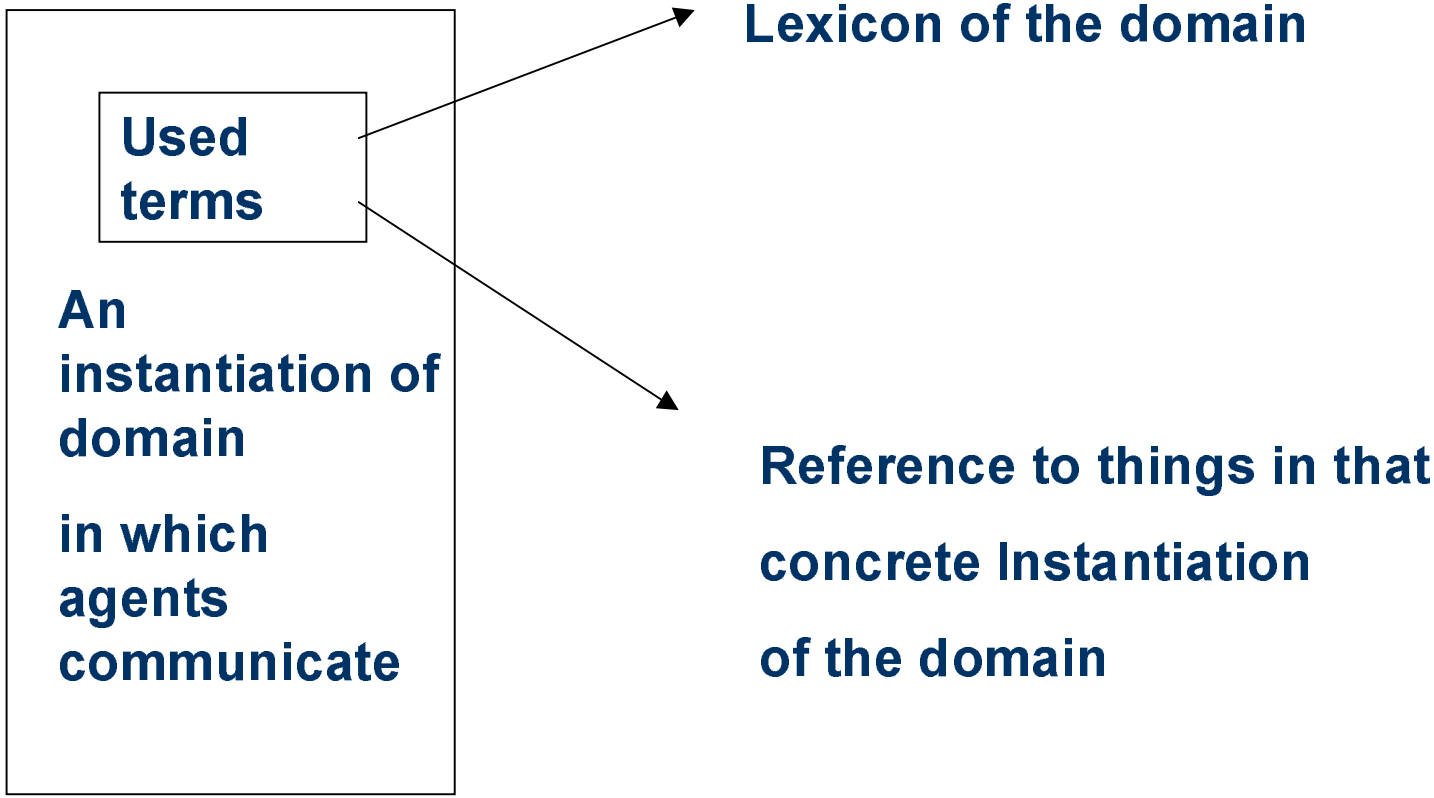
Aufgabe 2

Communication - Vocabular

In a concrete domain there are two kind of symbols used for communication :

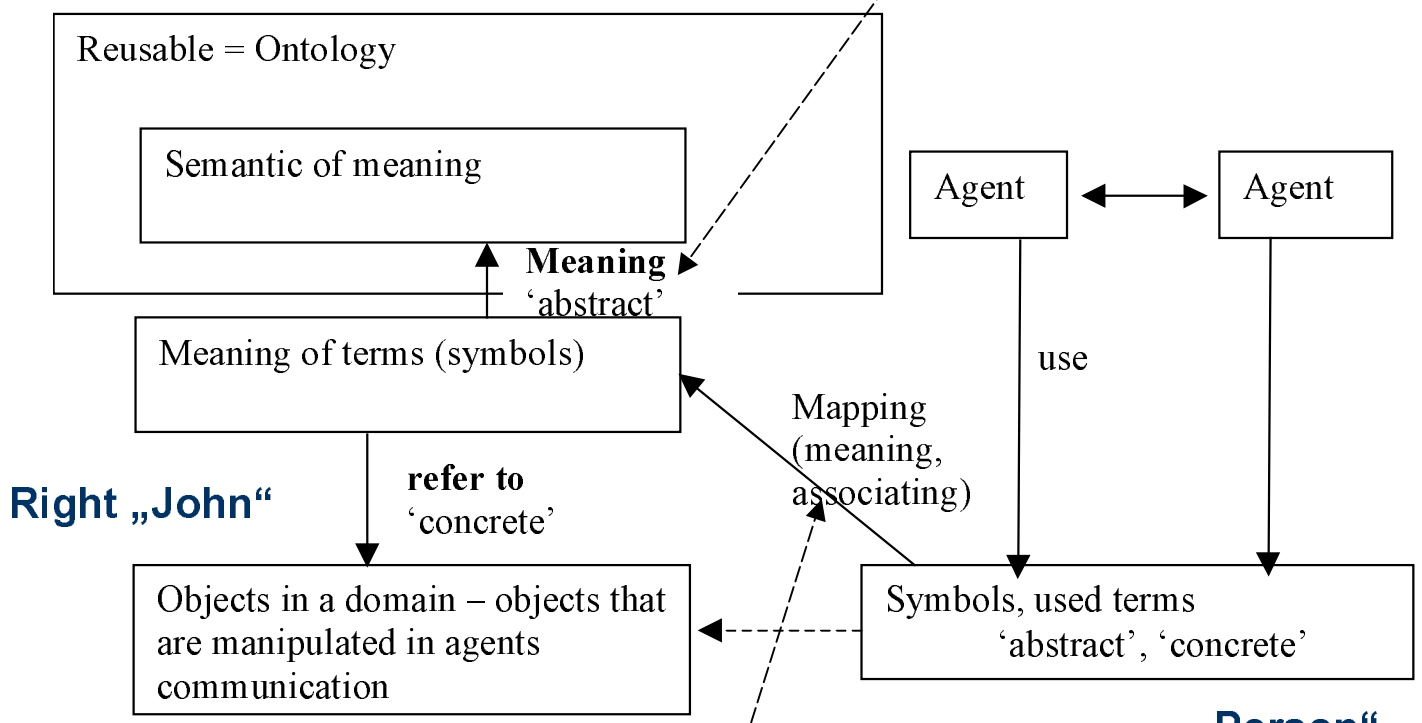


Aufgabe 2

Communication - correct referencing

„Person“ has characteristics .....

„Work“ has Domain/Range ....



Right „John“

„Person“ is concept

„Work“ is relation

„John“ is : Person

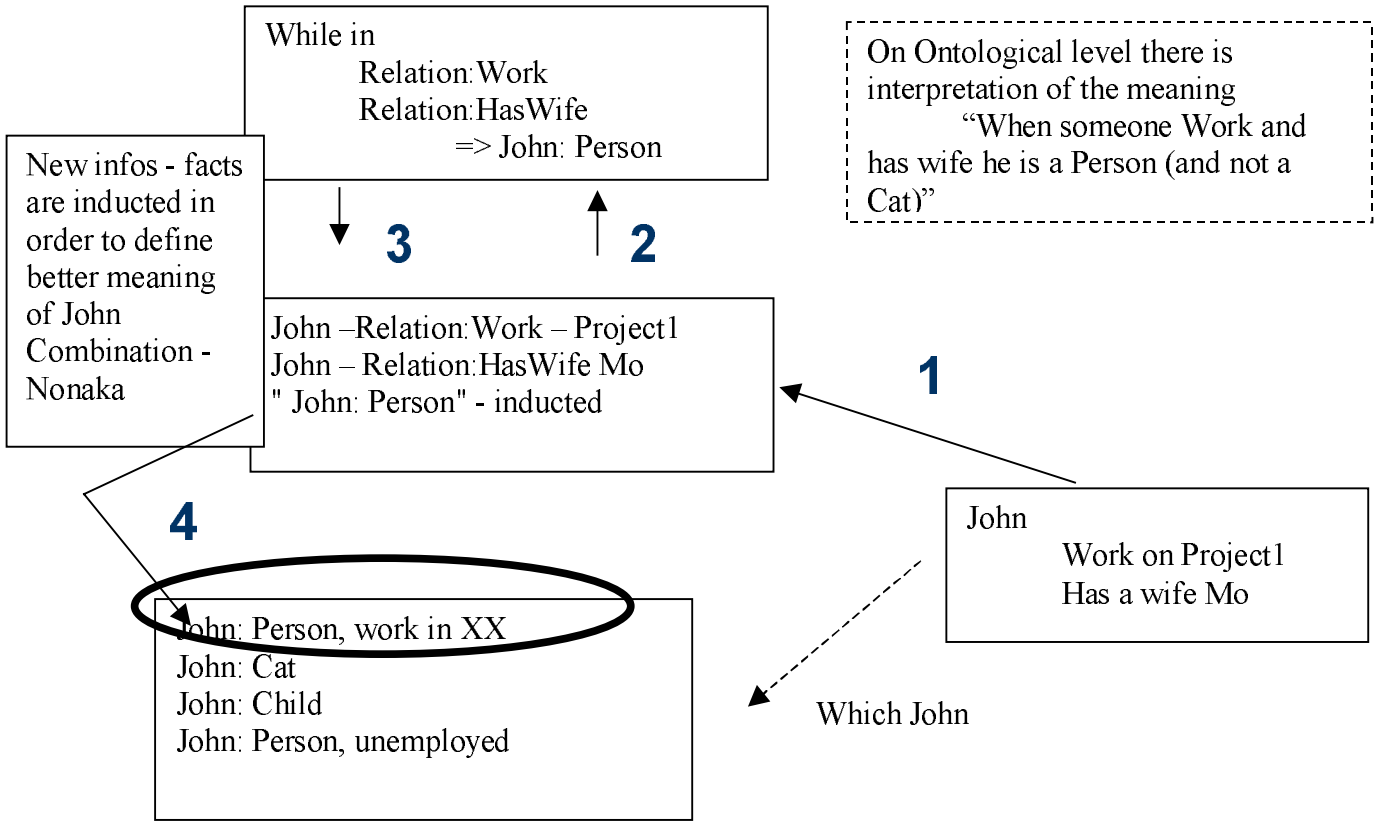
„Person“

„Work“

„John“

Aufgabe 2

Communication - correct referencing example



1 - associating symbols to meaning (concepts, relations, facts)

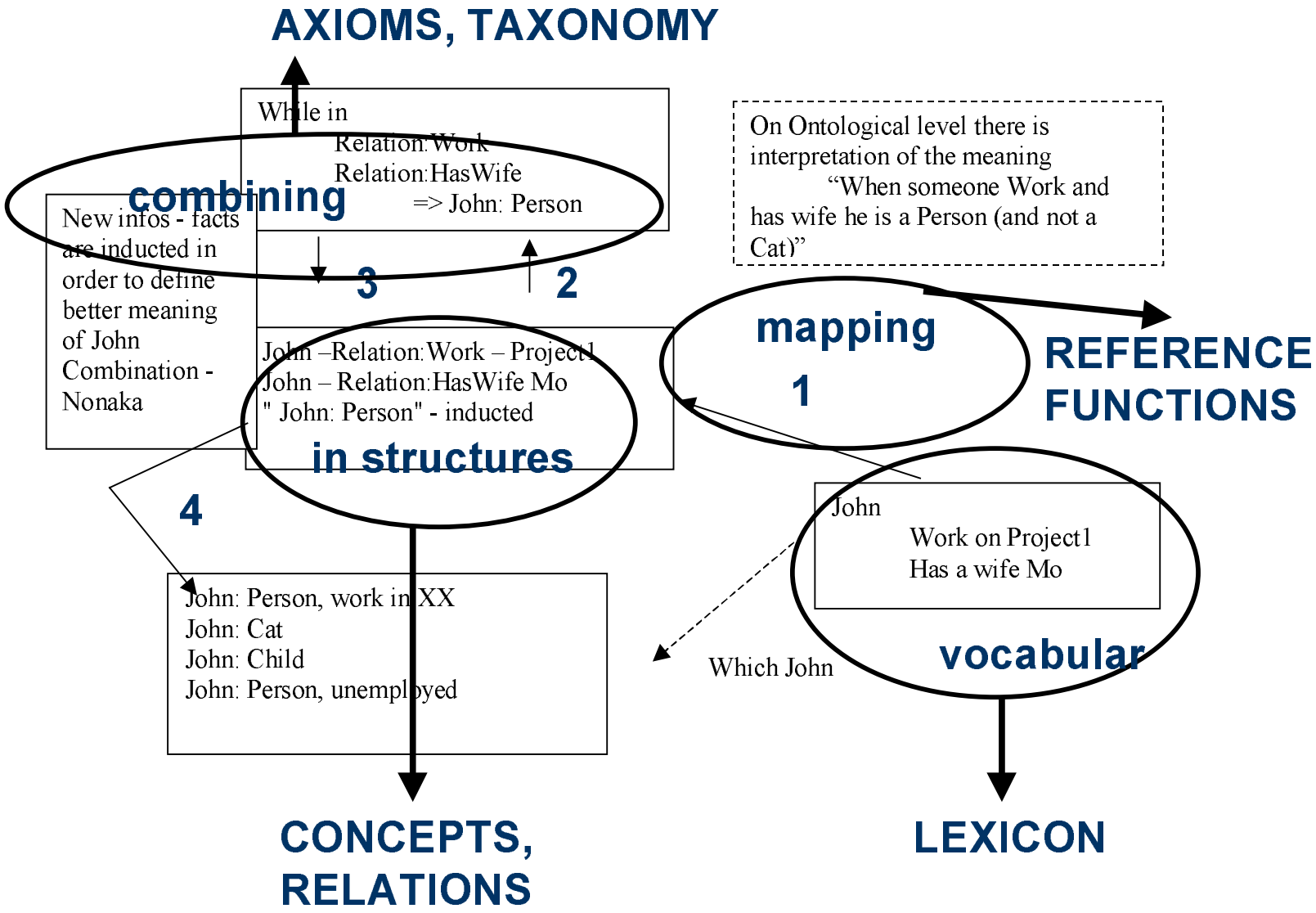
2, 3 - searching for new information about „symbols“

- combining (explicit knowledge -> explicit knowledge)

4 - correct referencing

Aufgabe 2

Communication - necessery components



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Aufgabe 2

Communication – human-machine

How two humans communicate: They NOT use Ids, but Names

Human1: “John has a meeting with Jim”

Human2: “Who is Jim?” ?

Two situations:

1) HumanSender, HumanReciver, Jim are in the same room

Answer: This is Jim

2) HumanSender, HumanReciver, Jim are not in the same room

Answer: Jim, that work at Project X

Which one?

That, that has wife Mary

Oh, That Jim

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Aufgabe 2

Communication – human-machine

How two machine agents communicate: They use IDs

Machine1: “URI-xxxxxx has a meeting with URI-yyyyyy”

Machine1: Roger

term John has no sense for machine (term John and information about that term are used to find corresponding URI)

Which URI-xxxxxx-Question has no sense

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Aufgabe 2

Communication – human-machine

? How communicate human and machine agent?

As like as possible in the human manner, but as processable as possible for machines

Object-attribute-value (the simplest combination of words that has meaning = subject-predicate-object == RDF)

Human:

"John has a meeting with Jim"

Machine agent interprets that in

"URI-xxxxxx has a meeting with URI-yyyyyy"

Basically: MA "interprets" John in URI-xxxxx, the same for Jim

For this interpretation formally represented ontology, processabile for machine agents, is necessary

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Aufgabe 2

Communication – human-machine

Human: “John has a meeting with Jim”

Machine: “Wait a moment, to find the URI of Jim? Jim is the Name, isn’t it?”

Q: ?X[Name->>John]

A: URI-x, URI-y, URI-z, URI-w, URI-v

Hey, there are five Johns in KB

Human: “Jim, that work at Project X”

Q: ?X[Name->>John] and X[work->>ProjectX]

A: URI-y, URI-z, URI-w

Hey, there are still three Johns in KB

Human: “Jim, that has wife Mary”

Q: ?X[Name->>John] and X[work->>ProjectX] and X[wife ->> Marry]

A: URI-z

That URI

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Aufgabe 2

Communication – human-machine

Comment:

There is a situation in which Human agent does not know more information about Jim, or can not find any relevant information

In that case machine for each retrieved list of URI-s finds more information about URIs (name, affiliation, PHOTO) to refresh memory of human agent

Human: "John has a meeting with Jim"

Machine: "Wait a moment, to find the URI of Jim? Jim is the Name, isn't it?"

Which one

Human: No, No, No, This one

Machine: That URI

URI-x

Aufgabe 2

Communication – human-machine

Comment II:

In a situation in which Human agent does not know more information about Jim, machine agent HAS TO

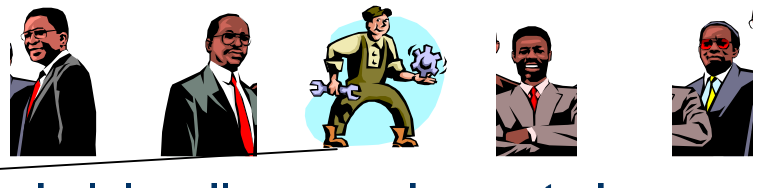
- put minimal set of questions to Human

- AVOID impossible solutions – trivial questions

Human: “John has a meeting with Jim”

Machine: “Wait a moment, to find the URI of Jim? Jim is the Name, isn’t it?”

Which one



Human: No, No, Hey this is technician Jim = no chance to have a meeting with him = trivial question = You have to know that manager have meetings only with managers

Machine: How to know that “manager have meetings only with managers”

Human: Use, for example, knowledge about relation Meeting - Meeting is a sort of talking between managers

Machine: That means, for each relation could be compiled a rule, which should be used to enhance recall in IR

Aufgabe 2

Communication – human-machine

Relation: meeting

Domain: Manager

Range: Manager

⇒ FORALL X, Y X:Manager and Y:Manager <- X[meeting->>Y]

Repeating

Human: “John has a meeting with Jim”

Machine: “Wait a moment, to find the URl of Jim? Jim is the Name, isn’t it?”

Q: ?X[Name->>John] AND X:Manager

Which one?

….

….

…

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Aufgabe 2

Communication – human-machine –
Why axioms are necessary

To avoid misinterpretation

To avoid considering of impossible solutions

Impossible solution = solution inconsistent with ground facts (with semantic of query)

Example

"John has a meeting with Jim", Which Jim

Q1 ?X[Name->>John]

A1 X:Technician – inconsistent

with meaning of relation meeting

Q2:?X[Name->>John] AND X:Manager

A2 –

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Abstract Model of an Ontology (I)

Definition: An ontology is a sign system O:=(L, F, G, C, H, R, A), which consist of:

- A **lexicon**: The lexicon contains a set of signs (lexical entries) for concepts, Lc, and a set of signs for relations, Lt. Their union is the lexicon $L:=Lc \cup Lt$

- A set C of **concepts**: About each $c \in C$ exists at least one statement in the ontology, viz. its embedding in the taxonomy

- A set of binary **relations** R: R denotes a set of binary relations. They specify pairs of domain and ranges (D,R) with D,$R \in C$

  The functions d and r applied to a binary relation R yield the corresponding domain and range concepts D and R, respectively

Abstract Model of an Ontology (Ia)

Example:

lexicon: L = {"employee", "Angestellter", "Angestellte“, “Organisation", “Projekt", “member", “participant", “client", “participate", ... }

concepts: C = {Person, Employee, Manager, Project, Company, FinanceComp, ...}

relations: R = {participantOf, member, client, ...}

d ={(participantOf, Person), (member, Project), (client, Project)},

r ={(participantOf, Project), (member, Person), (client, Company)}

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Abstract Model of an Ontology (II)

- Two **reference functions** F, G, with F: $2^{Lc} \rightarrow 2^{C}$ and G: $2^{Lt} \rightarrow 2^{R}$. F and G link **lexical entries** $\{Li\} \subset L$ to the **concepts** and **relations** they refer to, respectively, in the given ontology.

In general, one lexical entry may refer to several concepts or relations and one concept or relation may be referred to by several lexical entries.

Remark: In order to map easily back and forth and because there is a **n** to **m** mapping between lexicon and concepts/relations, F and G are defined on sets rather than on single objects.

Example:

reference function F: {({"employee", "Angestellter" , "Angestellte"}, {Employee}),...,({"organisation", "Unternehmen" }, {Company}),...}

reference function G: {({"member", "participant"}, {member}), ({"participate"}, {participantOf}), ({"client"}, {client}), ...}

Abstract Model of an Ontology (III)

- A **taxonomy** H: Concepts are taxonomically related by the irreflexive, acyclic, transitive relation H, ($H \subset C \times C$).

  $H(Ci, Cj)$ means that Ci is a subconcept of Cj

- A set of ontology **axioms**, A

Example:

taxonomy: H = {(Manager, Employee), (Employee,Person), (FinanceComp, Company)}

axiom:

in natural language:

IF Person X is participantOf Project Y THEN Project Y has as member Person X

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Aufgabe 2

Struktur von Ontologien

Concrete:

- specific for the given instantiation of domain (they are not domain-general, but instantiation-specific)

- they are CONCRETE in the sense that someone could refer to them with: THAT ENTITY
  Example: John, X, Y

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Aufgabe 3

Ontology development - OTK

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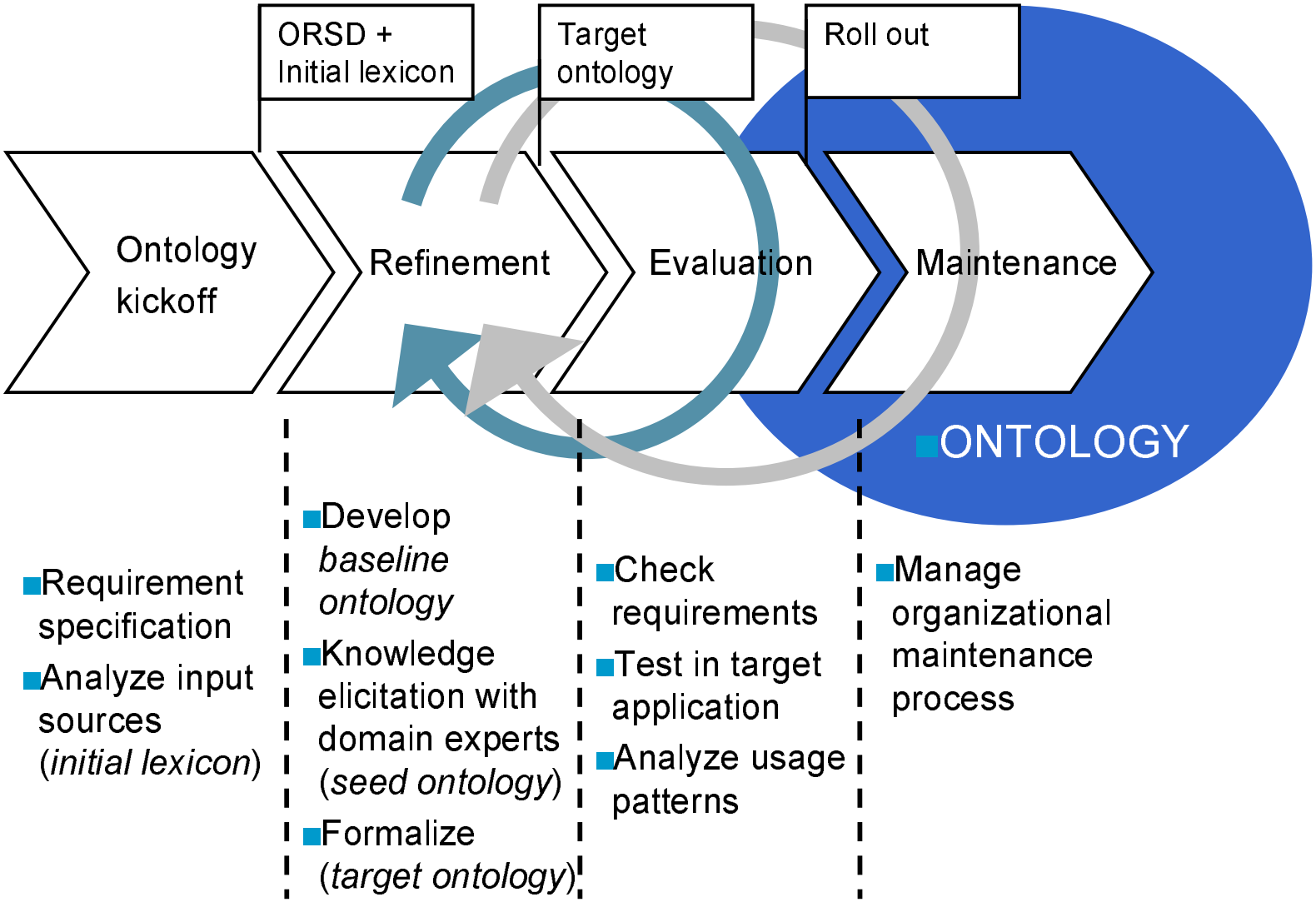
Aufgabe 3

Methodology for Ontology Development

- Development of an ontology-based KM application involves ontology development as a very important subtask
- Outcome of CommonKADS feasibility study is starting point
  - TM-2 worksheet: **Knowledge item analysis**
- Ontology development is split up in several phases:
  - Kick-off phase
  - Refinement phase
  - Evaluation phase
  - Maintenance phase

Ontology Development Process



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Kick-off Phase

- result is **Ontology Requirements Specification Document** (ORSD)
  - characterises the planned area of the ontology application
  - defines the scope of the ontology to be constructed

- ORSD is composed of parts:
  - **administrative information**
    - name
    - date
    - involved ontology engineer(s)
  - **requirements specification**

Ontology Requirements Specification Document

Ontology Requirements Specification Document	
Name:	Research-interest Ontology
Date:	2001/06/06
Ontology Engineer:	T. Model

Domain and Goal:
- The ontology is modeled for the domain *research-interest* which is a part of the *research organisation*
- The ontology serves as a model for sharing knowledge about research interests in a organisation
- Ontology serves as a base for semantic search for researcher/projects according to their research interests

Design Guidelines:
The ontology contains lexical entries in the domain of research-interest in a research organisation. Research-interest are connected to current-preferences, educational background and working-projects of a person. Research-topic hierarchie should be modeled in more details and should not exeed 100 topics. Topic-hierarchy should be modeled at instance level (topics are instances and not concepts). Axioms are planned.

Supported Applications:
Intranet based Research-skill Management System at institute AIFB

Knowledge Sources:
- AIFBweb site - personal pages
- Research reports, publications
- Internal document about institute (organisation, staff)
- Interviews with researcher

Users and Use cases:

G. Peoplefind, Human Ressource Department;	attached use case 1
B. Boss, Project Manager	attached use case 2

Competency Questions:
Attached CQ 1

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Requirements Specification (I)

- **Domain and Goal**
  - what is the objective of the planned KM application
  - based on task analysis (TM-1)
- **Design Guidelines**
  - description of domain in use
  - estimation of size of ontology
  - exploit knowledge item worksheet (TM-2)
- **Supported Applications**
  - brief characteristics of planned application
  - specification of system environment

Requirements Specification (II)

- **Knowledge Sources**
  - types of knowledge sources may be very different
    - domain experts
    - (reusable) ontologies
    - documents / systems
      - dictionaries
      - thesauri
      - product descriptions
      - organisational charts
      - employee role descriptions
      - …
  - Knowledge item analysis is important input (TM-2)

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Requirements Specification (III)

- **Usage Scenarios** (Users and Use cases)
  - describe users/user groups
  - identify stakeholders
  - describe usage scenarios
    - how do they want to use the system?
    - what kind of support do they expect ?
    - use e.g. UML use-case diagrams
- **Competency Questions**
  - define collection of queries that should be supported by the system
  - analyze queries to find relevant lexical entries (concepts and relations)
  - explore scenarios
  - collect competency questionnaire

Competency Questionnaire

Competency Questionnaire No. 1			
Name: skill-man-ontology			
Date: 2001/03/22			
Ontology Engineer: T. Model		**Domain Expert:** X. Pert	
No.	Competency Question	Lexical Entries	Type
Q1	What are the name, position, telefon and e-mail of researcher from research group EA that has research interest in research topic Knowledge Management and work on project with the name Ontobroker ?	researcher	concept
		research group	concept
		research topic	concept
		Knowledge Management *is a* research topic	*isA* relation
		researcher *has research interest* in research topic	relation
		EA is a research group	*isA* relation
		Researcher has name	relation
		Researcher has position	relation
		Researcher has telefon	relation
		... Researcher has e-mail	relation

Competency Questionnaire

Competency Questionnaire No. 1			
Name: skill-man-ontology			
Date: 2001/03/22			
Ontology Engineer: T. Model		**Domain Expert:** X. Pert	
No.	Competency Question	Lexical Entries	Type
Q1	What are name, position, research-group, room number, telefon, email for selected person	researcher	concept
		research group	concept
		research topic	concept
		Knowledge Management *is a* research topic	*isA* relation
		researcher *has research interest* in research topic	relation
		EA is a research group	*isA* relation
		Researcher has name	relation
		Researcher has position	relation
		Researcher has telefon	relation
		... Researcher has e-mail	relation

Competency Questionnaire

Competency Questionnaire No. 1			
Name: skill-man-ontology			
Date: 2001/03/22			
Ontology Engineer: T. Model		**Domain Expert:** X. Pert	
No.	Competency Question	Lexical Entries	Type
Q1	What is secretary for selected professor	professor	concept
		Professor isA researcher	isArelation
		secretary	concept
		Professor has secretary	relation
	Who is supervisor for a selected HiWi	HiWi	concept
		HiWi isA student	isArelation
		HiWi has supervisor	relation
		...	

Competency Questionnaire

Competency Questionnaire No. 1			
Name: skill-man-ontology			
Date: 2001/03/22			
Ontology Engineer: T. Model		**Domain Expert:** X. Pert	
No.	Competency Question	Lexical Entries	Type
Q1	What are the code and name of project from research group EA that is in topic Knowledge Management and that has a researcher named Carter?	project	concept
		research group	concept
		research topic	concept
		Knowledge Management *is a* research topic	*isA* relation
		project *has* research topic	relation
		EA is a research group	*isA* relation
		Project has name	relation
		Project has code	relation
		Researcher has name	relation
		...	

Competency Questionnaire

Competency Questionnaire No. 1			
Name: skill-man-ontology			
Date: 2001/03/22			
Ontology Engineer: T. Model		**Domain Expert:** X. Pert	
No.	Competency Question	Lexical Entries	Type
Q1	What are code, name, research-group, starting-date, description, founded by property, researcher and research-topic for selected project	project	concept
		project has code	relation
		project has name	relation
		project has research group	relation
		project has starting-date	relation
		project has description	relation
		project has founding	relation
		project has researcher	concept
		project has research-topic	concept
		...	

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Initial lexicon

Researcher

Resersch-group

Research-topic

...

Student,

Professor,

...

has research group

has research topic

has researcher

has project

....

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Refinement Phase

- Construct a mature application-oriented target ontology

- Step 1: **Gather baseline ontology**
  - derive **concepts** from lexical entries in initial lexicon
  - embed concepts into **is-a hierarchy** (taxonomy)
  - add additional concepts to taxonomy,
    e.g obvious generalisations of concepts

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Refinement Phase

- Step 2: **Develop Seed Ontology**
  - add additional **concepts**
  - add **relations** between concepts of the baseline ontology
  - add **attributes** to concept descriptions
  - add **axioms** (informal descriptions)
  - perform knowledge elicitation process with domain experts
- Step 3: **Develop Target Ontology**
  - **formalize** seed ontology
  - choose appropriate representation language,

    e.g. Frame Logic, RDF Schema, OIL, DAML+OIL, ...

Refinement Phase

STEP 1: Baseline ontology

Concepts:

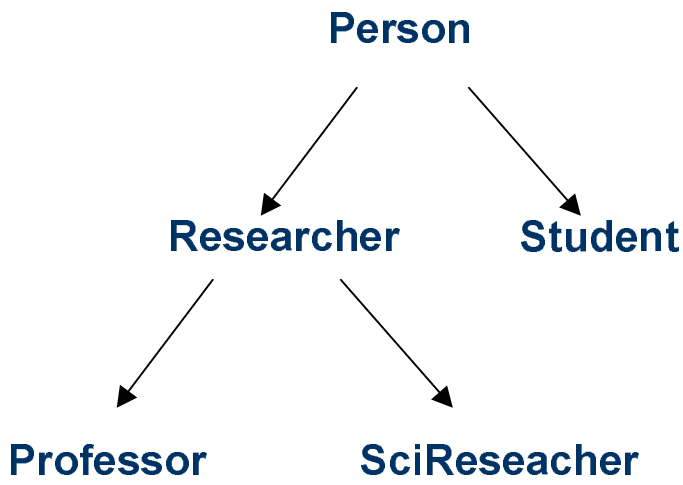
Researcher

Resersch-group

Research-topic,

....

Hierarchy:



Refinement Phase

STEP 2: Seed ontology

Relations:

- Researcher – has research interest – Research-topic
- Project – has research topic – Research-topic
- Project – has researcher – Researcher
- Researcher – has project – Project
- …

Attributes-characteristics of concepts :

- Researcher - has name - String
- Project - has code - String
- ...

Refinement Phase

STEP 2: Seed ontology

Axioms – Possibility to combine relations:

inverse (Person - Project)

transitive (Reseach-topic)

quazi-transitive = possibile syntax patterns

Researcher – has project – Project, Project – has research topic – Research-topic ->
Researcher – has research interest – Research-topic

range-equal = possibile patterns

Researcher – has research interest – Research-topic, Project – has research topic – Research-topic -> Researcher – has project – Project

domain-equal = possibile patterns

Project – has researcher – Researcher, Project – has research topic – Research-topic -> Researcher – has research interest – Research-topic

IF ProjectX has researcher ResearcherX AND ProjectX has research topic Research-topicZ THEN ResearcherX has research interest Research-topicZ

Refinement Phase

STEP 3: Formalize ontology

Concepts, Relations, Axioms

Example: In F-Logic

- **Inverese** FORALL ProjectX, ResearcherX

  ResearcherX:Researcher[has project - >>ProjectX]
  <- ProjectX:Project[has researcher ->> ResearcherX].

- **Transitive**

- **Composition (combination)**

IF ProjectX has researcher ResearcherX AND ProjectX has research topic Research-topicZ THEN ResearcherX has research interest Research-topicZ

FORALL ProjectX, ResearcherX, Research-topicZ

ResearcherX:Researcher[has research interest - >>Research-topicZ] <- ProjectX:Project[has researcher ->> ResearcherX] and ProjectX[has research topic->> Research-topicZ]

Refinement Phase

STEP 3: Ontology formalised in RDF (a part)

```
.....
 <rdfs:Class rdf:ID="Person">
      <daml:restrictedBy>
        <daml:Restriction>
          <daml:onProperty rdf:resource="#titel"/>
          <daml:toClass rdf:resource="http://www.w3.org/TR/xmlschema-2/#string"/>
        </daml:Restriction>
      </daml:restrictedBy>
      <daml:restrictedBy>
        <daml:Restriction>
          <daml:onProperty rdf:resource="#nachname"/>
          <daml:toClass rdf:resource="http://www.w3.org/TR/xmlschema-2/#string"/>
        </daml:Restriction>
      </daml:restrictedBy>
      <daml:restrictedBy>
        <daml:Restriction>
          <daml:onProperty rdf:resource="#vorname"/>
          <daml:toClass rdf:resource="http://www.w3.org/TR/xmlschema-2/#string"/>
        </daml:Restriction>
      </daml:restrictedBy>
...
  </rdfs>
```

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Refinement Phase

STEP 3: Ontology formalised in F-Logic (a part)

```
...
Person ::  Root.
Person[
 nachname=>>STRING;
 vorname=>>STRING;
 telefon=>>STRING;
 fax=>>STRING;
 email=>>STRING;
 raumnummer=>>STRING;
 titel=>>STRING;]

Mitarbeiter ::  Person.
Mitarbeiter[verwaltungsfunktion=>>STRING].

Administrativer_Mitarbeiter ::  Mitarbeiter.
Administrativer_Mitarbeiter[funktion=>>STRING].

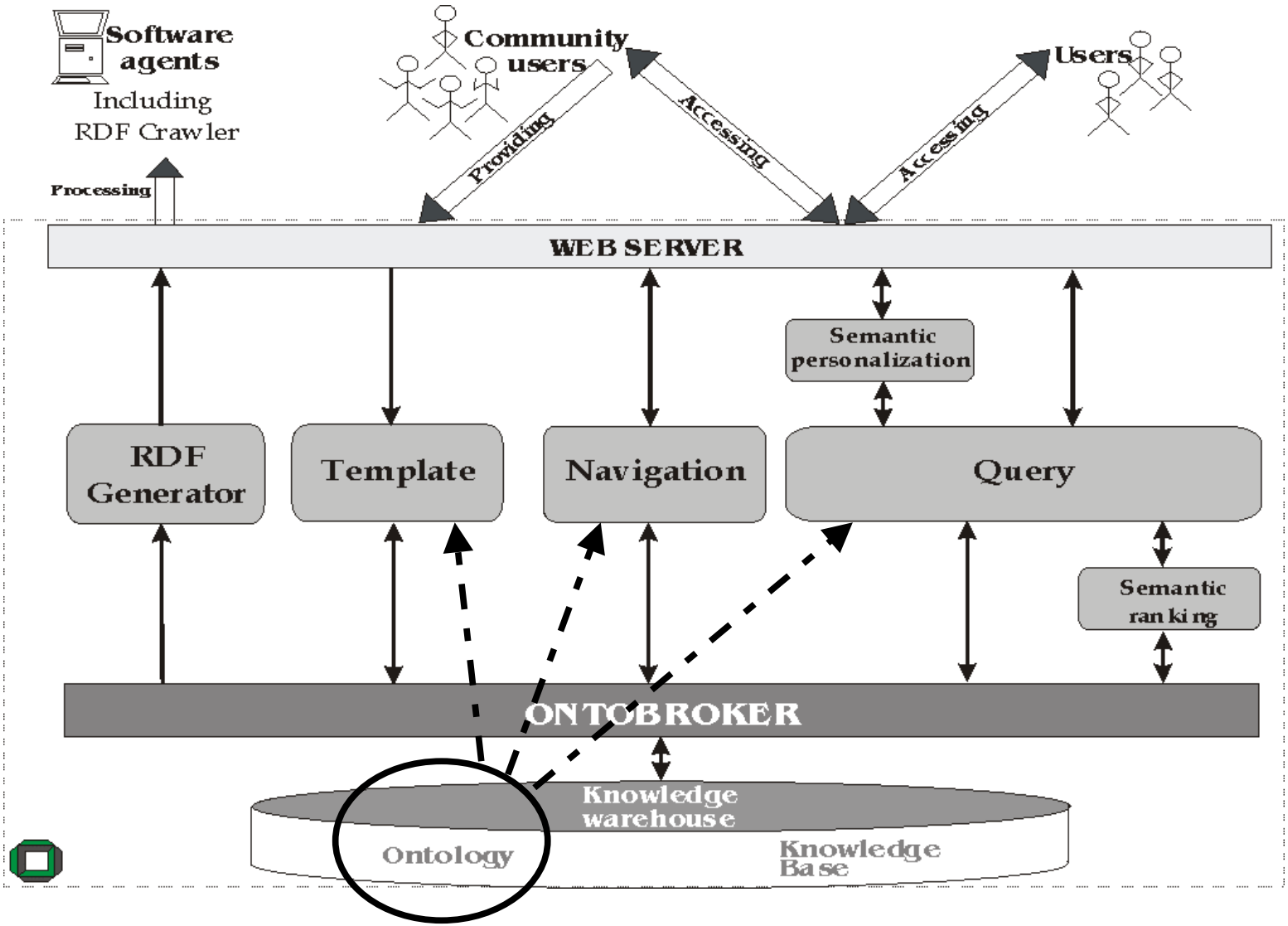
Sekretaerin ::  Administrativer_Mitarbeiter.

...
```

Maintenance Phase

- running application has to adapt to changing environment
  - ontology has to adapt as well (**evolving ontology**)
- evolving aspects:
  - new lexical entries show up in application
    - extend ontology
  - lexical entries change meaning
    - change reference function
  - parts of ontology became obsolete (not needed anymore)
- set up clearly defined **organisational process** for updating the ontology
  - feeds back to refinement phase
  - update ontology by ontology engineer based on collection of proposed changes

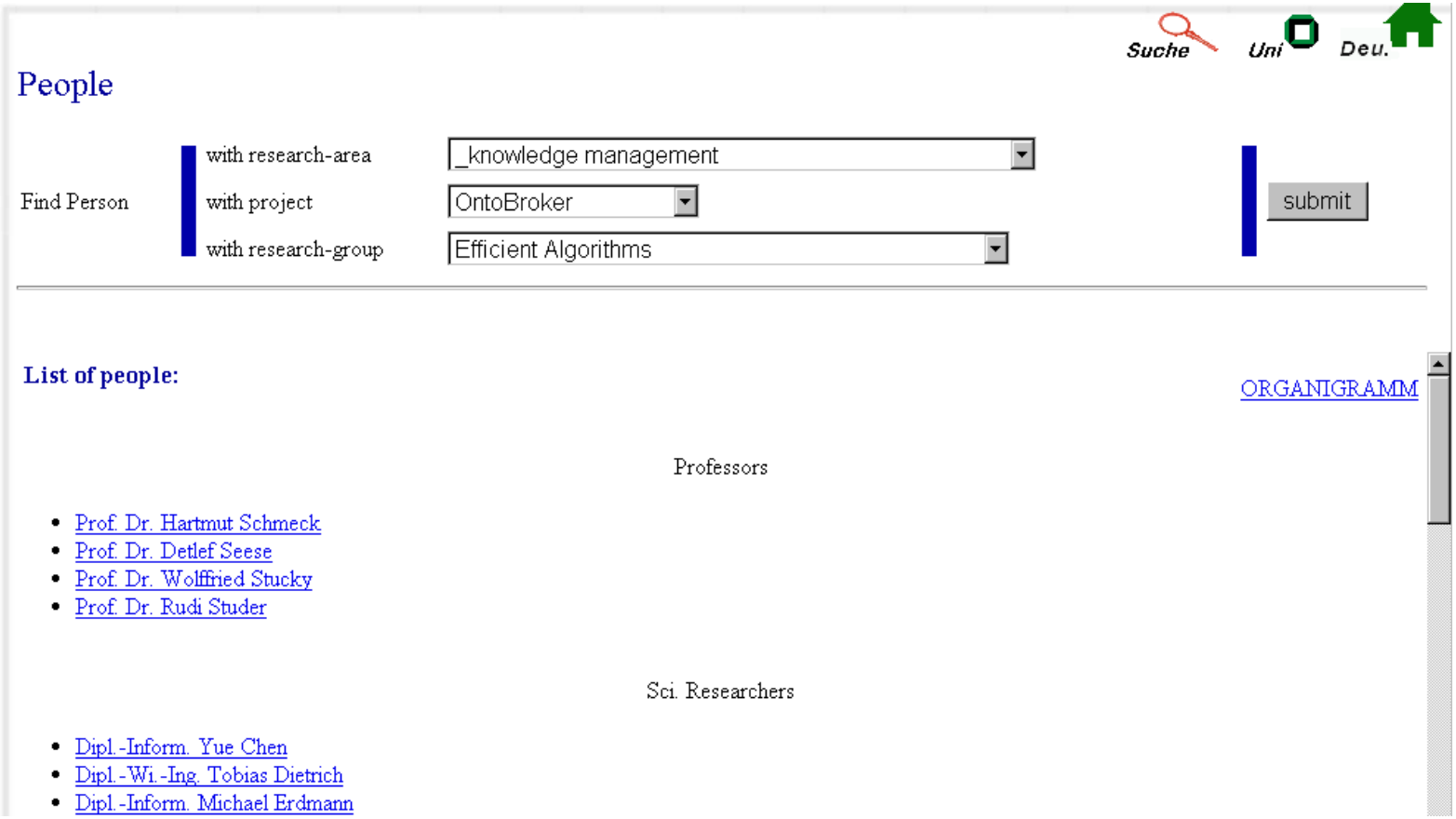
Aufgabe 3 - realisation



Aufgabe 3

User requests (Competency Questionnaire) are implemented:

What are the name, position, telefon and e-mail of researcher from research group EA that has research interest in research topic Knowledge Management and work on project with the name Ontobroker ?



Aufgabe 3

User requests (Competency Questionnaire) are implemented:

What are name, position, research-group, room number, telefon, email for selected person

Dipl.-Inform. Michael Erdmann

Institute for Applied Informatics and Formal Description Methods - AIFB
University of Karlsruhe
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Research Group: Knowledge Management

Position: sci. researcher

Telephone: +49 721 608-6592

eMail: erdmann@aifb.uni-karlsruhe.de

Room number: 262

More Info:

- in german
- in english

Research:

- Publications

Projects:

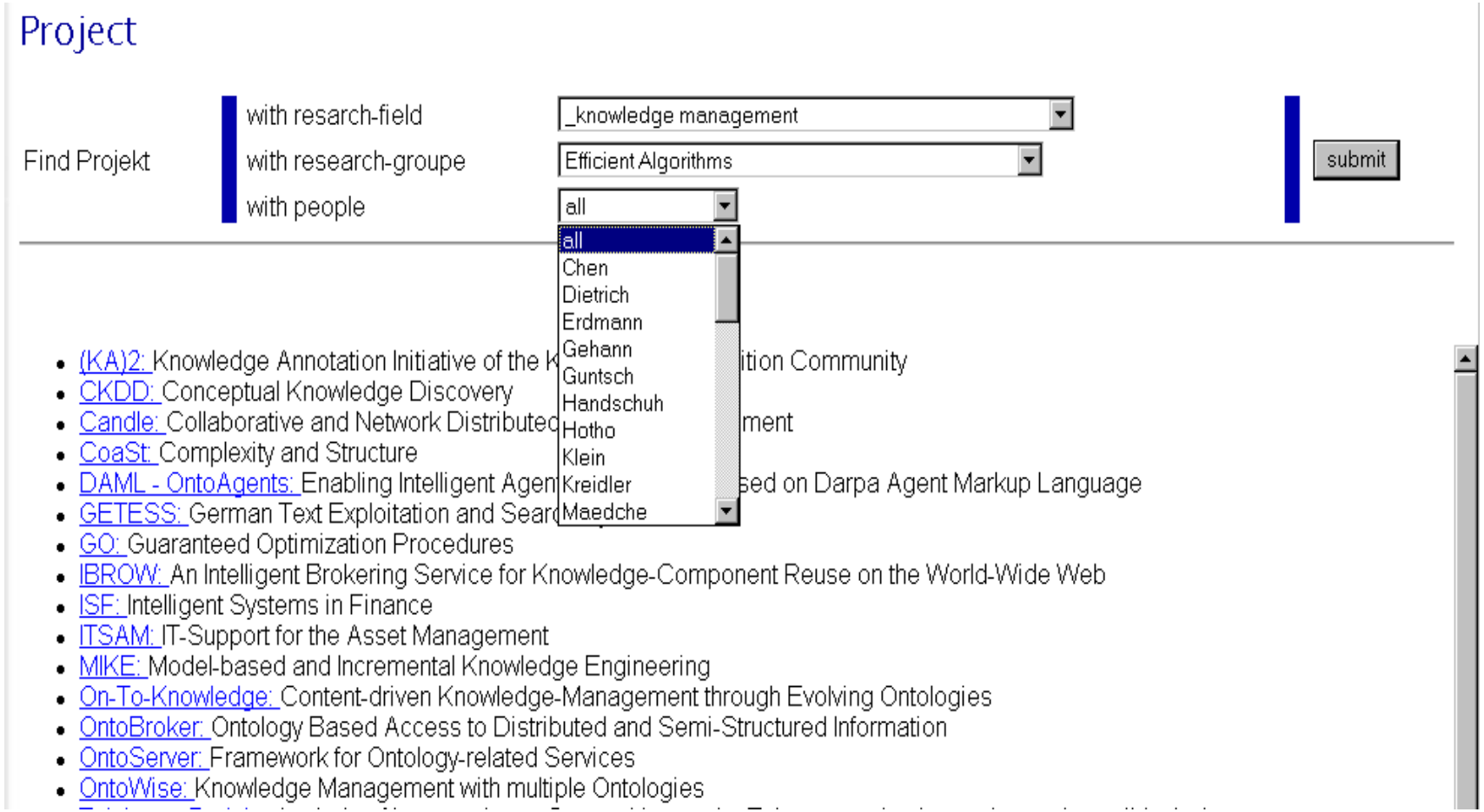
- OntoBroker
- (KA)2

Field of research:

Aufgabe 3

User requests (Competency Questionnaire) are implemented:

What are the code and name of project from research group EA that is in topic Knowledge Management and that has a researcher named Carter?



Aufgabe 3

User requests (Competency Questionnaire) are implemented:

What are code, name, research-group, starting-date, description, founded by property, researcher and research-topic for selected project

OntoBroker:

Ontologie-basierter Zugriff auf verteilte und semi-strukturierte Informatione

Forschungsgruppe:
- Wissensmanagement

Forschungsgebiete:
- Ontology Engineering
- Wissensmanagementsysteme

Mitarbeiter:
- Erdmann Michael
- Staab Steffen
- Studer Rudi

Homepage: http://ontobroker.aifb.uni-karlsruhe.de/

Beschreibung: During the last years the WWW has become increasingly popular leading to a incredible large amount of knowledge that is provided by it. However, intelligent access to its knowledge pieces is still very limited. The Ontobroker project uses ontologies to annotate and wrap Web documents and provides an ontology-based answering service to overcome this bottleneck. The Ontobroker supports clients that query for knowledge as well as providers that want to enhange the accessability of their web documents.

Engl.

Aufgabe 3

Source of a web page

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Informatione":DESTRING'></a>
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semi-strukturierte Informatione"]'> Ontologie-basierter Zugriff auf verteilte und semi-
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>>"c_Wissensmanagementsysteme"]'></a>Wissensmanagementsysteme</a></li>
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...
```

Aufgabe 3

Onto-Edit