



Case-Based Reasoning and Expert Systems

Klaus-Dieter Althoff

**Competence Center
Case-Based Reasoning
German Research Center
for Artificial Intelligence (DFKI)
Intelligent Information Systems Lab
Institute of Computer Science
University of Hildesheim**

The DFKI research labs



Saarbrücken



Kaiserslautern



Bremen

Intelligent
User Interfaces
Prof. Wahlster

Knowledge
Management
Prof. Dengel

Robotics
Prof. Kirchner

Language Technology
Prof. Uszkoreit

Augmented Vision
Prof. Stricker

Cyber-Physical
Systems
Prof. Drechsler

Agents and
Simulated Reality
Prof. Slusallek

Embedded Intelligence
Prof. Lukowicz

Institute for
Information Systems
Prof. Loos

Center for Human-
Machine Interaction
Prof. Zühlke

Associated Labs

The DFKI research labs



Saarbrücken



Kaiserslautern



Bremen

Intelligent
User Interfaces
Prof. Wahlster

Knowledge
Management
Prof. Dengel

Robotics
Prof. Kirchner

Language Technology
Prof. Uszkoreit

Augmented Vision
Prof. Stricker

Cyber-Physical
Systems
Prof. Drechsler

Agents and
Simulated Reality
Prof. Slusallek

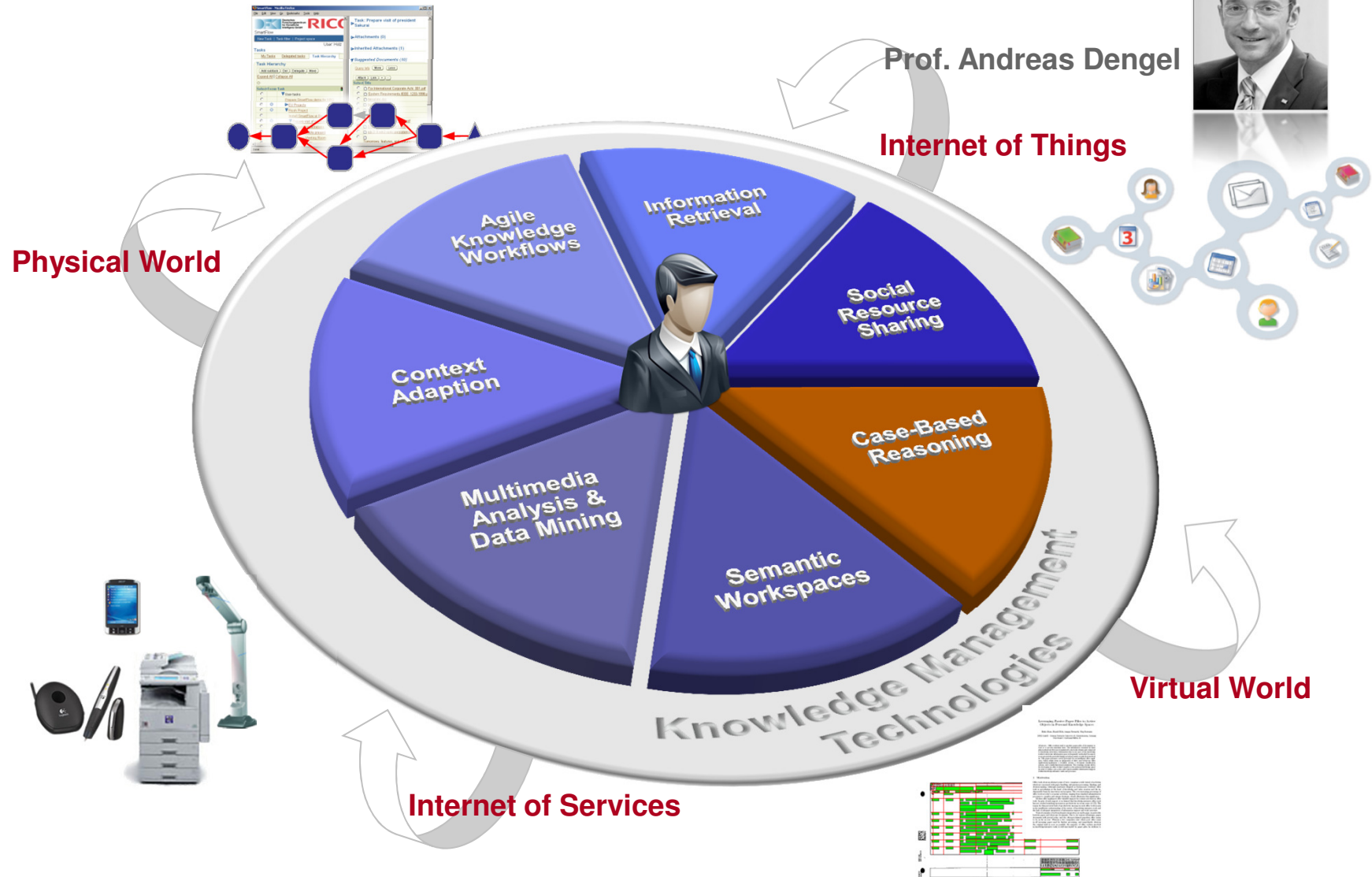
Embedded Intelligence
Prof. Lukowicz

Institute for
Information Systems
Prof. Loos

Center for Human-
Machine Interaction
Prof. Zühlke

Associated Labs

The Knowledge Management Department aims at the technological support of knowledge workers



Prof. Andreas Dengel



- ▶ Founded in May 2010
 - Collaboration contract with University of Hildesheim
- ▶ Currently 3 (Senior) Researchers
 - further PhD students / student assistants
- ▶ myCBR project
 - Collaboration with University of West London (Prof. Roth-Berghofer)
- ▶ Current projects
 - Travel medicine
 - Computer cooking / nutrition
 - Life counseling
 - UNIFARM EU project
- ▶ Former projects on diagnostics, decision support, experience management, customer support / help desk
 - VW Financial Services, John Deere, etc.



Case-Based Reasoning and Expert Systems

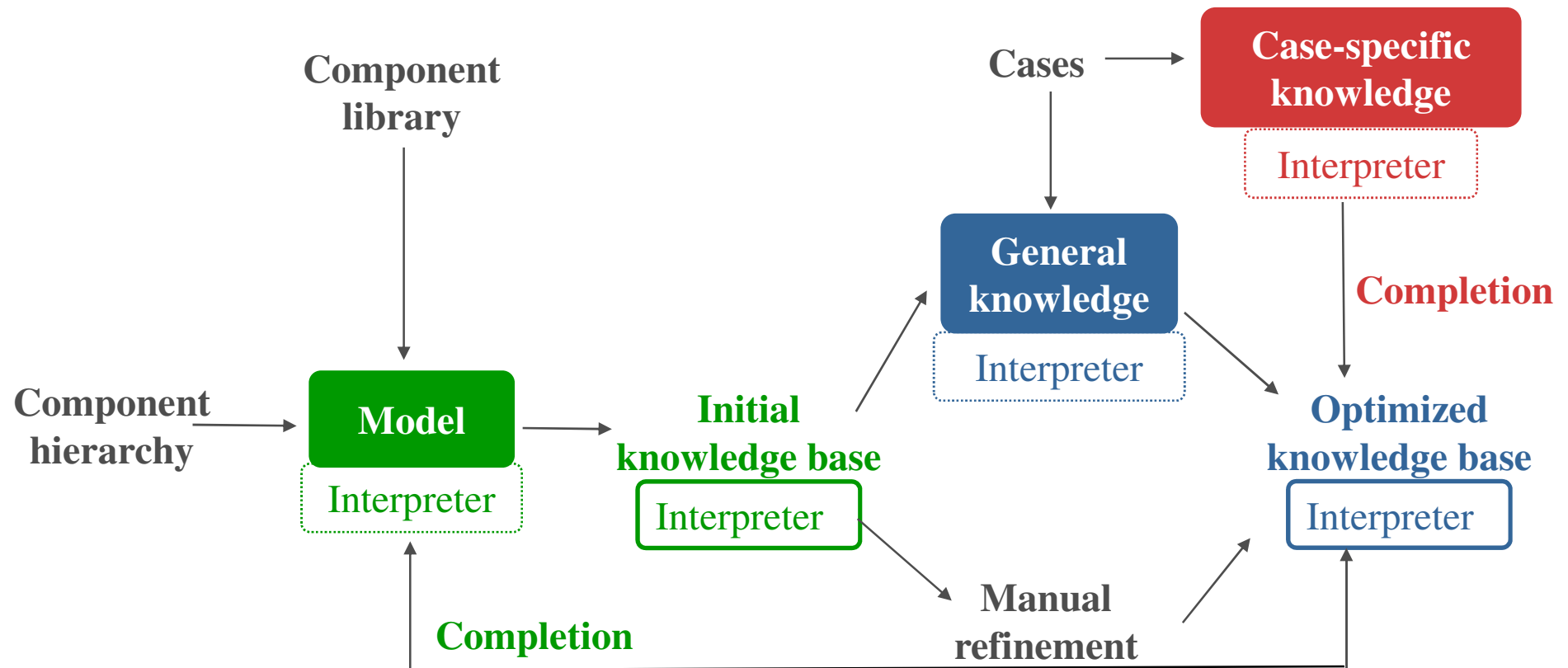
Klaus-Dieter Althoff

**Competence Center
Case-Based Reasoning
German Research Center
for Artificial Intelligence (DFKI)
Intelligent Information Systems Lab
Institute of Computer Science
University of Hildesheim**

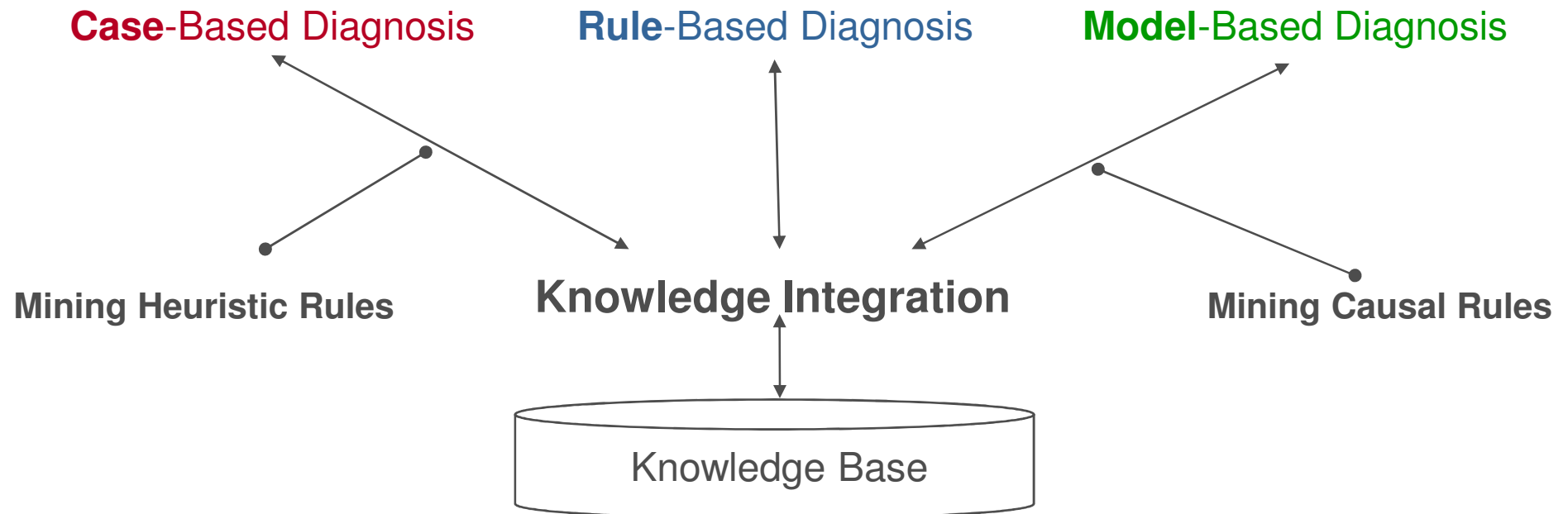
Some Bits of History

- ▶ Case-based reasoning (CBR) and expert systems have a long tradition in artificial intelligence
 - Expert systems since the late 1960s.
 - Expert systems are based on expertise and expert reasoning capabilities for a specific area of responsibility
 - CBR since the late 1970s
 - CBR is an approach for problem solving and learning of humans and computers.
- ▶ MOLTKE project on technical diagnosis
 - Different techniques for technical diagnosis
 - Different roles CBR can play here

Model-Based, Associative Diagnostic System (MOLTKE)



Different Reasoning Strategies for Technical Diagnosis



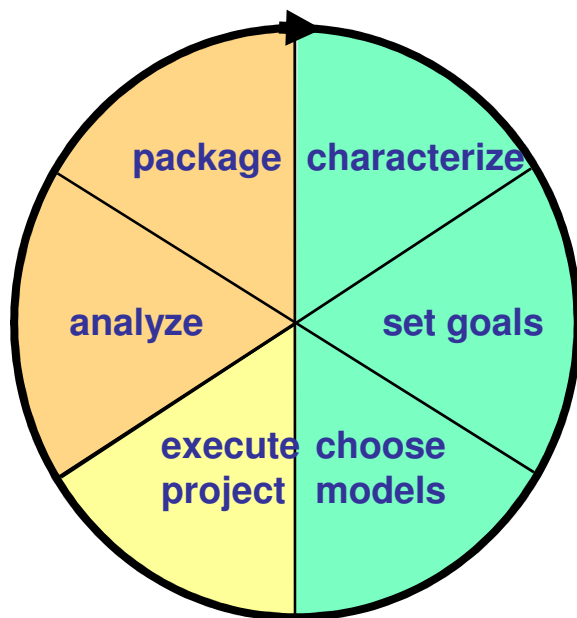
- ▶ Achievements and challenges
 - Knowledge acquisition bottleneck
 - Expertise modeling
 - Ontologies / semantic web technologies
 - Artificial Intelligence and Software Engineering
- ▶ Learning from humans to improve expert systems
 - Integrating problem-solving and learning
 - Combining different problem solving strategies
 - Utilizing different kinds of knowledge
 - Becoming experts for specific areas of responsibility
- ▶ Since humans do all these processes as background jobs, we need a scientific approach that easily supports us to develop expert systems with such abilities
 - Potential of CBR to become a core part of future expert systems

Artificial Intelligence and Software Engineering

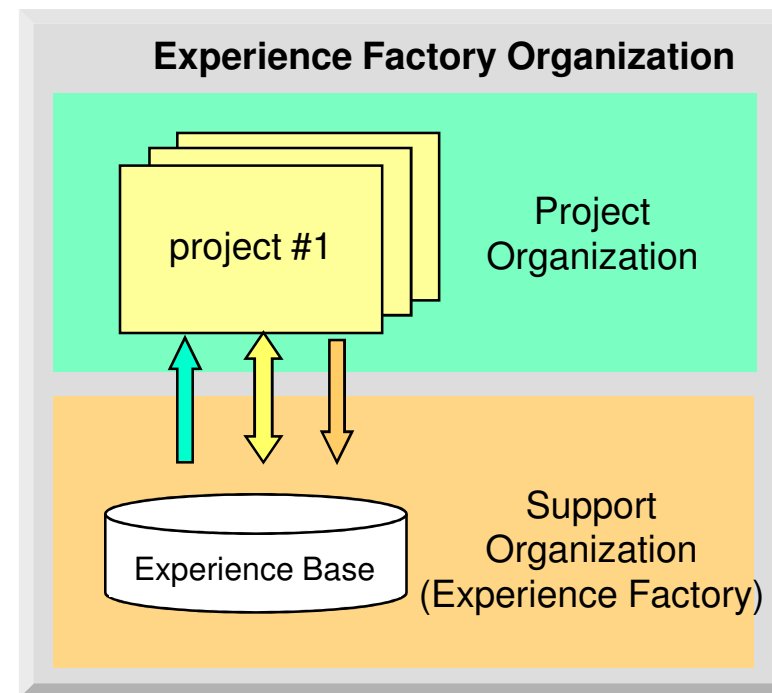
- ▶ Software Engineering
 - Software Product Line
 - Experience Factory

Experience Factory and Quality Improvement Paradigm

Quality Improvement (QIP) Paradigm (Basili, Rombach, 1988)



Experience Factory (EF) Organization (Basili, Rombach, 1988)

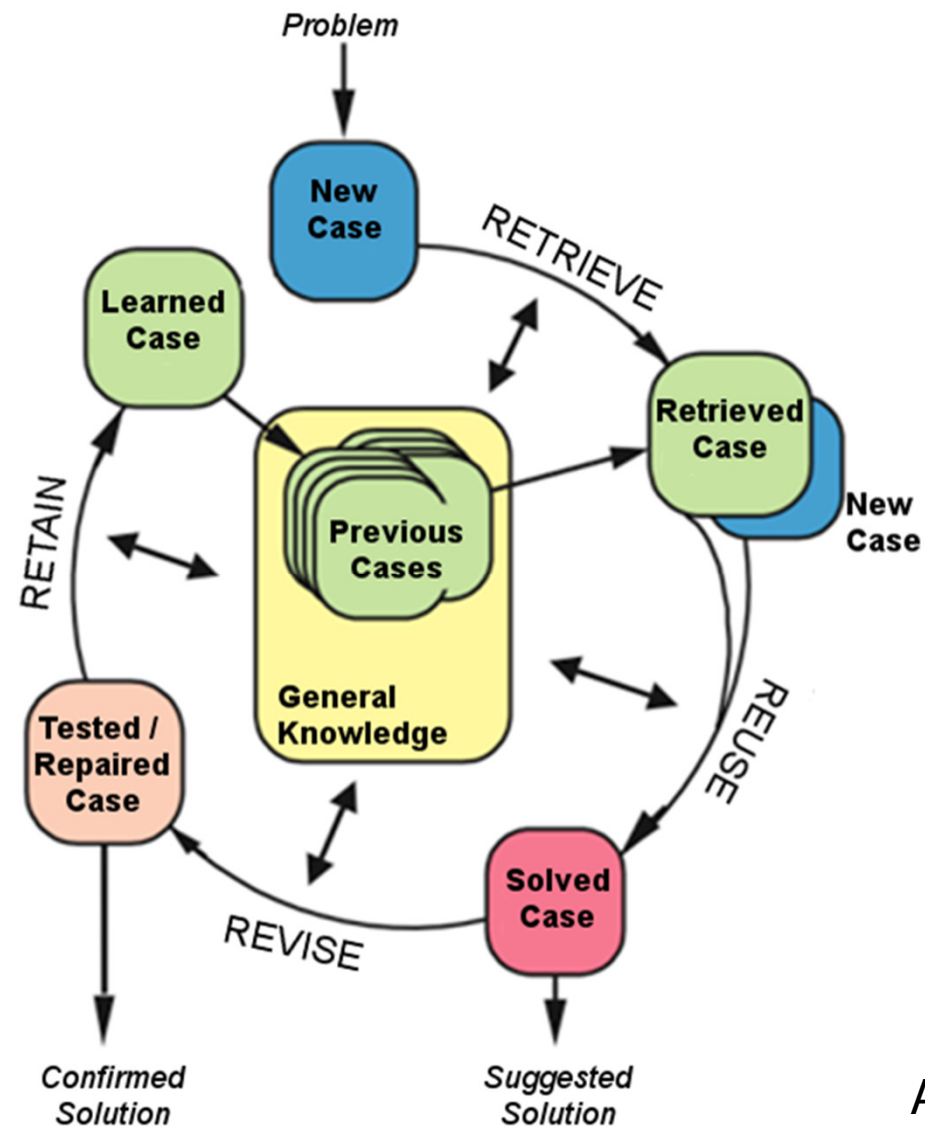


Artificial Intelligence and Software Engineering

- ▶ Software Engineering
 - Software Product Line
 - Experience Factory
- ▶ Artificial Intelligence
 - Case-Based Reasoning
 - Multi-Agent Systems
- ▶ Collaborative Multi-Expert-Systems (CoMES)
 - Case Factory
 - Knowledge Line

- ▶ Good research is often the search for the right level of abstraction ...

CBR cycle



Aamodt & Plaza 1994

Artificial Intelligence and Software Engineering

- ▶ Software Engineering
 - Software Product Line
 - Experience Factory
- ▶ Artificial Intelligence
 - Case-Based Reasoning
 - Multi-Agent Systems
- ▶ Collaborative Multi-Expert-Systems (CoMES)
 - Case Factory
 - Knowledge Line
- ▶ Good research is often the search for the right level of abstraction ...
 - But it also has to open up for further detailing ...

CBR Task-Method Decomposition

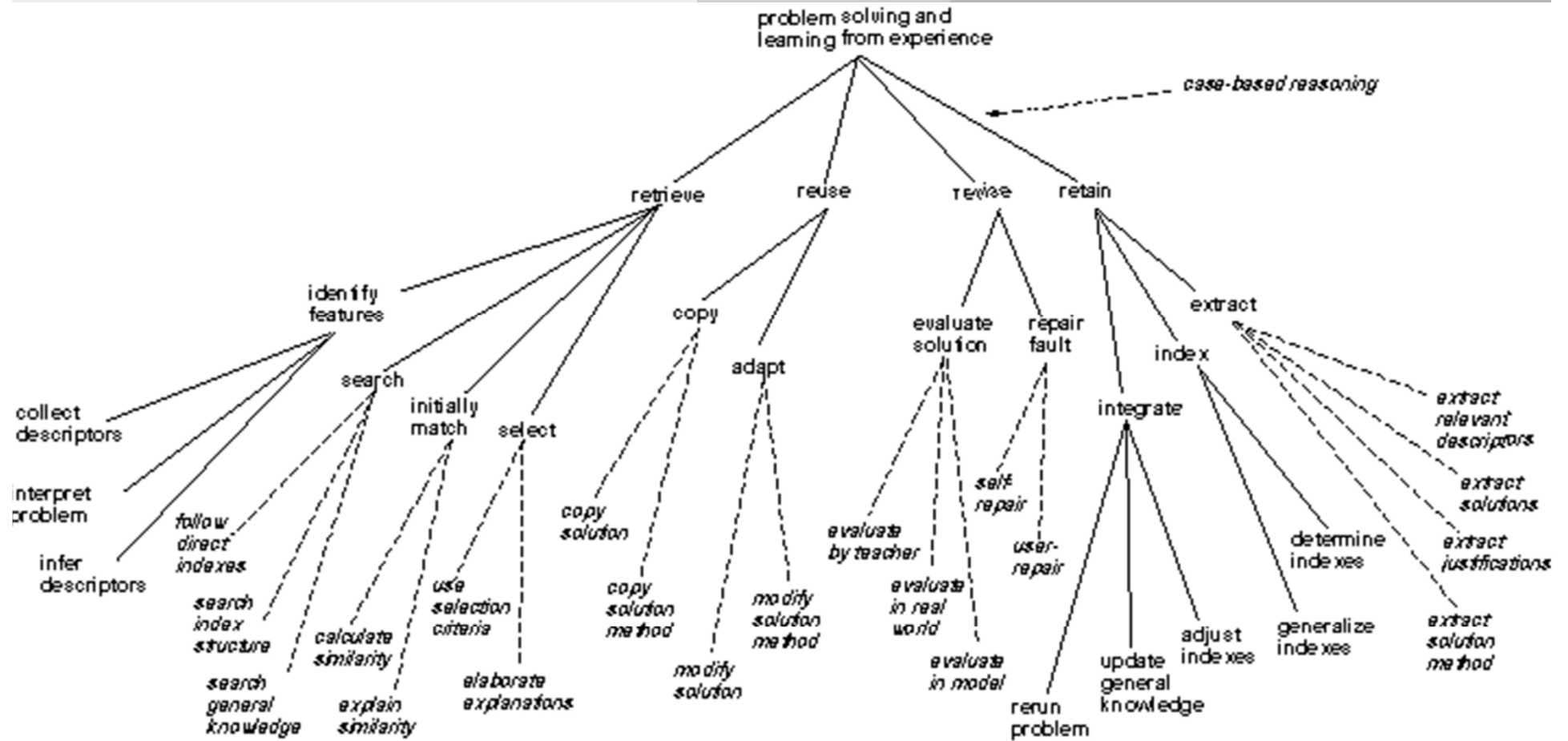
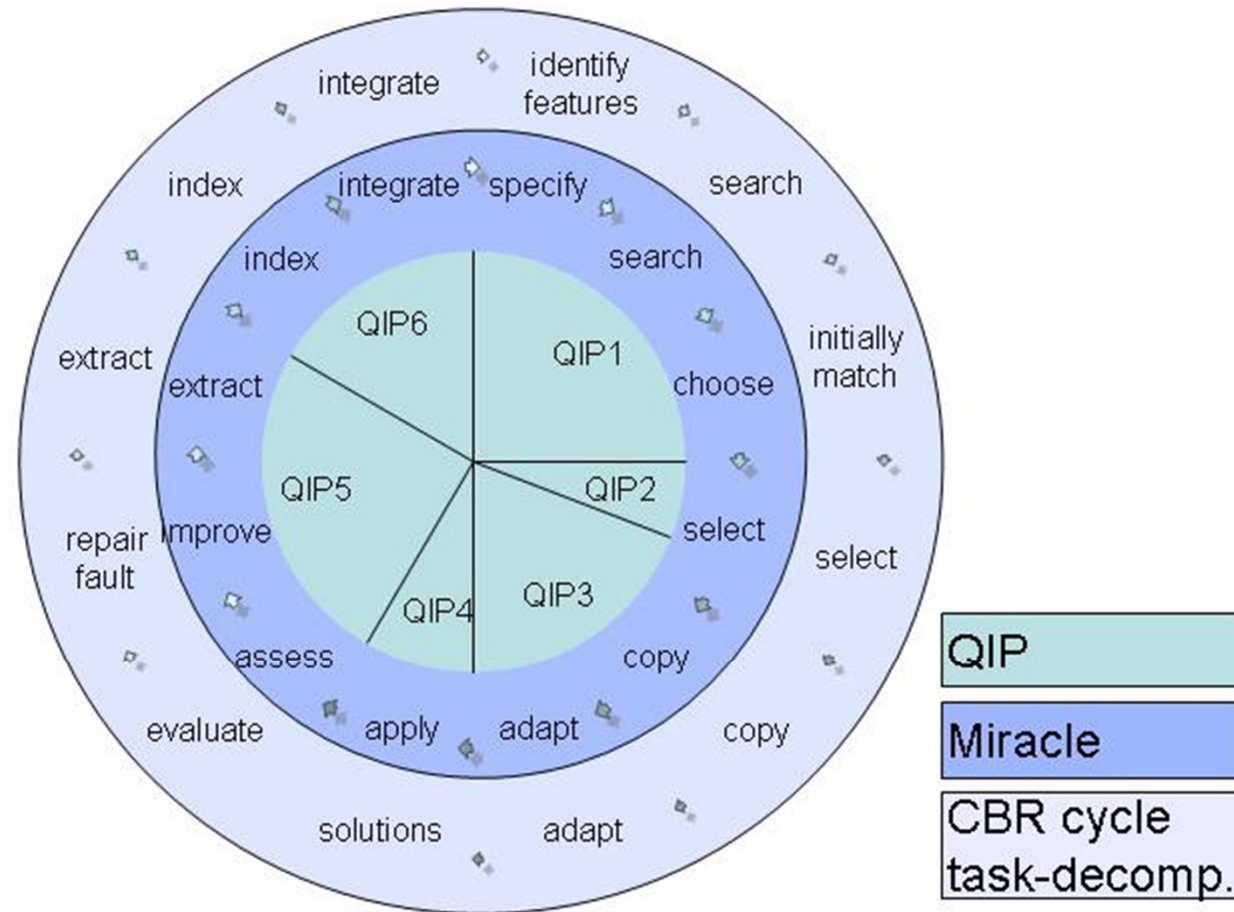


Figure 2. A task-method decomposition of CBR

Aamodt & Plaza 1994

Relating CBR and EF/QIP

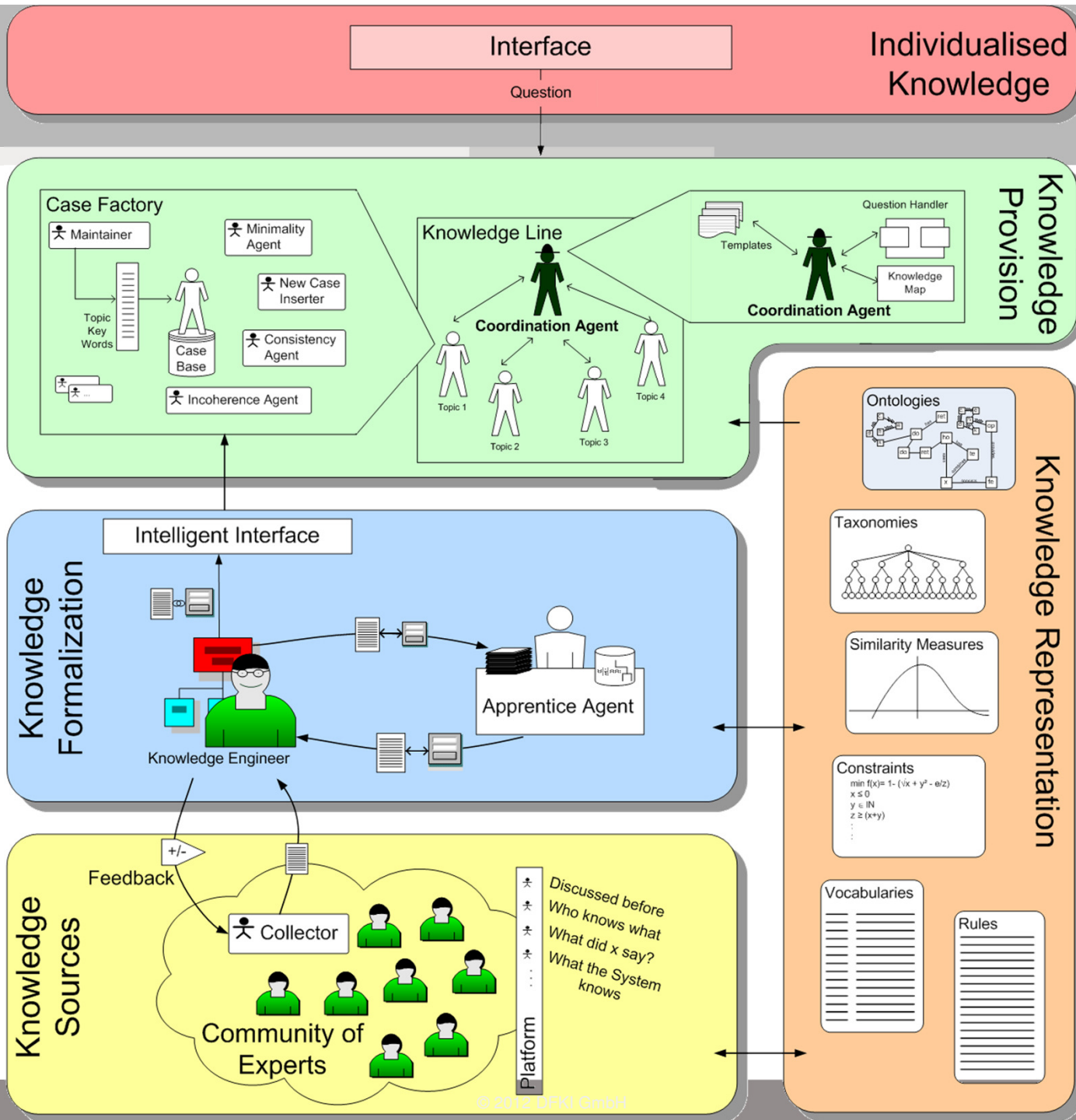


Tautz 2001

Sharing Experience using an Agent-based System Architecture Layout (SEASALT)

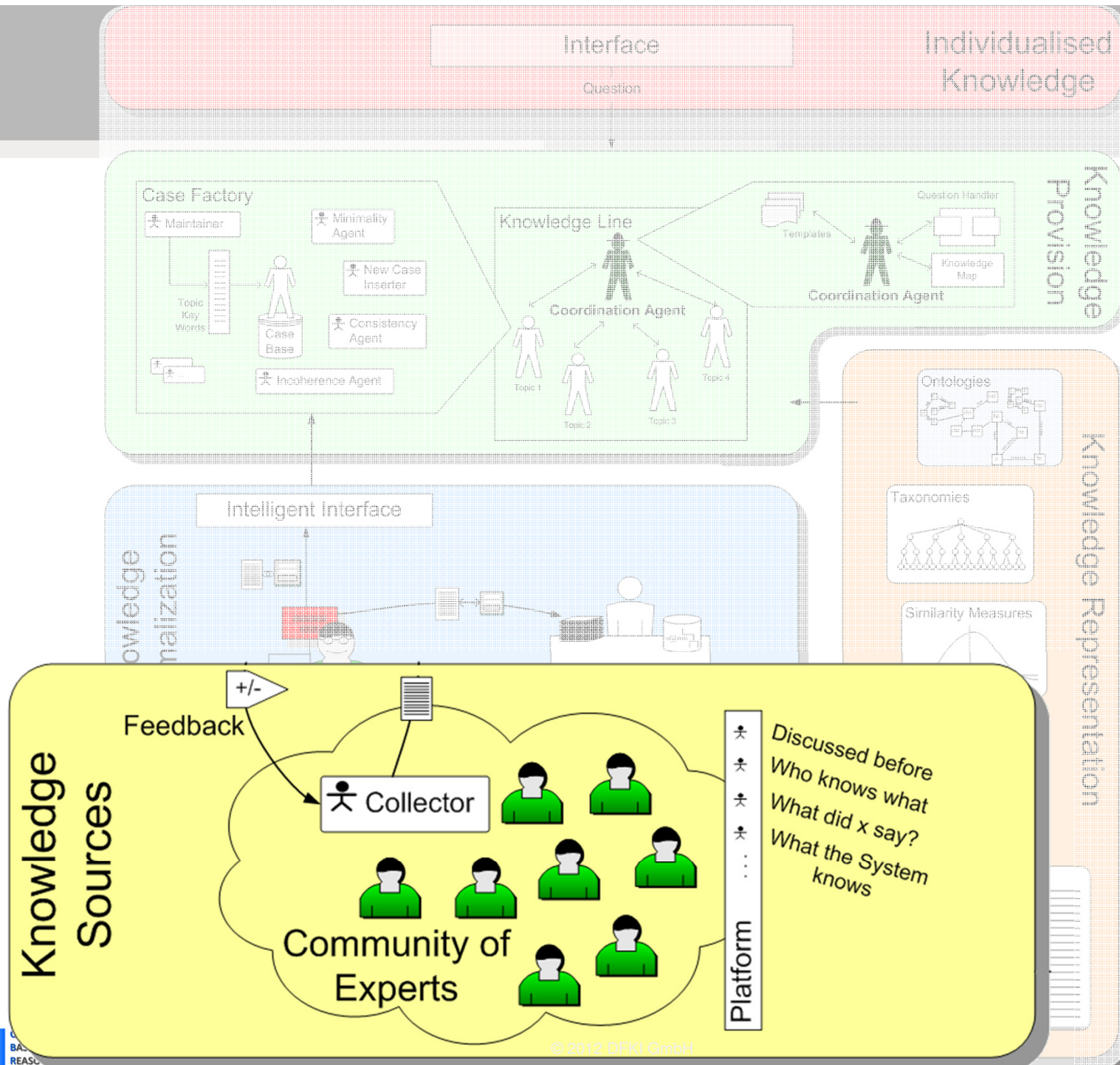
- ▶ SEASALT – Instantiating CoMES
 - Knowledge sources
 - Knowledge formalization
 - Knowledge provision
 - Knowledge representation
 - Individualized knowledge
- ▶ With SEASALT we hope to have a valuable level of abstraction
- ▶ Besides describing our own activities on this level of detail - together with our concrete implementations - we are also looking for collaboration partners
 - We already collaborate with University of West London (Th. Roth-Berghofer) with respect to explanation awareness

SEASALT



- ▶ docQuery
 - Intelligent information system on travel medicine
 - Instance of the SESALT architecture
- ▶ Holds modularised information on ...
 - countries and regions
 - risks of diseases at destinations
 - travelling limitations arising from chronic illnesses
 - activities and related risks
 - medicaments, vaccinations
- ▶ Used by (prospective) travellers both at home and on site
- ▶ Knowledge maintained by a community of experts on travel medicine

SEASALT



Experience in Web Communities

- ▶ Experts discuss topics in their field
- ▶ Collector agents monitor their discussion
 - JADE-based MAS
- ▶ Classification of relevant snippets
 - Snippet: single post in a discussion thread
 - Supervised Learning: SVM Agent and C4.5 Agent (Weka library)
 - Gazetteer Agent

Knowledge Engineering View (Classification)

Feedback-GUI des Klassifikationstool zur Reisemedizin

Übersicht Foreneinträge Wortlisten

zu bearbeiten alle bearbeitet

30 Foreneinträge

Nutzer	Thema	Eintrag	Datum	Thread-ID	TopicThread-ID	Nutzer-ID
Strolchi	Impfung Polio-Tetanus und D...	Hi, fliegen heute in...	Zugriff z.Z. nicht möglich	24563	4206	1292
Strolchi	Re:Impfung Polio-Tetanus un...	Also ich wär da vorsichtig. <br ...	Zugriff z.Z. nicht möglich	24582	4206	1292
Strolchi	Re:Impfung Polio-Tetanus un...	Moin Sweetlipp, ic...	Zugriff z.Z. nicht möglich	24583	4206	1292
Strolchi	Re:Impfung Polio-Tetanus un...	Hallo, ich arbeite selbst ...	Zugriff z.Z. nicht möglich	24615	4206	1292

markierter Foreneintrag

Nutzer: Strolchi

Nutzer-ID: 1292

Thema: Re:Impfung Polio-Tetanus und Diphtherie

Foreneintrag: MOIN SWEETLIPP,

ich **HALTE** die **TETANUSIMPFUNG** für **WICHTIGER** als die gegen Typhus und würde die noch machen lassen. Wenn Du Rechtshänder bist, lasse sie Dir halt in den linken **ARM** verpassen. Schau mal hier: <http://WWW.fit-for-travel.de/REISEMEDIZIN/KRANKHEITEN/TETANUS.htm> Wenn man sich den Erreger erst mal eingefangen hat, ist es für die **IMPFUNG** meines Wissens zu spät.

Wenn Dein Immunsystem nach der **IMPFUNG** noch eine Woche später geschwächt sein sollte, dann bestimmt nicht wegen der **IMPFUNG**, sondern wegen der Angst, daß sie diese Auswirkungen haben könnte.

Gruß
Wolfgang

Klassifikation

Schlagworte anzeigen ARRF-Attribute anzeigen

Collectoragenten: gefundene ARRF-Attribute der Klasse:

Ihre Klassifikation:	SW:	C4.5:	SVM:	Anzeigen:
<input checked="" type="checkbox"/> Krankheiten	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="radio"/>
<input type="checkbox"/> Aktivitäten	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>
<input type="checkbox"/> Regionen	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="radio"/>
<input type="checkbox"/> Personen	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>
<input type="checkbox"/> Medikamente	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>
<input checked="" type="checkbox"/> Gesundheitsrisiken	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="radio"/>
<input type="checkbox"/> Krankenhäuser	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>

Agent übernehmen <->

Wort hinzufügen:

einfügen in:

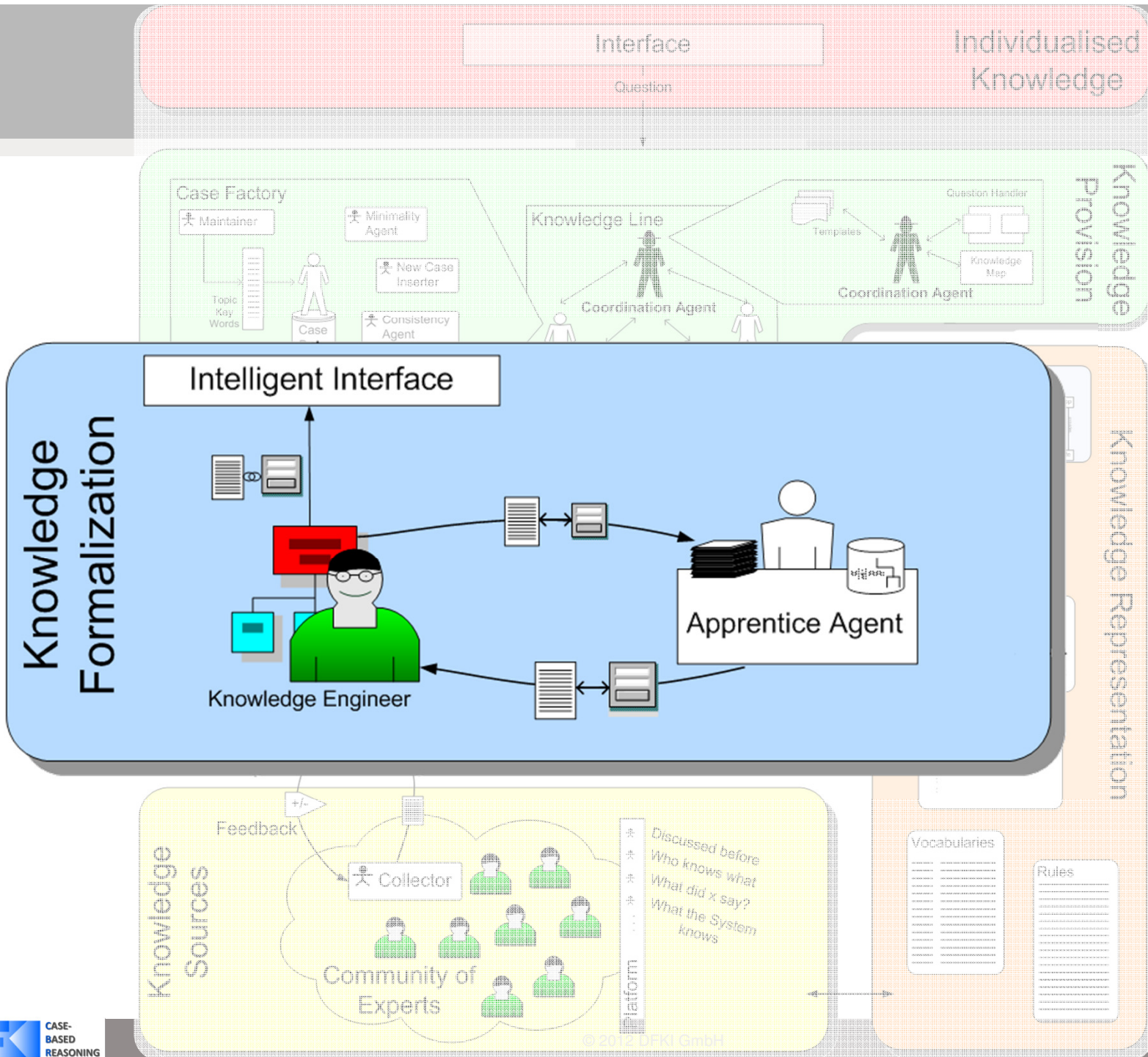
markiertes Wort entfernen

hinzufügen

Klassifikation bestätigen

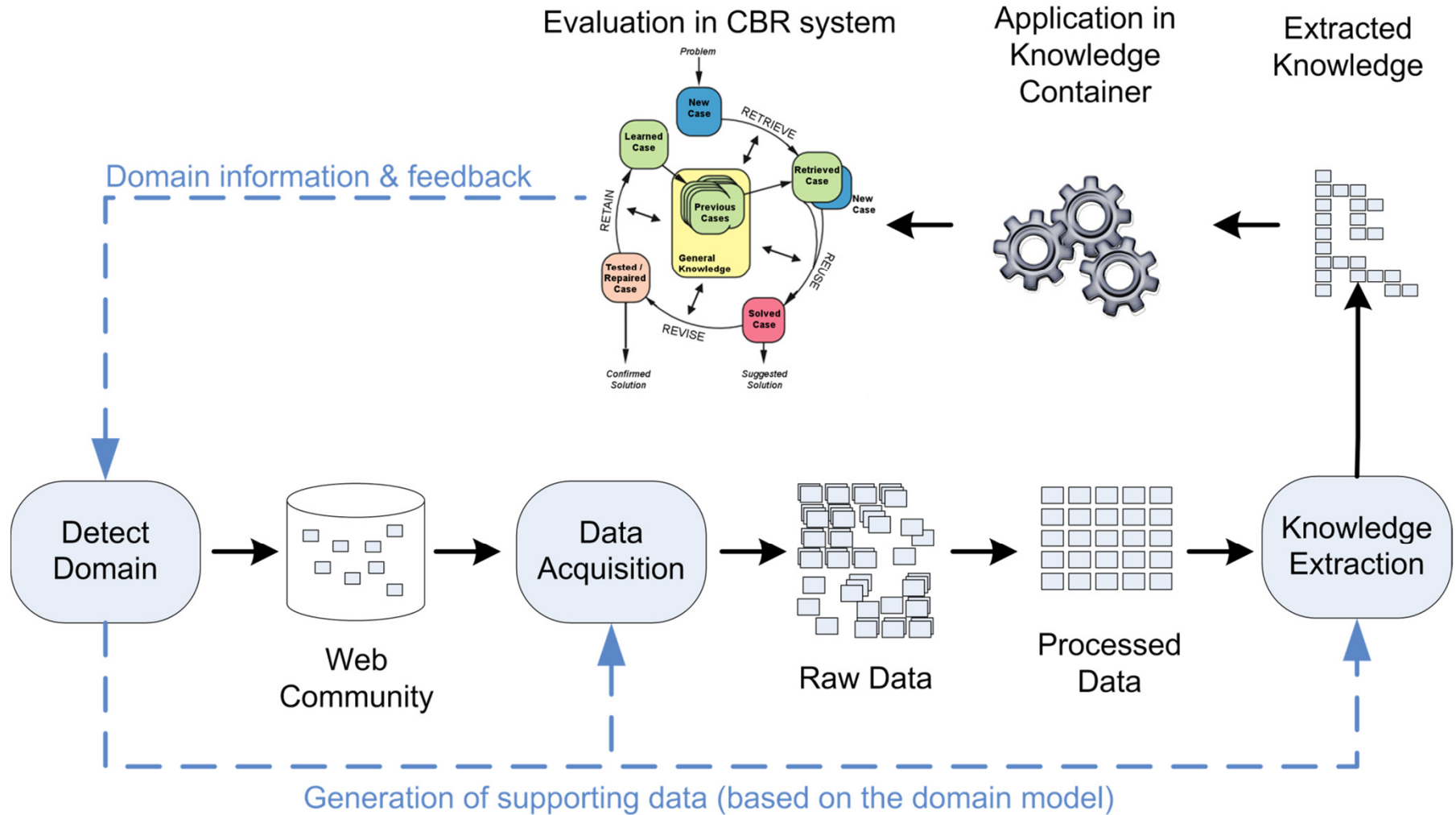
Einträge aktualisieren

SEASALT



- ▶ Knowledge acquisition bottleneck
- ▶ Goals
 - (Semi-) automatic extraction of knowledge
 - Web communities as knowledge sources
 - Results applicable in CBR systems
- ▶ Applying Information Extraction for creating knowledge models

Knowledge Extraction Process



Knowledge Extraction Experiments

► Term Extraction

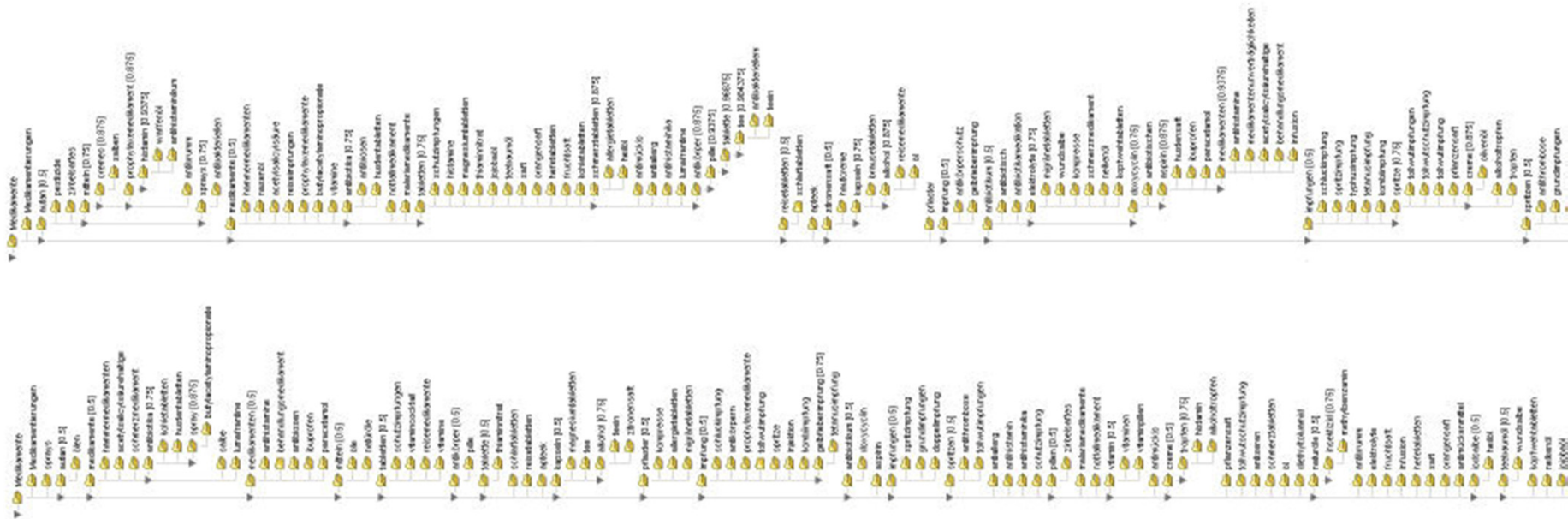
category	manual	found	false	correct	rule-based	completeness	precision	F1-Score
location	60	57	5	52	26	0.866	0.912	0.888
disease	63	63	7	56	44	0.888	0.888	0.887
medicament	65	43	6	37	35	0.569	0.860	0.684

► Taxonomy Quality

category	total	integrated correct	integrated false
medicament	230	187 (81.7%)	42 (18.3%)
disease	257	212 (82.8%)	44 (17.2%)

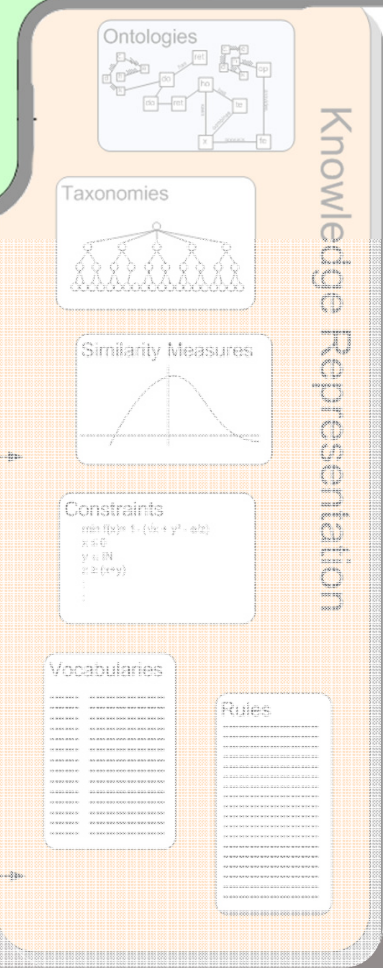
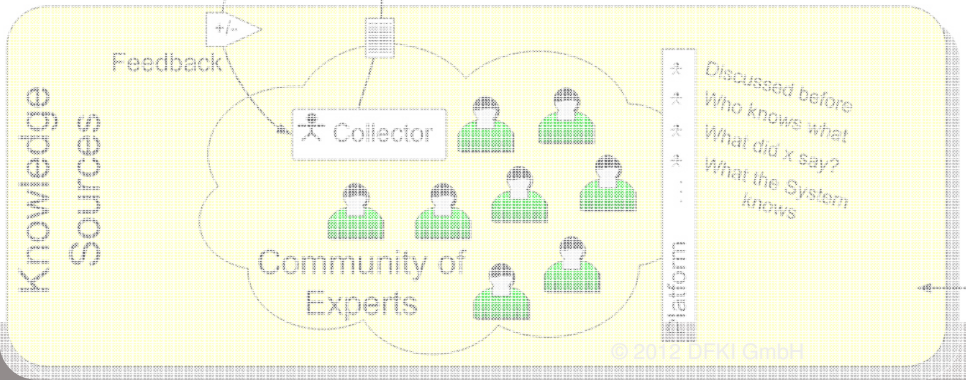
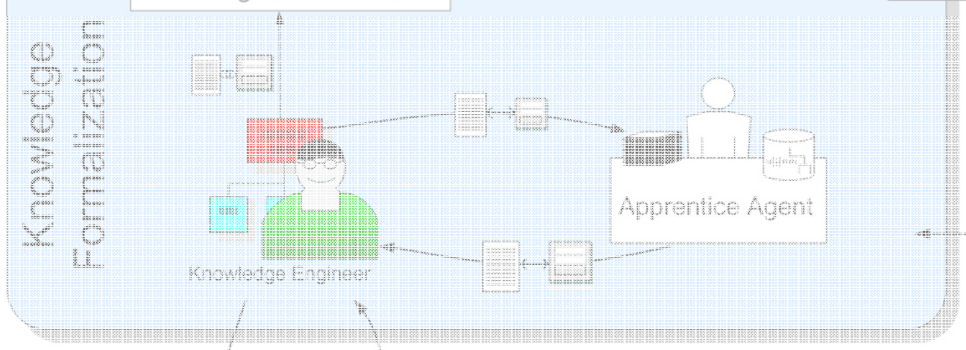
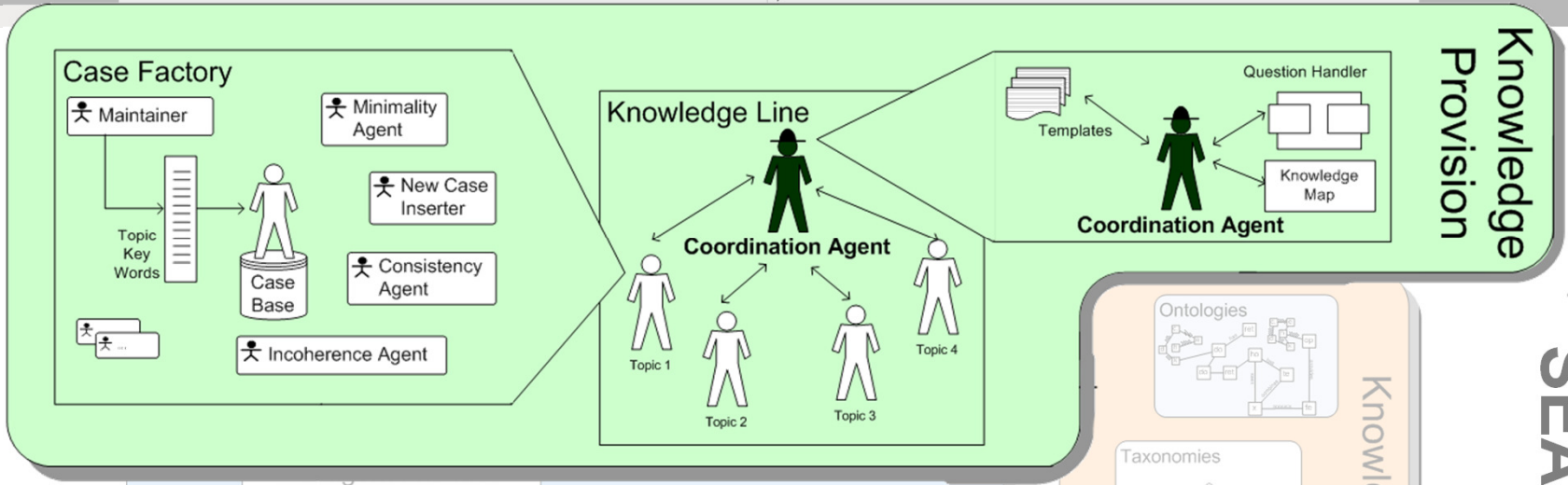
Knowledge Extraction Experiments

► Term Extraction



Interface
Question

Individualised
Knowledge

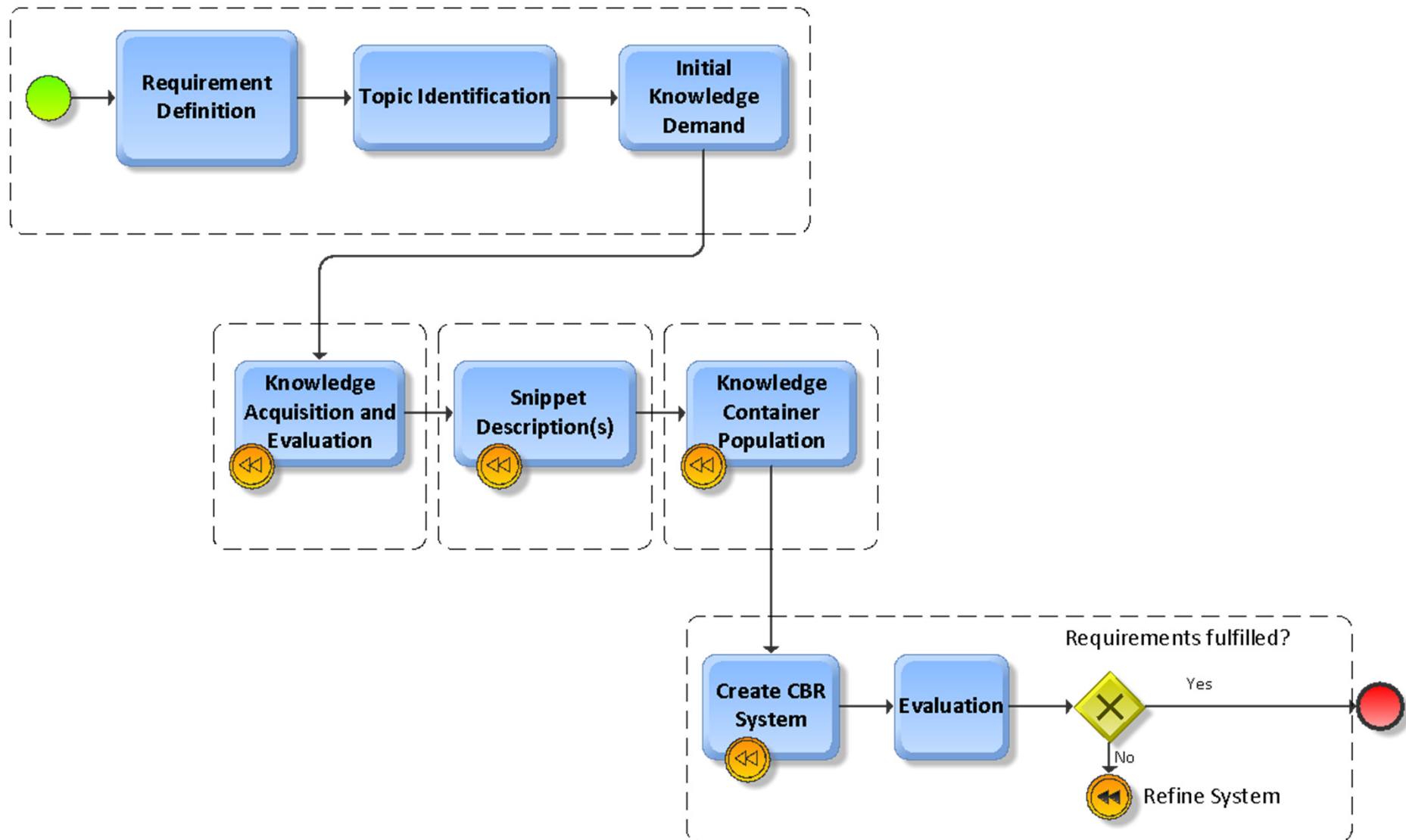


SEASALT

Knowledge Modularization

- ▶ Collaborative Multi-Expert-Systems (CoMES)
- ▶ Building a Case Factory
 - Learning from experience with respect to operation and development of SEASALT based systems
 - Supporting the knowledge input from knowledge sources like web communities via knowledge formalization
- ▶ Building a Knowledge Line
 - Supporting goal-oriented development
 - Taking the SE perspective
 - Completion of existing CBR development methodologies
 - Inreca
 - DISER
 - Supporting the Knowledge Engineer

Knowledge Modularization



- ▶ Knowledge Map
 - Representing retrieval paths between knowledge sources
 - Quality of Knowledge Sources
- ▶ **Contextual Reuse of Experience-Based retrieval paths (CoREB)**
- Storing retrieval paths as cases
- Context sensitivity: using retrieval paths in dependence on which information is presented in the user's query
- Experience based: Learning of cases based on the behavior of the coordination agent
 - Case based improvement of knowledge line retrieval strategies

Query 1

Age: 32

Gender: Male

Chronic Illnesses: none

Travel Destination: Malaysia

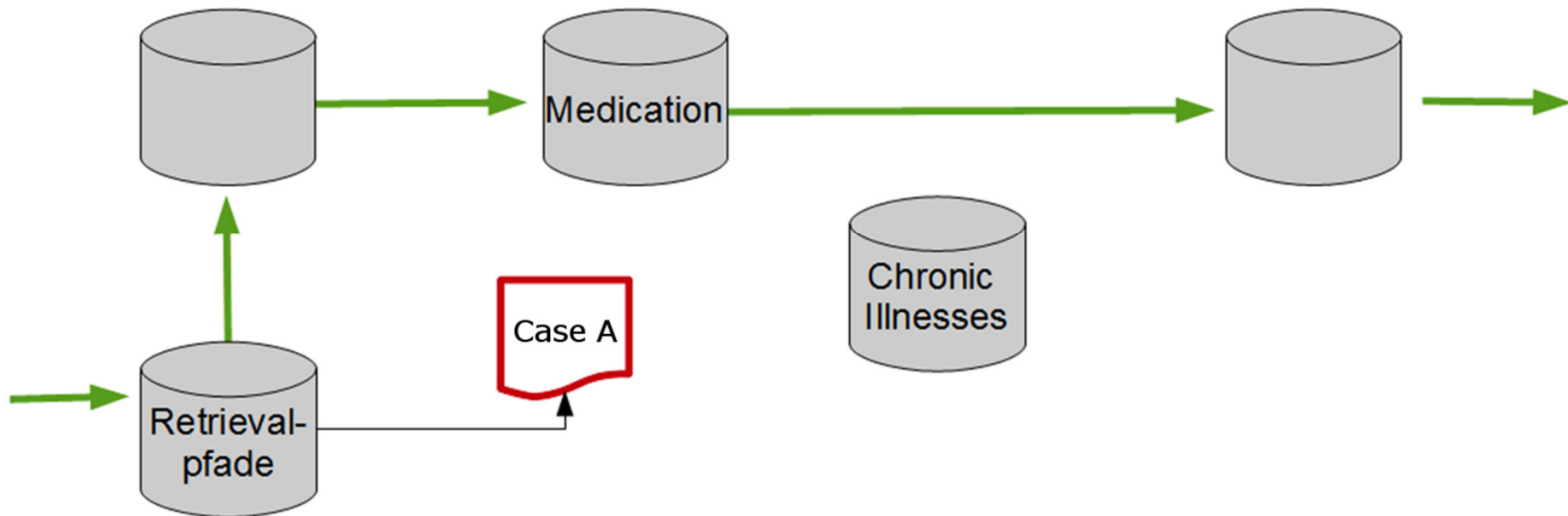
Query 2

Age: 21

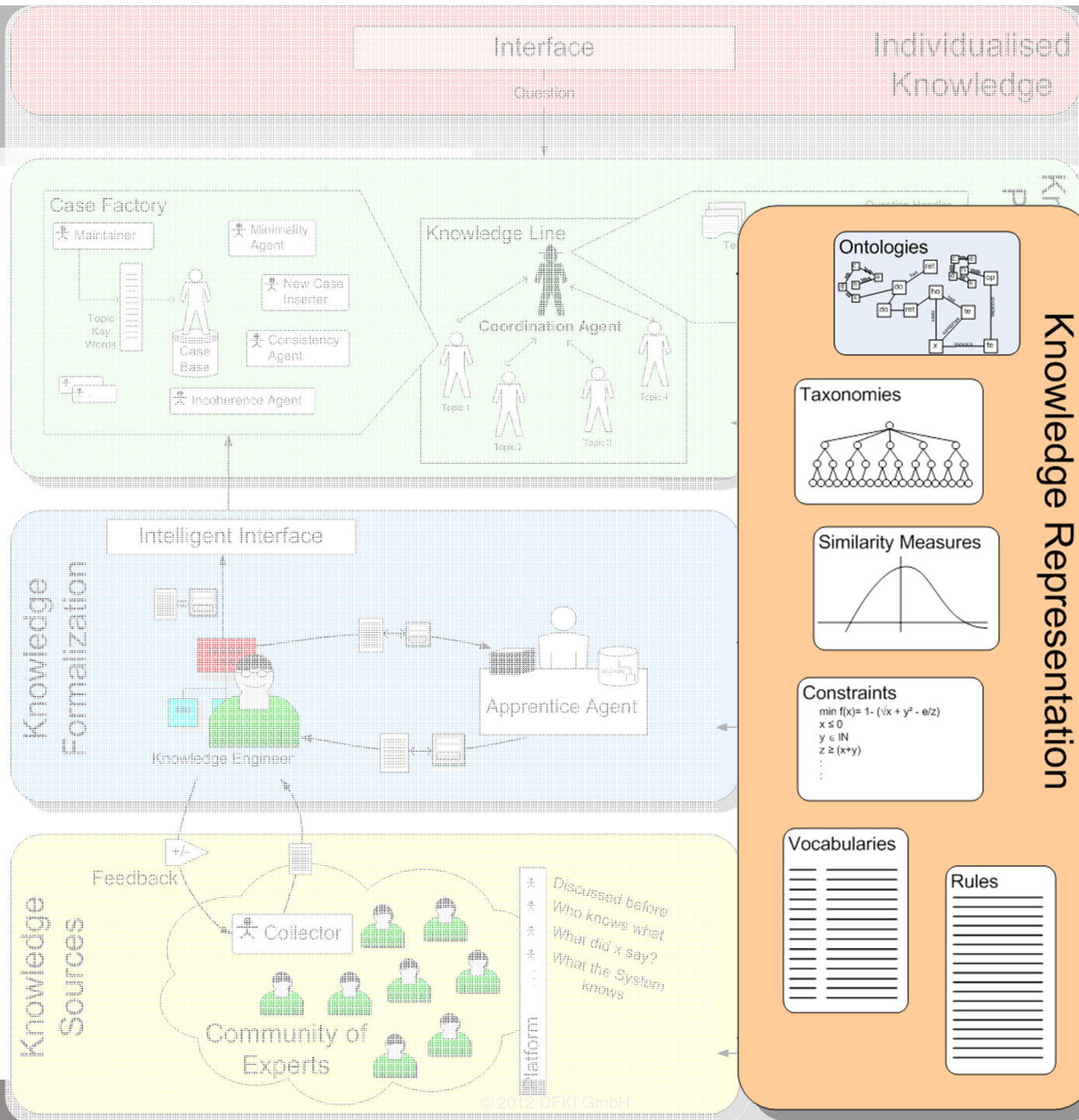
Gender: Female

Chronic Illnesses: none

Travel Destination: Spain

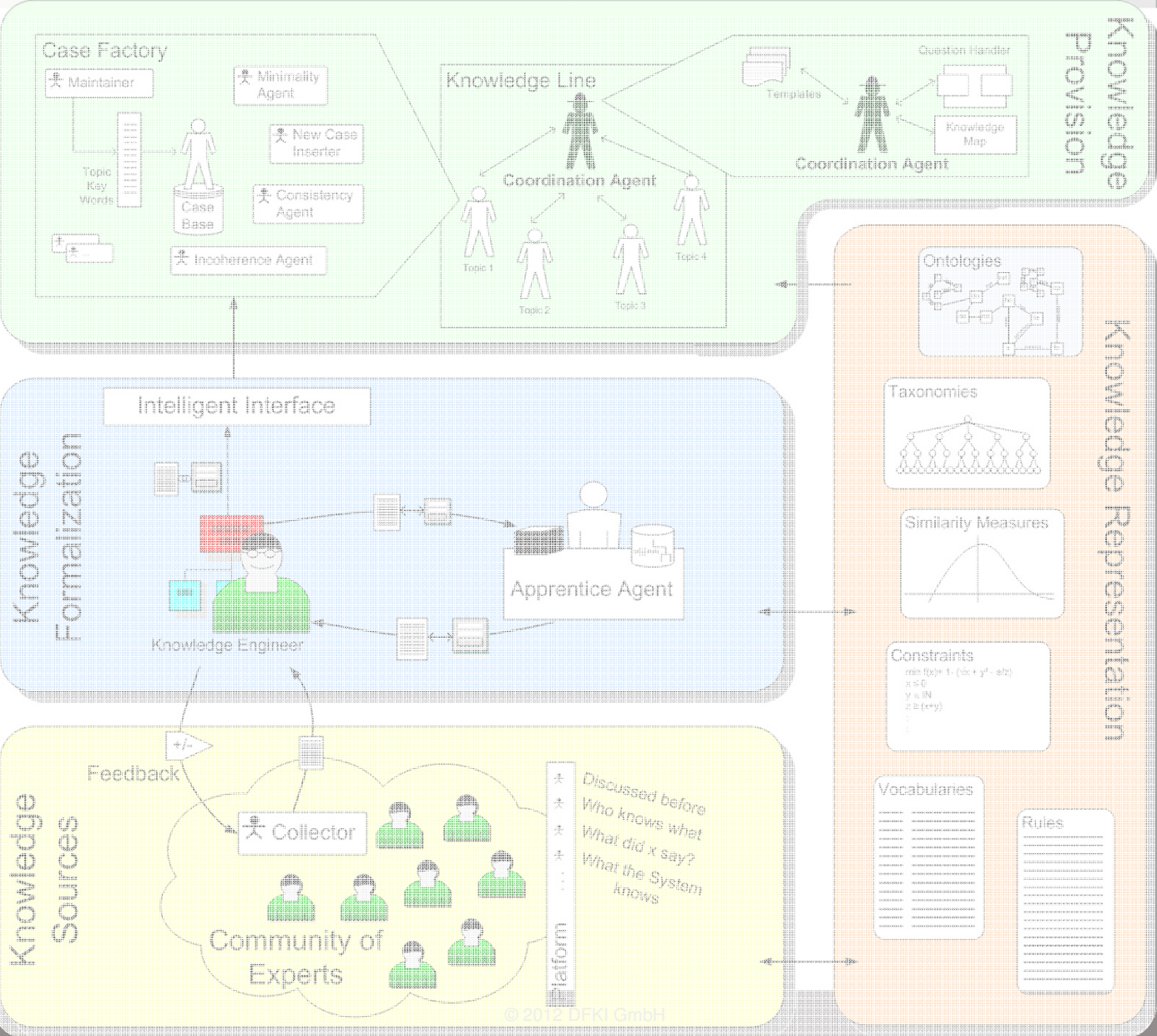


SEASALT



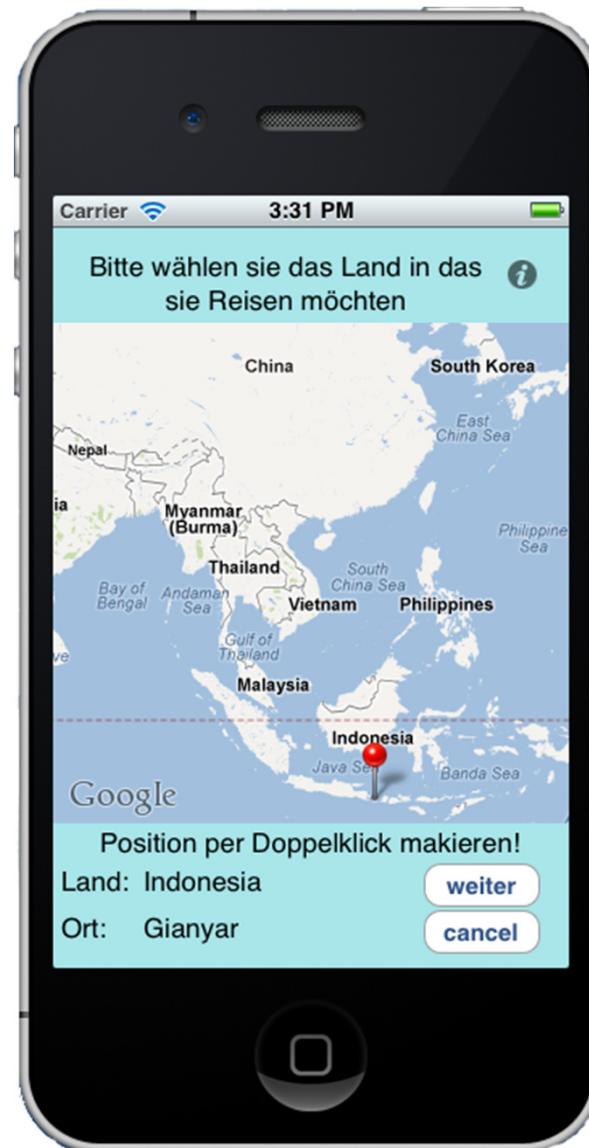
Interface
Question

Individualised Knowledge

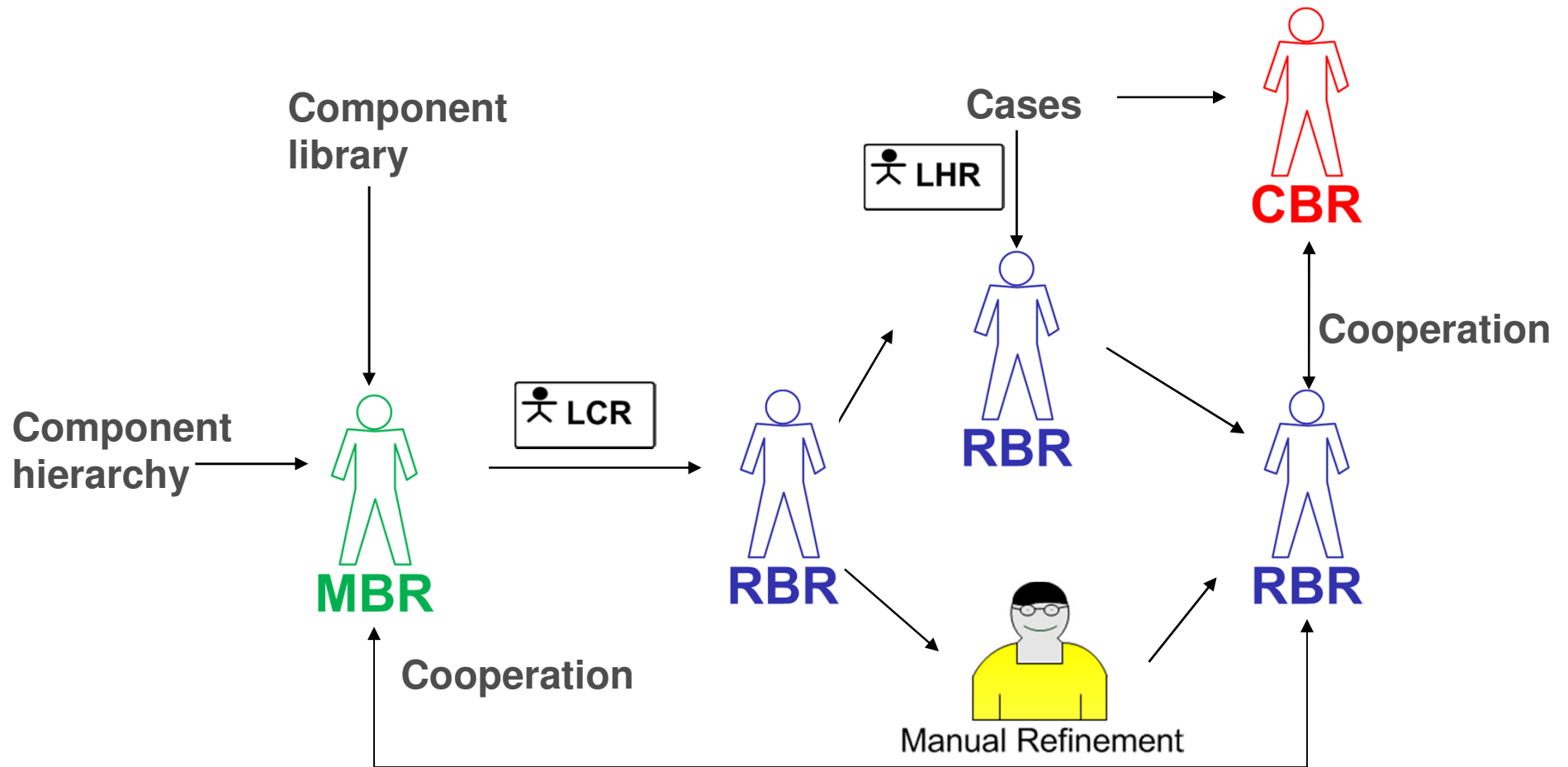


SEASALT

docQuery App

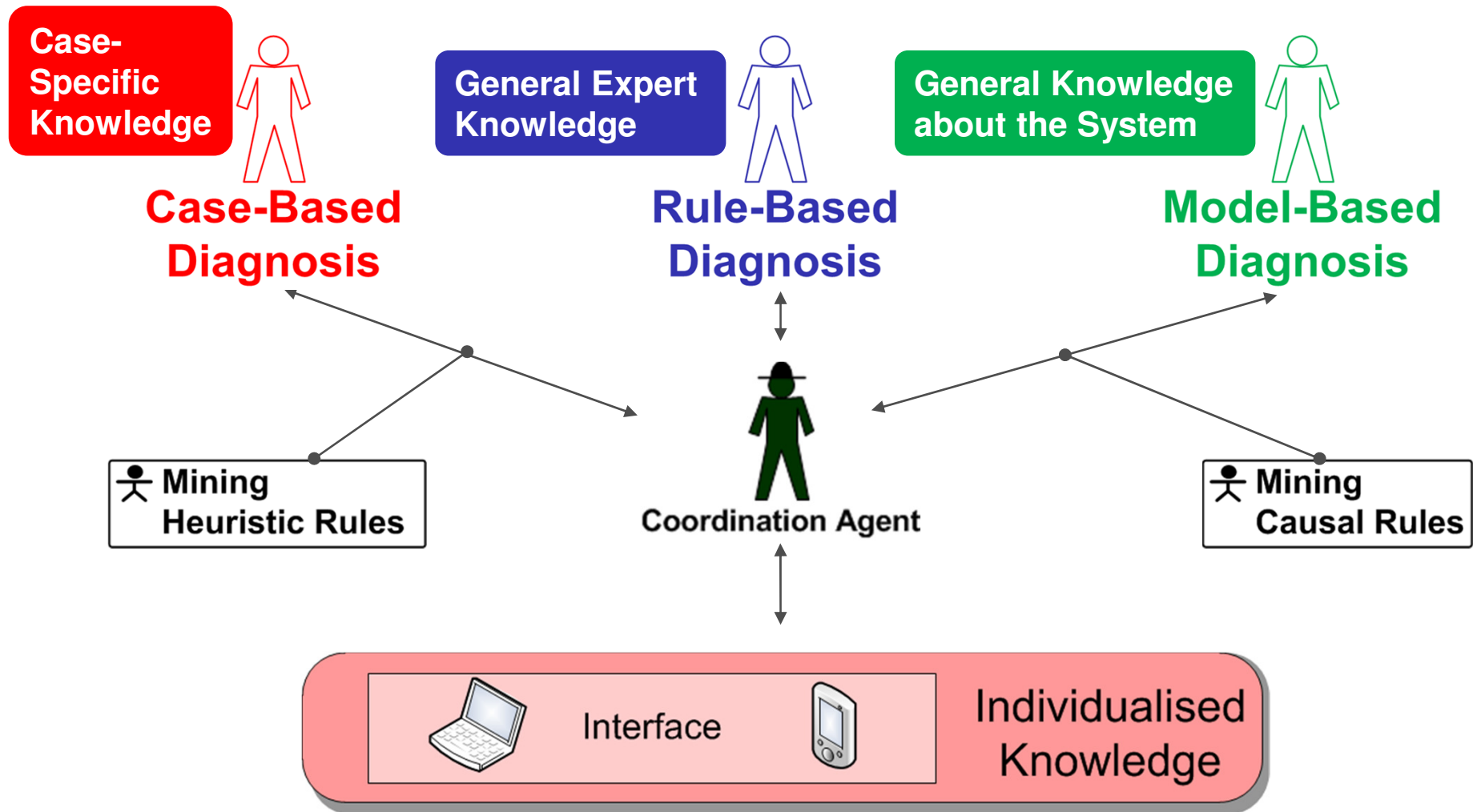


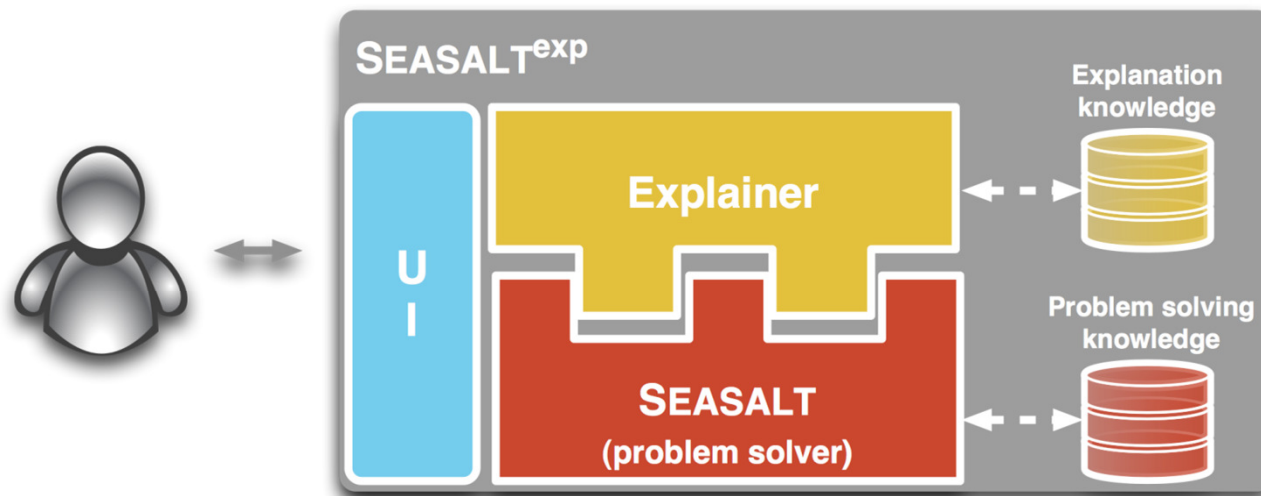
Integrated Diagnostic Reasoning Based on SEASALT Agents

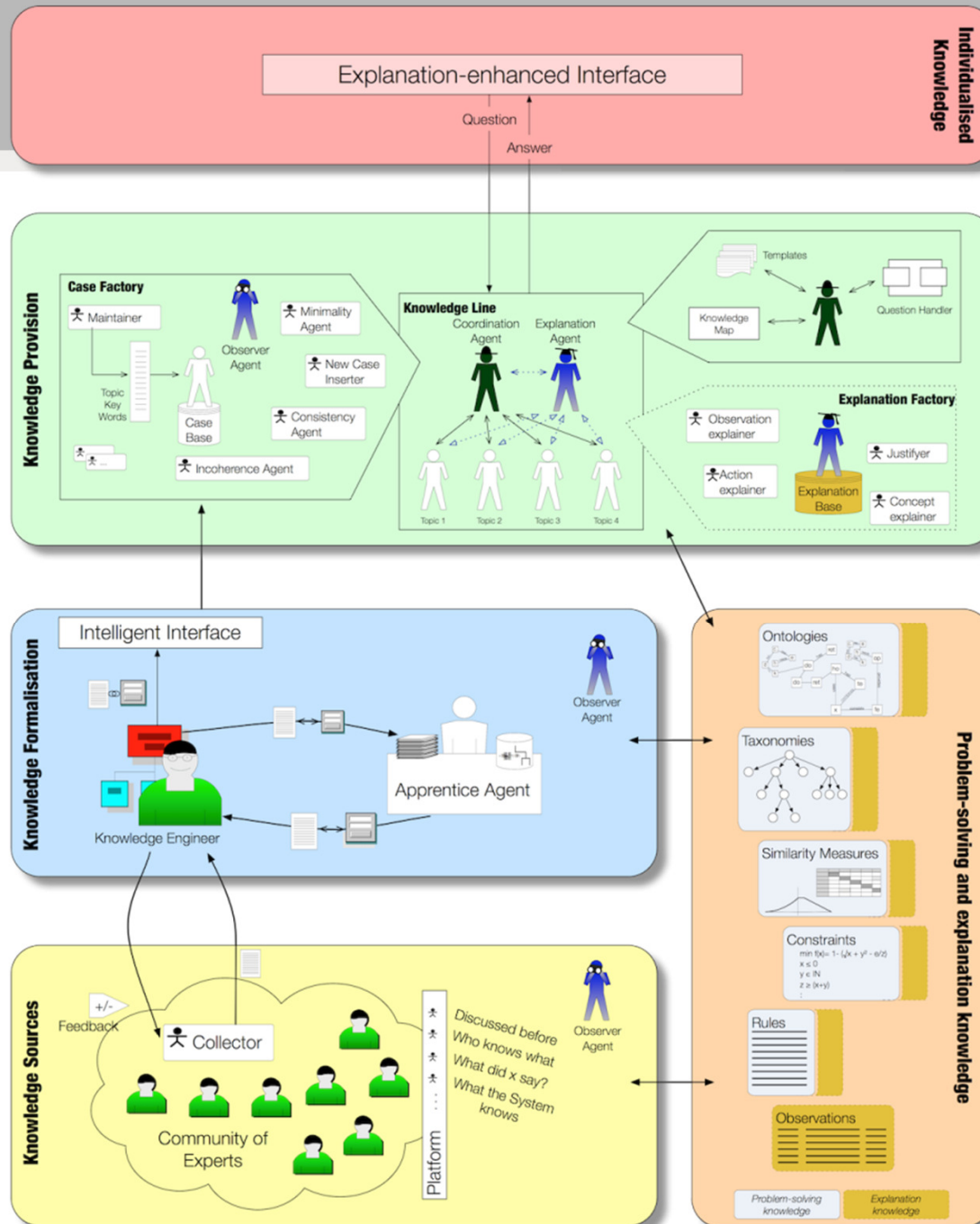


MBR=Model-based reasoning **RBR**=Rule-based reasoning **CBR**=Case-based reasoning
LHR=Learning heuristic rules LCR=Learning causal rules

Agent-Oriented Modeling for Technical Diagnosis Using SEASALT







See also:
 T. Roth-Berghofer, C. Sauer, K.-D. Althoff, K. Bach & R. Newo
 SEASAL^{exp}— An Explanation-aware Architecture for
 Extracting and Case-Based Processing of Experiences
 from Internet Communities
 Proc. of the annual German Workshop on Knowledge and
 Experience Management (FGWM 2011), Magdeburg, 2011.

- ▶ PhD thesis Kerstin Bach (will be submitted end of Sept.):
 - Knowledge Acquisition for Case-Based Reasoning Systems
 - Master thesis Pascal Reuß:
 - Conceptualization and implementation of a knowledge line - retrieval strategies for modularized, homogenous topic agents within a multi-agent system
 - Master thesis Sara Marter:
 - Case-based coordination agents - knowledge modularization and knowledge composition for decentralized, heterogeneous case bases
- ▶ myCBR
 - cf. presentations by Thomas, Kerstin, and Christian
- ▶ docQuery, CookIIS (cf. Kerstin's presentations from Monday)
- ▶ Still in its initial phase
 - SeBaPort – Life Counselor Support
 - Experience based decision support for farmers

Conclusion and Outlook

- ▶ SEASALT is an improvement if compared with MOLTKE
- ▶ SEASALT supports fusion of technologies, e.g. for:
 - CBR and expert system technologies
 - CBR and artificial intelligence technologies
 - Artificial intelligence (AI) and software engineering technologies
 - CBR/AI and information technologies
- ▶ WebCBR
- ▶ Parallel CBR
- ▶ SEASALT^{exp}
- ▶ Applying semantic technologies in industrial contexts
 - using CBR for providing situation specific knowledge and learning
- ▶ CBR and expert systems will converge towards each other

- ▶ Integrating general expert knowledge in CBR architectures and explicitly considering **knowledge evolution**
 - A form of learning for generating (more general) knowledge to be executed within a CBR architecture
- ▶ We have to extend the knowledge container model of Michael Richter
 - and include general knowledge as such of the respective area of competence (of the expert system) as well as inference capabilities based on such general knowledge
- ▶ We need models for both integrated problem solving and for natural growing
- ▶ And even while growing such a CBR based expert system, it must be able to reasonably solve problems, maybe not all and not the difficult ones

Why talking about CBR and Expert Systems?

- ▶ It is important to establish a holistic view on expert systems
 - The CBR community can contribute to this
- ▶ As a consequence, we also have to professionally care about (certain kinds) of general expert knowledge
- ▶ We need extend the CBR cycle to explicitly include **knowledge evolution**
- ▶ We should discuss:
 - Which kind of general knowledge to be covered?
 - Diagnosis, decision support, configuration, fuzziness, teamwork, etc.?
 - Whether we approach experts for our PC who have the required competencies and an interest in CBR / **knowledge evolution**?
 - Whether we initiate a journal on, e.g., „CBR and expert systems“ or work together with an existing journal
- ▶ Last but not least, we should rethink our teaching accordingly

Thank you for your attention!
Questions?

