Fourth European Business Intelligence Summer School (eBISS 2014)

Seminar on

Knowledge Reuse

July 2014

Kurt Sandkuhl
Kurt Sandkuhl

**Background**
PhD (Dr.-Ing) and Diploma in Computer Science (TU Berlin)
Lecturership (Docent) (Linköping University)

**Positions**
TU Berlin (- 1994), Fraunhofer ISST Berlin (- 2002),
Jönköping University, School of Engineering (since 2002)
Rostock University (since 2010)
Chair Business Information Systems
Faculty of Computer Science and Electrical Engineering

**Contact details**
Phone +49 381 498 7400
E-Mail kurt.sandkuhl@uni-rostock.de and kurt.sandkuhl@jth.hj.se
Web http://www.informatik.uni-rostock.de/index.php?id=2169
Mail Konrad-Zuse-Building, Albert-Einstein-Str. 22, D-18059 Rostock
The University of Rostock: (soon) 600 years of tradition and innovation

Established 1419
- 15,000 students and 5,000 staff
- 10 faculties
- 70 different courses of study

Four profile lines gather research capacities:
- Life, Light & Matter
- Maritime Systems
- Aging Science and Humanities
- Knowledge – Culture – Transformation

Welcome Center http://www.welcome-center.uni-rostock.de/
Institute of Computer Science: Konrad-Zuse Building
Research Area

Industrial Organisation
- Enterprise modelling languages
- Methods for enterprise modelling
- Enterprise Engineering
- Best practices
- Tools for enterprise modelling and architectures
- etc.

Organisational Knowledge

Computer Science
- Knowledge representation techniques
- Ontology Engineering
- Development of knowledge-based applications
- Methods and best practices
- Tools for ontology construction
- etc.
Knowledge Reuse

Warm-up
What is knowledge and knowledge reuse?

What is knowledge reuse from your understanding? Please give an example for a knowledge reuse approach!
Knowledge Reuse: The „Big Picture“

Knowledge Management

Knowledge reuse situations

KM approaches

How to identify knowledge?
How to store knowledge?
How to apply knowledge?
How to evaluate knowledge?
How to manage knowledge?

Text-to-knowledge

Knowledge Representation

Knowledge Fusion

Knowledge Engineering

Economics

Business Information Systems

Computer Science
Knowledge Reuse: The „Big Picture“

Knowledge Management

Knowledge reuse situations

Knowledge Management approaches

Knowledge Reuse Approaches

Knowledge Representation

Knowledge Engineering

Economics

Business Information Systems

Computer Science

KM systems
Content and Learning Objectives

Content

• The seminar investigates different approaches for knowledge reuse from computer science and business information systems. Starting from a discussion of fundamentals of knowledge reuse, different ways of reuse and their characteristics are introduced and compared.

Learning Objectives

• Ability to define and explain the term knowledge reuse and challenges involved
• Knowledge about contemporary developments in knowledge reuse
• Ability to compare different approaches for knowledge reuse
Time Plan, Material

- Rough time plan
  - 9 – 10:30: lecture on knowledge reuse
  - 10:30 – 11: coffee break
  - 11 – 11:45: “hands-on” – analyze approaches for knowledge reuse
  - 11:45 – 12:30: discussion of the results of the analysis

- Material
  - Lecture slides
  - Scientific papers

- Upcoming
  - Documentation in eBISS lecture notes
The Context for Knowledge Reuse Techniques
What is knowledge?

One of many definitions:

“Knowledge is the result of a process of understanding, accomplished by the classification of information in a certain context based on individual experiences” (T.H. Davenport)

Types of Knowledge

Explicit Knowledge
- knowledge that was acquired, validated, structured, and saved

Tacit Knowledge
(implicit knowledge)
- knowledge that is not stored but carried by a person
- can possibly be acquired using special tools

Declarative knowledge
- knowing that something is true or false
- can be represented with knowledge representation languages

Procedural knowledge
- knowing how to do something
- can be represented with programming languages
What is knowledge?

Knowledge Staircase

knowledge

information + interconnection

data + semantics

count

+ syntax

By K. North
Knowledge Management Building Blocks [Probst et al., 2000]
Knowledge Reuse Situations (1) [Markus, 2001]

Shared work procedures
- People working together on a team, either homogeneous or cross-functional
- Producers of knowledge for their own later reuse

Typical purposes knowledge reuse
- Keep track of current status and things needing attention
- Recall reasons for decisions need to be revisited or when there is turnover among team members
- Learn how the team can perform better on the next project

Shared work practitioners
- People doing similar work in different settings
- Producers of knowledge for each other's reuse

Typical purpose of knowledge reuse
- Acquire new knowledge that other have generated (e.g. how to handle a particular problem)
- Get advice how to handle in particularly challenging or unusual situation that is new to the team
- Gain access to observations that spur innovation
Knowledge Reuse Situations (2) [Markus, 2001]

**Expertise-seeking novices**
- people with an occasional need for expert knowledge that they do not possess and do not need to acquire themselves because they need it rarely

Typical purpose of knowledge reuse
- Answer an arcane question or solve an ad hoc problem
- Approximate the performance of experts
- Minimize the need for experts

**Secondary knowledge miners**
- People who seek to answer new questions or develop new knowledge through analysis of records produced by other people for different purposes

Typical purpose of knowledge reuse
- Seek answers to new questions or create new knowledge
Knowledge Services [Maier, 2010]

I – Access Services

II – Personalization Services

III – Knowledge Services
- Search
- Publishing
- Collaboration
- Learning

IV – Integration Services

V – Infrastructure Services
- Intranet
- Extranet
- DMS, Files
- Databases
- Data from PIM Systems
- Internet Content
- external databases
An ontology is a formal, explicit specification of a shared conceptualization

- Conceptualization: abstract model of phenomenon
- Explicit: concepts & constraints are explicitly defined
- Formal: Machine-readable
- Shared: Consensual knowledge that is accepted by a group
Seven Steps to Create an Ontology
[Noy + McGuinness, 2001]

Ontology Development 101: A Guide to Creating Your First Ontology

Step 1. Determine the **domain and scope** of the ontology
Step 2. Consider reusing **existing ontologies**
Step 3. Enumerate **important terms** in the ontology
Step 4. Define the **classes** and the **class hierarchy**
Step 5. Define the **properties of classes** – slots
Step 6. Define the **facets of the slots**
Step 7. Create **instances**
Tool Support: Protégé
Knowledge Reuse Techniques
Overview

What is knowledge and knowledge reuse?
• Allen Newell’s view
• Nonaka’s and Takeuchi’s view

What knowledge reuse approaches have been proposed?
  – How can these approaches be compared and characterized?

Some examples for knowledge reuse
• Patterns
• Reference models

Knowledge

- **knowledge** is that which an observer ascribes to an intelligent agent (human or machine) that allows the observer to construe the agent’s behavior as rational (i.e. behavior that allows the agent to achieve its perceived goals)
- knowledge is an abstraction that cannot be written down

Knowledge base

- data structures that we might use to encode knowledge in a computer knowledge base are not equivalent to the knowledge (the capacity for behavior) that those data structures represent
- we are able to use data structures (symbols) to represent knowledge, but those symbols cannot generate intelligent behavior - unless some process is applied to those symbols
- distinguish the symbols in a knowledge base (knowledge representation) from the knowledge (capacity for rational behavior) that the symbols can be used to generate
Sharing and Reuse of Knowledge

- knowledge bases have meaning only when they are processed by some *interpreter* - either by a computer program or by our own minds
- We cannot share and reuse knowledge bases if we do not also share and reuse the inference engines (or mental processes) that bring our knowledge bases to life
- although we may speak of transferring “knowledge” from one site to another, we can at best transfer knowledge bases. We design our knowledge bases so that they can be processed to produce intelligent behavior.
SECI Spiral Model [Nonaka, 1994]

SECI Spiral Model

Observations: Newell vs. Nonaka/Takeuchi

- Newell’s and Nonaka/Takeuchi’s views are not conflicting
  - common ground: knowledge is more than what can be captured in knowledge representations / explicit knowledge
- Emphasis on different viewpoints
  - Knowledge representation / interpreter vs. transition between tacit and explicit knowledge
- Indicate many different options how to support reuse
  - Starting either from Newell’s knowledge levels or from the SECI phases
Knowledge Reuse Techniques

– and how to compare them
Knowledge Reuse – Related Subjects in Literature

Some examples:

- Semantic patterns
- Knowledge patterns
- Ontology modules
- Ontology design patterns
- Task patterns
- Information demand patterns
- Knowledge architecture
- Enterprise knowledge reference models

- Ontology architecture
- Knowledge formalization patterns
- Active Knowledge Architectures
- Active Knowledge Models
- Information Supply patterns
- Analysis Patterns
- Knowledge Transformation Patterns
- Workflow patterns
- … there is more …

Are all of them really supporting knowledge reuse?
What are the differences? How to compare?
What is the right approach for a specific purpose?
Some criteria for comparing knowledge reuse approaches

- Reuse techniques (from literature)
- Reuse situations (inspired by Markus)
- Capacity of knowledge representation (inspired by Newell)
- Addressee of knowledge (inspired by Nonaka/Takeuchi)
- Maturity (inspired by research validation approaches)
- Scope (from own experiences)
- Phase of solution development (from own experiences)
Some Reuse Approaches

Which reuse approach is used?

• Module: self-contained component of a solution with defined interfaces hiding the actual implementation
  – Use the module „as is“ and compose it with other modules to a solution

• Reference Model / Architecture: identifies the main building blocks of a system with their interfaces and dependencies
  – Knowledge reuse „in the large“

• Template: pattern or gauge to be used as a guide in making something accurately for a defined purpose
  – defines the structure but not the content; usually no behavioral aspects included

• Pattern: provides solution principles (and how to implement them) for a recurring problem in a specific context by abstracting from actual application
  – Exposes the core elements of the solution (structure and behavior) and consequences of using it
Reuse Situations (according to L. Markus)

Shared work procedures
- People working together on a team, either homogeneous or cross-functional
- producers of knowledge for their own later reuse

Shared work practitioners
- People doing similar work in different settings
- producers of knowledge for each other’s reuse

Expertise-seeking novices
- People with an occasional need for expert knowledge that they do not possess and do not need to acquire themselves because they need it rarely

Secondary knowledge miners
- People who seek to answer new questions or develop new knowledge through analysis of records produced by other people for different purposes
Capacity of the Knowledge Representation

Inspired by Newell’s distinction between knowledge representation and interpreter (mental process / inference engine)

What is the capacity of the knowledge representation used?
• Knowledge representation format
• Reusable lexicon / shared vocabulary
• Shared conceptual model (classes of objects, characteristics of classes, relationships)
• Process reuse: process to be performed by interpreter is independent of knowledge representation format but dependent on interpreter
• Problem solving reuse: process to be performed by interpreter is independent of knowledge representation format and interpreter
Addressee of knowledge

Inspired by Nonaka/Takeuchi’s spiral:

Who is the target group of the knowledge provided?

• Individual
• Group
• Organisation
• Inter-organisation
What is the main scope of the knowledge?

- Knowledge about a product or service
- Knowledge about an IT solution or artefact within the solution development process
- Knowledge about a process
- Knowledge about organizational structures
Phase of solution development

In which solution development phase is the knowledge supposed to be useful / applied?

- Analysis
- Specification
- Design
- Implementation
- Verification and Validation
- Operation
- Maintenance
Maturity: Which validation steps were completed for the reuse approach under consideration?

<table>
<thead>
<tr>
<th></th>
<th>Theory</th>
<th>Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal, development</td>
<td>Validation against state of research, internal consistency checks</td>
<td>Prototype implementation for checking feasibility, test in lab environment</td>
</tr>
<tr>
<td>team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External, in validation</td>
<td>Peer-review of publications describing approach and concepts, comparison to known best practices of the domain.</td>
<td>Case studies with application partners using the artifacts for evaluation purposes</td>
</tr>
<tr>
<td>context</td>
<td></td>
<td>Application of the developed artifacts in cooperation / under instruction from developers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External, in application</td>
<td>Development of extensions or enhancements of the concepts and approaches by external actors</td>
<td>Use of the artifacts developed (e.g. algorithms, methods, software components) for solutions</td>
</tr>
<tr>
<td>context</td>
<td>Application of the artifacts for creation of new theoretical knowledge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comparison with related approaches</td>
<td></td>
</tr>
</tbody>
</table>

Inspired by Lincoln and Guba, „naturalistic inquiry“
Ontology Design Patterns
Ontology Design Patterns

• Definition: “a set of ontological elements, structures or construction principles that intend to solve a specific engineering problem and that recur, either exactly replicated or in an adapted form, within some set of ontologies or is envisioned to recur within some future set of ontologies.”
Competency Questions:
- What are the transactions involved in this invoice?
- What is the order this invoice is referring to?
- What is the line item for this invoice?
- What is the amount of the transactions involved in this invoice?
- What currency is applied to this invoice?
Ontology Design Pattern – Simple Example

Competency Questions:
• What are the transactions involved in this invoice?
• What is the order this invoice is referring to?
• What is the line item for this invoice?
• What is the amount of the transactions involved in this invoice?
• What currency is applied to this invoice?
Knowledge Reuse Lifecycle: Example of Ontology Patterns

Based on [Blomqvist, 2009]
Applying the criteria for ODP

- Reuse approaches: Pattern
- Reuse situation: “expertise-seeking novices” (aim) or “shared work practitioners” (current status)
- Capacity of knowledge representation: problem solving reuse (at least this is the aim)
- Addressee of knowledge: individual
- Maturity: unclear (external, in validation context? Or already in application context?)
- Scope: Knowledge about an IT solution or artefact
- Phase of solution development: Design
Reference Models
Reference Model

Reference model is a general model for a class of issues with the following characteristics:

- On the basis of the model, specific models can be developed
- The general model can be used as an object for comparison with other models that are describing the similar issues

RM represent high-quality knowledge and best practices sharable by all stakeholders involved in a certain community and work area

Based on [Lillehagen and Krogstie, 2009]
RM components

• Main components of an RM are:
  – Basic model building blocks, structures, components, parameters, rules and services
  – Architecture of the entire RM and its modules with data and examples of practice
  – Description language that is used for a uniform display and for exchanging information between different actors
  – Rules and guidelines for applying the reference model to generate a specific model
RM example: ITIL

• The Information Technology Infrastructure Library (ITIL) is a set of concepts and practices for Information Technology Services Management (ITSM), Information Technology development and IT operations.

• IT Service Management is concerned with delivering and supporting IT services that are appropriate to the business requirements of an organization. This improves efficiency and effectiveness and reduces the risks of managing IT services.

• ITIL gives detailed descriptions of a number of important IT practices and provides comprehensive checklists, tasks and procedures that any IT organization can tailor to its needs.

• ITIL originates from UK, Office of Government Commerce (OGC, earlier CCTA).
ITIL Service Management (v3)
ITIL Service Management (v3)

Service Strategy
- Strategy Management for IT Services
- Business Relationship Management
- Financial Management for IT Services
- Service Portfolio Management
- Demand Management

Service Design
- Design Coordination
- Service Catalogue Management
- Service Level Management
- Availability Management
- Capacity Management
- Information Security Management
- IT Service Continuity Management
- Supplier Management

Service Transition
- Transition Planning and Support
- Change Management
- Service Asset and Configuration Management
- Release and Deployment Management
- Service Validation and Testing
- Change Evaluation
- Knowledge Management

Service Operation
- Event Management
- Incident Management
- Request Fulfilment
- Problem Management
- Access Management

Continual Service Improvement
ITIL V3: Service Strategy/Service Portfolio
ITIL V3 Processes are Decomposed into Nine Aspects

1. Purpose/Goal/Objective
2. Scope
3. Value to Business
4. Policies, Principles and Basic Concepts
5. Process Activities, Methods and Techniques
6. Triggers, Inputs, Outputs, and Interfaces
7. Information Management
8. Key Performance Indicators
9. Challenges, Critical Success Factors, and Risk
Applying the criteria for ITIL

- Reuse approaches: Reference Model
- Reuse situation: Shared work practitioners
- Capacity of knowledge representation: conceptual model
- Addressee of knowledge: organization
- Maturity: external, in application context
- Scope: Knowledge about an artefact, process and organization structures
- Phase of solution development: Analysis, Design
“Hands-on” Part
“Hands-on” Part

Work in groups of 2
Each group will receive one scientific papers about an approach to knowledge reuse

Your tasks:
• Read the article
• Prepare to present a short summary of the articles’ content for the seminar group
• Categorize / classify the approaches in the papers according to the features discussed in the lecture
• Reflect: Does the categorization work? Any features missing/superfluous/wrongly named in the categorizations? Any other categorization to be included?
• Present your findings in max. 5 minutes!
Papers for the "Hands-on" Part

  http://doi.acm.org/10.1145/1321440.1321451
Literature for this Lecture