Agent-Mediated Knowledge Management

Virginia Dignum

Center for Content and Knowledge Engineering
- Utrecht University -

virginia@cs.uu.nl

IAT'07 Tutorial

Outline

Starting Point	Knowledge Management
KM Approaches	Supporting organizational success
Agents in KM	Agents and its applications to KM
Towards AMKM	The OperA approach
Conclusions	Summary and Outlook

Outline

Starting Point	Knowledge Management
KM Approaches	Supporting organizational success
Agents in KM	Agents and its applications to KM
Towards AMKM	The OperA approach
Conclusions	Summary and Outlook

Knowledge Management: The theory

- KM aims to create company value and improve performance
  - optimal creation, distribution, sharing and use of knowledge sources
  - link knowledge workers
  - 'the right knowledge, to the right people at the right moment'
 - practical, measurable initiatives, with concrete results

KM is more than Information Management

- KM provides also answers to questions such as

  - **What** do we know about this?
  - **Who's** done this **before**?
  - **What** did they **do**?
  - **What** did they **learn**?
  - **Who** has the skills to do this **now**?
  - **What's** the **best** way to solve this?

    - KM addresses also the management of the 'knowledge' held in people's heads and on the interactions between people

---

KM life cycle
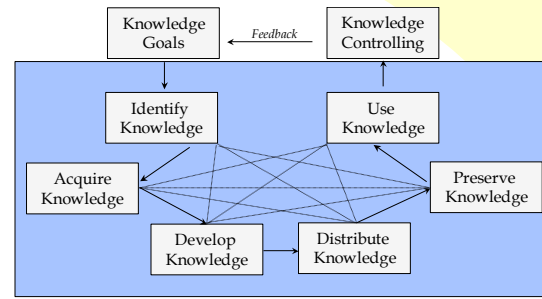
Adapted from: Probst/Raub/Romhardt

Knowledge Management: The practice

- Knowledge Management (KM) Research is Strongly Driven by Real World Needs of Today's Enterprises
- Nonaka/Takeuchi attributed Japan's success over the US economy (in the eighties) to improved knowledge creation
- Many companies define themselves as becoming "Knowledge Organizations"
- Many companies have KM projects (often assessed as flops ☹)
- Many companies have Information/Document Management projects (often labeled as KM projects and rated as flops ☹)
- Many companies still have (Info/Document/___) Management projects that root in bad KM
- There are still public discussions about the transition of many countries into "Knowledge/Information Societies"
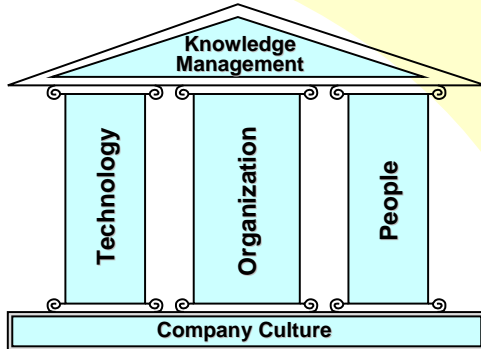

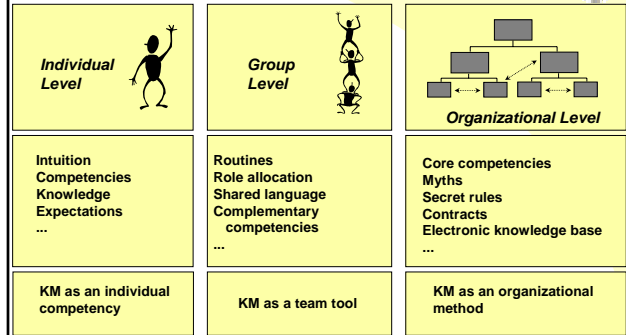## KM intends a holistic approach

Knowledge Management is

– a structured, holistic approach

– to improve the handling of knowledge

  (know-how, experience, skills, active documentation)

– on all levels (individual, group, organizational)

– in order to save costs, improve quality, support

  innovation

see: www.netacademy.org

Slide 9

Credo: Successful KM is Holistic

Knowledge Management

Technology | **Organization** | **People**

Company Culture

Slide 10

KM levels

Individual Level	Group Level	Organizational Level
Intuition **Competencies** **Knowledge** **Expectations** ...	**Routines** **Role allocation** **Shared language** **Complementary** **competencies** ...	**Core competencies** **Myths** **Secret rules** **Contracts** **Electronic knowledge base** ...
KM as an individual competency	**KM as a team tool**	**KM as an organizational method**

Adapted from: M. Eppler/St. Gallen

Slide 11

Approaches to KM

- Self-service – intranet portals; yellow pages; people finder

- Networks and Community of Practice – knowledge sharing; learning communities

- Facilitated transfer – internal consultants; dedicated facilitators; known experts

Slide 12

Outline

Starting Point	Knowledge Management
KM Approaches	Supporting organizational success
Agents in KM	Agents and its applications to KM
Towards AMKM	The OperA approach
Conclusions	Summary and Outlook

Evolution in support systems

Knowledge era — Semantic integration, individual view, AMKM

Information era — DMS/groupware/intranet

Data era — Wrappers: CORBA, DCOM

'Pre history' — Dedicated data, separation of systems
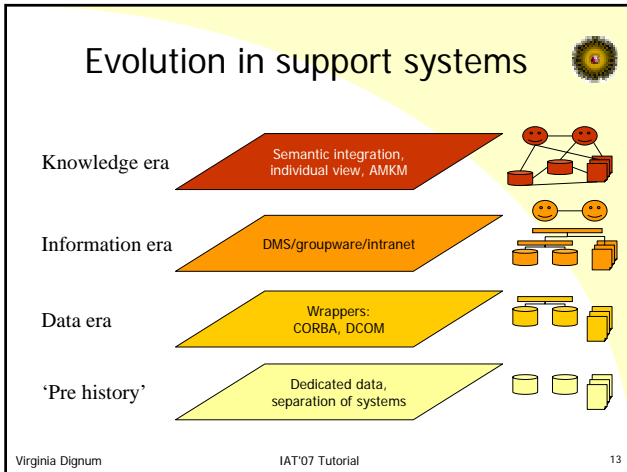
Organizations in the knowledge era

- Operate in a changing environment
- Distributed management, knowledge and data
- Process integration
- Culture integration
  - Global goals vs. individual goals
  - Balance control and independence
- Personalized products and services
  - Non standard products
  - Non standard interaction forms
  - Non standard pricing mechanisms

Challenges for KM in the knowledge era

- manifold logically and physically dispersed actors and knowledge sources
- different degrees of formalization of knowledge
- different kinds of (web-based) services and (legacy) systems
- conflicts between local (individual) and global (group or organizational) goals

Requirements for KM in the knowledge era

- Provide uniform and transparent access to a diversity of knowledge and information sources
- Proactively identify and deliver timely, task relevant information
- Create personalized virtual and dynamic links between knowledge needs and knowledge sources
- Inform users about changes that have been made elsewhere in the business process
- Proactively store and distribute results of activity

Distributed KM

- Various stakeholders in an organization have different requirements
  - Power, trust, competition, reciprocity,
- Information sources are structured according to the particular needs of the respective stakeholder
  - Different types of work require different support
- A monolithic central system is seldom feasible
  - competing, dispersed results
  - individual solutions resist global standardizations

KM in the knowledge era

- Knowledge Management Environments
  - adapt environments to people and organizations
  - focus on the interactions between people
  - focus on creativity, challenges, emotions

- Aim is making KM Environment invisible, embedded in our natural surrounding and present whenever we need it

Models for KM environments

- How to model KM environments so that
  - Participants and organizational goals and requirements are taken in account?

  - Changes in the environment or in strategic direction can be better understood and incorporated dynamically?

- Agent-based models
  - Autonomy, reactive and proactive, social behavior

Why agent models?

- The characteristics of distributed KM in realistic enterprise scenarios
  - components have to be considered as autonomous units
    - individual business units, information sources and structures
    - individual procedures cope with local particularities
    - individual goals result in different commitments
  - cooperation relies on agreements between partners
    - societies of agents with agreed-upon roles
    - interactions are governed by rights and obligations
- Using the agent paradigm to model KM results in clear roles, responsibilities, and communication structures

Outline

Starting Point	Knowledge Management
KM Approaches	Supporting organizational success
Agents in KM	Agents and its applications to KM
Towards AMKM	The OperA approach
Conclusions	Summary and Outlook

Software agents?

- **Development metaphor**
  - Software Engineering
  - Methodology
- **Technology**
  - agent theory
  - agent architectures
  - agent languages

Agents: a Definition

- An agent is a computer system that is capable of *independent* action on behalf of its user or owner (figuring out what needs to be done to satisfy design objectives, rather than constantly being told)'
  - Autonomous
  - Pro-active
  - Reactive
  - Social ability

From Agents to Multi-Agent Systems

- Agent **communication**
- **Social** abilities
  - realise there are other agents
  - use other agents for your actions
- **Collective** plans, goals, etc.

Multi agent Systems

- A multiagent system is one that consists of a number of agents, which *interact* with one-another
- In the most general case, agents will be acting on behalf of users with different goals and motivations
- To successfully interact, they will require the ability to *cooperate*, *coordinate*, and *negotiate* with each other, much as people do

Current agent applications to KM

- **Agents implement KM functionality**
  - Search for, acquire, analyse, integrate and archive information from multiple heterogeneous sources
  - Inform us (or our colleagues) when new information of special interest becomes available
  - Negotiate, purchase and receive information or services
  - Explain the relevance, quality and reliability of information
- **Agent support KM system development**
  - Models of organizations where the KM system will operate
  - Integrate global organizational goals, environment requirements and individual preferences
  - Describe social order regulation mechanisms

How are agents used in KM?

- System development level
  - Organizational Analysis
  - System Architecture
  - System Implementation
- Macro-level structure of the multi-agent system
  - Single Agent
  - Homogeneous Multi-Agent Systems
  - (Heterogeneous) Agent Societies
- KM application area
  - E.g., Nonaka: Socialization, Externalization, Internalization, Combination
  - E.g., Probst/Raub/Romhardt: Identification, Acquisition, Development, Distribution, Preservation, Utilization

An overview on many working points in this design space can be found in: van Elst, Dignum, Abecker (2003), Springer LNAI 2926.

Types of agents in KM

- **Personal Assistants** represent the interests of the user and provide the interface between users and the system.
- **Cooperative Information Agents** (CIAs) focus on accessing multiple, distributed and heterogeneous information sources.
- **Task analysts** are agents that monitor a certain task in the business process, determine the knowledge needs of the task, and gather that knowledge by communicating with other agents..
- **Source keepers** are agents dedicated to maintaining knowledge sources and are responsible for describing the knowledge contained in the source and extract relevant information for a given request.
- **Mediators** are agents that can provide a number of intermediate information services to other agents.

Personal Knowledge Agents

- Letizia is a user interface browser agent.
  - tracks user behavior
  - anticipate items of interest
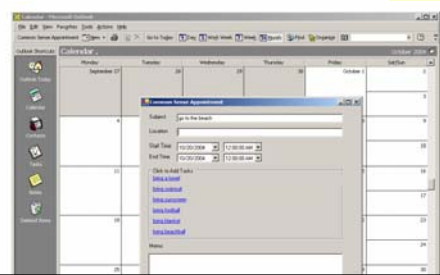 - automates a browsing strategy by best-first search

---
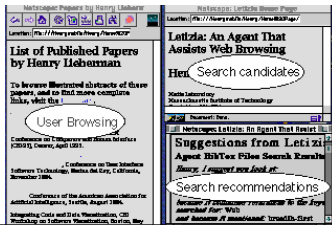
MIT

Task Agents

- agent that predicts tasks users may be interested in adding to their to-do list, based on the context of appointments they are adding to their calendar


DFKI

Agent architectures for KM

- FRODO: A flexible Framework for Distributed Organizational Memories (DFKI)
  - facilitates the evolution of OMs by integrating different local solutions
  - extends the OM paradigm towards a less rigid, distributed scenario
  - Multi-agent architecture:
    - Workflow–related agents
    - Personal User Agents
    - Info Agents
    - Context Providers
    - Domain Ontology Agents
    - Wrapper Agents and
    - Document Analysis and Understanding Agents
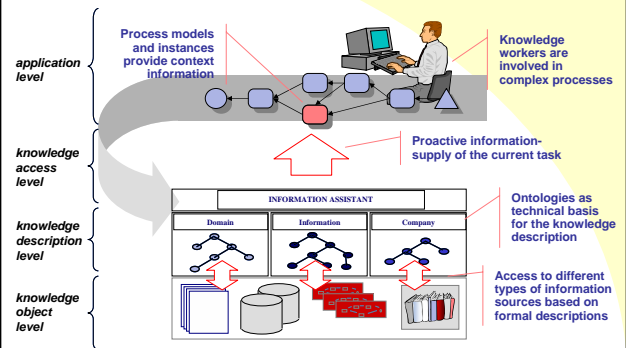
Frodo overview

Outline

Starting Point	Knowledge Management
KM Approaches	Supporting organizational success
Agents in KM	Agents and its applications to KM
Towards AMKM	The OperA approach
Conclusions	Summary and Outlook

Agent models for KM environments

- But...
- ... individual agents will not work together just because they happen to be together
- ... organizational systems have global requirements and goals

- ... need to predict/verify overall behavior
- ... model must balance organizational aims and agent desires

---

Extra needs

- Reflect and Support Organizational Design
  - Structure: roles, norms, interaction
  - Global goals and requirements
- Predictability
- Explicit rules and interaction possibilities
- Representation and manipulation of non standard 'goods'

➔ Agent societies

Autonomy Requirements

- Specify interaction independently from the internal design of the agent
  (**internal autonomy requirement**)
- Balance organizational design and agent autonomy
  (**collaboration autonomy requirement**)

Agent Societies

The role of any society is to allow its members to coexist in a shared environment and pursue their respective goals in the presence and/or in co-operation with others.

– Global goals and requirements

– Predictability

– Explicit rules and interaction possibilities

↳Enforce organizational perspective

Characteristics of Agent societies

- Role models reflect social competence of agents
  – modelled by rights and obligations
  – influence agent behaviour
  – resulting in typical speech acts and protocols for society build-up
- Role models allows to ensure some global system characteristics while also preserving individual flexibility
  – Explicit rights and obligations allow to commit to specific roles
  – roles guarantee global behaviour
  – role descriptions are represented by formal models
- Interaction models reflect workflows and business processes
  – Explicit procedures and access
  – Scenes descriptions are formally specified which allows verification
  – Animation of societies

OperA Model

- **Organizational Model**
  – represents organizational aims and requirements
  – roles, interaction structures, scene scripts, norms
- **Social Model**
  – represents agreements concerning participation of individual agents ('job' contracts for agents)
  – rea = role enacting agent
- **Interaction Model**
  – represents agreements concerning interaction between the agents themselves ('trade' contracts between reas)

Agent Society Model

Interaction Model
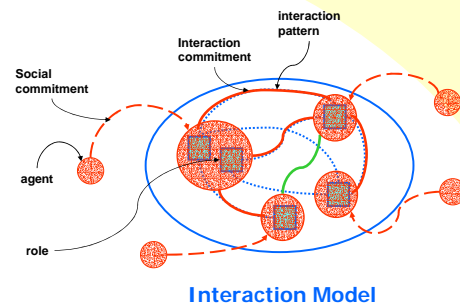
AMKM Application: KEN

- KEN: Knowledge Exchange Network
- Objective: support knowledge sharing and improve collaboration
- Domain: distributed groups developing non-life insurance products

Realization KEN

- Face to face workshops
  - Community forming
  - Create and maintain domain knowledge
  - Moment interaction
- Virtual network
  - Collaboration facilities
  - Knowledge repository
  - Continuous interaction

Architecture: phase I

Evaluation: use of repository is limited
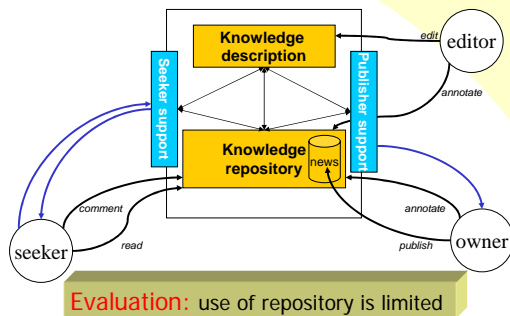
KEN phase II: Knowledge Market

- Motivation
  - Knowledge coupled to owner
  - Recognition of one's value
  - Direct reward
- Agent mediated collaboration
  - vindicate user's interests
  - Both owner and seeker can initiate sharing

11

KEN phase II: Share Requirements

- Stakeholders and requirements
  - Knowledge owners:
    - want to share with controllable, trusted group
    - want to decide on sharing and conditions
    - want fair exchange (reward for share)
  - Knowledge seekers:
    - are not aware of all possibilities
    - want decide on acquisition conditions
  - Organisation:
   - fairness of interactions
    - reuse and maintenance of knowledge

KEN roles

| ROLE	RELATION TO SOCIETY	ROLE OBJECTIVES	ROLE DEPENDENCIES
Applicant	*Potential members*	*Join society*	*Gatekeeper*
Knowledge seeker	Represents stakeholder: Knowledge seeker	Request knowledge	Matchmaker
		Exchange knowledge	Knowledge owner
Knowledge owner	Represents stakeholder: Knowledge owner	Announce offers	Matchmaker
		Exchange knowledge	Knowledge seeker
		Publish knowledge	Editor
Editor	Realization of validation objective of non-life department	Publish validated knowledge	Knowledge owner
		Distribute knowledge	Visitor, seeker
Visitor	Realization of distribution objective of non-life department	Browse repository	Matchmaker Editor

KEN: Norm Analysis

Description		Norm Analysis
Handling of seeker requests	Responsibilities	Initiator: knowledge seeker Action: matchmaker
	Triggers	Pre: seeker issues request Post: owners are informed of request
	Specification	**whenever** *knowledge-request* **then** *matchmaker* **is** *obliged* **to do** *distribute-request-to-partners*
Answer knowledge requests	Responsibilities	Initiation: matchmaker Action: knowledge-owner
	Triggers	Pre: matchmaker issues knowledge request Post: owners answer request
	Specification	**whenever** *request-knowledge* **then** *knowledge-owner* **is** *obliged* **to do** *answer-request* **before** *deadline*

Role dependencies

12
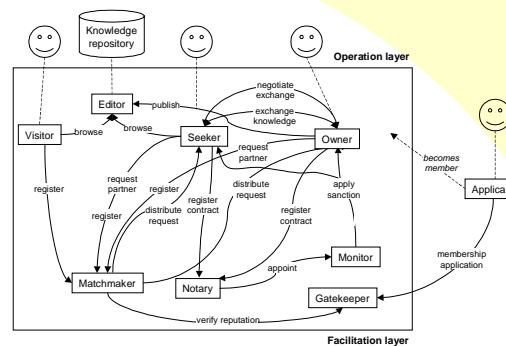
Interaction Structure
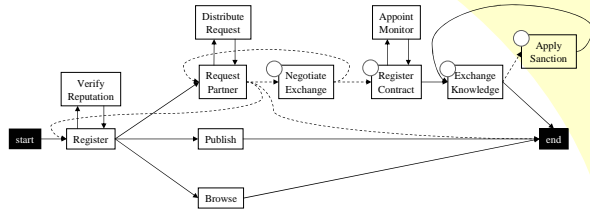
Scene example

Interaction Scene: Partner Request	
Description	*Seeker requests possible partners that can answer knowledge need*
Roles	S: Knowledge-seeker(1), M: Matchmaker (1)
Results	DONE receive-partners(S, M, question, ListPartners)
Patterns	
Norms	OBLIGED request-knowledge(M, knowledge-owners, answer-deadline) BEFORE deadline IF request-knowledge(matchmaker, P, question, deadline) THEN OBLIGED answer-request(P, M, YN, question) BEFORE deadline

Social Model design

- Depends on the specific agents
- Methodological support to determine what role aspects can be negotiated
- Based on:
  - The role descriptions specified in the OM
  - The way role negotiation scenes are specified in the OM
  - The characteristics of the agents that apply for society roles

Social Contract	
Agent	Anne
Role	Knowledge seeker
Clauses	
	1. PERMITTED(Anne, access-kb([KB1, KB3, KB7]) 2. OBLIGED(Anne, publish-received-knowledge(item, KB3) | allows(KO, publish)) 3. ∀p: contract(p, Anne) → PERMITTED(p, publish(p, Anne's-item, kb))

Interaction Model design

- Implementation issue
  - Specific protocols supported by the agents
- Match available capabilities to interaction landmarks
- Based on
  - The specific reas and their social contracts described in the SM
  - The scripts for interaction scenes specified in the OM

Interaction Contract: '*ID* '	
Parties	Anne (A), Bob (B)
Clauses	
	1. OBLIGED A DONE(A, receive(B, report-concurrent-prices) BEFORE *next-week* 2. IF received(B, report-concurrent-prices) THEN OBLIGED B (receive(A, comment-report-concurrent-prices) BEFORE *3-days* AND receive(A, *concept-pricing*) BEFORE *1-month*) 3. IF delayed(B, concept-pricing) THEN OBLIGED B inform(A, delayed(concept-pricing))

Outline

Starting Point	Knowledge Management
KM Approaches	Supporting organizational success
Agents in KM	Agents and its applications to KM
Towards AMKM	The OperA approach
Conclusions	Summary and Outlook

Summary: towards AMKM

- Characterization of KM environments show drawbacks of centralized approaches
  - Distributed nature of knowledge
  - Flexibility of knowledge-intensive processes

- Agent models for KM require:
  - Socially-enabled agents reflect the social aspects of knowledge
    - Goals, plans, rights and obligations
  - Agent society platform (OperA)
    - configuration by specification of formal models
    - agents take up roles:
      - flexible creation of and cooperation between agents
      - individual agent behavior enhances the systems's adaptiveness

Successful KM (1)

- Respect the distributed nature of knowledge in organizations
  - Particular views of stakeholders (individuals, groups, departments)
  - Balance individual and global needs by negotiating shared aspects
  - Provide means for handle context switches (e.g, for knowledge assets in case of diverging views)

- Inherent goal dichotomy between business processes and KM
  - KM processes are typically second order processes (especially knowledge conservation, evolution, organization)
  - Assistant systems and proactivity
  - Business process-oriented KM

Successful KM (2)

- KM is "wicked problem solving"
  - No a priori solution description and planning,
  - social processes

  - Support the complex interactions
  - relatively sophisticated processes like planning, coordination and negotiation of knowledge activities.

- KM has to deal with changing environments
  - Agile architectures

Agent-Mediated Knowledge Management

- Distributedness
- Flexibility of interaction
- Goal orientation, social aspects
- Re- and proactivity

Make Societies of Agents Balance the "KM Seesaw"!

Current and future research

- Methodologies to support the analysis and specification of knowledge management needs of organisations
- Reusable agent-oriented knowledge management frameworks
  - including the description of agent roles, interaction forms and knowledge description
- Agent-based tools for organisational modelling and simulation
- The role of learning in agent-based knowledge management systems

---

Ackowledgements

- Ludger van Elst, DFKI, Germany

- Jurriaan van Diggelen, Uni. Utrecht, NL

- Andreas Abecker, FZI, Germany

- Renata Guizzardi, Uni. Twente, NL

- Anna Perini, ITC-irst, Italy

- *And all participants and contributors to the AMKM series!*

Thank you for your attention!

More information

Springer LNAI 2926, 2003

Special issue in KES to appear in 2006

PhD Dissertation on OperA model, 2004

Workshop Series on AMKM:

- AMKM-03: http://www.dfki.uni-kl.de/~elst/AMKM
- AMKM-04: http://www.dfki.uni-kl.de/~elst/AMKM2004
- AMKM-05: http://www.cs.uu.nl/%7Ejurriaan/AMKM2005
- CfP for KES special issue:

OperA model: http://www.cs.uu.nl/~virginia

Virginia Dignum   IAT'07 Tutorial   61

16