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Knowledge Sharing Medium

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Abstract: A vision of future knowledge management is introduced and discussed from various points of view.

Keywords: Ubiquitious knowledge management, collaboration, knowledge sharing

1   The Vision

The future of Knowledge Management will be the creation of a self-organising knowledge sharing medium that operationalises collaboration and capturing as well as dissemination and retrieval of relevant knowledge and experience for knowledge-intensive tasks.

2   Rationale

This vision is grounded on the view of future knowledge management being based on a transparent ambient medium, i.e. invisible but always available to the user, that

- transmits and routes knowledge rather than just information

- stipulates and captures the creation of knowledge

- leverages the collaboration of its user community

We already sense this vision today. We are facing the transition from a society that is based on the division of labour towards a society based on the division of knowledge. In this knowledge based economy the individual expertise is increasingly specialised. Hence, the ability of one individual to tackle a specific task and to innovate is decreasing. Solving a task requires teams, i.e. the problem and task oriented dynamic networking of skills and expertise. This development is already obvious in most of our organisations: hierarchies are flattened and replaced by networks. Successful knowledge management must reflect this change. It must be

driven by market mechanisms in which individuals become entrepreneurs dealing with knowledge. Hence knowledge management must meet electronic commerce.

In contrast, existing knowledge management approaches can be characterized as either planned economies or anarchies. The "planned economy" approaches manually analyse knowledge needs. Knowledge management programs are set up to satisfy the anticipated needs. These approaches are very time-consuming and require a continuous effort for maintenance. Consequently, they bear the risk that the information needs of the organisation have already changed by the time they have been identified and the corresponding knowledge has been acquired. The analysis of needs is a bottleneck for organisational knowledge management considering that the half-life of knowledge is steadily decreasing. On the other hand, "anarchy" approaches try to circumvent this bottleneck by collecting all knowledge available, regardless of its value to the organisation. Therefore, these approaches often capture irrelevant knowledge. In addition they dilute vital knowledge or may even hinder its creation.

The knowledge sharing medium reflects a new knowledge management paradigm that will overcome these shortcomings by introducing the self-organising regulatory power of the networked knowledge marketplace, controlled by supply and demand.

Knowledge is valued by its utility for the organisation and its members. Its value is not determined by an externally anticipated importance. When viewing knowledge management as networking, it is clear that the quality of networking is not only measured in terms of the captured knowledge, but also in how quickly it locates and brings together the required expertise, in particular people, according to the problem or task specific requirements. Available knowledge and the speed of its deployment determine the organisation's ability to innovate, i.e., to compete in the knowledge based economy.

Having the network analogy in mind, the knowledge sharing medium is not just a "simple" routing and distribution device that delivers knowledge to predefined recipients' addresses. Instead, it exhibits intelligent behaviour by utilising "semantic fingerprints" to determine when to send which documents to whom. The semantic fingerprints are formal representations of meta knowledge about the knowledge items. This meta knowledge characterises the knowledge for the purpose of deciding when to transfer a knowledge item to whom and for what purpose. The data transported by the medium are not units of information (e.g., bits and bytes) but units of knowledge (e.g., topics, concepts and terms).

The ability to identify these knowledge units from the behaviour of users and other knowledge sources as well as the ability to execute computations with the knowledge units, enable the medium to relate knowledge sources to each other. The set of knowledge units that identifies a source is its "semantic fingerprint". The case-based comparison of fingerprints or logical reasoning are possible types of computations. This combined with the capability to learn new knowledge units

from knowledge sources and their use turns the knowledge sharing medium into a truly self-organising collective memory.

The use of knowledge units and the computational framework requires that the medium will be built on top of a formal or semi-formal knowledge representation and reasoning mechanism.

One may object that past approaches to create large explicit knowledge models failed, e.g. CYC. The reason for this is, that the top down approach got stuck in the effort-intensive and time-consuming knowledge acquisition bottleneck. The knowledge sharing medium will not try to formally represent the organisation's knowledge, but only to formally characterize the knowledge. Hence, what is represented is not the knowledge itself but meta-knowledge - descriptions. Further, the knowledge sharing medium solves the knowledge acquisition problem by distributing the acquisition effort across the community of all its users. The users will thereby define and structure their own vocabulary and its interpretation. Thus the medium is close to its users' everyday language and is not dictated by the outside of the community nor is it strictly formalised. Thus the medium becomes the mirror of the individuals' perceptions of the world including ambiguity.

Additionally, since an explicit knowledge representation is independent of a natural language, the medium overcomes multi-lingual barriers. Each knowledge unit can be expressed by many (multi-)lingual wordings. Hence, the knowledge sharing medium will overcome the drawbacks of text-based search. Content (such as documents) is no longer selected because of matching keywords (which are different in every language) but by its meaning, i.e., semantic similarity.

Technically, knowledge acquisition takes place by collective learning. The medium analyses user behaviour, documents and other content. Analysing means identifying candidates for new knowledge units. Candidates are selected by statistical significance and are proposed to the interested part of the community, that is, those users who deal with the candidate decide whether it becomes a knowledge unit and how it is related to other existing units. Therefore, the medium is a mediator of knowledge evolution by discovering new subjects and drawing attention to them. It is expected that the effort necessary for the knowledge acquisition by each individual will be far outweighed by the benefits such as a reduced effort for relating new terms to personally known ones or the immediate and far more complete location of relevant information sources. Thus, the medium facilitates organisational learning.

Last but not least, the knowledge sharing medium will be operated like a real economic market. As economy it is lubricated by money. The use of a virtual currency will replace nowadays bartering practice. Within a commercial organisation, this currency can be underpinned by real value like, e.g. a Miles & More programme. Hence, users not only act as entrepreneurs on a knowledge marketplace, they are also rewarded like entrepreneurs.

3   Technical Requirements

Following the above rationale for a Knowledge Sharing Medium it will consist of

- A software tool infrastructure for a self-organizing knowledge sharing medium that is transparent to its users.

- An initial body of knowledge that acts as the core for the medium and is easily adaptable to various organizational needs.

- An extended body of knowledge that acts as the "knowledge seed" for a self-learning, self-organizing medium.

- A method for setting-up and configuring the medium.

- A method for keeping the medium alive.

The Knowledge Sharing Medium will be a self-organising and learning knowledge representation. Required properties are that it enables

- the semantic cross-lingual search based on explicit knowledge representations

- the delivery of information according to the working circumstances of the individual, namely context, task and role

- the timely delivery by constantly monitoring its traffic and appropriate reaction

- the dynamic networking of experts and other knowledge sources on demand

- the latter leveraging knowledge sharing, collaboration and socialisation within an organisation

4   State-of-the-Art

According to [AB+00] successful organisational memory and knowledge management systems need to fulfil five major requirements, or criterions:

(1) Collection Criterion: The systems forms a central and systematically organised repository of the usually scattered information and knowledge that is available in an organisation, including the tacit expertise represented by skilled persons.

(2) Seeding Criterion: A successful knowledge management system requires explicit knowledge representations. However the knowledge engineering

effort has to be minimised to ensure a low entry barrier for deploying such a system.

(3) Growing Criterion: User feedback and utility must be exploited to grow and evolve the systems content. This should happen as automatic as possible to reduce maintenance cost and to ensure that the system is actually maintained.

(4) Ubiquity Criterion: The system must be seamlessly integrated into the workplace to ensure user acceptance and actual usage.

(5) Activity Criterion: The system must actively provide useful information and act as a helpful co-worker, opposed to a reacting search agent.

Comparisons such as [Wen98, AM+00] show that successful knowledge management systems must fulfil all of these criterions. Failure on one or more of them makes the failure of the whole system probable. [Wen98] as well as other authors additionally stress the long-term social and motivational aspects. In most cases user acceptance and motivation is stipulated by organisational measures or occasional incentives. We believe, that this should become the 6th criterion:

(6) Motivational Criterion: Successful knowledge management systems require accompanying motivational measures or must include an appropriate reward mechanism for contribution and usage of content.

The proposed knowledge sharing medium will fulfil all six criteria and is as such unique by its holistic approach. In particular the introduction of economic principles into organisational memories and knowledge management is a significant innovation. State-of-the-art approaches, whether they are of commercial or academic nature, still need significant advance to satisfy the above criteria. The following is just an exemplary selection partially adopted from [AB+00] to illustrate some of the differences:

- the Answer Garden (AG) [Goo99], is a "classic" academic organisational memory system that focuses on the sharing of information within groups of people. Knowledge is represented as a taxonomy of questions with related experts. The taxonomy as well as the relation to expertise are created manually. This structure is a static one. By representing any knowledge source, including human experts, in a homogenous formalism that is embedded into an inference mechanism, knowledge.direct provides an automated dynamic association of expertise to tasks – even if the task was not foreseen by a knowledge engineer.

- the Knowledge Sharing Environment (KSE) [Goo99], aims at improving the exchange of information between people. It stores information with user provided annotations that indicate interest that are served by the information. Each user is represented by a profile that models his interests and informational needs, allowing for active information provision by

matching annotations with profiles. However, since KSE is not integrated into the workplace it requires the initiative of the user to look for information. The knowledge sharing medium's innovation in this field is the permanent monitoring and analysis of the users activity. Hence it is able to actively offer semantically relevant information when it is needed by the user.

- Autonomy [Goo99], is a commercial information portal system that utilises Bayesian and neural networks to learn relevant terms and probabilistic associations among them from textually accessible sources including e-mails. The occurrence of the same or a related term in two e-mails or documents indicates that the authors belong to a community of interest. The system utilises a sub-symbolic learning approach that automates the seeding and growing process. However, the resulting meta-knowledge is a black-box that is not comprehensible for the human user. It escapes the control of strategic knowledge management, while the self-organised knowledge structures of the knowledge sharing medium discovers unused or missing knowledge. The innovation of knowledge.direct is that the medium explicitly reflects the actual knowledge of its users in eligible way and thereby allows for the integral development of an organisations knowledge.

- Hyperwave [Goo99], is one of, if not the, most sophisticated corporate portal tools. It includes means for asynchronous and synchronous communication of people; offers dynamic link management and meta-attributes to describe and retrieve stored information and much more. Here again the structuring of information and content has to be done manually, changes that take place in the working environment require manual intervention. This is cost and time intensive and bears the constant risk of obsolete and outdated structures.

5 Research

Having looked at examples of the state-of-the-art and the vision of a Knowledge Sharing Medium we can take a closer look at the technical innovations and the research that is required.

5.1 Routing and Transmitting Knowledge

By comparing the semantic content of documents and messages to individual's interests (via semantic fingerprints), the medium determines whom to send newly created knowledge. This innovative form of communication takes the burden off

the sender to think who might be interested in the information and to decide whom to send the information to. The information reaches "automagically" the right recipients.

However, the medium does not only enable communication in an innovative way, but also acts as an archive. This way the medium can "play back" knowledge on demand, for example, if a user poses a query to the medium. In such a case, the medium will deliver stored knowledge as well as pointers to experts within the organization. At the same time it forwards the search request to the most promising experts within the organization. If there is no "good matching" knowledge available within the organization, the medium may even activate agents to find relevant information in the web (e.g., through search engines). The medium itself becomes an active communication partner.

One problem with this approach is that knowledge need and knowledge supply will rarely match exactly. Therefore, the comparison of semantic fingerprints must be done based on the notion of similarity. However, this will result in documents that match the knowledge seeker's request only partially. Also, an expert may receive a request that does not fit 100% to his or her expertise. Thus, the medium must *explain* why it selected certain knowledge sources. An exemplary explanation could look like this: "This request was routed to you because you are considered to be an expert on topic X. To answer the request, expertise about topics Y and Z is needed. Unfortunately, there is no one in the organization who is considered to be an expert in Y. Since X is a specialization of Y, your answer would be highly appreciated." A similar explanation could be given to the knowledge seeker to explain why the particular expert has been chosen by the medium. This enables the knowledge seeker to put the received answer into context.

The ability to explain partial hits and to make "compromises" regarding the selection of recipients constitutes another innovation. By transmitting knowledge in addition to the content, the medium provides personal, context-sensitive functionality for the dynamic provision and sharing of relevant knowledge.

5.2   Medium-Based Collaboration

As outlined in the objectives, the performance of many tasks requires a team consisting of individuals with complementary skills and abilities. The medium supports the identification of adequate teams via its semantic fingerprint mechanism. To commence a task, it suffices to submit a task description to the medium. The medium will respond with a list of experts for the required knowledge, ranking them from generalists (who have knowledge on several required topics) to specialists (who complement the team by providing knowledge for a particular topic). In addition, the medium will display explicit knowledge available as documents. This provides the task initiator with the state-of-the-practice of the organization regarding the required expertise. Topics for which a lot of explicit knowledge ex-

ists may not need to be represented by an expert in the team, because experts of closely related topics may fill in.

Novel in this approach is the fast identification of suitable experts resulting in multi-lingual teams since the selection is based on the language-independent semantic fingerprints. Experts are identified based on the intensity they elaborate on a particular topic (e.g., the more an individual "publishes" on a particular topic, the more expertise on this topic is assumed by the medium). Hence, the medium improves the working life of individuals since they are no longer assigned to tasks that are not related to their interests merely because better suited experts were not known to the task initiator. By allowing individuals to specify their interests (i.e., topics they would like to learn more about), the freedom of choice regarding work assignments is improved.

5.3   Economy of the Knowledge Market

Central to the new knowledge management medium is the concept of a knowledge marketplace. In this market, the price of knowledge is determined by supply and demand. For this purpose a virtual currency called the Knowledge Currency Unit "KCU" (pronounced as "Kay Cue") is introduced in an organization. Documents are tagged with a price by their authors. Those utilizing the document have to pay this price. The more often a document is utilized the higher the authors' revenues. Reviews can be awarded with KCUs as well. Although we are all familiar with the notion of putting a price on knowledge (we do it every time when we buy a book or newspaper), this concept has not been applied to organization-internal knowledge yet. Also, we are used to putting a price on experts' advice (e.g., lawyers), but in organizations asking a colleague is free. Through the medium such consultations become accountable.

However, as in the traditional economy, it may become necessary to exert influence on knowledge trading, for example, for strategic reasons. These can be seen in analogy to economic politics. Corresponding political instrument aim, for example, at setting up rules for competition, stabilizing the market, nurturing growth, or redistributing money to give all economic subjects a fair chance.

Questions are

- in how far it is feasible to simplify or model the mechanisms of the traditional economy.

- what kind of (political) instruments should be applicable to the medium.

5.4   Seeding and Configuring the Medium

The set-up and running of the knowledge sharing medium could be based on the results of the EU project ENRICH. The ENRICH methodology distinguishes the initial seeding of the knowledge repository and the growing phase. Applied to the knowledge sharing medium, the initial seeding establishes the basic vocabulary of the medium. Beyond that a novel semi-automatic modelling method is required. This method analyses existing documents and other content, suggests important concepts based on statistical significance and allows the interactive definition of semantic relationships between these concepts. During the indexing phase, documents are associated automatically with the identified concepts, that is, the semantic fingerprint of a document is not constructed manually but computed automatically.

Furthermore, initial profiles of the users (describing their interests and preferences) are derived from information already existing in the organization such as documents authored by the users and descriptions of job positions. In addition, formal communities can be identified (e.g., by exploiting documents such as organizational charts). Goal of this project is to find out in how far these activities can be automated.

Moreover, as part of the seeding phase, the parameters for controlling the behaviour of the medium have to be defined. This requires an extension of existing seeding methods since they are based on other knowledge management paradigms.

5.5   Self-Organizing Growth Through Machine Learning

The dynamic knowledge and meta-knowledge of the medium that enables it to select relevant knowledge items or sources for transmission must itself be managed (acquired, evaluated, maintained) and represented in a way that it can be processed automatically by the medium. Since manual knowledge management and formalisation is a quite cost-intensive task and violates the transparency goal for the medium, this is only feasible during the seeding of the medium. After the medium is seeded it must show a self-organising and adapting behaviour. Therefore it is necessary to

- define a measurable objective function as optimisation goal for the knowledge selection behaviour of the medium (e.g., average relevance of knowledge items, average value of selected knowledge items, etc.).

- make use of machine learning and knowledge discovery approaches to generate and update dynamic knowledge automatically, based on observed user behaviour, i.e., update the relevance assessment knowledge (e.g., a similarity measure) to improve the optimisation goal.

- proactively generate and ask specific questions to users that allow to obtain the necessary feedback as input to the learning approaches, while keeping the additional burden as low as possible.

- assess the impact of potential changes of the dynamic knowledge to obtain a goal directed learning behaviour.

To attain these objectives, existing techniques from case-based reasoning, machine learning, and information retrieval will be combined in a novel way. The resulting method will be applied for the new knowledge management paradigm described in this project proposal.

6   Conclusion

There are only few approaches to knowledge management that come close to the idea of a medium and its underlying vision (besides science fiction and philosophical considerations like the epistemification of machines). While the knowledge economy is widely accepted as a fact no actual attempt has been made to transfer its principles from the macrocosm of the global economy to the microcosm of a knowledge centric organisation. In this sense the medium can be seen as being visionary and we must be aware of its risk according to the quality of the learned knowledge as well as the level of user acceptance that we will obtain. But the same is true for our society and its attitude to the knowledge economy.

However, the proposed knowledge sharing medium can be seen as an epitome of the Semantic Web, i.e. a perfect small-scale projection. The Semantic Web, as being described by Tim Burners Lee's vision of the future of the Internet, will build on self-organising principles as they are required in the everyday business of our knowledge work, just on a much larger scale. It can be expected that significant research efforts will take place to make this vision a reality. It is an agenda to follow.

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